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Spatial scales and the detection of externally forced signals in regional sea surface height in climate simulations

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Various detection and attribution studies have found an anthropogenically forced signal in global thermosteric sea surface height as well as global glacier mass loss. However, detection on regional scales is hindered due to the increased magnitude of internal variability on smaller spatial scales. In regions of elevated internal oceanic variability such as the western tropical Pacific Ocean, it can take several decades for a forced signal to emerge from the background noise. Once the contribution of glacier mass loss is taken into account, the time of emergence is earlier, due to the high signal-to-noise ratio of this contribution, except close to the melt sources.

Here, we investigate the spatial scales that are necessary to detect an externally forced signal in regional sea surface height within a selected fixed time period. We consider steric and dynamic sea surface height as well as the effect of glacier mass loss. Using control simulations with no evolving forcing we quantify the magnitude of regional internal variability depending on the degree of spatial averaging. We test various averaging techniques such as zonal averaging, ocean basin averages and averaging gridpoints within a certain radius. By comparing the results from the control simulations with the simulations of past and future climate, we estimate to what degree the data has to be averaged spatially in order to detect a forced signal within a certain period of time (e.g. 20 years - the period with available global sea surface height observations). Having identified, for each grid point, the averaging radius that is necessary to detect an external signal during the past 20 years, the results can be applied to observations and it can be assessed on which spatial scales regional detection and attribution studies may yield meaningful results.