# Tracking sea-ice seasonal cycle, dynamics, and hazards at Pt. Barrow, AK with coastal ice radar

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*(1) Arctic coastal sea ice*

*(2) Barrow/Utqiaġvik ice observatory*

*(3) Ice velocity & deformation fields*

*(4) Landfast ice breakouts*

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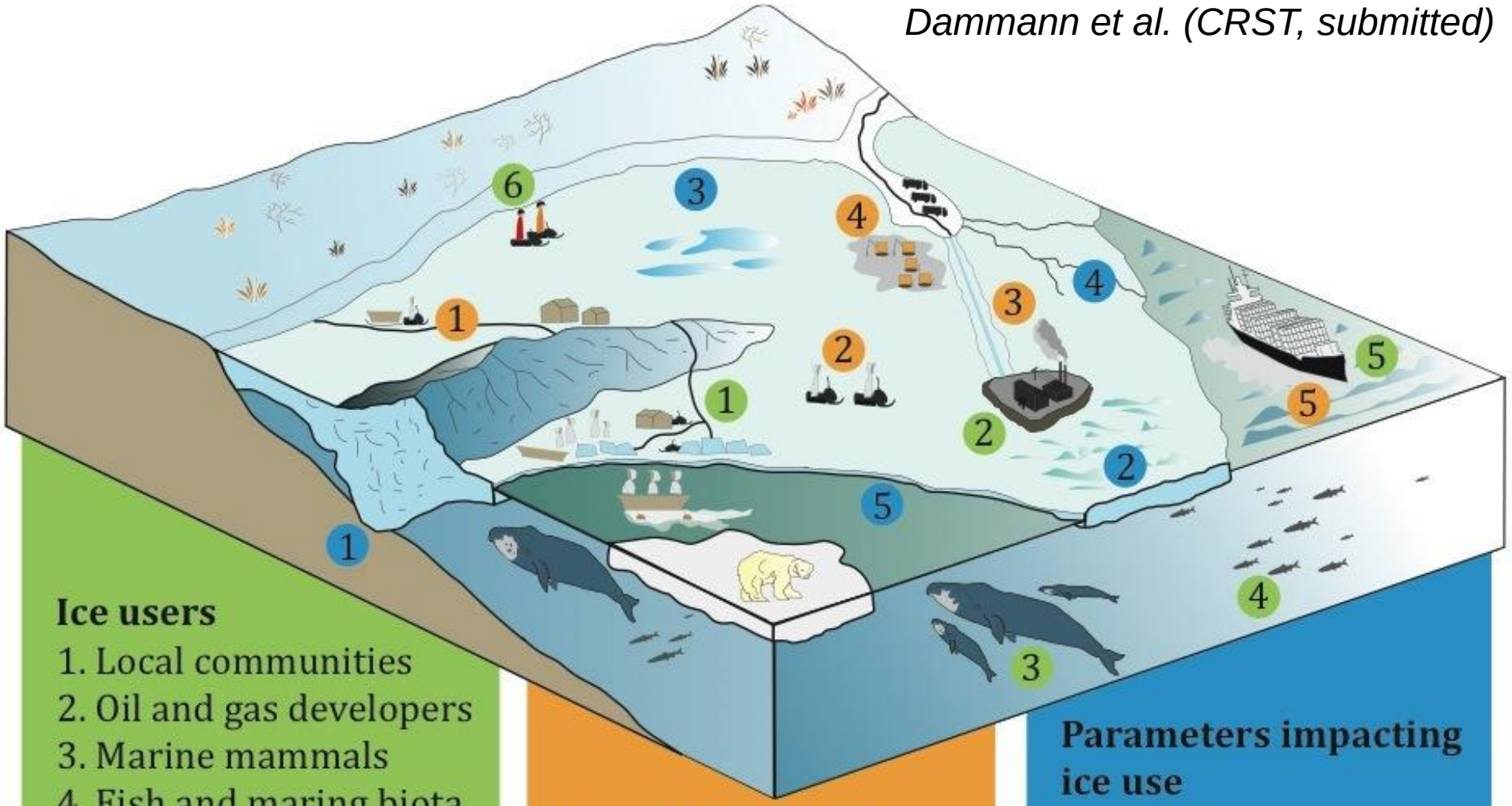
*Dammann et al. (CRST, submitted)*




**Ice users**

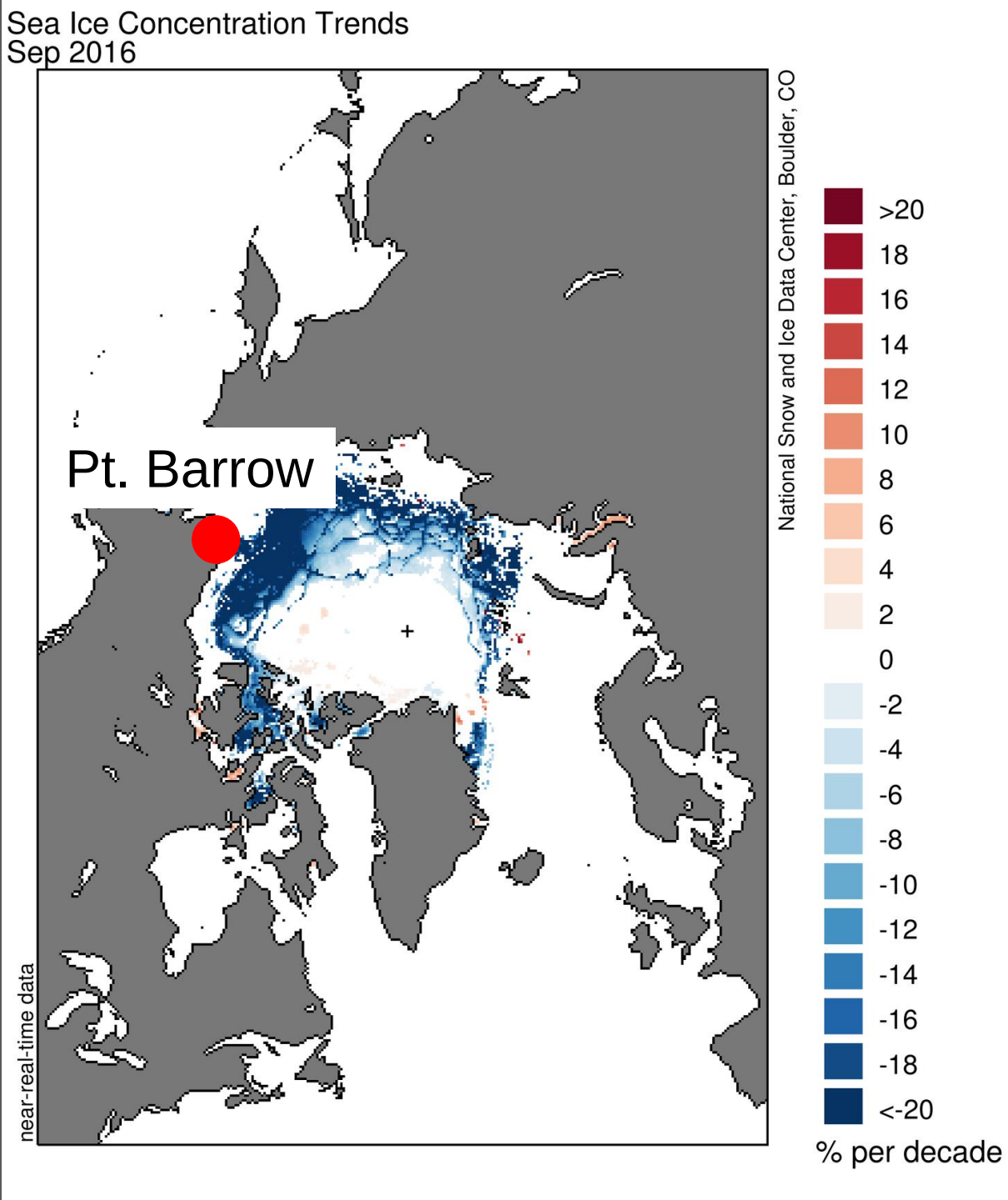
1. Local communities
2. Oil and gas developers
3. Marine mammals
4. Fish and maring biota
5. Shipping companies
6. Tourists

**Examples of ice use**

1. Short-term ice trails
2. Oportunistic travel
3. Permanent ice road
4. Staging of equipment
5. Navigating through ice

**Parameters impacting ice use**

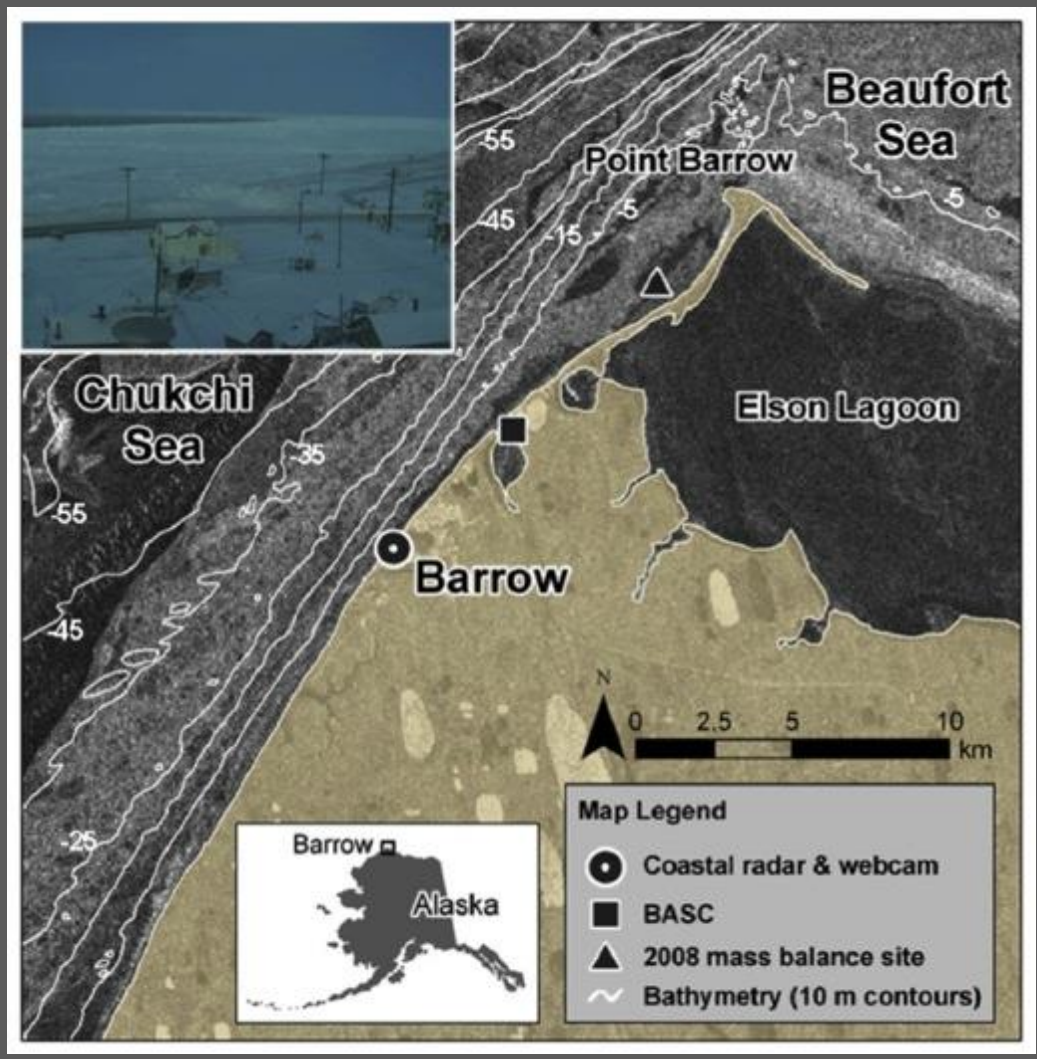
1. Stability
2. Roughness
3. Surface conditions
4. Fractures
5. Ice extent




- Large swath of reduced ice concentation in Pacific Arctic sector
- Impacts on coastal communities & infrastructure
- Increased ice velocities & less stable ice threaten maritime & on-ice operations

# The Pt. Barrow – Utqiaġvik sea-ice observatory

- *Remote sensing* (km-scale)
- *Coastal radar* (sub-km scale)
- *Thickness and topography* (sub-km scale)
- *Ice mass-balance* site (10s m-scale)
- *Moored oceanographic instruments* (sub-km scale)
- *Local ice observations* (J. Leavitt, B. Adams, and many others)




M. Druckenmiller et al., CRST, 2009

- www.sizonet.org; eloka-arctic.org/sizonet; seaice.alaska.edu/gi

# Ground-based ice radar

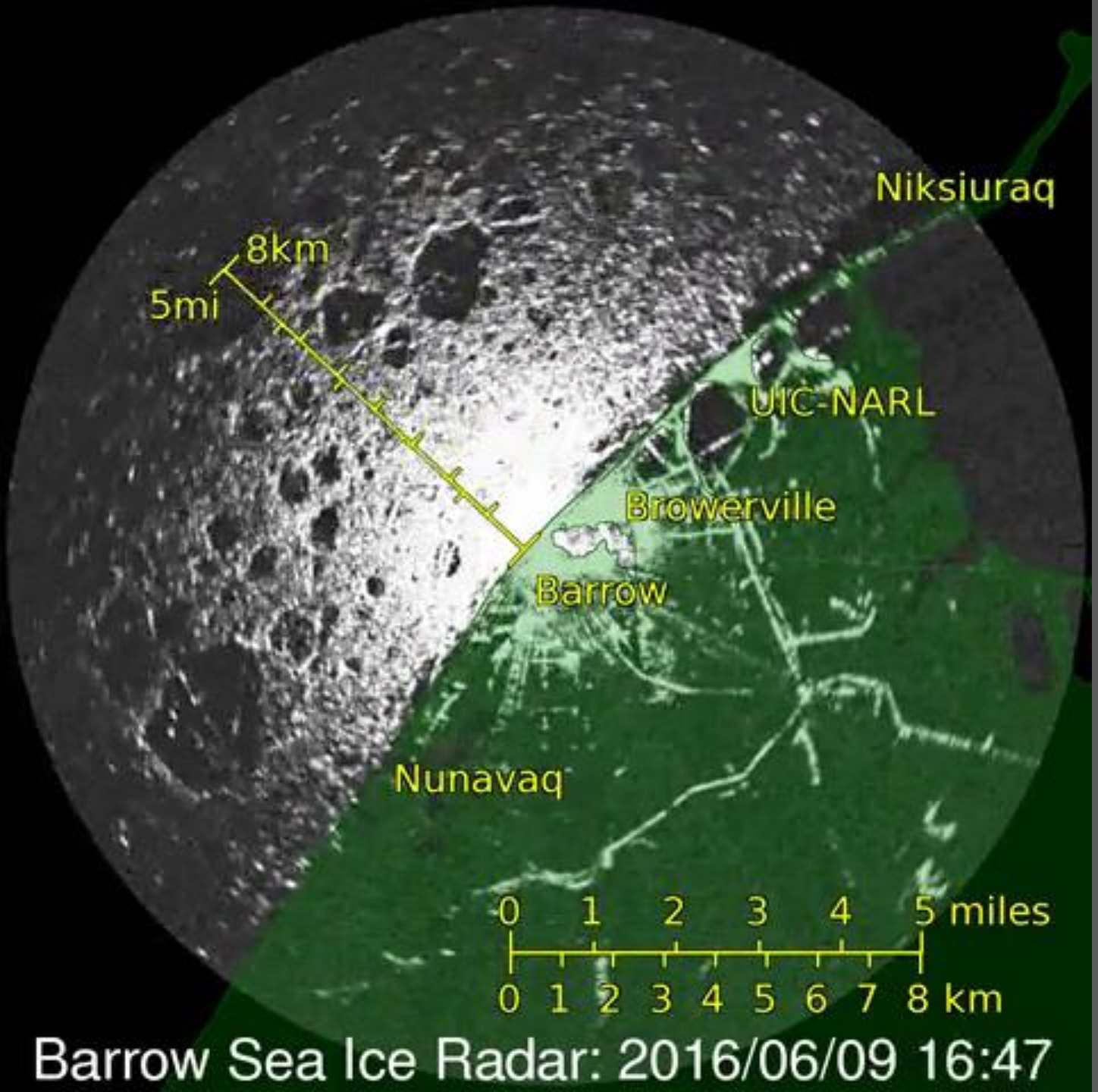
- High spatial resolution (<30 m)
- High sampling rate (<5 $min^{-1}$)
- Near-realtime availability of data & information products (<20 min lag)
- Low cost (<$100k)

→ Resolve complicated spatial ice motion & deformation patterns

→ Capture short-term/high-frequency (e.g., tidal) forcing

→ Track vessel/vehicle & hazard movement

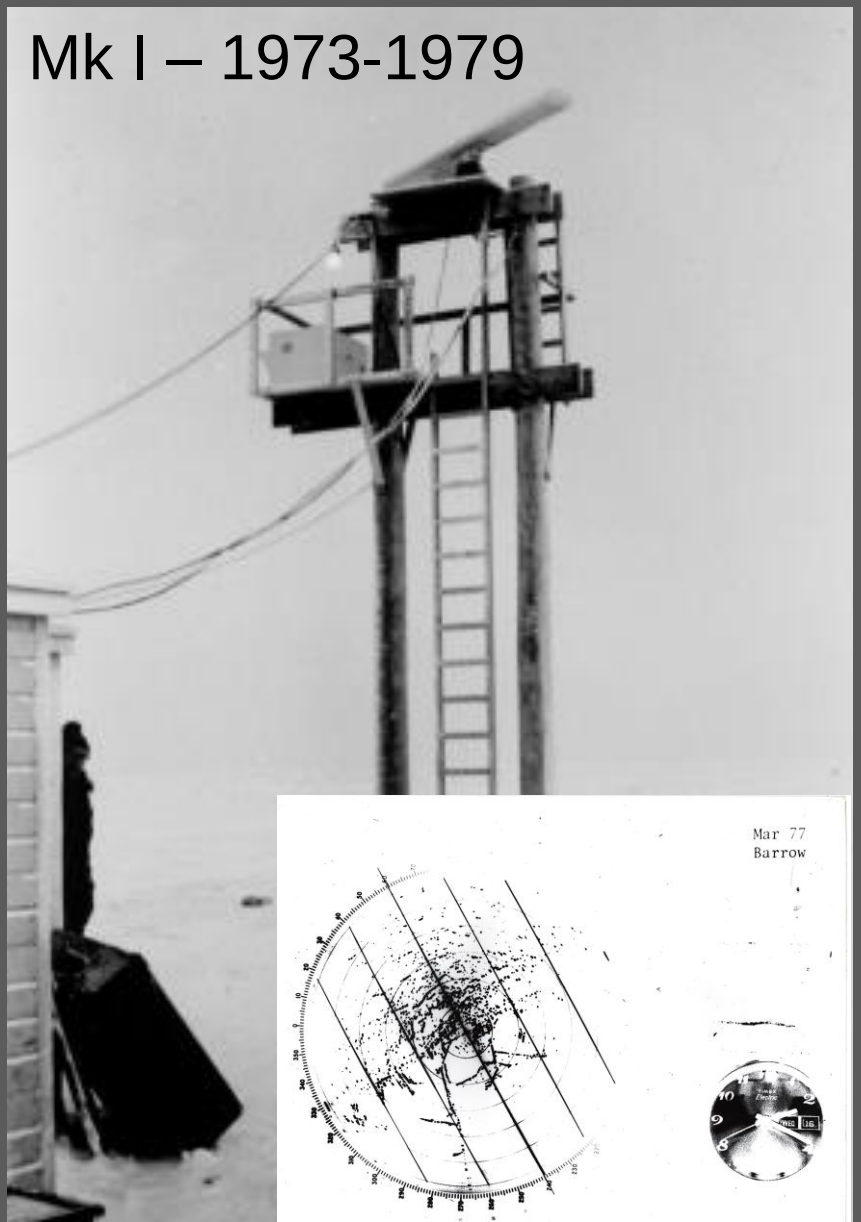
→ Utility as hazard assessment & emergency response tool



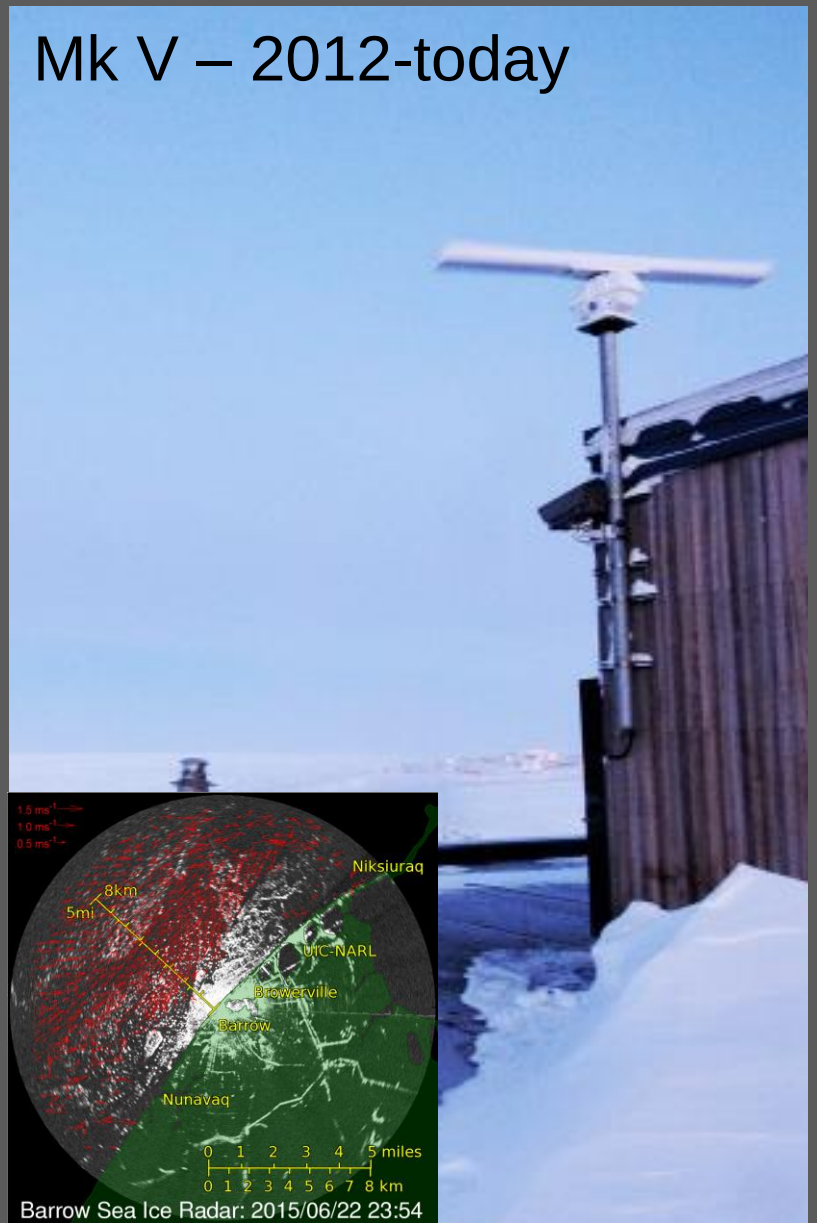

- Ice drift
- Shear
- Conver-gence
- Shorefast ice accre-tion

# UAF Barrow/Utqiaġvik Sea Ice Radars

Mk I – 1973-1979




Mk V – 2012-today



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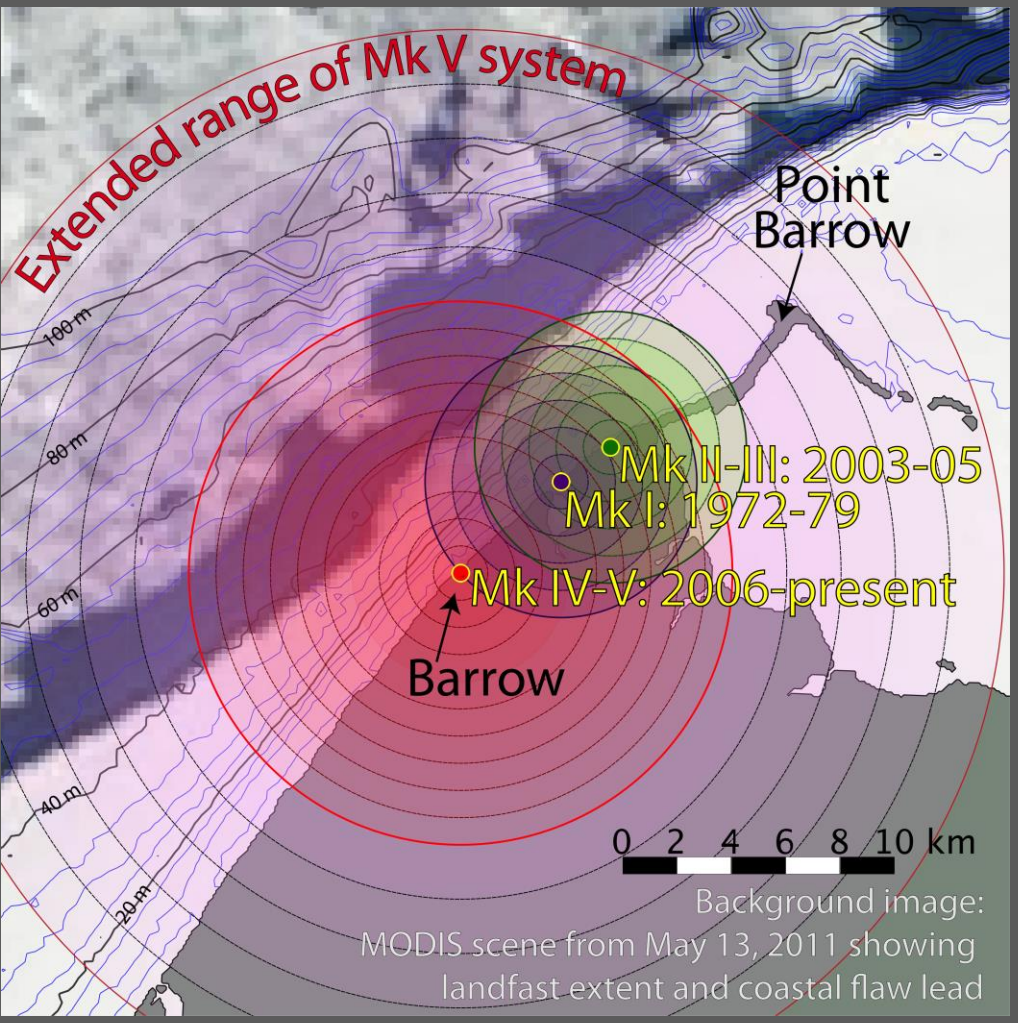
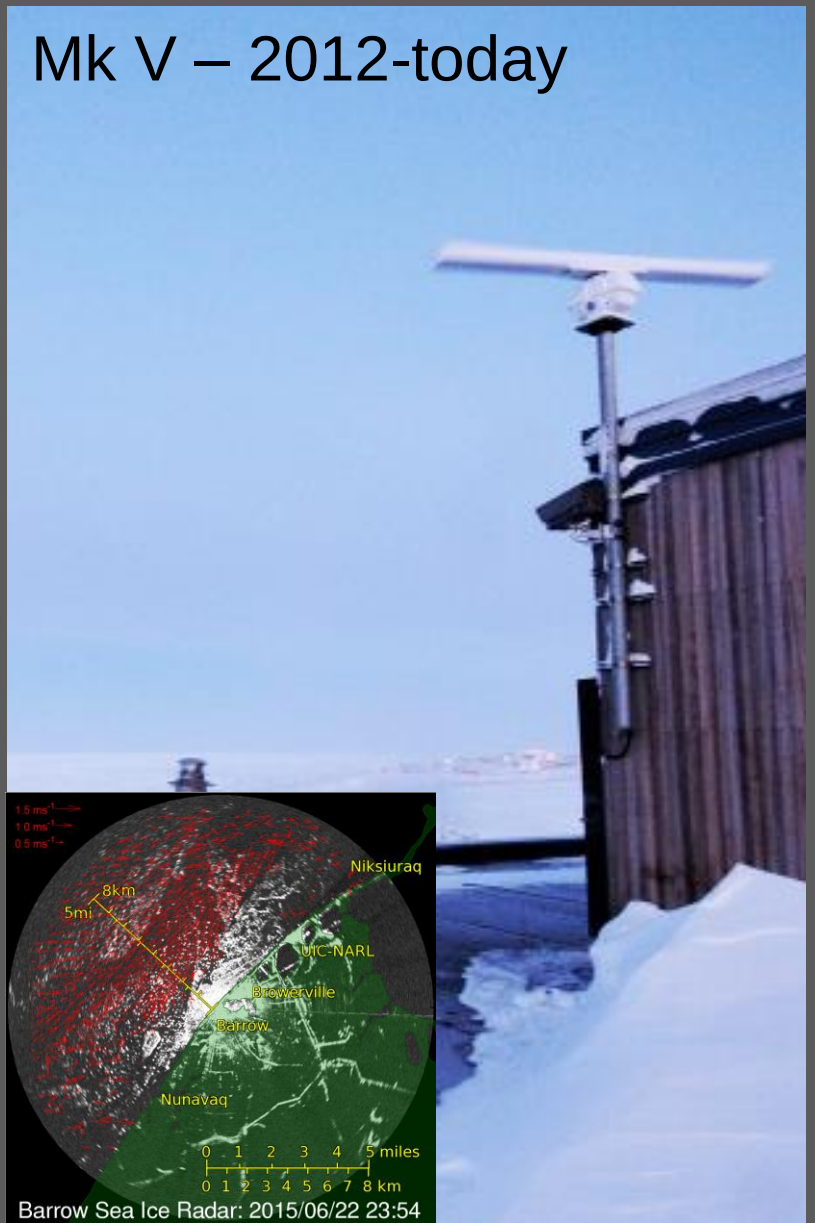


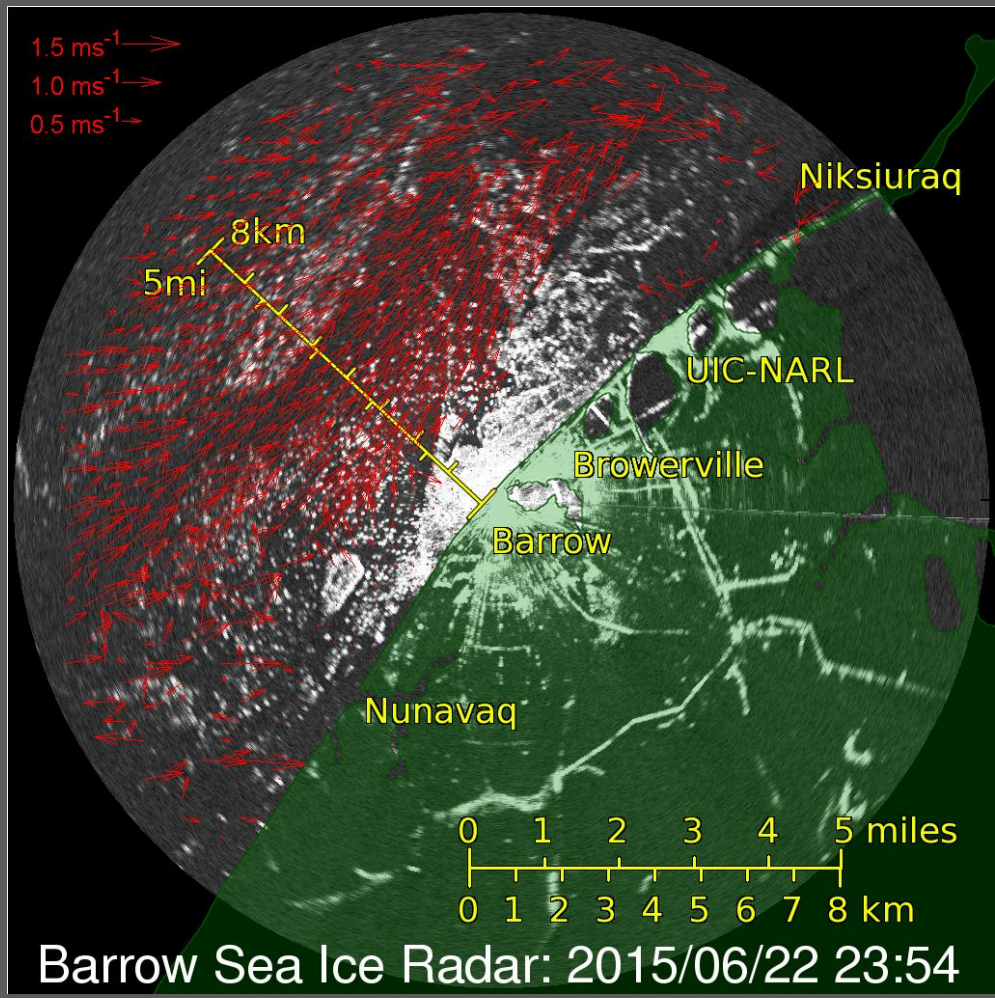



# UAF Barrow/Utqiaġvik Sea Ice Radars

- Mk I – 1973-79: 25kW, 12 m a.s.l.; 35 mm timelapse camera photos of screen
- Mk II – 2002-03: 5kW, 10 m a.s.l.; webcam capture of radar controller screen
- Mk III – 2003-05: 10kW, 10 m a.s.l.; PC screen capture, internet upload
- Mk IV – 2006-11: 10kW, 22 m a.s.l., digital video interface, internet upload
- Mk V – 2012ff.: Furuno X-band FAR2127, 25kW, 2.4 m open array, 22 m a.s.l.; digital controller/output, internet upload

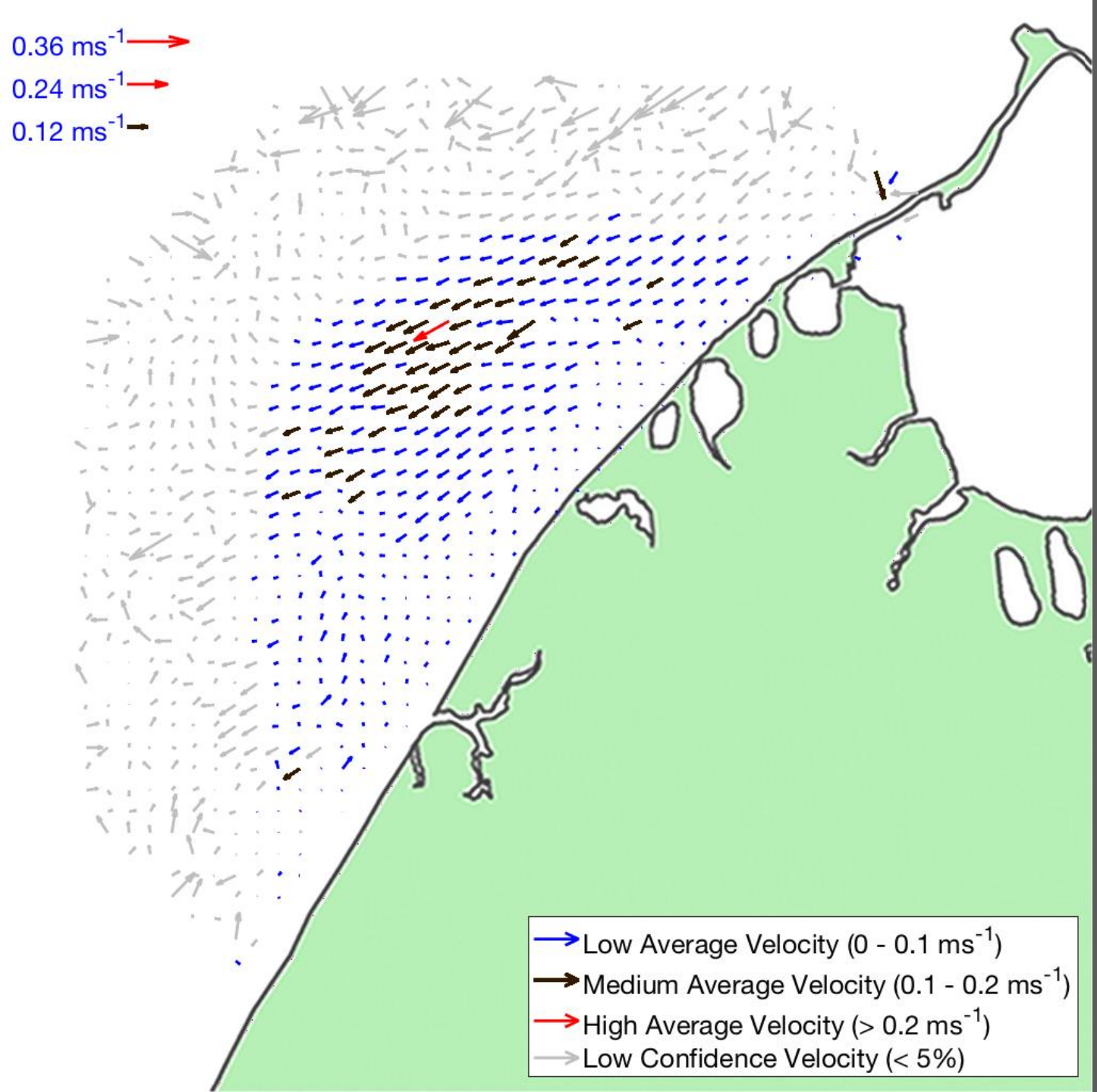
# Near-realtime sea ice velocity from ice radar

- Velocity calculated on 20 x 20 pixel grid (438 m)
- Combination of sparse and dense optical flow techniques
- Local “similarity filtering” used to exclude spurious results



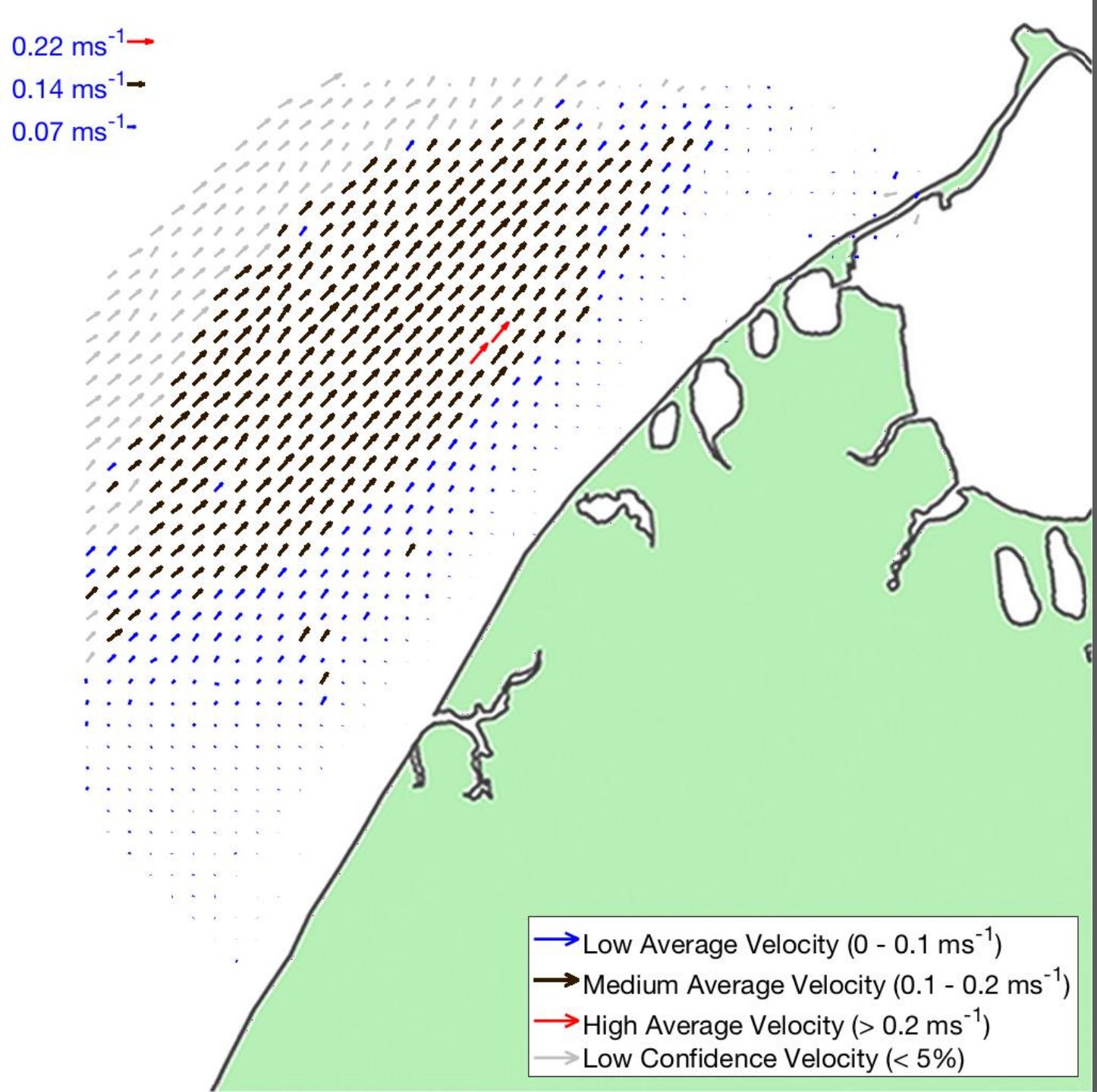

*MV, Rohith, et al. (2013), IEEE Transactions on Geoscience and Remote Sensing, 51(5), p2556-2570*

http://seaice.alaska.edu/gi/observatories/barrow_radar/sea-ice-velocity




*November mean (2007-2015) velocity field*

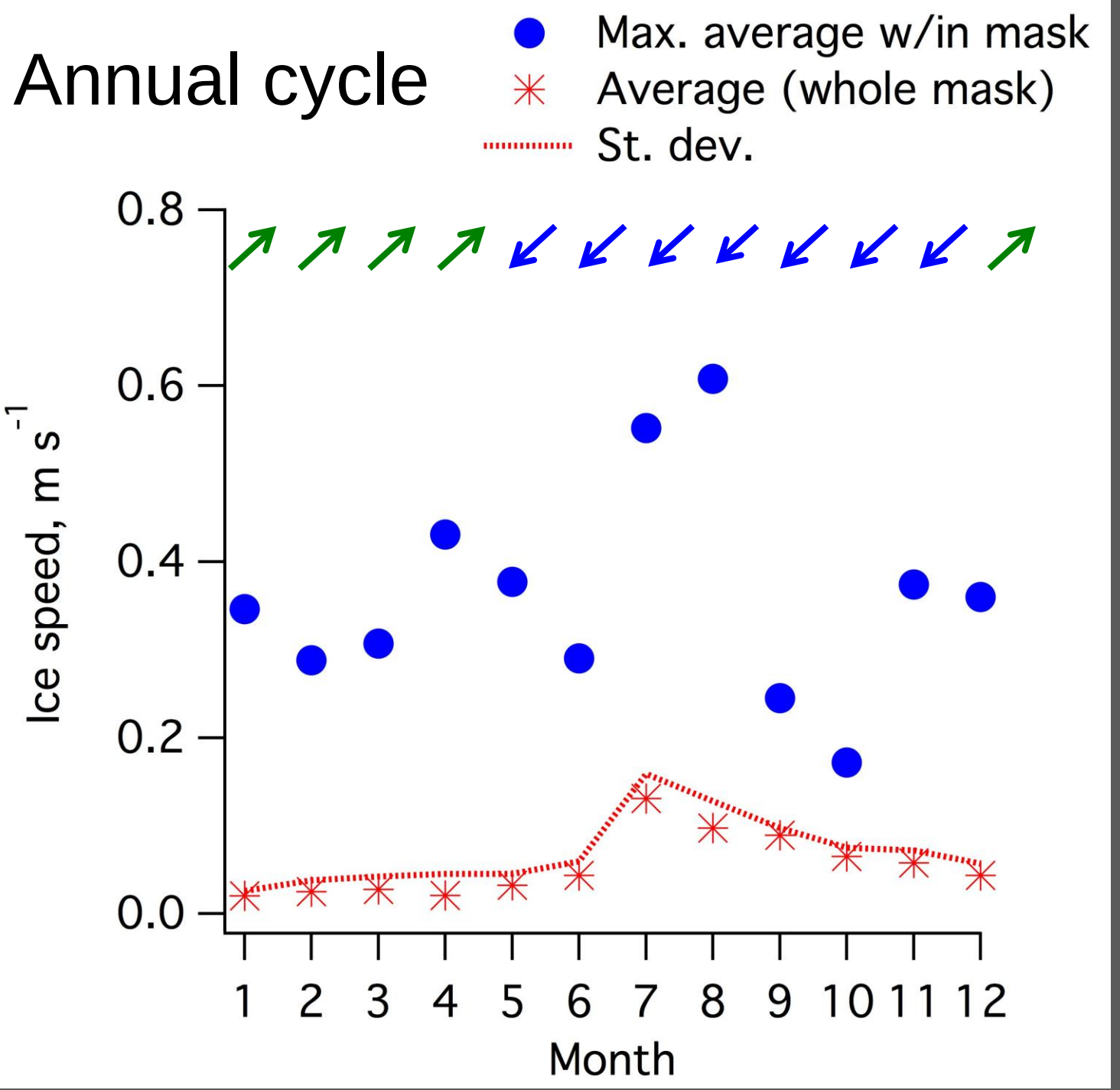
- Onset of stationary/landfast ice formation
- Anomalous ice motion events
- Prevailing drift from NE

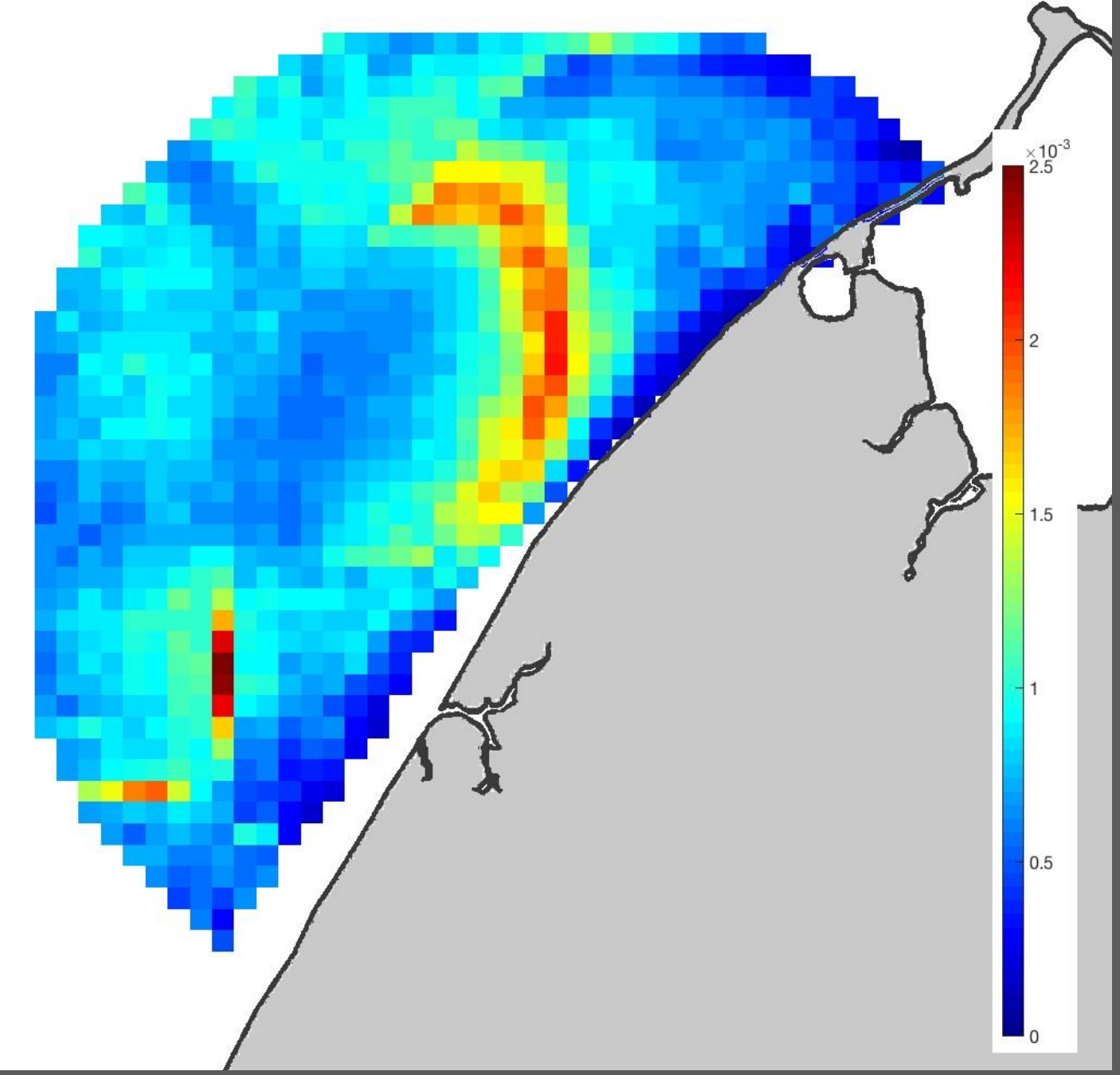



# *June mean (2007-2015) velocity field*

- Stable landfast ice
- Ice speed smaller than in November
- Prevailing drift from SW

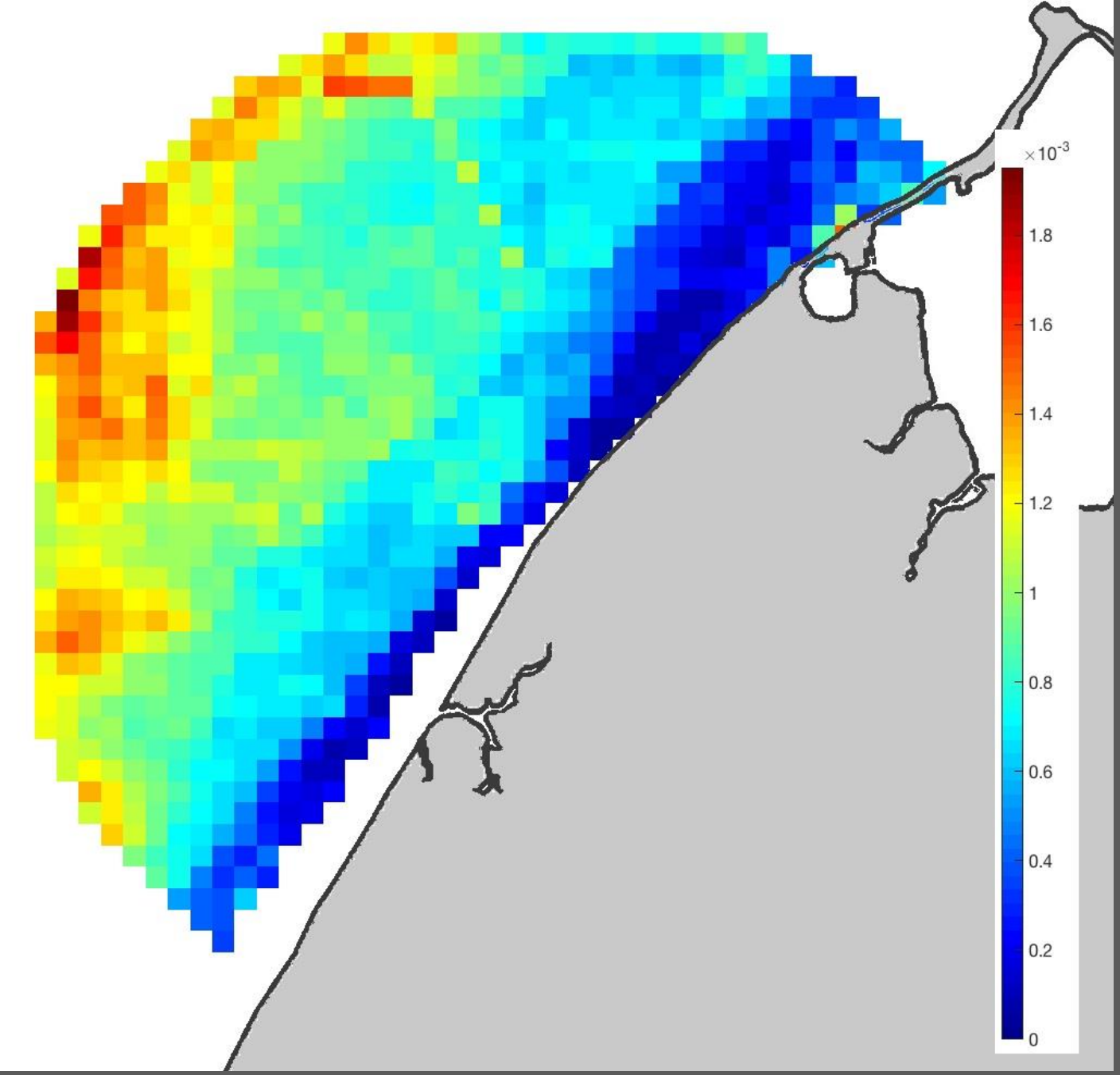
# Annual cycle






*November mean (2007-2015) divergence*

- Onset of stationary/landfast ice formation
- Anomalous ice motion events
- Prevailing drift from NE

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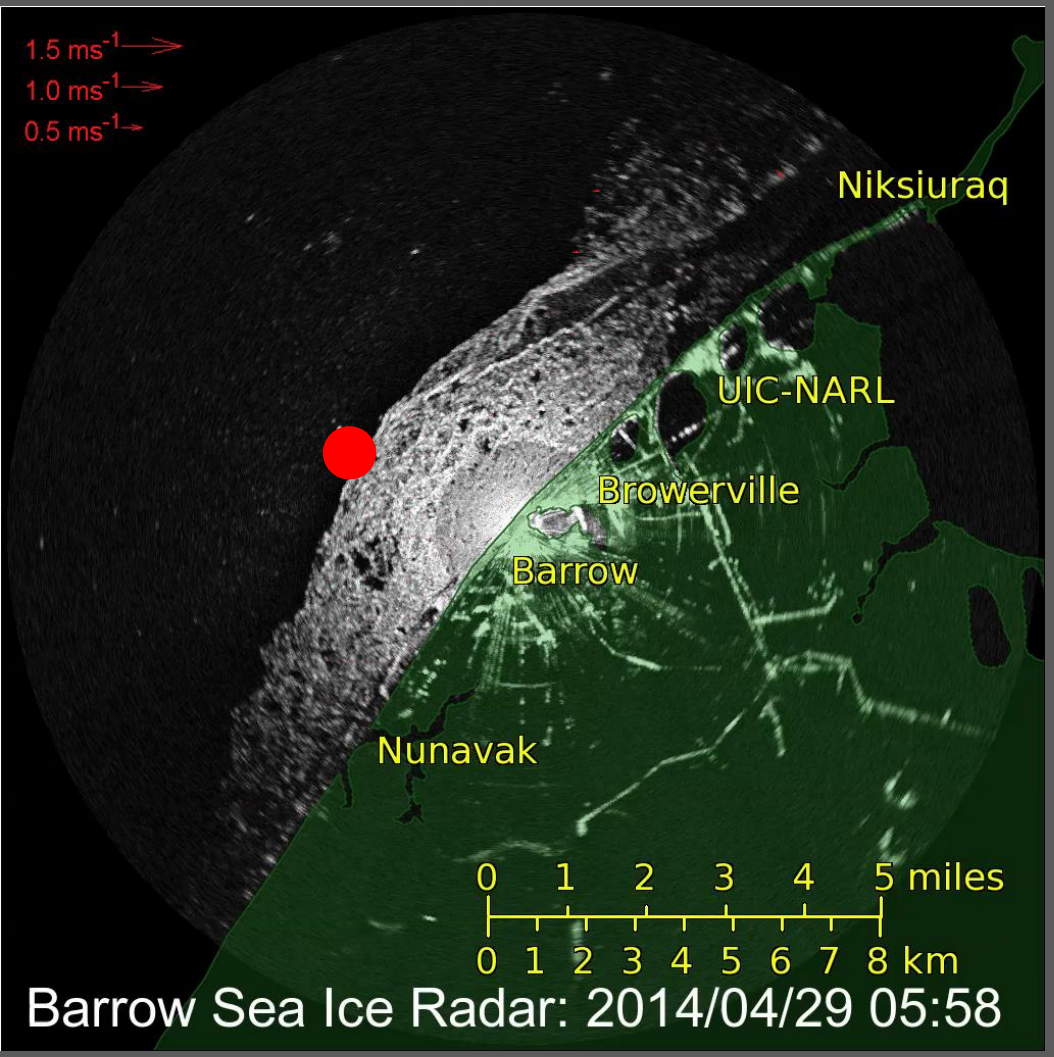
# Landfast ice break-out event & rescue - 29 April 2014

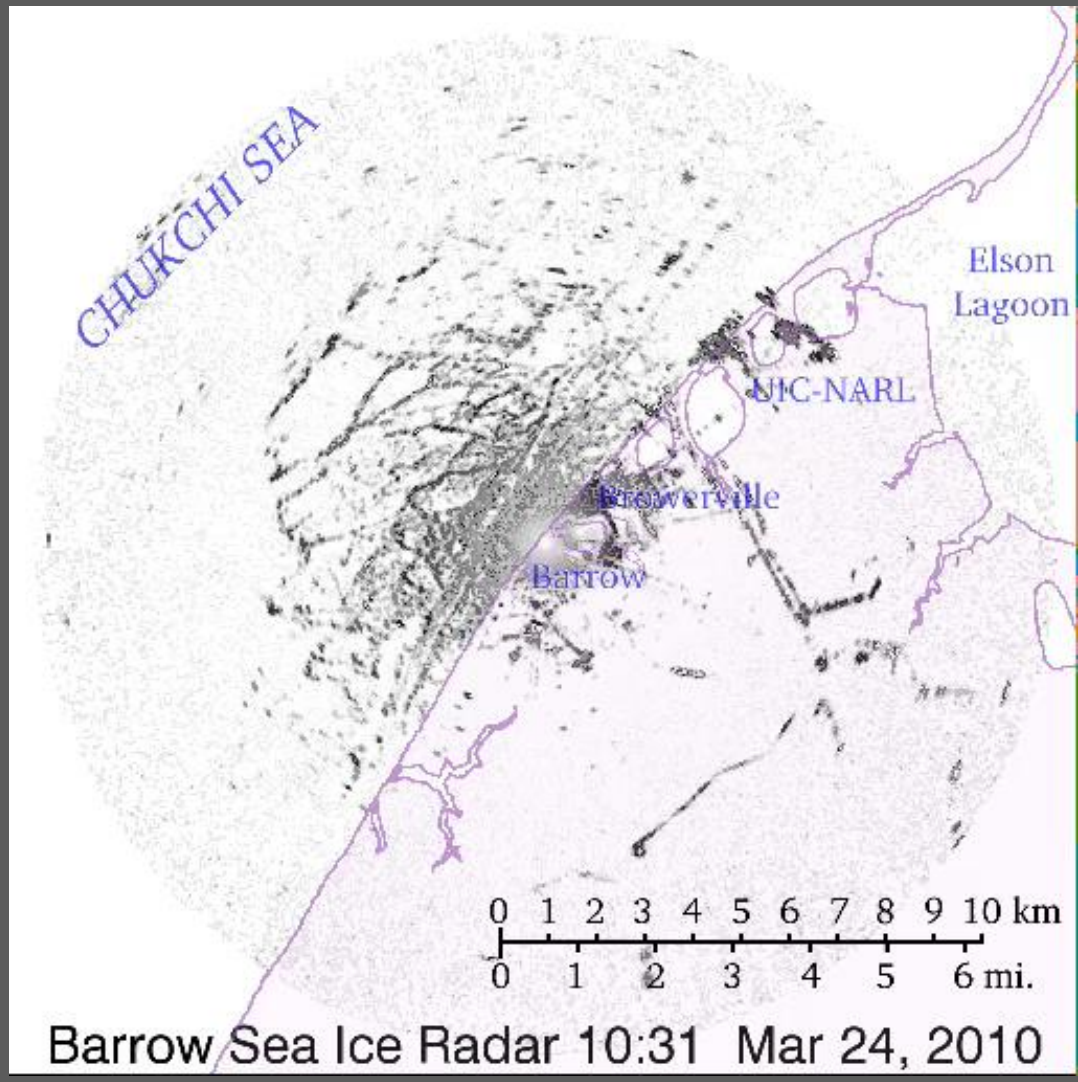



- Destabilization of shorefast ice as major hazard to communities & industry
- Use of radar data: Assess stability & track breakout, support evacuation & rescue
- Moored instrument deployments guided by research interests & local concerns

● Oceanographic mooring; Hokkaido University/UAF – Fukamachi, Oshima et al.

# Understanding causes of break-out events - March 2010

- Ice deformation can form grounded ridges - tracked with coastal radar
- Extent of grounded ridges provides insight into landfast ice strength
- Wind & current stress, sealevel & ocean temperature provide insight into causes of breakouts
- Collaboration with K.-I. Ohshima & Y. Fukamachi, Hokkaido U.




*Jones et al. (2016) Continental Shelf Research, 126:50–63*

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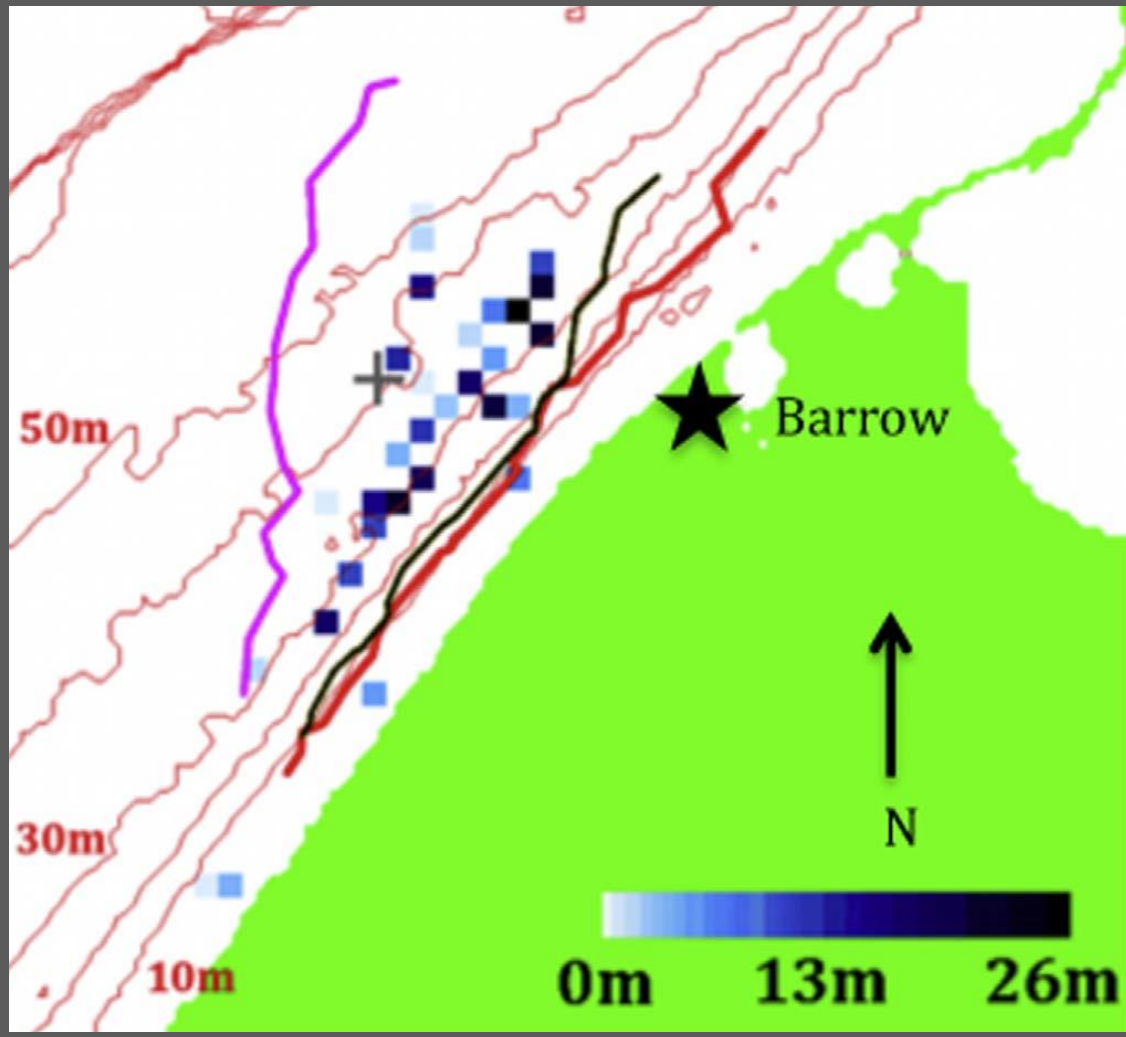
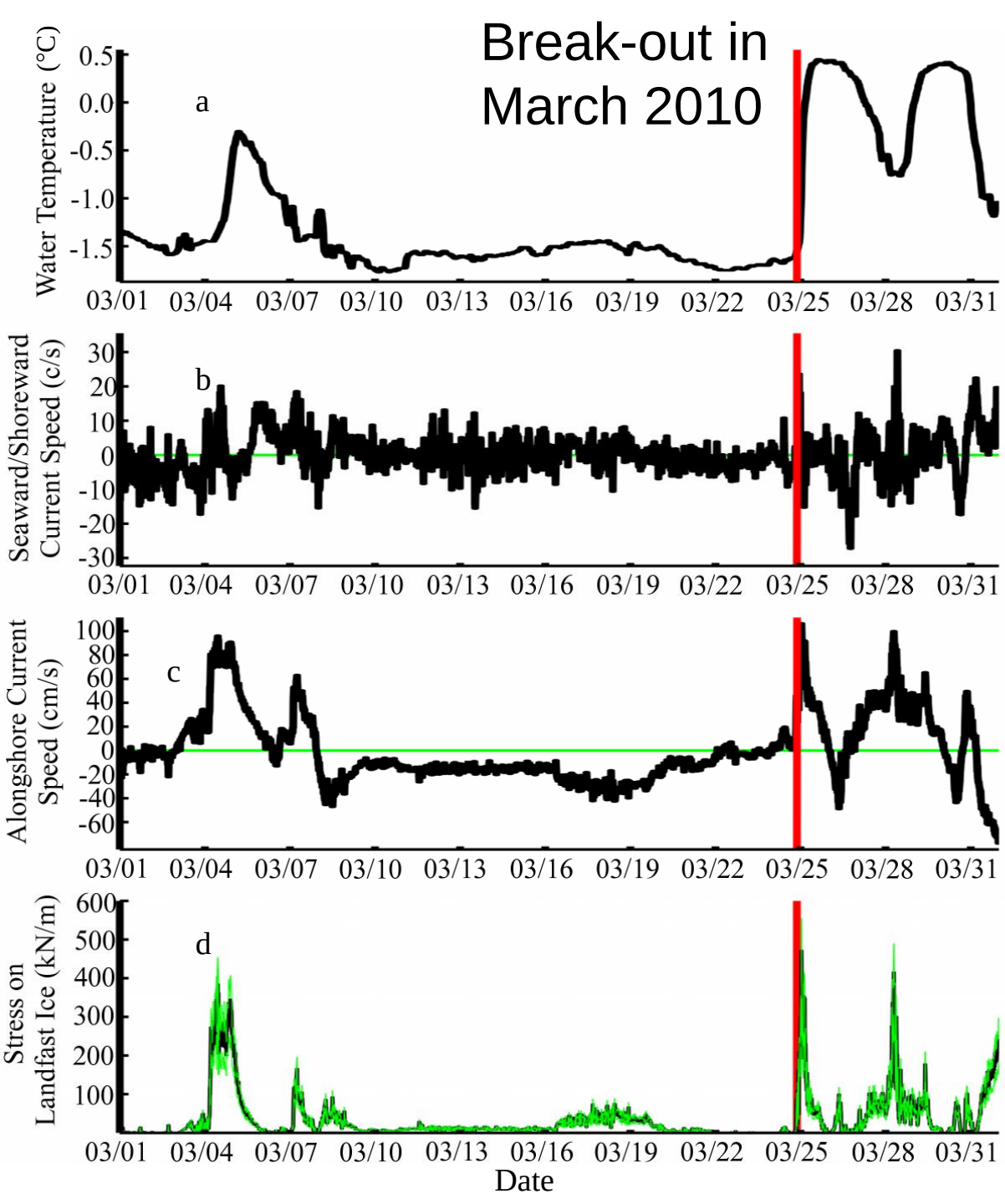
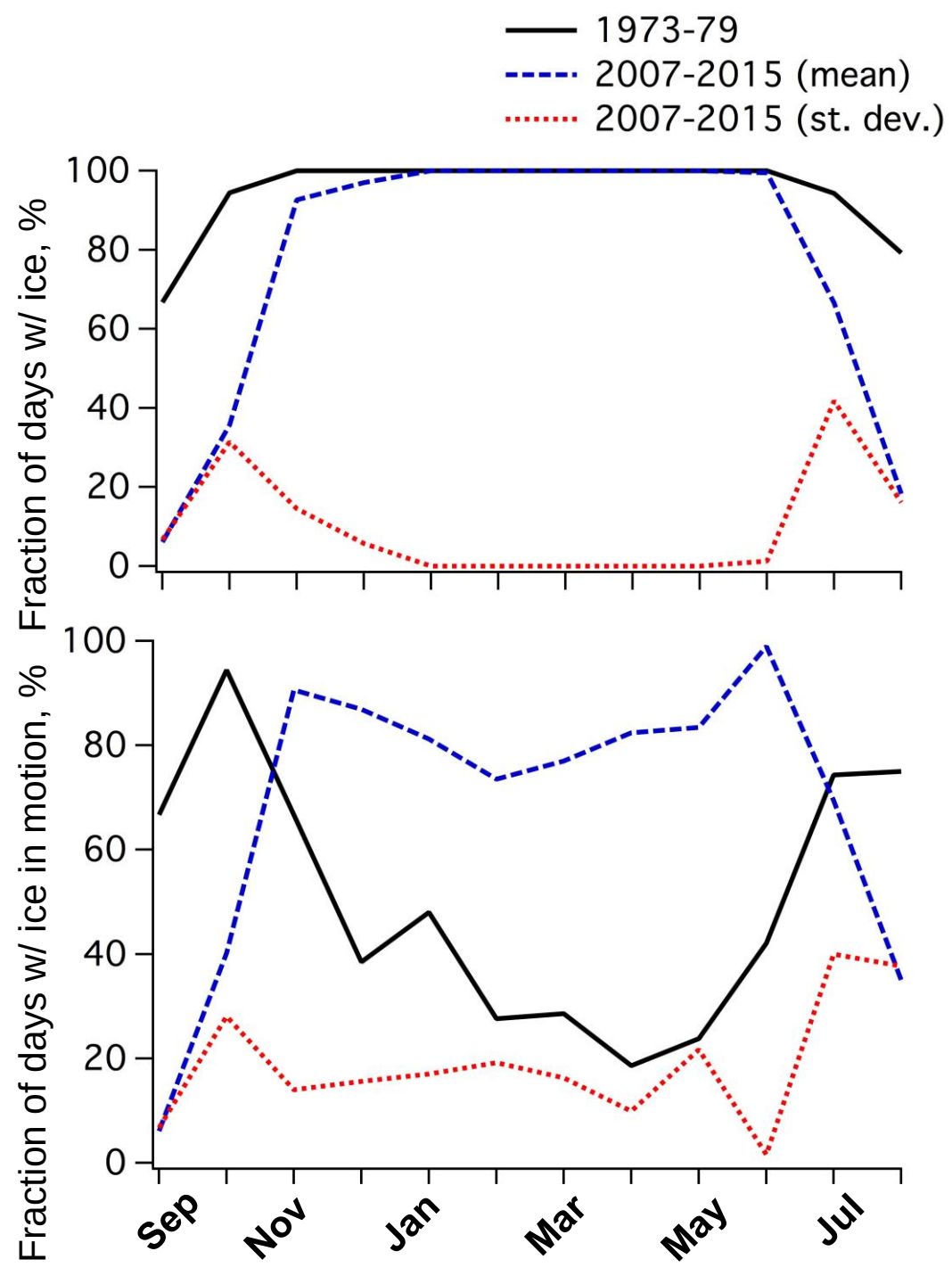



*Jones et al. (2016) Continental Shelf Research, 126:50–63*

- Grounded ridge density & anchor strength
- Ridge ungrounding: Preconditioning & bottom ablation

- Current stress
- Wind stress
- Pack-ice shorefast ice interaction

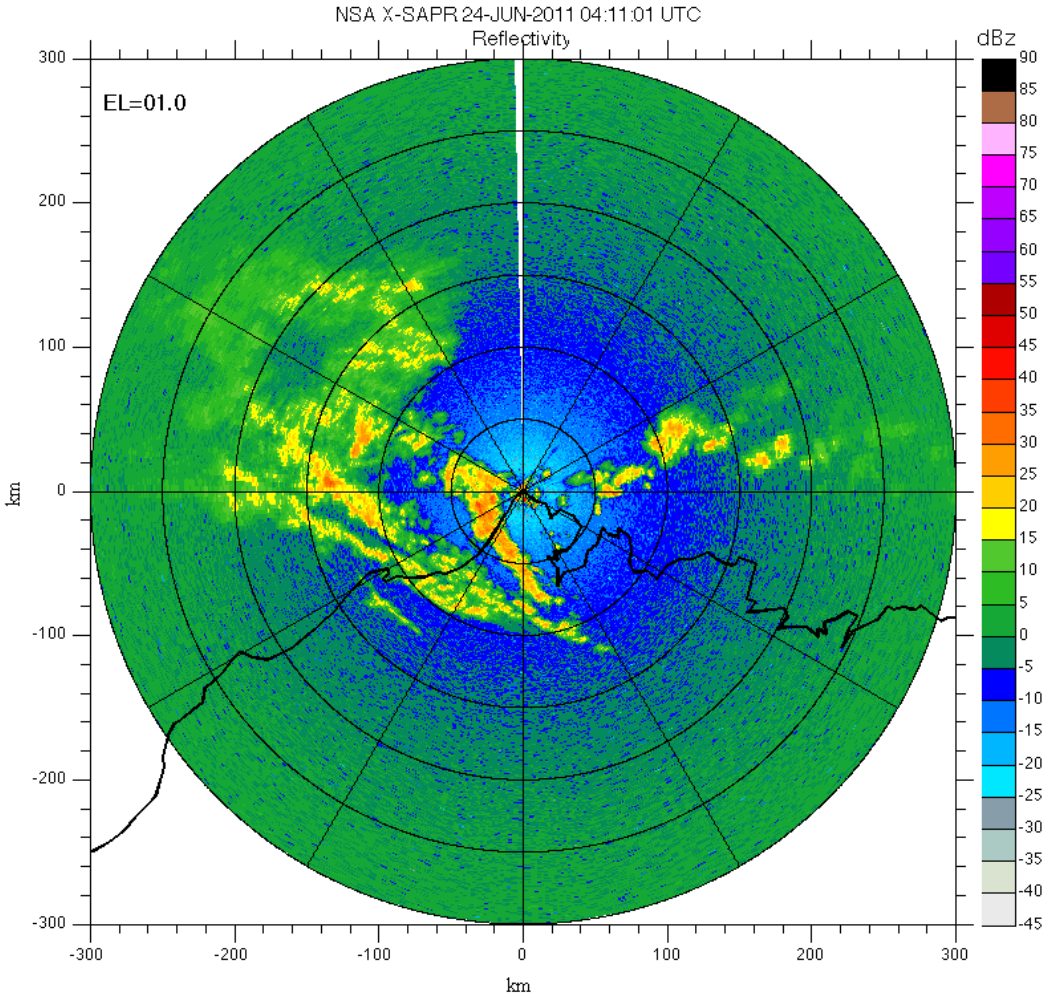





# Ice radar key points

- Cost-effective
- Information on short-term variability & long-term change in ice dynamics
- 00s & 10s coastal ice much more dynamic & less stable than 70s ice
- Hazard assessment & emergency response support

# Sea ice velocity fields from DOE Atmospheric Radiation Measurement (ARM) X-band radar?




- Low elevation X-band data from ARM XSAPR: Evaluate suitability to detect sea ice & derive velocity fields
- Greatly extended range

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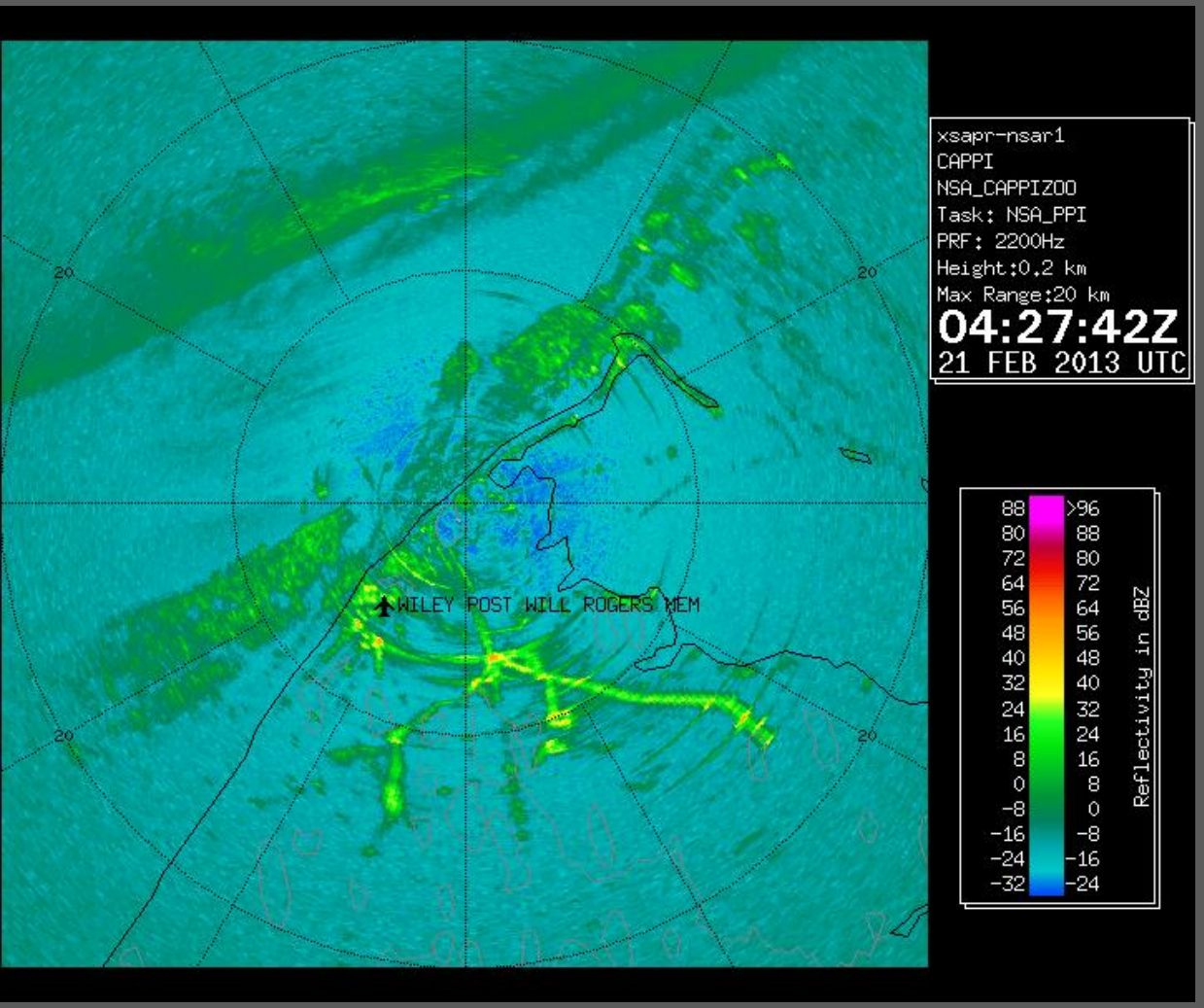


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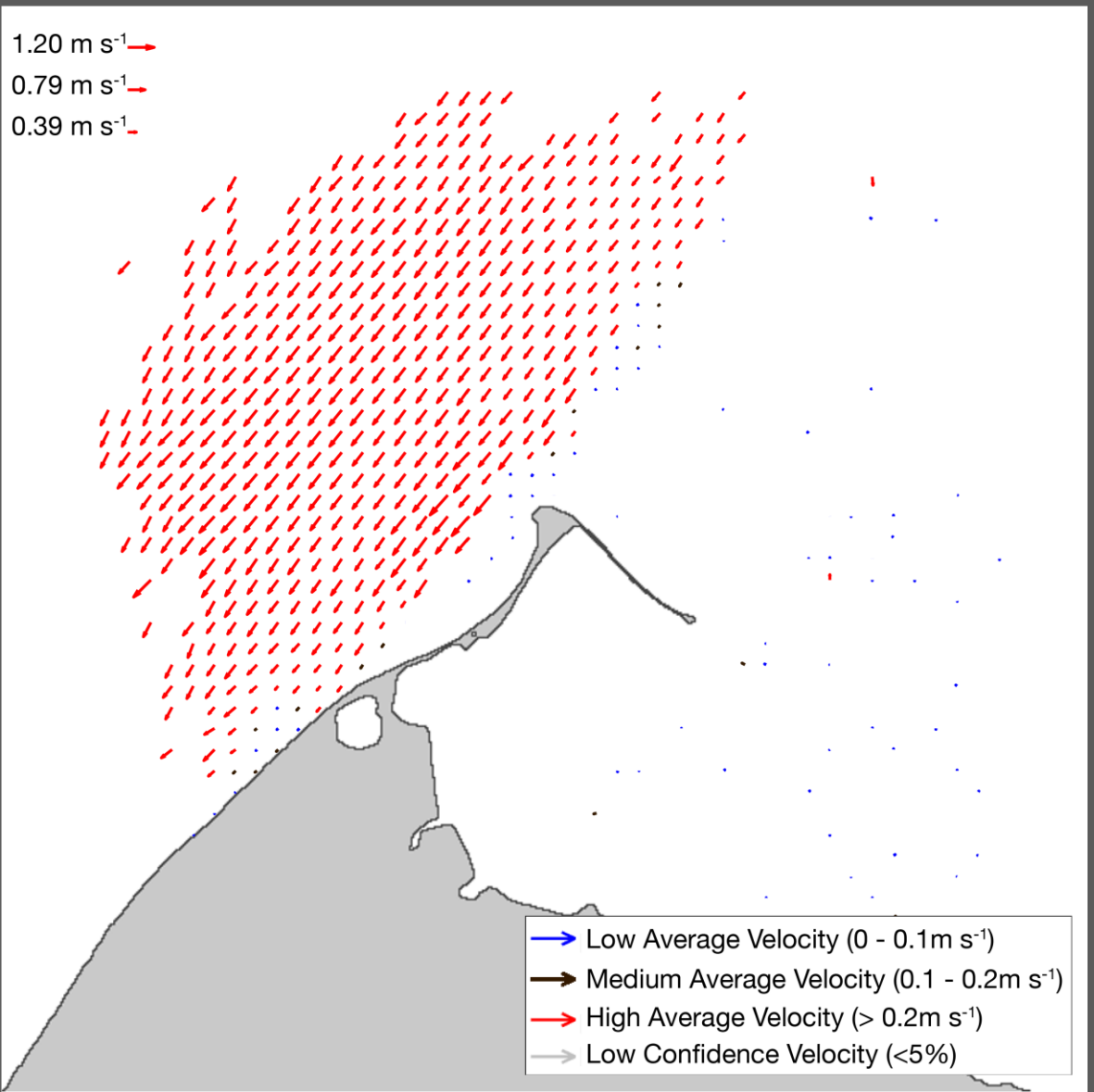


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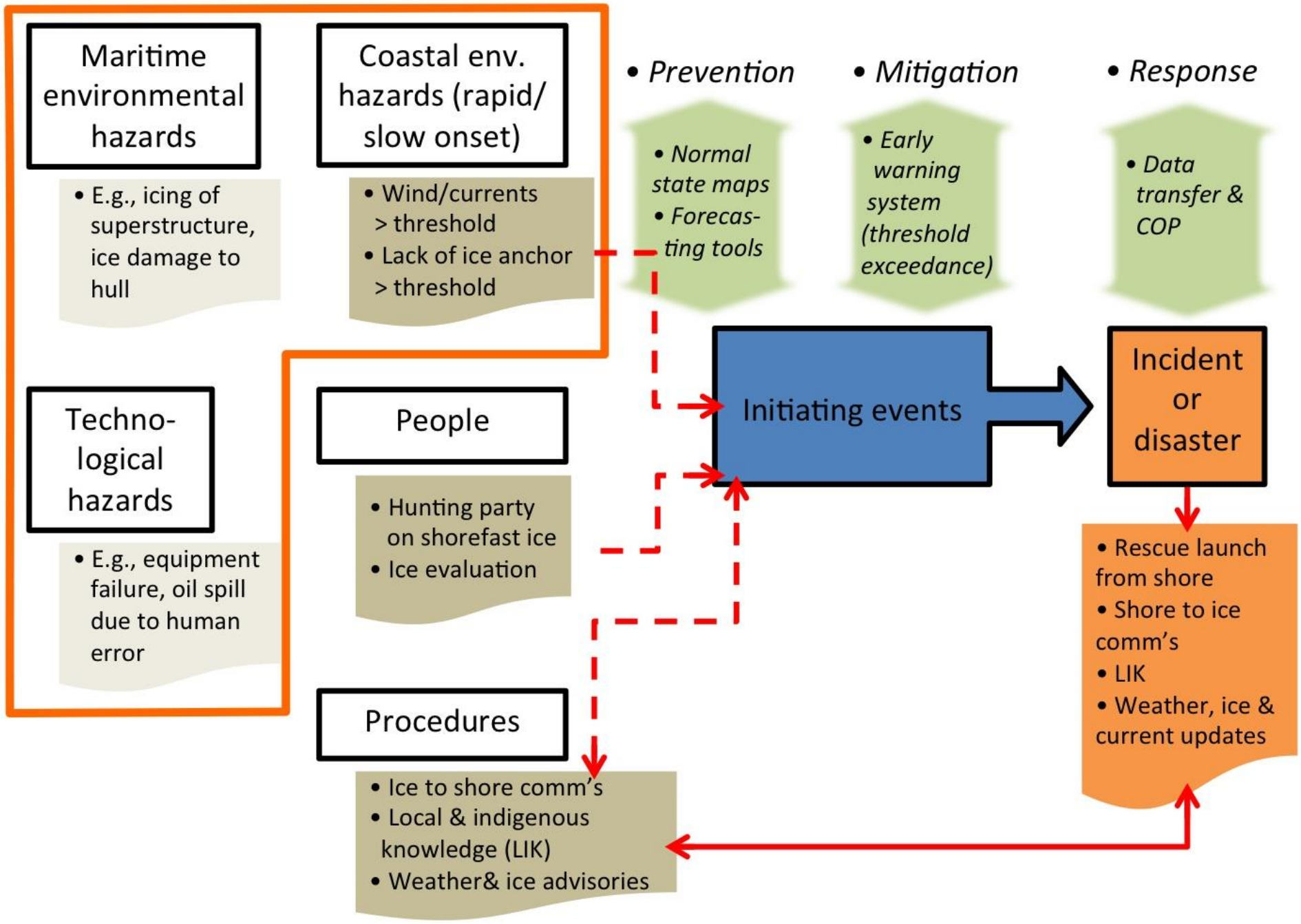
Maritime environmental hazards
• E.g., icing of superstructure, ice damage to hull
Coastal env. hazards (rapid/ slow onset)
• Wind/currents > threshold
• Lack of ice anchor > threshold
Techno-logical hazards
• E.g., equipment failure, oil spill due to human error
People
• Hunting party on shorefast ice
• Ice evaluation
Procedures
• Ice to shore comm's
• Local & indigenous knowledge (LIK)
• Weather& ice advisories
• Prevention
• Normal state maps
• Forecas-ting tools
• Mitigation
• Early warning system (threshold exceedance)
• Response
• Data transfer & COP
Initiating events
Incident or disaster
• Rescue launch from shore
• Shore to ice comm's
• LIK
• Weather, ice & current updates