THE IMPACTS OF ATMOSPHERIC CHEMICAL CHANGES ON TERRESTRIAL CARBON AND NITROGEN CYCLE

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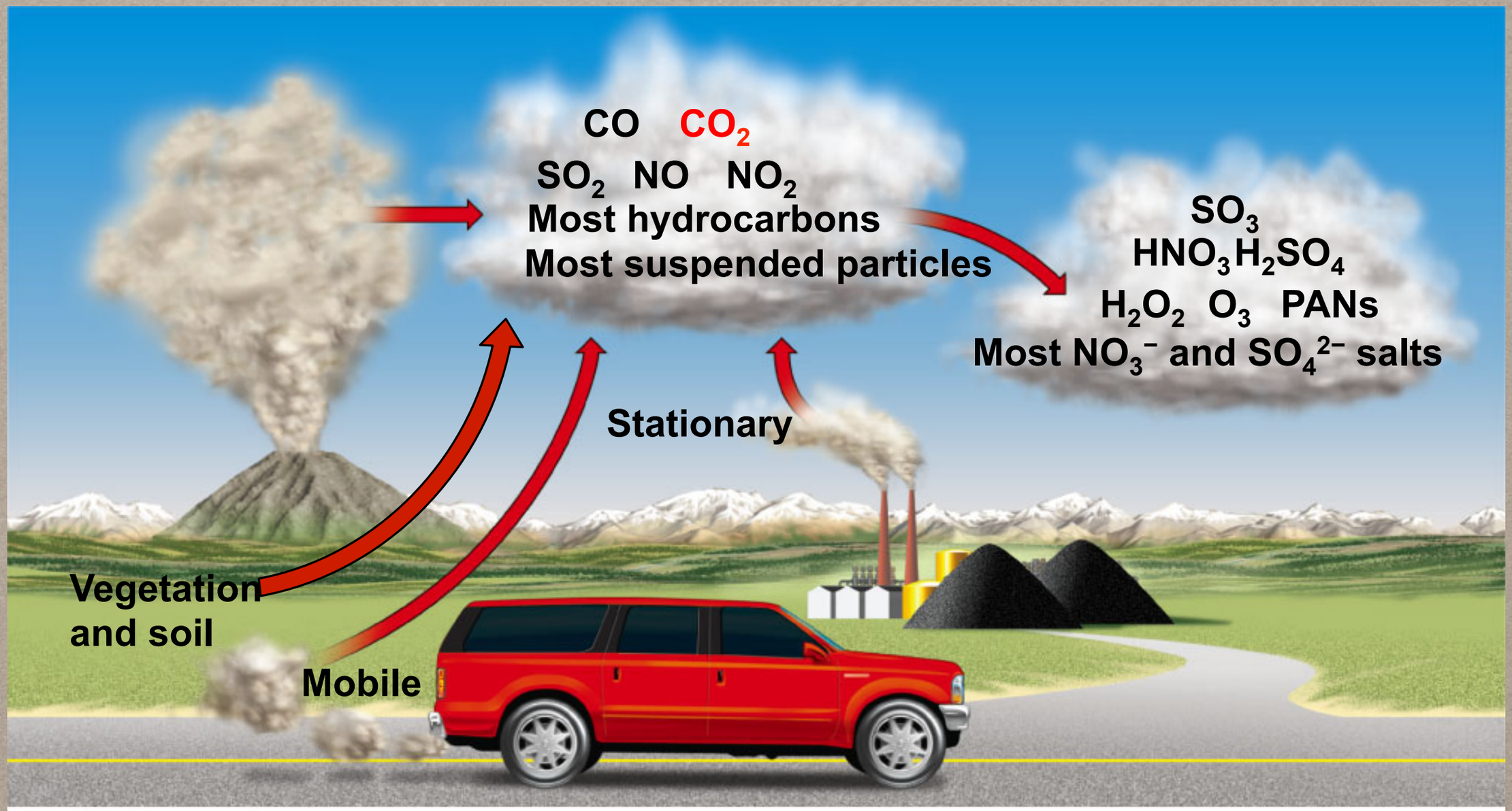
SINO – FRENCH INSTITUTE SPRING SCHOOL, MAY 15 2014

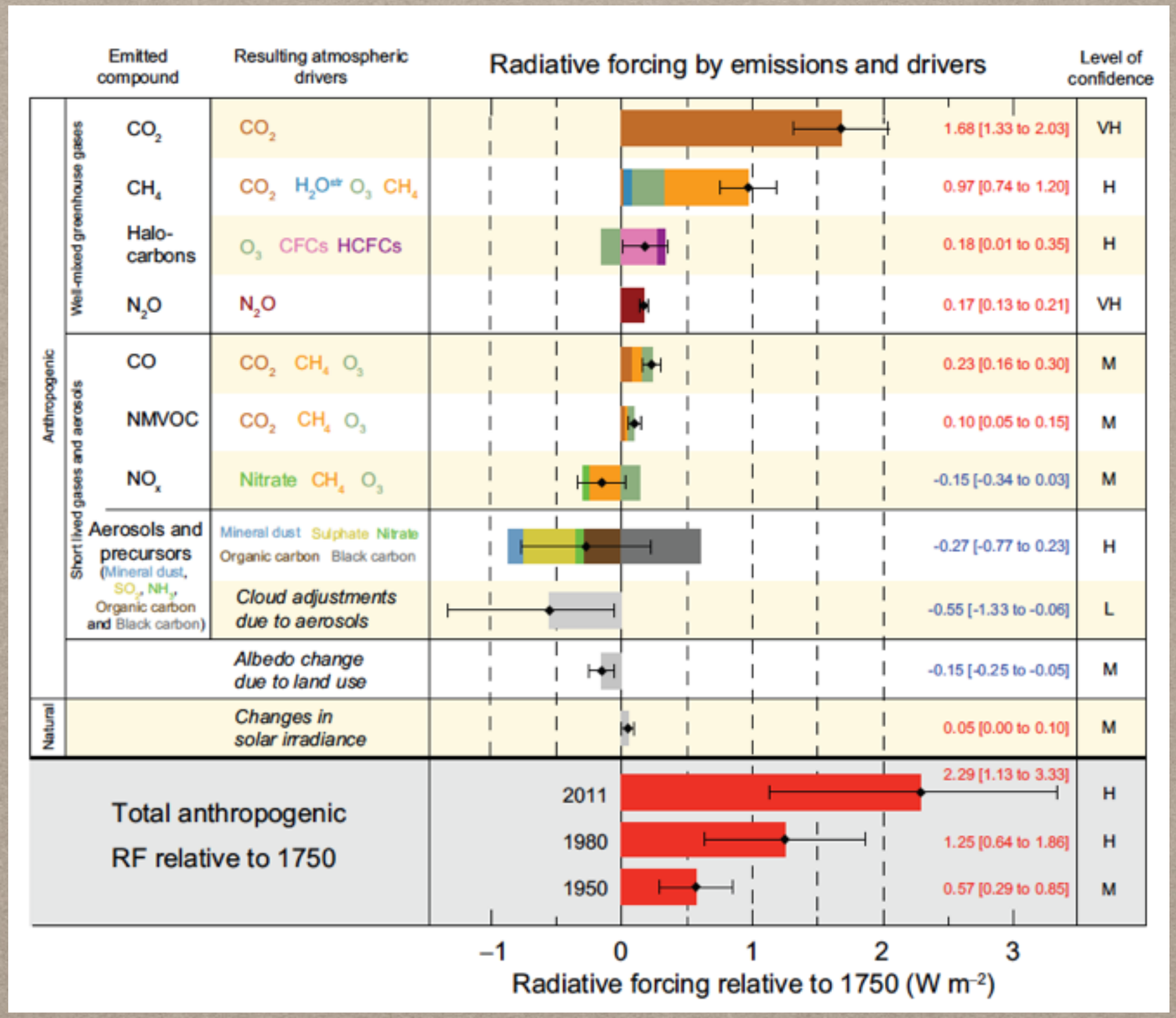
OUTLINE

- The problem: global atmospheric chemistry is changing
- The impacts of reactive nitrogen on climate change
- The impacts of aerosol on carbon cycle

GLOBAL ATMOSPHERIC CHEMISTRY IS CHANGING

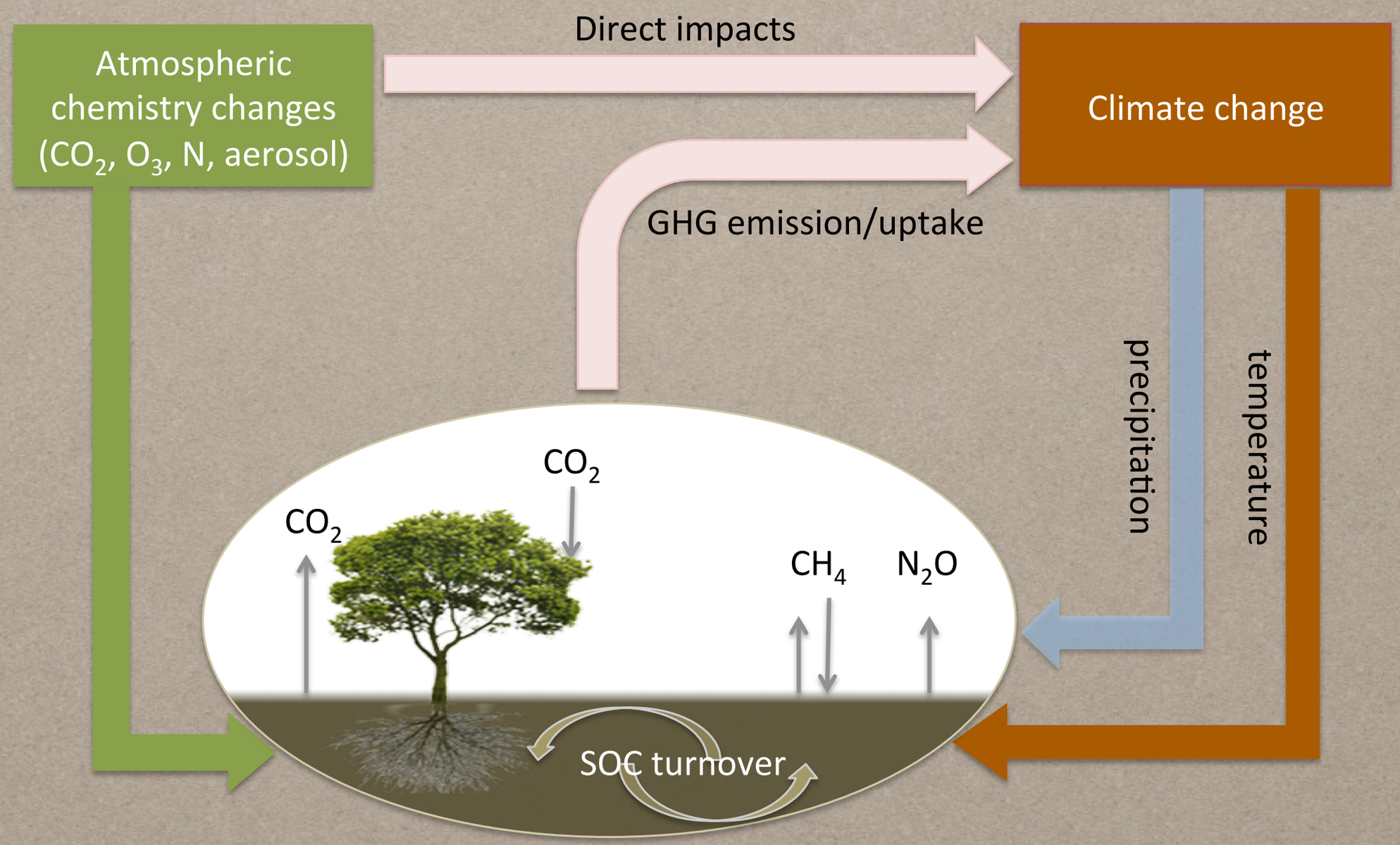


THE DIRECT IMPACTS ON RADIATIVE FORCING



IPCC 2013

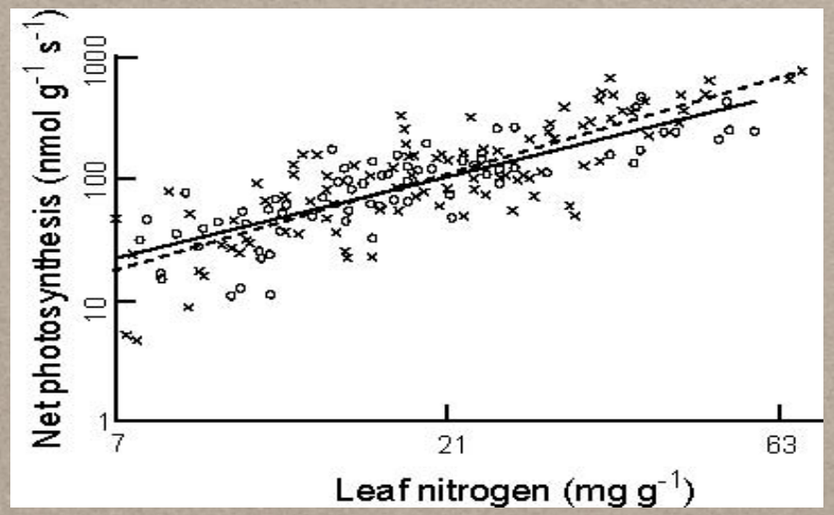
THE INDIRECT IMPACTS BY ALTERING BIOGEOCHEMICAL CYCLES



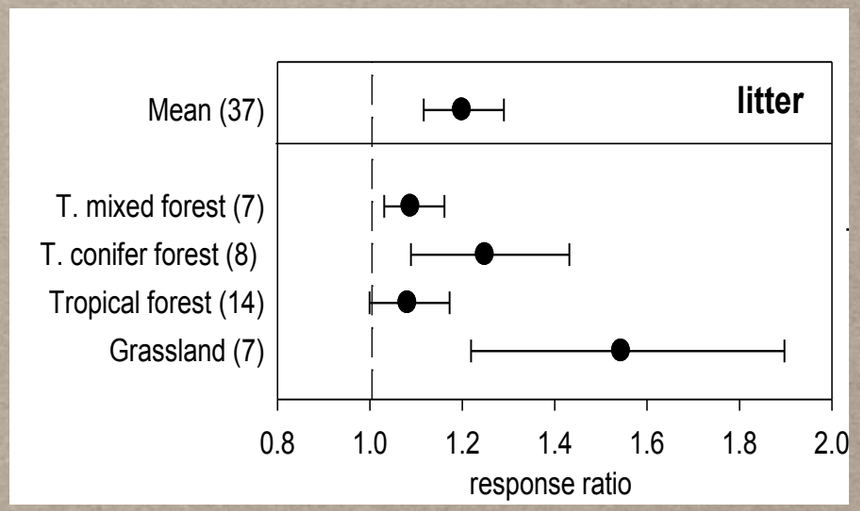
NITROGEN'S CLIMATE IMPACTS

NITROGEN'S CARBON BENEFIT

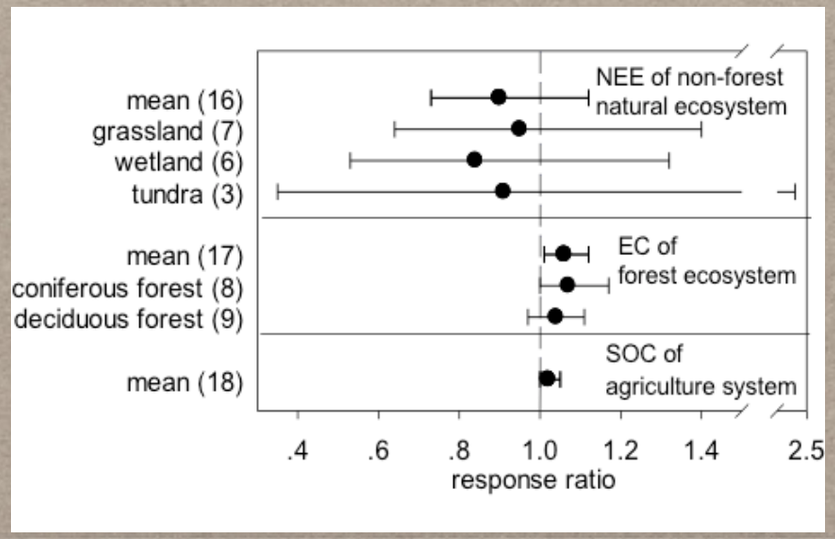
- N constrains net primary production in most terrestrial ecosystems
- N deposition could increase leaf N concentration and simulate plant to produce more leaves



Reich et al. 1997 PNAS

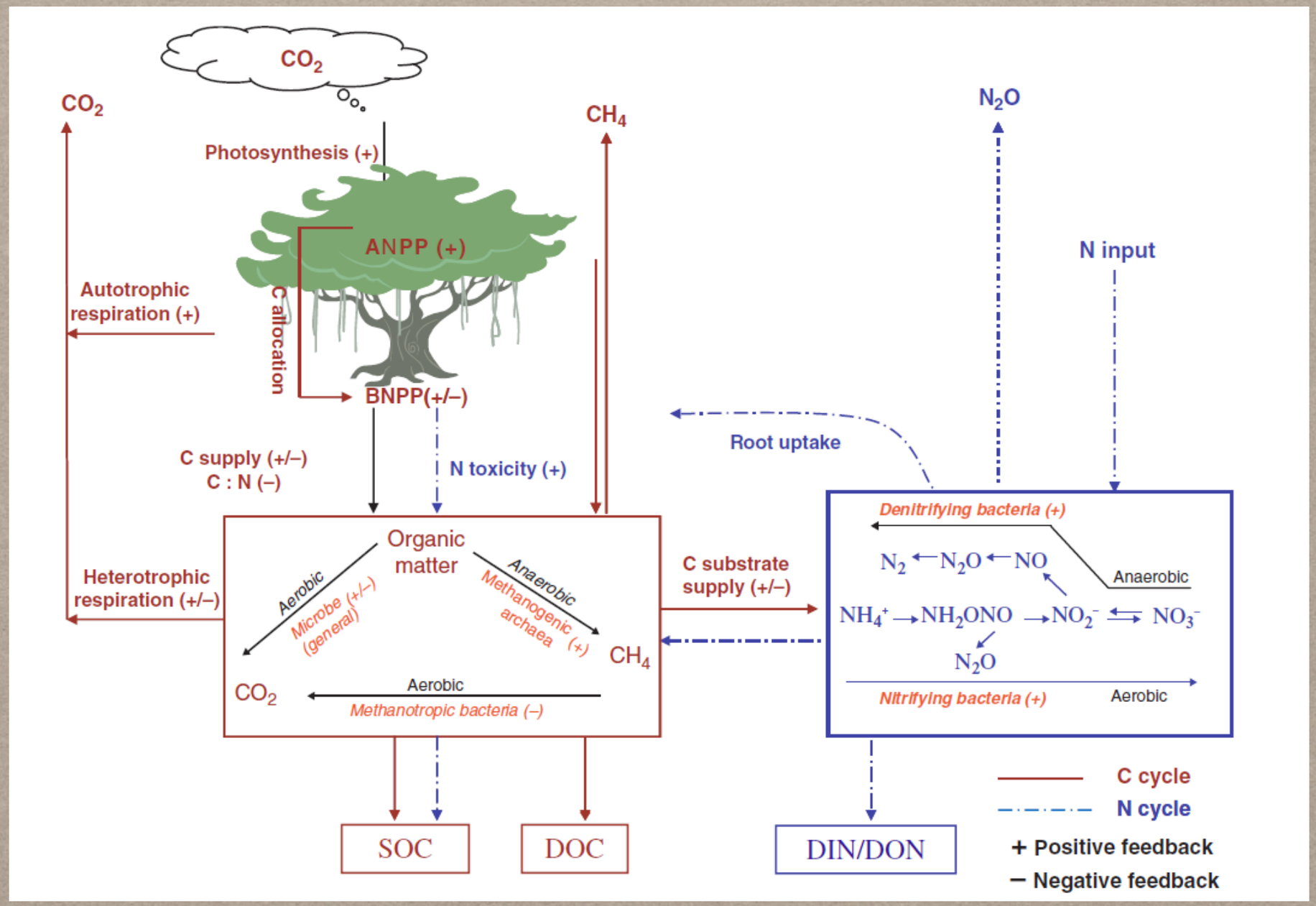


Liu and Greaver 2010 Ecology Letters



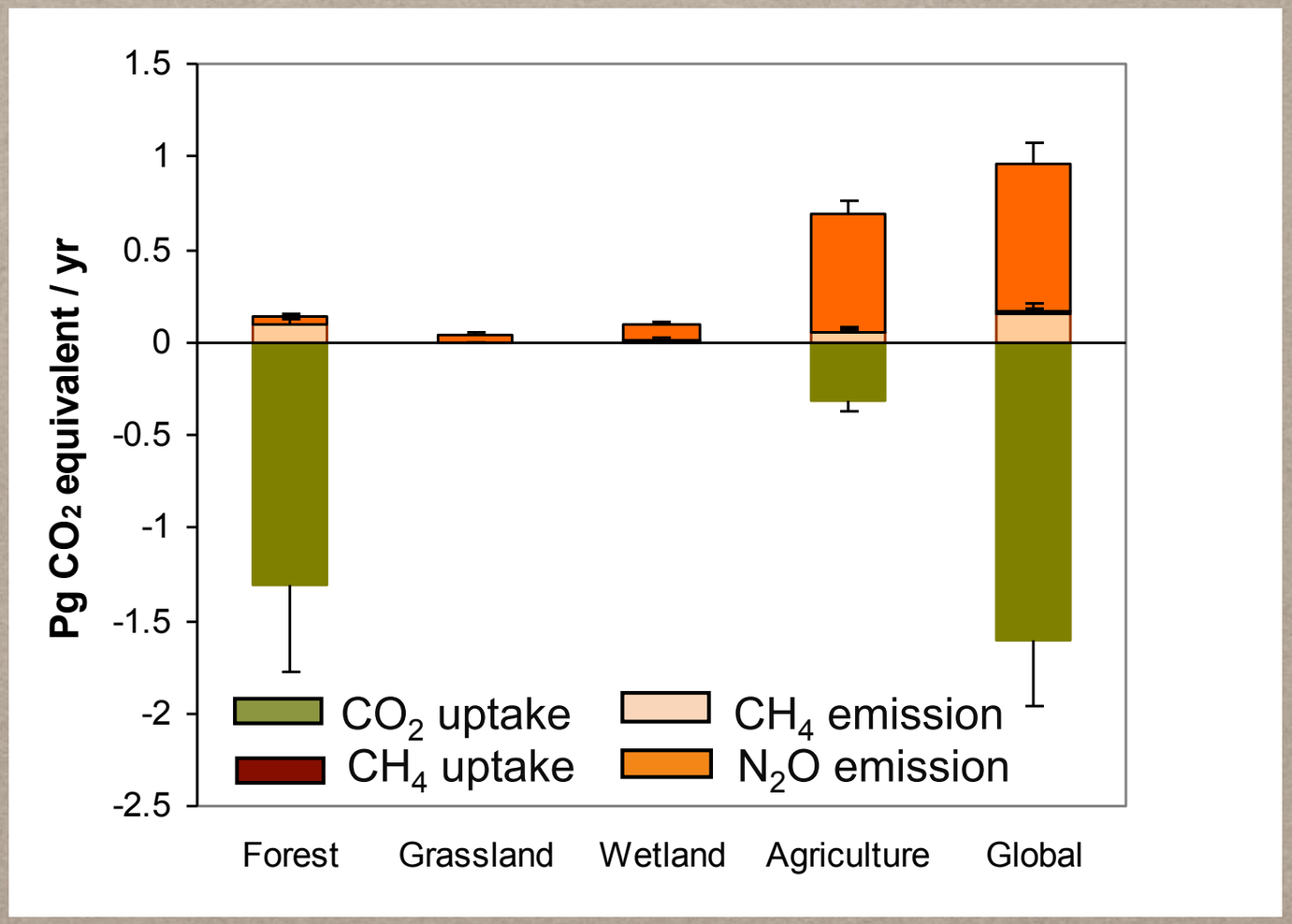
Liu and Greaver 2009 Ecology Letters

REACTIVE NITROGEN ALSO ALTERS N_2O AND CH_4 EMISSION



Liu and Greaver 2009 Ecology Letters

COOLING EFFECTED CAUSED BY CO2 UPTAKE PARTIALLY OFFSET BY N_2O AND CH_4 EMISSION



Liu and Greaver 2009, Ecology Letters

IMPACTS OF REACTIVE NITROGEN ON CLIMATE CHANGE

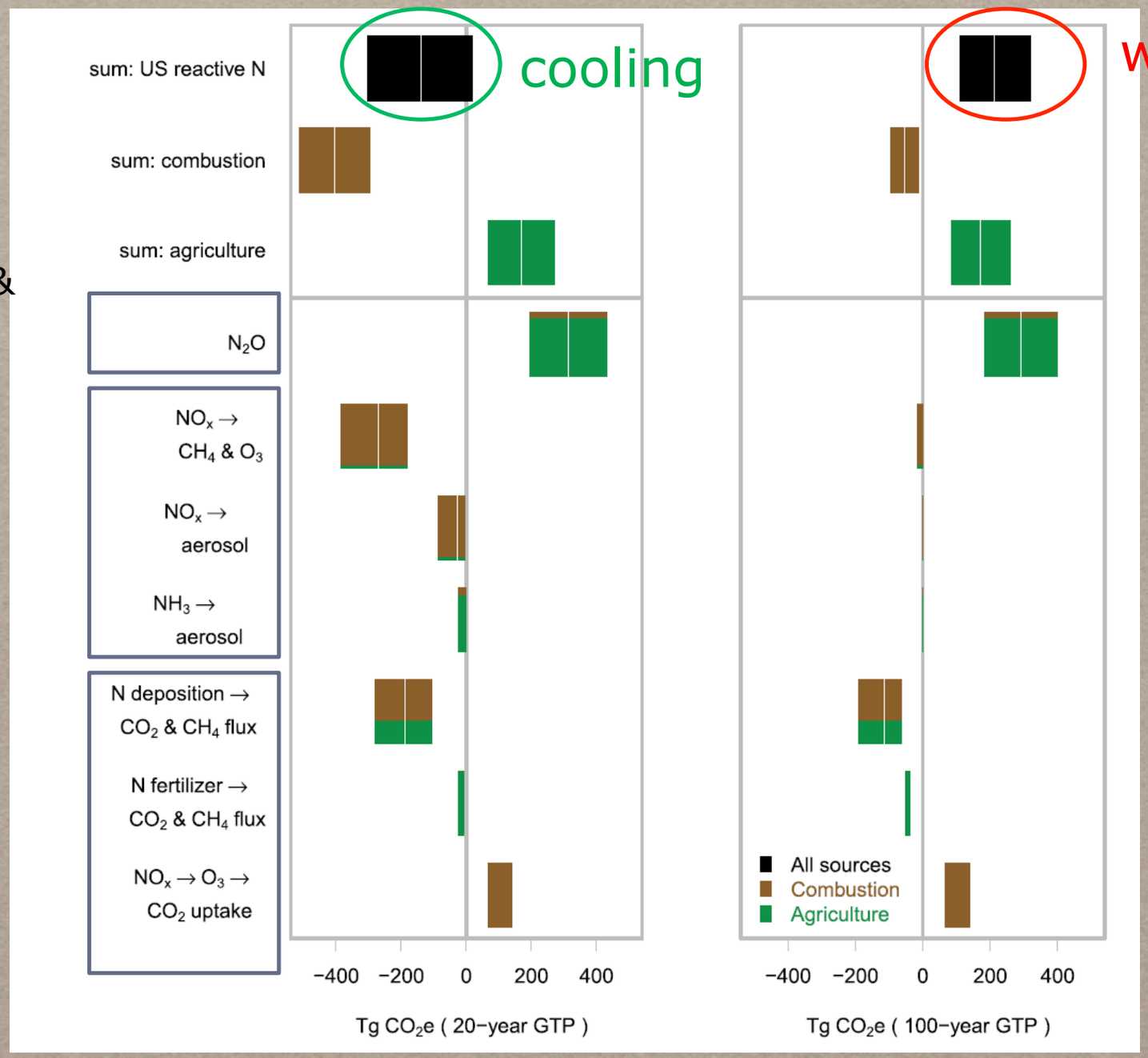
Process altered by reactive N	Climate forcer	direction	description
N_2O	N_2O emission	warming	ecological and atmospheric processes
N deposition➔ CH_4	CH_4 emission	warming	ecological processes
N deposition➔ CO_2	CO_2 uptake	cooling	ecological processes
NOx➔ ozone ➔ CO_2	CO_2 emission	warming	ecological processes
NOx➔ ozone ➔ CH_4	ozone, CH_4	cooling	Atmospheric processes
Nox ➔ aerosol	sulfate, nitrate, ammonium aerosol	cooling	Atmospheric processes
NH_3➔aerosol	sulfate, nitrate, ammonium aerosol	cooling	Atmospheric processes

CLIMATE CHANGE IMPACT OF US NITROGEN EMISSIONS FOR 20 AND 100 YRS

Atmospheric & ecological processes

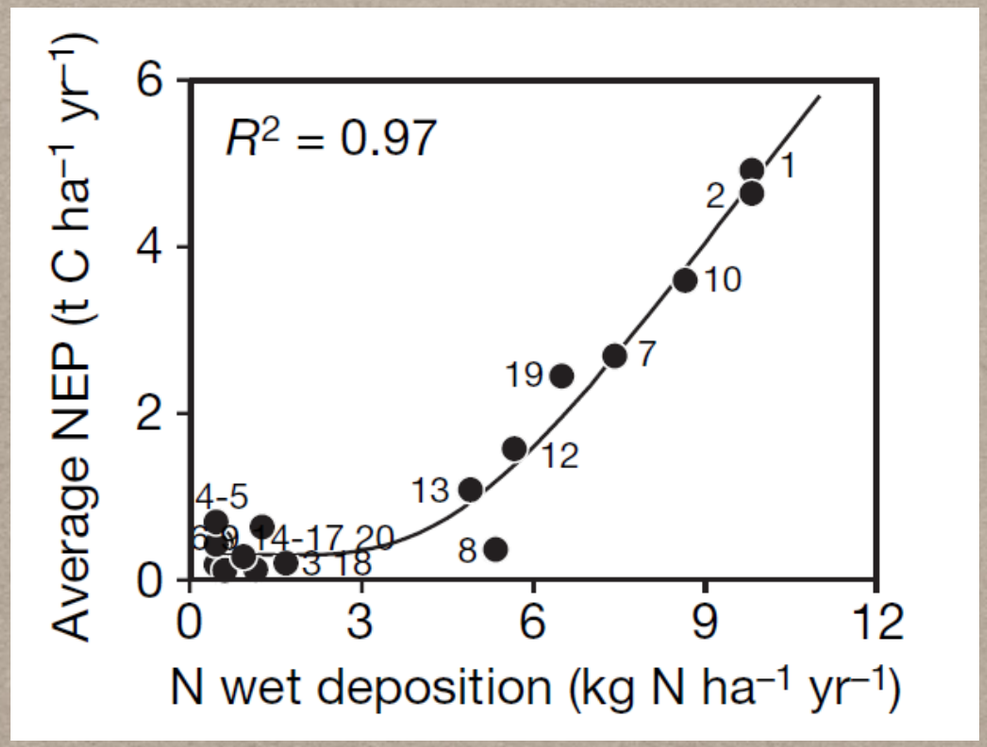
Atmospheric processes

Ecological processes



Pinder et al. 2012 PNAS

HOW MANY KG C CAN BE FIXED WITH 1KG N/HA NITROGEN DEPOSITION?



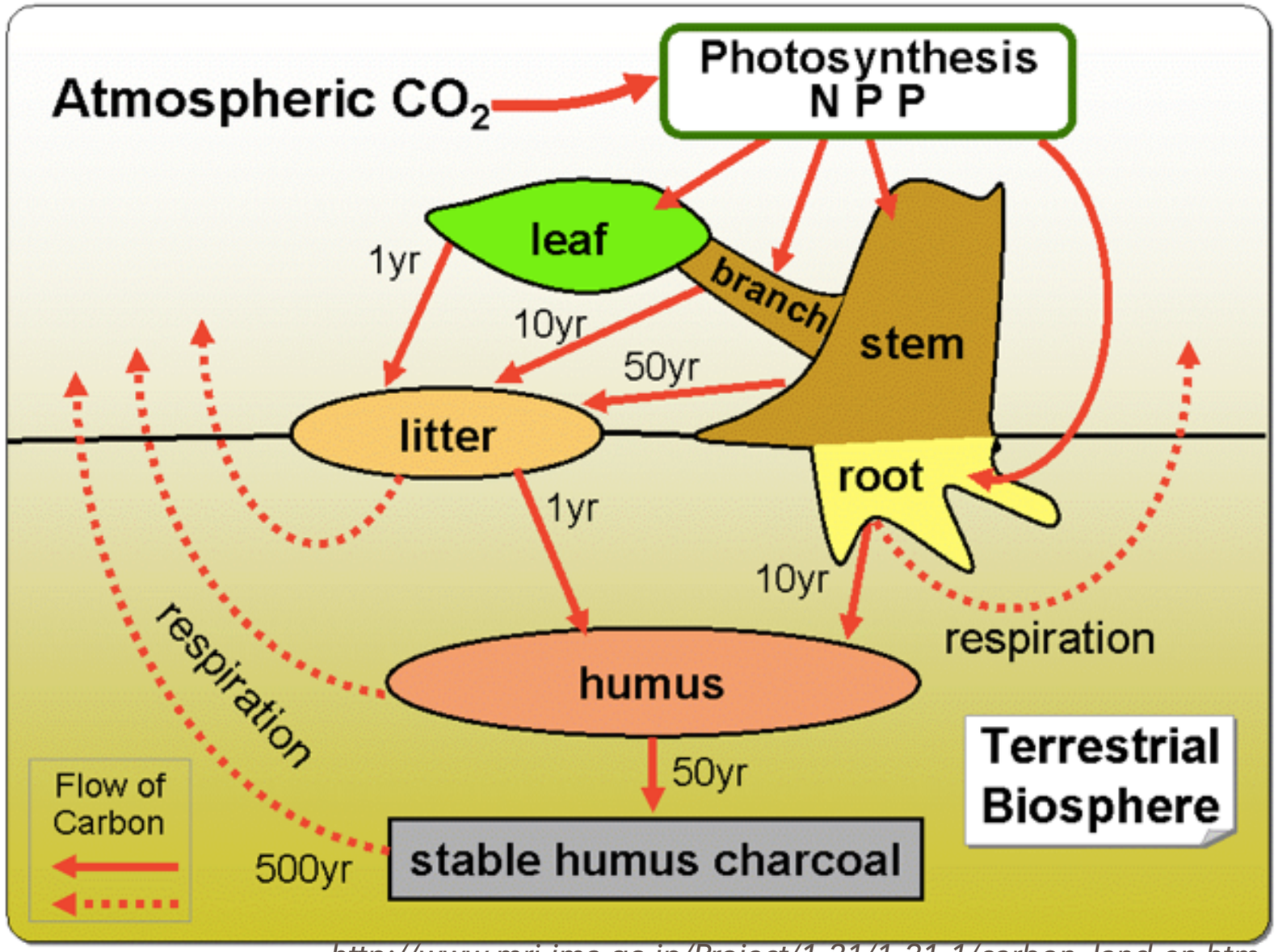
Magnani et al. 2007, Nature

Critical C:N ratio

Wood	**200+**
Leaves	**20-40**
Legume leaves	**10**
Fungi	**8-15**
Bacteria	**5-10**
Surface soil	**14**

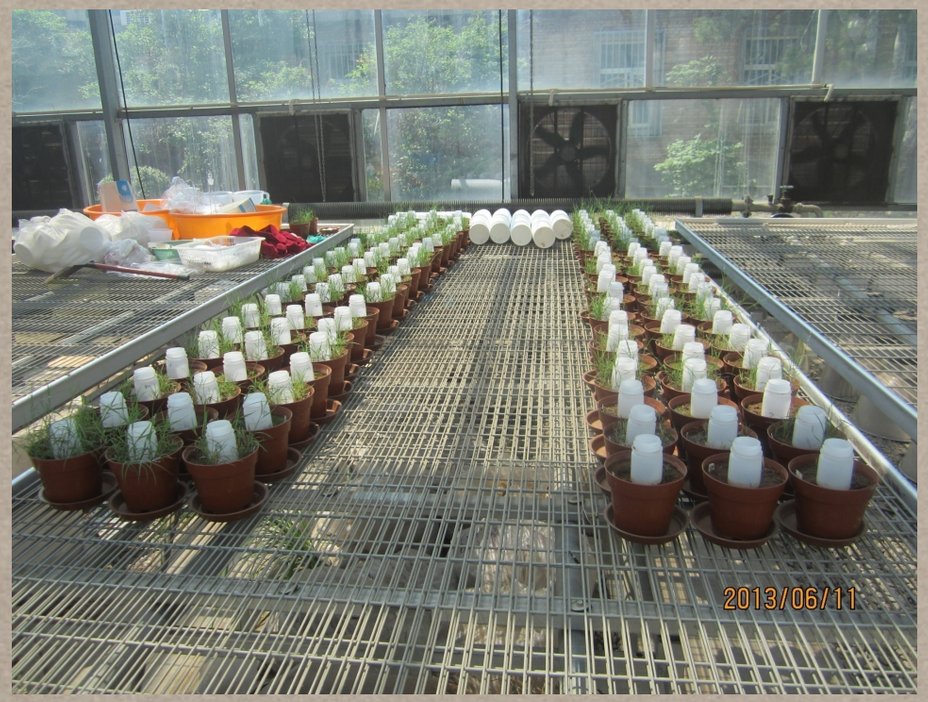
- 175-225 kg C per Kg N (Magnani et al. 2008, *Nature*)
- 30-70 kg C per Kg N (de Vries et al. 2008, *Nature*)
- 65 kg C per Kg N (Thomas et al. 2010, *Nature Geoscience*)
- 24.5 kg C per Kg N (Liu and Greaver 2009, *Ecology letters*)

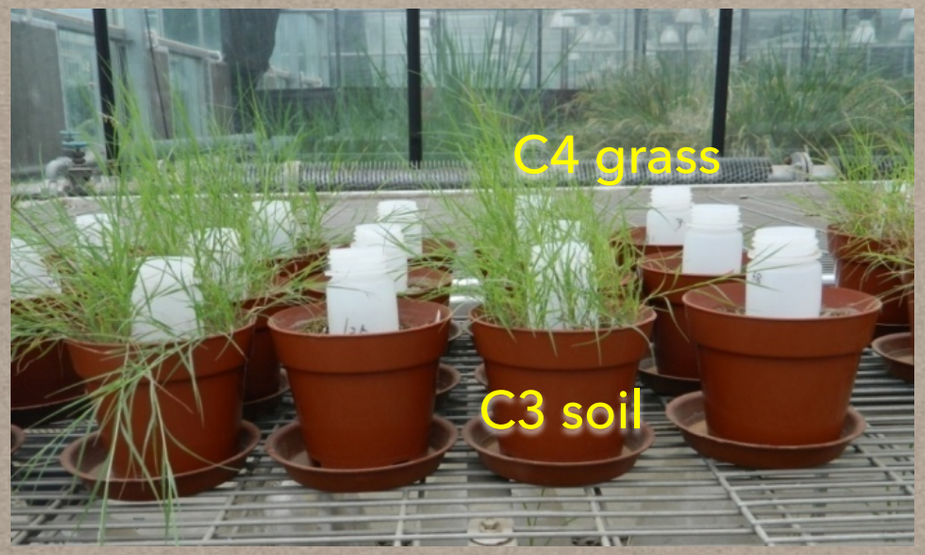
WILL NITROGEN DEPOSITION ALTER ECOSYSTEM CARBON TURNOVER TIME?

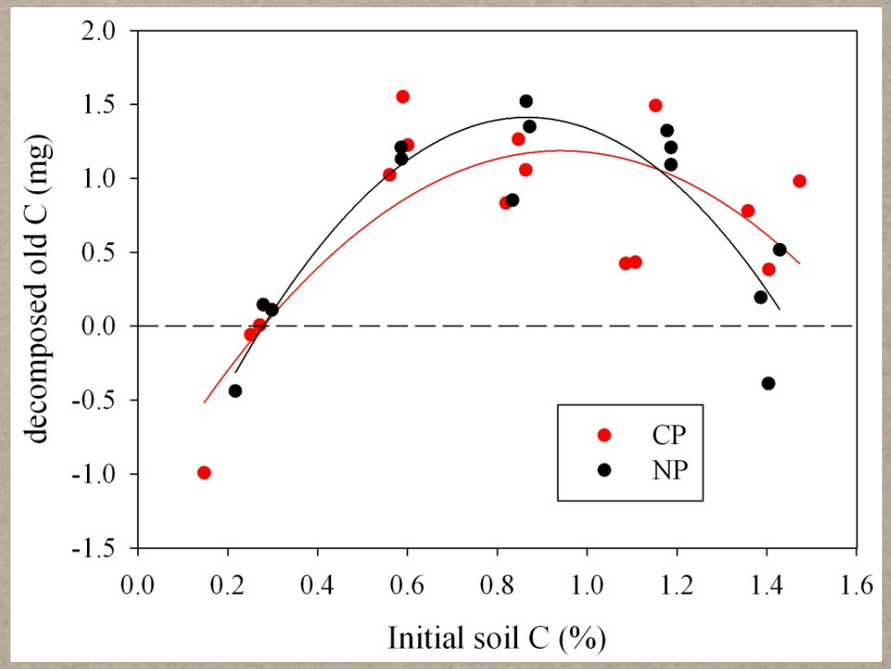


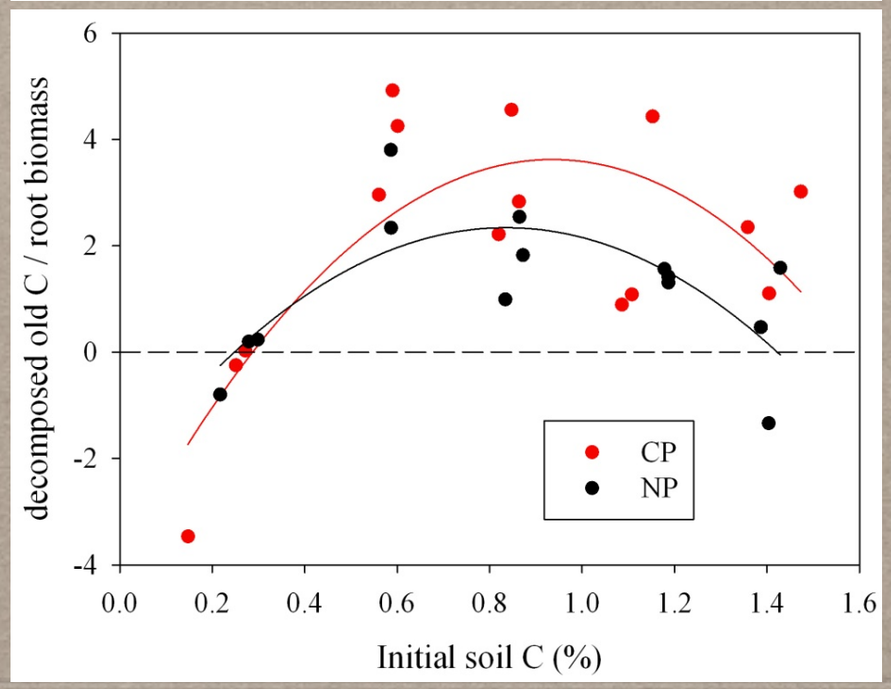
http://www.mri-jma.go.jp/Project/1-21/1-21-1/carbon_land-en.htm

NITROGEN MAY REDUCE THE PRIMING EFFECT OF ROOTS





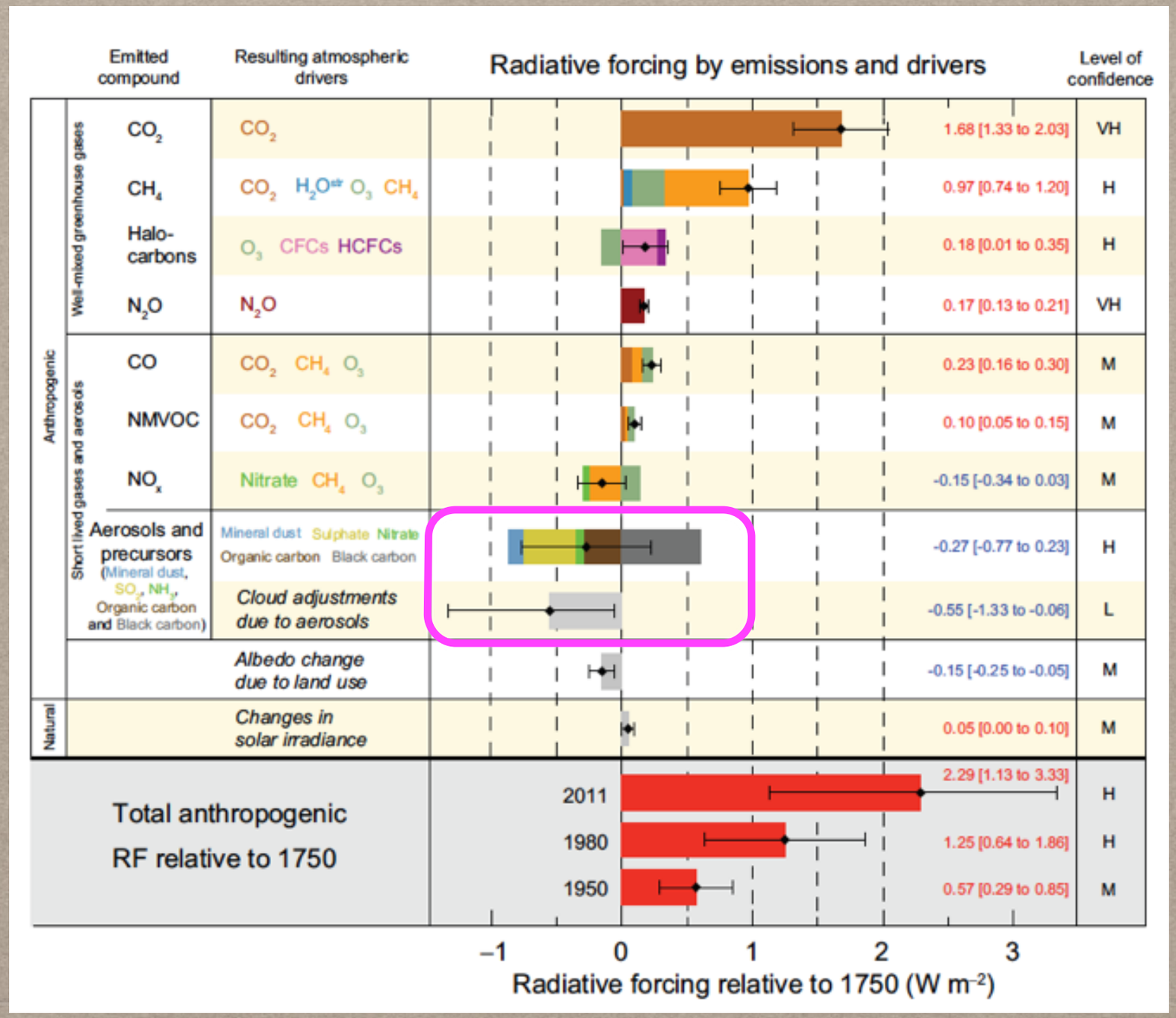




Xu et al. unpublished data

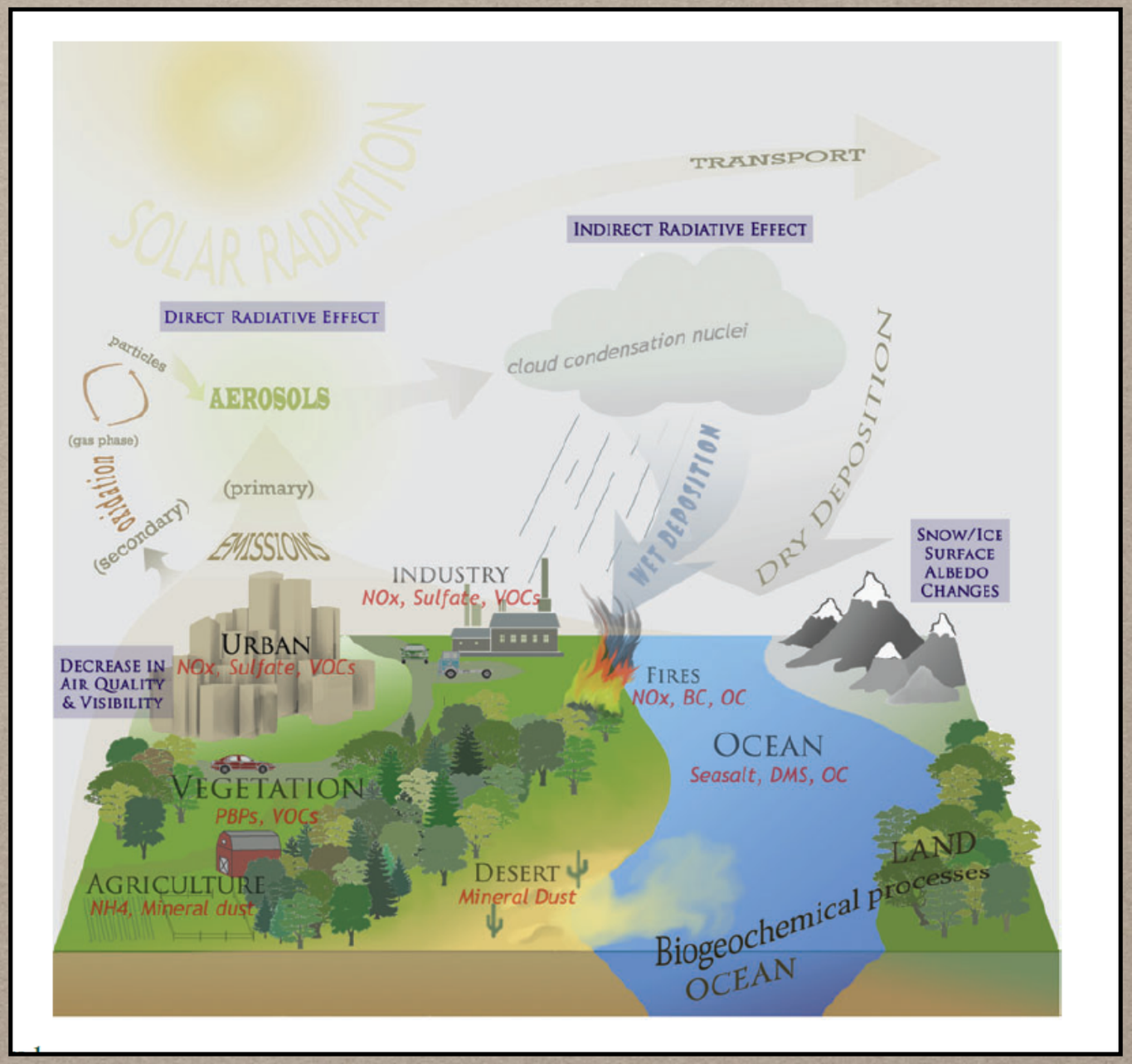
AEROSOL'S CLIMATE IMPACTS

AEROSOL'S DIRECT IMPACTS ON CLIMATE CHANGE



AEROSOL'S ECOLOGICAL CONSEQUENCE: A BIG UNKNOWN

- Temperature
- Precipitation
- Nutrient / acid deposition
- Radiation



Mahowald et al. (2011). Annual Review of Environment and Resources

AEROSOL ALTERS SOLAR RADIATION: REDUCES TOTAL RADIATION

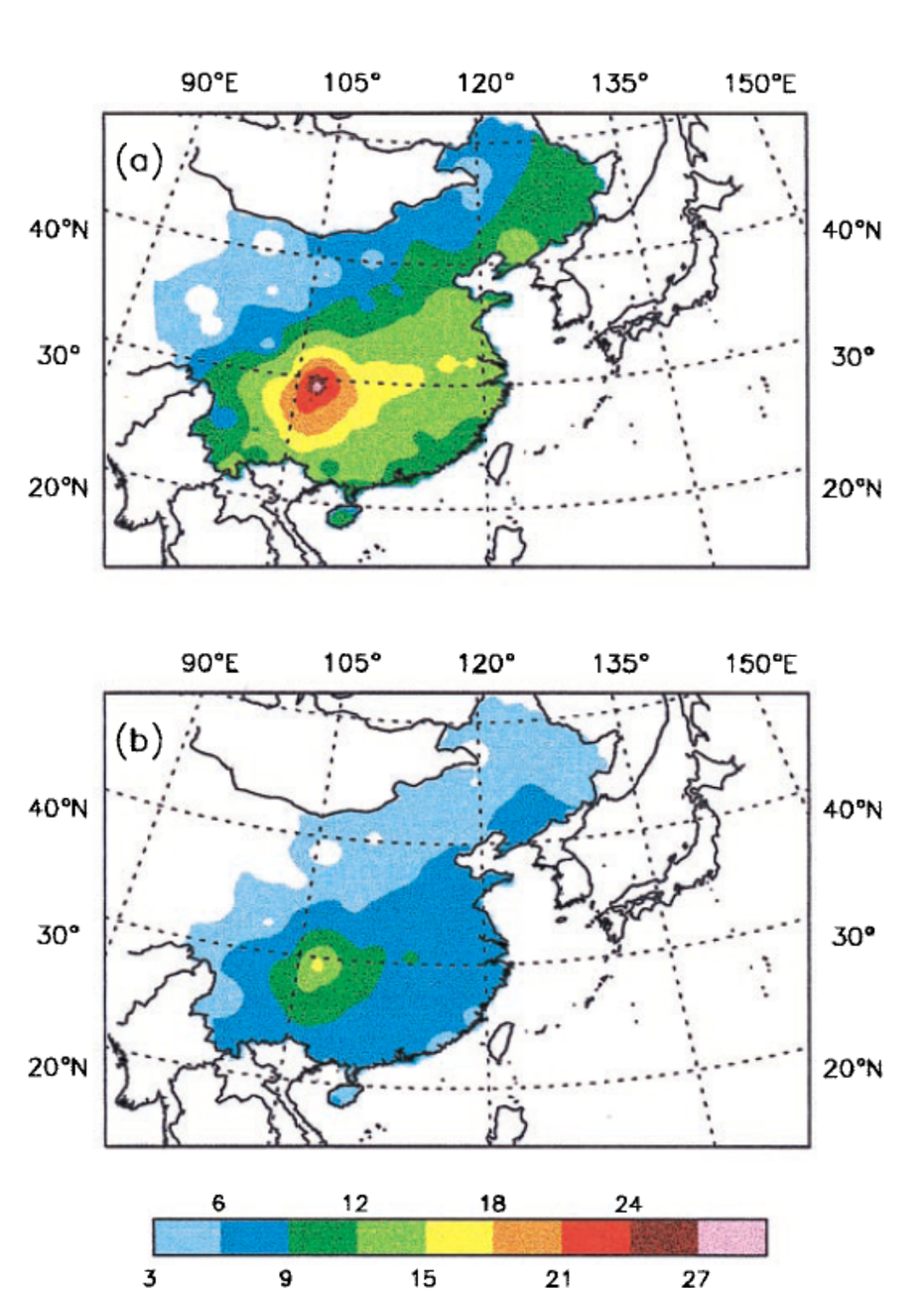
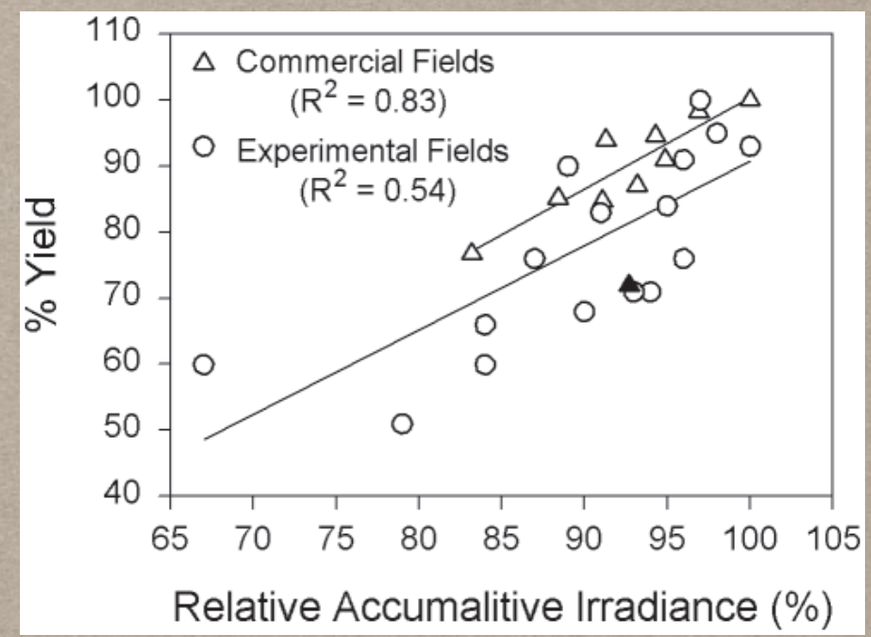
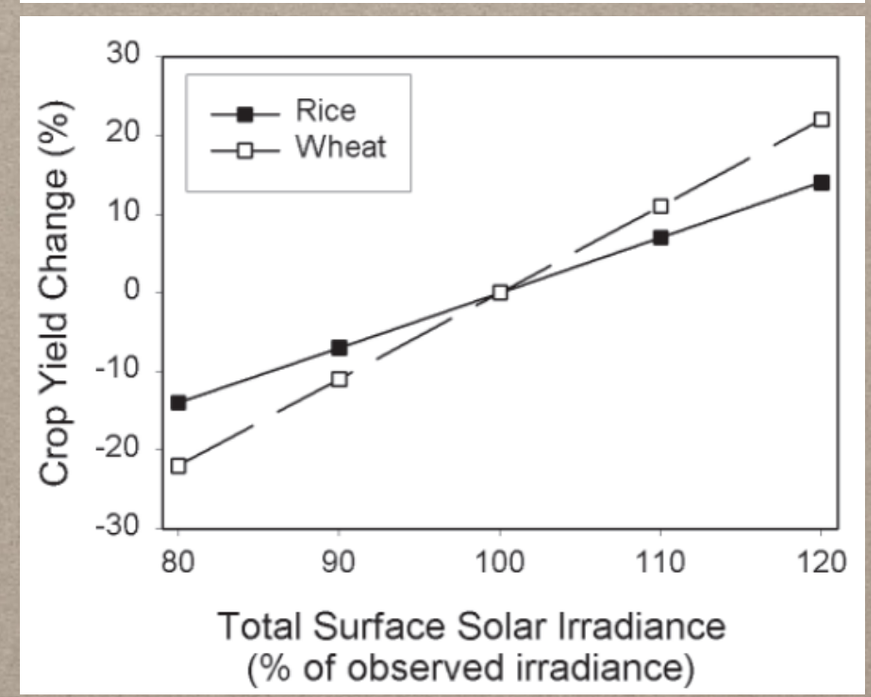


Fig 4. Calculated ΔI_s^{tot} (in percent), the percent reduction in the total surface irradiance over China for summertime conditions using model-estimated τ_as. (*a*) The Cloud-Free, High Absorption Case. (*b*) The Cloud-Free, Low Absorption case.





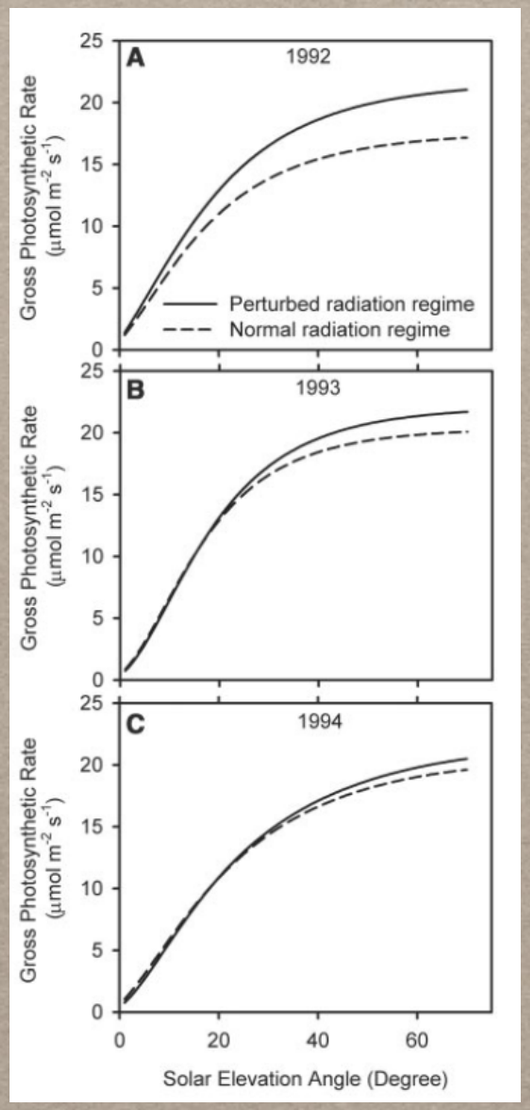
Chamedies et al. 1999, *PNAS*

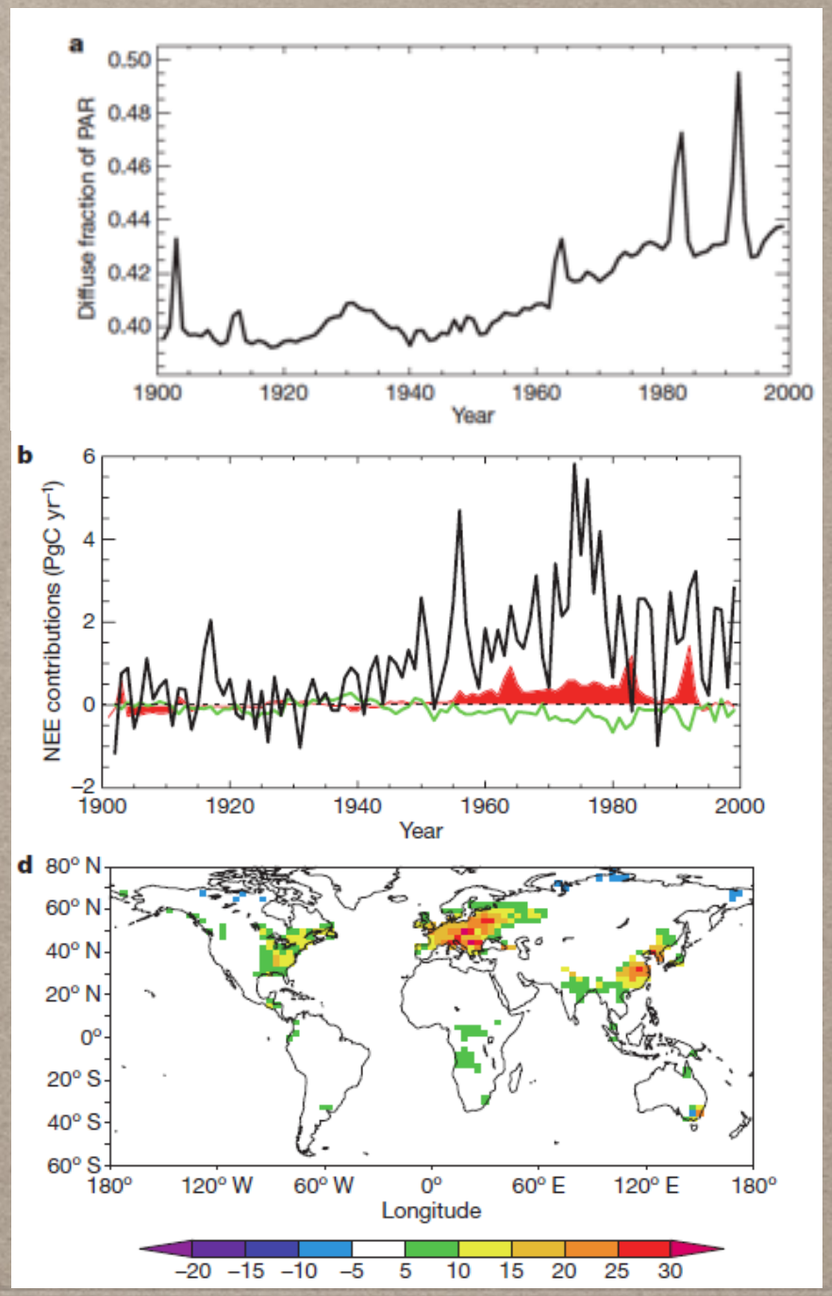
BUT INCREASE THE FRACTION OF PHOTOSYNTHETICALLY ACTIVE RADIATION

- The 'diffuse-radiation fertilization ' effect can be significant

Mt Pinatubo erupted in 1991

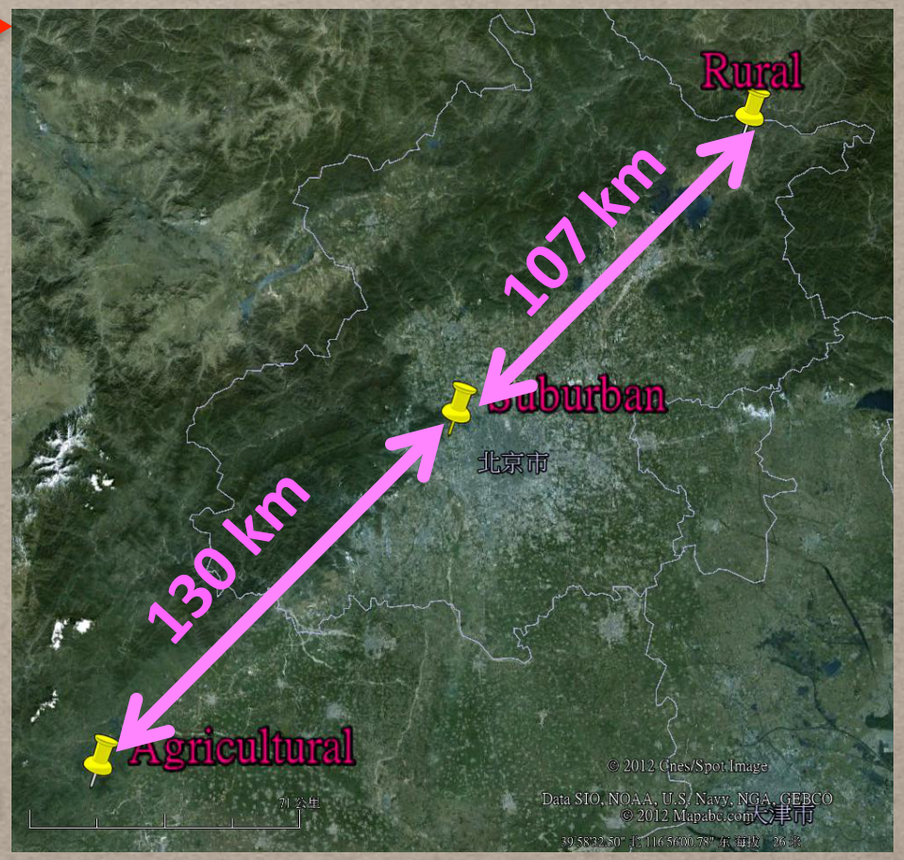
Gu et al. 2003, *Science*

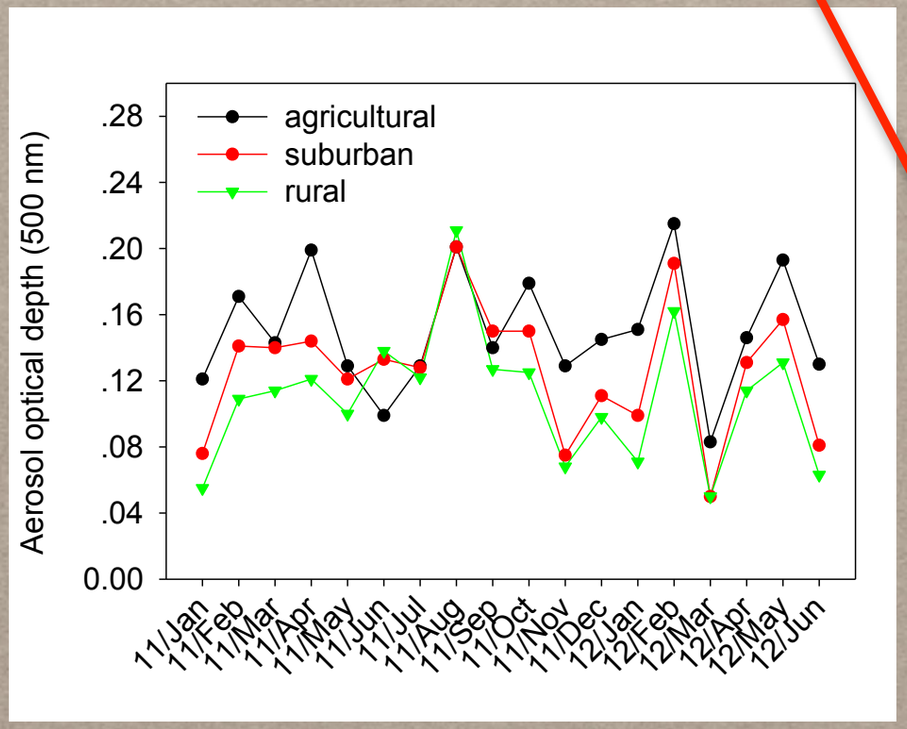




Mercado et al. 2009, *Nature*

COULD AEROSOL'S IMPACTS ON PHOTOSYNTHESIS BE OBSERVED AT LEAF LEVEL?



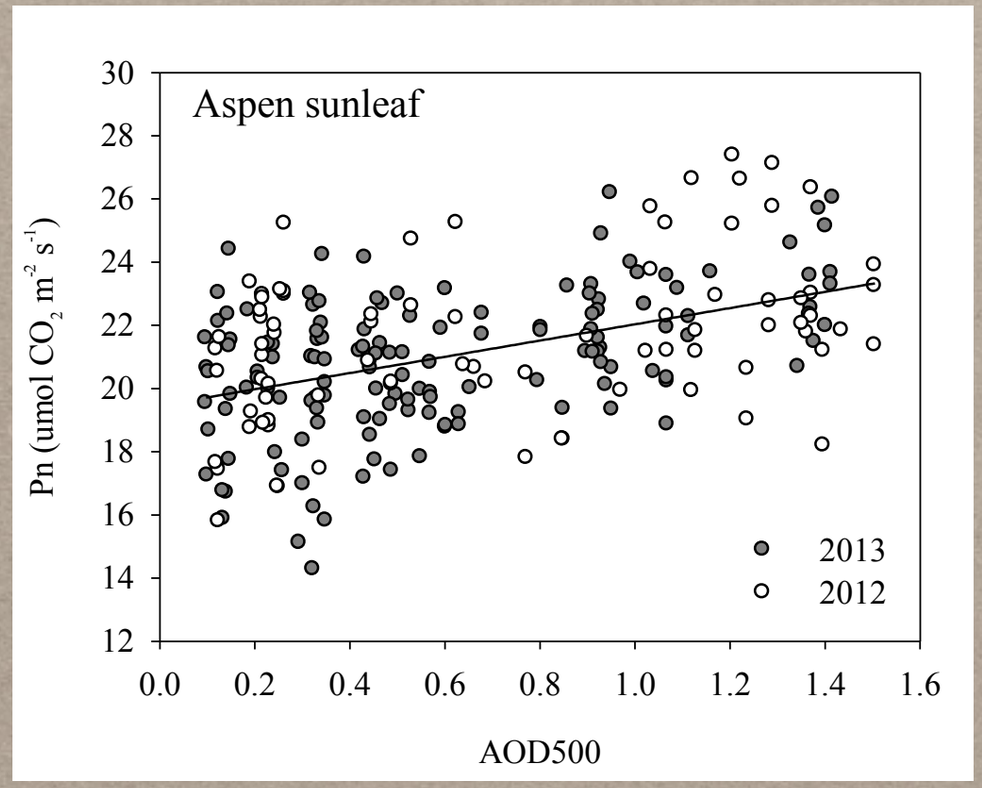


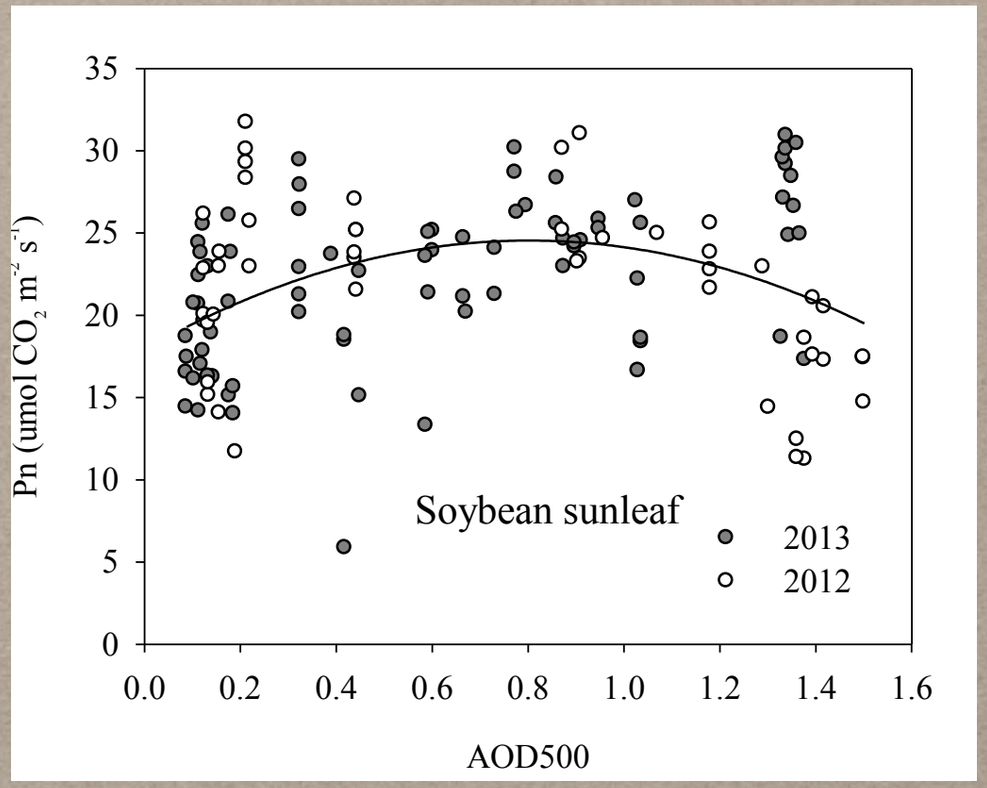
SOIL TRANSPLANT

March 2011

PRELIMINARY DATA

- photosynthesis rates were correlated with aerosol loading
- the responses of aspen and soybean are different





Wang et al. unpublished data

THANK YOU!

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