4D-LETKF Compared with SODA on a Global Ocean Model

Stephen G. Penny

Eugenia Kalnay **Jim Carton**
Brian Hunt **Kayo Ide**
Takemasa Miyoshi **Gennady Chepurin**

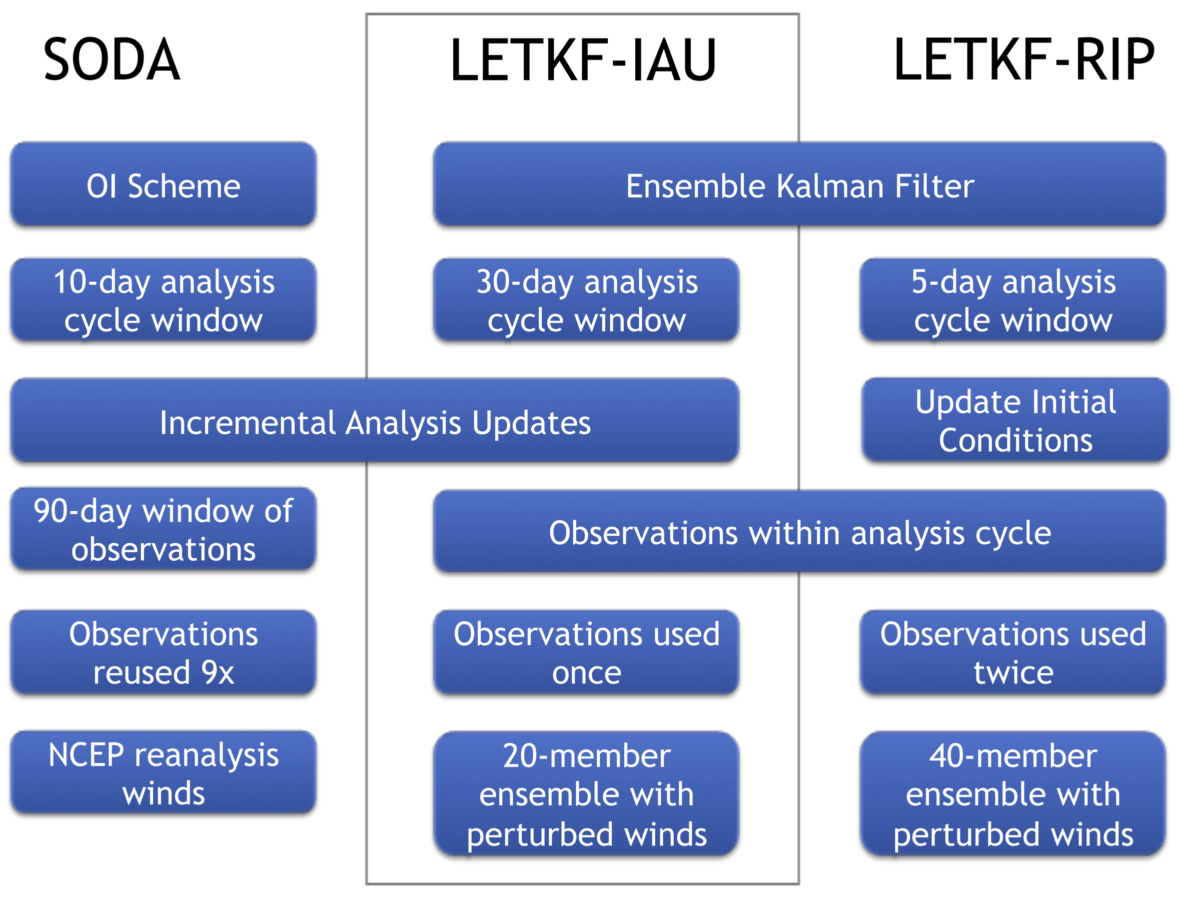
UNIVERSITY OF MARYLAND
Weather & Chaos
A NUMERICAL WEATHER FORECASTING AND APPLIED DYNAMICS PROJECT

Introduction

- Testing a new oceanic LETKF data assimilation system for potential operational implementation at NCEP
- SODA (an Optimal Interpolation variant) is the control
- Two versions of LETKF have been implemented:
  - LETKF-IAU, using the incremental updates of Bloom, as used by SODA
  - LETKF-RIP, using the Running-in-Place procedure of Kalnay and Yang

Methodology

Assimilation Methods

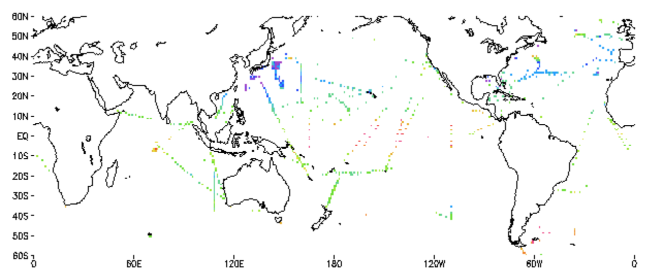


Observation Coverage

Data includes:
- Mechanical bathythermographs (MBTs)
- expendable bathythermographs (XBTs)
- conductivity-temperature-depth devices (CTDs)
- measurements from thermistors, reversing thermometers and salinity from CTD and station
- Argo data is also used starting at its inception in 1999.
- Additional data includes moored thermistor chains, stations, and ship intake temperatures.

For the purpose of this study, only in situ profile data was used.

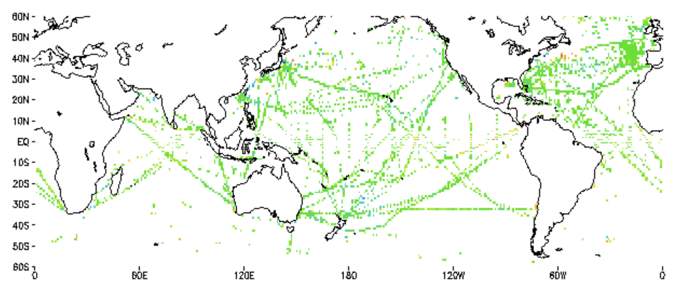
Example locations of vertical profiles for a 5-day window in 1997



(Temperature)

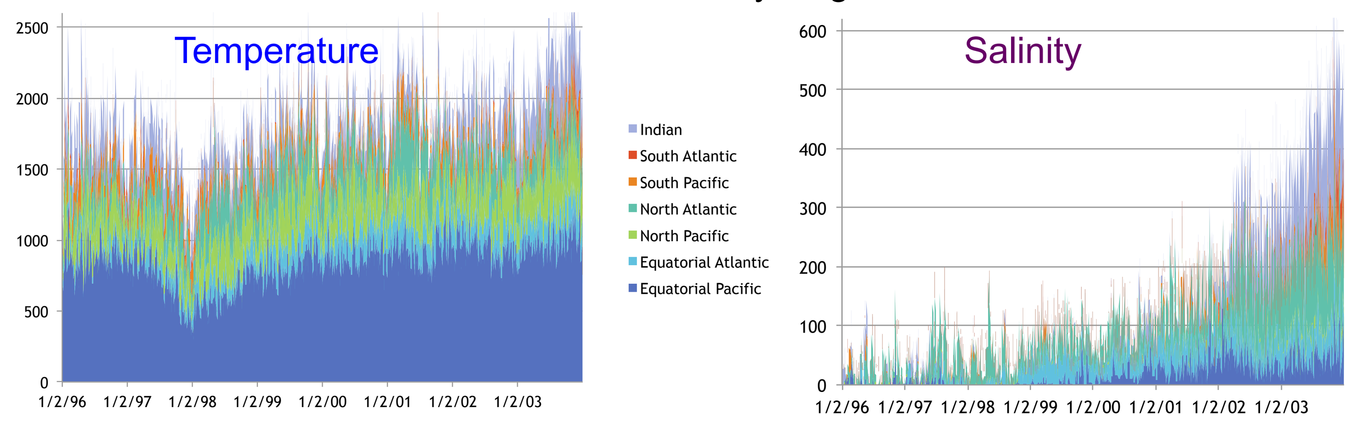
Extremely sparse data coverage on temporal scales on the order of days

Example locations of vertical profiles over 55-day window in 1997



Sparse, but improved, data coverage on temporal scales on the order of months

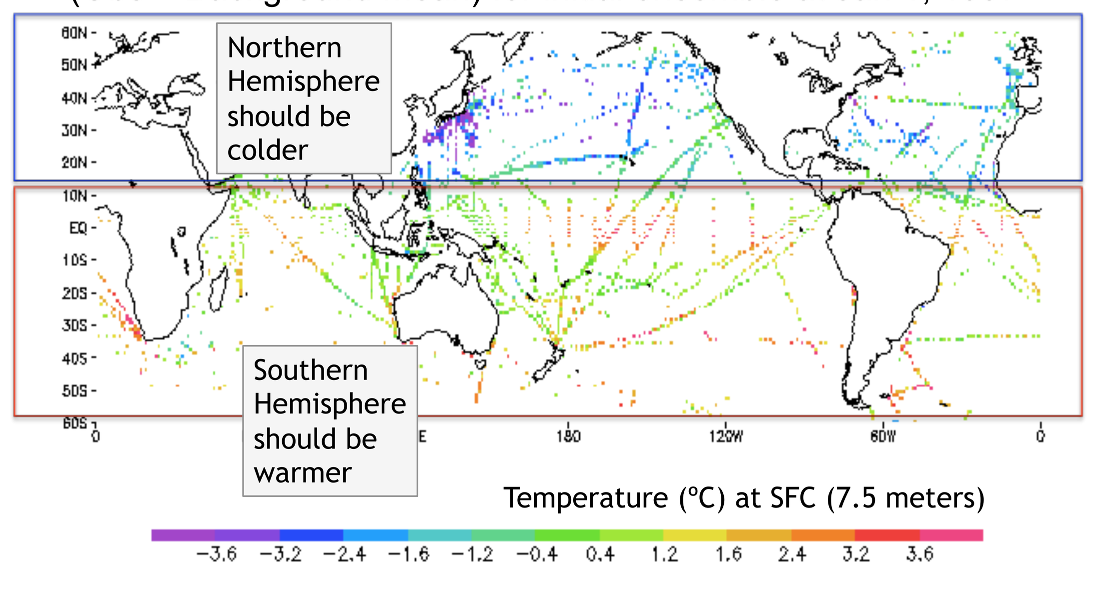
Observation Count by Region



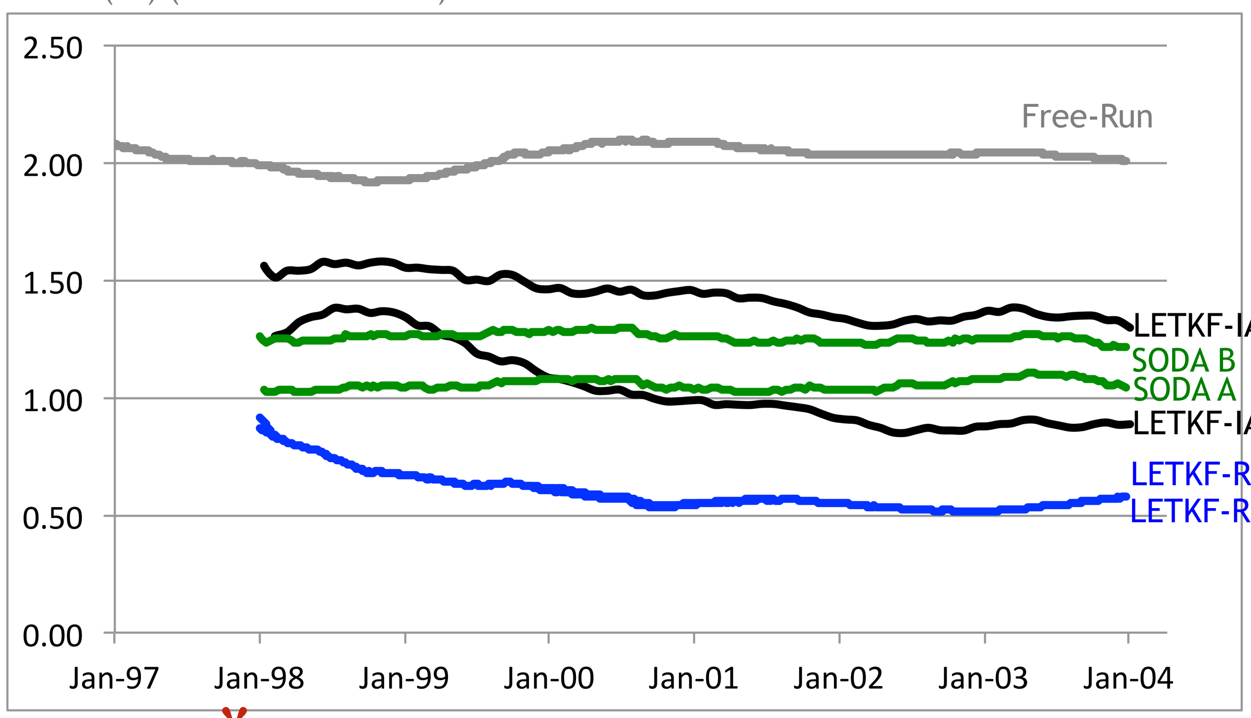
Model

- GFDL's Modular Ocean Model (MOM2)
- Experiment spanning Jan 1997 to Jan 2004
- Monthly surface wind stress and sea surface temperature (SST) data used from the NCEP reanalysis. Climatology used for sea surface salinity.
- There is presence of hemispheric bias, strongest near the surface, as illustrated below.

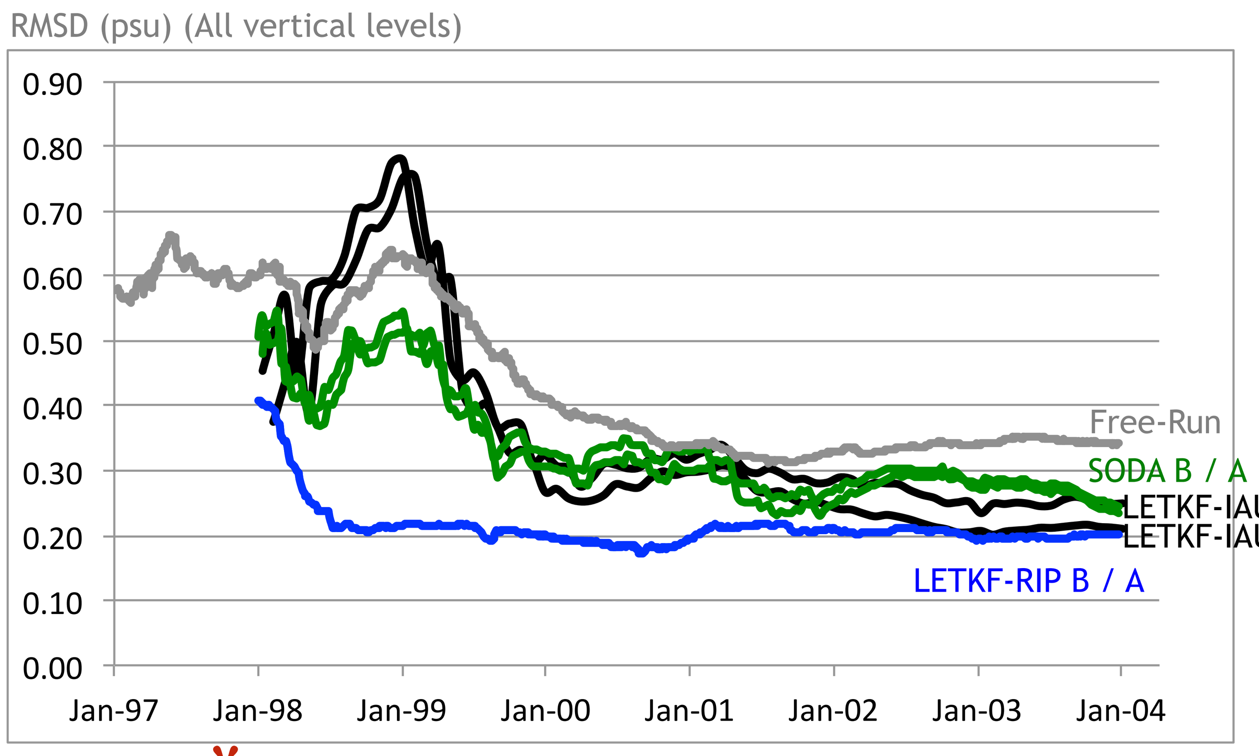
(Obs – Background mean) for initial ensemble at Jan 1, 1997



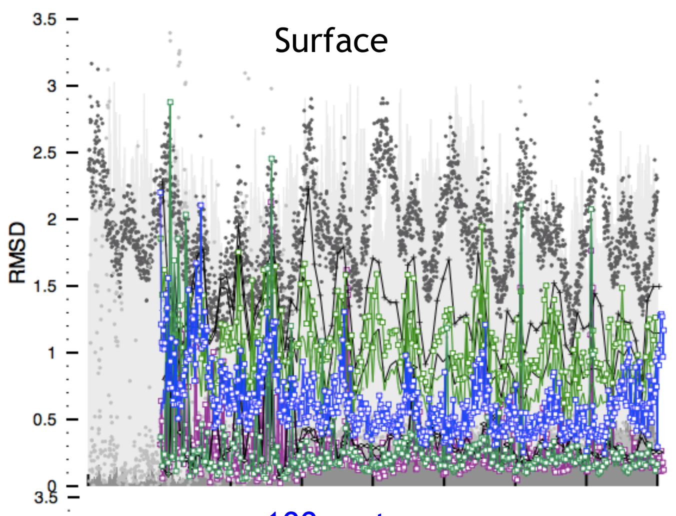
Results



*12-month moving average
Temperature RMSD (°C)



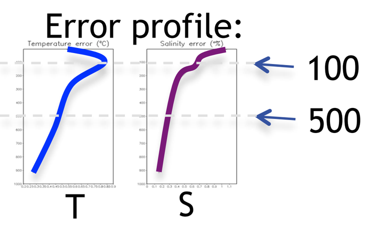
*12-month moving average
Salinity RMSD (psu)

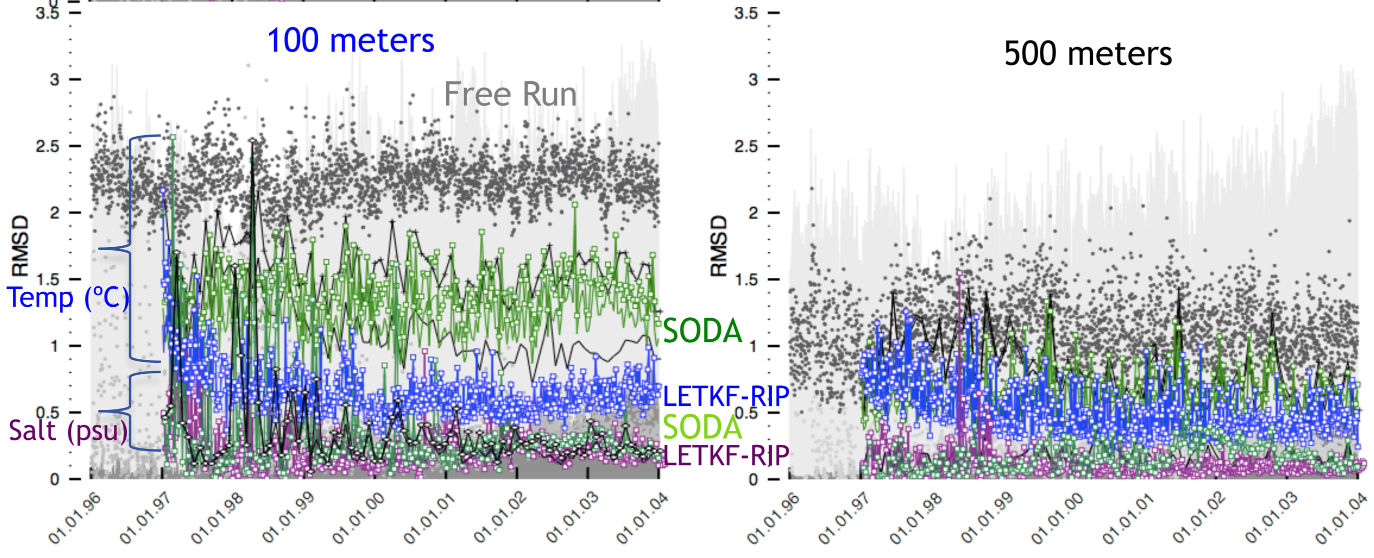


*RMSD by Depth

Big improvement at 100 meter depth

Error profile:

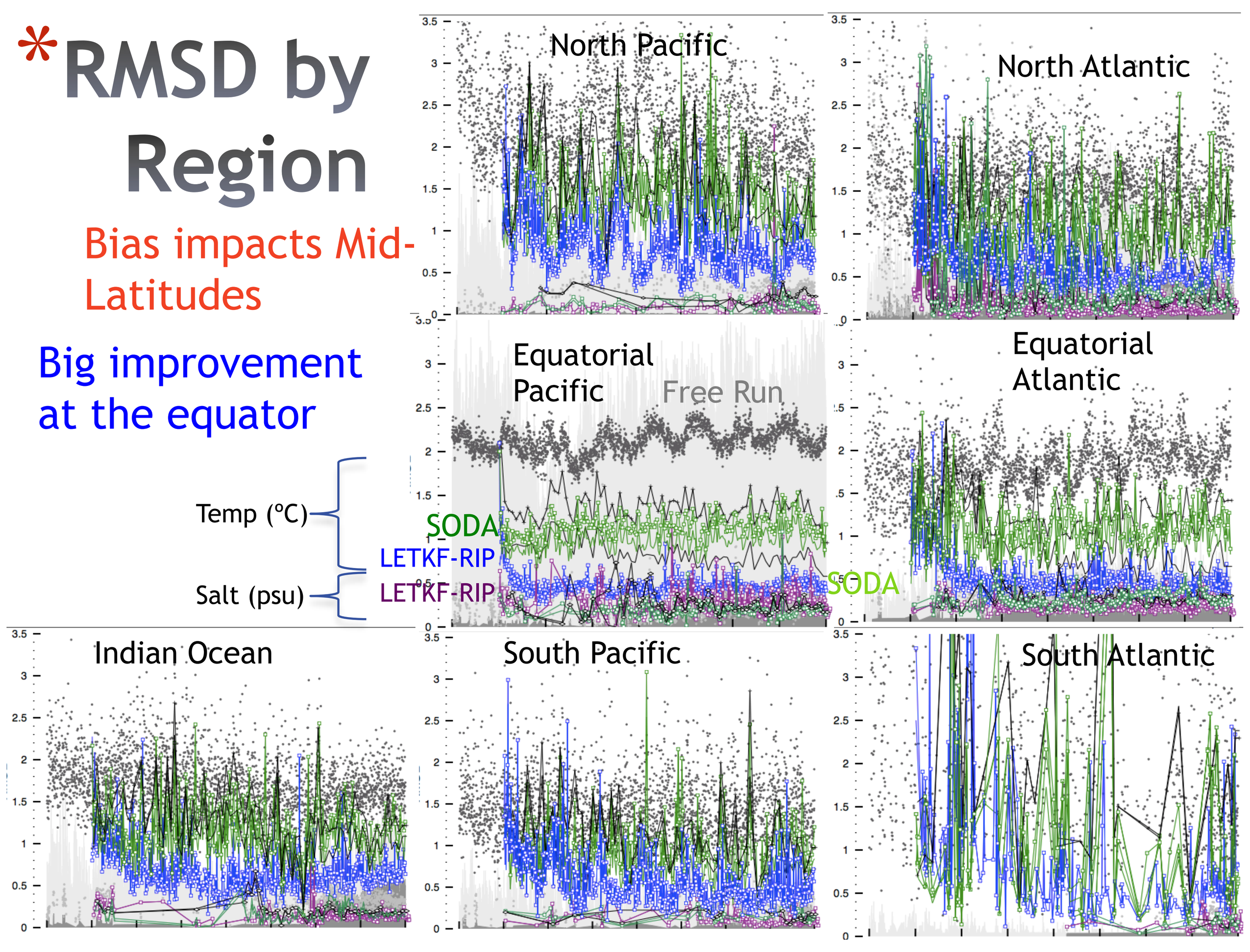




*RMSD by Region

Bias impacts Mid-Latitudes

Big improvement at the equator



Conclusions

- LETKF-RIP outperforms SODA in the metric measuring RMS error between observations and forecast (O-F), and observations and analysis (O-A).
- LETKF-IAU performs on par with SODA after sufficient spin-up even though it is limited to using observations only once.
- LETKF performance is best in the Equatorial regions where there is more dynamic instability, more consistent observational coverage, and lowest model bias
- LETKF performs best in the vertical level with greatest variability (e.g. the thermocline depth)

References

[CCC00a] Carton, J.A., Chepurin, G., CAO, X., Giese, B. *A Simple Ocean Data Assimilation Analysis of the Global Upper Ocean 1950-95 Part I: Methodology.* Journal of Physical Oceanography, Volume 30, p. 294-309, 2000.

[CCC00b] Carton, J.A., Chepurin, G., CAO, X., Giese, B. *A Simple Ocean Data Assimilation Analysis of the Global Upper Ocean 1950-95 Part II: Results.* Journal of Physical Oceanography, Volume 30, p. 311-326, 2000.

[HKS08] Hunt, B.R., Kostelich E.J., Szunyogh, I. *Efficient Data Assimilation for Spatiotemporal Chaos: A Local Ensemble Transform Kalman Filter.* arXiv:physics/0511236 v1 28 Nov 2005. Dated May 24, 2006.

[KY08] Kalnay, E., Yang, S.C., Accelerating the spin-up of Ensemble Kalman Filtering. [http://www.atmos.umd.edu/~ekalnay/AcceleratingSpinupEnkf_QJRMS.pdf]

Content from the Ph.D. Dissertation of Stephen G. Penny, University of Maryland College Park
Contact: pennysg@umd.edu