Forschungszentrum Karlsruhe
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[1]Institut für Meteorologie und Klimaforschung, Universität Karlsruhe/Forschungszentrum Karlsruhe, Postfach 3640, 76021 Karlsruhe, Germany, Samiro.Khodayar@imk.fzk.de

Initiation of precipitating convection based on data analysis

[1]Khodayar, S., [1]Kalthoff, N.

I. INTRODUCTION AND MOTIVATION

Thunderstorms, and precipitation associated with deep convection are an important ingredient in many high-impact events such as flash floods. Such events are highly localized but predicting where such storms will break out is a challenge. The goal of the Convective Storm Initiation Project (CSIP) is to increase the understanding of the initiation of convective storms. The CSIP field campaigns were performed during the summers of 2004 and 2005 in the south region of the UK. This area is characterized by an intermediate level of orography together with nearby coastlines. Furthermore, the maritime nature of the British climate and the absence of major mountains mean that the convective instability and capping inversions are often quite weak on convective occasions.

The IOP5 29 June 2005 is used as example for this work.

On this day showers in the CSIP area are observed by 12:00 UTC. The showers became widespread slightly later than 12:00 UTC within the CSIP area but they did become intense enough to form a band of heavy precipitation extending east-west across Britain. Because of this heavy rain, some flash flooding occurred in Oxfordshire (Fig.1).

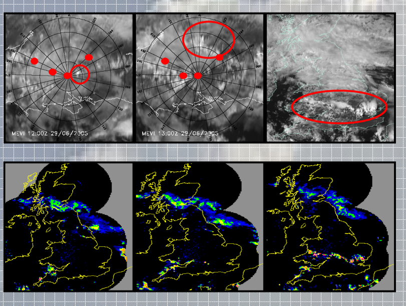


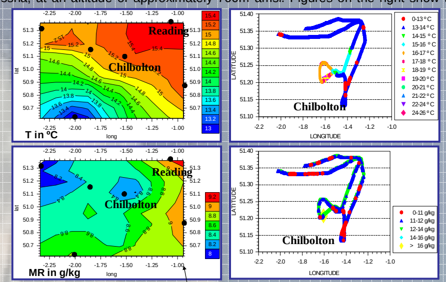
Fig. 1: Meteosat Second Generation (MSG) satellite image (top) and radar rain-rates (bottom) at 12:00,13:00 and 15:00 UTC on 29 June 2005.Range rings are centred on the Chilbolton radar and shown at 25 km intervals. Positions of the radiosonde sites are indicated by red dots (west to east are Bath, Larkhill, Chilbolton and Reading).

II. BOUNDARY LAYER CONDITIONS

Which meteorological parameter shows the main variability in the Boundary Layer, T, q?

Making use of the data at 12:00 UTC from the six radiosonde stations located in the investigation area (black dots in the figure to the left-top/bottom), the spatial distribution of temperature and moisture are interpolated in the CSIP area (left top/bottom). On this day two flights took place in the CSIP area, the first by an instrumented Dornier-128 towards the west of Chilbolton and the second by an instrumented Cessna, towards the north-east of Chilbolton. Temperature, water vapour, pressure, radar height above ground and upwelling longwave irradiance were measured at one second resolution by instruments on the Cessna, at an altitude of approximately 700m amsl. Figures on the right show the temperature in ℃ (right-top) and mixing ratio in g/kg (right-bottom), along the Cessna flight track. As expected the small scale horizontal variations in the boundary layer can not be resolved by the network of radiosondes. However, aircraft data did provide direct observations of the small scale moisture and temperature horizontal variations in the boundary layer.

We can conclude that the humidity field shows the main variation in the Boundary Layer.



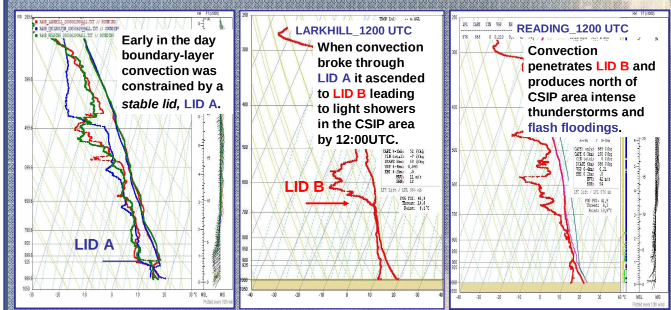
Flight (10 min—36 km)	Mean	Maximum	Minimum	STDEV
Temperature (in ℃)	15.44	16.01	14.45	0.27
Mixing ratio (in g/kg)	9.15	11.64	6.9	0.87

IV. THE ROLE OF THE LIDS

A lid is a stable layer phenomenon. It is characterised as a **layer of warm, dry air beneath potentially colder air in the middle and upper troposphere.** It is observed in many pre-storm environments. It can be quantified making use of the Lid Strength Index (LSI). The evolution and later removal of a lid can determine where and when convective outbreaks occur. According to an experimental threshold defined by Carlson et al. (1980), the most favorable conditions for the convective storm occurrence is the presence of a lid with a strength in the order of 1 to 2 ℃.

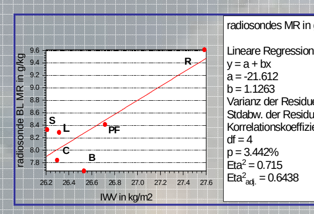
1℃ < LSI < 2℃ → **Heat and moisture trapped below the lid accumulate during the day, and serve as a fuel for future thunderstorms.**

On the 29 June 2005 the temporal and spatial evolution of the lids determine the timing and location of the convective outbreaks.



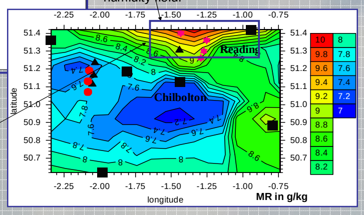
III. INTEGRATED WATER VAPOUR FROM GPS VS. WATER VAPOUR MIXING RATIO FROM RADIOSONDES

A correlation is made between the water vapour mixing ratio (g/kg) from the radiosonde stations, at some characteristic level in the boundary layer and the Integrated Water Vapour (IWV in kg/m²) from the GPS, assuming that the maximum proportion of water vapour in the atmosphere is located in the lower troposphere.



$MR = -21.612 + 1.1263 * IWV$

Comparing the mixing ratio spatial field obtained by interpolation between the radiosonde stations and the one calculated using the correlation between the IWV and the radiosonde mixing ratio data, one may notice how appreciable is the difference in the structure of the humidity field.



A clear indication of the area where convection develops is observed.

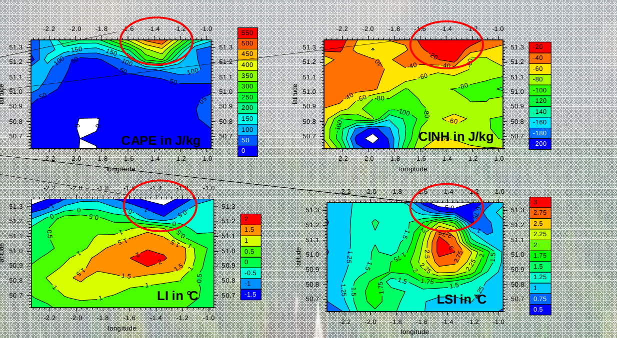
V. HYPOTHESIS

Recommendable that both the LID index and the Lifted index be evaluated jointly.

Regions where deep convection is predicted should be limited to regions of negative lifted index and outside the 2.0 lid contour.

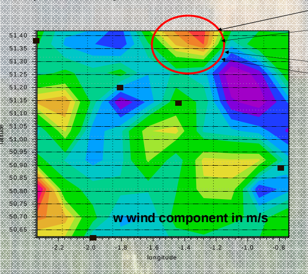
VI. CONVECTIVE INDICES AND CONVECTIVE INITIATION

A combination of radiosonde data, aircraft observations (Dornier-128 and Cessna), Automatic Weather Stations (AWSs), SYNOP stations and Global Positioning System data (GPS) are used to analyse the CSIP IOP5, 29 June 2005. From the original radiosonde interpolated temperature field and the humidity field obtained from the correlation between the radiosonde moisture field and the IWV (GPS), the following convective indices are calculated; the Convective Available Potential Energy in J/kg (top-left), the Convective Inhibition in J/kg (top-right), the Lifted Index in ℃ (bottom-left) and the Lid Strength Index in ℃ (bottom-right). From those fields and according with our hypothesis the more likely area for the initiation of convection is the area with higher CAPE, lower CINH, most negative LI and lower LSI.



VII. CONCLUSION

- Temperature, moisture or wind inhomogeneities in the order of 10 km² are required for convective outbreaks.
- Location and timing of the initiation of convection depends critically on the structure of the humidity field in the planetary boundary layer.
- A combination of radiosonde data and GPS humidity data can be used to estimate the location of primary initiated convective cells.
- Regions where deep convection is predicted should be limited to regions of negative LI and outside the 2.0 lid contour.
- The process of overcoming the lid controls if, where, and when storms occur.



A combination between the spatial distribution of the convective indices calculated and the large scale vertical wind field (m/s), from the 12 km resolution Mesoscale Met Office Model, help us in a more accurate determination of the area where the convection initiates.

VIII. REFERENCES

Browning, K., Blyth, A., Clark, P., Cosmeier, U., Morcrette, C., et al., 2006a: The Convective Storm Initiation Project, *Bull. Am. Met. Soc.*, Submitted

Carlson, T. N., R. A. Anthes, M. Schwartz, S. G. Benjamin and D. G. Baldwin, 1980: Analysis and prediction of severe storms environment. Bull. Amer. Meteor. Soc., 61, 1018-1032.

Schaedler, G., 1989: Triggering of atmospheric circulations by moisture inhomogeneities on the Earth's surface. *Boundary-Layer Meteorology,* 51 1-29.

Weckwerth T. M., 1999: The effect of Small-Scale Moisture Variability on Thunderstorm Initiation. *Mon. Weather Rev.*,128, 4017-4030