Precipitation patterns above Belgium using weather radar and COSMO model reflectivity data

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1. INTRODUCTION

Detailed knowledge on temporal and spatial variability of precipitation is of wide interest, since many processes on Earth are affected by precipitation. For example from precipitation data in Uccle (Belgium) derived variability in rain erosivity shows that beside the rainfall amount also the intensity is an important factor [1]. Atmospheric models of high resolution can analyse the variability in precipitation amount and rate. In this project of the Flemish Science Organisation (FWO) the precipitation patterns above Belgium are investigated using the output of the state-of-the-art non-hydrostatic atmospheric model COSMO [2] and radar data.

2. WIDEUMONT RADAR

Different in-situ and remote sensing instruments provide complementary data on the precipitation patterns. In a first step of the project different case studies with convective and stratiform precipitation events are analysed. There are two weather radars in Belgium: one in Wideumont (Ardennes, SE-Belgium) and one in Zaventem (Brussels region). Up to now only Wideumont volume radar data are available for analysis. The Wideumont radar [3,4] is situated on a 50 m high tower at 535 m above sea level. The radar is a Gematronik pulse Doppler radar and works in the C-band at 5.64 GHz (λ=5.3 cm, mean transmit power 250 W). The maximum horizontal range reflectivity processing is 240 km and Doppler processing 120 km with a typical range resolution of 0.5 km. The Wideumont radar performs a 5-elevation reflectivity scan every five minutes, a 10-elevation scan every 15 minutes, and a 8-elevation Doppler scan every 15 minutes. In this study, volume data from the 10-elevation (0.5° - 17.5°) were used. The comparison is based on the eastern and south-eastern regions of Belgium (southeast of Brussels) and the surrounding regions (Western Rhineland (D), Saarland (D), Luxembourg (L), Northern Lorraine (F)) inside a 120 km circle around Wideumont (observation area).

3. COSMO MODEL

The *COSMO* model is integrated using high spatial (2.8 km) and temporal (30 s) resolution. Lateral and initial data are taken from *COSMO-EU* with a spatial resolution of 7 km and temporal resolution of one hour. Each model run is initialised at 12 UTC on the previous day, implying a spin-up time of 12 hours for each forecast period of 24 hours (00 to 24 UTC). This study aims to evaluate models with different microphysics. From *COSMO 3.21* to *COSMO 4.3* several model changes were implemented. In the microphysics the most important change in the parameterisation of snow was the replacement of a constant intercept parameter to a temperature depending intercept parameter based on [5]. Additionally changes in the temperature-dependent sticking efficiency as well as in the geometry and fall speed of snow were implemented. The rain parameterisation was changed by replacing the autoconversion rate from the Kessler autoconversion and accretion scheme (1969) to the Seifert and Beheng formulation [6] by assuming a constant cloud droplet number concentration. More details are also given in [7] and in the cited literature. In order to test the effect of these changes in the snow and rain parameterisation we did a control run (*COSMO 4.3*) and two sensitivity runs. These sensitivity runs differ from *COSMO 4.3* only in one respect: 1) in the run referred to as *COSMO 3.21a* the parameterisation of snow microphysics was replaced by the older *COSMO 3.21* parameterisation and 2) in the run referred to as *COSMO 3.21b* the parameterisation of the autoconversion / accretion was replaced by the older *COSMO 3.21* parameterisation.

4. CASE STUDIES

In the following we will refer to five events. On two days frontal systems passed Belgium (warm front on

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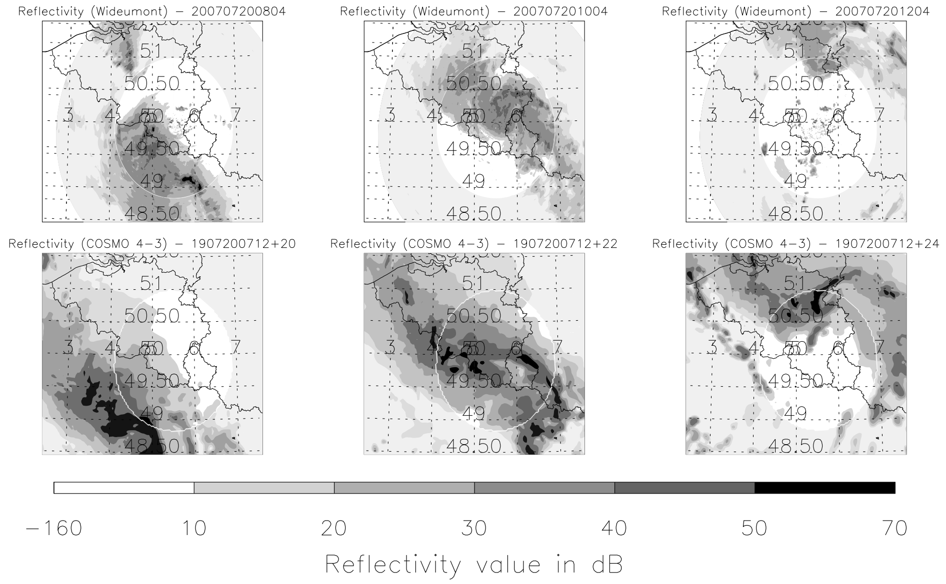

Figure 1. 20 July 2007, 08-12 UTC: Comparison of maximum reflectivity value (top: radar Wideumont, bottom: COSMO 4-3) representing the centre of a low pressure system crossing Belgium from SW to NE. The white inner area (observation area) represents an area of 120 km around the radar, where observed reflectivity values are considered as reliable.

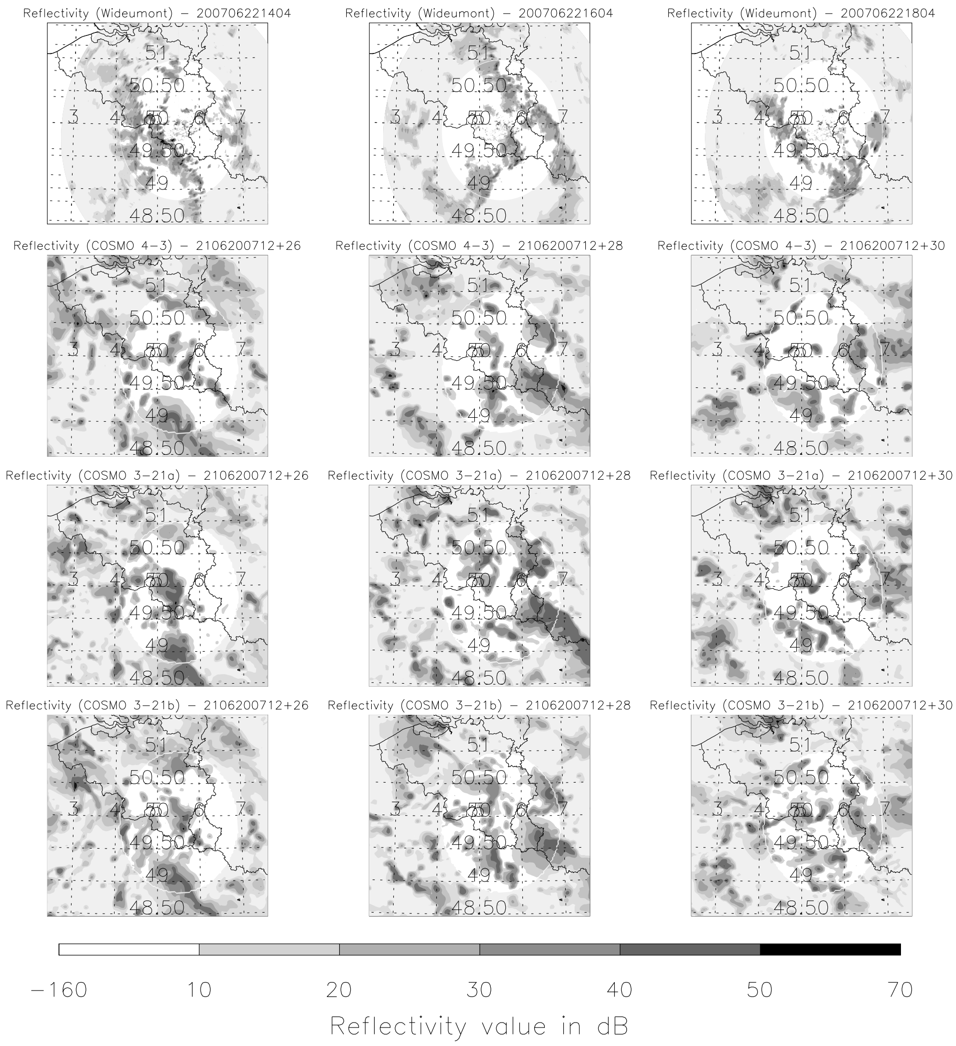

Figure 2. 22 June 2007, 14-18 UTC: Comparison of maximum reflectivity value (from top to bottom: radar Wideumont, COSMO 4-3, COSMO 3-21a, COSMO 3-21b) representing a convergence line crossing Belgium from SW to NE.

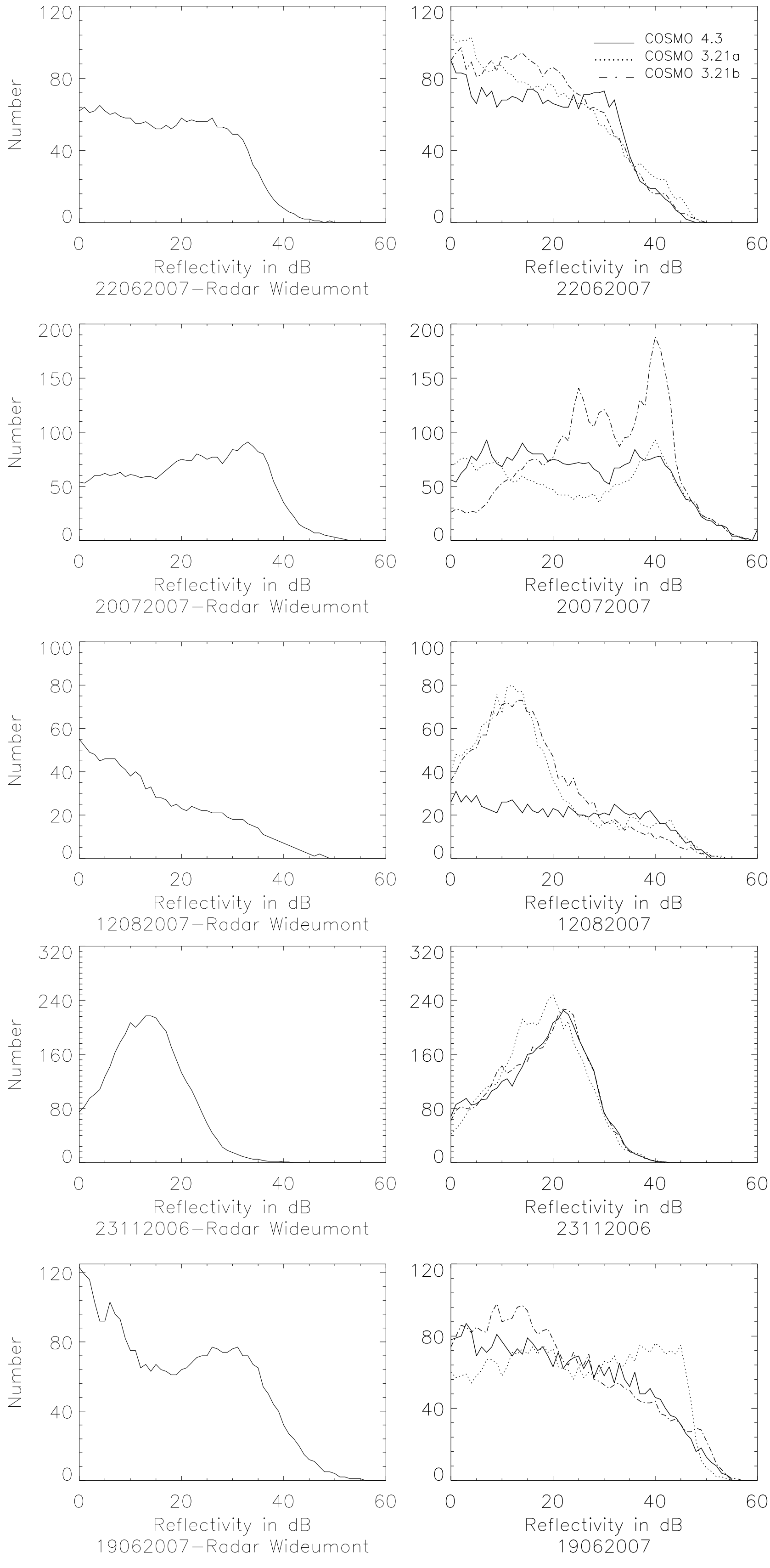

Figure 3. Histograms of maximum reflectivity values averaged over the event time (time the system is present in the observation area). In the left column the histograms of the Wideumont radar are shown. In the right column the solid line represents COSMO 4-3, the dotted line COSMO 3-21a and the dashed line COSMO 3-21b.

23 November 2006, occlusion on 19 June 2007), on two other days convergence lines (22 June 2007 and 12 August 2007) and on one day the center of a low pressure area crossed Belgium (20 July 2007). The two events from 20 July 2007 and 22 June 2007 will be in focus.

Figures 1 and 2 show the cases of 20 July 2007 and 22 June 2007, respectively, comparing the volume radar maximum reflectivity and the modelled maximum reflectivity (maximum value in the vertical column). The case of 20 July illustrates nicely how well COSMO 4.3 forecasts the event in the temporal development crossing Belgium from Southwest to Northeast. Although reflectivities are overestimated the timing of the rain over the domain is very well represented by COSMO 4.3.

The case of 22 June (Fig. 2) shows the result of COSMO 4.3 in comparison both to the radar observation and to *COSMO 3.21a* and *COSMO 3.21b*. The comparison of the different parameterisations shows that in COSMO 4.3 much less areas are marked with reflectivity values ≤ 10 dB, which is representing no or light precipitation (more white areas in the observation area). The reflectivity histogram (Fig. 3 top), where the number of reflectivity values are averaged over the event-time, confirms this tendency. In *COSMO 4.3* 15% of the pixels in the entire observation domain are within the interval from 1 to 10 dB , while in *COSMO 3.21a* and *COSMO 3.21b* the percentage is with 19% resp. 18% larger. The observed number of the radar is 12%. The figures are very similar for light to moderate precipitation between 11 and 20 dB with 14% in *COSMO 4.3*, 16% in *COSMO 3.21a* and 18% in *COSMO 3.21b* while the radar percentage is 11%. *COSMO 3.21a* overestimates the number of pixels above 35 dB compared to the radar (7% against 3%), whereas the other two versions correspond with 5% more closely to the radar.

In general the gradient in the reflectivity histograms of all days (Fig. 3) is smoother and much similar to the observations in version *COSMO 4.3* than in *COSMO 3.21a* and *COSMO 3.21b*. The figures show also that for some cases the change in the snow microphysics (e.g. 22 June 2007) and for other cases the change in the autoconversion / accretion (e.g. 20 July 2007) leads to larger differences in comparison to the *COSMO 4.3* results.

5. CONCLUSION

In summary all cases show an improvement with the new parameterisation formulations for a variety of event types (convergence lines, low pressure zones, fronts) in comparison to the radar data observations. Nevertheless there are still some aspects that need further investigation, e.g. if the results can be confirmed by a longer time series analysis, what is the effect of uncertainties in the observations and if the use of other complementary information from different remote sensing and in-situ observations also shows an improvement for the new model parameterisations.

The study is one of the studies in the project *QUEST* (Quantitative evaluation of regional precipitation forecasts using multi-dimensional remote sensing observations, [8]). In *QUEST* different remote sensing instruments (satellite, ground-based radar and microwave radiometer, ceilometer, GPS) are used both in long-term and short-term (case studies) model evaluation.

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