Correlating video meteors with GRAVES radio detections from the UK

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The area of meteor ablation layer illuminated by the GRAVES radar is low on the horizon from southern UK. A number of simultaneous video meteor and radio detections suggested that it was possible to record common events despite the unfavorable relative positions. This was investigated further to see what the constraints are and whether there is any prospect of obtaining useful data.

1 Introduction

Wilcot lies some 700km from the GRAVES radar but most of the region illuminated by the radar at 100km altitude is just above the horizon, although much of it is obscured by vegetation and buildings. A spectacular example of bright meteor coinciding with a strong radar echo is shown in *Figures 1a and 1b* . This meteor burned up far from the active area and the simultaneous detections could be down to chance, especially during a shower when the frequency of strong echoes is much greater.

2 Equipment

Video

Six video cameras are operated from the Wilcot site as part of UKMON. These use standard Watec 902H Ultimate cameras fitted with f1.2 lenses. The field of view is approximately 60 degrees and the cameras are arranged to provide coverage from the horizon up to an elevation of 40 degrees in all directions. The meteors are recorded with the SonotaCo UFOCapture program running on two PCs, processed files are uploaded to the UKMON server every few days.

All the capture machines are synchronized via the internet every 30 minutes using Dimension4 software, which keeps a log of corrections made. Typical corrections are less than 0.1 second but can approach 0.3 seconds.

Radio

The antenna is a horizontally mounted home-made Yagi based on a design by Derek Hilleard[1]. It has an estimated -3dB beamwidth of ~70 degrees. This feeds a Funcube Pro+ dongle running on a Windows 8 laptop. Spectrum Lab software processes the signal to produce 2D waterfall plots which are saved every 30 seconds and uploaded to the S.P.A.M[2] server.

The large distance from GRAVES means that aircraft reflections are rare, so a relatively simple Spectrum Lab script, based on a suggestion by Andy Smith, is sufficient

Figure 1a – Video capture of a very bright Perseid.

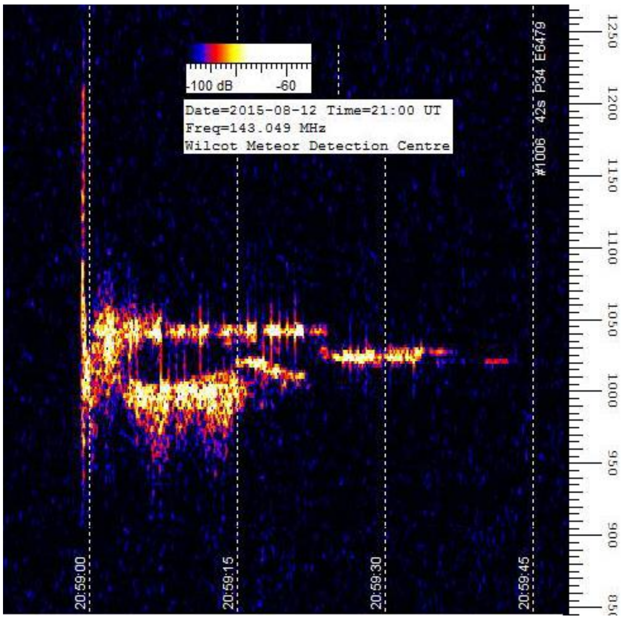


Figure 1b – Composite from Spectrum Lab output.

to automatically detect and log events. It compares the signal in a 200Hz band with the noise level each side of that. When a significant spike is detected in the observed band the intensity is recorded across ten narrow frequency bands centered on the peak frequency. This is accumulated at 0.1 second intervals until the signal falls

[1] http://www.britastro.org/radio/projects/Antennas_for_meteor_radar.pdf.
[2] http://www.merriott-astro.co.uk/spam2D.htm.

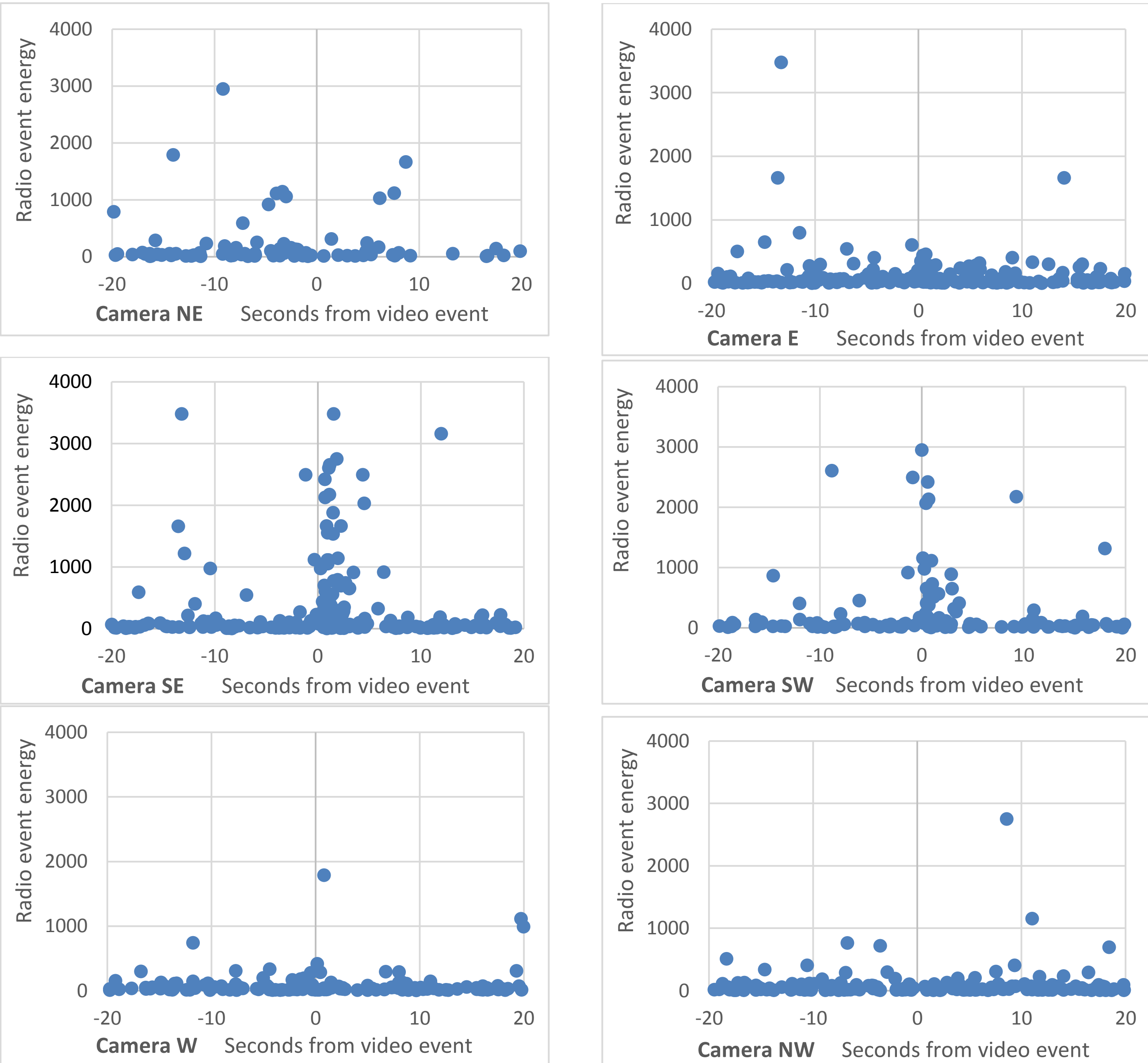
below a threshold determined by the current noise level. The total provides a measure of the overall energy reflected by the event, in arbitrary units. Details of each event are recorded in a log file and stamped on to the waterfall plots. The script was adapted to cope with varying levels of interference and produces relatively few false positives.

3 Analysis

A total of 21010 radio events and 3076 video events were collected over a six week period in July–August 2015. Approximately 500 events from each camera were compared separately with the full list of radio events.

'Mcsv' files produced by the UFOAnalyser program and logs from the Spectrum Lab script were combined into Excel spreadsheets and sorted into time order. For each video event the time difference was calculated between the preceding and following radio events. Further sorting identified radio events within a few seconds of the video time. Plots of the total energy of radio events against time difference with the video event are shown in *Figures 2a to 2f*. The radio event energy is in arbitrary units, the higher the number the stronger the event.

Generally there is a fairly even spread of low energy events along with a scattering of more energetic events. Radio events with a negative time difference precede the video event and therefore cannot be related. Even allowing for the duration of the meteor, timing errors and signal fluctuations, events more than a few seconds afterward are also unlikely to be related Cameras SE and SW point in the general direction of the area covered by GRAVES and show significantly more energetic events at the expected time. Cameras E and W were unlikely to record as much because of the antenna direction. Cameras NE and NW point away from GRAVES and serve as controls to give an indication of the rate of false matches As a final check Camera SE was reprocessed after 100 seconds had been subtracted from the radio timings, the spike disappeared confirming that the method was not introducing spurious matches. (The very energetic event in *Figure 1* matched to 0.3 seconds, but was omitted from the SW plot to keep the scaling consistent).



Figures 2a, 2b, 2c, 2d, 2e, 2f – Plots of received radio energy against time difference with nearest video event.

4 Results

A lower cutoff of 500 on the energy scale was chosen to help distinguish likely match candidates from the general noise. A time difference of up to one second before and five seconds after the video time was allowed for timing errors, meteor duration and signal variations. This produced 52 candidate events.

The video capture and waterfall plots for the candidates were checked to confirm that they were meteors. The capture files were then processed in UFOAnalyzer to produce a ground plot of where the individual meteors were observed. For a single station this is only an estimate but is sufficient for the current purpose.

Figure 3 shows a plot of the various components overlaid on a map of the UK and France. The camera coverage (yellow and green), takes into account gaps caused by obstructions on the horizon. The receiver coverage (red) is a simplistic estimate based on a beam width of 70 degrees, but in practice it is not as sharply defined as the cameras. The estimated GRAVES radar coverage (blue) is for an altitude of 100km. The white dots represent the positions of the candidate meteor events within 3 seconds of the video time. Grey dots represent events up to a second before or more than 3 seconds after the video time.

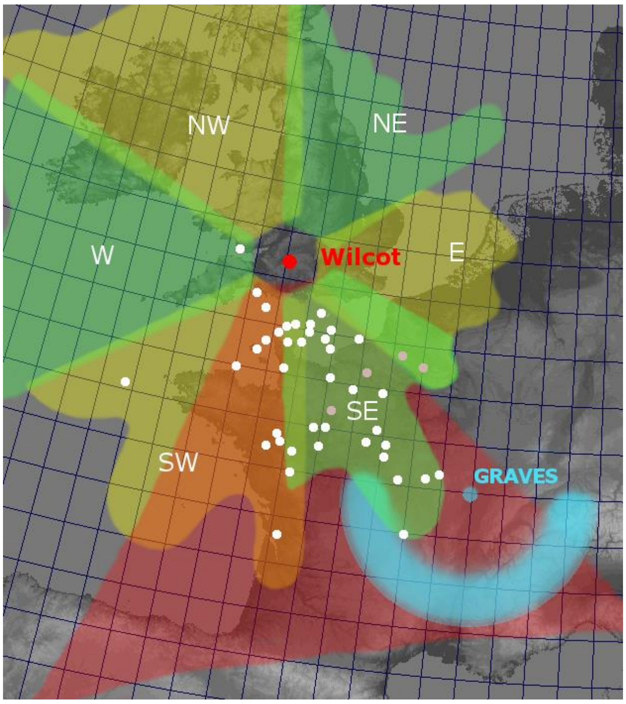


Figure 3 – Plot of matched meteor locations, camera and radio coverage.

5 Discussion

Some guides for radar meteor observation[3] suggest that, for meteor purposes, the main detection area of the GRAVES radar is limited by the narrow beam width to southern France – the blue area in *Figure 3*. This is not a problem for radio observation but a southerly location with a low horizon and clear weather would be needed to detect the same meteors by video.

On that basis Camera SE was the only one that was expected to have a reasonable chance of detecting the same meteor events, if they occurred in or close to the blue area. *Figure 3* shows that there are many matching events recorded by Camera SE much closer to the receiver. These are far outside the main area apparently covered by GRAVES and are to the side of the main beam directions.

Camera SW camera also recorded some matching events, although these tend to be on the eastern edge of its field of view. Both events for camera E were more than three seconds after the video and of lower confidence. The single event on camera W is within one second of the video time and was well above the plane of the antenna, so a radio detection cannot be ruled out.

The mutual detections found here may be limited by the antenna direction – different directions would need be tried to find out whether detections can be made outside the area shown in red on *Figure 3*

The detection of events much closer to the receiving station than expected confirms that there is enough energy radiated outside the main GRAVES beam to allow for both radio detection and direct visual observation of the same meteors from much of the UK. Radar echoes are being detected from a much larger volume of atmosphere than just the blue area, which could affect any estimates of meteor rates based that assumption.

The small number of possible false matches on cameras pointing away from GRAVES and outside the antenna coverage is encouraging. Even the simple method used here can give useful results and could be refined to search for weaker matches. It should be possible to use data from multiple stations, provided the combined accuracy of the radio and video data is better than one second.

Some of the brighter video events in the active area identified here were not detected by radio, but more data is needed to see if this is a general pattern.

6 Conclusion

Video meteor captures and radar reflections of the GRAVES radar from the same meteor event can be successfully matched from Wilcot. This is not limited to the brightest events or to events that occur over southern France. Stations further north in the UK, where the main GRAVES detection area is below the horizon, should also be able to match video meteors and radio events from this transmitter.

[3] http://www.britastro.org/radio/projects/MeteorRadarSDRReceiver.pdf