

ANCILLARY OBSERVATIONS FOR A FIRST ECHO STUDY: FIVE MILLION ANTENNA CAMERA DIGITAL IMAGES

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1. INTRODUCTION

An antenna-mounted digital still camera system (AntCam) was installed on the NCAR/EOL S-PolKa radar for the **RICO** experiment. **RICO** (Rain In Cumulus over the Ocean) was, in part, an experiment to study the initial formation of rain in shallow cumulus over the undisturbed ocean. S-PolKa, a dual frequency (S-band and Ka band) polarimetric radar (Keeler, et al. 2000 and Farquharson, et al., 2005), was fielded on the island of Barbuda, the most northeastern island in the Antilles chain. S-PolKa had an unobstructed view in all directions out to a maximum radar range of ~155 km over the open ocean. S-PolKa's role was to establish a climatology of rain clouds for the region, to study the time-to-formation of first precipitation from that region's small cumulus, and to further study the full life-cycle of individual cumulus cells.

As part of "first echo" studies, it was required that S-PolKa be outfitted with an antenna-mounted camera. In the past, analog video cameras have been infrequently used in such a capacity, producing adequate but not optimal results. Analog image quality was often impacted by electronic radio frequency interference, image resolution was limited (video quality of 352x240 pixels), and linkage of images to particular times and scan directions was labor intensive. Antenna rotation made it difficult to compile a visual time history of a moving, changing cloud system.

Reported here is one solution to the rotating, antenna mounted camera problem. The solution consists of a properly chosen camera, and the development of web-based software for filtering/selection and display of specific camera images.

2. THE CAMERA

The camera chosen for the AntCam was an Axis 211 Network Camera. The camera has good low-light performance, but excellent bright light tolerance, allowing it to scan the sun without damage. Additionally, the camera used progressive scanning for image creation, which reduced any tendency for creation of jagged edges when the camera is in motion. Table 1 lists some relevant camera characteristics.

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Figure 1. Photo showing network camera enclosure mounted to side of Ka-band radar; Ka radar is mounted to large S-band dish. Arrow indicates camera; Ka dish is 0.7 m diameter (28 inches). Photo courtesy J. Hurst.

The antenna camera was enclosed in a weather-proof housing. The camera was a full network webcam, communicating via ftp with computers in the operations van through a simple, wireless network connection. The wireless network used 802.11b protocol, operating at 2.4 GHz. In order to avoid the potential for shadowing of the two wireless network ends by the rotating antenna, the decision was made to place both ends of the wireless in the S-Pol vertical tube (the antenna vertical support structure). The S-Pol waveguide is also enclosed within the tube, and S-Pol operates at high power at 2.8 GHz. No interference was noted in the wireless network (packet receive statistics remained solid), and no images were lost.

The camera was set to a horizontal field of view of approximately 27°. Images were transmitted at a rate of 2 per second, or one for typically 4° of antenna

motion. Images were created with the camera timestamp in the upper left corner of each image. (It was attempted to slave the camera clock to the local S-Pol computer network using NTPD, but the synchronization was not established properly, resulting in time drift of the date/time imprinted on the images.)

The camera was carefully aligned with the main S-band radar beam by ensuring that a nearby hard target was centered in the camera image when radar return was at a maximum (estimated accuracy is about +/- 2° for both azimuth and elevation).

The quality of the camera images can be gauged from figure 2, an image of a rainbow taken while the antenna and camera was moving at about 8 degrees per second.

AXIS 211 Network Camera	
Image resolution	640x480 pixels
Typical Image size	40 KBytes
Field of view (horiz)	27 degrees
Light sensitivity	0.75 to 500,000 Lux
Max frame rate	30 fps
Communications	ftp

Table 1: Camera characteristics, Axis 211 Network Camera.

3. THE IMAGE DATA SET

The camera was operated on the antenna from 25-Nov-2004 through 25-Jan-2005, with only four days interruption when the Ka system was removed for service. Images were collected at a rate of two per second during all daylight hours from approximately 1000 UTC through 2300 UTC. Images were saved in JPEG format with individual sizes ranging from about 25 to 45 Kbytes. Individual image files were named with date, time, and fraction of second. Over 4.8 million images were archived in a data set of approximately 120 GBytes.

4. VIEWING SOFTWARE

Intelligent review of such a large, complex image data set requires a reasonable method for filtering images according to date/time and pointing direction. Tools to enhance “trolling” ability are also desired. Issues of access to images for viewing become intertwined with those of data storage and distribution. It is also recognized that only a very small fraction of all images are likely to be reviewed, but which fraction is desired is unknowable.

Access of images through a web browser is an obvious solution to both the viewing and distribution problems. However, data set size argues for an off-line or packaged distribution method. The difficulty is in designing a viewer and accompanying data

associations (a database) that can be used in both the on-line and local modes, preferably without requiring any licensed software. Since web browsers can be directed at both on-line and local content and are familiar to all users, a browser-based approach was chosen. If content is properly designed, operation can be the same either on- or off-line.

To address the issue of the database, array constructions in JavaScript were used. JavaScript an interpreted language embedded in most browsers, and permits dynamic alteration of browser pages. Image swapping and updating can be performed reliably, giving the appearance of image animation. JavaScript can be implemented entirely “client side”, satisfying the need for off-line code. JavaScript, however, has many quirks that are “browser-dependent”, and this can result in somewhat frustrating code development, or produce a page that is not functional in all browsers (the current antenna camera browser still has issues with functionality using the Safari browser).

Figure 3 shows an example page of the antenna camera image browser. (It should be emphasized that this is still very much a work in progress, and not all illustrated features work.) The browser shows a set of time selection widgets in the upper left, followed by selection of radar scan types and scan limits. There is an accompanying radar image showing both the S-band and Ka-band reflectivity; this image is active, and selecting a point on the radar image will cause the photo for that azimuth direction to be displayed. It is further planned to add logic to allow tracking of individual radar echoes with the antenna camera.

The control buttons in the browser allow both forward and reverse play through the set of images selected with the pre-filters of the left-hand panel. Progress through the image set is shown in a relative way by the progress “lights” below the antenna cam image.

5. IMAGE DATA DISTRIBUTION

The full RICO AntCam data set is too large to maintain in its entirety on NCAR web servers, and access and perusal would likely be too slow for most internet users. Only limited samples of the image archive will be made available directly on the web. It is planned that all images will be distributed via ftp, complete with viewing code. Images will be grouped in tar archive files by day (or possibly, two tar files per day). Some small number of data requests may be fulfilled by distribution of images on DVD, again complete with code. However, perusal of images from DVD will be relatively slow as compared to perusal directly from system hard drive.

6. FUTURE WORK

The image viewing code described here is still very much a work in progress, with incomplete functionality and a need to improve reliability. Additionally, problems are still encountered with cross-browser support (a

feature of JavaScript). It is desired to improve code modularity and allow simpler configuration of image information for import to the viewer.

7. SUMMARY

The concept of the antenna camera presented here may not have widespread applicability beyond radar first echo studies. Possible other applications could include scanning lidar or an independently scanning camera with azimuth reporting.

Analysis of RICO first echoes has barely begun, and the utility of the RICO antenna cam image set is largely unknown. For RICO itself, a clutter of small cumulus and the effect of haze prevent clear imaging of many of the specific clouds that produce radar echoes. But a major obstacle to use of antenna camera images has been reduced with the creation of this viewer tool: relevant images may be selected based upon time and pointing direction, and animated for easy review.

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The views expressed in this paper are those of the authors and do not necessarily represent the official policy or position of the U.S. government. Any mention of a commercial product by name or brand should not be construed as an official endorsement of such product.

References

Further information on topics touched upon here may be found on the NCAR/EOL Web pages. See the EOL data and project pages, beginning with the URL:

<http://www.atd.ucar.edu>

For examples of the antenna camera browser and related code, as it evolves, see:

<http://www.atd.ucar.edu/rf/projects/rico2004/spol>

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Figure 2. Antenna camera image of a rainbow. Image was made while antenna was rotating at 8 degrees per second.

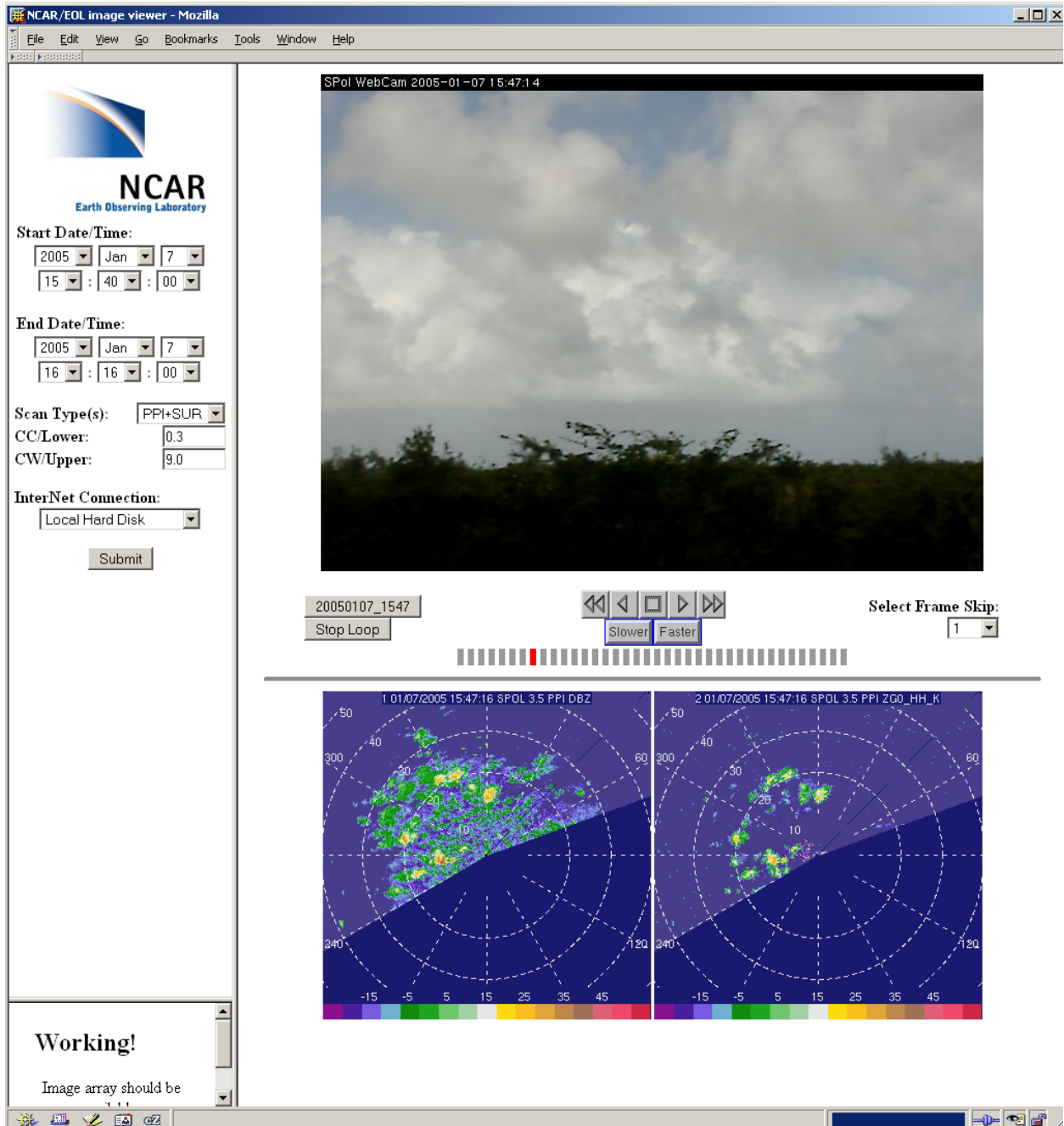


Figure 3. Static page showing layout of antenna camera image browser. The time selection widget is shown on the upper left, along with specification of scan filter criteria (scan type and angular limits). In the main panel, the antenna camera is pointed due north showing the cloud indicated by the radar display image on the bottom (S-band reflectivity on the left, Ka reflectivity in the right panel, north toward top of the radar panel).