CRUCIAL: Cryosat-2 Success over Inland Water and Land

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Introduction

- CRUCIAL is funded in successful response to ESA ITT ESRIN/AO/1-6827/11/I-NB, to investigate the application of CryoSat-2 data over land and inland water.
- Expertise in satellite radar altimetry, including generation of inland water and land heights and development of Global Digital Elevation Models.
- Expertise of River Modelling to highlight the potential of inland water heights from Cryosat-2.
- CryoSat's primary instrument is SIRAL (SAR Interferometric Radar Altimeter).
- SIRAL operates in one of three modes (Low Resolution Mode(LRM), Synthetic Aperture Radar(SAR) and Interferometric Synthetic Aperture Radar(SARIN).
- The project is investigating innovative land and water applications from Cryosat-2 with a forward-look component to the future Sentinel-3 mission.

Method and Tracks

- The Earth's land surface is, in general, a relatively poor reflector of Ku band energy, with the exceptions of inland water, salar and ice surfaces.
- This has enabled the series of earth-orbiting satellite radar altimeters to be used for land surface applications including mapping and measurement of river and lake systems.
- Research with EnviSat Burst Echoes has shown that substantial high frequency information content is present at short spatial scales as the small bright reflecting patch at nadir is able to dominate the returned echo. This effect is most strongly seen with inland water.
- The previous generation of satellite radar altimeters loses significant amounts of information due to onboard echo averaging .
- The high along-track sampling of Cryosat-2 altimeter in SAR mode offers the opportunity to recover high frequency signals over much of the Earth's land surface, contributing to mapping applications, and transforming the inland water height retrieval capability.
- This is constrained by the limited availability of SAR FBR data from Cryosat-2 over the land
- Selected SAR and LRM tracks are shown in Figure 1.

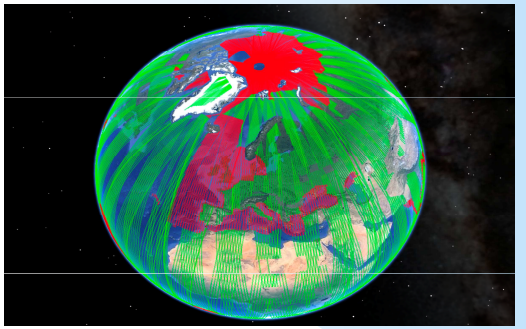

Figure 1: Selected SAR (Red) and LRM (green) track over the Earth

Mekong – LRM (Figure 2) and SAR (Figure 3) Tracks

- LRM track put through expert system tuned for Cryosat-2 LRM waveform shape recognition (Table 1).
- High proportion of complex (land/water) multi-target echoes, these are most often associated with snagging on bright targets.
- Figure 4 shows comparisons of LRM heights and ACE2 heights.
- Good agreement apart from rough topography where Cryosat-2 did not receive the echoes.

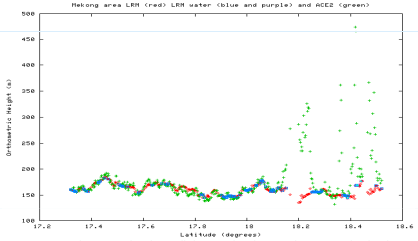

Figure 4: Mekong LRM heights. All the LRM heights are shown in red. Inland water flagged heights in blue and cyan and ACE2 DEM heights in green.

Processing LRM data	Number of Waveforms
Total input	420
Accepted and retracked	399
Slope affected echoes	115
Inland water echoes	96
Complex echoes	172
Broad echoes	16

Table 1: Results of LRM waveshape recognition.

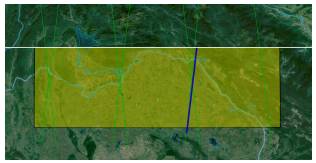

Figure 2: LRM Mekong Tracks. The bounding box is between 102 - 105°E and 17.4 – 18.5 ° N. The blue line is the target track

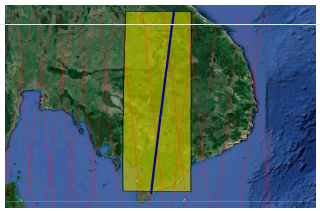

Figure 3: SAR Mekong Tracks. The bounding box is between 104.22- 106.86°E and 9.06– 17 ° N. The blue line is the target track

- SAR track put through expert system tuned for Cryosat-2 SAR waveform shape recognition (Table 2).
- Very high proportion of complex multi-target echoes (associated with land/water echoes particularly around the tidal delta with water not at the nadir point)
- Figure 5 shows comparisons of LRM and ACE2 heights.
- Good agreement apart from rough topography (e.g. 14.8° N) where Cryosat-2 did not receive the echoes.

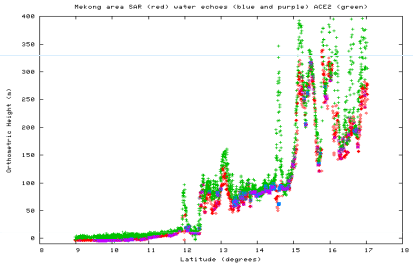

Figure 5: Mekong SAR heights. All the SAR heights are shown in red. Inland water flagged heights in blue and cyan and ACE2 DEM heights in green.

Processing SAR data	Number of Waveforms
Total input	2960
Accepted and retracked	2674
Flat terrain	125
Slope affected echoes	22
Inland water/ ocean echoes	626
Complex echoes	1886
Broad echoes	15

Table 2: Results of SAR waveshape recognition.

Amazon Tributary - SAR Tracks

- SAR Track over an Amazon River tributary (Figure 6 and Table 3) .
- Automated identification of water echoes multi- shape gives two river crossings (Figure 7).
- Snagging occurs on bright targets.

Processing SAR data	Number of Waveforms
Total input	2395
Accepted and retracked	2299
Flat terrain	300
Clean water echoes	310

Table 3: Results of SAR waveshape recognition.

Figure 6: SAR track over an Amazon River tributary

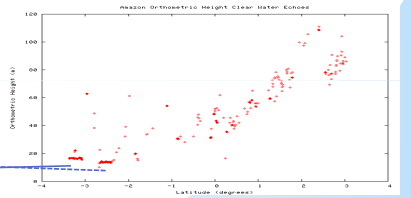

Figure 7: SAR heights. The water level in the two river crossing can clearly be seen

Conclusions

Excellent progress is being made on the analysis and retracking of Cryosat-2 waveforms. A database of water heights will be developed for use in hydrology including assimilation into river basin models. This work will be extended with the future Sentinnel-3 mission.

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References: Berry, P. A., Smith, R. G., Salloway, M. K., & Benveniste, J. (2012). Global Analysis of EnviSat Burst Echoes Over Inland Water. *Geoscience and Remote Sensing, IEEE Transactions on*, *50*(5), 1980-1985.
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