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Sensitivity of Severe Convective Storms to Soil Moisture and Lower Atmospheric Water Vapor

Brian Ancell and Christian Nauert
Texas Tech University, Lubbock, Texas, United States (brian.ancell@ttu.edu)

Numerous studies have examined the sensitivity of the atmospheric state to soil moisture on time scales of up to a day. Dry line intensity, lower tropospheric water vapor content, and precipitation have all been shown through modeling studies to be affected by modest perturbations to upstream soil moisture content and subsequent lower atmospheric water vapor. Since all of these aspects could be associated with convection, a high-impact forecast event that exhibits rapid nonlinear error growth, it is reasonable to expect that irrigation practices might influence severe convective storms. Understanding the link between soil moisture and specific convective elements could have broad implications for severe weather forecasting, and could reveal the degree to which irrigation-induced storm-scale inadvertent weather modification exists. This work examines the sensitivity to soil moisture and lower atmospheric water vapor content of a severe convective storm that struck Moore, Oklahoma, USA on May 20th, 2013, killing 24 people.

While adjoint sensitivity analysis that employs the tangent linear version of a numerical weather prediction model might be used to examine convective sensitivities to soil moisture, the strong nonlinearity associated with these events likely renders this technique inaccurate. Alternatively, the approach here utilizes backward trajectory analysis to identify the regions up to a day prior to which the storm might be sensitive. Once the regions are identified, an ensemble of model forecasts is created by varying initial soil moisture to reveal the degree to which perturbations must be made to influence the downstream storm. Subsequent comparisons are made between the required soil moisture perturbations and realistic soil water values added through irrigation.