Scaling observation error for optimal assimilation of CCI SST data into a regional HYCOM EnOI system

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- Ongoing efforts to create oceanographic operational and decision making products in South Africa
- This research builds on efforts towards an operational ocean forecasting system for the South African region
- Forecasting of currents, temperature, salinity
- Many will benefit from this system, including other operational and decision making tools

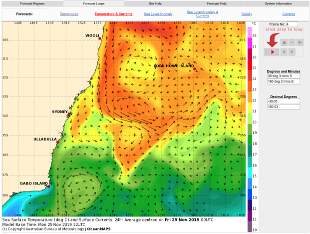


Figure: Australia's OceanMAPS operational ocean forecasting system.

Hybrid Coordinate Ocean Model (HYCOM)

- Regional model developed by Backeberg et al. (2014)
- Resolution: 1/10°
- Domain: 0–60°E, 10–50°S.
- ERA-interim atmospheric forcing
- 30 vertical layers
- Nested in basin-scale model of Indian and Southern Oceans (George et al. 2010)

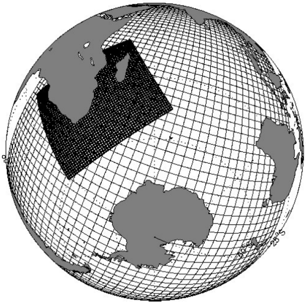


Figure: Nested and basin-scale model domains.

Climate Change Initiative (CCI) SSTs

- L4 global reanalysis SST product, produced by ESA
- Synthesis of (A)ATSR, SLSTR and AVHRR observations
- 0.05° resolution
- Adjusted to 20 cm depth
- Version 2.0

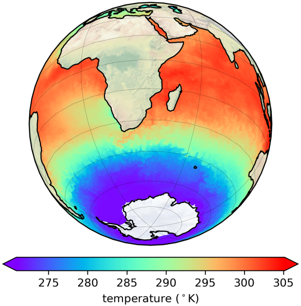


Figure: CCI L4 SST.

Ensembe Optimal Interpolation (EnOI) scheme

- Ensemble optimal interpolation (EnOI, Oke et al. 2002)
- Less computationally expensive than Monte Carlo simulations such as Ensemble Kalman Filter (EnKF)
- EnKF generates an ensemble of model states from which a single forecast is created
- EnOI generates a single forecast from a static ensemble of model states

Analysis equation

- From the forecast (ψ^{f}), the analysis (ψ^{a}) is calculated as:

Analysis equation

$$\psi^{\mathrm{a}} = \psi^{\mathrm{f}} + \alpha \mathbf{A}'\mathbf{A}'^{\mathrm{T}}\mathbf{H}^{\mathrm{T}} \left(\alpha \mathbf{H}\mathbf{A}'\mathbf{A}'^{\mathrm{T}}\mathbf{H}^{\mathrm{T}} + \mathbf{T}\mathbf{T}^{\mathrm{T}} \right)^{-1} \left(\mathbf{d} - \mathbf{H}\psi^{\mathrm{f}} \right) \quad (1)$$

- $\mathbf{T}\mathbf{T}^{\mathrm{T}}$ is the observation error term
- α is the scaling factor

Inflating observation errors

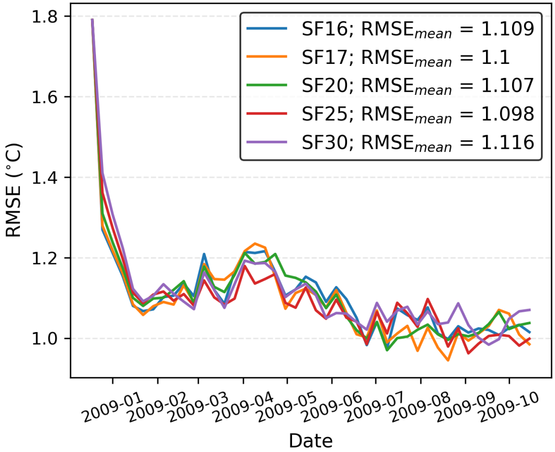
- From Equation 1, observation error ($\mathbf{TT}^{\mathsf{T}}$) is 'inflated' by scaling factor (α) yielding inflated observation error ($\mathbf{R}_\alpha$):

Inflating observation error

$$\mathbf{R}_\alpha = \frac{1}{\alpha}\mathbf{TT}^{\mathsf{T}} \tag{2}$$

- Larger (smaller) scaling factor results in weaker (stronger) model fit to observations
- N.B. process in assimilation systems

SST RMSE between model and observations



- Aim for lowest mean RMSE without model crash
- Values below 16 all crashed
- Best result: scaling factor 25 (RMSE$_{mean}$ = 1.098°C)
- OSTIA used scaling factor of 5 (Rapeti & Backeberg 2016)

Error difference between CCI & OSTIA

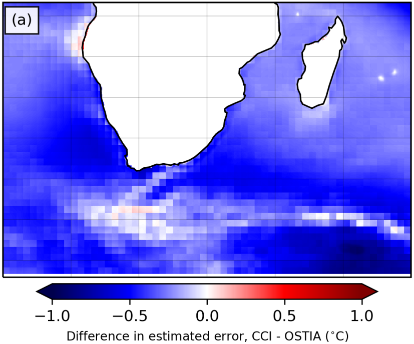


Figure: Spatial mean difference in estimated error.

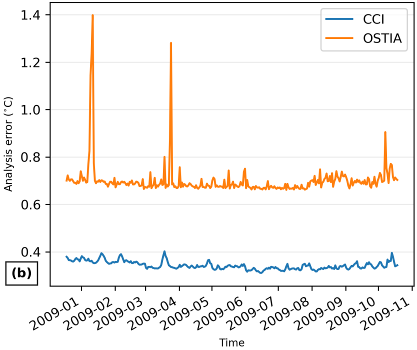


Figure: Difference in estimated error over time.

Introducing a 'floor'

- Postulating error estimation to perhaps be overconfident
- Introduce minimum threshold ($\mathbf{R}_{\text{floor}}$) for observation errors:

Observation error floor

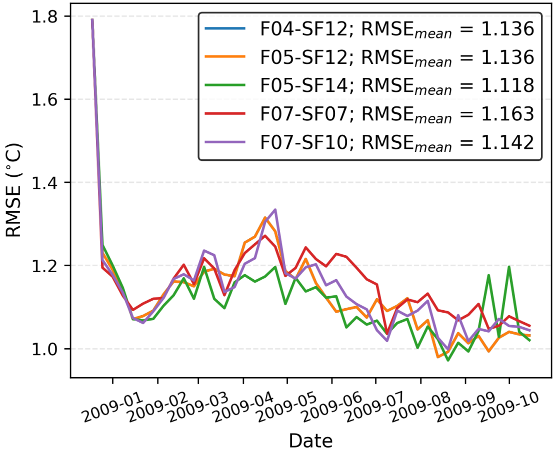
$$\mathbf{R}_\alpha = \max\{\mathbf{R}_{\text{floor}}, \mathbf{R}_\alpha\}, \tag{3}$$

where

$$\mathbf{R}_\alpha = \frac{1}{\alpha}\mathbf{T}\mathbf{T}^{\mathsf{T}} \tag{2}$$

- Floor values of 0.4°C, 0.5°C, and 0.7°C were tested

Floor results



- Smallest successful scaling factors shown
- Best result: scaling factor 14 with floor of 0.5°C
- However, still not improving on 'unfloored' scaling factor of 25 (RMSE$_{mean}$ = 1.098°C)

Conclusion

- Scaling factor less than 16 resulted in model failure
- Introducing a floor to the observation errors produced no improvement
- Best result: scaling factor of 25 ($RMSE_{mean} = 1.098^{\circ}C$)

Future work

- These results form part of a larger research project
- Compare assimilation of L4 and along-track SSTs in this region
- Determine best method to assimilate SST observations
- CCI will be assimilated using scaling factor of 25

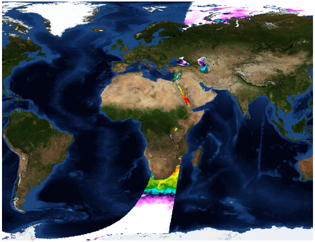


Figure: Along-track microwave SST observations.

Thank you!

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