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Evaluating Properties of Intense Storms using MSG SEVIRI Observations and Derived Microphysical Properties

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Meteosat Second Generation (Meteosat–8) SEVIRI observations were collected for severe weather events over Europe. The main research direction taken was to evaluate, for severe and non-severe storms, key characteristics found at cumulus cloud tops from so-called 0-1 hour convective initiation (CI) fields and temperature–particle effective radius (T–Re) fields, from 2-3 hour in advance of storm maturity. A fundamental research component is that storm severity is largely determined by atmospheric instability that affects updraft intensity. Updraft intensity can be inferred directly through CI fields (Mecikalski et al. 2008), and indirectly by the fact that cloud drops in stronger updrafts have shorter time to grow and glaciate, thereby possess smaller Re for a given cloud-top temperature, and also colder glaciation temperatures (Tg) (Lensky and Rosenfeld 2006; Rosenfeld et al. 2008).

A total of 340 individual cells were monitored in 5-min resolution imagery over 2 hours on 6 different stormy days (15 August 2010, 1, 7 and 21 July 2012, and 20 June and 29 July 2013). 47 combined CI and T–Re fields were analyzed as clouds were tracked by hand as they grew from the cumulus cloud scale to when they later possessed large anvils and –possibly- overshooting tops. Analysis was performed over three scales relevant to storm growth over 2-hour time periods: A "cloud scale" (3 x 3 pixels) for the 11 CI fields used, a "storm scale" (9 x 9 pixels) for T–Re fields, and an "environmental scale" (51 x 51 pixels) for T–Re fields Validation of the storm severity was made against surface reports of the European Severe Weather Database (ESWD), and 34 (10%) of the events were co-located with a severe weather report, that occurred within 1 hour and 75 km of the 2-hour location of the given storm.

An analysis of specific field evolution over time, of CI and T–Re fields, shows that the clouds that later produced a severe weather report possess overall stronger updrafts, delayed glaciation at cloud top, and a higher likelihood of producing overshooting tops. Results also show that more rapidly growing clouds exhibiting low Tg and relatively small Re, and that stronger storms exhibited both a delay in glaciation relative to Tg and defined cloud-top ice signatures as thick anvils form (as compared to weaker storms).

A linear prognostic multivariate analysis (LDA) was performed after transforming all the predictors into their Empirical Posterior Probability (EPP) of having a severe weather occurrence. After removing highly correlated predictors, the best subset of predictors that optimize the maximum Pierce skill score (Manzato 2007) on both the training and test sets consists of T1451 (the environmental 14 μm temperature), Tg9 (storm-scale glaciation temperature), and Rebrtg51 (environmental cloud top temperature and the T–Re profile's breakpoint effective radius). The physical reasons for the importance of these variables are along the lines of that already stated above (for T1451 and Tg9), with delayed particle growth and glaciation in strong updrafts. The physical relationship between severe weather and the Rebrtg51 variable is that strong updrafts produce microphysical particles with anomalously small sizes, as compared to what occurs in more average convection (Rosenfeld et al. 2008). Results will also be presented on similar analyses done over the U.S., using a more automated procedure within the GOES-R CI algorithm.