Wet, Wetter, Wettest

Amazon Rainforest Responsiveness to Short-Term Drought

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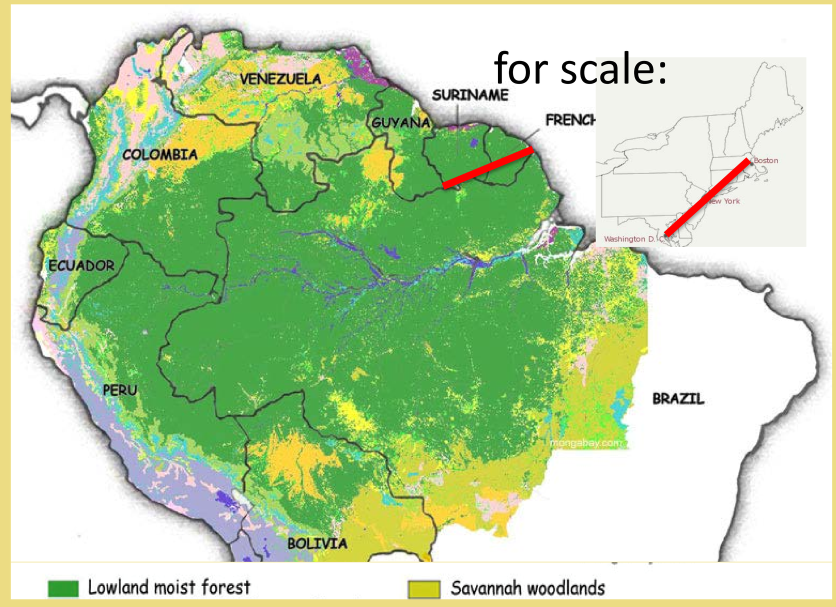
Why the Amazon Matters for Climate



- HUGE.
- Productive
- Over-size share of world's **land:air CO_2 exchange**

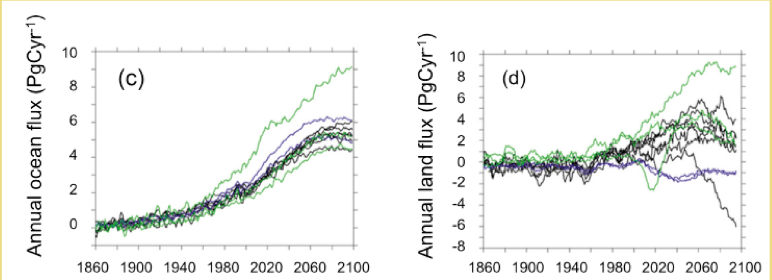
What's in store for the Amazon?

More rain variability,

MORE DROUGHTS

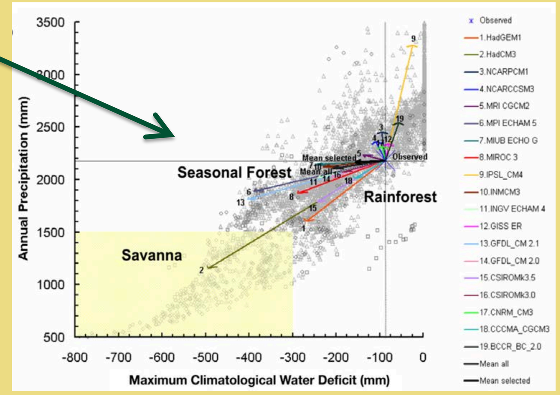
Warmer. Rain amount = ??

Future land absorption of CO_2 is relatively uncertain.



Land v. ocean removals of atmospheric carbon, GCM projections. Source: Freidlingstein 2014, Fig. 4.

GCM projections of rain changes, eastern Amazon



Arrow: One model's change from 1970-1999 versus 2070-2099, medium-high (A2) emissions. Grey dot: Estimate for a point location in a year, 1998-2006.
Source: Malhi 2009, Fig. 2

Research Questions

Purpose:

Refine expectations about Amazonian resilience to drought.

- How strongly do photosynthetic rates of Amazonian broadleaf evergreen forests respond to a dry month?
- How does responsiveness vary with climatology?

Next??

- Try different grid scales, rain lags, other satellites' SIF data.
- Build, test responsiveness climate model metric for the International Land Model Benchmarking Project (ILAMB).
- Explore OCO-2 SIF re: seasonal cycles & full-year droughts.

Citations

Frankenberg, Christian, Chris O'Dell, Joseph Berry, Luis Guanter, Joanna Joiner, Philipp Köhler, Randy Pollock, and Thomas E. Taylor. "Prospects for Chlorophyll Fluorescence Remote Sensing from the Orbiting Carbon Observatory-2." *Remote Sensing of Environment* 147 (May 2014): 1–12. doi:10.1016/j.rse.2014.02.007.

Guan, Kaiyu, Ming Pan, Haibin Li, Adam Wolf, Jin Wu, David Medvigy, Kelly K. Caylor, et al. "Photosynthetic Seasonality of Global Tropical Forests Constrained by Hydroclimate." *Nature Geoscience* 8, no. 4 (March 9, 2015): 284–89. doi:10.1038/ngeo2382.

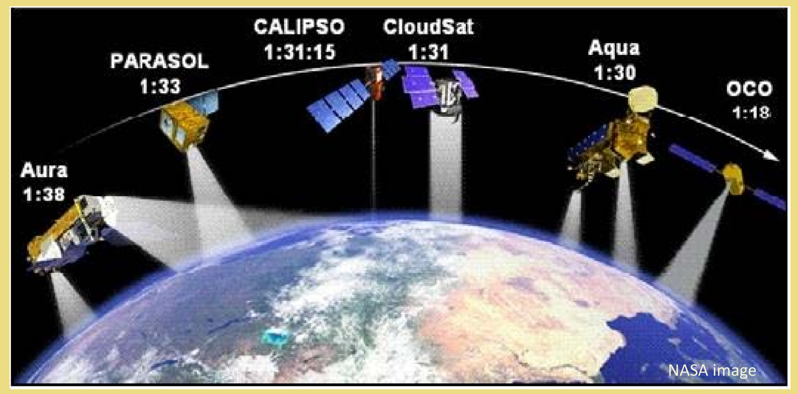
Joiner, J., Y. Yoshida, A. P. Vasilkov, E. M. Middleton, P. K. E. Campbell, Y. Yoshida, A. Kuze, and L. A. Corp. "Filling-in of near-Infrared Solar Lines by Terrestrial Fluorescence and Other Geophysical Effects: Simulations and Space-Based Observations from SCIAMACHY and GOSAT." *Atmospheric Measurement Techniques* 5, no. 4 (April 24, 2012): 809–29. doi:10.5194/amt-5-809-2012.

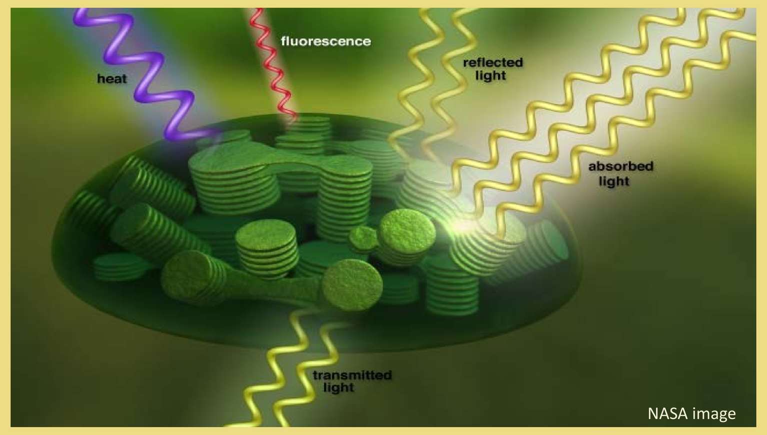
Malhi, Y., L. E. O. C. Aragao, D. Galbraith, C. Huntingford, R. Fisher, P. Zelazowski, S. Sitch, C. McSweeney, and P. Meir. "Exploring the Likelihood and Mechanism of a Climate-Change-Induced Dieback of the Amazon Rainforest." *Proceedings of the National Academy of Sciences* 106, no. 49 (December 8, 2009): 20610–15. https://doi.org/10.1073/pnas.0804619106.

Abstract

The Amazonian rainforest's massive gas exchanges with the atmosphere strongly affect CO_2 concentrations globally. Dry periods in the Amazon are expected to become more common and could hinder vegetation. We compare a proxy measure of photosynthetic rate, solar-induced fluorescence (SIF) from the Orbiting Carbon Observatory 2 (OCO-2) satellite, to rainfall in the previous 30 days. In the climatologically wettest regions, photosynthesis barely responded or even increased in response to short-term drying. In rainforest areas with longer dry seasons, photosynthesis weakly declined after reduced rain. The finding is consistent with and more precise than earlier studies, and offers a metric for evaluating photosynthesis projections for the Amazon.

Data and Methods



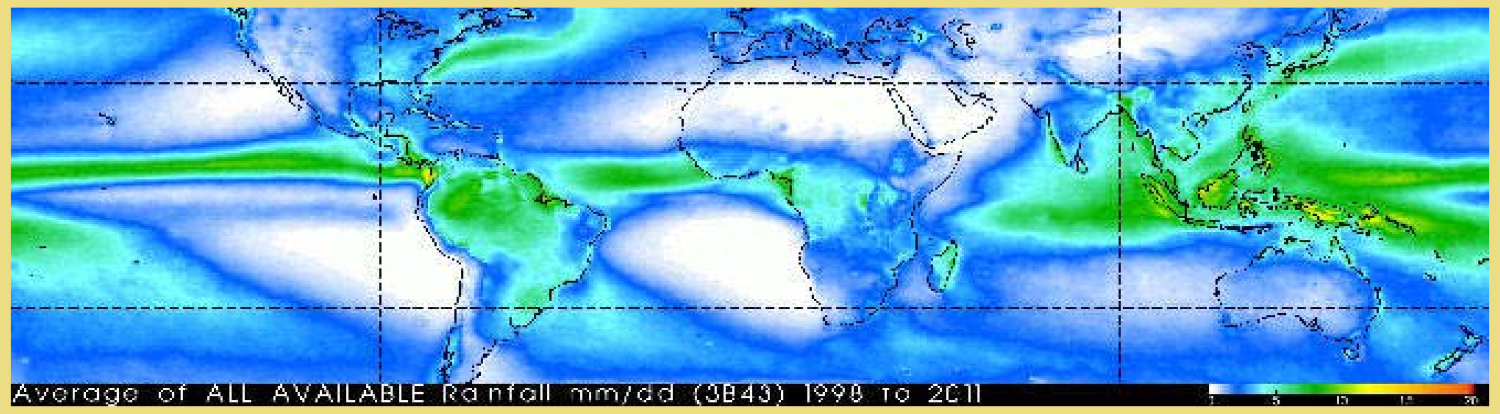


Photosynthesis rate:

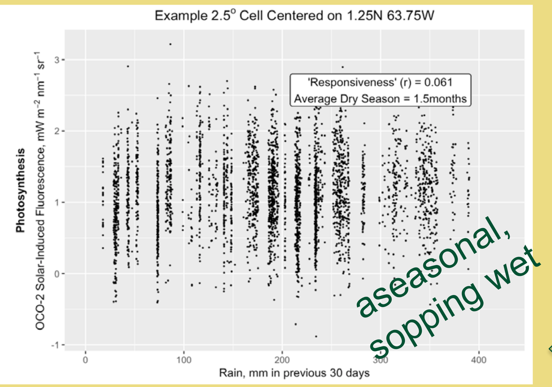
Solar-induced fluorescence (SIF) from NASA's new OCO-2 satellite

Details in Joiner 2012.

Rain in 30 days prior

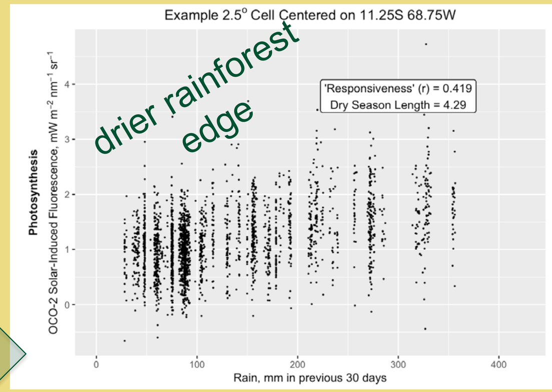


Global mean annual precipitation, from Tropical Rainfall Monitoring Mission



"Rain responsiveness" = correlation coefficient (r) of SIF : recent rain

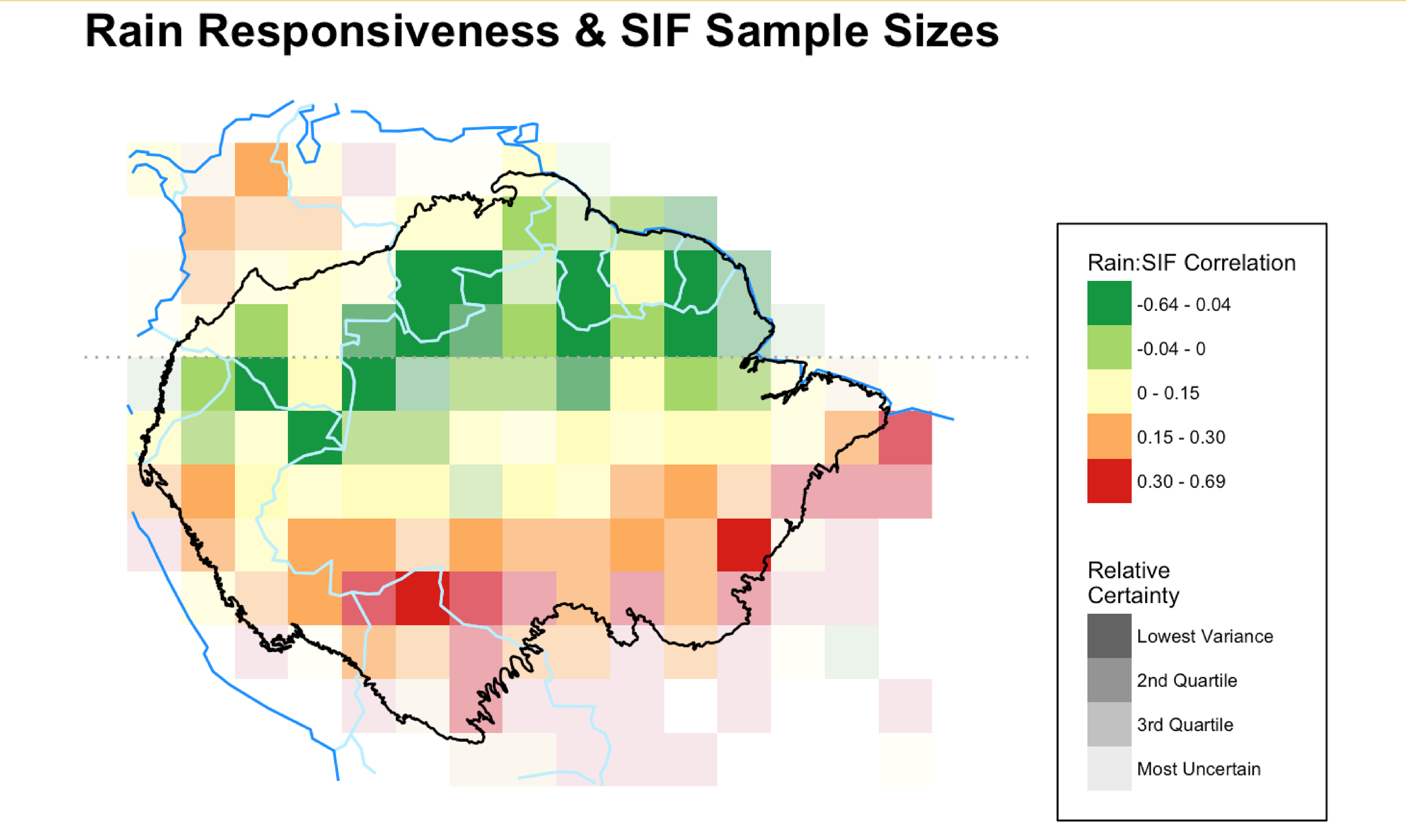
Example grid cells



Conclusions

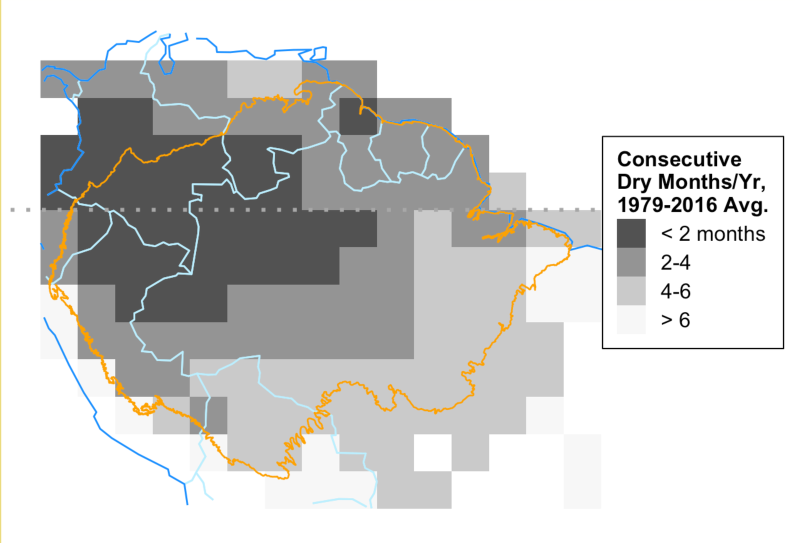
- Photosynthesis **barely changes** after short-term drying in **wettest** parts of the Amazon, a finding consistent with Guan 2015.
- In **drier** rainforest, **plants respond**, but most correlations < 0.4.
- Responsiveness **varies with** average **dry season lengths**.
- **OCO-2** SIF, **fine-scale & frequent**, can show the relationship.

Pattern Emerges!

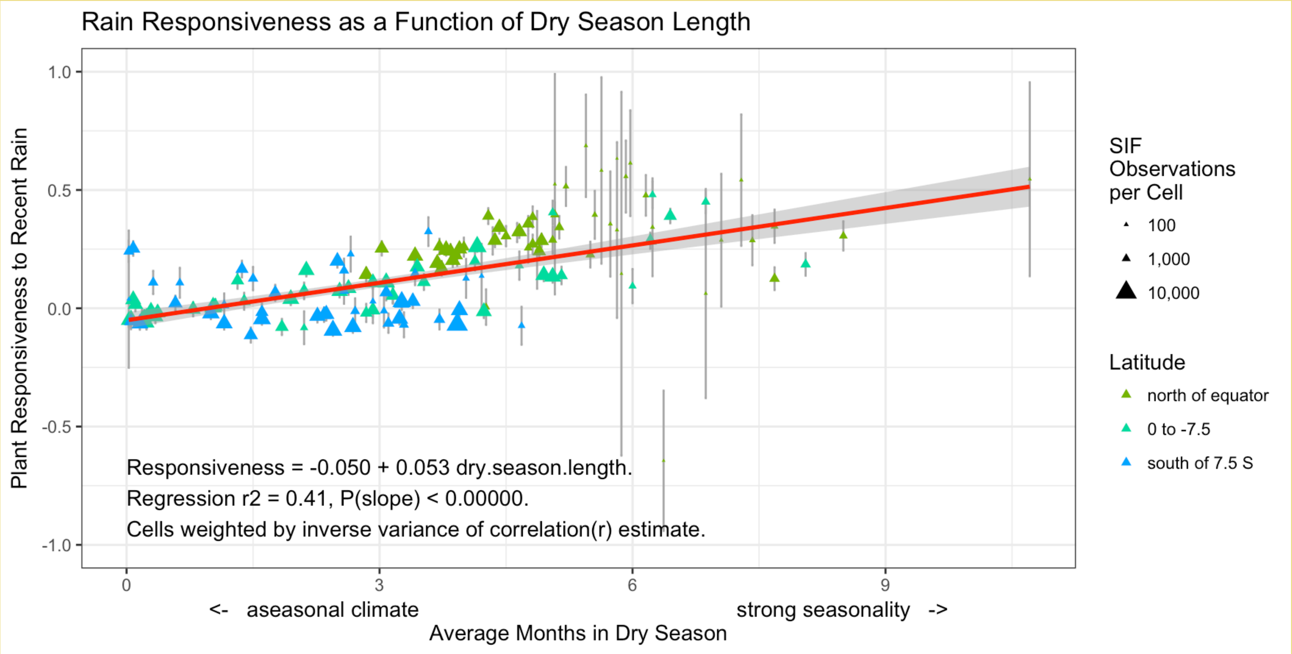


"Dry" Season Length:

≤ 100 mm (4"!) rain/month, ≅ all a plant can use



from Global Precipitation Climatology Project (GPCP)



Results consistent with Guan 2015's Figure 2b: