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Objective: The ToPAZ system is designed to monitor and forecast the ice-ocean system primarily in the Arctic and Nordic Seas.

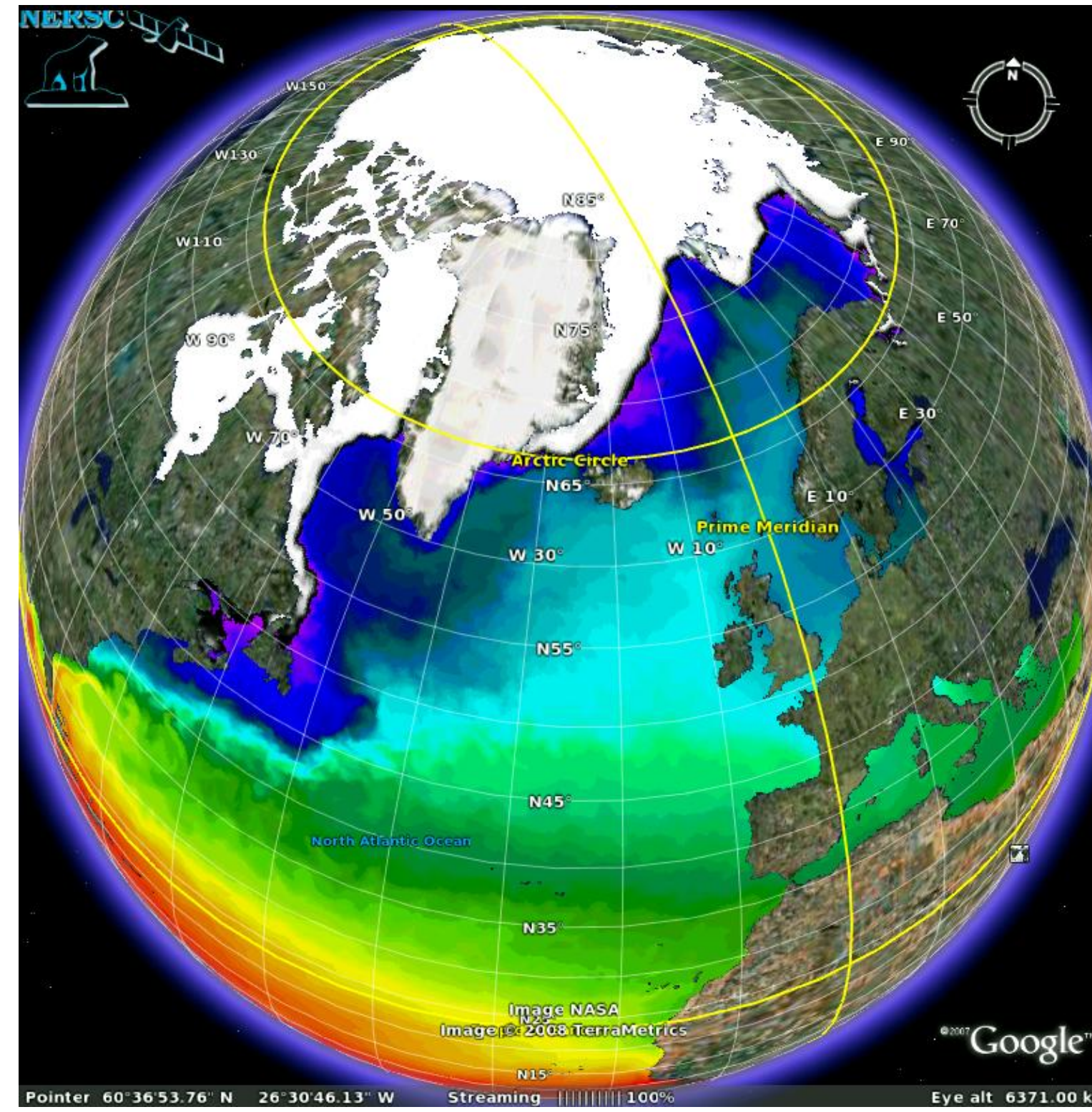
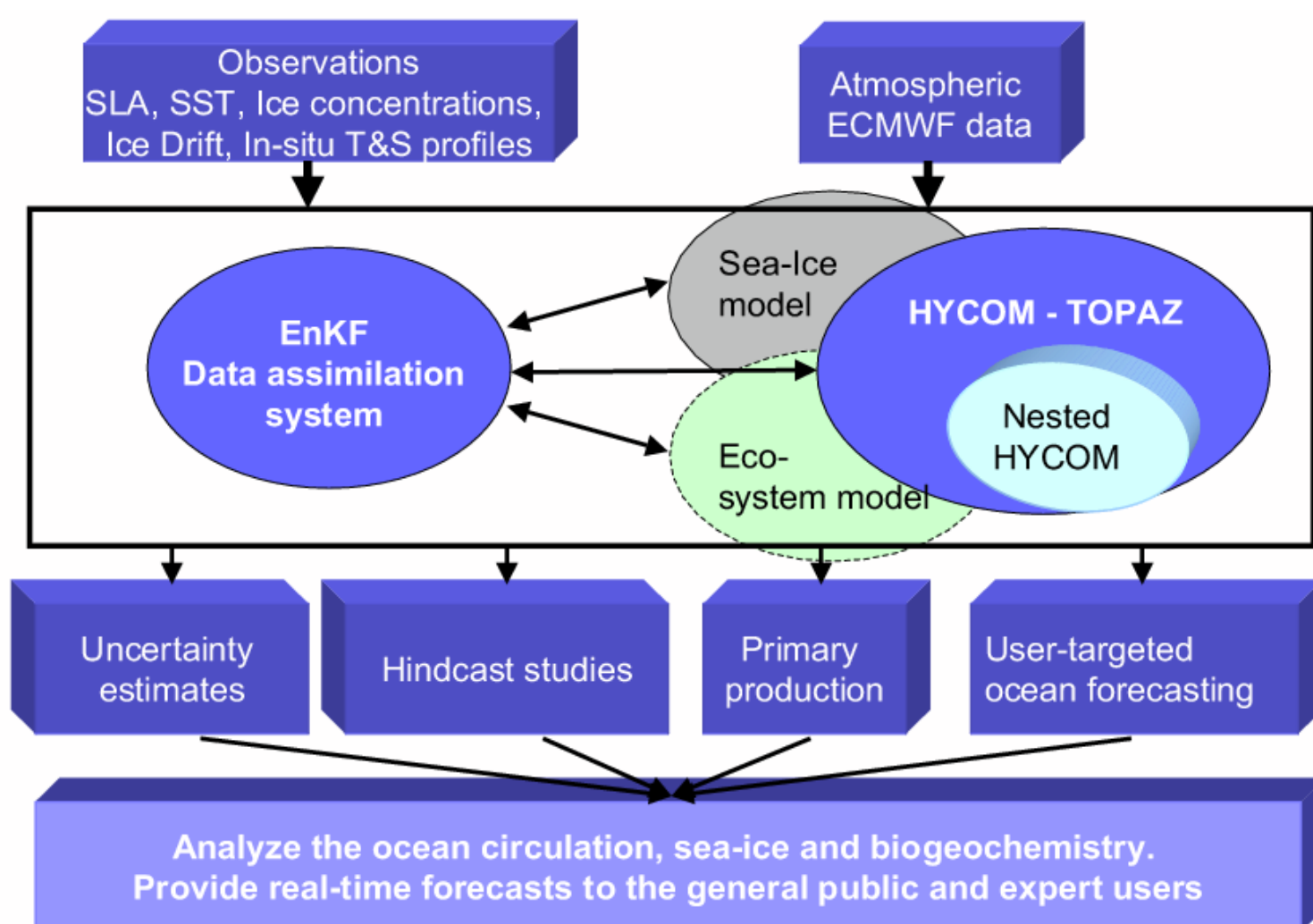
Principle: The ToPAZ system is based on an Atlantic and Arctic configuration of HYCOM and runs with the EnKF. An ensemble of 100 members provides multivariate flow-dependent error covariances and a single member provides a 10-days ocean and sea-ice forecast every week.

System evolution

MERSEA WP09

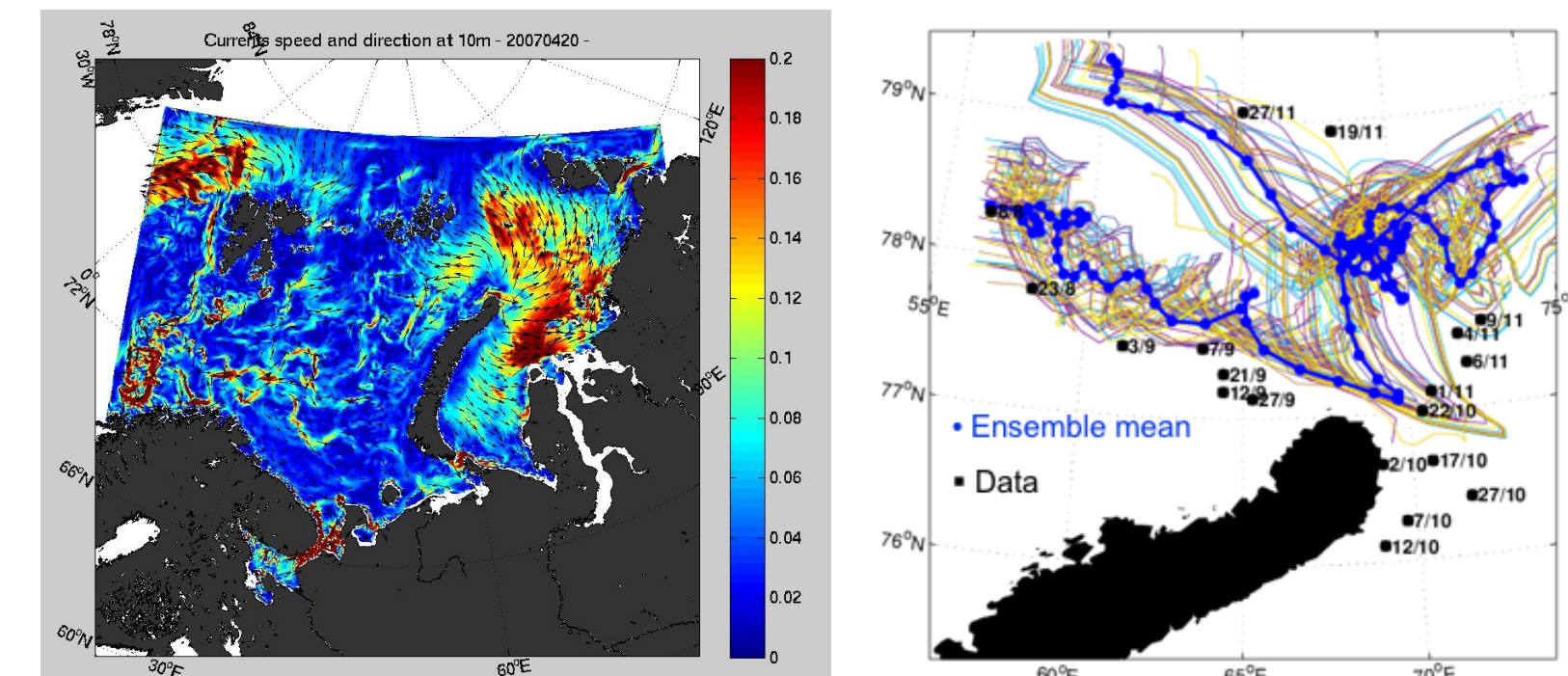
Successive MERSEA Arctic system versions:

- V0 (Apr. 2004): Assimilation of SLA from CLS, Reynolds SST and ice concentrations from SSM/I. Model horizontal resolution 18 km to 36 km.
- V1 (Oct. 2005): ToPAZ2, HYCOM upgraded v2.1. Live data service.
- V2 (Jul. 2007): ToPAZ3, Double horizontal resolution (11 km to 16 km) and assimilation of ice drift (from Ifremer). Tested nesting into the Global system.
- V3 (Jun. 2008): Assimilation of Coriolis T&S profiles, ecosystem demo.

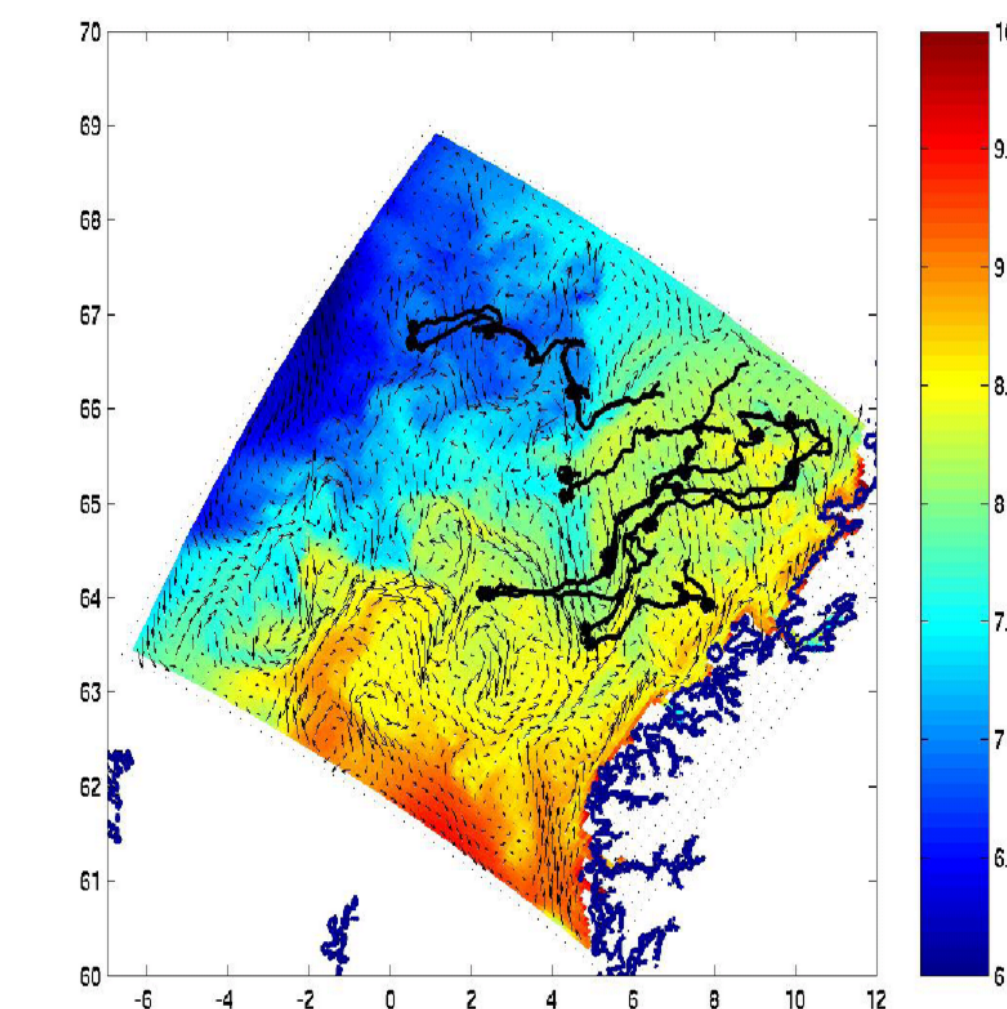


Regional systems and applications

MERSEA WP12

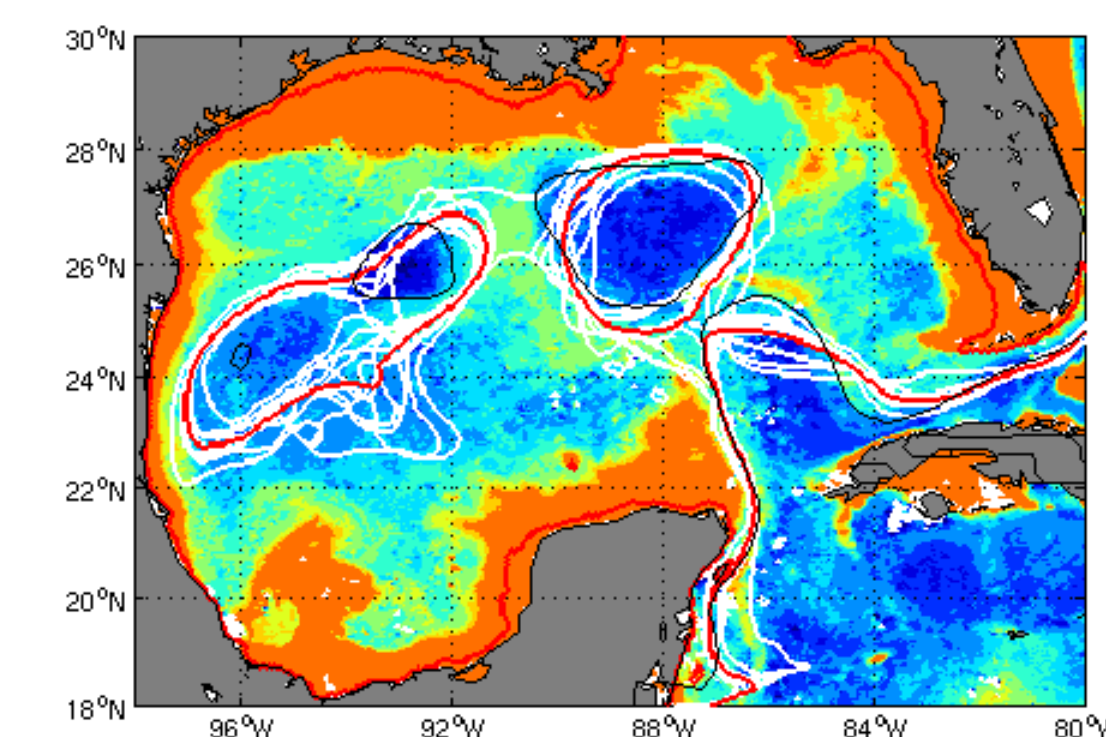


A nested HYCOM model has been set up in the **Barents and Kara Seas** with tidal forcing in order to drive an iceberg drift model. Ensemble iceberg drift against observations from the IDAP program in 1988.



Ecosystem modelling: Simulated drift of zooplankton in a nested 5 km resolution HYCOM model of the Norwegian Sea. The simulated zooplankton feeds on the output of a primary production model (the NORwegian ECOsystem Model, NORWECOM, from the IMR and Uni. of Bergen). Background, simulated SST from HYCOM.

A nested HYCOM model has been set up in the **Gulf of Mexico** with local assimilation of altimeter data using the Ensemble OI. An ensemble forecast has been tested for Eddy Yankee in July 2007 when the Eddy presented a threat to the oil and gas operations. We acknowledge partial funding from Shell E&P for the ensemble forecast study. The same model system has also been used to simulate the effect of tropical hurricanes on currents.



Ensemble forecast spaghetti of fronts (white), ensemble mean front (red), front deduced from altimeter (black) and ocean colour background on 19th July 2007. 7-days forecasts.

Users The TOPAZ system is used in the DAMOCLES Integrated Project of the International Polar Year (IPY) for downscaling to a high-resolution model of the Fram Strait and supporting acoustic tomography array design. It is used at met.no for oil spill monitoring, at ECMWF for wave forecasting, by the oil and gas industry for prospective studies for future gas exploitation in the Arctic. An improved sea-ice rheology for the Marginal Ice Zone will be implemented as a contribution from TOTAL E&P. The MERSEA Arctic system is contributing to the objectives of the Arctic ROOS.

Main findings

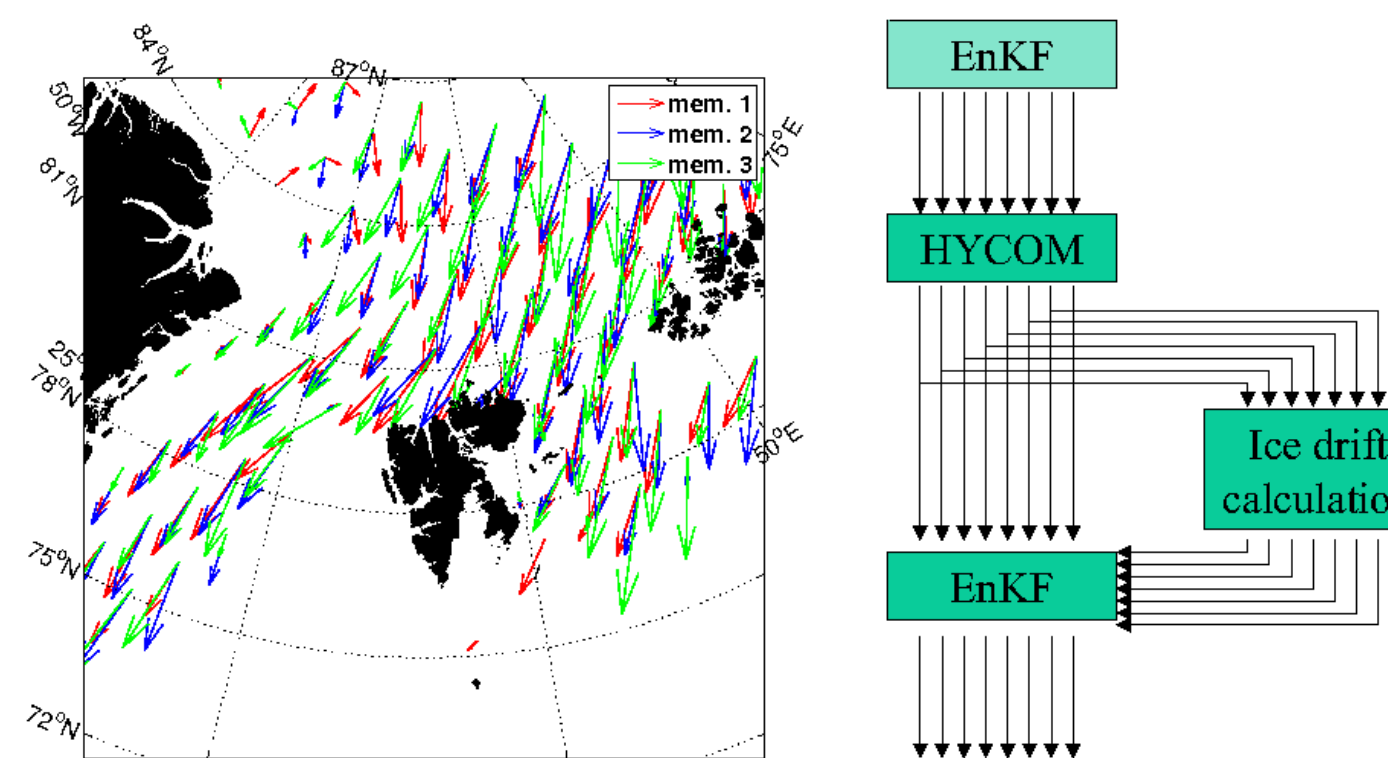
The TOPAZ system has undergone three successive upgrades and provided validation metrics during the two MERSEA Targeted Operational Periods (TOP1 and TOP2) showing that the upgrades have improved

- The circulation in the Nordic Seas.
- The inflow of Atlantic waters into the Arctic.
- The forecast efficiency in terms of sea surface heights and ice coverage.

The system has thus proven robust and flexible and shows promising perspectives for assimilation of additional datasets and ensemble forecasting, thanks to the use of advanced data assimilation.

Data Assimilation

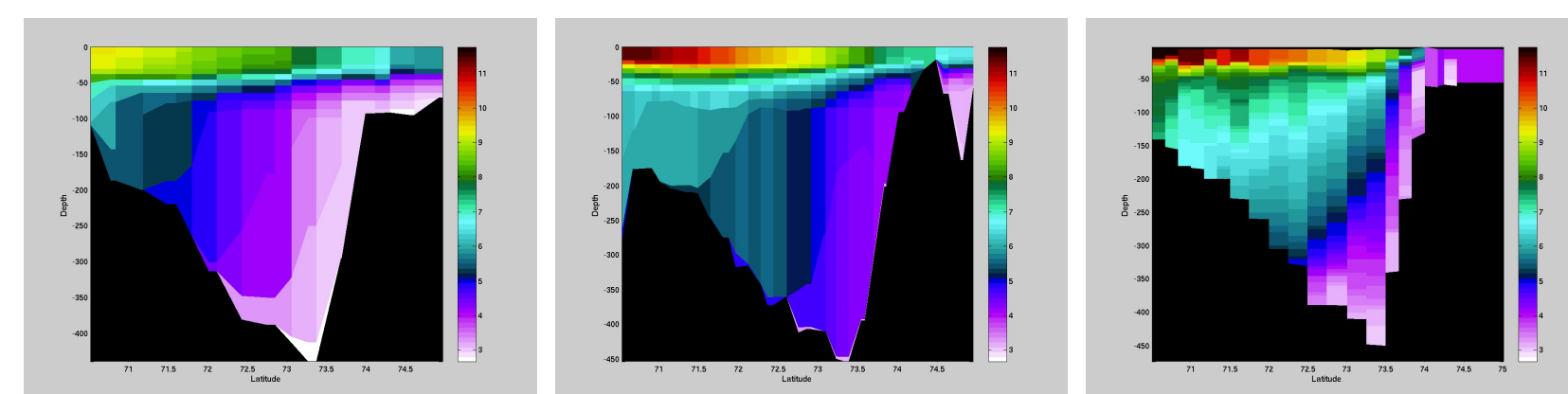
MERSEA WP07



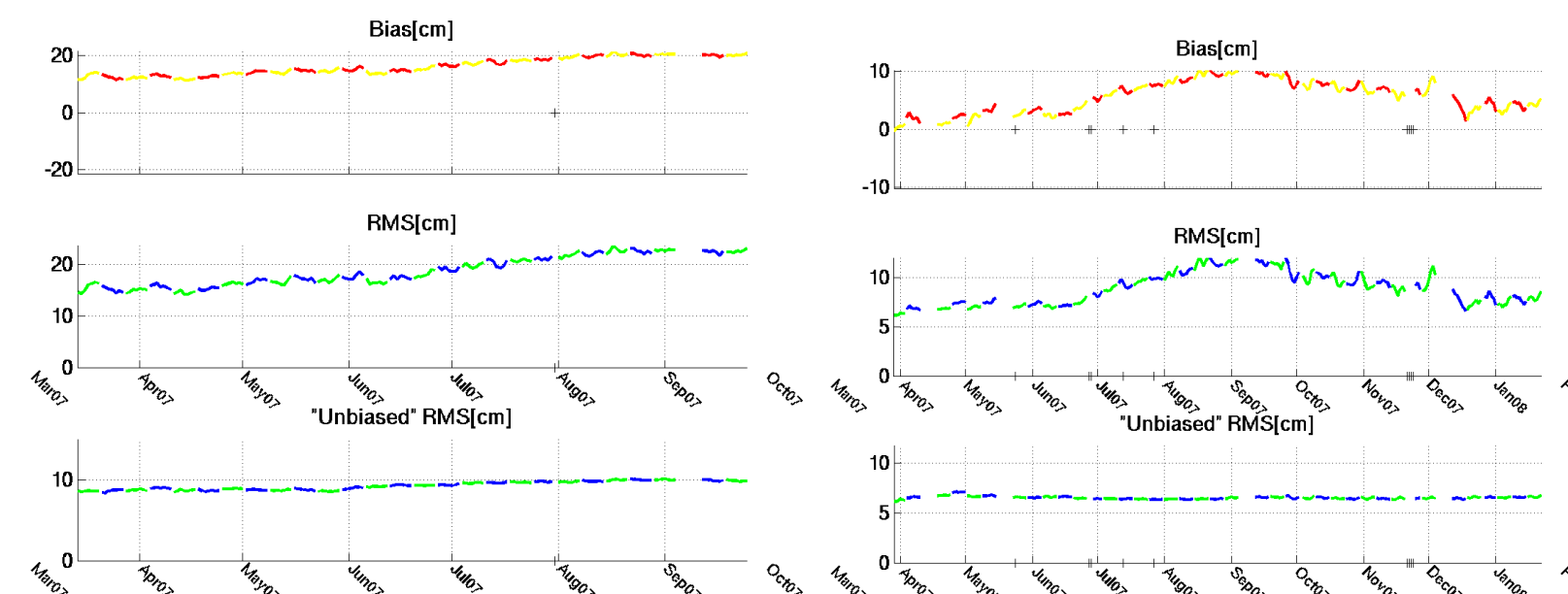
The assimilation of ice drift in ToPAZ illustrates the 4D assimilation capability with the EnKF. Left: sea-ice drift vectors from three ensemble members, right: the Lagrangian drift is calculated for each ensemble member and delayed ensemble correlations used to update all state variables at analysis time.

System Validation

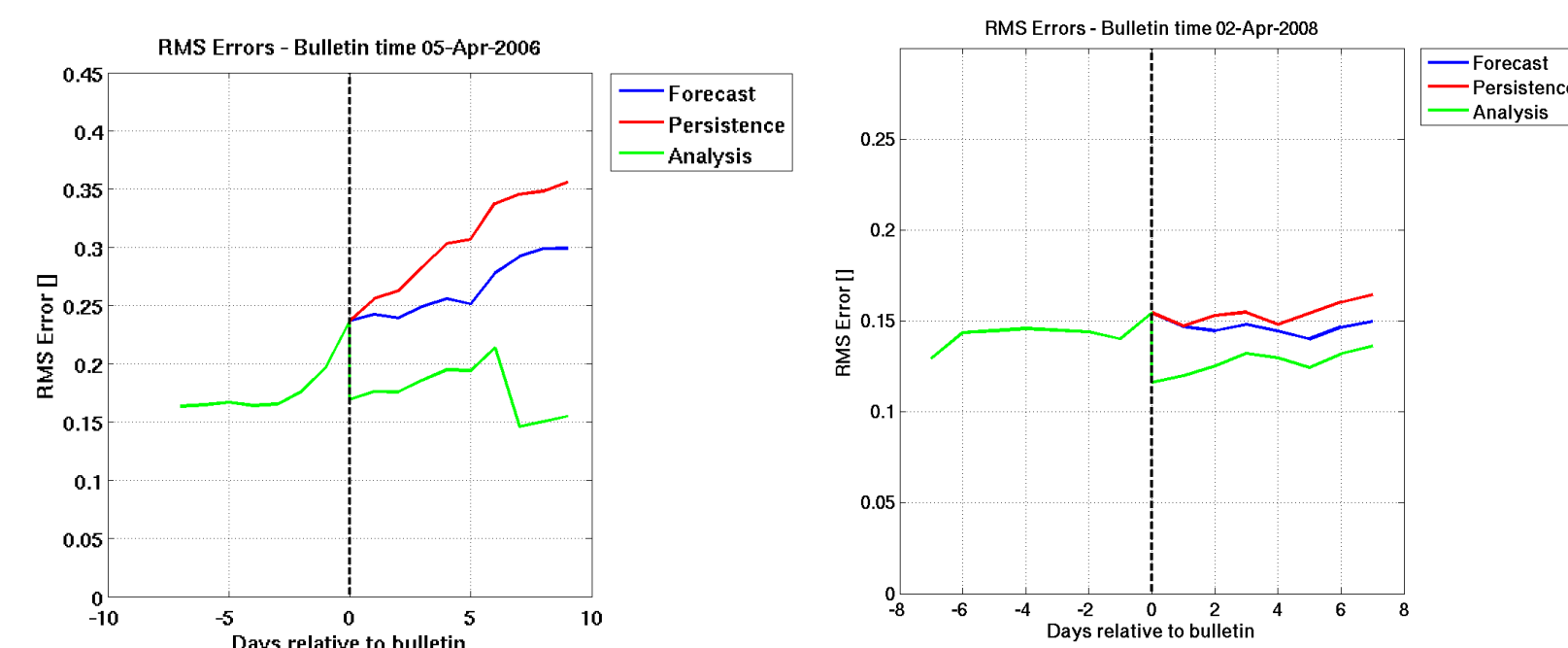
MERSEA WP09



Consistency. V1, V2 system and IMR temperature section from Norway to Bear Island in August 2007. The inflow of surface warm waters is improved in the new system as well as the vertical structure.



Accuracy. From the V1 to the V2 system, the performance of sea level anomalies in the Azores improved mostly due to increased model horizontal resolution.



Performance. Sea-ice forecasts in the Barents Sea in the V1 and V2 systems.

Plans The TOPAZ system is ported to met.no's operational suite and will continue providing Marine Core Services within the MyOcean project. NERSC will process a 20-years reanalysis by 2011, intended for climate, ecosystem research, marine safety, and different downstream services.

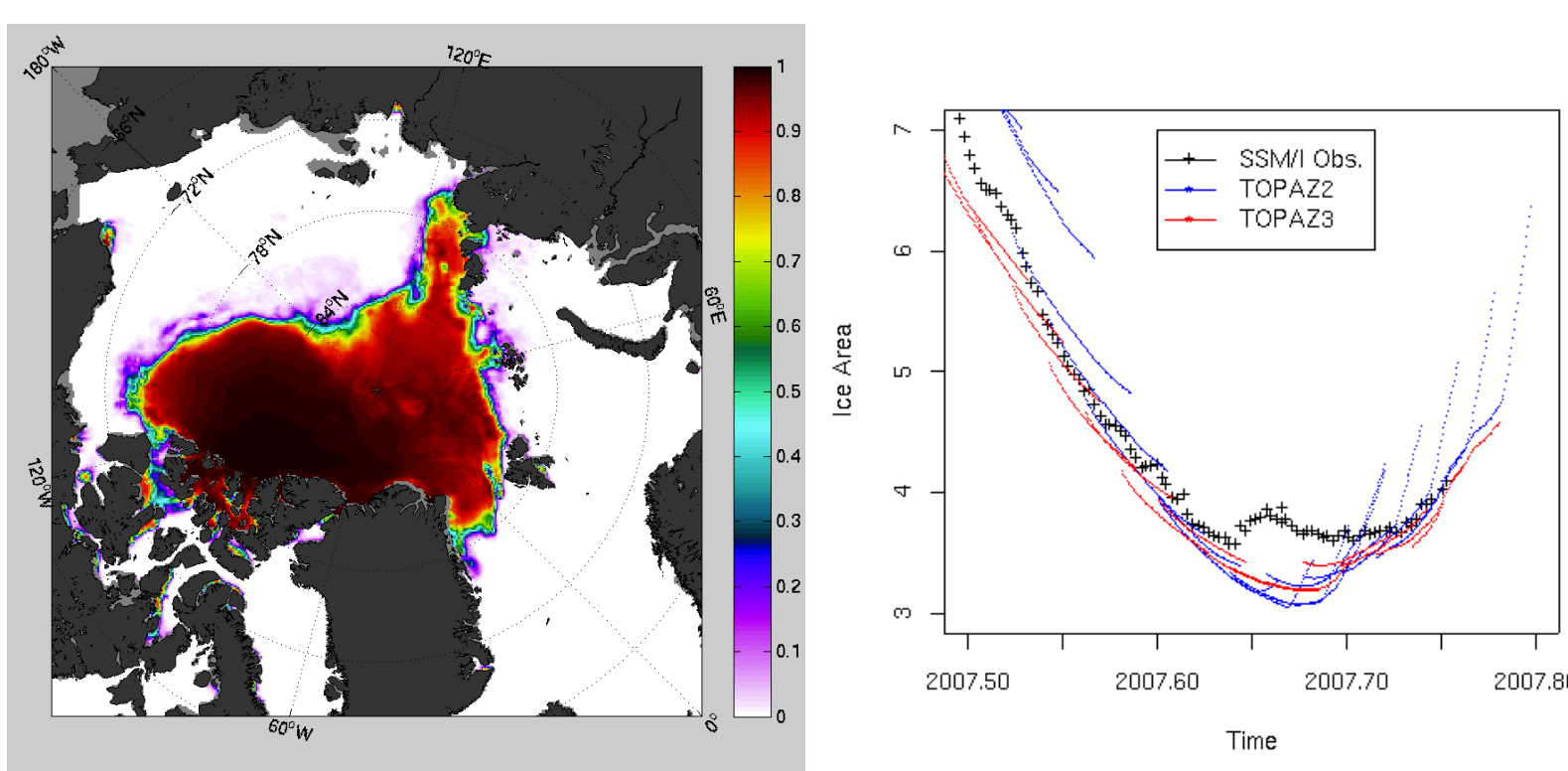
Products and indicators

MERSEA WP05

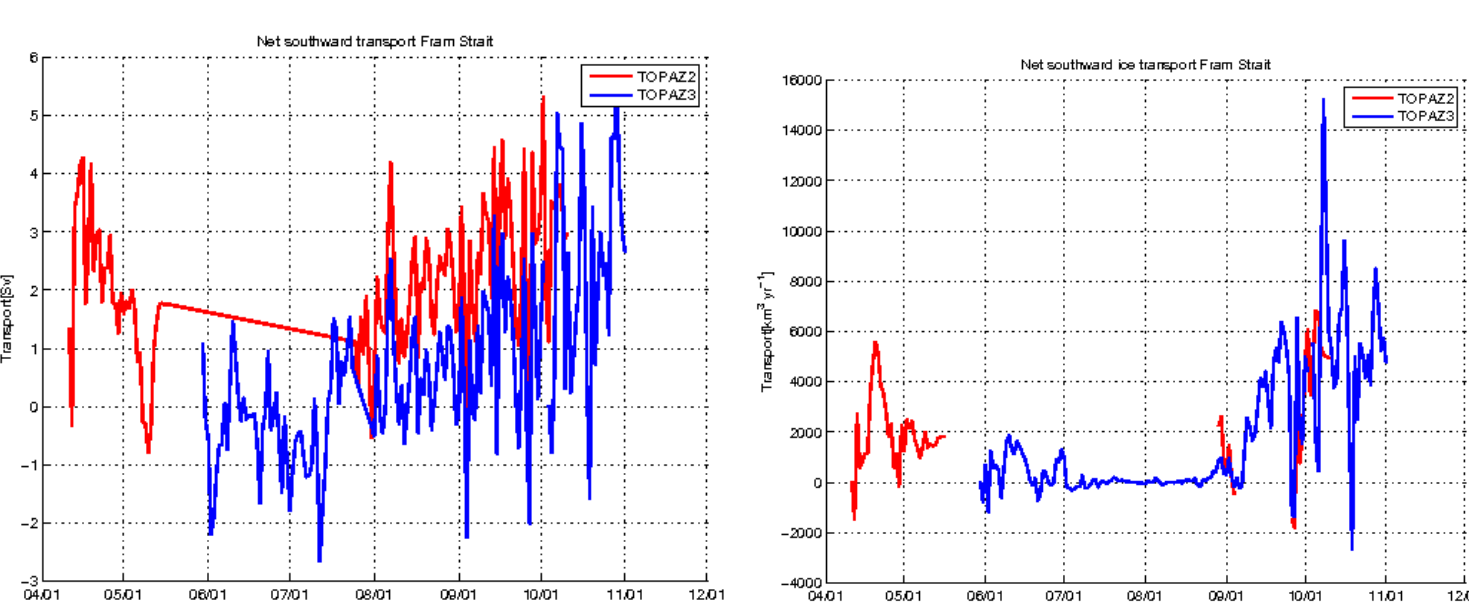
The Arctic system provides output along the MERSEA WP05 standards:

- Class1: 3D interpolated fields on a polarstereographic grid of resolution 12.5 km. Physical ocean and sea-ice variables.
- Class2: 2D sections and moorings in specific areas of the Arctic.
- Class3: Integrated sea-ice and water fluxes.
- Class4: Differences of forecast, nowcast and analysis fields to observations.

The products are NetCDF files provided on an OPeNDAP/THREDDS server. Most of the results on this poster can be reproduced from the data server: <http://topaz.nersc.no/thredds>



Successive 7-days analyses and 10-days forecasts of the **historical sea-ice minimum** in Sept. 2007, showing forecasts of the sea-ice minimum and of the following freeze-up. Left: ice concentrations from ToPAZ, 19th Sept. 07. Right: time series of ice area from ToPAZ and raw satellite data.



Examples of **indicators** provided by the ToPAZ system. Net volume transports (water to the left and sea-ice to the right) through the Fram Strait in 2007. V1 system in red, V2 system in blue.

Links

- ToPAZ home page: <http://topaz.nersc.no>
- Arctic forecasting system page: <http://arctic.mersea.eu.org>
- The EnKF distribution page: <http://enkf.nersc.no>
- The HYCOM home page: <http://www.hycom.org>
- The Arctic ROOS: <http://www.arctic-roos.org>

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