BISTATIC RADAR NETWORKS

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1. Introduction

Bistatic multiple-Doppler radar networks provide an alternative to traditional multi-transmitter Doppler networks. Bistatic network technology has advanced considerably since the deployment of the first prototypes (Wurman et al. 1993, Wurman 1994). The current state-of-the-art is described and an overview of existing networks is presented.

2. Existing and Past Networks

Several different bistatic networks have been deployed since 1993 (Fig. 1). NCAR's network has been deployed with the SPOL radar to various locations. NCAR developed the first bistatic networks which were tested in Boulder Colorado with the CP-2 10 cm klystron radar. NCAR's network, now connected to SPOL, was tested in several field programs, including the CASES experiment in Wichita Kansas in 1997, the STEP experiment in eastern Colorado in 2000, and in the IMPROVE experiment in Washington/Oregon in 2001. McGill University, in collaboration with the University of Oklahoma and NCAR deployed a network connected to their 10-cm klystron radar, in Montreal, Quebec, Canada. The first magnetron-based network was installed at DLR in 1998, near Munich Germany, and connected to its 5-cm polarimetric radar, POLDIRAD. A magnetron-based 3-cm system was installed on Hokkaido University's ILTS radar. This system is portable and has operated in Osaka and Nagaoka, Japan and near Shanghai, China. A new bistatic network is under construction for installation on Okinawa Island, Japan late in 2001. Bistatic experiments with co-located receivers were carried out at Chilbolton, United Kingdom, but a dual-Doppler network was never operational.

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3. Magnetron-based Networks

Many radars employ incoherent magnetron transmitters. With high speed communications links, it is possible to operate a bistatic network with magnetron transmitters. Since the phase of the transmitted pulses is random, it must be measured and sent to the bistatic receivers. The bistatic receivers must defer processing Doppler data until these phases are received. Furthermore, the changing frequency of the magnetron must be sent to the remote

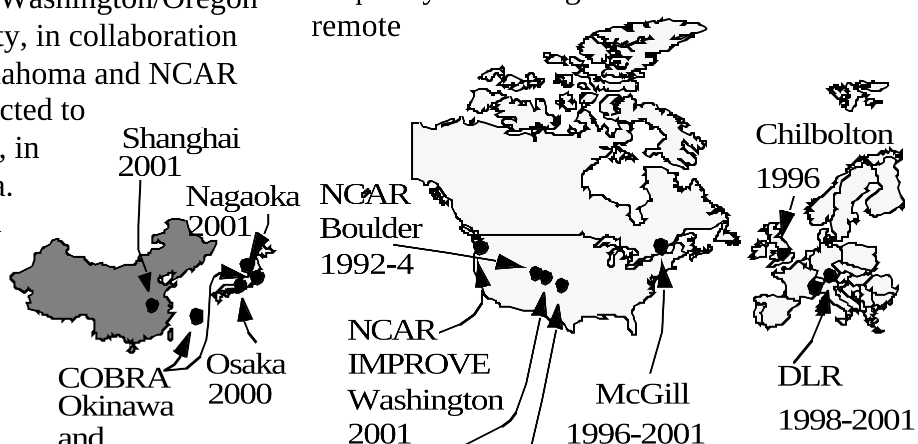


Figure 1. Bistatic Network Locations

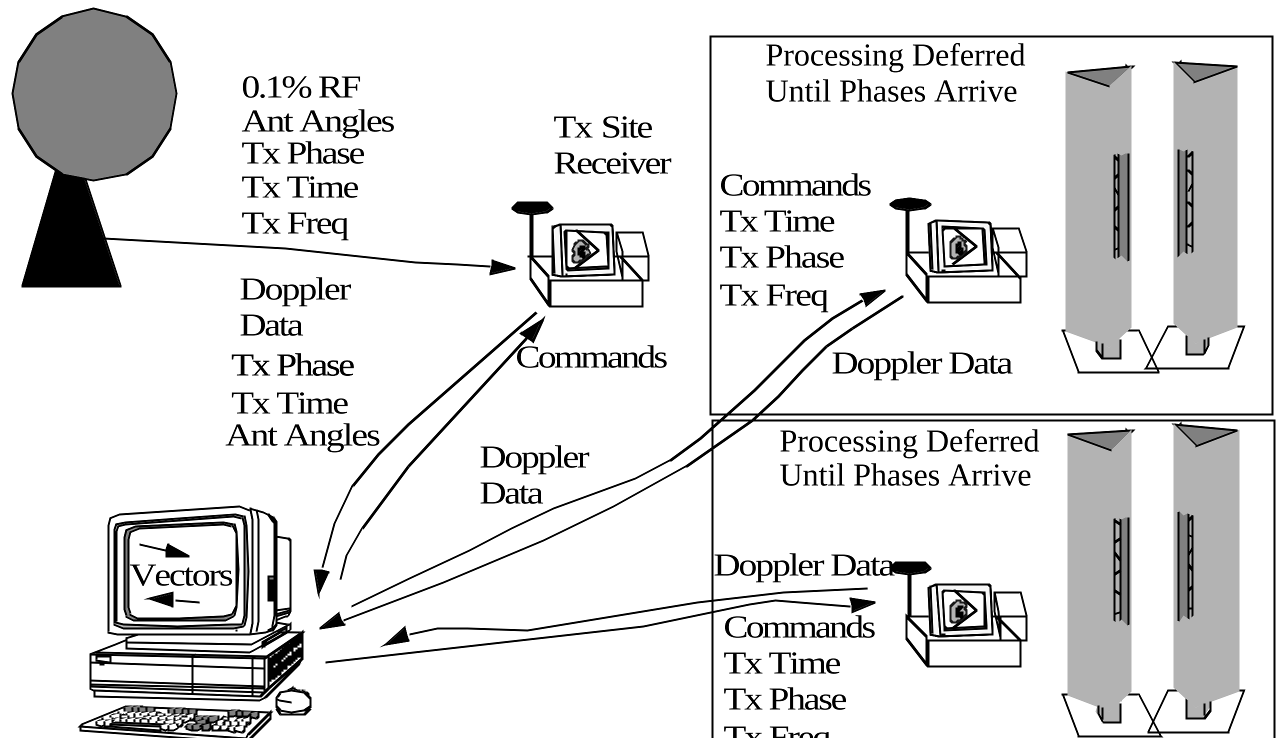


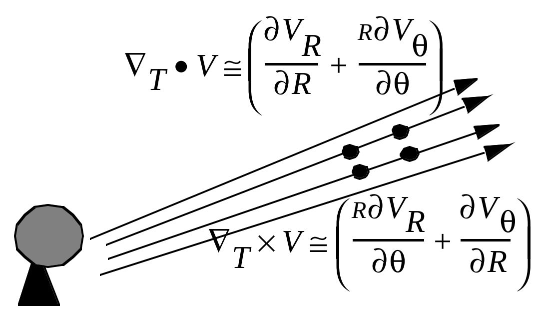
Figure 2. Magnetron Bistatic Data Flows

receivers as illustrated in Fig. 2. The first magnetron based bistatic network was established in 1998 at DLR, the 2nd in Japan.

4. Real-Time polar format processing

Most bistatic networks use a real time bistatic hub display which calculates overdetermined ("best") wind vectors from data from an array of bistatic receivers and the transmitter. Slantwise quasi-vertical vorticity and quasi-horizontal divergence are calculated on a gate-by-gate, non-interpolated basis (Fig. 3). The hub program permits remote control of all bistatic sites, enabling the automatic detection and changing of prf, gate spacing, and other parameters. An example of a snapshot from a real-time display running during the NCAR CASES experiment near Wichita Kansas during 1997 is shown in Figure 4. Note that the data is unedited and unfiltered, so that noisy vectors appear in regions where precipitation is absent or bistatic sensitivity is low.

Figure 3. Gate-to-Gate Vorticity and Divergence calculations.



5. Bistatic Antenna Switching and Scanning

The use of multiple, automatically switching, antennas was proposed as far back as Wurman et al 1993. The purpose was to retain a broad region of high sensitivity, while retaining high gain. One possible switching array is shown in Fig. 5, where a bistatic receiver is switched among various antennas depending on the elevation angle of the transmitted beams. The process is complicated since the elevation angle of illuminated volumes along a transmitted beam, as viewed from the bistatic

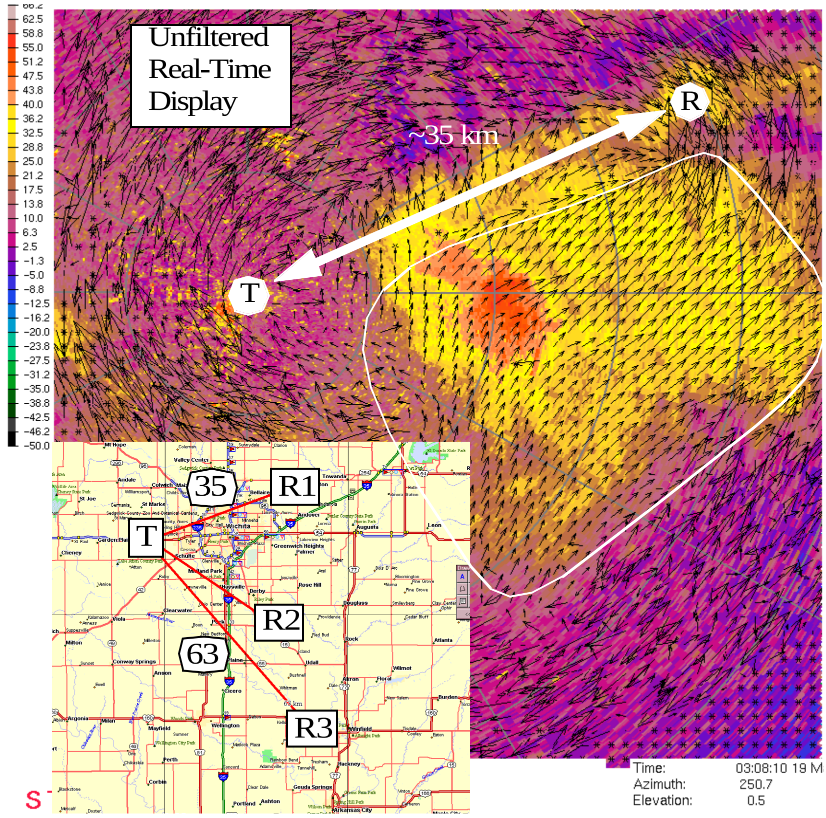


Figure 4. Snapshot of real-time bistatic data from the NCAR CASES experiment. Good vectors are only produced in region with precipitation and where bistatic sensitivity is high. Location of transmitter and 3 bistatic receivers are shown in inset with ranges to the Tx of 35-63km. dBZ shaded.

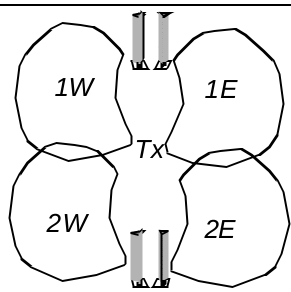


Figure 7. COBRA network geometry with antenna switching into each dual-Doppler lobe

location, varies along the transmitted beam.

Bistatic antennas could be mechanically tilted, with a changeable angle of orientation with respect to the vertical, in order to align with transmitted beams. In this fashion, a narrow fan beam bistatic antenna, with, say, a 2°-3° beamwidth in the elevation direction, and a broad azimuthal sensitivity, could be tilted (and shifted) back and forth as the transmitting antenna conducts volumetric scans, as shown in Fig. 6. This process is very different than pulse chasing, and only requires a slow movement of the bistatic antenna as the transmitting antenna scans relatively slowly through the range of azimuths.

The first implementation of a switched antenna system will be for the COBRA radar on Osaka Island, Japan. The COBRA bistatic network will employ two bistatic antennas at each of two remote bistatic receiver sites (total of 4 antennas, 2 receivers). When the transmitted beam crosses a projection of the Tx-Rx baseline, the bistatic receivers are switched from one antenna (E-W-E-W...)to the other in order to observe first one, then the other bistatic dual-Doppler lobes (Fig. 7).

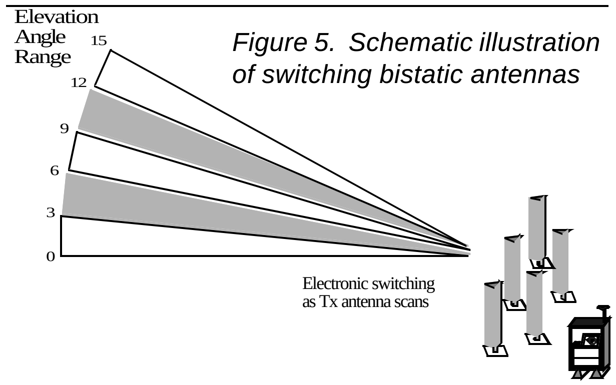
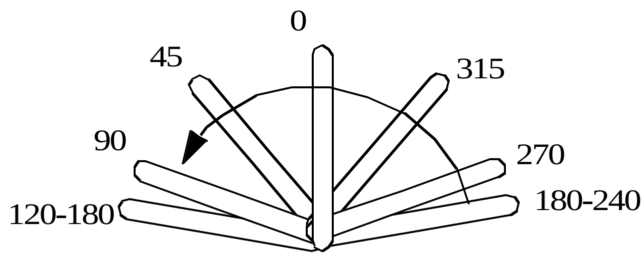


Figure 5. Schematic illustration of switching bistatic antennas

Figure 6. The slow variation of the inclination of a bistatic fan beam antenna pattern as it tracks the transmitted beam. The numbers indicate the azimuthal pointing angle of the transmitting antenna. It is assumed that the bistatic receiver is to the north of the transmitter.



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