Climate Change – The Physical Background

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KNMI

- Basics of the climate system
- Anthropogenic influence
- Projected changes & impact

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Climate – what's that?

Climate = statistics of weather

Weather = state of atmosphere
at a particular time

"Climate is what you expect,
weather is what you get"

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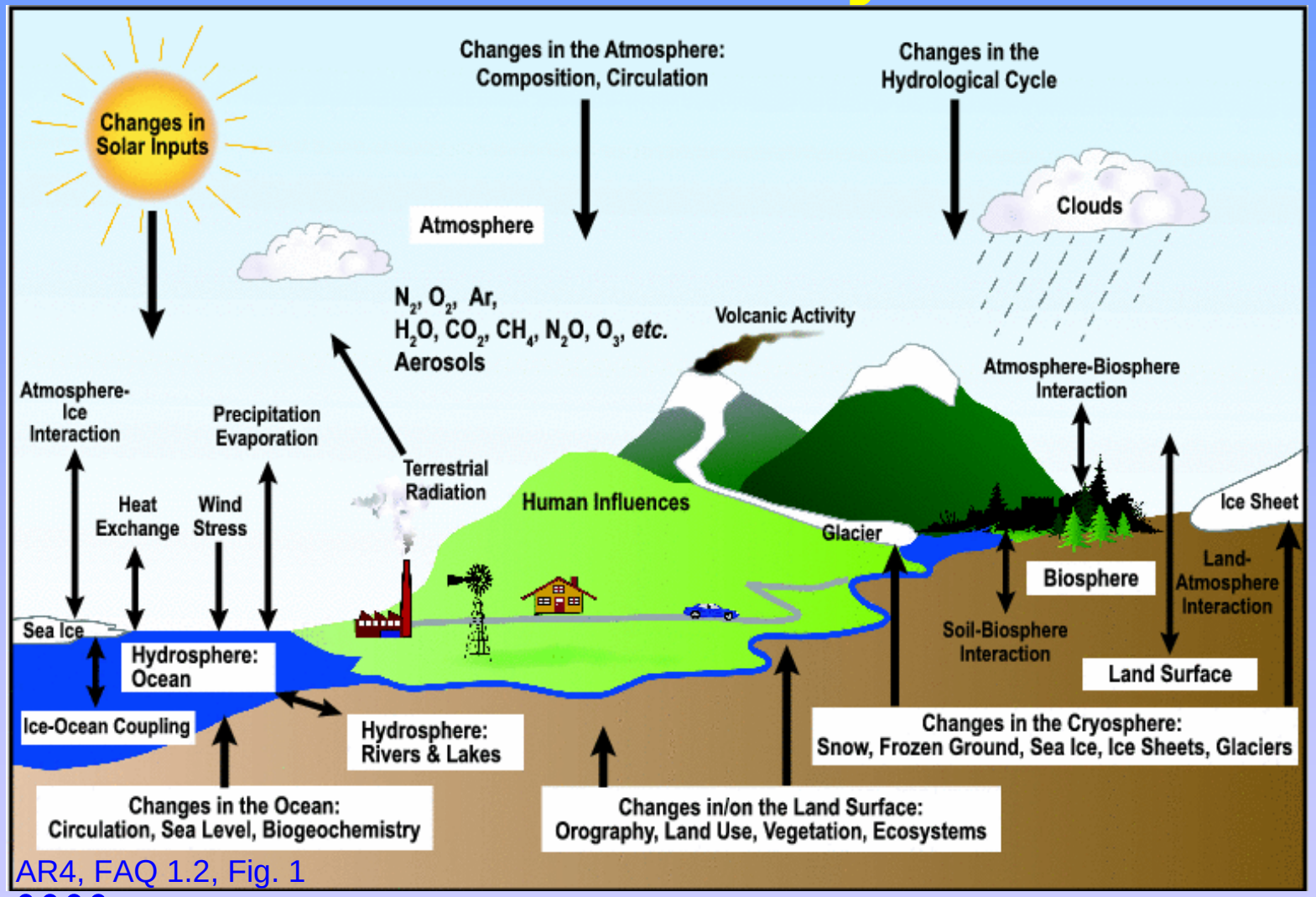
The climate system



AR4, FAQ 1.2, Fig. 1

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How does the climate system work?

- short-wave radiation (sun) heats (tropics)
- atmosphere and ocean transport heat poleward
- modulated by continents
- long-wave radiation into space cools

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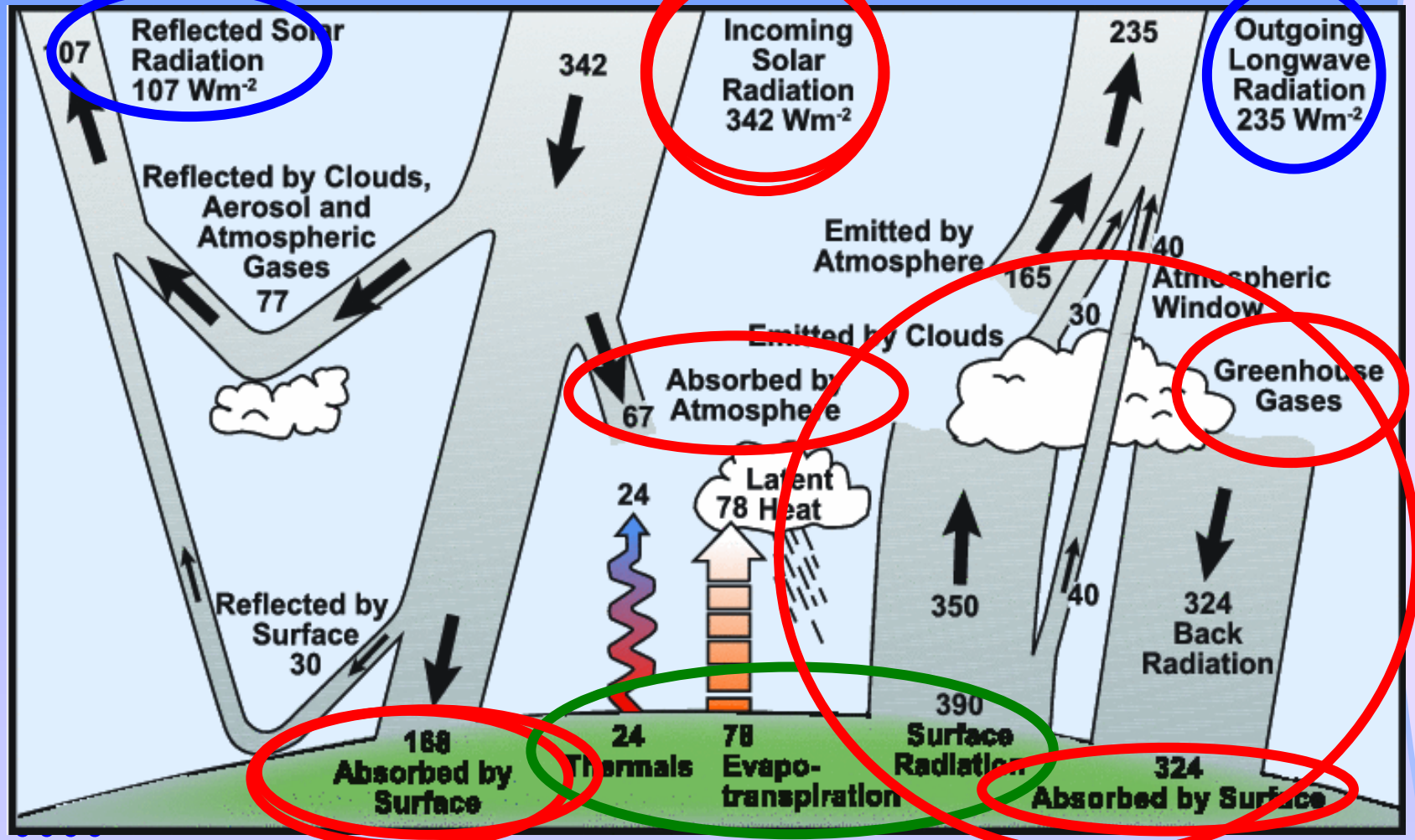
Radiative forcing



AR4, FAQ 1.1, Fig. 1

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Greenhouse effect

Outgoing longwave radiation is absorbed in the atmosphere and radiated back to the surface.

without: T_{glob} = -15°C
observed: T_{glob} = +15°C

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Greenhouse gases

only 1 % of atmosphere

- H_2O 70 % <= feedback (~2x)
- CO_2 15 %
- CH_4)
- N_2O) 5 %
- Ozone, …)
- (clouds 10 %) <= feedback (?)

(van Dorland, 1999, p. 17/18)

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Observed climate change

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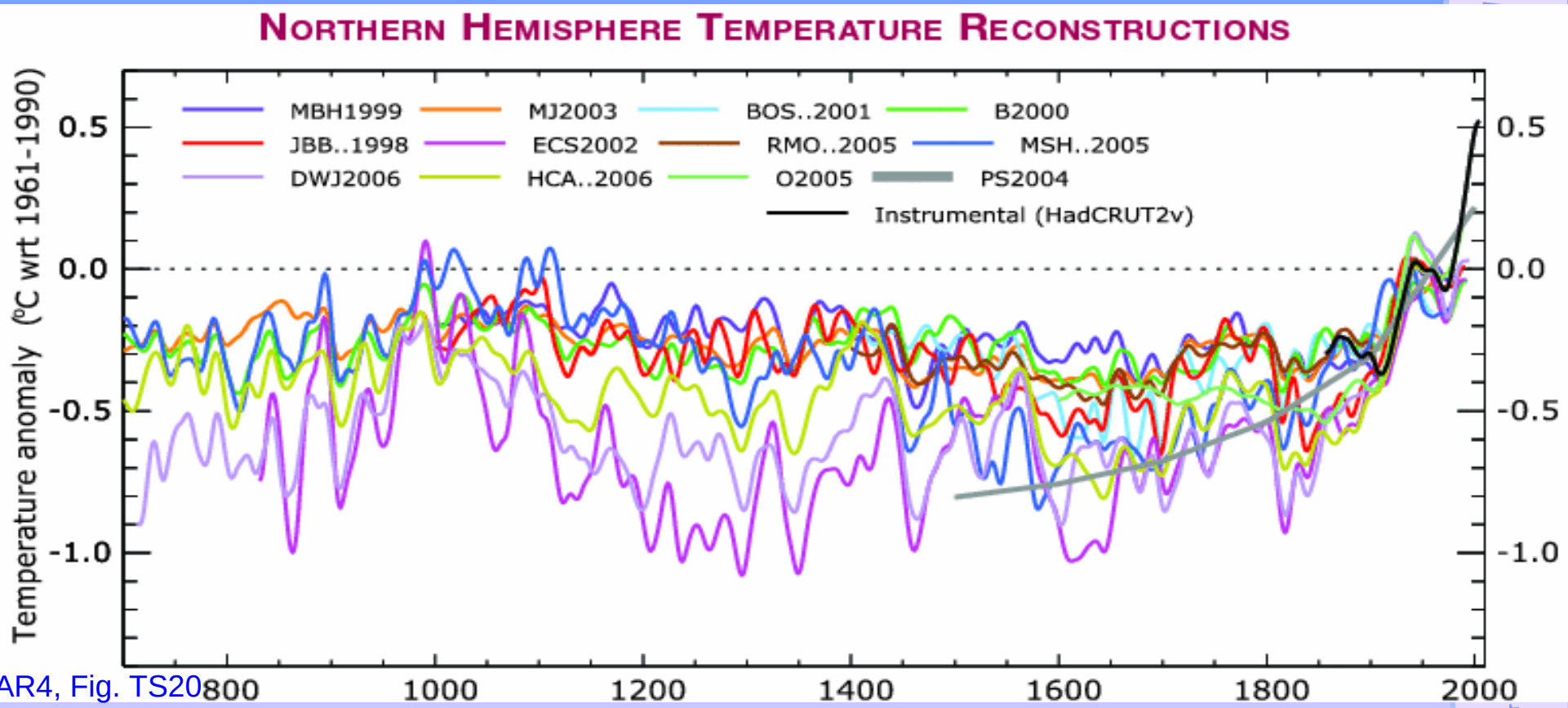
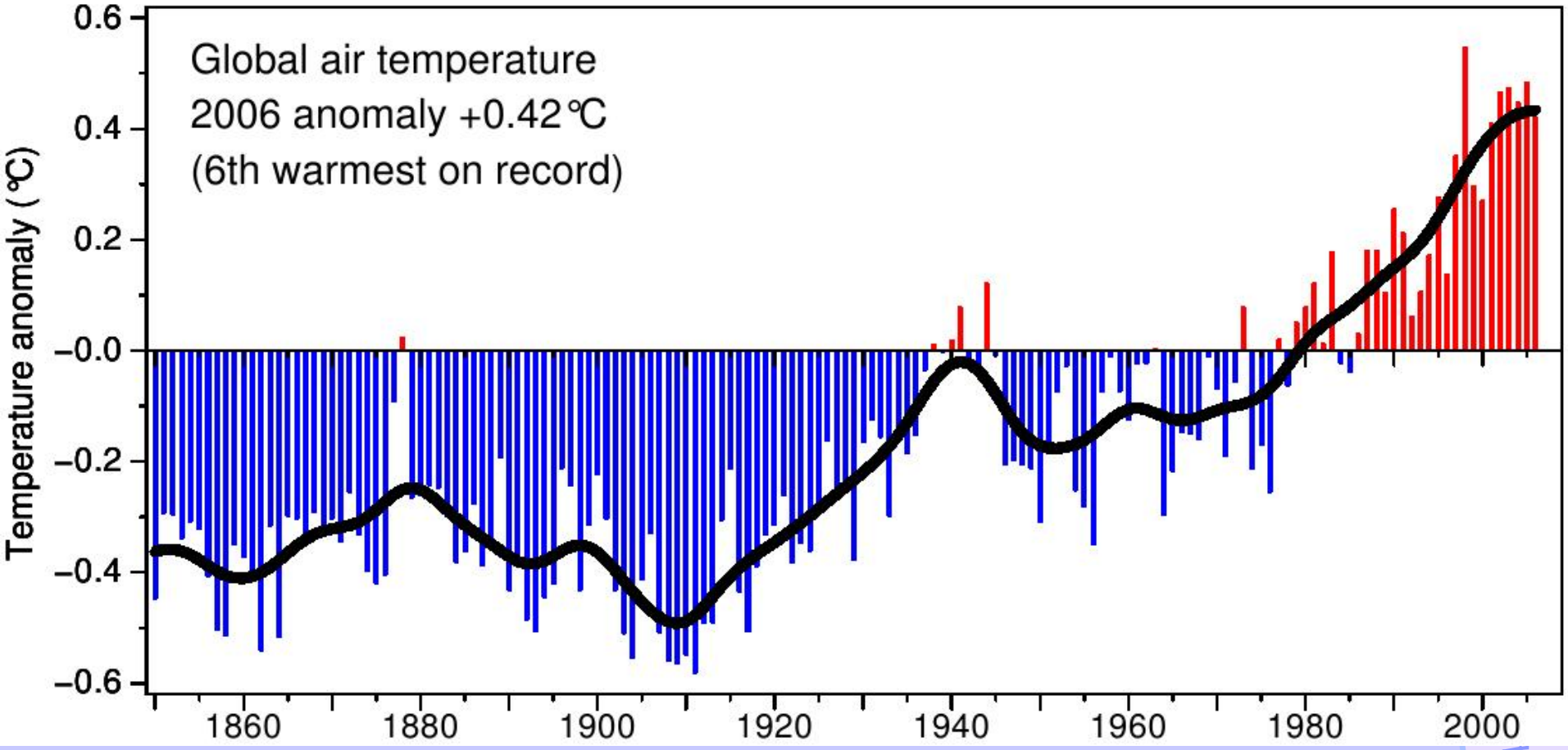
The past 1300 years

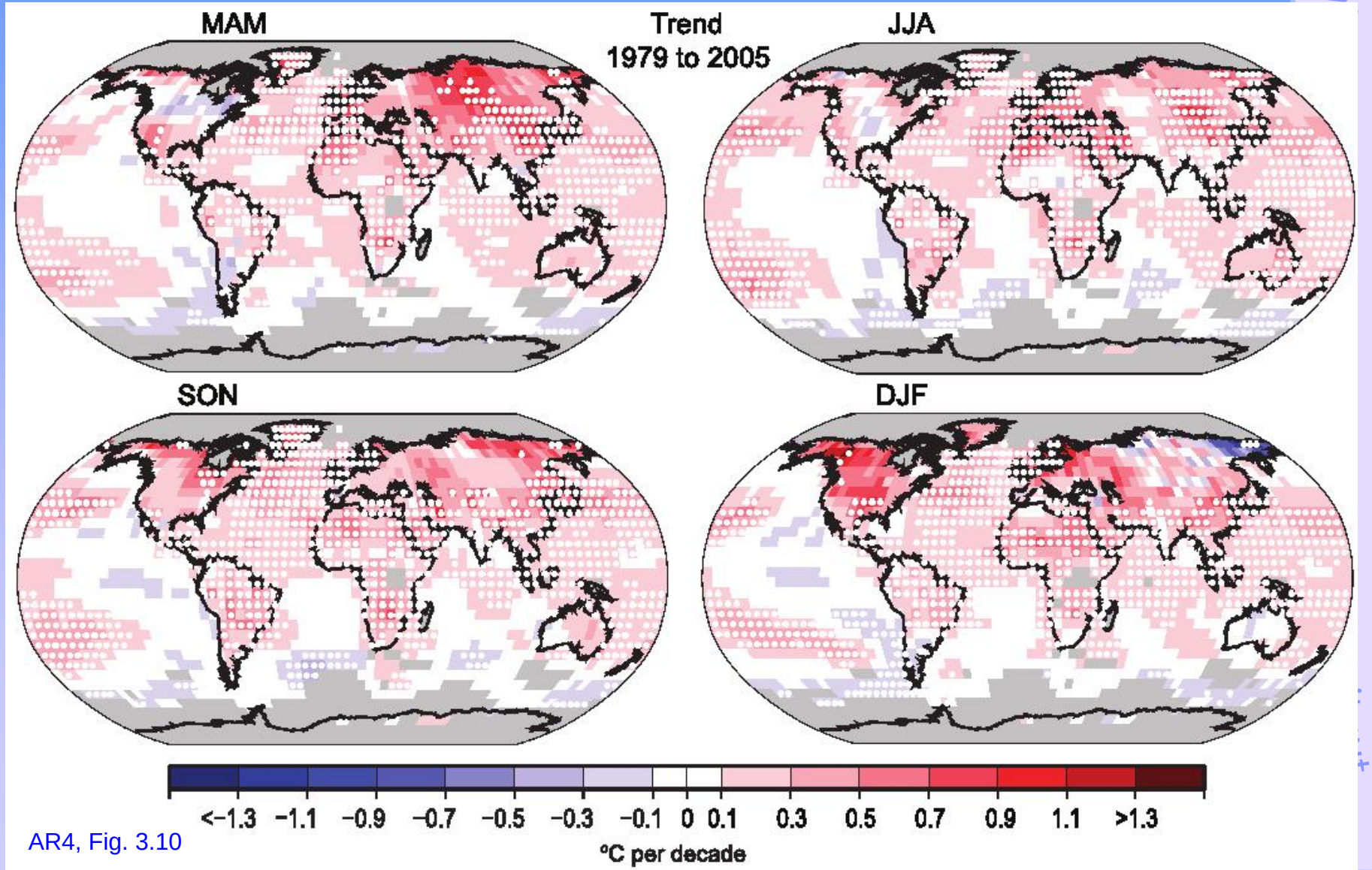


AR4, Fig. TS20

The past 157 years



Temperature trends



AR4, Fig. 3.10

http://www.gletscherarchiv.de

KNMI

1900

2000

1.10.2007

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Possible causes

- earth's orbit
- sun (brightness)
- internal variability
- volcanoes
- land-use
- aerosols
- GHGs (CO_2, CH_4, N_2O)
- …

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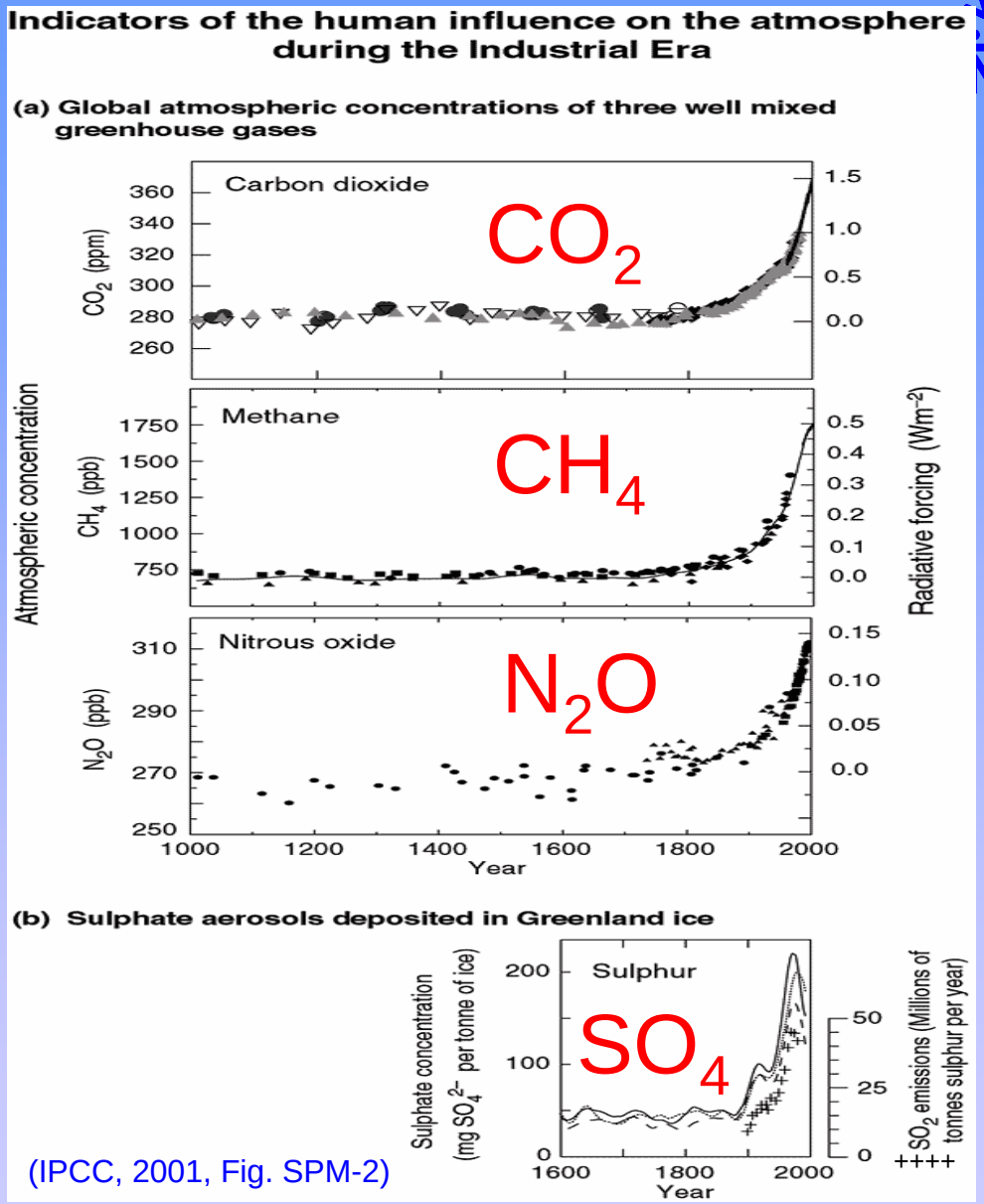
Increasing GHG concentr a-tions



(IPCC, 2001, Fig. SPM-2)

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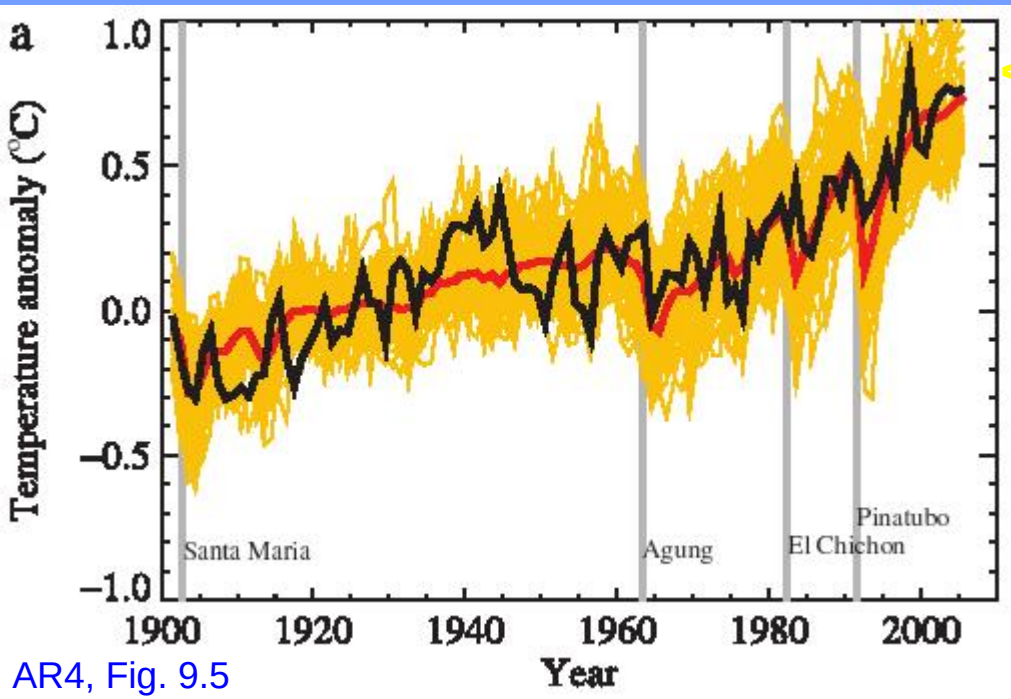
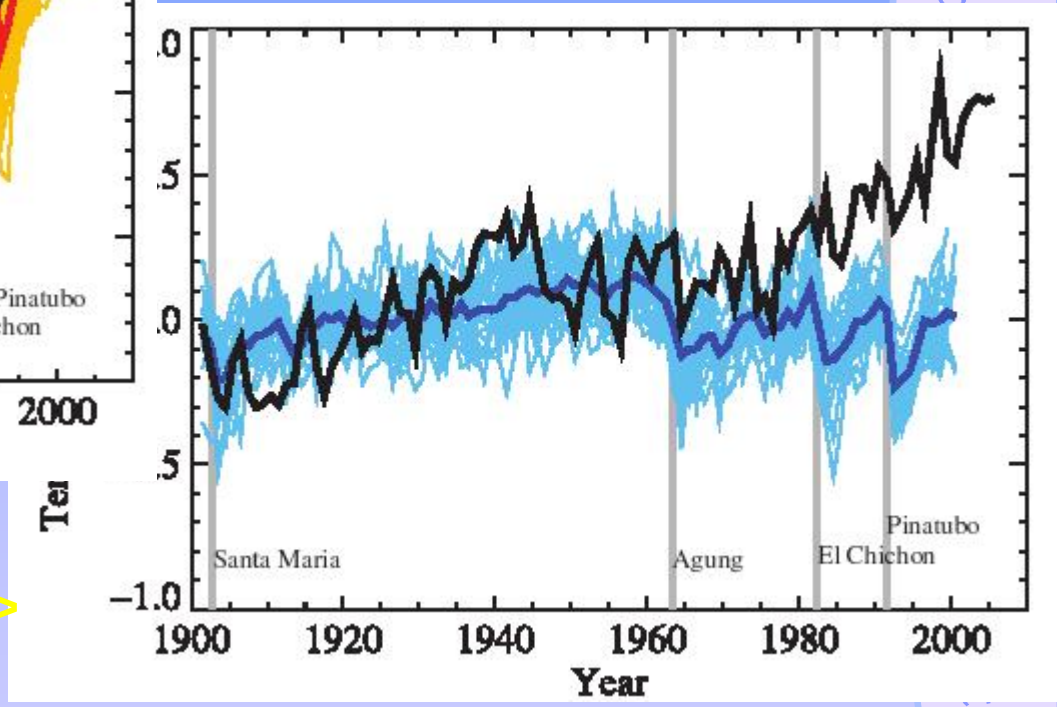
Simulations



AR4, Fig. 9.5

<= multi model, all forcings



Multi model, natural forcings =>

Conclusion

The changes after 1950 can only be understood if changing GHG concentrations are taken into account.

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Projections

1. Scenarios
   "How will the world change?"

2. Scenarios => CO_2 emissions and concentrations

3. CO_2 concentrations => climate

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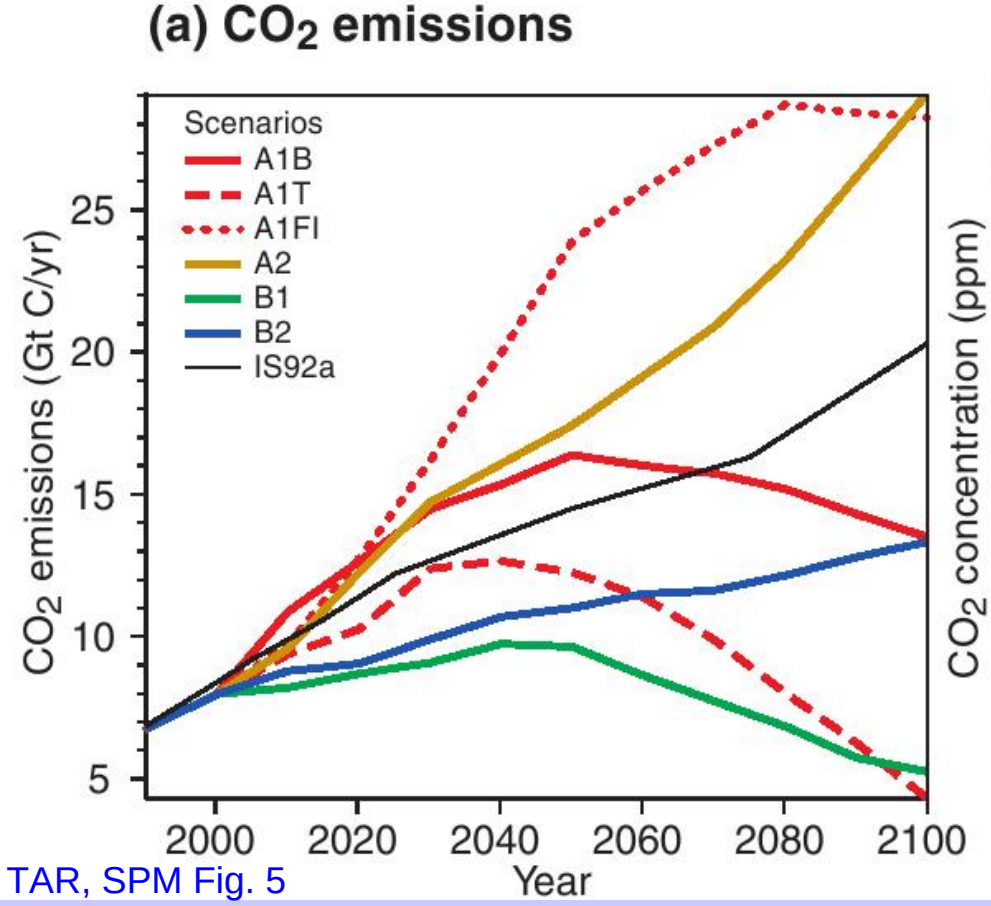
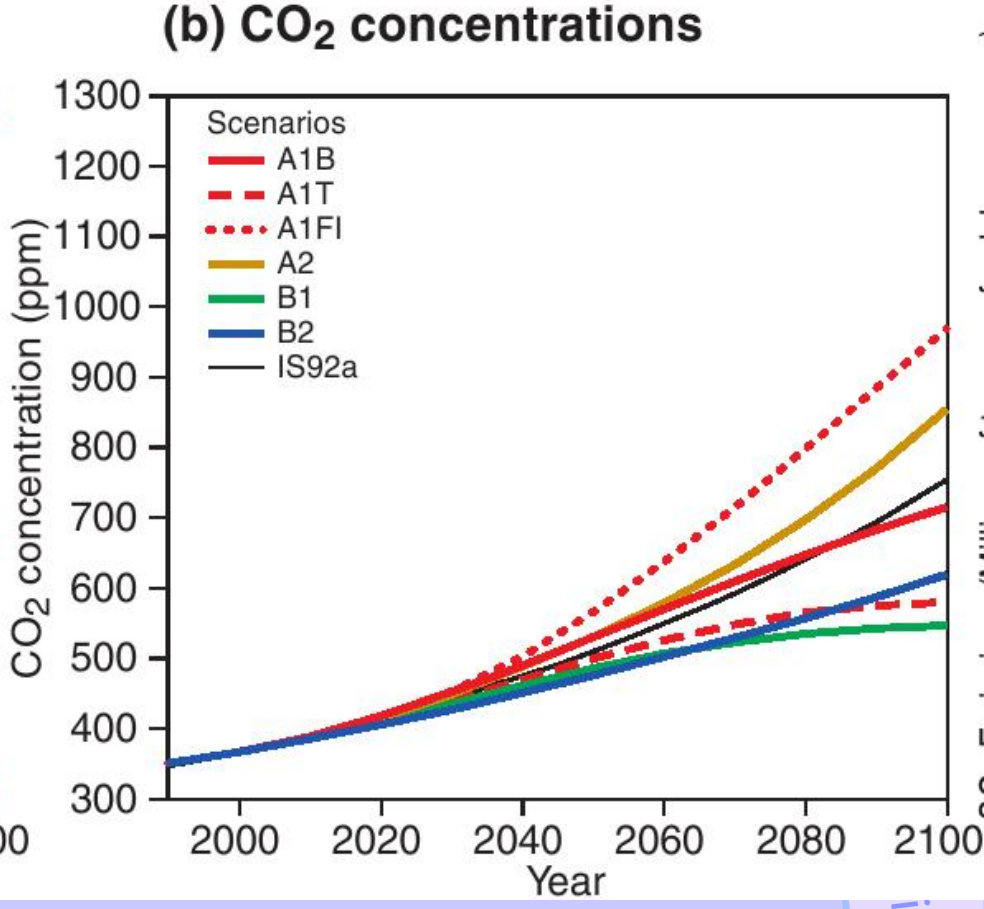
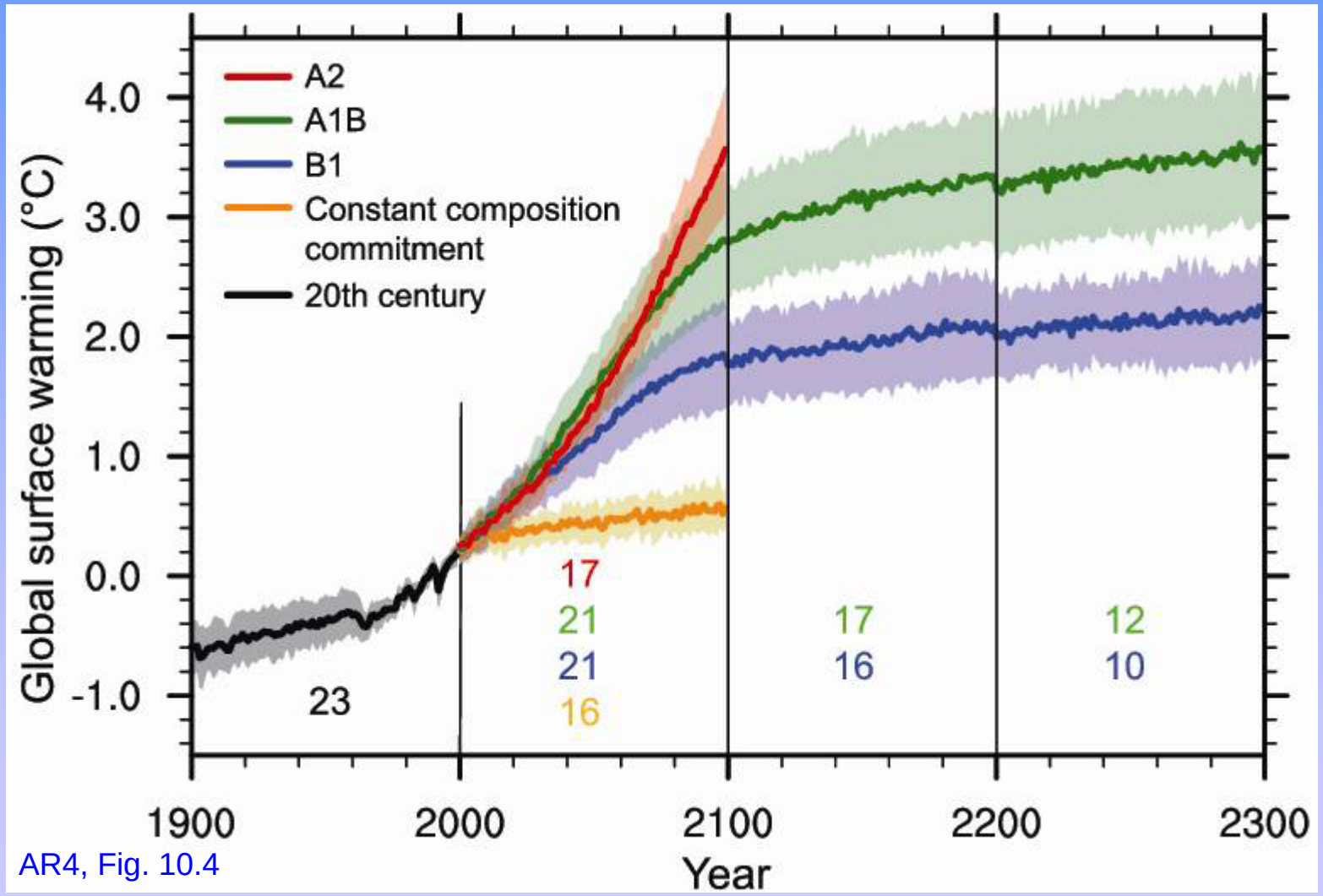
Emission scenarios





TAR, SPM Fig. 5

Projected changes



AR4, Fig. 10.4

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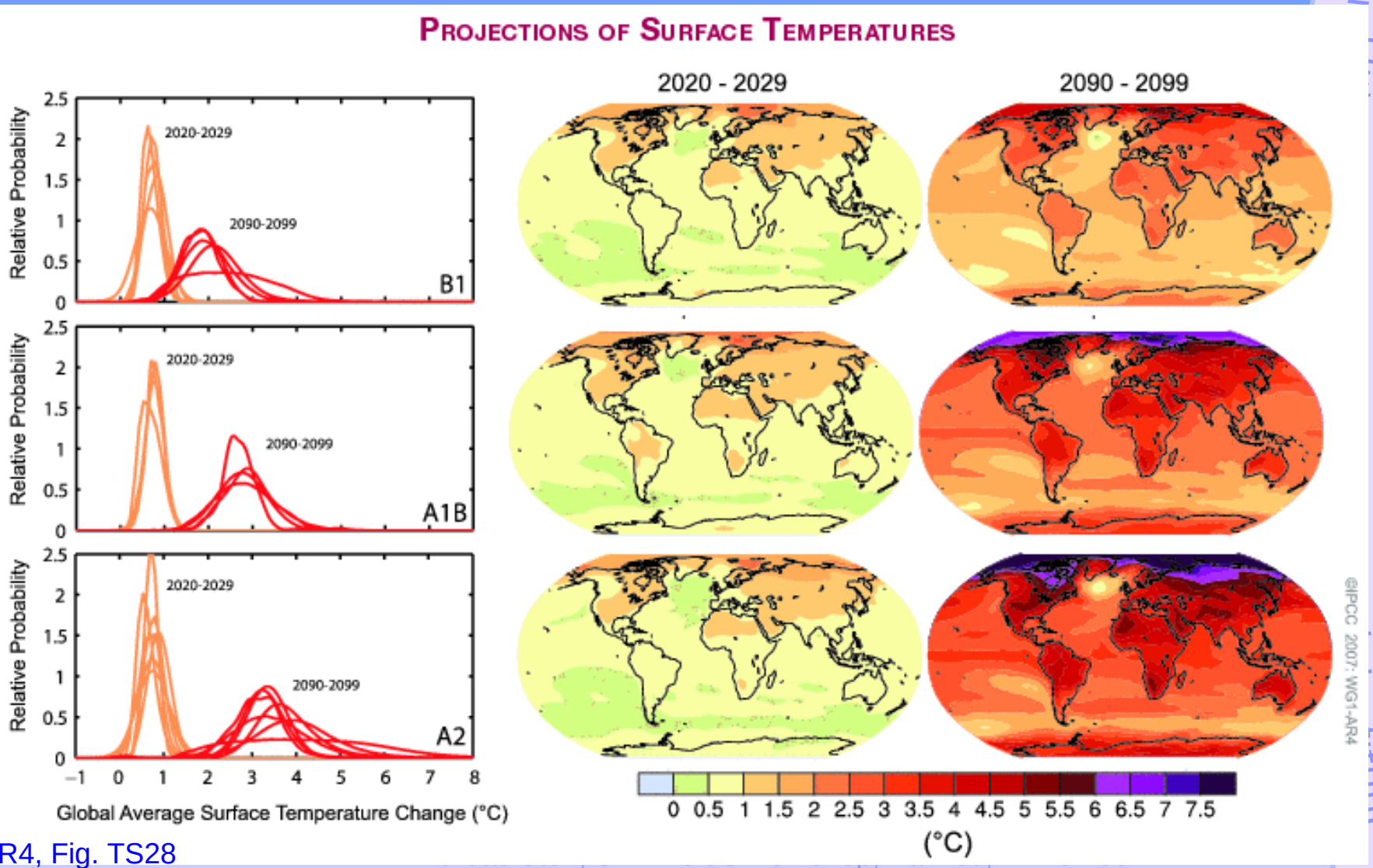
Projected patterns

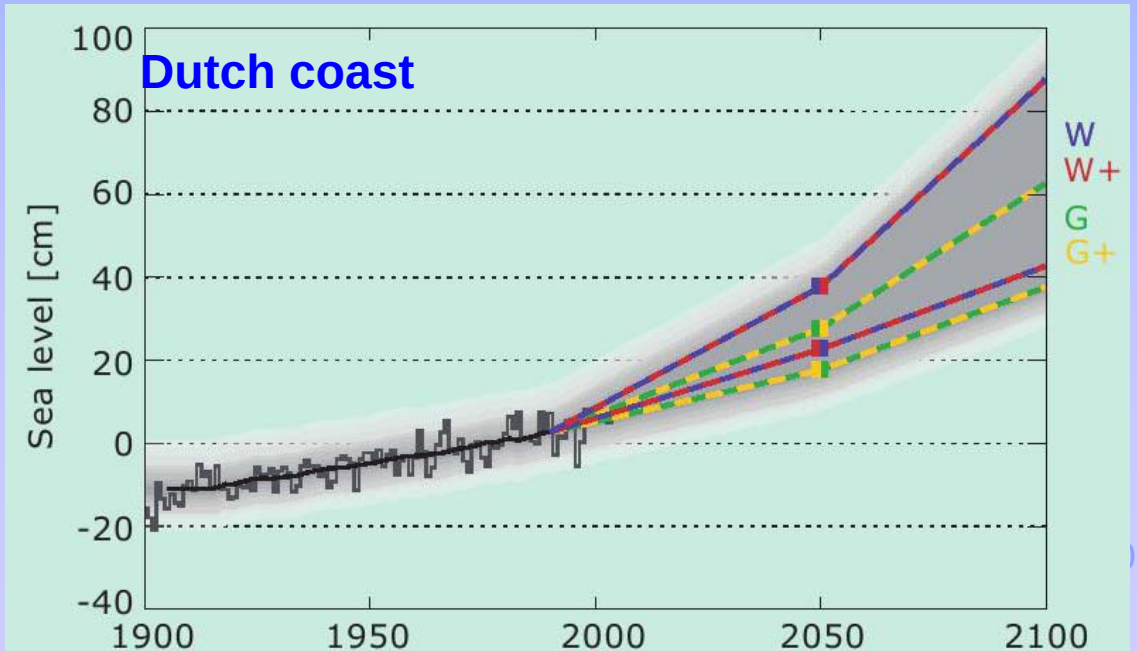


AR4, Fig. TS28

Sea level rise

A1b, 21st century:

- thermal expansion 13-32 cm
- dynamical effects (local) ±20 cm
- small icecaps 8-15 cm
- Greenland and Antarctica ???



.2007

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ESSENCE

- 17 runs
- 1950 - 2100
- observed GHG's – SRES A1b
- ECHAM5/MPI-OM

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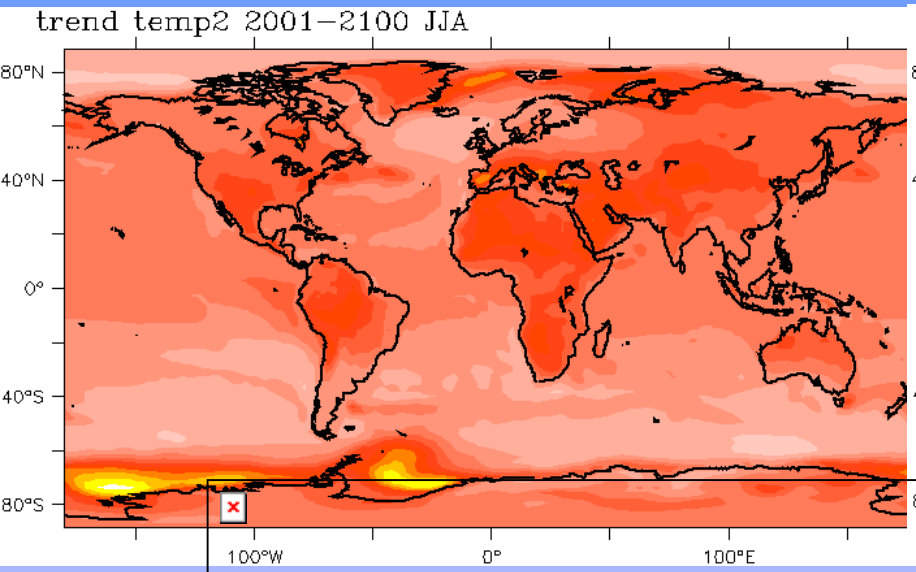
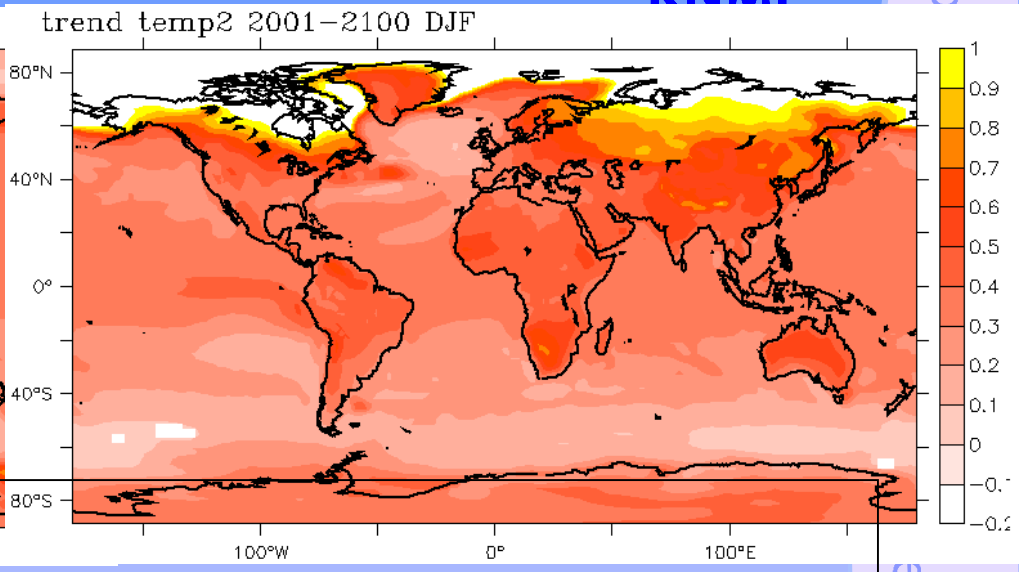
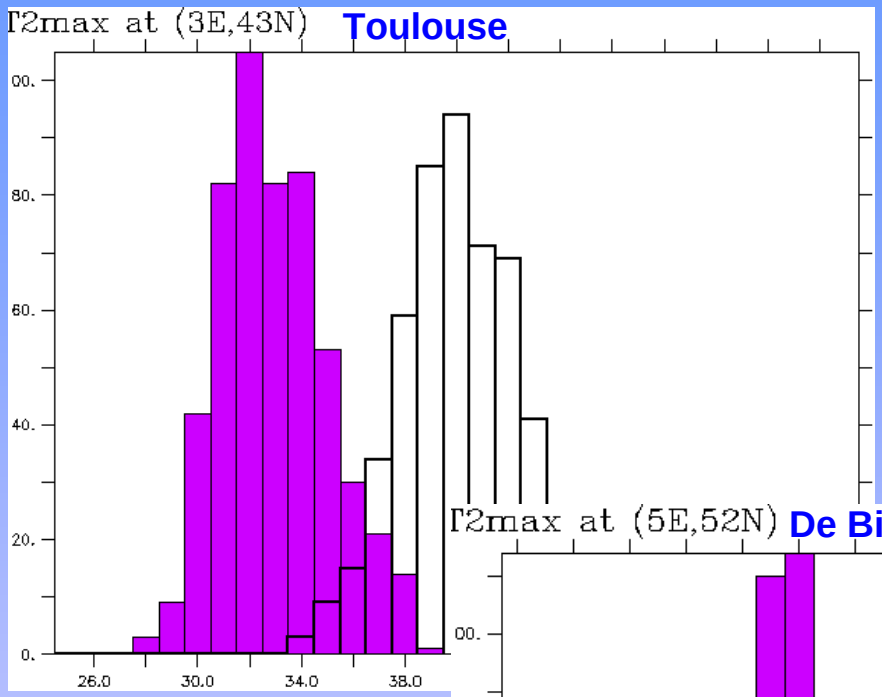
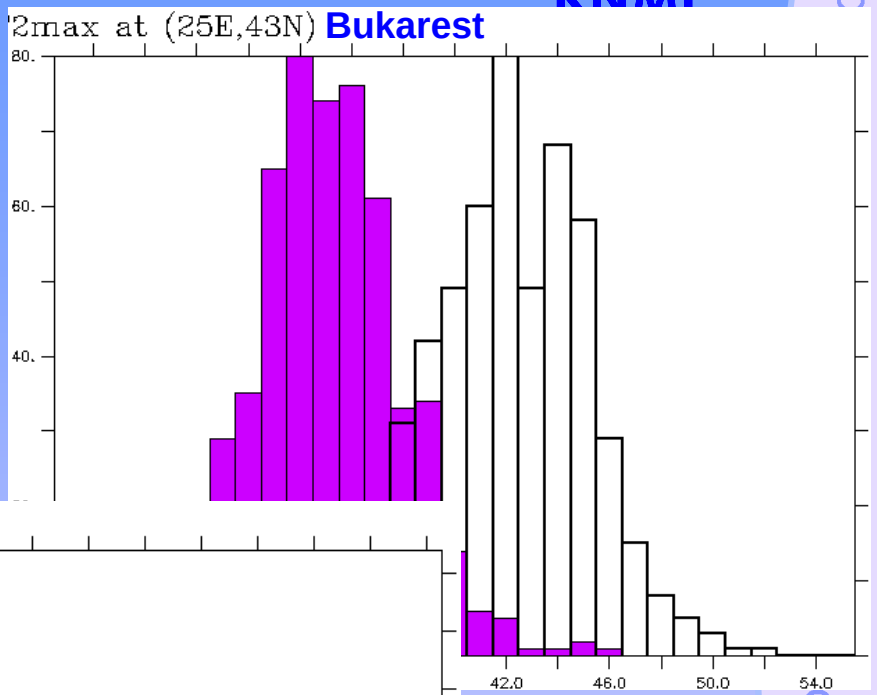
Temperature

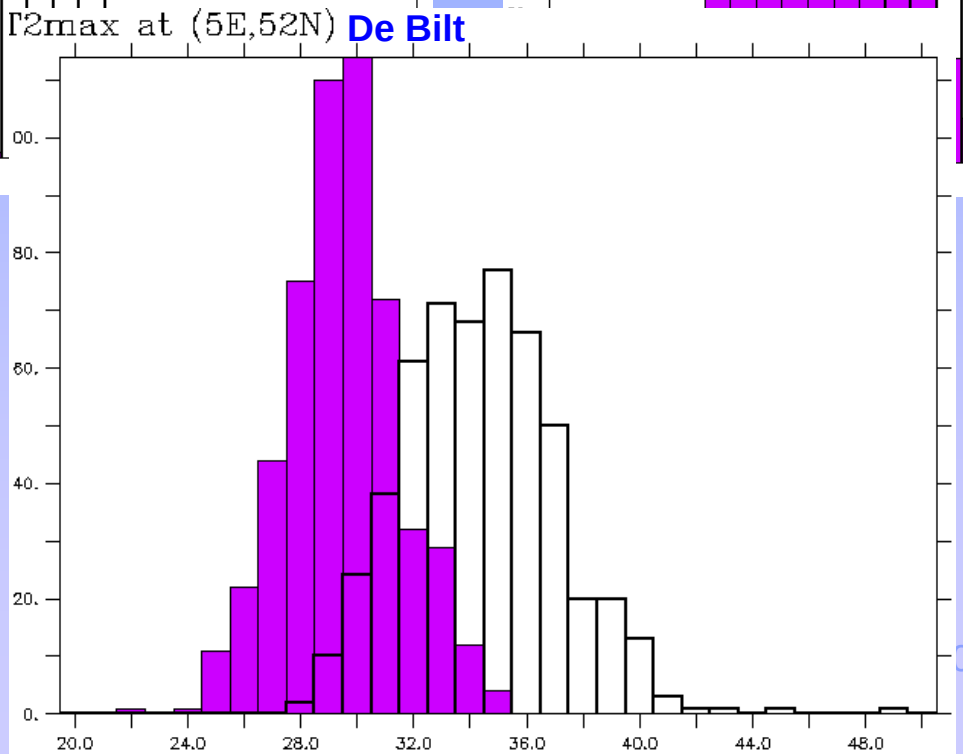




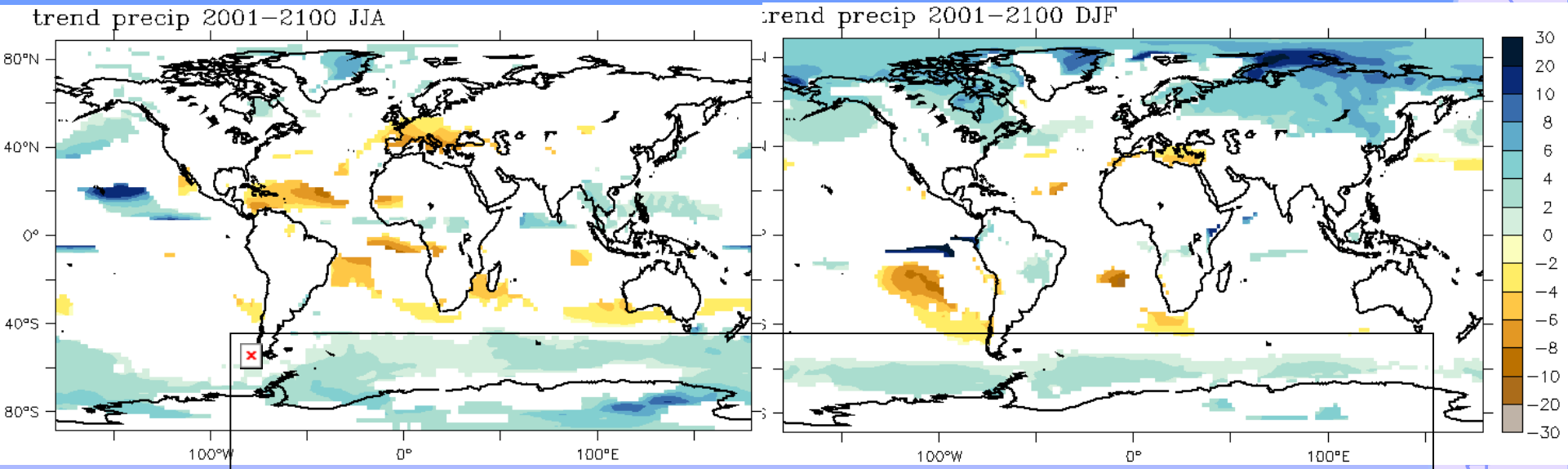
Maximum Temperatures



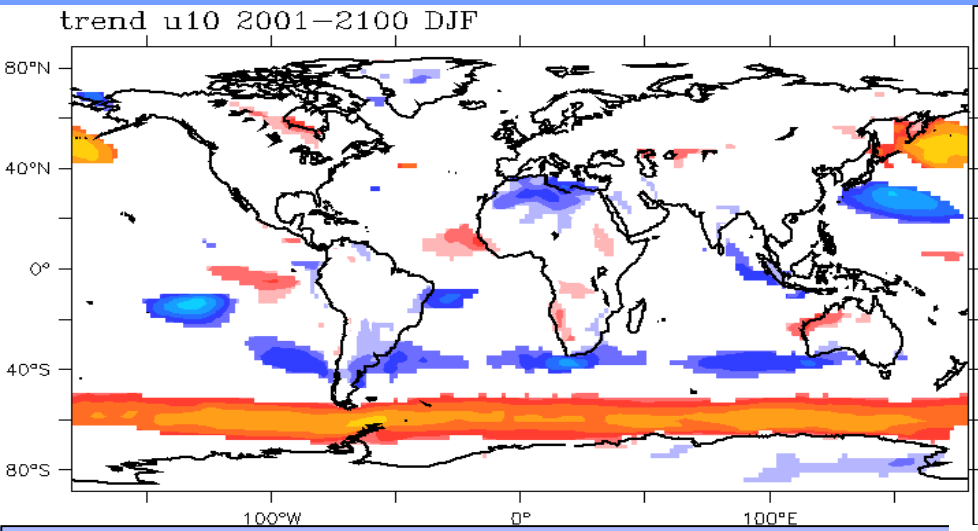


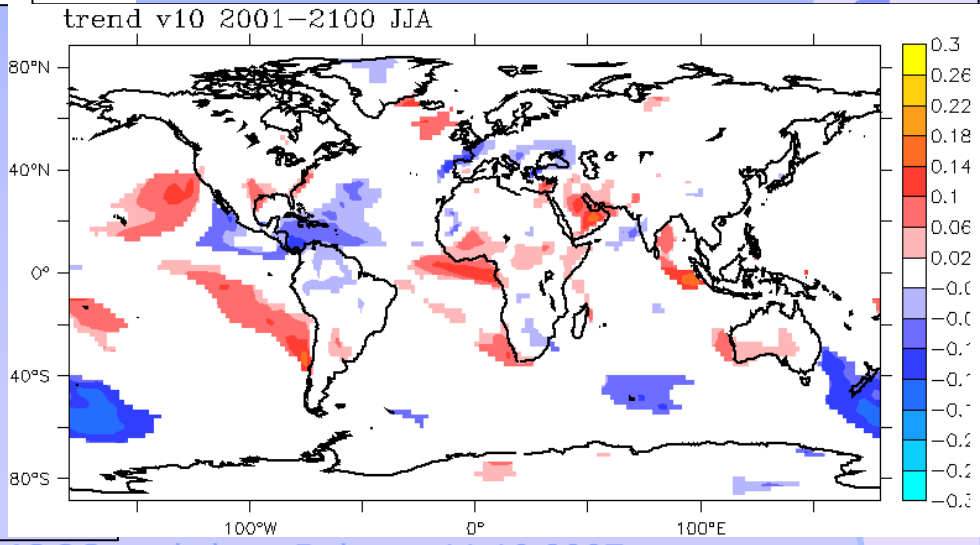


Precipitation



Essence: wind changes





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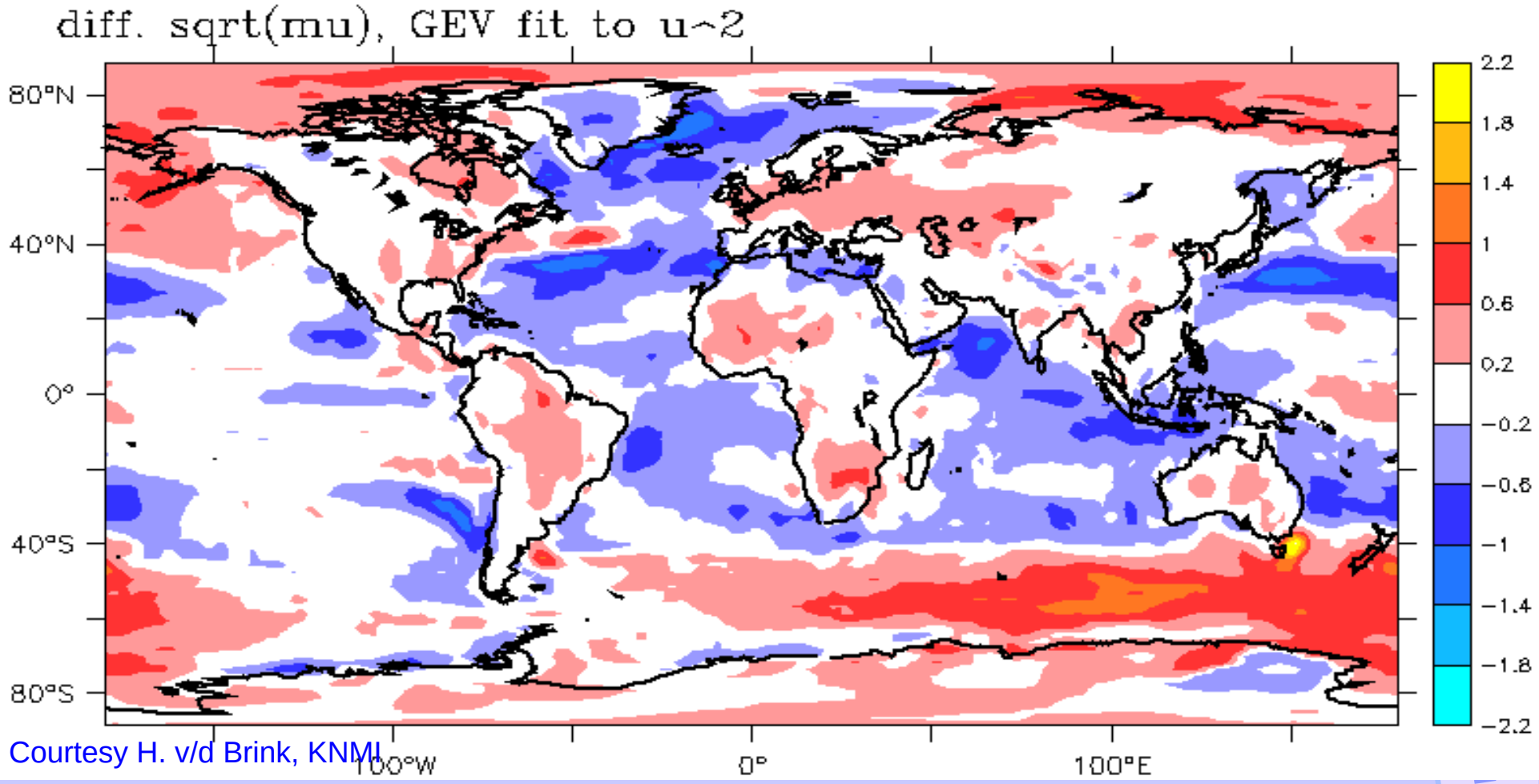
Extreme winds



Courtesy H. v/d Brink, KNMI

Conclusions

- Climate is already changing and will go on changing:
- Temperatures increase
- Extreme temperatures increase even more
- high latitudes get wetter
- subtropics get drier
- ice is melting
- sea level is rising
- wind regimes move

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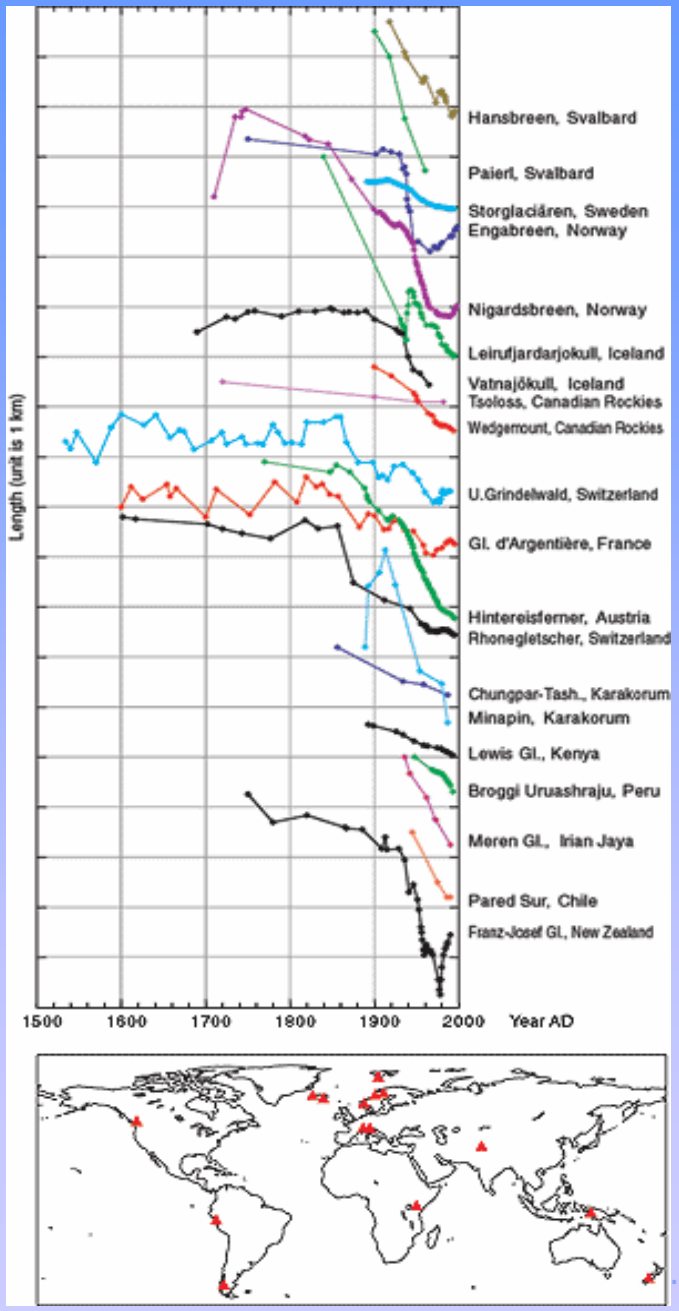
Glacier lengths



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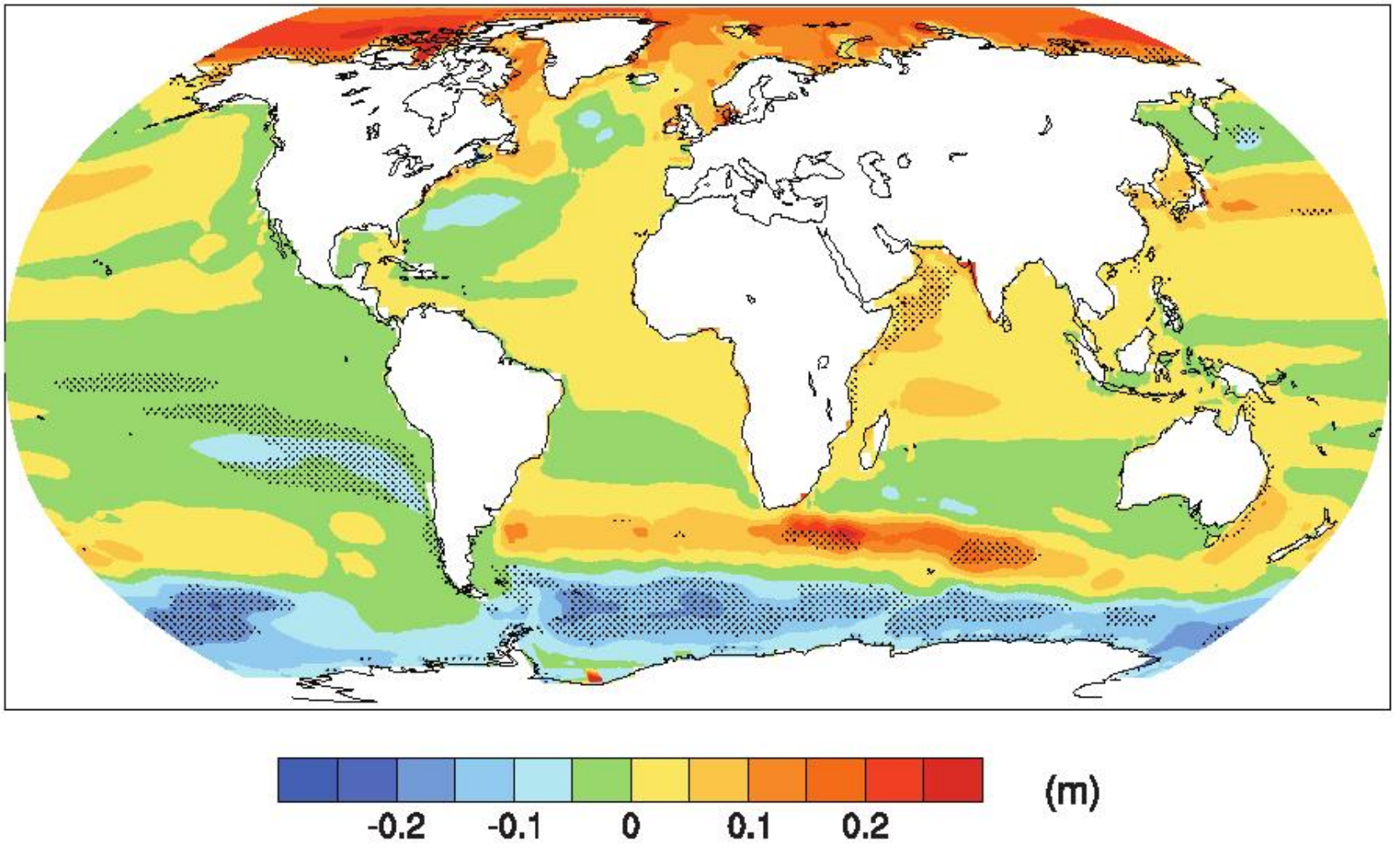
Relative sea level change



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Significance of trends - 1

Naïve: z-val:

$$z = \frac{|T_{\text{end}} - T_{\text{begin}}|}{\sqrt{\frac{\sigma^2_{\text{end}}}{17} + \frac{\sigma^2_{\text{begin}}}{17}}} > 1.96$$

=> Every change significant if enough members

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Significance of trends - 2

time series:	$x(t_i), \quad i = 1, ..., n_t$
regression line:	$\hat{x}(t_i) = a + bt_i$ (ens. average)
regression residuals:	$e(t_i) = x(t_i) - \hat{x}(t_i)$
standard error of b:	$s_b = \frac{s_e}{\sqrt{\sum(t_i - \bar{t})^2}}$
variance of residuals:	$s_e^2 = \frac{1}{n_{\text{eff}} - 2} \sum e(t_i)^2$ (ens. members)
t-value:	$t_b = \frac{b}{s_b} = b \sqrt{\frac{\sum(t_i - \bar{t})^2}{\sum e(t_i)^2}(n_{\text{eff}} - 2)} > 1.96$
effective dof:	$n_{\text{eff}} = n_t \frac{1 - r}{1 + r} \cdot 17$

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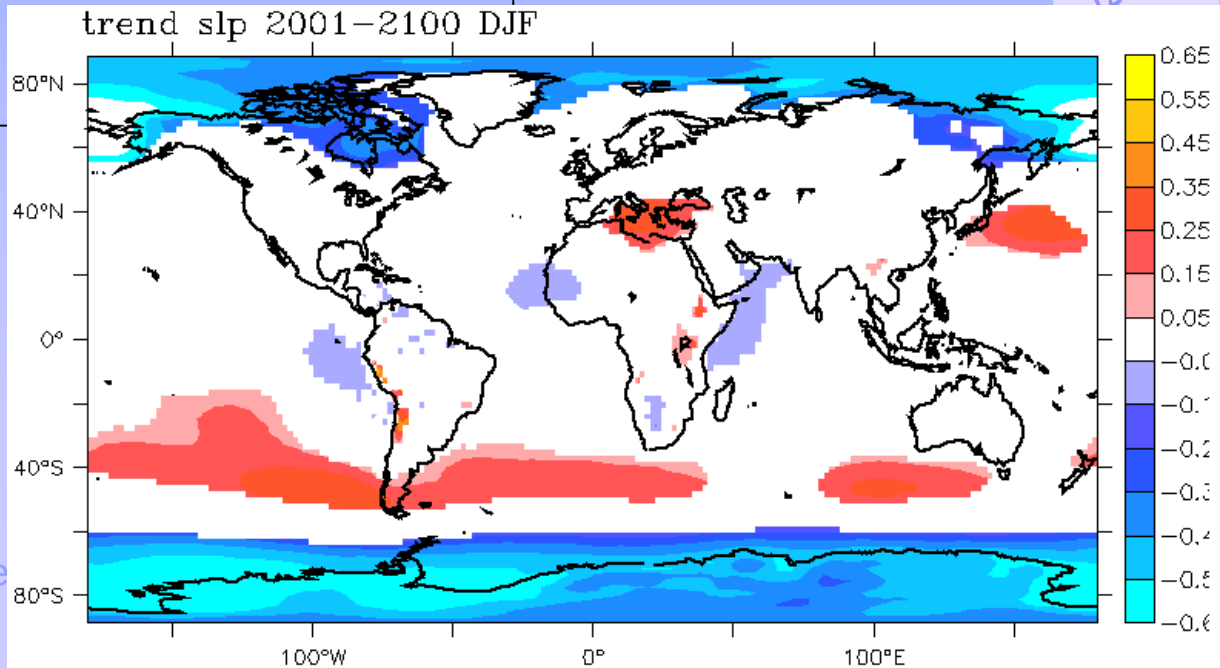
Sea Level Pressure



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