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Arctic Sea Ice Thickness Distribution as an Indicator of Arctic Climate Change – Synthesis of Model Results and Observations

Wieslaw Maslowski (1), Jaclyn Clement Kinney (1), Jaromir Jakacki (2), Robert Osinski (2), and Jay Zwally (3)

(1) Naval Postgraduate School, Oceanography, Monterey, CA, USA (maslowsk@nps.edu), (2) Institute of Oceanology, Polish Academy of Sciences, Sopot, Poland, (3) NASA Goddard Space Flight Center, Greenbelt, MD, USA

The Arctic region is an integral part of the Earth's climate system through its influence on global surface energy and moisture fluxes and on atmospheric and oceanic circulation. Within the Arctic, its sea ice cover is possibly the most sensitive indicator of the polar amplified global warming and of the state of Arctic climate system as a whole. Hence changes in Arctic climate and the decline of multi-year sea ice cover have significant ramifications to the entire pan-Arctic region and beyond. Having the recorded average global surface temperature about 0.54°C (0.96°F) above the 20th Century average the decade of 2000-2009 has been the warmest of the 130-year record, with the maximum positive temperatures anomalies in the northern high latitude regions. Satellite records of the Arctic sea ice show a decreasing and accelerating trend in ice extent and concentration since the late 1979, as a result of the global warming. More importantly there is growing evidence that the Arctic sea ice thickness and volume have been decreasing at even faster rate. This means that our knowledge of the Arctic sea ice melt might be significantly biased due to the interpretation of 2-dimensional sea ice extent / concentration records only instead of ice thickness and volume.

The rates of recent ice thickness and volume melt derived from our pan-Arctic coupled ice-ocean model results combined with recent remotely sensed data suggest an accelerating negative trend. This trend is robust and lends credence to the postulation that the Arctic not only might but it is likely to be ice-free during the summer in the near future. However, global climate models vary widely in their predictions of warming and the rate of Arctic ice melt, suggesting it may take anywhere from a couple of decades to more than a century to melt most of the summer sea ice cover. Also many regional models are limited in their representation of the rapid Arctic sea ice thinning and volume loss. The inability of models to reproduce the recent warming and ice melt in the Arctic Ocean diminishes their accuracy of future climate predictions, which bears significant consequences for both science of climate change and policymaking. Some of the critical model limitations include: sea ice thickness distribution, deformation, variability and export, air-ice-sea interactions, northward oceanic/atmospheric heat convergence, and freshwater export into the North Atlantic. We argue that high resolution combined with advanced model physics is required to realistically model such processes and to improve predictive skills in general circulation models. Further studies involving observations and better models are needed to verify how rapidly and why Arctic sea ice is melting and to re-evaluate predictions of a summer ice-free Arctic Ocean.