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OBSERVATION OF HURRICANE GEORGES WITH A VHF WIND PROFILER AND THE SAN JUAN NEXRAD RADAR OVER PUERTO RICO

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1. INTRODUCTION

Hurricane Georges originated from a tropical wave, observed by satellite and upper-air data, which crossed the west coast of Africa late on 13 September. Radiosonde data from Dakar, Senegal showed an attendant 35 to 45 knot easterly jet between 550 and 650 millibars (mb). By mid-morning of the 21st an upper-level low over Cuba, denoted in water vapor imagery, was moving westward away from Georges thereby reducing the possibility of Georges moving to the northwest, away from Puerto Rico. Later in the afternoon, the shear appeared to diminish and the outflow aloft improved but Georges never fully recovered due in part to the circulation's interaction with Puerto Rico. The hurricane moved inland over Puerto Rico and weakened slightly and then moved into the Mona Passage early on the 22nd.

Over Puerto Rico (Sept. 21-22, 1998), hurricane Georges moved generally westward near 8 m/s, from its landfall on the southeast coast until it exited the island on the southwest coast and entered the Mona Passage. Its eye as seen by Doppler weather radar, described an oscillating motion, at times over the Central Mountain Range, and at other times to the south of the mountains. Between 8 PM LT and 9 PM LT (LT = UTC – 4h) Doppler weather radar imagery showed that an area of especially strong thunderstorms developed along the southeast section of the eyewall and affected the mountainous portions of the island. The estimated maximum sustained winds were of up to 51m/s, with gusts of 167 m/s, and its eye diameter ranged from 32 to 48 km.

Arecibo Observatory is located in the Northwest part of the Island. During Hurricane Georges passage, the main thunderstorm activity with heavy precipitations took place in the South part of the island on the other side of the mountain range, relative to Arecibo. The closest raingauge measurements to the Arecibo observatory was the U.S. Geological Survey (USGS) gauge in Rio Grande De Arecibo; it reported 325 mm accumulated for September 22nd (0000-2400). (Bennett and Mojica, 2000).

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2. OBSERVING SYSTEM

Unique observations with a 46.7 MHz ST radar where taken during the passage of Hurricane Georges over Puerto Rico. The measurements were carried out at VHF (46.7MHz) with a 2µs pulse, the IPP being 1ms. Due to the extreme winds, the antenna was fixed at constant zenith and azimuth angles (8.8 degrees from the vertical and about 240 degrees in the azimuth). The first 50 gates are consecutive and their sampling starts at 40 µs; the last ten gates correspond to the calibration; the sampling of this group starting at 900 µs. The in-phase and in-quadrature data are recorded without any coherent integration.

In clear air or with precipitation observations, the gate #10 of the VHF-ST radar is at a range of 9km (#20 at 12km, etc.). However, the lower gate is at 6km, which does not allow the observation of any melting level. It was then measured time-altitude variations of the radial velocity and reflectivity in the pointing directions, for heights between 5 km up to an altitude located above the cyclone top.

These measurements were part of a field experiment at the NAIC Arecibo Observatory in 1998 (a description of the campaign is given by Petitdidier et al., 1999).

The NEXRAD radar was located in the Southeast part of Puerto Rico, 76km away from the observatory. For each scanning volume sampled by the NEXRAD over the Arecibo observatory during the Georges event, time series for the height variation of reflectivity (in dBz), radial Doppler velocity (magnitudes already unfolded, for negative values corresponding with wind components from WNW, and positive values with wind components from ESE) and velocity spectral width were obtained.

Figure 1 presents a description of the radar sites, as well as the track of Georges' eye (from NEXRAD fixes).

3. RESULTS

3.1 Reflectivity

The selected period goes from 5 UTC until 10 UTC on September, 22,1998.

On the NEXRAD data, no melting layer was observed as it was expected in convective system

and hurricane rainbands. Although only the northerly part of the hurricane eye passed over Arecibo, an eye signature of a few minutes can be seen at about 4:00 UTC on 22/9/98. During the analysis period, Georges showed a predominance of its rainbands over the eastern semicircle.

For the VHF-ST data at 6:27 UTC, a vertical maxima of reflectivity coincides with a maxima in Doppler velocity and spectral width. At 7:24 and 7:42 UTC, on the other hand, maxima of reflectivity are associated with minima in Doppler velocity, and no significant variation in the spectral width occurs. Vertical band structure associated with an increase of reflectivity was also observed. Furthermore, in the 13-15km zone the reflectivity increases, corresponding probably with the upper part of (or just above) the hurricane.

3.2 Doppler Velocity

The NWS/NOAA reported a significant upper-level northerly vertical wind shear, induced by an upper-level anticyclone located over the eastern Caribbean. Accordingly, areas of large negative values in the NEXRAD Doppler velocity are observed over the upper troposphere. At the lower troposphere, the NEXRAD indicates maximum velocities over the eye wall. Some large magnitudes (about 45 m/s or more) can be located within the rainbands.

For the Arecibo VHF-ST radar, due to the pointing angle, the radial Doppler velocity is a combination of the vertical velocity, W, which may be important, and the horizontal one, Vh, by means of the relation:

$$Vr = W \cos(8.8) + Vh \sin(8.8) \quad ; \quad \text{i.e.}$$
$$Vr = 0.988\, W + 0.153\, Vh \quad .$$

As a consequence, the interpretation of the velocity variation as a function of time and altitude is not straightforward.

In addition, except for numerical model output, there were no other data to compare with our observations during the Georges passage over Puerto Rico.

4. FUTURE WORK

Further work consists in:

- Reducing the set of NEXRAD and VHF-ST data for the whole event.
- Retrieving the 3D wind field by combining NEXRAD and VHF-ST data within the method of Scialom and Lemaître (1990)

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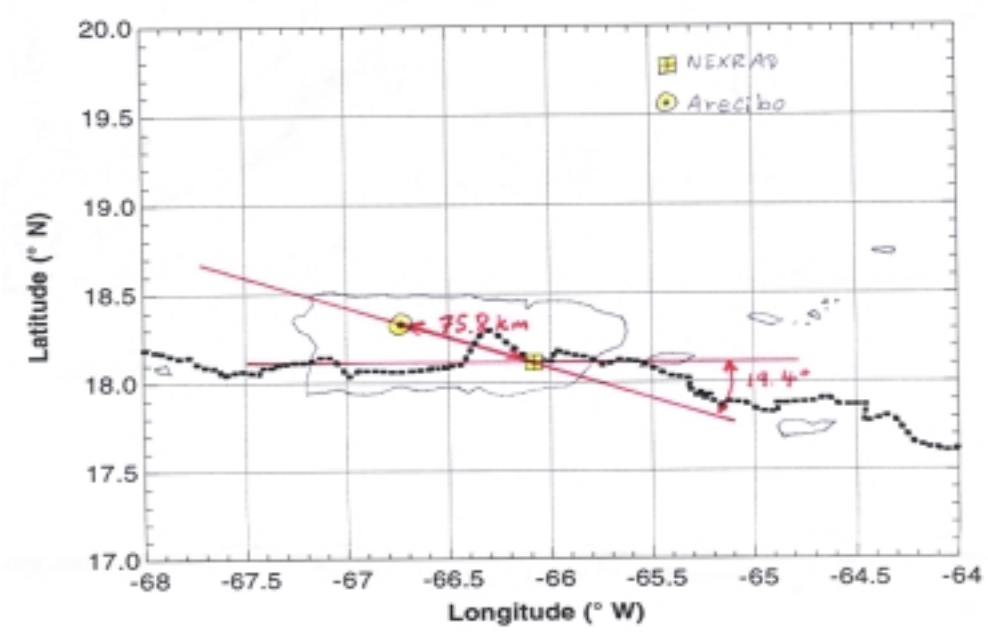

Fig. 1. Description of the radar sites and the track of Hurricane Georges' eye.