Linear inverse modeling of the tropical Atlantic

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The tropical Atlantic features variability at interannual and decadal time scales that is known to have a strong influence on the surrounding continents and possibly other ocean basins. Current prediction systems, however, struggle to skillfully predict sea-surface temperature (SST), let alone its impact on rainfall over the adjacent continents. It is often assumed that this poor prediction skill is due to the severe SST biases and misrepresented variability patterns that most models feature in the region but this has recently been called into question.

In the present study, we construct a simple statistical model of the tropical Atlantic to 1) investigate the influence of model biases on prediction skill, and 2) establish a benchmark to evaluate dynamical model against. Using 35 fully coupled ocean-atmosphere GCMs from the pre-industrial control experiment (piControl) of the Coupled Model Intercomparison Project Phase 5 (CMIP5) we construct a linear inverse model (LIM) for each GCM based on tropical SSTs only. The LIM thus constructed is then used to predict SSTs for the period 2000-2017 from the NCEP/NCAR reanalysis. These predictions are compared to those from a LIM constructed using the NCEP/NCAR reference for the period 1948-1999 as training data. Since each of the model LIMs is constructed from more or less unrealistic variability patterns one would expect to see a clear impact on prediction skill.

The results, however, indicate that prediction skill in the tropical Atlantic is relatively insensitive to the tropical variability patterns of each model. Only some cases see a marked deterioration of prediction skill relative to the reference model. The LIM performs well in the subtropical north and south Atlantic. In the equatorial Atlantic, on the other hand, skill is rather poor at 3 months lead time, though clearly above persistence. Our analysis suggests that in many CMIP5 models misrepresentation of variability should not be a major stumbling block toward skillful prediction. This indicates that the current lack of prediction skill in the region is due to other factors, such as model initialization or inherent predictability limits due to noise.
Comparing several dynamical hindcast experiments with the LIM constructed from observations, we find that the LIM generally has superior prediction skill over most parts of the tropical Atlantic.

Keywords: linear inverse modeling, tropical Atlantic, seasonal prediction

