Towards a Regional Arctic Climate Model for SEARCH

Wieslaw Maslowski
Naval Postgraduate School

Collaborators: J.C. Clement, J. Dixon (NPS)
W. Walczowski, R. Osinski (IOPAN)
W. H. Lipscomb, E. Hunke (LANL)

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9-km Coupled Ice-Ocean Model

1. New IBCAO bathymetry
2. New hydrographic climatology (PHC)
3. Freshwater sources from river runoff (Yukon, Mackenzie, and Russian rivers)
4. Numerical tracers for Pacific Water, Atlantic Water, and river runoff
5. Completed +70-year integration (with ‘old’ sea ice model):
   - 48-year spinup with ECMWF reanalysis
   - 1979-2001 integration using realistic ECMWF fields
- General assumption: global change => melting of the Arctic Ice Cap; evidence in the 1990s
- Global climate models show largest climate variations and have largest errors there
- (Mis)representation of ocean – sea ice – atmosphere feedbacks is one of the main problems!
- Requirement of high resolution in each of the above components is another big problem!
- Large scale circulation in this region occurs via narrow (~100 km) boundary currents
- Outside communications via narrow and/or shallow passages
- Small-scale atmosphere/ice/ocean processes determine large scale interactions
- Vast shallow shelves receiving large fresh water runoff from rivers
- Radius of Deformation ~10 km – this model at 1/12-degree - eddy permitting
Atmospheric Forcing of Sea Ice Drift (m/s) and Concentration (%)

1982 Mean 10-m Wind Speed

1982 Mean Sea Ice Concentration
Sea Ice Thickness (m) vs Concentration (%) and Drift (m/s)
Atmospheric Forcing of Sea Ice Drift (m/s) and Concentration (%)

1992 Mean 10-m Wind Speed

2 m/s
Atmospheric Forcing of Sea Ice Drift (m/s) and Concentration (%)
Decadal Difference of Mean Atmospheric Forcing, Sea Ice Drift (m/s) and Concentration (%)

1992-1982 Mean 10-m Wind Speed
Decadal Difference of Mean Sea Ice Thickness (m), Sea Ice Drift (m/s) and Concentration (%)
1992-1982 Difference of Mean Sea Ice Thickness (m)
Atmospheric Forcing of Sea Ice Drift (m/s) and Concentration (%)

2001 Mean 10-m Wind Speed
Atmospheric Forcing of Sea Ice Drift (m/s) and Concentration (%)
Decadal Difference of Mean Atmospheric Forcing, Sea Ice Drift (m/s) and Concentration (%)
Decadal Difference of Mean Sea Ice Thickness (m), Sea Ice Drift (m/s) and Concentration (%)
2001-1992 Difference of Mean Sea Ice Thickness (m)
1979-93 Sea Ice Thickness Anomaly Distribution - Movie
Arctic sea ice thickness anomaly time-series – area-averaged estimates from ERS altimeter

Ice thickness change > 0.6 m between 1998 and 2000, i.e. 2 years

Winter 01/02

S. Laxon, Nature 2003
1979-2001 Monthly Mean Sea Ice Area, Thickness, Volume Anomalies

- Sea Ice Area Anomaly
- Sea Ice Thickness Anomaly
- Sea Ice Volume Anomaly
Decadal Variability: Pacific Water Tracer Distribution (%) at depth 10-15 m

- Cyclonic shift
- Anticyclonic shift
Net Mean Heat Flux – Atlantic Layer (268-850m); Tref = -0.1°C

In – Out imbalance of ~1.8 TW suggests upward heat transport

- McPhee et al., GRL (submitted): NPEO measurements of increased upward oceanic heat fluxes over bathymetric features (i.e. Yarmak Plateau)
Net Mean Freshwater Flux – Upper Layer (0-220m), Sref = 34.70 ppt

Out – In imbalance of >16 mSv suggests source of freshwater

- McPhee et al., 1998: excess of fresh water at SHEBA camp crossing Chukchi Borderland
Summary / Conclusions

- Model simulates the cyclonic shift in the sea ice and ocean circulation during the late 1980s through mid-1990s (Maslowski et al., 2000)

- An opposite trend is modeled in the late 1990s through 2001 but sea ice area, thickness, and volume decreasing at least since 1997/98 (Maslowski et al., 2001)

- Large areas of mean net upward heat transport available for melting ice in the central Arctic Ocean (Dixon, 2003) – slow upward release of excess of heat imported into the Canadian Basin due to the warming regime – need oceanic heat flux measurements

- Model indicates that large scale changes of order 0(1 m) in the arctic sea ice thickness distribution may occur at relatively short time scales (1-5 years)

- Large-scale picture of spatial and temporal variability (e.g. ice thickness) – need to validate with remotely sensed / in situ data

- High resolution modeling: guidance to future field campaigns, boundary conditions to atmospheric and biological models - important step towards arctic ecosystem modeling (J.J. Walsh et al., 2003)

- 1957-present quality atmospheric data (ERA40) at resolution of ~100 km soon available for multi-decadal model integrations but …

- Need a high resolution regional arctic climate model to account for sea ice/ocean – atmosphere feedbacks and to approach issues of Unaami prediction and predictability – SEARCH legacy similar to El Nino prediction?
THE END