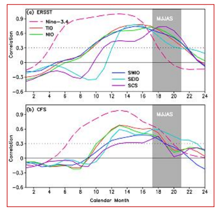
Biases in the Tropical Indian Ocean subsurface temperature variability in a coupled model

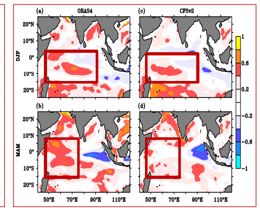
Rashmi Kakatkar*, C. Gnanaseelan, J. S. Chowdary, J. S. Deepa, Anant Parekh
Climate Variability and Data Assimilation Research, Indian Institute of Tropical Meteorology, Pune

Introduction:

- Unrealistic rapid decay of TIO basin-wide SST warming is seen in CFSv2 during the developed to decaying phases of El Niño
- CFSv2 failed to capture the subsurface – surface interaction in south-western TIO during DJF and MAM as compared to ORAS4 or observations
- Thus, detailed study of subsurface mode and its impact on surface and air-sea interaction in coupled models is very important, especially for prediction purposes
- This has motivated us to understand the TIO subsurface variability, the forcing mechanisms, the characteristics etc., in CFSv2



Chowdary et al., 2016, CD



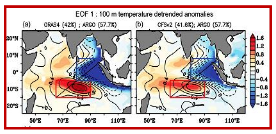
Correlation between 100m temp anomalies and SST anomalies

Data and Methodology:

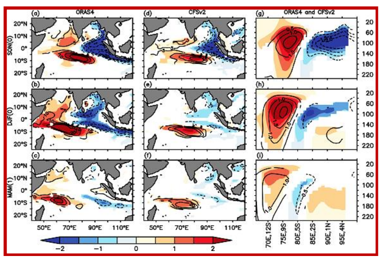
ÅORAS4 and ARGO ocean temperature
ÅERA40-Interim
ÅCFSv2 Free run [Roxy (2014)]
ÅEOF analysis
ÅCorrelation analysis
ÅRegression analysis

Results and Discussions

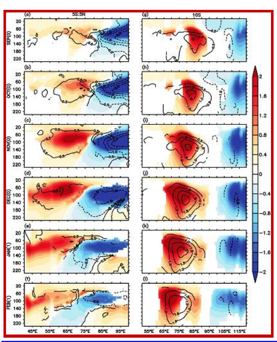
Evolution of subsurface temperature mode in TIO in CFSv2



CFSv2 is able to represent inter-annual variability patterns during SON season



CFSv2 fails to capture the intensification of the mode in DJF(0): Southern warming weakens with no extension to the west and the northern cooling almost disappears



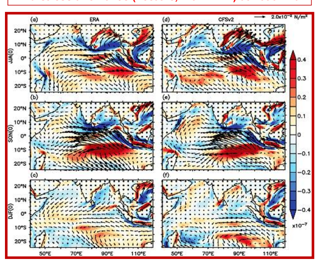
Peak warm anomalies are at around 100 m in the reanalysis where as they are at about 150 m in the model. This discrepancy in the model could be due to the deeper than observed thermocline

ÅUpward propagation of warm anomalies in the central to western region: strengthen the subsurface surface interaction and in turn amplify the air–sea interaction

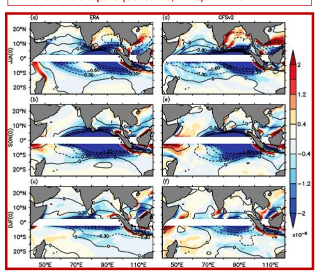
ÅSuch upward propagation of warm anomalies is underestimated in the model contributing to the suppression of thermocline SST coupling

Mechanisms behind early decay of subsurface dipole in TIO in CFSv2

wind stress curl anomalies (shaded,×10^{-7} N/m^3) and wind stress anomalies (vectors,×10^{-2} N/m^2) at 1000 hPa



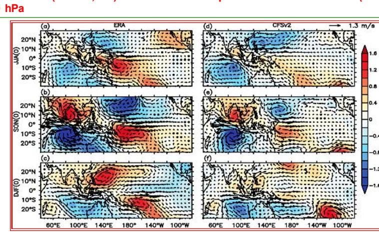
Ekman pumping velocity (shaded,×10^{-6} m/s) and Ekman meridional transport (contours, m^2/s) at 1000 hPa



ÅSurface wind anomalies and associated Ekman transport and Ekman pumping are not represented well in CFSv2 ➔ Weaker downwelling Rossby waves

ÅEquatorial easterlies are not represented well in CFSv2 ➔ Weak upwelling Kelvin wave propagation

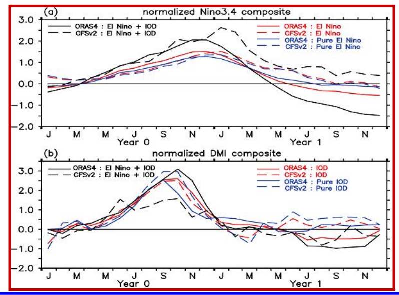
Stream function (shaded, s^{-1}) and rotational component of wind anomalies (vectors, m/s) at 1000 hPa



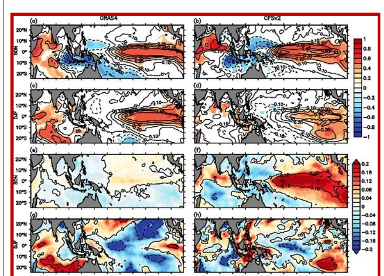
ÅThe southern anticyclone is not correctly positioned in the model, while northern anticyclone is much weaker.

ÅThis resulted in the misrepresentation of surface equatorial winds and in turn the north–south mode in the model

Impact of subsurface temperature mode in TIO on SST in CFSv2



Anomalously prolonged decay phase of El Niño in CFSv2 is found only during the El Niño, IOD co-occurrence years



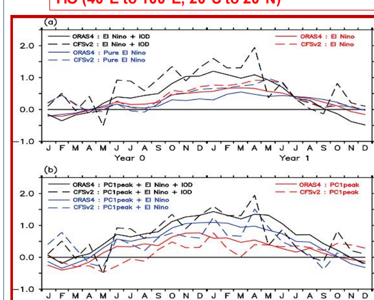
Correlation coefficient and Regression coefficient

Without IOD

Regression coefficient

Without ENSO

Composite of normalized SST anomalies averaged over TIO (40°E to 100°E, 20°S to 20°N)



The misrepresentation of subsurface variability in CFSv2 during DJF is closely associated with the rapid decay of El Niño forced TIO warming

Summary: CFSv2 displays early decay of the subsurface mode in DJF season.

- The misrepresentation of equatorial surface wind anomalies, associated Ekman transport as well as the Ekman pumping and misrepresentation of surface anticyclonic circulations resulted in the early weakening of the TIO subsurface mode in CFSv2.
- The anomalously prolonged decay phase of El Niño in CFSv2 is found only during the El Niño, IOD co-occurrence years. It is also found that the misrepresentation of subsurface variability in CFSv2 during DJF is closely associated with the rapid decay of El Niño forced TIO warming. The subsurface-surface interaction is not well captured by CFSv2 mainly during DJF.
- Proper temporal and spatial evolution of TIO subsurface temperature modes in models feedback to surface thereby improving the air–sea interactions.

Reference:
ÅRashmi Kakatkar, C. Gnanaseelan, J. S. Chowdary, J. S. Deepa, Anant Parekh, 2018, Biases in the Tropical Indian Ocean subsurface temperature variability in a coupled model, Climate Dynamics, online, https://doi.org/10.1007/s00382-018-4455-1.

Acknowledgements: Authors acknowledge the support and facilities provided by ESSO-IITM, Pune and MoES