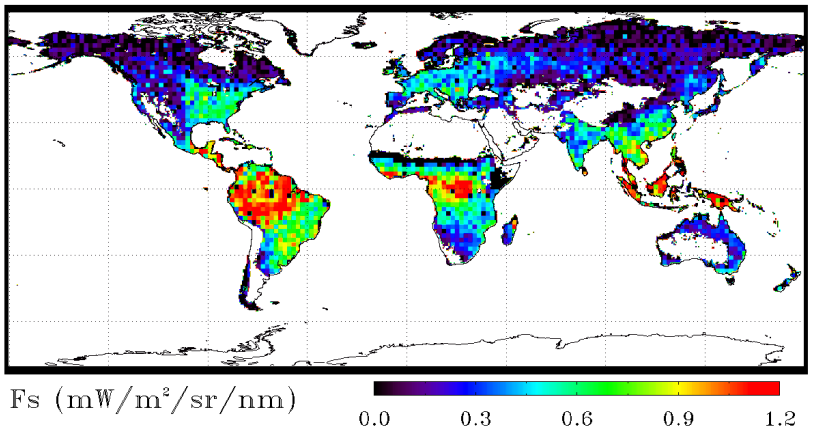

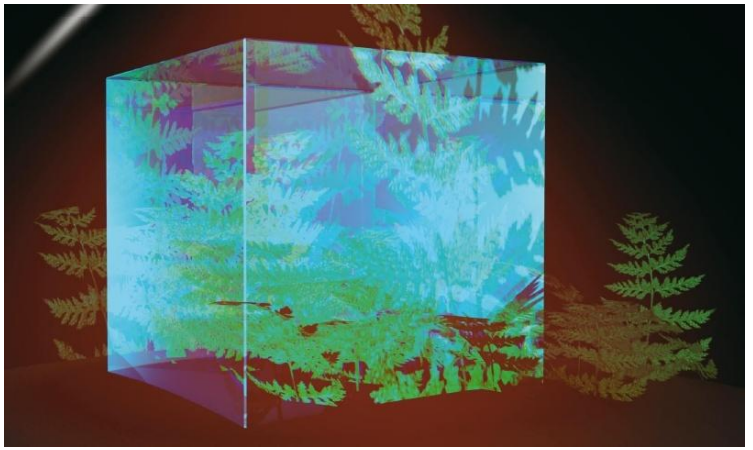

Global monitoring of terrestrial chlorophyll fluorescence from GOSAT/FTS and MetOp-A/GOME-2

Luis Guanter, Maximilian Voigt, Yongguang Zhang, Philipp Köhler
Free University of Berlin, Germany

Christian Frankenberg, Jung-Eun Lee
JPL, California Institute of Technology, USA

Joanna Joiner
NASA Goddard Space Flight Center, USA

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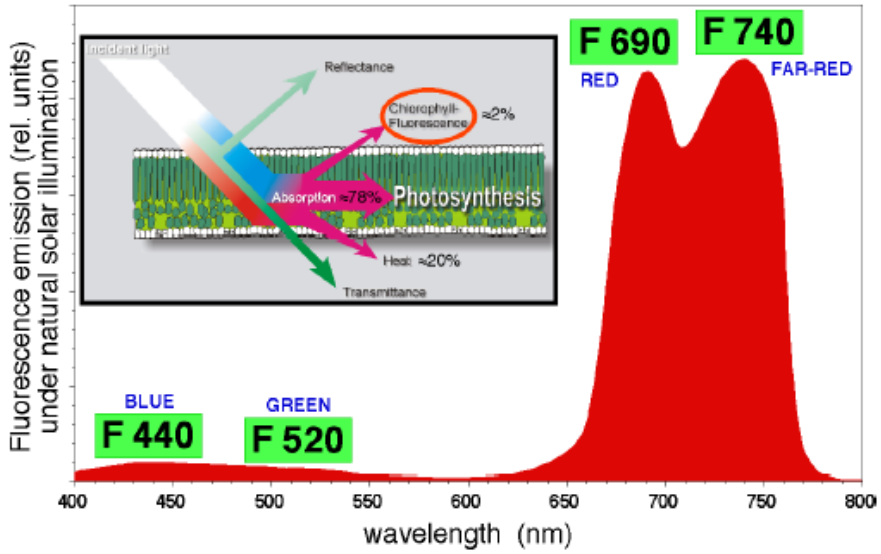
Emmy Noether-Programm
Deutsche Forschungsgemeinschaft DFG

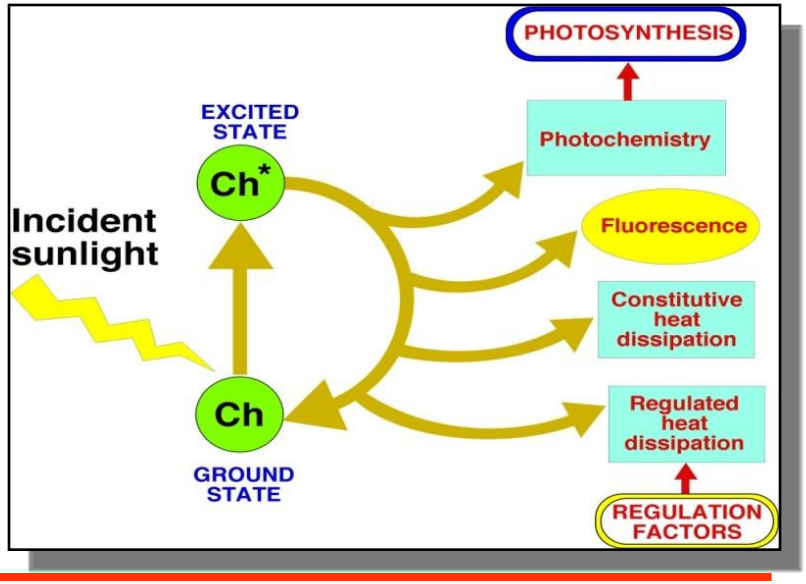
Freie Universität Berlin

Sun-induced chlorophyll fluorescence (SIF)

- **Fate of solar energy after absorption by chlorophyll in a leaf:**
  - Part of the energy is used for photochemical processes and photosynthesis resulting in ecosystem gross primary production (GPP).
  - Part of the energy is dissipated as heat.
  - **A remaining fraction is re-emitted as fluorescence.**
- Under natural conditions, fluorescence and photosynthesis positively correlated → **a measurement of fluorescence can be interpreted as a direct measurement of photosynthesis.**



De-excitation path ways



First SIF global maps produced in 2011 by Joiner et al and Frankenberg et al

nature climate change

Home | Opinion & Analysis | Research | Curr

Archive > 2011 > September > Snapshot

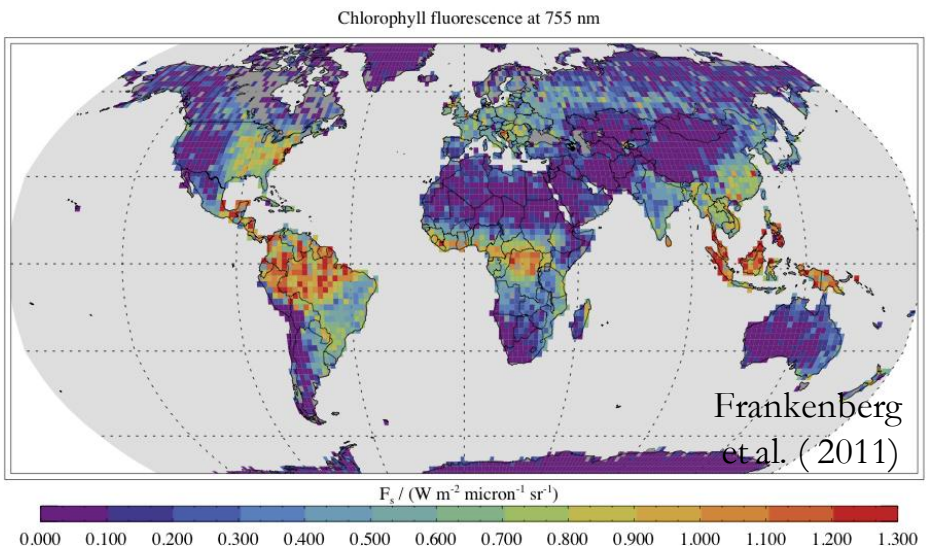
NATURE CLIMATE CHANGE | SNAPSHOT

Mapping photosynthesis

Sid Perkins

Nature Climate Change **1**, 282 (2011) | doi:10.1038/nclimate1208

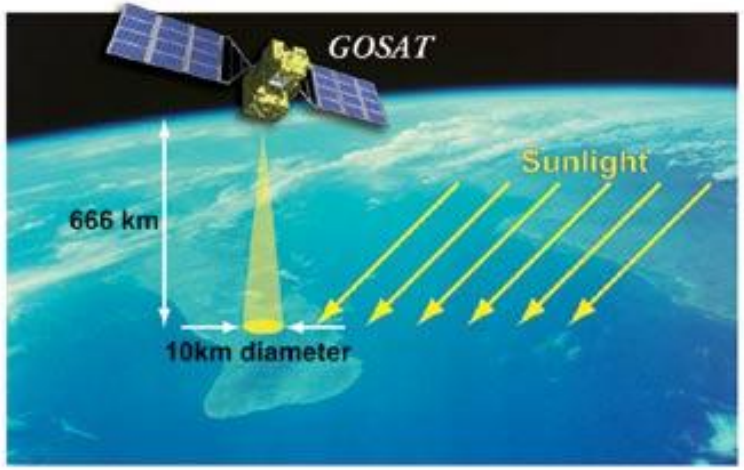
Published online 26 August 2011



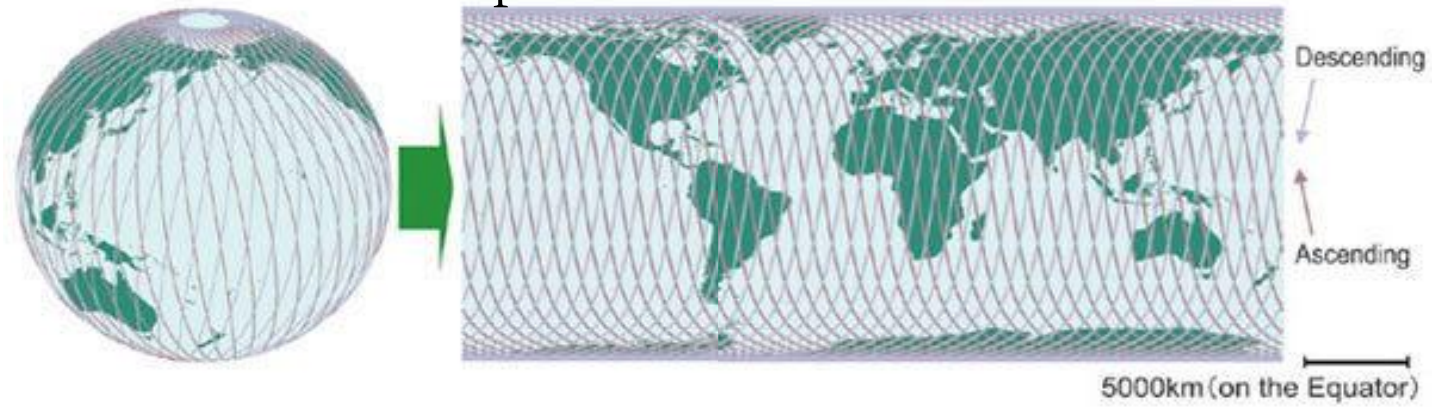
Researchers have created a global map of the fluorescence emitted by land-based plants during photosynthesis. This subtle glow at certain wavelengths could serve as an early warning system for plant stress and help scientists better understand Earth's carbon cycle.

Greenhouse Gases Observing Satellite (GOSAT)

- World's first satellite optimized to observe CO_2 and CH_4 from space.
- Developed by the Japan Aerospace Exploration Agency (JAXA).
- Launched on 23 January 2009.
- Sun synchronous orbit, 13h LT
- Fourier Transform Spectrometer
  - O_2-A, CO_2, CO_2/CH_4
  - FOVs of 10km Diameter

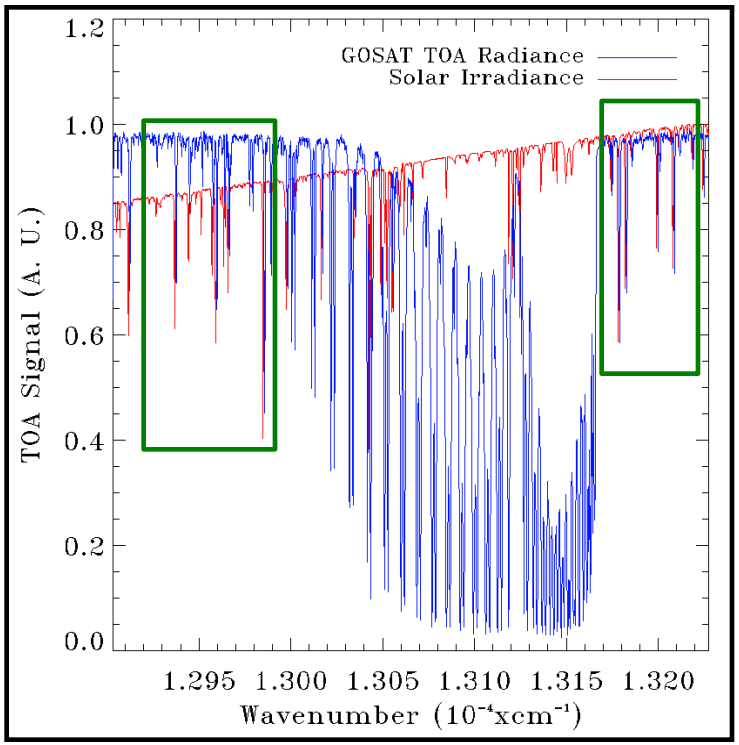


- Over a 3-day period, ~10000 points distributed uniformly over the surface of the Earth are sampled.

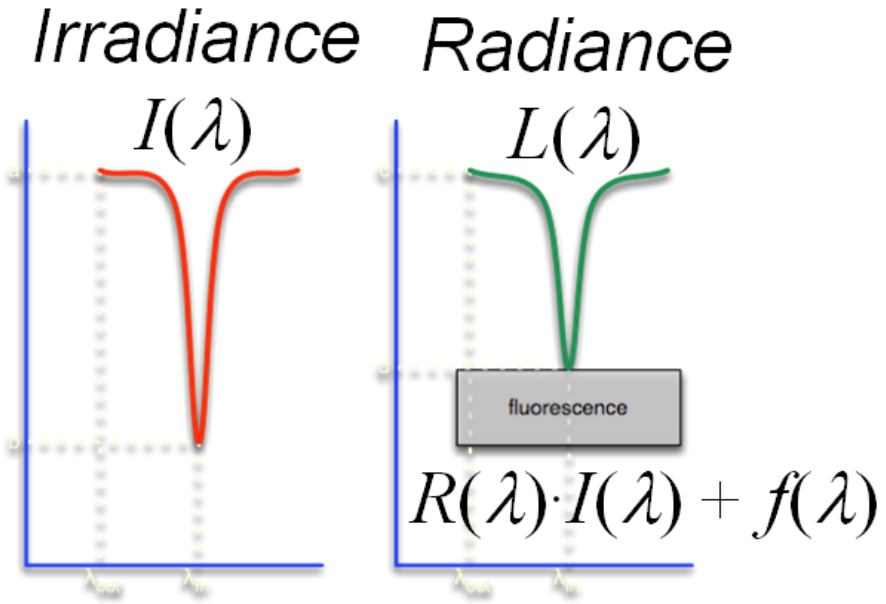


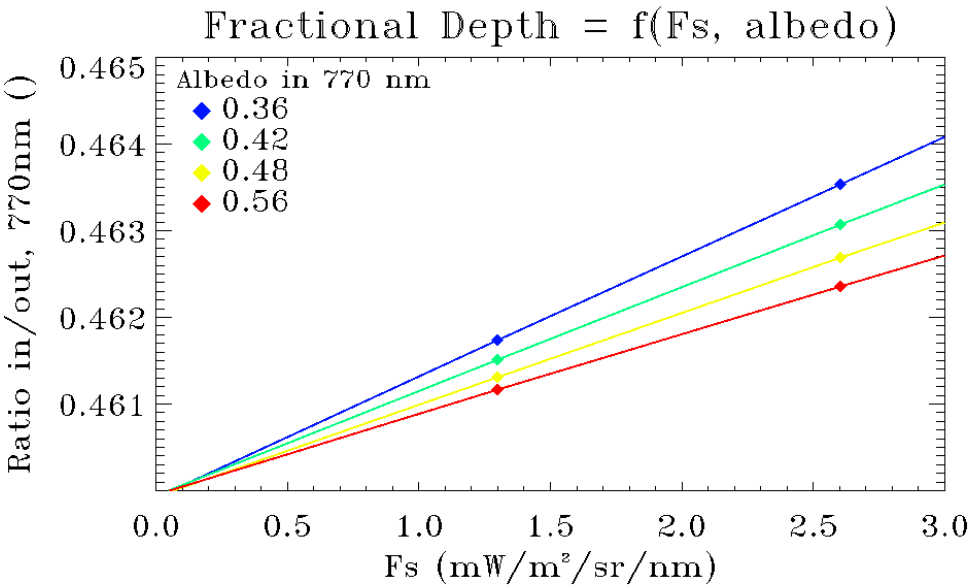
SIF retrieval from space: in-flling of solar Fraunhofer lines

Measurements by the GOSAT Fourier Transform Spectrometer (FTS)



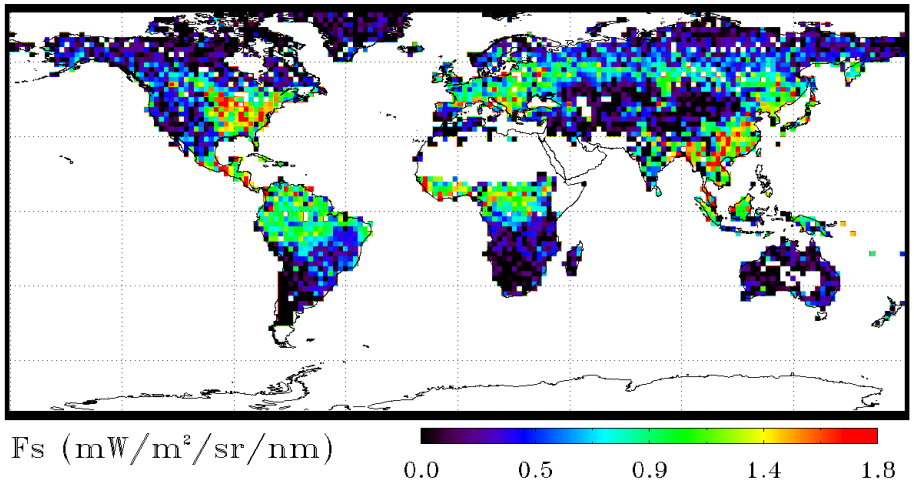
Fractional depth of absorption features decreases with an additive signal (e.g. SIF)

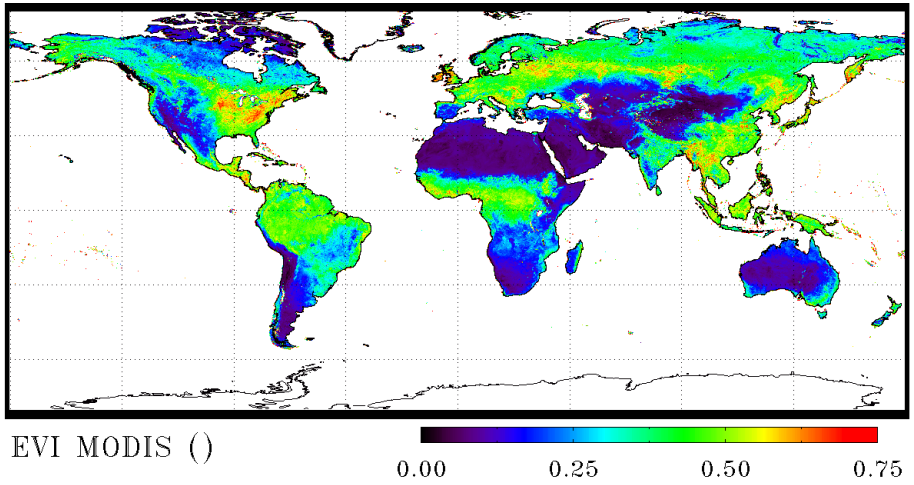




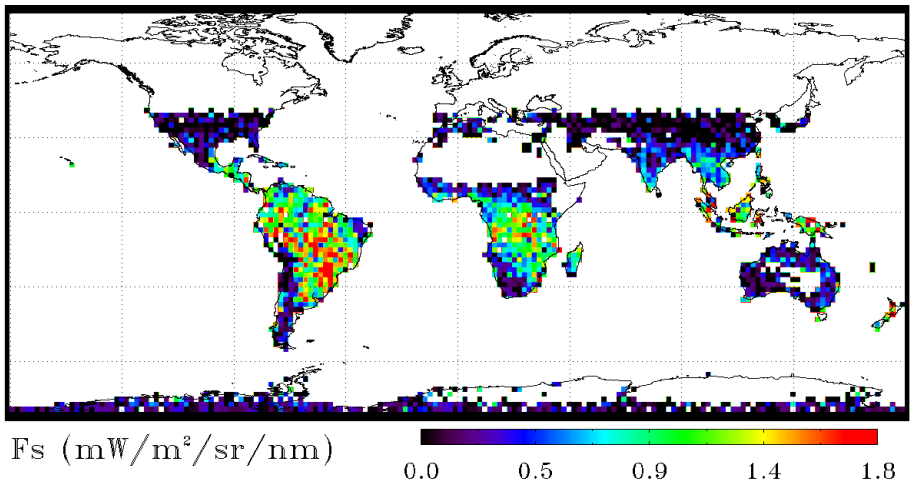
Monthly Composites

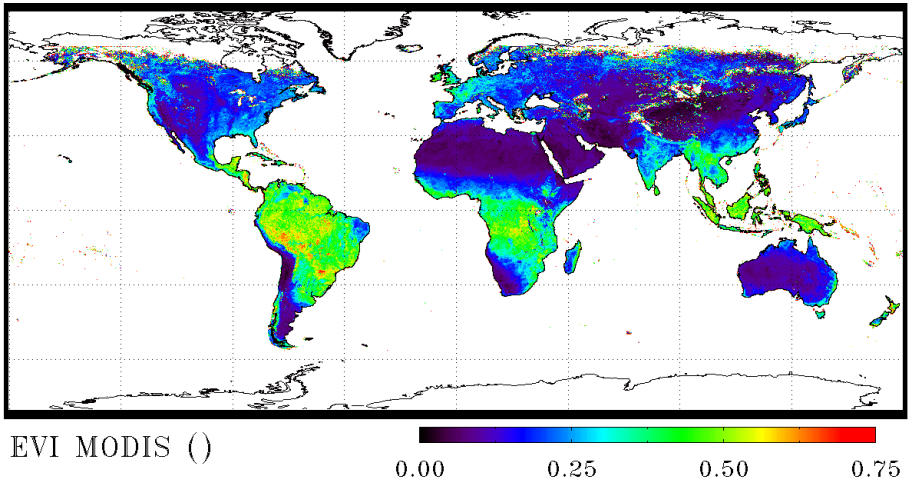
July 2009



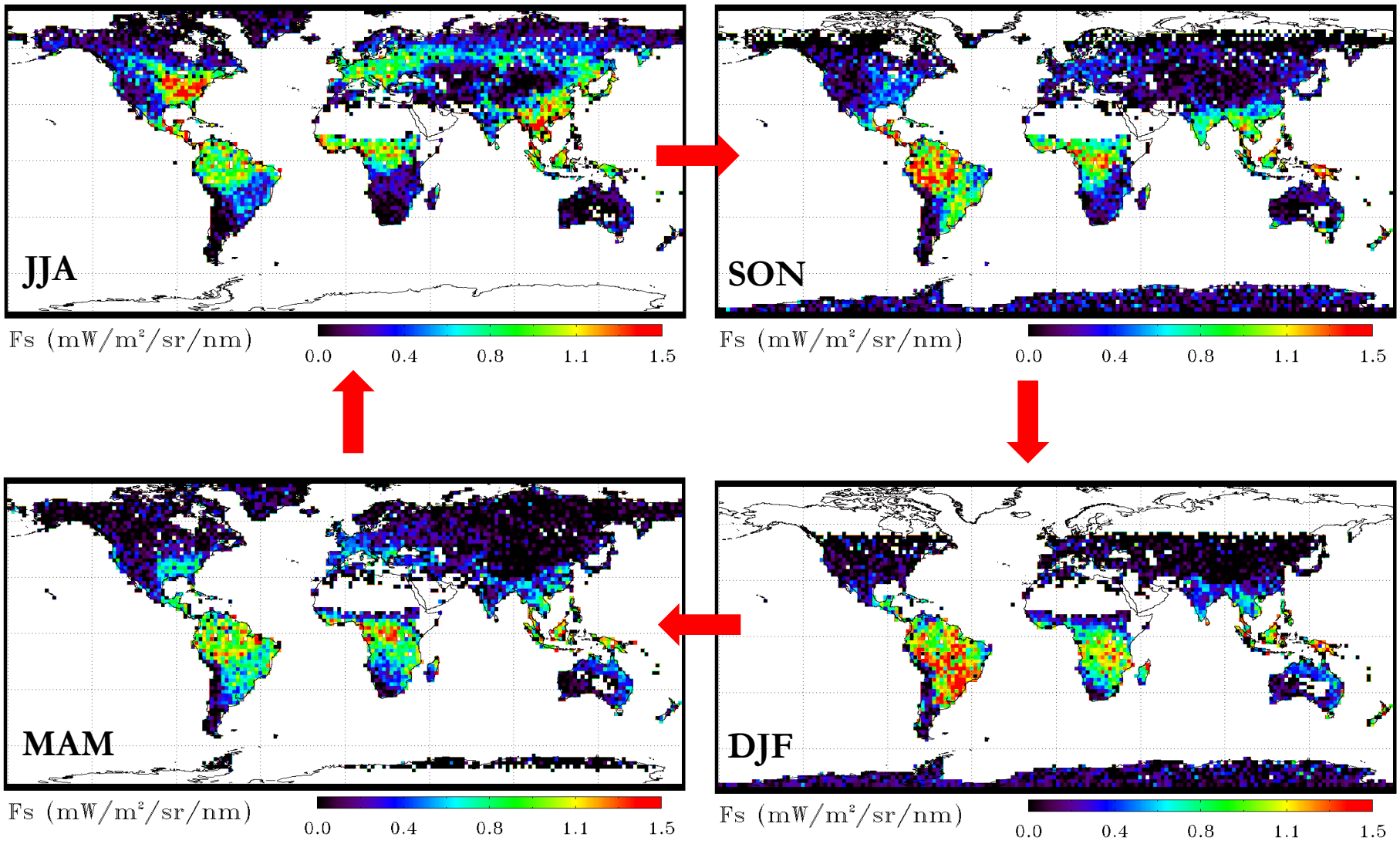


December 2009



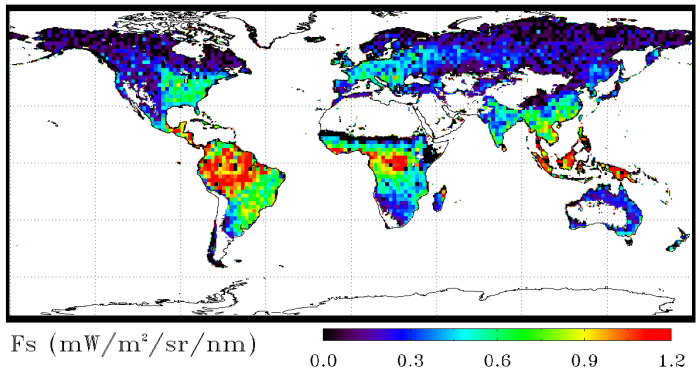


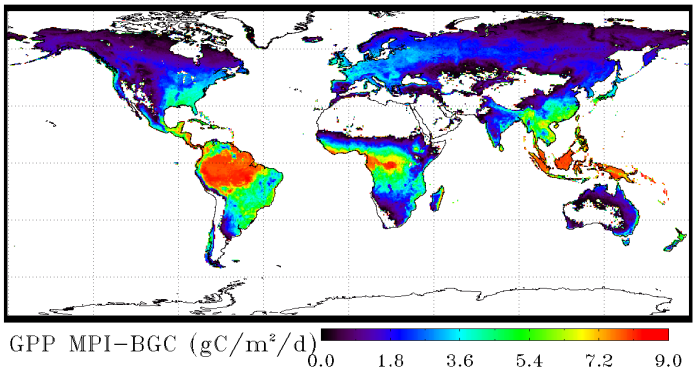
Seasonal Cycles



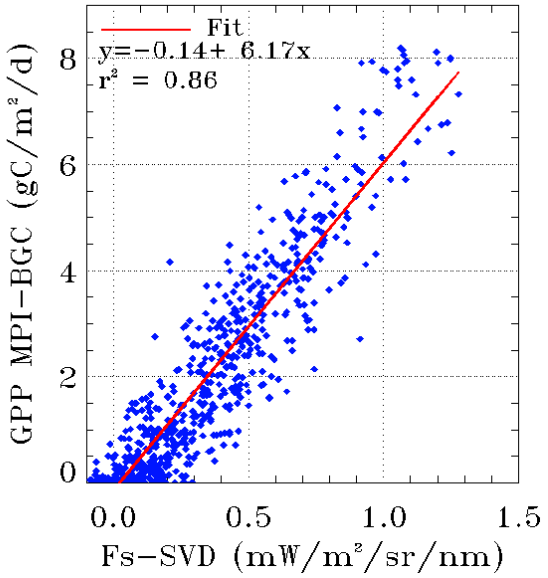
SIF to improve GPP modelling

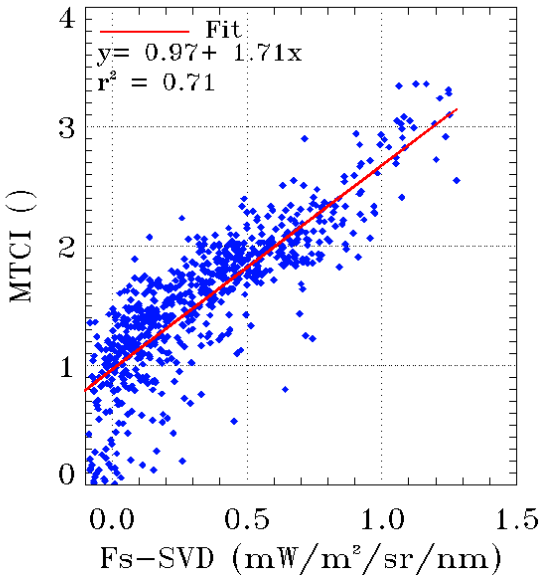
Annual Average Jun09-May10

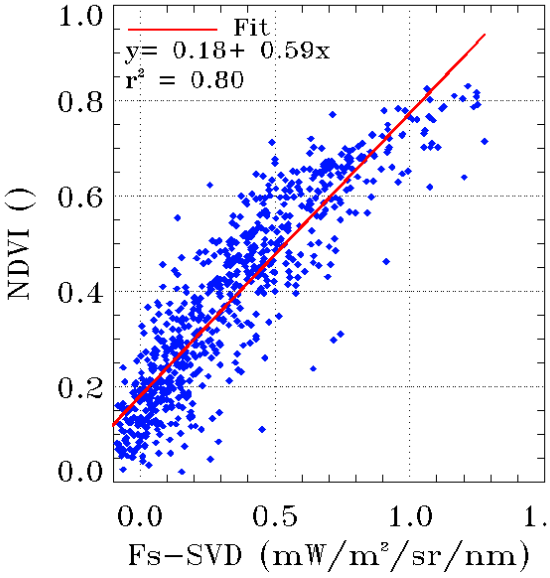


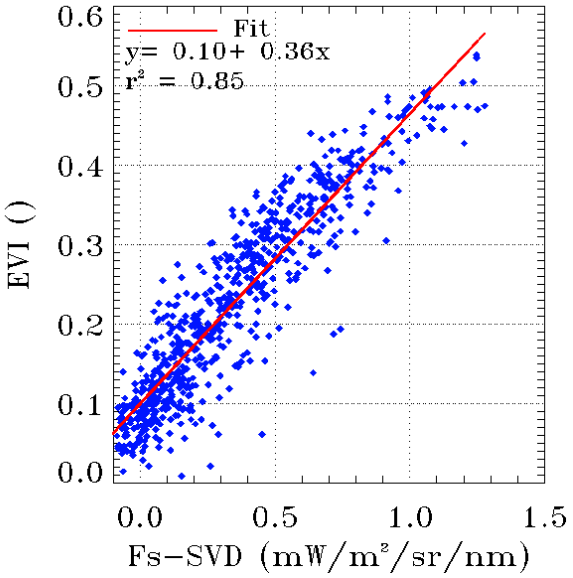


Guanter et al, RSE, 2012





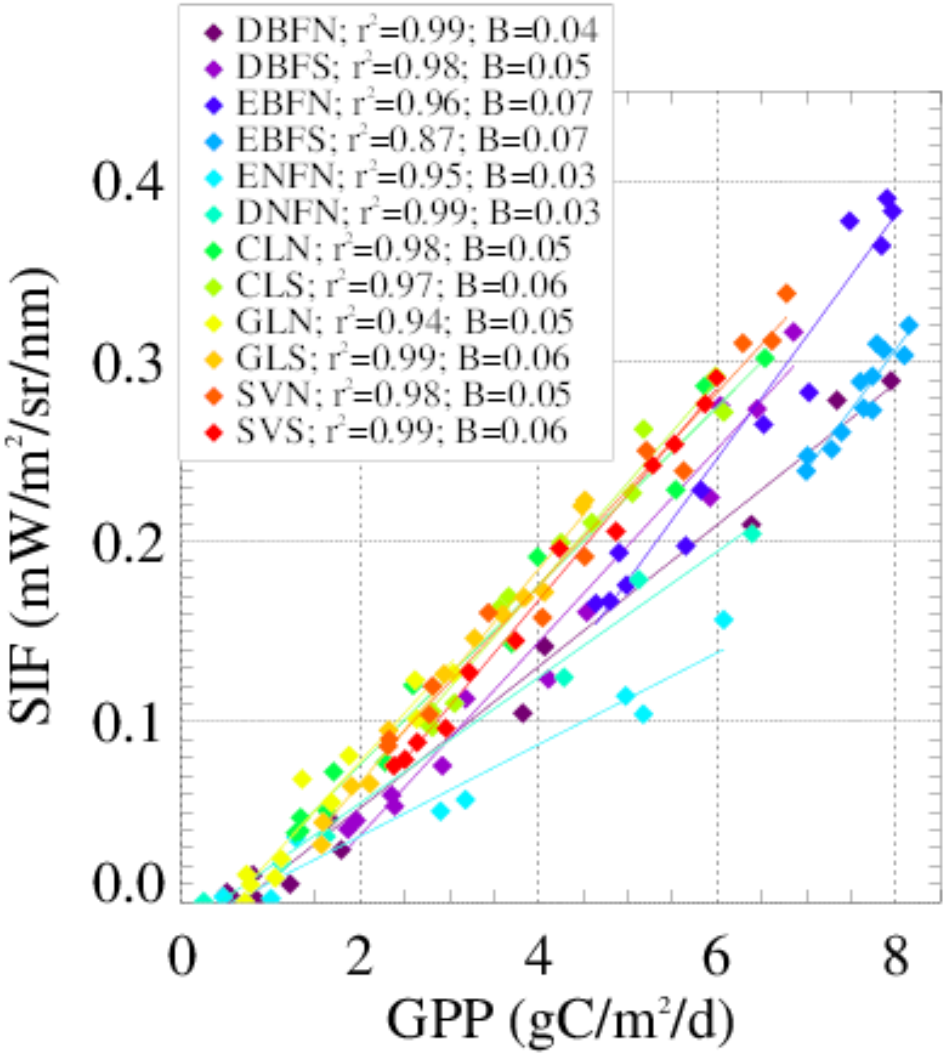




SIF-GPP per biome

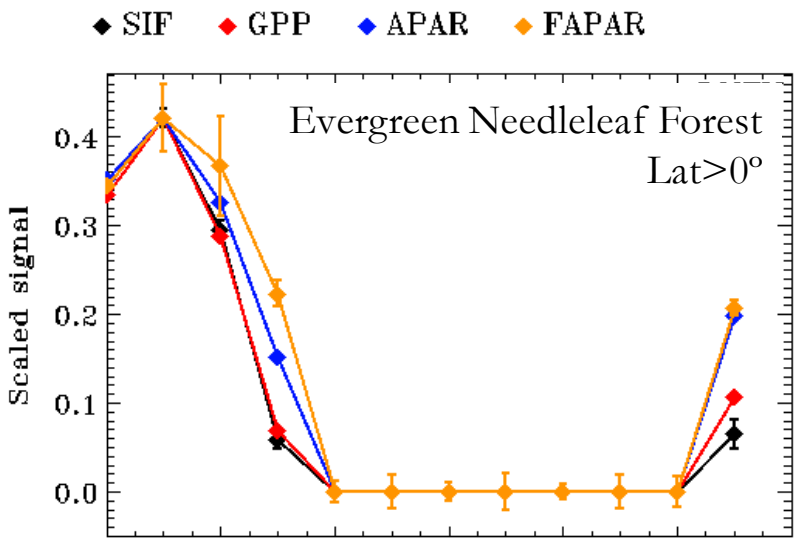
Each point is a monthly mean

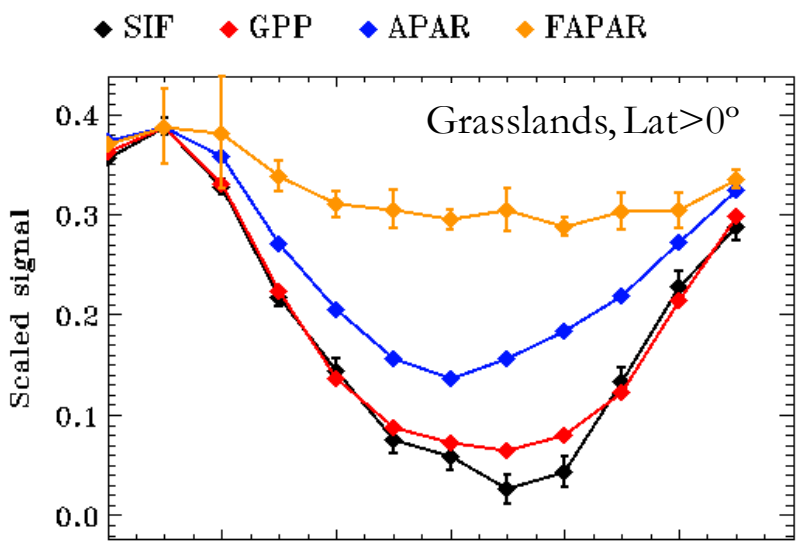
High linear relationship, but GPP/SIF varies with biome: canopy structure? biochemistry? meteorology?
→ Scaling SIF to GPP not straightforward

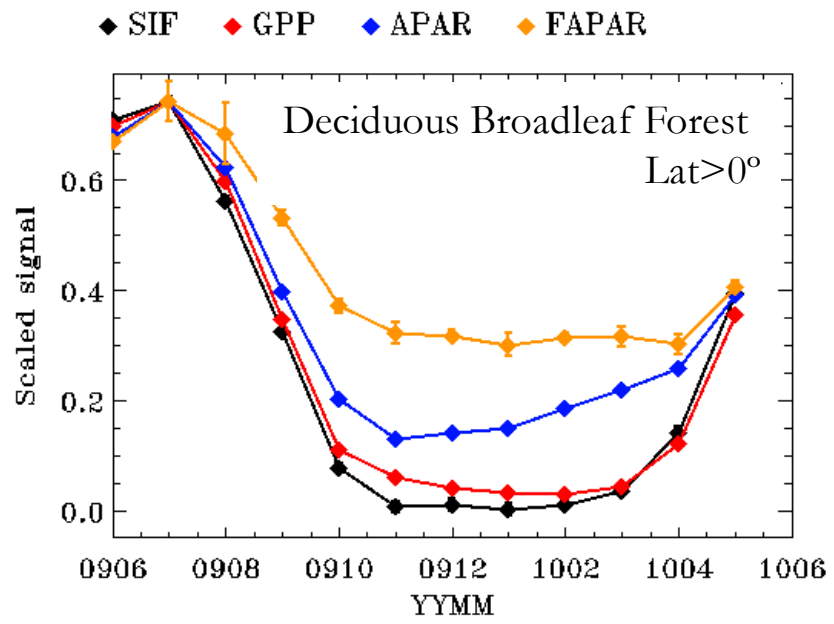


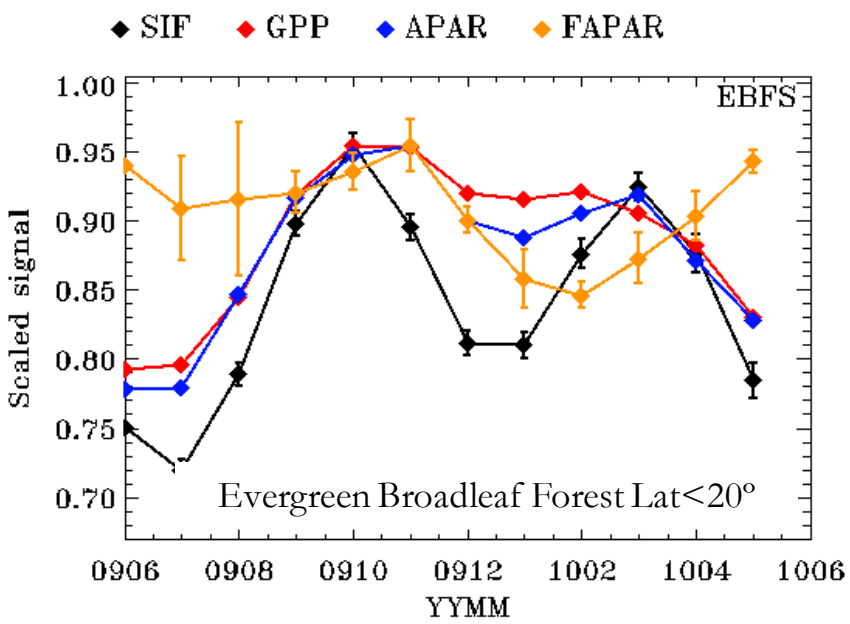
GPP from data-driven approach
M. Jung – MPI-BGC

SIF, GPP, APAR & FAPAR for different biomes



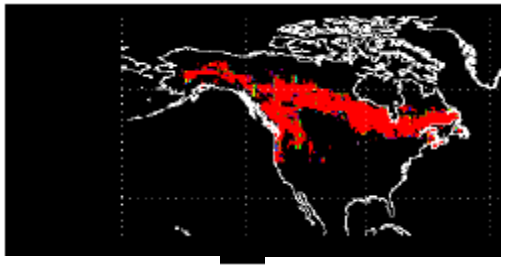


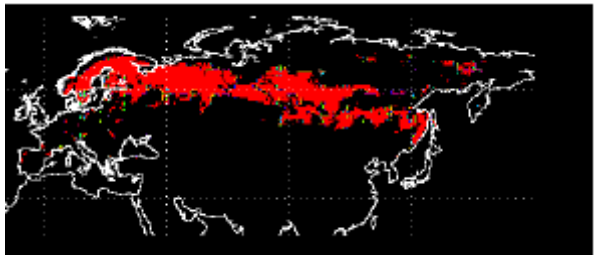


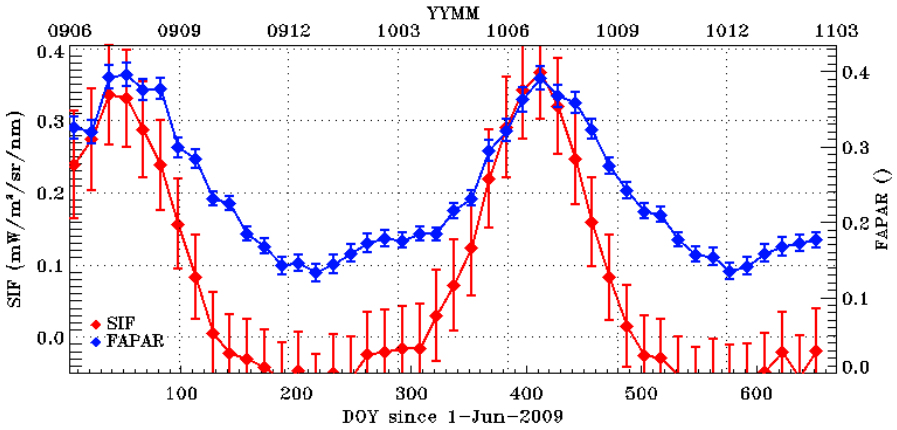


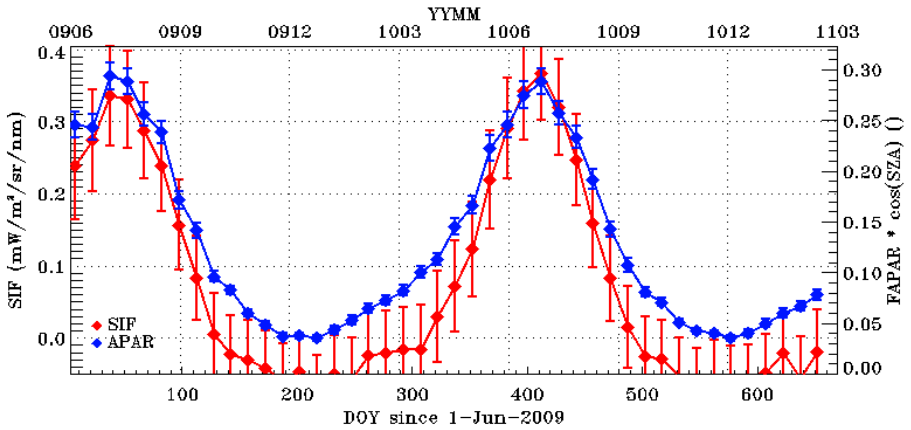
SIF to indicate photosynthetic activity

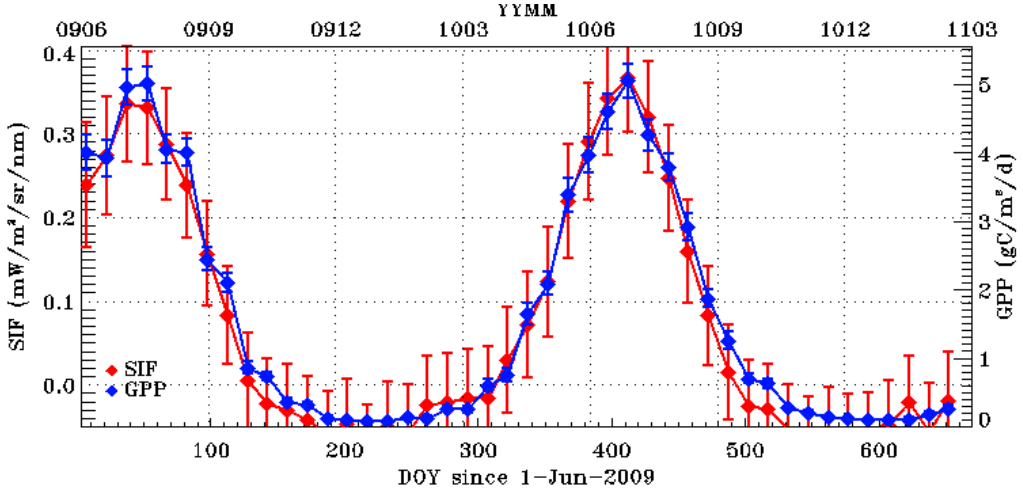
SIF vs
[FAPAR, APAR, GPP]







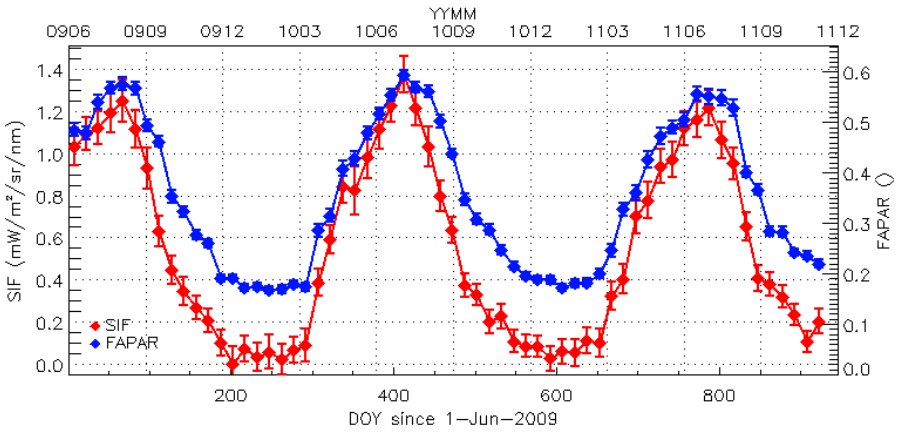


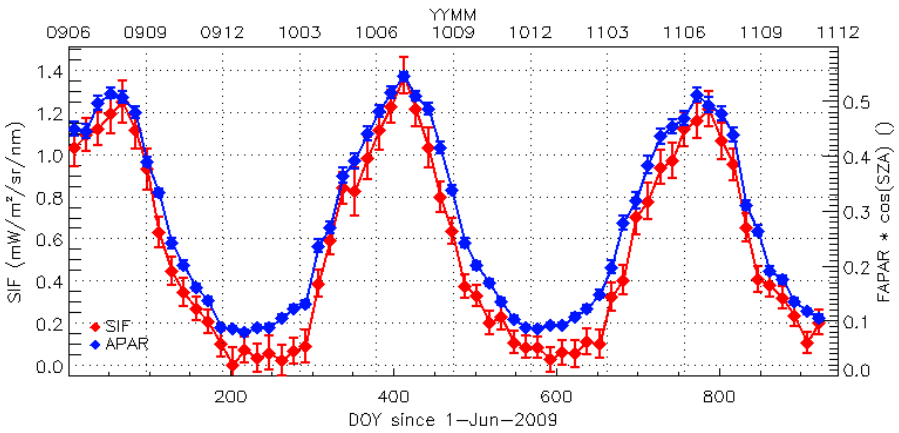


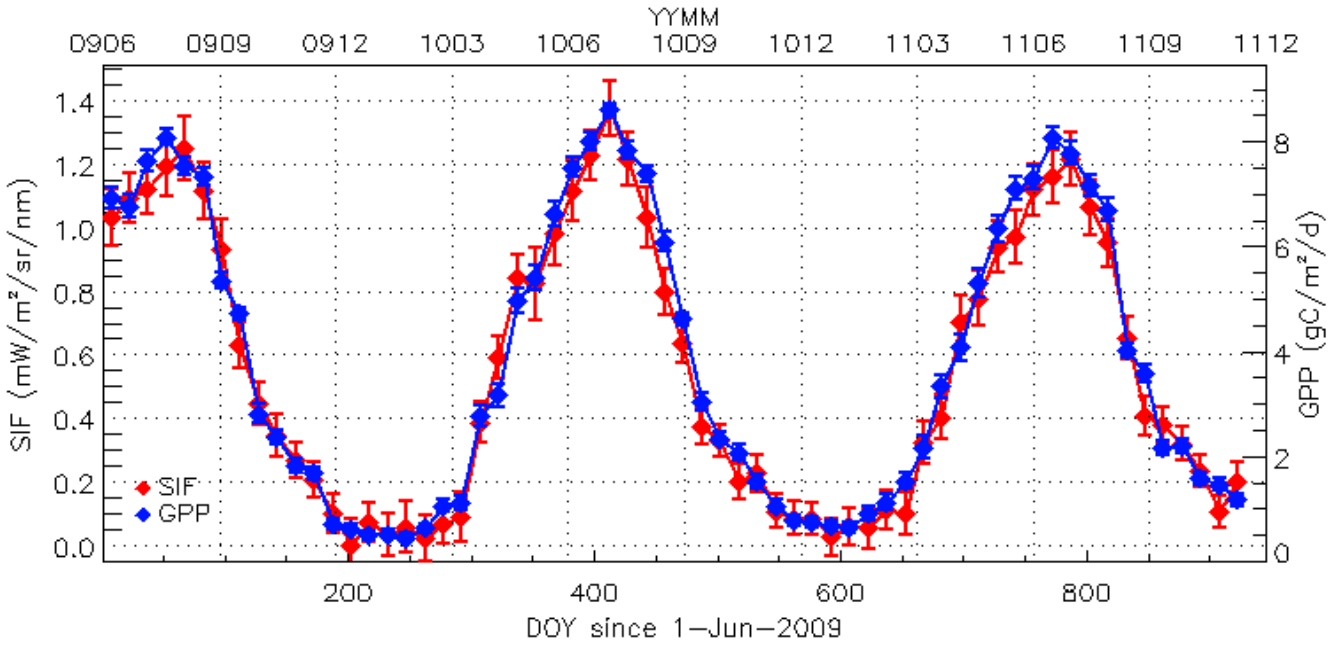
Evergreen needleleaf forest
Lat = [45°, 80°]

SIF to indicate phenology and photosynthetic periods

SIF vs [FAPAR, APAR, GPP]

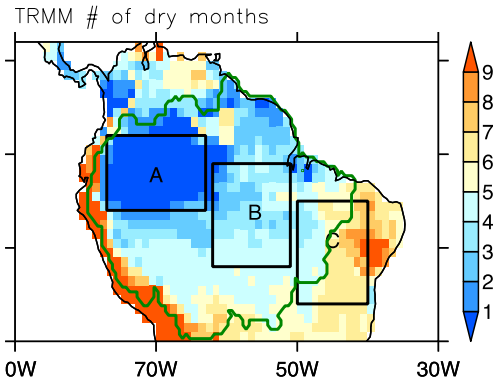




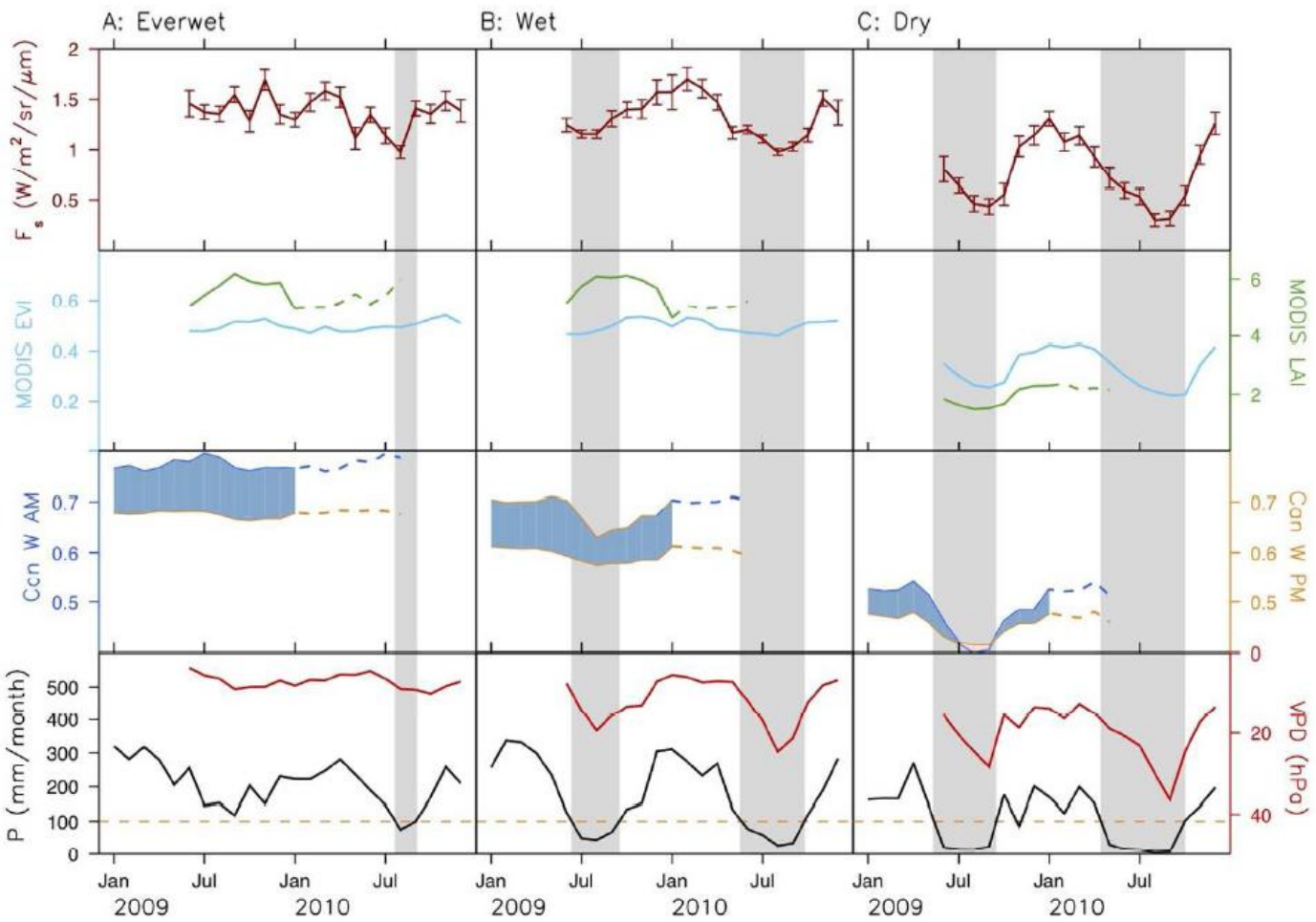


Croplands Midwest US

Amazonian productivity vs water stress



2010 drought

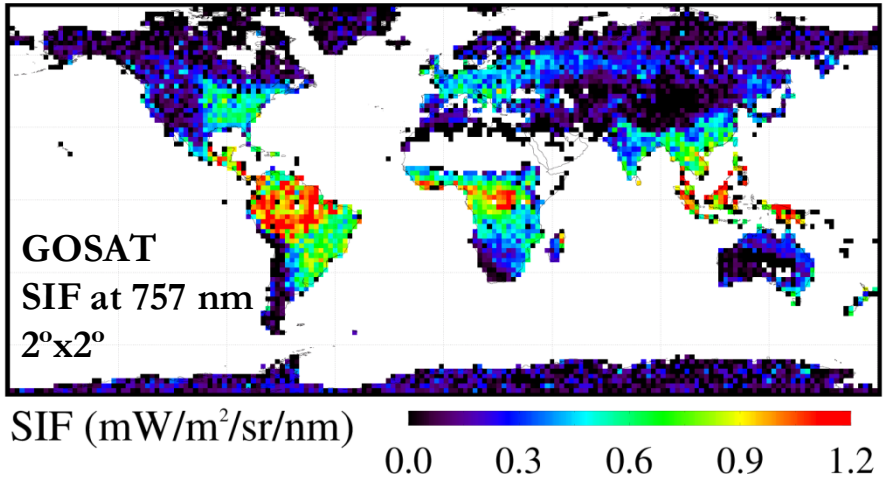


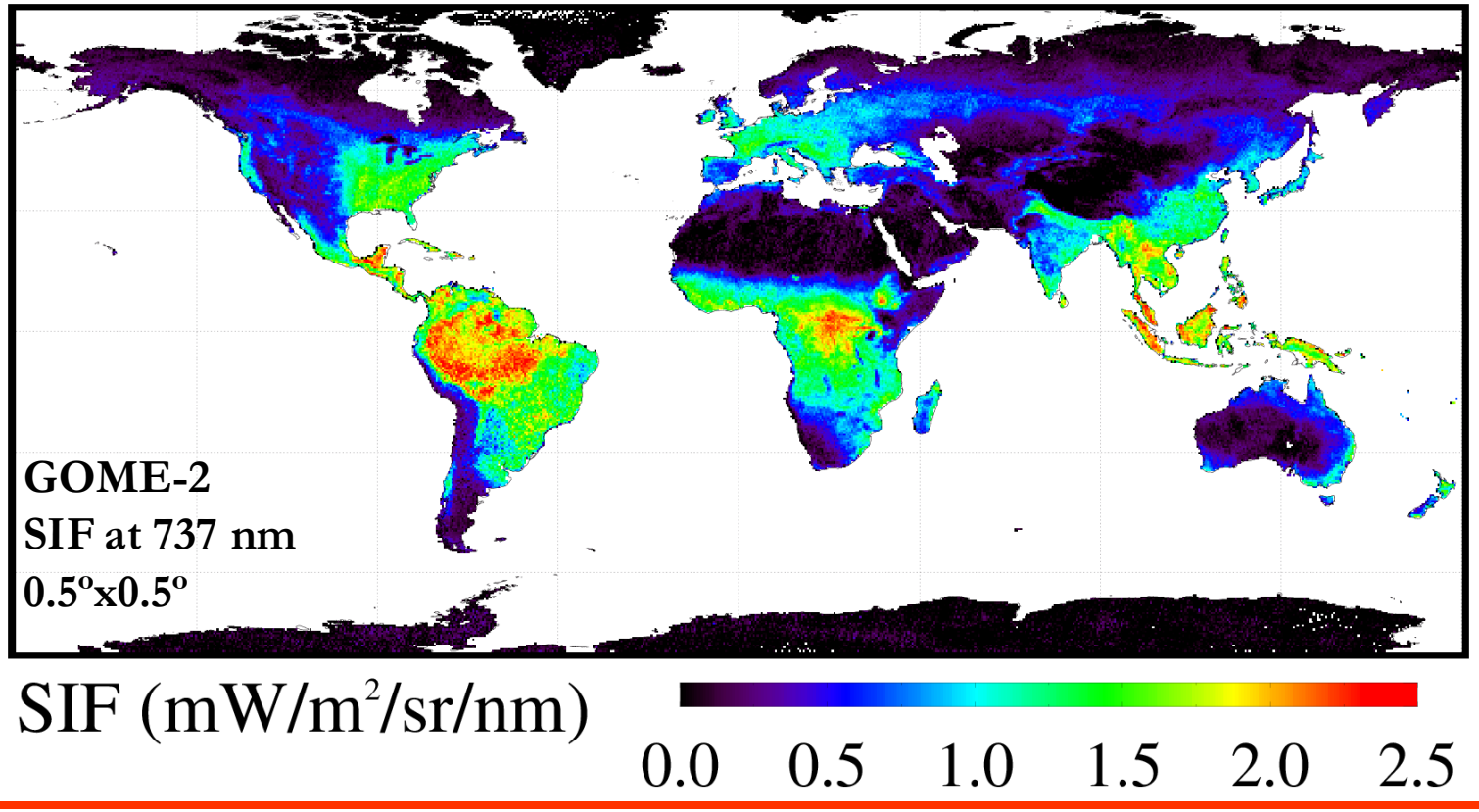
Lee et al, Amazonian productivity to seasonal water stress: observations from GOSAT chlorophyll fluorescence, Proc Royal Soc. B, 2013.

Recent achievement: MetOp-A GOME-2 SIF retrievals

Joiner et al, AMTD, 2013

Annual Average
Jun09-May10

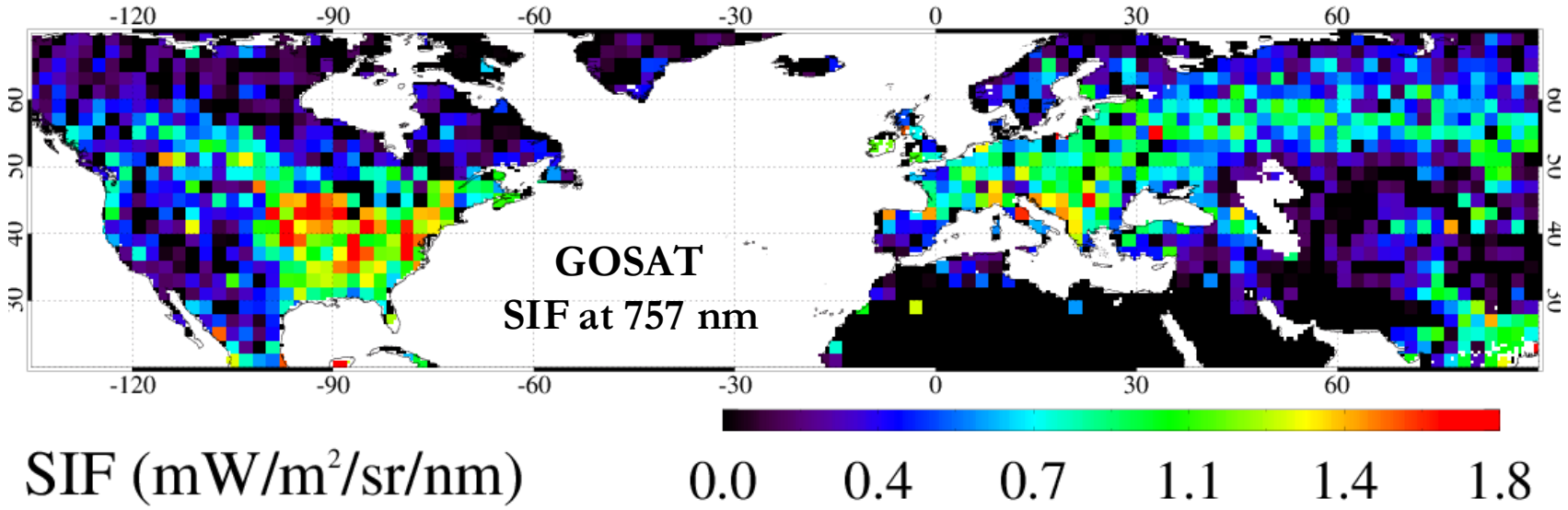


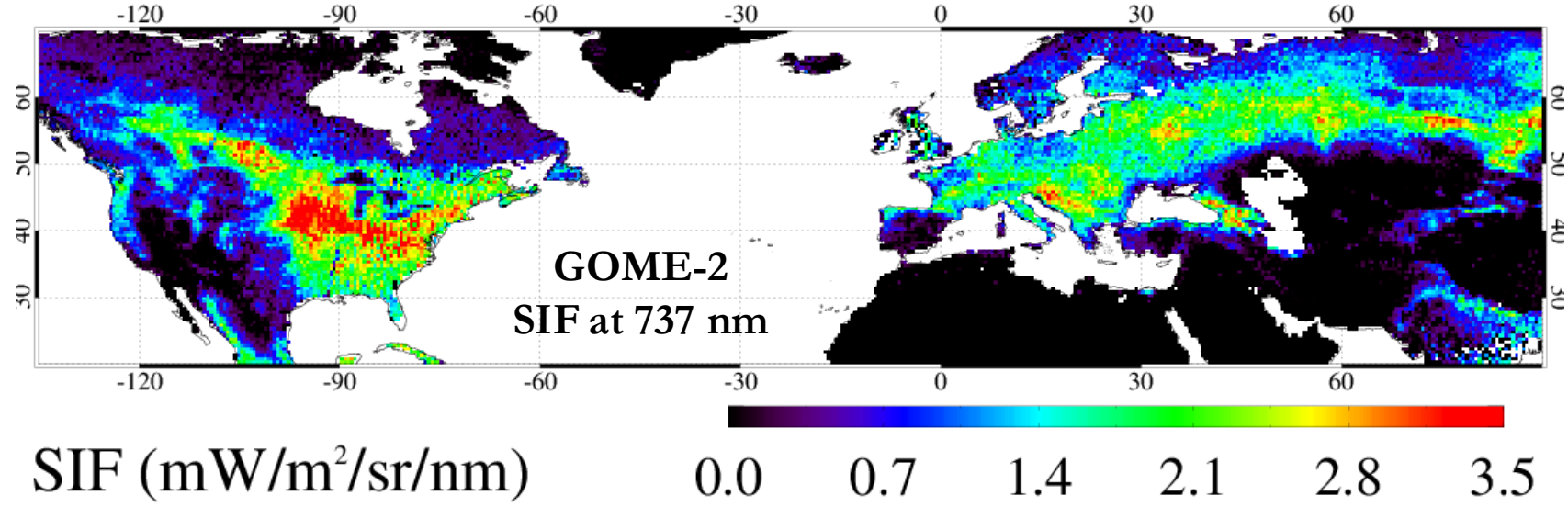


Recent achievement: GOME-2 SIF retrievals

July 2009

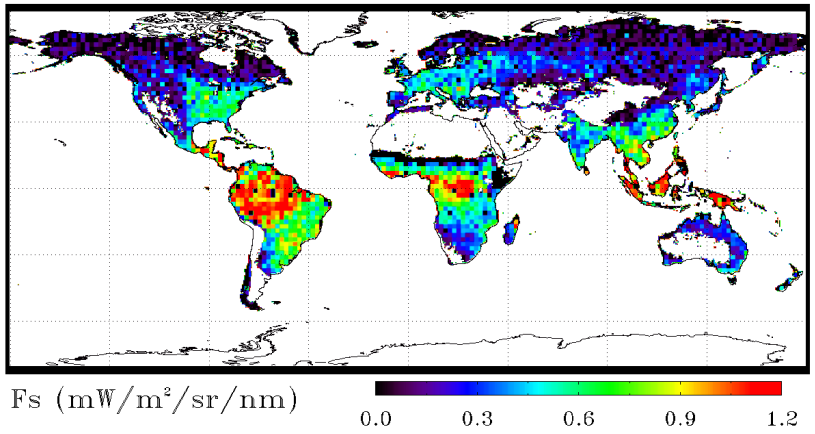
Joiner et al, AMTD, 2013

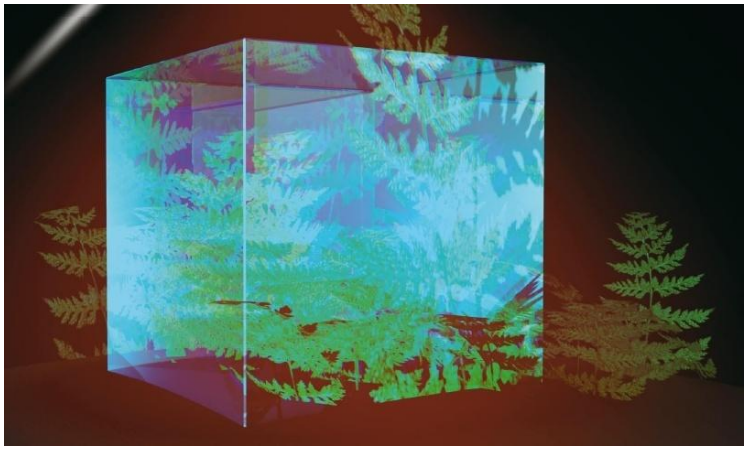




Summary

- **Sun Induced Chlorophyll Fluorescence:** a new data stream to look into the terrestrial carbon cycle from space.
- **Breakthrough #1 – 2011, global measurements of SIF** from GOSAT/FTS (low spatial coverage & temporal resolution).
- **Potential of space-based SIF to monitor vegetation functioning on a global basis is being evaluated:**
  - Better correlation to GPP than greenness-driven (FAPAR, EVI) parameters, but modeling needed to scale SIF to absolute GPP.
  - Intrinsic link to green APAR → Good indicator of phenology.
- **Breakthrough #2 – GOME-2 SIF retrievals (2007-2011),** new data set with improved spatial and temporal resolution.



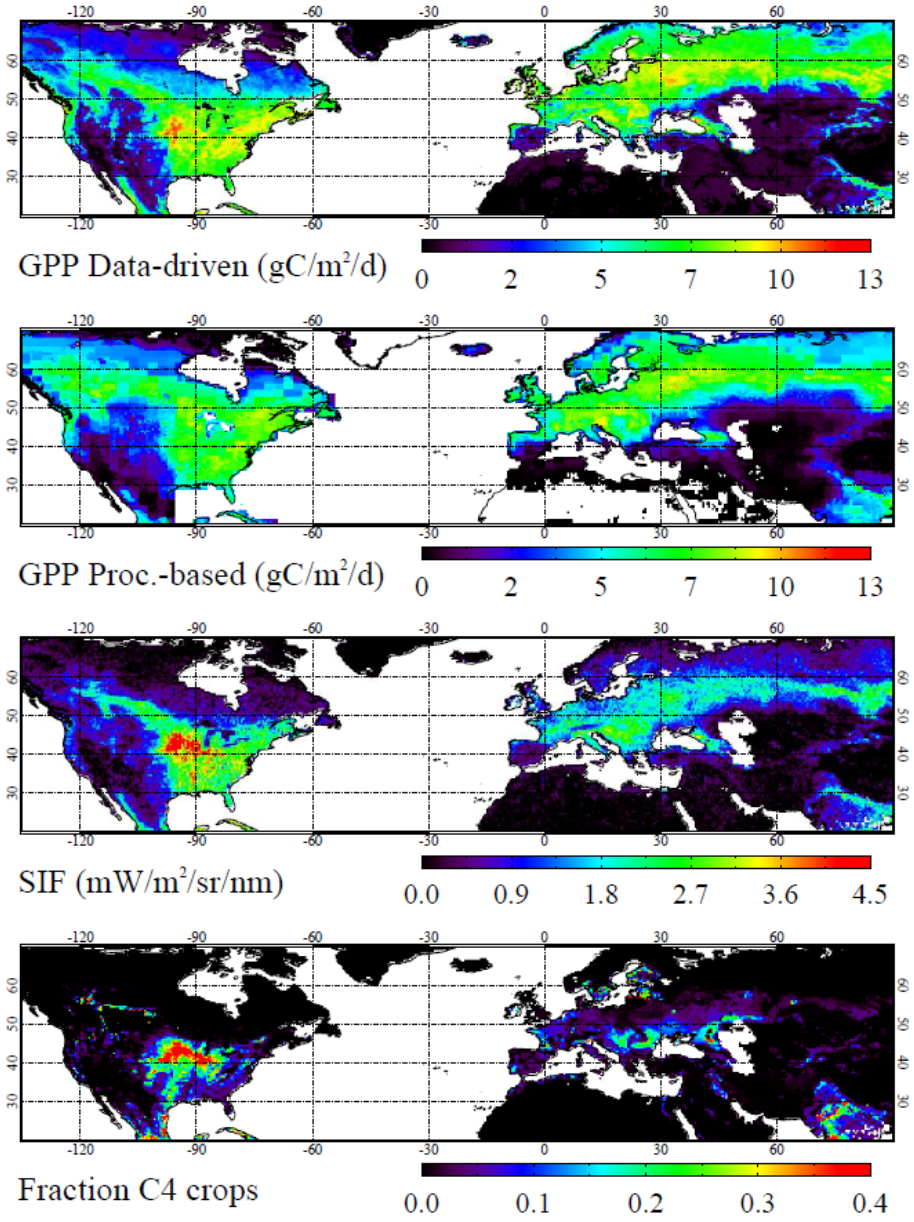


Thank you for your attention!

…and also:

- **Data: JAXA/NIES/MOE, NASA, ESA & Eumetsat**
- **Funding: German Research Foundation, Emmy Noether Programme, GlobFluo project**

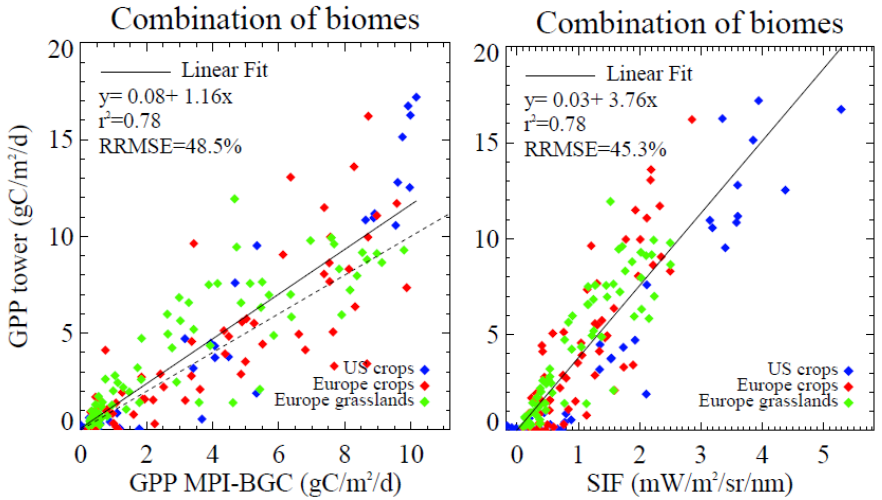
SIF to indicate crop productivity in the US Western Corn Belt



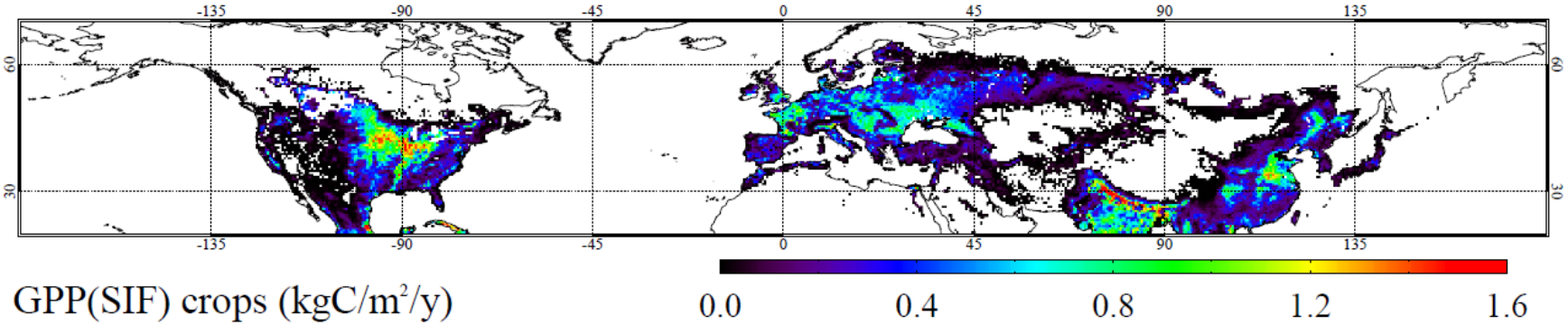
US WCB: highly productive cropland area

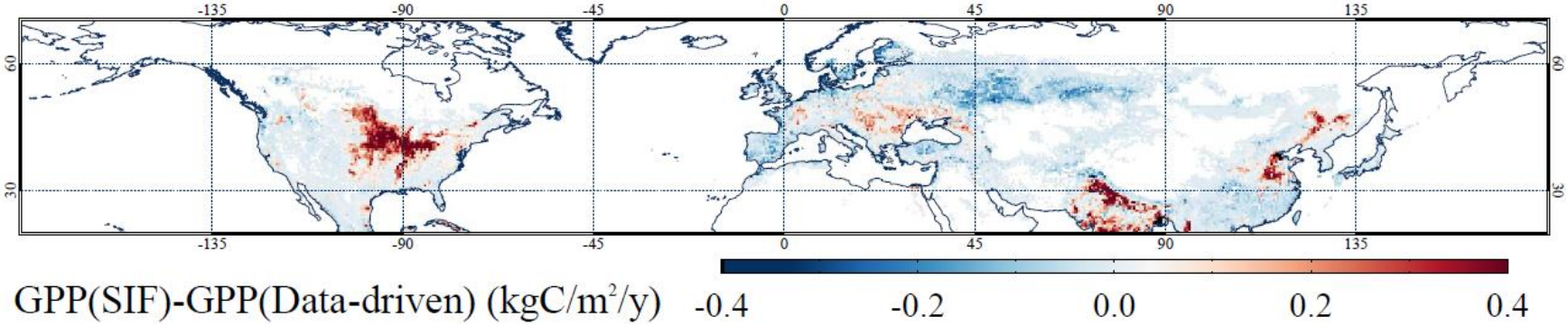
→ Not apparent in process-based and data-driven LSM ensembles (Piao et al, Beer et al)

→ SIF shows different spatial patterns at the peak of the growing season: high values at the US WCB



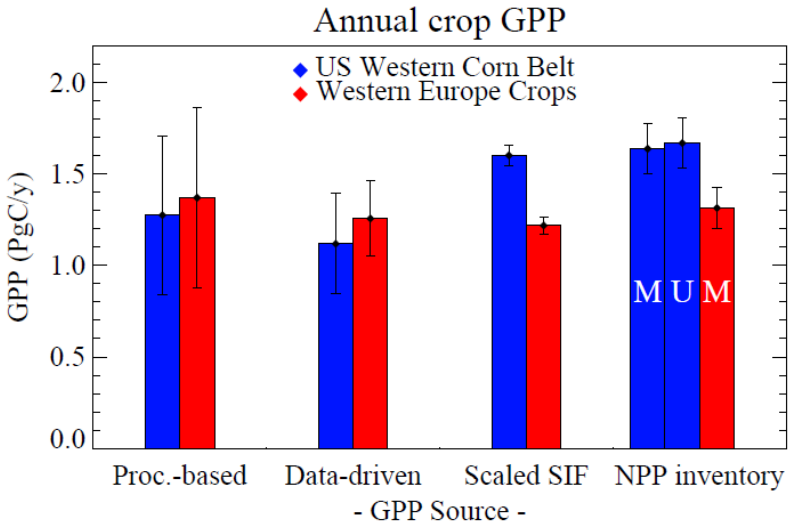
Guanter et al, in preparation





New estimates of cropland GPP based on SIF observations

Good comparison with NPP inventories (NPP/GPP=[0.55-0.65])



Guanter et al, in preparation