Geophysical Research Abstracts
Vol. 17, EGU2015-8508, 2015
EGU General Assembly 2015

On the Role of Sea Ice Deformations in Arctic Climate Change

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Understanding air-sea interactions and their effects on arctic climate change requires comprehensive knowledge of the sea ice dynamics and thermodynamics at a process level. While significant advancement has been made for example in understanding and model representation of sea ice rheology, surface albedo and ice-albedo feedback, there are other processes such as sea ice deformations, which require further studies and model improvement. Of particular potential interest are leads, which control winter air-sea heat exchange and buoyancy input into the ocean, or sea ice ridging and shearing, which affect the ice-ocean coupling. Their importance in arctic climate change under an increasing first-year ice cover is yet to be determined, as global climate models commonly do not resolve such sea ice features at their actual scale, magnitude and frequency and stand-alone high-resolution atmosphere or ice-ocean models do not allow studies of air-sea-ice interactions.

We use the Regional Arctic System Model (RASM), which is a fully coupled, high-resolution regional climate model, to study sea ice deformation processes and resulting coupling across the air-sea interface. RASM includes the Weather Research and Forecasting (WRF) atmospheric model, the Parallel Ocean Program (POP), the Community Ice Model (CICE) and the Variable Infiltration Capacity (VIC) land hydrology model. It is configured for the pan-Arctic region at an eddy-permitting resolution of 1/12° for the ice-ocean and 50 km for the atmosphere-land model components. In addition, all RASM components are coupled at high frequency, i.e. at a 20-minute time step. The sea ice component has been upgraded to the Los Alamos Community Ice Model version 5 (CICE5), which allows either Elastic-Viscous-Plastic (EVP) or a new anisotropic (EPA) rheology and incorporates form drag to more realistically represent sea ice morphology and estimate ice-ocean and ice-atmosphere stresses. Results from multiple RASM simulations, using different CICE5 options combined with varying parameter space, are inter-compared and evaluated against observations with emphasis on model representation of sea ice deformation, drift and thickness distribution and their role in exchanges across the air-sea interface.