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Atlantic multi-decadal variability and its climate impacts in CMIP3 and CMIP5 models

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Atlantic Multi-decadal Variability (AMV), also known as the Atlantic Multi-decadal Oscillation (AMO), is characterized by a sharp rise and fall of the North Atlantic basin-wide sea surface temperatures (SST) on multi-decadal time scales. Widespread consequences of these rapid temperature swings were noted in many previous studies. Among these are the drying of Sahel in the 1960-70s and change in the frequency and intensity of Atlantic hurricanes on multi-decadal time scales. Given the short instrumental data records (about century long) the central question is whether these climate fluctuations are robustly linked with the AMV and to what extent are these connections subject to changes in a changing climate. Here we address this issue by using the CMIP3 and CMIP5 simulations for the 20th, 21st, and pre-industrial eras with multiple IPCC models. While CMIP3 models tend to produce AMV of shorter periods (20-30 years) than suggested by the observations, the spatial structures of the SST anomaly patterns and their association with worldwide precipitation are remarkably similar between models (with differing external forcing) and observations. Our results confirm the strong link between AMV and Sahel rainfall and suggest a clear physical mechanism for the linkage (meridional shifts of the Atlantic ITCZ). The results also help to clarify influences that may not be robust, such as the impacts over North America, India, and Australia. The temporal and spatial structures of the AMO will be further examined using the newly available CMIP5 model outputs. The focus is on the robustness of the AMO in CMIP5 models with differing radiative forcing (20th, 21st, and pre-industrial) as well as its comparison to CMIP3 and 20th Century observations. The critical questions to be addressed in this presentation include the following: 1. Why is AMO time period shorter in models than suggested by 20th Century observations? Are results based on CMIP5 consistent with that from CMIP3? 2. CMIP3 models suggest a differing association in Pacific Ocean with AMO as compared to 20th Century observations, a relative warm tropical eastern Pacific in CMIP3 models versus a weak cooling in the same region for observations associated with warm AMO. This difference may be responsible for how North American rainfall is affected by the AMO. Are CMIP5 models consistent with that in CMIP3 or supporting observations? Why? 3. The 20th Century observations reveal more rainfall in the Indian monsoon region during positive AMV, but this is not consistent across the CMIP3 model simulations. What is the mechanism for the Indian monsoon - AMO linkage and how is it represented in CMIP5 simulations?