Operational support for wave & ice X-band radars

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UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

X-band radar program’s responsibilities

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- Calibrate radars’ heading/range/time biases and significant wave height.
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- Improve products’ visibility through web viewer on ship network.
- Remotely monitor radar operations with error notification and status emails.
- Collaborate with R2R to publicly archive radar products.

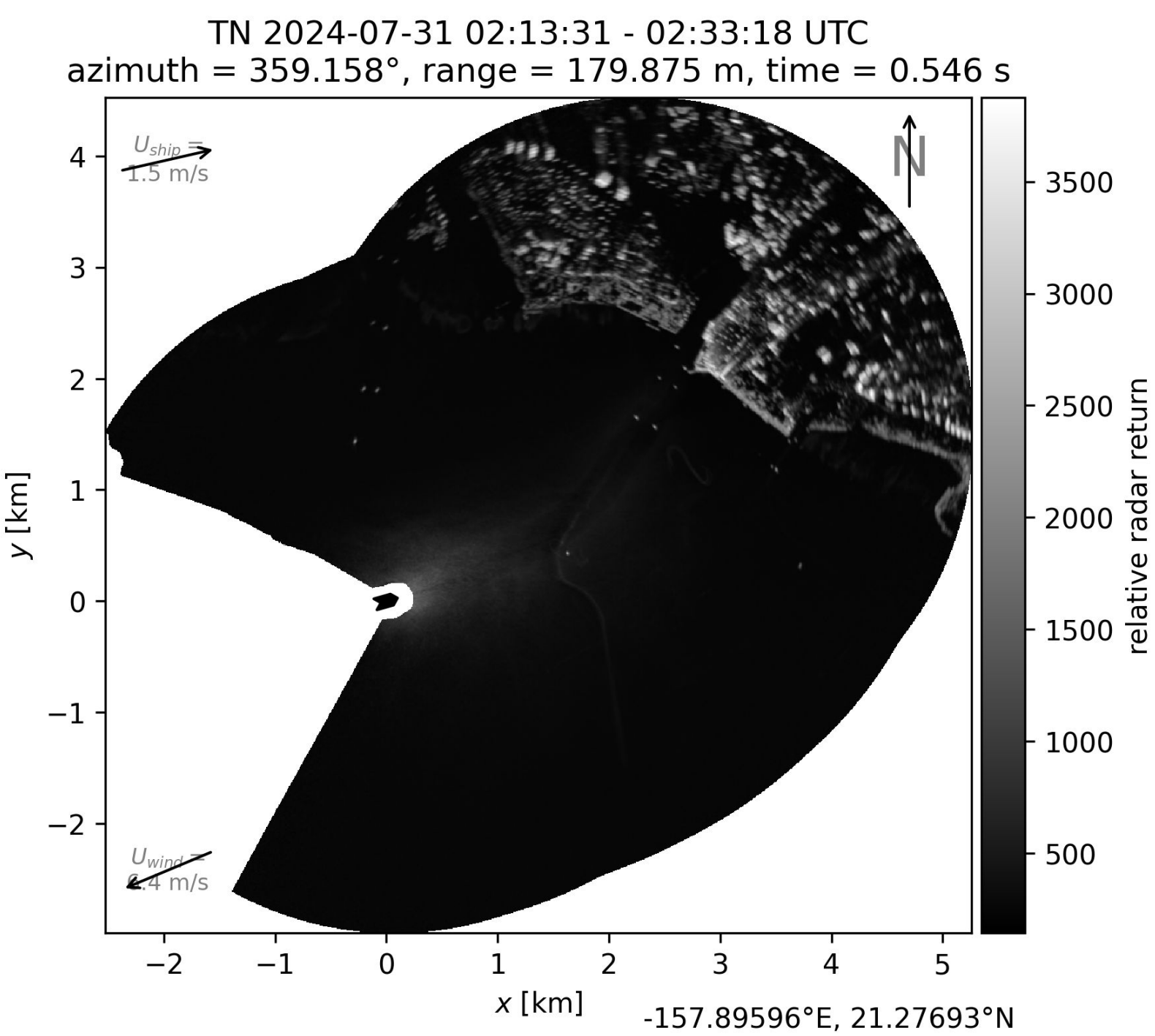
Radar calibration

Finds the radar azimuth, range, and time offsets that maximize the image sharpness.

Requires fixed targets observed from a moving vessel.

Calibrations are repeatable within 0.1° and 0.1 s.

Following McCann & Bell (2018).



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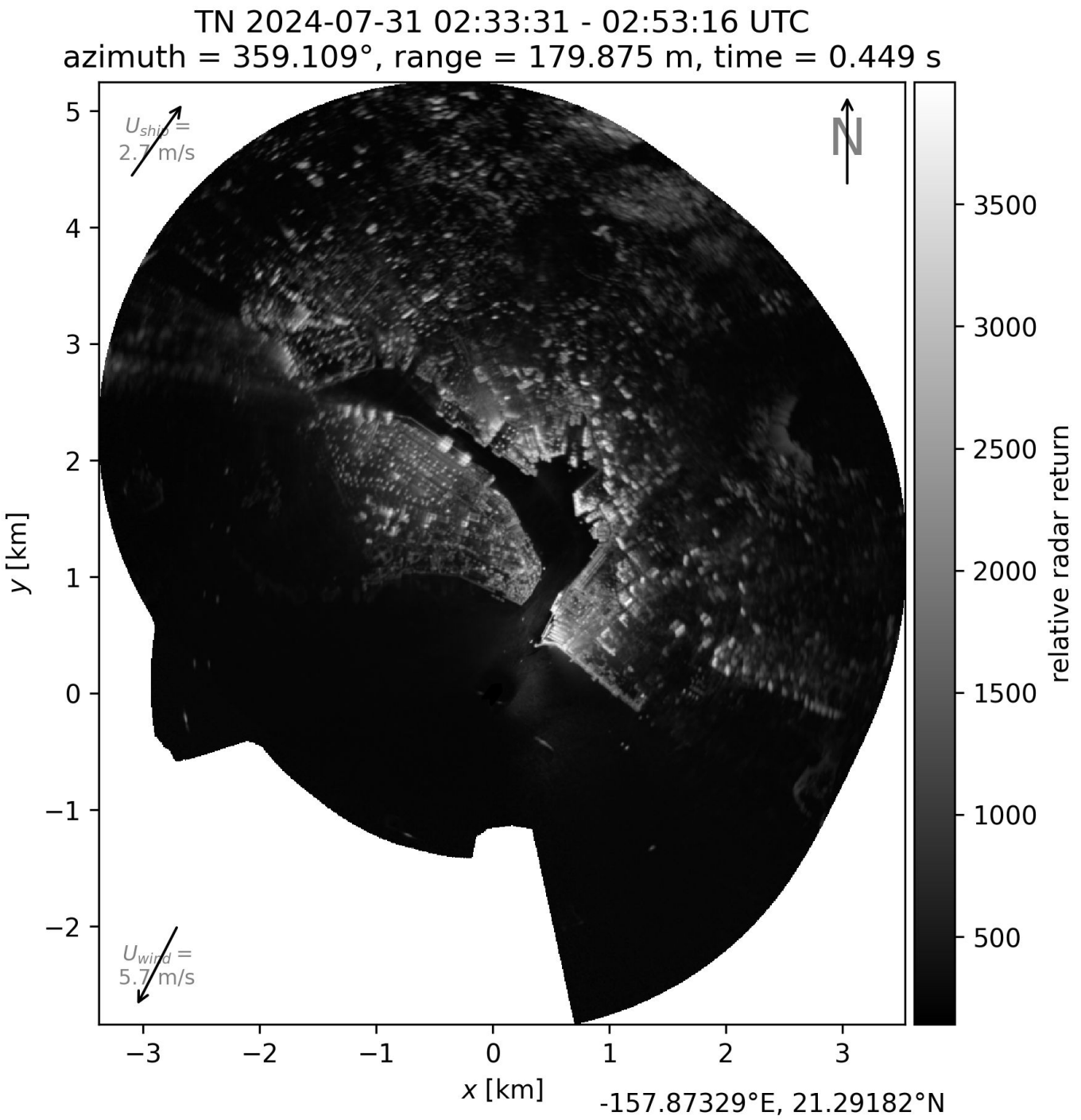


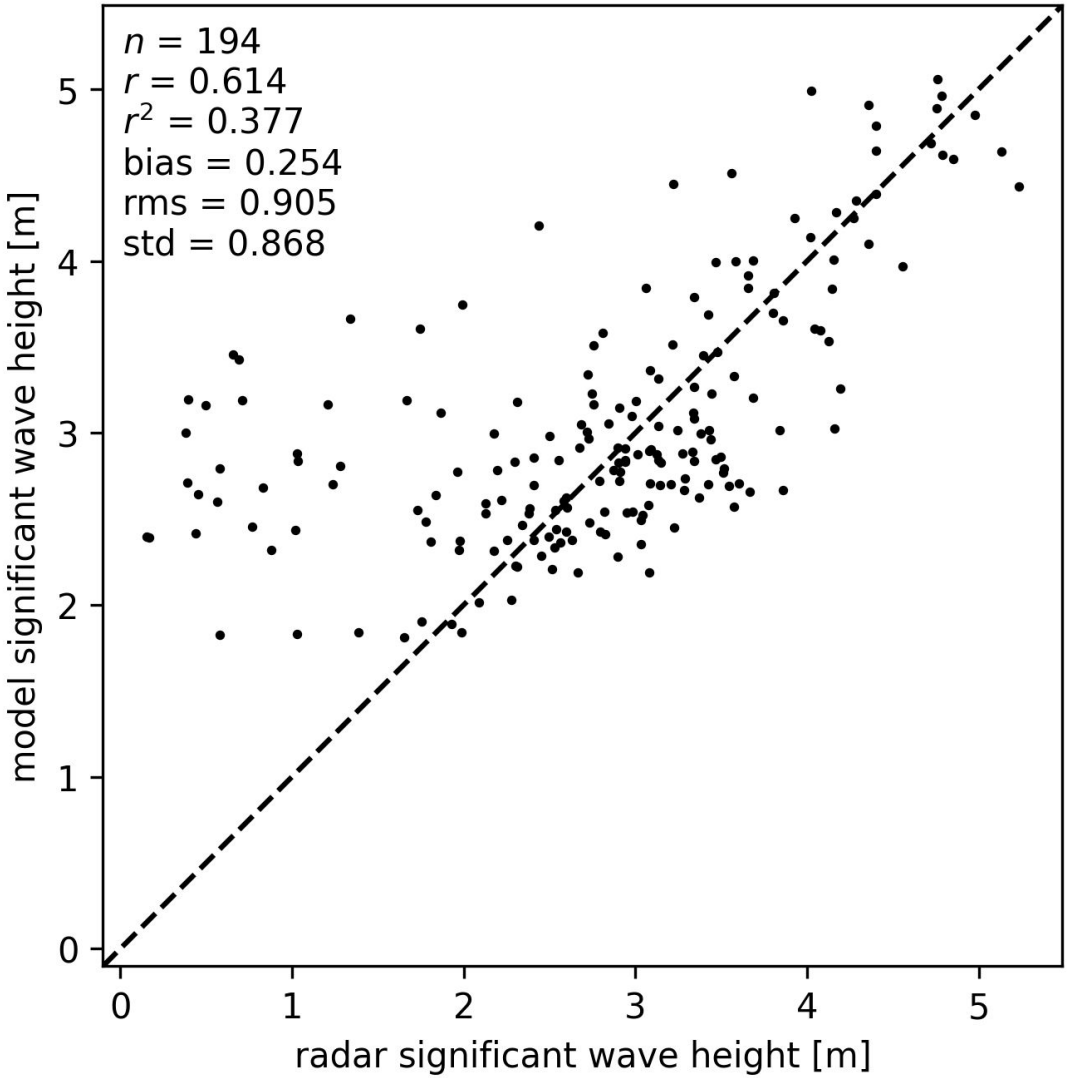
Significant wave height calibration

Marine X-band radar significant wave height measurements must be calibrated.

In absence of reference in situ measurements, wave model results can be used.

Scatter plot compares the radar significant wave height after calibration against the global MFWAM wave model.

Time series shows that model and radar wave parameters are in good agreement.



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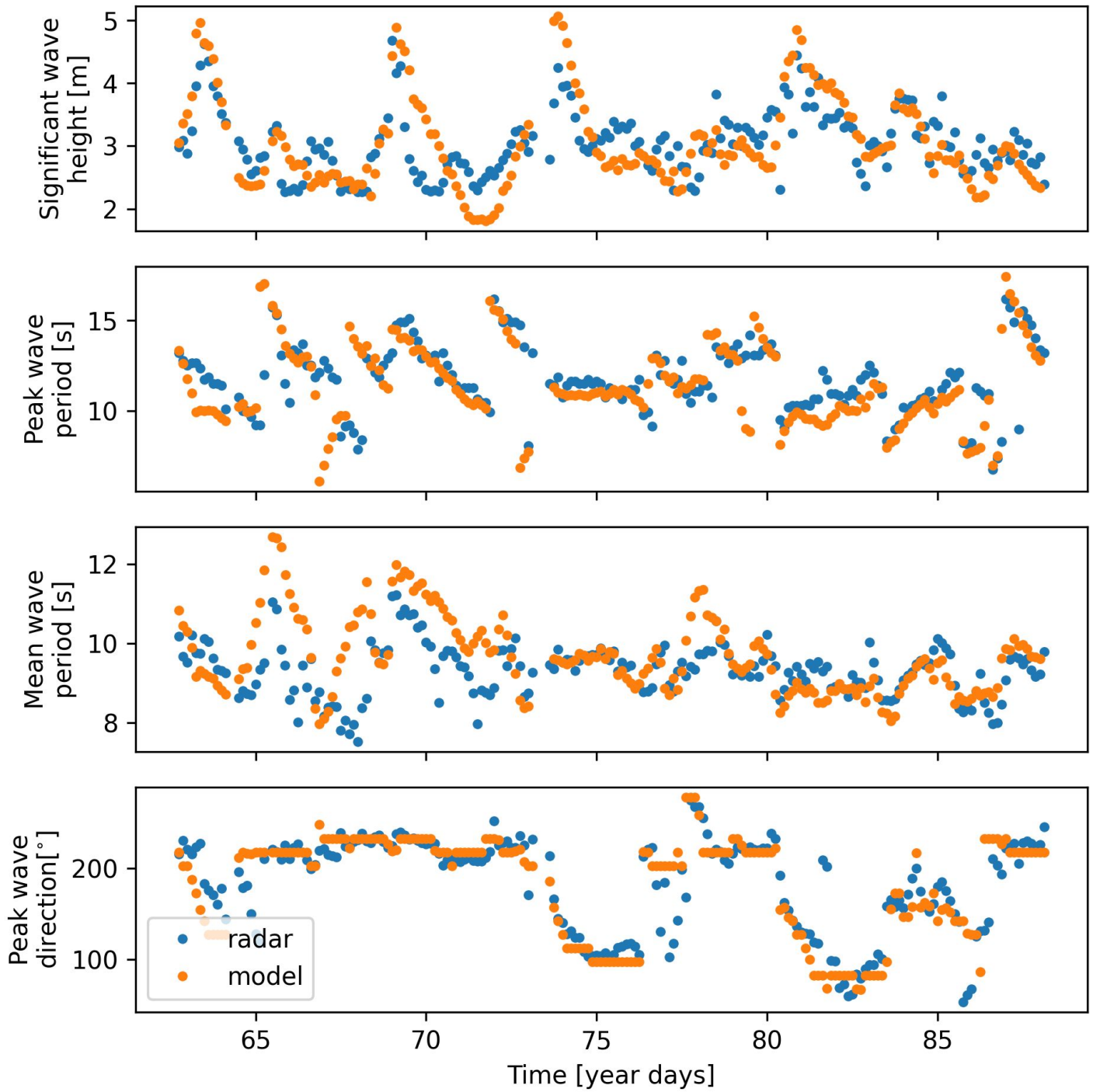

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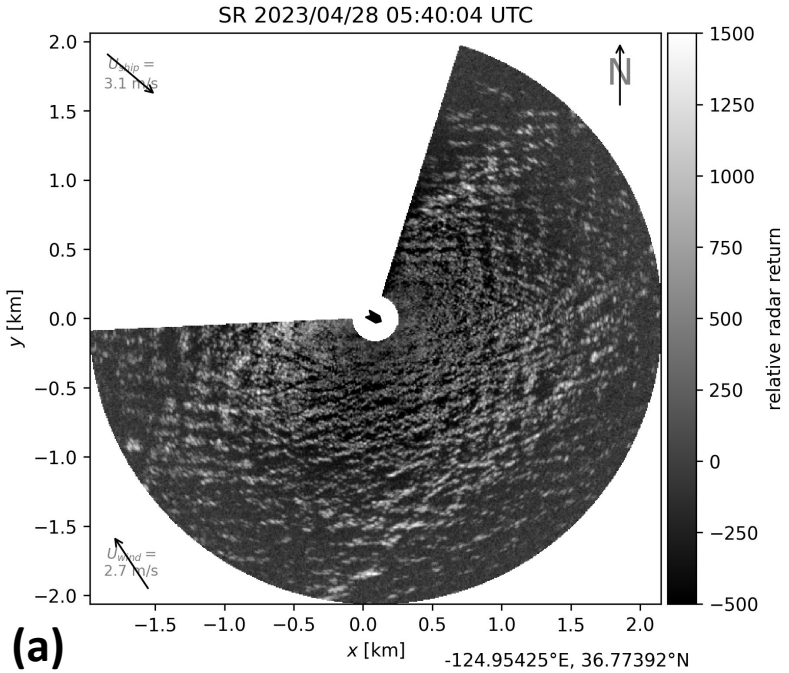
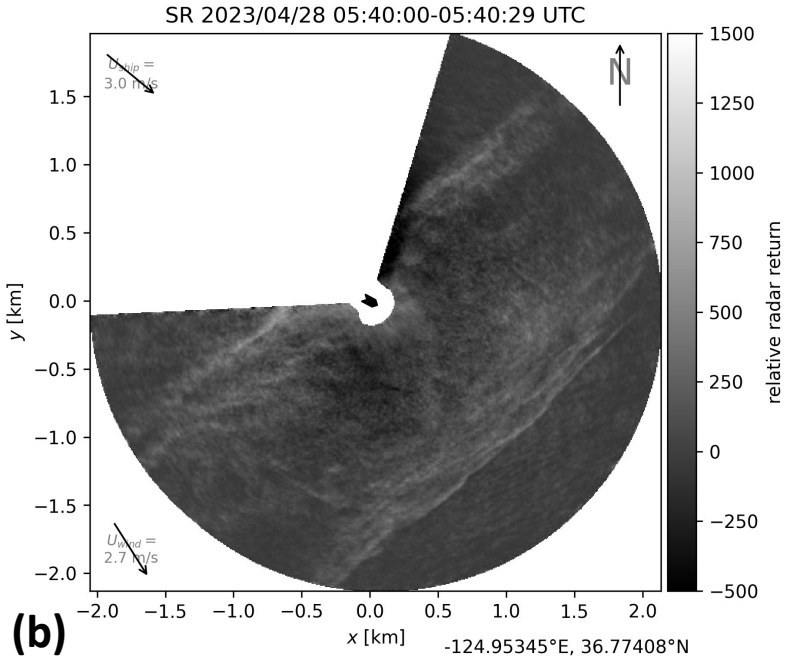
Sea surface roughness images

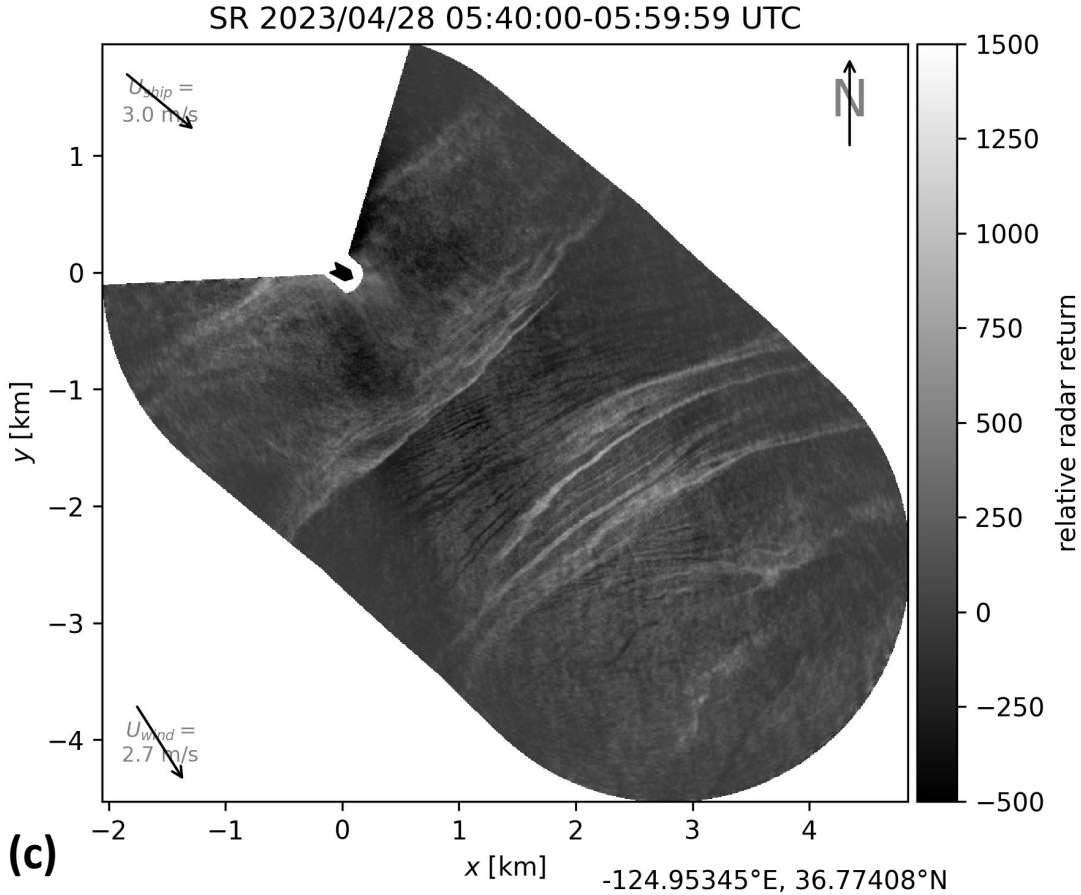
(a) Single scan radar image with wave signatures,

(b) 1-min averaged radar image with current front,

(c) 20-min radar image mosaic with current fronts
(each pixel is a 30-s average).





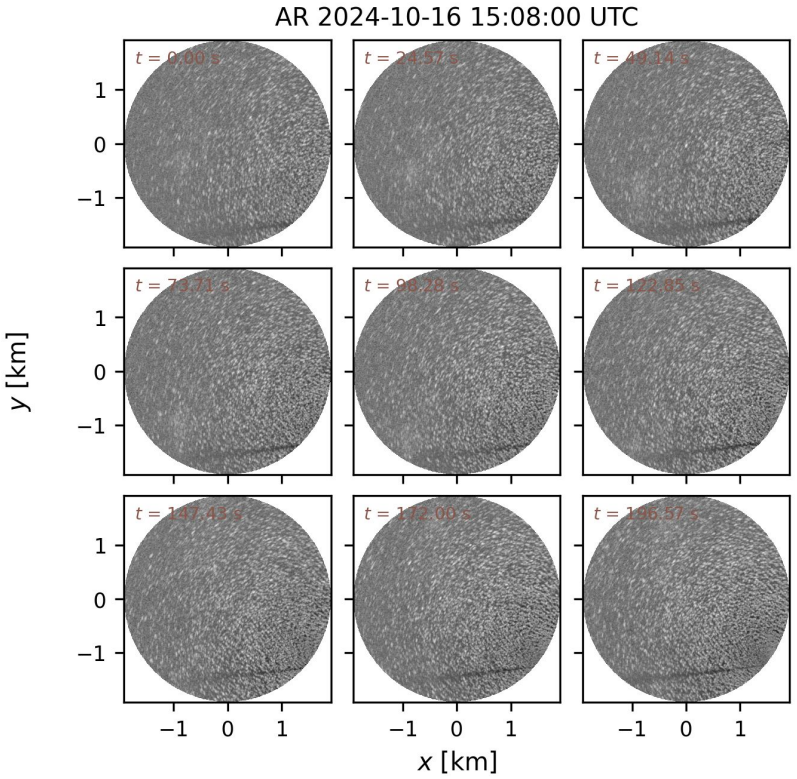


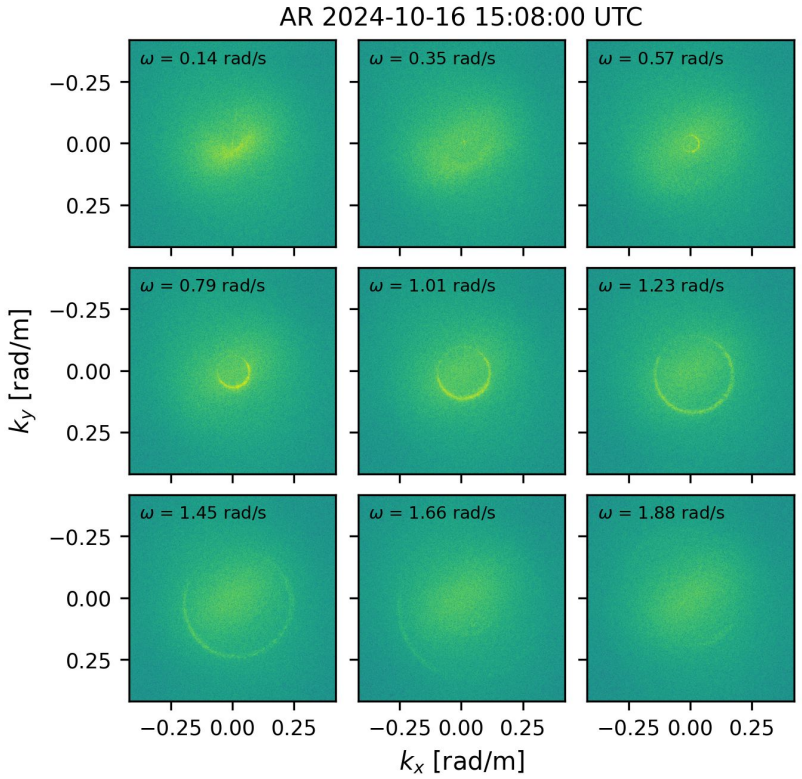
Wave measurements

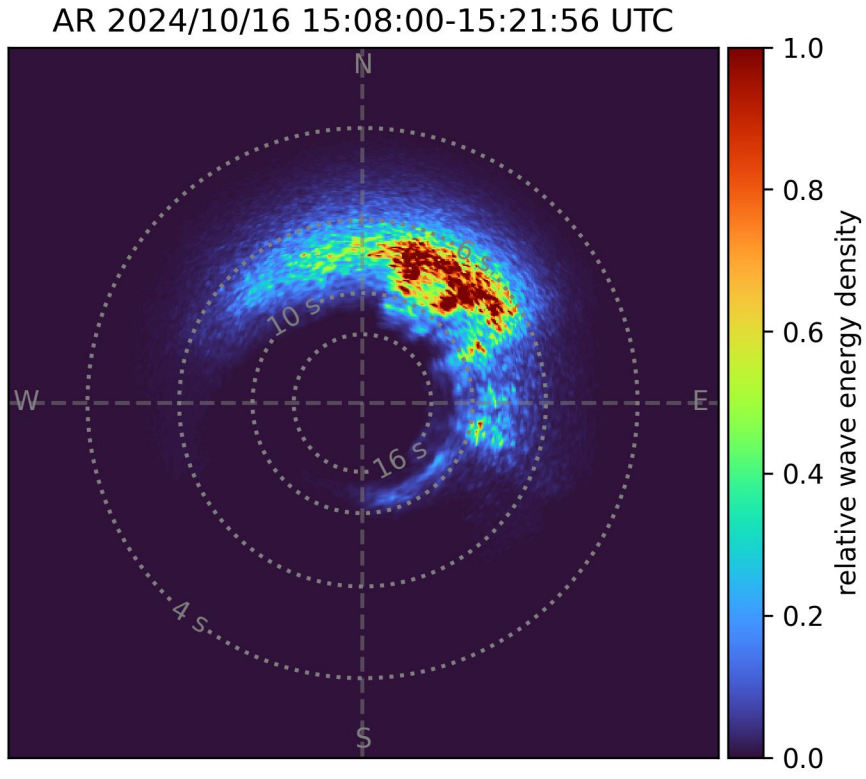
Sequence of radar images within a circular analysis window.

Corresponding wavenumber frequency spectrum with prominent wave signal.

Two-dimensional wave energy density frequency spectrum via dispersion filter.





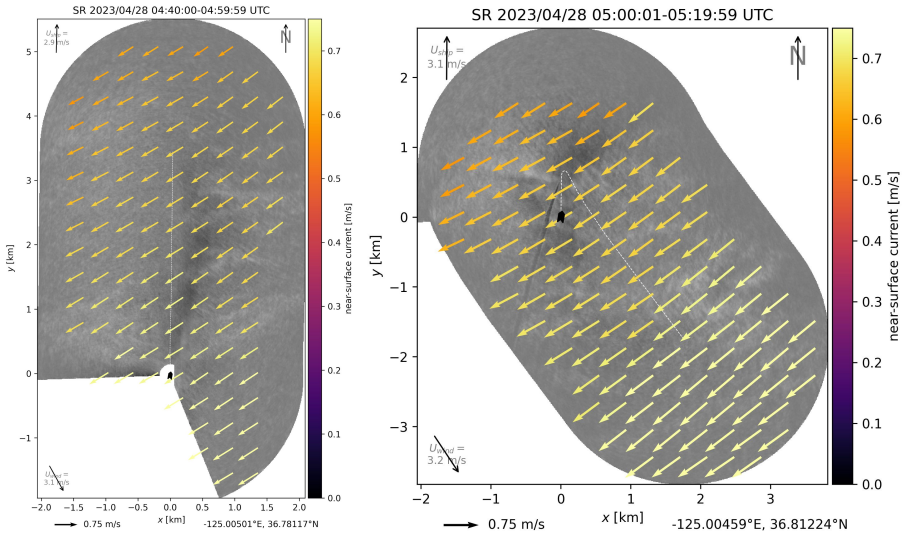


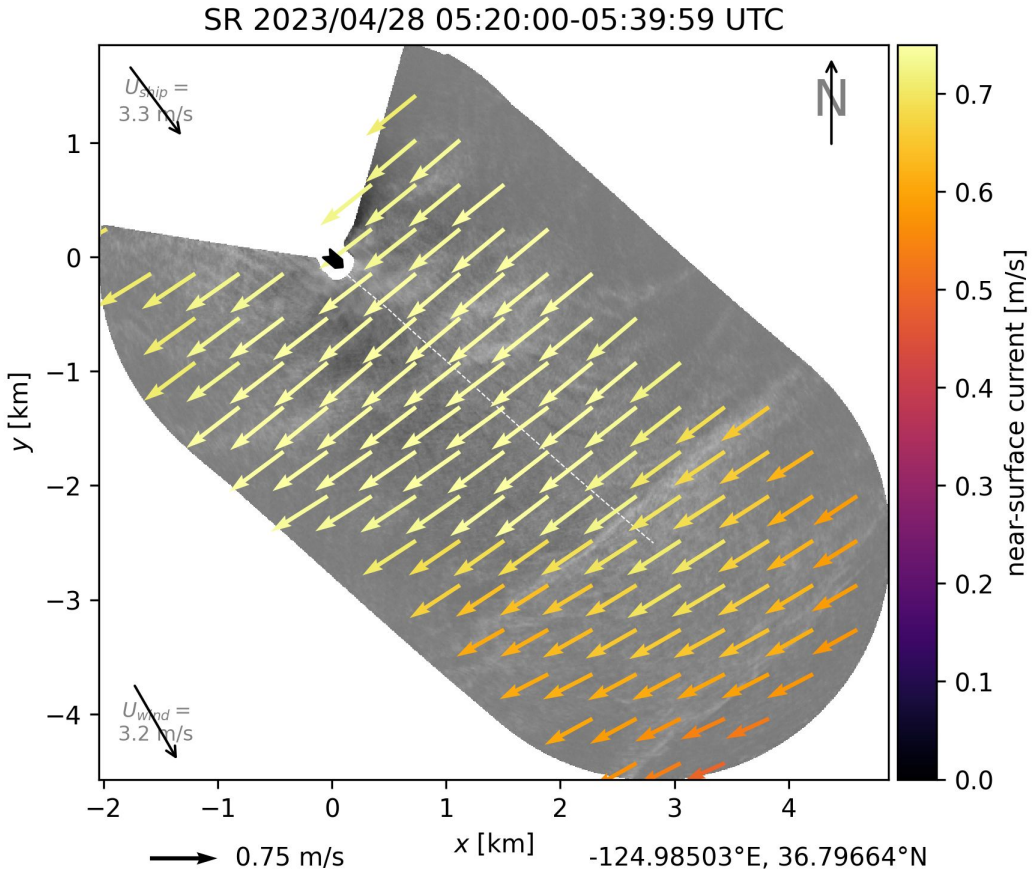
See Lund et al. (2016) for details on the method and a model comparison: https://doi.org/10.1007/s10236-016-0961-z.

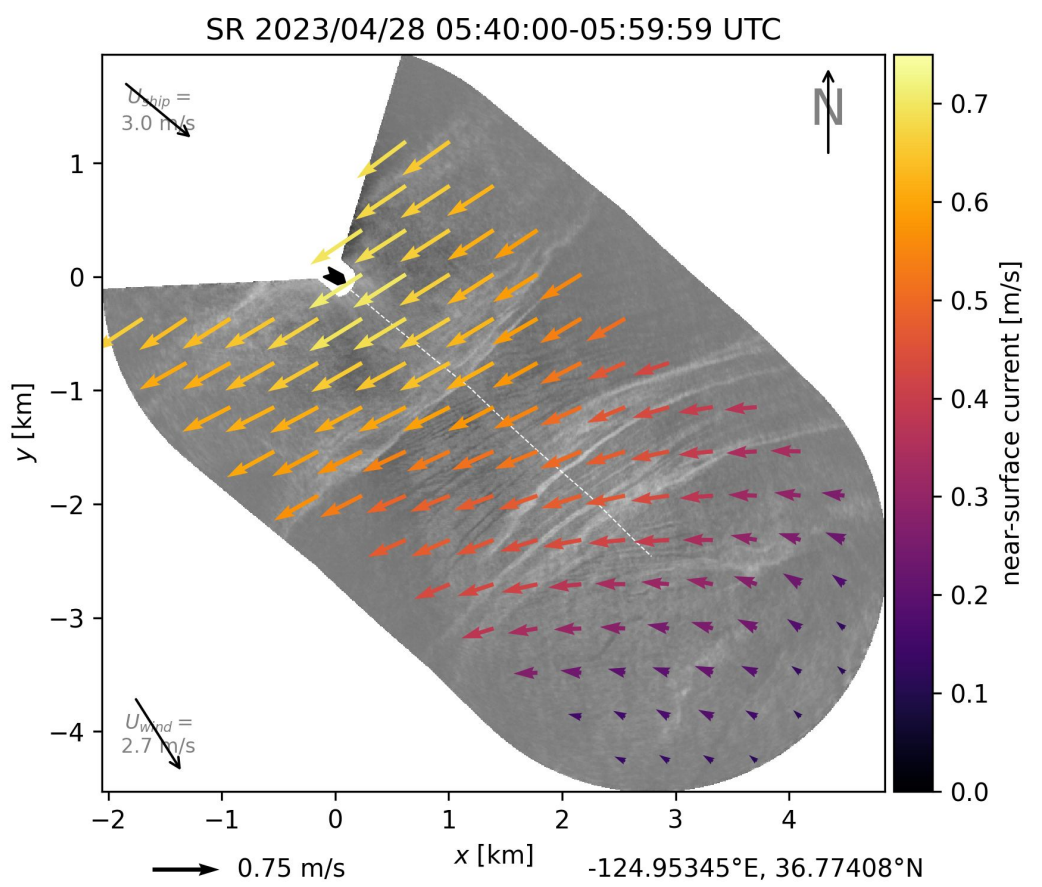
Near-surface current maps

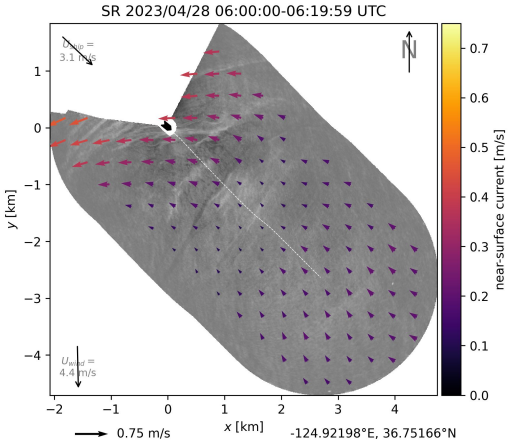
Time series of radar near-surface current maps from R/V Sally Ride (Apr 2023) over radar image mosaics with ship tracks as white dashed lines.

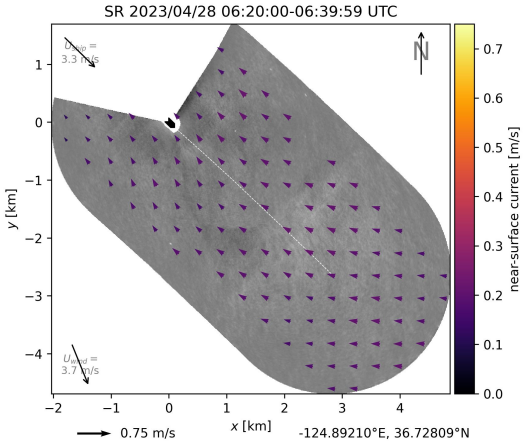
See Lund et al. (2018) for details on the method and a drifter-based validation: https://doi.org/10.1175/JTECH-D-17-0154.1





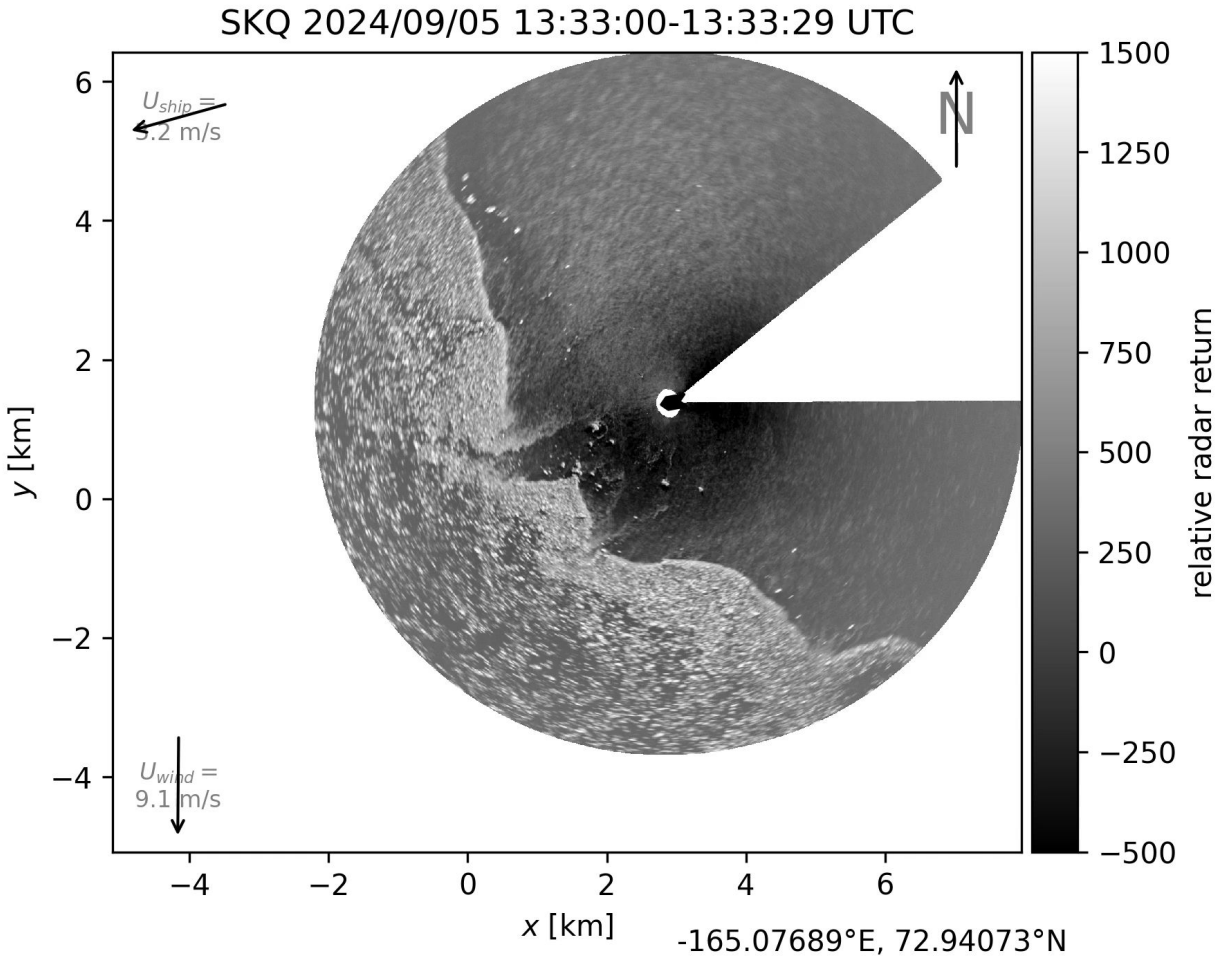




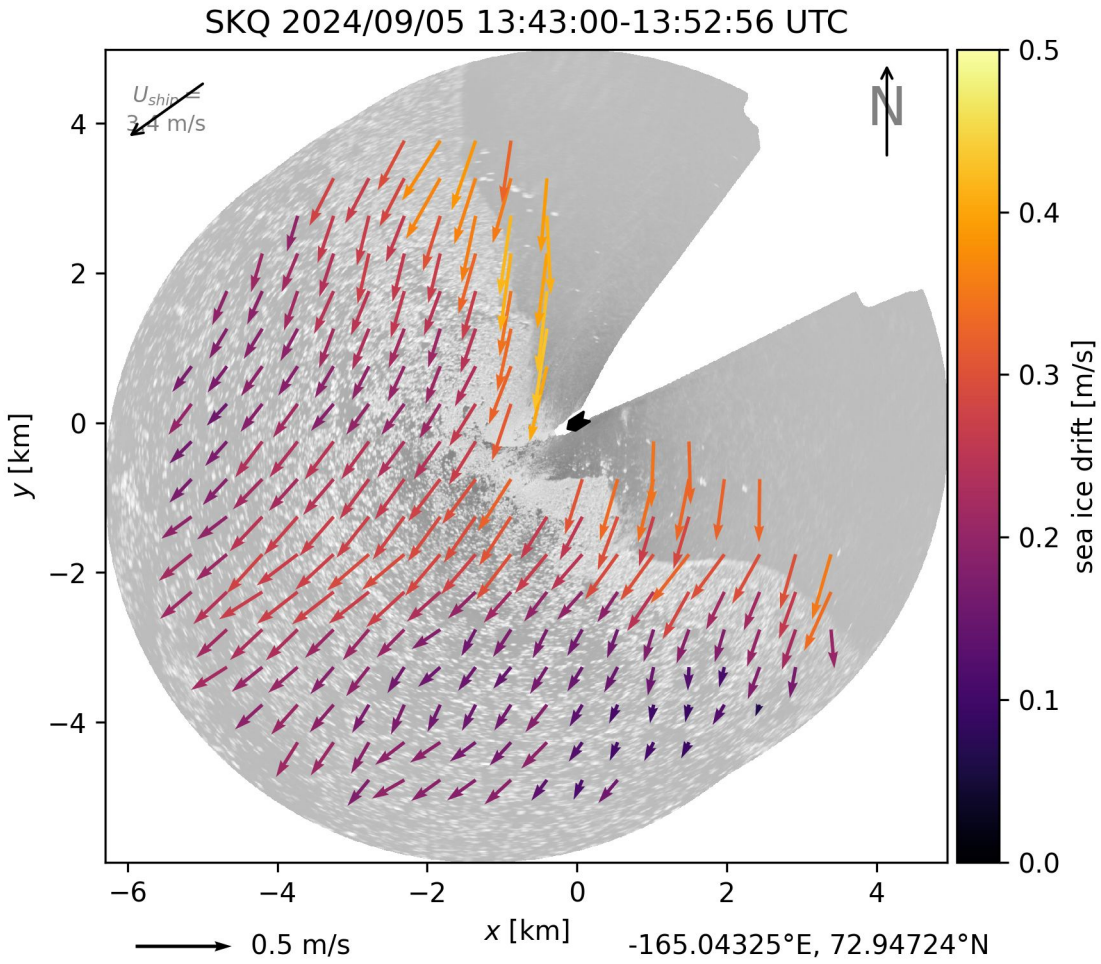


Sea ice drift maps

Movie of 30-s averaged marine X-band radar sea ice images from R/V Sikuliaq.



Corresponding radar-derived sea ice drift maps.



See Lund et al. (2018) for details on the method and a buoy-based validation: https://doi.org/10.1029/2018JC013769

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Control Panel

CSTARS MR Viewer

Controls

Dark Mode: Automatic
Orientation: North Up
Live Tracking
Speed in Knots
Update Rate: 30 sec
Vector Range (m/s): 0 0.5

Data **Map History**
Vessel Info: 10 hr
Sea Roughness:
Current/Sea Ice Vectors:

Data **Graphs History**
Current: 20 min
Sea Ice Drift: 20 min
Waves: 20 min

Info

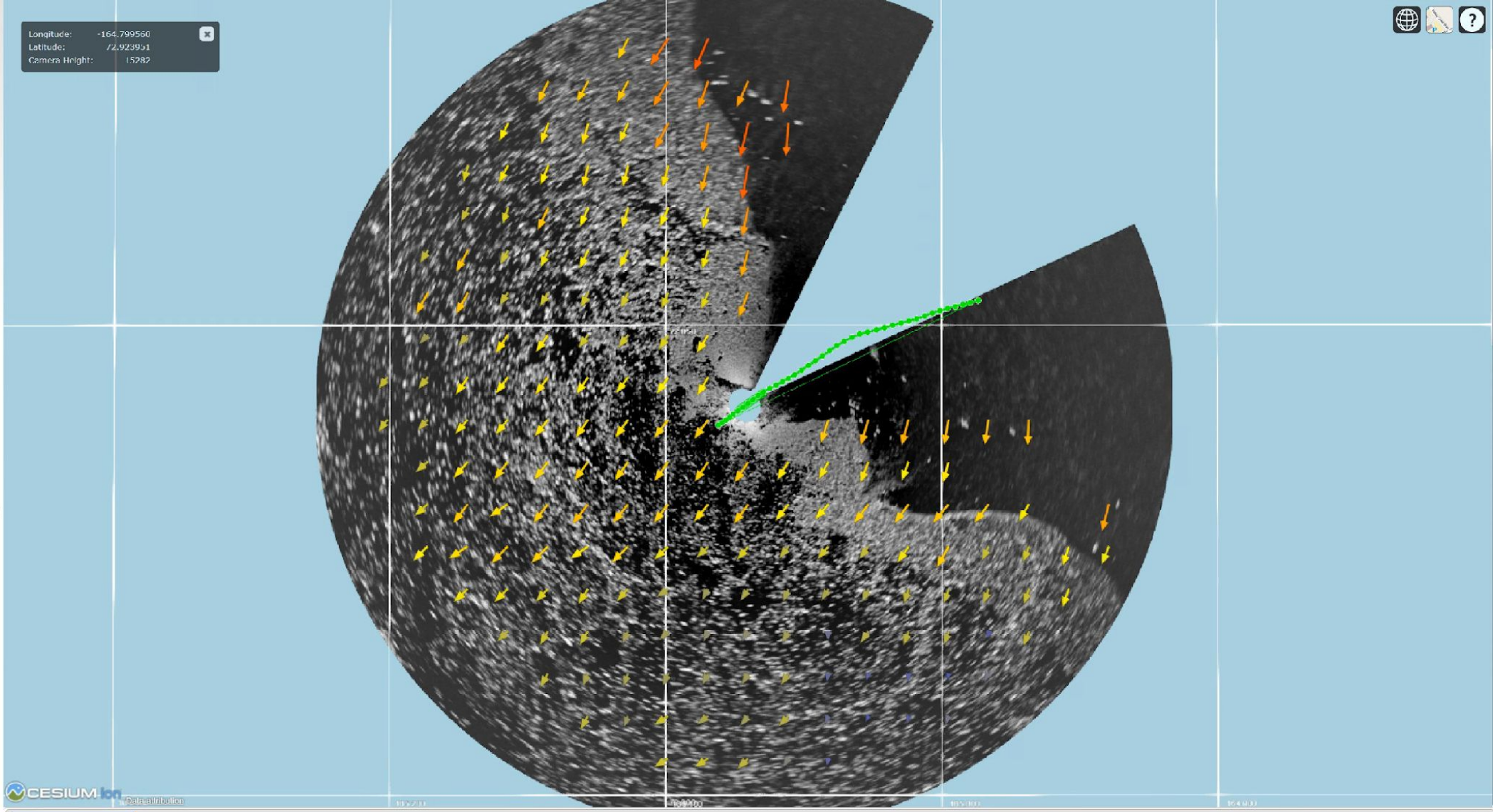
Last Update: 2024-09-05 21:06:01
Location: -165.070170, 72.942205
Bearing: 235.00 degrees
Current: -
Sea Ice Drift: 0.22 m/s, 210.00 degrees
Peak Waves: -

Plots

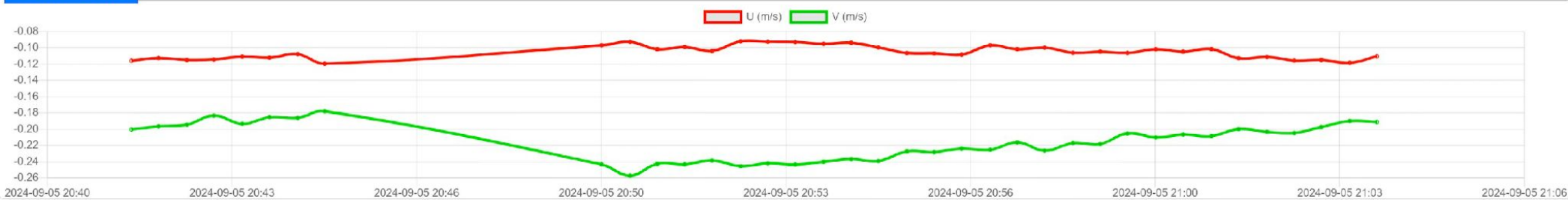
Select data to plot | Pop-out

MarineRadarViewer 2.1.0

Longitude: -164.799560
Latitude: 72.923951
Camera Height: 15282



Sea Ice Drift Graphs



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Dark Mode: Off

Orientation: North Up

Live Tracking ☑

Speed in Knots ☐

Update Rate: 30 sec

Vector Range (m/s): 0 – 0.5

Data — **Map History**

Vessel Info: ☑ 20 min

Sea Roughness: ☑

Current/Sea Ice Vectors: ☑

Data — **Graphs History**

Current: 20 min

Sea Ice Drift: 20 min

Waves: 20 min

Info

Last Update: 2024-10-07 14:32:01

Location: -146.788504, 57.102350

Bearing: 338.00 degrees

Current: 0.24 m/s, 220.93 degrees

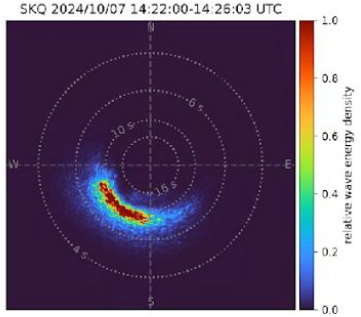
Sea Ice Drift: -

Peak Waves: 214.99 degrees (8.42 s period)

Plots

FTH Spectrum | Pop-out

SKQ 2024/10/07 14:22:00-14:26:03 UTC



MarineRadarViewer 2.1.1

styx.cstars.miami.edu

Longitude: -146.662150
Latitude: 57.124265
Camera Height: 14562

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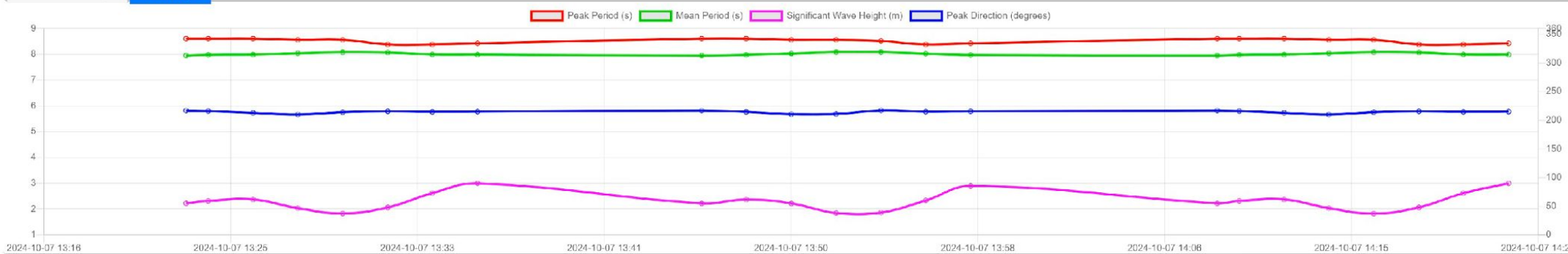
Mean Current Graphs | Wave Graphs



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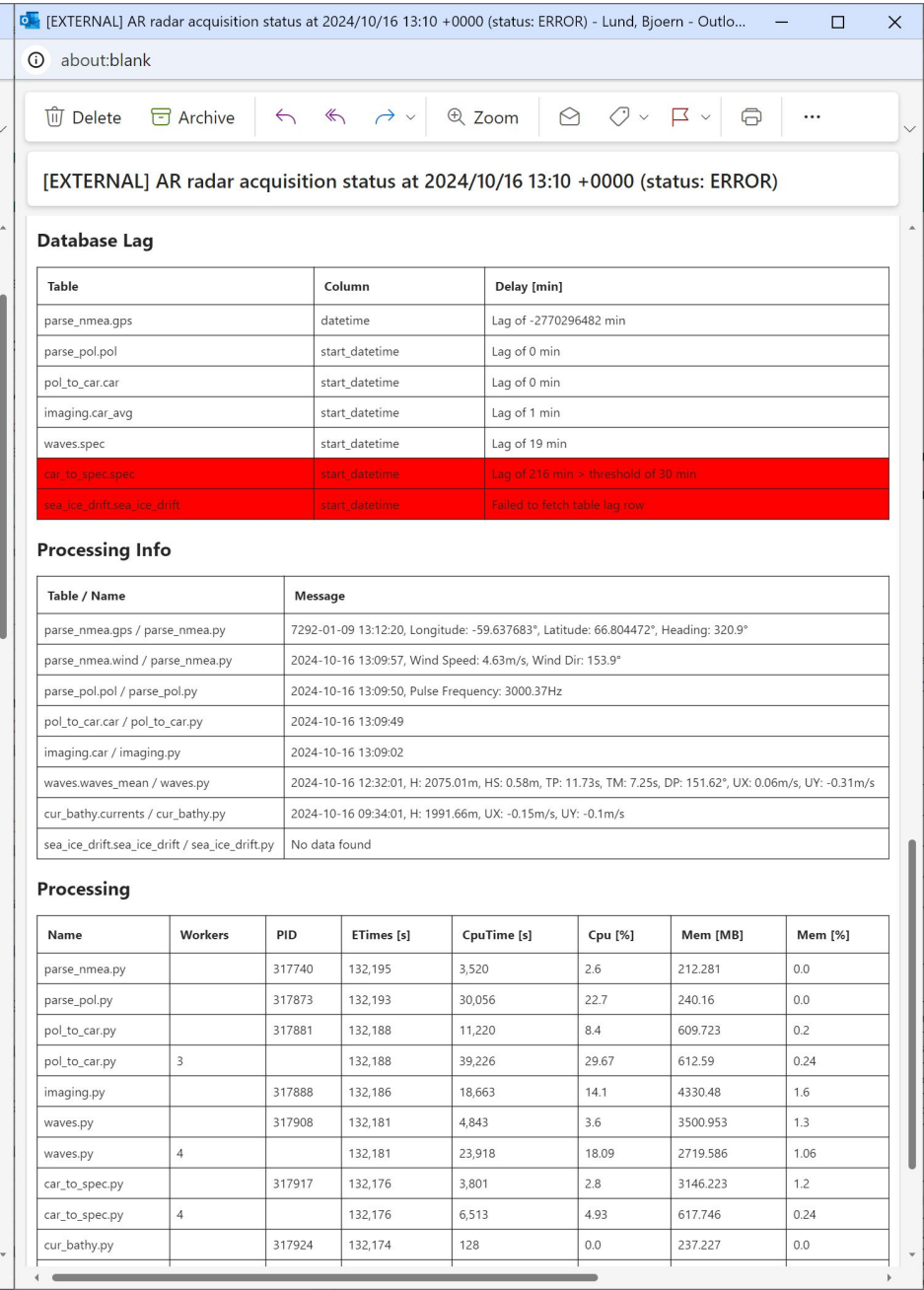
System status monitoring

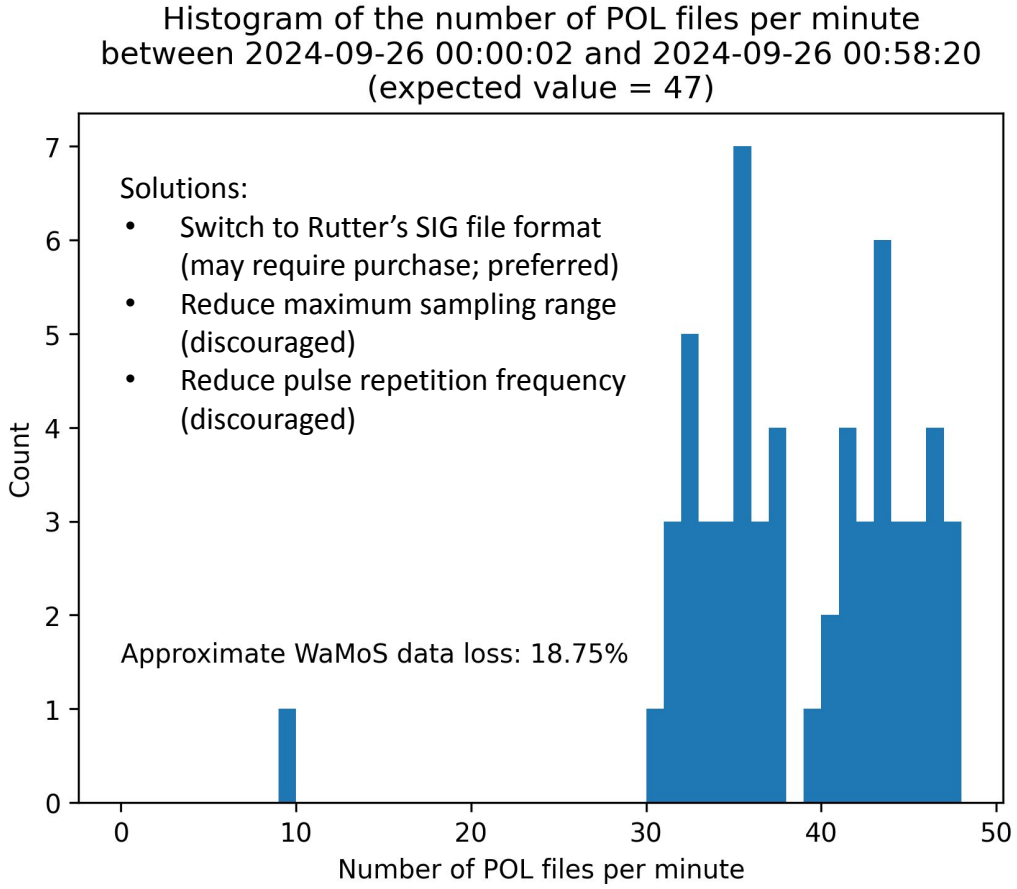
Sample system status emails from R/V Sikuliaq (status “good”) and R/V Neil Armstrong (status “ERROR”).

Remote access allows us to resolve issues when they occur.

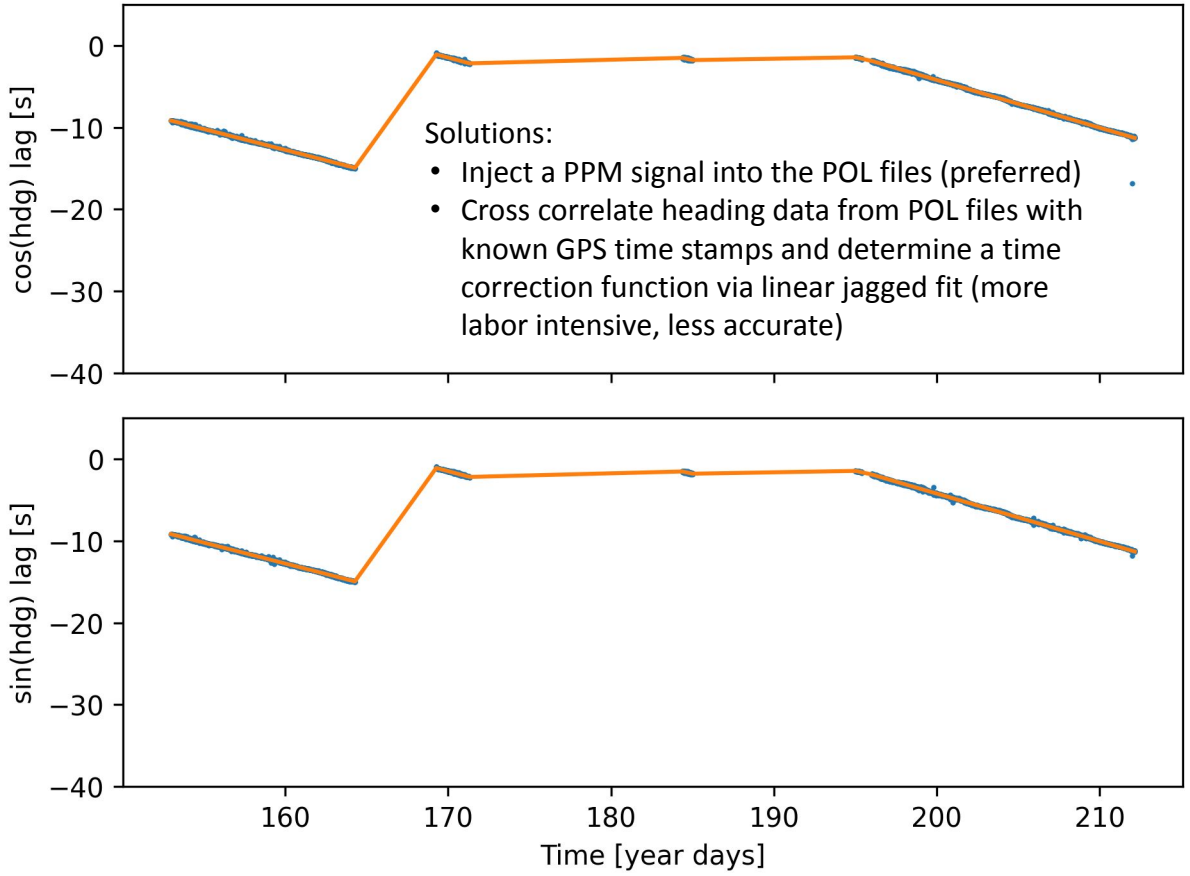


Troubleshooting fleetwide WaMoS issues

Frequent radar raw data (POL file) loss at irregular intervals



Drifting radar raw data (POL file) time stamps despite NTP synchronization



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Radar product sharing and raw data archiving

- Marine X-band radar data volumes (assuming 250 sea days/year):
  - Radar products on R/V Sikuliaq: ~12 GB/day, ~3 TB/year.
  - Radar products on R/V Neil Armstrong ~20 GB/day, ~5 TB/year.
  - WaMoS radar raw data on R/V Sikuliaq: ~450 GB/day, ~113 TB/year.
  - Hereon radar raw data on R/V Neil Armstrong: ~530 GB/day or ~133 TB/year.
- Radar products:
  - Will be stored in NetCDF format following the Climate and Forecast (CF) metadata conventions.
  - Will be included in the cruise data set & added to the R2R catalog.
  - More than 90% of the data volume is due to roughness images; it can be reduced by lowering their update rate or storing mosaics only.
- Radar raw data:
  - Radar raw data are archived using pairs of Synology NAS servers with ~96 TB capacity per unit.
  - Shipboard technicians swap Synology when full and ship to CSTARS where we archive the radar raw data to tape.
  - We are exploring options for a public long-term radar raw data archive using the WMO CF Radial standard.

X-band radar program's timeline (abridged)

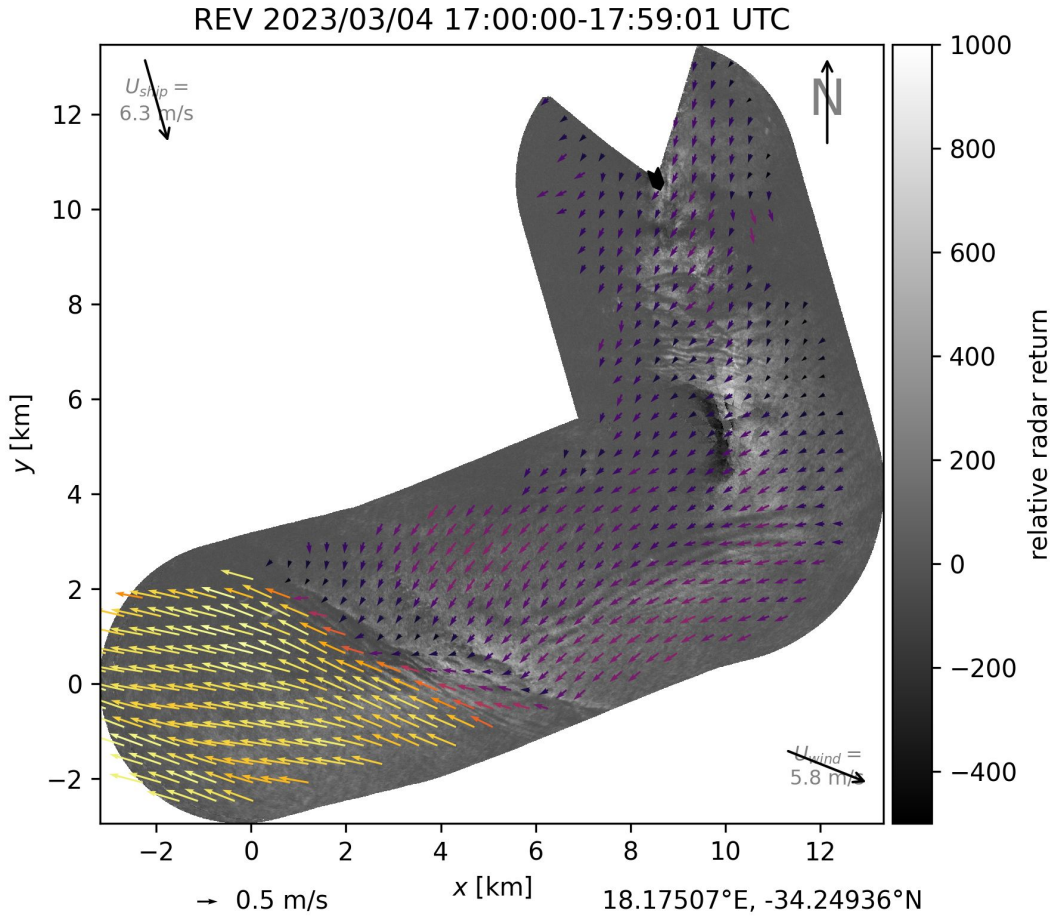
- PY1 (Sep 2023 – Aug 2024):
  - Upgraded Hereon radar input card & radar motor on R/V Neil Armstrong.
  - Installed new radar processing & storage servers on R/Vs Sikuliaq & Neil Armstrong.
  - Calibrated radars in terms of azimuth/range/time offsets and significant wave height.
  - Continuously updated our radar processing software & added a fully operational sea ice drift mapping program.
  - Started archiving radar raw data from R/Vs Sikuliaq & Neil Armstrong at CSTARS.
- PY2 (Sep 2024 – Aug 2025):
  - Add radar products to cruise data set and R2R catalog.
  - Develop documentation and open-source software to ease radar data access.
- PY3 (Sep 2025 – Aug 2026):
  - Extend radar support to other radar-equipped research vessels.
  - Identify long-term archive for radar raw data.

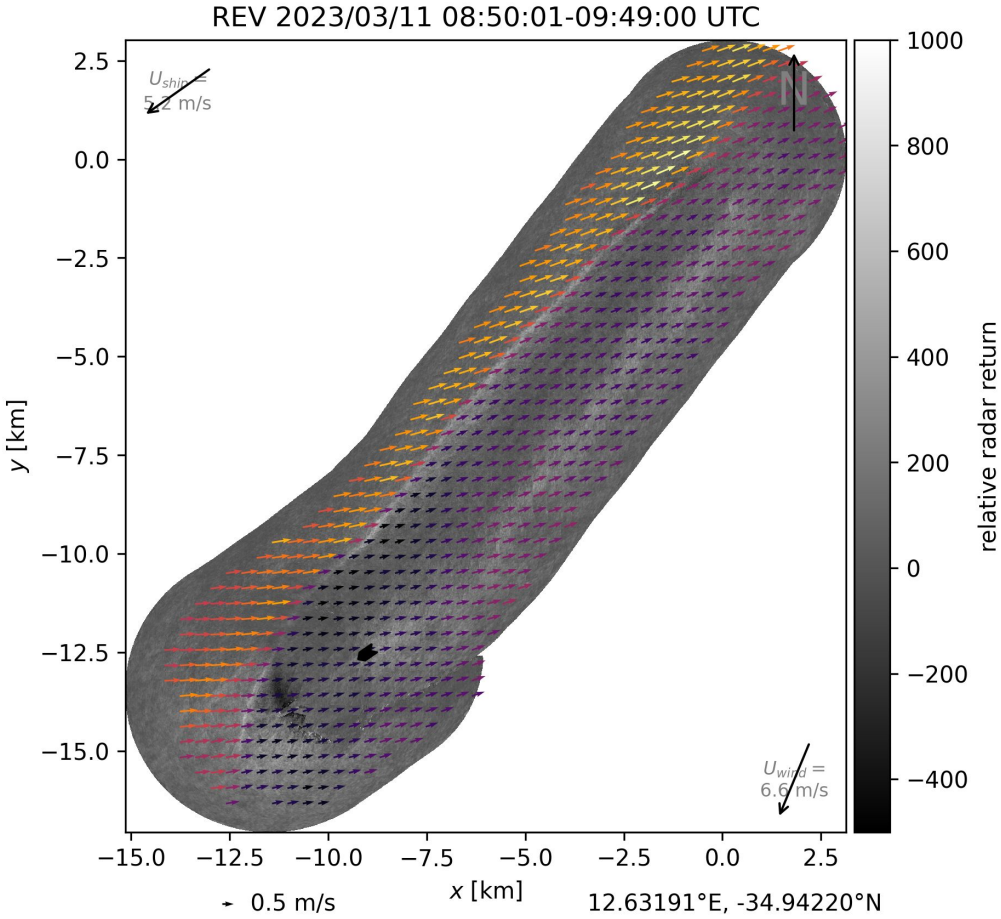
Best practices & questions

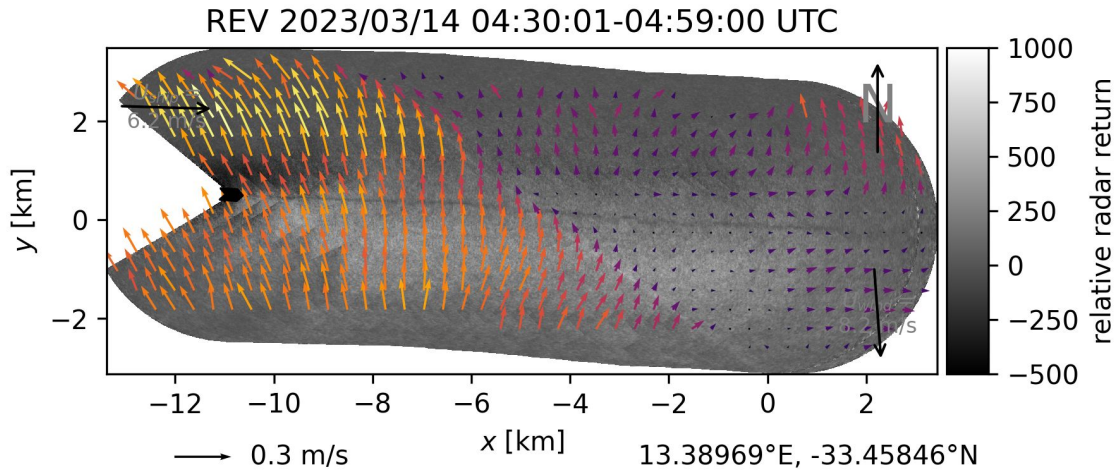
- Record GPS and accurate heading data at high temporal resolution (>1 Hz) via serial feed.
- Enable regular radar calibrations by recording radar raw data while departing from and returning to port.
- Synchronize the radar acquisition server with the ship's time server.
- **Interested in enhancing your shipboard X-band radar's capabilities?**
- **Have suggestions for big data storage, transfer, & public archiving?**
- **Contact** marineradar@cstars.miami.edu **or** blund@cstars.miami.edu**.**

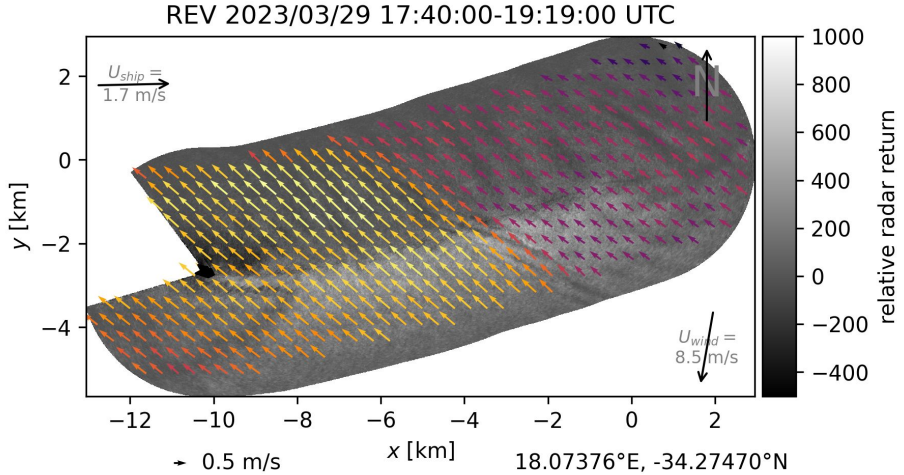
Near-surface current maps

Sample radar near-surface current maps from R/V Roger Revelle (Mar 2023) over radar image mosaics.









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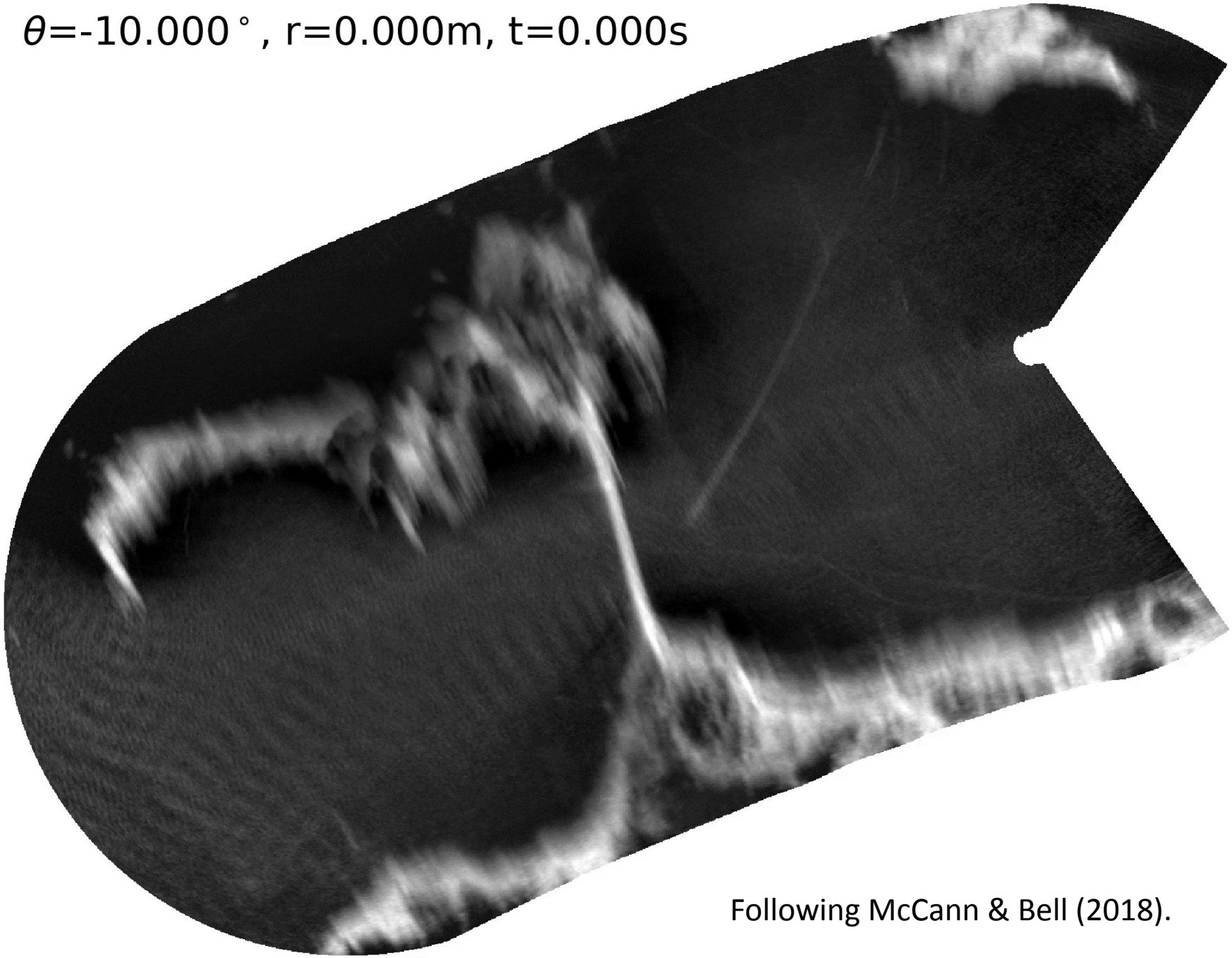

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