Technical University of Denmark

Consolidating ICESat-2 Ocean Wave Characteristics with CryoSat-2 during the CRYO2ICE campaign

Presenter: Bjarke Nilsson[1]

Co-authors: Ole B. Andersen[1], Heidi Ranndal[1] & Mikkel L. Rasmussen[2]

[1]DTU Space, Technical University of Denmark

[2]DHI GRAS

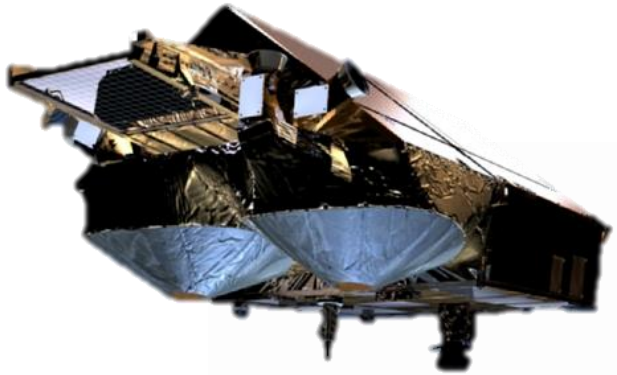
ESA Living Planet Symposium, Bonn, Germany, 26 May 2022

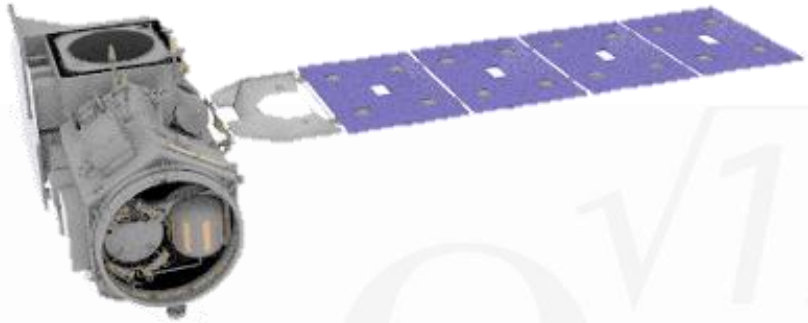
Overview

Currently: Majority of global wave observations are done by radar

Goal: Provide higher resolution observation of ocean surface waves

Scope & Data

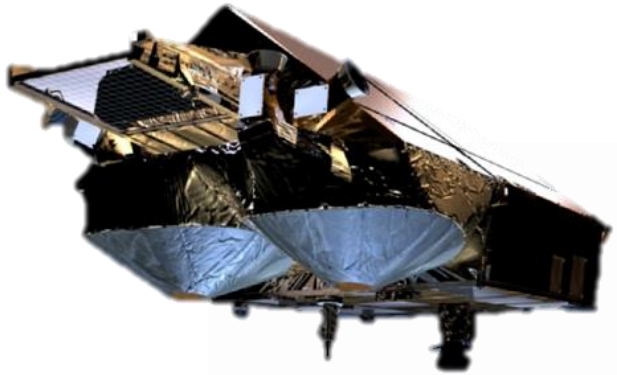


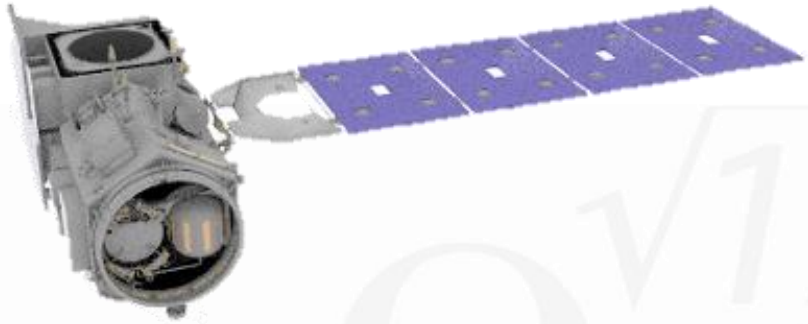


Use active missions to consolidate ICESat-2 for observing Significant Wave Height (SWH)

Images: ICESat-2: https://nasa3d.arc.nasa.gov/detail/icesat2 CryoSat-2: https://www.esa.int/Applications/Observing_the_Earth/FutureEO/CryoSat/CryoSat-2_on_the_road_to_recovery

Scope & Data





Use active missions to consolidate ICESat-2 for observing Significant Wave Height (SWH)

CryoSat-2

- Radar Observations

ICESat-2

- LiDAR Observations

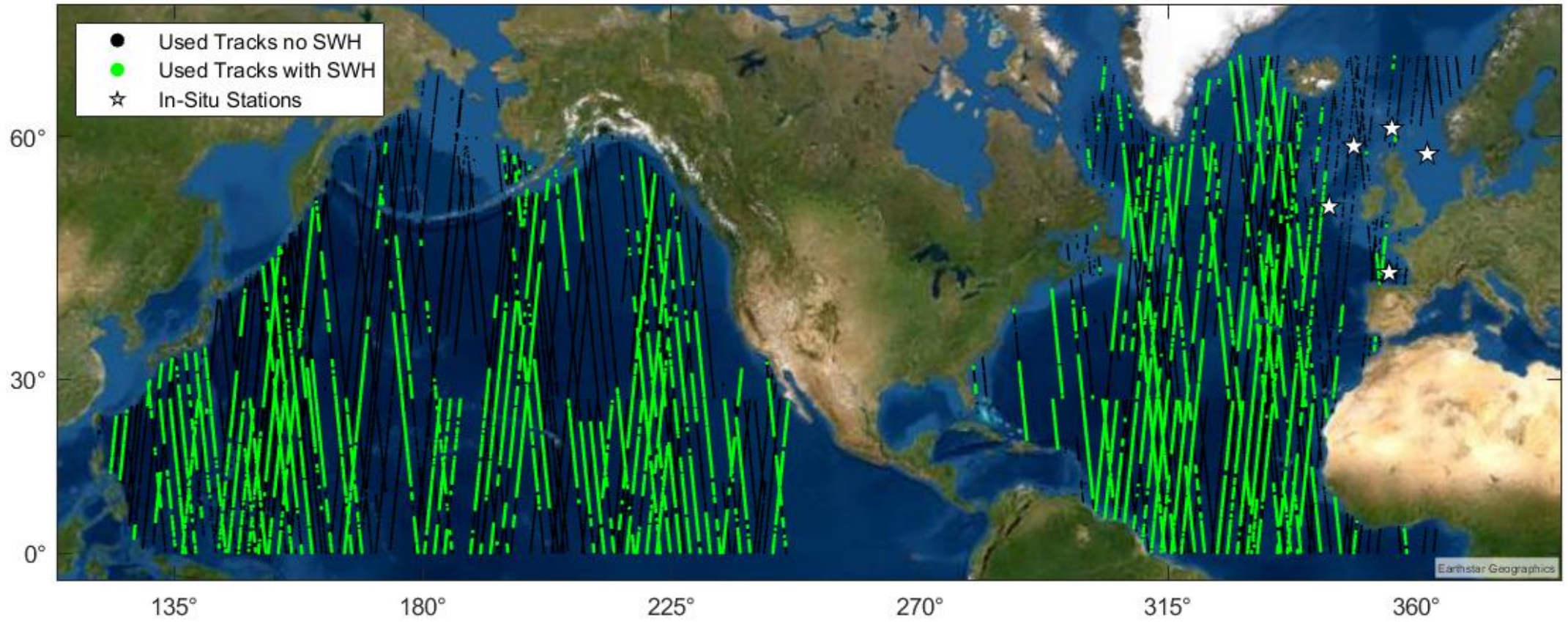
We want to link these

Images: ICESat-2: https://nasa3d.arc.nasa.gov/detail/icesat2 CryoSat-2: https://www.esa.int/Applications/Observing_the_Earth/FutureEO/CryoSat/CryoSat-2_on_the_road_to_recovery

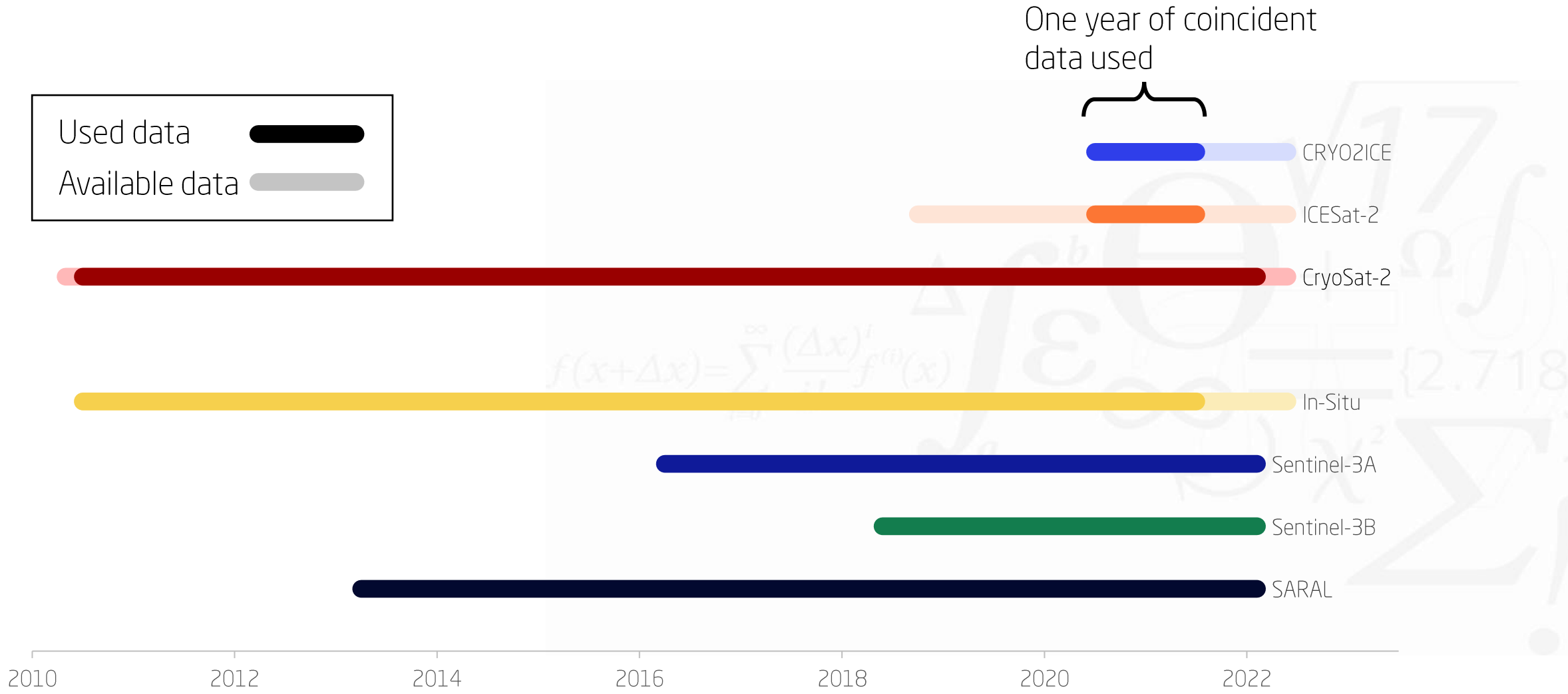
CRYO2ICE

Coincident data between ICESat-2 and CryoSat-2!

- Data in northern hemisphere from summer 2020



Data Overview



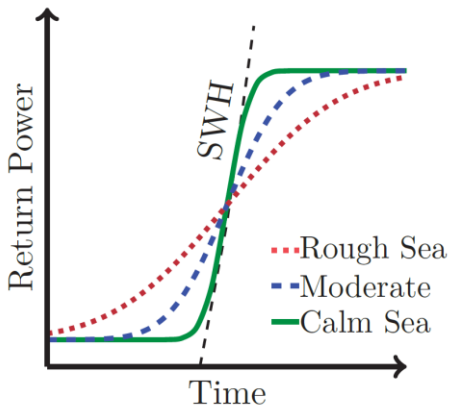
Models

Validation over 10 years

CryoSat-2

Radar observations

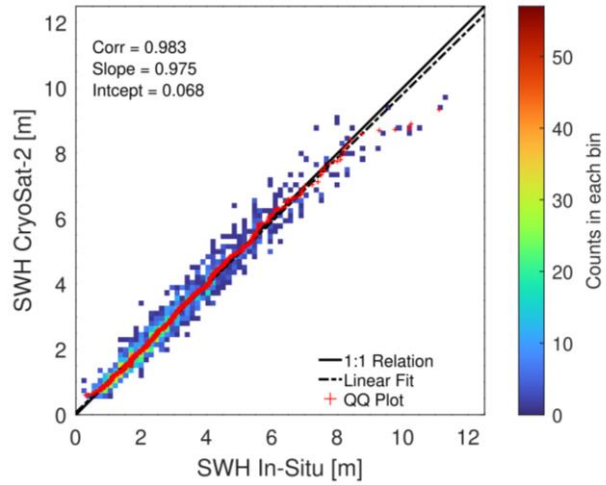
- Empirical relations with waves
- Large footprint



In-Situ

Direct time-series measurements

- Used for validating CryoSat-2



Models

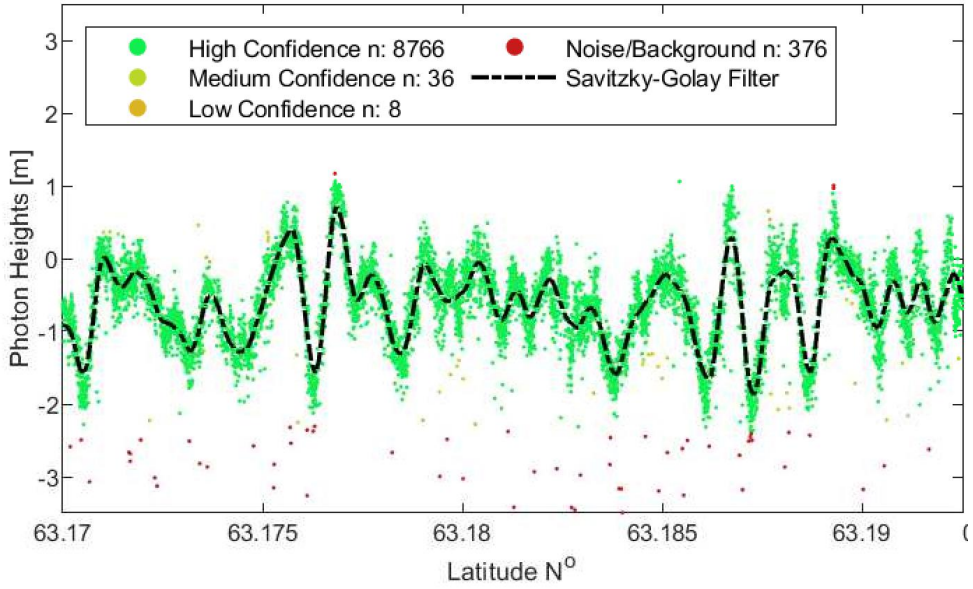
Direct comparison possible due to CRYO2ICE!

Validation over 10 years

ICESat-2

Return-Photon counter (ATL03)
Three different models

- ATL12
- Wave based model
- Standard Deviation based model



CryoSat-2

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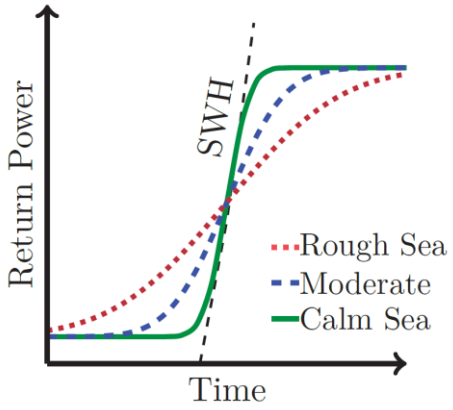

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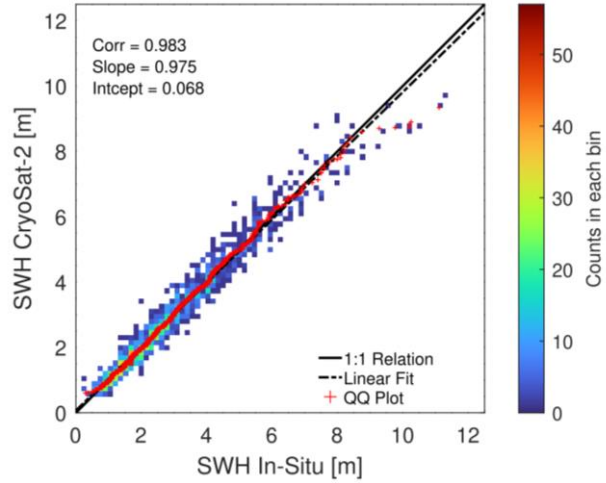


ICESat-2 SWH-Models

ATL12

Provided data output based on ATL03

$$p(H) = \frac{\mathrm{H}}{4m_0} \exp\left(-\frac{H^2}{8m_0}\right)$$

$$\mathrm{SWH} = 4\sqrt{m_0}$$

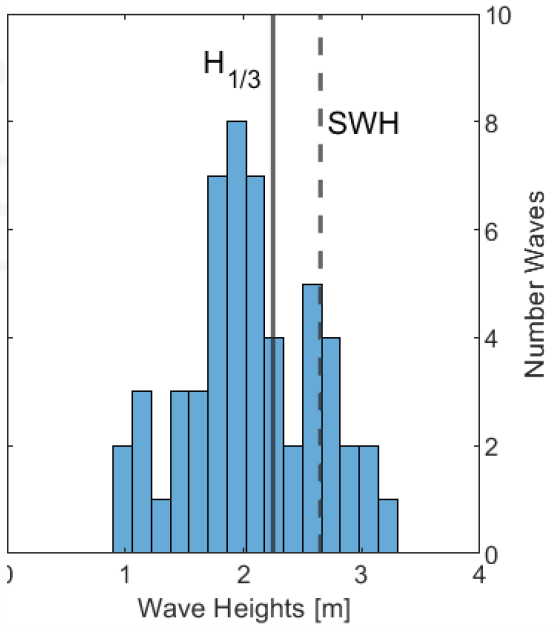
Standard Deviation Model

Same fundamental processing as ATL12

- Same sorting as wave histogram model

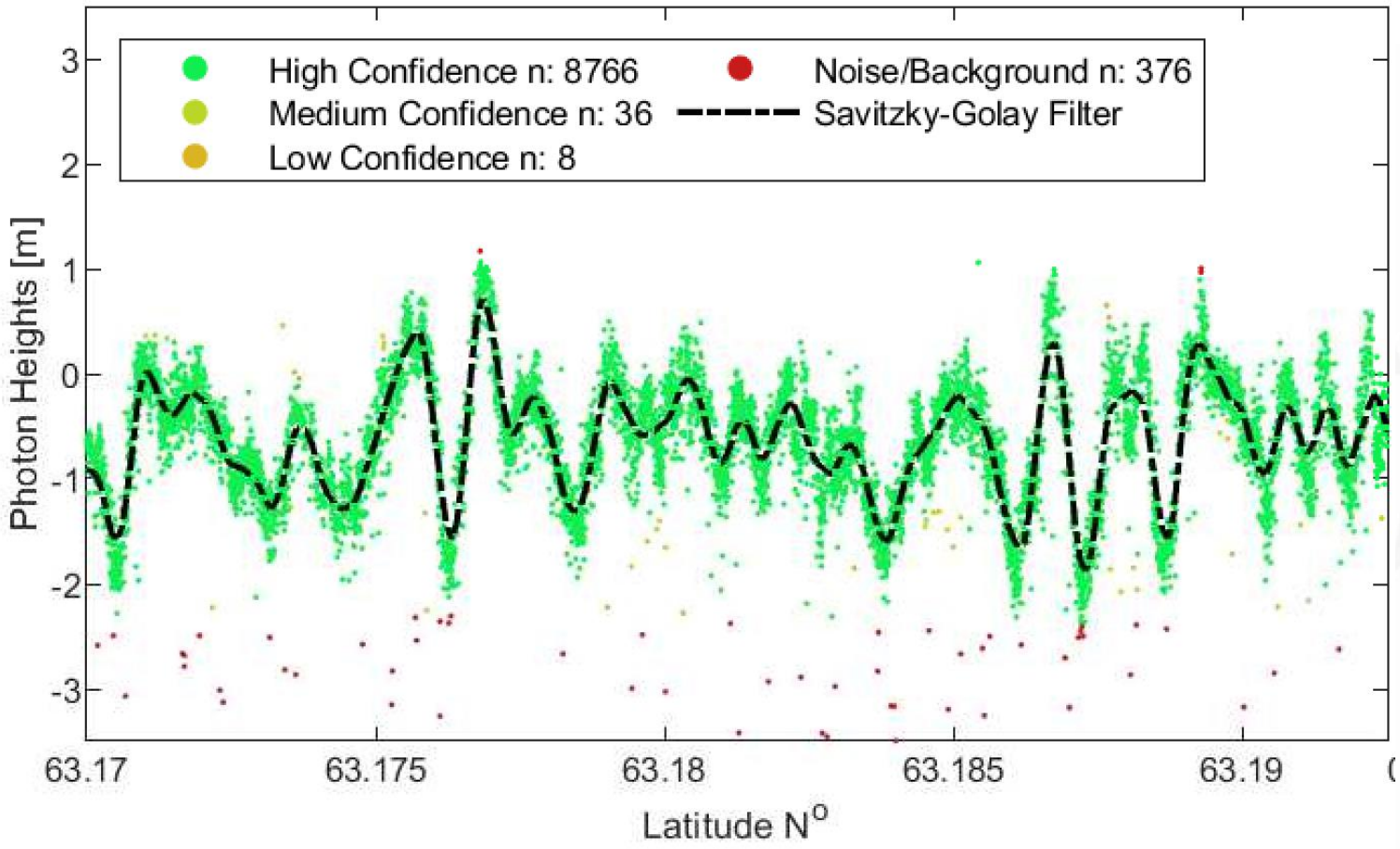
Wave Histogram Model

Modelled surface waves from individual photon heights



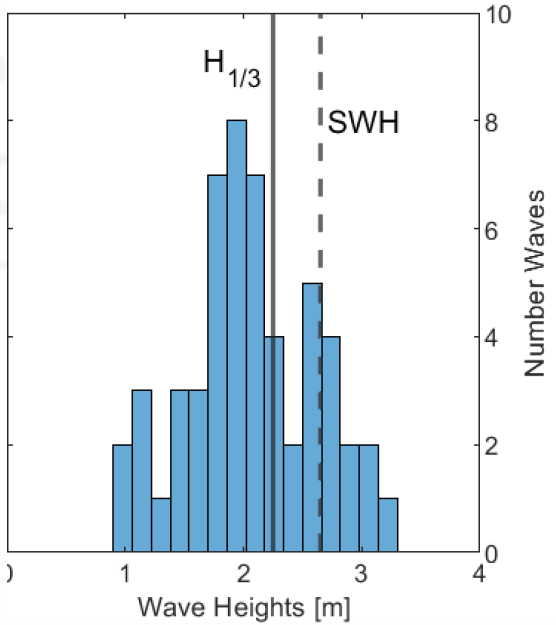
See also:
Klotz, B. W., et. al., 2020, https://doi.org/10.1029/2019GL085907

ICESat-2 SWH-Models



Wave Histogram Model

Modelled surface waves from individual photon heights



See also:
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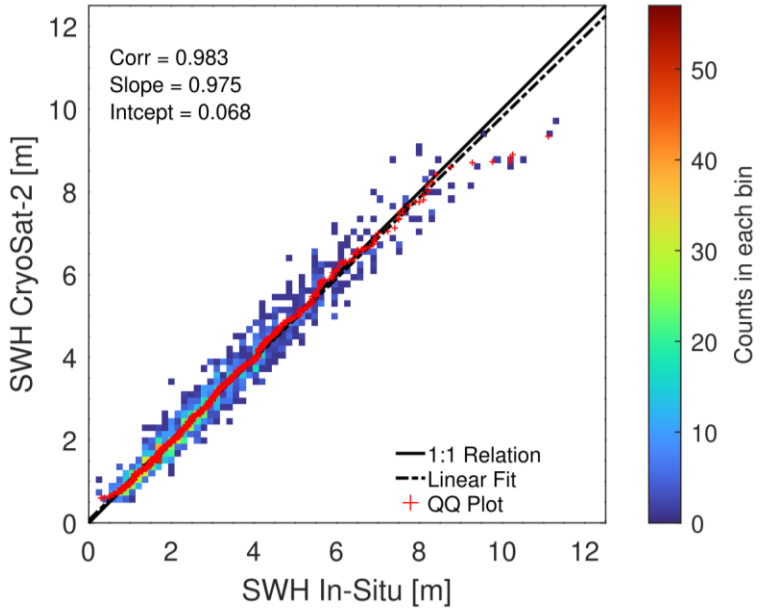
CryoSat-2 validation

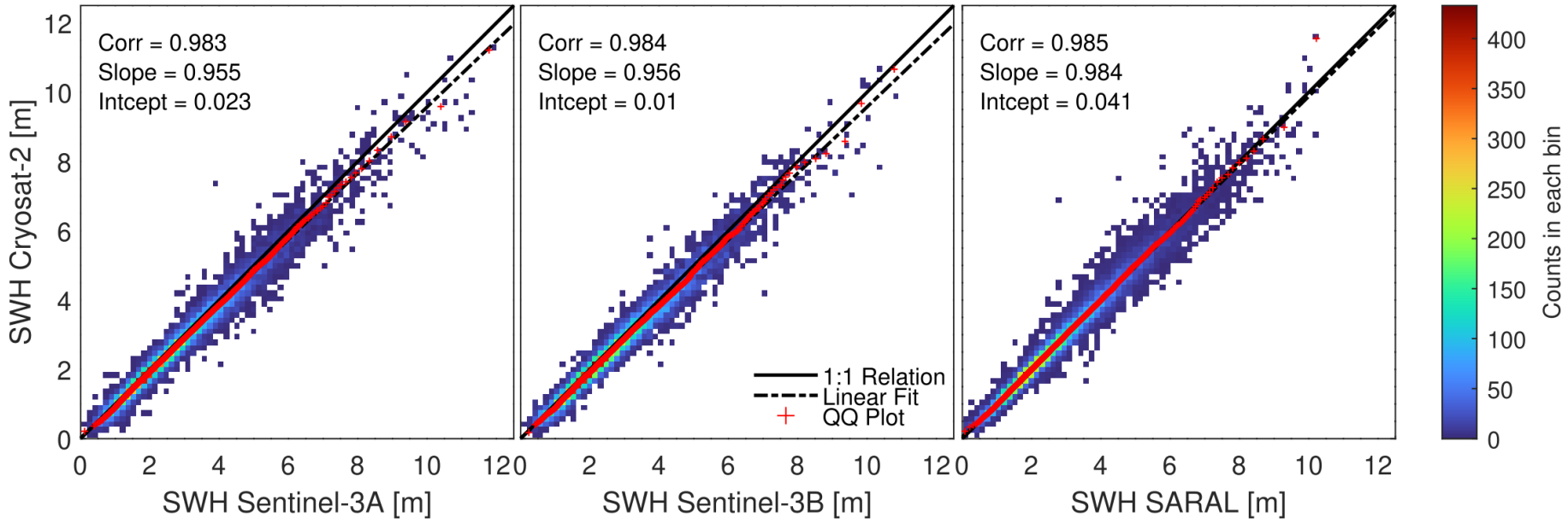
In-Situ data (right)

- North West Shelf Data Portal

Radar Altimeters (below)

- Sentinel-3A/B
- SARAL

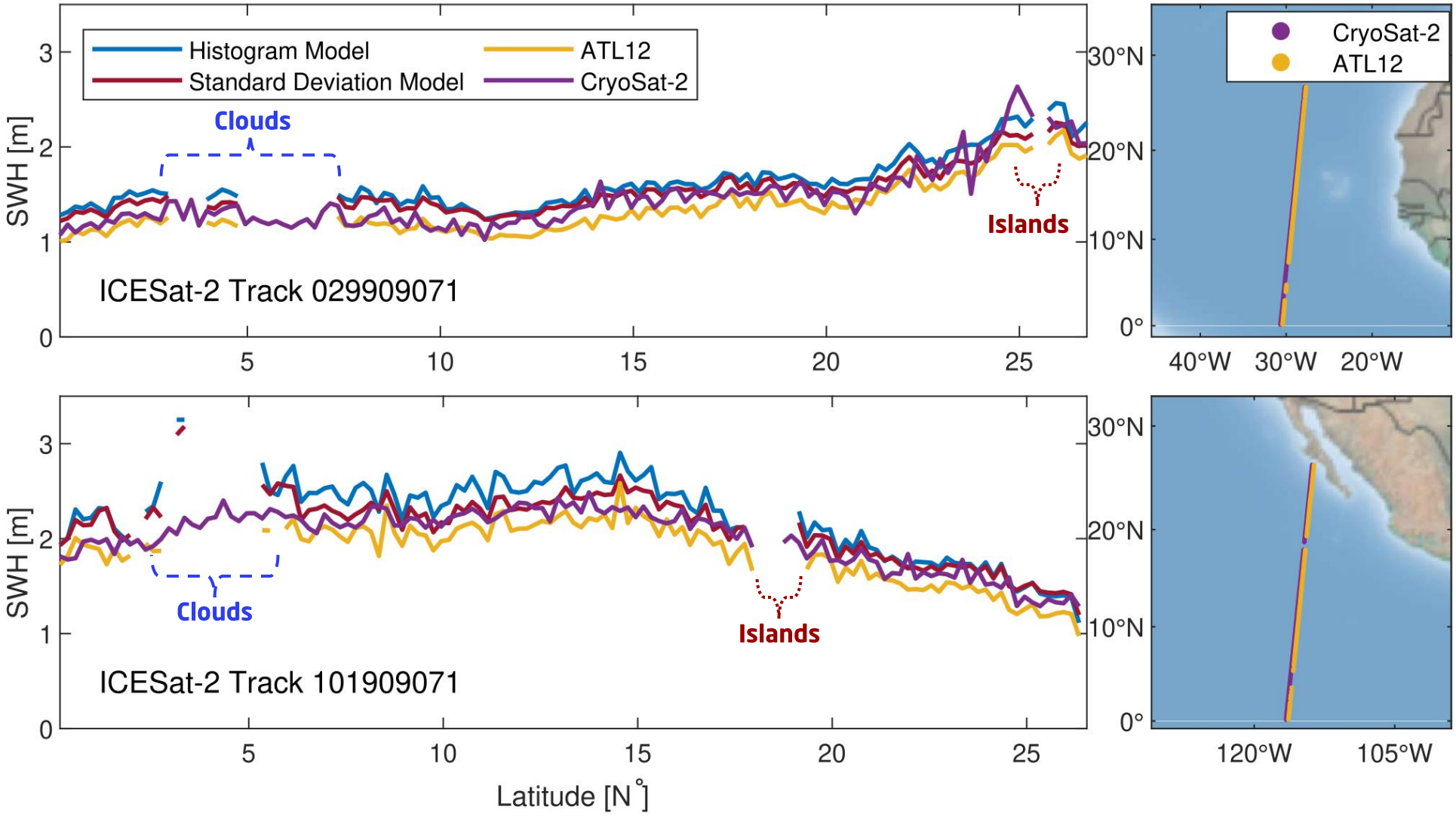




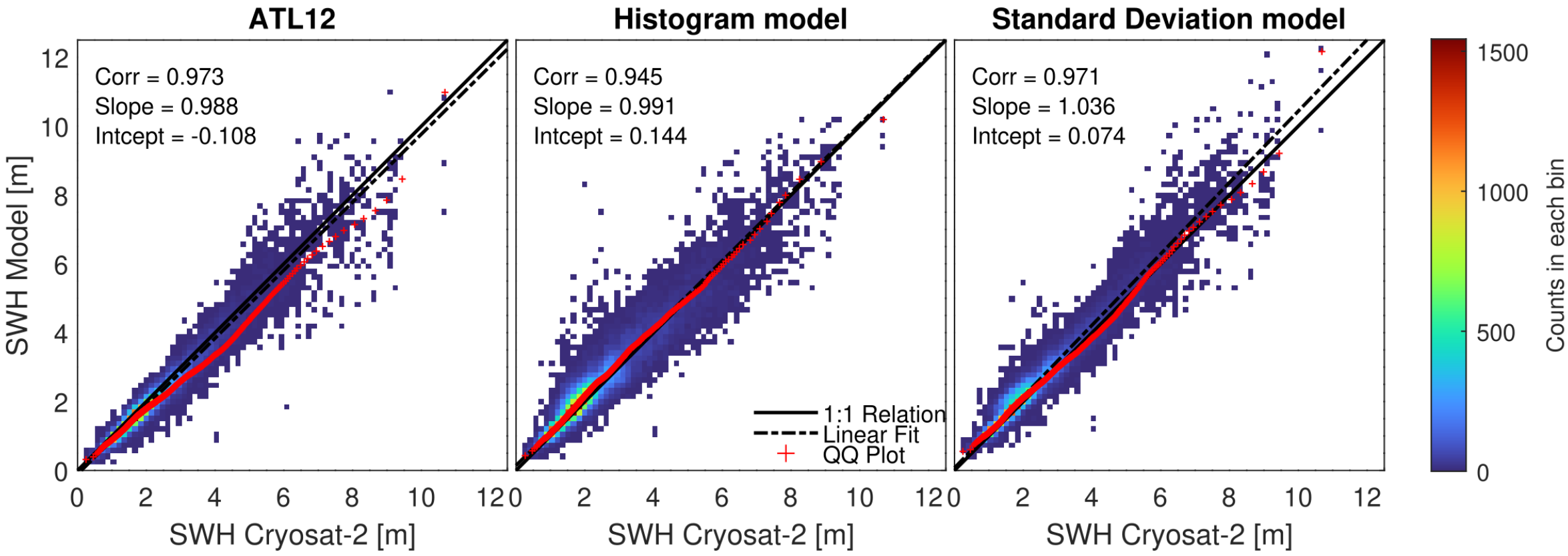
2-3 H timelag!

Results

Observations along groundtracks



Observations from ICESat-2 ref. CryoSat-2



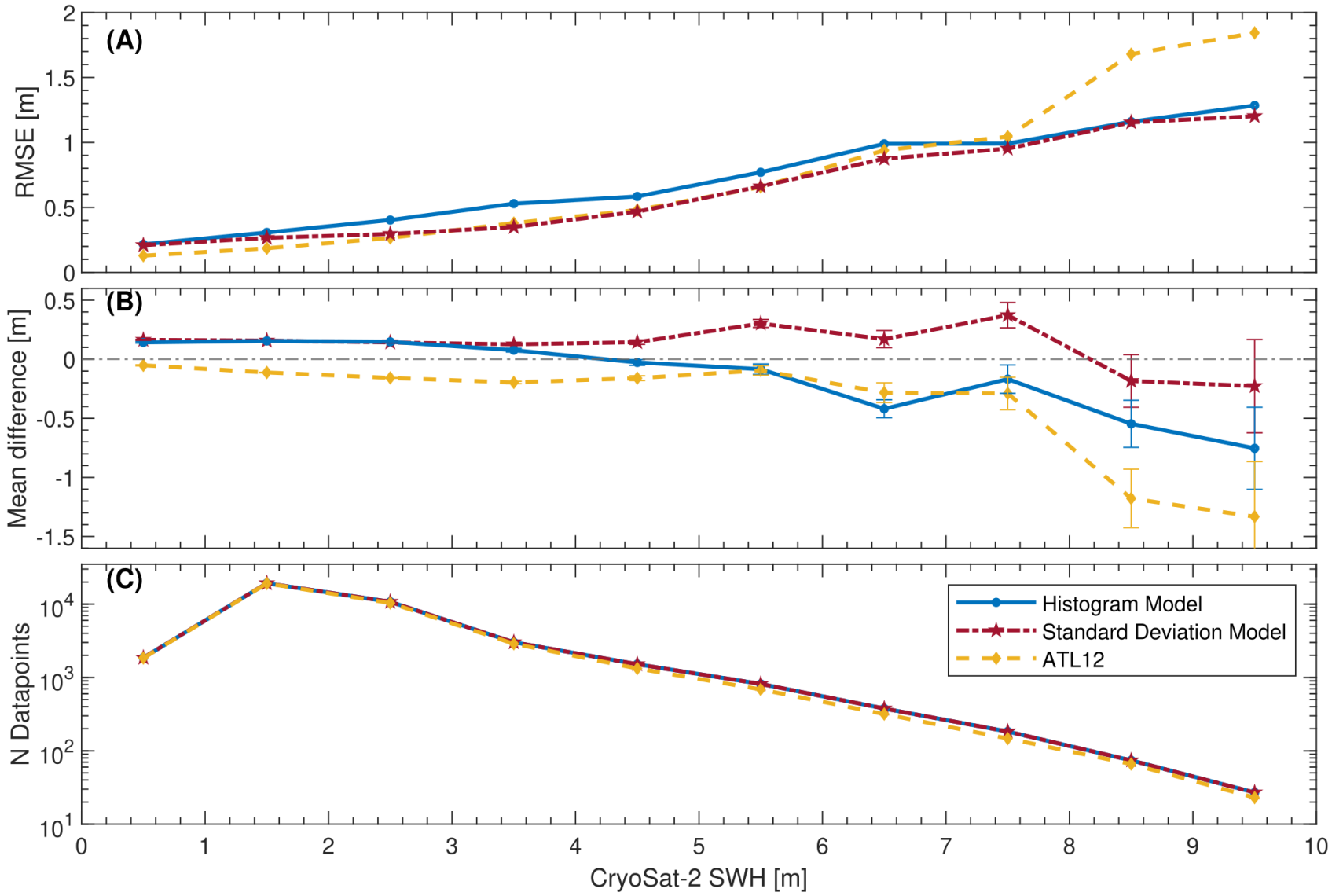
Observations from ICESat-2 ref. CryoSat-2

RMSE

- Histogram (wave): 0.42 m
- Standard dev.: 0.33 m
- ATL12: 0.29 m

Mean difference

- Histogram (wave): 0.14 m
- Standard dev.: 0.17 m
- ATL12: -0.12 m



Outlook

- Validation at higher SWH
  - South Polar Ocean
  - Future CryoSat-2 orbital correction
- Determination of individual waveheights on global scale
  - Extreme wave heights

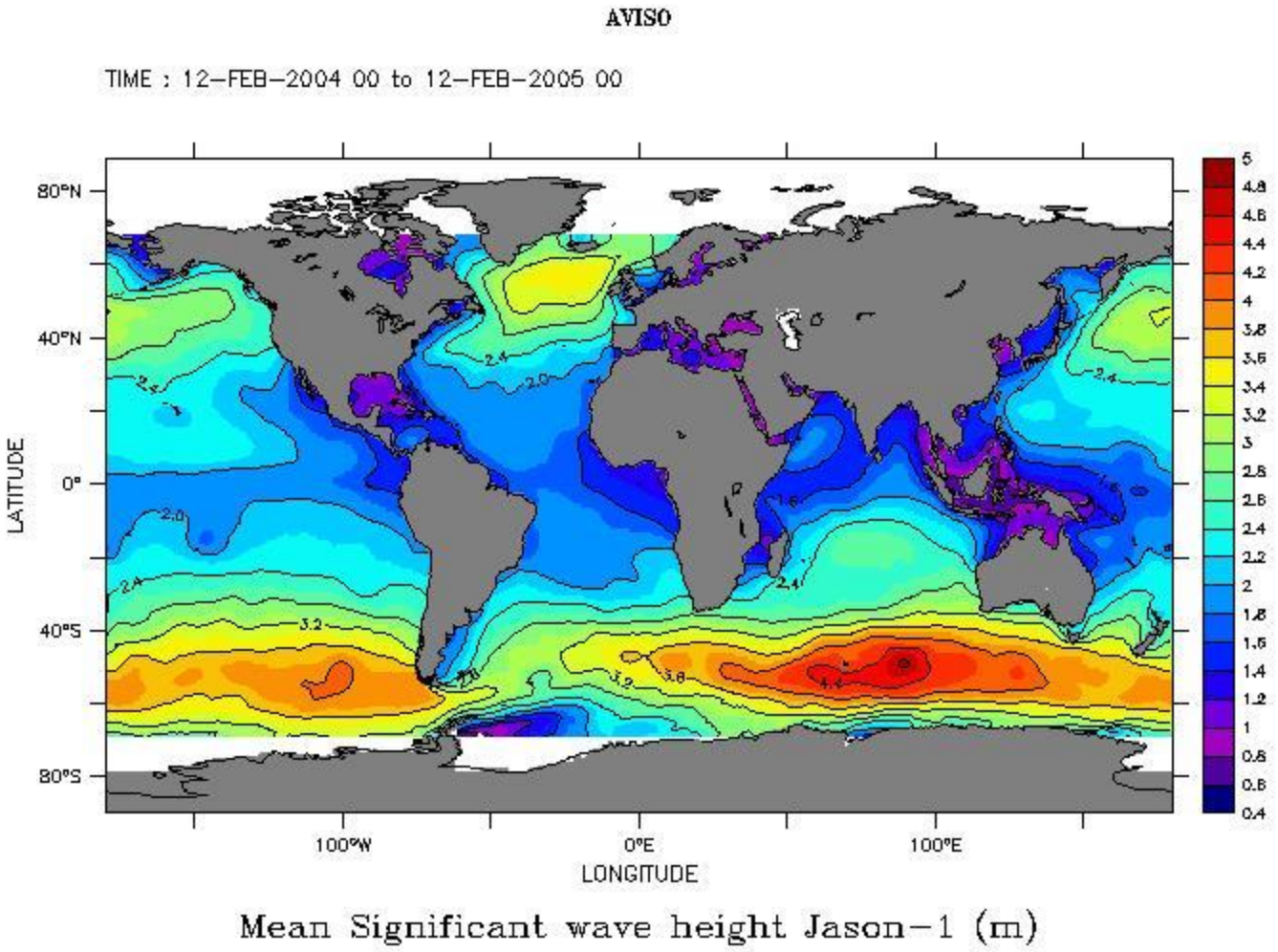


Image from: https://gcos.wmo.int/en/essential-climate-variables/sea-state

Conclusion

- **It is possible** to obtain SWH observations from ICESat-2 data with the possibility of **extracting the individual wave heights** from the data.
- More robust methods are possible to develop as this method is **more sensitive than conventional methods**.
- Behavior at **higher wave heights** is still in need for **validation**.

Thank you for the attention!

Bjarke Nilsson
DTU, Elektrovej 327
2800 Kgs. Lyngby, Denmark
s180866@student.dtu.dk

For more information:

Nilsson, B.; Andersen, O.B.; Ranndal, H.; Rasmussen, M.L. Consolidating ICESat-2 Ocean Wave Characteristics with CryoSat-2 during the CRYO2ICE Campaign. *Remote Sens.* 2022, *14*, 1300. https://doi.org/10.3390/rs14061300