A.52: THE WRF LIGHTNING FORECAST ALGORITHM: CHARACTERIZATION OF LIGHTNING JUMPS IN SIMULATED STORMS

Short-term Prediction Research and Transition Center

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Background

- WRF-based Lightning Forecast Algorithm (LFA) was developed based on observed robust relationships between LTG flash rates and large precipitating ice in storms
- LFA was designed to be entirely empirical, easy to implement
- LFA uses two proxy fields: graupel flux at -15°C, GFX, and vertical ice integral, VII
- GFX represents amplitude, time variability of LTG; VII represents amplitude, areal coverage of LTG; a weighted average blend, Threat 3, gives best overall results
- Original LFA study used 2 km mesh, WSM6 microphysics, and was based on storm cases from only North Alabama for which NALMA data were available for calibration; recent WRF efforts have used 4 km CONUS mesh, varying microphysics
- Since LFA was designed to preserve time variability of lightning in storms, here we explore ability of WRF and LFA to depict lightning jumps, which are known to often foretell severe weather events
- Here we examine the amplitude of storm flash rate jumps, and also their frequency of occurrence, to see how well they correspond to observations.

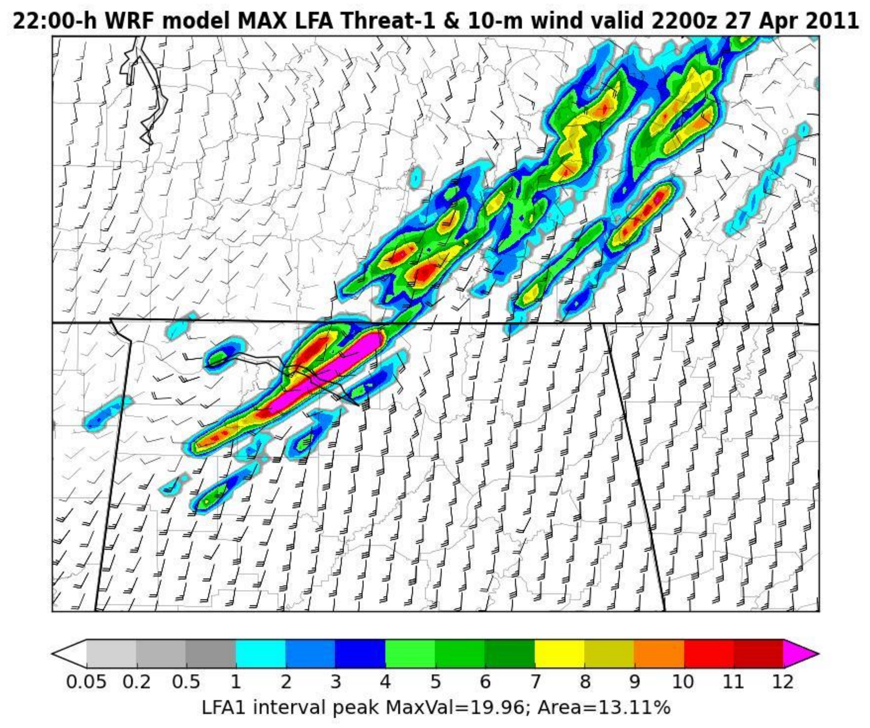
Methodology

- Calculate and plot hourly fields of maximum GFX threat, since it controls LFA depiction of time varying lightning threat.
- Modify WRF code to output not only hourly maxima of fields, but also hourly maxima and minima of the time tendencies of the basic fields. Time tendencies are evaluated across 5 model time steps of 24 s, or a total of 2 min. For propagating steady-state storms, these time tendencies will be dominated by advection, but will also contain temporal anomalies such as jumps and lulls. Storms will appear as stripes along the simulated storm tracks.
- Add together the fields of maximum and minimum time tendencies, so that the steady-state advection cancels. The remaining field will show only the anomalous portions of the time tendencies of the chosen field.
- Method is applied to GFX threat; could also work for wmax, perturbation pressure, vorticity, or any other field of interest.

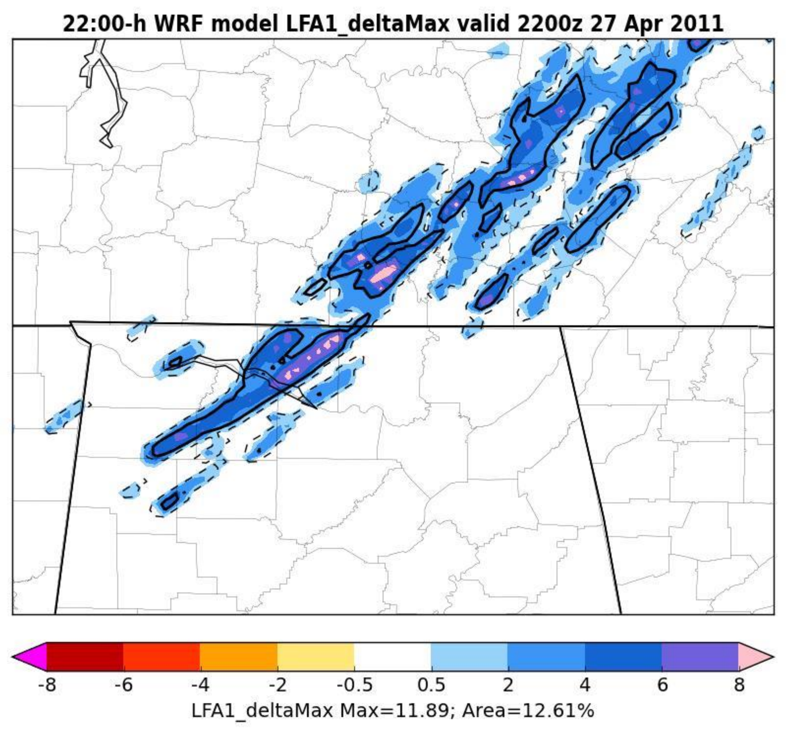
Results

- LFA time tendencies do indeed show that the WRF is capable of simulating storms with intensity variations that would be associated with lightning jumps and lulls.
- For the Superoutbreak of 27 April 2011, many of the simulated supercells contain 2 lightning jumps per hour, consistent with observational analyses from LMA. Advantage of this technique is that spatial structure of jumps and lulls can be visualized.
- At end of each hour, jump artifacts can happen, because positive advection effects at the end of a track cannot be cancelled by negative advection effects. This is not an issue for observations of jumps, because storm tracking can compensate. Also not an issue for modeled storms, except for the last hour of a run, because the next hour can always be examined and advection effects updated at each hourly transition. Artifacts are not present at t=0, unless data assimilation is used.
- Lightning jumps tend to occur along with jumps in updraft max, but do lightning lulls often coincide with jumps in rotation, drops in surface pressure? Further research is in progress.

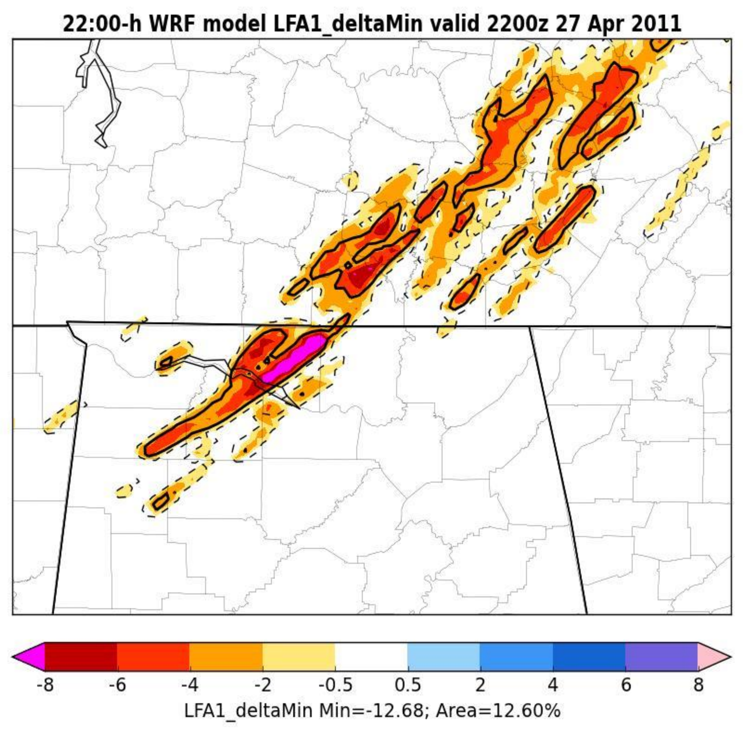
LFA Threat 1 (Graupel flux), Hourly max at 22 UTC:



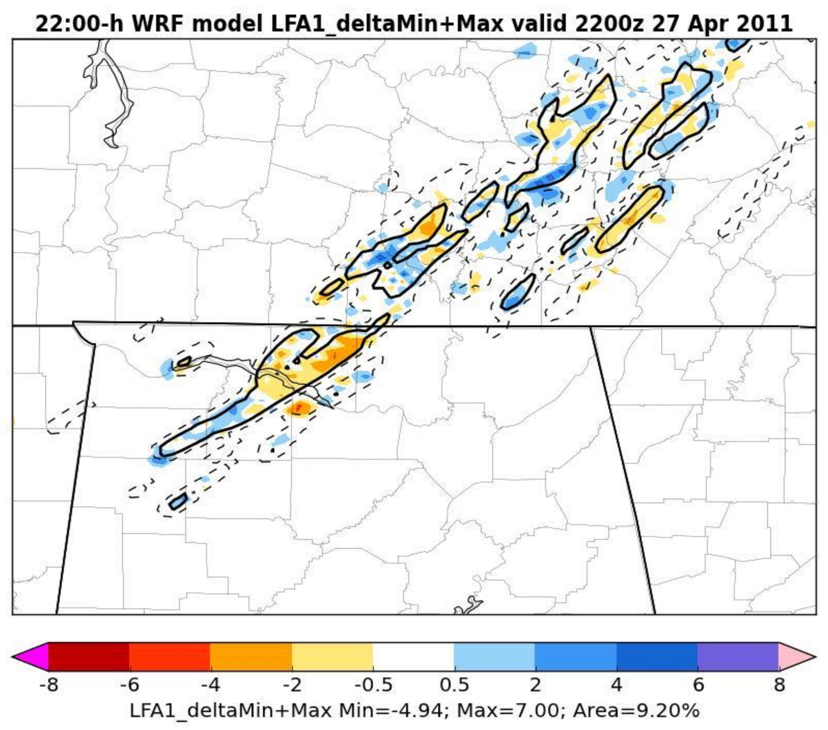
LFA Threat 1 tendency, Hourly max at 22 UTC:



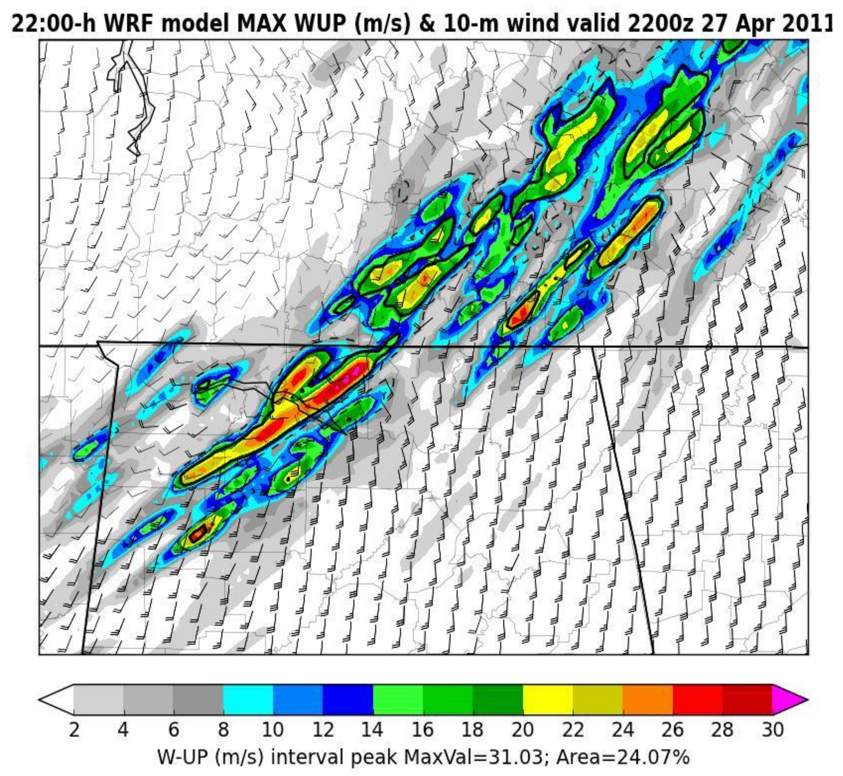
LFA Threat 1 tendency, Hourly min at 22 UTC



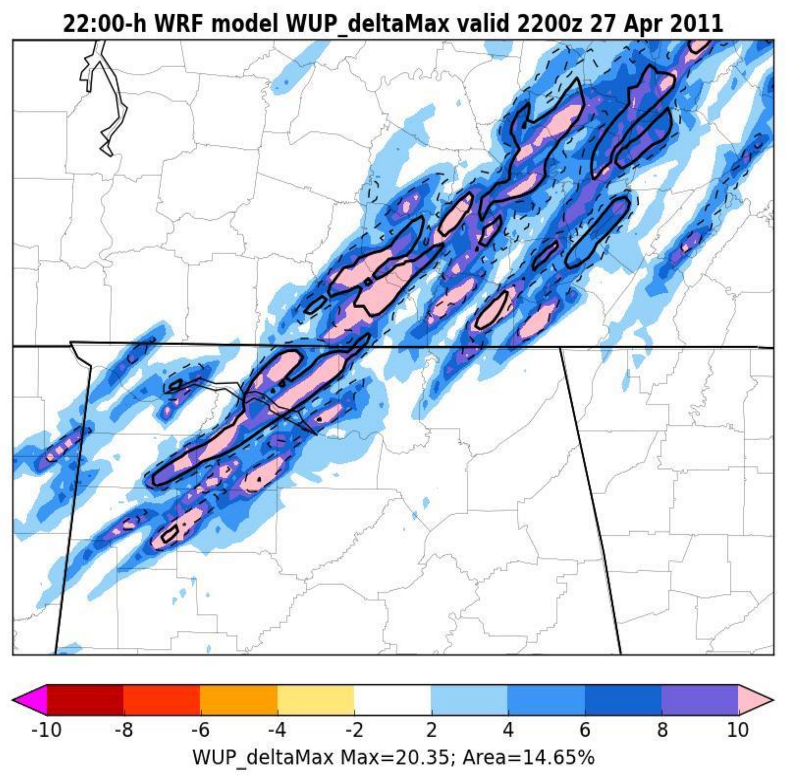
LFA Threat 1 tendency, Hourly sum at 22 UTC



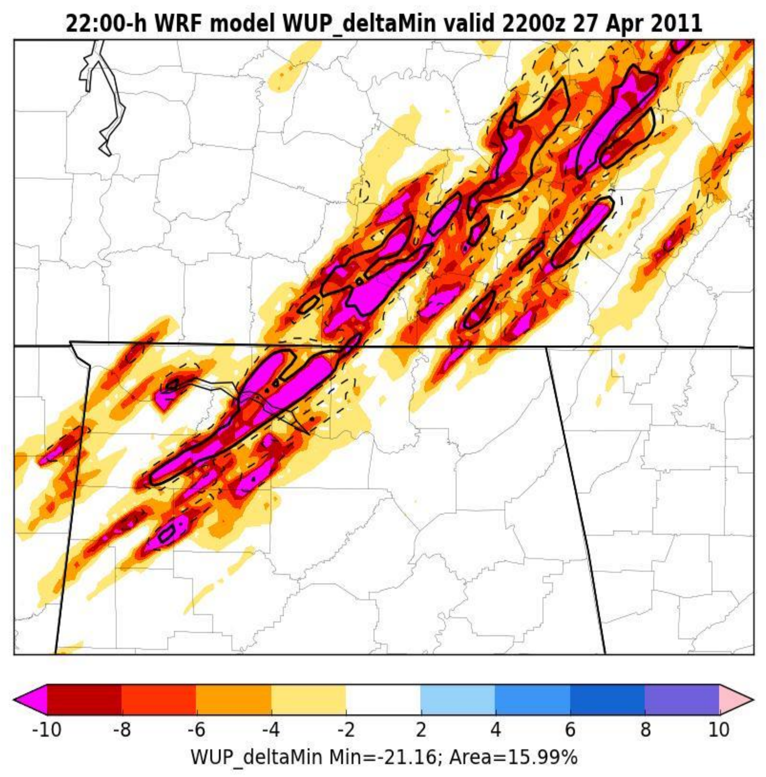
WRF peak updraft wmax, Hourly max at 22 UTC



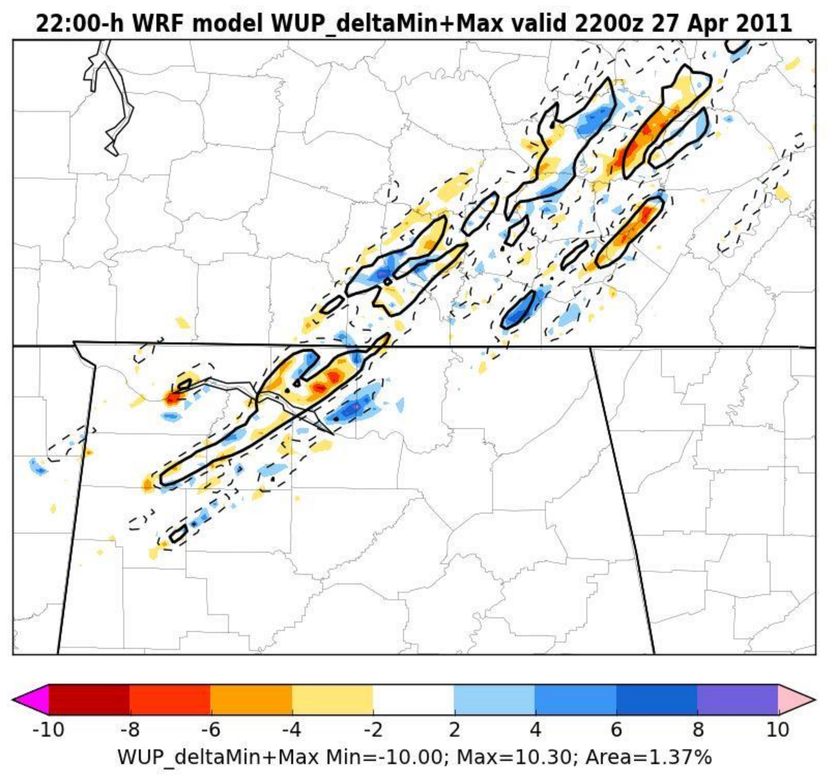
WRF wmax tendency, Hourly max at 22 UTC



WRF wmax tendency, Hourly min at 22 UTC



WRF wmax tendency, Hourly sum at 22 UTC



Advantages, *Disadvantages*

- Method shows spatial structure of field jumps and lulls.
- Method requires no cell tracking; steady-state advection effects are eliminated using max+min tendency sums.
- *Artifacts can occur at final hour, if disturbances of interest*
- *are still active; artifacts unlikely at t=0..*
- *Plotted features will be indistinct for stationary or training storms that have multiple jumps per hour.*

Future Work

- Add time tendency software to WRF groups at semi-operational forecast centers.
- Examine behaviors of time tendency fields in a wide range of storm cases.
- Assess realism of time tendency fields for LFA lightning threat, other severe predictor fields.

Acknowledgments

- NASA/SPoRT executed the WRF simulations used for development of the software extensions that allow for assessment of time tendencies and their hourly extrema.
- NOAA and NASA provided support for this research effort.