

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

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Annual meeting of CHE and VERIFY
Reading, March 2019



Max Planck Institute
for Biogeochemistry



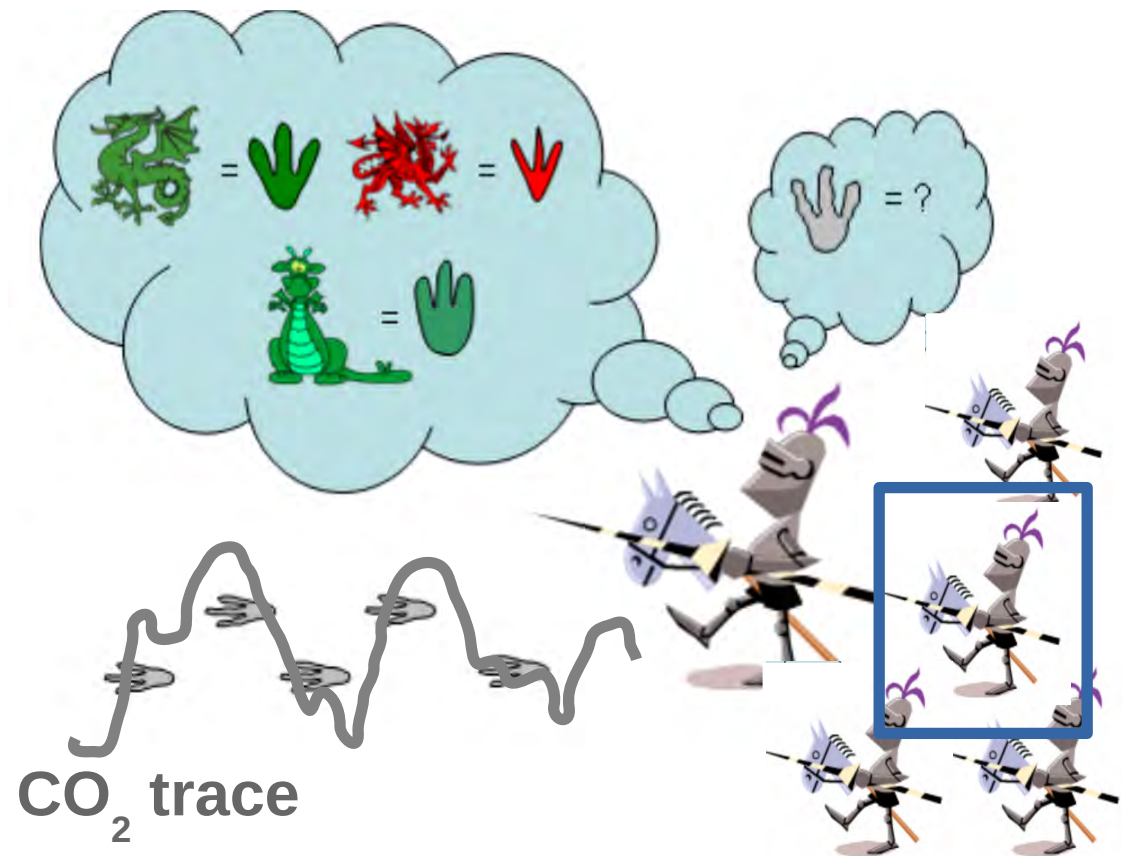
FluxCom



ICOS

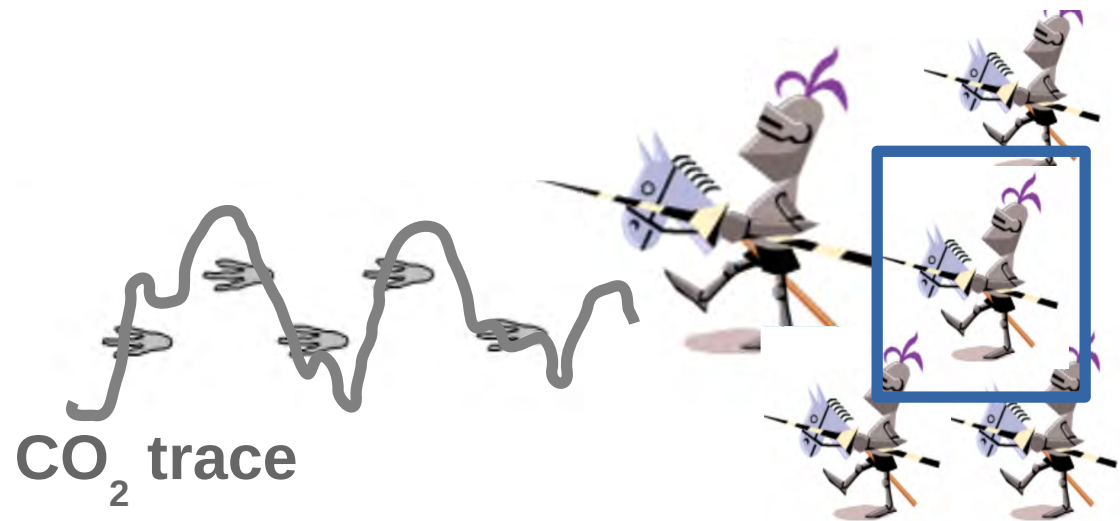
INTEGRATED
CARBON
OBSERVATION
SYSTEM

We're all after the CO₂ signature



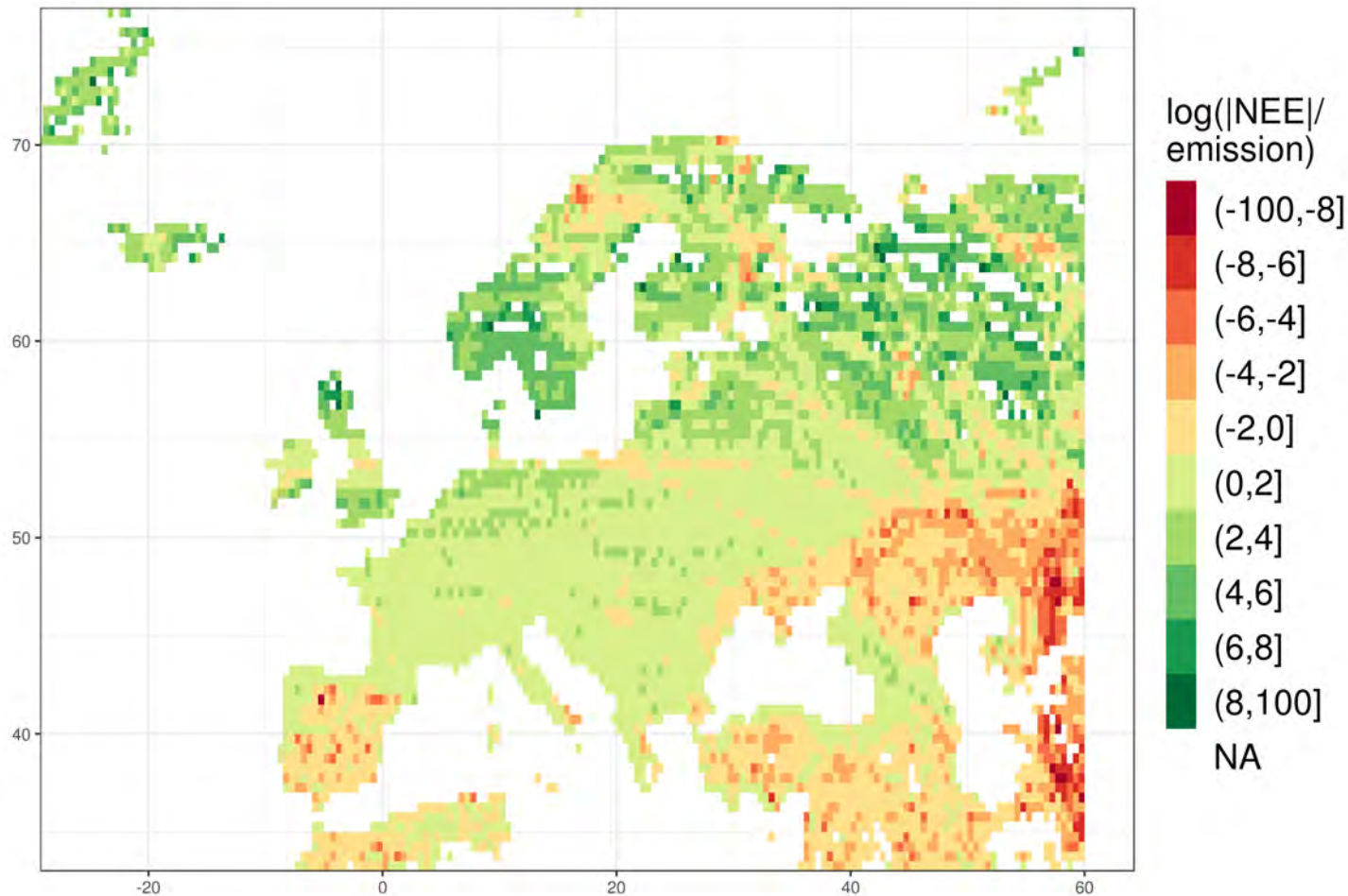
How can this help the other science knights to characterize the unknown dragon?

- find a split from anthropogenic emissions
- prior for atmospheric inversions
- cross-consistency checks for NEE from other approaches
- sensitivity of atm. CO₂ to different kinds of uncertainties in NEE at variety of scales
- process understanding through factorial experiments



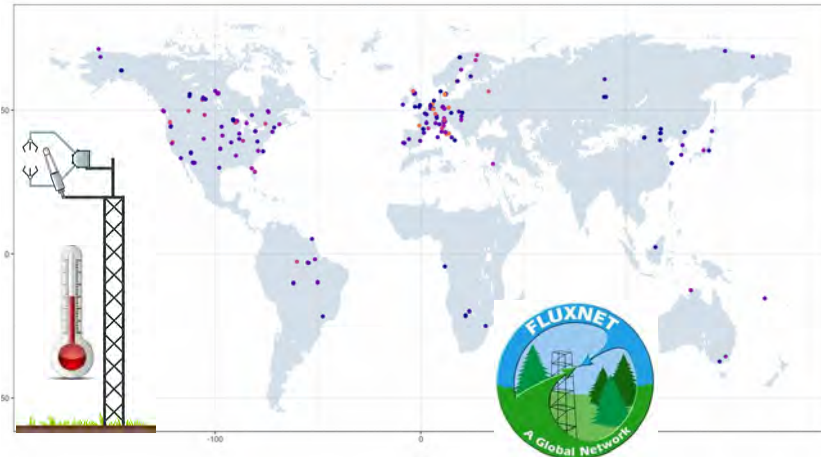
Biogenic fluxes dominate fossil fuel signal (in growing season)

June 2012



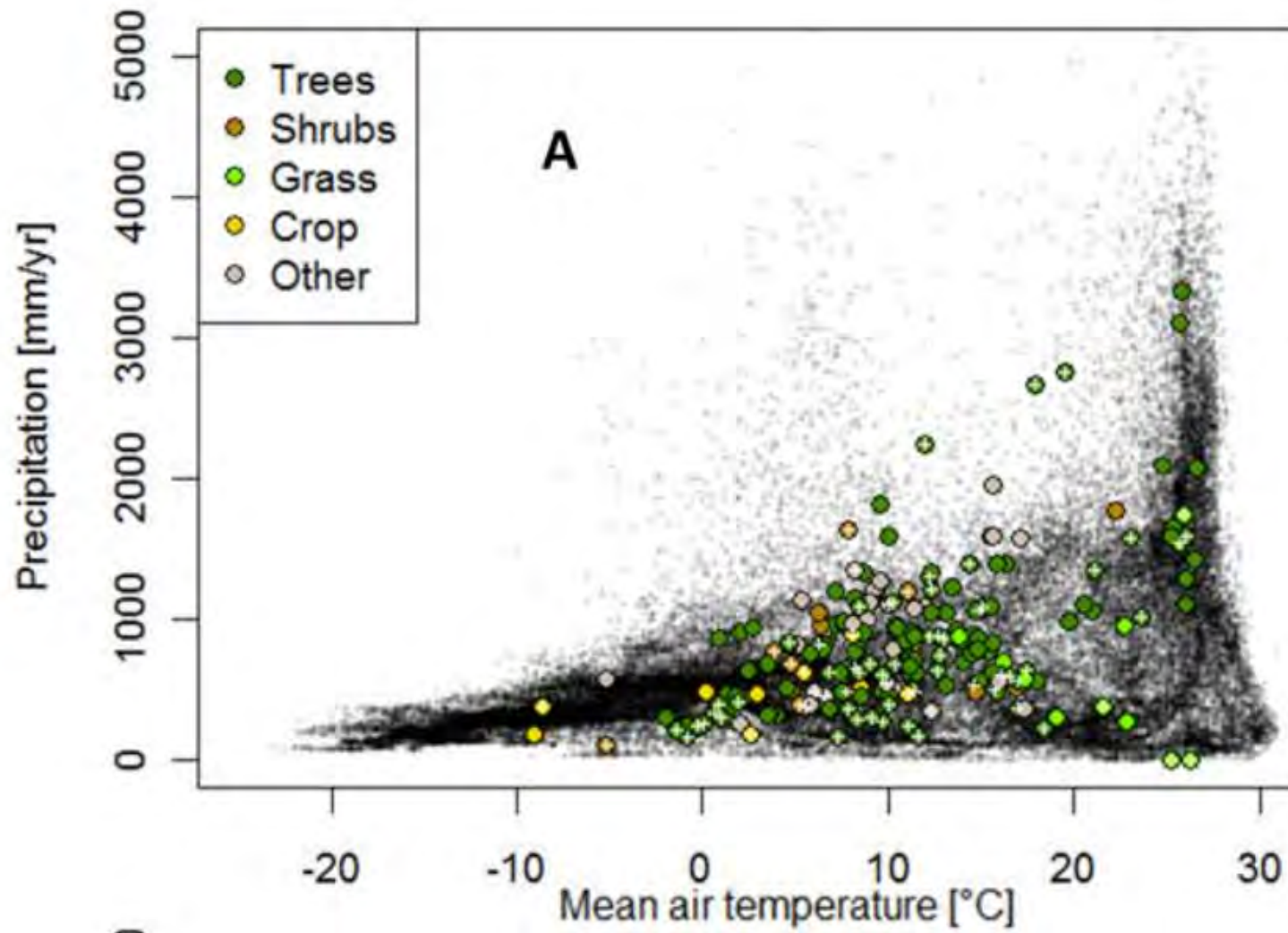
Fuel CO₂ emission: monthly, Peking University, Wang et al., 2013
NEE: hourly, MPI-BGC Jena

Our approach to modelling the biospheric trace

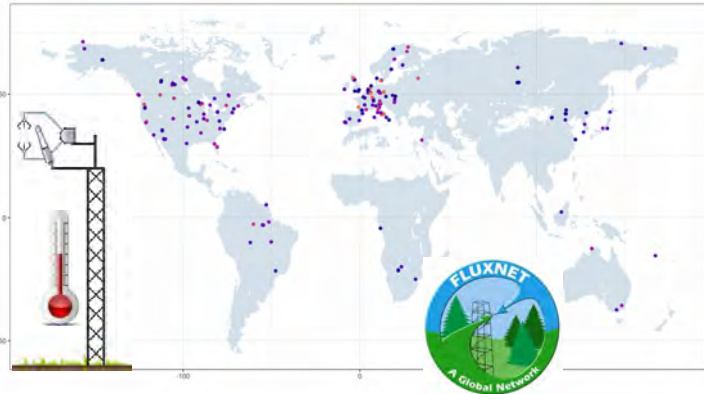


In-situ eddy-covariance
carbon fluxes &
meteorology

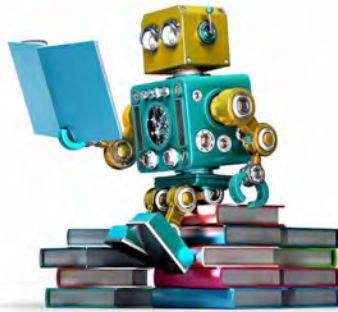
In-situ obs cover large part of the climate space



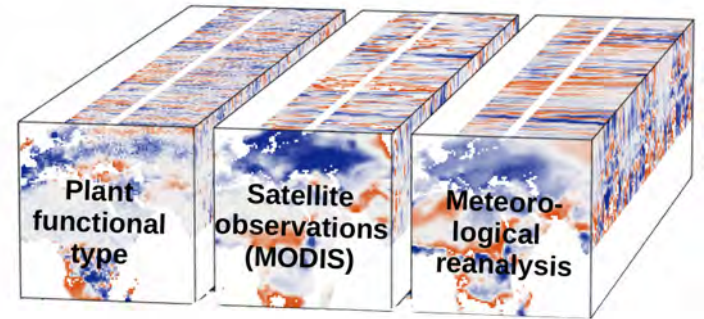
Our approach to modelling the biospheric trace



In-situ eddy-covariance carbon fluxes & meteorology



machine learning

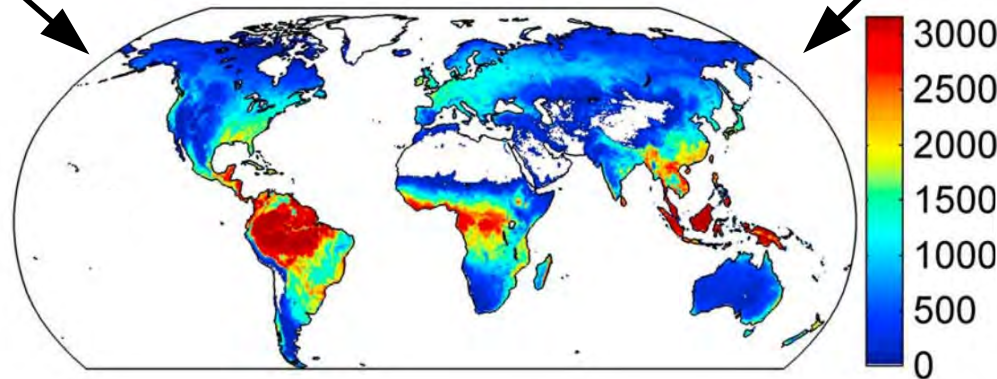


global gridded data sets of predictors

+

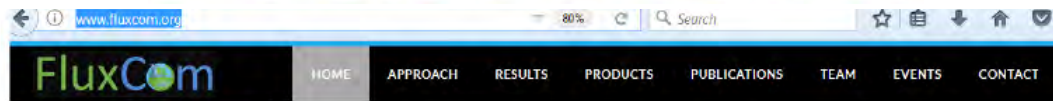
+

GPP [gC/m²/yr]



Global gridded flux estimates of NEE, GPP, TER

FluxCom



M.Jung



M.Reichstein



D.Papale



K.Ichii



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).

"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

Links

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

www.fluxcom.org



S.Koirala

G. Tramontana



C.Schwalm



G.Camps-Valls



F.Gans



U.Weber



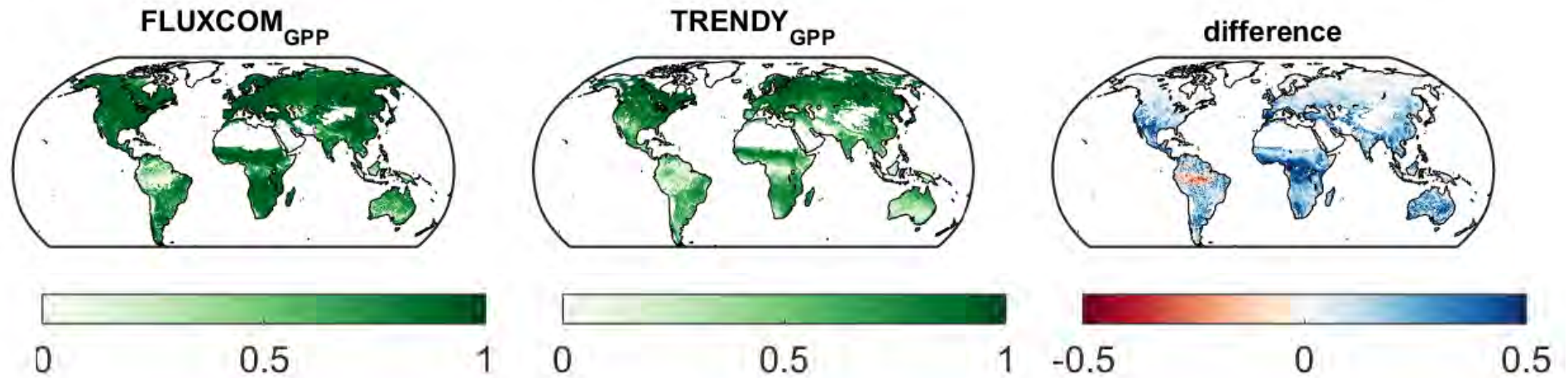
Two complementary set-ups creating ensembles

	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

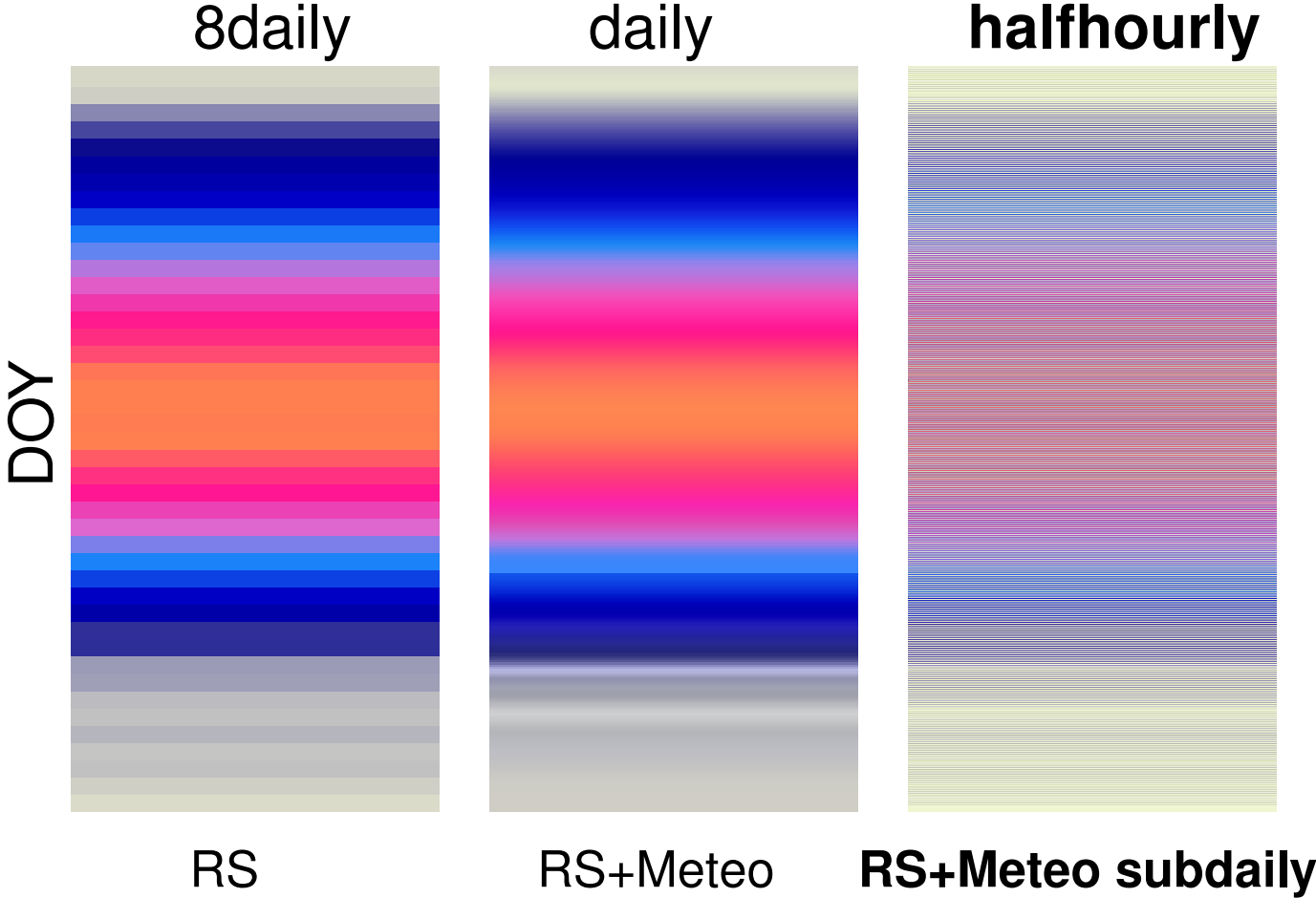
Higher consistency in seasonality with SIF than TRENDY



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

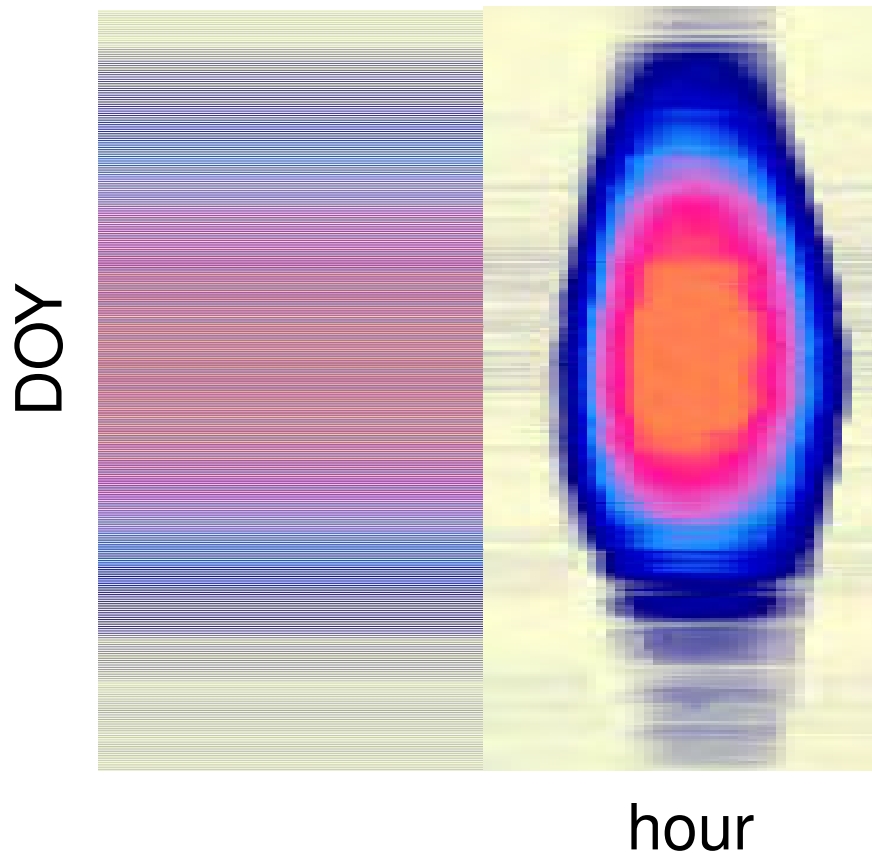


Tramontana et al. 2016
Jung et al. 2017

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

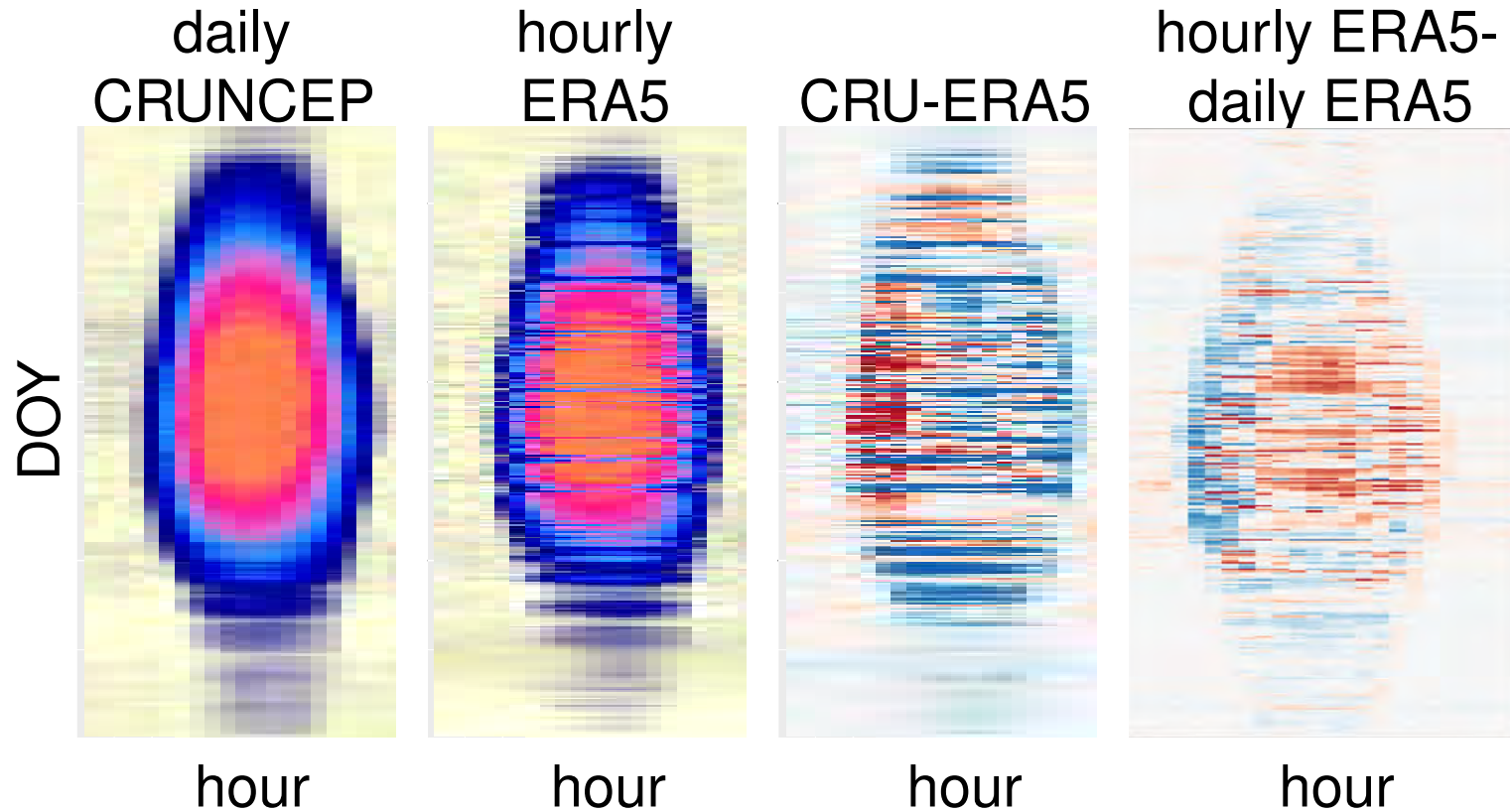
Paul Bodesheim et al. 2018

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

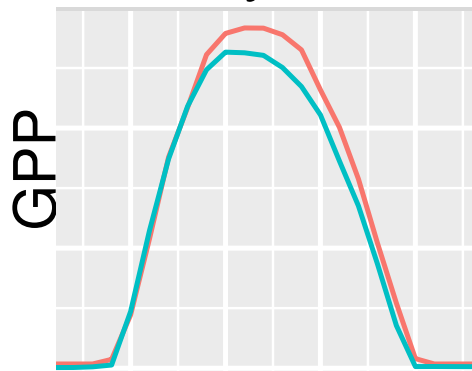
⇒ include additional hourly predictors

Example: GPP

first sub-daily fluxes



Diurnal cycle in July:

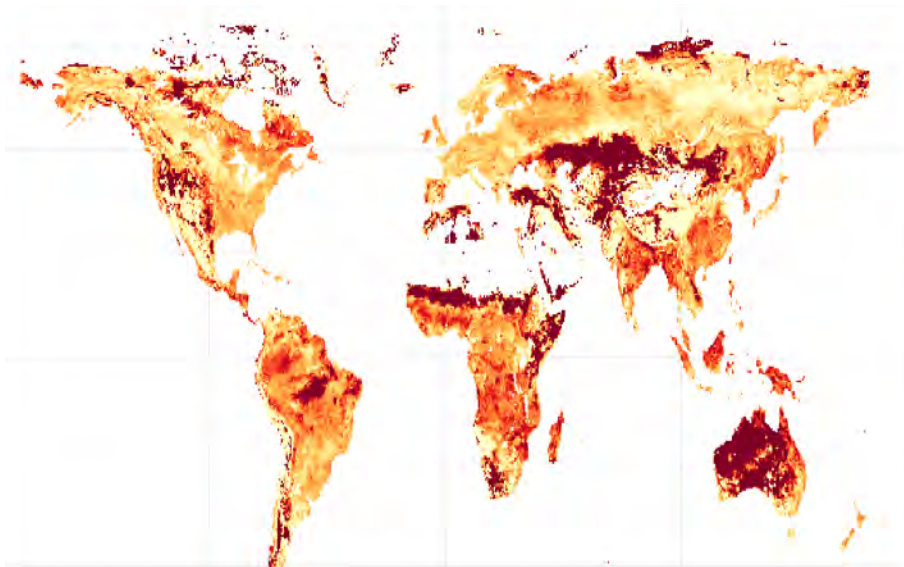


- negative positive
- **hourly meteo shifts diurnal cycle**
 - **biases in reanalysis strongly affect magnitude of fluxes**

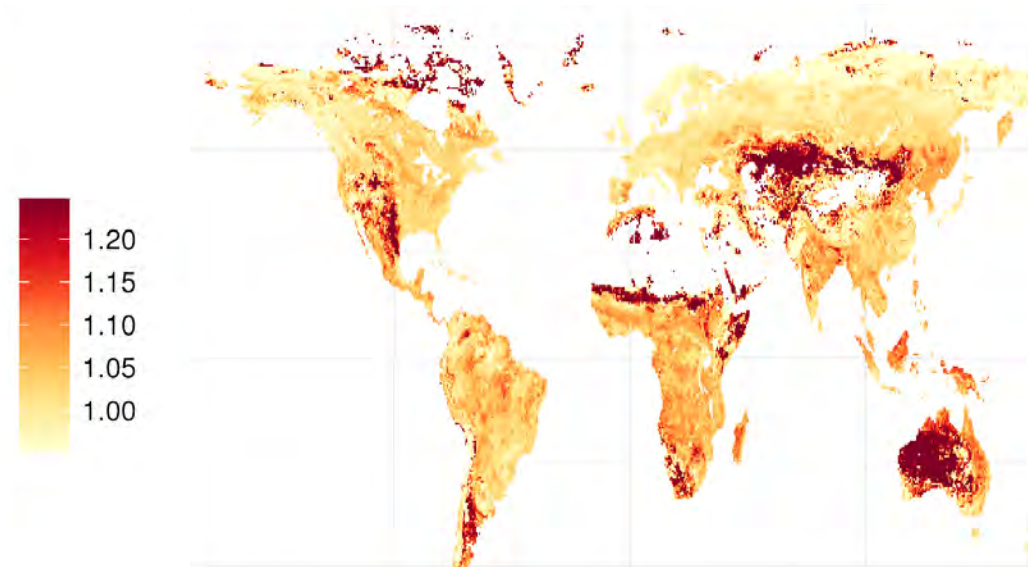
— CRUNCEP — ERA5

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

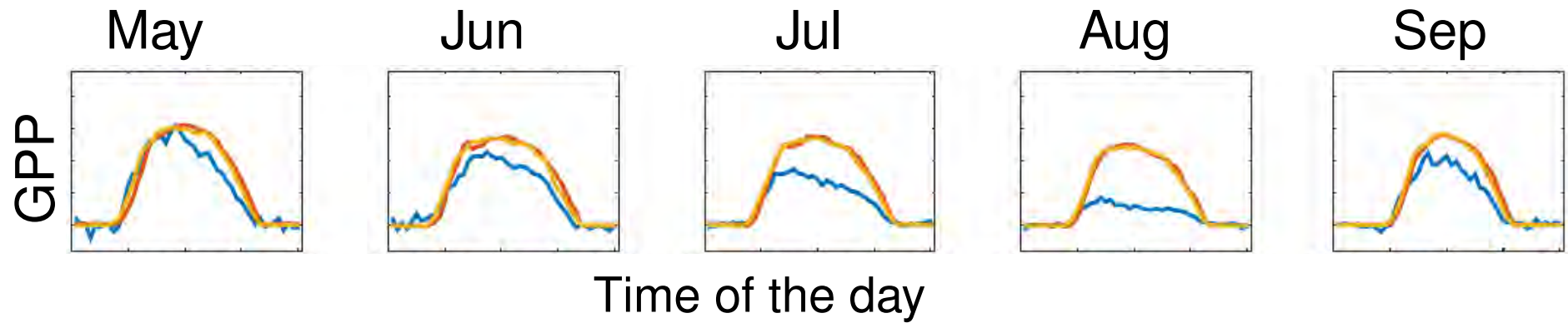
daily CRUNCEP/hourly ERA



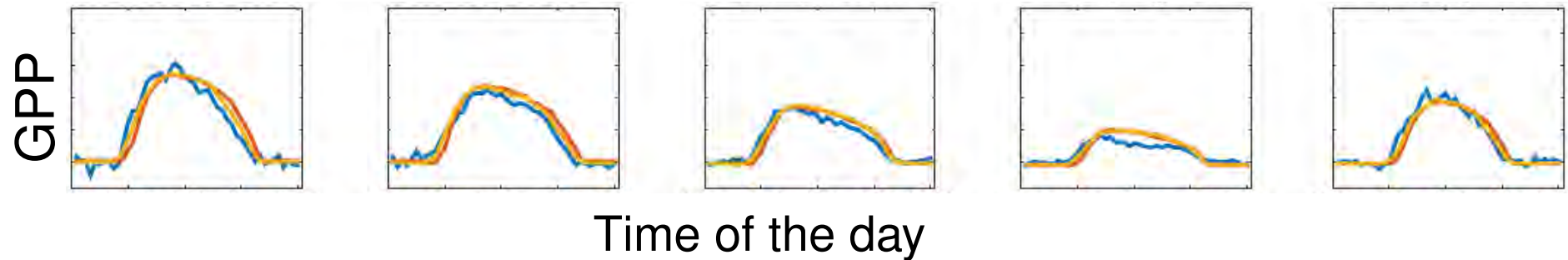
daily CRUNCEP/daily ERA



Drought effects not well represented



Daily GPP as additional daily predictor:

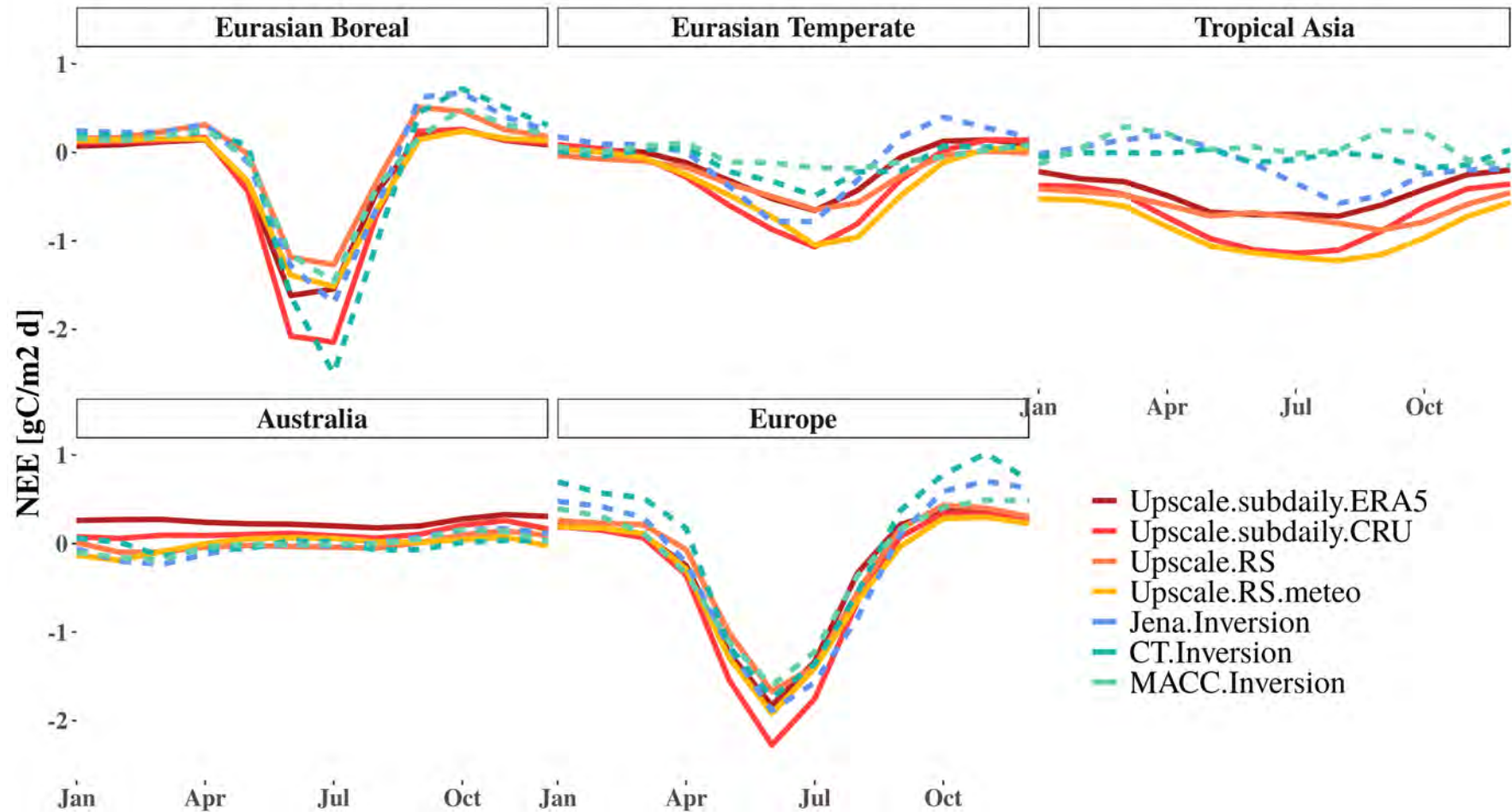


- observation
- modelled with daily predictors
- modelled with daily & halfhourly predictors

Puechabon



Seasonal consistency of NEE with inversions



Towards high spatial AND high temporal resolution

Number of voxels per 10 years (log)

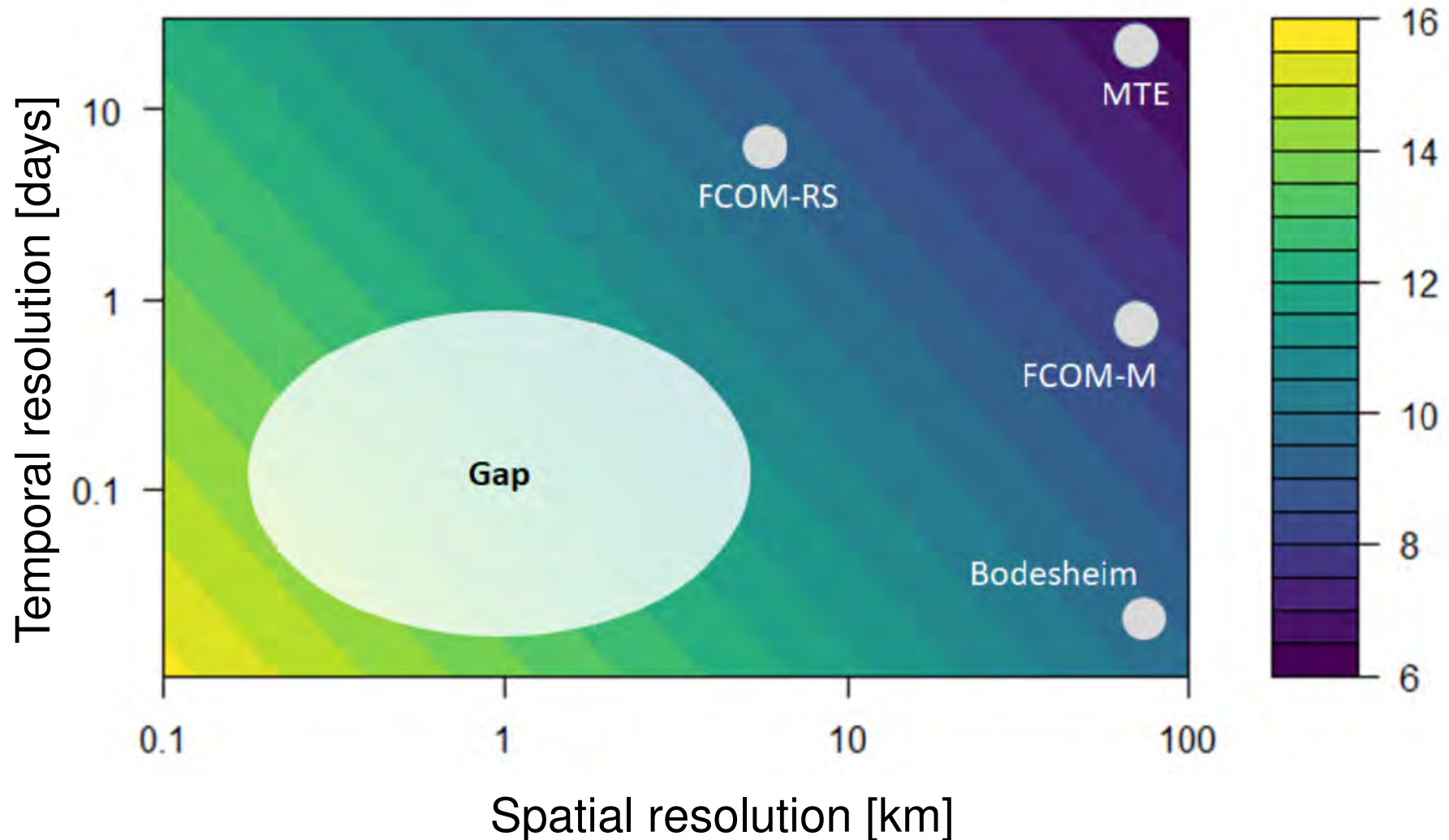


Figure courtesy Martin Jung

Towards dedicated products:

FluxCom2.0

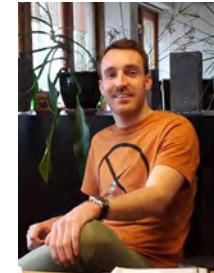
Ongoing efforts for improvements in terms of:

- **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:

