Absolute calibration of Jason-1 and Envisat Ku-band Sigma0

N. Tran, O.-Z. Zanife
CLS/DOS, Ramonville St-Agne, France

B. Chapron
IFREMER, Brest, France

D. Vandemark
NASA GSFC, Wallops Islands, USA

P. Vincent
CNES, Toulouse, France

From a manuscript submitted in J. Atmos. Oceanic Technol. (October 2004)

Abstract-

One year of collocated, rain-free nadir Ku-band backscatter cross-section measurements from the Tropical Rainfall Mapping Mission (TRMM) Precipitation Radar (PR) and both Jason-1 and Envisat RA-2 altimeter measurements (from GDR products) have been compiled to compare the three sources of Ku-band radar cross-section. All three Ku-band measurements compare very well in term of dependencies upon model wind speed estimates and significant wave height measurements. The altimeter radars and the rain radar thus provide consistent measurements and observed biases can be rationalized as differences in the radar calibration. The precipitation radar has been absolutely calibrated using a transponder. Consequently, the relative offsets can be used to indirectly calibrate both Jason-1 and Envisat altimeter Ku-band radar cross-section in an absolute sense.

Relative calibration versus absolute calibration:

Relative backscatter calibration is sufficient for the retrieval of geophysical products (e.g. wind speed, rain flag, altimetric wave period, …).

- It provides an easy way to use early developed retrieval algorithm such as the MCW (Witter and Chelton, 1991) based on Geosat data for the wind speed.
- Relative biases range from tenths to several dB between the different altimeters.

Lack of absolute sigma0 calibration represents today a certain limitation to fully exploit this altimeter information:

- To extract quantitative information about short scale roughness using both Ku- and C-band (or S-band);
- To better combine altimeter measurements with scatterometer and radiometer ones;
- To improve our understanding of the sea state bias that is still instrument dependent;
- To quantify which part of the TOPEX 3.5 dB and Jason-1 1.74 dB backscattering inter-frequency biases is of physical origin and which part is due to the different calibration of the two frequency bands;
- To facilitate calculation of gas transfer velocity that uses altimeter frequency differing sensitivity to breaking wave statistics
- …

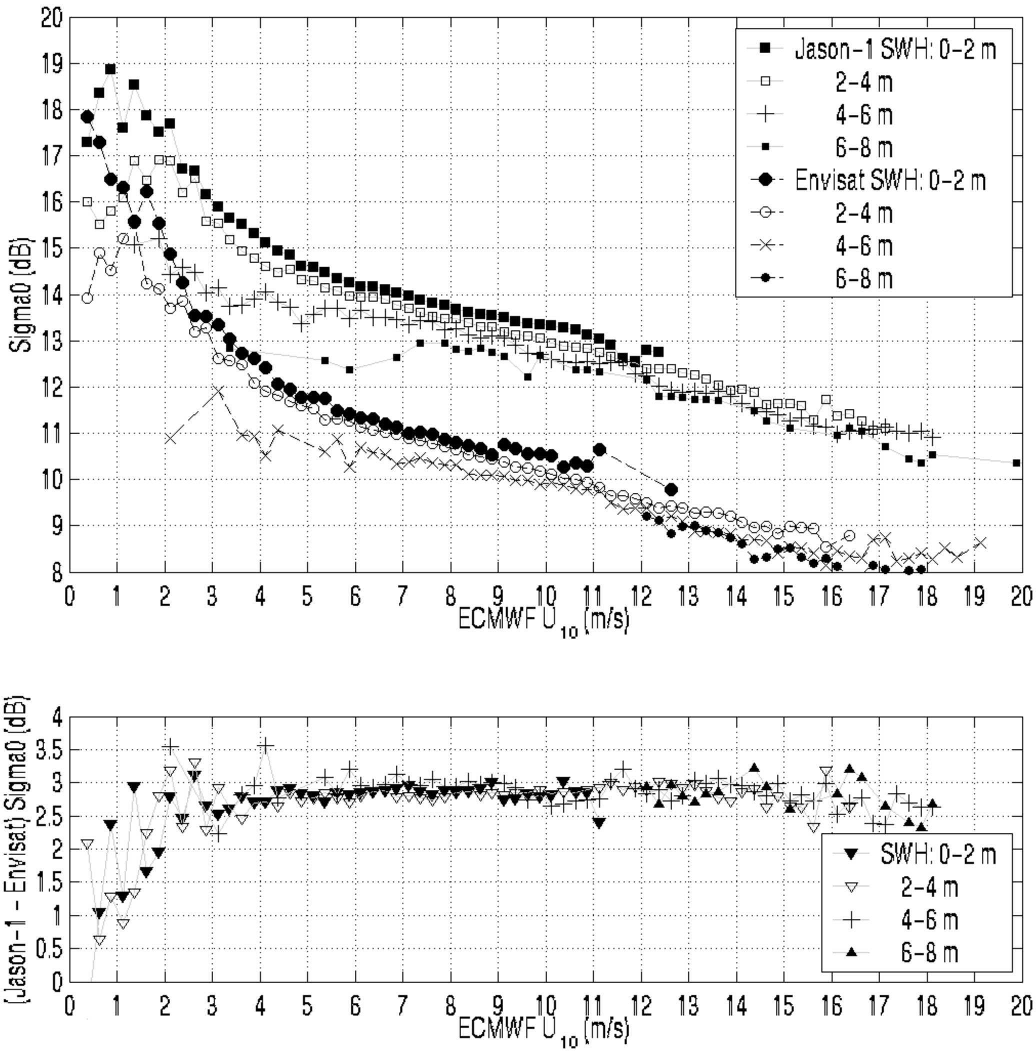


Figure 1: (top) Jason-1 and Envisat bin-averaged sigma0 as a function of wind speed for four intervals of 2 m SWH values. (bottom) Differences (Jason-1 minus Envisat) between the corresponding data plotted above. This latter displays a quasi-constant bias of +2.8 to +3.0 dB for wind speeds between 4 and 15 m/s and SWH lower than 8 m.

Both Ku-band sigma0 measurements present the same wind speed and significant wave height sensitivities.

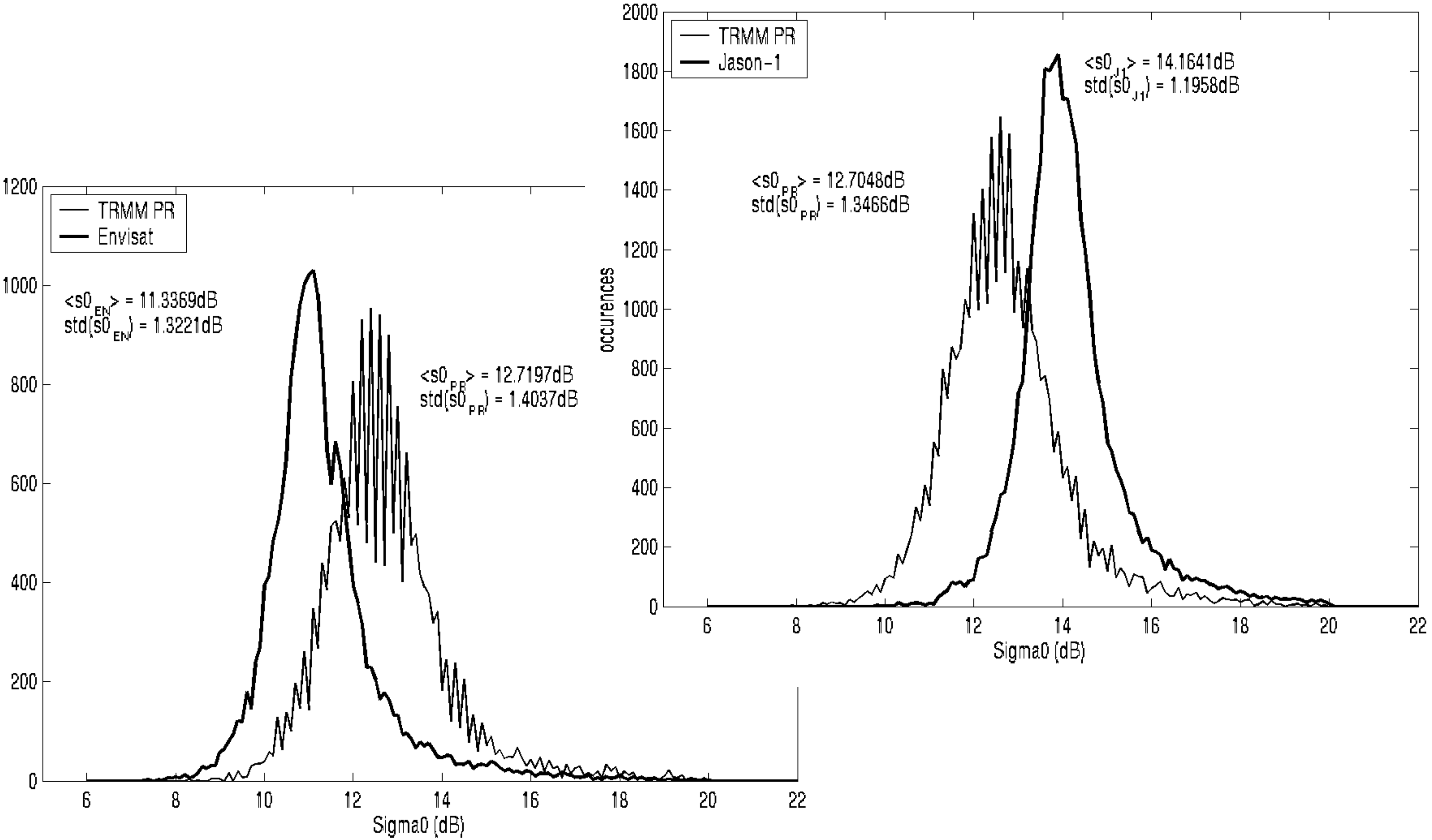


Figure 2: Histograms of collocated Ku-band sigma0 measurements from respectively (left) Envisat/PR subset and (right) Jason/PR subset by intervals of 0.1 dB. They exhibit similar dissymmetrical shape with offsets.

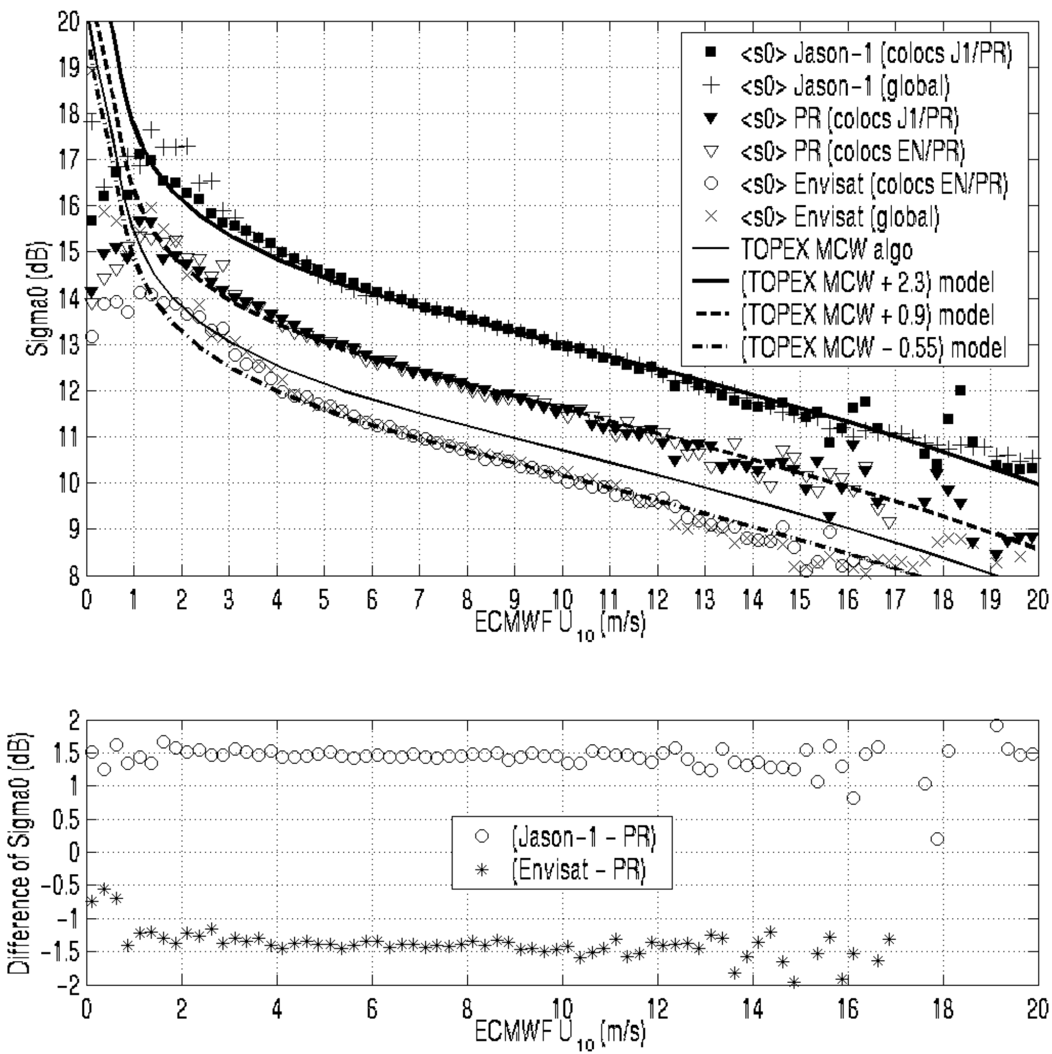
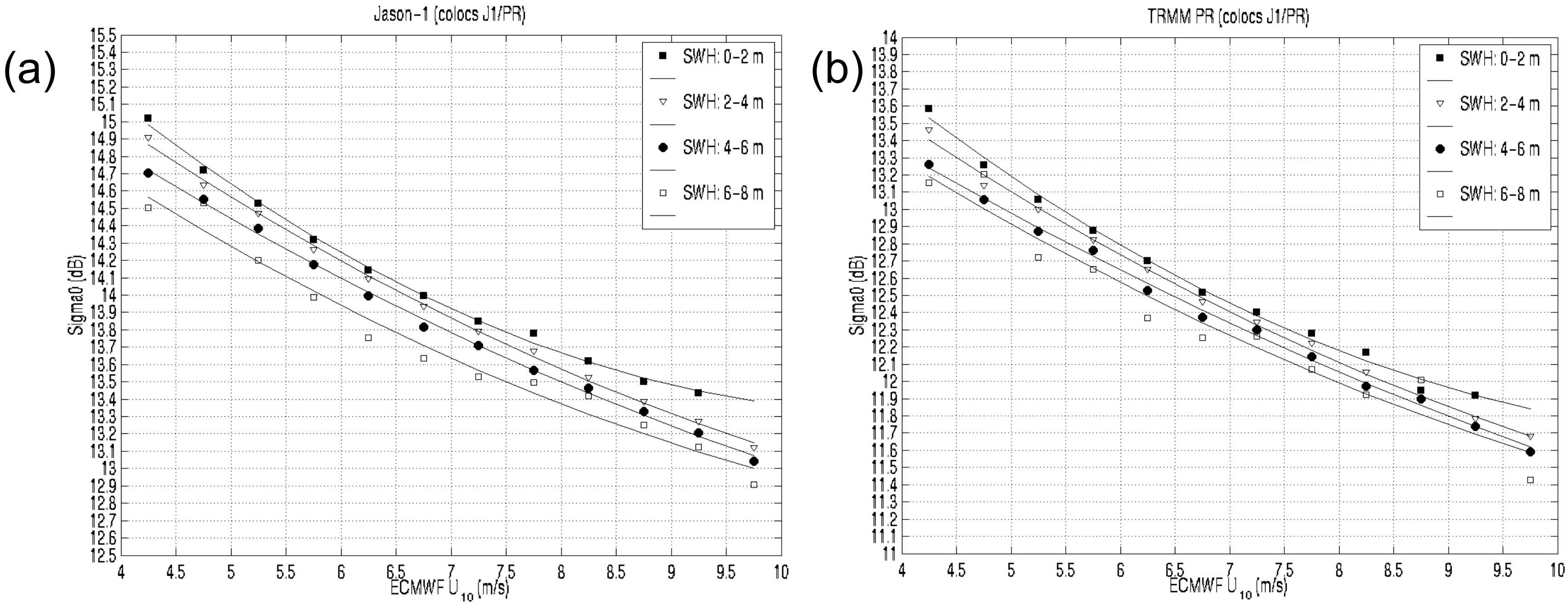


Figure 3: (top) Binned averages of Ku-band sigma0 measurements from Jason-1 and Envisat altimeters and from TRMM PR as a function of sea surface wind. The different curves represents TOPEX MCW model and this latter offset by respectively +2.3, +0.9, and -0.55 dB at all wind speed over 0 to 20 m/s interval. (bottom) Difference between respectively Jason-1 and Envisat with PR sigma0 versus wind speed from the collocated subsets. We can observe nearly constant bias of +1.4 to 1.6 dB between Jason-1 and PR data over a wind speed interval from 2.0 to 12.0 m/s. At the opposite, we have a negative bias between -1.3 and -1.5 dB for Envisat/PR crossovers between 3.0 and 13.0 m/s wind speeds.



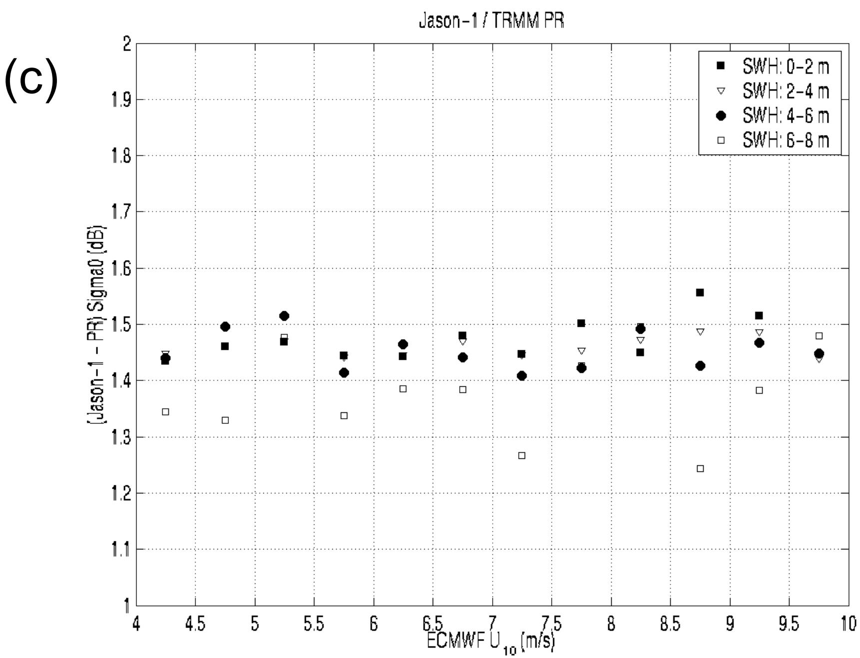
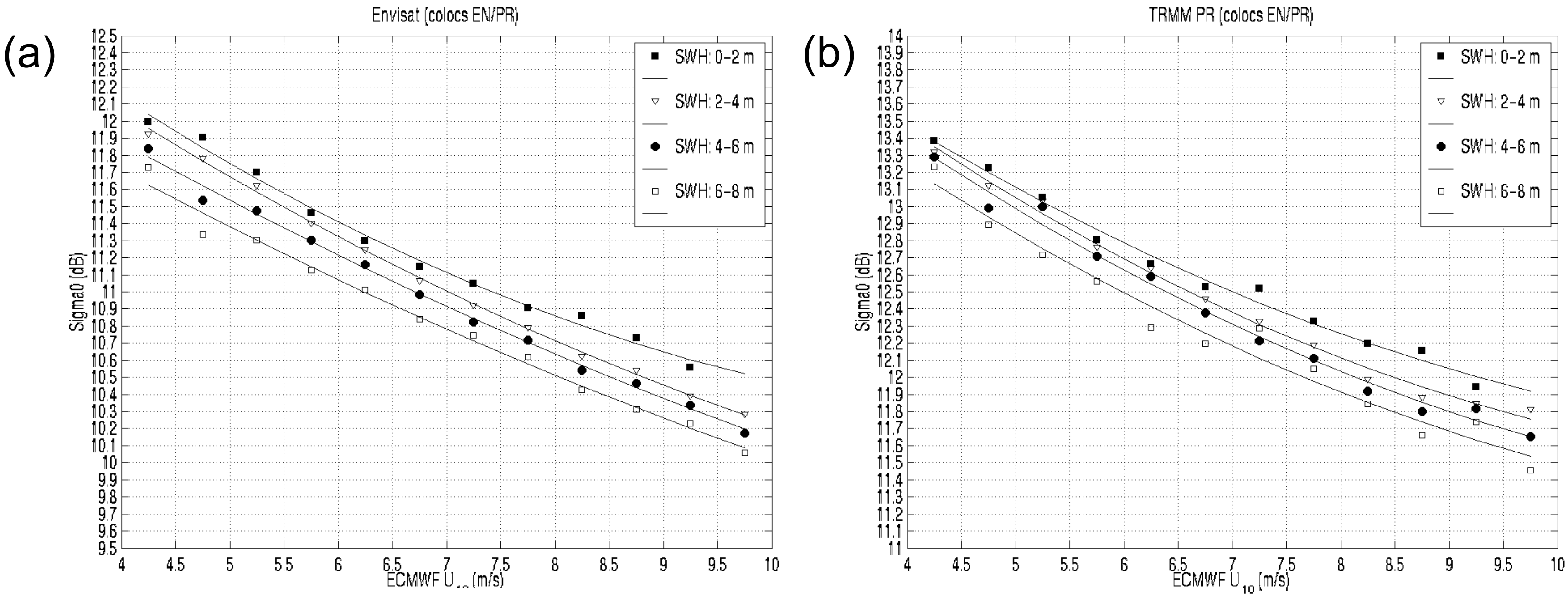


Figure 4: (a) Jason-1 and (b) PR bin-averaged sigma0 as a function of wind speed for four intervals of 2 m SWH values from the collocated subset. Overlaid are second order polynomial fits to better illustrate the different behaviors.(c) Differences between the corresponding data plotted in (a) and (b). As altimeter sigma0, the TRMM PR sigma0 exhibits clear dependence on both wind speed and significant wave height.



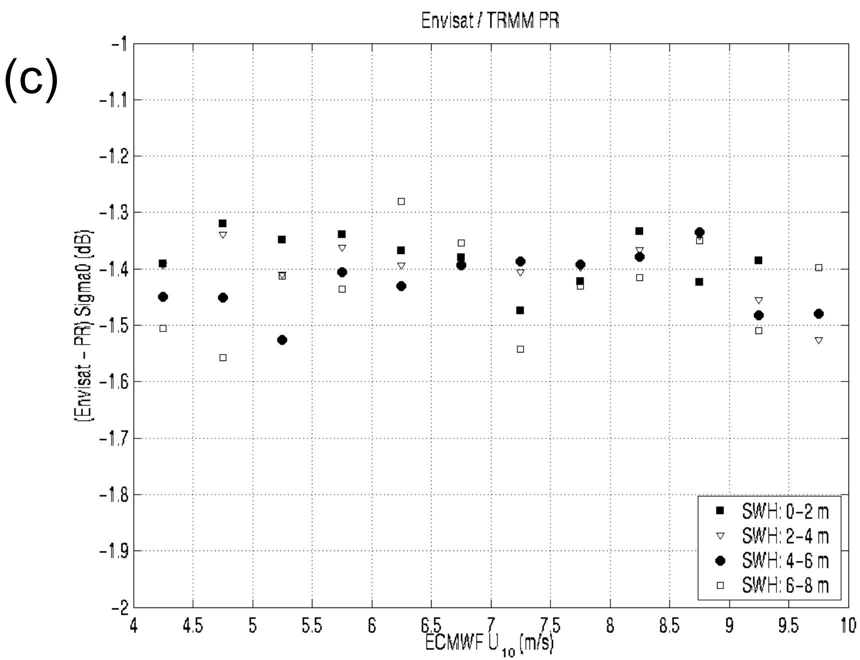


Figure 5: Same as Figure 4 from Envisat/PR collocated dataset. The differences are nearly constant within 0.15 dB around +1.45 dB for Jason-1/PR comparison and within 0.1 dB interval centered at -1.4 dB for Envisat/PR comparison. These results lead to conclude that there is no significant difference between altimeters and precipitation radar Ku-band sigma0 measurements in term of sea surface roughness sensitivity.

Concluding remarks-

Jason-1, Envisat, and PR Ku-band backscatter cross-sections respond with a quasi-equivalent sebnsitivity to both wind speed and significant wave height. This confirms that radar cross section is a fundamental property of the sea surface dependent on frequency but not on the instrument used to perform the measurement. The obtained differences can be attributed to difference in calibration, leading to the conclusion that Jason-1 data are larger in magnitude by ~(+1.46) dB than the PR ones while it is the opposite that is observed for Envisat measurements which seems to be lower by ~(-1.40) dB than the PR ones. Note that in the sigma0 values reported in the Envisat GDR products, a bias of -3.24 dB has been already applied to make the data consistent with ERS2. So removing this constant bias move Envisat values closer to Jason-1 ones and the relative bias with the PR data becomes +1.84 dB. These relative biases can be used to calibrate Jason-1 and Envisat sigma0 in an absolute way since the on-orbit PR has been absolutely calibrated using a transponder with an accuracy better than ~1 dB.