Challenges and Opportunities of a Year in the Arctic Sea Ice

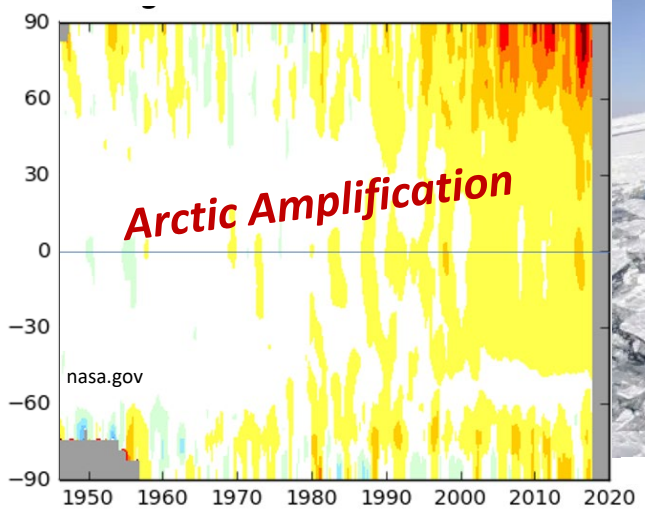
MOSAiC
Multidisciplinary drifting **O**bservatory
for the **S**tudy of **A**rcti**c** **C**limate

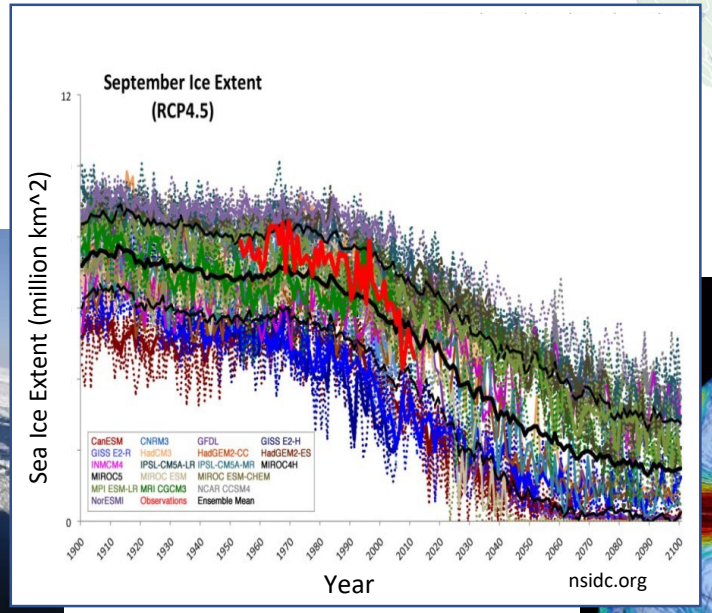
Matthew Shupe
University of Colorado / NOAA
BERAC, 23 October 2020

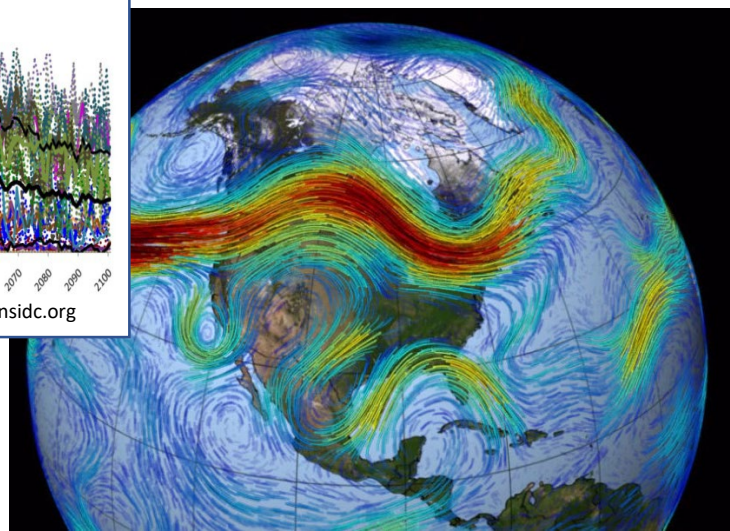
Photo: Markus Rex

Motivations

- Rapid change… sea-ice decline, amplification
- Poor model predictive capabilities
- Emerging operational/management needs
- Questions about global linkages
- Dearth of observations

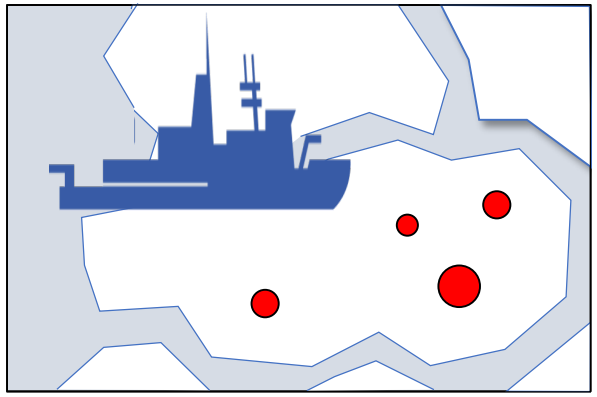


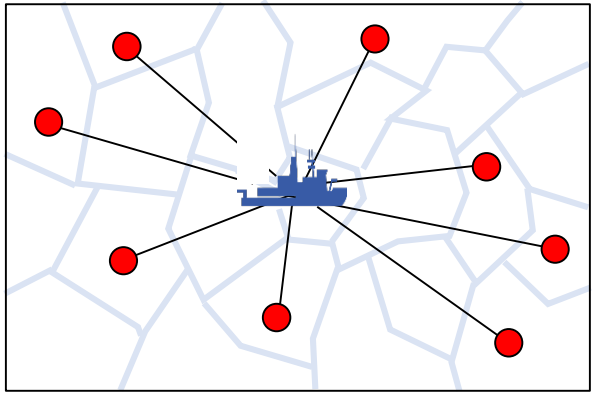


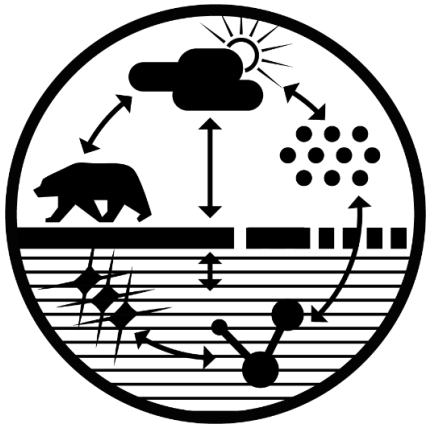


Plans for an Expedition

- International: IASC, AWI, many US agencies (12 years of planning!)
- Interdisciplinary: ATMOS-ICE-OCEAN, physical-chemical-biological
- Multiscale: Point, grid-cell, pan-Arctic
- Integration: Observations and Models
- Annual Cycle: Contiguous seasons in the ice

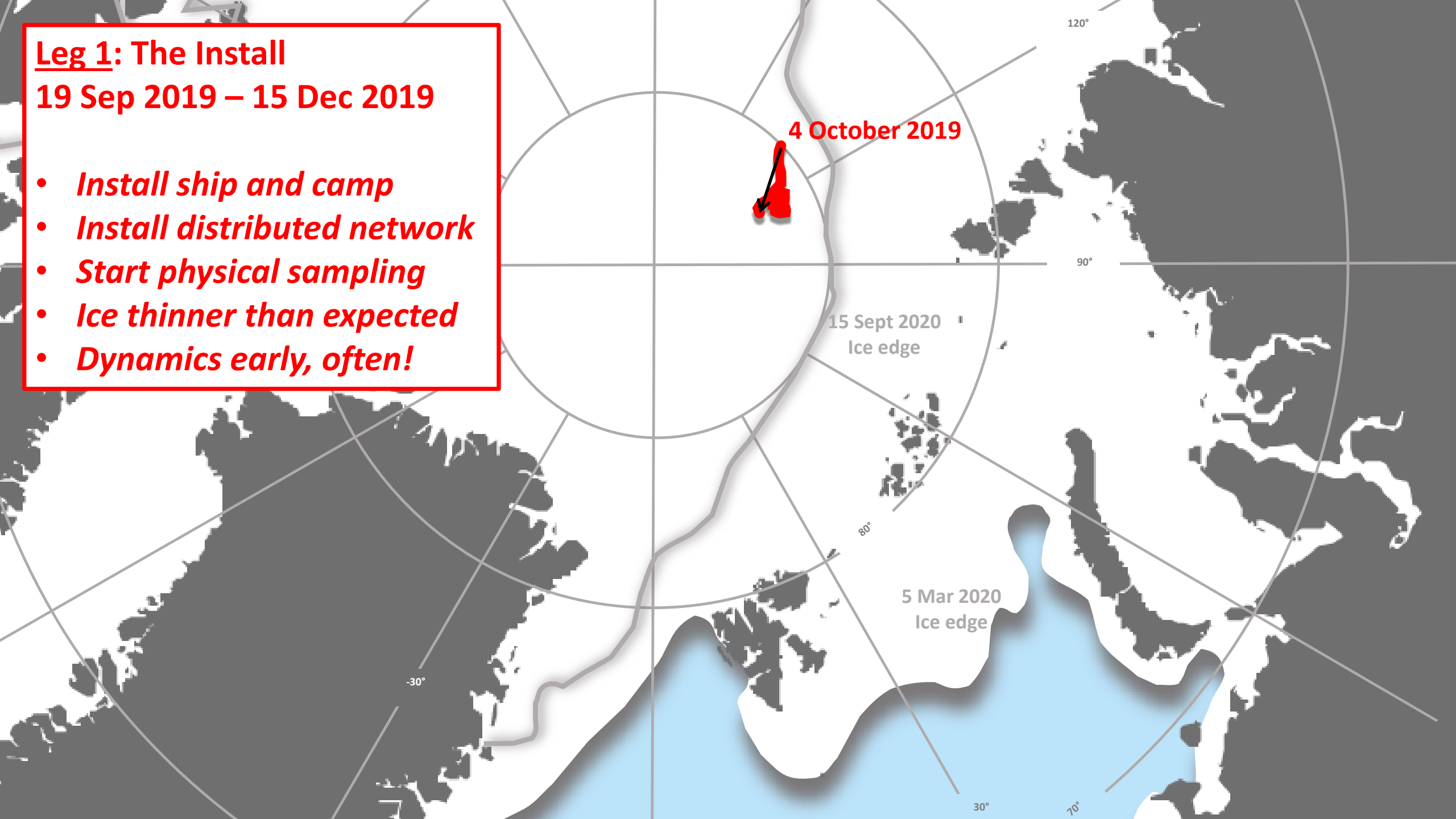






So how did it go?

Let's take the journey


Leg 1: The Install
19 Sep 2019 – 15 Dec 2019
• Install ship and camp
• Install distributed network
• Start physical sampling
• Ice thinner than expected
• Dynamics early, often!
4 October 2019
15 Sept 2020
Ice edge
5 Mar 2020
Ice edge
120°
90°
80°
-30°
30°
70°

Packed to capacity


NOAA109401
NOAA109401

Dave Stenssen

First exploration of MOSAiC floe

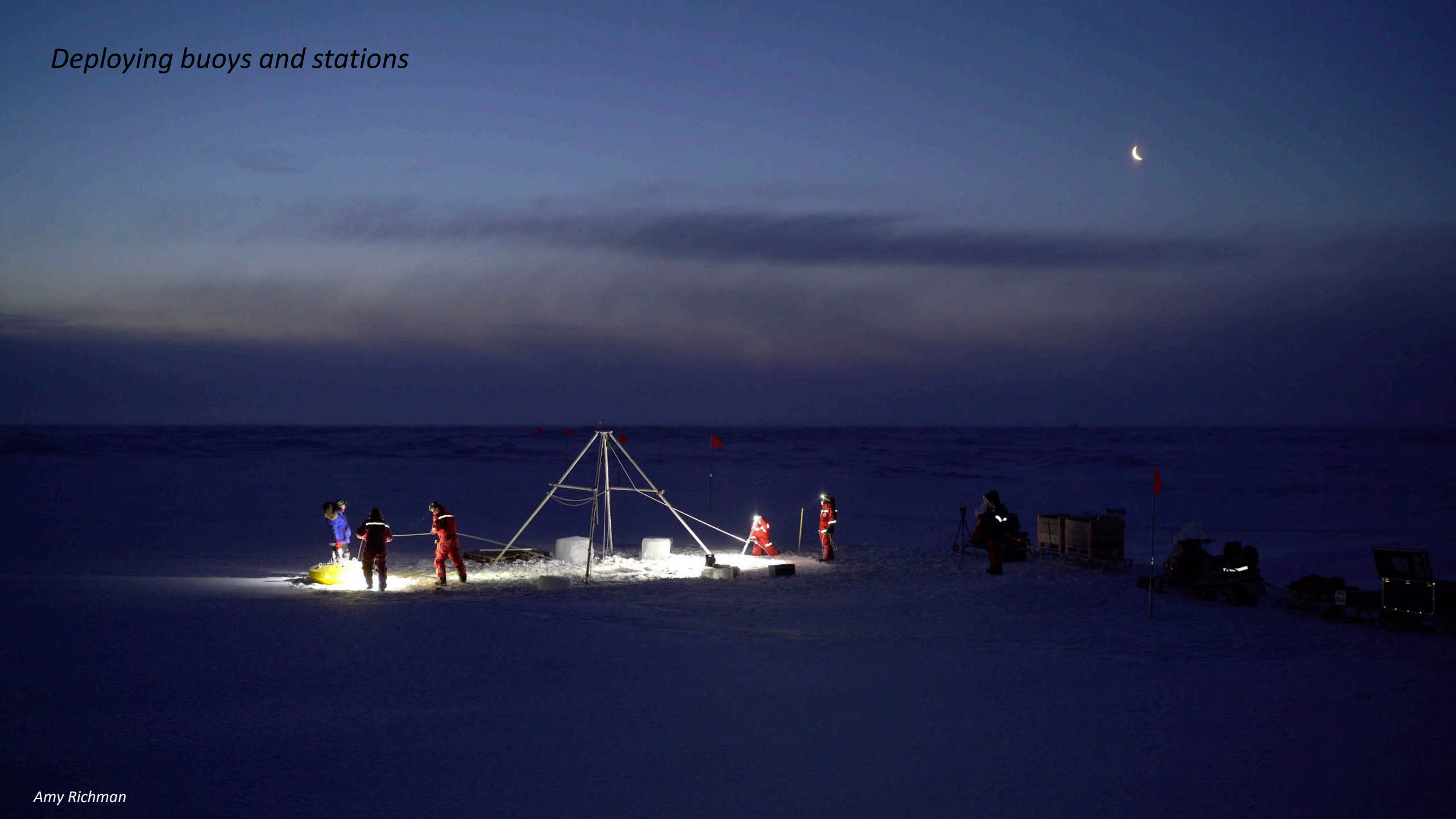
Sebastian Grote

Esther Horvath

“Cities” on the ice

Matthew Shupe

Deploying buoys and stations



Amy Richman

Comprehensive physical measurement and sample programs

Marcel Nicolaus

Ice dynamics…. early and often

Marcel Nicolaus

Marcel Nicolaus

Marcel Nicolaus

Where is the Aerosol?

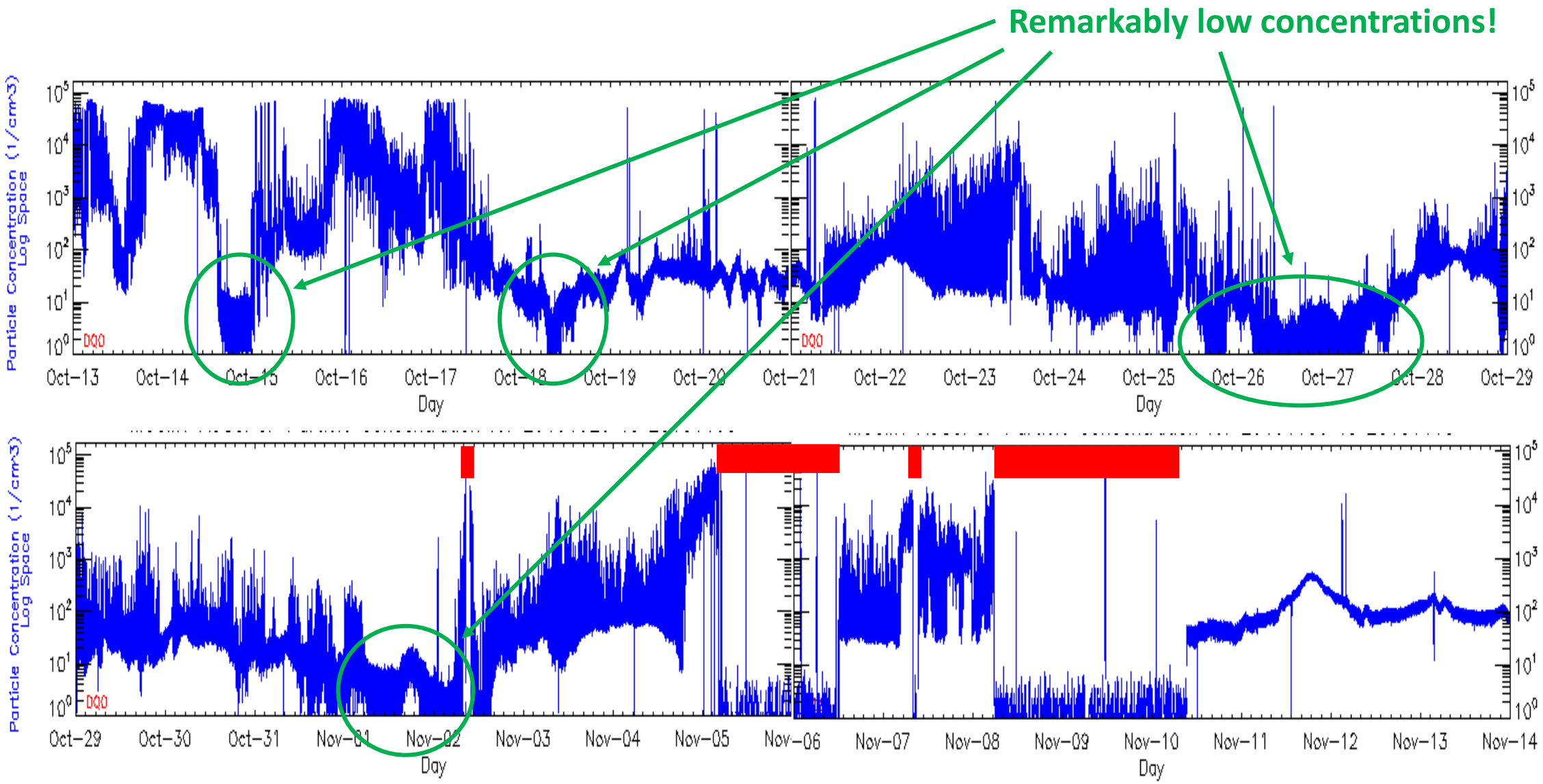


Image provided by the ARM Data Quality Office: 20200124.212011

Image provided by the ARM Data Quality Office: 20200124.211344

Clouds

Radar and ceilometer show clouds

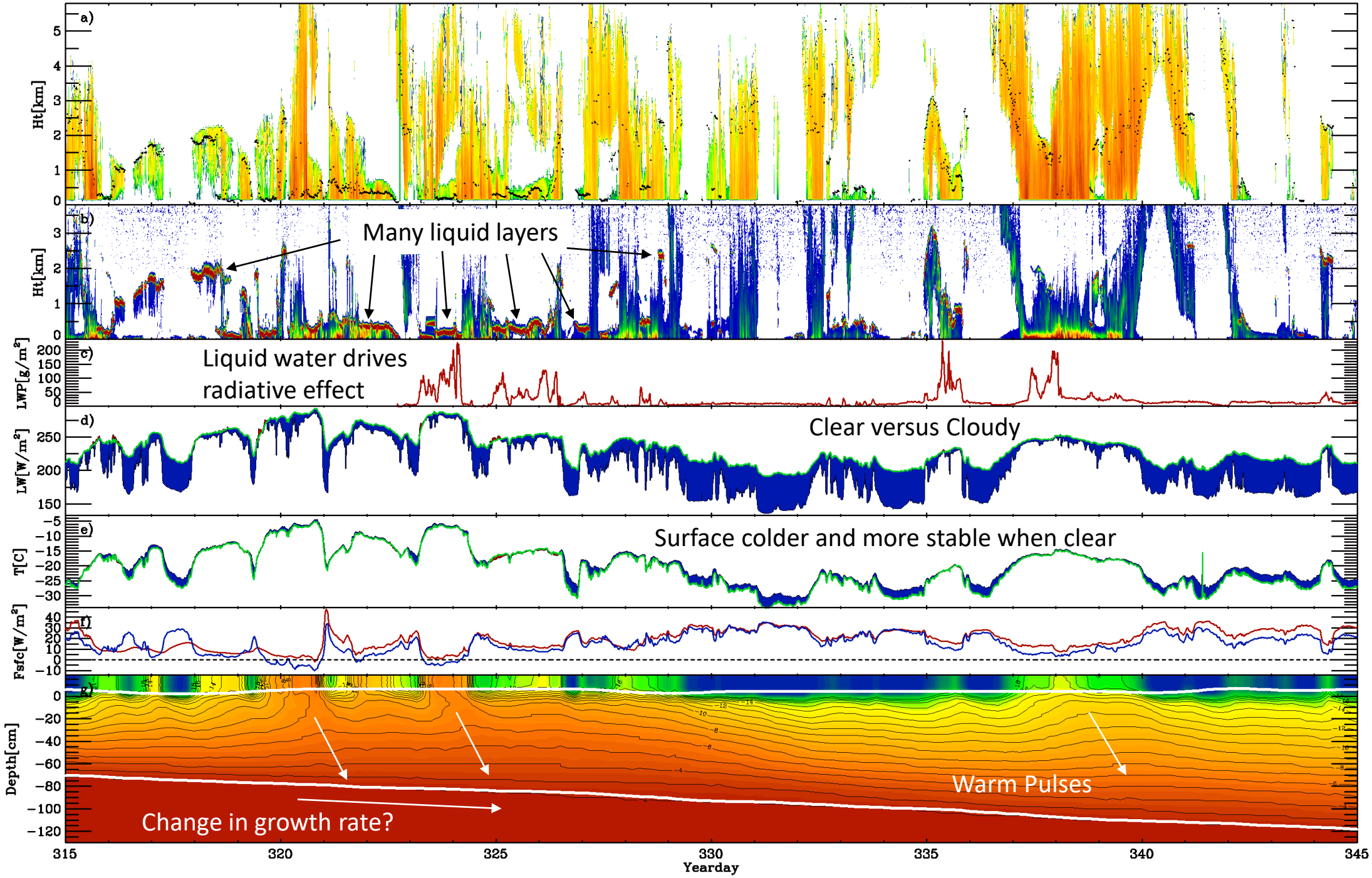
MWR-derived liquid water

LW Radiative balance

Near-surface stability

Sfc Fluxes

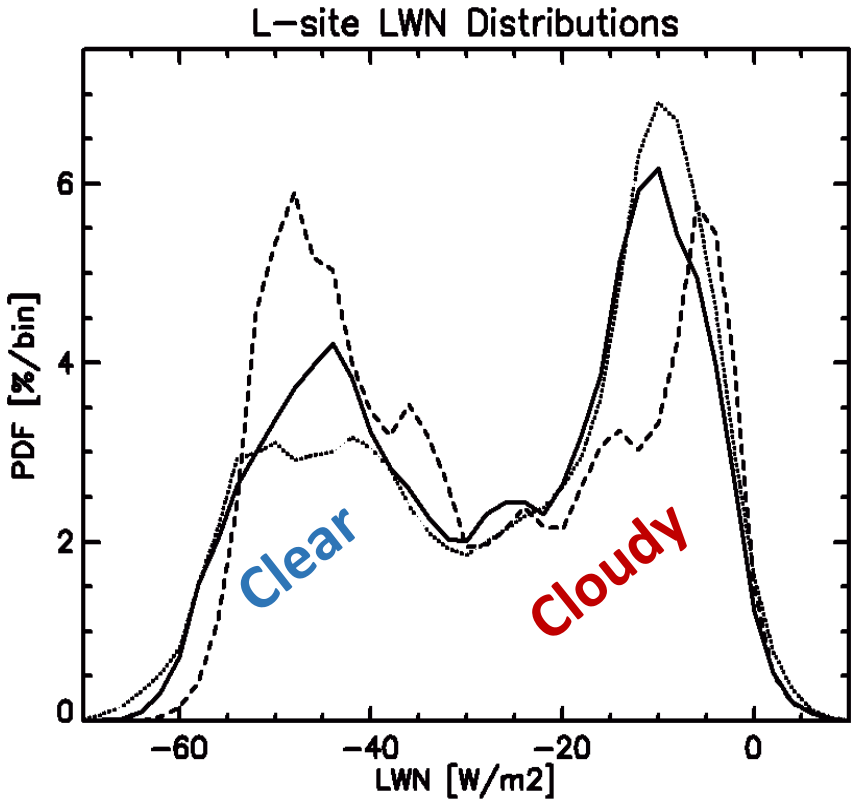
Ice / snow / ocean temps

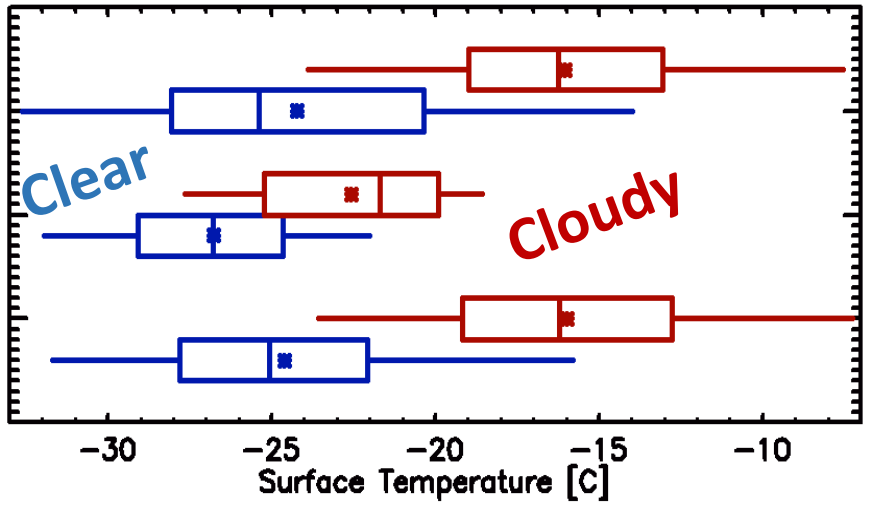


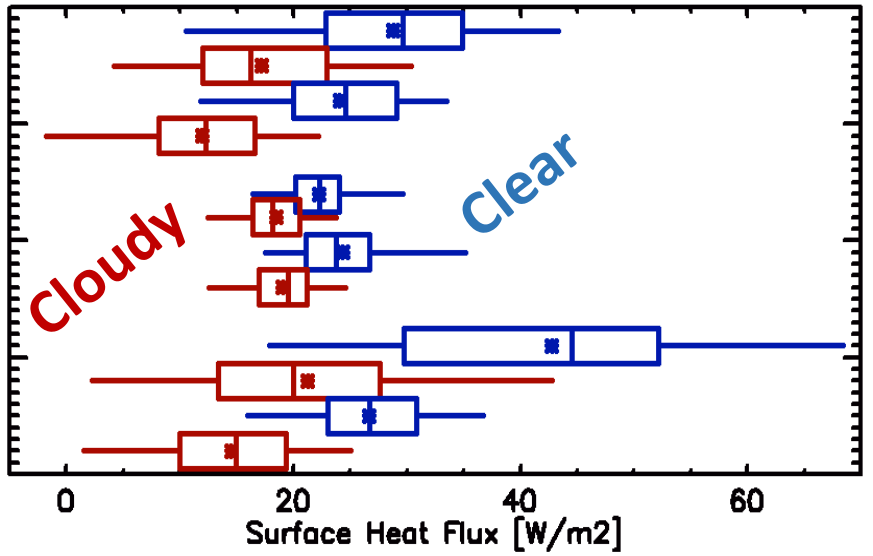
Cloud Impacts on SEB Partitioning

Two Arctic States

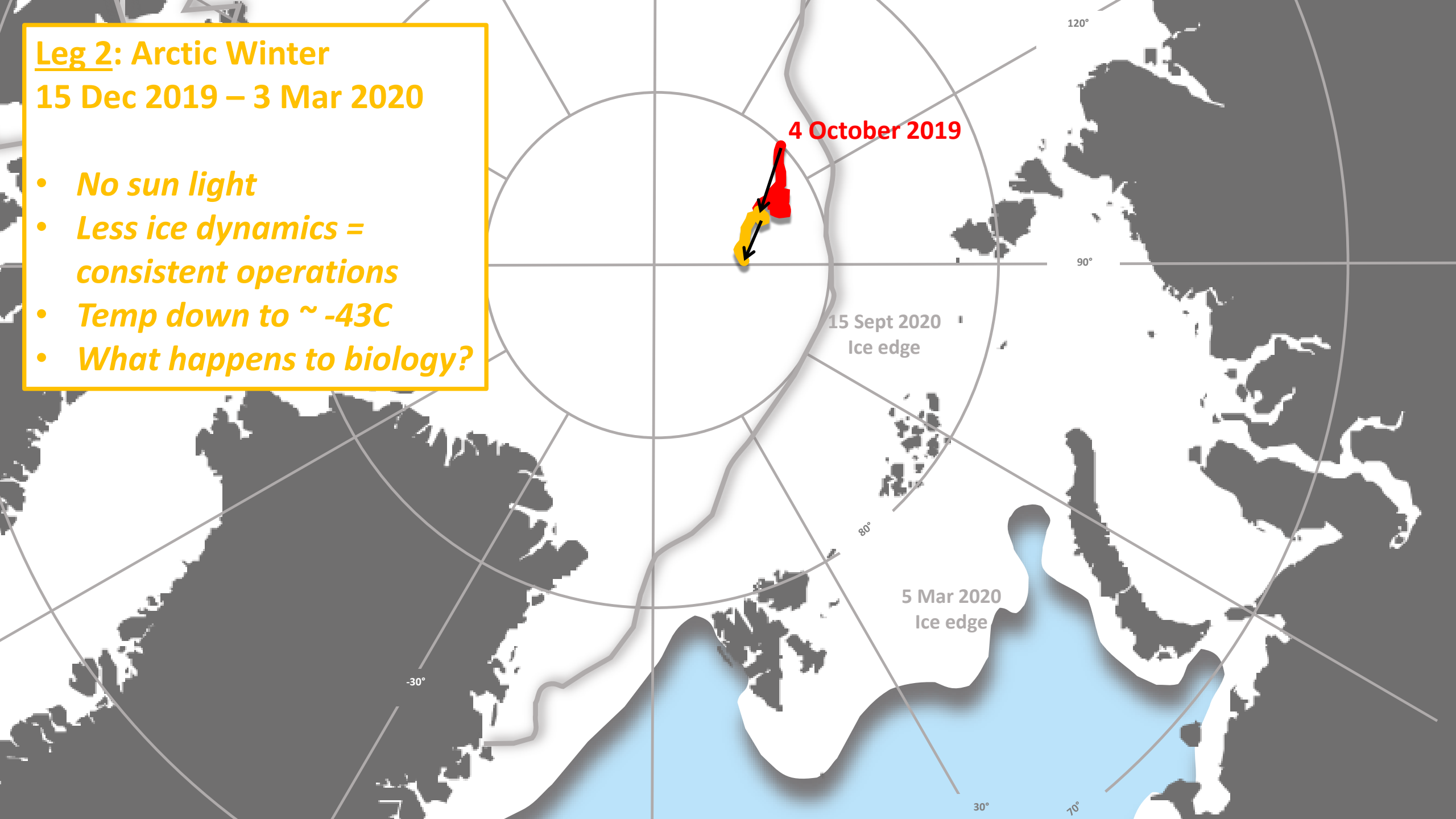
1) Optically Thick: Liquid water clouds
2) Optically Thin: Clear sky or ice clouds





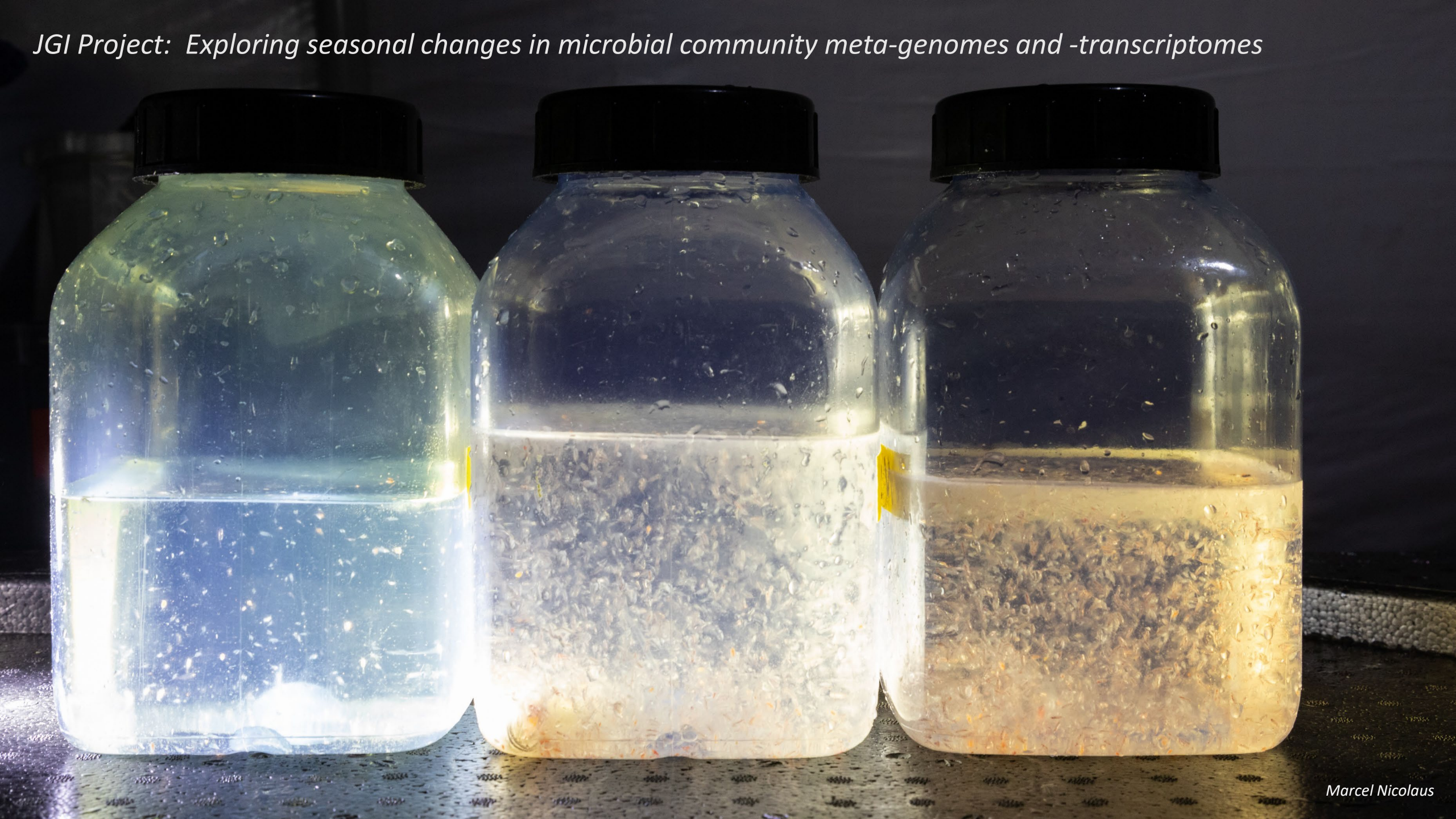


- How do other energy terms respond?
- What is the effect of variable ice-snow thickness?

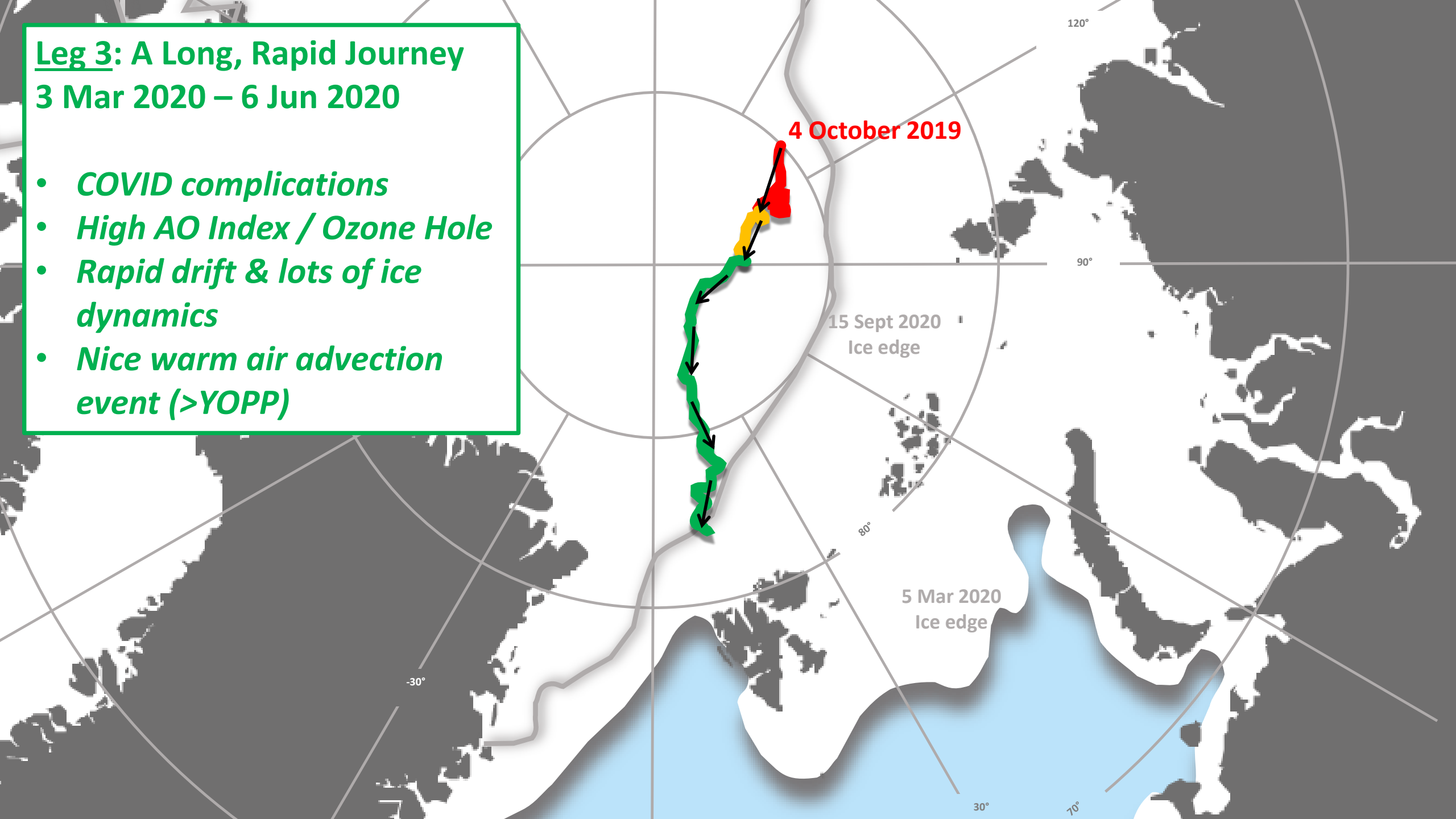

Leg 2: Arctic Winter
15 Dec 2019 – 3 Mar 2020
No sun light
Less ice dynamics = consistent operations
Temp down to ~ -43C
What happens to biology?
4 October 2019
15 Sept 2020
Ice edge
5 Mar 2020
Ice edge
120°
90°
80°
-30°
30°
70°

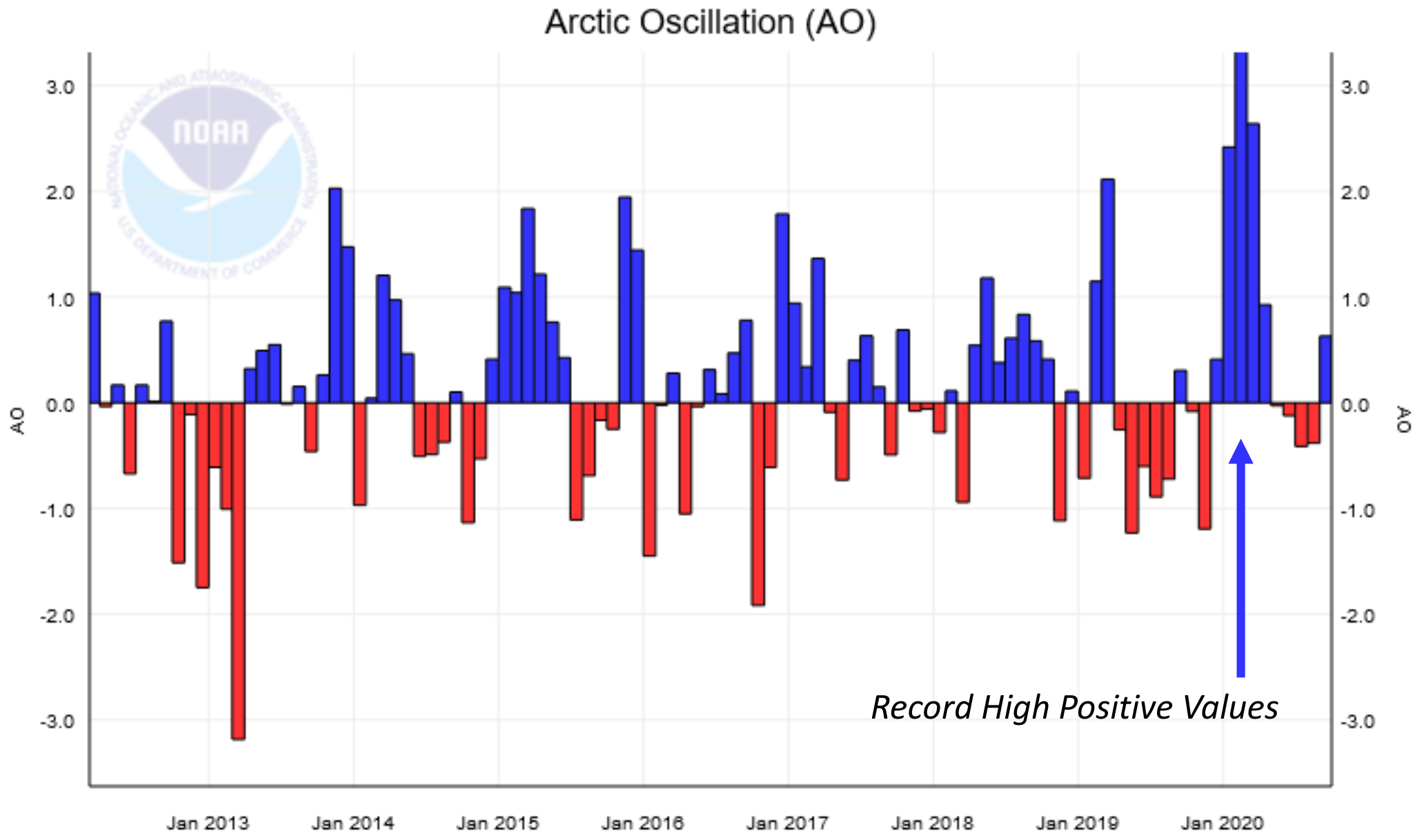

Descent into in to Night
Michael Gallagher

JGI Project: Exploring seasonal changes in microbial community meta-genomes and -transcriptomes



Marcel Nicolaus

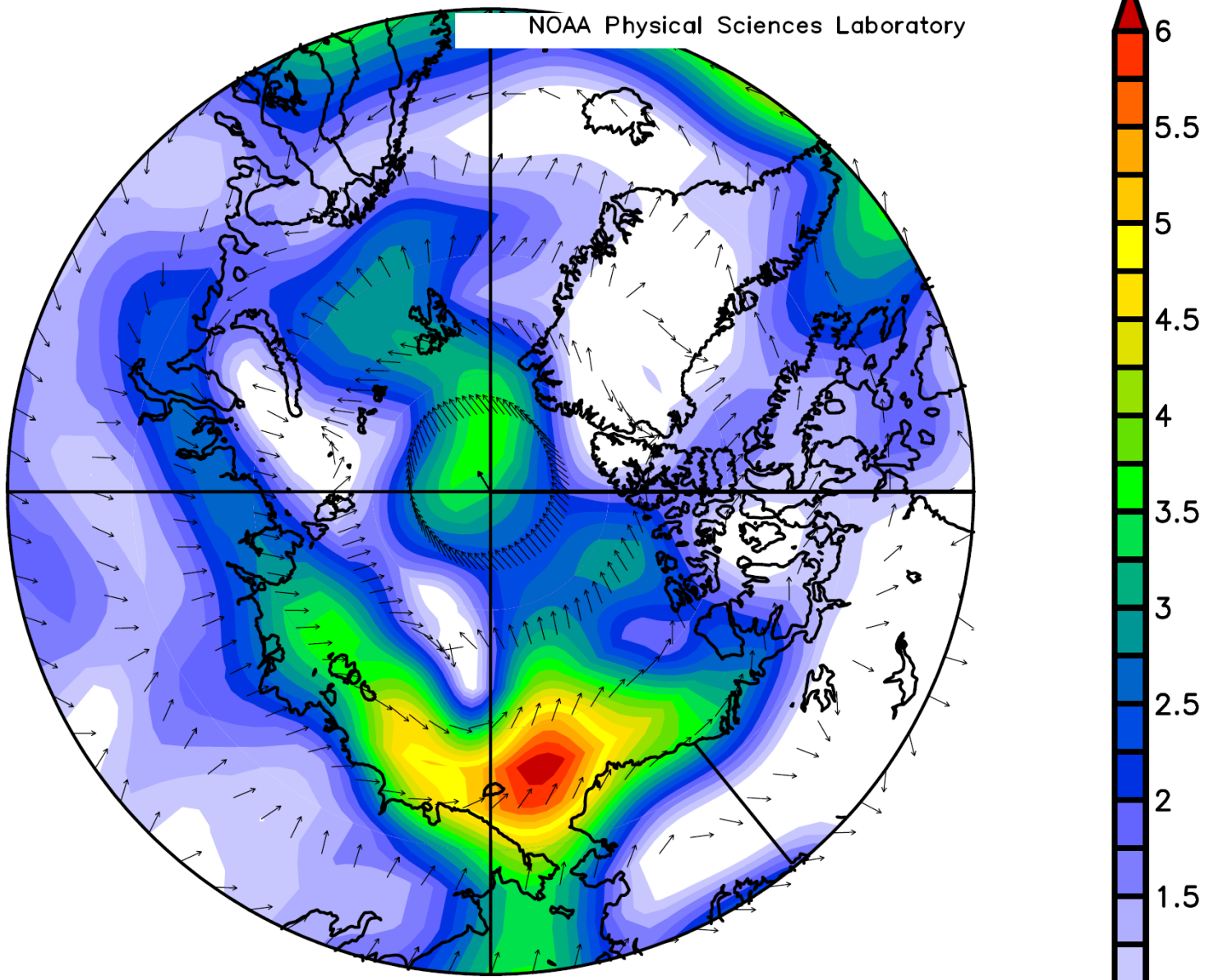

Leg 3: A Long, Rapid Journey
3 Mar 2020 – 6 Jun 2020
• COVID complications
• High AO Index / Ozone Hole
• Rapid drift & lots of ice dynamics
• Nice warm air advection event (>YOPP)
4 October 2019
15 Sept 2020
Ice edge
5 Mar 2020
Ice edge
120°
90°
80°
-30°
30°
70°



ncdc.noaa.gov

NCEP/NCAR Reanalysis

1000mb Vector Wind (m/s) Composite Anomaly 1981–2010 climo

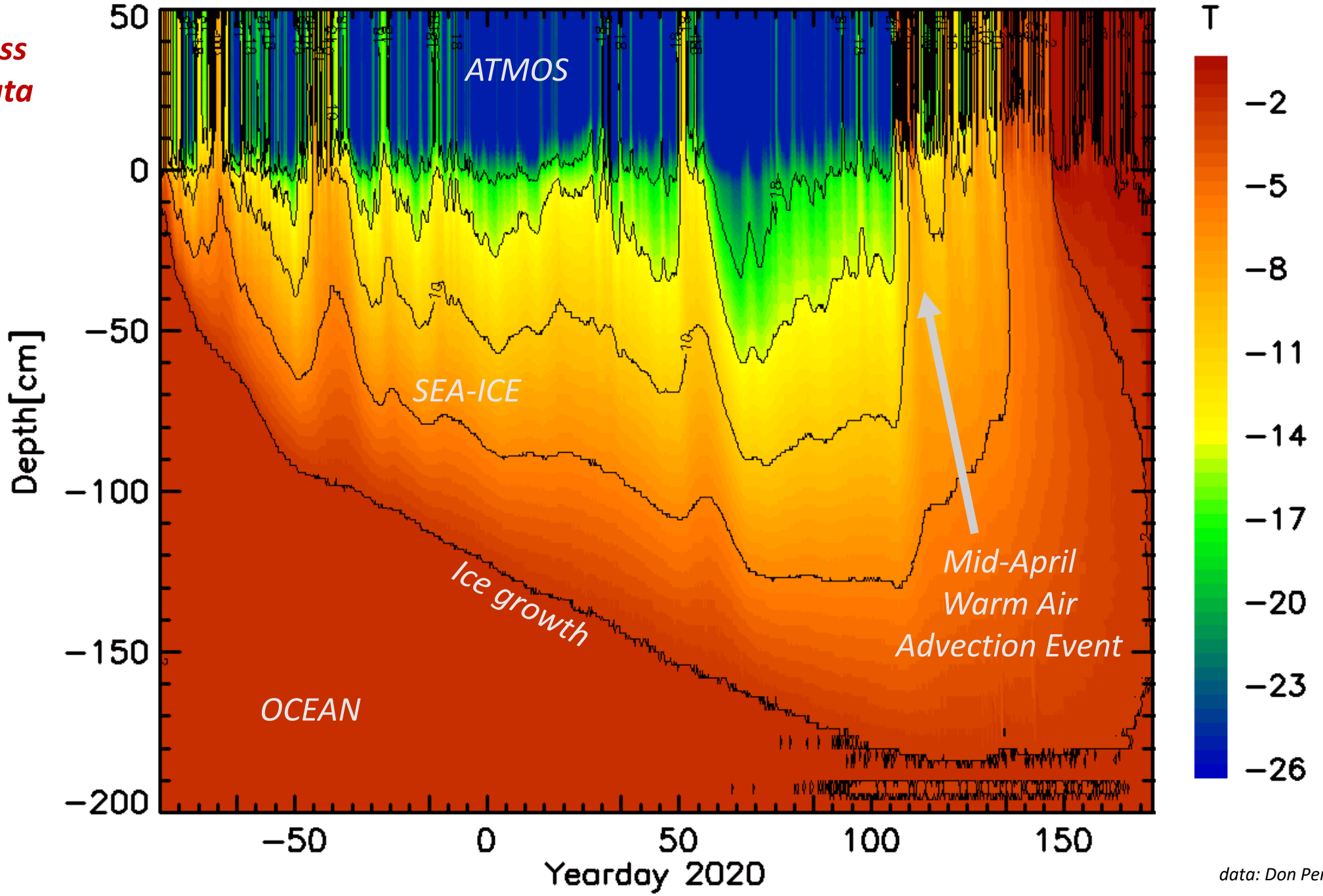


Pushed by Anomalous Winds

Jan to Mar: 2020

psl.noaa.gov

Seasonal Ice Mass Balance buoy data



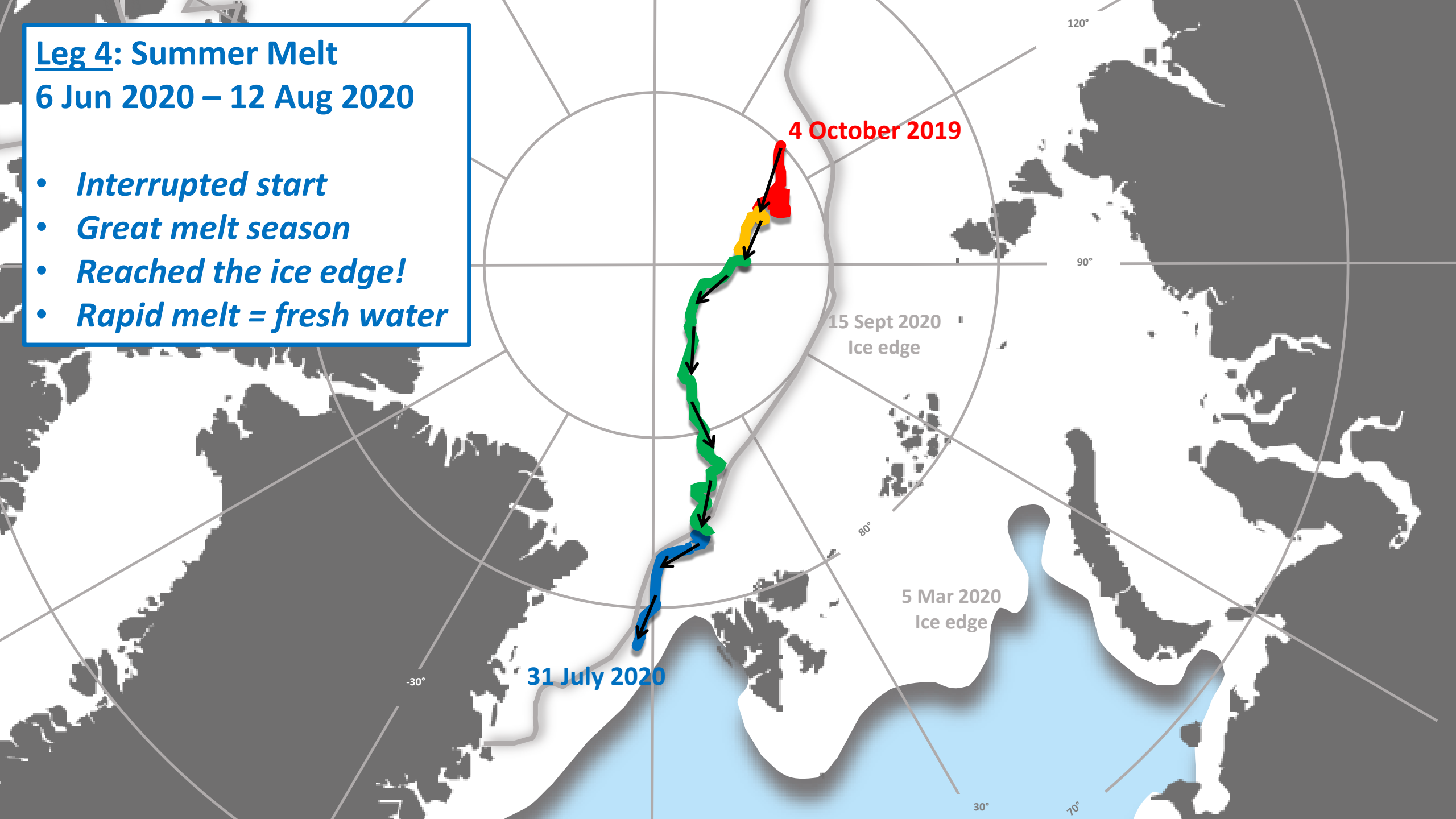
data: Don Perovich

Major ice shear zone kept things on edge

Michael Gutsche

Frequent adaptation of strategy

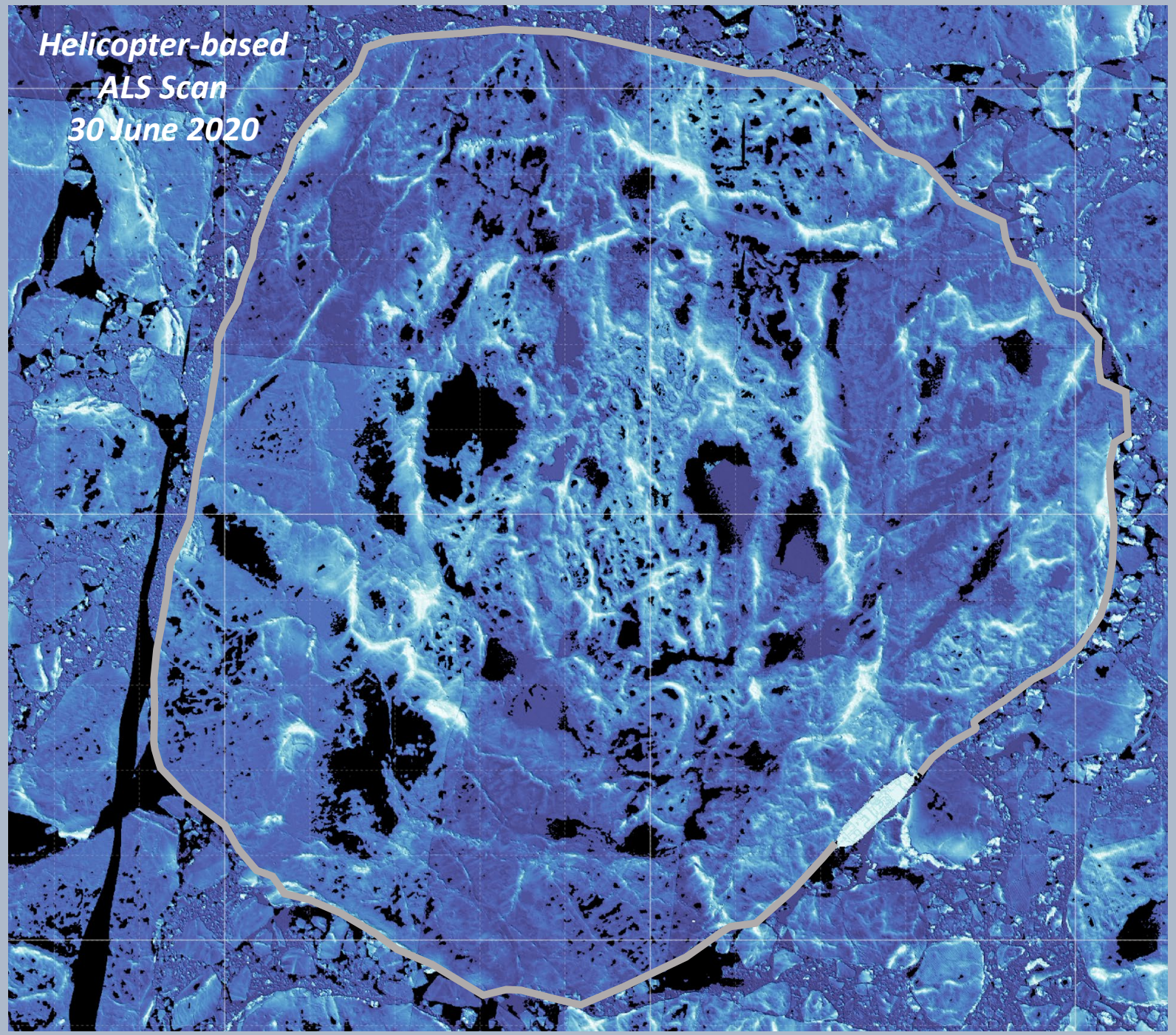
Christopher Cox

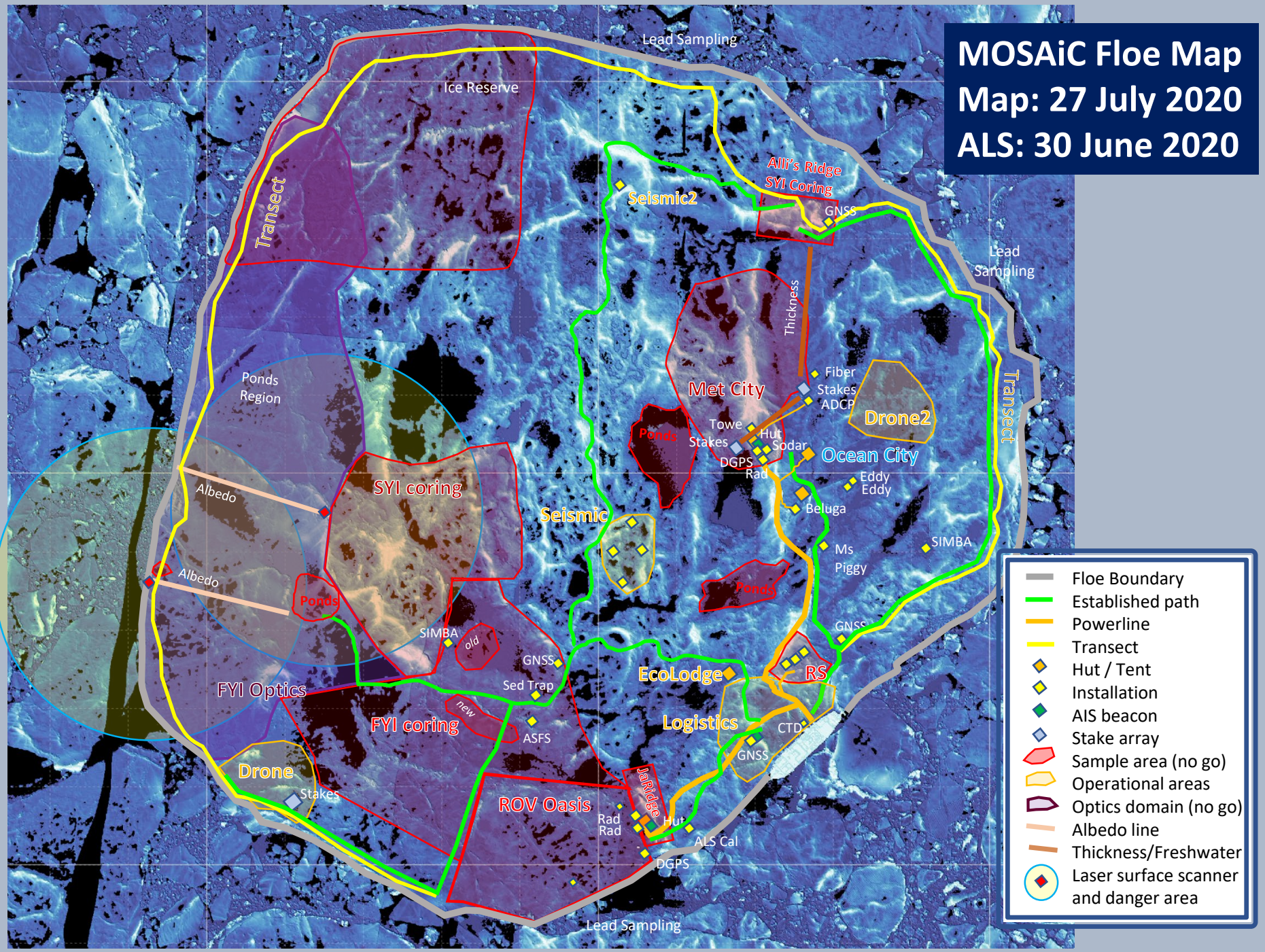

Leg 4: Summer Melt
6 Jun 2020 – 12 Aug 2020
• Interrupted start
• Great melt season
• Reached the ice edge!
• Rapid melt = fresh water
4 October 2019
15 Sept 2020
Ice edge
5 Mar 2020
Ice edge
31 July 2020
120°
90°
80°
-30°
30°
70°

Continuous measurements onboard

Matthew Shupe


MOSAiC Floe 2.0
Markus Rex


Helicopter-based
ALS Scan
30 June 2020


MOSAiC Floe Map
Map: 27 July 2020
ALS: 30 June 2020
Lead Sampling
Ice Reserve
Transect
Alli's Ridge
SYI Coring
Seismic2
GNSS
Lead
Sampling
Thickness
Fiber
Stakes
ADCP
Met City
Drone2
Towe
Stakes
Hut
Sodar
DGPS
Rad
Ocean City
Eddy
Eddy
Beluga
Ponds
Region
Albedo
SYI coring
Seismic
Ms
Piggy
SIMBA
Albedo
Ponds
Ponds
SIMBA
old
GNSS
Sed Trap
EcoLodge
RS
GNSS
FYI Optics
new
FYI coring
ASFS
Logistics
CTD
GNSS
Drone
Stakes
JaRidge
ROV Oasis
Rad
Rad
Hut
ALS Cal
DGPS
Lead Sampling
Floe Boundary
Established path
Powerline
Transect
Hut / Tent
Installation
AIS beacon
Stake array
Sample area (no go)
Operational areas
Optics domain (no go)
Albedo line
Thickness/Freshwater
Laser surface scanner
and danger area

Adventures in field operations

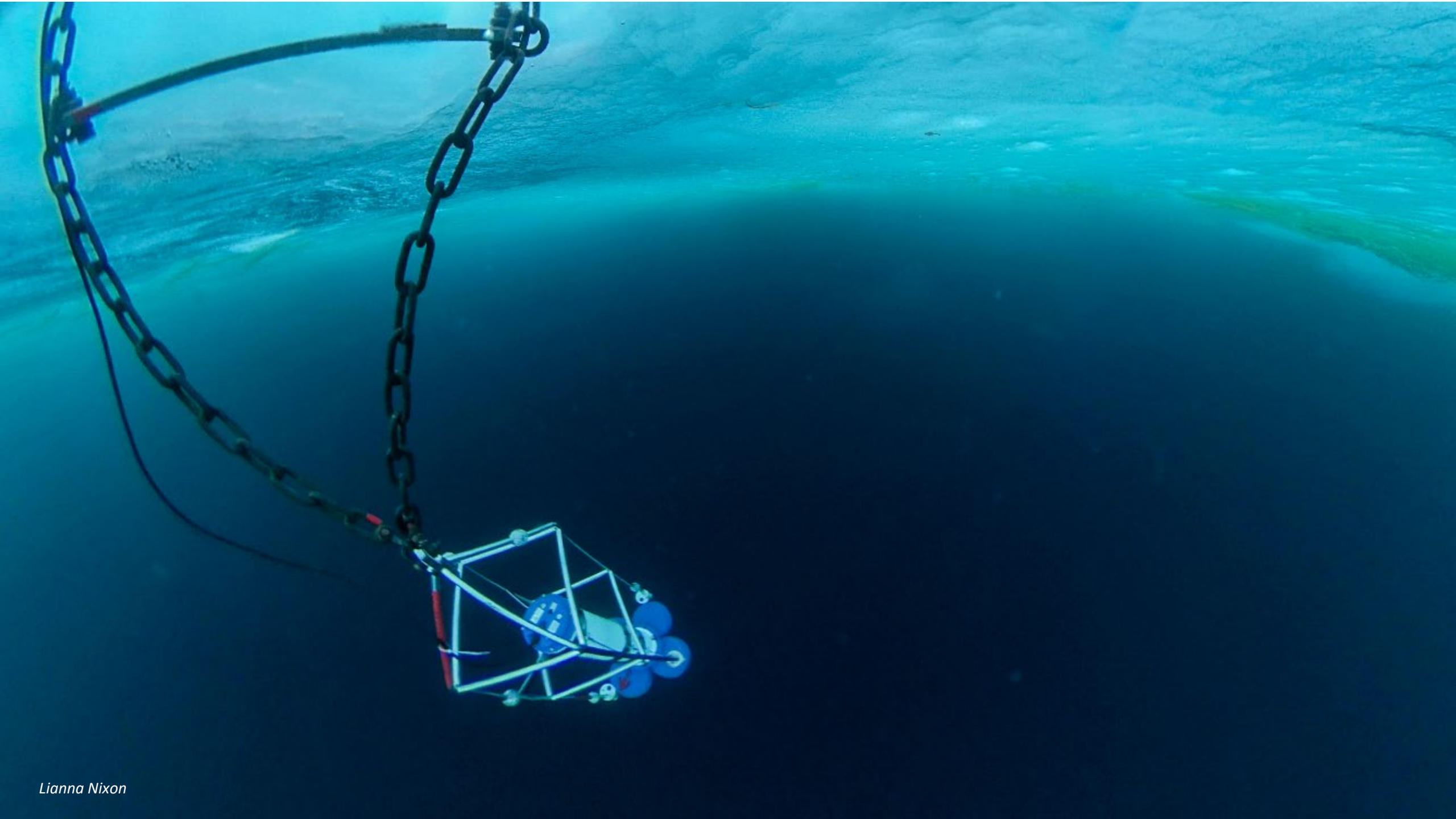
Lianna Nixon

Lianna Nixon

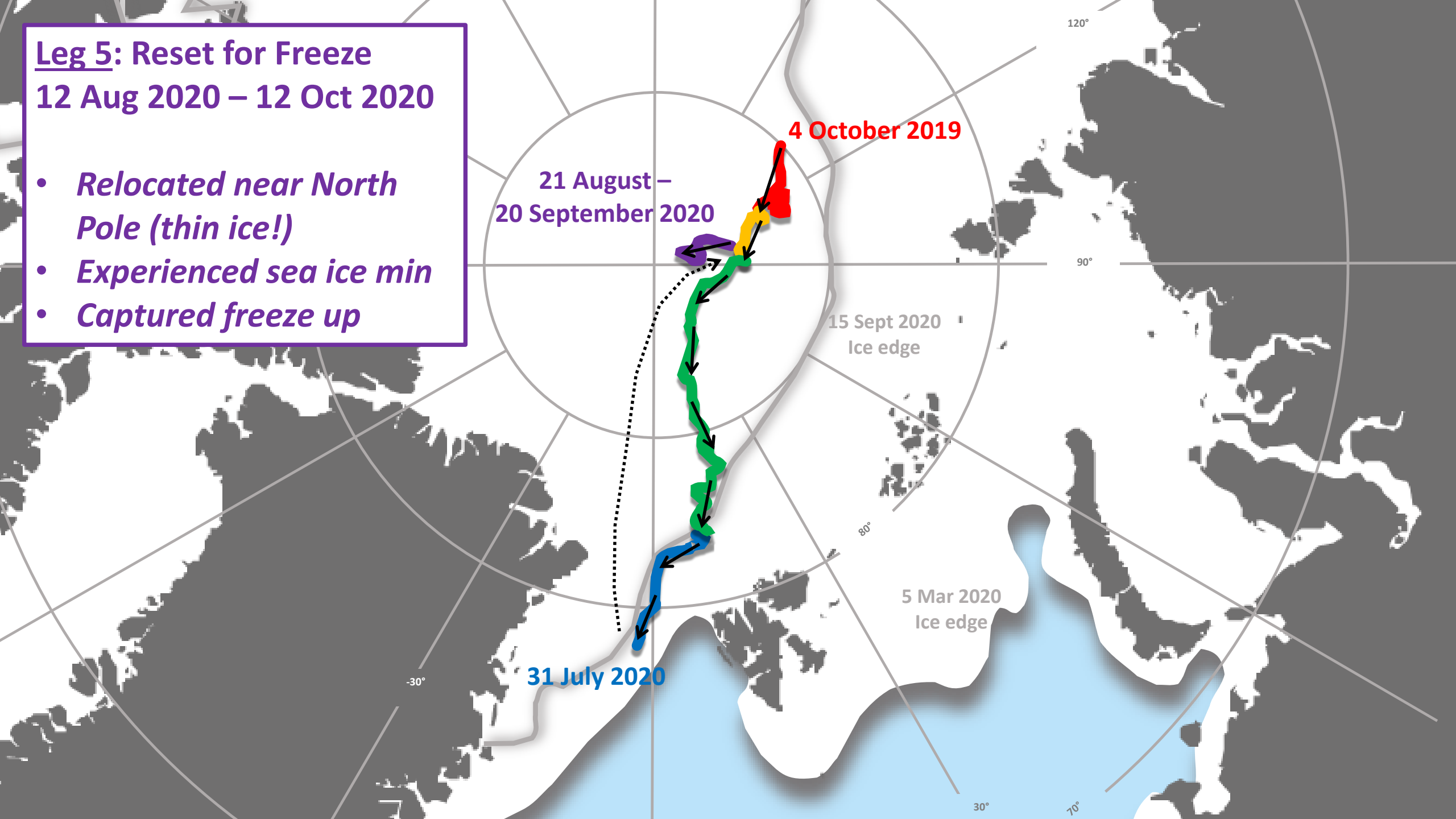
Lianna Nixon

Lianna Nixon

Matthew Shupe



Lianna Nixon


Leg 5: Reset for Freeze
12 Aug 2020 – 12 Oct 2020
• Relocated near North Pole (thin ice!)
• Experienced sea ice min
• Captured freeze up
4 October 2019
21 August – 20 September 2020
15 Sept 2020 Ice edge
5 Mar 2020 Ice edge
31 July 2020
120°
90°
80°
-30°
30°
70°

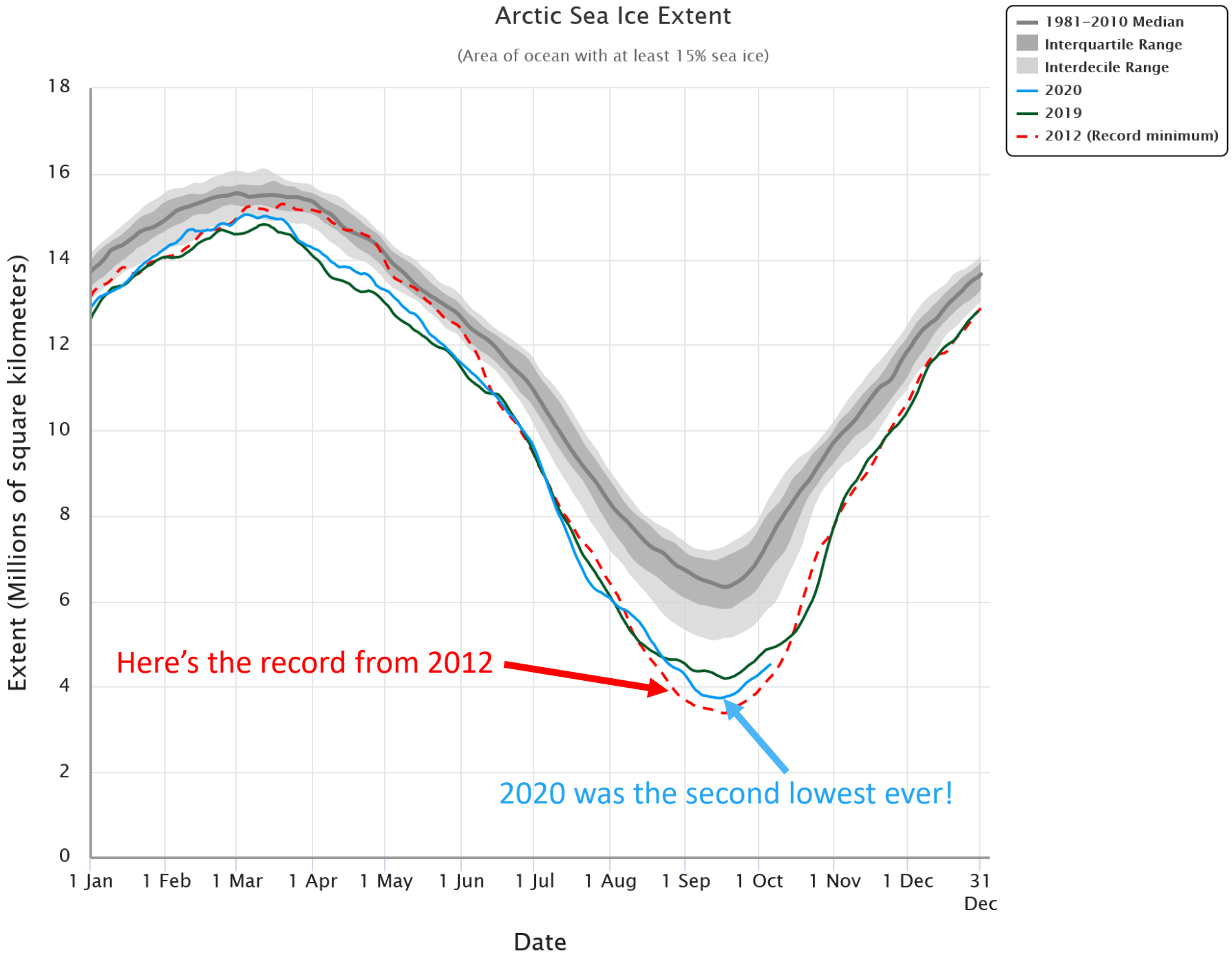
Setting up camp for the third time

Michael Gallagher

Getting ready to freeze in….

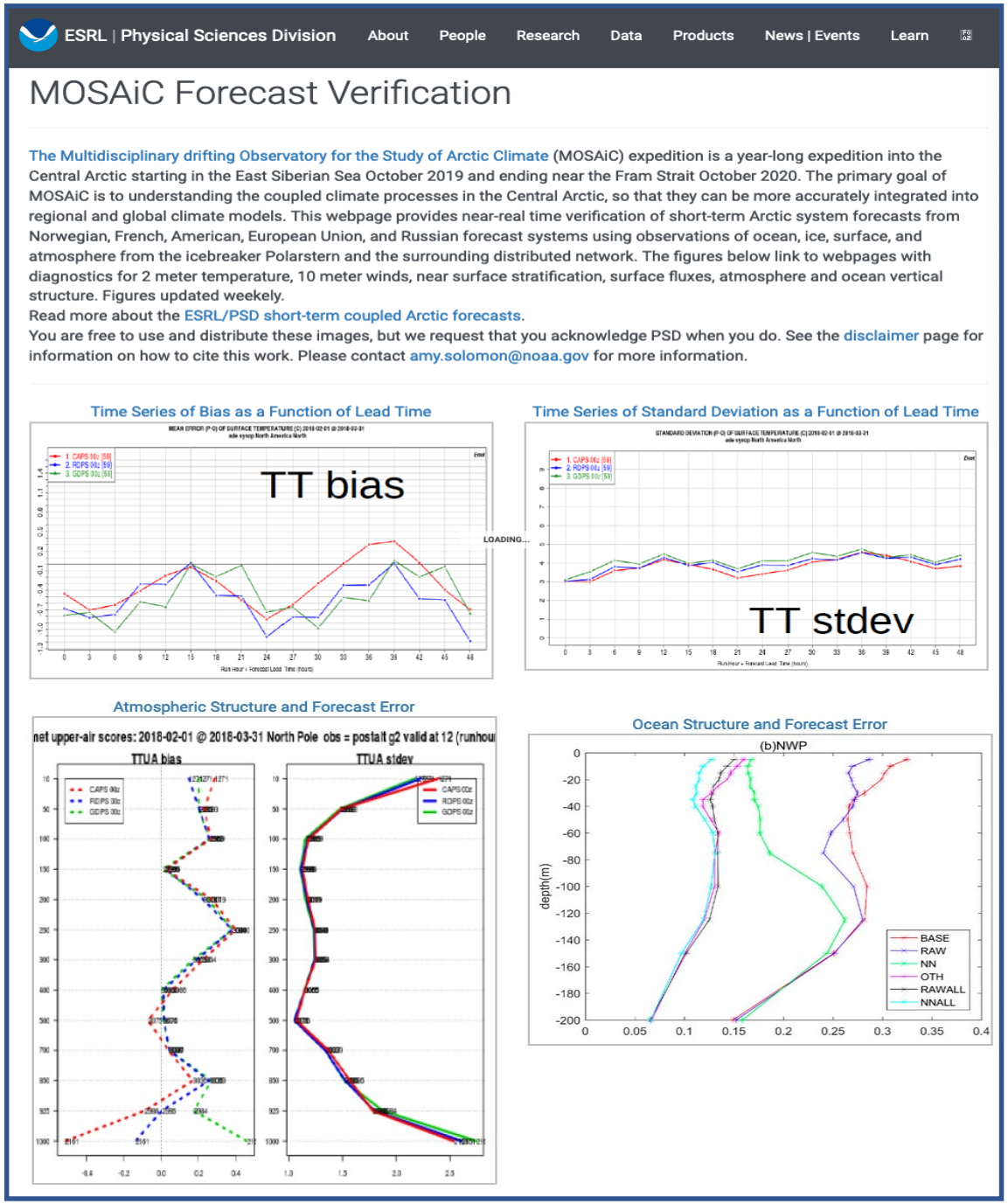
Michael Gallagher

Not a record, but close!



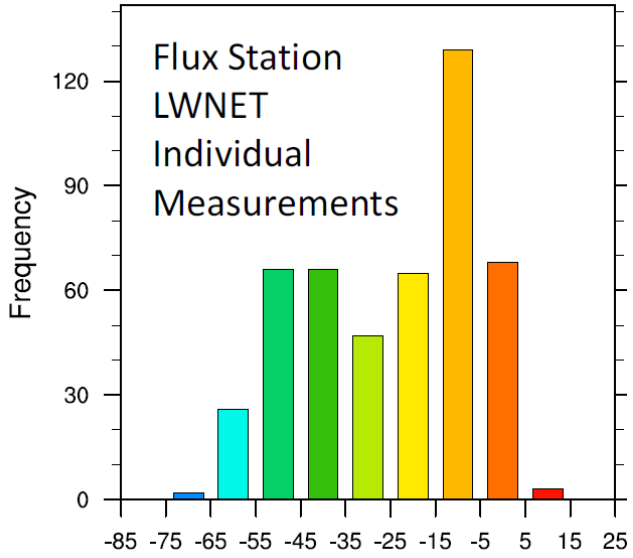
Model Activities

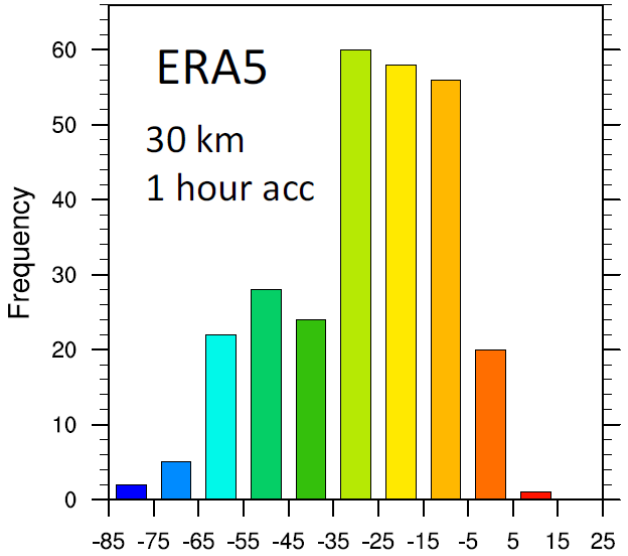
- Near real-time verification of forecasts
- Development of Merged Observatory Data Files
- Partnership with WMO Polar Prediction Project (YOPPsiteMIP)
- Some 70+ discrete modeling activities planned

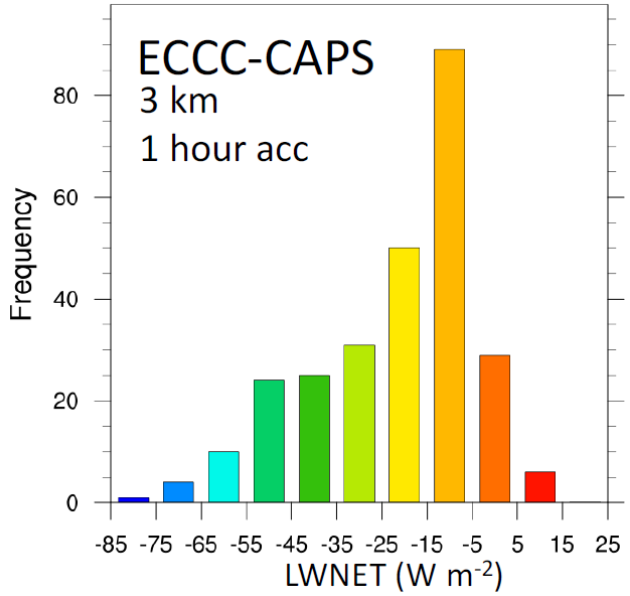


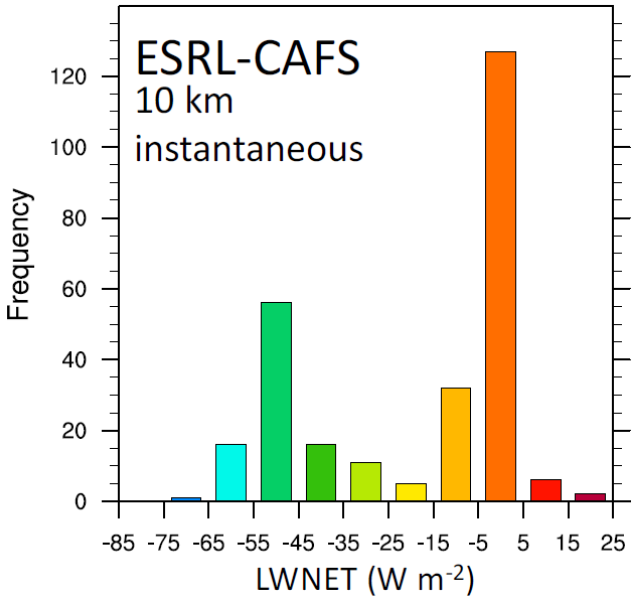
Model Assessment

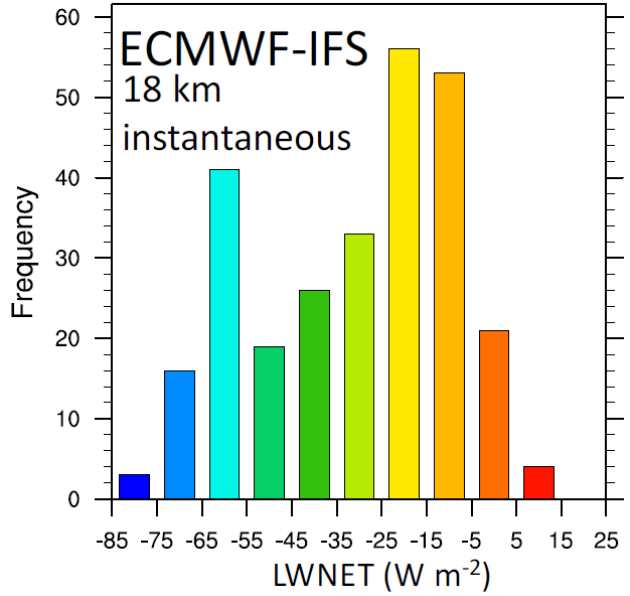
Validation with Radiation Measurements 10/1 – 12/6/2019









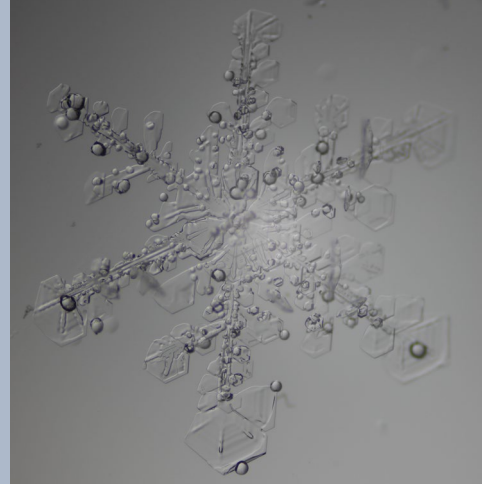
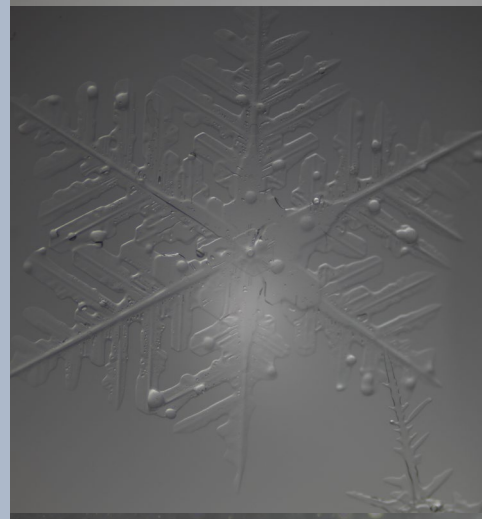


By the Numbers

20 Nations
7 Icebreakers/ships
>80 Institutions
>400 field participants
>$170M total
>$40M US

Summary

- Many challenges that brought opportunities to engage the emerging Arctic
- Thin, dynamic sea ice! We were in the middle of it.
- Tons of science! Packed in as much as possible.
- Broad participation: International, interagency, interdisciplinary
- Capacity building: New generation trained field scientists; new concepts for research on thin ice.

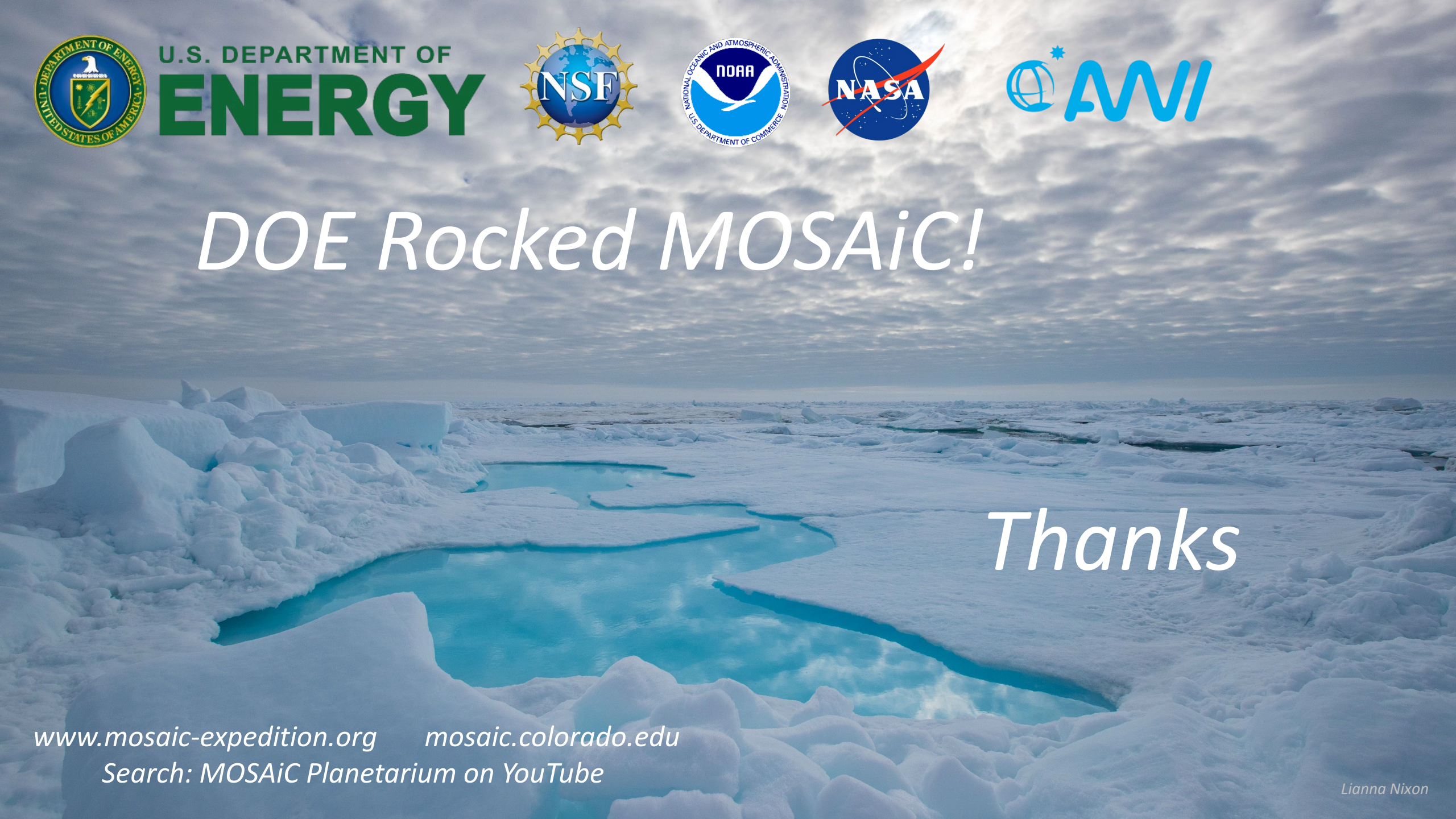

Scientific Pathways Forward

- Cloud forcing of the surface energy budget
- Dynamical drivers of ice motion
- Dynamics vs thermodynamics for sea ice forecasting
- Aerosols, sources, processes
- Precipitation and snow on sea-ice
- Cloud microphysical and radiative properties
- MODFs and YOPP model assessment
- High-resolution cloud modeling
- ABL depth calculations and assessment
- JGI microbial meta-genomes and –transcriptomes

We are just getting started!

Esther Horvath

Lianna Nixon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