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Realtime Storm Surge Measurement with a Scanning Radar Altimeter

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I. Introduction

The NASA Scanning Radar Altimeter (SRA) was designed primarily to measure the energetic portion of the directional wave spectrum by generating a topographic map of the sea surface [1]. The SRA measurement geometry is shown in Fig. 1. The specific numbers refer to the Hurricane Bonnie landfall flight to be described shortly.

The SRA sweeps a radar beam of 1° (two-way) half-power width across the aircraft ground track over a swath equal to 0.8 of the aircraft height, simultaneously measuring the backscattered power at its 36 GHz (8.3 mm) operating frequency and the range to the sea surface at 64 positions at 0.7° incidence angle intervals. The maximum scan rate was 8 Hz during the Hurricane Bonnie flights, but it is presently 10 Hz. In realtime, the slant ranges are multiplied by the cosine of the off-nadir incidence angles (including the effect of aircraft roll attitude) to determine the vertical distances from the aircraft to the sea surface. These distances are subtracted from the aircraft height to produce a sea-surface elevation map which is displayed on a monitor in the aircraft to enable realtime assessments of data quality and wave properties.

On 24 August 1998, the SRA, aboard a NOAA hurricane research aircraft, provided the first documentation of the directional wave spectrum throughout a hurricane in open water when Hurricane Bonnie was about 400 km east of Abaco Island, Bahamas [2]. On 26 August 1998, the SRA provided the first documentation of the directional wave spectrum throughout a hurricane making landfall as Bonnie was approaching Wilmington, NC [3].

II. SRA Wave Topography Measurements

Figure 2 shows a gray-scale-coded topographic map produced from about 700 SRA scan lines as the aircraft crossed Cape Lookout (34.58°N, 76.53°W) during the landfall flight. The aircraft flight direction was from right to left in Fig. 3. The wave topography shows a dramatic spatial variation in the wave field with the waves propagating toward the northwest on the east side of Cape Lookout, and toward the north on the west side.

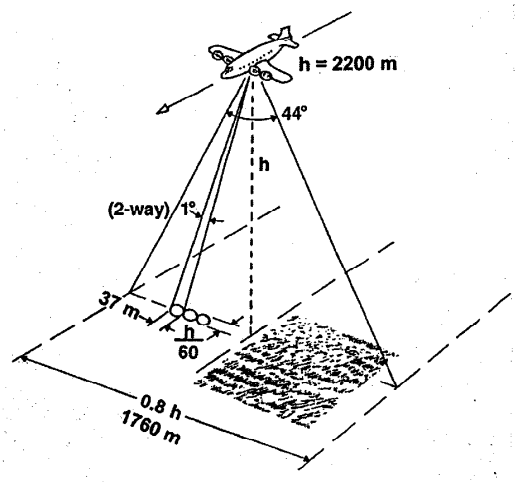

Fig. 1. Scanning Radar Altimeter measurement geometry.

Figure 3 shows five contiguous 10-km segments of SRA gray-scale coded topography on a different flight line as the NOAA aircraft headed north toward Cape Hatteras (35.27°N, 75.44°W). The waves were just starting to "feel" the ocean floor at the beginning of this data set, and the water depth decreased along the track. The waves were initially propagating toward about 335°. As the waves approached the shore, the wavelength shortened, the amplitude decreased, and the propagation direction turned toward the north and finally northeast. The surf zone began at about 6.3 km up from the bottom of the right 10 km segment. The tip of Cape Hatteras is apparent at the top of the same segment.

All the analysis described so far does not require an absolute determination of the height of the aircraft. The swath is wide enough that each scan line can be processed independently and its mean elevation set to zero.