Along-Track Zero Padding for the Processing of Unfocused SAR Altimetry Waveforms

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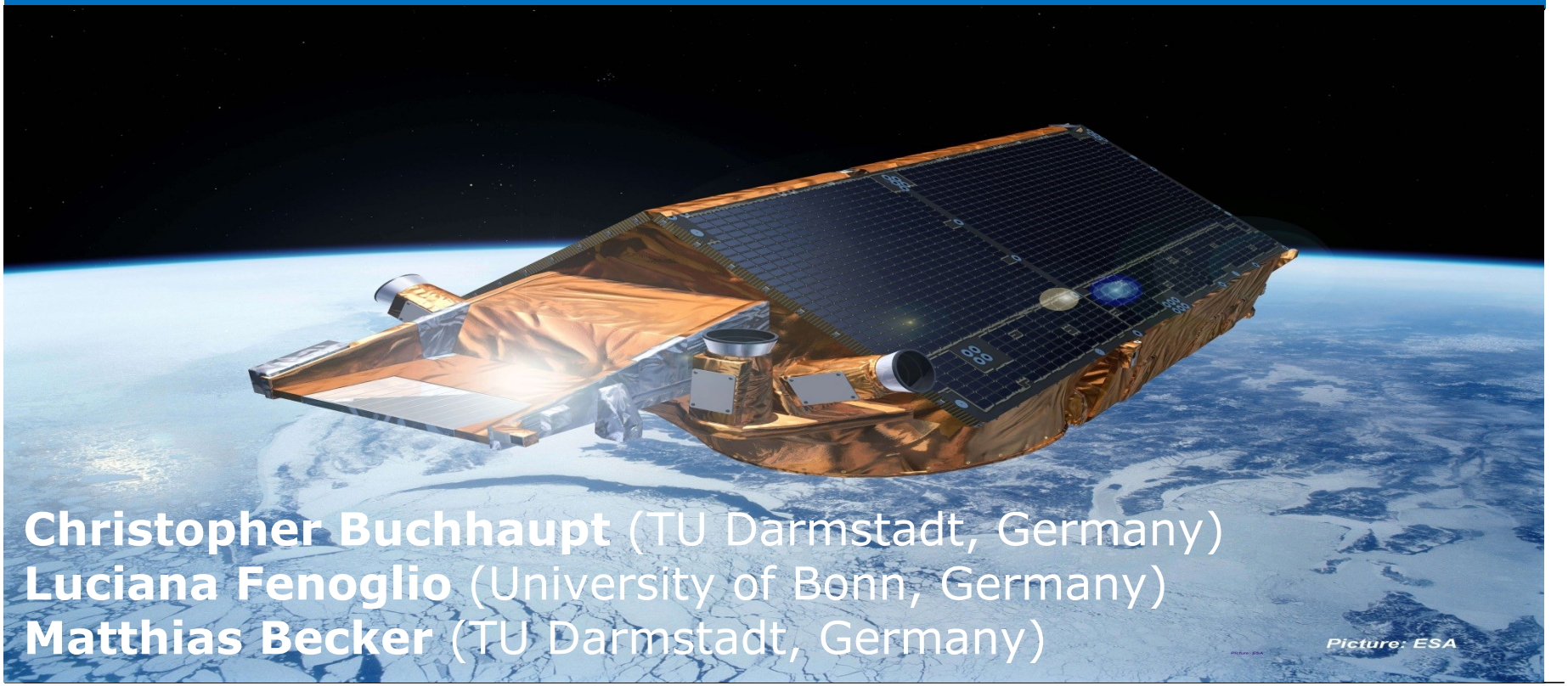

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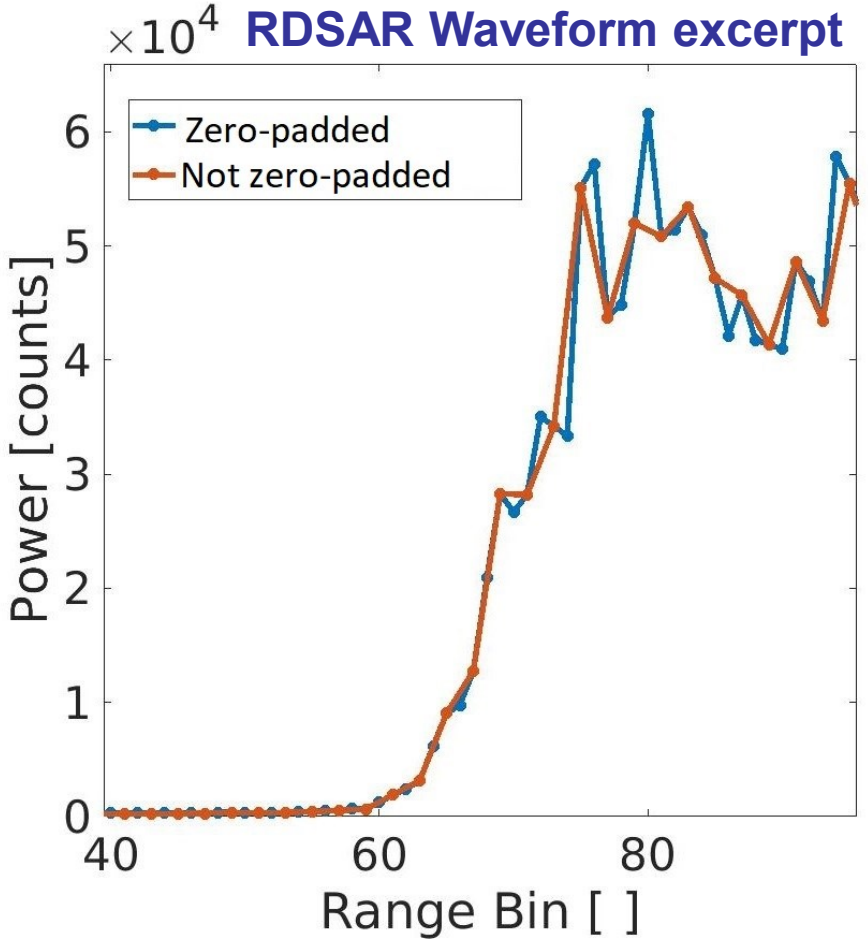
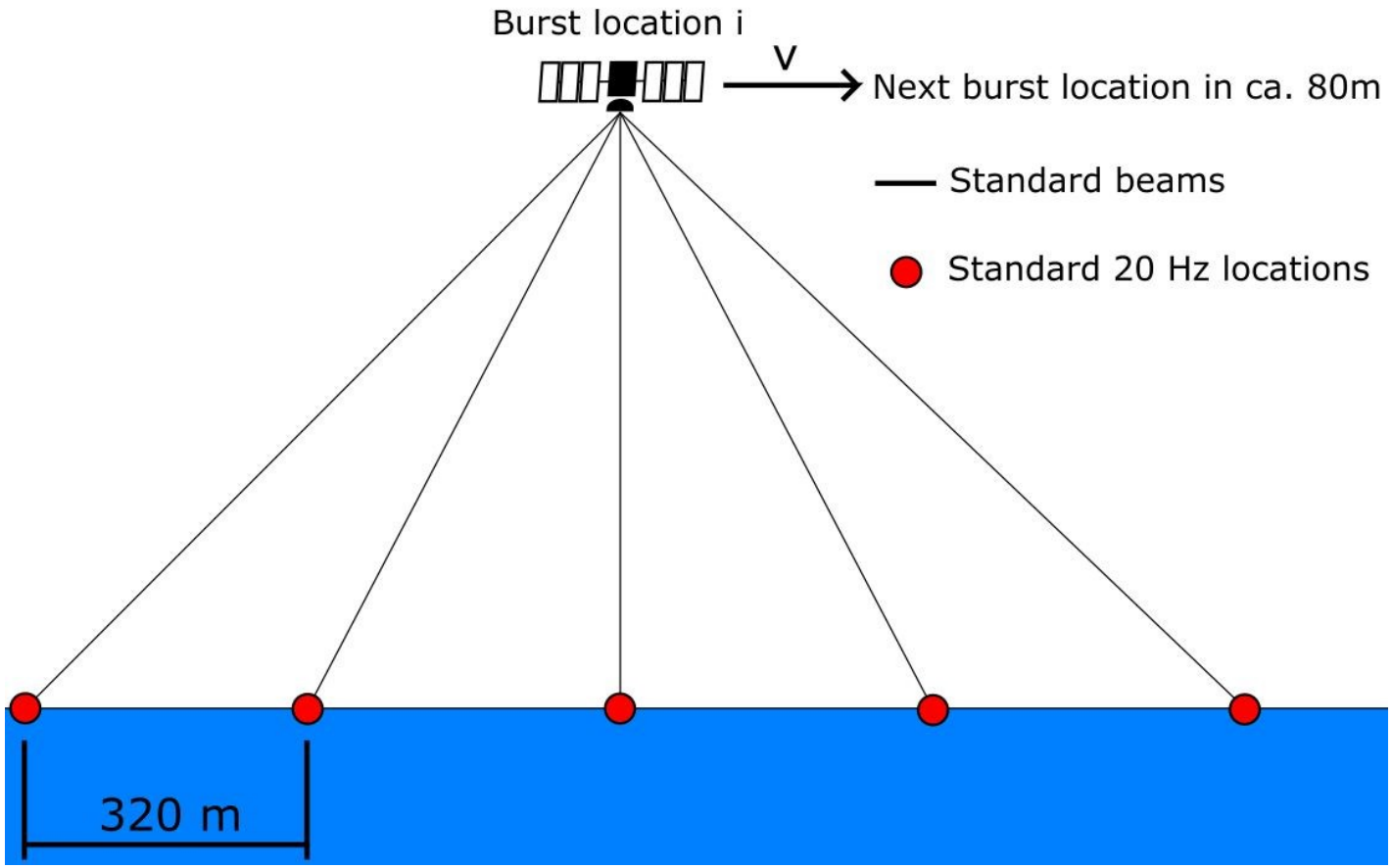
Motivation

- Zero-padding prior to the range compression improves quality of geophysical parameters
- Due to windowing and discretization altimeter signals are strictly bandlimited
- Squaring the signal prior to averaging doubles the bandwidth which causes aliasing
- Zero-padding is an ideal bandlimited interpolation method solving this issue

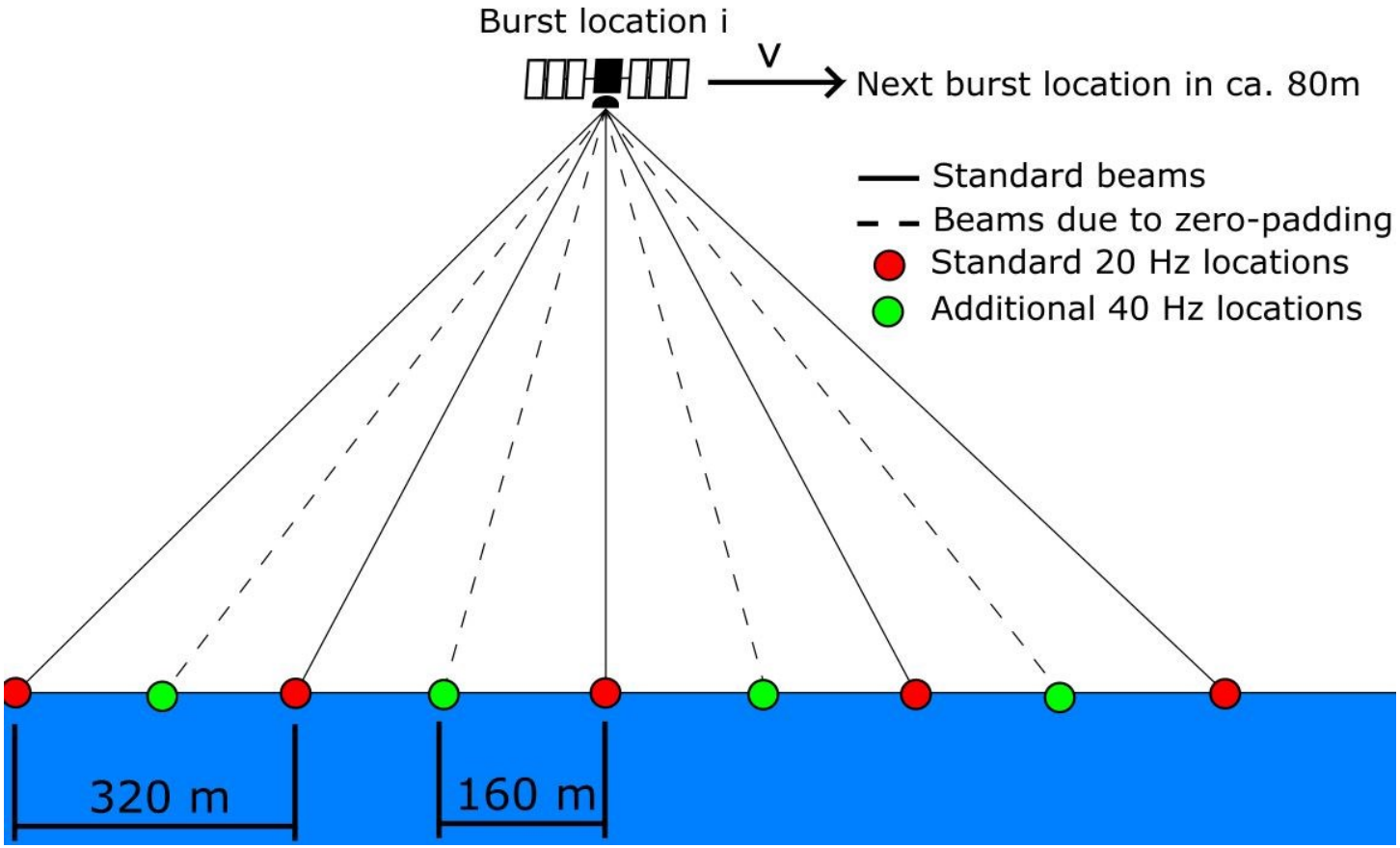
- Can zero-padding improve SAR mode also along-track ?



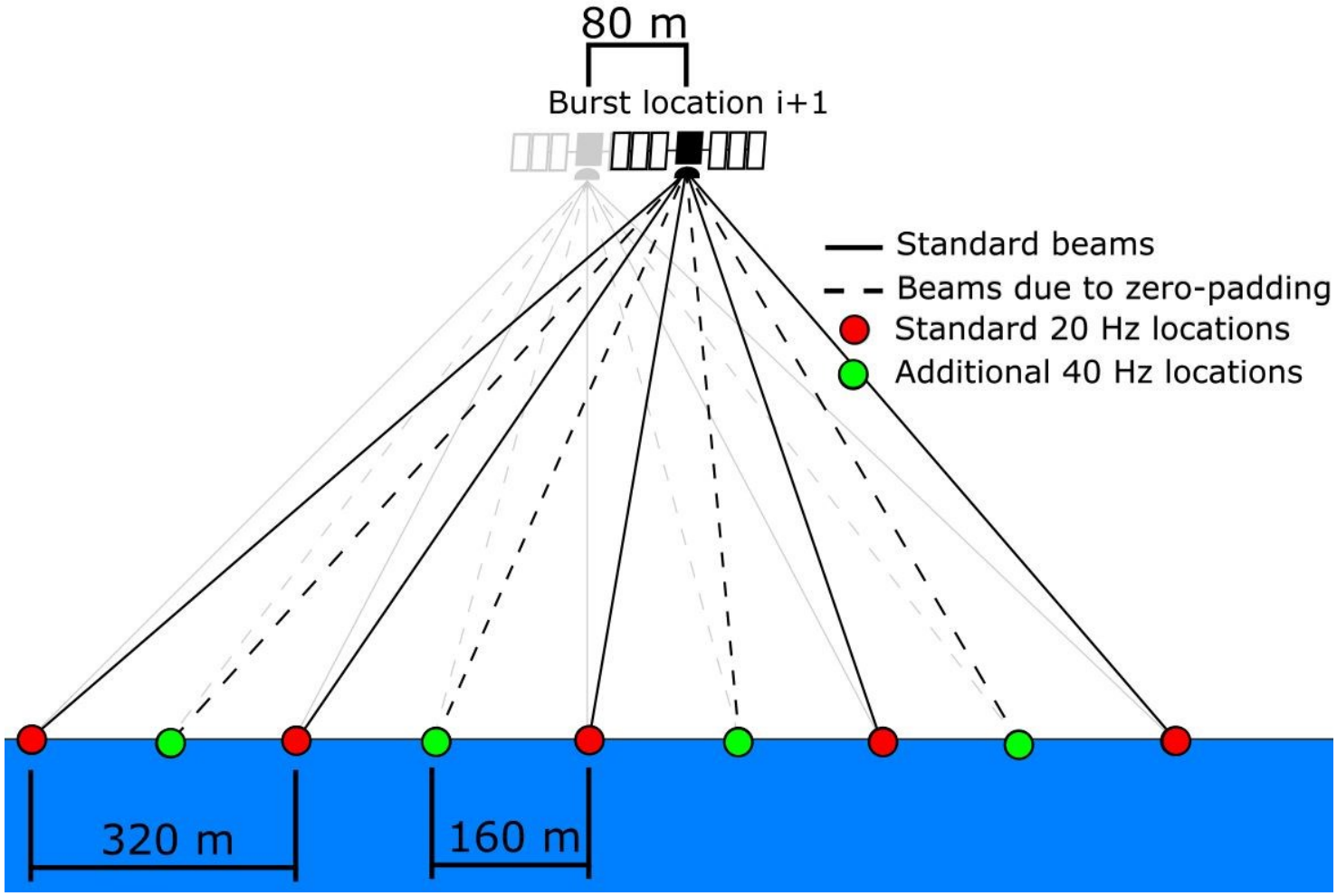
Motivation


Burst location i
V
Next burst location in ca. 80m
Standard beams
Standard 20 Hz locations
320 m

Motivation


Burst location i
v
Next burst location in ca. 80m
Standard beams
Beams due to zero-padding
Standard 20 Hz locations
Additional 40 Hz locations
320 m
160 m

Motivation


80 m
Burst location i+1
Standard beams
Beams due to zero-padding
Standard 20 Hz locations
Additional 40 Hz locations
320 m
160 m

Motivation

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- For each burst:
  - Zero-padding prior along track FFT increases surface sampling rate by a factor of two
  - Standard 20 Hz surface location cannot observe these additional beams
  - Adding of additional surface locations to increase the dataset to 40 Hz
- For each surface location:
  - Waveforms now are “truly” oversampled
  - Signal to noise ratio is improved

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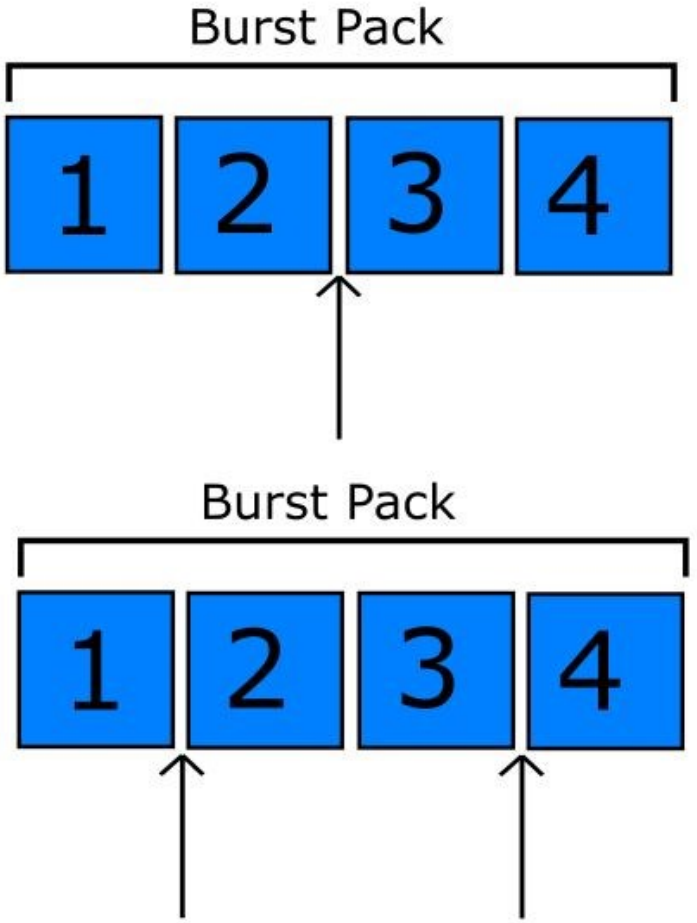
Surface Locations

- CryoSat-2 burst-packs contain four bursts each
- Surface location for 20 Hz data is placed between burst 2 and 3
- For oversampled 40 Hz surface locations are placed between burst 1/2 and 3/4
- This preserves consistency of SAR and RDSAR
- 1 Hz data have the same location and time tag for 20 Hz and 40 Hz for SAR and RDSAR
- Implementation is straightforward



ROI and Retracking

- The region of interest is the region from 2.5°S to 25.5°S and from 160°W to 85°W (Pacific Box) from October 2012 to October 2013
- Waveforms are retracked using a fast convolution based model called SINC*
  - RDSAR is retracked with SINC2
  - SAR is retracked with SINCS
  - No PTR approximation used

* Buchhaupt et al., 2017: A Fast Convolution Based Waveform Modell for Conventional and Unfocused SAR Altimetry, Advances in Space Research CryoSat-2 Issue, Accepted

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I. Motivation

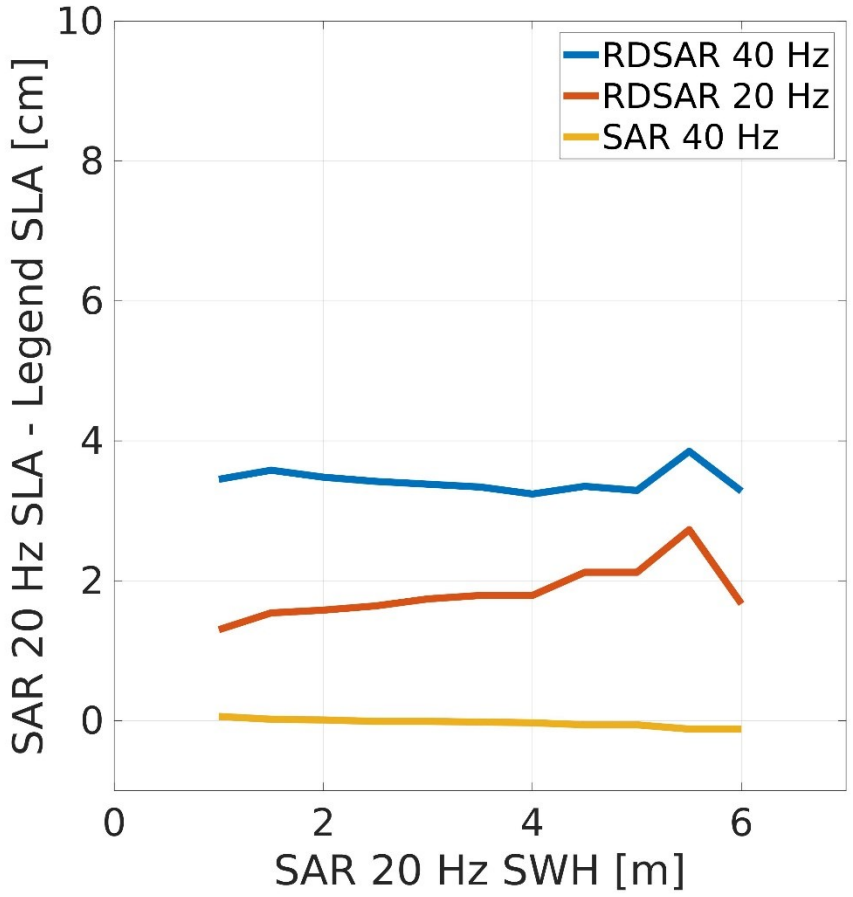
II. Methodology
- Choice of Surface Locations
- Region of Interest and Retracking

III. Results
- 1 Hz Mean Differences of Geophysical Parameters
- 1 Hz Precision of Geophysical Parameters
- Wave-Number Spectra

IV. Conclusion

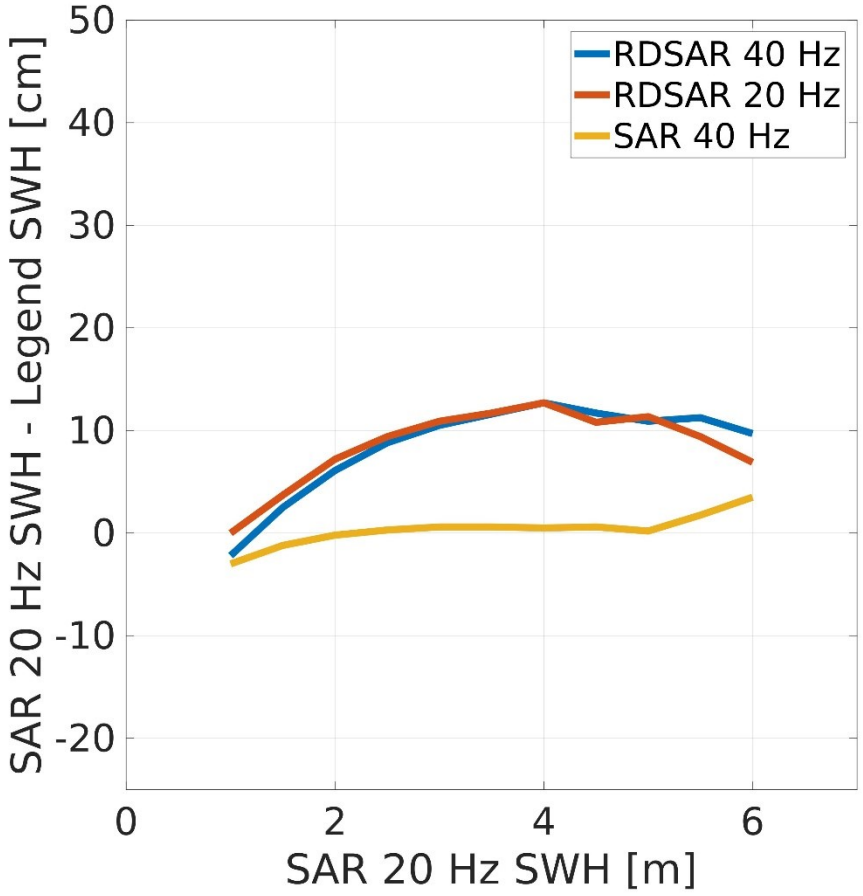
Mean SLA Differences

- Differences are formed w.r.t. 20 Hz SAR data
- No sea state biases applied
- Differences of averaged 1 Hz values are calculated
- RDSAR shows significant sea state dependent differences
- No significant difference between 20 and 40 Hz SAR solution



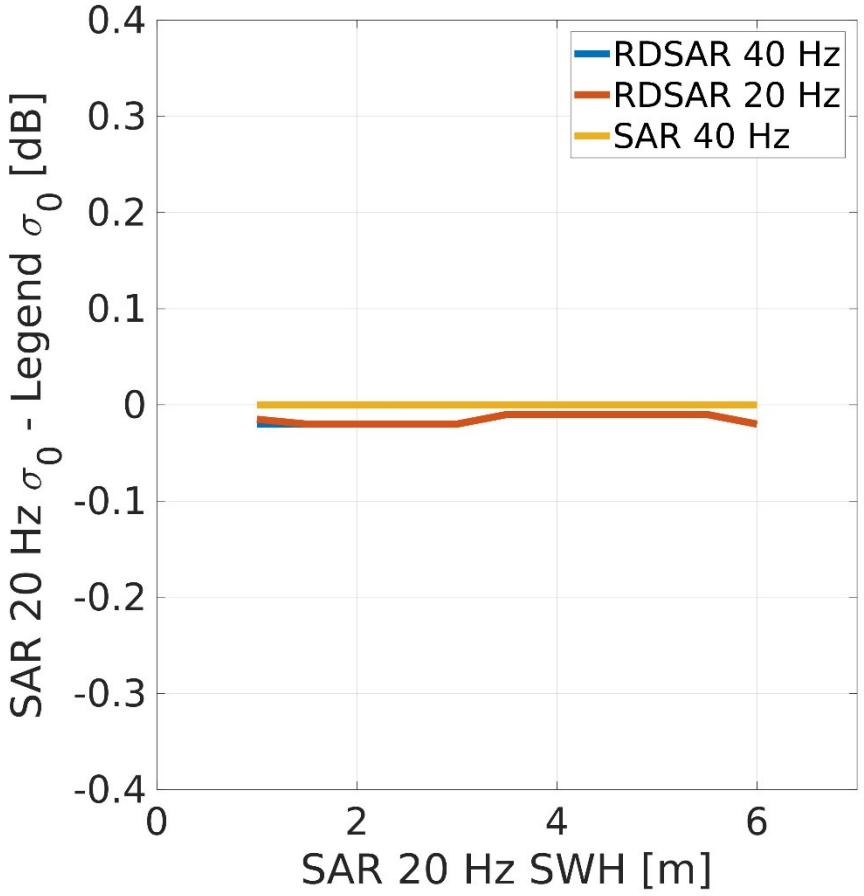
Mean Difference SWH

- RDSAR shows significant sea state dependent differences
- SAR data are similar to each other with just maximal 5 cm difference
- No significant difference between 20 and 40 Hz RDSAR solution



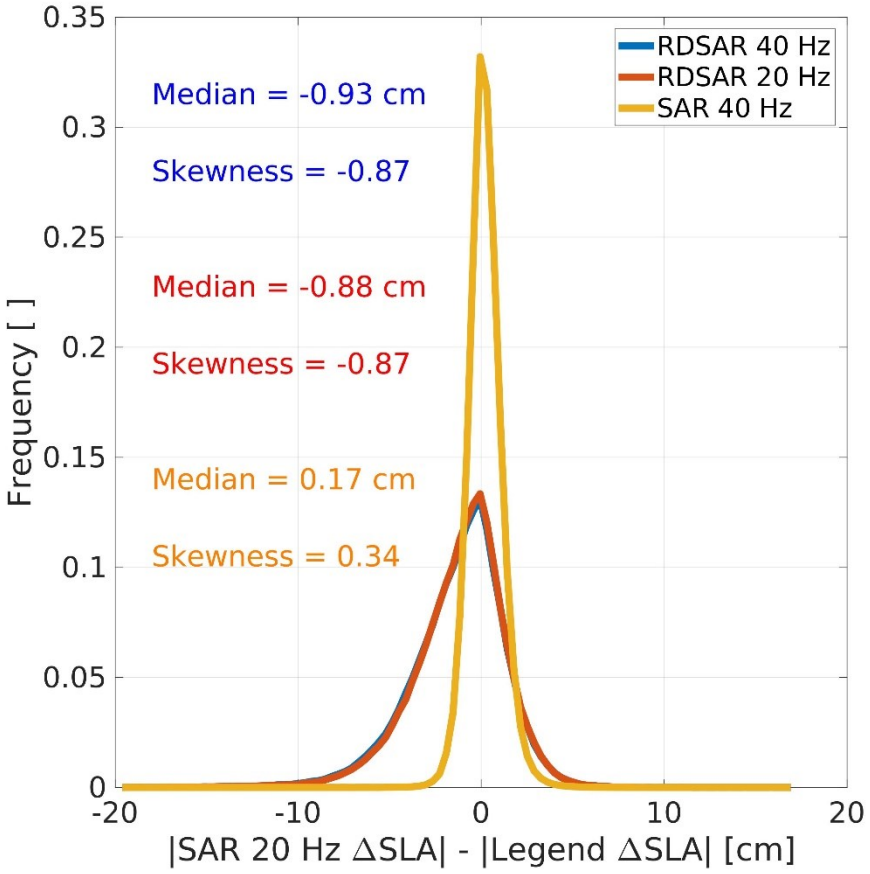
Mean Difference Sigma0

- Small differences between SAR and RDSAR
- No differences between the solutions of the two data rates in SAR and RDSAR



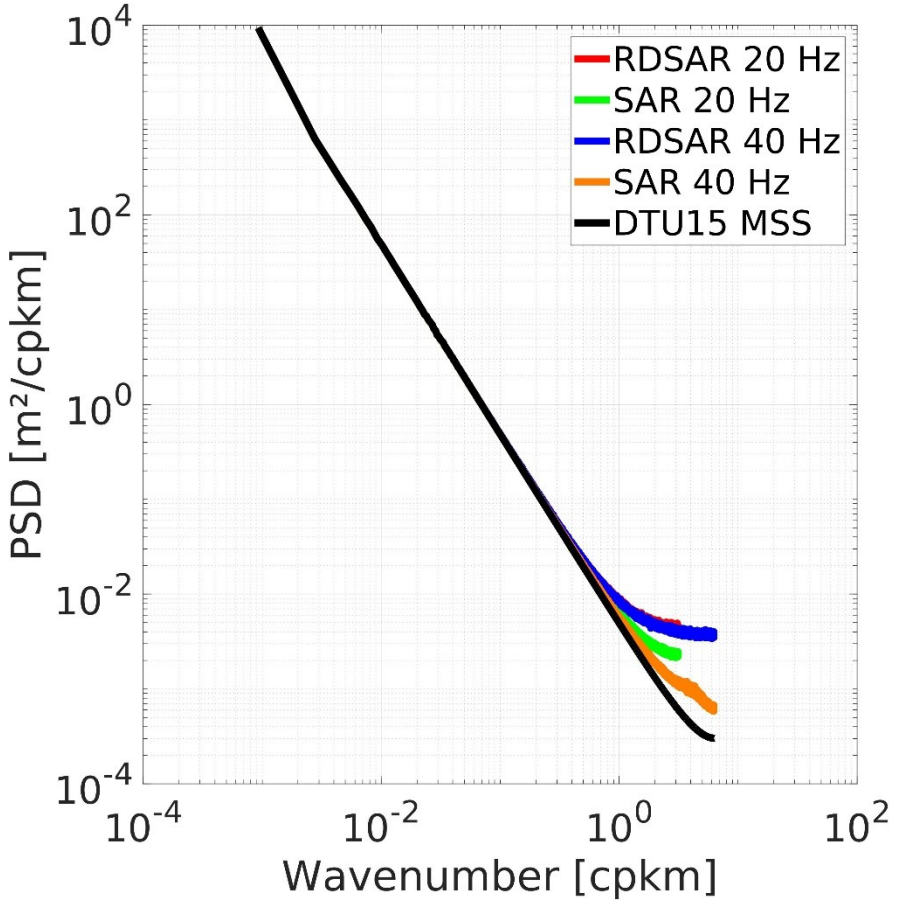
SLA Precision

- Estimated standard deviations are not helpful as the correlation between the 40 Hz SAR values is not known
- Absolute values of the differences between two consecutive 1 Hz SLA ‘s are used
- Effect of SLA slope is minimized as differences from two different datasets are used
- Median and skewness are a coarse measure for the difference in precision
- SAR 40 Hz SLA has a small gain in precision
- RDSAR data are both less precise



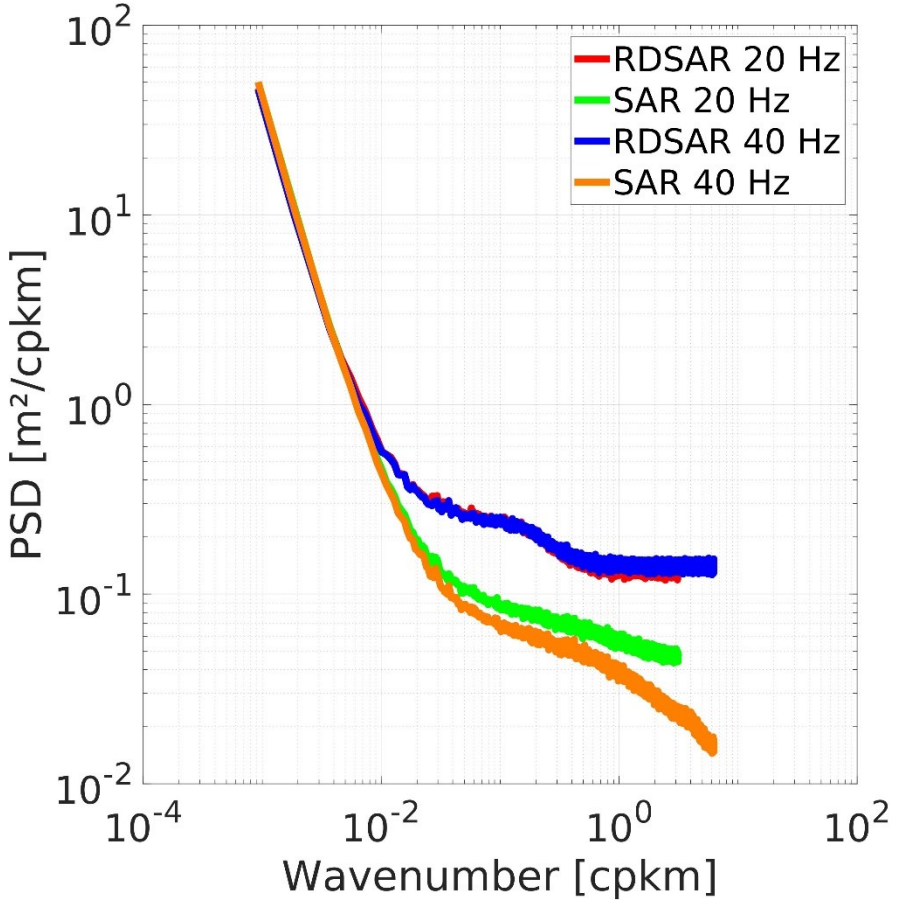
SSH Wave-Number Spectra

- Average Wave-Number Spectra are calculated with 6800 20 Hz values or 13600 40 Hz values each
- The DTU15 MSS serves here as a reference
- Both RDSAR datasets show similar performance
- SAR outperforms RDSAR
- SAR 40 Hz is significantly closer to DTU15 at higher frequencies
- SAR 40 Hz shows a bump at ca. 10 cycles per km



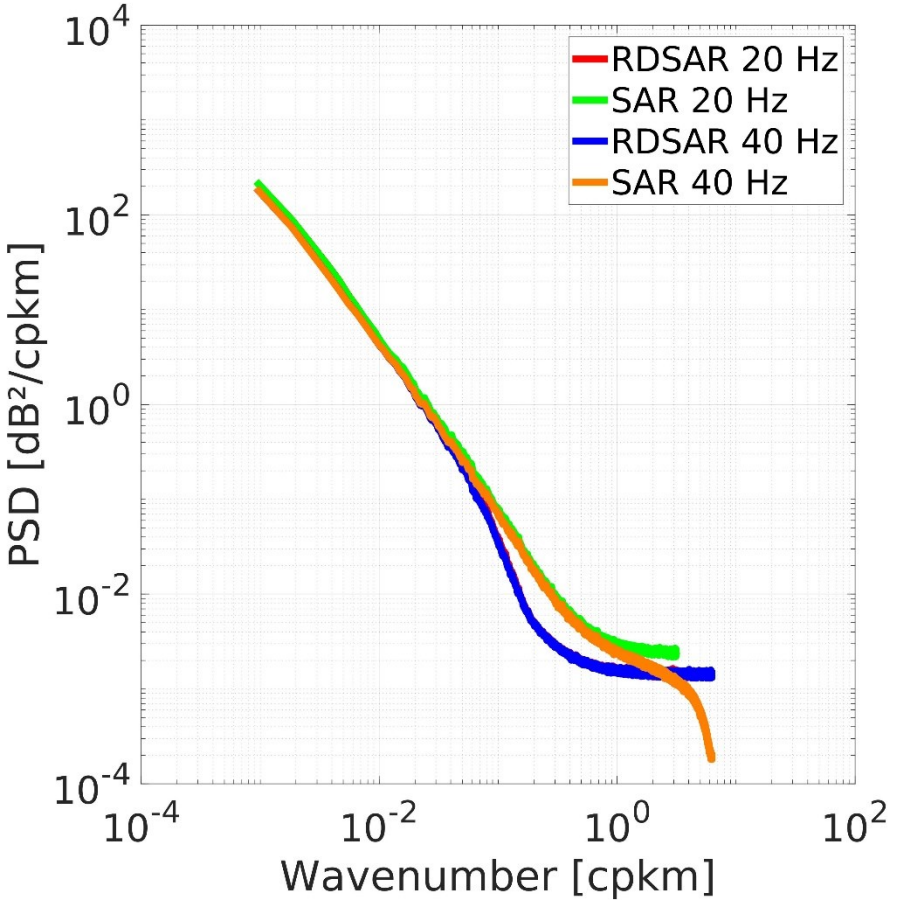
SWH Wave-Number Spectra

- Both RDSAR datasets show similar performance
- SAR outperforms RDSAR
- SAR 40 Hz shows a better performance than SAR 20 Hz at higher frequencies



Sigma0 Wave-Number Spectra

- Both RDSAR datasets show similar performance
- RDSAR outperforms SAR below ca. 10 cpkm
- SAR 40 Hz shows a better performance than SAR 20 Hz at higher frequencies



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- Zero-Padding of the bursts before the along-track FFT leads to additional beams not available in standard 20 Hz surface locations
- A surface sampling rate of 40 Hz allows to use these additional beams
- Small improvement of precision for SLA (ca. 10-20%) is observable for 40 Hz unfocused SAR data
- Spectral analysis shows significant improvements for SWH, SSH, sigma0 derived from the 40 Hz SAR