Air-sea interactions during Arctic storms

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- Significant ice loss has been observed in the Arctic Ocean
- Loss of sea ice enhances air-sea interactions

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Outline

• Case study: air-sea interaction during a summer storm
• Impacts of Arctic storms on water volume transport
• Summary
The storm originated in northern Siberia and slowly moved into the Chukchi and Beaufort Seas.
Significant open water in the Beaufort Seas on July 31, 2008
Canadian Regional Climate Model (CRCM)

- Horizontal resolution: 45km
- 29 vertical levels
- Lateral boundary: 6-hourly CMC wind, temperature and specific humidity.
Coupled Ice-Ocean Model (CIOM)

Ice model
Thermodynamics: Thickness distribution function with 7 categories (Thorndike, 1975)
Surface heat and salt fluxes: Mellor model (1989)

Princeton Ocean Model (POM)
25 Sigma levels
0.29x0.25 horizontal resolution
PHC monthly climatology provide lateral boundary for CIOM.
Experiments

- CRCM-CIOM is integrated from 29 July to 4 August 2008.
- CRCM provides surface forcing for CIOM
- CIOM passes SST, ice concentration and ice thickness to CRCM
- Experiment 1 (EP1): the sea ice in CRCM is prescribed as climatology
- Experiment 2 (EP2): the sea ice in CRCM is predicted by CIOM
CMC Sea level pressure

0:00 UTC 29 July

0:00 UTC 30 July

0:00 UTC 31 July

0:00 UTC 1 August

CMC CRCM-CIOM
Loss of sea ice:
• has no significant impact on storm track
• decreases central pressure by 1-2 hPa
• increases maximum wind speed by 3-4 m/s
Surface wind speed

- CRCM-CIOM can reproduce wind speed in QSCAT
- Loss of sea ice significant increases the wind speed on the right side of storm track
Loss of sea ice increases surface air temperature in the Beaufort Sea.
Loss of sea ice increases surface sensible heat flux in the Beaufort Sea
Surface latent heat flux (W)

Loss of sea ice increases surface latent heat flux in the Beaufort Sea
Sea surface temperature

Loss of sea ice reduces sea surface temperature in the Beaufort Sea
Ocean responses to Arctic storms
Annual water temperature

1970-1999

PHC
Annual water temperature at 320m
Warming in the early 1990s (320m)
Warming in the 2000s (320m)
While strong AO index in the 1990s may be able to explain the warming in the 1990s, it is about average in the 2000s.
Increased storm activity west of Spitsbergen in the 1990s and the 2000s.
Recent warming events are associated with increased storm activity west of Spitsbergen.
The increasing trend in water inflow through Fram Strait is associated with increased storm activity.
Storm activity in the southwestern Barents Sea increases in 1980-2019, but decreases afterwards.
Water volume transport through the Barents Sea Opening
Summary

• Loss of sea ice in the Beaufort Sea increases wind speed associated with summer Arctic storm by 3-4m/s, and intensifies air-sea interactions.

• On decadal scale, increased storm activities in the Greenland sea enhances the water volume and heat flux into the Arctic ocean, and increases water temperature of the Atlantic water layer

• Under climate change scenario, the changes in the storm activity play a key role in the changes of water volume transport through the Barents Sea Opening.