

Analysis, Integration and Modeling of the Earth System

Advancing the Understanding of Coupled Human–Environment Dynamics in the Anthropocene

Arizona State University, Tempe, AZ, USA

September 8-10. 2019

Hannah Liddy

AIMES Executive Officer



HISTORY OF GEC PROGRAMS

Phase 1: understanding individual components of the Earth System



bioGENESIS
bioDISCOVERY
ecoSERVICES
ecoHEALTH



GAIM
IGAC
IMBER
SOLAS
PAGES
ILEAPS



iHOPE
UGEC
LOICZ
GLP
LOICZ
ESG
GCP



CLiC
SPARC
GEWEX
CLIVAR

Phase 2: humans as components of the Earth System

2001



Phase 3: towards sustainability

2015



AIMES IPO Location

- Columbia University at the Center for Climate Systems Research located in NASA Goddard Institute for Space Studies (GISS)
- Started September 2017



NASA GISS

I. Process and Parameterization

Observations and process models for global model development, evaluation

II. Regional-Global Integration

Focus on regions where rapid rates of human development trigger changes

III. Applied Earth System Science

End-to-end analyses that track fundamental research and transition to applic

IV. Integrative Earth System Modeling

Development of increasingly complex coupled models of climate, biogeochemical dimensions



A comprehensive view on climate change: coupling of earth system and integrated assessment models

Detlef P van Vuuren^{1,2}, Laura Battle Bayer³, Clifford Chuwah⁴, Laurens Ganzeveld⁵, Wilco Hazleger⁶, Twan van Noije⁴, Brian O'Neill⁶ and I



TOPICAL REVIEW
Integrated human-earth system modeling—state of the science and future directions

Katherine Calvin^{1,2} and Ben Bond-Lamberty¹

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ELSEVIER

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha



Methods and approaches to modelling the Anthropocene

Peter H. Verburg^{a,*}, John A. Dearing^b, James G. Dyke^b, Sander van der Leeuw^{c,h},

Colin T. Hope^d, Michael J. Glantz^{e,f}, Christopher D. Funk^g, Daniel C. Schlesingerⁱ,

John W. Hargrove^j, Mark L. Wiesner^k, and

James R. Kiesecker^l



Future directions

- Robustly assess the sign and magnitude of human-Earth system feedbacks
- Diversity of approaches
- More interdisciplinary research
- Better data and accompanying detailed metadata



Modelling feedbacks between human and natural processes in the land system

Derek T. Robinson¹, Alan Di Vittorio², Peter Alexander^{3,4}, Almut Arneth⁵, C. Michael Barton⁶, Daniel G. Brown⁷, Albert Kettner⁸, Carsten Lemmen⁹, Brian C. O'Neill¹⁰, Marco Janssen¹¹, Thomas A. M. Pugh^{12,13}, Sam S. Rabin⁵, Mark Rounsevell^{3,5}, James P. Syvitski¹⁴, Isaac Ullah¹⁵, and Peter H. Verburg¹⁶

AIMES STEERING COMMITTEE ACTIVITIES

*- Highlight key challenges for working across
communities with different methodological emphases
and philosophies*

Alex Ruane – VIACS Advisory Board for CMIP6

Building Bridges between Modeling and Applications Communities

The Vulnerability, Impacts, Adaptation and Climate Services (VIACS)
Advisory Board for CMIP6

Phase I (2016-2018)

Establishing the VIACS Advisory Board and informing the design of CMIP6 simulations

Phase II (2019-2021)

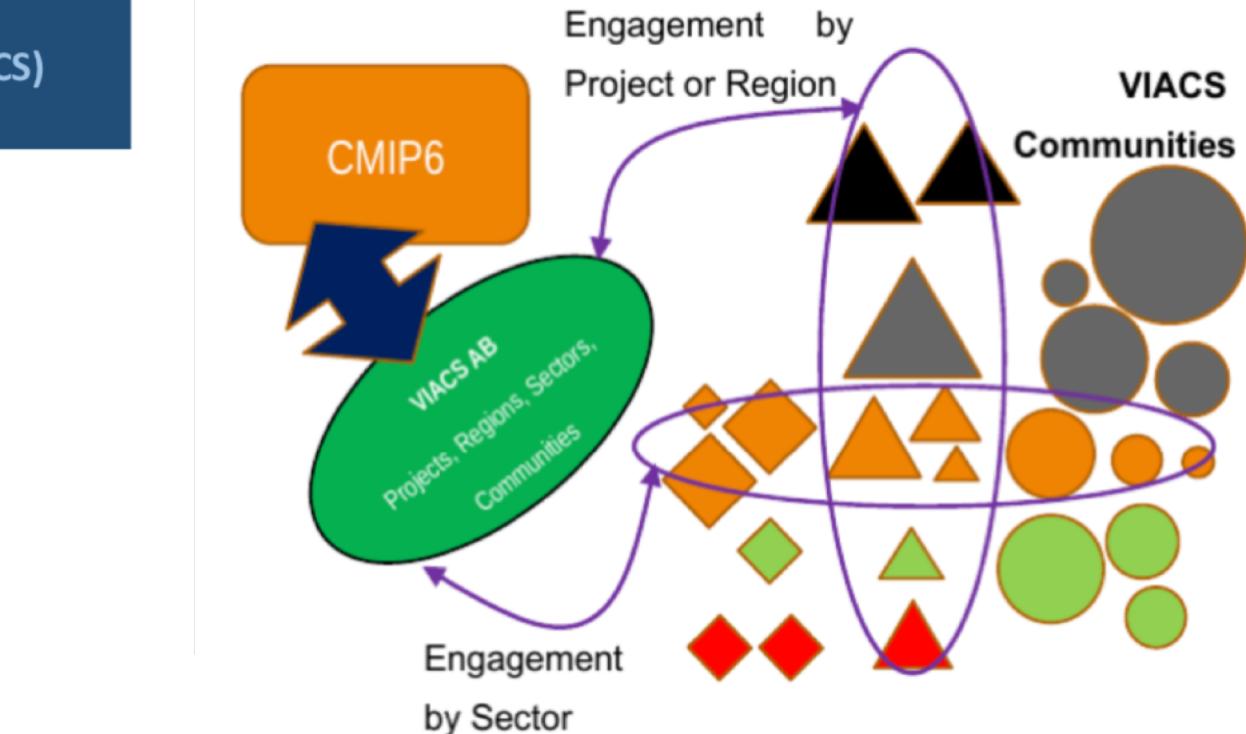
Initial evaluation of CMIP6 models using DECK experiment outputs and the application of broader CMIP6 outputs

Key challenges for VIACS/ESM connection

- Improved VIACS models and analyses to make use of improved outputs
- Practical use of huge variety of models, ensemble members, and MIP experiments
- Incorporation of offline VIA results and VIA-oriented diagnostics for ESM development
- ESM expert guidance and technical facilitation for VIACS translation and application

Practical ideas to enhance communication:

- Create working groups on selected topics, (e.g., guidance on model output usage and model performance, FAQ, etc.)
- One VIACS/ESM contact person per participating modelling-group
- "Consumer reports" for ESMs listing known, VIACS-relevant biases
- Demonstration papers for CMIP6 MIPs: VIACS leader and MIP leader model application
- VIACS participation in major CMIP (and related) workshops and conferences



VIACS AB
Mailinglist:



Ruane et al., 2016 Geosci. Model. Dev.
Eyring et al., 2019 Nature Climate Change

Michael Barton – Open Modeling Foundation

(more this afternoon)

THE OPEN MODELING FOUNDATION

HOME MISSION VISION ACTIVITIES MEMBERSHIP

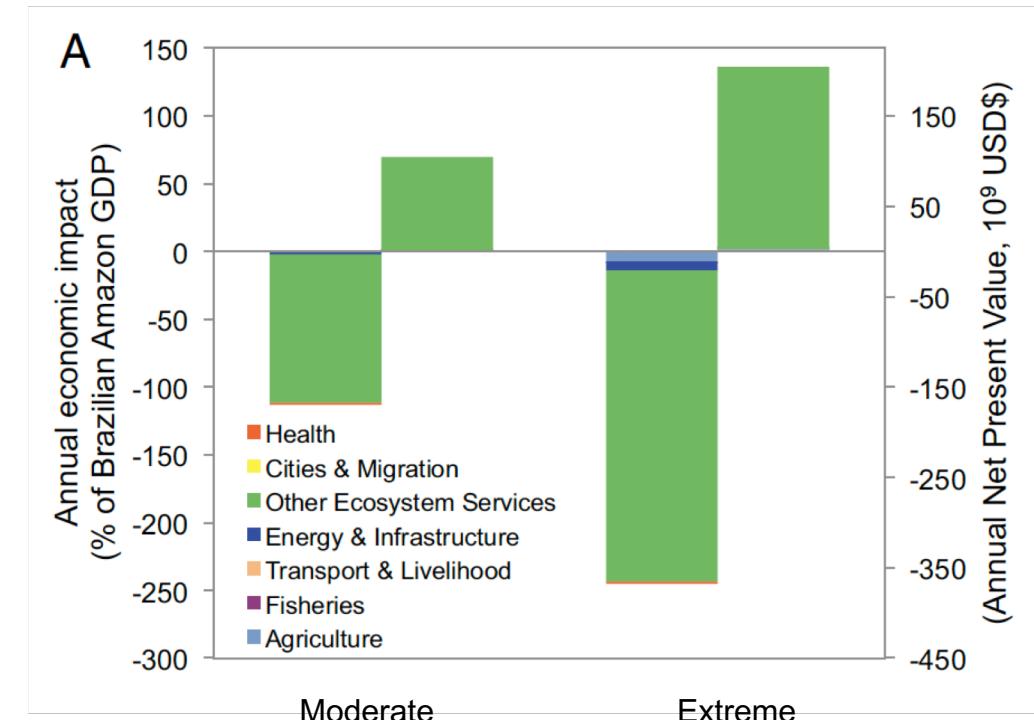
Enabling next generation modeling of human and natural systems

The Open Modeling Foundation is an alliance of modeling organizations that coordinates and administers a common, community developed body of standards and best practices among diverse communities of modeling scientists.



Patricia Pinho – Governance in the Amazon

- Large uncertainties in the Amazonian forest dieback hypothesis
- Should mitigation or adaptation action be taken now, later, or not at all in light of such uncertainties?
- Mitigation alternatives (\$64 billion) cost less but efficacy in achieving forest resilience is uncertain
- Risk perspective: low probability but high risk of socioeconomic impacts
- Local perceptions help to ground policy decisions on local realities and meanings (Pinho et al., 2015)

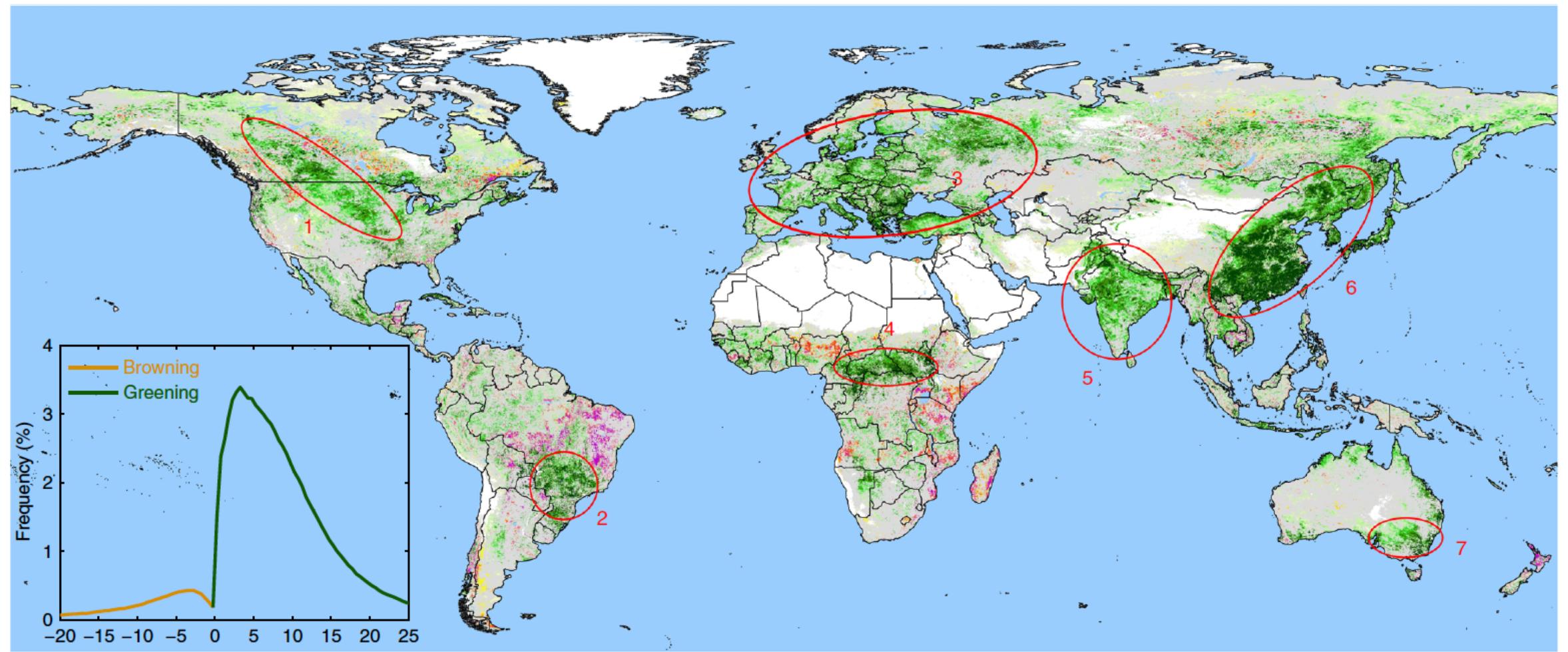


*Degradation of Tropical Forests: Observation, Modeling, and Socio-environmental implications, 11-13 November 2019,
Manaus, Brazil*



***HIGHLIGHT OPPORTUNITIES FOR FUTURE MODELING
FRAMEWORKS***

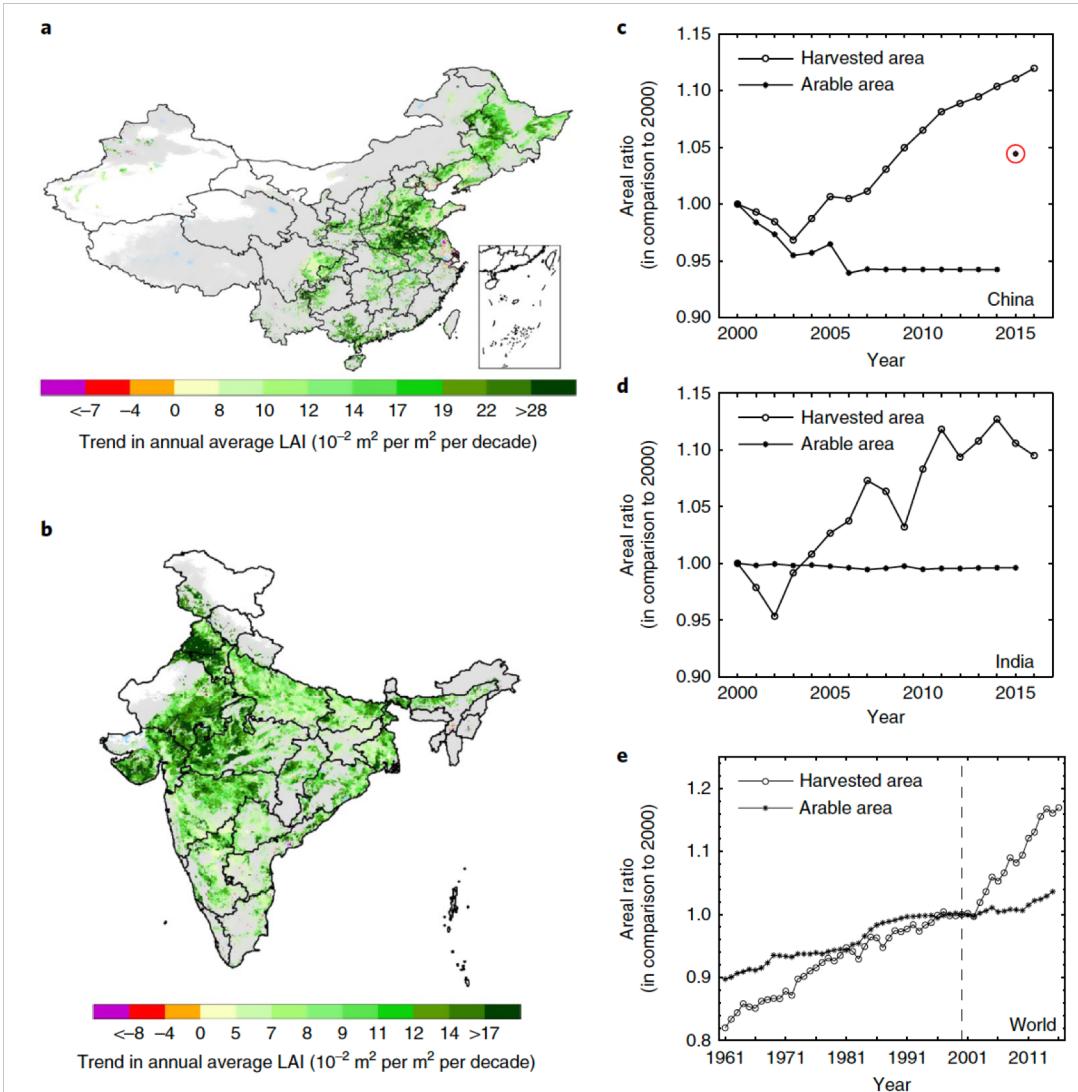
Land use is now detectable from space



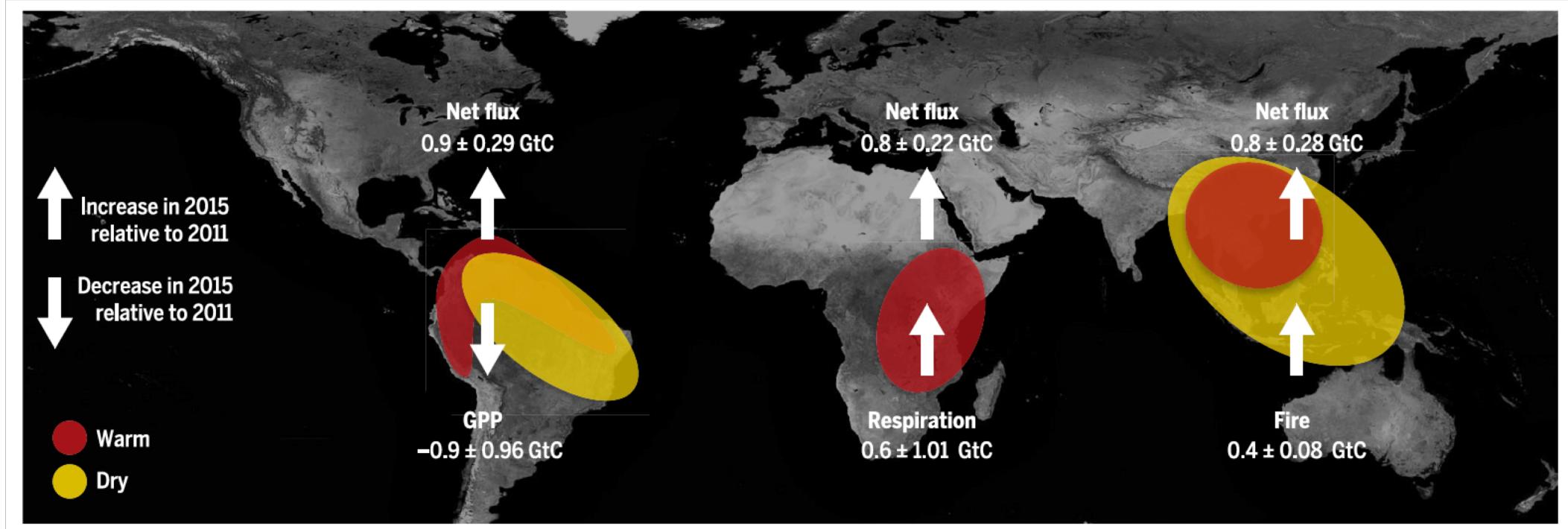
Trend in annual average LAI ($10^{-2} \text{ m}^2 \text{ per m}^2 \text{ per decade}$)

Chen et al., 2019, Nature Sustainability

Greening trends attributed to crop land and afforestation policies



Carbon sink behavior affects mitigation potential with policy/perception implications



Carbon Dioxide Removal Model Intercomparison Project; Keller et al., 2018

Zero Emissions Commitment Model Intercomparison Project (ZECMIP); Jones et al., 2019

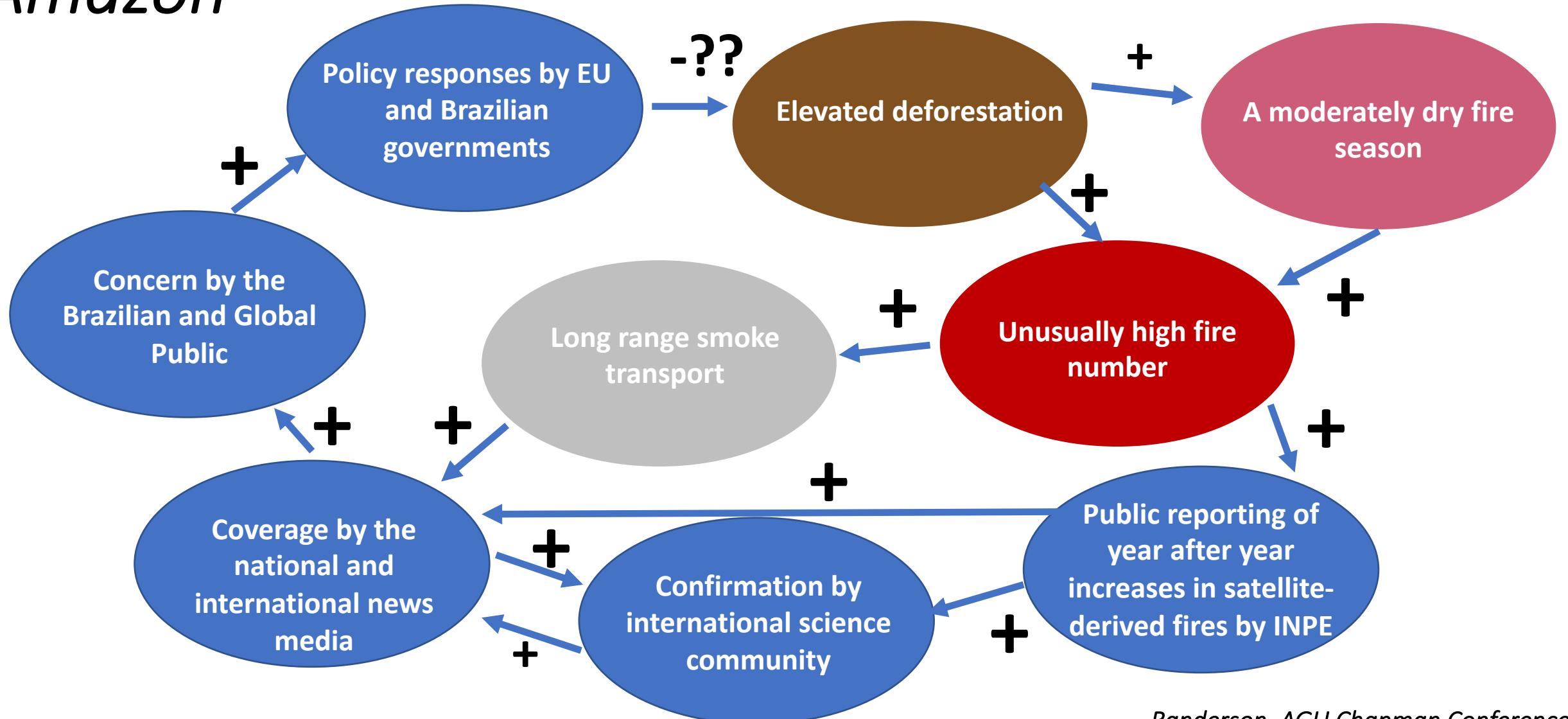
MEDIA ANALYSIS

27 August 2019 ⏲ 17:36

Media reaction: Amazon fires and climate change

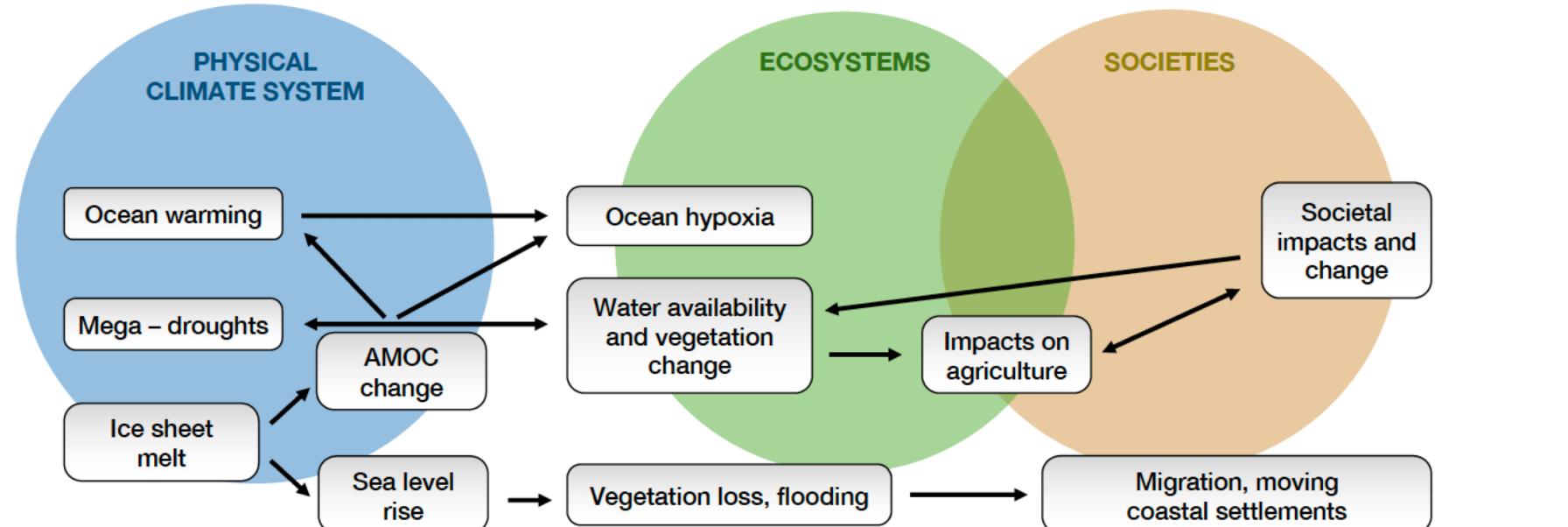


Current bio-social-economic-carbon feedback in the Amazon

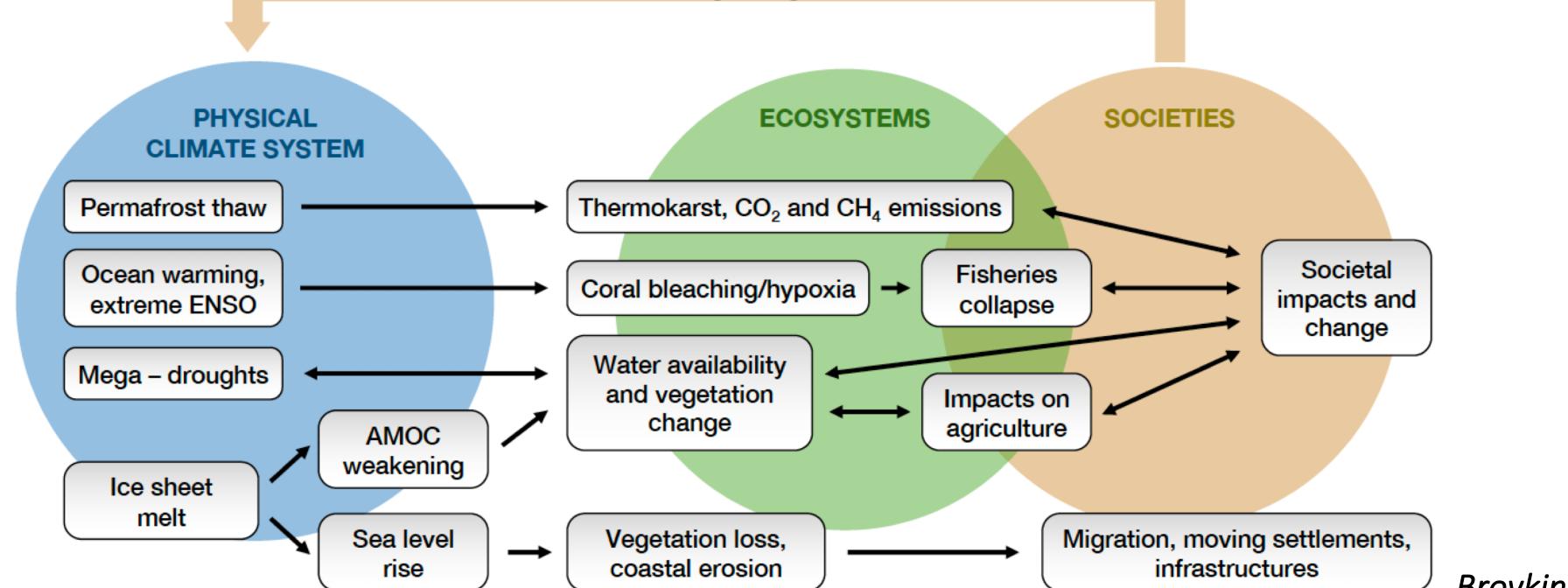


B. Future

A. Past



Climate change mitigation



The background image is a high-resolution aerial photograph showing a complex landscape. It features a mix of agricultural land, characterized by green fields in various shades of green and blue, and industrial or urban areas with dense clusters of buildings and infrastructure. A prominent river or canal cuts through the center of the image, winding its way through the terrain. The overall scene is a blend of natural and human-made environments.

WAYS FORWARD THROUGH THE AIMES-GLOBAL LAND PROGRAMME STRUCTURE

AIMES-GLP Working Group

- Networks of cross-disciplinary international researchers
- Development of large scale databases
- Development of research questions and methods



An interdisciplinary community of science and practice fostering the study of land systems and the co-design of solutions for global sustainability

LOG-IN  SEARCH 

WHO WE ARE | HOW WE WORK | OUR SCIENCE | NEWS & EVENTS | FIND A SCIENTIST | OSM 2019 | BECOME A MEMBER | 

How We Work

- Open Science Meetings
- Working Groups
 - Co-production of Sustainable Land Systems
 - Archetype Analysis
 - Land Systems for Mountain Futures
 - Integration of Rural and Urban Land Systems
 - Remote Sensing in Big Data Era
 - Telecoupling Towards Sustainable Transformation
 - Large-scale Behavioural Models of Land Use Change
- Nodal Offices

Large-scale Behavioural Models of Land Use Change

Short Description

The working group will support the development of the next generation of large-scale (global to continental/national scales), land-use models that are based on human behaviour, agency and decision-making processes. The purpose of this approach is to explore a wide range of key research (and policy) questions at the nexus of food, ecosystems, water, climate and energy. This will support understanding of adaptation and mitigation processes within the land system in which the land system is used as an exemplar of other socio-ecological systems. The working group will create an alternative to the current range of 'top-down' global models (based on macro-economics) and thus, will provide a working laboratory to test theories of human decision making, and undertake social simulation experiments in a globally (inter-)connected world, i.e. taking account of telecoupling. This includes new representations of institutional processes and their relationships with local land users. We also envisage coupling of large-scale, land-use models with other models types, such as Dynamic Global Vegetation Models (DGVMs), biodiversity models and/or climate emulators to explore a wide range of environmental change drivers and to evaluate the consequences of these for ecosystem services. In practice, we will work towards a common 'modelling framework', or a suite of models operating within a common structure. This reflects the many different ways of modelling land use change processes, especially with respect to theories of land-use decision-making. We will explore alternative realisations of these decisional processes within the common modelling framework. All model results will be made available to the broader community through an online portal.

Future Earth Open Science Conference



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June 14-17, 2020
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Future Earth, which supports the largest global community of systems-focused sustainability researchers and innovators, and the Belmont Forum, the world's largest consortium of transdisciplinary global change and sustainability research funders, are joining forces to establish a marquee congress in which the world's foremost research and innovation communities come together to share successes, exchange views, and work across disciplines and sectors to support a global transformation to sustainability.

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Conclusions

- *Great advancements in understanding of the Earth System through Earth observations and CMIP6 experiments*
- *Human-Earth system feedbacks are still missing*
- *More models, more studies, more data are needed to robustly assign the sign and magnitude of feedbacks*
- *Foster community through AIMES-GLP networks and activities*

Thank you!

What We Do

- AIMES facilitates, enables, coordinates international climate and related research activities with an emphasis on biogeochemical processes and social interactions with the environment.

Upcoming events:

- ***Large-scale behavioral models of land use change, 8-10 September 2019, Tempe, Arizona, USA***
- ***Degradation of Tropical Forests: Observation, Modeling, and Socio-environmental implications, 11-13 November 2019, Manaus, Brazil***

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Future Earth Global Research Projects



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Programme on
Ecosystem Change and Society



AIMES



Integration of Natural and Social Systems

Research Themes

Process and Parameterization

Earth System Dynamics

Regional-Global Interactions

Applied Earth System Science

Integrated
Socio-
Environmental
Models

Land Use
Change

Carbon-Climate
Feedbacks

Tipping
Points in
the Earth
System

Science Topics

AIMES Mission

To advance scientific collaboration between social and physical sciences to achieve a more quantitative and deeper understanding of the interactions between human activities, biogeochemical cycles and the physical climate system.

