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Representation of the Seasonal Cycle of sea surface temperature in CMIP6 models

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Sea surface temperature (SST) seasonal extrema are important for water mass formation, intensification of tropical cyclones and coral bleaching, so should be well-represented in models used for future climate projections. Typically, climate model evaluations focus on annual or longer-term mean SST. However, accurate mean SST does not guarantee accurate seasonal extrema or annual cycles. Models that have no biases in mean SST can have biases in seasonal extrema and annual cycles, and vice versa.

Here we assess seasonal extrema in a selection of CMIP6 model historical runs (including BCC-CSM2-MR, CanESM5, CESM2, GFDL-CM4 and GISS-E2-1-G), averaged over 1981-2010, against the World Ocean Atlas (WOA18) observational climatology. The magnitude and pattern of SST biases for seasonal extrema vary from model to model. GFDL-CM4 and CESM2 simulate SST extrema reasonably well, while BCC-CSM2-MR and GISS-E2-1-G have obvious deficiencies. The global area-weighted root mean square (RMS) difference from WOA18 is larger than 2^{o}C in BCC-CSM2-MR and GISS-E2-1-G, and their common maximum bias (larger than 5^{o}C) is the cold bias located in the subpolar North Pacific, Greenland Sea and Norwegian Sea. The model biases of maximum SST (summer SST) and minimum SST (winter SST) are in some cases different, leading to biased SST annual cycles. The SST biases are typically smaller for summer, except for models with significant winter cold bias in the high latitudes of the Northern Hemisphere (BCC-CSM2-MR and GISS-E2-1-G). Generally speaking, the bias of the SST annual cycle is smaller than that of seasonal extrema; models that are too cold in winter are typically also too cold in summer. In eastern boundary regions, the models have too small annual cycles. In these regions, the warm bias of winter SST is less than the warm bias of summer SST. This is because the warm bias in models due to poorly captured stratocumulus can be compensated by coastal upwelling, which cools the sea surface more in summer than in winter.

We note that extra attention should be paid when evaluating SST extrema in some polar areas as the observational climatology there can be unrealistic, particularly in winter.