TOPAZ pilot reanalysis

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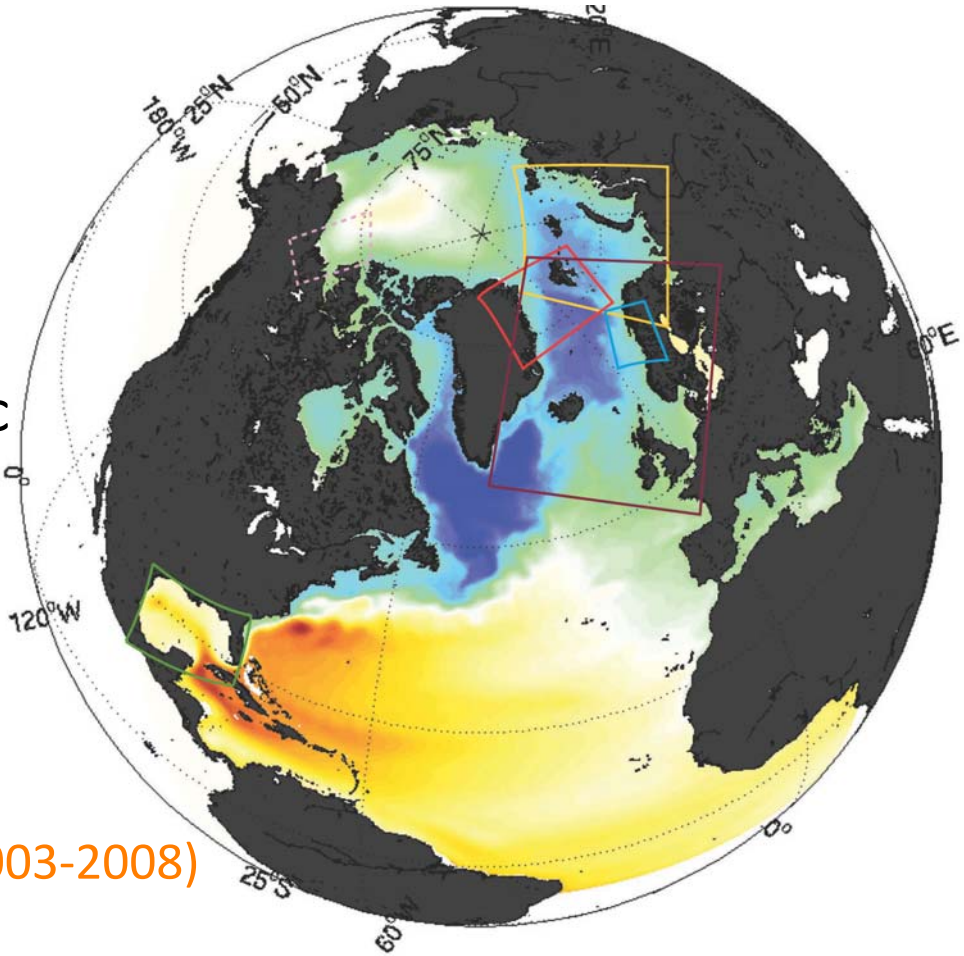
TOPAZ system

TOPAZ system is a forecasting system responsible for Arctic in MyOcean
MyOcean intends to set up a pan-European capacity for ocean monitoring and forecasting
Challenges in the Arctic:

- Mesoscale ~2-4 km
  → Nested model
- Few observations
- Non-linearity with ice dynamic
  → Advanced data assimilation



Some outcomes of the pilot reanalysis (2003-2008)

Model configuration

Common code and utilities (Nansen-Zhu; Nansen-Tutu, NERCI, Met.no):
https://svn.nersc.no/hycom/

TOPAZ :

- HYCOM 2.2
- 12-16 km horizontal resolution; 28 hybrid layers (sig-0)
- WENO PPM; GISS; FCT2; biharmonic viscosity
- ECMWF forcing (ERA-interim)
- Combined WOA05-PHC climatology
- SSS and lateral boundary relaxation
- Barotropic inflow in Bering Straits
- Rivers discharge computed from hydrological model (TRIP)+ERA-I
- Short wave flux recomputed every 3h (from clouds)

Ice model:

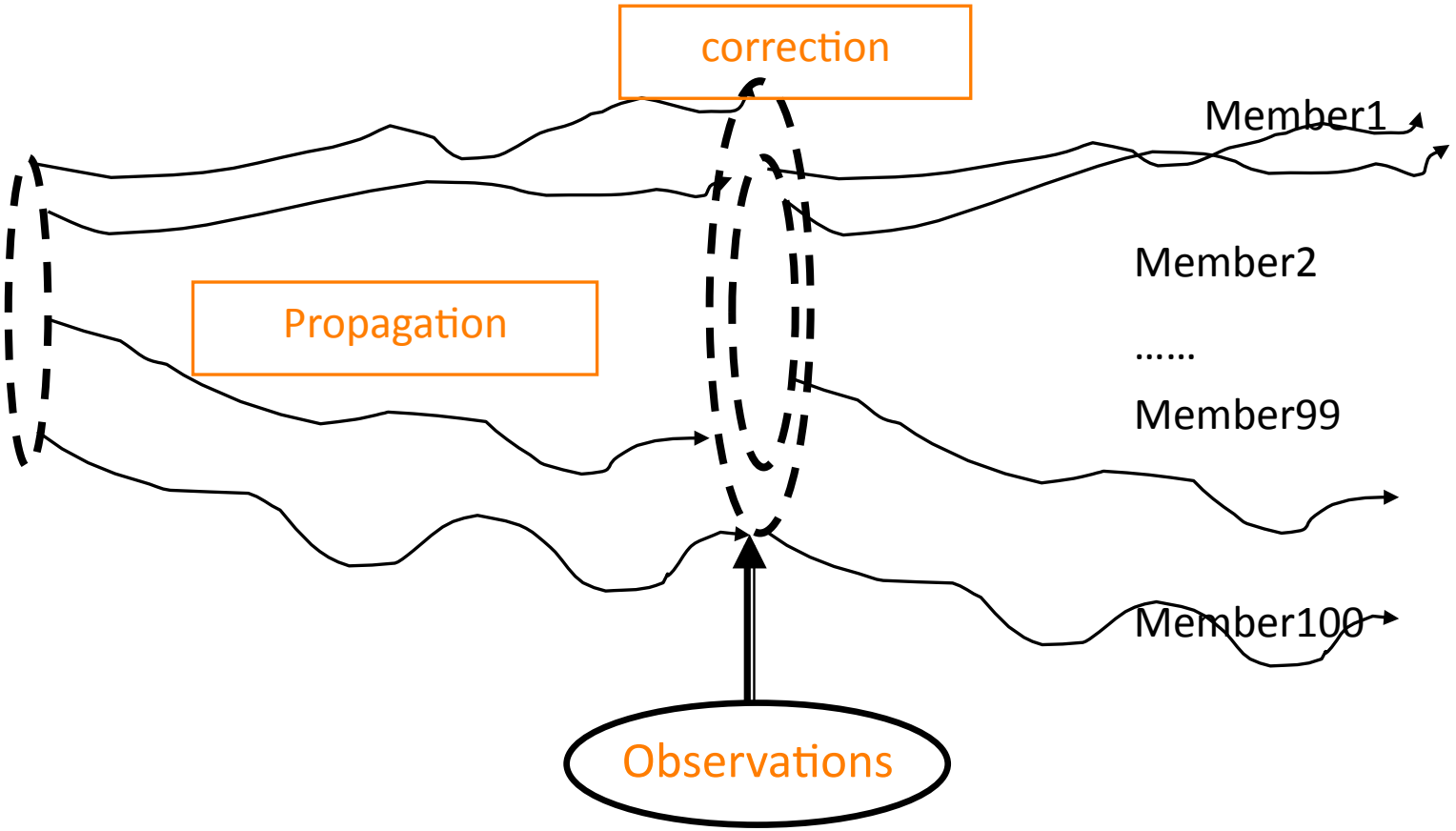
- Elasticous Viscous Plastic
- Single category
- Thermodynamic from Dange and Simonsen 96
- Advection WENO Runge Kutta 2nd order

Data assimilation

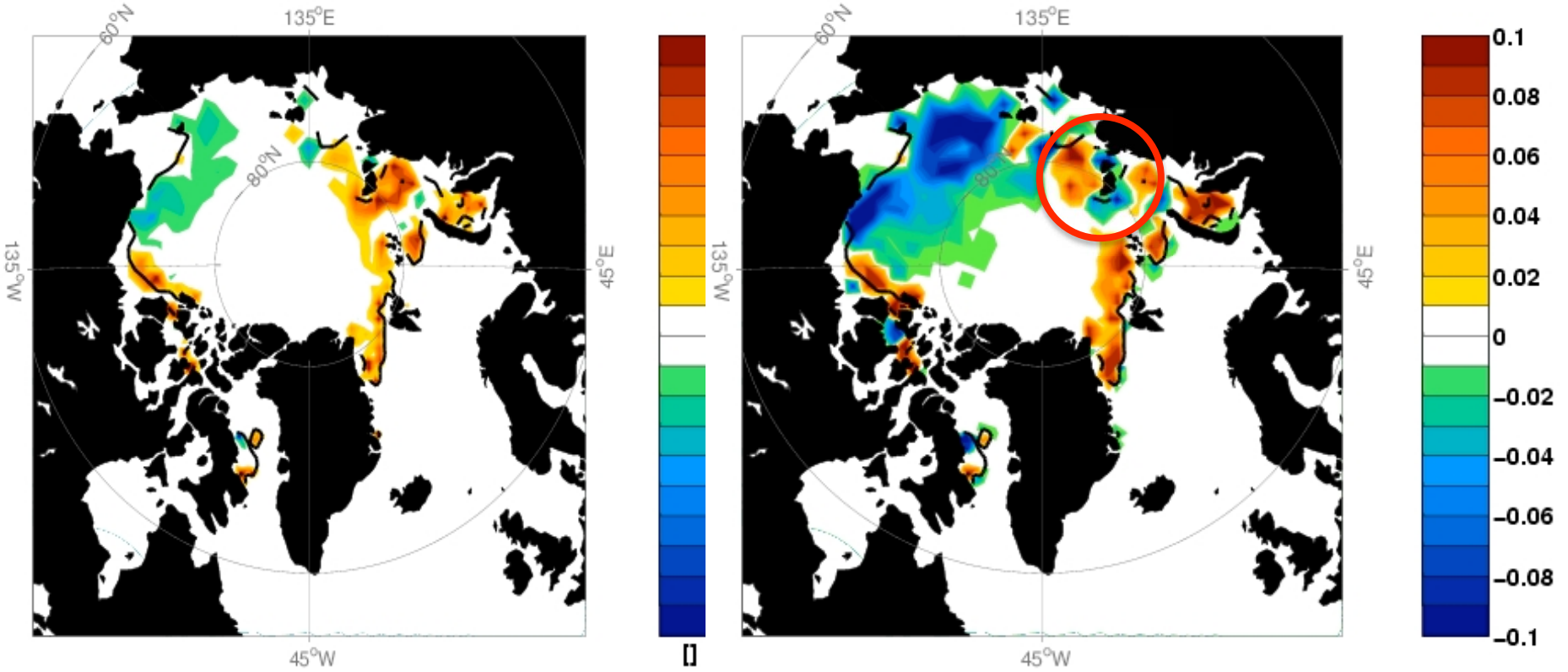
Statistic method based on ensemble (Monte-Carlo methodology)

Sequential data assimilation method:

- Propagation step (Ensemble spreads in chaotic region → proxy for error)
- Correction step (Estimate optimal model state from [model, error] [obs, error])



Flow dependent Multivariate
Ice concentration salinity



Ice concentration update

Surface salinity update

[Lisæter et al. 2003]

Data assimilation specification

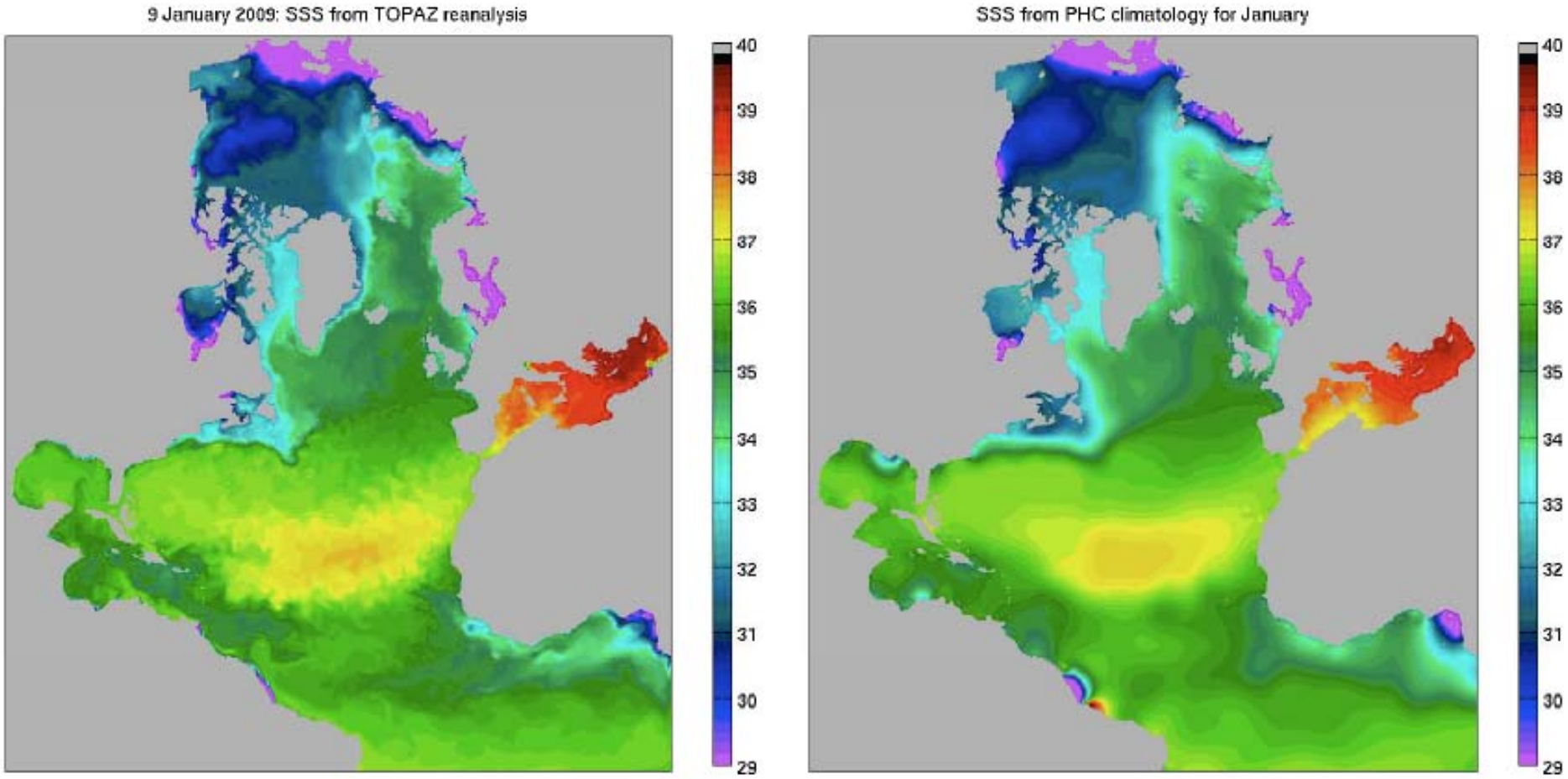
- Square root filter scheme (DEnKF)
- 100 members
- Assimilation window 1 week
- Asynchronous assimilation
  - Compare model and data at similar time
  - Account for correlation with time (as in 4DVAR)
- Localization (300 km; tapering with G&C)
- Solve analysis in observation/ensemble space (optimal numerically)
- Moderation
- Parameter estimation (SSH, SST, π^*)
- Inflation

Observations

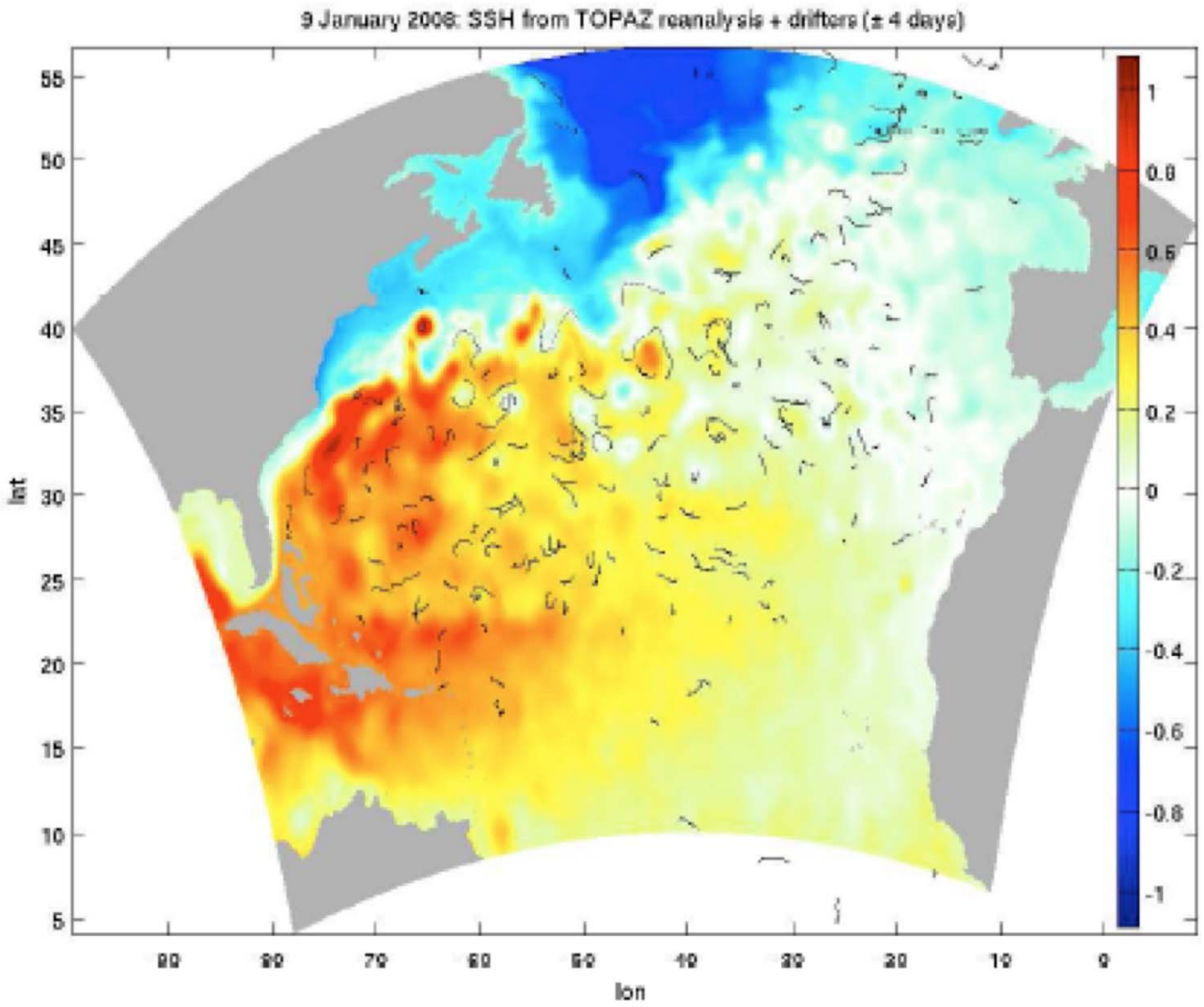
Type	Number	After SO	Asynchronous
Track SLA	$9 \cdot 10^4$	$4 \cdot 10^4$	Yes
SST (Reynolds)	$6 \cdot 10^3$	"	No
SST (OSTIA)	$2 \cdot 10^6$	$2.2 \cdot 10^5$	No
In-situ T	$2 \cdot 10^4 + 1.5 \cdot 10^4$	$6 \cdot 10^3$	No
In-situ S	$2 \cdot 10^4 + 1.5 \cdot 10^4$	$6 \cdot 10^3$	No
Ice conc. (AMSR)	$1.6 \cdot 10^5$	10^5	No
Ice drift (CERSAT)	$6 \cdot 10^3$	"	Yes
Total	$2.3 \cdot 10^6$	$4 \cdot 10^5$	

in situ includes: ARGO, ITP (IPY), Nansen database

Comparison to climatology (PHC)

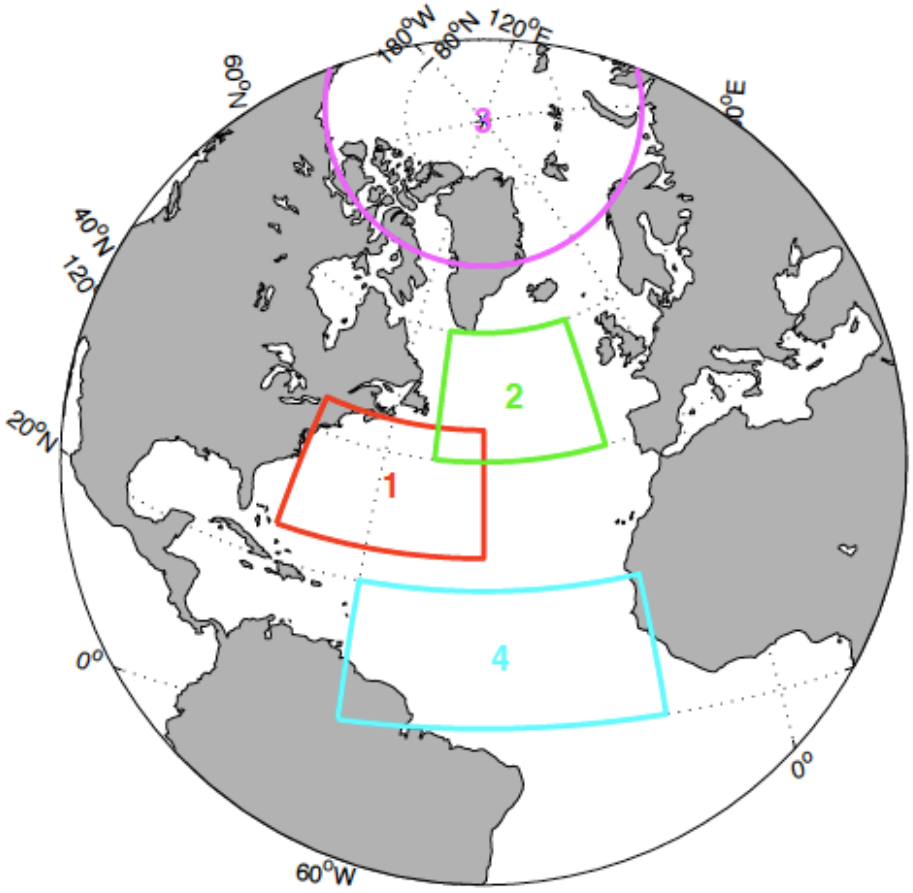


Drifter comparison

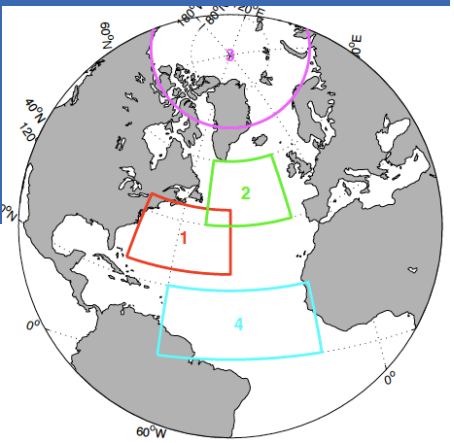


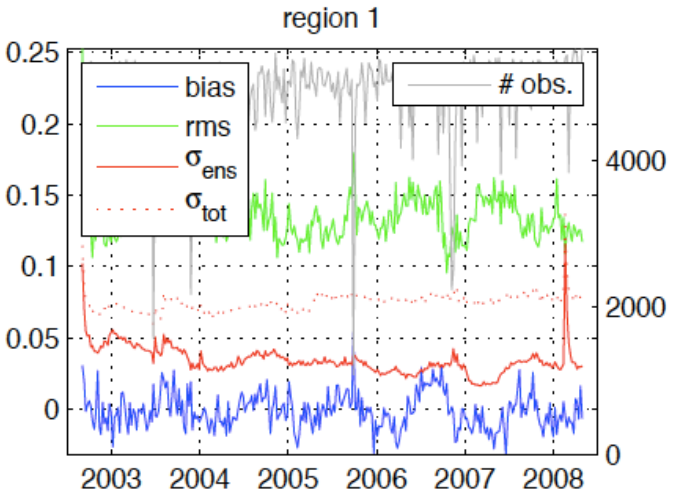
Innovation Statistic

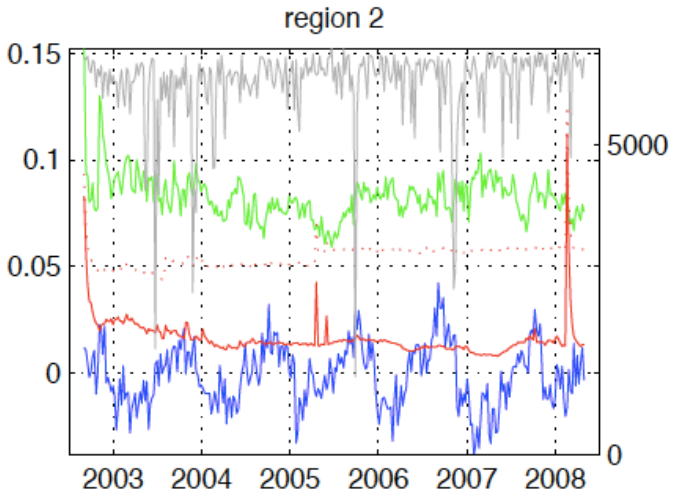
$$\text{innovation} = \mathbf{d} - \mathbf{H}\mathbf{x}^f = \text{observations} -$$ 7-day forecast

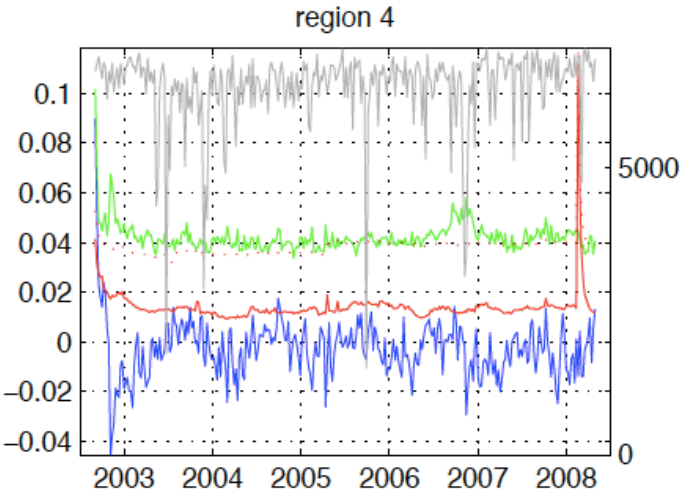


Innovation Statistic
SLA

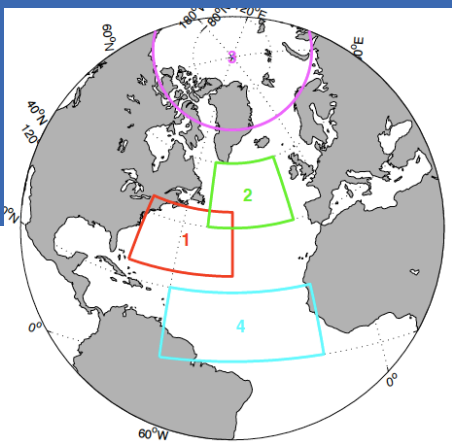


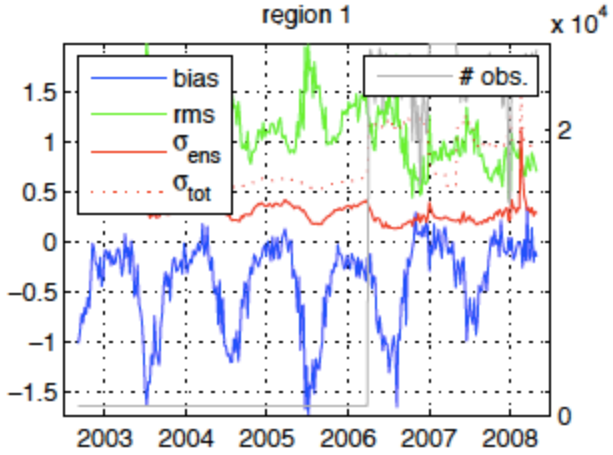


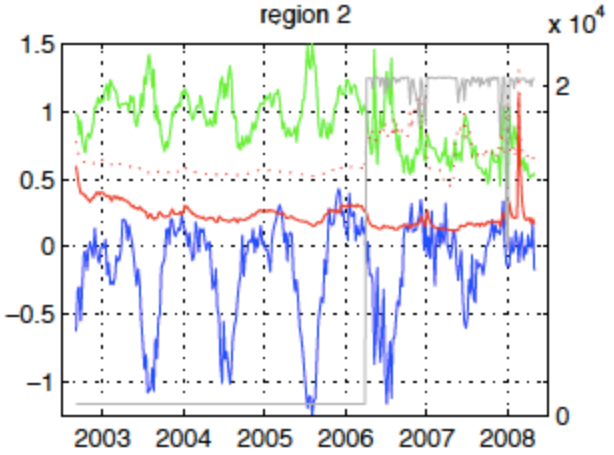


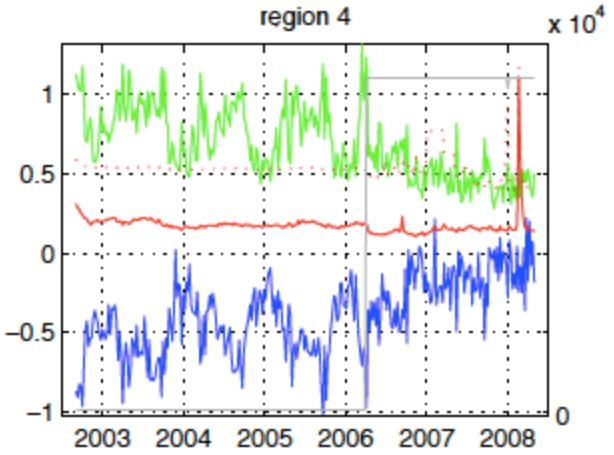


Innovation Statistic
SST





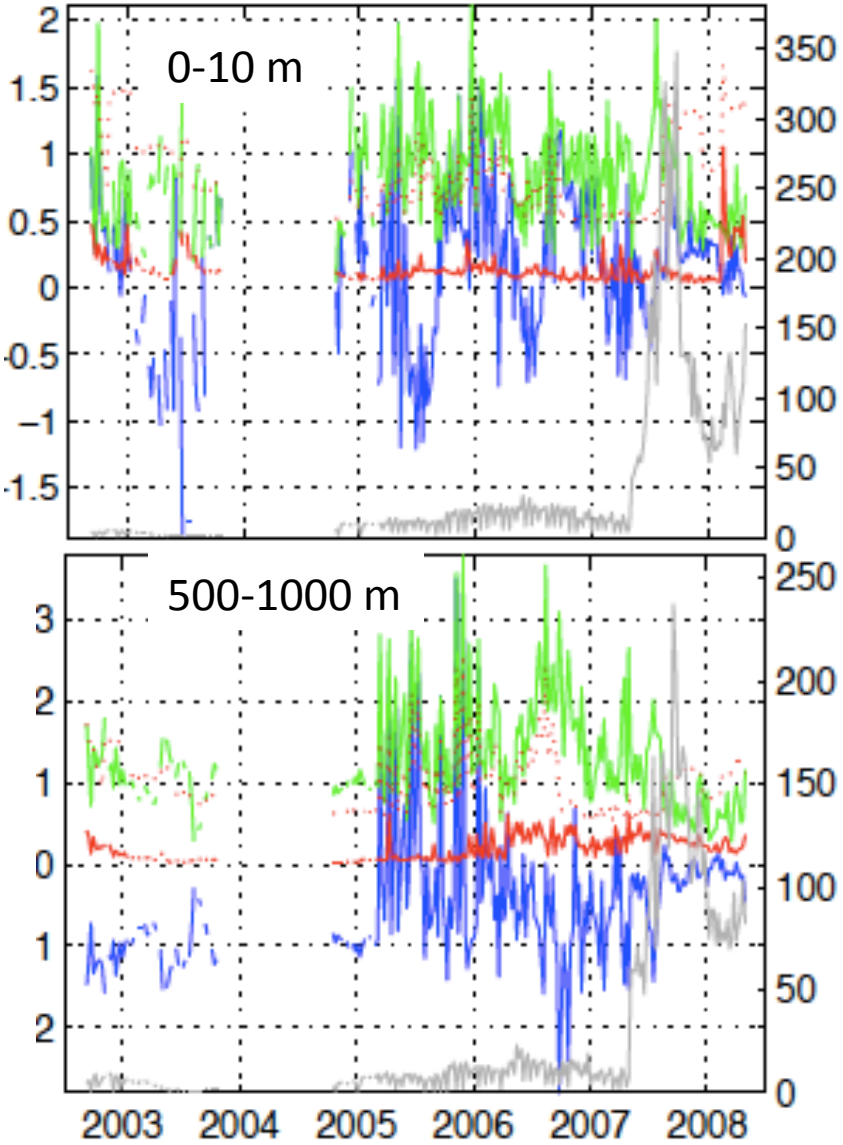


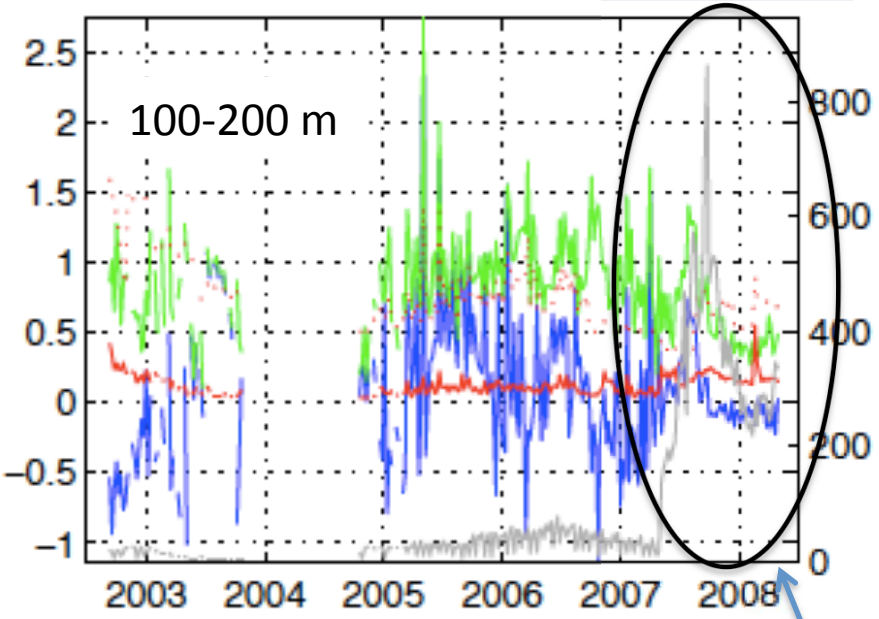


Large bias in the model:

- Seasonality ?
- Reduced once OSTIA data used
- Reduced with bias estimate

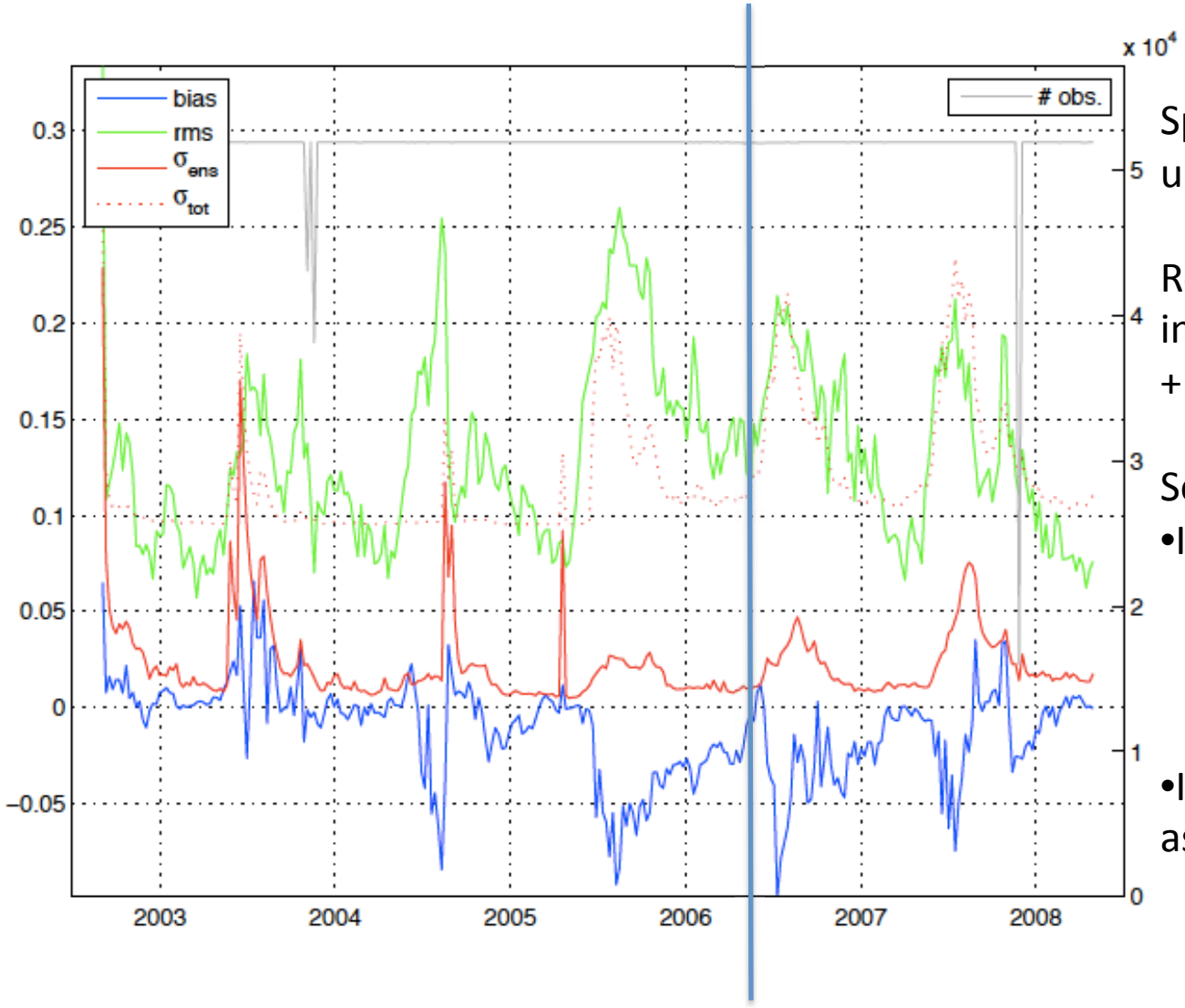
Innovation Statistic (Arctic) Temperature





Impact of IPY data (ITP)

Innovation statistic
Ice concentration



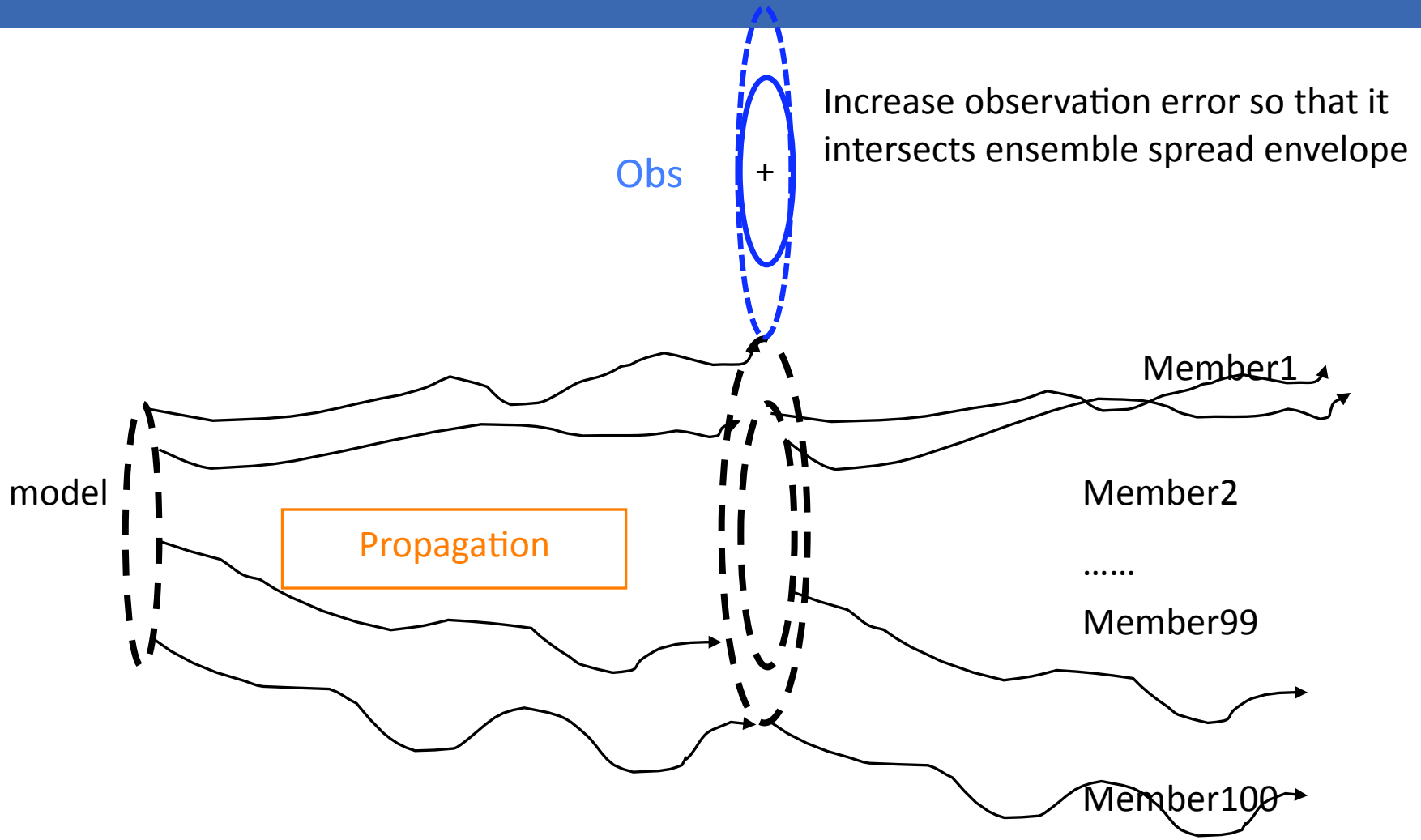
Spurious update appeared:
unrealistic pattern in sal, SSH

Result from combined
insufficient ensemble ice spread
+ spurious correlation

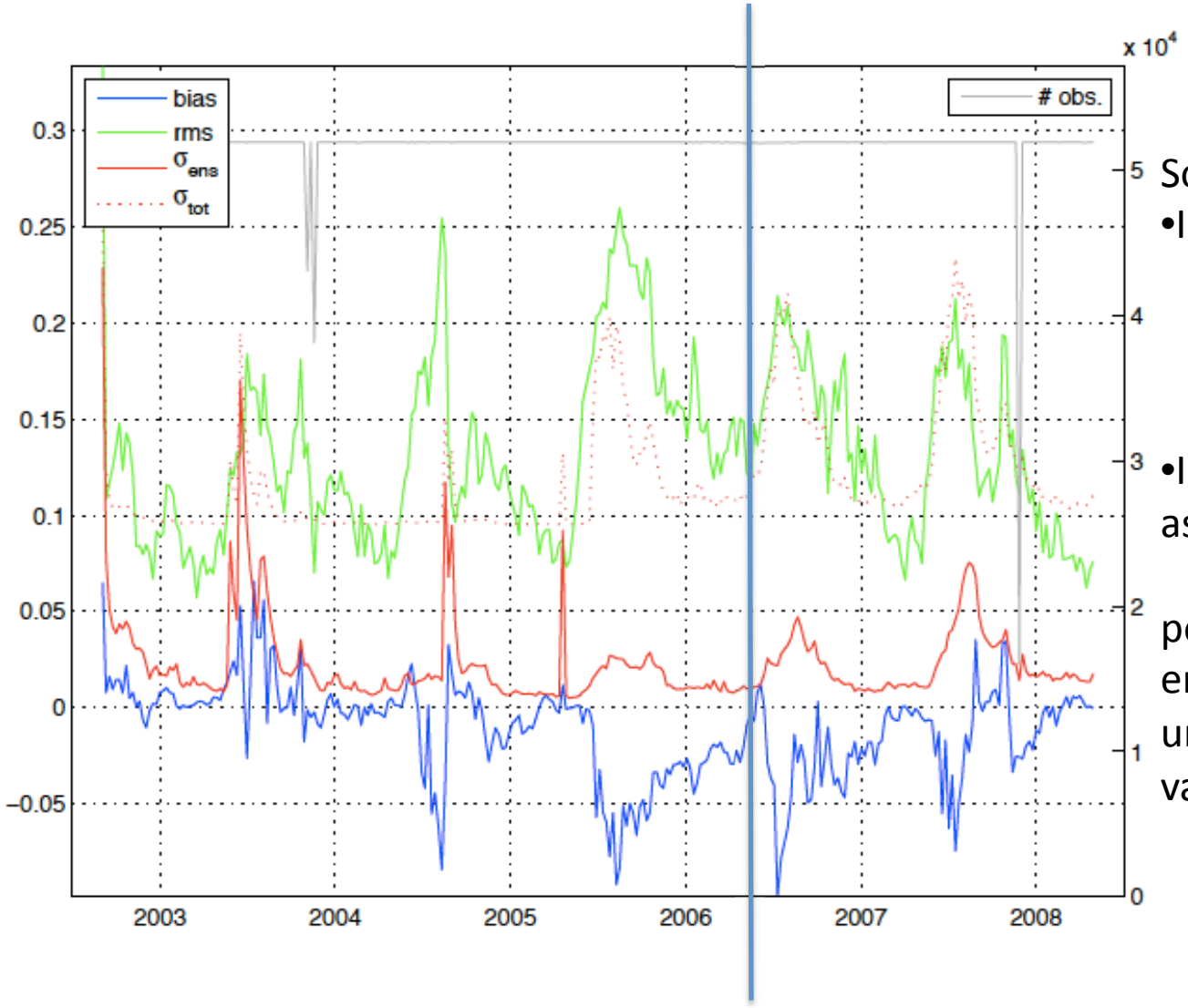
Solved by:

- Improved perturbation:
  - Precipitation
  - cloud
  - e^2 in EVP
- Introduced moderation in data assimilation

Moderation


Obs
+
Increase observation error so that it intersects ensemble spread envelope
Member1
model
Propagation
Member2
……
Member99
Member100

Innovation statistic
Ice concentration

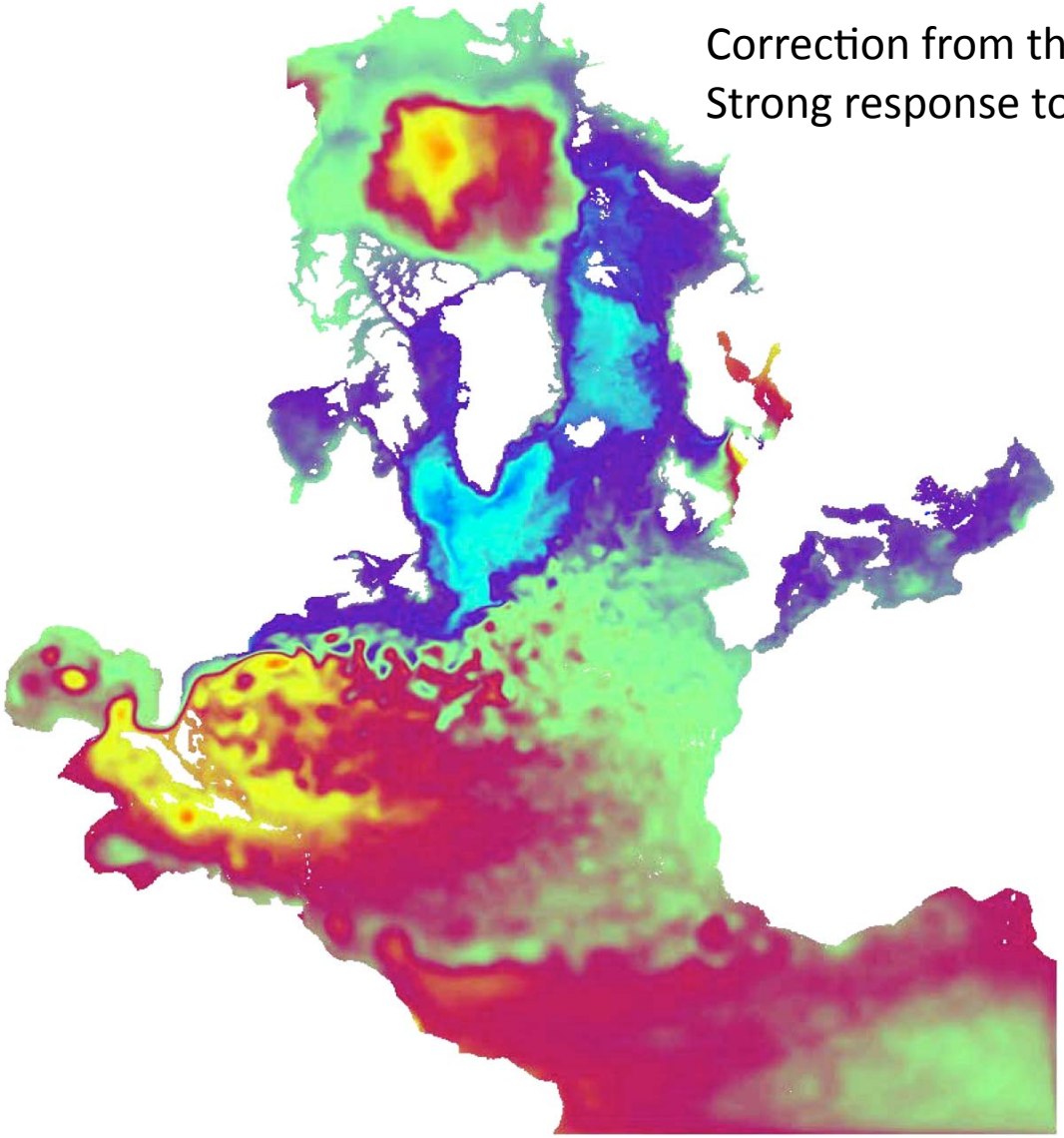


Solved by:

- Improved perturbation:
  - Precipitation
  - cloud
  - e^2 in EVP
- Introduced moderation in data assimilation

posterior to the change the error in icec reduces and the unrealistic pattern reduces or vanishes

SSH evolution



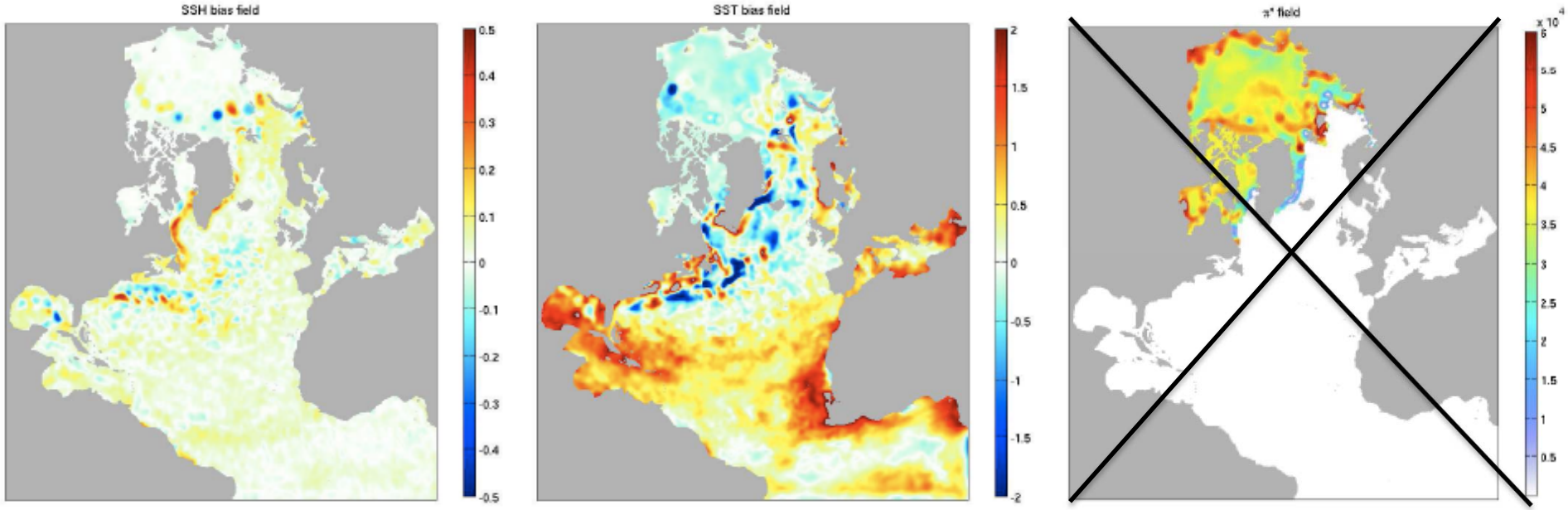
Correction from the unrealistic high SSH in the arctic
Strong response to ITP profile in the arctic

Parameter estimation

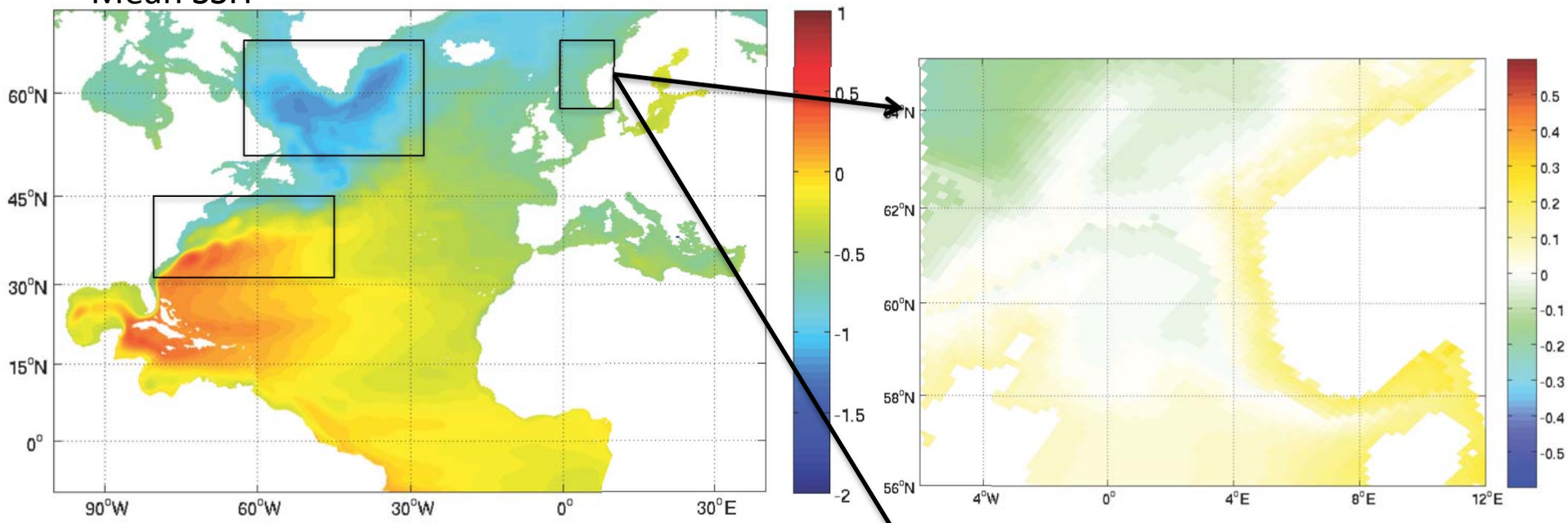
EnKF used to estimate unknown model parameter or model bias

Test made over 10 cycles for :

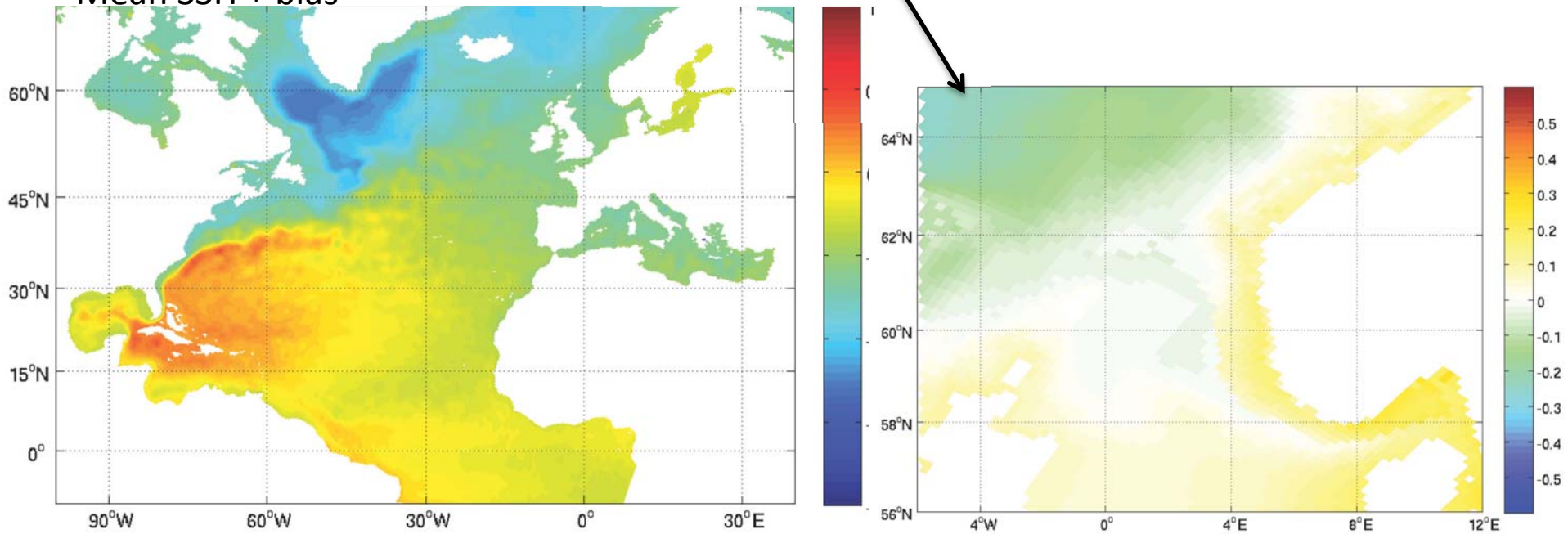
- Bias SSH
- SST bias
- P* (sea ice strength)



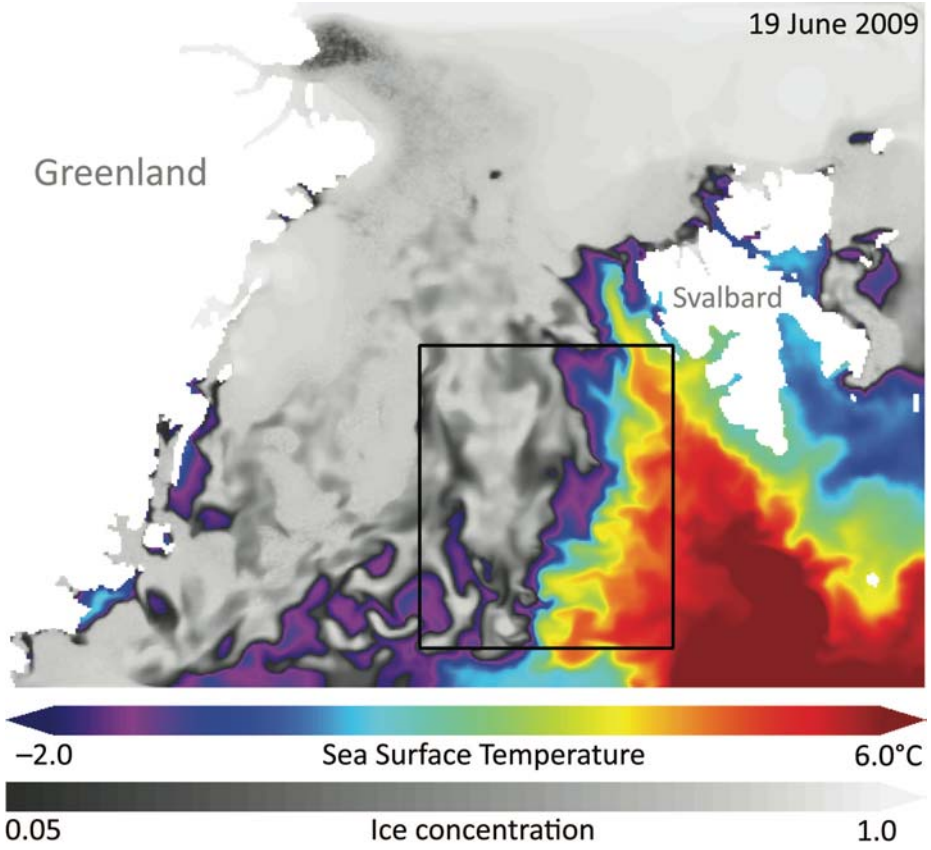
Mean SSH



Mean SSH + bias



Nested configuration



WAVES-IN-ICE FORECASTING
IFAR
FOR ARCTIC OPERATORS

Fram Strait:

- 3.5-km resolution
- Rheology MIZ(Marginal Ice Zone)-EVP
- Interaction with waves to estimate transition front from floe size
- Real-time

Dumont, D., A.L. Kohout and L. Bertino, A wave-based model for the marginal ice zone including a floe breaking parameterization. *J. Geophys. Res., accepted.*

Conclusion

Pilot reanalysis :

- Robust and computationally effective
- Allows from improved performance through:
  - Moderation
  - Parameter estimation (SSH bias; SST bias)
- Shows encouraging skills quantitatively and dynamically

Further perspectives:

- The main reanalysis for the period (1990-2010) is running and available from Nov. 2011
- Further research to be done for parameter estimation of quantity that vary spatially
- Similar framework will be used for seasonal-decadal prediction with NorESM