Use of CryoSat SIRAL FBR SAR Level 1a data to test Delay-Doppler resolution of ocean surface geophysical signals

CryoSat Data AO Proposal 2690 for
Innovative Use of SIRAL SAR Mode Data
(Proposal Accepted)

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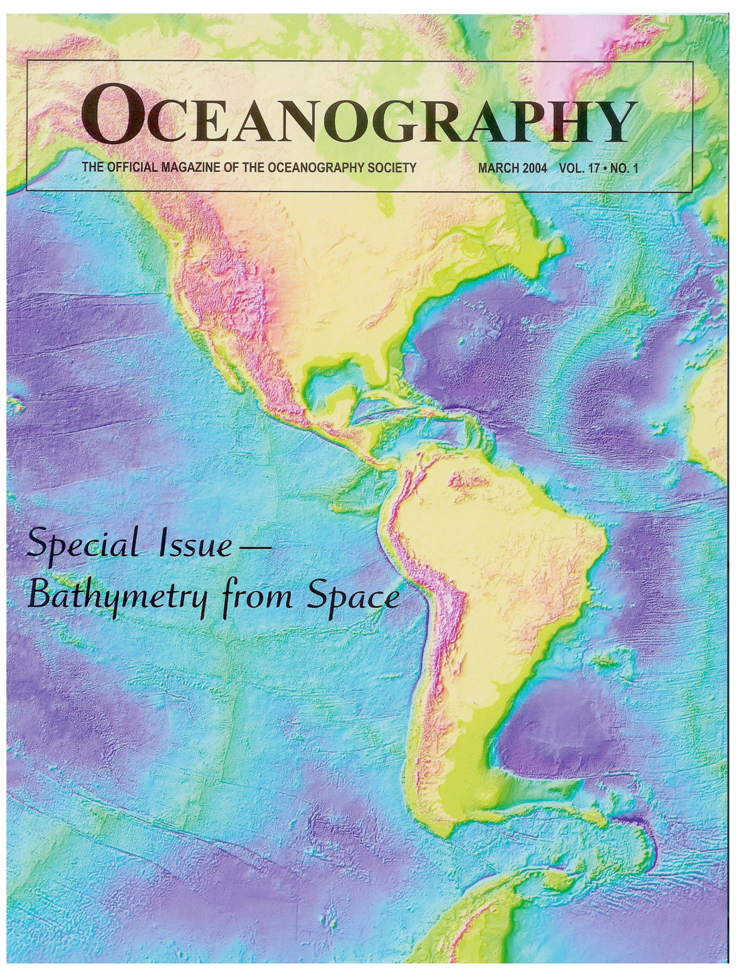
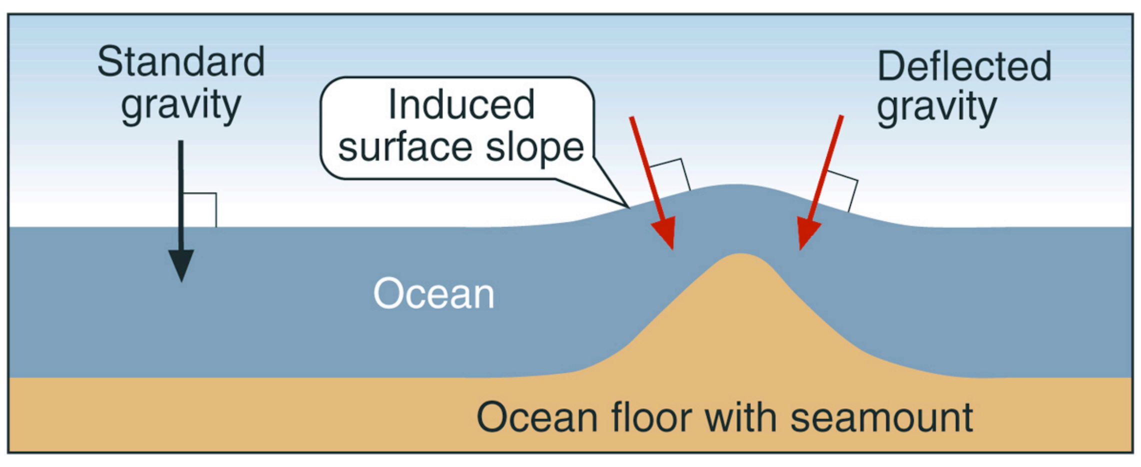
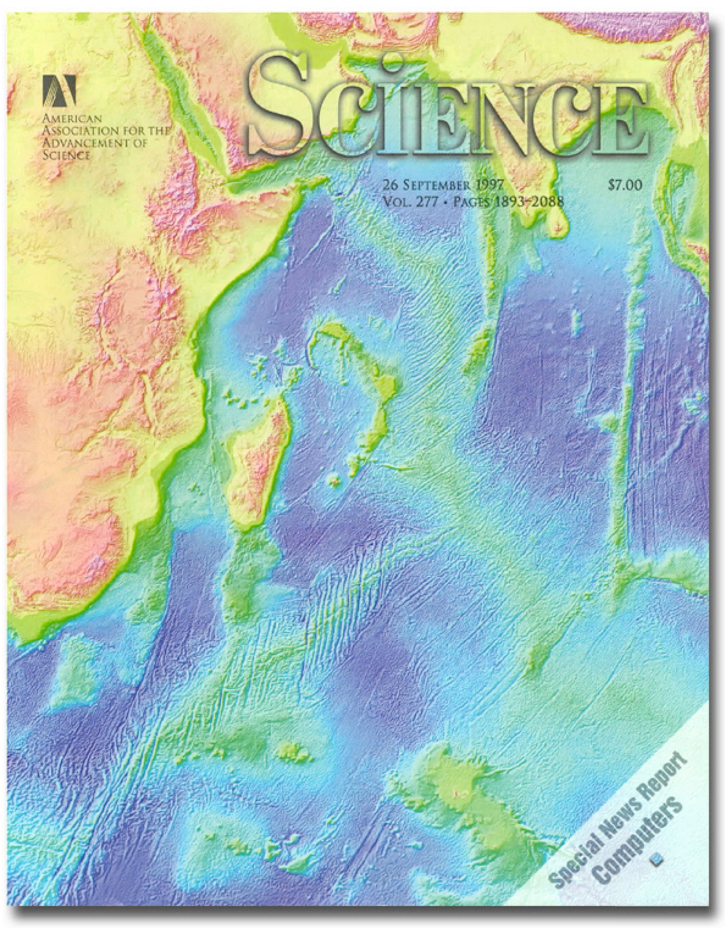
Abstract:
This proposal makes Innovative Use of the CryoSat SIRAL radar altimeter operating over two select areas of the ice-free ocean in SAR mode. The objective is to show that the CryoSat SIRAL in SAR mode is superior to conventional altimetry (CA) at resolving short spatial scale sea surface slope signals associated with ocean floor topography. This work complements another proposal by R. K. Raney; the Raney proposal objective is to show that SIRAL SAR precision is superior to CA precision. Our method will be to obtain full-bit-rate (FBR, Level 1a) data in small and select areas of the ice-free ocean, and to process these data in each of two ways: as a conventional pulse-limited ocean radar altimeter (CA), and as a Delay-Doppler altimeter (DDA, an unfocused nadir-looking SAR). This will yield both kinds of altimeter range measurements (CA and DDA) under the same performance conditions: identical hardware, path environment, and surface scattering characteristics. Ground-based simulations have shown that the random range error due to ocean surface waves should be less in a DDA than in a CA, and that the relative improvement (DDA:CA) should increase as significant wave height (SWH) increases. These simulations suggest that the CryoSat SIRAL SAR may be expected to significantly outperform a CA at recovery of short-wavelength geophysical signals, especially in areas of large ocean surface waves. A definitive demonstration, however, will require collection of CryoSat SIRAL SAR FBR data in two select areas, Area A and Area B. Both must have high power in the marine geoid signal at short spatial scales, so that there is something to measure; the criterion for improved resolution is that the geophysical signal will stand out above the noise level at spatial wavelengths shorter than conventionally resolved. The two areas should be quite different as to their expected wave height, SWH. We propose that both areas should be above mid-ocean ridges; Area A should be in the Equatorial Atlantic Ocean (low SWH year-round) and Area B should be in the South West Indian Ocean (high SWH year-round). We will work flexibly with the CryoSat team to determine the precise specification of Areas A and B, how much area they cover, whether SAR mode data are collected along both ascending and descending tracks, or only in one direction, etc. We would like each area to yield several SAR mode profiles with ground track extent of a few hundred km each, to facilitate robust spectral analysis. Deliverables will include the processed range measurements, sea surface height profiles, and resolution analyses. Funds for data processing will be obtained from NASA's Oceans and Ice program, the U.S. National Science Foundation, NOAA, or other sources.



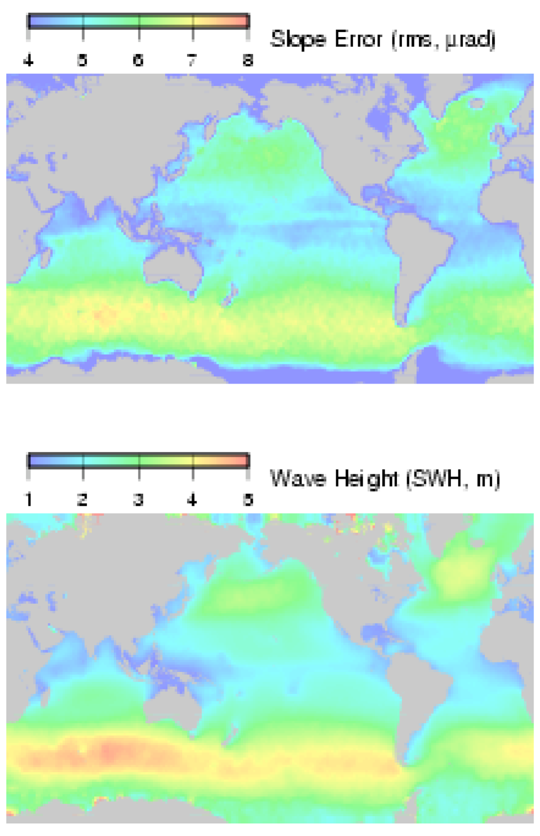
Bathymetry from Satellite Altimetry

requires high signal-to-noise ratio in sea surface slopes (height gradient) at short (5 to 100 km) spatial scales. Conventional altimeter data yield slopes with a root-mean-square error around 4 micro-radians (mm per km). Useful signal could be recovered if this could be reduced to 1 μrad.





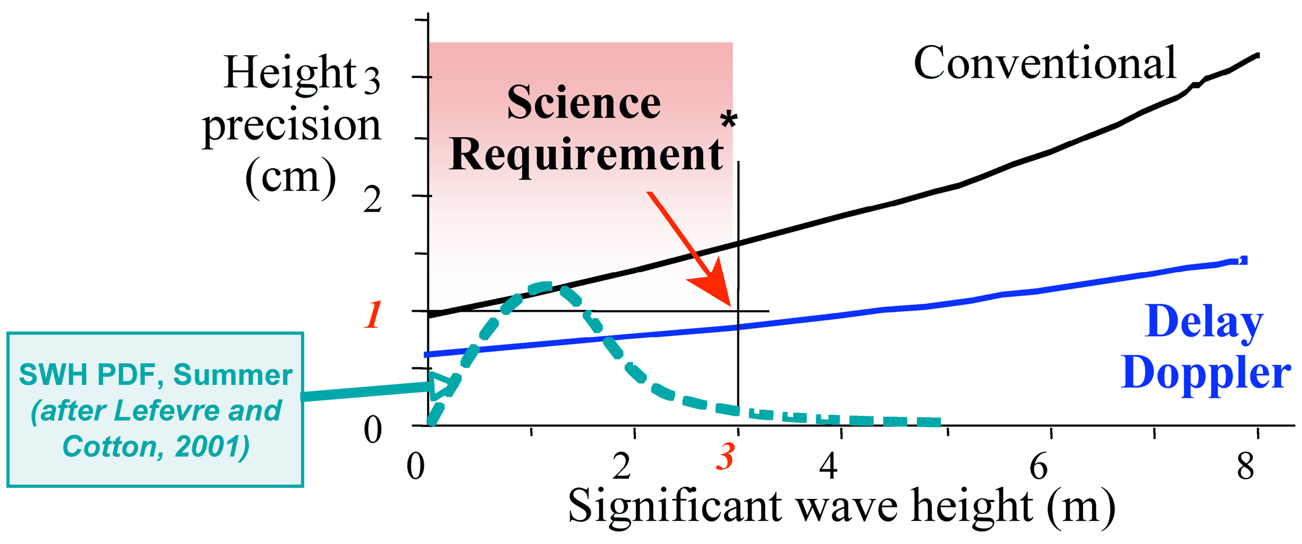
Precision in sea surface slope is limited by random errors which grow as wave height grows.



The root-mean-square error in sea-surface slope (top map at left) as measured by conventional altimetry is correlated with seasonally-averaged ocean wave height ("SWH", bottom map at left). The SWH field is correlated over long (> 50 km) distance in deep water, and so any *systematic* error in altimetry that grows with SWH ("sea state bias") has a negligible slope. The slope error is instead due to *random* errors in altimetry that increase as SWH increases.

A delay-Doppler altimeter is expected to have better precision than a conventional altimeter,

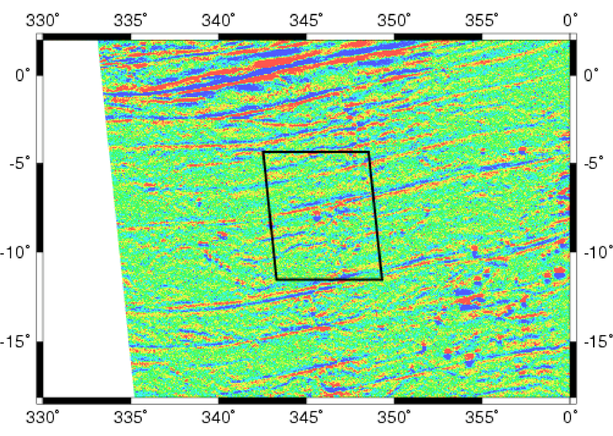
and increasingly so as wave height grows. We propose to use CryoSat data to demonstrate that this can yield improved recovery of sea surface slope signals associated with seafloor topography.



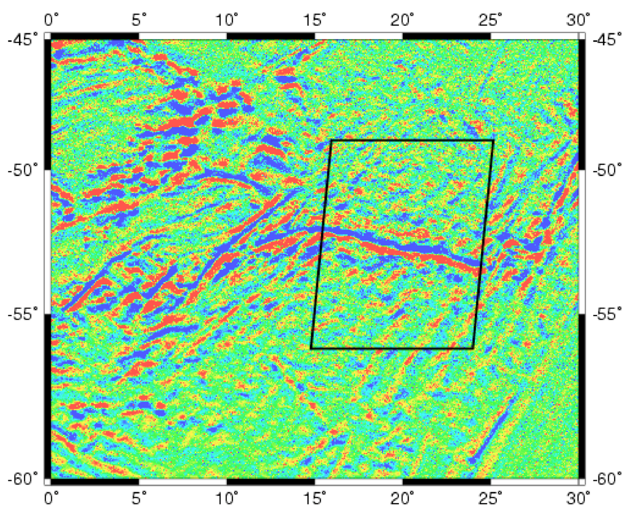
HBR data in two test areas is required.

To demonstrate improved resolution of the seafloor geophysical signal, we require that signal stand out above background noise. We therefore have requested high-rate (SAR mode) data in two areas, A (left) and B (right). The details of the areas can be adjusted as needed. Each should have geophysical signals with power at short wavelengths, and the two areas should differ in having relatively low (A) or high (B) expected wave heights.

Smith proposal 2690 HBR Area A



Smith proposal 2690 HBR Area B



Shown above are images of the north-south component of sea surface slope as recovered from conventional altimetry (ESA's ERS-1 Phases E and F (geodetic phases) and U.S. Navy's GeoSat Geodetic Mission). Area B (right) covers the South-West Indian Ridge, the roughest mid-ocean spreading ridge known, and an area where large wave heights can be expected. Descending CryoSat tracks will be at angles nearly perpendicular to the ridge axis. Area A (left) covers the Mid-Atlantic Ridge in an area of rough sea floor near Ascension Island, where ascending CryoSat tracks will lie nearly orthogonal to the fracture zones. If by chance a CryoSat track crosses Ascension Island during this experiment, we will also be able to test how the presence of land in the ocean footprint affects both conventional and delay-Doppler altimetry.

The exact specification of these areas can be adjusted as mission requirements dictate. We are able to negotiate the size of the areas and their centroid locations. We hope to have several tracks, each several hundred km long, in each of two ice-free areas, each with large short-wavelength geophysical signals, one with low and one with high wave height. These are the only requirements of this proposal.