Pacific-Atlantic Interactions and Decadal Climate Variability

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Summary. Substantial decadal variability in rainfall and temperature is associated with two well documented "modes" with distinct sea surface temperature (SST) signatures: Pacific Decadal Variability (PDV) and Atlantic Multidecadal Variability (AMV). The causes of PDV and of AMV remain uncertain. Both basins may generate decadal variability by internal processes, but recent literature has highlighted Pacific-Atlantic connections: variability in the Pacific influences the Atlantic, the AMOC, and climate in Europe and the Mediterranean, while variability in the North Atlantic and trends in the AMOC force changes in Pacific rainfall, North Pacific SST, North American rainfall, and ENSO.

We will study the modes of Atlantic and Pacific decadal variability and their interactions, with emphasis on the role of the atmosphere and ocean-atmosphere coupling. For atmospheric anomalies driven by SST anomalies (SSTAs) in basin A to generate decadal variability in basin B, one of two things must happen. Either (i) SSTAs in basin A have a decadal time-scale and the associated atmospheric anomalies persist without substantial modification by coupled processed in basin B, or (ii) the atmospheric anomalies kick-start inherently decadal processes in basin B (e.g., slow oceanic Rossby waves or changes in oceanic overturning or gyre circulations). We will investigate whether these hypotheses can explain the correspondence in Atlantic and Pacific variability at decadal time scales, and thus an important and potentially predictable fraction of decadal variability in the climate system.

We will investigate the "target basin" response to prescribed SSTAs in the "origin basin" using a hierarchy of model configurations, in which coupled interactions in the target basin modify the atmospheric response in increasingly complex ways: (i) AGCM forced by fixed SSTAs representative of AMV and PDV and combinations thereof. (ii) GOGA, TAGA, POGA: We will use existing ensemble simulations forced by historical SST globally or in a single tropical basin (tropical Atlantic, or tropical Pacific ocean), with either climatological SST or a slab mixed layer in the rest of the world oceans. (iii) OGCM: We will simulate the full dynamic response in the "target" Atlantic basin and identify whether the original atmospheric anomalies force decadal oceanic processes. (iv) Zebiak-Cane: We will look at ENSO and PDV in a modified ZC model of the tropical Pacific that includes wind stress and stability forcings generated from the Atlantic. (v) CGCM: We will identify the effects of AMV on the Pacific in a fully coupled setting by using CCSM4 in a partial-coupling configuration (full ocean coupling is disabled in the Atlantic, where SSTAs are forced to match 20th century observations).

The above experiments, designed to sort out the global influence of SST anomalies originally confined to a single basin, will be complemented with a diagnosis of multi-model ensembles of coupled integrations (CMIP3 and, as soon as available, CMIP4). Finally, we will select those 21st century integrations that produce a substantial long-term trend in the strength of the MOC and verify whether the MOC/PDV statistical relationship derived from the pre-industrial integrations is valid at this longer timescale, or instead the response depends on the frequency of the MOC forcing (Te Raa et al., 2008).

Since Pacific and Atlantic SSTs have significant impacts on precipitation worldwide, and in particular on North American drought, the work will directly contribute to efforts to develop capacity for drought prediction. Broader impacts follow from the tremendous impact that drought has on the complex natural and human systems.