Possible climate change over Eurasia under different emissions scenarios

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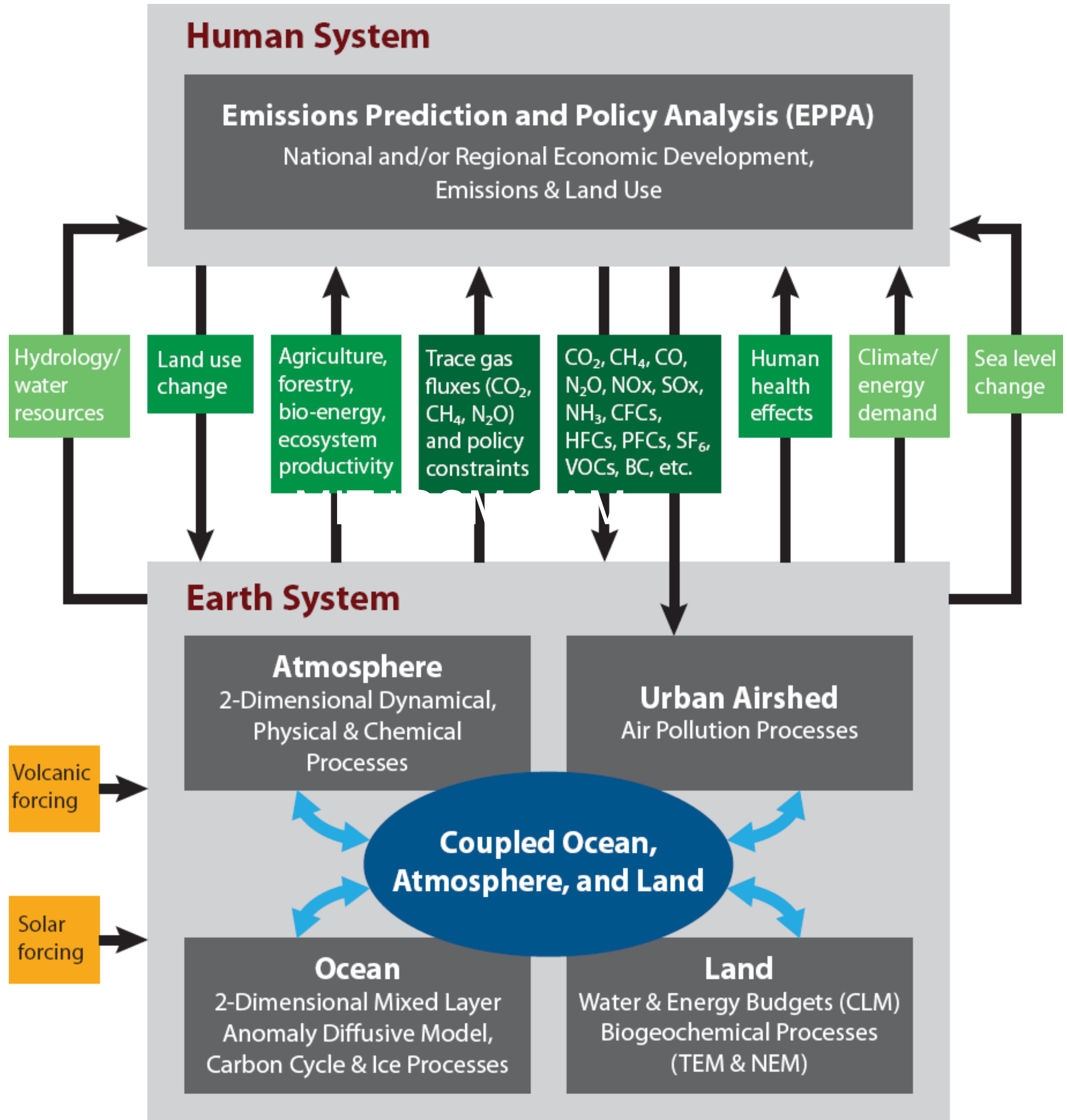
MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

http://globalchange.mit.edu/

MIT Integrated Global System Model



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Main sources of uncertainties.

Economics.
Uncertainties in labor productivity, resource availability, population growth, and cost and availability of new technologies.

Climate.
Climate sensitivity, rate of the heat uptake by the deep ocean, strength of the sulfate aerosol forcing, and uncertainty in carbon uptake by the ocean and terrestrial ecosystem.

Estimation of probability distributions for input parameters.

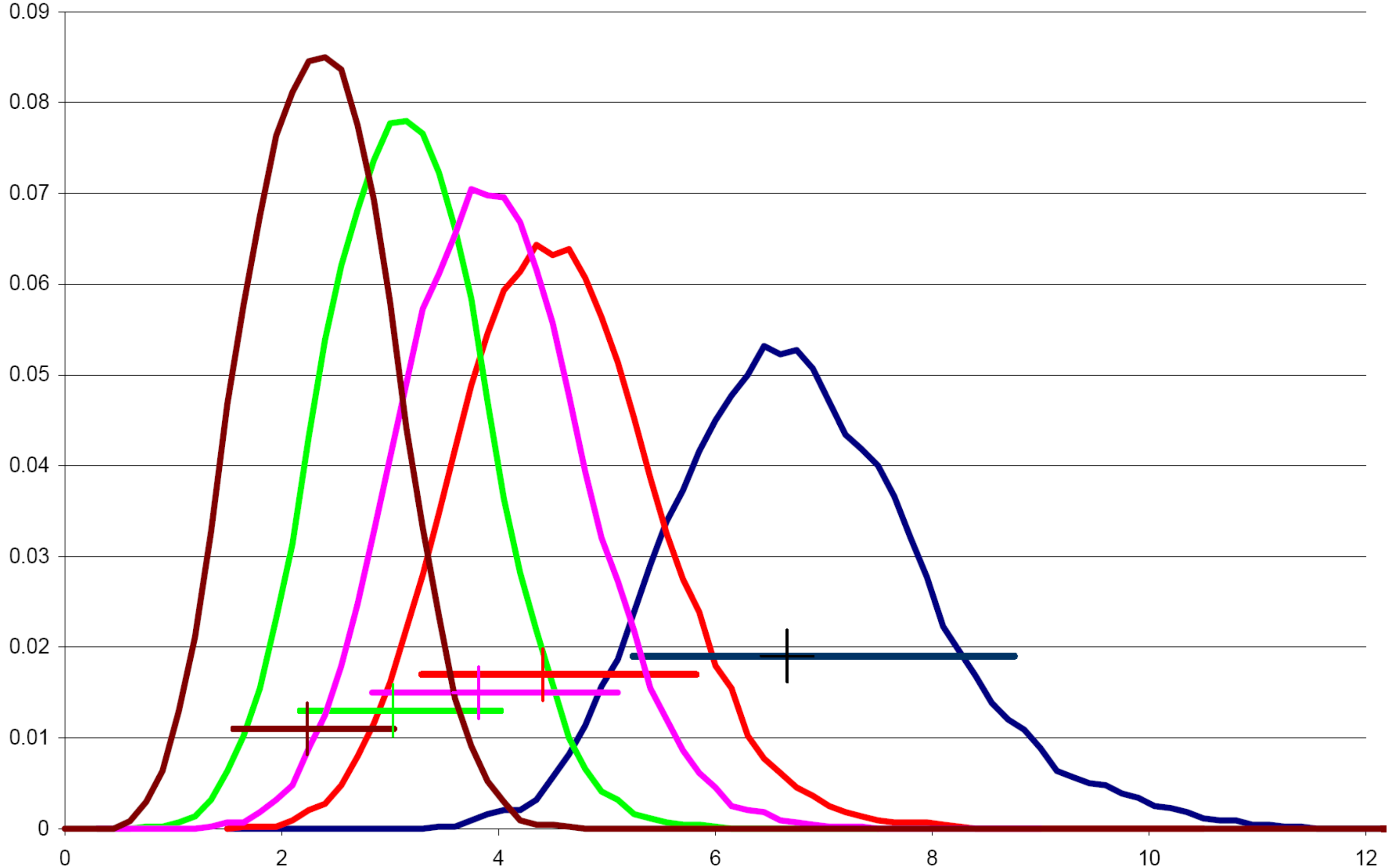
Large number of 19th - 20th centuries climate were carried out with climate model parameters (climate sensitivity, rate of heat uptake by the ocean and strength of aerosol forcing) varied over wide ranges. Probability distributions for climate parameters are defined based on comparing simulated and observed 20th century climate.

Probability distributions for economic model parameters are defined based on data for economic development over second half of 20th century

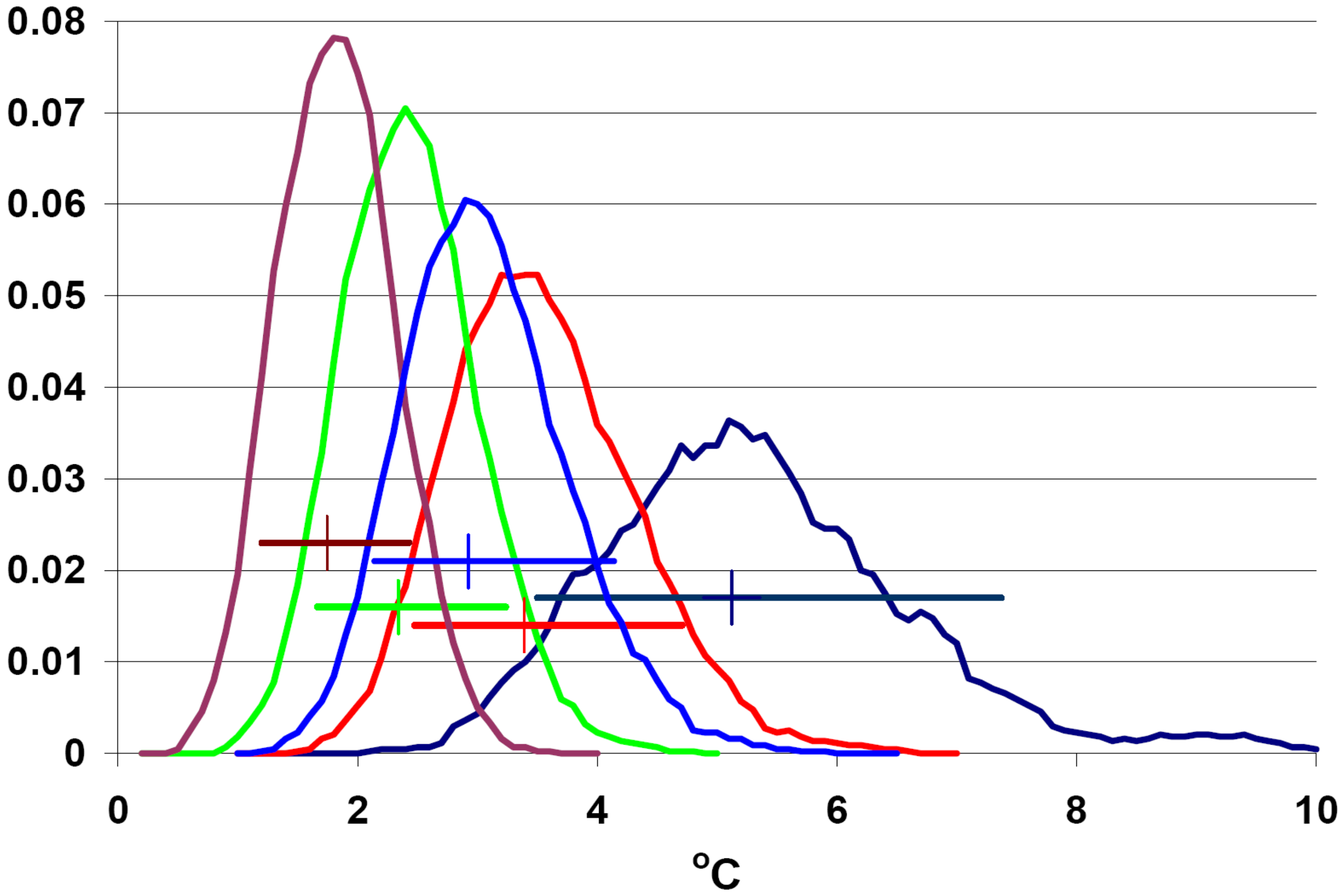
Median concentration, radiative forcing relative to 1860, and temperature change in last decade of 21st century relative to 1981-2000 average.

	CO_2 Concentrations (ppm)	CO_2–Equivalent Concentrations For all Long-lived Greenhouse Gases (ppm)	Total Radiative Forcing (W/m^2)	Change in Annual Mean Surface Temperature (Degrees C)
Level 1	477	552	4.22	1.75
Level 2	554	658	5.25	2.34
Level 3	643	787	6.30	2.93
Level 4	714	899	7.07	3.39
No Policy	866	1399	9.68	5.13

Frequency distributions for SAT increase over land north from 40N in 2091 to 2100 relative to the 1981 to 2000 average.

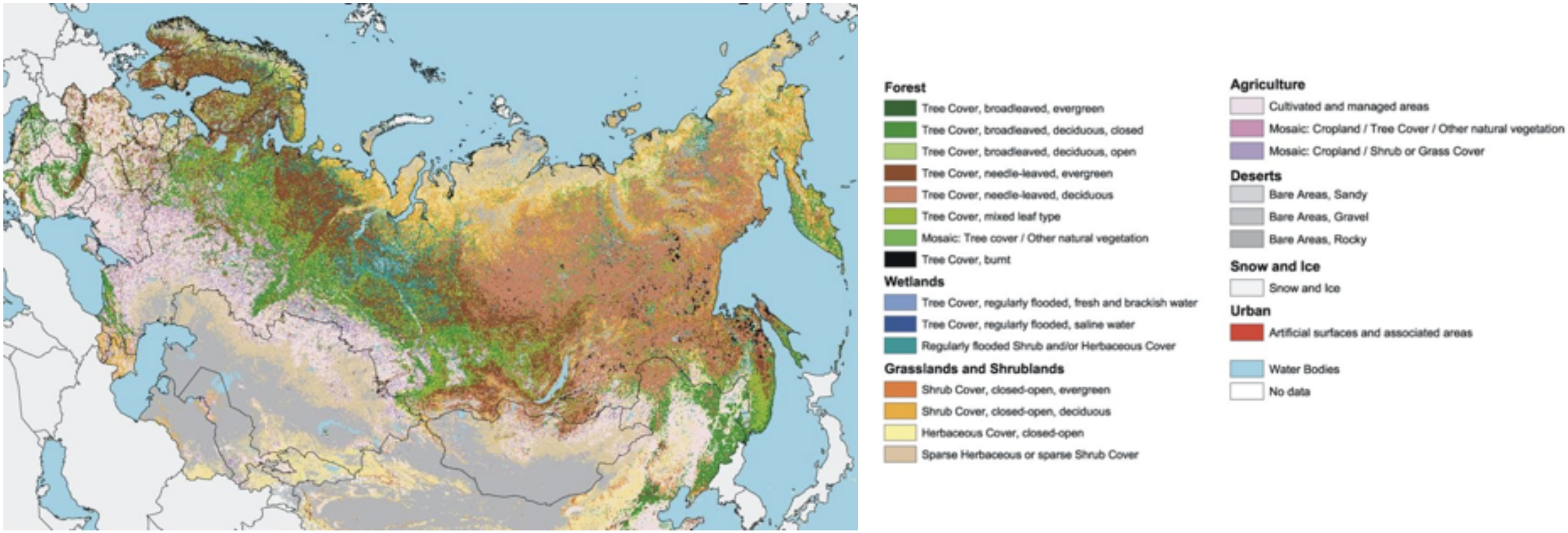


Probability Distributions for Global Mean Surface Temperature Change; average for 2091-2100 minus average for 1981-2000 for different policies.



Region of interest: NEESPI

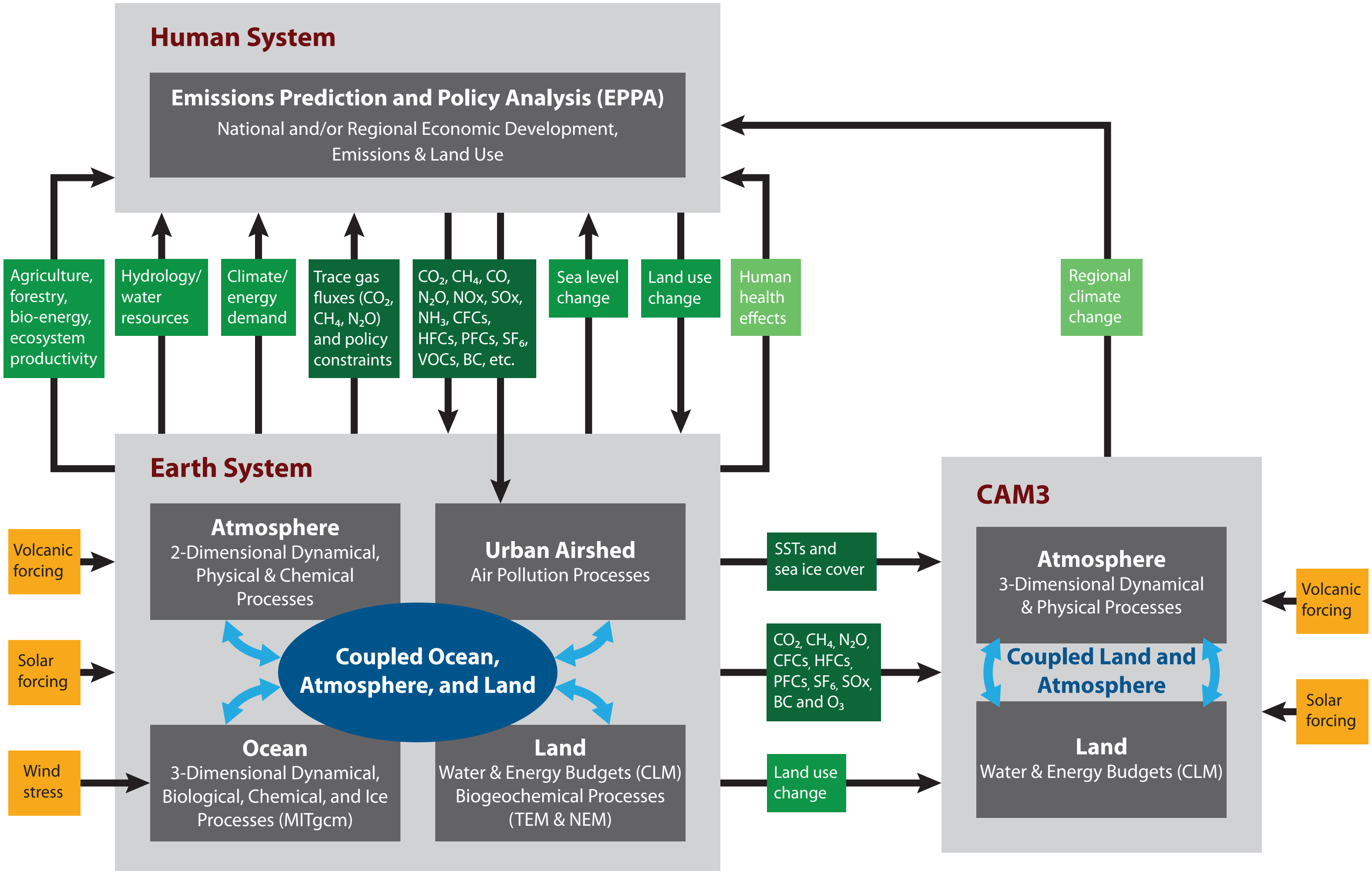
NEESPI: Northern Eurasia Earth Science Partnership Initiative



- Major player in global carbon budget because of boreal forests and peatlands
- Under threat of severe climate change which could lead to:
  - severe permafrost degradation
  - the release of large amounts of natural carbon dioxide and methane

➔ Need to quantify uncertainty in climate change over Eurasia

Modeling framework: MIT IGSM-CAM



Exchanges represented in standard runs of the system

Exchanges utilized in targeted studies

Implementation of feedbacks is under development

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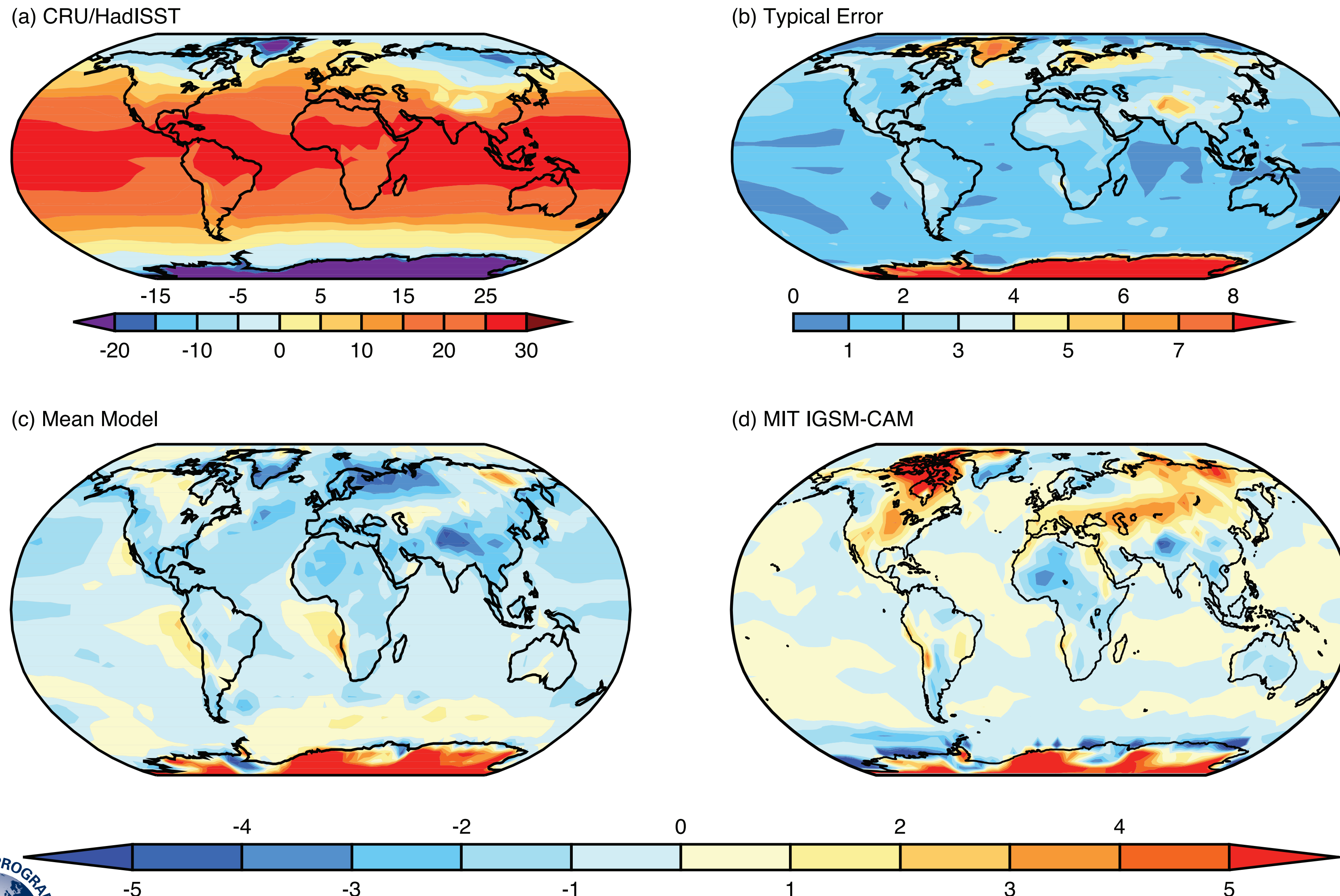
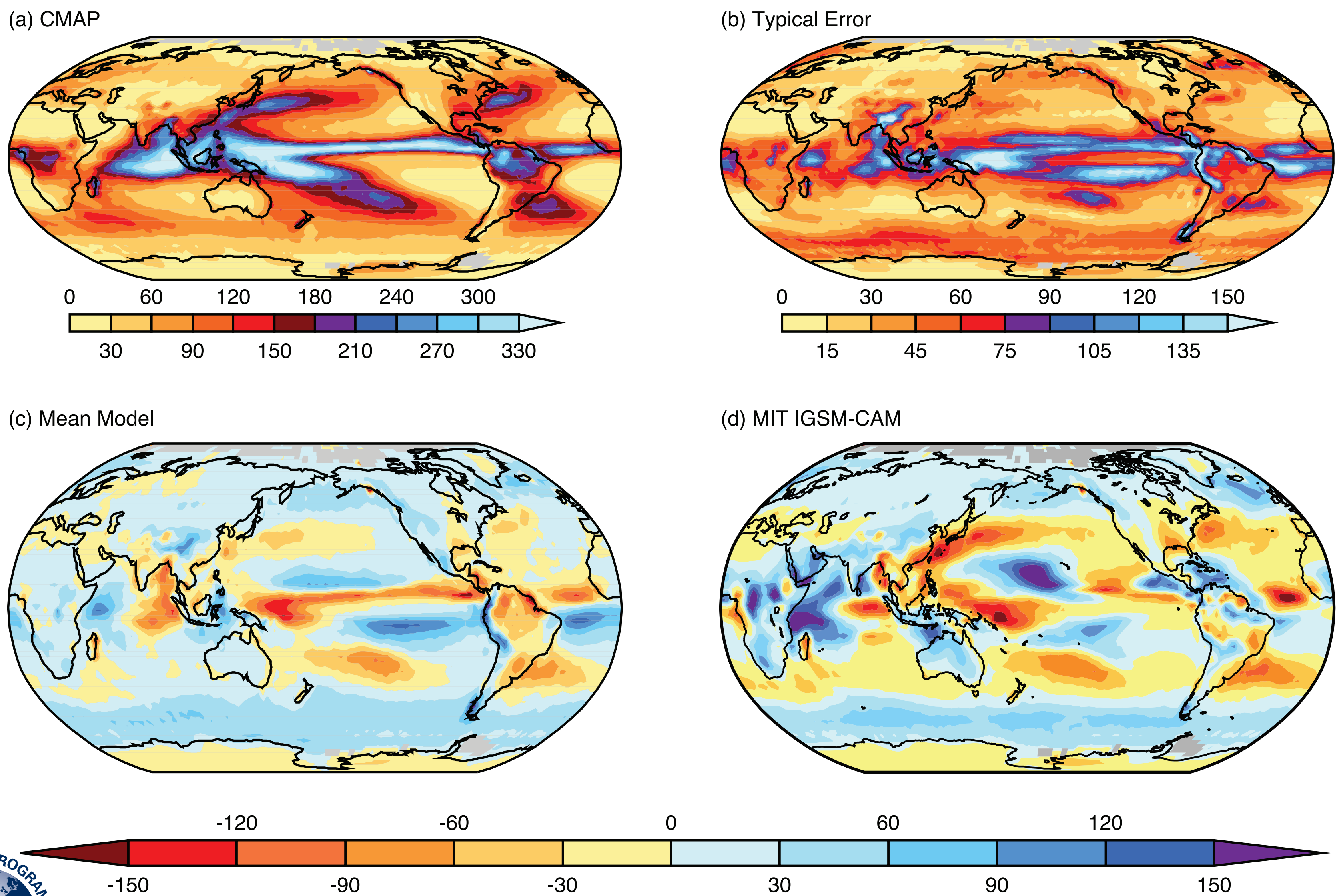
Present-day surface temperature



Present-day precipitation



Description of simulations

6 simulations to investigate the uncertainty in climate change associated with uncertainty in the climate response and emissions

<u>Uncertainty in climate response</u>

Lower bound, median and upper bound of 90% probability interval of climate change based on probability distribution functions of climate parameters (climate sensitivity, net aerosol forcing and ocean heat uptake rate)

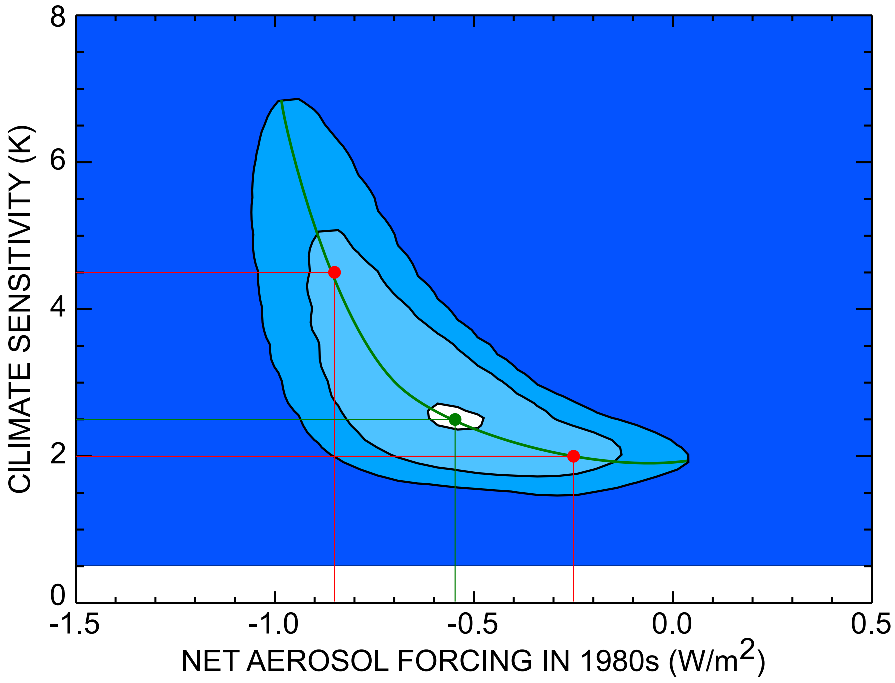
<u>Uncertainty in projected emissions</u>

2 emissions scenarios:

-“Business as usual” where no policy is implemented after 2012

-Policy scenario where greenhouse gases are stabilized at 660 ppm CO_2-equivalent (550 ppm CO_2-only) by 2100

Climate parameters

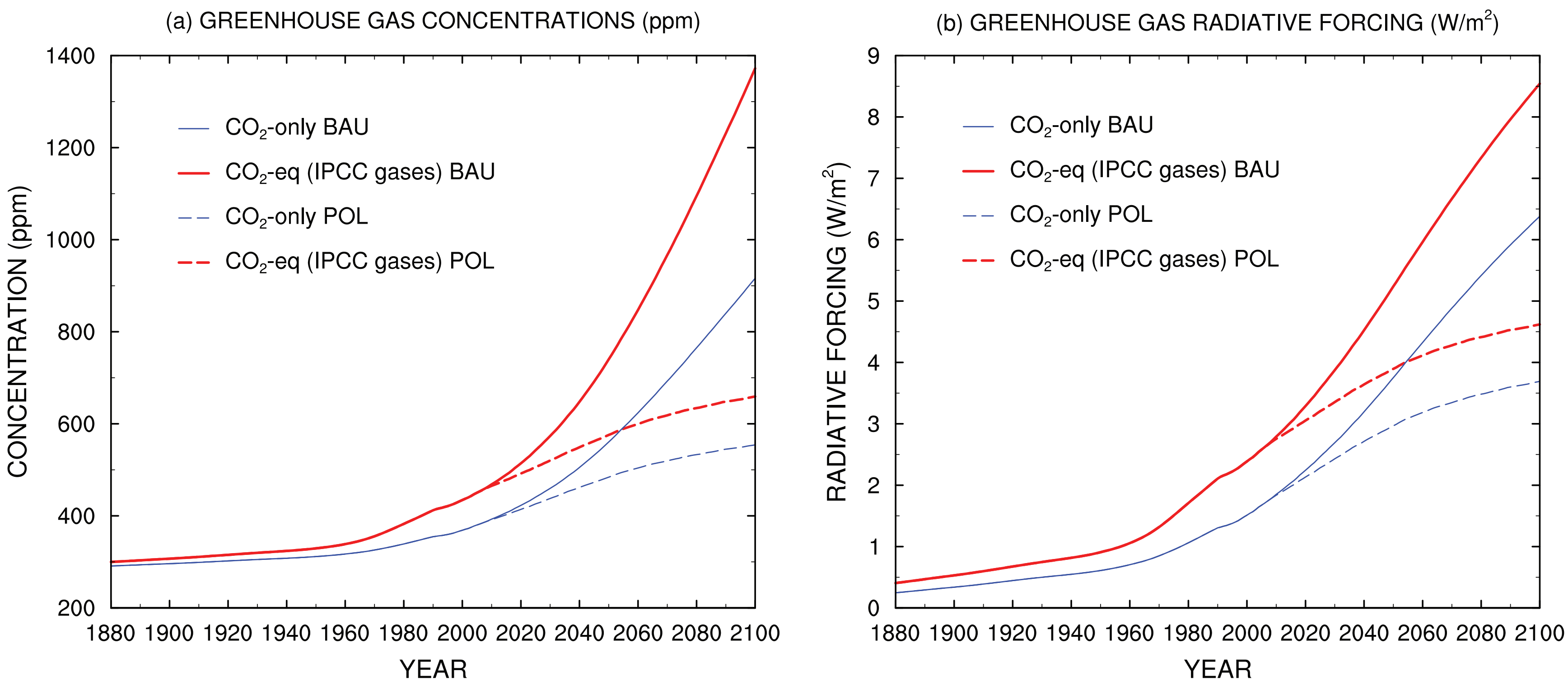


Marginal posterior probability distribution function with uniform prior for the climate sensitivity-net aerosol forcing parameter space. Blue shading denotes rejections regions for significance level: 1% (dark), 10% (blue), 50% (light).

Red dots represent lower and upper bounds of 90% probability interval. Green dot represents the median.

Because sulfate aerosols concentration significantly decrease over the 21st century, these simulations provide a good approximation for the median and the 5th and 95th percentiles of the probability distribution of 21st century climate change.

Emissions scenarios



The “business as usual” scenario is similar to RCP8.5

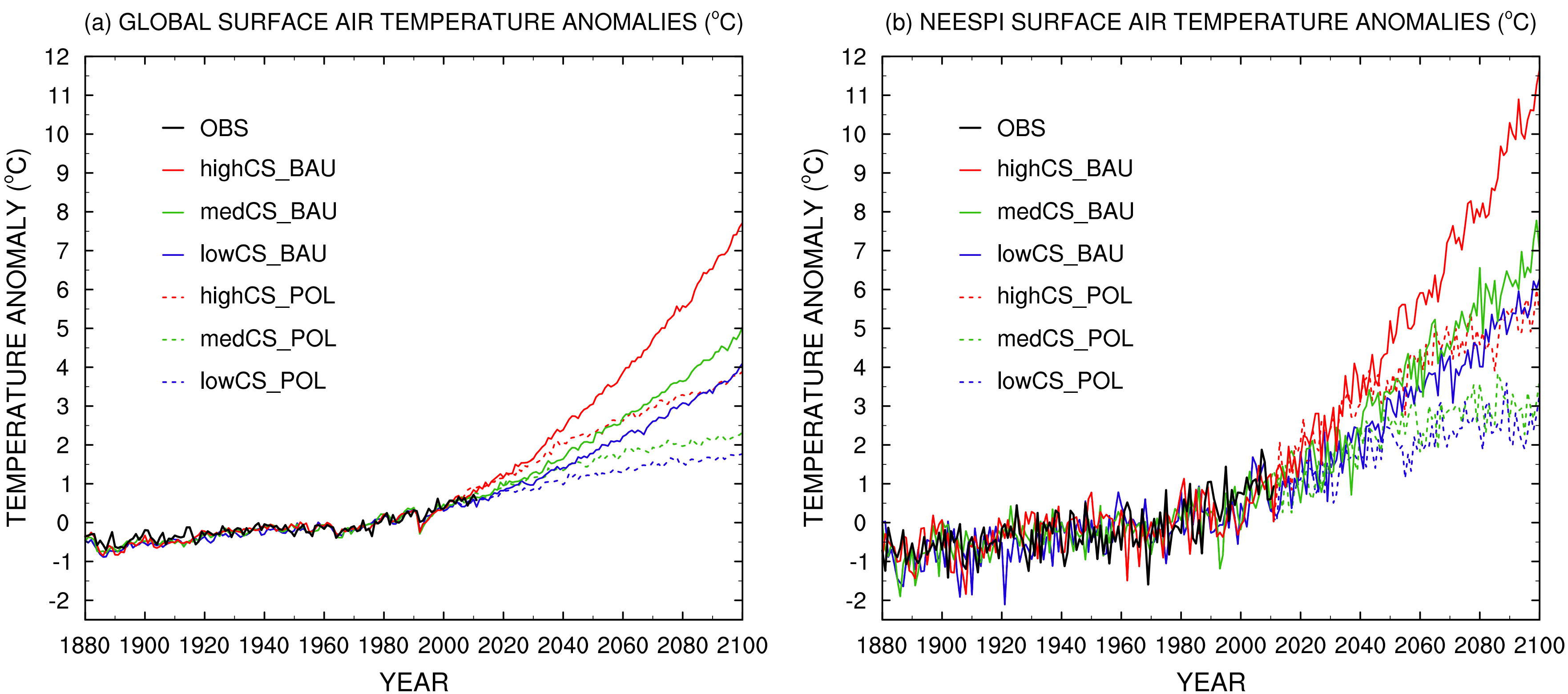
The stabilization scenario is similar to RCP4.5

Summary of simulations

Climate parameters		Emissions scenario	Name convention
Climate sensitivity	Net aerosol forcing		
4.5ºC	$-0.85\ W/m^2$	"Business as usual"	highCS_BAU
		Stabilization scenario	highCS_POL
2.5ºC	$-0.55\ W/m^2$	"Business as usual"	medCS_BAU
		Stabilization scenario	medCS_POL
2.0ºC	$-0.25\ W/m^2$	"Business as usual"	lowCS_BAU
		Stabilization scenario	lowCS_POL

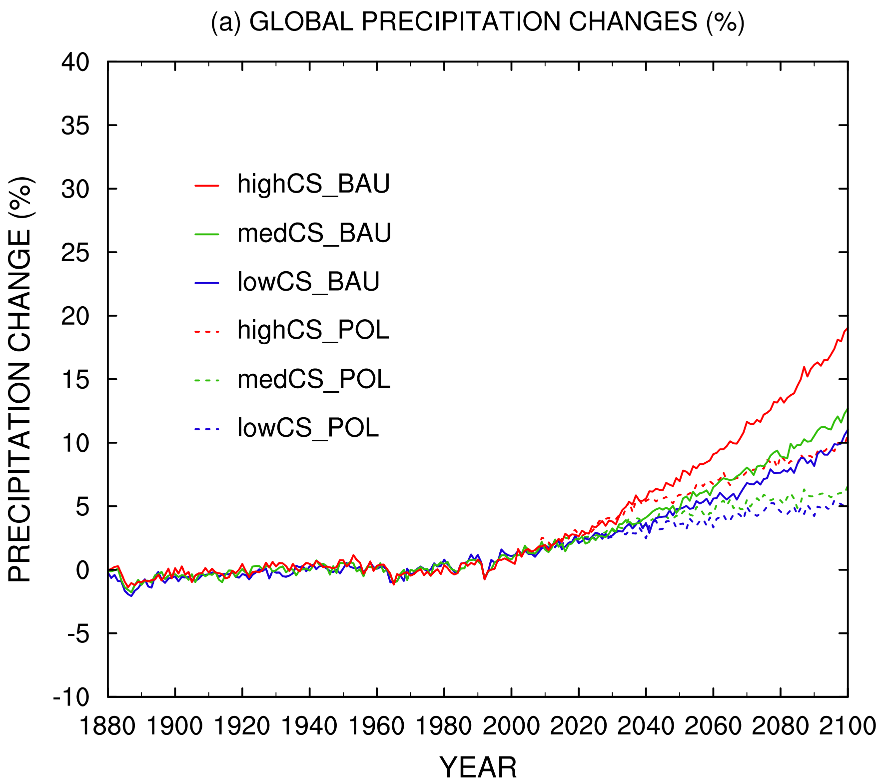
Surface air temperature time series

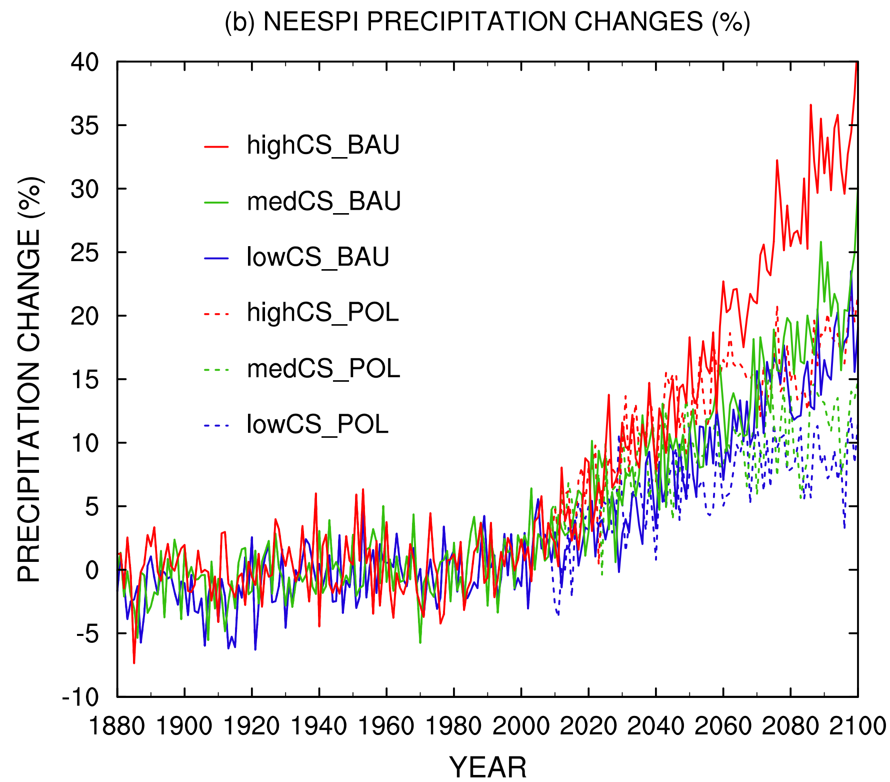
Surface air temperature anomalies (in ºC) from the 1951-1980 period



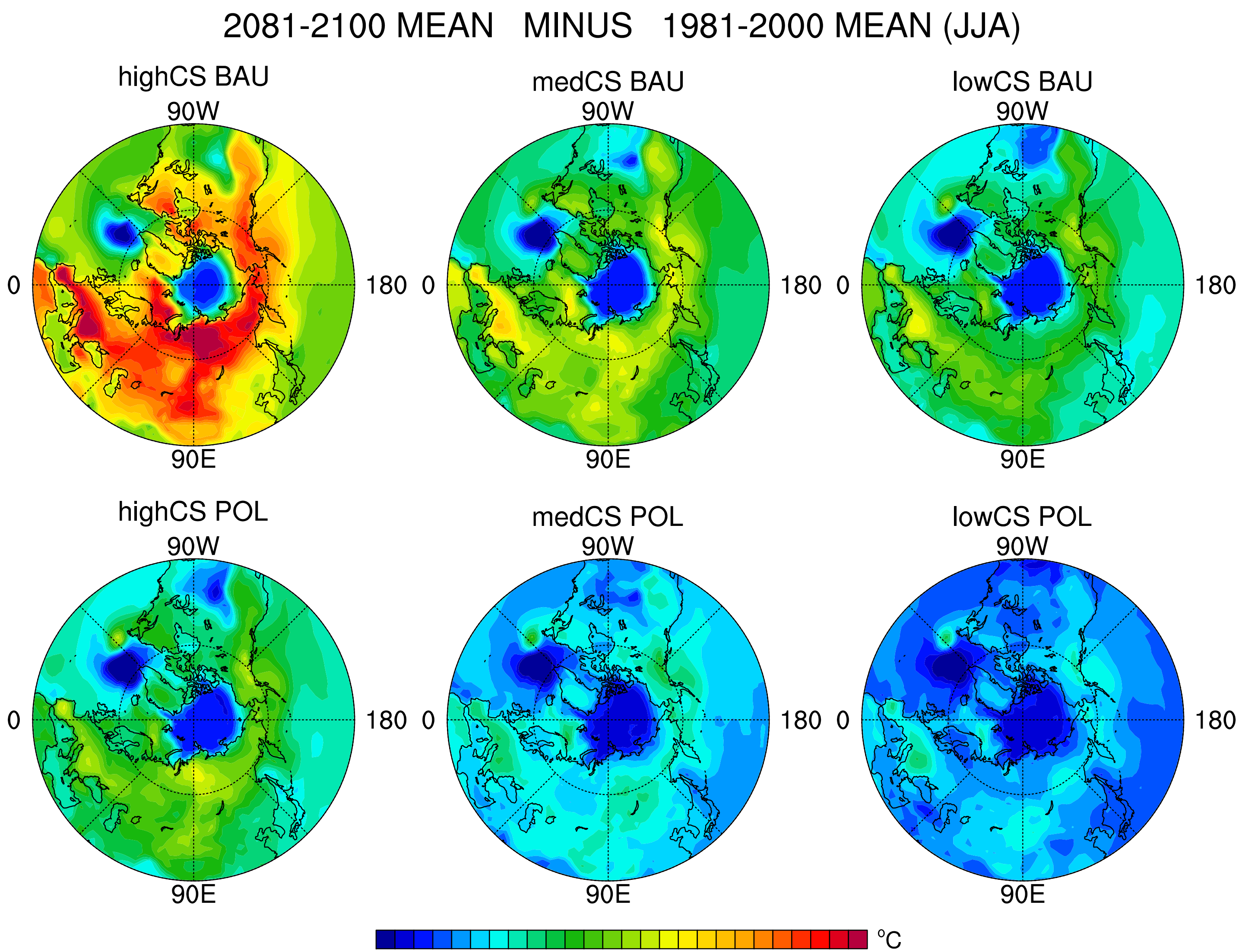
Precipitation time series

Precipitation changes (in percent) from the 1951-1980 period

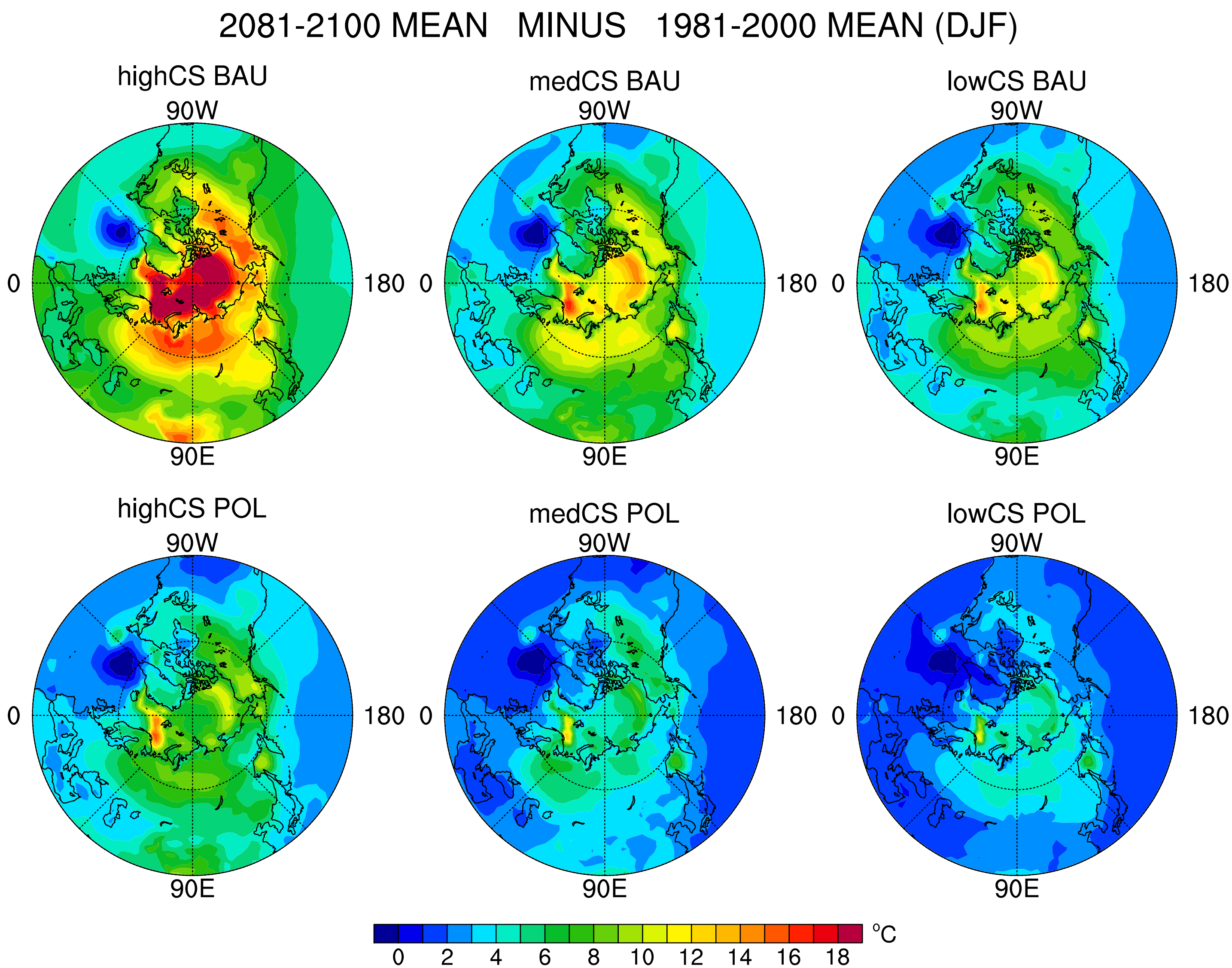




Maps of surface air temperature changes (JJA)



Maps of surface air temperature changes (DJF)

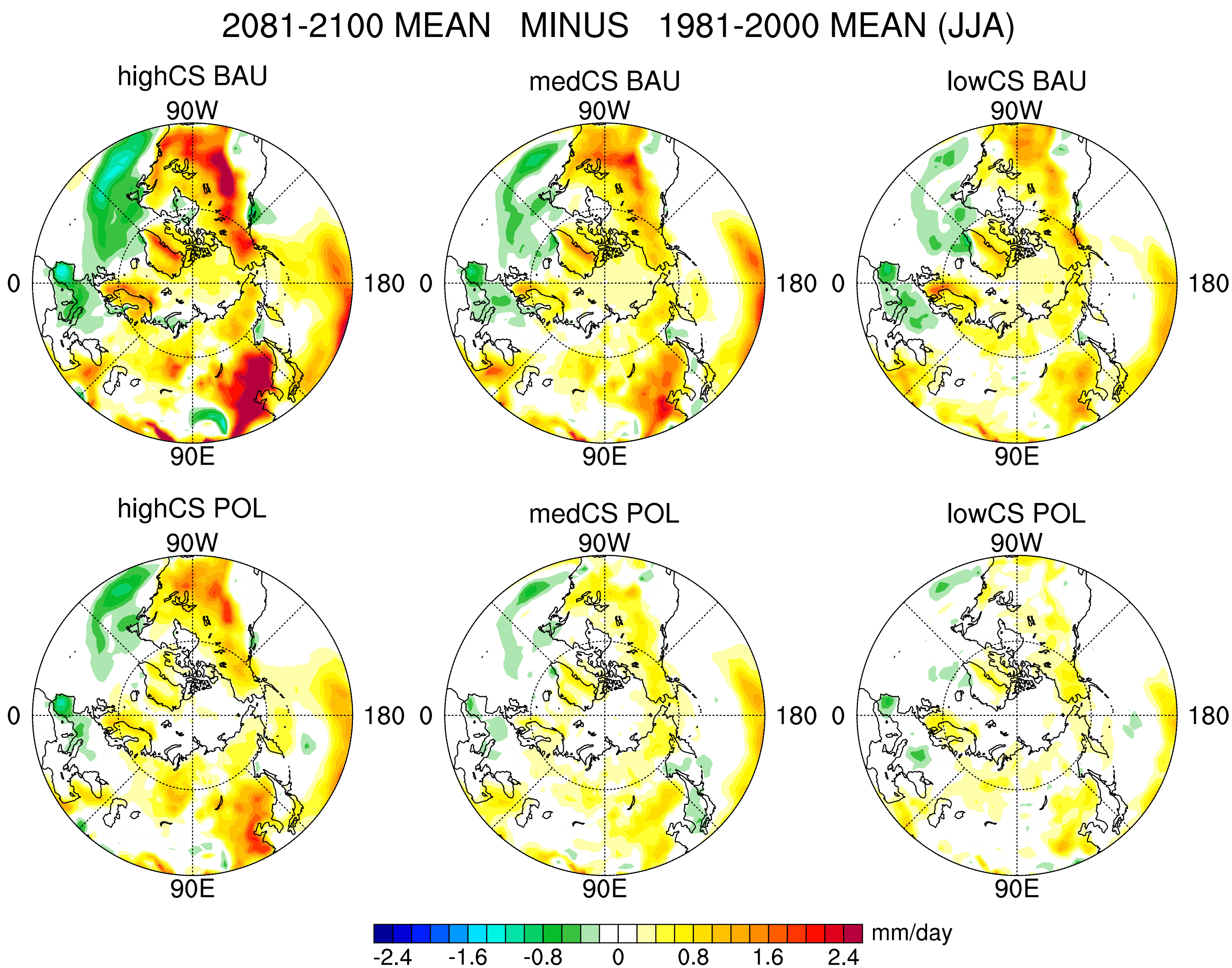


NEESPI surface air temperature changes

NEESPI changes in surface air temperature (ºC)
for the period 2081-2100 relative to 1981-2000

Scenario	"Business as usual"			Stabilization scenario		
	Annual	JJA	DJF	Annual	JJA	DJF
highCS	9.9	10.1	11.0	5.1	5.2	5.8
medCS	6.5	6.0	8.0	3.2	2.7	3.9
lowCS	5.2	4.7	6.6	2.5	2.0	3.2

Maps of precipitation changes (JJA)



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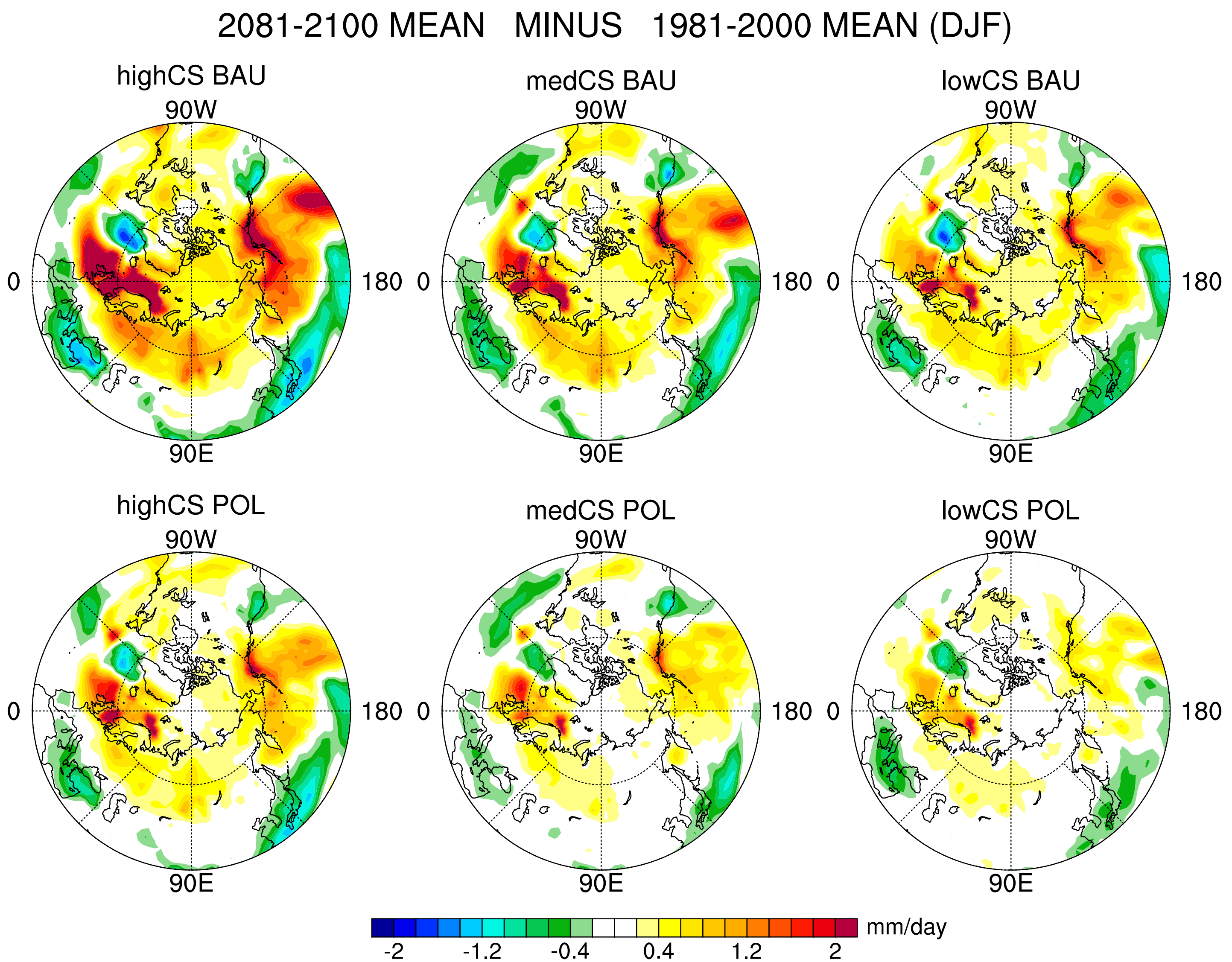
Maps of precipitation changes (DJF)



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NEESPI precipitation changes

NEESPI changes in precipitation (mm/day)
for the period 2081-2100 relative to 1981-2000

Scenario	"Business as usual"			Stabilization scenario		
	Annual	JJA	DJF	Annual	JJA	DJF
highCS	0.53	0.71	0.52	0.29	0.42	0.27
medCS	0.35	0.44	0.37	0.18	0.26	0.16
lowCS	0.26	0.30	0.30	0.13	0.17	0.14

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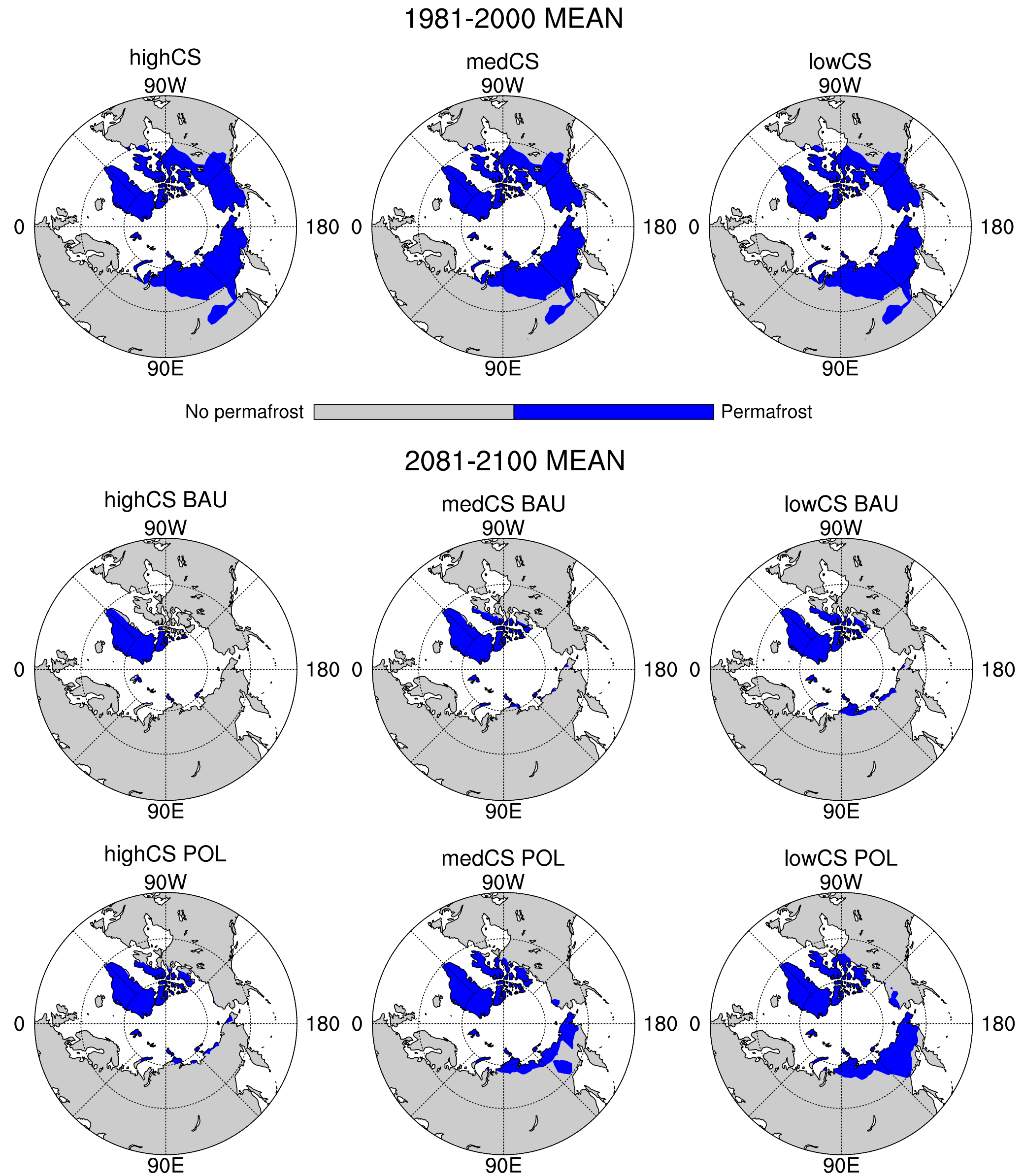
Maps of permafrost changes



Conclusions

The simulations presented in this study are a good approximation for the median, and the 5th and 95th percentiles of the probability distribution of 21st century climate change.

They also show the impact of different emissions scenarios.

Overall the results show that there is a large uncertainty in the climate change over Eurasia by the end of the 21st century, with similar contribution from uncertainty in the climate response and in emissions scenarios.

The simulations indicate that Northern Eurasia is at risk of severe climate warning, with severe permafrost degradation in all simulations.

They also underscores the effectiveness of a global climate policy, even given the uncertainty in the climate response.