A DIAGNOSTIC TOOL BASED ON MSG 7.3µ/6.2µ CHANNELS FOR THE ANALYSIS AND FORECASTING OF DEEP CONVECTION

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I. INTRODUCTION

The first step of the forecasting process, the 'early warning of convection', consists in determining the area where deep convection is possible in the near future (1 to 12 hour period). The second step is to forecast precisely the time and location of convective developments up to 3 hours, and then the last step is to identify existing convection and to forecast the evolution of the convective systems. The numerical forecast has improved these last years, but remains relatively poor as regard predicting intense convection. The job of the forecaster is to expertise all relevant available data in order to detect severe weather systems appearing or very likely in the near future. The main information source to perform this task remains observations, among which satellite imagery is the most important.

Water vapour channels 6.2 and 7.3 µm offering respectively information about the upper-level conditions and low- to mid-level atmospheric situation can be used to diagnose the convective potential of the situation. Interpreting 6.2 and 7.3 µm channels' information jointly with relevant fields can provide new diagnostic to help the analysis and nowcasting of deep moist convection.

The aim of the present work is to propose an efficient method for diagnosis that can help forecasters in predicting convection, and how best to exploit it. This diagnostic is derived from satellite data and available analysed (or very short range forecast) fields. To perform this task the investigation is accomplished through many convective cases studies in the framework of a joint project between Météo-France and the NIMH of Bulgaria. First results of the preliminary studies are presented as well as future prospects to improve the method for operational purposes.

II. WATER VAPOUR CHANNELS FOR DIAGNOSING PRE-CONVECTIVE ENVIRONMENT

Different authors have stressed on the benefit that can be got from water vapour (WV) imagery in predicting the environment of deep severe convection (e.g. Thiao et al., 1993; Georgiev, 2003; Krennert and Zwatz-Meise, 2003; Santurette and Georgiev, 2007). New MSG satellites offer radiances in 7.3 µm WV channel that contains information for low- to mid-level moisture distribution (Georgiev and Santurette, 2009). The two MSG 6.2 and 7.3 µm WV channels are sensitive to water vapour content at different altitudes and allow observing moisture and wind regimes in different layers of the troposphere. The MSG WV channels exhibit the following information content:

- The 6.2 µm imagery gives a view of the upper-level dynamics and may be used for upper tropospheric conditions analysis (jet stream evolution, PV anomalies). See Weldon and Holmes, 1991; Santurette and Georgiev, 2005.
- The 7.3 µm channel is able to detect moisture at low-mid-level; the images in 7.3 µm channel often exhibit clear features that can provide relevant information as regards to the low-level thermodynamic context (Georgiev and Santurette, 2009). So the study of the 7.3 µm imagery features helps to diagnose favourable low-mid-level environment for strong convection.

Potential instability is pronounced essentially when upper-levels are cold and dry while low-levels are warm and moist; that corresponds to 6.2 µm exhibiting warm brightness temperature (BT) while 7.3 µm exhibits cold brightness temperature. So a relative small WV BT difference (WVBTdif = 6.2 µm BT – 7.3 µm BT) when 6.2 µm BT is warm indicates potential instability; decreasing of this difference marks development initiation. FIG. 1 shows maps of WVBTdif over Europe on 30 June 2006.

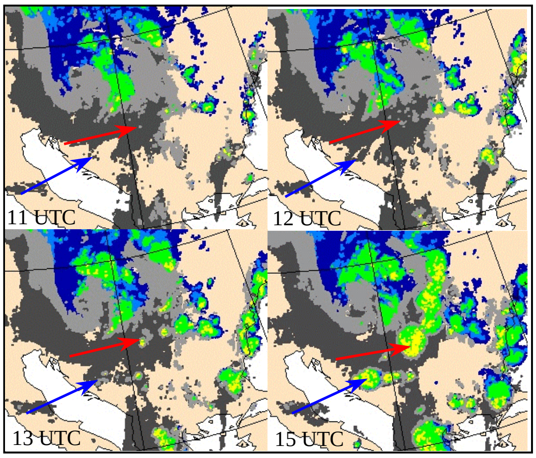

FIG. 1 WVBTdif images on 30 June 2006 over Europe; dark blue for difference from -18 to -10 °C, light blue for -10 to -5 °C, green for -5 to 0 °C, yellow for > 0°C. Grey shades indicate areas of potential instability; green and yellow indicate clouds developments. Convection develops after 12 UTC on the west and central part of Balkans; See text for explanations.

Grey shades indicate areas of potential instability since these areas correspond to 6.2 µm BT warmer than –39°C with weak value of WVBTdif; potential instability is more pronounced in light grey areas where in addition 7.3

µm BT is colder than – 19 °C. It can be seen that convection develops over the Balkans after 12 UTC inside light grey areas, which have appeared within the dark grey shades some time before (arrows in FIG. 1).

III. COMBINING WV CHANELS AND RELEVANT FIELDS TO ANTICIPATE CONVECTIVE DEVELOPMENT

During the early warning phase, the forecaster attempts to assess the degree of potential instability as well as the possible forcing mechanisms. Knowing potential instability is not enough to predict correctly strong convection, which requires potential instability and a low-level moisture source but also a lifting mechanism. In other words the motion field plays an important role in the deep convective process, mainly in case of severe long-lived convective systems.

FIG. 2 presents 100 m wind field and 950 hPa convergence field forecast by ARPEGE (06 UTC run) valid on 30 June at 12 and 15 UTC, superimposed on infrared image; It can be seen that convection developments occurring over the Balkans are well correlated with convergence wind areas forecast by the model (red and blue arrows on FIG. 2; corresponding with red and blue arrows on FIG. 1).

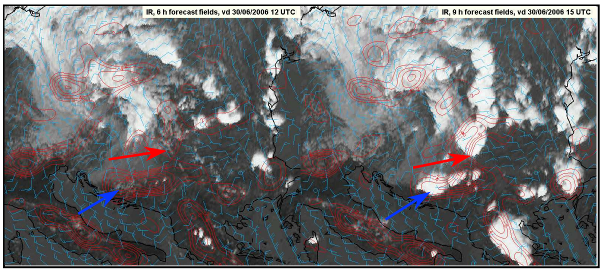

FIG. 2: IR image with superimposition of the wind at 100 m (blue) and of the convergence field at 950 hPa (red, > 2 x $10^{-5}s^{-1}$, interval 2 x 10^{-5} s^{-1}), forecast by the French ARPEGE model (06 UTC model run) on 30 June 2006, valid for 12 UTC (left) and 15 UTC (right).

Satellite imagery is not enough to anticipate the pre-convective environment. Assessing the wind field structures in addition to the potential instability is crucial in early forecasting convection. That's why we propose composite diagnostic tools, combining WVBTdif images with meteorological fields representing crucial process of deep convection outbreak. It is well known that low-level convergence (especially moisture flux convergence 'MOCON'), is required to produce long-lived convective system. Over continental areas, observations of 10 m wind is available hourly (like 2 m humidity). When not available, wind field can be well anticipated by numerical forecast thanks to the good skill models as regards to this parameter. So combining analysed or forecast low-level wind convergence with WVBTdif images offers a first step for a composite diagnostic tool to predict deep convection.

FIG. 3 shows a superimposition of the 10 m MOCON analysis (got from French observations) and WVBTdif image on 24 September 2006, when cold air overruns the southern part of France in southerly cyclonic flow. FIG. 3a shows that instability set on the south-west of France (light grey shade on FIG. 3a), while pronounced MOCON area is analysed in the Toulouse area (red arrow, FIG. 3a). A strong convective development occurs near Toulouse some hours latter well correlated with the superimposition of strong MOCON and instability as seen by WVBTdif image (red arrow, FIG. 3b).

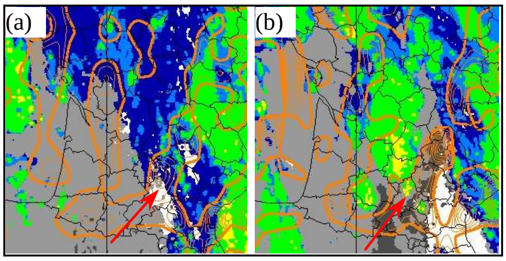

FIG. 3: WVBTdif images at (a) 11 UTC, (b) 15 UTC on 24/09/2006 over the southwest of France (same colours as in Fig. 1); MOCON (orange, from 3 x $10^{-7}s^{-1}$, interval 5 x $10^{-7}s^{-1}$). See text.

No thunderstorm was expected this day; However strong convection developed in the afternoon producing hail and the highway near Toulouse has been closed temporarily. Images of WVBTdif combined with convergence field (here analysed 10 m MOCON) could allow to discriminate the areas where the convection was most likely to develop.

IV. CONCLUSIONS

Water vapour channels 6.2 and 7.3 µm can be used to diagnose the convective potential of the situation. We found the difference of BT very useful as an observation of the evolution of the potential instability. Preliminary studies show that combining this information with relevant fields representing crucial elements in the deep convection development (analysis or very short range forecast of MOCON or low-level convergence wind) can be of great help in anticipating strong convective system.

This work has to be completed by discriminating the other relevant fields that could improve the efficiency of the diagnostic tool, like observed low-level dew point, upper-level divergence. We must also propose clear method regarding interpretation of WVBTdif images probably by considering types of situations. Experimentations have also to be completed in order to adjust the BT values as regards the threshold used for the definition of the grey shades.

V. REFERENCES

Georgiev C. G., 2003. Use of data from Meteosat water vapour channel and surface observations for studying pre-convective environment of a tornado-producing storm. Atmos. Res. 67–68, 231–246.

Georgiev C. G., Santurette, P., 2009. Mid-level jet in Intense Convective Environment as seen in the 7.3 µm Satellite Imagery. Atmos. Res. 93, 277–285.

Krennert, T., Zwatz-Meise, V., 2003. Initiation of convective cells in relation to water vapour boundaries in satellite images. Atmos. Res. 67–68, 353–366.

Santurette, P., Georgiev, C. G., 2005. Weather Analysis and Forecasting: Applying Satellite Water Vapor Imagery and Potential Vorticity Analysis. Elsevier Academic Press. ISBN: 0-12-619262-6, 200 pp.

Santurette, P., Georgiev, C.G., 2007. Water Vapour Imagery Analysis in 7.3/6.2µm for diagnosing thermo-dynamic context of intense convection. 2007 AMS-EUMETSAT Meteorological Satellite Conference, Amsterdam, The Netherlands, 24-28 September 2007.

Thiao W., Scofield, R., Robinson, J., 1993. The Relationship Between Water Vapor Plumes and Extreme Rainfall Events During the Summer Season. NOAA Tech. Memor. NESDIS 67, Sat. Appl. Lab., Washington, 69 pp.