What other observations are needed in addition to Fs for a robust GPP estimate?

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Background

- EO Fs product (GOSAT-FTS & SCIA)

755/865nm, ~monthly, ~100 km², clear-sky, fixed overpass time…

• Do the relationships between Fs and GPP at the leaf-level hold at the synoptic/monthly scale?

• What vegetation & meteorological parameters drive the Fs signal and its link to GPP at the spatial and temporal scales of the space-based Fs?

This talk:

• Potential issues for the exploitation of space-based Fs for GPP estimation

• Key parameters needed for either Fs analysis or Fs → GPP modeling
Estimating GPP from Fs observations

I. Understanding the space-based Fs signal
Structure matters: directional effects observed in space-based Fs

- Do we need to model them to avoid noise in the Fs composites?
- If the top-of-canopy dominates the Fs signal, could this lead to a sampling error (illuminated leaves vs entire canopy)?

Joiner et al, AMT, 2012

Guanter et al, RSE, 2012
Structure matters:
Emission, scattering and absorption processes coupled within the canopy

• Signal affected by reabsorption within the canopy.

• How to go from the top-of-canopy to the leaf level in complex canopies?

• Do we have a proxy to Cab on a global scale? Greenness indices?

Van der Tol et al.
Fs from PS I: ~APAR (green), canopy chlorophyll content

Fs from PS II: ~LUE, sensitive to down-regulation

→ From which photosystem comes our GOSAT-FTS Fs in 760 nm?

Temporal sampling:

Temporal sampling from GOSAT and SCIA:

- One observation every x-days sampling several kms
- At ~13:30 (GOSAT-FTS) or ~10:30 (SCIA)
- Only for clear-skies

Temporal sampling of Fs-based GPP products? Annual? Monthly?

How to extrapolate these observations to a monthly GPP estimate?
Some examples of global GPP-Fs comparisons

Annual Average
Jun09-May10

Guanter et al, RSE, 2012
Some examples of global GPP-Fs comparisons

September-October-November

![Map showing global GPP MPI-BGC comparison](image1)

![Graph showing fit and correlation](image2)
Some examples of global GPP-Fs comparisons

June-July-August

![Map of June-July-August GPP MPI-BGC (gC/m²/d)](image)

![Map of June-July-August Fs (mW/m²/sr/nm)](image)

![Scatter plot of GPP MPI-BGC vs Fs-SVD](image)

Fit

\[ y = 1.09 + 6.40x \]

\[ r^2 = 0.62 \]
Fs-GPP per PFT
Each point is a monthly average

High linear relationship, but a different slopes in the GPP-Fs relationship for different biomes

Structure?
Biochemistry?

GPP from
M. Jung – MPI-BGC
Some examples of global GPP-Fs comparisons

Same trends for two independent GPP models forced with different inputs

Guanter et al, RSE, 2012
Fs vs [GPP, APAR, FAPAR]

- Different slopes already at the Fs-FAPAR level (nothing to do with GPP modeling)
- Generally smaller slopes for the NH
- Possible explanations:
  - Structure (Cab reabs, green vs non-photosynthetically APAR)
  - Fsyield sensitive to meteorology
Estimating GPP from Fs observations

II. Data sets and EO missions
Potential parameters to constrain GPP-Fs models

**Vegetation**
- EVI/NDVI, FAPAR/LAI (MODIS)
- FAPAR, MTCI (MERIS)
- “Structure”: BRDF parameters (MODIS/MISR)
- “Structure”: Canopy height, JPL (Simard) ICESat/GLAS
- PRI: MODIS? SCIA?
- EO-driven GPP (MODIS, MPI)
- GPP from biosphere models?

**Meteorology**
- Temperature (daytime, nighttime, daily minimum…)
- Relative humidity (vapor pressure deficit)
- Illumination (PAR, Swflux, sunrise/sunset)
- Soil moisture (SMOS?)
- Soil water availability (MPI)

**Atmosphere**
- XCO2
- Tropospheric O3??

**PFTs**: IGBP (MODIS), Synmap (MPI)

*Question: how good are these parameters for GPP modeling? Spatial resolution/co-location issues?*
Towards self-consistent Fs\(\rightarrow\)GPP modeling: ESA’s FLEX mission

FLEX’s target parameters:

1. Photosynthesis rates from chlorophyll fluorescence
2. Gross primary production (GPP) from photosynthesis rates and complementary information (data assimilation)

The FLEX concept \(\rightarrow\) consistent observation of chlorophyll fluorescence and other key parameters to model GPP

1. Photochemistry: Fluorescence and PRI
2. Greenness, biomass: reflectance-based indices (fAPAR, LAI, Cab…)
3. Meteorological forcing: PAR, surface temperature and water vapour
FLEX/FLORIS instrument requirements

- **Broad Mission configuration**: FLORIS in tandem with S-3
  - ~815 km altitude
  - Local solar time: 10:00 LTDN
  - Temporal co-registration with S-3 < 6s

- **Mission Duration**
  - At least 3 full vegetation cycles
  - Target of 5 years

- **Spectral range** 520 nm to 800 nm

- **Spectral resolution** between 0.1 and 0.3 nm in core spectral range (Oxygen bands and red-edge)

- **Ground resolution** 300 m (500 m to enhance SNR)

- **Swath width** > 120 km – goal 150 km

- High imaging and spectral performance requirements
Ancillary parameters from GOSAT

- GOSAT FTS & CAI, able to provide useful parameters in addition to Fs to constrain GPP
  - Brightness temperature
  - Total column water vapor $\rightarrow$ Vapor pressure deficit
  - $\sim$ MODIS’ NDWI: canopy water content
  - (CAI) High spatial resolution NDVI $\rightarrow$ fAPAR

- Under-utilized so far? Is this interesting for a satellite-based GPP estimation? Should we bother to get those too?
- $\sim$ VPD, NDWI also for OCO-2, A-train could complete the others