CROSS-VERIFICATION OF THE RAPID DEVELOPING THUNDERSTORM AND THE PRECIPITATION PRODUCTS OF THE NOWCASTING AND VERY SHORT-RANGE FORECASTING SAF

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Abstract

The Hungarian Meteorological Service (OMSZ) verified three products of the Nowcasting SAF in the frame of a Visiting Scientist Activity: the Rapid Developing Thunderstorm (RDT), the Convective Rain Rate (CRR) and the Precipitable Clouds (PC) products. Both quantitative and qualitative verification were performed. Subjective evaluation was done by investigating case studies: successive images of 24 days in 2009 summer period (15 May – 15 September 2009) were analyzed. This paper shows the results of the subjective evaluation.

INTRODUCTION

The Hungarian Meteorological Service verified three products of the Nowcasting SAF in the frame of a Visiting Scientist Activity. These are the Rapid Developing Thunderstorm, the Convective Rain Rate and the Precipitable Clouds products. In this work beside statistics subjective evaluation was done through case studies. This paper shows the results of the subjective evaluation, which was done by analyzing successive images of 24 days in 2009 summer period (15 May – 15 September 2009).

The Rapid Developing Thunderstorm (RDT) product investigates time series of SEVIRI images. The aim is to detect cloud systems, track them to separate the convective clouds and to characterize them. We run RDT without the optional lightning input data.

The Convective Rain Rate (CRR) product estimates the rate of the convective precipitation.

The Precipitable Cloud (PC) product gives the probability of the precipitation (all types).

We validated these products separately and also cross-validated RDT with CRR and CRR with PC. We validated them in different synoptic situations and for day- and nighttime algorithms. We run the SAFNWC/MSG (version 2009) software locally at OMSZ. We visualized the products in 15 minute time step together with the Nowcasting SAF Cloud Type (CT) product, radar, lightning (cloud to cloud and cloud to ground flashes) and SEVIRI data. In the following images CRR is parallax corrected, the other satellite images and products are not parallax corrected.

CASE STUDIES

Some images are shown as examples to demonstrate the typical behaviour of the products in different synoptic situations.

2 July 2009: Week Upper Level Low

The SAFNWC/MSG version 2009 RDT code detects much more convective clouds than the earlier one did. Most of the cells are detected, except the small ones (see left panel of Fig.1). The majority of the detected convective clouds are in mature phase. The small cells just triggering or developing are more frequently missed. It is more difficult to discriminate them from other type of clouds. (The decaying convective clouds are not detected in the present version RDT.)
RDT is supposed to detect the ‘towers’ of the cloud. However the contours of the convective clouds are sometimes too ‘loose’, too big (see the right panel of Fig. 1). This happens usually at the beginning of convective cell detection (in 1-2 slots). Later the contour suits better to the cloud edge, cloud base or to the cloud towers.

25 June 2009, Upper Level Low

In Fig. 2 both CRR and PC reflect rather well the overall radar pattern. Although RDT algorithm was run without lightning data, it still discriminates as convective almost all clouds with lightning activities. There are some mainly small size cells, which are not detected by CRR or not marked with RDT contour. PC detects more small cells, however also not all. In this figure we see CRR and PC created by their daytime algorithms.

3 June 2009, Cold Front

In this situation small cells are developed with rather warm cloud top temperature (Fig. 3). The small cells show lightning activity. PC reflects quite well the overall radar pattern. CRR did not detect the convective rain except one cell in Serbia, which cloud top temperature was colder. RDT algorithm detects also only this cloud as convective. PC and CRR were created by their daytime algorithms.

18 July 2009: Cold front, Prefrontal Squall Line

On the prefrontal region huge convective multi-cell system developed with intense lightning activity. One of the cells was a supercell (most intense at 10:10 UTC). At 11:45 UTC (Fig. 4) CRR shows quite high values north of the Lake Balaton close to the location of the most active part of the corresponding radar cell. Both in 11:45 and 15:15 UTC images (Fig. 5) CRR and PC reflect rather well the radar pattern. CRR does not give values for the non convective precipitation (falling from mid-level clouds - yellow in Cloud Type image). This can be seen even better at the 15:15 UTC image. RDT detects well the convective cloud systems, MCSs. Both in Figs. 4 and 5 the CRR and PC were created by their daytime algorithms.

07 June 2009, Cold Front

A supercell developed on the cold frontal zone at 13:55 UTC. Fig. 6 shows it at 14:25 UTC. CRR estimates large rain rate values for the cloud over the Hungarian – Ukrainian borderer. It caused intense hail, strong wind in northeast Hungary. The distribution of CRR within the cloud system does not reflect the radar pattern. We cannot even wait this as CRR works with cloud top information without any microwave channel. CRR reflects the IR10.8 cloud top structure, the cold-U shape. Daytime CRR and PC algorithms were used.

In Fig. 7 a comparison is shown between radar and CRR 1 hour accumulated precipitation. In the left panels we see instantaneous rain rate (upper radar, below CRR), in the right panels we see 1 hour accumulated precipitation (upper radar, below CRR_ACCUM calculated from 5 successive slots, one of them is on its left). The color scale is the same for radar and CRR products, except that for radar we included a dark blue for 0.1-1 mm/hour interval. Similar features are seen on CRR and CRR_ACCUM images. CRR usually overestimates the precipitation area and underestimates the maximums. It looks like a ‘smoothed’ field. Here both CRR and CRR_ACCUM were created by daytime algorithm.

16 June 2009, Cold Front

Three supercells developed on the cold front over the Alps, two of them reached Hungary. In Fig. 8 the radar image shows comma echoes. RDT detected the convective cloud systems. CRR gave rather big values (in different distribution than the radar). It does not give value for the non convective precipitation over the Austrian - Slovakian - Hungarian border.
Figure 1: RDT overlaid on day microphysical RGB from 02.07.2009, 11:40 UTC (left). RDT overlaid on HRV cloud image (right) from 21 August 2009, at 12:10 UTC.

Figure 2: Radar rain rate at 13:45 UTC on 25 July 2009 (upper left), CT overlaid with 15-minute lightning data (gray to black dots; upper right), CRR overlaid with RDT (below left) and PC (below right). CRR, PC, CT and RDT are retrieved from the 13:40 UTC SEVIRI slot.
Figure 3: Radar rain rate at 12:45 UTC on 3 June 2009 overlaid with 30-minute lightning data (upper left), IR10.8 channel data overlaid with RDT (upper right), PC (below left), CRR overlaid with RDT (below right). CRR, PC, IR10.8 and RDT are retrieved from the 12:40 UTC SEVIRI slot.

Figure 4: Radar rain rate at 11:45 UTC on 18 July 2009 (upper left), CT channel data overlaid with 15-minute lightning data (black dots; upper right), CRR overlaid with RDT (below left) and PC (below right). CRR, PC, CT and RDT are retrieved from the 11:40 UTC SEVIRI slot.
Figure 5: Radar rain rate at 15:15 UTC on 18 July 2009 (upper left), CT channel data overlaid with 15-minute lightning data (black dots; upper right), CRR overlaid with RDT (below left) and PC (below right). CRR, PC, CT and RDT are retrieved from the 15:10 UTC SEVIRI slot.

Figure 6: Radar rain rate at 14:30 UTC on 7 June 2009 (upper left), IR10.8 channel data (TB < 240 K; upper right), CRR (below left) and PC (below right). IR10.8, CRR and PC are retrieved from the 19:55 UTC SEVIRI slot.
Figure 7: Radar rain rate at 13:15 UTC on 7 June 2009 (upper left), radar 1 hour accumulated precipitation 13-14 UTC (upper right), CRR at 13:10 UTC (below left) and CRR 1 hour accumulated precipitation 13-14 UTC (below right).

Figure 8: Images from 16 June 2009: satellite images and products at 15:55 UTC, radar image at 16:00 UTC. Day microphysical RGB overlaid with RDT (upper right), IR10.8 overlaid with RDT (middle left), radar rain rate (in the center), CT overlaid with 15-minute lightning data (middle right), VIS0.6 channel data (below left), CRR (below middle) and PC (below right).
RESULTS, CONCLUSIONS

RD'T is much more reliable than it was in the previous version. It detects the majority of the mature phase convective clouds. The developing convective cells are more often missed. Decaying phase convective clouds are not detected in this version.

- We found that the time stability improved. Once the convective cloud was detected it was marked during several slots.
- Mainly the small and/or warm cells are often missed.
- Better performance in ‘pure’ convective situation (only Cbs, MCSs and no front), than in frontal situation. Sometimes a huge part of a front is detected as convective.
- We have found some high level Lee clouds detected by RDT as convective. However their time stability was low.
- RDT is supposed to detect the towers of the cloud systems. However in some cases the contour is too ‘loose’, too big including some clear area or some part of a lower cloud as well. This happens more often at the beginning of the detection. Later the algorithm finds better the edge of the cloud/tower. In frontal situations one can also find too ‘loose’ contours. In some cases it is difficult to find the edge of an embedded cell.
- Sometimes the shape of the trajectory can be rather funny, ‘zig-zag’ like.
- We verified RDT without the optional lightning input. If we used lightning as input, we would get better results.

CRR is useful in area and season where and when mainly convective precipitation occurs.

- Usually it overestimates the area of the precipitation. The earlier version underestimated the rain rate values. The present version retrieves higher rain rate values. It still underestimates the radar maximums; however in their near vicinity it can overestimate the radar values. In the best cases CRR looks like a ‘smoothed’ field of the radar image.
- In synoptic situation containing only isolated Cbs or Cb clusters CRR is rather good unless the cells are warm or too small. Both CRR and RDT often miss the small warm cells. These radar cells could be detected later if they increased and their cloud top became colder.
- CRR usually detects the precipitation of the MCSs. It gives usually rather high rain rates for a severe MCS/squall line, however it cannot reflect the real rain rate distribution within the MCS (eg. location of squall line). As CRR works with cloud top features depending strongly on IR data, so we can often see the cold ring shape in the CRR image. Sometimes CRR can give low values, even zeros for the radar maxima, due to IR cold ring, or to shadow effects, or to a calibration matrix overflow problem.
- CRR is supposed to give zero values for non-convective precipitation. In frontal situation without embedded cells, CRR most of the times does not detect the non-convective precipitation, but sometimes it does.
- CRR has day- and nighttime algorithms. The daytime algorithm is more informative. For low sun elevations the CRR patch tends to became stripy and holy, due of the shadows and the low information content of the VIS0.6 channel data. The nighttime CRR field is smoother, than the daytime one at low sun elevation.

PC reflects often rather well the overall pattern of the radar image, mainly the daytime PC at high or medium sun elevation and in case of isolated Cbs, Cb clusters. It often retrieves even higher probabilities for intense radar rain rates and/or cells with more flashes.

- PC misses much less small/warm cells than CRR or RDT.
- PC like CRR cannot reflect the inner precipitation distribution of a severe MCS, it cannot see the location of a squall line.
- PC is quite good for week frontal precipitation. It is good at detecting the precipitation falling from mid-level clouds.
- PC seems to depend on the solar elevation. At low solar elevation the daytime PC patches becomes significantly smaller. Sometimes they can almost vanish.
- The nighttime PC algorithm is less informative. It retrieves more ‘flat’ field, the overestimation of the area is stronger.
• There is a **strong discontinuity** between the day- and nighttime PCs. The fact that the daytime algorithm underestimates the precipitation area in low solar elevation makes the discontinuity even stronger. **The discontinuity for PC is stronger, than for CRR.**

• **PC** can give non zero value for high level Lee clouds (non-precipitating clouds).

**CRR and PC** provide useful information on precipitation in lack of radar data. As **CRR** as PC estimates the precipitation rate/probability from SEVIRI data, they cannot use microwave information, only cloud top parameters, so we cannot wait very good results. CRR and PC are usually more similar to satellite than to radar image.

All three products are under **continuous development. Further improvements** are foreseen.

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