Modeled oceanic response to high-resolution atmospheric forcing during extreme mesoscale wind events around Greenland

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Motivation

Greenland's southeast coast presents a steep, tall obstacle for synoptic weather. As result of air flow around topography, high speed barrier winds and tip jets occur near the surface. The oceanic energy loss during strong winds from large turbulent heat fluxes may be important for triggering the open ocean convection that affects the oceanic thermohaline circulation.

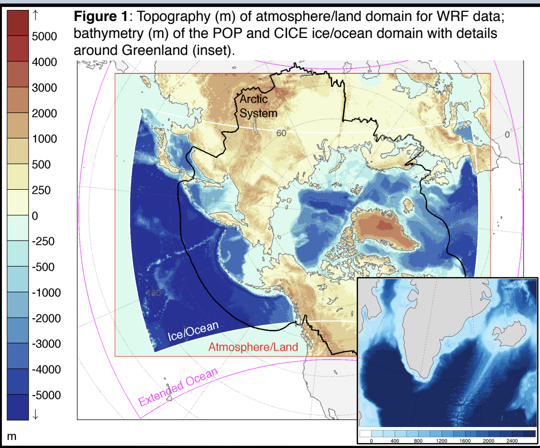


Figure 1: Topography (m) of atmosphere/land domain for WRF data; bathymetry (m) of the POP and CICE ice/ocean domain with details around Greenland (inset).

Method

We used a high resolution regional configuration of the POP ocean model and CICE sea ice models (Figure 1). The eddy resolving model has 9 km horizontal resolution, 45 vertical levels, and was forced with realistic 3 hourly atmospheric data from the Weather Research (WRF) and Forecasting model at two horizontal resolutions: 50 km and 10 km.

The model was spun up by cycling over WRF data from 2006, and analyzed during strong wind events between January 1 – March 31, 2007. We investigate how the mixed layer depth (MLD) around southeast Greenland responds to different surface forcing. The MLD is defined as the depth where the potential density exceeds the surface potential density by 0.005 kg m^{-3}.

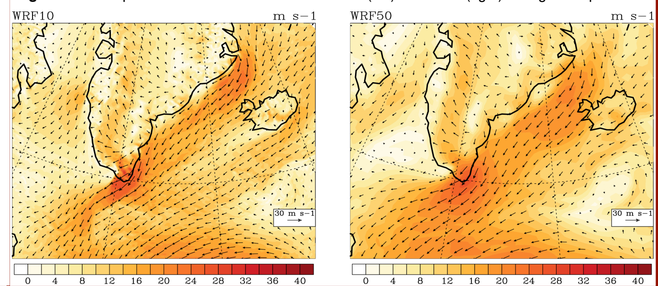
Easterly Tip Jet
Feb 20 00Z – Feb 22 00Z, 2007

Wind event lasts 48 hours and peaks on Feb 21, 2007 at 00Z with maximum wind speeds around 30 m/s.

The higher resolution WRF (10km) simulates a stronger, narrower easterly tip jet. High resolution jets better match observations because the high resolution model can better capture topographic influences.

How does the ocean respond to realistic, high speed atmospheric wind events?

Figure 2: Wind speed and direction from WRF at 10km (left) and 50km (right) during event peak.



Mixed Layer depth (MLD) and surface forcing:
Feb. 20th 00Z - 21st 00Z, 2007

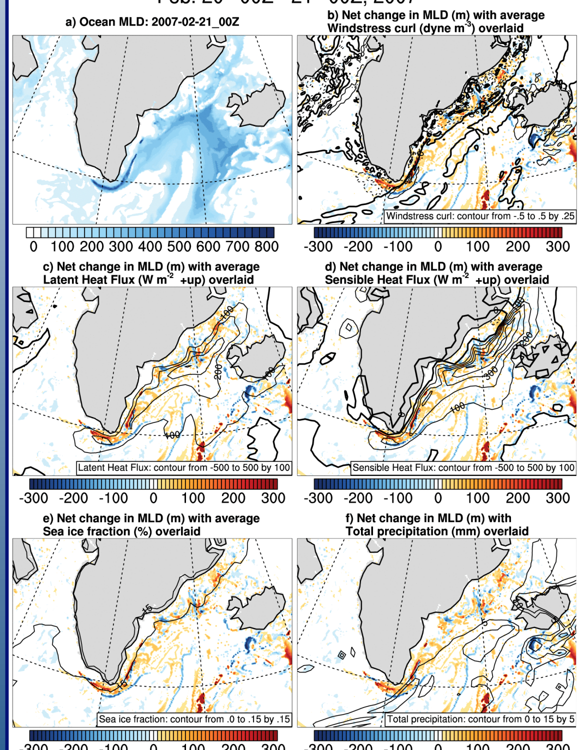


Figure 3: Mixed layer depth at peak of event (a). Change in mixed layer depth from start of event to event peak overlaid with associated WRF surface forcing (b) average wind stress curl, (c) average latent heat flux,(d) average sensible heat flux, (e) average sea ice edge, (f) total precipitation.

Ocean Response to 50km WRF Easterly Tip Jet

During an easterly tip jet there is strong MLD deepening in Denmark Strait and south of Cape Farewell. The MLD reaches the ocean bottom in some locations (not shown).

Deepening occurs where strong winds along the sea ice edge drive localized large sensible and latent heat fluxes from the ocean to the atmosphere.

MLD deepening occurs in regions of both positive and negative wind stress curl, contrary to theory from previous papers.

Weak precipitation is necessary for deepening; intensified precipitation can end convection in a region where strong MLD deepening occurred (not shown) by causing surface stratification.

Future Work

Compared to reanalyses, which are often used to drive POP/CICE, WRF has stronger winds. We determined that POP/CICE need tuning for the strong, realistic winds that occur in WRF.

Complete 10km spin up and analyze response of ocean to high resolution wind field.

Perform analysis comparing ocean response to similar wind events at both resolutions as well as an analysis of the differing response over a three month (January-March, 2007) time frame.

Quantify the number of convective events as well as the preconditioning with each forcing resolution.