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Observing convection with satellite, radar, and lightning measurements

Ulrich Hamann, Luca Nisi, Lorenzo Clementi, Jordi Figueras i Ventura, Marco Gabella, Alessandro M. Hering, Ioannis Sideris, Simona Trefalt, and Urs Germann

MeteoSwiss, Locarno, Switzerland (ulrich.hamann@meteoswiss.ch)

Heavy precipitation, hail, and wind gusts are the fundamental meteorological hazards associated with strong convection and thunderstorms. The thread is particularly severe in mountainous areas, e.g. it is estimated that on average between 50% and 80% of all weather-related damage in Switzerland is caused by strong thunderstorms (Hilker et al., 2010). Intense atmospheric convection is governed by processes that range from the synoptic to the microphysical scale and are considered to be one of the most challenging and difficult weather phenomena to predict. Even though numerical weather prediction models have some skills to predict convection, in general the exact location of the convective initialization and its propagation cannot be forecasted by these models with sufficient precision. Hence, there is a strong interest to improve the short-term forecast by using statistical, object oriented and/or heuristic nowcasting methods. MeteoSwiss has developed several operational nowcasting systems for this purpose such as TRT (Hering, 2008) and COALITION (Nisi, 2014).

In this contribution we analyze the typical development of convection using measurements of the Swiss C-band Dual Polarization Doppler weather radar network, the MSG SEVIRI satellite, and the Météorage lighting network. The observations are complemented with the analysis and forecasts of the COSMO model. Special attention is given to the typical evolutionary stages like the pre-convective environment, convective initiation, cloud top glaciation, start, maximum, and end of precipitation and lightning activity. The pre-convective environment is examined using instability indices derived from SEVIRI observations and the COSMO forecasts. During the early development satellite observations are used to observe the rise of the cloud top, the growth of the cloud droplet or crystals, and the glaciation of the cloud top. SEVIRI brightness temperatures, channel differences, and temporal trends as suggested by Mecikalski et al. (2010) are used to identify convectively active regions. Additionally, retrieved physical cloud properties of state-of-the-art cloud remote sensing algorithms such as the cloud top height, multilayer flags, cloud phase, optical depth and effective radius are employed. As soon as larger particles form, radar observations complement the satellite ones. Radar datasets are used in particular to observe the precipitation intensity and type, the vertical extension and structure of the convective cells. In the mature stage convective cells might start to produce lightning. The relation between the different observables and their suitability as predictors for the further convective development are discussed, e.g. strong updrafts in the developing phase are often followed by fast anvil spreading and intense precipitation in the mature phase. Threads and hazards due to heavy precipitation, hail, and wind gusts are estimated.

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