Studying land-atmosphere exchange of CO_2:

potentials and limitations of observational approaches

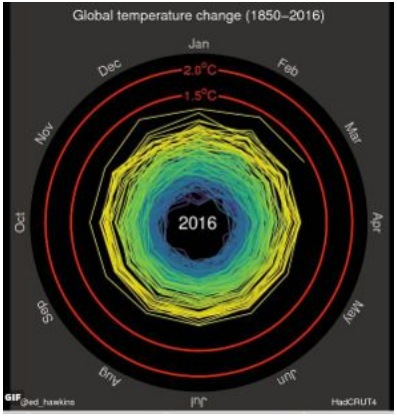
Miguel D. Mahecha, Paul Bodesheim, Jakob Zscheischler, Talie Musavi, Martin Jung, , Markus Reichstein et al.[1,2,3]

[1]Max Planck Institute for Biogeochemistry, Jena, Germany
[2]German Centre for Integrative Biodiversity Research (iDiv), Leipzig, Germany
[3]Michael Stifel Center Jena for Data-Driven and Simulation Science, Jena, Germany

November 22, 2016

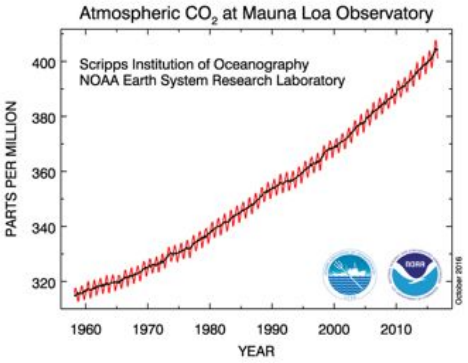
Motivation of our research

“Global change” our common issue

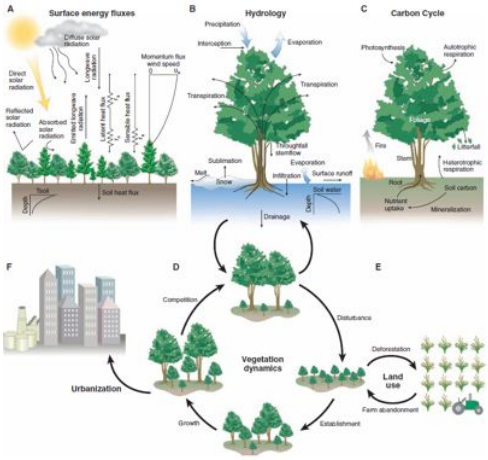


Visualization by Ed Hawkins

“Global change” our common issue

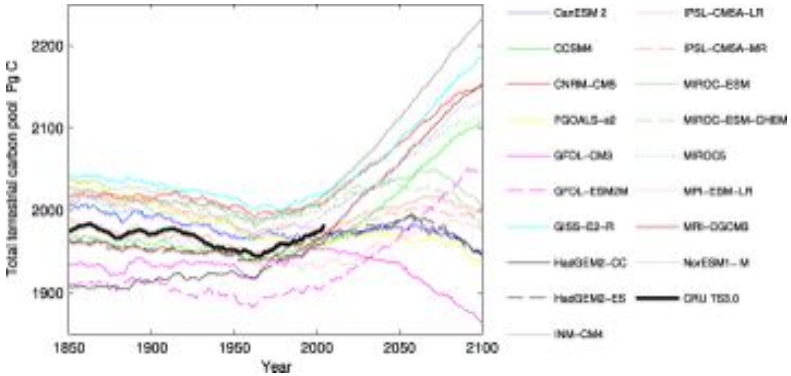


The terrestrial biosphere



Bonan (2008) Science, 320, 1444–1449.

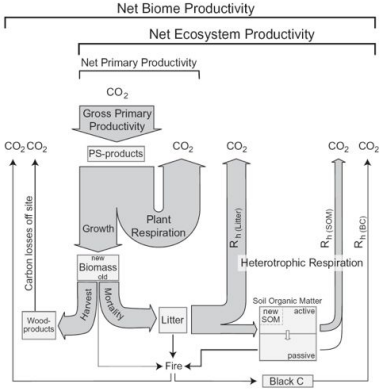
Uncertain future of biosphere responses



Ahlström (2012) Environmental Research Letters, 7, 4.
The total terrestrial carbon pool as simulated by LPJ-GUESS when forced by 18 GCMs and CRU TS3.0 historical data. A positive slope implies a negative NEE (sink of carbon), while a negative slope indicates a positive NEE (source of carbon)..

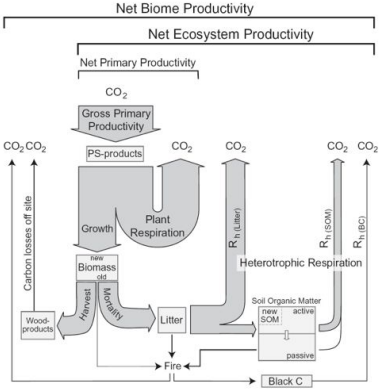
State of the observations of land-atmosphere fluxes

CO_2 exchange cycle



Schulze (2000) Biogeosciences, 3, 147–166.

CO_2 exchange cycle

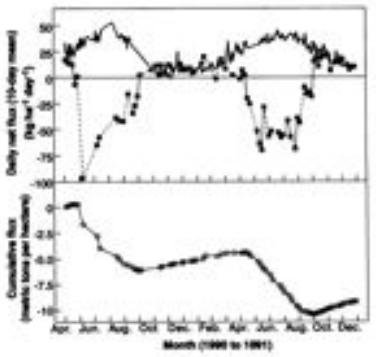


Schulze (2000) Biogeosciences, 3, 147–166.

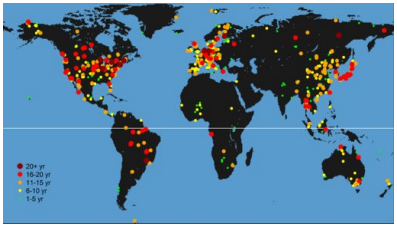
Expansion of in-situ observations: 1992

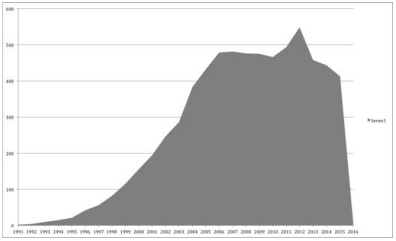
Wofsy et al. (1993) *Net Exchange of CO_2 in a Mid-Latitude Forest* Science 260, 1314–1317.

The eddy correlation method was used to measure the net ecosystem exchange of carbon dioxide continuously from April 1990 to December 1991 in a deciduous forest . . . The annual net uptake was 3.7±0.7 metric tons of carbon per hectare per year. . . . Carbon uptake rates were notably larger than those assumed for temperate forests in global carbon studies. Carbon storage in temperate forests can play an important role in determining future concentrations of atmospheric carbon dioxide.



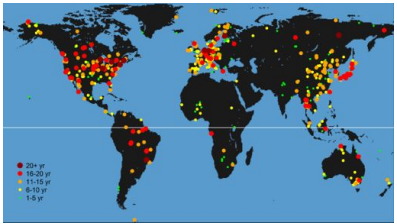
Expansion of in-situ observations: 2016

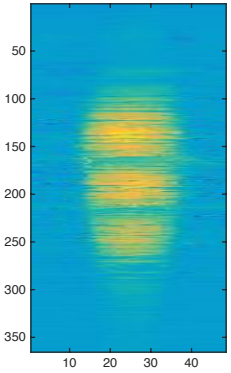




x-axis: Hour of the day
y-axis: Day of the year

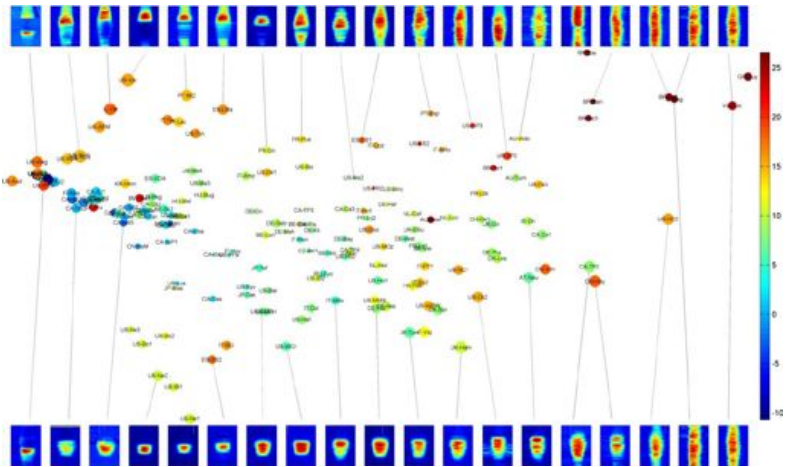
Expansion of in-situ observations: 2016





x-axis: Hour of the day
y-axis: Day of the year

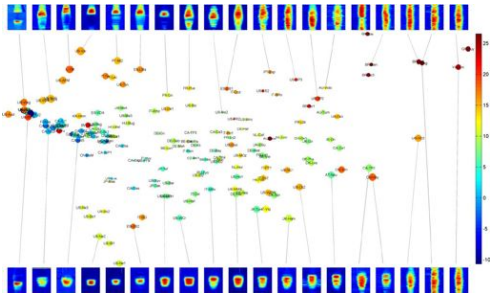
Opportunities to characterize global patterns

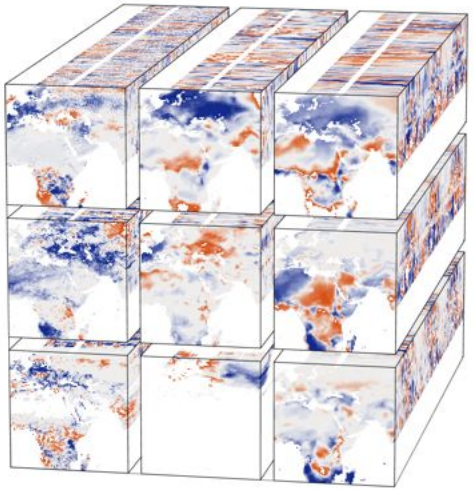


Nonlinear dimensionality reduction of FLUXNET fingerprints (Mahecha et al. (in prep.))

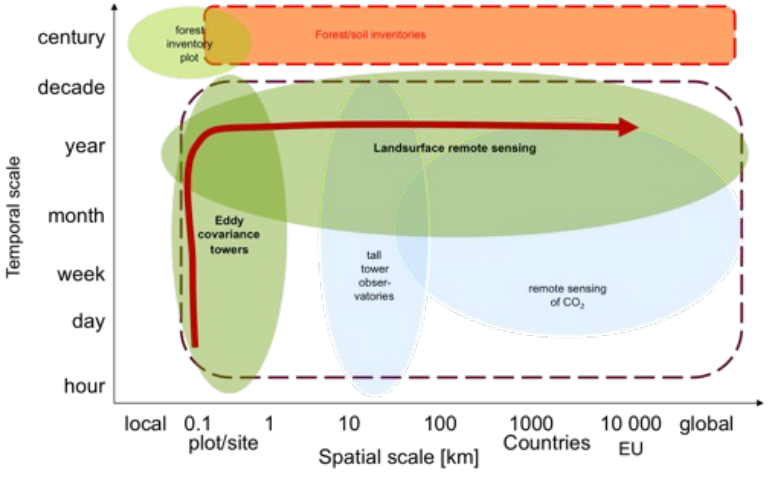
How to infer global patterns from point data?

From points to the globe



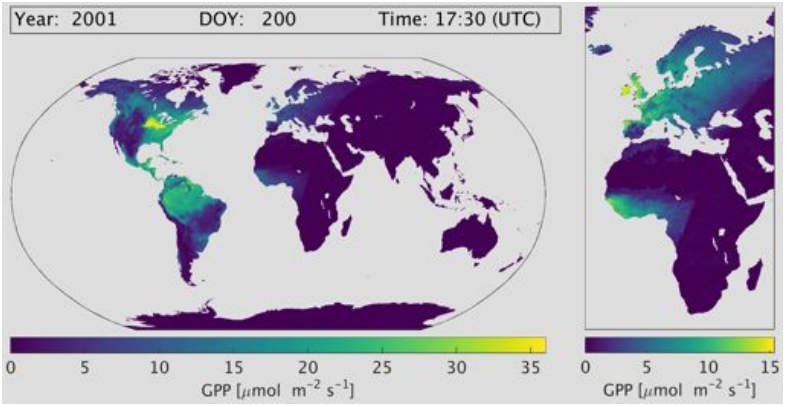


From points to the globe



Machine learning is the key . . . (Fig. by Reichstein et al. (various))

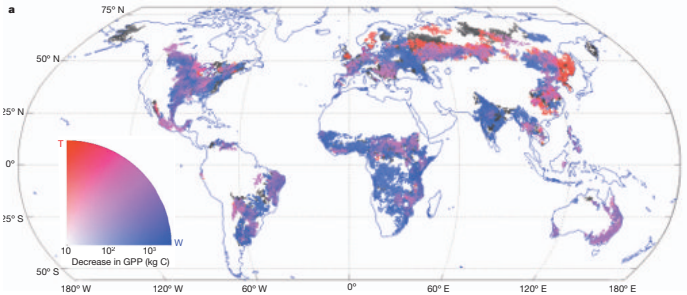
From points to the globe



First sub-daily global GPP by Bodesheim et al (in prep.).

What specific questions can we address now?

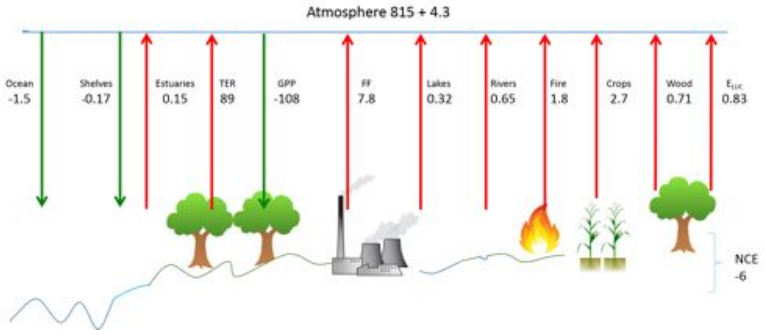
Extremes in GPP



Reichstein et al. (2013) Nature

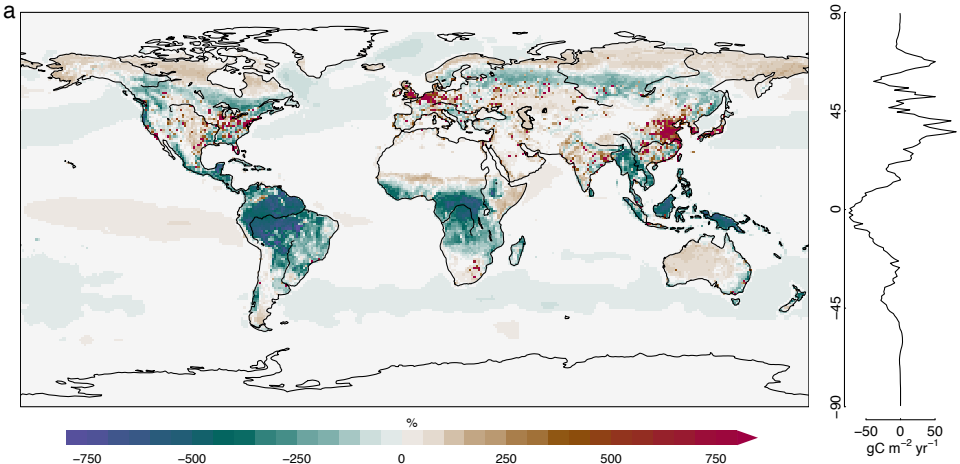
A global picture of C fluxes with observations only?

The GEOCARBON attempt:



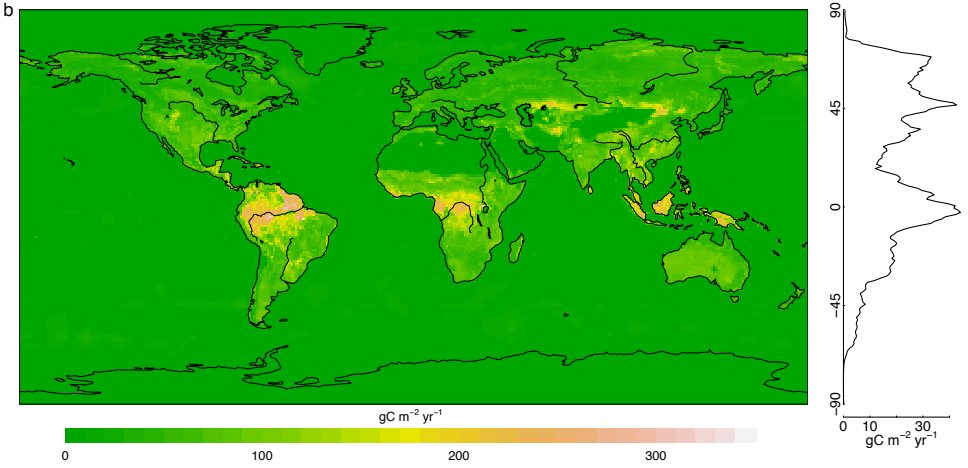
Zscheischler, Mahecha et al (2016) Biogeosciences – Discussions.

Integrated view of terrestrial & aquatic systems



Zscheischler, Mahecha et al. (2016) Biogeoscience Discussions.

Uncertainty of the “observed” net CO_2 exchange



Zscheischler, Mahecha et al. (2016) Biogeoscience Discussions.

Conclusions

- Long-term observatories have an high/global impact beyond their original intention . . .
- In-concert, point and Earth observations allows us to estimate global gross fluxes at high spatiotemporal resolutions.
- . . . allowing us e.g. to infer the relevance of regional processes at the global scale (example of extremes).
- Observational synthesis of C fluxes reveals the huge uncertainties at low latitudes.

Conclusions

- Long-term observatories have an high/global impact beyond their original intention . . .
- In-concert, point and Earth observations allows us to estimate global gross fluxes at high spatiotemporal resolutions.
- . . . allowing us e.g. to infer the relevance of regional processes at the global scale (example of extremes).
- Observational synthesis of C fluxes reveals the huge uncertainties at low latitudes.

Conclusions

- Long-term observatories have an high/global impact beyond their original intention . . .
- In-concert, point and Earth observations allows us to estimate global gross fluxes at high spatiotemporal resolutions.
- . . . allowing us e.g. to infer the relevance of regional processes at the global scale (example of extremes).
- Observational synthesis of C fluxes reveals the huge uncertainties at low latitudes.

Conclusions

- Long-term observatories have an high/global impact beyond their original intention . . .
- In-concert, point and Earth observations allows us to estimate global gross fluxes at high spatiotemporal resolutions.
- . . . allowing us e.g. to infer the relevance of regional processes at the global scale (example of extremes).
- Observational synthesis of C fluxes reveals the huge uncertainties at low latitudes.

Remark

We currently offer PhD & PostDoc positions

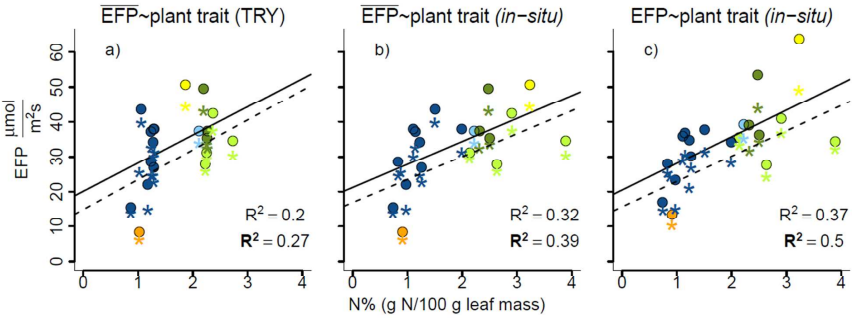
www.bgc-jena.mpg.de/bgi/index.php/Research/EmpiricalInference

miguel.mahecha@bgc-jena.mpg.de

What is the effect of biotic properties on the ecosystem's photosynthetic capacity?

Linking GPP_{sat} with functional traits

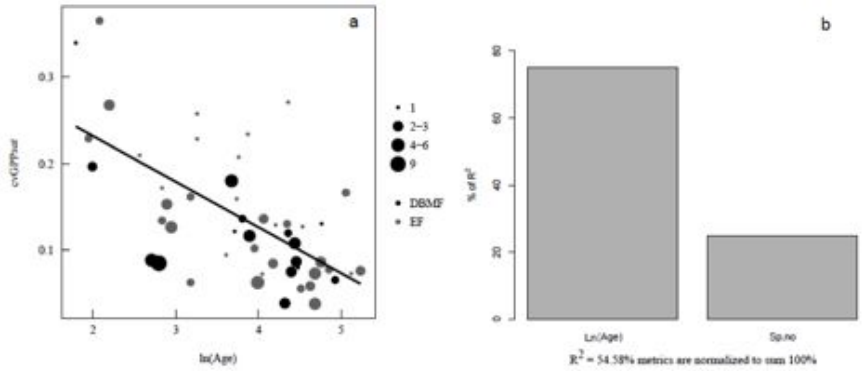
Obs. need to be synchronized in space and time!



PhD thesis by Talie Musavi; Musavi et al. (2016) Ecology and Evolution.

Interannual variability of GPP_{sat}

Higher stand age and species diversity dampen the interannual variability in GPP_{sat}



PhD thesis by Talie Musavi; Musavi et al. (accepted) Nature Ecology & Evolution.