The Hybrid Global Ocean Data Assimilation System at NCEP

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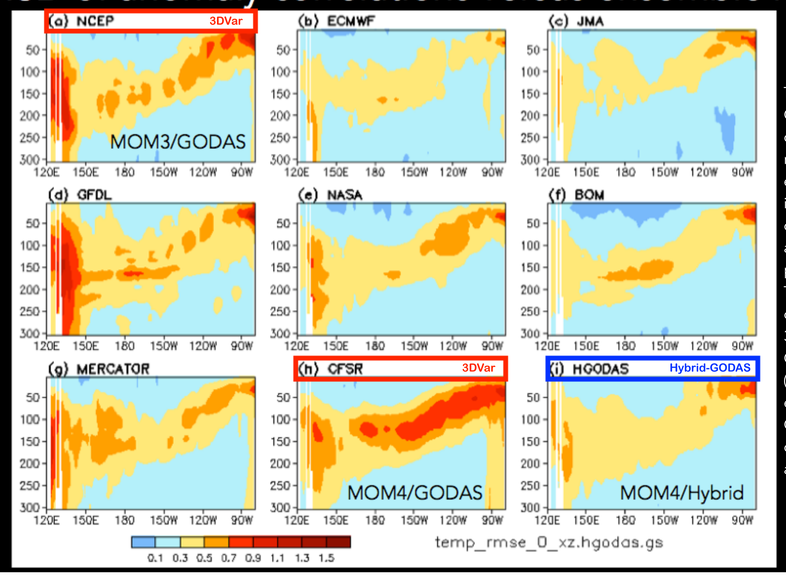
INTERNATIONAL COMPARISON

Equatorial Pacific temperature anomalies

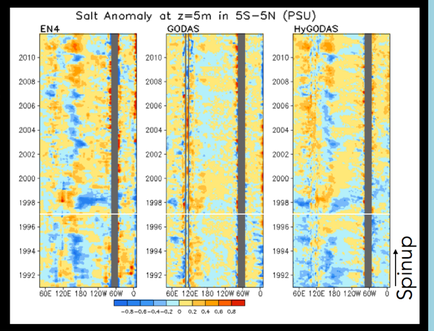
RMSD of anomaly correlations versus ensemble mean



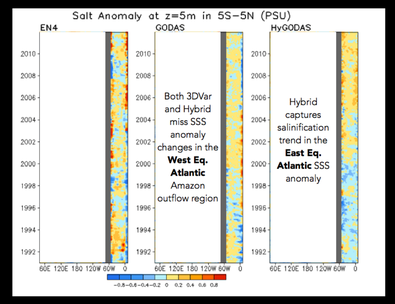
The Hybrid-GODAS falls closer to the mean of the ensemble of international ocean assimilation products. The operational 3DVar - GODAS (NCEP=forced by R2; CFSR=fully coupled) is an outlier.

NEAR SURFACE SALINITY

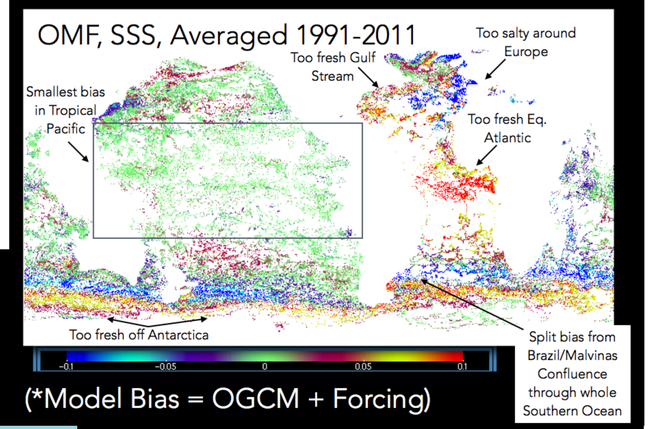
Seasonal variability of the SSS is improved.



NEAR SURFACE SALINITY

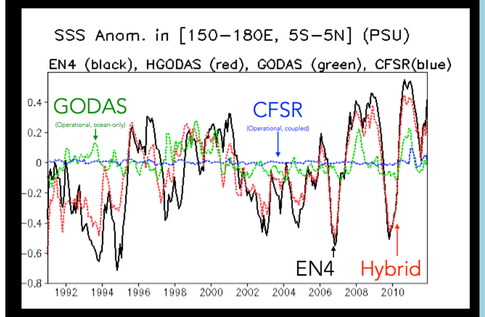


MODEL BIAS*, DIAGNOSED

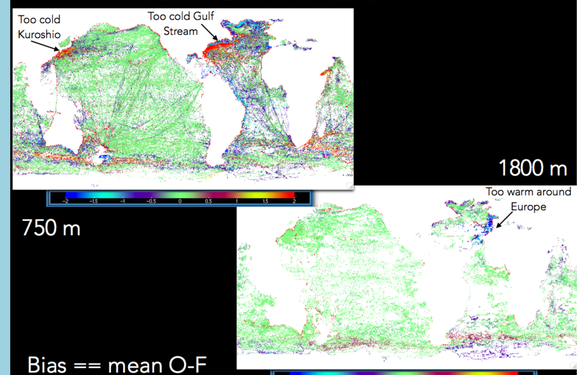


(*Model Bias = OGCM + Forcing)

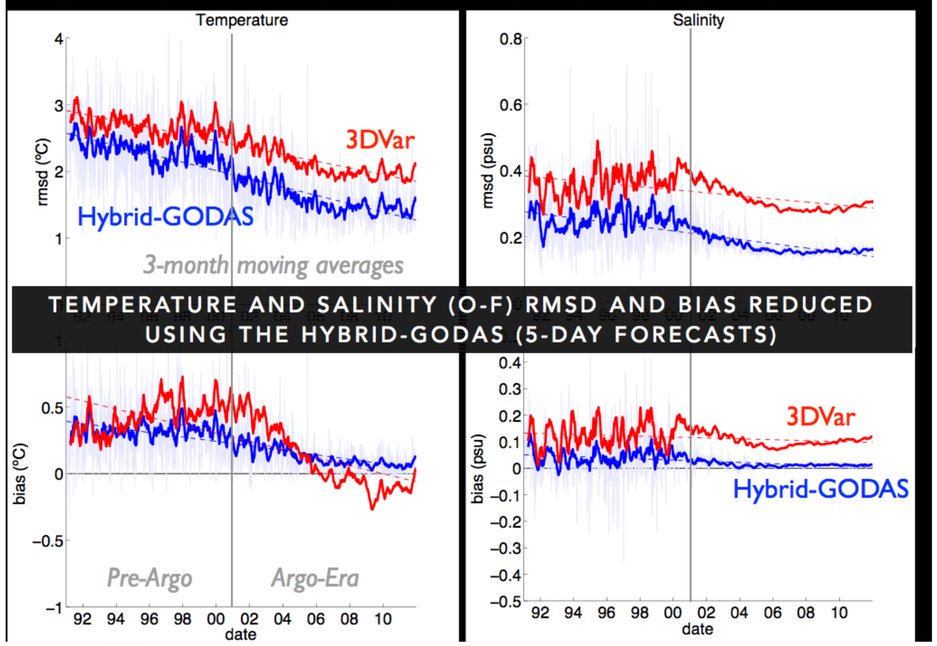
NEAR SURFACE SALINITY



TEMPERATURE BIAS



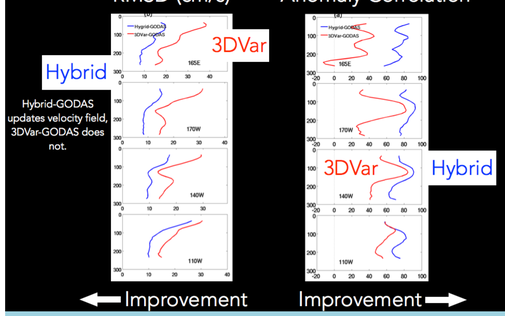
21-YEAR HYBRID-GODAS REANALYSIS



TEMPERATURE AND SALINITY (O-F) RMSD AND BIAS REDUCED USING THE HYBRID-GODAS (5-DAY FORECASTS)

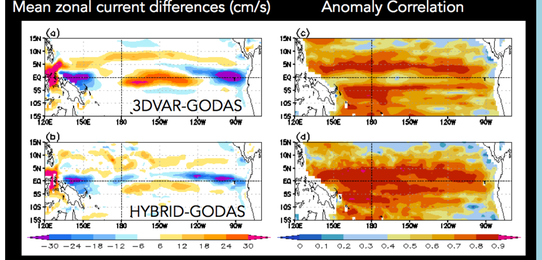
EQUATORIAL PACIFIC ADCP*

*Acoustic Doppler Current Profilers

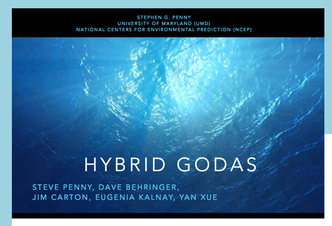


NEAR SURFACE OCEAN CURRENTS

Comparison to OSCAR* currents (~0-30m) from 1995-2011



*OSCAR currents derived from satellite altimeter and scatterometer data



The Hybrid-GODAS system (Penny et al., 2015) combines the operational 3DVar-GODAS (Behringer and Xue, 2004) with a newly developed Local Ensemble Transform Kalman Filter (LETKF; Hunt et al., 2007) based data assimilation system for the ocean (Penny et al., 2013).

MODEL

Model: GFDL MOM4p1

Resolution: 1/2°x1/2° with refinement to 1/2°x1/4° in the tropics (matches the NCEP Climate Forecast System operational resolution)

Surface Forcing: NCEP/DOE Reanalysis 2 (Kanamitsu et al., 2002), with perturbations from the 20th Century Reanalysis (Compo et al., 2011)

Surface Relaxation: To Reynolds OI Sea Surface Temperature (SST) analysis (10-day timescale) and Sea Surface Salinity (SSS) climatology (30-day timescale)

River Runoff: Climatology

OBSERVATIONS

Observations: Temperature and Salinity Profiles (XBT/CTD/Argo, etc.), as used operationally

DATA ASSIMILATION

Methods: The Hybrid-Gain method (Penny, 2014) is used to form a 3DVar/ LETKF hybrid ocean data assimilation system

Ensemble Size: 56 Members

Model Prognostic Fields updated: Temperature, Salinity, U, V

Observation error: estimated based on the vertical temperature gradient, as used operationally

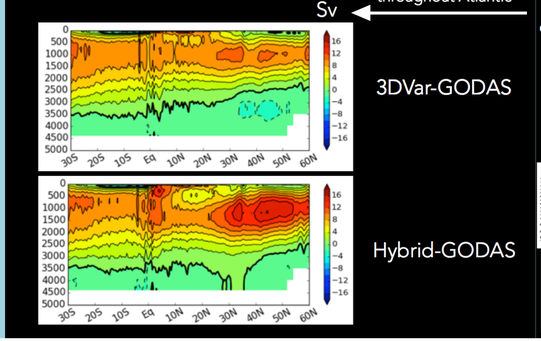
Horizontal Localization: 720km sigma-radius at the equator reducing linearly to 200m at the poles

Vertical Localization: none

Hybrid-Gain data assimilation has shown success in simple systems (Penny 2014), and in operational scale atmospheric (Hamrud et al., 2014; Bonavita et al., 2015) and oceanic applications (Penny et al., 2015).

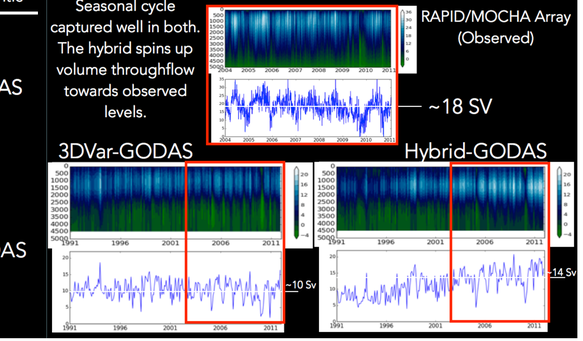
AMOC (1991-2011)

Similar increase throughout Atlantic



26.5°N, NORTH ATLANTIC

Seasonal cycle captured well in both. The hybrid spins up volume throughflow towards observed levels.



Publications

Penny, S., D. Behringer, J. Carton, and E. Kalnay, 2015: A Hybrid Global Ocean Data Assimilation System at NCEP. Mon. Wea. Rev. doi:10.1175/MWR-D-14-00376.1, In press.

Penny, S.G., 2014: The Hybrid Local Ensemble Transform Kalman Filter. Mon. Wea. Rev., 142, 2139–2149. doi: http://dx.doi.org/10.1175/MWR-D-13-00131.1

Penny, S.G., E. Kalnay, J.A. Carton, B.R. Hunt, K. Ide, T. Miyoshi, and G.A. Chepurin: The local ensemble transform Kalman filter and the running-in-place algorithm applied to a global ocean general circulation model, Nonlin. Processes Geophys., 20, 1031-1046, doi:10.5194/npg-20-1031-2013, 2013.

References

Behringer, D., Y. Xue, 2004: Evaluation of the Global Ocean Data Assimilation System at NCEP: The Pacific Ocean. Eighth Symposium on Integrated Observing and Assimilation Systems for Atmosphere, Oceans, and Land Surface, AMS 84th Annual Meeting, Washington State Convention and Trade Center, Seattle, Washington, 11-15 January 2004

Bonavita, M., M. Hamrud, L. Isaksen, 2015: EnKF and Hybrid Gain Ensemble Data Assimilation Part II: EnKF and Hybrid Gain Results. Mon. Wea. Rev., In press. doi: http://dx.doi.org/10.1175/MWR-D-15-0071.1

Compo, G.P., J.S. Whitaker, P.D. Sardeshmukh, N. Matsui, R.J. Allan, X. Yin, B.E. Gleason, R.S. Vose, G. Rutledge, P. Bessemoulin, S. Brönnimann, M. Brunet, R.I. Crouthamel, A.N. Grant, P.Y. Groisman, P.D. Jones, M. Kruk, A.C. Kruger, G.J. Marshall, M. Maugeri, H.Y. Mok, Ø. Nordli, T.F. Ross, R.M. Trigo, X.L. Wang, S.D. Woodruff, and S.J. Worley, 2011: The Twentieth Century Reanalysis Project. Quarterly J. Roy. Meteorol. Soc., 137, 1-28. DOI: 10.1002/qj.776

Hamrud, M., M Bonavita and L. Isaksen, 2014: EnKF and Hybrid Gain Ensemble Data Assimilation. ECMWF Technical Report #733. http://old.ecmwf.int/publications/library/ecpublications/_pdf/tm/701-800/tm733.pdf

Hunt, B.R., E.J. Kostelich, and I. Szunyogh, 2007: Efficient Data Assimilation for Spatiotemporal Chaos: A Local Ensemble Transform Kalman Filter. Physica D, 230, 112-126.

Kanamitsu, M., W. Ebisuzaki, J. Woollen, S.-K. Yang, J. J. Hnilo, M. Fiorino, and G. L. Potter, 2002: NCEP–DOE AMIP-II. Reanalysis (R-2). Bull. Amer. Meteor. Soc., 83, 1631–1643.