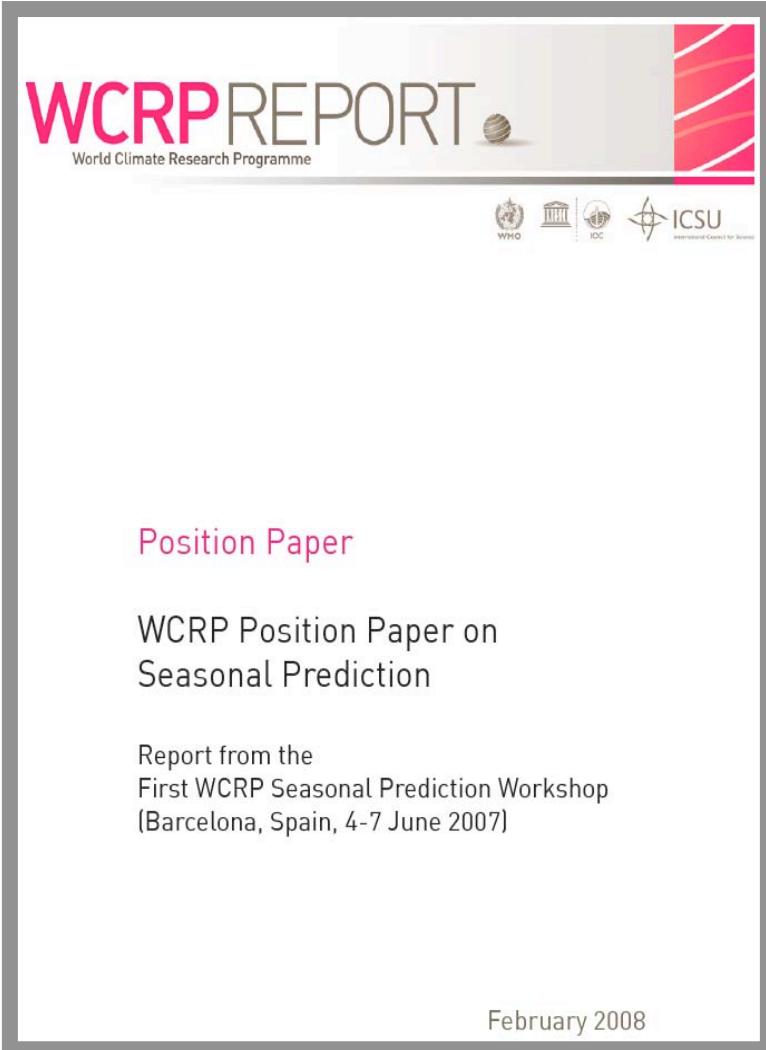




# Contribution of Northern Hemisphere snow cover (and northern or equatorial stratosphere) to seasonal climate variability and predictability

H. Douville, Y. Peings, D. Saint Martin  
CNRM-GAME

# Background and motivations



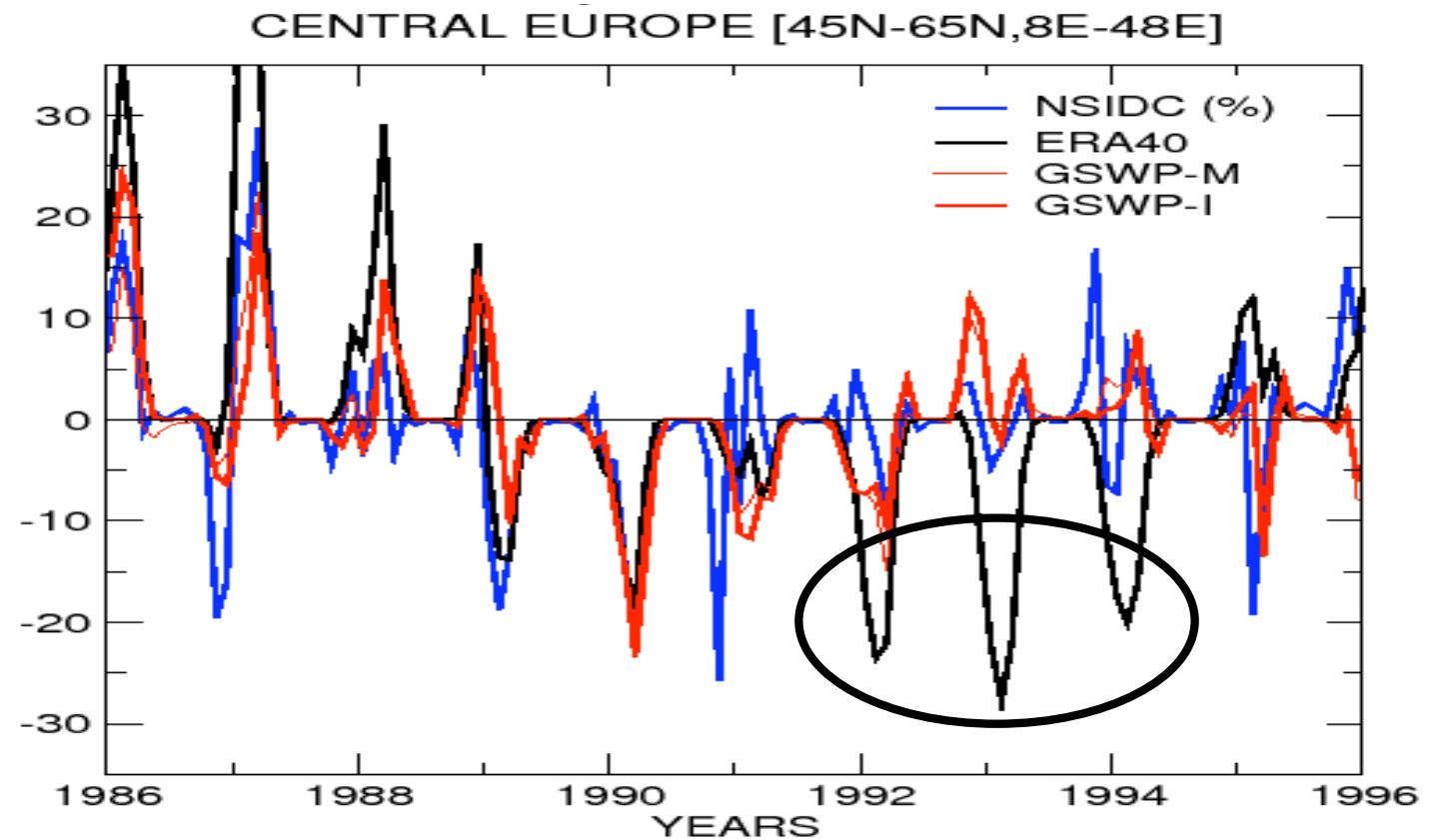
MISSTERRE

- ✓ The global ocean has a limited influence on atmospheric variability.
- ✓ The cryosphere and stratosphere have some memory and represent potential sources of long-range predictability.
- ✓ Both are sensitive to GHG concentrations.



# Comparison between GSWP/ERA40/NSIDC over Central Europe

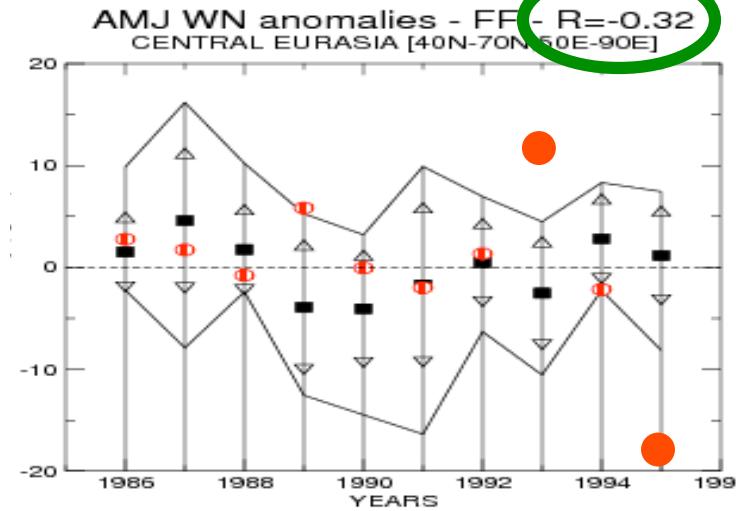
Monthly snow mass ( $\text{kg/m}^2$ ) or snow cover (%) anomalies against the 10-yr mean climatology



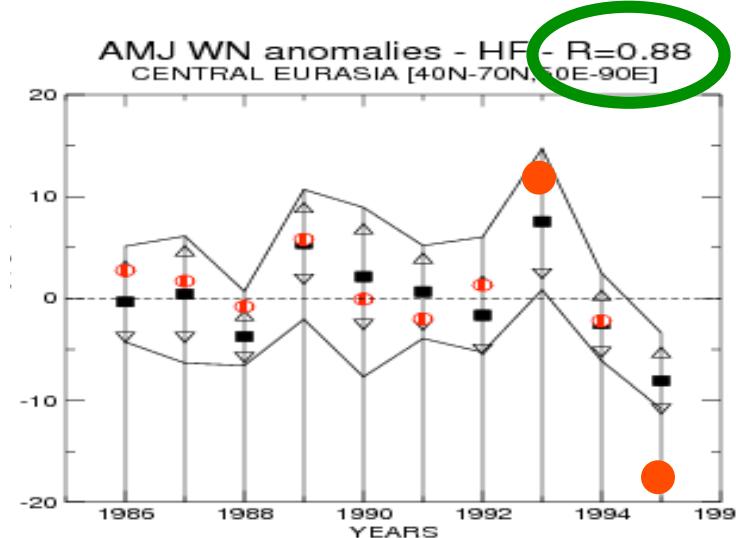
- ✓ Inconsistencies in the ERA40 reanalyses
- ✓ Non linear snow mass – snow cover relationship
- ✓ Use of GSWP for prescribing/initializing snow mass

# Predictability of snow mass in spring in ensemble simulations with Arpege-Climat

Springtime  
(AMJ)  
snow mass  
anomalies  
(kg/m<sup>2</sup>)  
over  
Central  
Eurasia  
relative  
to the  
1986-1995  
climatology



Control  
experiment  
(random initial  
conditions =>  
observed SST  
forcing only)



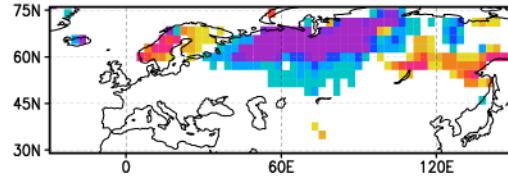
Seasonal  
hindcasts  
initialized with  
the GSWP  
climatology

From Douville (2009)

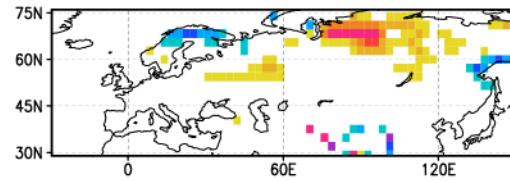
# April-May-June 1995 minus 1993

(for simulations, shading denotes statistical significance at a 5% level)

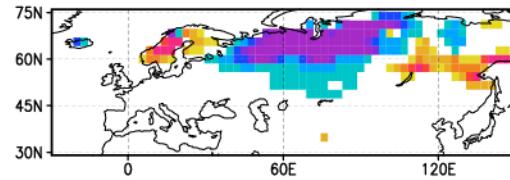
GSPW2 AMJ 1995–1993 SMass ( $\text{kg/m}^2$ )



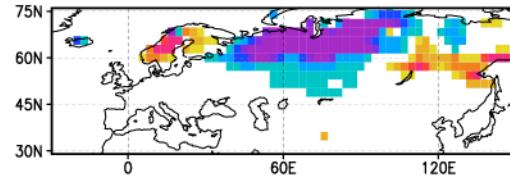
FF  $R=-0.29$



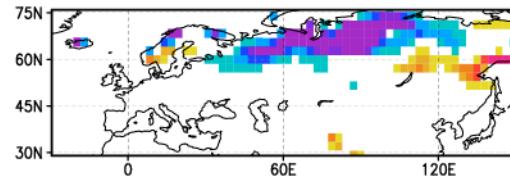
HC  $R=0.98$



HH  $R=0.98$



HF  $R=0.83$



## Analyses

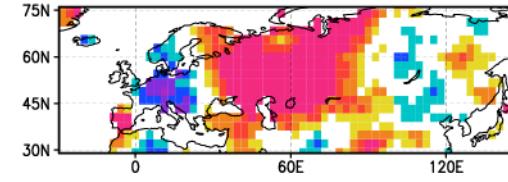
Obs. SST  
free land  
surface

Clim. SST  
GSPW BC

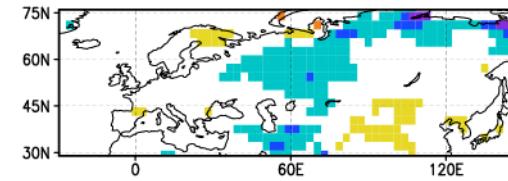
Obs. SST  
GSPW BC

Obs. SST  
GSPW IC

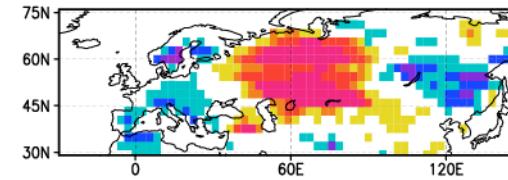
CRU2 AMJ 1995–1993 T2M ( $^{\circ}\text{C}$ )



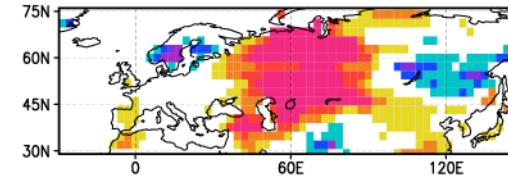
FF  $R=-0.30$



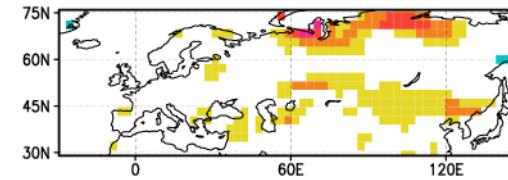
HC  $R=0.67$



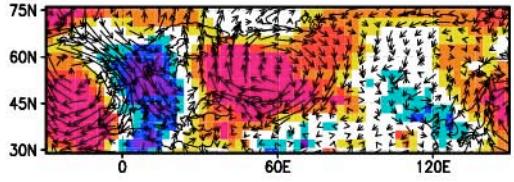
HH  $R=0.68$



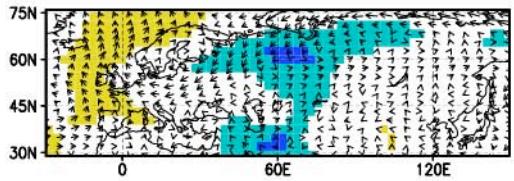
HF  $R=0.15$



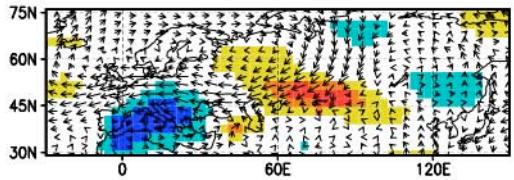
ERA40 AMJ 1995–1993 T850 ( $^{\circ}\text{C}$ )



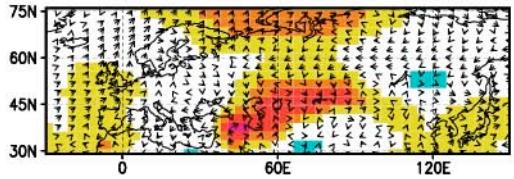
FF  $R=-0.25$



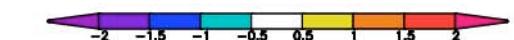
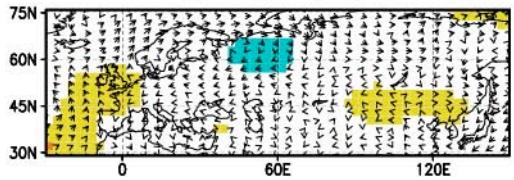
HC  $R=0.44$



HH  $R=0.36$



HF  $R=-0.10$



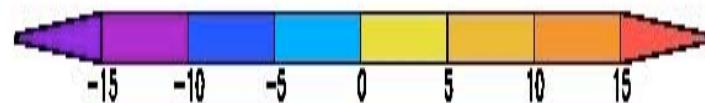
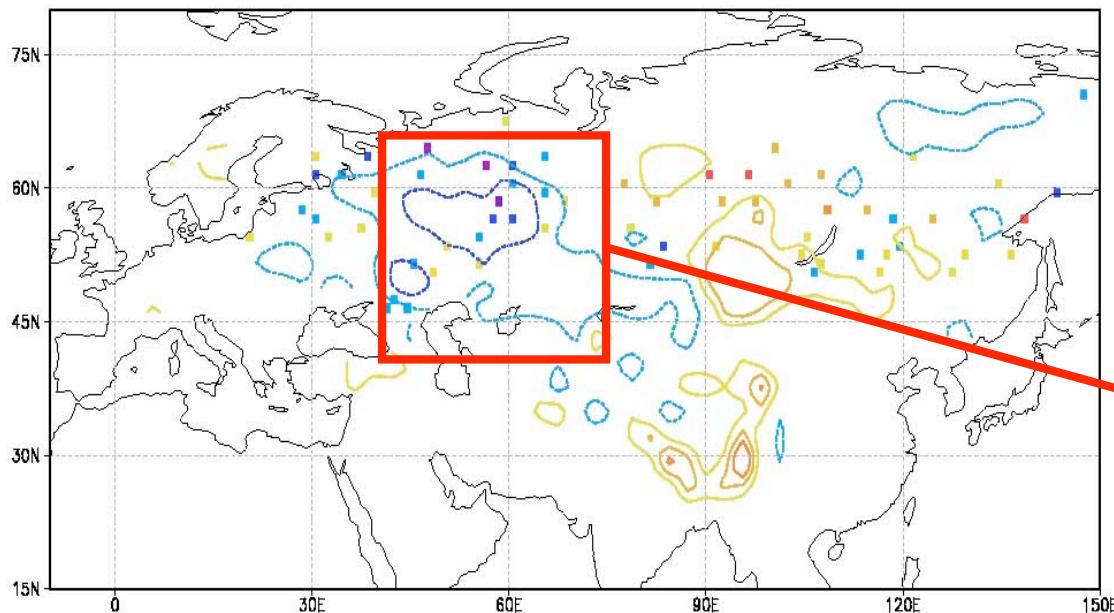
## Looking for remote impacts of NHSC on interannual climate variability

- ✓ Methodology: Maximum Covariance Analysis applied onto *detrended* seasonal mean timeseries derived from observations (40-yr NSIDC climatology) and 20th century CMIP3 simulations (subset of 8 models)
- ✓ Influence of the Eurasian snow cover in spring on the subsequent Indian summer monsoon rainfall (Blanford 1884, Hahn and Shukla 1976, Bamzai and Shukla 1999, Barnett et al. 1989, Yasunari et al. 1991, Douville and Royer, Fasullo 2004)
- ✓ Influence of the Siberian snow cover in fall on the subsequent winter AO-NAO (Cohen and Entekhabi 1999, Saunders 2003, Cohen and Saito 2003, Gong et al. 2003, Fletcher et al. 2007)

# Observed snow-monsoon relationship

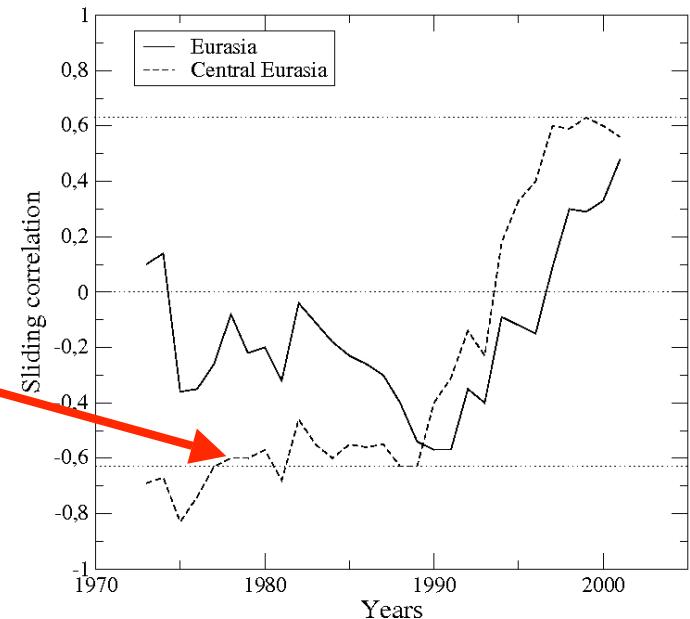
## Strong minus Weak monsoon composites

Strong–Weak monsoons: spring snow cover and snow depth anomalies  
1966–1995



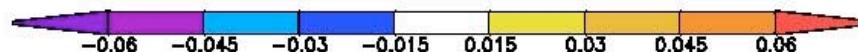
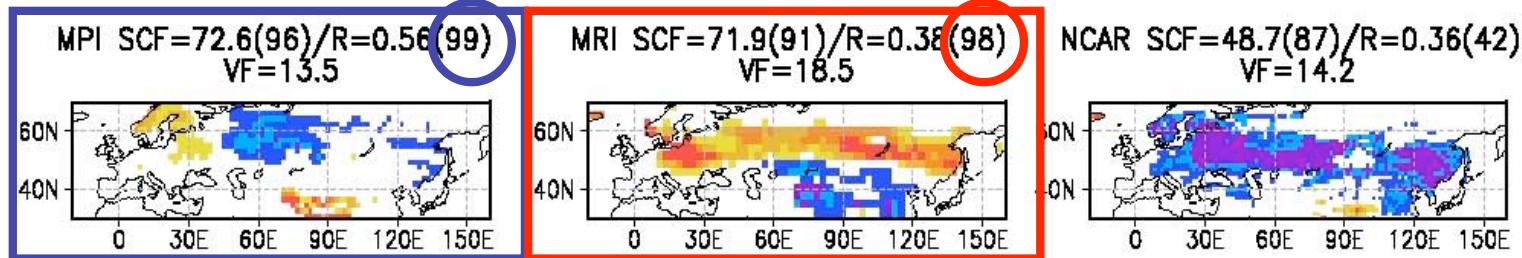
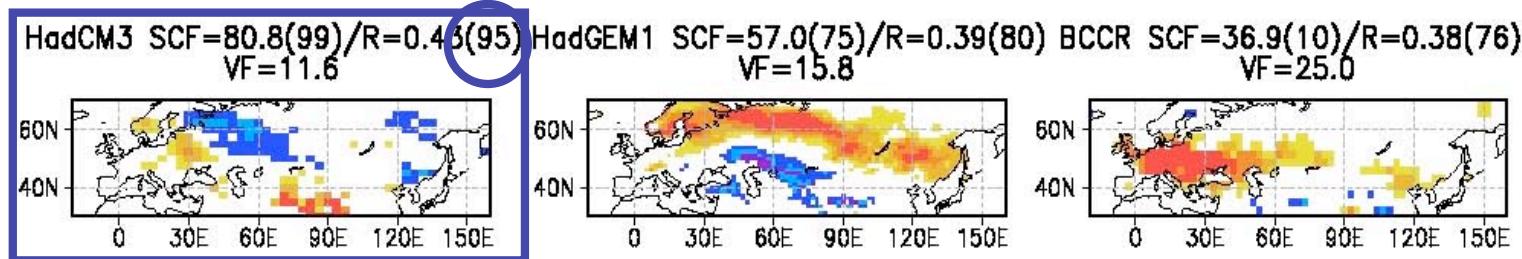
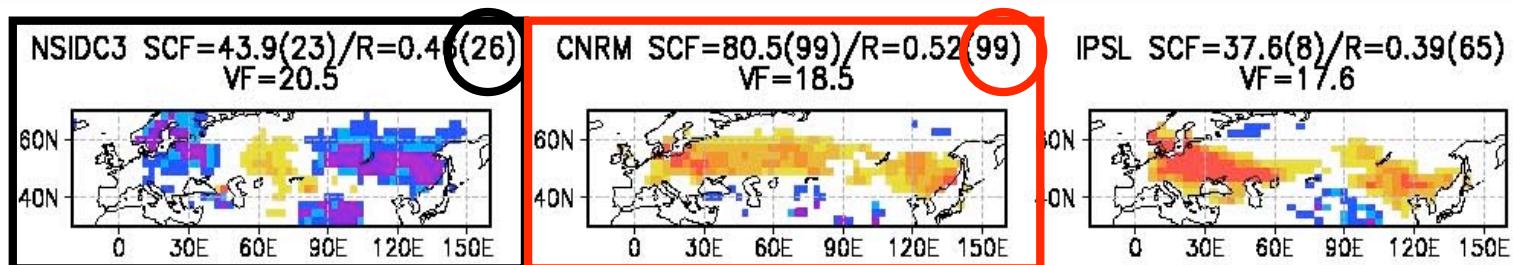
snow mass (pixels in kg/m<sup>2</sup>)  
and snow cover (isolines in %)

11-yrs sliding correlations - NSIDC3/OBS  
between snow cover MAM and AIR JJAS / 1967-2005

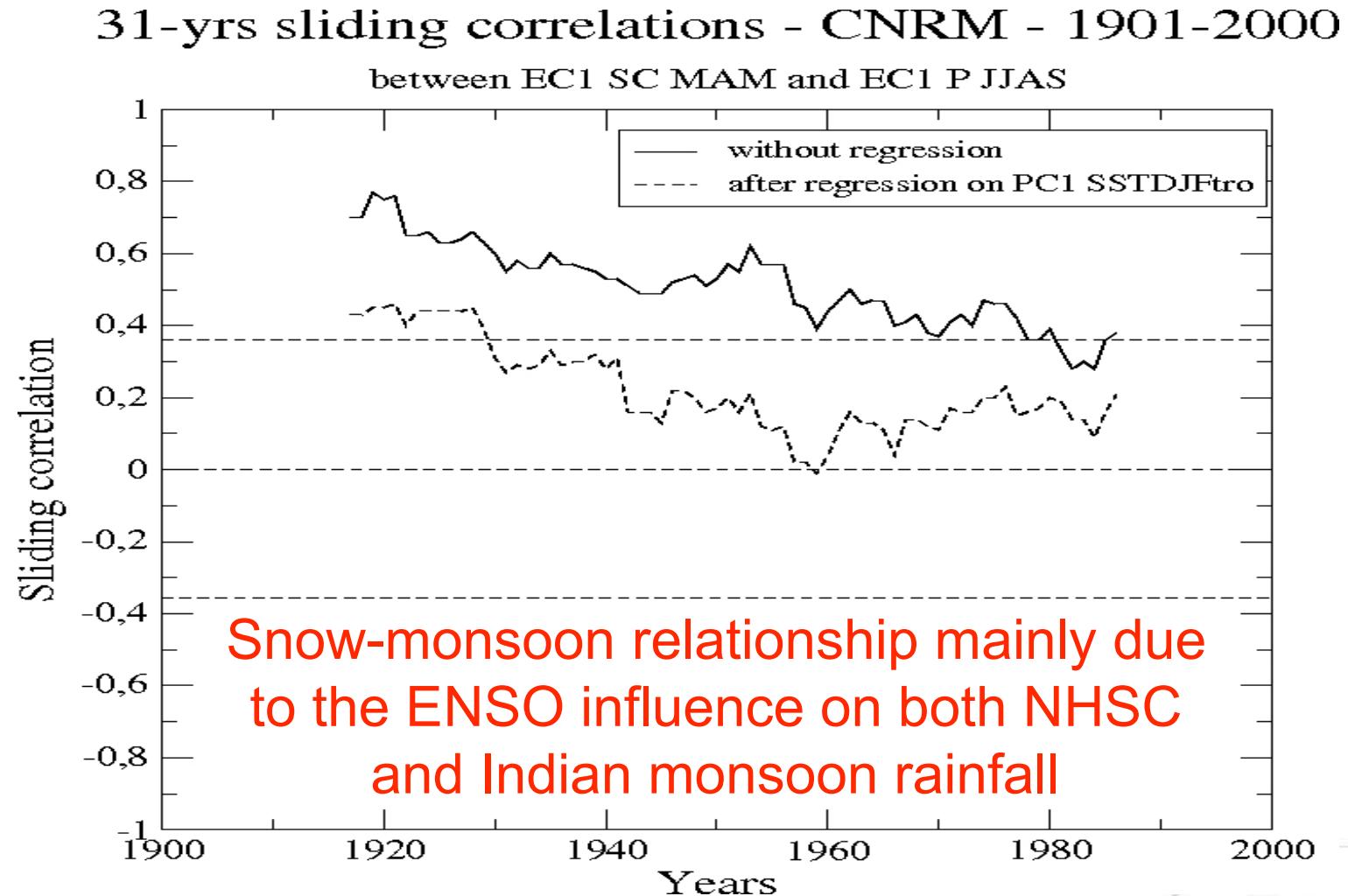


Collapse of the snow-monsoon relationship since the mid 1990's

# Snow cover - monsoon relationship Maximum Covariance Analysis (1901-2000)

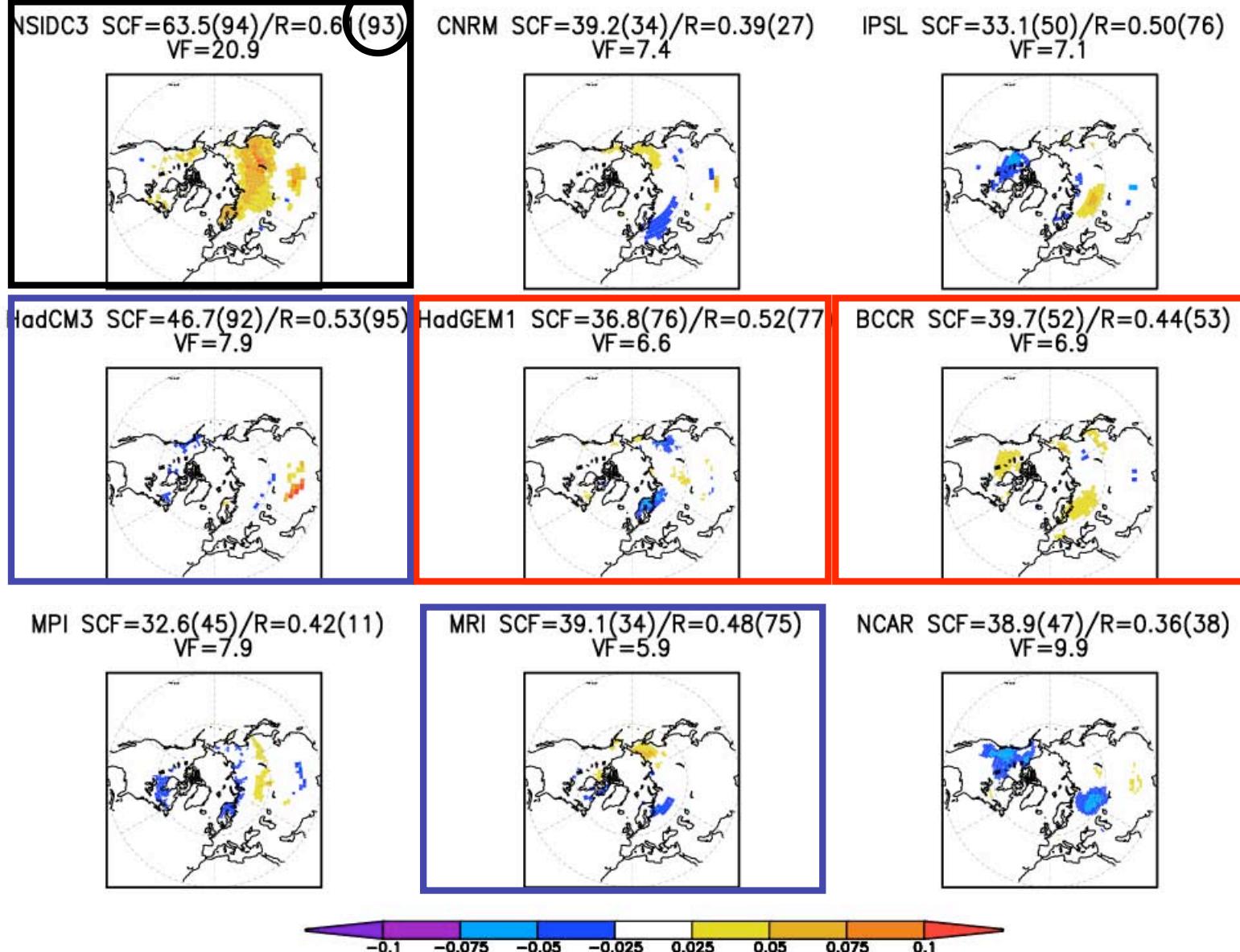


# Unrealistic snow - monsoon relationship in the CNRM model



# Snow cover – AO/NAO relationship

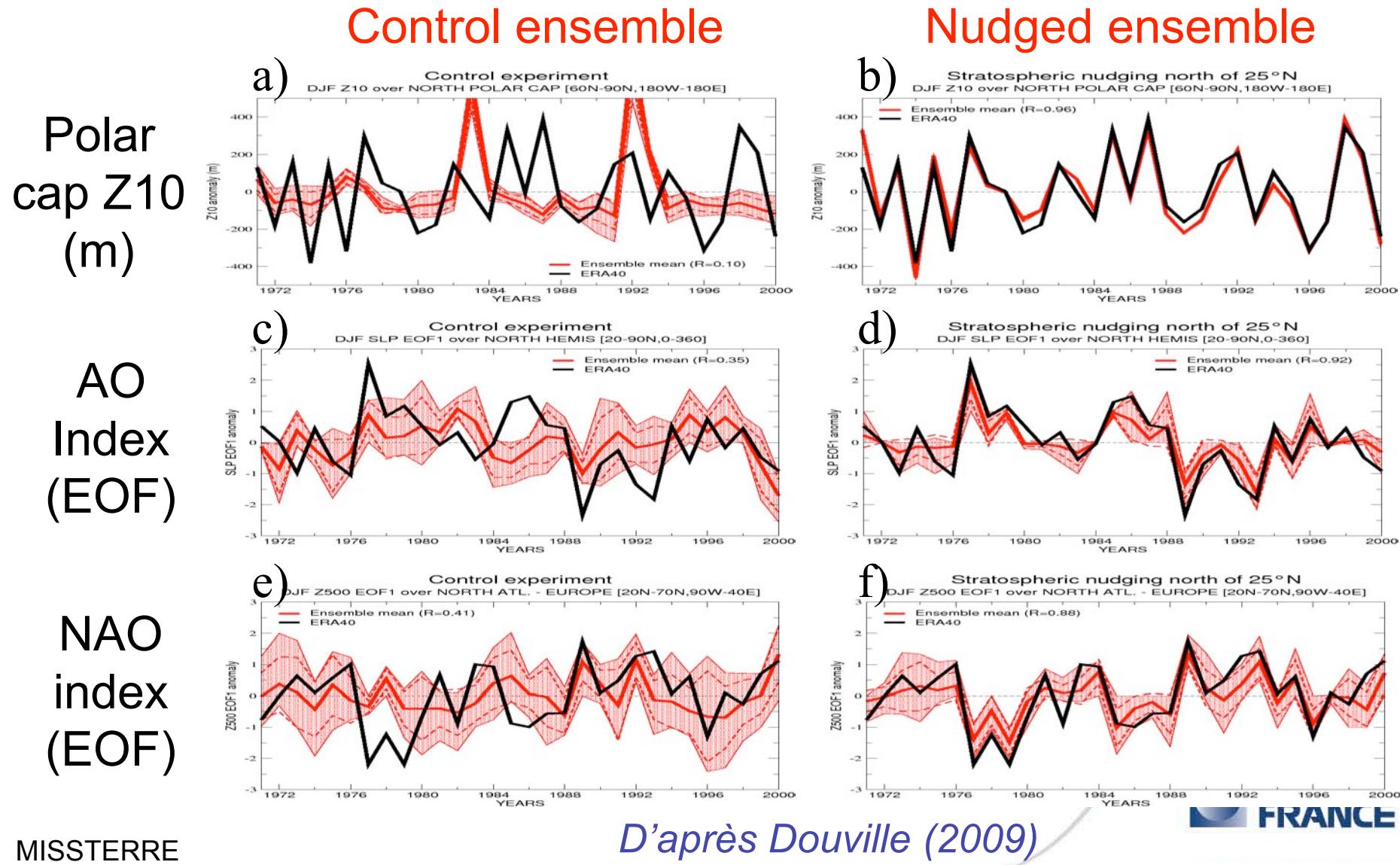
## Maximum Covariance Analysis (1901-2000)



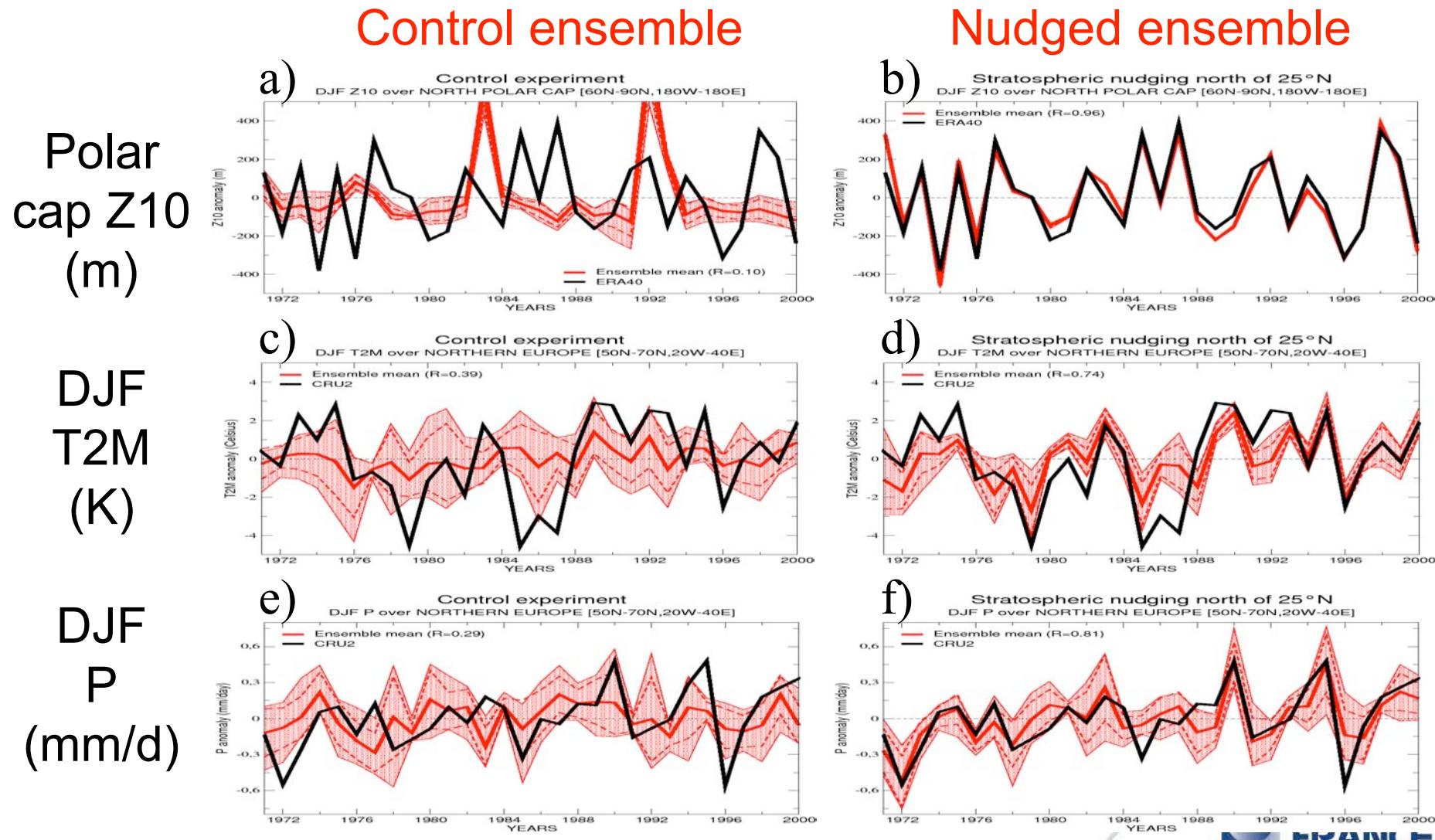
# Summary

- ✓ Snow cover shows a strong year-to-year variability that is partly predictable at the seasonal timescale;
- ✓ Snow anomalies can contribute to the predictability of surface air temperature, but have a weaker impact on the large-scale atmospheric circulation;
- ✓ Remote impacts both in the tropics and the extratropics have been suggested by observational and numerical studies, but are not necessarily robust and stationary;
- ✓ Such impacts are not simulated in the CMIP3 models (which does not mean that they do not exist), but *wrong* teleconnections are found in many models and are likely to alter the skill of dynamical seasonal prediction systems.

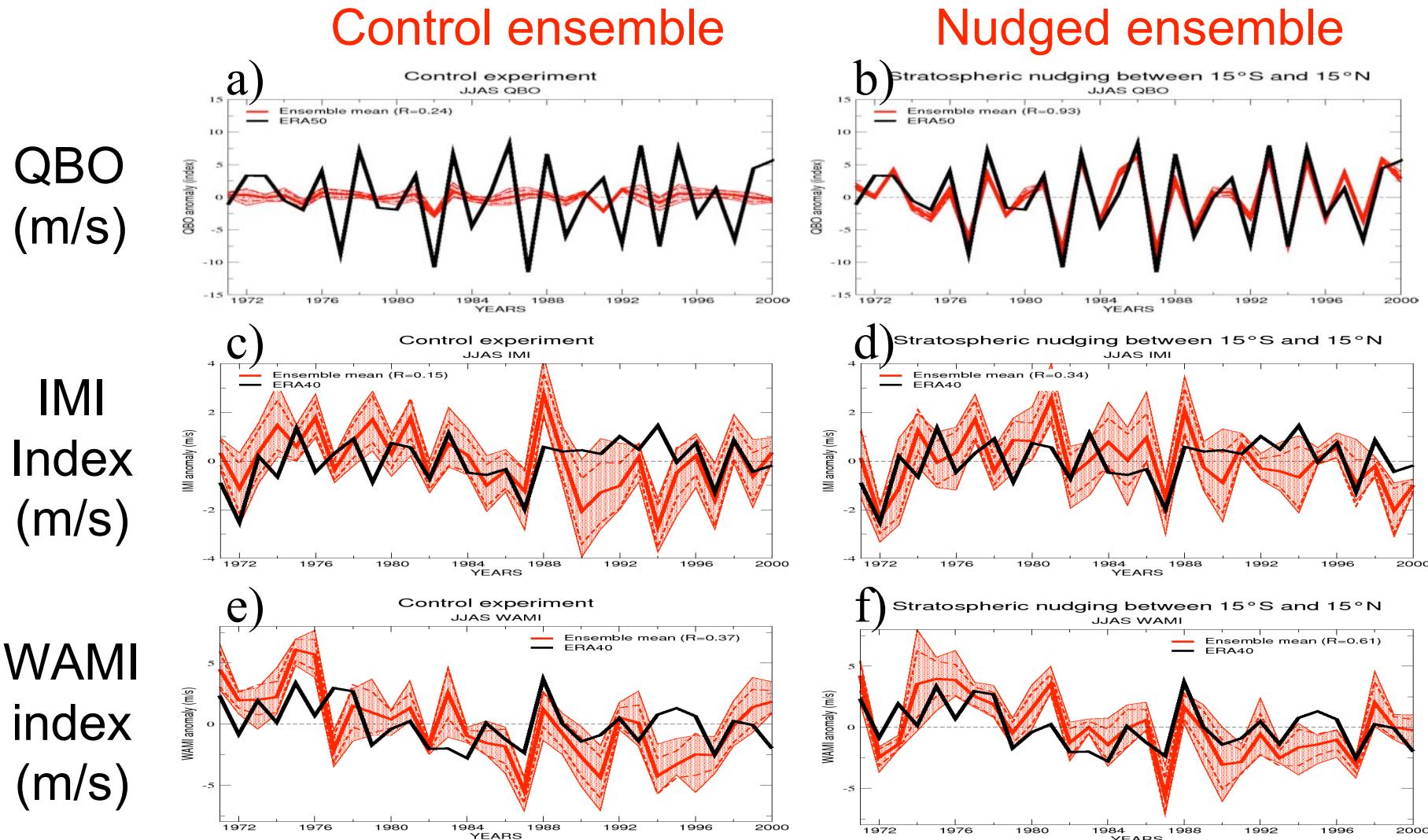
# Influence de la stratosphère (vortex polaire) sur la variabilité hivernale dans l'hémisphère Nord



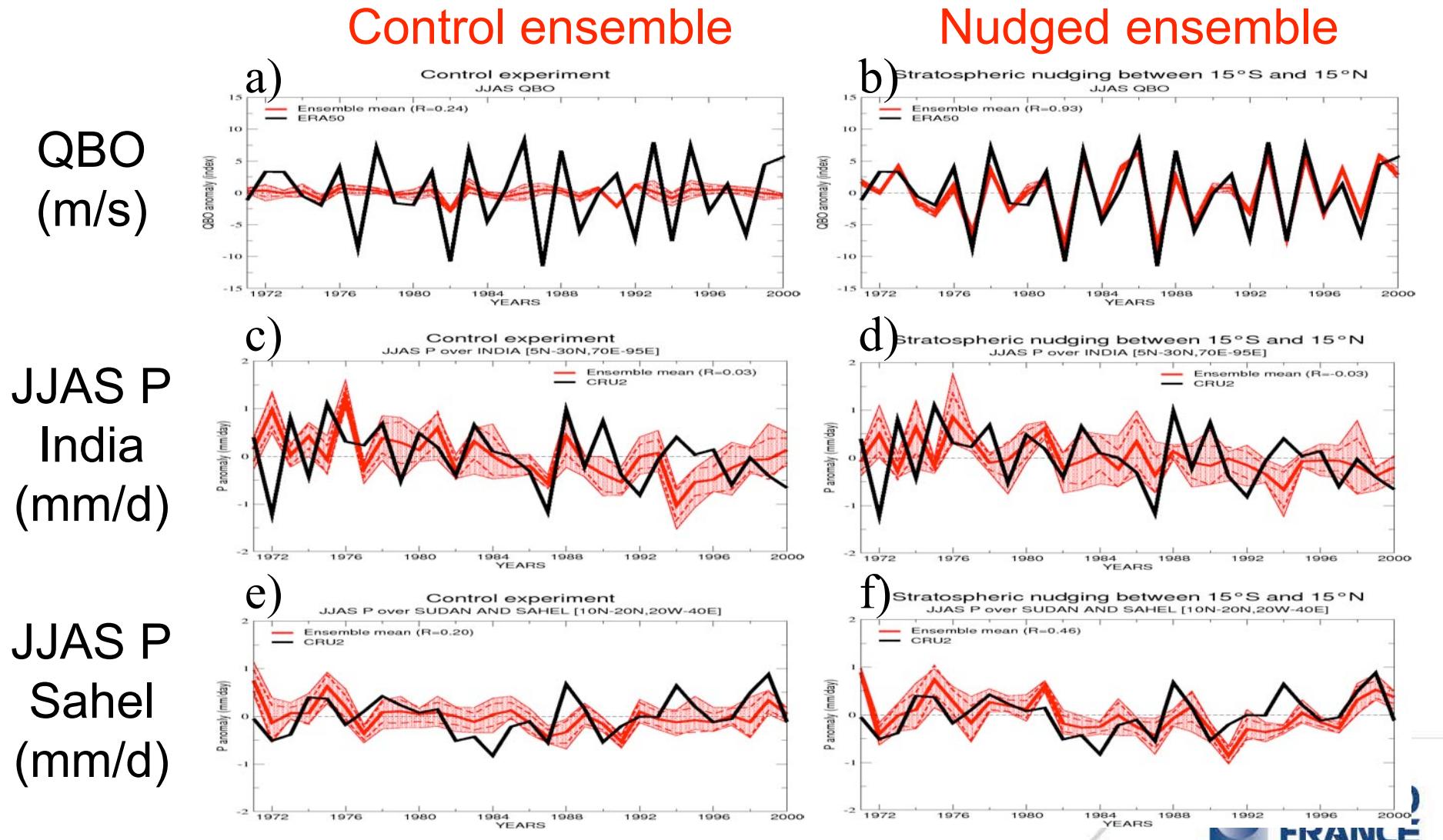
# Influence de la stratosphère (vortex polaire) sur la variabilité hivernale dans l'hémisphère Nord



# Influence de la stratosphère (QBO) sur la variabilité des moussons Indienne et Africaine



# Influence de la stratosphère (QBO) sur la variabilité des moussons Indienne et Africaine



## More details in:

- ✓ Douville H., 2009: Relative contributions of soil moisture and snow mass to seasonal climate predictability: A pilot study. Climate Dyn., doi: 10.1007/s00382-008-0508-1.
- ✓ Douville H. (2009) Stratospheric polar vortex influence on Northern Hemisphere winter climate variability. Geophys. Res. Lett. (en préparation).
- ✓ Peings Y., H. Douville (2009) Influence of the Eurasian snow cover on the Indian summer monsoon variability in observed climatologies and CMIP3 simulations. Climate Dyn., doi: 10.1007/s00382-009-0565-0.
- ✓ Peings Y., H. Douville, P. Terray (2009) Extended winter Pacific North America oscillation as a new precursor of the Indian summer monsoon rainfall. Geophys. Res. Lett. (revised).

# April-May-June 1989 minus 1988

(for simulations, shading denotes statistical significance at a 5% level)

