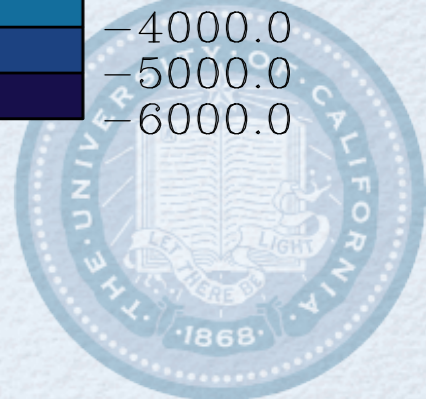
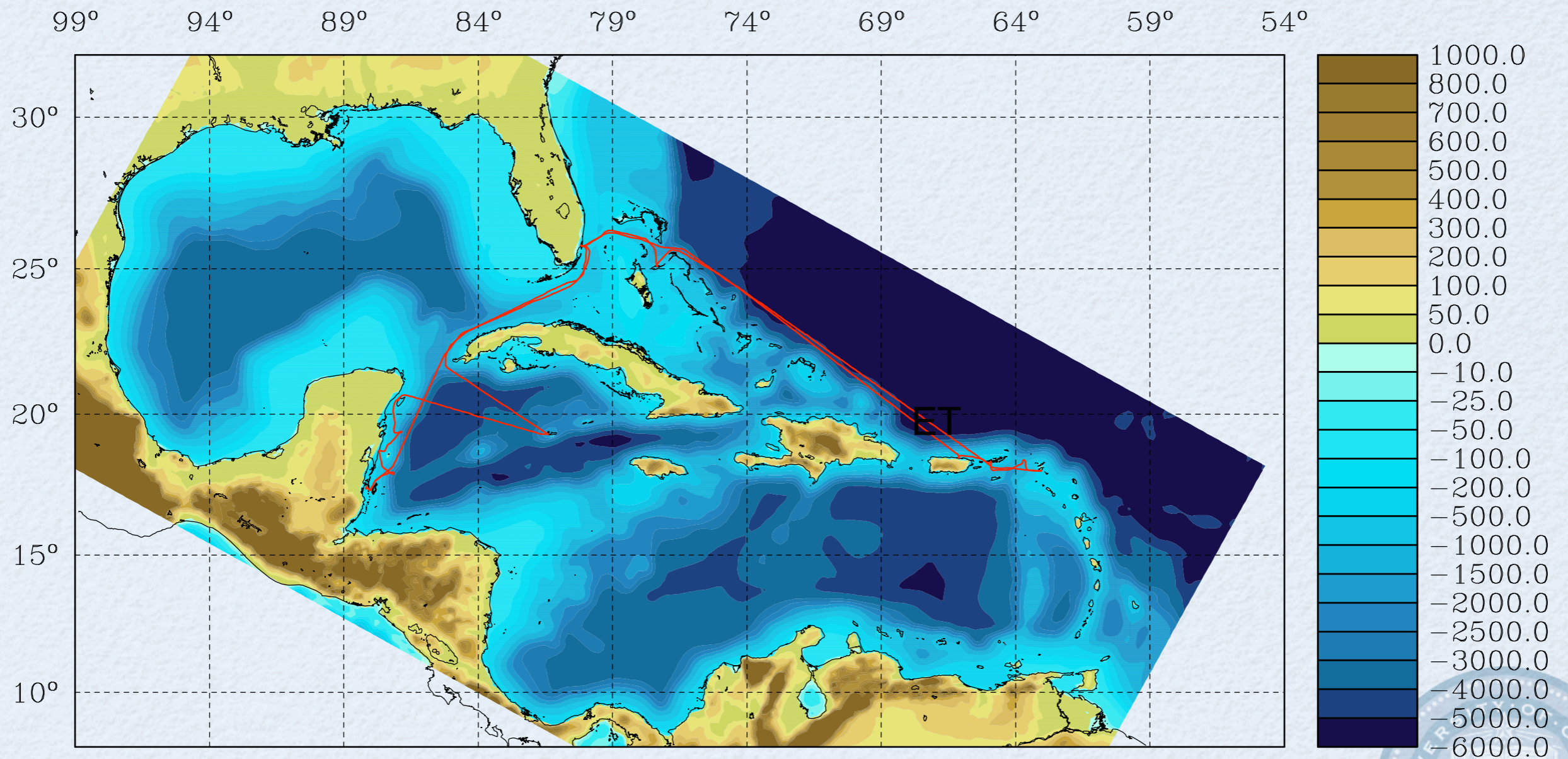


Realtime Data Assimilation & Prediction using ROMS

Brian Powell, Hernan Arango, Andrew Moore,
Emanuele Di Lorenzo, Ralph Milliff, and Dave Foley



Intra-Americas Sea



Motivation

- Explore the factors that limit predictability
- Develop Operational 4DVAR System
 - Realtime, ship-board system
- Study the validity of Sverdrup Dynamics w/ high resolution model



Setup

- ROMS version 3
- $1/3^\circ$ assimilation (reduced physics)
 - $1/6^\circ$ forward model
- NCEP Reanalysis + QuikSCAT (R. Milliff) / NCEP GFS
- GLS Vertical Mixing with MY coefficients
- Climatological Boundary Conditions provided by Rutgers North Atlantic Model



Incremental, Strong Approach

- Misfit between model and obs: $\mathbf{d} = \mathbf{y} - H\mathbf{x}^k$

- Assume “close” and minimize this misfit:

$$J_o(\delta x) = \frac{1}{2} (\mathbf{G}R\delta x_0 - \mathbf{d})^T \mathbf{O}^{-1} (\mathbf{G}R\delta x_0 - \mathbf{d})$$

- Simply solve! $\nabla_{\delta x_0} J_o(\delta x) = R^T \mathbf{G}^T \mathbf{O}^{-1} (\mathbf{G}R\delta x_0 - \mathbf{d})$

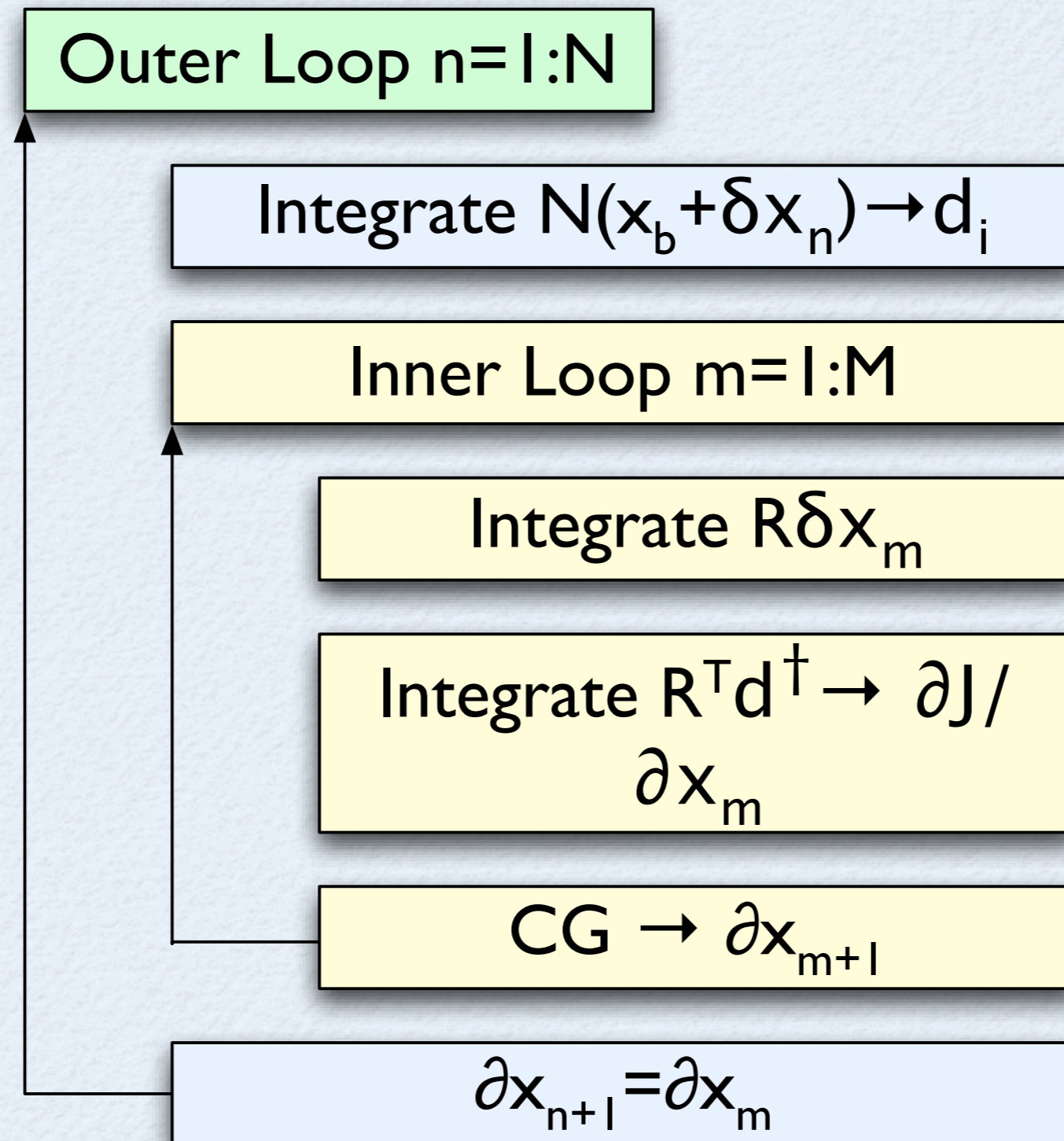
- Over-determined Case:

$$J(\delta x) = \frac{1}{2} \delta x_0^T \mathbf{B}^{-1} \delta x_0 +$$

$$\frac{1}{2} (\mathbf{G}R\delta x_0 - \mathbf{d})^T \mathbf{O}^{-1} (\mathbf{G}R\delta x_0 - \mathbf{d})$$



IS4DVAR



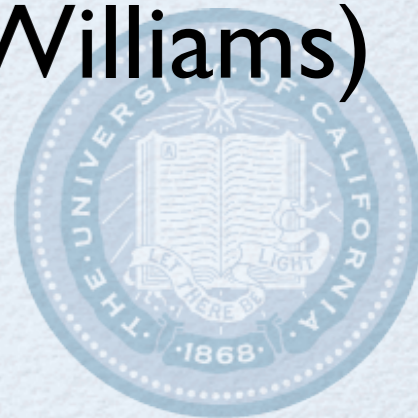
IS4DVAR

- 14 day assimilation: 1 outer, 25 inner loops
- Initial first-guess from 15 year model spin-up
- Unbalanced: $\underline{B} = K_b \Sigma C \Sigma K_b^T$
- 80km horizontal & 100m vertical length scales
- Observation Error Covariance
 - 0.09% of model grid observed over 14 days

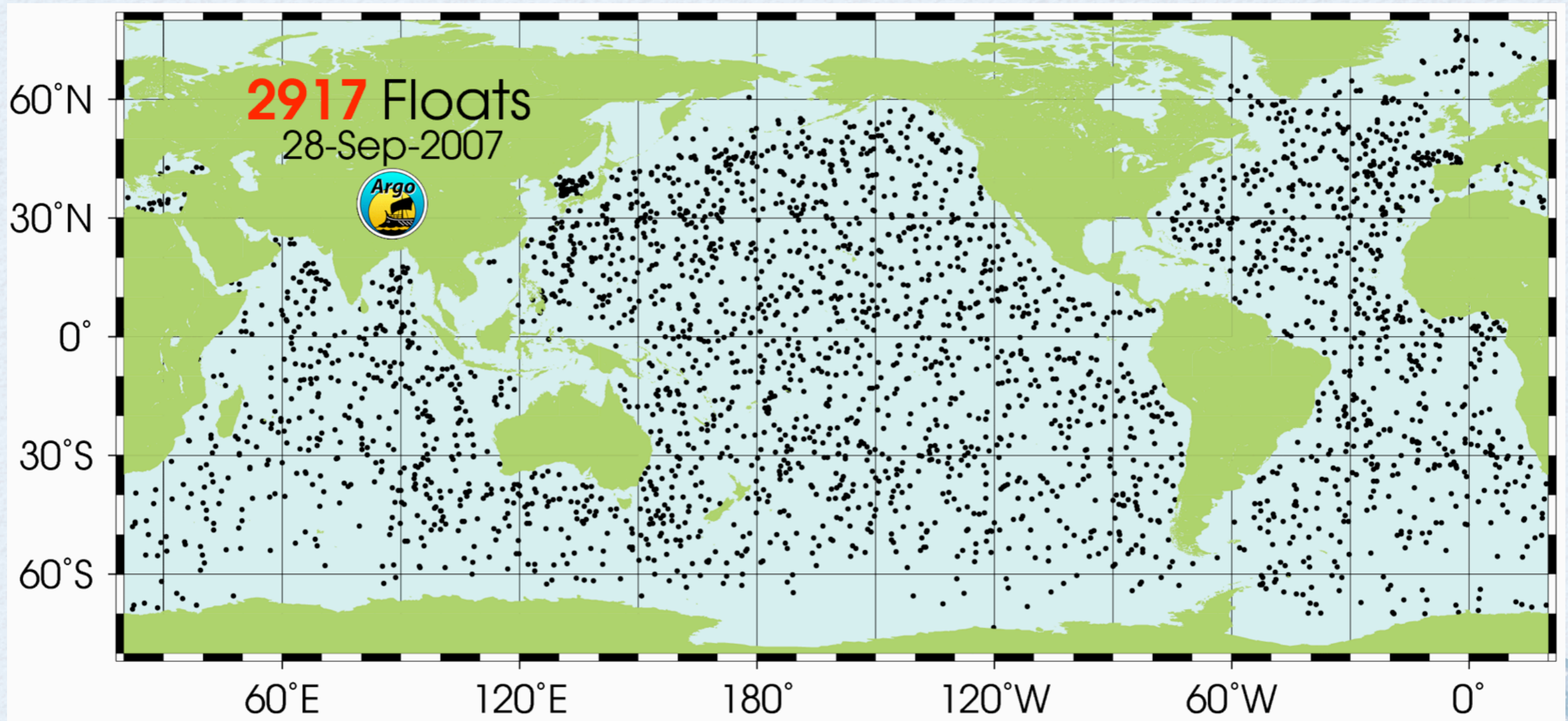


Observational Data

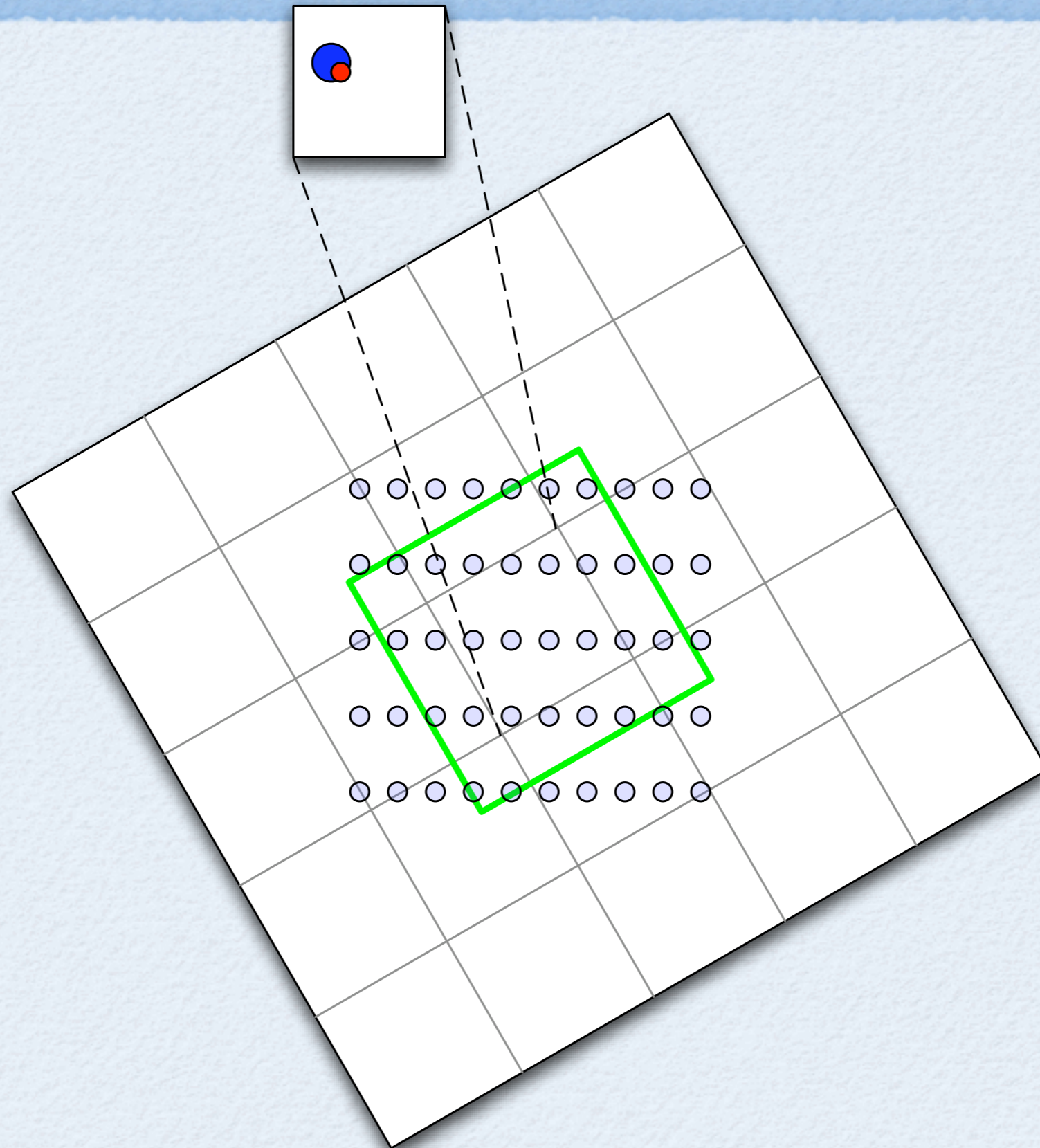
- Historical
 - SSH — Aviso, merged anomalies, (Steric–J. Willis, JPL)
 - SST — D. Foley (PFEL), merged IR/ μ
 - ADCP — *Explorer of the Seas* (Lisa Beal, Liz Williams)
- Realtime
 - SSH — R. Leben (CU/CCAR), (Steric–J. Willis, JPL)
 - SST — UK MetOffice
 - ADCP — *Explorer of the Seas* (Lisa Beal, Liz Williams)



Sampling Issue



“Super” Observations

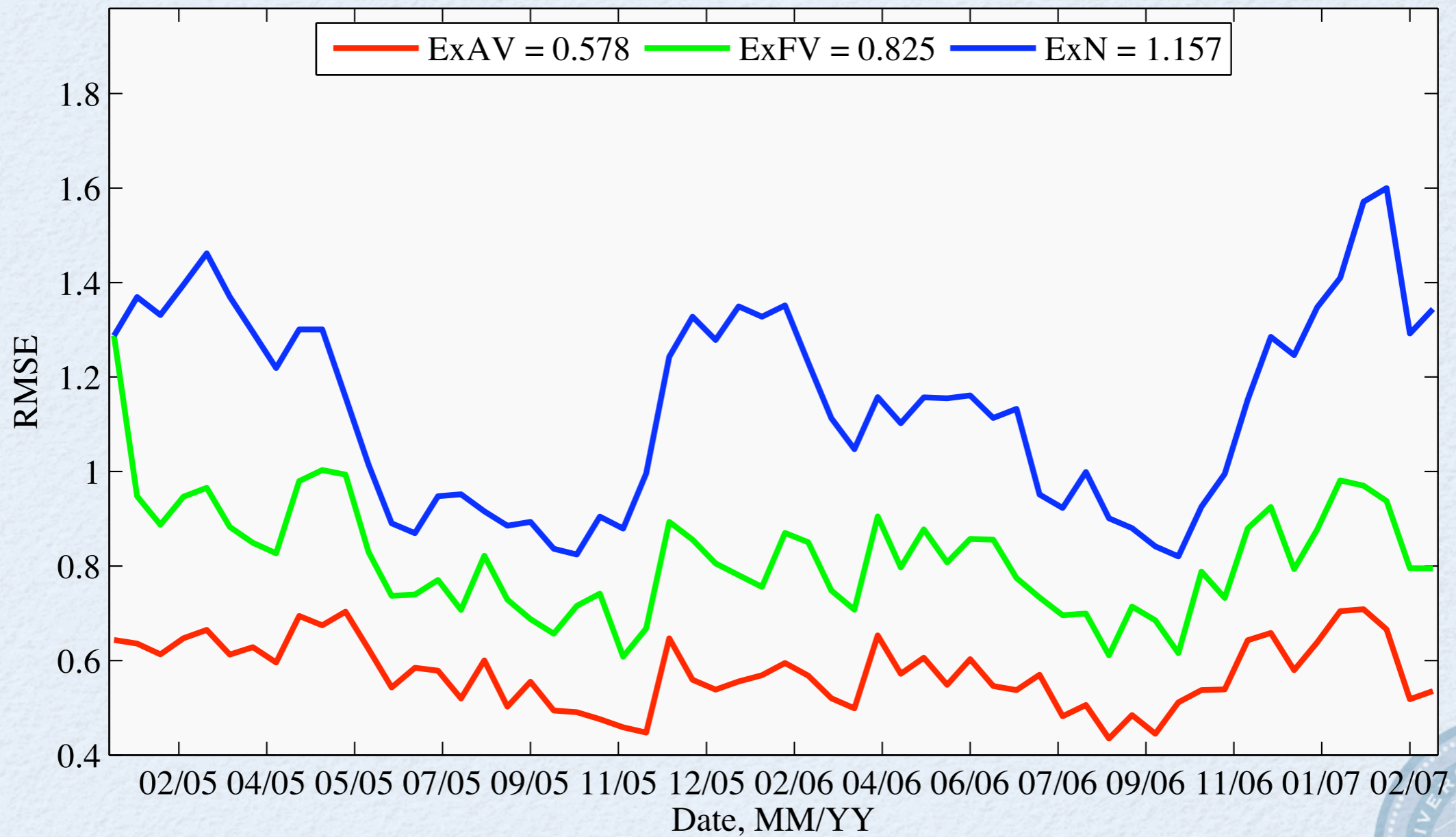


Experiment

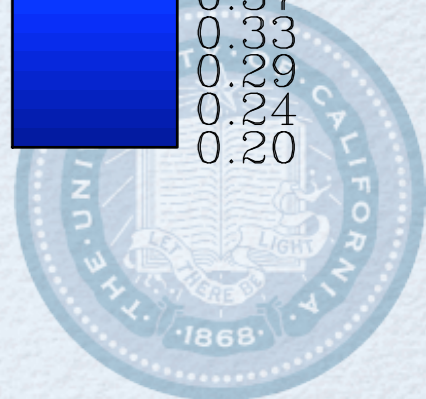
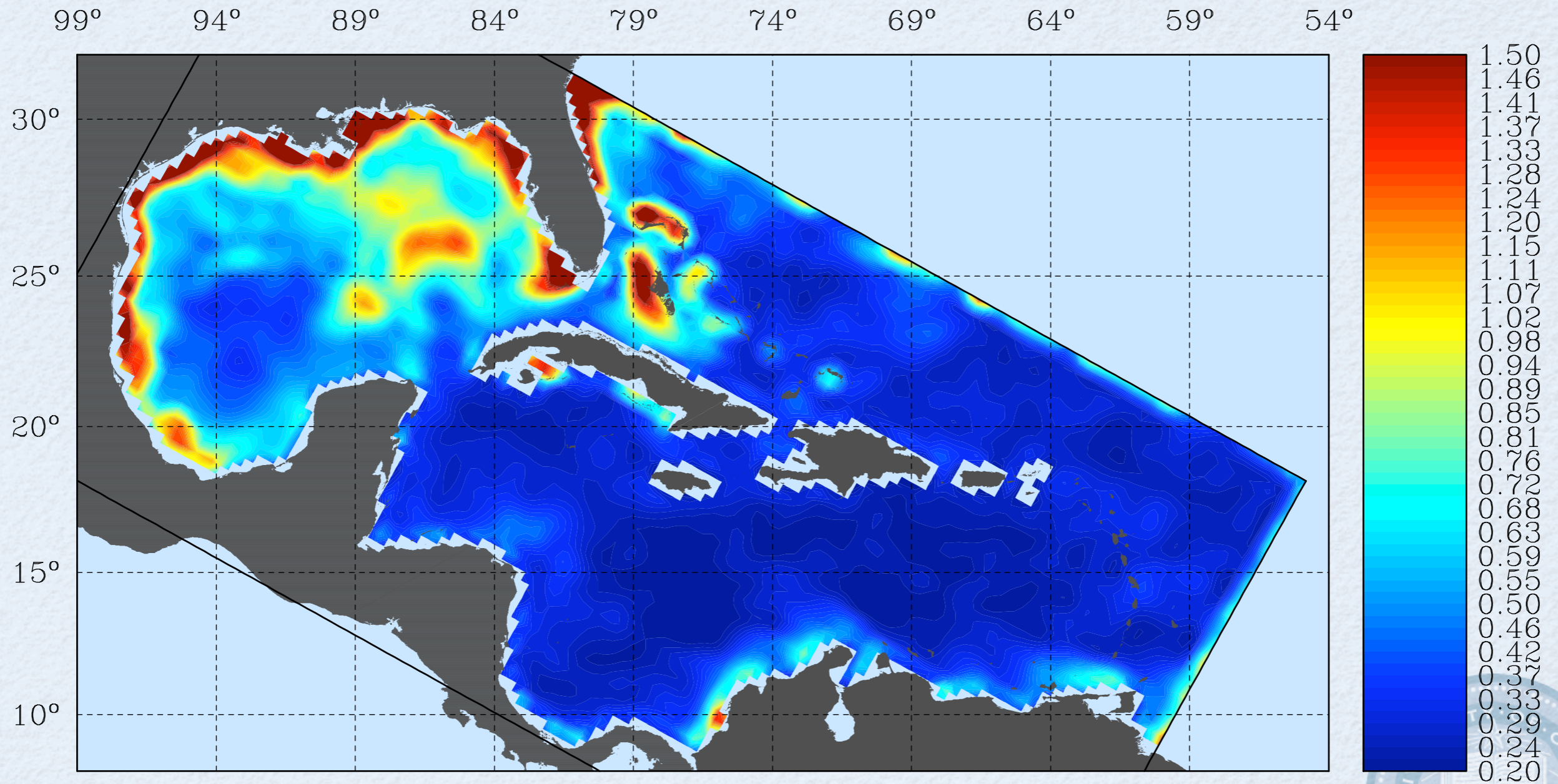
- Historical Spinup From 5 Jan, 2005 until 6 Dec., 2006
- Realtime Data used through Present
- Deployed Jan 7 — 6 weeks of human operation, now fully automated
- Initial first-guess from model spin-up
- Assimilate Previous Day back 7, Forecast 14 days



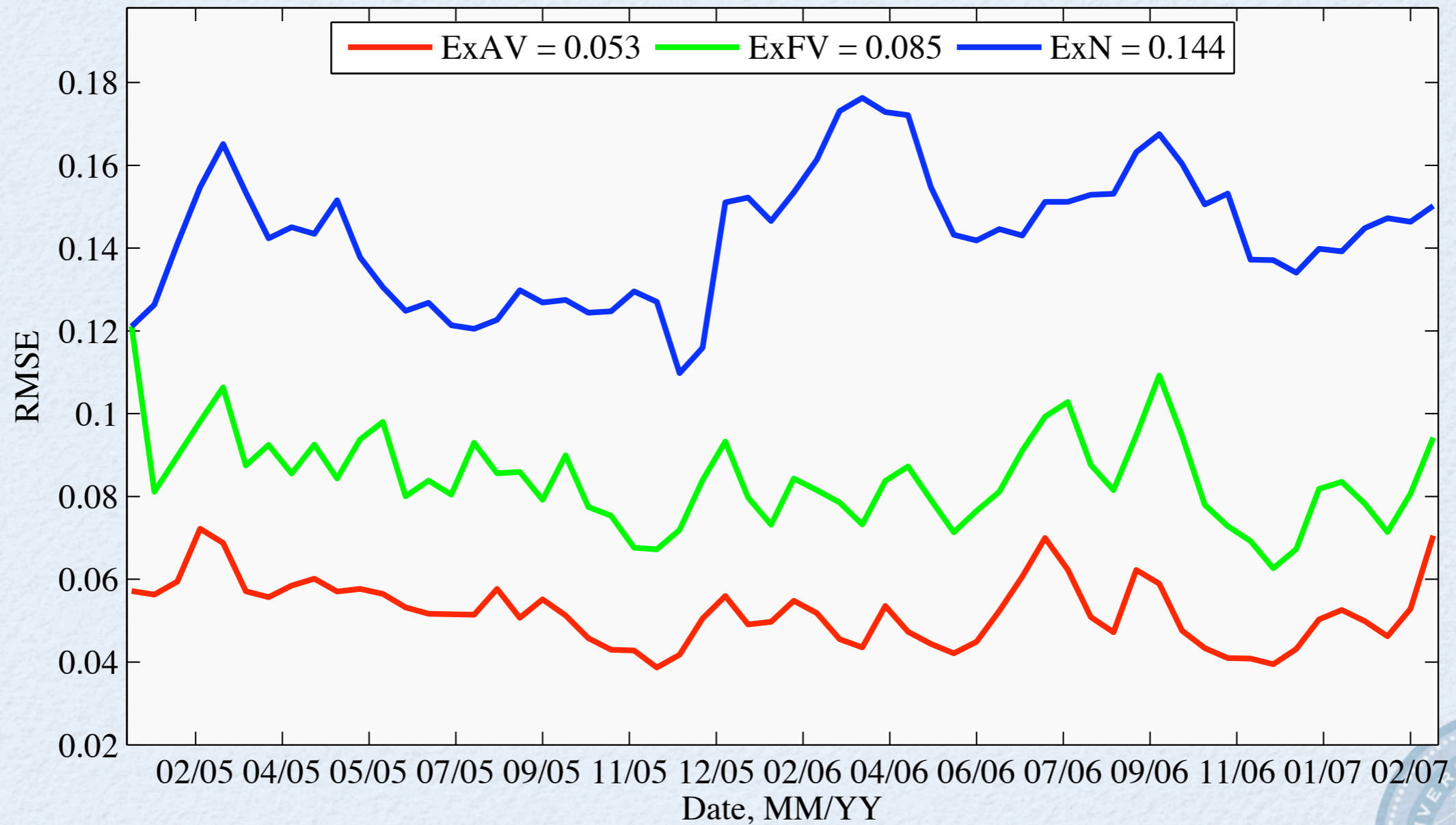
RMSE (SST)



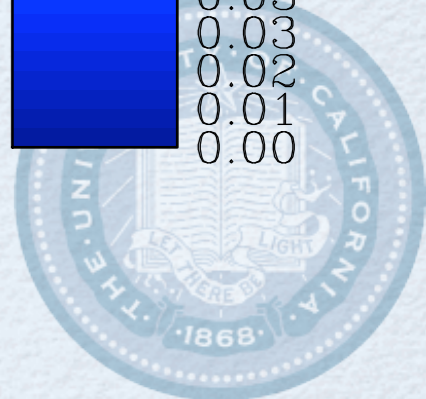
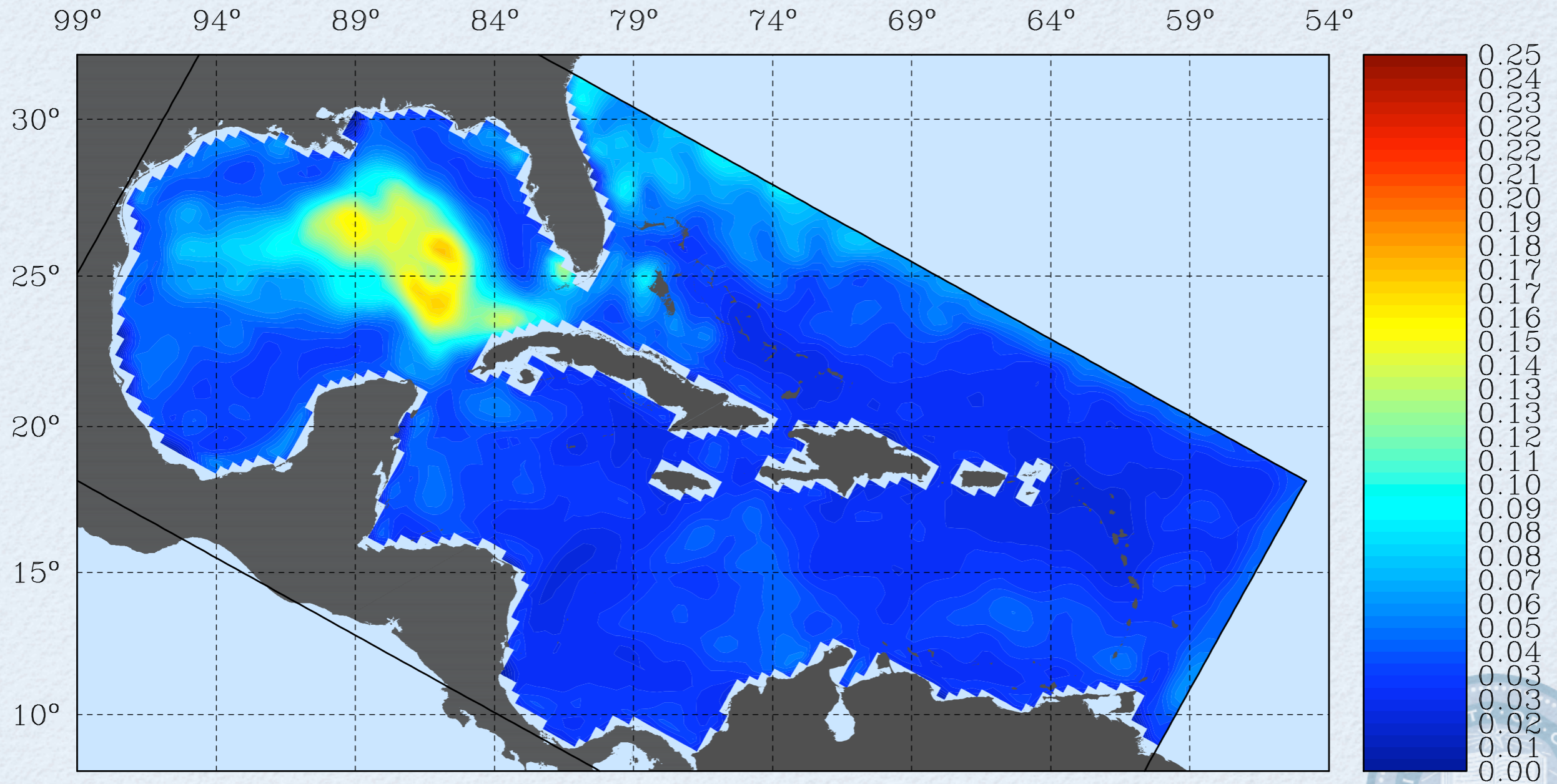
Observational Misfit (SST)



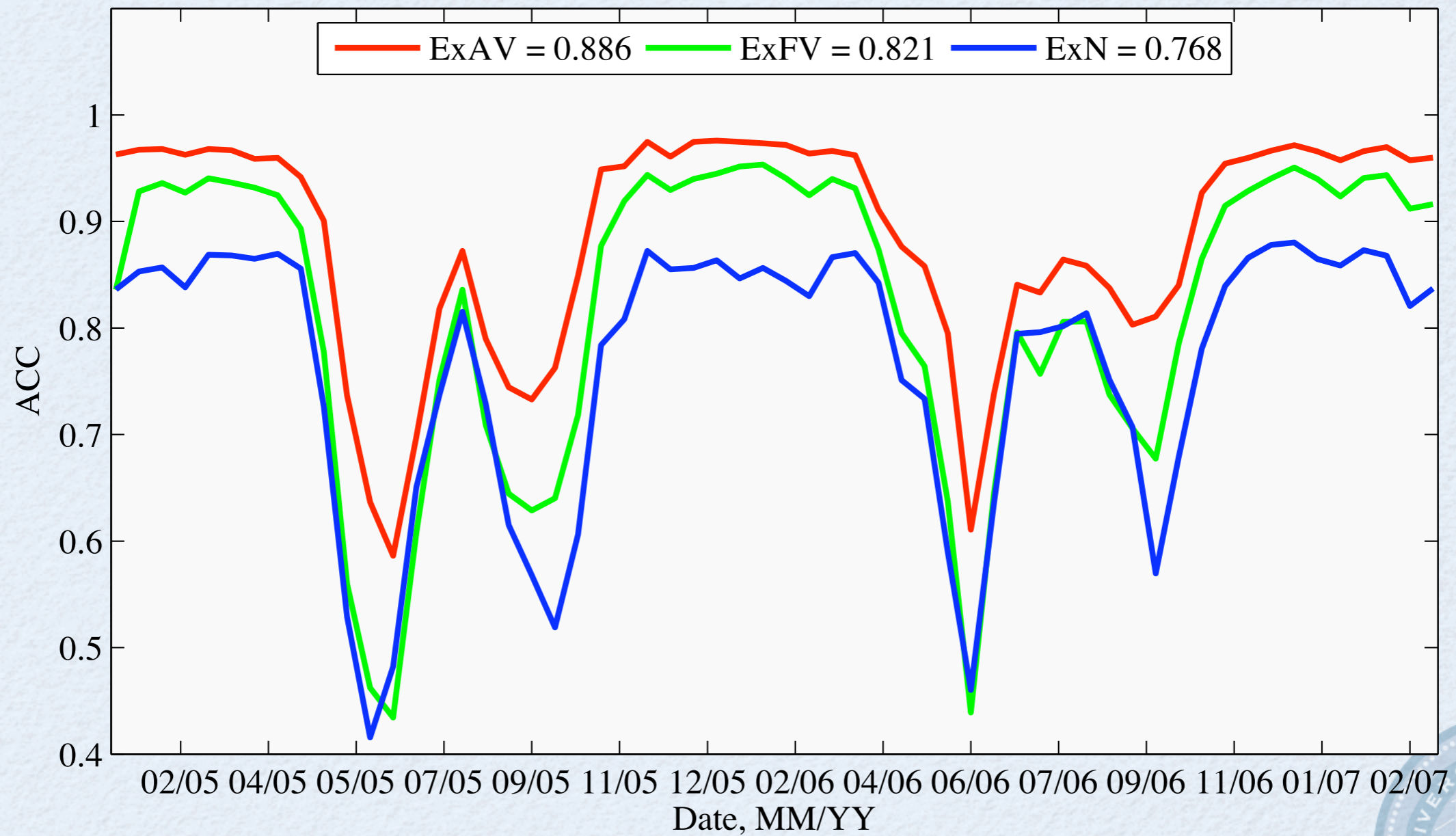
RMSE (SSH)



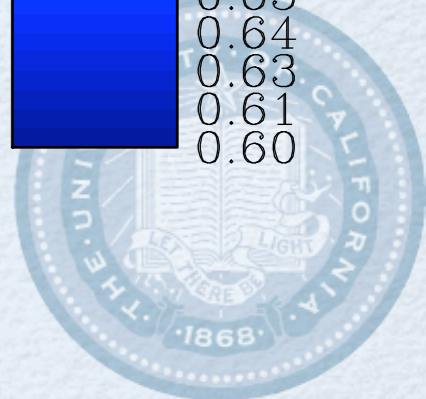
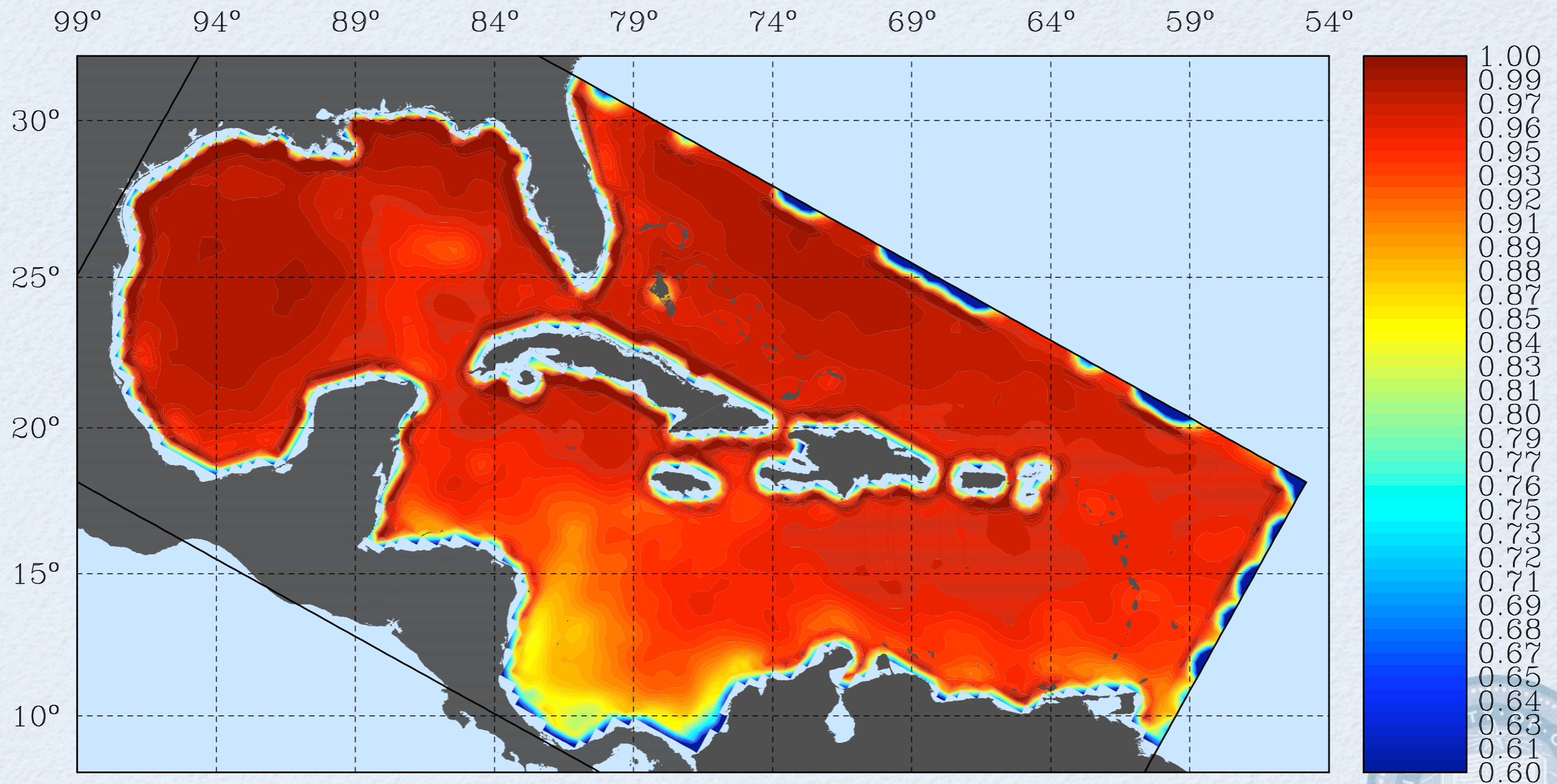
Observational Misfit (SSH)



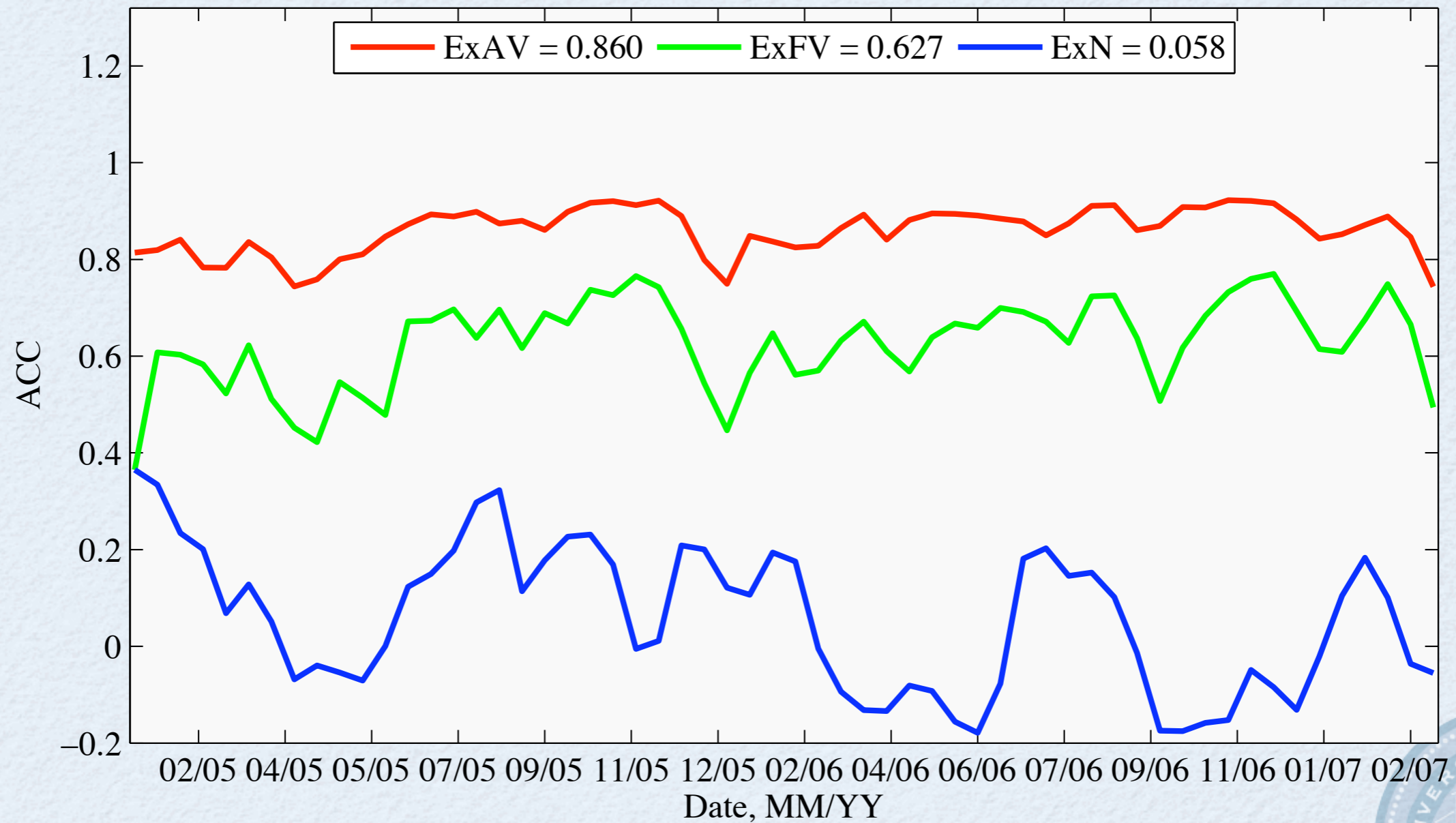
Correlation (SST)



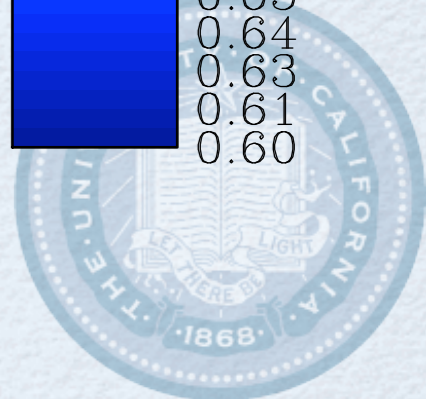
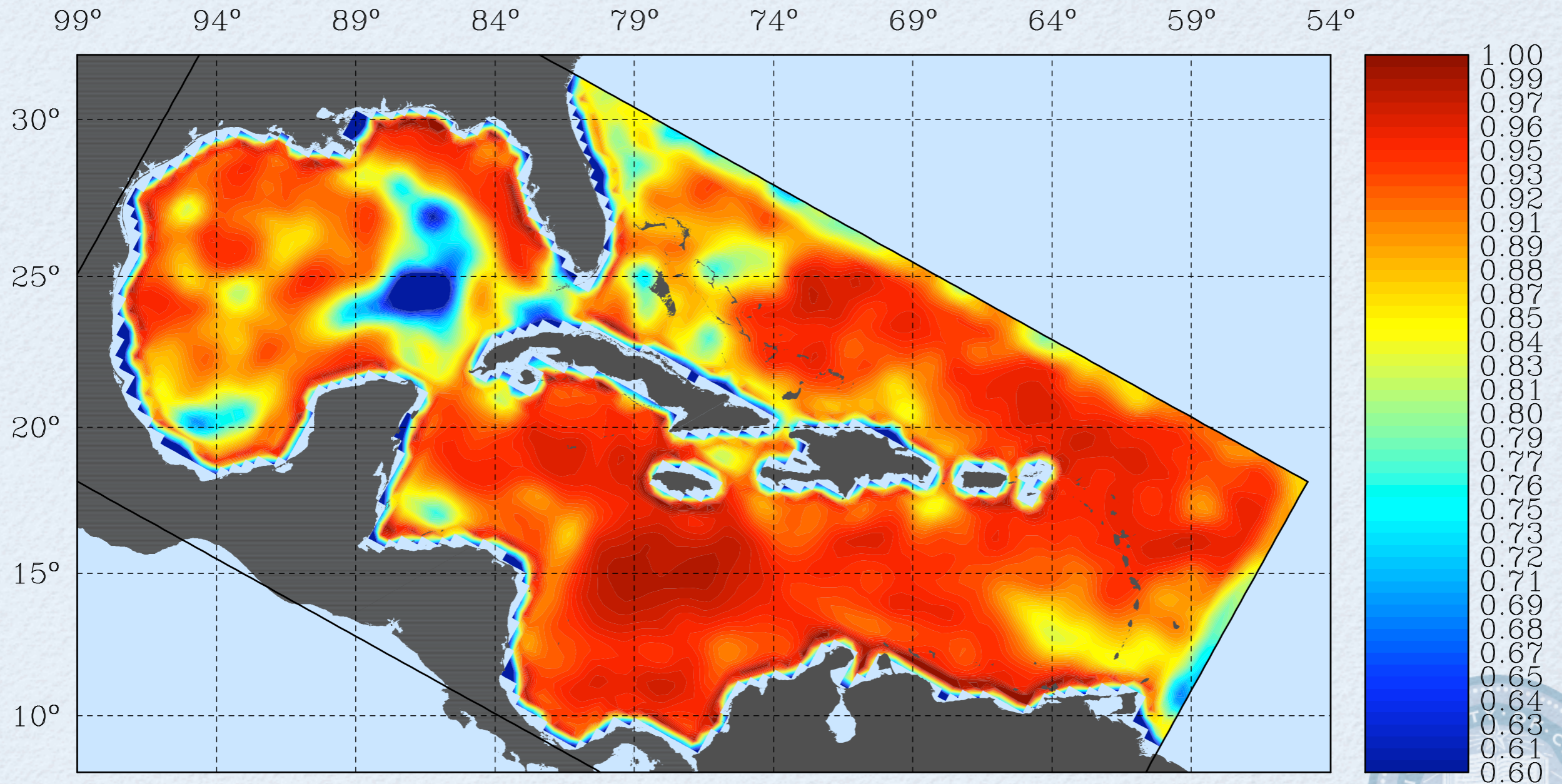
Correlation (SST)



Correlation (SSH)



Correlation (SSH)



Loop Current?

Experiment	Max West	Max North	Area (km ²)
Aviso	88.4°W ± 1.6	26.3°N ± 1.2	105,579 ±50,000
No Assim	87.5°W ± 1.9	25.0°N ± 1.0	72,349 ±44,159
Full Assim	88.8°W ± 1.9	26.0°N ± 1.6	104,604 ±69,000

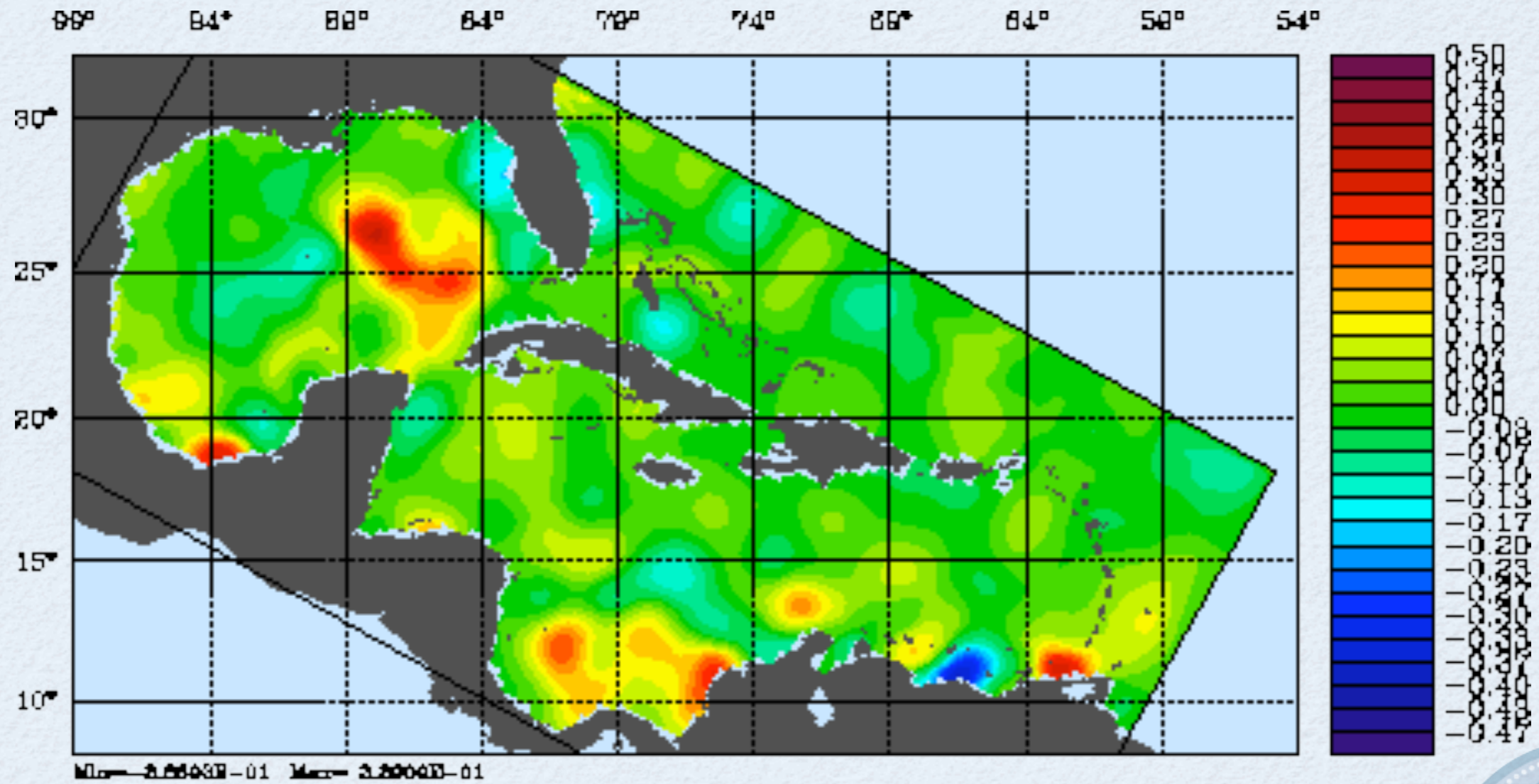


Forecasting

- Use $1/6^\circ$ model for NLM
- Assimilate at $1/3^\circ$
- Orthonormalize increments
- Ensemble Prediction



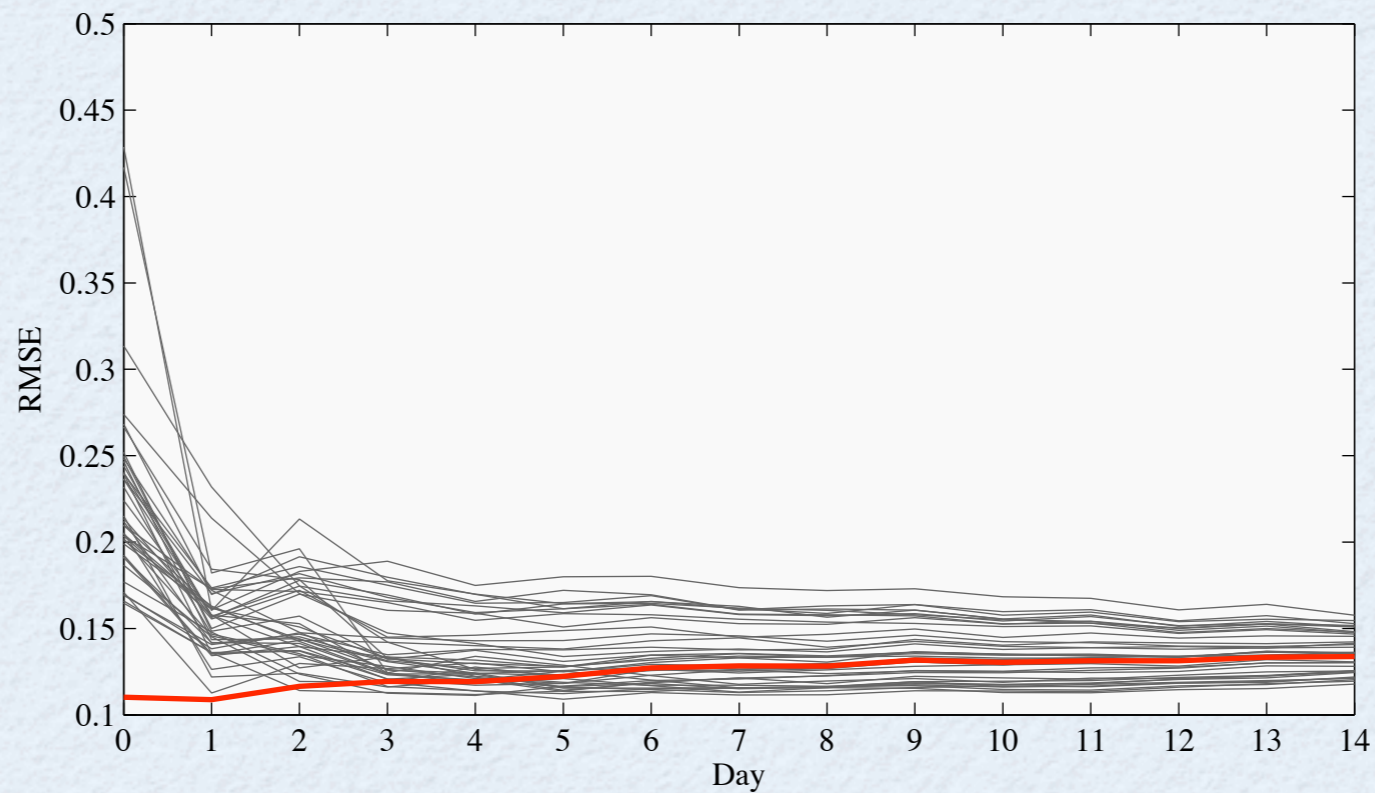
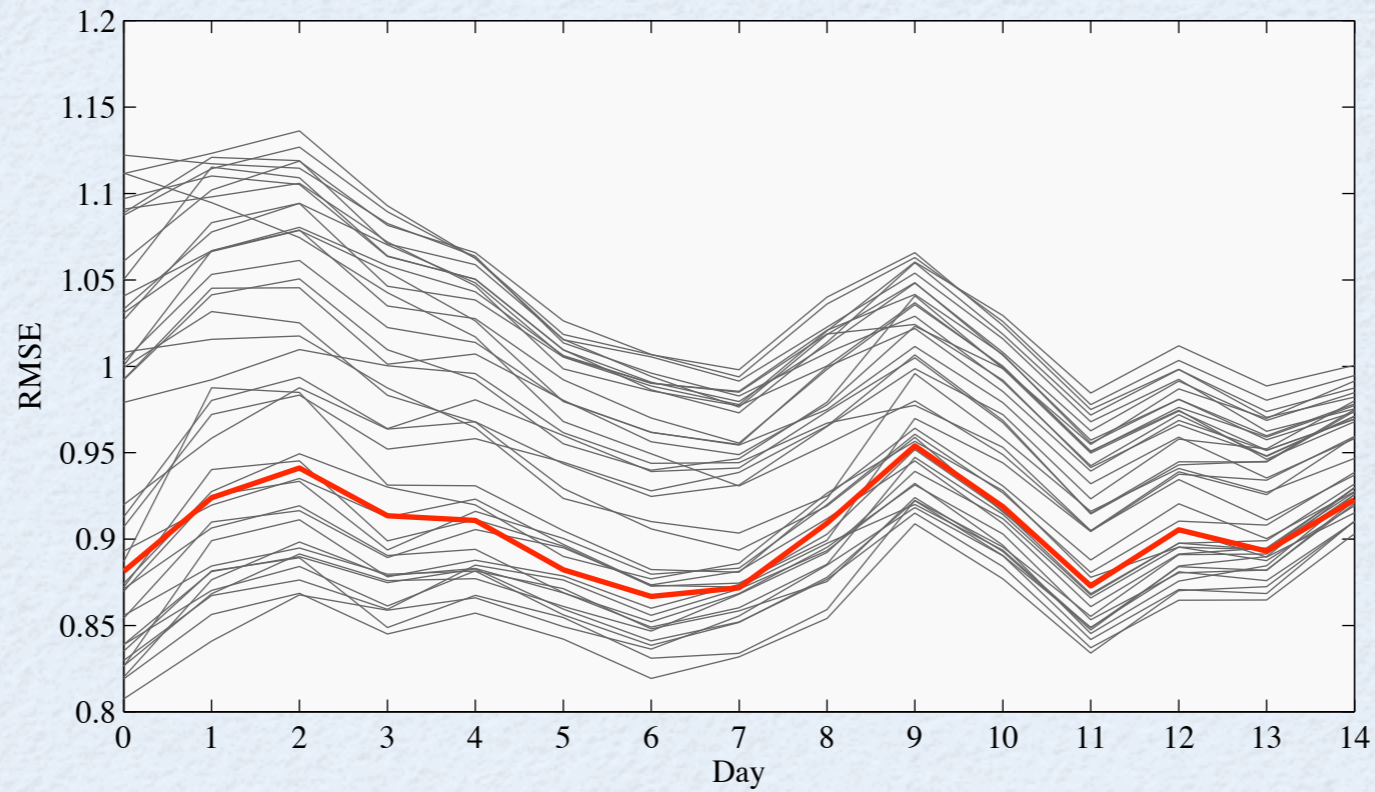
Typical Perturbation



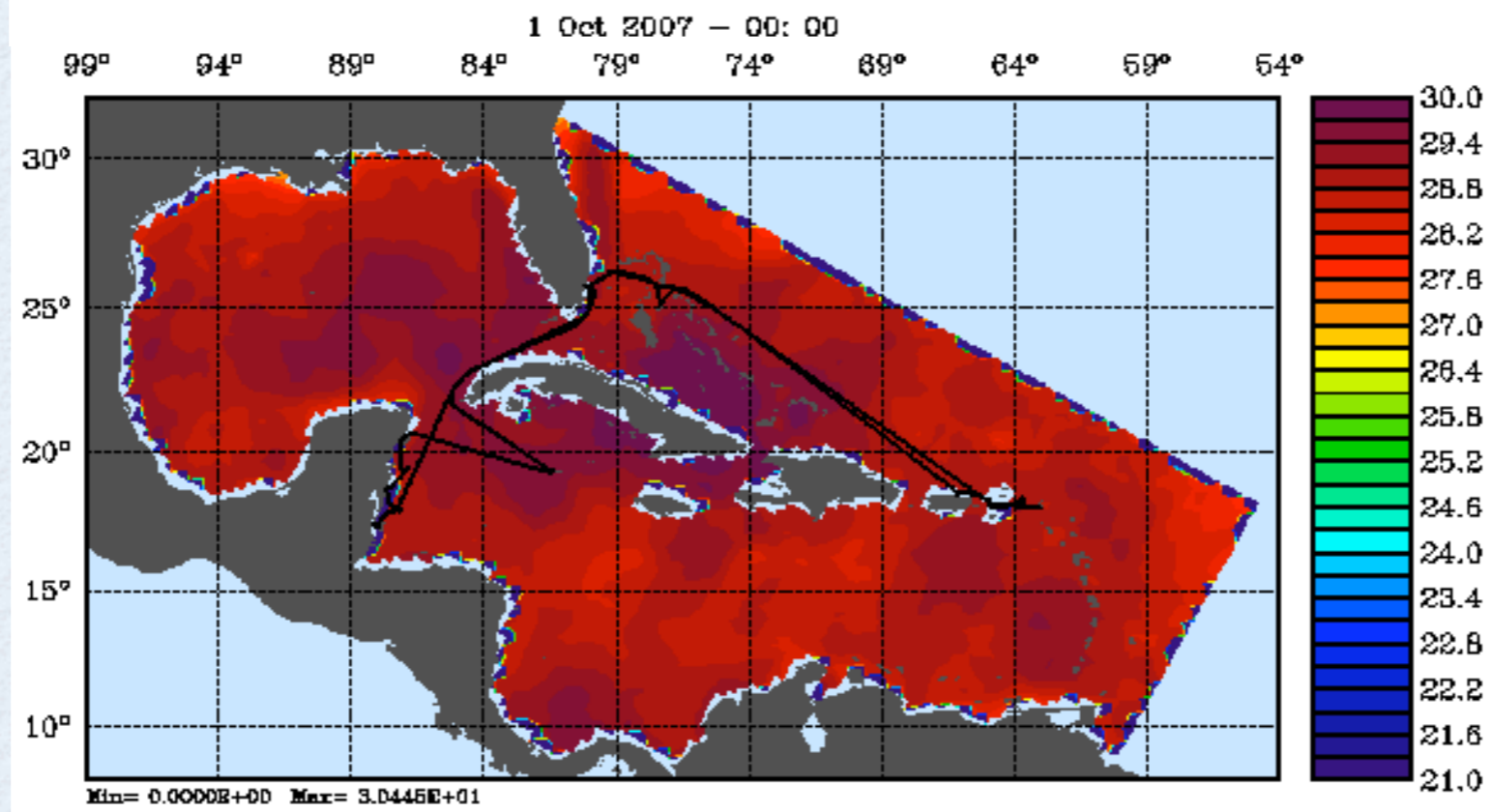
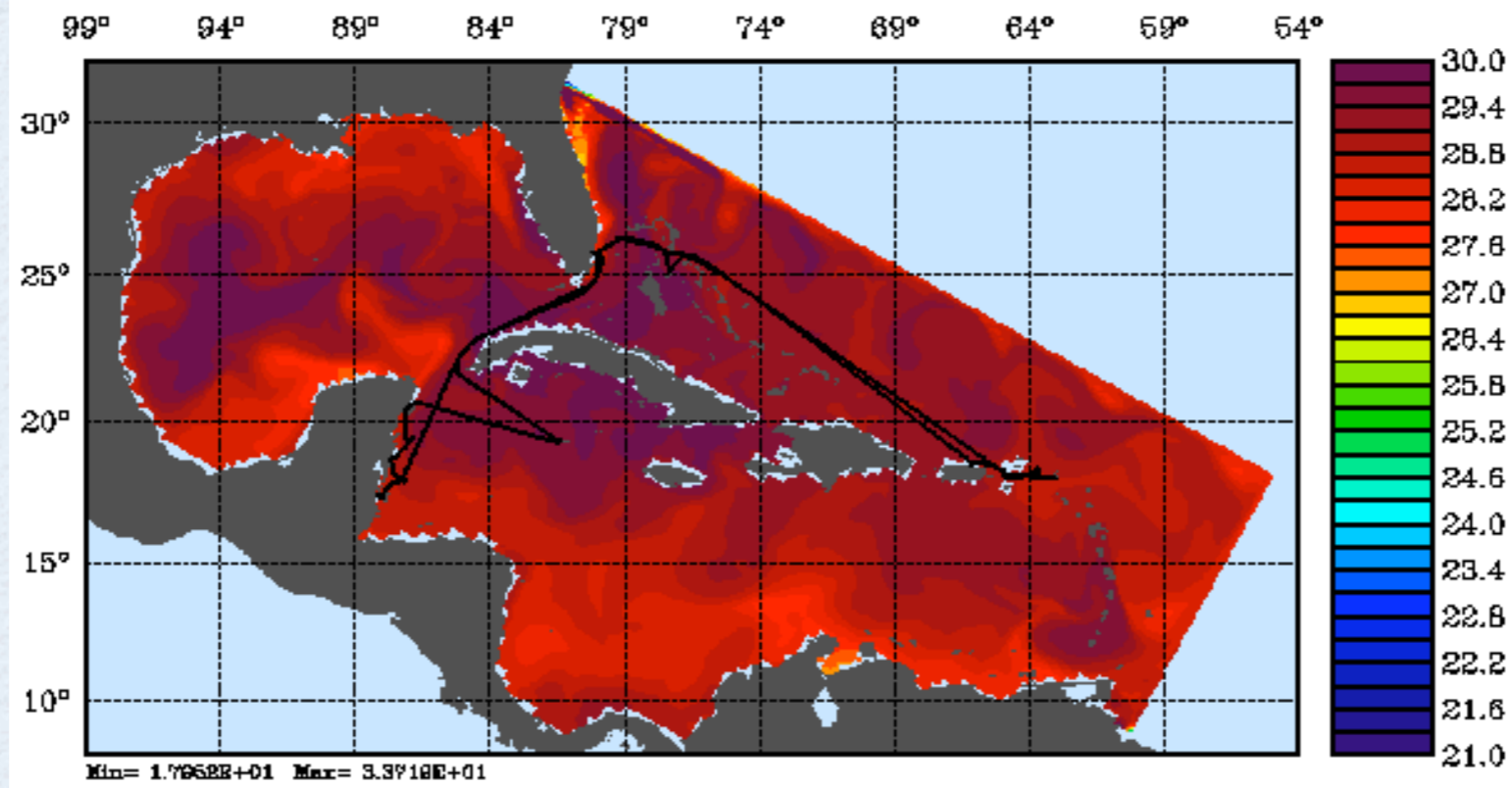
0264.00 Day



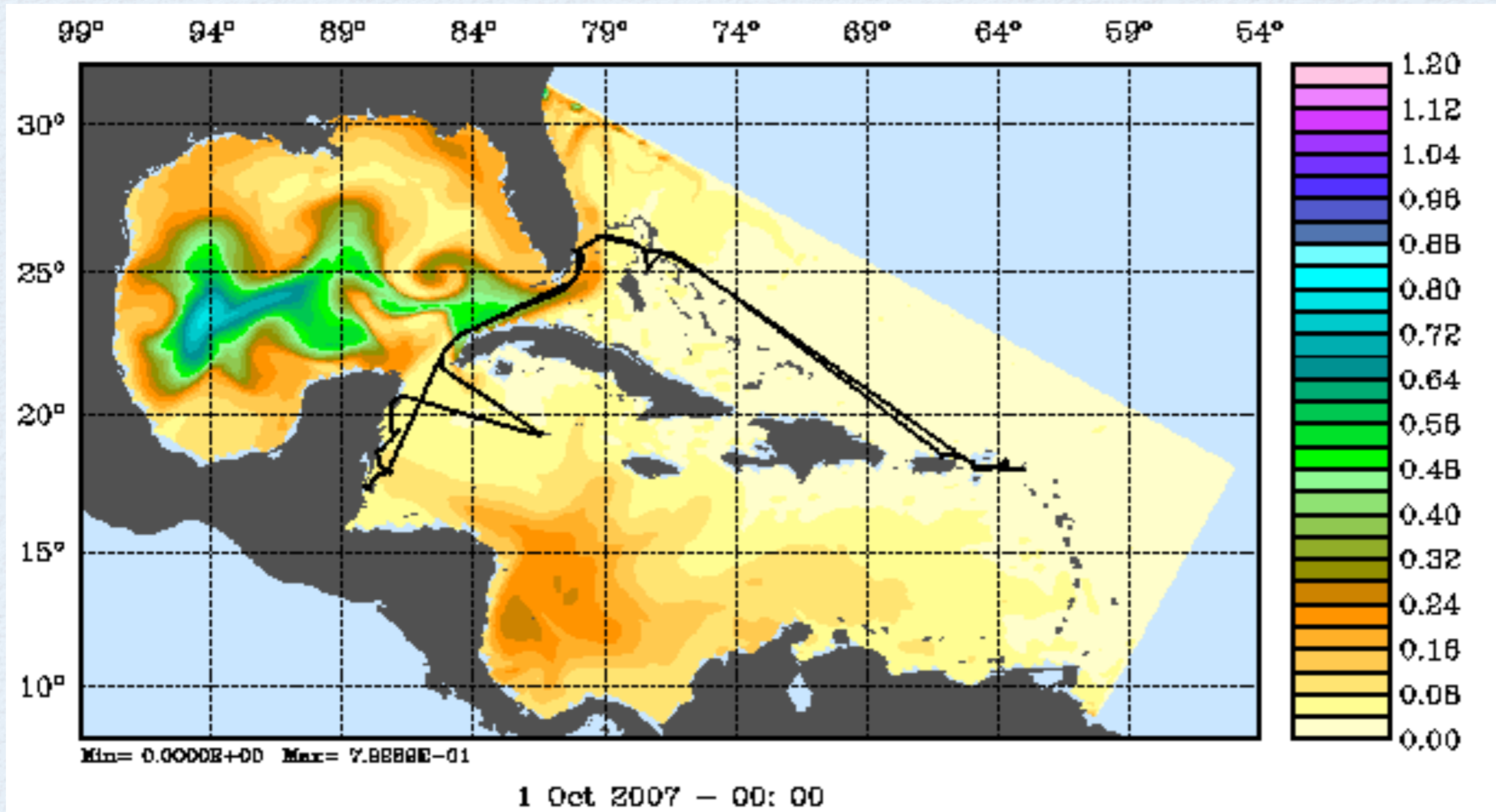
Ensemble Prediction



Current Prediction



Ensemble Variance



Resources

- Watch for paper in Ocean Modelling
- Real-Time Ensemble Prediction
- <http://www.myroms.org/ias>

