USE OF DUAL-FREQUENCY ALTIMETER MEASUREMENTS

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The NASA altimeter aboard the TOPEX/POSEIDON satellite is the first operational dual-frequency altimeter. In addition to the nominal Ku-band (2.1 cm) transmit frequency, the altimeter interleaves a C-band (5.5 cm) signal. The primary purpose of the second radar is to provide a collocated ranging measurement to correct for ionospheric path delay in the Ku-band range estimate. Our research deals with two other topics using the TOPEX C-band measurement: impact of precipitation and near surface wind speed refinement.

Impact of precipitation

The presence of rain in the sub-satellite track can significantly degrade altimeter measurements by causing an attenuation of the backscattered signal, a change in its path delay, and a change in the sea surface roughness. Rain attenuation at Ku-band signal is one order of magnitude larger than at C-band: a new rain flag has been proposed using a simple criterion based on the detection of simultaneous departure from the normal C-Ku backscatter relationship and an excess of liquid vapor content as estimated from the TOPEX Microwave Radiometer (TMR). From this departure a rain probability index has been proposed and the results suggest that TOPEX and its follow-on may serve as a complementary sensor to SSM/I (Special Sensor Microwave/Imager) in observing global oceanic precipitation.

Our resulting rain frequency statistics show quantitative agreement with those obtained from COADS (Comprehensive Ocean-Atmosphere Data Set) in the Intertropical Convergence Zone (ITCZ). Furthermore, the non-1-synchronous orbit of the satellite makes it possible to better characterize the diurnal variation of oceanic rainfall. Moreover, attempts to determine rain cell characteristics (size, rain rate) from waveform analysis have been carried out to give a high resolution description of the rain distribution under various weather conditions (see Figure 1).

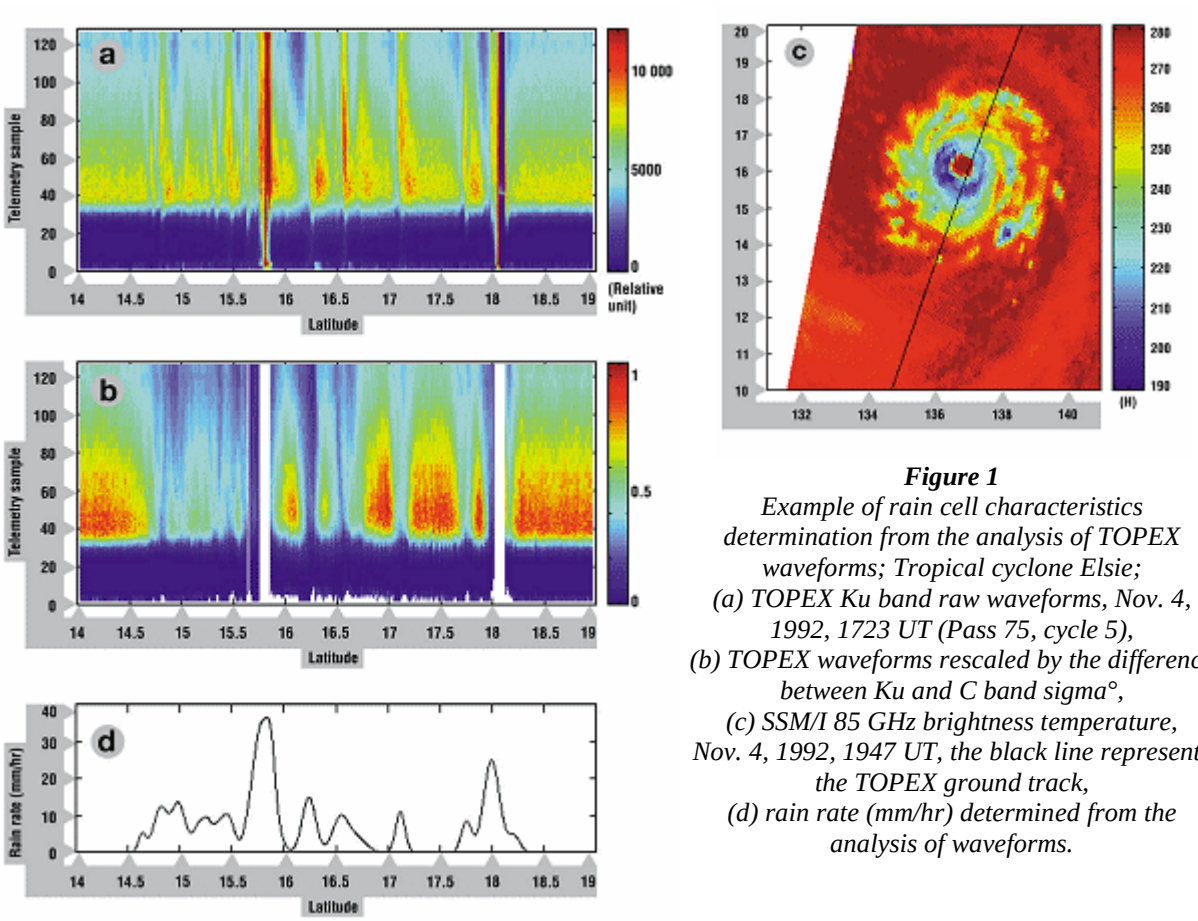

Figure 1
Example of rain cell characteristics determination from the analysis of TOPEX waveforms; Tropical cyclone Elsie;
(a) TOPEX Ku band raw waveforms, Nov. 4, 1992, 1723 UT (Pass 75, cycle 5),
(b) TOPEX waveforms rescaled by the difference between Ku and C band sigma°,
(c) SSM/I 85 GHz brightness temperature, Nov. 4, 1992, 1947 UT, the black line represents the TOPEX ground track,
(d) rain rate (mm/hr) determined from the analysis of waveforms.

Near surface wind speed refinement

A single frequency (Ku-band) algorithm is presently used to retrieve surface wind speed from the altimeter's radar cross section measurement (namely the Modified Witter and Chelton look-up table). The derived winds are in good agreement with in situ data but there is also evidence to suggest that an altimeter measurement is impacted by additional non-wind factors, the sea state degree of development being the largest contaminating factor.

The ocean surface typically comprises both local wind-waves and swell-waves and both will influence altimeter radar returns by affecting the slopes of the wave field. But long gravity waves will further modify the wind and wave coupling to enhance small gravity-capillary wave amplitude variations along their phases. Using TOPEX, our investigations demonstrate that using dual-frequency measurements directly isolates the sea surface small scale roughness signature (Figure 2). This helps to refine a near surface wind speed estimate but also to better assess the impact of small scale roughness elements on the total sea state bias.

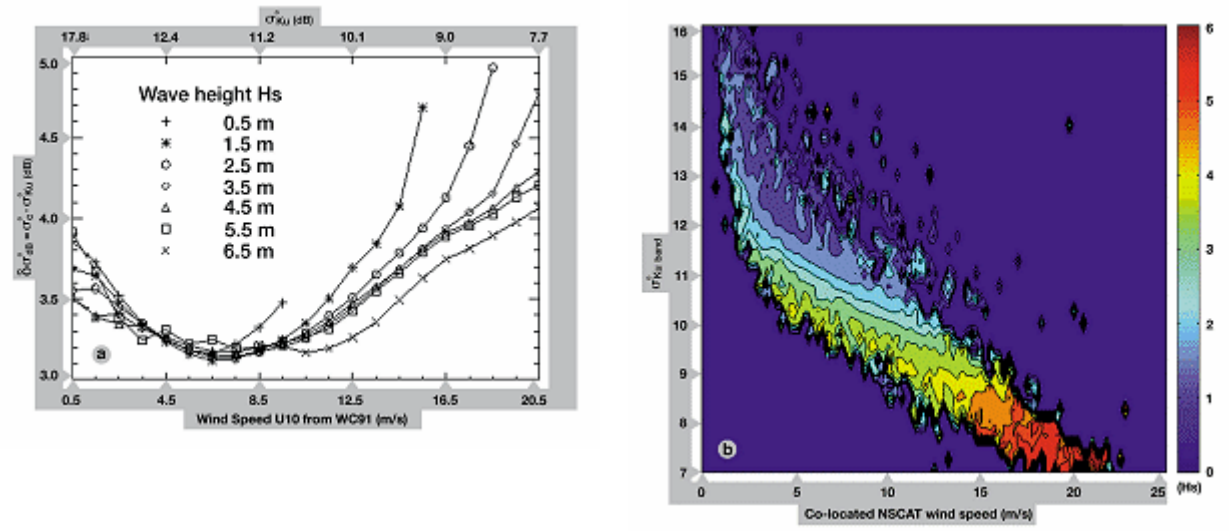

Figure 2

Illustration of sea state impact on altimeter radar cross section measurements:
(a) cross section difference dsigma°$_{dB}$ = sigma°$_{C}$ - sigma°$_{Ku}$ versus wind speed for TOPEX cycle 70. The x-axis indicates the corresponding wind speed as inferred by the Witter and Chelton (WC91) look up table;
(b) sigma°$_{Ku}$ and co-located NSCAT wind speed estimates as function of altimeter significant wave height.

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