Atmosphere-Sea Ice interaction during the Dalton Minimum within a historical simualtion with ECHO-G

Sebastian Wagner
Institute for Coastal Research, GKSS-Research Centre, Germany*

March 10, 2003

Introduction

This paper focuses on the interdependence between sea level pressure (SLP) and the sea ice coverage (SIC) within the North Atlantic region within a historical simulation with external varying solar and volcanic forcing with the climate model ECHO-G. An explanation for the SIC-SLP interdependence will be suggested in terms of a coupled SIC-SLP mode as well as possible underlying physical mechanisms.

SLP - SIC interdependence

In order to demonstrate the SLP-SIC interdependence, the winter months from December to March are analysed for the solar anomalous period of the Dalton Minimum (1790-1830). A reference period is chosen within the preindustrial era from 1625 to 1655. Fig.1 gives the differences between the Dalton Minimum and the reference period for the SIC (left hand side) and the SLP (right hand side).
Within the December-situation only small differences appear within the SIC and the SLP as well. The most striking feature is a SIC-dipole with an increased SIC southeast of Greenland and with an decreased SIC southwest of Greenland during the Dalton period which can also be seen within the SLP-pattern. The SIC-pattern persists throughout the whole Winter season but propagates southward on the western side. The January-situation shows a very prominent decrease within the SLP during the Dalton period over the Norh Atlantic and Europe but increased SLP over Northeast America. Furthermore, the SLP shows an longitudinal elongated decreased pressure zone into the Labrador sea and with silghtly increased pressure over the southeastern coast of Greenland during the Dalton period. The February and March siutation are quite simular. Within these two months the SIC is most pronounced within the annular cycle. The strongly reduced SIC over the Labrador sea is accompanied by low pressure anomalies, whereas the increase of SIC over the southeastern coast of Greenland and in the Nordic seas is accompanied by high pressure anomalies during the Dalton Minimum.

Discussion

It is important to note that the Atmosphere-Sea Ice interaction is a coupled mode, where a distinction between lead and lag modes of SIC and SLP, respectively, is hard to find out. For example, a pronounced negative phase of the NAO, possibly induced via the external forcing, could initiate a SIC-pattern similar to that within the DEC-MAR SIC figures. As the SIC has a much stronger autocorrelation than the SLP-field, there is indication that the SIC-patterns tend to stimulate the SLP-fields and hence e.g. the mode of the NAO. Fig. 1 demonstrates at least that those regions influenced by changes within the SIC also show significant changes within the SLP. Furthermore the influence of the SIC-pattern on the SLP-pattern seems mostly pronounced during those month with greatest SIC.
A physical explanantion for the negative and positive pressure and SIC, respectively, are possibly due to an altered atmosphere ocean heatflux exchange regime. Within regions of increased SIC the ocean can not supply the atmosphere with humidity and latent and sensible energy. The cold air over the ice covered regions sinks down increasing the SLP. Within regions of decreased SIC, the situation is reversed and the ocean induces negative pressure anomalies through slight convective processes.

Acknoledgements

The whole 500-year simulation was caried out at the German Climate Computing Centre (DKRZ) by F. Gonzalez (GKSS) and U.Schlese (DKRZ). The forcing data for the integration were kindly supplied by T. Crowley (Texas University).

*Corresponding author address: GKSS-Forschungszentrum, Max-Planck-Str.1, 21502 Geesthacht, Germany; e-mail: swagner@gkss.de

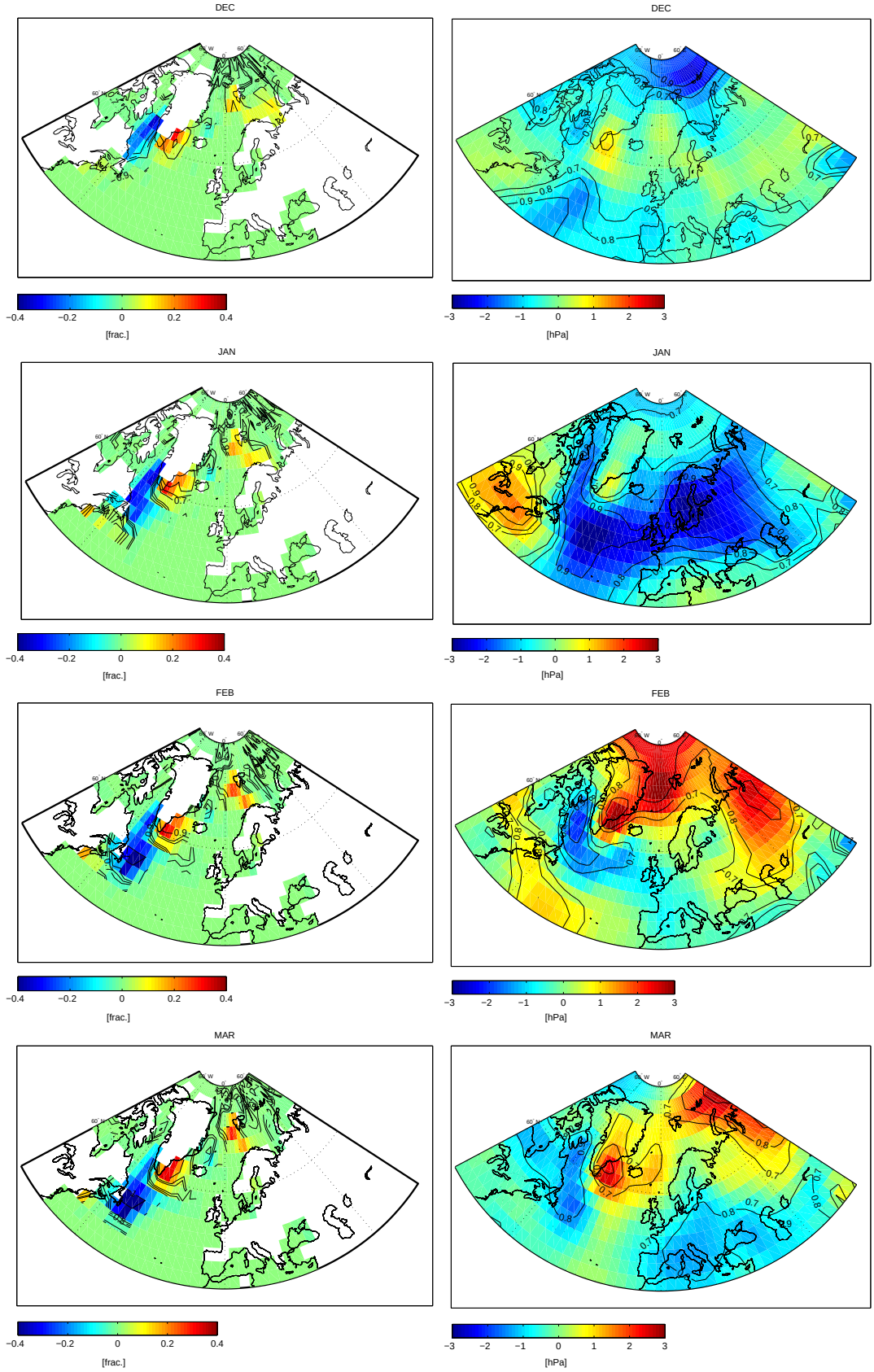

Figure 1: Differences within Sea Ice coverage (left hand side) and SLP (right hand sode) between the Dalton Minimum (1790-1830) and a normal period (1625-1655) for December to March. Note the strong resemblance of SLP-anomalies within the Ice coverage anoamlies around the coast of Greenland, especially in February and March. Contours denoting levels of significance ≥ 0.7 in steps of 0.1.