Using solar-induced fluorescence to constrain model GPP

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GPP = PAR \cdot FPAR \cdot \varepsilon_p
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SIF = PAR \cdot FPAR \cdot \varepsilon_f
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GPP = SIF \cdot \frac{\varepsilon_p}{\varepsilon_f}
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- Observed at 757nm and 771 nm
- \(E_p\) is a function of temperature and moisture stress. The satellite-retrieved SIF can identify periods of such stress, and show instantaneous response whereas NDVI and LAI are more integrated responses.

Drought-induced reduction in SIF when no concurrent decline in LAI or NDVI observed.

Using solar-induced fluorescence to constrain model GPP

- GPP is highly correlated with SIF (as it should be – both are a function of radiation)
- How do we do on the biome level?
- Okay for temperate and tropical grasslands.
- Boreal forests and Mediterranean shrub not great.
- Tundra is very bad (often too productive)
Application: 2010 Amazon drought

Drought sensitivity of Amazonian carbon balance revealed by atmospheric measurements

Observed total flux to atmosphere was positive during JAS-OND 2010.

TRENDY models incorrectly simulated a C sink in JAS, and incorrect in the NW and NE regions in OND.
the unburned Amazonian vegetation to being a sink in 2011 seems to have been driven primarily by precipitation, which changed from a negative anomaly in 2010 to a positive anomaly in 2011 (Extended Data Fig. 1a, b). However, temperatures were higher than average for both years, reflecting a net warming trend in recent decades (Extended Data Fig. 1c, d).

A more detailed picture of the Amazonian carbon cycle response to climate is revealed by the quarterly fluxes and by focusing first on RBA, TAB and ALF. For both years, during the first quarter of the year (the start of the wet season), measurements indicate a net carbon sink, and during the second and drier half of the year, measurements indicate a net source (Fig. 4a). However, during the second quarter of 2010 (in TAB 2010), RBA 2010, ALF 2010, SAN 2010

- TRENDY models: fFire+fLuc too weak in NW in JAS 2010.
- The source in OND is due to overly strong fFire+fLuc.
Natural fluxes were a C sink in JAS, C source in OND except for NE.

TRENDY models capture the JAS sink but it is too strong.

Do not capture the OND source in NE and SE.
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Figure 3 | Surface flux signals in vertical profiles. a–d, Mean difference between CO$_2$ profiles measured in 2010 at the four Amazonian aircraft sampling sites and oceanic CO$_2$ background (that is, DCO$_2$) during the dry (red lines) and wet (blue lines) seasons, respectively (solid lines) and the standard deviation divided by the square root of number of profiles (dashed lines). The background is estimated from in situ SF$_6$ and CO$_2$ at the NOAA/ESRL monitoring stations ASC and RPB, as described in the main text. e–h, As for a–d, but for CO. p.p.t., parts per trillion. The dry season (red lines) is affected by fires at most sites and is here defined as July–October for illustrative purposes only; it does not correspond to all months with fire emissions (see Methods).

• How does JULES compare with the other TRENDY models?
  
• The LUC flux is miniscule and no firs, so NBP = NBP_natural

• Uptake is too strong in JAS (similar to the other models).

• C source in OND better simulated in JULES.
The new PFTs:

- Give JULES the ability to represent more biomes.
- 9 is not a hard-wired number so experiments can be done with more or less.
- More closely match observed physiology.
- Evaluation against multiple datasets enables us to pinpoint regions most in need of further development.
- None of these runs used tuned parameters – so we know we can do better.
- In common with other DGVMs, JULES underestimated the GPP sensitivity to the 2010 Amazon drought, but captured some lag effects on overall biome C flux.