Cloud-Radiation Effects on Sea Ice Loss

Contributors
Graeme L. Stephens, *Colorado State University*

Research Highlight

Passive microwave satellite observations, available from 1979 to present, show declines in Arctic sea ice extent. Downward trends, while present in all months, are largest in September when the ice reaches its annual minimum extent. While the downward trend in the minimum ice extent has substantial inter-annual variability, the 2007 minimum extent represents a dramatic departure from the historical trend line. The 2007 minimum extent was 4.13 million km2 on September 16, 2007, down 43% from 1979 and down 22% from the previous record in 2005. During 2007, large negative anomalies in ice extent persisted from July through early September, mostly in the Pacific sector of the Arctic.

Reduced cloudiness and enhanced downwelling radiation are associated with the unprecedented 2007 Arctic sea ice loss. Over the Western Arctic Ocean, total summertime cloud cover estimated from spaceborne radar and lidar data decreased by 16% from 2006 to 2007. The clearer skies led to downwelling shortwave (longwave) radiative fluxes with increases of +32 Wm-2 (- 4 Wm-2) from 2006 to 2007. Over three months, simple calculations show that these radiation differences alone could enhance surface ice melt by 0.3 m, or warm the surface ocean by 2.4 K, which enhances basal ice melt. Increased air temperatures and decreased relative humidity associated with an anti-cyclonic atmospheric circulation pattern explain the reduced cloudiness. Longer-term observations show that the 2007 cloudiness is anomalous in the recent past, but is not unprecedented. Thus, in a warmer world with thinner ice, natural summertime circulation and cloud variability is an increasingly important control on sea ice extent minima.

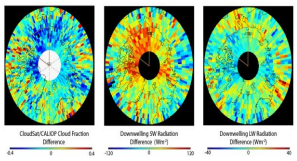
Satellite and ground-based observations show that decreased cloudiness and increased downwelling shortwave radiation are associated with the record-breaking 2007 sea ice extent minimum. While the 2007 cloud reductions are anomalous in the recent past, a 62-year record of cloudiness from Barrow hints that the 2007 cloudiness was not unprecedented. Thus, our results suggest that when sea ice is vulnerably thin, natural year-to-year variations in the summertime atmospheric circulation and associated changes in clouds and shortwave radiation can play an increasingly large role in modulating sea ice extent.

Reference(s)

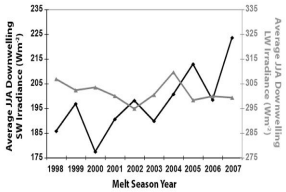
Kay, JE, T L'Ecuyer, A Gettelman, G Stephens, and C O'Dell. "The contribution of cloud and radiation anomalies to the 2007 Arctic sea ice extent minimum." To appear in Geophysical Research Letters.

Working Group(s)

Cloud Properties



Clouds and downwelling radiation 2007-2006 differences (June 15-Sept 15). a. Total cloud fraction differences based on radar and lidar data. b. Downwelling SW radiative flux difference. c. Downwelling LW radiative flux difference. The Western Arctic Ocean is outlined in brown.



ARM ground-based radiation observations at Barrow, Alaska.

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