SATELLITE PRECIPITATION PRODUCTS BEHAVIOR IN COLD SEASON CONDITIONS IN POLAND cases studies analysis

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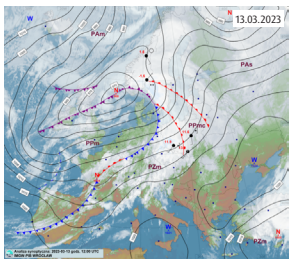
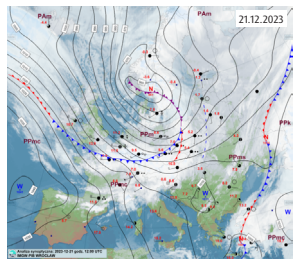
ABSTRACT

Detecting and estimating rainfall amounts based on satellite data is a challenging task, especially when dealing with weak, stratiform rainfall in moderate latitudes. At the same time, prolonged weak precipitation can potentially lead to local floods, underscoring the importance of accurate detection and monitoring of such events within meteorological and hydrological forecasting systems. The satellite derived precipitation estimates may serve as a valuable complement to ground-based and radar precipitation data when its quality is known.
This presentation will show the results of an analysis aimed at evaluating the accuracy of satellite precipitation products, including H-SAF and GPM ones, in estimating the sums of stratiform precipitation during cold season in Poland. The study examined selected cases of cold season precipitation, considering variations in the presence or absence of snow cover, and utilized data from rain gauges and radar networks.

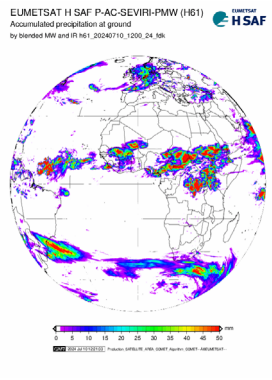
METEOROLOGICAL SITUATIONS

Winter precipitation in Poland is usually caused by extra-tropical cyclones and related frontal systems passing over the country. In such cases, the rainfall zone moves from west to east or from north-west to south-east of Poland. These are usually moderate rainfall or sleet. Detecting such rainfall using satellite data is not easy and is usually subject to a greater error than in the case of summer convective rainfall.
Two typical meteorological situations of the cold period were selected for analysis, which occurred on March 13 and December 21, 2023.

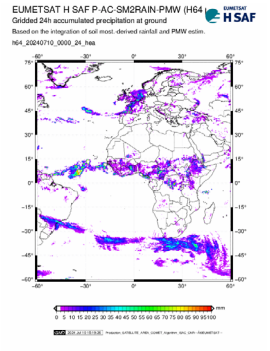




SATELLITE PRODUCTS

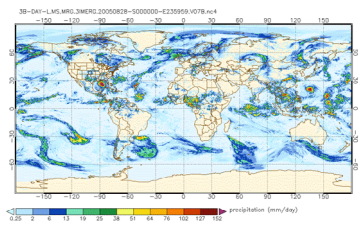


H-SAF:
H61B - Near-real time accumulated precipitation obtained by integration the instantaneous precipitation maps (P-IN-SEVIRI-PMW) generated based on inter-calibrated Level 2 PMW instantaneous precipitation rate estimates blended with 10.8 μm channel from SEVIRI instrument. The integration is performed providing hourly the 1 hour accumulated precipitation and every six hours (at 00, 06, 12 and 18 UTC) the 24 hour accumulated precipitation.



H-SAF:
H64 - Gridded daily precipitation obtained by merging soil moisture-derived rainfall with Passive Microwave (PMW) rainfall estimates, provided by H-AUX-23 and H67 precipitation products.

GPM
IMERG v.7.0 - The Integrated Multi-satellitE Retrievals for GPM (IMERG) IMERG is a NASA product estimating global surface precipitation rates at a high resolution of 0.1° every half-hour beginning 2000. It is part of the joint NASA-JAXA Global Precipitation Measurement (GPM) mission, using the GPM Core Observatory satellite as the standard to combine precipitation observations from an international constellation of satellites using advanced techniques.



Huffman, G.J., E.F. Stocker, D.T. Bolvin, E.J. Nelkin, Jackson Tan (2024), GPM IMERG Late Precipitation L3 1 day 0.1 degree x 0.1 degree V07, Edited by Andrey Savtchenko, Greenbelt, MD, Goddard Earth Sciences Data and Information Services Center (GES DISC), Accessed: [01.07.2024], 10.5067/GPM/IMERGDL/DAY/07

GROUND DATA

For the comparison the combined product RainGRS was used.
The RainGRS system, has been carried out in the Polish National Meteorological and Hydrological Service for nowcasting and hydrological applications in Poland.
G – gauges R – radar, S - satellite
For each of the three data sources, different quality algorithms have been designed:

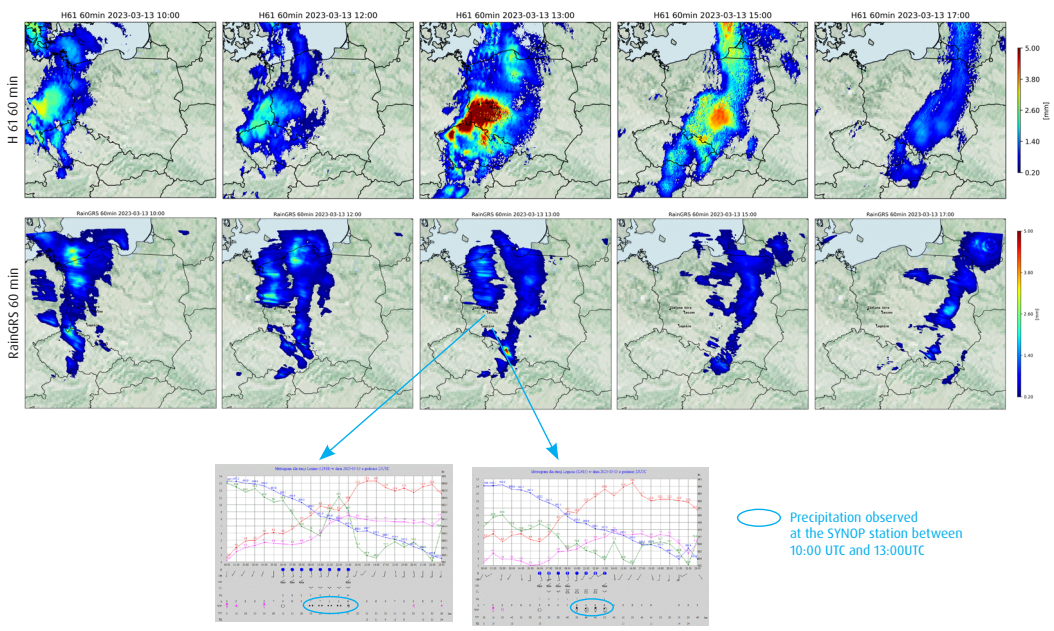
(i) rain gauge data is quality controlled and, on this basis, spatial interpolation and estimation of quality field is performed,
(ii) radar data are quality controlled by RADVOL-QC software that corrects errors identified in the data and characterizes its final quality,
(iii) NWC SAF (Satellite Application Facility on support to Nowcasting and Very Short-Range Forecasting) products for both visible and infrared channels are combined, and the relevant quality field is determined from empirical relationships that are based on analyses of the product performance.

Subsequently, the quality-based QPE is generated with a 1-km spatial resolution every 10 minutes (corresponding to radar data).

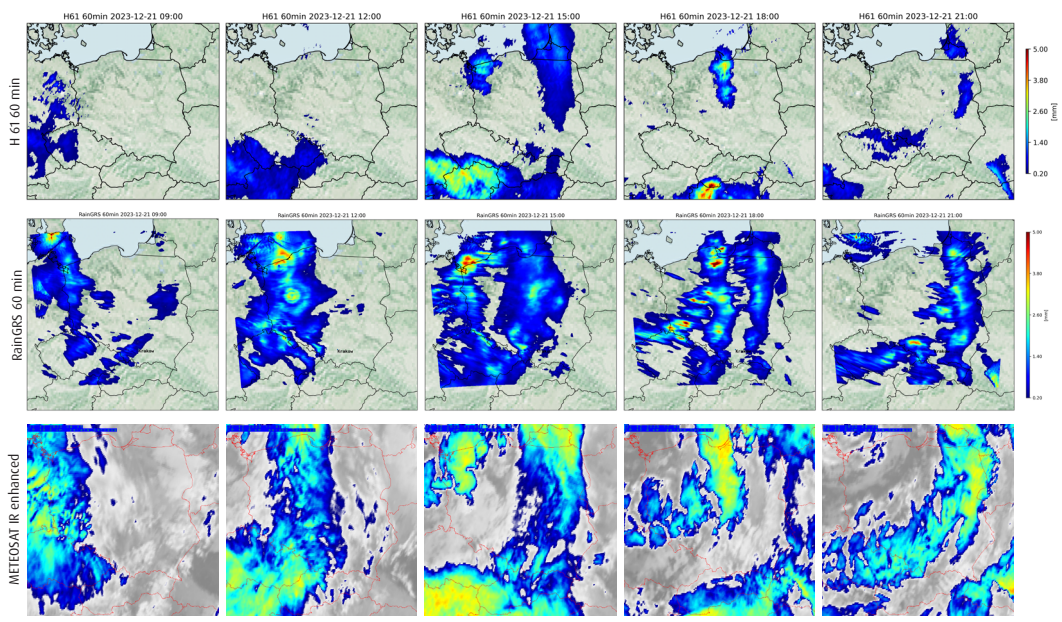
A.Jurczyk, J.Szturc, I.Otop, K.Ośródka and P.Struzik, Quality-Based Combination of Multi-Source Precipitation Data, Remote Sens. 2020, 12, 1709; doi:10.3390/rs12111709

COMPARISION

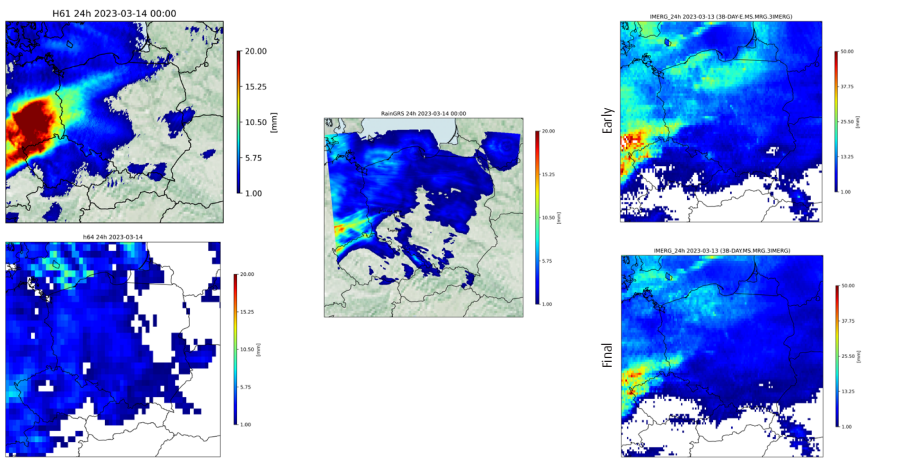
13 March 2023, Hourly rainfall totals



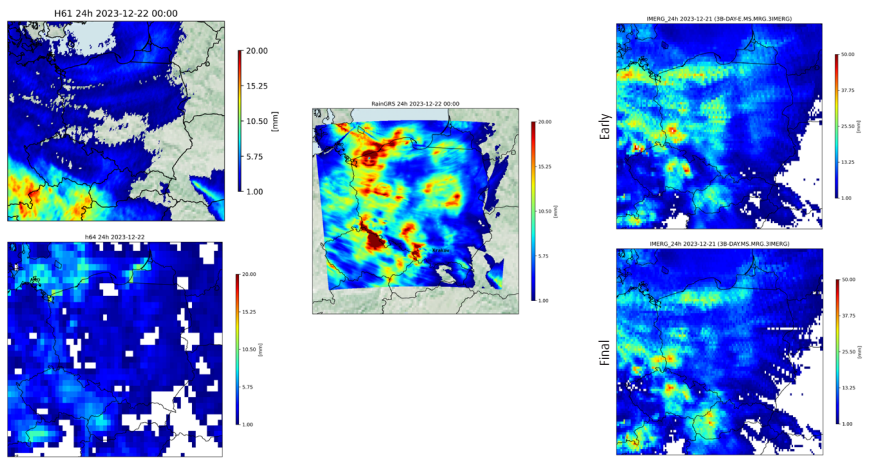
21 December 2023, Hourly rainfall totals



13 March 2023, Daily rainfall totals



21 December 2023, Daily rainfall totals



13 March 2023 Insights

- H61 60 min accurately reflects the movement of the precipitation zone from western Poland to the east.
- The clear differences in the spatial distribution of precipitation in southwestern Poland in the morning hours are rather the result of RainGRS inaccuracy than the satellite product, which seems to be confirmed by the meteograms from the SYNOP stations in Leszno and Legnica.
- Both H61 and IMERG v.7.0 located the maximum of the daily precipitation sum in accordance with RainGRS.
- In the case of H64, only the maximum of the precipitation sum occurring over the sea was correctly estimated. Over the remaining area of Poland, H64 shows a uniform distribution without the maxima visible in the other products.
- IMERG v.7.0 reflected the distribution of precipitation over northern Poland in accordance with RainGRS and over western Poland in accordance with H61 and RainGRS. The values of daily totals in areas of heavier rainfall are clearly overestimated for the Early version. In the case of the Final version, this overestimation is smaller.

21 December 2023, Insights

- Precipitation occurring over Poland until 13:00 UTC was not detected by H61 60 min. The situation improved in the afternoon, but only part of the rainfall visible on RainGRS was correctly estimated by H61. Comparison with Meteosat IR_enhanced images shows that only clouds with tops' temperatures below c.a. -55 °C were recognized as precipitation by H61.
- As a consequence, the values of daily totals are significantly underestimated on H61 24h.
- We also see underestimated daily rainfall values in the H64 product. Similarly to March 13, 2023, only over the sea, i.e. where only microwave data are used, the daily precipitation totals are slightly better estimated. This means that in this case the change in soil moisture caused by precipitation was not adequate to the rainfall amount.
- The distribution and values of the daily rainfall totals determined by IMERG are most similar to RainGRS among the analyzed satellite products. Interestingly, in this case the Early version agrees better with RainGRS than the Final version.

Summary

- A clear link between the area and intensity of precipitation on H61 and the coldest cloud tops. Precipitation from low Stratus clouds may not be detected.
- On the other hand, the case of March shows that „the link" between the H61 precipitation and clouds with cold tops allowed detection and a reasonably good estimate of the precipitation 'missed' by RainGRS.
- The examples presented demonstrate the limitations of H64 in estimating precipitation over moist or frozen land. This makes it difficult to use this product in moderate and high latitudes, during the cold season.
- IMERG v.7.0 captured areas with moderate and heavy rainfall very well in the analyzed situations. The detection of light precipitation, not confirmed by RainGRS, may result from an error in the IMERG algorithm, but it may also be correct and the error is on the side of RainGRS, which, as shown for March 13, 2023, might not detect all precipitation.