AmeriDendro2022

Montréal, Canada

FULL PROGRAM

Montréal / Tiohtià:ke

June 27-30, 2022

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WinDENDRO™ 2022

Tree-Ring & Wood Density Analyser
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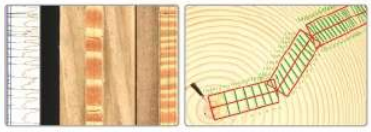
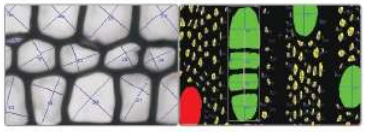


- Automatic / Interactive ring detection
- Multi-segment paths
- Earlywood / Latewood boundary
- Ring-widths & Cross-dating graphics
- Correlation functions
- Smoothing spline displayed to choose the best parameters for detrending
- Wood density using x-ray films, digital x-ray imaging, or "Blue intensity" reflected-light method
- Analysis of multiple samples at a time by using more than one measurement window
- Data can be saved directly in Decadal format
- 32-bit and 64-bit versions included with each licence
- Can read large BigTIFF files over 4GB (64-bit version)

WinCELL™ 2022

Wood-Cell Structure Parameters
Analyser over Annual Rings



- Cell area, length, width, position, perimeter, form coefficient
- Ring boundaries including years identification
- Lumen and Wall true area measurement
- Integrated knowledge of wood cell anatomy and annual tree-ring formation
- Analysis per annual ring for one or more rings per image
- Spatial distribution to analyse variations in function of cell position on annual rings
- Data computed on a yearly basis in a format similar and compatible with WinDENDRO™
- Analysis of multiple samples at a time by using more than one measurement window
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Contents

Introduction

Word of Welcome

Dear colleagues,
Dear friends,

Welcome to Montréal!

The Université du Québec at Montréal (UQAM) is proud to host the 4th edition of the AmeriDendro conference in our beloved city! The Montréal edition hopes to build on the huge success of previous editions in Vancouver (Canada) in 2008, Tuscon (U.S.A.) in 2013 and Mendoza (Argentina) in 2016. Our city is a vivid, dynamic and multicultural / multilingual place that is particularly enjoyable in the summer period, with plenty of festivals and outdoor activities for all tastes. Therefore, we are confident that AmeriDendro 2022 attendees will have a memorable time before, during and after the event.

Overall, nearly 200 abstracts were submitted to this 4th edition of AmeriDendro, with speakers originating from 24 different countries from the Americas and around the world. The scientific committee made huge efforts to ensure that all fields of dendrochronology are represented in workshops, sessions, symposia and keynote presentations. We therefore strongly believe that the final program represents a stimulating set of activities that reflect the most recent, state-of-the-art development in tree ring sciences.

Lastly, we would like to highlight the generous contributions from sponsors who made this event possible. We acknowledge the unconditional support from the Tree Ring Society, Tourism Montréal, Regent Instruments ®, the GEOTOP and CFR research centers, The Sciences and Humanities Faculties of UQAM, the department of geography, Olympus ®. Without precious support, it would have been impossible to organize this event, given the highly volatile and uncertain context of previous years.

Now let's work on the "reconstruction... of our tree-ring community"! Have a great conference everyone.

Étienne Boucher, chair

On behalf of the Local Organizing Committee and the Scientific Committee

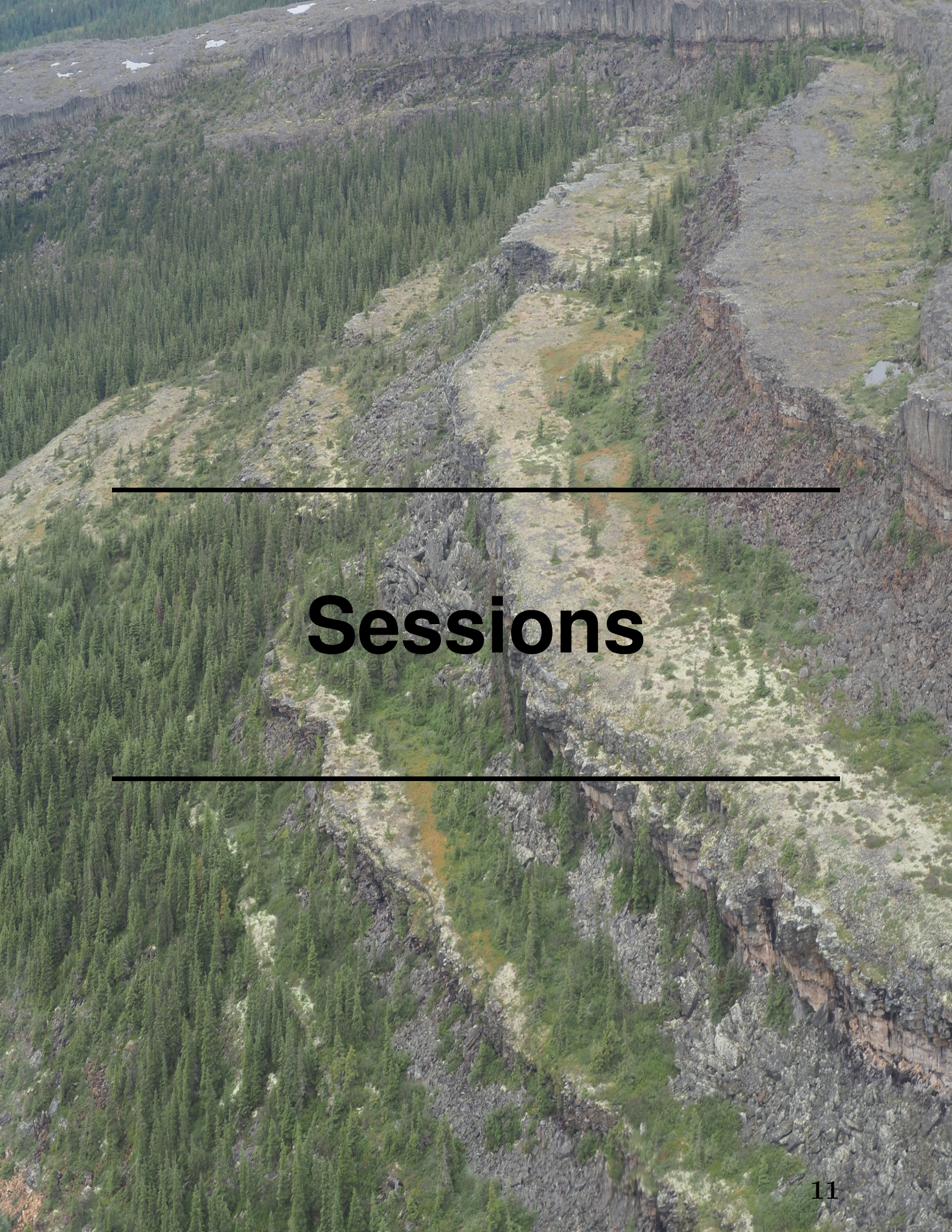
Local Organizing Committee

- Étienne Boucher, Université du Québec à Montréal
- Sandrine Solignac, Université du Québec à Montréal
- Luc Lauzon, Université du Québec à Montréal
- Fabio Gennaretti, Université du Québec en Abitibi-Témiscamingue
- Trevor Porter, University of Toronto – Mississauga
- Camille Lepage, Université du Québec à Montréal
- Ignacio Hermoso de Mendoza Naval, Université du Québec à Montréal
- Emilie Labourdette, Université du Québec à Montréal
- Maya-Gabrielle Lévesque, Université du Québec à Montréal

Scientific Committee

- Rocío Urrutia, Universidad Austral de Chile, Chile
- Ignacio Mundo, Universidad Nacional de Cuyo at Mendoza, Argentina
- Meagan Rochner, University of Louisville, USA
- Jim Speer, Indiana State University, USA
- Valerie Trouet, University of Arizona, USA
- Colin Larocque, University of Saskatchewan, Canada
- Jill Harvey, Canadian Forest Service, Canada
- Kelsey Copes-Gerbitz, University of British Columbia, Canada
- Lori Daniels, University of British Columbia, Canada
- Fabio Gennaretti, Université du Québec en Abitibi-Témiscamingue, Canada
- Étienne Boucher, Université du Québec à Montréal, Canada
- Sepideh Namvar, Department of Biology, Université du Québec à Montréal, Canada
- Trevor Porter, University of Toronto – Mississauga, Canada

		June 27			June 28			June 29		June 30			
Start	End	SH-3220	SH-3420	SH-3260	Amphitheatre	Poly	SH-3420	Amphitheatre	Poly	Amphitheatre			Poly
08:00		Registration opens			Registration opens			Registration opens		Registration opens			
08:25	08:45	Worshop	Worksop		Welcome			Welcome		Welcome			
08:45	09:00	Blue intensity	MAIDENiso		Florence E. Hawley			Keynote Kuitems		Keynote Locosselli			
09:00	09:15				Ngoma								
					5min								
					Symposium 1	Dendroecology	Dendroclimatology	Symposium 7	Symposium 2	Symposium 8			Proxies and models
09:20	09:35				Bouriaud	Evans	Davi	Bossema	Chhin	Ortega Rogriguez / Veiga			Esper
09:35	09:50				Bouriaud	Alfaro-Sanchez	Nogueira	Rao	Axelson	Arturo Pacheco-Solana / E.Ziaco			Wang
09:50	10:05				Heilman	Yu-Mei Jiang	Pace	Domingues-Delmas	Rozenberg	panel discussion			Rezsöhazy
10:05	10:20				Gea-Izquierdo	Martin-Benito	Leland	Rubino	Depardieu	Ticse-Otarola / Rodrigues-Morata			Torbenson
10:20	10:35				DeRose	Chavardes	Hébert	Miyake	Robert	Morales / Rodriguez-Caton			Correa-Diaz
					BREAK					panel discussion			
					Symposium 1	New perspectives	Dendroclimatology	Symposium 7	Dendrogeosystems	Symposium 8			Symposium 4
11:00	11:15				Gutierez	Capshew	Martinez del Castillo	Juliette Taieb	Scott St.Georges	Jorge A. Giraldo / Oelkers			Gennarretti
11:15	11:30				Girardin	Griffin	Nolin	Duncan Christie	Nixon	Scipioni / Ferrero			Berkhellamer
11:30	11:45				Marchand	Pederson	Campbell	Griggs	Sauchyn	panel discussion			Haines
11:45	12:00				Strimbu	Rydval	Trumper	Eilen Kuhl	Klesse	Jim Speer / Pons Ganddini			Porter
12:00	12:15				Mirabel	Munoz-Salazaar	Trouet	Greg King		panel discussion			
					LUNCH				15min: (room conversion)	LUNCH			
								12:30-14:30 POSTER SESSION (Poly-room)					
					Symposium 5	Ecophysiology	Dendroclimatology	All poster presenters		13:25	13:30	Welcome	
13:30	13:45		Workshop	Workshop	Bonney	Segovia-Rivas	Granato-Souza	FREE LUNCH FOR ALL ATTENDEES		13:30	13:45	Keynote: Arseneault	
13:45	14:00		Open dendro	Best practices	Rissanen	Thivierge	Ferrero			13:45	14:00		
14:00	14:15			δ13C	Vitali	Rinne-Garmston	Lucas			5min		Symposium 3	Xylogenesis and anatomy
14:15	14:30				Rochner	Puchi Gonzalez	Rhee			14:05	14:20	Jia Hu	Lange
14:30	14:45				Hirsch	Angove	Gedalof	Outdoor activities		14:20	14:35	Kinzie Bailey	Gao
14:45	15:00				Martin	Badaroux	Parsons			14:35	14:50	Marco Lehmann	Silvestro
					BREAK					14:50	15:05	Rossella Guerrieri	Butto
										15:05	15:20	Soumaya Belmecheri	
					Dendrogeochemistry	Dendroecology	Dendroclimatology			15:20	15:35	Brandon Strange	room conversion
15:15	15:30				Csank	Guiterman	Homfeld			15:35	15:50	Laia Andreu-Hayles	
15:30	15:45				Ortega Rogriguez	Robles	Wilson			15:50	16:05		Symposium 6 Allyship Panel
15:45	16:00				Gideon Olugbadieye	Copes-Gerbitz	J. Maxwell			16:05	16:20		Buck, Copenheaver,
16:00	16:15				Hermoso de Mendoza	Hoffman	Reinig			16:20	16:35		Axelson, Gentry,
16:15	16:30				Szejner	Kunz	Higgins			16:35	16:50		Copes-Berbitz,
16:30	16:45				Javier del Hoyo Gibaja	Stambaugh	Daux			16:50	17:05		Zampieri,
16:45	17:00				Tucker	Mandra	Therrel			17:05	17:20		
17:00	17:15					Comeau	Dawson			17:20	17:30		Farewell
		17h30 Ice Breaker FREE						18h30 TRS AWARDS CEREMONY PRE-DINING COCKTAIL + LIVE JAZZ AGORA Hydro-Québec (CO-R500) FREE				JAZZ FEST!!!!	



Sessions

Workshops

- Workshop. Use and applications of the process-based model MAIDENiso: *Ignacio Hermoso de Mendoza*, *Fabio Gennaretti*, *E Boucher* Classroom (SH-3420), June 27th, 08:30 - 12:30
- Workshop. Blue Intensity for Dendrochronology: *Rob Wilson*, *Grant Harley*, *Karen Heeter*, *Emily Reid* Classroom (SH-3220), June 27th, 08:30 - 12:30
- Workshop. openDendro: Advanced Open-source Tools for Dendrochronology and Paleoenvironmental Reconstruction: *Andy Bunn* Classroom (SH-3420), June 27th, 13:30 - 17:30
- Workshop. Blue Intensity for Dendrochronology (continued): *Rob Wilson*, *Karen Heeter*, *Grant Harley*, *Emily Reid* Classroom (SH-3220), June 27th, 13:30 - 17:30
- Workshop. Best practices for using tree-ring stable isotopes of Carbon and Oxygen in paleoclimate and ecophysiology.: *Soumaya Belmecheri*, *Milagros Rodriguez-Caton*, *Alienor Lavergne*, *Paul Szejner*, *Valérie Daux* Classroom (SH-3260), June 27th, 13:30 - 17:00

Keynote presentations

- Dr. Florence Hawley Ellis Lecture (Keynote presentation): *Justine Ngoma* Amphitheatre (SH-2800), June 28th, 08:45 - 09:15
- Exact Dating of the First Europeans in the Americas (Keynote presentation): *Margot Kuitems*, *M.W. Dee* Amphitheatre (SH-2800), June 29th, 08:45 - 09:15
- A tipping point for tropical tree longevity (Keynote presentation): *Giuliano Locosselli* Amphitheatre (SH-2800), June 30th, 08:45 - 09:15
- Short fire intervals and long tree ring chronologies in the eastern Canadian taiga (Keynote presentation): *Dominique Arseneault* Amphitheatre (SH-2800), June 30th, 13:30 - 14:00

General sessions

Dendroclimatology, PT1 Classroom (SH-3420), June 28th, 09:20 - 10:50

- Evaluating Tropical Cyclone Impacts and Climate Response of a Maritime Forest (1737-2018), Montauk, N.Y.: *Nicole Davi*

- 400-year multi-parameter reconstruction of Carpathian temperatures from tree rings: *Juliana De Sousa Nogueira*
- A 211-year moisture reconstruction in southern Quebec based on snowpack-sensitive trees: *Alex Pace*
- Volcanic Cooling Events: Impacts on Climate and Indigenous Peoples in Northwestern North America: *Caroline Leland*
- Using dendrochronological data to characterize the spatio-temporal structure of climate variablity: *Raphaël Hébert*

Dendroclimatology, PT2 Classroom (SH-3420), June 28th, 11:00 - 12:15

- Modelling future temporal and spatial growth dynamics of Pinus sylvestris across Europe: *Edurne Martinez del Castillo*
- A 247-years tree-ring reconstruction of spring temperature and relation to spring flooding in Eastern Boreal Canada: *Alexandre Florent Nolin*
- Subalpine tree growth responses to climate vary by species, tree size, and local site conditions: *Elizabeth Campbell*
- Topography mediates growth and drought sensitivity in California valley oak (Quercus lobata): *Matthew Trumper*
- 800 years of summer European-North Atlantic jet stream variability and its impact on climate extremes and human systems: *Valerie Trouet*

Dendroclimatology, PT3 Classroom (SH-3420), June 28th, 13:30 - 15:00

- Proxy and historical evidence for rainfall extremes in the Amazon and northeastern Brazil, 1790-1900: *Daniela Granato*
- Two centuries of hydroclimatic variability reconstructed over the Amazonian Andes of Peru: *María Eugenia Ferrero*
- Cross-continental hydroclimate proxies: Tree-rings in Central Chile reconstruct historical streamflow in Southeastern So: *Christine Lucas*
- Estimating Uncertainties in the Multidecadal Variability of Colorado River Flows from Treering Data: *George Rhee*
- Effects of climate on the radial growth of mixed stands of Nothofagus nervosa and N. obliqua in Patagonia: *Ze'ev Gedalof*
- Reconstructing Late Pleistocene Atmospheric Radiocarbon using Subfossil New Zealand Kauri (Agathis australis): *Priyadarshini Parsons O'Brien*

Dendroclimatology, PT4 Classroom (SH-3420), June 28th, 15:15 - 17:15

- Freshet- and drought-season runoff reconstructions for the Fraser Basin Headwaters, British Columbia, Canada: *Inga K. Homfeld*
- 500 years of past temperatures derived using Blue Intensity from Araucaria araucana in Northern Patagonia, Argentina: *Rob Wilson*
- Recent increases in tropical cyclone precipitation extremes over the US east coast: *Justin Maxwell*
- Subfossil trees re-date the Laacher See eruption to 13,006 BP and synchronize the Younger Dryas: *Frederick Reinig*
- Can we identify volcanic signals in Southern Hemisphere tree rings?: *Philippa Higgins*
- Isotope-inferred temperature variations in Northern Patagonia are asynchronous with global records over the last 1000-y: *Valérie Daux*
- Tree-ring reconstructions of streamflow variability for Southeastern U.S. Interstate Rivers: *Matthew Therrell*
- Persistent and cumulative impacts of drought on forest growth: a Douglas fir case study: *Andria Dawson*

Dendroecology, PT1 Salle polyvalente (SH-4800), June 28th, 09:20 - 10:35

- Tree-ring data reject the leading edge-trailing edge hypothesis for species range change: *Margaret Evans*
- Unprecedented increase in tree growth rates in boreal forests on the Taiga Shield during the 21st century: *Raquel Alfaro-Sánchez*
- Impact of disturbance signature on ring width and blue intensity chronology structure and climatic signal in Carpathians: *Yu-Mei Jiang*
- Long-term carbon storage and residence time in old-growth forests: *Dario Martin-Benito*
- How does the surrounding environment determine tree growth in boreal forests of western Québec?: *Raphael Chavardes*

Dendroecology, PT2 Salle polyvalente (SH-4800), June 28th, 15:15 - 17:15

- Historical diversity of fire regimes across Arizona and New Mexico: *Chris Guiterman*
- Synoptic-scale climatic controls of fire activity in the red pine forests point to the role of winter and spring conditions: *Daniela Robles*

- The role of Indigenous land use in a mixed-severity fire regime in the dry forests of British Columbia, Canada: *Kelsey Copes-Gerbitz*
- Reconstructing historic fire activity with whitebark pine in Tweedsmuir Provincial Park, northern British Columbia: *Kira Hoffman*
- Elevational differences in the timing and intensity of larch budmoth outbreaks in two valleys of the European Alps: *Marcel Kunz*
- Frontiers in fire ecology exist in tree-ring fire scar reconstructions of the southeastern U.S.: *Michael Stambaugh*
- Does disturbance impact the climate sensitivity of surviving trees in diverse temperate forests?: *Tessa Mandra*
- Divergent patterns in yellow-cedar growth driven by anthropogenic climate change: *Vanessa Comeau*

Dendrogeochemistry Amphitheatre (SH-2800), June 28th, 15:15 - 17:15

- New annually resolved records of Neogene Arctic climate from tree rings and estuarine shells from the Canadian Arctic: *Adam Csank*
- Climate signals in tree-ring chemical components of Cedrela fissilis Vell. growing in Brazilian Amazon: *Daigard Ricardo Ortega Rodriguez*
- Tracking Water Sources and Root Water Uptake of Boreal Trees on Fluvioglacial Deposits: Perspectives from Stable Isotope: *Oloruntobi Gideon Olugbadieye*
- A new snow module improves predictions of isotope-enabled MAIDENiso forest growth model: *Ignacio Hermoso de Mendoza*
- Long-term drought effects on semi-arid forests influenced tree capacity to respond to abrupt seasonal changes: *Paul Szejner*
- Dendroprovenancing instream wood at the watershed scale: *Javier del Hoyo Gibaja*
- Dendrochronological Evidence of Extreme Events on the Gulf of Mexico Coast: *Clay Tucker*

Dendrogeosystems Salle polyvalente (SH-4800), June 29th, 11:00 - 12:15

- Four decades of paleoflood hydrology through wood anatomy: *Scott St. George*
- Assessing Vulnerability of American Holly (Ilex opaca) Trees in Coastal Maritime Forests of N.Y. and N.J.: *Troy Nixon*
- Proxy versus Modelled Hydrology, Saskatchewan and Athabasca River Basins: *Dave Sauchyn*

- Drought legacy effects in radial tree growth are meaningful but rarely significant under heightened statistical scrutiny: *Stefan Klesse*

Ecophysiology Salle polyvalente (SH-4800), June 28th, 13:30 - 15:00

- Temperature is not the main driver of vessel diameter(when standardized by height) across climatic gradients in Viburnum: *Ali Segovia-Rivas*
- Intra-annual boreal tree growth and water stress responses to environmental changes: *Jeanny Thivierge-Lampron*
- Interpretation of intra-annual tree-ring d13C profiles of control, droughted and re-watered Scots pines: *Katja Rinne-Garmston*
- Long-term eddy covariance fluxes and xylem anatomy for understanding carbon fixation in white pine woody biomass: *Paulina Fernanda Puchi Gonzalez*
- Ecological implications of leaf water deuterium enrichment: *Charlotte Angove*
- Potential growth scenarios for boreal forests with the ecophysiological model MAIDEN: *Marceau Badaroux*

New perspectives and developments Salle polyvalente (SH-4800), June 28th, 11:00 - 12:15

- Toward a Historiography of Dendrochronology: *James Capshew*
- Emerging technologies with dendrochronology: platforms, progress, and potential: *Daniel Griffin*
- To discard or not to discard: On cross-dating ecological tree-ring collections: *Neil Pederson*
- High-resolution wood surface imaging for dendrochronology: towards the development of unbiased reflectance timeseries: *Milos Rydval*
- Tree-rings as a natural encyclopedia: itinerant and interactive exhibition as an educational tool for students: *Tomás Muñoz-Salazar*

Proxies and models Salle polyvalente (SH-4800), June 30th, 09:20 - 10:50

- IPCC Paleoclimate Streamlining: An alternative Perspective on Common Era Temperature Variability: *Jan Esper*
- Filling the North American gap with robust and temperature-sensitive millennial tree ring density data: *Feng Wang*

- Using a process-based dendroclimatic model in a data assimilation framework: a test case in the Southern Hemisphere: *Jeanne Rezsöhazy*
- The use of hydrological model output as targets in tree ring-based streamflow reconstructions: *Max Torbenson*
- The greening effect described by remote sensing data was not coupled with phenological and tree growth rates in Mexicco: *Arian Correa-Diaz*

Xylogenesis and anatomy Salle polyvalente (SH-4800), June 30th, 14:05 - 15:35

- Forward modelling reveals a complex pattern of climatic control on wood formation in conifers at cold-limited sites: *Jelena Lange*
- Origin of intra-annual density fluctuations in a semi-arid area of Northwestern China: *Jiani Gao*
- Upscaling xylem phenology: Sample size matters: *Roberto Silvestro*
- Contrasting carbon allocation strategies related to wood porosity converge toward similar growth responses to drought: *Valentina Buttò*

Symposia

Symposium 1 (PT 1). Tree rings from national forest inventories: a timely opportunity to assess tree growth across space and through time Amphitheatre (SH-2800), June 28th, 09:20 - 10:35

- Tree-ring research and the theory of sampling: NFI-based samples strength and specificities: *Olivier Bouriaud*
- Fusing tree-ring growth and national forest inventory data to forecast tree growth and aboveground biomass across scales: *Kelly Heilman*
- Understanding carbon allocation dynamics after disturbance combining dendroecological and permanent sampling plots: *Guillermo Gea-Izquierdo*
- Adding tree rings to North America's national forest inventories: *R. Justin DeRose*

Symposium 1 (PT 2). Tree rings from national forest inventories: a timely opportunity to assess tree growth across space and through time Amphitheatre (SH-2800), June 28th, 11:00 - 12:15

- Growth and wood density in conifer forest: a climatic analysis of samples from Mexico's National Forest Inventory: *Genaro Gutierrez*

- Cold-season freeze frequency is a pervasive driver of sub-continental forest growth: *Martin Girardin*
- Changes in juvenile growth rates of Norway spruce and European beech from Central Europe in link with climate warming: *William Marchand*
- Impact of climate change on the growth of main tree species in Romania using dendrochronological data: *Bogdan Strimbu*
- Boreal forests tree-ring data provide insights for improving climate sensitivity of terrestrial biosphere models: *Ariane Mirabel*

Symposium 2. Common garden experiments to evaluate tree adaptation in a changing climate Salle polyvalente (SH-4800), June 29th, 09:20 - 10:35

- Development of a universal response function to integrate climatic and genetic effects on diameter growth of eastern white pine: *Steve Chhin*
- A dendrochronological approach to reveal climate sensitivities and productivity of Douglas-fir in a long-term range-wide: *Jodi Axelson*
- The evolutionary value of tree-ring plasticity in Douglas-fir: *Philippe Rozenberg*
- Joining dendroecology and genomic approaches to identify genes implicated in resilience to drought in the model conifer: *Claire Depardieu*
- The use of common gardens and dendroecology to guide assisted gene flow in black spruce: *Etienne Robert*

Symposium 3. Ecophysiological interpretations of stable isotopes in dendroecology Amphitheatre (SH-2800), June 30th, 14:05 - 15:50

- Landscape influences on the oxygen isotope of tree rings within a watershed in the western U.S.: *Jia Hu*
- Differential use of North American Monsoon precipitation by Pinus ponderosa in the American southwest: *Kinzie Bailey*
- The phylogenetic impact on hydrogen isotopes in sugars and cellulose of woody plant species: *Marco Lehmann*
- Effects of simulated increases in nitrogen deposition on a mature temperate forest as revealed by a dendroecological app. . . : *Rossella Guerrieri*
- Global trends and drivers of photosynthetic carbon isotope discrimination in trees: *Soumaya Belmecheri*
- The North American Monsoon and the Megadrought: How Precipitation Influences Forest Responses to Drought Conditions: *Brandon Strange*

- Ecophysiological response of white spruce to climate in high-latitude boreal forests in North America: *Laia Andreu-Hayles*

Symposium 4. Dendrogeochemistry 'moving beyond potential' Salle polyvalente (SH-4800), June 30th, 11:00 - 12:15

- Time delays between environmental forcing and isotopic signatures of tree-rings: *Fabio Gennaretti*
- Enhanced use of summer rain for Rocky Mountain conifers during the last interglacial warm period: *Max Berkelhammer*
- Detecting SEP events of varying magnitude by their 14C concentration in Southern Hemisphere and Equatorial tree rings: *Heather Haines*
- Neogene paleotemperature estimates from lignin-methoxy hydrogen isotopes of sub-fossil wood in the Canadian Arctic: *Trevor Porter*

Symposium 5. Applications of dendrochronology in urban environments Amphitheatre (SH-2800), June 28th, 13:30 - 15:00

- The application of tree rings for monitoring urban forest change: A remote sensing perspective: *Mitchell Bonney*
- Urban tree resiliency to heat and drought stress across Canadian cities: *Kaisa Rissanen*
- Urban trees for a cooler future - Growth patterns of urban trees in a changing climate: *Valentina Vitali*
- Explorations of Urban Dendrochronology in Louisville, Kentucky, USA: *Maegen Rochner*
- Drought tolerance differs between urban tree species but is not affected by traffic pollution: *Mareike Hirsch*
- Quantifying nuclear power plant emissions and fossil fuel contributions using dendrochronology & radiocarbon techniques: *Danielle Martin*

Symposium 6. Advancing (Ameri)Dendro Allyship Salle polyvalente (SH-4800), June 30th, 15:50 - 17:20

Symposium 7 (PT 1). Historical Timbers and Wooden Artifacts as Archives: New Glimpses On Trees, Ecology, and People Amphitheatre (SH-2800), June 29th, 09:20 - 10:35

- Applications and advances in X-ray Computed Tomography (CT) for dendrochronology: *Francien Bossema*

- The potential of tree-ring drought atlases for dating and provenancing archaeological timbers: *Mukund Palat Rao*
- Using dendrochronology to determine the production place of wooden artifacts and works of art: *Marta Domínguez-Delmás*
- Coupling tree-ring and timber species analysis to gain insights on forest harvesting and construction techniquesSy: *Darrin Rubino*
- Carbon-14 spikes caused by solar energetic particle events: *Fusa Miyake*

Symposium 7 (PT 2). Historical Timbers and Wooden Artifacts as Archives: New Glimpses On Trees, Ecology, and People Amphitheatre (SH-2800), June 29th, 11:00 - 12:15

- Dating of Alaskan Neo-Inuit architectural timbers (11-13th): wiggle-matching and oxygen isotope cross-dating: *Juliette Taieb*
- Drought and Inca rituals in the summits of the Andes of Atacama: *Duncan Christie*
- Dendrochronology and ecology of central-western New York, 1448-1902: *Carol Griggs*
- Dendroprovenancing with machine learning – a new approach to reveal the original growth site of historical timber: *Eileen Kuhl*
- Reconstruction of Precipitation & Lake Levels in the UNESCO Beaver Hills Biosphere: *Greg King*

Symposium 8 (PT 1). Dendrochronological progress in tropical Americas Amphitheatre (SH-2800), June 30th, 09:20 - 10:50

- Multiproxy approaches to understanding the formation of tree rings in tropical species: exploring anatomical, physical a. . . : *Daigard Ricardo Ortega Rodriguez*
- Using wood autofluorescence to explore the diversity of wood anatomy in the tropics and improve tree-ring visualization: *Milena Veiga*
- Advances in quantitative wood anatomy and radiocarbon dating to better assess climate sensitivity in the Andean Tropics: *Arturo Pacheco Solana*
- Wood anatomy of Puerto Rican trees: an ecological archive without tree-rings: *Emanuele Ziaco*
- Age structure and climate sensitivity of a high Andean relict forest of Polylepis rodolfo-vasquezii in central Peru: *Ginette Ticse*
- Revealing Polylepis microphylla as novel Andean specie suitable for dendrochronology and quantitative wood anatomy: *Clara Rodriguez Morata*

- A 389-yrs precipitation changes in the Northern South American Altiplano reveals an increase in extreme drought events s: *Mariano Morales*
- Climate and physiological signals in tree-ring stable isotopes of Polylepis tarapacana from the South American Altiplano: *Milagros Rodriguez-Caton*

Symposium 8 (PT 2). Dendrochronological progress in tropical Americas Amphitheatre (SH-2800), June 30th, 11:00 - 12:15

- Annual growth rhythm evidence of trees from the rainiest neotropical region: *Jorge A. Giraldo*
- Assessing the dendroclimatic potential of tropical tree species in northern Bolivia: *Rose Oelkers*
- Effects of cold conditions on the growth rates of a subtropical conifer: *Marcelo Scipioni*
- Precipitation variations and tree growth in the semi-arid Chaco region of South America: *María Eugenia Ferrero*
- A North Tropical Atlantic Sea Surface Temperature Reconstruction from the Dominican Republic Using Pinus occidentalis: *Jim Speer*
- Central American Tree-Ring Research: A Review: *Diego Pons Ganddini*

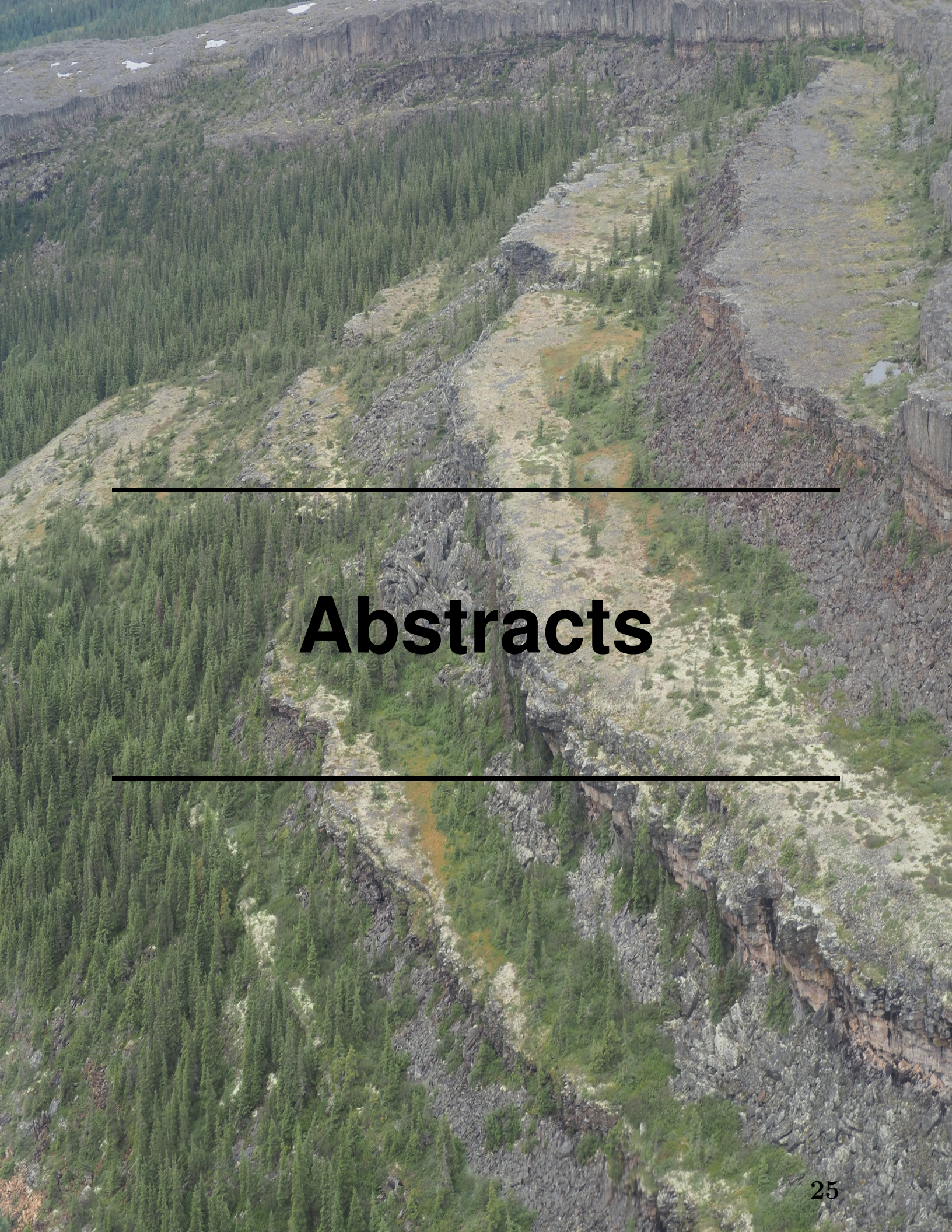
Poster session

Salle Polyvalente, June 29th, 12:30-14:30

- Comparing riparian and non-riparian boreal black spruces for their responses to climate: a dendroisotopic analysis: *Pauline Balducci*
- Tree-ring oxygen isotopes as an indicator of hydroclimate variation in eastern Amazon over the past century: *Bruna Hornink*
- Spatio-temporal analysis of soil moisture variations explains the tree-growth decline of multiple species in Mediterranean: *Alvaro Gonzalez-Reyes*
- Re-evaluating Divergence in Western Canada: *Emily Reid*
- Sensitivity in annual growth of Midwestern conifers to multiple dimensions of winter and spring climate: *Mara McPartland*
- Non-pooled oak stable isotopes reveal enhanced climate sensitivity compared to ring widths: *Michal Rybnícek*

- Elevation versus species effects in climate-growth relations in the Central Italian Alps: *Nikolaus Obojes*
- Introducing the North America Paleo-temperature Atlas, a Spatial Field Reconstruction of Warm Season Air Temperature: *Karen Heeter*
- Multi-species tree growth response to climate change in southwestern Germany: *Philipp Römer*
- Tropical Dendroclimatology in Zambia: Brachystegia boehmii: *Stockton Maxwell*
- Nitrogen Deposition and Tree Growth Have Declined Strongly at an Old Growth Temperate Boreal Ecotone Forest Since the Cl: *Steven Voelker*
- Asynchronous phenologies of photosynthetic carbon assimilation and tree-growth in temperate oaks scaled from cells to sa: *Mukund Palat Rao*
- Upward recruitment patterns and Basal area increment (BAI) of Abies spectabilis (D. Don) Mirb. provide evidence of incre: *Rajman Gupta*
- Compilation of recent oak tree-ring chronology for southwestern Ukraine: *Irena Sochová*
- A dendroecological comparison of two Miombo woodlands under differing anthropogenic disturbances in Zambia: *Nicole Zampieri*
- Why do trees grow older in the wet tropics?: *Giuliano Locosselli*
- Was the 16th century temperature-fire-drought nexus foreshadowing for the Greater Yellowstone Ecosystem?: *Grant Harley*
- Case study of a 536-years-old South American tree: biomass growth and carbon accumulation: *Claudia Fontana*
- Fast recovery of Norway spruce trees after thinning from above on a drained peatland forest site: *Katja Rinne-Garmston*
- Flood rings production modulated by river regulation in Eastern Boreal Canada: *Alexandre Florent Nolin*
- Integrating xylogenesis in carbon balance projections for boreal forests: *Lucie Barbier*
- Wood anatomy to anticipate the silvicultural potential of future northern sugar maple forests: *Ana Verhulst-Casanova*
- Impact of variable retention harvesting on carbon sequestration in a red pine plantation in southern Ontario: *Michael Pisaric*
- Tree rings and the colorful history of Beaver Island, Michigan: *Matthew Bekker*

- Intra- and inter-annual productivity of Betula glandulosa in Umiujaq, Nunavik (QC): *Camille Lepage*
- Influence of Humans and Climatic Variability on Historic Wildfire Dynamics in Jasper National Park, Canada: *Ze'ev Gedalof*
- An assessment of annularity in Sand live oak (Quercus virginiana) and Turkey oak (Quercus laevis) in central Florida: *Ze'ev Gedalof*
- Reconstructing Maximum flows using tree rings in Semiarid-Mediterranean climate transition of Chile: *Ariel Muñoz*
- Trade-offs in productivity and drought resilience of five dominant tree species in the Central European temperate forest: *Peter Marcis*
- Intra-annual isotopes for water management in the Metropolitan Area of Sao Paulo / Brazil: *Giuliano Locosselli*
- Hydroclimate and ENSO Variability Recorded by Oxygen Isotopes From Tree Rings in the South American Altiplano: *Milagros Rodriguez-Caton*
- Progress in developing tree-ring growth and stable isotope records of extreme winter climate anomalies across North America: *Steven Voelker*, *Victor Humanes Fuente*
- Intra-annual relationships between d13C ratios and xylogenesis for Black Spruce (Eastern North America): *Sepideh Namvar*
- The unknown third - the exploring the climatic and non-climatic signals in hydrogen isotopes in tree-ring cellulose: *Valentina Vitali*
- Big sagebrush growth and carbon isotope responses to climate are modified by topography and harvester ant mounds: *Steven Voelker*
- Changing inflow at Dez dam (Iran) and implications for irrigation and hydropower generation: *Salman Sharifazari*, *Philippa Higgins*
- Dendrochronological Study on Pinus roxburghii Growth Resilience with Changing Climate Conditions in Lesser Himalayas, Pakistan: *Mehvish Majeed*
- A clarion call from a fading record– tree-rings, fire-scars, and restoration implications for central Appalachian red pine (Pinus resinosa Ait.) forest communities: *Joseph Marschall*



Abstracts

June 27th

Workshop. Use and applications of the process-based model MAIDENiso

Ignacio Hermoso de Mendoza, Fabio Gennaretti, E Boucher

Classroom (SH-3420), June 27th, 08:30 - 12:30

Free, in person and online

MAIDENiso is a numerical process-based model that allows researchers to simulate the growth of a virtual tree. Using daily meteorological data, the model simulates the physical and physiological processes taking place in the tree and its environment, to produce daily and yearly outputs comparable to dendrological observations. The model has been adapted and used successfully in boreal regions in North America. In an inverse mode, tree-ring observations can be used to estimate past meteorology.

MAIDENiso offers a detailed simulation of the complex processes taking place in a tree and the land surface, while keeping computational costs low. It is a good alternative to statistically-based response functions when exploring the mechanisms explaining the relationships between tree-ring proxies and climate, specially for complex process such as water isotopes. It simple to use in common laptops, and can be easily set up to work in a cluster to perform more complex experiments.

In this workshop, we will show you how to use MAIDENiso and the set of tools we have developed around it. These topics include:

-Downloading, compiling and running the code.

-Inputs and outputs of the model.

-R package “maidentools”, developed to facilitate running the model and analysing / visualizing the outputs.

-Modifying the code, modifying inputs and setting up synthetic experiments.

-Calibration procedure for unknown parameters.

-Inversion procedure to reconstruct past meteorologies.

-Using MAIDENiso in a cluster and parallelization of the calibration and inversion procedures.

Workshop. Blue Intensity for Dendrochronology

Rob Wilson, Grant Harley, Karen Heeter, Emily Reid

Classroom (SH-3220), June 27th, 08:30 - 12:30

Free, in person and online

Blue Intensity (BI) is a cost-effective analytical method for measuring relative wood density in the rings of conifer tree species. Since early concept papers in the 1990s/2000s, there has been a recent explosion in the application of this method for both dendroclimatology and historical dating as well as other dendro-disciplines. The beauty of BI is that the analytical costs, mainly related to the cost of a high-quality scanner, are extremely cheap compared to traditional densitometric methods while training is also relatively simple. This means that compared to traditional ring density approaches, higher volumes of data can be produced. There are however limitations of the method with respect to wood colouration issues (i.e. heartwood/sapwood colour changes, fungal discolouration etc) and scanner resolution that can impact the quality of the derived data. In this workshop, through presentations and hands-on measurement and basic analysis, we will introduce the BI method and its application in dendrochronology and communicate both the strengths and limitations of the data produced by current laboratory methods. We will finish by introducing a range of possible solutions to these limitations.

Workshop. openDendro: Advanced Open-source Tools for Dendrochronology and Paleoenvironmental Reconstruction

Andy Bunn

Classroom (SH-3420), June 27th, 13:30 - 17:30

Free, in person and online

We will hold a practical, skills-based workshop introducing openDendro – an open-source framework of the base analytic software tools used in dendrochronology in both the R and Python programming languages. openDendro is a new unified set of tree-ring analysis tools in open-source environments that provides the necessary baseline for dendrochronologists to adopt open-science practices and increase both rigor and transparency in their work. The workshop will lead participants through some of the most common tasks in dendrochronology (including detrending, chronology building, and crossdating) as well as data visualization. All examples and exercises will be presented in both R and Python.

Workshop. Blue Intensity for Dendrochronology (continued)

Rob Wilson, Karen Heeter, Grant Harley, Emily Reid

Classroom (SH-3220), June 27th, 13:30 - 17:30

Free, in person and online

Blue Intensity (BI) is a cost-effective analytical method for measuring relative wood density in the rings of conifer tree species. Since early concept papers in the 1990s/2000s, there has been a recent explosion in the application of this method for both dendroclimatology and historical dating as well as other dendro-disciplines. The beauty of BI is that the analytical costs, mainly related to the cost of a high-quality scanner, are extremely cheap compared to traditional densitometric methods while training is also relatively simple. This means that compared to traditional ring density approaches, higher volumes of data can be produced. There are however limitations of the method with respect to wood colouration issues (i.e. heartwood/sapwood colour changes, fungal discolouration etc) and scanner resolution that can impact the quality of the derived data. In this workshop, through presentations and hands-on measurement and basic analysis, we will introduce the BI method and its application in dendrochronology and communicate both the strengths and limitations of the data produced by current laboratory methods. We will finish by introducing a range of possible solutions to these limitations.

Workshop. Best practices for using tree-ring stable isotopes of Carbon and Oxygen in paleoclimate and ecophysiology.

Soumaya Belmecheri, Milagros Rodriguez-Caton, Alienor Lavergne, Paul Szejner, Valérie Daux

Classroom (SH-3260), June 27th, 13:30 - 17:00

Free, in person and online

The stable isotopic compositions of carbon and oxygen (d13C and d18O) measured in tree rings are valuable proxies for reconstructing paleoclimate and are increasingly used as paleophysiological proxies. Applying these proxies in ecophysiology and paleoclimate can be challenging as they rely on complex process-based models and poorly constrained input data. In recent years, however, significant progress has been made in bridging tree-ring stable isotopes with ecophysiological models enabling improved quantitative tree ring-based reconstructions and interpretations of tree's physiological response to environmental changes such as the increase of atmospheric CO2 concentration and temperature, or changes in precipitation patterns.

This interactive workshop will focus on best practices for 1) using d13C to reconstruct ecophysiological indices; and 2) using d18O forward modelling for paleoclimate and ecophysiological reconstructions. Using a hands-on approach (R-script Notebooks), the workshop organizers will demonstrate how researchers can work with tree-ring isotopic data in a comprehensive and reproducible way. This will include process-based models of photosynthesis and leaf water evaporation, and using state of the art input data and parameters.

The format of the workshop will correspond to executable demonstrations in R-Notebook (using some specific R-packages) in a collaborative environment. The demonstrations will be based on onboard datasets but will also include a chance for participants to use their own datasets.

June 28th

Dr. Florence Hawley Ellis Lecture (Keynote presentation)

Justine Ngoma

Amphitheatre (SH-2800), June 28th, 08:45 - 09:15

Africa is faced with a number of challenges including climate change and ecological disturbance due to various anthropogenic activities. These problems adversely affect the forests and also ecosystem services. My appreciation for the forests motivated me to pursure my undergraduate studies in Forestry. I first applied dendrochronology during my PhD research which focused on understanding the climate change vulnerability of the Zambezi teak forests in Zambia. However, lack of research facilities and limited number of Dendrochronologist in Africa posed a challenge to acquire Dendro knowledge and skills on the continent. Hence, my first participation in the Dendro Field Week training in 2014 in Tasmania (Australia). I established positive significant relationship between tree-ring indices of Baikiaea plurijuga and rainfall in the wetter region. Exploratory Dendro studies in the wet miombo woodlands reviewed clear growth-ring formation in various tree species. We successfully cross dated Julbernardia paniculata and Brachystegia boehmii. Currently, I have established a Dendro lab and a training program at the Copperbelt University (CBU) in Zambia. The first Africa Dendro Training was offered at CBU from 24th October to 7th November, 2021. 24 people from seven countries of three continents were trained. I have also contributed to the establishment of a web-based database on Zambian woods and motivated women on the importance of education. In future, I plan to continue developing dendrochronology through research and providing Dendro trainings. The Second Africa Dendro training will be offered in July-August, 2022. I will also, continue to encourage girls and women on the importance of education.

General Session (Dendroecology, PT1)

Speakers: Margaret Evans, Raquel Alfaro-Sánchez, Yu-Mei Jiang, Dario Martin-Benito, Raphael Chavardes, Justin Maxwell, Pauline Balducci

Salle polyvalente (SH-4800), June 28th, 09:20 - 10:35

Tree-ring data reject the leading edge-trailing edge hypothesis for species range change

Margaret Evans

Salle polyvalente (SH-4800), June 28th, 09:20 - 09:35

Climate change poses an existential threat to trees, given our understanding of the importance of climate in shaping their geographic distributions. Climate envelope models are commonly used to predict how species will respond to climate change. These models give rise to the leading edge-trailing edge paradigm for range change: populations at the cool edge of a species' distribution are expected to benefit from warming, whereas populations at the warm edge are expected to decline. We challenged this paradigm with a spatial network of 1,633 tree-ring time series on Pinus edulis collected in 937 forest inventory plots encompassing this species' entire geographic distribution. A Bayesian multiple regression analysis of ring widths showed that growth of P. edulis increases with temperature variation across space (warmer sites have higher growth rates, especially at relatively wet, warm sites) but that trees everywhere grow less in warmer-than-average years. This ubiquitous negative response to interannual temperature variability implies that instead of expecting "leading edge" populations to prosper with warming, we should expect all populations to experience decreased performance (and fitness), which may require either assisted evolution or assisted migration to mitigate. We question the underlying assumption of climate envelope models that global (species-wide) climatic tolerances can be translated directly into projections of range change, ignoring individual-level plasticity and local adaptation. We conclude that predictions of the effects of climate change on trees' geographic distributions should be re-evaluated with spatial networks of longitudinal (time series) data.

Unprecedented increase in tree growth rates in boreal forests on the Taiga Shield during the 21st century

Raquel Alfaro-Sánchez

Salle polyvalente (SH-4800), June 28th, 09:35 - 09:50

During the 21st century, the boreal biome has warmed at rates 3-4 times the global average, impacting forests directly through changes in temperature and precipitation and indirectly through acceleration of disturbances including permafrost thaw and wildfire. Despite this, little is known about the ability of boreal trees to adapt in the face of such rapid environmental changes. Warming-induced growth rate increases are predicted for the boreal biome, but these would be largely dependent on water availability. Here we use climate and tree-ring data from mature black spruce (Picea mariana (Mill) BSP) boreal forests of the Taiga Shield ecozone, in northwestern Canada, to quantify changes in growth trends over the 21st century (2000-2016). Our sample consisted of 308 black spruce trees evenly distributed over 44 sites, with and without near surface permafrost soils. Increments in tree basal area were adjusted for tree size and age, and tested for temporal trends in annual tree growth. We found that tree growth increased significantly during the 21st century, at a mean annual rate of 0.42% at permafrost sites, and 0.76% at other sites. Climate-growth sensitivity analyses indicated that increased sensitivity to summer-autumn temperatures, and reduced sensitivity to summer climate moisture deficit, is the most likely explanation to this unprecedent increase in growth rates. Environmental conditions also modulated the response. As such, mean growth over the 21st century was higher in sites with low terrestrial lichen biomass and was positively associated with active layer depth. We conclude that these mature black spruce stands are likely to increase their aboveground carbon storage capacity in response to rising temperatures.

Impact of disturbance signature on ring width and blue intensity chronology structure and climatic signal in Carpathians

Yu-Mei Jiang

Salle polyvalente (SH-4800), June 28th, 09:50 - 10:05

Tree radial growth is influenced by various climatic and non-climatic factors, which can complicate the extraction of climate signals in tree rings. We investigated the disturbance impact on tree ring width (RW) and latewood blue intensity (BI) chronologies of Norway spruce in Carpathian Mountains. Aiming to explore the extent to which disturbance can affect the expression of temperature signals in tree rings. Nearly 15000 tree cores from 34 sites were collected and analyzed. Disturbance trends were detected by the curve intervention detection (CID) method. RW chronology structures were compared among disturbed, and disturbance corrected chronologies in spatial (region/site/subset) scales. Sites which showed apparent disturbance trends, structure comparisons were performed for BI chronologies as well. Temperature sensitivities have been assessed in chronologies of both parameters. Results showed disturbance trends can be observed in RW chronologies in site/subset scales with a relatively small replication compared with regional scale. BI chronologies were mostly unaffected by disturbance and contained quite stronger growing season temperature signals compared with RW chronologies. The temperature signals in BI appeared to be spatial-temporal coherent. Evidence of our research indicates that influence of non-climatic factors on tree ring series exist, especially in traditional ring width chronologies. Such influence should be considered when undertaking dendroclimatic research, especially involving in the reconstruction of historical climate. Blue intensity is a promising alternative tree ring parameter for dendroclimatological studies with stronger temperature signals and disturbance-cleaner chronology structures.

Long-term carbon storage and residence time in old-growth forests

Dario Martin-Benito

Salle polyvalente (SH-4800), June 28th, 10:05 - 10:20

Forest disturbances and tree growth are major drivers of dynamics and long-term carbon storage in forests. Combining forest inventory data and tree-ring analysis allows for a retrospective estimate of aboveground forest biomass (AGB) and disturbance dynamics at decadal to centennial scales, both being directly related to net primary productivity (NPP). We used this combined approach to estimate precisely-dated ages of aboveground carbon in over 20 temperate old-growth forests in Western Europe and Eastern North America, where trees exceed 400 years of age. We also estimated carbon turnover times as the ratio of stand AGB to AGB annual increment. In some forests, the combination of no logging and natural disturbance regimes dominated by small, frequent disturbances over centuries resulted in high forest stability, long carbon turnover times, and high mean carbon ages. Carbon turnover times ranged between 140 and 250 years whereas mean carbon ages ranged between 100 and 170 years. Up to 20% of total AGB was stored for 300 years or longer while more than 50% of total AGB was stored for more than 100 years. In contrast, more recently disturbed forests or forests with dynamics dominated by more intense disturbances appear to have reduced ages of mean carbon (<100 years) and turnover rates (<125 years). In general, annual forest aboveground productivity (i.e. faster growth rates) was inversely correlated with mean AGB age and thus long-term carbon storage potential. The large amounts of biomass stored at long time scales in uncut old-growth forests highlight the importance of forest management, ecosystem stability, and natural disturbance as a part of the global carbon cycle.

How does the surrounding environment determine tree growth in boreal forests of western Québec?

Raphael Chavardes

Salle polyvalente (SH-4800), June 28th, 10:20 - 10:35

Growing concerns about vulnerabilities of boreal forests to climate change and disturbances warrants additional information about their impacts on the growth of dominant tree species in different surrounding environments. To address these concerns, we investigated how the surrounding environment influences the growth of such trees and their responses to climate and insect epidemics in stands of eastern Canada's boreal forest. For this, we focused on 96 black spruce, jack pine, and trembling aspen focal trees in stands spanning a double gradient of species diversity and soil granulometry within a 36 km^2 study area of the Nord-du-Québec region. For each focal tree, we developed a basal area increment chronology to compare growth rates, tested climate-growth relations with growing season length and summer heat stress, and evaluated tree growth during epidemics of spruce budworm and forest tent caterpillar. We established a cell around each focal tree to describe the surrounding environment, namely stand structure and diversity, soil, and topography. We then defined stepwise multiple linear regression models to assess how responses of the focal trees were influenced by the surrounding environment. We found that variables characterizing stand structure and diversity were most often included in models and had the strongest influence on tree growth and responses to climate and epidemics. Our research offers novel insights on the potential role of the surrounding environment in mitigating the vulnerability of eastern Canada's boreal trees to climate change and insect epidemics.

General Session (Dendroclimatology, PT1)

Speakers: Nicole Davi, Juliana De Sousa Nogueira, Alex Pace, Caroline Leland, Raphaël Hébert, Valentina Vitali, Jim Speer

Classroom (SH-3420), June 28th, 09:20 - 10:50

Evaluating Tropical Cyclone Impacts and Climate Response of a Maritime Forest (1737-2018), Montauk, N.Y.

Nicole Davi

Classroom (SH-3420), June 28th, 09:20 - 09:35

Maritime forests are extremely important for coastal protection as they buffer storm surge and wind, conserve nutrients, and store groundwater. They grow several 100 meters behind primary beach dunes or along intertidal marsh-forest ecotones and within range of salt spray, near shoreline estuaries, where they support large amounts of biodiversity and migratory birds. Trees in these forests typically handle small concentrations of salt spray, strong winds, and slight flooding, but prolonged exposure or saltwater intrusion can damage and even devastate the coastal forest habitat. There are very few century-old maritime forests left in the US Northeast because much of the coastal regions have been developed for commercial and residential purposes. Here we focus on a long-lived white oak (Quercus alba) forest growing in Montauk, N.Y. to better understand how major tropical cyclone activity can be recorded in tree-ring records, and to determine how vulnerable/resilient these forests are to climate change and extremes events. We evaluate ring suppression in tree-ring records as a result of severe tropical cyclone events. Superposed epoch analysis shows that the tree-ring record captures a large-scale tropical cyclone signal. Results from our work evaluating holly (Ilex opaca) from N.Y. and N.J. are presented by Nixon et al., (this conference).

400-year multi-parameter reconstruction of Carpathian temperatures from tree rings

Juliana De Sousa Nogueira

Classroom (SH-3420), June 28th, 09:35 - 09:50

Although numerous proxy-based climate reconstructions have been developed and despite the prevalence of relatively long instrumental records throughout Europe, reliable information about past climate is still lacking in some regions, particularly eastern parts of the continent. This issue is linked to limitations in data quality and large uncertainties in existing records. The REPLICATE project aims to fill this spatial paleoclimatic and data quality gap by applying a tree-ring multi-parameter approach to reconstruct climate using Norway spruce (Picea abies) samples. We are developing a set of temperature reconstructions across the Carpathian Mountain arc that will advance our understanding of recent climatic variability in this region. Therefore, annually resolved, robust, high-quality summer temperature reconstructions covering the past 300-400 years are developed for four locations across the Carpathians from chronologies of tree-ring width (RW) corrected for disturbance, blue intensity (BI), and color bias-free surface intensity (SI) from scanned and microscope-based high-resolution images, and traditional and surface-based quantitative wood anatomy (QWA/sQWA). This combination of parameters strengthens the climate signal considerably, and initial results indicate that these Carpathian temperature reconstructions will yield records with reduced uncertainty that explain between 50% and 60% of the regional temperature variability. This will provide improved spatial information on the transition from the LIA to the modern warm period, which is important for tuning and downscaling climate models by providing constraints on climate model performance and improving predictions of future climate scenarios.

A 211-year moisture reconstruction in southern Quebec based on snowpack-sensitive trees

Alex Pace

Classroom (SH-3420), June 28th, 09:50 - 10:05

We present a 211-year tree-ring-based reconstruction of the annual mean flow of the Sainte Anne River, Gaspésie, Québec, Canada. The river traverses through the interior of the Gaspé Peninsula where the instrumental hydrological and climatic records are particularly short. This is the first streamflow/soil moisture reconstruction between the Hudson River and north-central Québec, filling a substantial geographical gap along the eastern North American margin, and adding to the only three existing river reconstructions of the Atlantic coast. Our skillful nested reconstruction (maximum R2 = 0.61, maximum RE = 0.36) is based upon eight site chronologies from locations where high snowpack limits the length of the growing season and the energy available to trees. Although energy-limited tree-ring chronologies are well-known in western North America, we find the first energy-limited snow proxy sites in eastern North America, in this region noted for its high snowfall. We found sustained periods of low flows and high flows not captured in the relatively short instrumental record. This Gaspésie reconstruction shows drought and pluvial synchronicities in common with multi-centennial-length river/soil moisture reconstructions from along the Atlantic Seaboard from New York, Delaware and Maryland, as well as with net basin water supply reconstructions from much closer north-central Québec. The Sainte Anne River is an important salmon fishing river located in the Parc national de la Gaspésie (PNG). The PNG is the last refuge south of the St. Lawrence River of the once-common woodland caribou, and the troop in the PNG are critically endangered. Hence, our reconstruction is of interest to wildlife and fisheries managers.

Volcanic Cooling Events: Impacts on Climate and Indigenous Peoples in Northwestern North America

Caroline Leland

Classroom (SH-3420), June 28th, 10:05 - 10:20

Evidence of volcanic cooling and its human impacts has been described for various regions of the globe over the past several centuries to millennia, derived from paleoclimatic and historical data. Due to its remote location, detailed accounts of such impacts over Northwestern North America (NWNA) are still quite limited. Here we use a newly expanded tree-ring density network (derived from blue intensity as well as maximum latewood density parameters) to assess the climatic and human impacts of major extreme volcanic cooling events of the past half millennium, such as 1601 (Huaynaputina, Peru), 1783 (Laki, Iceland) and 1815 (Tambora). Results indicate that spatial and temporal patterns of cooling vary across the region depending on the nature and timing of each particular eruption. These findings are confirmed by archaeological data and historical indigenous records from NWNA.

Using dendrochronological data to characterize the spatio-temporal structure of climate variablity

Raphaël Hébert

Classroom (SH-3420), June 28th, 10:20 - 10:35

The spatial scale of climate fluctuations, or effective spatial degrees of freedom (ESDOF), depends on the timescale and the forcing: while local scale variability between far away locations may be independent on short timescales, they may become coherent over sufficiently long timescales, or if they are driven by a common forcing. While ESDOF have been estimated from instrumental data over the historical period and climate model simulations, it remains difficult to perform such analysis on paleoclimate data given the time uncertainty and proxy-specific bias. We take advantage of a database of absolutely dated annual proxies comprising tree ring, corals and varved sediments in order to provide the first estimate of ESDOF for longer than multi-decadal timescales based on proxy-data.

Symposium 1 (PT 1). Tree rings from national forest inventories: a timely opportunity to assess tree growth across space and through time

Moderators: R. Justin DeRose, Kelly Heilman, Guillermo Gea-Izquierdo, Olivier Bouriaud

Speakers: Martin Girardin, Babst Flurin, R. Justin DeRose, Margaret Evans, Genaro Gutierrez, Stefan Klesse

Amphitheatre (SH-2800), June 28th, 09:20 - 10:35

Tree-ring time series provide long-term, annually resolved information on the growth of individual trees. However, public tree-ring archives contain a considerable portion of data collected from trees that have been selected with specific research questions in mind (e.g., for climate reconstruction). This makes these archives a biased representation of the sensitivity of forest ecosystems to ongoing climate variation (e.g. temperature, precipitation), including non-stationarity (i.e., global warming and associated changes to Earth's climate). Many public collections also lack the tree and forest information needed to quantify forest-level growth, making it very difficult to scale-up tree-level information to ecosystem estimates of biomass accumulation and carbon sequestration. National forest inventories (NFIs), by comparison, are systematic observatories of forest ecosystems designed specifically for large-scale inference. Yet, this spatial information comes at relatively low temporal (e.g. decadal) resolution and hampers the investigation of forest responses to annual climate variability as well as seasonal and climate extremes. When tree-ring data are collected in NFIs (or other statistically designed) forest plot networks, multiple influences on tree growth can be captured in an unbiased and representative way—not just climate, but also competition, disturbance processes, and other environmental factors (atmospheric CO2 concentration, N deposition)—which is critical to parse their effects and understand how they may interact. A systematic effort to sample tree rings in NFIs can yield unprecedented temporal and spatial resolution of the drivers of forest and carbon dynamics. This symposium aims to showcase the latest work on the development and applications of tree rings collected from NFIs and forest plot networks. Applications of NFI tree-ring data may include retrospective analyses of spatial variations in productivity and climate sensitivity, efforts to improve carbon accounting, examinations of climate change impacts, and assessments of mitigation potential critical for Earth's habitability.

Tree-ring research and the theory of sampling: NFI-based samples strength and specificities

Olivier Bouriaud

Amphitheatre (SH-2800), June 28th, 09:20 - 09:50

Tree-ring research studies depend heavily on samples, but the connection to the sampling theory remains loose. Tree-ring studies need to be based on samples of restrained size for several reasons: measuring tree-ring features remains labour-intensive, costly, and sampling cannot be seen as totally free of consequences for trees. Sampling, the art of selecting observational units to produce population-level estimates, comes with constraints that, when not respected, lead to biases and loss of confidence.

When constructing tree-ring series, several spatial scales are been crossed: the sites, which selection represents one sampling step; the trees, which selection was perhaps the most studied and proved so influential in many field.

The theory of sampling was developed initially for discrete and finite populations but recently also expended to continuous populations. Particularly suited to forests, these methods bring solutions to the sampling of one of the most difficult populations: the forest trees. National Forest Inventories (NFIs) are large-scale multipurpose surveys based on such probabilistic sampling and estimation methods, which ensure unbiased area-based estimations over large territories. The sampling framework of NFIs hence produce invaluable samples with desirable properties for inference, particularly ensuring balanced sampling and spatial representativity.

But, the advanced methods of NFIs also come at the price of a high complexity in the data structure, and the use of the samples they generate. A short list of points of concerns is recapitulated: loss of independence, unequal sampling probabilities, spatial and temporal correlations. Hence precautions in their use is necessary.

Fusing tree-ring growth and national forest inventory data to forecast tree growth and aboveground biomass across scales

Kelly Heilman

Amphitheatre (SH-2800), June 28th, 09:50 - 10:05

Forest responses to climate change are highly uncertain, but critical for forecasting and managing forest carbon dynamics. Tree-ring time series data provide annually resolved growth responses to climate, but often lack the stand-level information needed to scale growth up to carbon uptake. In contrast, the U. S. Forest Service Forest Inventory and Analysis (FIA) Program is an exceptional spatial network to estimate forest carbon, but lacks the annual resolution needed to determine how tree growth and carbon uptake respond to interannual climate variation. Tree rings sampled from national inventories thus provide a unique opportunity to include climate sensitivity in forecasts of tree- and plot-level aboveground biomass. We used a Bayesian state-space model to fuse tree-ring time series sourced in the U. S. national forest inventory with decadal measurements of bole diameter from $>$ 900 ponderosa pine across the interior western U.S., and estimated the effects of climate, stand density, tree size, and their two-way interactions on tree growth. We estimated tree diameter and annual diameter increment for all trees in each inventory plot, then scaled to aboveground tree- and plot-level biomass estimates using allometric scaling. Fusion of forest inventory data with tree-ring growth advances forecasting of tree growth and plot-level biomass across space and time– first, it provides empirically-constrained forecasts of how climate change influences tree growth and aboveground biomass over time, including the uncertainty surrounding this response, and second, it provides a framework to quantify how tree- and site-level factors (i.e. tree size, tree density, plot conditions) drive spatial variation in forest carbon dynamics.

Understanding carbon allocation dynamics after disturbance combining dendroecological and permanent sampling plots

Guillermo Gea-Izquierdo

Amphitheatre (SH-2800), June 28th, 10:05 - 10:20

Past forest mortality after disturbances creates one source of uncertainty that needs to be taken into account to reconstruct biomass dynamics. Additionally, using unitless normalized data from tree-ring records to calibrate stand productivity in vegetation models constitutes another source of uncertainty for model calibration. In this presentation I would assess these two sources of uncertainty and discuss the influence of calibration technique in model-data fusion. I combined data from permanent resampling plots and dendroecological plots to estimate annual woody biomass growth (ABI) in several forests. ABI were used to benchmark a process-based vegetation model to analyze time variability in forest productivity and carbon allocation. The model used implements source and sink limitations explicitly. Disturbances, species life-history strategy and climatic variability modified the carbon allocation pattern. Bias in tree-ring reconstructed ABI increased back in time from data collection and with increasing disturbance intensity. ABI bias raised to over 100% in stands with major disturbances. Environmental variability and leaf area explained much variability in woody biomass allocation. Divergence between tree-ring estimated and simulated ABI were caused by unaccounted changes in allocation or misrepresentation of some functional process independently of the model calibration approach. Using directly unbiased estimates of biomass growth improved model performance. Higher disturbance intensity produced greater modifications of the C-allocation pattern. Legacy effects from disturbances increased error in reconstructed biomass dynamics, reducing the potential use of ABI as a proxy to net primary productivity.

Adding tree rings to North America's national forest inventories

R. Justin DeRose

Amphitheatre (SH-2800), June 28th, 10:20 - 10:35

Tree-ring time series provide long-term, annually resolved information on the growth of individual trees. When sampled in a systematic context, tree-ring data can be scaled to estimate the forest carbon capture and storage of landscapes, biomes, and ultimately the globe. A systematic effort to sample tree rings in national forest inventories would yield unprecedented temporal and spatial resolution of forest carbon dynamics, and help resolve key scientific uncertainties, which we highlight in terms of evidence for forest "greening" (enhanced growth) versus "browning" (reduced growth, increased mortality). We describe jump-starting such a tree-ring collection across the continent of North America, given the commitments of Canada, the United States, and Mexico to visit forest inventory plots, along with existing legacy collections. Failing to do so would be a missed opportunity to help chart an evidence-based path toward meeting national commitments to reduce net greenhouse gas emissions, urgently needed for climate repair.

General Session (New perspectives and developments)

Speakers: James Capshew, Daniel Griffin, Milos Rydval, Tomás Muñoz-Salazar, Neil Pederson, Scott St. George, Ignacio Hermoso de Mendoza

Salle polyvalente (SH-4800), June 28th, 11:00 - 12:15

Toward a Historiography of Dendrochronology

James Capshew

Salle polyvalente (SH-4800), June 28th, 11:00 - 11:15

”Emerging in the early 20th century, the scientific study of tree-rings has a rich but under-cultivated history. This project reviews the historiography (or the history of historical writing) of dendrochronology. From the pioneering work of A.E. Douglass and others to the establishment of institutions dedicated to advancing dendrochronology by the 1950s, the field has secured its place as an ensemble of techniques to interpret tree rings, with applications in archeology, climatology, ecology, geomorphology, and history of artifacts, among others.

Historical information can be gleaned from scientific publications (textbooks, journals, review articles, etc.) as well as scientists’ popular writings, reflections, and obituaries. Consensus on methods and aims precedes advances in scientific knowledge and concomitant growth of scientific specialists. Dendrochronology enjoyed popular interest in the 1920s and the 1950s, as well as in the present day. After the Second World War, when a critical mass of researchers was achieved in North America and Europe, familiar signs of academic institutionalization became noticeable.

As a small scientific specialty, few studies of dendrochronology have appeared in the history of science literature, with some important exceptions. This review of historiography aims to present preliminary findings, including a tentative historical periodization, a timeline of key scientific milestones and organizational advances, comments on the increasing sophistication of historical analysis, and arguments for paying more attention to the historical development of dendrochronology.

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Emerging technologies with dendrochronology: platforms, progress, and potential

Daniel Griffin

Salle polyvalente (SH-4800), June 28th, 11:15 - 11:30

Ultra high resolution imaging is becoming standard across the sciences and must be a priority for dendrochronology. Large format scanners fail to resolve micro rings and the anatomical structures of increasing scientific interest. Meanwhile, current software limitations include cost, user experience, data management flexibility, and capacity for handling large file sizes. We argue for a new paradigm and present a technology framework that integrates gigapixel macro photography, a cloud-hosted digital asset management system, and an internet accessible toolbox that facilitates rapid measurement, dating, and annotation on tree ring imagery. DendroElevator is our open-source platform for tree-ring image curation, visualization, and analysis. With a basic internet connection and modern web browser, end users can easily access microscope quality tree-ring images online. JavaScript tools facilitate ring-width measurement, dating, and annotation, all within the web browser. DendroElevator transforms what is possible with remote research, distanced collaboration, training, teaching, and outreach. We are rapidly growing an online image archive to complement entire collections of physical tree-ring specimens. In light of recent debates about missing rings and data authenticity, we argue that our progress and goals represent a critical and overdue step towards open science standards in dendrochronology. Further integration of emerging technologies will transform throughput capacity for dendro data development. Toward the end of automated quantitative wood anatomy, recent computer vision results with machine learning are encouraging. The most urgent priority is to develop an affordable platform for gigapixel image acquisition.

To discard or not to discard: On cross-dating ecological tree-ring collections

Neil Pederson

Salle polyvalente (SH-4800), June 28th, 11:30 - 11:45

Tree-ring research has given generations of scientists a long memory of what is acceptable for a tree to be included for data analysis. The established criteria, however, were set through purposeful goals to maximize the response for climatic reconstructions. Ecology is different. Tree-rings are increasingly being used to study a wide swath of ecology, including the carbon cycle or the response of ecosystems to global changes. A fundamental aspect of ecology is to understand the range of response within a population. The fundamental process of crossdating for climatic reconstructions, however, brings the decision to discard or not to discard “problematic” samples. This approach is limiting likely highly limiting to broadening our understanding of ecology. Ergo, all cores provide useful information when trying to understand the ecology of a forest It is tempting to dismiss the samples that do not appear to crossdate according to common standards, but we discourage this practice. These individuals, often slow-growing suppressed trees, are sometimes the most ecologically interesting and represent a significant portion of aboveground carbon and offer information on competition and disturbance dynamics. As such, they contain an important, but often overlooked signal for the ecology of a population from a tree-ring perspective. We present case studies where more than a few trees appear better “crossdated” via COFECHA at different calendar dates than what see as crossdated using maker rings and other visual features. We will then offer a synthesis of how we solved these almost intractable samples and make recommendations on how to present/justify these samples for publishing.

High-resolution wood surface imaging for dendrochronology: towards the development of unbiased reflectance timeseries

Milos Rydval

Salle polyvalente (SH-4800), June 28th, 11:45 - 12:00

Dendroclimatic reconstructions play a key role in contextualizing recent climate change by improving our understanding of past climate variability. The climatically-sensitive blue intensity (BI) parameter is gaining prominence as a more accessible alternative to X-ray densitometry. Yet accurately representing low-frequency trends and high-frequency extremes using scanner-based BI remains a challenge due to color biases and resolution limitations. As part of the REPLICATE project, methodological advances in surfacing and imaging have yielded measurements analogous to BI from ultra-high resolution ($\sim$74 700 true dpi) images. Such series from microscope-based sample surface reflected light images, termed surface intensity (SI), represent the binary segmentation of wood anatomy and so approximate anatomical density. The most substantial drawbacks of scanner BI (i.e. discoloration and resolution biases) are bypassed in part by eliminating color altogether and hence low-frequency climatic trends and high-frequency extremes can be better represented. A comparison with multiparameter datasets by Björklund et al. (2019) showed that SI can outperform BI in terms of common (r-bar) and climate signals, and is on par with the best X-ray MXD data. Yet measurement software improvements are still required to unlock the full potential of SI. Ongoing development of these techniques will aid the attainment of unbiased long chronologies by overcoming color biases and resolution issues, but also holds promise for producing surface anatomical (sQWA) datasets from reflected light images. These advances will lead to more accurate tree-ring-based paleoclimatic reconstructions but could also serve a wider range of dendrochronological applications.

Tree-rings as a natural encyclopedia: itinerant and interactive exhibition as an educational tool for students

Tomás Muñoz-Salazar

Salle polyvalente (SH-4800), June 28th, 12:00 - 12:15

In this work we show the application of dendrochronology as an educational resource for schoolchildren and as a mean to disseminate science to society. Tree rings are popularly known in Chile due to the massive use of wood for construction, handicrafts and firewood. The visible tree rings generate a distinct, tangible and familiar curiosity in many people. “Tree-Rings as a Natural Encyclopedia of Environmental Archives” is an exhibition built as an educational project for schoolchildren, which uses tree rings, digital and multimedia materials of Austrocedrus chilensis from Central Chile to disseminate science. The specific objectives of this display were: i) making people aware about dendrochronology, ii) to promote a scientific thinking highlighting the importance of curiosity, iii) to disseminate the present knowledge of the iconic and millennial Andean forests of A. chilensis, and iv) to promote environmental education and nature conservation especially in elementary and middle school students. Our outcomes indicate that dendrochronology is a valuable tool that offers multiple options to develop science education, mathematics and history. More than 7,000 students visited our exhibition of tree ring samples, used microscopes, interacted with digital and multimedia material, and learnt about dendroclimatological and dendroarchaeological findings from Central Chile. This experience confirms the role of dendrochronology as an educational tool of interdisciplinary sciences that draws the attention not only of children, but also of the overall community. Watch here https://youtu.be/N82RCQ52LhI

General Session (Dendroclimatology, PT2)

Speakers: Edurne Martinez del Castillo, Alexandre Florent Nolin, Elizabeth Campbell, Matthew Trumper, Valerie Trouet, Jim Speer, Fabio Gennaretti

Classroom (SH-3420), June 28th, 11:00 - 12:15

Modelling future temporal and spatial growth dynamics of Pinus sylvestris across Europe

Edurne Martinez del Castillo

Classroom (SH-3420), June 28th, 11:00 - 11:15

The past and future of forests are unequivocally controlled and determined by global climate. Constraining the uncertainties within this multifaceted relationship has been the focus of vast research efforts. A spatial perspective, however, is often neglected. Using the geographical constraints (e.g. latitude, altitude) and climatic drivers of tree dynamics as a benchmark, we address the spatial patterns and changes of forest growth at a continental scale and quantify the forest growth response to recent climate change. We compile an extensive network of tree-ring data from 390 Scots pine (Pinus sylvestris L.) sites and explore past growth rates and trends across the species' European distribution (from 40°N to 70°N). We develop an empirical model based on tree-rings to forecast potential growth changes with respect to the latest Representative Concentration Pathway scenarios until the end of the 21st century. Our results indicate significant changes in growth patterns during the past century, modulated by altitudinal and latitudinal gradients across Europe. The growth of Scots pine is highly sensitive to warmer and drier climates, and our model suggests that productivity will change dramatically due to the projected climatic shifts. The results provide unique and insightful evidence of how climate change could lead to growth decreases between 20% and 50% in some areas, entailing major economic and ecological consequences.

A 247-years tree-ring reconstruction of spring temperature and relation to spring flooding in Eastern Boreal Canada

Alexandre Florent Nolin

Classroom (SH-3420), June 28th, 11:15 - 11:30

Few spring paleoclimate records are available for boreal Canada and given the warming of spring temperatures in recent decades and its impact on snowmelt and hydrological processes, the search for spring climate proxies is receiving increasing attention. Tree-ring anatomical features and intra-annual widths were used to reconstruct regional mean March-April-May temperature from 1770 to 2016 in eastern boreal Canada. Nested principal component regressions calibrated on 116 years of gridded temperature data were developed from one Fraxinus nigra and ten Pinus banksiana sites. The reconstruction indicated three distinct phases in spring temperature variability since 1770. Ample phases of multi-decadal warm and cold springs persisted until the end of the Little Ice Age ($\sim$1875) and were gradually replaced since $\sim$1940 by decadal to interannual variability associated with an increase in the frequency and magnitude of warm springs. Significant correlations with other paleotemperature records, and gridded snow cover extent and runoff support that historical high floods were associated with late, cold springs with heavy snow cover. Most of the high spring floods reconstructed for the nearby Harricana River also coincided with the lowest reconstructed spring temperatures. However, the last 50 years of observed and reconstructed mean spring temperature showed a reduction in the number of extreme cold springs contrasting with the last few decades of extreme flooding in the eastern Canadian boreal. This result indicates that warmer late spring mean temperatures on average may contribute, among other factors, to advance the spring ice break-up and to likely shift the contribution of snow to rain in spring flooding processes.

Subalpine tree growth responses to climate vary by species, tree size, and local site conditions

Elizabeth Campbell

Classroom (SH-3420), June 28th, 11:30 - 11:45

Models of tree growth responses to climate variability provide insight about the potential effects of global warming on forests. Using a unique dataset containing tree ringwidth measurements from all trees (>4 cm in diameter at breast height) in 1ha plots, we modelled time series of annual basal area increment (BAI) in subalpine forests of western Canada, which are expected to be highly sensitive to the effects of global warming. Our objective was to determine how BAI responses to inter-annual climate variable fluctuations varied among tree size classes, species, and sites. We tested multiple approaches for estimating climate effects on growth – which incorporated a priori detrending of BAI for size, age, legacy, and competition effects – and settled on a parametric generalized least squares model. We found that the climate signals in our time series of BAI were weak; < 6% of the interannual variance in growth was explained by climate variables. Nevertheless, there were clear patterns in growth-climate relationships related to tree size and species. BAI of the largest trees was most sensitive to climate variable fluctuations, and Callitropsis nootkatensis growth responses were significantly different in direction and magnitude than those of co-occurring Pinaceae species. Growth responses were idiosyncratic among sites. While growth-climate relationships were stable over the 20th for large trees, the sensitivity of small trees to fluctuating climate variables decreased from the 1940s onward. Overall, our individual-tree and parametric modelling approaches emphasized the complexity of growth responses to climate variability and challenges associated with predicting future forest growth using tree rings.

Topography mediates growth and drought sensitivity in California valley oak (Quercus lobata)

Matthew Trumper

Classroom (SH-3420), June 28th, 11:45 - 12:00

Complex topography can facilitate climatic and hydrologic microenvironments that buffer plants against climate change and extreme drought. However, the extent to which topographic position mediates tree growth response to climate is still poorly understood. Dendrochronology, the use of precisely dated tree rings to study environmental processes and history, has been critical for assessing tree growth response to climate variability across topographical gradients. We developed new tree-ring data from valley oak (Quercus lobata) growing in upland and riparian landscape positions along a 1,300-meter (4,265-feet) elevational transect in the Tehachapi Mountains of California to understand how topography acts as a mediating factor on tree growth, drought sensitivity, and biological reaction to environmental extremes. Because valley oak is understood to be highly dependent on groundwater, we hypothesized that higher groundwater availability at the riparian sites may mediate valley oak drought vulnerability. Preliminary results showed that valley oak growth and drought sensitivity varied substantially as a function of landscape position and elevation. Growth-climate analyses indicated consistently weaker correlations between valley oak radial growth and precipitation at riparian sites compared to upland sites, consistent with our hypothesis that increased groundwater availability at riparian sites may act to decouple valley oak productivity from precipitation variability. This study adds to a growing body of literature examining vegetation drought vulnerability in California and North America, where climate extremes and associated tree dieback are an early harbinger of future drought-induced tree mortality.

800 years of summer European-North Atlantic jet stream variability and its impact on climate extremes and human systems

Valerie Trouet

Classroom (SH-3420), June 28th, 12:00 - 12:15

Climate extremes are driven by a combination of thermodynamical and dynamical factors. In Europe, the primary dynamical driver of summer climate extremes is the position of the jet stream over the Europe-North Atlantic (EU) region. To study long-term variability in the position of the EU jet, as well as its potential impact on past climate extremes and human systems, we have reconstructed EU jet variability over the past 800+ years (1200-2005 CE). To accomplish this, we have combined five European tree-ring chronologies to reconstruct the July-August jet stream latitude for the EU domain (EU JSL). Our reconstruction explains 40% of summer EU JSL variability over the instrumental period with strong skill.

We find that, over the past 800 years, opposite phases of EU JSL variability have consistently resulted in contrasting climate extremes between the British Isles versus the Balkans and Italy. These summer climate extremes include heatwaves, droughts, floods, and wildfires that have been captured in a network of historical documentary data that further document the societal impacts of EU JSL-related climate extremes on both sides of the dipole.

Our summer EU JSL reconstruction shows a century-long negative phase from ca. 1355-1450 CE, corresponding to anomalously wet and cool summers over the British Isles and dry and hot conditions over the Balkans. This negative phase is comparable to the recent (1970-present) EU JSL configuration. We also found a positive phase, with opposite summer climate dipole conditions, from ca. 1812-1861 CE. Our results thus suggest that the EU JSL has been a long-term primary driver of the European summer climate dipole, as well as of the associated climate extremes and societal impacts.

Symposium 1 (PT 2). Tree rings from national forest inventories: a timely opportunity to assess tree growth across space and through time

Moderators: Genaro Gutierrez, Martin Girardin, William Marchand, Bogdan Strimbu, Ariane Mirabel

Speakers: Martin Girardin, Babst Flurin, R. Justin DeRose, Margaret Evans, Genaro Gutierrez, Stefan Klesse

Amphitheatre (SH-2800), June 28th, 11:00 - 12:15

Tree-ring time series provide long-term, annually resolved information on the growth of individual trees. However, public tree-ring archives contain a considerable portion of data collected from trees that have been selected with specific research questions in mind (e.g., for climate reconstruction). This makes these archives a biased representation of the sensitivity of forest ecosystems to ongoing climate variation (e.g. temperature, precipitation), including non-stationarity (i.e., global warming and associated changes to Earth's climate). Many public collections also lack the tree and forest information needed to quantify forest-level growth, making it very difficult to scale-up tree-level information to ecosystem estimates of biomass accumulation and carbon sequestration. National forest inventories (NFIs), by comparison, are systematic observatories of forest ecosystems designed specifically for large-scale inference. Yet, this spatial information comes at relatively low temporal (e.g. decadal) resolution and hampers the investigation of forest responses to annual climate variability as well as seasonal and climate extremes. When tree-ring data are collected in NFIs (or other statistically designed) forest plot networks, multiple influences on tree growth can be captured in an unbiased and representative way—not just climate, but also competition, disturbance processes, and other environmental factors (atmospheric CO2 concentration, N deposition)—which is critical to parse their effects and understand how they may interact. A systematic effort to sample tree rings in NFIs can yield unprecedented temporal and spatial resolution of the drivers of forest and carbon dynamics. This symposium aims to showcase the latest work on the development and applications of tree rings collected from NFIs and forest plot networks. Applications of NFI tree-ring data may include retrospective analyses of spatial variations in productivity and climate sensitivity, efforts to improve carbon accounting, examinations of climate change impacts, and assessments of mitigation potential critical for Earth's habitability.

Growth and wood density in conifer forest: a climatic analysis of samples from Mexico's National Forest Inventory

Genaro Gutierrez

Amphitheatre (SH-2800), June 28th, 11:00 - 11:15

Mexico has a forest cover of 660,400 km2, representing 34% of its territory. Due to deforestation and land-use change, Mexico has lost 32,200 km2 over the last 25 years, representing 1.9% of its territory. Mexican forests are now additionally threatened by climate change. Currently, there is no assessment of the impact of current and future climatic changes on forest productivity to develop mitigation and adaptation plans in the forestry sector. Most growth studies in Mexico focus on climate-growth responses, using tree-ring analysis. The drawback of these studies is that they are mainly focused on water-stressed old trees that do not represent the broad spectrum of Mexican forest's structural, topographical, and edaphic conditions. Our study analyzes the influence of climate on tree growth and wood density of 600 cross-dated increment cores of 37 conifer species from Mexico's National Forest Inventory. Our results indicate a positive relationship between tree growth and precipitation for two periods: from April to June (Pearson correlation coefficient r = 0.34), and from September to October (r = 0.26). Maximum temperature and solar radiation influenced tree growth negatively from April to September (r = 0.28 and 0.29). Winter minimum temperatures and winter solar radiation positively influenced tree growth from December to January (r = 0.2 and 0.28). Mean diurnal range and annual temperature range correlated negatively with tree growth (r = 0.33 and 0.32). Finally, wood density was negatively related to altitude (r = -0.42) and positively to annual minimum and maximum temperatures (r = -0.42 and -0.41). We discuss the implications of these results in the context of Mexico's forest biomass and carbon assessments.

Cold-season freeze frequency is a pervasive driver of sub-continental forest growth

Martin Girardin

Amphitheatre (SH-2800), June 28th, 11:15 - 11:30

As northern latitudes experience rapid winter warming, there is an urgent need to assess the effect of varying winter conditions on tree growth and forest carbon sequestration potential. We examined tree growth responses to variability in cold-season (November-April) frequency of freeze days (FFD) over 1951-2018 using tree-ring data from 35,217 trees and 57 species at 4,375 sites distributed across Canada. We found that annual radial growth responses to FFD varied by species, with some commonalities across genera and clades. The growth of gymnosperms with late spring leaf-out strategies was negatively related to FFD; years with high FFD were most detrimental to the annual growth of Pinus banksiana, Pinus contorta. Larix lyalli, Abies amabilis, and Abies lasiocarpa. In contrast, the growth of angiosperms with early leaf-out strategies, Populus tremuloides and Betula papyrifera, grew better in the coldest years and gymnosperms with intermediate leaf-out timing, such as widespread Picea mariana and Picea glauca, had no consistent relationship to FFD. Tree growth responses to FFD were further modulated by tree size, tree age, regional climate (i.e., mean cold-season temperature) and local site conditions. Overall, our results suggest that moderately warming winters may temporarily improve growth of widespread pines and some high-elevation conifers in western Canada whereas warming winters may be detrimental to the growth of widespread boreal angiosperms. Our findings also highlight the value of using species-specific climate-growth relationships to refine predictions of forest carbon dynamics.

Changes in juvenile growth rates of Norway spruce and European beech from Central Europe in link with climate warming

William Marchand

Amphitheatre (SH-2800), June 28th, 11:30 - 11:45

Montane forests of Central Europe are experiencing faster changes in climate than the average trends. It is still unclear how these natural forests, and especially saplings, have responded to recent modifications in growth conditions. We took advantage of the REMOTE forests network to look at the changes in juvenile growth rates of Norway spruce and European beech, two economically important tree species in Europe. This network includes ring-widths series of more than 19,000 spruces and 14,000 beeches located in montane forest patches within the Carpathians and Balkans mountains. We first assessed changes in growth rates since 1750, with a focus on the juvenile life-stage, i.e. the period when trees were below a diameter of 10cm at breast height. Then, we studied the trees' sensitivity to climatic water balance, vapor pressure deficit, temperature, nitrogen and sulfur depositions. Finally, we assessed the modulating effects of competition, stand structure and species diversity. Juvenile growth of both species accelerated since 1750, the trend in spruce being twice the trend in beech. Spruce saplings responded positively to temperature and this response was higher in species-rich and low competitive environments. Spruces were also sensitive to moisture availability, suggesting that the boost in growth rates could be only transitory. Beech saplings benefited less from higher temperatures and were even negatively affected at low elevation. High levels of acidic depositions buffered the negative effect of a high competition pressure on growth of both species. These results suggest that sylvicultural practices favoring species-diverse and low-density stands could help maintain high growth rates under a warmer climate.

Impact of climate change on the growth of main tree species in Romania using dendrochronological data

Bogdan Strimbu

Amphitheatre (SH-2800), June 28th, 11:45 - 12:00

The objective of this study is to identify and estimate the impact of the change in climate on the annual growths of the three main forest species from Romanian forests: Norway spruce, European beech, and sessile oak. We have used more than 6500 increment cores of the National Forest Inventory in combination with the Romanian homogenized climatic data. To ensure more than 30 observations per time step, we have used quinquennials rather than years. Using a longitudinal autoregressive mixed model, we found that the average radial growth changed significantly since 1960 for all three species and almost all ecoregions. The response of each species in respect to the climate variables considered in the study differs notably, as Norway spruce exhibited a radial growth unaffected by climate change, but sensitive to the previous quinquennial growth, the ecoregion, and the calendar quinquennial. European beach, however, had a radial growth that depends on the precipitations and temperatures during the summer and growing season as well as to the previous quinquennial growth, the ecoregion, and the calendar quinquennial. The radial growth of sessile oak was similar to the European beech, except for the growing season temperature, which seems to have an insignificant impact. While the ecoregions were already proven to play a significant role in radial growth for all the tree species, the inclusion of climate distilled evermore the differences among the ecoregions. Consequently, when considering the quinquennial calendar and climate, the data suggest the existence of two distinct growth areas for Norway spruce and six different growth areas for European beech and Sessile oak.

Boreal forests tree-ring data provide insights for improving climate sensitivity of terrestrial biosphere models

Ariane Mirabel

Amphitheatre (SH-2800), June 28th, 12:00 - 12:15

Our understanding of climate change impacts on boreal forest net primary productivity (NPP) largely rely on terrestrial biosphere models (TBMs). TBMs characterize forest NPP through predictions of plant carbon fluxes and allocation from climatic data, physiological parameters and process logic. TBMs' outcomes may be highly variable, a major source of uncertainty being the formulation of ecophysiological processes and their parameterization. In our study, we compared patterns of growth response to climate across Canada's boreal forest obtained either from a spatially-extensive tree-ring network to or from NPP outputs of fourteen (TBMs). We found that tree growth varied along a southwest/northeast longitudinal gradient of decreasing water limitation to increasing energy limitation. All but two TBMs partially reproduced this spatial gradient of growth limitations. Amongst the climatic variables tested, there was a strong mismatch in the strength and direction of growth responses to summer temperature, largely positive for NPP but negative for tree growth. The negative relationship impact of summer temperature on growth mainly took place during the year prior to ring formation; no such lagged effect was found in the NPP responses. Much of the temperature signal in tree growth could be explained by seasonal fluctuations in atmospheric vapor pressure deficit and soil moisture availability, suggesting a dominant indirect effect of temperature on boreal tree growth via these two variables. Our results suggest that the formulation of processes representing growth responses to climate and their parameterization are not adequately representing productivity of Canada's boreal forest in a majority of tested TBMs.

Symposium 5. Applications of dendrochronology in urban environments

Moderators: Kaisa Rissanen, Mitchell Bonney, Valentina Vitali, Maegen Rochner, Mareike Hirsch, Danielle Martin

Speakers: Greg King, Kaisa Rissanen

Amphitheatre (SH-2800), June 28th, 13:30 - 15:00

As of 2020, 56% of the world's population live in urban areas. These individuals benefit from numerous ecosystem services provided by urban forests, including urban heat island mitigation, energy use reduction, stormwater interception, wildlife and pollinator habitat provision, air pollution removal, and carbon sequestration. Urban greenspaces are also often the most accessible avenue for exposure to the natural environment, providing additional aesthetic, recreational, and psychological benefits. However, we know surprisingly little about urban tree growth often applying knowledge from non-urban ecosystems. Dendrochronology offers a valuable field-based method that can improve quantification of urban tree growth, evaluate response to environment, and project how planted trees can be expected to perform in various environments in the future. A few possible avenues of investigation include: the potential to measure the impact of urban land-use on urban forest growth, evaluate the scale and monetary value of carbon sequestration, determine the spatial and temporal legacies of environmental pollution using urban trees for biomonitoring, and assess resistance and resilience of urban forests to extreme climatic events. This potential is also challenged due to larger spatial heterogeneity in growth conditions and many co-occurring anthropogenic effects (e.g. soil compaction, mechanical wounding, excess irrigation, salinity, etc.) that may impact cross-dating and developing common growth curves.

The application of tree rings for monitoring urban forest change: A remote sensing perspective

Mitchell Bonney

Amphitheatre (SH-2800), June 28th, 13:30 - 13:45

Tree rings have long been used to monitor forest change by measuring differences in tree ring widths through time derived from a representative sample of forest trees. However, for many reasons, tree rings have only rarely been utilized to monitor urban forest change. Urban forest change monitoring has more commonly occurred with time-series of remote sensing imagery, such as yearly stacks of Landsat satellite imagery converted to some vegetation index or other proxy. Tree rings and remote sensing time-series are thus similar, providing temporal records of forest productivity change from different perspectives and processes. From an urban forest remote sensing perspective, tree rings represent a unique natural validation tool for detected changes that has not been utilized. In an urban-rural watershed west of Toronto, Canada, we explored the forest history information provided by both tree rings and overlapping Landsat time-series data at 16 sites. We directly compared the two information sources over the overlapping period (1972-2018) statistically and by temporally matching increase-decline trends. Stronger connections occur at coniferous forest sites, potentially driven by differential response to summer temperature change. We also identified how major events in the region, such as a recent ice storm and the pressures of suburbanization, influence change in both sources. Many of the results discussed here are based on a paper ("Temporal connections between long-term Landsat time-series and tree-rings in an urban-rural temperate forest") published in 2021.

Urban tree resiliency to heat and drought stress across Canadian cities

Kaisa Rissanen

Amphitheatre (SH-2800), June 28th, 13:45 - 14:00

Urban trees are expected to help in mitigating the negative effects of climate change on infrastructures and human well-being in cities but warming climate with longer and more intensive dry and hot periods will also affect urban tree function and survival. To better understand the resilience and resistance of urban trees in the face of climate change, we conducted a Canada-wide collection of tree cores from cities with diverging climates (Edmonton, Montreal, Quebec City, and Halifax). We use dendrochronology to assess tree growth responses to dry and hot periods, comparing common urban tree species with differing water-use strategies in parks and on streets. We expected street trees to show more growth reductions than park trees after dry and hot periods due to the more restrictive conditions. Preliminary results in Montreal show that contrary to our initial hypothesis, street trees seem to be more resilient to thermal and drought stress and present more variability in growth in comparison to park trees among honey locust, green ash, and Siberian elm. Street tree species comparisons in Edmonton revealed that green ash trees were more susceptible to years with low precipitation, while bur oak were more impacted by years with high temperatures. However, in all cases, there appears to be recovery in growth following the notable years. We will also examine tree growth responses over the climate gradient to see whether heat waves and dry periods affect tree growth more negatively in cities with hot summers in comparison to cities with cool summers. With this information, we aim to form predictions on the growth and resilience of urban trees in the future conditions.

Urban trees for a cooler future - Growth patterns of urban trees in a changing climate

Valentina Vitali

Amphitheatre (SH-2800), June 28th, 14:00 - 14:15

Urban trees provide important environmental services and are indispensable for the regulation of a city's climate, whilst growing in stressful conditions with low water and space availability. However, compared to their forest counterparts, little is known about urban trees' capability to cope with climate change. Due to the heat island effect, Montreal has already experienced 1.4°C higher temperatures, creating increasingly challenging conditions for urban trees. Planting resilient trees is necessary to minimize the efforts needed to ensure their health and performance and the provisioning of environmental services. Through dendrochronological analyses, we have compared the growth rates of four common urban tree species Norway maple (Acer platanoides), silver maple (Acer saccharinum), lime (Tilia cordata), common hackberry (Celtis occidentalis). Trees were sampled in the metropolitan area of Montreal across an urban gradient, from trees growing in pavement pits to lawns in residential areas, and in parks. Contrary to expectations, in the last decades, the least accomodating conditions of the urban center have been showing an increase in growth rates. Both Acer species growing in pavement pits have shown a significant increase in growth rates, reaching the ones achieved by park trees. Climate correlations indicate a strong positive effect of autumn temperature, indicating an increase of the vegetative period in this area and therefore an increase in growth. Eastern Canada has recorded an increase in temperature as well as precipitation, explaining the consistent increase in growth in the last decades. Dendrochronological results proved to be a necessary assessment to understand the complex system of urban forestry.

Explorations of Urban Dendrochronology in Louisville, Kentucky, USA

Maegen Rochner

Amphitheatre (SH-2800), June 28th, 14:15 - 14:30

Urban trees and forests provide a variety of social and environmental benefits, but their function, and therefore the benefits they provide, can be enhanced or diminished by human influences. More work is needed to understand how urban forests mitigate, and are affected by urban heat, pollution, and other anthropogenic influences, especially in light of modern urbanization and climate change. As concentrated sites of accelerated environmental change, urban forests may also provide insight into how regional ecosystems may respond to expected, global-scale changes. One way to examine urban forests is through dendrochronology, but tree-ring methods have been applied rarely in urban areas, typically avoided in favor of areas with limiting climates and older trees. The objective of ongoing work in Louisville, Kentucky is to explore dendrochronology as an avenue for research into the growth and sensitivity of urban trees in relation to anthropogenic factors. We developed white oak tree-ring chronologies for six sites across the urban-rural gradient in Louisville, including two each of urban, peri-urban, and non-urban sites. We find that (1) growth patterns and climate-growth response, with some short-term differences, are comparable across the urban-rural gradient and that (2) land-use histories and disturbance likely drive differences. Across all six sites, tree growth sensitivity to climate variables is shifting or declining over the instrumental period. Extreme dry and wet years are the main driver of marker rings in all chronologies, but this may change with shifting sensitivities. In all, we find no signal that is unique to trees from urban environments.

Drought tolerance differs between urban tree species but is not affected by traffic pollution

Mareike Hirsch

Amphitheatre (SH-2800), June 28th, 14:30 - 14:45

Urban trees provide multiple benefits such as shading and cooling, which become more and more important due to the increasing frequency and severity of heat and drought periods. It is thus necessary to identify tree species, which are able to tolerate such extreme conditions in urban areas. We studied the resistance and resilience of stem diameter growth of five deciduous tree species in an urban area in Southwest Germany to three exceptional drought periods for differences between and within species, especially considering the intensity of traffic emissions (NOx). We further investigated the stable isotopic composition of carbon (d13C) and oxygen (d18O) in the tree rings. By analysing the stable isotopic composition of nitrogen in the wood, we aimed to find out if d15N may serve as an indicator of NOx emissions from traffic. Stem diameter growth in all species was strongly limited by low water availability in spring, as was also reflected in elevated d13C and d18O values in Acer platanoides and Tilia cordata, which were particularly sensitive to drought. In contrast, growth of Platanus × hispanica and Quercus robur was less affected by drought, and resistance of Carpinus betulus ranged in between. Across species, d15N was higher in trees experiencing higher NOx traffic emissions and being located closer to roads. These conditions, however, unexpectedly did not significantly affect drought resistance and resilience. Our study demonstrates both the large potential and the associated interpretative challenges of coupled dendroecological and multi-isotopic analyses. It also indicates clear species-specific differences in drought tolerance and thus helps to identify suitable tree species for urban areas.

Quantifying nuclear power plant emissions and fossil fuel contributions using dendrochronology & radiocarbon techniques

Danielle Martin

Amphitheatre (SH-2800), June 28th, 14:45 - 15:00

Dendrochronology can provide a glimpse into past periods that lack long-term ecological and environmental data. With the growing concern of climate change and the need to reach net-zero carbon, contributions of nuclear energy sources to meet net-zero goals continue to be discussed. Ontario obtains a large amount of energy from Canadian Deuterium (CANDU) reactors at the Bruce, Pickering and Darlington nuclear facilities. Conveniently, tree-rings can be used to measure radiocarbon (14C) emissions released during maintenance activities. Atmospheric 14C can be measured in tree rings via accelerator mass spectrometry (AMS). These proxy-records can provide annually resolved data that integrates atmospheric carbon dioxide (CO2) via photosynthesis. Continuing the work of past studies, we will be measuring 14C to determine how atmospheric CO2 is being influenced by 14C emissions from nuclear sources and old carbon derived from fossil fuel combustion (12C or 13C). Tree-ring 14C data will be compared to atmospheric CO2 and 14C levels measured by Environment and Climate Change Canada (ECCC), environmental monitoring of reactors from the Canadian Nuclear Safety Commission and to data from the ECCC clean-air site location in Egbert, ON. White spruce (Picea glauca) trees were sampled near the Bruce nuclear facility and in the City of Toronto to investigate fossil fuel emission impacts from high traffic areas as well as potential effects COVID-19 may have had with the significant decrease in fossil fuel consumption after March 2020. It is hypothesized that samples from Bruce will be enriched in 14C, while samples from Toronto will be severely 14C-depleted until 2020 with evidence of decreased 12C and 13C levels.

General Session (Ecophysiology)

Speakers: Ali Segovia-Rivas, Jeanny Thivierge-Lampron, Katja Rinne-Garmston, Paulina Fernanda Puchi Gonzalez, Charlotte Angove, Marceau Badaroux, Sepideh Namvar, Guillermo Gea-Izquierdo

Salle polyvalente (SH-4800), June 28th, 13:30 - 15:00

Temperature is not the main driver of vessel diameter(when standardized by height) across climatic gradients in Viburnum

Ali Segovia-Rivas

Salle polyvalente (SH-4800), June 28th, 13:30 - 13:45

It is generally assumed that tree-rings, and their vessel diameters, are wider in warmer and wetter years. To maintain constant conductance per unit leaf area as trees grow taller, stem vessels should widen from tip to base. But wider vessels are more susceptible to embolism, so taller plants are progressively becoming more vulnerable to drought or cold as they grow. The traditional theory of vessel hydraulic adaptation postulates that vessel diameter is affected by climate, with cold environments selecting for narrower vessels. Recent work suggests that plant height is an important driver, hence the relationship between vessel diameter, climate and height remains to be explored. In order to do this, we installed 16 climate stations along 5 strong elevational gradients in Mexico and measured vessel diameter of the most recent tree ring along the stems of 57 trees of 10 species of Viburnum (Adoxaceae). We examined the possibility that there could be adaptive variation in the Y-intercept of within-plant tip-to-base vessel widening curves, with plants in dry and cold areas having lower intercepts (narrower vessels for a given height) than in moist-warm places. We found no evidence that temperature affects vessel widening, though total plant height, leaf area, and possibly wood density appears to affect the Y-intercept of vessel widening profiles of individual stems. These findings stimulate new questions including the need to understand how vessel widening in the leaves is coordinated with that in the stem.

Intra-annual boreal tree growth and water stress responses to environmental changes

Jeanny Thivierge-Lampron

Salle polyvalente (SH-4800), June 28th, 13:45 - 14:00

In the context of climate change, more research is needed to better understand the impact of short-term environmental stressors on forest productivity. Intra-annual data provide crucial information to achieve this objective. Our project aims to determine the responses of tree growth and water status of boreal tree species (jack pine, black spruce and quaking aspen) under variable meteorological conditions and on contrasted soil surficial deposits using intra-annual measurements from dendrometers. Four monitoring sites were established in the north-west region of Quebec as part of the pan-Canadian Smartforest network. Our experimental design includes sites with mixed forests on contrasting soil types (i.e., clay and sand). At each site, together with detail environmental monitoring, including soil and meteorological conditions, high frequency and precision stem dendrometers are deployed to monitor stem radial variations of a total of 50 trees (20 jack pines, 20 black spruces and 10 quaking aspens). These data are used to quantify the temporal dynamics of intra-annual tree growth (irreversible variation) and water status (reversible variation). Here, we will assess how the environmental variability affects the tree water status of the studied trees during the first growing season and will compare the response of tree growth between sandy and clay sites. Our results contribute to better understand the impact of site-specific conditions and short-time disturbances on growth and water stress of boreal trees. These results have important implications for the prediction of boreal forest productivity in a climate change context.

Interpretation of intra-annual tree-ring d13C profiles of control, droughted and re-watered Scots pines

Katja Rinne-Garmston

Salle polyvalente (SH-4800), June 28th, 14:00 - 14:15

Intra-annual tree-ring d13C record has the potential to provide deep insights into past plant performance and environmental conditions. With concomitant high temporal resolution d13C analysis of non-structural carbohydrates, the processes behind observed low- and high-frequency d13C changes in tree-ring record could be interpreted more reliably. This is essential for predicting forest response to impacts of climate change, such as more frequent and severe drought episodes. To better understand post-photosynthetic 13C-fractionation processes and drought associated changes in tree function, we conducted a drought experiment with Scots pine saplings in a greenhouse during a growing season. Scots pine clones were exposed to two treatments: control trees, and trees exposed to drought and subsequent re-watering. We analysed d13C of individual sugars (compound-specific isotope analysis) and starch in leaves, phloem and roots at weekly resolution, to study how environmental changes were recorded in leaf assimilates and modified in down-stem transport. Tree physiological response was monitored to support interpretation. High resolution d13C profiles of tree-rings were obtained using laser ablation isotope ratio mass spectrometry, which enabled us to identify how the d13C signal of assimilates was finally recorded in stem xylem, and to determine which processes distorted this signal. The results shed new insight into the widely reported 13C-enrichment of sink organs relative to leaves and demonstrate the potential of using high-resolution tree-ring d13C-profiling to understand drought associated processes in xylem formation.

Long-term eddy covariance fluxes and xylem anatomy for understanding carbon fixation in white pine woody biomass

Paulina Fernanda Puchi Gonzalez

Salle polyvalente (SH-4800), June 28th, 14:15 - 14:30

Improving our understanding of the carbon cycle is key to addressing the challenges of climate change. In this study, we investigated the relationships between intra and inter-annual climate variations, carbon fluxes, and the xylem biomass in an 80-year plantation of Pinus strobus at Turkey Point, Ontario, Canada. From eddy covariance tower, we obtained daily Gross Primary Production (GPP), precipitation and air temperature for the period 2003-2018. To determine inter-and intra-annual xylem biomass we selected 12 trees and built wood anatomical trait chronologies (cell lumen area, cell wall thickness, cell number, cell wall area and ring wall area) over the past 50 years. Using moving windows, we correlated all chronologies with daily climate data and GPP to analyse their associations at intra-annual scale.

The analysis showed that cell lumen area and cell wall thickness were strongly influenced by spring and summer temperature and precipitation. For the first time, we observed strong positive and significant correlations between GPP in the growing season and the cell wall area (which estimates the amount of carbon in each xylem cell) both in earlywood (May 10 - Aug 4, r = 0.685) and latewood (Jul 3 – Sep 3, r = 0.885). Strong positive correlations were also found between GPP and cell number and ring wall area. These results suggest a direct linkage between CO2 fluxes and the accumulation of carbon in woody biomass. This work will help to reconcile two important techniques that are widely used to study carbon sequestration in forests. It will help to reduce uncertainty in woody carbon accumulation and will open new perspectives in the study of the forest carbon cycle.

Ecological implications of leaf water deuterium enrichment

Charlotte Angove

Salle polyvalente (SH-4800), June 28th, 14:30 - 14:45

Leaf water isotopic enrichment (¡U+0394¿D[LW]) is the original source of climatic information stored in tree-ring d18O and dD. Tree-ring d18O temporal variability has been correlated to environmental variables such as temperature, precipitation, relative humidity (RH), and phenomena such as tropical cyclones and drought. Meanwhile, more development is needed to use tree-ring dD temporal variability as a paleoclimatic bioindicator. An increased understanding of the climatic signal of ¡U+0394¿D[LW] could help to better interpret temporal variability of tree-ring dD. Leaf-water d18O enrichment (¡U+0394¿18O[LW]) exhibits stronger relationships to environmental variables such as RH, and physiological rates such as transpiration rate, compared to ¡U+0394¿D[LW]. ¡U+0394¿D[LW] has been correlated to the disequilibrium between atmospheric water vapor dD (dD[WV]) and plant-stem water dD. New evidence shows that dD[WV] in forests varies diurnally, and such variability is related to ecosystem-level processes such as evapotranspiration. Such relationships suggest that ecosystem-level processes in forests can participate a role in the disequilibrium between dD[WV] and plant-stem water dD. Resultantly, there is a potential for ¡U+0394¿D[LW] to exhibit previously unidentified correlations to ecosystem-level processes. In this study, we aimed to explore the potential of ¡U+0394¿D[LW] as a bioindicator of ecosystem-level processes such as evapotranspiration and gross primary productivity. We used a temporal survey of P. sylvestris ¡U+0394¿D[LW], ¡U+0394¿18O[LW] and eddy covariance data during 2019 at Hyytiälä, central Finland. This poster shows comparisons of ¡U+0394¿D[LW] and ¡U+0394¿18O[LW] to climatic variables and ecosystem processes for new insights about ¡U+0394¿D[LW] as a bioindicator of ecosystem-level processes.

Potential growth scenarios for boreal forests with the ecophysiological model MAIDEN

Marceau Badaroux

Salle polyvalente (SH-4800), June 28th, 14:45 - 15:00

In the context of climate and environmental change, the boreal forest is subject to potential changes in structure and function. Stand-level physiological models can be used to predict these responses over time and to understand the interaction between tree ecophysiological processes and climate variability. We present here a project that aims to develop potential growth scenarios for Canadian boreal forest stands based on the characterization of their ecosystem fluxes using the MAIDEN model. First, we will assess site-level processes using a data-model fusion approach. Using inventory and tree-ring data, and flux towers data, the MAIDEN carbon allocation model will be calibrated and refined to highlight the relationships between climate variables and carbon allocation. Various optimization methods will be used including gradient descent algorithms in Bayesian frameworks. Landscape level simulations will then be performed and validated using MODIS satellite images. The calibrated model will be used to run potential growth scenarios for boreal forest species and determine the evolution of forest ecosystem fluxes over time. We will use climate scenarios to predict the evolution of climate variables, and the results will be analyzed by various statistical methods to determine the involvement of climate in the evolution of the productivity of the species studied. The poster will present the proposed data-model fusion approach, data sources used to inform the modelling, the MAIDEN carbon allocation scheme and preliminary simulations for specific sites. The project will improve understanding of how boreal tree species grow under changing climatic conditions, and the impact of future climate variability on boreal carbon fluxes.

General Session (Dendroclimatology, PT3)

Speakers: Daniela Granato, María Eugenia Ferrero, Christine Lucas, George Rhee, Ze'ev Gedalof, Priyadarshini Parsons O'Brien, Grant Harley, Matthew Bekker

Classroom (SH-3420), June 28th, 13:30 - 15:00

Proxy and historical evidence for rainfall extremes in the Amazon and northeastern Brazil, 1790-1900

Daniela Granato

Classroom (SH-3420), June 28th, 13:30 - 13:45

Historical accounts in the Brazilian Digital Library provide independent support for most of the tree-ring reconstructed wet season rainfall extremes in the eastern Amazon during the late-18th and 19th centuries. Newspapers, government reports, and other documents describe crop failure, livestock mortality, water shortages, and ship groundings on the Amazon River during many of the tree-ring reconstructed drought extremes. Heavy rains and flooding are described during some of the wet extremes, including the overtopping of the Bittencourt Bridge in Manaus by floodwaters during the tree-ring reconstructed wet year of 1892. The elevation of the Bittencourt Bridge in 1892 may provide a benchmark for comparison with modern flood extremes on the Rio Negro/Rio Amazon system. The “Unknown Drought” of 1865 was the lowest wet season rainfall total reconstructed with tree-rings in the eastern Amazon from 1759-2016 and appears to have been one of the lowest stream levels observed on the Amazon River during the historical era, according to descriptions by the Louis Agassiz-Major Coutinho Expedition and others. The economic impact of the drought in 1865 appears to have been moderated by the highly inflated price of cotton, which benefitted Brazilian growers, following the collapse of production in the American South during the Civil War. This may help explain why the extreme low water levels on the Amazon during the Unknown Drought have received limited scientific attention. The proxy and historical evidence for late-18th and 19th century rainfall extremes provide useful perspective on modern climate variability and change in the Amazon.

Two centuries of hydroclimatic variability reconstructed over the Amazonian Andes of Peru

María Eugenia Ferrero

Classroom (SH-3420), June 28th, 13:45 - 14:00

Half of the tributaries of the Amazon River originate in the tropical Andes; however, it is difficult to assess hydroclimatic conditions due to the scarcity of long, high-quality instrumental records. Data from the Global Precipitation Climatology Project (GPCP) provides a complete record since 1979 and offers a good representation of rainfall over the tropical Andes. Longer records are needed to improve our understanding of rainfall variability and summer monsoon behavior at various scales. We developed the first annually-resolved precipitation reconstruction for the tropical Andes in Peru, based on tree-ring chronologies of Cedrela and Juglans species. The annual (November-October) reconstruction extends the short instrumental records back to 1817, explaining 68% of the total variance of precipitation over the 1979-2007 calibration period. The reconstruction reveals the well-documented influence of ENSO on Amazon rainfall at interannual scales ($\sim$19% of total variance), and significant multidecadal variability with alternating periods of about 40 years ($\sim$13% of rainfall variability) related to the Atlantic Multidecadal Oscillation (AMO). Both oscillatory modes can explain dry and humid periods observed within the reconstruction and are likely associated with the negative trends of rainfall in the short instrumental records and the increased drought recurrence in recent decades. Our results show that montane tropical tree rings can be used to reconstruct precipitation with exceptionally high fidelity, characterize the interannual to multidecadal variability and identify remote forcings in the hydroclimate over the Andean Amazon basin of Peru.

Cross-continental hydroclimate proxies: Tree-rings in Central Chile reconstruct historical streamflow in Southeastern So

Christine Lucas

Classroom (SH-3420), June 28th, 14:00 - 14:15

Regional teleconnections permit cross-continental modeling of hydroclimate throughout the world. Tree-rings are a good hydroclimatic proxy used to reconstruct drought and streamflow in regions that respond to common global forcings. We used a multi-species dataset of 32 tree-ring width chronologies from Chile and Uruguay as a climate proxy to infer annual streamflow (Q) variability in the Negro River basin, a grassland-dominated watershed of lowland Southeastern South America. A positive linear correlation between tree-ring chronologies from Central Chile and annual Negro River instrumental streamflow from 1957-2012 indicated a cross-continental teleconnection between hydroclimate variability in Central Chile and Northeastern Uruguay. This relationship was mediated in part by the El Niño Southern Oscillation (ENSO), whereby the El Nino 3.4 Index was positively correlated with regional rainfall, annual tree growth, and Q anomalies. Despite the proximity of Uruguayan tree-ring chronologies to Negro River hydrometric stations, the Chilean tree-ring chronologies best predicted annual streamflow. Thus, using tree-ring data from four long-term moisture-sensitive chronologies of the species Cryptocarya alba in Central Chile (32-34°S), we present the first streamflow reconstruction (1890-2009) in the Lower La Plata Basin. The reconstruction supports regional evidence for increasing frequency of extreme flood years over the past century in Uruguay. We demonstrate how climate teleconnections that mediate local hydroclimate variability permit the cross-continental reconstruction of streamflow, filling a major geographical gap in historical proxies for flooding and drought in grassland biomes of the southern hemisphere.

Estimating Uncertainties in the Multidecadal Variability of Colorado River Flows from Treering Data

George Rhee

Classroom (SH-3420), June 28th, 14:15 - 14:30

The Colorado river supplies water to forty million people. The river system in crisis due to; an ongoing twenty year drought, a historical overallocation of river flows and an increasing demand for water due to an increasing population. One historical cause of the crisis was the assumption one hundred years ago by the signatories of the Colorado River Compact that the natural flows of the Colorado River do not vary significantly on timescales longer than a decade. Since then, one hundred and fifteen years of gauged Colorado river data indicate that the natural flows fluctuate significantly on all the timescales of the gauged record (up to one hundred years). Rhee et al (2019) have used a gaussian inference model to predict future river flows on the timescale of a few decades. A key parameter of this model is the slope (spectral index) of the fourier power spectrum of the yearly river flow fluctuations. This parameter can be best estimated from the thousand year record of Colorado river flows inferred from tree ring measurements. The trees are located in the upper Colorado River Basin at locations where tree growth is most sensitive to annual precipitation. In a recent paper, Butgen et al., 2021 have demonstrated that the estimation of long term fluctuations in tree ring proxies is quite sensitive to the detrending method as well as the proxy calibration method used. We use their approach to estimate the uncertainties in the Colorado river flow multidecadal variatiability (power spectrum spectral index). These uncertainties are critical in estimating the probabilities of reduced river flows for the coming decades which are critical for risk assessment and determining river management policies.

Effects of climate on the radial growth of mixed stands of Nothofagus nervosa and N. obliqua in Patagonia

Ze'ev Gedalof

Classroom (SH-3420), June 28th, 14:30 - 14:45

Climate models for North Patagonia in Argentina project dryer conditions, due to a decrease in mean precipitation combined with an increase in mean temperatures. The temperate mixed Nothofagus forest, which exists along a steep precipitation gradient, could be directly impacted. For this study, we evaluated the influence of mean climate on the growth of the significant deciduous species: N. nervosa and N. obliqua. For the first time in Argentina, dendroclimatological analyses were done on both species using a network of 14 chronologies, covering their longitudinal distribution along a gradient of declining precipitation from west to east. Seasonal correlation analysis revealed that temperature has a negative effect on the growth of both species across all sites, particularly during summer of the previous and current growth season. Precipitation has a positive effect on the growth of trees for both species, which is stronger in N. nervosa. The relationship between early-summer climate and growth remained relatively stable over time for N. nervosa; however, for N. obliqua the detrimental effects of temperature increased towards the end of the 20th century, and the positive effects of precipitation decreased, particularly at the driest end of the gradient. These results suggest that a continued decrease in rainfall with a rise in temperature could impact growth for both of these species.

Reconstructing Late Pleistocene Atmospheric Radiocarbon using Subfossil New Zealand Kauri (Agathis australis)

Priyadarshini Parsons O'Brien

Classroom (SH-3420), June 28th, 14:45 - 15:00

Annually resolved subfossil kauri (Agathis australis) trees, recovered from bogs in northern New Zealand, provide unique insights into past climate events over multi-millennial timescales. Their tree-rings faithfully capture annually resolved information about climate and carbon dynamics occurring during their lifespan. Preserved material has contributed tree-ring chronologies spanning much of the Holocene and extending into the late Pleistocene (i.e. the last 50,000 years). A recently discovered site (called Waipu) has yielded over 40 kauri logs that have resulted in four floating tree-ring chronologies which span a combined total of more than 6,000 years during the time interval of 32,000 - 22,000 years before present (BP). This time period is of great scientific interest as it includes the transition towards the Last Glacial Maximum (LGM) as well as abrupt warming events (Dansgaard-Oeschger events) and an extreme cold event (i.e. Heinrich 3). The preliminary results of the visually cross-matched samples were tested using the recently developed 'RingdateR' software as it was specifically designed to deal with unknown-age material. The positive results have meant the approach will be used to help with streamline processing logs from other sites. More logs are currently being measured from the Waipu site, and the final chronologies will be sampled to produce bi-decadal radiocarbon measurements that will help refine the radiocarbon calibration curve. The subsequent dataset of atmospheric radiocarbon content will help provide information to precisely align and date terrestrial, marine and ice core records of climate and environmental events. Offering a potential world-class palaeo-archive for radiocarbon calibration.

General Session (Dendroecology, PT2)

Speakers: Chris Guiterman, Daniela Robles, Kelsey Copes-Gerbitz, Kira Hoffman, Michael Stambaugh, Tessa Mandra, Vanessa Comeau, Marcel Kunz, Jill Harvey, Camille Lepage

Salle polyvalente (SH-4800), June 28th, 15:15 - 17:15

Historical diversity of fire regimes across Arizona and New Mexico

Chris Guiterman

Salle polyvalente (SH-4800), June 28th, 15:15 - 15:30

Fire regimes shaped forest ecosystems for centuries in the southwestern United States prior to a century of fire exclusion. Tree-ring fire history studies have been vital to our ecological understanding of fire regimes and to inform management. Regional-scale synthesis efforts have revealed the strong connection between fire and climate, but by focusing on coarse-scale patterns over time, such studies may have overlooked finer-scale interactions of fire, climate, vegetation, and human activities. Now, with new tools (burnr and TreeFire), and a plethora of available data (569 sites, 6031 trees, and 44639 fire scars), we examine the diversity of tree-ring fire scar records across Arizona and New Mexico with regard to fire regime metrics and drivers. We found sub-regional patterns of fire-scar seasonality that are likely driven in part by the progression of summer monsoon precipitation, which ends the early-summer fire season. Inter-annual fire-climate relationships varied spatially across the region, but wet years followed by drought were commonly associated with extensive fire. Multi-decadal fire frequency had high spatiotemporal variability, but also contained sub-regional patterns, likely driven by a combination of climate and humans. The synthesis provides a valuable framework for uncovering new spatiotemporal patterns in historical fire regimes and the processes that drive these patterns, which can be used to further inform management and forecast future fire regimes.

Synoptic-scale climatic controls of fire activity in the red pine forests point to the role of winter and spring conditions

Daniela Robles

Salle polyvalente (SH-4800), June 28th, 15:30 - 15:45

We examined the effects of large-scale modes of climate variability on regional fire history of red pine forests of eastern North America using (a) a network of sites with fire scar-based reconstructions of fire histories over 1675-1900 AD, (b) reconstructions of circulation indices (1675-2019), and (c) the 20th century observational records of weather (1950-2019) and fire (1959-2019). In exploring climate-fire relationships over the distribution range of red pine, we hypothesized that there are states of atmospheric circulation as captured by circulation indices that are consistently associated with increased fire activity, and that these states mark periods of increased climatological fire hazard over the region. Years with increased fire activity in the reconstructed fire records were associated with El Niño, positive NAO, and the combination “La Niña - PDO neutral”. Applying a climate analogue approach, we studied climate conditions over the distribution of red pine during the identified fire-prone states, using the modern climate data. Warmer winters and springs leading to an earlier onset of the fire season possibly drive development of fire-prone conditions and occurrence of high fire activity years. However, only the combination “La Niña - PDO neutral” proved to be fire-prone in the modern fire record. Notably, all fire-prone states identified in reconstructed records became less frequent during the 20th century. This trend limited our ability to test climate-fire association in this period. Less fire-prone climate during the 20th century, in comparison to the portion of the Little Ice Age studied (ca. 1675-1850), likely contributed to the modern low fire activity

The role of Indigenous land use in a mixed-severity fire regime in the dry forests of British Columbia, Canada

Kelsey Copes-Gerbitz

Salle polyvalente (SH-4800), June 28th, 15:45 - 16:00

Indigenous land stewardship and mixed-severity fire regimes both encourage landscape heterogeneity and the relationship between them is an emerging area of research. To contribute to this exploration, we reconstructed the historical fire regime of Ne Sextsine, a 6000-ha dry, Douglas-fir-dominated forest in the traditional territory of the T'exelc (Williams Lake First Nation) in British Columbia. Between 1550 and 1982 CE, we found median fire intervals of 15 years at the plot-level and 4 years at the study site-level. Ne Sextsine was characterized by a historical mixed-severity fire regime, dominated by frequent, low-severity fires indicated by fire scars with infrequent, mixed-severity fires indicated by cohorts. Differentiating low- from mixed-severity plots was key to understanding the drivers of the fire regime at Ne Sextsine: high fire frequency in low-severity plots plateaued in the 1870s, following the smallpox epidemic, the forced relocation of Indigenous peoples into small reserves, and the prohibition of Indigenous burning. In contrast, high fire frequency in the mixed-severity plots continued until the 1920s when industrial-scale grazing and logging began. T'exelc oral histories and archaeological evidence at Ne Sextsine speak to varied land stewardship across the area, reflected in the spatiotemporal complexity of low- and mixed-severity fire. Across Ne Sextsine, 63% of cohorts established after the Indigenous fire regime collapsed, resulting in a dense, homogenous landscape that is more likely to burn at uncharacteristic high severities. This nuanced understanding of the Indigenous contribution to a mixed-severity fire regime is critical for advancing proactive fire mitigation that is eco-culturally relevant.

Reconstructing historic fire activity with whitebark pine in Tweedsmuir Provincial Park, northern British Columbia

Kira Hoffman

Salle polyvalente (SH-4800), June 28th, 16:00 - 16:15

There is a growing need for improved methods and approaches for managing wildfires in British Columbia, as uncharacteristically large wildfires exceed government capacities for control and suppression. The 2018 Tweedsmuir complex fire exceeded half a million hectares, negatively impacting several endangered species and the ecosystems they depend on. Tweedsmuir Provincial Park is one of BC's largest protected areas and plays a critical role in connecting diverse landscapes and allowing plants and animals to move and adapt to climate change. To understand the frequency and spatial extent of historic wildfire activity within Tweedsmuir Park we reconstructed historic fire activity from eleven sites containing previously killed whitebark pine, an endangered tree species due to the combined impacts of biotic and abiotic disturbances. Our reconstruction extends our understanding of fire activity to 1600, indicating that frequent, low-severity and human-driven fire events in combination with sporadic lightning fires characterize the region. First Nations have used fire as a tool for resource management in Tweedsmuir Park for millennia and continue to be keepers of fire knowledge and stewards of biodiversity, ecosystem connectivity, and resiliency. As wildfire seasons grow longer, fire behavior is becoming more uncontrollable, and as we strive to adapt to a changing climate, current fire management systems are becoming stressed. It is more important than ever to have multiple experiences and voices participating in solving wildfire issues and contributing to long-term land management plans.

Elevational differences in the timing and intensity of larch budmoth outbreaks in two valleys of the European Alps

Marcel Kunz

Salle polyvalente (SH-4800), June 28th, 16:15 - 16:30

Cyclic outbreaks of the larch budmoth (Zeiraphera griseana, hereafter referred to as LBM) have affected the growth of their larch host trees (Larix decidua) in the European Alps. These regular defoliation events have weakened since the 1980s, likely in response to climate change, but recured in 2018. Here, we investigate the LBM activity along two elevational gradients in the Swiss Alps using tree-ring width (TRW) and maximum latewood density (MXD) measurements from 15 sites between 1,400 and 2,300 m a.s.l. While the effect of the LBM events overall disrupted the tree-ring climate signal, correlations with instrumental JJA temperature recordings remain significant (p = 0.001) for TRW (0.38 at 2,000 m and 0.64 at 2,300 m a.s.l.) and MXD (0.54 at 2,000 m and 0.74 at 2,300 m a.s.l) with the latter recovering quicker from the negative effects of LBM defoliation. Redfit and wavelet spectra as well as superposed epoch analysis of site chronologies reveal a maximum impact of LBM outbreaks at elevations around 1,900 and 2,000 m a.s.l. from where the signal gradually diminishes towards the upper and lower ends of the LBM distribution range. The timing of the growth response to LBM events varies between the two valleys but also between different elevations within the same valley.

Frontiers in fire ecology exist in tree-ring fire scar reconstructions of the southeastern U.S.

Michael Stambaugh

Salle polyvalente (SH-4800), June 28th, 16:30 - 16:45

The most frequent fire regimes in the world exist in environments that balance maximum fuel production and maximum fire occurrence potential. Often these environments exist at low elevations, correspond to subtropical climates, and have long growing seasons that push the limits of reliable annual ring formation. Historical fire regimes in ecosystems with these conditions are poorly studied. We investigated fire scarring in such conditions in southwestern Georgia, USA and successfully constructed a tree-ring and fire scar chronology from 1485 to 2017 (533 years) based on cross-sections cut from 32 dead and living trees. New challenges in this work existed from the beginning stages of field sampling through the final stages of data analysis and interpretation. For example, many scars existed at or below ground line, presenting challenges in dating anomalous rings associated with basal tree flare. Many non-fire associated injuries existed and high frequency fire led to many more and smaller fire scars (n=6367) than is typical in comparable studies in temperate pine forests. High frequency fire and mixed seasonalities challenge existing fire scar history reconstruction metrics. Historical fire regime data new insights into longleaf pine forest ecology, including climate-independent fire regimes and hyperfrequent disturbance theory.

Does disturbance impact the climate sensitivity of surviving trees in diverse temperate forests?

Tessa Mandra

Salle polyvalente (SH-4800), June 28th, 16:45 - 17:00

Insect and pathogen outbreaks, fires, hurricanes, severe drought and other disturbances alter the structure, composition and function of forests. Results from silvicultural experiments suggest disturbances in lower density forests lead to better mitigation of drought stress for surviving trees than those in higher density stands. As drought and insect and pathogen outbreaks are expected to become more severe and frequent, understanding how surviving trees' climatic response is affected by disturbance provides valuable insight into how future compound events alter tree growth.

Hemlock woolly adelgid (HWA) is an exotic insect pest introduced to the eastern U.S. in the 1950s. At our old-growth study site in New Jersey, HWA began killing Tsuga canadensis in the mid-1990s. We hypothesized HWA-related mortality would avail resources to surrounding trees, reducing sensitivity to summer drought post-disturbance, especially for drought-sensitive species. We used bootstrapping methods and a state-space model analysis to examine climate-growth correlations before and after disturbance.

Our results reveal climate-growth relationships clearly differ before and after HWA in all species except Pinus strobus and Acer rubrum. Surviving Tsuga canadensis, Betula lenta, Quercus montana, and Quercus rubra trees followed the expected pattern and have become less sensitive to June-July water stress over time. This suggests disturbances alter forest response to changing climate by affecting the resources and climatic limitations of surviving trees. These responses will likely vary depending on species and disturbance type. Our findings emphasize the need to consider the role of disturbances to understand forest vulnerability to climate change.

Divergent patterns in yellow-cedar growth driven by anthropogenic climate change

Vanessa Comeau

Salle polyvalente (SH-4800), June 28th, 17:00 - 17:15

The global rise in temperature and associated changes in climate have led to decline of forests around the globe. A particularly severe example of this is yellow-cedar (Callitropsis nootkatensis) decline along the coast of British Columbia and Alaska, where anthropogenic climate change has led to reduced insulating snowpack, leaving yellow-cedar roots vulnerable to thaw-freeze events, resulting in freezing damage to roots and water stress during the subsequent growing season. Yellow-cedar decline is complex, with the potential for freezing injury over multiple years and damage that can accumulate over time. We used tree rings to uncover the relationship between yellow-cedar decline and climate. Declining stands included healthy trees and trees at various stages of decline, from long dead to currently declining. A traditional single site-level chronology would have masked these complex signals. Instead, we conducted a principal component analysis and identified four distinct growth patterns, with divergent responses to climate, among yellow-cedars within the same stands, across all sites. We found three distinct periods of an onset of decline (1960s, 1990s, 2000s). Yellow-cedars affected by decline were decreasing in growth and negatively associated with warmer drier winter conditions. Whereas, yellow-cedars not affected by decline were increasing in growth and positively associated with warmer growing season temperatures. The limiting factors for declining trees, warm dry winter conditions, are consistent with the hypothesis from the mainland that climate warming has led to root freezing. Our research highlights the need to consider multiple signals within a site that would be obscured by a single site-level chronology.

General Session (Dendrogeochemistry)

Speakers: Adam Csank, Daigard Ricardo Ortega Rodriguez, Oloruntobi Gideon Olugbadieye, Ignacio Hermoso de Mendoza, Paul Szejner, Javier del Hoyo Gibaja, Clay Tucker, Trevor Porter, Scott St. George

Amphitheatre (SH-2800), June 28th, 15:15 - 17:15

New annually resolved records of Neogene Arctic climate from tree rings and estuarine shells from the Canadian Arctic

Adam Csank

Amphitheatre (SH-2800), June 28th, 15:15 - 15:30

The Pliocene is often identified as an example of a past warmer world. Studies of subfossil wood from fossil forest localities in the Canadian Arctic have allowed us to explore the amplified effects of global climate change in the Arctic during the Pliocene and to provide important information on how arctic ecosystems respond to these changes. Here we report new annually resolved climate records developed from Meighen and Prince Patrick Islands, which span a time period from 6.2 Ma to 2.7 Ma (Late Miocene-Pleistocene). These records were developed using a combination of ring width and stable carbon and oxygen isotope values. We also present new information on the seasonal ranges of climate on Meighen Island established using stable isotope values from fossil shell material found in an estuarine unit directly underlying the unit containing the fossil forest to show how climate may have differed during what has been interpreted as an interglacial-glacial transition period within the Pliocene. Data from Meighen Island shells show a seasonal range of temperatures of 12 C, summer temperatures estimated from tree rings average $\sim$9 C. Preliminary results from Prince Patrick indicate temperatures $\sim$17 C. We hope to develop seasonal records from tree rings for both locations. A seasonally-resolved record of Neogene climate from the Arctic will help us to better understand climate and ecosystem changes during this period.

Climate signals in tree-ring chemical components of Cedrela fissilis Vell. growing in Brazilian Amazon

Daigard Ricardo Ortega Rodriguez

Amphitheatre (SH-2800), June 28th, 15:30 - 15:45

Chemical traits of tree-rings are sparsely used for dendroclimatic analysis. The difficulty of the laboratory process to obtain these proxies and understand their physiological relationship with meteorological variables have limited the development of dendrochemistry in tropical forests. Here, we show the first Micro X-ray fluorescence (µXRF) time series of chemical elements from Cedrela fissilis trees growing in southern Brazilian Amazon. We assess the relationships among wood traits (widths, density and chemical composition) and local and regional climate. Fourteen radii were selected from a tree-ring width chronology and dated by radiocarbon to be then X-rayed by Itrax Multiscanner at DendrOlavide. We tested the responses of annual ring width (RW), ring density (RD), and relative concentrations of Sulfur (S), Potassium (K) and Calcium (Ca) to precipitation and temperature. The mean between-trees correlation of indexed values (rbt) for RW, RD, S, K and Ca is 0.51, 0.48, 0.27, 0.31 and 0.21, respectively. The K concentrations enhances at the beginning of the wet season precipitation (November-1 to December-1, r= 0.43), RW at the middle of the wet season (February to March, r= 0.44), RD during late wet season (March to May, r= 0.30), and the S concentrations during the end of the dormancy season (August to October, r=0.46). While, Ca correlate with temperatures during the wet season (r= 0.52). We confirm the potential of long-term wood-chemistry studies based on the µXRF non-destructive technique for dendroclimatic studies in tropical regions. Grants 2020/04608-7, 2018/22914-8 and 2017/50085-3, Sao Paulo Research Foundation (FAPESP).

Tracking Water Sources and Root Water Uptake of Boreal Trees on Fluvioglacial Deposits: Perspectives from Stable Isotope

Oloruntobi Gideon Olugbadieye

Amphitheatre (SH-2800), June 28th, 15:45 - 16:00

Global warming in boreal forests is more pronounced than elsewhere, as temperature is increasing twice as fast as the rest of the planet. Low water availability in some boreal forest stands is one of the numerous consequences of increasing temperature. Sites with coarse surficial deposits where water drains fast are more vulnerable to water stress, such as sites on esker fluvioglacial deposits. The eskers of the Abitibi region of Quebec (Canada) are valuable ecosystem for wood provision and water recharge but are easily susceptible to water stress. Understanding the interplay between forests on eskers and water is crucial to develop effective conservation strategies for these ecosystems. This study aims to track the water sources and the root water uptake of the soil-plant-atmosphere continuum in the Saint-Mathieu Berry esker of the Abitibi region using stable isotopes of hydrogen and oxygen (d2H & d18O). Rainfall, snowpack, groundwater, plant xylem, and soil samples will be collected between April and November from the saturated and unsaturated zone of the esker. Plant and soil water will be extracted using cryogenic vacuum distillation, and isotopic ratios will be measured with an isotope ratio mass spectrometer. The Bayesian mixing model MixSIAR will be used to analyse the contributions of source water to the plant isotopic composition and to quantify the depth of root water uptake. We expect water uptake from the upper soil at the beginning of the growing season and a shift to deeper soil water utilization at the end of the growing season. The outcome of this study will provide a better understanding of plant-soil water interactions and of forest responses on esker to hydroclimatic changes linked to global warming.

A new snow module improves predictions of isotope-enabled MAIDENiso forest growth model

Ignacio Hermoso de Mendoza

Amphitheatre (SH-2800), June 28th, 16:00 - 16:15

The representation of snow processes in forest growth models is necessary to accurately predict the hydrological cycle in boreal ecosystems and the isotopic signature of soil water extracted by trees, photosynthates and tree-ring cellulose. Yet, most process-based models do not include a snow module, consequently their simulations may be biased in cold environments. Here, we modified the MAIDENiso model to incorporate a new snow module that simulates snow accumulation, melting and sublimation, as well as thermal exchanges driving freezing and thawing of the snow and the soil. We tested these implementations in two sites in East and West Canada for black spruce (Picea mariana (Mill.) B.S.P.) and white spruce (Picea glauca (Moench) Voss) forests, respectively. The new snow module improves the skills of the model to predict components of the hydrological cycle. The MAIDENiso model is now able to reproduce the spring discharge peak and to simulate stable oxygen isotopes in tree-ring cellulose more realistically than in the original, snow-free version of the model. The new implementation also results in simulations with a higher contribution from the source water on the oxygen isotopic composition of the simulated cellulose, leading to more accurate estimates of cellulose isotopic composition. Future work may include the development of inverse modelling with this new version of MAIDENiso to produce robust reconstructions of the hydrological cycle and isotope processes in cold environments.

Long-term drought effects on semi-arid forests influenced tree capacity to respond to abrupt seasonal changes

Paul Szejner

Amphitheatre (SH-2800), June 28th, 16:15 - 16:30

The ongoing North American megadrought has persisted since the year 2000, and has been characterized by anomalously low amounts of winter and summer precipitation. The climate systems providing these seasonal precipitation regimes are distinct in their origins but overlapping in their geographic ranges. However, our understanding is still incomplete in how alternation in water resources influences forest growth and physiology during extreme and persistent drought, including whether replete water from one seasonal source might rescue trees from drought in a different season. Here, we examined how winter versus summer precipitation has influenced tree productivity and intrinsic water-use efficiency since 1900 in five forests in the fringe of the North American monsoon region, with a particular focus on shifts in patterns of water use since the onset of the current two-decade-long megadrought. We addressed the hypothesis that this unusual type of sustained decadal-scale drought has systematically altered patterns of winter versus summer precipitation use, and disrupted physiological mechanisms of drought resilience that have led to overall declines in forest productivity.

Dendroprovenancing instream wood at the watershed scale

Javier del Hoyo Gibaja

Amphitheatre (SH-2800), June 28th, 16:30 - 16:45

Dendroprovenance is a discipline usually linked to dendroacheology or wood commercialization; however, other purposes as inferring the origin of wood in rivers (i.e., instream large wood, LW) are often overlooked. LW in fluvial ecosystems enhances its geomorphology and biodiversity, but also increases potential risk during floods. Thus, knowledge about its source is crucial for understanding LW dynamics and optimizing river and riparian forest management.

This project aims at developing a fingerprinting technique to decipher LW origin in mid-size river catchments (i.e., 1000 – 5000 km2). So far, we tested D/H and 18O/16O stable isotopes coming from the water molecule. They show spatial variations due to fractionation during evaporation-precipitation processes. When a tree takes up water, stores a specific isotopic signal in the cellulose. Since this signal is linked to a location, it may be used to trace LW's provenance once it has been recruited and transported through the river network.

Our study area is a 50 km reach of the Rhone river, between the Lake Geneva and the Genissiat dam, where all incoming wood material is retained.

Initial results showed significant differences between the two main wood supply areas in the basin, the Arve and the Valserine tributaries; these distinctions were clearer in the most recent tree rings.

Finally, we will analyse other tracers related to geology (i.e., minor and trace elements), and combine them with the isotopic ratios in a multivariate analysis to determine more precisely the origin of the wood. Thereby, we will have developed a new dendroprovenance method that can be extrapolated to other fields, stepping forward in the application of our knowledge about tree rings.

Dendrochronological Evidence of Extreme Events on the Gulf of Mexico Coast

Clay Tucker

Amphitheatre (SH-2800), June 28th, 16:45 - 17:00

Drought, flooding, and hurricane activity disrupt the human and natural landscape throughout the southeastern United States. Instrumental records through the past century suggest that the patterns of these extreme events are changing through time, especially in relation to rising global temperatures. However, instrumental records before the industrial revolution are rare, thus proxy records like tree rings are useful for comparing climatological conditions before massive human modification of the atmosphere. Tree-ring records are also useful as indicators of change to the natural landscape. The research in this presentation demonstrates three tree-ring proxy methods that can be used to extend long-term records of extreme events into the past: tree-ring width, wood anatomy, and chemical composition. These methods indicate that (1) long-term drought is present in tree-ring streamflow reconstructions, (2) intense flooding causes marked differences in wood anatomy in a single year of growth, and (3) hurricane activity, though nuanced, affects both chemical and physical processes of wood formation. As researchers continue to use these methods on old-growth trees, long-term event-based climatologies can describe millennial-length changes in the environment of the southeastern U.S.

General Session (Dendroclimatology, PT4)

Speakers: Inga K. Homfeld, Rob Wilson, Justin Maxwell, Frederick Reinig, Philippa Higgins, Valérie Daux, Matthew Therrell, Stockton Maxwell, Grant Harley

Classroom (SH-3420), June 28th, 15:15 - 17:15

Freshet- and drought-season runoff reconstructions for the Fraser Basin Headwaters, British Columbia, Canada

Inga K. Homfeld

Classroom (SH-3420), June 28th, 15:15 - 15:30

Floods and droughts have recently worsened in the Fraser River Basin (FRB), British Columbia, causing significant impacts to western Canadian economy, ecosystems, and societal wellbeing, as well as the costliest natural disaster in the province's history in 2021. These extreme events present a major management challenge since the FRB is susceptible to unregulated spring flood and summer drought events, even in the same year. Meanwhile observational streamflow datasets are both short and potentially forced by anthropogenic warming, providing an incomplete record of long-term natural hydrological variability. Here, we present the first multi-century, seasonally-resolved paired freshet and drought reconstructions for the Fraser Basin Headwaters, the primary driver of overall FRB discharge. By independently reconstructing spring freshet- and summer drought-season runoff, we overcome methodological limitations that precluded prior attempts to reconstruct total water-year runoff in this basin. The reconstructions more than double the length of existing hydrologic datasets, and are used to analyze the magnitudes, durations, and statistical probabilities of anomalously high and low runoff of the past 140 years. We find that high freshet-season flows have intensified, enhancing the risk of flooding in the event of coeval extreme precipitation and that the frequency and temporal clustering of both high freshet and low drought-season runoff has intensified in recent decades. Our new datasets suggest existing hydrologic data underestimate past and future extreme events, and signal managers and stakeholders should take more conservative approaches in adapting to future FRB conditions under climate change.

500 years of past temperatures derived using Blue Intensity from Araucaria araucana in Northern Patagonia, Argentina

Rob Wilson

Classroom (SH-3420), June 28th, 15:30 - 15:45

Ring-width (RW) and Blue Intensity (BI) parameters (earlywood - EWB, inverted latewood – LWBinv, and delta - DB) were measured from samples of Araucaria araucana from six sites in northern Patagonia, Argentina. The distance between the most southerly and northerly sites is ca. 130 kms. Despite a much weaker between-tree signal for the BI parameters than RW, principal component analysis identifies a much stronger regional between-site signal for the BI parameters. Split period correlation response function analysis (1901-1958 / 1959-2017) of the tree-ring parameters against monthly temperatures, precipitation and PDSI (CRUTS-4) shows an insignificant or unstable coherence with hydroclimate, but a strong stable response between DB and summer mean temperatures. LWBinv also shows a similar temperature response but it is slightly weaker for the earlier period (1901-1958). Regional composite averaging and principal component regression experiments lead to similar reconstructions of past December-March mean temperatures, dominated by the DB parameter, that explain 41-43% of the temperatures. Despite these encouraging results, a weakening in the calibrated signal in recent decades is noted. The reconstruction variants indicate a significant regional ca. 1 oC warming of summer temperatures since the late-19th century and distinct cold years which are coincident with major volcanic eruptions (e.g. 1729, 1815).

Recent increases in tropical cyclone precipitation extremes over the US east coast

Justin Maxwell

Classroom (SH-3420), June 28th, 15:45 - 16:00

The impacts of inland flooding caused by tropical cyclones (TCs), including loss of life, infrastructure disruption, and alteration of natural landscapes, have increased over recent decades. While these impacts are well documented, changes in TC precipitation extremes—the proximate cause of such inland flooding—have been more difficult to detect. Here, we present a latewood tree-ring–based record of seasonal (June 1 through October 15) TC precipitation sums (STCP) from the region in North America that receives the most STCP: coastal North and South Carolina. Our 319-y-long STCP reconstruction reveals that STCP extremes (=0.95 quantile) have increased by 2 to 4 mm/decade since 1700 CE, with most of the increase occurring in the last 60 y. Consistent with the hypothesis that TCs are moving slower under anthropogenic climate change, we show that seasonal STCP along the US East Coast are positively related to seasonal average TC duration and TC translation speed.

Subfossil trees re-date the Laacher See eruption to 13,006 BP and synchronize the Younger Dryas

Frederick Reinig

Classroom (SH-3420), June 28th, 16:00 - 16:15

The Laacher See Eruption (LSE) ranks among Europe's largest Upper Pleistocene volcanic events. Although its tephra deposits represent an important isochron for the synchronization of proxy archives at the Late Glacial to early Holocene transition, uncertainty in the eruption age has prevailed. Combined analysis of high-precision ring width and radiocarbon measurements from individual rings of trees that were killed during volcanic eruptions and buried by their deposits can provide eruption dates with annual and even sub-annual resolution. Here, we present dendrochronological and radiocarbon measurements of subfossil trees buried by pyroclastic deposits that firmly date the LSE to 13,006 ± 9 cal BP, more than a century earlier than hitherto accepted. The revised age of the LSE, now the oldest volcanic eruption worldwide dated with such precision, necessarily shifts the chronology of European varved lakes relative to the Greenland ice core record, thereby dating the onset of the Younger Dryas at 12,807 ± 12 cal BP, around 130 years earlier than thought. Our results synchronize the Younger Dryas onset across the North Atlantic-European sector, preclude a direct link between the LSE and Greenland Stadial-1 cooling, and suggest a large-scale common mechanism of a weakened Atlantic Meridional Overturning Circulation under warming conditions.

Can we identify volcanic signals in Southern Hemisphere tree rings?

Philippa Higgins

Classroom (SH-3420), June 28th, 16:15 - 16:30

”Little is known about the impact of volcanoes on trees from the Southern Hemisphere. In this study, we investigated whether volcanic signals could be identified in ring widths from eight dendrochronological species from New Zealand, using superposed epoch analysis. We found that most species are good recorders of volcanic dimming and that the magnitude and persistence of the post-event response can be broadly linked to plant life history traits - whether the species responds as a ’stress tolerator’ or a ’fast responder’ to changes in climate conditions. Across species, we founds that site-based factors, particularly altitude and exposure to prevailing conditions, are more important determinants of the strength of the volcanic response than the species. We then investigated whether chronology selection impacts the magnitude of post-volcanic cooling in tree-ring based temperature reconstructions by developing two new multi-species reconstructions of New Zealand summer (December-February) temperature using principal components regression. Both reconstructions showed temperature anomalies remarkably consistent with studies based on instrumental temperature, and with the ensemble mean response of climate models, demonstrating that New Zealand ring widths are reliable indicators of regional volcanic climate response. However, we also found that volcanic response is complex, with positive, negative, and neutral responses identified - sometimes within the same species group. Species-wide composites thus tend to underestimate the volcanic response. The has important implications for the development of future tree ring and multi-proxy temperature reconstructions from the Southern Hemisphere.”

Isotope-inferred temperature variations in Northern Patagonia are asynchronous with global records over the last 1000-y

Valérie Daux

Classroom (SH-3420), June 28th, 16:30 - 16:45

The current climate warming is unique in terms of its ubiquity and synchrony on a global scale. Over the last millennium, pre-industrial periods with warmer and colder temperatures occurred at different times in different locations around the globe (Neukom et al., 2019). Long-term temperature reconstructions in the Southern Hemisphere remain sparse and not always consistent among them (Lara et al., 2020). Therefore, to understand the temporal and spatial patterns of global-scale temperature variations, reconstructions are still needed in this part of the world.

Here, we present an annually resolved, a 1025-year long reconstruction of summer temperature in Northern Patagonia. It was build using the d13C of the tree-rings from 6 Fitzroya cupressoides from Rio Alerce, northern Patagonia (41.19S, 71.77W). All trees cover the whole period.

Our d13C chronology shows that Patagonia underwent cold phases during 1100-1350 and 1650-1750, and warm phases during 1400-1650 and since 1900. These temperature variations are not consistent with the putative Medieval Climate Anomaly and Little ice Age, which occurred roughly in 800-1200 and 1300-1850 in Europe and North America. Surprisingly, the d13C-derived temperature pattern does not match with the one reconstructed from tree-ring width from the same species. Over the last century, the d13C variations are consistent with observed Pacific Decadal Oscillation and Antarctic Oscillation fingerprints.

Tree-ring reconstructions of streamflow variability for Southeastern U.S. Interstate Rivers

Matthew Therrell

Classroom (SH-3420), June 28th, 16:45 - 17:00

We report on research to develop quantitative, annually resolved, multi-century, tree-ring reconstructions of streamflow for 12 interstate river systems in eight states (Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Virginia) in the South Atlantic Gulf Basin (AGB) of the southeastern United States.

We used a nested principal components regression method to develop annually resolved tree-ring reconstructions of warm-season (March-October streamflow for the 12 interstate rivers and select tributaries, for the past ∼300-1,000 years, in the AGB. These reconstructions explain between 30 and ∼70% of the instrumental streamflow variance at multiple instrumental gages. Our reconstructions demonstrate that recent multi-year average flows (∼2000 to present) were in many cases among the lowest in the ∼1,000-year record, and although consumptive withdrawals may exacerbate low flow conditions, observed regional precipitation and streamflow from unimpaired gages display substantially similar decadal declines to those shown in the tree-ring reconstructions.

This research will provides insight into not only the long-term variability of streamflow, but also sheds light on the associated physical, social, economic and ecological impacts this variability has on coastal watersheds in the AGB and SE U.S. Improved understanding of streamflow variability will directly benefit the development of water policy in the SE, by informing a variety of socially and economically relevant areas related to water withdrawals, streamflow variability, and drought and flood mitigation.

Persistent and cumulative impacts of drought on forest growth: a Douglas fir case study

Andria Dawson

Classroom (SH-3420), June 28th, 17:00 - 17:15

Circulation models forecast changes in global temperature and precipitation that will likely alter forest function. North America is expected to experience increases in intensity and frequency of hot days and nights, and is already experiencing severe and frequent drought and forest fires. Current forest dieback has been attributed to climate change, however forest resilience to climate variability is not well understood. Tree ring records can be used to assess this resilience. In particular, trees exhibit ecological memory: delayed, persistent, and cumulative responses to disturbances. This is attributed to physiological feedbacks, which exacerbate disturbance impacts. Quantifying ecological memory will improve insight about tree growth response to disturbance. This is important for forecasting growth under future climate scenarios; the impact of frequent and severe droughts will likely be cumulative and persistent.

North American Douglas fir is drought tolerant, and in its distribution covers a large latitudinal gradient in North America. It is an ideal candidate for understanding impacts of drought. Previous work shows that Douglas fir trees in the southern range exhibit greater drought tolerance than in the northern range, suggesting adaptation to drought consistent with the latitudinal moisture index gradient. Ecological memory to drought events has not been quantified. We quantify both the ecological memory of Douglas fir to drought using tree ring records from the International Tree Ring Data Bank, and relevant climate data. This work advances understanding of impacts of disturbance on tree growth, improving predictions of forest function.

June 29th

Exact Dating of the First Europeans in the Americas (Keynote presentation)

Margot Kuitems, M.W. Dee

Amphitheatre (SH-2800), June 29th, 08:45 - 09:15

Dendrochronology is considered one the most precise of all the scientific dating techniques. However, it requires long sequences of tree rings and a master record for both the species and region in question. At the University of Groningen, we have been pioneering a new approach to dating that combines the precision of dendrochronology with the versatility of radiocarbon dating. It relies on the detection of spikes in the annual radiocarbon record, thought to be the result of enormous solar storms. Several such spikes have already been identified in dendrochronological archives around the world. Thus, by identifying one in a sample of unknown age, it is possible to date the sample to the exact year. The method theoretically only requires a handful of growth rings, and it can be applied to all annually growing species. The team at Groningen recently employed this technique to date the earliest evidence for Europeans in the Americas. Three samples were obtained from the Norse layers at L'Anse aux Meadows, Canada, all of which exhibited cut-marks made by metal blades, a material not manufactured by the local indigenous people. In each case, the 993 CE spike was found 28 growth rings from the waney edge, implying the trees were cut down in 1021 CE. Here, the likelihood of driftwood can almost be completely discounted given the objectives of the Norse voyagers, and the very low probability of obtaining three old wood samples with exactly the same final growth year. However, our date does not necessarily represent the first or last year the Norse were in the Americas, only one specific year in which they were active on the continent. It is expected that this method will allow many other chronological questions to be resolved.

Symposium 2. Common garden experiments to evaluate tree adaptation in a changing climate

Moderators: Claire Depardieu, Steve Chhin, Philippe Rozenberg, Jodi Axelson, Etienne Robert

Speakers: Claire Depardieu, Martin Girardin, Steve Chhin, Philippe Rozenberg

Salle polyvalente (SH-4800), June 29th, 09:20 - 10:35

Current and projected changes in climate are estimated to be from 10 to 100 times faster than the natural adaptive capacity of trees whose generation times are long. As extreme climatic events are becoming more frequent and exert a strong selection pressure on tree populations, there is an urgent need to better characterize the genetic variability involved in the response of trees to climate. There is currently a lack of knowledge on the role of genetic variability in tolerance to climatic variations and on population evolution in trees. This context advocates the use of multidisciplinary approaches and innovative tools to measure traits that reflect how and when climate exerts selective constraints on trees. The concurrent analysis of tree-ring traits derived m from dendroecology, wood anatomy, and genotypes from provenance tests allows the quantification of the genetic variability associated with traits important for climate adaptation, within and between populations planted on the same site. This symposium aims to showcase the latest work on the development and applications of tree rings and genomics from provenance testing under common garden experiments. In particular, we will show that the development and implementation of interdisciplinary projects is the key to quickly and effectively preparing tree species for future climate. The studies presented at this symposium may include those that assess genetic differentiation, climate sensitivity across populations, support land use planning efforts, identify adequate seed sources for reforestation, and increase forest performance and value under future climatic constraints.

Development of a universal response function to integrate climatic and genetic effects on diameter growth of eastern white pine

Steve Chhin

Salle polyvalente (SH-4800), June 29th, 09:20 - 09:35

The main objective of this study was to develop a universal response function to integrate climatic and genetic effects on the diameter growth of 13 eastern white pine (Pinus strobus L.) provenances planted at seven test sites throughout the part of the species' native distribution in eastern North America. The test sites (i.e., Wabeno, Wisconsin, USA; Manistique, Michigan, USA; Pine River, Michigan, USA; Newaygo, Michigan, USA; Turkey Point, Ontario, Canada; Ganaraska, Ontario, Canada; and Orono, Maine, USA) examined in this study were part of a range-wide white pine provenance trial established in the early 1960s in the eastern United States and Canada. Universal response functions of white pine diameter growth were developed that considers the climatic conditions of the trial site location and the seed source locations. The universal response function for white pine diameter growth that was fully cumulative to the time of sampling indicated that it was affected both by trial site and seed source temperature and precipitation. Additional universal response functions will be developed for each annual year increment of diameter growth before the main inventory to examine the temporal stability of the universal response functions. The best universal response function will then be used to project future diameter growth under different climate change scenarios based on different Representative Concentration Pathways (RCP) developed by the Intergovernmental Panel on Climate Change (IPCC).

A dendrochronological approach to reveal climate sensitivities and productivity of Douglas-fir in a long-term range-wide

Jodi Axelson

Salle polyvalente (SH-4800), June 29th, 09:35 - 09:50

In the 1970s, forest geneticists with the British Columbia Forest Service established a number of long-term provenance trials throughout the province. The Trinity Valley (TV) provenance trial was established in 1975 in the southern interior to evaluate interior Douglas-fir (Pseudotsuga menziesii var. glauca) across the species' range. TV is a factorial experiment, where 64 populations of 4 year-old Douglas-fir seedlings were planted in a randomized complete-block design with three replicate blocks at a 3 x 3 m spacing. Our study leverages this long-term provenance trial to take a dendrochronological approach to examine the following questions: 1) to what extent do different populations differ in their climatic tolerances? 2) what trade-offs exist between population productivity and resilience to extreme events such as droughts? and 3) what will be the productivity of the populations under future climates? Of the initial 64 planted populations, 51 having sufficient survival were identified. Of these, 20 (CA=2, OR=2, WA=1, BC=15) were selected to sample the provenance climate space as widely as possible, resulting in populations from mean annual temperature ranging from 1.5 to 11.5 °C and mean annual precipitation from 391 mm to 2409 mm. Increment cores were collected at breast height in each replicate for a total of 15 trees/population. Using total, and latewood ring width, we will 1) evaluate moisture sensitivity of each population under current and future projected climate; 2) quantify the trade-off of diameter growth with resilience and resistance to drought events, particularly more recent droughts in 2003 and 2017; and 3) predict the future productivity of these populations at the test site.

The evolutionary value of tree-ring plasticity in Douglas-fir

Philippe Rozenberg

Salle polyvalente (SH-4800), June 29th, 09:50 - 10:05

Climate change threatens forest trees. Their ability to resist depends on their potential to adapt. Phenotypic plasticity, i.e. the potential for individual adaptation, is a rapid mechanism that can allow trees to adjust to new climatic conditions. Tree-rings allow retrospective estimation of phenotypic plasticity of wood formation to climate in forest trees. In this study we show how to estimate linear reaction norms of annual ring variables as a function of climate. We use the slope of the reaction norms as an estimate of phenotypic plasticity of Douglas-fir. We then estimate the variation in phenotypic plasticity between provenances, and relate it to past climate variation in the natural range. We show that there is an individual potential to adapt to climate change in Douglas-fir, that this potential is variable and genetically determined and is related with local adaptation to drought in the species natural range. As a conclusion we show that there is a potential for evolutionary adaptation of phenotypic plasticity of traits related with resistance to drought in Douglas-fir. Whether this potential is enough for Douglas-fir to adapt to climate change remains an open question.

Joining dendroecology and genomic approaches to identify genes implicated in resilience to drought in the model conifer

Claire Depardieu

Salle polyvalente (SH-4800), June 29th, 10:05 - 10:20

Rapidly warming climate affects water availability for boreal conifer species, thus urging the need for assessing their adaptive capacity to better predict forest vulnerability and resilience under drier climates. In this study, we first used a dendroecological approach to determine the level of climate sensitivity of white spruce (Picea glauca [Moench] Voss) trees grown in a provenance-family common garden. We detected a clear signal of local genetic adaptation to drought, with provenances originating from drier locations showing a higher resilience than those from wetter locations. Based on those results, we further dissected the genomic features underlying white spruce adaptation to drought, by combining gene-environment associations (GEA), genotype-phenotype associations (GPA) and transcriptomics. We identified a set of 285 genes significantly associated with climatic factors or phenotypic traits, among which 110 genes were differentially expressed under drought stress in greenhouse-controlled conditions. The interlinked phenotype-genotype-environment network revealed eight high-confidence genes involved in white spruce adaptation to drought, among which four were also drought-responsive in the expression analysis. Our findings represent a significant step towards the characterization of the genomic basis of drought resilience in conifers, and provide a new opportunity to improve drought resistance of seedlings used in reforestation.

The use of common gardens and dendroecology to guide assisted gene flow in black spruce

Etienne Robert

Salle polyvalente (SH-4800), June 29th, 10:20 - 10:35

Assisted gene flow (AGF) may help facilitate tree species' adaptation to future climatic conditions. When applied to resource-producing species such as black spruce (BS, Picea mariana), AGF could contribute to maintaining forest productivity and therefore carbon sequestration. For AGF to succeed, it is important to determine how growth varies among different populations under different climates, especially for species with large distribution ranges. Existing common garden experiments represent a unique opportunity to assess and guide AGF. Using BS common garden experiments established across Canada in the seventies, the objectives of our study were to assess: 1) which black spruce population is best suited for AGF and 2) which climatic factors are the most influential in terms of growth. We achieved this by modelling the growth of black spruce using an artificial neural network trained with dendroecological and genetic data obtained from more than 2600 trees ($>$ 80 provenances) growing in four common gardens. When simulating growth until 2100 using the common gardens as planting sites and climate projections following RCP4.5, populations from the Maritimes are amongst the most productive in all gardens except Alberta. In the latter case, local provenances are the most productive. As a general trend, populations that perform the best are from the same latitude or slightly lower latitudes. Climatic variables having the most importance in these predictions were autumn evapotranspiration and autumn mean air temperature (current and previous year of growth). In conclusion, it seems that for black spruce, AGF could be more interesting for migration from maritime to continental climates rather than from south to north.

Symposium 7 (PT 1). Historical Timbers and Wooden Artifacts as Archives: New Glimpses On Trees, Ecology, and People

Moderators: Marta Domínguez-Delmás, Francien Bossema, Mukund Palat Rao, Darrin Rubino, Fusa Miyake

Speakers: Caroline Leland, Maegen Rochner, Marta Domínguez-Delmás, Neil Pederson

Amphitheatre (SH-2800), June 29th, 09:20 - 10:35

Information garnered from historical timbers and wooden artifacts (e.g. houses, barns, ships) can greatly enhance our understanding of human, ecological, and climate history, especially in regions where few old-growth forests and trees remain, tree longevity is relatively short (less than 300-400 years), and environmental conditions break down wood rather quickly, like in mesic to wet regions. Over the last decade plus, the application of tree-ring techniques on wooden archaeological material is quickly growing beyond the dating of historic structures and climate reconstructions. New advances and recent works have highlighted a range of applications, including ecological change and disturbance, human-environment interactions, and deeper questions about historical human development (e.g. trade and migration through provenancing materials). Our symposium will feature a diverse set of international scientists who work with materials and data from historical timbers and wooden artifacts in different subdisciplines including ecology, human history, and astrophysics. Speakers will cover the breadth of these studies, including the movement of wooden materials between broad regions, cultural and economic uses of wood material, shipwrecks, and new approaches in provenancing wooden pieces created by people and moved to new regions or continents. We also hope to feature a geneticist to educate us about the application of new techniques that could be applied to tree-ring research and, specifically, historical timbers and wooden artifacts.

Applications and advances in X-ray Computed Tomography (CT) for dendrochronology

Francien Bossema

Amphitheatre (SH-2800), June 29th, 09:20 - 09:35

Over the past 10 years, X-ray Computed Tomography (CT) has been increasingly applied to dendrochronological research. This technique provides 3D images of the internal structure of objects, allowing non-invasive access to tree rings in cultural heritage objects that are often inaccessible from the outside. Here, we will present the state-of-the-art of tomographic X-ray imaging for the application to dendrochronology. We will give a comprehensive overview of how X-ray computed tomography is used to answer dendrochronological questions of historical objects (panel paintings, sculptures and furniture), and will discuss the hardware and software requirements to enable dendrochronological investigation on the resulting reconstructed images. Furthermore, we will highlight the limitations for the application of X-ray CT to dendrochronological research, such as the material composition of the object, object size and image resolution. These topics will be illustrated with examples of our work, including our recent breakthrough in X-ray imaging for dendrochronology of large wooden objects, which is based on line-trajectory scanning. This method exploits the shape of the tree rings to visualise them with limited data, so that the object only needs to move sideways as opposed to a full rotation in regular CT. We will close with a discussion of future applications of X-ray imaging to cultural heritage made of wood.

The potential of tree-ring drought atlases for dating and provenancing archaeological timbers

Mukund Palat Rao

Amphitheatre (SH-2800), June 29th, 09:35 - 09:50

Humans have relied on wooden timber material for the construction of buildings, trade, ships, artifacts, and works of art for many millennia. Using dendrochronological methods, it is often possible to develop to build internally cross-dated but undated 'floating' tree-ring chronologies using this historic wooden material. However, the dynamic nature of human mobility and long-distance transport of timber can often make it difficult to accurately date and provenance wooden material. Accurate dating of historical timbers can be challenging due to matches with multiple reference chronologies for different dates, while the provenance of timbers can sometimes be difficult to determine due to wide species distribution ranges that allow for multiple sourcing locations. Here we will showcase the potential of the tree-ring drought atlas network as a novel tool to date and provenance historical timbers. Case studies will include the i. provenancing of construction timbers used in multiple 19th and 20th century buildings in New York City that were sourced from relatively distant locations ii. and the provenancing and dating of a 19th century shipwreck found in the Golfo Nuevo, Argentina. Our results suggests that tree-ring drought atlases can be a powerful tool for dendroarchaeology to both date and provenance wooden material particularly when it is possible to build a robust chronology using multiple historical timbers at a site.

Using dendrochronology to determine the production place of wooden artifacts and works of art

Marta Domínguez-Delmás

Amphitheatre (SH-2800), June 29th, 09:50 - 10:05

Dendrochronology is a well-established science used to determine the date of wood from cultural heritage objects, and often, to infer the geographic origin of the wood withing certain regions. Dendrochronologists insists that this science provides a date and provenance for the wood, not the object. However, recent research shows that it may be possible to determine the production place of works of art based on the area supplying the wood, and on inferences about wood derived from individual trees. For example, knowledge about historical timber trade gained through decades of dendrochronological research in central and northern Europe provides a clear picture of the flows of timber in different periods from specific geographic areas into the historical Low Countries (current Netherlands and Belgium). Given that some parts of the Low Countries were preferentially supplied by specific areas, it is sometimes possible to propose the

production region of unattributed works of art. Similarly, linking wooden elements from different objects to individual trees can aid in the attribution of works of art to specific workshops. Several case studies from the Low Countries and Ancient Egypt will be presented to illustrate and discuss these propositions. Such results highlight the need to continue exploring and improving methods to determine the geographic origin of the wood and to systematically publish and describe intra-/inter-tree variability to improve inferences about timber derived from the same tree. Furthermore, they represent a great contribution to the attribution of wooden artifacts and works of art to specific production centres.

Coupling tree-ring and timber species analysis to gain insights on forest harvesting and construction techniquesSy

Darrin Rubino

Amphitheatre (SH-2800), June 29th, 10:05 - 10:20

The Mid-Ohio River Valley's (USA) rich cultural fabric is preserved in the extant 19th century buildings that dot the landscape. Extensive tree-ring analysis 3has provided construction and modification dates for regional buildings (n $>$ 200) such as barns, houses, mills, churches, and various outbuildings. In addition to determining construction dates, the goals of this long-term study include identifying the various timber types used in construction, determining potential bias and causes for bias in timber species selection, and determining the source of non-native timber found in regional structures. Ultimately, we hope to gain insights into how timber resources were used and potentially how landscapes changed over time. Timber species analysis reveals extensive use of tulip poplar, white oak, beech, and ash throughout the 19th century. Less commonly encountered species include red and white elms, walnut, hickory, black gum, and sweet gum. Timbers have yielded chronologies for the region reaching back to 1436. Unexpectedly, temporal analysis of species use shows no discernable regional patterns such as a decrease in preferred species use over time. Additionally, species selection shows little to no correlation with witness tree and old-growth forest community studies. White pine and hemlock timber in regional buildings have, with mixed success, been dendroprovenanced to northwestern Pennsylvania with importation occurring from the 1820s through the 1870s along the Ohio River. Mining chronologies and coupling them with timber species analysis and historic documents may provide valuable insights into the changes experienced in regional forests and construction techniques.

Carbon-14 spikes caused by solar energetic particle events

Fusa Miyake

Amphitheatre (SH-2800), June 29th, 10:20 - 10:35

Carbon-14 (14C) is produced via a nuclear reaction between the atmosphere and cosmic rays. Although the main source of 14C is galactic cosmic rays, solar energetic particles (SEPs) also contributes in producing 14C. Extreme SEP events are considered to produce 14C spikes that considerably exceed the 14C amount produced by galactic cosmic rays. Thus far, several signatures of 14C spikes originates by extreme SEP events have been reported, such as the 774 CE, 992 CE, and ∼660 BCE events. In this presentation, the detected 14C spikes and a further survey of past SEP events will be introduced.

General Session (Dendrogeosystems)

Speakers: Scott St. George, Troy Nixon, Dave Sauchyn, Stefan Klesse, Ignacio Hermoso de Mendoza, Feng Wang

Salle polyvalente (SH-4800), June 29th, 11:00 - 12:15

Four decades of paleoflood hydrology through wood anatomy

Scott St. George

Salle polyvalente (SH-4800), June 29th, 11:00 - 11:15

Forty years ago Dr. Tom Yanosky, a research botanist with the US Geological Survey, reported that ash trees growing along the Potomac River contained rings with abnormal wood anatomy caused by flood damage. Dr. Yanosky recommended these rings — which he dubbed “flood rings” — could be used to estimate the date, seasonal timing, and (most importantly) peak stage of past floods. Since that discovery, flood rings have been identified for forested river systems in eastern France, central Canada, northwestern Quebec, and the lower Mississippi basin, and kindred anatomical signals due to riverine flooding have also been reported for tropical rivers in Bangladesh and Colombia. Flooding experiments conducted on juvenile trees have confirmed the unambiguous interpretation of these abnormal features — flood rings only form after stem flooding — but also underscore the pivotal interplay between phenology and hydrology — to be recorded, floods must happen during the period of earlywood formation. Although the oldest reported flood ring dates to BCE 3180 (in late Neolithic timbers from northwestern France), riparian forests near major population centers have often been recently clear-cut and so far it has been rare for flood-ring chronologies to go back more than a few centuries. Despite that limitation, flood-ring evidence has entered into the planning of flood-mitigation infrastructure in Canada, and as of 2019, has been formally incorporated into US government guidelines for quantitive flood risk assessments. Four decades after Dr. Yanosky’s seminal study on the Potomac, we are now positioned to deliver on his promise of a deeper appreciation of floods gleaned from abnormal tree rings.

Assessing Vulnerability of American Holly (Ilex opaca) Trees in Coastal Maritime Forests of N.Y. and N.J.

Troy Nixon

Salle polyvalente (SH-4800), June 29th, 11:15 - 11:30

Coastal maritime forests in northeastern USA are mostly fragmented and currently threatened by climate change. This study focuses on American holly (Ilex opaca) trees located in the coastal maritime forests of Sandy Hook, N.J. and Fire Island, N.Y. to better understand how vulnerable and resilient these forests are to future climate scenarios. There are few published studies that use tree-ring methods in the maritime forests of N.J. and dendrochronological research on holly species has just begun being explored. Our objectives are to evaluate the impacts of sea level rise, tropical cyclones, and saltwater inundation on northeastern coastal forests by analyzing ring damage and growth suppression patterns. We sampled living trees and retrieved cross sections from downed trees from each study site. Due to the severity of recent storms, this study has become increasingly relevant and important in creating necessary foundational research on these unique and rare forests. American holly chronologies are currently being constructed using rigorous cross-dating techniques. Early indications show a sharp decline in growth rate the year following prolonged saltwater inundation due to Superstorm Sandy in 2012. Once completed, we will compare the holly tree-ring records with site-specific meteorological data to determine the climate signal and climate variables that impact tree growth. We will also evaluate the oxygen isotopic composition of each ring in several of the older tree specimens to better understand the signature of atmospheric dynamics. Our oldest sample dates back to the late 1700's, allowing us to provide extended insights into forests' response to climate change and storm frequency in the N.Y. metropolitan region.

Proxy versus Modelled Hydrology, Saskatchewan and Athabasca River Basins

Dave Sauchyn

Salle polyvalente (SH-4800), June 29th, 11:30 - 11:45

In western Canada, internal natural variability is the dominant source of uncertainty for the climate model projection of precipitation and related variables. Tree-ring records capture this natural variability and also enable testing of the capacity of climate models to simulate significant modes of variability. We compare millennial tree-ring reconstructions of the weekly flows of the Athabasca and North Saskatchewan Rivers to weekly flows from a hydrological model forced with climatology from various runs of CMIP6 Earth System Models. Relative to the proxy streamflow time series, the climate / hydrological models have a high-frequency bias and underestimate decadal scale hydroclimatic variability. Inter-annual to decadal variability represent more of challenge for water resource management than incremental slow-onset changes in water yield resulting from the regional impacts of global climate change.

Drought legacy effects in radial tree growth are meaningful but rarely significant under heightened statistical scrutiny

Stefan Klesse

Salle polyvalente (SH-4800), June 29th, 11:45 - 12:00

”Drought legacy effects (DLE) in radial tree growth (RTG) have been extensively studied over the last decade and are found to critically influence carbon sequestration in woody biomass. However, the statistical significance of DLE depends on our definition of expected vs. unexpected growth variability, a definition that has not received sufficient scrutiny.

Here, we revisit popular DLE analyses using the ITRDB and employ a synthetic data simulation to disentangle four key factors influencing the magnitude of DLE. We show that DLE can be explained by the auto-correlation of RTG, depend on climate-growth cross-correlation, are directly proportional to the year-to-year variability of RTG, and scale with the chosen extreme event threshold. Using this simulation, we can reproduce the magnitude of observed pattern, meaning DLE cannot be distinguished from biological memory. We further find that the interpretation of DLE following isolated drought events at individual sites is challenged by high stochasticity, and show that the commonly perceived stronger DLE for conifers are a result of higher auto-correlation compared to deciduous broadleaves.

We present two pathways to improve the future assessment and interpretation of DLE: First, we provide a simulation algorithm to a posteriori account for auto-correlated residuals of the initial regression model between growth and climate, thereby retrospectively adjusting expectations for the statistical null model. The second pathway is to a priori include lagged climate parameters in the regression model. Doing so heavily reduces the magnitude of observed DLE and thus challenges us to consider the full spectrum of expected variability when evaluating drought-induced growth deviations.”

Symposium 7 (PT 2). Historical Timbers and Wooden Artifacts as Archives: New Glimpses On Trees, Ecology, and People

Moderators: Juliette Taieb, Duncan Christie, Carol Griggs, Eileen Kuhl, Greg King

Speakers: Caroline Leland, Maegen Rochner, Marta Domínguez-Delmás, Neil Pederson

Amphitheatre (SH-2800), June 29th, 11:00 - 12:15

Information garnered from historical timbers and wooden artifacts (e.g. houses, barns, ships) can greatly enhance our understanding of human, ecological, and climate history, especially in regions where few old-growth forests and trees remain, tree longevity is relatively short (less than 300-400 years), and environmental conditions break down wood rather quickly, like in mesic to wet regions Over the last decade plus, the application of tree-ring techniques on wooden archaeological material is quickly growing beyond the dating of historic structures and climate reconstructions. New advances and recent works have highlighted a range of applications, including ecological change and disturbance, human-environment interactions, and deeper questions about historical human development (e.g. trade and migration through provenancing materials). Our symposium will feature a diverse set of international scientists who work with materials and data from historical timbers and wooden artifacts in different subdisciplines including ecology, human history, and astrophysics. Speakers will cover the breadth of these studies, including the movement of wooden materials between broad regions, cultural and economic uses of wood material, shipwrecks, and new approaches in provenancing wooden pieces created by people and moved to new regions or continents. We also hope to feature a geneticist to educate us about the application of new techniques that could be applied to tree-ring research and, specifically, historical timbers and wooden artifacts.

Dating of Alaskan Neo-Inuit architectural timbers (11-13th): wiggle-matching and oxygen isotope cross-dating

Juliette Taieb

Amphitheatre (SH-2800), June 29th, 11:00 - 11:15

In Northwestern Alaska, well-preserved architectural timbers from coastal Neo-Inuit archaeological sites can be used to document the climatic variations and cultural transformations of the beginning of the 2nd millennium AD. In this treeless tundra environment, the main wood resource is driftwood from interior Alaskan forests, carried to the coast by major rivers and ocean currents. Conventional dendrochronology allowed cross-dating 68 architectural timbers out of 282 archaeological Picea glauca disks from 5 coastal Neo-Inuit sites. These disks cross-date with each other and with millennium master Kobuk River chronology (AD 974-2002, Northwest AK) and range from the 11th to 17th centuries. Among the remaining 214 undated tree-ring series, 39 cross-date with each other allowing us to build 10 ”floating” sequences of at least 2 individual series. We present our attempt to combine conventional dendrochronology, wiggle-matching technique, and dendro-isotopy (oxygen isotopes dating) to annually date these floating sequences. The wiggle-matching dating of 8 archaeological cross-sections belonging to 5 floating sequences (based on 75 radiocarbon dates) allows us to constrain as closely as possible the calendar interval of each dated disk last growth ring, which correspond to a “plateau” period of the radiocarbon calibration curve. At the same time, we are cross-dating 3 of the wiggle-matched cross-sections with our newly built oxygen sequence based on 5 of the 68 cross-dated timbers. Combining 14C and d18O approaches allows us to increase annual chronological and calendar information about Neo-Inuit sites in Northwestern Alaska and develop preliminary tree-ring referential for cross-dating other Neo-Inuit architectural wood.

Drought and Inca rituals in the summits of the Andes of Atacama

Duncan Christie

Amphitheatre (SH-2800), June 29th, 11:15 - 11:30

Fluctuations in water resources is one of the main factors modulating ecosystem dynamics, human population changes and culture in semiarid regions. One of the largest high-altitude semiarid regions of South America is the Altiplano in the Central Andes. With an elevation of 4.000 m this region has been the environment for the settlement of many communities who have inhabited the region for thousands of years. Tree-ring research has been developed in this region allowing the reconstruction of the dynamics of water resources during the last millennia. Besides, on the mountain tops of the Altiplano exists many high-altitude pre-Columbian sanctuaries which are framed within the remarkable relationship between mountains and water, which was a fundamental feature on which local cultures based their complex religious beliefs related to mountains as sources of fertility. The existence of archaeological wood on this sites utilized as offerings and/or firewood, and the possibility to develop regional tree-ring chronologies in the area allow the tree-ring dating and the development of precipitation reconstructions. Here we present a new precipitation reconstruction for the Andes of Atacama and the dating of three high-altitude sanctuaries located on mountain tops at 6,000 m asl utilizing tree-ring widths and 14C wiggle-matching of tree-ring sequences. For the last, we utilize a recently developed regional 14C curve from the Altiplano region. The dating and occupancy of these water-related sanctuaries will contribute to a better understanding of the relationship between humans' religious beliefs and the semiarid environment that inhabited.

Dendrochronology and ecology of central-western New York, 1448-1902

Carol Griggs

Amphitheatre (SH-2800), June 29th, 11:30 - 11:45

Dendrochronology in eastern New York State, USA, was established from timbers used in European settlement and development of the Hudson and Mohawk River Valleys starting in the mid-17th century. The abundant primary forests were the source, and timbers were used locally and exported via the rivers. West of the Hudson River Valley, successful settlement was more precarious from human conflict until the late 18th - early 19th century, and the oldest dated buildings are located along major waterways and the canals developed in the early 1800s. Timber trade from the Adirondack Mountains was also established in the early 1800s, and railroads were built across the state in the mid-1800s. The timber trade and agricultural development took out the primary forests by ca. 1850 and timber import became a major factor. These processes radically altered the ecology and regional climate across the state, especially in the early 1800s. Here we offer three historic tree-ring chronologies of oak (Quercus sp. L.), 1448-1872, eastern white pine (Pinus strobus L.) 1536-1852, and eastern hemlock (Tsuga canadensis (L.) Carr), 1506-1902, from over 30 structures in west-central New York built in the late 18th to early 20th century. Comparison of the site chronologies show significant changes in climate over time, especially from rapid deforestation and the changing landscape. Similarities in chronologies from buildings outside of the region indicate an early and rapid expansion of export, and the presence of timbers of non-native species illustrate a necessary import starting around 1850. These findings are used to assess sources, the timber trade, and changes in the ecology of west-central New York over time.

Dendroprovenancing with machine learning – a new approach to reveal the original growth site of historical timber

Eileen Kuhl

Amphitheatre (SH-2800), June 29th, 11:45 - 12:00

Dendroclimatological reconstructions are often extended into the past with wood from historical buildings. However, the varying, though frequently unknown origin of timbers not only affects the growth rate but also the climate response of individual tree-ring samples. We tested nine supervised machine learning algorithms for the geographical provenancing of 99 historical tree-ring samples. We sampled 143 living larch (Larix decidua Mill) trees at seven sites along an elevational gradient from 1400-2200 m asl in the European Alps. We measured tree-ring width and density to parametrise state-of-the-art classification models. A tree-ring width model (RWM_gen), a density model (DM_gen), and two larch-specific models including the larch budmoth influence (RWM_sp, DM_sp) were trained. From the nine tested machine learning algorithms, Extreme Gradient Boosting showed the best performance. The density-based DM models work better than the ring width models with the DM_sp reaching the highest score. The performance metrics of each elevational class reveal that the DM_sp also executes best within classes and especially high, temperature sensitive classes show very high accuracy. The application of the DM_sp enabled us to sort the historical series with high confidence to elevations. The most important advantage of our approach using density-based machine learning models is that a common period between living and historical data is not required for provenancing and thus will help to improve the reliability of millennium-length climate reconstructions.

Reconstruction of Precipitation & Lake Levels in the UNESCO Beaver Hills Biosphere

Greg King

Amphitheatre (SH-2800), June 29th, 12:00 - 12:15

Over the last 140 years, lakes in the UNESCO Beaver Hills Biosphere, located east of Edmonton, Alberta, have experienced significant water level changes. At Cooking Lake, lake levels are estimated to be 9 feet lower than the historic high. These changes have been attributed to declines in precipitation, although water levels in Cooking Lake were not consistently measured until after 1956, with few measurements in the first half of the 20th century and no information on water levels prior to 1900. Annual growth rings from white spruce have been used to reconstruct water levels elsewhere in Alberta and could provide a proxy for years with no measurements. Forests around Cooking Lake experienced a succession of fires from 1895 to 1930, destroying most of the older trees in the area. However, local histories revealed several former island locations that were spared from these fires and retained older white spruce. We also located several log cabins built between 100 and 125 years ago, believed to be constructed from local spruce. Using a combination of living (n = 30) and archeological samples (n = 41), we built a chronology that extends from A.D. 1724-2020. Using water level records of Cooking Lake along with regional temperature and precipitation data, we aim to reconstruct environmental signals inferred from the annual tree-ring records. Initial results suggest that there is an acceptable strength for reconstruction of precipitation back to A.D. 1808. We will also present updated information on connections between precipitation and lake water levels. We strengthen this reconstruction by examining local history accounts to relate significant water level fluctuations with our chronology.

June 30th

A tipping point for tropical tree longevity (Keynote presentation)

Giuliano Locosselli

Amphitheatre (SH-2800), June 30th, 08:45 - 09:15

How old are tropical trees? This fundamental question has long driven the curiosity of laymen and scientists. But only recently, a great number of studies conducted by many brave dendrochronologists resulted in a significant tree-ring-based knowledge that allows us to start accurately estimating tree ages across the globe. As science goes, not only knowing the longevity of tropical trees is essential to understanding forest dynamics and its role in biogeochemical cycles, but one must also know how it compares to the extratropics and what drives the variability in tropical tree longevity and growth rate. Our literature survey combined with the ITRDB datasets show that the longevity and growth rate of trees covary negatively across world biomes, and that tropical biomes hold trees that are on average half of the age of the trees outside the tropics while growing twice as fast. Within the tropics, the longevity of trees is higher in the wet than in the dry biomes challenging the common sense that trees tend to be older under water limiting conditions as long observed in temperate forests. Our Bayesian model shows that not only does longevity of tropical trees seems to be limited in the driest sites, but it is strongly limited by temperature above an estimated threshold of 25.4°C. About 37% of the whole tropics is already under the influence of temperatures above this threshold, and this area is expected to increase to 60% by 2050. These independent effects of water availability and temperature on tropical tree longevity are in accordance with observed changes in the dynamics of forests and carbon pools in the Amazon and Western Africa impacting the role of tropical vegetation in the carbon cycle.

Short fire intervals and long tree ring chronologies in the eastern Canadian taiga (Keynote presentation)

Dominique Arseneault

Amphitheatre (SH-2800), June 30th, 13:30 - 14:00

A gap of millennial tree-ring data suitable for dendroclimatology has long been evident in the North American boreal forest. In my talk, I will describe the adaptive approach we have developed to build and improve a data network for millennial dendroclimatology in the eastern Canadian taiga. Recurrence of stand replacing wildfires is the most important constrain to the elaboration of long tree ring chronologies, which can only be developed away from regions of high fire activity. The most interesting sites comprise an old-growth lakeshore forest stand generating a constant flux of tree remains to a wind-protected lake with thick sediments. Sampling thousands of living trees and subfossil stems in those specific conditions has allowed us to develop a homogeneous and well-replicated data network. Based on knowledge of regional forest dynamics, we circumvented significant problems that influence chronology development and progressively refined our interpretations of past climate variability. For the future, we plan to increase the replication of the data network for the first millennium CE, explore new climate proxies and use our master chronology as a dating tool to reconstruct the southward expansion of tundra vegetation at the northern edge of the taiga during the Common Era

General Session (Proxies and models)

Speakers: Jan Esper, Feng Wang, Jeanne Rezsöhazy, Max Torbenson, Arian Correa-Diaz, Guillermo Gea-Izquierdo, Camille Lepage

Salle polyvalente (SH-4800), June 30th, 09:20 - 10:50

IPCC Paleoclimate Streamlining: An alternative Perspective on Common Era Temperature Variability

Jan Esper

Salle polyvalente (SH-4800), June 30th, 09:20 - 09:35

The assessment of pre-instrumental climate variability during the Common Era (CE) has been a key element of IPCC reports and was recently emphasized by showing a single temperature reconstruction as the first figure in the 2021 Summary for Policymakers (SPM). This reconstruction is derived from dozens of proxy records including tree-rings, corals, ice cores and sediments, and displays the course of global temperatures over the past 2000 years. Show casing a single study for paleoclimate contextual evidence of recent warming in the SPM is not unprecedented. This was already done in 2001, when the now iconic Hockey Stick reconstruction was the main teaser of this important document. In 2001, however, all other reconstructions that were state-of-the-art at the time were also included in the full IPCC report. This is now different as none of the various recently published reconstructions is illustrated in the latest report that in its current form extends over some 3500 pages. Streamlining the 2021 SPM and report to only one reconstruction affects the conclusions that can be drawn from state-of-the-art paleoclimate research. We here show all recently published CE temperature reconstructions, discuss differences in reconstructed temperature variance and trends, and conclude that the reduced reconstructed variability highlighted in the 2021 SPM for the first millennium might substantially change when more high-resolution proxy series covering the entire CE become available.

Filling the North American gap with robust and temperature-sensitive millennial tree ring density data

Feng Wang

Salle polyvalente (SH-4800), June 30th, 09:35 - 09:50

”Maximum latewood density (MXD) is the most sensitive proxy for reconstructing temperature variations over past centuries to millennia. However, the development of long MXD chronologies has lagged far behind that of ring width chronologies, especially in North America. Among a handful of millennial MXD records across the northern hemisphere, only a few are from North American sites. In this study, we fill this data gap by developing a millennial MXD data network from an unprecedented number of measurements from 1,249 black spruce (Picea mariana (Mill.) B.S.P.) trees in the eastern Canadian boreal forest. This data network has been combined with an existing MXD dataset (45 trees) as well with published ring width, ¡U+F064¿18O, and ¡U+F064¿13C chronologies via a Bayesian framework to reconstruct growing-season temperatures over the last millennium. The resulting summer temperature reconstruction explains a high (60%) fraction of temperature variations with a large spatial domain covering the northeastern half of North America. Our reconstruction emphasizes well-defined Medieval Climate Anomaly, and Little Ice Age, followed by an unprecedented warming trend during the last century. Our results also highlight the important role of volcanic forcing in the regional climate system. Due to its high replication, climate sensitivity, and strategic provenance, our MXD dataset is an important data source that will complement the next generation of large-scale millennial temperature reconstructions and will benchmark climate simulations.”

Using a process-based dendroclimatic model in a data assimilation framework: a test case in the Southern Hemisphere

Jeanne Rezsöhazy

Salle polyvalente (SH-4800), June 30th, 09:50 - 10:05

Tree-ring widths represent the most commonly used proxy to reconstruct the climate of the last millennium at high resolution, thanks to their large-scale availability. The approach often relies on a relationship between tree-ring width series and climate estimated on the basis of a linear regression. The underlying linearity and stationarity assumptions may be inadequate. Dendroclimatic process-based models, such as MAIDEN, may be able to overcome some of the limitations of the statistical approach. MAIDEN is an ecophysiological model that simulates tree-ring growth starting from surface air temperature, precipitation and CO2 concentration daily inputs. In this study, we successfully include the MAIDEN model into a data assimilation procedure as a proxy system model to robustly compare the outputs of an Earth system model with tree-ring width observations and provide a spatially-gridded reconstruction of continental temperature, precipitation and winds in the mid to high latitudes of the Southern Hemisphere over the past centuries. More specifically, we evaluate the benefits of using process-based tree-growth models such as MAIDEN for reconstructing past climate with data assimilation compared to the commonly used linear regression. The comparison of the reconstructions with instrumental data indicates an equivalent skill of both the regression- and process-based proxy system models in the data assimilation framework. Nevertheless, important steps have been made to demonstrate that using a process-based model like MAIDEN as a proxy system model is a promising way to improve the large-scale climate reconstructions with data assimilation.

The use of hydrological model output as targets in tree ring-based streamflow reconstructions

Max Torbenson

Salle polyvalente (SH-4800), June 30th, 10:05 - 10:20

Tree-ring records have been used extensively to reconstruct past streamflow variability. Annually resolved estimates for several centuries prior to observations, and in some cases millennia, have been produced from dendroclimatic proxies. However, despite an often strong hydroclimatic signal embedded in the rings, some factors limit the skill of such reconstructions, including human interference with the hydrological cycle. We examine the relationship between local output from a Precipitation-Runoff Modeling System and tree-ring chronologies from six U.S. regions of varying climate and ecology. Strong positive correlations between tree growth and capillary zone moisture variability are recorded. When compared to correlations with precipitation, the tree ring-capillary zone relationship is overall stronger with a more coherent seasonal focus within the respective regions. The capillary zone moisture also appears to capture spatial variability at a finer resolution than gridded soil moisture products. This difference could isolate uncertainties during model calibration but also help identify localities from which new proxies containing independent and unexplained variance may be collected. Although the results are not equal across regions, we suggest that there are several potential advantages to be gained from using hydrological model parameters as the target in dendroclimatic reconstruction exercises.

The greening effect described by remote sensing data was not coupled with phenological and tree growth rates in Mexicco

Arian Correa-Diaz

Salle polyvalente (SH-4800), June 30th, 10:20 - 10:35

In temperature-limited ecosystems such as high-elevation forests, rising temperatures and increasing carbon dioxide can result in a greening effect, and changes in the phenology and tree growth rates of the forests. We assessed the long-term trend dynamics (greenness and land surface phenology) using the Normalized Difference Vegetation Index (NDVI) and compared them with data from an existing dendrochronological network that came from eight protected mountains in the Trans-Mexican Volcanic Belt in central Mexico during the last 20 yr (2000–2019). We found three main NDVI clusters reflecting a longitudinal geographical pattern (Pacific, Center, and the Gulf of Mexico). A notable greening effect at the canopy level was seen for all mountains (up to 23.8% increase concerning the year 2000). Nevertheless, the NDVI trends were not uniform, and they differed along an elevation gradient with the highest increases at the bottom. Minimum temperature and soil moisture positively impacted the NDVI time series and explained up to 87% of the variance, while maximum temperature negatively affected. Regarding phenological metrics, the start, and end of the growing season were the day of the year 148 ± 20 (late-May) and 9 ± 12 (early-January), respectively, with an average length of 226 ± 33 d, differing from annual tree-ring formation studies. Finally, our investigation revealed that the common greening effect was not parallel with radial growth trends, except for the wettest site from the Gulf of Mexico cluster, and partially related to the forest management strategies. Further modelling of regional phenology coupled with more intensive tree-ring monitoring is needed under a global warming outlook.

Symposium 8 (PT 1). Dendrochronological progress in tropical Americas

Moderators: Daigard Ricardo Ortega Rodriguez, Arturo Pacheco Solana, Milena Veiga, Emanuele Ziaco, Ginette Ticse, Mariano Morales, Clara Rodriguez Morata, Milagros Rodriguez-Caton

Speakers: Laia Andreu-Hayles, María Eugenia Ferrero, Giuliano Locosselli, Kevin Anchukaitis, Clara Rodriguez Morata

Amphitheatre (SH-2800), June 30th, 09:20 - 10:50

Dendrochronological archives in the tropics of the Americas have been under-studied for a long time. Some of the challenges include the Identification of tree-ring boundaries in certain tree species, absence of winter dormancy associated to low temperatures in most of the cases, and logistic difficulties of fieldwork in remote sites. However, part of the slow progress is also related to the fact that historically much less resources have been invested in dendrochronological research in the tropics than in other regions of the world. Nevertheless, more studies have been published over the last decade leading to important achievements such as the expansion of tree-ring networks due to an increase in the number of available chronologies from a wide variety of tree species, as well as different methodological approaches. In addition to tree-ring width (TRW), now stable carbon and oxygen isotopes, Quantitative Wood Anatomy, autofluorescence and chemistry provide means to develop tree-ring research in the tropical region. In this symposium, we will show progress done in the Tropical Americas highlighting studies from different countries. Mexico has been pioneering with the development of over 40 TRW chronologies, while new TRW chronologies in Guatemala can contribute to a better management of water resources. In South America tree-ring chronologies were generated from multiple tree species measuring distinct parameters at the western (dry) and eastern (wet) flanks in Central Andes of Peru and Bolivia, while in the seasonally dry forests of Brazil, alive and subfossil tree-ring records have been developed. This symposium intends to provide new insights into forest responses to climate, stand dynamics or other environmental events, based on tree-ring analyses, and updated on more useful methodologies with the main goal being to push tropical dendrochronology for the following decades through international collaborative research.

Multiproxy approaches to understanding the formation of tree rings in tropical species: exploring anatomical, physical a...

Daigard Ricardo Ortega Rodriguez

Amphitheatre (SH-2800), June 30th, 09:20 - 09:27

Methodological advances in the latest years have opened new perspectives for dendrochonological studies by facilitating the visualization, delimitation, and analyses of tree-rings. These novel methodologies have incorporated complementary physical and chemical parameters to the traditional anatomical procedures used to describe annual growth rings. Here, we present the results of new studies which explore the relationships among wood density features and chemical elements involved in the annual tree ring formation of tropical species. We also provide protocols for macroscopic distinction (radial growth and wood density), microscopic analyse by long histological sections (anatomy) and X-ray densitometry (physical) and X-ray fluorescence (chemical). The findings presented in these studies suggest that multi-proxy analysis combining physical and chemical parameters together with wood anatomy would contribute to improve the definition of the seasonal growth patterns, ring boundary and improve the further applications of dendroecology, dendroclimatology and dendrophysiology in tropical forests.

Using wood autofluorescence to explore the diversity of wood anatomy in the tropics and improve tree-ring visualization

Milena Veiga

Amphitheatre (SH-2800), June 30th, 09:28 - 09:35

Exploring new study sites and potential species is still a fundamental step in tropical dendrochronology. The results of exploratory field campaigns usually reflect the intrinsic biodiversity of the tropics: a plethora of wood anatomy variation and seemly true tree-ring boundaries. Often, some species are excluded during the process of selecting the best species due to indistinct or rather unclear tree-ring delimitation, aside from the difficult task to discriminate the commonly found false rings. Thus, any method that can improve tree-ring visualization is of great value to the development of tropical dendrochronology. We tested the use of wood autofluorescence to aid the process of species selection and tree-ring visualization. Using different combinations of filtered wavelengths in a fluorescence stereomicroscope, we evaluated the potential improvements in the visualization of wood anatomy and tree-ring boundary. We tested this method with 38 species and more than half showed some improvement in tree-ring visualization without any additional surface preparation. Our results also show the enhanced contrast among fibres, vessels, and parenchyma that can aid automatic detection and improve measurements in anatomical studies. We observed distinct growth rings in tree species previously described as bearing indistinct tree-ring boundaries and were able to highlight differences between true and false rings in Cedrela fissilis and Hymenaea courbaril. Although the wood autofluorescence should not be seen as a silver bullet for the rather challenging tropical tree species, it is certainly an additional method available in many research institutions that could significantly leverage dendrochronology in the tropics.

Advances in quantitative wood anatomy and radiocarbon dating to better assess climate sensitivity in the Andean Tropics

Arturo Pacheco Solana

Amphitheatre (SH-2800), June 30th, 09:35 - 09:42

Tropical regions are generally characterized by dynamic ecosystems where the abundant availability of energy and resources allows for an almost constant growth of its flora, being xeric forests and flood plains some exceptions. Classical dendrochronology studies have been scarce in these areas as many tree species does not show well defined tree-ring boundaries. We present different study cases on how quantitative wood analysis and radiocarbon can complement classical dendrochronology increasing the number of tree species suitable for tree-ring analyses, plus new tree-ring parameters useful as paleoclimate proxies. We selected a broad set of species along several climatic zones in the mountainous regions of Bolivia: Prosopis alba and P. ferox from dry highlands, Amburana cearensis, Cedrela fisilis and C. odorata from dry tropical forest at medium altitudes, Juglans boliviana from mesic medium altitude forests and Polylepis pepei at treeline elevations. This wide range of tree species allow us to study different types of radial growth from a xylem architecture perspective and climate sensitivity, broadening the possibilities of finding suitable species for further climate research. Besides we also measured quantitatively several tree-ring parameters showing the potential to investigate intrannual dynamics of growth and seasonal environmental variations. Radiocarbon (14C) pulse dating was also used to guarantee the accuracy of calendar dates obtained with dendrochronological methods. To implement dendrochronology as a tool to identify how tropical forests respond to climate change, we need to complement approaches and technologies that will allow us to reveal the vast information still locked within tropical tree species.

Wood anatomy of Puerto Rican trees: an ecological archive without tree-rings

Emanuele Ziaco

Amphitheatre (SH-2800), June 30th, 09:43 - 09:50

In tropical environments of central America, tree-ring forming species are rare to find, especially in areas with pronounced aseasonality, but wood anatomical traits can equally provide important information on species life-histories and response to disturbances. Dating wood anatomical structures remains a crucial task to decipher the ecological information recorded in xylem cellular parameters in absence of defined ring boundaries, particularly to observe the footprint of discrete disturbance events. We present the results of research on 10 species in the Luquillo Forest Dynamics Plot (Puerto Rico, USA). In 2017, hurricane Maria struck the island and caused nearly complete defoliation and high tree mortality, offering us the opportunity to investigate xylem plasticity in response to extensive damage to the forest canopy. We combined high-resolution measurements of diameter growth and anatomical features for 74 individuals to date wood anatomical structures. We related stem radial growth with changes in wood anatomical features and hydraulic conductivity, identifying changes in growth patterns and xylem structures in the pre- and post-hurricane periods. We found shifts in wood anatomy within individuals that were consistent across species and generally reflected increased hydraulic conductivity. We assessed the relationships between xylem traits and species life-histories and highlighted differences in variations of wood anatomy at the species vs. community level. This work helps lay foundations for a broader understanding of the responses of xylem in tropical species to environmental factors and will be expanded in the future to include portions of the island of Puerto Rico with a more pronounced climatic seasonality.

Age structure and climate sensitivity of a high Andean relict forest of Polylepis rodolfo-vasquezii in central Peru

Ginette Ticse

Amphitheatre (SH-2800), June 30th, 10:05 - 10:12

The state of fragmented populations of tree Polylepis genus heavily impact by human activities leads to the need to conduct ecological studies to better understand their vulnerability. We evaluated the newly identified tree species Polylepis rodolfo-vasquezii, endemic to central Peruvian Andes, distributed from 3700 to 4750 m a.s.l. and suitable for dendrochronological studies. Our objectives were twofold: (1) to determinate age population in both forests and developed linear models that compared the relationships between tree size and age; (2) to assess the synchronicity in tree growth and climate sensitivity of the tree-ring chronologies. We present a newly developed 191-year tree-ring chronology, located at 11°S and 75°W, together with an update of the 157-year tree-ring chronology previously published from a forest nearby at 36 km of distance. The radiocarbon bomb pulse dating determined that the seasonal pattern of radial growth for these trees is primarily annual. Distinct tree age-size correlations were found in both populations, possibly explained by natural disturbances and human activities. Nevertheless, significant low correlation was found between growth patterns from both chronologies, and they shared high sensitivity to temperature of the current growing season. Our findings report that P. rodolfo-vasquezii is the second oldest Polylepis tree species reaching ages of 190 years old. Also, an important take-home message is that in this tree species allometric variables cannot be used to estimate tree age. P. rodolfo-vasquezii represents a unique tree-ring archives to understand past environmental history in the high central Andean in South America.

Revealing Polylepis microphylla as novel Andean specie suitable for dendrochronology and quantitative wood anatomy

Clara Rodriguez Morata

Amphitheatre (SH-2800), June 30th, 10:13 - 10:20

In the tropical Andes several species of the genus Polylepis have been reported to be useful to record climate variability using tree-ring width, expanding the geographical distribution of proxy records into the tropical region. However, in the tropics classical dendrochronology based on ring-width patterns is often challenging, hampering the development of climate reconstructions. Alternative methods can confirm annual periodicity of tree rings, and help on extracting more reliable climate information from them. To evaluate the dendrochronological potential of Polylepis microphylla, we propose the use of radiocarbon (14C) analyses as an independent method to validate the dendrochronological calendar dates couple with quantitative tree-ring anatomical features evaluations. P. microphylla is an endemic species from the Ecuadorian and the Peruvian Central Andes, which was described for the first time in 1861 but it has not yet been used in dendroclimatic studies.

Through dendrochronological and quantitative wood anatomy (QWA) methods, we generated several tree-ring chronologies covering the period 1965-2018 based on ring-width, cell wall thickness and lumen area from vessels and fibers. High-precision ^{1}4Cbomb pulse dating helped on confirming the annual periodicity in P. microphylla growth. Regarding the relationship with climate, significant correlations were found between ring-width and local temperature (i.e. positive during the current growing season) and precipitation (i.e. positive during prior and current growing season). QWA records exhibits similar results pointing out the potential of this approach to provide dendroclimatic records in the Central Andes.

A 389-yrs precipitation changes in the Northern South American Altiplano reveals an increase in extreme drought events s

Mariano Morales

Amphitheatre (SH-2800), June 30th, 10:20 - 10:27

Given the short span of instrumental hydroclimatic records in the South American Altiplano, longer time records are needed to understand the nature of climate variability and to improve the predictability of precipitation, a key factor modulating the socio-economic development in the Altiplano and adjacent arid lowlands. In this region growths P. tarapacana, a long-lived tree species being very sensitive to hydroclimatic changes and widely used for tree-ring studies in central and southern Altiplano. However, exist a gap of hydroclimatic tree-ring records in the northern sector of the Peruvian and Chilean Altiplano (16º-19ºS). Our study provides an overview of the climate of the northern Altiplano (NA) through the identification of long-term wet or dry periods and the temporal evolution in annual precipitation during the last ∼four centuries. An increase in the frequency occurrence of extreme dry events have been recorded since the second half of the 20th century in the NA within the context of the last ∼four centuries. This is in agreement with the reported increase in the occurrence of extreme climate events in different parts of the world under the current global warming scenario. The persistent drought/wet periods recorded over the past 389 years are highly consistent with evidence from the paleoclimatic records available in the region. We highlight the temporal and spatial synchrony of drought conditions since 1980s recorded by different tree-ring based hydroclimate reconstructions across the Altiplano region. This information together with the growing demand for water is essential to understand the vulnerability/resilience of the region to the projected evapotranspiration increase for the 21st century.

Climate and physiological signals in tree-ring stable isotopes of Polylepis tarapacana from the South American Altiplano

Milagros Rodriguez-Caton

Amphitheatre (SH-2800), June 30th, 10:28 - 10:35

Polylepis tarapacana is the longest paleoclimatic tree-ring archive in the South American southern tropics. It grows up to 5200 m a.s.l. in the South American Altiplano, a semiarid-high elevation Andean Plateau. P. tarapacana ring-widths (RW) have provided centuries of past hydroclimate information, but the potential use of tree-ring stable isotopes for paleoclimatic or ecophysiological studies remained understudied for this species. Here, we developed a network of four RW, oxygen (d18O) and carbon (d13C) stable isotope chronologies from P. tarapacana tree rings for 1950-present along a latitudinal-aridity gradient (18ºS-22ºS). Among these three parameters, d18O recorded the strongest current growing season January to March precipitation signal (r=0.6-0.8), coincident with the peak of the South American Summer Monsoon in this region. This finding allowed for the development of the first centennial precipitation reconstruction (1700-2013) based on P. tarapacana tree-ring d18O, which explains more than 55% of the variance in precipitation. From the physiological perspective, the development of this network was crucial to identify that current-growing season temperature regulated RW at the northern-wetter sites, while prior-growing season precipitation influenced RW at the southern-drier sites. Warm and dry current growing seasons resulted in more enriched tree-ring d13C and d18O at all study sites. The synchronous (asynchronous) climate conditions influencing RW and stable isotopes, as well as significant (non-significant) correlations between RW and d13C in the northern (southern) sites, indicate a coupling (decoupling) between wood formation and leaf gas exchange for wetter (drier) conditions along the aridity gradient.

Symposium 4. Dendrogeochemistry 'moving beyond potential'

Moderators: Fabio Gennaretti, Max Berkelhammer, Heather Haines, Trevor Porter

Speakers: Adam Csank, Valérie Daux, Soumaya Belmecheri, Steven Voelker, Alienor Lavergne

Salle polyvalente (SH-4800), June 30th, 11:00 - 12:15

In their book chapter in 2011 Gagen et al. (2011) highlighted the need for stable isotope dendroclimatology to move beyond studies that simply demonstrate 'potential'. This symposium, more than a decade since this publication, will focus on dendrogeochemical studies that demonstrate that the field has moved beyond studies focused on 'potential'. In particular, this session will strive to identify compelling new insights into unique aspects of reconstructions that can be developed through the use of dendrogeochemical records. We also welcome submissions that present multi-proxy studies including isotopes to highlight the advantages that can be gained by expanding our dendroclimatological toolbox.

This symposium should thus serve to stimulate new advances and collaborations by showing how geochemical records from tree-rings can be used as a valuable tool in ways that serve to complement or enhance what can be gained through traditional ring width-based dendroclimatology.

Tree ring stable isotopes, for example, can record different, or stronger, climate signals than those available from traditional tree-ring proxies, do not require detrending, and thus can provide a more comprehensive view of past climates. New high resolution radiocarbon studies from tree rings have improved our ability to date archaeological material, as well as provided insight into past cosmogenic events, finally providing evidence of the elusive solar signals originally sought by A.E. Douglass. Advances in dendrogeochemistry of mercury, and other heavy elements has provided important insight into historic patterns of atmospheric pollution, wildfire and volcanic activities. This session aims to demonstrate to the tree-ring community how far beyond potential dendrogeochemistry has come.

Time delays between environmental forcing and isotopic signatures of tree-rings

Fabio Gennaretti

Salle polyvalente (SH-4800), June 30th, 11:00 - 11:15

The use of multiple data from tree-rings, including isotopic ratios and xylogenesis monitoring, can enhance our interpretations on tree functioning and on tree-environment relations. Here, we explored whether understanding of carbon deposition to tree-rings could be improved using: (1) monitoring of wood cell formation during the growing season, (2) intra-annual data of d13C in tree-ring cellulose and (3) ecophysiological modelling. We collected wood micro-cores to monitor wood cell formation of six Silver fir trees at two forest sites in the Vosges mountains (France) and detect periods of cell division, cell enlargement and cell wall thickening of 10 tree-ring subsectors per year over three years (2007-2009). The same trees were sampled to measure d13C of tree-ring cellulose (d13Ccell) over similar 10 tree-ring subsectors of the same three years. We then used an ecosystem model, integrating a model for sugar availability and carbon isotope fractionation, to identify periods of carbon deposition in each tree-ring subsector based on the agreement between simulated and observed d13Ccell values. Our results show how intra-annual patterns of 13C/12C ratios of tree-ring cellulose were driven by vapor pressure deficit variations over the growing season and that cellulose deposited in the tree-ring subsectors integrated carbon that started to be assimilated in the cells during the cell division phase and before the cell enlargement and wall thickening. This means that there is a time delay between the environmental forcing and the isotopic signature of tree-rings. Our study provides useful insights on carbon allocation to wood in Silver fir that can be used to improve interpretations of isotopic time series of this species.

Enhanced use of summer rain for Rocky Mountain conifers during the last interglacial warm period

Max Berkelhammer

Salle polyvalente (SH-4800), June 30th, 11:15 - 11:30

Recent droughts have highlighted concerns of how rising summer temperatures will increase tree mortality rates across the western United States. However, there remains uncertainty about how summer rain might respond to warming and whether this will ameliorate the moisture stress associated with warming. We analyzed subfossil wood samples from Colorado dating to the last interglacial to assess the response of two common conifers to a previous warm period. The trees experienced comparable growth rates and water use efficiency during the interglacial relative to modern despite evidence from model simulations of a 30% increase in evaporative demand during the peak of the growing season. High-resolution isotopic analysis of the wood samples show an enrichment in the late season cellulosic d18O relative to modern samples, which we find was associated with increased reliance on summer rain. The data are consistent with model simulations showing the interglacial was associated with wetter summers across the western US. We propose enhanced summer rain during this period compensated for drought stress imposed by higher evaporative demand. The tree ring data from the subfossil wood are compared against a multi year field campaign measuring sap velocity and xylem water isotopes during years of historically high and low summer rains to illustrate the response of these trees to changing summer rain inputs.

Detecting SEP events of varying magnitude by their 14C concentration in Southern Hemisphere and Equatorial tree rings

Heather Haines

Salle polyvalente (SH-4800), June 30th, 11:30 - 11:45

Solar Energetic Particle (SEP) events cause an increase in atmospheric radiocarbon (14C) concentration.14C spikes in 774-775 and 993-994 CE have been measured in numerous tree-ring chronologies worldwide. Two other 14C excursions, in 1052 and 1279 CE, have been reported from Northern Hemisphere tree-ring chronologies. A critical factor for SEP event detection is the resolution of the tree-ring samples. Annually resolved records required to detect these short-term excursions can be costly, time consuming, and may require large sample quantities The UNSW MICADAS AMS system allows for high throughput of samples with only 10 mg of wood needed providing an ideal opportunity to search for SEP events. We have identified all four of the larger known SEP events using Manoao colensoi tree-ring samples from Oroko Swamp, New Zealand. Sub-annual slices were taken from two years prior, to two years after, each of the SEP events. These sub-annual results help to refine the seasonality of these events. We next attempted to identify the smaller Carrington Event (1-2 September 1859 CE). Preliminary results from Swedish oak were thought to show a noticeable 14C increase but no other occurrences have been reported. We sub-annually sampled the Oroko Swamp M. colensoi rings as well as those from Athrotaxis seleganoides (Tasmania, Australia), Callitris intratropica (Northern Territory, Australia), Pinus merkusii (Thailand), Pseudotsuga menziesii (Vietnam), and Cedrela odorata (Brazil) for 1857-1861. Our results failed to detect this small SEP event from across this wide range of locations and species. We conclude that either the magnitude of the event was too small to be detected or that the timing was outside of the seasonal growth period.

Neogene paleotemperature estimates from lignin-methoxy hydrogen isotopes of sub-fossil wood in the Canadian Arctic

Trevor Porter

Salle polyvalente (SH-4800), June 30th, 11:45 - 12:00

Neogene fossil beds in the Canadian Arctic Archipelago (CAA) provide a window into past greenhouse intervals and insights on what a future, warmer Arctic may look like. In this study, we use the hydrogen isotopes of lignin-methoxy groups (d2HLM) from sub-fossil wood from six CAA sites (73-80°N) as a proxy for the d2H of precipitation-derived plant water and paleotemperatures; five study sites cover Pliocene timeslices (∼5.3-2.6 Ma) and the other site captures the middle Miocene (∼15 Ma). Forty-three samples (all gymnosperms – Pinus, Picea and Larix spp.), each representing an individual tree, were analysed. The d2HLM measurements were used to estimate paleo-d2Hprecip for each site assuming the net fractionation for conifers (eLM/precip = -204 ± 12). The data reveal average precipitation during the Neogene timeslices was deuterium-enriched compared to modern precipitation (¡U+0394¿d2Hprecip = +37.6 to +64.7‰ relative to modern), consistent with warmer mean paleoclimates. Assuming the modern-day d2Hprecip-temperature sensitivity for the region (3.9‰·°C-1), the ¡U+0394¿d2Hprecip anomalies indicate paleotemperature anomalies (¡U+0394¿T) were +9.7 to 16.7°C warmer than today. Our ¡U+0394¿T estimates are corroborated by independent proxy data from five sites and provide the first quantitative ¡U+0394¿T estimates from Prince Patrick Island (Beaufort Fm.). Our results demonstrate high potential for the d2HLM proxy in Cenozoic paleotemperature studies and confirm the Neogene Arctic climate was dramatically warmer than today. Future research is needed to resolve the relative contributions of global versus regional boundary conditions in driving past warming in the CAA to better understand its warming potential under future greenhouse gas scenarios.

Symposium 8 (PT 2). Dendrochronological progress in tropical Americas

Moderators: Jorge A. Giraldo, Marcelo Scipioni, Rose Oelkers, Jim Speer, María Eugenia Ferrero, Diego Pons Ganddini

Speakers: Laia Andreu-Hayles, María Eugenia Ferrero, Giuliano Locosselli, Kevin Anchukaitis, Clara Rodriguez Morata

Amphitheatre (SH-2800), June 30th, 11:00 - 12:15

Dendrochronological archives in the tropics of the Americas have been under-studied for a long time. Some of the challenges include the Identification of tree-ring boundaries in certain tree species, absence of winter dormancy associated to low temperatures in most of the cases, and logistic difficulties of fieldwork in remote sites. However, part of the slow progress is also related to the fact that historically much less resources have been invested in dendrochronological research in the tropics than in other regions of the world. Nevertheless, more studies have been published over the last decade leading to important achievements such as the expansion of tree-ring networks due to an increase in the number of available chronologies from a wide variety of tree species, as well as different methodological approaches. In addition to tree-ring width (TRW), now stable carbon and oxygen isotopes, Quantitative Wood Anatomy, autofluorescence and chemistry provide means to develop tree-ring research in the tropical region. In this symposium, we will show progress done in the Tropical Americas highlighting studies from different countries. Mexico has been pioneering with the development of over 40 TRW chronologies, while new TRW chronologies in Guatemala can contribute to a better management of water resources. In South America tree-ring chronologies were generated from multiple tree species measuring distinct parameters at the western (dry) and eastern (wet) flanks in Central Andes of Peru and Bolivia, while in the seasonally dry forests of Brazil, alive and subfossil tree-ring records have been developed. This symposium intends to provide new insights into forest responses to climate, stand dynamics or other environmental events, based on tree-ring analyses, and updated on more useful methodologies with the main goal being to push tropical dendrochronology for the following decades through international collaborative research.

Annual growth rhythm evidence of trees from the rainiest neotropical region

Jorge A. Giraldo

Amphitheatre (SH-2800), June 30th, 11:00 - 11:07

The occurrence of annual growth rings in tropical trees—the result of the seasonal activity of vascular cambium—has been explained either by seasonal periods of water deficit or flooding. However, little is known about the drivers of annual tree-ring formation under tropical hyper-humid conditions without evident seasonal dry periods or flooding (ever-wet conditions). Shelford's law states that both the deficit and the excess of environmental resources limit plant growth. Accordingly, we hypothesize that reduced solar radiation, excess soil moisture, and a slight reduction of precipitation control annual growth rings in ever-wet tropical forests (lacking seasonal droughts and flooding). We first tested the occurrence of rhythmic growth in several tree species from the Biogeographic Choco Region (annual rainfall 7,200 mm) using three different methods: Radiocarbon (14C) dating, tree ring synchronization, and dendrometer bands. Then, we assessed the effect of environmental drivers (rainfall, short wave radiation, temperature, and soil moisture) on tree growth based on tree ring and dendrometer observations. Depending on the tree species, we observe both positive (n = 2) and negative correlations (n = 2) between growth and water, and growth and light availability. This relationship suggests that both excess or deficit of environmental factors may explain seasonal cyclicity of growth rhythms in some trees, but not in others. We showed for the first time the occurrence of annual growth rhythms in several tropical tree species under extreme ever-wet conditions in the neotropics. Our analysis opens a new frontier for tree ring science, helping to disentangle multiple climatic influences on growth rhythms in the tropical forest.

Assessing the dendroclimatic potential of tropical tree species in northern Bolivia

Rose Oelkers

Amphitheatre (SH-2800), June 30th, 11:08 - 11:15

The most biodiverse region in the world can be found in the tropical Andes (∼5º-24ºS) between Venezuela and the Bolivian Altiplano, yet it is highly under-sampled in dendrochronology in part due to the prevalence of trees without rings (continuous growth) and the overall hyperdiversity of the ecosystems. The Madidi National Park (MNP) in northern Bolivia. (∼14 ºS, -68◦W) is a biodiversity hotspot with lowland rainforests and high montane environments that provide unique opportunities for tree-ring analyses. This study focuses on determining which climate factors limit radial growth, expressed by tree-ring width (TRW) data, in two tree species in the MNP: Juglans boliviana from a tropical wet forest (1400 m a.s.l.) and Polylepis pepei, a high elevation species (4400 m a.s.l.). To investigate the climate sensitivity of TRW, we conducted spatial analysis using mean monthly and daily temperature and precipitation data from nearby station and gridded reanalysis products for the period 1960-2015. We found that P. pepei TRW was influenced by precipitation during the onset of the austral summer wet season (November-December). This is different than the response of P. tarapacana from the southern Altiplano (prior-year growing season signal; see: Morales et al., 2012). The TRW variability in the J. boliviana chronology appears to have had a positive response to austral summer (DJF) temperature and precipitation since the 1970s. To our knowledge this is the first time that J. boliviana has been reported as suitable for dendrochronological studies. These newly developed chronologies in the northern altiplano are at least 150 years old and may be useful in a region where century-long climate data is not available.

Effects of cold conditions on the growth rates of a subtropical conifer

Marcelo Scipioni

Amphitheatre (SH-2800), June 30th, 11:15 - 11:22

Araucaria angustifolia is an endangered species that occurs in the high and cold regions of southern Brazil. This species has economic importance due to its wood and seeds, as well as playing a fundamental ecological role for the southern fauna and flora. Climate change can affect it sdistributional area and conservation, making it urgent to investigate the effect of climate on its development. The objective of our study was to investigate how growth rates of A. angustifolia vary in relation to interannual precipitation, temperature, frost and snowfall events. For this purpose, we used two samples obtained from each of 33 individual trees from a forest fragment on the Santa Catarina plateau, Brazil. Classical dendrochronological methods were applied for the preparation and dating of the samples. The tree rings were measured using specialized software. Superposed Epoch analysis was used to test the snow accumulation events. The climatic variables were tested by means of a correlation analysis. The Superposed Epoch analysis was used to test the snow accumulation events. Our results indicate that the species shows significant sensitivity to the climate, with the maximum and minimum absolute temperatures respectively correlated with positive and negative growth rates. Snowfall also reduced growth of A. angustifolia. Overall, extreme cold events are threats to the conservation of the species.

Precipitation variations and tree growth in the semi-arid Chaco region of South America

María Eugenia Ferrero

Amphitheatre (SH-2800), June 30th, 11:23 - 11:30

The semi-arid Chaco is one of the most extensive forest formations in South America and has been subjected to high deforestation rates since the 1970s. At present, the main ecological, social and production problem in the region is the variation in water availability, a complex situation that combines a negative water balance and flood events. In this work, we studied the spatial and temporal variability of precipitation patterns, using rainfall instrumental records and tree rings of Schinopsis lorentzii, in three sites in the semi-arid Chaco region of Argentina. We cross-dated annual rings and compared tree growth with local and regional climatic variables, including rainfall and temperature. We found that interannual variability of precipitation is not homogeneous across the region, but shows a differential east-to-west distribution of moisture. Variability in tree-ring width responded positively to climatic signals related to water availability and inversely to temperature, mainly during the period of greatest water deficit and the onset of the growth period. The three chronologies displayed an increase in interannual values and a significant change in growth variability from the 1950s, consistent with an increase in the magnitude and variability of precipitation in the last decades. The analysis involving gridded regional climatic variables revealed the differential predominance of the large-scale moisture sources that enter the region. The results obtained in this study enabled us to disentangle the roles of the different sources of moisture, their spatial and temporal variability, and their impact on the tropical dry ecosystems of the Chaco region.

A North Tropical Atlantic Sea Surface Temperature Reconstruction from the Dominican Republic Using Pinus occidentalis

Jim Speer

Amphitheatre (SH-2800), June 30th, 11:45 - 11:52

The Caribbean, like much of the tropics, is underrepresented by tree-ring chronologies making global climate reconstructions a challenge because of these blind spots. We have developed a multi-centennial tree-ring chronology from 120 samples of Pinus occidentalis trees located above 2800 m elevation on the dry slopes of Loma la Pelona in the Cordillera Central (19.035278 N, -71.005278 W) of the Dominican Republic. We used skeleton plotting on multiple radii from each crossection to date the samples and checked our dating with COFECHA. Climate response of these trees was tested using monthly temperature and precipitation data and with the Palmer Drought Severity Index calculated for meteorological data from the town of Constanza, located at 1160 m elevation 62 km ESE of the sampling site. Climate response was also compared with proxy records of sea surface temperature from Caribbean sites. The chronology correlates positively with rainfall days during the late dormant season on the windward mountain flank, and negatively with early growing season temperature on the leeward flank. One of our strongest responses is with February North Tropical Atlantic sea surface temperature with 24% variance explained. We also used 14C to date seven samples of older remnant wood preserved on a block field to obtain an idea of how long of a chronology might be possible and found ages of up to 930 years. Further work to collect more old wood from this site could yield a millennial length chronology that is sensitive to Atlantic sea surface temperature.

Central American Tree-Ring Research: A Review

Diego Pons Ganddini

Amphitheatre (SH-2800), June 30th, 11:53 - 12:00

In this presentation we discuss the current status of tree-ring research in the neotropical Americas outside of México. The most relevant findings are discussed, including the region-wide wet season precipitation signal associated with large-scale tropical atmospheric dynamics. Our analysis suggests that local climate response patterns vary between sites, with the strongest correlations ranging from the previous summer to the current spring. Correlations with accumulation of daily precipitation suggest possible thresholds for growth initiation and sensitivity to conditions at the start of the growing season. We also present recent results from stable oxygen isotope analysis suggesting an association between the Caribbean Low-Level Jet (CLLJ) at 900mb winds and the isotope ratios. Overall, the chronologies assessed here cover the period from 1655 to 2015. Lastly, we also discuss the recent interest from the Meteorological Service in Guatemala to develop research on tree-rings from the lowlands of Petén, the enabling factors, and the limitations moving forward with tree-ring research in the region.

Symposium 3. Ecophysiological interpretations of stable isotopes in dendroecology

Moderators: Rossella Guerrieri, Jia Hu, Kinzie Bailey, Marco Lehmann, Soumaya Belmecheri, Brandon Strange, Laia Andreu-Hayles

Speakers: Paul Szejner, Alienor Lavergne, Steven Voelker, Rossella Guerrieri, Adam Csank

Amphitheatre (SH-2800), June 30th, 14:05 - 15:50

The interpretation of stable isotopes in a dendroecological framework can provide powerful insights into how trees adjust physiologically in response to the environment. This symposium aims to bring together researchers who use stable isotopes in tree rings to address ecophysiological responses to environmental changes from intra-annual to multi-decadal resolution. We hope this symposium will enable fruitful discussions and new ideas and help identify new research directions aiming to foster new collaborations between researchers within the scientific community. Therefore, we welcome submissions presenting new scientific approaches on tree-ring isotopic observations and comparisons to data and models based on forest dynamics, ecophysiology, hydrology, biogeochemistry and, remote sensing. Specific topics this session is anticipated to include:

1. Changes in carbon isotope discrimination and water-use efficiency in response to environmental changes (climate, atmospheric CO2, atmospheric deposition).

2. Seasonal and environmental changes recorded in intra-annual isotopic variations (Studies using xylogenesis, Quantitative wood anatomy, and isotopes).

3. Changes in water source and source versus relative humidity interactions. (Oxygen isotopes)

4. Using d15N in tree rings to assess changes in environmental conditions (Nitrogen availability, atmospheric deposition).

5. Impacts of climate change on plant functioning under different environmental conditions (dry versus humid) (multi-species interactions).

6. Forest responses to disturbances (e.g., fires, outbreaks, etc.).

7. Improvements of vegetation models using multiple tree ring parameters.

8. Projections of forest responses to future climate change informed by stable isotopes.

Landscape influences on the oxygen isotope of tree rings within a watershed in the western U.S.

Jia Hu

Amphitheatre (SH-2800), June 30th, 14:05 - 14:20

Climate change across the western US has increased air temperature, resulting in decreased snow and lengthening of the summer drought. Recent studies have also highlighted the positive feedback loops between soil moisture and vapor pressure deficit (VPD), which can exacerbates aridity in water limited ecosystems. These interactions can make it difficult to untangle the influences of soil moisture and VPD on tree growth, and yet our ability to untangle these parameters is important for building a predictive framework for forests vulnerability to drought. In montane ecosystems, the complexity of watershed characteristics, such as aspect, microtopography, soil properties, and plant species composition can further complicate the interactions between source water use and VPD, and influence how these parameters are recorded in the d18O of wood cellulose (d18Owc). Thus, a primary objective of this study was to understand if there were consistent and predictable patterns in d18Owc that were controlled by watershed characteristics and/or species composition. Through d18Owc analysis of three dominant tree species, including Ponderosa pine, Douglas fir, and Engelmann spruce, we found that topographic mediation of the microclimate, such as soil moisture and VPD, had a larger influence on the d18Owc than species specific traits. We also found that accurate estimates of source water d18O was important for modeling d18Owc, and that we could not assume d18O of source water was the same as d18O of precipitation. Finally, we found that including the influence of the Peclet effect was more important in the d18O model in trees that were growing in more mesic landscape positions, compared to drier landscape position.

Differential use of North American Monsoon precipitation by Pinus ponderosa in the American southwest

Kinzie Bailey

Amphitheatre (SH-2800), June 30th, 14:20 - 14:35

In the southwestern U.S. the North American Monsoon (NAM) delivers summer precipitation from July – September and the rest is provided as snowmelt in early spring. Both periods serve as an important water source for plants, but due to the heterogeneous nature of the NAM, not all locations within the region receive precipitation, leading to differences in soil moisture. Understanding how spatially heterogeneous soil water storage controls plant water use is needed, especially with projected changes in western U.S. hydroclimate. We examined the importance of NAM precipitation as a water source in different populations of Pinus ponderosa (PIPO) growing in the northern boundary of the NAM. We asked: 1) Which populations of PIPO switch from winter precipitation to NAM precipitation as a water source throughout the year? 2) Does the amount of winter precipitation affect how PIPO use NAM precipitation? 3) How does tree size and location impact water use? We measured xylem water isotopes in trees from eight sites across southern Utah and northern Arizona for two years. We found the southern sites had a distinct separation in water use before and after the NAM, while the northern sites had a less distinct separation. We also found that differences within populations seem to be a function of tree size, elevation, and aspect. By understanding how the isotopic signal of xylem water changes throughout the growing season, we can better recognize how different hydroclimatic years can impact tree growth.

The phylogenetic impact on hydrogen isotopes in sugars and cellulose of woody plant species

Marco Lehmann

Amphitheatre (SH-2800), June 30th, 14:35 - 14:50

Hydrogen isotope ratios in tree ring cellulose (d2HC) have been recognized as a potential proxy for plant-climate interactions, plant physiology, and carbon metabolism. This goes along with recent studies showing species-specific d2HC differences that cannot be explained by climatic conditions. However, systematic investigations on the phylogenetic impact on 2H-fractionations in carbohydrates of woody plant species are missing. Here, we sampled leaves and twigs of 152 trees and shrubs, out of 73 species representing 48 genus, 19 families and 12 orders containing evergreen and deciduous angio- and gymnosperms groups in a common garden. We extracted leaf water and sugars, as well as twig water and the current year twig xylem cellulose for d2H analysis, using a newly established hot water vapour equilibration method. We found a clear phylogenetic impact on d2H for sugars (>150‰) and cellulose (>80‰) across species growing under common conditions. The strongest differences were observed at the group level, with sugar and cellulose of gymnosperms being more 2H depleted than in angiosperm. Yet, we found no d2H difference between leaf shedding types (evergreen vs. deciduous). Significant differences in d2H of sugars and cellulose were also observed between different orders and families, but not between genus and species within a family or genus, respectively. The phylogenetic differences are likely explained by 2H-fractionation at the leaf level rather than by those in sink tissues. Our study thus advances the knowledge for applying d2HC in dendro and paleo sciences for the reconstruction of physiological and metabolic responses of trees to climate.

Effects of simulated increases in nitrogen deposition on a mature temperate forest as revealed by a dendroecological app...

Rossella Guerrieri

Amphitheatre (SH-2800), June 30th, 14:50 - 15:05

The ability of forests to continue absorbing atmospheric CO2, and hence mitigating climate change, depends on the extent to which their productivity is limited by nutrients, with nitrogen (N) being particularly important in temperate and boreal regions. Fertilisation experiments offer an opportunity to directly determine whether atmospheric N input can contribute to alleviating N limitation. However, the majority of the experiments have normally considered soil N applications, which do not mimic changes in N deposition, as they exclude atmosphere-canopy exchanges, including direct foliar N uptake. In this context, the manipulation experiment established in a mature Fagus sylvatica L. forest in Italy represents a unique resource for advancing understanding on forest responses to global change. At this site, four different treatments have been carried out since 2015: control, canopy (30 kg ha-1 yr-1) and soil (30 and 60 kg ha-1 yr-1) N additions. Our goals are to: i) explore long-term (1940-2020) changes in tree growth and elucidate main drivers (climate vs. anthropogenic factors), ii) assess whether soil and canopy N additions lead to different dynamics in terms of growth and intrinsic water-use efficiency (the ratio between photosynthesis and stomatal conductance). For this purpose, dendrochronological analyses will be combined with the measure of d13C, d18O and d15N in annual rings. Preliminary analyses indicate that tree growth has increased over the last 80 years, and that climate factors were the main drivers. On-going d13C analyses will provide insight regarding the physiological mechanisms underpinning growth changes in relation to different ecosystem N dynamics (retention vs. loss pathways).

Global trends and drivers of photosynthetic carbon isotope discrimination in trees

Soumaya Belmecheri

Amphitheatre (SH-2800), June 30th, 15:05 - 15:20

Under elevated CO2, photosynthetic carbon isotope discrimination is expected to increase in response to photosynthesis stimulation. While this response is widely documented in laboratory and field experiments, long-term proxies indicate that such response is not universally observed in response to the growth of atmospheric CO2. We investigated historical trends of photosynthetic carbon isotope discrimination derived from carbon isotope measurements of tree rings (¡U+0394¿13C) from 147 chronologies across a variety of climate regions and biomes. We specifically studied the deviation of tree-ring ¡U+0394¿13C from the predicted ¡U+0394¿13C response to CO2 as reconstructed from a recent meta-analysis of paleo and elevated CO2 data. We found that most records (∼80%) exhibited a negative deviations from the expected ¡U+0394¿13C if driven by a CO2 stimulation of photosynthesis (A). Chronologies with negative deviations were negatively correlated with vapor pressure deficit (VPD), and sites showed a maximum of 30% increase in VPD over the period of record. The widespread negative ¡U+0394¿13C deviations are consistent with a reduction of stomatal conductance (gs) or A having not increased as much as expected for a given CO2-driven stimulation of A. The global tree-ring data analyses suggest that a warmer and often drier climate have had a stronger effect on ¡U+0394¿13C compared to that of rising CO2.

The North American Monsoon and the Megadrought: How Precipitation Influences Forest Responses to Drought Conditions

Brandon Strange

Amphitheatre (SH-2800), June 30th, 15:20 - 15:35

Drought conditions have been projected to increase globally as atmospheric CO2 (ca) and vapor pressure deficit (VPD) increase. Experimental and modelling studies have suggested that forest responses to drought may be bolstered by increased ca, but it remains unclear how prevalent this response is in natural forest ecosystems. We developed a framework using intrinsic water use efficiency (WUEi = assimilation (A)/ stomatal conductance (gs)) and evaporative water use efficiency (WUEE = A/transpiration (E)) to evaluate how a dominant species' drought response within the Western US, Pinus ponderosa, has been affected by increased ca during a multi-decadal megadrought (MD). Using a hierarchical clustering approach we identified two distinct populations within our sites, those within the core region of the North American Monsoon (NAM), and those on the periphery of the NAM. Across all populations, WUEi increased from 1960-2017, corroborating published studies, however, WUEE did not increase at a commensurate rate with meaningful discrepancies between the two populations. WUEE diverges from WUEi during the MD as WUEE accounts for the impact of increasing VPD on E, but WUEi does not. Despite reduced gs via higher ca during the MD, increased VPD drove larger gradients of water vapor pressure between leaves and the atmosphere, leading to higher E. These findings suggest that reductions in gs may be offset by increasing VPD & E, leading to increased water loss in forests through evapotranspiration. Enhanced E rates despite reduced gs are important to consider for forests globally as temperatures, and VPD, continue to rise with climate change.

Ecophysiological response of white spruce to climate in high-latitude boreal forests in North America

Laia Andreu-Hayles

Amphitheatre (SH-2800), June 30th, 15:35 - 15:50

The boreal forest located in high northern latitudes stores about a third of the world's carbon and covers almost a quarter of the Earth's land surface. This region is experiencing one of the fastest temperatures increases on the planet. Yet it is unclear how global warming affects carbon sequestration and storage in this biome. Here, we explore how white spruce (Picea glauca [Moench] Voss) growing in North America responded to climate change during the 20th century using tree-ring width and stable carbon (d13C) and oxygen (d18O) chronologies from 10 sites between 60-69ºN and 104-162ºW. We found that carbon isotope discrimination (¡U+2206¿13C) tended to increase over time and especially since 1982, but that d13C and d18O were not significantly or only weakly related to each other. These results suggest that stomatal regulation is not the most important driver of the observed increase in water-use efficiency and that photosynthetic CO2 uptake increased. However, radial growth did not increase concomitantly at all the study sites, suggesting that distinct environmental drivers affect leaf gas exchange processes and wood formation or xylogenesis. This agrees with different sensitivity of stable isotopes and tree-ring growth to spring and summer environmental variables. A strong spring temperature signal and the same large-scale atmospheric patterns were recorded by tree-ring d18O and modelled precipitation d18O (i.e. source water signal). This may have attenuated the physiological signal in tree-ring d18O related to summer temperature (i.e. leaf evaporative isotopic enrichment). Overall, white spruce in high-latitude forests seems to benefit from warming, but how the carbon is distributed within the plant is still unknown.

General Session (Xylogenesis and anatomy)

Speakers: Jelena Lange, Jiani Gao, Roberto Silvestro, Valentina Buttò, Matthew Bekker, Sepideh Namvar

Salle polyvalente (SH-4800), June 30th, 14:05 - 15:35

Forward modelling reveals a complex pattern of climatic control on wood formation in conifers at cold-limited sites

Jelena Lange

Salle polyvalente (SH-4800), June 30th, 14:05 - 14:20

Treeline ecotones at high latitudes and high elevations are generally temperature-limited environments. However, there is evidence that temperature control on tree growth has recently decreased at treelines due to climate change, while water availability is increasingly reported as a seasonally important growth-limiting factor. Analyzing climate-growth responses at intra-annual (wood cell) level can help unravel these complex patterns, but long time series of wood formation data are often unavailable.

We compiled a dataset of tree-ring width series and wood formation data for seven polar and alpine treeline sites across Eurasia and North America and including eight species of three conifer genera (Picea, Pinus, Larix). We calibrated process-based (Vaganov-Shashkin) models of tree growth and simulated temperature- and moisture-driven growth rates and wood formation dynamics for 1950-today at daily resolution.

Our models showed that temperature has remained the main growth-limiting factor at all sites, but the number of days with prevailing moisture-limited growth has increased at many sites over the past decades. Furthermore, preliminary results indicate that growth resumption in spring has shifted to earlier dates by several days and thus growing season length has increased at most sites. Model validation with observation data is ongoing and generally confirms model findings.

Our analysis explicitly demonstrates how multiple climatic factors, namely temperature and water availability, can simultaneously limit tree growth at treelines in varying proportions. Our findings thus contribute to a better understanding of non-linear climate-growth responses and climate change effects on tree growth in treeline forest ecosystems.

Origin of intra-annual density fluctuations in a semi-arid area of Northwestern China

Jiani Gao

Salle polyvalente (SH-4800), June 30th, 14:20 - 14:35

Intra-annual density fluctuation (IADF) is a structural modification of the tree ring in response to fluctuations in the weather. To reveal the timings and physiological mechanisms behind IADF formation, we monitored cambial activity and wood formation in Chinese pine (Pinus tabuliformis) during 2017-2019 at three sites in semi-arid China. We compared the dynamics of xylem formation under a drought event, testing the hypothesis that drought affects the process of cell enlargement and thus induces the production of IADF. Wood microcores collected weekly from April to October were used for anatomical analyses to estimate the timings of cambial activity, and the phases of enlargement, wall thickening and lignification of the xylem. Xylogenesis started from late April to mid-September. Trees produced IADF in 2018. During that year, a drought in June limited cell production in the cambium, only 36% of the xylem cells being formed in IADF trees, compared to 68% in normal tree rings. IADF cells enlarged under drought in early July and started wall thickening during the rainfall events of late July. The drought restricted cell enlargement and affected wall thickening, resulting in narrow cells with wide walls. Cambium and cell enlargement recovered from the abundant rainfall, producing a new layer with large earlywood tracheids. IADF is a specific adaptation of trees to cope with water deficit events occurring during xylem formation. Our findings confirmed the hypothesis that the June-July drought induces latewood-like IADFs by limiting the process of cell enlargement in the xylem and suggests a higher occurrence of IADF in trees in arid climates of continental Asia if the more frequent drought events occurred in June.

Upscaling xylem phenology: Sample size matters

Roberto Silvestro

Salle polyvalente (SH-4800), June 30th, 14:35 - 14:50

Trees exhibit different growth rates and timings of wood formation. However, the factors explaining these differences remain undetermined, making samplings and estimations of the growth dynamics a complicated task based on technical rather than statistical reasons. We collected weekly wood microcores in 159 balsam firs (Abies balsamea (L.) Mill.) from April to October 2018. We tested spatial autocorrelation, tree size, and cell production rates as explanatory variables of xylem phenology, and we assessed the margin of error for different sample sizes. Xylem growth lasted between 40 and 110 days, producing between 12 and 93 cells. Neither the spatial proximity nor the size of individuals explained the variability in xylogenesis. A higher cell production corresponded to an earlier onset and later ending of xylem differentiation. A sample size of 23 trees estimated xylem phenology at 95% confidence level with a margin of error of a week. The relationship observed between the timings of xylem differentiation and annual cell production support the hypothesis of a potential connection between xylogenesis and carbon uptake in trees. When studying growth dynamics at high temporal resolutions, sample size assessment must suitably represent the variability in xylem phenology and consider the annual growth rates of the trees. The possibility of increasing sample size over the growing season can help evaluate the enhancing variability among trees. Sampling may profit trees located in the same plot, given that the variability has a similar magnitude within and among plots. Incorporating the variability in phenology and growth rates among individuals could allow more reliable upscaling of carbon allocation at stand or landscape level.

Contrasting carbon allocation strategies related to wood porosity converge toward similar growth responses to drought

Valentina Buttò

Salle polyvalente (SH-4800), June 30th, 14:50 - 15:05

In mixed forests, diffuse-porous and ring-porous species represent two distinct functional groups undergoing similar environmental variations, but allegedly displaying different growth responses due to their anatomical features. We hypothesized that in sympatric species, functional groups-specific carbon allocation strategies result in different relationships between wood traits and canopy architecture, mirroring contrasting sensitivity to drought.

We selected 2 diffuse-porous species (sugar maple and yellow birch) and 2 ring-porous species (red oak and American ash) growing in a mixed forest in Quebec, Canada. In 8 individuals per species, we measured traits linked to wood anatomy and canopy architecture, covering the period 2008–2017. We finally assessed tree-growth sensitivity to water balance by relating all growth variables with the standardized precipitation evapotranspiration index (SPEI).

Stem elongation in diffuse-porous species depended upon the number of ramifications and the xylem vessels' hydraulic diameter, while in ring-porous species stem elongation depended upon the productivity of the current year. In April, cold and wet soil conditions could explain the negative relationship between SPEI and tree growth. In late spring, greater water availability affected carbon partitioning, by promoting the formation of larger vessels in all species.

Drought responses in both functional groups were determined by different growth-related factors, but ultimately resulted in a similar overall loss of biomass. Growth responses to drought showed intra-annual patterns specific to the functional groups, suggesting that in the future their vulnerability will depend on the timing, duration, severity and frequency of droughts

Symposium 6. Advancing (Ameri)Dendro Allyship

Moderators: Joe Buck, Carolyn Copenheaver, Nicole Zampieri, Jodi Axelson, Chris Gentry, Kelsey Copes-Gerbitz

Speakers: Jodi Axelson, Chris Gentry

Salle polyvalente (SH-4800), June 30th, 15:50 - 17:20

Allies have emerged as key enablers of diversity and inclusivity initiatives in the workplace, in professional associations, and in everyday life. But what is an ally? What skills are required to be an effective ally? How do we hold ourselves and our community members accountable for being effective allies? This symposium will provide a deeper understanding of what it means to be an ally and the skills to help advance allyship as individuals and as a community. Furthermore, this symposium will bring together different perspectives of allyship and provide attendees an opportunity to ask questions and practice important allyship skills in a safe and welcoming space. Specifically, we envision a 1.5-hour session that includes a facilitated panel discussion, bystander intervention training, and an opportunity to discuss the topics covered in more detail. First, the facilitated panel discussion will bring together 4-5 individuals in different careers and career stages related to dendrochronology who will speak to why allyship is important and how they have worked to enact it within their own lives and careers ($\sim$30 minutes). This panel will include time for audience questions. Then, there will be a bystander intervention training that includes small group activities to help attendees learn and practice skills necessary to act as effective allies ($\sim$45 minutes). This training will ideally help address some of the problematic scenarios or explore the opportunities discussed in the panel. Finally, we will close with a small or large group session (depending on audience size) for final questions and reflections ($\sim$15 minutes).

Posters

Comparing riparian and non-riparian boreal black spruces for their responses to climate: a dendroisotopic analysis

Pauline Balducci

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:30

The objective of this study is to verify if stable isotopes (C, O) and growth series retrieved from black spruce trees (Picea mariana) growing on boreal lakeshores (riparians trees) show similar variations to those growing away from the shores (non-riparian trees). In NE Canada, riparian trees are particularly interesting because they eventually become lake subfossils, which form the main archives of hydro-climate conditions. However, the extent to which those riparian trees, growing in old-growth, humid environments, bear signals that are representative of regional growing / fractionation conditions, remains unclear. We studied 25 riparian and 15 non riparian trees. The sampling method permitted the construction of annually resolved d18O and d13C series with a replication of five trees per year between 1950 and 2015 for the two populations of trees. Our analysis of the linkages between selected climate variables and chronologies of ring widths and d13C values shows a similar response and a strong correlation between riparian and non-riparian trees. The trends in ci (intracellular concentration of CO2), and ci/ca ratios are similar between both populations. Also, both d18O and d13C present the same correlation with climatic variables, such as growing season maximum temperature. These results suggest that black spruce trees found in lakes are representative of the mechanisms of response to climate that predominate in boreal forests. Therefore, the proxy series from ancient riparian trees (now on lake floors or buried in sediments) should yield climate reconstructions that are illustrative of regional phenomena.

Tree-ring oxygen isotopes as an indicator of hydroclimate variation in eastern Amazon over the past century

Bruna Hornink

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Oxygen isotope ratios in tree rings (d18OTR) from Amazon forests have been shown to provide historical records of rainfall amounts at a large scale, due to the rainout of heavy isotopes during moisture transport. Here, we present a 110-year oxygen isotope record obtained from tree ring-cellulose of six Cedrela odorata trees (rbar = 0.57, EPS = 0.89) from the region of Tapajos River, Eastern Amazon. Our analysis indicates that d18OTR series reflects inter-annual variability of wet season (JFMAM) precipitation over Northeast Brazil, as indicated by HYSPLIT moisture trajectories and by correlations with regional precipitation (r = -0.66, p<0.0001) and trajectory mean accumulated rainfall at 3000 m (r = -0.86, p<0.001). The strongest correlation is observed with rainfall from March to May, which corresponds to the peak of precipitation over Northeast Brazil when the ITCZ reaches its southernmost positions. Spatial correlations of d18OTR with sea surface temperatures (SST) show association with the El Niño 3.4 region and Tropical North Atlantic SST. Historical droughts in Northeast Brazil are 90% represented by elevated d18OTR values, only a few years do not correspond to recorded droughts. This suggests that our d18OTR series may be used as a reliable record of historical droughts in Northeast Brazil over the past century. Grant 2017/50085-3, Sao Paulo Research Foundation (FAPESP).

Spatio-temporal analysis of soil moisture variations explains the tree-growth decline of multiple species in Mediterranean

Alvaro Gonzalez-Reyes

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Soil moisture (SM) is a crucial variable to the energy balance between the soil and the atmosphere. Given the lack of long-term instrumental SM measurements, information captured by satellites and climate reanalysis emerges as a useful tool. In the Mediterranean ecosystems of Chile (MC; 30°-36°S), several studies have reported a forest decline mainly associated with a persistent mega-drought (MD) during the last decade. We evaluated the main spatio-temporal patterns of tree growth during 1962-2015 performing a PCA and utilizing 35 tree-ring chronologies of 11 tree species growing across the MC. In addition, we study their relationships performing Pearson correlations with SM during 1980-2015 and from three sources (ESA-CCI, GLEAM v3.5, and the skin reservoir contained SRC ERA5-Land). Results show that PC1 explained 39% of the total variance of tree growth, while PC2 and PC3 capture 10% and 8%, respectively. PC1 captures a regional tree-growth signal and exhibits a decrease since 2007. The temporal relationships between PC1 and all SM products exhibited a significant strong relationship during the entire calendar year, reaching the highest values with GLEAM and SRC products. Significant correlation values between 0.4 to 0.9 were found with both products. Furthermore, correlations between -0.5 to 0.67 were recorded using SM ESA-CCI. A regional mean SM time series derived by the annual average of the GLEAM and SRC products covering the entire MC revealed a remarkable relationship with the PC1 of tree-growth (r=0.89). Our results suggest that SM is the main factor controlling the tree growth in multiple species in MC, and the current growth decline since the year 2007, is a response to the unusual SM decrease during the MD.

Re-evaluating Divergence in Western Canada

Emily Reid

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

The classic definition of the so-called “divergence problem” is a decoupling of temperature sensitive tree-ring chronologies from the instrumental record – expressed either as a loss or weakening in the inter-annual signal, or a divergence in trend in the recent period. Western Canada is one such area where divergence is ostensibly prevalent. However, recent observations using ring-width (RW) and latewood blue intensity (LWB) parameters challenge our views on divergence in this region: tree-ring parameter/climate response-change over time is much more complex than the traditional definition of this phenomenon suggests.

Tree-ring analyses using RW data from central (YUKcen) and south western Yukon (YUKsouth), and southern British Columbia (SBC) show that temporal instability in response to summer temperatures was found at lower frequencies, but it was not present at very high frequencies. However, the phenomenon is variable between regions. For unfiltered RW chronologies (detrended using age dependent splines), correlations with maximum temperatures are 0.22 (YUKcen), 0.35 (YUKsouth) and 0.35 (SBC). After first differencing, these correlations increase to 0.57, 0.67 and 0.55, respectively. For these regions using LWB chronologies, the unfiltered (1st differenced) correlations are 0.62 (0.70), 0.60 (0.70) and 0.62 (0.66). In our presentation, we will report time-varying climate response analyses which will detail that the problem with RW is not the inter-annual signal, but rather the low frequency signal, while LWB shows greater climate fidelity at all timescales. Ongoing research will explore these large scale coherent multidecadal and longer timescale trend differences in RW.

Sensitivity in annual growth of Midwestern conifers to multiple dimensions of winter and spring climate

Mara McPartland

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Anthropogenic climate warming is altering the ecosystem function of temperate and boreal forests. A number of studies have indicated a rise in overall ecological productivity due to a lengthening growing season, particularly into early spring. However, interactions between temperature and precipitation remain understudied with respect to their combined impacts on the responses of trees to warming in spring. Here, I examine the sensitivity of common Midwestern conifers to multiple dimensions of climate during the early growing season. I combine tree-ring chronologies, satellite observations, and daily climate records to examine relationships among early season weather, leaf-out phenology and annual growth rates. In multiple species of common Midwestern conifers growing across heterogeneous landforms, I found a universal sensitivity of annual tree-ring widths to both temperature and precipitation in winter and spring. My results suggest that the effects of warmer air temperatures may be offset if heavy precipitation suppresses soil temperatures and delays the onset of cambial activity. Amidst the recent pluvial affecting the Midwest region, the sensitivity of forests to warming air temperatures may be modified by the fraction of precipitation that falls as rain versus snow. These results underscore the competing pressures faced by forests to respond to dramatic recent changes in winter and spring climate.

Non-pooled oak stable isotopes reveal enhanced climate sensitivity compared to ring widths

Michal Rybnícek

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Multi-centennial to millennial-long oak ring width chronologies from living and relict wood are frequently used for climate reconstructions, but the amount of explained hydroclimatic variation remains relatively small. Although stable carbon and oxygen isotopic ratios (d13C and d18O values) in tree rings may offer enhanced climate sensitivity, our understanding of their paleoclimatic sensitivity is still limited by the general lack of well-replicated and high-resolution datasets. Here, we assess the temperature, precipitation and drought signal of annual d13C, d18O values and tree-ring width (TRW) measurements from 21 oaks that were growing under different ecological settings in the Czech Republic. Compared to the overall low climate sensitivity of TRW, the d13C and d18O chronologies reveal significant positive and negative correlations with March–August mean temperature and hydroclimate (p <0.051901-2018), respectively. Additional tests on the effect of sample size demonstrate robust climate sensitivity of the isotopic chronologies when non-pooled alpha cellulose from the latewood of at least six individual oaks was used. Our study suggests that oak stable isotopes are possibly the best high-resolution paleoclimatic proxy for the central European lowlands, as well as any other temperate habitat where the species has been used historically as construction timber, and where traditional tree-ring parameters, such as TRW, tend to fail.

Acknowledgements

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Elevation versus species effects in climate-growth relations in the Central Italian Alps

Nikolaus Obojes

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

To estimate the effects of a warmer and drier future climate on mountain forests, we analyzed the climate response of radial growth of five different conifer species along elevation transects between 1070 m and the forest line near 2400 m above sea level within an inner-alpine dry valley in the LTSER area Matsch—Mazia in Northern Italy. For additional information in growth processes and tree hydraulics automatic dendrometer measurements were used. As expected, we generally observed positive growth responses to temperature near the forest line and to precipitation at low elevation. However, water availability and extremely dry years surprisingly affected growth of Larix decidua and Picea abies up to 1800 m. On the other hand, Pinus nigra and Pinus sylvestris did not show a significant precipitation response at the lowest site, where their growth rate was constantly low. Near the forest line Pinus cembra benefited less from warming in the last 40 years than L. decidua, dendrometer measurements revealed that its growth was strictly limited by vapor pressure deficit. Overall, site elevation determined tree growth patterns, but within the same elevation species-specific differences were found, especially between L. decidua and the pine species, with P. abies in-between. Our results should contribute to a sustainable adaption of mountain forest management in the Alps to future climate conditions.

Introducing the North America Paleo-temperature Atlas, a Spatial Field Reconstruction of Warm Season Air Temperature

Karen Heeter

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Spatially-resolved climate field reconstructions are ideal for analyzing spatial anomaly patterns and characterizing regional-scale trends resultant from climate change. To date, few fine-scale, spatially-resolved paleotemperature datasets exist in the Northern Hemisphere. Here, we present a 2.5x2.5o temperature field reconstruction of warm season (April-August) mean surface air temperatures, developed from a network of 130 tree-ring chronologies. In the reconstruction's current form, statistical calibration and validation tests indicate that tree-ring predictors for each of the individual grid points provide robust, multi-centennial to multi-millennial length estimates of historical temperature variability across many parts of North America. Further, we identify areas of North America where more data are needed to improve both the spatial and temporal gaps in the coverage of the paleotemperature atlas. A completed paleotemperature atlas will allow us to examine and compare the historical presence, persistence, and modes of external forcings of trends in surface air temperatures, and it will improve our understanding of the spatiotemporal relationships between temperature and other climatic variables across North America. We highlight the importance of increasing the density of temperature-sensitive tree-ring predictors in North America by the creation of new collections, but we also strongly emphasize the utility of re-examining preexisting tree-ring collections using novel techniques such as blue intensity. As such, we propose network-wide collaboration of tree-ring researchers in order to improve this dataset for its optimum effectiveness and usage by the broader paleoclimate community.

Multi-species tree growth response to climate change in southwestern Germany

Philipp Römer

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Central Europe has been affected by unprecedented summer droughts in the 21st century, resulting in large-scale forest decline that has impacted many native tree species. Growth analyses of multiple tree species from mid to low elevation in Europe remain sparse, despite decades of dendroclimatological studies, and limit our understanding of how forests will evolve under changing climate conditions. Here, we introduce a new multi-species tree-ring width network of 65 individual sites (>2500 trees) from southwestern Germany and assess the climate sensitivity of major European species (Abies, Picea, Pinus, Pseudotsuga, and Quercus genera). Early spring temperature and mid-summer drought conditions were identified as regional climatic drivers of forest growth. The dense network also provides new in-sights into local- and species-specific climate-growth relationships and outlines a warming-induced shift in climate sensitivity towards greater water dependence at the end of the 20th century. Our findings highlight the usefulness of multi-species approaches in evaluating future changes to Central European forests and management strategies.

Tropical Dendroclimatology in Zambia: Brachystegia boehmii

Stockton Maxwell

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Dendroclimatology in the tropical forest regions has lagged behind the more temperate forested regions of the world because of the challenge of determining annual ring formation. Despite over 230 tropical tree species known to form annual rings, the ITRDB shows few published chronologies in tropical forests in Sub-Saharan Africa. As part of the first "Training in Tree-Ring Science and its Applications" workshop conducted in Kitwe, Zambia, our team explored the dendroclimatic potential of Brachystegia boehmii in the Miombo Woodland. Instrumental weather data is sparse for Zambia and extending records back in time requires interpolation from stations hundreds of kilometers away. To better place the present and future changes in climate in the context of past decades to centuries, we must develop annual proxies to model climate variables. Our work was guided by three research questions: 1) Does B. boehmii form annual rings?, 2) Do the tree ring crossdate within species at a single sampling location?, and 3) Do the annual ring widths correlate with monthly moisture variables like precipitation and drought? We collected two cores per tree from 20 trees. Our research indicates that B. boehmii does form annual rings with bands of terminal parenchyma but determination of ring boundaries can be difficult because of inter-annual banding. Crossdating samples at our site was difficult but possible. Our preliminary dating has 10 series with a series intercorrelation of 0.30. While this is low, correlations between trees indicates a common growth signal. Early analysis indicates that growing season precipitation is correlated with ring width. However, we expect this relationship will strengthen as we crossdate more samples.

Nitrogen Deposition and Tree Growth Have Declined Strongly at an Old Growth Temperate Boreal Ecotone Forest Since the Cl

Steven Voelker

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

To determine how trees of a temperate to boreal ecotone forest have responded to climate change and nitrogen deposition we investigated tree-ring growth and stable carbon isotope responses of sugar maple and white spruce at Turkey Lakes Watershed (TLW), in Ontario, Canada. Trees at TLW underwent a dramatic surge in age-adjusted tree basal area increment (¡U+0394¿BAI) between 1900 and 1970 and have declined thereafter. The early ¡U+0394¿BAI pulse was acutely expressed in sugar maples and white spruce whereas recent growth declines were less dramatic for spruce. Such a long growth pulse is inconsistent with disturbance dynamics. Dendroclimatic analyses of ring-width indices (RWI) demonstrated positive responses to warmer temperatures. Additionally, tree-ring carbon isotopes combined with leaf-level gas exchange measurements indicated stomatal conductance has declined only for sugar maples growing on wet sites during recent decades. Therefore, warming and drought stress has not been the primary cause of growth declines. For the years 1985 to 2016 maple RWI was positively related to precipitation, nitrate concentration, or wet deposition whereas spruce showed weak or even negative relationships. Across a longer timescale, 1900 to 2016, ¡U+0394¿BAI was linearly related to nitrogen oxide emissions from the United States for sugar maple growing on either wet or dry sites (r2 = 0.74 and 0.41, respectively) whereas for white spruce the growth response was sigmoidal, or saturating (r2 = 0.79). Overall, evidence points toward the growth pulse at TLW being primarily caused by increasing N deposition during much of the 20th century followed by a reversal in response to the U.S. Clean Air Act and its amendments after 1970.

Asynchronous phenologies of photosynthetic carbon assimilation and tree-growth in temperate oaks scaled from cells to sa

Mukund Palat Rao

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Photosynthesis and tree-growth are interconnected processes that are independently modulated by environmental variables. The lack of co-located high spatiotemporal resolution measurements of photosynthesis and growth has limited our understanding of their relationship with each other and their environment. Here, we study photosynthesis and tree-growth at near-instantaneous timescales using in-situ and satellite remote-remote sensing, point dendrometers, quantitative wood anatomy, and Pulse Amplitude Modulated chlorophyll fluorescence. Tree and leaf-level measurements are being made on eight oak (Quercus spp.) trees in a temperate forest in southern New York. Specifically, we will determine the periods of initiation and cessation of tree-growth, the periods of canopy development and senescence, and the attainment and loss of the full photosynthetic capacity. Preliminary data for 2021 suggests that oaks commenced radial growth in the first week of April approximately one-month prior to canopy development that was not completed until the first week of May. Further, the development of foliar photosynthetic capacity lags leaf expansion by nearly two weeks. This two-week lag between the completion of leaf expansion and subsequent development of photosynthetic capacity is not captured by conventional remote sensing metrics. Further, we find that oak growth for the season is completed by early August while high levels of photosynthetic activity are maintained for three additional months until early November. Finally, we show that oak tree-ring width network for the Northeastern US reflect these lag effects between photosynthetic carbon assimilation and tree-growth.

Upward recruitment patterns and Basal area increment (BAI) of Abies spectabilis (D. Don) Mirb. provide evidence of incre

Rajman Gupta

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Treeline migration on account of climate change have been reported from various forest ecosystem of the world. The Himalaya are no exception to this. Meteorological records from the western Himalaya, show increasing trend in mean annual temperature in the last century with rapid winter warming. The forest vegetation at the ecotone zone are sensitive to changes in climate variability having profound effects on species composition and diversity, recruitment pattern and altitudinal shifts. We carried out dendrochronological study to investigate the treeline migration and BAI in the treeline ecotone region at Tungnath, Uttarakhand, western Himalaya at an elevation of 3300 m asl. The tree cores (n=125) were collected from the dominant Abies spectabilis (Himalayan fir) and standardised. The response function analysis between ring-width index and climate variables (temperature and precipitation) shows temperature of the winter months are conducive for tree growth. Precipitation of previous year November and current year February is significant predictor of tree growth in the region. BAI shows increasing trend from 1950 AD to late 20th century. The treeline have been reported to have upward migration at $\sim$7.6 m per decade attributed largely due to increased temperature trend over the region. However, the shift rate fluctuates with altitudes and time period, it was $\sim$2.46 m/year between 1636 and 1715 AD, $\sim$3.95 m/year between 1715 and 1772 AD and 0.38 m/year between 1773 and 1907 AD. Presence of only few seedling shows poor regeneration of Himalayan fir at the treeline ecotone largely due to the increased changes in land use patterns for the last few decades and thus future monitoring for overall growth and survival is needed.

Compilation of recent oak tree-ring chronology for southwestern Ukraine

Irena Sochová

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Western Ukraine are largely forested, especially Transcarpatia with more than 50% of the land covered by forests. Despite this fact, Transcarpathian Ukraine belongs to the last European regions without a long and well replicated oak TRW chronology. The first step in compiling a new tree-ring width (TRW) chronology is to start with living trees; therefore, a new recent oak TRW chronology was assembled.

In this study, totally 336 oak samples from 16 oak forest stands and 1 sawmill from the Transcarpathian region have been collected and processed using standard dendrochronological methods. Samples were taken from sites with different altitudes, which ranged from 140 to 550 m a.s.l.

296 well cross-dated TRW series have been used to compile a new recent oak TRW chronology for Transcarpathian Ukraine. The TRW chronology is 185 years long and covers the period 1836–2020. The analysis of the number of sapwood rings has also been performed since this number changes depending on the latitude and longitude and is crucial for exact dendroarchaeological dating. The mean number of sapwood rings has been calculated to be 14, ranging from 5 to 27.

The next steps will be to extend this recent TRW chronology with tree-ring series from historic wooden constructions, especially wooden churches, of which there are many in the region. The future chronology will enable further dendroarchaeological studies as well as dendroclimatological studies in this region.

The paper was supported by the grant no. IGA-LDF-22-IP-004 (the Internal Grant Agency FFWT MENDELU) and by the project SustES – Adaptation strategies for sustainable ecosystem services and food security under adverse environmental conditions (CZ.02.1.01/0.0/0.0/16_019/0000797).

A dendroecological comparison of two Miombo woodlands under differing anthropogenic disturbances in Zambia

Nicole Zampieri

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

The Miombo woodlands of interior Africa are fire adapted ecosystems with a relatively open canopy dominated by Brachystegia spp., Julbernardia spp., and Isoberlina spp. These ecosystems are threatened due to deforestation, habitat fragmentation, and impacts from climate change, and in Zambia, they are further threatened by the rapidly growing mining industry which contributes to air pollution, contamination of soils and water, and land degradation. In this study, we used modified variable area transects to determine stand structure of an old-growth, unlogged, but fire-excluded Miombo woodland and at a degraded and recently logged Miombo woodland near Kitwe, Zambia. At the old growth woodland, we developed local chronologies for 10 species. The site was dominated by Julbernardia paniculata (2000+ stems/ha). Using establishment dates, we identified a significant shift in the species composition associated with fire exclusion. The degraded site was comprised of a monoculture of Albizia adianthifolia (3000+ stems/ha). Seedlings and juveniles had the highest densities (450-800 stems/ha). We were unable to develop a chronology for the species due to a lack of definitive annual ring boundaries. Our results describe the characteristics of two different degraded Miombo woodlands, showing how different anthropogenic disturbances (fire-exclusion vs. logging) lead to a transformation of the species composition and affect the trajectory of the ecosystem. Additionally, this research contributes to a growing body of chronologies for the African continent, the least sampled continent for dendrochronological research.

Why do trees grow older in the wet tropics?

Giuliano Locosselli

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

It has been shown that trees get older in the wet tropics, but the mechanisms behind this observation are still not clear. Literature shows that moisture could directly affect longevity by modulating physiological processes of trees. Other studies point to the potential role of water on tree size, which could indirectly affect longevity if one reconciles to the fact that the growth rate of tropical trees doesn't differ significantly between wet and dry sites. The third group points to the potential role of light competition in the understory of tallest tropical forests where trees may take decades to reach the canopy. Although these hypotheses are intrinsically linked, we evaluated the most critical mechanisms that result in long lifespans in the wet tropics using a tree-ring dataset of 22 population and 450 trees of Hymenaea spp. across South America. We used disturbance analysis to assess the age of the trees during major canopy or gap releases and tested the potential role of precipitation on tree longevity using Path Analysis. The oldest analyzed tree was 372 years old, and it only showed a major release at 237 years old and 34.1 cm of DBH in the tall forests of the eastern Amazon. The path analysis reveals that the direct effect of precipitation on tree longevity is rather weak as is the indirect effect of precipitation mediated by tree size. Still, precipitation significantly modulate canopy height and trees remain longer in understory of the tallest forests. The time to the canopy or gap release is then strongly associated with tree longevity at the site level. Thus, competition for light and the time spend in the understory seem to be the most critical mechanisms resulting in older trees in the wet tropics.

Was the 16th century temperature-fire-drought nexus foreshadowing for the Greater Yellowstone Ecosystem?

Grant Harley

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

As climate change continues at a rapid pace, compounding ecosystem disturbances are becoming an issue of global concern. The limits within which ecosystems operate are likely to be altered by catalytic, or compounding, disturbances, threatening their resilience. Positioned in the heart of the western US, the Greater Yellowstone ecosystem (GYE) is a well-studied and large wildland region dominated by conifer forests characterized by an infrequent, high-severity fire regime with return intervals ranging from 40 to 300 y. We present an annually-resolved, tree-ring based record of fire for the GYE that covers the past 1,801 years (220-2021 CE). The mean fire return interval of the reconstruction is 40 y, which is consistent with conventional fire frequency knowledge within lower-elevation, mixed-conifer forests of the GYE. We find fire activity was most frequent during the 16th century than during any other period in the past 1800 y. Further, we find remarkable agreement between our fire record and a group of independent GYE charcoal influx fire records derived from lacustrine sediments over the past ca. 1,000 y. The unprecedented fire activity captured during the 16th century is contemporary with a period of anomalously warm summer temperatures, severe drought conditions, and increases in sunspot activity, upper-level atmospheric pressure, and human population. These multiple, comprehensive lines of evidence suggest that summer temperatures, possibly initiated by increased geopotential height, acted as a catalyst during the 16th century for increased fire activity, which gives us historical context for trends in current fire-climate interactions.

Case study of a 536-years-old South American tree: biomass growth and carbon accumulation

Claudia Fontana

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Recent studies have shown that long-lived tropical trees are able to recover from senescence stages and maintain high rates of aboveground carbon and biomass accumulation throughout their life span. In this study, we present a tree-ring-based analysis to estimate the annual accumulation of aboveground biomass (AGB) and carbon (C-accumulation) of an Ocotea porosa tree over the last five centuries (1485–2016). The study site is located in southern Brazil, under a subtropical climate. AGB was estimated using a pantropical allometric equation, based on radial growth and intra-annual wood density (WD) measured by X-ray densitometry. The tree analyzed is estimated to be 536 years old, with a diameter of 220 cm (measured at a height of 2.23 m above the ground - environmental crime) and a total height of 23.9 m. Our estimate indicated a volume of 37.54 m^3, corresponding to 19.15 Mg (min=0.00/max=0.14 Mg) of AGB and 9.57 Mg (min=0.00/max=0.7 Mg) of C-accumulation. Wood density profile showed a linear increase in density during the first 200 years (WD=0.42 ±0.04 g/cm^3, r^2 =0.98), stabilizing at 0.51 ± 0.005 g/cm^3, after this period. This trend reflects low rates of AGB and C-accumulation in the first life-century and an increase in subsequent years. Analysis of increment rates indicates two cycles of maximum accumulation of AGB and C-accumulation. One occurred in the 18th century (up to ∼250th year) and the second over the 20th century, highlighting the 1940's. This study case suggests that old subtropical trees present growth plasticity, maintaining high rates of AGB and contributing to carbon stock in tropical forests. Further analyzes are in progress. Grant 2017/50085-3 and 2019/27110-7, Sao Paulo Research Foundation (FAPESP).

Fast recovery of Norway spruce trees after thinning from above on a drained peatland forest site

Katja Rinne-Garmston

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Continuous cover forestry (CCF) has been promoted as an environmentally sustainable option for drained peatlands. The CCF management has also been challenged due to potential lower tree growth compared to traditional even-aged management, especially with suppressed trees that are released during thinning. Our objective was to quantify the time lag of stem growth response after CCF thinning with suppressed Norway spruce trees. We also tested if carbon uptake of these trees increases immediately after thinning. We used tree increment cores from suppressed Norway spruce trees to estimate the impact of thinning from above on the delay and quantity of diameter growth and photosynthesis. The study was conducted in Lettosuo experimental site, where part of the stand was thinned according to CCF principles, and the other part was left as a control. We used d13C measurements to quantify how reduced between tree competition alters the photosynthetic rate and stomatal conductance ratio of sampled trees. Those sampled trees from the thinned area were then compared to those from the control area. Our results show that there was an average delay of 2 years with a moderate increase in the diameter increment of the suppressed trees after thinning, while during years 3 and 4 after thinning, the increase in the diameter was much greater. In contrast to that delay, we found that the photosynthetic rate increased immediately after thinning, as shown by the instant 2.5‰ change in d13C during the following summer.

Flood rings production modulated by river regulation in Eastern Boreal Canada

Alexandre Florent Nolin

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

In eastern boreal Canada, in the absence of long gauge records, changes in tree-ring anatomy of periodically flooded trees have allowed reconstruction of spring floods in natural rivers. This study analyzes the effect of regulation on the flood rings (FR) occurrence and on ring widths in Fraxinus nigra trees growing at 5 sites distributed along the Driftwood River floodplain to determine if a flood reconstruction using FR could be done in regulated rivers. Driftwood River was regulated by a dam in 1917 that was replaced at the same site in 1953. Ring width revealed little to no evidence of the impact of regulation, unlike the FR. Prior to 1917, high frequencies of well-defined FR were recorded during known floods, as indicated by significant correlations with reconstructed discharge of the nearby Harricana River. FR frequencies and intensities after 1917, and mostly after 1953, gradually decreased and were composed of weakly-defined FR, some corresponding to known floods, other years likely reflecting dam management. Strength of the correlations with Harricana River discharge also gradually decrease starting after 1917. At each site, trees in the upper floodplain recorded less frequent FR following 1917 and 1953 than shoreline trees, indicating that water level regulation limited floodplains' flooding. Compared to downstream of the dam, upstream sites recorded more FR in the post-dam period, highlighting the importance of considering the position of the site in the river continuum and relative to flood exposure during sampling. The results showed that sampling trees in multiple riparian stands and hydrological contexts at a far distance from dams could help disentangle the flooding signal from the dam management signal.

Integrating xylogenesis in carbon balance projections for boreal forests

Lucie Barbier

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Forest carbon (C) balance projections rely on models describing tree physiological processes to assess forest growth. The representation of C allocation and xylogenesis is still a source of uncertainty in these projections. The objective of this project is to improve boreal C balance projections by including explicitly tree C allocation and wood formation processes in modeling.

We will use xylogenesis monitoring data from micro-cores and dendrometers over two gradients. A longitudinal gradient, collected since 2000 on black spruce stands. An edaphic gradient including data for two growing seasons (2021-2022) for black spruce and jack pine on clay and sandy soils. An additional dataset contains measurements of ecosystem fluxes from flux tower sites in black spruce stands (2010-2015). All data was collected in Quebec, Canada and will be used to calibrate and validate the ecophysiological modeling of intra-annual forest C dynamics with MAIDEN, a model that simulates photosynthesis, phenology and allocation. We will use data-model fusion approaches and optimization algorithms to achieve this objective. A new module for xylogenesis will be implemented to model each step of wood cell formation and associated biomass accumulation.

This project will reduce uncertainties on growth and C responses of boreal trees to meteorological variability due to, for example, model assumptions of proportionality between stem biomass increase and girth increment. We will quantify how the environmental variability impacts xylogenesis with implication for the C balance at the stand scale. The new model for xylogenesis could also be integrated in land surface models to improve the representation of the C fluxes at the forest-atmosphere interface.

Wood anatomy to anticipate the silvicultural potential of future northern sugar maple forests

Ana Verhulst-Casanova

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Trait plasticity supports tree growth and survival in multiple environments and is important at the edges of species ranges, with limited tree growth. Xylem anatomical traits determine sap, nutrient flow and mechanical strength. Trait analysis can provide information on species adaptation to extreme climatic conditions. My project studies xylem anatomical traits over the distribution range of the sugar maple in Quebec, where it finds its northern limit. We intend to understand the links between environmental conditions and wood anatomy in northern populations to determine species adaptation to its environments. 17 sites were inventoried along north-south and east-west gradients from 2019 to 2021. 180 wood disks were sampled, corresponding to 6 trees per site. Wood cores will also be sampled to complete the data. The size, number and distribution patterns of wood conductive cells will be identified by using microscopy and image analysis. Measurements of wood density via X-ray densitometer techniques and wood fiber quality will help to characterize the evolution of wood quality along gradients. Field data will be investigated to describe the variability of wood anatomical traits along latitudinal and longitudinal gradients, link them to climate variations and understand the relationship with wood quality. We expect a higher variability of wood anatomical traits at the northern limit where the inter-annual environmental sensitivity should be higher. We also expect a decrease in fiber quality and wood density northward. Our results will allow determining how the species will respond to climate change at the northern edge and which environmental factor limits wood quality and maple growth in these current populations.

Impact of variable retention harvesting on carbon sequestration in a red pine plantation in southern Ontario

Michael Pisaric

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Forest management options aimed at mitigating the rate of increase in atmospheric concentrations of CO2, include thinning and partial harvesting to increase growth and carbon (C) capture of residual trees as a stand matures. Variable retention harvesting (VRH) can be used to increase forest growth rates and C sequestration, while enhancing biodiversity and resilience. Across southern Ontario, Canada, numerous plantations were established in the early 20th century on abandoned agricultural lands to stabilize soils, restore forest habitat, and produce wood products. Red pine (Pinus resinosa Ait.) was often planted because it grows rapidly and tolerates a variety of soil types. An 88-year-old red pine plantation was sampled to examine tree and stand level growth responses to different VRH treatments during a five-year pre- (2009–2013) and post-harvest (2014–2018) period. The treatments included: 33% and 55% aggregate retention, 33% and 55% dispersed retention, and an unharvested control. Stem radial growth and annual C increment were calculated for individual trees and at the stand level. At the tree level, growth and C increment increased under a dispersed retention pattern, regardless of the percentage of trees retained. At the stand level, total C increment was greatest at the higher retention levels and did not vary with retention pattern. The results suggest that retention level and pattern are important determinants of the mitigation potential of VRH. Where maximizing total stand C is a primary objective, higher retention levels should be considered. In comparison, a dispersed retention pattern can be used to maximize stem growth, C storage rate, and size of individual trees for use in long-lived wood products.

Tree rings and the colorful history of Beaver Island, Michigan

Matthew Bekker

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Beaver Island, Michigan was occupied by a religious sect led by James J. Strang from 1848-1856. Strang was crowned king of the group, but assassinated by disgruntled followers in 1856, whereupon local fishermen drove the “Strangites” off the island and reportedly took over or destroyed their buildings. Some of the structures from the Strangite period have known construction dates, while details for others are uncertain. We identified the species and cutting dates for logs in eight structures or ruins on the island to determine whether they were built during or after the expulsion of the Strangites, and whether more recent structures may have incorporated repurposed Strangite logs. We identified species based on wood anatomical characteristics, and compared floating chronologies by species and structure against regional ITRDB chronologies to determine cutting dates. The most common species varied by structure, including eastern hemlock (Tsuga canadensis), northern white-cedar (Thuja occidentalis), eastern white pine (Pinus strobus), and red pine (P. resinosa). Cutting dates also varied by structure; some were contemporaneous with the Strangites, some entirely post-dated their expulsion, and others included a range of cutting dates suggesting the use of repurposed timbers. This research adds to the allure of this isolated island, provides a more solid basis for historical preservation decisions, and contributes new tree-ring data for near-threatened eastern hemlock.

Intra- and inter-annual productivity of Betula glandulosa in Umiujaq, Nunavik (QC)

Camille Lepage

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

The main objective of this project is to quantify the increased productivity of Betula glandulosa Michx in Umiujaq, Nunavik, northern Quebec and evaluate how climatic and edaphic conditions influence this change. The speed at which climate change is affecting the northern ecosystems remains poorly understood and data are needed to anticipate future ecological and physiological trajectories of the vegetation. We produced a tree-ring chronology from approximately 40 specimens of Betula glandulosa collected from two well-drained and two poorly-drained sites (mineral and organic soils). Tree rings were made into thin sections using a sliding microtome, stained and mounted on slides for analysis under the microscope. The samples were photographed using a camera mounted on a microscope. In addition to ring widths, multiple anatomical variables were measured from the thin sections such as the vessel sizes and the lumen area. These analyses enabled us to determine the interannual variability of shrub productivity within two different drainage conditions. H2O and CO2 gas exchanges were also monitored (3 years) using an eddy covariance flux tower (GPP, ER, NEP, NEE, EVT) within the vicinity. These data are coupled with local hydrometeorological variables in order to describe intra-annual variations in shrub productivity. Preliminary results show a strong positive correlation between the samples from the same environment, as well as between the environments, suggesting that the shrub productivity in Umiujaq (QC) responds to the same climate variables.

Influence of Humans and Climatic Variability on Historic Wildfire Dynamics in Jasper National Park, Canada

Ze'ev Gedalof

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

We reconstructed wildfire history from fire-scars to detect the influences of climatic variability and land-use change on wildfire dynamics in the lodgepole pine (Pinus contorta var. latifolia Engelm.) forests of Jasper National Park in the Canadian Rocky Mountains. New original analyses were performed on 170 cross-section samples collected in the 1970s from 52 sites around Jasper, Alberta. The updated fire record reveals that fire occurrence was highly variable: site-level mean fire return intervals ranged from 4.9-52.5 years. Fire activity (i.e. fire size and frequency) decreased through time, with fire exclusion becoming widespread during the 1950s. Along with less fire activity on the landscape, there were also shifts in fire seasonality from mostly spring burns that were probably intentionally ignited by First Nations to summer fires that are probably caused by a combination of lightning and accidental ignitions (p<0.05). While most fires were localized and seemingly driven by topographic controls, the 18 widespread fires (events occurring across at least 10% of sites) were primarily driven by dry and warm climatic conditions, often associated with El Niño events. Large regional fires burned across almost all sites, although some remnant patches remained unburned, suggesting a historically mixed-severity fire regime. This fire history is distinct from an adjacent region, where there is very limited public access, where there have been almost no fires since ca. 1925. To be consistent with historic patterns, large-scale restoration via prescribed burning should be scheduled to promote a frequent, patchy, and mixed-severity wildfire regime.

An assessment of annularity in Sand live oak (Quercus virginiana) and Turkey oak (Quercus laevis) in central Florida

Ze'ev Gedalof

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

The Tiger Creek Preserve in central Florida has one of the highest concentrations of threatened and endangered plants and animals in the United States. Historically it was probably a longleaf pine savanna, but fire exclusion in recent decades has almost certainly led to increased basal area by mid-story oaks (mainly Quercus geminata and Q. laevis). Determining the date of establishment of these trees, as well as the early fire history of the site, would provide evidence to support appropriate management of this ecosystem as well as insights into how quickly these sites degrade in the absence of fire. Here we evaluate the annularity of these oaks from cross sections of Q. virginiana and Q. laevis collected from the Preserve using dendrochronological techniques. Cross sections from both species were scanned at high resolution and ring widths were cross-dated and measured by two groups working independently. Preliminary results suggest that Q. laevis produces annual rings reliably, and that the independent groups came to nearly identical results. Rings are present in Q. virginiana, but they are often difficult to discern and the annularity in this evergreen species growing at Tiger Creek is not yet clear. Fire scars are present in both species in the early portion of their growth, but not in recent decades. Growth climate analysis of Q. laevis will be undertaken.

Reconstructing Maximum flows using tree rings in Semiarid - Mediterranean climate transition of Chile

Ariel Muñoz

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Despite their potential benefits, streamflow reconstructions from tree-rings have not been widely used in water systems analysis because the flow is generally constructed at annual resolution, which may be too coarse for analysis of drought/flood vulnerability and decision making. In semi-arid regions of Chile there are very good relationships between these daily and annual flow, which is explained because within these regions, few hydrological events within a year explain most of the annual flow. The understanding of the long-term evolution of peak flows has direct effects on public works planning, since the design of all infrastructure associated with water (including dams, bridges, etc.) rely on a risk assessment calculated from flood return periods and the work's service life. Flood return periods are calculated from the streamflow maxima annual time series (i.e., one value per year). Unfortunately, instrumental records are often too short to make accurate estimation of flood recurrence intervals. In this context, we did the first streamflow reconstructions of maximum daily flow of the Limarí river in the semiarid climate, and the Petorca river in the Mediterranean region of Chile. The reconstructions explain the 59% and 52% of the total instrumental record variance, in both cases with good calibration and error statistics. These reconstructions are too short today, only 100 years, extending around 60 years the the instrumental records, but are not enough to compare the extreme return interval with the hydrological estimation. New tree-ring chronologies are been developing to solve this issue. We hope in the near future compare the new long-term records with the hydrological estimation to build infraestructure.

Trade-offs in productivity and drought resilience of five dominant tree species in the Central European temperate forest

Peter Marcis

Salle polyvalente (SH-4800), June 29th, 12:30 - 13:30

Increasing frequency of droughts strongly affect the available soil water. Lower water availability was often reported to reduce radial growth not only in climate-limited, but also in optimal areas of tree species distribution. Sampling strategies in dendrochronology focus on specific sites, often in climate-limited conditions. Using tree ring samples collected within National Forest Inventories provides an opportunity to assess growth-climate responses statistically representative of the great variability in environmental conditions. A total of 859 tree ring cores from 5 dominant tree species of European temperate forests (Norway spruce, silver fir, Scots pine, European beech and sessile oak) were collected during the 2015 - 2016 cycle of the Slovak National Forest Inventory. To quantify the drought events, we used SPI of spring and summer period derived from CRU climate database. The results indicated a significant inter- and intra-specific variability in growth-climate responses across the environmental gradients. In addition, a difference in the radial increment recovery period was found between the species.

Intra-annual isotopes for water management in the Metropolitan Area of Sao Paulo / Brazil

Giuliano Locosselli

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Water scarcity is a major 21st century challenge that is increasing the vulnerability of the human population, especially in cities. Water risk assessment is a fundamental task in many cities worldwide that often lack long-term and spatially-resolved records of precipitation and level of water reservoirs. Past rainfall and reservoirs levels may be alternatively assessed using tree-ring stable isotopes of urban trees. We assessed the past variability of precipitation and reservoirs level through the intra-annual variation of the stable isotopes in the tree rings of Tipuana tipu (Fabaceae) across the Metropolitan Area of São Paulo (MASP). All tree rings were divided into 10 parts with similar weight and not width as commonly employed in the literature, and the intra-annual isotope series were then synchronized among individuals before any analyses. The results show a strong association between the synchronized intra-annual oxygen isotopes and the precipitation levels both in the North and South of the MASP. The drought during the summer of 2013/2014 that impacted the water supply in the city is clearly recorded in the intra-annual oxygen isotope series. Because of this strong association, we observed high correlation values between the oxygen isotopes from the middle of the tree ring and the volume of the main water reservoirs that supply the city ($r = -0.94$ and $r = -0.90$ in the North and South of the MASP, respectively). Thus, intra-annual tree-ring isotopes may be considered a valuable source of high-resolution past information of water resources that may leverage informed decision-making in the cities.

Hydroclimate and ENSO Variability Recorded by Oxygen Isotopes From Tree Rings in the South American Altiplano

Milagros Rodriguez-Caton

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Hydroclimate variability in tropical South America is strongly regulated by the South American Summer Monsoon (SASM). However, past precipitation changes are poorly constrained due to limited observations and high-resolution paleoproxies. We found that summer precipitation and the El Niño-Southern Oscillation tarapacana (ENSO) in the Chilean variability and Bolivian are well registered Altiplano in in tree-ring the Central stable Andes oxygen (18–22°S, isotopes 4,500 (d18OTR) m a.s.l.) of Polylepis with the northern forests having the strongest climate signal. More enriched d18OTR values were found at the southern sites likely due to the increasing aridity toward the southwest of the Altiplano. The climate signal of P. tarapacana d18OTR is the combined result of moisture transported from the Amazon Basin, modulated by the SASM, ENSO, and local evaporation, and emerges as a novel tree-ring climate proxy for the southern tropical Andes.

Progress in developing tree-ring growth and stable isotope records of extreme winter climate anomalies across North America

Steven Voelker, Victor Humanes Fuente

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Trees do not grow during winter where freezing temperatures occur regularly. Therefore, much of what has been learned from tree-ring data about variability in Earth's climate is driven by summer conditions. To investigate winter climate and atmospheric circulation over North America, we employ a multi-proxy approach. First, we use earlywood carbon and oxygen stable isotopes of trees growing adjacent to Lake Superior to capture the climate memory embodied by this inland sea. Indeed, previous research suggests that Lake Superior winter climate is linked to a seesawing pattern of high-pressure ridge and low-pressure trough from western to eastern North America. Winter conditions from western North America are based on updated ring-width records of blue oaks growing in California, which are one of the strongest proxies for winter precipitation anywhere on Earth. This multi-proxy approach explains 50 to 70% of the inter-annual variation in what we term the North American winter circulation "dipole index". The dipole index, the strength of which strongly influences weather patterns over much of North America, is the winter-mean difference between the geopotential height eddies located at the stationary wave peak locations for the North Pacific High (i.e., Gulf of Alaska) and the Hudson Bay Low. Here we discuss progress in constructing the long chronologies from both regions. Second, we demonstrate how the locations of these different climate proxies, both around the perimeter of Lake Superior and across the extent of blue oak in California, determines their collective ability to accurately predict dipole index variability and the past winter extreme weather it suggests.

Intra-annual relationships between d13C ratios and xylogenesis for Black Spruce (Eastern North America)

Sepideh Namvar

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

The use of stable isotope proxies in combination with tree-ring parameters has become a well-established tool to unravel plants' responses to a changing environment. However, while there have been many studies on intra-annual wood formation processes, the specific details of the fractionation of stable isotopes in high-resolution time scales -knowing the exact date of fractionation- remain unknown. Such a time scale mismatch, provides obstacles to investigate the timing, sensitivity and interactions among important ecophysiological processes (e.g., photosynthesis, stomatal conductance) that drive responses over shorter time scales. Consequently, process-based modeling remains poorly constrained, casting important uncertainties on the prediction of forest responses to meteorological variability. Here, we circumvent this difficulty by analysing weekly wood anatomical features jointly with carbon stable isotope fractionation (d13C), measured on black spruce (Picea mariana) trees, in eastern Canada, during two consecutive growing seasons (2020 and 2021). The results illustrate a positive correlation between weekly fractionation of d13C and cell production (number of cells per week), showing a rising trend from the beginning to the end of the growing season. There is also a positive correlation between cell wall thickness and fractionation of d13C during the growing season. Both of these correlations indicate that fractionation of d13C may be a good proxy for intra-annual, photosynthesis-driven variations in tree productivity during the growing season. These results may also help to improve modelling of the ecophysiological response of black spruce forests in the context of climate variability.

The unknown third - the exploring the climatic and non-climatic signals in hydrogen isotopes in tree-ring cellulose

Valentina Vitali

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Stable carbon (d13Cc) and oxygen (d18Oc) isotopes in tree-ring cellulose, and tree-ring width (TRW), have been used extensively to investigate the effects of climate on tree growth. By contrast, the information recorded by the non-exchangeable carbon-bound hydrogen (d2Hc) isotopes, has been far less explored.

To create a comprehensive assessment of d2H potential as a proxy for climate, hydrology, plant metabolism, and physiology we explored its relationships with climate and TRW in 100-years chronologies from two major genera (Pinus and Quercus) across a European gradient.

The climate correlation of d2Hc in the high-frequency chronologies showed a weaker climate signal compared to the d13Cc and d18Oc strong continental-scale correlations with climate. The d2Hc climate signal strength varied largely between sites and was stronger and more consistent for Pinus than for Quercus. Focusing on years with extremely dry summer conditions, we observed a significant 2H-enrichment in tree-ring cellulose for both genera. Our findings indicate that d2Hc does record information about hydrology and climate, but also changes in physiological mechanisms.

To disentangle the climatic and non-climatic signals in d2Hc, we investigated its relationships with TRW, which were negative in precipitation- and light-limited sites, while temperature-limited sites showed positive a one, suggesting that different stress conditions may trigger a differential use of carbon assimilates for wood formation.

Advancements in the understanding of 2H-fractionations and their relationships with climate, physiology, and species-specific traits are needed to improve the mechanistic modeling and interpretation of past plant physiology.

Big sagebrush growth and carbon isotope responses to climate are modified by topography and harvester ant mounds

Steven Voelker

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Here we report shrub-ring isotope records for big sagebrush (Artemisia tridentata) from below the “reverse treeline” in central Utah, USA. Despite sectorial growth, ring-widths of mature plants (age range 9 to 54 years) cross-dated well. Plants were sampled in upland locations (controls) as well as adjacent to mounds (circular patches of denuded soil approximately five m diameter) made by harvester ants (Pogonomyrmex occidentalis) and in swale locations where water drains during monsoon rainfall. For each of the three location types ring-width index (RWI) and carbon isotope discrimination (¡U+0394¿13C) chronologies were constructed for the years 1989-2018. For each of the three habitats ring-width indices were significantly correlated with summed Spring and monsoon period precipitation (r = 0.42). ¡U+0394¿13C chronologies were strongly influenced by precipitation summed across the previous November to June (r = 0.80) as well as May to July average vapor pressure deficit (r = -0.75). Unlike ring-widths, ¡U+0394¿13C was not related to summer monsoon precipitation (0.09 = r =-0.04), indicating water used to support leaf gas exchange was from deep soil layers. Basal area increment of plants that grew adjacent to ant mounds or in swales grew 35% and 61% faster than controls, respectively. Likewise, the 30-year trend in intrinsic water use efficiency (iWUE) was 0.98 µmol CO2 mol H2O-1 yr-1 for controls, but only 0.65 and .60 for and mound or swale sagebrush, respectively. Differences in iWUE between controls and mound or swale sagebrush were greatest during the driest years, indicative of ant mounds and swales providing summer moisture subsidies to sagebrush when the ongoing Megadrought across the Southwestern US has been most severe.

Changing inflow at Dez dam (Iran) and implications for irrigation and hydropower generation

Salman Sharifazari, Philippa Higgins

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:30

Long-term streamflow records are essential for water resources management in semi-arid regions. However, the shortness of instrumental records in Iran and the limited availability of the regional paleoclimate proxies to extend these records back in time hinder our understanding of hydrologic variability. Here, we used the annually resolved tree-ring chronologies from neighboring countries to present the first multi-centennial ($\sim$500 years) streamflow reconstruction for the Dez catchment, southwestern Iran, to help understand natural streamflow variability. The Hierarchical Bayesian Regression (HBR) model accompanied by the parsimonious predictor selection method was used to derive the most robust model output. The selection method retained 27 precipitation-sensitive tree-ring chronologies, mainly from regions with similar hydroclimate features to the Dez River catchment. The resulting reconstruction of the lower gauge station accounts for 62% of the variance in streamflow observations, closely matching known historical events and other regional reconstructions. Of particular interest is the recurrence pattern of extreme flow events. Floods were more frequent than low flow extremes (i.e. resembling droughts) during much of the 18th and early 19th centuries. In contrast, droughts were more frequent during the early 17th century. Worryingly, both flood and drought hazards have increased simultaneously from the beginning of the twentieth century.

Dendrochronological Study on Pinus roxburghii Growth Resilience with Changing Climate Conditions in Lesser Himalayas, Pakistan

Mehvish Majeed

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

In the last few decades, natural disturbances and human activities intensified the negative impact on the forest cover on a global scale. The impact of climate change on species distribution and structure, population dynamics, and growing conditions are more prominent now than ever before. To understand the impact of these extreme climate events on the forests, the tree growth resilience approach has been used significantly. This concept has been widely adopted in tree ring studies to analyze the ability of certain tree species to retain pre-disturbance growth levels after the disturbances. Forest is a long-lived ecosystem providing essential services and the productivity and these services are influenced by the climatic and non-climatic conditions the assessment of these influencing factors can help for better forest management. This study aims to reconstruct the past climate conditions and investigate the impact on the growth resilience of Pinus roxburghii in the lesser Himalayan region in Pakistan at different elevations on a temporal scale. The dendrochronological data generated from the study will assist in scientific efforts to further understand the ecological role of temperature, precipitation, and fire to imply better sustainable management practices and growth dynamics of the Pinus roxburghii forest. The future climate trend and the impact on tree growth outcomes, if used by forest managers, will be very helpful to improve the productivity of the forest.

A clarion call from a fading record– tree-rings, fire-scars, and restoration implications for central Appalachian red pine (Pinus resinosa Ait.) forest communities

Joseph Marschall

Salle polyvalente (SH-4800), June 29th, 12:30 - 14:00

Fire-dependent red pine (Pinus resinosa Ait .) vegetation communities in the central Appalachians face significant threats from mounting land-use and climate change pressures. Tree-ring and fire-scar chronologies developed from living and remnant (stumps, snags) red pine trees can provide critical historical ecology information to guide modern restoration of fire-adapted vegetation communities. Here, we present tree-ring and fire-scar records recovered from red pine trees (n= 267) covering the time period of 1370-2016 CE from a landscape in north-central Pennsylvania, USA, and discuss the clear call to restoration they provide. Dated fire scars show that fire was an important ecological component of this landscape prior to when fire exclusion practices were widely adopted circa 1915, and that the current period of reduced fire activity is unprecedented in at least the previous 500 years. Beyond fire scars, the spatial and temporal extent of the red pine tree-ring record provides evidence that red pine was historically a more important component of this landscape than it is today. The conservation and perpetuation of central Appalachian red pine vegetation communities will require incorporating recurring prescribed fire into their management.

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