GeoMIP simulations using CAM4

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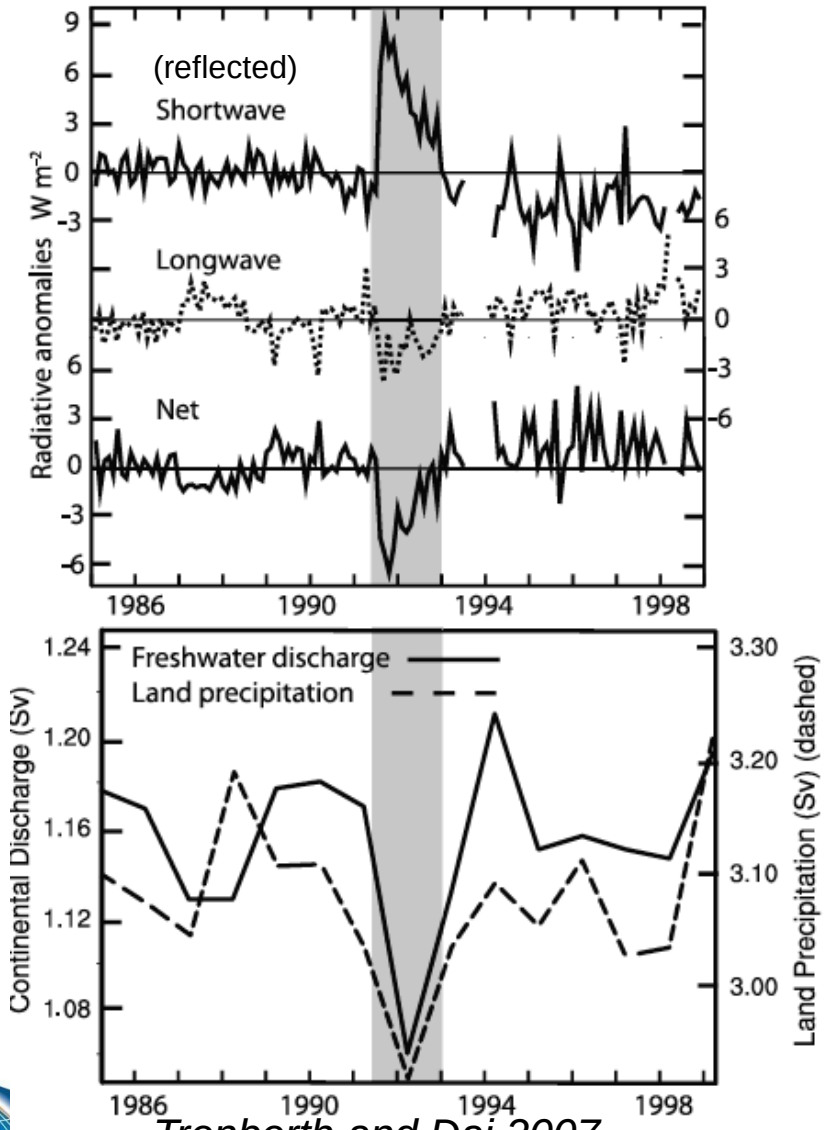
- Motivation
- GeoMIP experiments
- Impact on Surface Temperatures
- Impact on Precipitation

Motivation

20°S-20°N



Trenberth and Dai 2007

Decrease of Precipitation after major volcanic eruption as a result of:

Reduction of solar radiation:

- Cooling of the surface
- Reduction of evaporation and latent heat release
- Reduction of precipitation
- Droughts and reduced fresh water resources

Increased greenhouse gases:

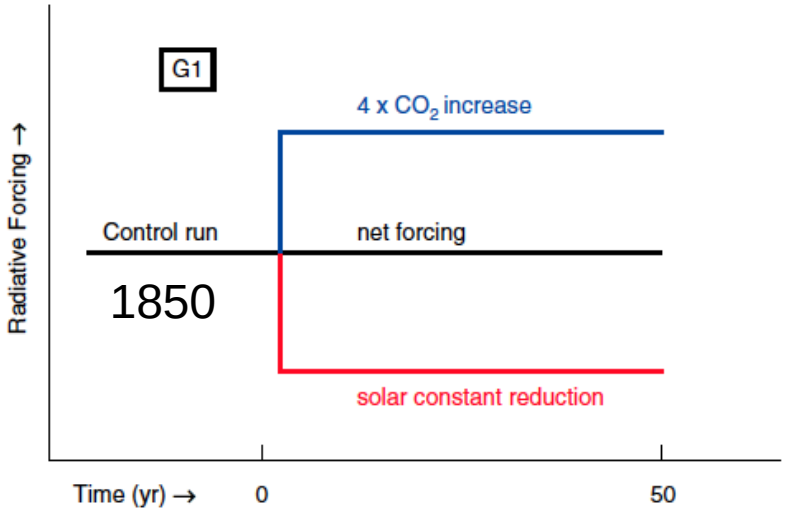
- Increased temperature -> more RH in the air (Clausius-Clapeyron) 7%RH per 1K
- More intense precipitation, while reduction of frequency and duration
- Droughts

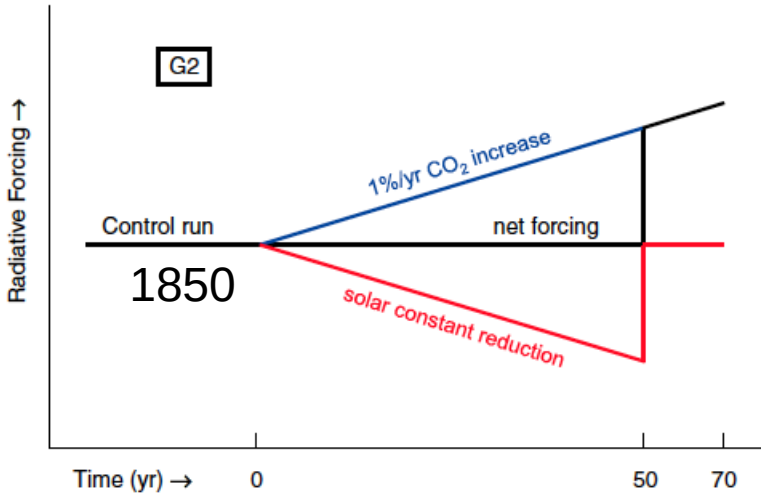
What is the impact of Solar Dimming in a future climate?

GEOMIP Simulations

Four proposed experiments: G1-G4

G1, G2: balancing incoming LW forcing with reduced SW forcing (reduction of solar constant)





G1: Baseline: CMIP5 4xCO_2, **Geoeng**.: radiative forcing will be balanced (model specific based on the planetary albedo)

G2: Baseline: CMIP 1% /yr CO_2 increase, **Geoeng.**: derived from G1 experiment

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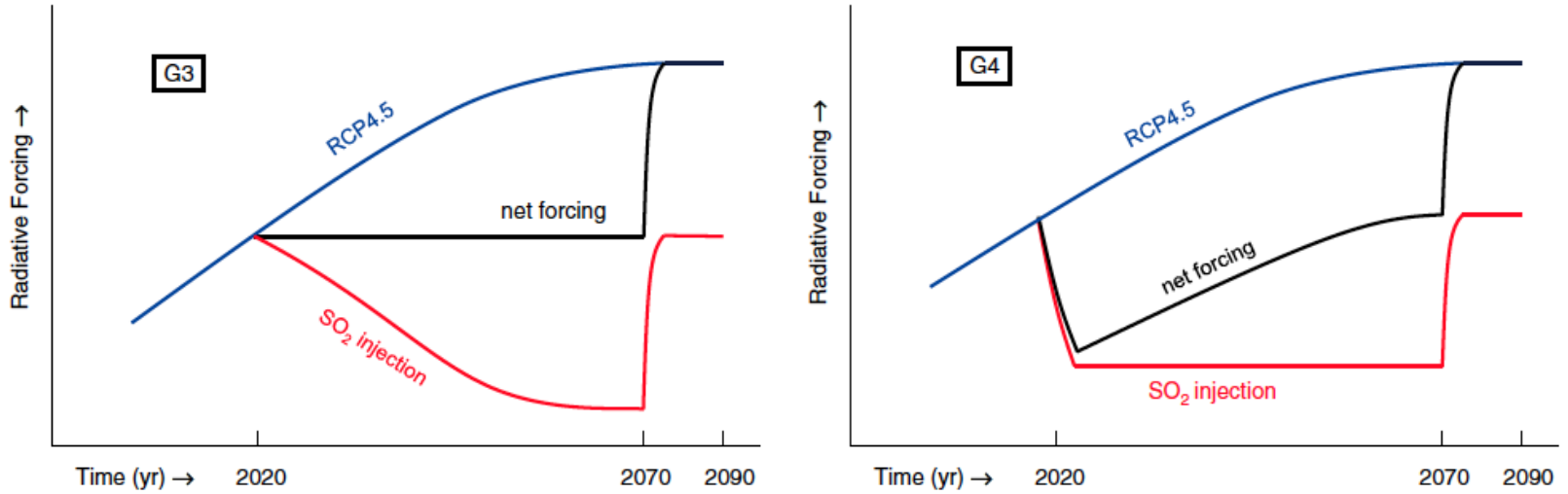
GEOMIP Simulations

G3, G4: balancing incoming LW forcing with stratospheric aerosol injection

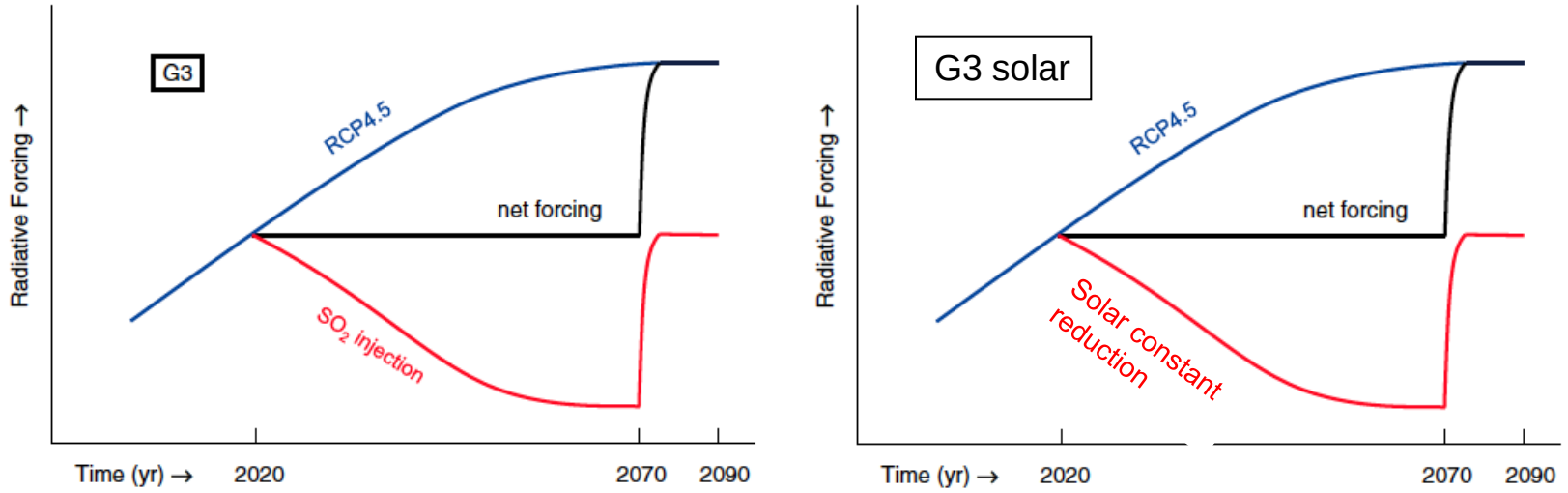


G3: Baseline: RCP4.5, **Geoeng.:** stratospheric aerosols in 2020 to balance are to be increased gradually, equatorial injection)

G4: Baseline: RCP4.5, **Geoeng.:** fixed aerosol injection of 5 Tg SO_2 per year, after 50 years, stop of injection

GEOMIP Simulations

G3, G4: balancing incoming LW forcing with stratospheric aerosol injection

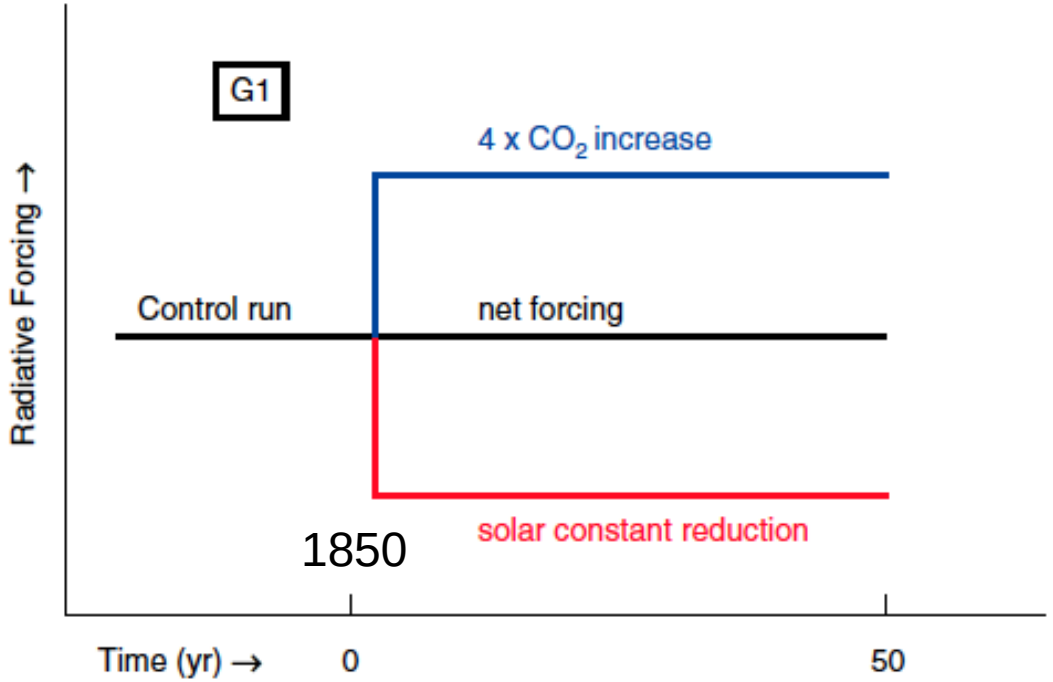


G4: Baseline: RCP4.5, **Geoeng.:** fixed aerosol injection of 5 Tg SO_2 per year, after 50 years, stop of injection

G3: Baseline: RCP4.5, **Geoeng.:** stratospheric aerosols in 2020 to balance are to be increased gradually, equatorial injection)

GEOMIP Simulations

G1 Simulations completed with CESM4 (0.9x1.25x26L), coupled ocean



Krawitz et al, 2010

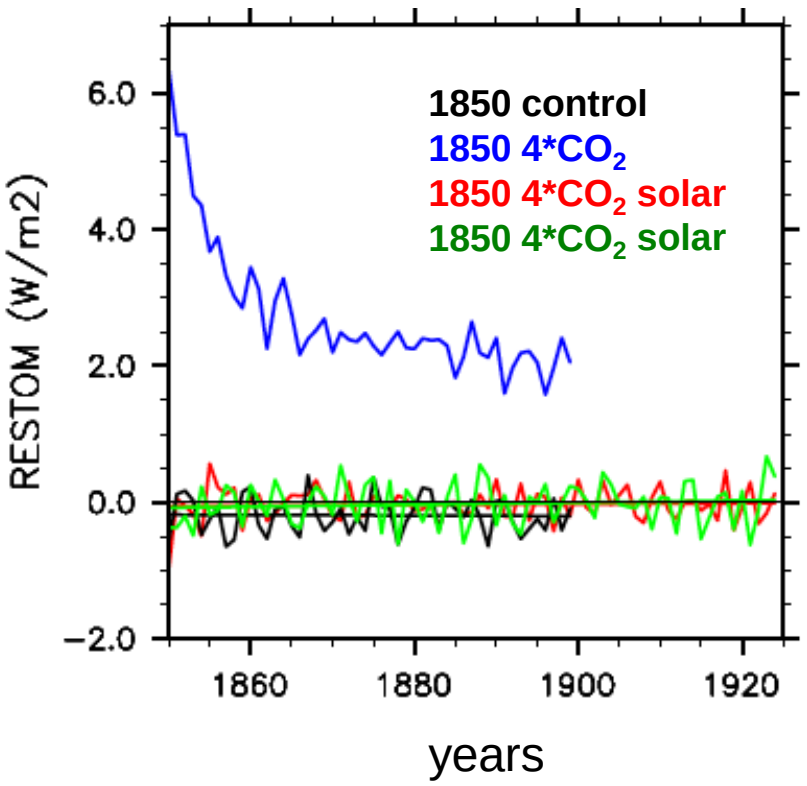
Idealized Experiment:

- No impact of aerosols
- No changes in chemistry
- No changes in BGC

Solar constant reduction: radiative forcing will be balanced (model specific based on the planetary albedo)

Balancing Radiative Forcing

SW+ LW: Residual on Top of the Atmosphere



4 x CO_2:
solar constant: 1360.89 W/m^2
CO_2: 1138.8e-06
RESTOM 1st year: 7.2 W/m^2

4 x CO_2 solar:
radiative forcing (RF) balanced:
RF= S/4 * (1-albedo)
S: solar constant reduction
-> S = 41.3 W/m^2 ,albedo = 0.3
not sufficient!

Balance:
Solar Constant = 55.8 W/m^2
CMIP5 4xCO_2, solar constant: 1305.09 (reduction of 4.1%)

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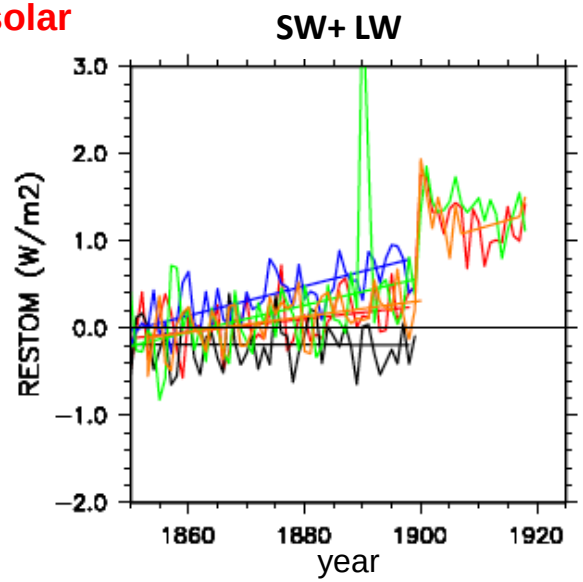
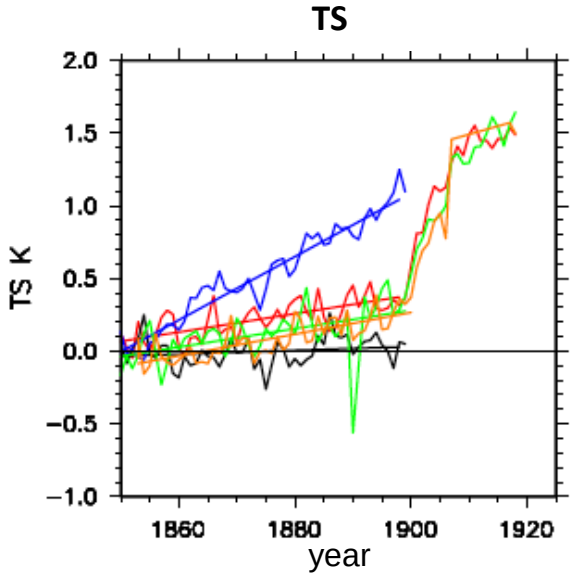
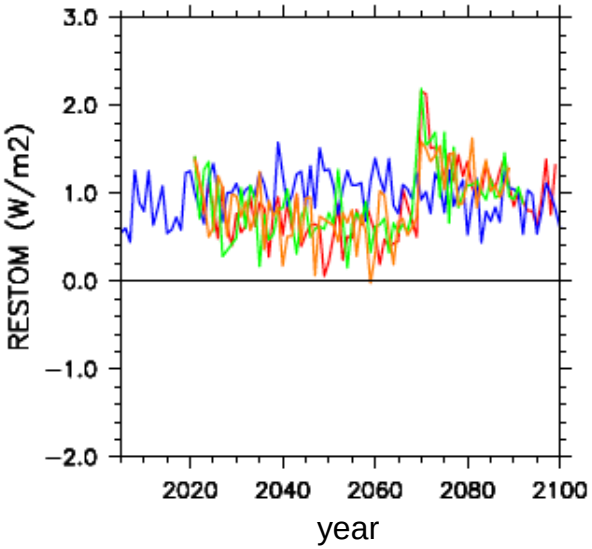
1850 control
1850 1% CO_2
1850 1% CO_2 solar

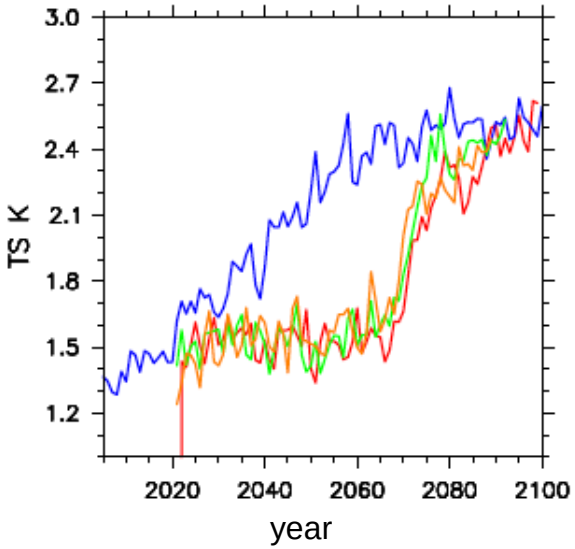
G2 Simulation





G3 solar Simulation





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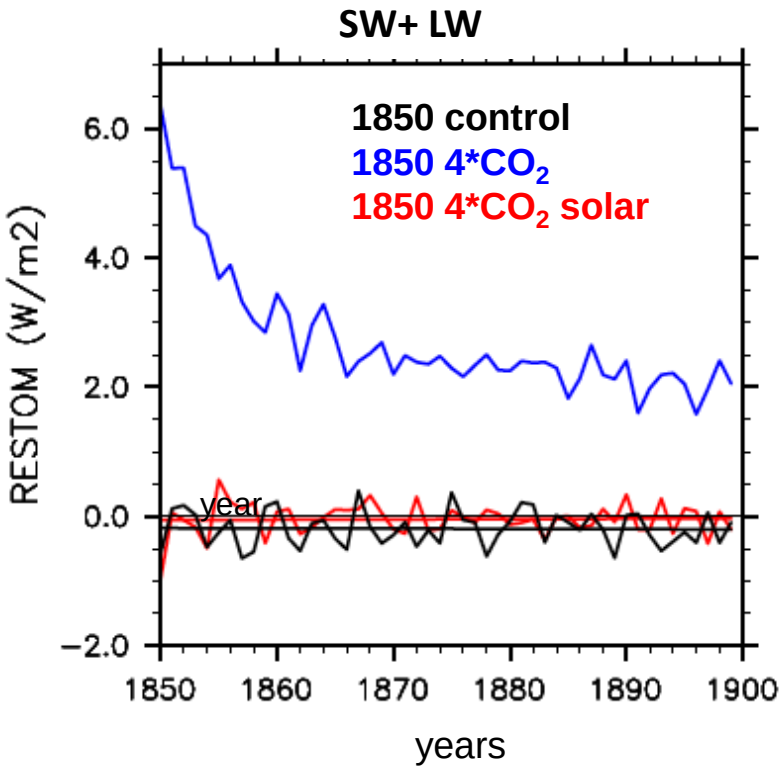
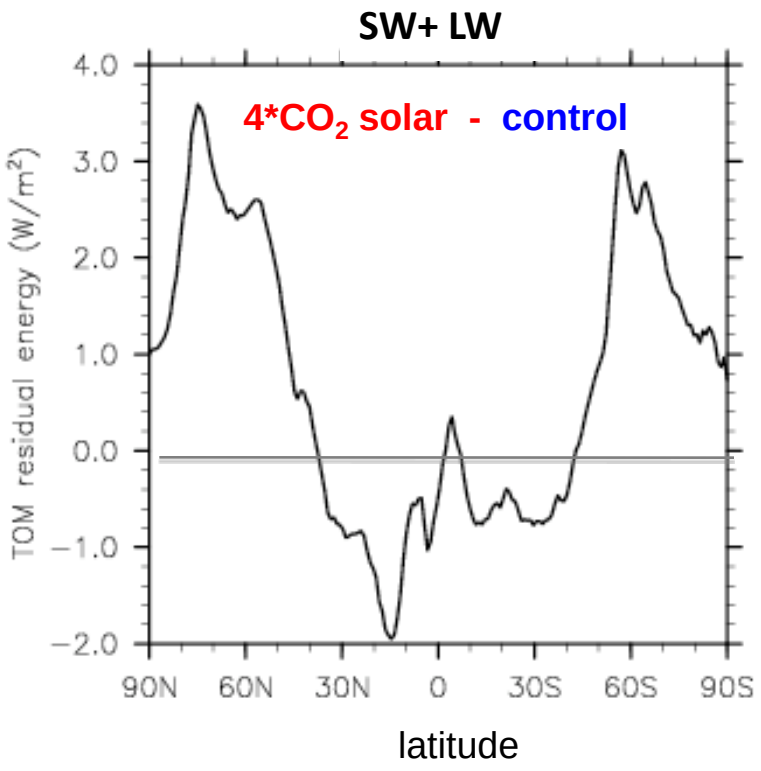
Balancing Radiative Forcing





Zonal response: RESTOM is not balanced.
-> Cooling in the Tropics and a heating in the middle and high latitudes

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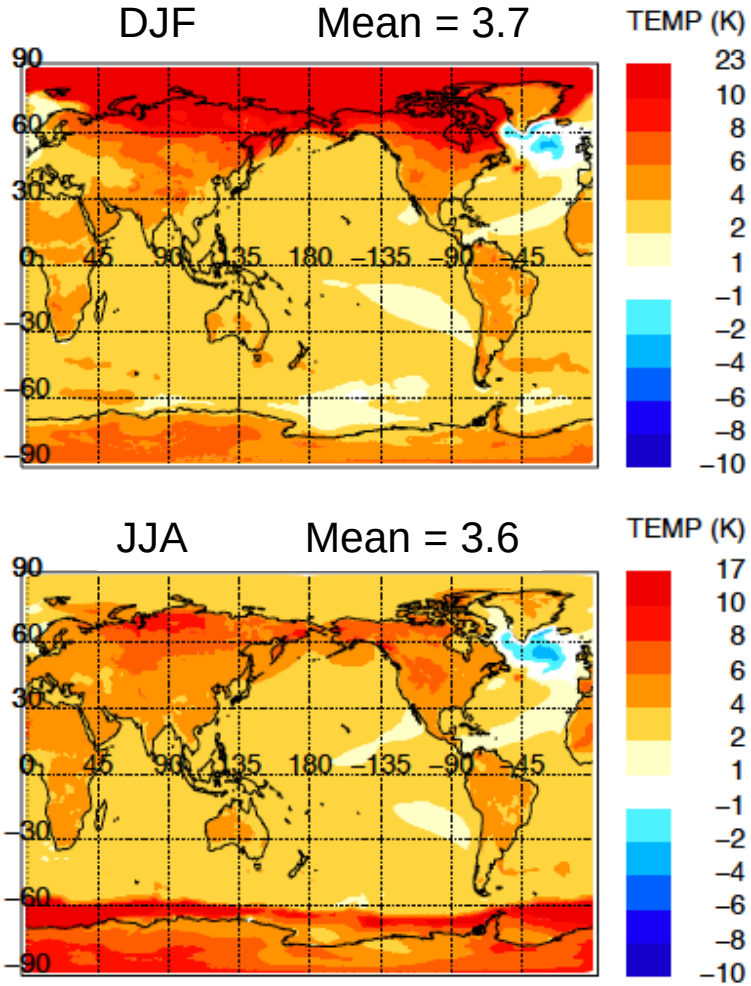
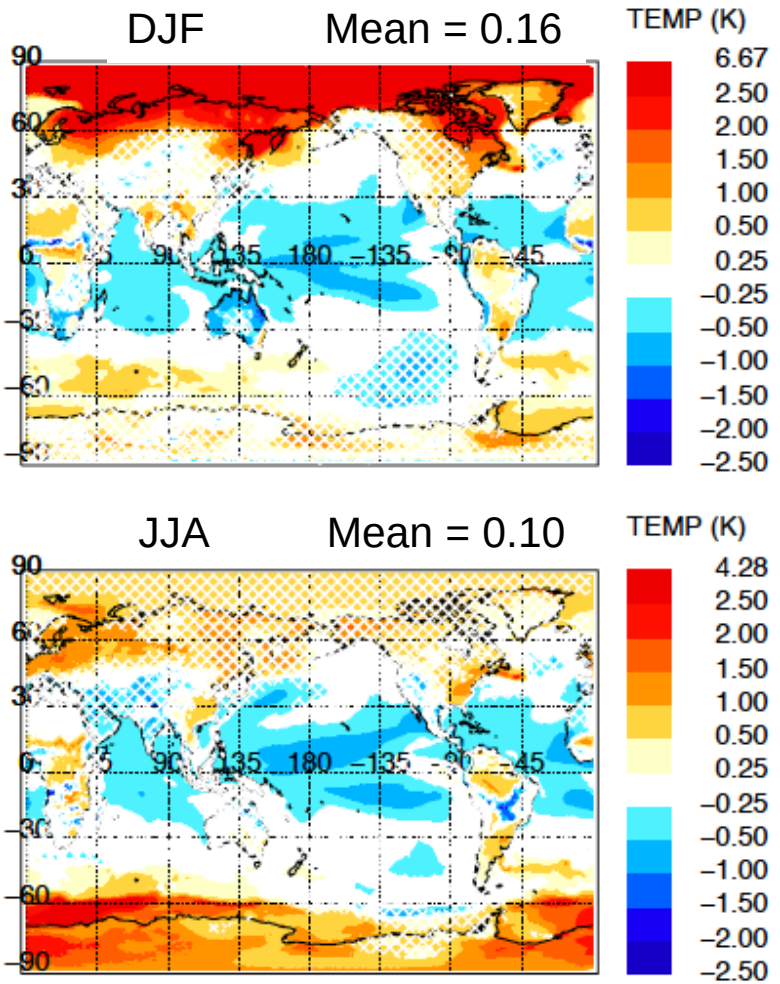
Temperature Response

$4*CO_2$ – 1850 control



$4*CO_2$ solar - 1850 control



Hatched areas are not significant at 95% level based on Student's t test.

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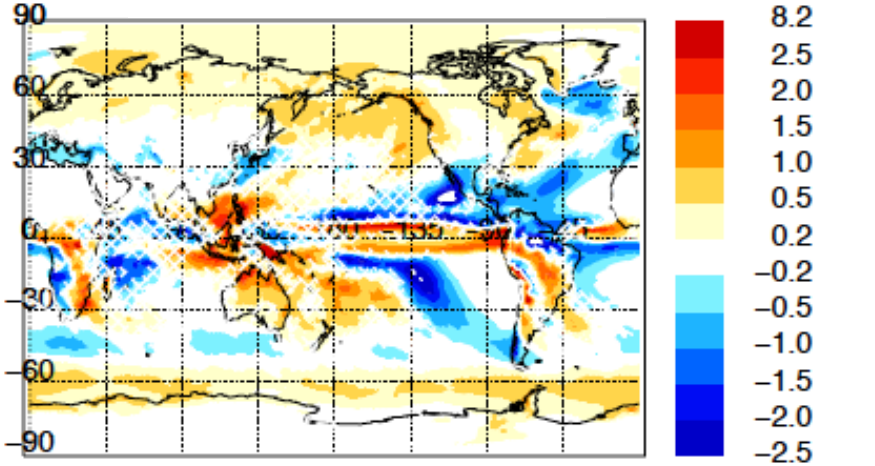
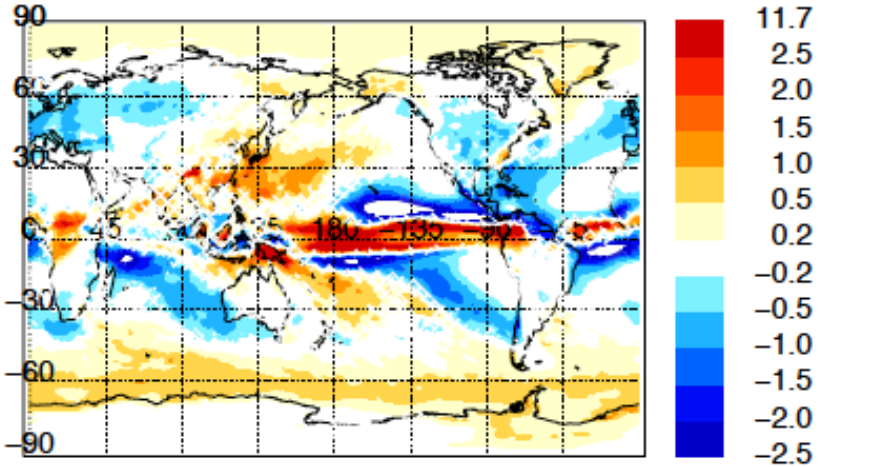
Precipitation Response

$4*CO_2$ – 1850 control

DJF Mean = 0.19

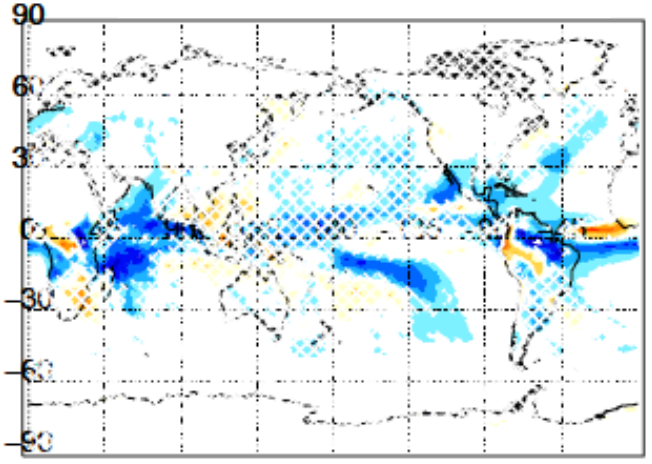


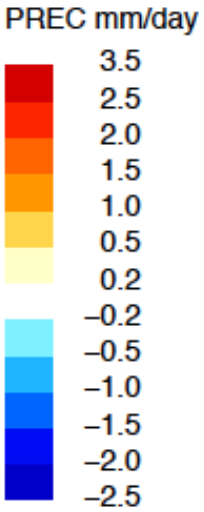
JJA Mean = 0.15



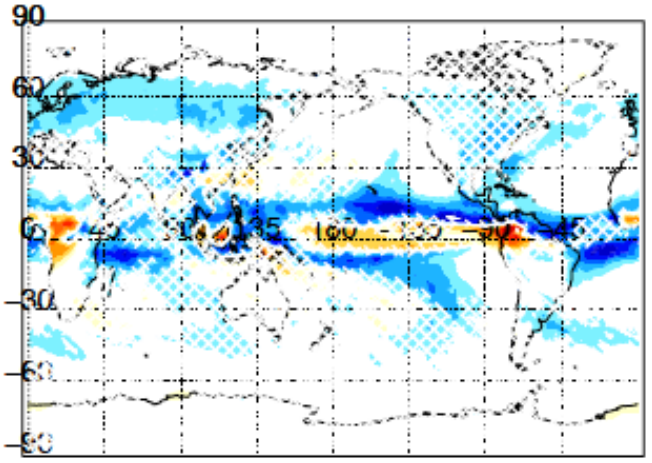
$4*CO_2$ solar - 1850 control

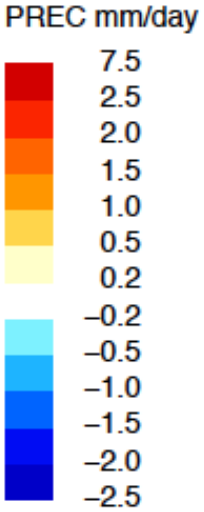
DJF Mean = -0.18





JJA Mean = -0.23





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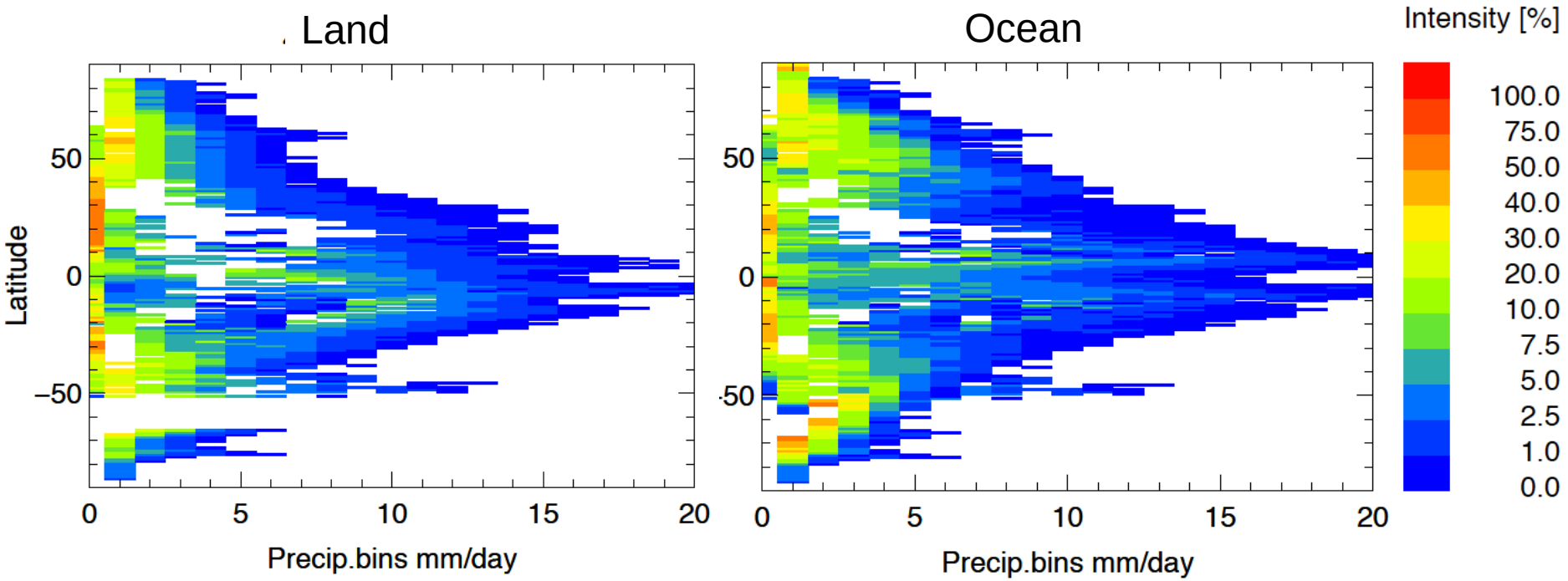
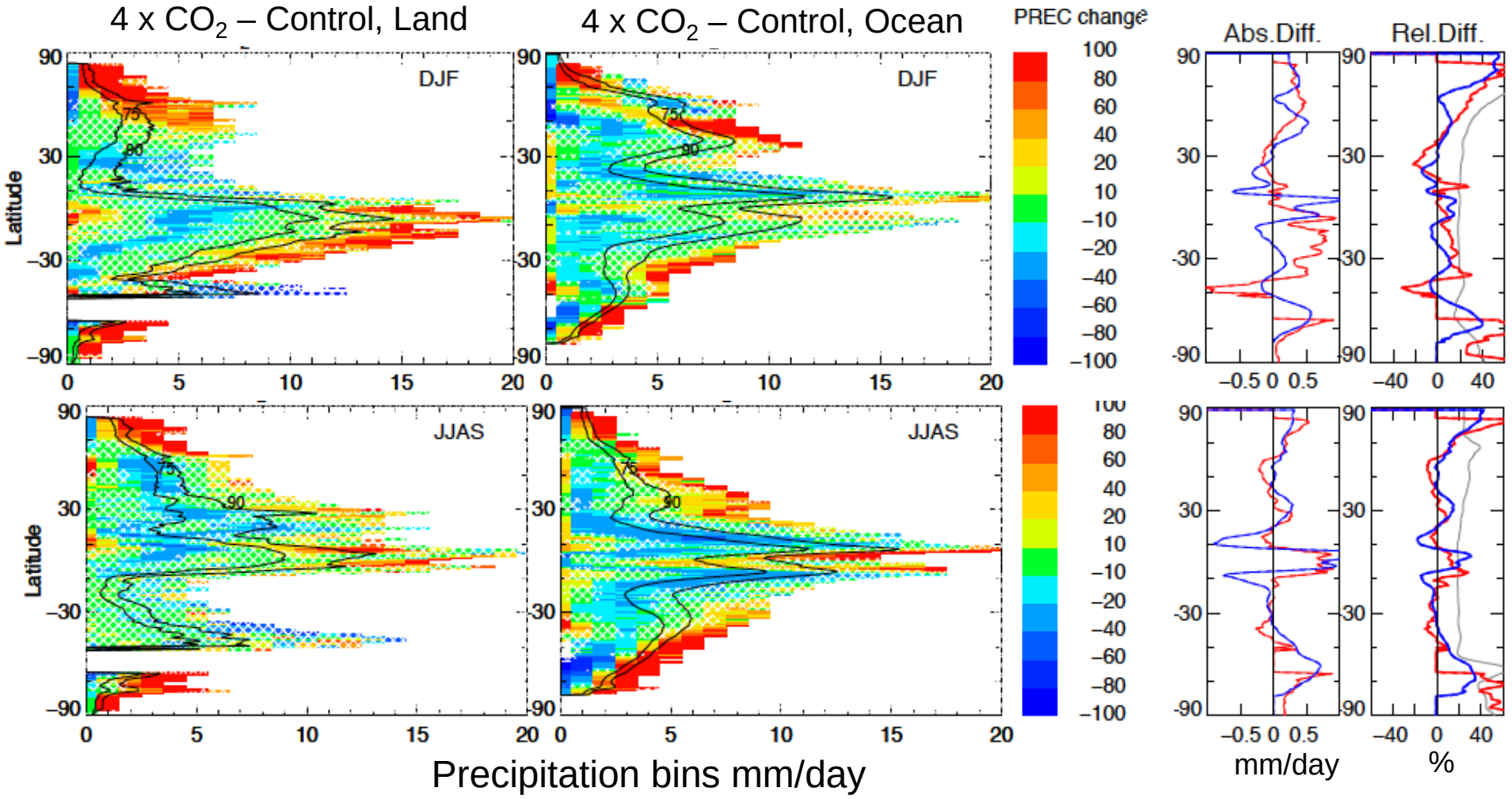
Precipitation Intensity



Base state: Land/Ocean precipitation intensity different. Land-Sea contrast of precipitation trends in climate models more robust than mean changes.

Precipitation Response



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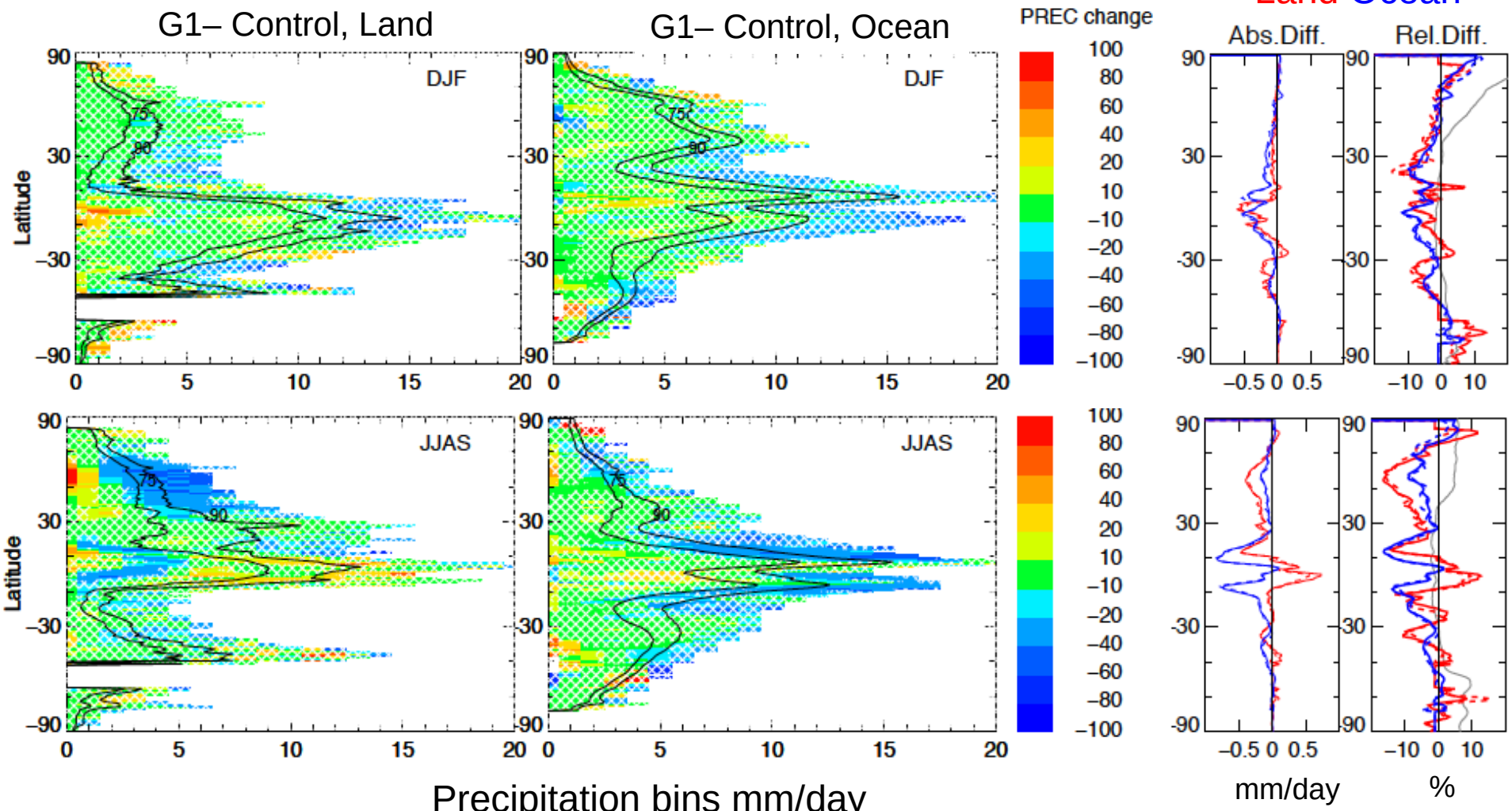
Precipitation Response



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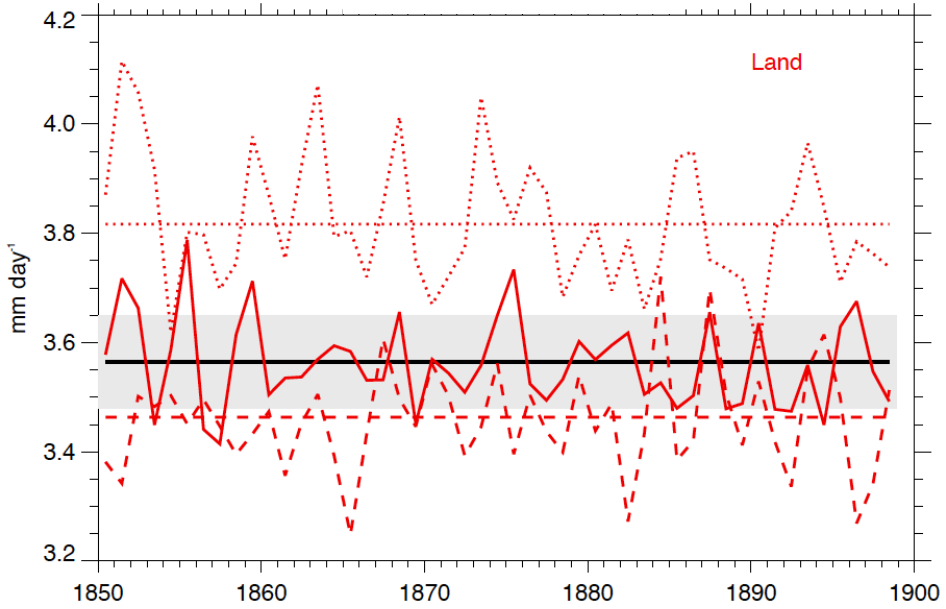
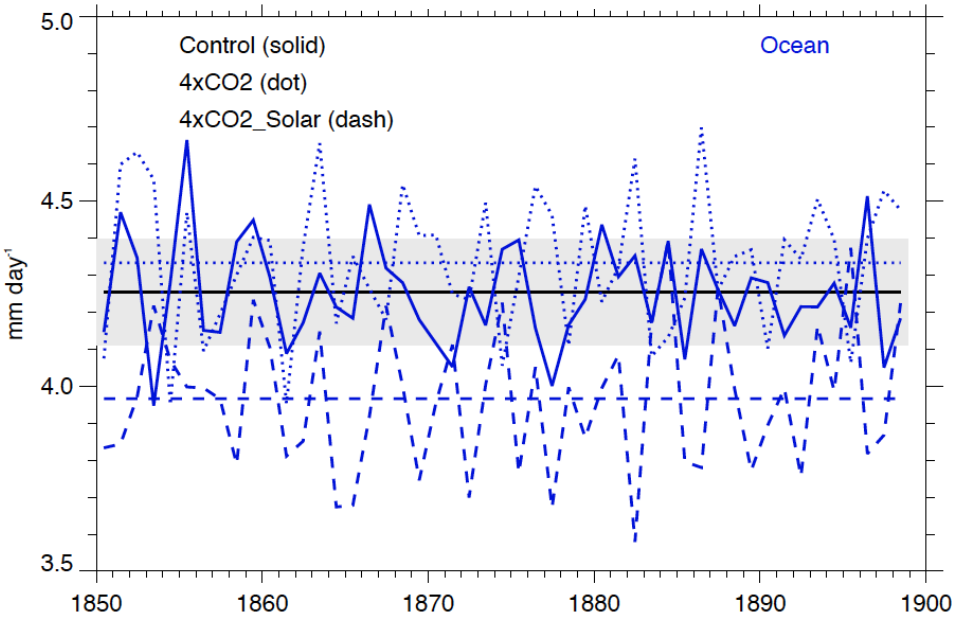
Global Monsoon Rainfall

Land



Control: solid
4xCO2: dot
G1: dashed

Ocean



4xCO$_2$: pronounced increase of precipitation over land and not significant increase over the ocean
G1: pronounced decrease over the ocean, smaller but significant decrease over land

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Next Steps

- Comparison to G2 (slowly increasing greenhouse gases) and G3 solar (future scenarios)
- Different answers with tropospheric chemistry, and bio-geo-chemistry?
- Different answers using WACCM CARMA?