# The SAMOSA project

## Development of SAR Altimetry studies over Oceans, coastal zones and inland Water

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**SAMOSA**

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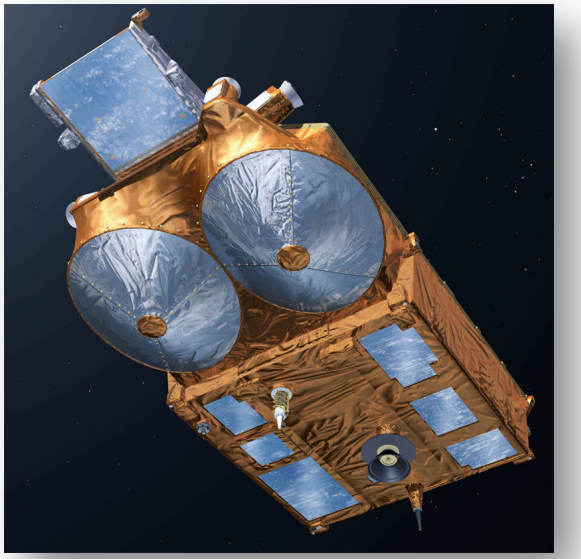
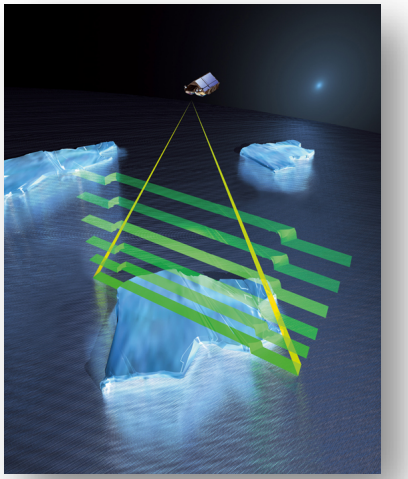
STSE Support To Science Element

# SAMOSA Motivation and Mission

## MOTIVATION

- CryoSat-2 → SIRAL
  - First satellite-borne SAR altimeter





## MISSION

- To quantify the improvements of SAR altimetry compared to conventional altimetry for observations over ocean, coastal zones and inland waters

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# SAMOSA TEAM

Expert Advice and Support:

- JHU - APL — R.K.Raney
- ESA - ESTEC — R.Cullen
- MSSL — CRYMPS

# SAMOSA OBJECTIVES

1. To establish a **state of the art review for SAR altimetry** capabilities to observe water surfaces
2. To reduce SARM data into LRM data and perform a scientific study of the **potential improved capability of SAR** data **compared to conventional altimetry** over water surfaces
3. To develop a **theoretical model** for the SAR altimetry mode echoes over water surfaces
4. To define a **new re-tracking method** for the SAR altimetry mode
5. To perform a **scientific study** of the potential capabilities of SAR altimetry data to characterise coastal zones, estuaries, rivers and lakes
6. To evaluate the SAMOSA re-tracker with **ASIRAS** data

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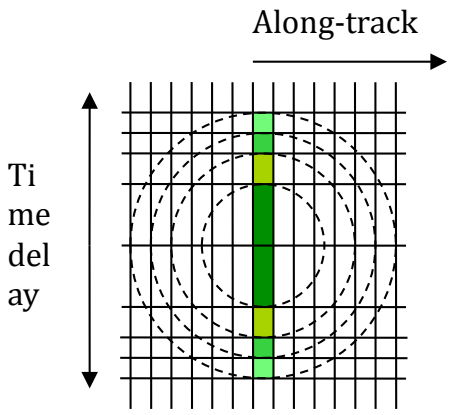
# SAMOSA Modelling / CRYMPS

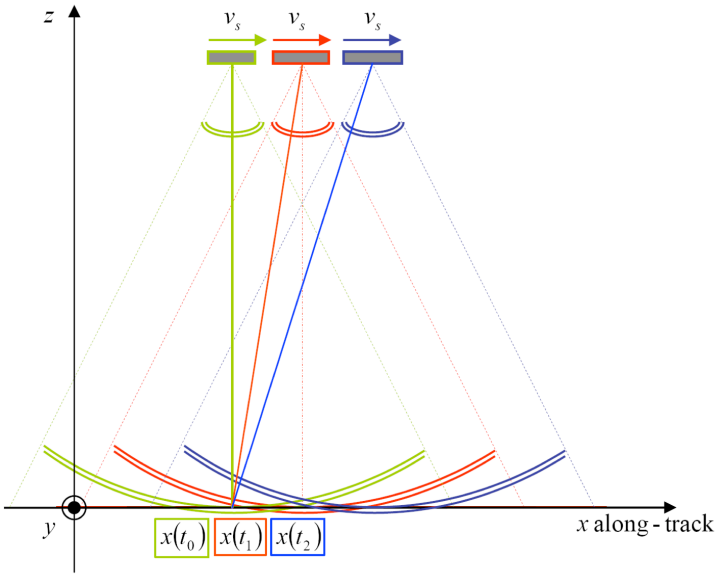
- In the absence of “real” data needed access to modelled SIRAL output to test theory and develop software
- Low Rate Mode and SAR mode simulated waveforms produced for a set of scenarios:
  - Initial rudimentary ocean surface: varying sea state
  - A sea floor topography scenario, variations in sea surface height, low swh, short wavelength
  - Inland waters scenarios: Amazon Basin, Canadian Lakes
  - Realistic ocean wave spectra, varying sea state
  - Coastal zone scenarios: one “oceanographic”, one river delta
- Thanks to MSSL for running these scenarios

# SAMOSAO1: State of the art review

- The SAMOSA team defined a SAR Altimetry state of the art review available at:

  http://www.satoc.eu/projects/samosa/



# SAMOSAO2: RDSAR

- The SIRAL modes are mutually exclusive

- For the quantitative comparison of SARM and LRM data the SAMOSA team is working on the reduction of SAR data such that it emulates conventional altimetry data

- Achieving this objective would allow to retrieve LRM data and SARM data from a single operating mode

# SAMOSA O3: SAR altimeter theoretical model

- An analytical waveform model has been defined for:
  - Gaussian Antenna Pattern
  - No curvature effects across track
  - No radial velocity effects
  - Gaussian sea surface statistics
  - Absence of across-track miss-pointing effects
- Currently the team is improving this model:
  - Introduce Elliptical antenna pattern
  - Consider curvature effects across track
  - Study radial velocity effects
  - Use of non-Gaussian sea surface geometry

# SAMOSA Derivation of the waveform model

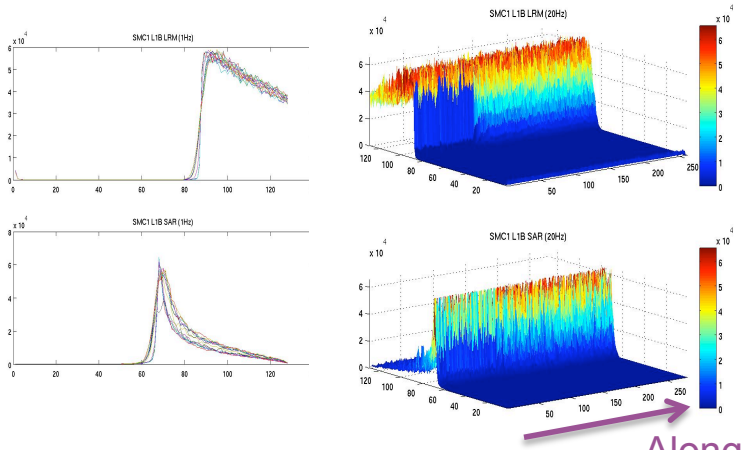
- Given the new shape of SARM echoes there is a need to define a new theoretical model to retrack waveforms
- SAMOSA team has defined a new retracker.
- The SARM single-look waveform shall be defined as the convolution:

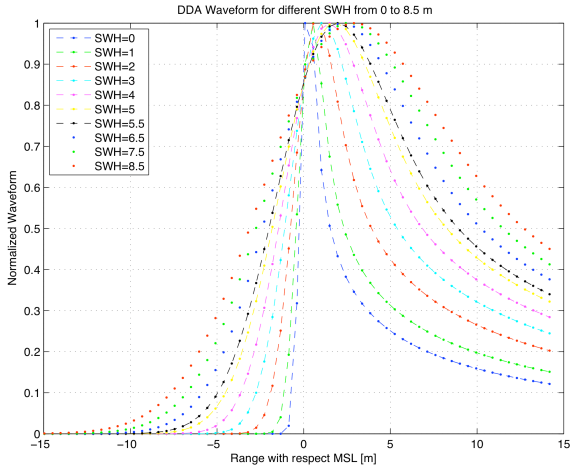
$$W(\tau_i, f_a) = P_{FS}(\tau_i, f_a) ** S_{PTR}(\tau_i, f_a) * \left(\frac{c}{2}\right) P_z\left(\frac{c}{2}\right)$$

- Where τ refers to delay time, or range window, with respect MSL; $f_a$ corresponds to a Doppler bin within the burst; $P_{FS}$ is the average flat surface response; $S_{PTR}$ the radar system point target response; and $P_z$ the surface elevation pdf. The major difference with respect to conventional altimetry is that $S_{PTR}$ is defined as:

$$S_{PTR}(\tau_i, f_a) = \mathrm{sinc}^2\left(T f_a\right)\ \mathrm{sinc}^2\left(\tau_u s \tau\right)$$

- Where T is the long-track boxcar time, $\tau_u$ the useful pulse length and s the chirp slope.

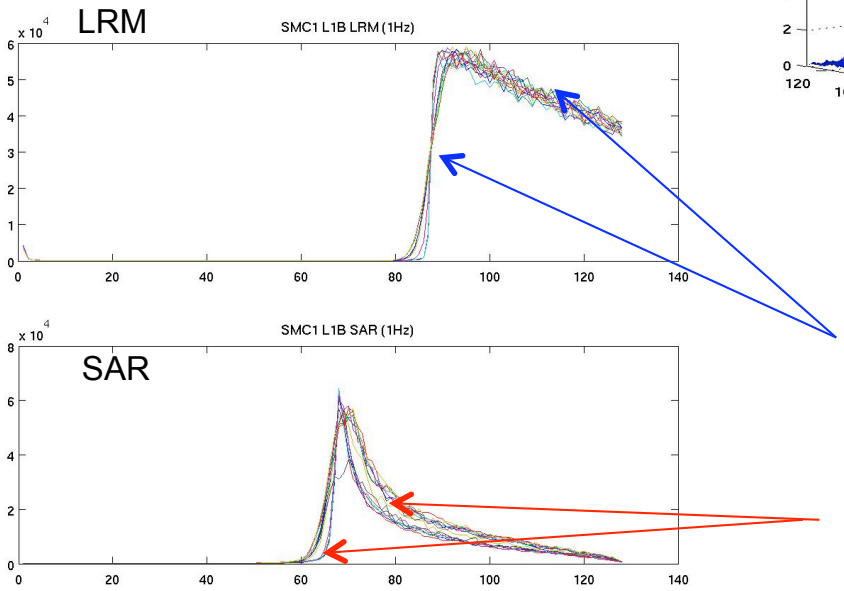


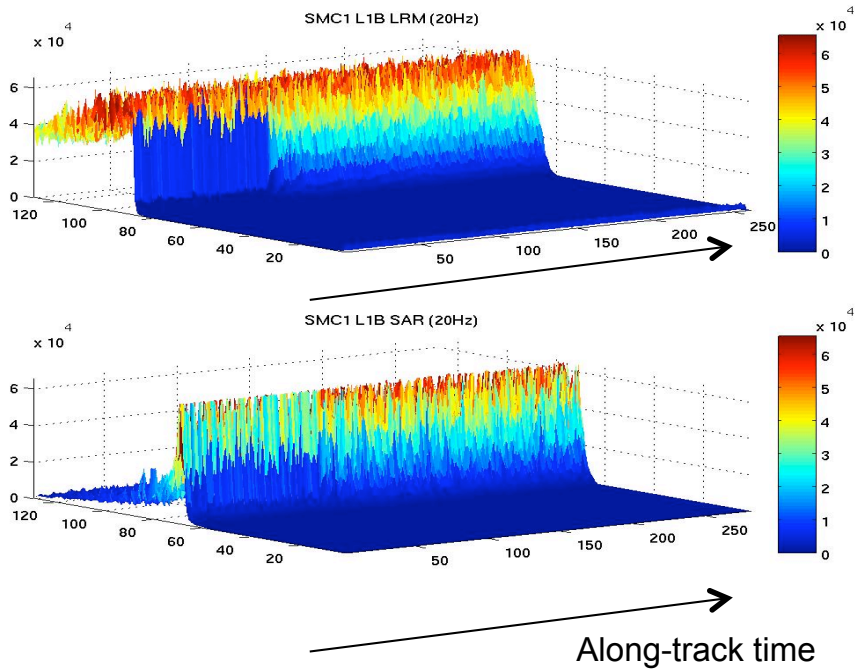



# SAMOSAO4: SAR Altimeter re-tracker

- A SAR altimeter re-tracker has been developed based on the analytical expression derived in the previous objective
- Good agreement was found between theoretical & numerical SAR waveforms, but the multi-looking methodology is still being optimised
- A DPM for the Sentinel-3 SRAL retracker has been delivered.

# SAMOSA LRM & SAR L1B Scenario C1 ( 0.1/4/5 m swh)




**LRM:** slow decaying trailing edge & increased tilt of leading edge for high SWH

**SAR:** peaky waveforms, fast decaying trailing edge, peak broadening at high SWH

# SAMOSA Single-look SAR Alt Delay-Doppler Map

- New theoretical model developed by Starlab within SAMOSA
- Provides numerical and analytical solutions for SAR Altimeter Delay Doppler Maps for single burst.
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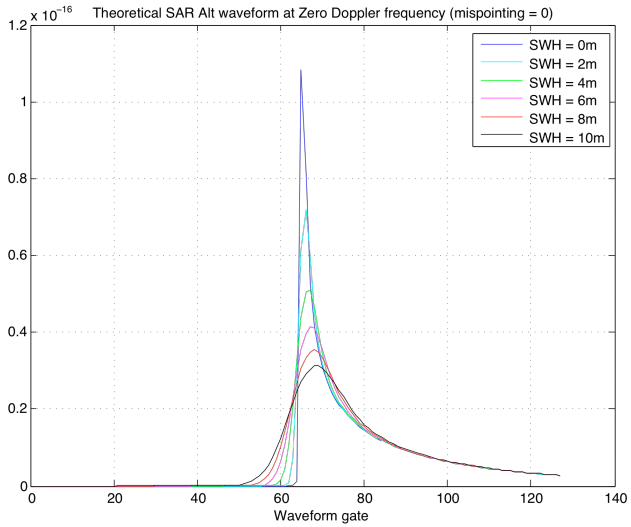
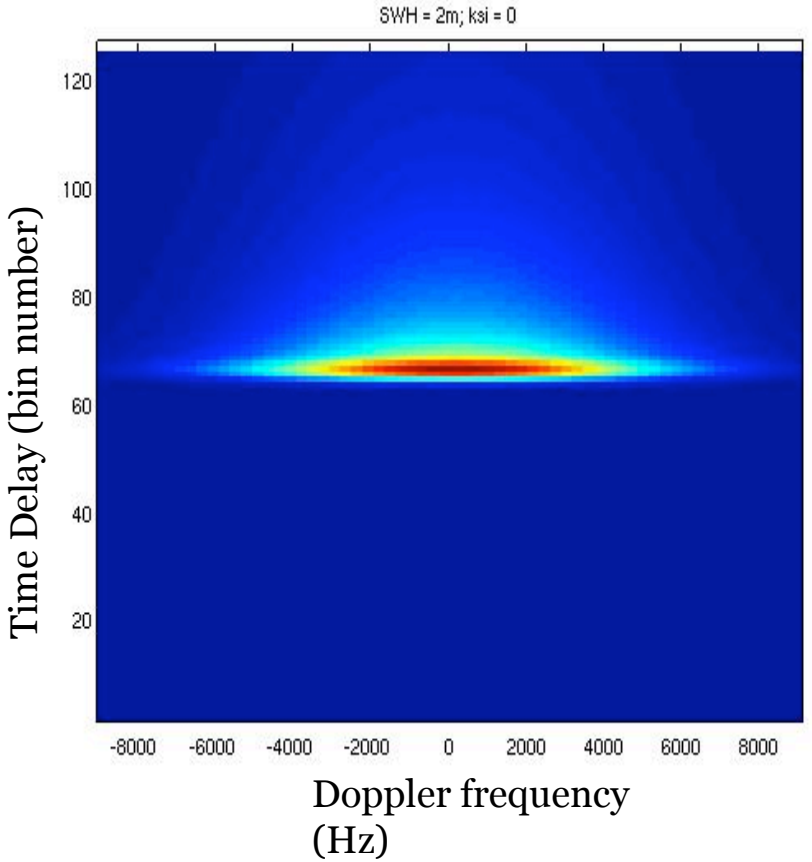
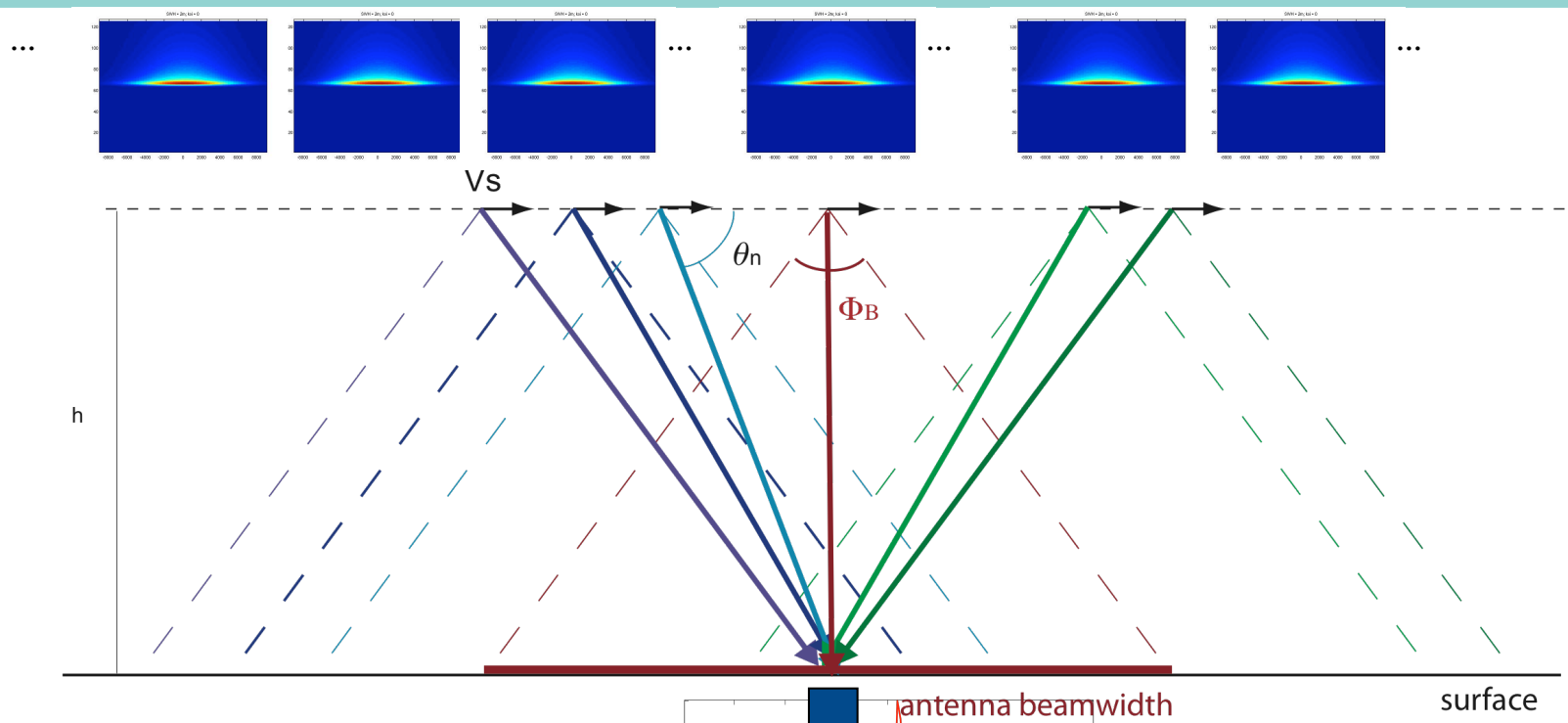
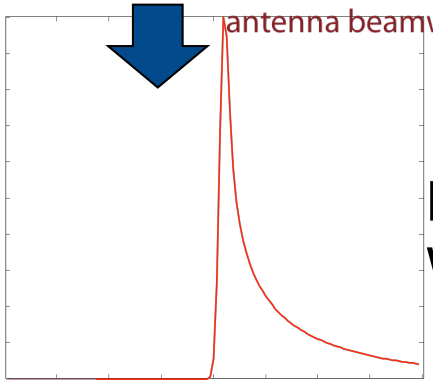


# SAMOSA Multi-looking



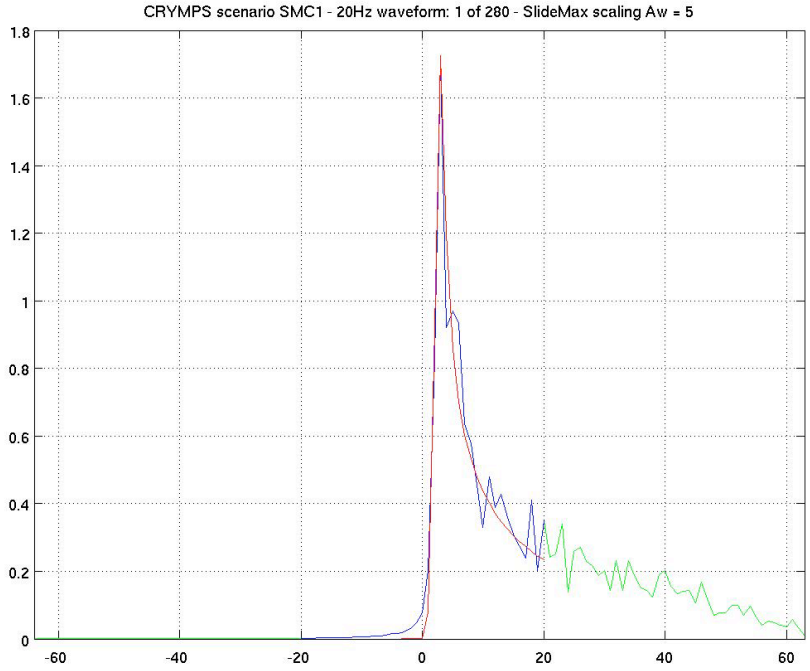

Doppler-beam selection & incoherent integration over multiple bursts



Multi-looked SAR L1B Waveform at 18Hz

# SAMOSA Prototype SAR Alt ocean retracker

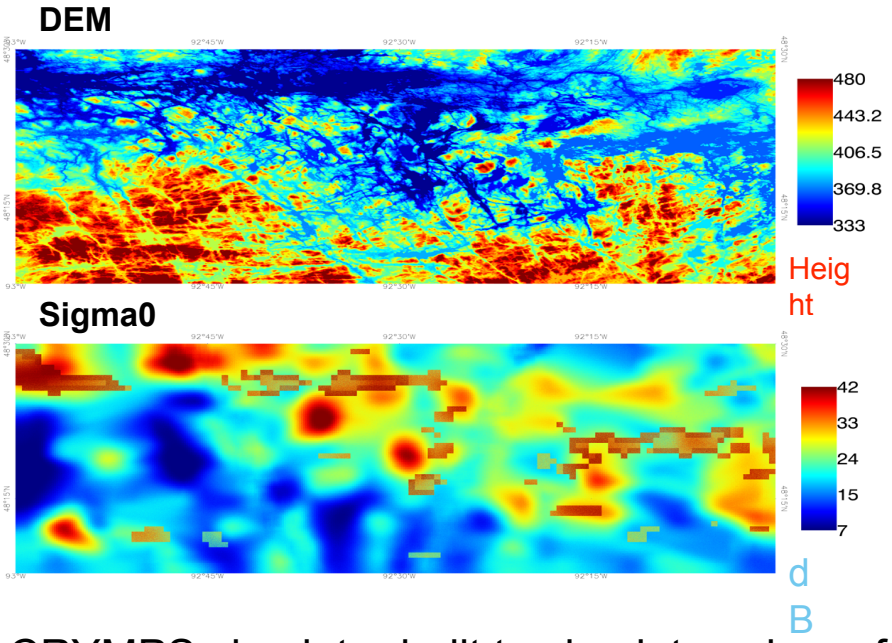
- Single-look DDA model and multi-looking implemented at NOC as prototype SAR Alt ocean re-tracker
- Applied to CRYMPS
- Good fit between theoretical and CRYMPS waveforms
- Multi-looking & noise being optimised

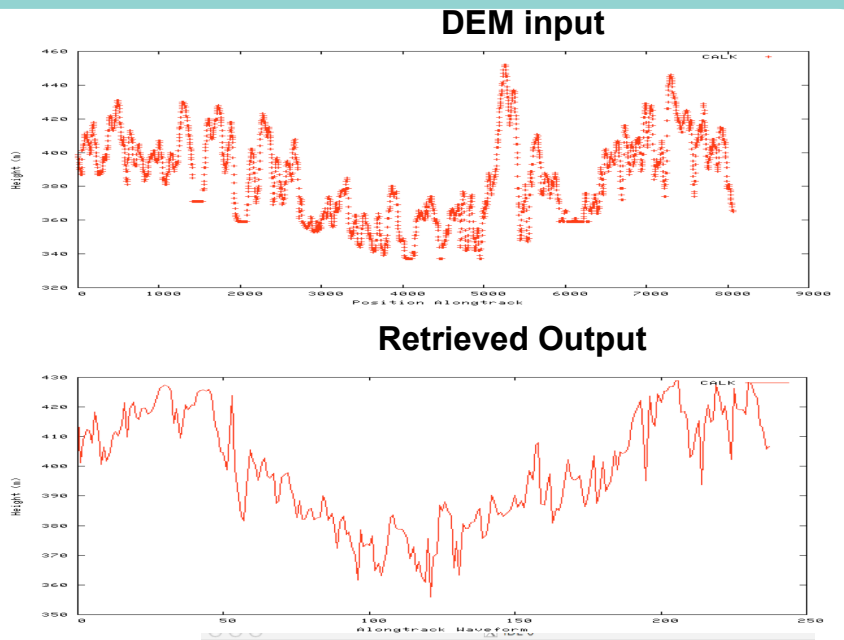


# SAMOSAO5: Coastal & Inland Waters

- What improvements does SAR mode altimetry offer for coastal and inland waters? Two types of scenario have been modelled:
  - Lakes
  - Coastal Zones

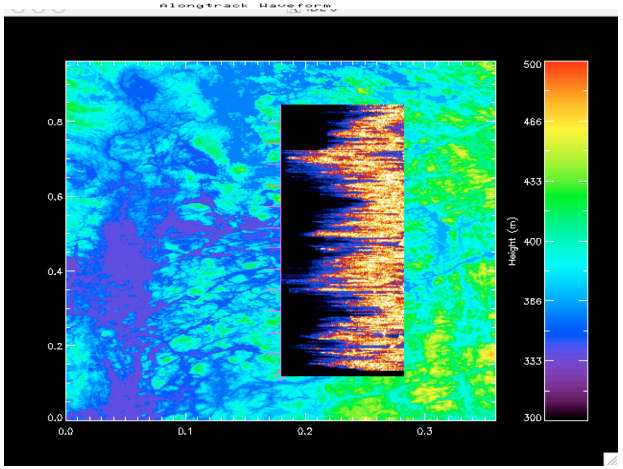
# SAMOSA Lakes Scenario for CRYMPS



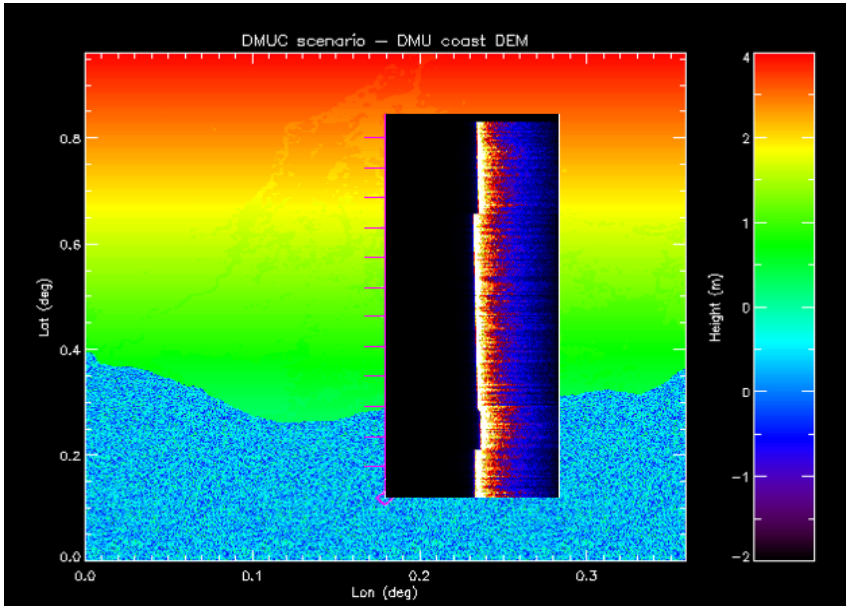




CRYMPS simulator built to simulate echoes from CryoSat2

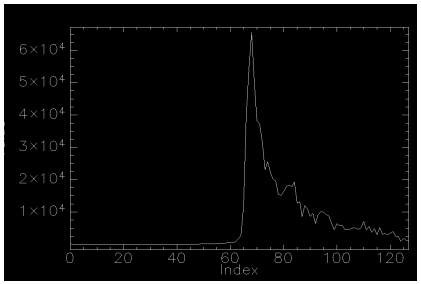
- Scenarios designed for inland water
- Lakes scenario for CRYMPS run: to test response to bright lake targets
- DEM from SRTM 1” USA data
- Sigma0 model mix of real and simulated data

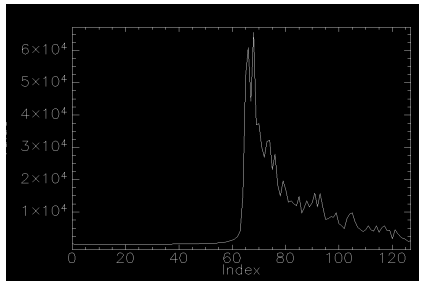


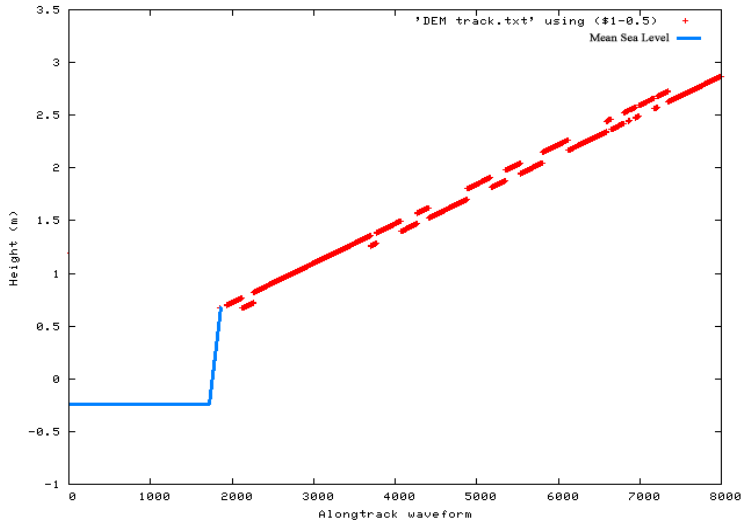
# SAMOSA Coastal zone results

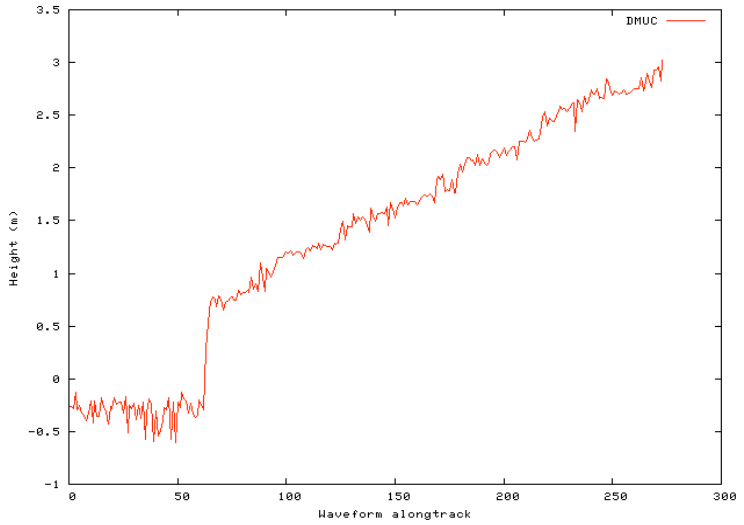



DEM picture courtesy of D.Brockley MSSL



# SAMOSAO6: ASIRAS and SAMOSA

- Evaluate the SAMOSA re-tracker against real SAR altimetry data
- Gain information on the differences between space- and airborne data
- Processing scheme for airborne data to allow comparison with space-borne data

# SAMOSASAMOSA main progress

- Investigations to reduce SAR mode to LRM
- Definition of SAR Altimetry waveform model
- Development of SAR retracker
- CRYMPS investigations
- Analysis of performance of SAR retracker with ASIRAS data

Thanks For Your Attention!

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