



**The Abdus Salam  
International Centre for Theoretical Physics**



**1968-20**

**Conference on Teleconnections in the Atmosphere and Oceans**

*17 - 20 November 2008*

**On the robustness of ENSO teleconnections**

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# Are observed/modelled ENSO teleconnections robust?

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**KNMI, De Bilt, The Netherlands**

Sterl, A., G.J. van Oldenborgh, W. Hazeleger, and G. Burgers (2007)  
On the robustness of ENSO teleconnections  
Clim. Dyn., 29, (2007), 469-485, doi: 10.1007/s00382-007-0251-z



# Teleconnection

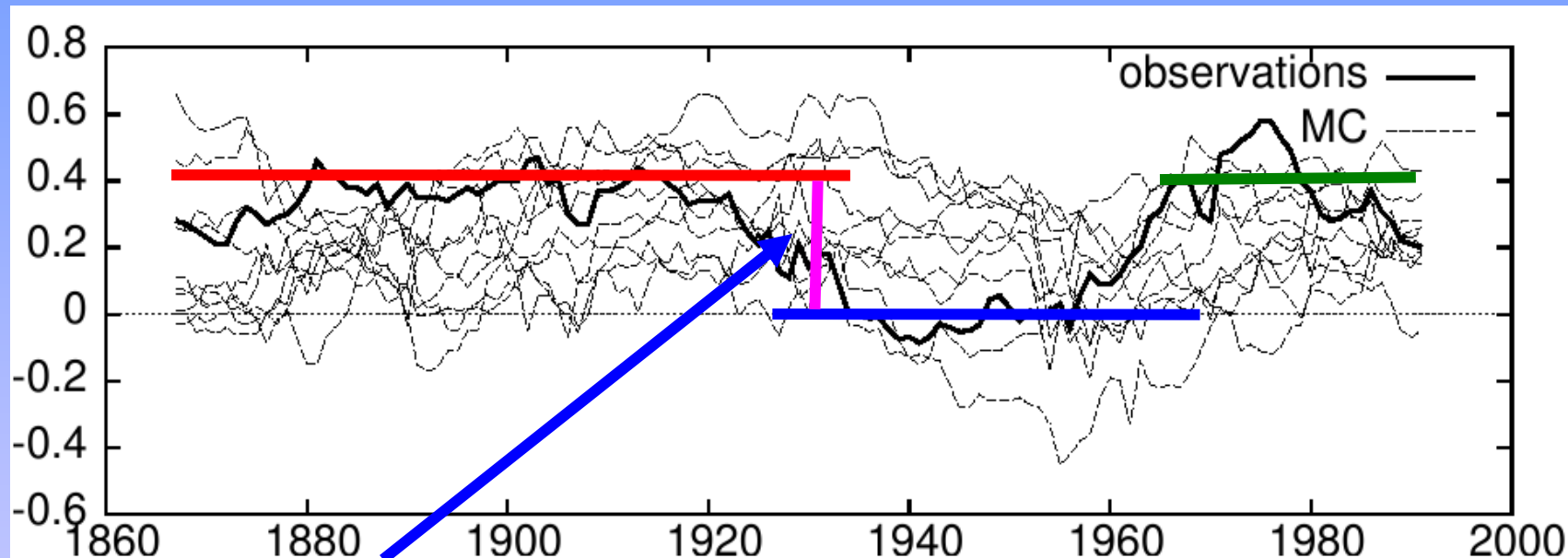
- correlation (regression) between spatially separated time series
- used for
  - (seasonal) forecasts
  - reconstruction
- necessary
  - teleconnection is robust
  - = teleconnection is stationary
  - = **correlation is stationary**

# Example



## Running correl $N_{34}$ – precip in De Bilt

Van Oldenborgh & Burgers (GRL, 2005)



**Is this a change or a statistical fluctuation?**  
**MC method → fluctuation**

Andreas Sterl, Trieste, 17.11.2008

## Concept - I

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

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

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

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

••••

## Concept - II

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

**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  $\Delta c_{\text{obs}}$  within PDF ?**

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## Field significance

....

$A_{sig}$  = fraction of area with signif  $>$   
90%

naively:  $A_{sig} = 10\%$  by chance

but: finite dofs (grid points,  
dependence)

$\Rightarrow A_{sig} > 13\%$  (Livezey & Chen, 1983)

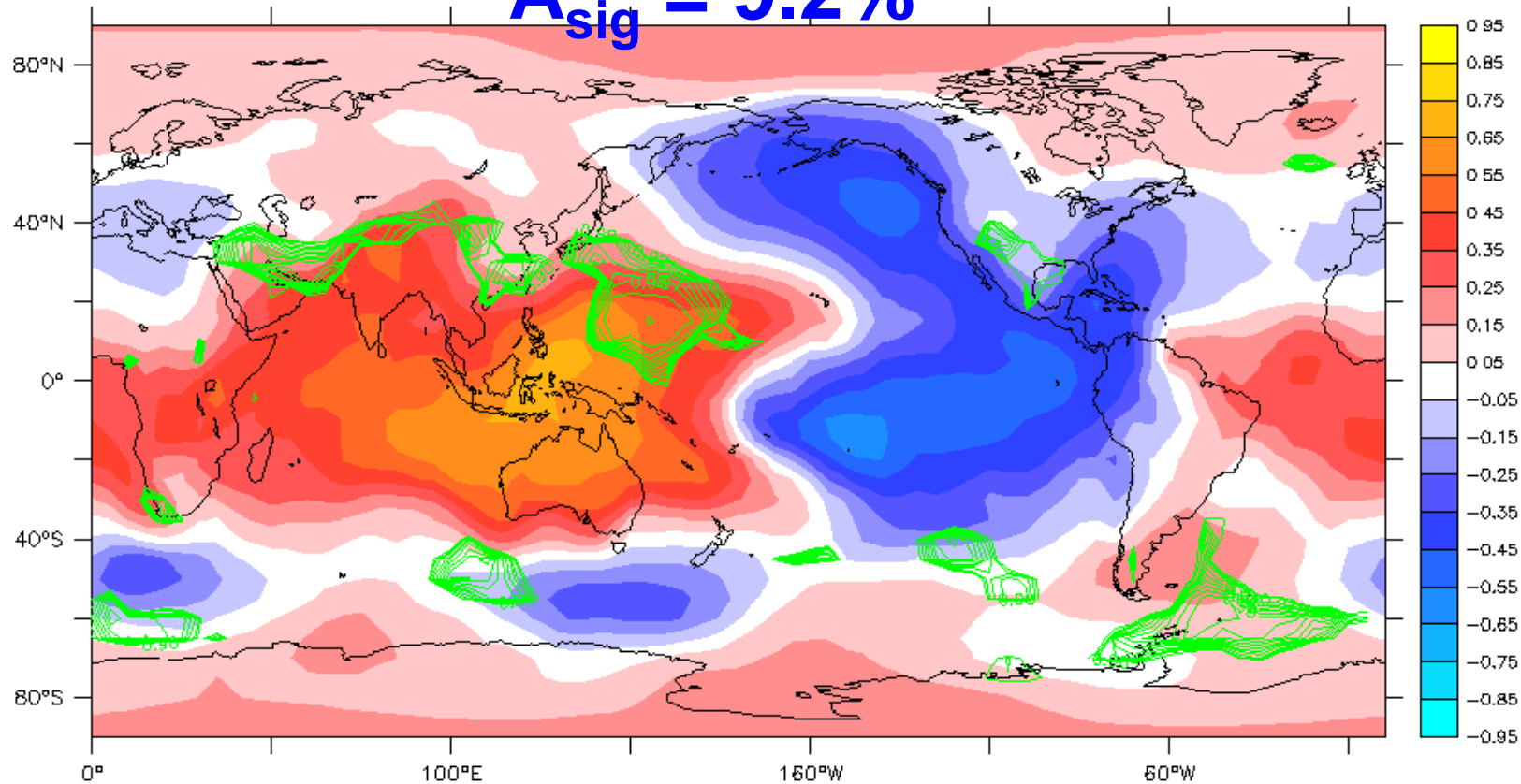
## Datasets

- **obs:** HadSLP1
- **reanalysis:** ERA-40
- **AGCM:** SPEEDY (20-member ensemble)
- **CGCM:** Challenge (62-member ensemble)
- **CGCM:** ECHAM5/MPI-OM (CONTROL + A1b)



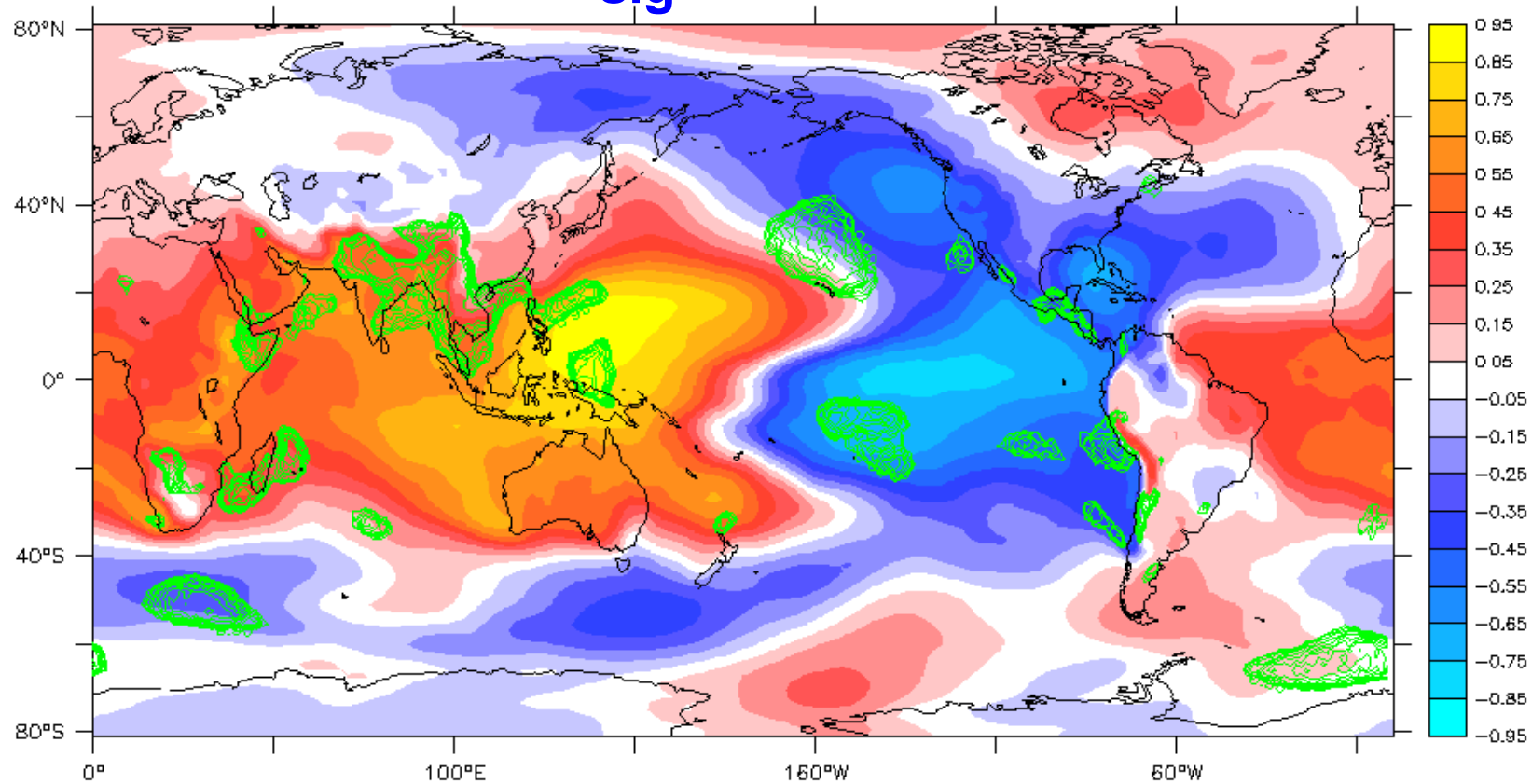
# HadSLP1 – jan

$A_{sig} = 9.2\%$



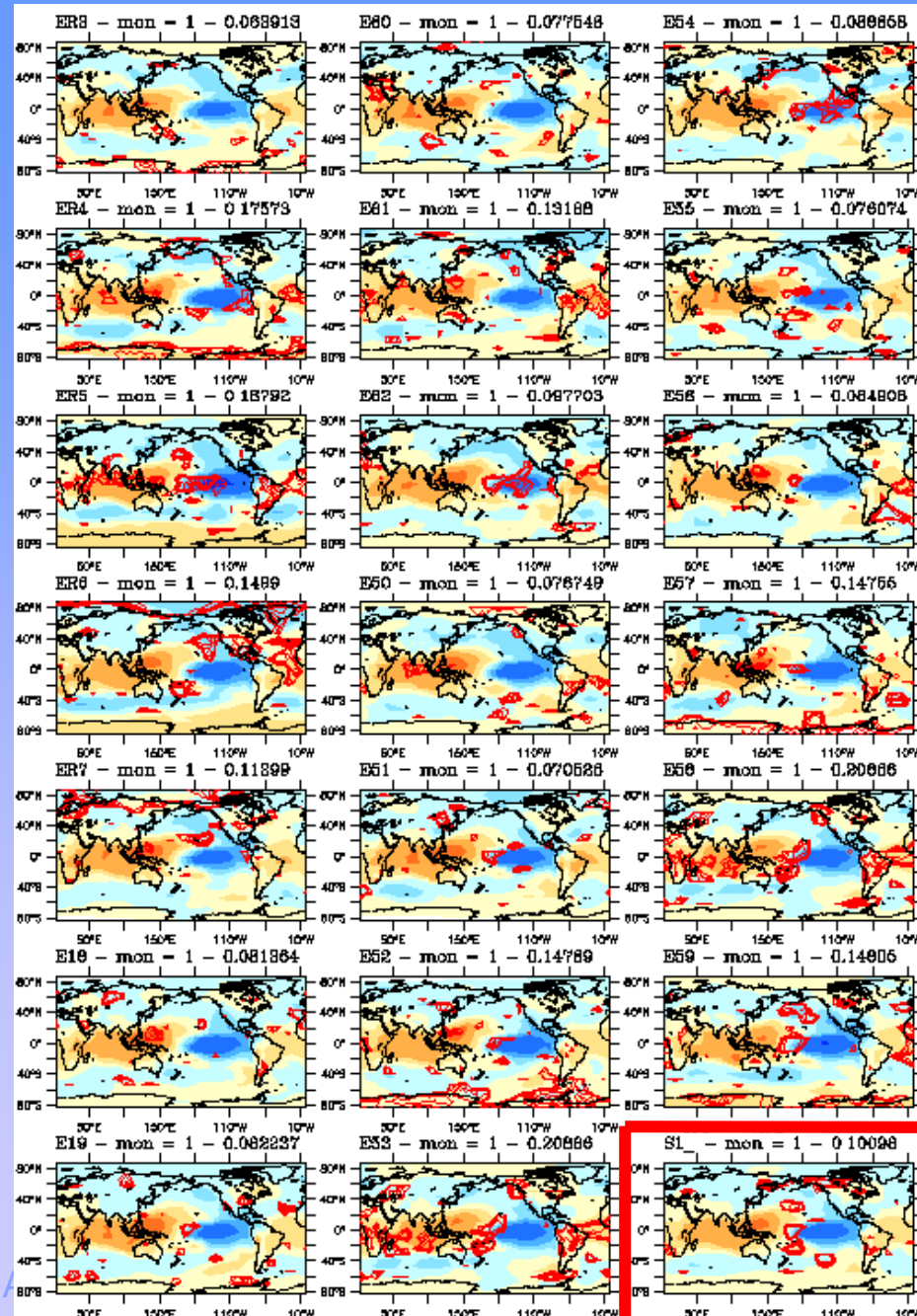
# ERA-40 SLP - jan

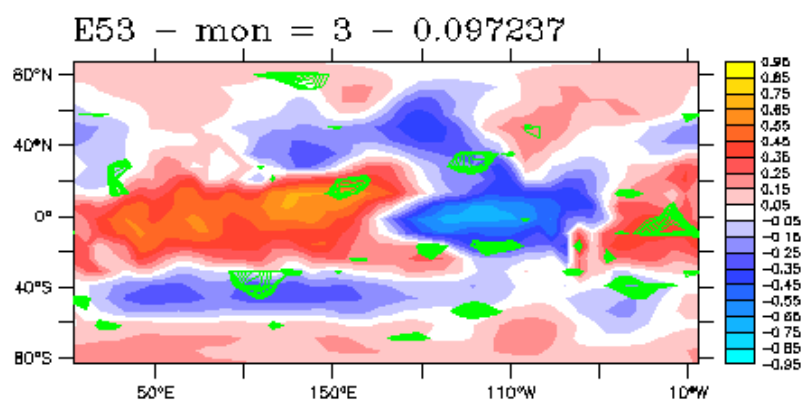
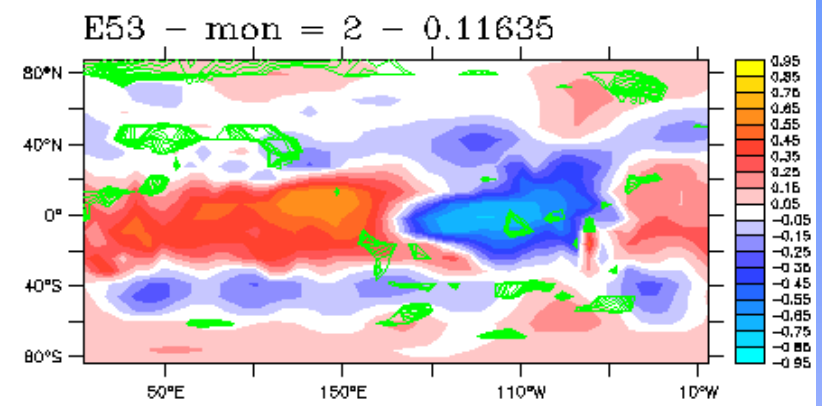
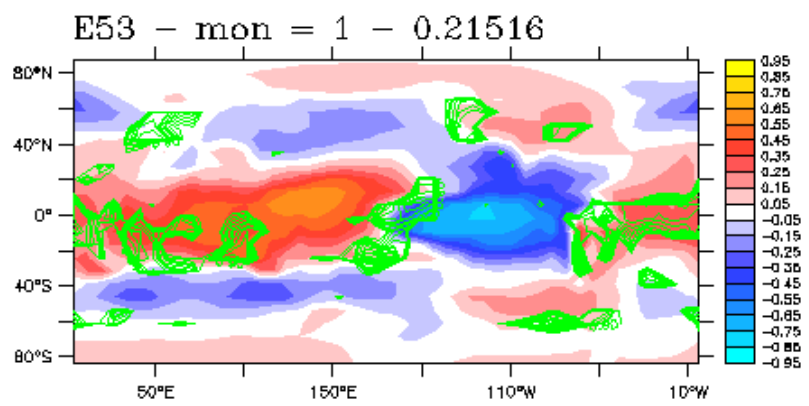
$A_{sig} = 8.3\%$



Significance of changes in strength of ENSO-SLP teleconnections

**SPEEDY**





(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



**Table 3**  $A_{\text{sig}}$  for  $z_{500}$  in the CCSM1.4-ensemble

	All members			First 31 members			Second 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>	<b>16.6</b>	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	<b>17.9</b>	11.4	10.3	<b>22.0</b>	5.2	6.8
Mar	<b>28.7</b>	<b>16.2</b>	10.8	<b>39.9</b>	11.7	7.0	<b>13.2</b>	<b>13.0</b>	8.6
Apr	<b>19.3</b>	<b>14.6</b>	<b>14.4</b>	<b>13.2</b>	8.0	<b>15.8</b>	<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	<b>17.1</b>	<b>31.3</b>	8.7	<b>14.6</b>	<b>20.2</b>	<b>13.0</b>
Jul	<b>19.9</b>	<b>24.6</b>	9.3	<b>33.3</b>	<b>26.0</b>	<b>13.8</b>	7.7	4.3	12.4
Aug	<b>23.6</b>	<b>14.1</b>	6.0	<b>35.0</b>	11.0	<b>14.1</b>	12.5	11.3	12.2
Sep	<b>22.6</b>	<b>16.4</b>	<b>25.9</b>	<b>22.9</b>	12.1	<b>34.7</b>	6.8	<b>15.7</b>	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	<b>13.4</b>	7.5	12.0	11.3	<b>14.4</b>
Dec	12.7	<b>27.9</b>	5.4	<b>16.6</b>	<b>30.2</b>	3.4	5.5	5.0	10.2

Statistically significant values (> 13%) are in boldface

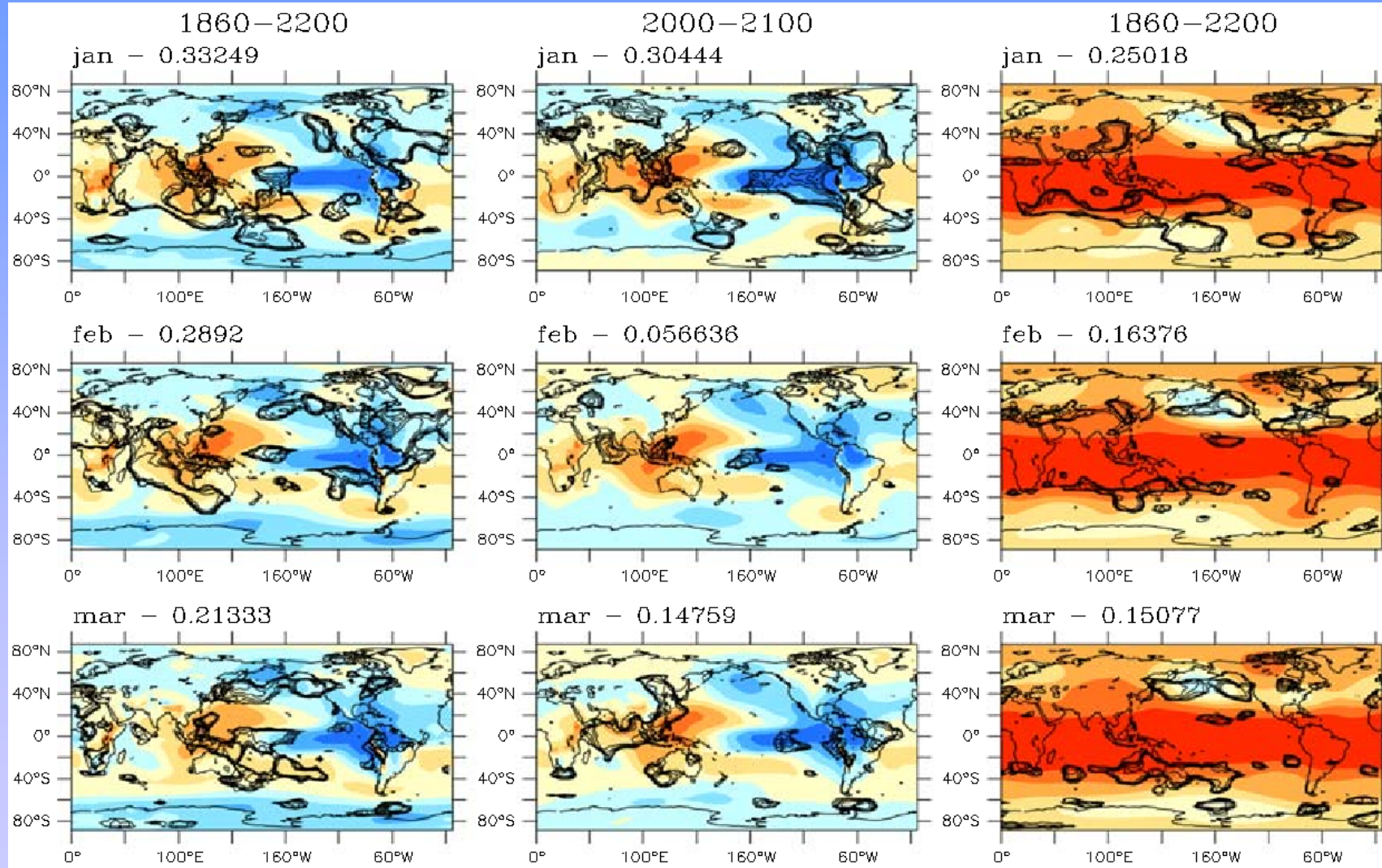


## Challenge ensemble - II

- $A_{sig}$  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



Andreas Sterl, Trieste, 17.11.2008



....

## ECHAM5/MPI-OM ensemble

- large  $A_{\text{sig}}$  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/MPI-OM:** possible
- **better diagnostics needed ?**



**The End !!!**



....

# Correlation and Regression

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

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

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

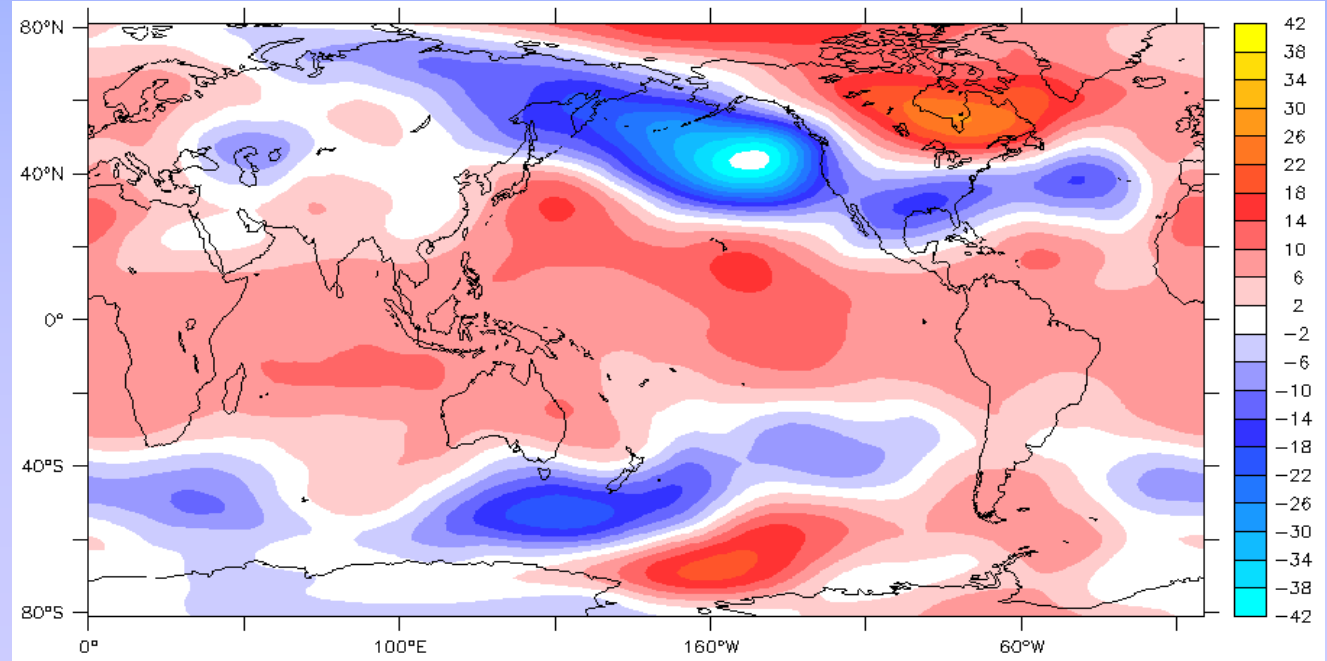
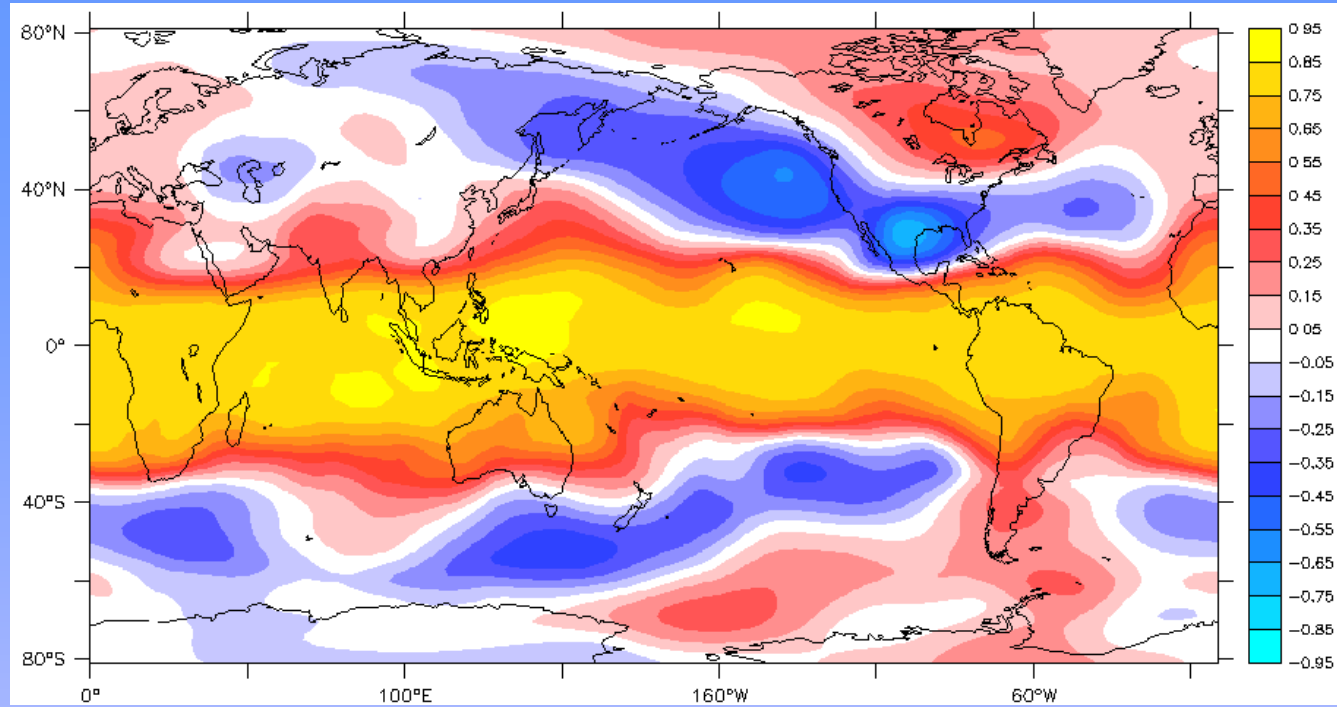
**Correlation**       $\text{corr}(a,b) = \sigma_{ab} / (\sigma_a \sigma_b)$   
symmetric, independent of amplitude

**Regression**       $\text{regr}(a,b) = \sigma_{ab} / \sigma_a^2$   
unsymmetric, “change of b per unit  
change of a”

....



← corr  
↓ regr



ERA-40  
NINO3.4  
Z<sub>500</sub>  
January  
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