Challenges in retrieving and using space-based fluorescence information

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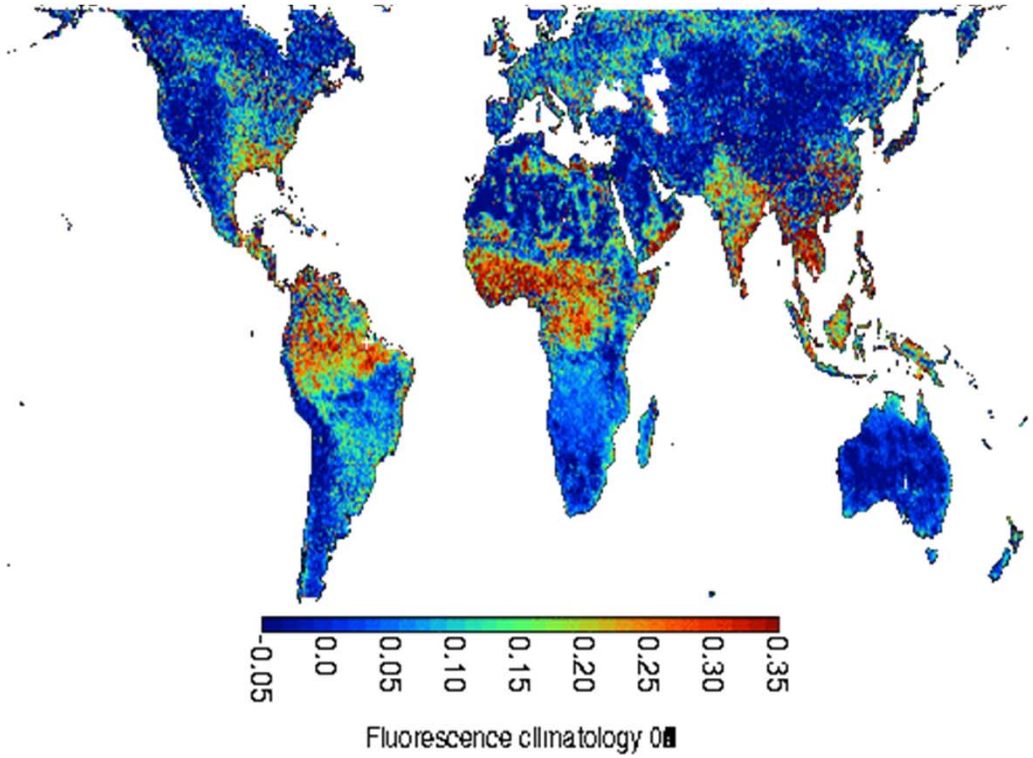
KISS workshop, summer 2012



SCIAMACHY climatology

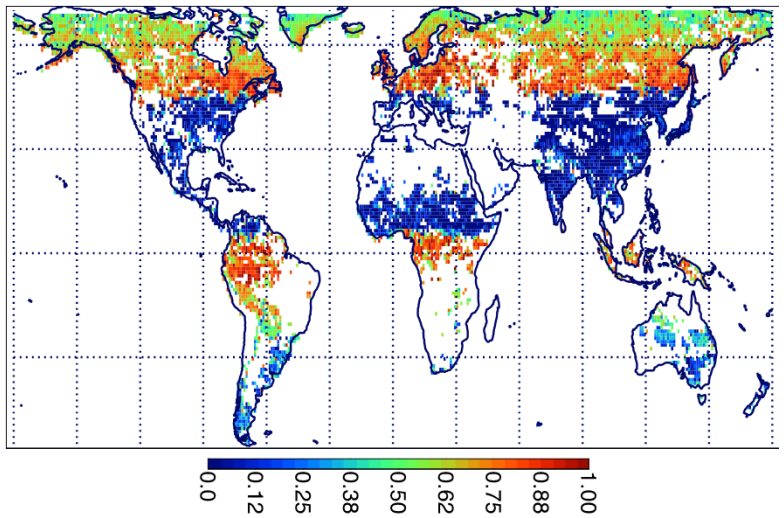
Other factors that can fill in solar lines

- Instrumental artifacts
- Rotational Raman scattering
- Fluorescence from rock, soil, other compounds in vegetation besides chlorophyll, and other biological material, e.g., fluorite with impurities
- Thermal emission from high heat sources (>650K) such as fires and volcanoes - unlikely to cover large fraction of larger satellite footprints like GOSAT and SCIAMACHY, but an issue for FLEX.

Latter 2 effects should be separable from fluorescence if large fitting window is used.

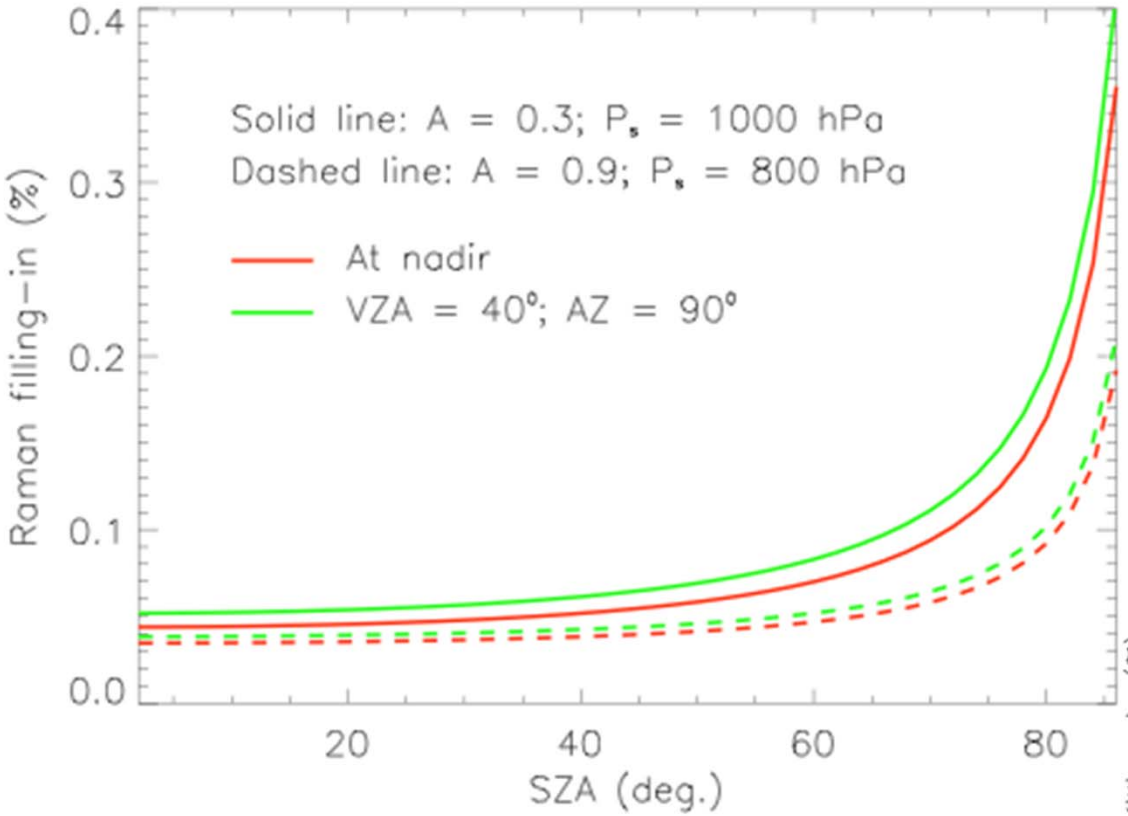
Factors affecting filling-in of Fraunhofer lines in satellite spectra

- SCIAMACHY
  - Memory effect (signal level of previous readout has measurable effect on current readout). Produces “coastline effect”.
  - Dark current
  - General non-linearity; effects of different detector integration times.
  - Abrupt and slowly varying gain (non-linearity) changes
  - Stray light (spectral and spatial)
- GOSAT
  - Non-linearity in filter and other components leads to zero-level offset; varies in time and signal level
  - Saturation
- BOTH
  - Wavelength shifts and dispersion
  - Absolute calibration



SCIA bright (cloudy) scenes

Rotational-Raman (inelastic) scattering (Ring effect) from N_2 and O_2 (see Kattawar et al., 1981)



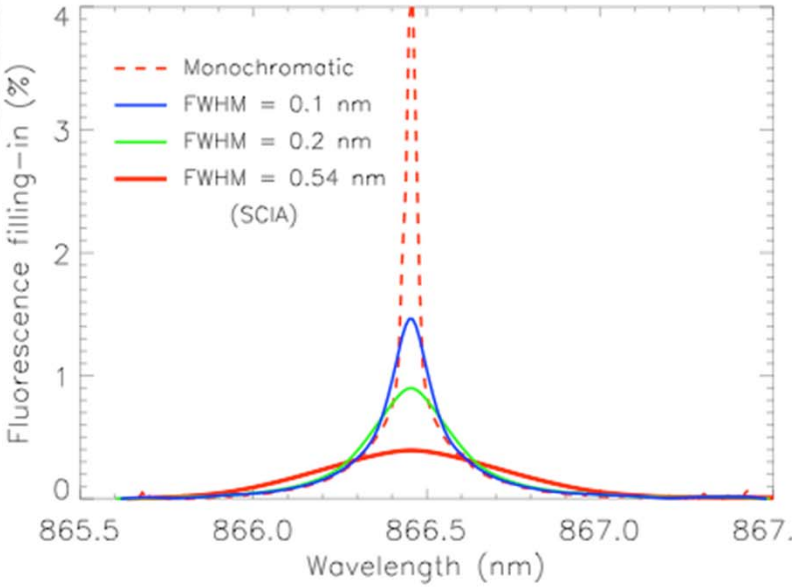
From Joiner et al. (2012)

Increases with decreasing wavelength, more of a factor for Fraunhofer lines shortward of the 680 nm fluorescence peak and O2 B band

•Dependence on (cloud) pressure, surface albedo, sun-satellite viewing geometry;

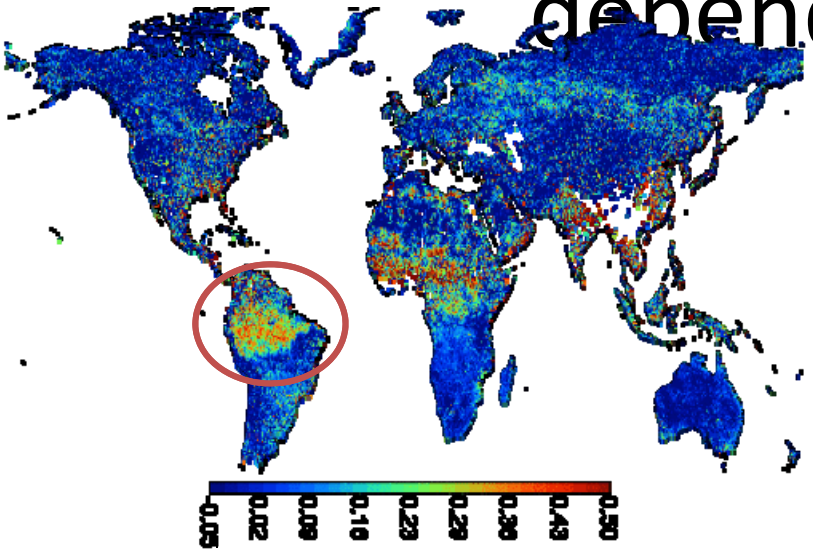
•Also a factor for ground-based measurements. Ideally "reference" should have same direct to diffuse ratio.

Similar spectral dependence (line filling) as fluorescence

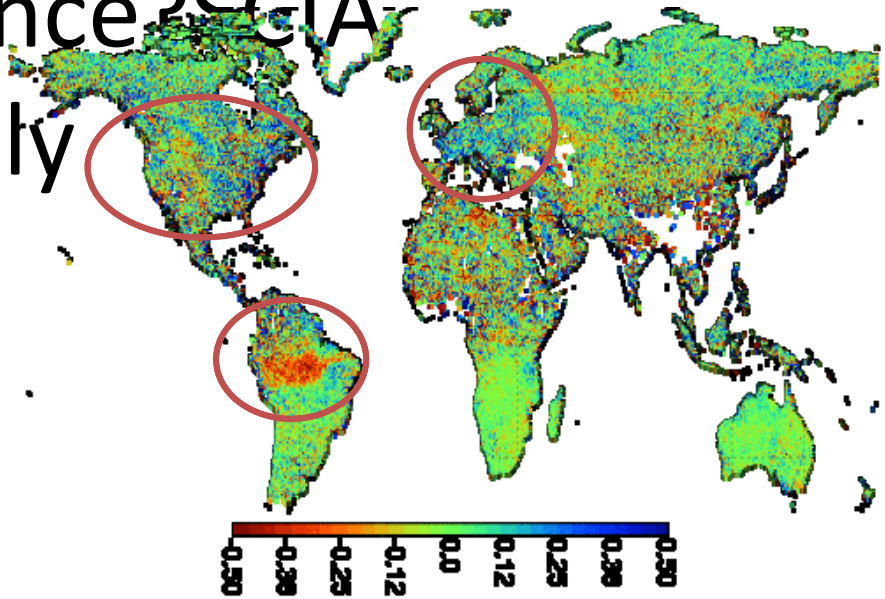


Does F have an angular dependence? SCIA-July

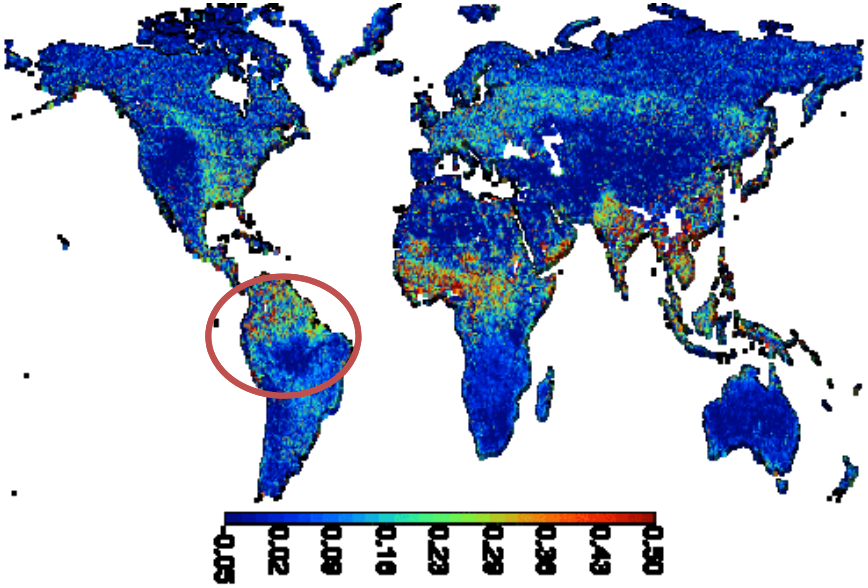
F Backscatter ('hot spot') direction



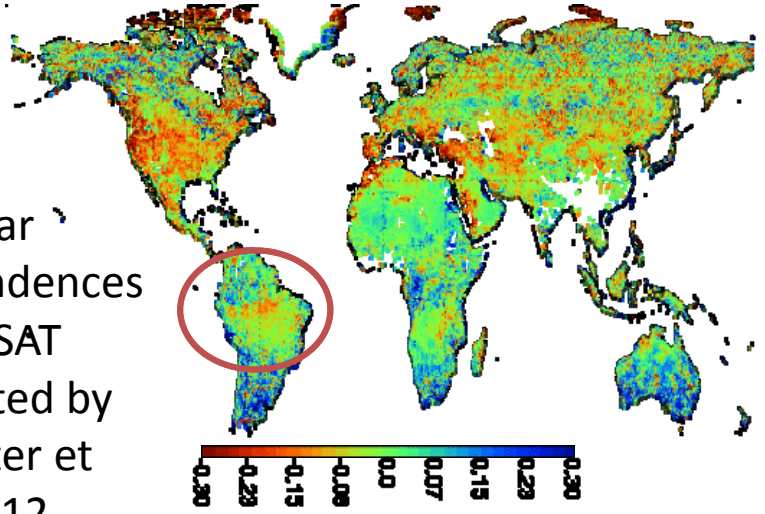
F Difference (Back – forward scatter)



F Forward-scatter ('cold spot') direction



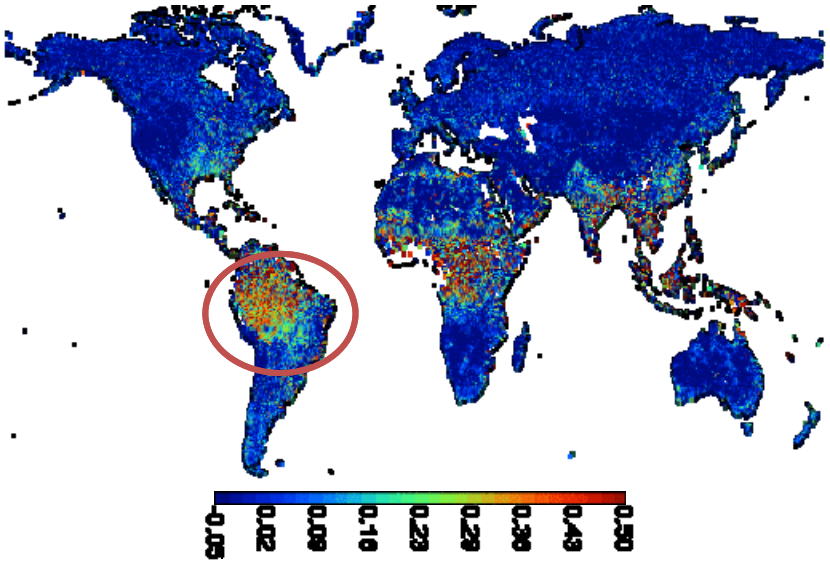
Radiance Diff. (Back – forward scatter)



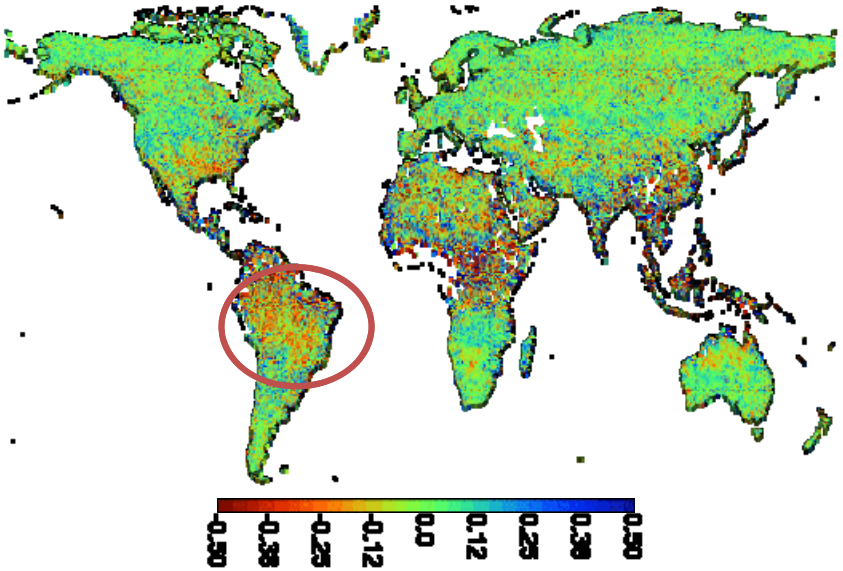
Angular dependences in GOSAT reported by Guanter et al., 2012

September

F Backscatter (‘hot spot’) direction



F Difference (Back – forward scatter)



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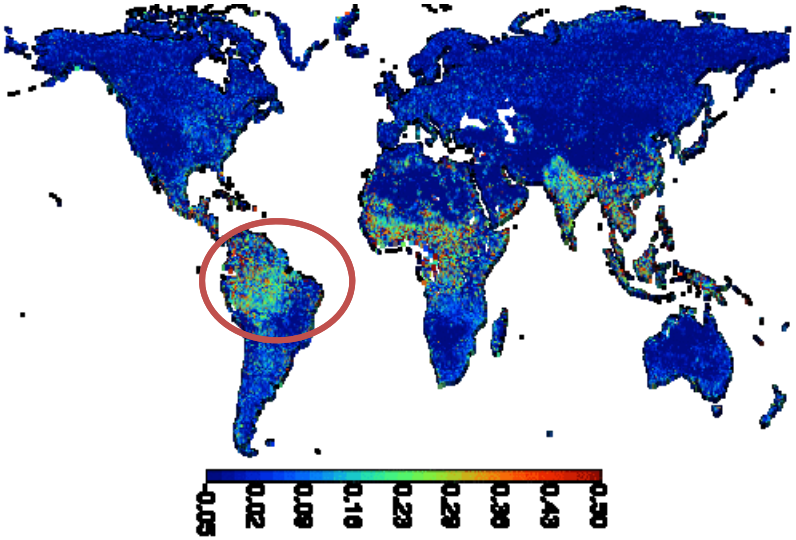

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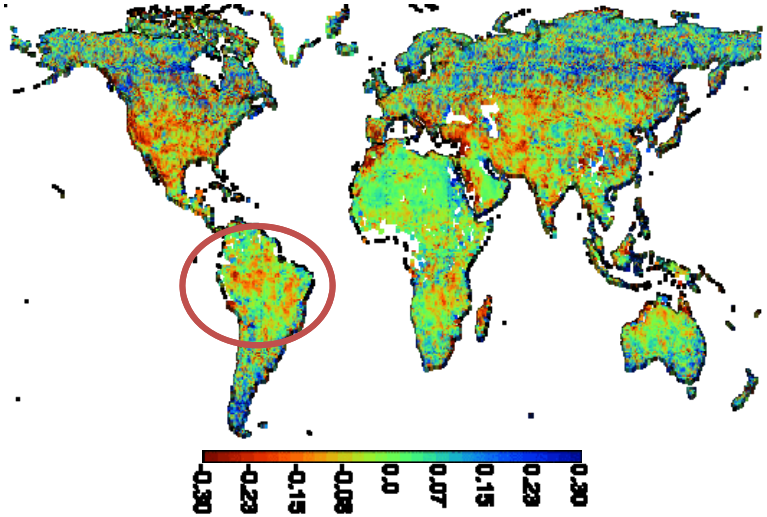

Discussion points: some covered later

- Ground-based:
  - Use of spectrometers in flux towers –challenges from retrieval point of view
  - Automatic measurements: Higher resolution and Fraunhofer lines?
  - Instrument trade-offs: spectral resolution vs spectral range

- Satellite-based
  - Encouraging early results. Fluorescence appears to show information that is independent of reflectance-based data (e.g., FPAR).
  - How do we address validation?
  - Time of day – is there an optimal eq. crossing time for a LEO satellite? What can be learned from satellites in other orbits (GEO or low inclination e.g., space station)?
  - Tradeoffs – spectral vs spatial resolution
  - Need to be careful about variations in illumination and viewing conditions
  - Looking forward to more satellite measurements, particularly with higher SNR (e.g., OCO-2) as current measurements are noisy

- Both
  - Some remaining retrieval issues to deal with, e.g., rotational-Raman scattering