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Section 6

Developments in global forecast models, case studies, predictability investigations, global ensemble, monthly and seasonal forecasting

Seasonal to interannual predictability of high northern latitude climate

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Introduction:

The aim of this ongoing work is to analyze the predictability of seasonal to interannual climate conditions in high northern latitudes. One climate mode showing a high potential for interannual predictability is characterized by the formation of sea ice anomalies at the Siberian coast, their propagation across the Arctic towards Fram Strait, anomalous sea ice export through Fran Strait and advection of the sea ice/freshwater signal into the Labrador Sea, where it significantly influences ocean convection, salinity, sea ice distribution, ocean- and air temperature (Koenigk et al., 2006). The potential predictability of climate is analyzed by performing ensemble experiments with a global coupled atmosphere-ocean-sea ice model.

Model, Experiments and Method:

The model used in this study is the Max-Planck-Institute for Meteorology global atmosphere-ocean-sea ice model ECHAM5/MPI-OM (Roeckner et al., 2003; Marsland et al, 2003). The atmosphere model is run at T31 resolution and has 31 vertical levels. The grid spacing of the ocean model varies between about 30 km and 390 km. The model has 40 vertical layers.
A set of 40 ensemble simulations was performed to analyze the predictability. Each ensemble consists of 6 members and all runs were started in January from different initial conditions of a 300-year control integration. In half of the ensembles, the members of one ensemble were differently perturbed by a slight change of the atmospheric diffusion parameter in the first model month. In the other half, a small randomly distributed perturbation was added to ocean temperature, salinity and sea ice thickness. However, it turned out that on the time scales of interest it does not make any difference where a perturbation, if small, is introduced to the system. The prognostic potential predictability (PPP) in the model of a climate variable X at time t is calculated:

$$PPP(t) = 1 - \frac{\frac{1}{N(M-1)} \sum_{j=1,N} \sum_{i=1,M} \left[X_{i,j}(t) - \underline{X}j(t)\right]^2}{\sigma^2}$$

$X_{i,j}$: run i of ensemble j, $\underline{X}_j$: mean of ensemble j, N (M): number of ensemble runs, σ^2: variance of control run.

A PPP of 1 shows perfect predictability while a value of 0 shows no predictability at all. The 95%-significance level (using a F-test) varies between values of 0.2 and 0.3 depending on the decorrelation time of the different variables. Furthermore, the gain of predictability of the ensemble experiments in comparison to the predictability gained by the autocorrelation of the control run is analyzed ($PPPa=PPP-r^2_{auto}$).

Results:

Arctic sea ice thickness shows a high predictability in the first two years in most areas of the central Arctic, the Canadian Archipelago and in the Labrador Sea (fig. 1). A large part of this predictability is due to the persistence of sea ice thickness. However, in an area from the Laptev Sea across the North Pole to Fram Strait and along the east coast of Greenland and in the Labrador Sea, the persistence explains only a small part of the predictability. This gain of predictability is attributed to the advective character of the climate mode mentioned above. Also air temperature and surface salinity show a quite strong gain of predictability in the Labrador Sea in comparison to the predictability by the autocorrelation. The largest PPP of 2m air temperature after one year occurs in the northern North Atlantic and in the northern North Pacific (fig. 2). Here, significant predictability lasts for several years. Beside a relatively high autocorrelation, advection of sea surface temperature anomalies into these areas lead to high and long-lasting predictability. Over the continents and in the ice-covered Arctic, the one-year predictability of air temperature is much smaller than over the oceans. Only in parts of southern Europe, southern Asia and in Alaska, PPP is significant. PPP of spring (MAM) temperature is significant in most of Europe with a lead time of 2 to 4 months. In contrast to air temperature, the predictability of sea level pressure is generally quite small and do not show any land – sea contrast. Also the predictability of the NAO is not significant.

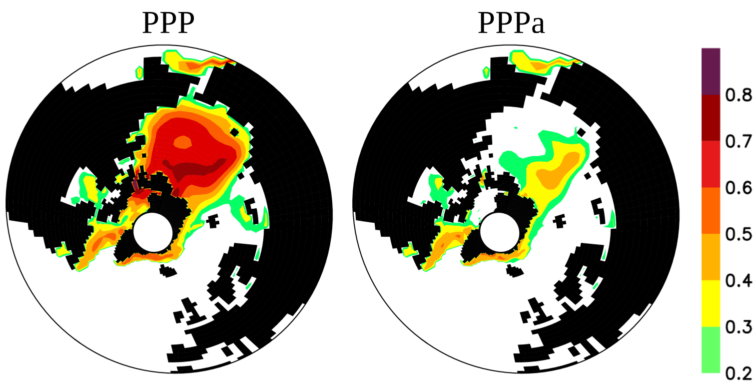

Fig.1: Predictability and gain of predictability compared to predictability of the autocorrelation for winter centered annual mean sea ice thickness after one year.

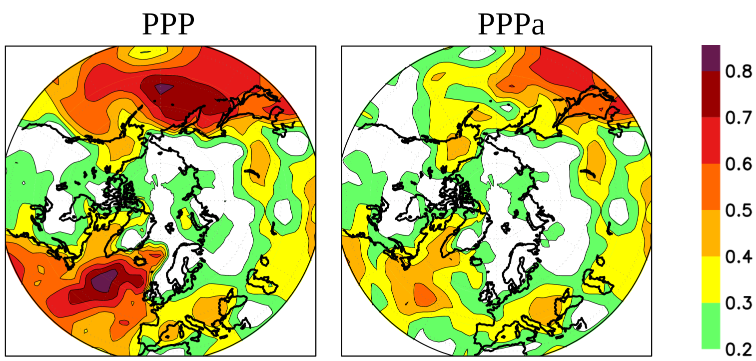

Fig.2: Predictability and gain of predictability compared to predictability of the autocorrelation for winter centered annual mean 2m air temperature after one year.

Outlook:

Further predictability experiments are planned: Sets of ensemble simulations with initial conditions from summer, from high/low NAO-cases, high/low sea ice exports shall be performed. Larger perturbations in the different ensemble members shall be used to get more realistic initial conditions.

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High Resolution Ensemble West Atlantic Basin Seasonal Hurricane Simulations

By T.E. LaRow[*1], Y.K. Lim, D.W. Shin, S.D. Cocke and E. Chassignet

Introduction

This paper will examine the use of an ensemble of seasonal integrations using a global spectral model at a high horizontal resolution (T126L27) in hindcasting the June-November Atlantic tropical storm activity for the seasons 1986-2005. This horizontal resolution is generally higher than existing seasonal tropical system studies, although there are a few studies of note which are of even higher horizontal resolution (e.g., Bengtsson et al. 2006). We will examine whether the use of a high horizontal resolution improves the seasonal hindcasts in terms of interannual variability and intensity.

Model and Experiments

The Florida State University/Center for Ocean Atmospheric Prediction Studies model (Cocke and LaRow 2000) with a relaxed Arakawa-Schubert deep convection scheme was used. Four ensemble members for each of the 20 years (1986-2005) were calculated. Time lagged initial conditions for the atmospheric model were obtained from the ECMWF re-analysis and were centered on 1 June of the respective year. Observed weekly SSTs were obtained from the Reynolds and Smith ((1994). The detection algorithm is the same as that used in Vitart et al. (2003) and modified slightly for our model resolution. In this paper, the observed tropical storms are identified by the National Hurricane Center Best Track data set, HURDAT (available at http://www.nhc.noaa.gov/pastall.shtml).

Interannual Variability

The number of storms for each year from each ensemble is calculated from the detection algorithm and the ensemble mean is plotted along with the observed as a function of time in Figure (1). The observed number of storms is shown with the solid black line while the ensemble mean is the dotted line. The spread of the ensembles is shown by the two squares. Overall the ensemble mean does well in simulating the interannual variations in the storm numbers except during the cold ENSO event years of 1998 and 1999 when the ensemble mean was much higher than the observed. The pattern of reduced number of storms during a warm event and increased numbers during a cold event is clearly seen in the ensemble mean. The model did well in simulating the record number of storms during 1995 and 2005. The temporal correlation of the ensemble mean with the observed was 0.78. The observed variance was 25.25 while the ensemble mean variance was slightly lower at 12.55. The high correlation and variances noted are most likely related to the use of weekly observed SSTs and the choice of the convection scheme.

Intensity

For each of the four ensembles the storm's lowest surface pressure was identified and shown in Figure (2). Out of the four ensembles, the lowest surface pressure found was 936hPa, indicating that even at this high horizontal resolution the model was able to generate only one category 4 storm on the Saffir-Simpson scale. Similar difficulties in producing intense storms using a even

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higher resolution model than used in this study were noted by Bengtsson et al. (2006). Indicating that model resolution (and perhaps model physics) are still insufficient.

Acknowledgments

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