Small global effect on terrestrial net primary production due to increased fossil fuel aerosol emissions from East Asia during the last decade

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1) Motivation

- Fossil fuel (FF) carbon emissions have sharply increased since the turn of the century but surprisingly global atmospheric CO_2 growth rates were relatively constant during this period (Ballantyne et al., 2012).
- Coincident trends in land use carbon emissions and the ocean sink appear insufficient to explain this observation, implying that terrestrial carbon sinks must have substantially increased in this period (Sarmiento et al., 2010; Fig. 1).
- In this study, we test whether increases in FF aerosols and changes in diffuse radiation have led to more efficient plant carbon uptake which would causally link the recent trends in FF emissions and land carbon sink.

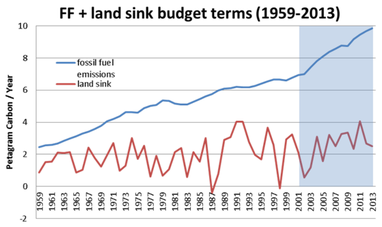

Fig 1 – Temporal change in FF carbon emissions and land carbon sink. Data are from the Global Carbon budget from Le Quere et al. (2014)

2) Methodology

- **Aerosol** distribution is simulated using GLOMAP (Mann et al., 2010) over the study period 1998-2010.
- Impact of aerosols on light regimes (**diffuse radiation**) is simulated using a radiative transfer model (Edwards and Slingo, 1996).
- Effects on **net primary productivity (NPP)** is simulated using the JULES land-surface model (Best et al., 2011).
- Factorial analysis is used to **isolate** the impact of various **drivers** on plant carbon uptake.

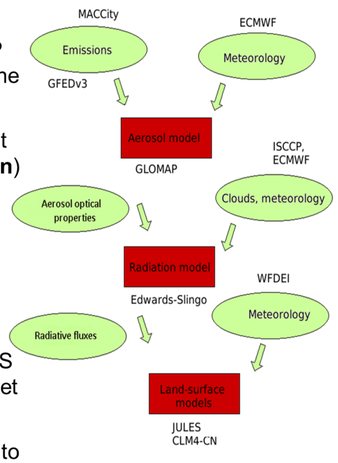

Fig 2 – Schematic of modelling approach

3) Results

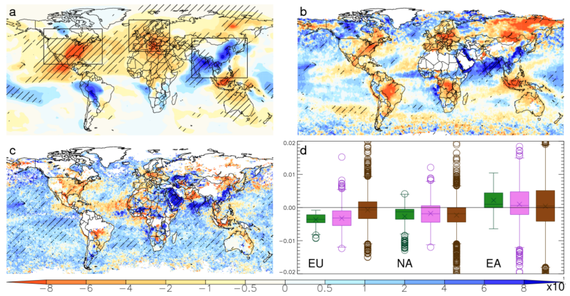

Fig 3 – Comparison between (**a**) modelled and (**b,c**) satellite annual mean **AOD trends** (/yr) for 2001-2010. Panel (**d**) depicts linear trends for three focus regions, Europe (EU), North America (NA), and East Asia (EA) based on GLOMAP (green), MODIS (violet), and SeaWiFS (brown). Focus regions are outlined in (**a**).

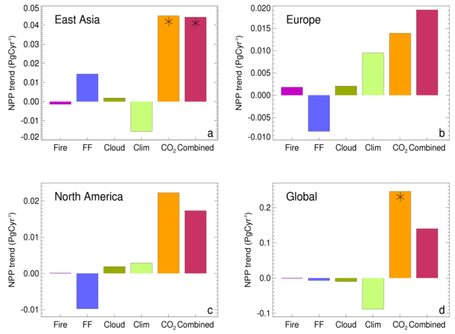

Fig 5 – Global and regional contribution from each driver considered on trends in NPP over the study period 1998-2010.

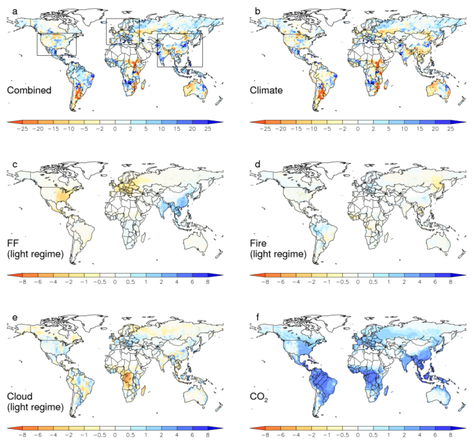

Fig 4 – Contribution of various drivers to the trend in NPP ($gC/m^2/y^2$) over 1998-2010. Panel (**a**) depicts the combined effect of all drivers considered on trends in NPP. Panel (**b**) shows the surface climate influence on NPP trends. In (**c**), (**d**), and (**e**) changes in NPP due to changes in the fraction of diffuse radiation from each driver, fire emissions, fossil fuel emissions, and changes in cloud cover respectively, are shown. Panell (**f**) shows the impact of increased atmospheric CO_2 concentrations on carbon uptake. Stippling indicates significant trends ($P<0.05$).

4) Key points

- Modelled aerosol trends show good agreement with observations, especially in areas where fossil fuel emissions dominate the AOD trends (Fig3).
- Increases in NPP due to increased diffusivity (from FF aerosols) in East Asia are offset by reductions in diffuse radiation and NPP across Europe and North America (Fig 4c), leading to a small global effect (Fig. 5).
- This suggests that if the recent increase in the land carbon sink would be causally linked to fossil fuel emissions it is unlikely via the effect of aerosols but due to other factors such as nitrogen deposition or nitrogen-carbon interactions.

5) Future work

- Quantifying net ecosystem productivity by estimating respiration fluxes to identify the regional distribution of carbon sinks/sources along with the driving processes and mechanisms.
- Quantifying the beneficial/limiting effect of nitrogen on plant productivity with the use of GLOMAP-N and CLM4-CN.
- Extend period of study to evaluate the long-term trends in carbon fluxes to shed more light on the long-term drivers of the terrestrial carbon sinks.
- Finally, extensive model evaluation with the use of observed radiation and carbon fluxes (e.g. FLUXNET).

References

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