Changes in sea ice melt and freeze-onset derived from satellite passive microwave data and its interactions with sea ice concentration, and ocean and atmosphere temperatures

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The onset of melt and melt season length are important variables for understanding the Arctic climate system. Given the recent large losses of the Arctic summer sea ice cover it has become critical to investigate the causes of the widespread decline in Arctic sea ice and the consequences of its continued decline. Extended or more extensive sea ice melt in response to increasing atmospheric temperatures may be one of the primary drivers of reduced summer sea ice. The total amount of solar energy absorbed during the summer melt season was strongly related to the timing of when melt begins. Earlier melt onset allows for earlier development of open water areas that in turn enhance the ice-albedo feedback. In order to explore changes and trends in the timing of Arctic sea ice melt onset and freeze-up, and therefore melt season length, we developed a method that obtains this information directly from satellite passive microwave data, creating a consistent data set from 1979 through present [1]. Using this method we analyze trends in melt onset and freeze-up for 10 different Arctic regions. With the exception of the Sea of Okhotsk, all areas in the Arctic show a trend towards earlier melt onset and also a trend towards later freeze up. For the entire Arctic, the melt season has lengthened at a rate of 6.4 days decade^{-1} when only the period of continuous melt is considered, and 4.7 days decade^{-1} when the period between the first day of melt and the last day of melt is considered. Largest trends of over 10 days decade^{-1} are seen for Hudson Bay, the East Greenland Sea, the Laptev/East Siberian Seas, and the Chukchi/Beaufort Seas. This means that from 1979 to 2007, the melt season has lengthened by almost

20 days. Since the ice is thinner overall today than in the 1980s, and the melt is happening earlier and earlier, open water areas develop earlier than before, and become more extensive throughout the summer. These open water areas absorb solar radiation, heat up, and foster more melting of the ice. This feedback process has always been present, yet with more extensive open water areas, this feedback process becomes even stronger and further boosts ice loss. The subsequent increased warming of the mixed layer of the Arctic Ocean results in a trend towards later freeze up, further reducing the sea ice mass. The later freeze onset also has ramifications on the eventual maximum sea ice cover the following winter. Additionally, marine ecosystems are very sensitive to changes in melt onset and freeze-up dates.

This new data set is being compared with satellite passive microwave sea ice concentrations and, for the period of 2003 to present, with sea surface temperatures from Aqua AMSR-E and air temperatures from Aqua AIRS in order to gain a better understanding of the interactions between sea ice melt and ocean/atmosphere interactions.

References:

[1] Markus, T., J.C. Stroeve, and J.A. Miller, Recent changes in Arctic sea ice melt onset, freeze-up, and melt season length, *J. Geophys. Res.*, doi:10.1029/2009JC005436, 2009.