

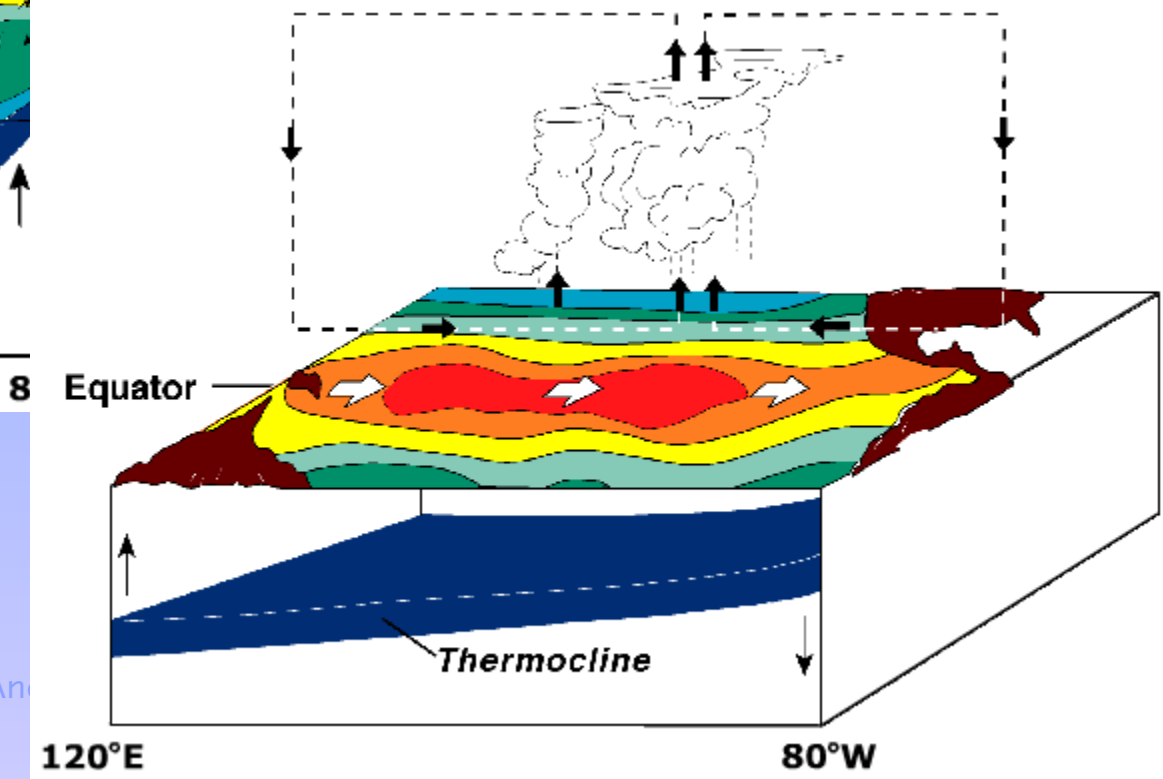
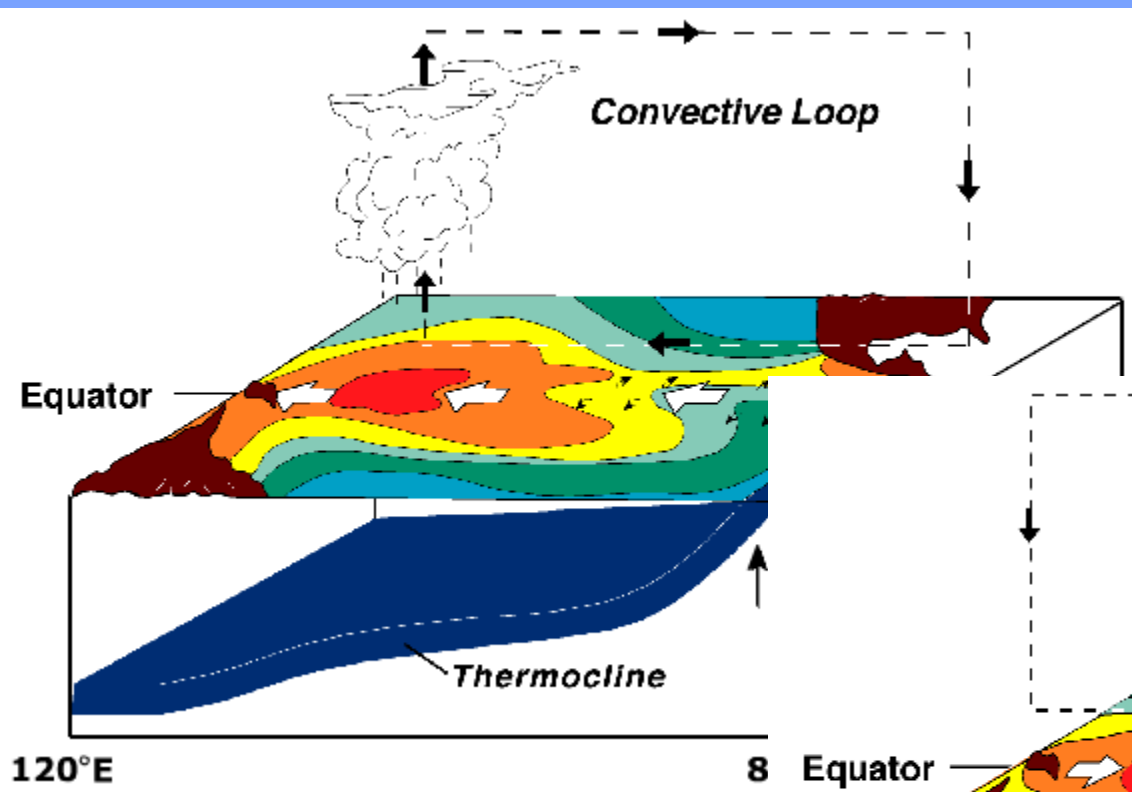
# Are observed/modelled ENSO teleconnections robust?

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KNMI, De Bilt

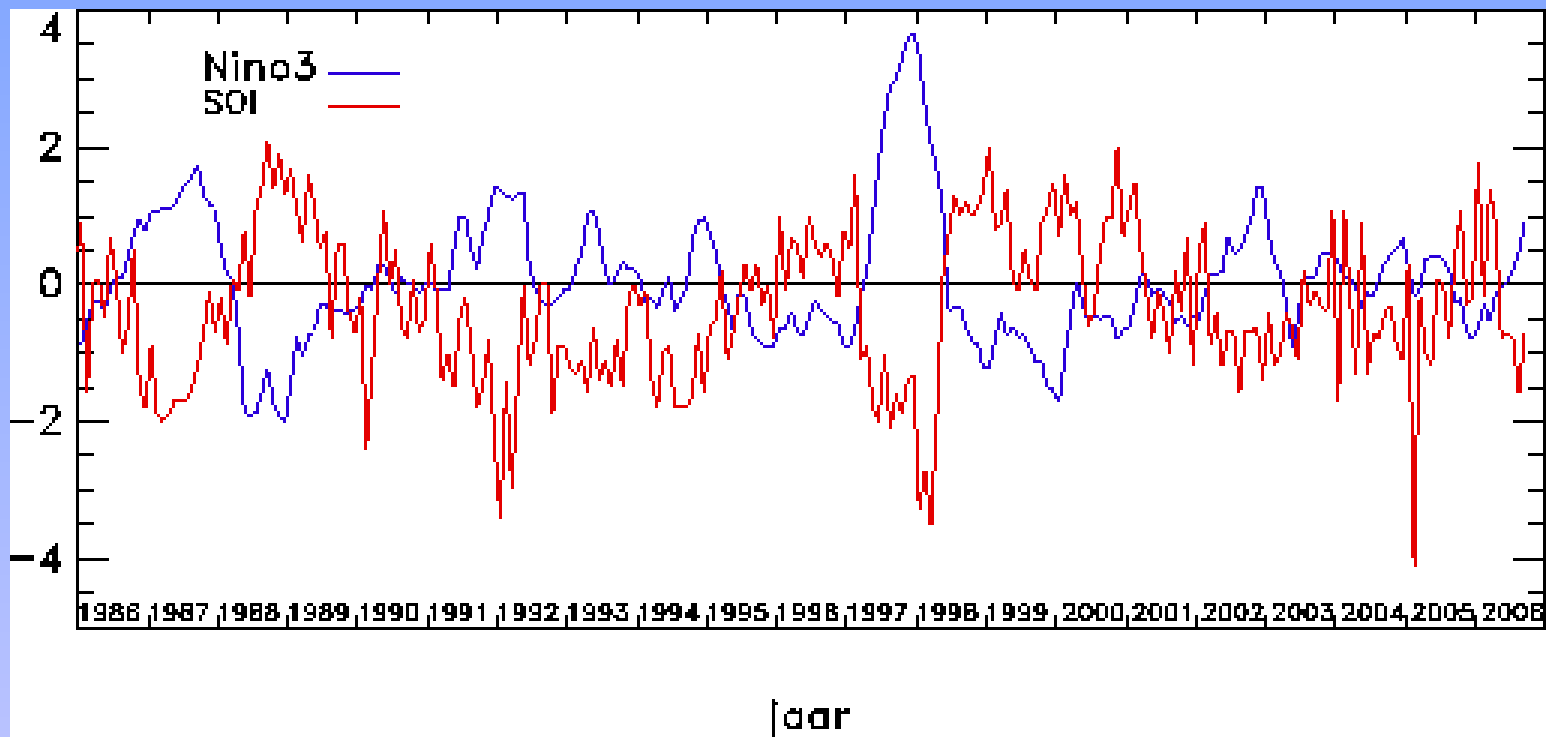
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# ENSO = El Niño – Southern Oscillation



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# NINO-3 and SOI indices



# Correlation and Regression

Time series  $a(t)$  and  $b(t)$

Covariance  $\sigma_{ab} = \langle a(t) b(t) \rangle$

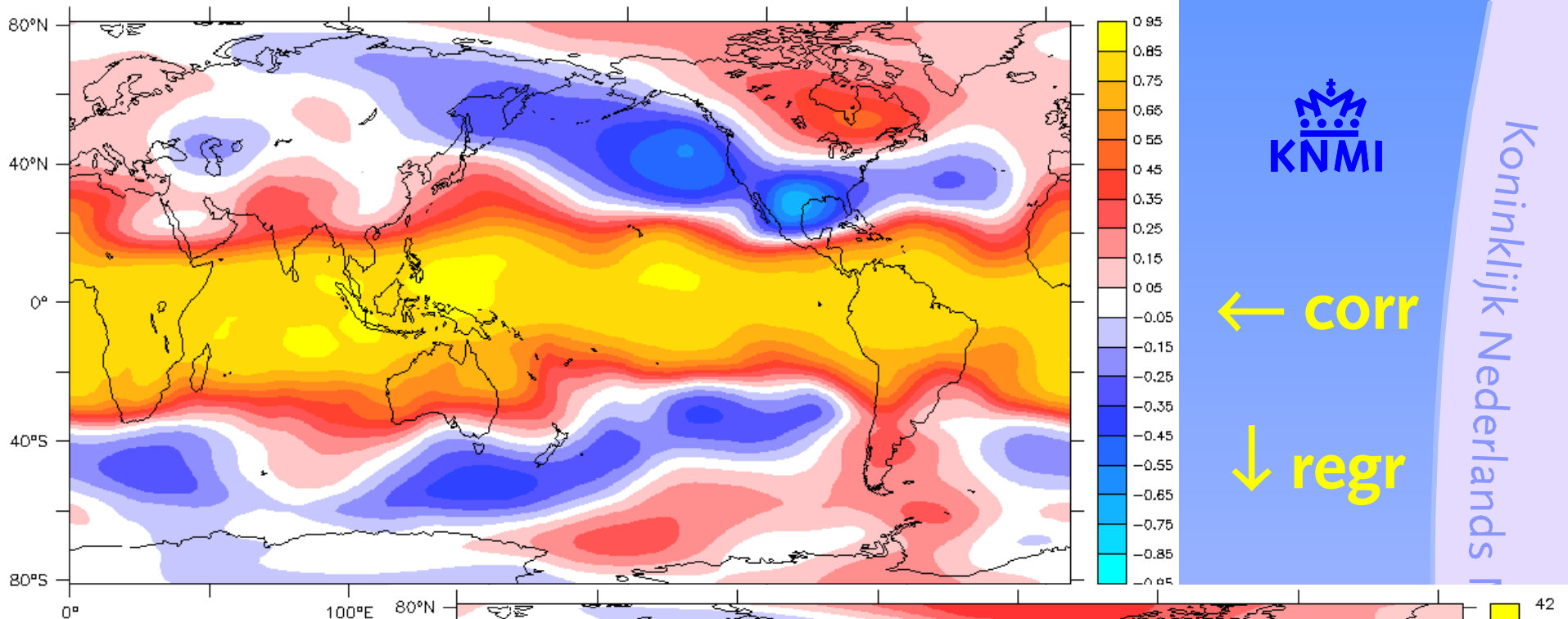
Variance  $\sigma_{aa} = \sigma_a^2$

**Correlation**  $\text{corr}(a,b) = \sigma_{ab} / (\sigma_a \sigma_b)$

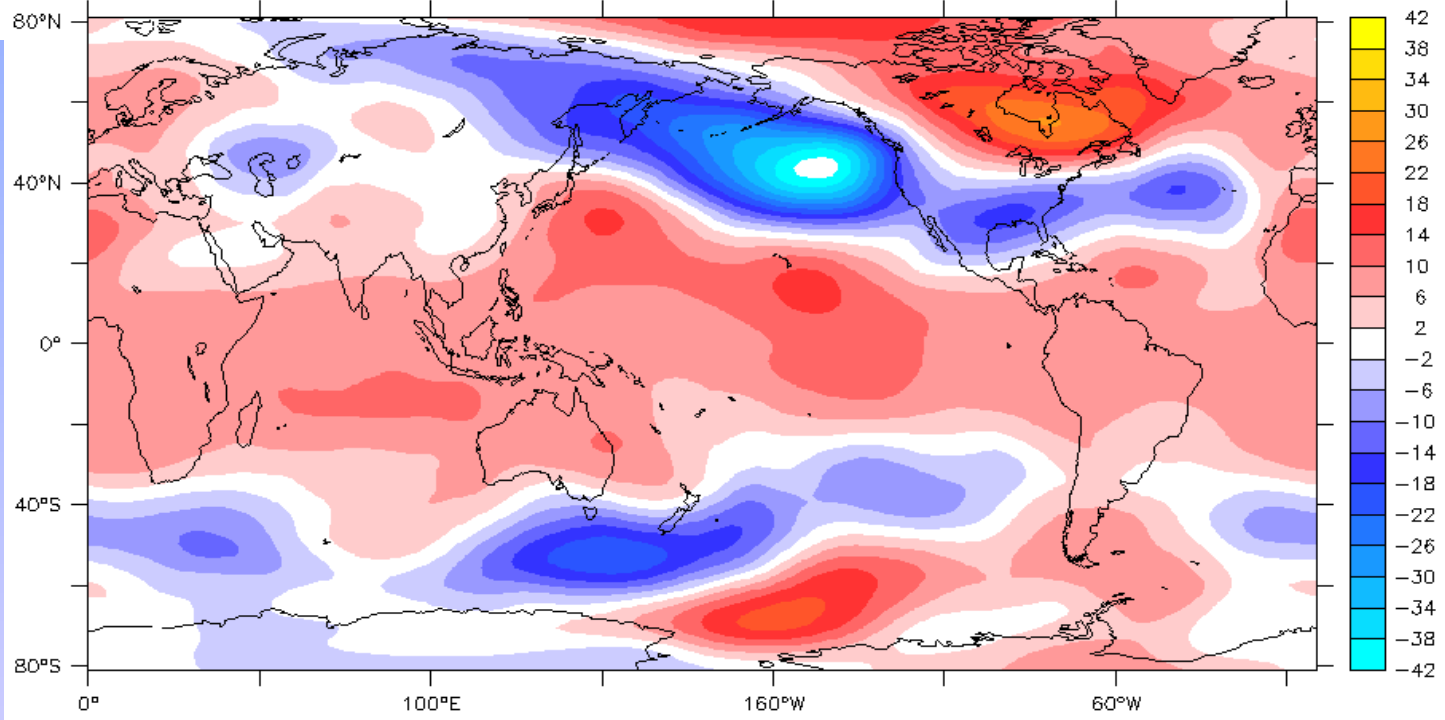
symmetric, independent of amplitude

**Regression**  $\text{regr}(a,b) = \sigma_{ab} / \sigma_a^2$

unsymmetric, “change of  $b$  per unit change of  $a$ ”



ERA-40  
NINO3.4  
 $Z_{500}$   
January



teleconnection robust  
=  
teleconnection stationary  
=  
correlation stationary

## Concept - I

$p(t)$  – signal,  $N_{34}(t)$  – NINO3.4 index

$r = \text{regr}(N_{34}, p)$ ,  $c = \text{corr}(N_{34}, p)$

$$\begin{aligned} p &= r N_{34} + [p - r N_{34}] \\ &= r N_{34} + \sigma_p \sqrt{1-c^2} \eta \end{aligned}$$

$\text{corr}(N_{34}, \eta) = 0$ ,  $\langle \eta \rangle = 0$ ,  $\sigma_\eta = 1$

••••

## Concept - II

$$p = r N_{34} + \sigma_p \sqrt{1-c^2} \eta$$

**draw**  $\eta \in N(0,1) \Rightarrow$  synthetic series  $p_s$

moving correlation:  $c(t) = \text{corr}(N_{34}, p_s)(t)$

**simulate** PDF of  $\Delta c = c_{\max} - c_{\min}$

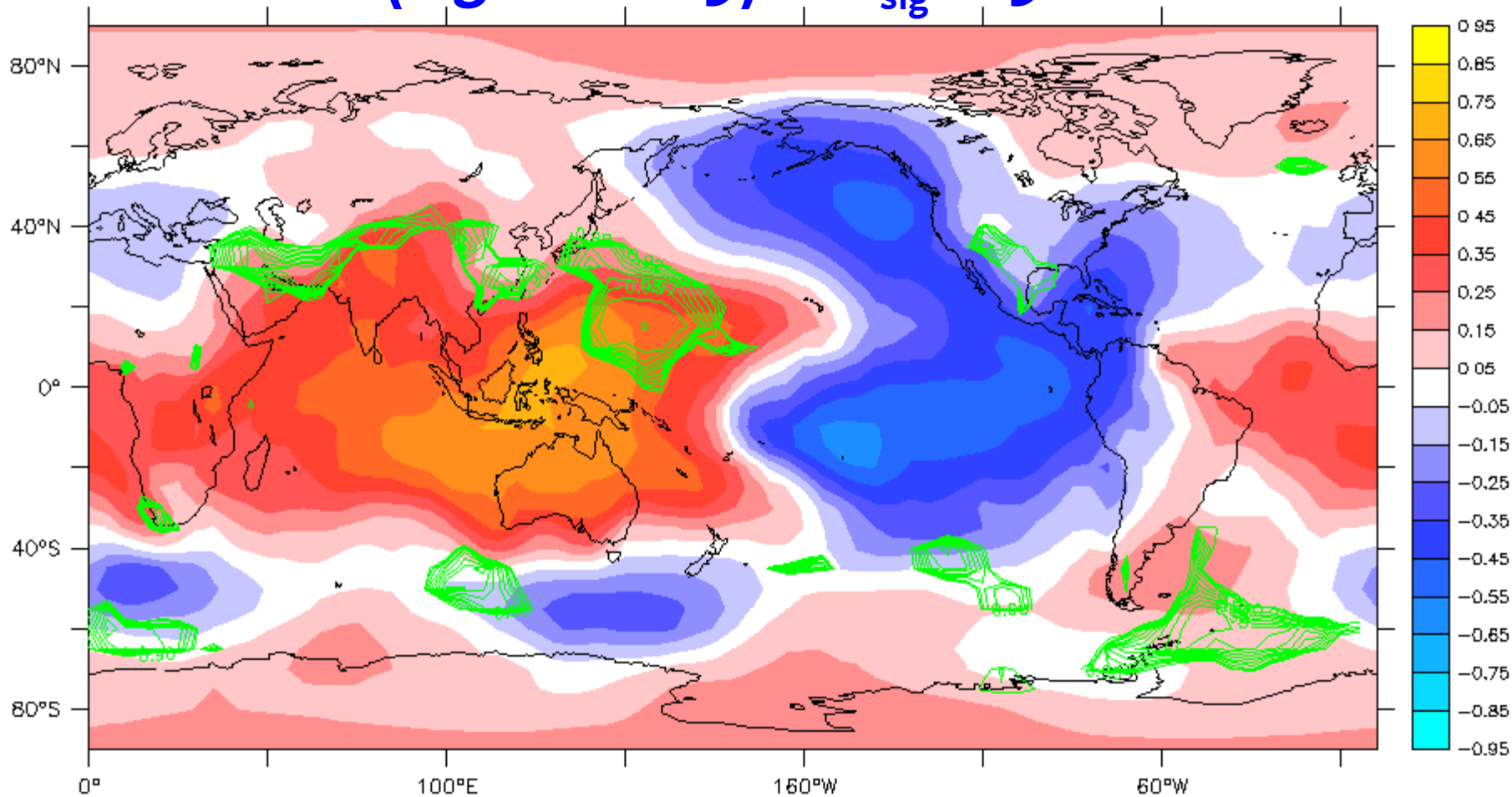
Is observed  $\Delta c$  within PDF ?

## Datasets

- **obs:** HadSLP<sub>1</sub>
- **reanalysis:** ERA-40
- **AGCM:** SPEEDY (20-member ensemble)
- **CGCM:** Challenge (62-member ensemble)
- **CGCM:** ECHAM<sub>5</sub>/MPI-OM (CONTROL + A2)

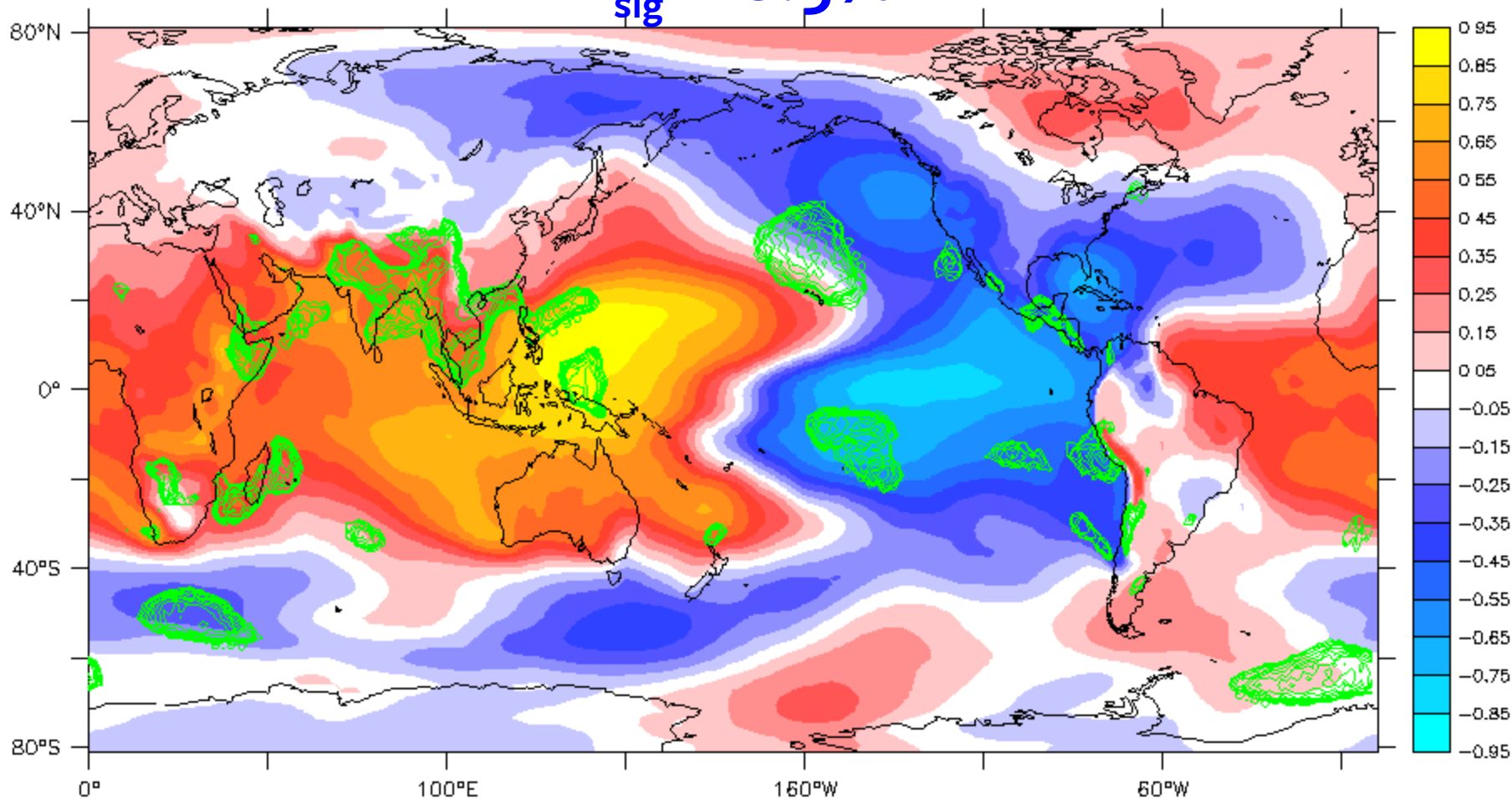
# HadSLP1 – jan

Area(signif > 0.9) =  $A_{\text{sig}}$  = 9.2%



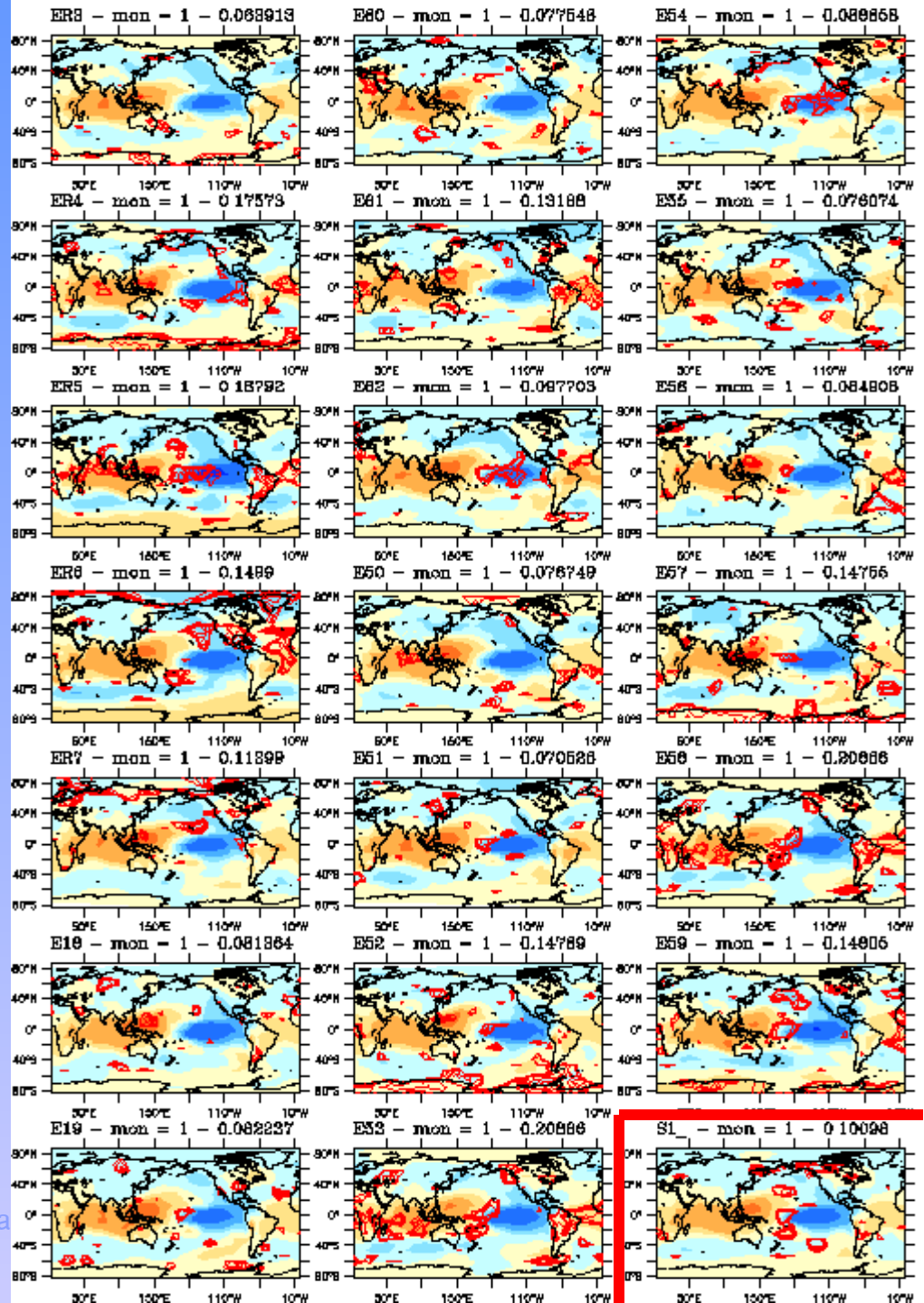
# ERA-40 SLP - jan

$$A_{\text{sig}} = 8.3\%$$

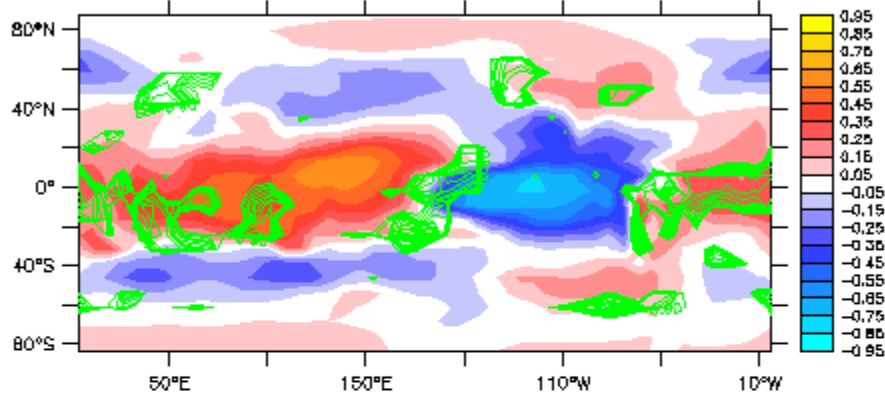


Significance of changes in strength of ENSO-SLP teleconnections

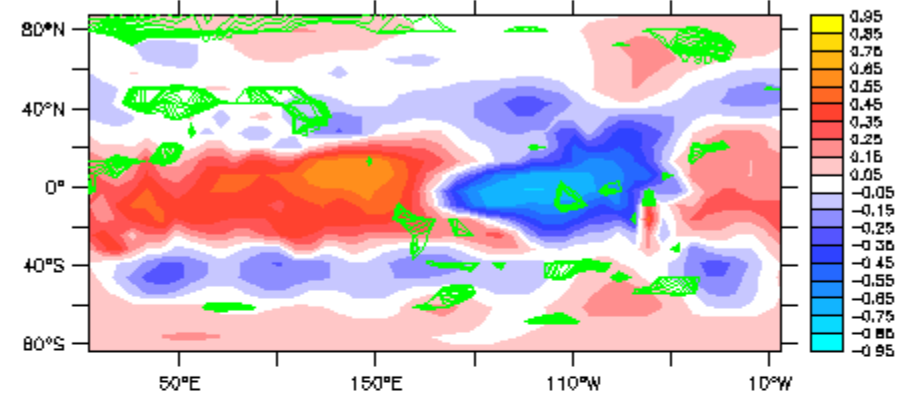
**SPEEDY**



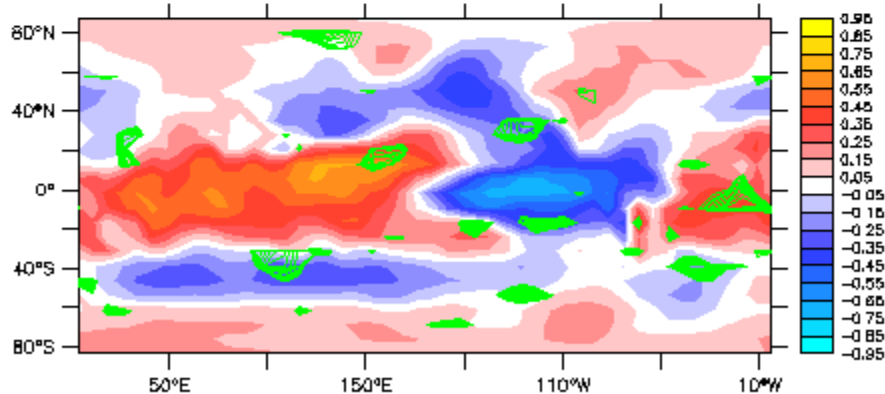
E53 - mon = 1 - 0.21516



E53 - mon = 2 - 0.11635



E53 - mon = 3 - 0.097237



(Dis-)continuity in time



## Obs:

- small  $A_{sig}$

## Speedy:

- large differences between members
- small  $A_{sig}$  for whole ensemble
- no month-to-month consistency

=> No change; teleconnection stationary



# Challenge ensemble - I

	all members			1 <sup>st</sup> 31 members			2 <sup>nd</sup> 31 members		
	1940 -2080	1940 -2000	2001 -2080	1940 -2080	1940 -2000	2001 -2080	1940 -2080	1940 -2000	2001 -2080
jan	<b>39.0</b>	16.6	6.5	<b>25.9</b>	<b>23.3</b>	7.8	<b>25.8</b>	<b>19.2</b>	7.1
feb	<b>32.7</b>	6.8	7.0	17.9	11.4	10.3	<b>22.0</b>	5.2	6.8
mar	<b>28.7</b>	16.2	10.8	<b>39.9</b>	11.7	7.0	13.2	13.0	8.6
apr	<b>19.3</b>	14.6	14.4	13.2	8.0	15.8	<b>23.7</b>	11.9	11.7
may	10.5	7.9	10.5	11.4	<b>28.2</b>	5.6	11.3	6.3	12.9
jun	<b>21.9</b>	<b>31.6</b>	9.9	17.1	<b>31.3</b>	8.7	14.6	<b>20.2</b>	13.0
jul	<b>19.9</b>	<b>24.6</b>	9.3	<b>33.3</b>	<b>26.0</b>	13.8	7.7	4.3	12.4
aug	<b>23.6</b>	14.1	6.0	<b>35.0</b>	11.0	14.1	12.5	11.3	12.2
sep	<b>22.6</b>	16.4	<b>25.9</b>	<b>22.9</b>	12.1	<b>34.7</b>	6.8	15.7	4.9
oct	7.3	10.2	10.1	8.2	6.7	11.1	3.9	7.4	6.2
nov	11.8	8.3	8.2	10.0	13.4	7.5	12.0	11.3	14.4
dec	12.7	<b>27.9</b>	5.4	16.6	<b>30.2</b>	3.4	5.5	5.0	10.2

Table 4:  $A_{\text{sig}}$  for  $z_{500}$  in the CCSM 1.4-ensemble. Statistically significant values ( $> 18.5\%$ , see Table 1) are in boldface.

## Challenge ensemble - II

$A_{\text{sig}}$  large, but ...

larger for historical period than for future

large differences between runs

no month-to-month consistency

**=> no conclusive evidence**

# ECHAM5/MPI-OM ensemble



1860-2200

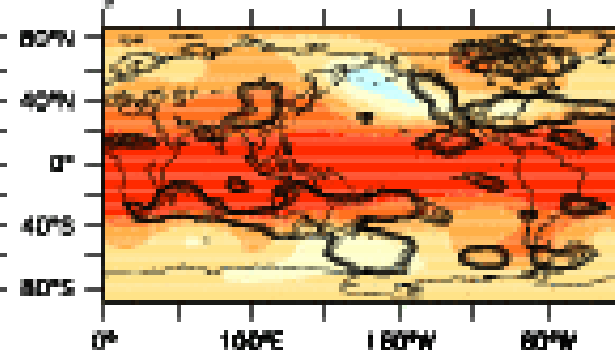
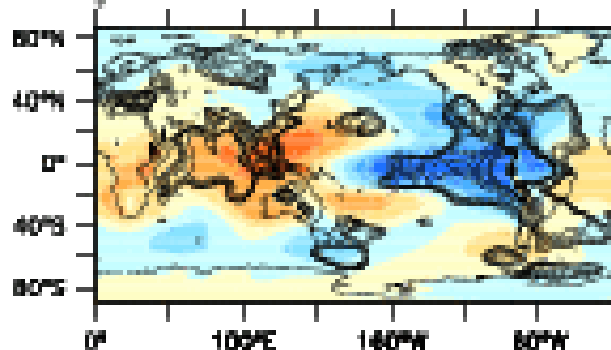
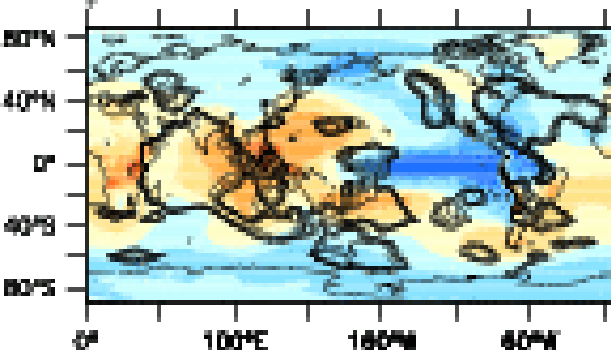
2000-2100

1860-2200

jan - 0.33249

jan - 0.30444

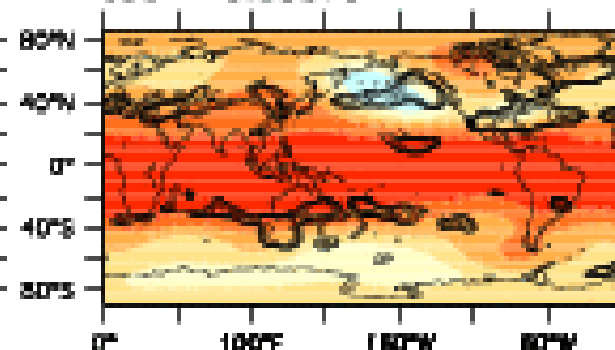
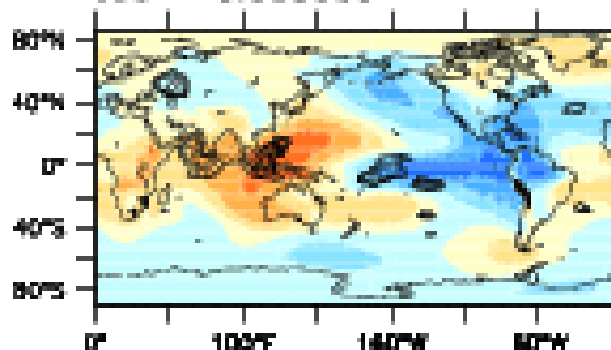
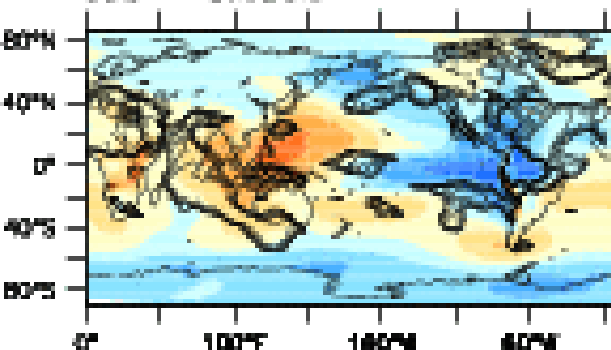
jan - 0.25018



feb - 0.2892

feb - 0.066636

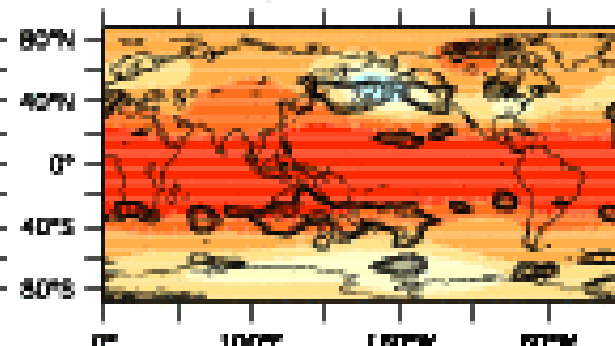
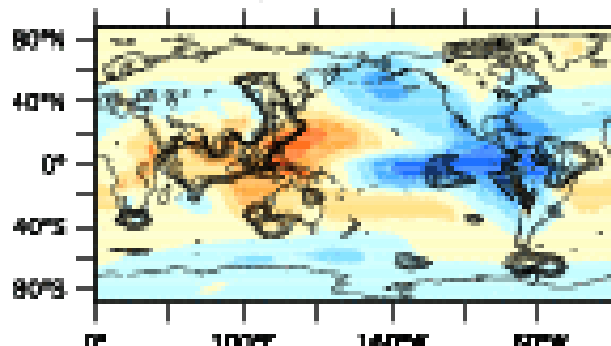
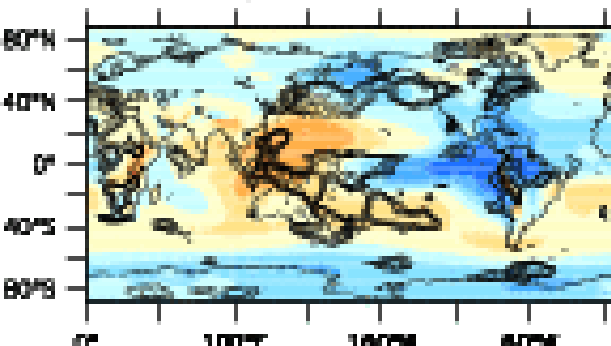
feb - 0.16376



mar - 0.21333

mar - 0.14759

mar - 0.15077



# ECHAM5/MPI-OM ensemble

large  $A_{sig}$  values for SLP

small values for  $z_{500}$

month-to-month consistency

largest changes over 21<sup>st</sup> century

differences between members

**=> changes in ENSO teleconnections possible**

## Conclusions

- obs: no change
- Speedy: no change  
(no consistency between month & members)
- Challenge: questionable
- ECHAM5: possible
- **better diagnostics needed**

