Snapshots from ecohydrology and ecosystem modeling at Luke

Samuli Launiainen

Team: J-P Nousu, Kersti Leppä, Olli-Pekka Tikkasalo, Toprak Aslan, Pavel Alekseychik, Leena Stenberg, Aura Salmivaara, Katja Rinne-Garmston et co.

Who?

PhD meteorology (UH, 2004-2010)

- Forest-atm interactions, EC, turbulence, canopy models

Senior Researcher (Metla, 2010-2015)

- Forest hydrologist, environmental impacts

Academy Res. Fellow (Luke, 2016-2021)

- Moss layer into ecosystem models

Principal Researcher (Luke 2021-)

- Ecohydrology in a broad sense

Ecohydrologist & ecosystem modeler

Tellus (2008), 60B, 167–178
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TELLUS

H_2O and CO_2 fluxes at the floor of a boreal pine forest

By LIISA KULMALA[1*], SAMULI LAUNIAINEN[2], JUKKA PUMPANEN[1], HARRY LANKREIJER[3], ANDERS LINDROTH[3], PERTTI HARI[1] and TIMO VESALA[2], [1]Department of Forest Ecology, P.O. Box 27, FIN-00014, University of Helsinki, Finland; [2]Department of Physical Sciences, P.O. Box 64, FIN-00014, University of Helsinki, Finland; [3]Department of Physical Geography and Ecosystem Analysis, Lund University, Sölvegatan 12, 223 62, Lund, Sweden

AMBIO
DOI 10.1007/s13280-013-0380-z
KUNGL. VETENSKAPS-AKADEMIEN
REVIEW

Is the Water Footprint an Appropriate Tool for Forestry and Forest Products: The Fennoscandian Case

Samuli Launiainen, Martyn N. Futter, David Ellison, Nicholas Clarke, Leena Finér, Lars Högbom, Ari Laurén, Eva Ring

Forest Ecology and Management 304 (2013) 482–491
Contents lists available at SciVerse ScienceDirect
Forest Ecology and Management
journal homepage: www.elsevier.com/locate/foreco
ELSEVIER
Full length article

Effects of clear-cutting on annual and seasonal runoff from a boreal forest catchment in eastern Finland

Jun'ichiro Ide*, Leena Finér, Ari Laurén, Sirpa Piirainen, Samuli Launiainen

Global Change Biology
Global Change Biology (2016), doi: 10.1111/gcb.13497

Do the energy fluxes and surface conductance of boreal coniferous forests in Europe scale with leaf area?

SAMULI LAUNIAINEN[1], GABRIEL G. KATUL[2], PASI KOLARI[3], ANDERS LINDROTH[4], ANNALEA LOHILA[5], MIKA AURELA[5], ANDREJ VARLAGIN[6], ACHIM GRELLE[7] and TIMO VESALA[3,8]

Agricultural and Forest Meteorology 295 (2020) 108198
Contents lists available at ScienceDirect
Agricultural and Forest Meteorology
journal homepage: www.elsevier.com/locate/agrformet
ELSEVIER

Vegetation controls of water and energy balance of a drained peatland forest: Responses to alternative harvesting practices

Kersti Leppä, Mika Korkiakoski, Mika Nieminen, Raija Laiho, Juha-Pekka Hotanen, Antti-Jussi Kieloaho, Leila Korpela, Tuomas Laurila, Annalea Lohila, Kari Minkkinen, Raisa Mäkipää, Paavo Ojanen, Meeri Pearson, Timo Penttilä, Juha-Pekka Tuovinen, Samuli Launiainen

AGU100 ADVANCING EARTH AND SPACE SCIENCE
JGR
Journal of Geophysical Research: Biogeosciences
RESEARCH ARTICLE
10.1029/2018JG004491

Modeling the Effect of Moss Cover on Soil Temperature and Carbon Fluxes at a Tundra Site in Northeastern Siberia

Hotaek Park[1,2], Samuli Launiainen[3], Pavel Y. Konstantinov[4], Yoshihiro Iijima[5], and Alexander N. Fedorov[4]

Key Points:
- Assessing the influences of moss cover on soil temperature, active

Hydrol. Earth Syst. Sci., 23, 3457–3480, 2019
https://doi.org/10.5194/hess-23-3457-2019

Hydrology and Earth System Sciences
EGU

Modeling boreal forest evapotranspiration and water balance at stand and catchment scales: a spatial approach

Samuli Launiainen[1], Mingfu Guan[2,1], Aura Salmivaara[1], and Antti-Jussi Kieloaho[1]
[1]Natural Resources Institute Finland, Latokartanonkaari 9, 00790 Helsinki, Finland

Forestry An International Journal of Forest Research
Institute of Chartered Foresters
Forestry 2020; 1–13, doi:10.1093/forestry/cpaa010

Towards dynamic forest trafficability prediction using open spatial data, hydrological modelling and sensor technology

Aura Salmivaara[1,*], Samuli Launiainen[1], Jari Perttunen[1], Paavo Nevalainen[2], Jonne Pohjankukka[2], Jari Ala-Ilomäki[1], Matti Sirén[1], Ari Laurén[3], Sakari Tuominen[1], Jori Uusitalo[4], Tapio Pahikkala[2], Jukka Heikkonen[2] and Leena Finér[3]

The Cryosphere, 18, 231–263, 2024
https://doi.org/10.5194/tc-18-231-2024

The Cryosphere
EGU

Modeling snowpack dynamics and surface energy budget in boreal and subarctic peatlands and forests

Jari-Pekka Nousu[1,2,3], Matthieu Lafaysse[2], Giulia Mazzotti[2], Pertti Ala-aho[1], Hannu Marttila[1], Bertrand Cluzet[4], Mika Aurela[5], Annalea Lohila[5,6], Pasi Kolari[6], Aaron Boone[7], Mathieu Fructus[2], and Samuli Launiainen[3]

forests
MDPI
Article

NutSpaFHy—A Distributed Nutrient Balance Model to Predict Nutrient Export from Managed Boreal Headwater Catchments

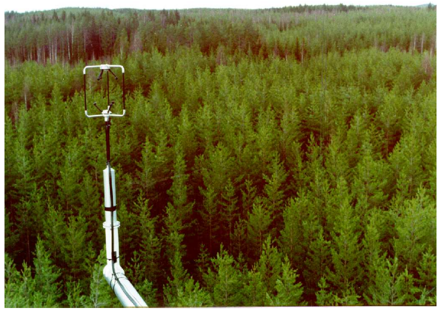
Annamari (Ari) Lauren[1,*], Mingfu Guan[2], Aura Salmivaara[3,†], Antti Leinonen[4,†], Marjo Palviainen[5,†] and Samuli Launiainen[3]

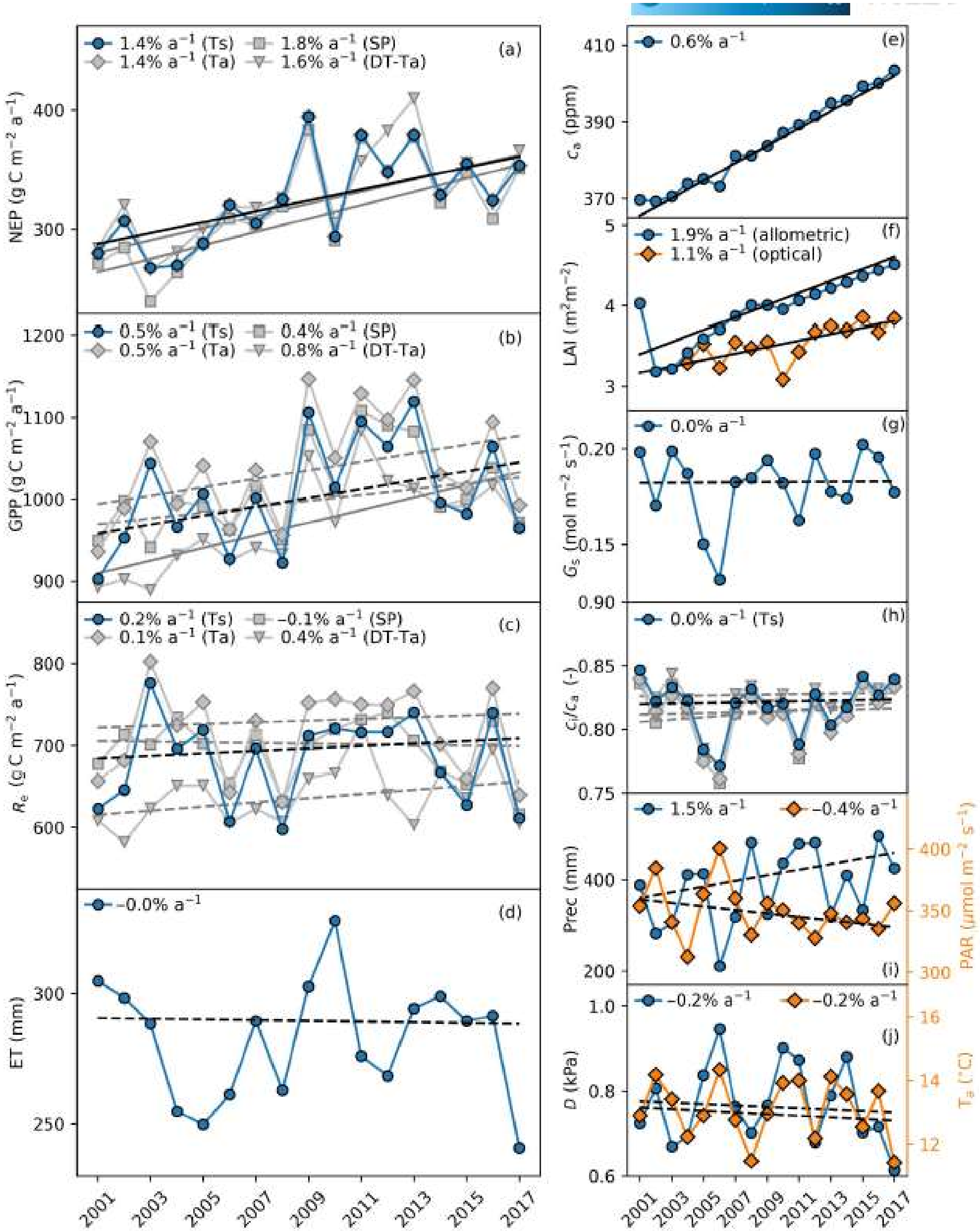
Why C sink increases at Hyytiälä?

NEP = - NEE increasing (+1.4 – 1.8% a-1)

- Due to increasing GPP (+0.4 – 0.8 % a-1)
- GPP trend resembles that of CO2

- No statistically significant change in Re
- No change in ET
- Statistically insignificant increase in WUE & LUE





Multiple factors can explain increasing GPP

GPP = f(light, CO2, T, water availability, amount of biomass, …)

Atmospheric CO2 increase (+0.8 %a-1)
- More food available

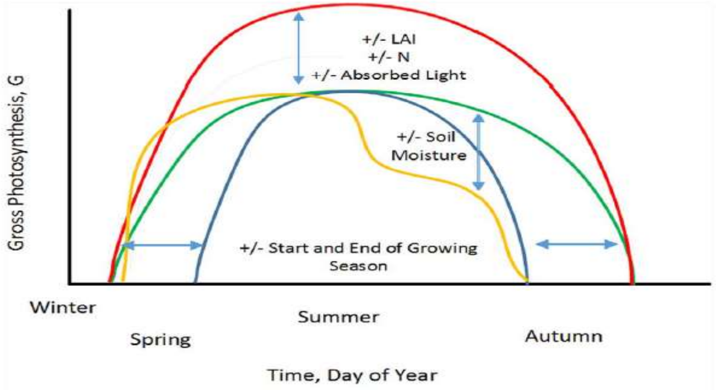
Longer growing seasons (yes, spring advance, p>0.05)
- More time for breakfast and supper

Increasing diffuse radiation (yes, p>0.1)
- Leaves deeper can eat more

Increasing leaf nitrogen content (yes)
- hungrier leaves

Increasing biomass and LAI (+1.1 – 1.9 %a-1)
- More leaves at the dinner table

Changing footprint (inevitably)
- The part of forest seen by EC gets smaller as trees get taller



Baldocchi et al. 2018. Agr. For. Met

- All can occur simultaneously (and likely are)
- Importance depends on timescale and env. conditions

Trends – when?

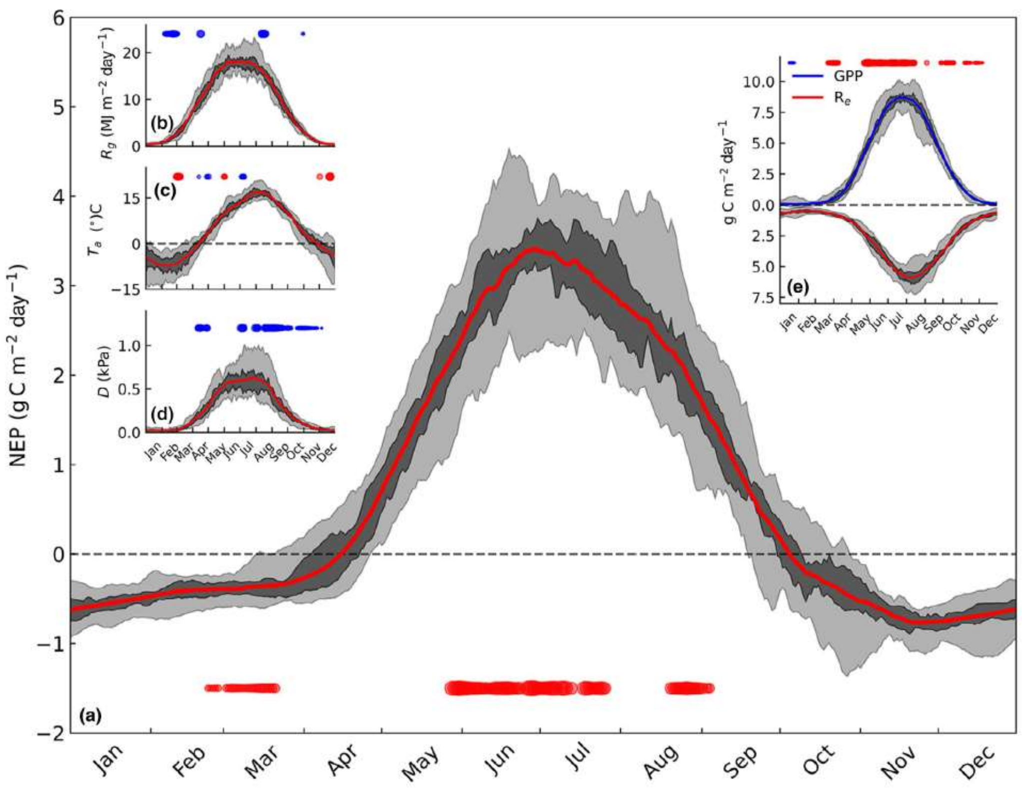


FIGURE 1 Seasonal patterns of net ecosystem productivity (NEP), gross primary productivity (GPP), and ecosystem respiration (R_e) and environmental conditions in 2001–2017. The lines show 31-day moving average, dark shades are 25/75th percentiles, and light shade are the entire variability range. In each panel, positive/negative trends ($p < .1$) are shown by red/blue circles, respectively. The size is relative to maximum absolute trend value. The R_e trends were all nonsignificant

Drivers?

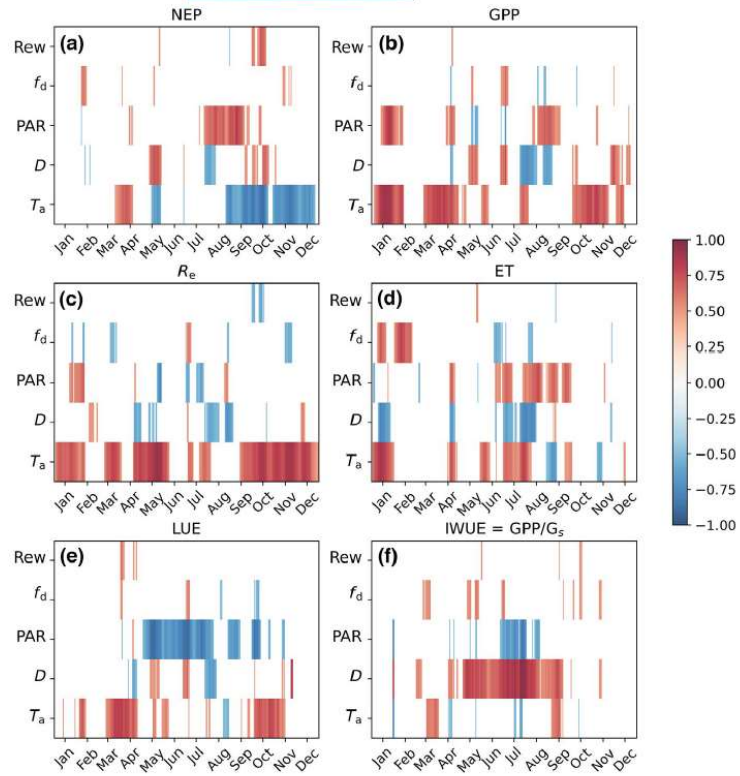


FIGURE 2 Partial correlation coefficients (r_p) between net ecosystem productivity (NEP) (a), gross primary productivity (GPP) (b), R_e (c), evapotranspiration (ET) (d), light-use efficiency (LUE, e) and intrinsic water-use efficiency (IWUE, f), and their potential environmental drivers. T_a air temperature, D vapor pressure deficit, PAR photosynthetically active radiation, f_d its diffuse fraction, Rew plant available water. The colors show marginally significant correlations ($p < .1$, corresponding to $|r_p| > 0.41$ for 17-year timeseries) in monthly window

Pearson correlation in 30-day moving window

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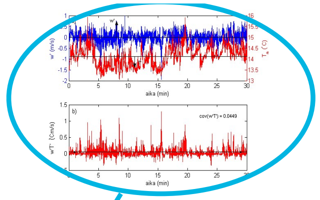
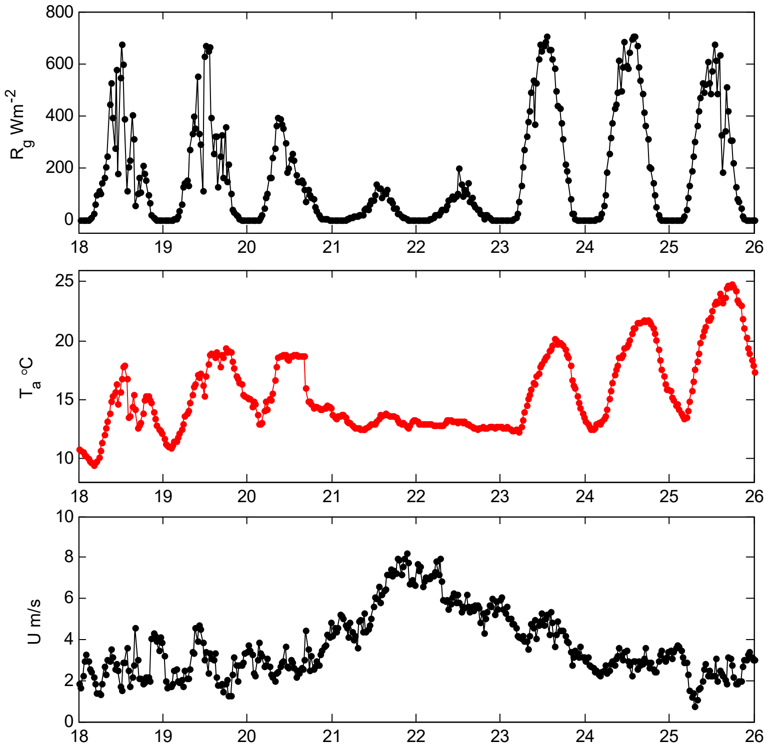
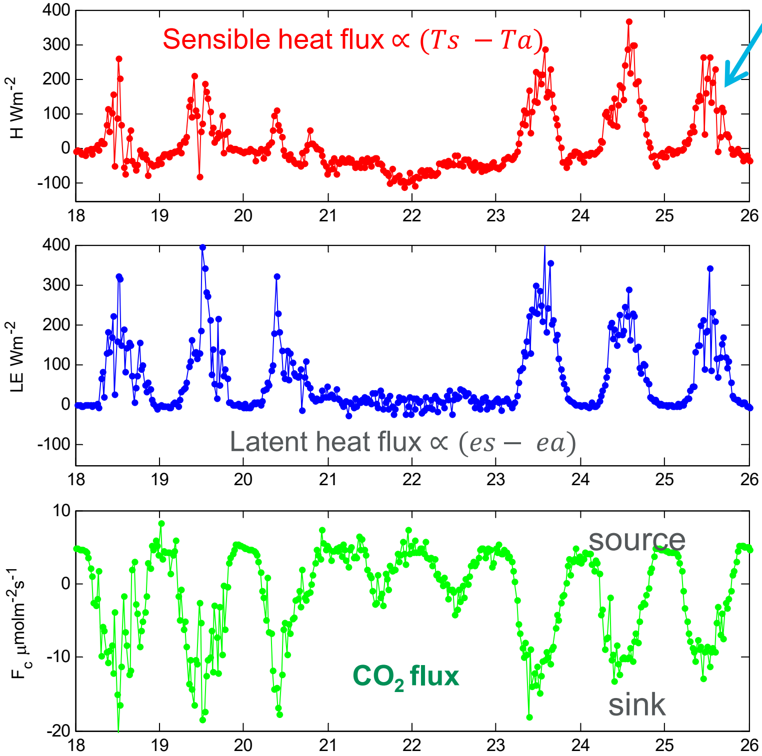


Environmental conditions



Day in July 2008

Ecosystem – atmosphere fluxes



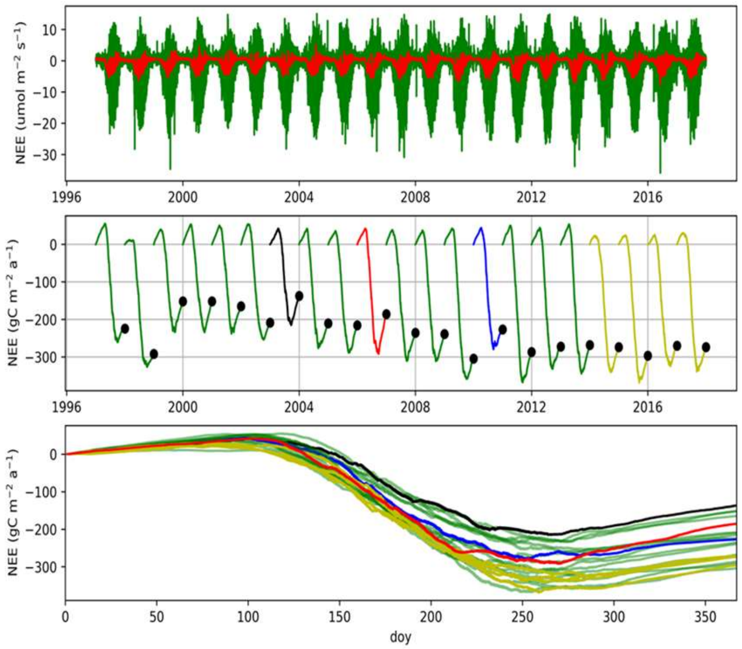
Day in July 2008

Short-term responses 'well' understood. Effects of extreme conditions, acclimation and delayed impacts not

Annual carbon balance = time-integrated NEE

- Numerous pathways to same annual balance
  - Processes non-linear
  - Strong seasonality
  - Compensatory periods

- Trends are weak compared to uncertainty
- Average environmental variables not relevant to explain or model inter-annual variability
- Standard statistical methods not necessarily meaningful



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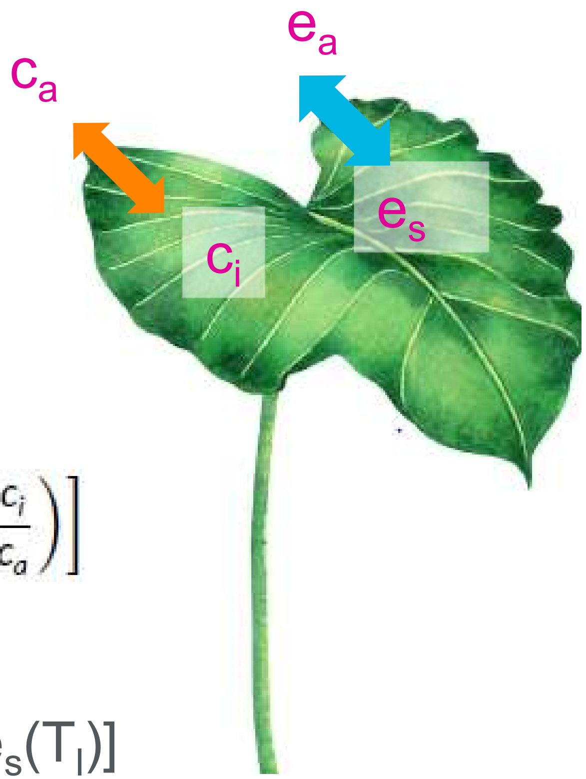
Ecosystem as a big leaf



$$A_n = g_s (c_a - c_i)$$
$$= c_a g_s (1 - c_i/c_a)$$

$$GPP = LAI \left[c_a g_s \left(1 - \frac{c_i}{c_a} \right) \right]$$

$$T_r = 1.6 g_s [e_a - e_s(T_l)]$$

$$ET = 1.6\, g_s\, LAI\, D + E,$$

light, T, VPD, water
plant traits
canopy structure

How trends will change GPP & ET?

$$\mathrm{GPP} = \mathrm{LAI}\left[c_a\, g_s \left(1 - \frac{c_i}{c_a}\right)\right]. \qquad (1)$$

Using a first-order Taylor series expansion, the relative changes in GPP can be expressed and interpreted as

+ + ?

$$\frac{\delta \mathrm{GPP}}{\mathrm{GPP}} = \underbrace{\left[\frac{\delta c_a}{c_a}\right]}_{\text{fertilization}} + \underbrace{\left[\frac{\delta \mathrm{LAI}}{\mathrm{LAI}}\right]}_{\text{structural}} + \underbrace{\left[\frac{\delta g_s}{g_s} + \frac{\delta\left(1 - c_i/c_a\right)}{1 - c_i/c_a}\right]}_{\text{physiological}}, \qquad (2)$$

$$\frac{\delta \mathrm{ET}}{\mathrm{ET}} = \left[\frac{\delta \mathrm{LAI}}{\mathrm{LAI}} + \frac{\delta D}{D} + \frac{\delta g_s}{g_s}\right] + \frac{\delta \mathrm{E}}{\mathrm{E}}$$
$$= \left[\frac{\delta \mathrm{GPP}}{\mathrm{GPP}} + \frac{\delta D}{D} - \frac{\delta c_a}{c_a} - \frac{\delta\left(1 - c_i/c_a\right)}{1 - c_i/c_a}\right] + \frac{\delta \mathrm{E}}{\mathrm{E}}, \qquad (6)$$

\+ + - ? ?

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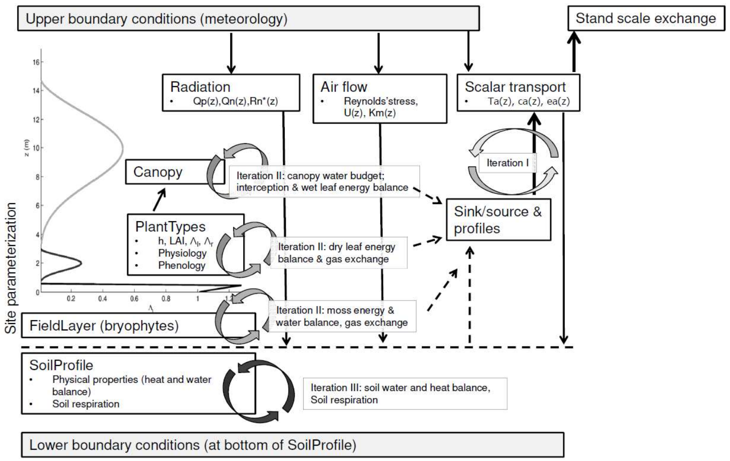
External forcings

$$X(t_0) = [x_1(t_0) \\ x_2(t_0) \\ \ldots \\ x_n(t_0)]$$

pyAPES

Processes ~ functions
System components = sub-models
Parameters ~ properties; depend on current conditions and/or history
States ~ model state variables; depend on history



Fluxes between system and the environment

$$Y(t_0) = [y_1(t_0) \\ y_2(t_0) \\ \ldots \\ y_m(t_0)]$$

GPP, ET & partitioning
LUE = GPP/Par
WUE = GPP/ET
IWUE = GPP / Gc

Launiainen et al. 2015. Ecol. Mod; 2016 Global Change Biol.
Leppä et al., 2020. Agric. For. Met

Luke NATURAL RESOURCES INSTITUTE FINLAND affect model parameters

External inputs X_n change

Numerical experiment, factorial design

- LAI + CO2 + Nleaf + Met
- LAI + CO2 + Met
- LAI + Nleaf + Met
- CO2 + Nleaf + Met
- LAI + Met ← observed LAI trend
- CO2 + Met ← observed CO2 trend
- Nleaf + Met ← Vcmax, Jmax, etc. = f(Nleaf)
- Met ← meteorological forcing (light, VPD, T, …). Constant CO2

- *Crank through number of runs*
- *Analyze trends and compare to observed*
- *Interpret findings*

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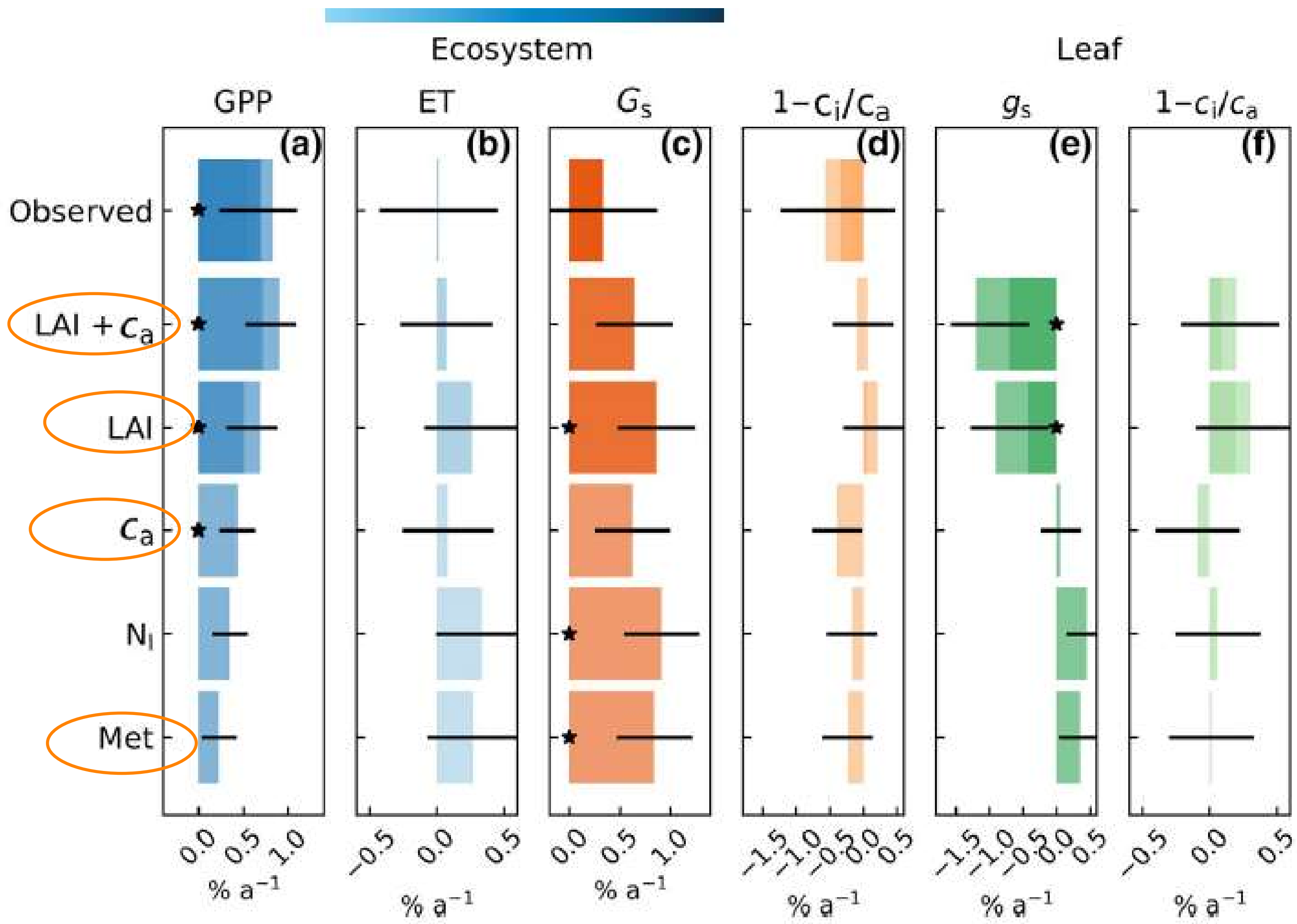


FIGURE 4 Observed and modelled trends in gross primary productivity (GPP, a), evapotranspiration (ET, b), ecosystem surface conductance (G_s, c) and C_i/C_a (d), and modelled trends in canopy mean stomatal conductance (g_s, e) and leaf c_i/c_a (f). The trends are slopes (±SE) of linear regression to yearly sums/averages of daytime dry-canopy conditions in May–September. Trends are shown as % of the 2001–2017 mean, and (*) denotes statistically significant ($p < .05$) slope. The relative trends in $\delta c_a/c_a = 0.6\%\ a^{-1}$ and δ LAI/LAI = 1.1–1.9% a^{-1} (Figure 3). The shades correspond to different flux-partitioning and LAI-trend estimates

Met → inter-annual variability
Ca → 1/3 of observed trend
LAI → 2/3 of -”-
LAI + Ca → true trend + realistic change in WUE

Interpreting the results using BL framework

$$\mathrm{GPP} = \mathrm{LAI}\left[\mathrm{c_a\,g_s}\left(1-\frac{\mathrm{c_i}}{\mathrm{c_a}}\right)\right]. \qquad (1)$$

Using a first-order Taylor series expansion, the relative changes in GPP can be expressed and interpreted as

$$\overset{+}{\frac{\delta\mathrm{GPP}}{\mathrm{GPP}}} = \underbrace{\overset{+}{\left[\frac{\delta c_a}{c_a}\right]}}_{\text{fertilization}} + \underbrace{\overset{+}{\left[\frac{\delta\mathrm{LAI}}{\mathrm{LAI}}\right]}}_{\text{structural}} + \underbrace{\left[\overset{-}{\frac{\delta g_s}{g_s}} + \overset{+/-}{\frac{\delta\left(1-c_i/c_a\right)}{1-c_i/c_a}}\right]}_{\text{physiological}}, \qquad (2)$$

$$\frac{\delta\mathrm{NEP}}{\mathrm{NEP}} = (1-\mathrm{cue})\frac{\delta\mathrm{GPP}}{\mathrm{GPP}} + \frac{\delta\mathrm{R_h}}{R_h}. \qquad (4)$$

$$ET = 1.6\, g_s\, LAI\, D + E, \qquad (5)$$

$$\overset{+/-}{\frac{\delta\mathrm{ET}}{\mathrm{ET}}} = \left[\overset{+}{\frac{\delta\mathrm{LAI}}{\mathrm{LAI}}} + \overset{-}{\frac{\delta D}{D}} + \overset{-}{\frac{\delta g_s}{g_s}}\right] + \overset{-}{\frac{\delta\mathrm{E}}{\mathrm{E}}}$$

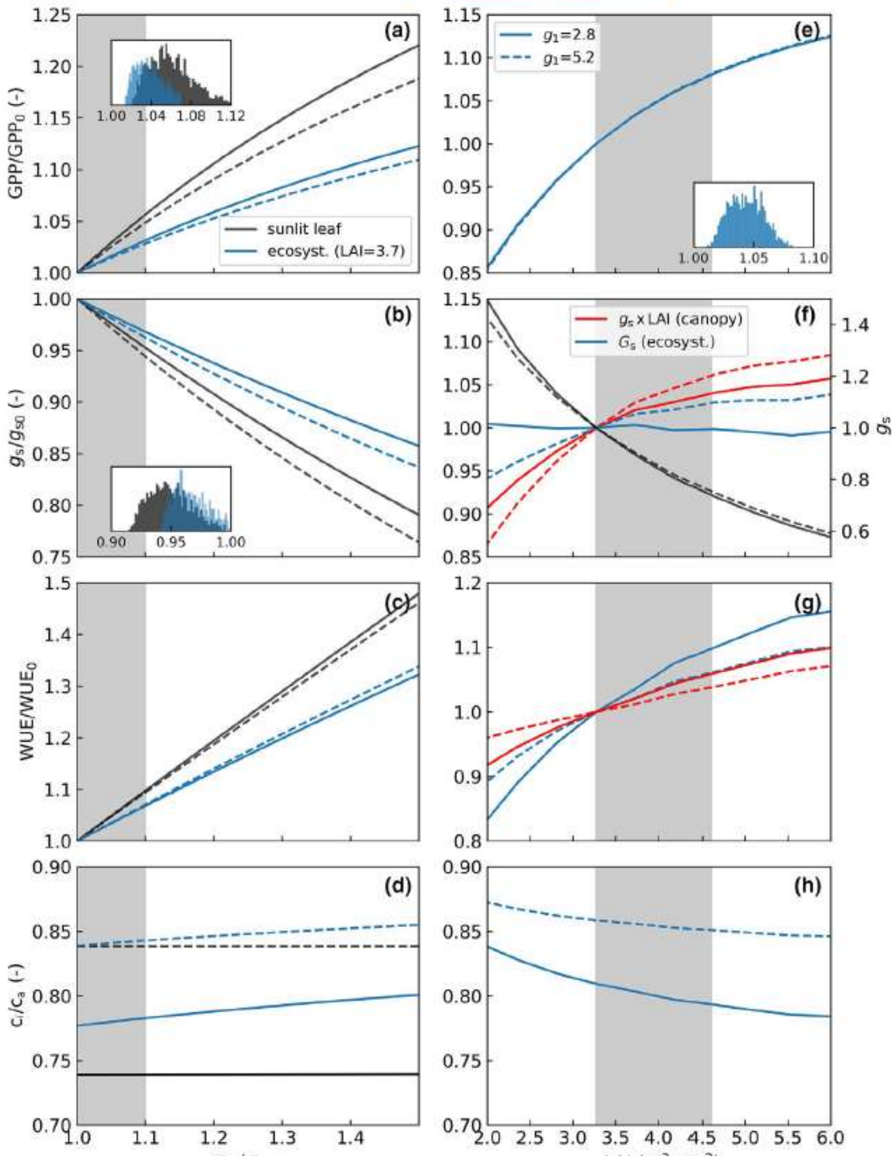
$$= \left[\frac{\delta\mathrm{GPP}}{\mathrm{GPP}} + \frac{\delta D}{D} - \frac{\delta c_a}{c_a} - \frac{\delta\left(1-c_i/c_a\right)}{1-c_i/c_a}\right] + \frac{\delta\mathrm{E}}{\mathrm{E}}, \qquad (6)$$

Mean leaf-level gs decreases due to increase in LAI (light limitations) and ca, but does not change ci/ca.
Magnitude of physiological adjustments ~ effect of LAI → terms cancel each other
We get apparent dependency on CO2: dGPP/GPP ~= dCa/Ca

CO2 effect

- Light limitations
- Temperature limitations
- ’Liebig’s law’
- Interplay between photosynthetic capacity & stomatal traits
- Weaker at ecosystem level than at sunlit leaves
- Weaker than thought in boreal forests?

FIGURE 5 Modeled leaf and ecosystem response of gross primary productivity (GPP), stomatal/surface conductance (g_s), water-use efficiency (WUE), and c_i/c_a to atmospheric CO_2 (c_a) (left). The right panels show ecosystem scale response to lead-are index (LAI) (right). The values are means of daytime dry-canopy values (PAR > 100 μmol m^{-2}s^{-1}, no rain in previous 24 h) over a typical growing season (2008). The leaf values represent a sunlit leaf at top of the canopy, and the three first rows are normalized by response at $C_{a,0} = 375$ ppm (left) or LAI (right) observed at the study site, whereas the gray shaded area shows the respective ranges. The solid/dashed lines represent water use strategies (g_1) characteristic for coniferous and deciduous trees, respectively. In (f) g_s is canopy average stomatal conductance, $g_s \times LAI$ represents canopy conductance and G_s is the ecosystem surface conductance. The insets show pdfs of instantaneous fertilization and LAI effects arising from microclimatic variability during the growing season



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DOI: 10.1111/gcb.16117
RESEARCH ARTICLE
Global Change Biology WILEY

Does growing atmospheric CO_2 explain increasing carbon sink in a boreal coniferous forest?

Samuli Launiainen[1] | Gabriel G. Katul[2] | Kersti Leppä[1] | Pasi Kolari[3] | Toprak Aslan[3] | Tiia Grönholm[4] | Lauri Korhonen[5] | Ivan Mammarella[3] | Timo Vesala[3,6,7]

[1]Natural Resources Institute Finland, Helsinki, Finland
[2]Department of Civil and Environmental Engineering, Duke University, Durham, North Carolina, USA

Abstract
The terrestrial net ecosystem productivity (NEP) has increased during the past three decades, but the mechanisms responsible are still unclear. We analyzed 17 years

To conclude…

- Increasing carbon sink mainly due to increasing GPP
  - LAI (stand growth!) was the main driver
  - CO2 fertilization explains ~1/3 of GPP trend. But explains improved water use efficiency
  - Respiration changes in line with GPP increase and litterfall (LAI) increase
  - NEP trend and trend in annual biomass growth ~comparable
  - Potential increase in leaf N has minor effect
    - No statistically significant changes in growing season length

- Trends are weak compared to inter-annual variability & uncertainties
- Long-term flux data is prone to errors
- Stand dynamics and 'supplementary data' not well enough measures

- **Compensatory mechanisms could be teased out only with a model!**

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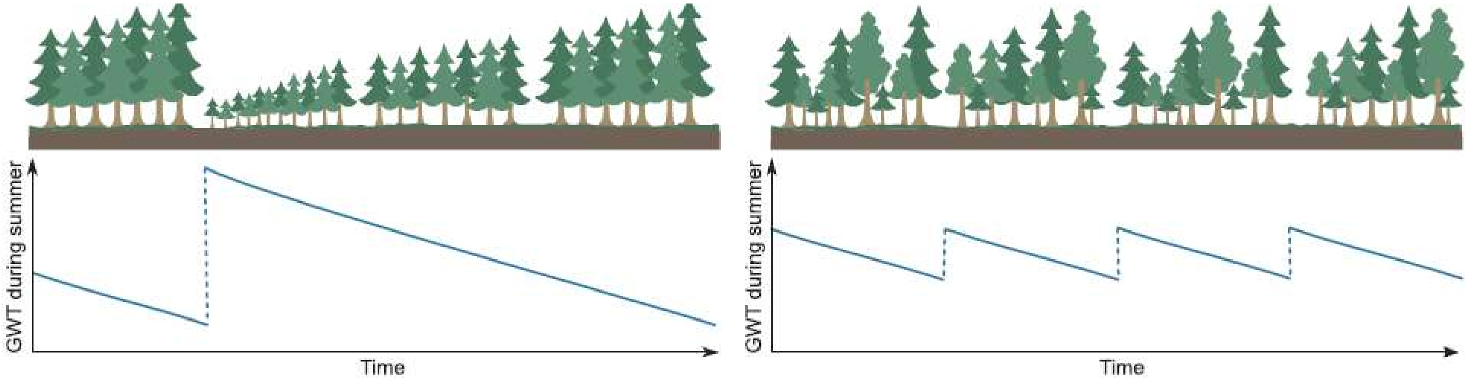
Peatland management ≈ water table management

4,7 Mha ditched from 1930's to 1980's. Spacing 20 – 60m, current depth 20 – 80cm

How WTL depends on stand attributes and peatland type across a climate gradient?



Growth = f(WTL)

GHG emissions = f(WTL)

Leaching = f(WTL)

Improved drainage by ditch maintenance: When needed & how deep is necessary?

Biological drainage == stand water use
How intense selection harvests or strip-cuttings can be used?

Nieminen et al. 2018; https://doi.org/10.1016/j.foreco.2018.04.046

Modeling water table response

Kersti Leppä

Ecohydrological theory & literature

- Process-model structure, functions, parameters

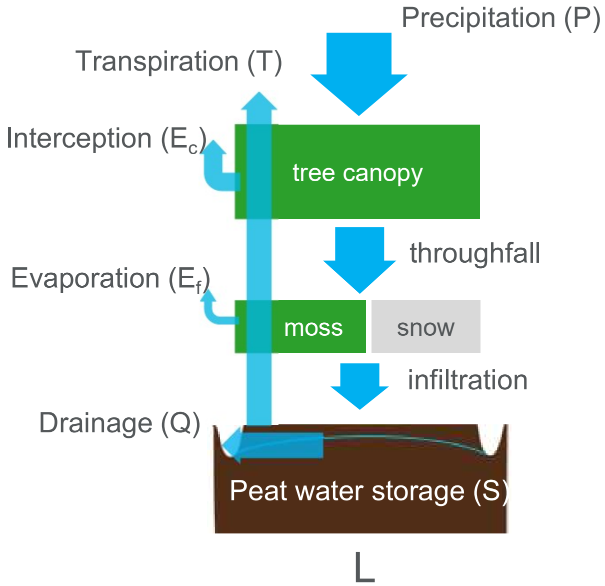
Inputs (open data + scenarios):

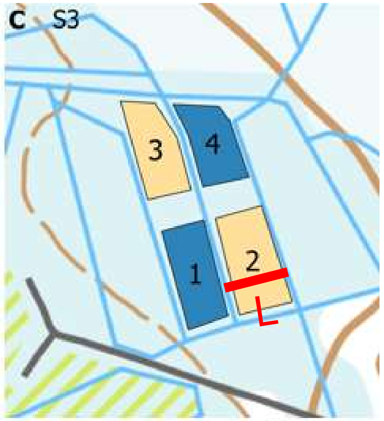
- Forest attributes: LAI, height, tree type
- Peat type: hydraulic properties
- Ditch spacing & depth
- Daily weather data

Outputs (daily):

- WTL, soil moisture, snow, ET & components, runoff

KISS for practical use ☺





$$\frac{\partial S}{\partial t} = P - (T - E_c - E_f) - Q$$

$$\frac{\partial WTL}{\partial t} = C(WTL)\frac{\partial S}{\partial t}$$

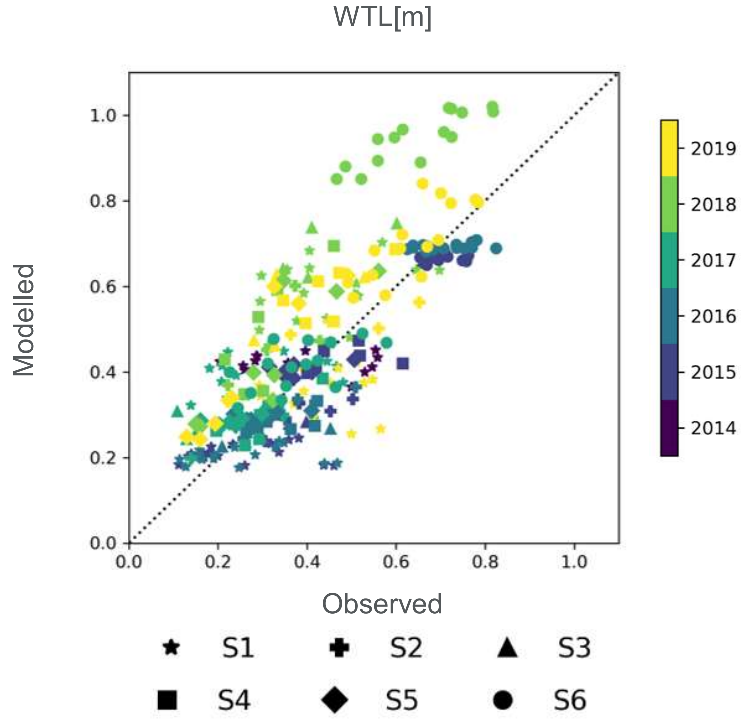
Benchmarking & factorial experiment

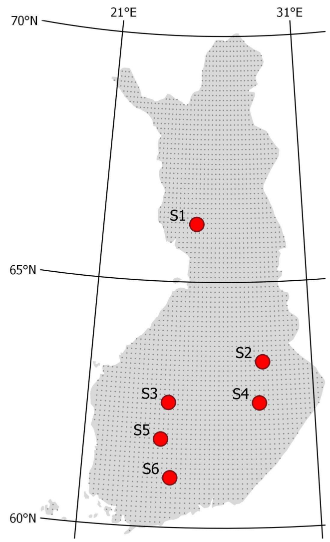
June-Oct mean WTL on the right ballpark

Next, factorial simulations:

- Basal area (BA): 6 to 30 m^2ha^{-1}, 5 levels
- deciduous fraction: 0 & 0.5
- ditch spacing: 25 & 75 m
- ditch depth: 0.3 & 1.0 m
- peat type: sphagnum/carex
- climate: south/north

Total 180 combinations



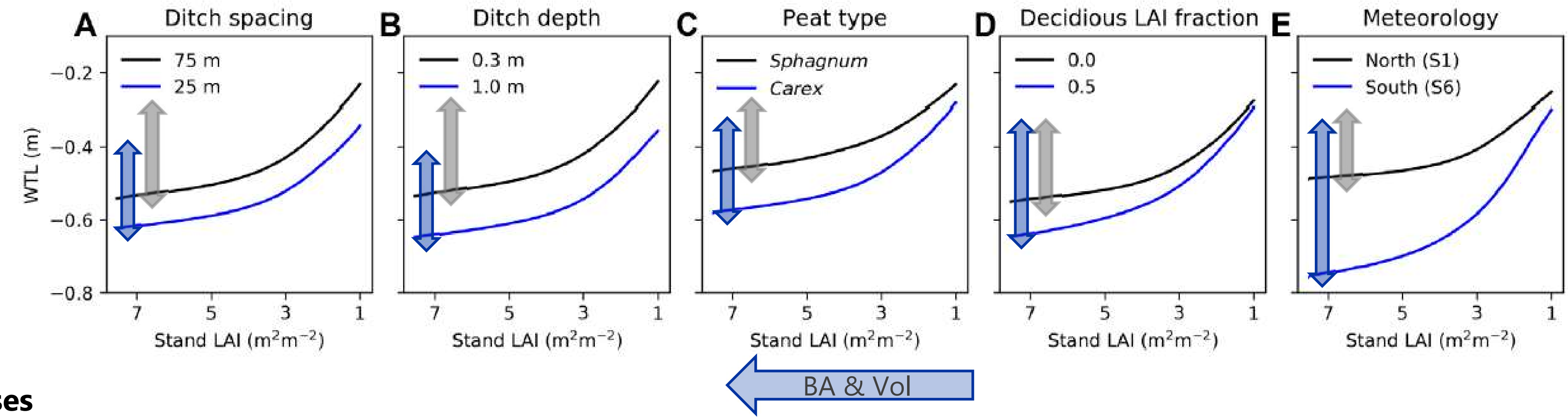


Leppä, K. et a. 2020. Front. Earth Sci., 8: 576510. https://doi.org/10.3389/feart.2020.576510

WTL vs. stand leaf-area

Deepens non-linearly with LAI,
increased interception & transpiration.

Mixed stands
Understories



Use cases

- Productivity and GHG-balance tradeoff of alternative management (e.g. Eyvindson et al. 2023, https://doi.org/10.1139/cjfr-2022-0101, Lehtonen et al. 2023, preprint)
- New guidelines for DNM: shallow ditches are often enough (Hökkä et al. 2022, https://doi.org/10.14214/sf.10494)
- Inverse question: how ditch blocking and emerging vegetation affects WTL after restoration?

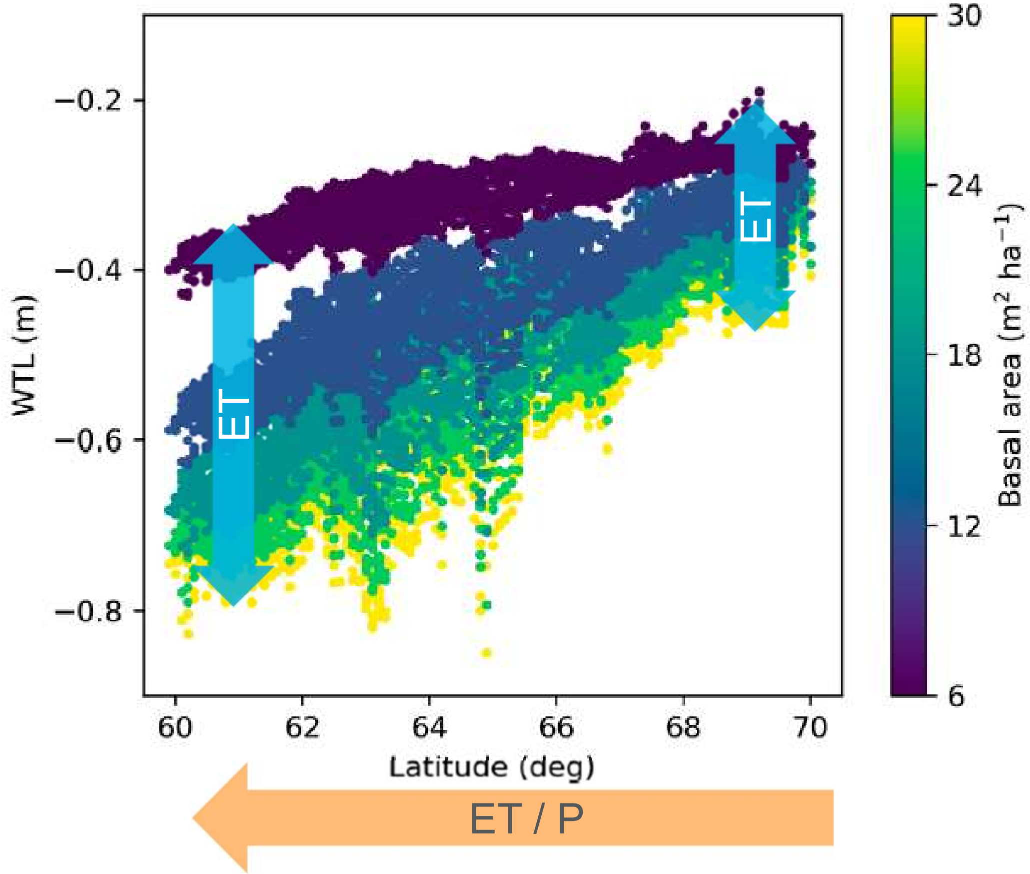
Simulations over climatic gradient in Finland

Biological drainage (ET) has great role in Southern Finland

- Strong potential for using CCF, less need for DNM
- Ditch drainage remains crucial in Northern Finland

Patterns will shift with climate change, due changing ET/P

Can WTL become too deep in the future?



forests

MDPI

Article

Measuring and Modeling the Effect of Strip Cutting on the Water Table in Boreal Drained Peatland Pine Forests

Leena Stenberg [1,*], Kersti Leppä [1], Samuli Launiainen [1], Annamari (Ari) Laurén [2], Hannu Hökkä [1], Sakari Sarkkola [1], Markku Saarinen [1] and Mika Nieminen [1]

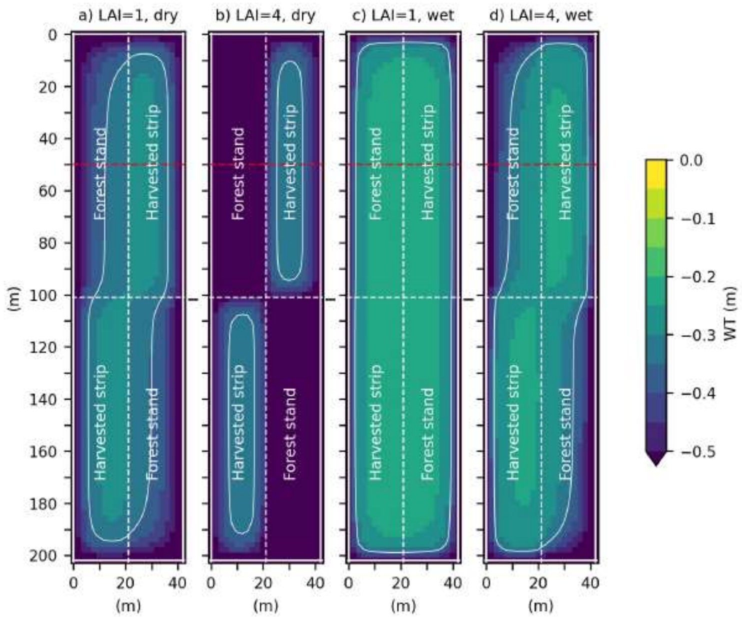


Figure 5. Snapshots of simulated WTs in a single day at the end of August in dry (**a**,**b**) and wet growing seasons (**c**,**d**). White contour lines (**a**–**d**) represent the isolines for a WT = −0.35 m. Unharvested stands and harvested (treeless) strips are separated by dashed, white lines. The peat profile was set to *Sphagnum*, and the ditch depth at the outer boundaries was equal to −0.6 m. Red, dashed lines indicate the location of the cross-sections presented in Figure 6.

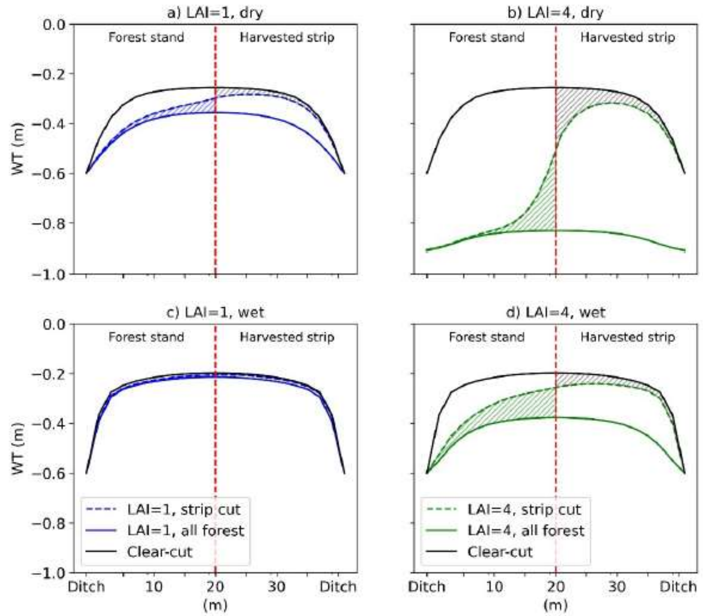


Figure 6. Cross-sections of (y = 50 m in Figure 5) the simulated WTs at the end of August during a dry (**a**,**b**) and wet growing season (**c**,**d**). The edge between the unharvested stands and the harvested (treeless) strips is shown by the red, dashed line. The blue (LAI = 1) and green (LAI = 4) hatched areas indicate the edge effect of the harvested strip on the adjacent unharvested stand. The gray hatched areas indicate the edge effect of the adjacent unharvested stand on the harvested strip. *Sphagnum* peat and a −0.6 m ditch depth were assumed.

2D saturated zone Darcy flow with constant head ditch BC

Adaptation: need to integrate ecohydrology better into forest dynamics models

- How water availability affects productivity & mortality?
- How and where possible to adapt management?

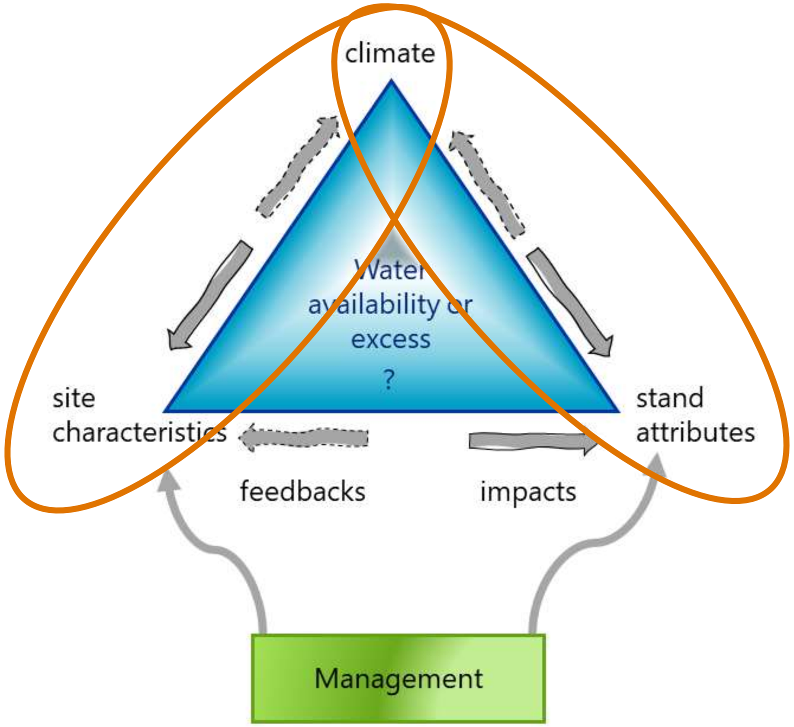
Mitigation: ecohydrology into C-cycle models

- Soil moisture and landscape heterogeneity as control of C balances
- Upscaling from point to regional scale

Capability to predict soil moisture and water table dynamics:

- Understanding & predicting forest disturbances
- Fire risks, forest vehicle trafficability
- Planning restoration

Merging GIS & ecosystem modeling



Spatial ecohydrology

Landscape soil moisture

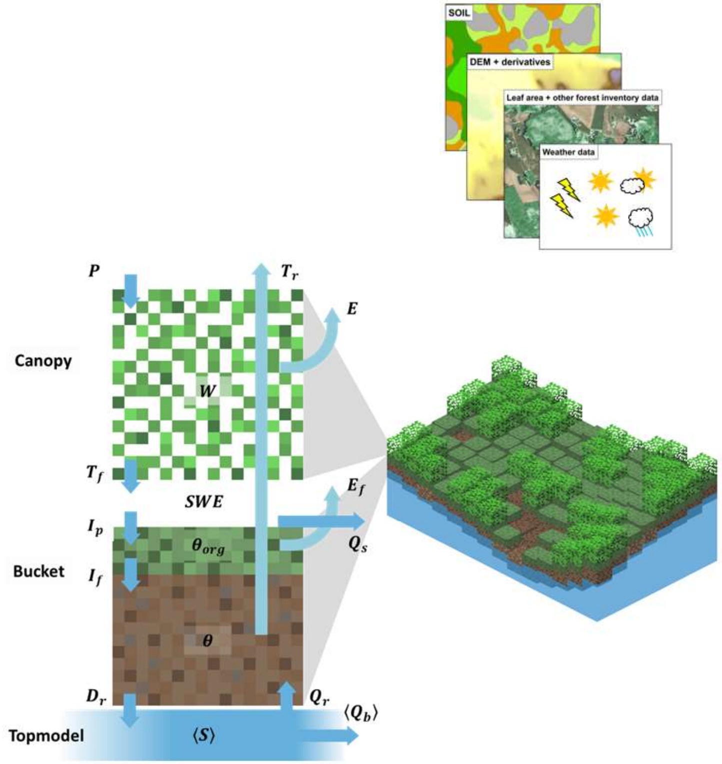
Soil strength: trafficability, harvest planning
Water availability: climate change adaptation

Excellent open data on

- Stand attributes (mNFI,16x16m)
- DEM, topographic wetness indices
- Streams, water bodies, non-forest areas

Soil hydraulic properties?

- We developed new PTF's to predict soil porosity, field capacity & wilting point from available spatial data
- Mineral forest soils: can be best estimated based on soil fertility type available in mNFI



Launiainen et al. 2019; https://doi.org/10.5194/hess-23-3457-2019
Launiainen et al. 2022, https://doi.org/10.3390/f13111797

SpaFHy model (Spatial Forest Hydrology)

J-P Nousu

Canopy module

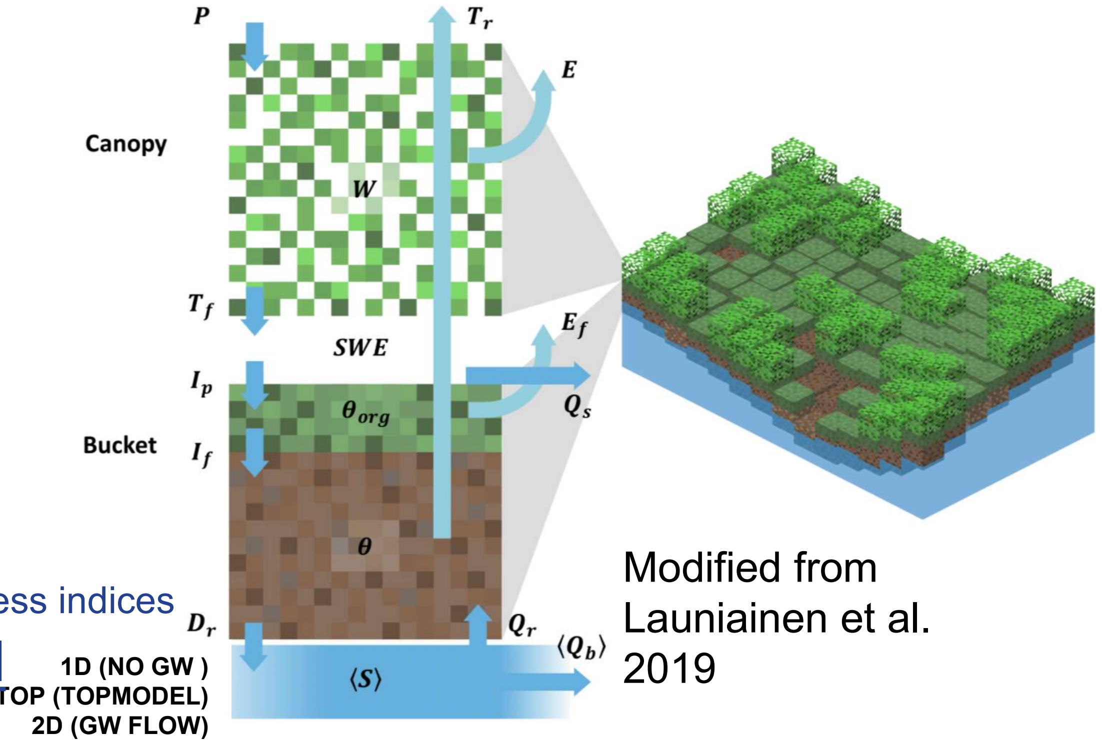
- Hydrology in vegetation and snowpack

Bucket module

- Organic moss-humus layer
- Rootzone layer

Groundwater modules

- <u>1D</u>: Free drainage from Bucket module
- <u>TOP</u>: TOPMODEL approach
  - Return flow from cells with high topography wetness indices
- <u>2D</u>: Lateral groundwater flow model
  - Explicit representation of groundwater dynamics



Modified from Launiainen et al. 2019

Written in Python

- *object-oriented programming*

SpaFHy inputs

16 m spatial resolution

Canopy module

- LAI (coniferous, deciduous, shrub, grass)
- Canopy height and fraction
- Shading coefficient

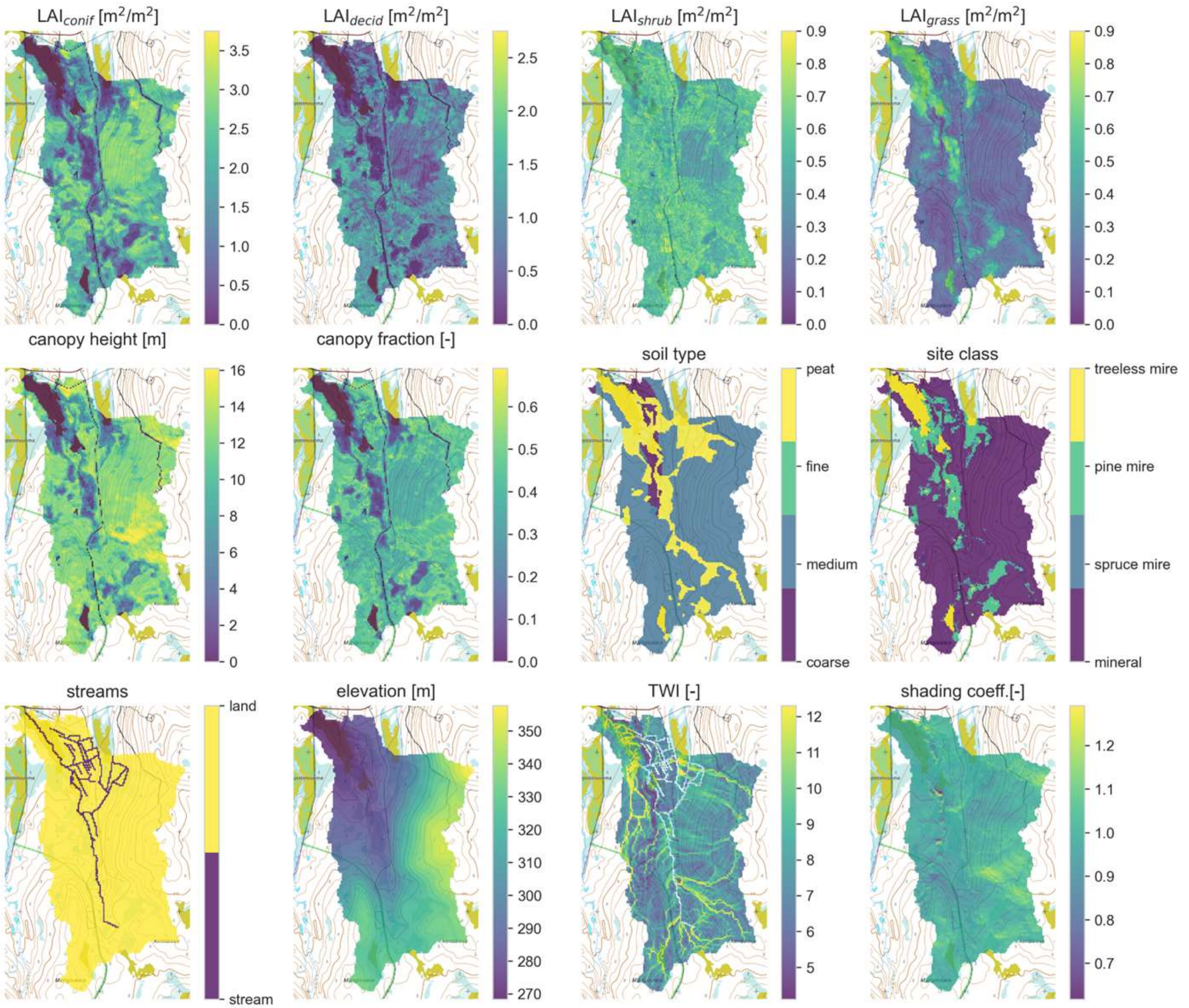
Bucket module

- Site class (organic moss-humus layer)
- Soil type (rootzone layer)

Groundwater modules (TOP, 2D)

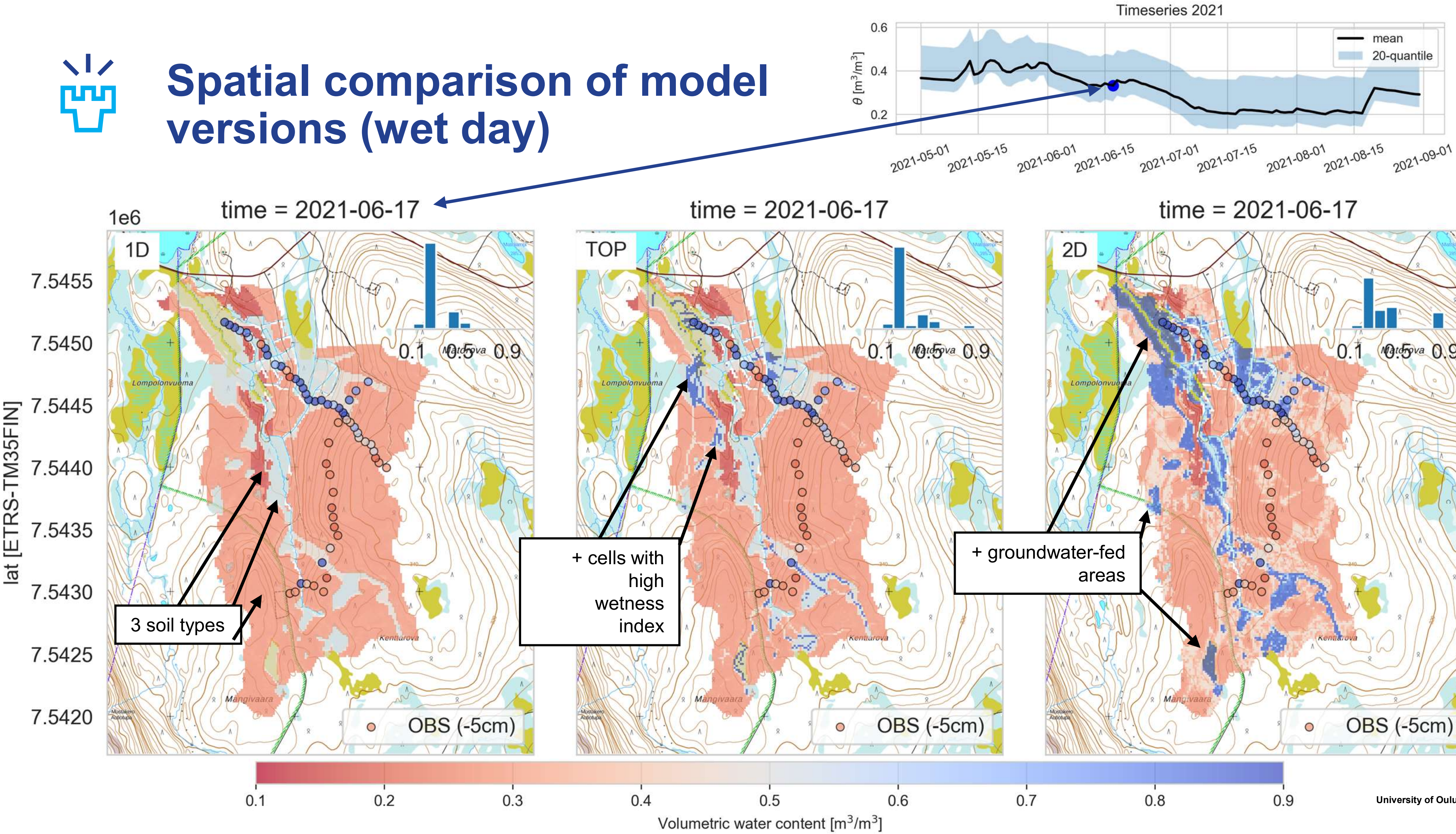
- Soil type, elevation, TWI, streams

+ Daily meteorological forcing



Input raster as ASCII
Outputs as NetCDF

Spatial comparison of model versions (wet day)



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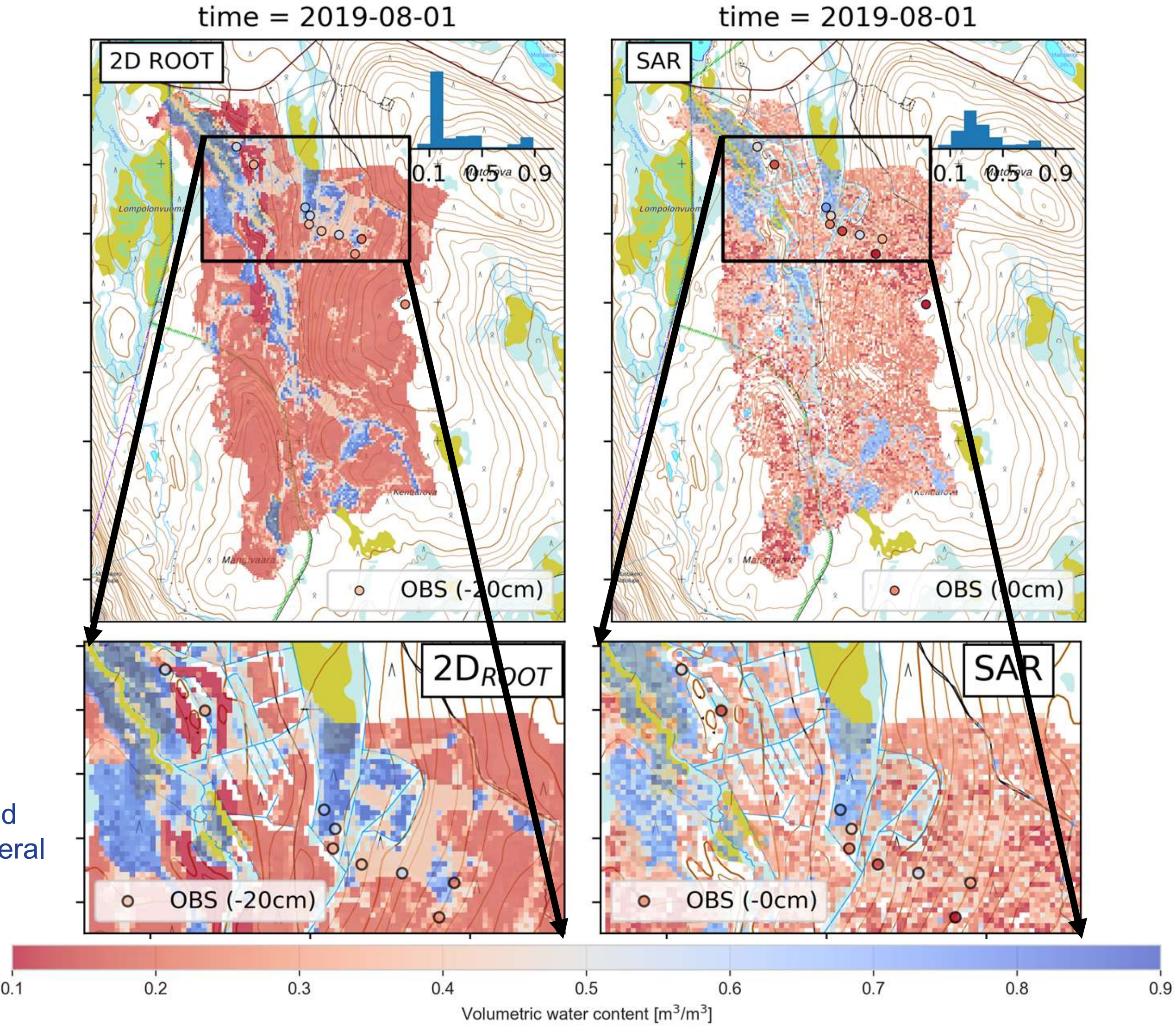
Spatial comparison to SAR-estimates (dry day)

- Main patterns are matching
- SAR contains high cell-to-cell variability (noise)



Nousu et al. (2024): Multi-scale soil moisture data and process-based modeling reveal the importance of lateral groundwater flow in a subarctic catchment (in prep.)

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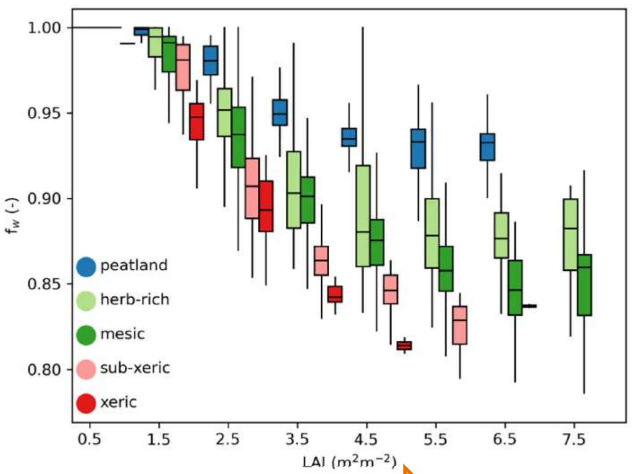
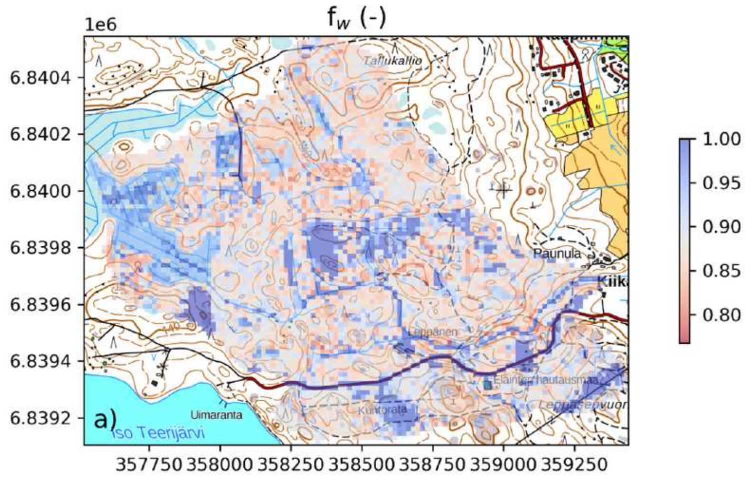
Water limitations – where most likely?

Paunulanpuro –catchment (ca. 150 ha), Orivesi, Southern Finland

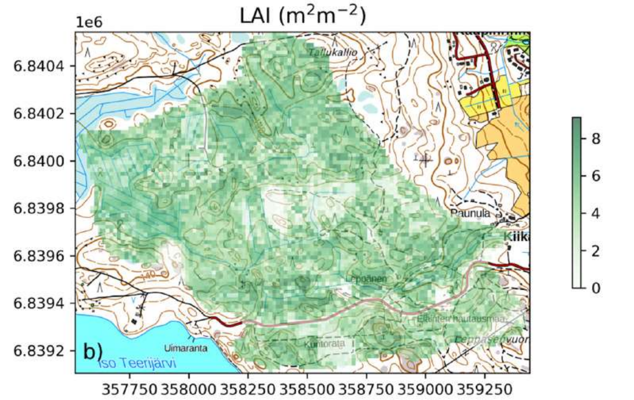
Simulated daily soil moisture for 2000 – 2015 period

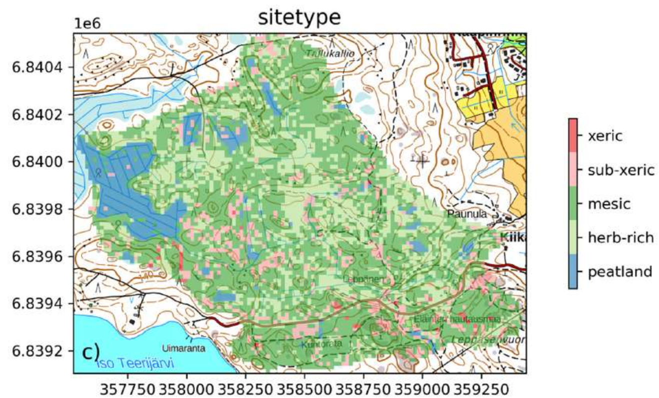


BA & Vol



Increasing water limitations →





Stand density effects modulated by soil water holding capacity, topographic position and species composition

From mNFI

Launiainen et al. 2022, https://doi.org/10.3390/f13111797

Ecosystem ecology with process-based models

pyAPES: vertically resolved view to soil-vegetation-atmosphere interface

→ ^{13}C & ^{18}O isotopes; stem water transport, snow energy balance

SpaFHy-C: distributed ecohydrology

→ high-resolution carbon budgets, merging with EO-data

→ 3D ray-tracing radiation model

NutSpaFHy: distributed nutrient balance & leaching

→ Stand growth, fertilization effects

Peatland Simulator Susi: holistic peatland forest management

→ Collaborating with Annamari Laurén (UH, peatland forestry)

Modular, open Python code

Tracking isotopic signals in trees using mechanistic modeling – unraveling the climatic response of boreal forests imprinted in decadal tree ring archives (Kersti Leppä 2021-2025, post-doc)

A novel intra-molecular isotopic approach to infer past climate and plant responses from tree-ring archives (MoleO 2021-2025, Katja Rinne-Garmston)

From forest structure to hydrological function – merging dense Earth Observation data and process-models (LS-HYDRO, 2023-2027)

Precision nutrient management - a tool for mitigation of climate change and environmental loading in boreal forestry (PREFER, 2022-2026)

DRONESTRESS – Multi-scale assessment of vegetation resilience to drought and pathogens: reconciling drone remote sensing, eddy-covariance, sap flow sensors and satellite data (2022-25, Pavel Alekseychik, post-doc)

See: https://github.com/LukeEcomod

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