

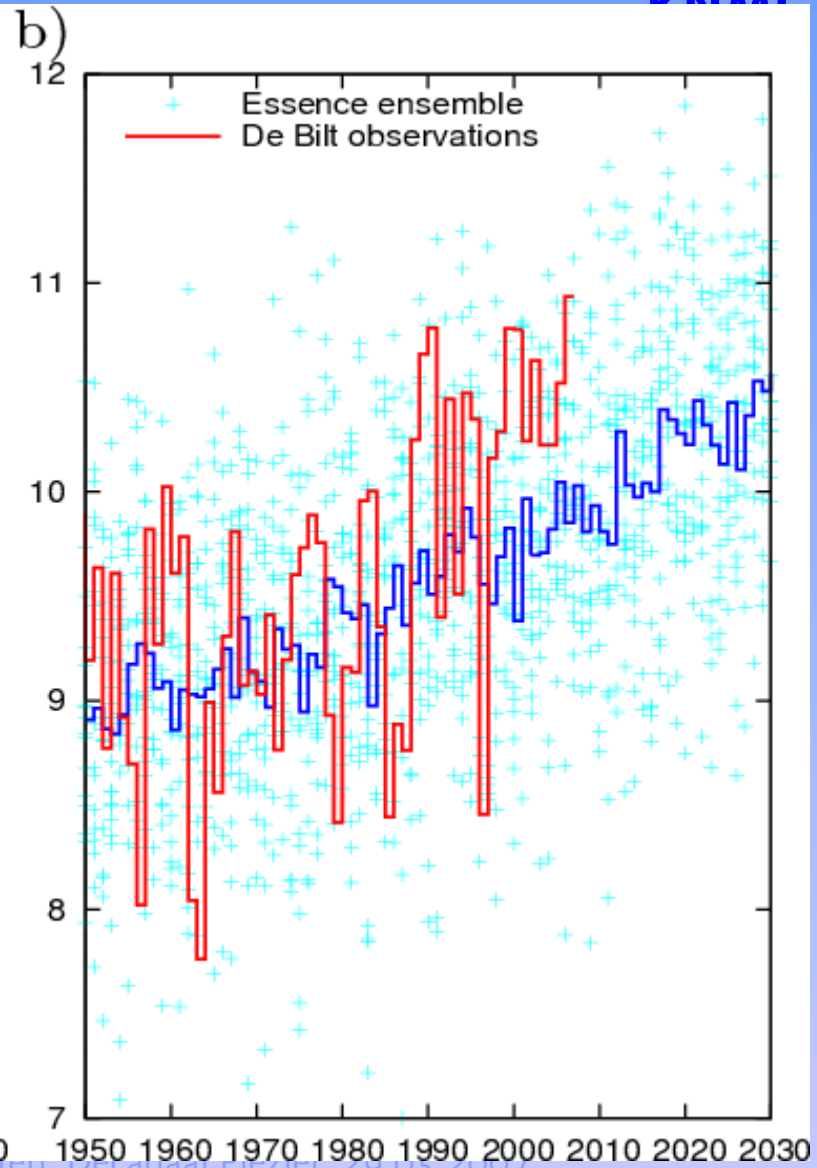
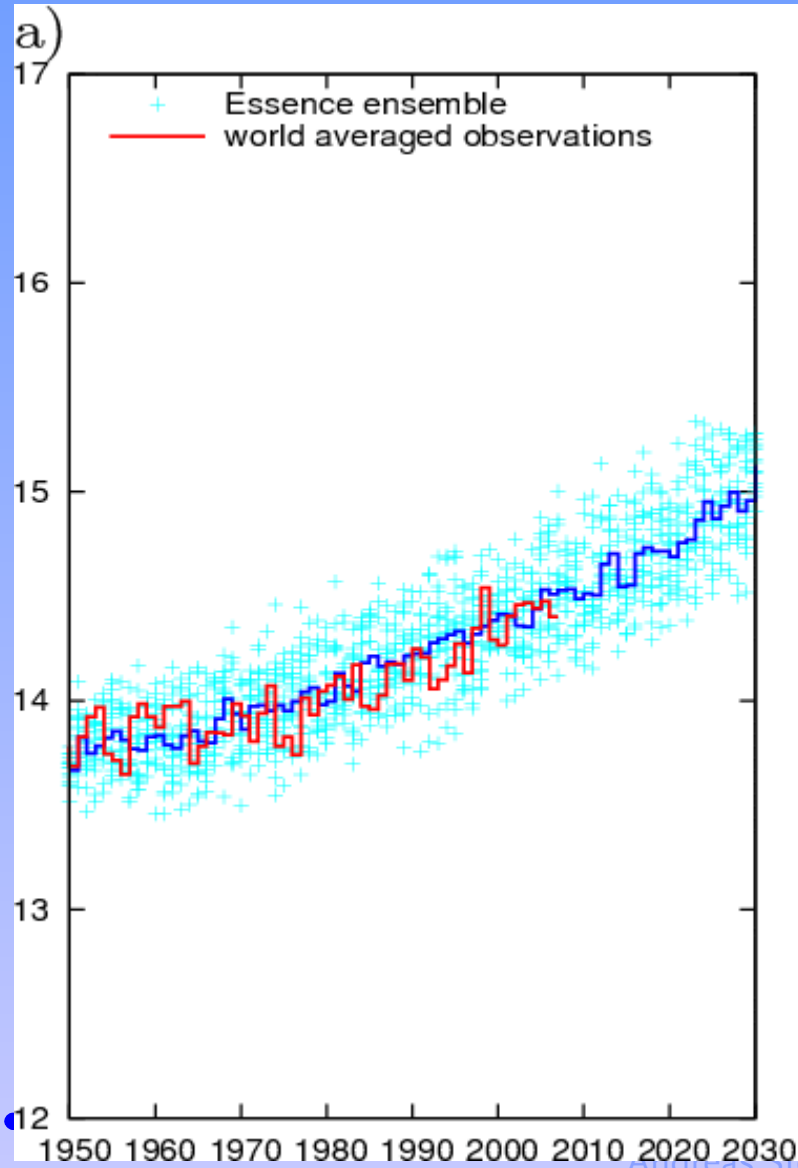
ESSENCE – signal detection

Andreas Sterl

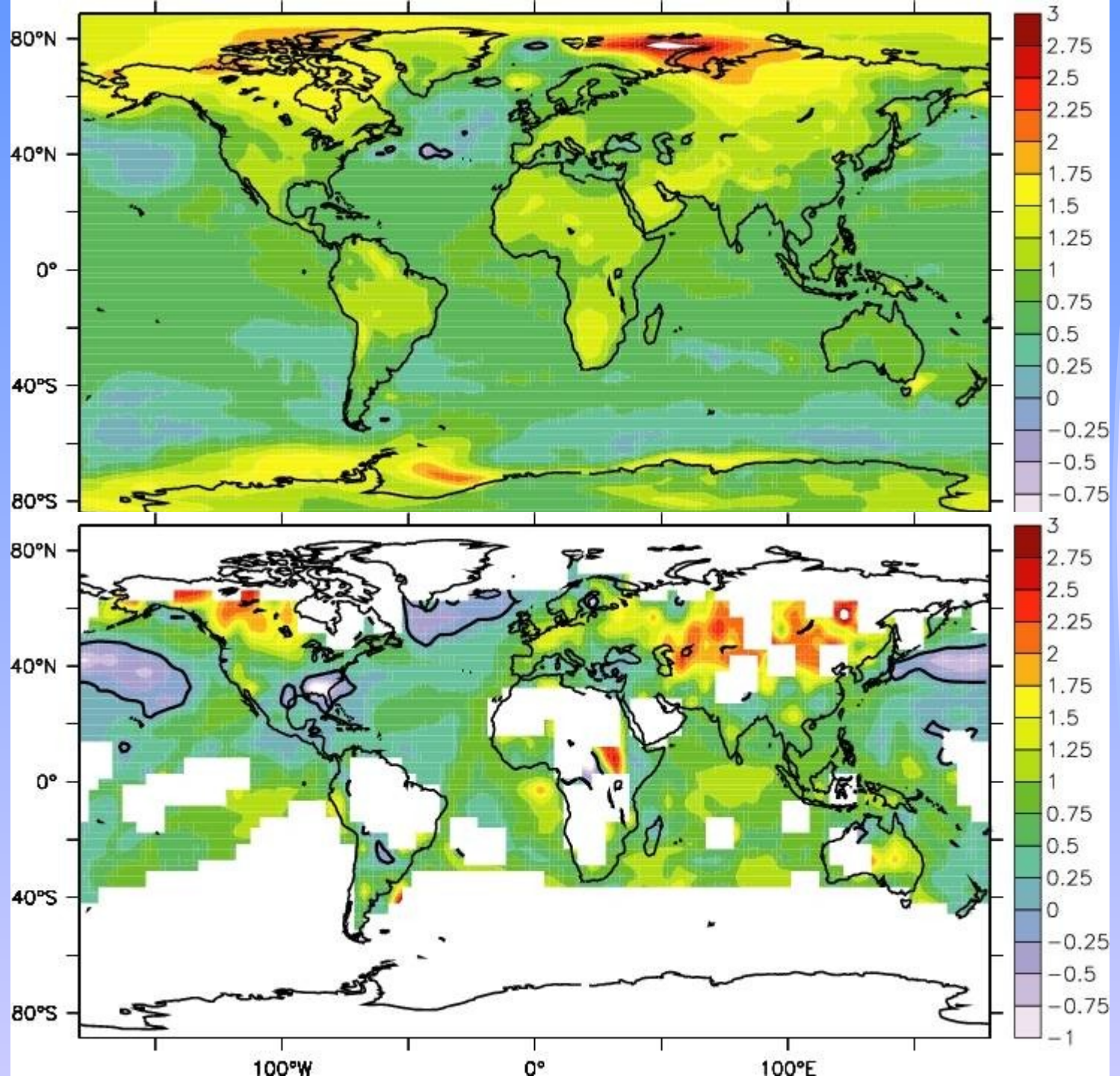
- Large ensemble => average out “noise”
- => detect forced signal

- Validation – past trends
- Projection - future trends

Temperatures



T_{2m}
Trend
1950
-2006
(K/57y)



Do observed and modelled trends differ?

$t_{\text{obs}} / t_{\text{mod}}$ – observed / modelled trend

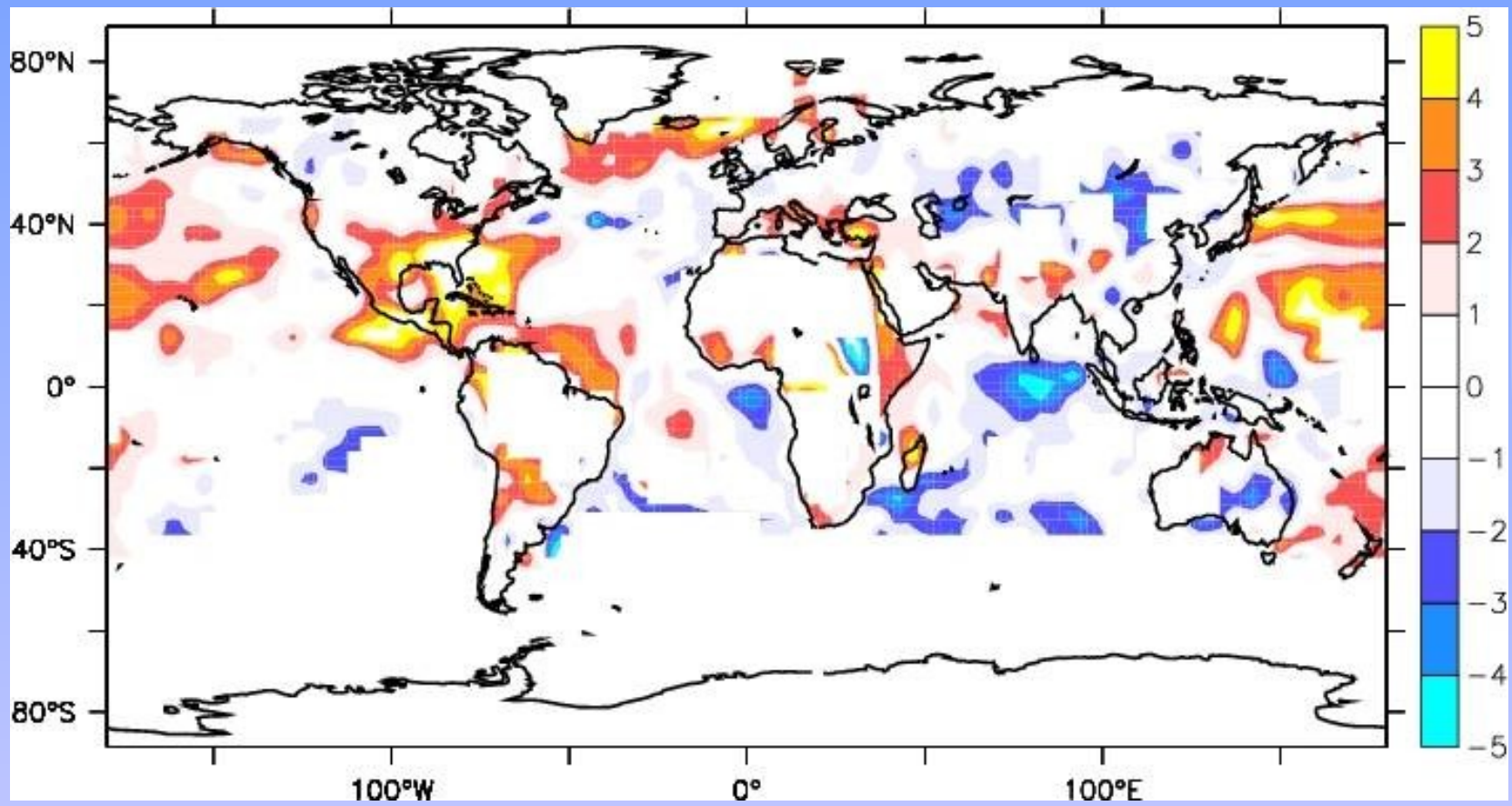
$\sigma_{\text{obs}} / \sigma_{\text{mod}}$ – uncertainty in trend estimates

$$z = \frac{|t_{\text{mod}} - t_{\text{obs}}|}{\sqrt{\frac{\sigma_{\text{mod}}^2}{n_{\text{mod}}} + \frac{\sigma_{\text{obs}}^2}{n_{\text{obs}}}}} > 2.12$$

$n_{\text{mod}} = 17$ $n_{\text{obs}} = 1$

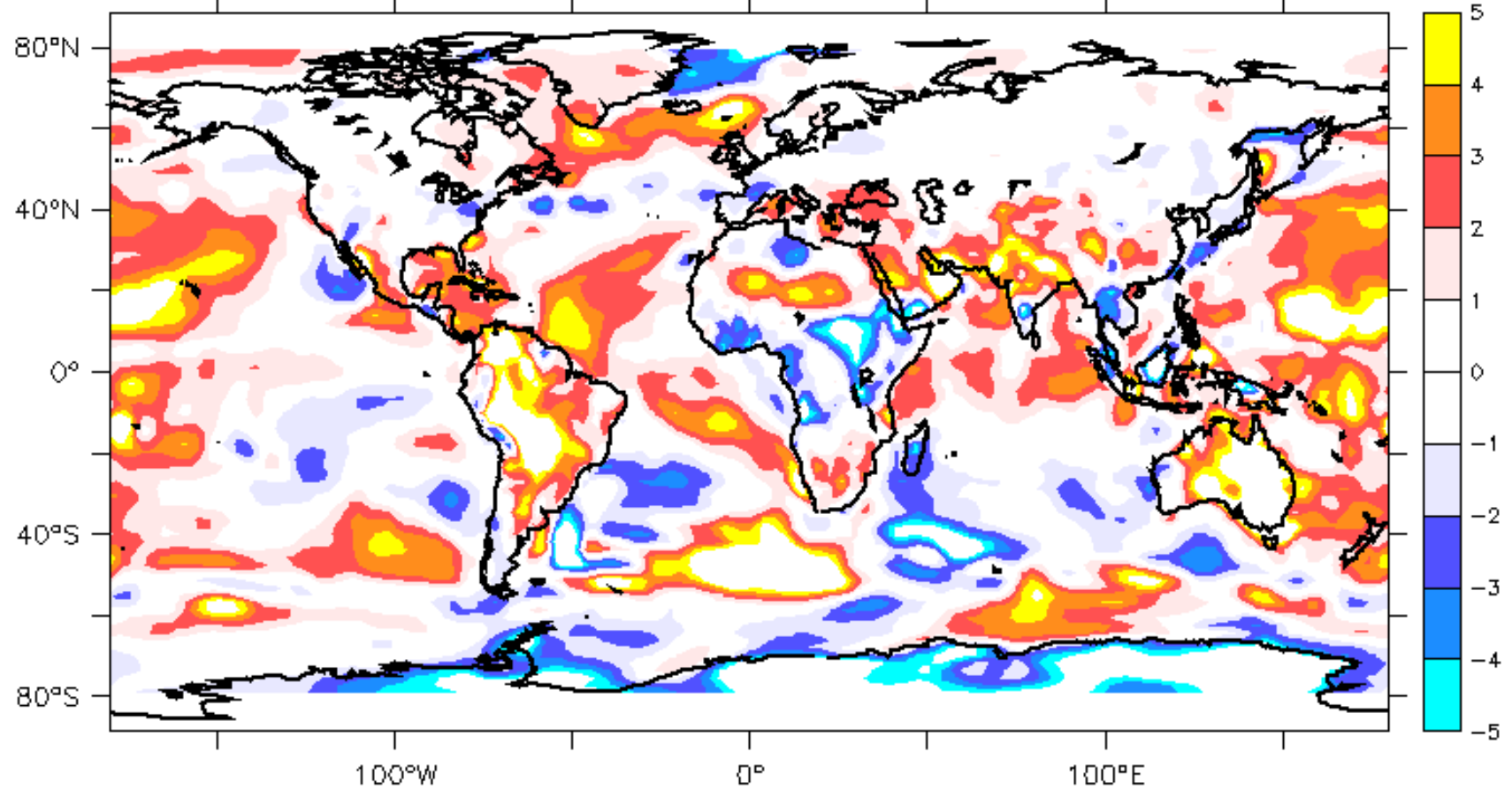
⇒ Sampling uncertainty from model negligible

z-val trend T_{2m} (HadCrut3)



z-val trend T_{2m} (ERA-40)

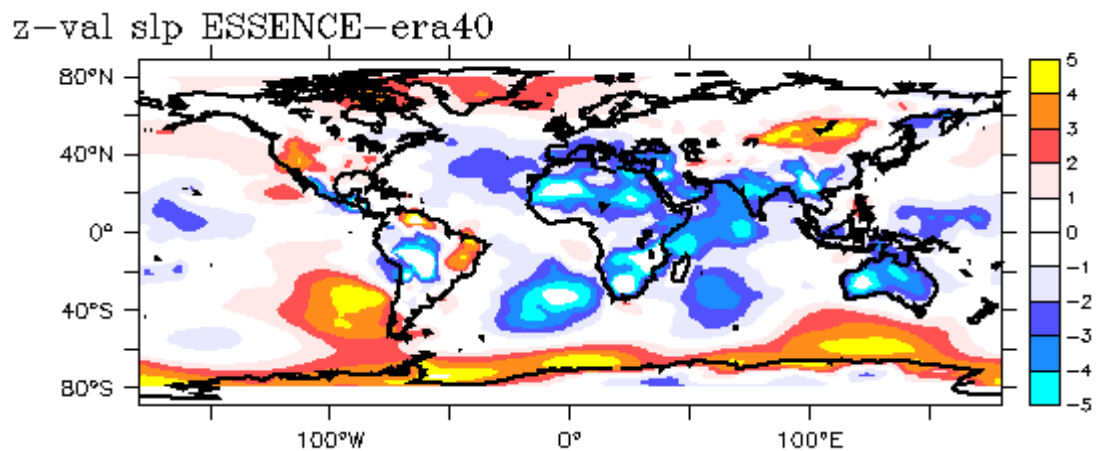
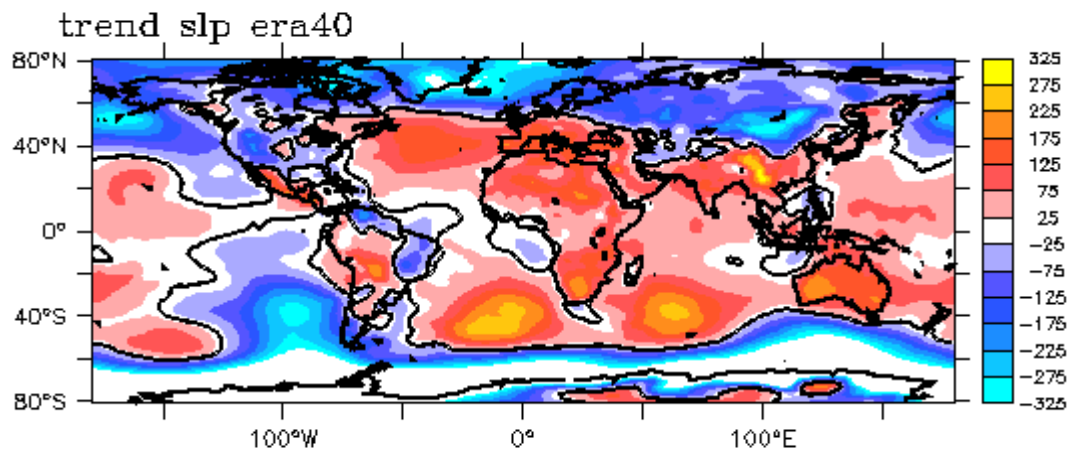
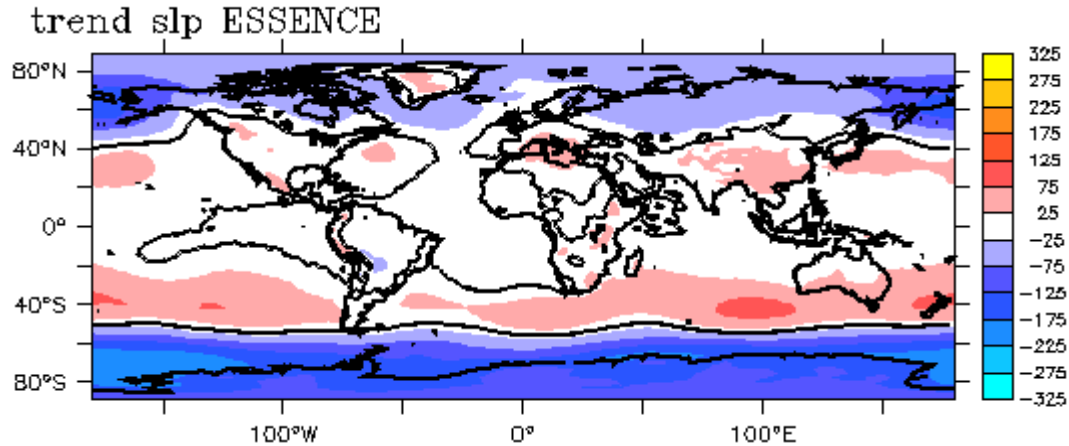
z-val temp ESSENCE-era40



•••••

trend SLP (ERA-40)

•••••



Significance of trends - 1

Naïve: z-val:

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

=> Every change significant if enough members

Significance of trends - 2

time series: $x(t_i), \quad i = 1, \dots, n_t$

regression line: $\hat{x}(t_i) = a + bt_i$ (ens. average)

regression residuals: $e(t_i) = x(t_i) - \hat{x}(t_i)$

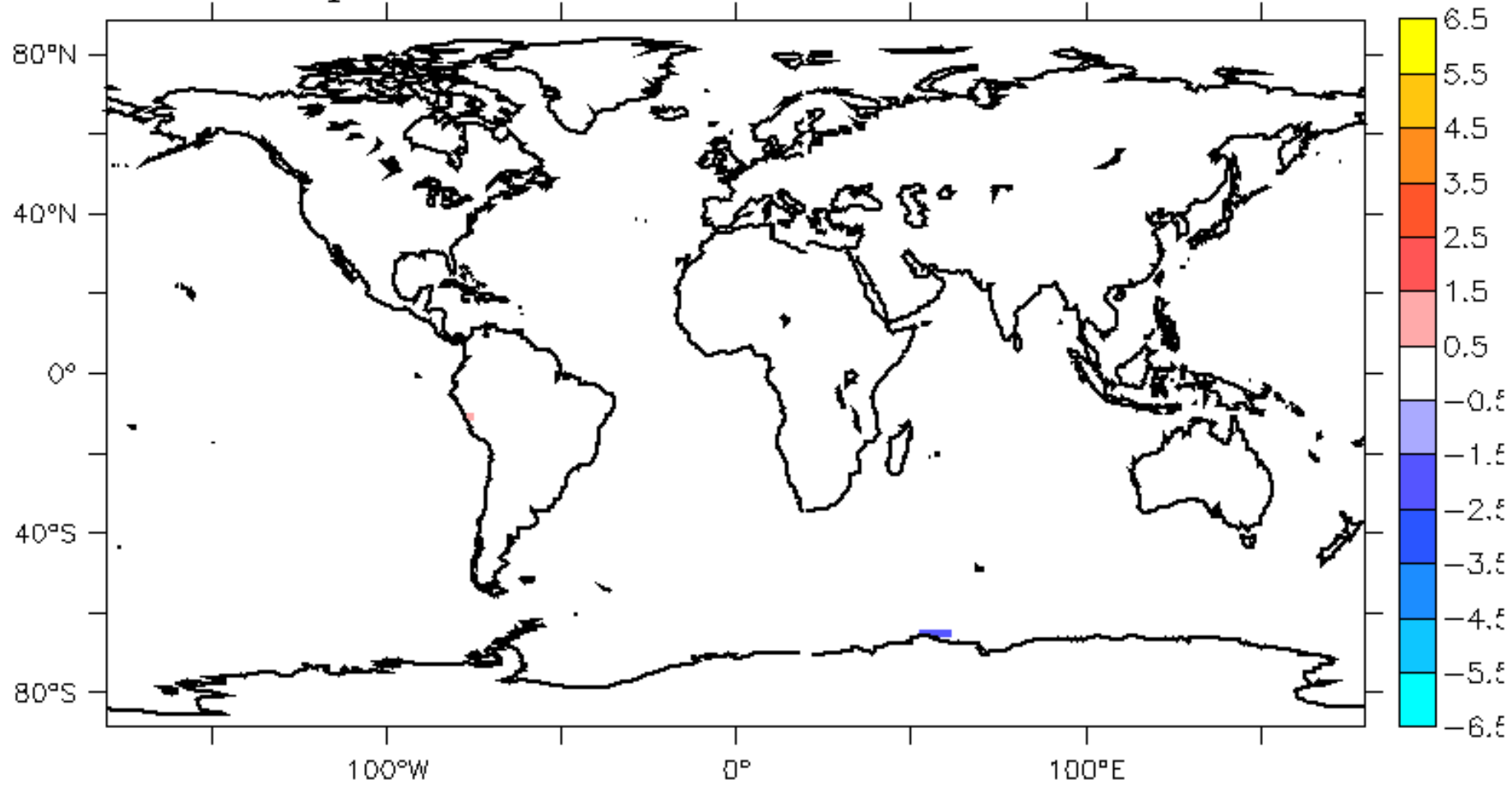
standard error of b : $s_b = \frac{s_e}{\sqrt{\sum(t_i - \bar{t})^2}}$

variance of residuals: $s_e^2 = \frac{1}{n_{\text{eff}} - 2} \sum e(t_i)^2$ (ens. members)

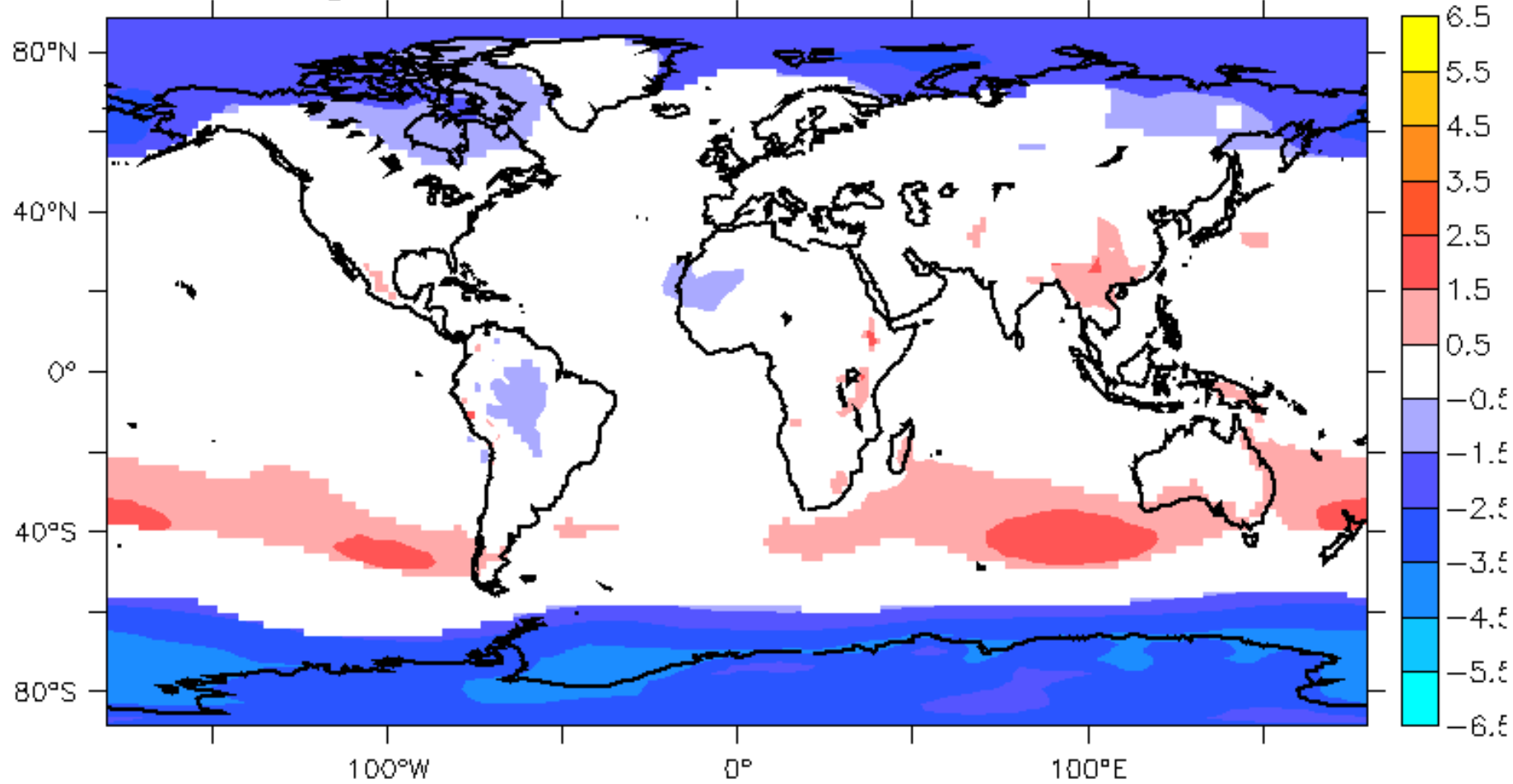
t-value: $t_b = \frac{b}{s_b} = b \sqrt{\frac{\sum(t_i - \bar{t})^2}{\sum e(t_i)^2} (n_{\text{eff}} - 2)} > 1.96$

effective dof: $n_{\text{eff}} = n_t \frac{1 - r}{1 + r} \cdot 17$

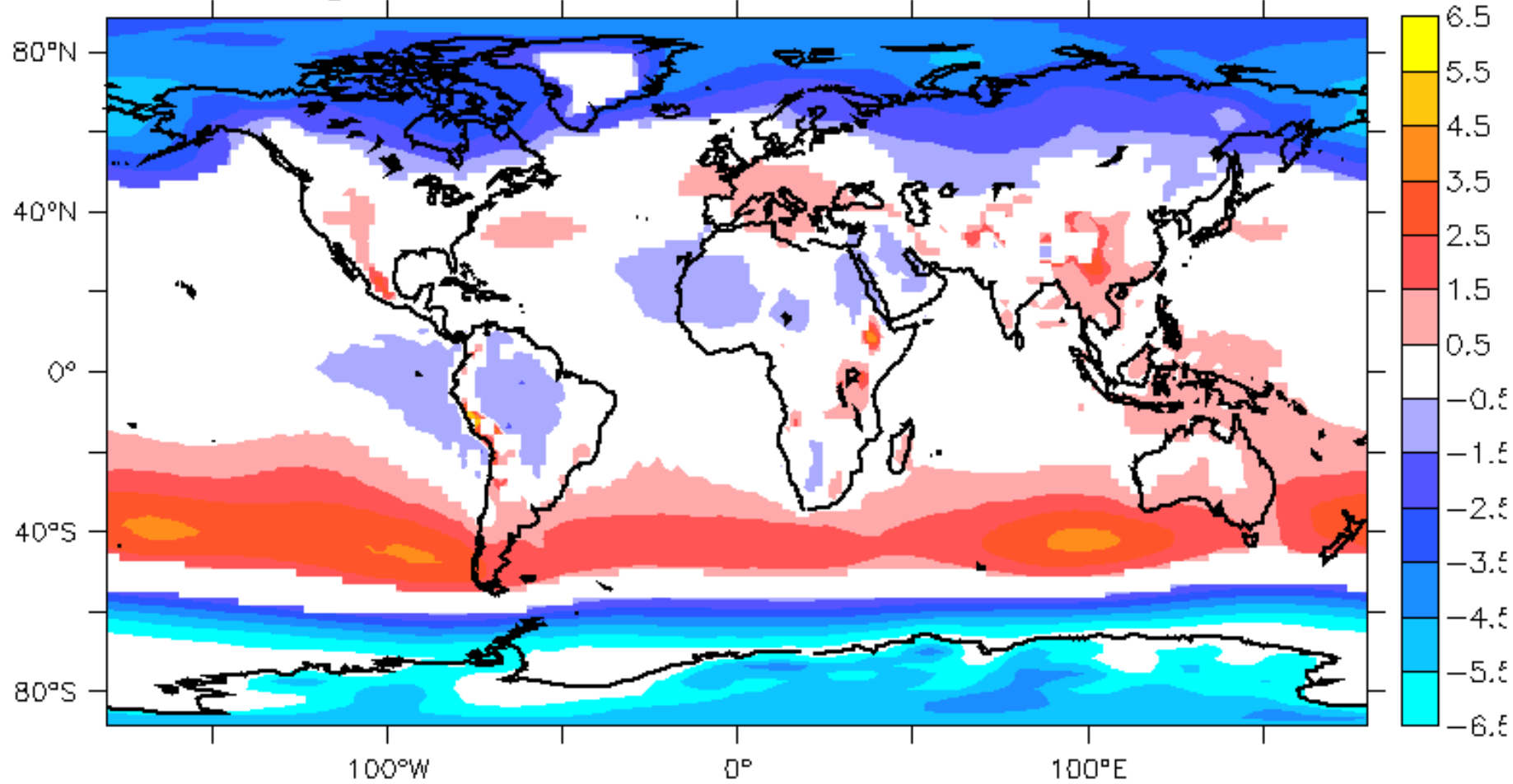
trend slp 1950-2000



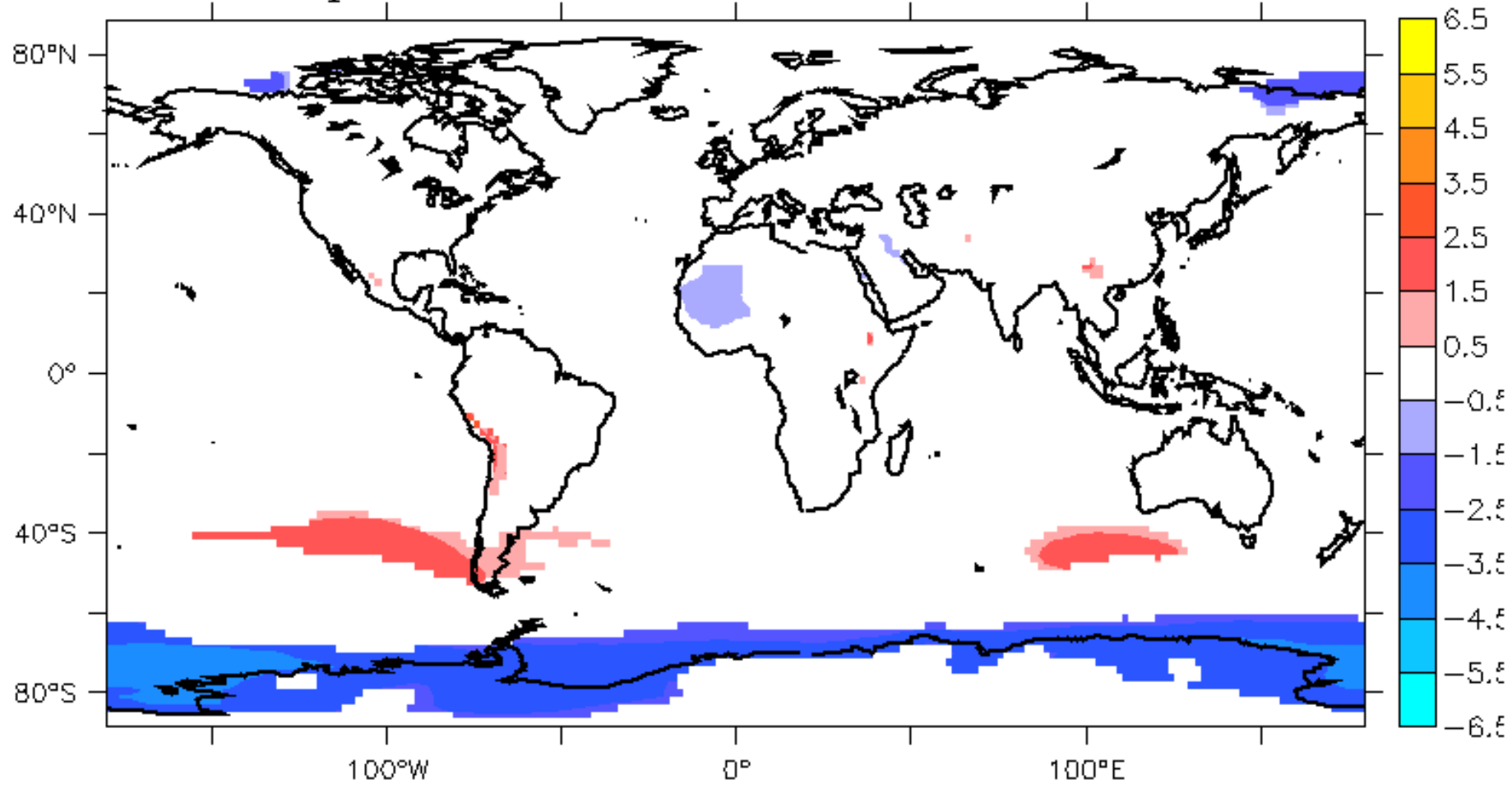
trend slp 1950-2050



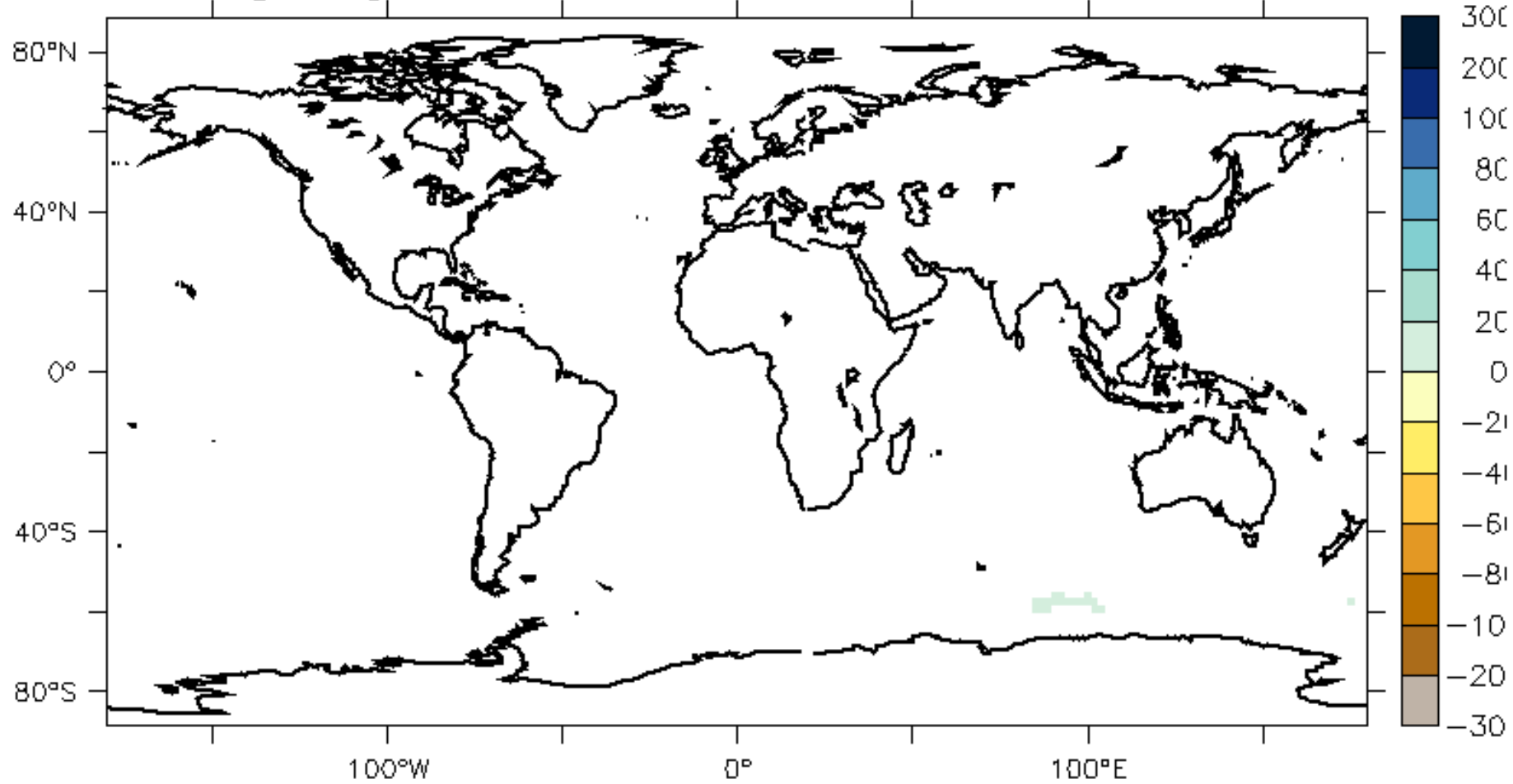
trend slp 1950-2100



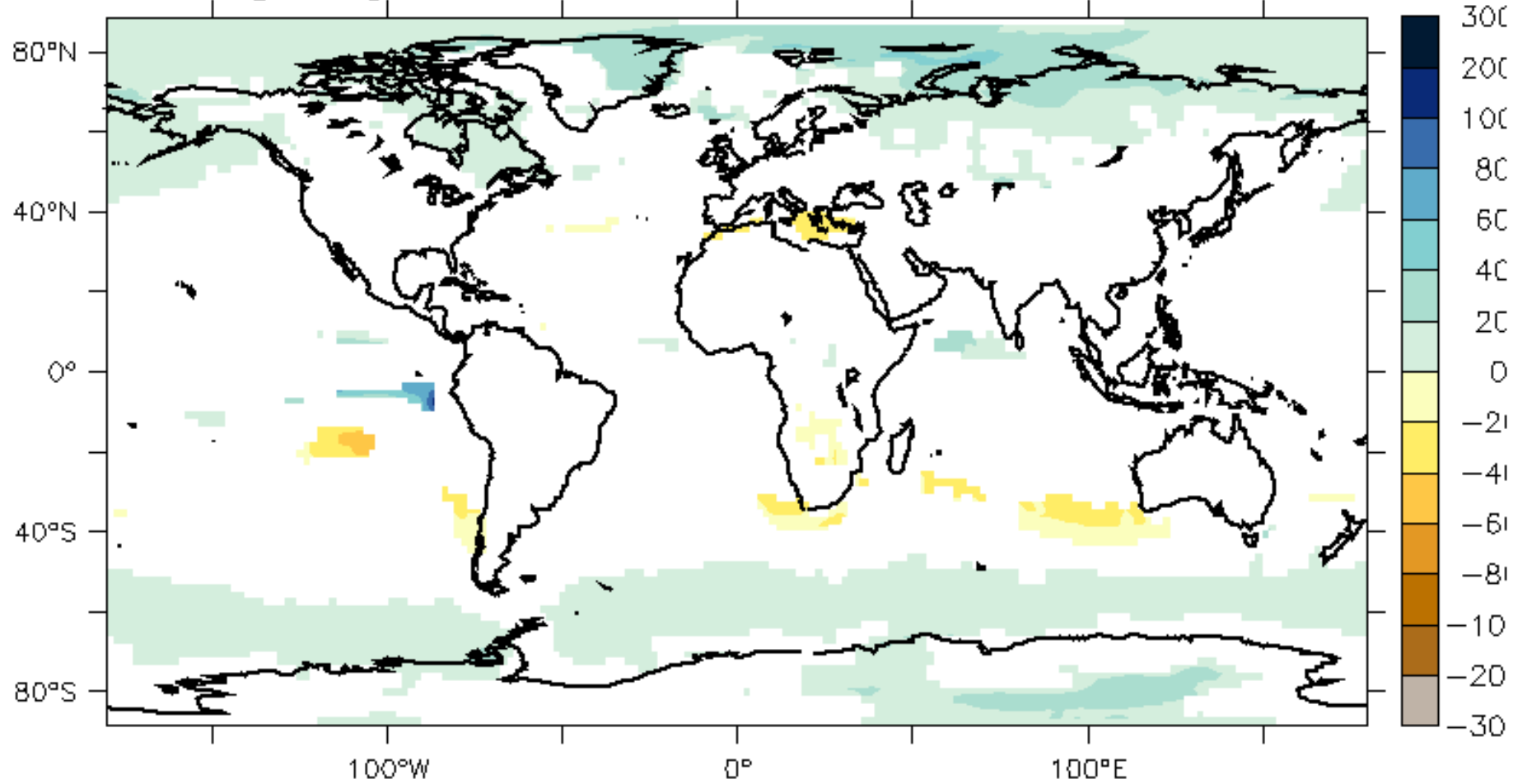
trend slp 2050-2100



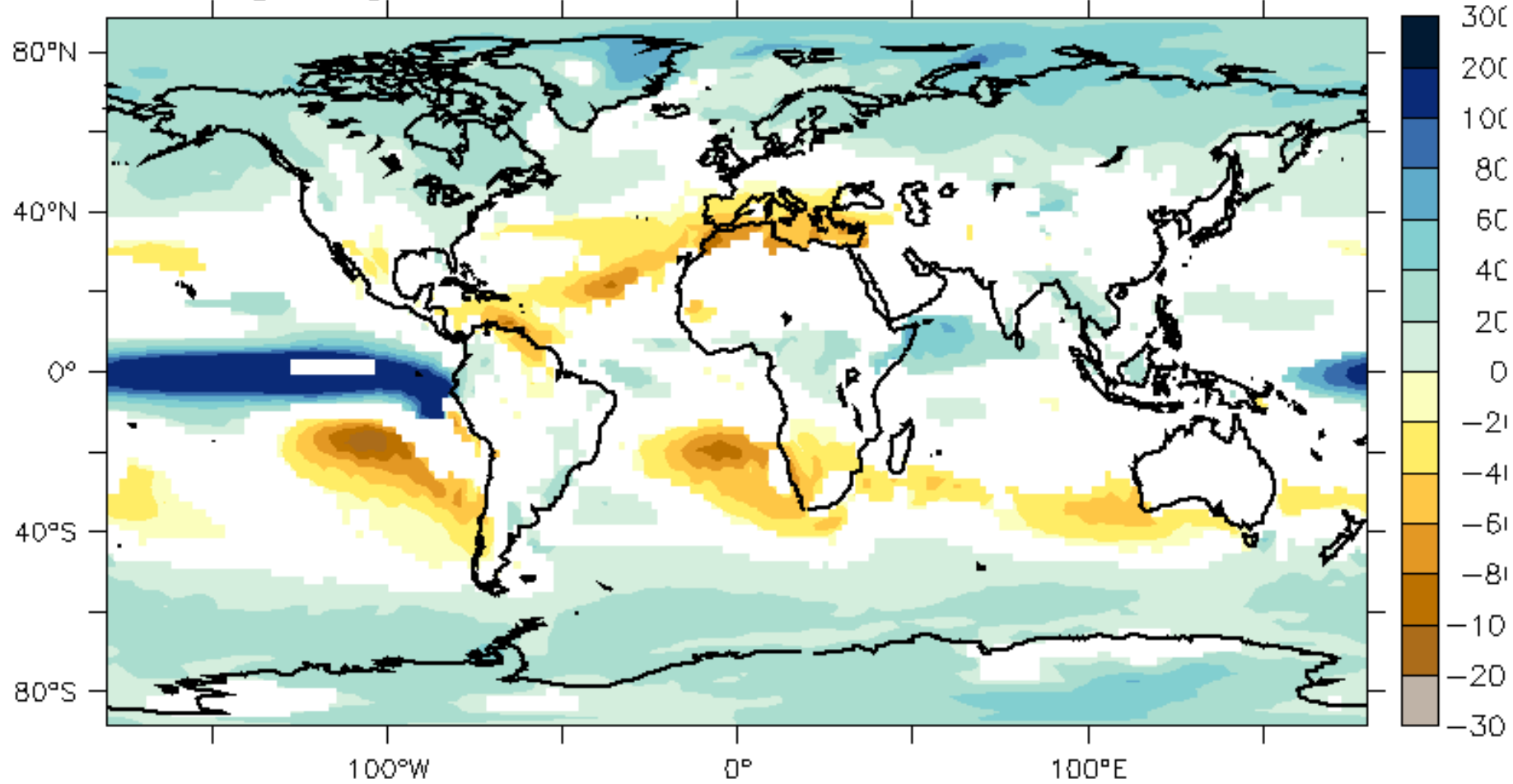
trend precip 1950-2000



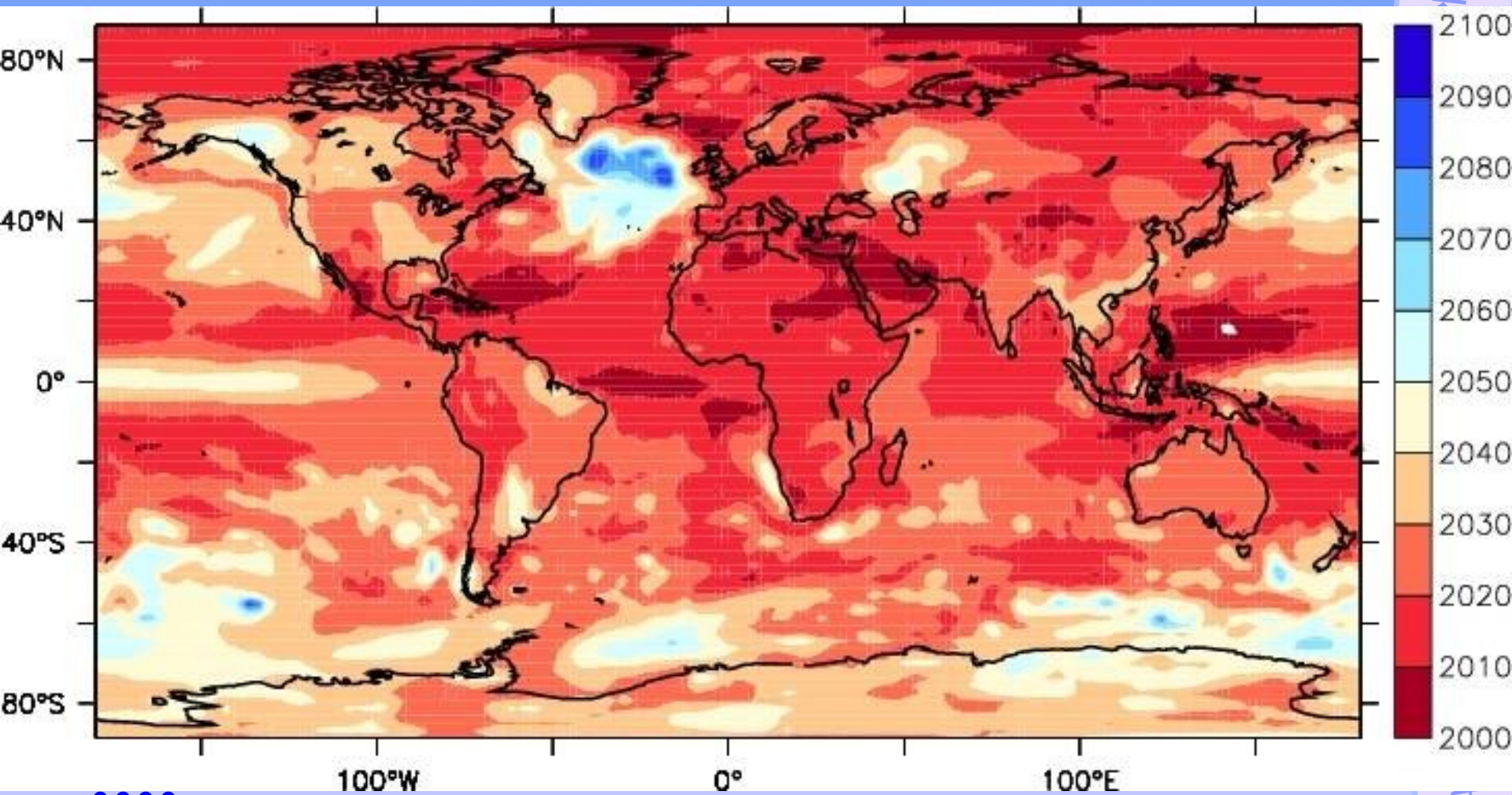
trend precip 1950-2050



trend precip 1950-2100



Trend > noise, T_{2m} (starting 1980)

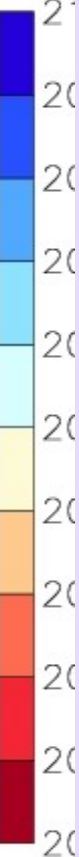


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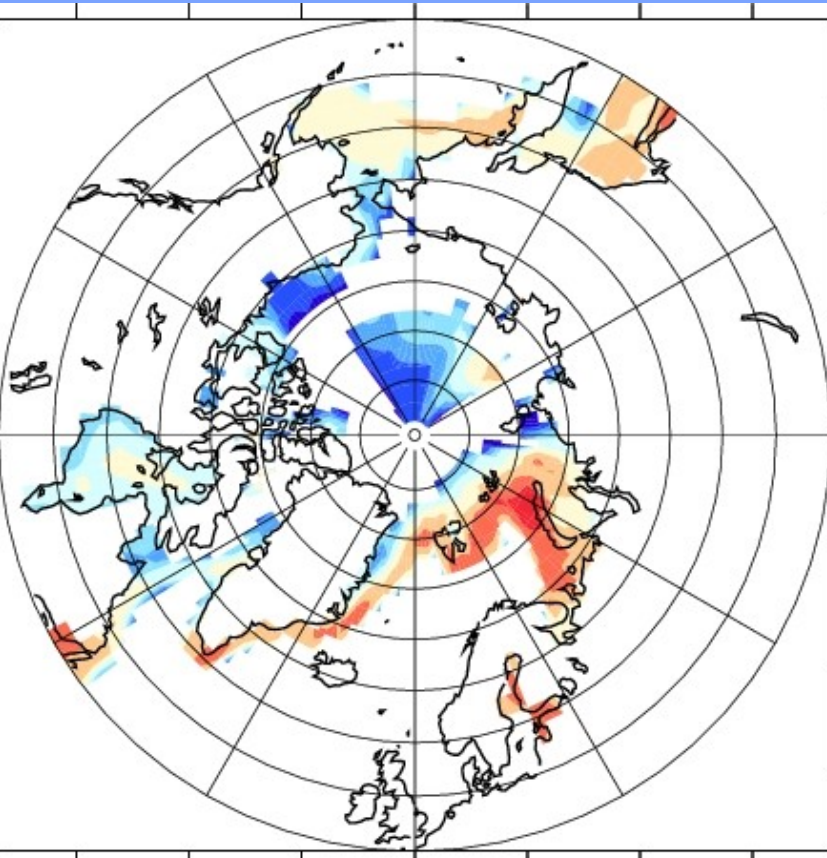
Trend > noise, sea ice (starting 1980)



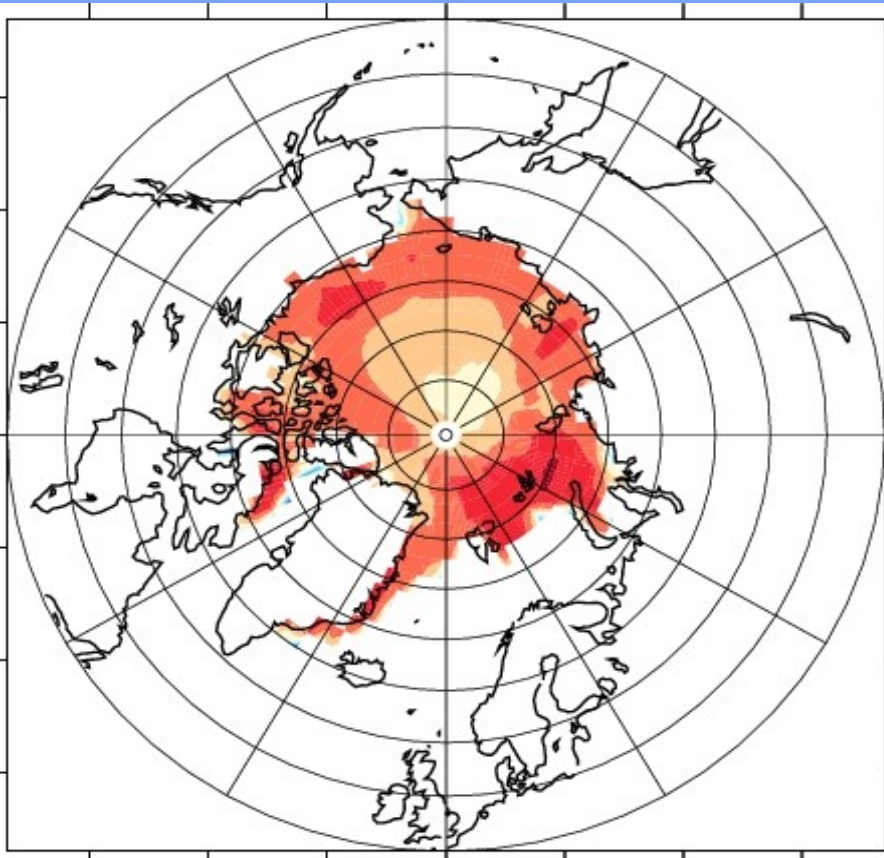
Konink



stituut



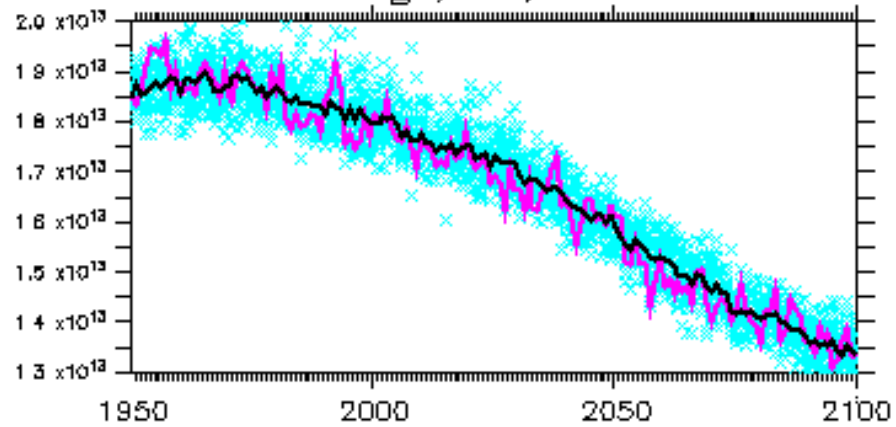
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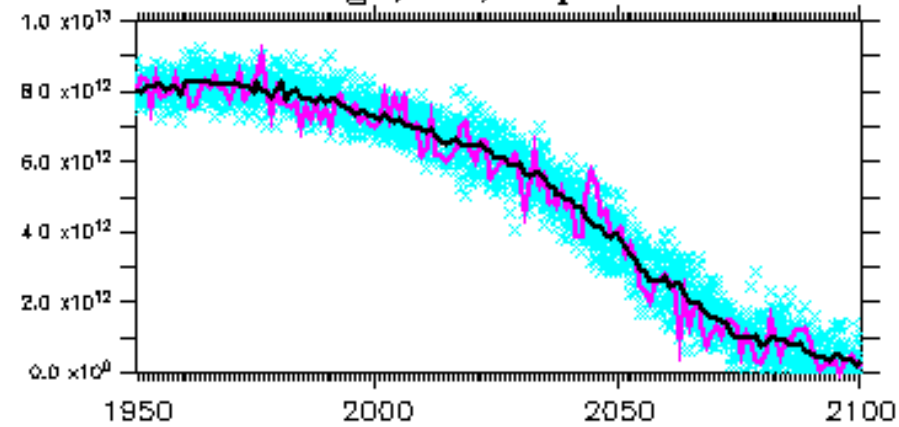
september

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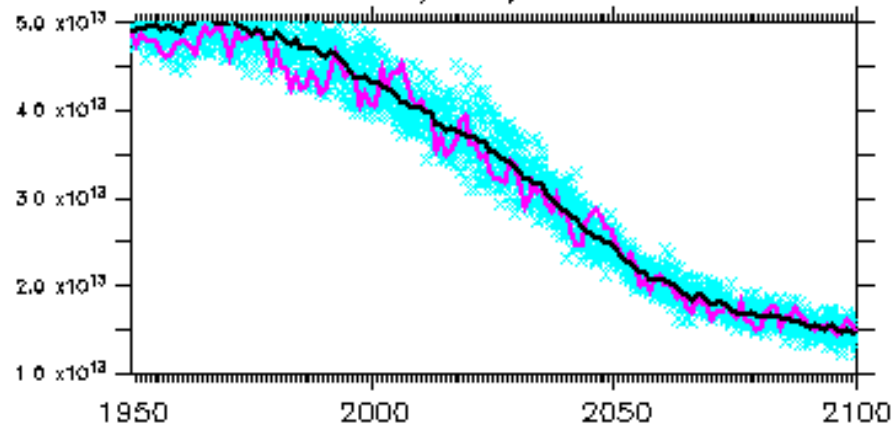
Sea ice coverage, NH, March .



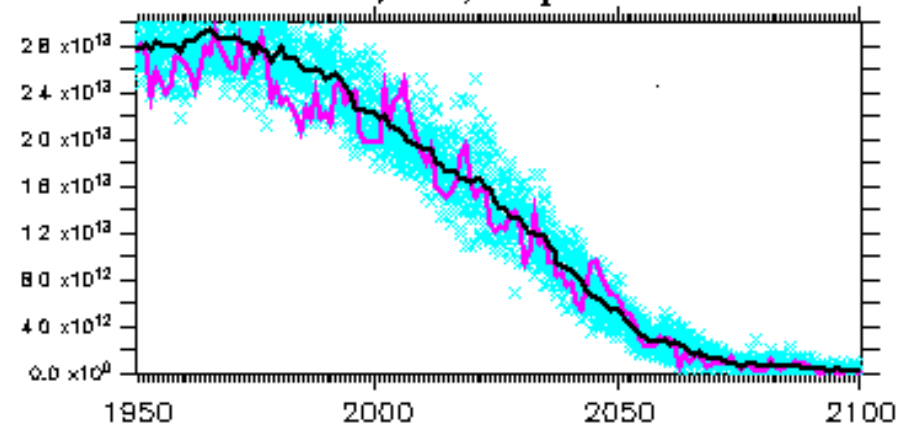
Sea ice coverage, NH, September



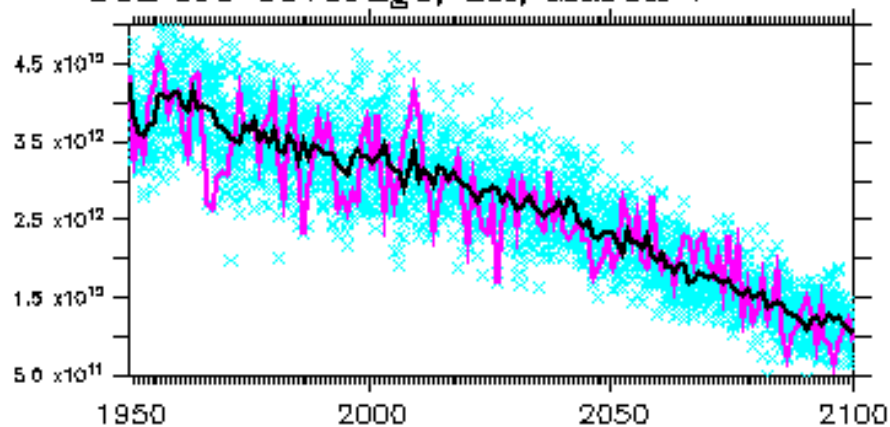
Sea ice volume, NH, March .



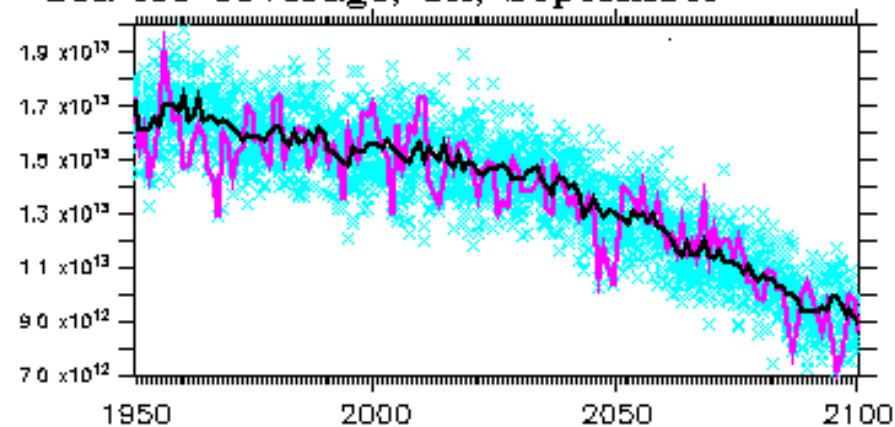
Sea ice volume, NH, September



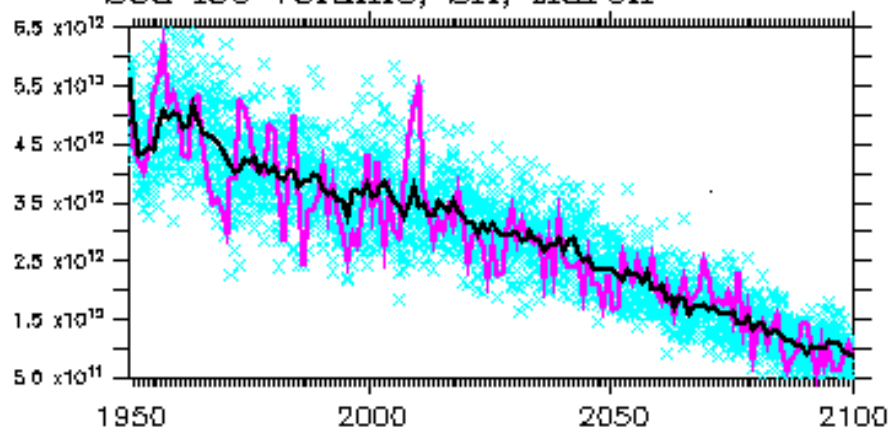
Sea ice coverage, SH, March .



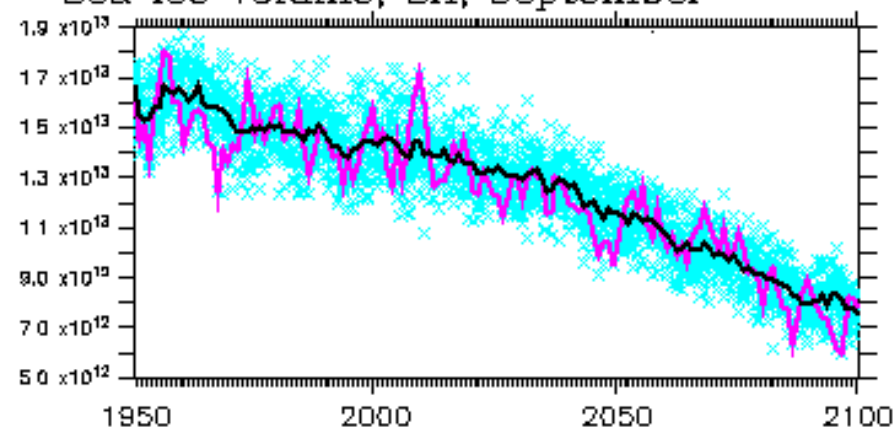
Sea ice coverage, SH, September



Sea ice volume, SH, March



Sea ice volume, SH, September





Conclusions



- large ensemble => noise reduced
- temperature signal already detectable at some places
- Precip & SLP change systematically, but slowly
- Arctic ice-free in summer around 2040/50

