HYPERBOLIC PRETRACKER: A means to filter waveform data

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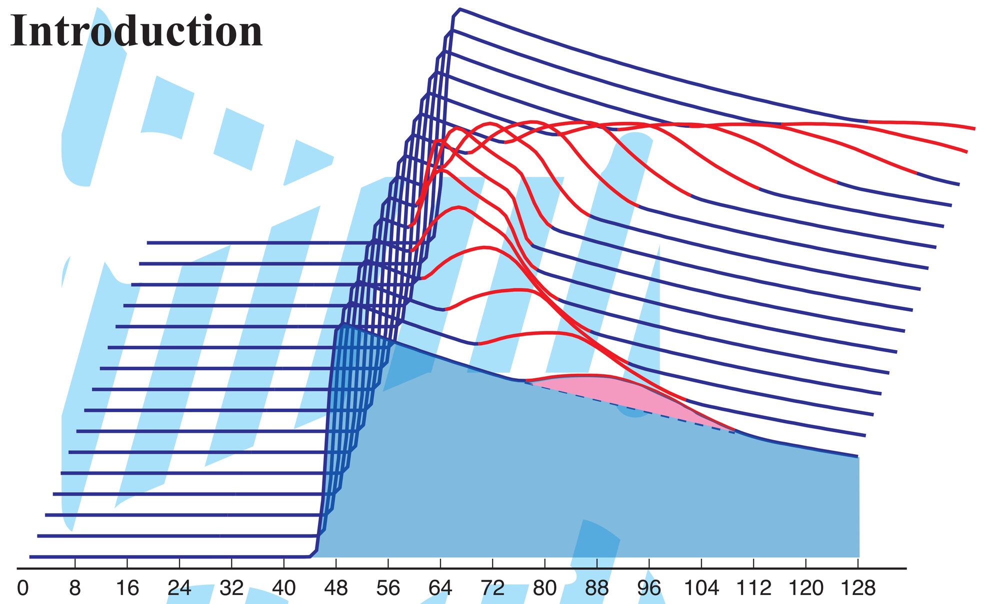
Introduction



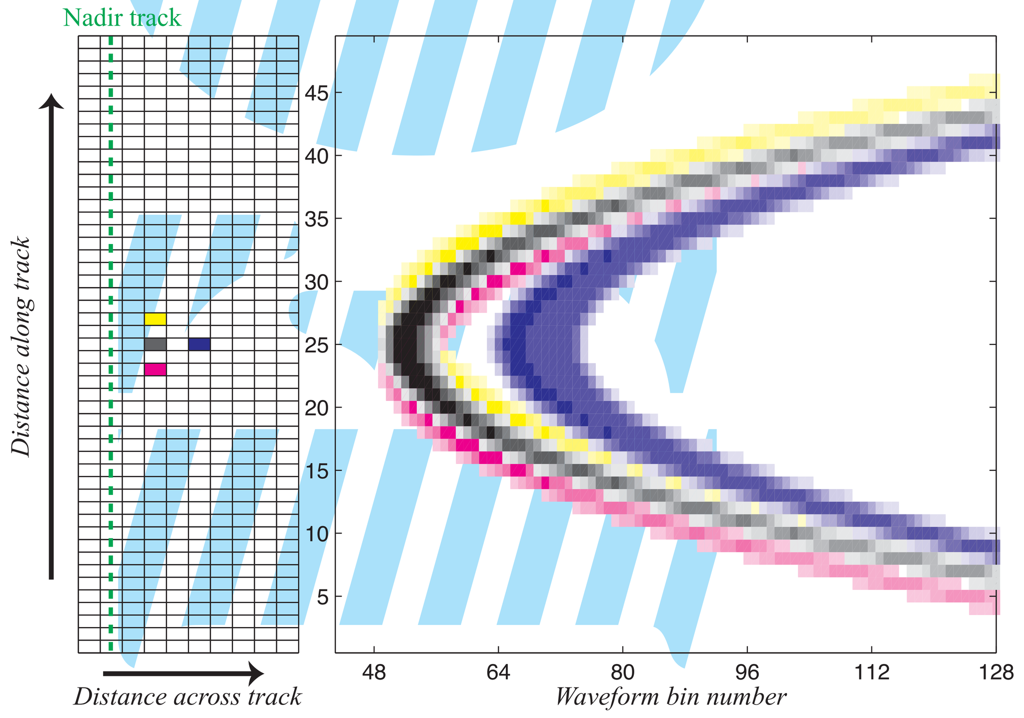
A small region of strong reflectance, a "bright target" will effectively provide a power excess in many succeeding waveforms, with the additive signal tracing out a hyperbolic trajectory.

Individual waveforms from such a series are problematic to waveform retrackers that assume a "Brown-like" signal. New techniques have arisen fitting a Brown plus one or two peaks, but these require estimation of up to 11 parameters. These approaches tend to ignore the expected continuity between successive waveforms. The **hyperbolic pretracker** is a 2-D filtering technique that estimates and removes the signal associated with discrete "bright targets".

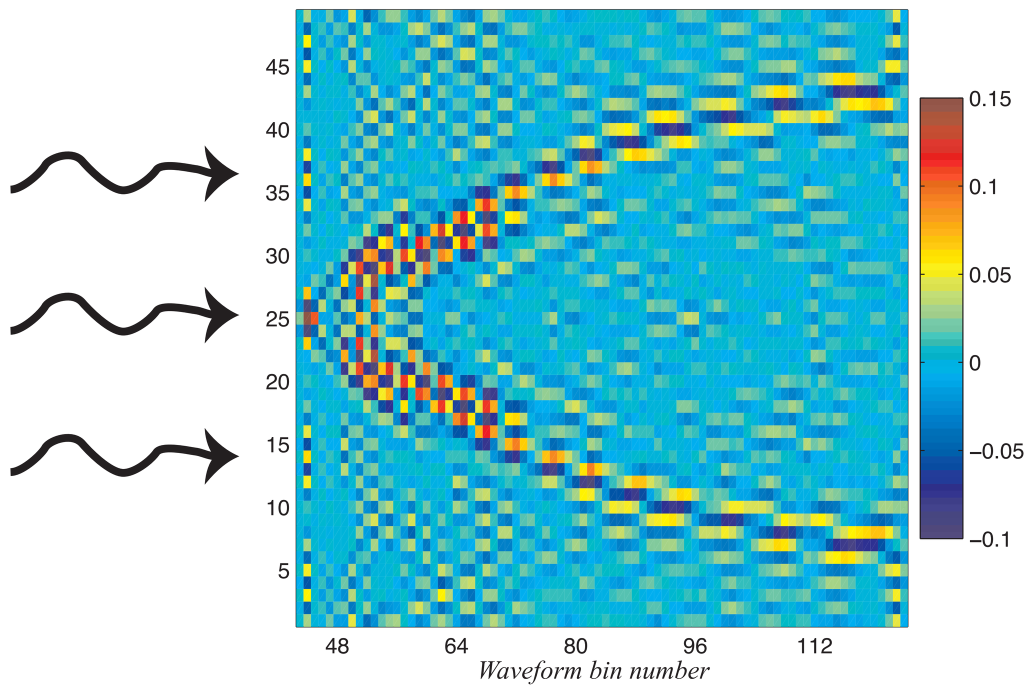
In idealised cases (such as above), the hyperbola is easily located and excised, but how is it applied to real data (multiple signals, varying strength, fading noise ...) ?

Inversion Model

Each patch (rectangular pixel) of increased reflectance gives rise to differently-positioned hyperbolae.



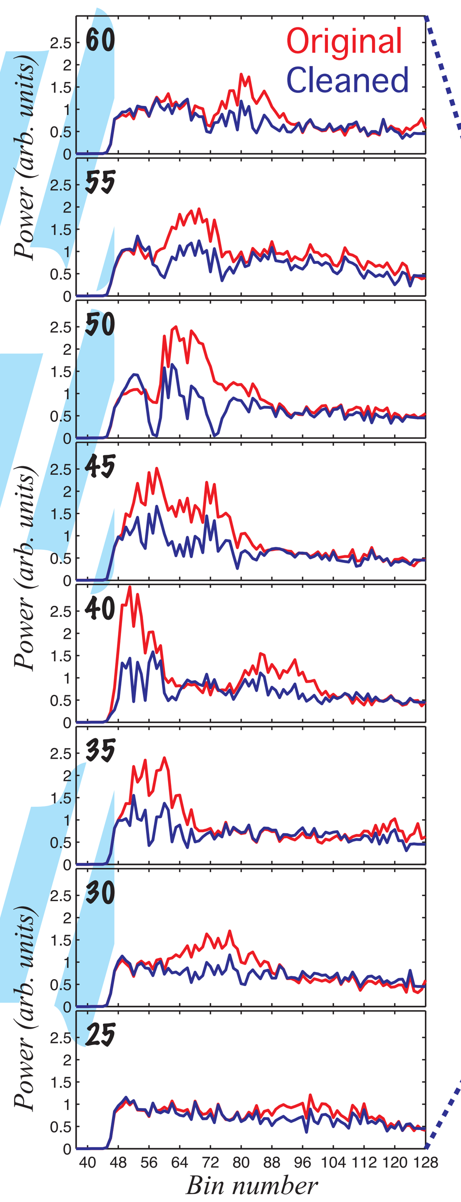
A set of weights is determined to estimate the strength of the grey hyperbola, but yield zero if only the other curves are present. The weights are optimized ($\min\{\sum w_i^2\}$) to give least sensitivity to fading noise.

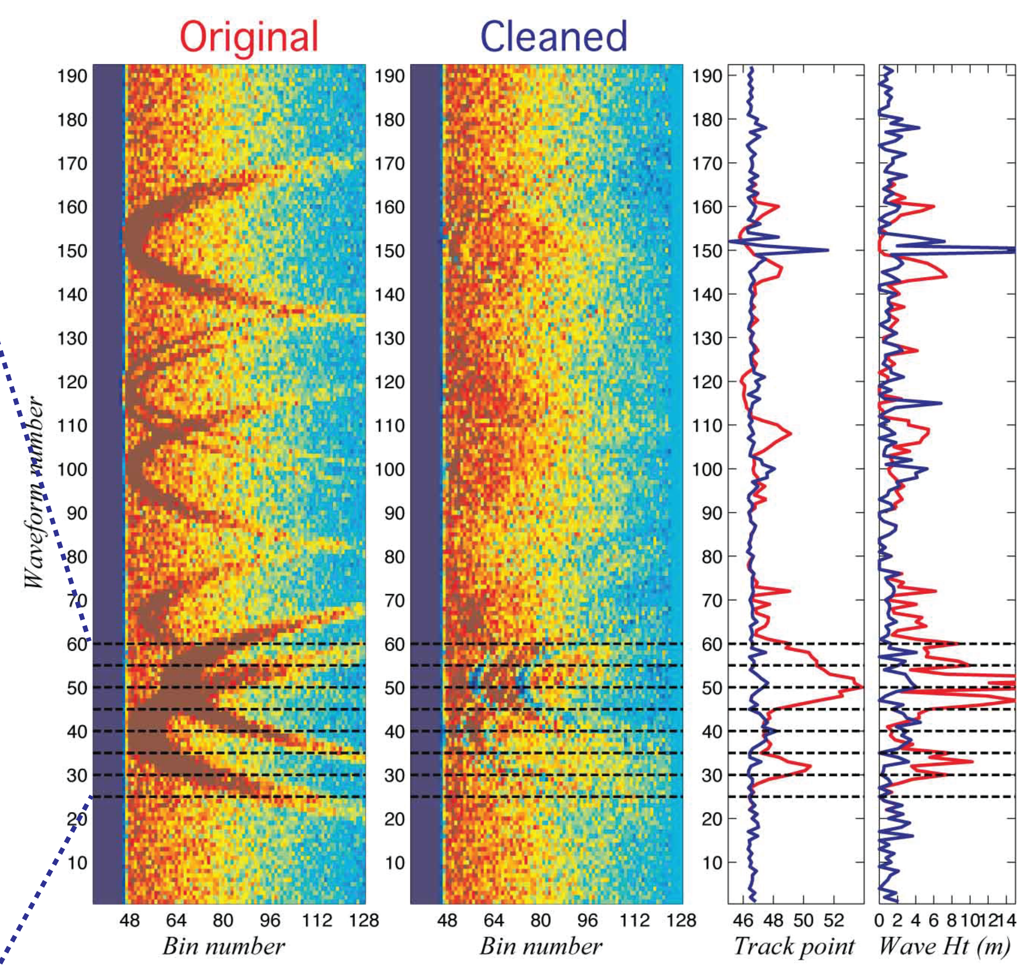


Complex simulation

Waveforms were simulated for an Envisat overflight over a number of differently shaped patches of strong reflectance, with fading noise applied. The simulated dataset ("original") is shown, along with the result afterm removing bright targets ("cleaned"). The far right panels show the output from a *simple* retracker applied to these two sets of waveforms.

Most of the hyperbolic features have been removed, although a weak pattern of +/- anomalies has resulted near waveforms 45 to 55. A few of these cleaned waveforms still lead to poor leading edge estimates, but far fewer than for the original simulated data.

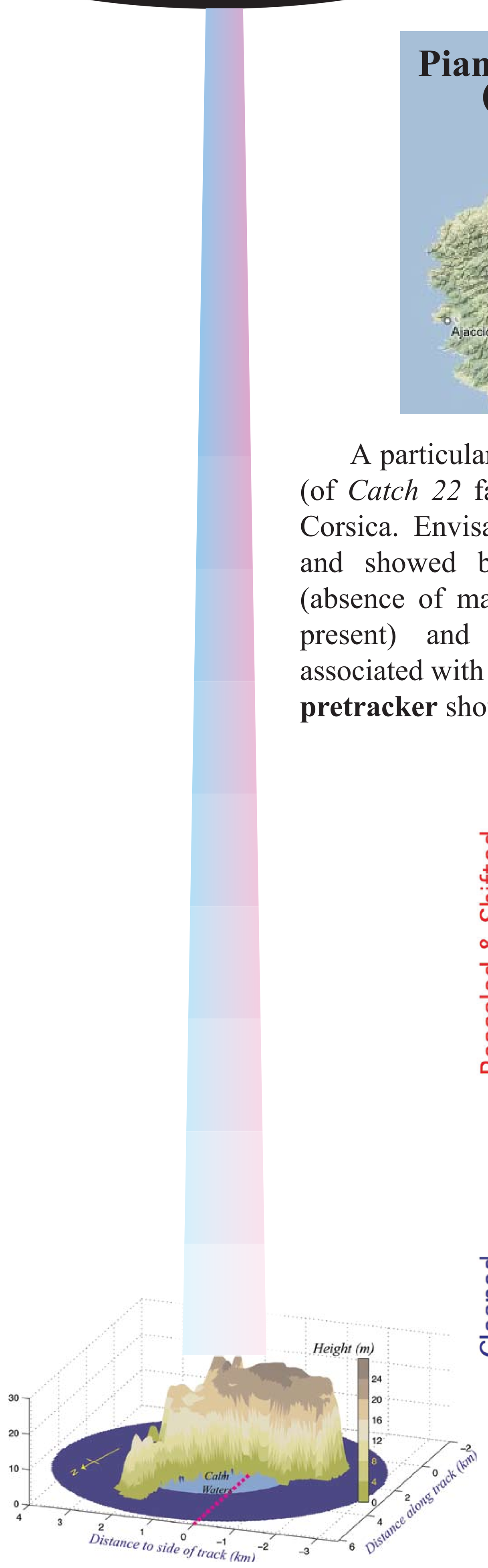


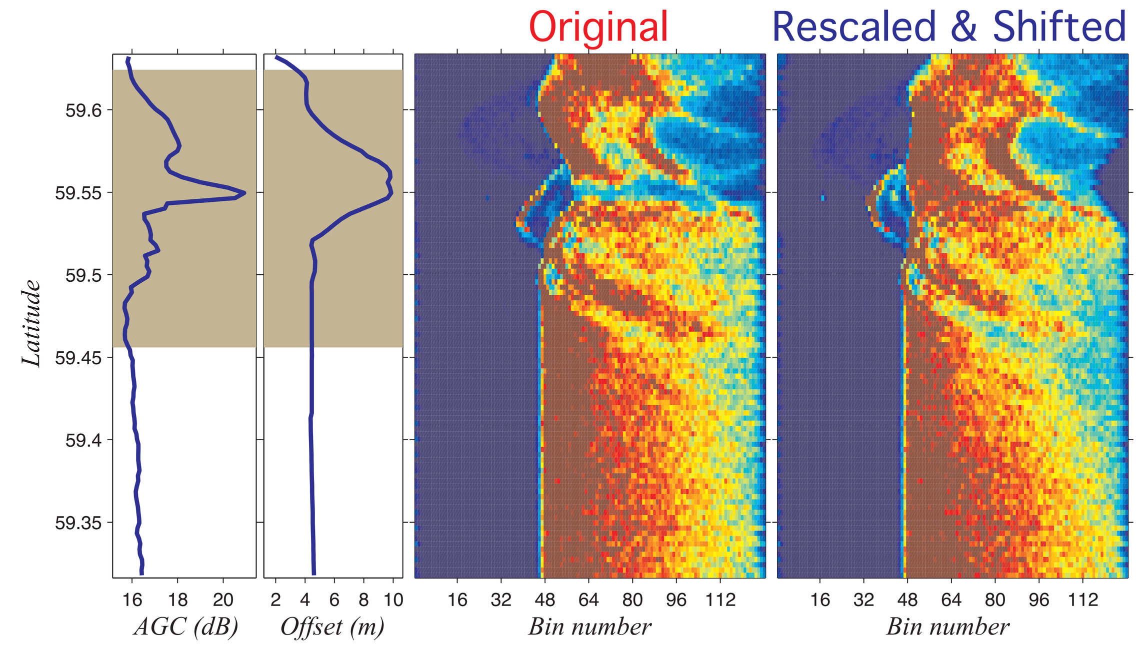


Abstract

Theory: Identify the characteristic hyperbolic signal of individual bright targets and remove from noisy waveform data to allow conventional ocean retrackers to be applied

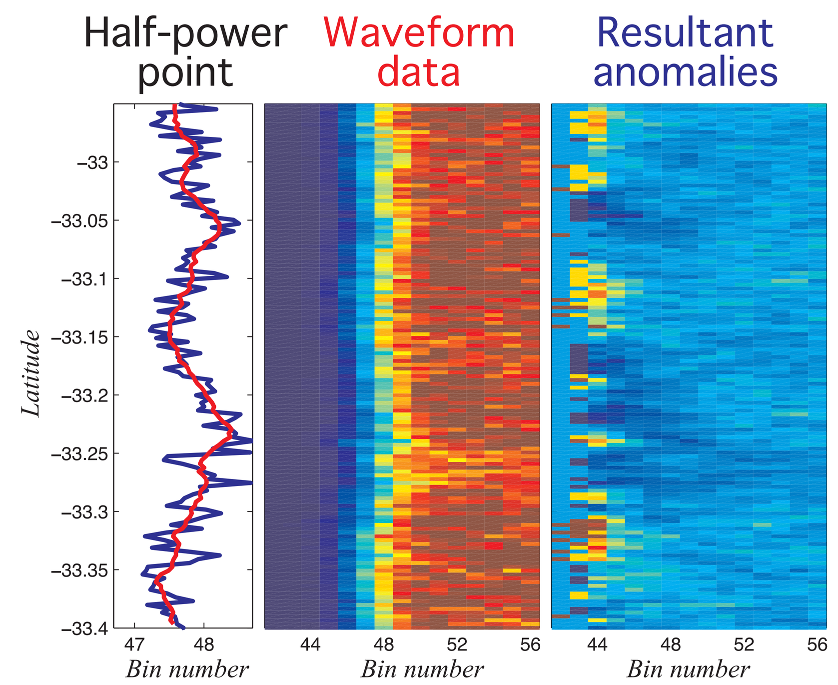
Practice: Somewhat more difficult!



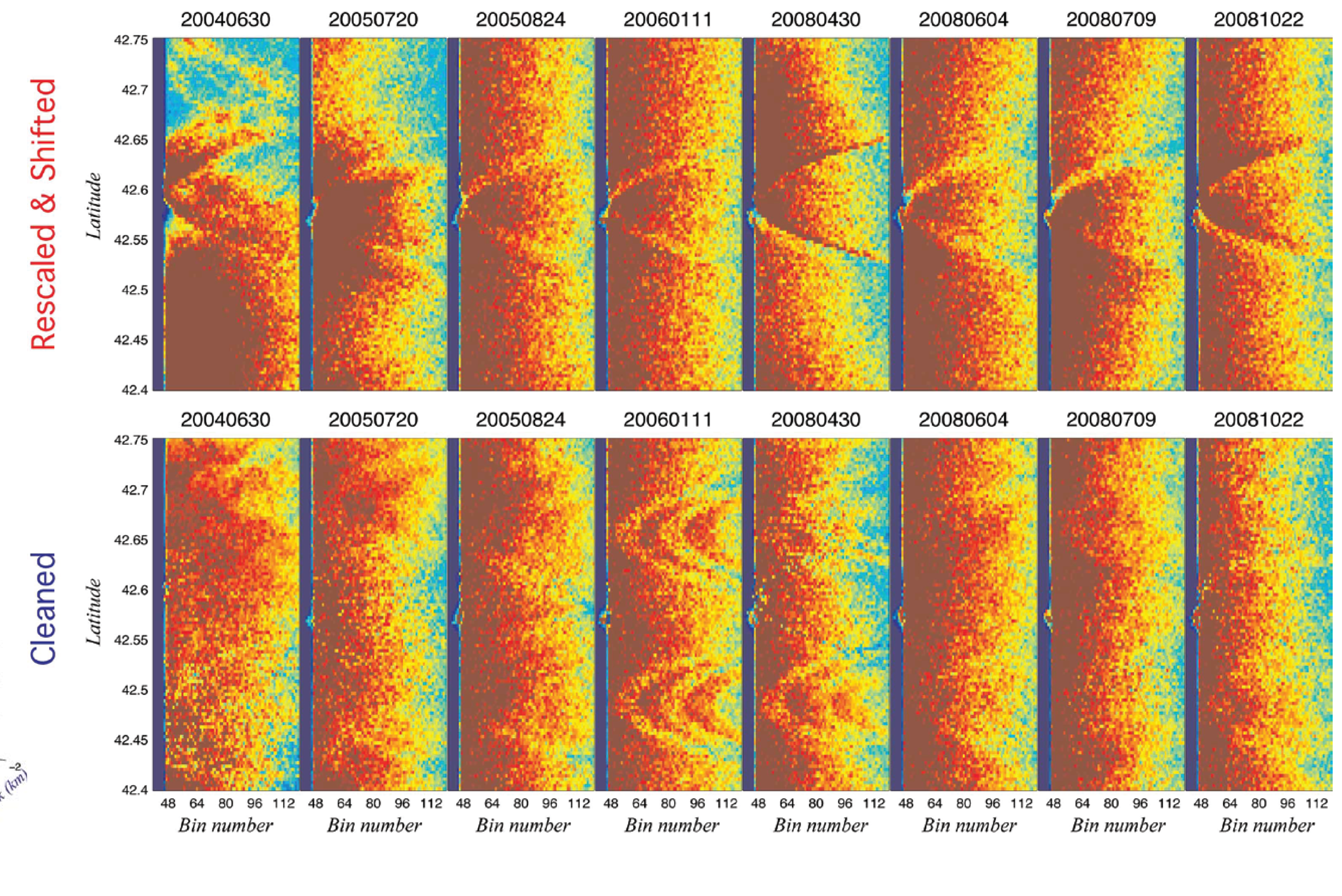


RA-2 data from NE Pacific — corrections are high-pass filtered before application to avoid large offsets. Note after the shift the feature at 59.55°N is now a complete hyperbola.

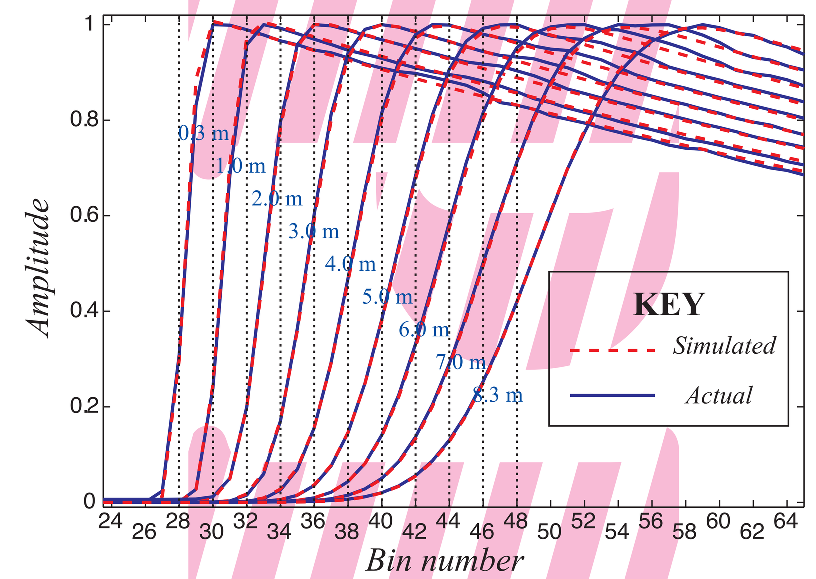
A particular interest has been Pianosa Island (of *Catch 22* fame), an island of ~10 km^2 near Corsica. Envisat crossed the island every 35 days and showed both a persistent power deficit (absence of marine reflectance where land was present) and an intermittent bright target associated with 2 sheltered bays. The **hyperbolic pretracker** should compensate for both features.



Sample of RA-2 data from SE Pacific, with middle panel showing zoom on leading edge, and left panel the derived half-power point (red line shows 9-point smoothing). Anomalies (i.e. sig/ref - 1) show strong features at toe of leading edge.



Mean waveform shape



Composite display of Envisat RA-2 mean waveforms with identical simulations (each set of wave heights is offset by 2 bins). They all show the mean to have a power excess (+2%) for bins 61- 63. Consequently, it is better to use the altimeter mean as a reference, rather than an idealised simulation.

Rescaling and Shifting

With simulated data, the series of waveforms is always consistent and complete. With real data, a variable AGC data has been applied and the waveform window is not always in the same location relative to the sea surface. A high-pass filtered version of the corrections is applied to the original data to give rescaled / shifted version.

Problems can also occur if the altimeter switches to a different chirp mode or if the tracker window is moving wildly.

Tracker jitter

The 2-D filtering procedure acts on waveform anomalies relative to a reference mean. However, in practice the tracker window is not perfectly arranged; its pre-ordained position may be a fraction of a bin early for 20 or 30 waveforms and then a fraction of a bin late. This is important as it generates large relative anomalies at the leading edge with respect to a fixed mean waveform.

Application to Pianosa

The figure to the left shows 8 Envisat passes over Pianosa. For most of the cases shown the power deficits and bright target signals are successfully removed, but for some cases, extraneous features are generated north and south of the island. This is being investigated.

Conclusions

There are a number of difficulties in applying the hyperbolic pretracker to real data, chiefly related to movement of the tracker window relative to the sea surface. However, for Pianosa the system works without too many catches, giving cleaned waveforms more amenable to conventional ocean retrackers.

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