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Ph.D. Dissertation Defense Announcement

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SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY

Ph.D. Dissertation Title:

Formation of Precipitation-Circulation-Sea Surface Temperature Patterns under Global Warming

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Abstract:

Most of CMIP5 models projected a weakened Walker Circulation and an El Nino like warming in the tropical Pacific, but what causes such a change is still an open question. We hypothesize that the following three mechanisms are responsible.

The first mechanism is a so called "longwave radiative – evaporative damping" mechanism. A simple analytical model was constructed to understand the formation mechanisms of future SST warming pattern under global warming. It is demonstrated that the future SST warming pattern is primarily determined by present-day mean SST and surface latent heat flux (Q_{lh}) fields through a longwave radiative – evaporative damping mechanism. Assume a local thermodynamic equilibrium without circulation and cloud changes. A uniform GHG forcing would lead to a smaller (larger) warming in the regions where mean SST and $\overline{Q_{lh}}$ are large (small). This longwave radiative – evaporative damping mechanism can explain a much greater warming in high latitudes than in tropics, and an El Nino like warming in tropical Pacific. In addition, cloud decreases (increases) in eastern (central) Pacific due to weakened Walker circulation (warmer SST), which also contributes to the El Nino like warming.

The second mechanism is "the richest get richer". In response to a uniform surface warming, the Asia-western North Pacific (WNP) monsoon system is enhanced by competing moisture with other large-scale ascending systems. The strengthened WNP monsoon induces surface westerlies in the western-central equatorial Pacific, weakening the Walker circulation. Idealized AGCM experiments that separate the effect of the mean warming and the relative SST warming pattern clearly demonstrate the effect of the mean warming on change of the equatorial wind.

The third mechanism is extra land surface warming. Due to a smaller heat capacity, the land obtains a larger warming than the ocean. In particular, a great thermal contrast between American continent and tropical Pacific causes a zonal pressure gradient and westerly anomalies in the eastern equatorial Pacific. This weakens the Walker circulation.

A traditional view of weakened Walker circulation is attributed to a slower increase rate of global mean precipitation than moisture. However, by analyzing a uniform warming experiment in an aqua-planet setting, it is demonstrated that the Walker circulation is strengthened, even though global averaged upward motion is weakened. This result suggests that the global moisture budget argument may not be sufficient to explain the change of the Walker circulation in the tropics. By conducting numerical simulations in a realistic land-ocean distribution, we demonstrated that the weakening of the Walker Circulation is attributed to both the monsoon and land forcing effects. The relative SST warming pattern also plays a role, but it is just an amplifier, not a fundamental cause.