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DOPPLER AND POLARIZATION MEASUREMENTS OF CLEAR AIR ECHOES AT CHILBOLTON

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1. INTRODUCTION

Clear air observations with microwave radars are a common occurrence (Battan, 1973, Wilson and Weckworth, 1993). The observations are mainly during the summer season in convective boundary layers. Although it is sometimes a sensitivity challenge to distinguish these weak echoes, it gives an opportunity for meteorological observations at times other than the normal rain observations. This has led to research in boundary layer convection and convective rolls, and studies of the movements of birds and insects.

2. OBSERVATIONS

The 25 metre antenna of the Chilbolton Advanced Meteorological Radar (51.6°N, 1.3°W) gives high sensitivity in a 0.25° beam at S Band. The low frequency and high sensitivity lends itself to clear air observations. Example cases from the Doppler Radar Observations Project of 1998 were given in Kilburn et al. (1999). A different case has been studied from the campaign, specifically 12 August 1998. The case has associated velocity data giving information on the dynamic structure, which has in turn been modelled.

Figure 1 shows results of a vertical scan through the atmosphere due North at 9:13UT. The radar reflectivity (Z in dBZ) in the top panel shows plume-like structures with the radar return coming from the top of the boundary layer and entrained high refractive index air pulled down at the edges of plumes. The results from a PPI (not shown) show that they are not isolated plumes but consistent wind parallel lined structures relating to convective rolls and possibly cloud streets. The differential reflectivity (Zdr) is the ratio between the reflectivity in the horizontally polarized channel to that in the vertically polarized channel. High Zdr can reveal the presence of insects or particulates as these are generally highly anisotropic targets. In this case, the Zdr is around zero indicating the targets are isotropic and must be from Bragg scatter from inhomogeneities in the refractive index at half the radar wavelength. At the same time, the high resolution visible satellite imagery from 12:30 UT shows that cloud streets were visible on that day indicating that there could be contributions to the echo from clouds forming in the updraft regions of convective rolls.

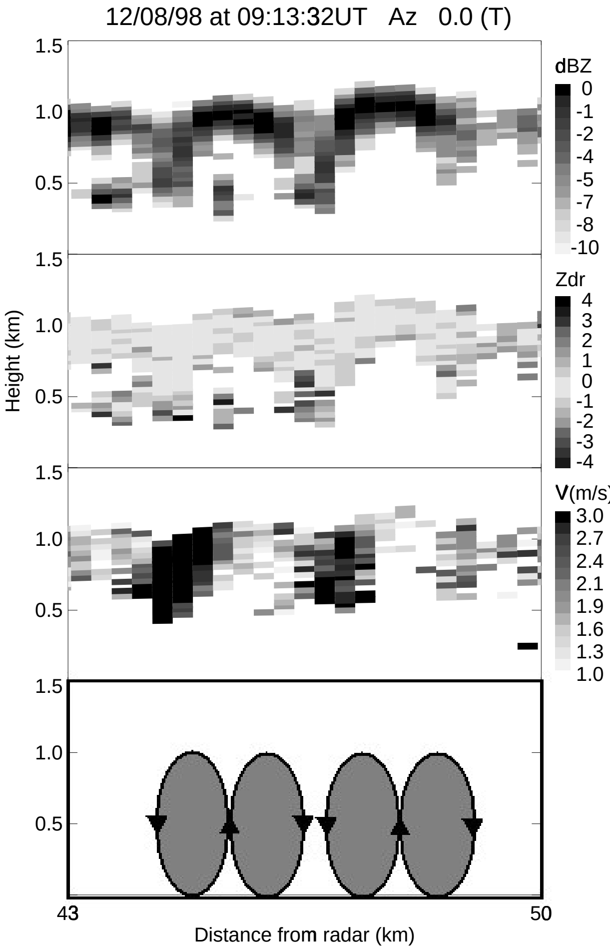

Figure 1. Reflectivity, polarization and Doppler results from clear air observations on 12 August 1998, with a schematic representation in the bottom panel.

The Doppler velocity (v in m/s) identifies regions of convergence and divergence in the convective structure. In this case, positive velocity is towards the radar and the whole structure is drifting towards the radar at 2 ms^{-1}. The near edges of the rolls are

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moving towards the radar 1 ms^{-1} faster than the background wind and the far edges are moving towards the radar 1 ms^{-1} slower. The observations are consistent with the schematic representation in the bottom panel.

3. MODELLING

In order to further understand the processes involved in the formation of the convective structures, simulations of the convective boundary layer have been performed for 12 August 1998. The model used was the UK Met Office boundary layer model named Blasius. Two major changes have been made to the model in order to simulate the diurnal evolution of the boundary layer: a radiation code and a simple surface model.

The topography was a 100 km by 100 km area in which the Chilbolton radar is located with a horizontal resolution of 1 km. A 10 km deep domain was chosen with a stretched vertical mesh of 30 points. An artificial Rayleigh damping layer was added to the top half of the model domain so that upward propagating wave energy was damped to negligible amplitudes when it reached the upper boundary, minimizing reflection.

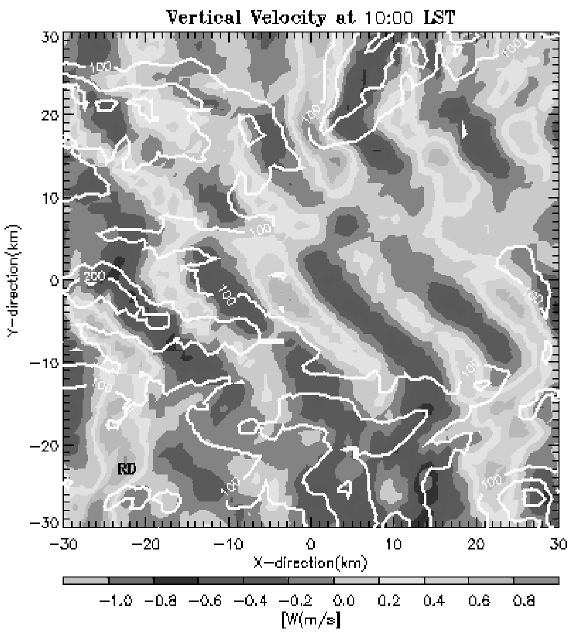

Figure 2 Plan view of vertical velocity modelling results at 09:00 UT on 12 August 1998.

The boundary conditions imposed around the simulation domain were the following. At the top boundary, the vertical velocity was zero, while zero vertical fluxes were assumed for horizontal wind components; the no-slip condition was applied at the lower boundary. The lower boundary conditions for temperature and humidity were provided by our surface model. Lateral boundary conditions were periodic. The model was initialized by the sounding profiles at 18:00 UT from a radiosonde station which is located in our model domain.

A horizontal slice of the atmosphere, 1000 m from the surface is shown in Figure 2. The results are at 10:00 local time, corresponding to 09:00 universal time. The location of the radar is marked by RD while the topography is represented by the white contour lines. Note that only the results over a 60 km by 60 km inner region of the model domain are shown. The wavelength of the vertical velocity variation is about 8 km as compared to the 3 km wavelength in Figure 1. More radiosonde and supporting data will be used to try to find the reason for the difference in a campaign planned for Summer 2001.

4. CONCLUSIONS

Clear air radar echoes are often seen in the summer boundary layer with the Chilbolton radar. A case from 12 August 1998 has been analysed which shows convective roll structure in the return from the top of the boundary layer. The polarisation parameter suggests the return was from turbulent backscatter although cloud echoes from cloud streets could have contributed. The velocity data clearly showed the convective structure. Modelling reproduced the convective rolls and the reason for the difference in wavelength needs investigating further.

ACKNOWLEDGEMENTS

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