

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

- Provide vessels with radar processing & storage servers and software.
- Calibrate radars' heading/range/time biases and significant wave height.
- CSTARS radar processing system collects radar raw & ancillary data to produce:
 - Sea surface (and sea ice) mean roughness images,
 - Near-surface current maps,
 - Wave measurements,
 - Sea ice drift maps, ...
- 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.

AR 2025-10-01 07:41:36 - 07:51:23 UTC
azimuth = 0.205°, range = 22.484 m, time = 0.054 s

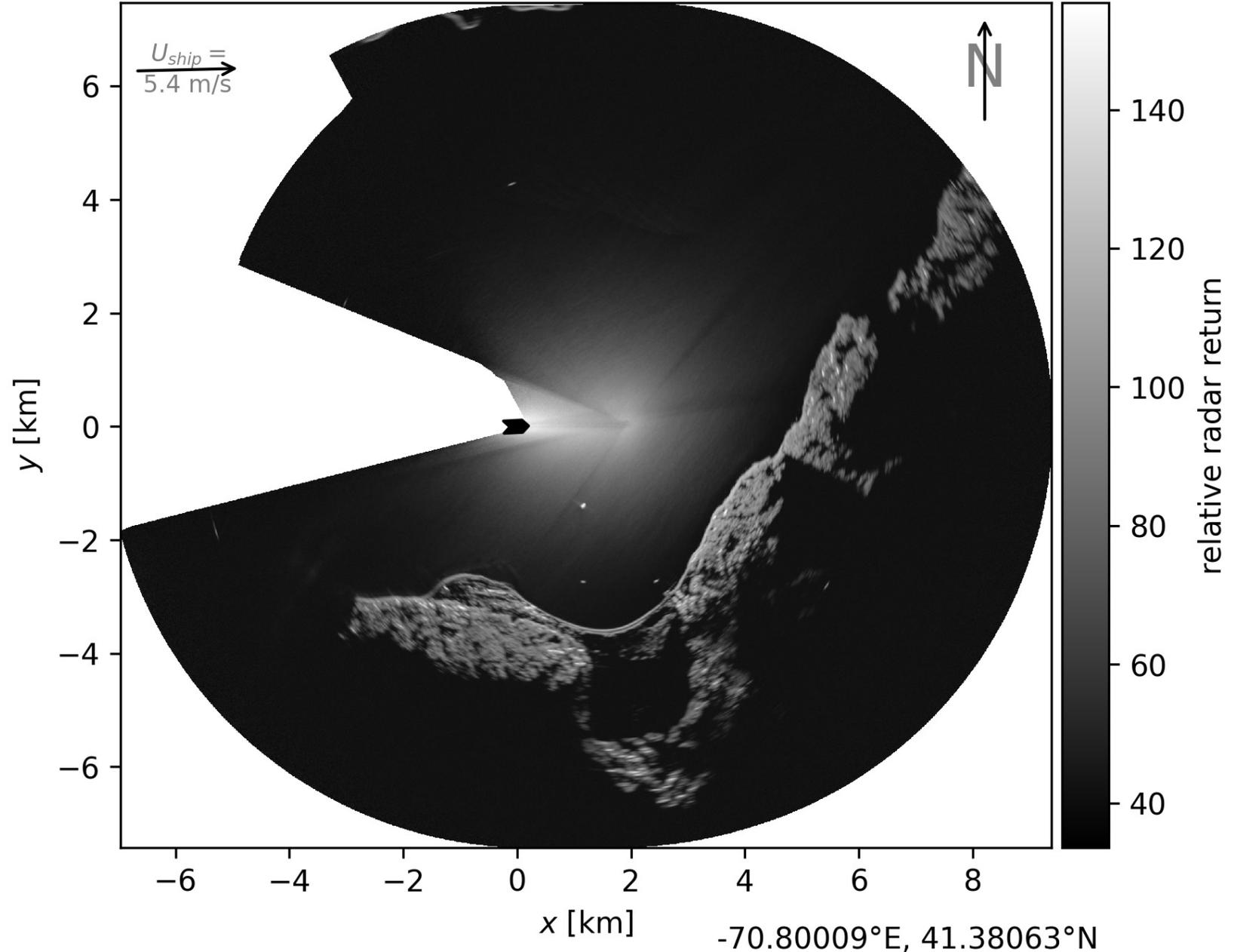
Radar calibration

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).



AR 2025-10-18 13:44:31 - 13:54:25 UTC
azimuth = 0.177°, range = 22.484 m, time = 0.007 s

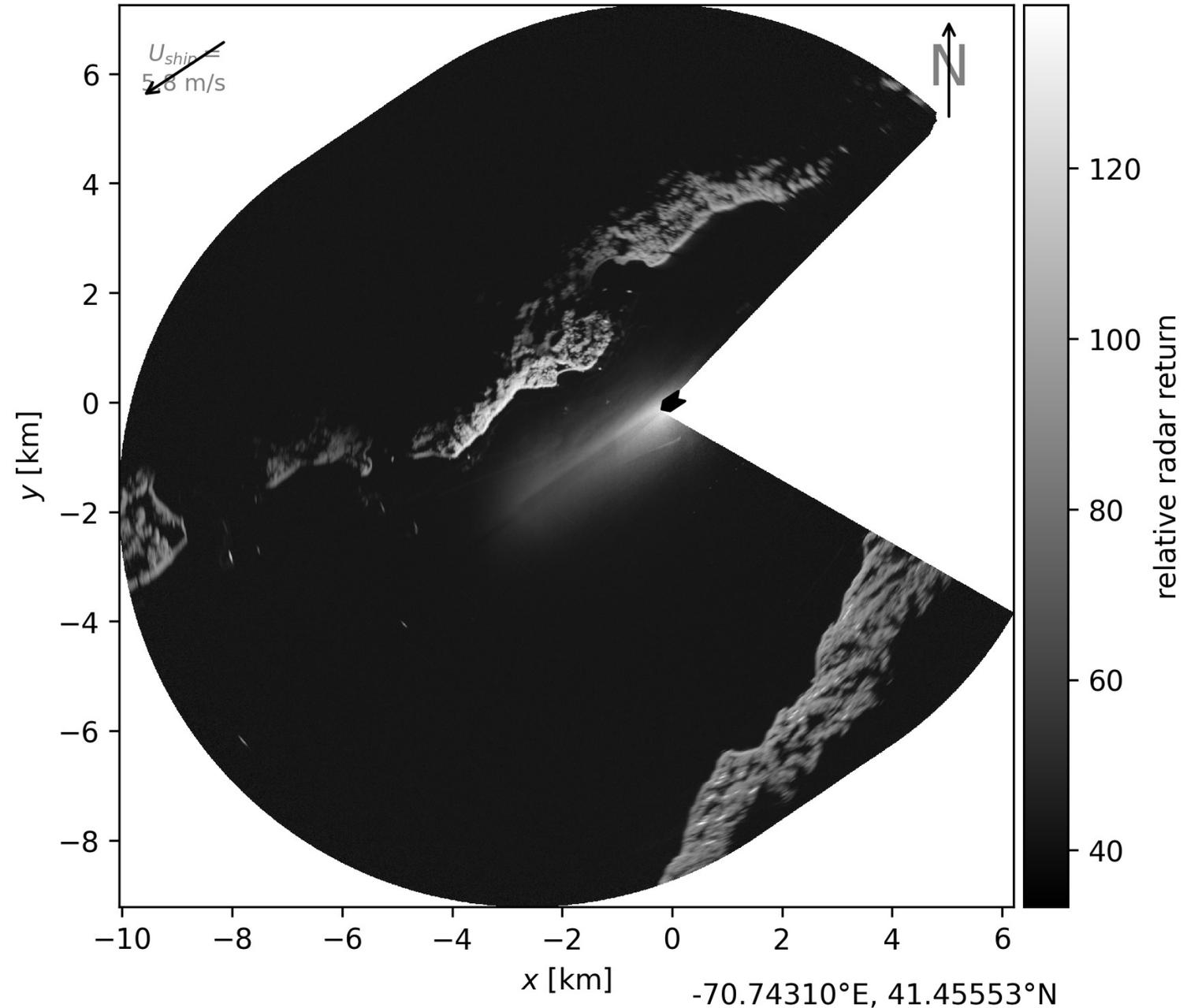
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Significant wave height calibration

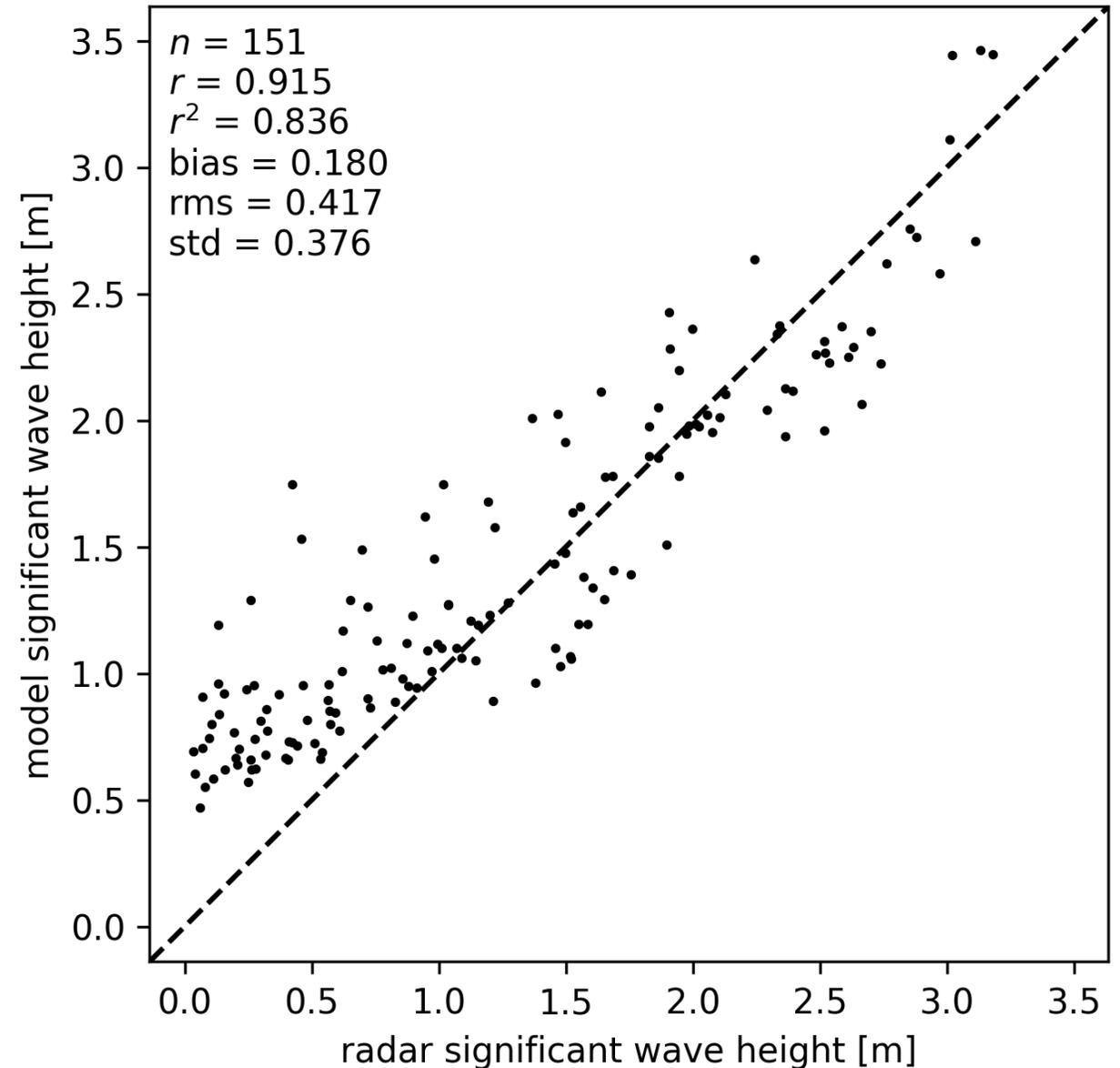
Marine X-band radar significant wave height measurements must be calibrated.

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.

R/V Sikuliaq, 2025-07-29 -> 2025-09-05



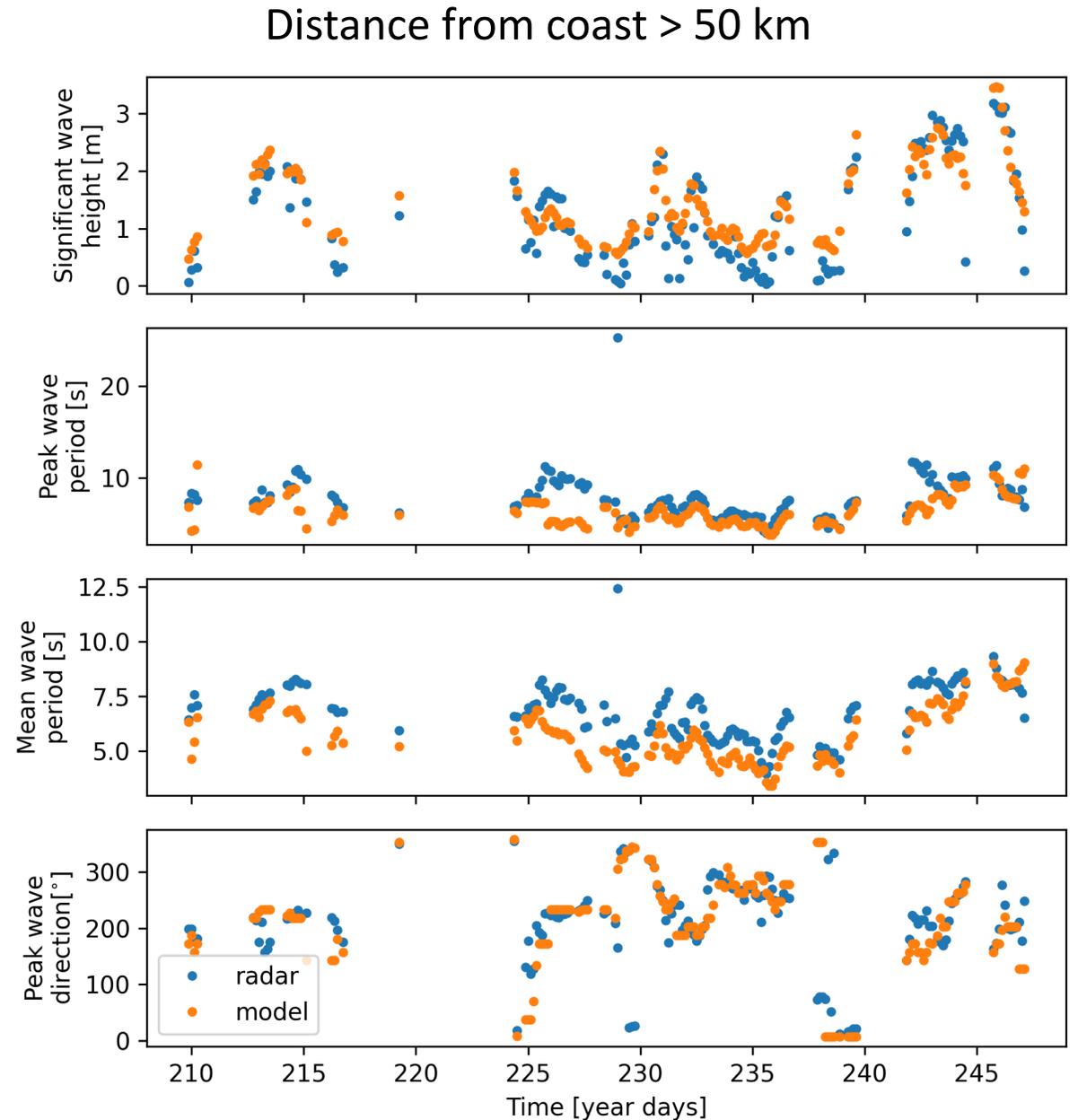
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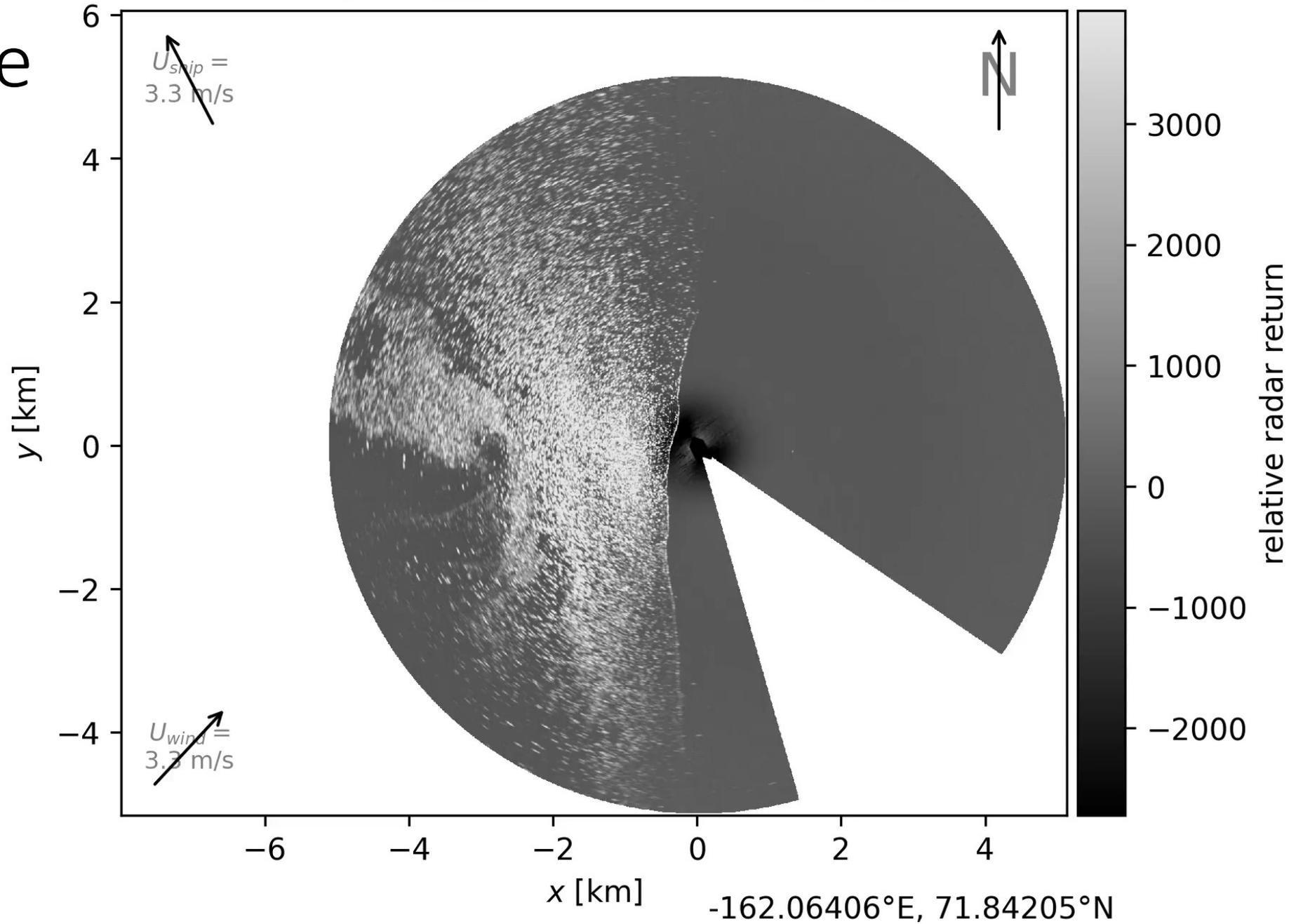
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SKQ 2025/08/23 12:00:00.328 UTC

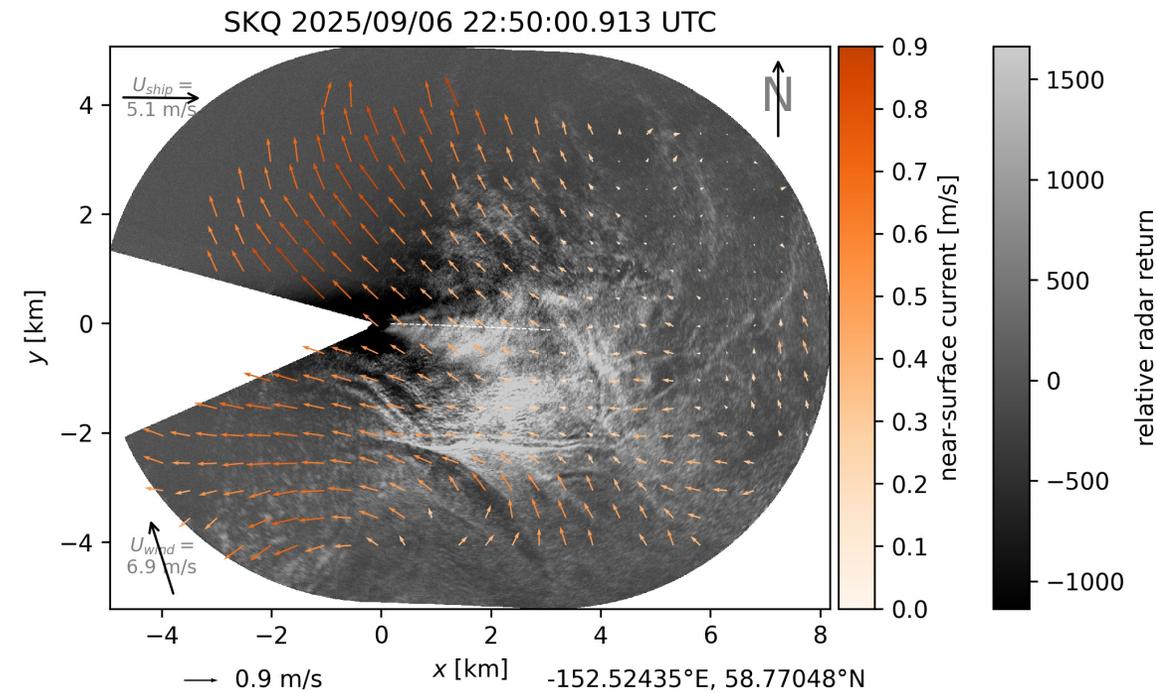
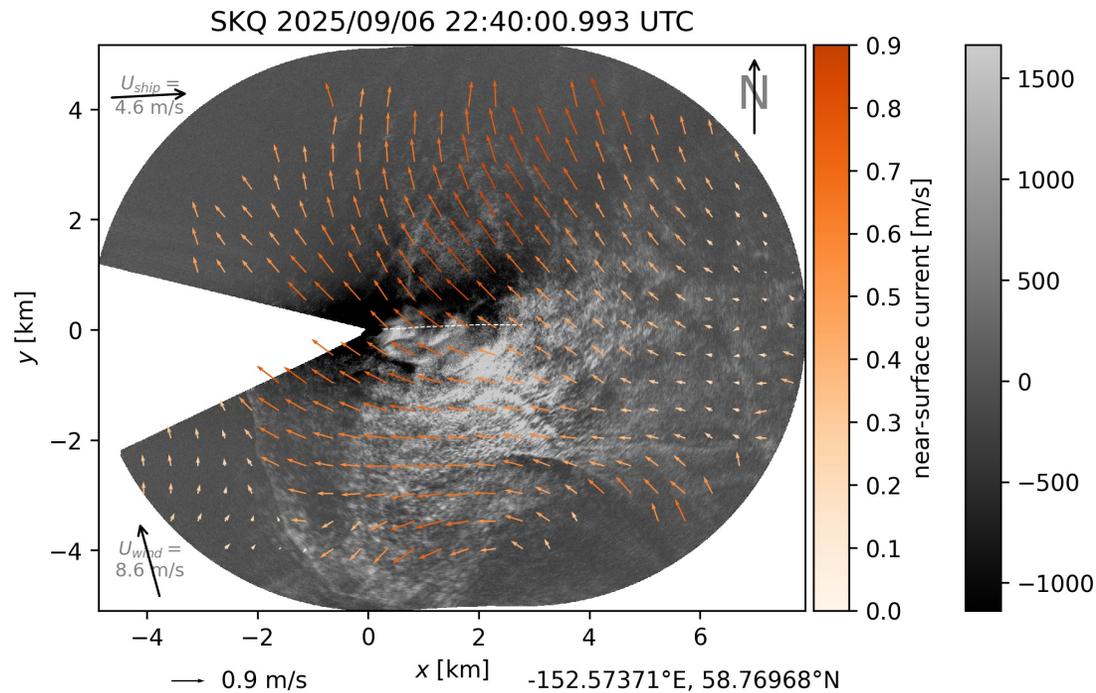
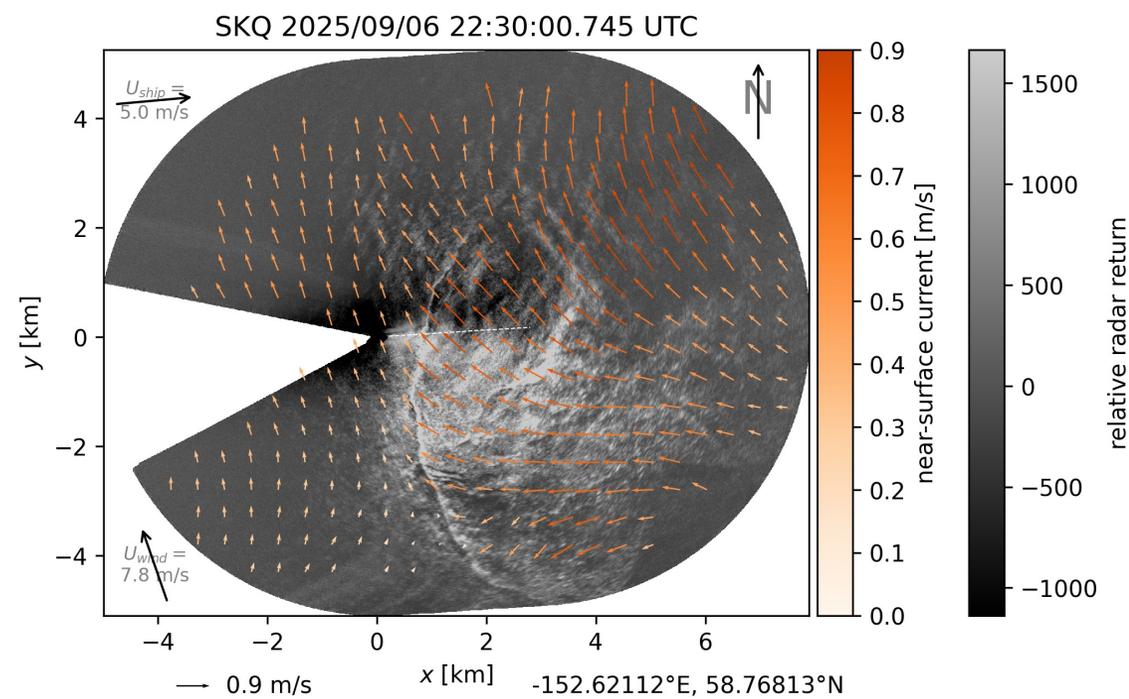
Sea surface roughness images

30-s averaged radar images from R/V Sikuliaq (23 August 2025) with sea ice and open water



Near-surface current maps & radar image mosaics

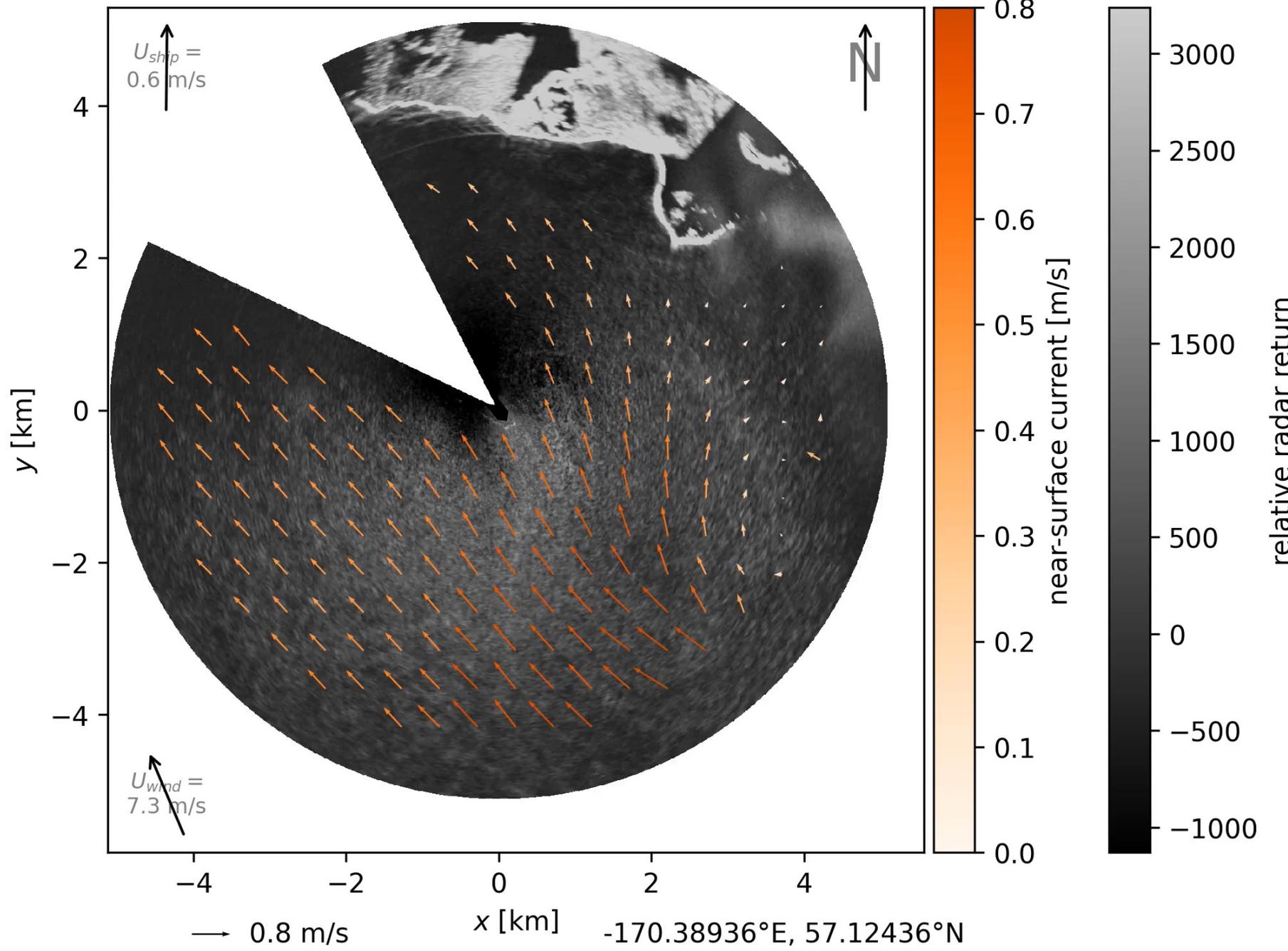
Time series of radar near-surface current maps from R/V Sikuliaq (6 Sep 2025) over radar image mosaics with ship tracks as white dashed lines



SKQ 2025/08/02 18:00:01.149 UTC

Near-surface current maps

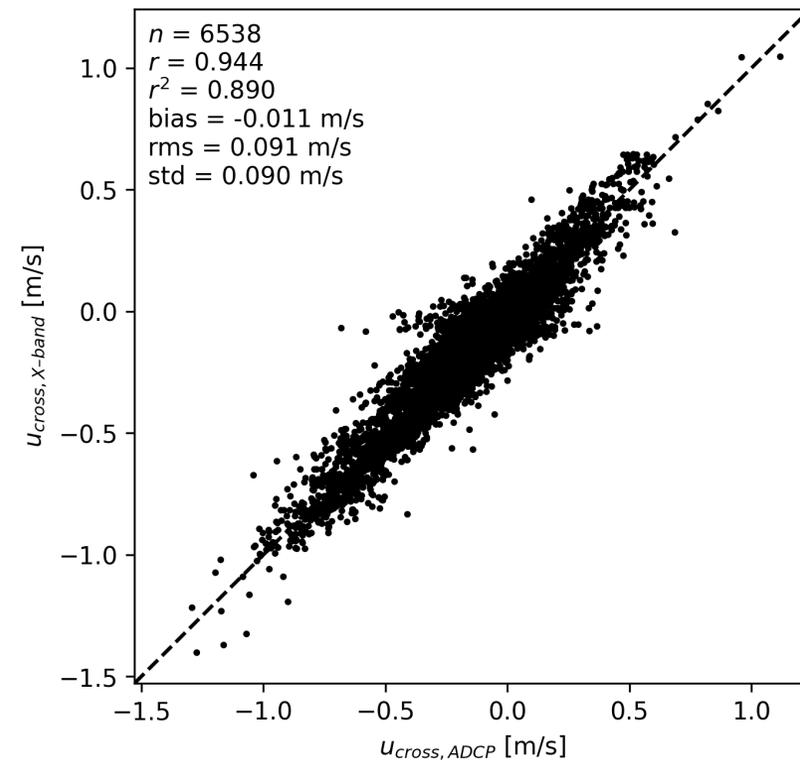
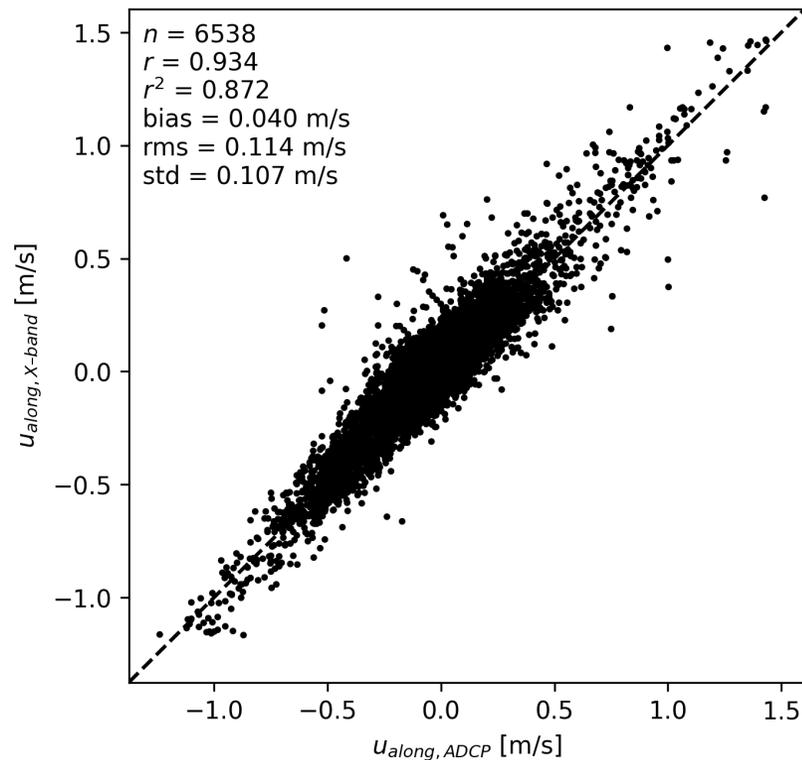
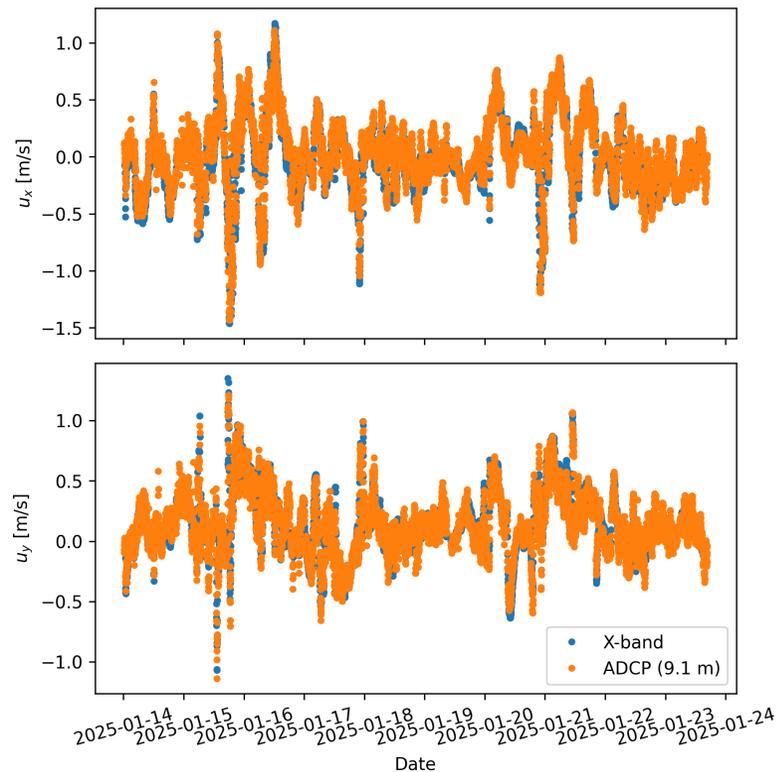
Near-surface current maps from R/V Sikuliaq (2 August 2025) over 30-s averaged radar images with current fronts and small-scale eddy



Near-surface current maps

Comparison between radar near-surface currents (1-4 m effective depth) and WH300 ADCP currents (9.1 m) by UHDAS from R/V Thomas G. Thompson (14-24 January 2025); due to vertical shear the radar currents have a 4 cm/s bias in the along-wind direction

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>

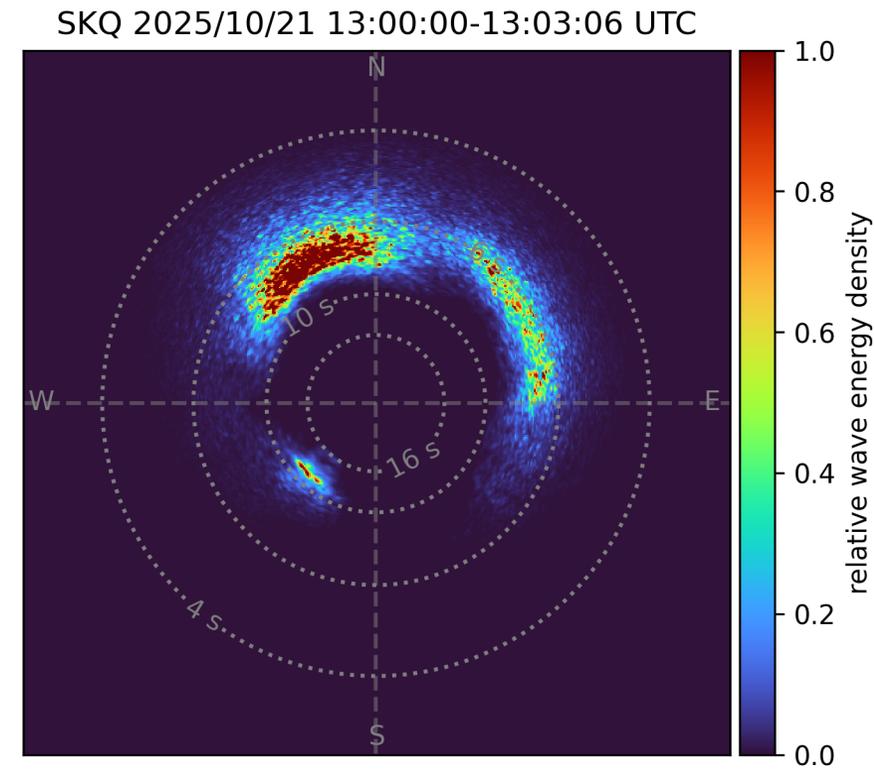
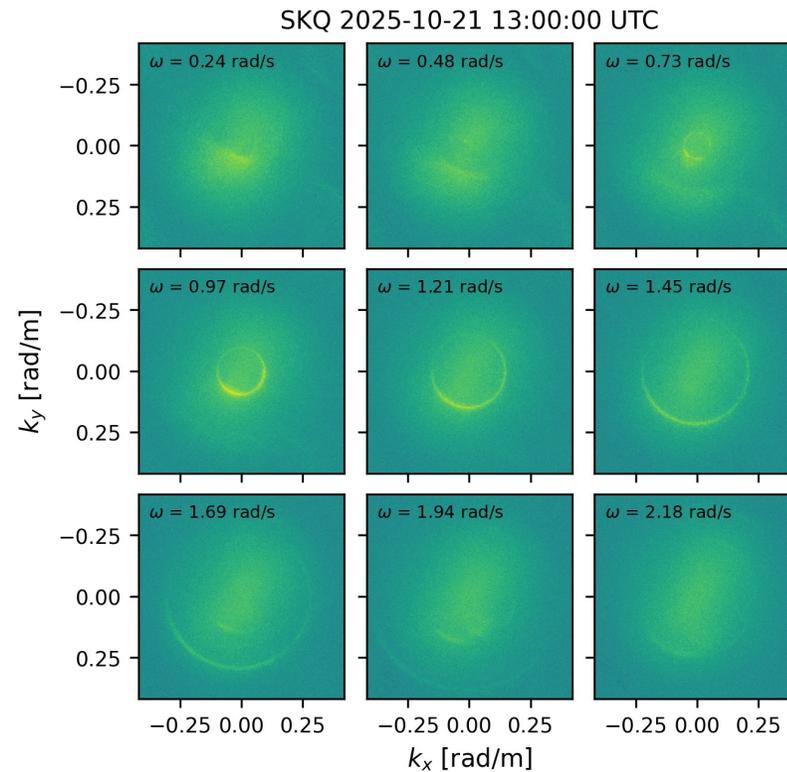
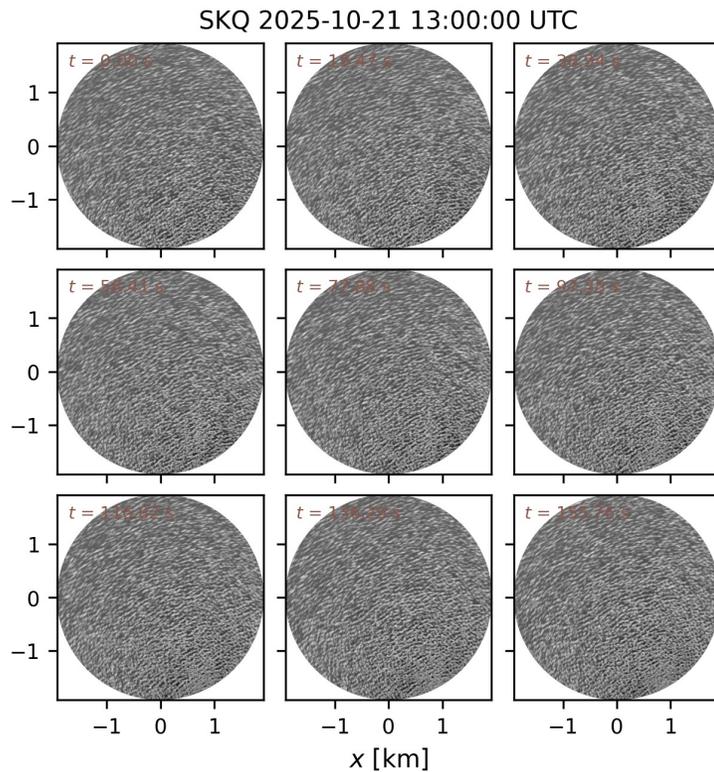


Wave measurements

Sequence of radar images within a circular analysis window from R/V Sikuliaq (21 October 2025).

Corresponding wavenumber frequency spectrum with prominent wave signal.

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



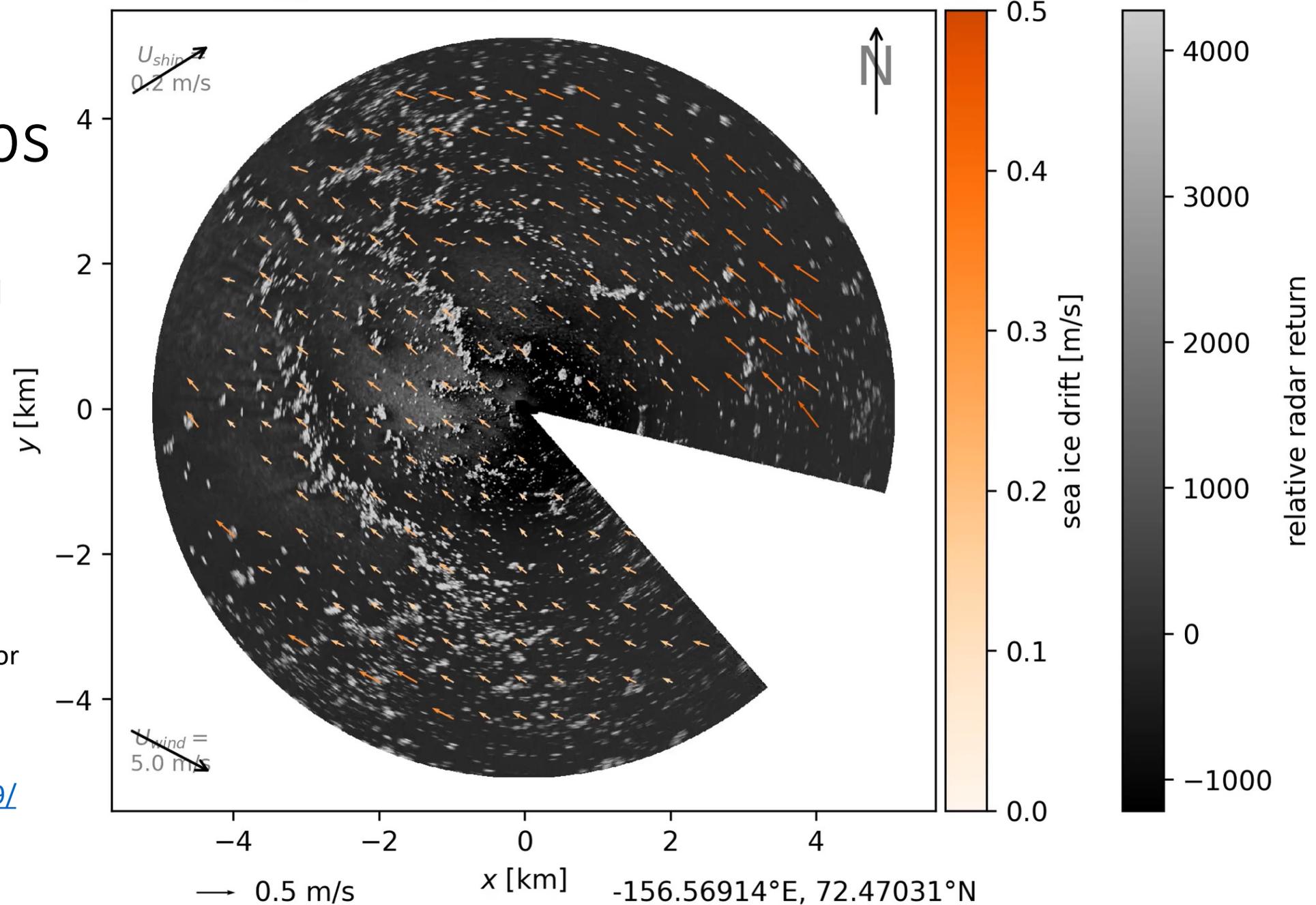
SKQ 2025/08/24 13:40:00.416 UTC

Sea ice drift maps

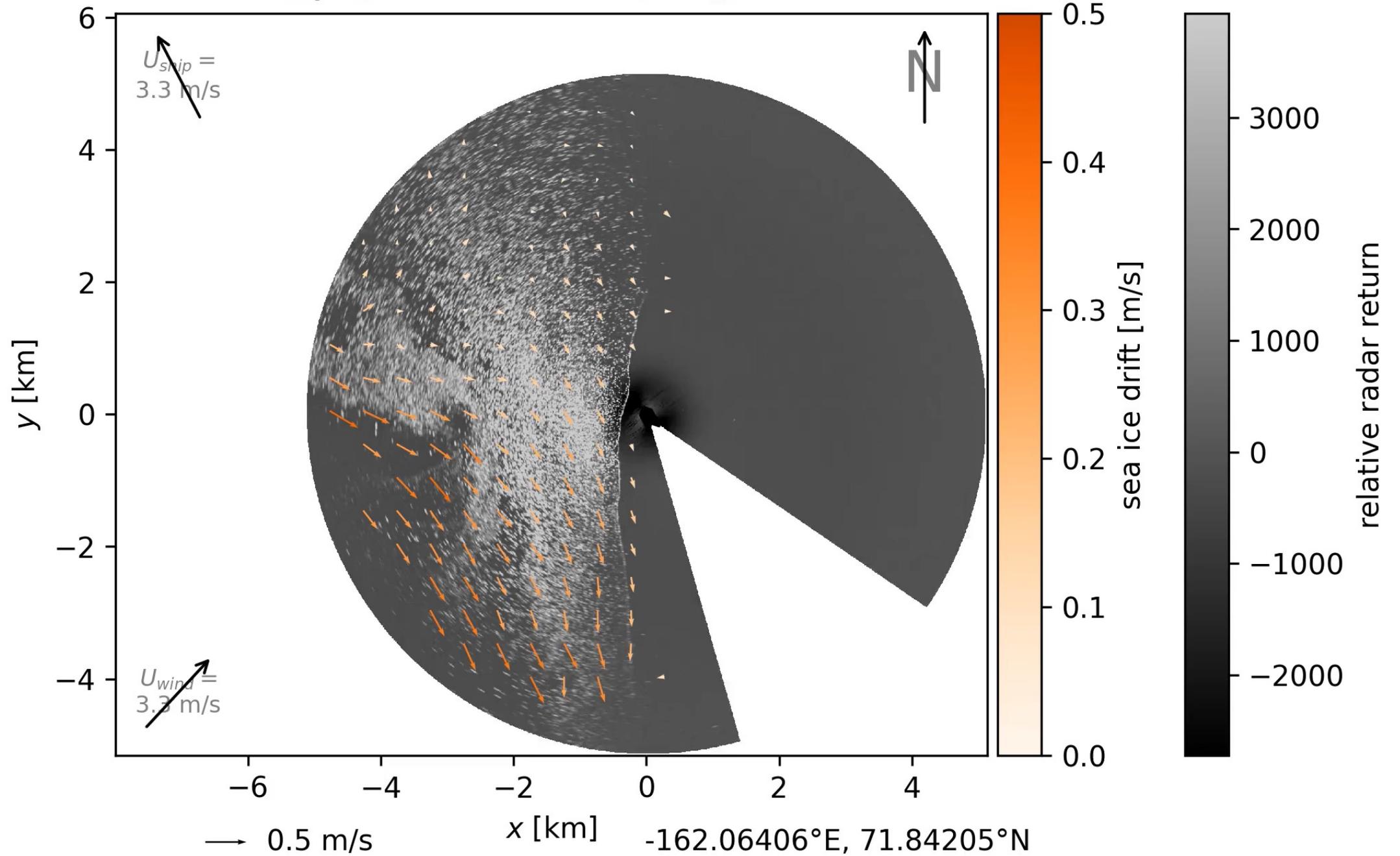
Sea ice drift maps over 30-s averaged radar images from R/V Sikuliaq (24 August 2025)

See Lund et al. (2018) for details on the method and a buoy-based validation:

<https://doi.org/10.1029/2018JC013769>



SKQ 2025/08/23 12:00:00.328 UTC



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Controls

Dark Mode: Off

Orientation: North Up

Live Tracking

Speed in Knots

Slider start: 10/18/2025

Slider end: 10/28/2025

Vector Range (m/s):

Data **Map History**

Vessel Info: 10 hr

Sea Roughness:

Current/Sea Ice Vectors:

Data **Graphs History**

Current: 6 hr

Sea Ice Drift: 6 hr

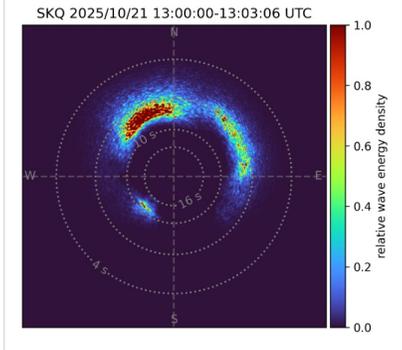
Waves: 6 hr

Info

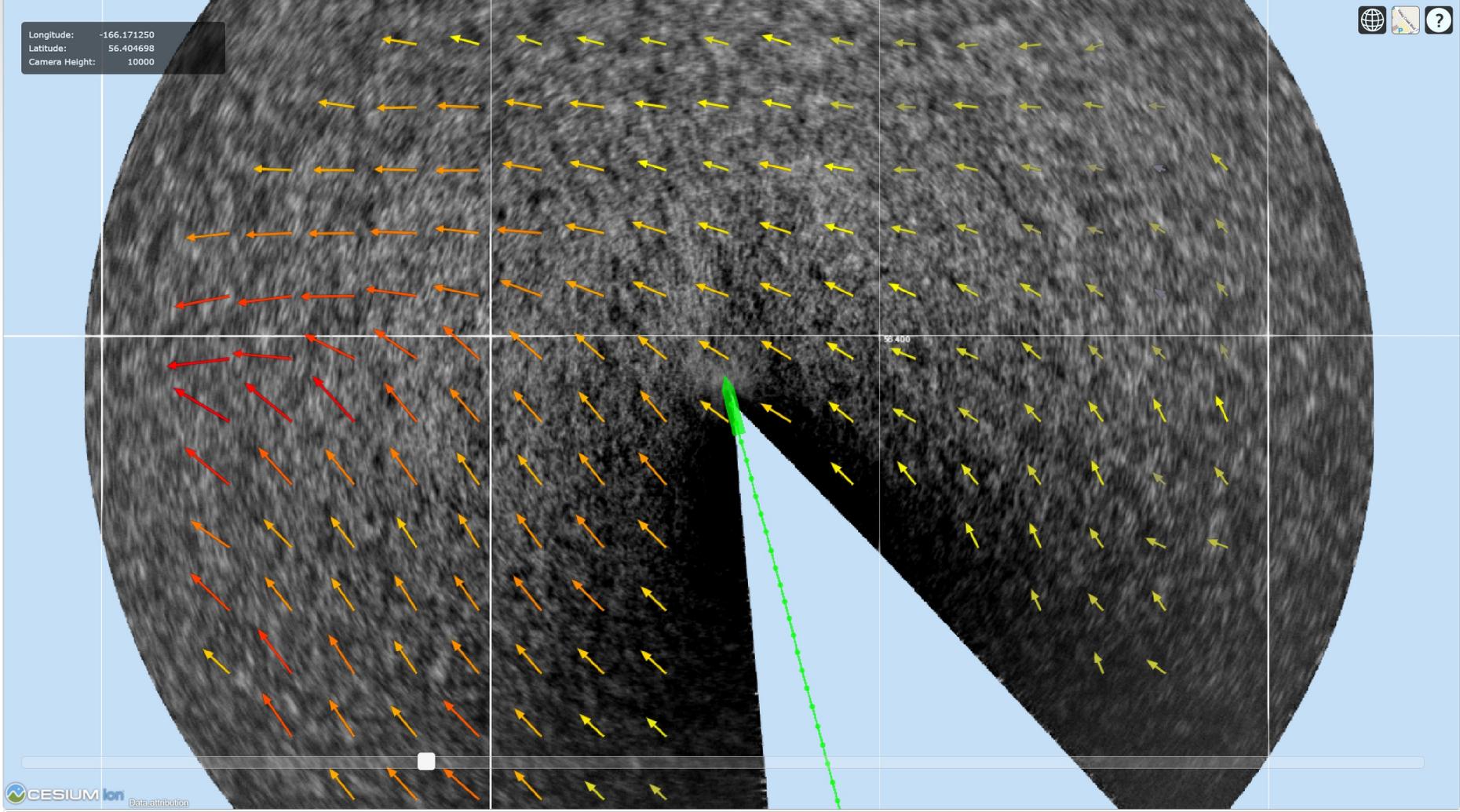
Last Update: 2025-10-21 13:01:30.2600
Location: 166.118997 W, 56.395254 N
Vessel: 5.12 m/s, 346.00 deg
Current: 0.11 m/s, 300.91 deg
Sea Ice Drift: N/A
Peak Waves: 6.98 s, 348.48 deg
Wave Height: 2.15 m

Plots

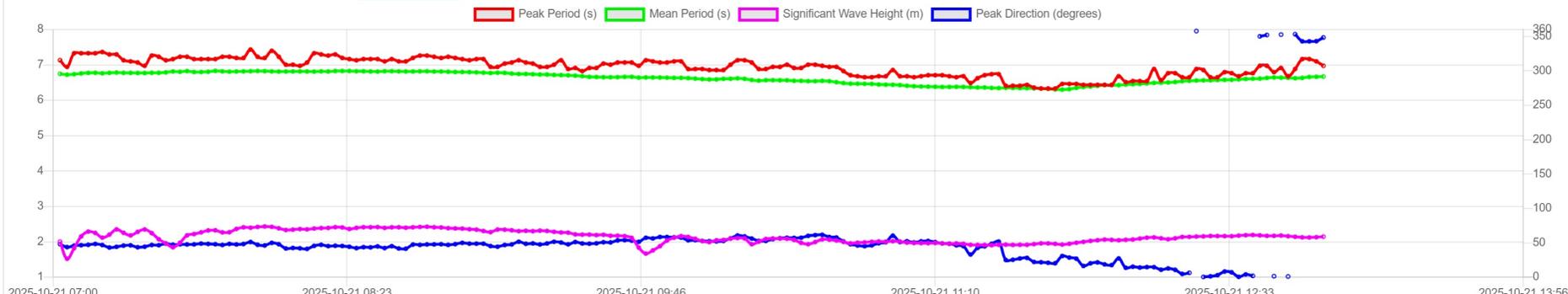
Wave energy frequency spectrum



MarineRadarViewer 2.1.9



Wave Graphs



Controls

Dark Mode:

Orientation:

Live Tracking

Speed in Knots

Slider start:

Slider end:

Vector Range (m/s):

Data **Map History**

Vessel Info:

Sea Roughness:

Current/Sea Ice Vectors:

Data **Graphs History**

Current:

Sea Ice Drift:

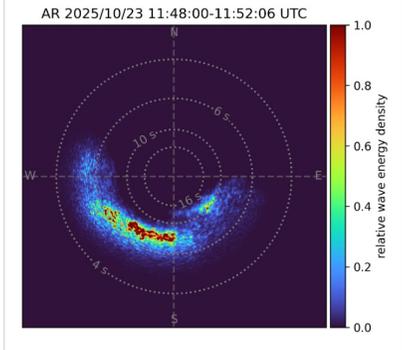
Waves:

Info

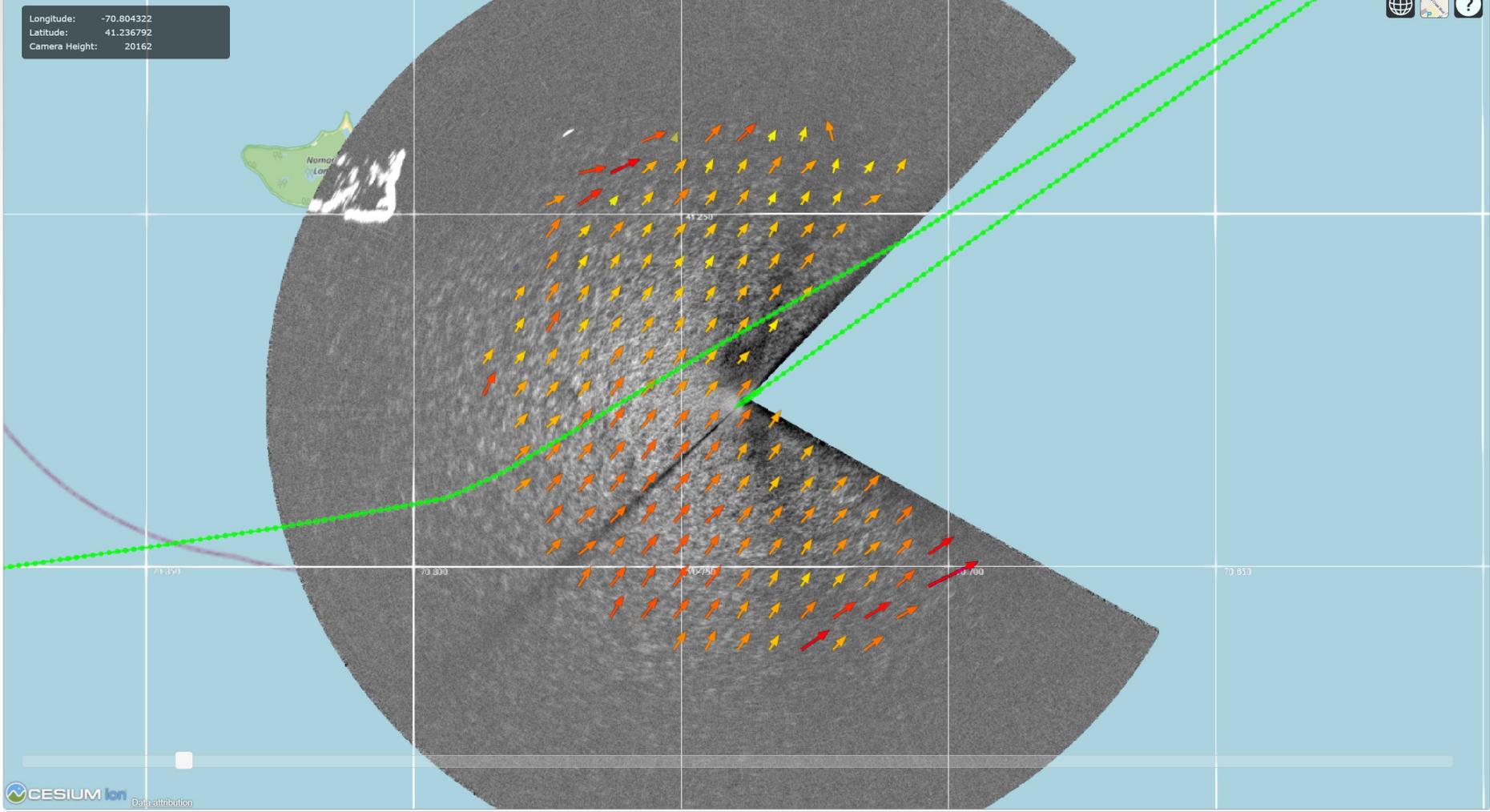
Last Update: 2025-10-23 11:49:30.3300
Location: 70.737699 W, 41.223989 N
Vessel: 4.60 m/s, 235.00 deg
Current: 0.13 m/s, 41.45 deg
Sea Ice Drift: N/A
Peak Waves: 7.37 s, 203.07 deg
Wave Height: 1.06 m

Plots

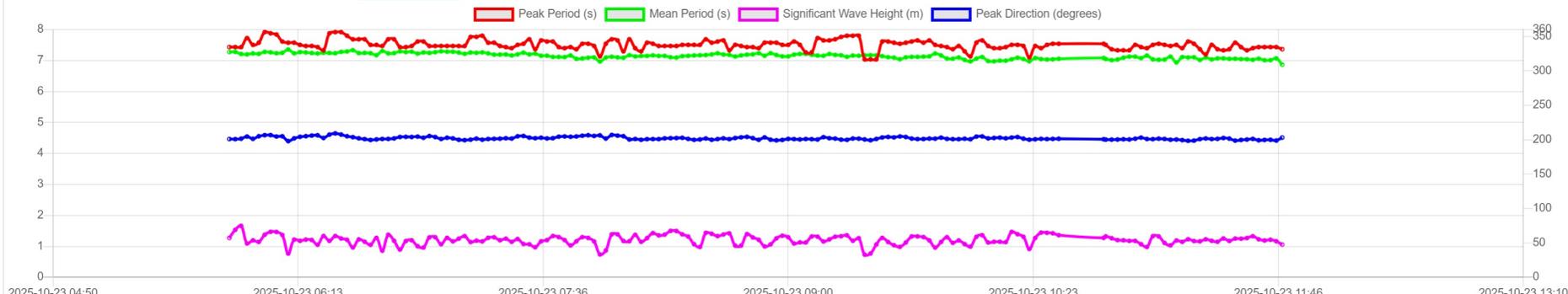
Wave energy frequency spectrum



MarineRadarViewer 2.1.9



Wave Graphs



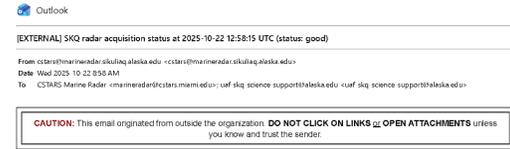
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System status monitoring

Sample system status email from R/V Sikuliaq (status “good”).

Remote access allows us to resolve issues when they occur.



Marine Radar Viewer Status - 2025-10-22 12:58:15 UTC

Position

Path	File	Message
/data/raw/serial/seapath/**.log	2025-10-22_seapath.log	Most recent GGA entry from 2025-10-22_22_seapath.log: 2025-10-22, 12:58:03.476632, \$GPRMC,A,12.2863,A,60.001940828,N,168.17739930,W,0.07,1.2,0.32,M,10.34,M,1.2,1.022*58 Open in Google Maps

Mountpoints

Mount	Message
/synology	Mount /synology is mounted
/rutter-internal	Mount /rutter-internal is mounted

Storage

Disk	Used [GB]	Total [GB]	Free [GB]	Used [%]
/dataproc	375.87	3666.45	3290.58	10.25
/data/raw	186.97	3666.45	3479.48	5.10
/	175.61	432.10	256.49	40.64
/synology	40979.52	71479.68	30500.16	57.33
/dev/shm	7.16	125.76	118.61	5.69

Acquisition Files

Path	Latest File	Last Accessed
/data/raw/sig/**.sig	/data/raw/sig/SKQ_2025-10-22_12:56:56.sig	2025-10-22 12:57:45 UTC
/data/raw/serial/seapath/**.log	/data/raw/serial/seapath/2025-10-22_seapath.log	2025-10-22 12:58:03 UTC
/data/raw/serial/mgc1/**.log	/data/raw/serial/mgc1/2025-10-22_mgc1.log	2025-10-22 12:58:03 UTC

Processing

Name	Workers	PID	ETimes [s]	CpuTime [s]	Cpu [%]	Mem [MB]	Mem [%]
parse_rmea.py		768531	336.575	31.225	9.2	61.875	0.0
parse_pol.py		768532	336.576	17.790	5.2	702.371	0.2
parse_pol.py	3		336.576	114.352	33.98	163.297	0.06
pol_to_car.py		768533	336.576	23.172	6.8	1173.98	0.4
pol_to_car.py	3		336.576	159.432	47.37	185.027	0.07
imaging.py		768535	336.576	34.342	10.2	3124.77	1.2
imaging.py		768537	336.576	44.882	13.3	17787.734	6.9
waves.py		768539	336.576	47.465	14.1	2243.984	0.8
waves.py	4		336.576	736.805	219.51	1893.035	0.73
car_to_spec.py		769114	336.575	48.988	14.5	1667.965	0.6
car_to_spec.py	4		336.575	323.006	95.97	596.48	0.23
cur_bathy.py		769115	336.575	7.079	2.1	230.016	0.0
cur_bathy.py	20		336.575	15,230,705	4525.2	4662.074	1.81

Network

Interface	IP Addresses	Bytes Sent [MB/min avg]	Bytes Received [MB/min avg]
lo	[127.0.0.1]	1.2	1.2
eno1	[192.168.100.101]	0.1	0.2
eno2	[10.3.0.47]	0.0	2.6
enp216d00	[10.20.30.40]	0.0	0.0

Last Image

Image timestamp: 2025-10-22 12:58:10 UTC

/data/raw/udp/wind/**.log	/data/raw/udp/wind/2025-10-22_wind_gll_wdmnt_true.log	2025-10-22 12:58:03 UTC
/data/raw/udp/cnav/**.log	/data/raw/udp/cnav/2025-10-22_cnav.log	2025-10-22 12:58:03 UTC

Quality Control

Type	Message
Radar raw data acquisition rate	Radar raw data rate of 12.64 MB/s (based on 8 sig files)
GPS measurement success rate	GPS measurement success rate of 100.0% (2968/2968); GPS measurement frequency of 10.00 Hz
Cartesian radar image update rate	Cartesian image creation success rate of 100.0% (420/420; median antenna rotation period of 1.30 s)
Current retrieval success rate	Current measurement success rate of 98.9% (3736/3778)

Acquisition Info

Type	Message
/data/raw/sig/SKQ_2025-10-22_12:56:16.sig	/data/raw/sig/SKQ_2025-10-22_12:56:16.sig has mean antenna rotation period of 1.22825 s with 1/2315 (0.04%) leading pulses lost
Polar radar image range	2025-10-21 12:58:24 -> 2025-10-22 12:56:55
Mean pulse repetition frequency	3092.631 Hz
Std pulse repetition frequency	0.528 Hz
Min pulse repetition frequency	3090.276 Hz
Max pulse repetition frequency	3095.337 Hz
Cartesian radar image range	2025-10-21 12:58:03.810453 -> 2025-10-22 12:57:10.620812
Median antenna rotation period	1.300s
Number of acquired radar scans	66422
Number of missed radar scans	0 (0.000%)

Database Info

Database	Size [MB]
car_to_spec	63.77
cur_bathy	2028.06
imaging	1.55
information_schema	0.00
marineradarviewer	141.88
mysql	2.70
parse_rmea	707.59
parse_pol	10.38

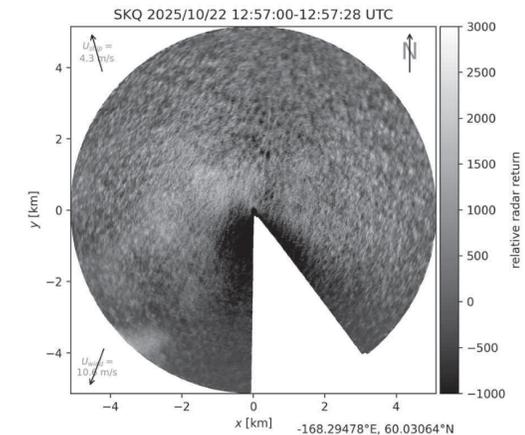
performance_schema	0.00
pol_to_car	15.58
scanning	0.11
sys	0.02
waves	161.73

Database Lag

Table	Column	Delay [min]
parse_rmea.gps	datetime	Lag of 0 min
parse_pol.pol	start_datetime	Lag of 1 min
parse_pol.gps	gps_datetime	Lag of 0 min
pol_to_car.car	start_datetime	Lag of 0 min
imaging.car_avg	start_datetime	Lag of 2 min
waves.spec	start_datetime	Lag of 6 min
scanning.car_avg	start_datetime	Lag of 18 min
car_to_spec.spec	start_datetime	Lag of 6 min
sea_ice_drift.sea_ice_drift	start_datetime	Table 'sea_ice_drift.sea_ice_drift' doesn't exist

Processing Info

Table / Name	Message
parse_rmea.gps / parse_rmea.py	2025-10-22 12:58:00, Longitude: -168.295621°, Latitude: 60.032231°, Heading: 353.38°
parse_rmea.gps_secondary / parse_rmea.py	None
parse_rmea.gyrosc / parse_rmea.py	2025-10-22 12:58:00, Heading: 353.21°
parse_rmea.wind / parse_rmea.py	2025-10-22 12:58:00, Wind Speed: 13.7m/s, Wind Dir: 12.2°
parse_pol.pol / parse_pol.py	2025-10-22 12:56:55, Pulse Frequency: 3092.77Hz
parse_pol.gps / parse_pol.py	2025-10-22 12:57:35.223803
pol_to_car.car / pol_to_car.py	2025-10-22 12:57:11
imaging.car_avg / imaging.py	2025-10-22 12:56:00
scanning.car_avg / imaging.py	2025-10-22 12:40:01
waves.waves_mean / waves.py	2025-10-22 12:52:00, H: 36.97m, HS: 2.68m, TP: 7.43s, TM: 7.94s, DP: 16.77°, UX: 0.37m/s, UY: -0.02m/s
cur_bathy.currents / cur_bathy.py	2025-10-22 12:52:00, H: 32.97m, UX: 0.39m/s, UY: 0m/s
sea_ice_drift.sea_ice_drift / sea_ice_drift.py	Table 'sea_ice_drift.sea_ice_drift' doesn't exist



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Radar product sharing and raw data archiving

- Marine X-band radar data volumes (assuming 250 sea days/year):
 - Radar products with or without roughness images at 30 s resolution:
 - R/V Sikuliaq: ~14.2 GB/day, ~3.6 TB/year or ~1.2 GB/day, ~300 GB/year.
 - R/Vs Neil Armstrong & Thomas G. Thompson: ~24.8 GB/day, ~6.2 TB/year or ~1.8 GB/day, ~450 GB/year.
 - Radar raw data:
 - R/V Sikuliaq: ~903 GB/day, ~226 TB/year.
 - R/Vs Armstrong & Thompson: ~502 GB/day, ~126 TB/year.
- Radar products:
 - Stored in NetCDF format following the Climate and Forecast (CF) and Sensing the Ocean with Marine Radar (SOMaR; currently in draft stage) metadata conventions.
 - To be included in the cruise distros & added to the R2R catalog.
- Radar raw data:
 - Stored shipboard with pairs of Synology NAS servers (~96 TB capacity per unit).
 - Currently archived on tape at CSTARS; we are seeking a long-term public archive solution.
 - Size can be reduced by lowering the range resolution and/or maximum range.

X-band radar program's timeline (abridged)

- PY2 (Sep 2024 – Aug 2025):
 - Extended radar support to R/V Thomas G. Thompson.
 - Replaced brushes on R/V Neil Armstrong, transitioned from POSMV to Seapath, replaced failed SSD & repaired file system.
 - Transitioned from POL to SIG files on R/V Sikuliaq, replaced failed SSD & repaired file system.
 - Regularly calibrated radar azimuth/range/time and significant wave height.
 - Continuously updated radar processing software.
 - Archived radar products and raw data at CSTARs.
- PY3 (Sep 2025 – Aug 2026):
 - Develop SOMaR standard for radar product variables not described by CF standard.
 - Write data paper as a reference for radar products.
 - Create wiki and develop open-source software to ease access to radar products.
 - Add radar products to cruise data sets and R2R catalog.
 - Identify long-term public archive for radar raw data: explore use of tape library and Globus.
 - Extend radar support to other radar-equipped research vessels.

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.**