Application of a 3D-var data assimilation scheme to an eddy-permitting North Pacific Model based on ROMS

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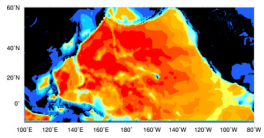
1. Object

A three-dimensional variational (3D-var) data assimilation scheme has been developed and applied to an eddy-permitting North Pacific model based on Regional Ocean Modeling System (ROMS). See the abstract about our final goal. In this poster, we show the scheme design and examine the performance of the 3D-var system in the western north Pacific.

2. Numerical model

The Numerical model is constructed by Kuroda et.al., 2009 (see in detail). After the simulation was run from 1980.1.1 to 1991.12.31, the assimilation has started



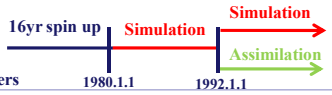


Fig.2.1: Model Domain. 0.5x0.5x48layers

3. 3D-variational data assimilation & IAU

$$J(x)=\frac{1}{2}(x^a-x^b)^T B^{-1}(x^a-x^b)+\frac{1}{2}\left[H(x^b)-y\right]^T R^{-1}\left[H(x^b)-y\right]+Jn \quad (1)$$

$$J(y)=\frac{1}{2}\sum_l\sum_m y_{l,m}^T B_{m,l}^{-1} y_{l,m}+\frac{1}{2}\left[Hx(y)-x^o\right]^T R^{-1}\left[Hx(y)-x^o\right] \quad (2)$$

$$x(y)=x_f+S\sum_m w_m U_m \Lambda_m y_m$$

A basic cost function (1) is difficult to solve because B^{-1} has large dimension and (1) is nonlinear. In order to overcome the difficulty, we adopt two methods: 1. a preconditioning method to avoid to calculate B^{-1}(see in detail Fujii, 2003) and 2. a reduction method of the dimension due to the analysis temperature and salinity profiles by using vertical coupled EOF modes (eqn. 2). Ys in (2) are the control variables, l is the order of EOF modes and m indicates partitioned areas such as Fig.3.1.

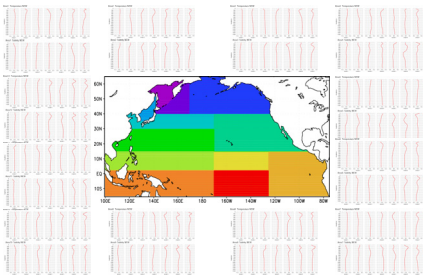


Fig.3.1: Area partition of vertical EOF modes.

IAU method

IAU (Incremental Analysis Update) is a method to remove some spurious signals in the analysis. The difference between IAU eqn. and Nudging eqn. is shown below.

$$\frac{dx(t)}{dt}=Mx+\frac{1}{\tau}\Delta x^a \qquad \Delta x^a \equiv x^a-x^b(\tau/2)$$ **IAU**

$$\frac{dx(t)}{dt}=Mx+\frac{1}{\tau}\left[x^a-x(t)\right]$$ **Nudging**

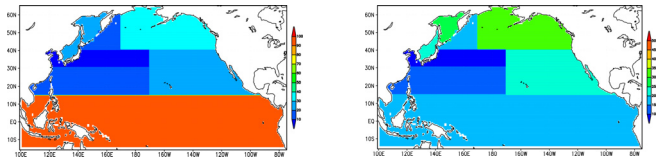
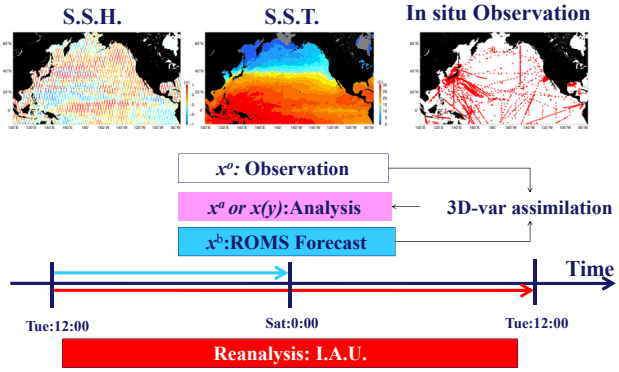


Fig.3.2: Horizontal Correlation scales. Left Zonal Right: Meridional.

4. System

Fig.4.1: Schematic diagram of the system.



5. S.S.H. map (1993.1.3)

(a)AVISO MADT 0.25x0.25 (b)Simulation 0.5x0.5 (c)3Dvar Reanalysis 0.5x0.5

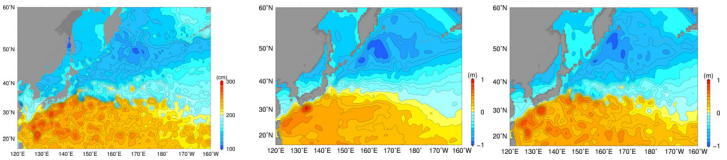


Fig.5.1: Sea Surface Height map at 1993.1.3. (a) is a AVSIO MADT 0.25x0.25map. (b) is a simulation output (without assimilation). (c) is a reanalysis of this 3D-var system.

6. Mean E.K.E. (1993～1998) at the surface

(a)AVISO MSLA 0.3x0.3(1999) (b)Simulation 0.5x0.5 (c)3Dvar Reanalysis 0.5x0.5

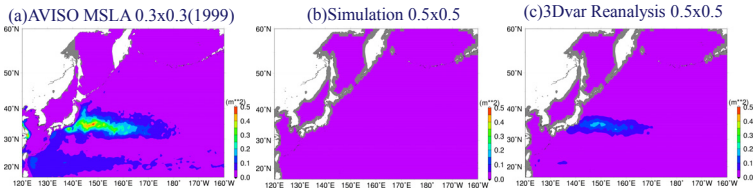


Fig.6.1: Mean eddy kinetic energy (1993～1998) at the surface. (a) is a AVSIO MSLA 0.25x0.25. (b) is a simulation output (without assimilation). (c) is a reanalysis of this 3D-var system.

7. N.P.I.W along 165E (1994.1.15)

(a)Simulation (b)3Dvar Reanalysis

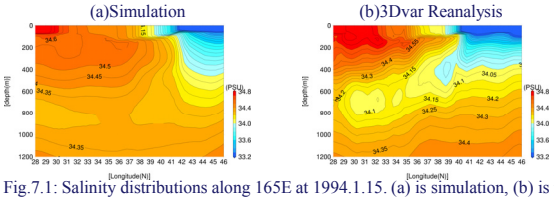


Fig.7.1: Salinity distributions along 165E at 1994.1.15. (a) is simulation, (b) is the 3D-var system. These figures are drawn to investigate the performance of the North Pacific Intermediate Water characterized by low salinity minimum.

8. Winter time S.S.T. difference between 1995 and 1996

(a)GHR S.S.T. (b)Simulation (c)3Dvar Reanalysis

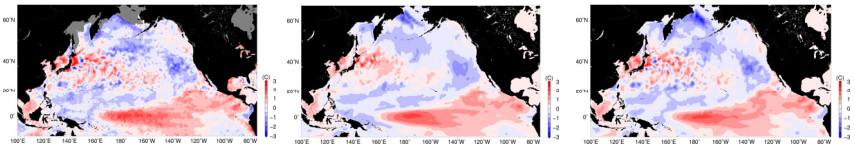


Fig.8.1: Winter time SST difference between 1995 and 1996. (a)GHRSST, (b)simulation, (c)3D-var Reanalysis. The PDO index is positive(negative) at 1995(1996).

9. S.T.M.W. along 137E (1994.January)

(a)Observation (b)Simulation (c)3Dvar Re-analysis

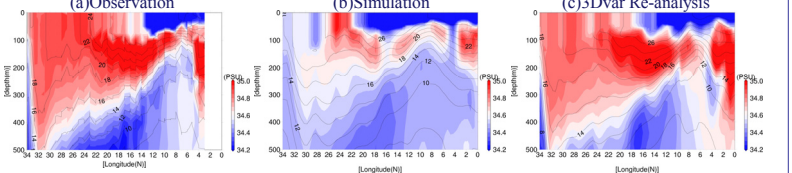


Fig.9.1: Salinity (shaded) and Temperature (contour) along 137E at 1994.Jan. (a) observations by JMA, (b) simulation, (c) the 3D-var system. These figures are drawn to investigate the performance of the Sub Tropical Mode Water identified as a layer of reduced stratification found below the seasonal thermocline and above the main thermocline.

10. Future works

It was found the 3D-var scheme works well and significantly improved simulation results in the western north pacific. That is, the reanalysis data is in better agreement with some of the observed data than the simulation without the data assimilation.

We have a plan to apply this 3D-var scheme to a high resolution numerical model based on ROMS (0.1degreex0.1degree ; Kuroda et al.2009) .