Welcome

ARCUS Arctic Research Seminar Series

"Observations and Predictions for Arctic Sea-Ice Use: Perspectives from Coastal Alaska"

30 November 2016

Presented by Hajo Eicken
University of Alaska Fairbanks

#arcuswebinar

Observations & predictions for Arctic sea-ice use

Perspectives from coastal Alaska

A. Mahoney

E.J. Stewart

Hajo Eicken

International Arctic Research Center

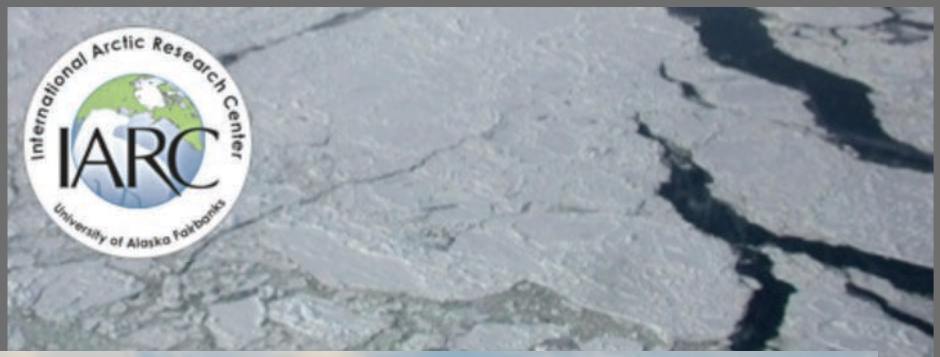
University of Alaska Fairbanks

Fairbanks, AK, USA

e-mail: heicken@alaska.edu

www.iarc.uaf.edu

Observations & predictions for Arctic sea-ice use



In collaboration with A.R. Mahoney, J.M. Jones, D.O. Dammann, M. Druckenmiller, M.A. Johnson, O. A. Lee, M.R. Kaufman; K.-I. Ohshima, Y. Fukamachi (Hokkaido University) & collaborators in coastal AK communities

A. Mahoney

E.J. Stewart

SIPN Sea Ice Prediction Network

NSF

UAF University of Alaska Fairbanks

ARCTIC DOMAIN AWARENESS CENTER
A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE

Observations & predictions for Arctic sea-ice use

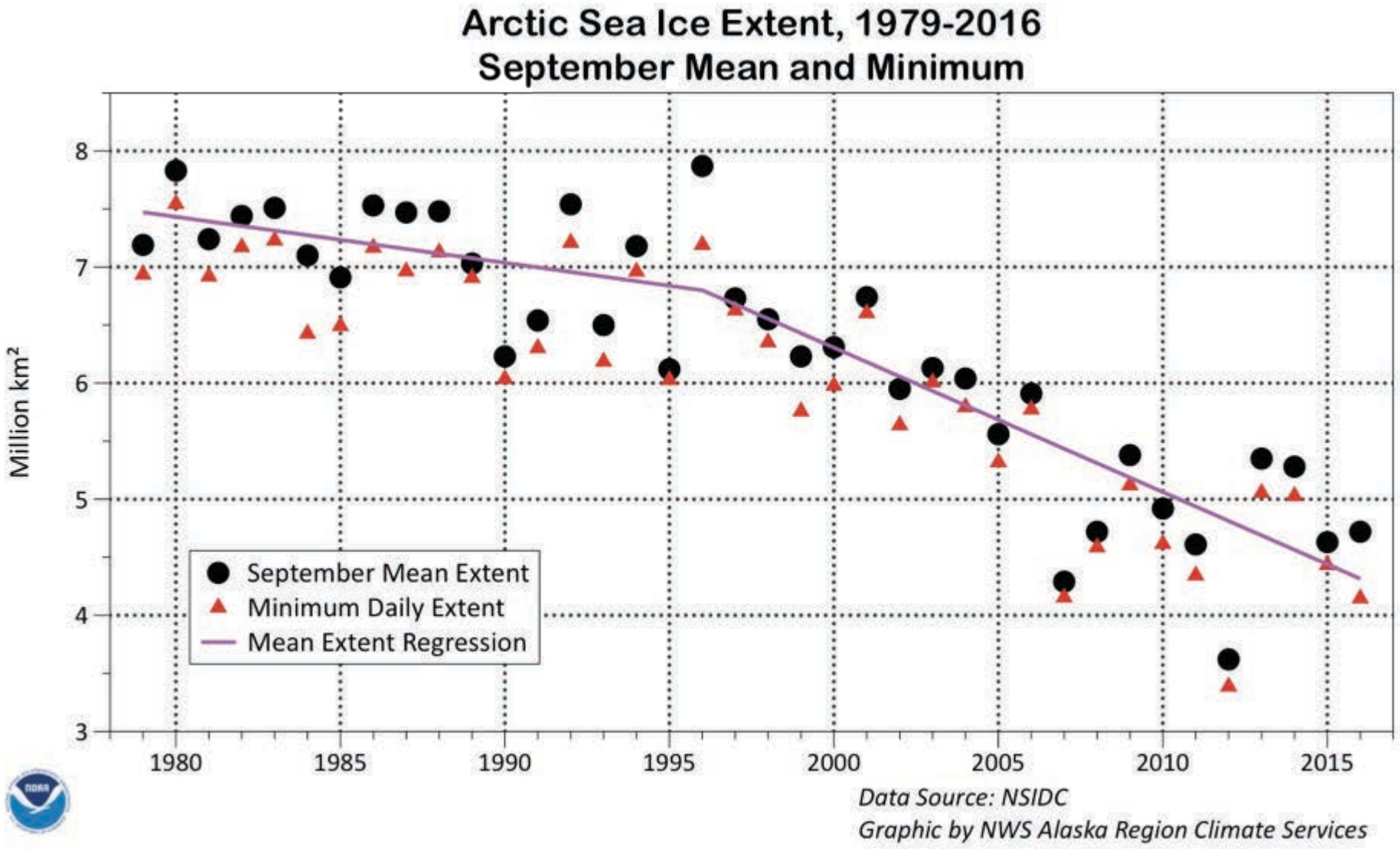

A. Mahoney

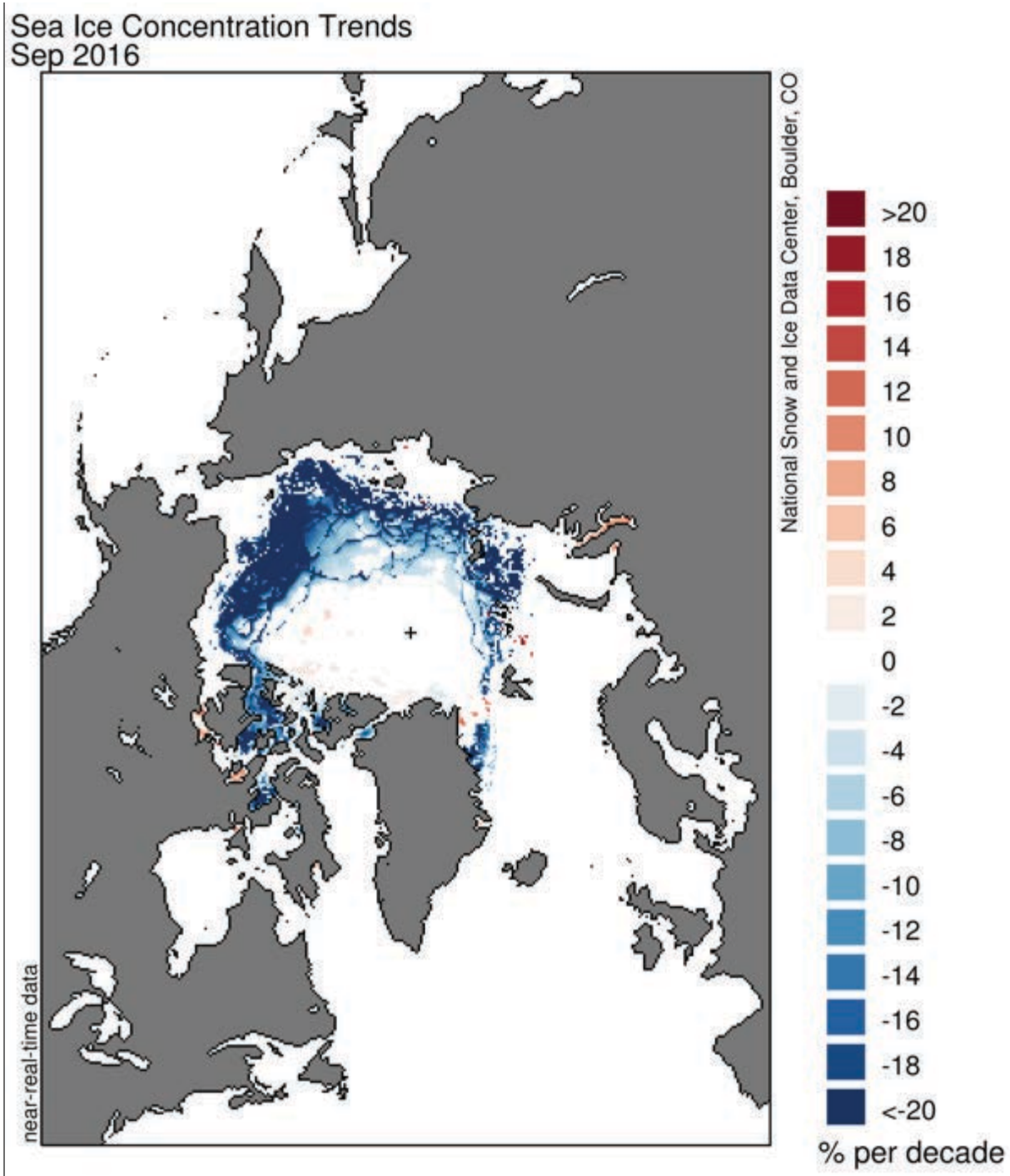

E.J. Stewart

- *Ice use & associated information needs*
- Ice seasonality
- Ice stability
  - Observable/predictand variables linked to ice use
  - Integrated observations & predictions
- Co-Management
  - Communication & knowledge transfer
  - Communities of Practice

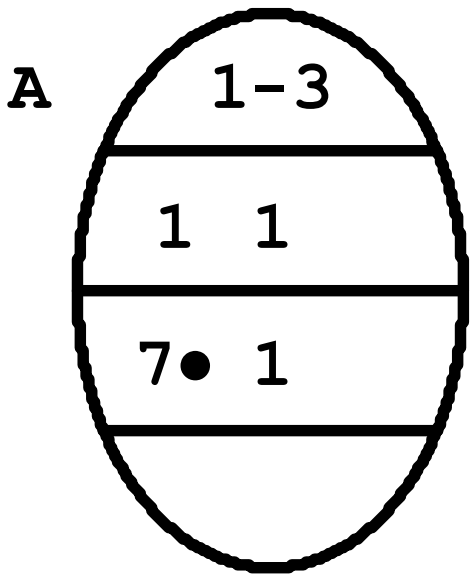
UAF UNIVERSITY OF ALASKA FAIRBANKS

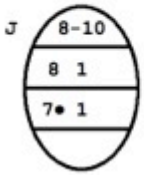
Transitioning into a new sea-ice regime

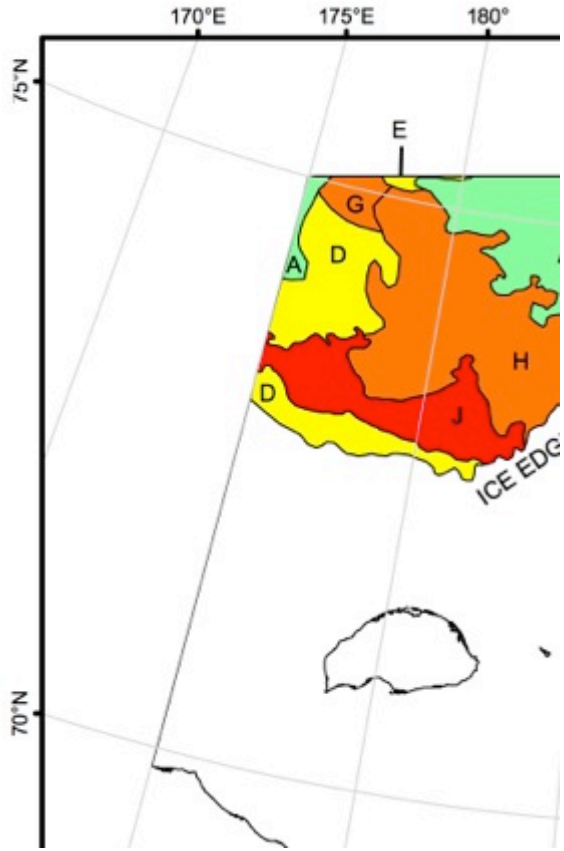


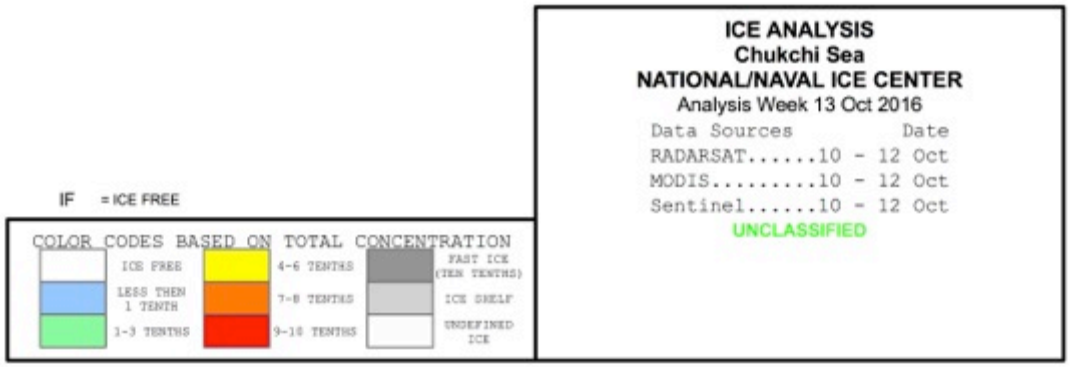


- Large swath of reduced ice concentation in Pacific Arctic sector
- Impacts on coastal communities & infrastructure
- Increased ice velocities & remaining ice hazards present old & new challenges



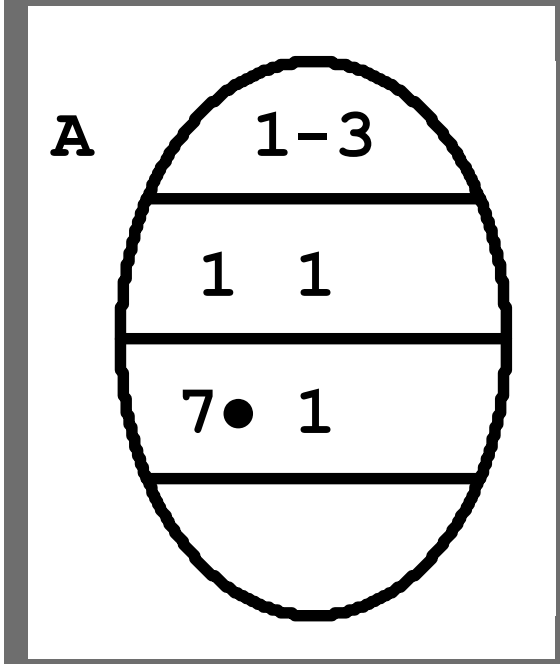






Information products & ice use: The Egg code

- Mature information product refined for target audience
- Ice categories (observables) relate to ice hazards
- Format addresses predominant means of communication



Egg code: ice concentration, thickness/stage & floe size by type

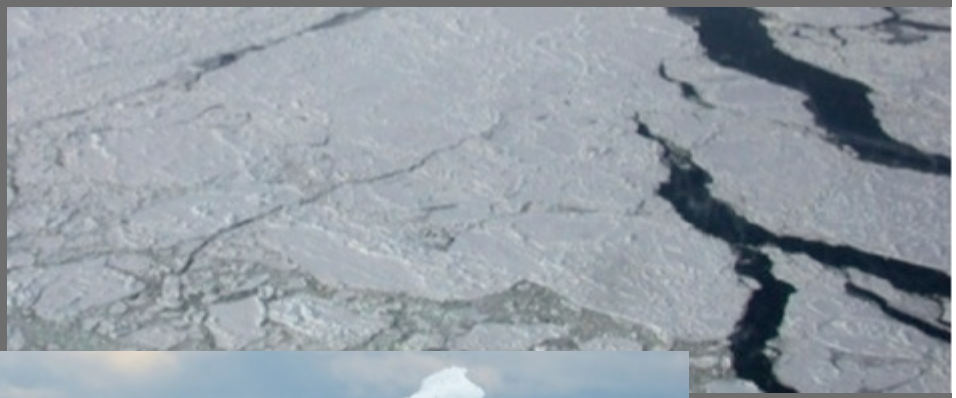
?

Ice conditions, ice uses & users, and ice hazards are evolving in a rapidly changing Arctic:

What comes after the egg code?

Arctic (Marine) System Services

Regulating services
- Ice-albedo & GHG feedbacks (climate regulation)
- Thermo-haline circulation
- Sealevel



Supporting services
- Marine/ice foodwebs
- Biodiversity

Provisioning services
- Source of food (commercial & subsistence)
- Transportation corridor

Cultural services
- Subsistence activities
- Cultural landscape (incl. tourism)

Eicken et al. (2009) Arctic

Sea-ice system services, ice use & ice hazards

- Sea ice provides services & hazards to people from the global to the local scale
- Slow onset
  - Climate regulation
  - Coastal protection
  - Geologic agent
  - Subsistence activities
- Rapid onset
  - Marine & coastal hazard
  - Transportation corridor
  - Platform

C. Nayokpuk, Shishmaref

Masterson

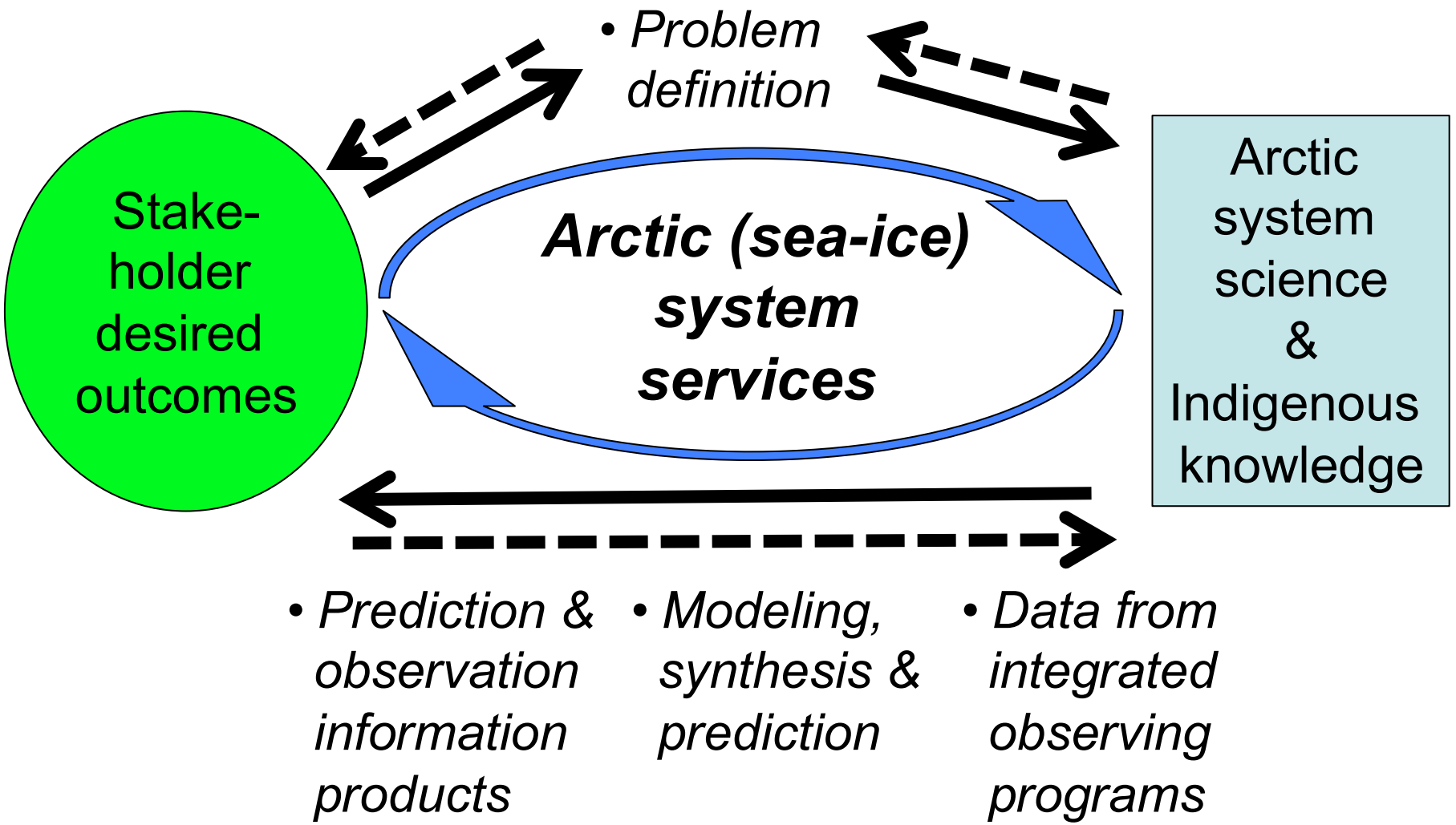
Sea-ice system services, ice use & ice hazards

- What sea-ice properties & processes are relevant to key ice users?
- How do these relate to sea-ice mass-balance and climate data variables?
- What is the range of interannual variability and what are longer-term trends in ice use variables?
- Focus on sea-ice use by Alaska coastal communities and industry

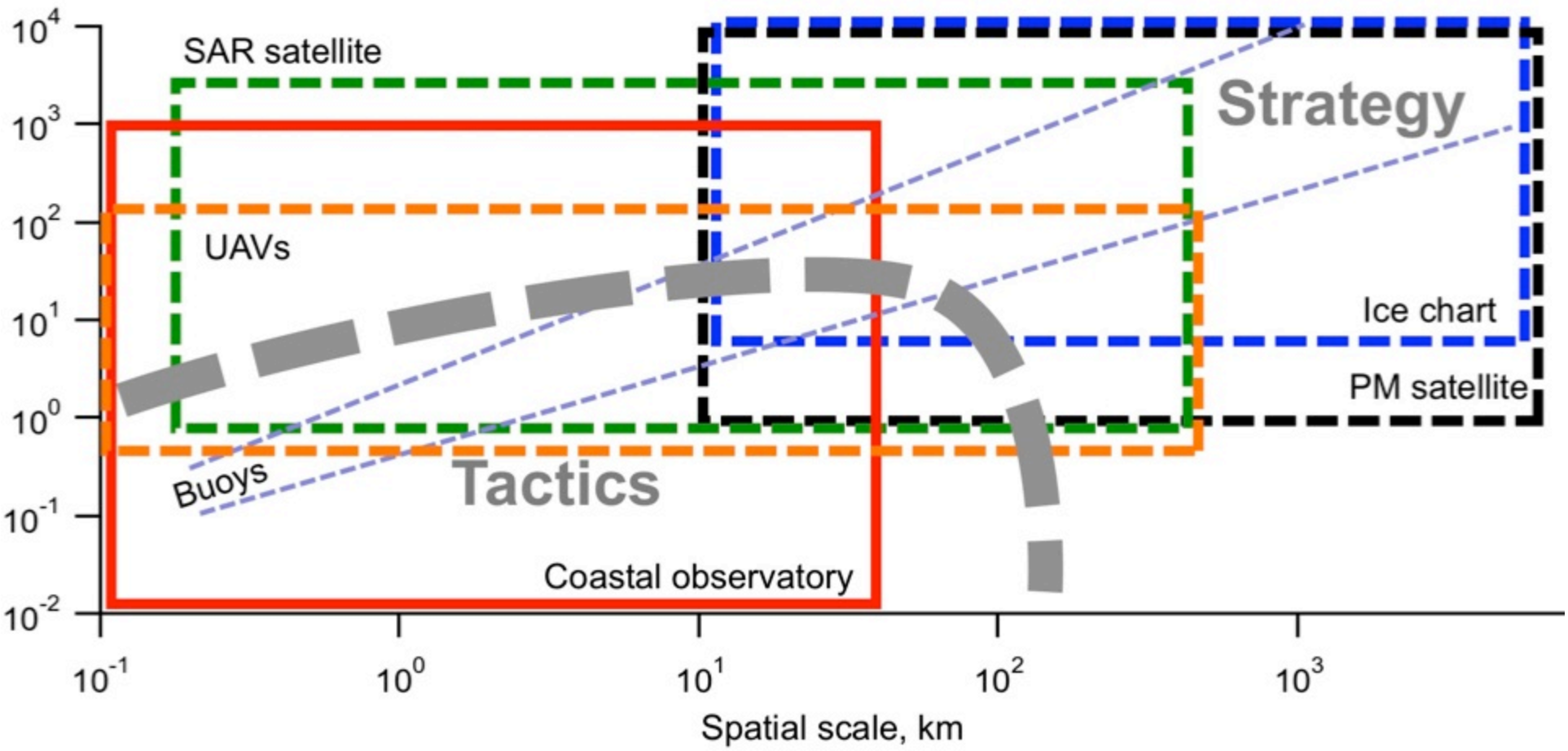
C. Nayokpuk, Shishmaref

Masterson

Responding to rapid Arctic change



Relevant spatial & time scales



Eicken et al., 2011, Marine Technol. Soc. J.

Observations & predictions for Arctic sea-ice use


A. Mahoney


E.J. Stewart

UAF UNIVERSITY OF ALASKA FAIRBANKS

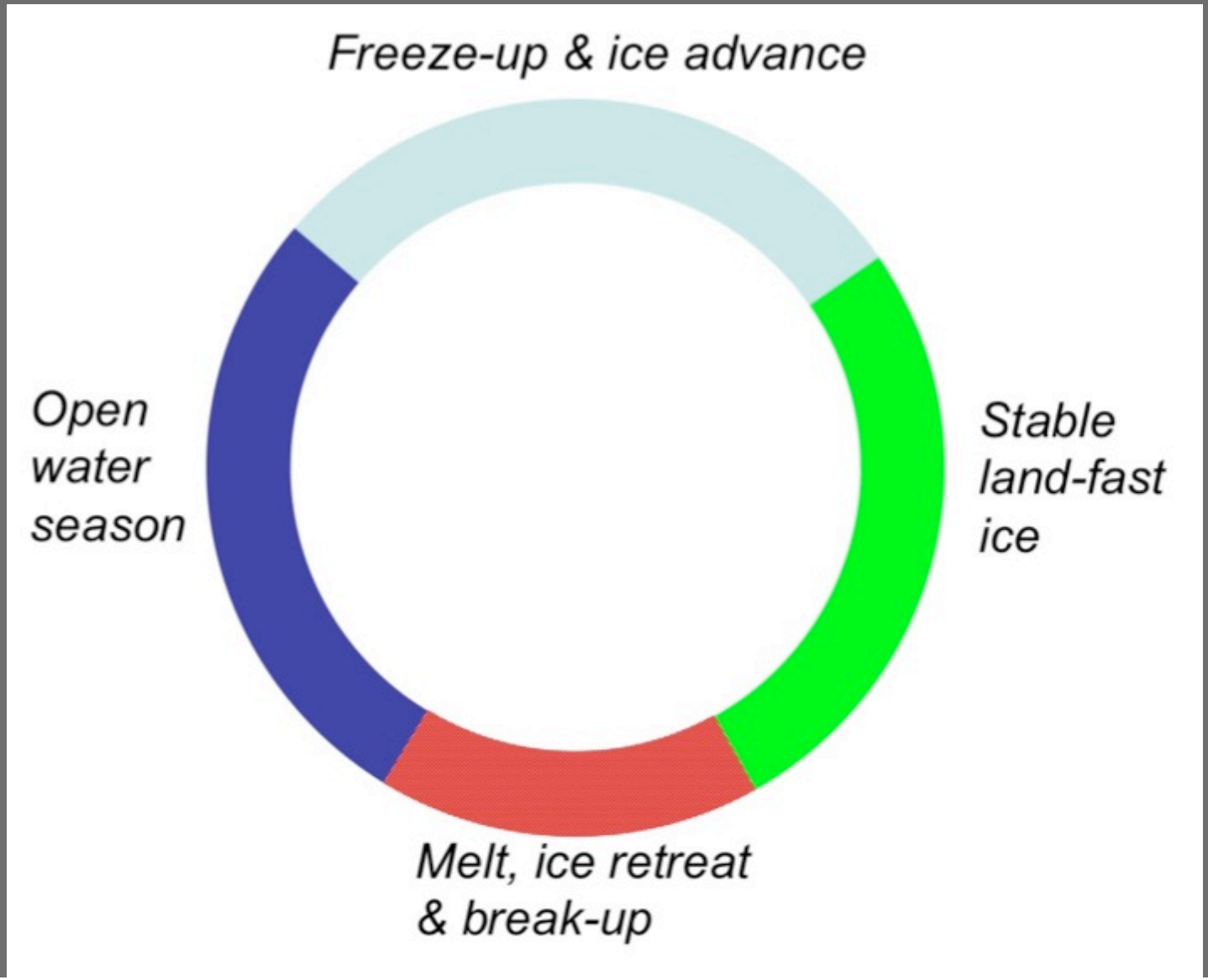
- Ice use & associated information needs
- *Ice seasonality*
- Ice stability
  - Observable/predictand variables linked to ice use
  - Integrated observations & predictions
- Co-Management
  - Communication & knowledge transfer
  - Communities of Practice

Open water & ice use windows: Freeze-up & break-up

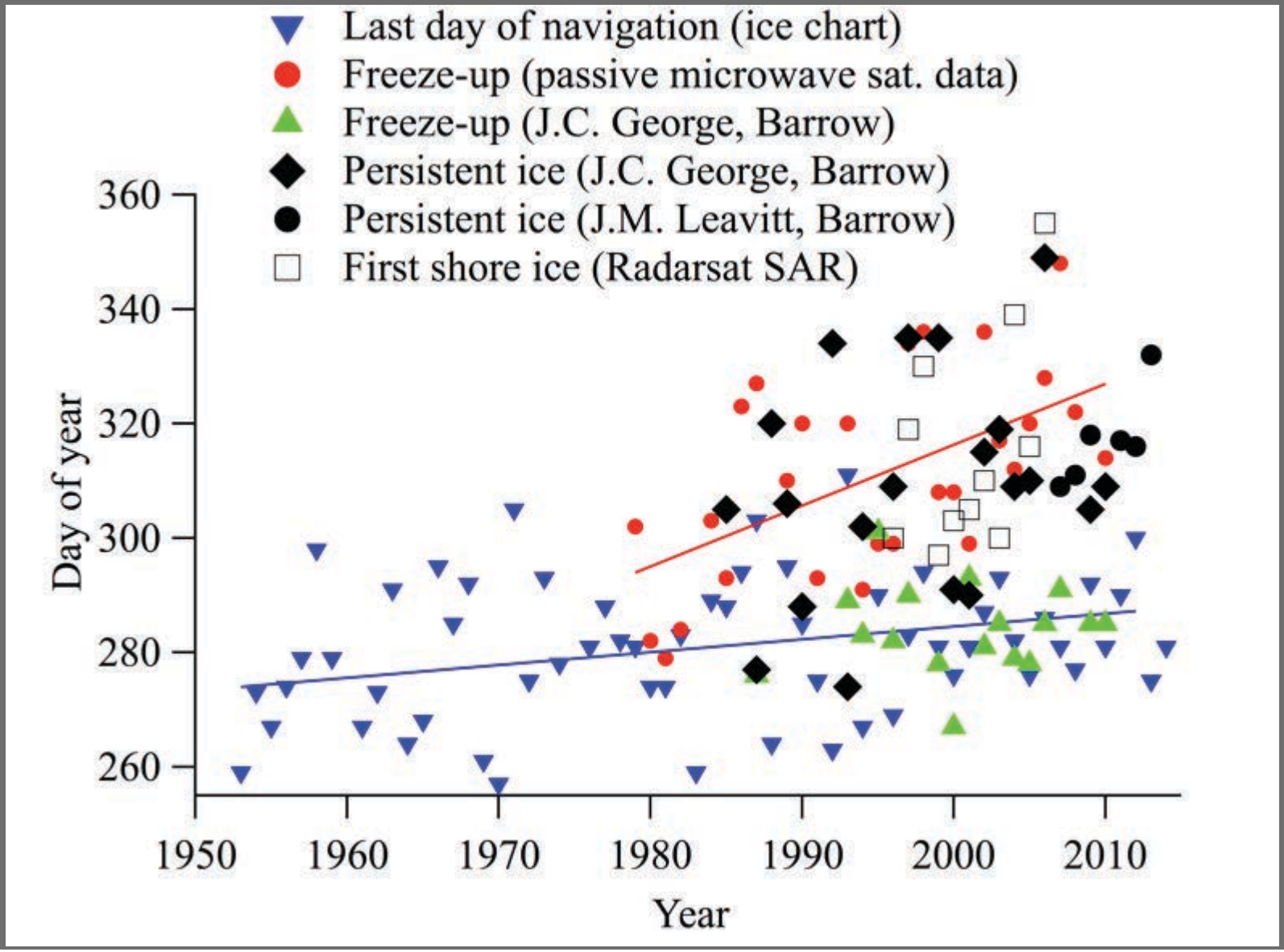
- Window of open water & ice use broadly defined by freeze-up & break-up
- Operations both threatened (e.g., shipping) & supported (e.g., subsistence, ice roads) by ice

- Defining, tracking & predicting windows for safe operations involves requires collaboration between ice users, researchers, local/Indigenous experts

Seasonal ice cycle

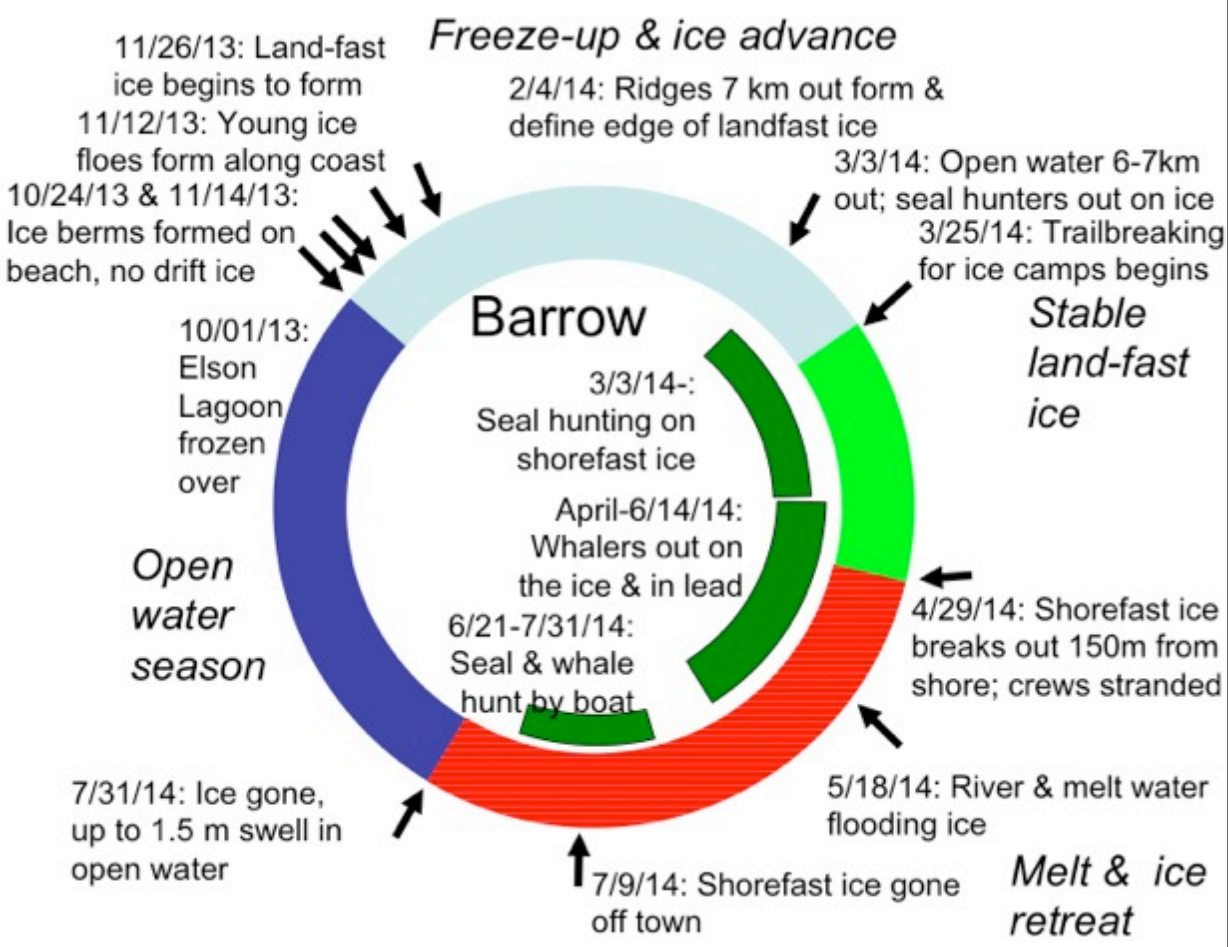


Freeze-up & first persistent ice – Barrow region



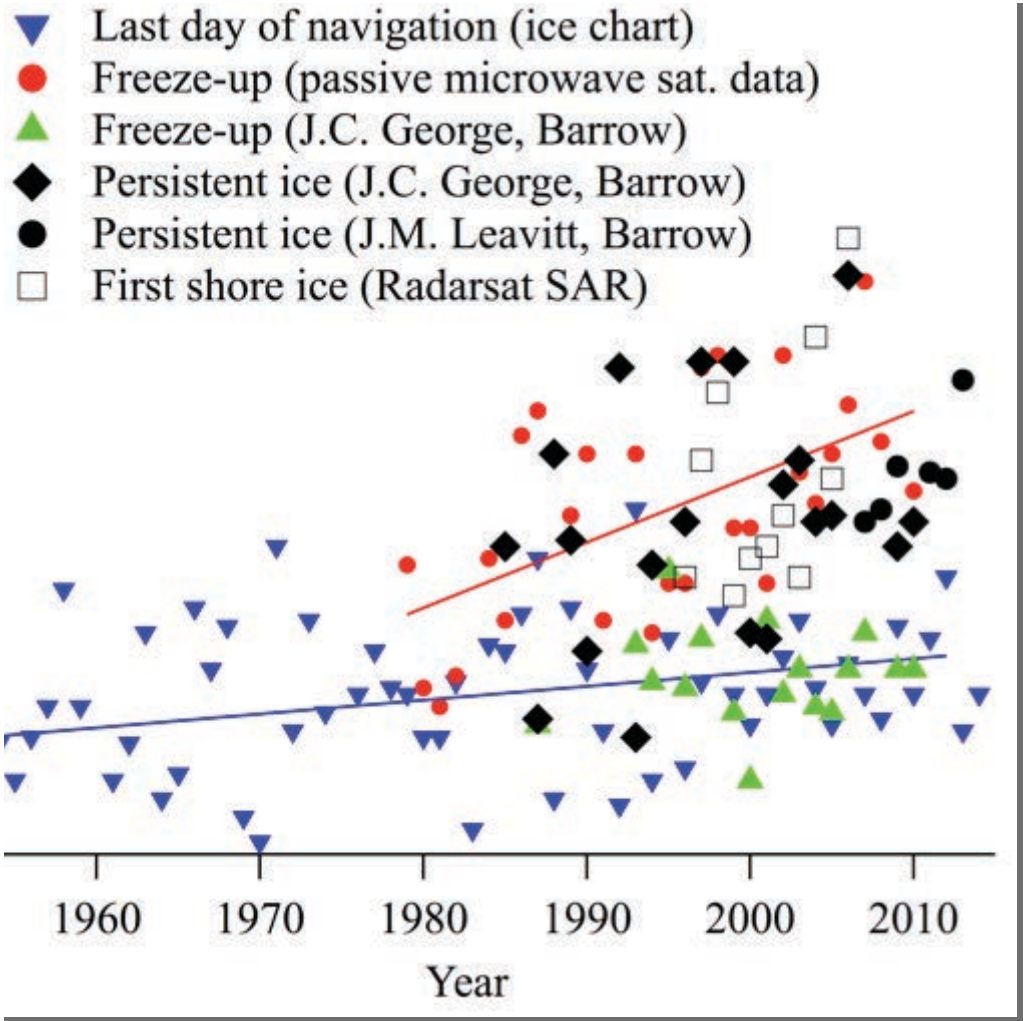
Johnson & Eicken, Elementa, 2016

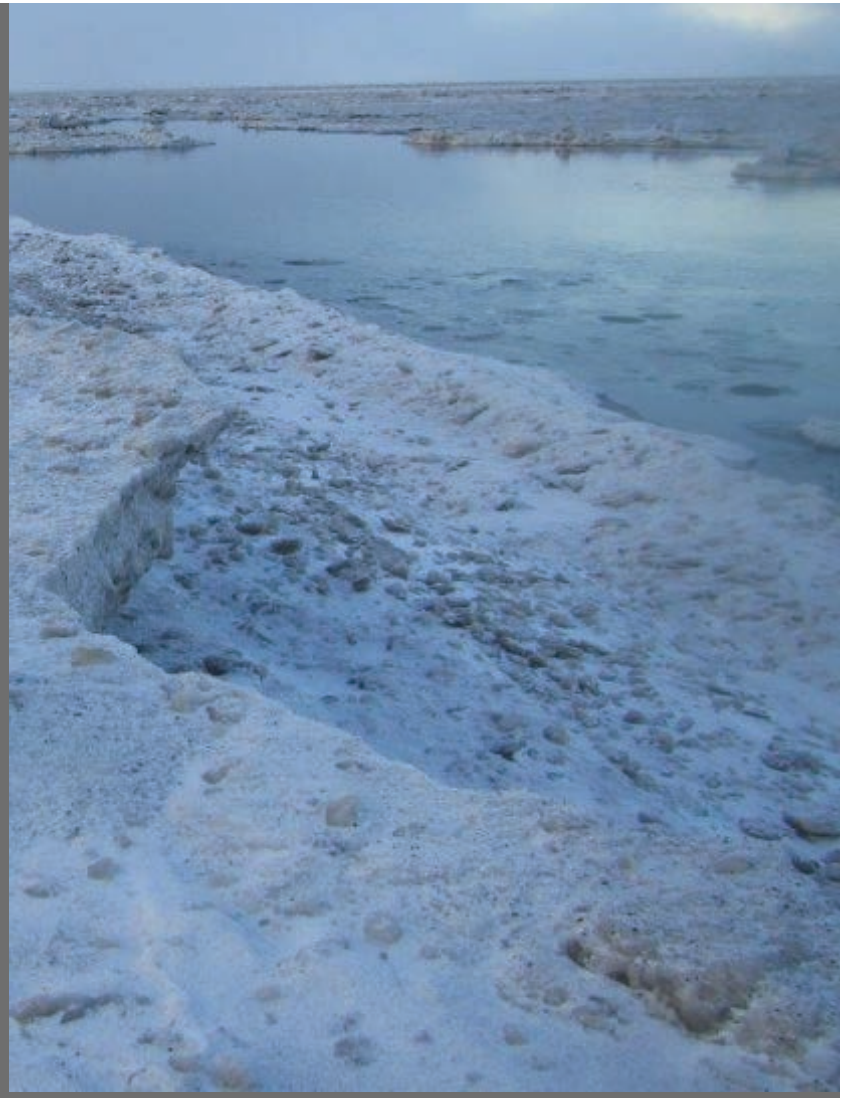
Alaska Indigenous ice experts: Changes in seasonal ice cycle – later freeze-up, earlier break-up, ice less stable



Community expert observations (>5000 daily logs)
https://eloka-arctic.org/sizonet

Eicken et al., Polar Geogr., 2014; http://dx.doi.org/10.1080/1088937X.2013.873090





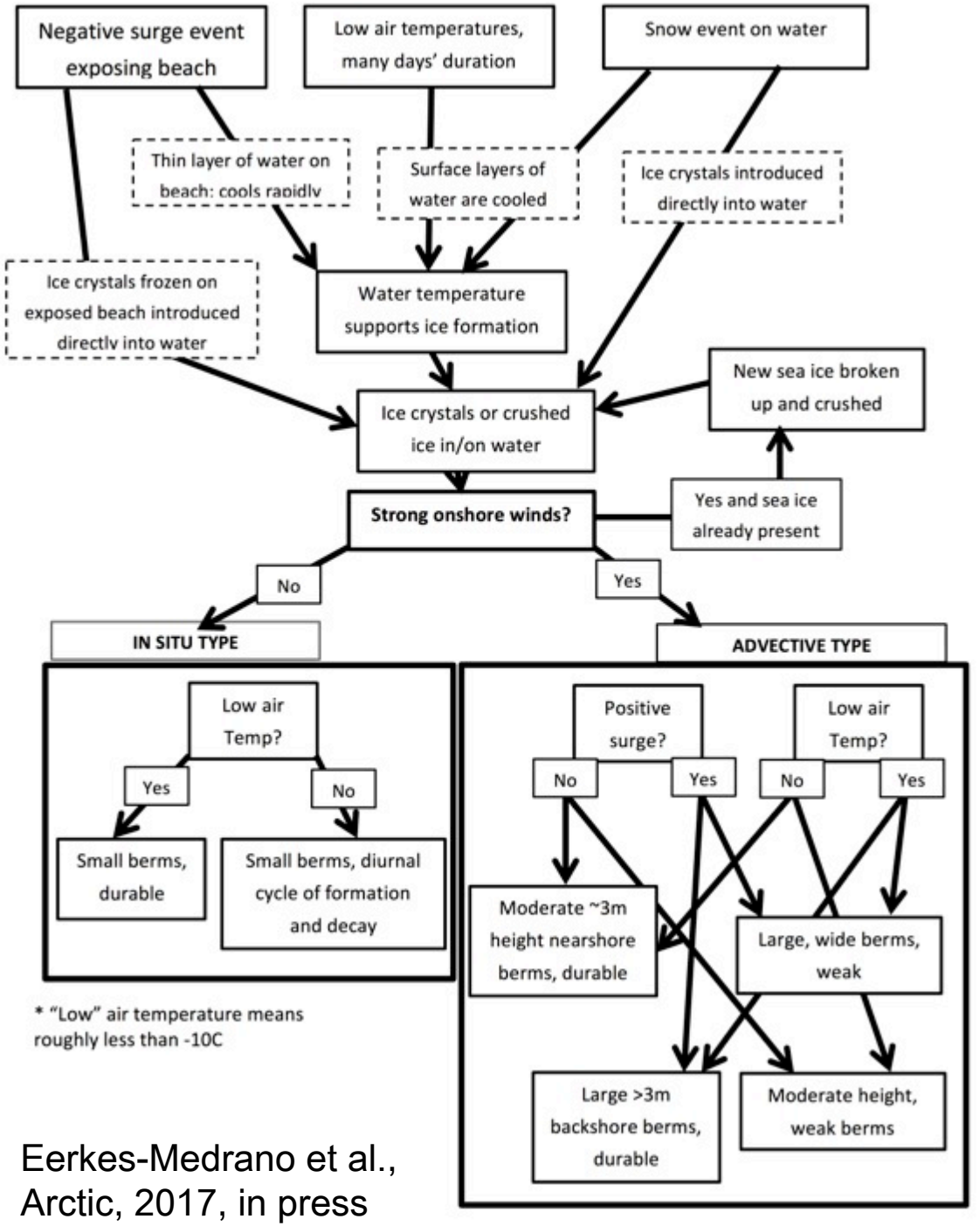
Billy Adams, Barrow, 26 Oct 2015:

• There is a 4-6 foot berm of frozen slush that has been made naturally as the Point is always a place where many things land to; […] new ice and waves have just [accumulated] slush there.

• Brown slush and young ice mixed that is what is coming in now from the north and east. At about 1 mile there is whiter clean ice that we can see further out.

Key variables to track/predict for ice berm occurrence:

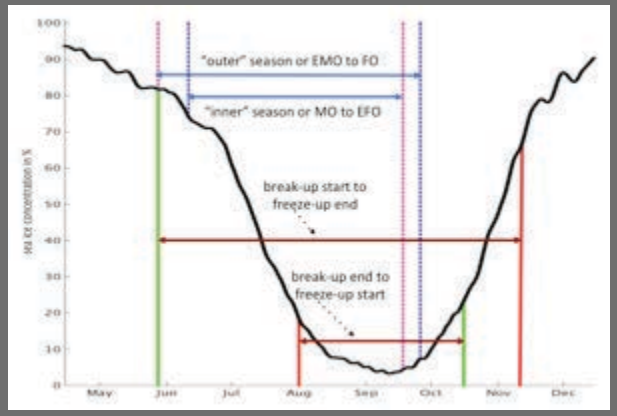
- Air temperature
- Changes in waterlevel/tides & sea state
- Water temperature, frazil ice presence
- Prediction system needs to resolve bathymetry & coastal processes at sufficient resolution

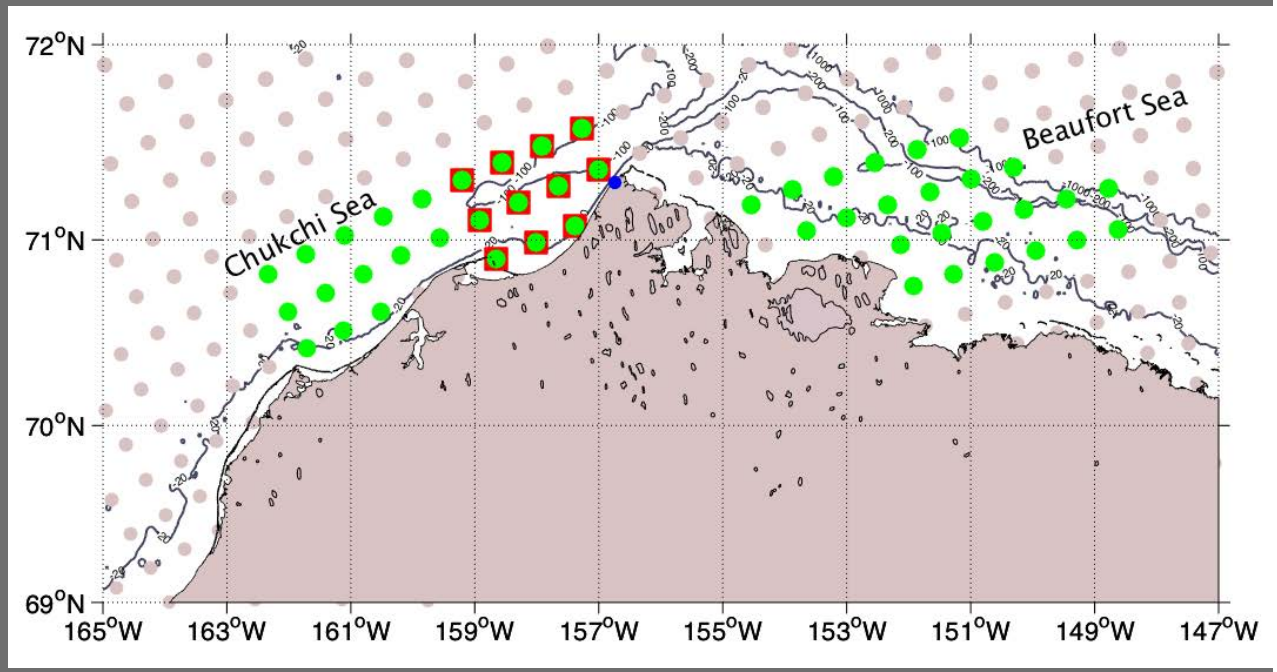


Eerkes-Medrano et al., Arctic, 2017, in press

Break-up & freeze-up climatology for the coastal Chukchi & Beaufort Seas

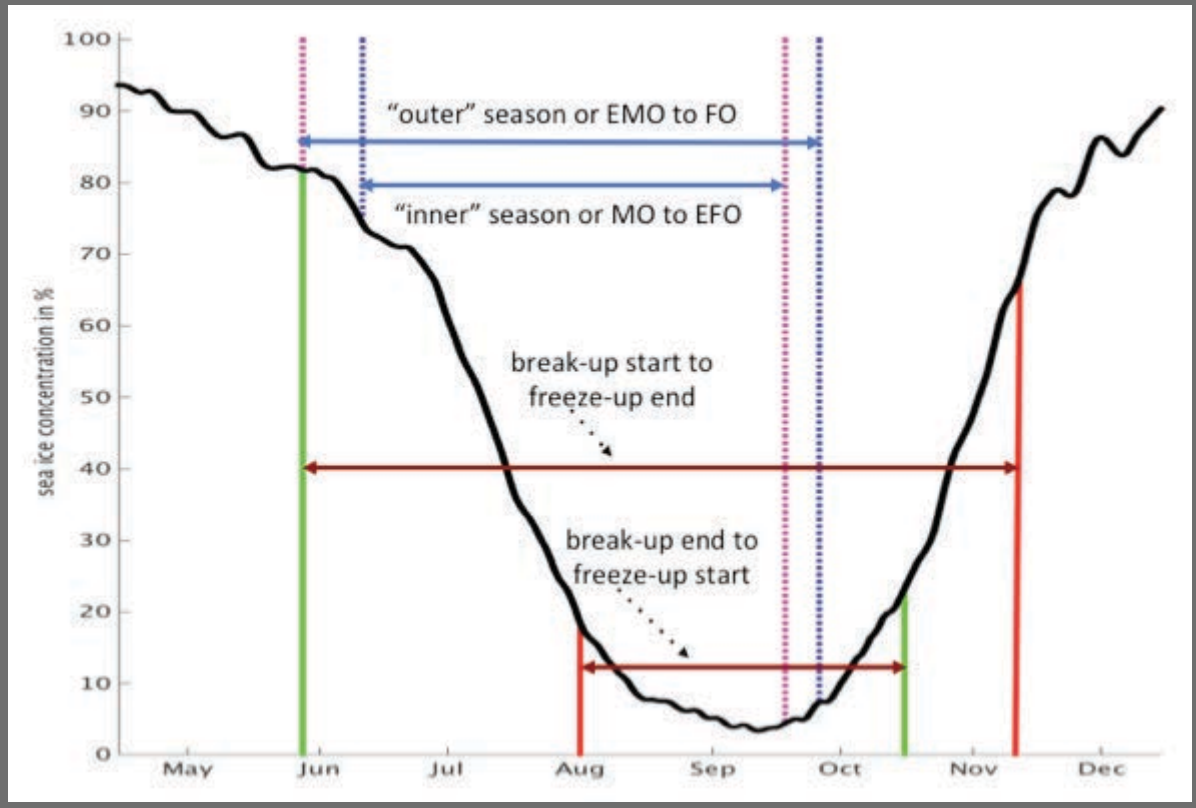
- Break-up/freeze-up climatology for coastal Chukchi & Beaufort Seas 1979-2007 from passive microwave satellite data (25 km grid cell size)
- Comparison of radiometric & use-based definition of freeze-up/break-up: Markus et al. (JGR, 2009 – blue/magenta) & Johnson & Eicken (Elementa, 2016 – red & green)

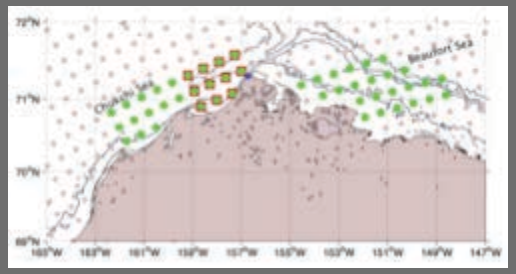




Break-up & freeze-up climatology for the coastal Chukchi & Beaufort Seas

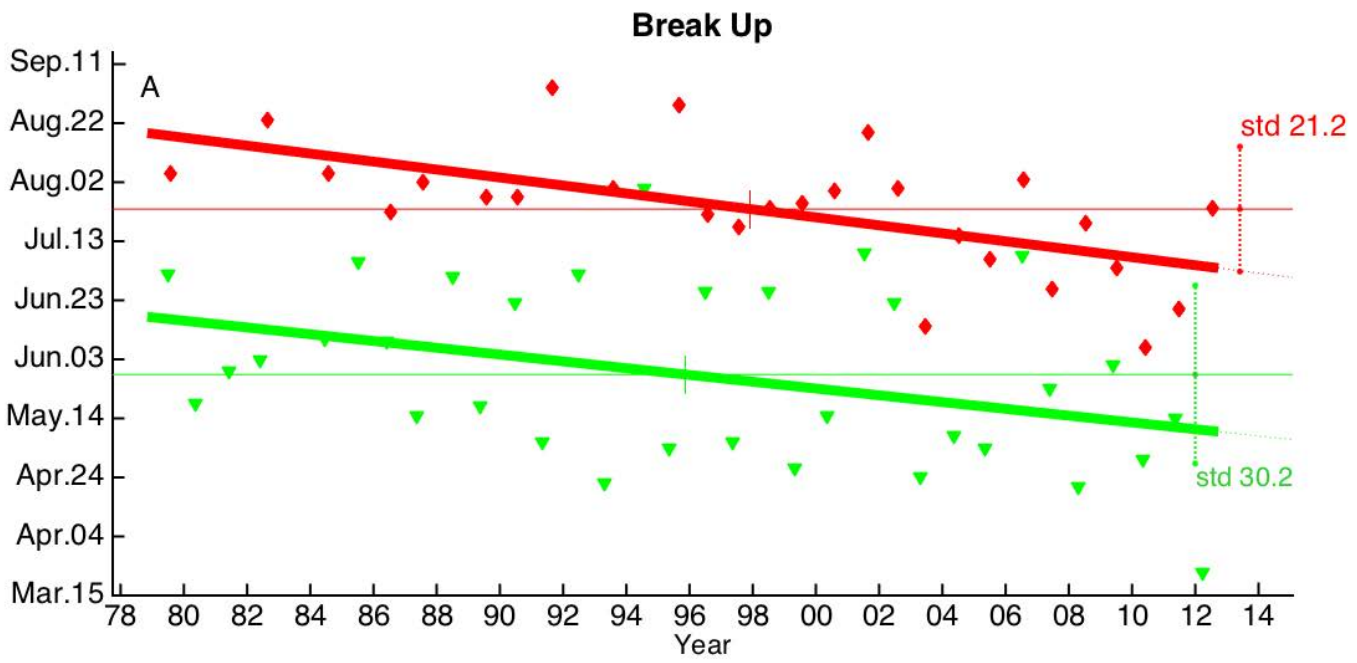
- Break-up/freeze-up climatology for coastal Chukchi & Beaufort Seas 1979-2007 from passive microwave satellite data (25 km grid cell size)
- Comparison of radiometric & use-based definition of freeze-up/break-up: Markus et al. (JGR, 2009 – blue/magenta) & Johnson & Eicken (Elementa, 2016 – red & green)

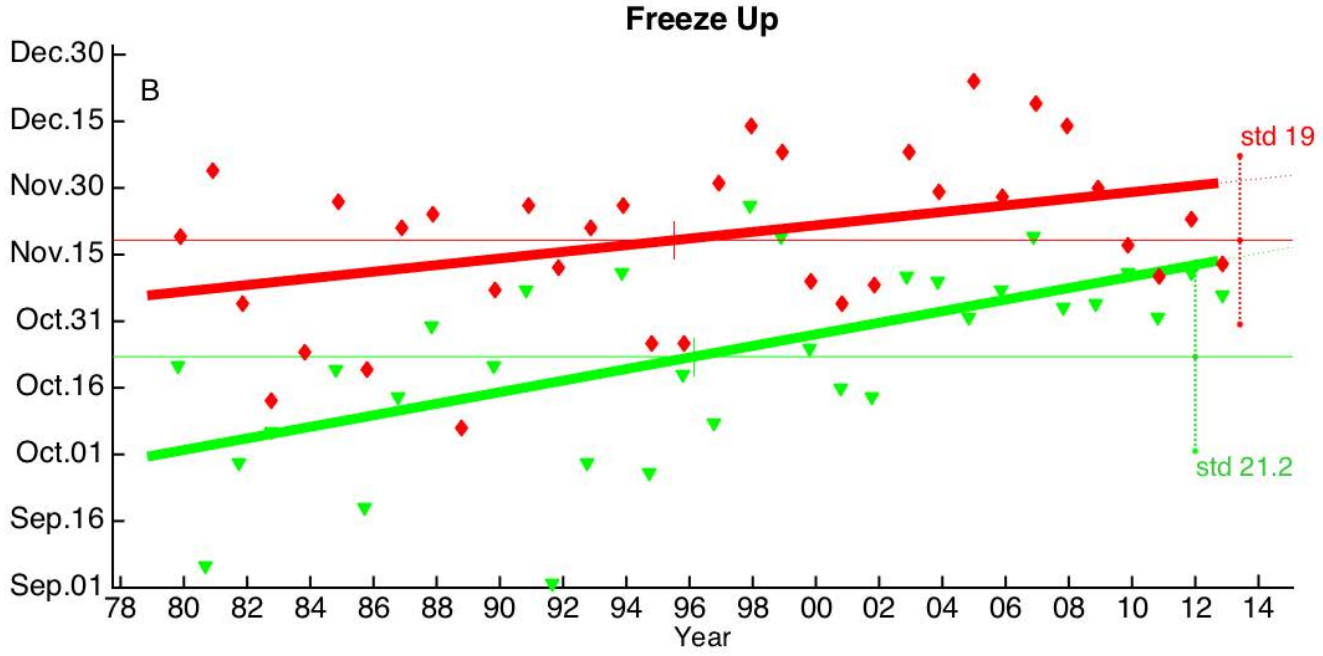




- Trend towards shortened ice season in coastal Chukchi & Beaufort Seas
- Linear trend:
  - By 2030 “open water” season doubled relative to 1979-2013
  - By year 2100 “open water” season year-round

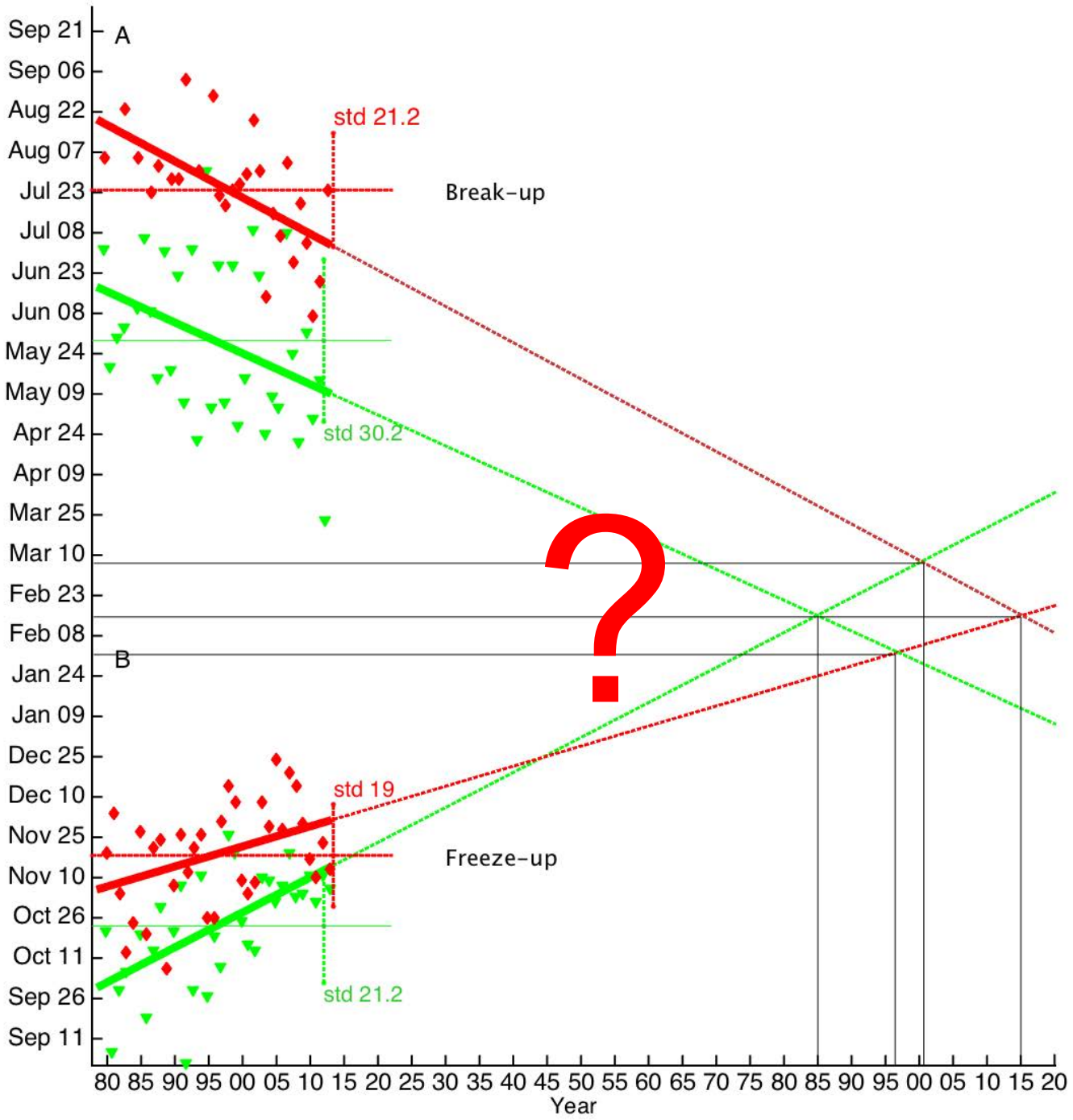
Johnson & Eicken, Elementa, 2016





- Trend towards shortened ice season in coastal Chukchi & Beaufort Seas
- Linear trend:
  - By 2030 “open water” season doubled relative to 1979-2013
  - By year 2100 “open water” season year-round

Johnson & Eicken, Elementa, 2016



Observations & predictions for Arctic sea-ice use

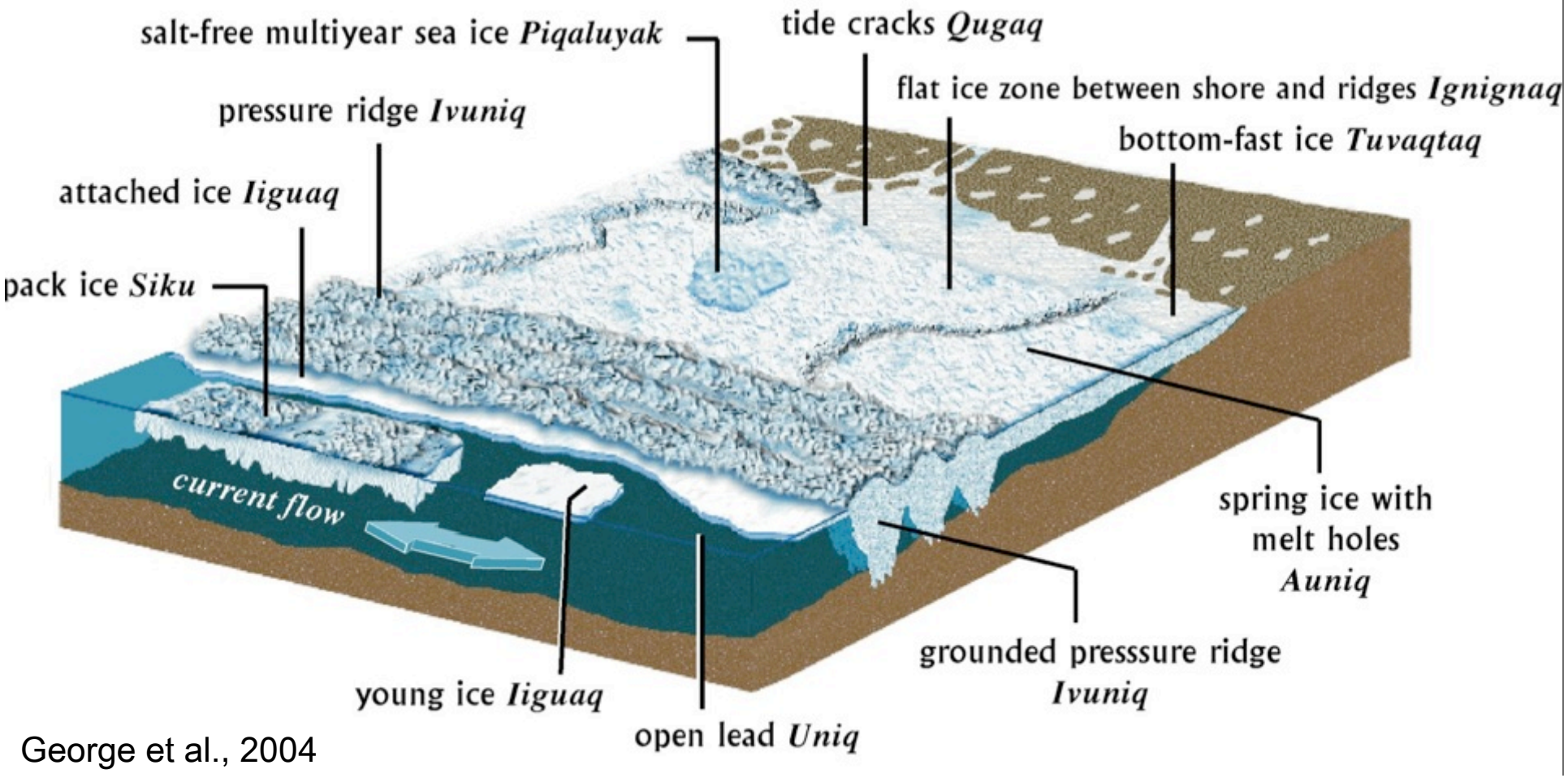

A. Mahoney


E.J. Stewart

- Ice use & associated information needs
- Ice seasonality
- *Ice stability*
  - *Observable/predictand variables linked to ice use*
  - Integrated observations & predictions
- Co-Management
  - Communication & knowledge transfer
  - Communities of Practice

UAF UNIVERSITY OF ALASKA FAIRBANKS

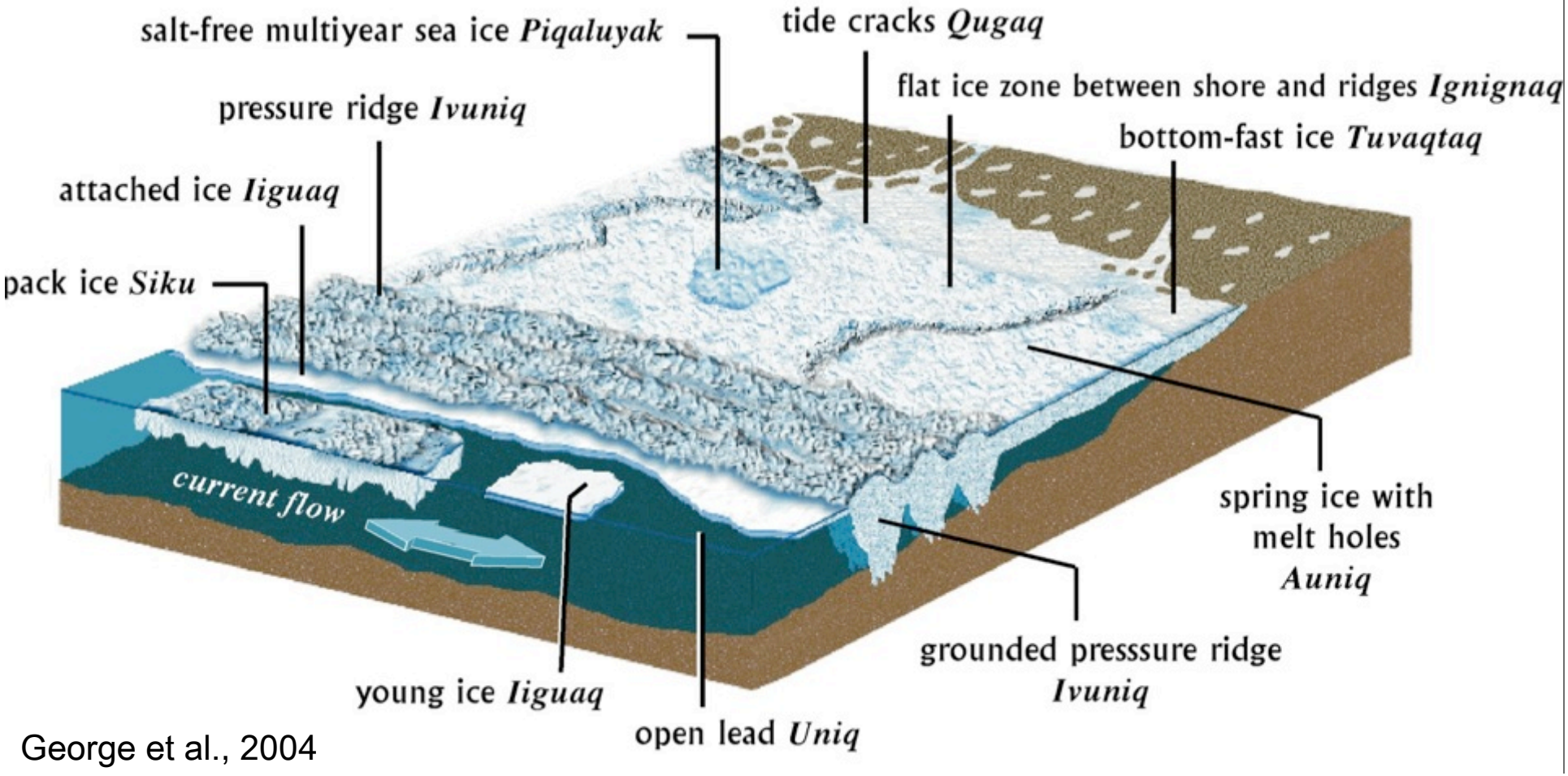
Use of shorefast ice as platform by coastal communities & industry in northern Alaska: *Observing & predicting ice stability & trafficability*



George et al., 2004

Observing & predicting ice stability:

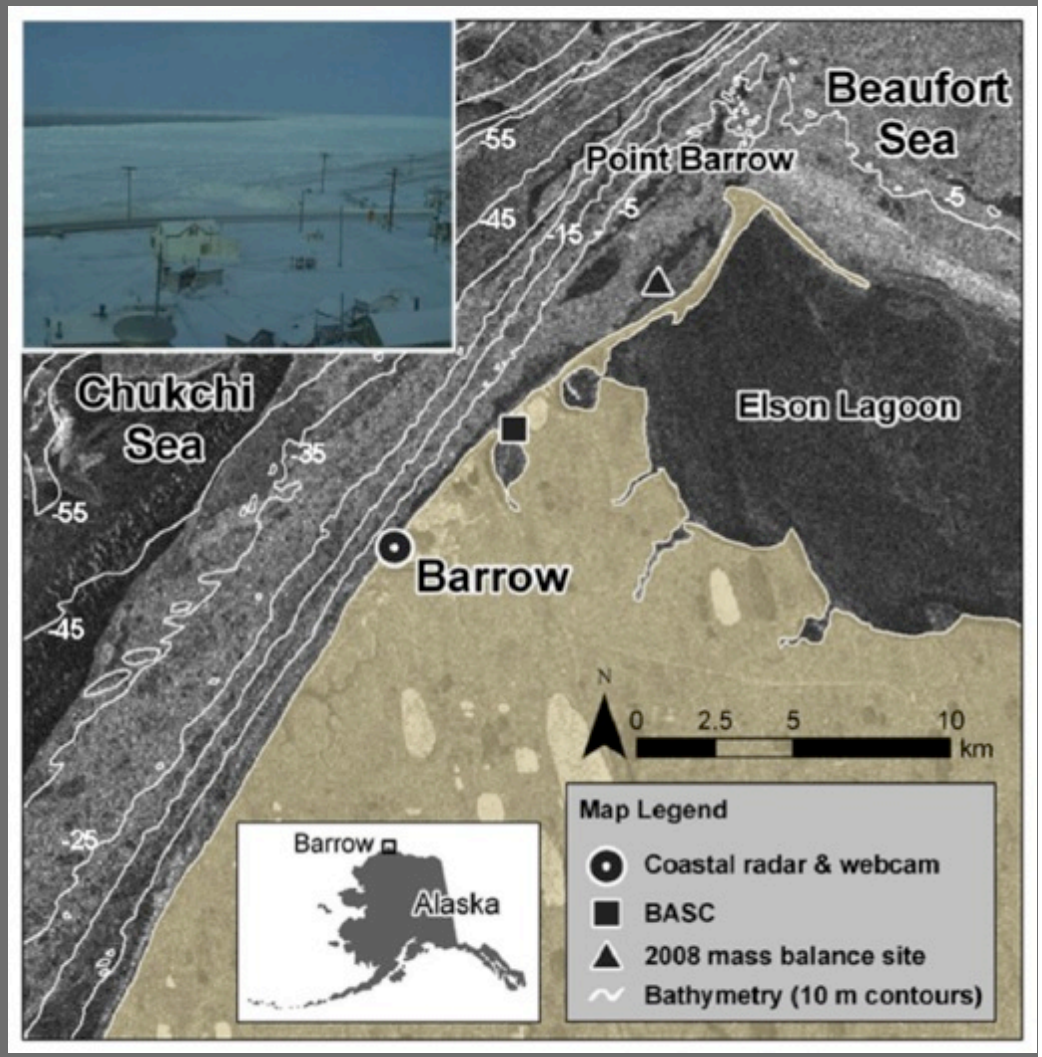
- *Safe use of ice as platform for hunting, camping, harvest processing, industry operations, transportation*
- *Presence & persistence on relevant time scales (days-months)*
- *Suitable thickness & surface morphology/state*



George et al., 2004

The Barrow sea-ice observatory

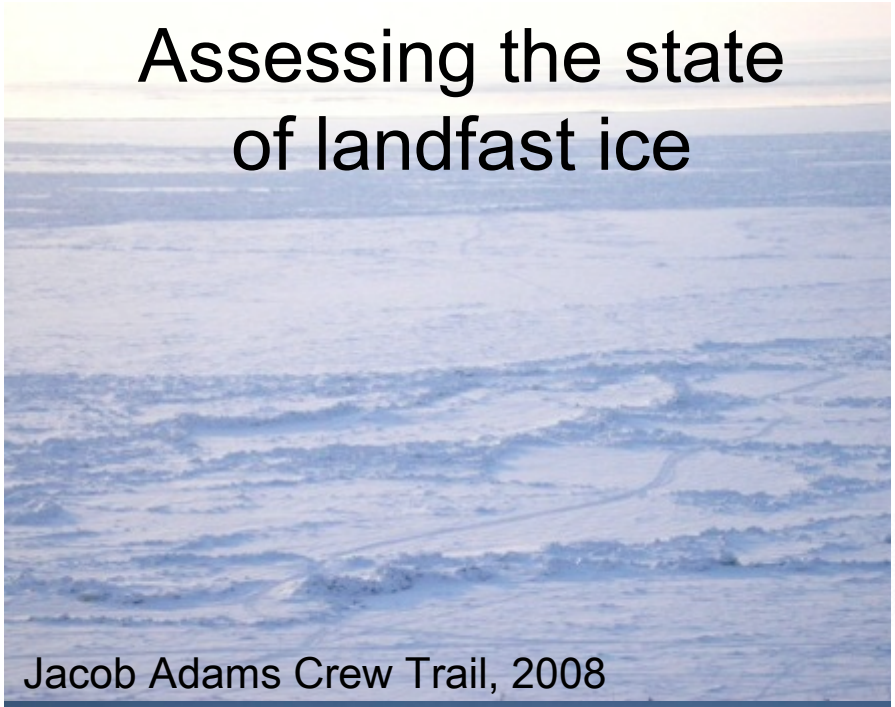
- *Remote sensing* (km-scale)
- *Coastal radar* (sub-km scale)
- *Thickness and topography* (sub-km scale)
- *Ice mass-balance* site (10s m-scale)
- *Moored oceanographic instruments* (sub-km scale)
- *Local ice observations* (J. Leavitt, B. Adams, and many others)



M. Druckenmiller et al., CRST, 2009

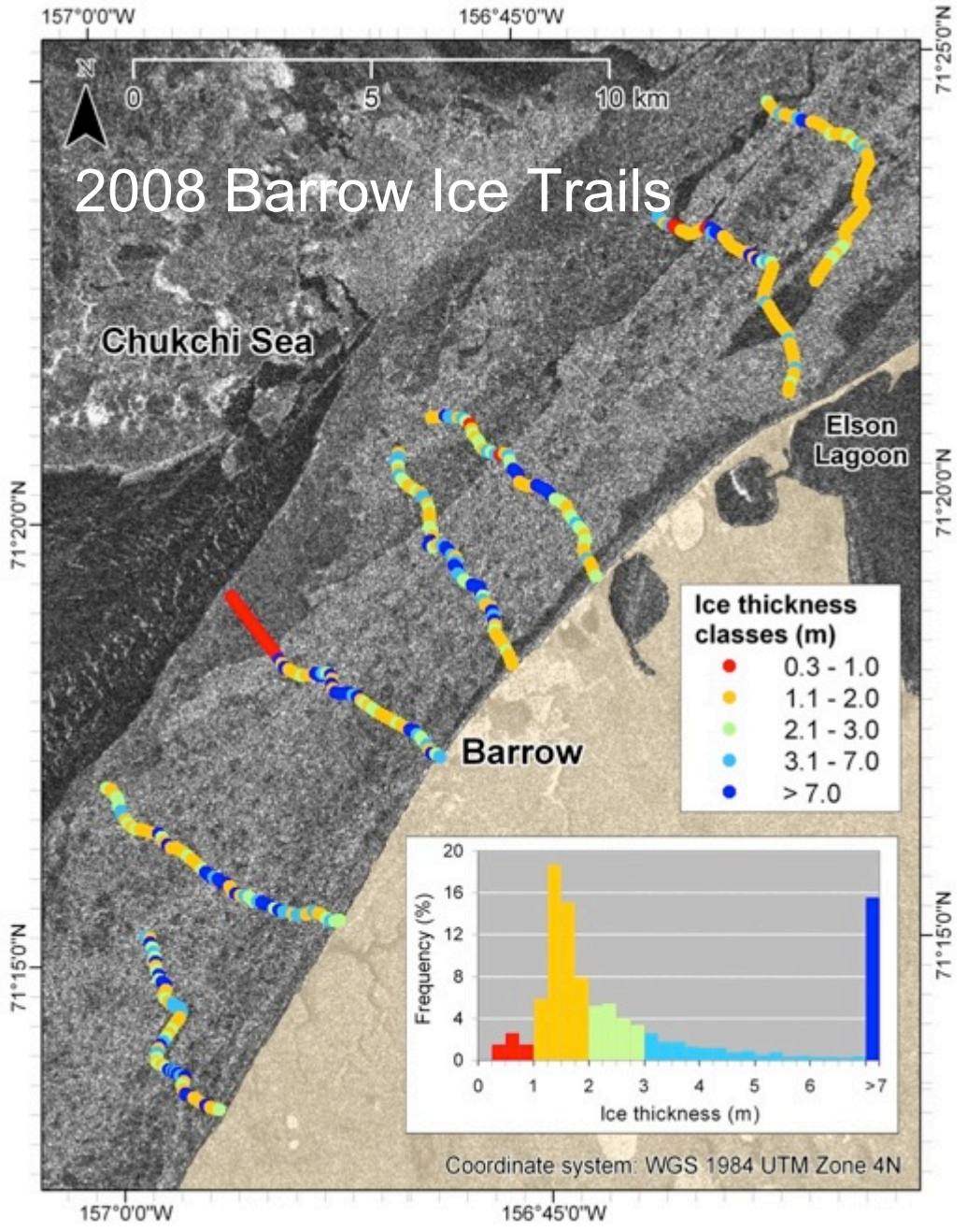
- www.sizonet.org; eloka-arctic.org/sizonet; seaice.alaska.edu/gi

Assessing the state of landfast ice

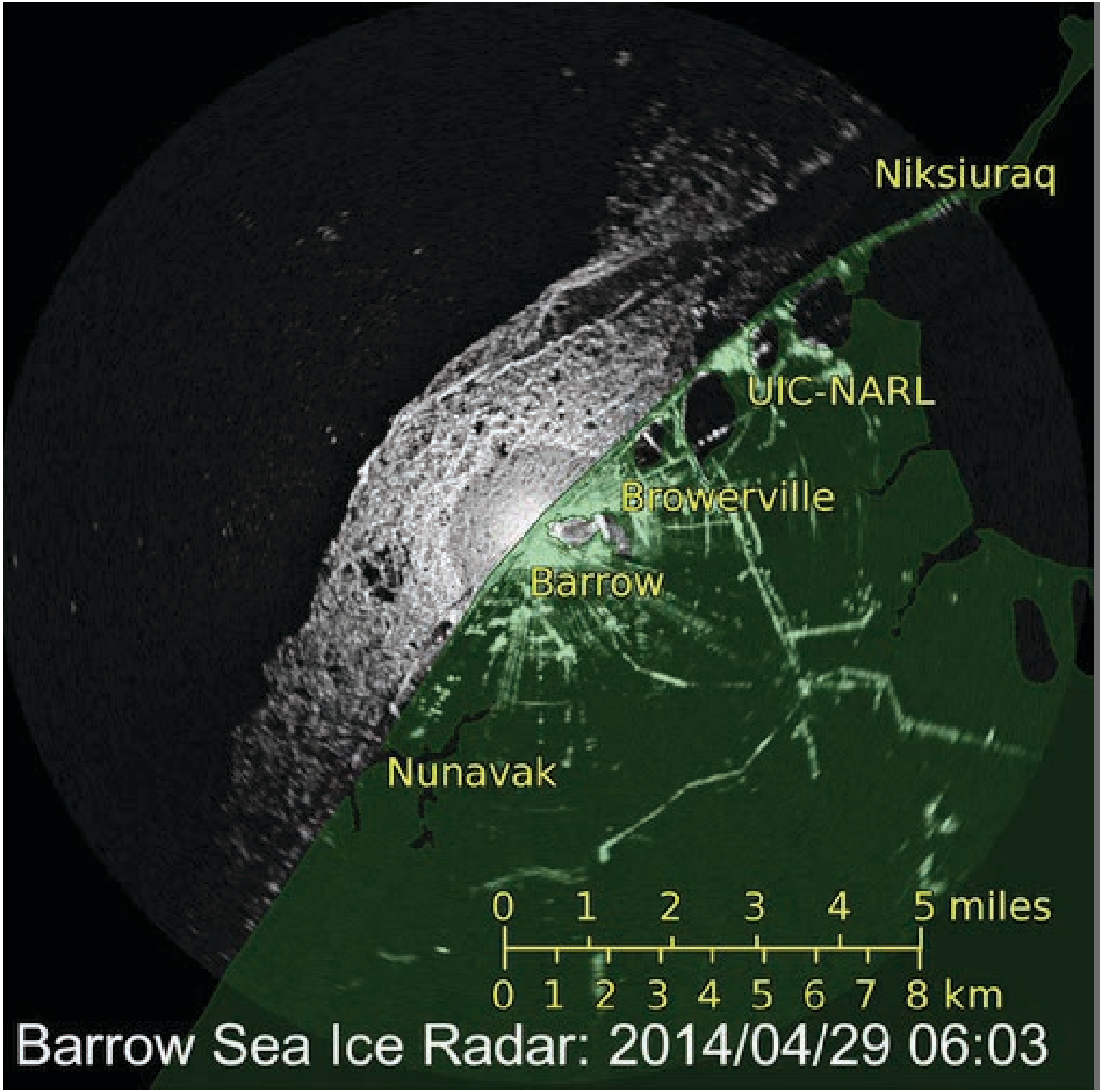


Jacob Adams Crew Trail, 2008

Photo: Craig George

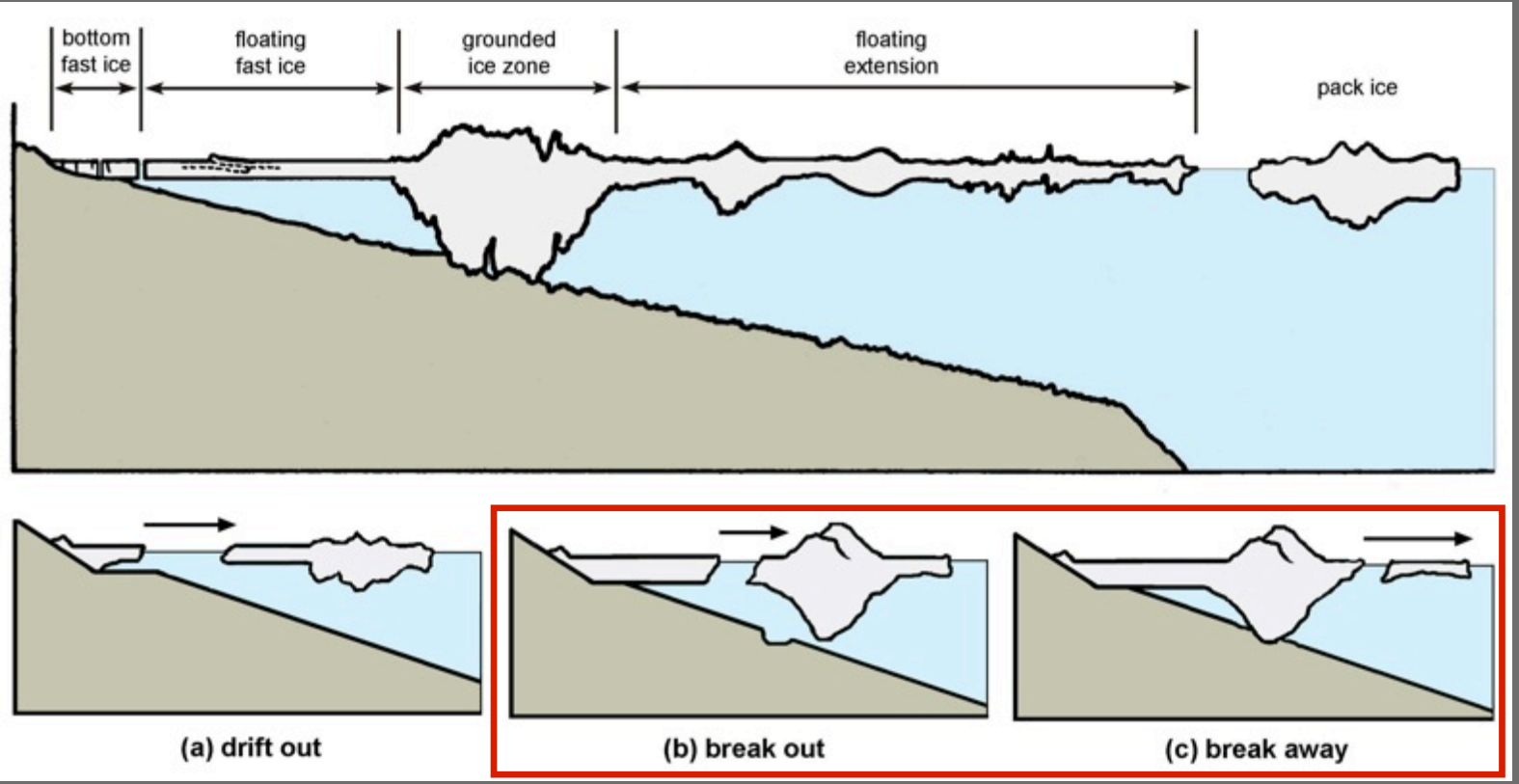


Druckenmiller et al., 2010



Shorefast ice break-out at Barrow, April 2014

Frameworks for risk assessment

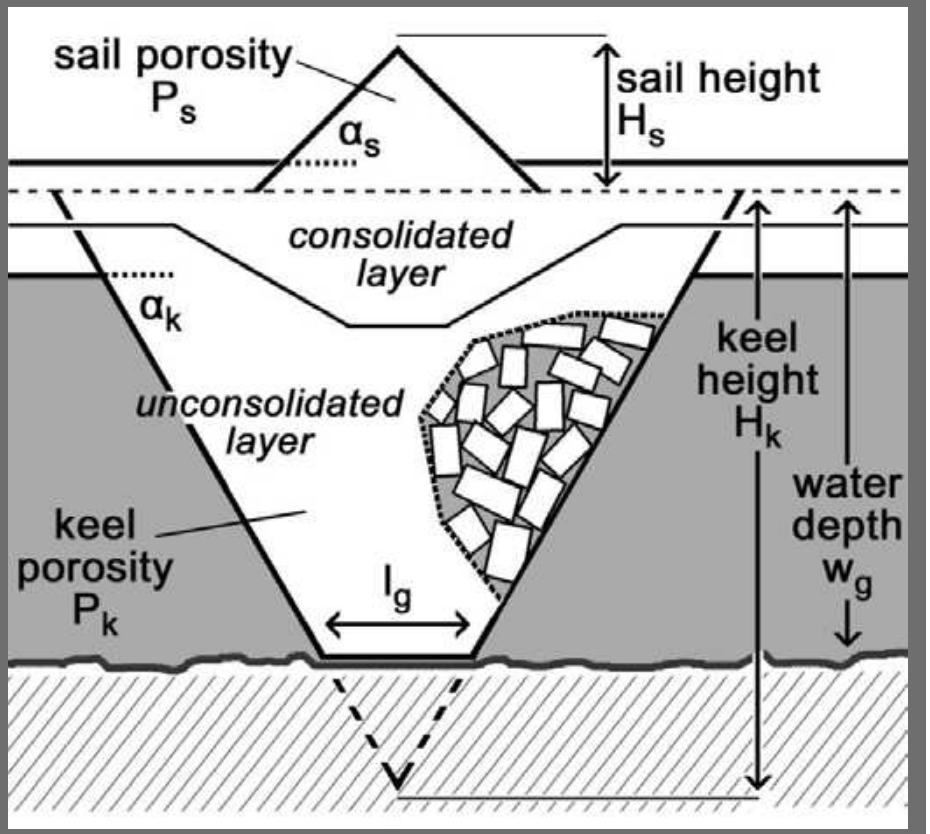


M. Druckenmiller et al., in prep.

- Hazard of landfast ice break-out/away events
- Environment, people & procedures: How to guide operations through integration of observing systems, models, local & indigenous knowledge, and engineering

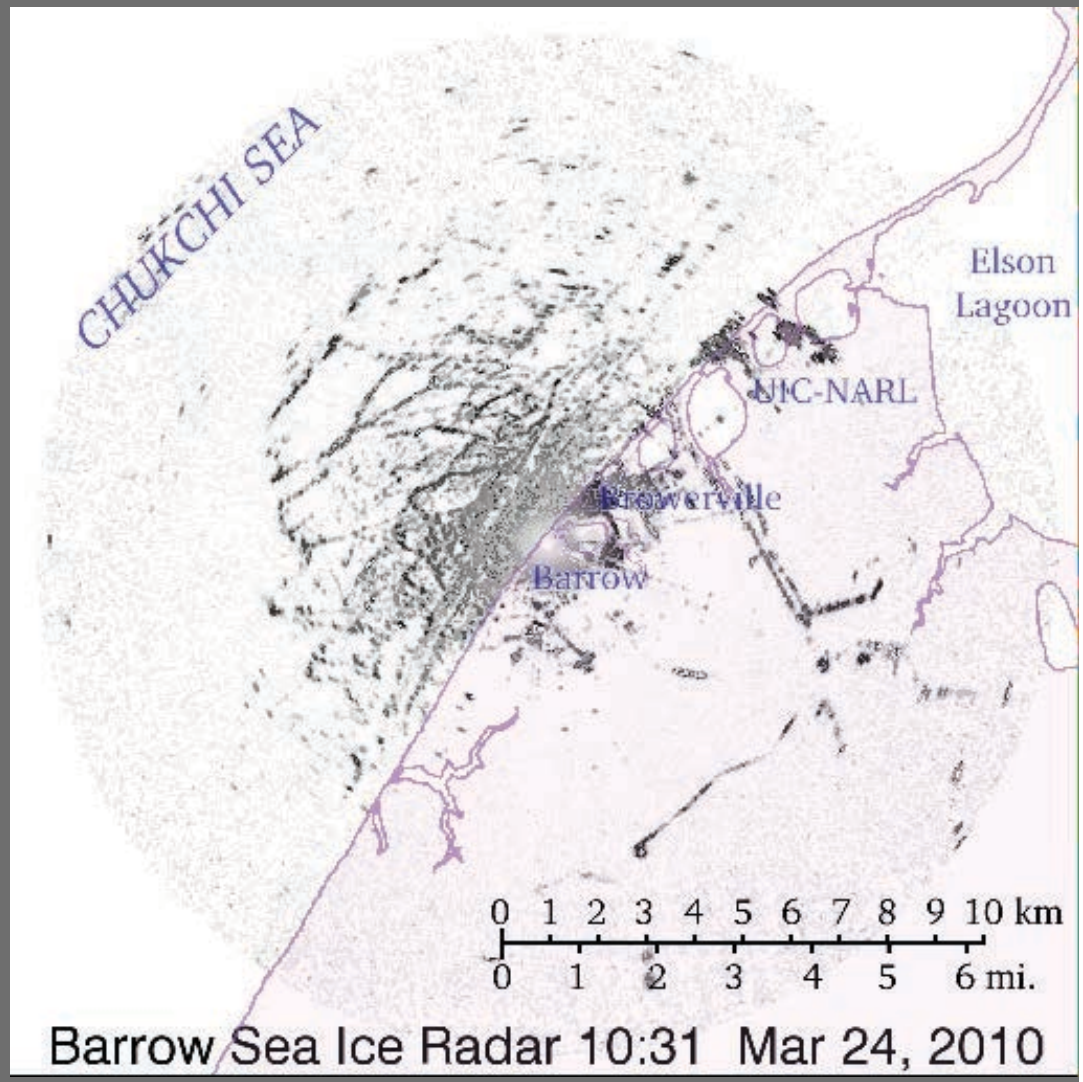
Break-out events: Key drivers & constraints

- Indigenous knowledge highlights impact of current stress on shorefast ice failure
- Field research explores role of grounded ridges in stabilizing ice cover
- Failure: wind/current stress exceeds frictional coupling
- Analysis of 10 break-out events



Break-out event March 2010

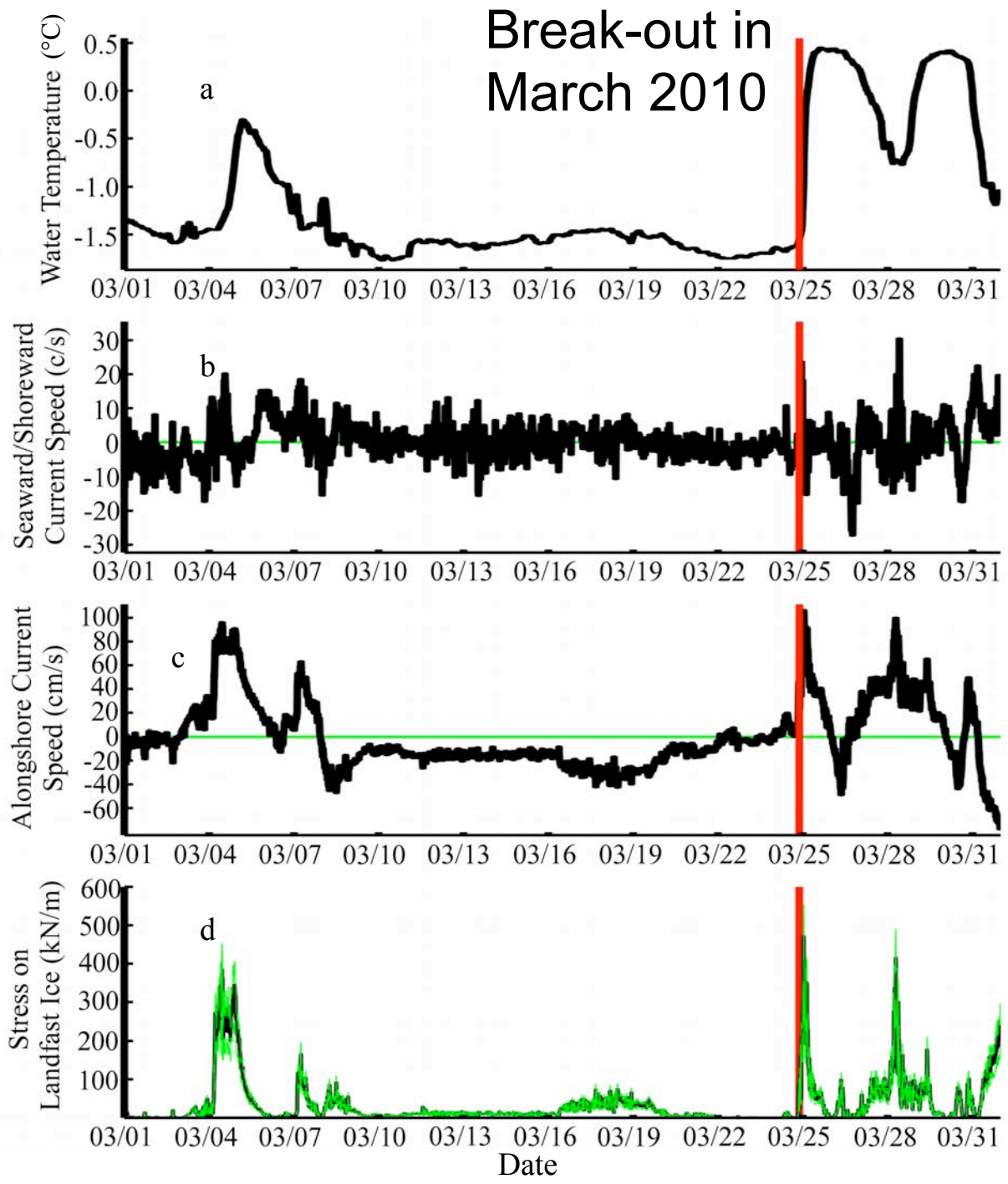
- Ice deformation can form grounded ridges - tracked with coastal radar
- Extent of grounded ridges provides insight into landfast ice strength
- Wind & current stress, sealevel & ocean temperature provide insight into causes of breakouts
- Collaboration with K.-I. Ohshima & Y. Fukamachi, Hokkaido U.



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

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

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



Observations & predictions for Arctic sea-ice use

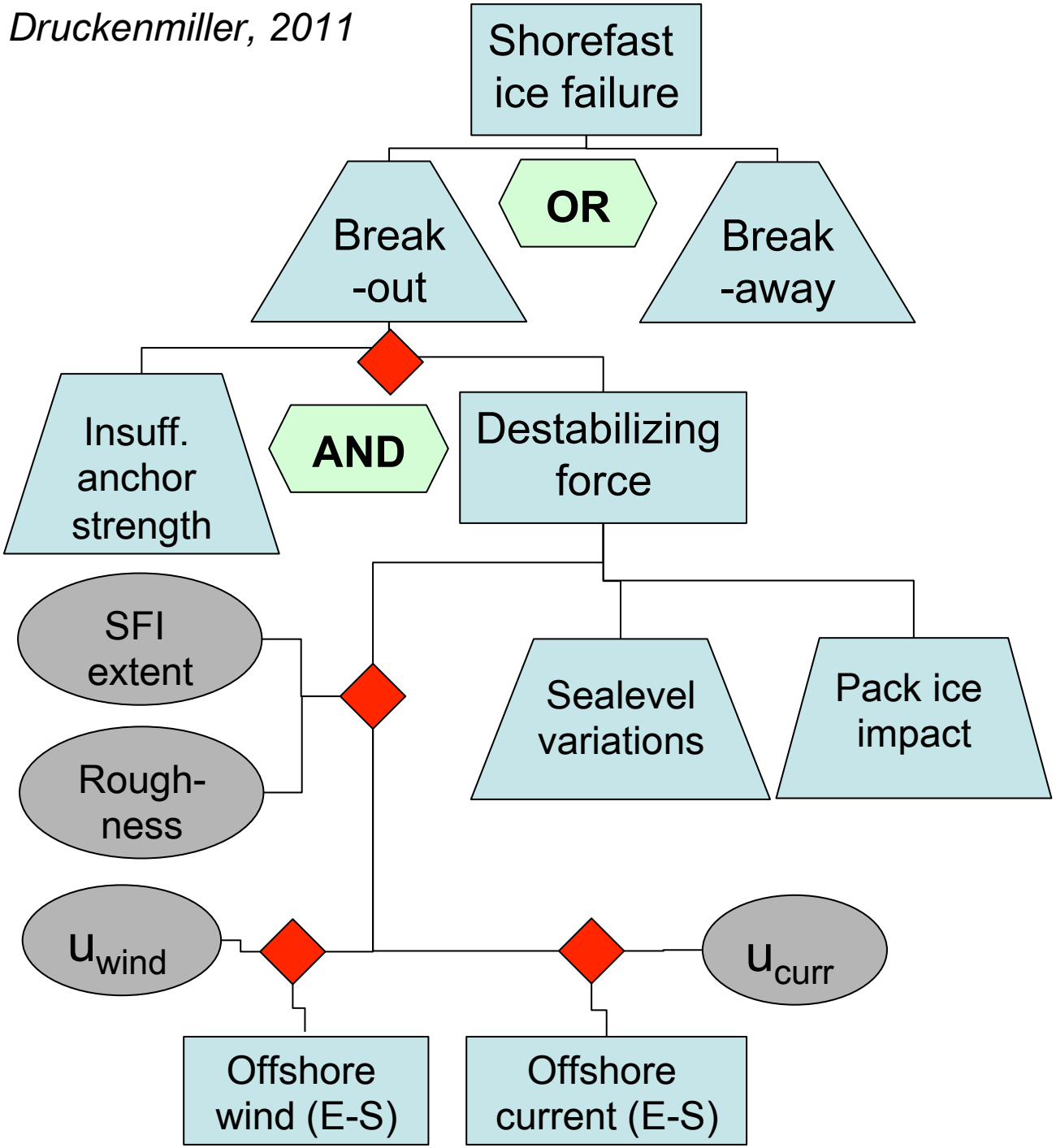

A. Mahoney


E.J. Stewart

- Ice use & associated information needs
- Ice seasonality
- *Ice stability*
  - Observable/predictand variables linked to ice use
  - *Integrated observations & predictions*
- Co-Management
  - Communication & knowledge transfer
  - Communities of Practice

UAF UNIVERSITY OF ALASKA FAIRBANKS

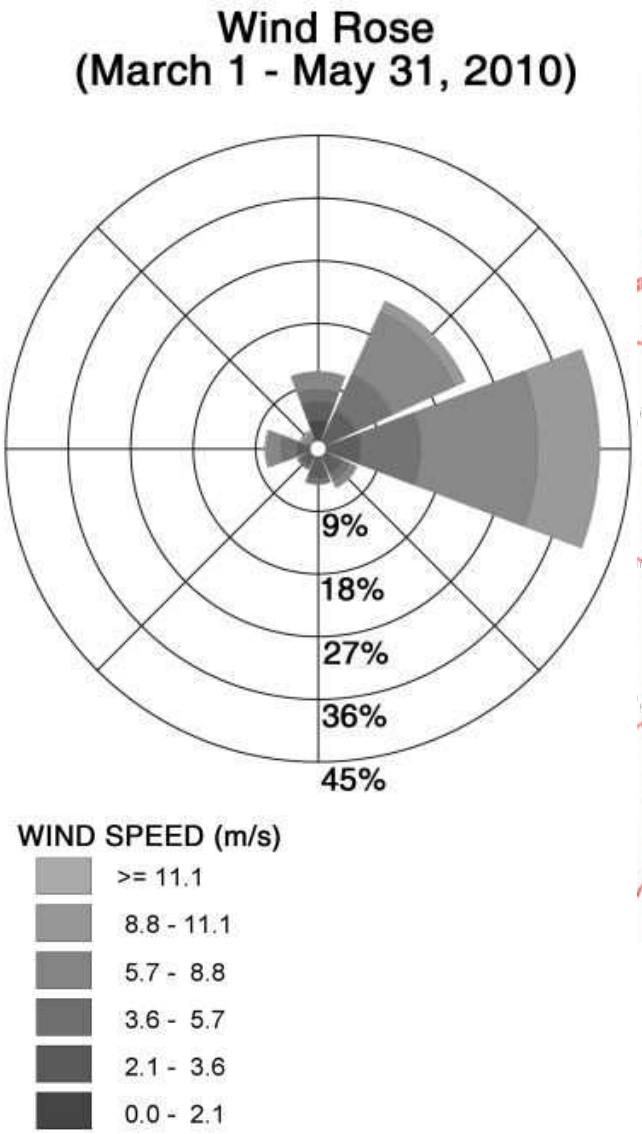
Druckenmiller, 2011

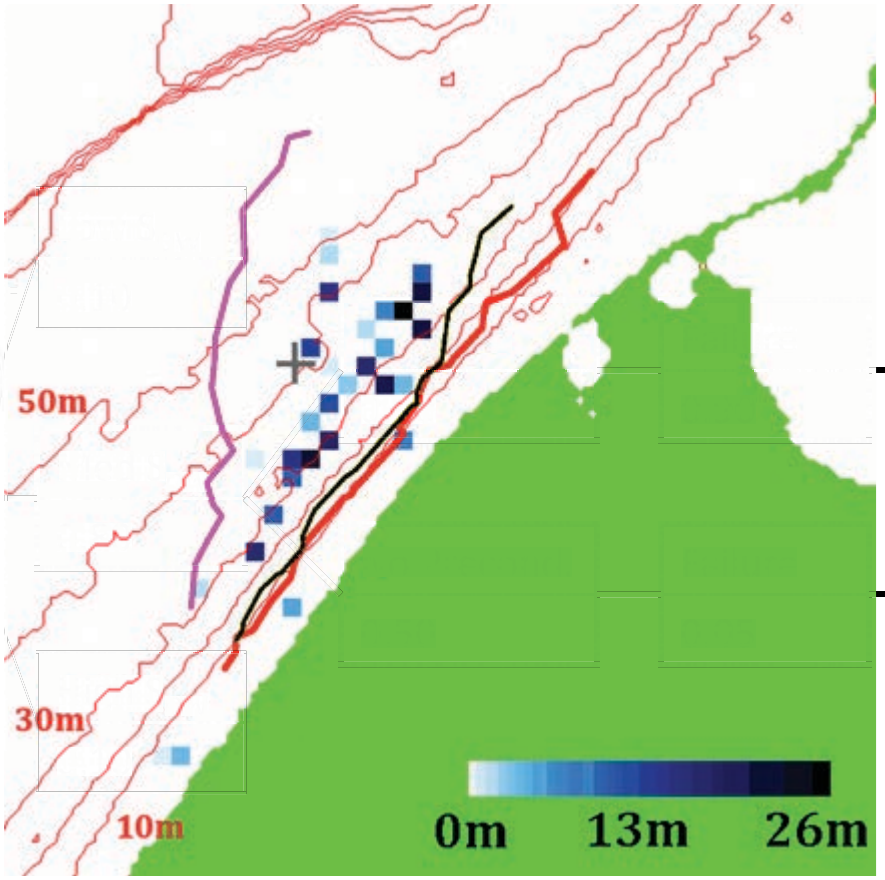


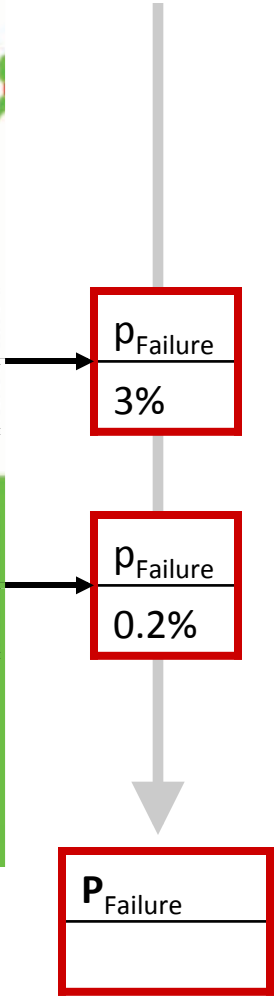
- ***Fault-tree analysis*** as a framework to evaluate hazards (M. Druckenmiller, PhD thesis research)
- Failure criteria based on force balances
- Statistics of met-ocean conditions & ice charac-teristics

Event trees to assess probability & magnitude

Wind Speed Stability Precond. Reliability Prob. of Failure

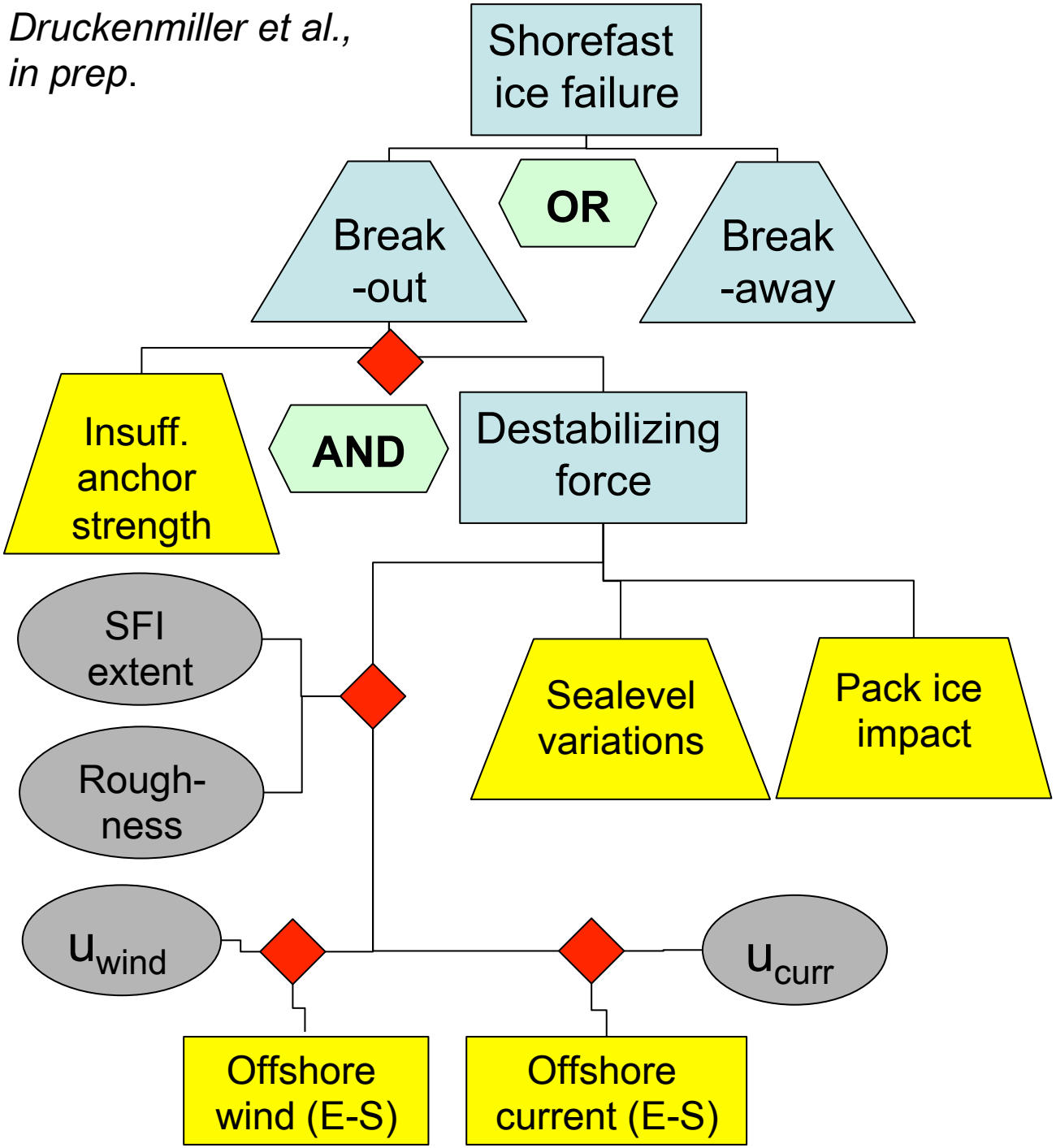






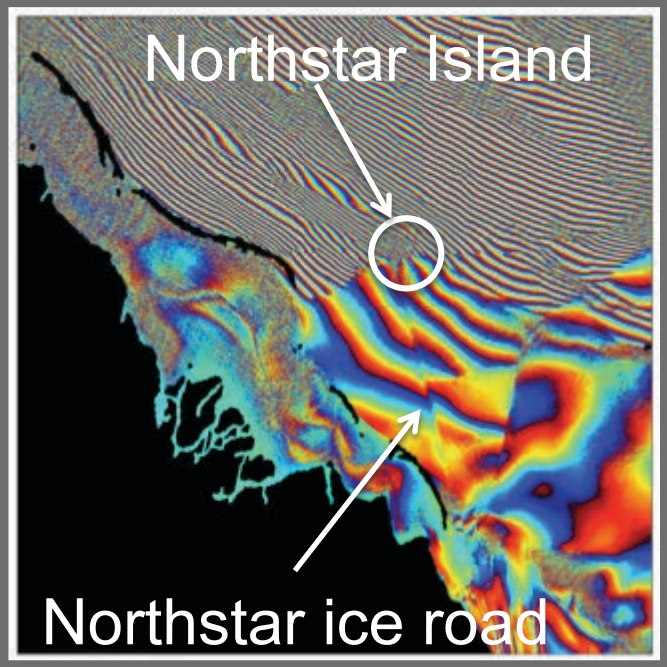
Druckenmiller et al., in prep.

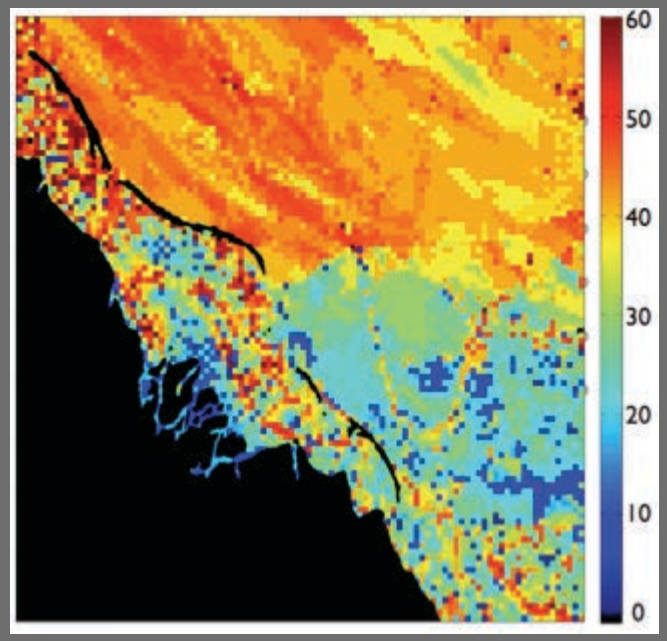
Druckenmiller et al., in prep.



- ***Fault-tree analysis*** as a framework for hazard evaluation & prediction drawing on geophysical data & local or Indigenous expertise

Remote sensing advances to support on-ice operations & predictions



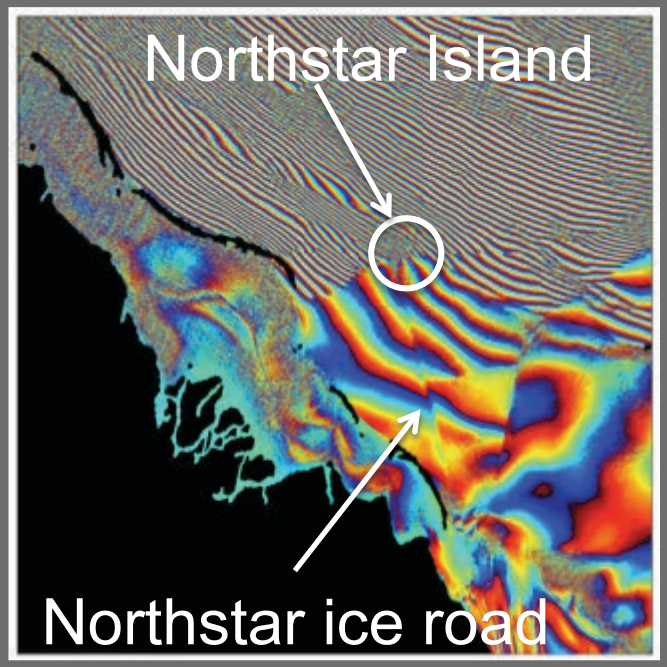


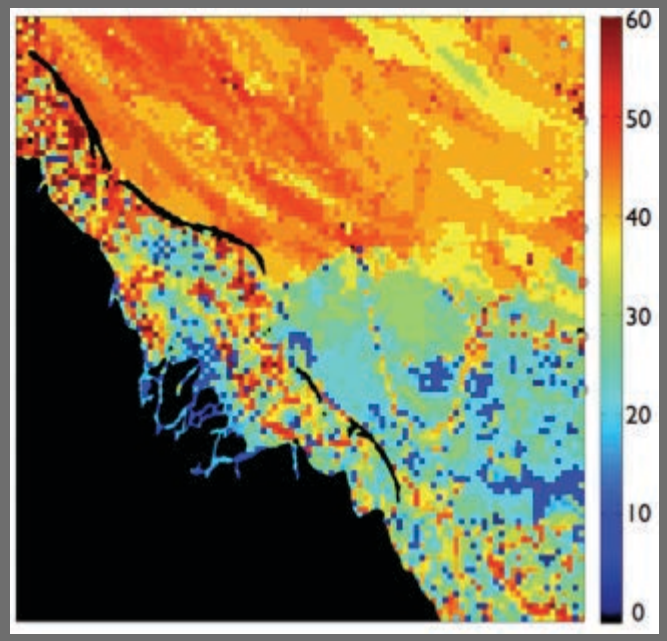
- Utilizing ALOS-PALSAR to assess ice stability around Northstar Island & ice road
- Developed an inverse model to extract deformation mode and strain from phase values

Goal: To develop a remote-sensing guided approach to assess sea-ice stability to support and ensure safety for on-ice operations

Dammann et al. (Rem. Sens. Env. 2016; doi:10.1016/j.rse.2016.10.032)

Remote sensing advances to support on-ice operations & predictions





- Utilizing ALOS-PALSAR to assess ice stability around Northstar Island & ice road
- Developed an inverse model to extract deformation mode and strain from phase values

Product/outcome: Maps of failure events (cracks) highlighting areas of reduced ice bearing strength & potential hazards

Dammann et al. (Rem. Sens. Env. 2016; doi:10.1016/j.rse.2016.10.032)

Sea ice observations & predictions for ice use

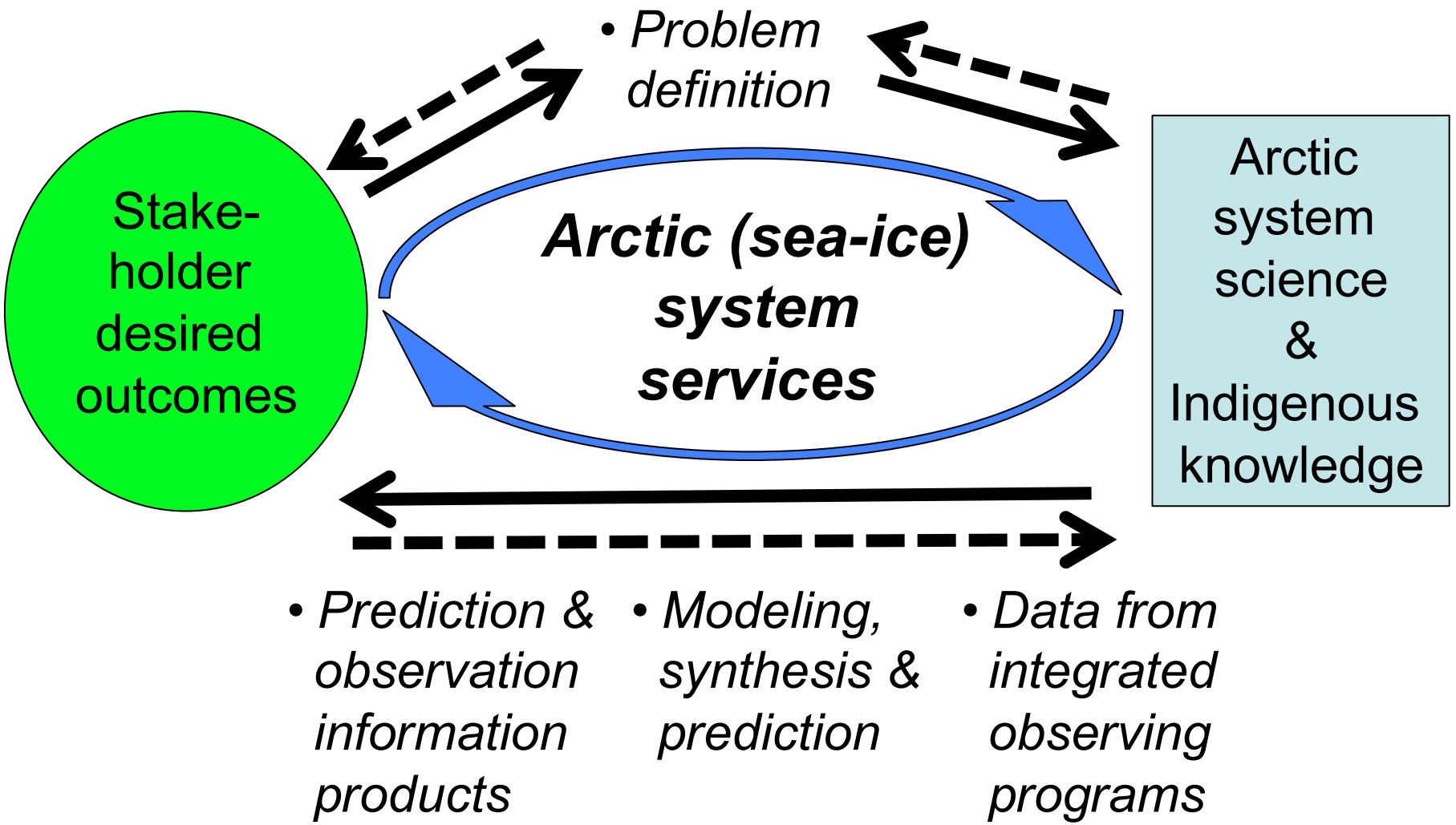

A. Mahoney


E.J. Stewart

UAF UNIVERSITY OF ALASKA FAIRBANKS

- Ice use & associated information needs
- Ice stability: Alaska case study
  - Observable/predictand variables linked to ice use
  - Integrated observations & predictions
- *Co-Management*
  - *Communication & knowledge transfer*
  - *Communities of Practice*

Responding to rapid Arctic change

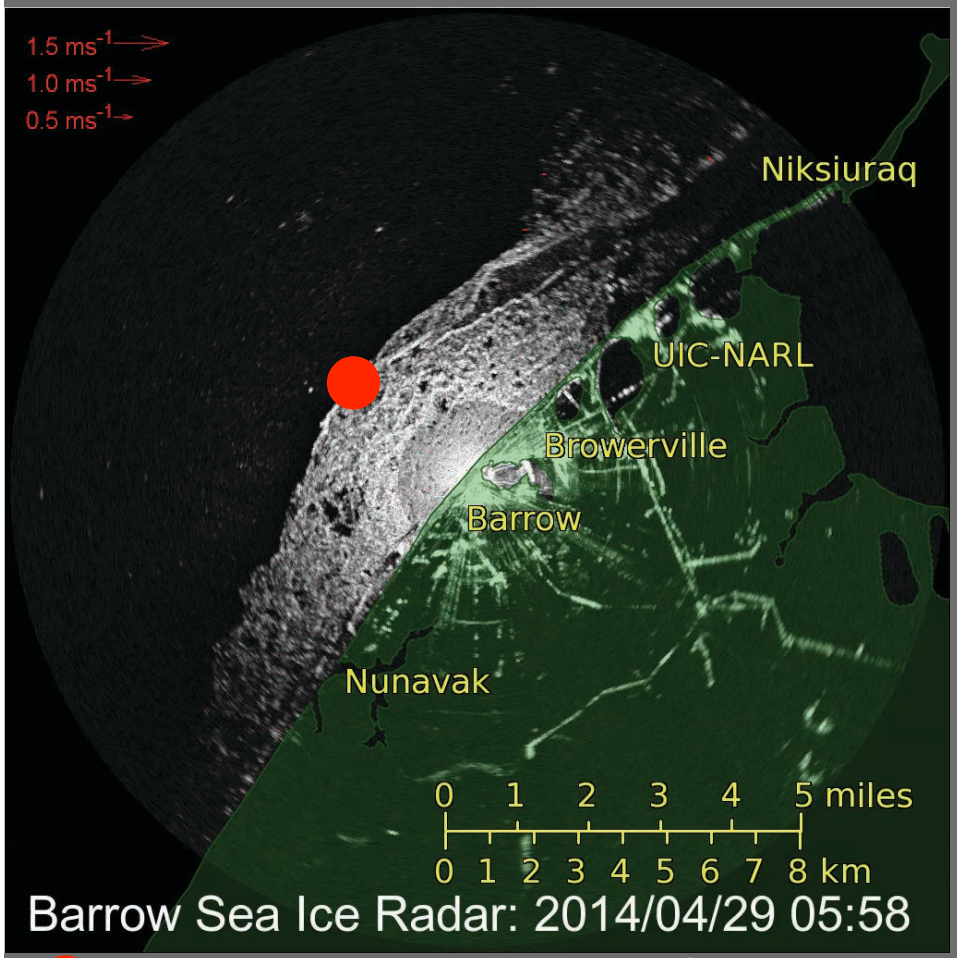


Towards Observation, Data & Prediction Co-Management

Key aspects of resource co-management (Berkes, 2009)

- Horizontal & vertical linkages for joint learning-by-doing
- Time scales allow for multiple cycles of learning and adaptation
- Multi-level organization with self-organized networks
- Capacity building addresses needs of all partners

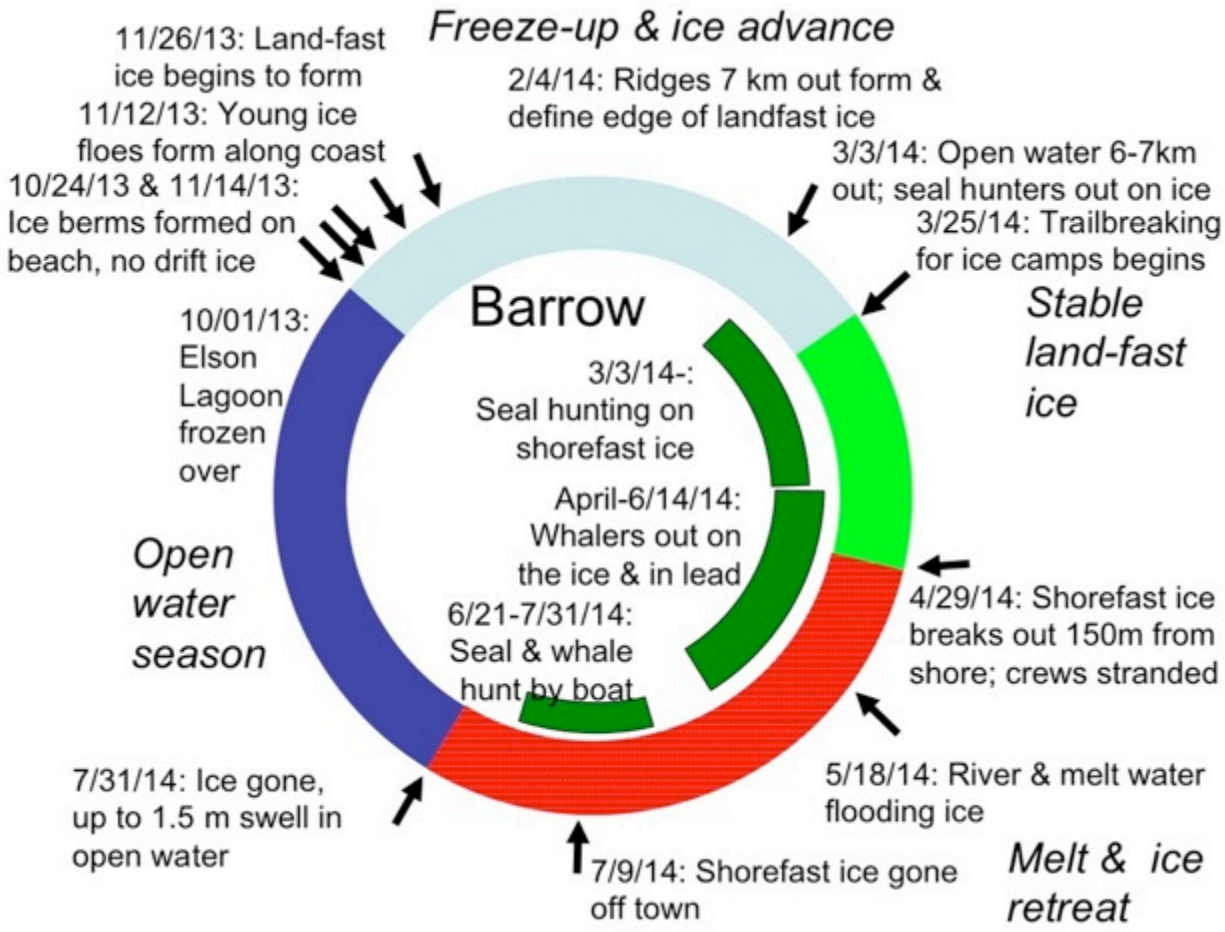
Co-management of marine mammals & safe use of coastal ice cover help guide observations

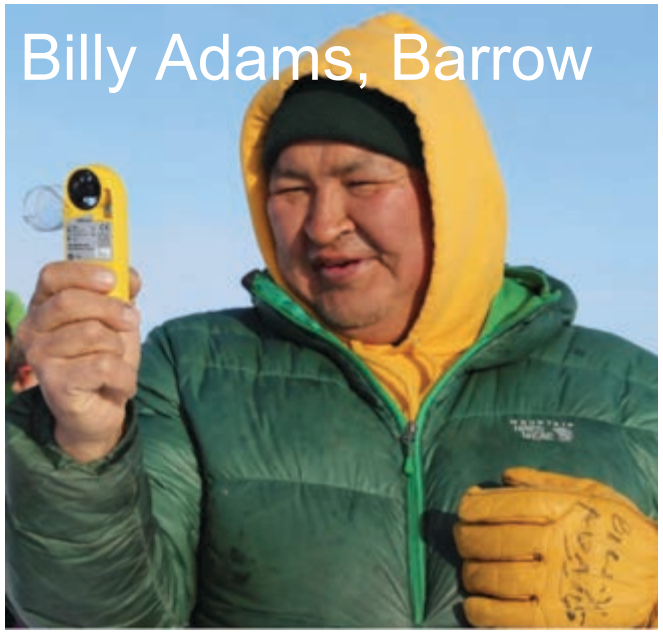


Mooring site to track state & dynamics of water column & cover; Hokkaido University – UAF collaboration

- Hybrid observatory, driven both by local stakeholder information needs & research into long-term changes in ice mass budget & dynamics
- International collaboration with deployment of moored instruments guided by research interests & local concerns

Key observations driven by information needs & environmental knowledge of Alaska Indigenous ice experts



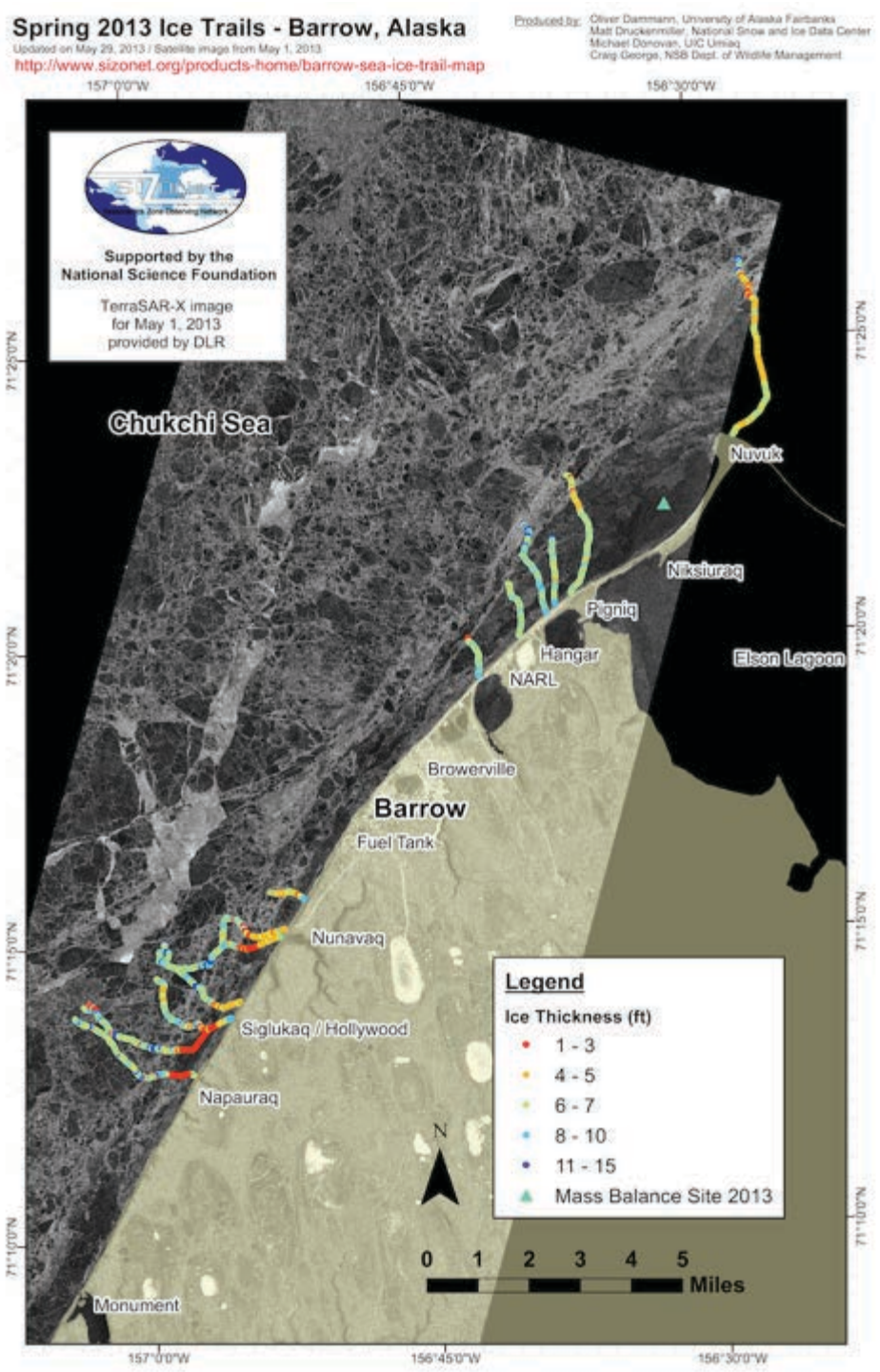


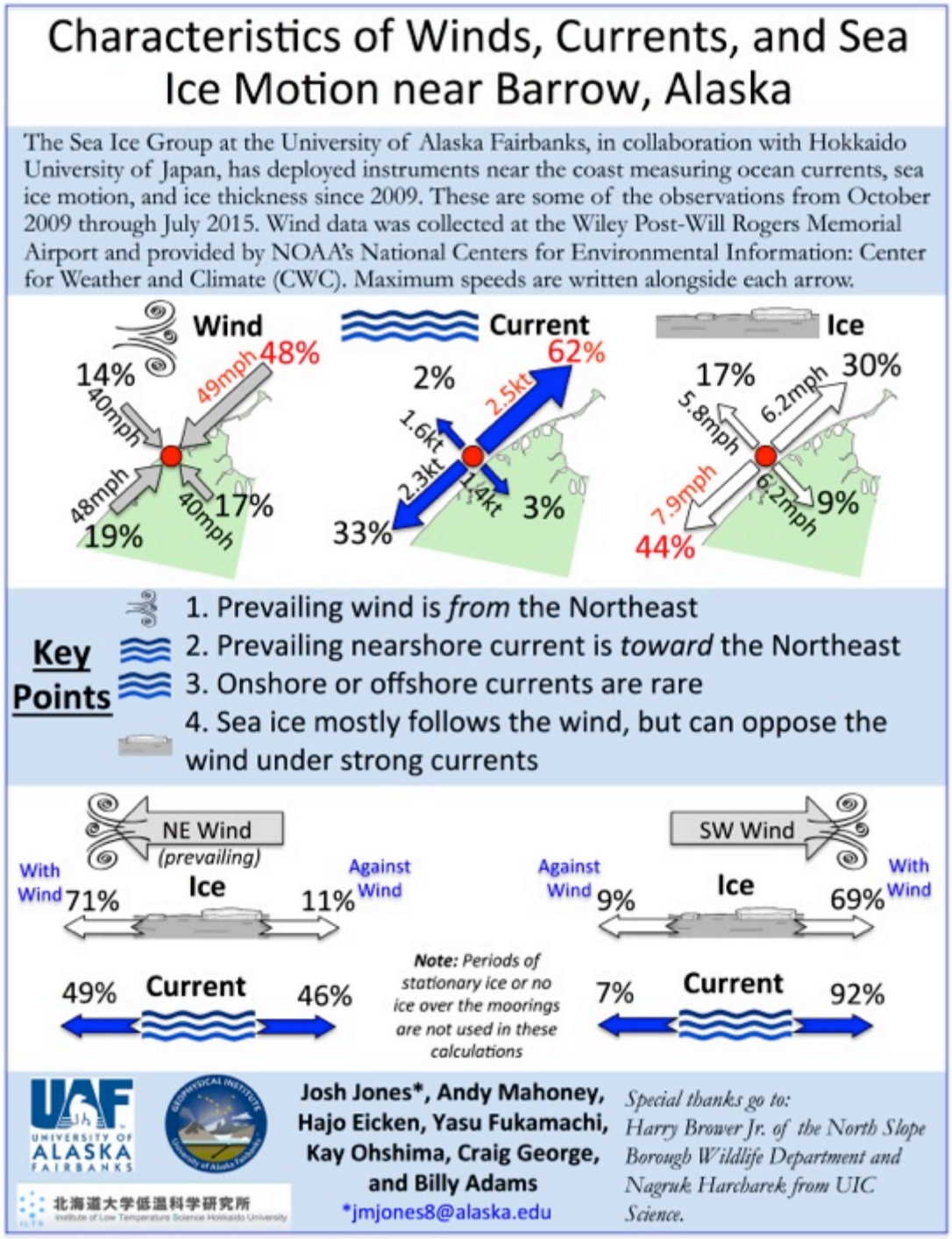
Community expert observations (>5000 daily logs)
https://eloka-arctic.org/sizonet

Eicken et al., Polar Geogr., 2014; http://dx.doi.org/10.1080/1088937X.2013.873090

Information products

- Information products for local communities: Trail maps (Grad students, NSB-DWM, BWCA)
- Local observer logs & interviews
- Communication: In-person meetings, flyers, Facebook, smartphone apps etc.





- Communication of key findings relative to local interests
- Communication means range widely: In-person meetings, flyers, Facebook, smartphone apps etc.

Conclusions

- Major changes in ice seasonality & stability are likely to have biggest impacts on Arctic (social-environmental) systems

- Ice use as a framework for observations & predictions
- Problem definition → Observable & predictand variables
- Common frameworks for data analysis & prediction

- Communication & information products to close gaps between research & user communities
- Link various services, observing & predictions "schools" into Communities of Practice

- *Arctic Council/IASC Sustaining Arctic Observing Networks (SAON) initiative as a means to bring together new types of observations & predictions in the context of coordinated Arctic observing systems*

Thank You!

- ARCUS Seminar Series recordings are available online at: https://www.arcus.org/research-seminar-series
- Please consider becoming an ARCUS member! More info: http://bit.ly/2ePsc5N
- The ARCUS 2016 Annual Meeting will be **14 December 6-7pm PT** at the San Francisco Marriott Marquis hotel. A reception for the Arctic research community will follow the meeting from 7-8:30pm PT. More info: http://bit.ly/2e8aetV
- Join us **11 January 2017, 12-1pm ET** for our next seminar with Craig Fleener, the State of Alaska's Arctic Policy Advisor

ARCTIC RESEARCH CONSORTIUM OF THE UNITED STATES
ARCUS
WWW.ARCUS.ORG
ARCTIC RESEARCH SEMINAR SERIES

#arcuswebinar