J7.7 VARIABILITY IN THE ARCTIC SEA ICE MELT SEASON

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1. INTRODUCTION

The timing and length of the Arctic sea ice melt season has the potential to strongly influence the Arctic ice mass budget. Measurements during the SHEBA field experiment showed that the ice mass lost during the melt season exceeded that gained in freezing ice through the year, resulting in thinner ice and a net absorption of energy (Perovich et al., 2003). The ice mass changes observed during SHEBA illustrated how the ice mass was affected during the melt season depending on the meteorological conditions (such as air masses, precipitation and cloud cover), ice dynamics, ocean water masses, and the past evolution of existing ice cover.

Year-to-year variations in the onset of melt season are apparent in measurements from ice-mass balance buoys. The ice buoys deployed at the North Pole Environmental Observatory (NPEO) between 2000 and 2004 have recorded significant variations in surface melt seasons (Morison et al., 2002). Pictures recorded by the NPEO cameras have shown years with rapidly-evolving melt ponds, and years with few (or very late-evolving) melt ponds. Variations in the ice mass lost during the melt season have also been recorded by the NPEO buoys. Further evidence of the influence of the length of the melt season on ice thickness has been provided by satellite data. A high correlation between melt season length and ice thickness changes gathered from satellite-based radar altimetry has been shown by Laxon et al. (2003).

In the ongoing project described in this paper, satellite data from NASA QuikScat instrument on the timing and location of surface melting of Arctic sea ice are compared to dynamic-thermodynamic sea ice model simulations. The QuikScat ice melt data are also employed as boundary conditions on the modeled melt season, to assess the impact of timing and length on the mass budget. This approach can be used as an independent verification of the hypothesis that the length of the melt season has a strong influence over mean Arctic ice thicknesses, as suggested by the satellite altimeter data and surface ice-buoy data.

2. DATA

The satellite data used for this project are taken from QuikScat, which is the SeaWinds microwave scatterometer launched on the NASA QuikBird satellite in June 1999. QuikScat (or QSCAT) is nearly identical to the SeaWinds scatterometer on Midori-II (ADEOS-II) satellite launched in December, 2002. The primary mission of these SeaWinds scatterometers is to measure winds near the ocean surface, but they area also useful for land and sea ice applications. The SeaWinds instruments operate at Ku-band (i.e., a frequency near 14 GHz).

The sea-ice melt data over the Arctic Ocean for this project are provided by Son Nghiem of NASA Jet Propulsion Laboratory. The onset of sea ice surface melt is detected by the coincident sharp temporal transition in scattering over melting sea ice. The onset of surface freezing is also detected by the change in scattering at the end of the season. The QuikScat data used in this project include years 2000 to 2003.

3. MODEL

The ice model used in this study is the Community Climate System Model (CCSM)

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Sea Ice Model version 5 (CSIM5), a dynamic-thermodynamic sea ice model developed through collaboration between Los Alamos National Laboratory, University of Washington's Polar Science Center sea ice model (Bitz 2000), and the National Center for Atmospheric Research (Briegleb et al. 2004). CSIM5 is nearly identical to the present version of the Los Alamos CICE model (Hunke and Lipscomb 2004). The main distinction between them is that CSIM5 is a component of CCSM version 3, a global, coupled atmosphere-ocean-ice general circulation model developed by the National Center for Atmospheric Research (NCAR) and collaborating national laboratory and university researchers. CCSM3 was released to the community in June 2004 and is presently being used for climate simulations, including scenarios for the fourth assessment of the Intergovernmental Panel on Climate Change (IPCC).

The CCSM Sea Ice Model version 5 (CSIM5) consists of: a thermodynamic ice model based on Bitz and Lipscomb (1999), which has multiple temperature levels for ice, an internal snow temperature, and temperature and salinity dependencies in the latent heat of formation; a Lagrangian ice thickness distribution model based on Bitz and Lipscomb (1999) that determines temperatures, growth rates, snow cover, and surface albedo for multiple thickness categories, including open water, thin ice, and thick (multiyear) ice; the elastic-viscous-plastic ice dynamics of Hunke and Dukowicz (1997) used in the CICE model with the elliptical yield curve, which has been updated in CICE and CSIM5 to include the metric terms on the general orthogonal grid.

In addition, CSIM5 contains several significant ice physics parameterizations that have been added or improved from earlier CSIM and CICE versions (Briegleb et al. 2004; Hunke and Lipscomb 2004): linear remapping of the evolution of ice in thickness space that reduces the discontinuities of ice state variables through time; mechanical redistribution due to rafting and ridging; Ice strength formulation computed from energetics of ridging; second-order horizontal advection using remapping, which accelerates the computation of advection of multiple variable fields; lateral and bottom melt processes; a surface albedo parameterization that treats melt ponds implicitly.

CSIM5 is used in this project as a stand-alone sea ice model, which is supported by options in CSIM5. The atmospheric forcing for the model is provided by surface air temperatures and sea-level pressures recorded by ice buoys in the International Arctic Buoy Program (IABP) over the years 2000 to 2003. The sea-level pressures are used to compute the geostrophic winds over the sea ice, and a constant turning angle of 25º is used. Radiative inputs from observations, including the effects of cloud cover, may not be available for these years, so average fields from previous years using the POLES model forcing data will be used (Zhang et al., 1998). The horizontal grid used for this study will be a rotated Mercator grid that closely matches the polar EASE grid used for the SSM/I products at 25-km resolution.

4. RESULTS

The variability in the sea ice melt from QuikScat in the summers of 2000, 2001, 2002, and 2003 is shown in Fig. 1 for the positions following the drift track of the 1997-98 SHEBA experiment. The melt duration ranged from 65 days to 112, with start dates as early as 21 May and as late as 11 June. Freezeup dates varied by a month from 8 August to 9 September.

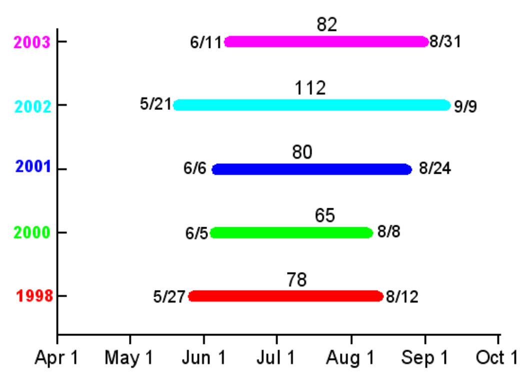

Figure 1. Dates of sea ice melt season along SHEBA drift track from SHEBA data (1998) and from QuikScat (2000 to 2003).

The simulations with the ice model are currently in progress at the time of publication. The results of the ice model simulations will be presented at the symposium.

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6. ACKNOWLEDGEMENTS

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