A Dual Assimilation System for Satellite Altimetry

I.Fukumori, T.Lee, D.Menemenlis, L.Fu, B.Cheng,
B.Tang, Z.Xing, M.Nakamura (JPL) and R.Giering (FastOpt)

ABSTRACT

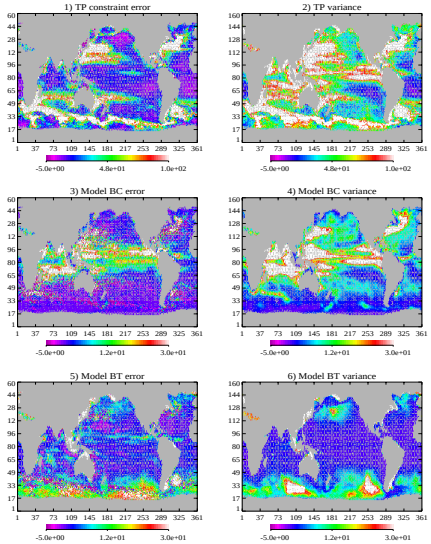
Progress has been made in implementing a complimentary, dual data assimilation system for estimating the time−evolving ocean circulation. The system consists of a "cellular" Kalman filter that provides error estimates and a means for routine analyses, and the adjoint method that is used for parameter estimation and rigorous reanalyses. The model is based on the MIT GCM and is global with a reasonably high resolution (Δz=10m, Δy=1/3°; 360×224×46) and advanced mixing schemes (GM & KPP). TOPEX/POSEIDON data are assimilated together with Levitus climatology and NCEP flux estimates.

PRIOR ERROR ESTIMATION

Statistics of prior data and model errors (R, P) may be estimated by comparing observations (D) and their model simulation (M);

$$< DD > = < SS > + 2 < SR > + < RR >$$
$$< MM > = < SS > + 2 < SP > + < PP >$$
$$< DM > = < SS > + < SP > + < RS > + < RP >$$

Data constraint error, R, may be uncorrelated over a short distance in space and/or time (e.g., meso−scale eddies in a non−eddy resolving model). Then, the lagged covariances above may be used to estimate < PP > and, then in turn, the zero lagged < RR >.

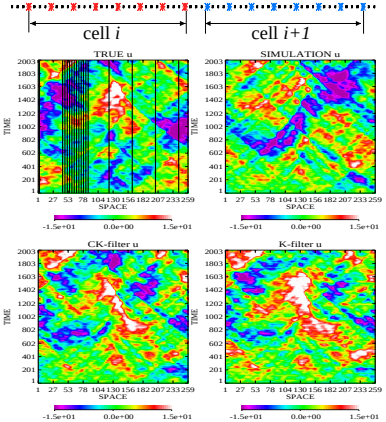


PRIOR SEA LEVEL ERROR ESTIMATES

Error estimates (left column) are compared with variances of TOPEX/POSEIDON and model (right column). The error estimates are based on spatial lag covariance along T/P ground tracks at 1.5 times the model resolution. Units in cm^2.

"CELLULAR" KALMAN FILTER

Certain model errors are approximately uncorrelated from others; e.g., Small−scale errors are independent over large distances. Such near independent errors can efficiently be estimated over a large domain by combining multiple overlapping regional (and/or physical) filters. Example: 1−d non−rotating shallow water model.

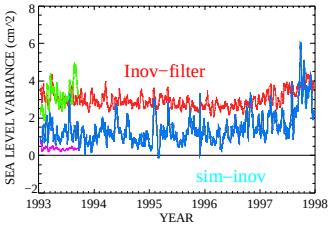


A CKF OSSE WITH A 1−D WAVE MODEL

Time−space diagrams of velocity; true solution, false solution, Cellular filter, and Kalman filter. Assimilated data are sea level at limited station locations indicated by vertical lines in the true solution.

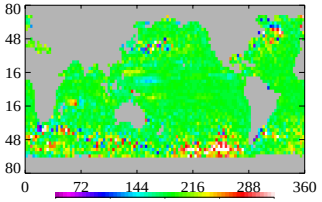
ASSIMILATION OF T/P BY KALMAN FILTERS

A global barotropic filter and a regional first baroclinic mode filter are constructed to establish a baseline estimate of the wind−driven circulation of the tropical Pacific Ocean.



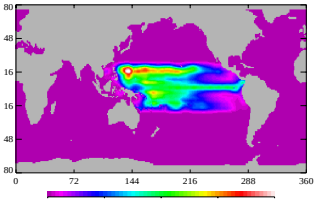
SKILL OF THE FILTERS

Difference in residual variance among simulation, filter prediction (innovation), and filtered estimate. Positive values indicate skill of the filter. The barotropic filter is based on a global coarse grid (6°×6°, 966 points, 3 variables).



SKILL OF THE BAROTROPIC FILTER

Difference in variance of simulation residual and innovation. Positive values indicate skill of the filter. Units in cm^2.

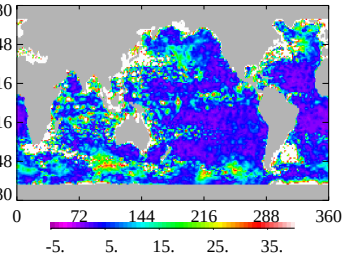


BAROCLINIC SIMULATION ERROR ESTIMATE

Model process noise is modeled as wind error. The baroclinic filter consists of amplitudes of the first baroclinic mode defined on a coarse grid spanning the tropical Pacific Ocean (10°×5°, 20°S~20°N, 132 points, 3 variables). Sea level, units in cm^2.

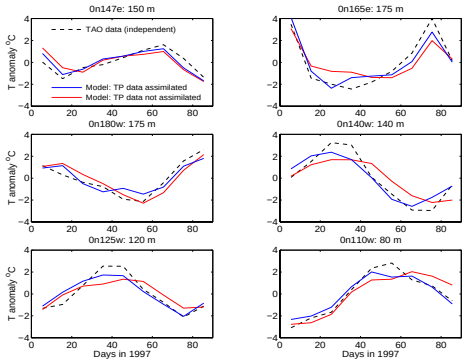
ASSIMILATION BY ADJOINT METHOD

T/P data are assimilated simultaneously with Levitus climatology and NCEP surface flux estimates. A time−hierarchical approach is taken whereby a longer assimilation is initialized by results from a shorter optimization. Results are shown for a three−month (Jan−March, 1997) optimization.



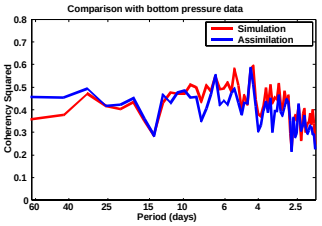
REDUCTION OF MODEL−T/P DIFFERENCE

The adjustment of initial state plays a much more important role than that of surface forcing during this short period of assimilation. Units in cm^2.



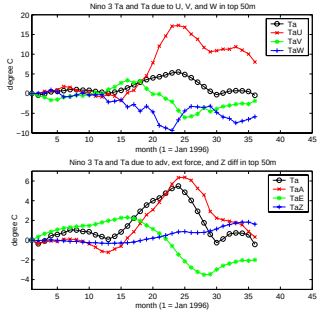
COMPARISONS WITH SUBSURFACE TEMPERATURE

Assimilation of T/P (adjoint) leads to an overall improvement of thermocline temperature variations when compared with independent TAO data.



COMPARISONS WITH BOTTOM PRESSURE GAUGES

Assimilation of T/P (BT K−filter) improves bottom pressure at periods longer than 20−days. (Average of 17 gauge records.)



NATURE OF NINO3 TEMPERATURE CHANGE

Analysis of model simulation shows Nino3 temperature change (Ta) is primarily due to zonal advection (TaU).