Amazon carbon and water cycling

Gerbrand Koren, *Shaun Harrigan, Arie Staal, Santiago Botía, Lucas G. Domingues, Liesbeth Florentie, Luciana V. Gatti, Manuel Gloor, Maarten C. Krol, Ingrid T. Luijkx , John B. Miller, Stijn Naus, Wouter Peters*

International TM5 Meeting
May 2022 - Wageningen

TM 5

Utrecht University

2015/16 drought in the Amazon

Amazon drought 2015/2016

PHILOSOPHICAL TRANSACTIONS B

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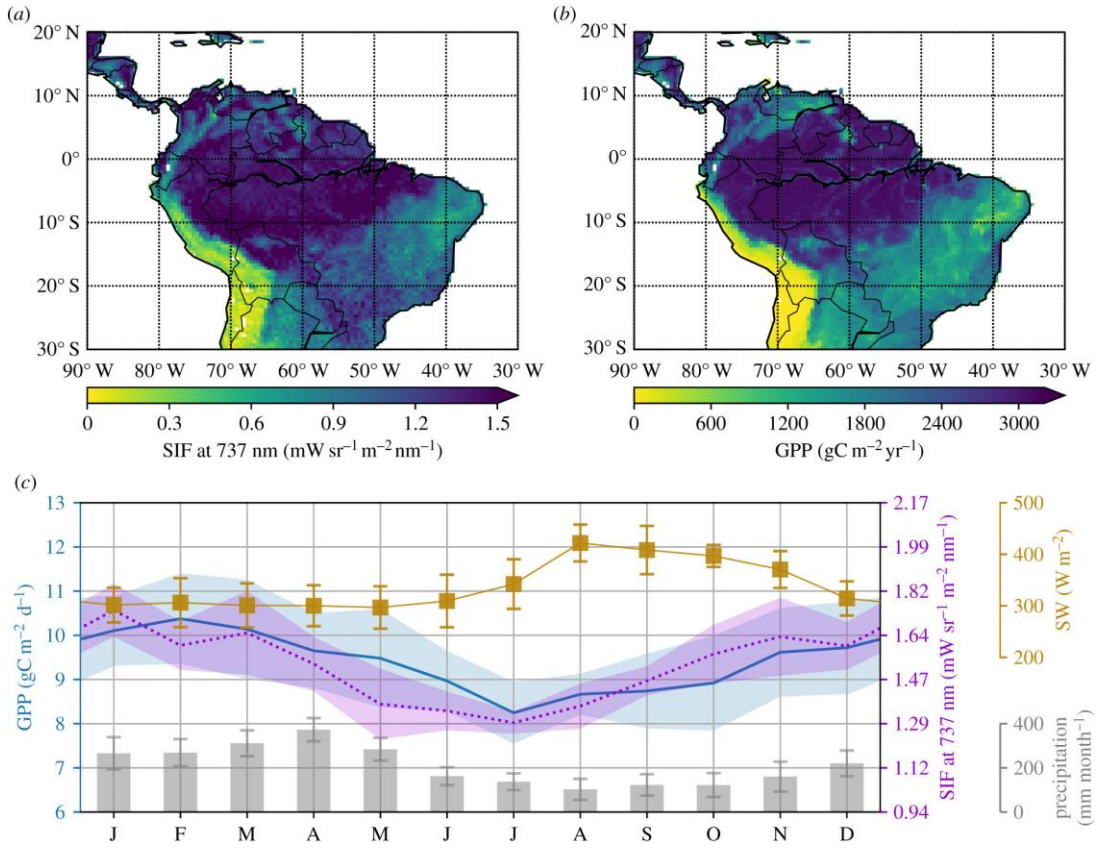
Widespread reduction in sun-induced fluorescence from the Amazon during the 2015/2016 El Niño

Gerbrand Koren[1], Erik van Schaik[1], Alessandro C. Araújo[2], K. Folkert Boersma[1,3], Antje Gärtner[1], Lars Killaars[4], Maurits L. Kooreman[3], Bart Kruijt[1], Ingrid T. van der Laan-Luijkx[1], Celso von Randow[5], Naomi E. Smith[1] and Wouter Peters[1,4]



- Remotely sensed sun-induced fluorescence (SIF) is a proxy for photosynthesis (GPP)
- WUR/KNMI developed an algorithm specifically for tropical regions (humid)
- Spatial and temporal patterns in SIF match with (upscaled) EC-derived GPP

Koren et al. (2018), https://doi.org/10.1098/rstb.2017.0408

Amazon drought 2015/2016

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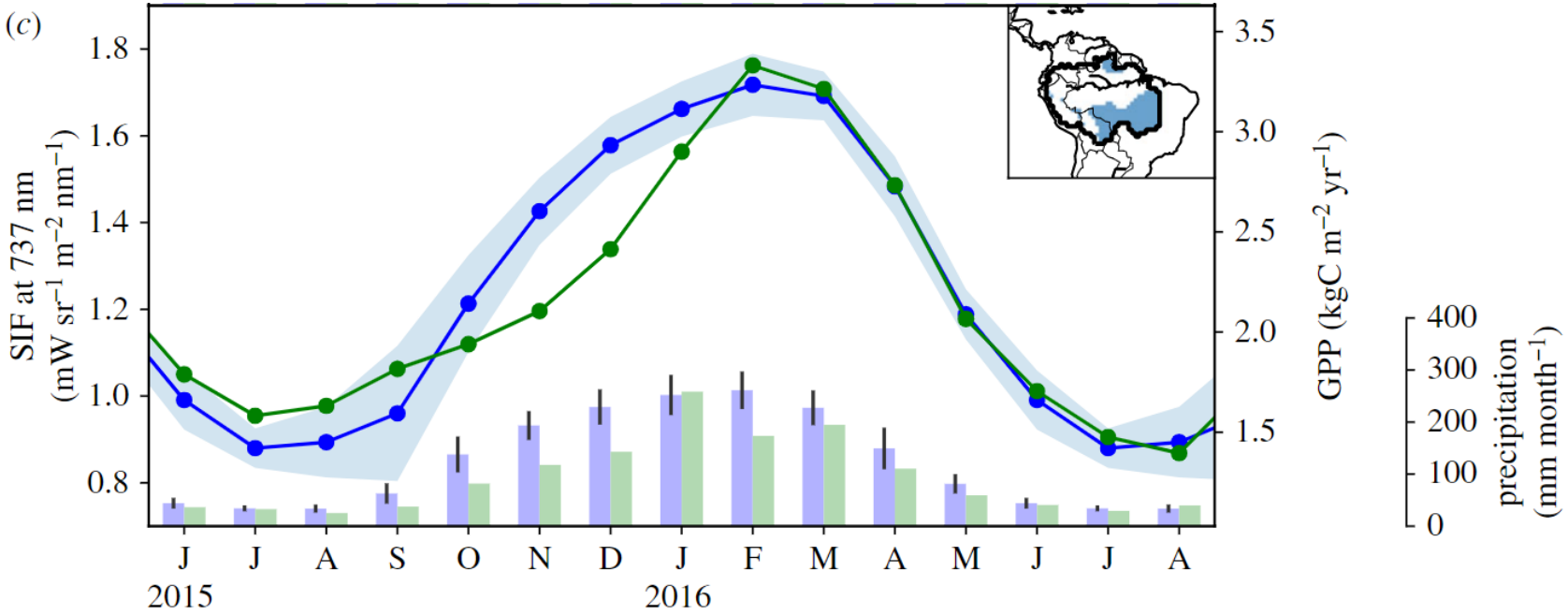
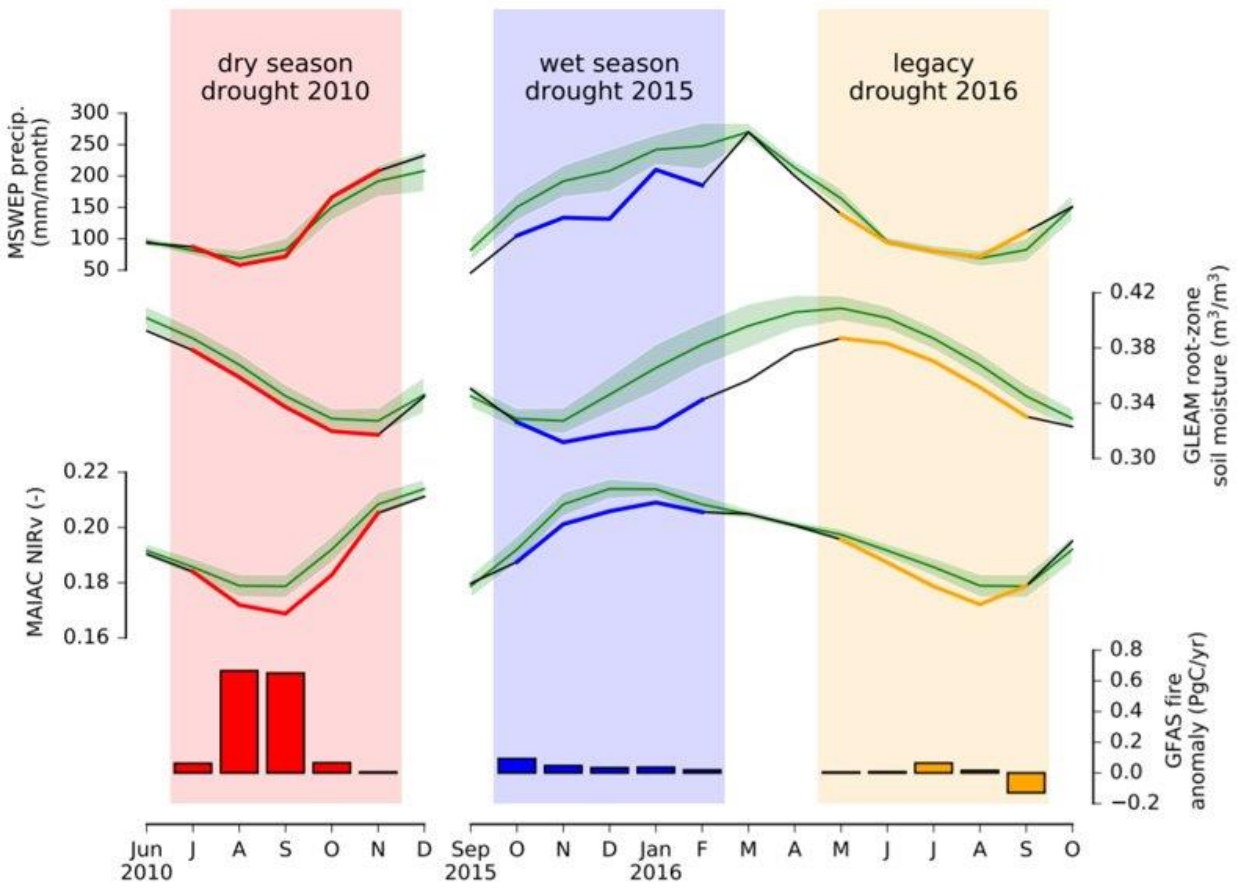


- Precipitation for 2007-2014 (n = 8, blue bars) exceeds that for period Sep-2015 to Feb-2016 (green bars) for Southern part of Amazon
- Reduction in SIF suggests reduction of photosynthesis during drought of 2015/16
- Error bars and shading refer to standard deviation over baseline period

Amazon drought 2015/2016



Koren et al., in prep.

- Direct and delayed impacts of the 2015/2016 drought on the Amazon carbon cycle
- Analysis based on remote sensing (SIF, NIRv) and inverse modeling

Amazon aircraft network

LETTER

doi:10.1038/nature12957

Drought sensitivity of Amazonian carbon balance revealed by atmospheric measurements

L. V. Gatti[1]*, M. Gloor[2]*, J. B. Miller[3,4]*, C. E. Doughty[5], Y. Malhi[5], L. G. Domingues[1], L. S. Basso[1], A. Martinewski[1], C. S. C. Correia[1], V. F. Borges[1], S. Freitas[6], R. Braz[6], L. O. Anderson[5,7], H. Rocha[8], J. Grace[9], O. L. Phillips[2] & J. Lloyd[10,11]

Article

Amazonia as a carbon source linked to deforestation and climate change

https://doi.org/10.1038/s41586-021-03629-6

Received: 11 September 2020

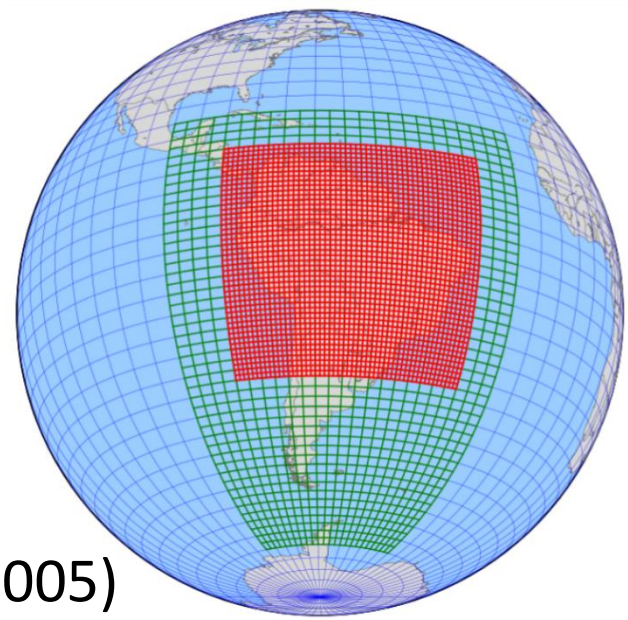
Accepted: 10 May 2021

Published online: 14 July 2021

Luciana V. Gatti[1,2]✉, Luana S. Basso[1], John B. Miller[3], Manuel Gloor[4], Lucas Gatti Domingues[1,2,5], Henrique L. G. Cassol[1], Graciela Tejada[1], Luiz E. O. C. Aragão[1,6], Carlos Nobre[7], Wouter Peters[8,9], Luciano Marani[1], Egidio Arai[1], Alber H. Sanches[1], Sergio M. Corrêa[1,10], Liana Anderson[11], Celso Von Randow[1], Caio S. C. Correia[1,2], Stephane P. Crispim[1] & Raiane A. L. Neves[1]

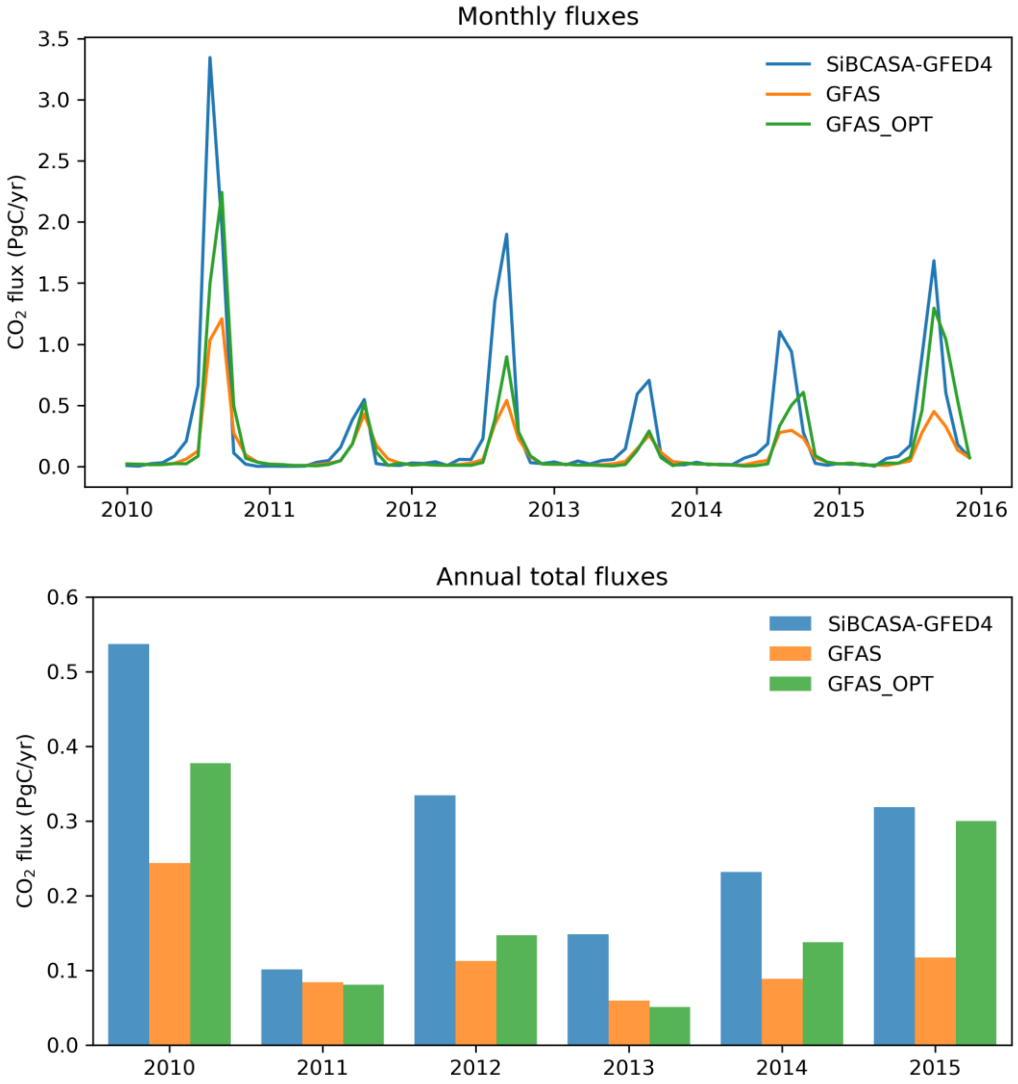
- Major studies from the group of Luciana Gatti based on network of small aircraft sampling air above Amazon forest

CarbonTracker South America



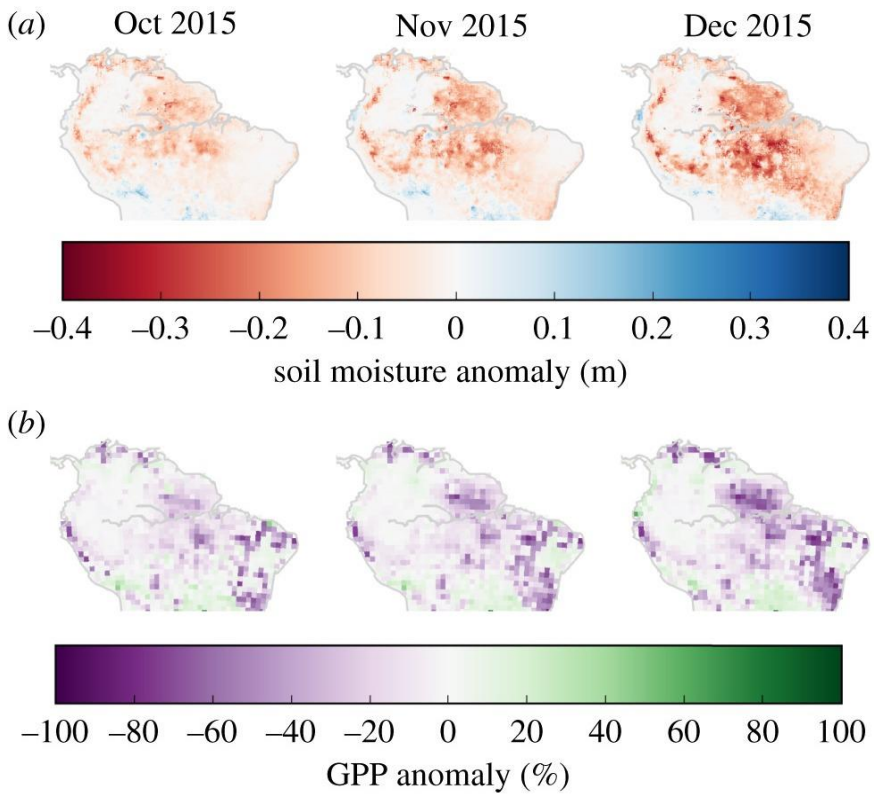
- TM5 with zoom regions over South America (van der Laan-Luijkx et al., 2015)
- Ensemble Kalman Filter (Peters et al., 2005)
- CO_2 profiles from Amazon (Gatti network)
- 5 different biosphere priors and 3 different fire products

GFAS-optimized CO_2 fire emissions



- GFAS prior CO_2 emissions multiplied with ratio of posterior-to-prior CO emissions to obtain 'optimized' GFAS CO_2 emissions
- On average better agreement between optimized GFAS and SiBCASA-GFED4 emissions

Biosphere prior SiBCASA-PCR



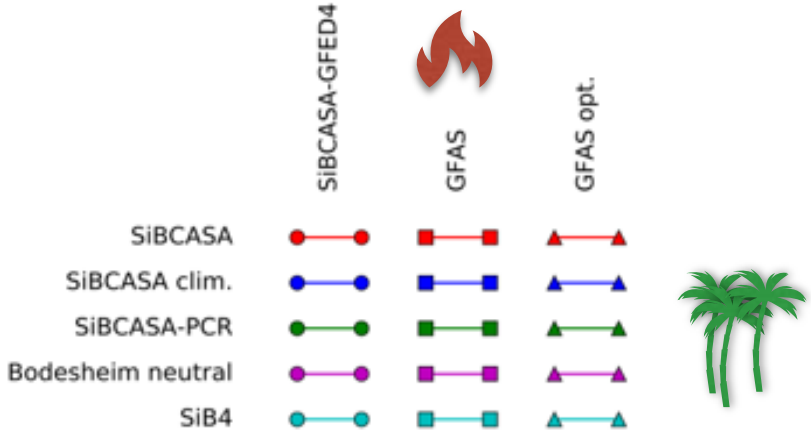
Changes in surface hydrology, soil moisture and gross primary production in the Amazon during the 2015/2016 El Niño

Erik van Schaik[1], Lars Killaars[2], Naomi E. Smith[1], Gerbrand Koren[1], L. P. H. van Beek[3], Wouter Peters[1,2] and Ingrid T. van der Laan-Luijkx[1]

- Coupling of PCR-GLOB with SiBCASA for more realistic soil moisture
- Validated using discharge observations from river gauge stations

CO_2 fluxes for Amazon

- Annual anomalies relative to the 2010-2017 baseline
- Very few observations from Gatti network in 2015



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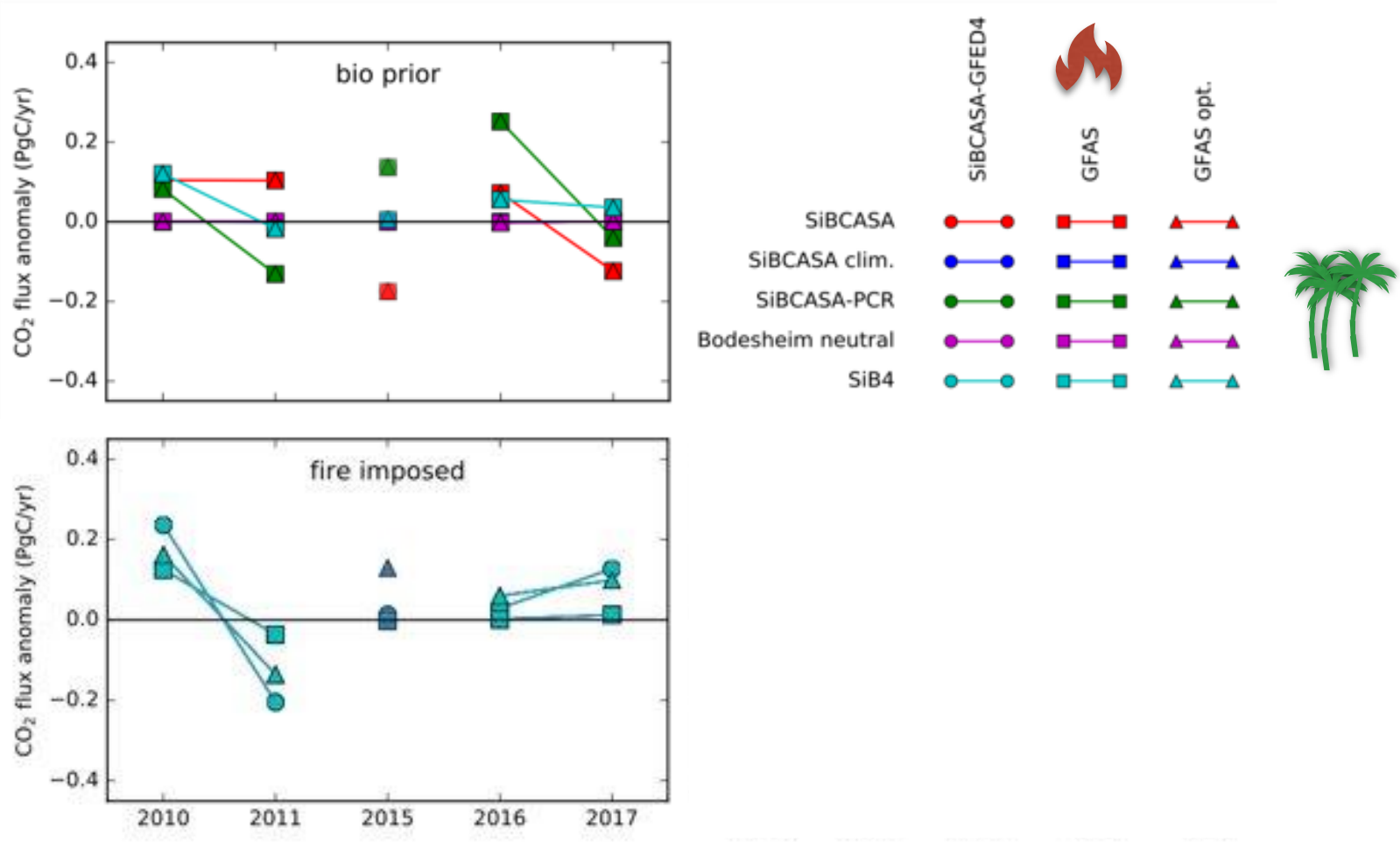

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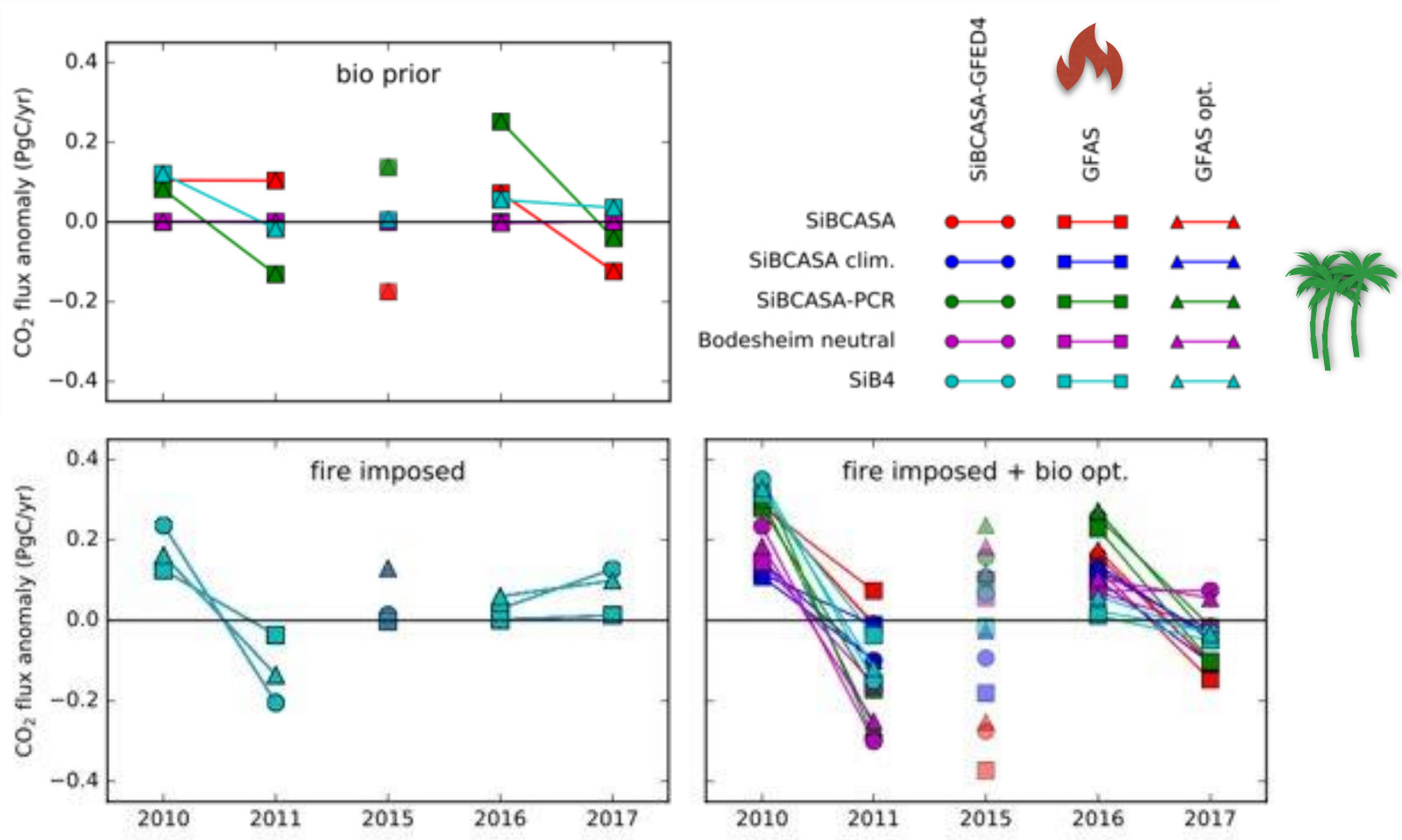
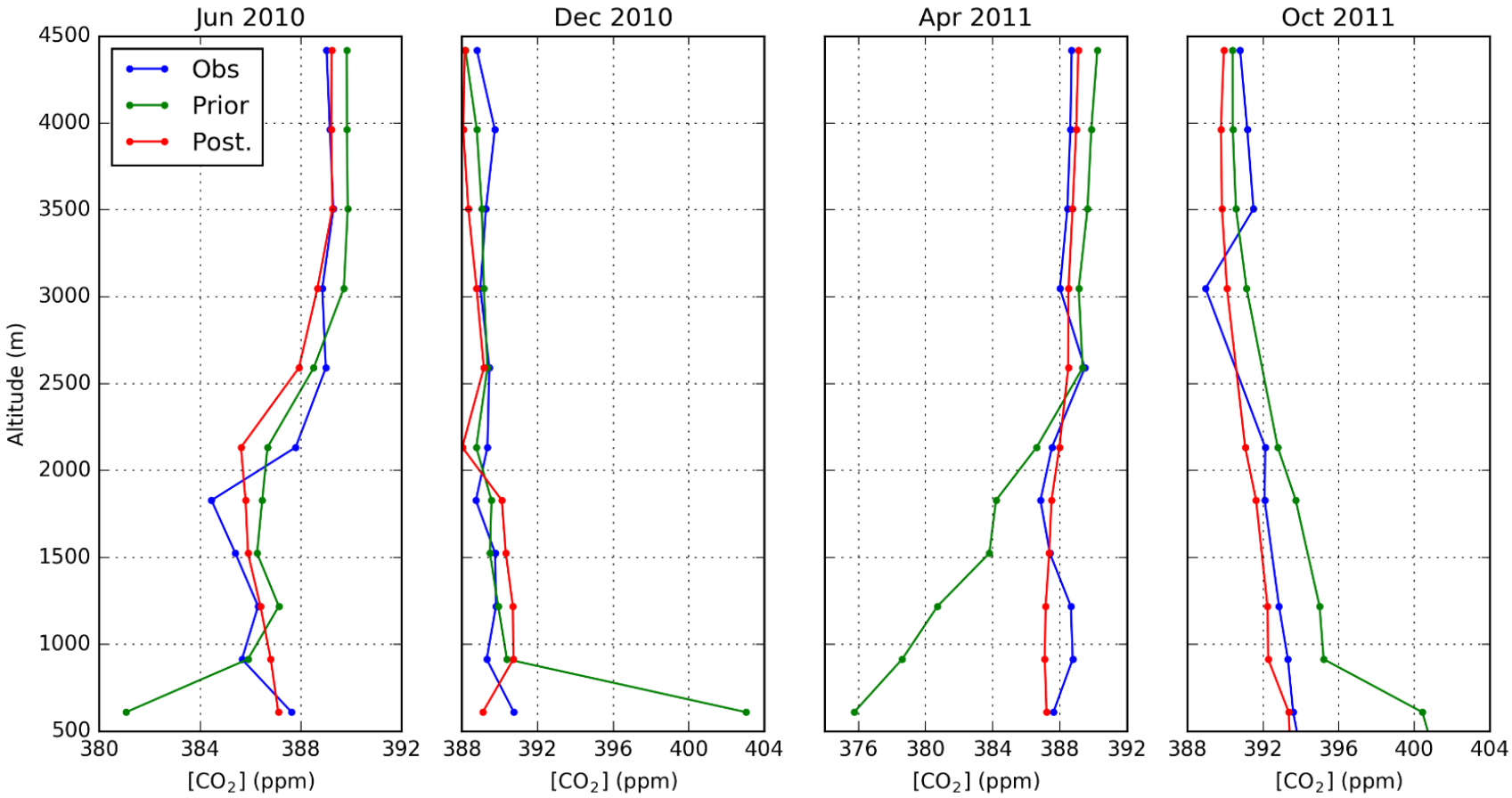


CarbonTracker-South America CO_2 profiles



- Examples of CO_2 profiles for Alta Floresta (ALF) from Gatti network
- Posterior profile matches better with obs. than the prior profile

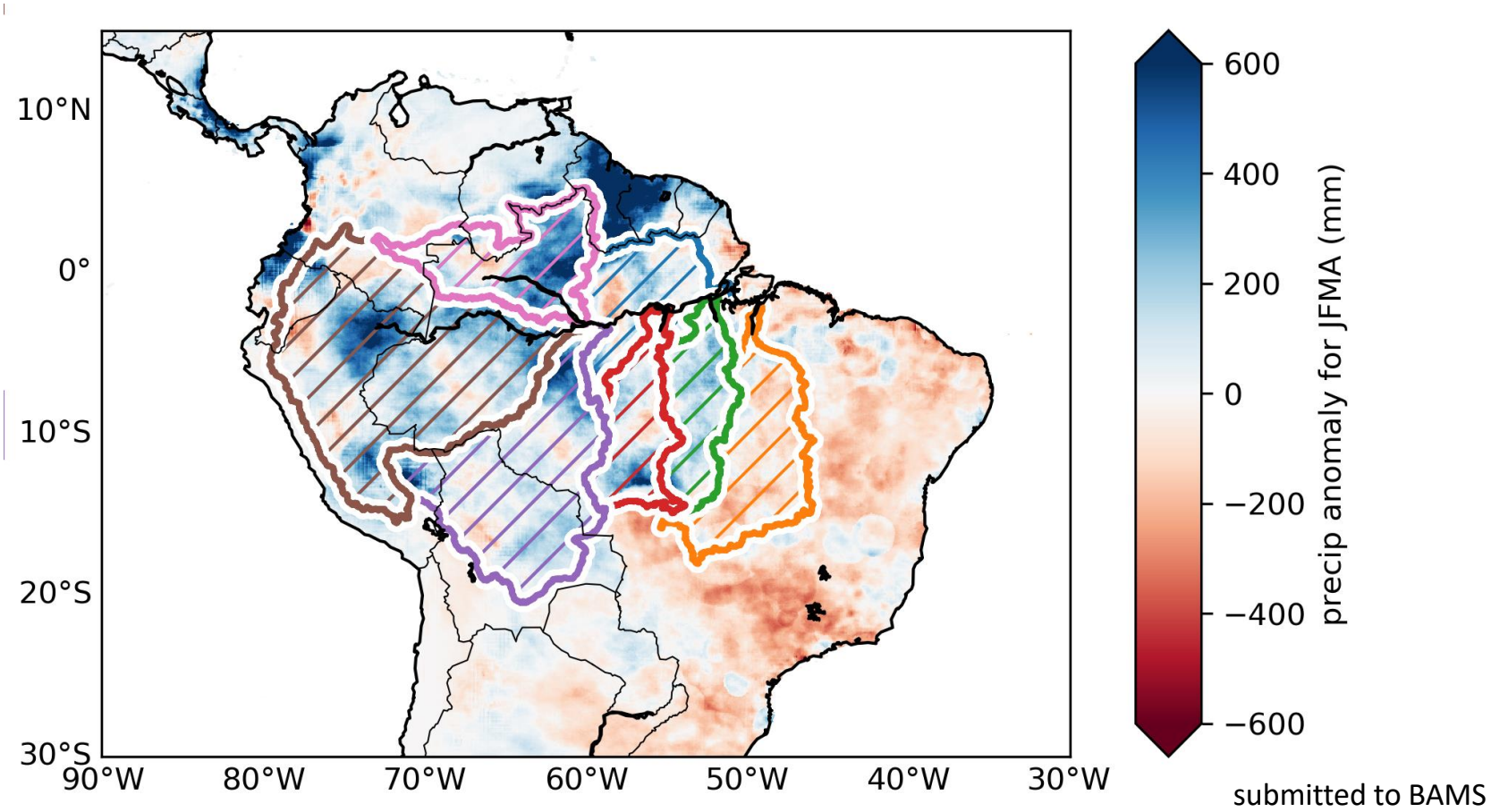
2021 floods in the Amazon

2021 floods in the Amazon

BBC/Reuters

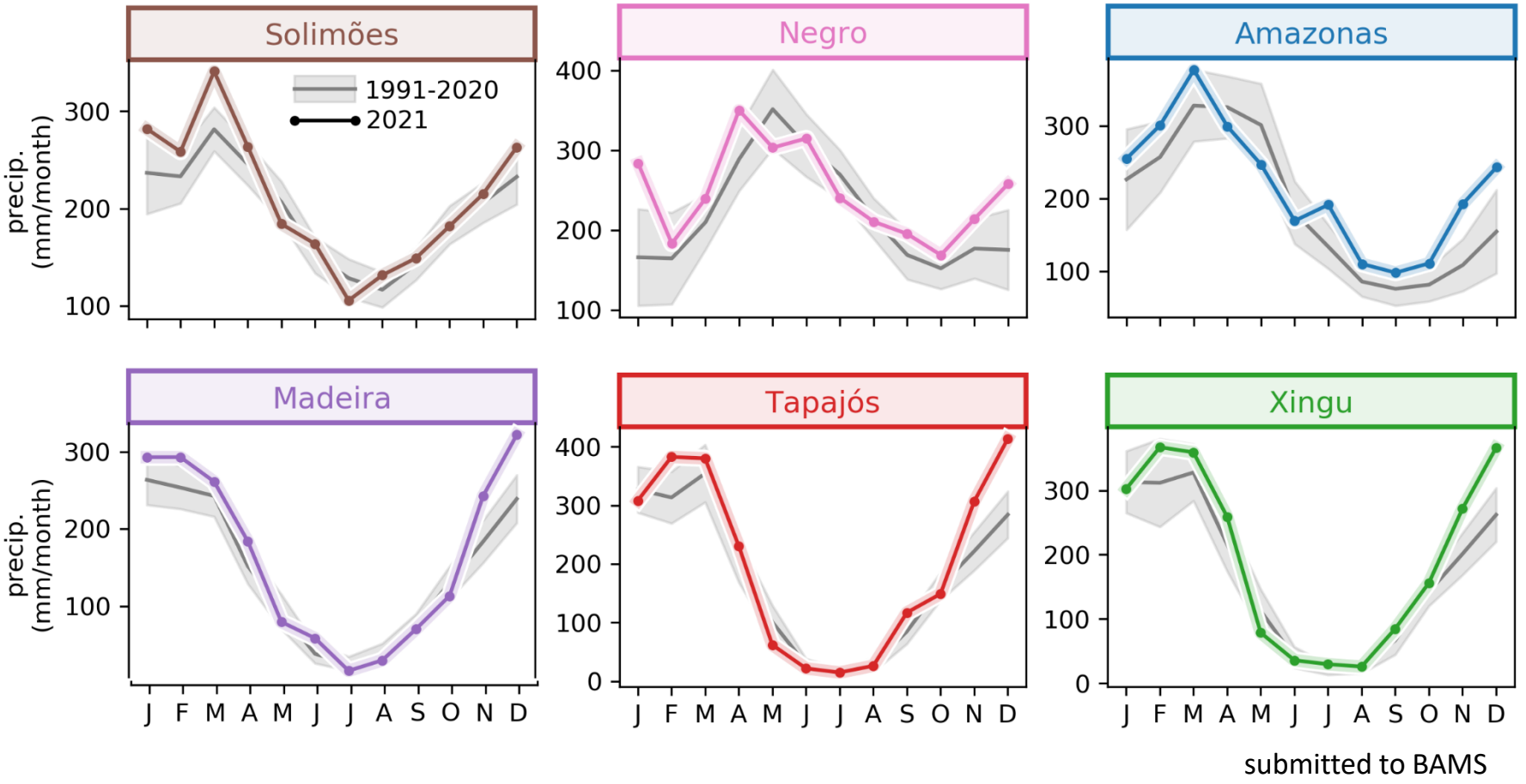
- First flood occurred around May/June 2021, while Brazil was facing high covid infections
- A second flood occurred at the end of the year

Precipitation anomalies in 2021



- Tropical precipitation in reanalysis products can be uncertain. Here we used CHIRPS (Funk et al., 2015), with 30-yr baseline period

Precipitation anomalies in 2021



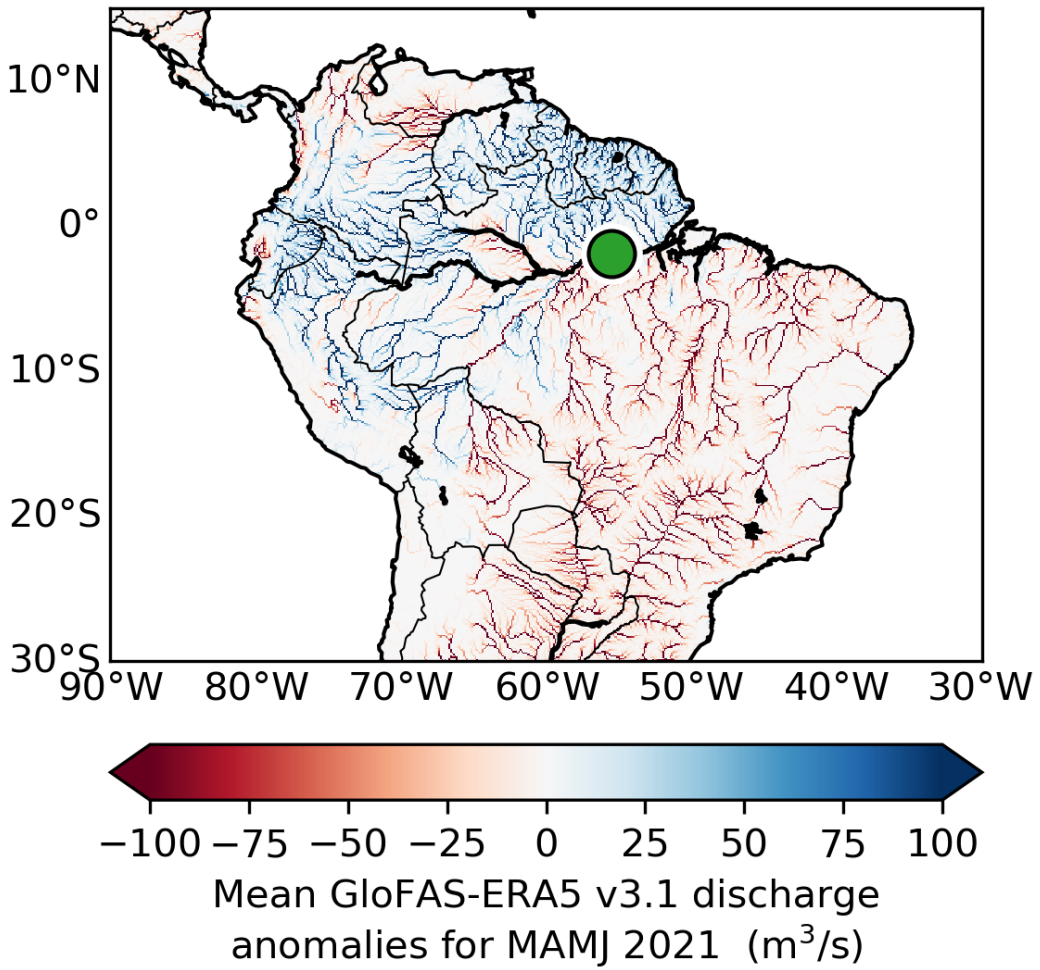
- For all regions, the end-of-year peak is exceeding the 1-σ range
- For most regions the absolute value of the first peak (March/April) is higher

Discharge anomalies in 2021

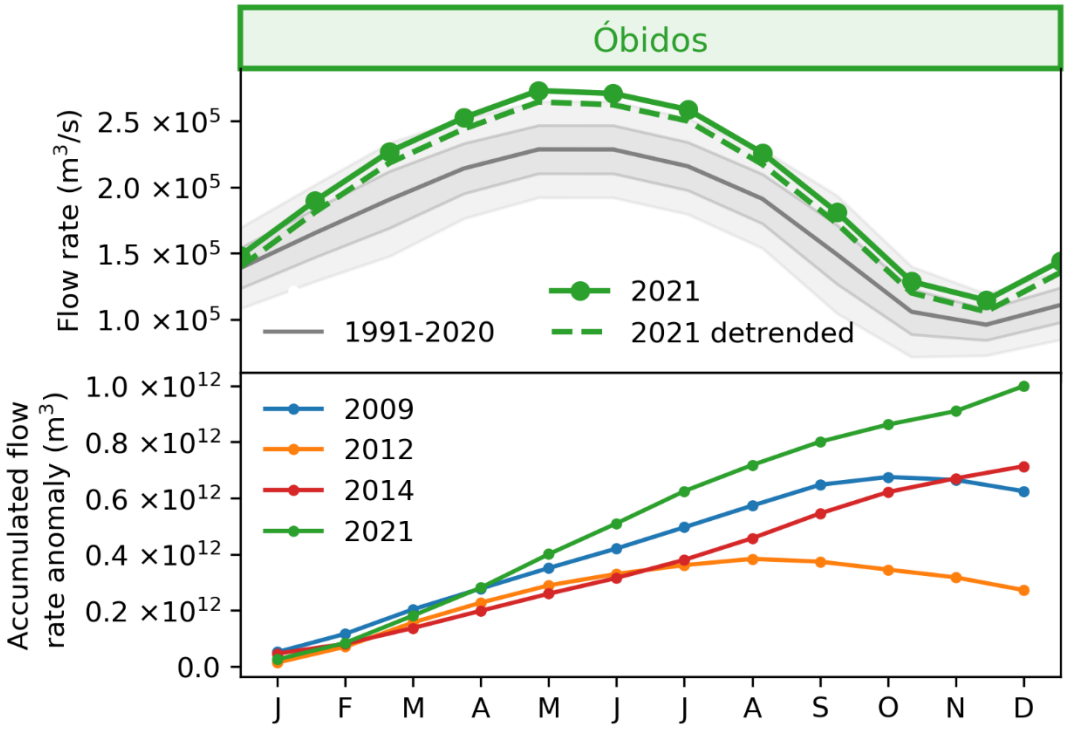
- GloFAS-ERA5 river discharge (Harrigan et al., 2020) suggests that May/June floods were mostly in Northern Amazon region

- Marker shows location of Óbidos discharge station.

submitted to BAMS



Discharge anomalies in 2021



submitted to BAMS

- Discharge peaks lag precipitation peaks by ~2 months
- Highest (peak) discharge occurs in (May) 2021, exceeding the 30 year 2-σ level (light shading), which is also exceeded in Dec 2021
- Accumulated discharge anomaly for 2021 exceeds that for earlier wet years

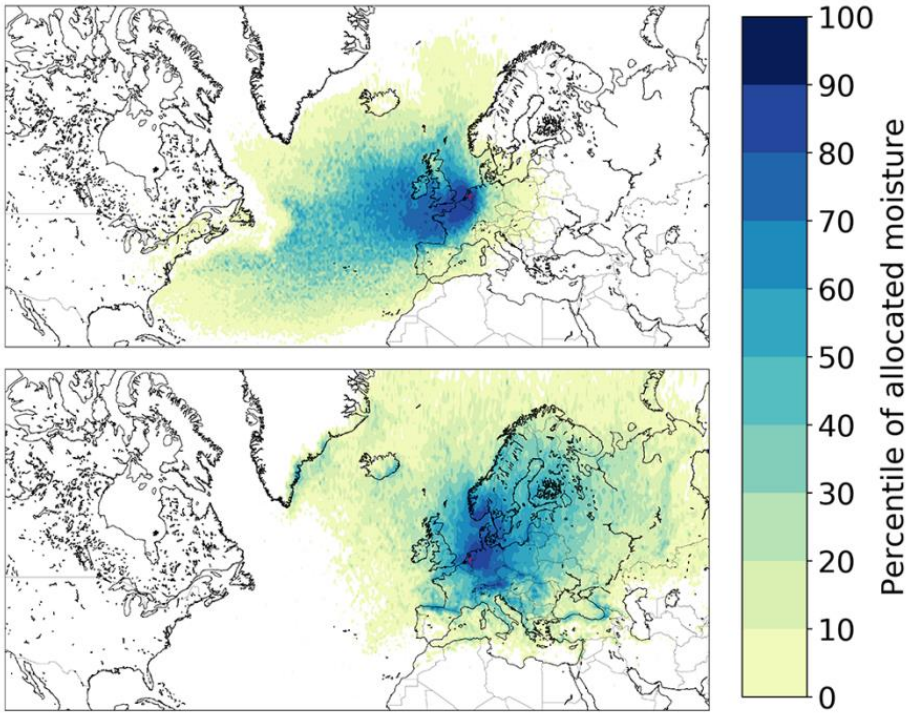
Open question: impacts on carbon cycle

- Waterlogging could result in stress, but highly productive floodplain forests are adapted to this.
- I expect little impact on carbon cycle (not confirmed yet)

Open question: moisture sources

Location of precipitation for water evaporated from Utrecht

Source of precipitation at Utrecht



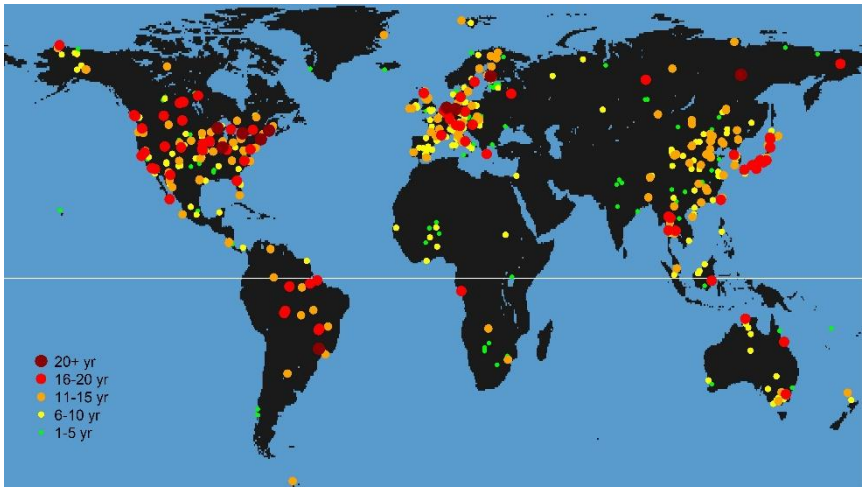
Tuinenburg et al. (2020)

- Langrangian moisture tracking model UTrack will be used, potentially also Eulerian model WAM-2layers
- Would there be any benefit in implementing moisture tracking in TM5?

New PhD project: TROPICS

Geographical bias

FLUXNET community



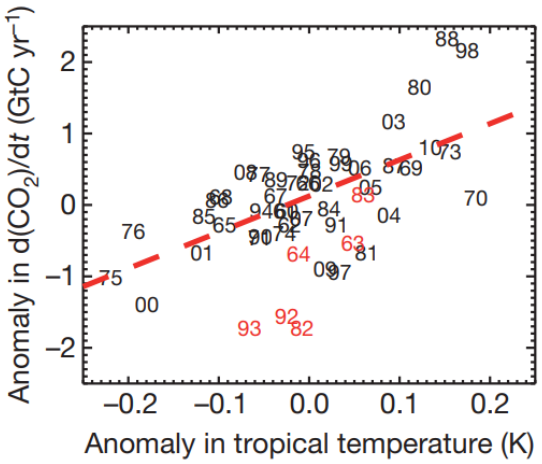
CMIP6 Modeling Groups (click on flags to reveal identity)

CMIP6 initiative

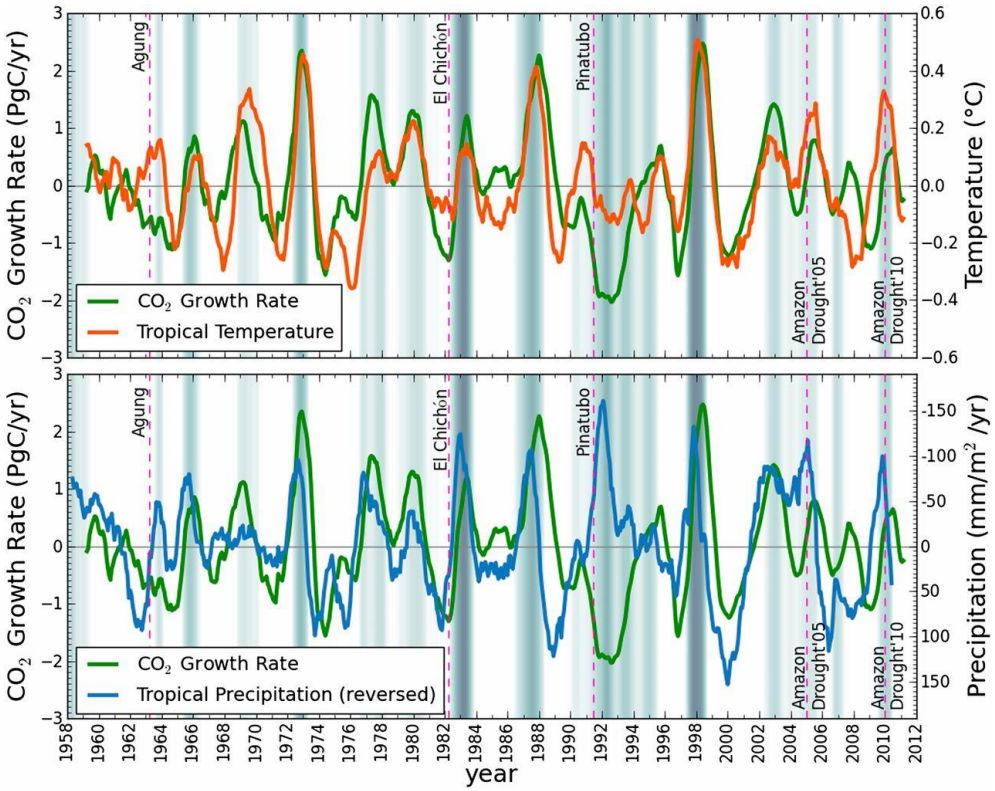
- Geographical bias in observational networks and scientists

Importance of tropical ecosystems

Cox et al., Nature (2013)



Wang et al., PNAS (2013)



- Tropical ecosystems control the interannual variation in the growth rate of atmospheric CO_2

New PhD project

- New PhD project Utrecht University: TRansforming towards OPen and Inclusive Climate Sciences (TROPICS)
- We are looking for a multi-disciplinary candidate
- Project will involve field work in tropical regions and TM5 modeling!
- Position not yet advertised, but feel free to suggest potential candidates g.b.koren@uu.nl

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