

Are we able to simulate the main observed processes and feedbacks? (in a climate context)

Jens Hesselbjerg Christensen
Danish Meteorological Institute



CP Hydrological Cycles

GA, Brussels 25-26 March 2015

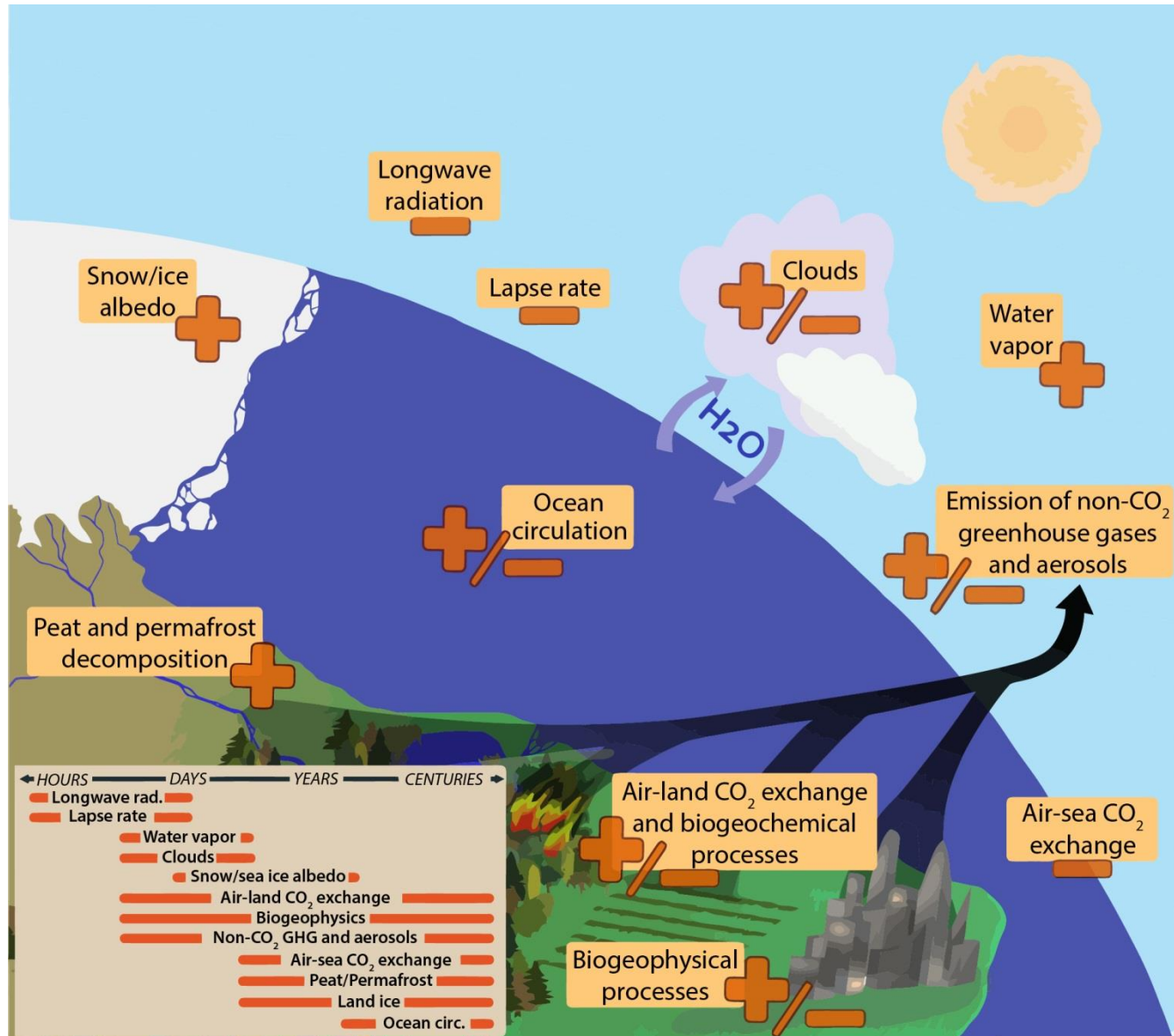
Diagnosing Hydrological cycle(s)

Watch out for the cycles in this picture



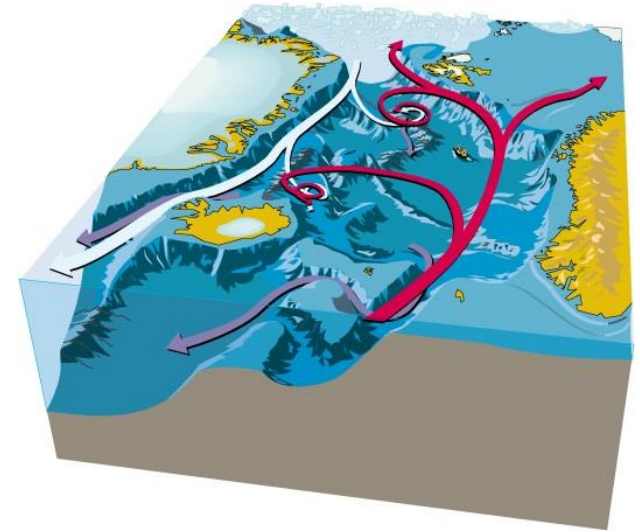
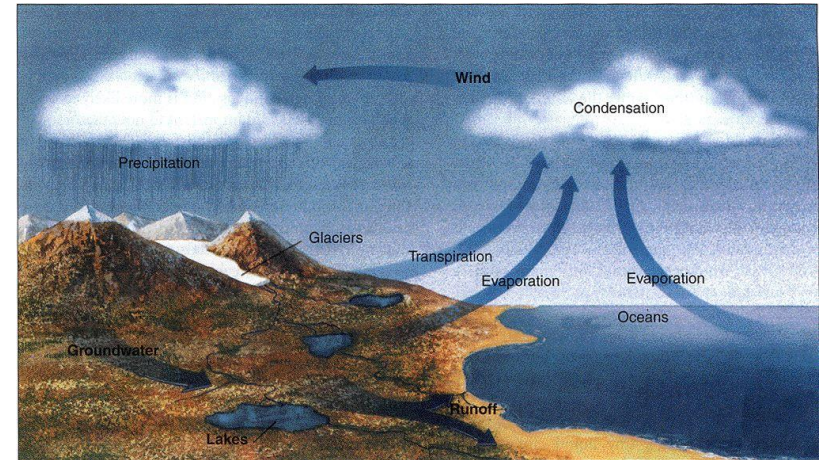


Climate feedbacks and timescales



Diagnosing Hydrological cycle(s)

- Atmosphere
 - Moisture
 - Clouds
 - Circulation
- Ocean
 - Thermohaline circulation
- Cryosphere
 - Glaciers
 - Ice Sheets
 - Sea ice
 - Permafrost
- Land
 - Lakes, rivers, surface, vegetation
 - Ground water

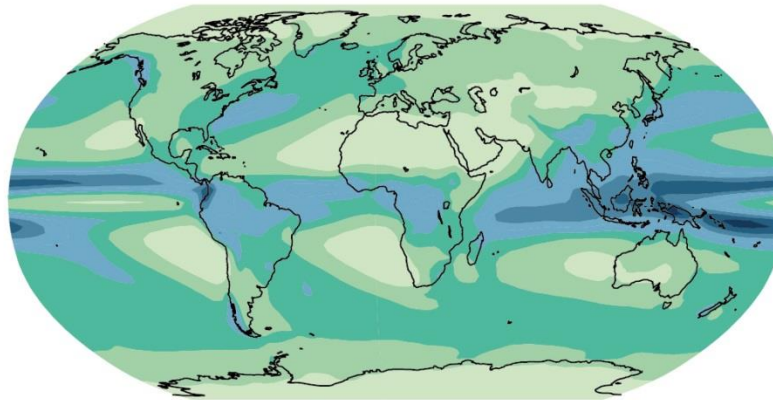


Using ensembles of models

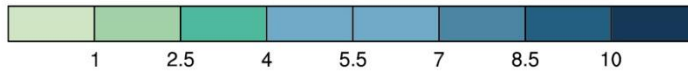


Atmosphere

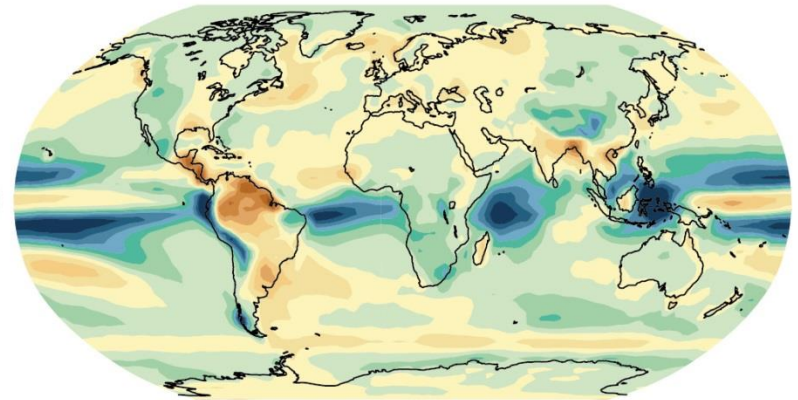
(a) Multi Model Mean Precipitation



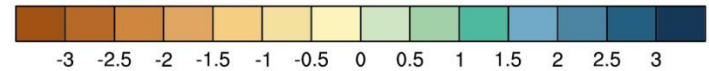
(mm day⁻¹)



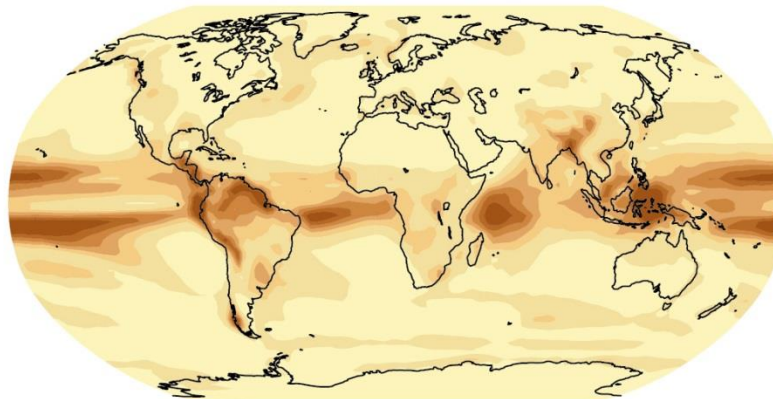
(b) Multi Model Mean Bias



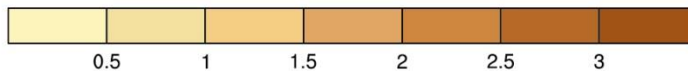
(mm day⁻¹)



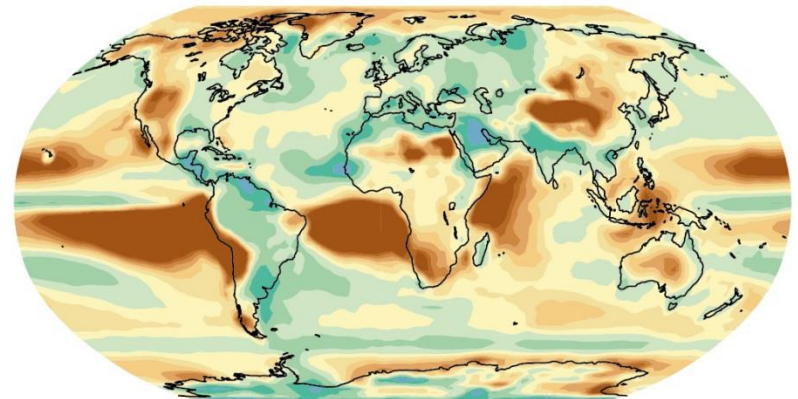
(c) Multi Model Mean of Absolute Error



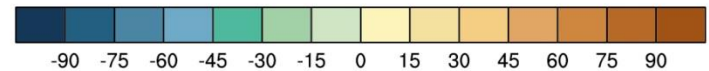
(mm day⁻¹)



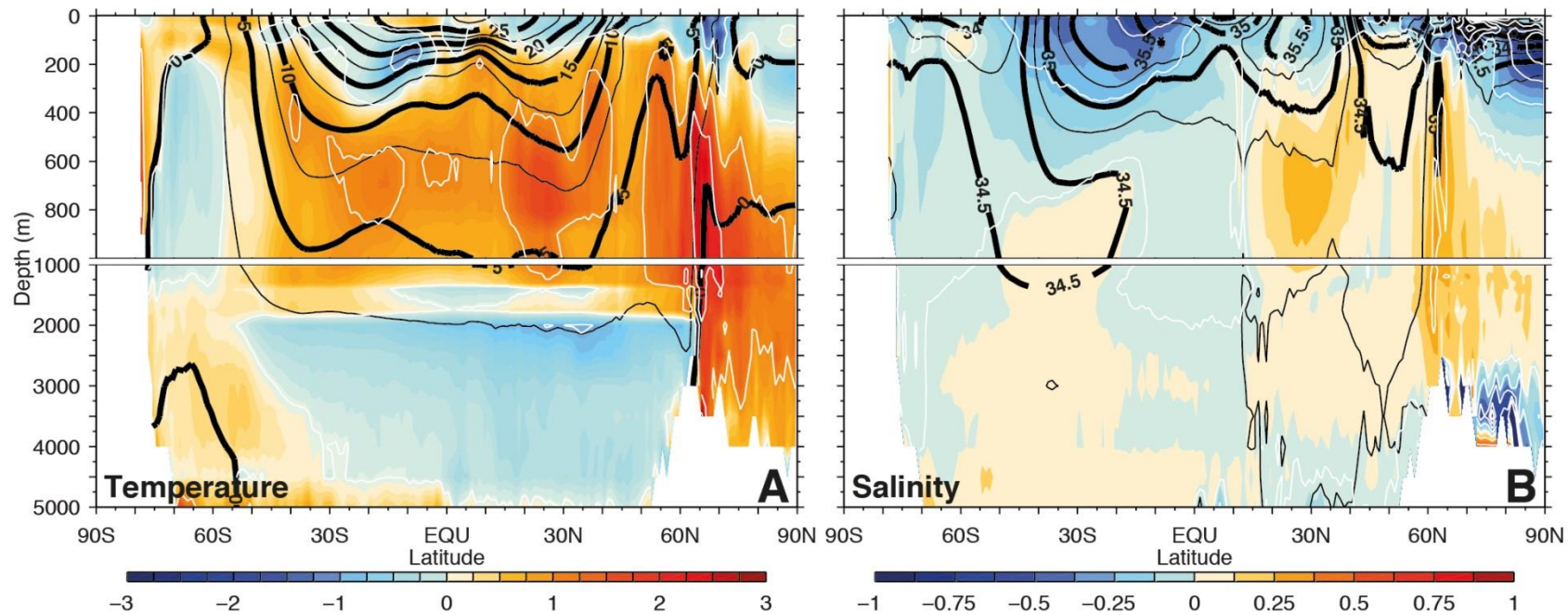
(d) Multi Model Mean of Relative Error



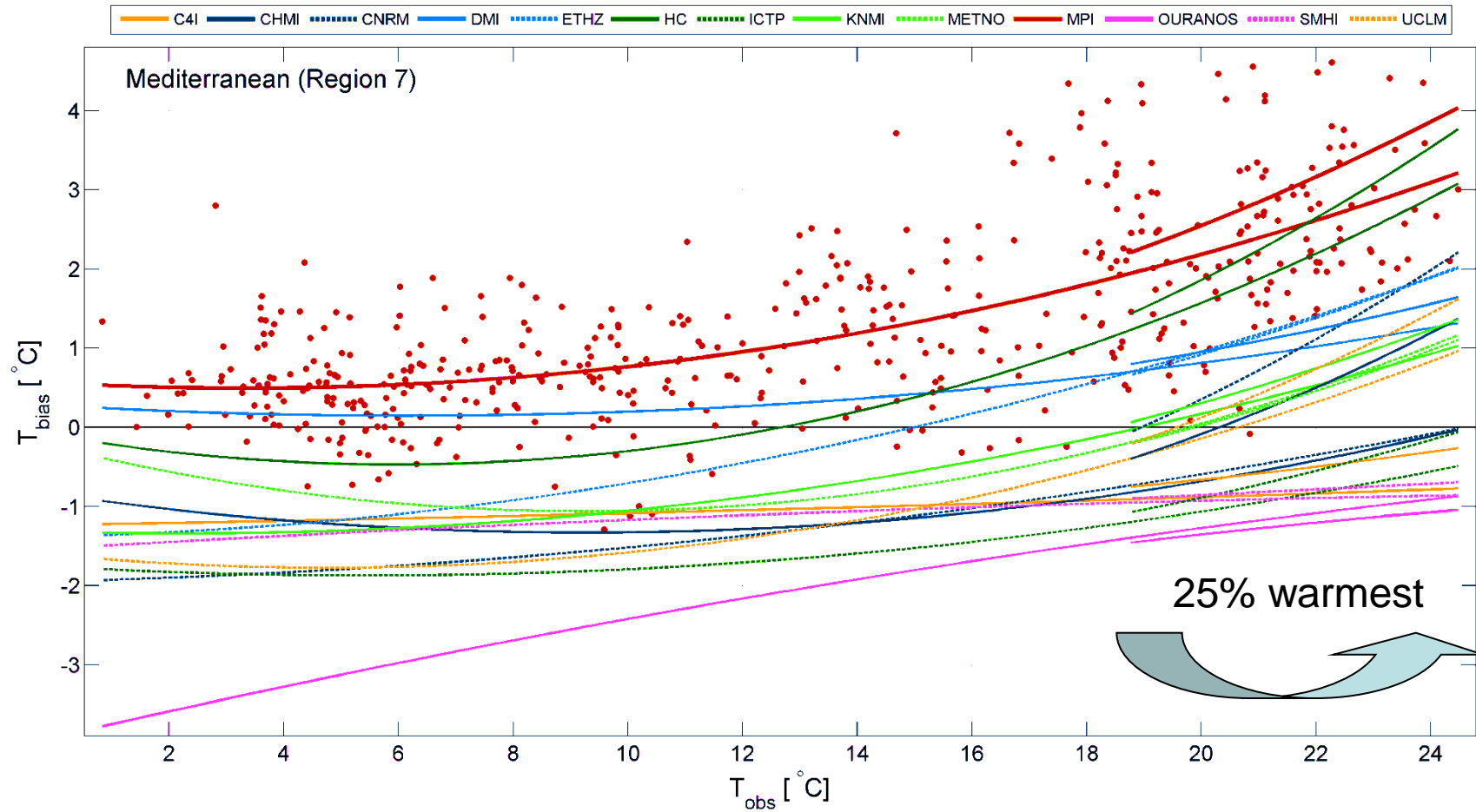
(%)



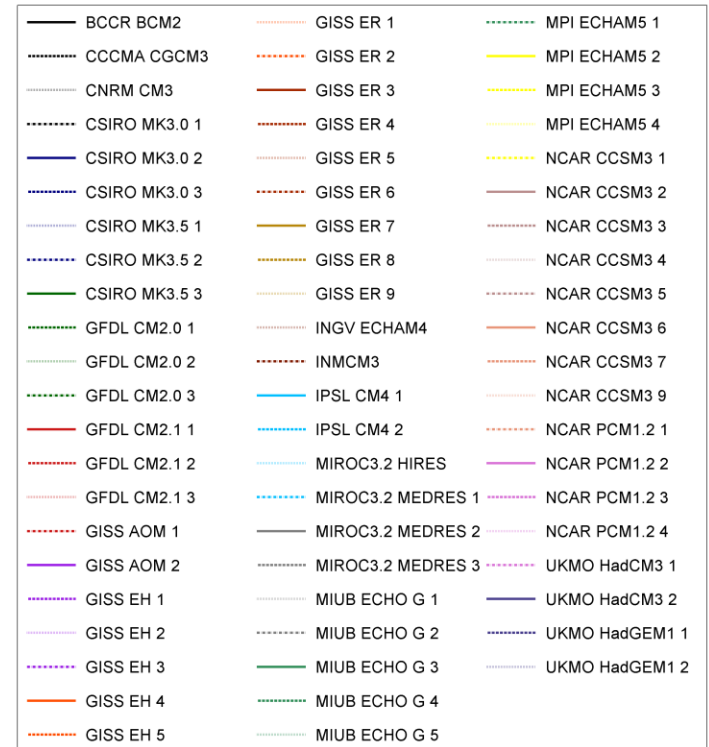
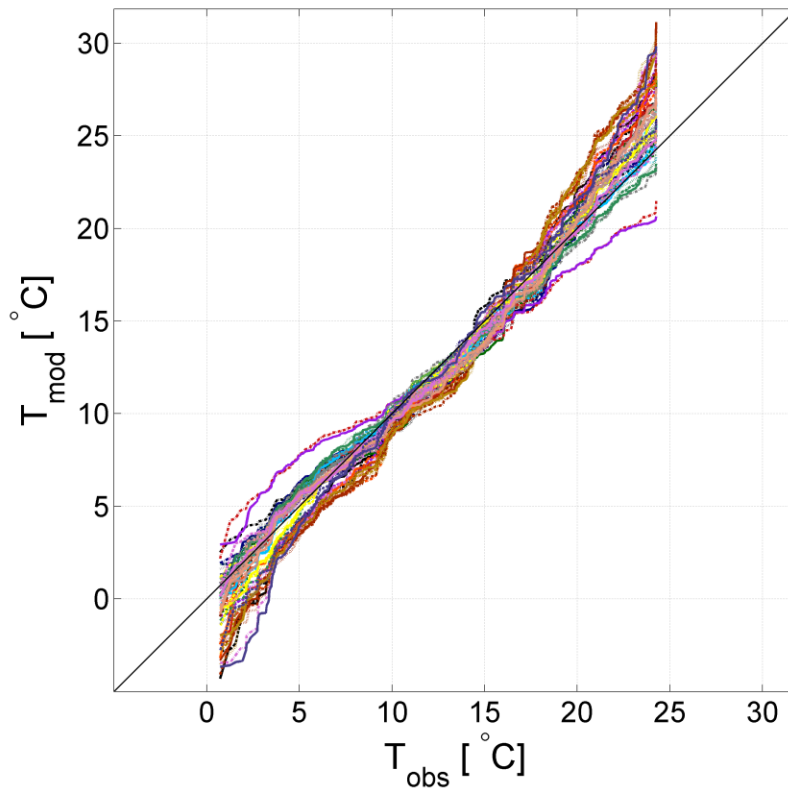
Ocean



Model bias vs. observations



(Christensen *et al.* 2008)

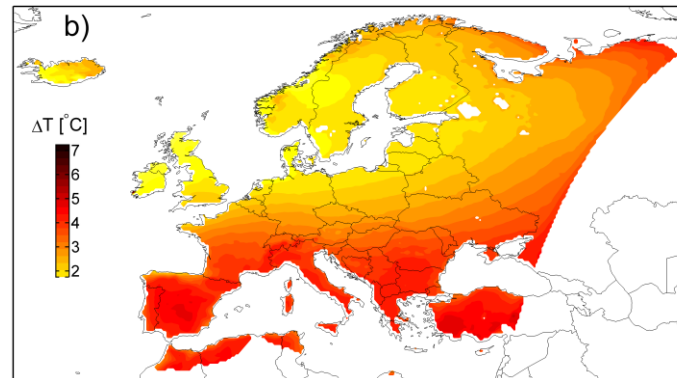


Mediterranean

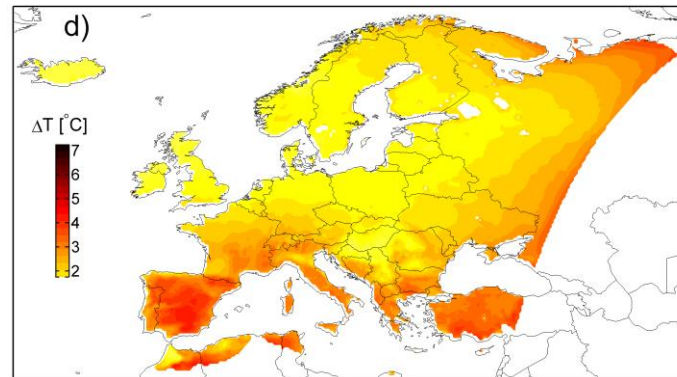
$$\langle T_{\text{change}} \rangle = \langle T_{2071-2100} - T_{1961-1990} \rangle - \langle \text{BC} \rangle$$

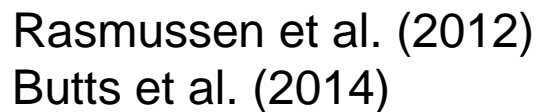
JJA

No bias Corr.



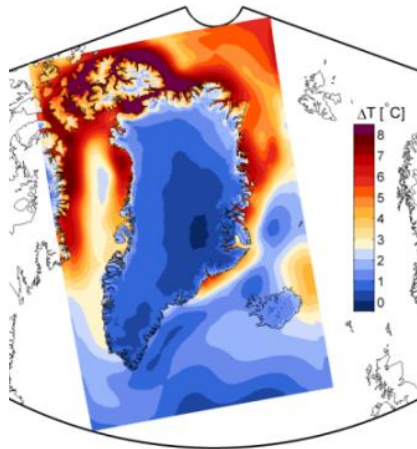
Bias Corr.



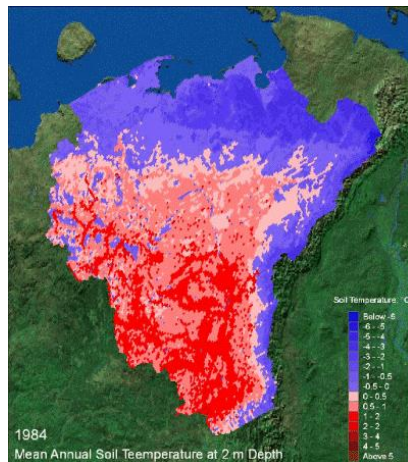


Larsen et al. (2015)

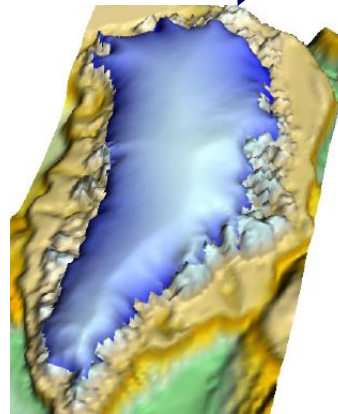
Model systems



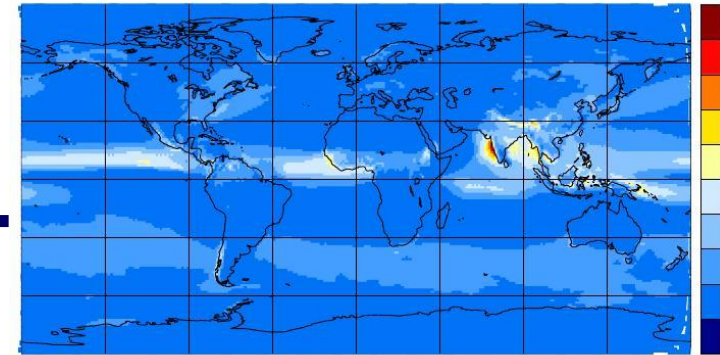
HIRHAM5



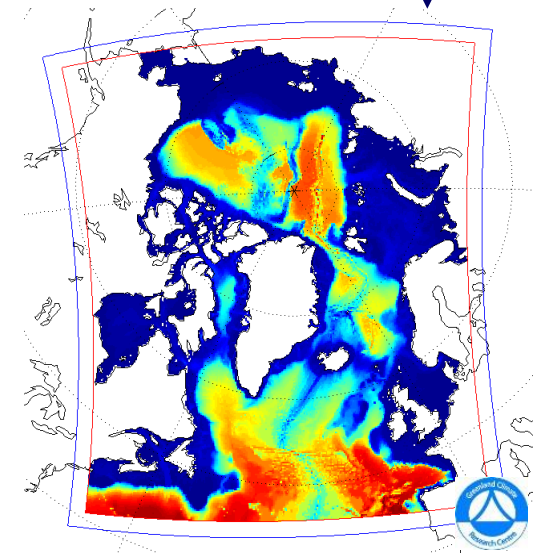
GIPL: permafrost model (UAF)



PISM: Parallel Ice Sheet Model (UAF)



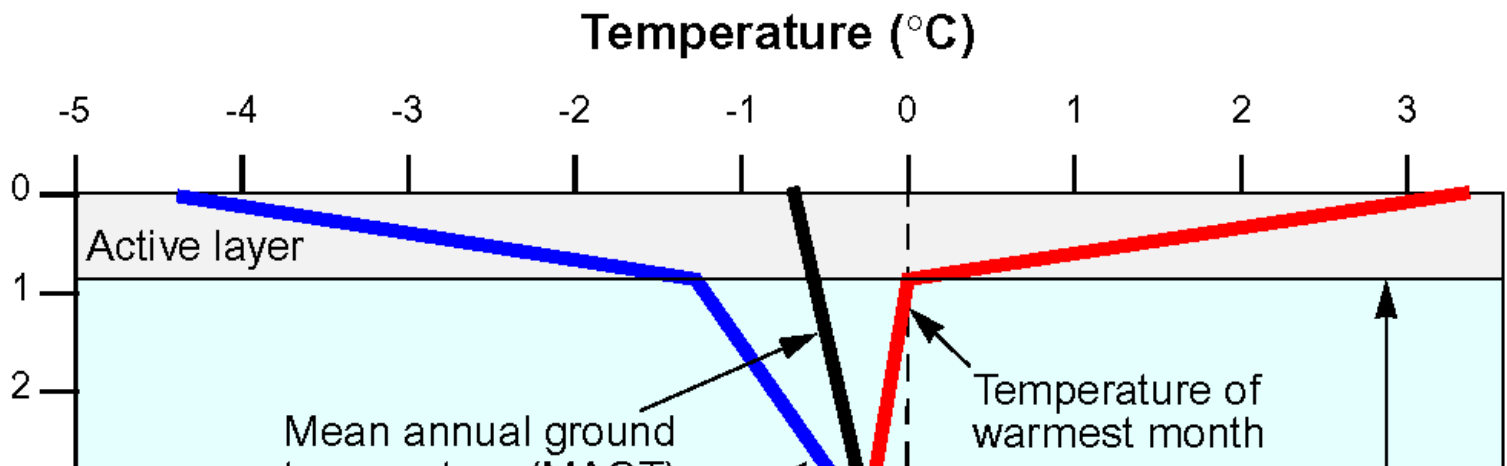
EC-EARTH
ERA Interim



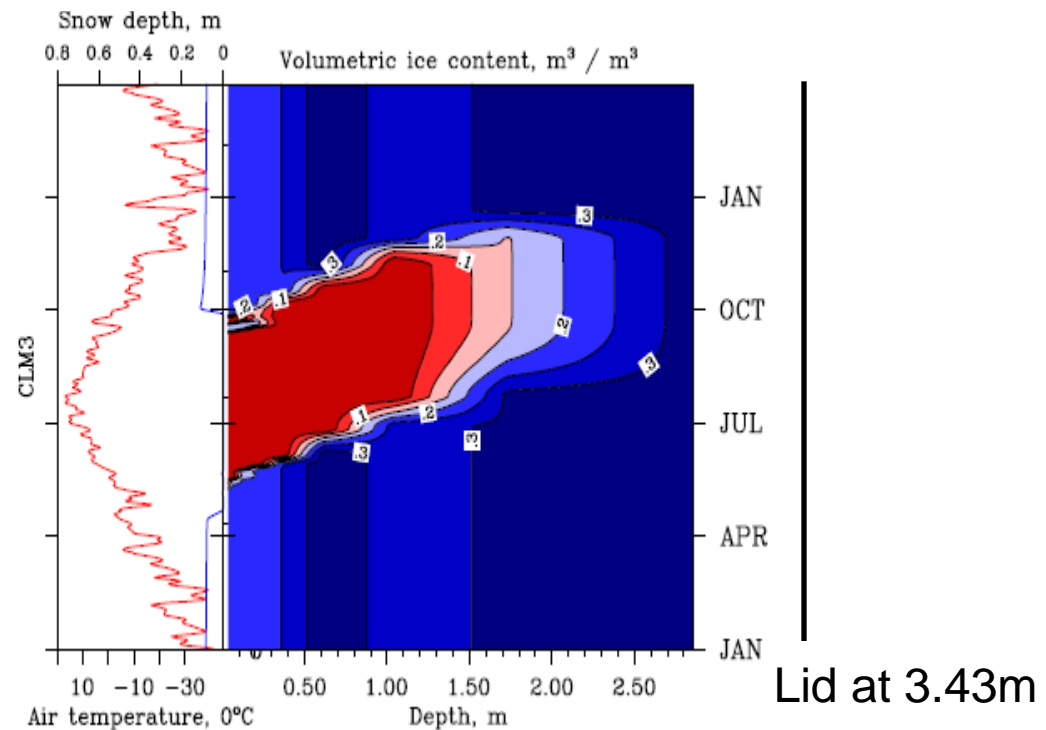
Ocean / sea ice models:
HYCOM-CICE
(coupled for North Atlantic)

Permafrost





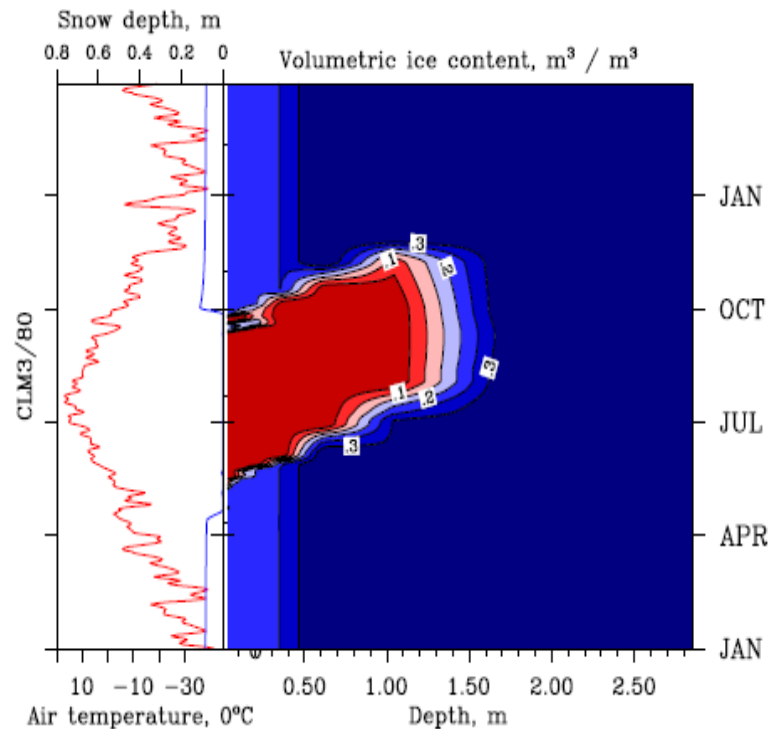
Formulation of soil processes



Deadhorse

Nicolsky et al. 2007

Formulation of soil processes



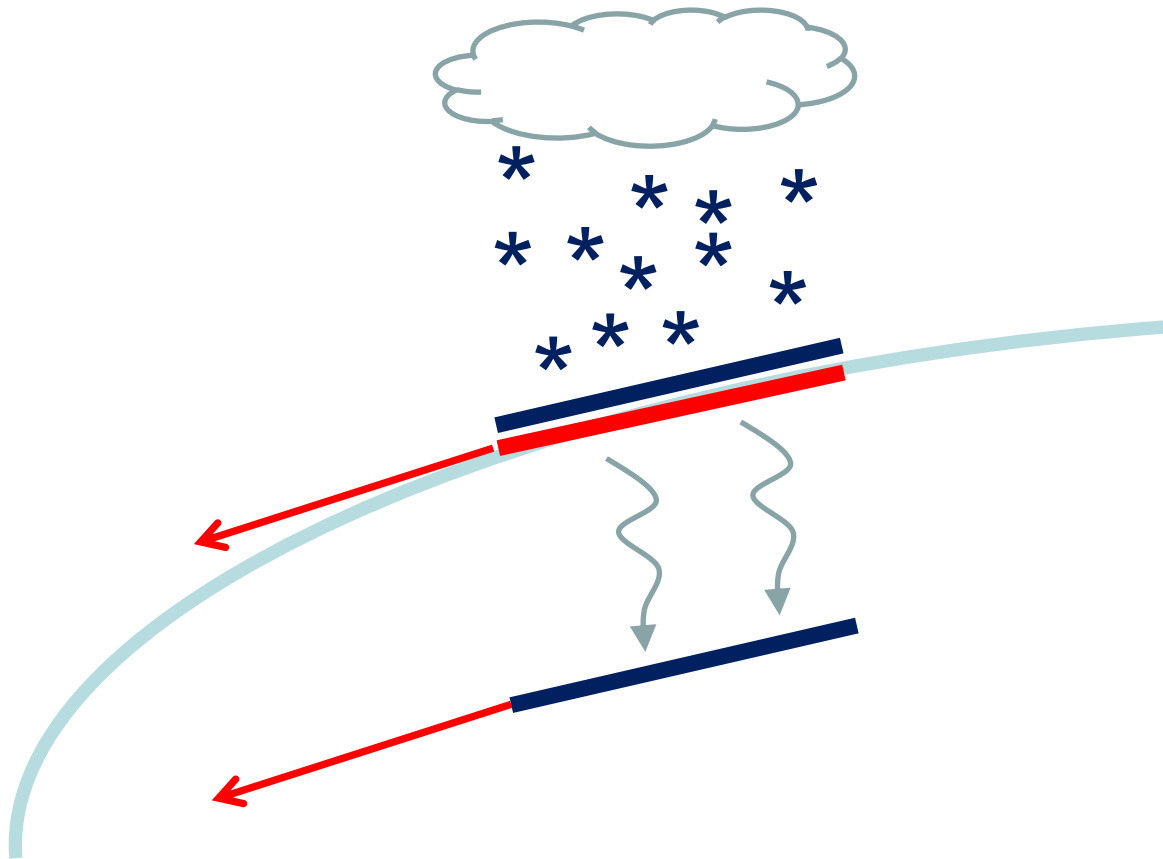
Deadhorse

Nicolsky et al. 2007

Ice Sheet



Surface mass balance

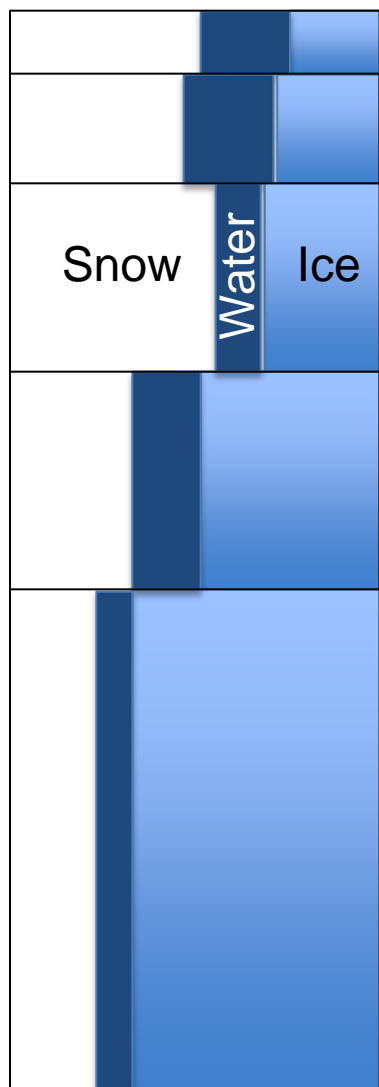


$$\text{SMB} = \text{Accumulation} - \text{Runoff}$$



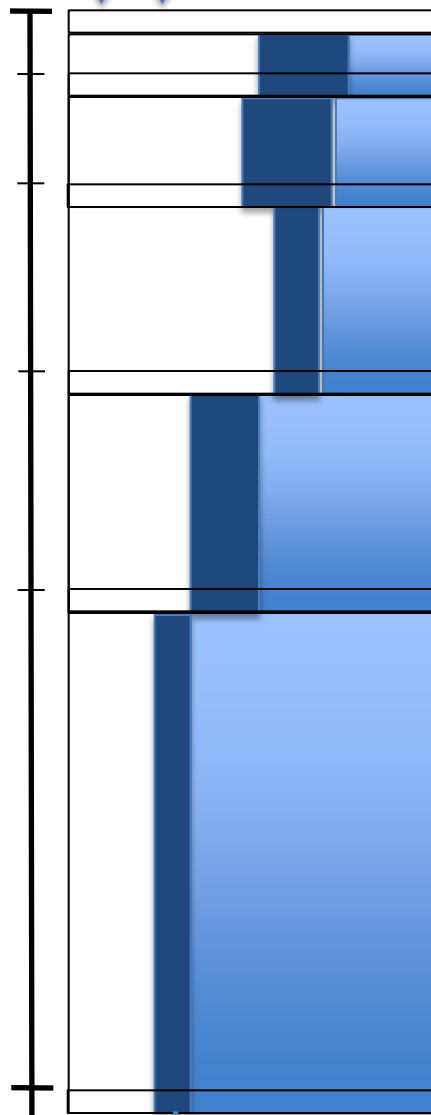
Snow, ice and water mass fractions

0 m weq



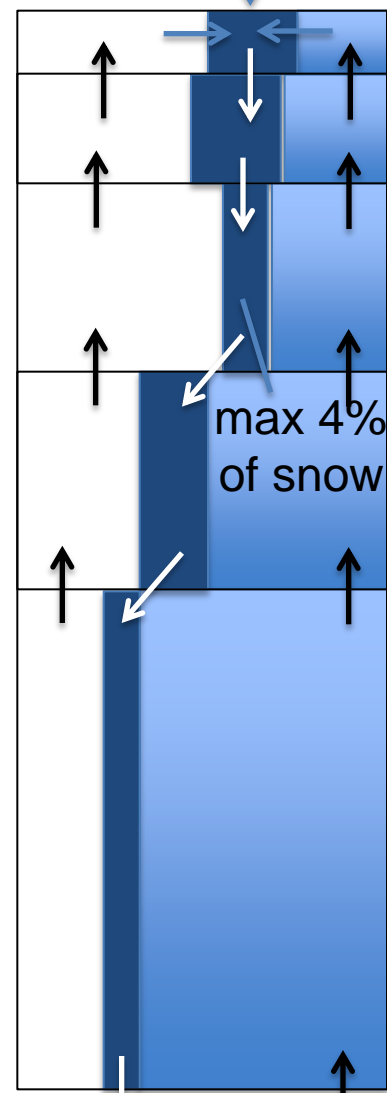
10 m weq

Snowfall



Runoff

Melt + rain



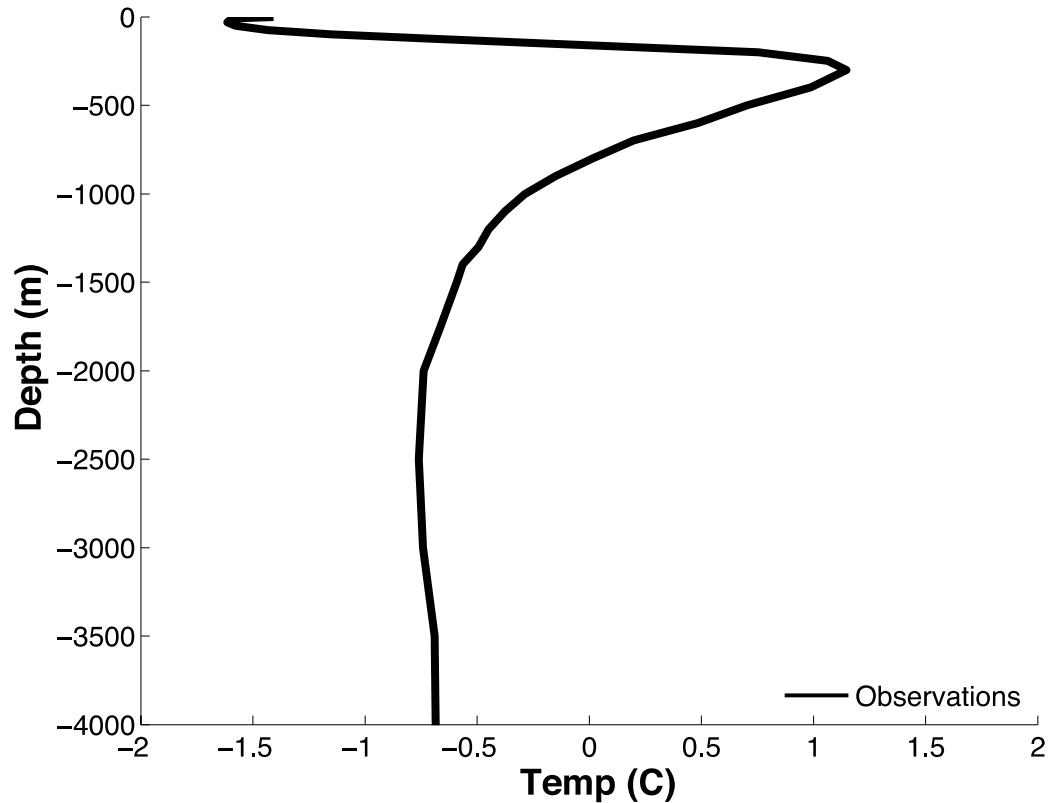
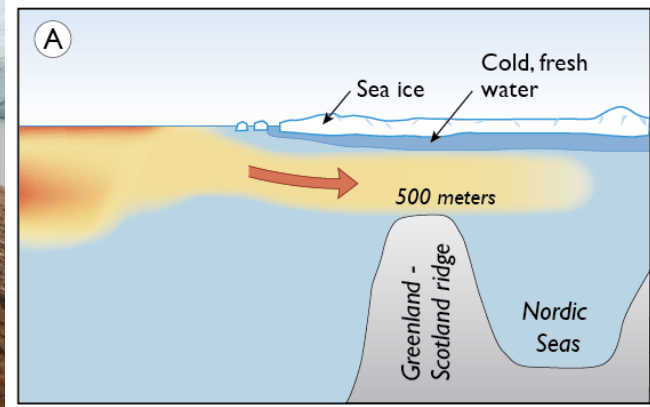
Runoff

Ice (-10²⁰°C)

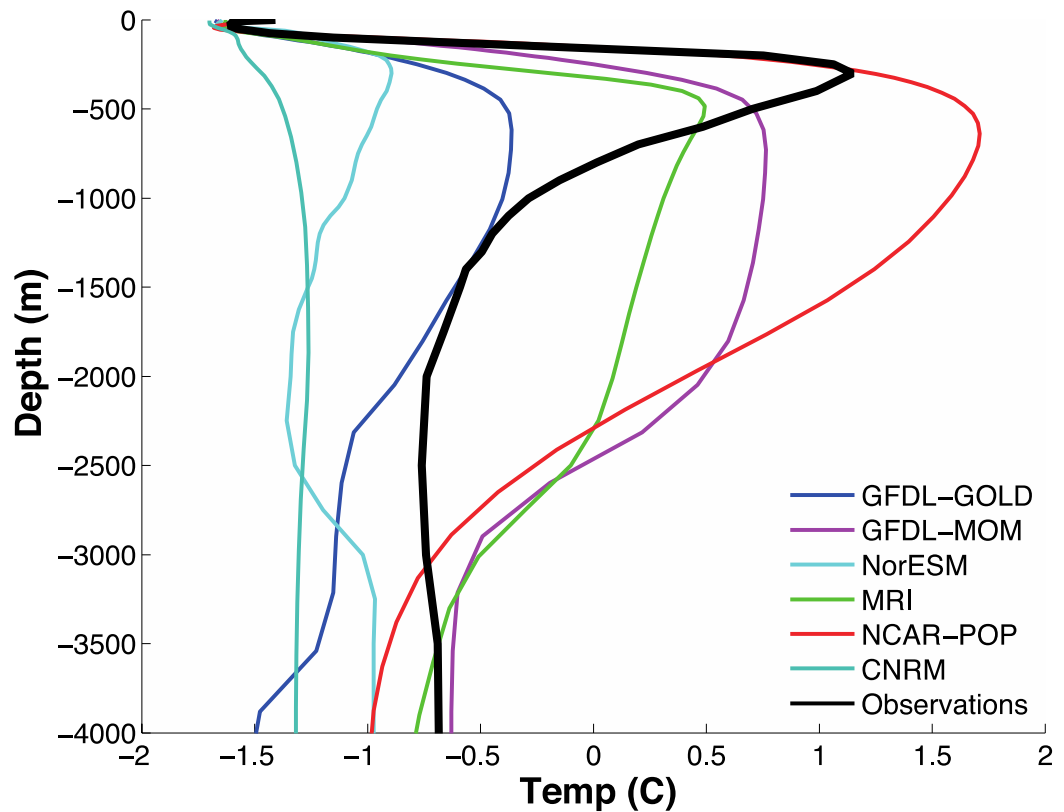
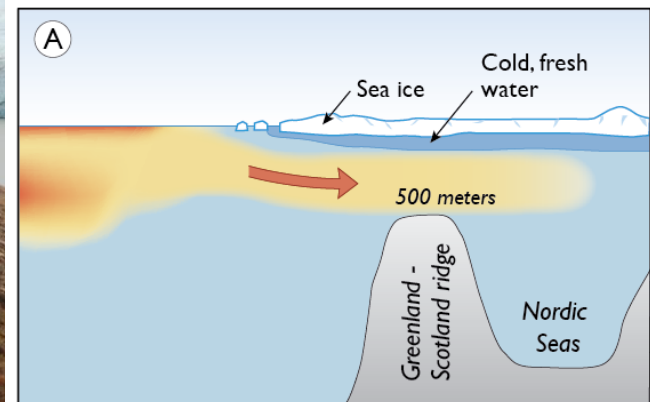
Ocean



Challenge of simulating Arctic ocean temperature



Challenge of simulating Arctic ocean temperature

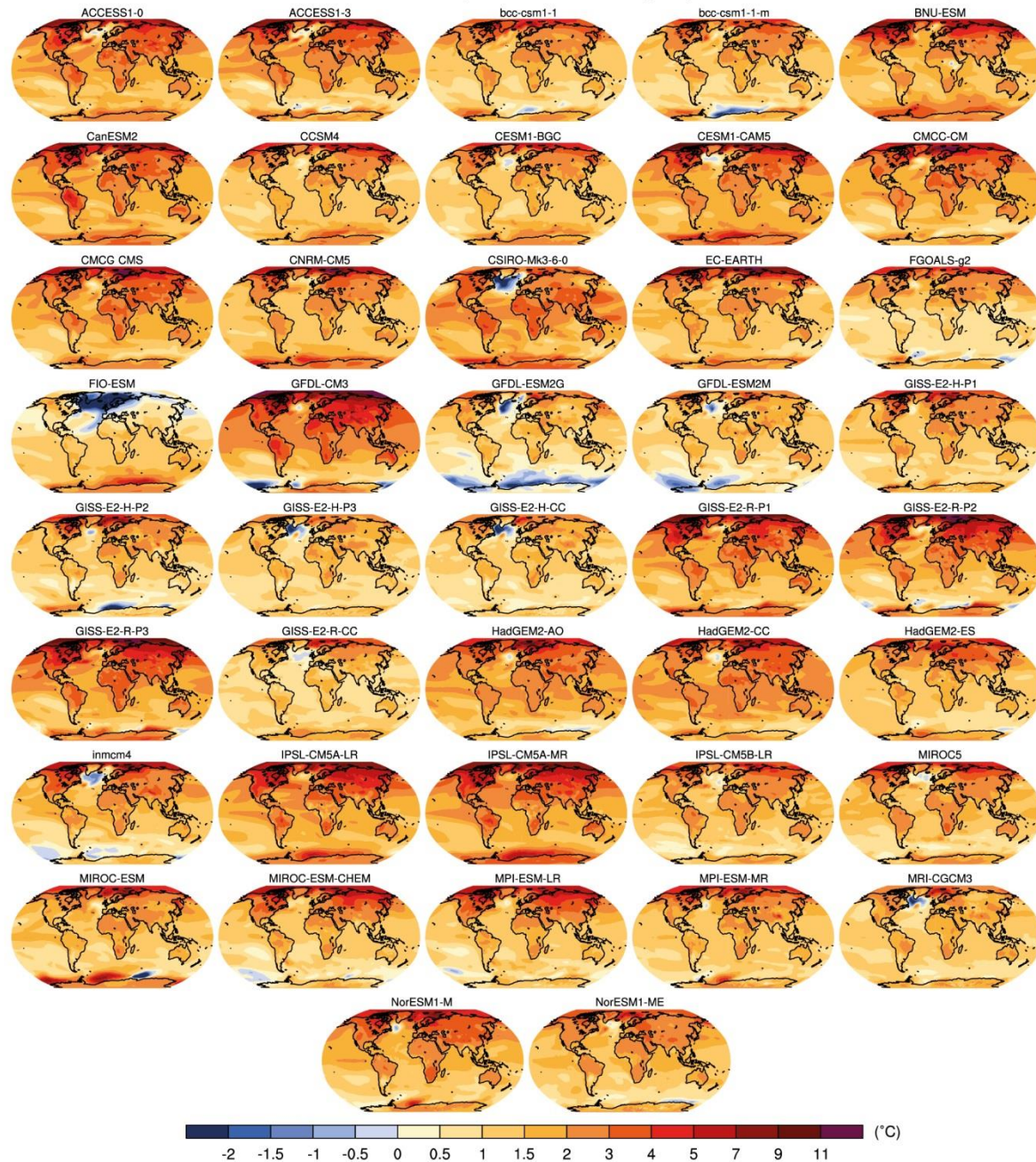


Are we able to simulate the main observed processes and feedbacks?

YES and NO

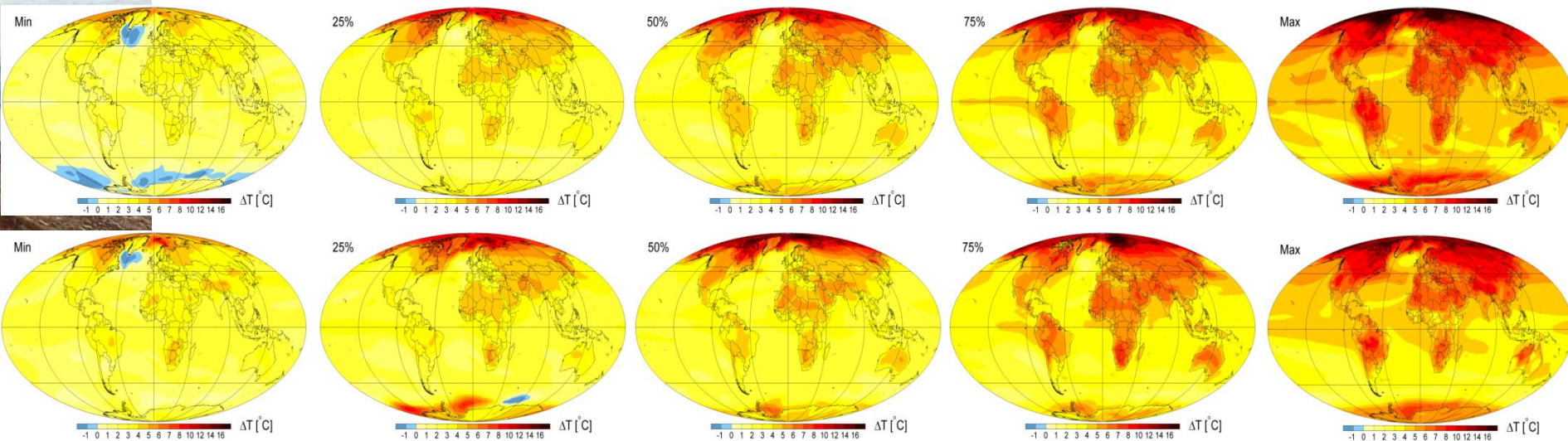
Thank you for your attention

Annual mean surface air temperature change (RCP4.5: 2081-2100)



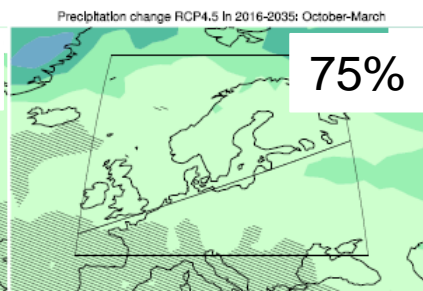
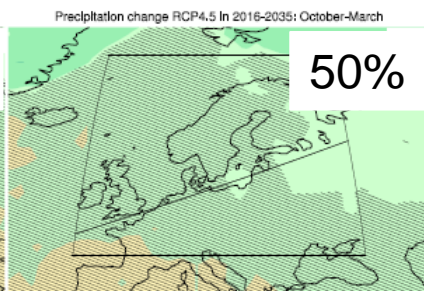
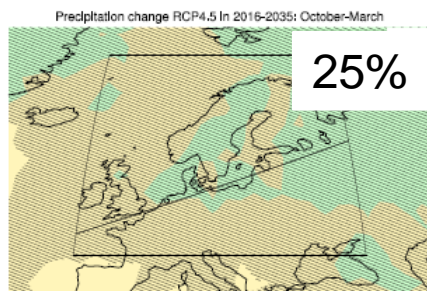
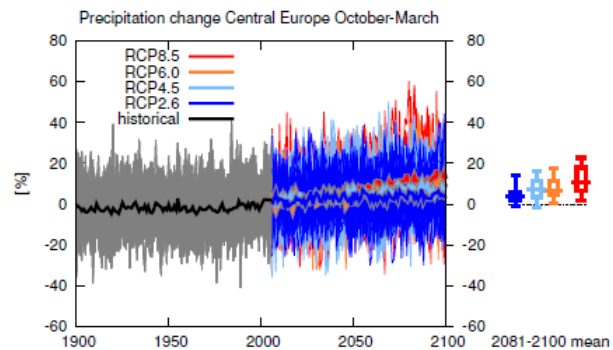
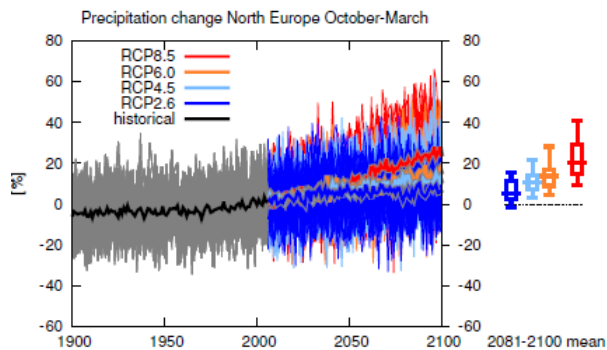
Stating the obvious Temperature

Grid point statistics

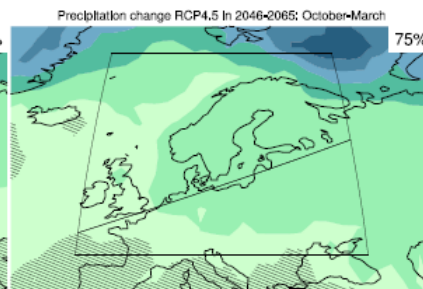
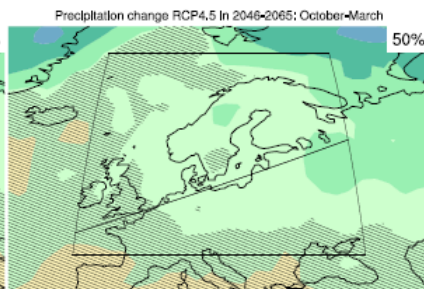
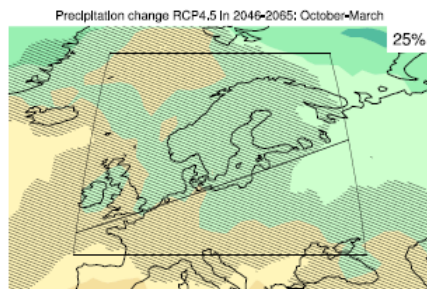


Model statistics – climate sensitivity

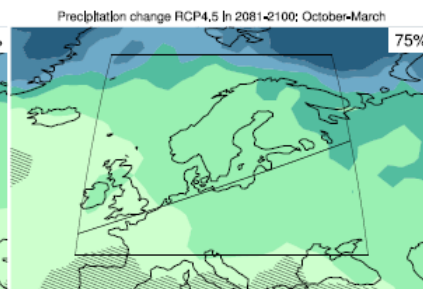
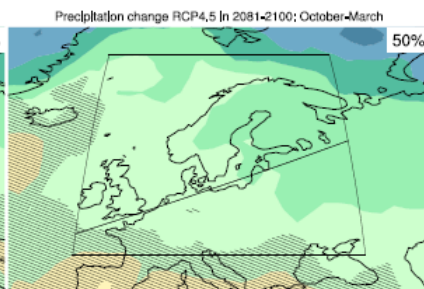
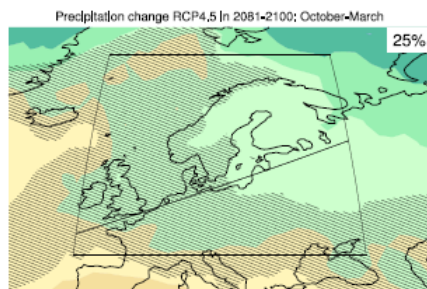
Using 37 CMIP5 models under RCP8.5
Comparing 2081-2100 with 1986-2005



2016-2035

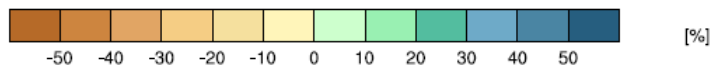


2046-2065



2081-2100

Atlas
(IPCC, 2013)



[%]

Annex I: Atlas of Global and Regional Climate Projections

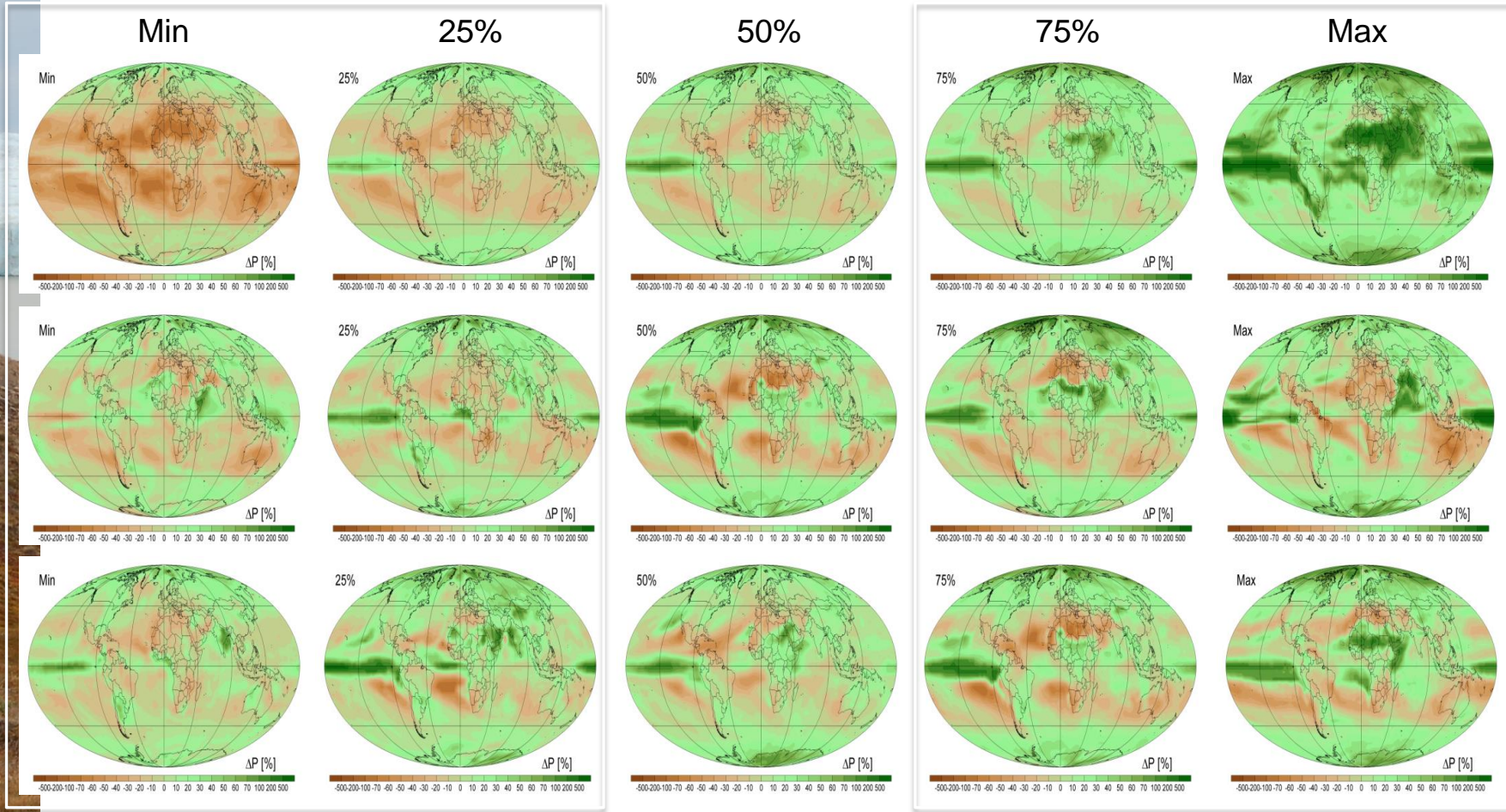
Stating the less obvious

Precipitation

Precip. Ranked
at grid level

Global mean
Precipitation

Global Temp.
Sensitivity



Method of estimating percentiles needs a relook?