Conference or Workshop Item

Mercado, Lina; Bellouin, Nicolas; **Sitch, Stephen**; Boucher, Olivier; **Huntingford, Chris**; Cox, Peter. 2008 Modelling the Impact of Radiation Changes on the Terrestrial Carbon Sink - over the 1900-2100 period. [Other] In: *Climate Change Impacts and Adaptation: Dangerous rates of change, University of Exeter, UK, 22-24 September 2008*. (Unpublished)

Modelling the Impact of Radiation Changes on the Terrestrial Carbon Sink

-over the 1900-2100 period-

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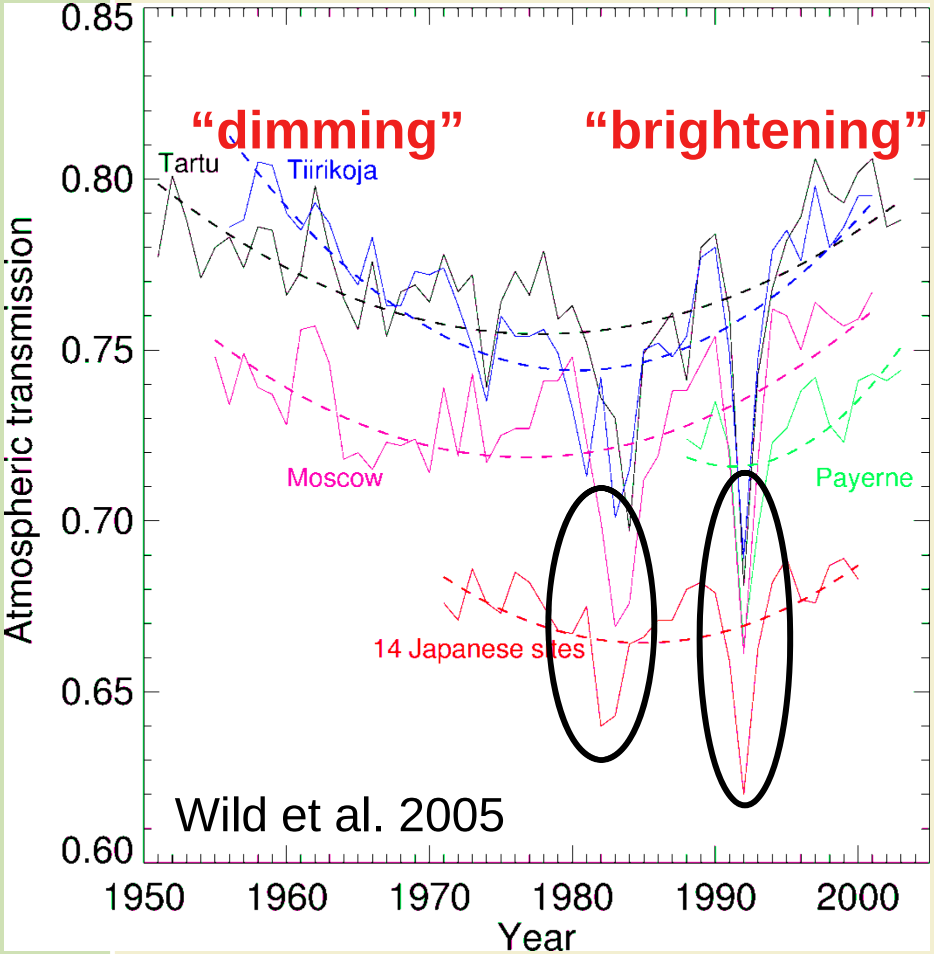
Olivier Boucher[2], Chris Huntingford[1] and Peter Cox[3] .

(1) CEH Wallingford, (2) Met Office and (3) University of Exeter

Background

Modelling the Impact of **Radiation Changes** on the Terrestrial Carbon Sink



Decrease in surface radiation (1950-1980)

Stanhill and Cohen 2001, Liepert 2002, Wild et al 2005

Subsequent increase radiation (1980-2000) **Wild et al 2005, 2007**

Linked to anthropogenic aerosol emissions

Solar global irradiance=
Direct global + Diffuse global

Evidence of changing diffuse component of global irradiance

Volcanic eruptions
El Chichón 1982 and Pinatubo 1991

Background

Modelling **the Impact** of Radiation Changes **on the Terrestrial Carbon Sink**

Measurements have shown plant productivity increases with increasing diffuse fraction (Rd/Rg)

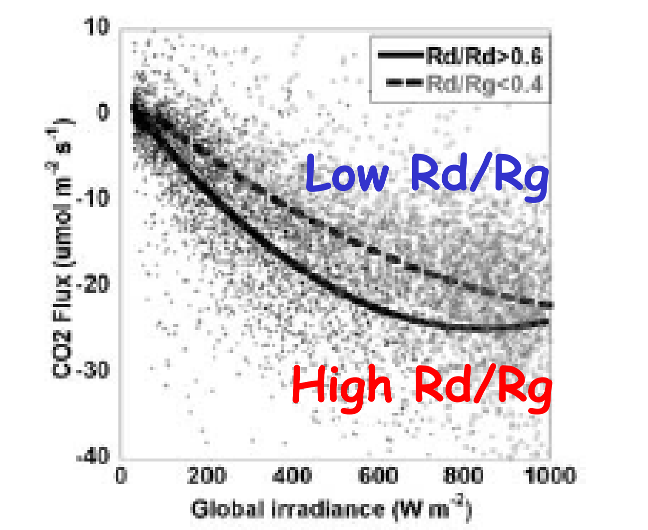
Measurements at different sites

Temperate forest , Gu et al. 2003

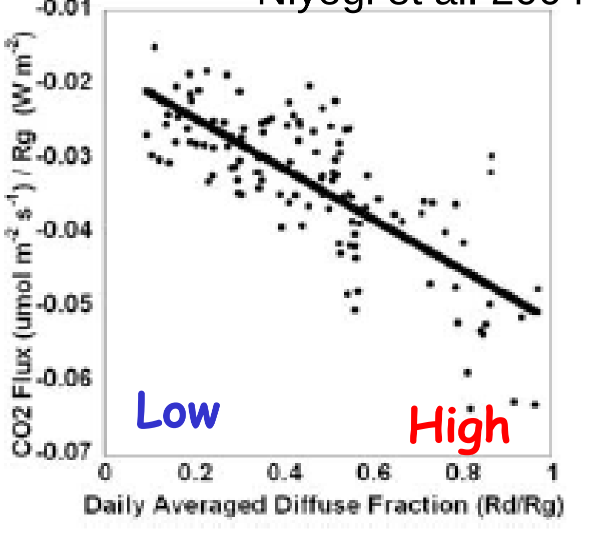
Temperate forest and crop lands, Niyogi et al. 2004

Tropical Amazon forest, Oliveira et al.2007

Why?



Niyogi et al. 2004



Why? plant productivity increases with increasing diffuse fraction

Direct light- Clear sky

- Top of canopy – a lot of light
- Bottom of canopy- dark
- a lot of shadows

Diffuse light – Cloudy/aerosol laden sky

- More light at the bottom of the canopy
- Illumination of canopy more uniform
- Less shadows

Main question of this study

-1. Is there an enhancement of the land C sink due to more efficient photosynthesis under increased diffuse irradiance ?

-During Post-Pinatubo event

-Global dimming & brightening periods

-2. What happens to the land C sink under a future scenario in which anthropogenic aerosols are likely to decrease ?

Method

Model : Modified -Land surface scheme of the Met Office GCM
Takes into account effects of changes of diffuse/direct radiation on photosynthesis

Forcing : CRU Climatology (Temperature, precipitation, cloud cover)

UK Met Office GCM reconstruction
Radiation SW and PAR direct and diffuse
Tropospheric (5 species) & stratospheric aerosols (*GISS*)

Model Validation: 2 Eddy correlation flux data sites where diffuse irradiance measurements available
21 sites (not observed diffuse irradiance)

Terminology

Net ecosystem exchange= NEE=NPP-RH

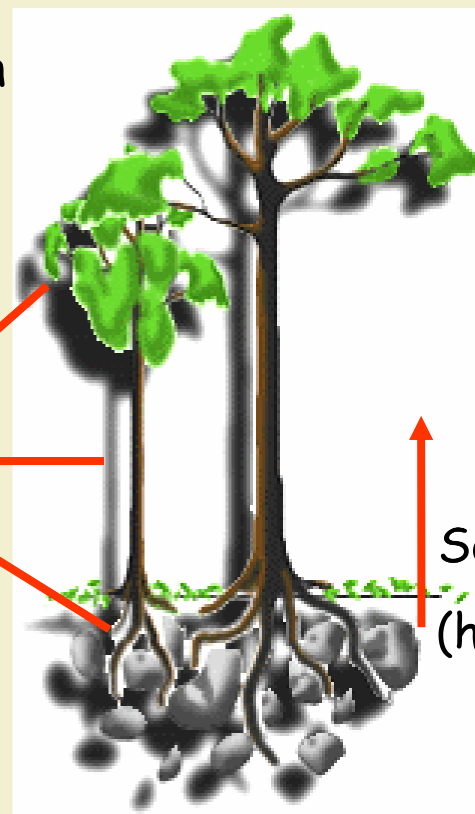
NPP RH

Photosynthesis

CO_2

Net Primary productivity (NPP)=

Photosynthesis-Plant respiration



Plant respiration

CO_2

CO_2

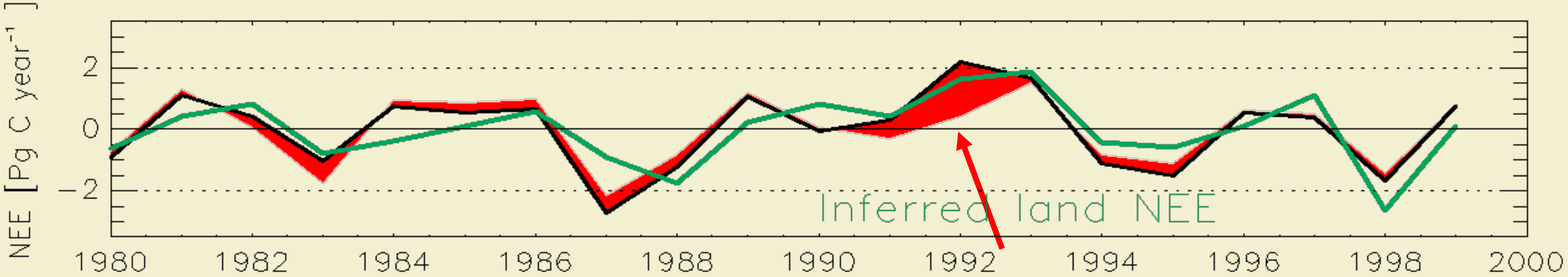
Soil respiration

(heterotrophic)

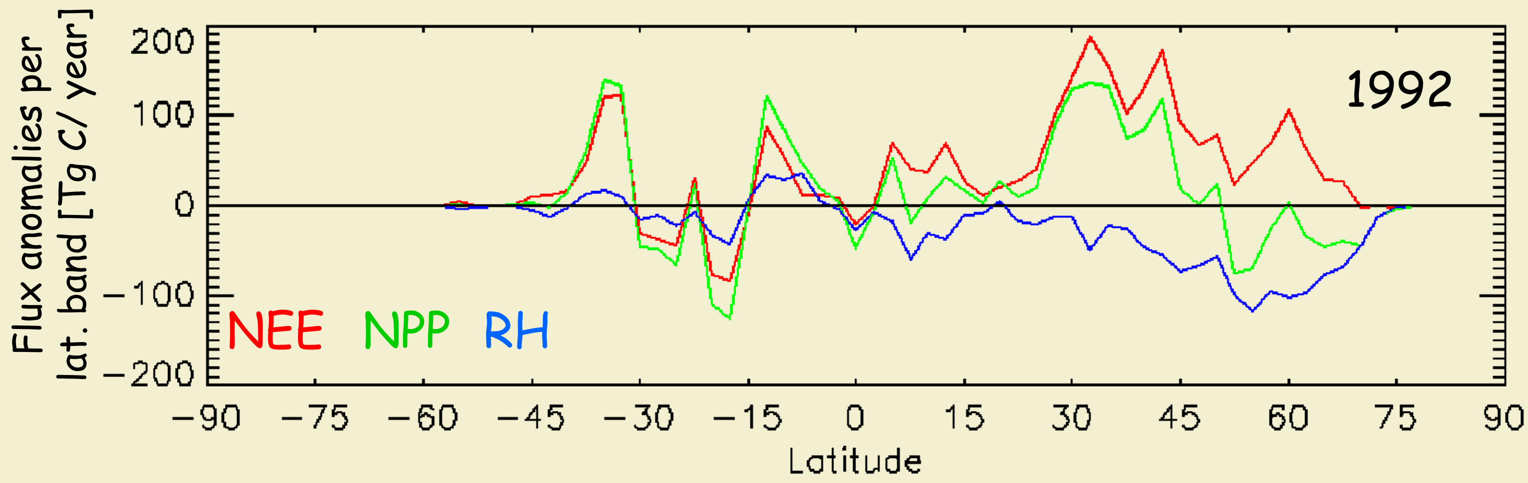
RH

Results 1: Impact of radiation changes-on land C sink after the Pinatubo eruption

Global flux detrended flux anomalies
Constant and variable diffuse fraction



Results 1: Impact of radiation changes- on land C sink after the Pinatubo eruption



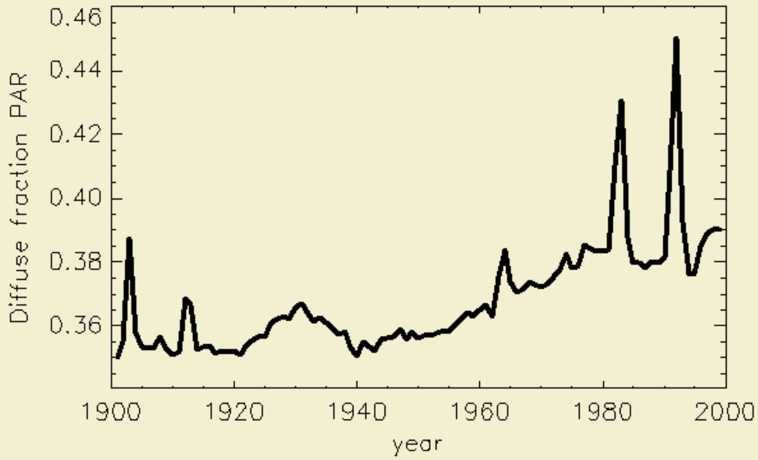
Land sink : NEE -92 (Temperate 50%, Tropics and SH 30% ,boreal 20%)

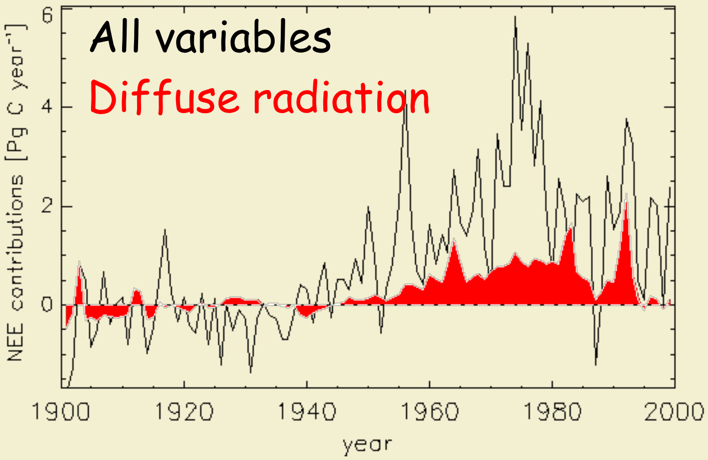
Consistent with (Cias et al. 1995, Battle et al. 2000 , Rodenbeck et al. 2003, Lucht et al. 2002)

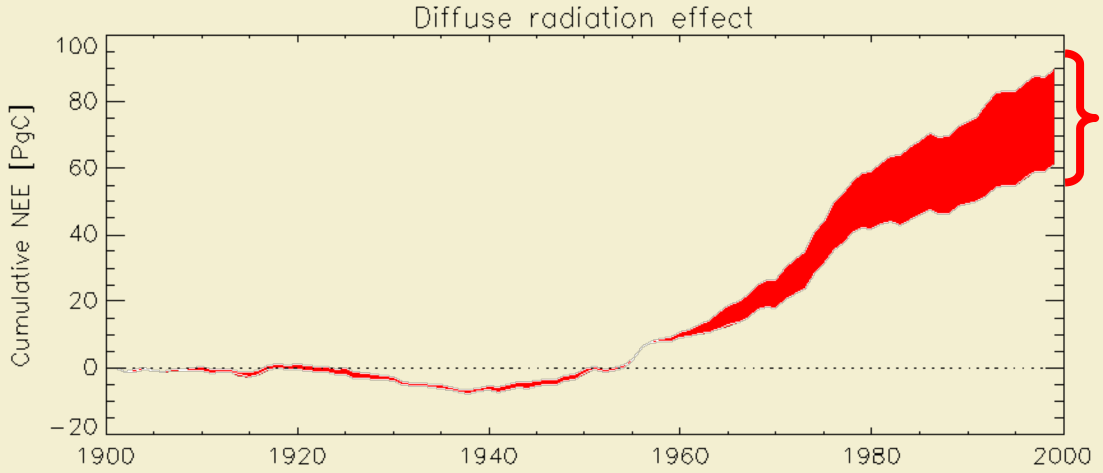
Combination of effects :Temperature on RH and diffuse irradiance on NPP

Results 2: Impact of radiation changes – dimming & brightening – on land C sinK

Global Level







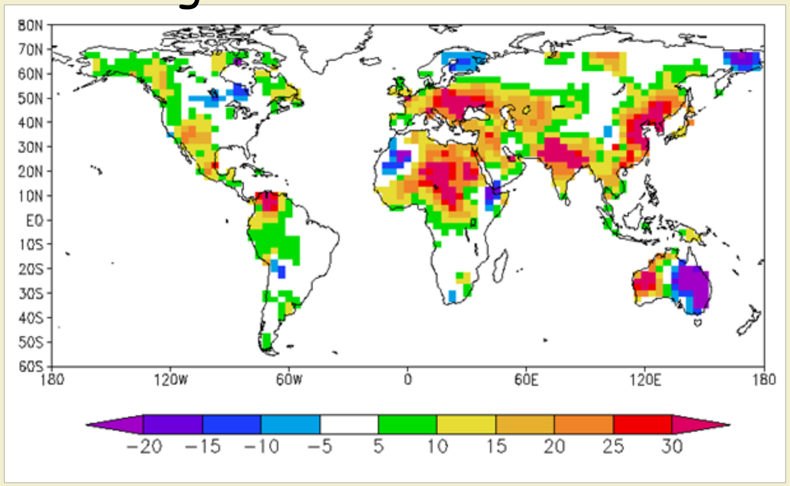
32% of accumulated Land sink is due to diffuse radiation effects on photosynthesis

Results 2: Impact of radiation changes dimming-brightening on land C sink

Regional level

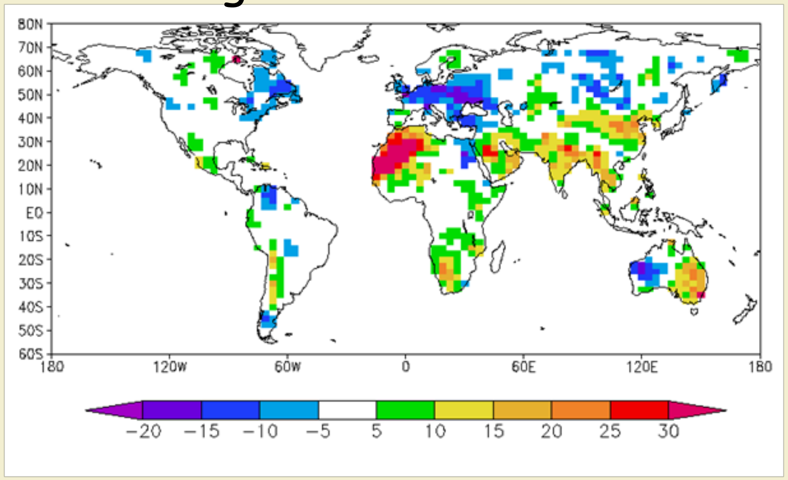
Global dimming period

% change in diffuse fraction

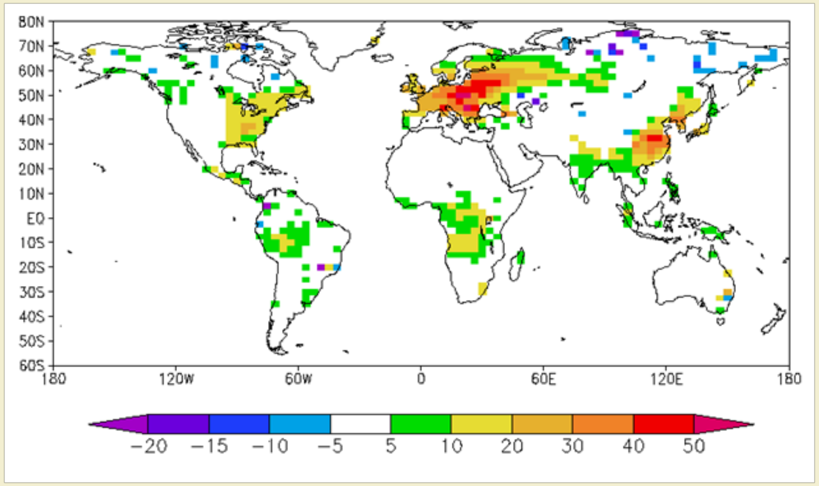


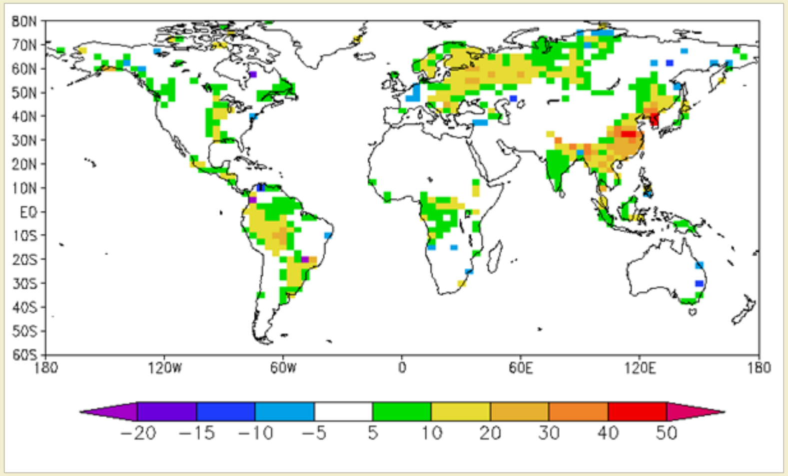
Global brightening period

% change in diffuse fraction

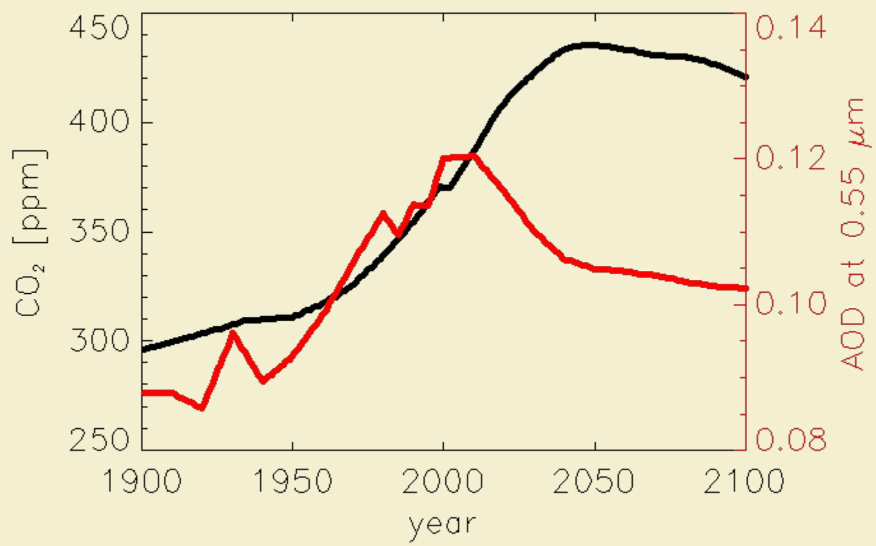


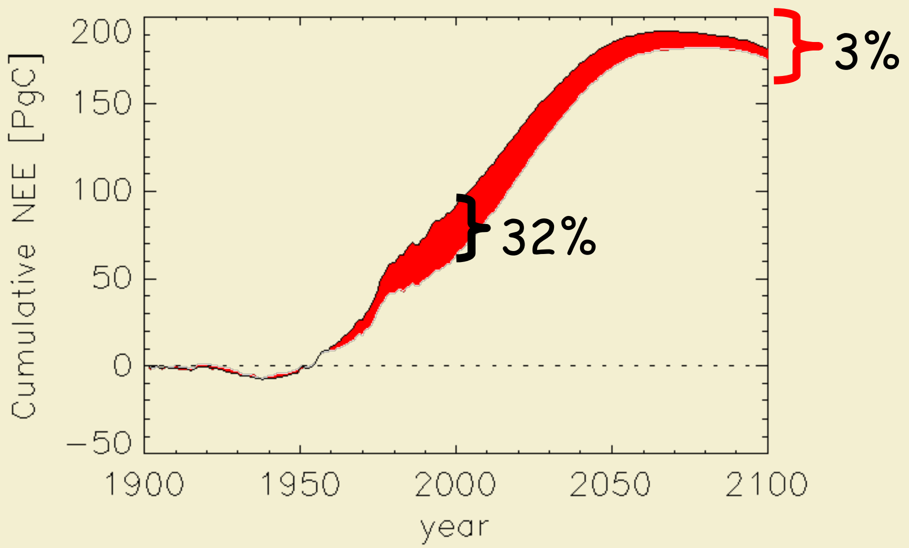
Contribution of diffuse fraction change to land carbon accumulation [g C m^{-2} $year^{-1}$]





Results 3: Impact of radiation changes on future land C sink





Future AOD emissions- (Ensembles A1B-450)

Green house and aerosol forcing

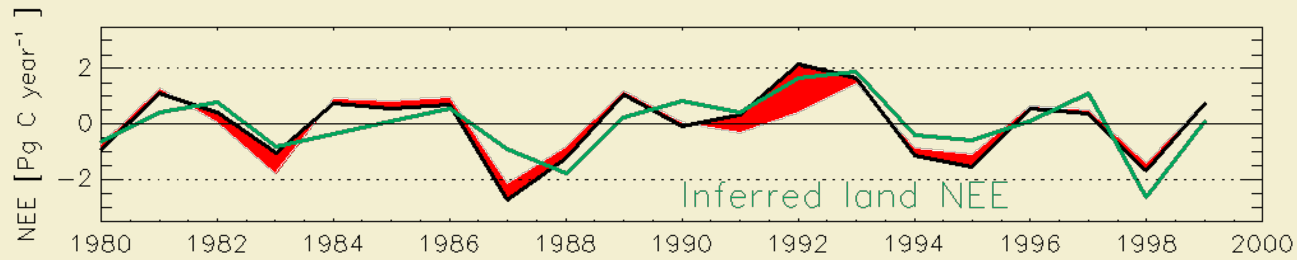
stabilize at 450 ppmv CO_2 equivalent

Contribution of diffuse radiation

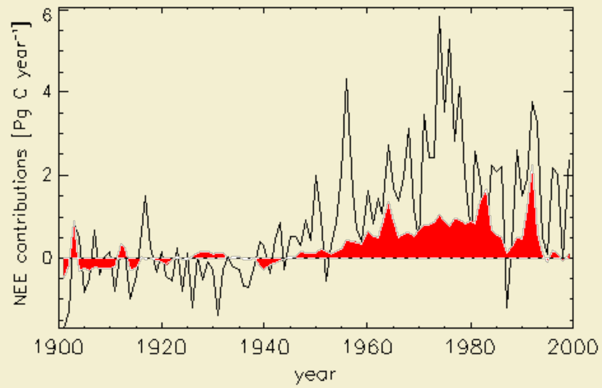
to Land C sink decreases

Summary

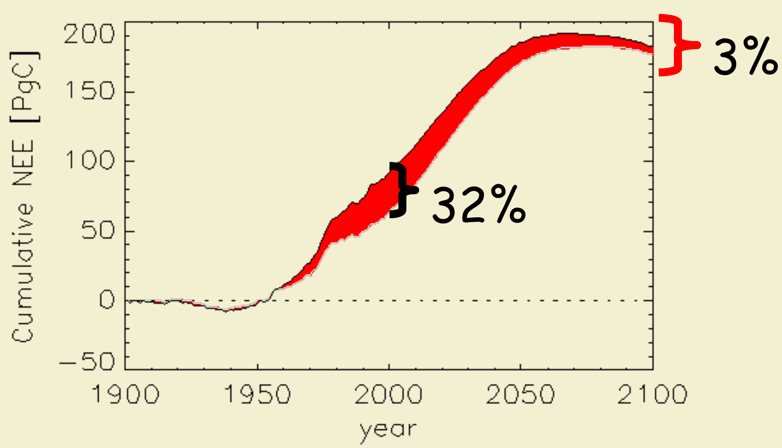
Large contribution to observed Post-Pinatubo land C sink from diffuse radiation fertilization on plants.



Global dimming & brightening contributing to decrease and in increase land C sink respectively.



Diffuse radiation contribution to land C sink will decrease under decreased aerosol emissions.



Model Validation: 2 Eddy correlation flux data sites where diffuse irradiance measurements available

20 sites (not observed diffuse irradiance)