Simulation of the Arctic temperature variability in the 20th century with a set of atmospheric GCM experiments

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The global warming during the last four decades exhibits highest trends in the Arctic [e.g. Jones et al. 1999]. Mechanism beyond the huge Arctic surface air temperature (SAT) variations, in particular strong recent warming trend or the early 20th century warming has not yet clarified [Serreze and Francis 2006]. The positive trend of the Arctic Oscillation, local atmospheric circulation changes [Bengtsson et al. 2004], or long-term oscillation involving the North Atlantic thermohaline circulation and Arctic sea ice [Jungclaus et al. 2005] may be possible explanations.
Here, Arctic SAT in a set of simulations with the atmospheric general circulation model ECHAM5 [Roeckner et al. 2003] forced by prescribed surface conditions (sea surface temperatures, SST, and sea ice concentrations, SIC) is analyzed. The following experiments have been performed: 4 member ensemble (with different initial atmospheric conditions) using Hadley Center SST and SIC analysis for 1900-1998 (HadISST1 dataset [Rayner at al. 2003]), later cited as HadISST, and 2 member ensemble using SST data from the HadISST1 dataset for the 1961-1998 and climatological (no interannual variability) SIC for the year 1966, the year of the minimum Arctic SAT in the second half of the 20th century, to be named as ClimSIC.

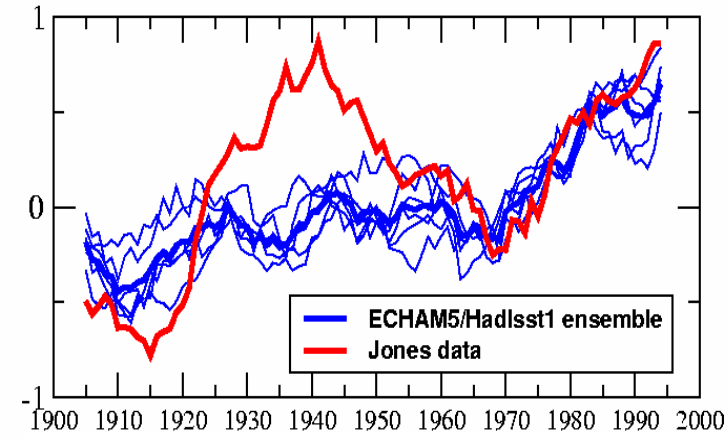

Fig. 1: Arctic winter time (Nov-Apr) SAT anomalies, K. 5 yr running means. Thick blue – ensemble mean.

Fig. 1 shows wintertime Arctic SAT (60°-90°N) anomalies as observed (Jones data) and simulated in the HadISST ensemble. The SAT trend for the last 30 years of the 20th century is very well reproduced. Some cooling of the 1950s and 1960s is also captured. However, the strong early century warming is absent. The Arctic SAT anomalies during winter time are closely related to the sea ice cover. Thus, the results imply a significant sea ice reduction in the Arctic, which is not described in the HadISST dataset. As it follows from the Fig. 2, the recent warming in the Arctic is not necessarily caused by the corresponding increase of the North Atlantic Oscillation (NAO). The model almost perfectly reproduced the SAT trend and captured some part of decadal variability (Fig. 2a) despite very weak NAO trends (Fig. 2b).

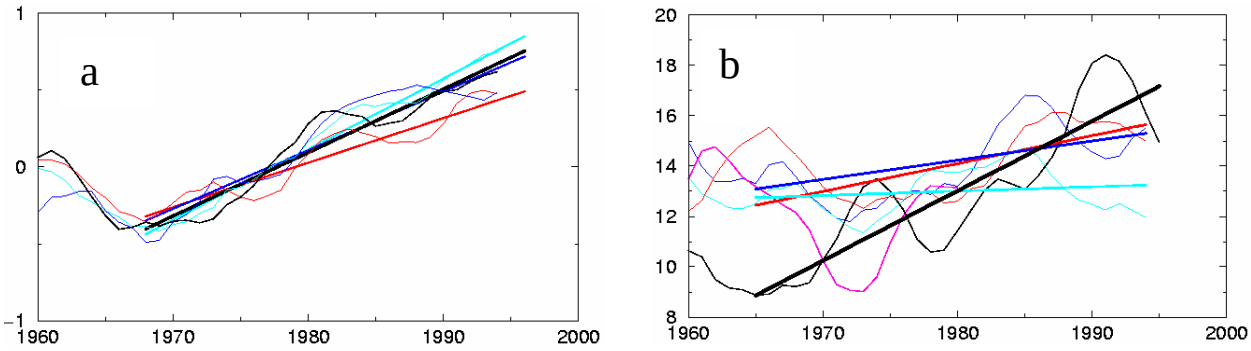

Fig. 2: observed (black) and simulated (colored, different ens. members) Arctic wintertime SAT anom., K (a), and SLP difference Lisbon-Iceland as an NAO index, mb (b). 7 yr running means and trends.

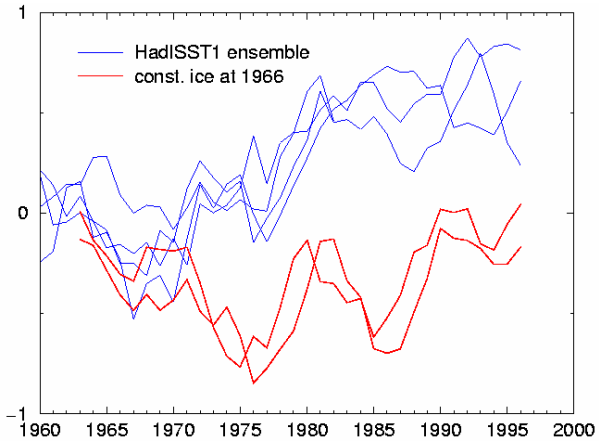

Fig. 3: Wintertime Arctic SAT anomalies in HadISST and ClimSIC simulations, K.

Without interannual variations of the Arctic sea ice cover (ClimSIC experiments) no significant Arctic SAT trend in the last decades of the 20th century is simulated (Fig. 3). All these results indicate that the sea ice cover extent in the Arctic, as a modulator of the oceanic heat loss in the marginal seas, may be the determining factor for the long-term (interdecadal) wintertime SAT variability. The sea ice analysis for the first half of the 20th century should be improved in order to represent presumably large anomaly corresponding to the early 20th century warming.

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