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An extended perspective for Deep Moist Convective Initiation in the Alpine Region?

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Predicting the exact location, intensity, morphology and propagation of thunderstorms and convective complexes remains a challenge to operational forecasters, in particular in the presence of orography, in the absence of fronts and when a forecast lead time of more than three hours is desired. Single-cell or pulse convection, developing without fronts, represents about 30% of the summertime convective activity in the Eastern Alpine region.

Studies of satellite imagery in similar cases showed that upper tropospheric moisture gradients are often favorable locations for the initial evolution from shallow to deep moist convection (DMC). Furthermore, numerical simulations clarified that the evolution often occurs in conjunction with a distinct increase in vertical wind shear, horizontal and vertical lapse rates and inertial instability. Hence, the coexistence of moist gravitational and moist symmetric instabilities along these upper-level moisture patterns seems plausible. This concept has been the subject of several investigations in the last decades, but thorough analyses of its applicability in real cases remain rare.

We describe a few representative case studies of single-cell convection within the greater alpine area. We quantify the parameters relevant for gravitational instability (i.e. CAPE, lift and low-level moisture) and identify the ingredients favorable for DMC onset through numerical simulations with the WRF model, ran at a km-scale horizontal resolution. We also devote special attention to the indicators for symmetric instability (i.e. negative equivalent potential vorticity) and to their temporal and spatial distribution during thunderstorm development. Finally, we compare the pre-storm conditions that lead to DMC to those that do not cause convection initiation, despite the presence of both gravitational and symmetric instability.