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Aliasing of the Indian Ocean anthropogenic warming spatial pattern by natural climate variability

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The pattern of Sea Surface Temperature change (hereafter, pSSTc) associated with anthropogenic climate change has important implications for regional climate impacts in the Indian Ocean (hereafter, IO). Here we investigate if the IO pSSTc can already be detected in observations and Coupled Model Intercomparison Project (CMIP) simulations. We focus more specifically on the interhemispheric, east-west equatorial and Arabian Sea minus Bay of Bengal SST gradients, which respectively influence monsoons, the IO component of the Walker cell and tropical cyclones. CMIP historical ensemble simulations indicate that the pSSTc is strongly aliased by internal climate variability, even over the entire 1871-2005 period. Future multi-model mean projections from 36 CMIP5 simulations indicate more warming in the Arabian Sea and western equatorial IO than in the southern IO at the end of the 21st century. We further estimate emergence times - i.e. when the long-term trend "signal" significantly emerges from the climate variability "noise". The IO-mean warming is clearly detectable, with an emergence time before 2000 in all models (and a ∼1930 median). A warmer Arabian Sea than Bay of Bengal also emerges before 2020 in 80% of the models, suggesting that this change is already detectable. On the other hand, the east-west equatorial and interhemispheric SST gradient signals only emerge from noise before 2020 in ∼40% and 30% of the models (with a median of ∼2030 and >2100, respectively), suggesting that these changes are not yet detectable, due to a large aliasing by internal climate variability. Finally, we examine long-term trends in observational products from 1871 to present. These trends are sensitive to the observational product, probably because of large data gaps in earlier parts of the record. While they all indicate a larger warming in the Northern Hemisphere, western equatorial Indian Ocean and Arabian Sea, the magnitude of this spatial contrast strongly decreases (and becomes more consistent with models) when subsampling data to only retain the most accurate grid-points. This suggests large uncertainties in observationally-derived pSSTc due to insufficient data coverage. Overall, these results call for extreme caution when analyzing pSSTc, due to a large aliasing by internal climate variability (even over the full historical period) and to observational issues. They however suggest that the Arabian Sea is already warming more than the Bay of Bengal in response to climate change.