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Clear-air radar observations of the evolution of the capping inversion prior to convective intiation

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1 Introduction

Clear-air radar data collected during the Convective Storm Initiation Project (Browning et al., 2006) are analysed to study the evolution of the boundary layer before the initiation of convection. Clear-air echoes are due to changes in the atmospheric index of refraction. These occur where there are strong gradients in temperature or humidity (Battan, 1973). The inversion at the top of the boundary layer is characterised by an increase in temperature and a decrease in humidity (e.g. at 740 mb in Fig. 1).

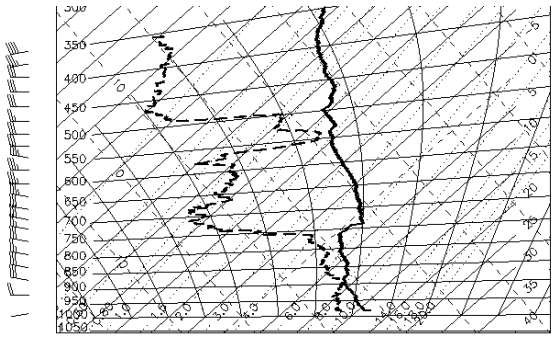

Fig. 1. Tephigram for the radiosonde launched from Bath at 1100 UTC (around 60 km from Chilbolton and less than an hour from when the data shown in Fig. 3 was collected.

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2 Scanning technique

In order to better detect these weak shallow clear-air echoes at long range, the elevation scan rate was decreased at low elevation. Figure 2 shows the change in elevation as a function of time during one range-height indicator (RHI) scan. The elevation scan rate is increased at higher elevation to keep the total time taken to collect each scan constant.

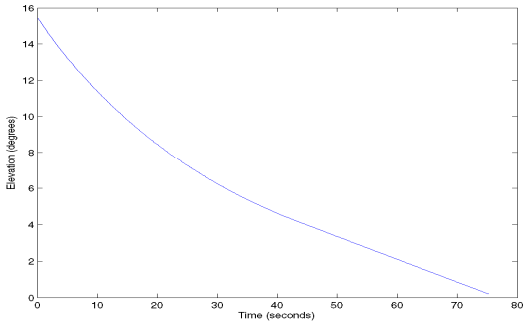

Fig. 2. The elevation scan-rate is elevation dependent. The slower scan-rate at low-elevation leads to better detection of weak signals at low altitude and long range.

3 Clear-air reflectivity

The inversion often shows up as a thin layer of weak reflectivity in the RHIs performed using the 3 GHz, S-band, radar mounted on the 25 m antenna at Chilbolton in southern England (Fig. 3). The height of the clear-air echoes measured by the radar is consistent with the height of the inversion seen in radiosonde data (Fig. 1).

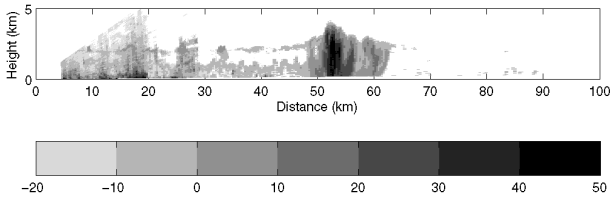

Fig. 3. A range-height indicator (RHI) of radar reflectivity showing clear-air echo from the inversion at the top of the boundary layer (e.g. at a height of between 2 and 2.5 km at ranges between 10 and 50 km)

4 Analysis method

The scanning sequence consists of 20 RHIs around 18 degrees of azimuth apart (Fig. 4).

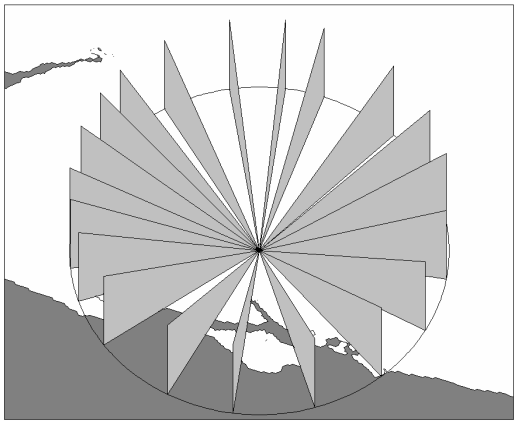

Fig. 4. The radar scan sequence comprises 20 RHIs 18 degrees in azimuth apart.

For each RHI, the height of the clear-air echo can be taken as the height of the maximum in reflectivity within the thin clear-air reflectivity layers (Fig. 5)

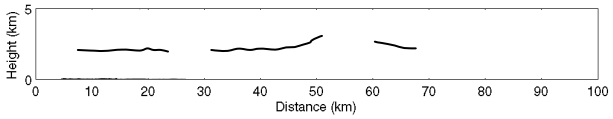

Fig. 5. Analysis of the height of the clear-air reflectivity echo.

By measuring the height of the clear-air echo as a function of azimuth and range, from a series of 20 RHIs, it is then possible to construct a map of the height of the inversion (Morcrette et al., 2006). The inversion is of particular interest from the point of view of convective initiation as it acts as a lid, preventing the development of convection. A detailed picture of the structure of the capping inversion and its evolution in time has been constructed (Fig. 6) and is compared to data from the 1.5 km grid-length version of the Met Office Unified Model (Fig. 7). The similarities between the model and the observations are encouraging. The model correctly simulates the spatial and temporal evolution of the lid and correctly forecast the breaking of the lid which leads to the development of a cluster of heavy convective showers.

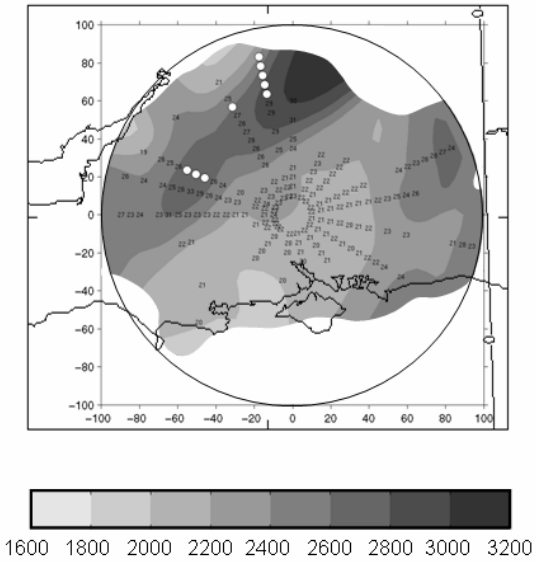

Fig. 6. Analysis of the height of the inversion derived from 20 clear-air radar vertical cross-sections.

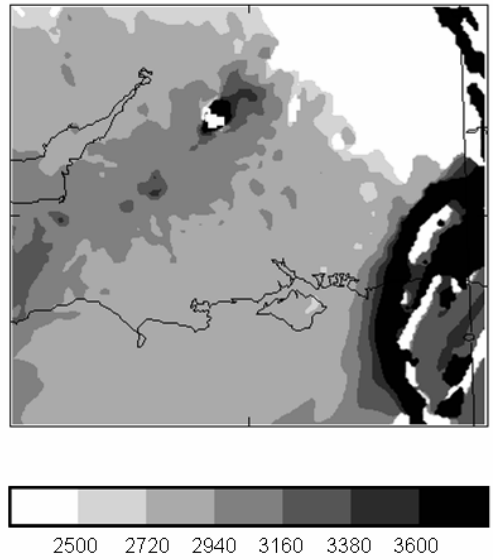

Fig. 7. Height of the inversion from the 1.5 km version of the Met Office Unified Model.

References

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