Internal Variability in a 200 Year Control Integration with a Coupled Ocean Atmosphere Model

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The response of a coupled ocean-atmosphere model to increased greenhouse gas forcing can be better understood if the internal variability of the model is known. We evaluated a 200 year control integration of the ECHAM-LSG Model, which has been used for climate change experiments (Cubasch et al., 1992). The horizontal grid spacing is about 5.6 degrees, the model contains 19 layers in the atmosphere and 11 in the ocean. The coupling procedure includes flux correction. Our results are based on global mean, zonal mean and single point time series as well as on EOF analysis of several atmospheric and oceanic parameters.

The 200 year control integration exhibits the following features:

- There is considerable **variability in decadal time scales** which is strongest in middle and high latitudes. Examples are shown in figure 1.

- Between the first and the tenth decade of the control run many parameters **shift to a new quasi-equilibrium**. This shift is reached within different time for different parameters, it is sometimes accompanied by large fluctuations (see e. g. fig. 3). This "new climate" is slightly cooler in the low latitudes, and a lot cooler in the arctic. This arctic cooling causes a drop of the global mean near surface temperature (figs. 2, 3). The amount of sea ice increases by two to three times the initial amount. Slight deviations from the initial patterns can be seen for sea level pressure and precipitation, with a dryer Arctic and wetter Antarctic and a weakening of the Hadley cell.

  These changes might be due to the coarse horizontal resolution of the model, which can not sufficiently resolve some features which are important for the regional climate. Additionally the linear flux correction has difficulties to deal with nonlinear phenomena like moving ice edges and deep water formation, it tends to pile up large ice masses.

- There are some indications for a **mode with a characteristic time of more than 200 years**, possibly overlaid by a **drift** (figs. 2, 3). For many variables, e. g. precipitation or sea level pressure, this drift is small compared to internal variability. For discussing this we first look at some regional changes in the Weddell and Ross Sea: During the first 70 years of integration, the Weddell Sea heats up and cools again, consequently the sea ice withdraws and returns, though does not reach the original thickness. In contrast to the Weddell Sea the Ross Sea warms throughout the integration, most of the ice in Sommer as well as in Winter disappears. This leads to dramatic temperature rises in regions initially covered by ice and a warming of about 3 K beyond the ice edge, it also causes the rise of the global mean near surface temperature after year 70 (fig. 2). The dominant near surface temperature EOF relative to the mean of the whole integration shows Weddell Sea cooling and Ross Sea warming (fig. 3). This feature shows some similarities with one phase of a 320 year mode of the ocean (Mikolajewicz et al, 1990), where the heat fluxes out of the ocean approximately lead to a similar near-surface temperature pattern. The analysis of ocean data yields also hints to such a low frequency mode or to a drift. However this is only speculation before knowing the results of the next few hundred years. These might still cause surprises.

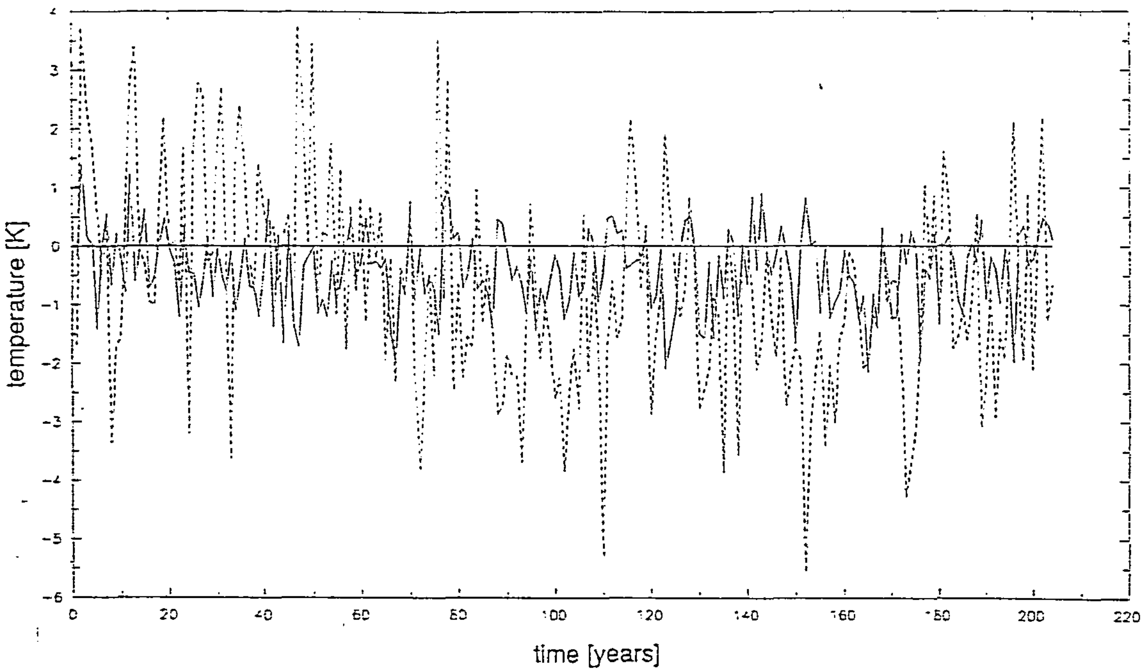

Figure 1: Time series of near surface temperature at a point in middle Europe (solid line) and in Hudson Bay (dashed line)

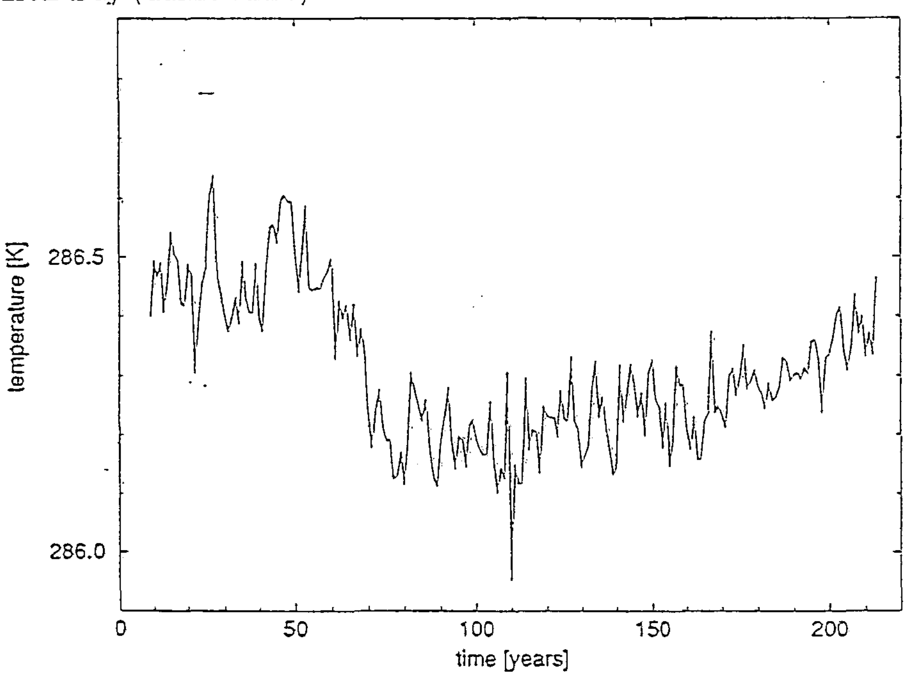

Figure 2: Time series of global mean near surface temperature

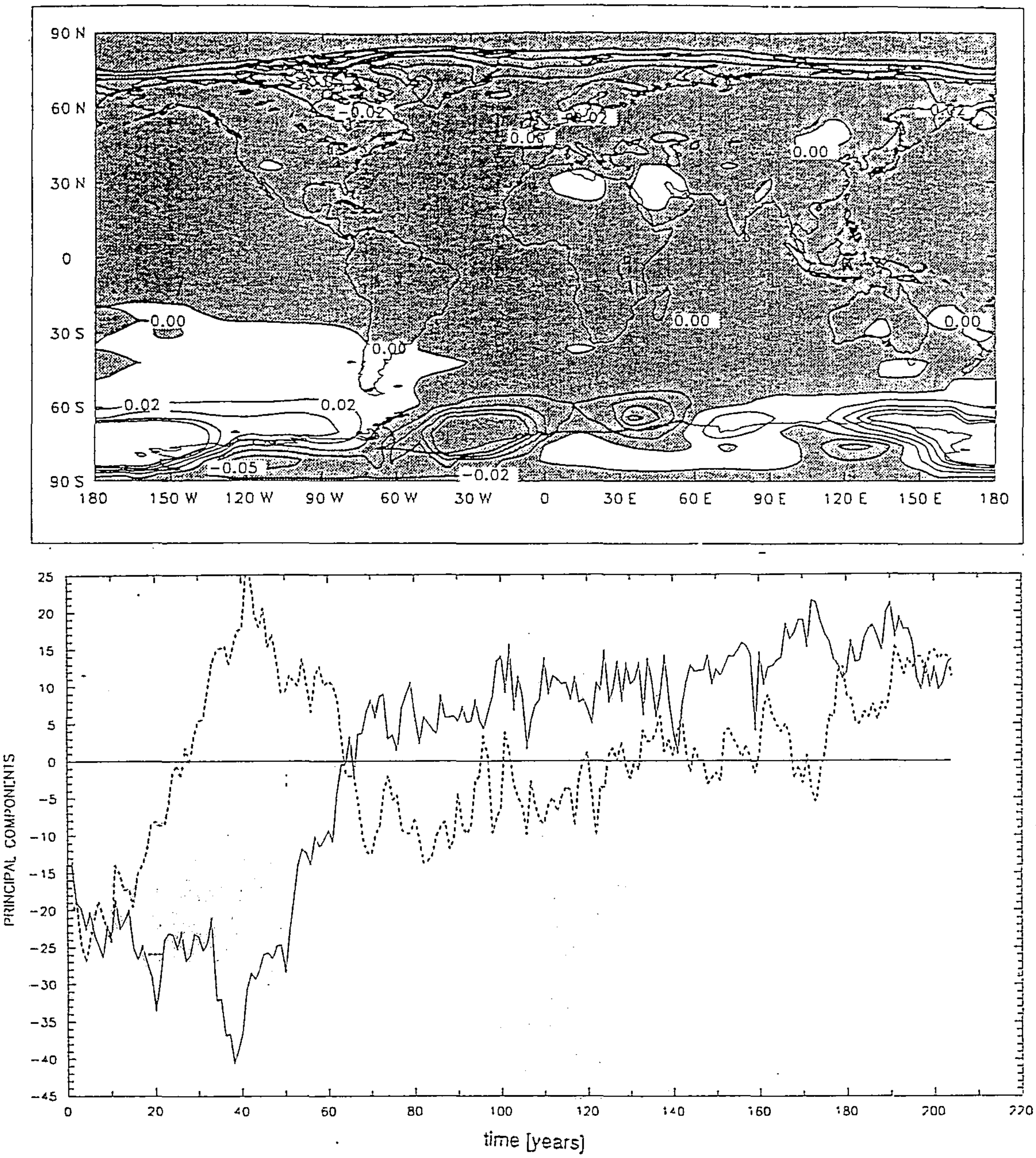

Figure 3: First EOF of the annual mean of near surface temperature relative to the 200 year mean (above) and the first two principal components (below, solid line: first component)

References:

U. Cubasch, K. Hasselmann, H. Hoeck, E. Maier-Reimer, U. Mikolajewicz, B. D. Santer, R. Sausen: *Time-dependent greenhouse warming computations with a coupled ocean-atmosphere model*, Climate Dynamics, in print

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