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Natural decadal sea-level variability in the Indian Ocean: Lessons from CMIP models

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Understanding natural sea-level variability is crucial to identify secular changes in regional sea level, since natural variability strongly aliases anthropogenic sea-level rise, especially at decadal timescales. One of the main caveats for the Indian Ocean is that the observational record does not resolve regional sea-level variations at decadal timescales. Those observational issues are a strong incentive to investigate the leading modes of IO decadal sea-level variability in climate models from the Coupled Model Intercomparison Project (CMIP). Two consistent modes of Indian Ocean decadal sea-level variability, which collectively explain about 50% of the total decadal sea-level variance, are identified in 26 CMIP control simulations. With opposite sea-level signals in the southwestern and eastern tropical IO, the dominant mode is largely related to the decadal modulation of the Indian Ocean Dipole (IOD), and characterized by opposite sea level signals in the eastern and southwestern equatorial Indian Ocean, as at the interannual timescales. While weaker than at interannual timescales, the tendency of the decadal IOD to co-vary with ENSO also yields sea-level signals along the west Asutralian coast (WAC), transmitted from the western Pacific via the Indonesian Throughflow. The second mode of Indian Ocean decadal sea-level variability consists of a broad sea-level pattern east of Madagascar, mainly driven by the wind-stress curl associated with the Mascarene High decadal modulations. In about one third of the models, this second mode is largely independent from IOD decadal modulations. In another third, this mode tends to lag decadal IOD modulations by $\sim$ 3 years with a $\sim$-0.5 lag correlation. This lag correlation originates from the tendency of the previous phase of decadal IOD variations to induce sea-level variations along the WAC, that propagate westward as Rossby waves, contributing to the second mode. The modes of decadal sea-level variability in CMIP models are broadly consistent with those derived from the relatively short altimeter dataset. In a poor observational sampling context, this suggests that CMIP models can provide guidance for identifying robust modes of IO decadal sea-level variability.