P1.4 ESTIMATION OF OROGRAPHIC PRECIPITATION DISTRIBUTION USING OROGRAPHIC MOISTURE FLUX IN THE SOUTH-EASTERN ALPS

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1. INTRODUCTION

Orographic precipitation is often inaccurately forecast even by the high resolution numerical models because of lack of measurements at lower levels. Underestimation of radio sonde measured wind speed and incorrect humidity profile usually makes the model atmosphere potentially too stable. Even at realistic model grid point altitude, the necessarily smoothed model orography could cause the air trajectory to be convex instead of a concave one. Also the parameterization of convective precipitation in numerical model could introduce significant errors to the result. A method for evaluating and possibly improving model precipitation results using measured data and orographic moisture flux is discussed in the paper.

2. METHOD

The classical methods for diagnosing precipitation rates using convective available potential energy (CAPE) are not applicable in mountains because of their high spatial variability. Starting from Doswell's (1996) 'ingredients-based methodology', Lin (2002) proposed an orographic contribution to the precipitation (P) as

$$P = u(\partial h/\partial x)q \qquad (1)$$

where u is low-level wind speed (low-level jet), $(\partial h/\partial x)$ is mountain slope and q is air-mass specific humidity. In the study of Strajnar, 2005 a method for estimation of maximum precipitation rate in the South-Eastern Alps based on measured data from the Udine radiosounding was presented. For several heavy precipitation cases measured maximum hourly precipitation rates in the region were plotted against the P resulting with the good agreement of regression line. In this paper the method will be extended to two dimensions using a numerical model.

According to Lin the horizontal distribution of precipitation rate is proportional to the orographic moisture flux

$$P_{HOR} = (\mathbf{v} \cdot \nabla h)q \qquad (2)$$

where **v** is the wind vector. This quantity is used to compare the results of a numerical simulation against observed precipitation distribution, with the aim of improving the calibration of model derived precipitation rates.

3. THE CASE STUDY OF 9 TO 10 OCTOBER 2004

The selected case is interesting because the precipitation forecast of all operational models at the Slovenian weather service (ECMWF and ALADIN/SI-10 km) as well as some experimental ones (COAMPS™) was dissatisfactory in precipitation distribution, precipitation accumulation and precipitation rate extremes. The maximum 12 h precipitation accumulation of all the models was only 34 mm.

From October 9th to 10th 2004 a cold front was almost stationary extending from the North-Eastern Europe over the Alps to the British Isles. There were south-westerly winds in lover levels bringing warm and moist air form the Adriatic, while in the upper troposphere relatively cold air persisted creating potentially unstable air conditions. This produced frequent and occasionally heavy orographically induced precipitation with observed rainfall of up to 51.5 mm per hour, 78.6 mm in two hours and 103.1 mm in three hours at Kneške Ravne (altitude 752 m) and 174 mm in 12 hours at Vogel (alt. 1535 m). The precipitation distribution was inhomogenous with small spots with much higher accumulations.

4 RESULTS

For the purpose of this study the wind and moisture fields were calculated using COAMPS non-hydrostatic model at resolution of 1 km (Žagar, 2005) with the initialization on October 8th 2004. The values of ∇h were calculated with 500 m resolution topography which brings much more realistic rainfall intensities than with the model topography resolution. After some

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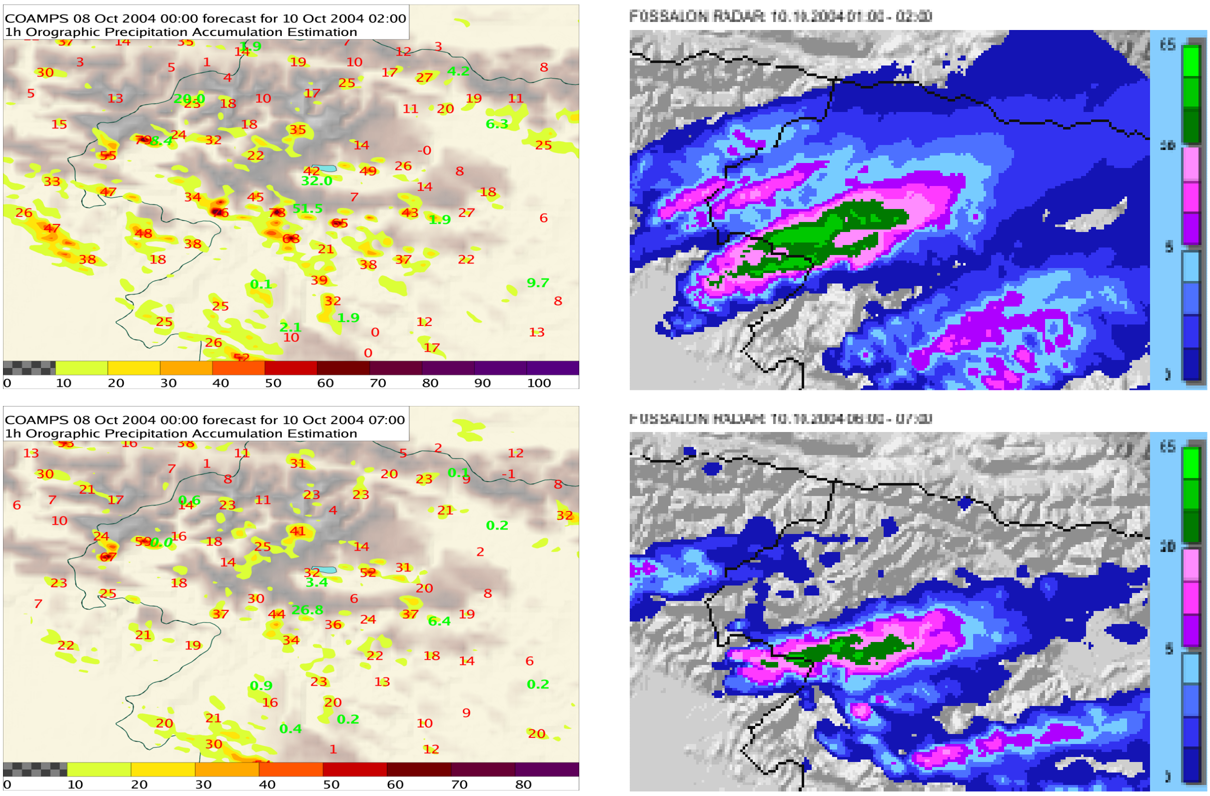

Figure 1. Estimation of 1 hour precipitation accumulation in mm calculated from COAMPS +38 h and +41 h forecast orographic moisture flux (only positive values) for 2 and 7 UTC on October 10th 2004, extreme values in red and measured values in green (left column) and 1 h Fossalon radar (ARPA-FVG, Italy) precipitation accumulation estimation for the same period (right column).

experiments the 900 mb level was selected for the calculation of orographic mass-flux.

Figure 1 shows the comparison between estimated hourly accumulation and measured one for two selected times with the heaviest rainfall. When comparing estimated fields of precipitation to the radar fields, we are interested only in position and magnitude of extremes of the estimated precipitation, not so much in the structure of the fields. The reason for this is lack of advection of precipitation in the lee of mountains in the estimation method. Only values where the orographic moisture flux is positive are shown.

Generally there is a good agreement of magnitude and location of estimated maxima of the fields with ground measurements, especially for mountain stations, but the number of measurements is too small to draw any conclusions. Also estimated position and the magnitude of extremes is close to the Fossalon radar ones, although the radar measurements of precipitation accumulation in mountainous terrain could have up to 300% error. On 0 UTC on October 10th there are some extremes with overestimated precipitation for example estimated maximum of 79 mm/h, while the nearest valley measurement in Log pod

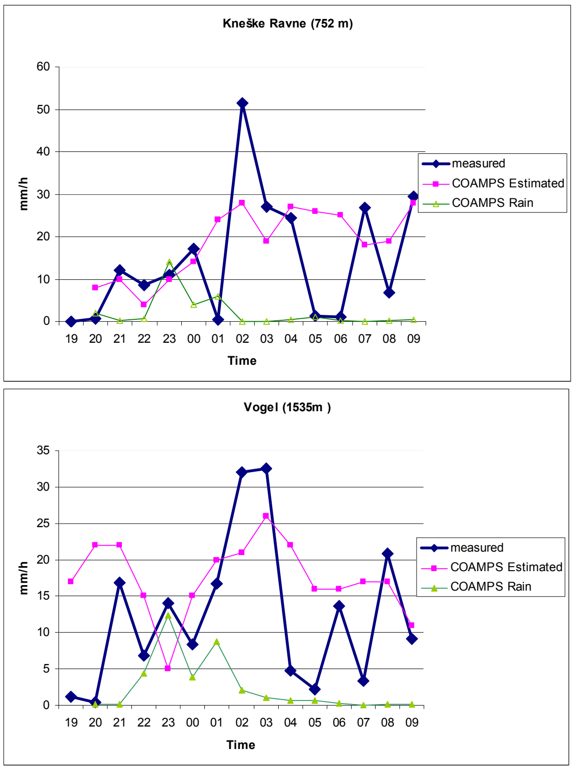

Figure 2. Comparison between 1h measured accumulations, estimated and model rainfall forecast. The time is running from 9 to 10 Oct. 2004.

Mangrtom is only 8.4 and the radar accumulation is about 20 mm/h.

On Fig. 2 the temporal evolution for COAMPS forecasted 1h accumulation and estimated rainfall is compared to the measured rainfall. COAMPS forecasted rainfall is underestimated with the biggest accumulation of 14 mm per hour at Kneške Ravne while the measured accumulation is up to 51.5 mm/h. On the other hand the COAMPS estimated rainfall is much more realistic in time evolution and in magnitude with the extreme of 28 mm/h. The measured accumulation from 21 UTC to 9 UTC is 217.7, the estimated 252, but the forecasted only 27.3 mm.

On the mountain station Vogel the estimated rainfall between 20 UTC of October 9th and 0 UTC October 10th is overestimated, but the COAMPS rain is more realistic. This could be explained by the nature of precipitation which was frontal during this period, not orographic. From 0 UTC, when the extreme precipitation started, estimated rainfall is more realistic than forecasted with the extreme accumulation of 26 mm/h at 3 UTC which is close to the observed value of 32 mm/h. Also the estimated 12 hour accumulated rainfall for the period of 21 UTC to 9 UTC is overestimated with 245, COAMPS rain is only 34, while the measured value is 181.8 mm.

5. CONCLUSIONS

For selected case a major improvement is reached by estimating precipitation using the orographic moisture flux, compared to the model forecasted precipitation. The positon and magnitude of extremes of 1 hour accumulation estimated precipitation fields is close to the observations and radar, but there are several extremes which are overestimated. For two mountain stations the temporal evolution of 1 hour estimated accumulation is much more realistic in timing and magnitude of extremes than COAMPS precipitation. Also the 12 hour accumulation are better than the model's, but the values are overestimated. Because the method is sensitive to the low level wind and moisture, further cases should be analyzed to find the best model level or levels combination to get the most realistic precipitation accumulation.

6. REFERENCES

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