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Variability of meridional circulations in the Indo-Pacific Ocean: zonal structure and inter-basin linkages

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The shallow meridional overturning circulations of the Pacific and Indian Oceans are believed to affect climate variability by regulating the tropical heat content. These circulations are often studied using the meridional transport stream function, a 2D quantity that masks out the zonal structure of the flow field. Moreover, they are often depicted through the meridional transport stream function of the Indo-Pacific Ocean as a whole to avoid the complication associated with the net volume transport of the Indonesian throughflow (that makes it impossible to define a stream functions for the two basins individually). This presentation discusses the zonal structure and relative variations of the Pacific and Indian Ocean meridional circulations and the inter-basin linkages using satellite data, reanalysis products, and IPCC models. The most conspicuous feature of the zonal structure in the Pacific Ocean is with regard to the western-boundary and interior pycnocline flows. For time mean, these flows re-enforce each other in regulating tropical heat content. On interannual-to-decadal time scales, however, they counteract each other with the interior flow being more dominant. This is the result of the oscillation of the tropical gyres in the western Pacific caused by off-equatorial wind stress curl. The latter is associated with the movements of the ITCZ and SPCZ that are correlated with the oscillation of the Walker circulation. The Indo-Pacific circulations are linked by atmospheric and oceanic processes. The oscillation of the Walker circulation leads to anti-correlated variability of the tradewinds over the Pacific and Indian Oceans and thus anti-correlated variations in poleward Ekman transports in the two oceans. Wind forcing associated with the Walker circulation also modulates pycnocline depth in the northwestern tropical Pacific, which transmits to the southeast Indian Ocean. Such modulation and wave transmission cause anti-correlated variations in the zonal pressure gradients that drive the equatorward pycnocline flow in the Pacific and Indian Oceans. Together, they play opposite roles in regulating the tropical heat content.