USING OF METEOSAT HRVIS CHANNEL FOR THE IMPOVEMENT OF THE DETECTION OF RAPID DEVELOPING THUNDERSTORM CLOUDS

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(Dated: April 27, 2007)

I. INTRODUCTION

The paper presents the results of the use of High Resolution Visible (HRVIS) channel data of MSG for the improvement of the discrimination of rapid developing thunderstorm clouds. The principle is to estimate of young convective cloud parameters due to the increased spatial resolution of the HRVIS channel (1 km at sub-satellite point against 3 km for the other channels). This should allow the HRVIS channel to describe smaller clouds than the size of IR10.8 channel pixel and improve the earliness of the first detection of convective systems during their growing phase in order to be able to warn and provide information to a forecaster when severe weather may occur. Brightness temperature field measured by satellite is traditionally used for description of convective objects with relevant properties (size, movement, minimum temperature, cooling rates area extentsion rate)(Senesi and Morel, 2000). In order to improve the evaluation of a brightness temperature over small convective clouds with a size less than one IR10.8 pixel we used cloud fraction parameter derived from HRVIS data. So, brightness temperature corrected for cloud fraction should allow to better monitor convective cloud top development from the earliest stage.

II. ESTIMATION OF CLOUD TOP TEMPERATURE CORRECTED FOR CLOUD FRACTION

At infrared frequencies the brightness temperature depends nearly linearly on the radiance, so that we may write

$$T_c = [T_{IR} - (1-N) \times T_s]/N \qquad (1)$$

where

T_c - is the temperature sensed from the TOA from the cloud (brightness temperature corrected for cloud fraction); T_{IR} - temperature sensed from the TOA from the pixel; and T_s - is the temperature sensed from the TOA from the surface.

Thus for evaluation of brightness temperature sensed from the TOA corrected for cloud fraction we have to estimate T_s and N (we do not address to the question of correcting for atmospheric effect).

III. CLOUD FRACTION ESTIMATION USING VISIBLE DATA

The cloud fraction estimation of a low resolution pixel (IR10.8) is based on the estimation of the cloud fraction of each high resolution pixel (HRVIS) in the corresponding low resolution pixel. For each high resolution pixel we estimate the cloud fraction N_{HR} as

$$N_{HR}=(R_{0.75}-R_{threshold0.75})/(R_{c0.75}-R_{threshold0.75}) \qquad (2)$$

where $R_{0.75}$ - the reflectance of HRVIS pixel, $R_{threshold0.75}$ – the threshold reflectance, $R_{c0.75}$ –the reflectance of the fully cloud covered HRVIS pixel.

We used the abbreviation High resolution Cloud Fraction Field (HCFF) for the cloud fraction field estimated from HRVIS data.

The cloud fraction (N) of low resolution pixel is

$$N=\left(\sum_{i=1}^{9} N_{HR,i}\right)/9 \ , \qquad (3)$$

where 9 – is the number of HRVIS pixels inside one low resolution.

It is the most suitable method for the cloud fraction estimation of small convective clouds. The accuracy of the method depends on the threshold reflectance and $R_{c0.75}$. We used the abbreviation Converted Cloud Fraction Field (CCFF) for cloud fraction field estimated using this method.

IV. ESTIMATION OF T_s

To define the most realistic T_s on IR10.8 channel we average values of brightness temperature for cloud free pixels, which passed the tests:

a) altitude test (to find the cloud free pixel, which located on the same altitude as cloudy pixel, in order to take into account the dependency of a brightness temperature on altitude);

b) water vapour test (to find the cloud free pixel, which has the same climatological water vapour content or contribution of atmosphere as cloudy pixel). We have rejected the idea to use the value of closest PoI (pixel of interest) to cloudy pixel, because, we defined many PoI which had a very low value of surface temperature, when we have tested the method. To all appearance, there were semi-transparency clouds over the pixels, which are mostly invisible on HRVIS channel.

V. DESCRIPTION OF CLOUD CONVECTIVE SYSTEMS

We have studied two developing convective systems on 4 July 2004. These systems were observed over North part of Africa (Fig.1). The first system (indicated as I on Fig.1) is an example of the very rapid developing thunderstorm characterized by continuous growth of one cloud from 11:15

to 12:00 UTC. The second convective system (indicated as II on Fig.1) was located close first one. This system is characterized by isolated small convective clouds, which begun to merge in a mature phase of their development.

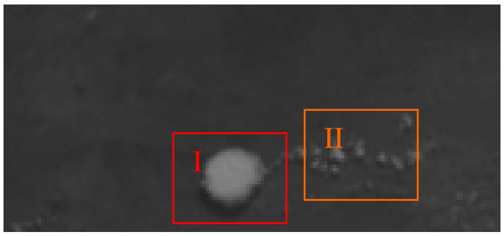

FIG. 1: HRVIS image of the rapid developing thunderstorm (11:45 UTC) on 4 July 2004. The red and yellow rectangles show the development of convective systems I and II.

VI. RESULTS

Analysis of the corrected brightness temperature fields, obtained from CCFF shows that for convective systems I we did not find any difference with IR10.8 value, because the size of a cloud is more that a low resolution pixel.

The convective system II is more interesting than convective system I in respect to detection of small convective clouds, because it is much smaller than other one and cloud field is inhomogeneous that prevent to detect a convective clouds on earlier phase of development. Analysis of estimated minimal CTT (cloud top temperature) from CCFF shows that it decreased from 13°C at 11:30 UTC to –39°C at 12:15 UTC and it is interesting to note that the minimal temperature at 12:00 UTC was -25°C. Moreover corrected brightness temperature field shows a developing convective cloud (four pixels, which have temperatures lower than 0), on IR10.8 channel only one pixel with CTT lower than 0 at 12:00 UTC.

In spite of suitability of obtained results of corrected brightness temperature we should pay attention on strong dependence of cloud top temperature estimation on N (1). As already noted that uncertainty in N leads to error in CTT estimation by a factor of 2 (Kryvobok, 2005).

V. REFERENCES

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