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A Recent Climatological Look at Tornado Events Relative to Sunset

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INTRODUCTION

- Climatologically, tornadoes are most frequently observed in the afternoon and early evening hours during spring and summer in association with convection forced by the heating.
- Sunset and disappearance of solar heating typically yields the collapse and stabilization of the boundary layer, and usually, the demise of tornadoes. Occasionally, tornadoes persist after sunset or even first occur after sunset.
- Nighttime tornadoes pose an elevated hazard due to difficulties in visualizing, communicating, and responding; it is thus particularly important to understand and be conscious of nighttime threats (e.g., Ashley et al. 2008).
- This research serves to quantify the distribution and climatology of tornado events relative to sunset. Further, it investigates the synoptic and mesoscale factors that distinguish between tornado events that begin in the afternoon and continue after sunset, those that start and then end before sunset, and those that initiate after sunset. Lastly, a case observed during the PECAN field campaign will be examined.

DATA AND METHODS

- The record of United States tornado tracks from the SPC SVRGIS database from 2000 to 2015 were classified relative to sunset based upon the geographic location and tornado start time.
- Tornadoes, using a clustering algorithm, were classified into tornado events that occur exclusively before sunset (EARLY), exclusively after sunset (LATE), and events that had tornadoes occur both before and after sunset (BOTH) based upon a buffer of 2 hours relative to sunset and 3 hours relative to sunrise.
- The synoptic and mesoscale environmental characteristics between each event class were examined using the North American Regional Reanalysis (NARR, Mesinger et al. 2006), especially vertical profile of kinematic and thermodynamic data following Potvin et al. (2010).
- This data was supplemented by using the SPC Storm Mode dataset (Smith et al. 2012) to examine the distribution of specific weather parameters over each event class.
- Radiosondes obtained by mobile assets of the PECAN field campaign (Geerts et al. 2017) on July 2nd, 2015 of a BOTH event will also be examined and compared to the bulk event characteristics.

Environmental Characteristics of EARLY, BOTH, and LATE events

- BOOTH events are associated with more tornadoes per event and are generally confined to the Mississippi Valley (Fig. 1b). EARLY events are common east of the Rockies and often have fewer tornadoes per event, compared to BOTH events (Fig. 1a). LATE events are most common in the coastal regions and are not typically associated with outbreaks (Fig. 1c).
- The spread of environmental conditions over which EARLY (yellow markets) events occur is much larger than both (blue) and LATE (purple) events (Fig. 2a).
- Largest differences between the sub-classes are seen in wind speed (Fig. 2d), relative humidity (Fig. 2c), low-level temperature profiles (Fig. 2a).
- The increase in wind speed in BOTH and LATE events points to the importance of the nocturnal low-level jet and wind shear profile in initiation or maintenance of tornadoes after sunset (Fig. 2d).

CONCLUSIONS and ACKNOWLEDGEMENTS

- BOTH and LATE events tend to have higher 0–1 km shear values and surface relative humidity values than EARLY events (Fig. 3a-b).
- EARLY events tend to be associated with the most MLCAPE (Fig. 3d); however, the corresponding LCL heights for BOTH and LATE events tend to be lower (Fig. 3e), which hints at a more boundary-layer moisture in the latter sub-classes.
- MLLFC heights overall tend to be lowest in the LATE case and highest in the BOTH cases (Fig. 3f).
- The significant tornado parameter (STP) is often highest for BOTH events and struggles to identify LATE events (Fig. 3e).
- BOTH and LATE events have a higher frequency of producing GLCS tornadoes, compared to EARLY events (Fig. 3g), which hints there is often upscale evolution of convection in the prior classifications.
- LATE events least frequently produce discrete tornadoes (Fig. 3h); however, BOTH events continue to produce discrete tornadoes at a high frequency.
- Cyclogenesis, since the ingredients for tornado production generally do not depend on the diurnal cycle, are most frequently associated with BOTH and LATE events, but this is dependent on timing of landfall (Fig. 3i).
- BOTH events generally produce the strongest tornadoes, with EARLY and LATE events producing relatively similar frequency distributions of F/E/F rating (Fig. 4b).
- More fatalities are associated with BOTH events, compared to the other sub-classes, for a given E/F/F rating (Fig. 4a). Further, more deaths for a given F/E/F rating are associated with LATE events than EARLY events (Fig. 4a).
- In situ soundings (Fig. 5) of a BOTH event during PECAN shows the presence of a nocturnal low-level jet, which enhances the 0–1 km shear values. Nocturnal stabilization is still seen but is potentially overcome in this scenario by the increase in low-level shear in the presence of already existing storms.

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