MID-LEVEL JETS IN INTENSE CONVECTION ENVIRONMENT AS SEEN BY 7.3 µm SATELLITE IMAGERY

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I. INTRODUCTION

Different authors have stressed on specific meso- and large-scale features related to the environment of severe convection that are seen on water vapour (WV) imagery in 6.3/6.7 µm channels (e.g. Ellrod, 1990; Thiao et al., 1993; Georgiev, 2003; Krennert and Zwatz-Meise, 2003; Santurette and Georgiev, 2005). As discussed in Doswell (1987), the problem of forecasting convection involves more than large-scale processes, but there does seem to be clear observational evidence for an association between large-scale systems and moist deep convection. Before the mesoscale low-level factors act to initiate significant updraft, the thermodynamic environment favourable for intense convection is usually created via large-scale processes, which may be diagnosed by using WV imagery.

Although radiances in 7.3 µm WV channel measured by geostationary satellites contain information for mid-level moisture distribution, there is still a lack of reports for using these data in synoptic scale analyses. This paper presents results showing the significance of 7.3 µm channel of Meteosat Second Generation (MSG) as a tool for diagnosing large scale thermodynamic context of intense convection.

II. PRESENTATION OF RESEARCH

Case studies on the 16 most severe convective storms over the Mediterranean area in 2004 and 2005 have been performed with the aim to establish the use of 7.3 µm WV channel imagery as a tool for identifying mid- and low-level features of thermodynamic convection environment. Table 1 shows 12 of these cases, in which a mid level jet (MLJ) at about 600 hPa is present in the southwesterly-southerly flow. Ten of these processes developed over the Western Mediterranean and two other occurred over the Eastern Mediterranean.

Western Mediterranean		**Eastern Mediterranean**
18 August 2004	17 August 2005	4 August 2005
24 August 2004	7 September 2005	5 August 2005
27 June 2005	9 September 2005	
29 July 2005	4 October 2005	
10 August 2005	15 November 2005	

TABLE I: Severe convective developments associated with mid level jets, along with the area of their development.

The studied areas of wind maximums seen in NWP model fields and cross-sections were tracked along with the corresponding satellite images. In many of the cases, the mid level jet is distinctly seen as a specific moisture boundary in 7.3 µm channel imagery, while this feature is not present or may be indistinct in the images of 6.2 µm and split window channels of Meteosat.

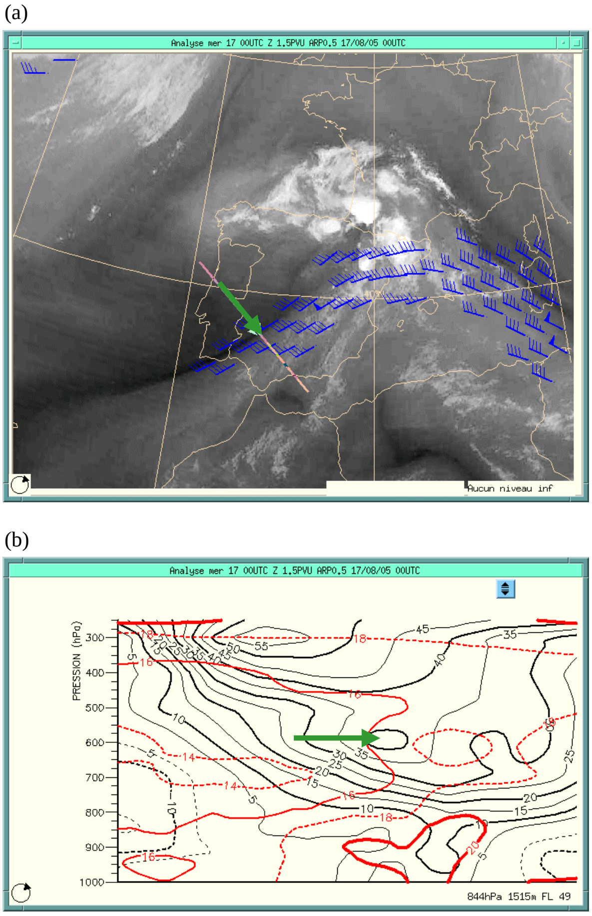

FIG. 1: Mid-level jet on 17 August 2005 00 UTC. (a) Meteosat-8 image in 7.3 µm channel overlaid by ARPEGE model wind vectors at 600 hPa (blue, only ≥ 35 kt). (b) Cross sections along the axis depicted in (a) of wind speed normal to the cross section plane (black) and wet-bulb potential temperature, θw (red). The green arrow indicate the position of the jet.

Fig. 1a, shows a 7.3 µm channel image overlaid by vectors of maximum wind at 600 hPa isobaric surface that gives an example of such a jet. The MLJ is detected by the 7.3 µm image along the moisture boundary at the position of the green arrow, where the cross-section of the wind speed in Fig. 1b exhibits a maximum at 600 hPa.

III. RESULTS AND CONCLUSIONS

The mid-level jet is recognised as an important feature in formation of a thermodynamic environment favourable for intense convection. The appearance of this feature in 7.3 µm WV imagery is always associated with the existence of a low-level baroclinic zone: high horizontal gradient of wet-bulb potential temperature (θw) as well as surface θw-anomaly beneath the MLJ, as seen in Fig 1b. In order to explain this result, it is useful to consider the thermal wind relation

$$\frac{g}{\theta_0}\frac{\partial \theta}{\partial x} = f\frac{\partial V_g}{\partial z} \tag{1}$$

where θ is potential temperature with reference value θ_o, g is the acceleration of gravity, f is the Coriolis parameter, Vg is the y-component of the geostrophic wind. Equation (1) tells that a strong horizontal θ-gradient creates a strong vertical geostrophic wind gradient. Therefore, the origin of the MLJ, seen in the 7.3 µm WV images, is likely a result of strengthening of a baroclinic zone (increasing θ-gradient at low- to mid-level) that is associated with a surface θ-anomaly.

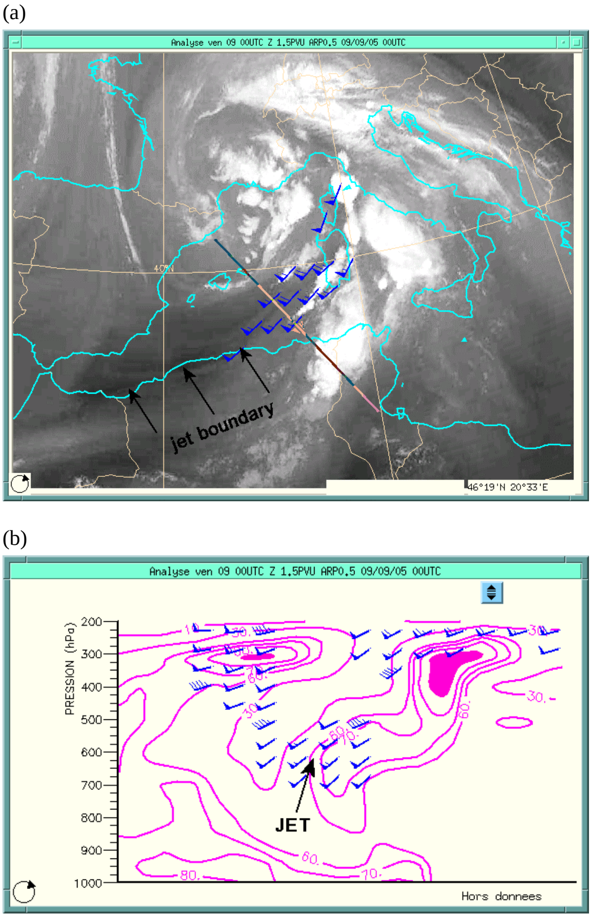

FIG 2. Mid-level jet on 9 September 2005 00 UTC. (a) Meteosat-8 image in 7.3 µm channel overlaid by ARPEGE model wind vectors at 600 hPa (blue, only ≥ 45 kt). (b) Cross sections along the axis depicted in (a) of wind vectors normal to the cross section (blue, only ≥ 45 kt) and relative humidity (pink, only ≥ 30 %).

Another example of a MLJ, seen in the 7.3 µm WV image as a distinct moisture boundary, is shown on Fig. 2a. Such a MLJ moisture boundary is a significant imagery signature that indicates a specific thermodynamic structure of intense convection environment. The following conclusions regarding this structure, seen in the image and the cross-section in Fig. 2, are noteworthy:

– Increasing of the horizontal θw-gradient in a low-level baroclinic zone has created an area of wind maximum at 600 hPa.

– Low-level moisture convergence exists resulting in a maximum of relative humidity (~80 % at the surface) related to the baroclinic zone at the equatorward side of the 7.3 µm WV boundary.

– Ascending motions are present at the equatorward side of the baroclinic zone that moistens the low- to mid-level air, while a transverse circulation with the MLJ contributes to descent and drying the air at the poleward side. This enables a specific moisture boundary of mid-level jet to be distinctly seen in the 7.3 µm image.

– Large scale movement of moist air (more than 70 % relative humidity) occurs with the jet on its equatorward side that enables mid-level moisture supply downstream (to the east of the black arrows in Fig. 2b).

The main results of the presented study may be summarised in two points. Firstly, the mid-level jet is an important feature, which is often related to severe thunderstorm development over the Mediterranean. Secondly, the presence of this signature enables to apply 7.3 µm channel WV imagery in diagnosis of mid- to low-level thermodynamic environment favourable for intense convection.

IV. AKNOWLEDGMENTS

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