REAL TIME PRECIPITATION DOWNSCALING

Reinhold Steinacker, Stefan Schneider, Manfred Dorninger

Department of Meteorology and Geophysics
University of Vienna, Austria
E-mail : reinhold.steinacker@univie.ac.at

Abstract: A method for precipitation downscaling by utilizing radar information is presented. The radar information is seen as a pattern, which is introduced with a variable weight into an analysis, based on direct station observations. The results for a case study shows clearly, that the weight of radar information is generally lower than unity and varies considerably over a domain covering eastern Austria. This means that there is usually a significant difference between the precipitation amount in the lowest volume, seen by radar and observed by rain gauges at the earth's surface. The advantage of the proposed method is the simple mathematical approach and the relative inexpensive computational effort. Also the extension towards other arbitrary information sources for the downscaling procedure promises an effective tool for operational high resolution precipitation analysis.

Keywords: *ICAM, convection, downscaling, radar, mountainous area*

1. INTRODUCTION

High resolution quantitative precipitation analysis in real time is a highly important issue for flood or avalanche forecasting and for all further issues, sensitive to certain precipitation amounts. Although high resolution models are increasingly able to forecast useful precipitation amounts, the local distribution and timing still lacks of the necessary precision. Therefore it is important to monitor precipitation with the highest possible accuracy in real time to validate model precipitation and to feed hydrological models. Radar is commonly used to downscale the precipitation field. Over complex terrain, however, the radar information is less accurate to estimate the surface precipitation due to radar shading and low level precipitation modification. Several attempts have been undertaken, to modify and adjust the quantitative precipitation fields in mountainous terrain, using additional information e. g. from climatology. Extended information on this problem may be found in Rossa et al, 2005 or in Meischner, 2003.

The basic problem consists in a mismatch between the observed precipitation values at surface stations and the precipitation amount derived from radar reflectivity. Even with an adequate Z-R relation, the mismatch may be caused by a difference between the lowest volume which is scanned by radar and topography. Both levels which may be vertically one, two or even more kilometers apart, precipitation may increase by feeding processes or decreasing by evaporative processes. Therefore the pattern of radar derived precipitation rather than the quantitative information should be used to downscale the precipitation field. As the ratio between both, radar and directly observed precipitation is by no means temporally or spatially constant, a method is recommended, which uses the radar pattern and calibrates the amount by direct observations.

The method, presented here, is utilizing the VERA (Vienna enhanced resolution analysis) approach; see Steinacker et al, 2004. This method is shortly presented in chapter 2. In chapter 3 the application of the method during a case of convective precipitation is shown and discussed. The conclusion gives some speculations on further approaches of this method and its suitability for real time application.

2. METHODOLOGY OF DOWNSCALING

The method which is being presented here, splits each field Ψ into one or several parts Ψ_m, which represent a predefined pattern with a – temporally and spatially – variable weight c_m and into the rest Ψ_s, which is unexplained by the predefined patterns. The predefined, known patterns Ψ_m are called fingerprints.

$$\Psi(x,y,t) = \Psi_S(x,y,t) + \sum_m c_m(x,y,t)\Psi_m(x,y,t). \qquad (1)$$

The solution for the Ψ and c_m at each grid point of an analysis domain at a fixed time is yielded by a smoothing constraint, e. g. by minimizing a cost function of the integral of the first and/or second spatial derivatives of both, Ψ_s and c_m . The method is closely related to a thin plate spline solution. A detailed description of the mathematical formulation and solution can be found in Steinacker et al, 2004.

For a precipitation analysis Ψ is the precipitation amount as observed by the surface station network, typically available from a station network with approximately ten or several tens of km distance. $\Psi_m \equiv \Psi_{radar}$ is the precipitation field as given by a radar network with a typical spatial resolution on the order of one km. Depending on the matching between the radar precipitation and the observed precipitation data at the stations the weight of the radar pattern (fingerprint) is taken into account in the analysis to refine (downscale) the final analysis.

3. CASE STUDY

For a summertime case (25 July, 2005) with wide spread convection over the Eastern Alps, see figures 1a

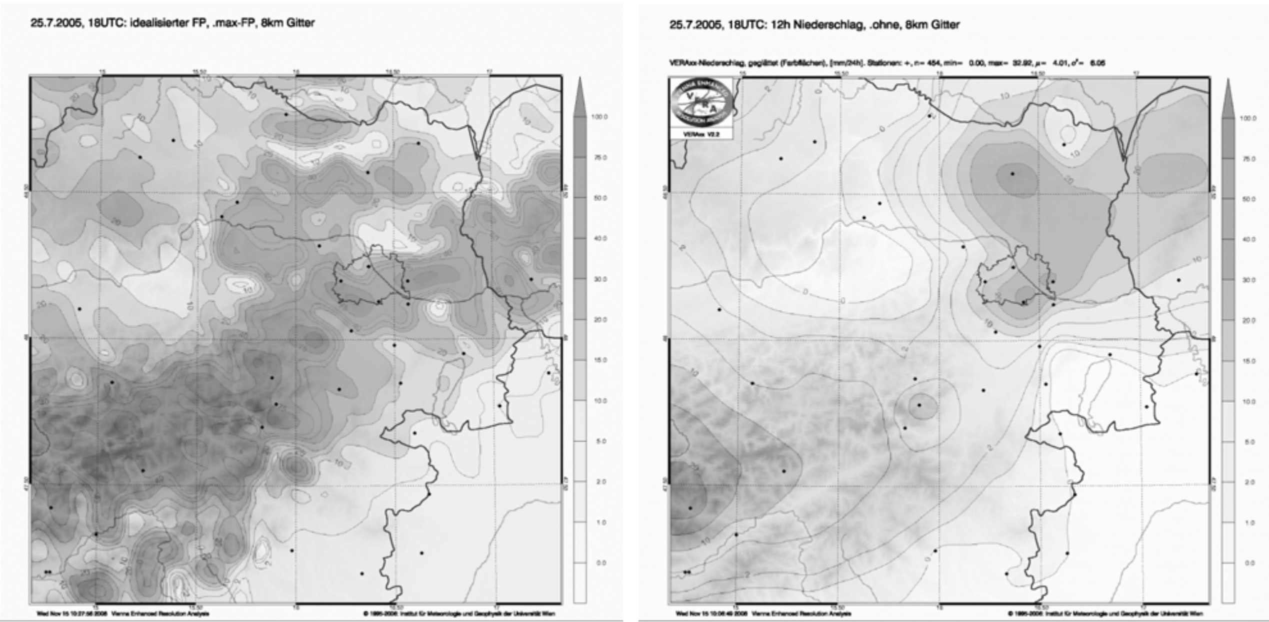

Figure 1 (a, left): 12 houly precipitation field on 25 July 2005 between 0600 and 1800 UTC as derived from radar, which is used as fingerprint, **(b, right)** same as left but analyzed from available synoptic station (dots) values.

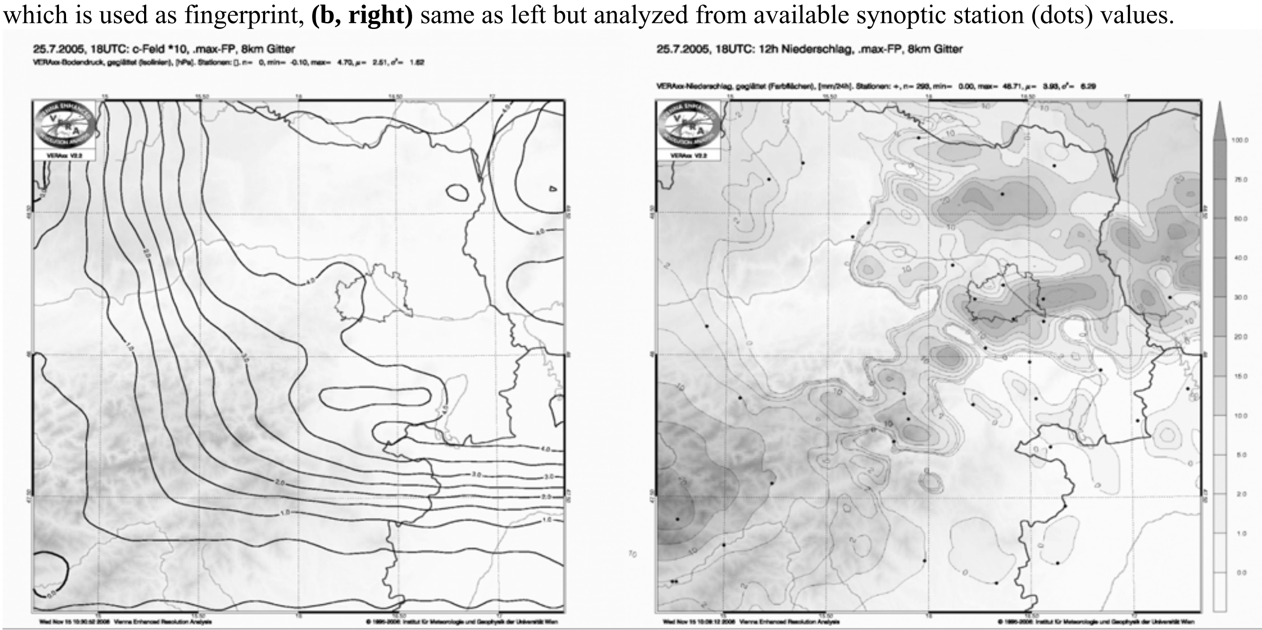

Figure 2 (a, left): weighting factor (multiplied by 19) for the radar fingerprint as determined by the downscaling method, **(b, right)** VERA analysis downscaled with the aid of the radar fingerprint.

and 1b, a radar precipitation field was generated by adding the 10 minute radar derived precipitation rates to create a 12 hour precipitation amount. On the other hand, the 12 hourly precipitation at synoptic stations were available. The comparison of the radar derived field (figure 1a) and the analysis of the station values by a thin plate approach (figure 1b) shows, as one can expect considerably more details in the radar derived field.

When calibrating the radar information, i. e. determining the weight of the fingerprint it is interesting to see, that the weights in the whole domain remain considerably below 1. This means, that the radar derived precipitation overestimated the observed value considerably. It is well known that during convective precipitation events a considerable amount of precipitation evaporates in the lower portion of the troposphere.

Furthermore it is interesting to see a pronounced gradient in the field of the weighting factor (Figure 2a). The weighting factor in the larger area of Vienna (upper right center of the Figures) is much higher than in the southern and western parts of the domain. The Radar is located close to Vienna, which means that the radar beams detect lower parts of the Atmosphere there as compared to the Southern and Eastern edges of the domain, where the shading by the Alps and the earth's curvature is most effective.

The final analysis with downscaling by radar is shown in Figure 2b. It is important to note that the value of both analyses, Figures 1b and 2b show the same values at the station locations, only in-between the stations the radar information creates a stronger variability. It can be easily seen, that the areal mean values of precipitation differ considerably between both analyses.

4. CONCLUSION AND OUTLOOK

The proposed downscaling approach is mathematically simple, computationally rather inexpensive and may hence be carried out in real time. If direct precipitation observations by an automatic network are available with a high temporal resolution, e. g. one hour or even 10 minutes, the full potential of the high temporal resolution of radar information may be utilized for downscaling purposes. The proposed real time downscaling is not yet implemented under operational conditions, but positive experiences with real time downscaling concerning other atmospheric parameters promise a useful application also for precipitation.

As shown in the case study, in areas distant from a radar locations and deep cut-in valleys, the radar pattern gives only limited signal to the real (surface) precipitation. The proposed downscaling method, however, may utilize more than the radar pattern. Prognostic model fields, climatological fields or topographic information or any additional knowledge about orographical influence on precipitation may be used as well to downscale actual precipitation fields. According tests have been conducted, which point towards a significant possible improvement in the future.

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