Review for egusphere-2025-1819: “Observation based precipitation life cycle analysis of heavy rainfall events in the southeastern Alpine forelands” by Stephanie J. Haas, Andreas Kvas, and Jürgen Fuchsberger

General Comments

1.) This paper nicely shows the potential of a sub-meso-scale observation network for providing insights to the initialization, evolution and decay of local Heavy Precipitation Events (HPE) over a hilly landscape in the south-east of Austria. In-situ and remotely measured meteorological variables are set into context with the precipitation development. However, I do see important factors missing in the data interpretation, which I outline in the Specific Comments below. These include the consideration of convective cold pools, advection and the synoptic situation.

2.) This paper deals with observations. However, measurement principles and errors are not discussed at all. For each observation type and variable, the authors need to provide a sound physical background, including relevant references. The resulting uncertainties should be included in the discussion of the results. This is especially true for all variables derived from the MWR and the GNSS water vapor retrievals.

3.) The MWR observations need to be interpreted in a more critical manner. Please quantify vertical resolution of the MWR retrievals and discuss the implication of vertical resolution of the MWR retrievals of the temperature and humidity profiles on the your interpretations.

Specific Comments

1.) Table 1: If I understand correctly, only one station provides wind speed information? If so, please indicate this in Fig. 1 and/or clarify.

2.) The observed CAPE values from the MWR in Fig. 3 are significantly smaller than the ERA5 values and also smaller than one would expect for HPE. CAPE values over 1000 J/kg are not exceptional over Europe. Please discuss where this originates from. And in this respect, describe in detail, how and what type of CAPE you have calculated. How do the values of the nearest radiosonde stations (Zagreb?) compare? Also, MSG-Seviri (and maybe already MTG?) provides a CAPE product which you should compare to.

3.) In Section 3.1 you write: *Another effect of the convective nature of HPEs is the deepening of the convective cloud system, represented by a decrease in the CBH anomaly of about 1000m prior to the event onset.* Once the air parcels have enough energy to reach the level of free convection, a deep convective system will develop and CTH will rapidly increase. Please explain in a physically plausible way, why you think the lowering of CBH is an indicator of a developing deep convective system.

4.) Fig. 4a: The vertical structure of the temperature anomaly is not discussed. I suggest analyzing the lapse rate anomalies before and after the HPE and discuss the mixing processes in the troposphere.

5.) In Section 3.1 you write: *Using the lower contour of the 80-90% RH area as a proxy for the CBH, we see a decrease in CBH of about 1 km in the 8 h before the event. This is in line with the drop in CBH anomaly already detected in Fig. 3d.* Is this really true? The strong decrease of CBH in Fig. 3 is only seen 1-2 hours before the HPE. Also,

please confirm with the actual CBH MWR/IRT retrieval that the CBH corresponds to your 80-90% contour.

6.) Fig. 5 interpretation: the increase in temperature variability goes along with the decrease of the mean temperature (Fig. 3). Relating this to clouds is probably only one part of the story. You should consider the effect of convective cold pools originating from evaporative cooling of precipitation and downward transport of upper tropospheric air (see Kirsch et al. https://doi.org/10.1002/qj.4626). Cold pools are often encountered before the actual HPE passes over the specific location. Your data are highly suited for analyzing spatial temperature variability and associated wind speeds with respect to the origin of the HPE.

7.) Fig. 7 interpretation: Please clarify in detail how you define the maximum precipitation amount? It is given in mm. What spatial and temporal extent does this amount refer to?

8.) In the discussion you write: *The energy build-up, which is also linked to the rise in temperature, is reflected by the increase of CAPE in the hours prior to the event onset (Fig. 3c).* Isn't it the airmass which is associated to a certain CAPE value and this potential energy can be set free when the surface heats or orographic lifting occurs? Wouldn't you think that the CAPE increase you see in the hours prior to the HPE is most probably due to advection of a warm and humid airmass? I suggest to check this through a more thorough characterization of the synoptic situation, e.g. by using the concept of a circulation weather type: (https://www.dwd.de/EN/research/weatherforecasting/met_applications/nwp_applications/grosswetterlagen_forecast.html)

This would provide a more comprehensive way of contextualizing your observations.