Combined use of Meteorological Data from "METEOSAT" Satellite and Meteorological Radars

Uliana T. Petrova[1]

Abstract – **Radar images often show precipitation echoes in areas where precipitation does not occur (ground clutter). Until there will be better radar techniques, radar results must be verified with other techniques. One way is to compare them with METEOSAT data. A cloud mask can be calculated using IR image and a reference image of surface temperature. Radar echoes can only be present in areas where algorithm identifies clouds.**
Keywords – **meteorological satellite images, radar meteorological images, educational satellite data, ground cutter map.**

I. INTRODUCTION

Especially for agricultural and aeronautical meteorology, the knowledge on the cloud top highs (CTH) is very important. To get the CTH from METEOSAT image, it is necessary to use additional information like radio-probe measurements or model output. For this case, a method was developed to combine the cloud top temperature (METEOSAT B-format) with temperature-high data from the EM-Model. Since equipment cost for the detection of satellite and radar meteorological transmission is becoming affordable to universities, some educational institutions have been involved in applying of this method, which opens ways for more efficient interactions between students and computers.

Radar meteorological images are usually tied to a single local observation. In the same time this observation is part of corresponding satellite observation. The two images can be obtained together using appropriate computer systems. Such presentations are very important not only for research, but also for training students and professionals. Several meteorological workstations are set up in the major meteorological office of the Ministry of Agriculture and in some regional offices. The main office is in one of the research laboratories for students training at the Technical University in Sofia.

Several meteorological program packages are provided on these workstations to construct surface weather charts, significant weather maps and to display model output or satellite images.

Research is conducted in cooperation with the Department of Medientechnik of the Technical University in Ilmenau, Germany.

The satellite image processing program is capable of showing composite radar images from the corresponding regional radar stations, to combine radar and satellite images and to present loops with satellite images as well as radar images.

Radar composites are constructed from 5 radar stations and are available every 15 minutes at the spatial resolution of 4 km.

II. VERIFICATION OF RADAR IMAGES WITH METEOSAT IMAGES

A. Ground clutters

In some cases radar images show echoes where precipitation activity does not occur. Echoes are caused by ground clutters. Such misleading ground clutter echoes occur most frequently under clear sky situation in the morning hours when well– pronounced surface inversions exist (Fig. 1 shows an example). There are several possibilities to remove these effects:

a) Modify the "Ground Clutter Map" when radar information is preprocessed;

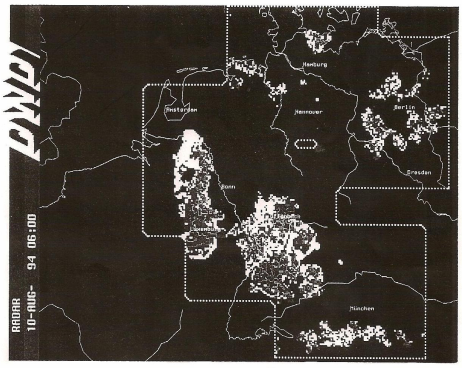
b) Use special procedure which analyses regions with ground clutters (in development);

c) Verify composite radar images against METEOSAT data.

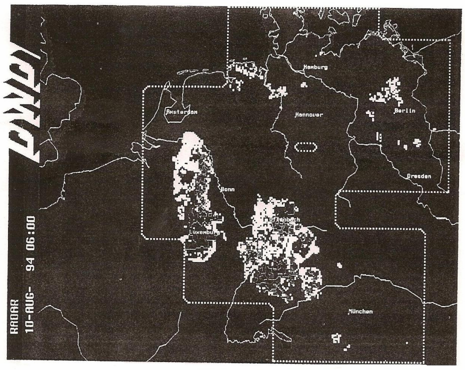
B. *Verification of radar composite images with METEOSAT data*

One way to correct radar composites is to compare radar data with METEOSAT images. A cloud mask from the IR data is calculated in order to perform automatic cloud detection. The cloud mask needs a thermal surface reference image. It is calculated on a daily basis out of the last ten 0400-UTC-IR images[1]. Each pixel of these reference images shows the minimum temperature at 4 UTC for this location. Alls pixels in the IR image, which are colder than the reference pixel, are considered a cloud. It is possible to calculate a cloud mask for every incoming IR – METEOSAT image. The user can change interactively parts of the reference images with a satellite image program. This is necessary when the last night happens to be colder than the previous nights thus locally warming up the reference. In this case too many pixels are identified as being cloudy. The cloud mask is also needed for the generation of specially processed images for TV presentation in the case of distance education. After composite radar picture enters the workstation, it is compared with the actual cloud mask (15 minutes max). Radar echoes are only displayed in those areas where the cloud mask detects clouds. When the cloud top temperature is above 0^0C, echoes intensity is reduced to the lowest

[1] Uliana T. Petrova is with the Faculty of Communications and Communications Technologies, Technical University, Kliment Ohridski 8, 1000, Sofia, Bulgaria, e-mail:uliana5@abv.bg



▲ Fig. 1: Radar composit without correction ▼ Fig. 2: Radar composit with correction



precipitation rate as more intensive precipitation activity can only be produced by clouds below freezing point (Fig. 2). Especially for TV presentation, the radar composite pictures ombined with clouds from METEOSAT images are available, also.

II. CALCULATION OF CTH WITH DATA FROM THE EUROPEAN MODEL (EM)

A. *The method*

Information about the cloud top temperature can be taken from the METEOSAT’s IR channel. For several applications, especially for agriculture and for aviation purposes, the high of clouds must be known. Cloud height can be determined if the surface temperature of the cloud and the current vertical temperature of the atmosphere are known. The first piece of information can be derived from METEOSAT satellite measurements and the second one from radio-probe observations, vertical satellite soundings, or from numerical weather prediction models. Only the last option offers widespread information on grid points which cover the whole satellite image area. The meso-scale “Europa Model” is a suitable tool to solve the task.

B. *Model data*

The “Europa Model” (EM) is part of a weather predicttion system, which also contains a global spectral model (GM) for large-scale predictions and a high-resolution meso-scale model [2].

The EM is working in the synoptic and meso-scale and provides more detailed forecasts of weather parameters close to the ground. For higher elevations, atmosphere is split into 20 layers of increasing thickness in a hybrid coordinate system. Eight layers are used for the lowest 2 km; four layers are placed around the tropopause and in the stratosphere. The integration of EM covers the North Atlantic and Europe with a net of 181*129 grid points (Mesh size 0.5^0). The true distance between grid points varies from 47,1 to 55,6 km.

C. *Horizontal Interpolation and Vertical Assignment*

METEOSAT AND- end EM-data are of different horizontal resolution. Due to the worse resolution of the model data, four grid points close to the METEOSAT pixel are chosen and data are bi-linearly interpolated to the pixel.

Then the level of best fit between the cloud top temperature from METEOSAT and the model temperature-level is searched in the vertical direction. The model level is interpolated to the level which corresponds to the cloud top temperature.

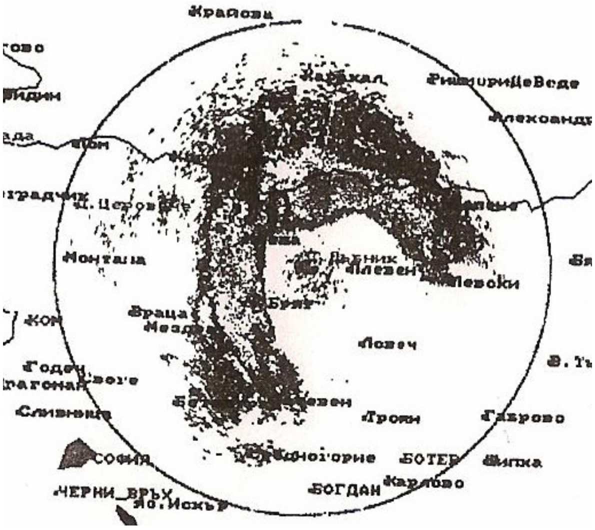
D. *Semi-transparent Cirrus*

The problem of semi-transparent cirrus is a well known problem: in the IR-image clouds appear as warmer clouds assuming to be in the lower atmosphere [3]. To overcome misinterpretations, the following assumption is made: cirrus clouds exist in regions of atmosphere where water vapor content is rather high. Using the METEOSAT WV image, which provides humidity information from higher levels of atmosphere, low clouds with high level of water vapor content above them are marked with a certain color (Fig. 3).

Not all cloud pixels are automatically marked, but the user can be warned when such suspicious clouds are detected.

E. *Results*

Cloud top charts are calculated four times a day by the Research and Training Laboratory at the Technical University in Sofia, Bulgaria and by the Department of “Medientechnik” at the Technical University in Ilmenau, Germany. Cloud level is evaluated using 6- or 12-hour forecasts from the EM. Cloud top charts are displayed within the interactive Graphical System (IGS). Figure 3 shows an example. At the left side, the color legend for the height assignment (in km) is displayed; for example heights between 0 and 12.5 km are in brown. In Fig.1 semi-transparent clouds are marked in a bright blue color; they cover a stripe from the coast of Norway to the Baltic Sea. A very narrow stripe, caused by an aircraft, can be seen over the North Sea for example. A similar strip can be seen over the North Sea just off the south coast of Norway. The highest tops result from thunderstorms near the east coast of Italy with heights of up to 11 km. From time to time, cloud top heights are compared with radio-probe measurements and show good agreement. Figure 4 displays a local radar image from Bulgaria. There are not any principal differences between this one and the above mentioned images without correction (Fig. 5).



F. Problems

Due to the different systems of the high assignment method, i.e. satellite radiation measurement and model simulation, the following problems may arise:

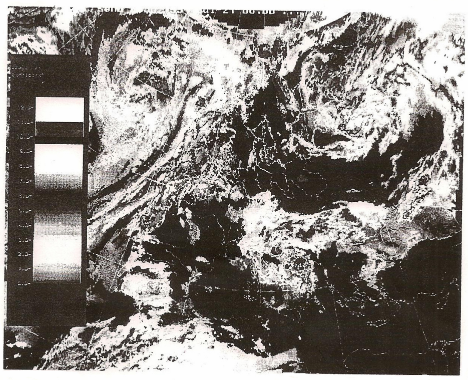


Fig. 3: METEOSAT CTH, 1994-JUL-21, 06 UTC semi-transparent cirrus is marked

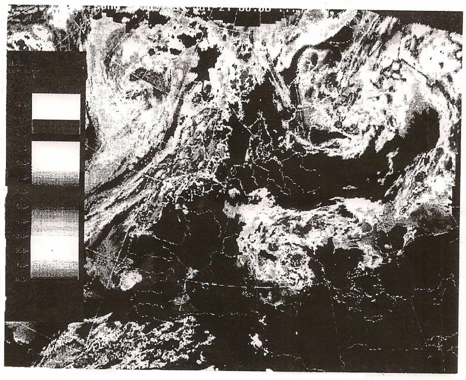


Fig. 4: Same situation: cirrus not marked ground effects corrected

a) model forecast is incorrect: fictive clouds would occur; b) model forecast is correct but surface model temperature is higher than the surface layer sensed by satellite: fictive clouds would also occur.

These and other problems have to be considered and resolved by the assignment method.

III. CONCLUSION

Radar images verification against METEOSAT data is a simple method to present a radar image with less ground clutter echoes. This method does not work if ground clutters appear simultaneously with clouds without rain. Another method is to analyze regions with high probability risk of ground clutters with numerical algorithms (this method is under development) or even better, with a new generation of radar stations like Doppler radar.

First results show that the method is capable of assigning correct cloud top highs with the aid of METEOSAT cloud top temperature and EM temperature forecasts. Users are warned of suspicious cloud top levels which are flagged by a warning color [4].

The operator (teacher or student) can retrieve satellite and radar data together from the hard disk for display using a mouse controlled menu. On top of the storage capability, facilities allow the user to: do series of radar and satellite images, use multicolor density slice feature, estimate temperature and contrast stretch, improve image definition. Radar images verification with the meteorological images is possible using appropriate software.

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