Simultaneous multi-waveform retracking in coastal regions

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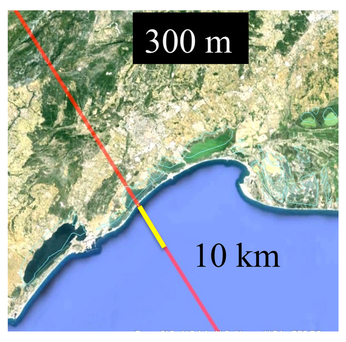
Coastal Waveforms on track 146 Jason-2

Goal

By using an inversion methodology, our goal is to obtain simulated waveforms as similar as possible to the measurements.For doing so, we define a scene parametrically, for surface height and backscatter propreties. The simultaneous inversion of all track waveforms on this parametrical scene gives as output its surface height (➔altimeter range) and σ_0 on the surface

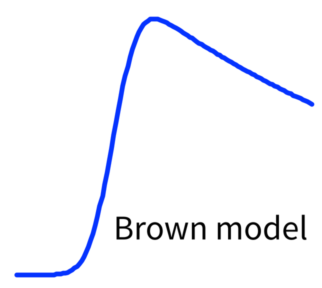
Geographical Setting

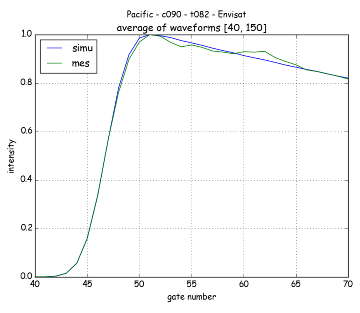


Track 146 (descending track) next to the city of Sète in southern France. Prominent features include topography up to 300m and the presence of ponds west of the ground track of a size of 15x5 km. Similar water bodies exist east of the track as well.

Simulation of open ocean waveforms is easy

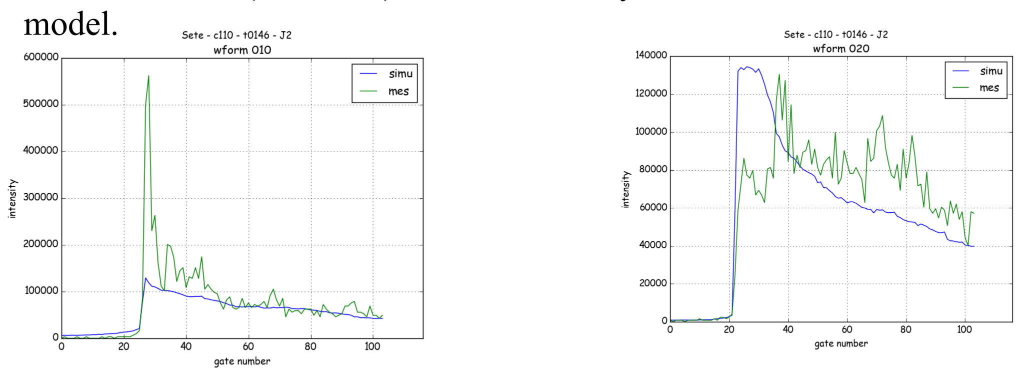
Altimetric waveforms in open ocean follow very closely the theoretical for given by the Brown model (below). As an example, track 82 of the Envisat mission over the Pacific ocean (green line) is fitted very well by a simulation (blue line) of the figure to the right.



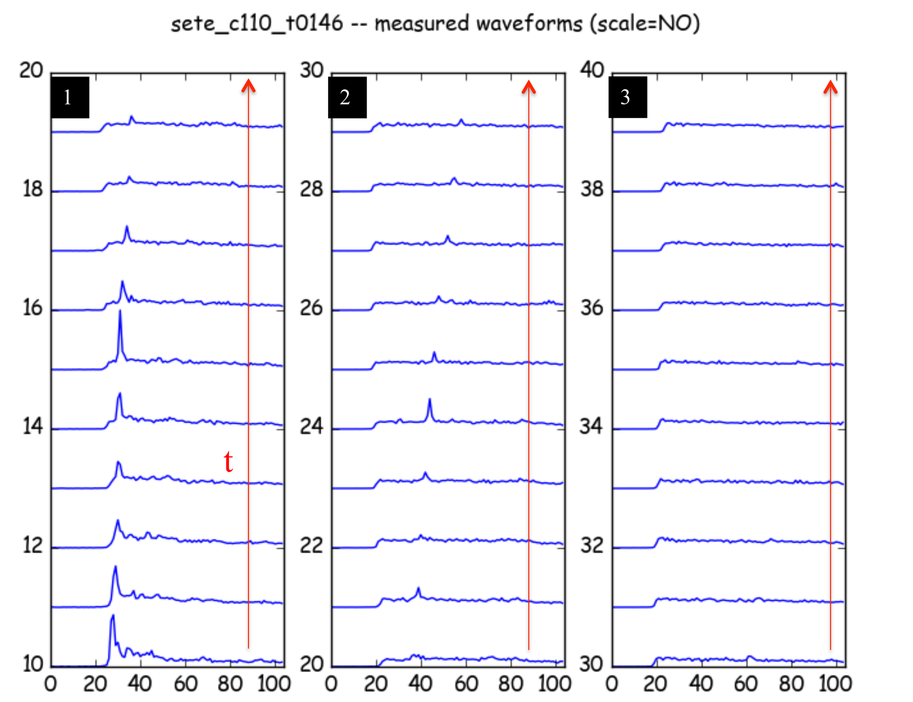


Coastal waveforms are difficult to model

In contrast, the waveforms of track 146 on the mediterranean sea near the coast of France (near Sète) show forms very different from the Brown model.



Observations



Altimetric waveforms for track 146 the 2011/06/23. We show successive waveform, starting from the 10th one, directly over the coastline. We see that there is a distinct peak on the 10th waveform, which moves to the right for each successive waveform (on increasing distance from the coastline), and disappears after 2km from the coast.

Waveform Inversion

Scene Definition

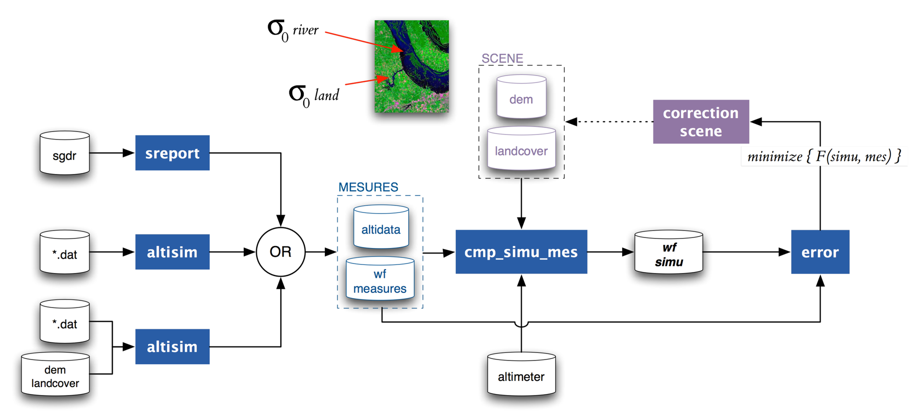
The scene used to generate simulated waveforms is defined as a parametrized surface consisting of a DEM over which corrections are added. These corrections are parametric scene generators

$$\text{surface} = \text{DEM}^{(\text{SRTM})} + \text{scene\_generators}^{(\text{profile})} + \text{sea ssh}^{(\text{ocean\_model})}$$

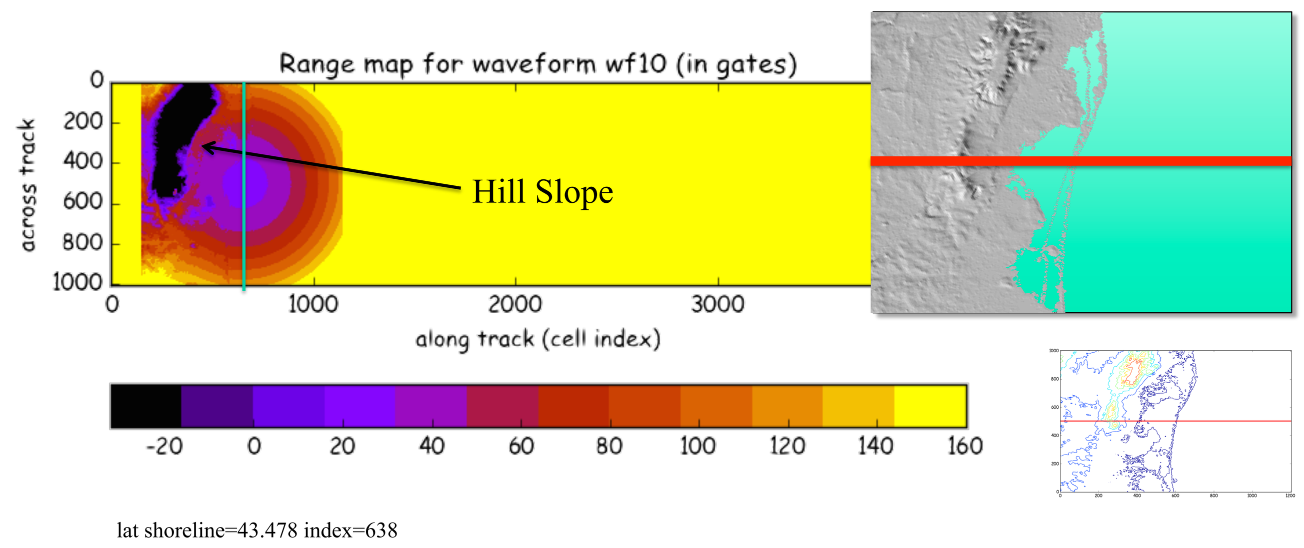
$$\sigma_0 = \sigma_0^{\text{landcover}} + \sigma_0^{\text{profile}}$$

Simultaneous multi-waveform inversion

We invert simultaneously all observed waveforms over the scene to obtain the parameters of the scene_generators, the values of σ_0 of the landcover classes, and the σ_0 profile values (spline interpolated).
The inversion is done in a loop (workflow below):
simulation ➔calculate error wrt observations ➔modify parameters ➔...



Topography effects

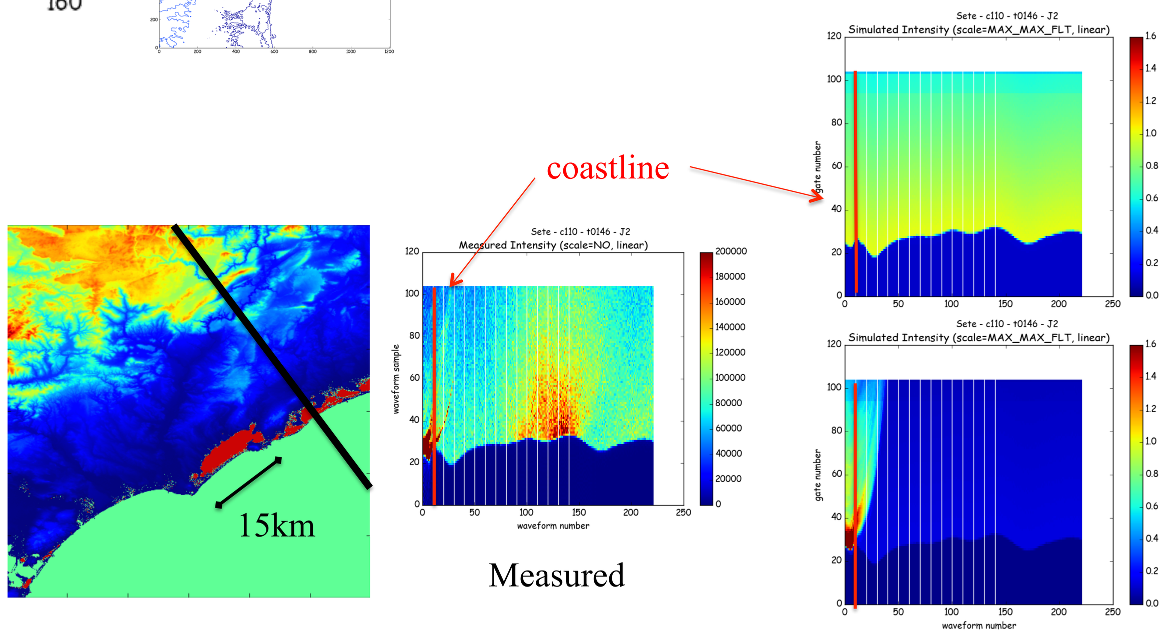


Range Maps

The Figure to the left shows a *range map* indicating which element of the scene contributes to which waveform gate, for waveform number 10. A gray shaded relief map with the trajectory in red (satellite going from left to right) is also shown.

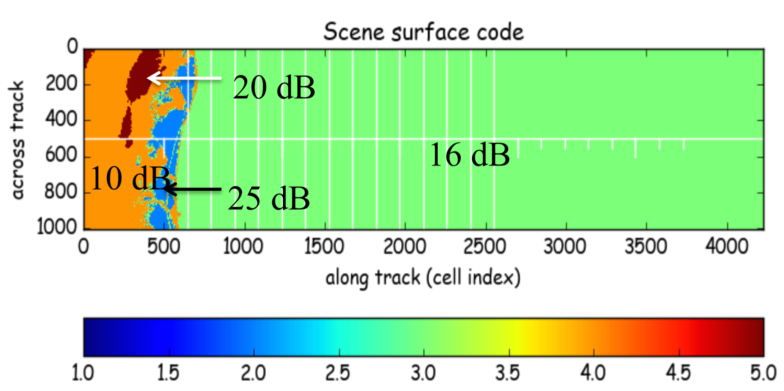
Pond effects

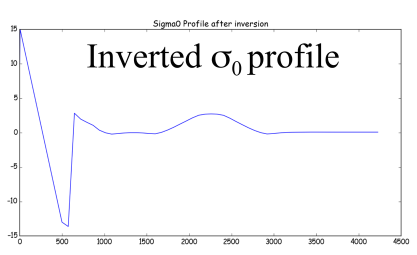
To the right we show a color-coded topography map where the sea is shown in green, and the ponds in red. If all topography is set to 0 in our simulations, we obtain the waveforms at the upper far right, which lacks the initial energy burst. By usig a high backscatter coefficient for the ponds (shown in red) the burst is replicated.

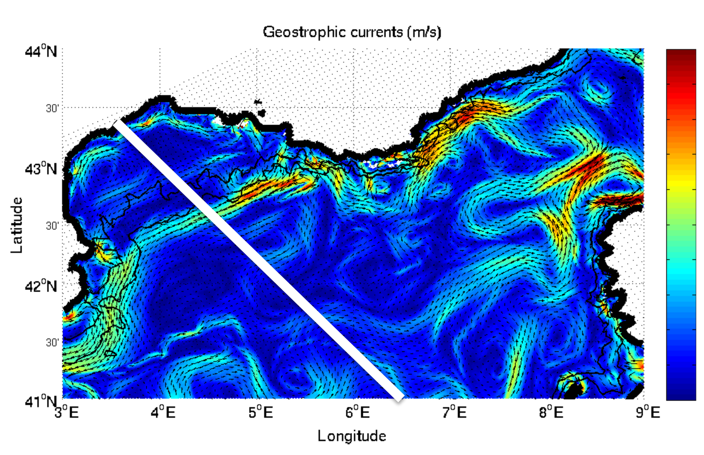


Backscatter and SSH

$$\sigma_0 = \sigma_0^{\text{landcover}} + \sigma_0^{\text{profile}}$$







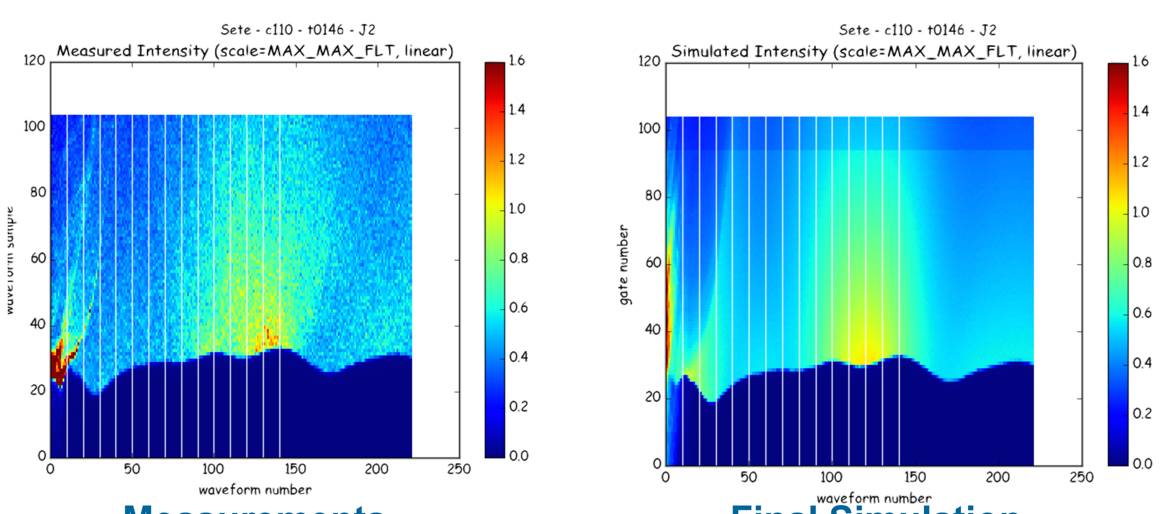
ssh of the ocean part of the scene is derived from Symphonie, the 3D ocean circulation model continuously developed by the SIROCCO system team (CNRS & Toulouse University).

Marsaleix et al., 2008, 2009, 2010, 2011, 2012

- Physical frame: Boussinesq hydrostatic, free surface
- Vertical grid: sigma coordinate system
- Horizontal Grid: curvilinear, from 0.6 km to 6 km
- Open boundary conditions: MERCATOR
- Run from the June 2011 to april 2015

The waveform measurements, bellow show a sigma bloom at the center of the image that does not exist on other cycles. To take into account this effect, other than the a priori landcover classification shown on the left (classes are *à priori*, values are found by inversion) we add a σ_0 profile to the backscatter (shown left). The ocean part of the scene (green part of landcover map) uses the daily average of the Symphonie model (below left).

When using the corrected topography, ssh, and corrected σ_0 we obtain a very good agreement with measurements, below..



Measurements **Final Simulation**

Conclusions

We have a tool we can use to study the interactions of the radar signal on complex scenes: cryosphere, hydrology, coastal.

A scene is described both by its surface and its backscattering properties. The topography is described as an original DEM with added parametric corrections, which is a profile in this particular case. The backscatter is the sum of a landcover map properties (a priori classification based on height with values found by inversion) and a backscatter profile (found by inversion also, given the ice1 σ_0 profile)
The parameters describing the scene are obtained by simultaneous inversion of waveforms – there is good agreement between simulations and observations.

Next steps:
Use model data and the tool to explore the signature of ocean physical processes on the coastal context; gain insights of the observability of small coastal structures.
Test the behaviour of different retracking algorithms on the simulated waveforms

Acknowledgements

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