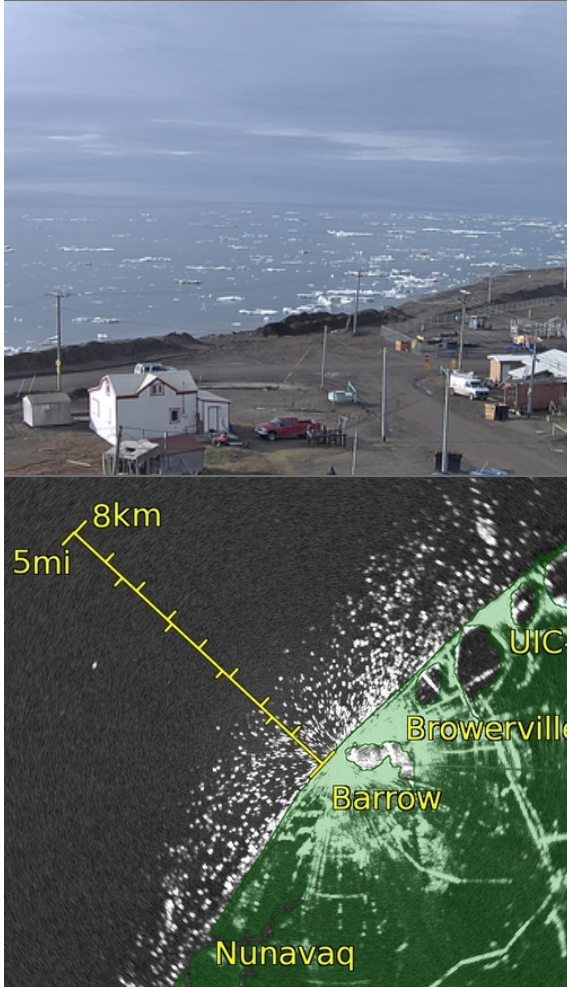


Sea Ice Prediction Network (SIPN) Webinar: Industry Needs for Seasonal and Sub-seasonal Sea Ice Information and Predictions



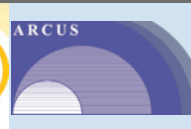
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- SIPN research: Arctic system science & stakeholders
- (Sub)Seasonal sea ice prediction: Merits & potential
- Prediction goals and predictand variables: Discussion of break-up & freeze-up
- Observations in support of seasonal sea ice prediction
- Data shown available at: aoncadis.org & seaiice.alaska.edu/gi/data

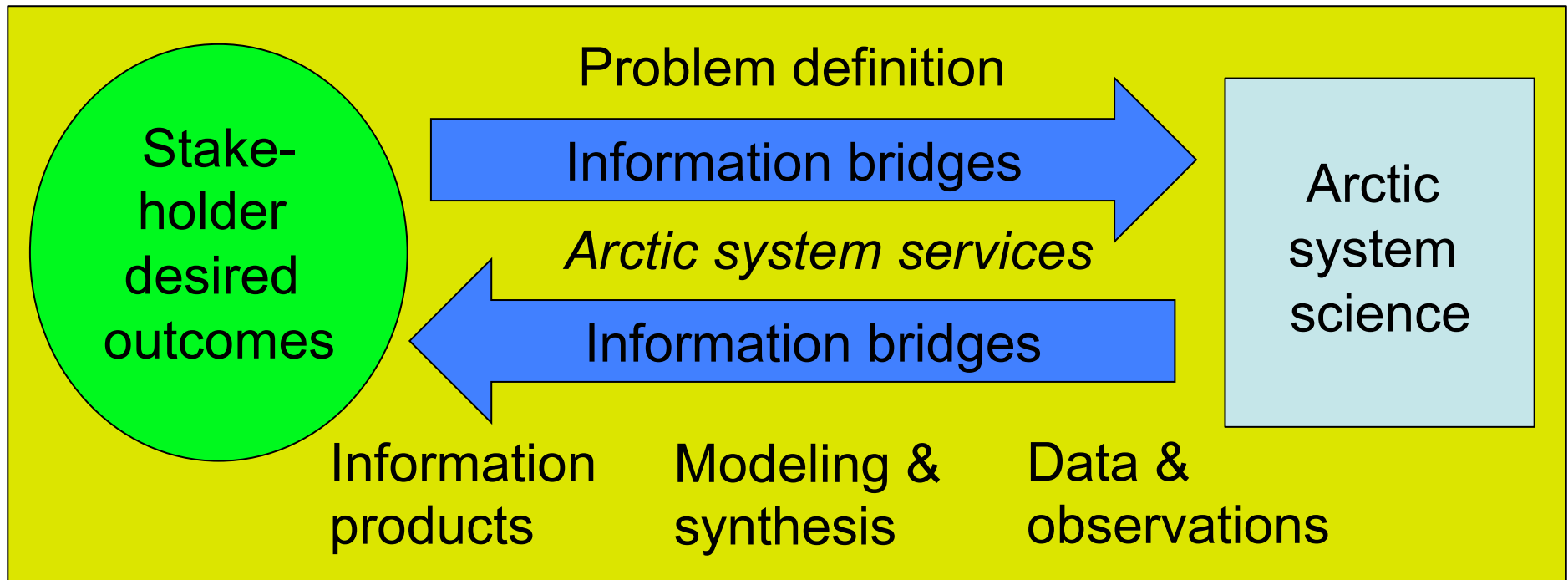


Sea Ice Prediction Network (SIPN) Goals

- SIPN is a collaborative research project – Not a forecasting system or service
- SIPN does not represent or speak for the private sector
- SIPN goals encompass research relevant to Arctic stakeholders, in particular coastal communities & maritime industry
- Coordinate and evaluate predictions
 - What is the potential value of predictions in Arctic maritime operations?
- Integrate, assess and guide observations
 - What is the overlap between observations for, e.g., climate data records and operationally relevant variables
- Synthesize predictions and observations
- Disseminate predictions and engage key stakeholders

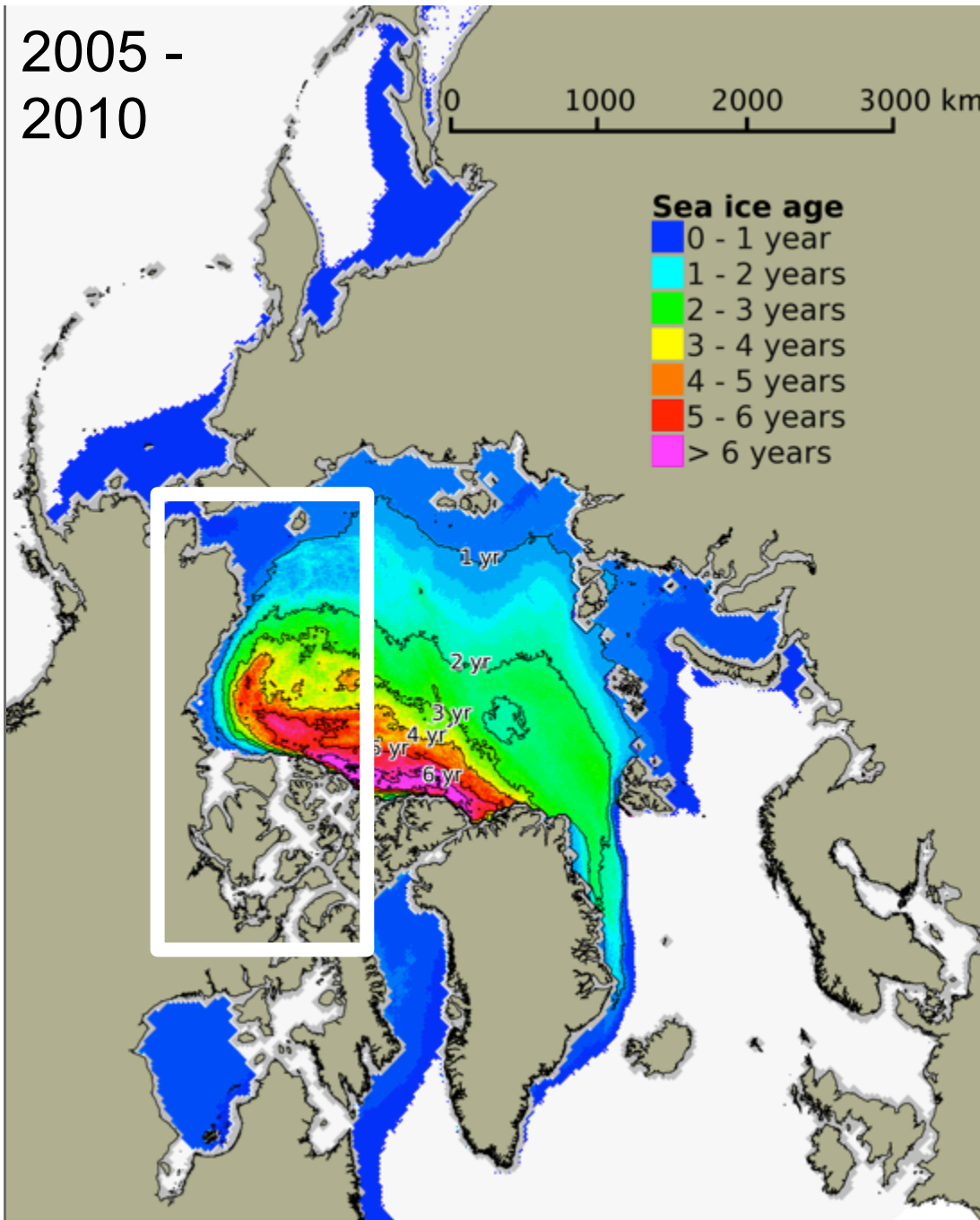


Locating SIPN in the Arctic system science & applied research landscape



- SIPN is at the interface between fundamental research on predictability of Arctic sea ice on subseasonal to multiannual scales and questions about the potential merit of (sub)seasonal predictions for maritime operations

2005 -
2010



Region of interest for seasonal prediction

- Ice thickness and velocity variations may be associated with predictive skill in North American Arctic
- Destinal traffic to coastal communities & mine sites; offshore oil & gas development

Nome 2012 fuel resupply & the case for seasonal prediction

- Nome fuel resupply by barge fails in November 2011 – late delivery prevented by “early” freeze-up & storm
- USCGC Healy supports delivery of 5000 tons of fuel by T/V Renda in Jan 2012
- Progress of Healy & Renda towards Nome delayed by convergent ice regime
- Potential role of (sub)seasonal prediction in the context of greater variability in seasonal cycle (e.g., freeze-up & break-up dates)

USCG photo



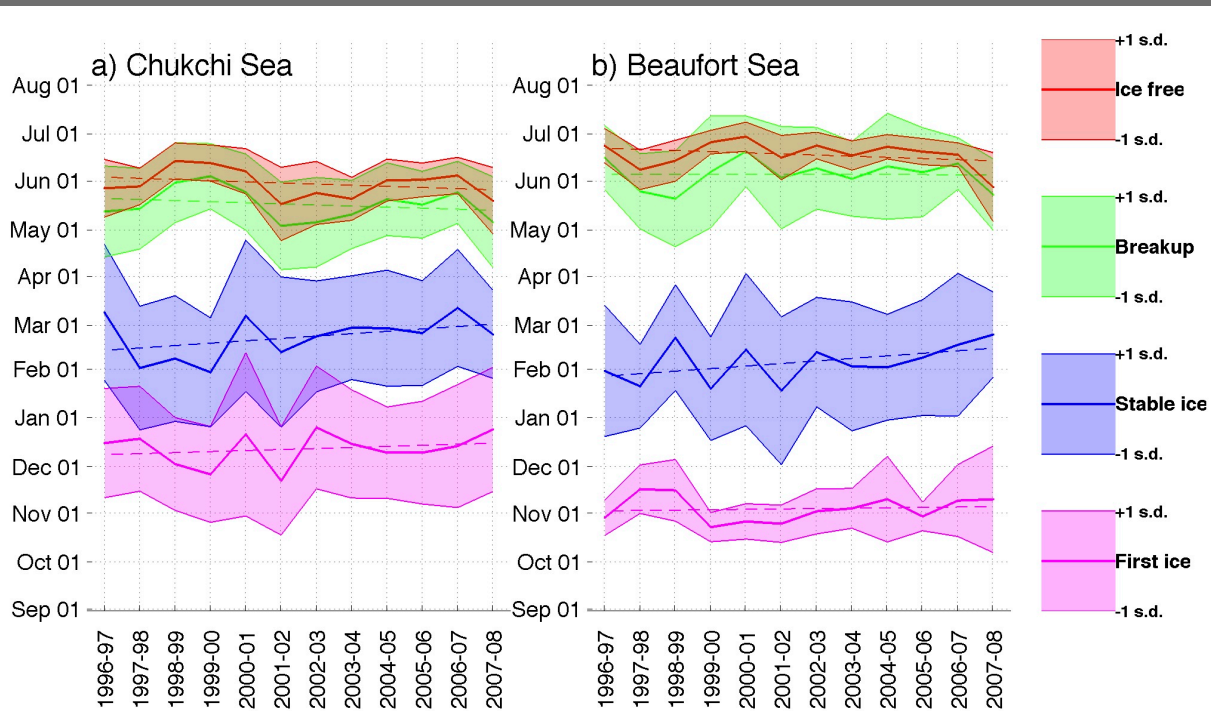
Relevant background

- Richter-Menge & Walsh (2012) Seasonal-to-Decadal Predictions of Arctic Sea Ice: Challenges and Strategies; Committee on the Future of Arctic Sea Ice Research in Support of Seasonal-to-Decadal Predictions; National Academies & Polar Research Board
- NOAA (2012) NOAA Sea Ice Forecasting - Workshop Summary
- Hughes (2013) Assessment of current monitoring and forecasting requirements from users and international providers of services; EU ACCESS Project, Report D. 2.14
- Seasonal scale prediction may lead to improved risk analysis and better planning of operations
- Specific guidance on how to improve seasonal scale predictions and supporting observations
- Limited exploration of specific information needs of private sector (i.e., target variables) and potential links to ongoing research efforts
- Potential barriers in achieving predictive skill vs. value in the context of heuristic forecasts

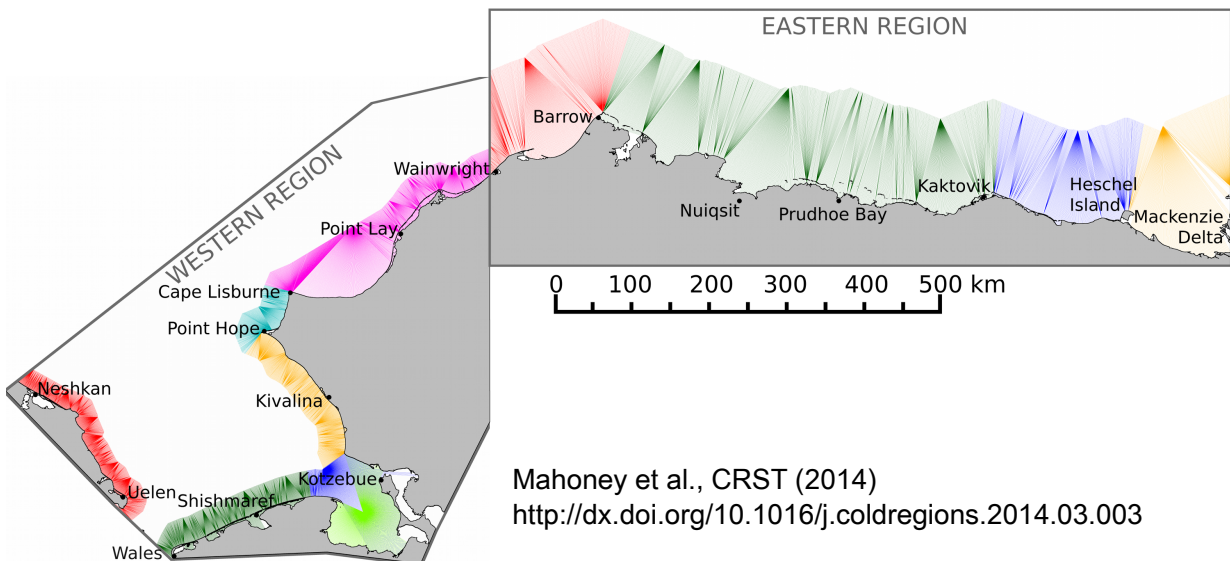
Hazards & threats: Relevant sea-ice variables

Activity or asset	Hazard or threat	Relevant variable	Setting/scale
<i>Shipping</i>	Ice contact & damage	<i>Ice concentration, ice type/strength, ice convergence</i>	Marginal ice zone, 10s-100s km
<i>Use of ice as platform</i>	<i>Ice break-out</i> or breaking through of personnel & equipment	<i>Landfast ice stability/anchoring strength, thickness, morphology</i>	Landfast ice, <1-10s km
<i>Coastal & offshore infrastructure</i>	<i>Loading, impact & damage by drifting ice</i> , ice push & gouging	<i>Ice velocity</i> , floe size, <i>thickness, ice type/strength</i>	Coastal & offshore drift ice, <1-10s km
<i>Emergency/spill response</i>	Oil spill or vessel sinking in ice, dispersal of contaminants by ice	<i>Ice velocity, trajectory of contaminated ice, morphology</i>	Landfast & drift ice, <1-100s km
<i>Maritime activities</i>	Slush ice build-up, clogging of intake valves etc.	<i>Freeze-up onset, frazil ice formation</i>	Coastal ocean during freeze-up, <1-100s km

Key dates in seasonal cycle of coastal (landfast) ice



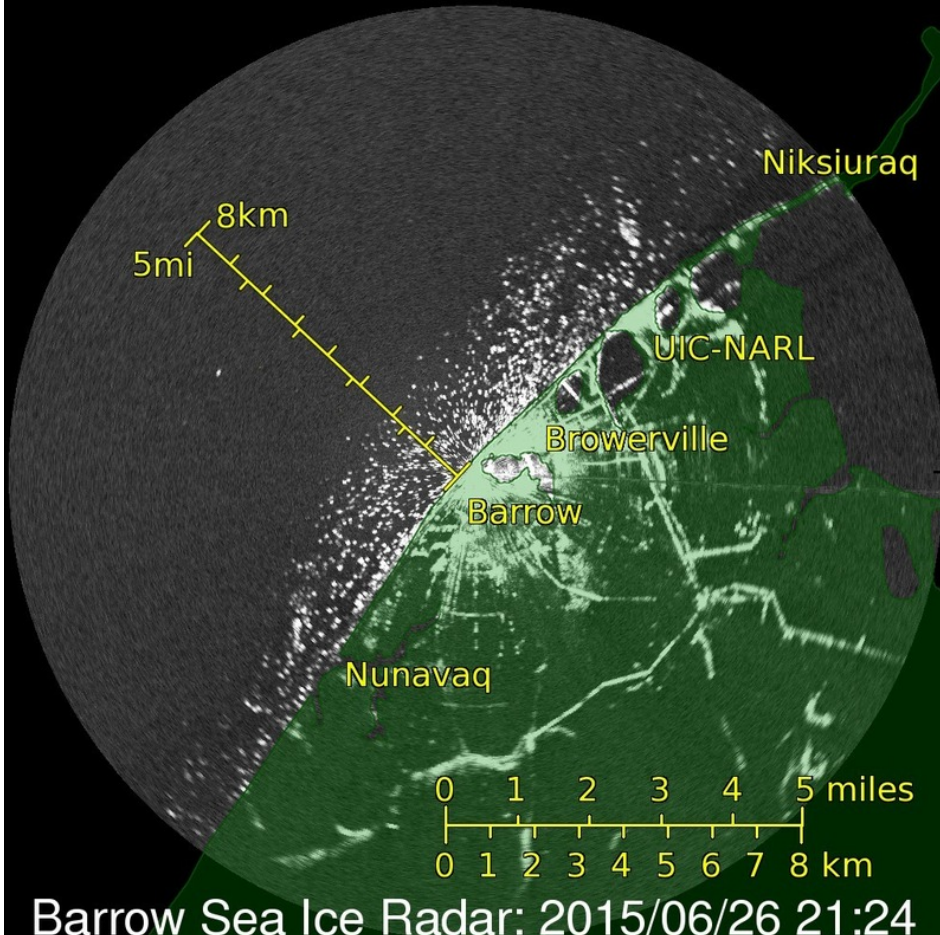
- Interannual & regional variability of key dates motivates and constrains (sub)seasonal forecasts
- Challenges in defining predictand variables



Break-up at Barrow, AK – 26-28 June 2015

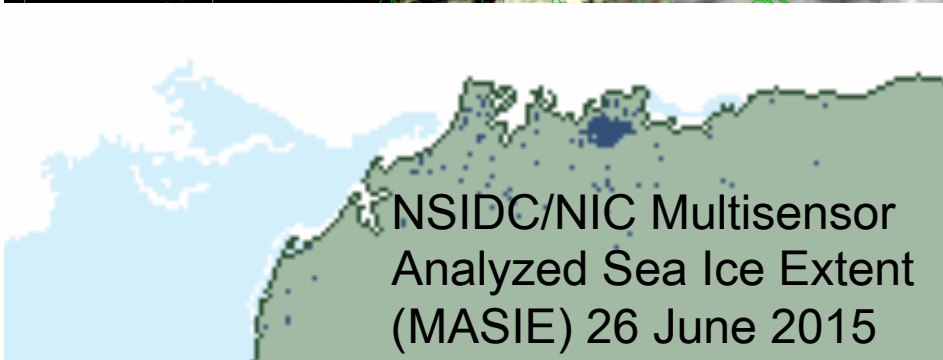
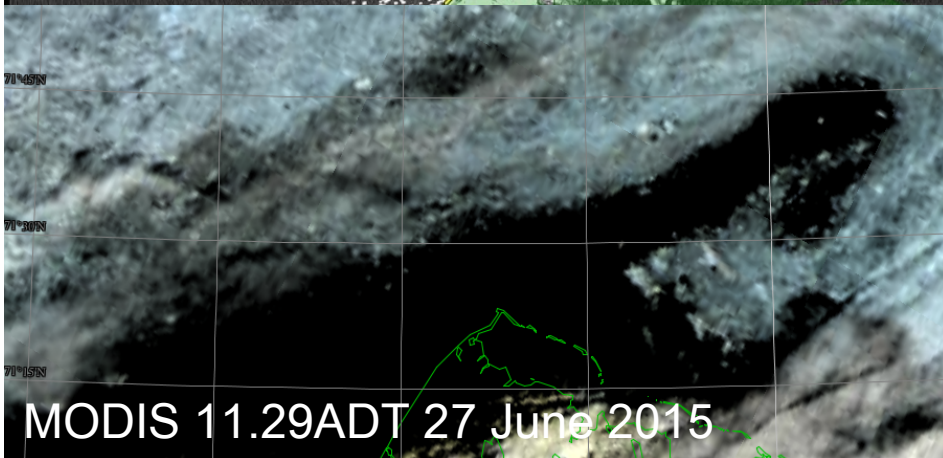


Break-up at Barrow, AK – 26-28 June 2015



- Interannual & regional variability of key dates motivates and constrains (sub)seasonal forecasts
- Challenges in defining predictand variables
- Local observers & radar indicate June 26 first full boat access to coastal ocean from shore; June 28 swath of no to traces of ice >10 km wide

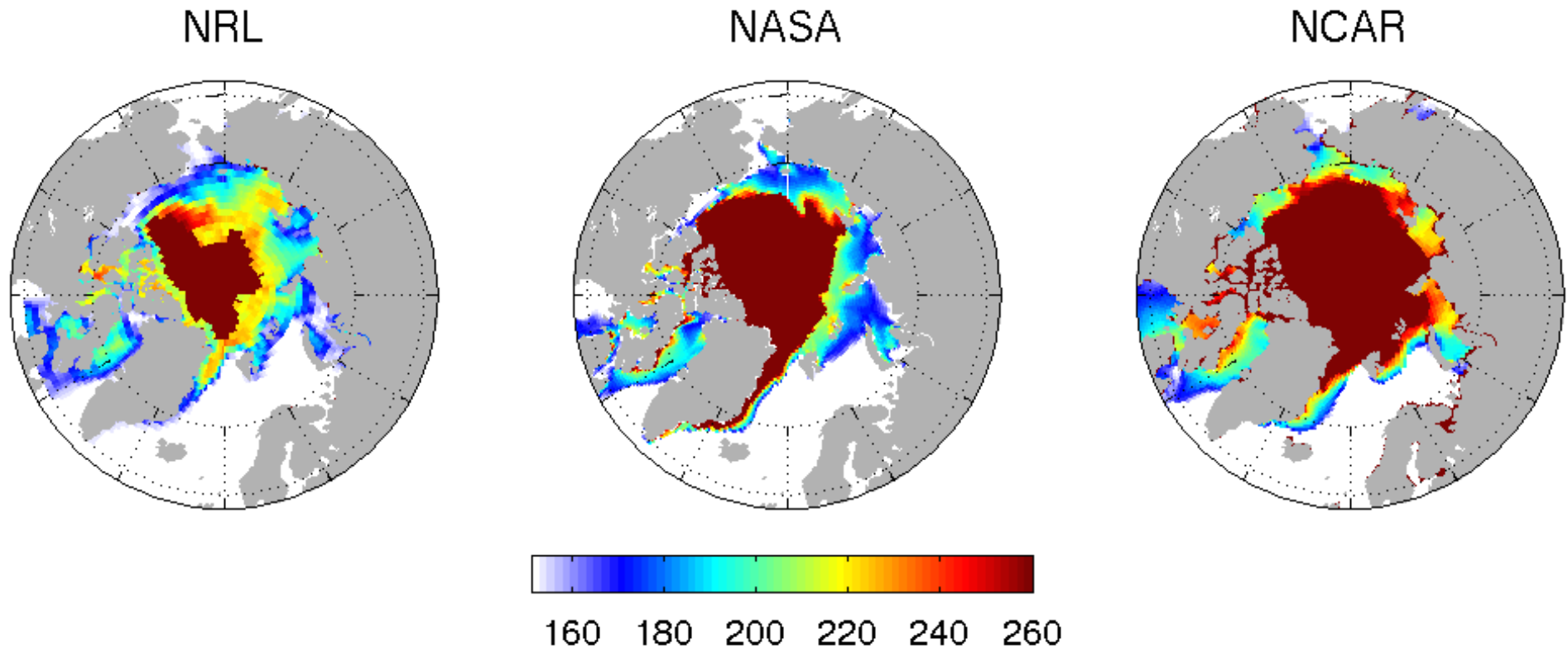
Webcam & Ice Radar
21.24ADT 26 June 2015



Break-up: 26-28 June 2015

- Interannual & regional variability of key dates motivates and constrains (sub)seasonal forecasts
- Challenges in defining predictand variables
- Observational/operational scale needs to be defined
- Local observers & radar indicate June 26 first full boat access to coastal ocean from shore; June 28 swath of no to traces of ice >10 km wide

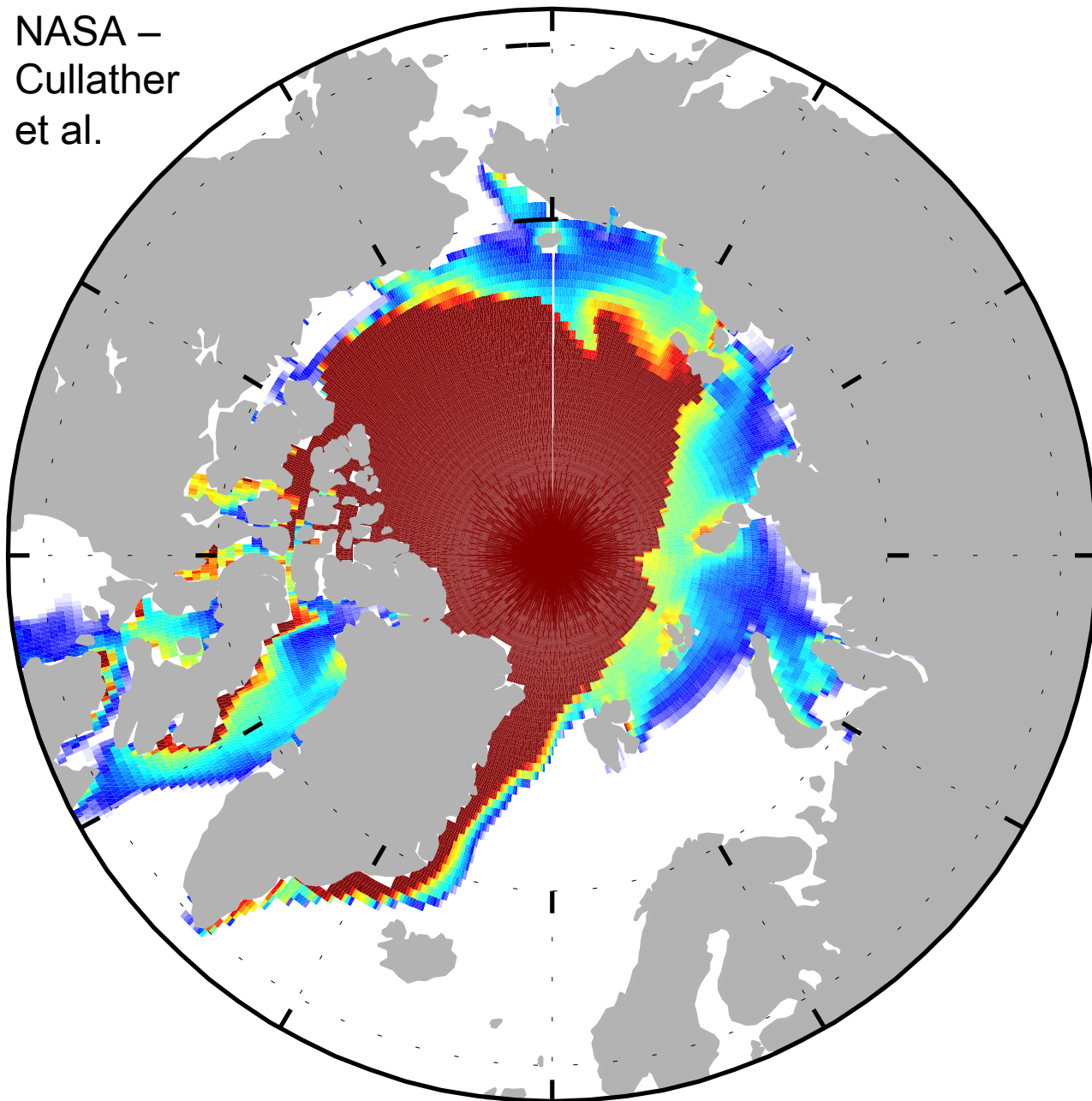
Arctic Sea Ice Outlook 2015 ice-free date predictions



- First day of <15% ice concentration from contributions to SIPN's Arctic Sea Ice Outlook (Posey et al.-NRL; Cullather et al.-NASA; Blanchard-Wrigglesworth et al.-NCAR – compiled by E. Blanchard-Wrigglesworth; more details at www.arcus.org/sipn/sea-ice-outlook/2015)
- Patterns north of Alaska are captured; broad range of estimates due to combination of factors, incl. inherent model uncertainties or biases, different model resolution and other factors

Arctic Sea Ice Outlook 2015 ice-free date predictions

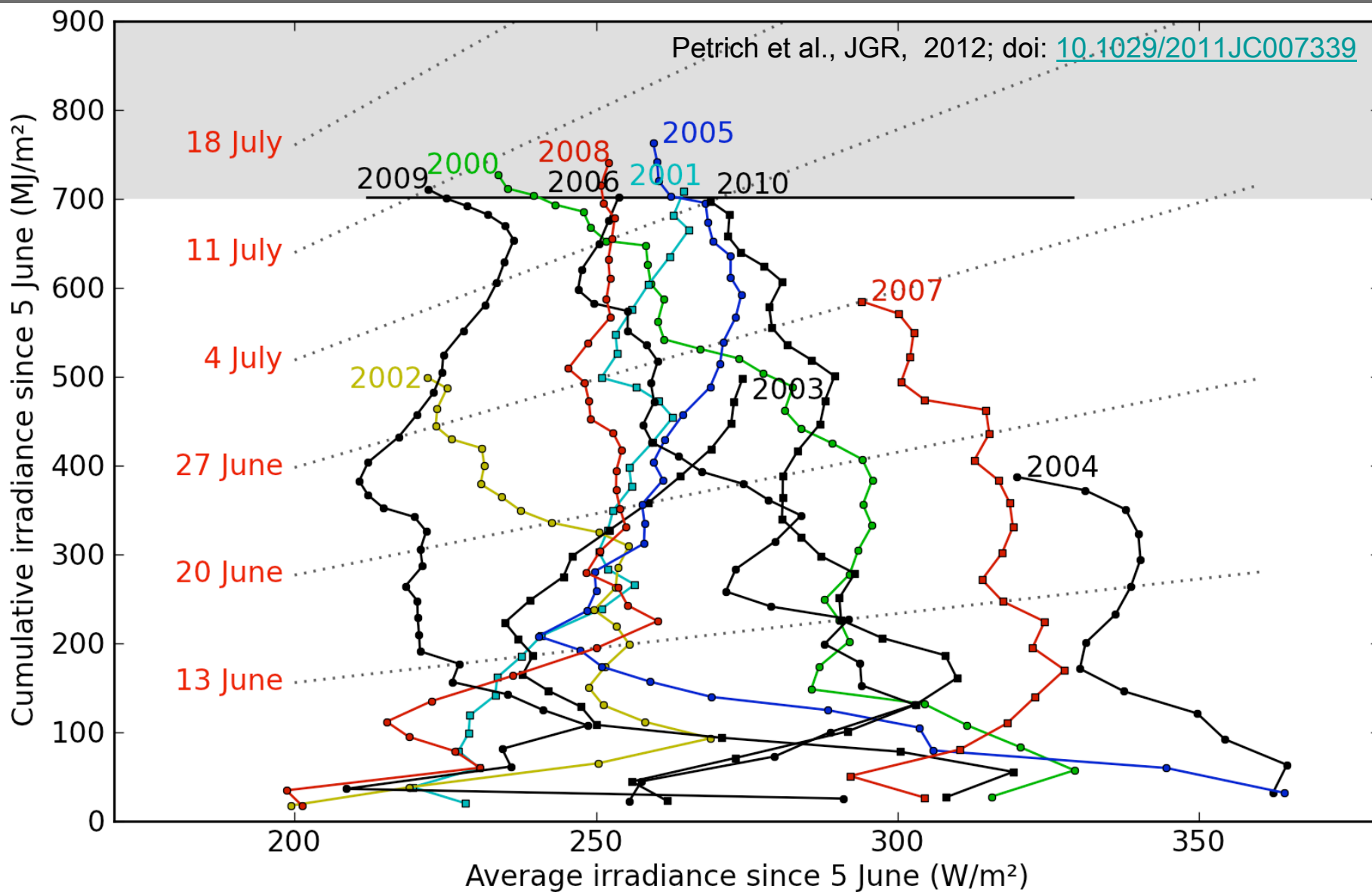
NASA –
Cullather
et al.



- First day of <15% ice concentration from contributions to SIPN's Arctic Sea Ice Outlook (Metzger et al.-NRL; Cullather et al.-NASA; Kay et al.-NCAR – compiled by E. Blanchard-Wrigglesworth; more details at www.arcus.org/sipn/sea-ice-outlook/2015)
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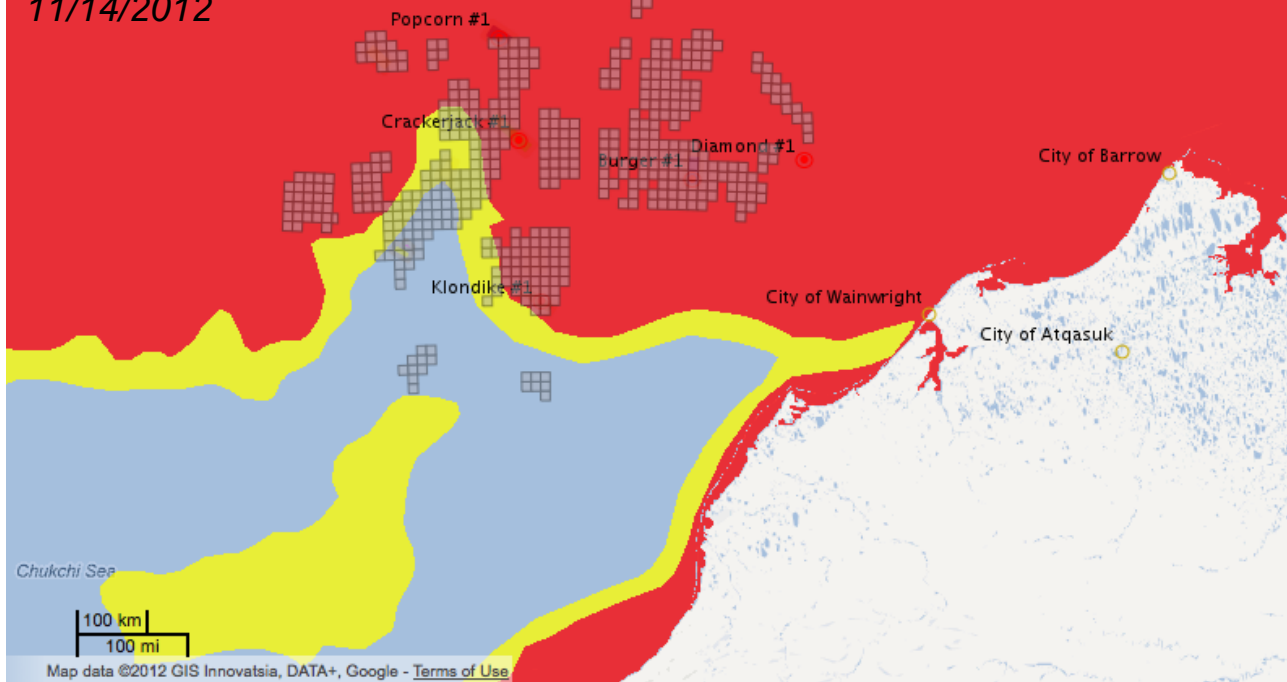
Forecasting break-up:

2-week forecast accurate to within ± 1 day (2009+10)



Summer ice conditions & freeze-up

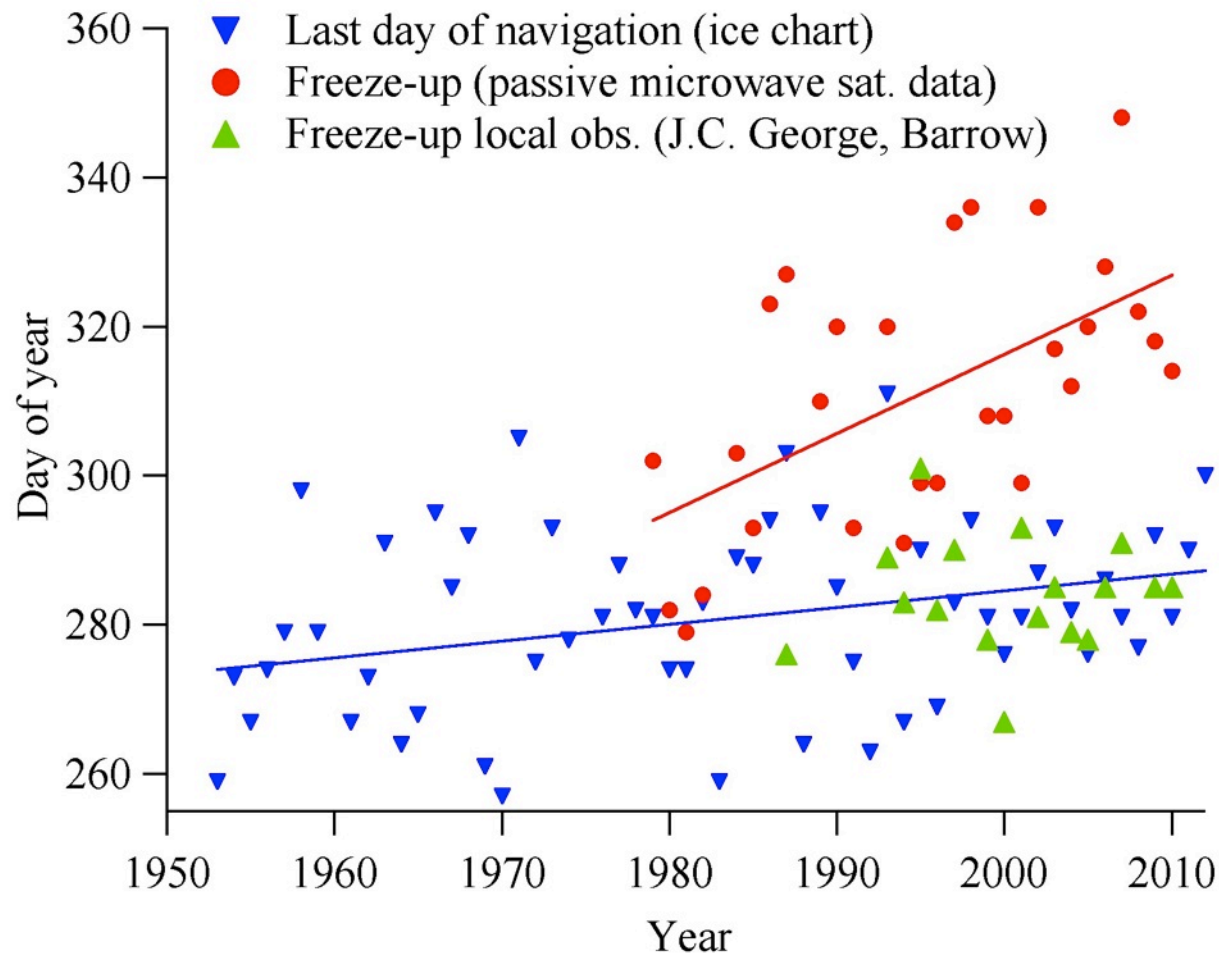
NOAA Arctic Environmental Response Management Application (ERMA)
11/14/2012



- Ice presence & freeze-up progression determine window of operations in Chukchi Sea
- Summer 2012 Shell exploration well drilling as example

- NOAA/NIC and NWS (Anchorage Ice Desk) provide
 - Briefings between NWS and Shell on weather and sea-ice conditions
 - Briefings for BOEM: Seasonal weather and sea ice outlooks; detailed 5-day weather and sea-ice forecast for all of Shell's vessels during transit to and from the Burger Site as well as while they are in theater

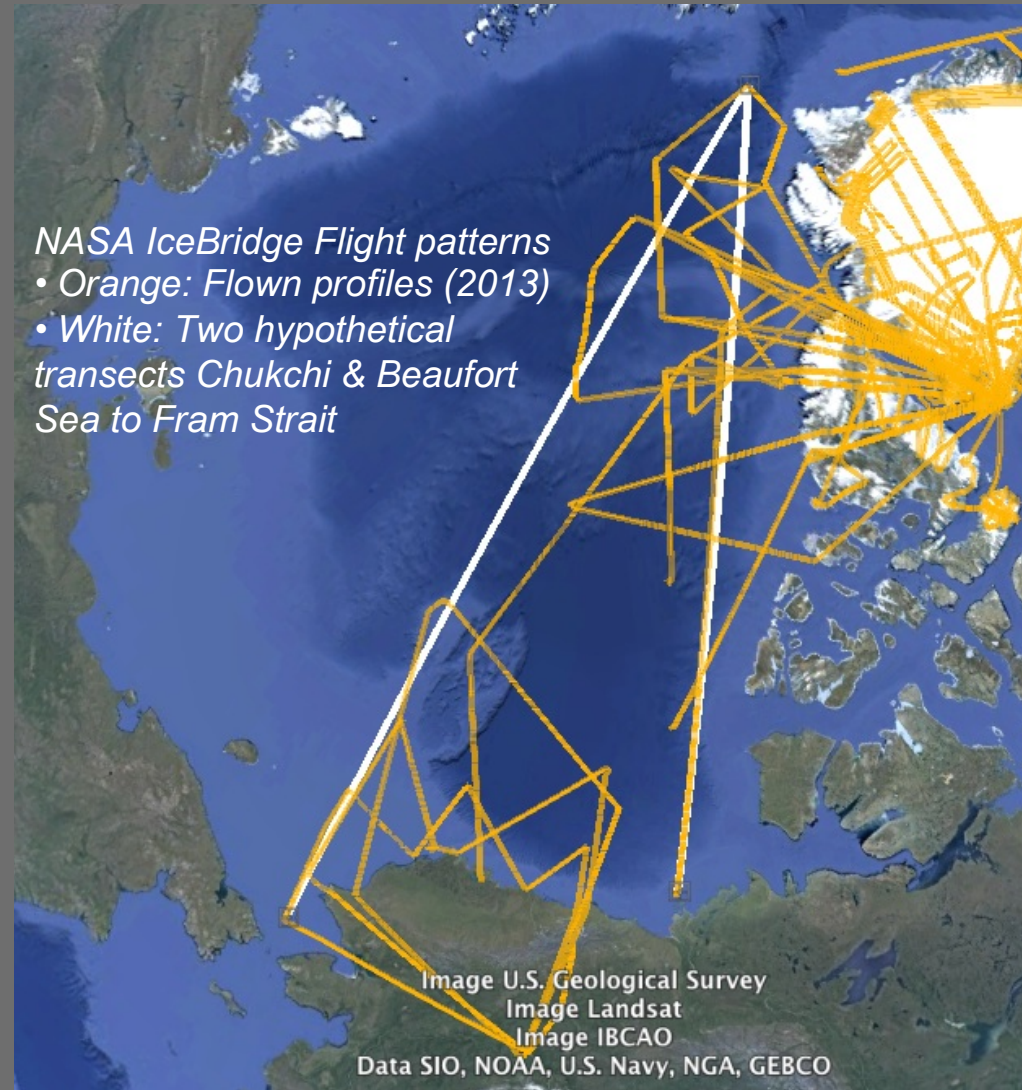
Timing of freeze-up & operational window depend on definition of freeze-up & observational method



- Divergent perspectives on freeze-up climatology
- Prudent navigation (NIC)
- Detectable new ice (satellite sensors)
- Local observations

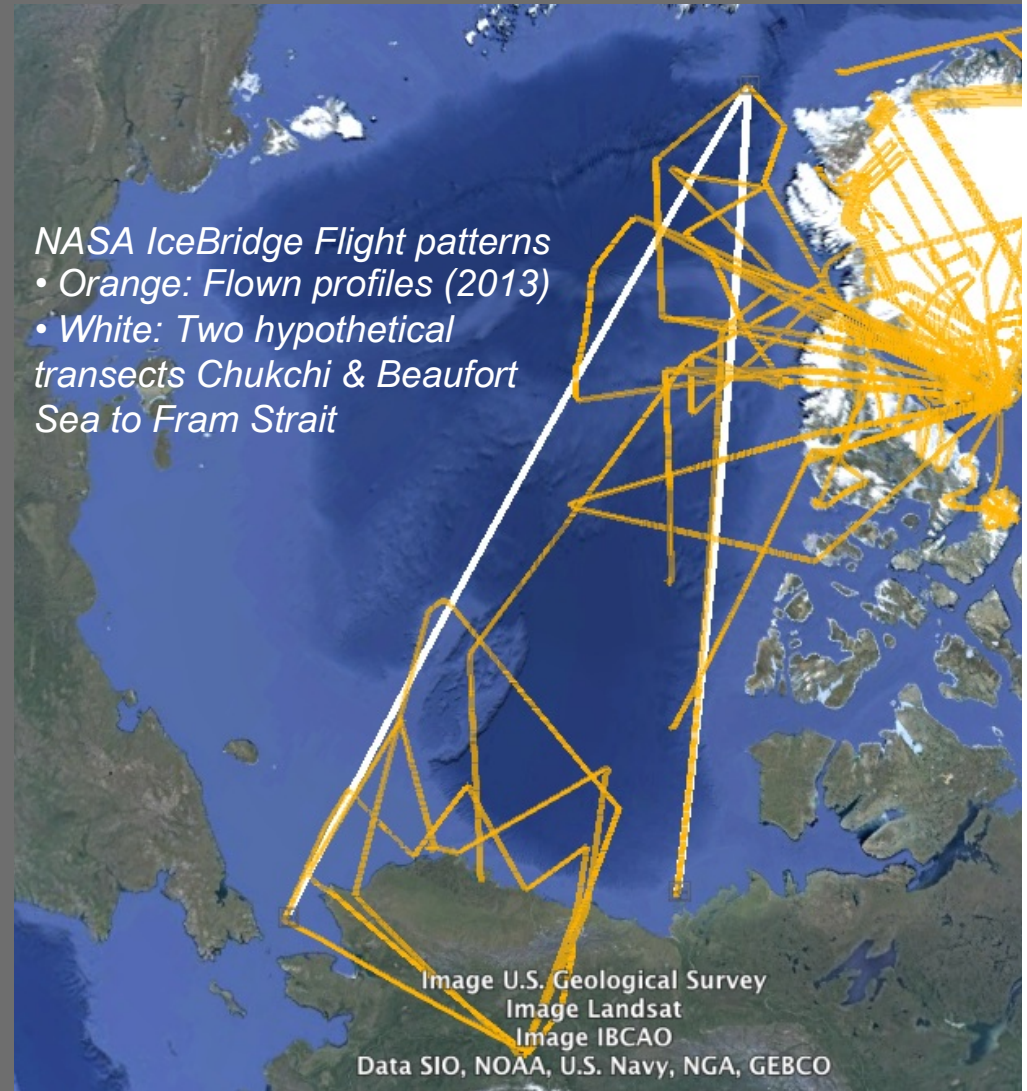
Observations for seasonal predictions: SIPN – EU ACCESS project collaboration

- Guidance on airborne thickness surveys to reduce uncertainty in prediction of ice area and volume weeks to months out
- Based on coupled ice-ocean model run within variational data assimilation system; measurement errors & uncertainties specified

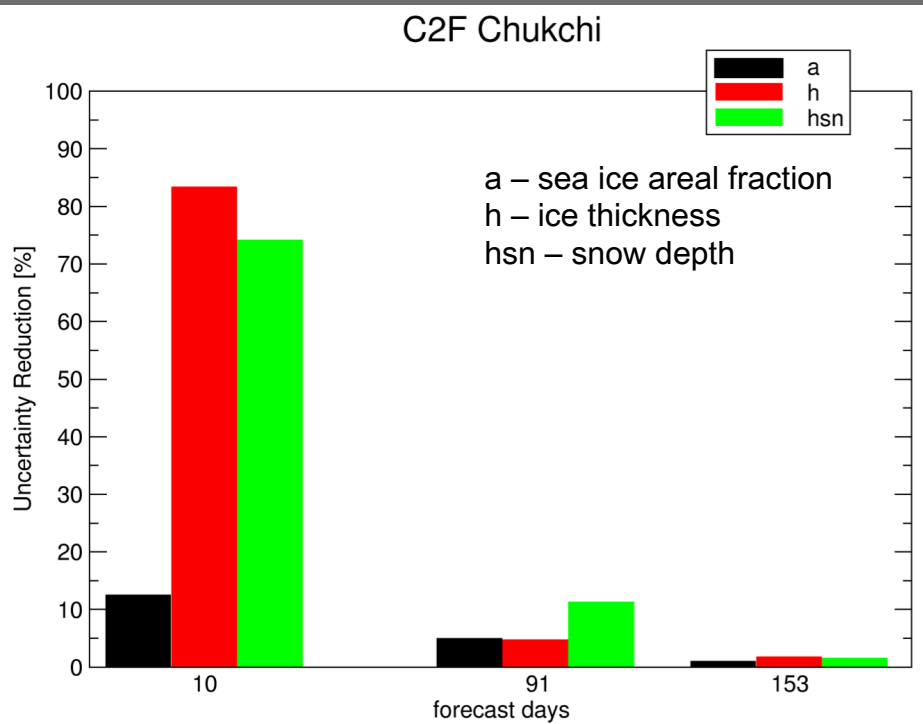


Observations for seasonal predictions: SIPN – EU ACCESS project collaboration

- Target quantities correspond to variables/ parameters that define the operationally relevant *Barnett Ice Severity Index* (BSI, duration & extent of ice cover along transit route along North Slope of Alaska) and *ice conditions in Chukchi Sea lease areas*
- Impact of two hypothetical ice thickness surveys (Chukchi & Beaufort Sea) is evaluated



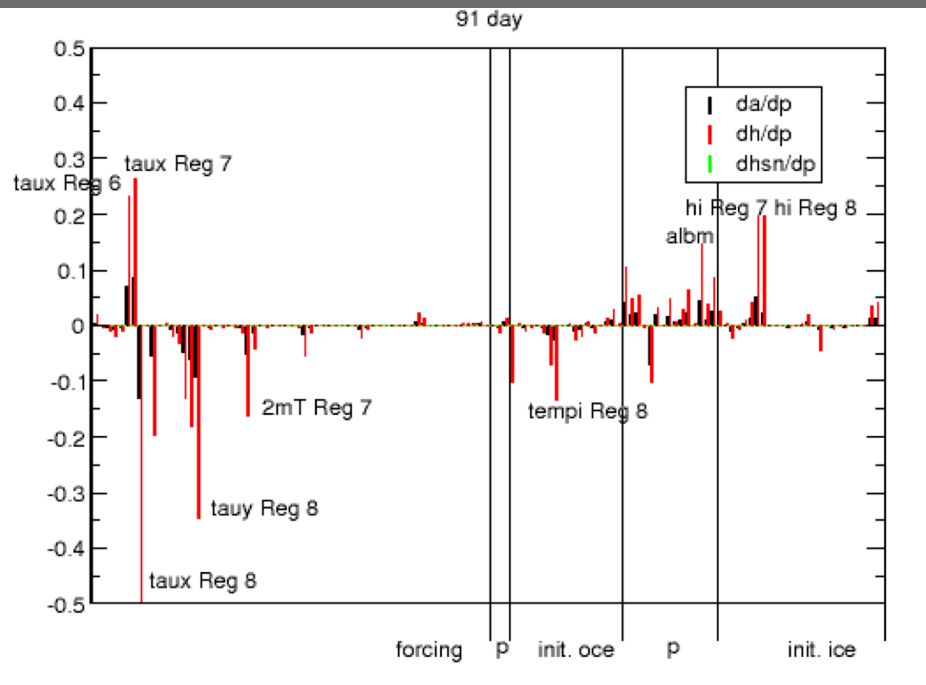
Reduction in uncertainty of predicted target variables on synoptic to seasonal scale



Kaminski et al., TCD (2015), doi:10.5194/tcd-9-1735-2015

- Uncertainty inherent in forcing data, initial state, parameterization and implementation of physical processes in the model, resulting in uncertainty (and associated errors) of predicted target variables
- By how much is the uncertainty in predicting target variables over Chukchi lease areas reduced through assimilation of ice thickness transect from Chukchi Sea to Fram Strait?
- Even transects outside of target region can significantly reduce target variable uncertainty

Reduction in uncertainty of predicted target variables on synoptic to seasonal scale



Kaminski et al., TCD (2015), doi:10.5194/tcd-9-1735-2015

- Sensitivity dx/dp of prediction target quantities to a change in uncertainty by one standard deviation of control variable p
- Wind stress in different Arctic subregions, initial ice and ocean state, albedo parameterization of particular relevance
- Provides guidance on how specific observations in conjunction with model improvements impact seasonal scale predictions at specific sites for specific variables

Conclusions

- Potential value of (sub-) seasonal sea ice prediction in operational context (incl. research) tied to
 - Goals & target variables clearly defined
 - Requirements for predictive skill and heuristic predictions stated
 - Framework for iterative evaluation and refinement
- Targeted observations & in-depth analysis of regional predictions hold significant promise
- SIPN as nucleus for a Community of Practice among researchers, agencies, industry, and other stakeholders
- Activities in Chukchi Sea potential basis for in-depth studies (e.g., NOAA Arctic Testbed, DBO and NSF-AON projects)

