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Rapid development of systematic trend errors in seasonal forecasts and their connection to CMIP6 trend errors

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Questions regarding the uncertainty of trends in both historical and projected climate model simulations have been limited by uncertainty about the relative importance of internal variability and external forcing to trends over the relatively short observational record. For example, is the discrepancy between historically simulated tropical Pacific trends (El Niño-like) and observations (broadly, La Niña-like) over recent decades a reflection of sampling issues or model error in internal variability and/or forced global responses (either locally or remotely, such as from the Southern Ocean)? At the same time, it is known that systematic operational seasonal forecast errors (e.g., westward shift of ENSO) are dominated by model errors that develop quite quickly, on the order of a few months of forecast lead time.

Here, we suggest that climate model trend errors can be usefully investigated by examining their rapid development within seasonal hindcast datasets. We show that many apparent climate simulation trend discrepancies are evident in trends computed from monthly seasonal hindcasts over the 1994-2016 period for a suite of operational initialised forecast models from C3S and NMME, and in many cases are well developed even at short lead times. These hindcasts use models similar to CMIP-class models and include the same CMIP historical external forcings, but critically are initialised with observations, removing uncertainty related to internal variability. We find these trend errors in many different regions worldwide for several key variables, including sea surface temperature, precipitation and sea level pressure, and investigate their seasonal dependence as well. Notably, we find tropical Pacific "El Niño-like" SST trend errors in all seasons but spring, and related surface pressure, temperature, and precipitation errors in autumn and spring, especially in the North America region. We also find errors in Southern Ocean SSTs, which develop less rapidly than the tropical Pacific SST errors or their global teleconnections.

We suggest that these hindcast trend errors reflect sensitivity of the model mean biases to the changing radiative forcing, rather than a forced response. That is, similarity between errors in free running simulations and hindcasts is a result of the seasonal forecast models quickly transitioning from nature's attractor to the climate model attractor, particularly in the atmospheric model component. This suggests that we might be able to better diagnose the climate model trend errors by looking at the early development of the forecast trend error in the seasonal forecast models.