Geophysical Research Abstracts
Vol. 18, EGU2016-11658, 2016
EGU General Assembly 2016

The super greenhouse effect in a warming world: the role of dynamics and thermodynamics

Karthik Kashinath, Travis O'Brien, and William Collins

Lawrence Berkeley National Lab, Climate Science Department (Earth and Environmental Sciences), Berkeley, CA, United States (kkashinath@lbl.gov)

Over warm tropical oceans the increase in greenhouse trapping with increasing SST can be faster than that of the surface emission, resulting in a decrease in clear sky outgoing longwave radiation at the top of the atmosphere (OLR) when SST increases, also known as the super greenhouse effect (SGE). If the SGE is directly linked to SST changes, there are profound implications for positive climate feedbacks in the tropics.

We show that CMIP5 models perform well in simulating the observed clear-sky greenhouse effect in the present day. Using global warming experiments we show that the onset and shutdown SST of the SGE, as well as the magnitude of the SGE, increase as the convective threshold SST increases. To account for an increasing convective threshold SST we use an invariant coordinate for convection proposed in a recent study [Williams et al., GRL (2009)]. However, even after accounting for the increase in tropical SST (by normalizing the SGE by surface emission) and accounting for the increase in the threshold temperature for convection (by using the invariant coordinate) we find that the models predict a distinct increase in the clear-sky greenhouse effect in a warmed world. This suggests that thermodynamics (i.e. SST) plays a crucial role in regulating the increasing clear sky greenhouse effect in a warming world. We use theoretical arguments to estimate this increase in SGE and derive its dependence on SST.

Finally, as shown in previous studies, we confirm that the increase in the clear-sky greenhouse effect is primarily due to upper tropospheric moistening. Although the absolute increase in upper tropospheric water vapor is small compared to that of the lower troposphere, since the absorptivity scales with fractional changes in water vapor, the contribution of the upper troposphere is more significant, as shown by Chung et al., PNAS (2014).