Assessments of salinity impacts on SST using a linear inverse model

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The upper ocean salinity undergoes significant variations associated with large-scale climate modes, such as the El-Niño and Southern Oscillation (ENSO) in the tropical Pacific and the Indian Ocean Dipole (IOD) in the tropical Indian Ocean. By changing the density of the seawater, these salinity variations alter the upper ocean stratification and circulation, and thus have the potential to feed back to the climate modes themselves. Indeed, by conducting a series of sensitivity experiments using a regional ocean model, our recent work has demonstrated that surface and subsurface salinity variations associated with the IOD act to damp sea surface temperature (SST) anomalies and serve as a negative feedback to the IOD. However, due to the complex nature of the coupling between temperature and salinity variability, it is not straightforward to clearly identify these salinity impacts only from observational datasets.

To address this issue, here we propose to apply a linear inverse model (LIM), which succinctly describes the evolution of tropical climate variations within a linear framework. We have first determined the linear operator of the LIM based on temperature and salinity anomalies in the tropical Indian Ocean derived from an ocean reanalysis product and carried out a long-term integration of the LIM as a reference experiment. It is found that our LIM reasonably reproduces the amplitude and spatial structure of the observed temperature and salinity anomalies associated with the IOD. Then, we have designed another LIM experiment *without* the coupling between temperature and salinity variations (referred as “T-S decoupled LIM”), by modifying the linear operator of the original LIM. A comparison of outputs from both LIM experiments reveals that the amplitude of the IOD in the T-S decoupled LIM is substantially stronger than that of the reference experiments. This suggests that the interactions between temperature and salinity act to reduce the amplitude of the IOD, consistent with our previous results based on dynamical approaches. Calculations of the growth rates of the IOD-related SST anomalies further confirmed the above idea. Our results imply that the LIM can be a powerful tool for understanding and diagnosing the salinity impacts on SST in a simple manner.

Keywords: Indian Ocean Dipole, Salinity variation, Linear inverse model

