Overview of Convective Storm Initiation Project (CSIP)

Carol Halliwell
Met Office JCMM, UK

Motivation

Severe convective storms can lead to flash flooding and strong winds. With increasing amounts of damage being caused by flooding and winds the problem of forecasting convective precipitation becomes an important one. Unfortunately, the forecasting skill for heavy convective showers and thunderstorms is currently very low, with the forecast accuracy of a mesoscale model being strongly dependent on the accuracy of the forecast of the initial development.

Very little theoretical or observational research has been done on the *initiation* of precipitating convection in the UK. With this is mind, a major project is underway in the UK which aims to address the problem of forecasting convective storms by studying the mechanisms leading to the initiation of moist convection.

CSIP

The aim of the Convective Storm Initiation Project (CSIP) is to conduct a special observational programme involving a consortium of seven university groups along with groups from the Met Office, UK. The most poorly understood aspect of forecasting convection is the initiation of new convective cells and the questions that are being asked during this project are:

(i). **What are the localized perturbations in the boundary layer that trigger new cells?**
Candidate processes include horizontal convergence and locally enhanced uplift directly associated with orography, land-sea contrast and land-use heterogeneity, as well as variability in temperature and moisture due to variations in surface characteristics and soil moisture, which lead to variability in boundary-layer convection and conditional instability.

(ii). **What are the mesoscale forcing processes in the troposphere that create regions sensitive to triggering?**
These will include mesoscale vortices and dry intrusions leading to split frontal structures and regions of conditional instability.

(iii). **How do local modifications of the atmosphere by previous convective cells influence or even dominate over the other perturbations?**
Convective clouds produce cold pools with associated lifting, as well as tropospheric moisture anomalies and transient static-stability variations due to convectively generated gravity waves.

The project is split into two phases. In Phase 1 a field campaign will be conducted over southern England in the summer of 2005. The data gathered in this field campaign will then be used in Phase 2 to develop and understand the processes associated with the initiation of precipitating convection and to evaluate and improve the performance of high-resolution and data assimilation techniques.

The field campaign is centred on the radar at Chilbolton in the south of England. Figure 1 shows the location of Chilbolton and the instruments that will be used in the project, many of which are operated by the University Facility for Atmospheric Measurements (UFAM). A key feature of the campaign is the new 1275 MHz clear air radar which, on convective summer days, will be capable of observing to a range of 60km, small-scale boundary layer features such as thermals, as well as the horizontal variations in wind speed and direction. The UMIST Cessna aircraft will also be available to gather data above potential regions of interest. The aim is to observe and statistically characterise the variations in convergence, wind shear, virtual temperature, water vapour, stratification etc. in the lower troposphere.

The data from the field campaign will be used to validate and develop the Met Office's mesoscale numerical weather forecast model. This model is now run routinely, for case studies, with a horizontal grid length of 1km and at this resolution deep convective clouds are represented explicitly rather than through parametrization. A High Resolution Trial Model (HRTM) Project is underway in JCMM to test the performance of the mesoscale model at high resolution. The model configuration, shown in Figure 2 is a 1km grid length domain, centred on Chilbolton and nested inside a 4km grid length domain, which is in turn nested inside a 12km grid length domain. The 12km and 4km domains have the standard 38 vertical levels and convection is parametrized using the Gregory-Rowntree convection scheme (although a limiter is applied to the mass flux in the 4km domain to allow more explicit convection). The 1km domain uses 76 vertical levels and no parametrized convection. Simple prognostic ice microphysics is used in all domains with prognostic rain at 4km and 1km. New data assimilation techniques are also being tested.

Preliminary results from a pilot project

In order to help the CSIP team plan for the three month campaign in 2005 and to highlight any potential problems a pilot project was conducted in July 2004. The team was fortunate to gather data during several events ranging from showers initiated at the head of gust fronts to the early stages of development of a large-scale system that produced significant precipitation in the Midlands. A description of one of the interesting events follows.

On the 6th July 2004 cloud streets were observed streaming from coastal headlands in southern England. These well defined lines of cumulus were well correlated with coastal and orographic features. Figure 3 shows evidence of sea breeze convergence, with the clouds aligned with the coast. A comparison of the observed cloud and the convergence of the 10m wind in the T+9 4km forecast shows the correlation between the cloud and coastal and orographic features. The 4km model was also able to capture well the location of the onset of convective precipitation, which was associated with a particular region of convergence. Other case studies have shown that the 4km grid length model, with the adjustment in the convection scheme to allow more explicit convection, gave a better indication of the likely accumulations of precipitation than the 12km grid length model, where the convection was parametrized.

The network of instruments allowed a closer look at the structure of the convection. Figure 4 shows the instantaneous reflectivity (dBZ), radial velocity (m/s) and spectral width (m/s) obtained from the radar, capturing three cells of light rain (Rayleigh echoes) below a cumulus cloud system (Bragg echoes). The continuous scanning of this radar can also give a picture of the development of convection.

At first glance the convection appears to be correlated with coastal and orographic features but a more in depth study needs to be done to establish the roles of lifting by orography, elevated heating over orography, frictional convergence (especially at the coast) and land/sea contrast.

The results from this project will greatly improve our understanding of the initiation of convection and thus improve the accuracy of forecasts of the initial development of heavy convective showers. This will then lead to significant improvements in the ability to forecast flooding and severe winds that are associated with storms.

For more information on CSIP go to **http://www.env.leeds.ac.uk/csip**

Acknowledgements

Peter Clark, Cyril Morcrette, Ed Pavelin, Nigel Roberts.

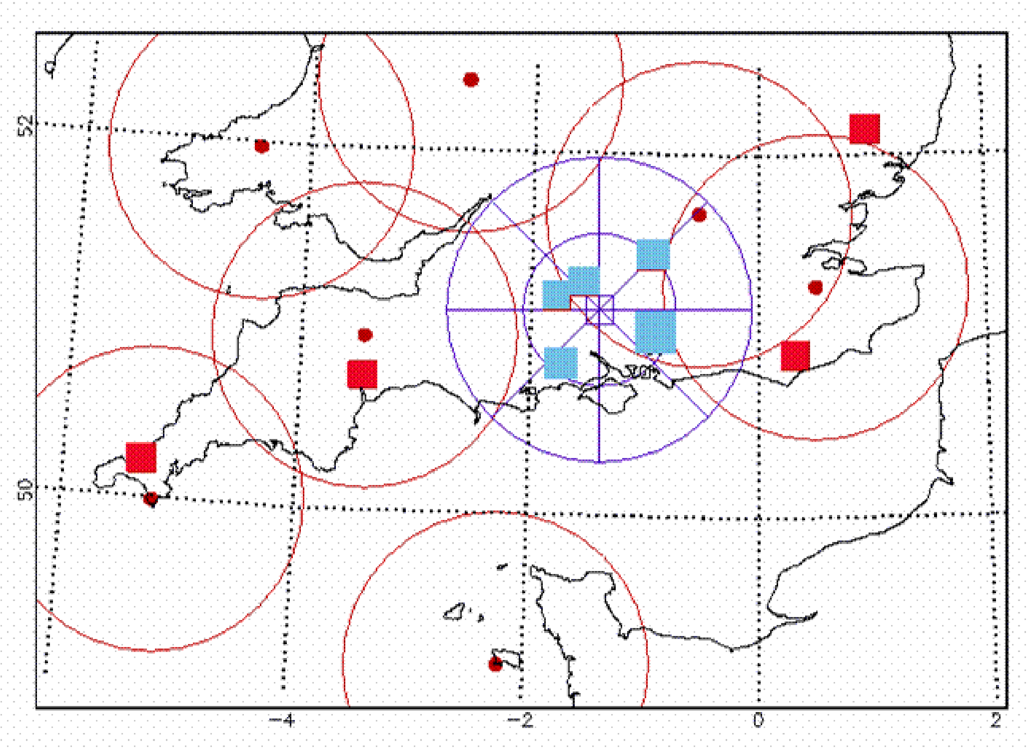

Figure 1: Position of ground based instruments in the field campaign. The key is as follows: Chilbolton radars - dark blue square with range rings; Met Office radars - red dot with range rings; UFAM instruments - blue filled squares; Met Office wind profilers – red filled squares.

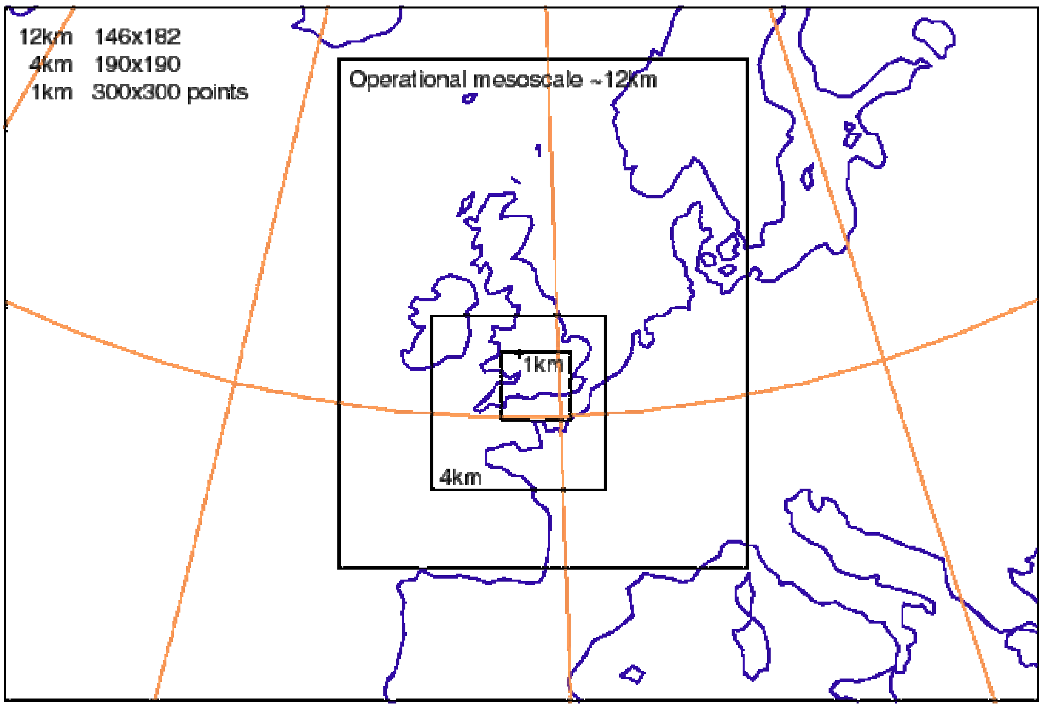

Figure 2: Configuration of High Resolution Trial Model (HRTM)

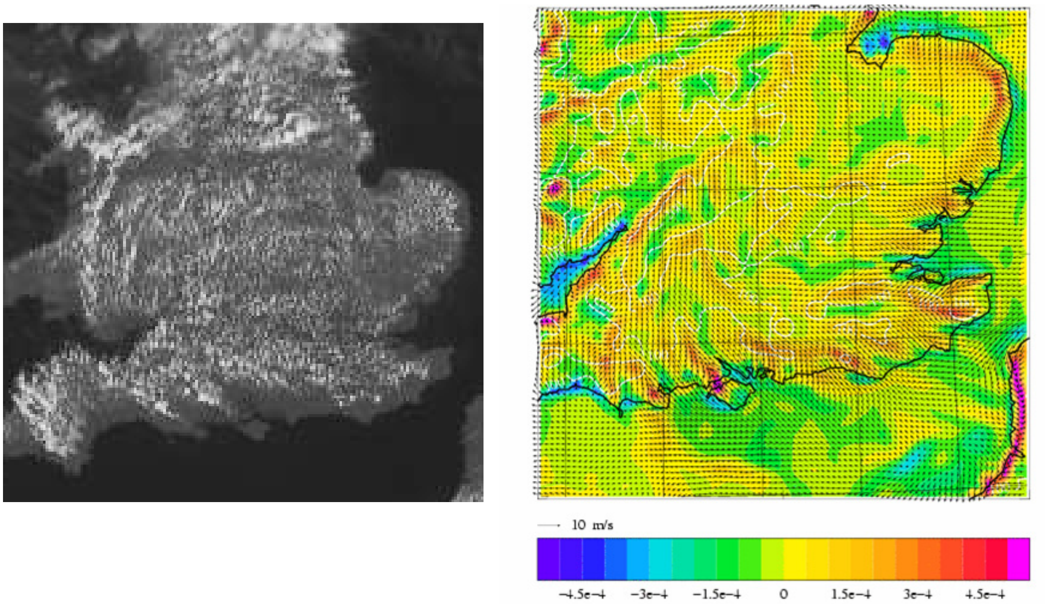

Figure 3: Left frame shows Meteosat Second Generation high resolution visible image from 12UTC on 6th July 2004. Right hand frame shows the convergence of the 10m wind at the same time from the T+9 4km forecast.

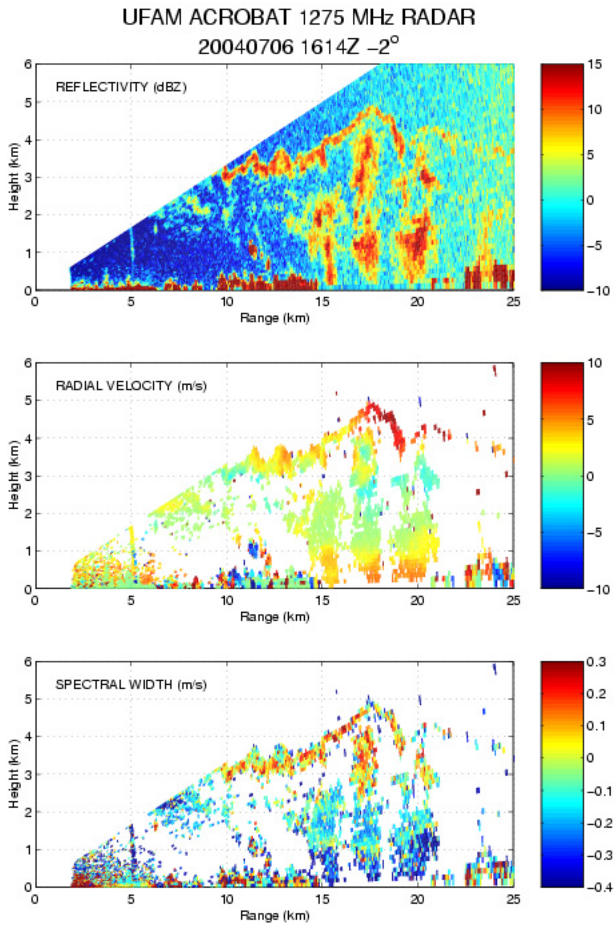

Figure 4: Reflectivity, radial velocity and spectral width obtained from clear air radar on 6th July 2004 at 1614Z