Influence of RAL3.X settings on precipitation forecasts and selected meteorological parameters in the area of Poland

Marta Kopeć, Małgorzata Melonek, Leszek Herman-Iżycki, Magdalena Gruziel-Słomka
Interdisciplinary Centre for Mathematical and Computational Modelling UW

Introduction

Several versions of RAL3 settings have been tested in the UM model in the domain over Poland. The most important change was implementation of the double-moment cloud scheme. In this study we focus on the influence of these settings on the precipitation and cloud cover forecasts. Additional verification was performed for visibility during the selected fog event.

Results were verified against various types of measurements (ground based and atmospheric profiles) and compared with currently used version of UM model (v10.1 with dedicated settings, close to RAL1M). For simple comparison of cloud cover results from ERA5 data were also used.

Most of the comparisons between new RAL3.X settings and the currently used model were obtained for selected test cases (this applies to results for cloud cover and visibility). In case of precipitation longer periods were analyzed.

In all figures, the distinction between models will be indicated mainly by the model version number.

Precipitation

The precipitation analysis was performed using two methods. Simple comparison was done for selected test cases and statistical analysis for 3 different periods (winter 2021, spring 2022 and summer 2022).

Simple comparison:

In case of spatial distribution of precipitation both models gave comparable results. The main difference was that for RAL3.2 settings a significant reduction of points with extremely large rainfall values was observed (see Figure 1, two panels from the left). In a presented case operational model produced lots of convective clouds where the maximum precipitation amount was higher than 100 mm/h (so called “point storms”). In RAL3.2 settings such values were not present and the obtained results were closer to the observations (see Figure 1, two panels from the right).

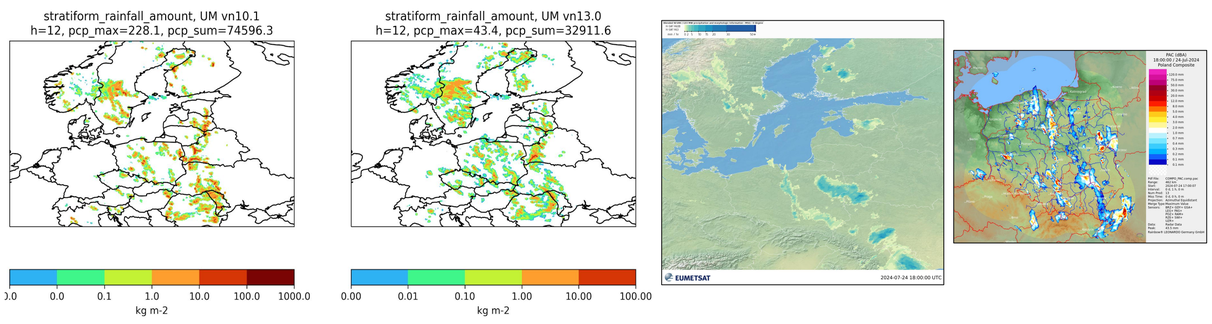

Figure 1. Precipitation forecasts for two model settings: operational model (leftmost panel) and RAL3.2 (second from the left). Forecast time:20240724T06UTC+12h). EUMETSAT precipitation data (second from the right panel) and radar data (rightmost panel). Radar data source: IMGW-PIB.

Performance diagrams:

Statistical analysis was performed for three selected periods: 20-30 of December 2021, 1-30 of April 2022 and 1-15 of July 2022. For all of the mentioned periods performance diagrams were prepared for 6h accumulated rainfall (Figure 2). Precipitation measurements were taken only from the synoptic rain gauges located on the territory of Poland and operated by IMGW-PIB. In this case results from the model with RAL3.1 settings were analyzed.

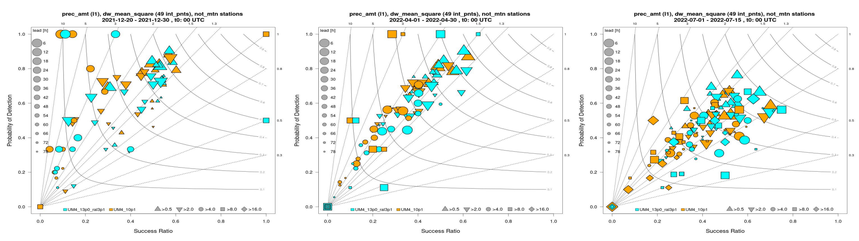

Figure 2. Performance diagrams for precipitation for winter period (left panel), spring period (middle panel) and summer period (right panel).

In winter and spring periods results indicate that both models overestimated precipitation. In the summer period results group around FBI=1, but the maximum TS was around 0.5 (while in the other periods was up to ~0.7).

The worst results were obtained for the winter period, but the results may be biased because this period was (in comparison with other ones) the shortest (just 10 days). Also in winter the number of precipitation events is usually smaller than in other parts of the year.

In general, the best results were obtained for the lowest threshold value (0.5 mm/h), with progressively worse results obtained for increasing the threshold.

Visibility

Visibility was analyzed only for one fog event from the 1st of December 2023. For both models (operational and RAL3.2 with #504.4 ticket) results were compared with measurements from the synoptic stations operated by IMGW-PIB.

Two set of model runs were analyzed: first set starting at 30.11.2023 18UTC and the second set from 29.11.2023 12UTC. Such dates were chosen because they gave better results over Poland, in comparison with other starting times (including the one from 01.12.2023 00UTC).

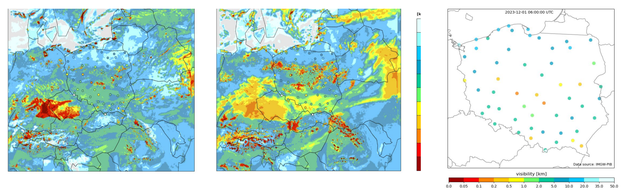

Figure 3. Visibility for two model settings: operational (left panel), RAL3.2 (middle panel) and observations (right panel). Forecasts time: 20231129T12UTC+42h.

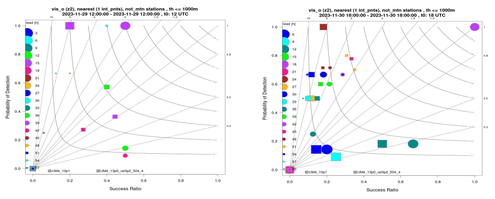

Figure 4. Performance diagrams for visibility for two forecast times: 20231129T12UTC+42h (left panel) and 20231130T18UTC+12h (right panel).

In general, model with RAL3.2 settings forecasted lower visibility in most grid point, but due to too few cases analyzed obtained results require further investigation.

Cloud cover

For the purpose of cloud comparisons results from RAL3.2 (+ticket #504.4) and an operational model were used. As a testbed single forecasts from both models were selected.

Visualisations & histograms:

Cloud cover visualisations (see Figures 5) revealed that the model with RAL3.2 settings gave results with (almost) binary distribution, compared to the operational model. It was confirmed by the histograms obtained for different cloud levels (see examples in Figure 6).

For most of the model levels cloud cover was either close to zero or one. It was also verified that changing the threshold value of optical transparency from 0.01 to 0.05 (ticket #637) almost didn’t change the results. Implementation of other corrections from the package #504.8 gave some improvement.

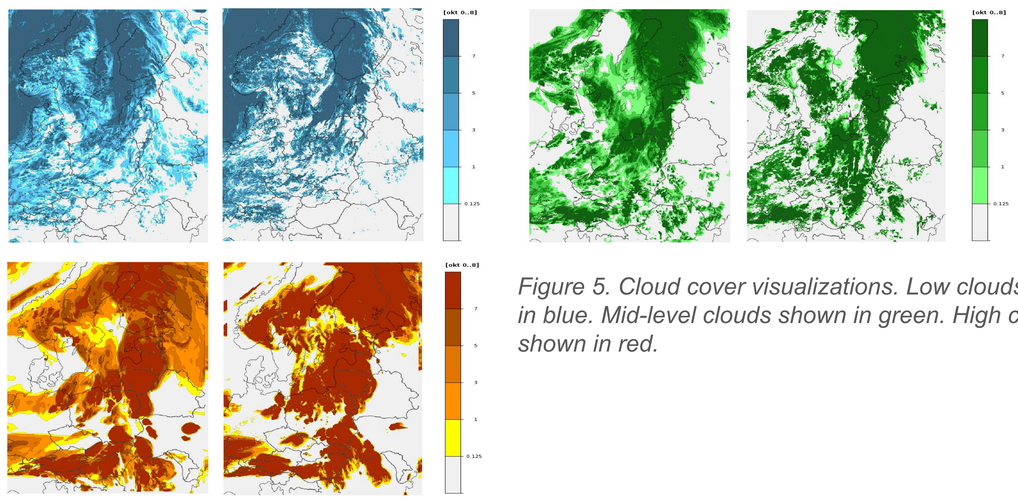

Figure 5. Cloud cover visualizations. Low clouds shown in blue. Mid-level clouds shown in green. High clouds shown in red.

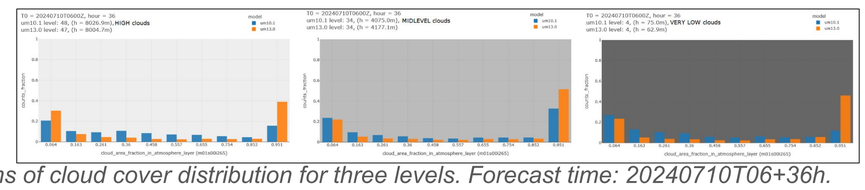

Figure 6. Histograms of cloud cover distribution for three levels. Forecast time: 20240710T06+36h.

Profiles:

More detailed analyses were performed based on atmospheric profiles and ERA5 data. Results shown on Figure 7. indicate that in the model with RAL3.2 settings (with #504.4) the problem with frozen fraction calculation exists (dew point temperature exceeds the values for the temperature at some model levels). It is also visible that cloud area fraction on different model levels significantly differs between both model settings as well as for the ERA5 data.

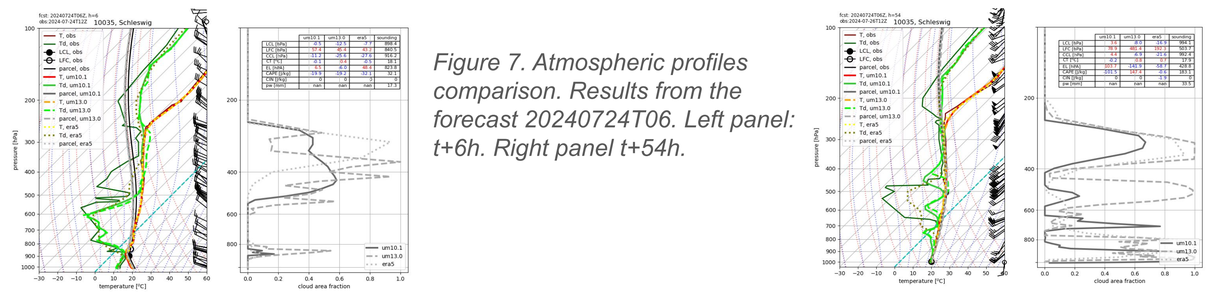

Figure 7. Atmospheric profiles comparison. Results from the forecast 20240724T06. Left panel: t+6h. Right panel t+54h.

More details can be found here:

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Conclusions & Future Plans

Results shown in this poster indicate that new RAL3.X settings give comparable results in case of precipitation. The most significant change concerns the elimination of the problem with very high rainfall values in single points (“point storms”). In case of visibility results were inconclusive (mainly due to too few cases analyzed) and further investigation is needed.

For cloud cover results, RAL3.2 settings clearly performed worse than operational model, especially in the case of the higher model levels, where dewpoint temperature significantly exceeded temperature. It may indicate that there is a problem with ice fraction calculations. Another observed problem was almost binary distribution for cloud cover results. Further investigation is needed to find the reason of such behaviour. Implementation of some recently added corrections, included in the package #504.8, showed some improvement in this area, but it didn't solve the problem completely.

Future plans: Further tests of the changes included in #504.8 package and implementation of changes in the electricity scheme.