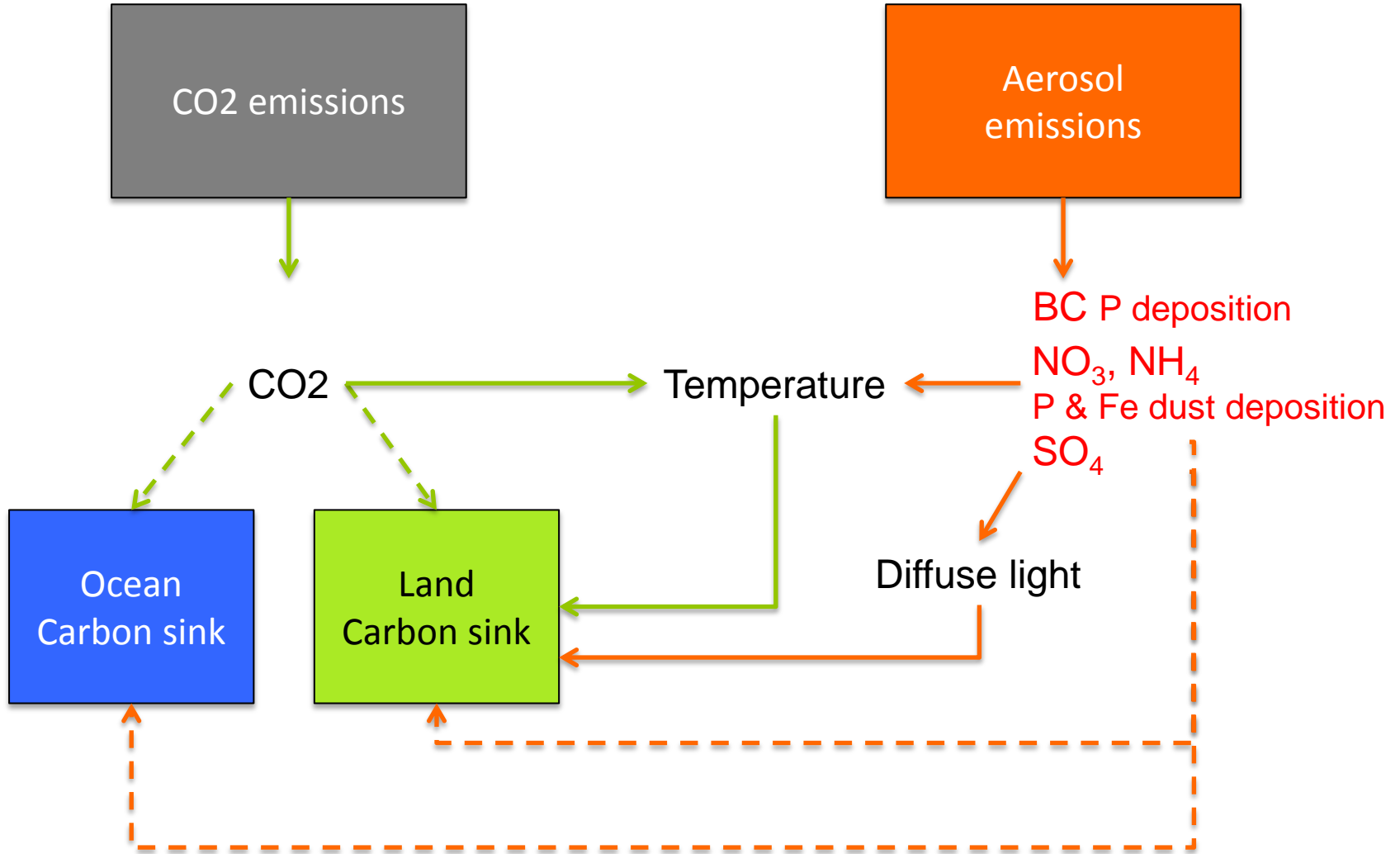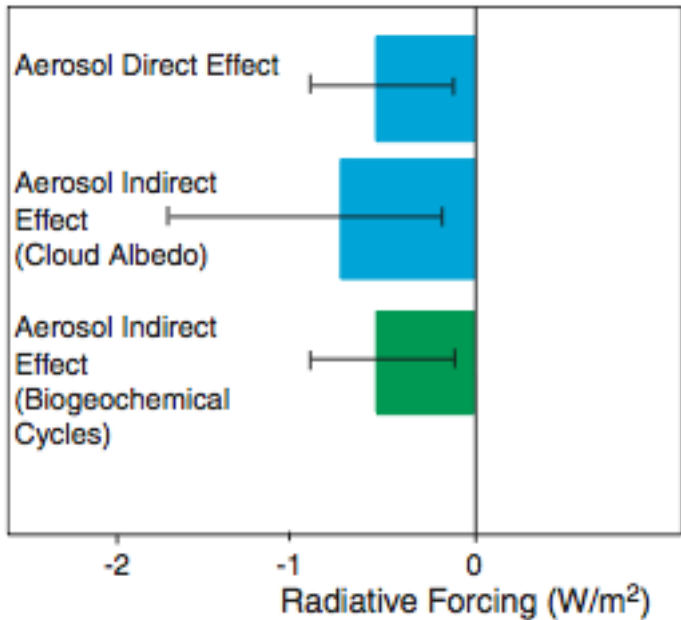# Interactions between aerosols and the carbon cycle

Dashed lines = biogeochemical effects (increase productivity)
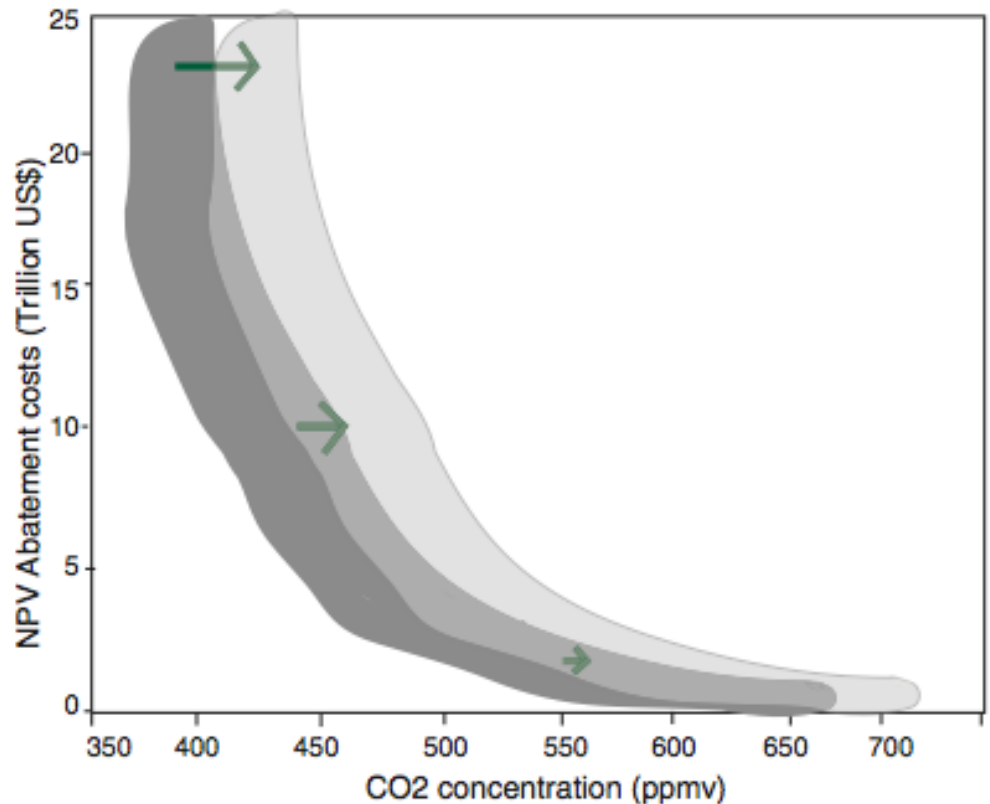
Solid lines = climatic effects

Interactions between aerosols and the carbon cycle

« Overall, aerosol indirect effects on biogeo-chemical fluxes are estimated to be responsible for the extra drawdown of 7 to 50 ppm of CO_2 or a radiative forcing of -0.5 ∓ 0.4 W/m2 (8), which is similar in magnitude to the direct effects (Fig. 1) »

Mahowald, Science, 2011

Coupling between Climate and the carbon cycle

$$\Delta C_R^c = \beta \Delta C_a^c + \gamma \Delta T^c$$

$$\Delta C_R^u = \beta \Delta C_a^u$$

$$\Delta T^c = \alpha \Delta C_a^c$$

α is the transient climate sensitivity
E is cumulative emissions
ΔC_R^c = Change in carbon storage of natural reservoir
ΔC_a^c = CO_2 increase coupled with climate
ΔC_a^u = CO_2 increase un-coupled (biogeochemical effect only)

$$E = \Delta C_R^c + \Delta C_a^c$$

$$E = \Delta C_R^u + \Delta C_a^u$$

$$\Delta C_a^c = \frac{1}{1 - g} \Delta C_a^u$$

$$g = \frac{\alpha \gamma}{1 - \beta}$$

Friedlingstein et al. 2006

Coupling between Climate and the carbon cycle with aerosols
e.g. N-aerosols A_N

Fertilization effect of nitrate aerosol deposition β_N

$$\Delta C_R^c = \beta \Delta C_a^c + \beta_N \Delta A_N + \gamma \Delta T^c$$
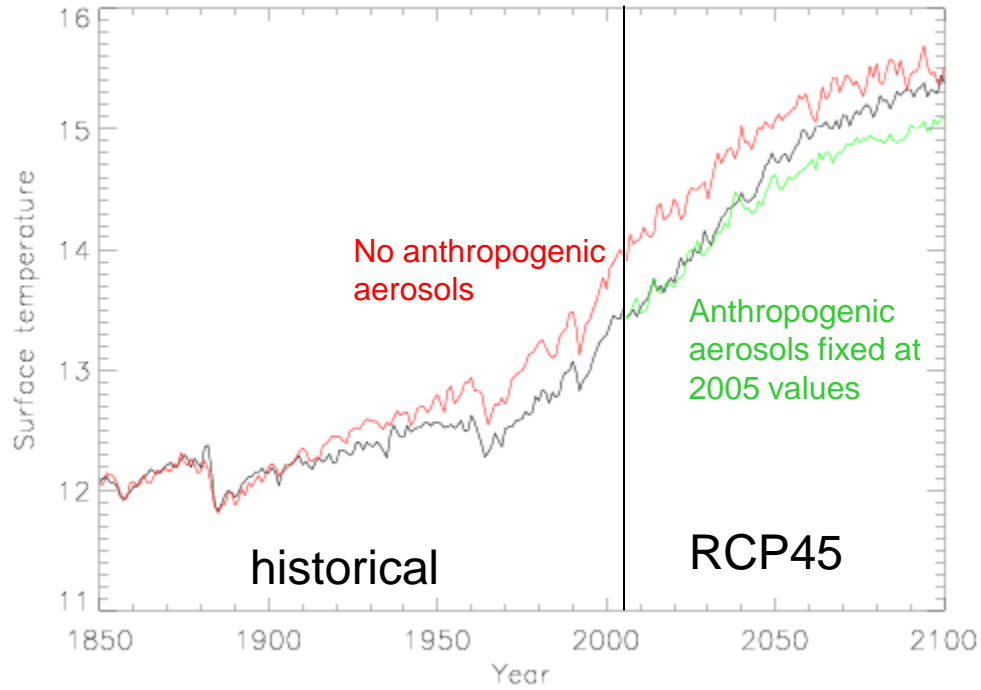
$$\Delta T^c = \alpha(\Delta C_a^c + f \Delta A_a)$$

f = radiative forcing conversion factor in CO2 equivalent

$$\Delta C_a^c = \frac{1}{1 - g_1} \Delta C_a^u - \alpha\gamma f / (1 + \beta + \beta_N + \alpha\gamma)\Delta A_N$$
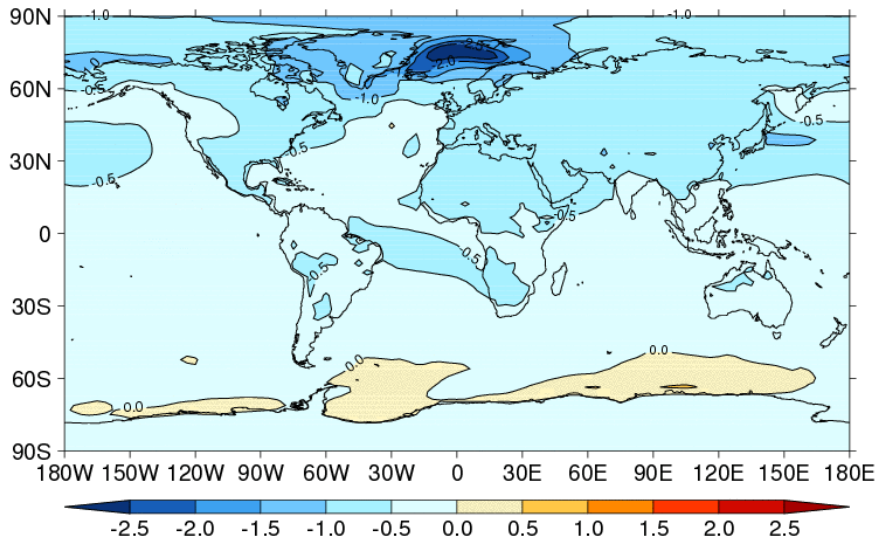
$$g_1 = \frac{\alpha\gamma}{1 + \beta + \beta_N}$$

IPSL-CM5A-LR climate model

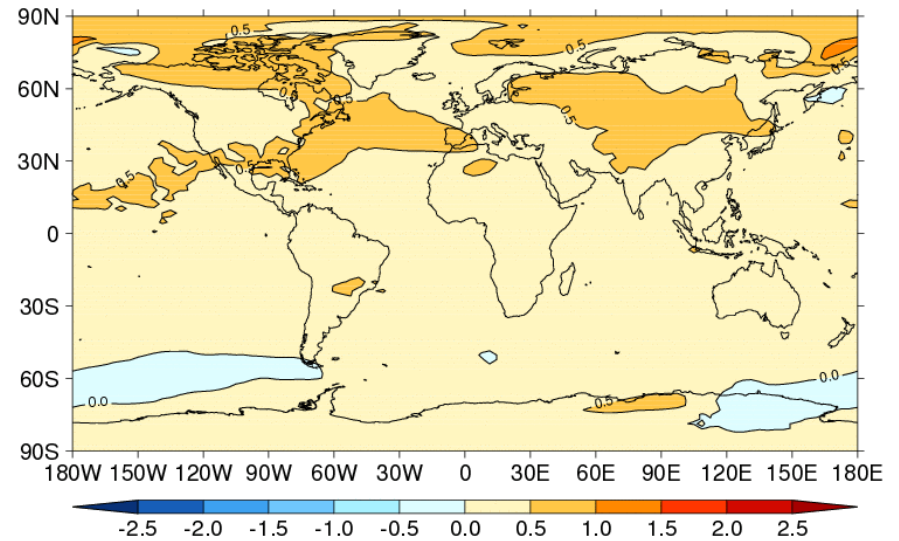Cooling due to anthropogenic aerosols in historical

Warming due to decreasing aerosols in RCP45

No anthropogenic aerosols

Anthropogenic aerosols fixed at 2005 values

historical

RCP45

Temperature change due to aerosols - IPSL-CM5A-LR

Temperature change due to aerosols - IPSL-CM5A-LR

What could be done

- Run offline ORCHIDEE and OPA simulations with and without temperature change due to aerosols

- Run offline ORCHIDEE and OPA simulations with 'fertilization' only effects of aerosols from N-, Fe-, P-deposition changes (due to human activities)

- Calculate time series of carbon sinks anomalies

- Introduce in OSCAR to calculate effect of aerosols on CO2 and climate

- Alternative : run ESM simulations