Geophysical Research Abstracts
Vol. 19, EGU2017-5283, 2017
EGU General Assembly 2017

A Process-Based Assessment of Decadal-Scale Surface Temperature Evolutions in the NCAR CCSM4's 25-Year Hindcast Experiments

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This study represents an initial effort in the context of the coupled atmosphere-surface climate feedback-response analysis method (CFRAM) to partition the temporal evolution of the global surface temperature from 1981 to 2005 into components associated with individual radiative and non-radiative (dynamical) processes in the NCAR CCSM4's decadal hindcasts. When compared with the observation (ERA-Interim), the CCSM4 is able to predict an overall warming trend as well as the transient cooling occurring during the period 1989-1994. However, while the model captures fairly well the positive contributions of the CO_2 and surface albedo change to the temperature evolution, it has an overly strong water vapor effect that dictates the temperature evolution in the hindcast. This is in contrast with the observation where changes in surface dynamics (mainly ocean circulation and heat content change) dominates the actual temperature evolution. Atmospheric dynamics in both the observation and model works against the surface temperature tendency through turbulent and convective heat transport, leading to an overall negative contribution to the evolution of the surface temperature. Impacts of solar forcing and ozone change on the surface temperature change are relatively weak during this period. The magnitude of cloud effect is considerably smaller compared to that in the observation and the spatial distribution of the cloud effect is also significantly different between the two especially over the equatorial Pacific. The value and limitations of this process-based temperature decomposition are discussed.