Midlatitude Storms in a Moister World: Lessons from Idealized Baroclinic Life Cycle Experiments

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Abstract

The response of midlatitude storms to global warming remains uncertain. This is due, in part, to the competing effects of a weaker meridional surface temperature gradient and a higher low-level moisture content, both of which are projected to occur as a consequence of increasing greenhouse gases. Here we address the latter of these two effects, and try to elucidate the effect of increased moisture on the development and evolution of midlatitude storms. We do this with a set of highly controlled, baroclinic lifecycle experiments, in which atmospheric moisture is progressively increased. To assess the robustness of the results, the moisture content is changed in two different ways: first by using different initial relative humidity, and second by varying a parameter that we insert into the Clausius-Clapeyron equation. The latter method allows us to artificially increase the moisture content above current levels while keeping the relative humidity constant.

Irrespective of how moisture is altered, we find that nearly all important measures of storm strength increase as the moisture content rises. Specifically, we examine the storm's central pressure minimum, the strongest surface winds, and both extreme and accumulated precipitation rates. For all these metrics, increased moisture yields a stronger storm. Interestingly, we also find that when moisture is increased beyond current levels, the resulting storm has a reduced horizontal scale while its vertical extent increases. Finally, we note that for moisture increases comparable to those projected to occur by the end of the 21st century, the actual amplitude of the increases in storm strength is relatively modest, irrespective of the specific measure one uses.