AMS Polar 2013

A Thin Ice Cover, a Strong Summer Cyclone, and the Record Minimum Arctic Sea Ice Extent in 2012

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Zhang et al. 2013 GRL

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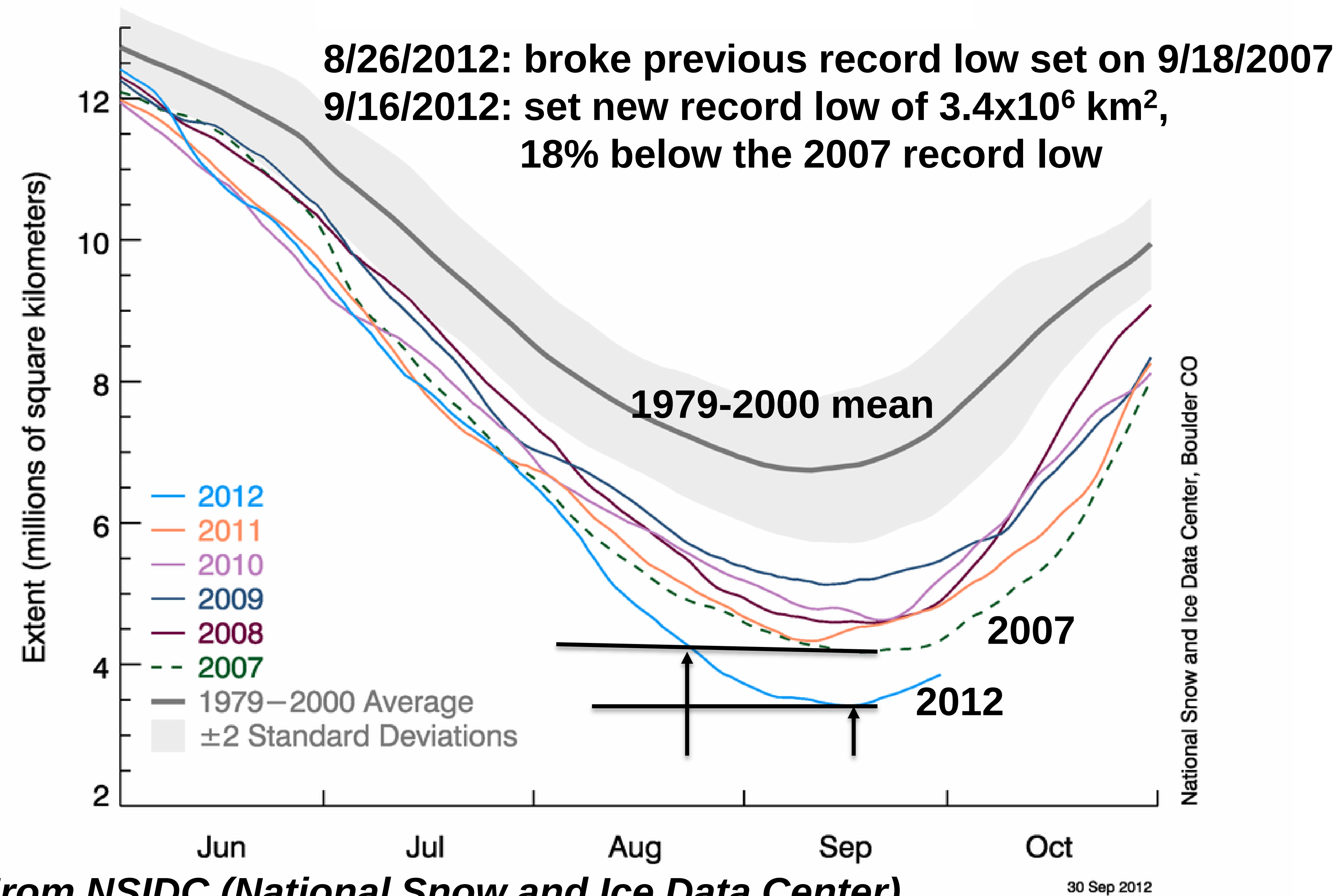
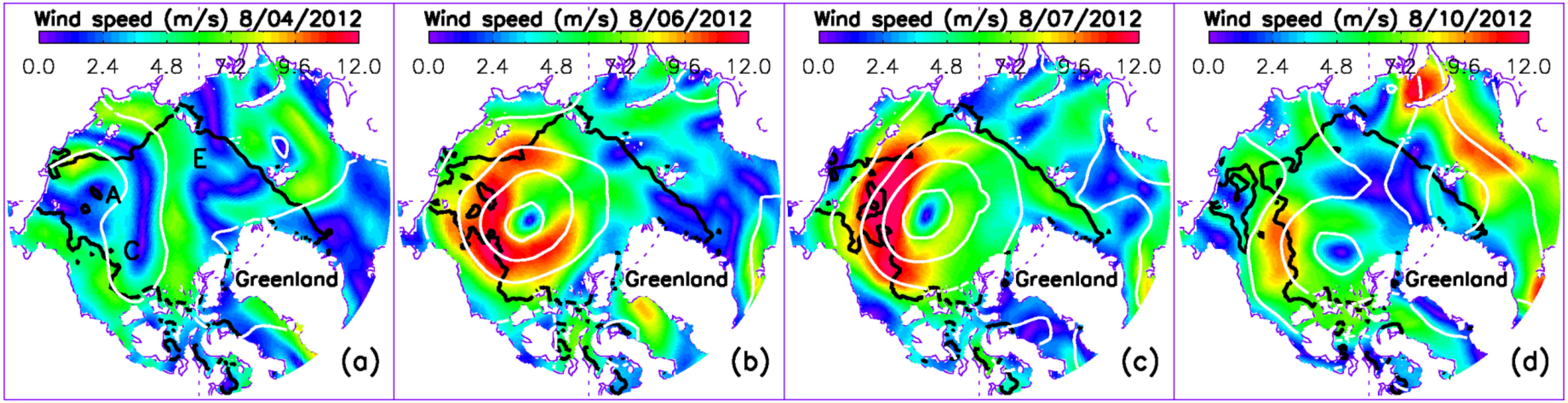
Satellite Arctic sea ice extent



From NSIDC (National Snow and Ice Data Center)

NCEP/NCAR wind speed and SLP before, during, and after the strong August 2012 cyclone



Wind speed: colors; SLP contours: while lines; Satellite ice edge: black lines

The storm was unprecedented in extent, intensity, and depth (*Simmonds and Rudeva,* 2012).

- **Q1: What was the response of the ice-ocean system to the storm?**

- **Q2: Did the cyclone have a significant role in creating the new record low Arctic sea ice extent in 2012?**

- **Modeling experiments using Pan-arctic Ice-Ocean Modeling and Assimilation System (PIOMAS).**

- **PIOMAS is driven by NCEP/NCAR reanalysis surface wind and thermal forcing that captures the cyclone.**

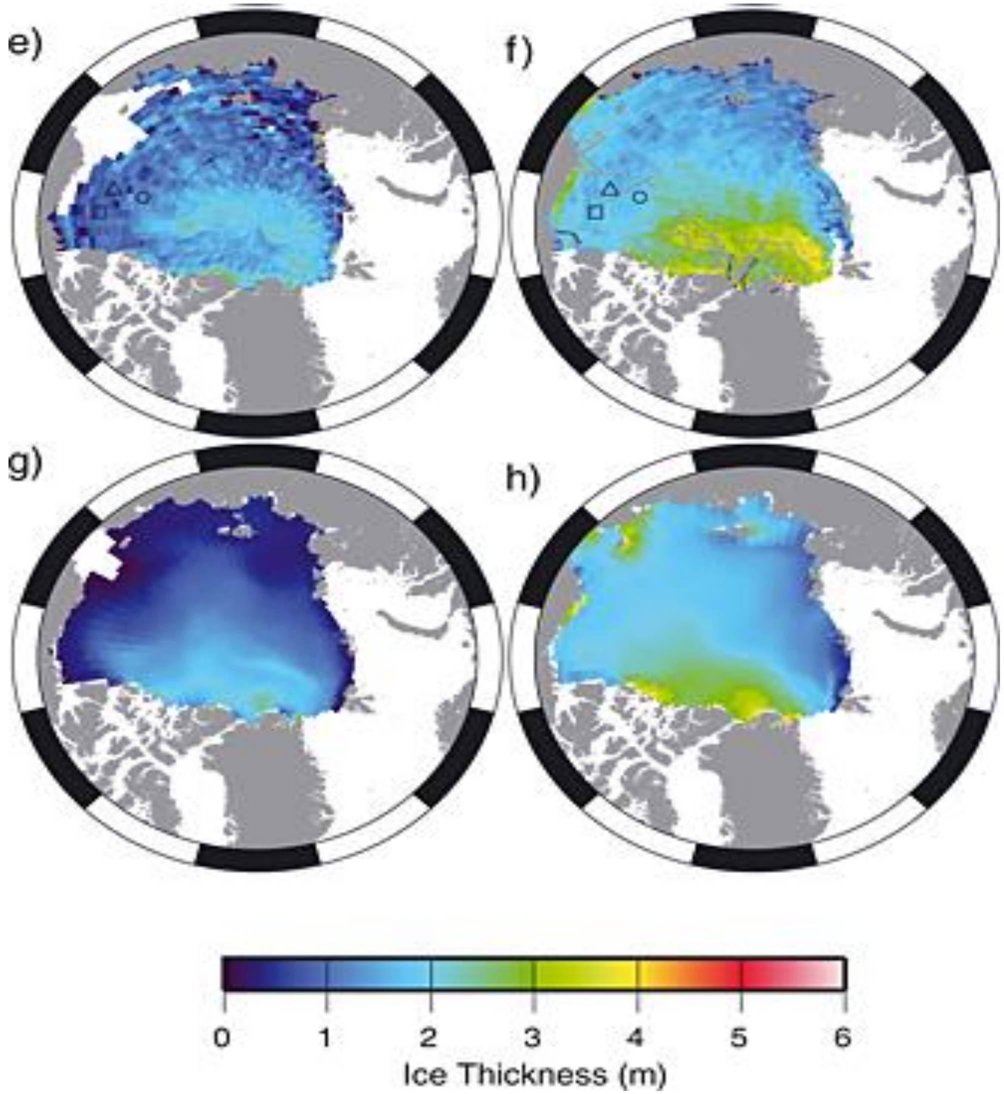
CryoSat-2 and PIOMAS estimates of Arctic sea ice thickness

CryoSat-2 Oct/Nov 2011

CryoSat-2 Feb/Mar 2012

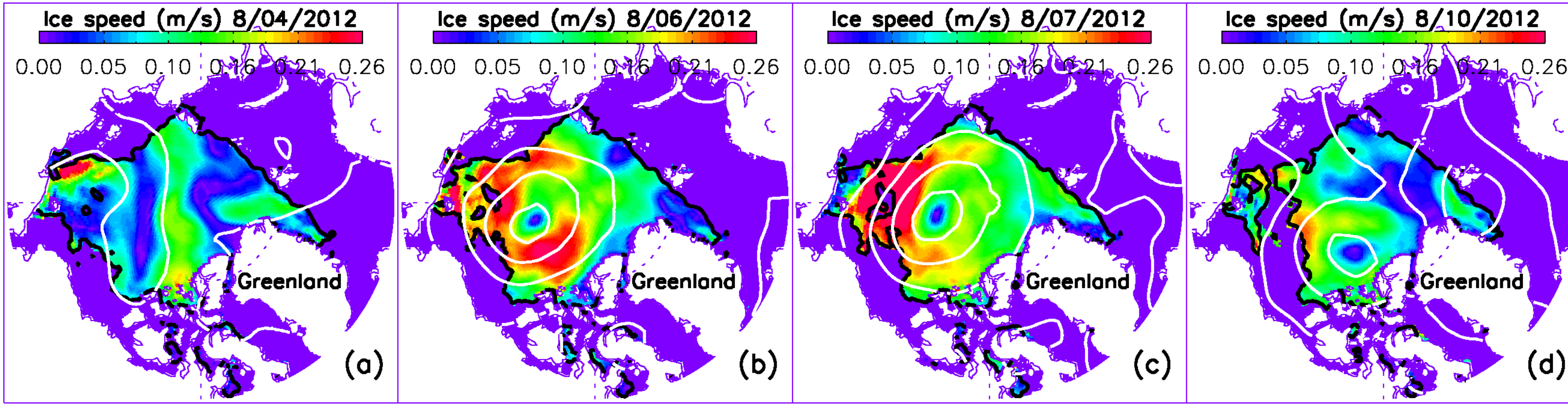
PIOMAS Oct/Nov 2011

PIOMAS Feb/Mar 2012



From Laxon et al. 2013

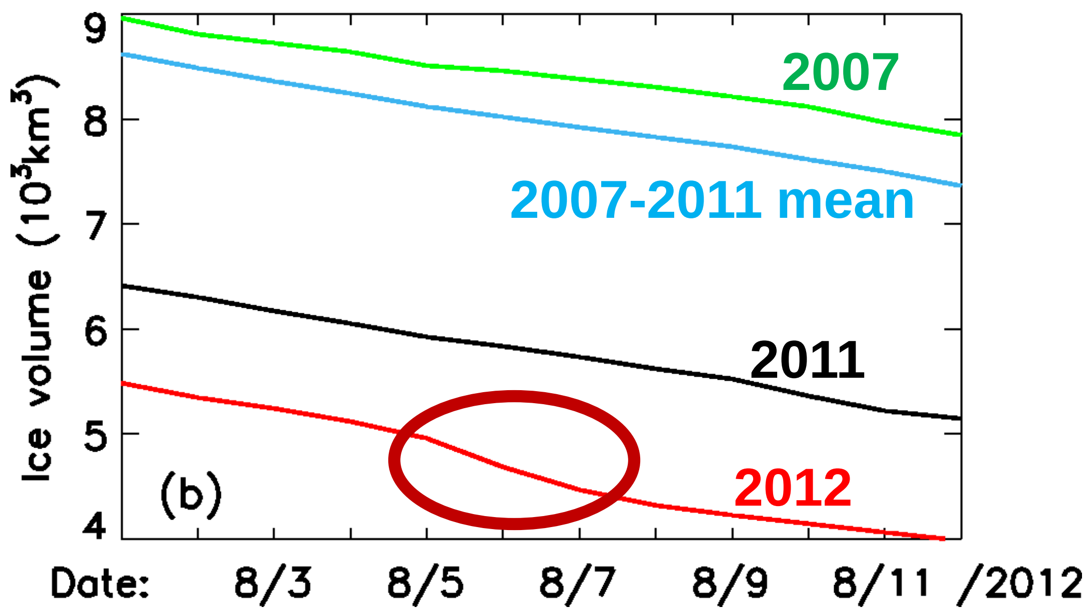
PIOMAS ice speed before, during, and after the cyclone



- **Strong ice motion in response to the storm**
- **A thin ice cover also allows ice to move faster**

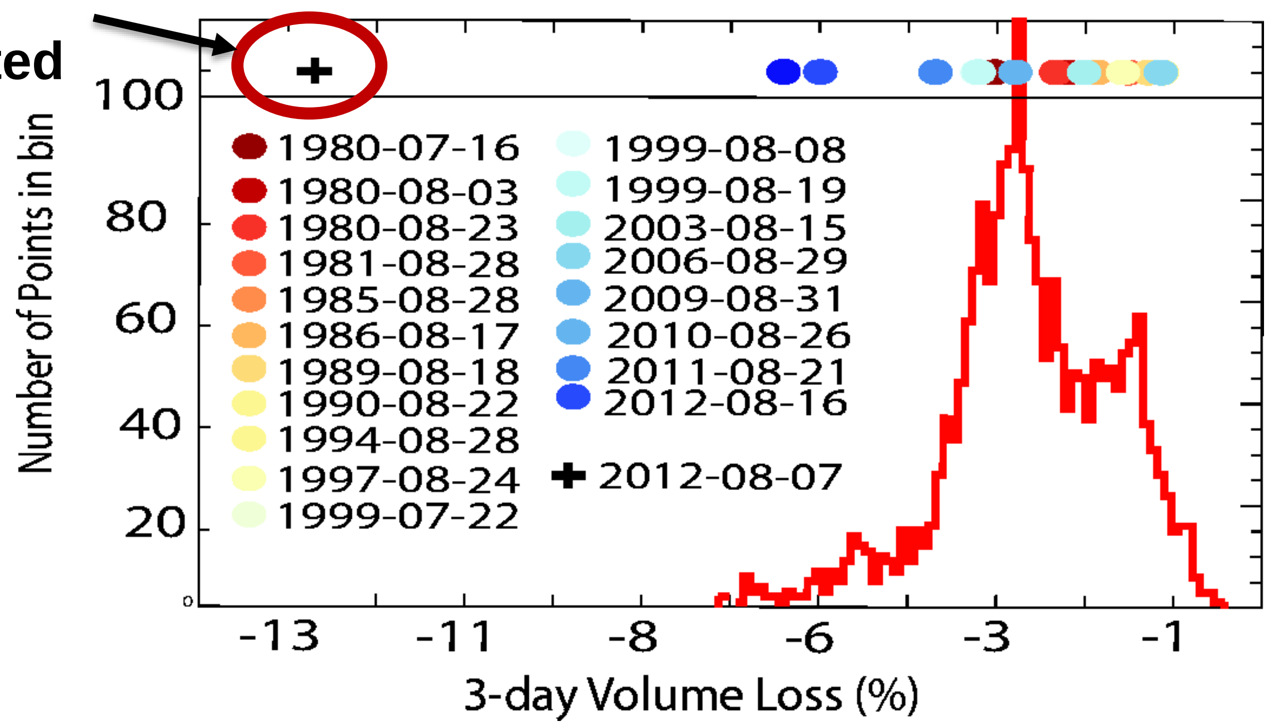
Ice speed: colors; SLP contours: while lines; Satellite ice edge: black lines

Simulated sea ice volume =>



3-day volume loss during August 6-8, 2012 much larger and unprecedented

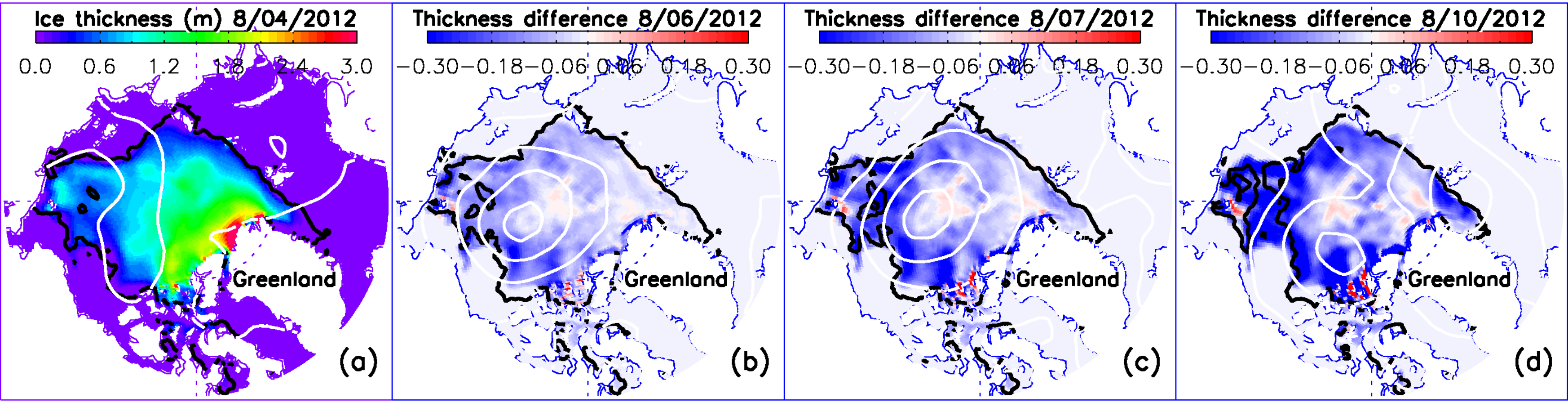
All 3-day ice volume losses during July-August of 1979-2012 =>



PIOMAS ice thickness & thickness difference

Thickness on 8/4/2012

Difference in ice thickness from 8/4/2012



8/6 minus 8/4 **8/7 minus 8/4** **8/10 minus 8/4**

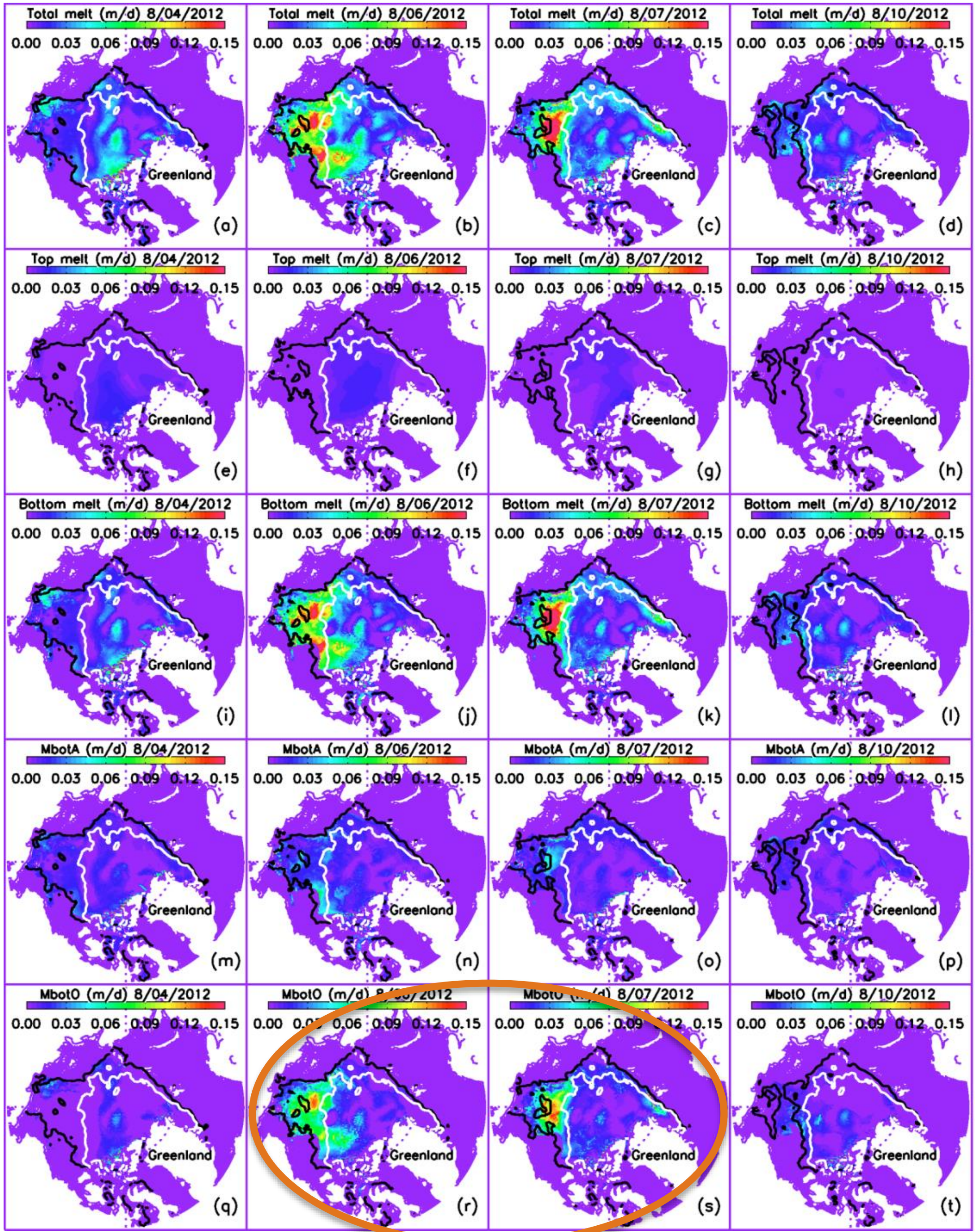
Total melt = >
on August 4, 6, 7, 10

Top melt =>

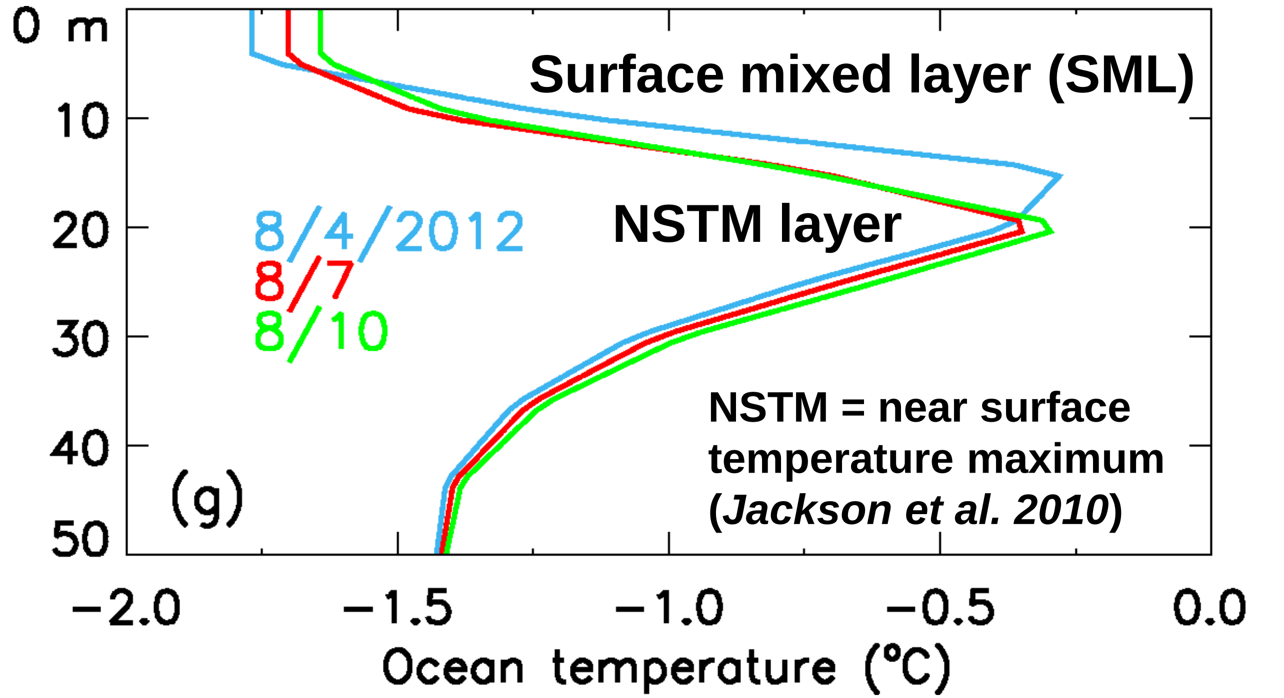
Bottom melt =>

Bottom melt due to atmospheric heating of ocean surface mixed layer (SML) =>

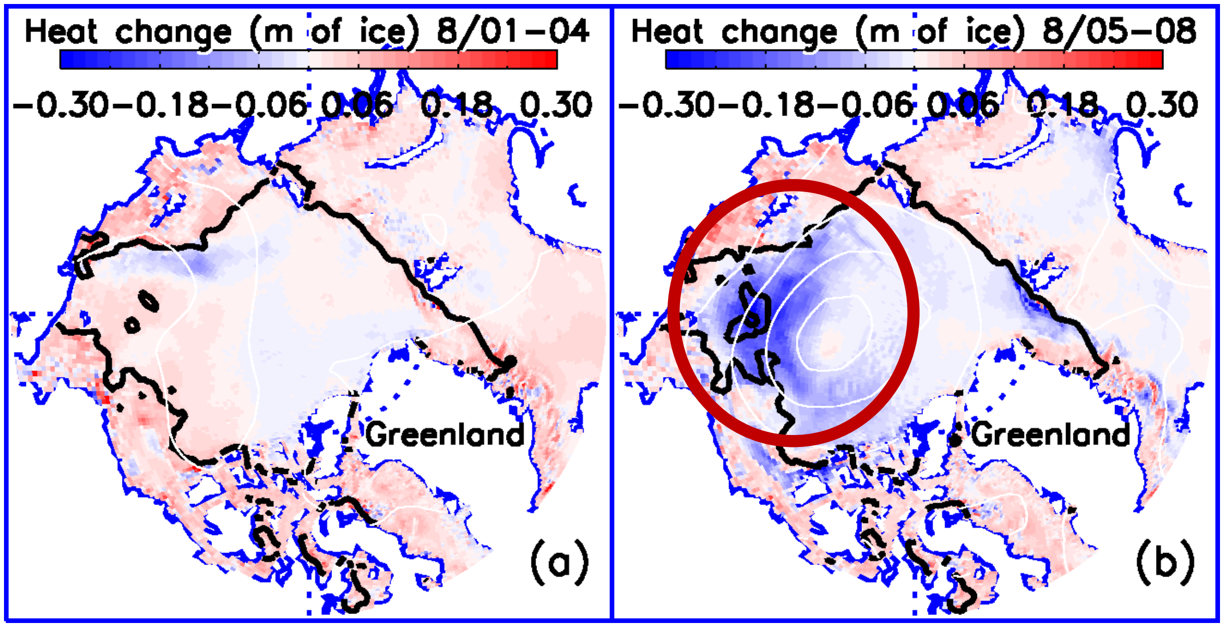
Bottom melt due to ocean dynamic heat transport =>



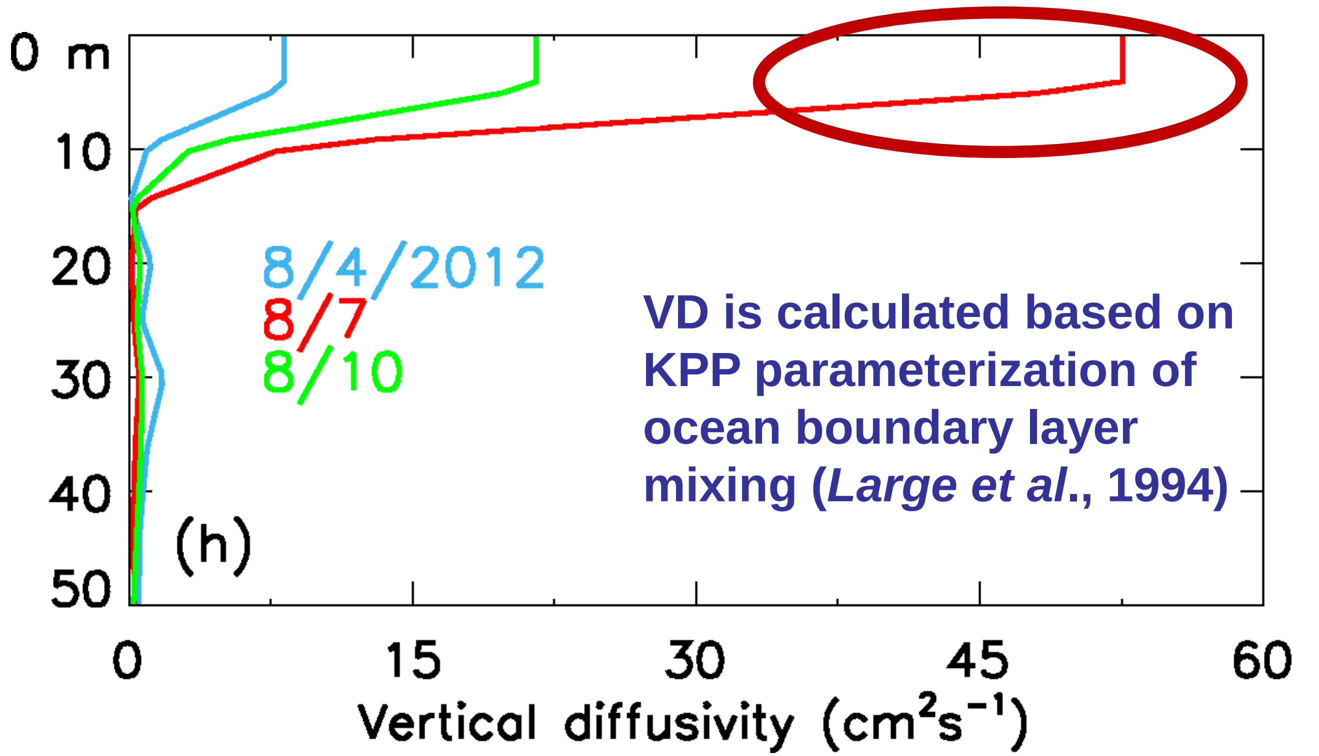
Average vertical profiles of upper ocean temperature =>



Ocean heat content change in the upper 15 m before and during the cyclone =>

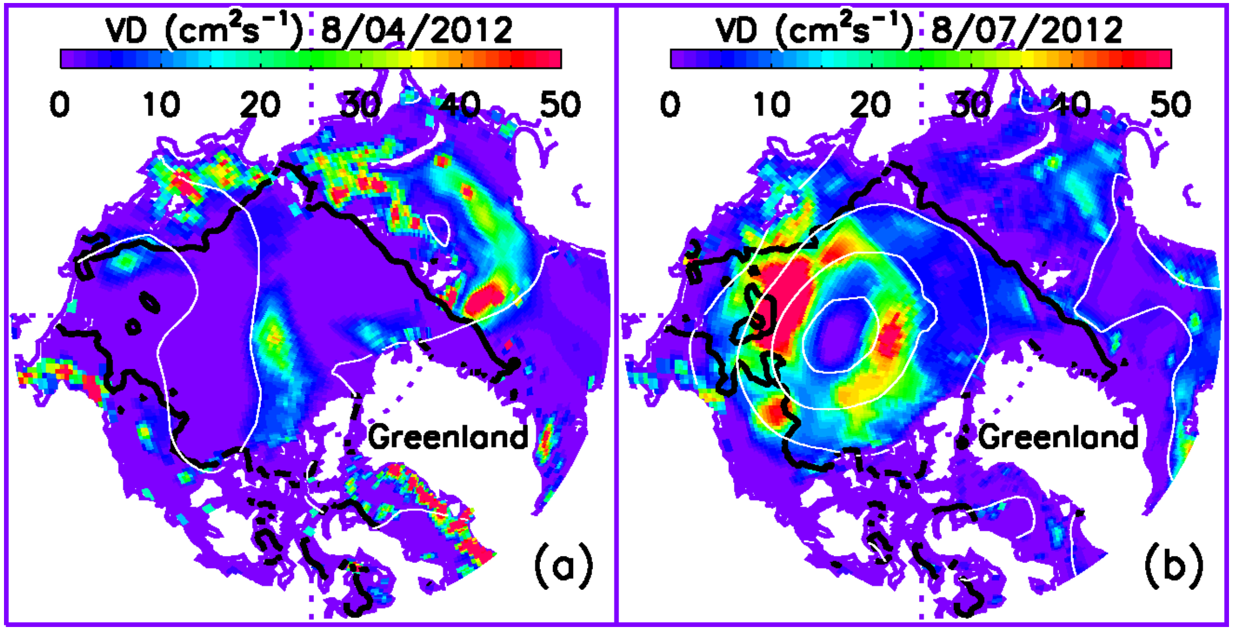


Average vertical profiles of vertical diffusivity (VD) =>

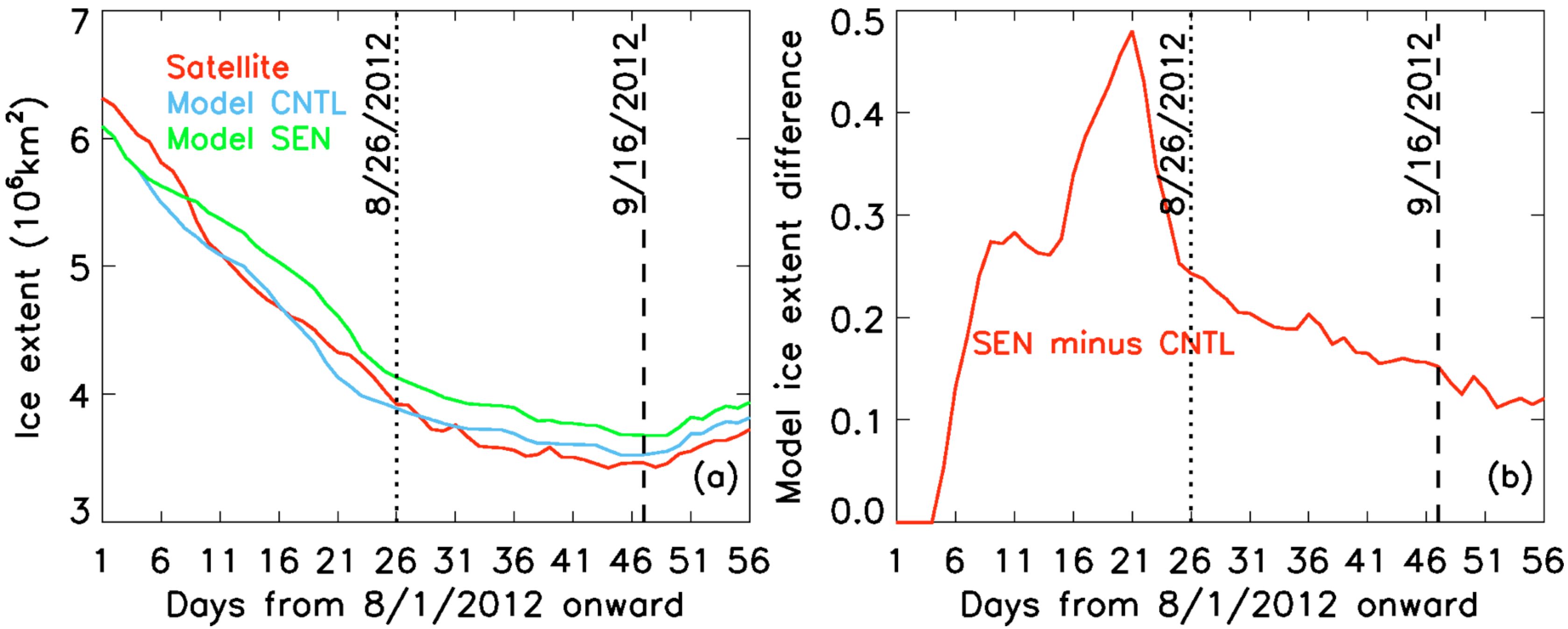


VD is calculated based on KPP parameterization of ocean boundary layer mixing (*Large et al*., 1994)

Vertical diffusivity in the upper 15 m before and during the cyclone =>

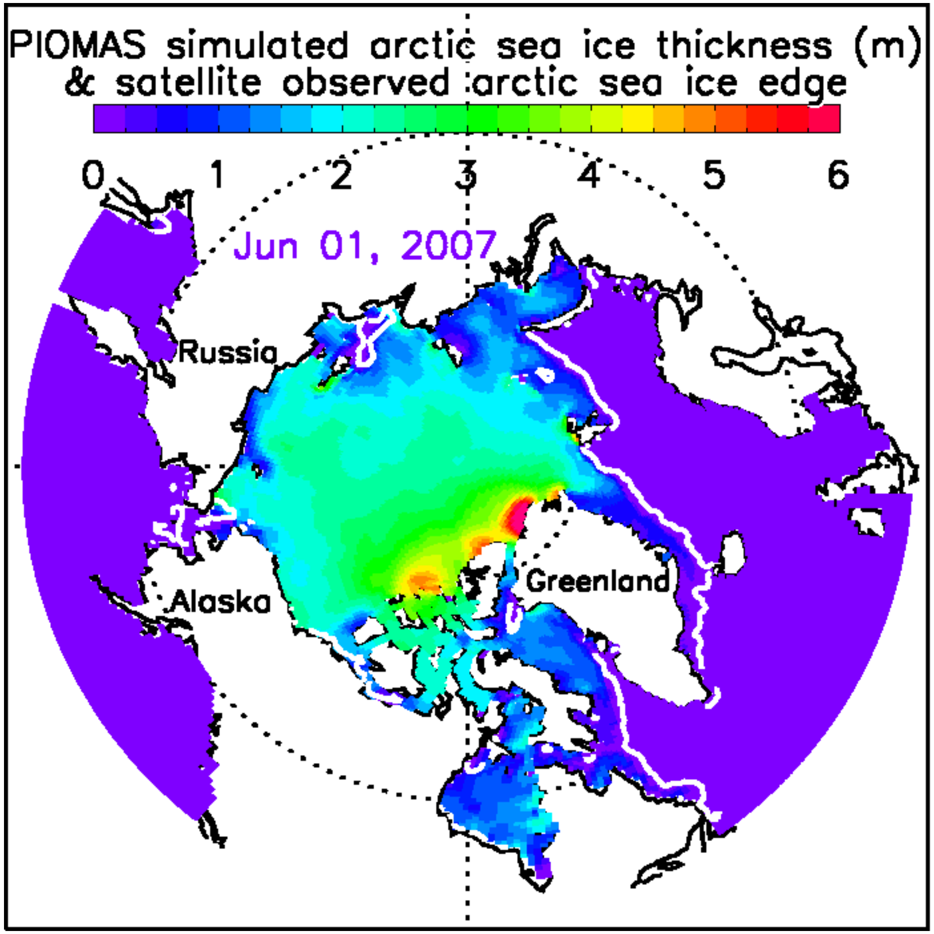


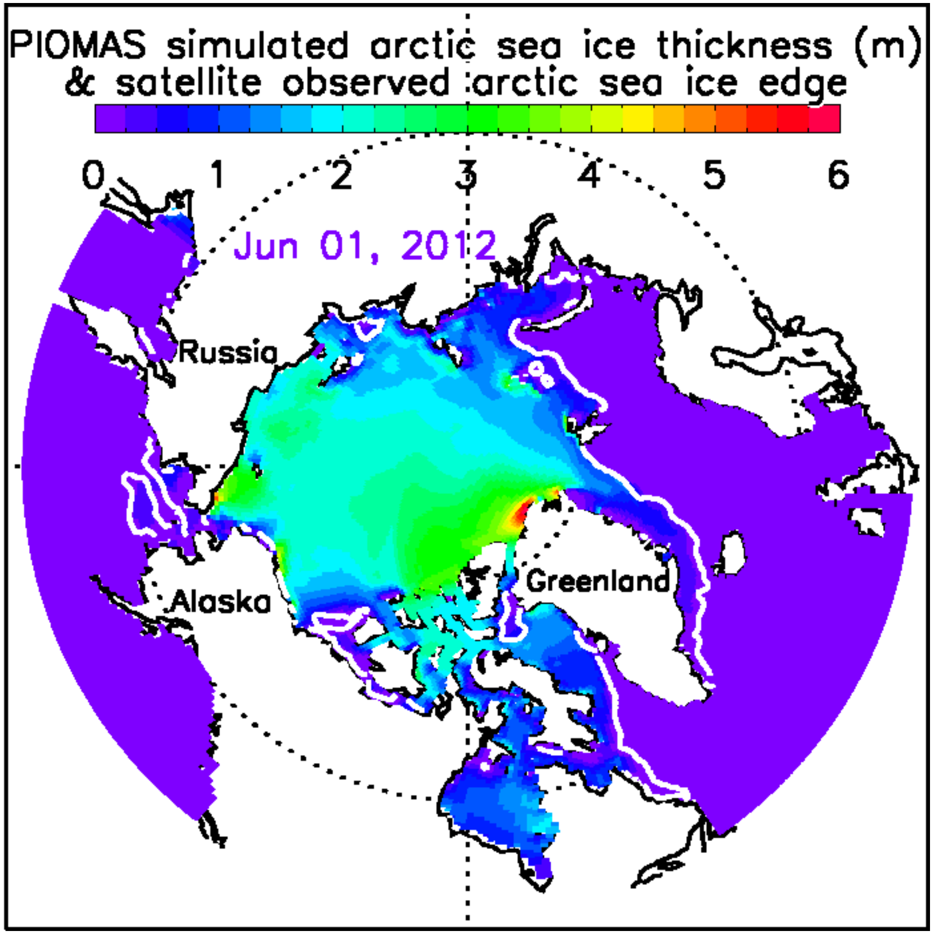
Impact of the storm on the 2012 ice extent minimum



- **CNTL: control run with NCEP/NCAR reanalysis surface wind and thermal forcing with cyclone effects.**
- **SEN: sensitivity run with no cyclone in the wind forcing during August 5-9, 2012 (by reducing wind speed by 50%, largely removing the cyclone effects in forcing).**

Simulated Ice Thickness and Observed Ice Edge 2007 vs. 2012





White line: satellite observed ice edge

Conclusions

- The cyclone passed when Arctic sea ice was thin and the simulated Arctic ice volume declined ~40% from the 2007–2011 mean.
- The thin sea ice pack and the presence of ocean heat in the near surface temperature maximum (NSTM) layer created conditions that made the ice particularly vulnerable to storms.
- During the storm, ice volume decreased about twice as fast as usual, owing largely to a quadrupling in bottom melt caused by increased upward ocean heat transport.
- Increased upward ocean heat transport was due to enhanced oceanic mixing with increasing heat entrainment into the ocean surface mixed layer from the NSTM layer, driven by strong winds and rapid ice movement.
- The simulated Arctic sea ice extent minimum in 2012 is reduced by the cyclone, but only by ~4.4%. Thus without the storm, 2012 would still have produced a record minimum.

Thanks