Design of a Wide Swath interferometric altimeter simulator for sea state bias estimation
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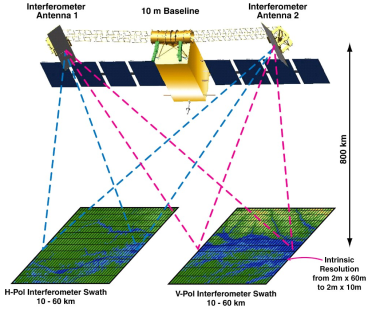
Introduction

Scope of the work

Sea State Bias impact on the elevations measurements of the futur instruments : interferometric large swath Radar

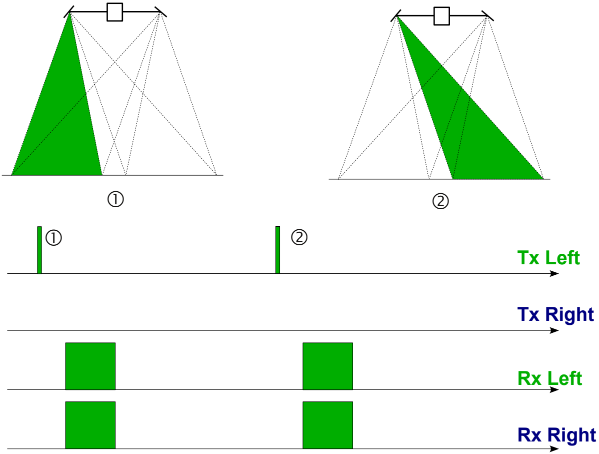
A quick introduction to the SWOT mission 1/3

- Hydrology and Oceanography mission
- high spatial resolution global measurments of ocean surface topography
- 120 km wide swath with a +/- 10 km gap at the nadir track
- KaRin instrument
  - Ka Band 35.6 GHz



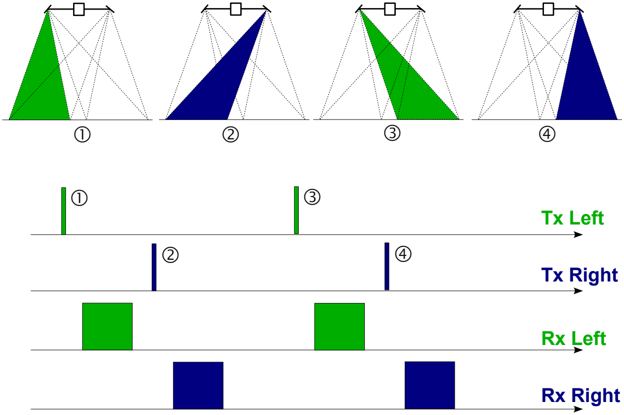
A quick introduction to the SWOT mission 2/3

The standard mode

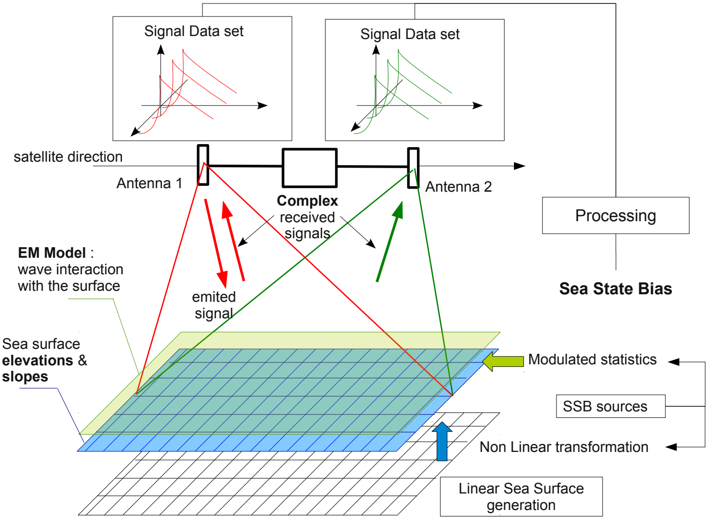


A quick introduction to the SWOT mission 3/3

The ping pong mode



Simulation principles 1/3



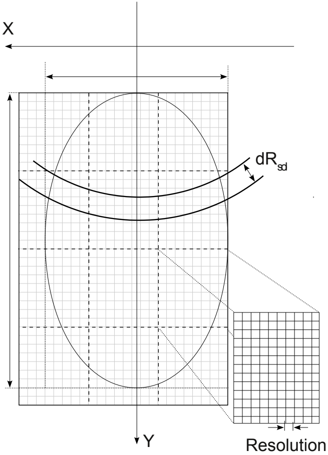
Simulation principles 2/3

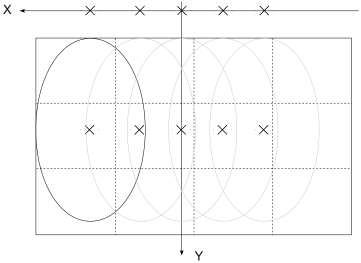
Even simple methods like the Kirchoff approximation suffer from intractable numerical burden when it comes to integrate large ocean surfaces (some km^2) at the radar wavelength resolution (some cm^2).

Our approach has been to adopt a two-scale integration scheme.

- The ocean surface is coarsely subdivided (1m scale pixels) and the elevation at this scale is explicitly integrated.
- The contribution coming from shorter scales within the pixels of resolution is accounted for in a statistical manner
- the pixel resolution is **not** linked to the radar resolution

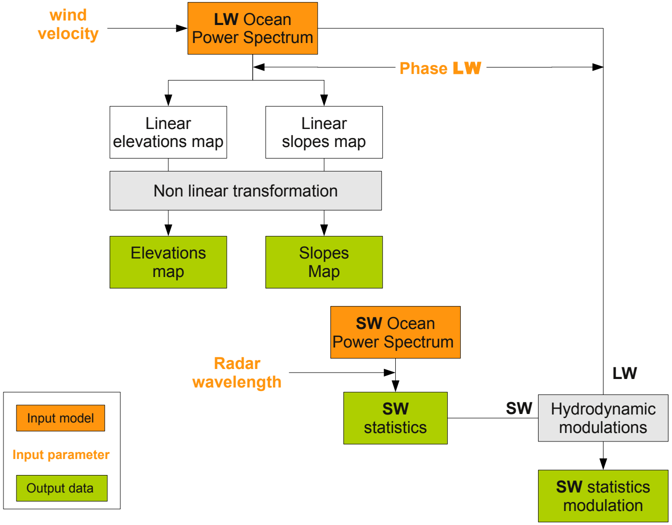
Simulation principles 2/3





- Resolution down to 1m
- Each patch is similar (in terms of elevations and slopes)

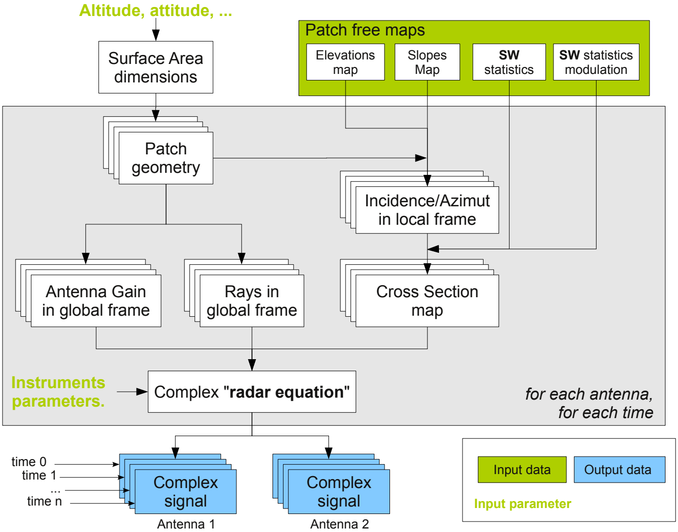
The Sea Surface contribution 1/2



The Sea Surface contribution 2/2

- the LW and SW ocean power spectrum used are parts of the Unified Elfouhaily spectrum [Elfouhaily, 1997]
- the non linear transformation of the is carried out by the Choppy Wave Model [Nouguier 2009]
  - based on first order expansions of particle trajectories in Lagrangian coordinates.
  - expressed as an horizontal deformation of a reference linear surface, instead of vertical one as most weakly nonlinear models do
- the hydrodynamics modulations are carried out by the first order (linear) Modulation Transfer Function [Elfouhaily, 2001]

The Complex Signal calculation 1/2

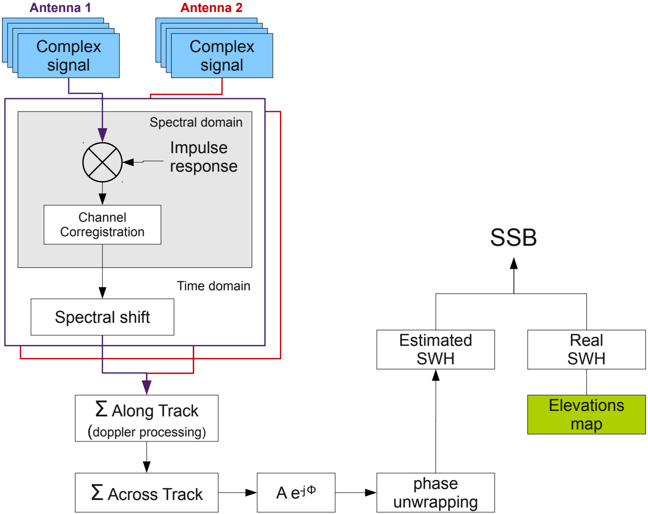


The Complex Signal calculation 2/2

$$W^{(pq)}(t) = \frac{\mathrm{i}\lambda}{4\pi} \sum_n \frac{{g_1}^{(pq)} {g_2}^{(pq)}}{R_1 R_2} \mathbb{S}\ \delta\left(t - t_{AR} - \frac{f_D}{K}\right) \mathrm{e}^{\mathrm{i}\frac{f_D}{K}(kc - \pi f_D)} \mathrm{e}^{-\mathrm{i}k(R_1 + R_2)} \quad (1)$$

- the sum is made over all the pixels describing the surface
- g_1 and g_2 are the antenna gain of the emiting/receiving (rectangular) antennas (resp.)
- R_1 and R_2 are the distance from the emiting/receiving antennas (resp.) to the pixel
- $\mathbb{S}$ caracterize the scattering ($\sigma = 4\pi|\mathbb{S}|^2$)
- f_D is the doppler frequency
- $\delta()$ is the dirac function : the impulse response is simulated by a convolution after the summation.

Processing 1/2



Processing 2/2

- Misregistration decorrelation : Channel Corregistration
  - the sampling of the 2 antennas is different since the difference of the view of the scene by the two antennas
  - on board algorithm : phase ramp applied within the range compression block

$$e^{i(a\Delta d\omega(\pm T_d + n\Delta t))}, \quad (2)$$

  - for the sake of simplicity, the corregistration is carried out during the attribution of the pixel to a range gate
- The geometrical decorrelation : Spectral shift
  - frequency shift due to slightly difference of the view of the scene by the two antennas
  - on board algorithm : phase ramp applied in the time domain

$$e^{i\Delta\omega_s(\theta_i)t} \quad (3)$$

the frequency shift $\Delta\omega_s(\theta_i)$ is a function of the incidence angle

Conclusions

- High resolution simulator
  - the modular design alllows to compare different configurations and to isolate the effects of each new feature on the SSB.
  - the validation relies on the validation of the simulator in the conventionnal Ku configuration.
- Sea Surface validation in progress
- Possibility to test the impact of the on board processing on the SSB (coregistration)

Thank you for your attention

Bibiography

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