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Fire air pollution reduces global terrestrial productivity

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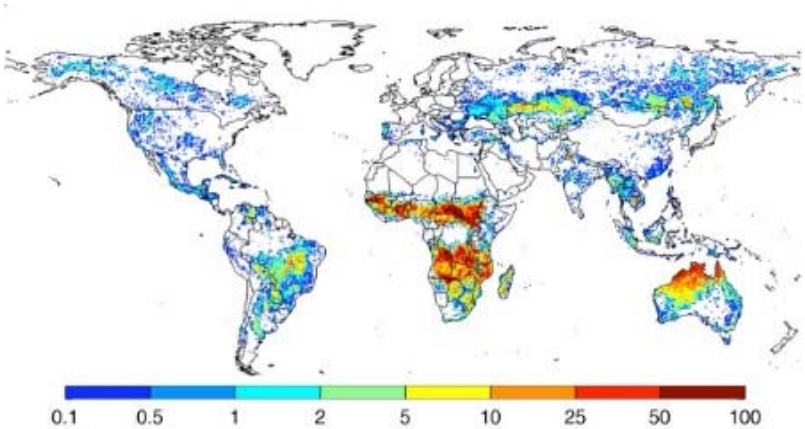
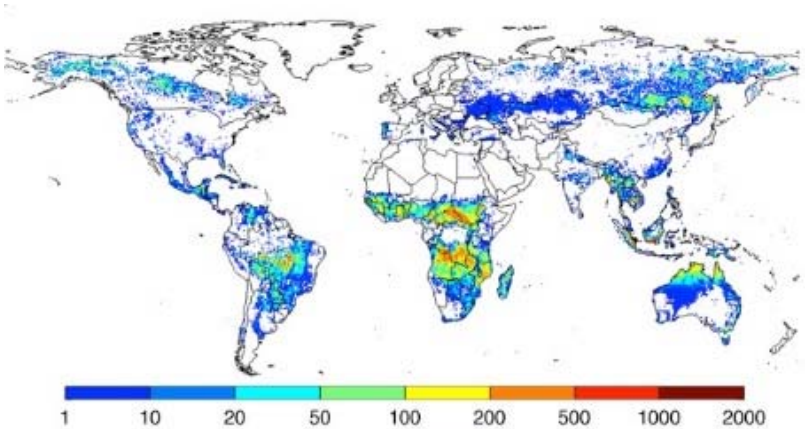
IGC9 meeting, Boston, May 7th, 2019

Fire is an important perturbation to global carbon budget

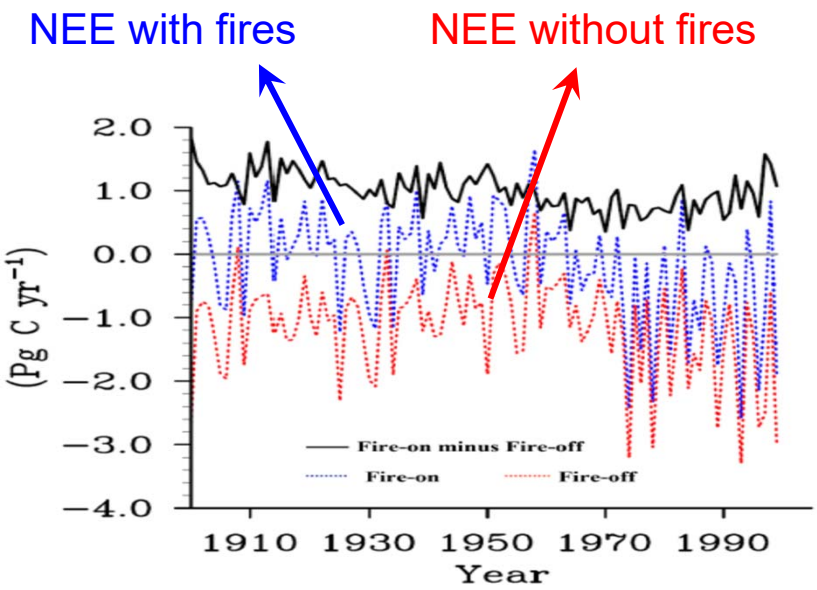
Global area burned



Global fire emissions



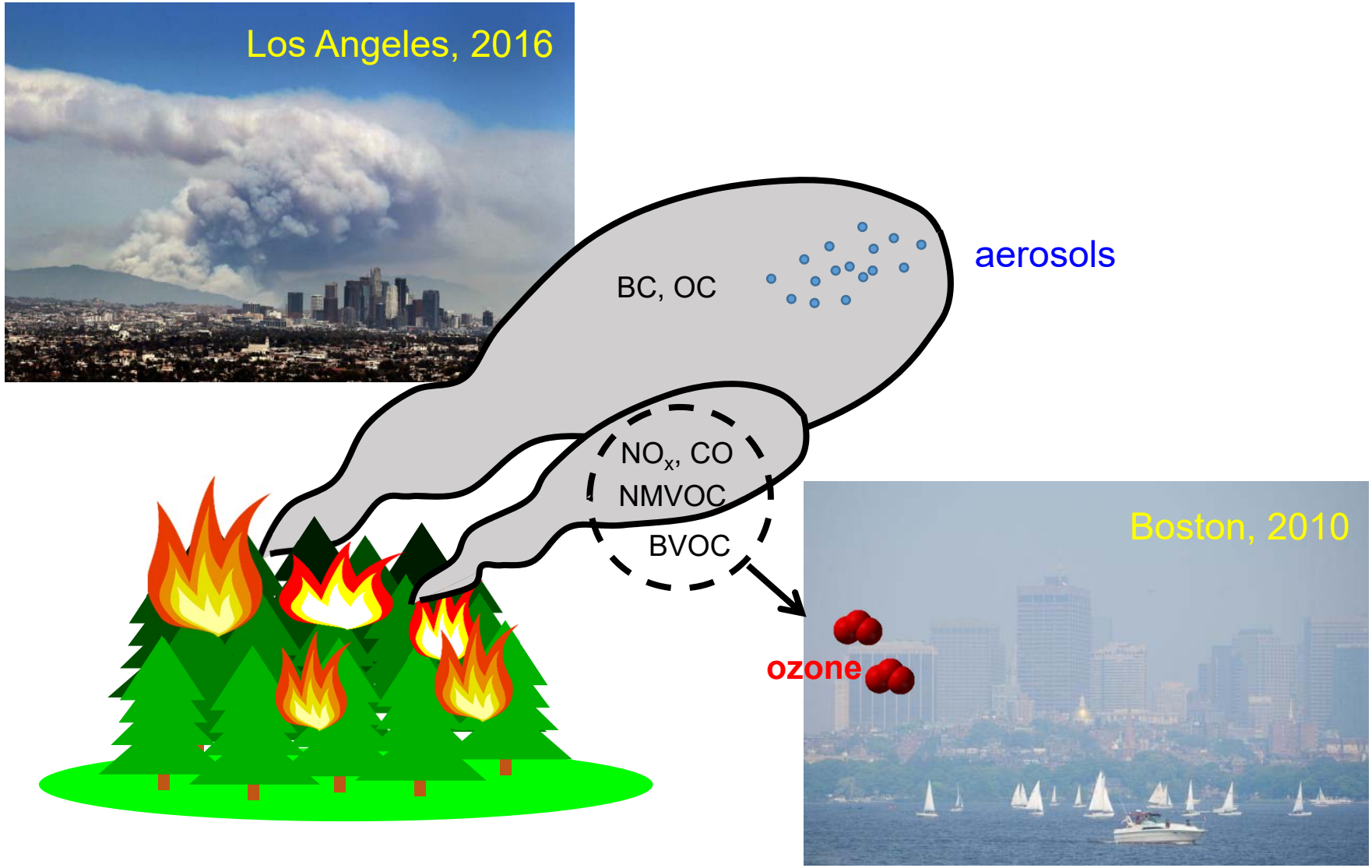
(Data source: Global Fire Emissions Database, version 3)



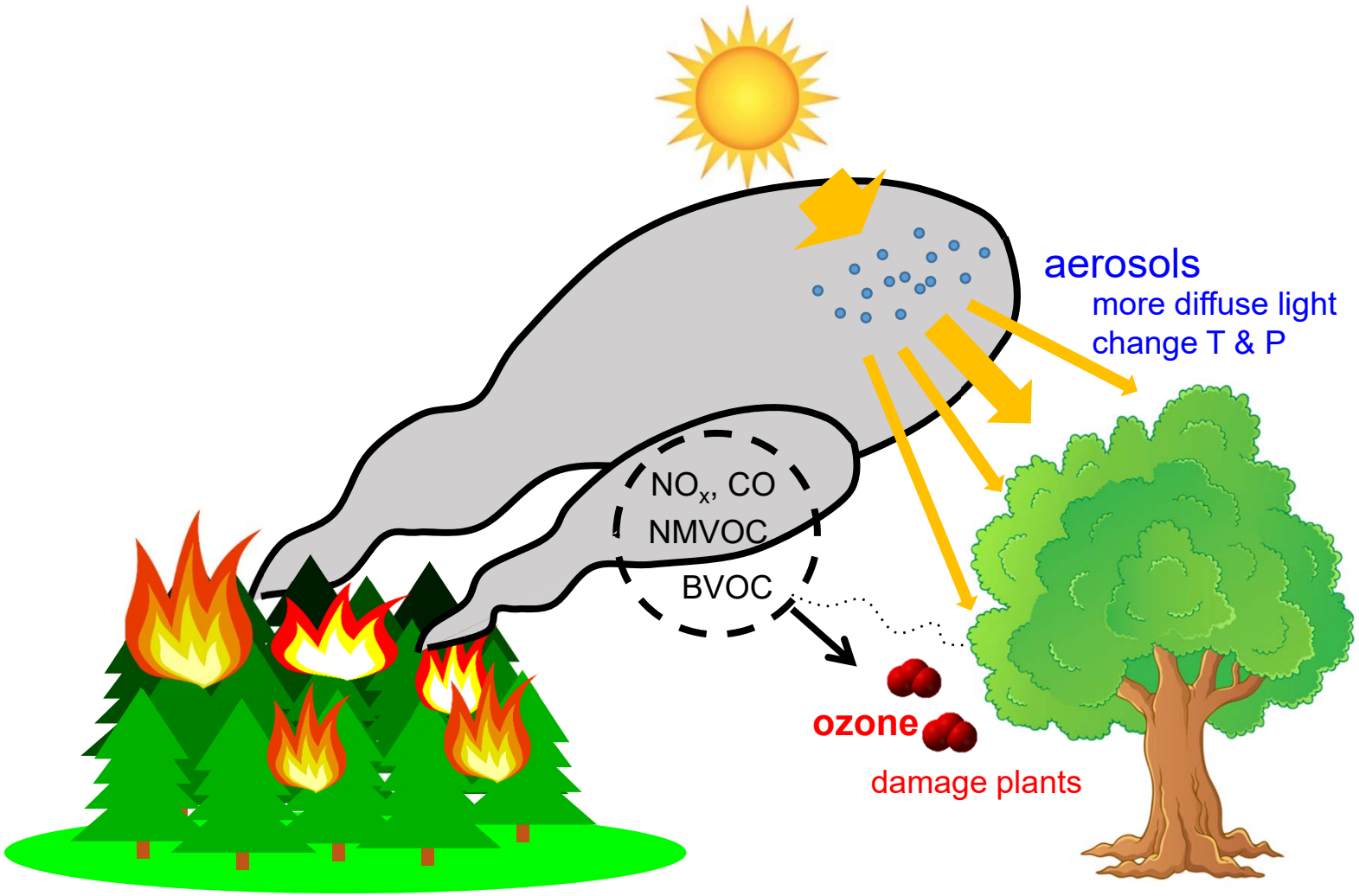
- Globally, fire emits about 2 Pg C every year.
- Land carbon uptake is weakened by fire emissions

(Li et al. 2014)

Fires generate air pollution

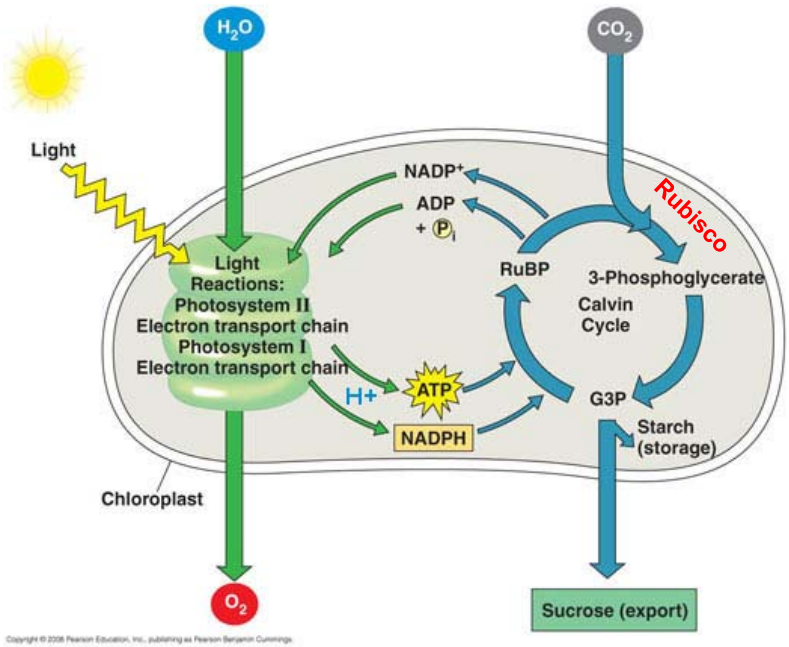


Fires influence ecosystem productivity indirectly



(Yue & Unger, *NCOMMS*, 2018)

How ozone affects photosynthesis?



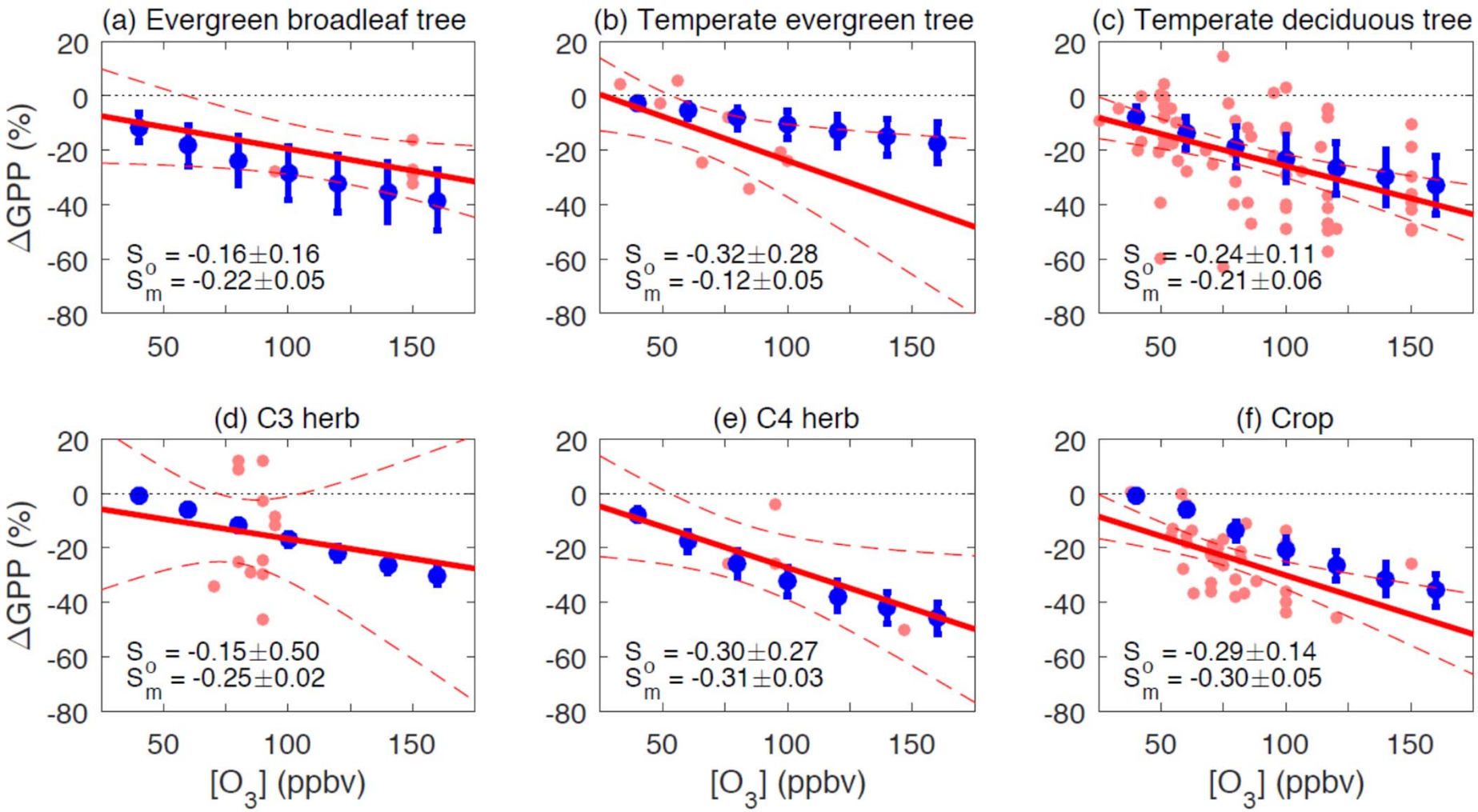
Stoma on apple leaves

Stoma on potato leaves

- Uptake of ozone through stoma damages both photosynthesis and stomatal conductance
- We use Sitch et al. (2007) scheme to quantify such damages on global scale

YIBs evaluation: GPP responses to O_3 damage

Hundreds of data are collected from >60 literature papers

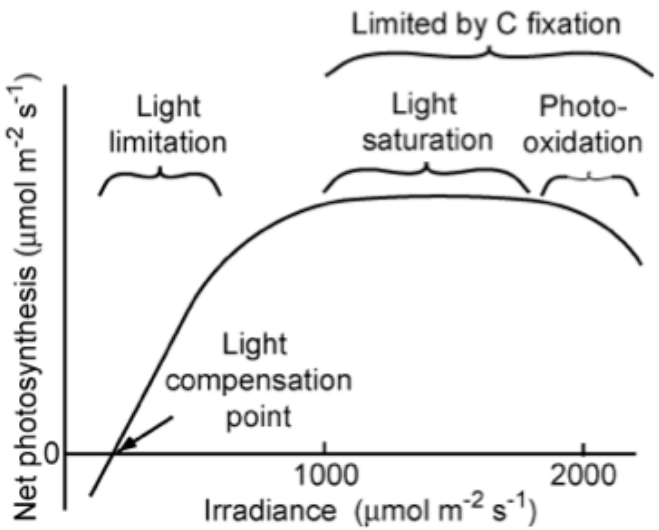


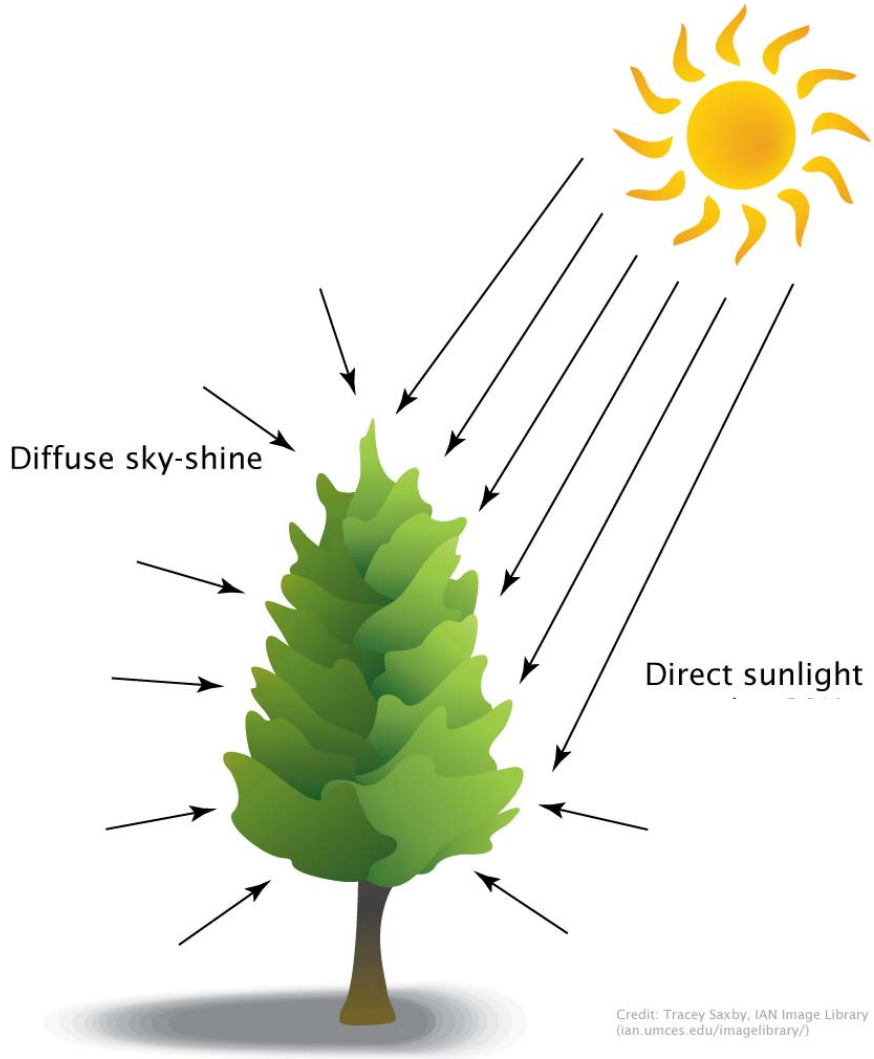
Blue: Model

Red: Measurements

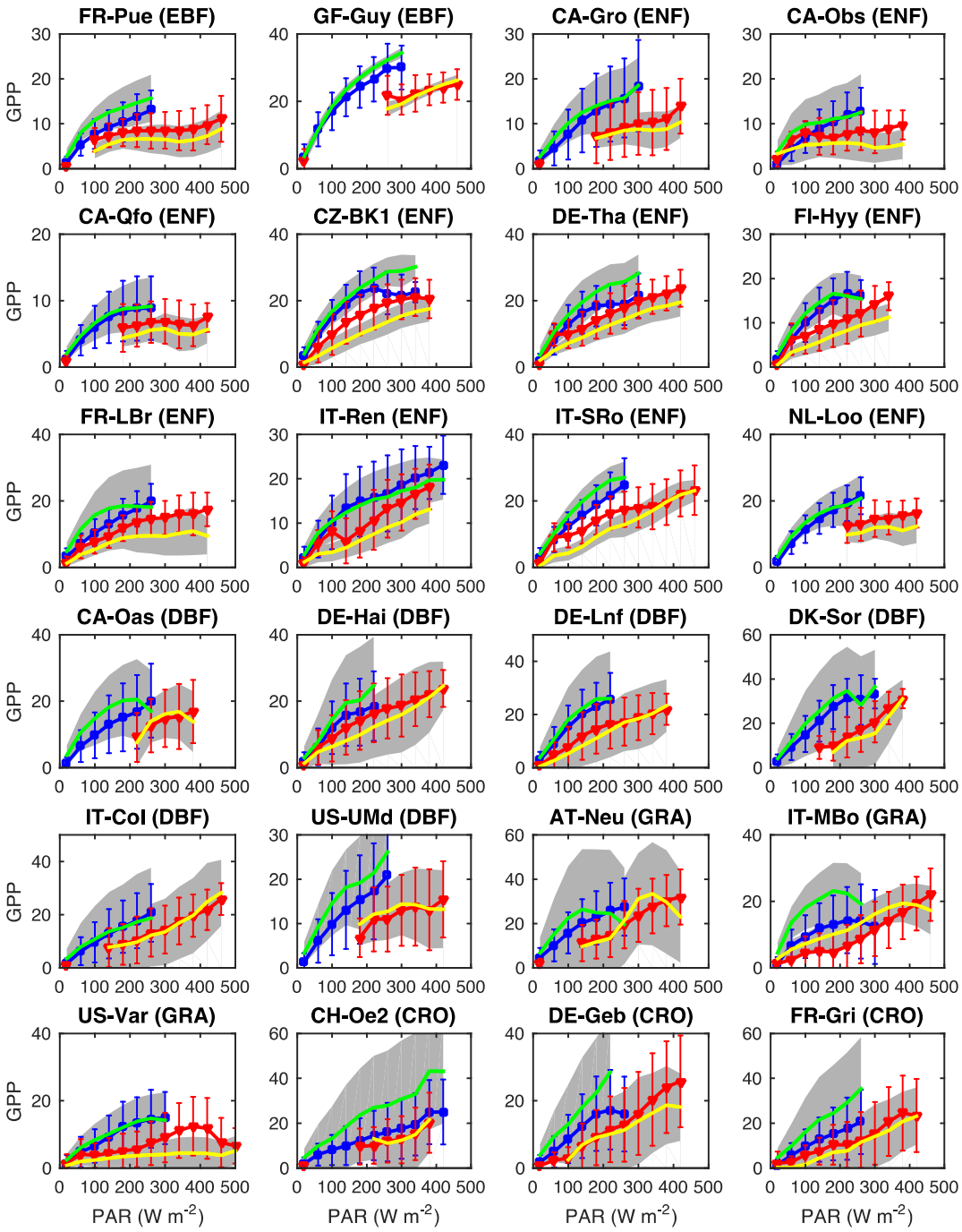
(Yue & Unger, *NCOMMS*, 2018)

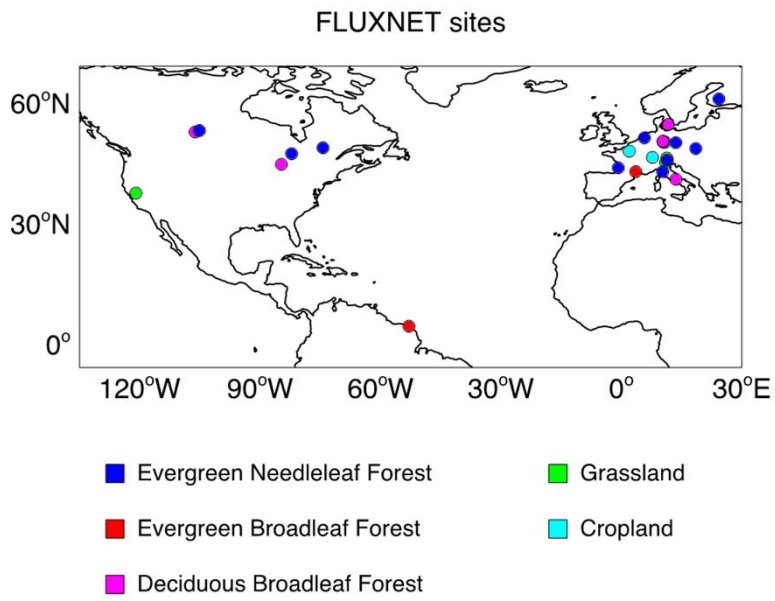
How aerosols affect photosynthesis?



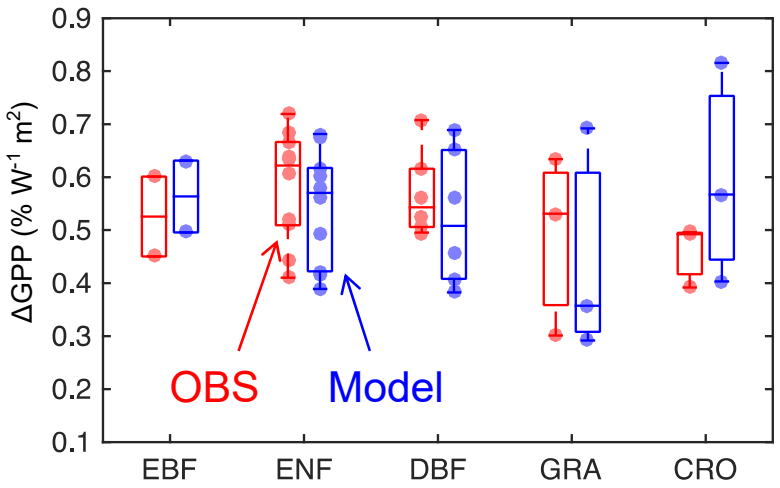


- Moderate reduction of direct light won't decrease photosynthesis
- Aerosol increases diffuse light, promoting photosynthesis for sunshade leaves



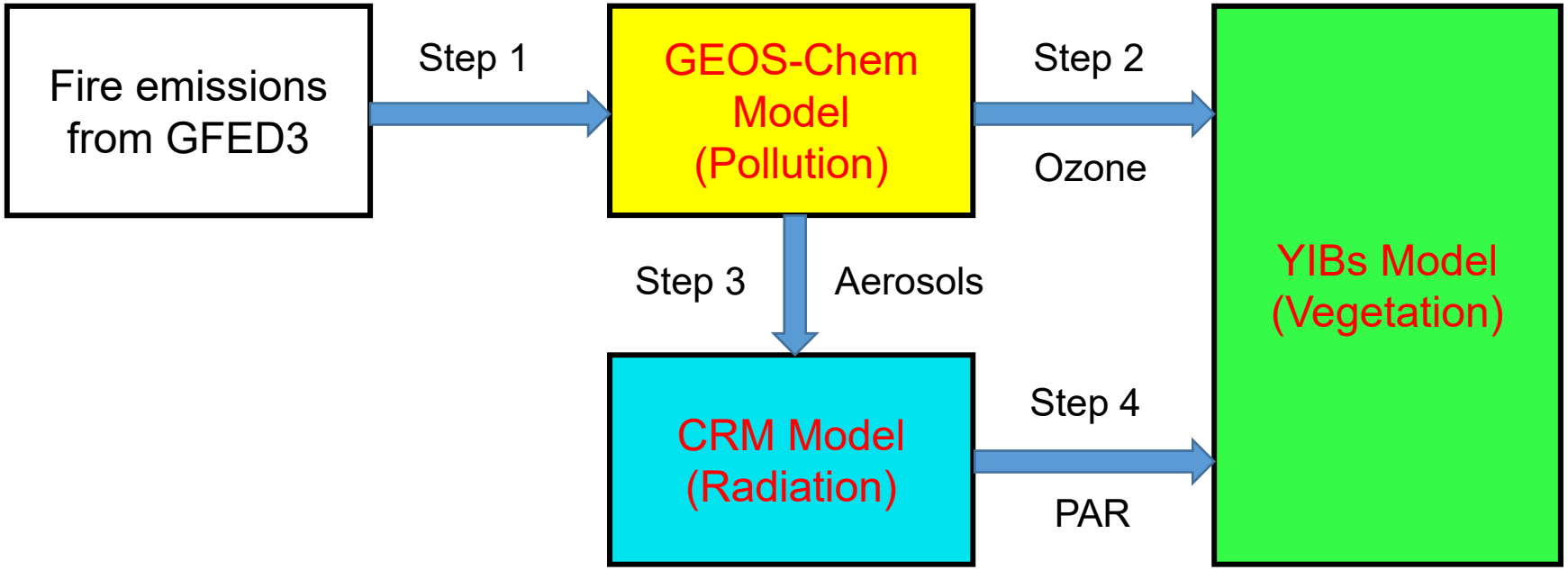


Diffuse fertilization effect



(Yue & Unger, *NCOMMS*, 2018)

Methods and models



Step 1: Simulate fire-induced aerosols and ozone using GEOS-Chem Model

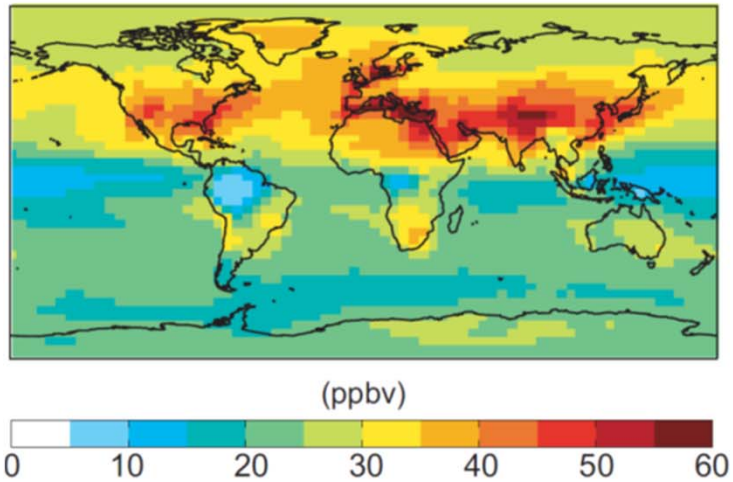
Step 2: Simulate ozone damaging to GPP using YIBs model

Step 3: Simulate aerosol-induced PAR radiation change using CRM model

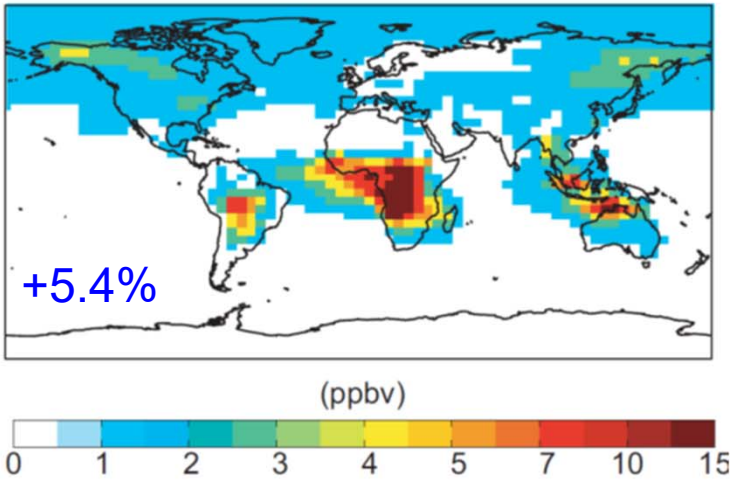
Step 4: Simulate GPP responses to PAR change using YIBs model

Model results: Ozone effects on GPP

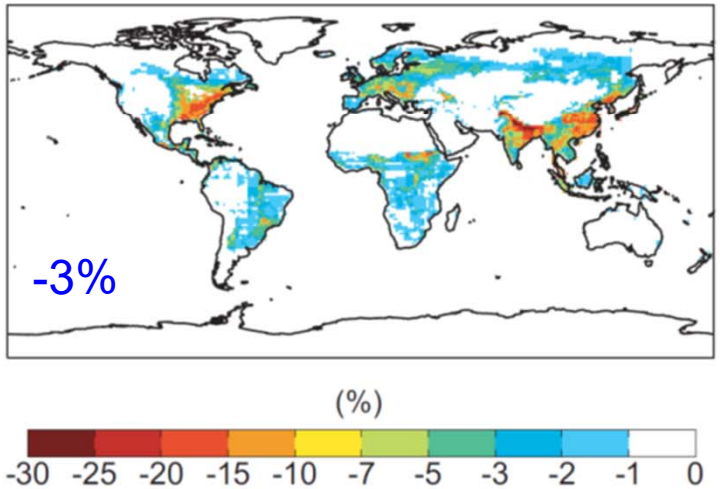
Non-fire O_3



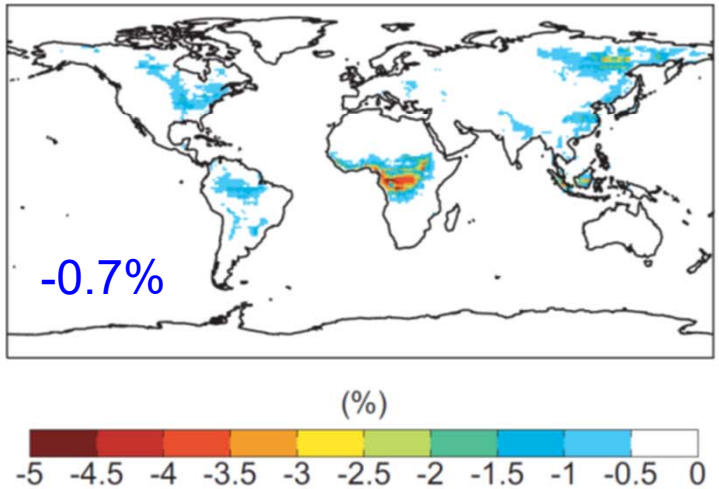
Fire-induced ΔO_3



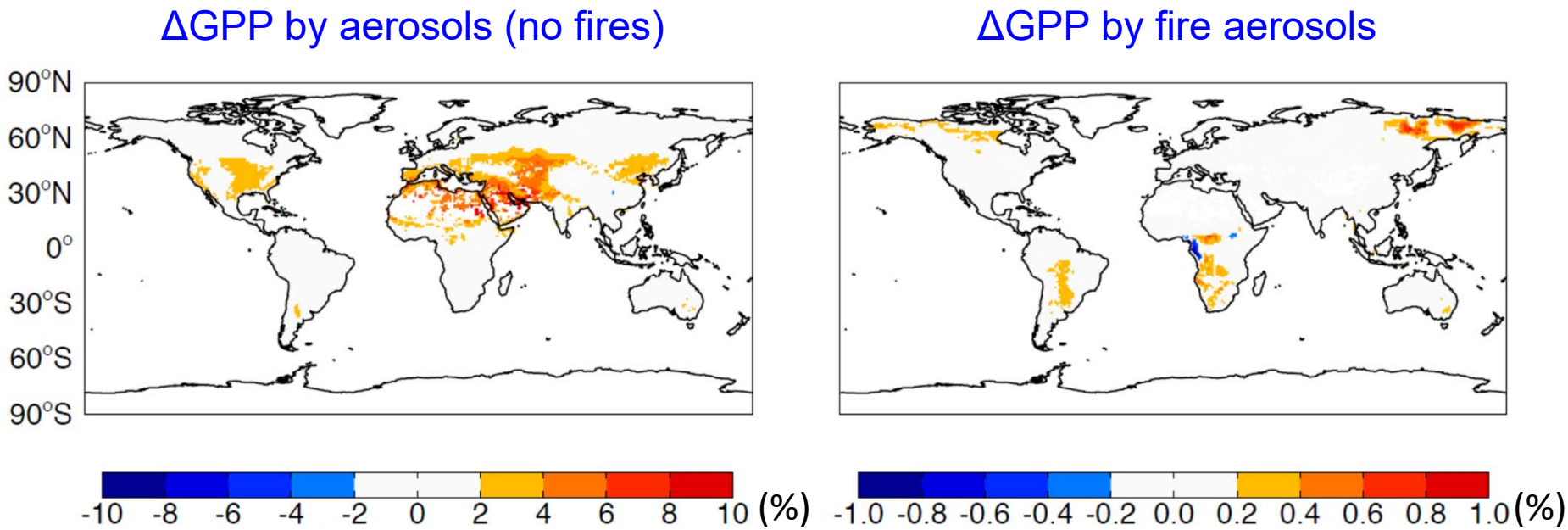
ΔGPP by non-fire O_3



ΔGPP by fire O_3

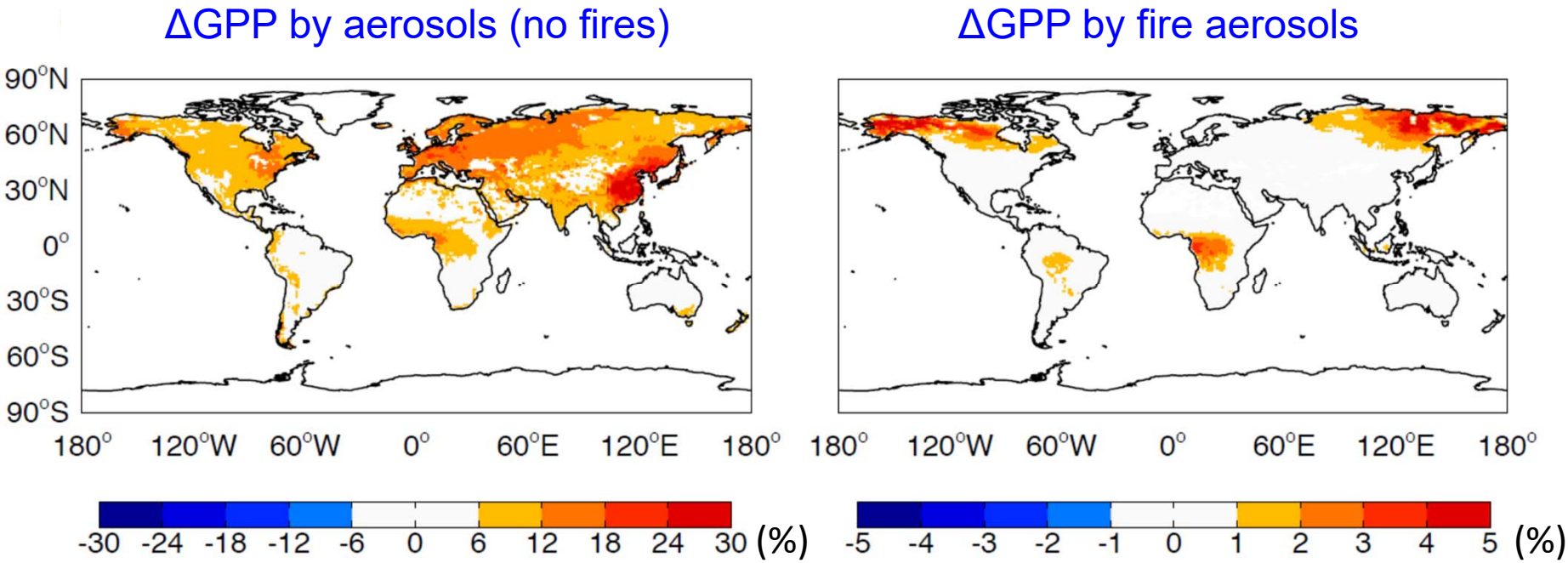


Model results: aerosol diffuse fertilization



- On the global scale, fire-free aerosol increases GPP by 0.7% with regional maximum of 2.2% over western Asia and 1.4% over northern Africa.
- Fire aerosols cause limited changes in GPP, with the largest GPP increase of 1% in eastern Siberia.

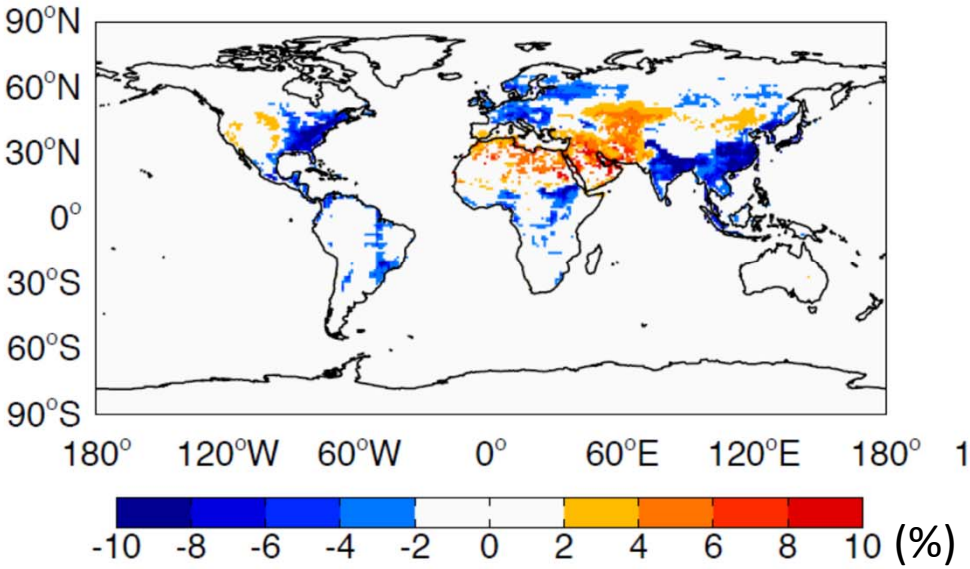
Model results: aerosol effects at clear sky



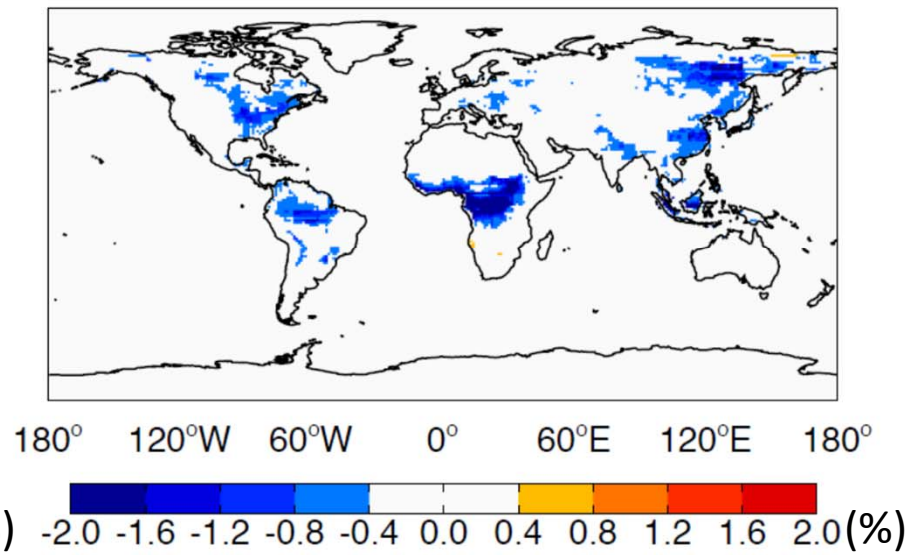
- For clear-sky conditions, fire-free aerosols increase GPP by 8.1% with regional maximum of 21% over eastern China.
- For clear-sky conditions, fire aerosols cause additional increase of 0.7% in GPP, with regional maximum of 3.6% in eastern Siberia.

Model results: ozone + aerosol effects

ΔGPP by ozone+aerosol (no fires)



ΔGPP by fire ozone+aerosol



- Ozone damage and aerosol diffuse fertilization show contrast spatial pattern for fire-free pollution. On the global scale, GPP is reduced by 2.1% because ozone effect is dominant.

- Fire pollution causes a net reduction of 0.6% in GPP because damages by ozone is much stronger than the fertilization by fire aerosols.

Thank you and comments?

Citation:

Yue, X., Unger, N. (2018) Fire air pollution reduces global terrestrial productivity. *Nature Communications,* 9, 5413.

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