Taking advantage of vertical temperature and dew point profiles derived from HEAP and MIRS software: Validation products over Poland and case study analysis

Tobiasz Górecki
Many thanks to Bożena Łapeta and Artur Rutkowski

13/05/2025, Goa India

Near Real-Time Monitoring of Atmospheric Conditions

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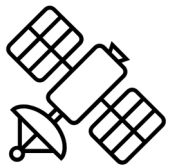
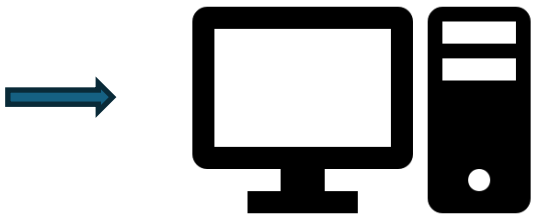


Atmospheric temperature
Atmospheric moisture

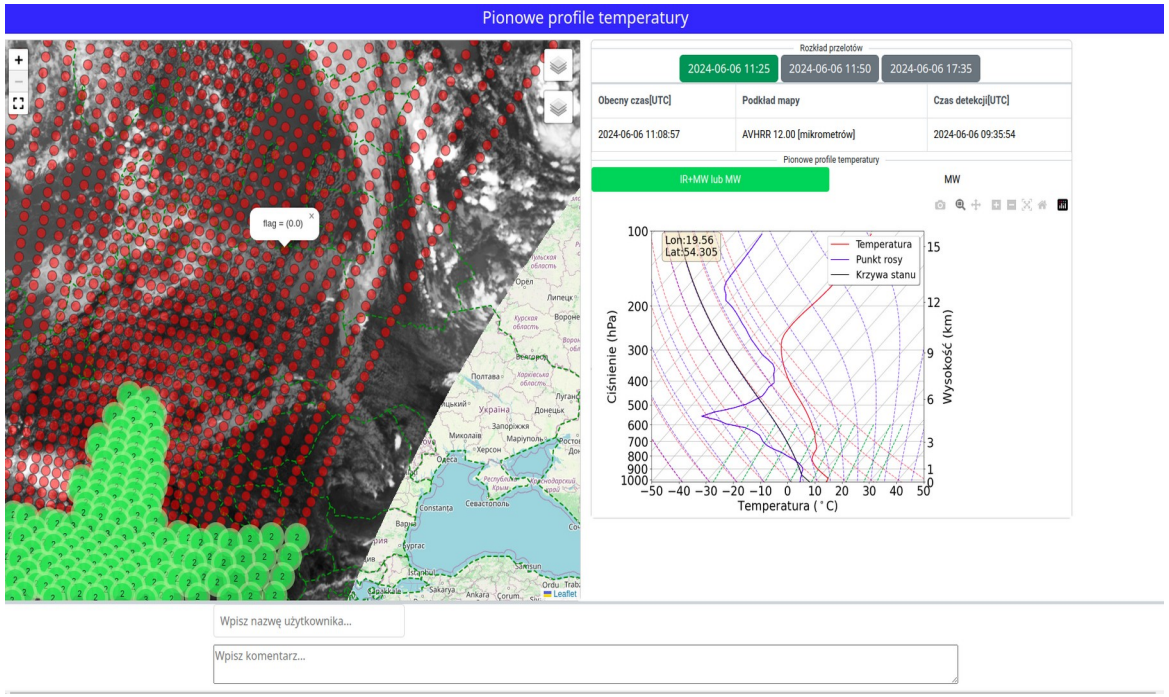
HEAP: Methane layer column density Carbon monoxide Carbon dioxide dry mixing ratio Methane mixing ratio Atmospheric ozone Trace gas mixing ratios CO, CH4, HNO3, N2O Carbon dioxide dry mixing ratio ...
MIRS: Rainfall Rate, Snow Fall Rate ...



The Community Satellite Processing Package (CSPP):

1. **CSPP HEAP NUCAPS CrIS/ATMS IASI/AMSUA/MHS Retrieval**
2. **CSPP MiRS Microwave Retrieval Software**

https://cimss.ssec.wisc.edu/cspp/



Validation product

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- Validation was performed using radiosonde data from three locations in Poland (Łeba, Legionowo, and Wrocław) at 00:00 UTC and 12:00 UTC.
- Latitude range: 49°–55°N
- Data collection period: August 2023 – April 2025

Problems:

- The satellite scan did not align precisely with the radiosonde launch time.
- Quality Flag

Validation product: HEAP (Hyperspectral + Microwave)

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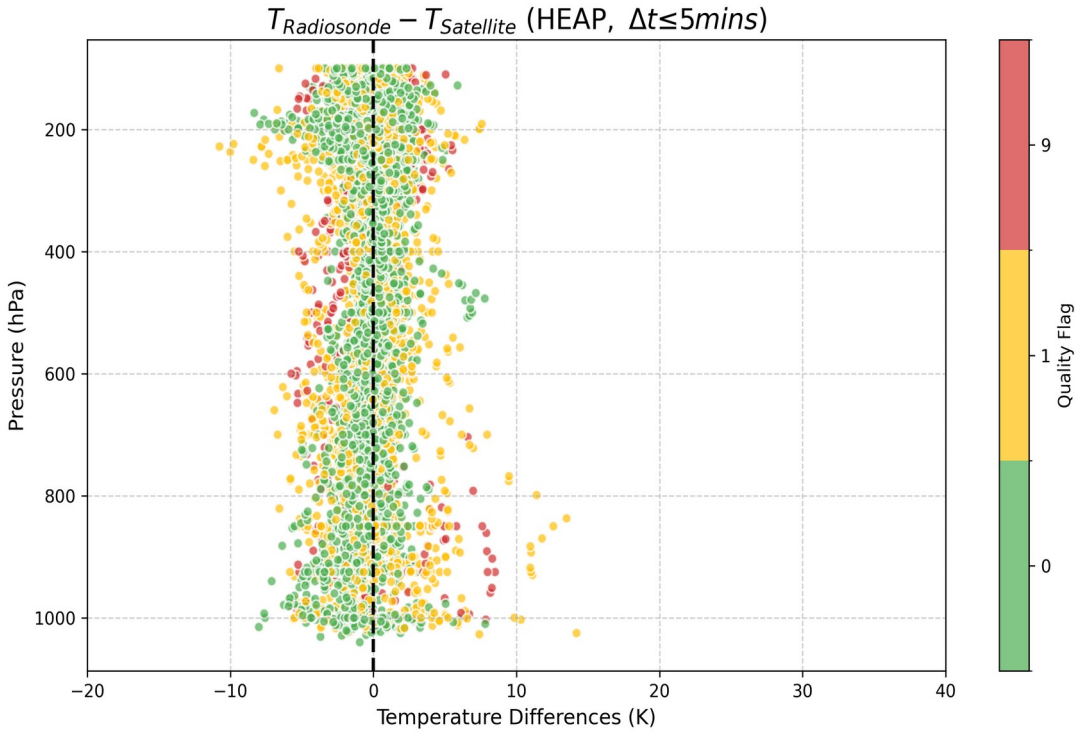
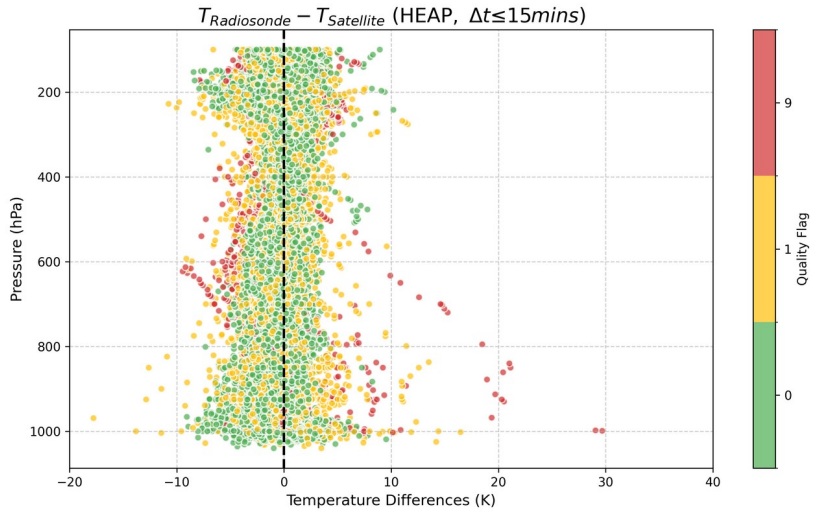
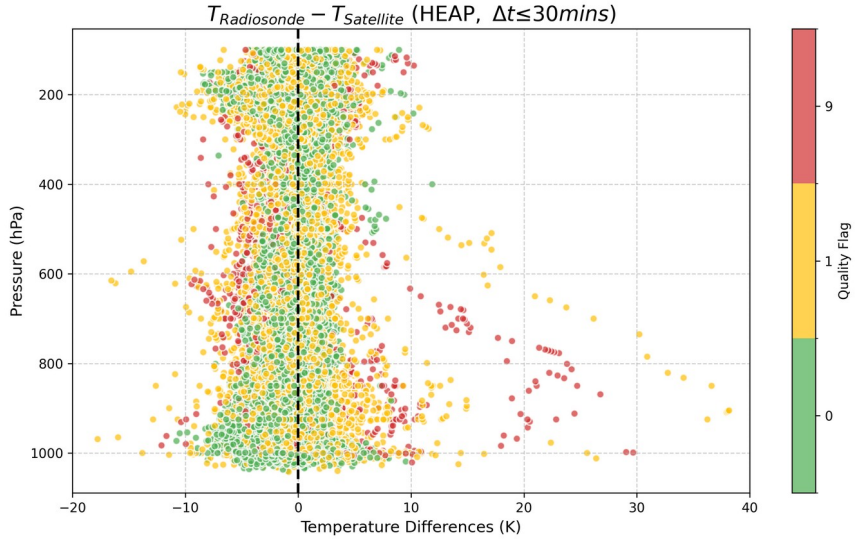
Temperatur



Most temperature differences cluster around 0 K, indicating good agreement between radiosonde and satellite measurements.

Lower Atmosphere (High Pressure):
- Flag 0: Overestimation by satellite.
- Flag 1: Underestimation by satellite.





- Greater Spread Than for Δt ≤ 5 min: Suggests increased error with longer time differences.

- Extreme outliers(mostly in Flag 1) → Differences exceed +40 K, both near the surface and in upper layers.

Validation product: HEAP (Hyperspectral + Microwave)

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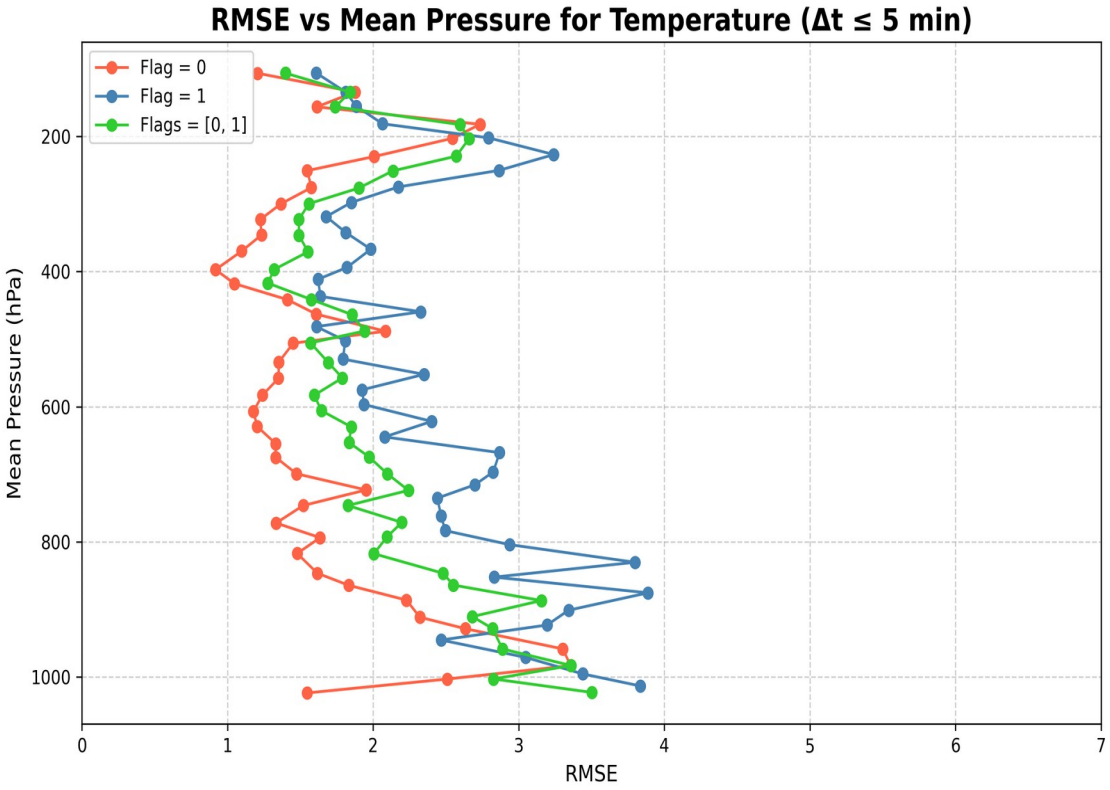
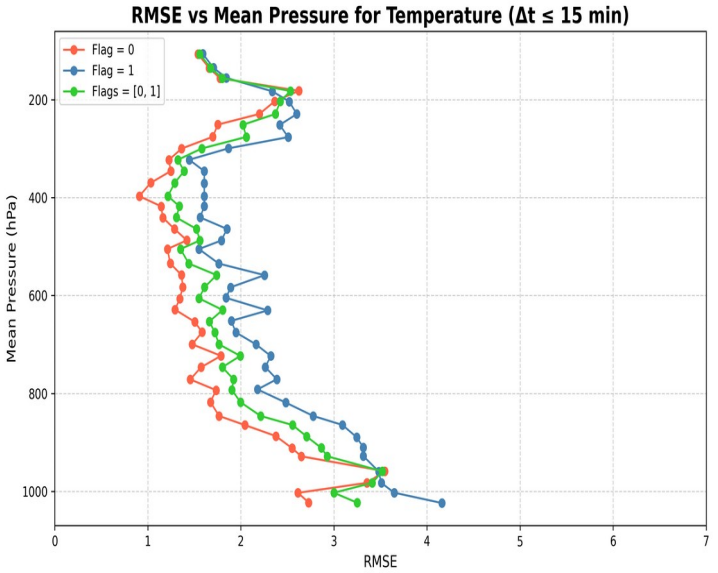
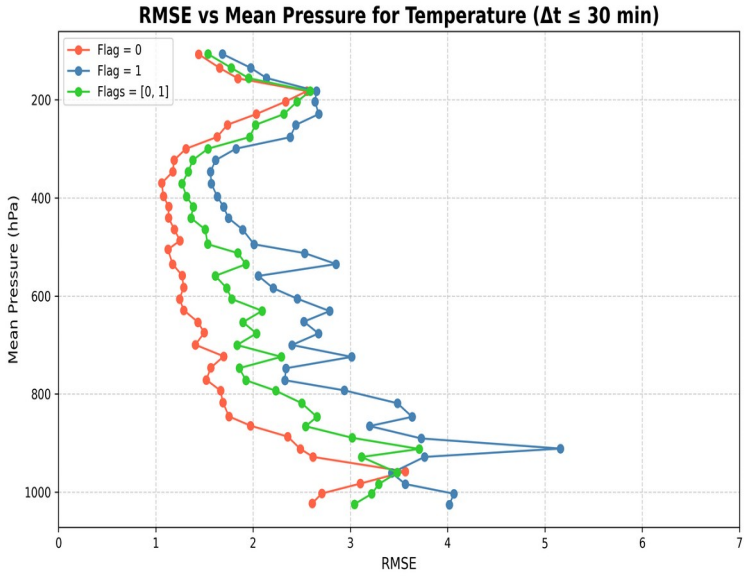
Temperature-







Flag 0 shows the lowest Root Mean Square Error (RMSE) across all pressure levels , except near 980 hPa, where RMSE increases → overall reflects highest data quality and best agreement between satellite and radiosonde temperatures.

Validation product: HEAP (Hyperspectral + Microwave)

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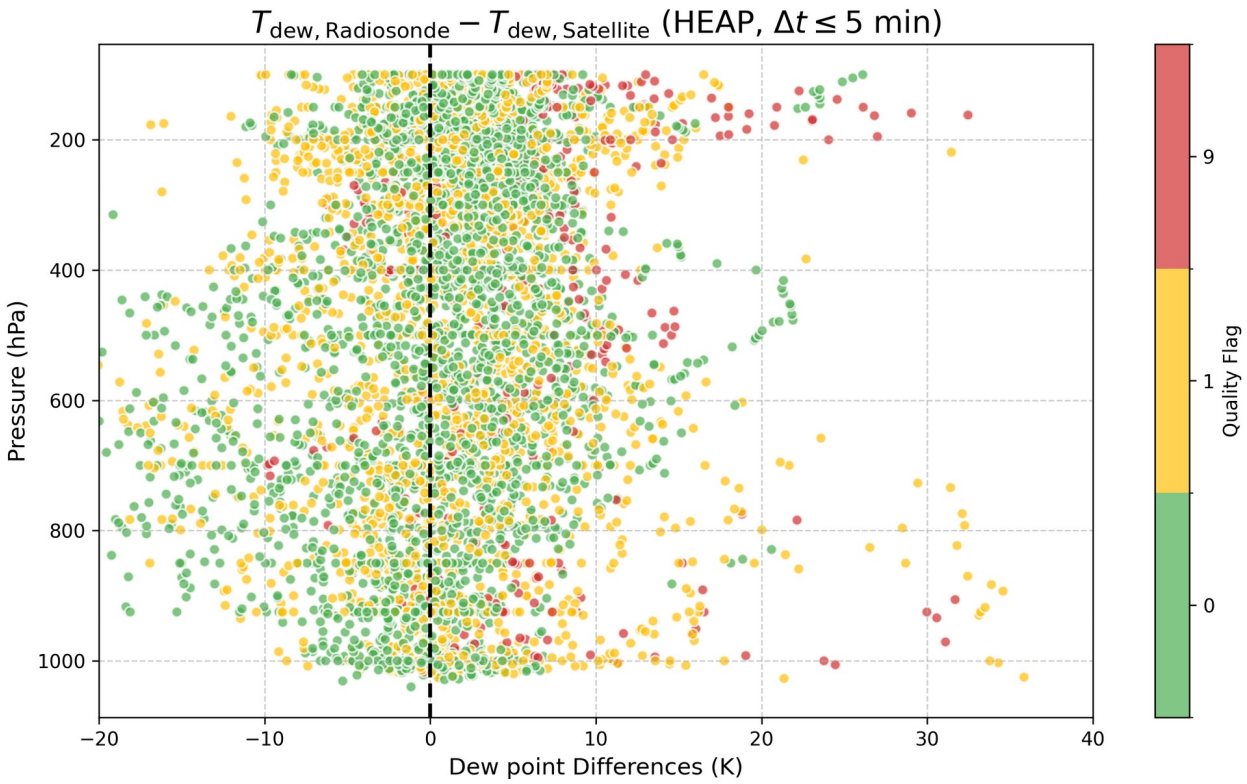
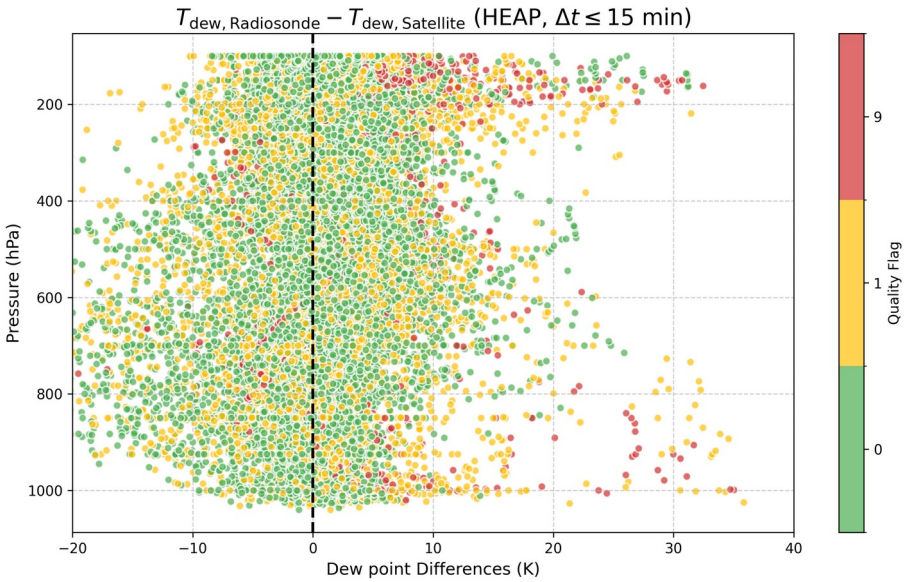
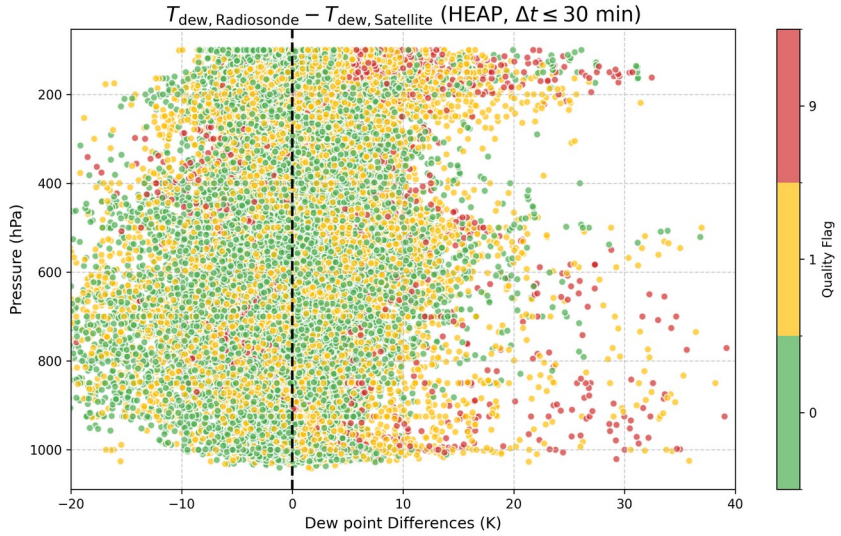
Dew







- Most points lie to the right of 0 K → indicates that the satellite often underestimates dew point.
- The overestimation between 400–850 hPa shows a clear negative shift in both Flag 0 and Flag 1, indicating a systematic satellite overestimation of dew point in the lower to mid-troposphere.

Validation product: HEAP (Hyperspectral + Microwave)

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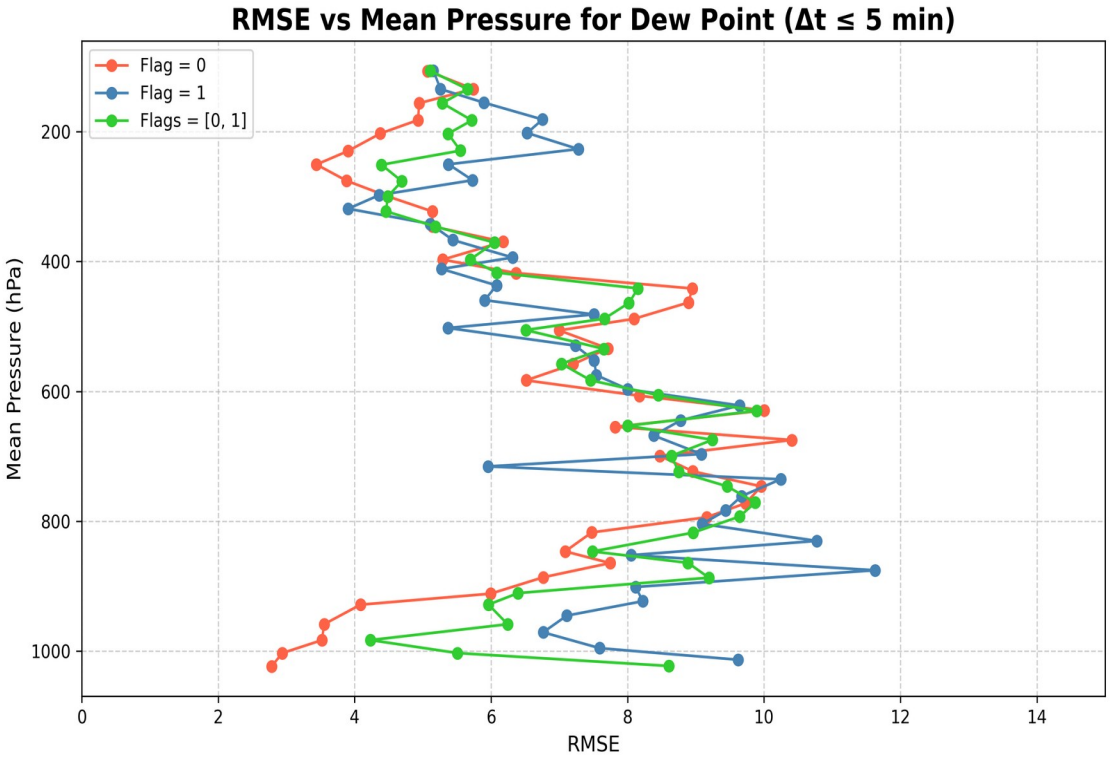
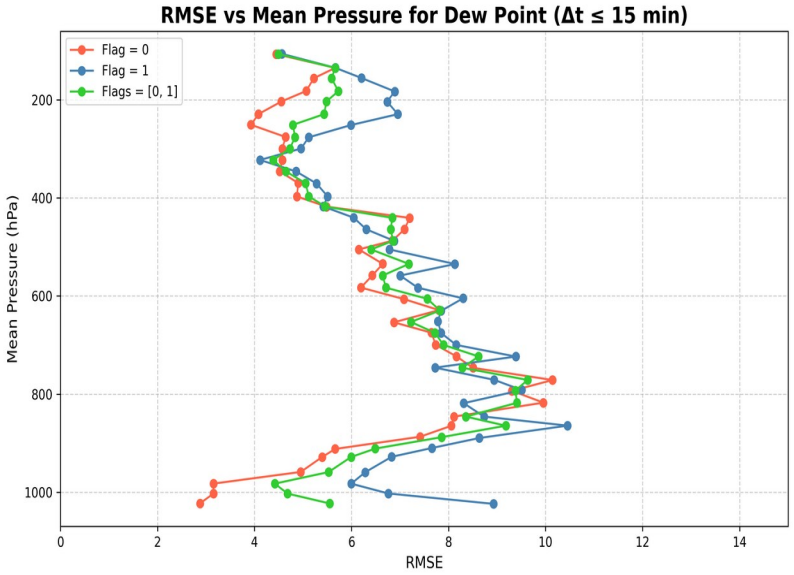
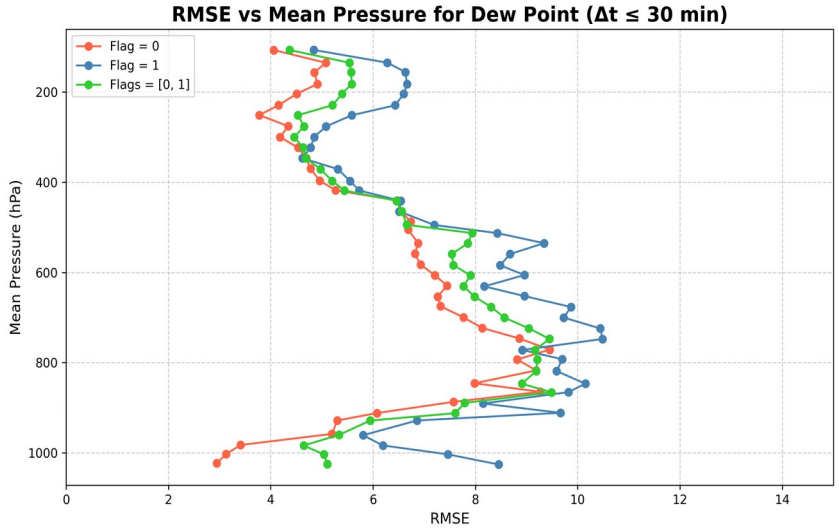
Dew point-RMSE







- Higher RMSE overall compared to temperature
- Large RMSE Increase Between 400–850 hPa → All flags show a notable jump in RMSE in this pressure range → suggests that satellite dew point estimates are less reliable in the lower to mid-troposphere.

Validation product: MIRS (Microwave)

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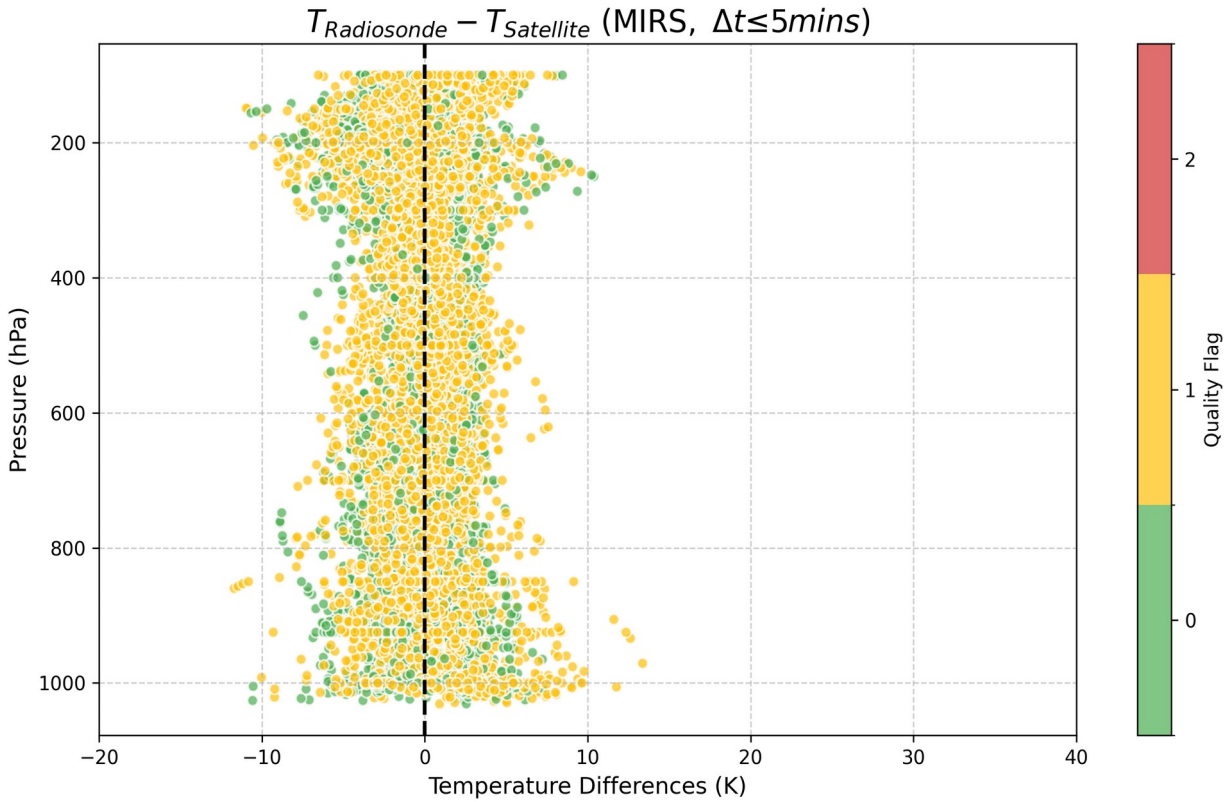
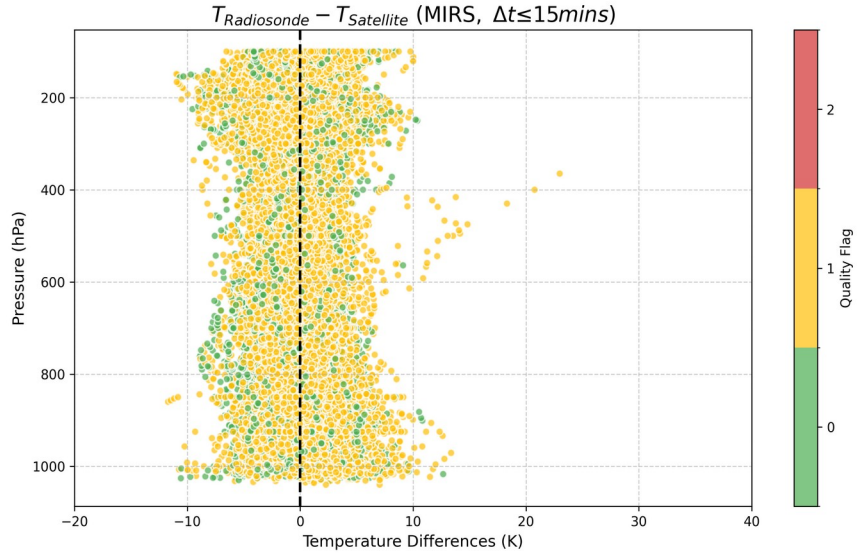
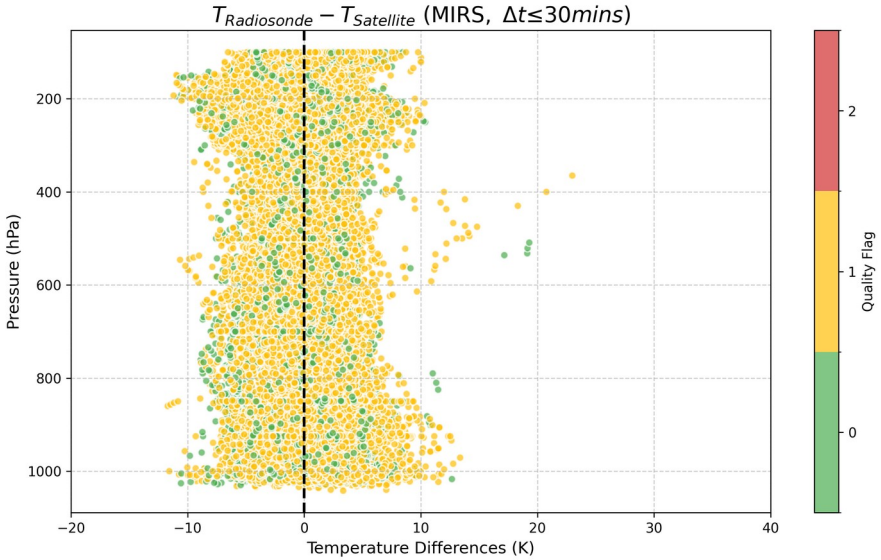
Temperature







Validation product: MIRS (Microwave)

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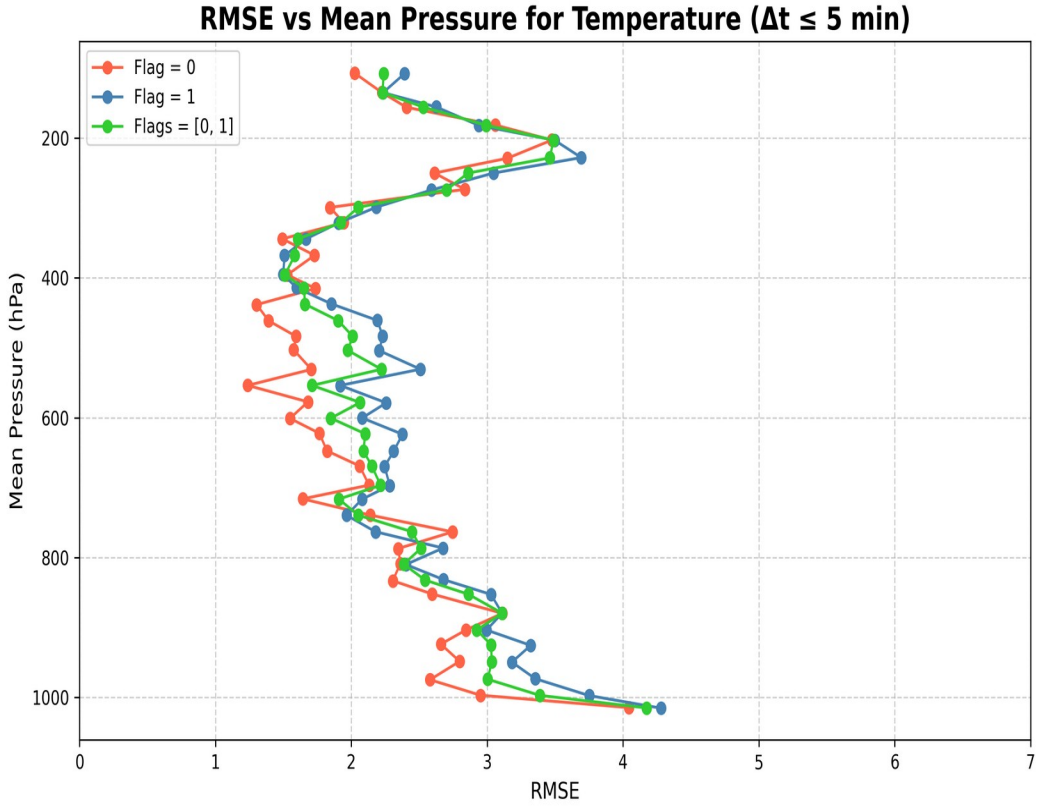
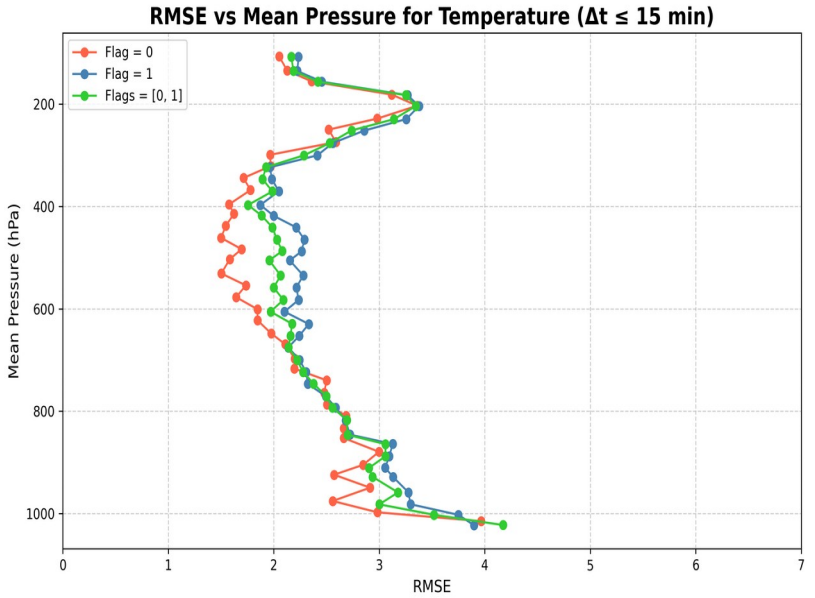
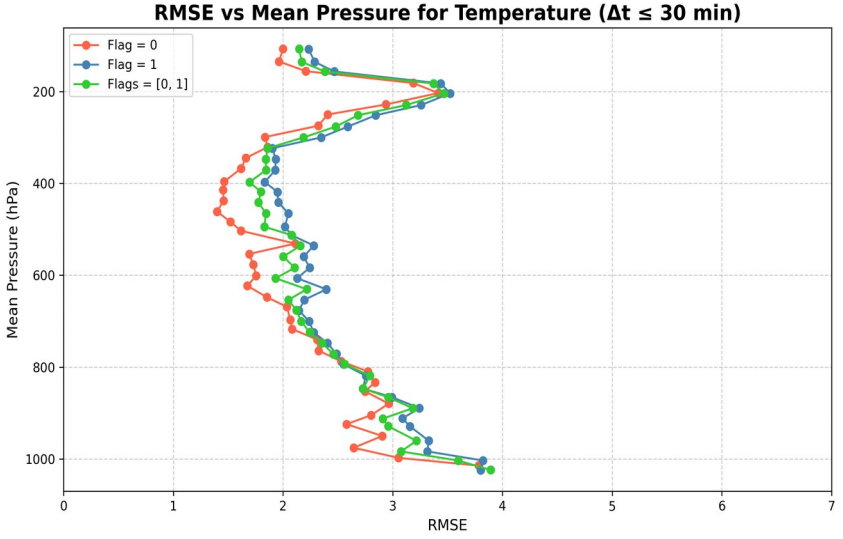
Temperature-RSME







- Overall low RMSE values indicate good agreement between temperature profiles and reference observations across most pressure levels
- RMSE increases sharply near the surface, reaching values of up to 4.2 K

Validation product: MIRS (Microwave)

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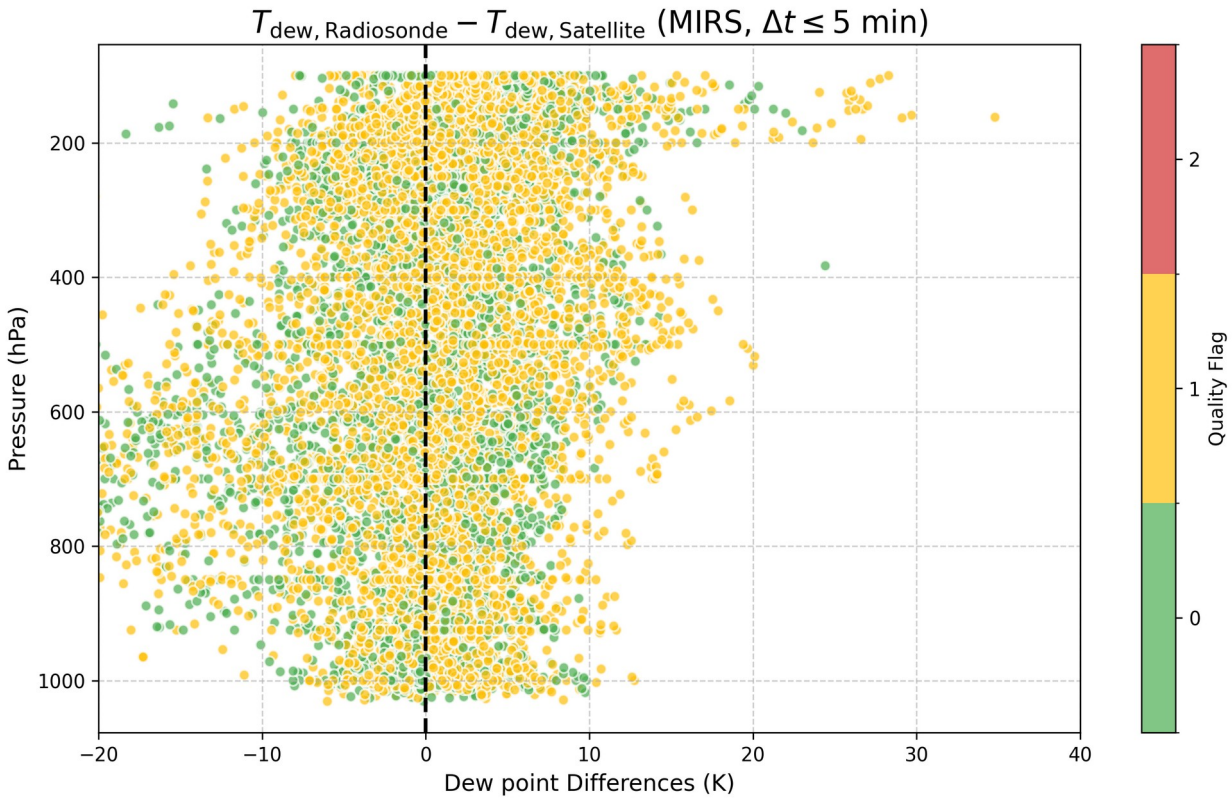
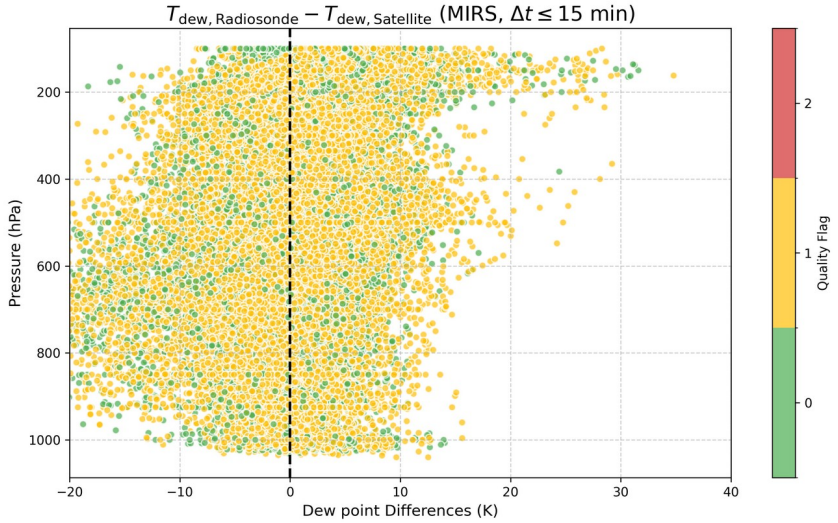
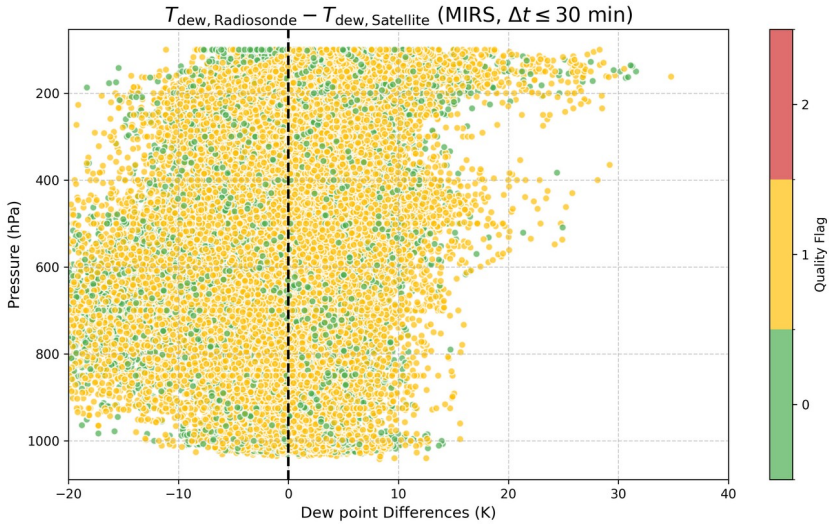
Dew point







Validation product: MIRS (Microwave)

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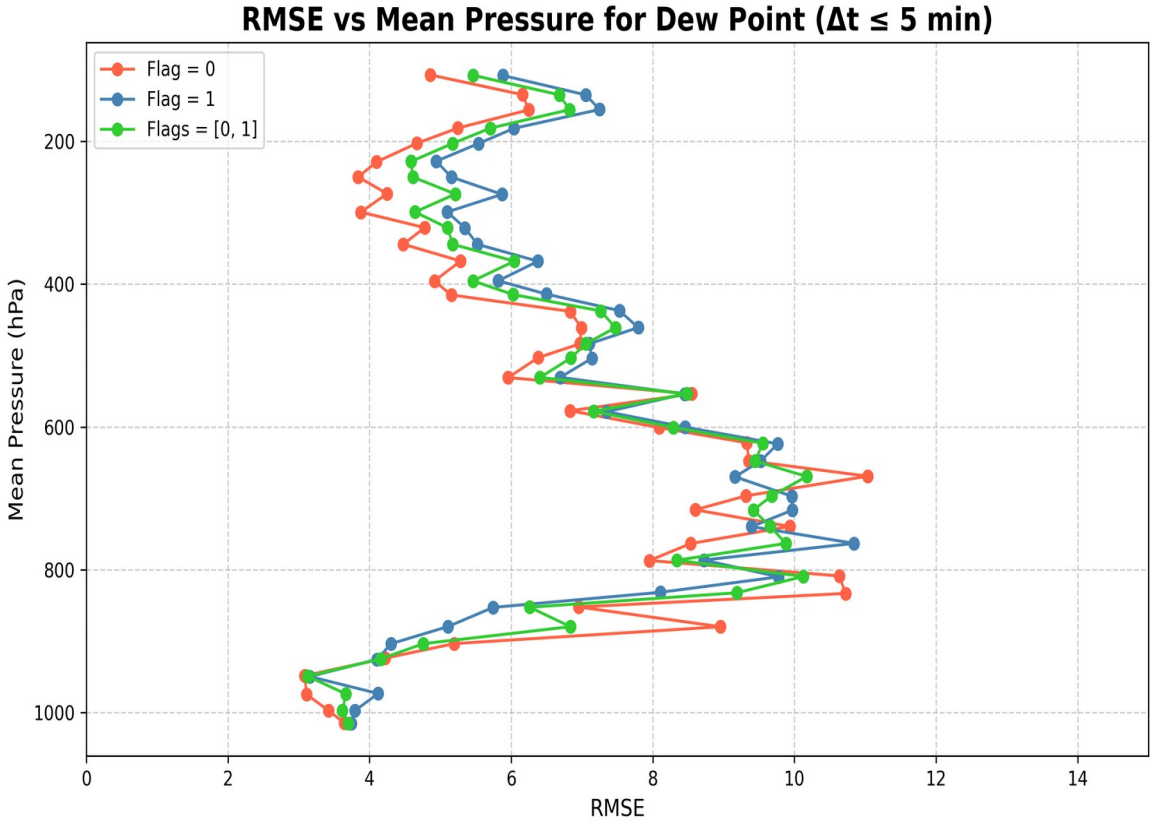
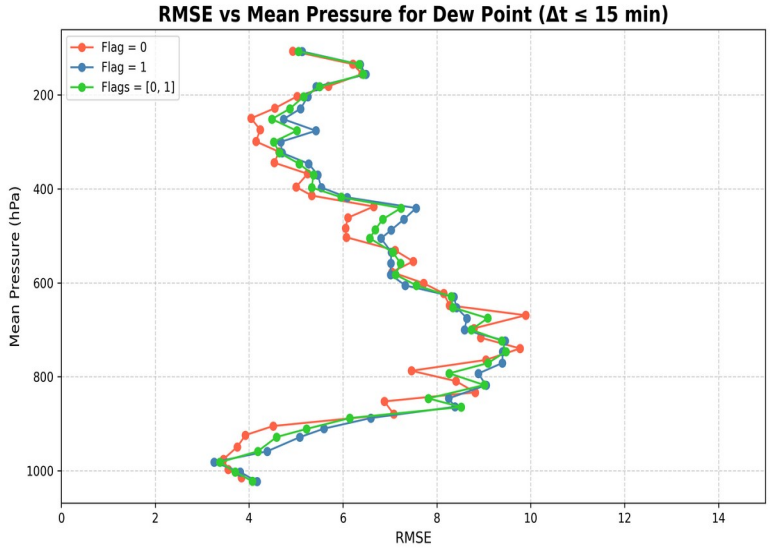
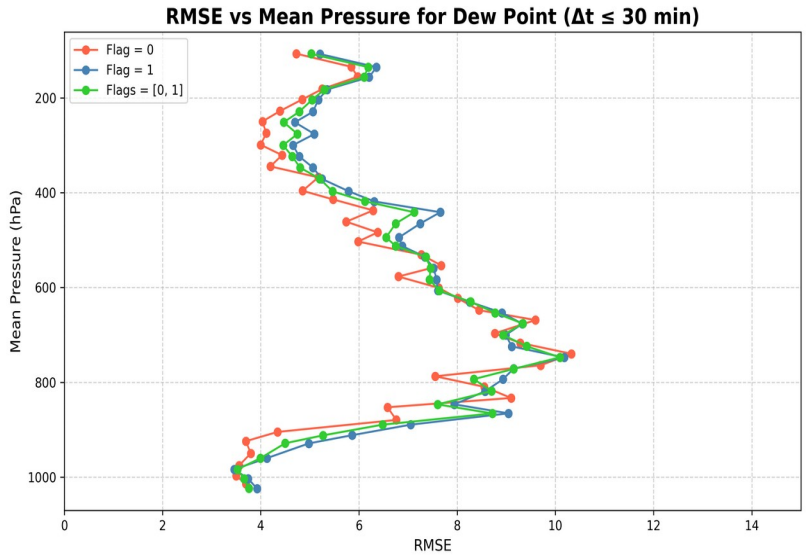
Dew point-RMSE







A significant increase in RMSE is observed between 400–850 hPa, similar to what is seen for dew point in HEAP.

Case Study of the Thunderstorm on 7 June 2024 – Temperature Profiles from Radiosondes

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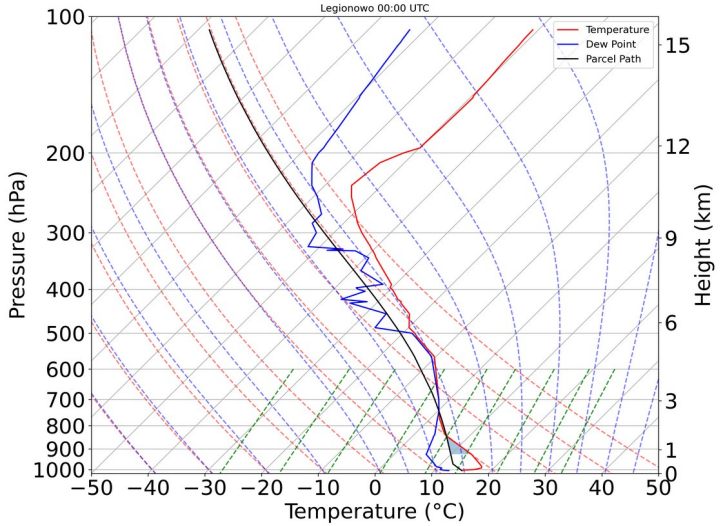
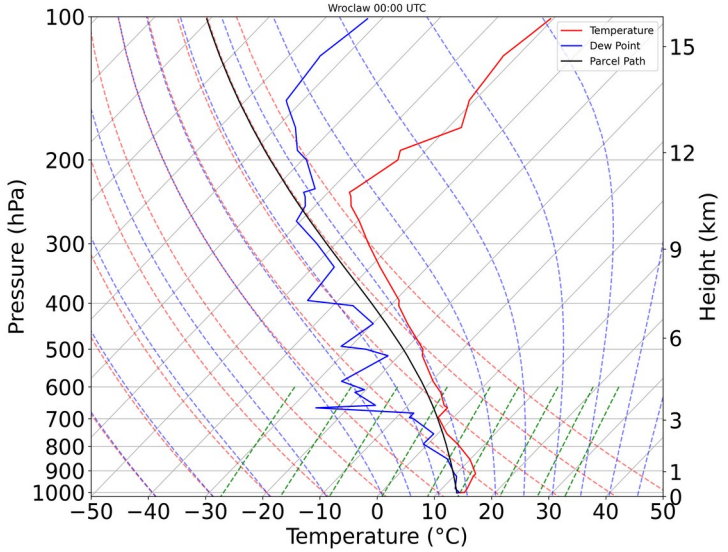
07 Jun 2024 00:00 UTC – Stable

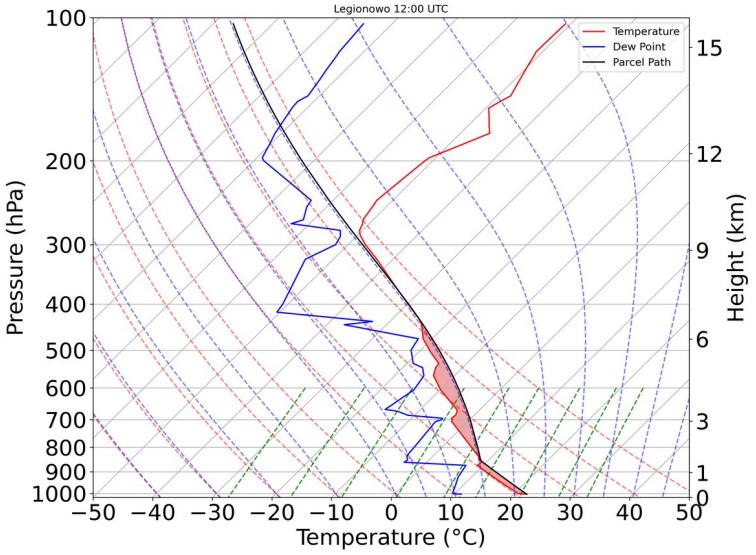


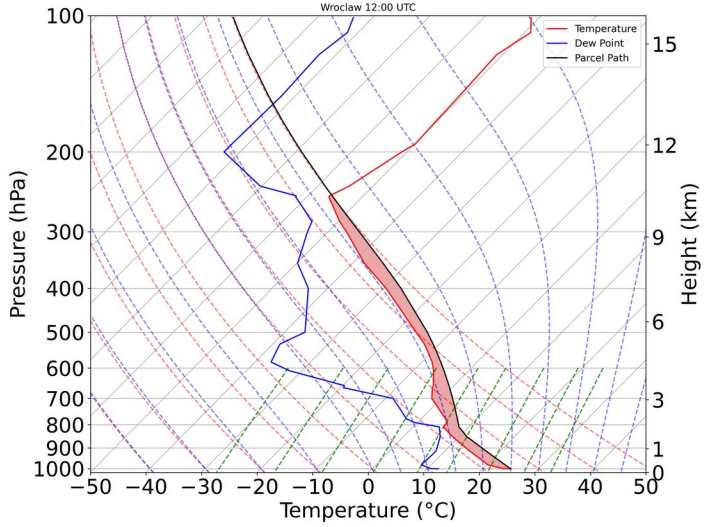


07 Jun 2024 00:00-12:00 UTC

?

07 Jun 2024 12:00 UTC Slightly Unstable





Case Study of Thunderstorm on 7 June 2024

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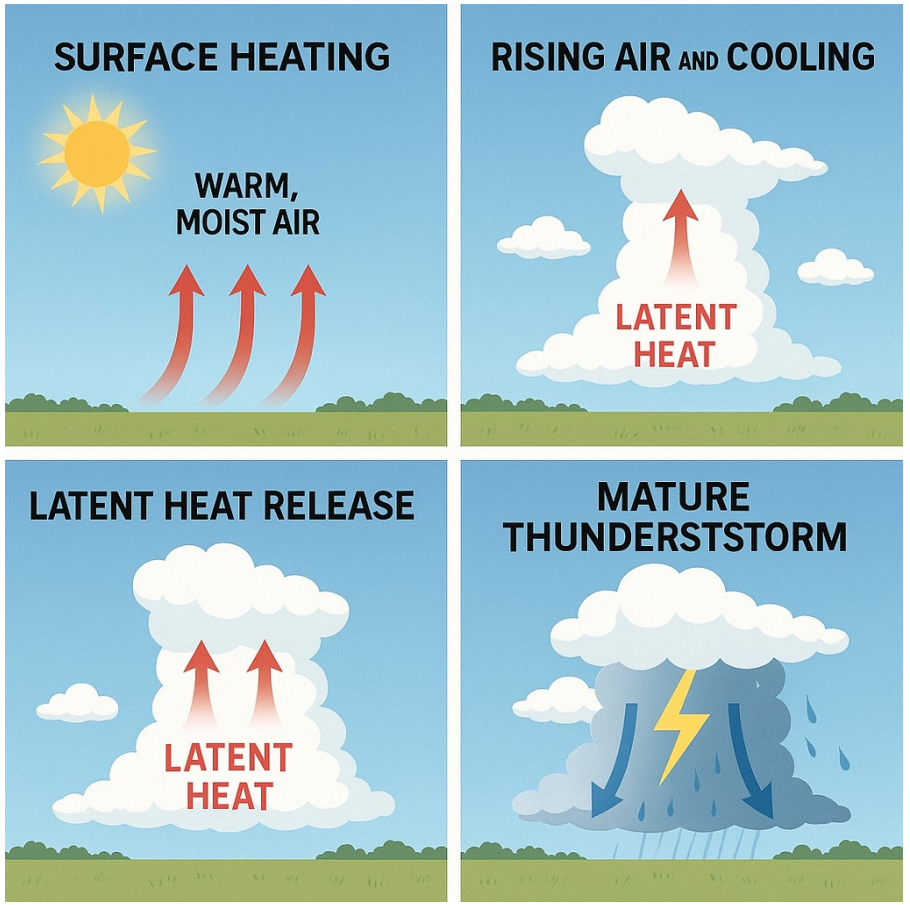

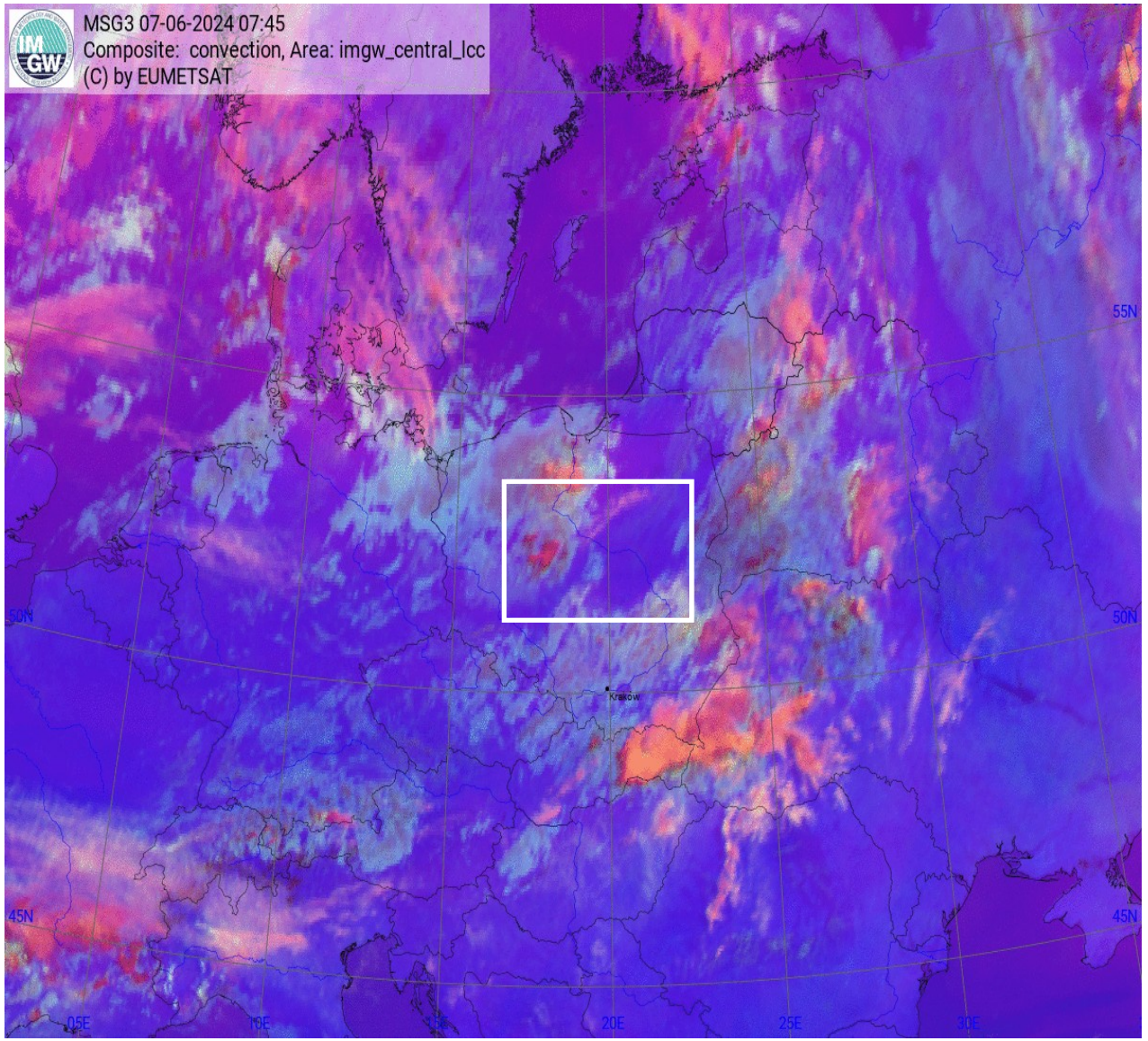

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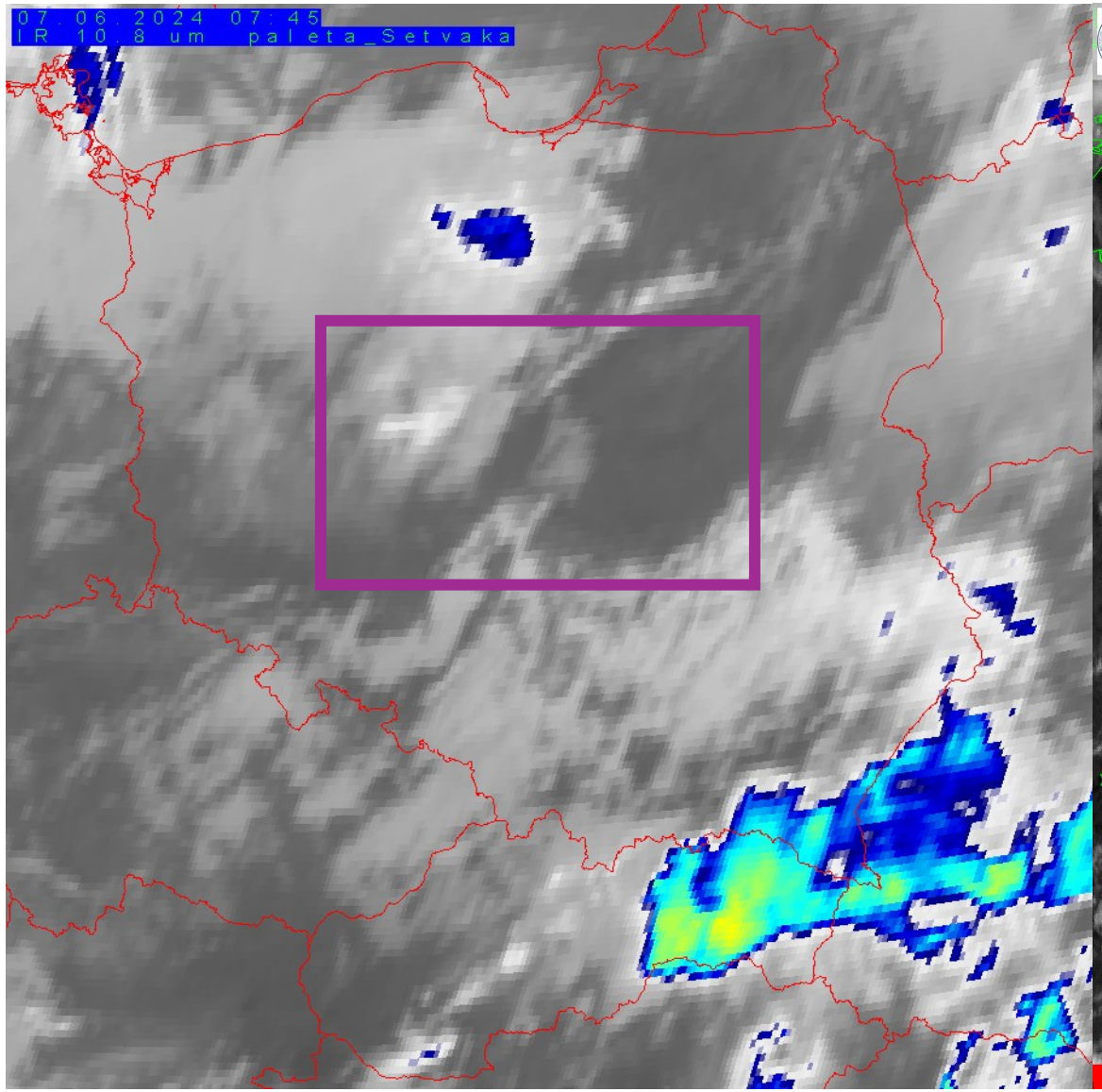

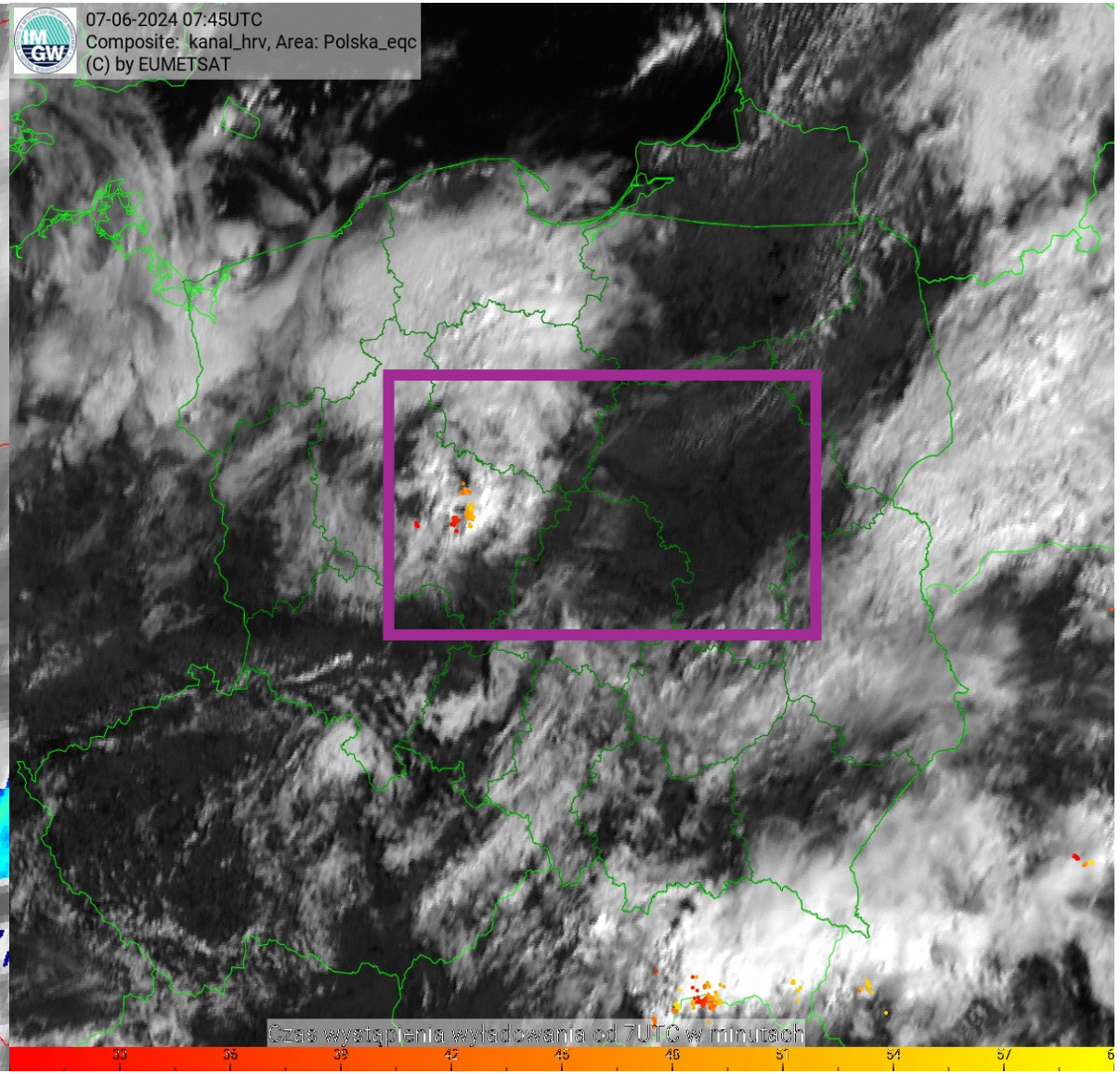

Case Study of Thunderstorm on 7 June 2024 - Precipitation

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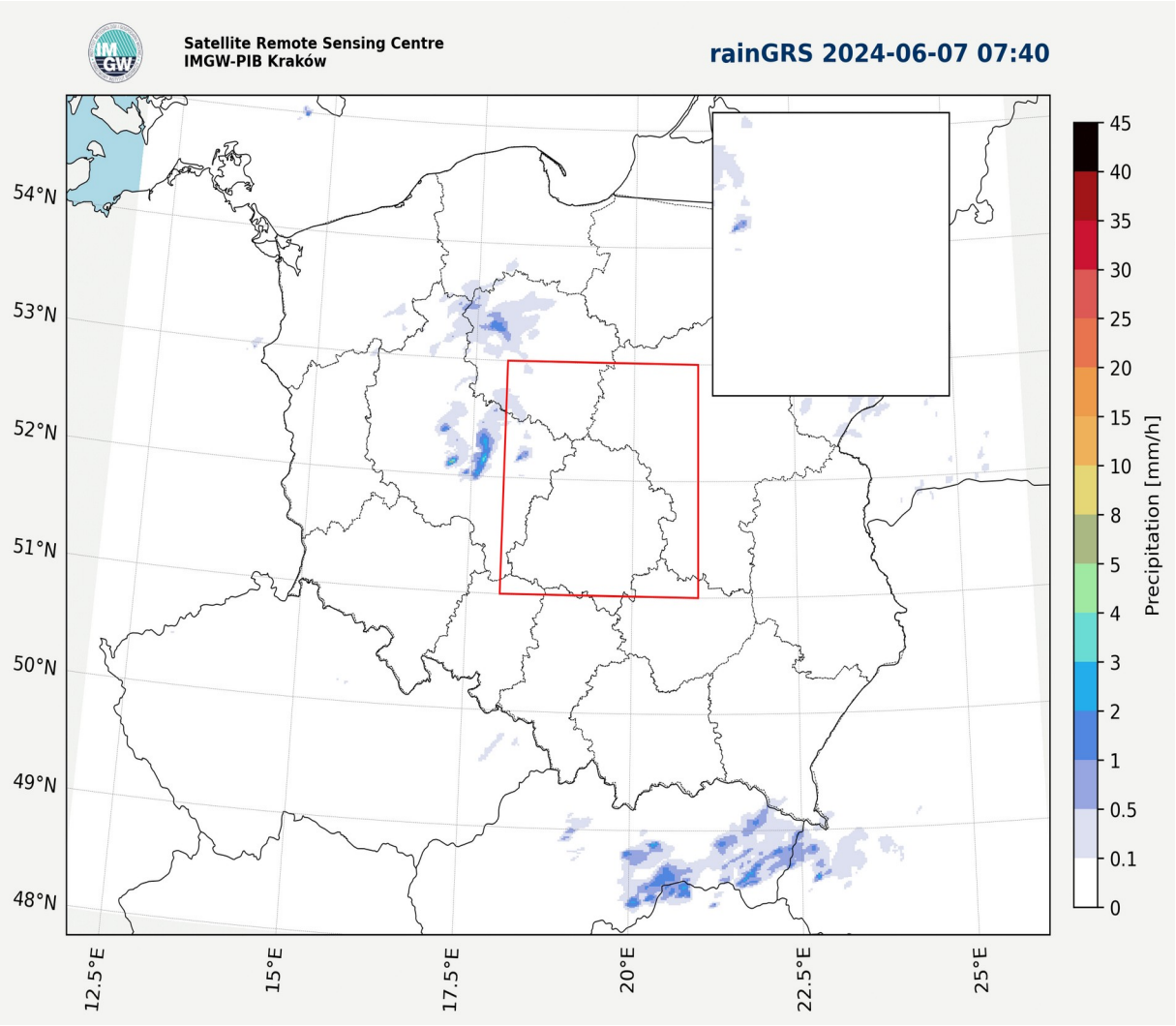

This thunderstorm brought very heavy rainfall and intense hail, with the largest hailstones measuring approximately 3.5 cm in diameter.

* RainGRS system - carried out at IMGW-PIB for nowcasting and hydrological applications in Poland.
It combines three data source: Ground (rain gauges), Radar and Satellite (NWCSAF Precipitating Clouds)

Case Study of Thunderstorm on 7 June 2024 – Model vs HEAP

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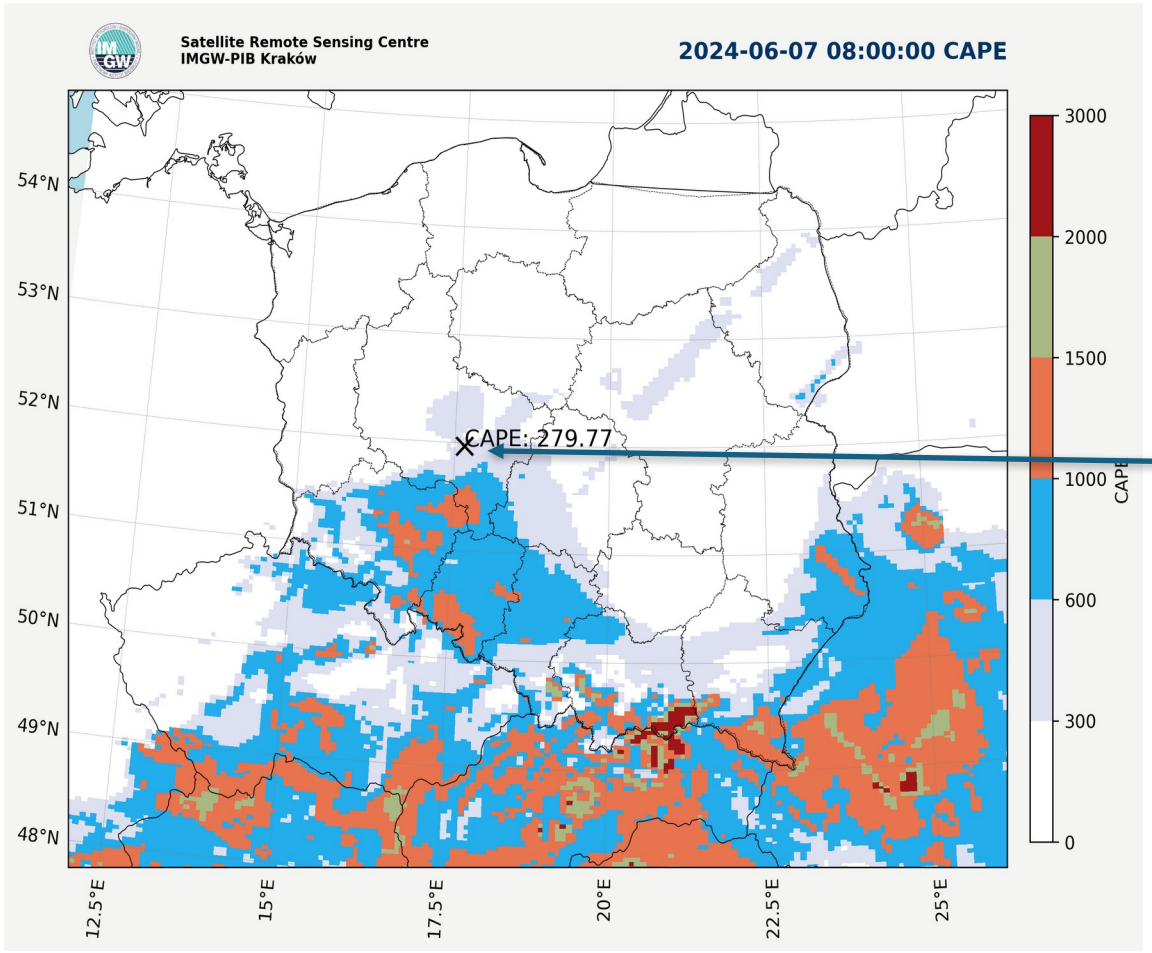

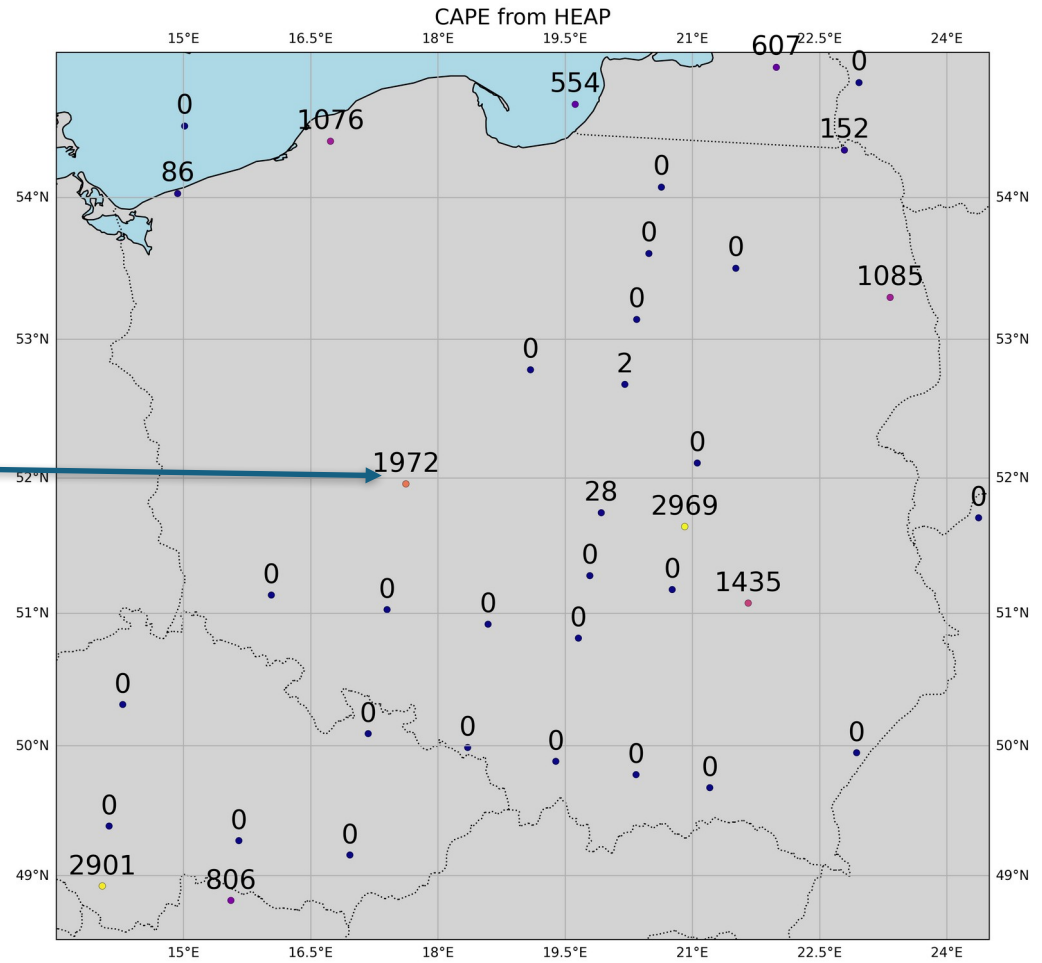

CAPE (Convective Available Potential Energy) is a measure of the amount of energy available for convection in the atmosphere. It indicates the potential for thunderstorm development and intensity. Higher CAPE values suggest stronger updrafts and a greater chance of severe weather, such as heavy rain, hail, or tornadoes.

Case Study of Thunderstorm on 7 June 2024

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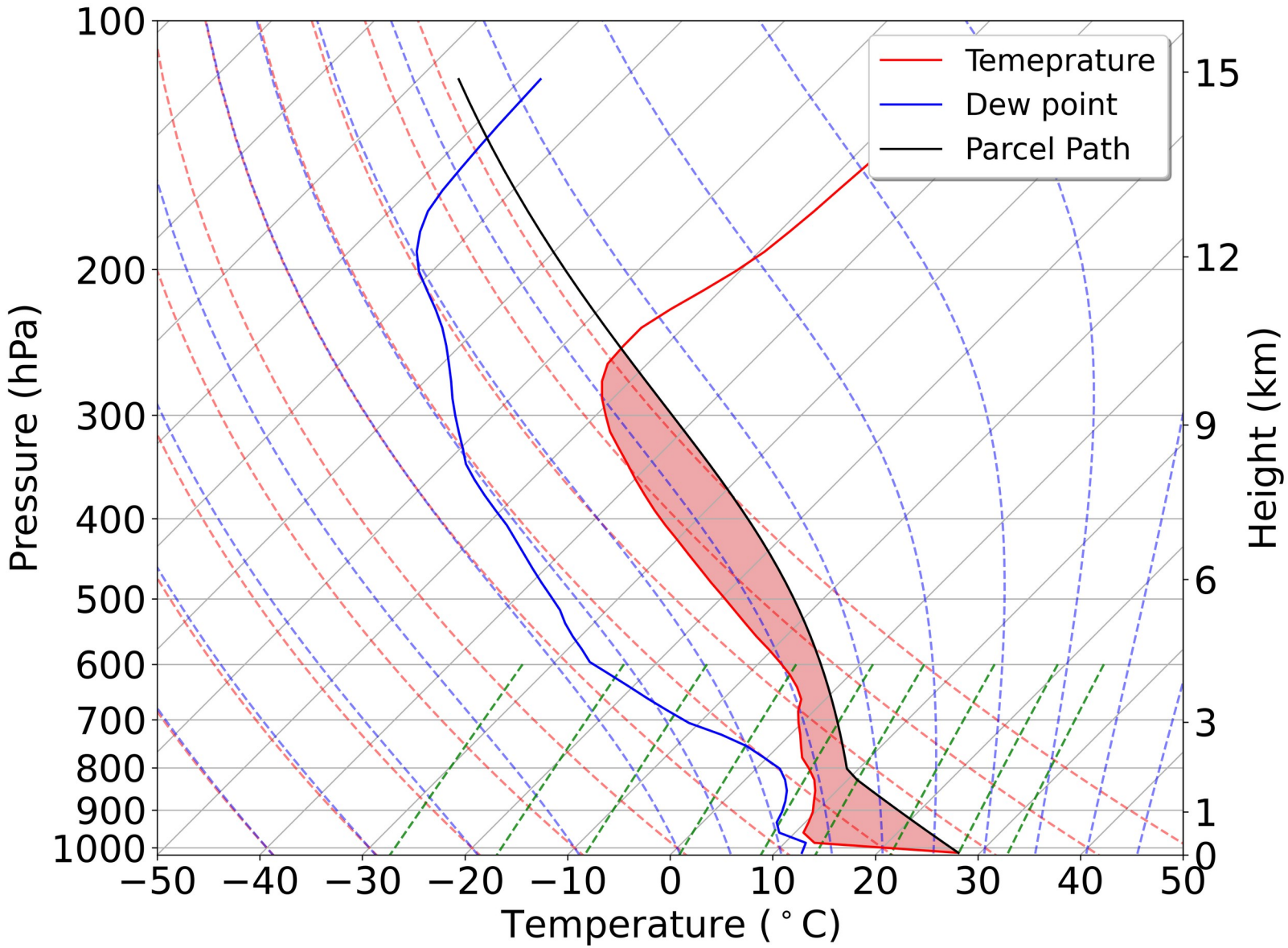

The Next Steps

1. Change the initial conditions from GFS to a local numerical model.
2. Validate not only over Poland, but also using radiosonde data from across Europe.
3. Use the collected data to compute a correction to the vertical profiles of temperature and dew point using ML/DL methods.

Thank you

Tobiasz Górecki

13/05/2025, Goa India

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