Analyzing the Seasonal Errors of the Upper Indian Ocean Temperature with NCEP-CFS forecasts

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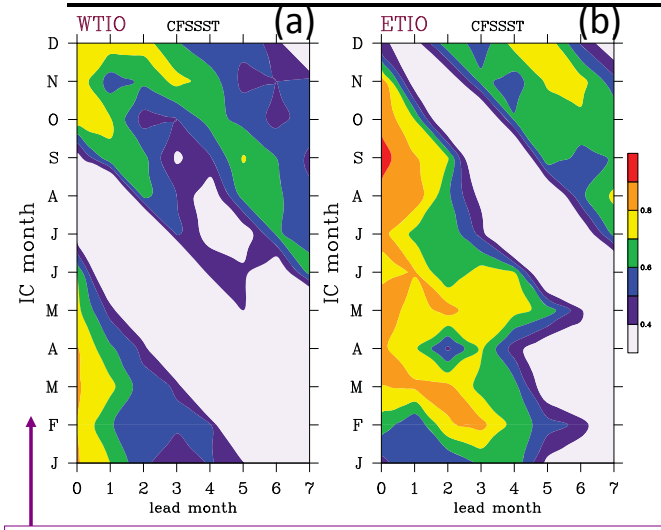
1. Northern Summer Predictability Barrier



Forecast skill is low regardless of the lead time, in the WTIO during the northern summer, and in the east during the northern winter.

Figure 1 Anomaly correlation coefficients of CFS forecast for the Tropical Indian Ocean SST, from the index regions in the western Tropical Indian Ocean (a, WTIO) and the eastern Tropical Indian Ocean (b, ETIO). X-axis indicates lead time in month. Y-axis indicates the initial condition months.

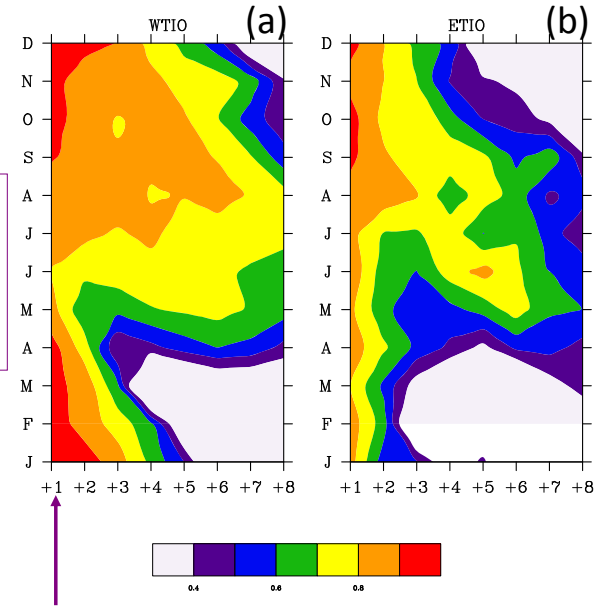


Figure 2 Same as the Fig.1, but for the upper 200m mean ocean temperature.

Winter barrier disappears with depth, while the summer barrier appears about a month ahead of SST.

2. Data and Methods

- **CFS real time ocean forecasts** (1982-2006)
- **GODAS** is compared, for CFS forecast is initialized with GODAS.
- For the monthly mean forecast for August, **heat budget analysis** is conducted in order to trace the major source of errors.

✓Local tendency $\rho c_p \int_{-200}^{0} \frac{\partial T}{\partial t} dz$

✓Surface heat flux Q_{srf}

✓Horizontal advection $\rho c_p \int_{-200}^{0} \left[-u \frac{\partial T}{\partial x} - v \frac{\partial T}{\partial y} \right] dz$

✓Vertical processes $\rho c_p \int_{-200}^{0} -w \frac{\partial T}{\partial z} dz + R$

, where R, non dynamiccal oceanic heat flux is mainly attributed to the vertical mixing processes

3. Heat Budget Analysis

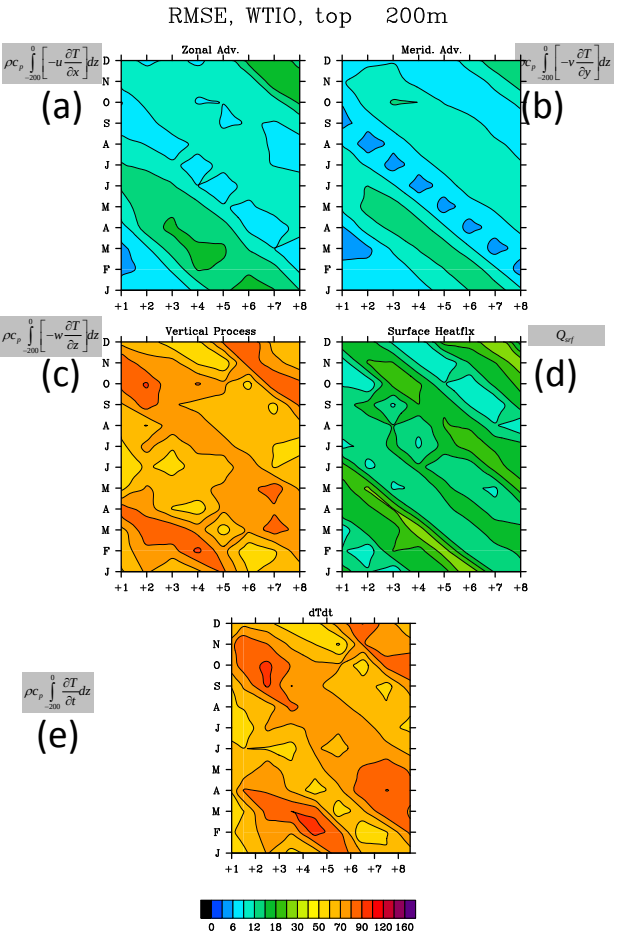
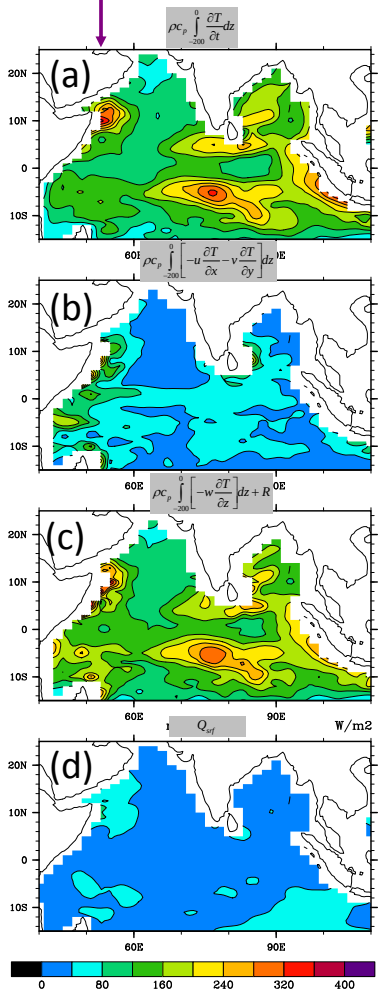


Figure 3 Root-Mean-Squared Errors of 200m heat content tendency in the WTIO separated into each term, (a) zonal advection, (b) meridional advection, (c) vertical advection, (d) surface heat flux and (e) total tendency, in Wm^{-2}. August forecast errors with June01 initial condition.

Figure 4 Root-Mean-Squared errors in WTIO, for the (a) 200m heat content tendency, as well as (b) horizontal advection, (c) vertical processes and (d) surface heat flux, in Wm^{-2}.



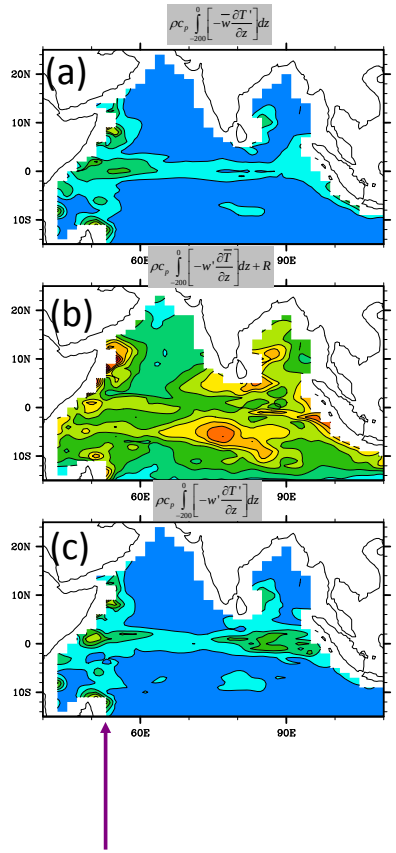


Figure 5 Same as Fig.4, but for the linearly separated vertical processes. (a) anomalous temperature advection by mean vertical currents, (b) mean temperature advection by anomalous vertical currents combined with the non dynamic processes and (c) nonlinear vertical advection.

4. Summary

- The forecast error in CFS ocean temperature in the Tropical Indian Ocean is closely examined.
- The SST forecast skill drops in the northern summer. This is strongly related to the errors in the subsurface thermal budget.
- The major error in the local heat content tendency can be attributed to the vertical processes rather than horizontal advection or surface heat flux.
- Linear separation further reveals that the major source of error is in the mean temperature advection due to the anomalous vertical currents.

References

Global Ocean Data Assimilation System, http://www.cpc.ncep.noaa.gov/products/GODAS/pl/introduction_godas_web.pdf

Saha S., and Co-authors, 2006: The NCEP Climate Forecast System. *J. Climate*, **19**, 3483-3517.

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