4–8 November 2019, Kraków, Poland
ECSS2019-44

Bayesian modeling of central U.S. tornado reporting rates

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Tornado report databases are indispensable for assessing tornado risk, investigating tornado–climate connections, and developing and verifying tornado prediction tools. Maximizing the value of these databases, however, requires accounting for systemically lower reported tornado counts in rural areas owing to a lack of observers. We have recently developed a new Bayesian hierarchical modeling framework to estimate tornado reporting rates (TRRs) and expected tornado counts from gridded tornado report counts (Potvin et al. 2019). The adopted model explains 73% (>90%) of the variance in reported counts in the Storm Prediction Center tornado database from 1975-2016 over the central U.S. at scales of 50 km (>100 km). Population density explains more of the variance in reported tornado counts than other examined geographical covariates, including distance from nearest city, terrain ruggedness index, and road density. The model estimates that only 45% of tornadoes within the analysis domain were reported, underscoring the magnitude of the under-reporting problem.

Recent work has focused on examining (1) the change in domain-mean TRR and expected tornado counts over the 1975-2016 period, and (2) the sensitivity of TRR to tornado attributes such as damage rating and path length. Bias-corrected tornado counts from (1) exhibit no significant trend with time, as opposed to uncorrected tornado counts that exhibit a sharp upward trend that has long been recognized as an artifact of under-reporting. The model-predicted domain-mean TRR plateaus near the end of the period near 55%, suggesting under-reporting remains a major problem even today. Preliminary results from (2) suggest that intense tornadoes are extensively under-rated in rural areas, and that significant and violent tornado frequency have been consequently underestimated by a factor of 2 or more over the central U.S. Long-track tornado reports, on the other hand, are much less sensitive to reporting bias, which suggests it may be better for climatological studies of intense tornadoes to threshold on path length than on damage rating.