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EVALUATION OF CRYOSAT-2 FOR HEIGHT RETRIEVAL OVER THE HIMALAYAN RANGE

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ABSTRACT

Here we present the first results of quality assessment of height retrieval by CryoSat-2 over the snow and ice covered Karakoram region. Using L1b data and an a-priori DEM, we simulate the successive areas tracked by CryoSat in SARIN mode in February 2012. We find that the closed-loop control is mainly tracking at altitude of mountains peaks and crests not allowing the recording of echoes returning from glacial valleys. When glacial valleys are imaged, waveforms show significant backscatter energy and coherent heights. We also note that successive bursts image slightly differents region which may impact on the quality of the retrieved SARIN product.

Key words: CryoSat-2, Himalaya.

1. INTRODUCTION

Climate warming over the 20th century has caused drastic changes in mountain glaciers globally, and of the Himalayan glaciers in particular. The stakes are high; mountain glaciers are the largest contributor to the increase in the mass of the worlds oceans, and the Himalayas play a key role in the hydrology of the region, impacting on the economy, food safety and flood risk to a large population. Partial monitoring of the Himalayan glaciers has revealed a mixed picture; while many of the Himalayan glaciers are retreating, in some cases locally stable or advancing glaciers in this region have also been observed. Recent controversies around the future of the Himalayan glaciers, fuelled by projections reproduced in the 2007 *Intergovernmental Panel on Climate Change* report, have highlighted our limited knowledge of the evolution of Himalayan glaciers, and our limited understanding of the relationship between climate change and Himalayan glaciers change.

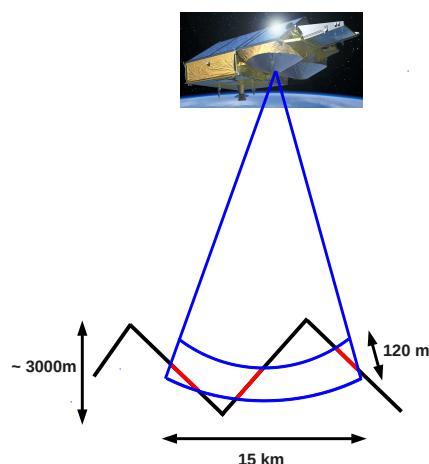In its interferometric mode, CryoSat-2 is designed to en-

Figure 1. Diagram explaining the principle of the method

able the retrieval of elevation over steep sloping terrain. If successful over mountain glaciers, height retrieval by CryoSat-2 could provide an invaluable datasets for the assessment of ice mass balance of the Earths mountain glaciers.

2. OBJECTIVES AND METHOD

CryoSat-2 SARin mode has a 120m range window which is small compared to the high denivelation in Himalaya; inside a CryoSat-2 footprint, the surface altitude can vary by up to 3000m. Here we estimate the regions effectively tracked by CryoSat-2.

In order to estimate the portion of the ground imaged by CryoSat-2, we :

- Compute CryoSat range window from L1b window delay and geophysical range corrections

- Simulate the range of regularly spaced points on the surface using an a-priori Digital Elevation Model (DEM) and the satellite position recorded in the L1b data

- Compute the intersection of the two to determine the regions tracked by CryoSat

Figure 1 summarizes the method.

We used the ESA delivered baseline B level 1B and 2 data for February 2012 over the region of Karakoram (74E, 34,5N to 78E, 37N). The DEM used is based on SRTM, filled and corrected from the best alternatives sources as e.g ASTER GDEM with spatial resolution of 3".

3. RESULTS

Figure 2 shows the tracked areas for a subregion covered by some important glaciers.

The first important result is that on the descending (left side) track and parts of the ascending track, the range window lies at the altitude of mountains peaks and crests. As a result we miss most of the glacierized areas. A second consequence is that echoes returning from this altitude come from very dispersed scatterers and thus we have very weaks and uncoherent echoes (figure 3(c)), which is the reason why the retracking fail and most L2 data are useless.

Moreover, analysis of the repeat track of the 10th of February 2013 show that over mountainous region, the tracking process might fluctuate randomly implying that the tracked regions are different from one year to another (cf figure . This makes year to year comparison difficult. Nevertheless, some valleys are imaged and waveforms show significant backscatter energy and coherent heights (cf figures 3(a) & 4). In the North-South valley, the tracked region is constrained to the bottom of the valley leading to a coherent and strong echo, constrasting with echoes from mountains peaks. On the East-West glacial valley, there are a few points with good height estimate compared to SRTM. Waveforms show several peaks probably returning from different scatterers on the glacier (figure 3(b)).

4. DISCUSSION

The problem of not tracking the regions of interest is really inherent to the way CryoSat works. In SARin mode, SIRAL indeed send a 40MHz burst between each measurement burst to track the surface with an alpha-beta tracker (the so-called closed-loop control). A more flexible loop control would significantly increase the area of interest covered by CryoSat-2 over mountainous regions and improve the quality of echoes.
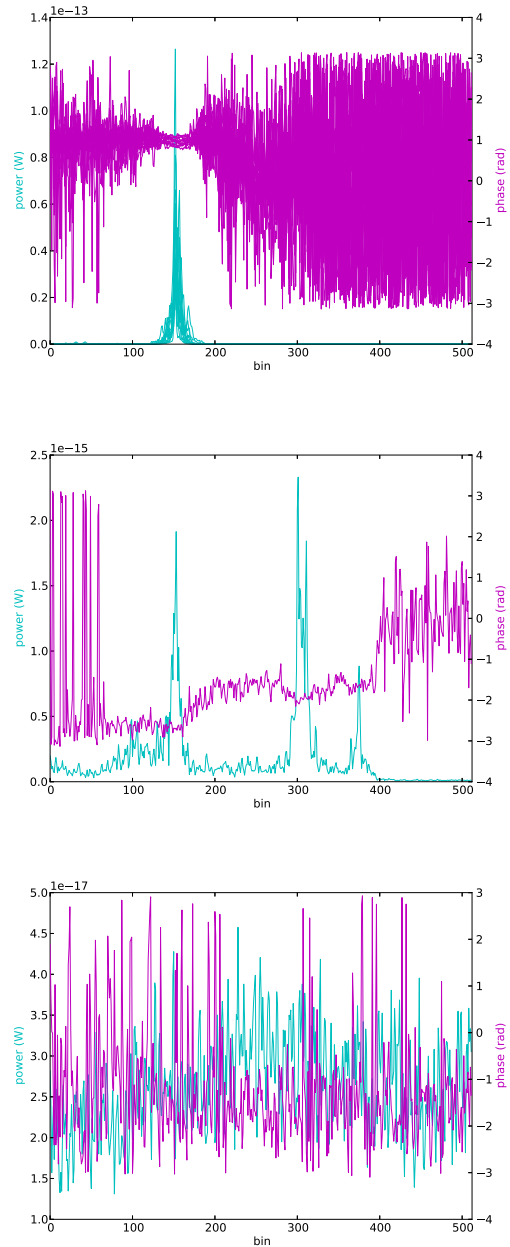

Figure 3. Power and phase for the echoes returning from the north-south valley (top), east-west glacial valley (middle) and a point of the descending track (down)
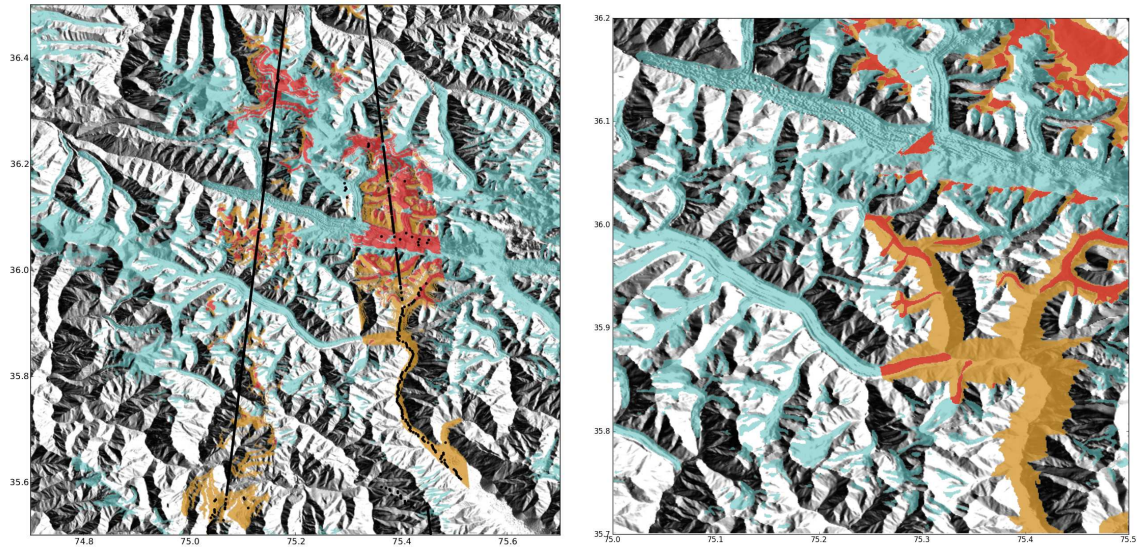
Figure 2. Tracks of CryoSat 2 measured in Feb. 2012 (left) and 2013 (right) over a subset region of the Karakoram (black dots) with the associated simulated tracked region (orange). Light blue masks are glaciers area from the Randolph Glacier Inventory and red areas are the tracked regions that lie over glaciers. Background is SRTM topography.
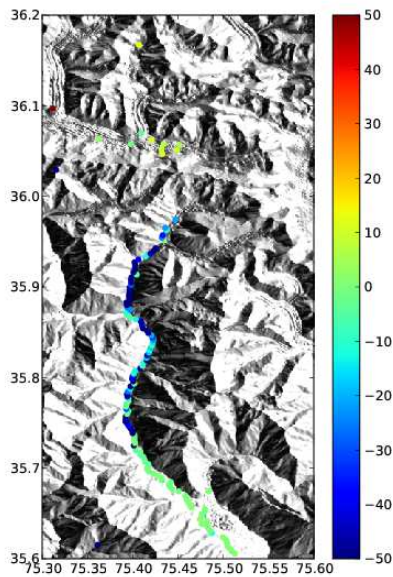

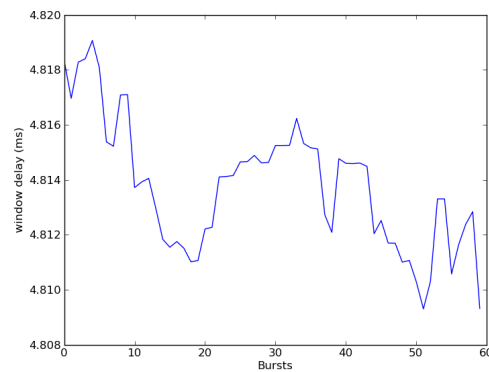Figure 4. Difference between CryoSat-2 height estimate and SRTM topography

Figure 6. CryoSat window delay over the studied region

Concerning multi-looking of successive burst, in some cases (over the East-West glacial valley), successive pulses track different areas (figure 5). This is due to abrupt changes in the window delay (figure 6). Multi-looking thus probably sums signals that are not coherent possibly affecting the quality of the SARIN product (figure 3(c)). Developing an on-board retracker that take into account all peaks might allow to get more points over glaciers valleys.

5. CONCLUSIONS

We've shown that the closed-loop control is missing most glacial valley, rather tracking at altitude of mountains peaks and crests, resulting in dispersed scatterer and weak echoes. Some valleys are successfully im-
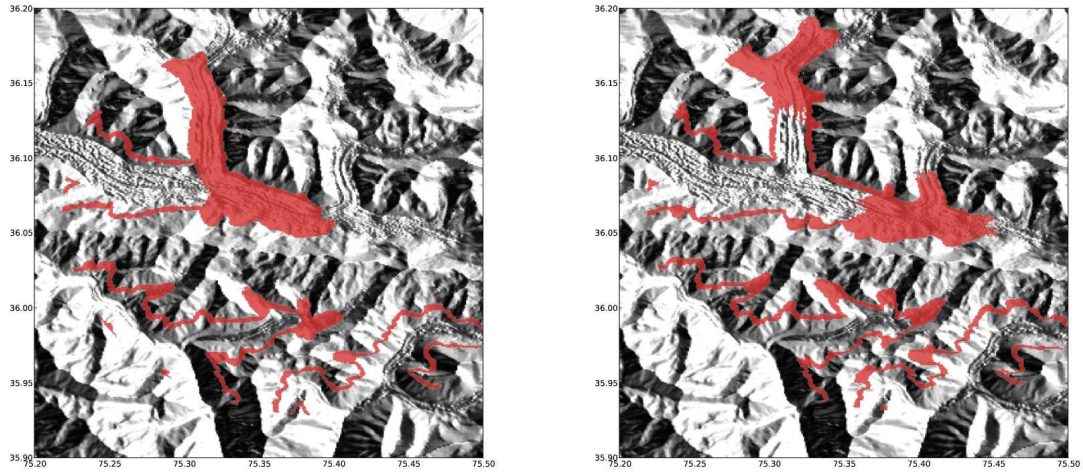
Figure 5. Regions tracked by CryoSat-2 for 2 successive pulses

aged and waveforms show significant backscatter energy and coherent heights. At last, taking into account abrupt changes in the window delay during the multi-looking process could allow getting every valuable information in the waveforms.

ACKNOWLEDGMENTS

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