Ph.D. Defense Announcement
Morgan Phillips
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Wednesday, October 17, 2018
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Defense
ATS Large Classroom (101 ATS)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Scott Denning (advisor)
David Randall
Christian Kummerow
Karan Venayagamoorthy (Civil and Environmental Engineering)

MULTIPLE SCALES OF SURFACE-ATMOSPHERE COUPLING IN AN EARTH SYSTEM MODEL

An Earth System Model that had been modified to use three distinct scales of coupling between the surface and atmosphere was used to simulate conditions that would be present under past and future climate scenarios of fixed Sea Surface Temperature forcing. The first of these was the Community Atmosphere Model coupled to the Community Land Model at a relatively coarse resolution of 2.5 degrees and a parameterized cumulus convection scheme. The second model architecture utilized ‘Super-Parameterization’, where the parameterized convection was replaced with a highly idealized, non-hydrostatic Cloud Resolving Model spatially discretized at 4 kilometers length but still coupled to a single land model at the coarse-scale. The third model type then coupled a unique land model to each Cloud Resolving Model column, allowing them to independently evolve and exchange information at the scale of 4 kilometers.

The models that use Super-Parameterization overdo convection in the Tropical West Pacific, and as a result display an invigorated Hadley Circulation that concentrates oceanic latent heat flux and precipitation over that area with a corresponding reduction in precipitation over land. The nature of precipitation has also changed to include more intense amounts at less frequent intervals as one moves to progressively smaller coupling scales. At the smallest coupling scale the 4 kilometer representation of clouds results in very dark and very light grid-cells, which then acts to reduce photosynthetic productivity by shifting land model cells into the light- limited and water limited regimes of the photo-response curve. The increase in precipitation intensity with decreasing coupling scale was investigated using for the historical simulations in terms of statistical extreme value distributions. Extreme precipitation estimates from fitted distributions obtained from the model with parameterized convection was severely underestimated when compared to distributions fitted to observations from point rain- gauge measurements for the corresponding time period, while the models with explicit convection were of the same order of magnitude as the observed data. The model that was coupled at the smallest scale overestimated precipitation extrema, but it was able to capture the most extreme events at individual locations within the 95% confidence intervals.

Finally, each model was used to simulate conditions under increased green-house gas concentrations following the Representative Concentration Pathway scenarios outlined by the Intergovernmental Panel on Climate Change. All models displayed a weakening on the Hadley Circulation with increasing Green-House Gas forcing, though the Super-Parameterized models maintained a stringer mean state flux of oceanic latent heat over the Tropical Western Pacific concurrent with enhanced convection. While the model coupled at the largest scale showed an increase in extreme precipitation as GHG forcing is increased, results for the models with Super-Parameterization show a decrease in the magnitude of extreme precipitation for the strongest GHG forcing scenario. This decrease in the most extreme events occurs over the subtropical subsidence regions while locations in the Tropics show an increase in extreme precipitation magnitude under projected GHG forcing.