Wave spectrum retrieval from SWIM data: speckle spectrum estimation Session: " Wave retrieval and applications "

Danièle Hauser, Lauriane Delaye, Thomas Grelier, Cédric Tourain, Céline Tison, Patrick Castillan

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1. Introduction

The Chinese and French Space Agencies propose to jointly carry out an innovative mission, CFOSAT (China France Oceanography Satellite project) devoted to the monitoring of the ocean surface and its related science and applications. CFOSAT will embark both a wind and a wave scatterometers, enabling a simultaneous measure of the wind and the wave vectors with a global coverage for the first time. The launch is planned for mid-2018.
The satellite embarks two payloads; both are Ku-band radar scanning around the vertical axis:
- the wave scatterometer SWIM, a rotating 6-beams radar at small incidence (0 to 10°) [1, 2],
- the wind scatterometer SCAT, a fan-beam radar at larger incidence angles (30° to 50°) [3].

This paper focuses on the processing of the SWIM data for the retrieval of the 2D wave spectrum and, especially the estimation of the speckle spectrum.

2. Overview of the SWIM data processing
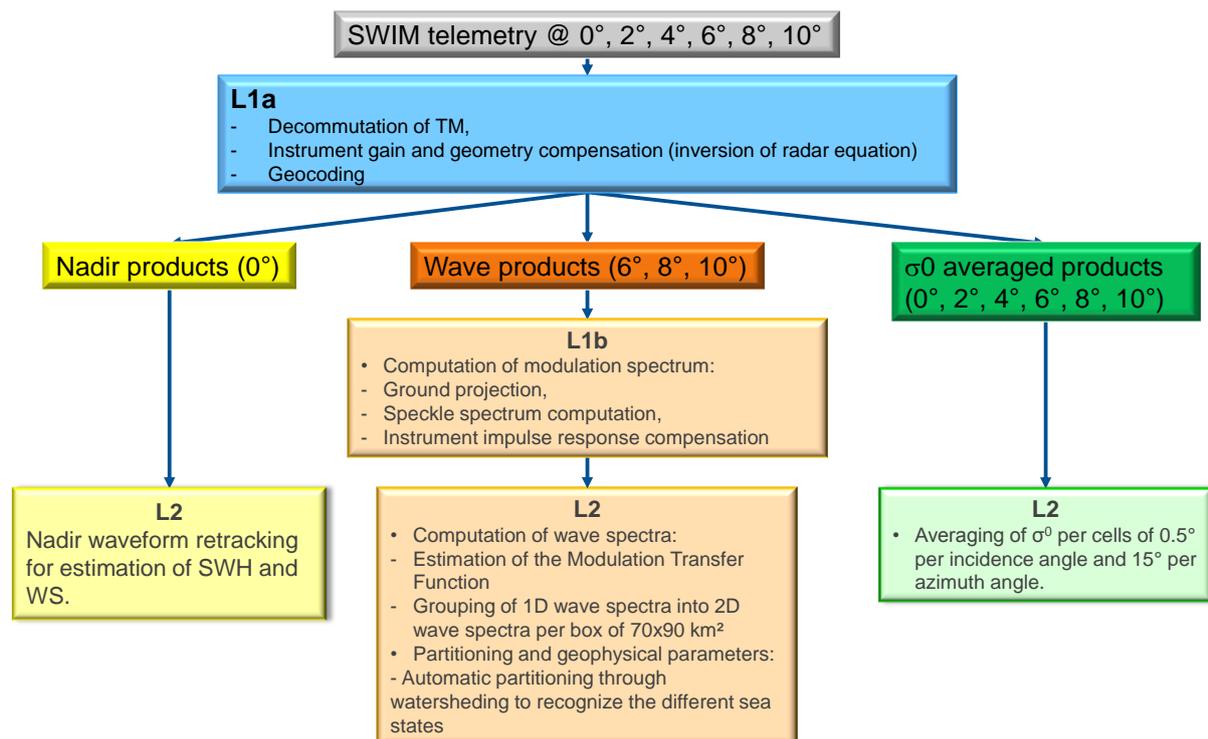
Figure 1. Overview of the SWIM L1 and L2 products and the associated processing.

The SWIM data are of three kinds [4]: the normalized radar cross-section profiles from 0° to 11°, the SWH and wind speed from the nadir beam and the wave spectrum from the 6°, 8° and 10°. The processing steps are following:
- inversion of the measured power to normalized radar cross section (inversion of the radar equation) and geolocalization of each radar gate,

- estimation of averaged normalized radar cross section per step of 0.5° in incidence and 15° in azimuth,
- retracking of the nadir waveform to estimate the SWH and the wind speed,
- estimation of the modulation spectrum from the σ^0 fluctuations and correction of the spectrum from speckle and impulse response,
- computation of the wave spectrum from modulation spectrum through the computation of the modulation transfer function.

There are two major issues: the estimation of the speckle spectrum and the estimation of the modulation transfer function. The paper addresses the issue of the speckle spectrum.


a) TM data for the 6 beams (1 macrocycle)

b) L1a data for the 6 beams (1 macrocycle)

c) L1b data (modulation spectrum) @8° for a complete rotation

c) L2data (wave spectrum) @8° for a box of 70 km along track
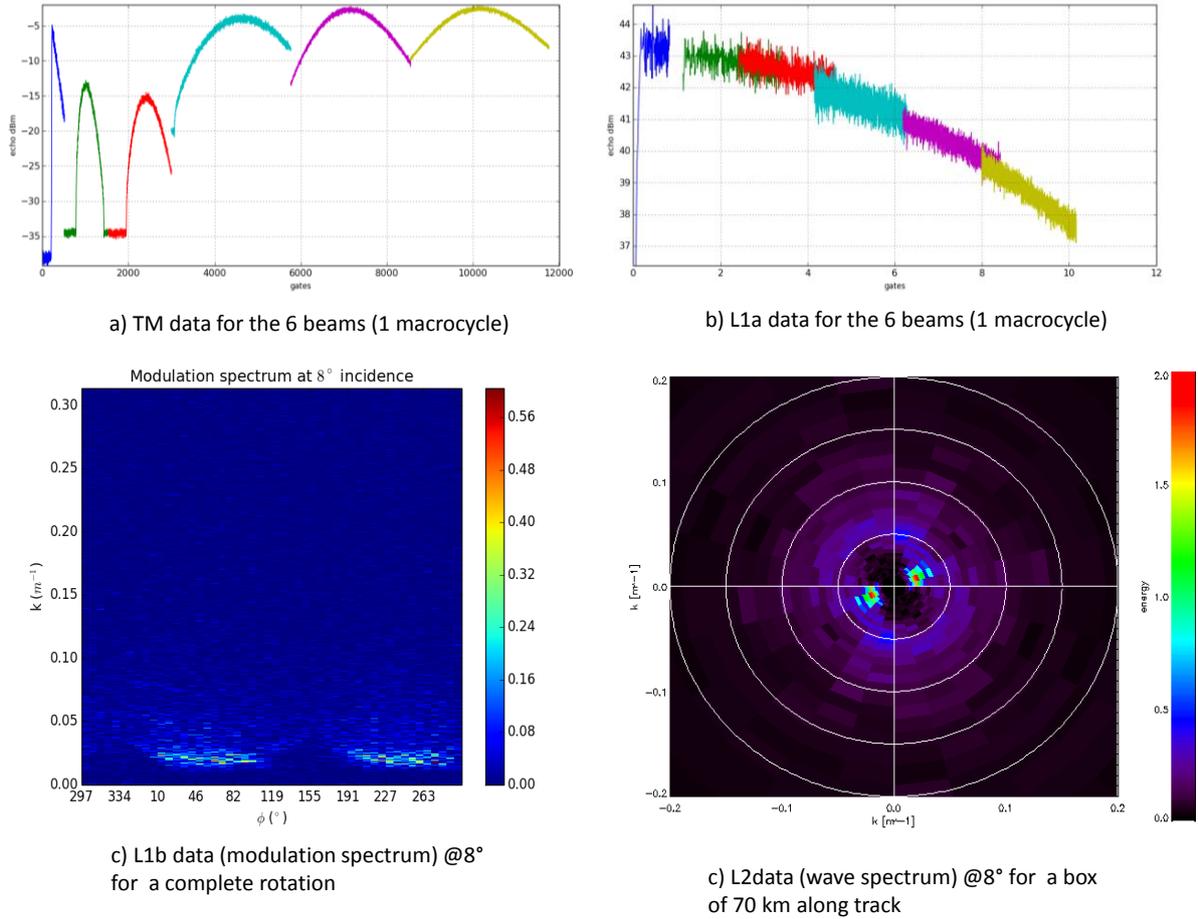
Figure 2. Illustrations of the SWIM products for wave spectrum computation.

3. Estimation of the speckle spectrum

The wave spectrum is estimated from the density spectrum of the fluctuation of the backscattering coefficient. This density spectrum is equal to [1, 2, 5]:

$$P_{\delta\sigma_0} = \frac{1}{2\pi} \int \langle \delta\sigma_0(x,\phi)\delta\sigma_0(x+\xi,\phi)e^{-ik\xi}d\xi \rangle$$

$$P_{\delta\sigma_0}(k,\phi) = \delta(k) + R(k)P_m(k,\phi) + \frac{1}{N_{imp}L_{dis}}P_{sp}(k) + \frac{1}{N_{imp}L_{dis}}P_b(k)$$

with $\delta\sigma_0$ the backscattering coefficient fluctuations (due to the long slopes), R the spectrum of the radar impulse response, P_m the modulation spectrum (linearly linked to the wave spectrum), P_{sp} the spectrum speckle, P_b the thermal noise spectrum, N_{imp} the number of pulses averaged in time, L_{dis} the number of averaged range gates. The aim is to estimate P_m.

The speckle spectrum depends on the real number of independent pulses [5]. The dependency of the spectrum to the sea state conditions is still under investigation. Three main methods are used:
- analytical methods,
- estimation from the noise floor,
- use of cross-spectrum computation.

The three methods will be detailed and discussed.

4. Results on simulated data and airborne data

The three methods have been tested on simulated data and on real airborne data. The results will be shown and discussed.
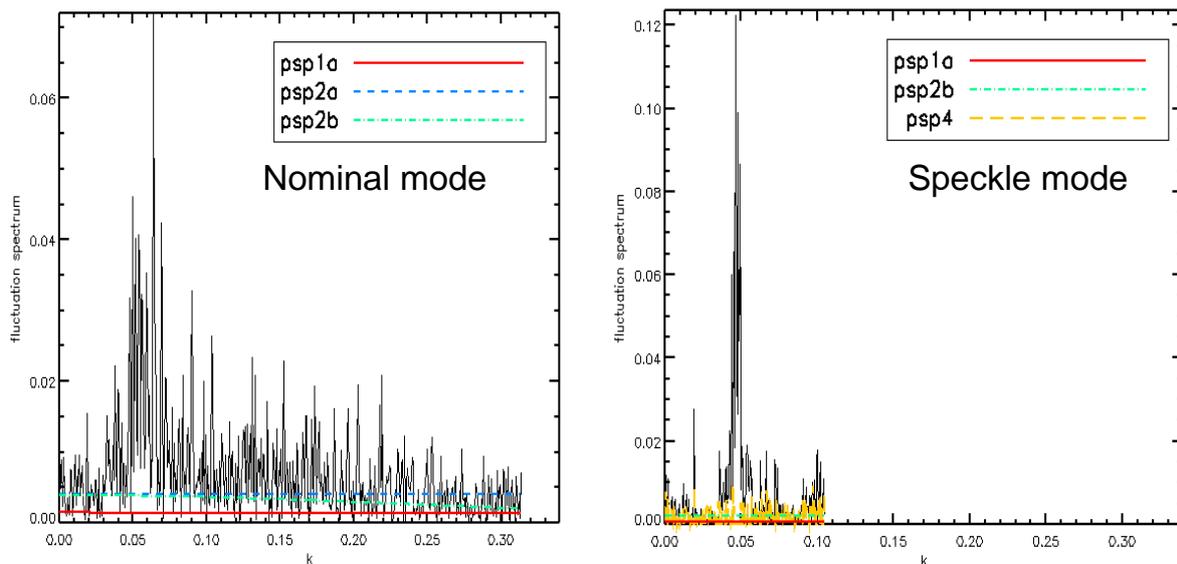
a) Nominal mode: PSP1a= analytical formula, PS2a: estimation from noise floor with k >0.2m^{-1}, PSP2b: estimation from noise floor in half a rotation (direction with no waves)

a) Speckle mode (3 dowloaded averaged power per cycle instead of one per cycle): PSP1a= analytical formula, PSP2b: estimation from noise floor in half a rotation (direction with no waves), PSP4: difference of fluctuation spetra from the same cycle

Figure 3. Illustrations of speckle estimation with different methods.

5. References

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