

A ROMS/DART data assimilation system with application to the South Australian Sea

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Motivation and background

South Australian Sea hosts the world's longest north boundary current and is one of the 64 Large Marine Ecosystems thus it's necessary to provide accurate analysis and forest of ocean state. In this study, a data assimilation system was established in this region by integrating the Data Assimilation Research Testbed (DART) and the Regional Ocean Modelling System (ROMS). A balance operator was used in this study to remove the imbalance and spurious noise caused by data assimilation.

Balance operator

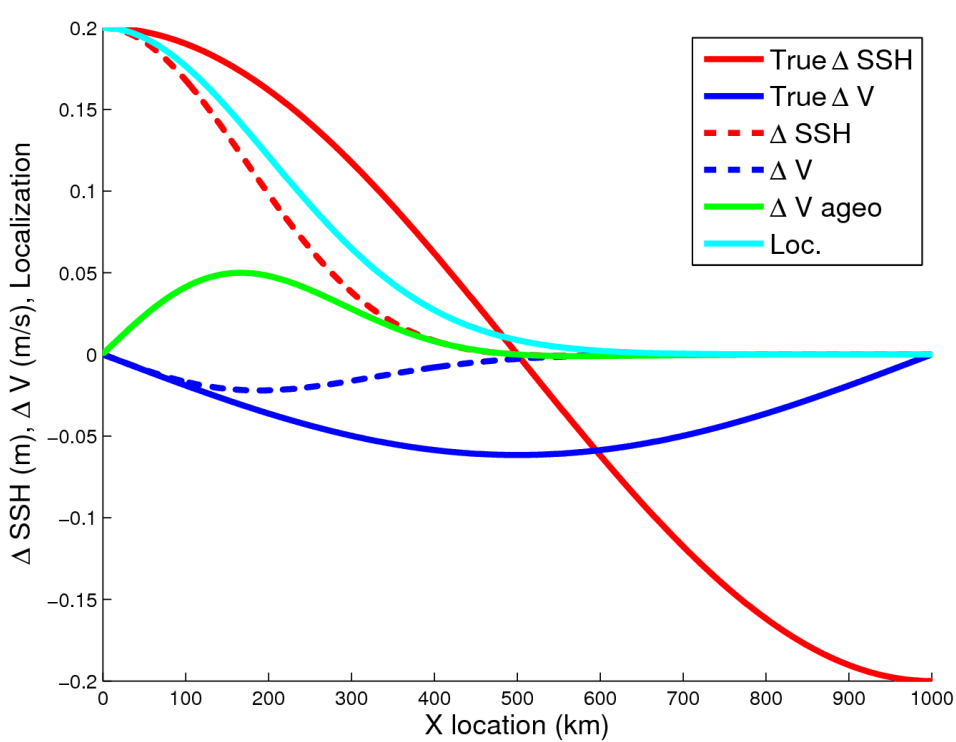


Fig 1. Schematic description of imbalance

Localization is necessary for DA but it introduces unbalance waves to the dynamic system (Fig 1) so we added geostrophic balance to the DA process. The physical balance in DA can be described by the following equations.

$$\begin{aligned}\delta T &= \delta T \\ \delta S &= K_{ST}\delta T + \delta S_U \\ \delta \eta &= K_{\eta p}\delta p + \delta \eta_U \\ \delta U &= K_{pU}\delta p + \delta U_U \\ \delta V &= K_{pV}\delta p + \delta V_U\end{aligned}$$

A shallow water model was used. The results (Fig 2) show that the balance operator reduces the error in two cases, and the effect is bigger in the wind forcing case.

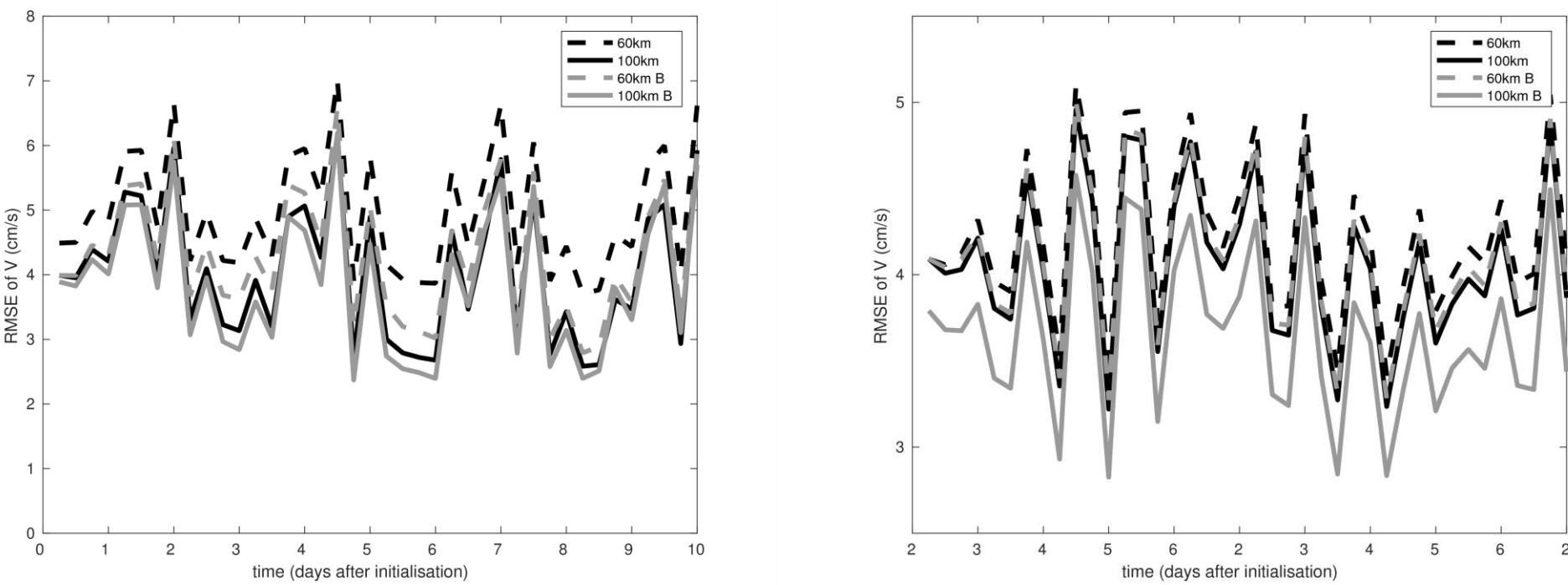


Fig 2. The RMS error of V as a function of time. Left: With wind, Right: Without wind

Model setup and experiment design

The domain is South Australian Sea (117°E ~ 140°E, 31.5°S ~ 39.5°S). The model was integrated on a 10km resolution with HYCOM boundary condition and CFSR atmospheric forcing. In the DA experiments (Table 1), satellite observed SSH and SST were assimilated with 50 ensembles using the Ensemble Adjust Kalman Filter (EAKF) from DART.

Table 1 Experiment design

Experiment	Assimilated variables	Balance operator
A (Control Run)	None	No
B	SSH	No
C	SST	No
D	SSH+SST	No
E	SSH	Yes

Acknowledges

This PhD project is sponsored by China Scholarship Council (CSC) - Imperial College London scholarship

Results

The results of different experiments were compared with OISST, AVISO gridded data and OSCAR ocean current dataset and the Root Mean Square (RMS) error is shown in Fig 3-5.

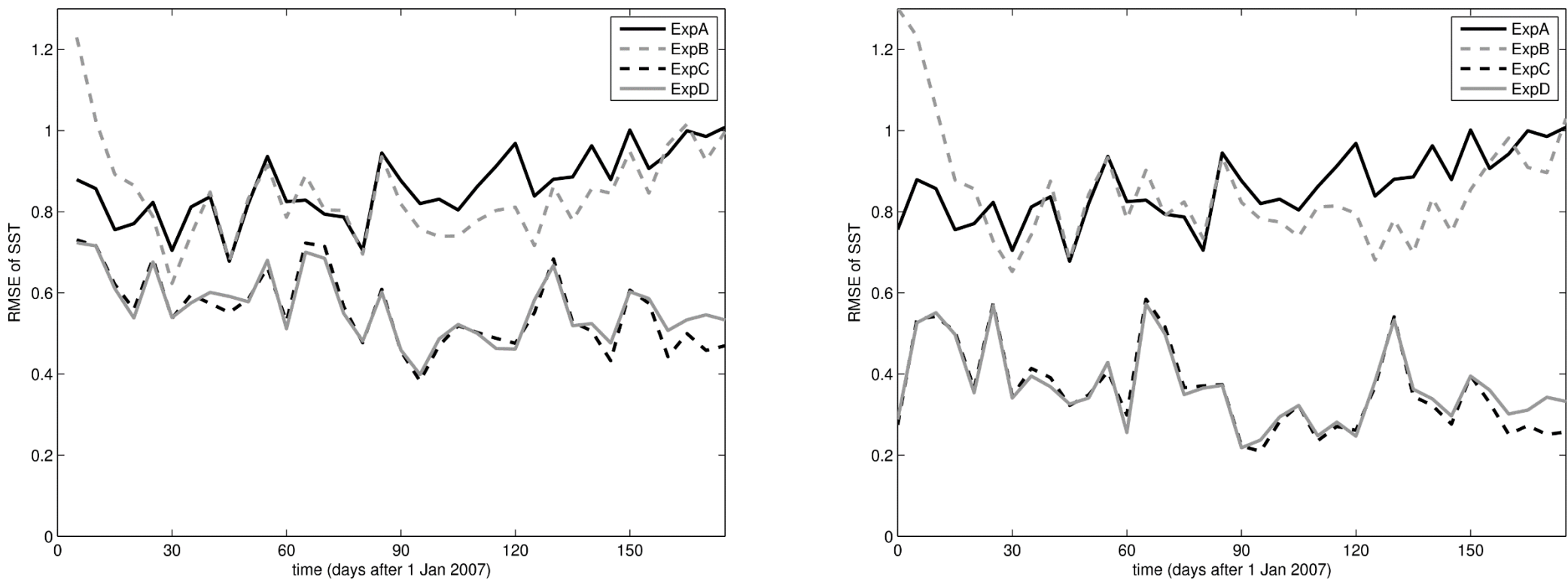


Fig 3. The RMS error of SST as a function of time. Left: Prior, Right: Posterior

Assimilating SST improved SST estimate, on the other hand, assimilating SSH alone didn't improve SST simulation.

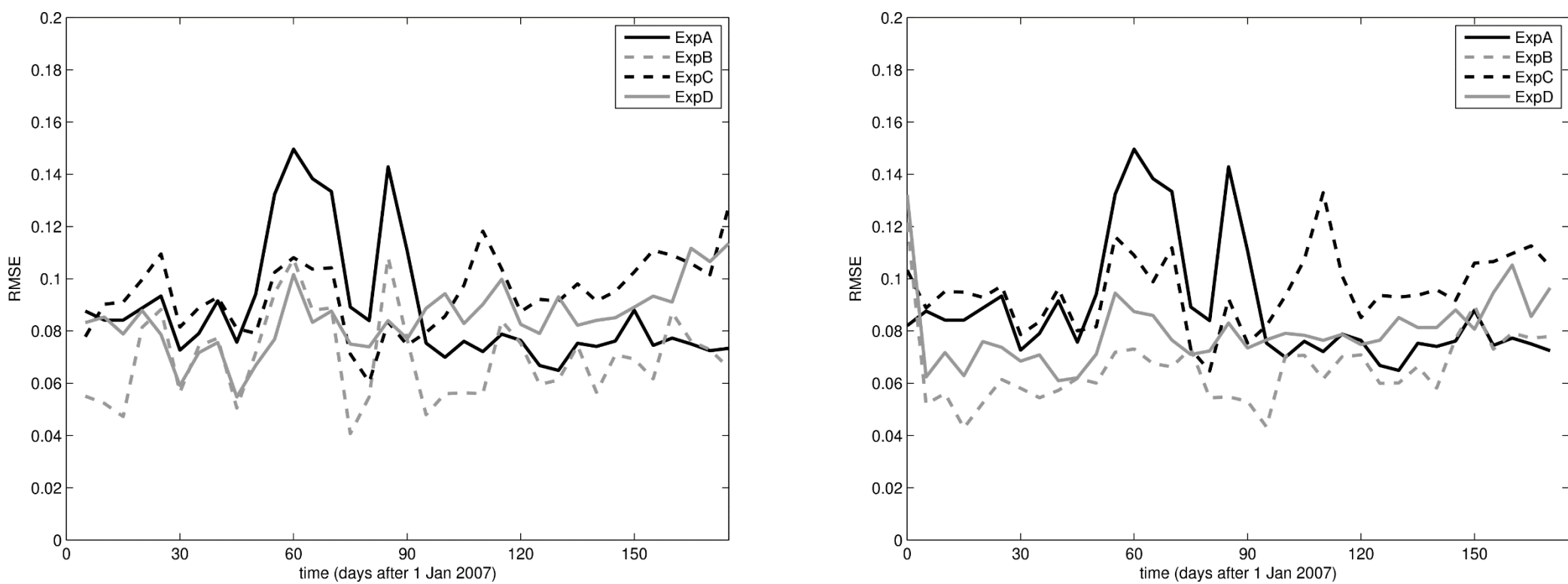


Fig 4. The RMS error of SSH as a function of time. Left: Prior, Right: Posterior

Assimilating SSH improved SSH simulation but assimilating SST subsided SSH.

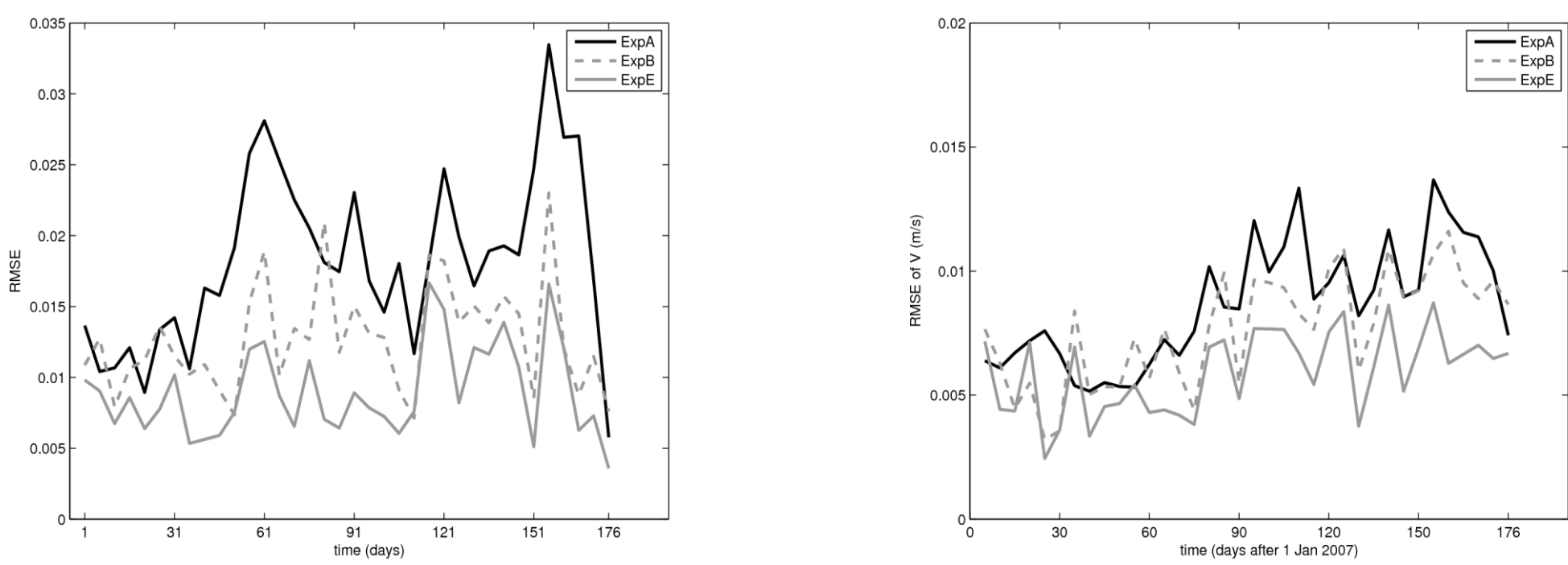


Fig 5. The RMS error of currents as a function of time. Left: Zonal, Right: Meridional

With the balance operator, the system produced better ocean currents. The RMS error of zonal current decreased from 18.3 cm/s (ExpA) to 13.5 cm/s (ExpB) and 10.7 cm/s (ExpE). The RMS error of meridional current decreased from 8.6 cm/s (ExpA) to 7.7 cm/s (ExpB) and 5.9 cm/s (ExpE).

Conclusion

- A ROMS/DART data assimilation system has been built (to our knowledge it is the first one), and satellite observations were assimilated.
- Balance operator was added to this system and ocean currents simulation was improved.

References

J. Anderson et al., 2009, *Bull. Am. Meteorol. Soc.*
S. J. Greybush et al., 2011, *Mon. Weather Rev.*
I. Hoteit et al., 2013, *Dyn. Atmos. Ocean.*
A. T. Weaver et al., 2006, *Q. J. R. Meteorol. Soc.*