Session: B12 Oral presentation

Quantifying contributions to global warming pattern in NCAR CCSM4 climate model

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The new climate feedback analysis method formulated in Lu and Cai (2009) is used to isolate contributions from both radiative and non-radiative feedback processes to the 3D global warming pattern at the time when the atmospheric CO2 concentration is doubled from the pre-industry level in NCAR CCSM4 climate simulations. These partial temperature changes due to the external forcing alone and subsequent feedbacks are additive and their sum is convergent to the total temperature change in the original CCSM4 climate simulations. The external radiative forcing alone causes a stronger surface warming in high latitudes than in low latitudes. Water vapor feedback has the strongest warming amplification in the tropics, acting to increase meridional temperature gradient. Cloud shortwave feedback dominates in the tropics whereas in high latitudes, cloud longwave feedback is stronger. The net effect of cloud feedbacks contributes to the polar surface warming significantly. The surface albedo feedback also plays an important role for the polar surface warming amplification. The atmospheric dynamical feedback further strengthens the surface warming in high latitudes. The evaporative feedback causes a warming reduction over most ocean surface, especially over subtropics. The surface sensible heat flux feedback in general is negative over land but positive over ocean, particularly along the east coasts of the two major continents in the North Hemisphere. The ocean dynamical feedback and ocean heat storage terms act to reduce warming over the North Atlantic and the Southern Ocean. In the troposphere, both the external forcing and water vapor feedback causes a stronger warming in the tropics and a weaker cooling in high latitudes, acting to strengthen the atmospheric meridional temperature gradient. The effect of cloud feedbacks is negative throughout the troposphere in high latitudes and in the lower troposphere in the tropics. In the lower troposphere, the maximum warming amplification by cloud feedbacks is in mid-latitudes but is in the upper troposphere in tropics. The atmospheric dynamical feedbacks amplify the warming in the upper troposphere in the tropics. It follows that the maximum warming center in the upper troposphere in the tropics is due to both cloud and atmospheric convective feedbacks. The atmospheric dynamical feedback plays a critical role in reverting the tropospheric cooling in high latitudes induced by the external forcing and radiative feedbacks (water vapor and cloud feedbacks) to a warming pattern in the total response to the external forcing. The maximum warming induced by the atmospheric dynamical feedback due to increased poleward energy transport takes place at the layers between 500 hPa and 300 hPa.