German contribution to CMIP5

MPI-M / DKRZ / BMBF

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Model configurations

- **MPI-ESM** = ECHAM6/MPIOM
  Main differences to ECHAM5/MPIOM used for CMIP3
  - C-cycle, land: JSBACH, ocean: HAMOCC
  - Stratosphere resolved up to 0.01 hPa

- MPI-ESM-LR: “long term”, “near term”, “diagnostic”
  - Atmosphere: T63/1.9°, 47 levels to 1Pa
  - Ocean: bi-polar grid, 1.5°, 40 levels
  - Land: Dynamic vegetation maps

- MPI-ESM-P: “paleo”
  - As MPI-ESM-LR, but with prescribed vegetation maps

- MPI-ESM-MR: “long term”, “near term”, “diagnostic”
  - Atmosphere: T63/1.9°, 95 levels to 1Pa → QBO
  - Ocean: tri-polar grid, 0.4°, 40 levels → smaller SST biases
  - Land: Dynamic vegetation maps

CMIP5 simulations

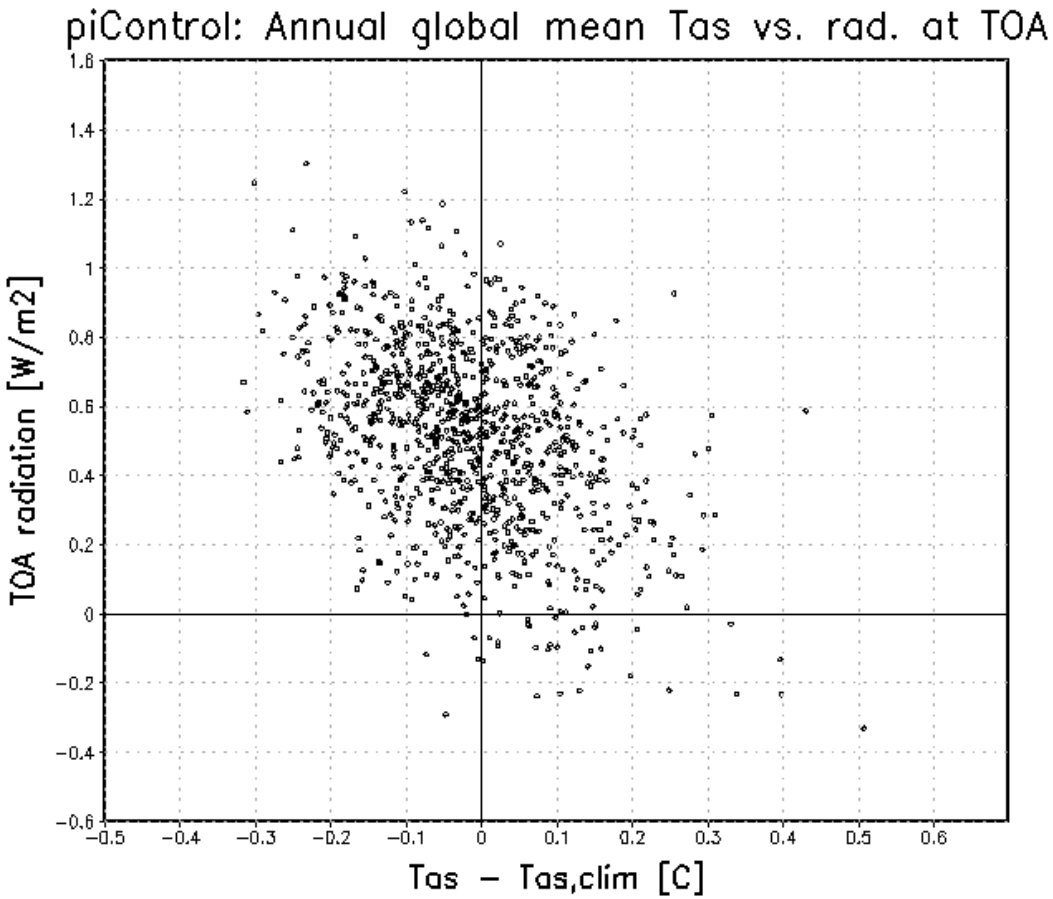
published done running/scheduled

- MPI-ESM-LR
  - amip(3x), amip4xCO2
  - piControl, 1pctCO2, abrupt4xCO2, sstClim, sstClim4xCO2
  - historical(3x), rcp45(3x2100, 1x2300), rcp26(3x…), rcp85(3x…)
  - esmControl, esmHistorical, esmRCP85, esmFdbk1, esmFixClim1
  - decadalYYYY(10x"original start dates", 3x"new start dates")
  - aquaControl, aqua4xCO2, aqua4K
  - Other MIPs: GeoMIP, LUCID
- MPI-ESM-P
  - piControl, 1pctCO2, abrupt4xCO2, sstClim, sstClim4xCO2
  - historical
  - lgm, midHolocene, past1000 (+extended to 2005)
- MPI-ESM-MR
  - amip, amip4xCO2
  - piControl, 1pctCO2, abrupt4xCO2, sstClim, sstClim4xCO2
  - historical(3x), rcp26, rcp45, rcp85
  - decadalYYYY(3x"all start dates")
  - aquaControl, aqua4xCO2, aqua4K

A few results

- Stability of the 1850 control run
- Climate sensitivity
- Transient climate response
- Hydrological sensitivity
- Arctic amplification
- Atlantic meridional overturning circulation
- Northern hemisphere sea ice
- Decadal prediction skill for T2m

Pre-industrial control “1850”



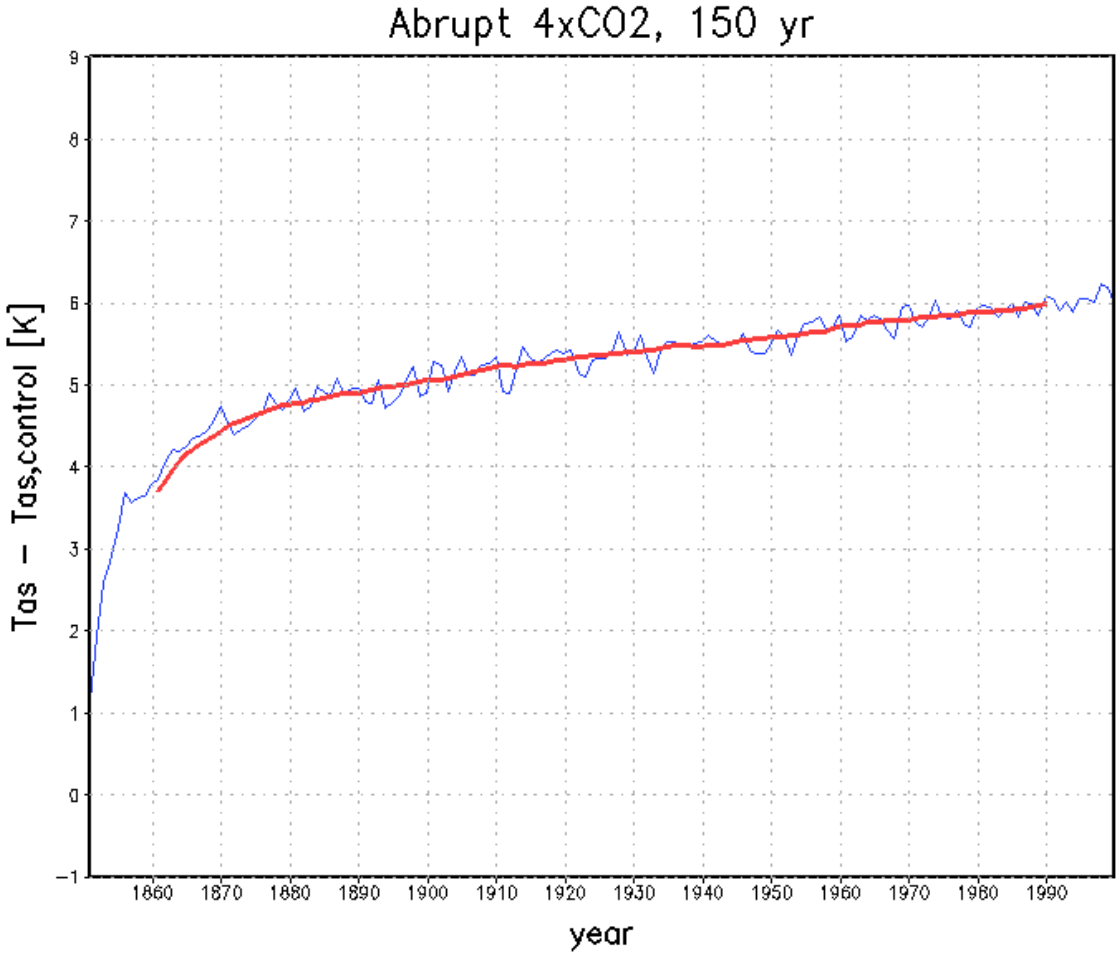
piControl 1000 years

Annual mean Temperature
mean = 13.5°C

TOA radiative forcing
SW 237.41 W/m^2
LW -236.89 W/m^2
Total 0.52 W/m^2

Equilibrium climate sensitivity

Abrupt $4xCO_2$ 150 years



Anomaly w.r.t. piControl

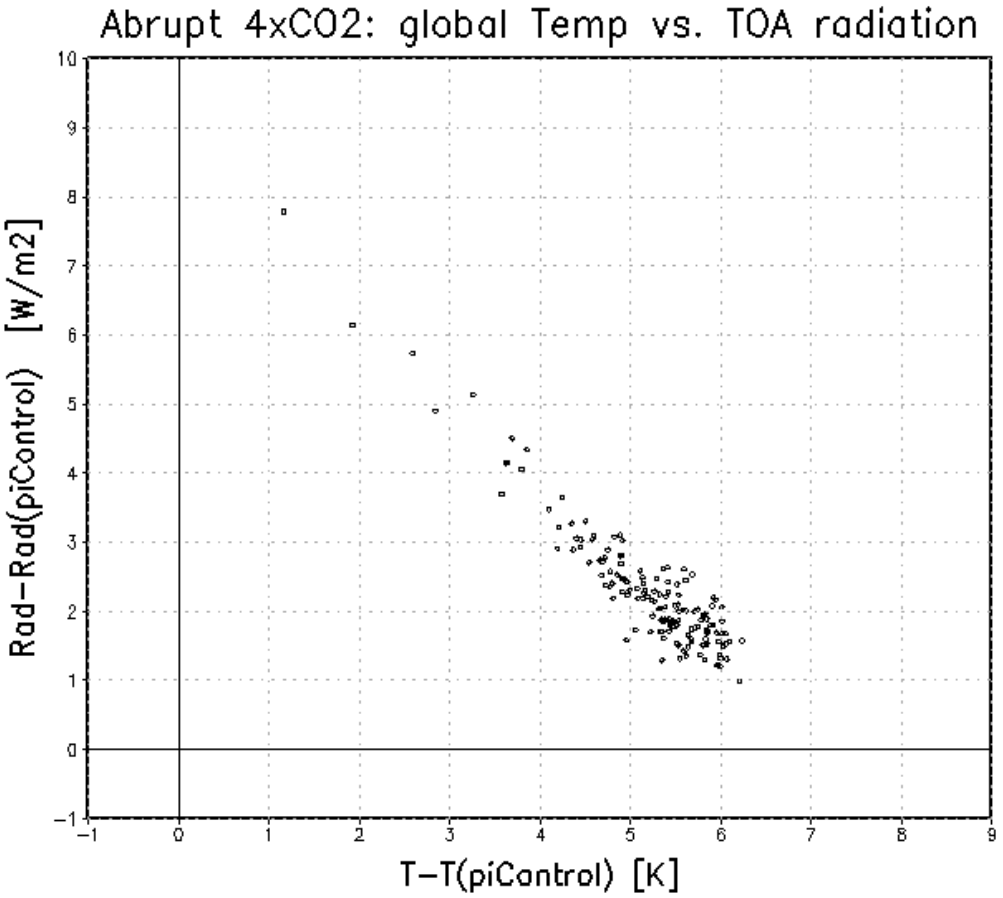
Annual mean

21 yr running mean

dT(150yr) = 6 K

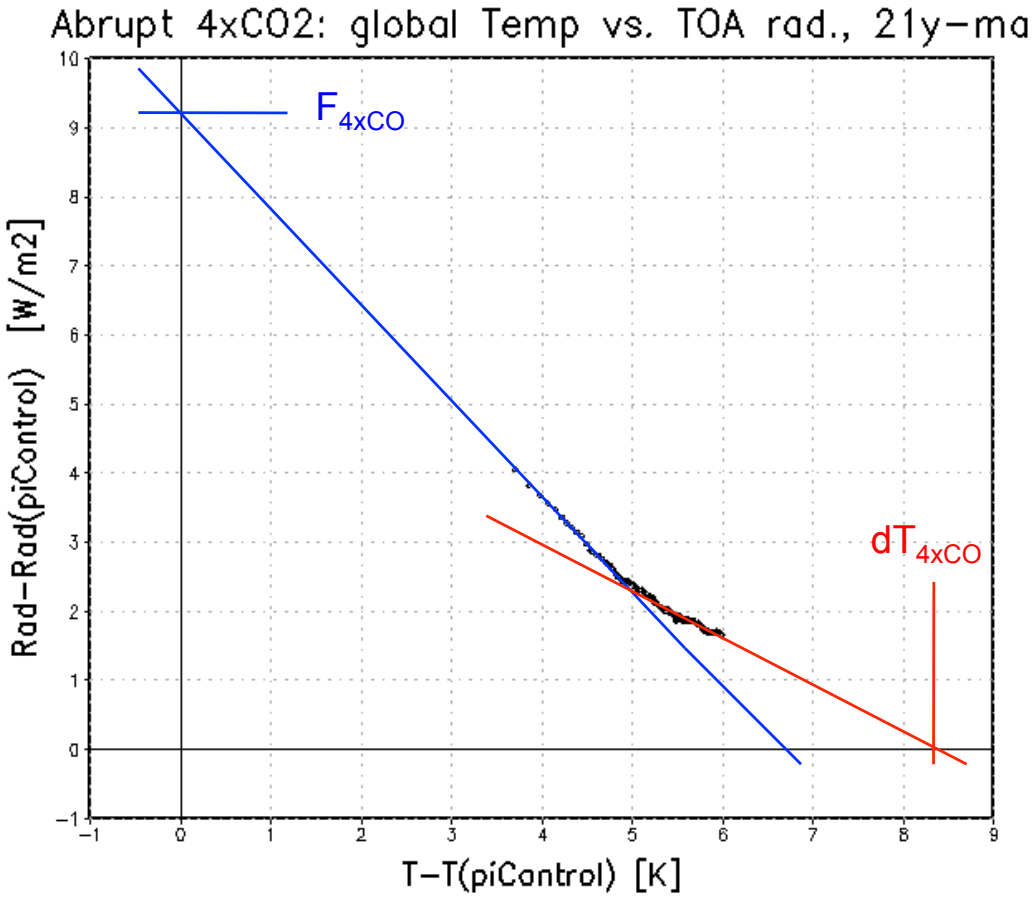
Ts vs. TOA rad. forcing

Annual mean



Ts vs. TOA rad. forcing

21-yr running mean



Anomaly w.r.t. piControl

Climate forcing:

F_{4xCO2} = ~9 Wm^{-2}

Climate response parameter α= -drad/dT:

α = 1.37 Wm^{-2} K^{-1}

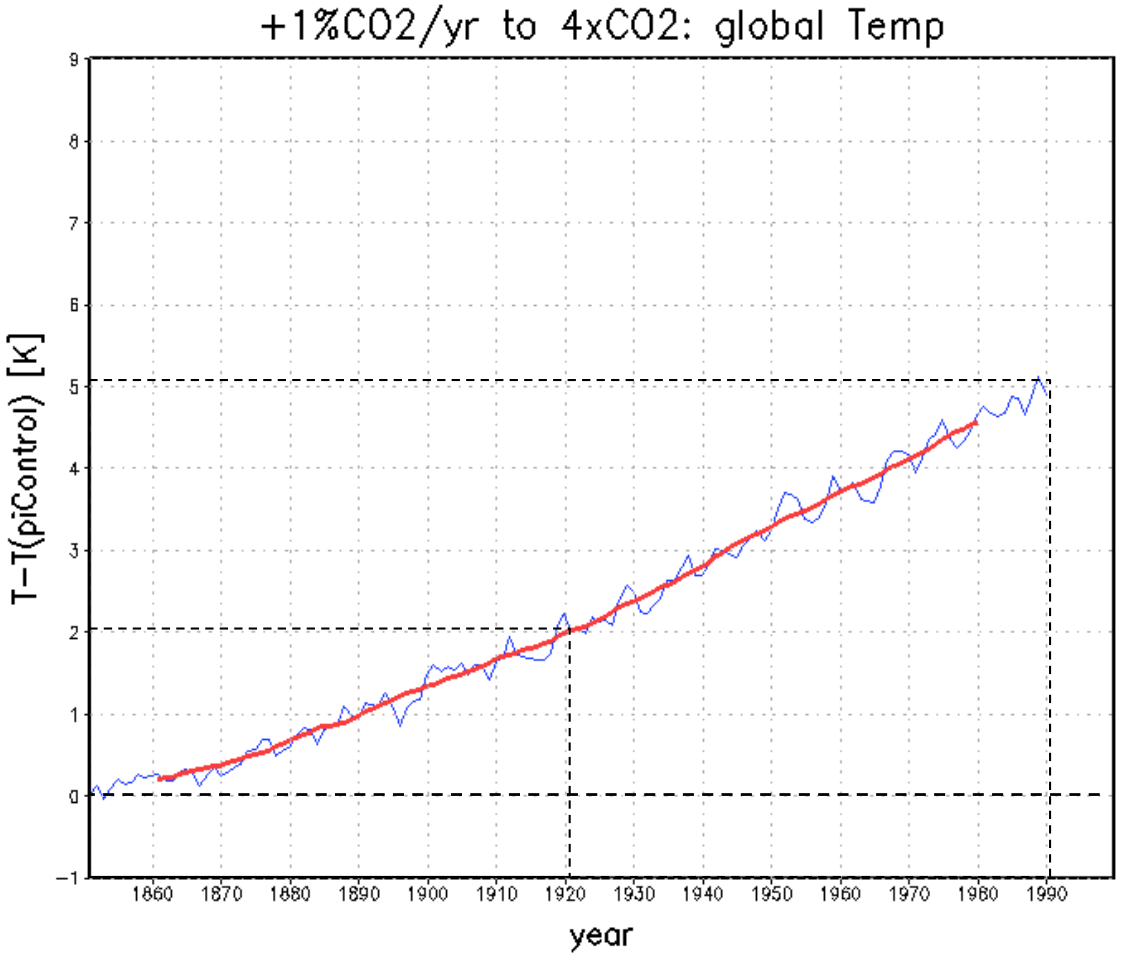
α = 0.67 Wm^{-2} K^{-1}

Extrapolated $4xCO_2$ equilibrium change:

dT_{4xCO2} = ~8.5 K **?**

Transient climate response

+1 % CO_2 per year up to 4xCO_2



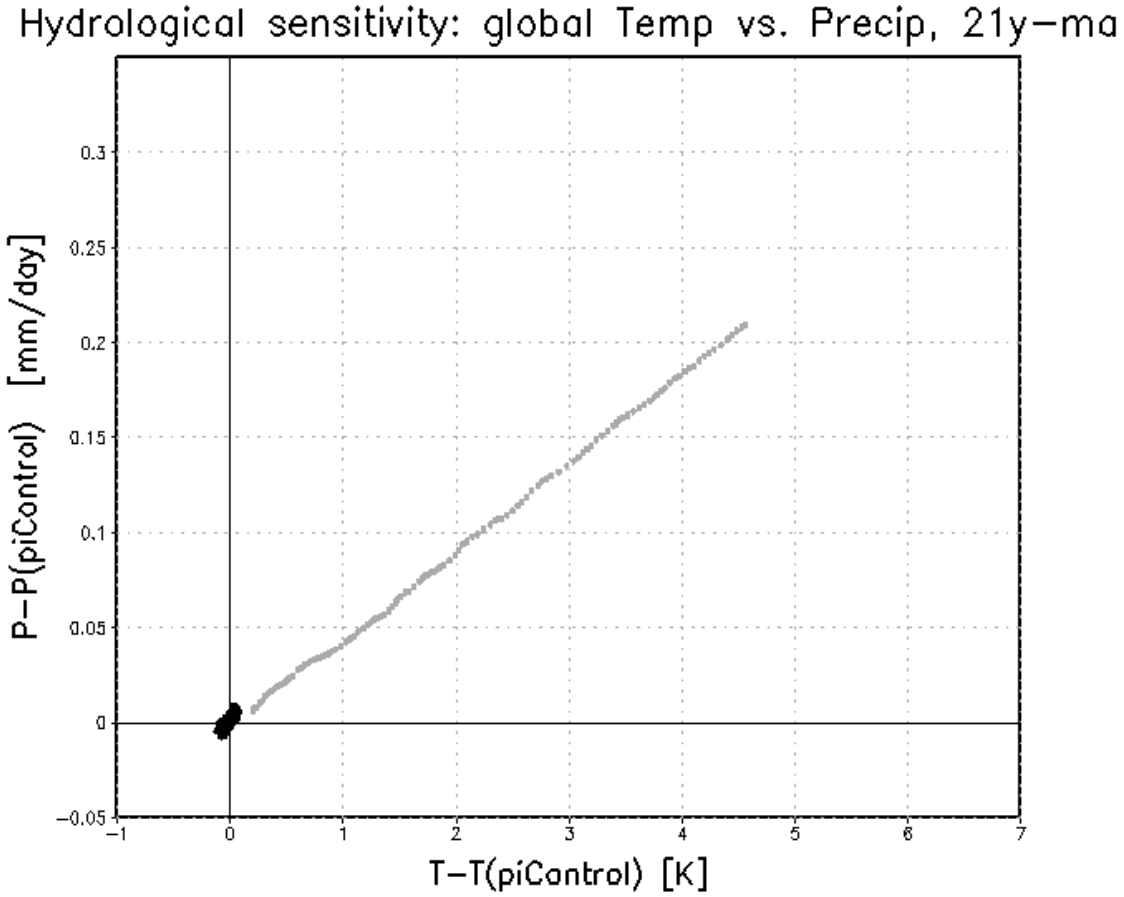
Anomaly w.r.t. piControl

1850: 1xCO_2

1920: 2xCO_2
dT = 2 K

1990: 4xCO_2
dT = 5 K

Hydrological sensitivity to CO_2 induced climate warming



Anomaly w.r.t. piControl

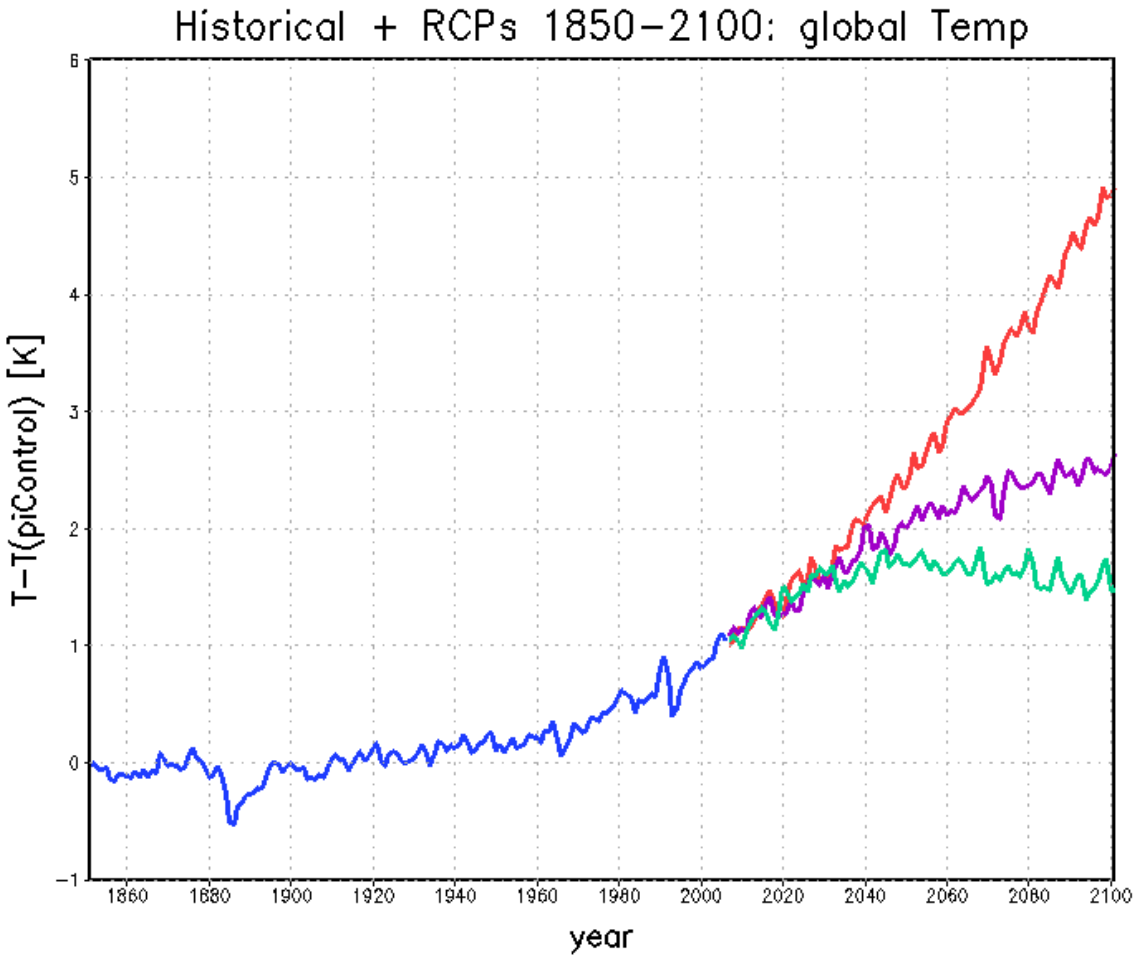
1pctCO2:

0.047 mm day^{-1} K^{-1}

1.6 % K^{-1}

Climate projections 1850 – 2100

Global mean near surface temperature anomaly

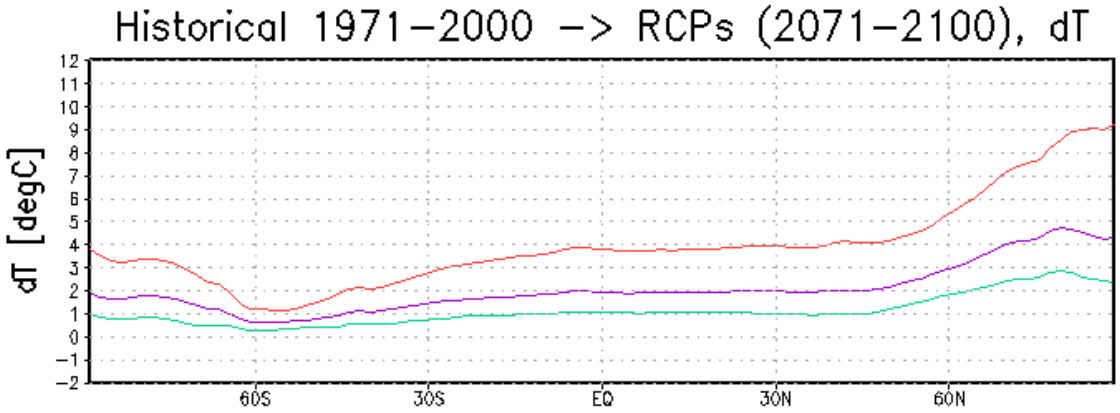


Anomaly w.r.t. piControl

Ensemble means
of 3 realizations of:

- Historical
- RCP85
- RCP45
- RCP26

Temperature and precipitation change
1971-2000 → 2071-2100

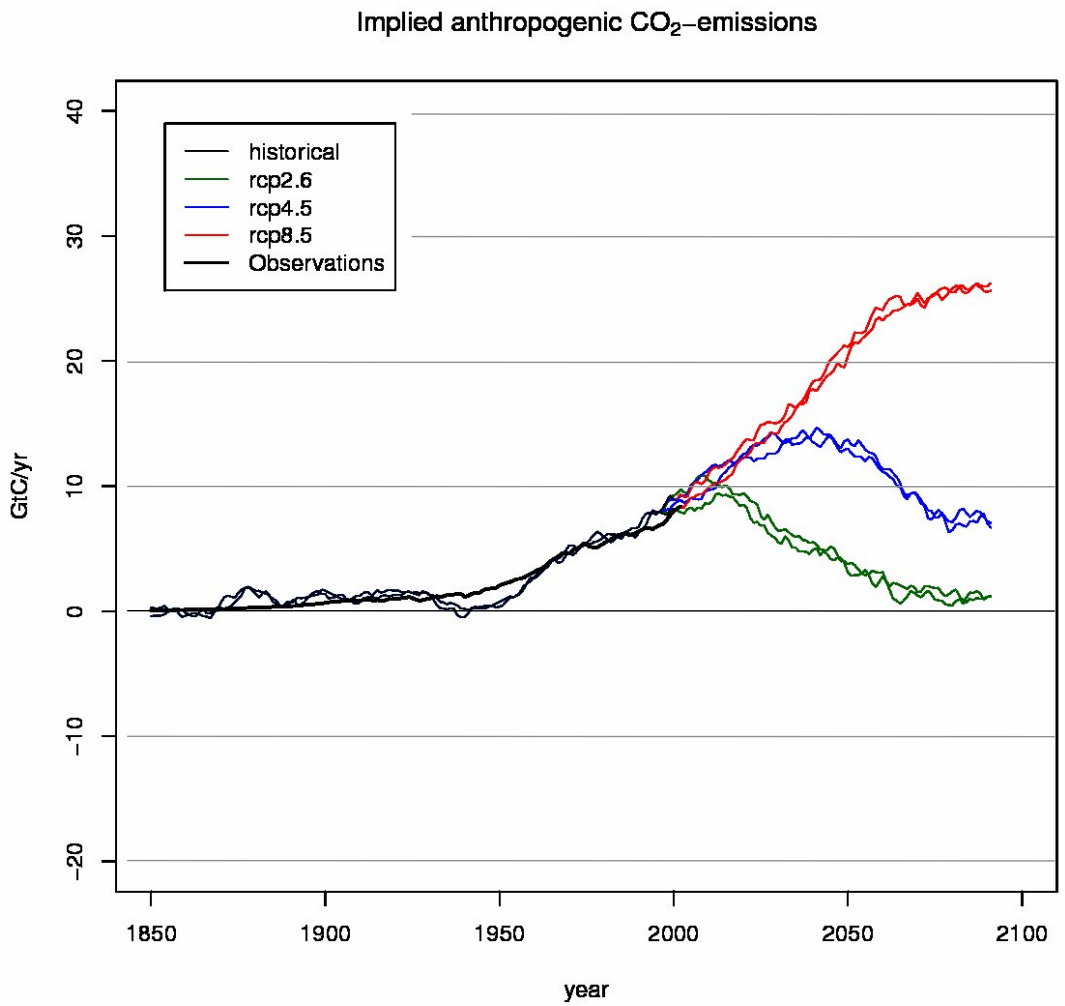


Anomaly w.r.t. piControl

Ensemble means
of 3 realizations

dT(NP)/dT(Eq-45N) = ~2
RCP85: 9/4
RCP45: 4.5/2
RCP26: 2.5/1

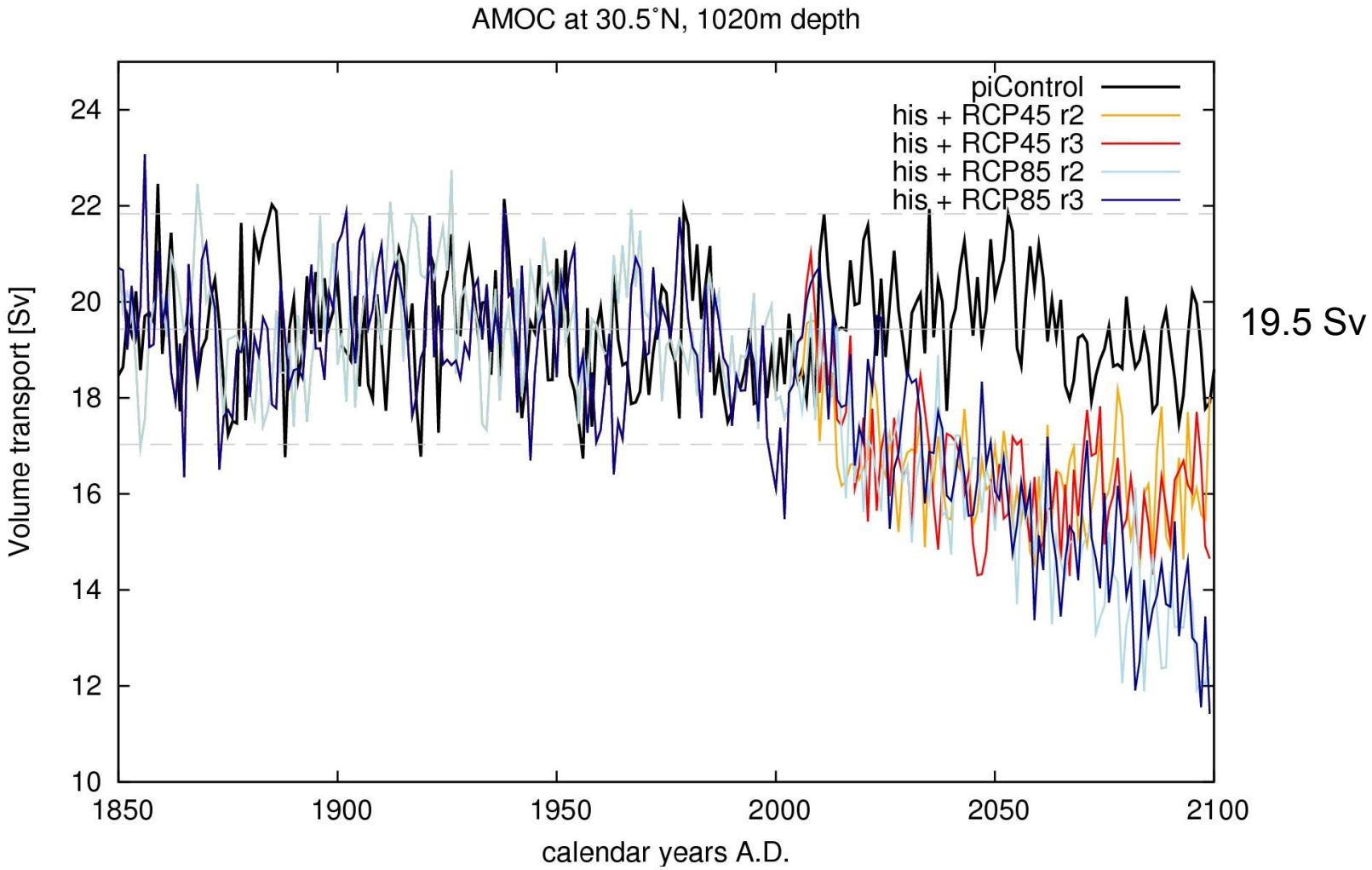
Allowable anthropogenic CO_2 emissions



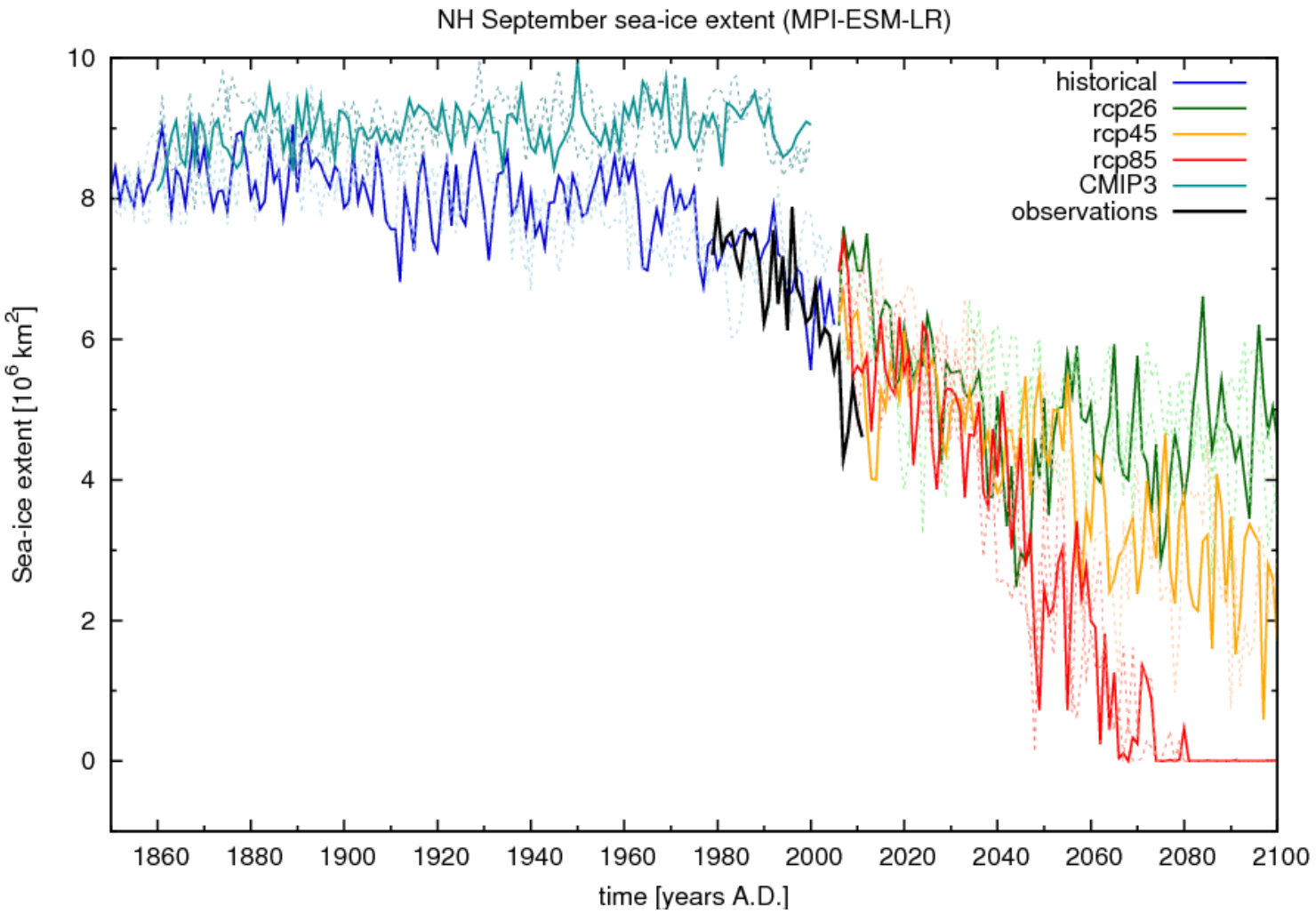
dC(atm) = dt * (
- F(atm→land)
- F(atm → ocean)
+ F(land use)
+ **F(fossil fuel)**)
= dC(RCP scenario)

observations
historical
rcp85
rcp45
rcp26

Atlantic meridional overturning circulation



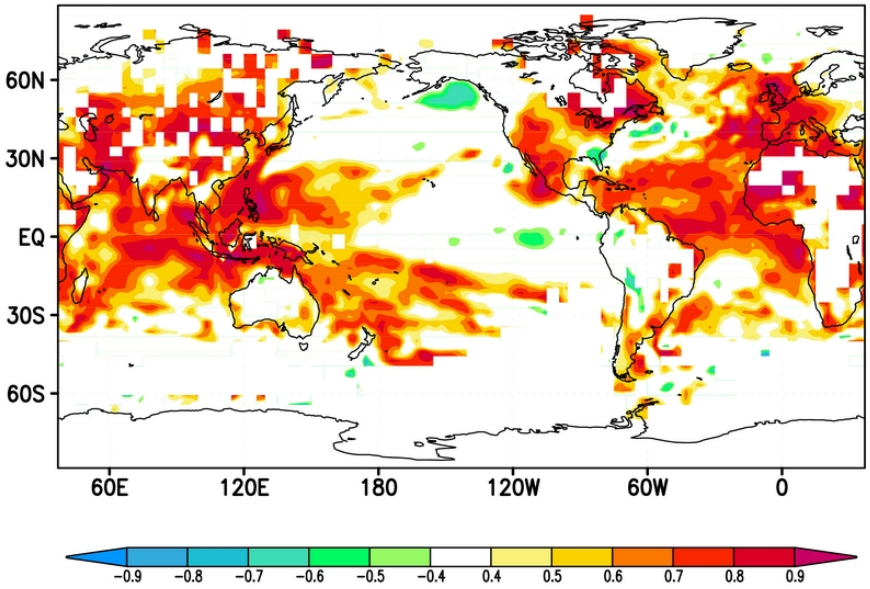
Northern hemisphere sea ice cover



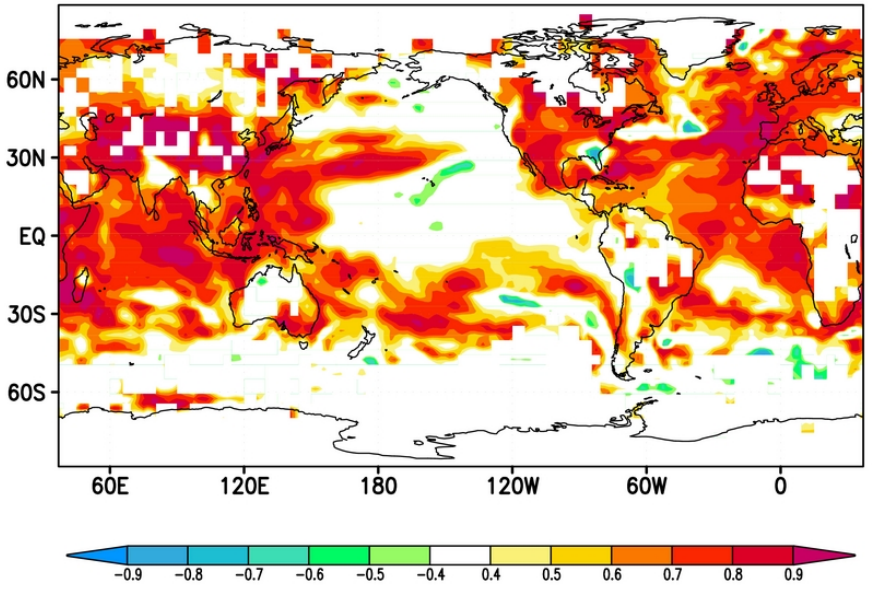
Decadal prediction experiments:

Surface temperature predictive skill at lead time 6-10 years

ECHAM5/MPIOM



MPI-ESM-LR



Anomaly-correlation coefficient between HadCRUT3v) and hindcasts

Same horizontal resolution A: T63/1.9°, O: 1.5°

“Old start dates”

Summary

- MPI-ESM-LR
  - For most CMIP5 experiments
  - Most simulations mostly done
  - Publication ongoing
- MPI-ESM-P
  - For Paleo
  - Most simulations done
- MPI-ESM-MR
  - For many CMIP5 experiments
  - Simulations still running

END