Research on Ecosystem stability and transitions at PIK

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Speaker of the working group “Ecosystem stability and transitions” in the Research Domain “Earth System Analysis”

Deputy Chair of Research Domain

Potsdam Institute for Climate Impact Research (PIK)

Potsdam Institute for Climate Impact Research (PIK)

- **Founded in 1992**
- **One of the important institutes in climate impact research**
  - **Participates in IPCC Assessment and special reports, e.g. leading WGIII in IPCC AR5**
  - **Science is designed for stakeholder interaction and policy recommendation**
- **Consists of 4 research domains**
  - **RD1 Earth System Analysis**
  - **RD2 Climate Impacts and Vulnerability**
  - **RD3 Sustainable Solutions**
  - **RD4 Transdisciplinary Concepts and Methods**

Ecosystem stability and transitions at PIK

Our research focuses on the following aspects

- **Functional diversity, elasticity of ecosystems and ecological tipping points**
- **Impacts of extreme events and (fire) disturbances on ecosystems**
- **Shifts in ecosystem services, role of natural vegetation and climate regulation services**

Team members: Delphine Zemp, Kirsten Thonicke, Werner von Bloh, Alice Boit, Finn Müller-Hansen, Catrin Ciemer, Ana Cano Crespo, Boris Sakschewski, Fanny Langerwisch (from left to right)

Importance of the Amazon biome

10 to 15% of world biodiversity

Stores 150 – 200 Billion t carbon = 33 – 44 % of global carbon storage

Giant atmospheric moisture pump:

- 25-50% of received precipitation recycled
- 20 Mio t per day transpired to the atmosphere
- contributes 19 % to precipitation to La Plata Basin

Amazon river discharges 15 % of freshwater input into the oceans

17 Mio tonnes per day

Giant atmospheric moisture pump

IRTG project: Delphine Zemp

IMPORTANCE OF CASCADING MOISTURE RECYCLING IN SOUTH AMERICA

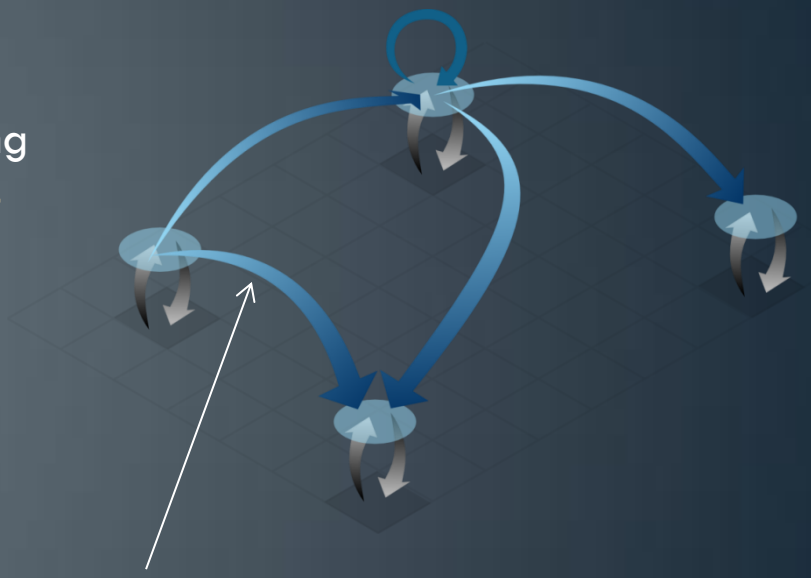
PIK

IRTG 1740

Quantifying atmospheric moisture transport using WAM2-Layers and complex networks

	Input 1	Input 2
Period	2000 - 2010	1989 - 1995
Precip.	TRMM	Average CRU, GPCC, GPCP, CPC
Evap.	MODIS	LandFlux-Eval
Wind	ERA-Interim	
Humidity		

Atmospheric moisture tracking model (WAM-2layers*)



Amount and direction of recycled moisture from the origin (evapotranspiration) to the destination (precipitation)

* van der Ent (Water Res. Res., 2010) , van der Ent (Earth Sys. Dyn. 2014)

Fraction of the evapotranspiration in the Amazon basin that contributes to rainfall over the La Plata basin during the wet season:

11-16%

through direct moisture recycling

16-23%

through cascading moisture recycling

Amazon basin

Intermediary

Fraction of the total rainfall over the La Plata basin that comes from the Amazon basin during the wet season:

6%

through cascading moisture recycling

18-23%

through direct moisture recycling

La Plata basin

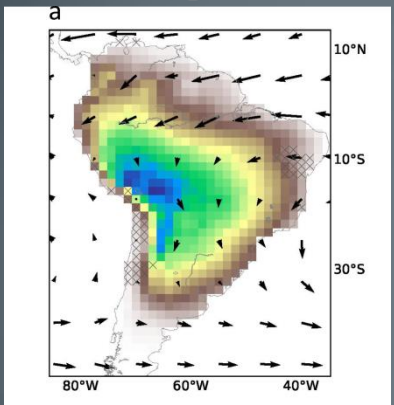
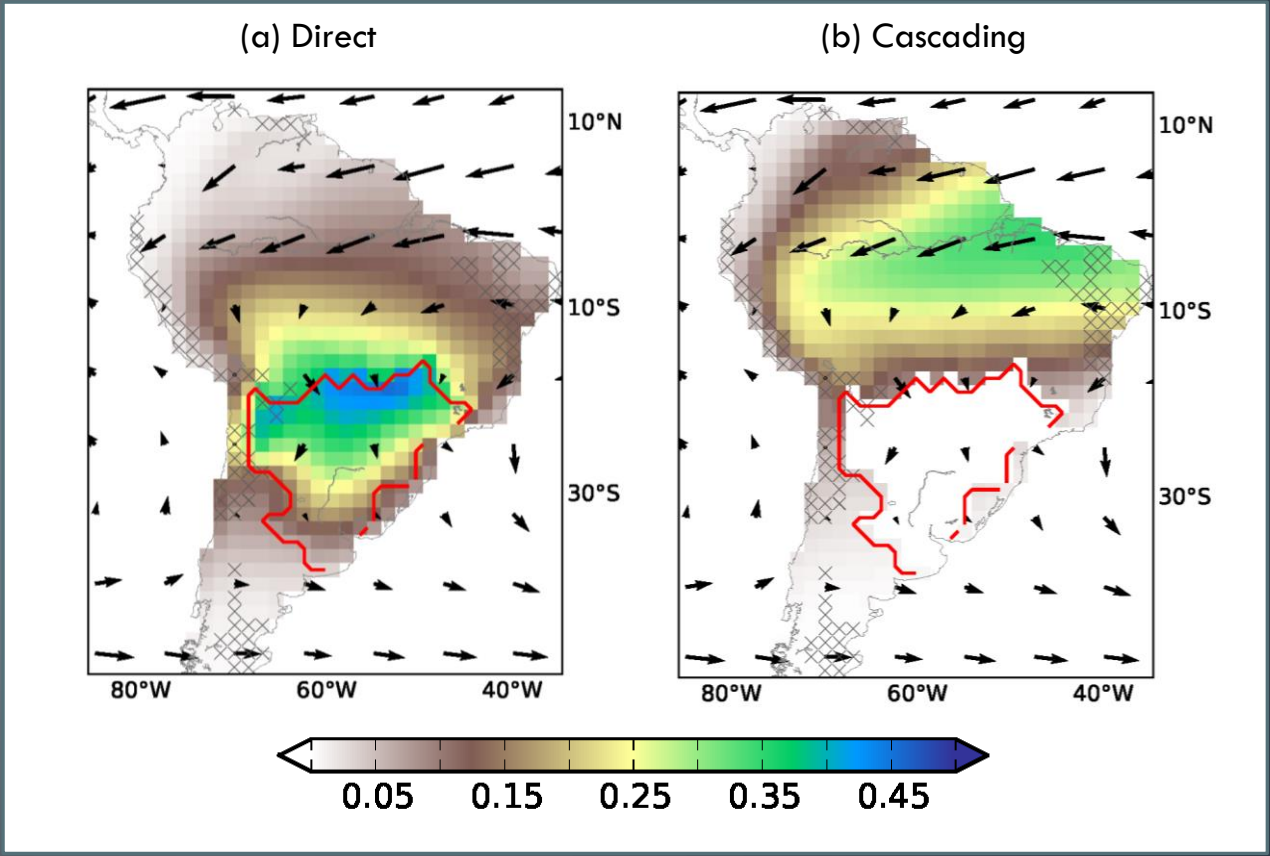


Fig. Key intermediary region as identified by using clustering coefficient, a measure from complex network analysis

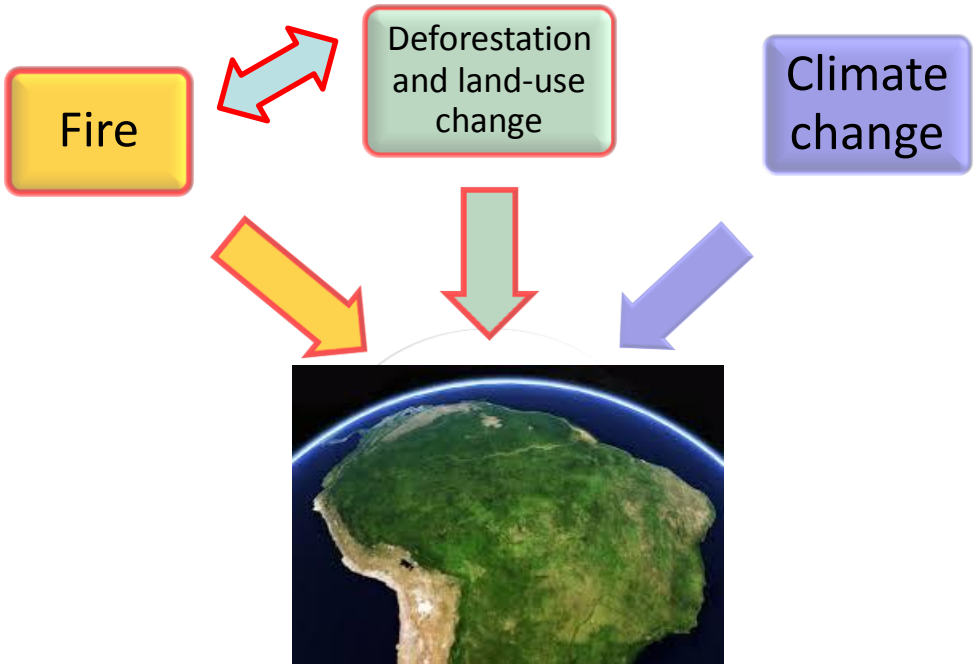
Origin of rainfall over the La Plata basin

Fraction of evapotranspiration that precipitates over the La Plata basin through direct and cascading moisture recycling



The southern part of the Amazon basin is not only a source of moisture but also an intermediary region that distributes moisture from the entire basin!

Zemp et al. (Atmos. Chem. Phys. Discuss., 2014).

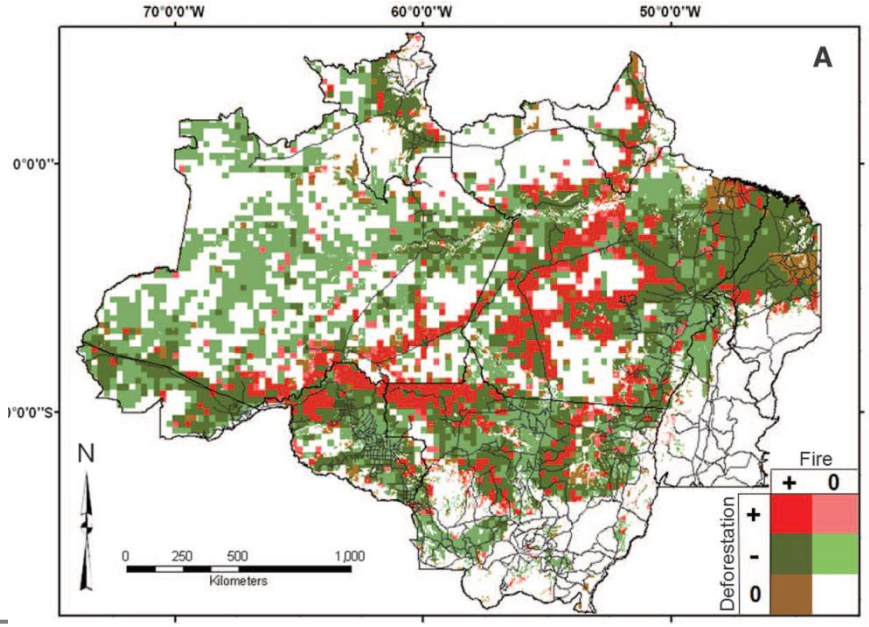


IRTG project: Ana Cano-Crespo

FIRE IN DIFFERENT LAND USE TYPES

Fire in the Amazon region

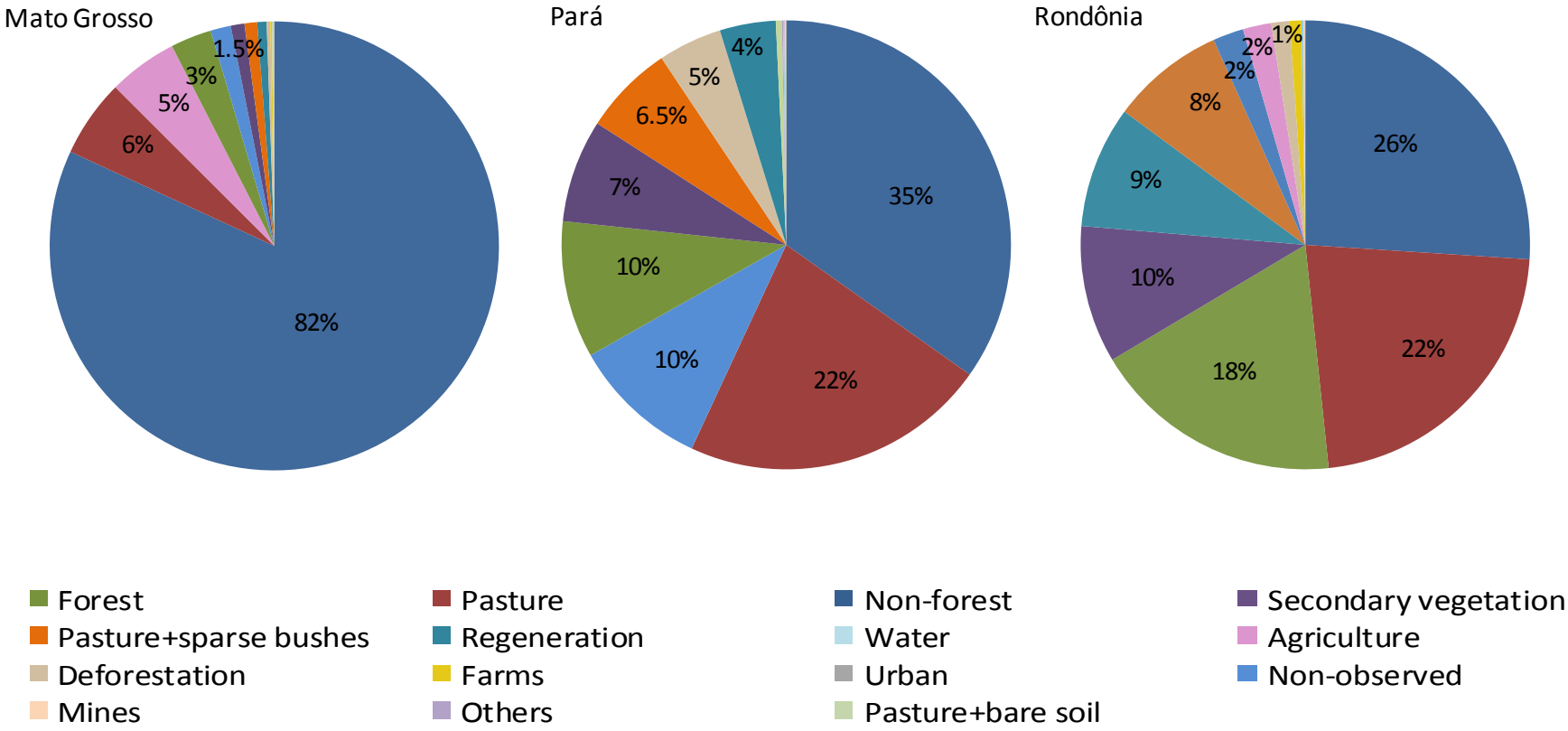
- **Fire used in deforestation process in the Amazon**
  - **Spatial overlay of coarse-resolution data**
- **How is fire used in land management?**
  - **Aragao et al. Science 2010: spatial hotspots moving away from deforestation to agriculture**
- **Can we confirm this relationship using high-resolution land-cover data?**



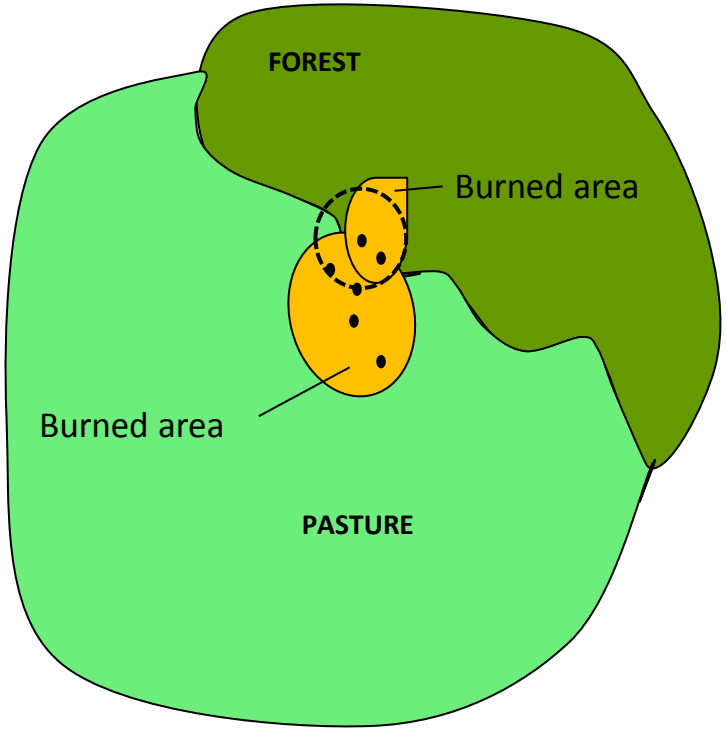
Aragao et al. Science 2010

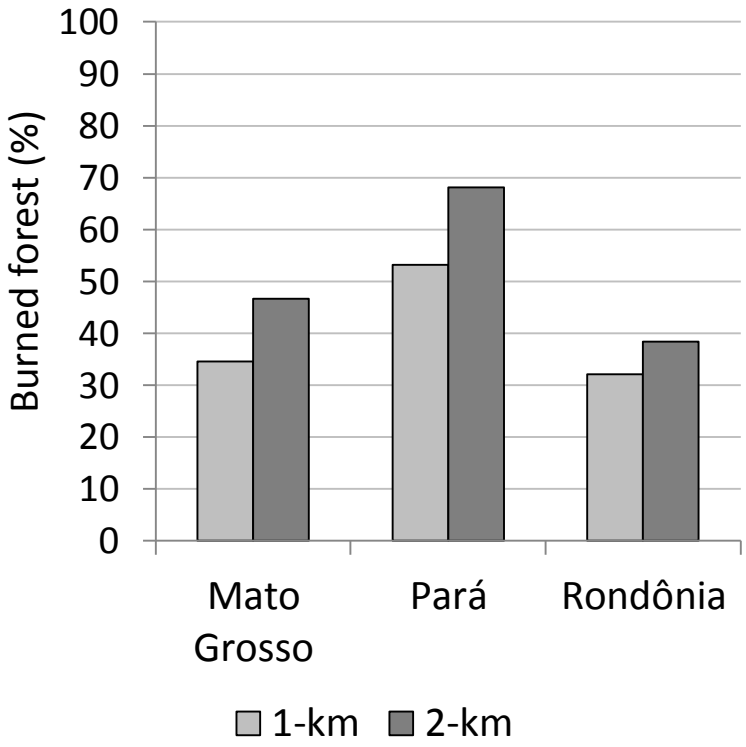
Area burnt per land-cover type 2008

State	Mato Grosso	Pará	Rondônia
Total area burnt [km²]	29100	3420	760
% of state	3.2	0.3	0.3

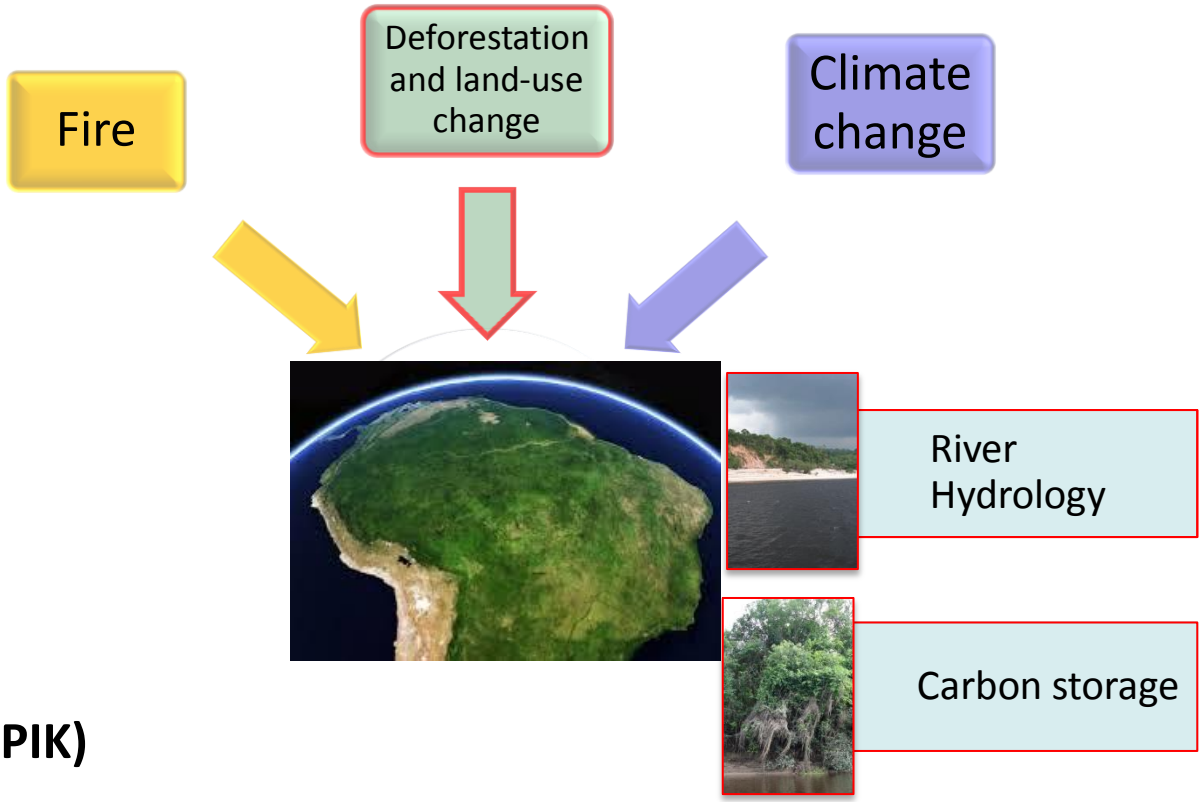


Pasture fires contribute 30-55% to forest fires





Cano-Crespo, A., P. J. C. Oliveira, A. Boit, M. Cardoso, and K. Thonicke (2015), Forest edge burning in the Brazilian Amazon promoted by escaping fires from managed pastures, J. Geophys. Res. Biogeosci., 120, 2095–2107, doi:10.1002/2015JG002914.



Study: F. Langerwisch (PIK)

IMPACT OF CLIMATE & LAND USE CHANGE ON THE AMAZON RIVER

Amazon basin: productive forest connected to huge river basin

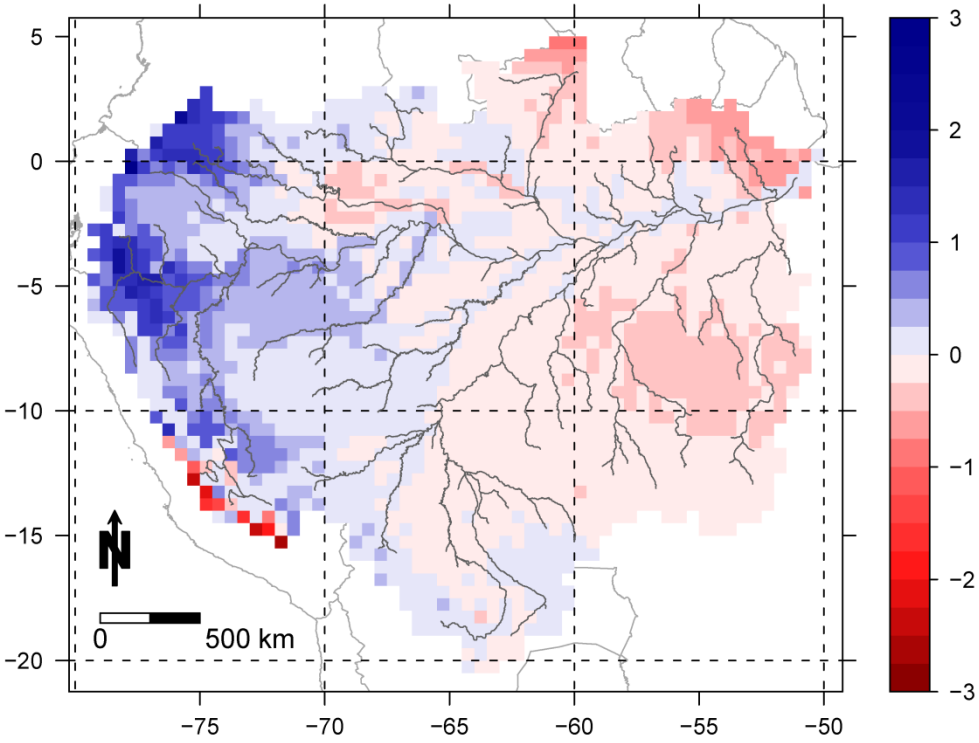
Very productive forest with dead organic material

Erosion

Regular flooding - inundation

Impacts of future climate change on inundation patterns

- **Changes in future temperature and precipitation on inundation pattern**
- **NW Amazonia experiencing longer time with inundated flood plains**
  - **Forest not adapted!**
- **SE Amazonia experiencing shorter time with inundated flood plains**
  - **Impacts on fishing**
  - **Seed distribution**
  - **Carbon dynamics (transport from forest to river, export to Atlantic ocean)**

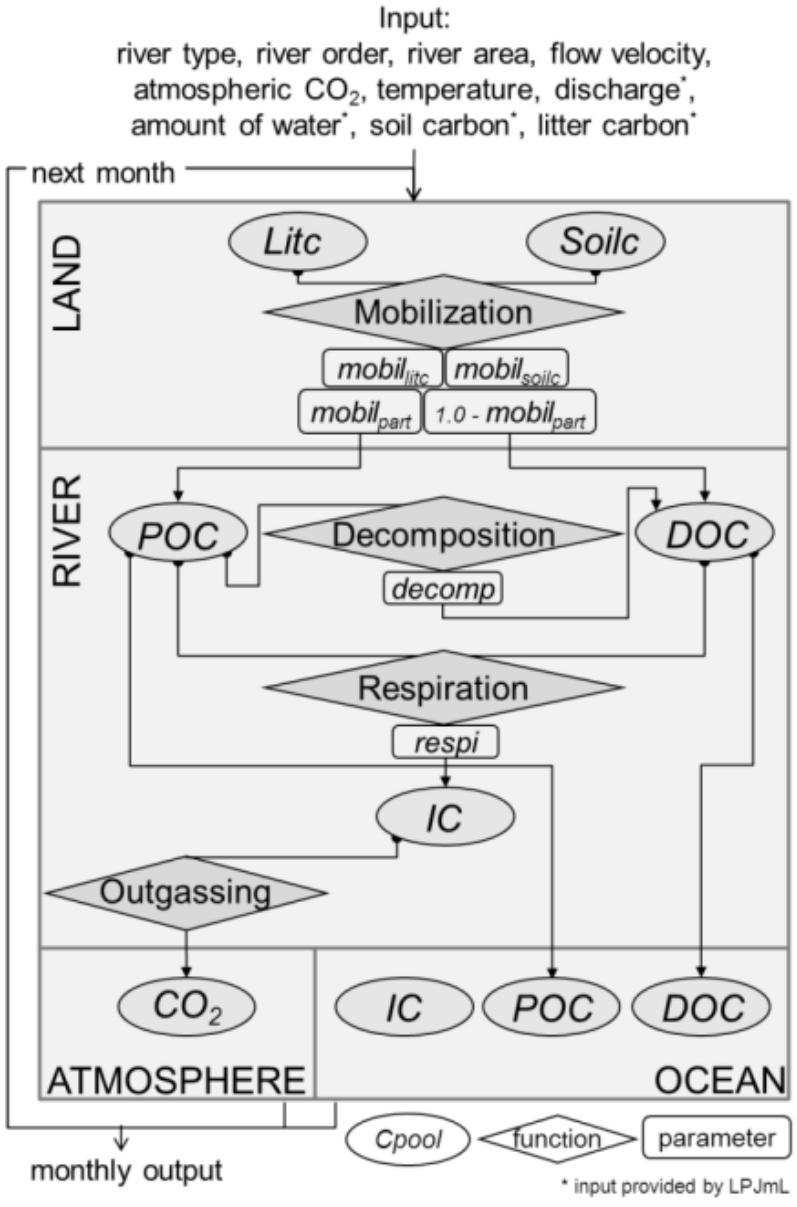


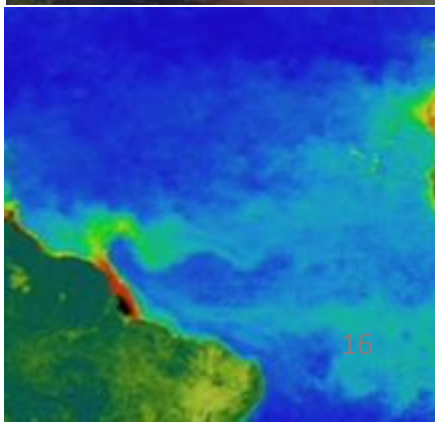
Lengthening (blue) and shortening (red) of duration of inundation in months (mean over 24 model realisations) between future (2070 to 2099) and reference (1961 to 1990) period.

Langerwisch F, Rost S, Gerten D, Poulter B, Rammig A, Cramer W 2013 Potential effects of climate change on inundation patterns in the Amazon basin. Hydrol. Earth Syst. Science, 17:2247-2262, doi:10.5194/hess-17-2247-2013

Riverine carbon model RivCM

- **Proportion of dead organic matter (as simulated by the LPJmL DGVM) exported to the river during flooding**
- **Within the river body decomposition of particulate organic carbon (POC) and dissolved organic carbon (DOC)**
- **both respired within the water body**
- **Outgassed to the atmosphere as CO_2**
- **POC and DOC exported to the ocean**

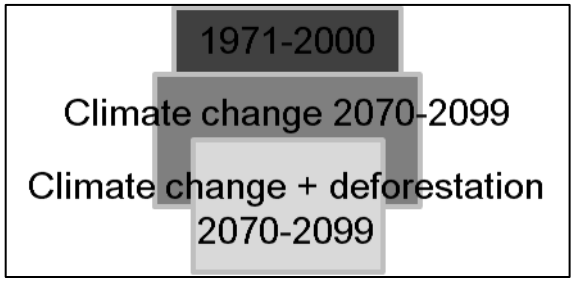


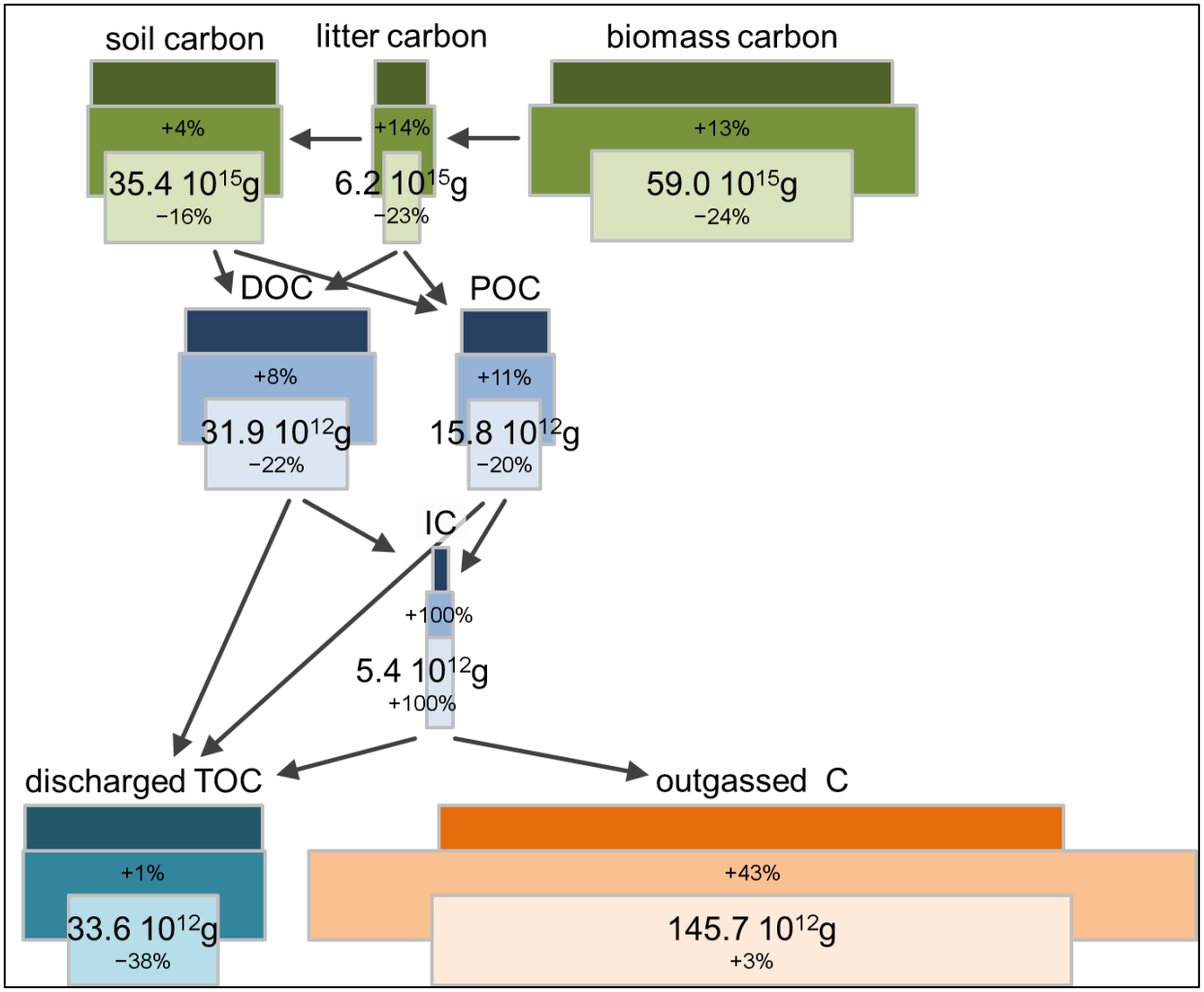


Climate change and effects of deforestation on future riverine carbon dynamics

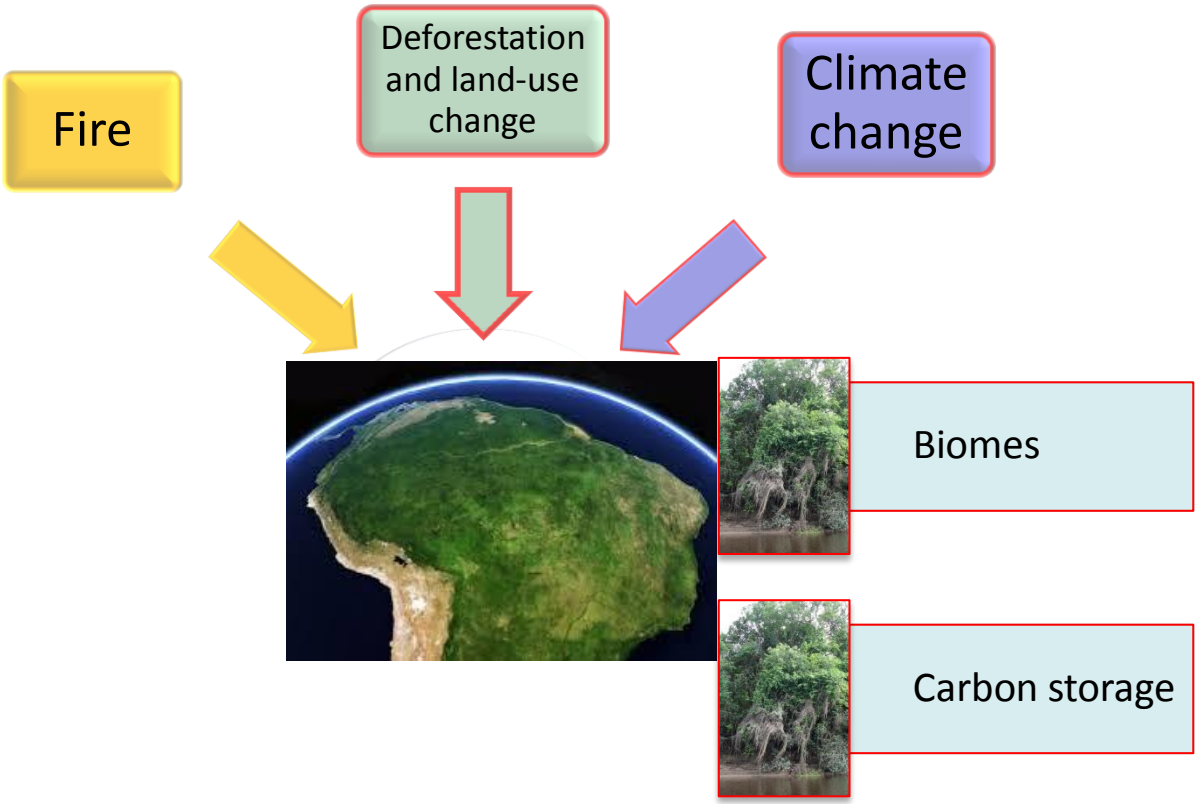
Climate change influences carbon dynamics in Amazon river

- **Higher productivity increases dead biomass and export to river**
- **More carbon outgassed from river**
- **Less in river discharge to Atlantic ocean**





Langerwisch F, Walz A, Rammig A, Tietjen B, Thonicke K, Cramer W (2016), Climate change increases riverine carbon outgassing, while export to the ocean remains uncertain, Earth Syst. Dynam., 7, 559-582, doi:10.5194/esd-7-559-2016



Study: A. Boit (PIK)

IMPACT OF CLIMATE & LAND USE CHANGE ON SOUTH AMERICAN BIOMES

Future anthromes formation and climate change impacts

- Considering changes in land cover and climate change
- Applying LPJmL DGVM to
  - climate change scenario RCP 2.6 and SSP1 vs RCP8.5 and SSP5
  - And combine it with Land use change scenario simulated by CLUE
- Most land-cover change happened during historic time and anthromes remain during 21st century
- Climate change impacts cause loss of natural biome in eastern Amazon

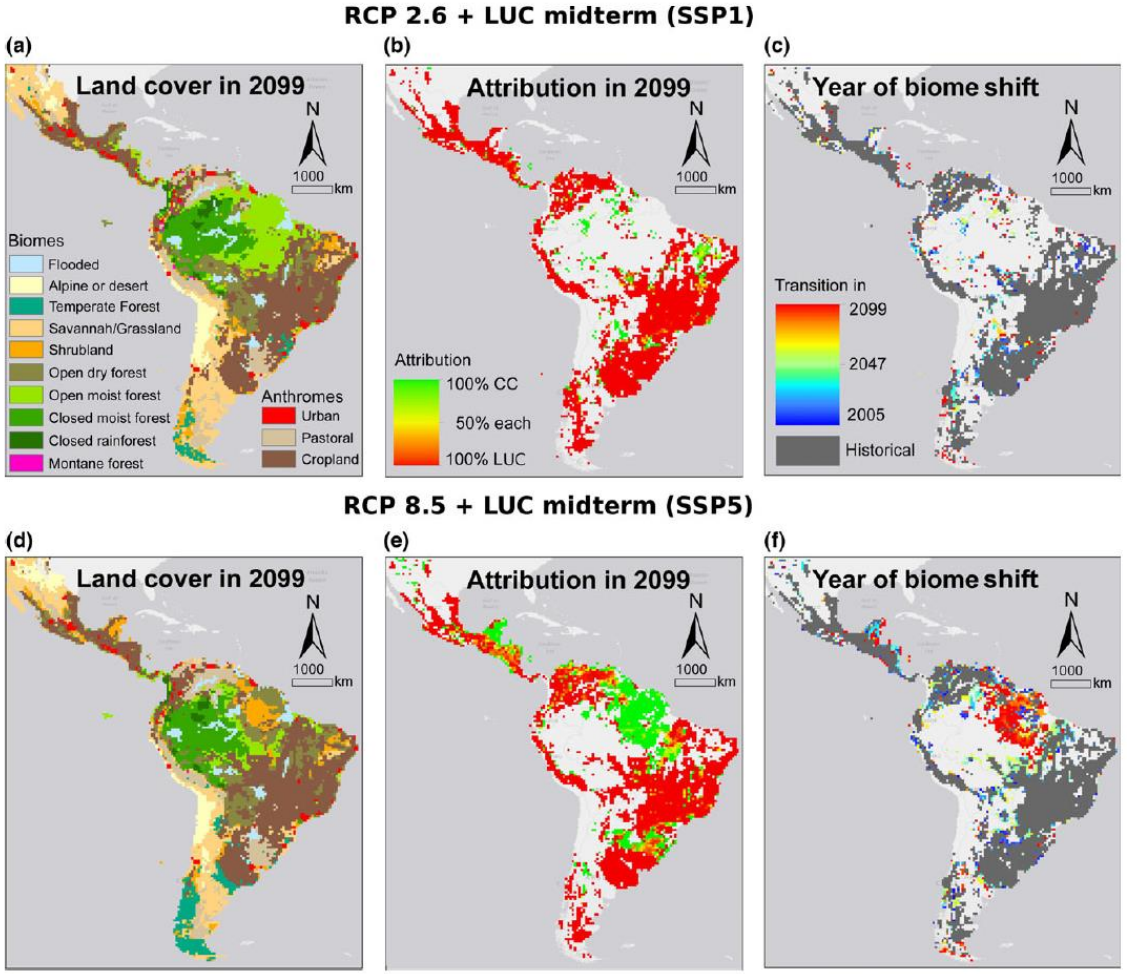
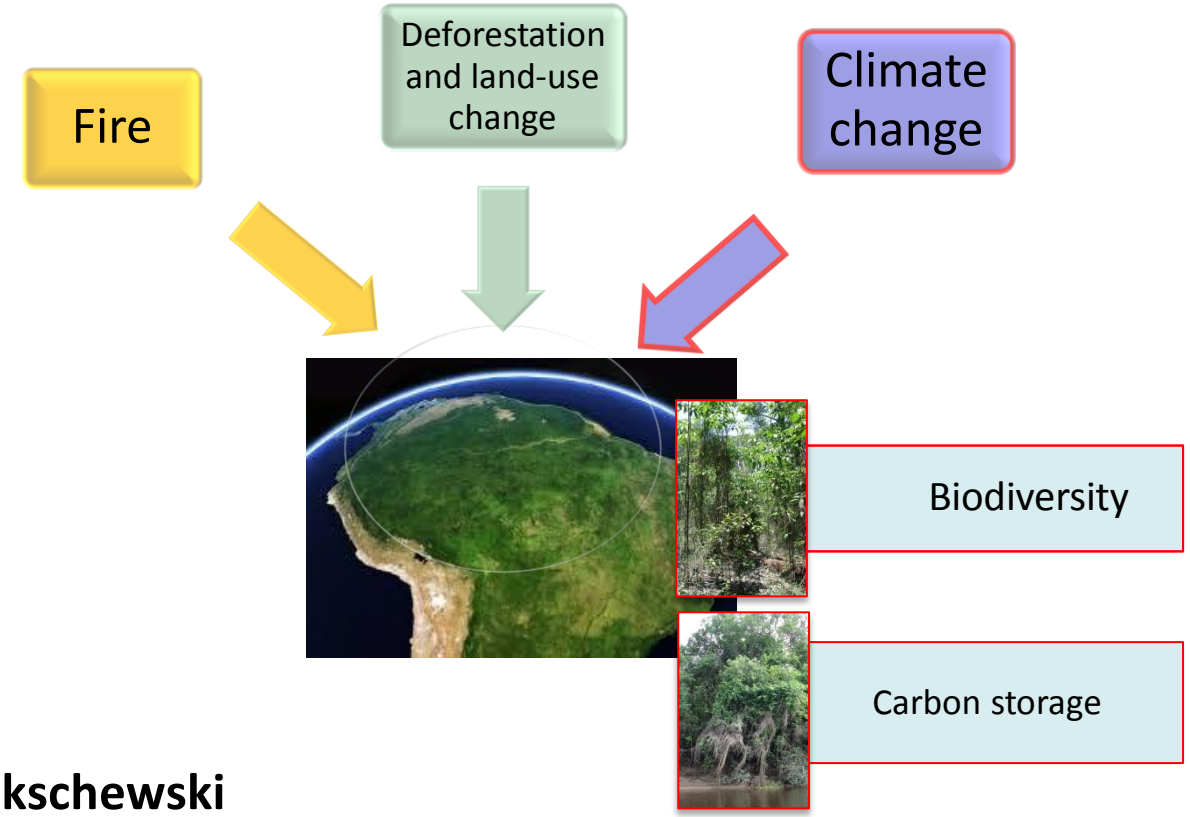


Fig. 4 Projected land cover, attribution of biome shifts to climate change (CC) and land-use change (LUC), and the year of biome shifts in Latin America. Maps for the 'best-case' scenario *RCP 2.6 + LUC midterm (SSP1)* (a–c) and the intermediate *RCP 8.5 + LUC midterm (SSP5)* (d–f) under the climate forcing of the GCM HadGEM2-ES. (a, d) Land cover divided into biomes and anthromes. (b, e) Attribution of biome shifts to climate change and land-use change, respectively. The relative contributions add up to 100% in each affected grid cell. (c, f) Year of detection of the biome shift leading to the final vegetation state shown in (a, d). Dark grey areas depict biome shifts caused by historical land-use change until 2005.

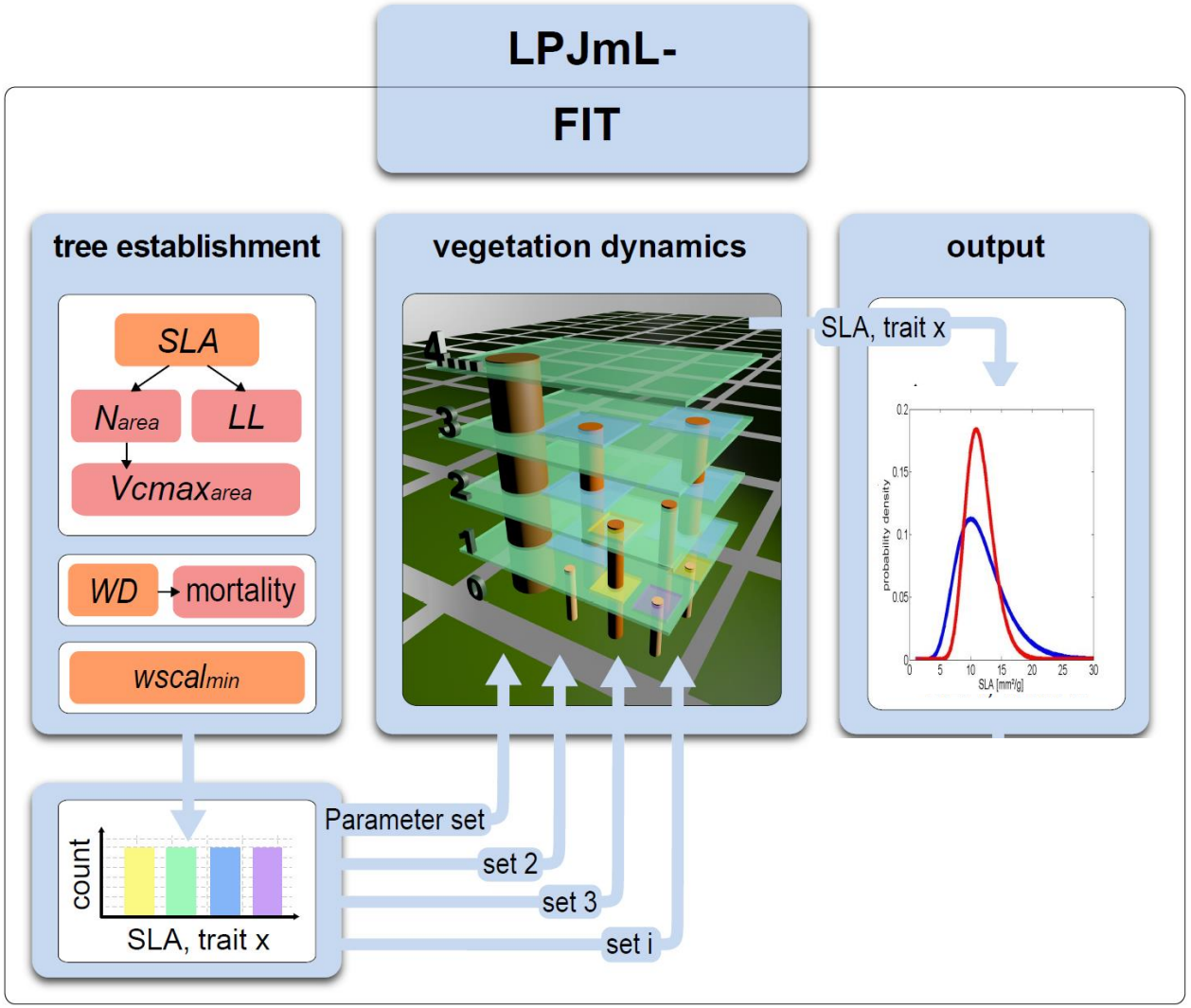
Boit A, Sakschewski B, Boysen L, Cano-Crespo A, Clement J, Alaniz NG, Kok K, Kolb M, Langerwisch F, Rammig A, Sachse R, van Eupen M, von Bloh W, Zemp D and Thonicke K (2016), Large-scale impact of climate change versus land-use change on future biome shifts in Latin America. Glob Change Biol., Doi:10.1111/gcb.13355



Additional study: B. Sakschewski

ROLE OF BIODIVERSITY FOR ECOSYSTEM RESILIENCE

Flexible Individual Traits in LPJmL

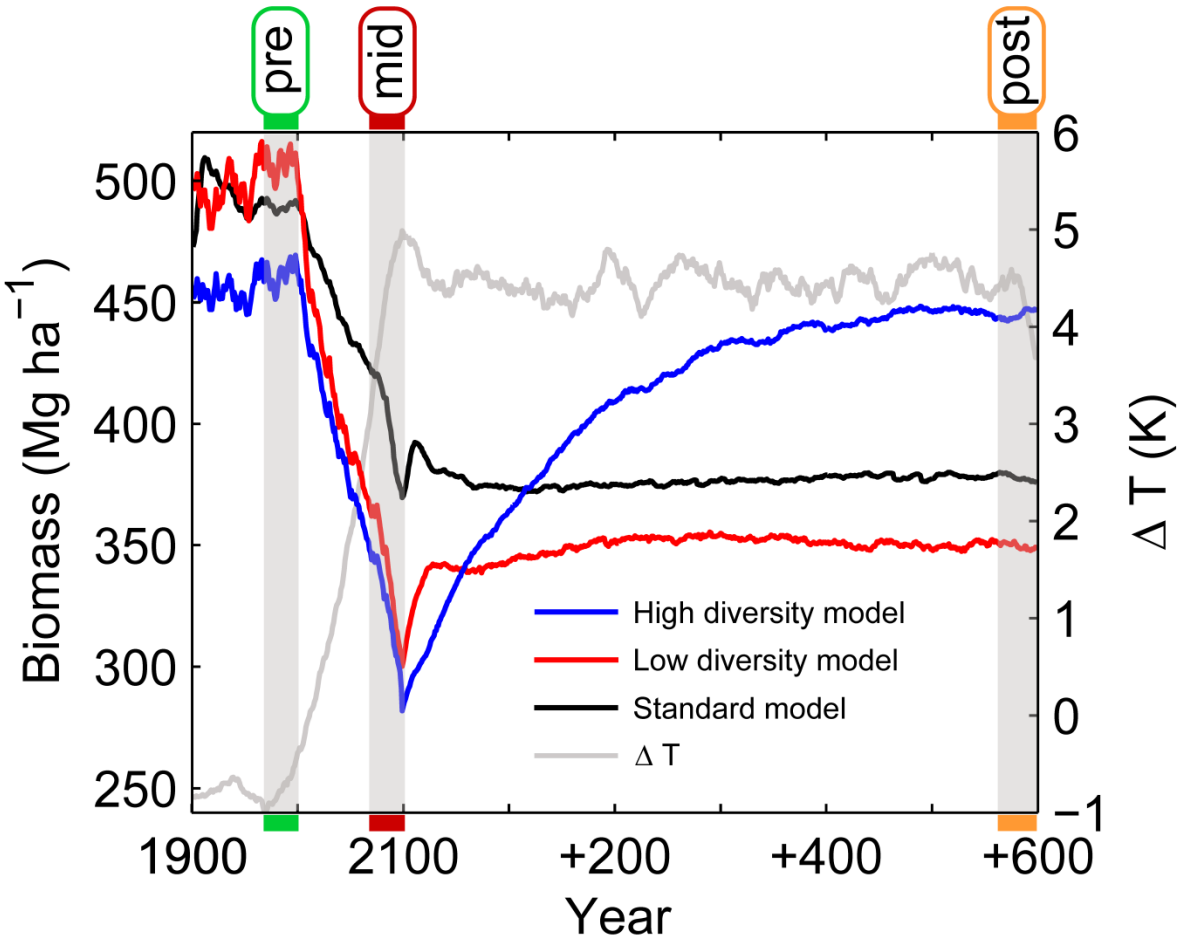


Sakschewski B, von Bloh W, Boit A, Rammig A, Kattge J, Poorter L, Peñuelas J and Thonicke K (2015) Leaf and stem economics spectra drive diversity of functional plant traits in a dynamic global vegetation model, Global Change Biology, DOI: 10.1111/gcb.12870

nature climate change
LETTERS
PUBLISHED ONLINE: 29 AUGUST 2016 | DOI: 10.1038/NCLIMATE3109

Resilience of Amazon forests emerges from plant trait diversity

Boris Sakschewski[1,2]*, Werner von Bloh[1,2], Alice Boit[1,2], Lourens Poorter[3], Marielos Peña-Claros[3], Jens Heinke[1,2], Jasmin Joshi[4] and Kirsten Thonicke[1,2]



- 400ha of site in Ecuador
- RCP 8.5 HadGEM
- shuffling climate of 2071-2100 from 2100 onwards

High diversity LPJmL-FIT

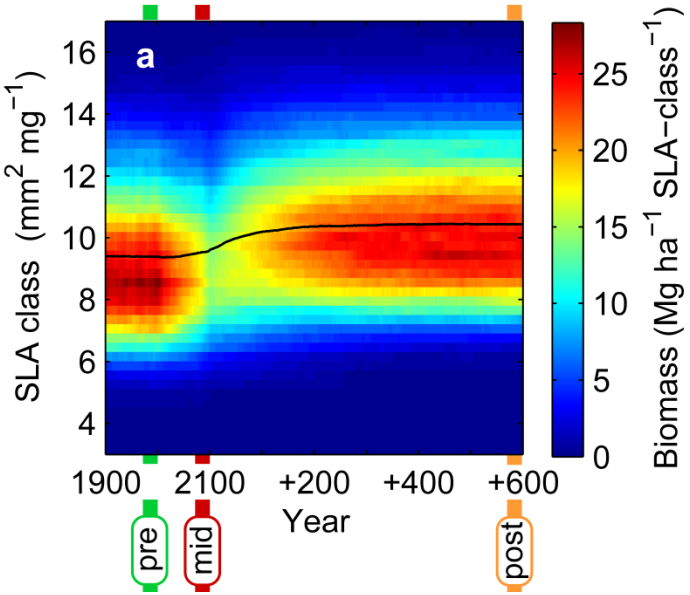
Low diversity LPJmL-FIT

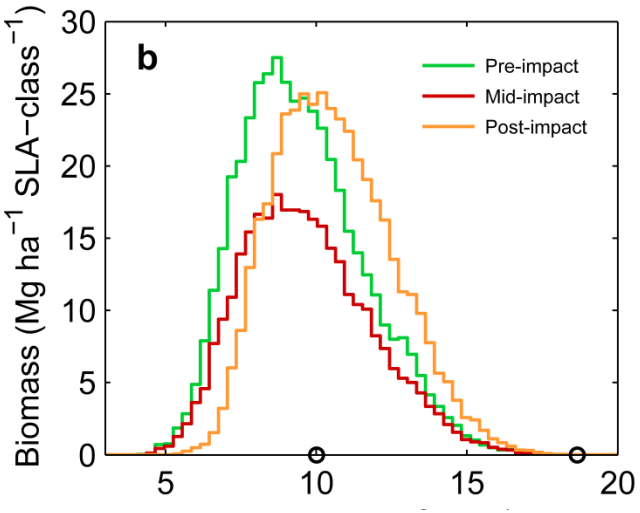
Standard LPJmL

Gap model

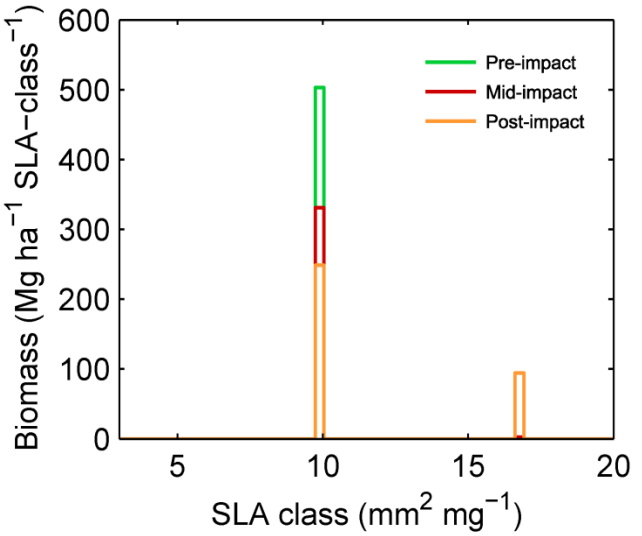
2 PFTs

Trait range allows the better adapted trees to take over and recover biomass





High diversity



Low diversity

Sakschewski et al. NCC 2016

Thanks to all colleagues who contributed to this work with ideas, comments and suggestions

and thank you for your attention!

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AMAZALERT

ROBIN