DATA ASSIMILATION OF OCEAN AND SEA ICE FOR FORECAST AND REANALYSIS WITH THE TOPAZ SYSTEM

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STATE OF THE ARCTIC, Miami, March 2010
Outline

- TOPAZ in the framework of *MyOcean*
- TOPAZ Model Free Run
  - HYCOM
  - Recent upgrades
- Data assimilation
  - Why EnKF?
  - Recent upgrades
- Applications in the Arctic
  - Fram strait model
  - Acoustic tomography
  - Icebergs drift prediction
MyOcean 2009-2012

Ocean monitoring and forecasting for:

1. Global Ocean
2. **Arctic Ocean (Nersc/Met.no)**
3. Baltic Sea
4. Atlantic North-West Shelves
5. Atlantic Irish-Biscay-Iberic area
6. Mediterranean Sea
7. Black Sea
TOPAZ System
Ocean and Sea Ice Models

Based on Hybrid Coordinate model
HYCOM (Bleck, 2002)

- 11-16 km grid cell resolution
- 28 vertical hybrid layers
  - Z-layers at the surface
  - Isopycnal layers on intermediate & deep waters
- Atmospheric forcing fields from ECMWF
- Ice dynamics from an elastic-viscous-plastic model (Hunke and Dukowicz, 1997)
- Thermodynamic fluxes from Drange and Simonsen,1996)

- 2 nested models in the Arctic
  - Fram strait
  - Barents Sea

TOPAZ3 SST May 1990 week 2
Model upgrades

- **Ocean Model**
  - From HYCOM 2.1 to HYCOM 2.2.12
    => Higher order vertical interpolation scheme (WENO-like PPM)
  - From 22 to **28** vertical layers (added target density specific for the Arctic)
  - River fluxes from hydrologic model (TRIP)
  - Prescribed inflow in the Bering Strait
  - ERA-Interim atmospheric forcing for the reanalysis

- **Sea Ice Model**
  - **New advection scheme (WENO)**
  - Tuning of $P^*$ (Sea ice strength)
TOPAZ : Model upgrade
Free run comparisons
### Ocean model major improvements

<table>
<thead>
<tr>
<th></th>
<th>TOPAZ3</th>
<th>TOPAZ4</th>
<th>Observed value</th>
<th>Positive is</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fram Straits (Net)</td>
<td>0.73 Sv</td>
<td>1.83 Sv</td>
<td>~2 Sv</td>
<td>Southward</td>
</tr>
<tr>
<td>Bear Island (Net)</td>
<td>1.08 Sv</td>
<td>2.00 Sv</td>
<td>2.2-2.5 Sv</td>
<td>Eastward</td>
</tr>
<tr>
<td>Nordic Sea (Northward) (Iceland-Færøe-Shetland-Scotland)</td>
<td>7.60 Sv</td>
<td>8.10 Sv</td>
<td>7-8 Sv</td>
<td>Northward</td>
</tr>
</tbody>
</table>

Improvement of the “critically important fluxes and water masses properties”
Minimum arctic sea ice better represented 2002-2007

Observed sea-ice from SSM/I, NORSEX algorithm

TOPAZ 3

Not Available

TOPAZ 4
Data Assimilation:
The Ensemble Kalman Filter
Sequential Data Assimilation (EnKF)
Recursive Monte Carlo Method

1. Initial uncertainty
2. Model uncertainty
3. Measurement uncertainty

Observations
Why EnKF since it is so costly?
Ice concentration multivariate update


=> Multivariate assimilation is process dependent
(different signs if ice is freezing or advected by the winds)
TOPAZ Real-time System

Observations

- Track sea level anomalies (CLS)
- SST (OSTIA)
- Sea Ice Concentr. (AMSR, NSIDC)
- Sea ice drift (CERSAT)
- Argo T/S profiles (Coriolis)

Runs weekly, 10 days forecasts

Ice drift and Track SLA are assimilated asynchronously (EnKF handle optimally correlation in 4D)
Applications

Acoustics

Icebergs

Marginal ice zone
Sea Ice Modeling in the Marginal Ice Zone

http://topaz.nersc.no/Knut/IceForecast/FramStrait/
Contact: dany.dumont@nersc.no

NERSC archive of ESA ENVISAT ASAR image, 24-10-2009
Integrated acoustic observing system for the Arctic

See poster today: Sagen & Sandven et al.
Session 2.2. Design and Optimization of an Integrated Arctic Observing System
Iceberg drift modeling
Climatology 1987-2005

Keghouche et al., (2009)

Keghouche et al., (submitted)  
POSTER SESSION 1  
TODAY 5:30-7:30 pm
Operational user ECMWF

Wave modelers *(J. Bidlot, ECMWF)*

- ECMWF is using TOPAZ data for operational wave forecasting
  - in the North Atlantic
  - until the ice edge.

- TOPAZ surface currents in ECMWF wave model
  - Hs: Small improvement of scatter index
  - Larger improvement for peak periods
  - But biases are slightly more negative

Figure 6: Wave height and peak period time series at buoy 42003 (East Gulf) for December 2007. The solid red line (f05j) is the run with currents and the dash blue line (ozy4) is the reference experiment.
LINKS & THANK YOU!

http://topaz.nersc.no
http://msc.nersc.no/
http://www.myocean.eu.org
http://www.arctic-roos.org

POSTER SESSION 1    TODAY 5:30-7:30 pm
“1.1 Advance in Arctic System Understanding ”: Modeling work on icebergs
“2.2 Design and Optimization of an Integrated Arctic Observing System”: Integrated Acoustic Observing System for the Arctic