MONITORING THE WORLD'S COASTAL OCEAN WITH SENTINEL-3 ALTIMETRY

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1. INTRODUCTION

Satellite altimetry has been the workhorse of operational oceanography for almost 25 years. Sea surface height (SSH), significant wave height (SWH) and (to a smaller extent) wind data are routinely used by operational systems: SSH data are assimilated for analysis and forecasting of currents (as long as for reanalysis of general circulation models for climate research), SWH are assimilated in wave models, and both SWH and wind are used for model verification and assessment of model changes. Estimates of effective model resolution for a given parameter can also be obtained by comparison of the model spectra with altimeter-derived spectra.

Altimetry has also been used to observe and understand several open ocean processes (currents, fronts, eddies, planetary waves) allowing a sizeable step forward in our understanding of ocean dynamics and its variability at different spatial and temporal scales. The accumulated altimetric record can be used to look for climate scale signals, for instance temporal and geographical variations of the rate of sea level rise as in European Space Agency's Sea Level Climate Change Initiative [1].

In the coastal zone altimetry is normally made more difficult by the effects of land returns and bright targets (coastal shelter waters or slicks) on the radar signal, which make waveform retracking more complicated, as well as difficulties with some of the corrections. As a result until a few years ago most of the data in the coastal strip were flagged as bad and discarded. However in recent years research by a very active community of coastal altimetry has shown that many of the measurements in the coastal zone can be recovered and used for applications that range from estimation of currents to monitoring variations in sea level (including extreme events such as storm surges) and observing the coastal wave field [2].

The advent of SAR altimetry is causing a quantum leap in coastal altimetry. Data from CryoSat-2 are confirming both the expected reduction in land contamination due to the narrow along-track resolution cell, much smaller (O 300m) than the conventional pulse-limited footprint, and the excellent precision of the instrument [3]. This allows uncontaminated measurements to be obtained much closer to the coast than for conventional Ku-band pulse-limited instruments. The finer resolution, combined with excellent signal-to-noise ratio, is also crucial for coastal dynamics as little averaging is necessary so smaller scales can be preserved. However CryoSat-2 data are collected in Low-Rate (pulse-limited) mode (LRM) over most of the oceans and only available in SAR mode over a handful of regions; this has made impossible to derive meaningful global SAR mode statistics of the various parameters and, for instance, a SAR mode Sea State Bias (SSB) correction.

Sentinel-3 will be the first mission to provide SAR mode altimetry over the entire ocean therefore will fully enable two distinct and complementary areas of activity:

a) Operational – S-3 will allow a full operational integration of the SAR altimeter data into global and local forecasting systems, including global coastal observing systems.
b) Scientific Research & Development – S-3 will enable a number of experimental R&D activities aiming at exploiting the novel technique for the derivation of new parameters or the improvement in the existing retrieval algorithms

In this contribution we will examine both those areas and illustrate them with examples.

2. SENTINEL-3 AS THE FIRST OPERATIONAL COASTAL ALTIMETER

In order to make possible the operational use of S-3 altimetry data in the coast, an important discriminating factor is the instrumental noise and its degradation on approaching the coastline. We will show results from CryoSat demonstrating that the performance of SAR altimetry in the coastal strip is excellent. One such example is reported in figure 1 below, from an analysis of SAR data around the coast of the UK carried out within ESA's CryoSat Plus for Oceans (CP4O) project [4]. The noise median in the example shows that the precision of the 20-Hz measurements is virtually flat and better than 5cm up to 5 km from the coast, and better and 6 cm at 3 km from the coast. This is very promising in terms of assimilation of SAR SSHs in coastal models, which will be discussed.

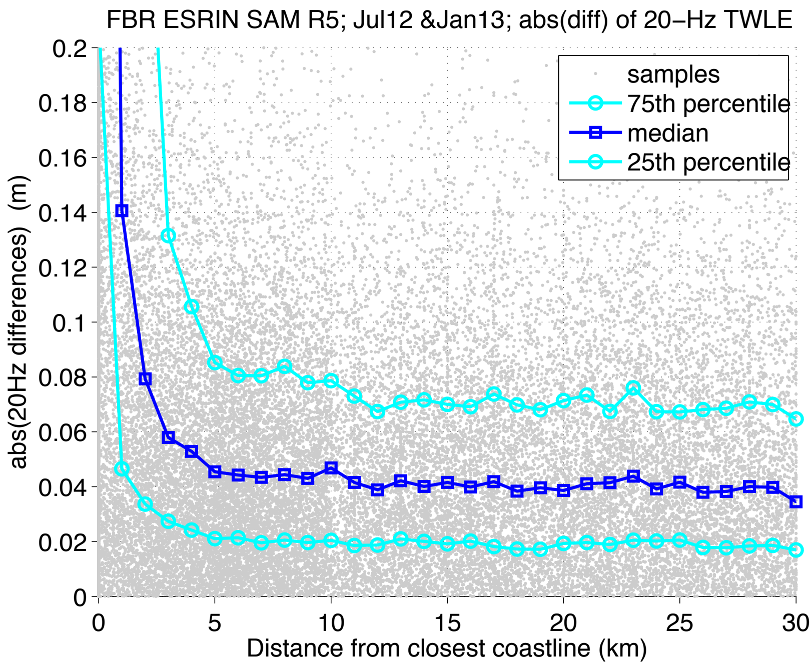

Figure 1: Instrumental noise (estimated as absolute value of the 20-Hz differences) for CryoSat-2 SAR data in Jul 2012 and Jan 2013 around the coast of the UK, as a function of distance from the coast. Data have been processed with the ESA/ESRIN SARvatore processor from Full Bit Rate data.

Another (pre-operational) use of the data is for the monitoring and forecasting of extreme events such as storm surges. We will show examples of surges captured by CryoSat-2 and discuss the lessons learnt by processing the data and making them available to the storm surge community within ESA's eSurge Project [5].

3. FURTHER SCIENTIFIC EXPLOITATION OF SENTINEL-3 DATA

A number of experimental activities are planned in the scientific community with the aim of studying the improvements from innovative algorithms in the Sentinel-3 SAR altimetry processing, focussing on the coastal zone. We will illustrate examples of those activities from a number of specific studies including:

c) trying to exploit the information in the SAR stack to optimize the retrieval of the geophysical parameters in the coastal zone, i.e. finding an optimal way of weighting the multi-looks in the SAR multi-look stack, with weights that optimize the retrieval of the geophysical parameters in the coastal zone, where we expect the surface parameters to be non homogenous in the across-track resolution cell;

d) trying to elucidate the dependence of stack data on mean square slope, and on wind and wave direction relative to the satellite track. This can be investigated by looking at the skewness and kurtosis of the power distribution amongst the different looks, and trying to link them to wind and wave statistics, in a small number of selected case studies;

e) investigating the effects of land proximity and morphology and of the orientation of the satellite track w.r.t. the coast on the precision of the geophysical estimates.

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