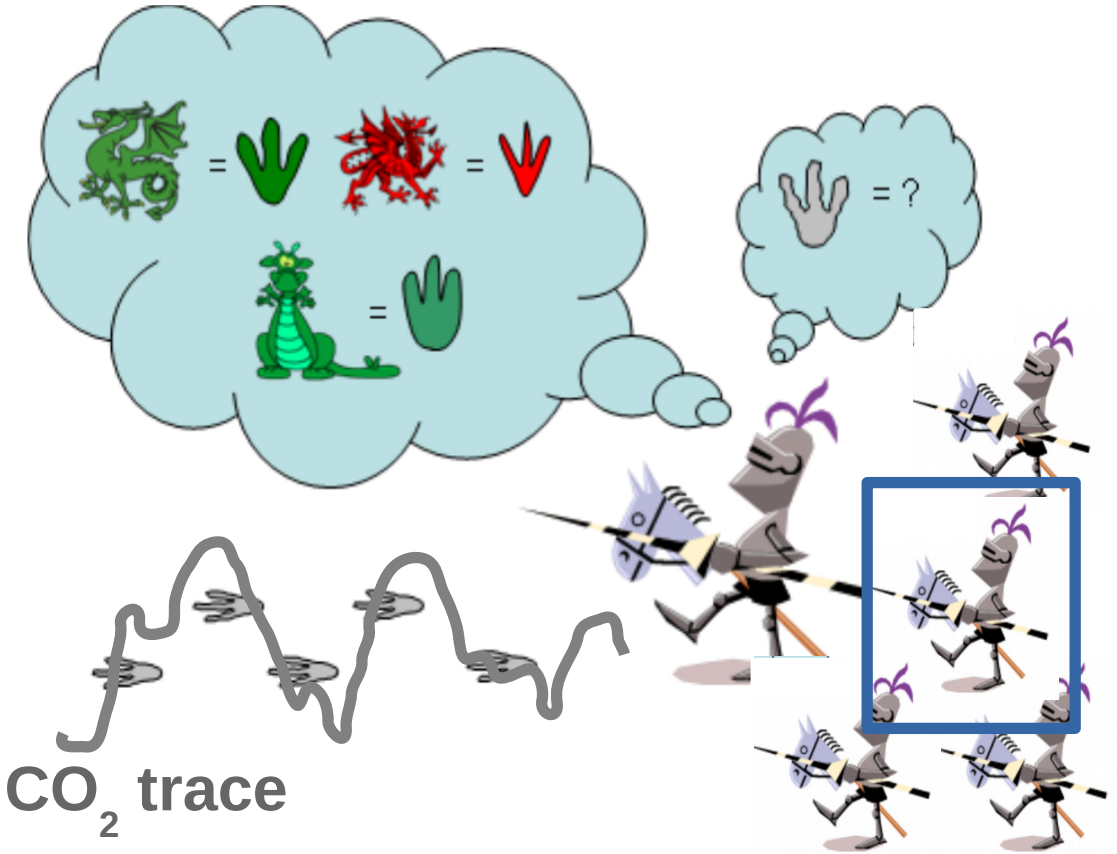
Data-driven bottom-up estimates of biogenic fluxes: An overview

Martin Jung, **Sophia Walther**, Paul Bodesheim, Markus Reichstein and the FLUXCOM team

Annual meeting of CHE and VERIFY

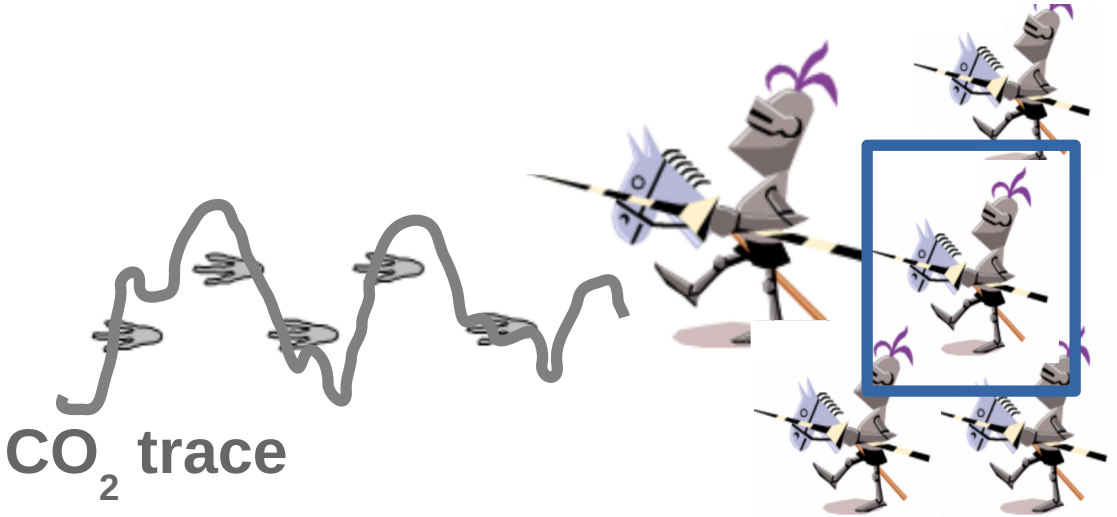
Reading, March 2019

We're all after the CO_2 signature

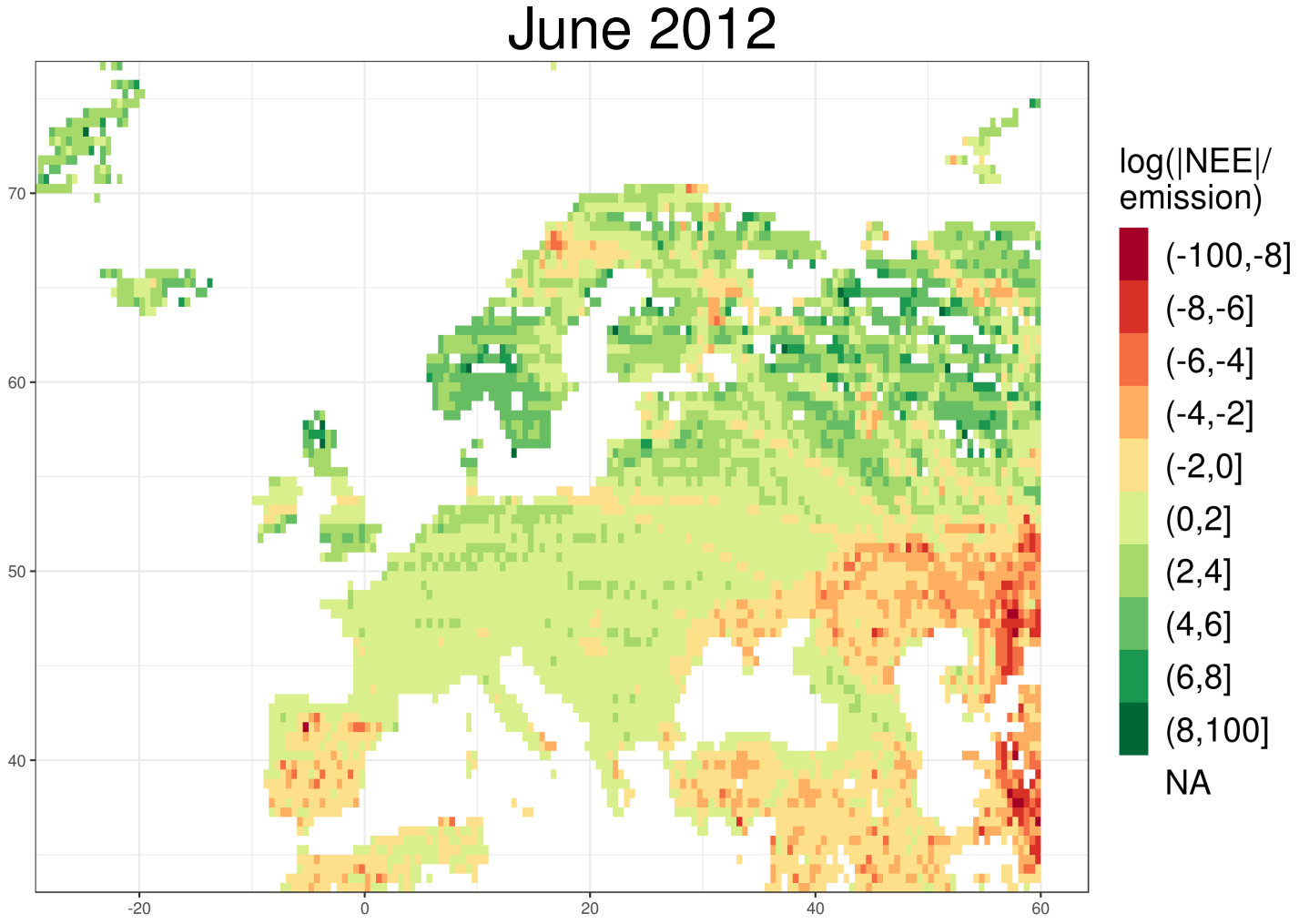


How can this help the other science knights to characterize the unknown dragon?

- find a split from anthropogenic emissions
- prior for atmospheric inversions
- cross-consistency checks for NEE from other approaches
- sensitivity of atm. CO_2 to different kinds of uncertainties in NEE at variety of scales
- process understanding through factorial experiments

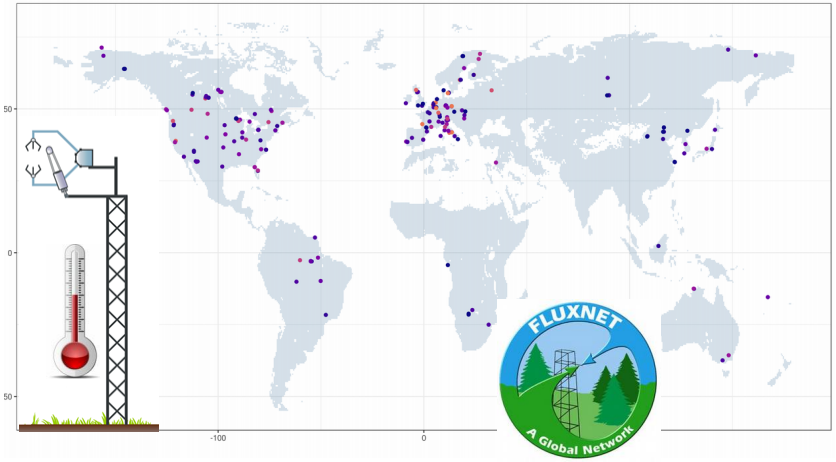


Biogenic fluxes dominate fossil fuel signal (in growing season)



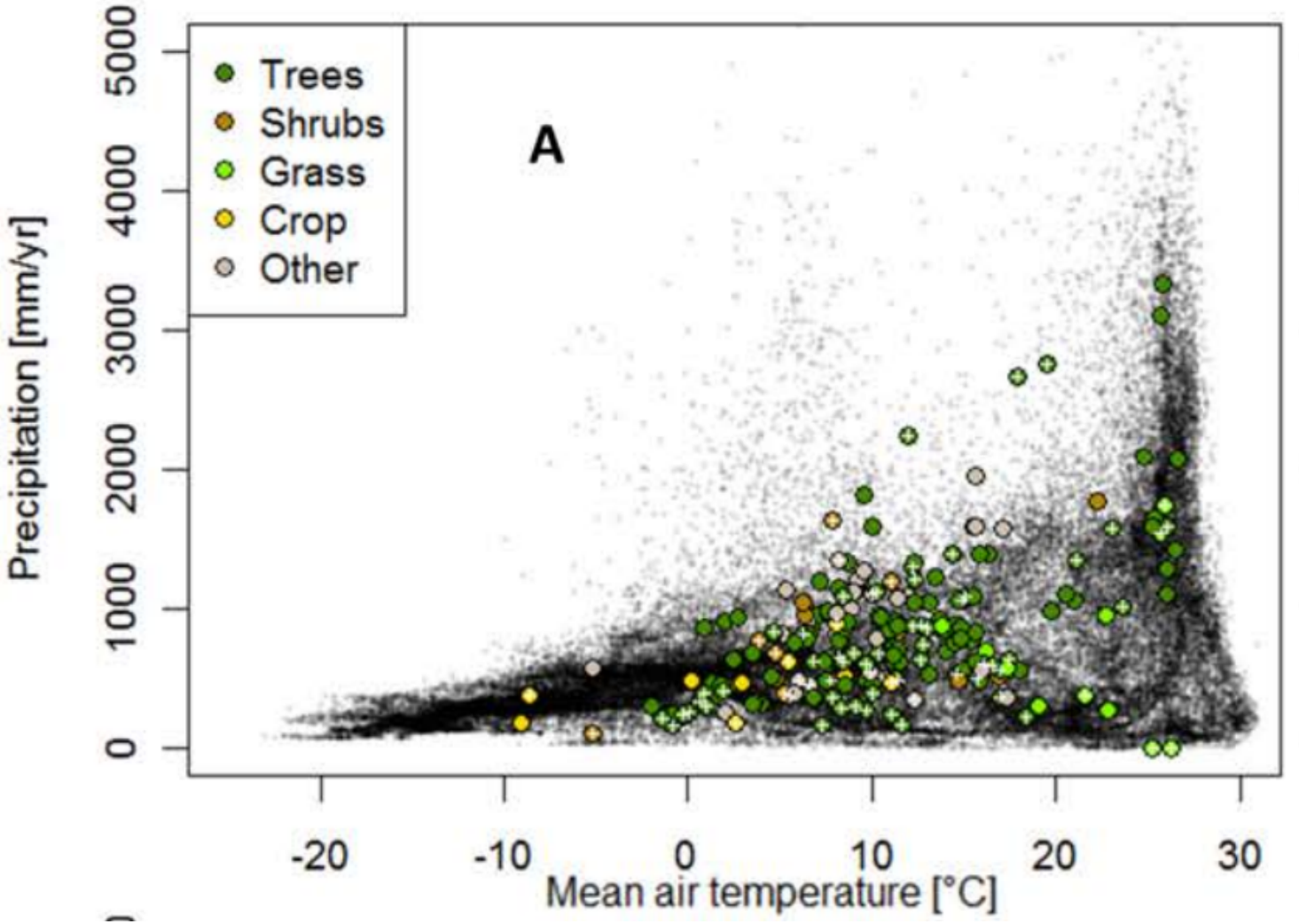
Fuel CO_2 emission: monthly, Peking University, Wang et al., 2013
NEE: hourly, MPI-BGC Jena

Our approach to modelling the biospheric trace



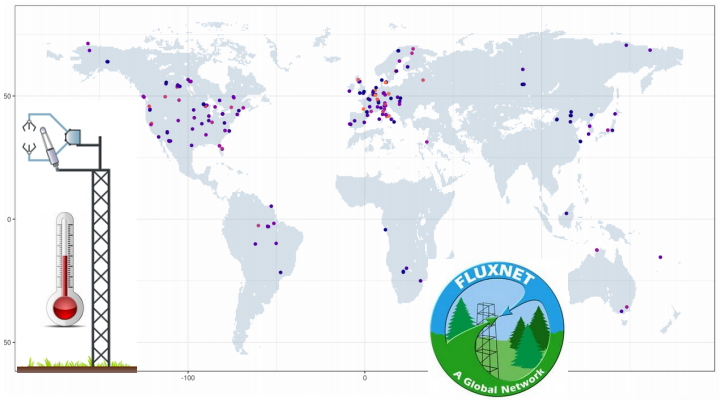
In-situ eddy-covariance carbon fluxes & meteorology

In-situ obs cover large part of the climate space



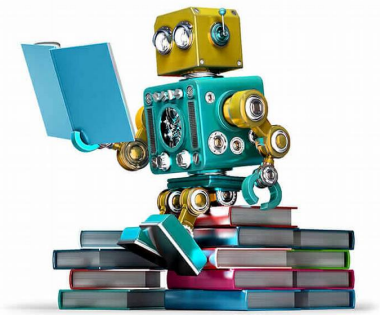
Reichstein et al. 2014

Our approach to modelling the biospheric trace



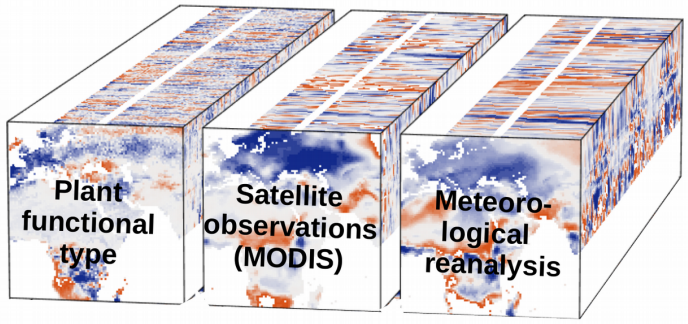
In-situ eddy-covariance carbon fluxes & meteorology

+



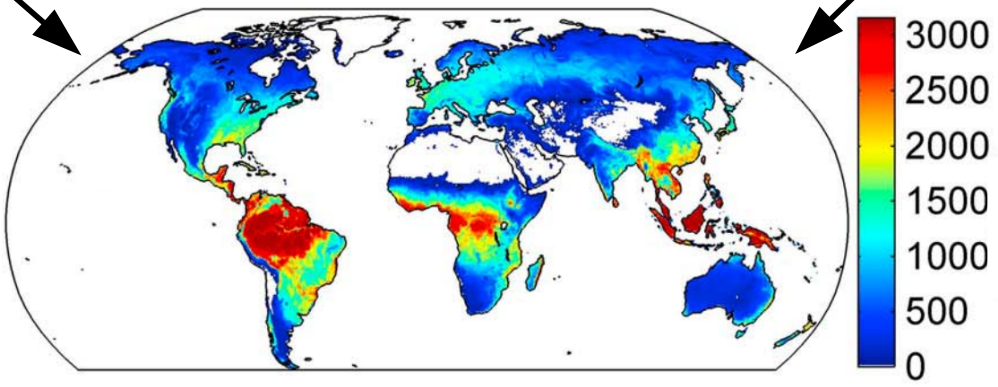
machine learning

+



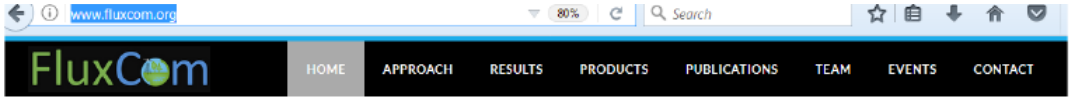
global gridded data sets of predictors

GPP [gC/m2/yr]



Global gridded flux estimates of NEE, GPP, TER

FluxCom



Recent News

- FLUXCOM Workshop, 2017 will be held in Jena from 16th -18th May, 2017.

-Based on a recent study, FLUXCOM GPP sees the imprints of relationships between vegetation and groundwater.

- A study based on FLUXCOM data highlights the compensatory effect of water and temperature on global carbon sink (Jung et al., 2017).

- The cross-validation paper by Tramontana et al. has been published (2016/07).

Links

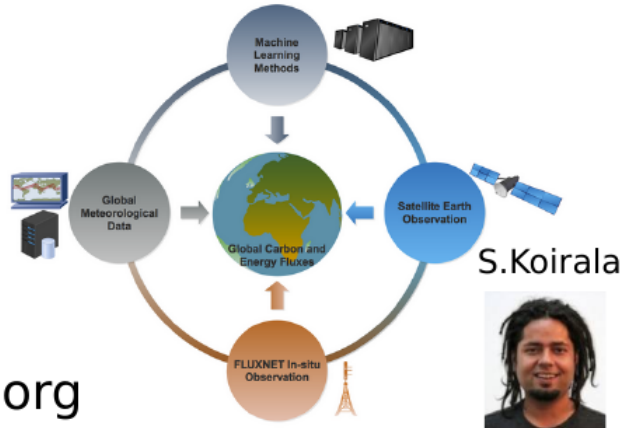
- http://www.fluxdata.org
- http://fluxnet.ornl.gov
-BGI Department, MPI-BGC

"An initiative to upscale biosphere-atmosphere fluxes from FLUXNET sites to continental and global scales"

Several experts joined hands for the collaborative **FLUXCOM** initiative. We use **upscaling** approaches based on **machine learning methods** that integrate **FLUXNET** site level observations, **satellite** remote sensing, and meteorological data. Our **data products** have promising values for assessing biosphere-atmosphere fluxes over large regions, and for evaluating process-based land models.

Aims

- Creating an **ensemble** of data products for global carbon and energy fluxes on land
- Understanding and characterizing **uncertainties** in this upscaling approach



A general overview of the FLUXCOM initiative.

www.fluxcom.org

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G. Tramontana

C.Schwalm

G.Camps-Valls

F.Gans

U.Weber

Two complementary set-ups creating ensembles

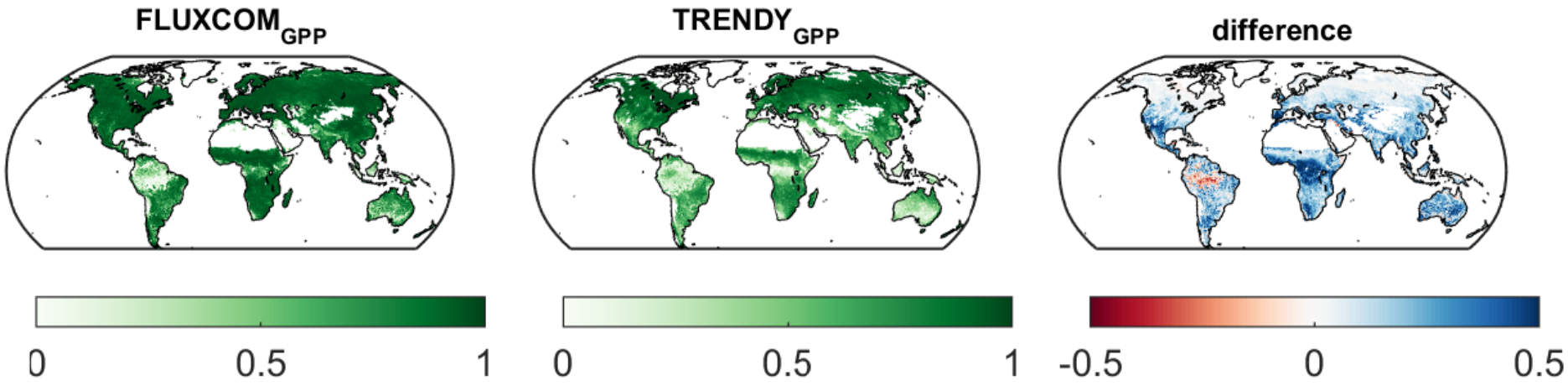
	RS+Meteo	RS
effective drivers	mean seasonality of satellite data and temporally resolved meteorology	only temporally resolved satellite data
spatial res.	0.5deg	0.083deg
temporal res.	daily	8-daily
years	1950-2017	2001-2015
ML methods	3	9
meteo forcing	4(6)	-

Two complementary set-ups

	RS+Meteo	RS
effective drivers	mean seasonality of satellite data and temporally resolved meteorology	only temporally resolved satellite data
R^2 between NEE/GPP_R/GPP_L and observations		
spatially ✓	0.46/ 0.77/ 0.79	0.48/ 0.78/ 0.78
seasonally ✓	0.59/ 0.77/ 0.77	0.61/ 0.76/ 0.77
anomalies !	0.13/ 0.12/ 0.11	0.13/ 0.18/ 0.16

Tramontana et al. 2016

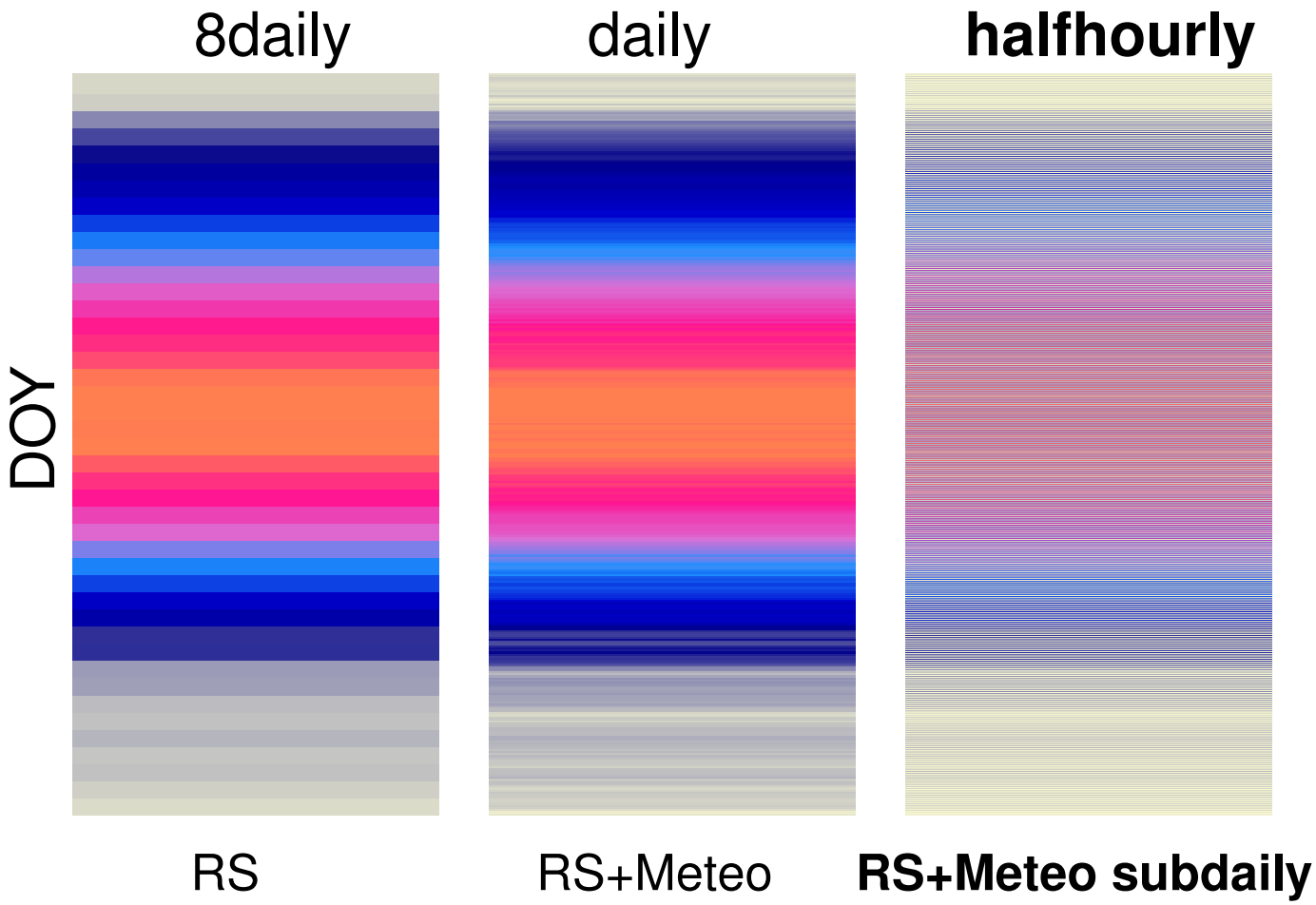
Higher consistency in seasonality with SIF than TRENDY



Jung et al. 2017

R^2 of monthly mean seasonal GPP with SIF for Trendy and Fluxcom (RS+meteo, only CRUNCEPv6)

Evolution of resolution of FLUXCOM

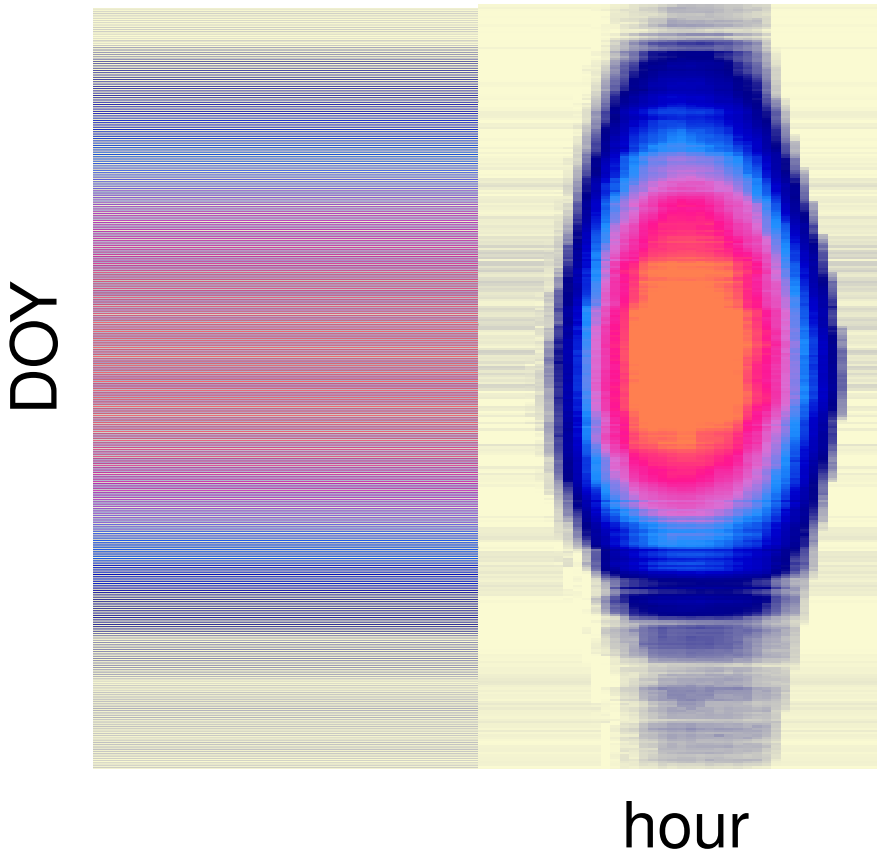


Tramontana et al. 2016
Jung et al. 2017

Bodesheim
et al. 2018

Sub-daily fluxes based on daily meteo

Example: GPP



Predictors:

Mean seasonality of RS
+ daily meteo from CRUNCEP
+ half-hourly potential radiation as the only subdaily predictor
+ hourly meteo from ERA5

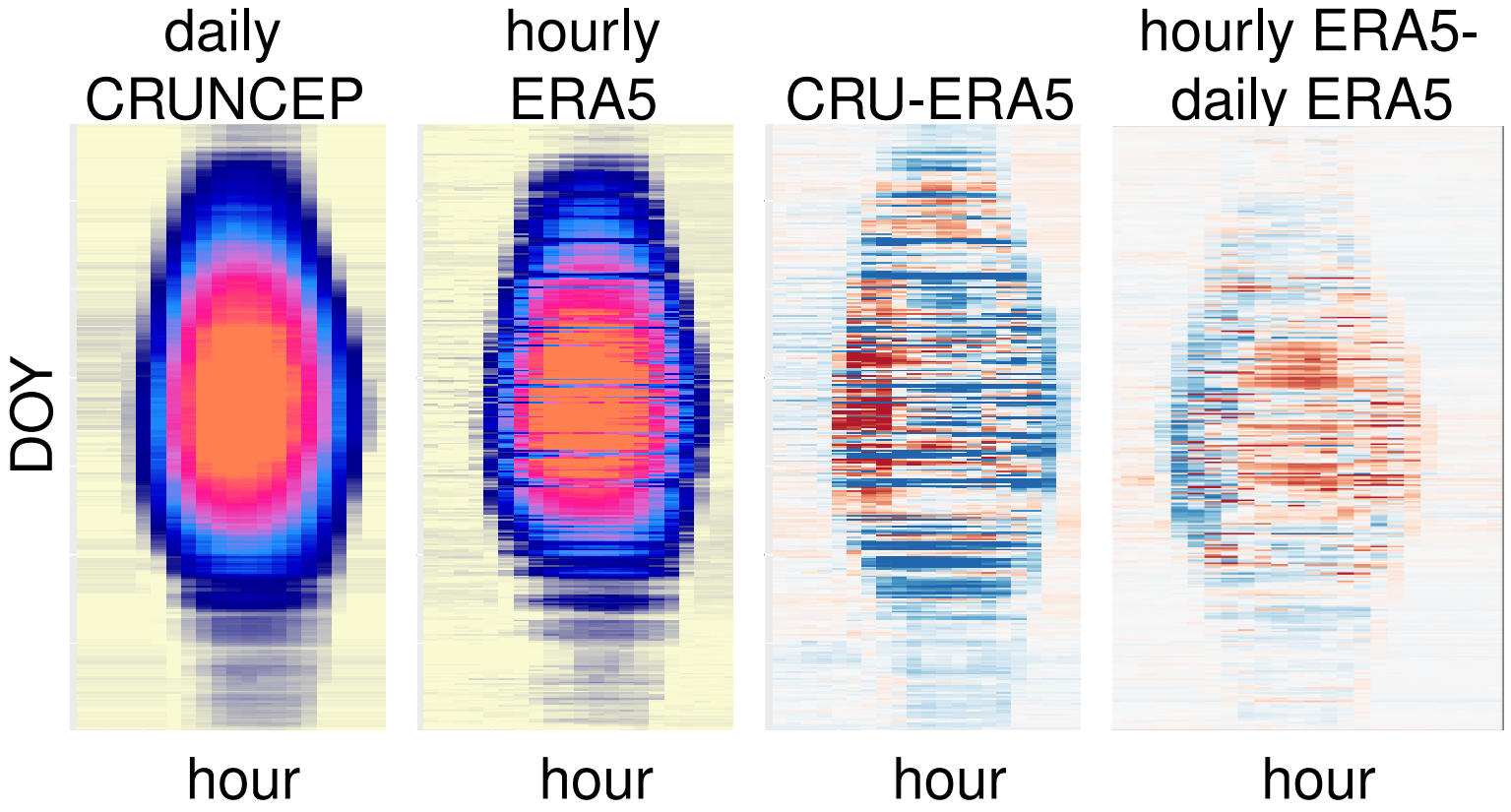
Paul Bodesheim et al. 2018

now **hourly** meteo from ERA5 reanalysis is available

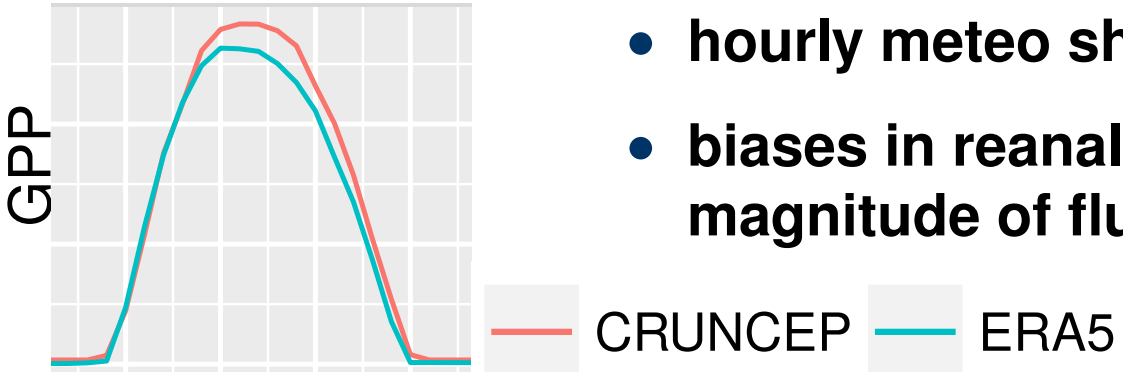
$\Rightarrow$ include additional hourly predictors

Example: GPP

first sub-daily fluxes



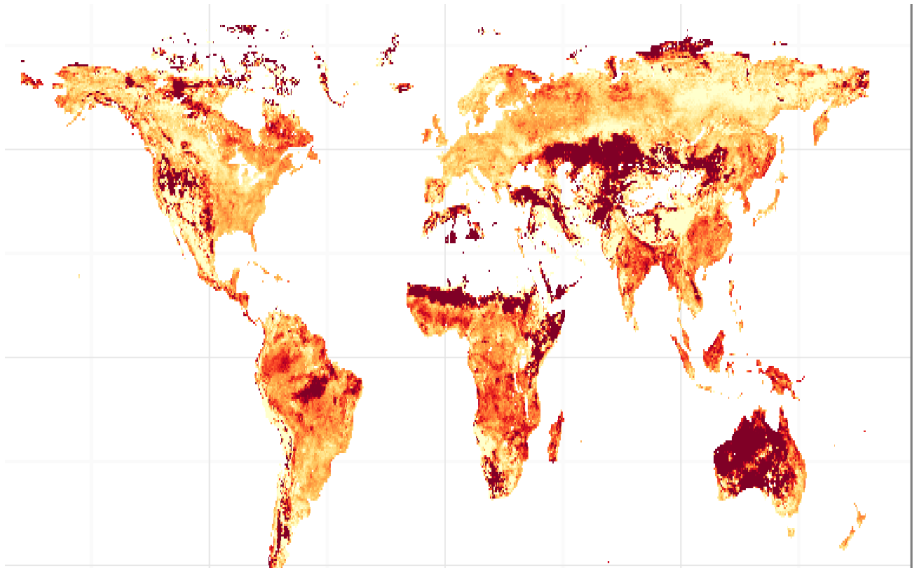
Diurnal cycle in July:

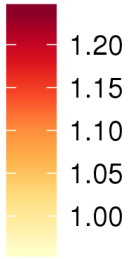


- **hourly meteo shifts diurnal cycle**
- **biases in reanalysis strongly affect magnitude of fluxes**

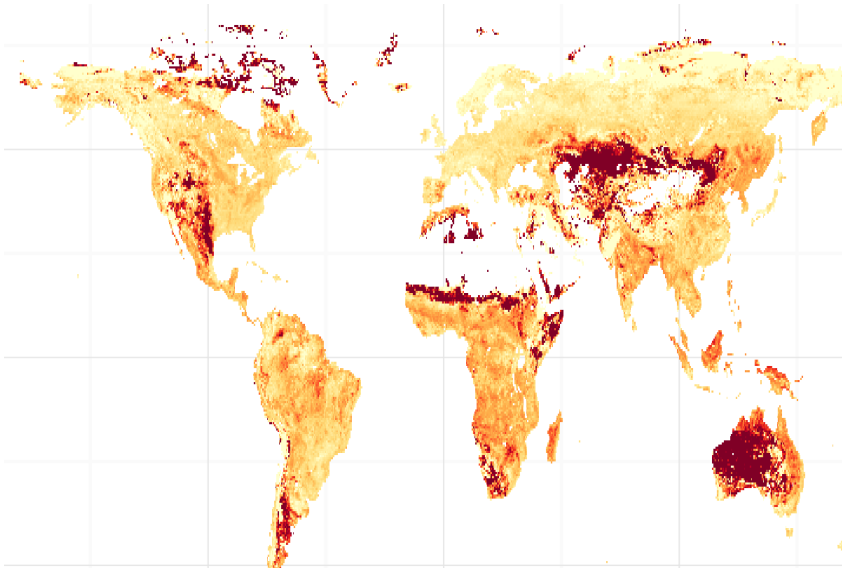
GPP annual sums: choice of meteo. driver is more important than inclusion of subdaily meteo

daily CRUNCEP/hourly ERA

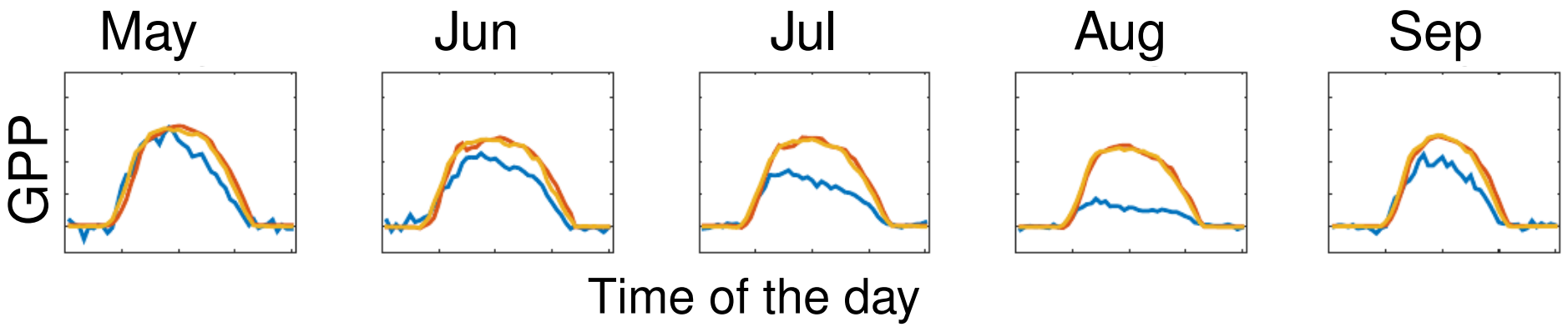




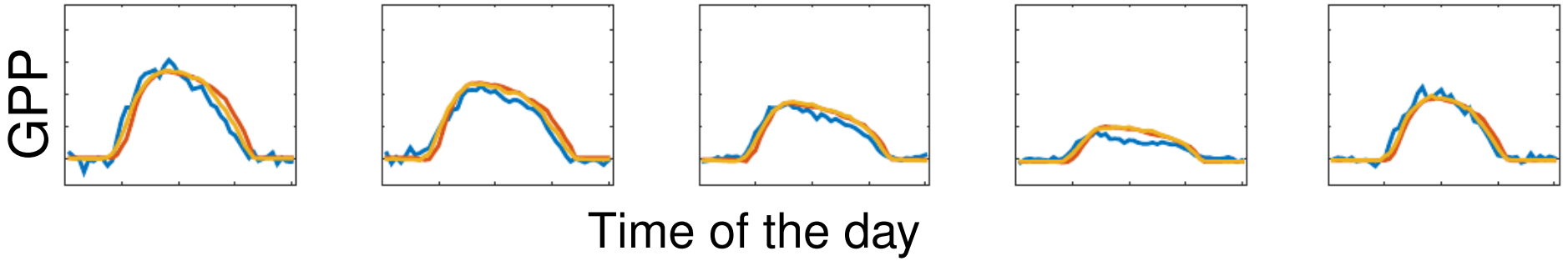
daily CRUNCEP/daily ERA



Drought effects not well represented



Daily GPP as additional daily predictor:

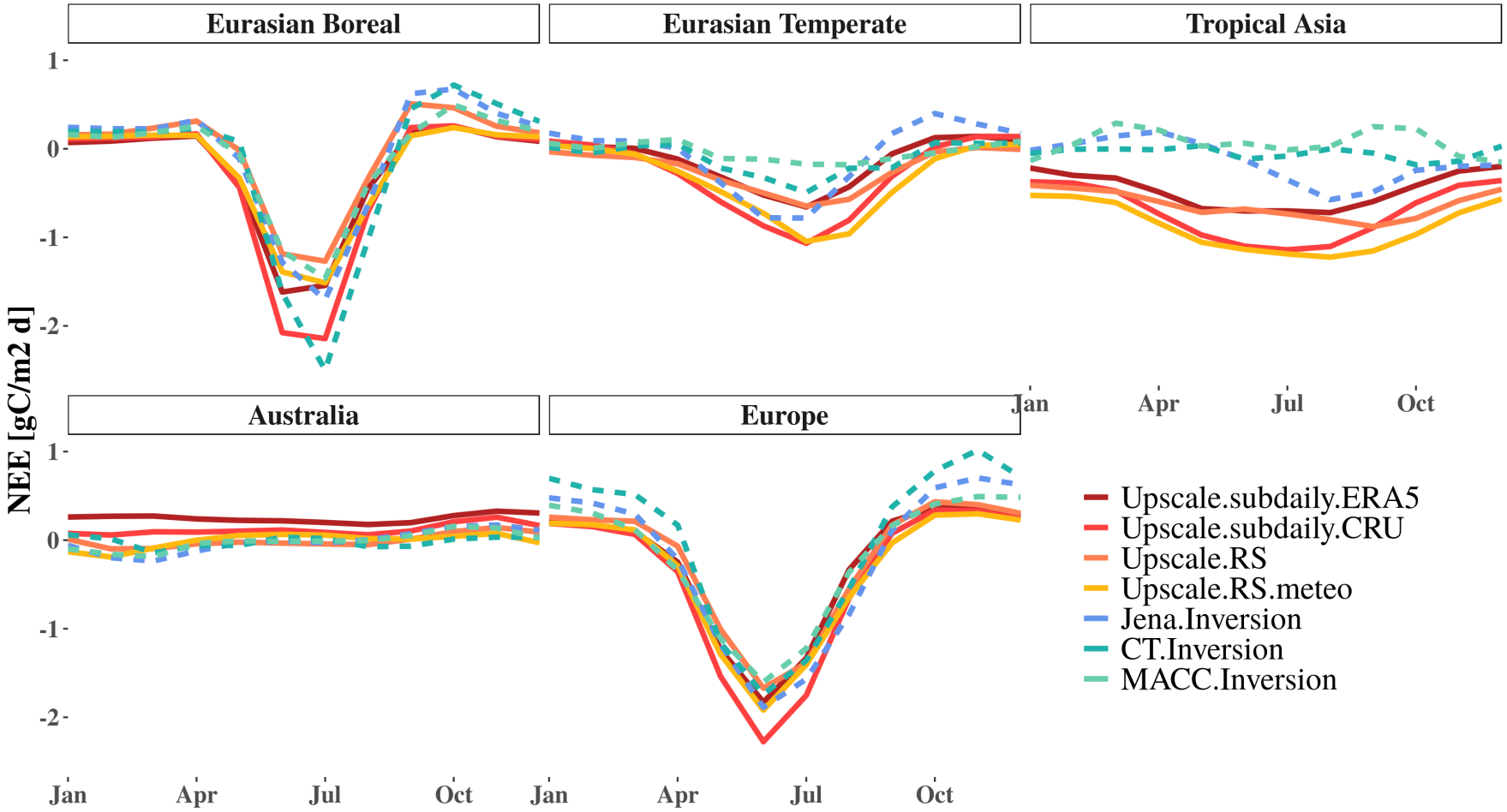


observation
modelled with daily predictors
modelled with daily & halfhourly predictors

Puechabon

Bodesheim et al. 2018

Seasonal consistency of NEE with inversions



Towards high spatial AND high temporal resolution

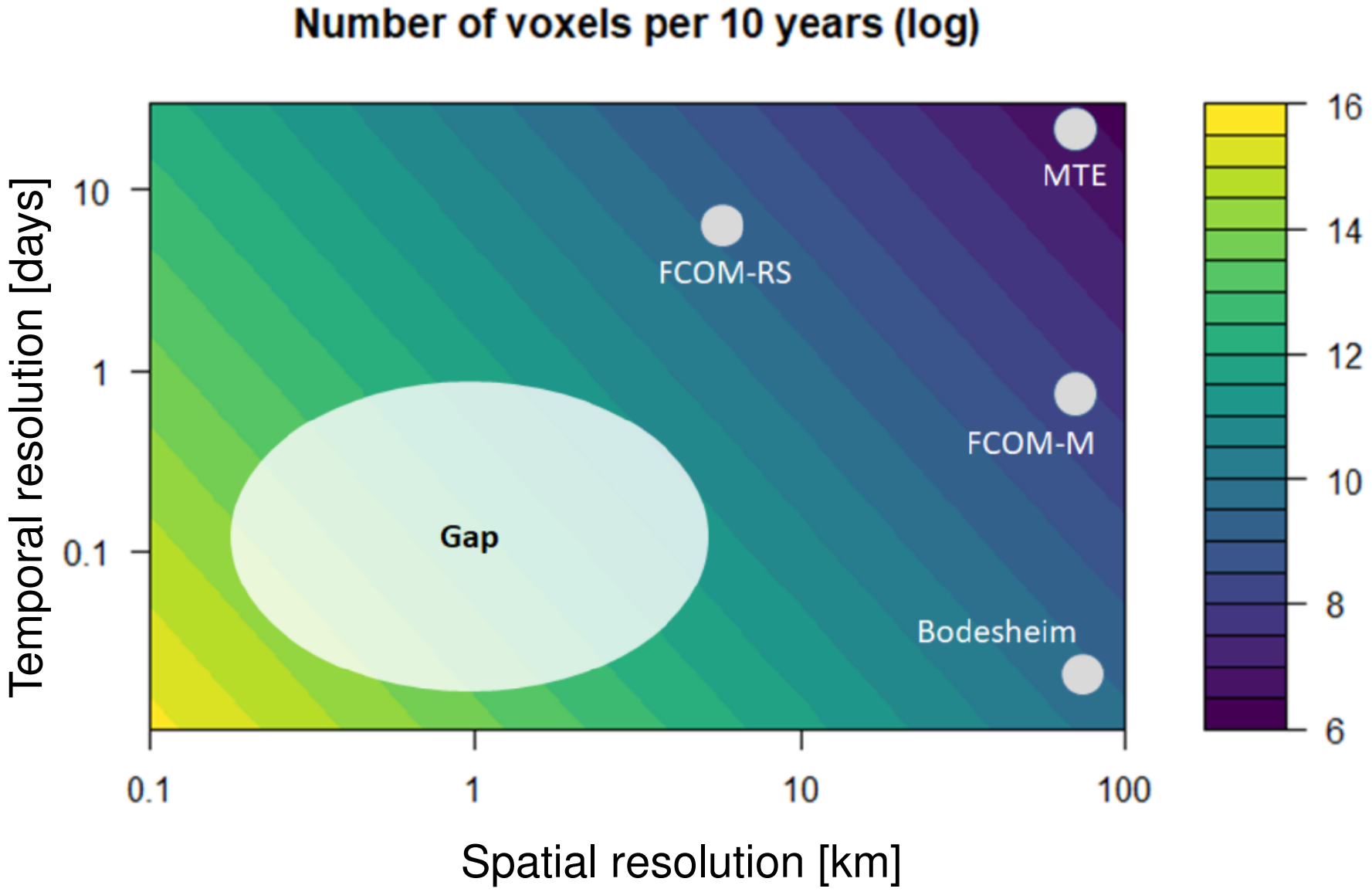


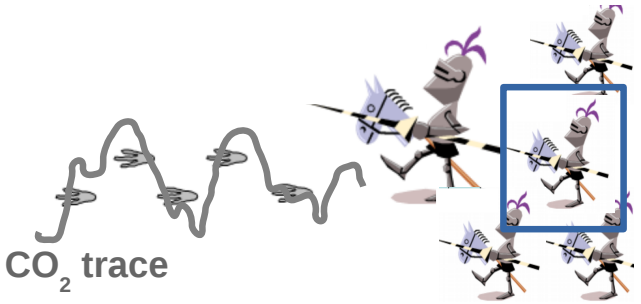
Figure courtesy Martin Jung

Towards dedicated products:

FluxCom2.0

Ongoing efforts for improvements in terms of:

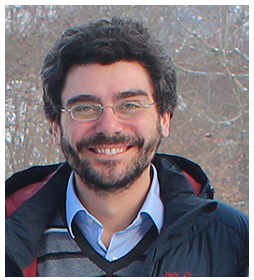
- **Training data:** more sites, more site-years, higher quality
- **spatio-temporal resolution:** ERA5, geostationary
- amount and accuracy of **predictor variables:** extensive QC, additional predictors (SIF, VOD, forest age, management on forests and crops,...)
- **machine learning methods** (e.g. memory effects, transfer learning)
- better **uncertainty** characterization
- **semi-operational** set-up



Acknowledgements

Ongoing efforts by Martin Jung, Sophia Walther, Jake Nelson, Ulrich Weber, Mirco Migliavacca, Nuno Carvalhais, Simon Besnard, Dario Papale






and others...

NEE in the pixel containing Jena: