Operational support for wave & ice X-band radars

[1]Björn Lund (blund@cstars.miami.edu),
[1]Kevin Polk, [1]Giancarlo Laso, [1]Hans C. Graber, & [2]Jochen Horstmann

[1]University of Miami, Center for Southeastern Tropical Advanced Remote Sensing (CSTARS)
[2]Helmholtz-Zentrum Hereon, Geesthacht, Germany

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

CSTARS
UNIVERSITY OF MIAMI
CENTER FOR SOUTHEASTERN TROPICAL ADVANCED REMOTE SENSING

A new shipboard X-band radar program

- Many UNOLS vessels are equipped with science marine X-band radars, mostly Wave Monitoring Systems (WaMoS), but hardly any measurements enter R2R's catalog, why is that?
  - Shipboard X-band radars must be carefully calibrated to (a) correctly remove ship motion and (b) measure wave height.
  - WaMoS is limited to wave measurements, but marine X-band radars can also yield near-surface current maps, sea ice drift maps, and sea surface (& sea ice) mean roughness images, among other products.
- New program's goal: Support science marine X-band radar operations on radar-equipped UNOLS vessels (currently, R/V Neil Armstrong and R/V Sikuliaq).

X-band radar program’s responsibilities

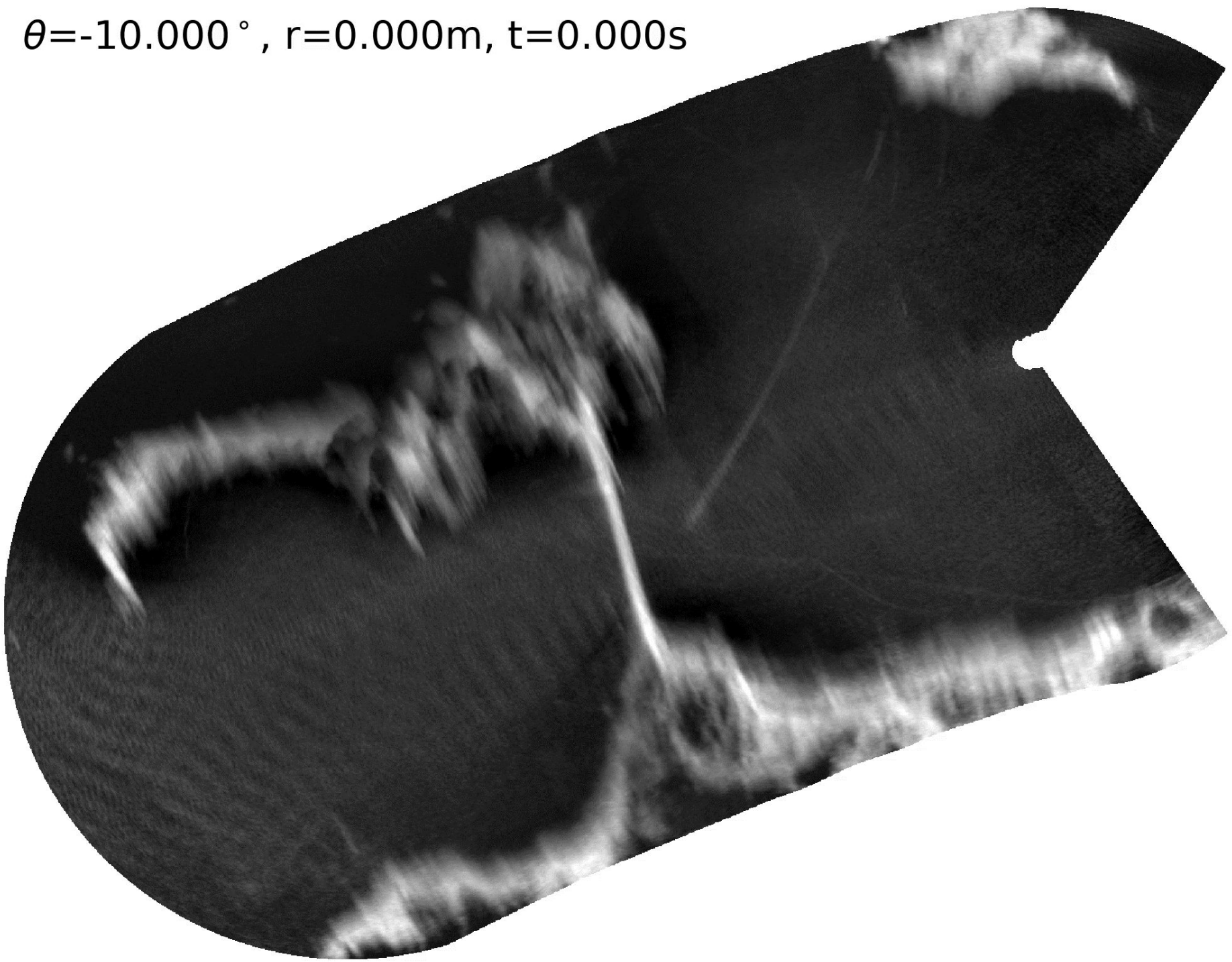
- Calibrate radar’s heading/range/time biases and significant wave height.
- Provide vessels with radar processing & storage servers and software.
- Radar processing software collects GPS, accurate heading, and radar raw data (e.g., from WaMoS) to produce in near-real time:
  - Near-surface current (and sea ice drift) maps,
  - 2D wave spectra,
  - Near-surface current maps,
  - Sea ice drift maps, …
- Improve products’ visibility through web viewer on ship network.
- Remotely monitor radar operations through twice daily status emails.
- Create documentation on radar operations, quality control, and products.
- Collaborate with R2R to publicly archive radar products and raw data.

Radar calibration

Find the radar azimuth (θ), range (r), and time (t) offsets with maximum image contrast.

Requires fixed targets observed from moving vessel.

Following McCann & Bell (2018).



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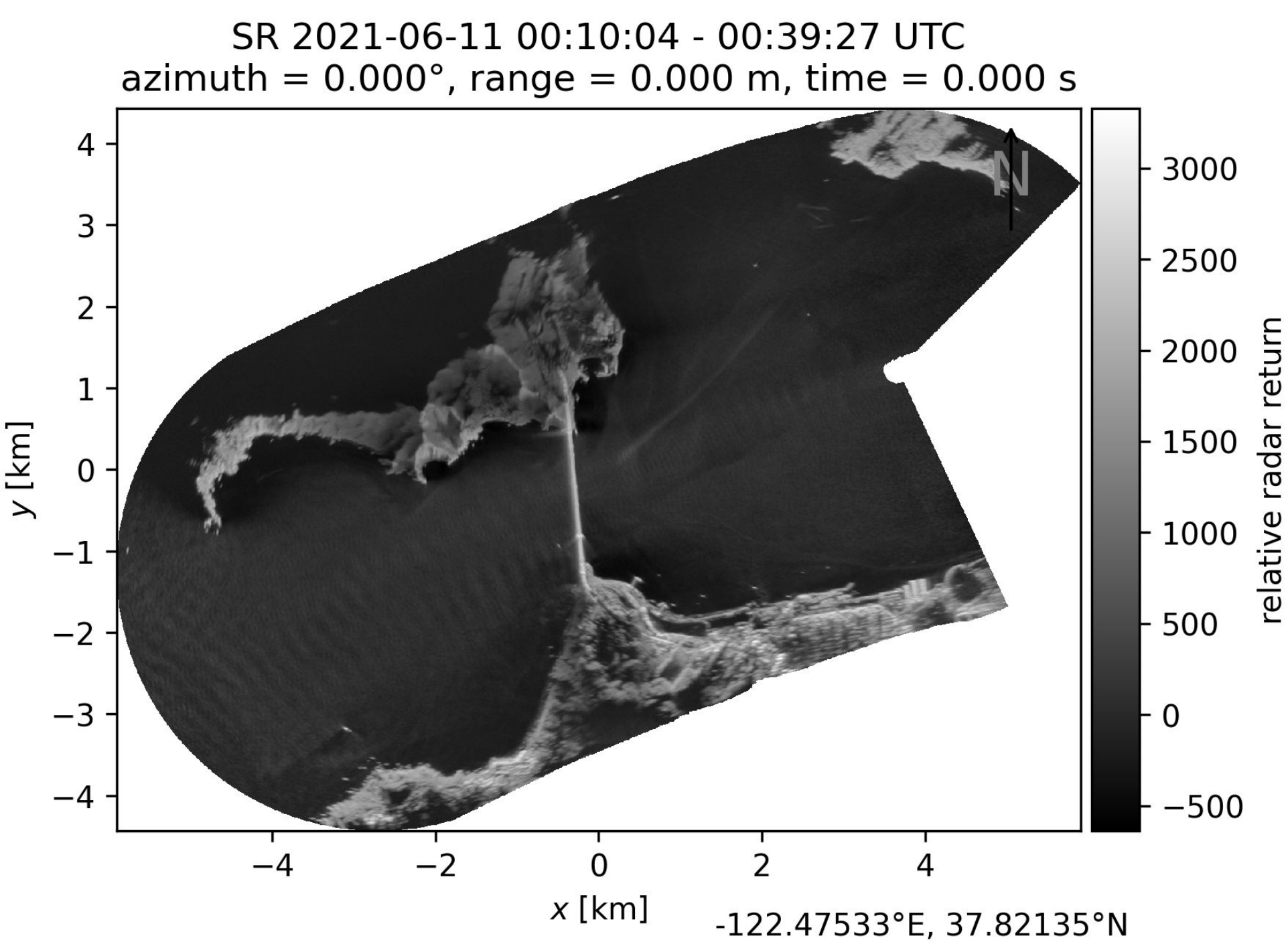

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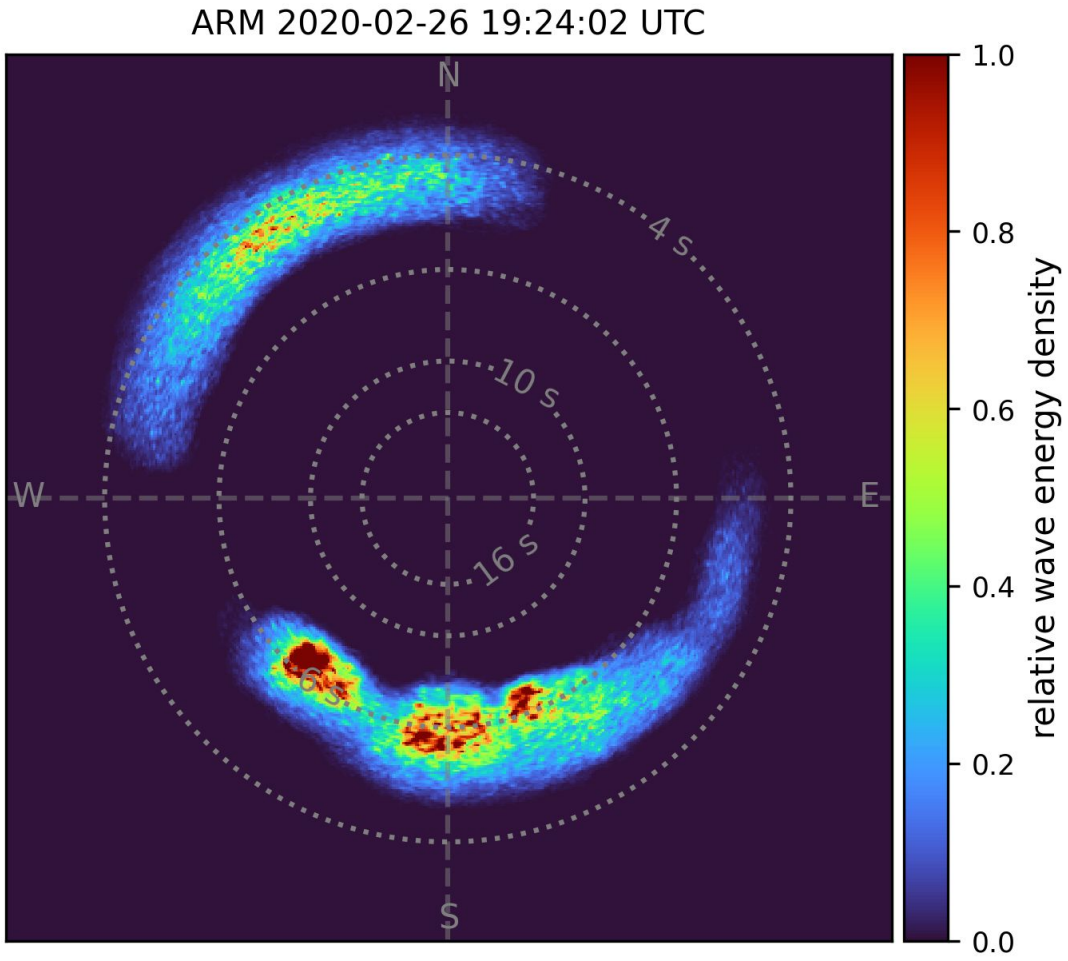
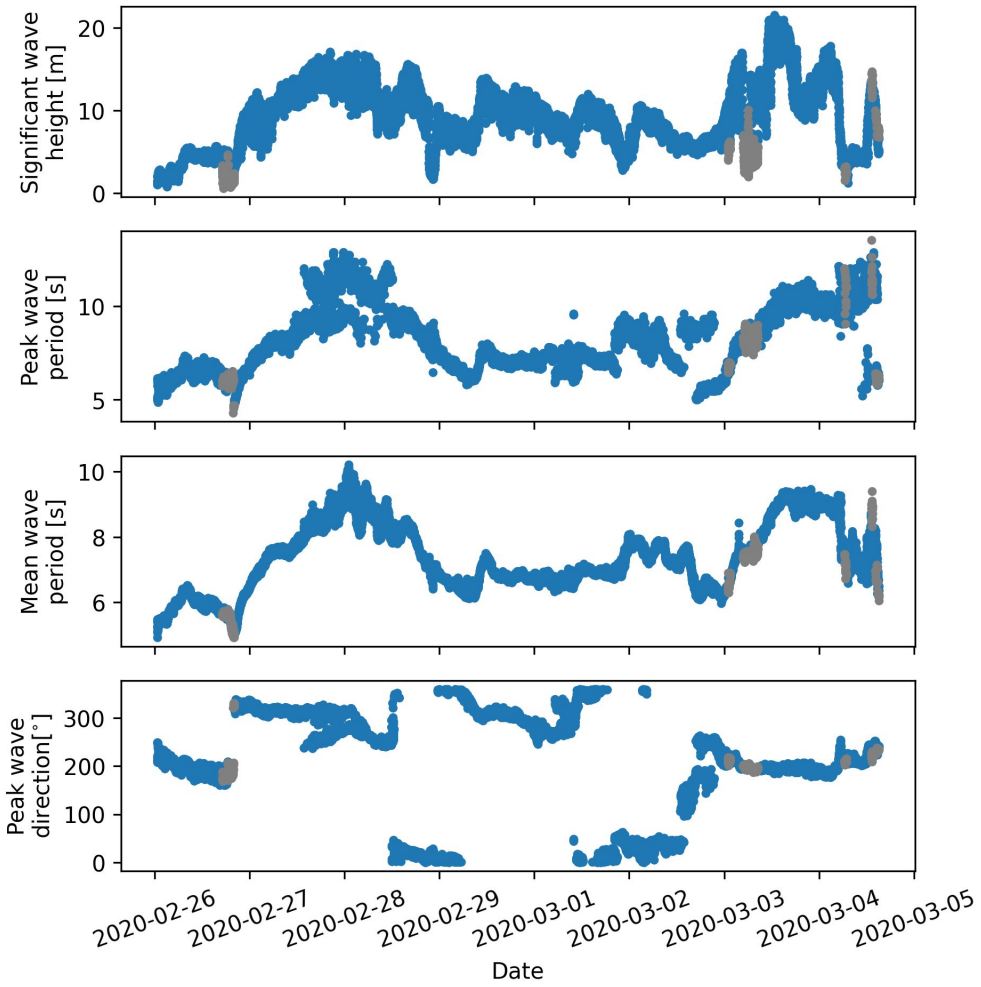
Wave measurements



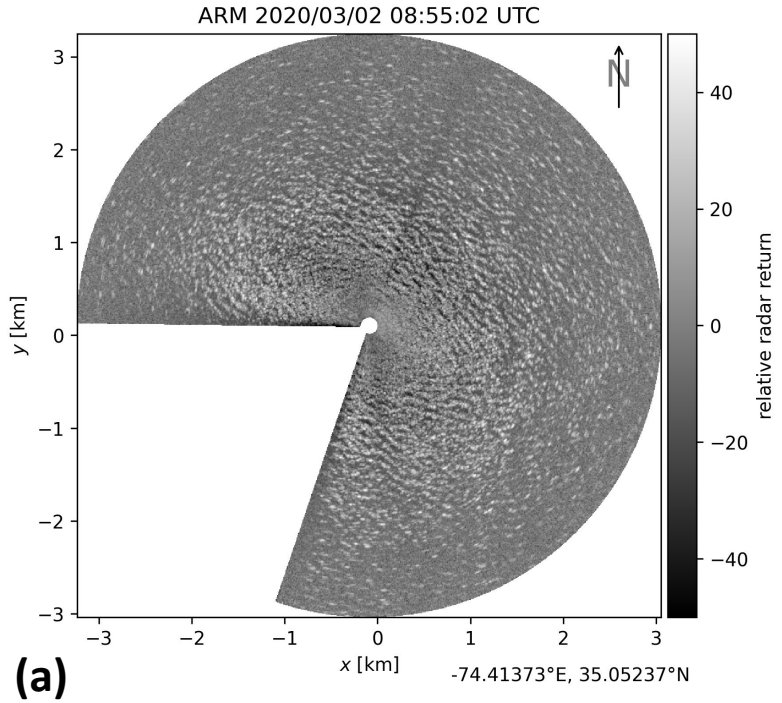
AR42-02 (Tampa, FL to Woods Hole, MA): Significant wave height is uncalibrated, rainy periods are marked in gray.

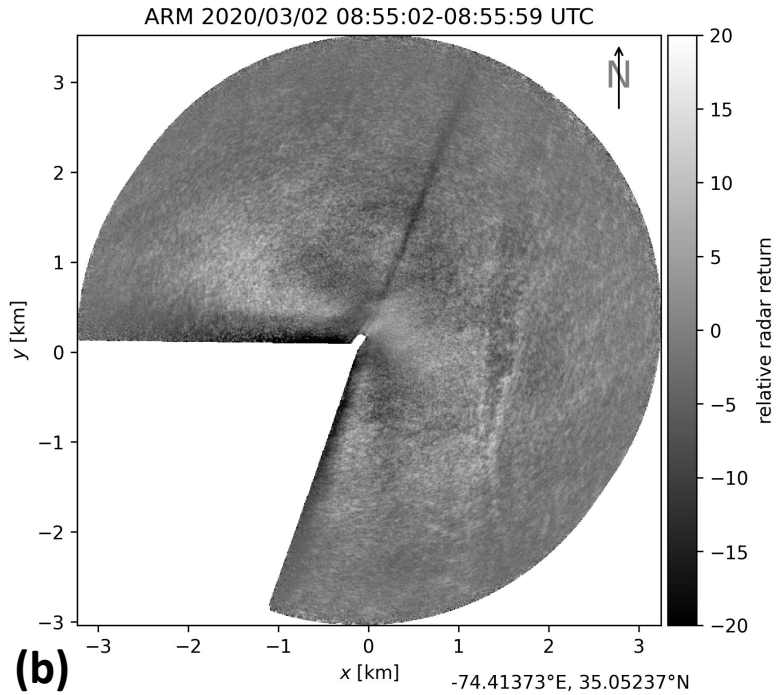


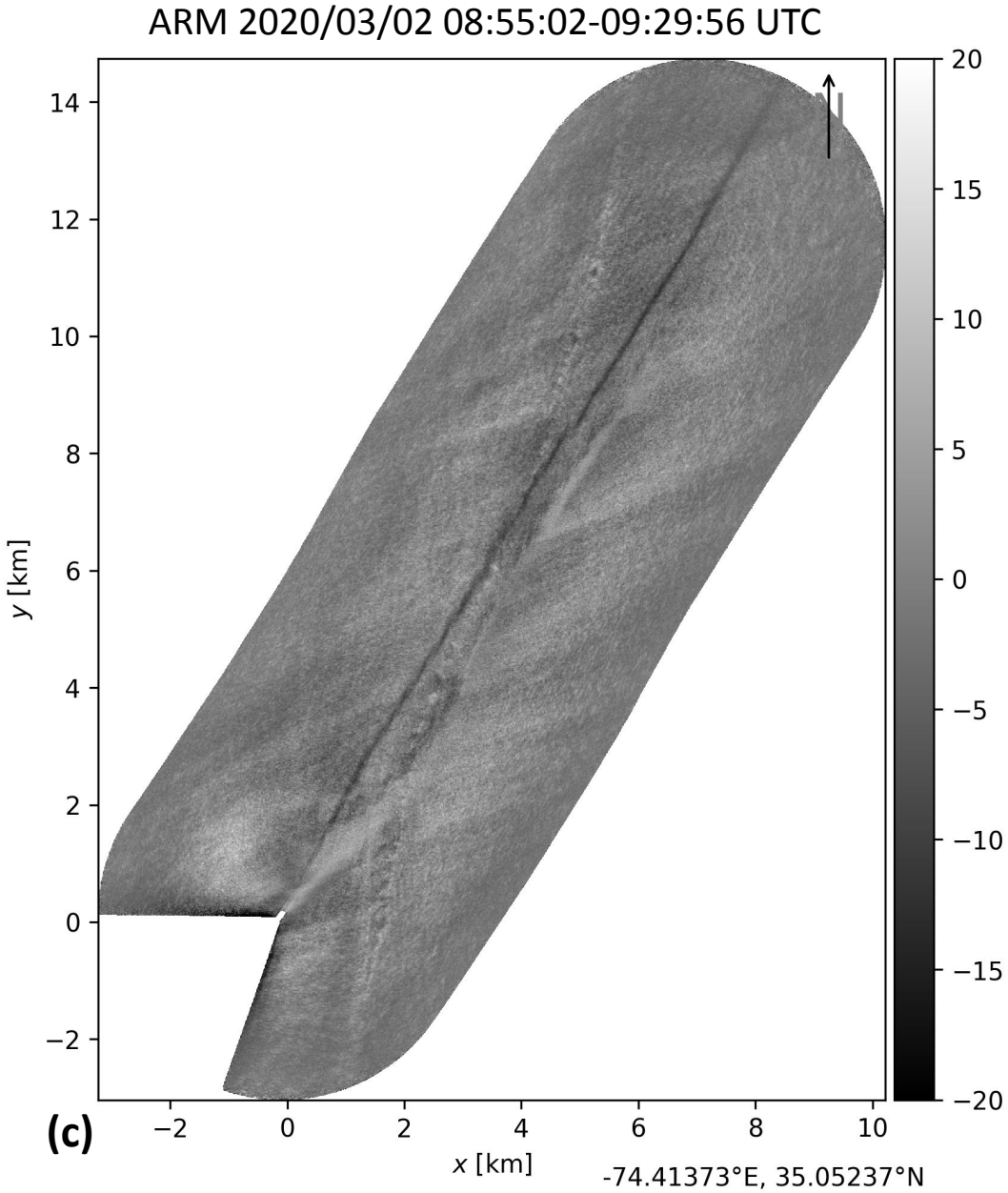
View movie of wave spectra: https://youtu.be/FvkxgXLODDg.

Sea surface roughness images

(a) Single scan radar image with wave signatures,
(b) 1-min averaged radar image with current front,
(c) 30-min radar image mosaic with current front (each pixel is a 1-min average).

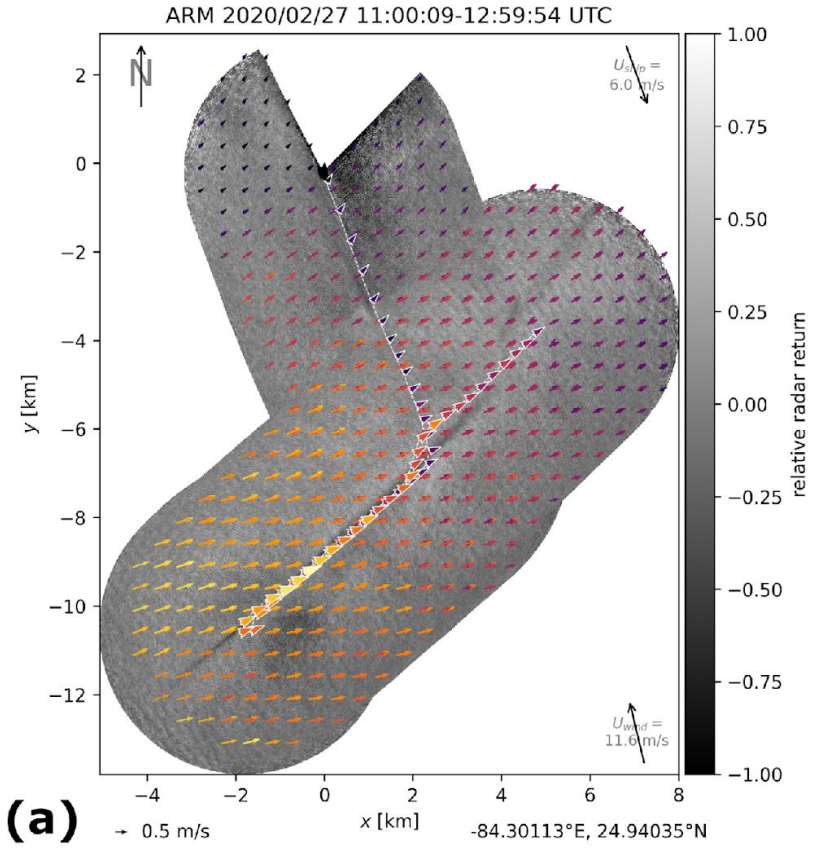


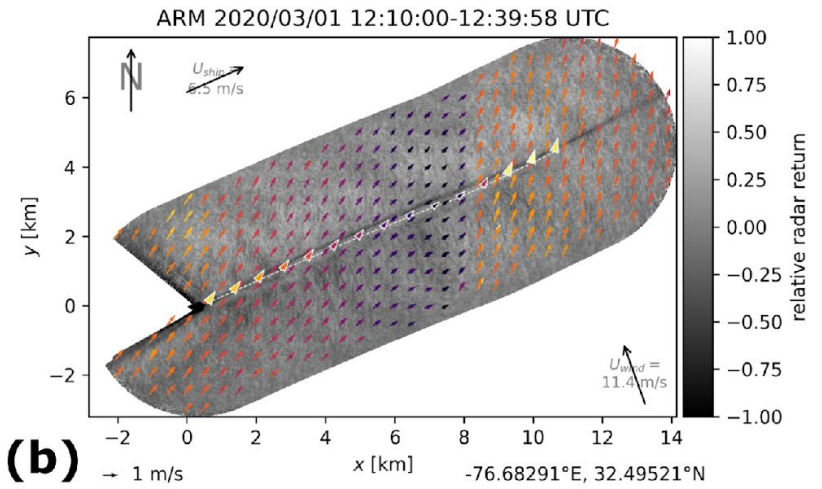


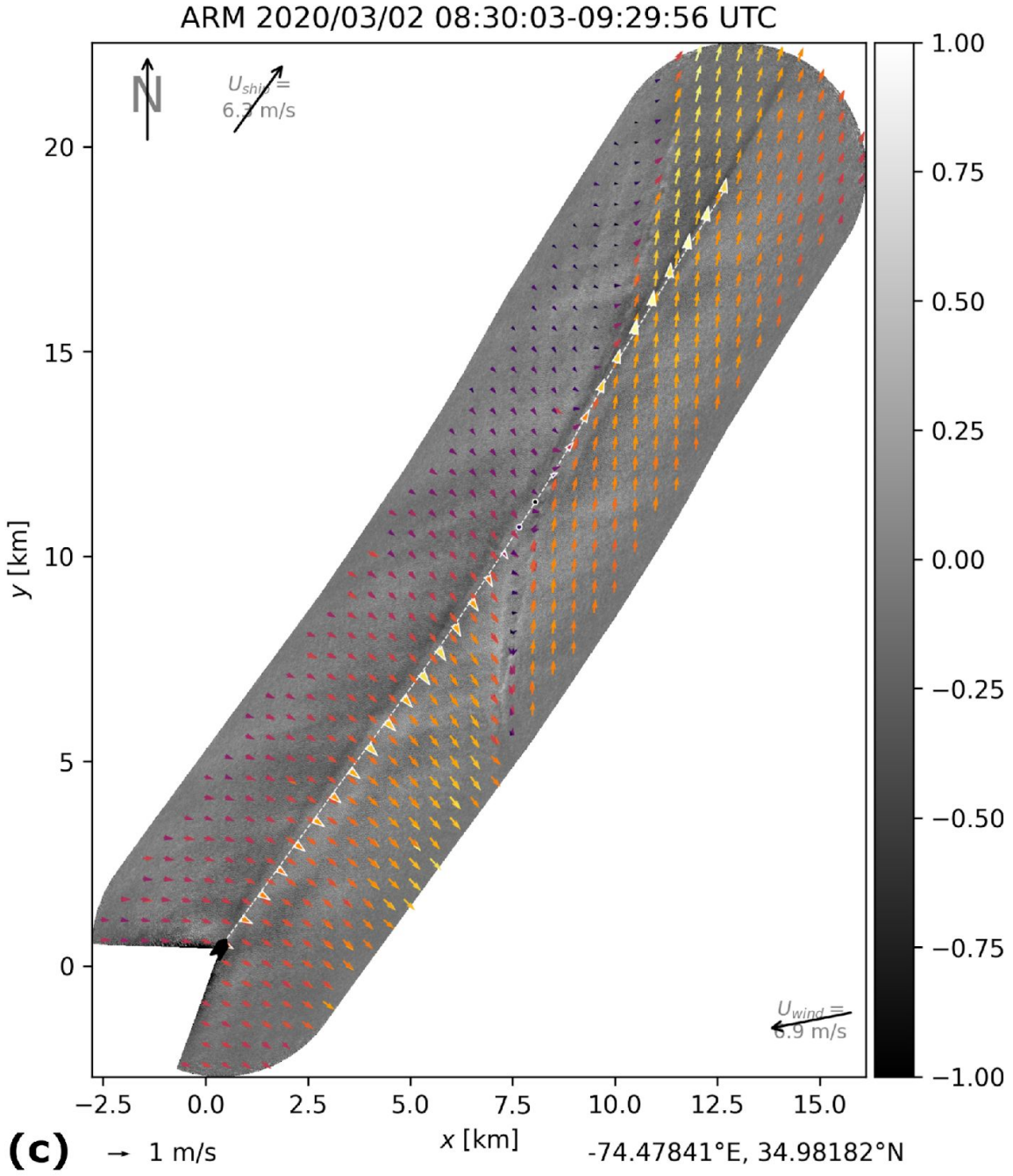


Near-surface current maps

Sample radar current maps over radar image mosaics with ship track as white dashed line and ADCP WH300 current vectors (topmost bin) with white borders.

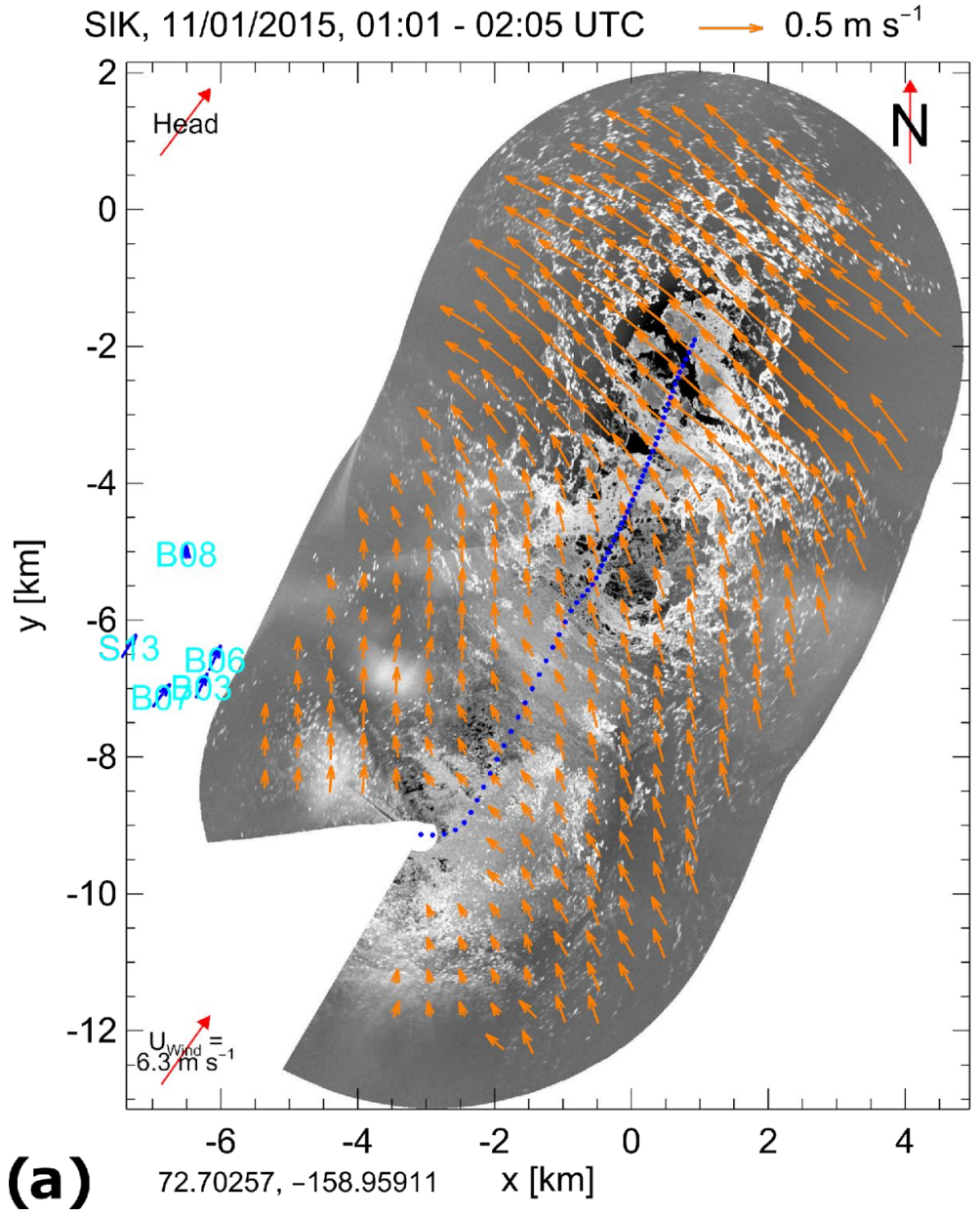


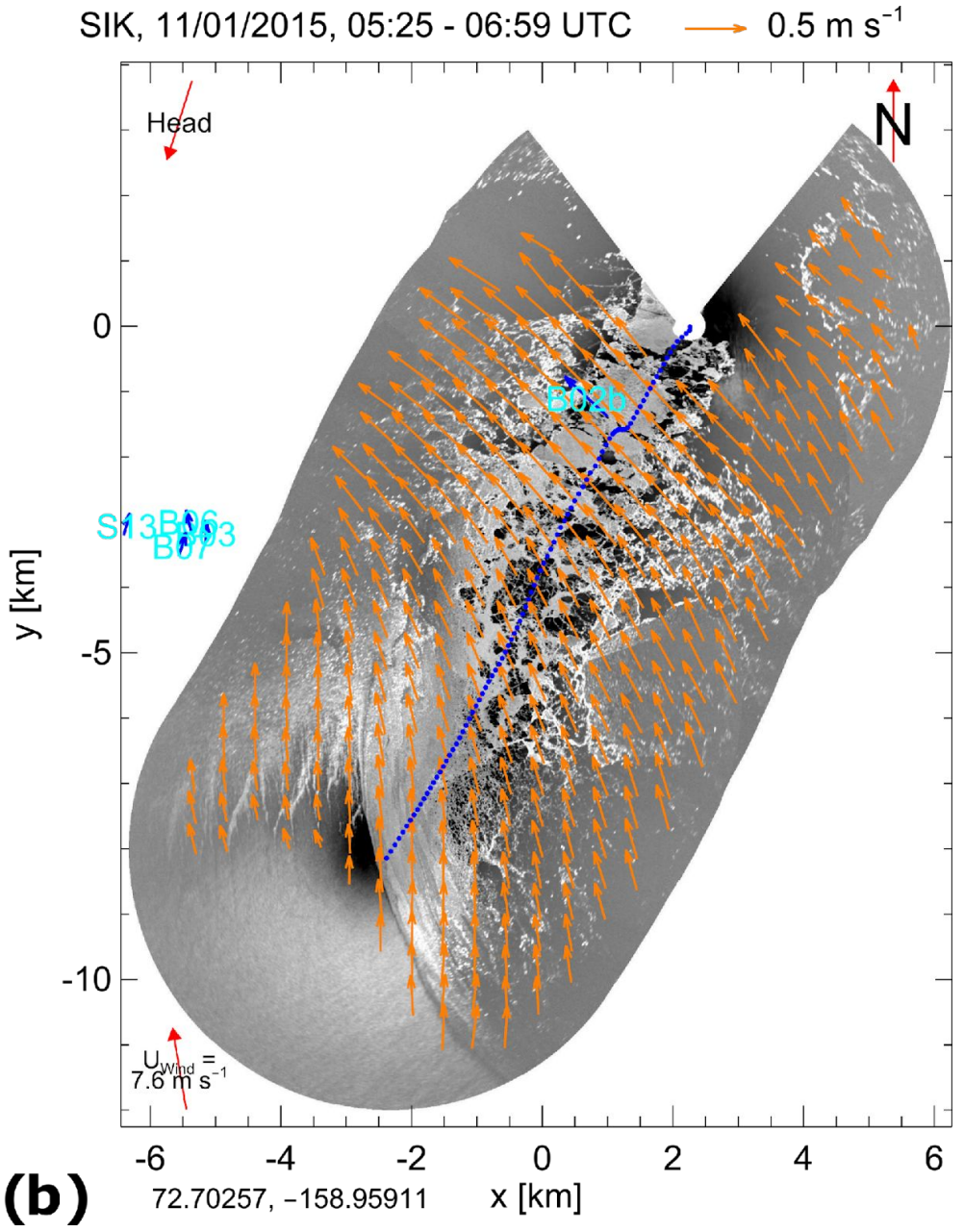




Sea ice drift maps

Sample radar sea ice drift maps over radar image mosaics from R/V Sikuliaq in the Beaufort Sea with ship track as blue dots and buoy drift vectors in blue.





View radar image movies of sea ice dynamics: https://youtu.be/nv5i_hUB-fw & https://youtu.be/It0aV66UiFM.

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CSTARS - Marine Radar Viewer

Not secure | https://localhost/MarineRadarViewer/html/index.php

New Tab

Auto-zoom: Latest data

Real-time: ☑

Update Rate: 15 sec

Current Range (m/s): 0 – 1.5

Data	History		
Vessel Info:	☑	10	hr
Sea Roughness:	☑		
Current:	☑	3	min
Waves:	☑	1	hr

Info

Last Update: 2023-10-17 15:08:00

Location: -83.33898983, 24.32519750

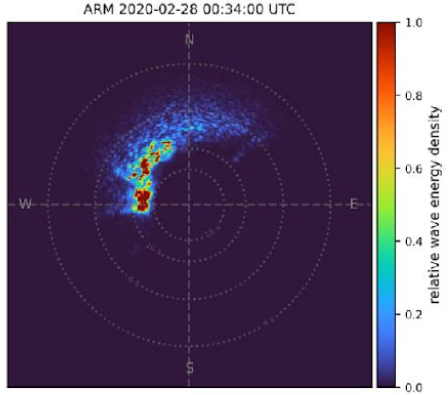
Bearing: 128.20 degrees

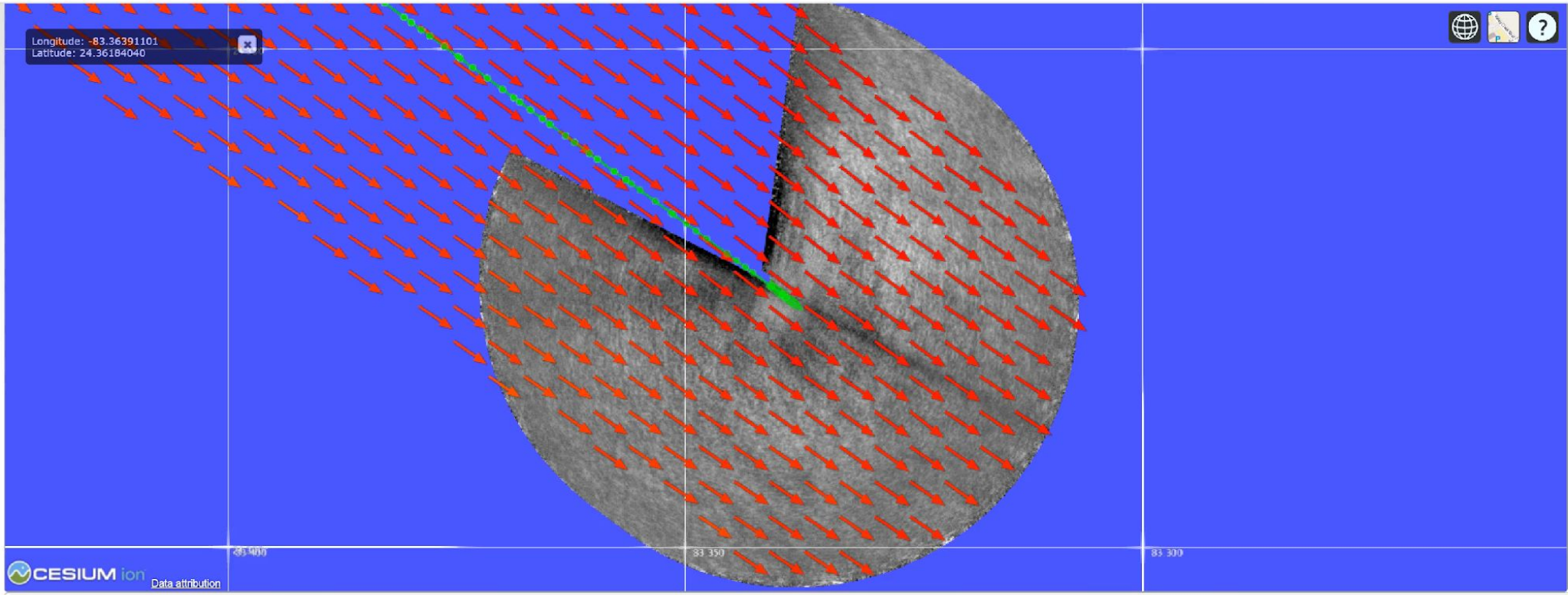
Peak Waves: 275.5 degrees (11.91 s period)

Plots

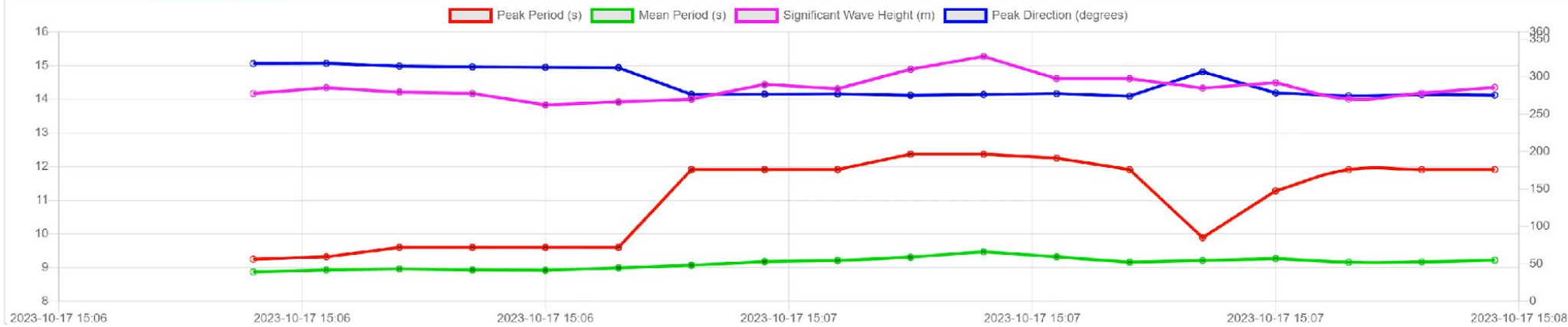
FTH Spectrum | Pop-out

ARM 2020-02-28 00:34:00 UTC





Current Graphs | Wave Graphs



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Radar product sharing and raw data archiving

- Science X-band radars generate large amounts of data:
  - WaMoS radar raw data on R/V Sikuliaq: ~200 GB/day,
  - Hereon radar raw data on R/V Neil Armstrong: ~300 GB/day,
  - Radar products per vessel (including imagery): ~10 GB/day,
  - Estimated yearly volume per vessel: ~55-65 TB.
- Current solution:
  - Select products are included in cruise data set but not yet cataloged by R2R.
  - Radar raw data are archived using 8-bay Synology NAS servers stacked with 16 TB hard drives and RAID-6 protection yielding ~96 TB per unit.
  - Shipboard technicians swap Synology when full and ship to CSTARS where data are reprocessed (if necessary) and archived to tape.
- Future solution:
  - Add radar products to cruise data set and R2R catalog,
  - Share radar raw data publicly (including open-source software to ease access).

X-band radar program’s timeline

- 2023:
  - Upgrade radar processing software & recalibrate radar on R/V Neil Armstrong,
  - Resume raw data archiving on R/V Neil Armstrong and at CSTARS.
- 2024:
  - Install radar processing and storage servers & calibrate radar on R/V Sikuliaq,
  - Develop documentation and open-source software to ease radar data access,
  - Develop fully operational sea ice drift mapping software,
  - **Add radar products to cruise data set and R2R catalog,**
  - **Identify long-term archive for radar raw data with R2R,**
  - **Extend radar support to other interested radar-equipped research vessels.**

Best practices & requests

- 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?**
- **Join us at today's breakout (Anthurium Room, 3:15-3:50 pm) or email me (blund@cstars.miami.edu).**