living planet symposium 2016

esa

A step towards the characterization of SAR Mode Altimetry Data over Inland Waters – SHAPE project

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Along-Track.com

Context

The SHAPE project : “Sentinel-3 Hydrologic Altimetry Processor prototypE”

Funded by ESA through the SEOM Programme Element to prepare for the exploitation of Sentinel-3 data over the inland water domain, with Objectives :

- **Characterise available SAR mode data over inland water.**
- Assess the performances, in Hydrology, of applying the Sentinel-3 IPF to CryoSat-2 data and emulating repeat-orbit Alti-Hydro Products (AHP).
- Analyse weaknesses of the Sentinel-3 IPF at all levels.
- Assess the benefits of assimilating the SAR/RDSAR derived AHP into hydrological models.
- Design innovative techniques to build and/or to refine the L1B-S and assess their impact onto L1B and AHP.
- Improve SAR/RDSAR retracking over river and lakes.
- Provide improved L2 Corrections (tropospheric, geoid) for Sentinel-3 over land and inland water.
- Specify, prototype, test and validate the Sentinel-3 Innovative SAR Processing Chain for Inland Water.

Context

Even with SAR mode, Alti-Hydrology is a difficult topic

- very wide variety of scenarios
- wide across-track integration → loss of accuracy & precision.
- off-NADIR hooking: tracker window not always centered at NADIR
- space and time variability of the water area with :
  - low waters → contaminated waveforms due to sand banks …
  - High waters → flooded areas sometimes (outside water masks)
- Existing SARM data (CS2) faces most of these issues

Questions

- How characterize S3 waveforms over inland from Cryosat-2 data ?
- Is geodesic orbit an issue ?

Objectives

New framework with Automated Water Masking

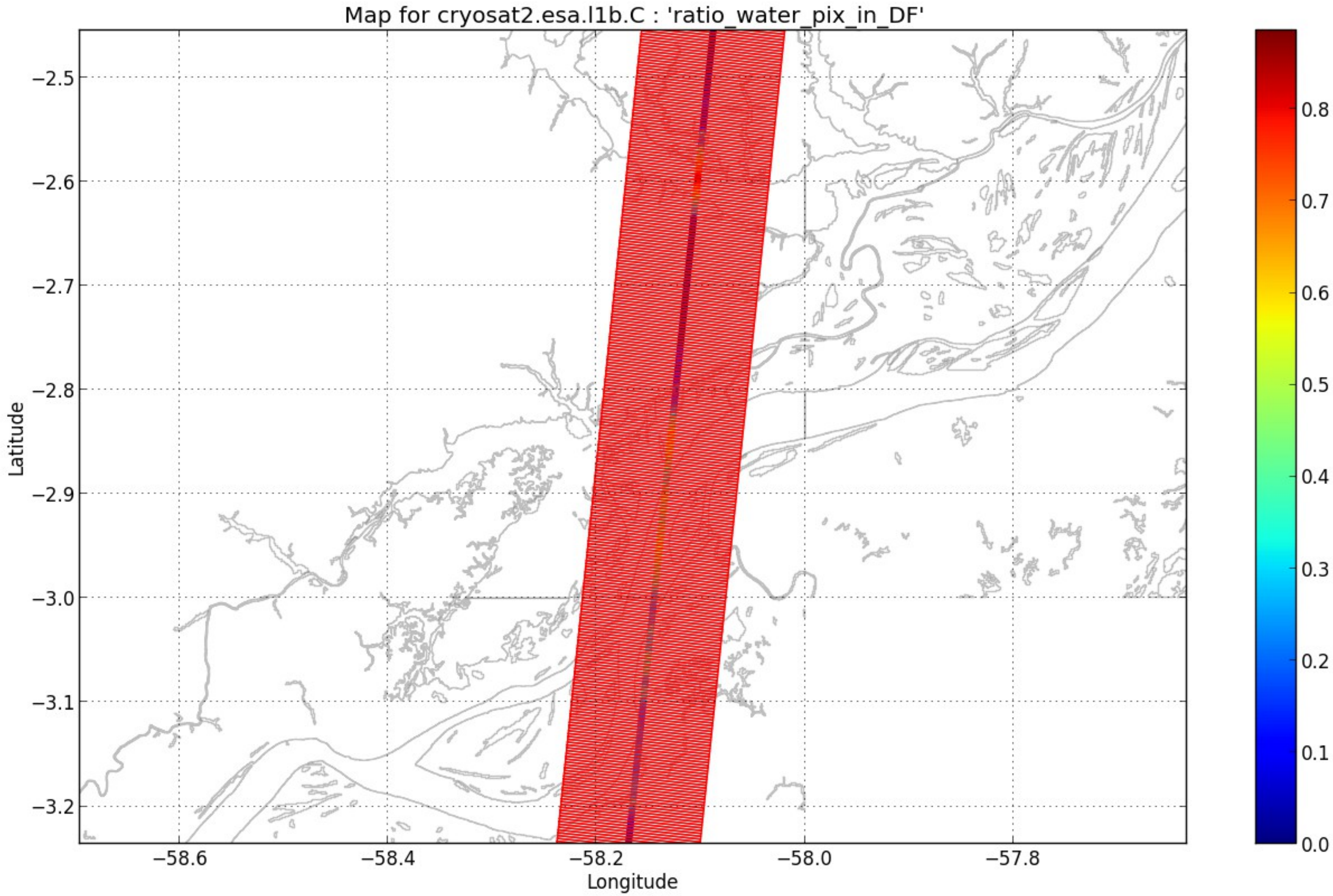
- use updated water masks => **synergy with imaging missions (S1)**
- L1B → characterization
- L2 → measurements within the new framework

- How to ?

  - Compute the Doppler Footprint**s** – to - Water Masks **intersection area**
  - Define classes according to **% of water mask within footprint**
  - Build Statistics (from beam behaviour param.) per class.
  - Average waveforms per class.

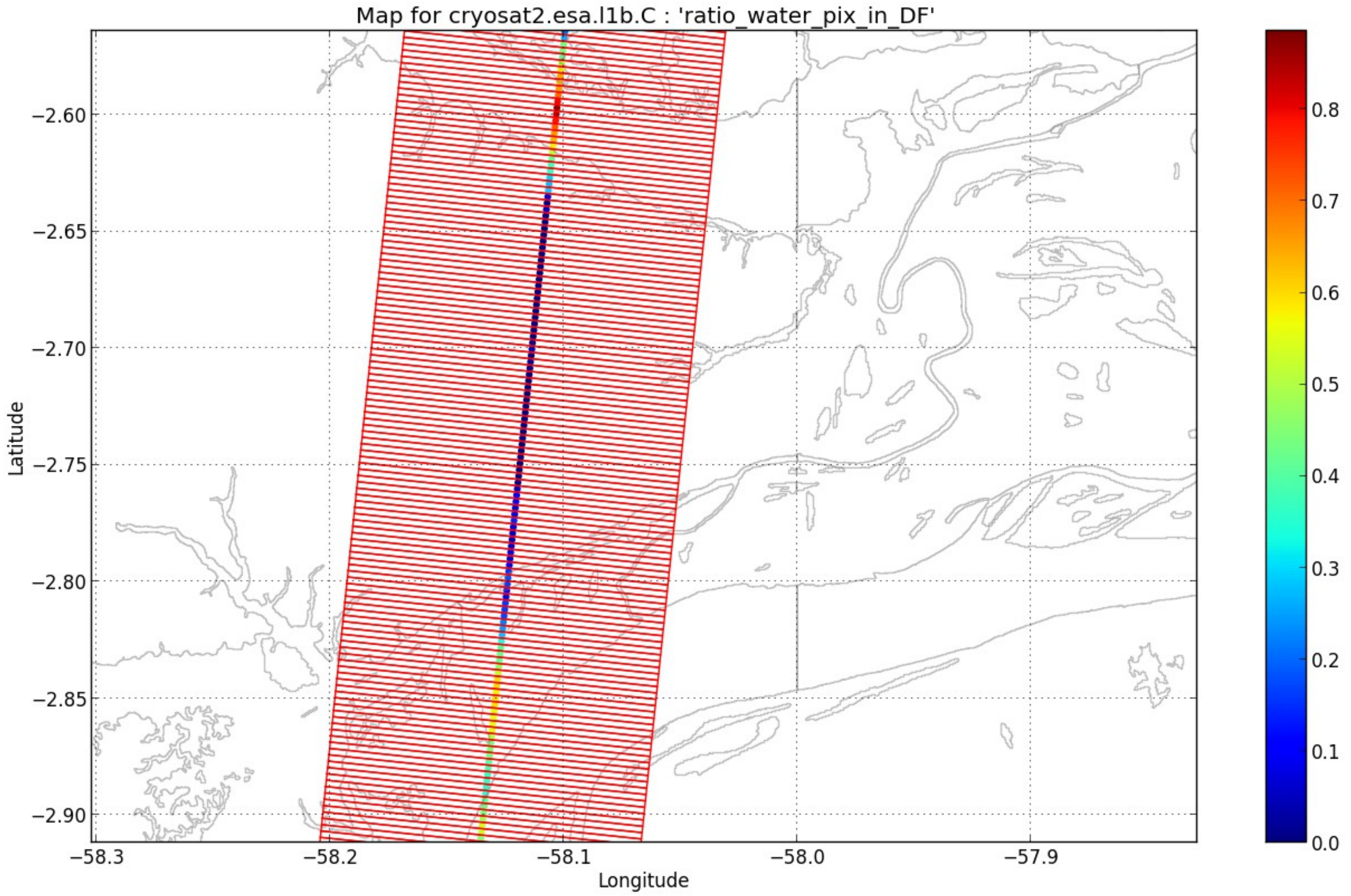
Methodology

SWBD shapefiles, Beam-Doppler limited footprint computed, at each record, from the actual system parameters found in the .DBL records !



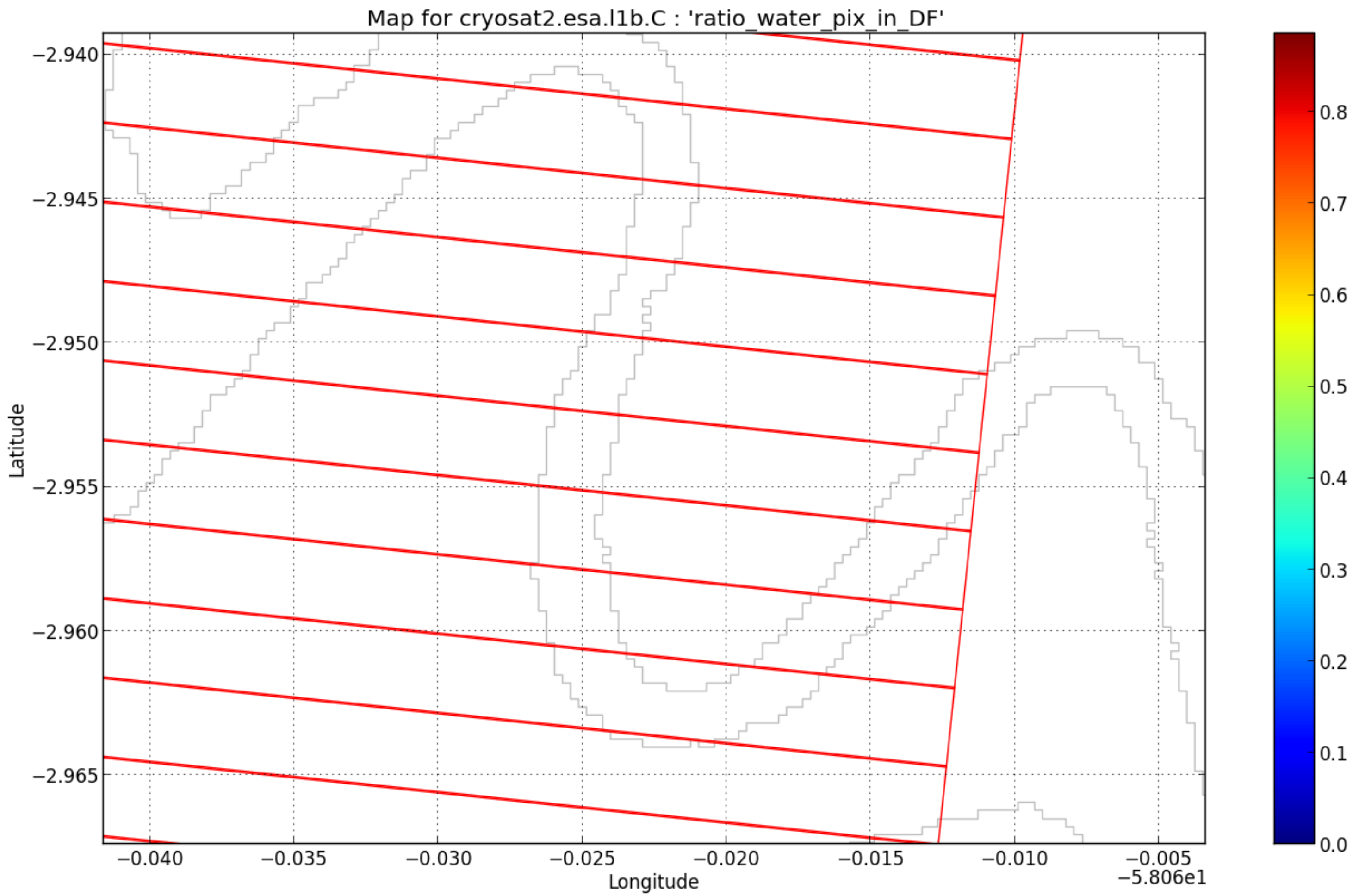
Water Fraction

Methodology



Water Fraction

Methodology

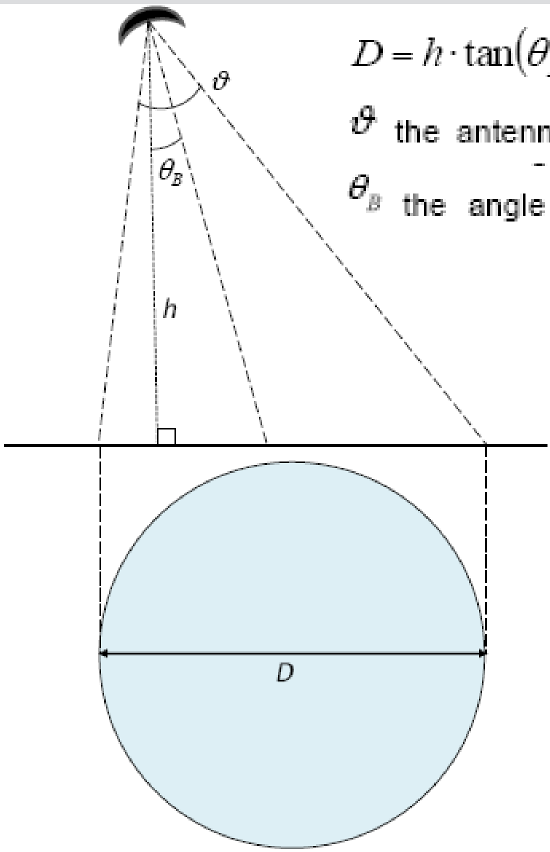


Water Fraction

Methodology

- Beam-Doppler footprint (eq. From Cryosat-2 handbook)

Across-track beam size



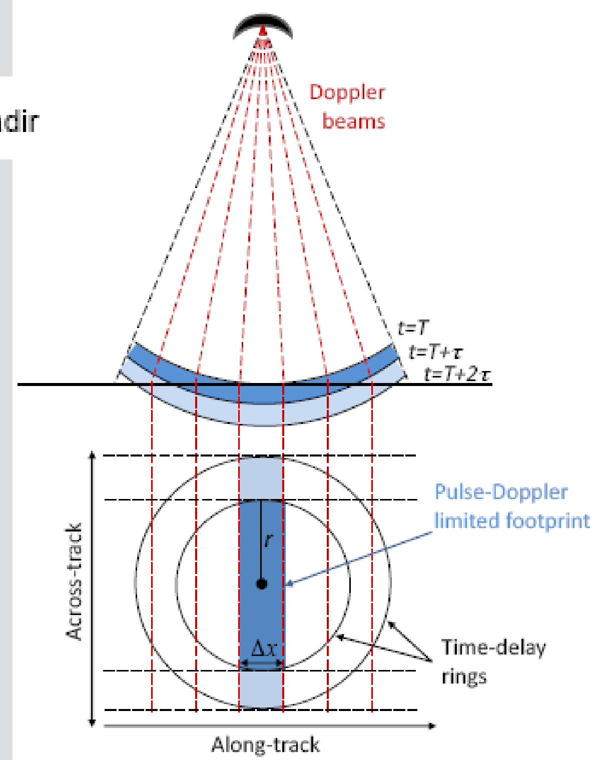
$$D = h \cdot \tan(\theta_B + \vartheta/2) - h \cdot \tan(\theta_B - \vartheta/2)$$

ϑ the antenna beam width at -3 dB,

θ_B the angle of the central beam direction with respect to the nadir

Along-track beam size

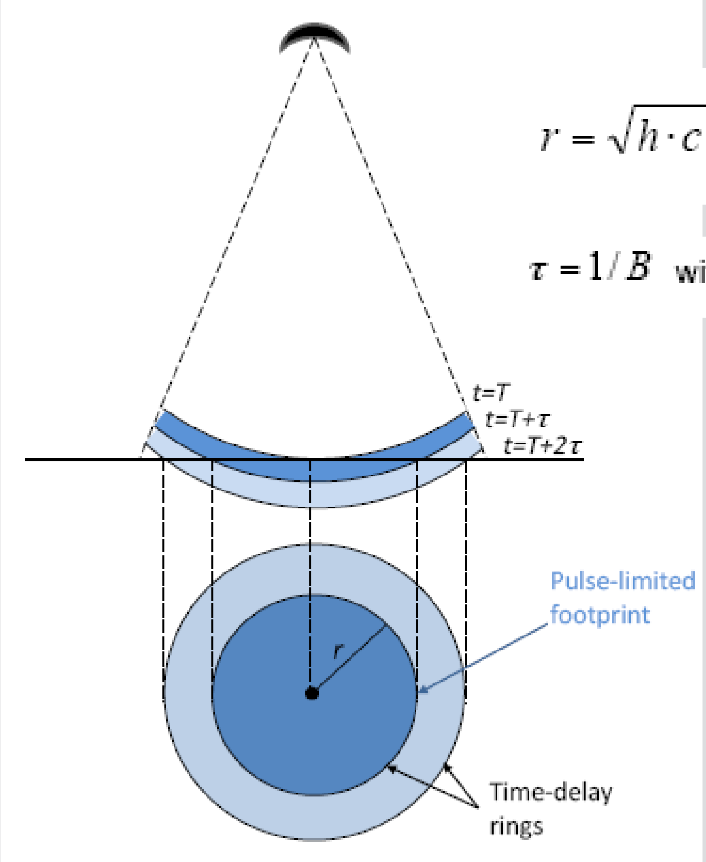
$$\Delta x = h \frac{\lambda}{2v} \frac{PRF}{64},$$



Methodology

- Pulse-Doppler footprint (eq. From Cryosat-2 handbook)

Across-track beam size

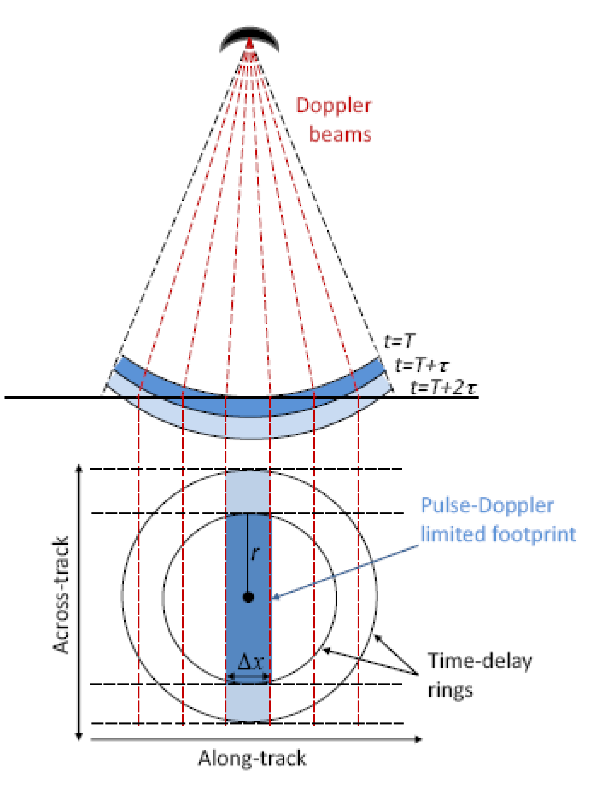


$$r = \sqrt{h \cdot c \cdot \tau} = \sqrt{h \cdot \frac{c}{B}}$$

$\tau = 1/B$ with B being the pulse bandwidth.

Along-track beam size

$$\Delta x = h \frac{\lambda}{2v} \frac{PRF}{64}$$



Methodology

- Compute :

  % water = footprint_water_pixels / footprint_all_pixels

- While reading the acquisition parameters for each record and building the Beam-Doppler limited footprints we also access the **beam behaviour parameters** contained in the L1B products.

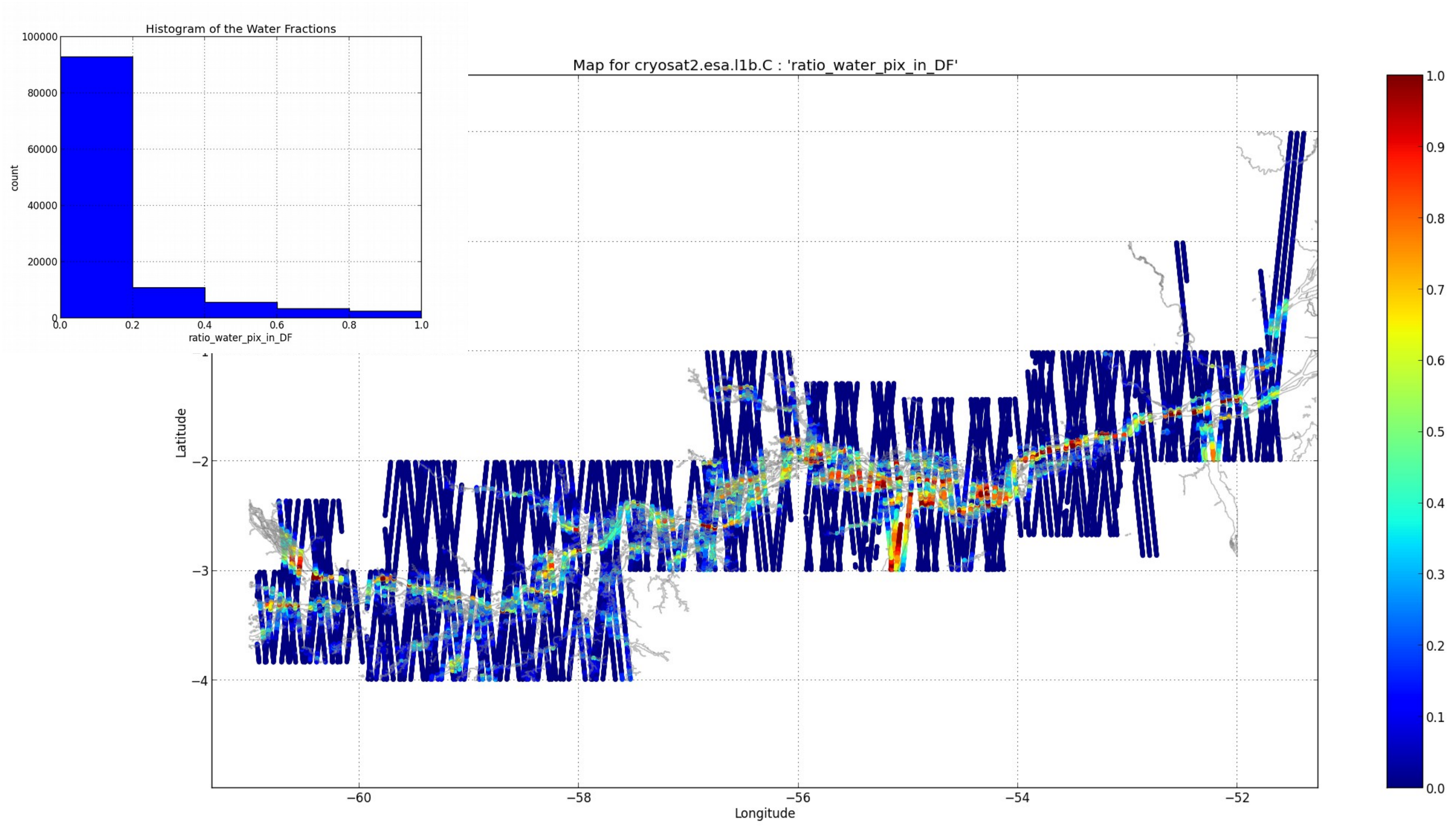
- Extract beam behaviour parameters from L1B (Stack Range Integrated Power Distributions)
  - **Mean Stack Standard Dev** of the Gaussian PDF fitting the stack RIP / record
  - **Mean Stack Centre** of the Gaussian PDF fitting the stack RIP / record
  - **Stack Scaled Amplitude** : amplitude scaled in dB/100 / record
  - **Stack Skewness** : asymmetry of the stack RIP distribution / record
  - **Stack Kurtosis** : peackiness of the stack RIP distribution / record

Data

- CryoSat-2 L1-B **Baseline C** data over Amazon (
- Time Period : 2014-01 to 2015-02 :
- 210 / 289 L1B files (120000 records → 12000 selected records)
- Variable Instrument parameters (sat. velocity, tracker range, lat, lon) are read in the L1-B files
- Fixed bandwidth, PRF, antenna, carrier freq., etc.)
- SWBD water masks :
  - WARNING : old (SRTM) description of the Amazon
  - WARNING : preliminary results only to illustrate the method

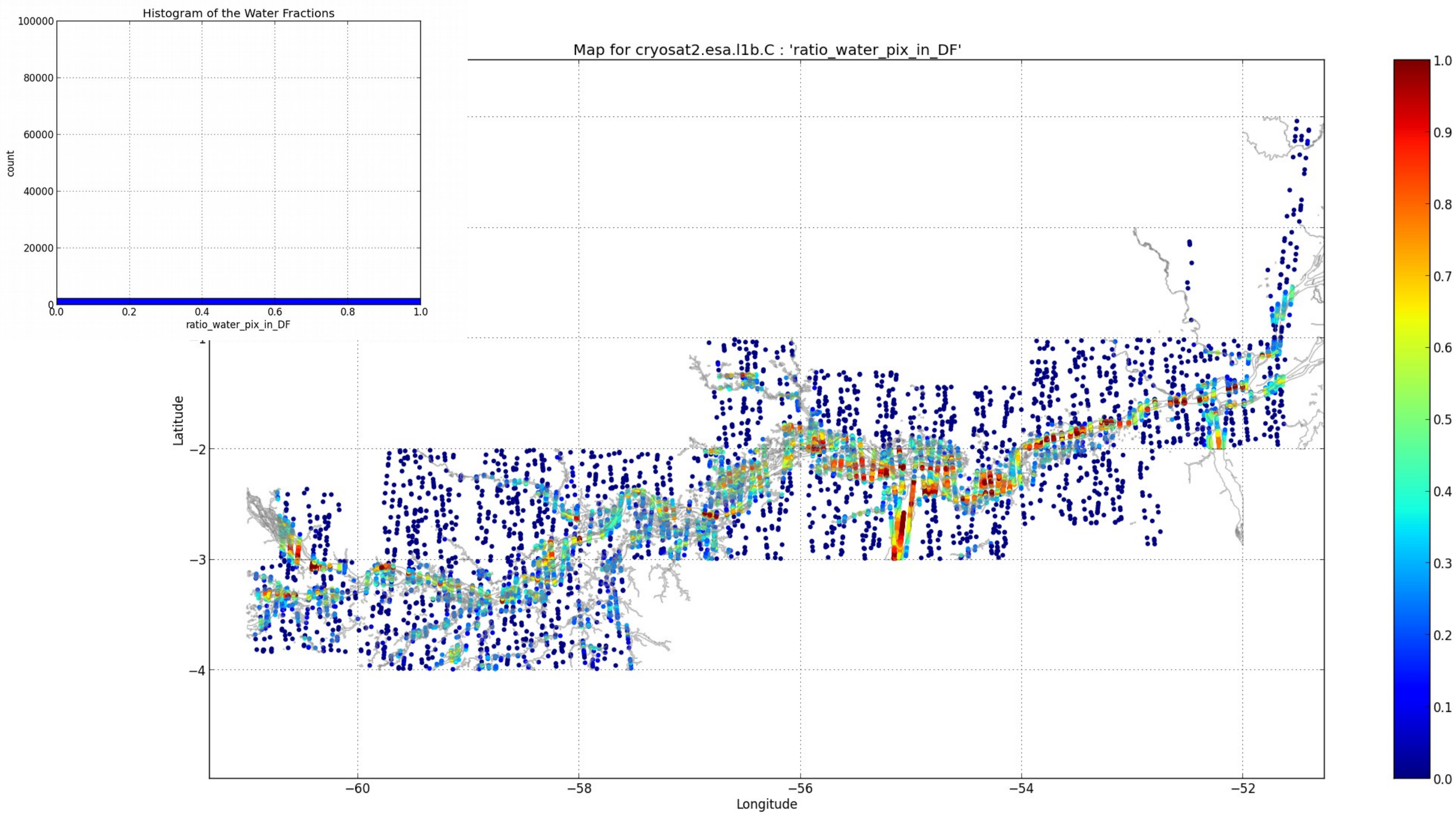
SWBD based file selection

Raw data selection & Histogram : 115113 records, smallest 2000 records

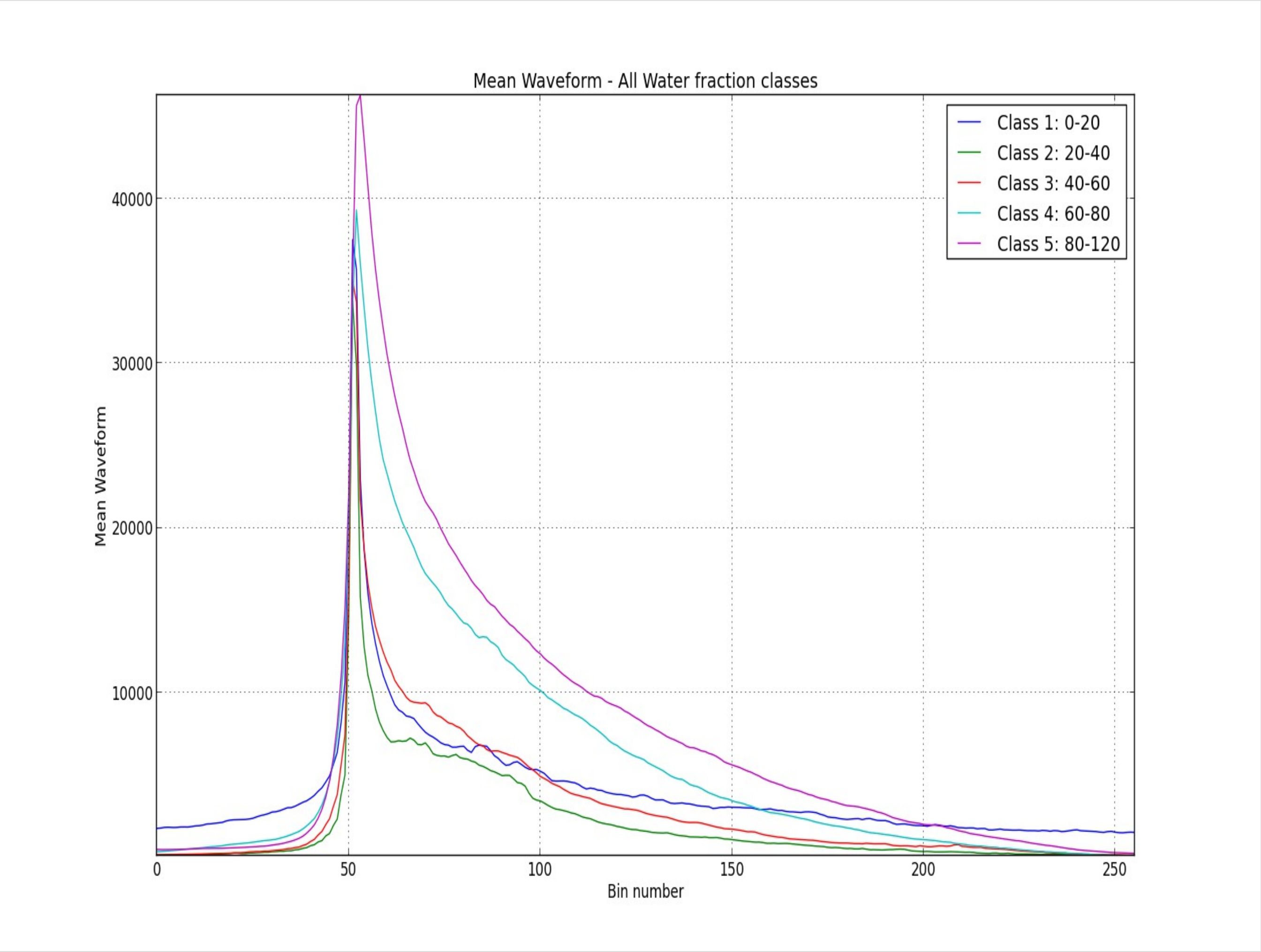


SWBD based file selection

Histogram Equalisation (random data selection) : 2000 records/class



Mean WF per Water Fraction



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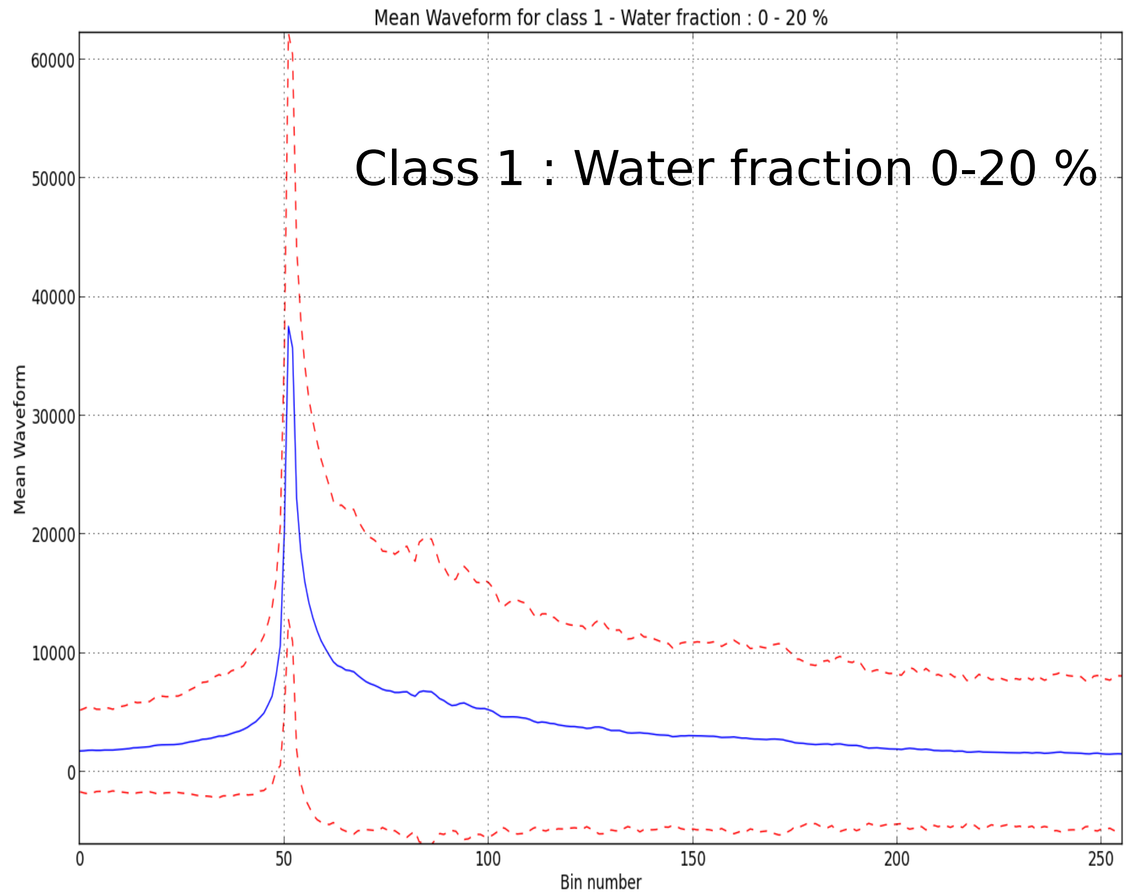

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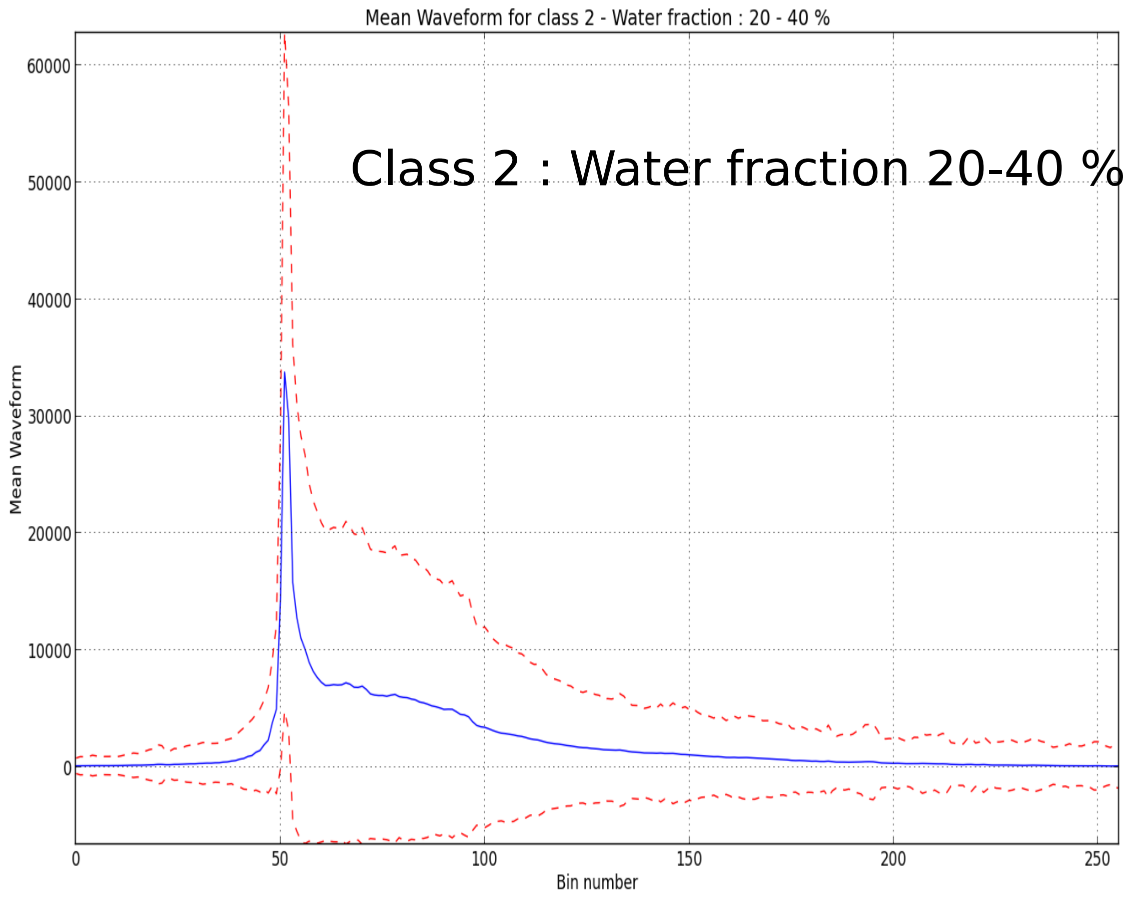

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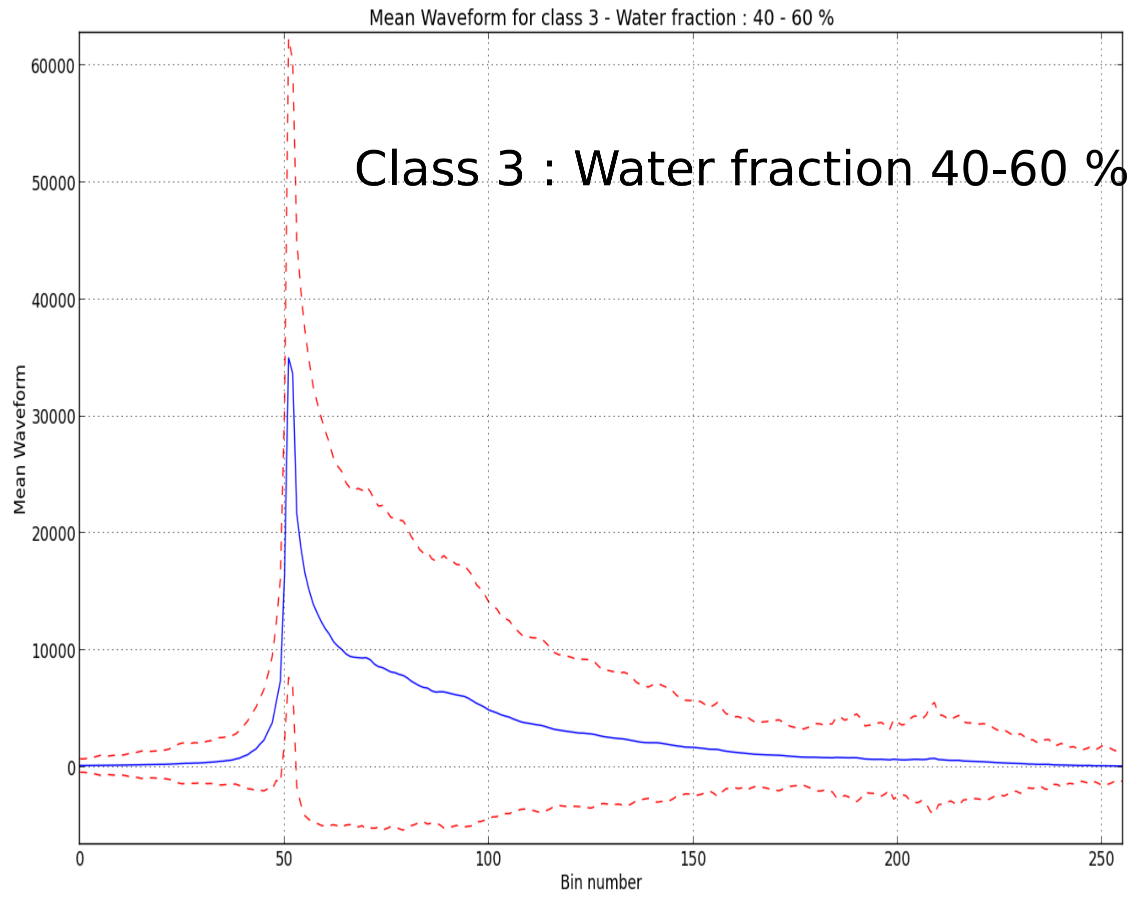

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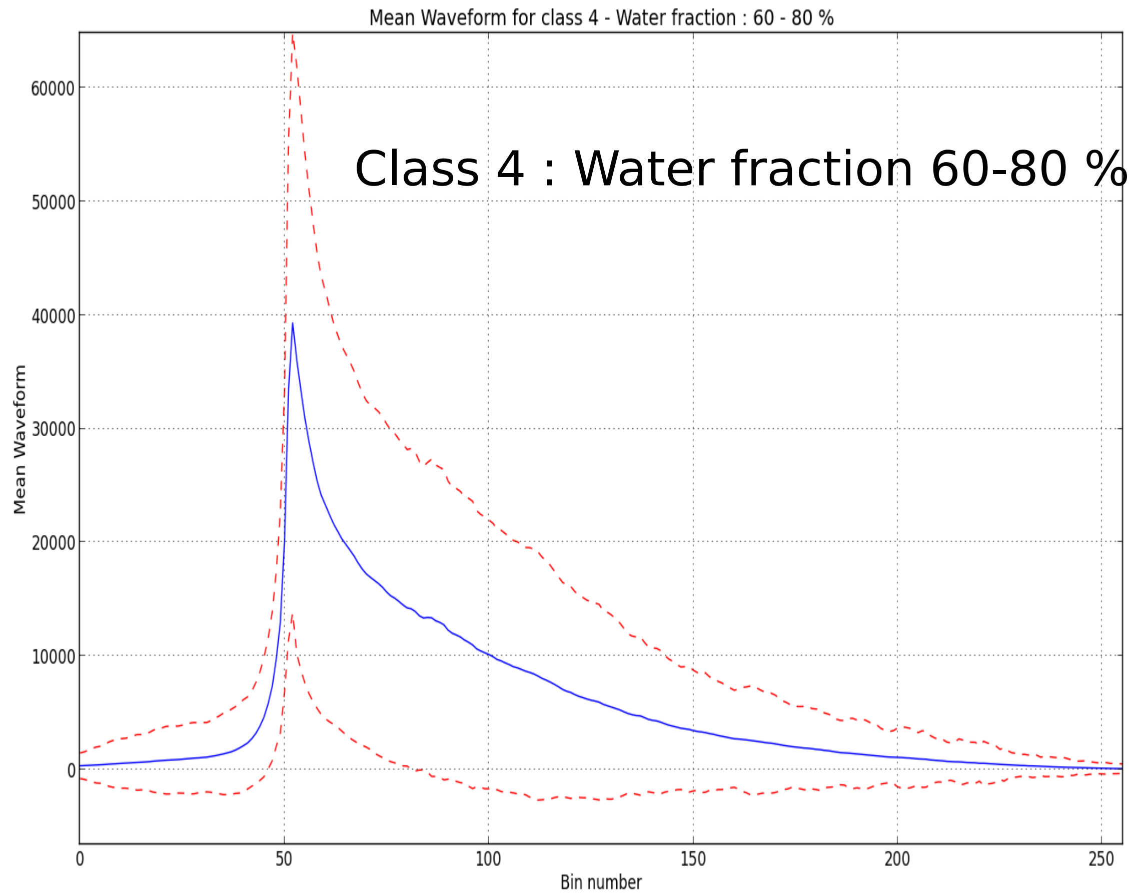
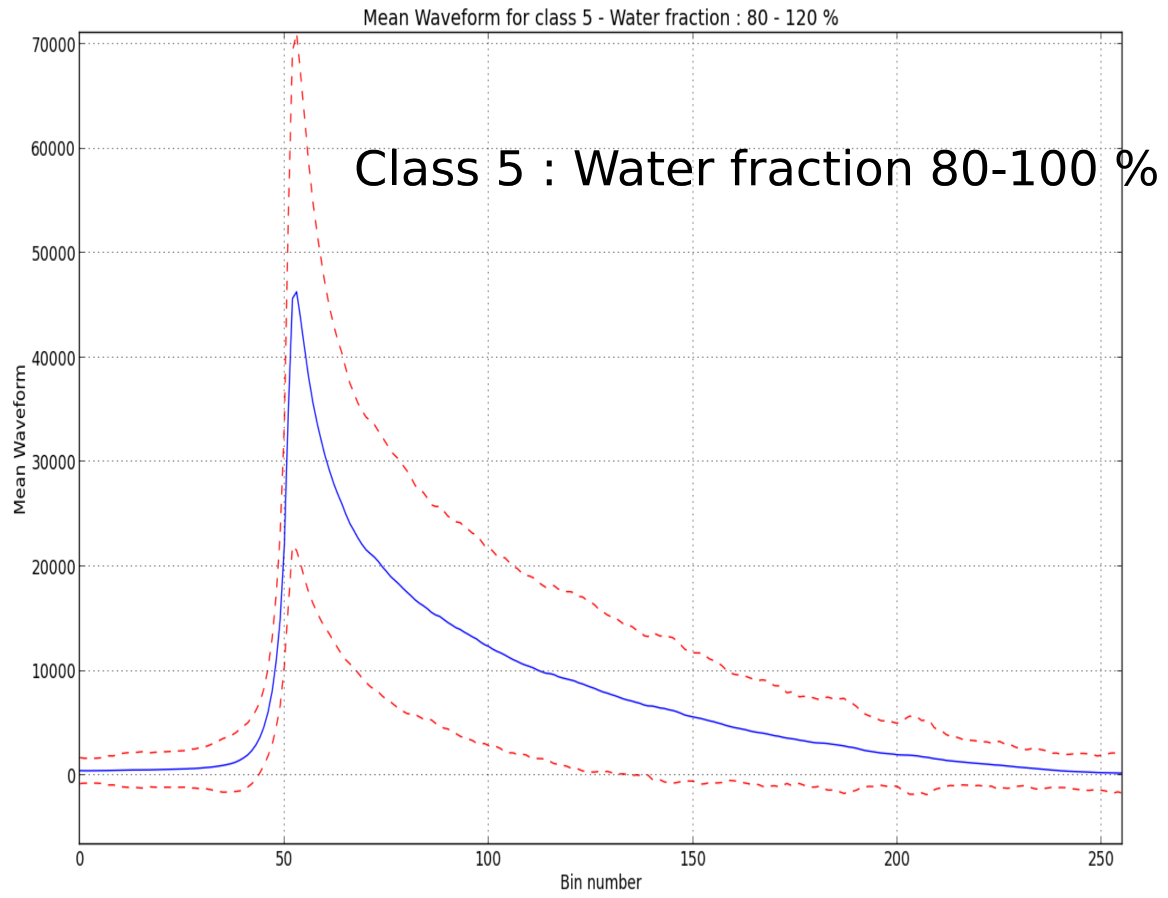
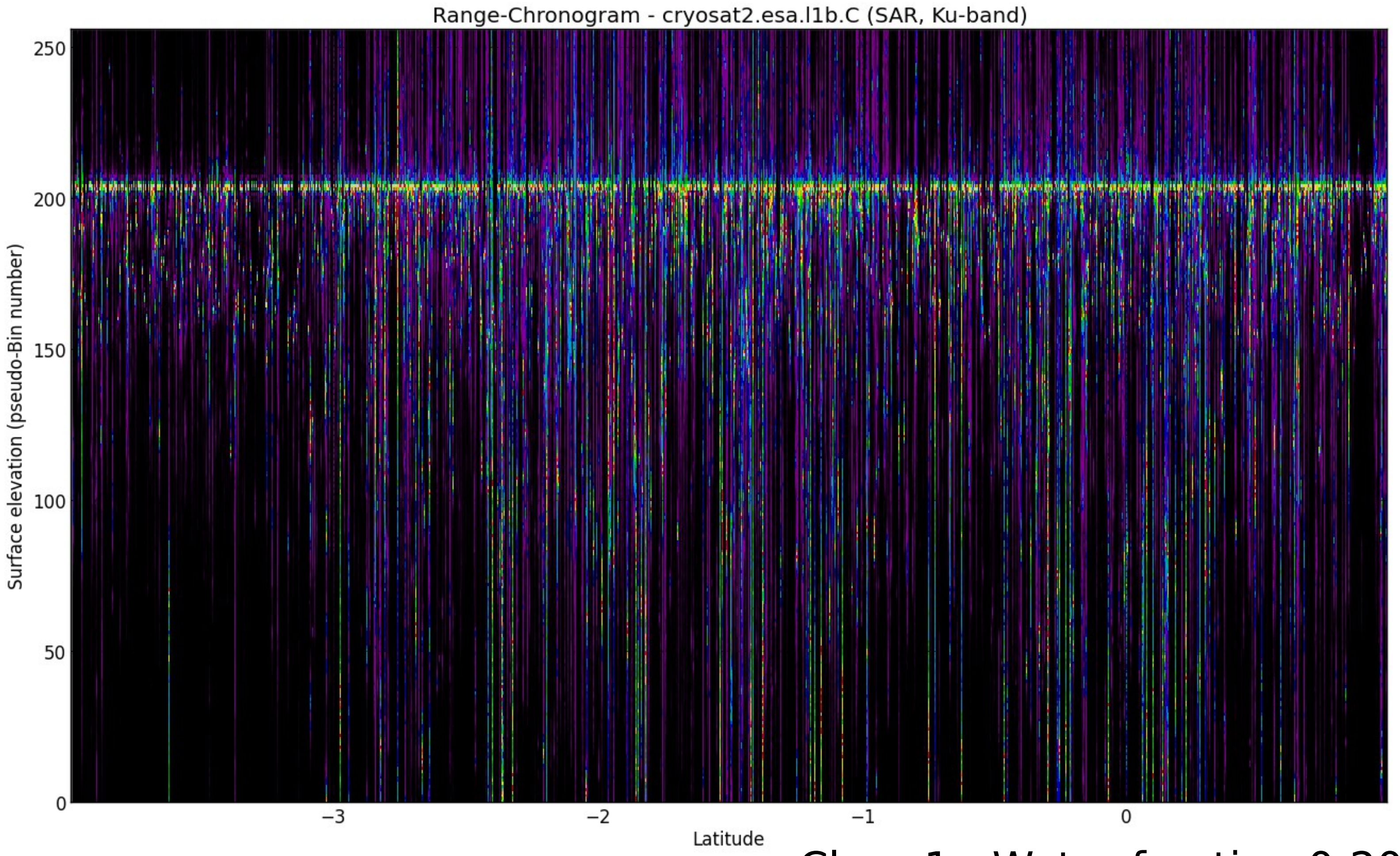


Mean WF per Water Fraction

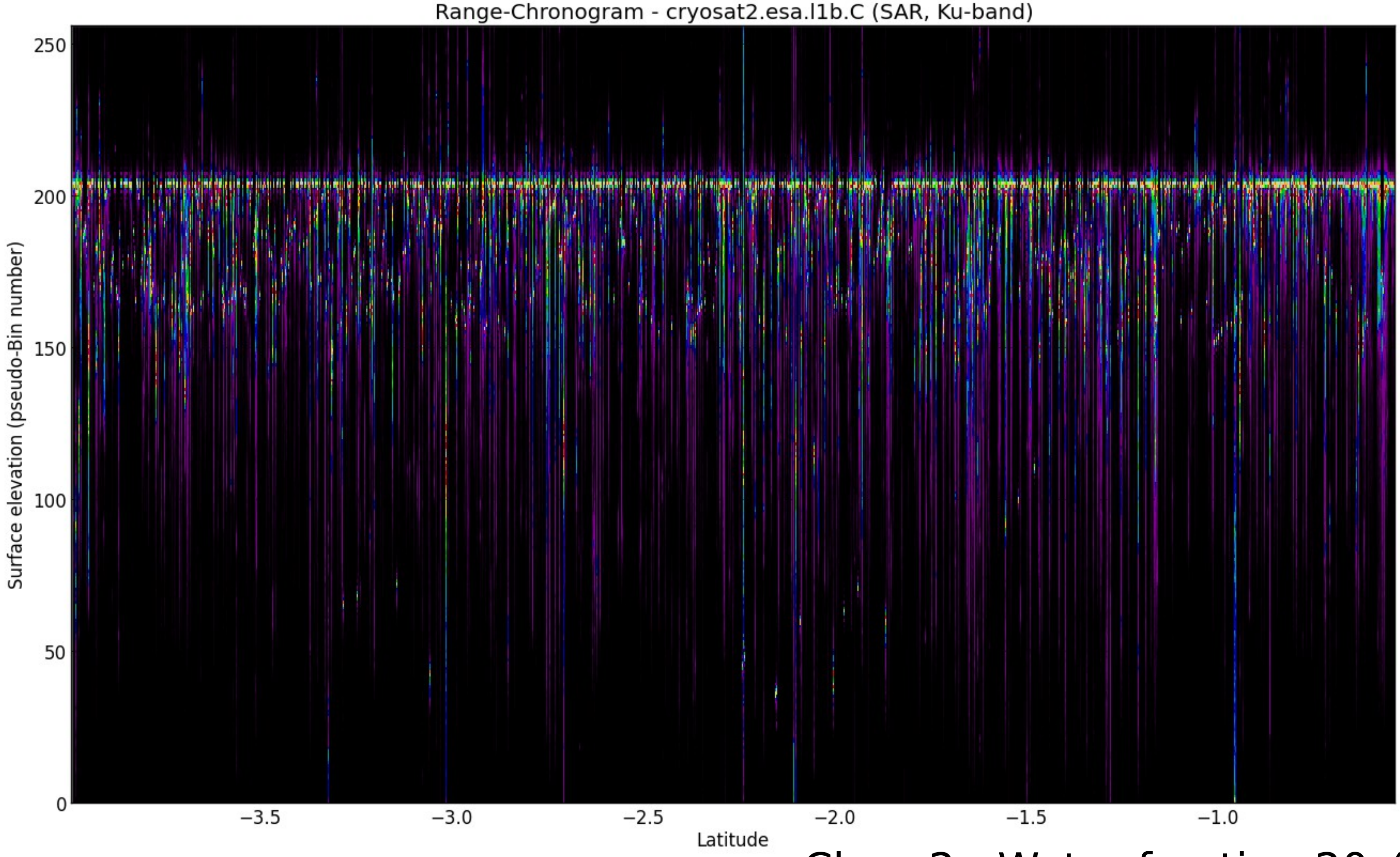


Waveforms per Water Fraction



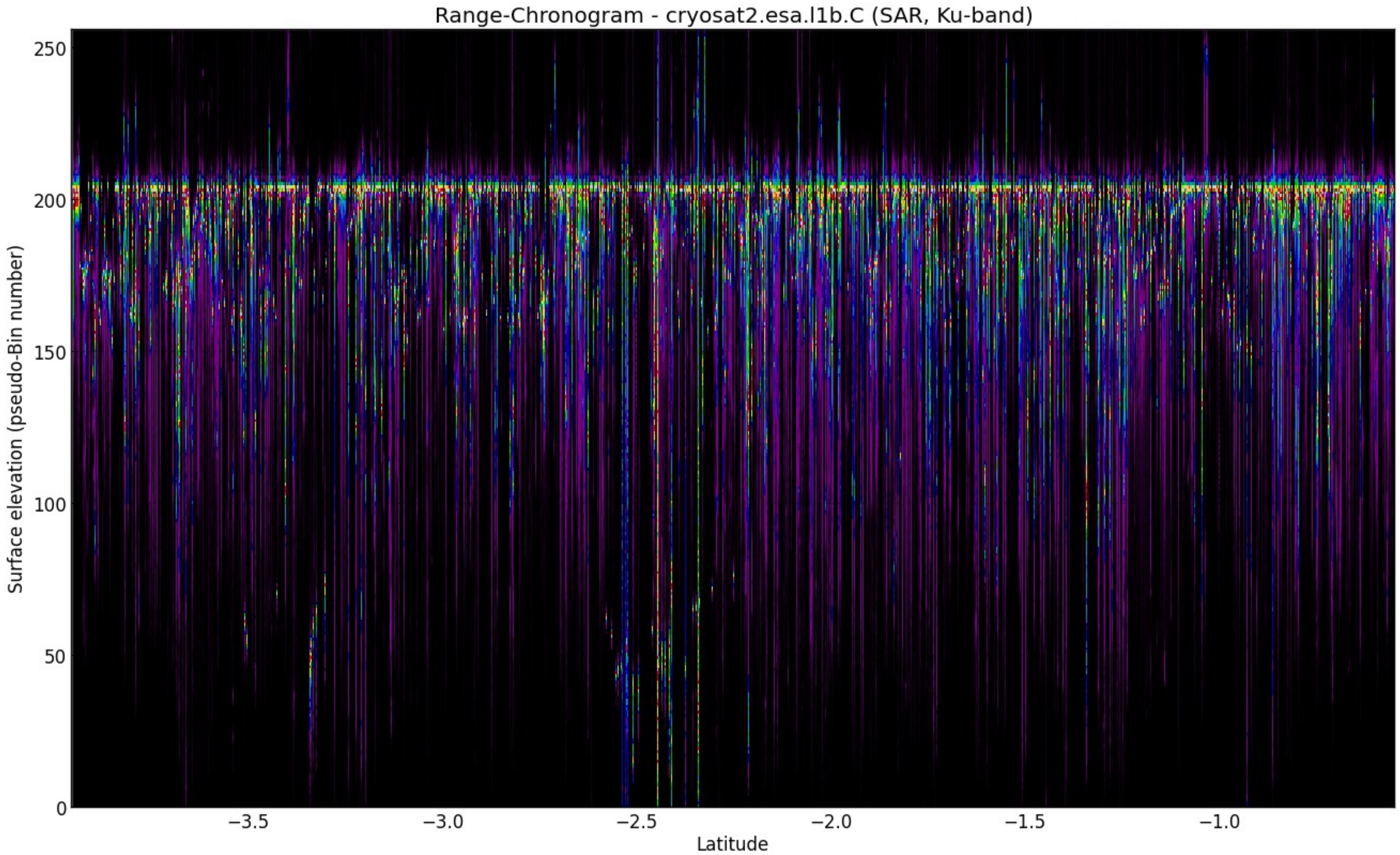
Class 1 : Water fraction 0-20 %

Waveforms per Water Fraction



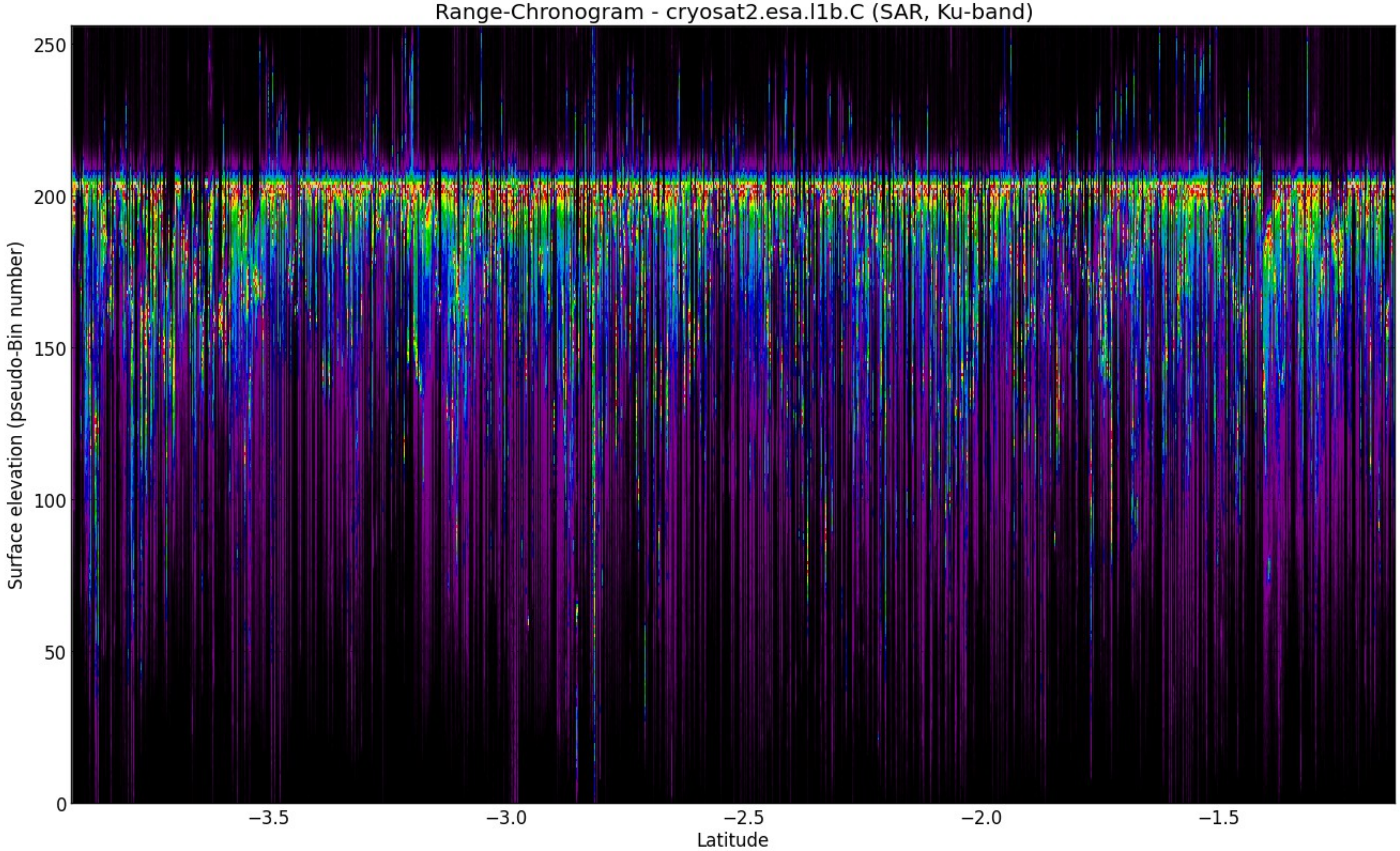
Class 2 : Water fraction 20-40 %

Waveforms per Water Fraction



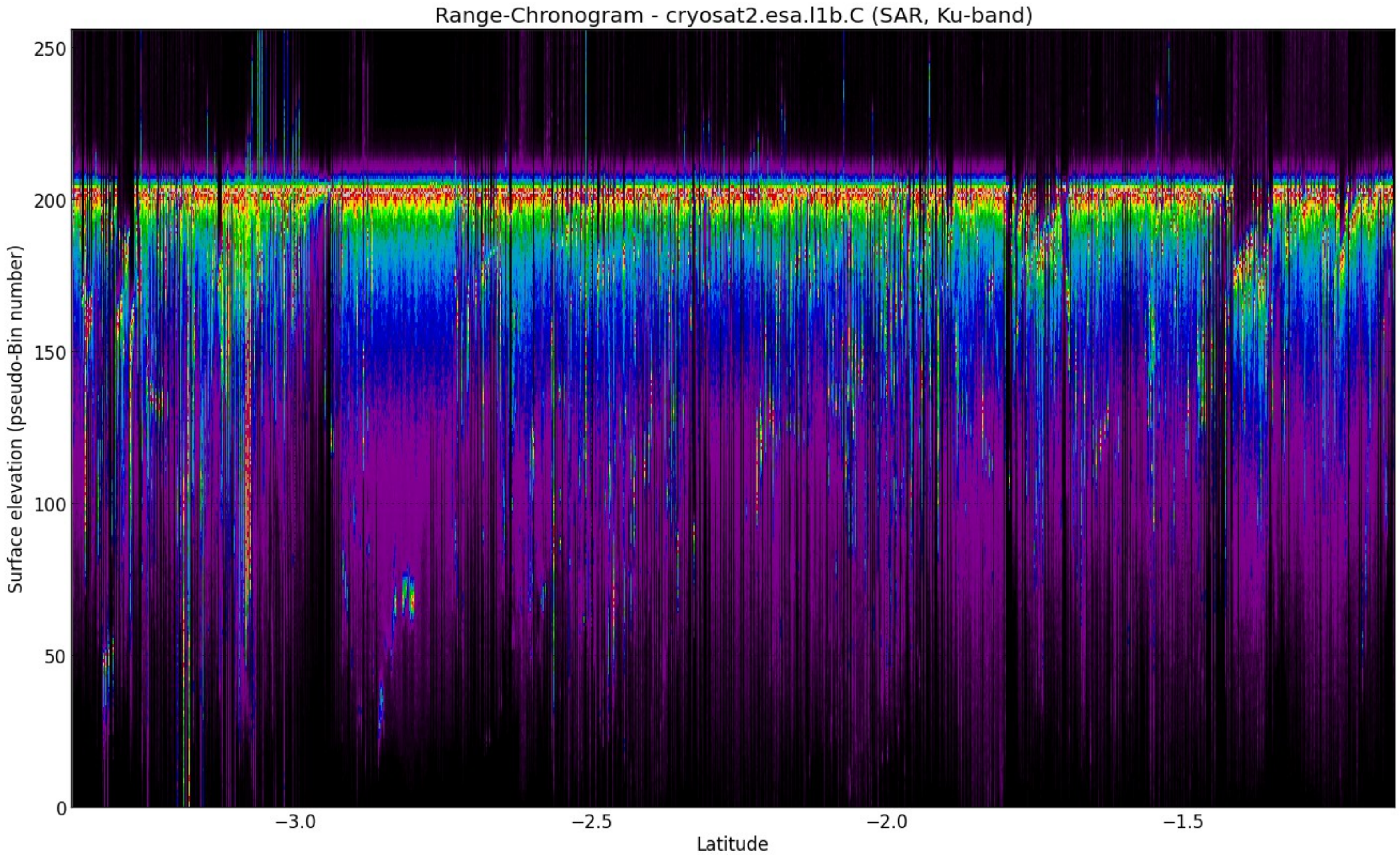
Class 3 : Water fraction 40-60 %

Waveforms per Water Fraction



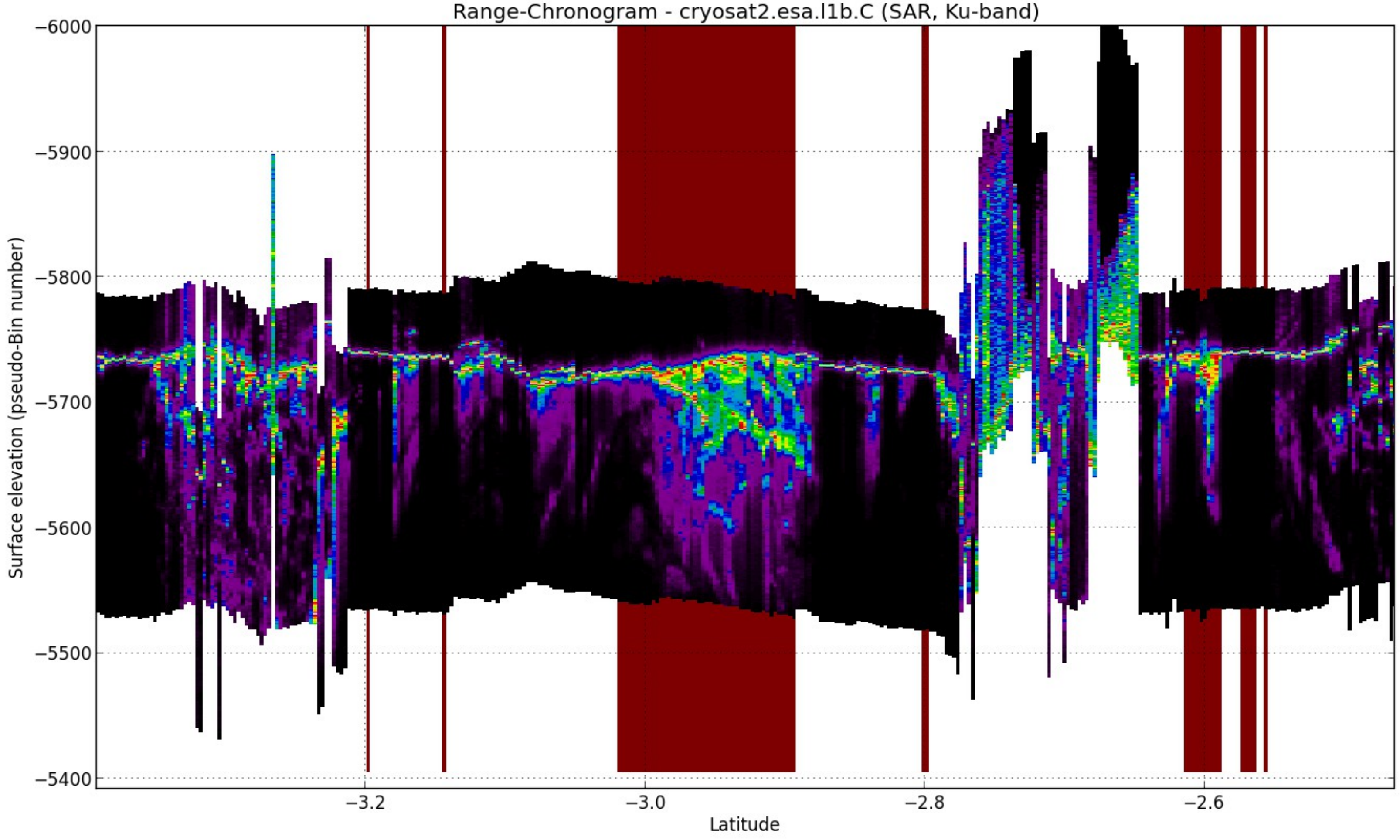
Class 4 : Water fraction 60-80 %

Waveforms per Water Fraction

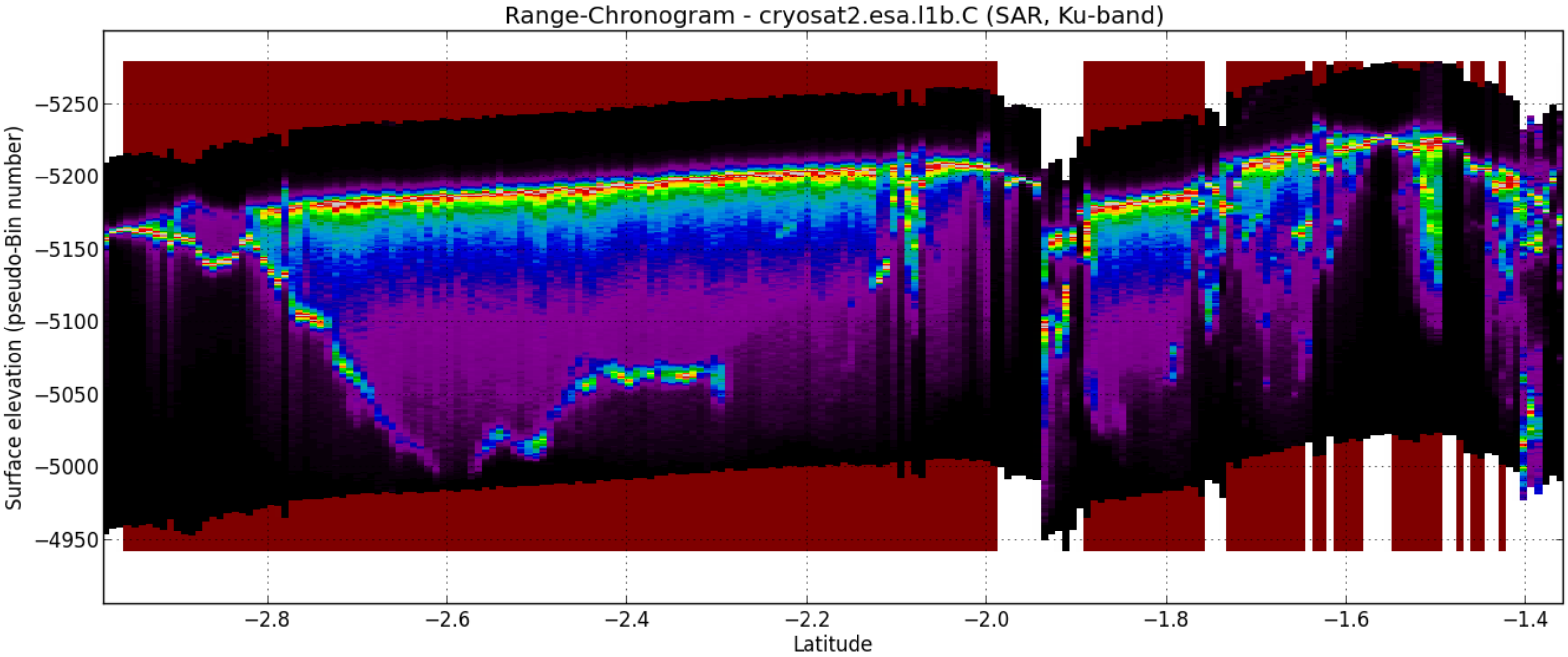


Class 5 : Water fraction 80-100 %

Range Chronograms



Range Chronograms

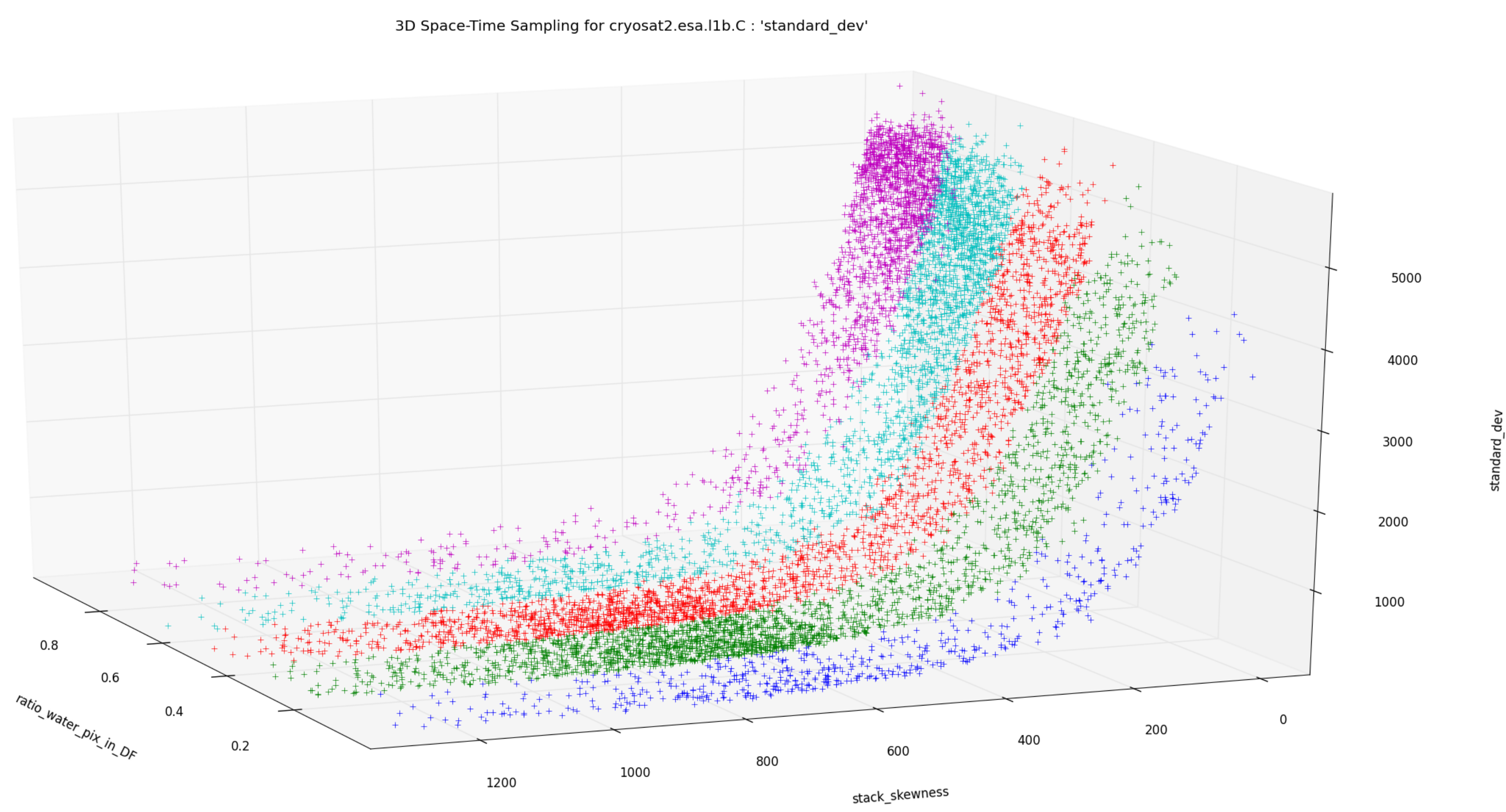


Results on the RIP

Standard Deviation of the RIP vs **Skewness**

High Water Fraction => High Standard Deviation and average assymetry

Angular Response due to Wind, Targets at Far End and ?



Results on the RIP

Kurtosis of the RIP vs **Skewness**

High Water Fraction => small assymetry, small peakiness

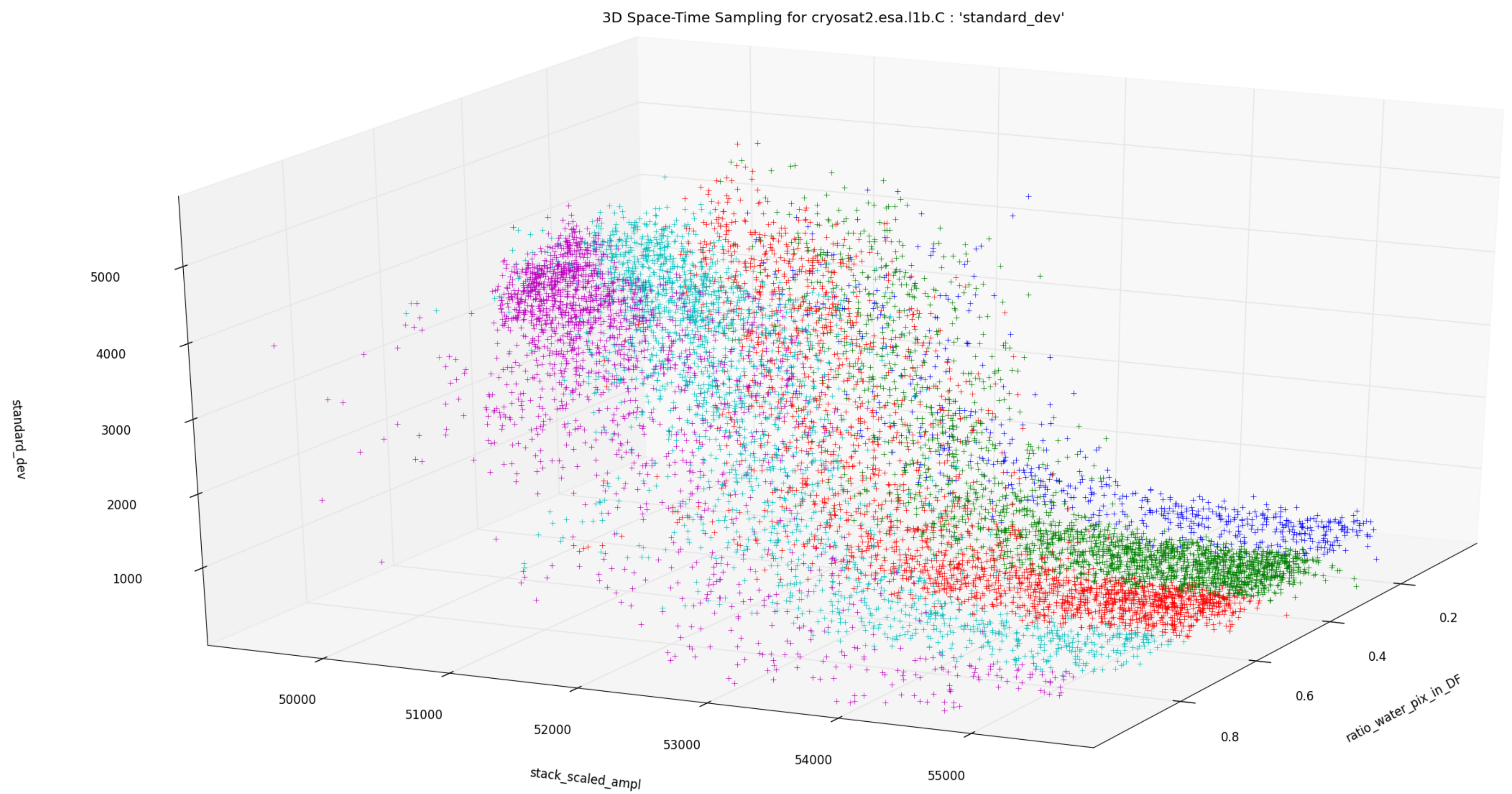
Angular Response due to Wind, Targets at Far End and ?

Results on the RIP

Standard Deviation of the RIP vs **Stack Scaled Amplitude**

High Water Fraction => High Standard Deviation and Low Amplitude

Angular Response due to Wind, Targets at Far End and ?



Notes

- The whole technique is worth the effort if we can get watermasks in an automated manner on a regular basis.
- **Sentinel 1** offers a **perfect synergy with S3**
- **Automated delineation works** (next slide)
- **Transcription into watermasks** from delineated images **is on the way** at ALONG-TRACK !

Conclusions

- We developed a tool to generate Doppler Footprints per record from the L1-B data
- And to intersect it with watermasks
- We've highlighted the need to use the **water fraction** information **within the Footprints** to help analysis
- We've automated these tasks
- This automated framework changes the paradigm of VS and makes it possible to go further into details and better exploit Cryosat-2 data over inland water

Perspectives

- More editing: use products quality flags
- Antenna Gain weighted Water Fraction
- Use platform attitude for an improved footprint placement
- Use up to date water masks derived from Sentinel-1
- Seasonal Climatologies to better understand the Relationships between parameters within a Water Fraction Class

Burman River (Sentinel-1, VV polar)