Modeling of the sea ice and the ocean in the Nares Strait

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Outline

• Purpose, motivation and setup
• Ice cover and flux
• North Water Polynya
• Ocean
Purpose

- One step towards an update of the operational system at dmi
- Flow (ocean and ice) through the Nares Strait limited described by models
- Challenging area for models
- One of the main sources for export of sea ice and fresh water from the Arctic
- Main focus of this talk is a validation with a 3 year hindcast
Domain

- Grid size 4-10 km
- 110x180x22 grid points
- Minimum 8 grid points across the strait
- Flow of sea ice and water is generally towards south
- Local winds are important
Overview Coupled model

- HYCOM: hybrid vertical Layered ocean model
- CICE: dynamic (EVP) and thermodynamic sea ice model
- Lateral boundary conditions:
  - Salt
  - Temperature
  - Currents (baroclinic and barotropic)
  - Barotropic pressure
  - Sea ice volume and energy
- Bathymetry: Etopo 1
## Simulation

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Hind cast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test of timing of events and validation of model setup</td>
<td></td>
</tr>
<tr>
<td>Lateral boundary</td>
<td>15km HYCOM+EVP sea ice (Nansen center)</td>
</tr>
<tr>
<td>Atmospheric forcing</td>
<td>HIRLAM 5km</td>
</tr>
<tr>
<td>Period</td>
<td>September 2005 – August 2008</td>
</tr>
</tbody>
</table>
Variation of the relative ice cover

- March 2006 – August 2007
- Full ice cover in winter
- Baffin Bay and Nares Strait ice free/ almost ice free
Ice flux – satellite observations

- 1996 – 2002
- 3 day drift averages
- Annual area ice Flux: $15 - 45 \times 10^3 \text{km}^2 \text{y}^{-1}$
- 06/07: $80 \times 10^3 \text{km}^2 \text{y}^{-1}$
- Assumes 4m thick ice
- Source: Ron Kwok (2005+2010)
Sea ice cover and flux

**Ice flux**

![Ice flux graph]

<table>
<thead>
<tr>
<th></th>
<th>Area flux (10^3 \text{km}^2/\text{year})</th>
<th>Volume flux (\text{Km}^3/\text{year})</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>2007</td>
<td>69</td>
<td>120</td>
</tr>
</tbody>
</table>

App. 80% of what is measured
Modeled sea ice cover compared to satellite images
North Water Polynya

- **Latent heat polynya:** Sea ice is advected away from the coast and new ice is formed due to latent heat
- Inuit’s know the place as a dangerous but great place to hunt
- Earlier spring bloom, large biological activity
Early opening 2006

2/13 model

2/13 satellite

Wind friction [N/m²]

01/29 02/05 02/12 02/19 02/26 03/05
Summer opening 2006 ice cover model (M) and satellite (S)
SST model (M) and satellite (s)
Summer opening 29/6 2006

- Heat flux keeps polynya open
- No sign of upwelling

Month

°C
T/S profiles

Database source: Kliem and Greenberg (2003)
General ocean flow

- Ssh Gradient in the Nares Strait
- Current from Greenland and round
- General flow is southward
Ocean flux - hindcast

- Expected volume flux 0.5 – 1 Sv
- Fresh water flux
- 25 msv (Münchow, Rabe + others)

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume Flux (Sv)</th>
<th>Freshwater flux (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>0,6</td>
<td>12</td>
</tr>
<tr>
<td>2007</td>
<td>0,9</td>
<td>18</td>
</tr>
<tr>
<td>2008</td>
<td>1,3</td>
<td>29</td>
</tr>
</tbody>
</table>
Conclusions

• General ice cover agrees reasonably well
• Modeled ice cover is slightly higher in winter and slightly lower in summer
• Large variation of the sea ice flux. Slightly less than measured by satellite images
• Volume ice flux is lower than expected due to too thin ice
• Ice flux is Connected to the formation of the ice bridge
Conclusions

- Modeled ice bridge is not as stable as the observed
- North Water Polynya in February opens at the same time as the measurements
- Heat flux from the atmosphere keeps polynya open in summer
- Reasonable oceanic transport
Thank you for your attention. Questions?