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Atmospheric Control of the Surface Energy Budget

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LONG-TERM GOALS

Provide the observational and theoretical foundation for the dynamics in a high resolution sea ice model. Understand how the atmosphere/ice system responds to changes in large-scale atmospheric forcing, including weather events and historical decadal trends.

OBJECTIVES

Understand the scale interaction between the multiple floe scale (<10 km), the regional granular continuum scale (10 - 200 km) and the sub-basin scale (>200 km). Document how large-scale atmospheric changes such as the Arctic Oscillation (AO) influence regional sea ice thermodynamic and dynamic processes based on the heterogeneous and plastic nature of sea ice.

APPROACH

We make use of basin scale gridded data sets of atmospheric and sea ice variables, AVHRR data, SAR ice motion vectors, and in situ ice thermodynamic and kinematic observations. The basin scale observations include analysis fields at all levels of the atmosphere and satellite estimates of the surface radiation budget and ice concentrations. AVHRR thermal imagery and SAR ice kinematic data provides the regional context for more limited in situ ice motion, stress and surface flux data collected during the SHEBA experiment. Investigation of the gridded sets uses four-dimensional pattern recognition, both statistical and observational, based on dynamic principals. Regional ice studies interpret ice kinematic features in terms of ice rheology theory, based on the plastic nature of sea ice.

WORK COMPLETED

We have completed our main analyses from the SHEBA program. The SHEBA drift was generally composed of compression toward the Alaskan coast in December 1996, westward motion and general opening in January 1997, and compression toward Wrangel Island in February and March 1997. For 48 cases the regional sensible heat flux and radiative flux were estimates from AVHRR surface temperatures in a 100 km x 100 km region centered on the SHEBA camp and in situ meteorological measurements. We were able to characterize the strain field for Beaufort sea ice for these three periods from SAR motion vectors derived from RADARSAT.

RESULTS

Thicker and thinner ice regions have colder and warmer surface temperatures. Because surface upward long radiation depends on the fourth power of temperature, the small percentage area of thin ice (<5%) contributes to an increased regional radiative flux which is 22% greater than if the ice were a uniform 2 m thick. Air temperatures over the ice, however, tend to adjust to give a regional near zero sensible heat flux. The increased upward heat flux over thin ice is balanced by downward flux over thicker ice.

SAR motion data show parallel systems of sliplines during ice compression events. This is a characteristic of a plastic material. The wider swath of RADARSAT (400 km) compared to previous ERS1 (80 km) is a much improved tool for understanding ice dynamics.

IMPACT/APPLICATIONS

A goal of SHEBA is to develop models that improve the simulation of Arctic climate. Strategic objectives include how the ice changes in response to atmospheric forcing and how to extend these relationships from local to aggregate scales. We have shown that the radiative fluxes can be modeled as the sum of fluxes for ice regions of different thicknesses. However, the sensible heat flux tends toward a regional minimum magnitude with the air temperature adjusting to be greater than the surface temperature over thick ice and less than the surface temperature over thin ice. This was true whether there was more or less thin ice in the region. Such an equilibrium can be considered to be an emergent property of the system which only shows up at the aggregate scale. Consideration of such a property should be made in formulating coupled ice/atmosphere models.

TRANSITIONS

We have completed qualitative comparisons between the SIMI and SHEBA SAR motions and the candidate PIPs3 model. Both show granular plastic slipline behavior.

PUBLICATIONS

Overland, J.E., J.M. Adams and N.A. Bond, 1999: Decadal variability of the Aleutian low and its relation to high latitude circulation, *J. Climate, 12*, 1542-1548.

Overland, J.E. and coauthors, 1999: Regional atmospheric forcing and ice response during SHEBA. 5th Conference on Polar Meteorology and Oceanography. American Meteorological Society, 443-445.

Overland, J.E. and coauthors, 2000: Regional sensible and radiative heat flux estimates for the winter Arctic during SHEBA, *J. Geophys. Res, 105*, in press.