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Impacts of Model Initialization and Volcanic Eruptions on Decadal SST and Land Climate Predictability in CMIP5 Experiments with the HadCM3, GFDL-CM2.1, and MIROC5 Global Earth System Models

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Decadal climate variability (DCV) influences water resources, agriculture, economy, and other societal sectors in many parts of the world. Therefore, it is becoming increasingly important to understand and predict DCV and its influences. Following several initial decadal climate predictability studies with global climate models, the WCRP has organized the CMIP5 project to assess ability of the current generation of Global Earth System Models (GEaSMs) used in IPCC assessments to simulate and hindcast (forecast retrospectively) decadal climate. Two sets of core decadal prediction experiments are being conducted under CMIP5. The first set is a series of 10-year hindcasts starting approximately in 1960. The second is a series of 30-year hindcasts starting in 1960, 1980, and 2005, the last a combined hindcast-forecast. In both sets, volcanic aerosols and solar cycle variability are prescribed from past observations. Each experiment has a minimum ensemble size of three members. Experiments are also being conducted under CMIP5 in which estimated volcanic and other forcings are used without initializing the models with observed data for a specific date/year.

We are using uninitialized (so-called historical runs) and initialized (so-called decadal hindcast runs) CMIP5 data from three GEaSMs, the UKMO-Hadley Centre, the GFDL, and the MIROC5, to assess decadal predictability of well-known DCV phenomena such as the Pacific Decadal Oscillation (PDO), the tropical Atlantic sea-surface temperature (SST) gradient variabiity (TAG for brevity), the west Pacific Warm Pool (WPWP) variability , and the Atlantic Multidecadal Oscillation (AMO). We are also assessing decadal predictability of SST anomalies averaged in latitude belts and individual oceans. Additionally, we are assessing decadal predictability of hydro-meteorological variables such as precipitation and surface air temperature in important land regions such as the Missouri, Colorado, and Mississippi River basins in the U.S.; the Indian, Southeast Asian, and East Asian monsoon regions; and the Sahel region of Africa. The following questions are addressed: Do aerosols due to volcanic eruptions influence/impact decadal climate predictability? If yes, can the role of this influence/impact be quantified in terms of changes in predictability skill? Does model inititalization modulate the influence/impact of volcanic aerosols? What causes inter-model differences in sensitivity of decadal predictability to volcanic aerosols? Is volcanic aerosol-influenced decadal predictability sensitive to volcano location and eruption strength? Is volcanic aerosol-influenced decadal predictability regionally confined?

Initial results from the analyses of historical and decadal hindcast experiments show that indices of DCV phenomena such as PDO, TAG, and WPWP appear in some decades to be moderately predictable (especially the 1960s and the 1990s), regardless of when or whether the models were initialized with observations. Our analyses also show that tropical SSTs, especially in the Indian Ocean and the WPWP region, appear to have a very high predictability for two to four years after a major volcanic eruption. In this oral presentation, comprehensive results of our analyses of predictability of the DCV phenomena as well as predictability of hydro-meteorological variables in selected land regions will be described. Impacts of model initialization on predictability will also be described.