Simulation of Laptev Sea polynya dynamics using the FESOM model with different atmospheric forcings

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Russian-German Cooperation Laptev-Sea System

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1. Motivation

The Laptev Sea polynyas play a key role for the shelf areas of the Siberian Arctic because of their impact on ice production. Changes in polynya dynamics result in modified fluxes of energy, momentum and matter in the atmosphere-ocean-sea ice system. An improved understanding and quantification of polynya effects in the Laptev Sea can be achieved by high-resolution sea ice-ocean models. Here we use the well-established Finite Element Sea Ice-Ocean Model FESOM (Timmermann et al. 2009).

2. Model description

FESOM consists of a hydrostatic primitive-equation ocean model and a dynamic-thermodynamic sea ice model. In the model version used here the dynamics of the Laptev Sea polynyas depend mainly on the components of the sea ice part. It is based on a 2-dimensional momentum equation (dynamic) and a scheme for energy balance (thermodynamic). The computational mesh is a triangular grid with 17 z-levels and corresponds to the regular grid with 5 km x 5 km of the COSMO model (Schröder et al. 2009). Operationally, the model is forced by daily NCEP/DOE (NCEP 2) reanalyses. In our study we use different types of forcing to investigate a polynya event during the TRANSDRIFT winter experiment 2008.

3. Initialisation

Initial pack ice concentration is taken from AMSR-E data, fast ice is treated as immovable sea ice with 100% concentration. The position of the fast ice edge (Fig.1) was derived from AMSR and MODIS data. Initial ice thickness is taken as 1 m, snow thickness on sea ice as 5 cm, and ocean temperature and salinity from the World Ocean Atlas (2001).

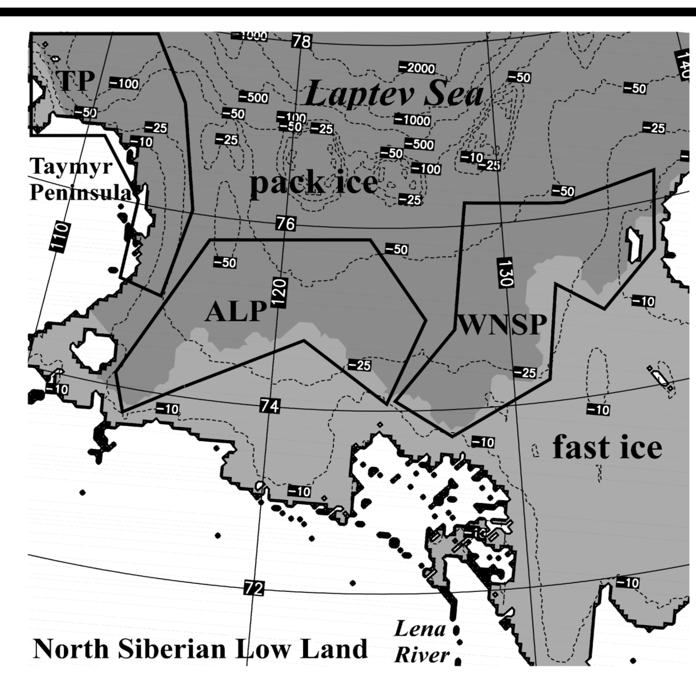

Fig.1: Fast ice edge in April 2008 derived from AMSR and MODIS data. The locations of the Taimyr (T), Anabar-Lena (AL) and the Western New Siberian (WNS) polynyas are indicated.

4. Atmospheric forcing

Different types of atmospheric forcings are used: Daily and 6-hourly NCEP 2 reanalyses (1.875° x 1.875°), 6-hourly NCEP 1 reanalyses (2.5° x 2.5°), 6-hourly GME analyses (0.5° x 0.5°) and hourly COSMO data (5 km x 5 km). The input data consists of 10 m-wind, 2 m-temperature and specific humidity, total cloudiness and precipitation rate. The simulations are started on 1 April 2008 and ended on 30 April 2008.

In order to test the quality of the forcing data, comparisons with in-situ data of the TRANSDRIFT experiment 2008 have been performed. They show shortcomings of the atmospheric model data with respect to the daily course of the temperature, but very good agreement for the wind (Fig.2).

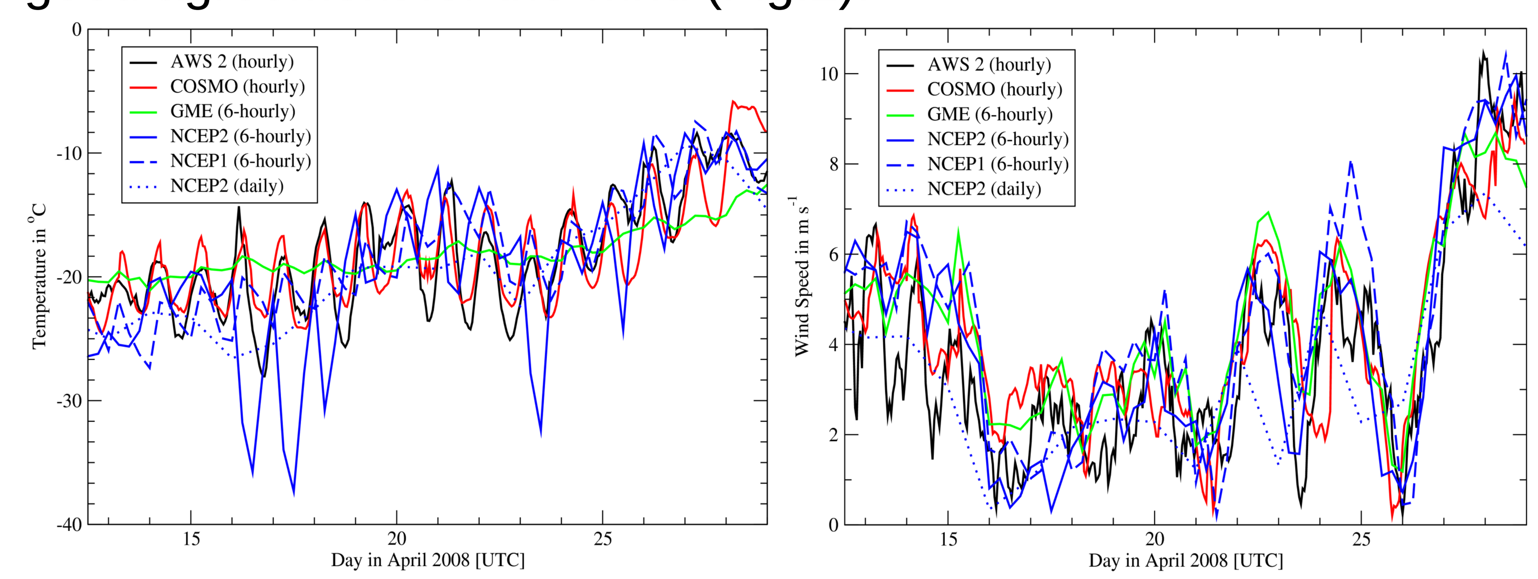

Fig.2: Meteorological measurements of the Automatic Weather Station 2 (AWS 2) at the fast ice edge in the WNS polynya area (Fig.1) and nearby NCEP 1, NCEP 2, GME and COSMO data.

5. Results

The last days of April are characterized by a grand polynya event of the WNSP. This opening process is realistically represented in the simulations with all different forcing fields except with daily NCEP 2 (Fig.3). However, there are differences in direction and velocity of the icedrift and in the location and development of the polynyas. While open water areas of the ALP and particularly of the southern part of the WNSP are slightly underestimated in the runs with 6-hourly GME and NCEP 1 forcing data, they are marginally overestimated with 6-hourly NCEP 2. In general, small-scale meteorological structures are best represented by the high-resolution COSMO data.

5. Results (continued)

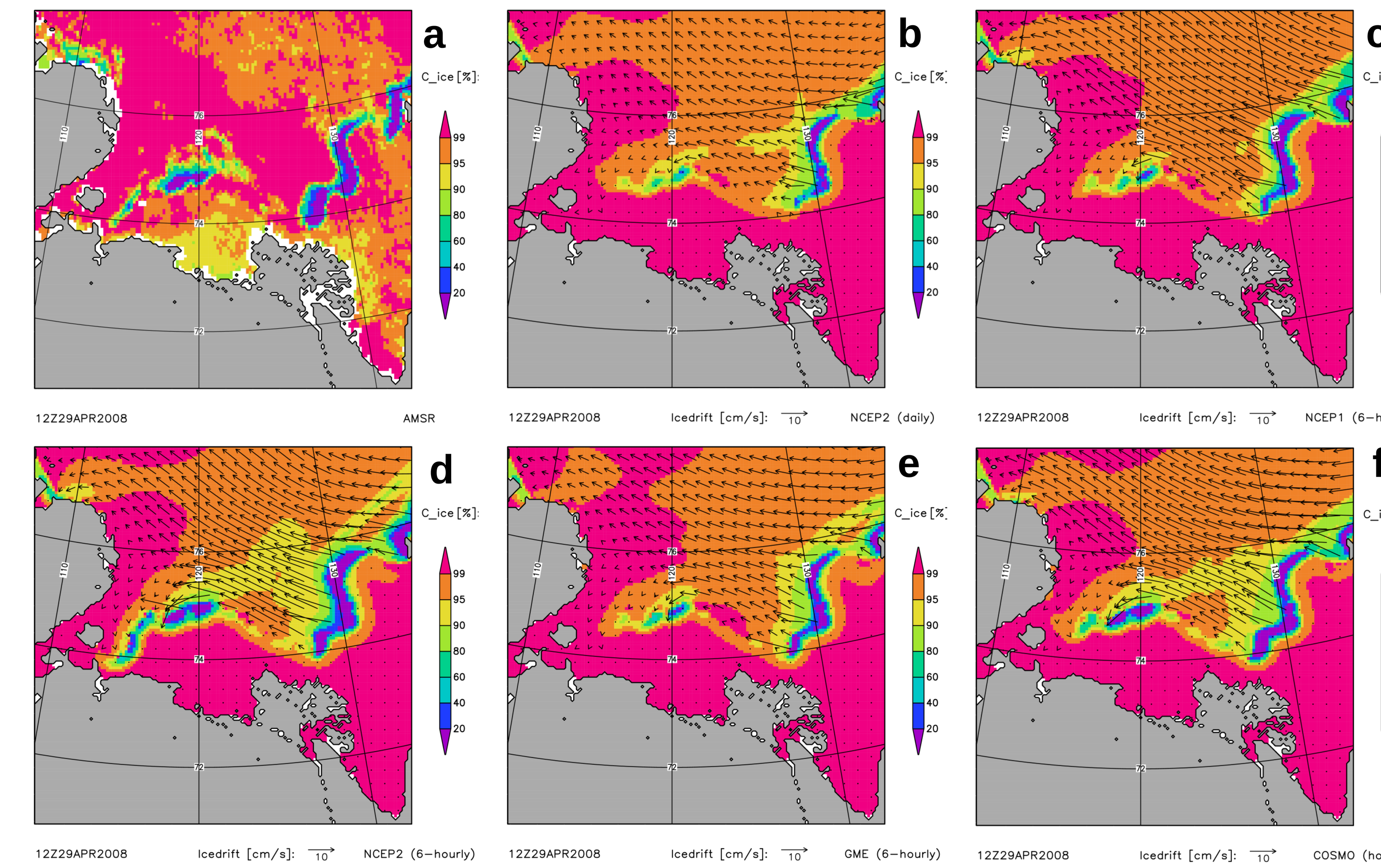

Fig.3: Comparison between AMSR-E (a), with daily NCEP 2 (b), with 6-hourly NCEP 1 (c), with 6-hourly NCEP 2 (d), with 6-hourly GME analyses (e) and with hourly COSMO data (f) simulated mean sea ice concentration and ice drift vectors in the Laptev Sea for 23 April 2008. Arrows represent ice drift vectors.

Polynya situations are captured in FESOM simulations with all forcing fields and the duration of the polynya events are reproduced realistically (Fig.4a). But during polynya events there is large spreading in the simulations. Due to the particularly well represented dynamics of the polynya area (ice concentration < 70 %), the hourly COSMO data are preferred as model forcing data. Except from the beginning of the melting period in May the progression of ice production correlates with the development of the polynya areas (Fig.4b). Though the simulation with 6-hourly NCEP 2 reacts extremely sensitively in respect of sea ice production.

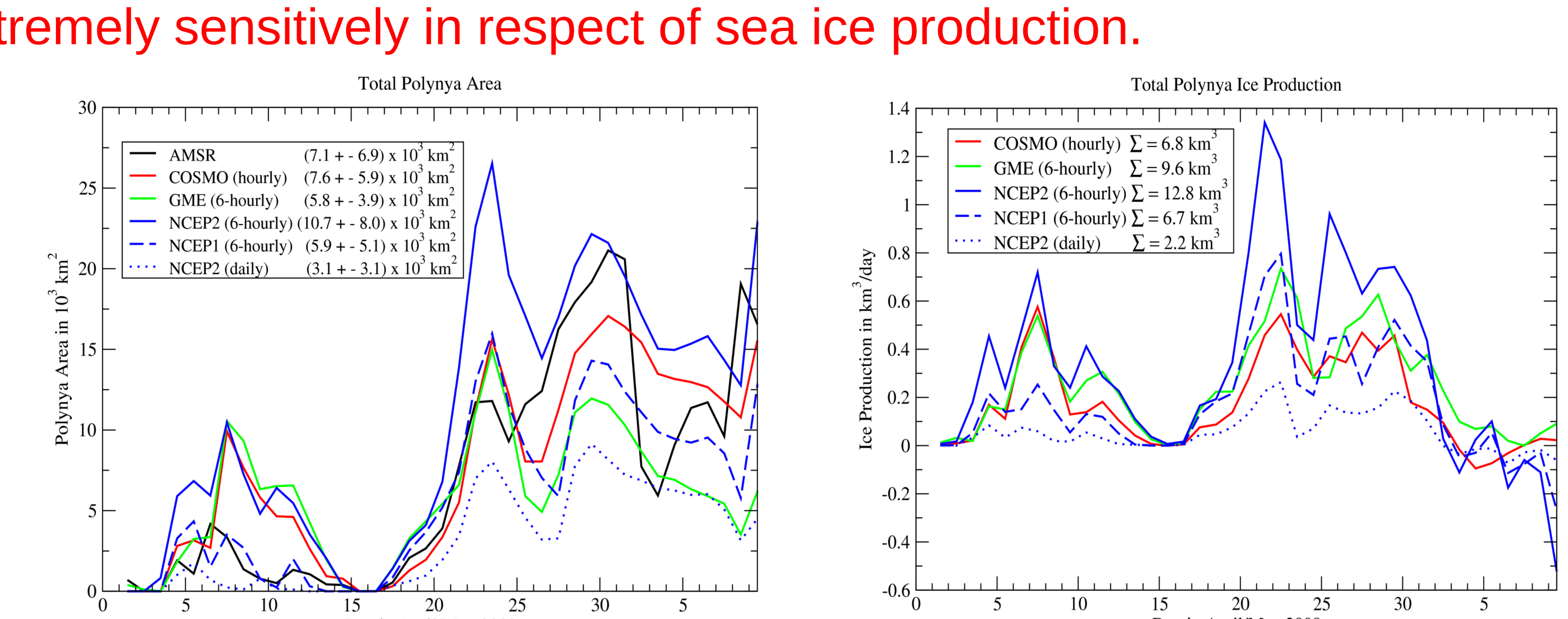

Fig.4: a) Comparison between from AMSR-E data derived and with different forcing data simulated mean polynya areas in the Laptev Sea. The mean total open water areas and standard deviations of the entire period are indicated for every case study. b) Comparison of total sea ice production in the Laptev Sea polynyas in FESOM simulations with different forcing data. The temporal mean over the whole period is given in the legend.

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