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Intraseasonal-to-interannual variability of South Indian Ocean sea level and thermocline: Remote versus local forcing

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Causes for interannual, seasonal, and intraseasonal variability of the Southern Indian Ocean (SIO) sea level and thermocline are investigated by quantifying the effects of local forcing over the IO and remote forcing from the Pacific via the Indonesian Throughflow (ITF). This is the first study to quantify the Pacific oceanic influence on the interior SIO thermocline depth and sea level and particular emphasis is placed on the thermocline ridge region (50E-75E, 5S-10S and 60E-80E, 8S-12S); where thermocline variability has been suggested to affect sea surface temperature. Two experiments are performed using an ocean general circulation model (OGCM) of the Indo-Pacific basin. In the Main Run (MR), the OGCM is forced by 3-day mean ERA40 fields for the period 1958-2001. In the experiment (EXP) run, the forcing fields over the Pacific are fixed to their 1958-2001 mean. Otherwise it is the same as the MR. The EXP run excludes the influence of atmospherically generated sea level and thermocline variability from the Pacific on the IO via the ITF. On interannual timescales, sea level and thermocline variability in the regions 50E-75E, 5S-10S and 60E-80E, 8S-12S is associated with the westward propagating Rossby waves and is largely driven by wind forcing acting upon the IO. Contributions from the Pacific in these regions impact the amplitude, rather than the phase of the anomalies. Further south (65E-75E; 13S-17S), the Pacific plays a much larger role in producing thermocline variability, effecting both the amplitude and phase of the anomalies. Composite analysis further suggests that remote forcing from the Pacific does make a secondary contribution to sea level and thermocline variability in the western SIO, however, its influence largely confined to the eastern IO. This is also true for the seasonal variability. Consistent with previous studies, results from the OGCM experiments suggest that semiannual variations of the thermocline dominate the annual cycle between 50E-75E, 5S-10S, and they are primarily forced by the semiannual component of local Ekman pumping velocity, with remote forcing from the Pacific enhancing their amplitudes. In the region of the ridge between 60E-80E, 8S-12S, however, the annual cycle dominates, and the annual variability is caused by both local and Rossby waves generated by the Ekman pumping from the east IO, with the remote forcing from the Pacific slightly weakening the amplitudes of thermocline variability. The strongest intraseasonal sea level variability is detected in the south eastern IO and the model results presented here suggest that the variability primarily arises from an internal nonlinear instability, which is modified by the Pacific. Unlike interannual and seasonal timescales, the higher frequency waves are mostly blocked from entering the SIO by Indonesian Archipelago and a limited amount of energy is directly transmitted into the SIO. The transmission of the intraseasonal Rossby wave is reflected in a 37% Pacific contribution to the total intraseasonal variability of the ITF.