On the global warming projection: a new approach based on scaling theory

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Global warming exerts a strong impact on the Earth system. Despite recent progress, the current Earth System Models (ESMs) still project a large range of possible warming levels. Particularly, the most recent generation of the ESMs from the Coupled Model Intercomparison Project Phase 6 (CMIP6) have been found to have the so-called “hot-model” problem. That is, many CMIP6 models may have overestimated the future warming trend under a given scenario (e.g., SSPs). In order to cope with the impacts of global warming, an improved projection of the future warming trend would thus be highly required. In addition to further developing the ESMs, alternative ways would be also worth a try. Here in this talk, I will show that the future global warming trend may be reliably projected from the perspective of statistical physics. It has been well recognized that the variability of many climatic variables (including the global mean surface temperature, GMST) has scaling behavior ranging from months to decades. This scaling behavior may induce long-term memory, which has been widely detected in the climate system. By introducing fractional integrals, recently a generalized stochastic climate model, namely the fractional integral statistical model (FISM), has been proposed to simulate the scaling behaviors revealed in many climatic records. One advantage of the FISM is that it can quantify the climate memory signal and further decompose a given timeseries into the memory part and the non-memory part. By employing this model, the GMST can be decomposed into the “direct-forcing-response” and the “indirect-memory-response”. In this way, a response operator was derived, with which one can compute the global mean surface temperature given specific forcing scenarios to quantify the impact of past emissions on current warming. Based on historical records, the trend of the direct-forcing-response is found to be weak, while the major portion of the observed global warming trend was attributed to the indirect-memory responses that are accumulated from past emissions. Compared to CMIP6 simulations, this approach projects lower global warming levels over the next few decades. The results suggest that CMIP6 models may have a higher transient climate sensitivity than warranted from the observational record, due to them having larger long-term memory than observed.