Parallax correction of Meteosat images using temperature profiles, radar echotops and combined method

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I. INTRODUCTION

The parallax correction of METEOSAT images for the area of the Czech Republic is of importance as it is located 50 degrees North and the apparent shift of convective cloud tops caused by parallax can be of order of ten kilometers.

The parallax error is a known problem which has been addressed by various authors (see e.g. Vicente et al., 2002). For the area of the Czech Republic the outlook of the problem was done by Radova, 2007.

The cloud top brightness temperature is usually compared with expected temperature profile of the atmosphere (either the standard atmosphere or actual radiosoundings or model profiles are used) when performing the parallax correction. This is used as the reference method. However the temperature-height assignment for cloud tops above the tropopause where the constant temperatures or inversions are observed is difficult. Therefore the method which uses Echotop product of the Czech radar network to estimate cloud heights was tested. The Echotop is defined as the highest altitude where the radar reflectivity exceeds 4 dBZ. The combined method uses primarily the radar measurements and moreover the temperature profiles to eliminate the false signals in radar data caused mainly by WiFi transmitters and to fill the areas where no radar measurements are available.

II. PRESENTATION OF RESEARCH

The convective storm cloud tops often reach the height of tropopause or even penetrate it. Besides the convective precipitation is very local phenomena and the knowledge of the accurate position is crucial for the nowcasting of local flash floods or the inputs to hydrological models. Therefore the parallax correction of convective storms is very important.

The parallax is in fact a trigonometry problem and its solution is unambiguous. The complexity of the procedure depends on how precisely we define the Earth globe shape. We can use the simple sphere approximation, more complex ellipsoid shape or even the geoid approximation. In this work we use the method described in Soler, 1994 which approximates the Earth globe simply by the sphere.

The substantial unknown value in the determination of the parallax shift is the real cloud top height. The most often used method of the assessment of the cloud top height is the comparison of cloud top brightness temperature obtained in one of the atmosphere window channels with the temperature profile. In this work we use the temperature profile of the international standard atmosphere which assumes the temperature 15°C at sea level, then linear decrease of temperature with the gradient −6.5 °C/km up to the height of 11 km. The temperature at 11 km level is −56.5 °C and between 11 km and 20 km the temperature remains constant. Thus above the tropopause we are not able to estimate the cloud top height. Moreover we can not distinguish the cases when the cloud top is not in thermal equilibrium with the surrounding like the penetrating cloud top which cools down adiabatically and thus is colder than the atmosphere around.

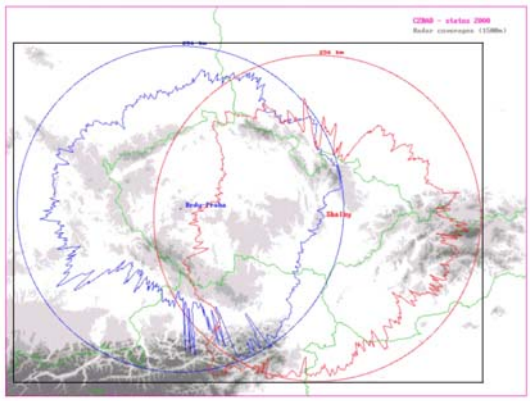

FIG. 1: Area covered by the CZRAD network.

Second method used in this contribution is based on the radar product Echotop (Havránek, Kráčmar, 1996). The area covered by two Czech radars (CZRAD) is shown on Fig.1.

The Echotop is defined as the highest altitude where the radar reflectivity exceeds 4 dBZ. This condition defines the Echotop as the top of relatively thick cloud, in fact the top of precipitation core. We take into account this restriction but as we are mostly interested in the convective rainfall we agree with it. The method which uses the radar product Echotop to determine the cloud top height was presented in Pesice, 2008.

Third method combines both above mentioned techniques. The height of cloud top is determined from Echotop as well as from temperature profile. In case there is no Echotop data (thin clouds, areas outside the radar umbrella) the height from temperature method is used. Otherwise the Echotop height is considered if it fulfils the condition that the difference of the heights acquired by both the methods is less than 5 km and the cloud top temperature is greater than the threshold -40°C. This condition should eliminate the false very high clouds in Echotop data caused usually by the signal from WiFi transmitters.

III. RESULTS AND CONCLUSIONS

The data from four summer seasons (2005-2008 from May to September) were processed. The total number of considered cases was 54915. Table 1. shows the distribution of the cases processed by different methods. The rows show the number of occurrences of cloud tops higher than given

height. We can notice significant decrease of high cloud tops when using the combined method due to filtering of false cloud tops by the above mentioned condition.

Height [km]	Temperature	Echo top	Combined
5	51391	52310	53877
10	29985	35063	37368
15		12352	6789
20		4527	1028

TABLE I: The total number of cases where the cloud tops exceeded the given height for three used methods.

Figure 2. shows the average temperature of cloud tops for all the methods. The cloud top temperature obtained by the temperature method of course decrease almost linearly while the Echotop method shows unrealistic increase of cloud temperature for highest clouds. Combined method largely eliminates this growth; it shows also the increase of temperature above 18 km which can relate to stratospheric temperature inversion.

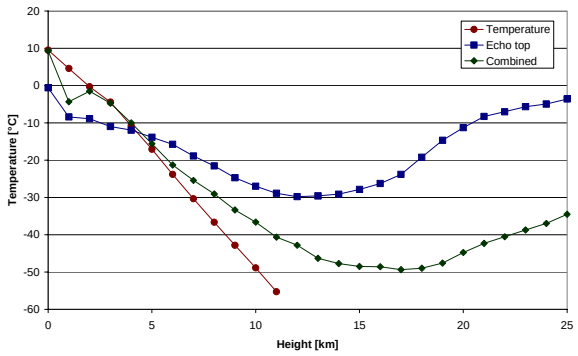

FIG. 2: The comparison of average cloud top temperatures of clouds of given height for three used methods.

Figure 3. shows an example which documents the behaviour of the methods on the real situation from 25th June 2008, which caused wind damages and local flash flooding. The bottom image shows the limitations of Echotop method when no radar data are available (top right corner). This is eliminated to a great extent by combined method.

IV. AKNOWLEDGMENTS

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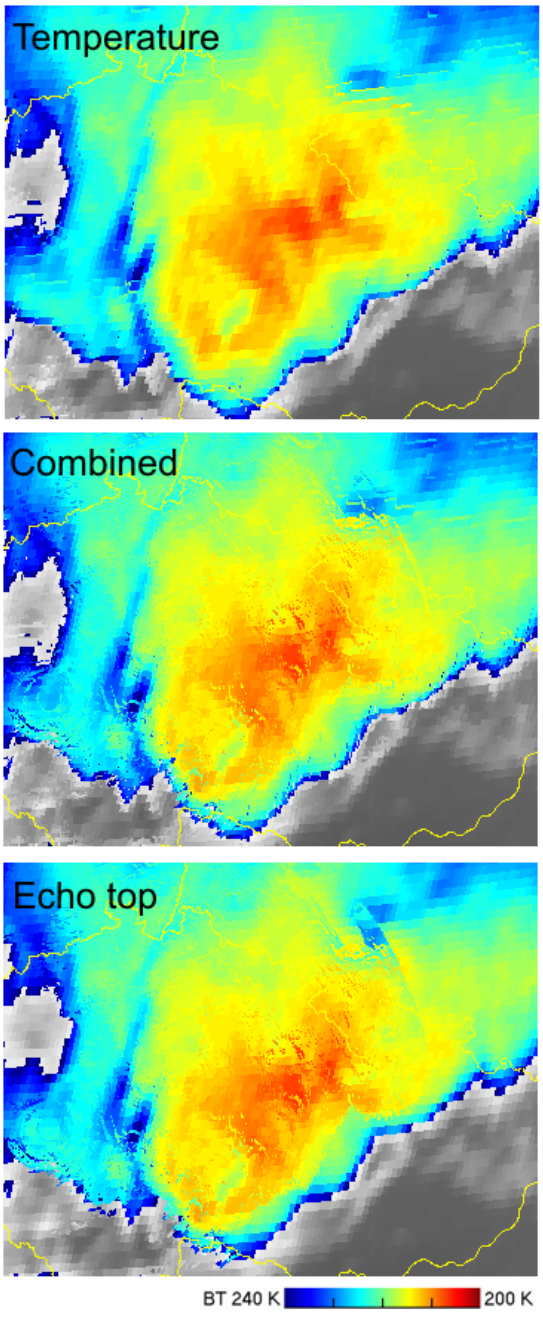

FIG. 3: The comparison of cloud top temperature fields for the situation of 25th June 2008 1800 UTC when parallax correction by various methods was performed.