TOPAZ4: development and plan

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TOPAZ system

- TOPAZ3: Atlantic and Arctic
 - HYCOM + EVP sea-ice model
 - 11- 16 km horizontal resolution
 - 22 hybrid layers
 - ECMWF forcing
- EnKF
 - 100 members
- Observations
 - Sea Level Anomalies (CLS)
 - Sea Surface Temperatures (NOAA)
 - Sea Ice Concentr. (AMSR, NSIDC)
 - Sea ice drift (CERSAT)
 - Argo T/S profiles (Coriolis)
- Runs weekly, 10 days forecasts







- TOPAZ represents the Arctic Forecasting Center in MyOcean project
 - MyOcean project is a major initiative in Europe:
 - 34 M€, 3 years duration 2009-2012
 - Coordinated by Mercator Ocean



- Aims at an operational marine core service for Europe
- TOPAZ duty:
 - Operational daily forecasts at met.no
 - 20-years reanalysis at NERSC
 - Demonstration of ecosystem model (HYCOM NORWECOM)
- TOPAZ system provides surface current to ECMWF wave model





TOPAZ4 What's new

- Ocean Model:
 - From HYCOM 2.1 to HYCOM 2.2.12
 - 28 layers (target density specific for the Arctic)
 - River fluxes from hydrologic model (TRIP)
 - Salinity relaxation fix
 - Port in the Bering Strait
- Ice Model:
 - New advection scheme (WENO)
 - Snow distribution
 - Tunning of P*
- Data assimilation progress:
 - AEnKF

NERSC

Assimilation of Ocean Color



Model innovation





River run-offs: Hydrological model and ECMWF data

hydrologic model (TRIP, Oki and Sud 1998) with ERA-interim run off



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River forcing - TRIP

Rivers in Asia on TRIP by 0.5°x0.5° mesh



Turn off salinity relaxation in the Gulf Stream

Small fix suggested by Mats Bentsen in order to avoid relaxation in the Gulf Stream. if (mod_sal-clim)> 0.5 psu then **do not relax.**

It avoids anomalous reduction of salinity for the water transported in the Nordic Sea.





Ice model

- •Multi-Category ice model coupled with HYCOM 2.2
- •New advection scheme (WENO)
 - \rightarrow Reduces some noise in the ice

•Data-assimilation in the multi-category ice model: Many more prognostic variables: (fice, hice, temp_profile)*nb_ice_layer + albedo, qbrine

which makes it more complex!





Snow module

•Two effects:

- Snow increases the albedo
- Isolates the ice

Probabilistic snow distribution:







Sensitivity to Sea ice strength (P*)

P* has high uncertainties, depends on the model resolution.

Test: Free run

NERSC

- little difference in winter
- ice holds longer in summer with larger P*





Model Inter-comparison & Validation (Free Run)





TOPAZ4-TOPAZ3 *Transport estimates*

	TOPAZ3	TOPAZ4	Observed value	Positive is
Fram Straits (Net)	0.69 Sv	2.0 Sv	~2 Sv	Southwards
Bear Island (Net)	0.85 Sv	2.19 Sv	2.2-2.5 Sv	Eastwards
Nordic Sea (Northwards) (Iceland-Færoe-Shetland- Scotland)	7.68 Sv	7.76 Sv	7-8 Sv	Northwards



Improvement of the "critically important fluxes"



TOPAZ4-TOPAZ3 Salinity

- Better penetration of Atlantic water
- Corrected the salt bias in the Arctic, **BUT**
 - corrected too much and have fresh bias
 - too much salt in the Labrador Sea

Solution:

- reduce the port in Bering Straits
- •increase thklms $(10 \rightarrow 15)$ + relax fix







TOPAZ V3



Sea ice

- Free the western side of Svalbard
- Narrower tongue north of Greenland
- Ice extends (usually) further south





TOPAZ4 & Validation (Free Run)





TOPAZ4 Validation vs. climatology











TOPAZ4 Validation *"North Atlantic"*





TOPAZ Validation *"Fram Straits"*



Progress in Data Assimilation





Assimilation of asynchronous data: AEnKF

Asynchronous data: Satellite track (SSH, SST), ice drift, profile

The AEnKF based on the EnKS solution and is essentially equivalent to 4DVAR without a need for the adjoint.

Method:

Store HX_t ' matrix while running the model at time and location of obs

 $X_{t=t0}^{a} = X_{t=t0}^{f} + X_{t=t0}^{f'} HX_{t}^{T} H^{T} (HX_{t}^{T} (HX_{t}^{T})^{T} + R)^{-1} (Y_{t} - HX_{t}^{T})$

- X : Ensemble of model state (η ,t,s,u,v,thk); (a:ana; f:forecast)
- X': centered ensemble (X'=X-X)
- Y : Perturbed observations
- H : interpolates from model grid to observation
- R: Observation error covariance





Assimilation of Ocean Color in TOPAZ-ECO

Net primary productivity (mgC/m3 day)

Data:

Satellite Ocean Color

Coupled Model:

HYCOM-NORWECOM (7 variables)

Problems:

Coupled 3-dimensional physical-biological modelHigh-dimension

•Non-Gaussian variables

Utilities:

•Environment monitoring

•Fisheries

•Methodological developments for future coastal HR systems





Ehouarn Simon

Gaussian anamorphosis with EnKF

Anamorphosis: prior transformation of the variables in a Gaussian space (Bertino et al.)

Twin experiments (surface chlorophyll-a synthetic observations) Surface CHLa RMS error



Simon and Bertino (OSD, 2009)

Conclusion

• First runs of TOPAZV4 showed some improvements (ice, inflow of Atlantic Water, front sharpness) but need some more tuning

- A 20 year AEnKF reanalysis of TOPAZV4 will be launch on October 2010
- Assimilation of Ocean Color shows encouraging results in twin experiments and is currently tested in a realistic application



