LETKF-ROMS: An improved predictability system for the Indian Ocean.

Acknowledgements:
Model Domain

Model :: Regional Ocean Modeling System (ROMS)

DOMAIN:
30\textdegree}E to 120\textdegree}E ; 30\textdegree}S to 30\textdegree}N

RESOLUTION:
1/12\textdegree} (Horizontal)
40 sigma levels (Vertical)

BOUNDARY CONDITIONS:
Derived from INCOIS-GODAS.

ATMOSPHERIC FLUX:
NCMRWF flux from GFS model.

Assimilation Scheme :: Local Ensemble Transform Kalman Filter (LETKF)
No. of Ensembles :: 80
Spatial Distribution of Assimilated Observations (Temp and Salinity) for Aug 2016-Aug 2017

Assimilated satellite track SST over Indian Ocean for Dec 2016
Pictorial Illustration of the system
Introduction of spatio-temporal Representational Error

Time Series of RMSD in SST


Introduction of two mixing schemes across ensembles

Ensemble combination with use of two mixing schemes and model parameters like diffusion and viscosity coefficients

Disadvantages of two mixing scheme

SST distribution across the ensemble members

**LETKF-ROMS**: 80 ens members driven by 80 fluxes; KPP in 40 members & MY in 40.

- **Exp 1**: Same as LETKF-ROMS (no assm); ensemble flux
- **Exp 2**: Same as LETKF-ROMS (no assm); identical flux
- **Exp 3**: Same as Exp 1; all ensemble members respond to KPP

Initial ensemble (black) and after 600 days of run of three control experiments (exp1 — blue, exp2 — green and exp3 — red) and LETKF-ROMS (dashed black)
Spatial ensemble spread on 1st September 2016, 1st March 2017 and 1st September 2017 of the surface (5 m) temperature ((a), (b) and (c) respectively) and subsurface (100 m) temperature ((d), (e) and (f) respectively). (g) Domain-averaged time series of spread in temperature at 5 m (blue) and 100 m (red) depth.
Analyses

Location of in-situ observations (RAMA, NIOT, ADCP) used for comparison and validation of the analysis

Taylor Diagram of SST from LETKF-ROMS, INCOIS-GODAS and O-ROMS with respect to RAMA

Comparisons at all locations is available in Technical Report. (Balaji et al., 2018)
Temperature and Salinity Analysis

RMSD time series of (a) temperature and (b) salinity

RMSD Vertical profile of (a) temperature and (b) salinity

(Balaji et al., Ocean Modeling 2019)
SST Analysis

Spatial Correlation and RMSD of SST against AVHRR

Correlation

RMSE

Spatial Correlation and RMSD of SST against AVHRR
Zonal Current Analysis

Correlation

RMSE

Spatial Correlation, RMSD of Zonal Current against OSCAR
Time-depth evolution of currents at Equator, 80.5° E from (a) ADCP, (b) LETKF-ROMS and (c) O-ROMS.
Spatial Correlation and RMSD of Meridional Currents against HF Radar observations on East Coast of India
An ensemble kalman filter based data assimilation is implemented using LETKF in 1/12° X 1/12° ROMS.
This system comprises of 80 ensemble members.
It assimilates in-situ temperature and salinity profiles and satellite track SST.
The ensemble members are tweaked to maintain healthy spread.
The assimilation showed significant improvement in estimation of tracers as well as independent variables.
The most profound improvements were seen in currents whose observations were not assimilated.
RMSE in currents is reduced by 5 cm/s over entire domain and 15cm/s in Equatorial IO and East Coast of Africa.
LETKF has shown better predictability of surface and subsurface currents.

Things to worry about:

- LETKF-ROMS is computationally expensive compared to FREE-ROMS.
- LETKF-ROMS requires periodic checks as the Ensemble system ideally works for Gaussian distributed ensemble members.


THANK YOU