

THE IMPACT OF INTERDECADAL VARIABILITY ON THE SKILL OF CLIMATE MODELS

Alice M. Grimm*, Atul K. Sahai**, and Chester Ropelewski***

* Department of Physics, Federal University of Paraná, Curitiba, PR, Brazil

** Indian Institute of Tropical Meteorology, Pune, India

*** International Research Institute for Climate Prediction, Palisades, NY, USA

MOTIVATION

Assessing the ability of atmospheric general circulation models (AGCMs) to reproduce observed atmospheric circulation given the lower boundary conditions, has been a recurrent concern in climate prediction. The performance of models has been shown to be seasonally-dependent. However, there has always been the assumption that model skill is constant for a given season throughout the period being analyzed. The influence of long term climate variability on model skill has not been addressed.

Two AGCMs are examined in conjunction with observations for the period 1950 to 1994: the ECHAM3 (version 3.6, Max Planck Institute) and the NCEP (MRF9, National Centers for Environmental Prediction) model. The ensemble means of seven runs of the ECHAM3 model and thirteen runs of the NCEP model are examined. Both models are forced by reconstructed observed SST Observations are based on the NCEP-NCAR reanalysis.

Is the interdecadal variability prone to influence the performance of models, as is seasonal variability?

INTERDECADAL VARIATION OF THE MODELS' SKILL

Interdecadal variability of model performance is assessed through analysis of simultaneous correlation coefficients (CCs) between boreal winter (DJF) seasonal means of the reanalysis data and the model output for 200 hPa streamfunction, averaged over every 20° latitude × 40° longitude region over the globe. The CCs are computed for sliding 11-year periods, and their temporal variation points to interdecadal variation of the models' skill (Fig. 1).

Fig. 1a. NCEP REANALYSIS X ECHAM3

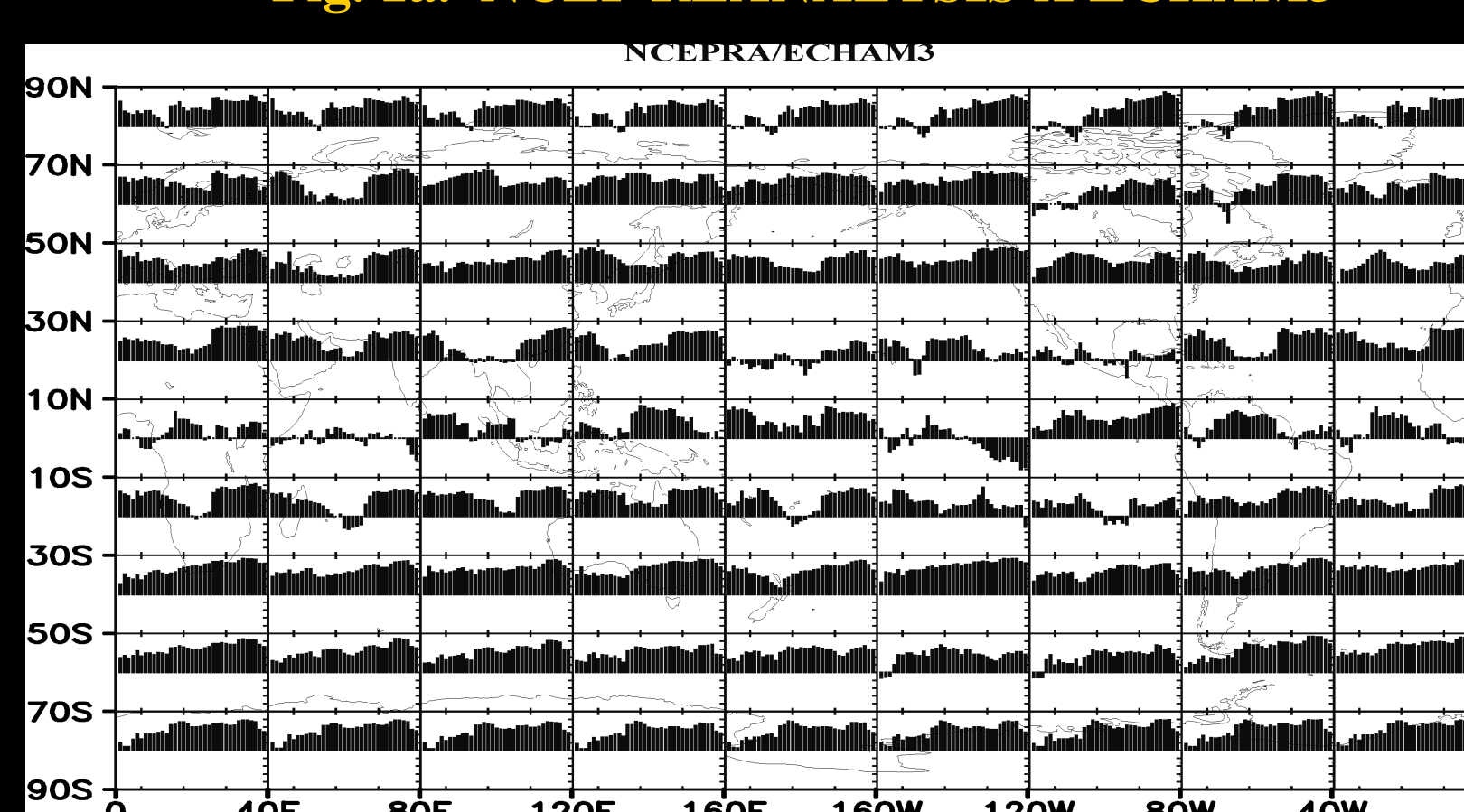
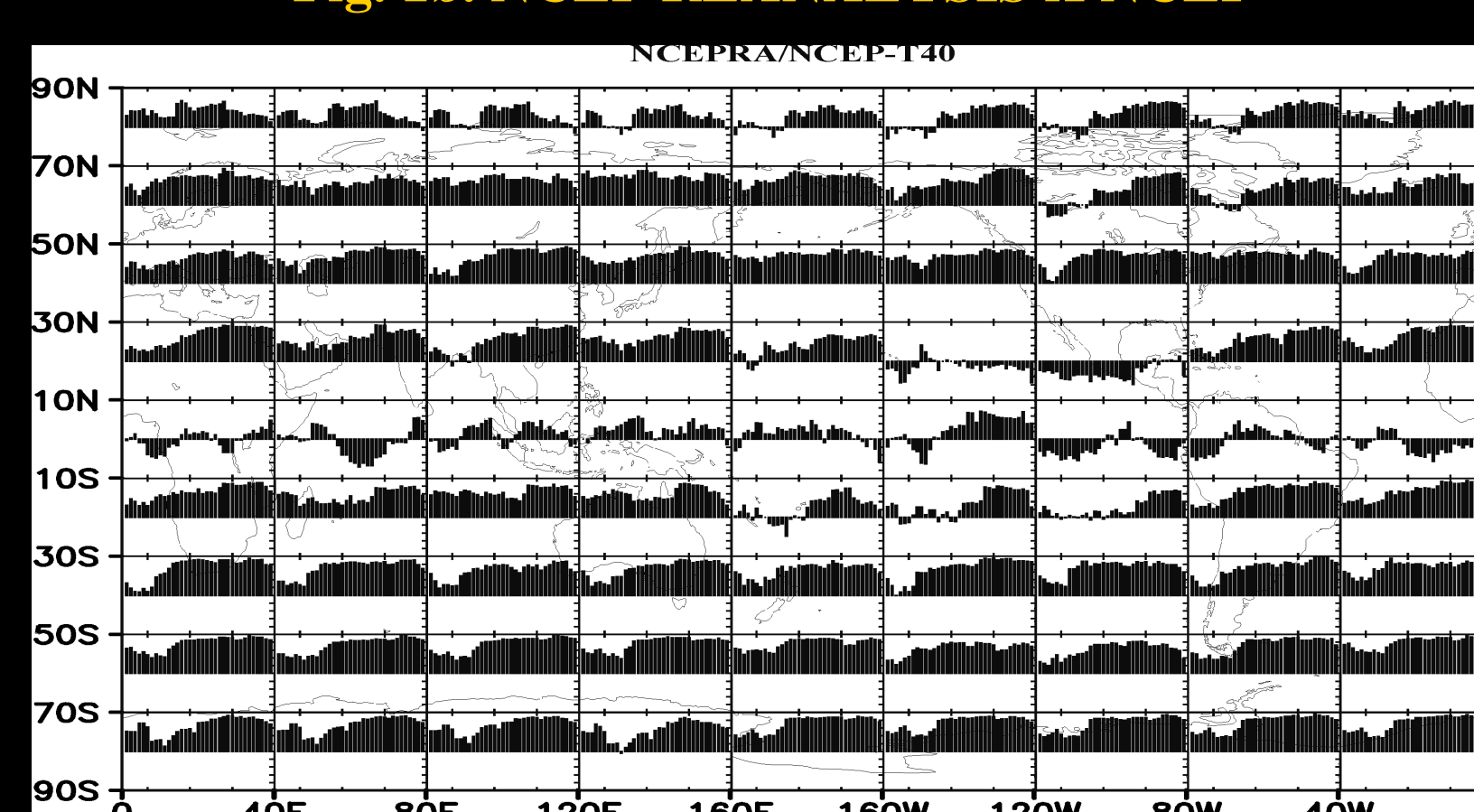


Fig. 1b. NCEP REANALYSIS X NCEP



Another way of examining the long-term variations of the model's performance is comparing the variability of the observed atmospheric response to ENSO with the temporal variability of the models' response to ENSO. To this end, correlations between 11-year running series of SST in the Niño 3 region and observed seasonal 200 hPa streamfunction are compared with the corresponding sliding correlations between Niño 3 SST and streamfunction output from each AGCM (Fig. 2).

NIÑO 3 X REANALYSIS 200 hPa STREAMFUNCTION

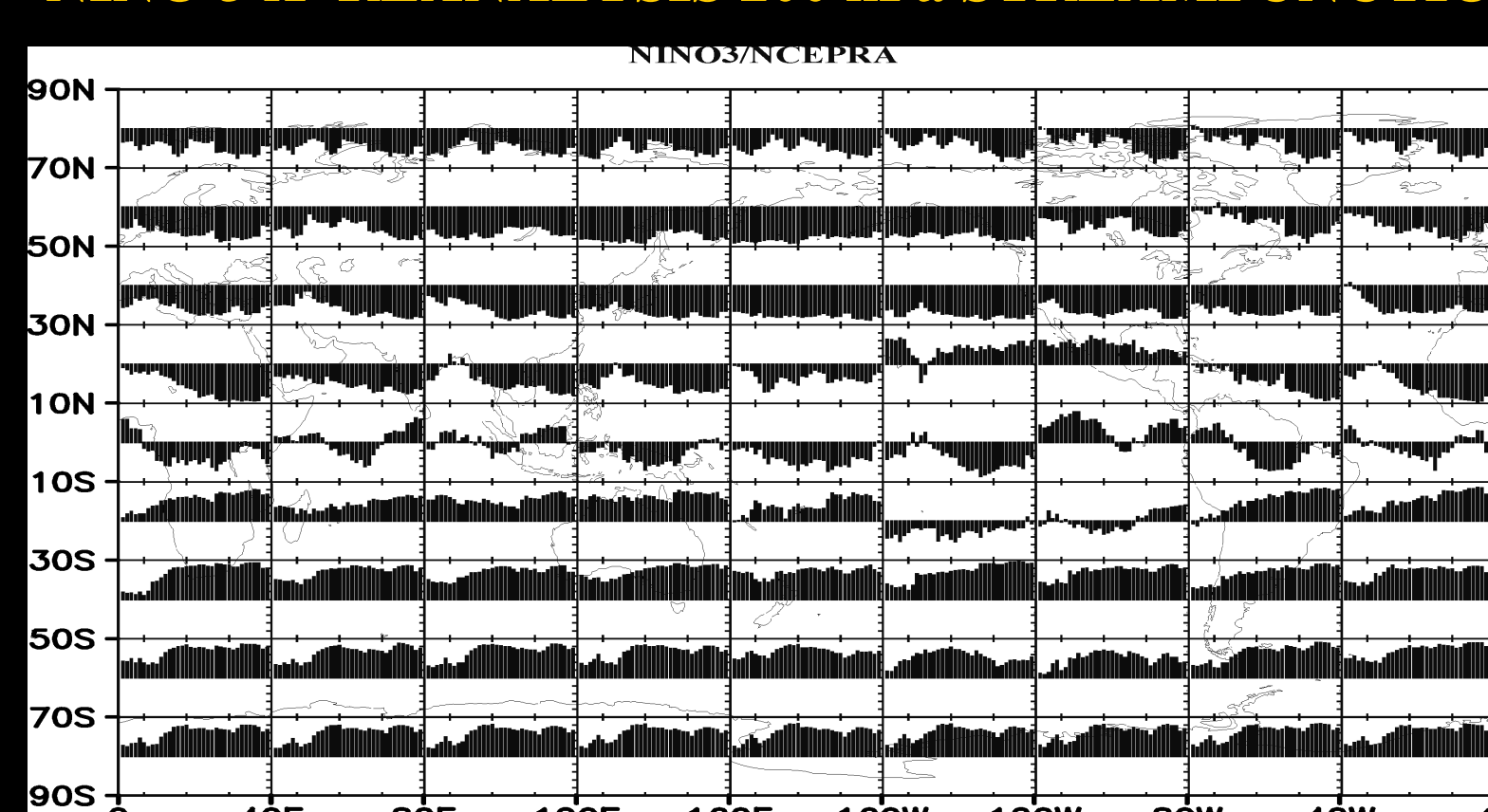
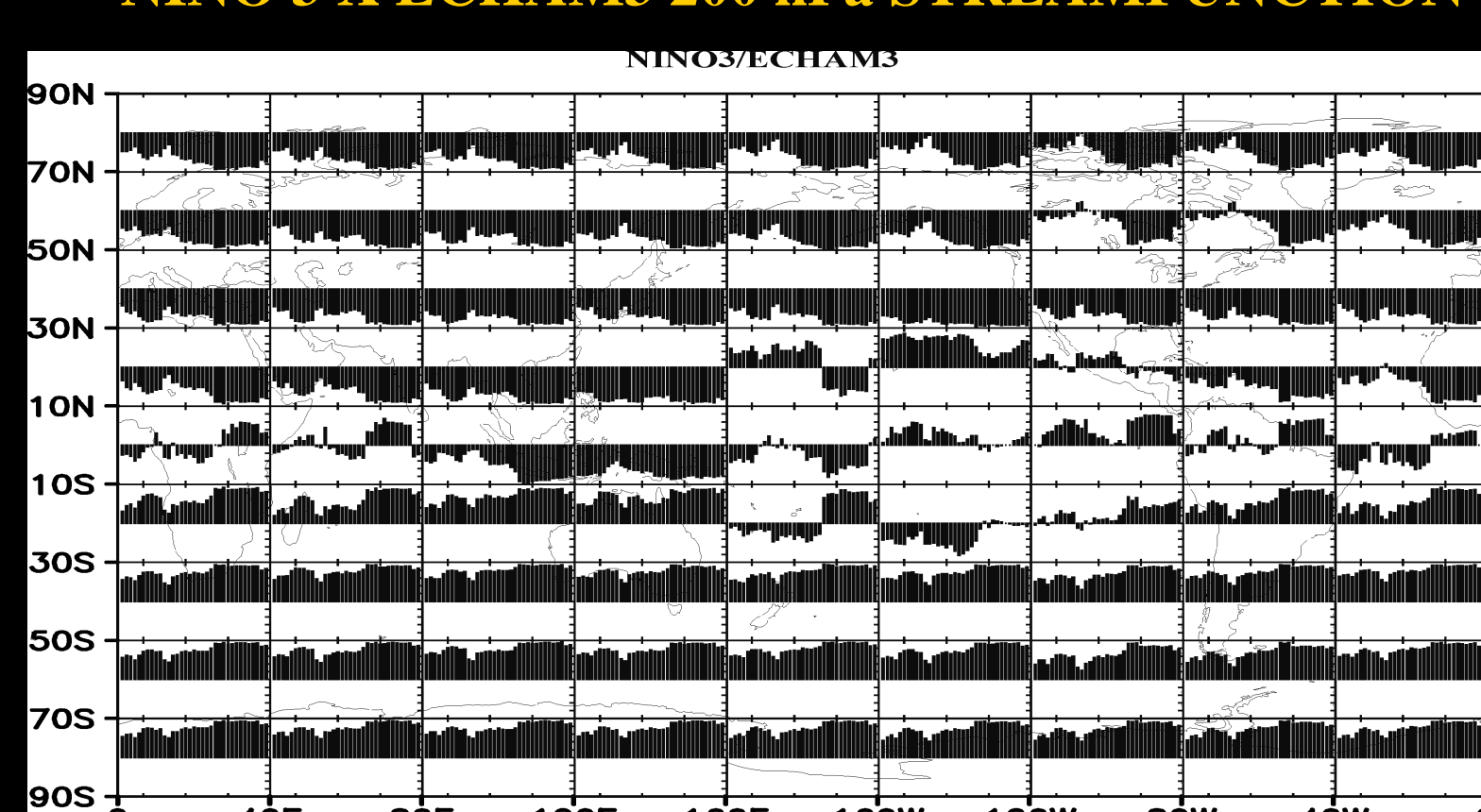
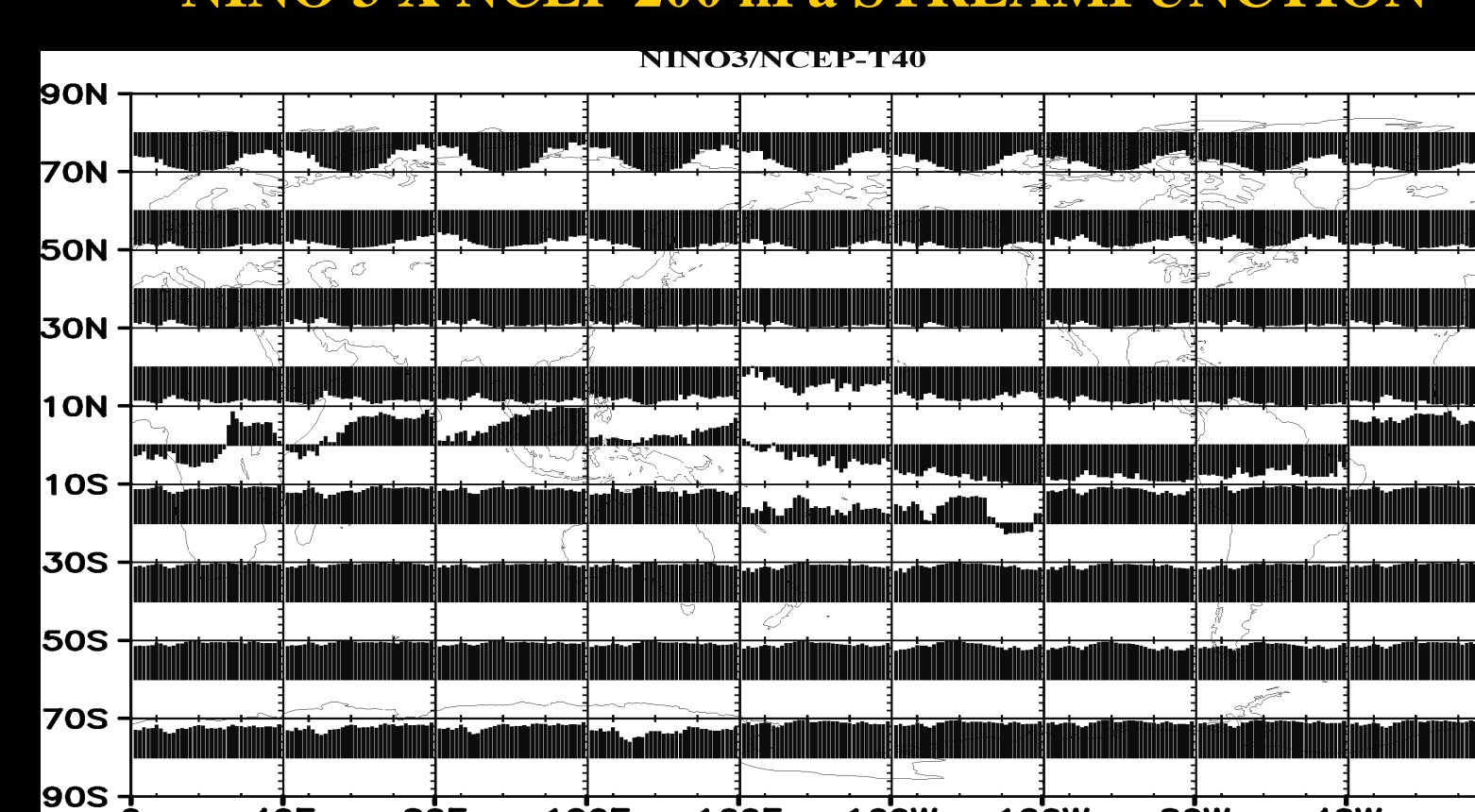


Fig. 2. The sliding correlation between Niño 3 SST and 200 hPa streamfunction undergoes stronger variations in the observations (left), indicating interdecadal variability in the ocean-atmosphere climate link, than in the models ensemble means. The ECHAM3 model reproduces the observed changes in that relationship more faithfully.

NIÑO 3 X ECHAM3 200 hPa STREAMFUNCTION



NIÑO 3 X NCEP 200 hPa STREAMFUNCTION



CONNECTION BETWEEN INTERDECADAL SST VARIABILITY AND INTERDECADAL VARIATIONS OF THE MODELS' SKILL

a. Modes of variability of the models' skill

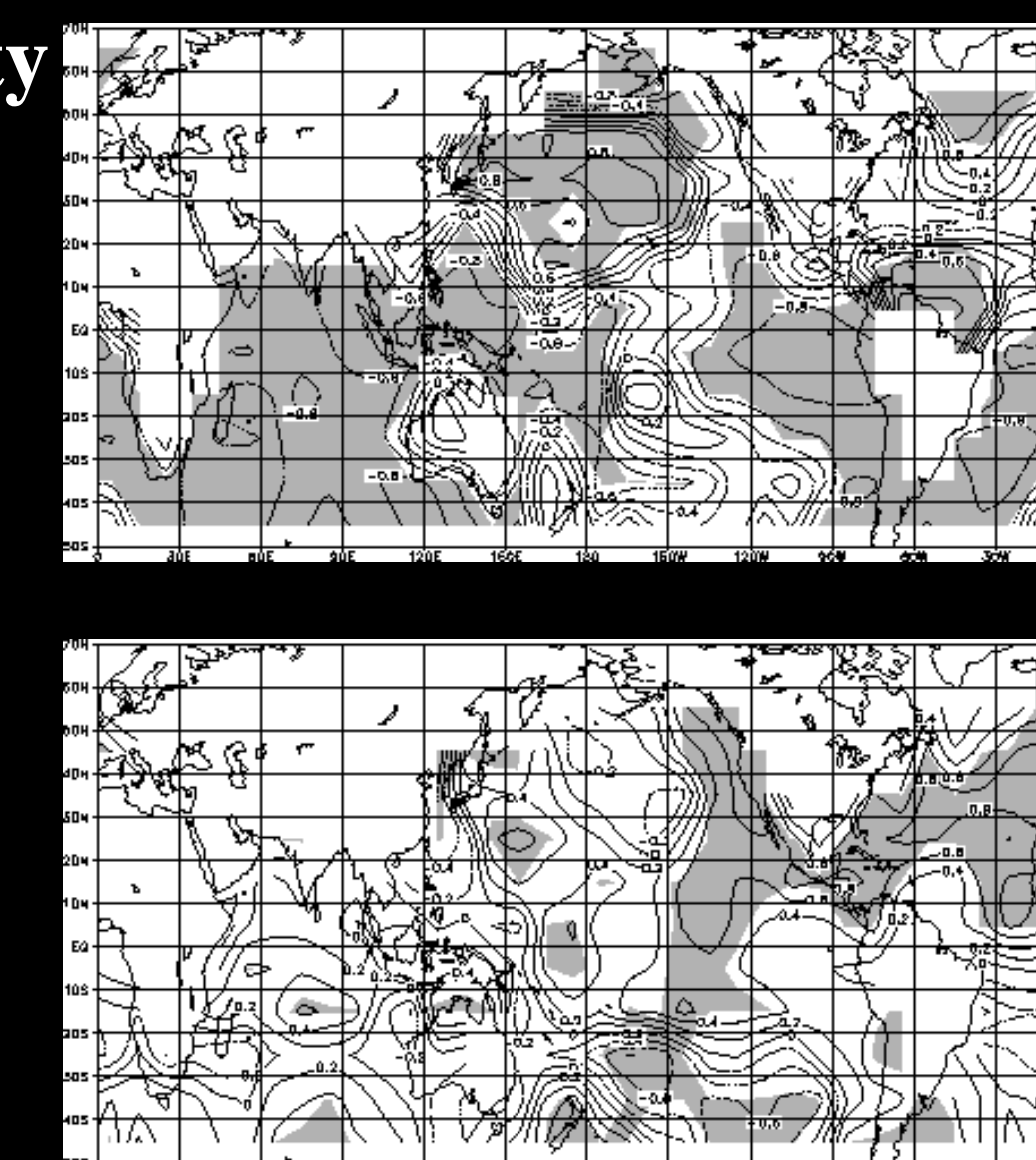


Fig. 3. (Left) Factor loadings of the first EOF (46% variance) of the 11-year running correlation coefficients between the DJF 200 hPa streamfunction from the NCEP/NCAR reanalysis and from the ECHAM3 model output, in the period 1950-1994 (35 running decades), shown in Fig. 1a. (Middle) same as above for the second EOF (26% variance). (Right) First two PCs of the 11-year running correlation coefficients between the DJF 200 hPa streamfunction from the NCEP/NCAR reanalysis and from the ECHAM3 model output, in the period 1950-1994 (35 running decades).

The factor loadings show a dominant zonal distribution, but there are also zonal asymmetries like those produced by Rossby wavetrain propagation.

b. Relationships between skill and SST modes of variability

Fig. 4. (Top) Distribution of correlation coefficients between 11-year running means of SST for the period 1950-1994 and the first PC (Fig. 3, Right, continuous line) of the 11-year running correlation coefficients between the DJF 200 hPa streamfunction from the NCEP/NCAR reanalysis and from the ECHAM3 model output, in the period 1950-1994 (35 running decades). The 11-year running means of SST are averaged over 10° × 10° latitude-longitude regions. Regions where CC is significant at 0.01 level are shaded. (Bottom) Same as above, but for the second PC.



The first correlation field resembles the patterns of SST variability associated with the Atlantic multidecadal mode and some features of Pacific multidecadal mode, two modes of non-ENSO low-frequency SST variability (Enfield and Mestas Nunez, 1999).

The second field resembles another non-ENSO mode, the Pacific interdecadal variability. The results obtained are very similar when using NCEP model output.

CONCLUSIONS

- In spite of the differences in overall skill, the two models point coherently to interdecadal variations in their performances, reflecting fluctuations in the ocean-atmosphere links related to decadal/interdecadal climate variability.
- The un-modeled climate variations are likely due to un-modeled climate processes and have serious implications for seasonal climate prediction as well as greenhouse-gas scenarios.
- Several hypotheses should be analyzed further: i) the models may not reproduce correctly the anomalous tropospheric heat sources associated with interdecadal modes of variability ; ii) the misrepresentation of these sources may impact significantly on the atmospheric circulation; iii) the models may not reproduce the interdecadal changes in the atmospheric basic state, which modifies their ability to represent well some processes, like the propagation of Rossby waves (Fig.5).

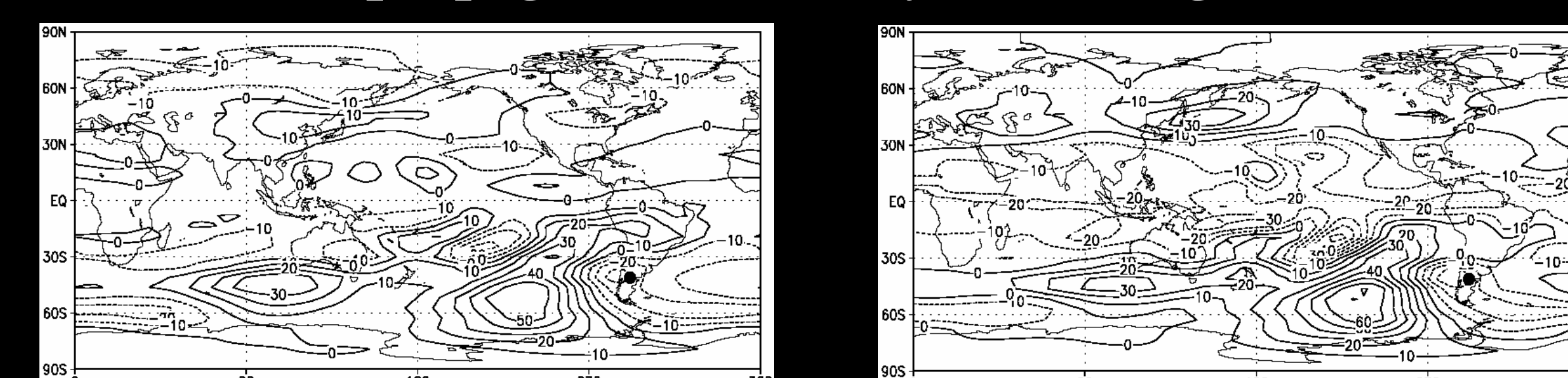


Fig. 5. (Top) Influence function for a target point in southern South America (black circle) for the December basic state of the period 1949-1978. (Bottom) Same as above, for the period 1973-2002. The values indicate the efficiency of upper level divergence (in the tropics related to tropospheric heat sources) in producing stream-function anomalies around the target point.