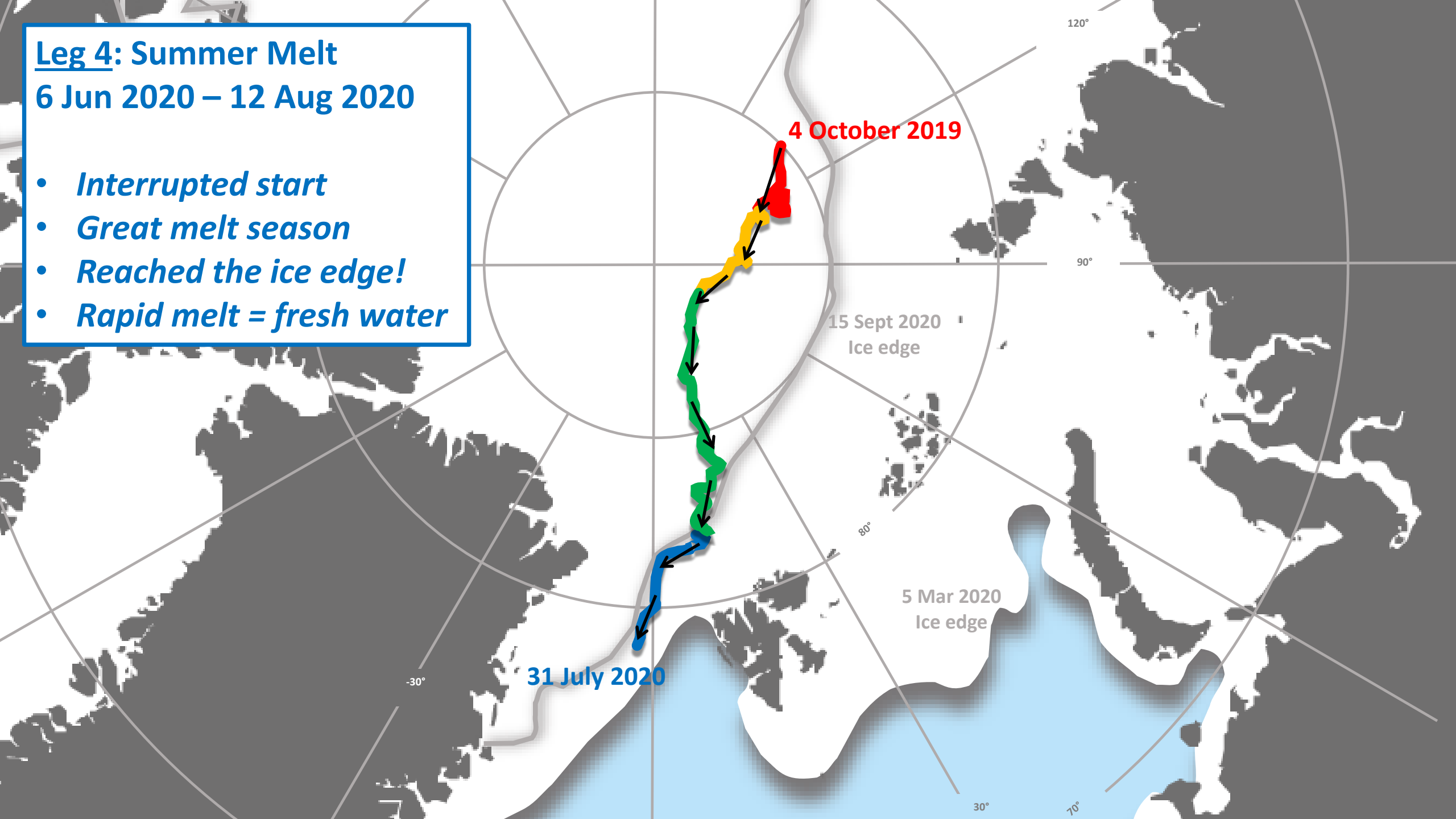
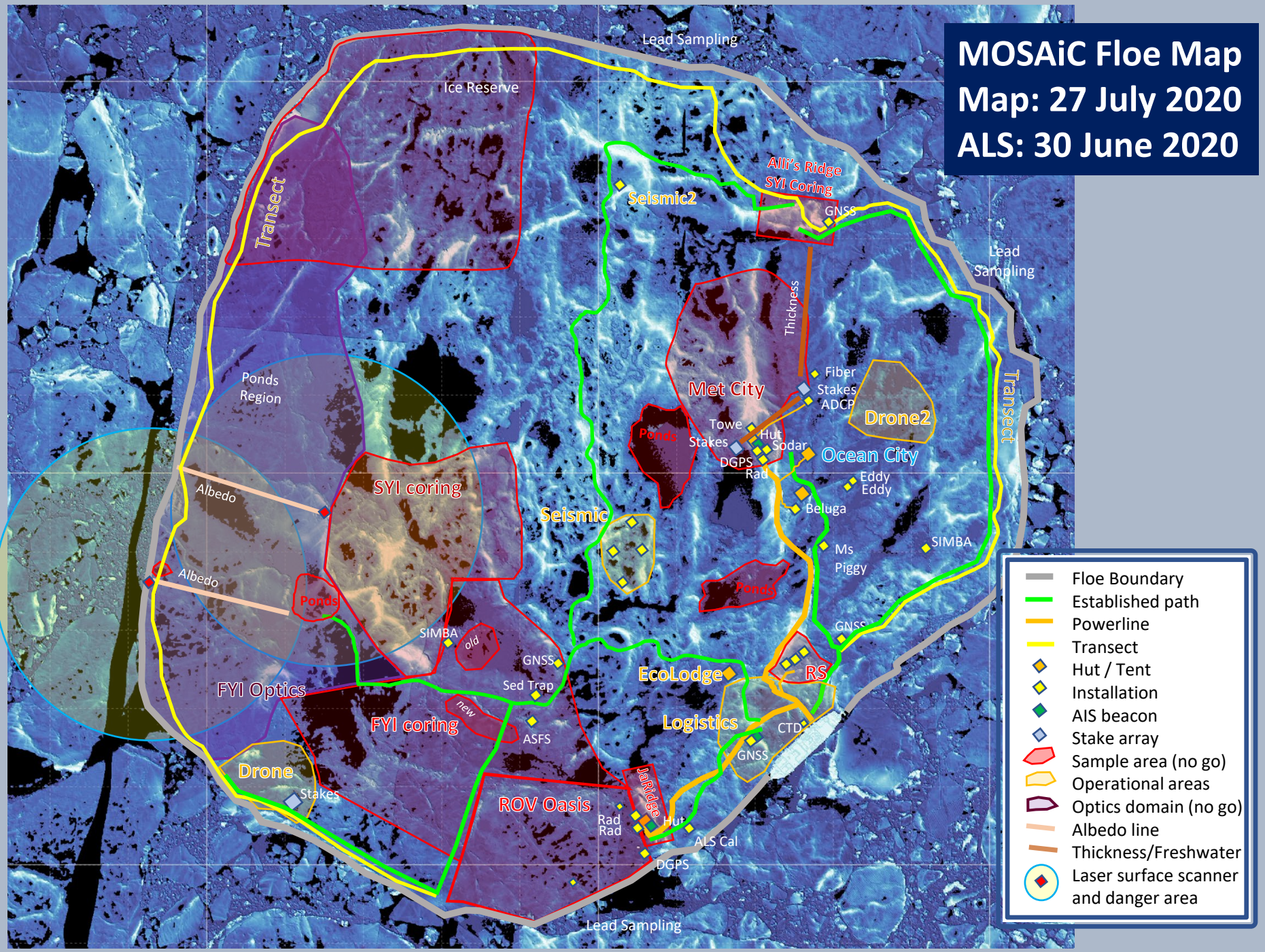

Leg 4: Summer Melt
6 Jun 2020 – 12 Aug 2020
• Interrupted start
• Great melt season
• Reached the ice edge!
• Rapid melt = fresh water
4 October 2019
15 Sept 2020
Ice edge
5 Mar 2020
Ice edge
31 July 2020
120°
90°
80°
-30°
30°
70°


ARM on Ice
ARM Equipment
POLARSTERN
ARM
Lianna Nixon

MOSAiC Floe 2.0

Markus Rex


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

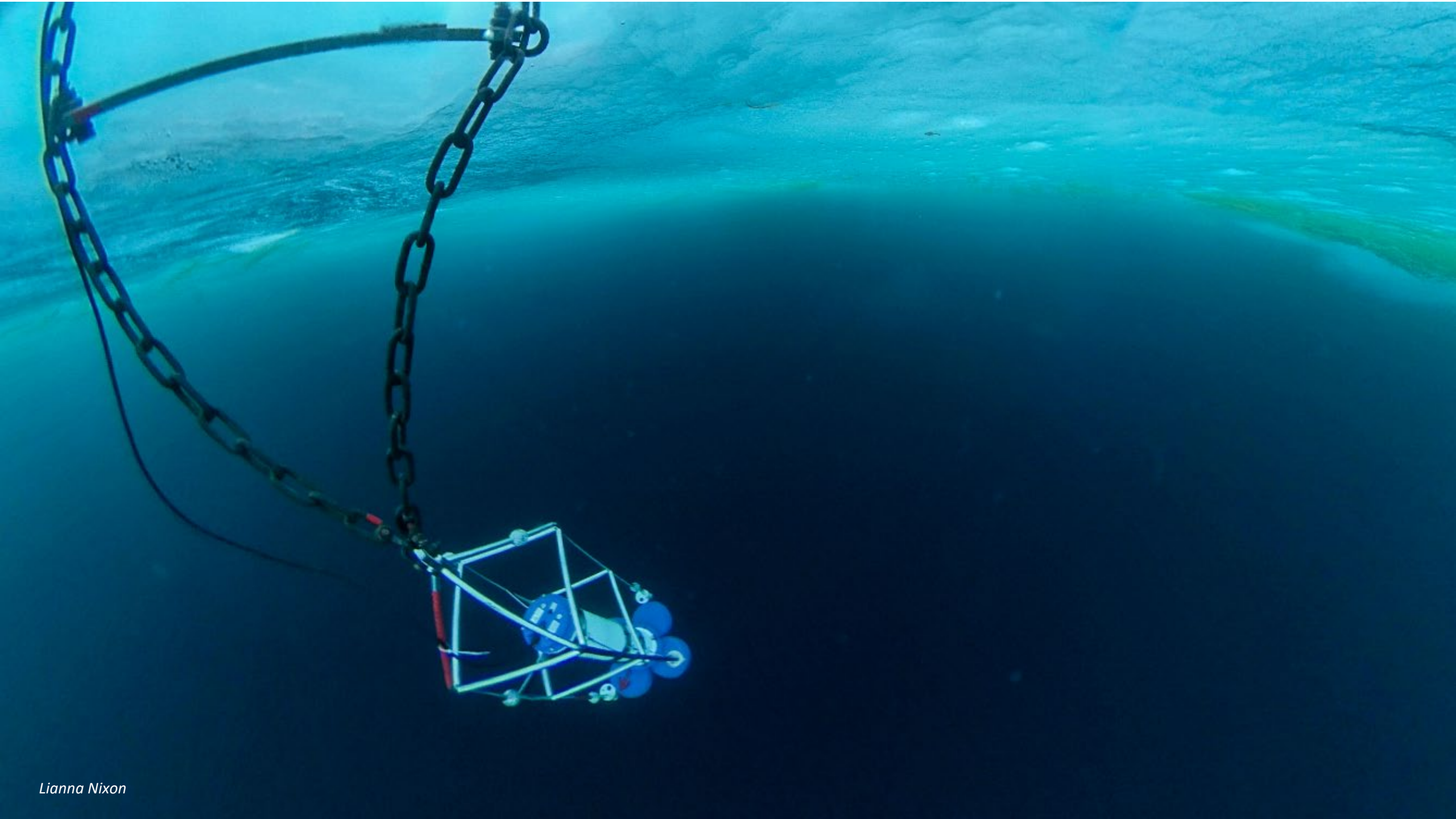
Lianna Nixon

Lianna Nixon

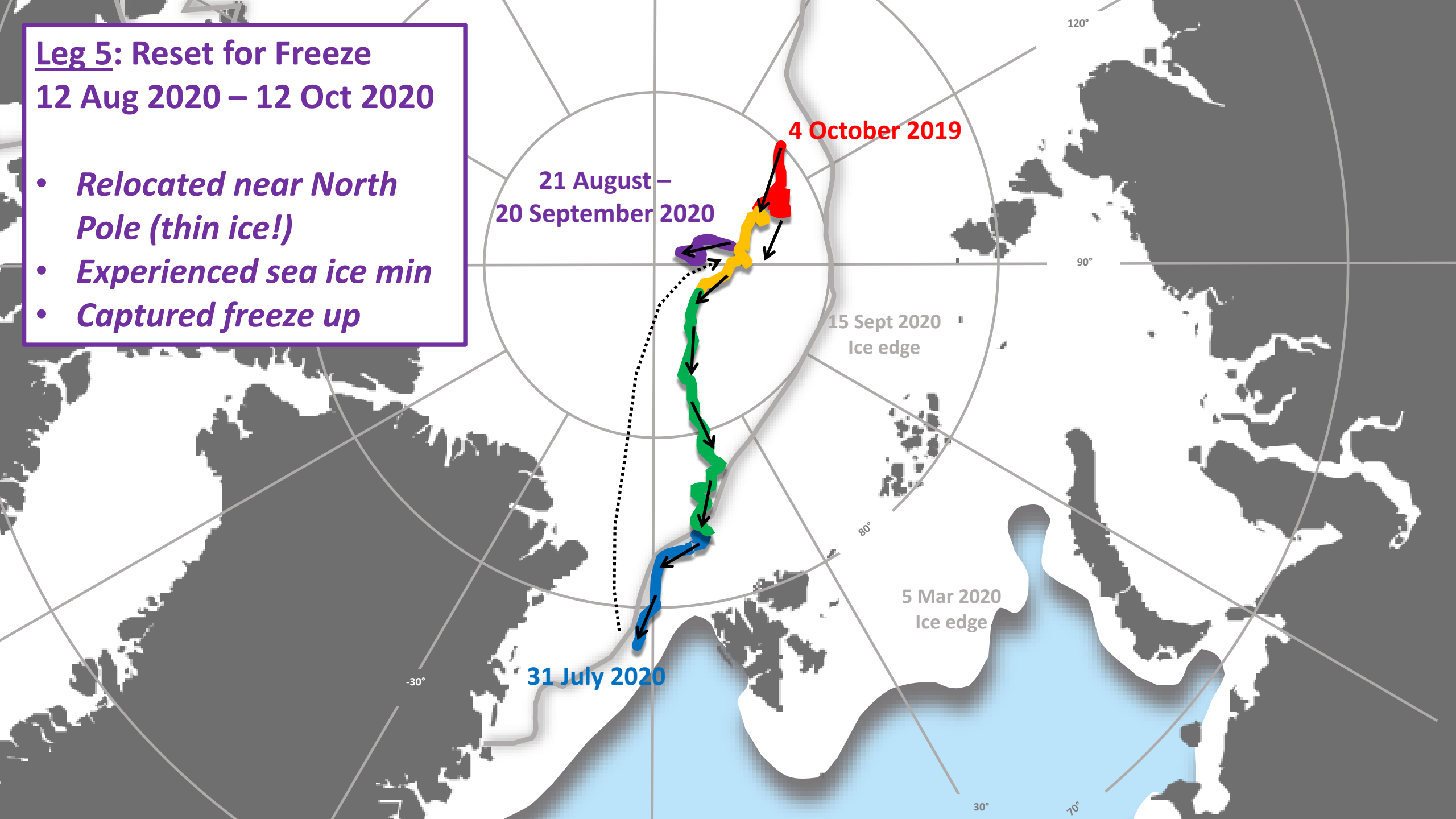
Lianna Nixon

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°

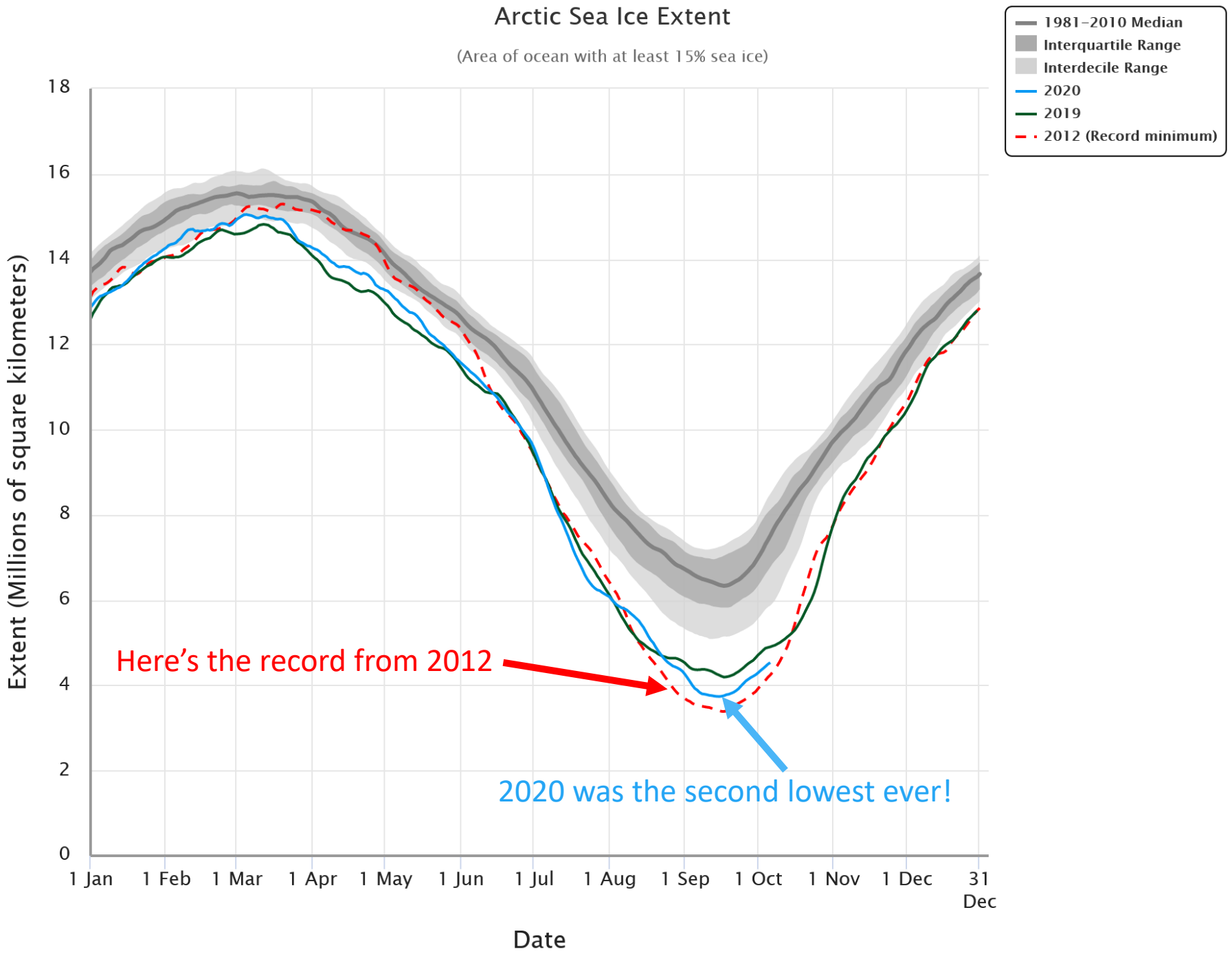
Setting up camp for the third time

Michael Gallagher

Getting ready to freeze in….

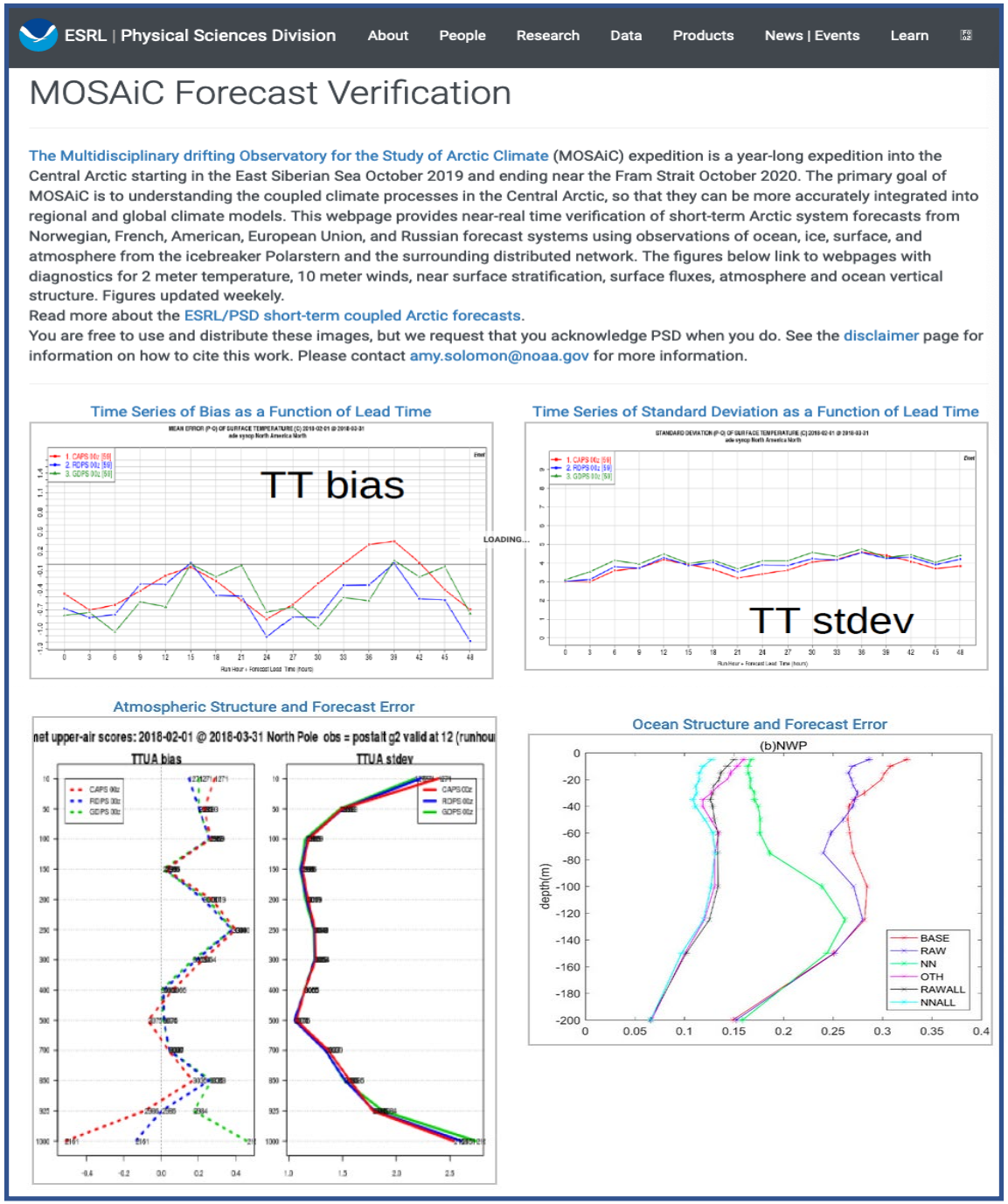
Michael Gallagher

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)
- LES, regional, and large-scale modeling to examine many processes
- Some 70+ discrete modeling activities planned

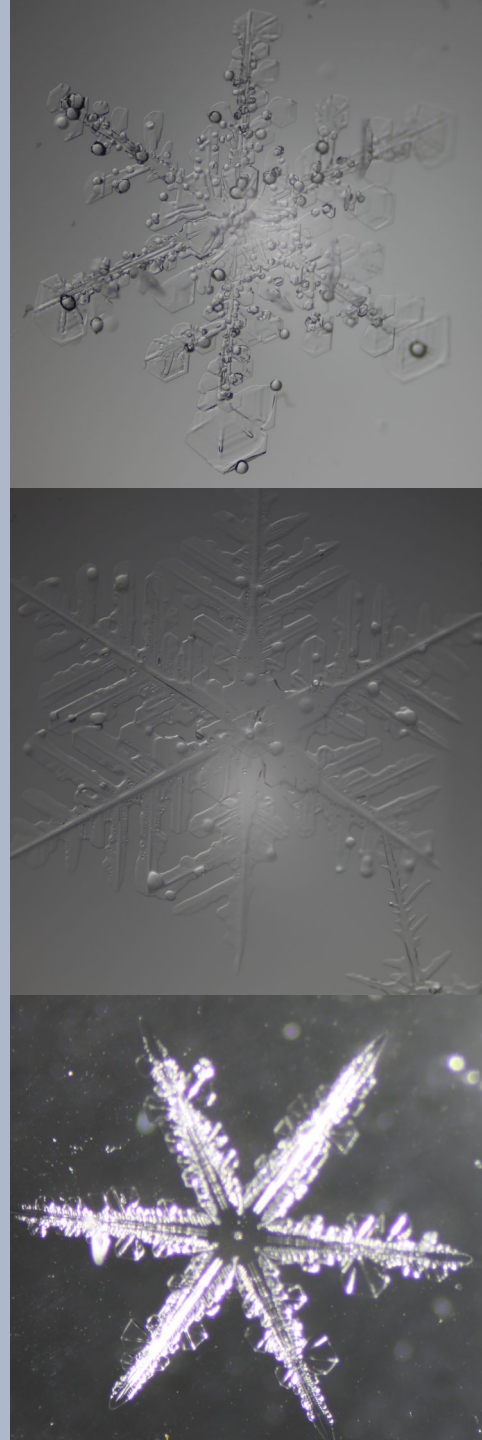


By the Numbers

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

Summary

- Challenges that brought opportunities to engage the emerging Arctic. We were in the middle of thin, dynamic sea ice!
- Tons of science! [ATMOS, ICE, OCEAN, ECO, BGC, REMOTE SENSING, AIRCRAFT, MODELING]
- ARM a major player on the ATMOS team
- Broad participation: International, interagency, interdisciplinary
- Capacity building: New generation trained field scientists; new concepts for research on thin ice.



Atmos State and Radiation

Instrument	Measurement and/or Derived Parameters
Radiosondes	Pressure, temperature, relative humidity, winds, 4-daily launched from ship (contribution to AWI-led effort)
Sky-viewing broadband radiometer suite	Downwelling broadband solar and terrestrial radiation, direct and diffuse solar partitioning, sky infrared temperature, deployed on sea ice
Sky-viewing broadband radiometer suite	Downwelling broadband solar and terrestrial radiation, two systems
Surface-viewing broadband radiometer suite	Upwelling broadband solar and terrestrial radiation, infrared surface temperature, deployed on sea ice
Multifilter Rotating Shadowband Radiometer	Upwelling irradiance at 6 wavelengths, deployed on sea ice
Marine Atmospheric Emitted Radiance Interferometer	Spectral infrared radiation (sky, surface), trace gas and cloud properties
Sun Photometer	Solar irradiance & sky radiance at 6 wavelengths, fixed pointing zenith
Beam-Steerable Radar Wind Profiler	Wind profiles, typically below 4km
Doppler Lidar	Wind profiles, vertical velocity, turbulent dissipation rate, below 1km
Microwave Radiometer, 2-Channel	Sky brightness temperature; Integrated water vapor & liquid water path
Microwave Radiometer, 3-Channel	Sky brightness temperature; Integrated water vapor & liquid water path

Clouds and Precipitation

Instrument	Measurement and/or Derived Parameters
Ceilometer	Backscatter, cloud base height
Micropulse Lidar	Backscatter, depolarization; profiles of cloud and aerosol properties
High Spectral Resolution Lidar	Backscatter, depolarization; profiles of cloud and aerosol properties
Ka-band ARM Zenith Radar	Doppler radar moments and spectra, profiles of cloud properties
Marine W-band ARM Cloud Radar	Doppler radar moments and spectra, profiles of cloud properties
Ka-band Scanning ARM Radar	Doppler radar moments, Spatial cloud distribution and properties
X-band Scanning ARM Radar	Doppler radar moments, Spatial cloud distribution and properties
Total Sky Imager	Visible hemispheric sky images, cloud coverage
Present Weather Detector	Precipitation occurrence and intensity, on ship and on sea ice
Laser Disdrometer	Precipitation and particle size distribution, on ship and on sea ice
Weighting Bucket Rain Gauge	Precipitation occurrence and mass, on sea ice
Siphon Rain Gauge	Precipitation occurrence and mass, on ship

Aerosols and Gases

Instrument	Measurement and/or Derived Parameters
Condensation Particle Counter	Two systems: Total particle concentration >10nm and >3nm
Scanning Mobility Particle Sizer	Particle size distribution 10-500 nm
Ultra-High Sensitivity Aerosol Spectrometer	Particle size distribution 50-1000 nm
Humidified Tandem Differential Mobility Analyzer	Mass, size, and particle size distribution as a function of relative humidity, hydroscopicity
Cloud Condensation Nucleus Counter	CCN concentration, supersaturation of 0.4% and scanning from 0-0.8%
Aerosol Chemical Speciation Monitor	Mass spectrum, particle composition
Single Particle Soot Photometer	Black carbon mass concentration
Nephelometer	Light scattering at dry relative humidity at 3 wavelengths
Particle Soot Absorption Photometer	Light absorption at 3 wavelengths
Total Aerosol Filter Sampler	Aerosol loadings for offline ice nucleating particle analysis, offline DNA sequencing (Guest Instrument: Colorado State Univ.)
Davis Rotating-drum Unit for Monitoring	Size-resolved aerosol loadings for offline ice nucleating particle analysis, 3 bins 0.15-12 µm (Guest Instrument: Colorado State Univ.)
Davis Rotating-drum Unit for Monitoring	Size-resolved aerosol loadings, offline single-particle morphology and elemental composition (Guest Instrument: Univ. Michigan)
Ozone Monitor	Ozone concentration
Trace Gas Monitor	Carbon monoxide, Nitrous oxide, and water vapor concentration

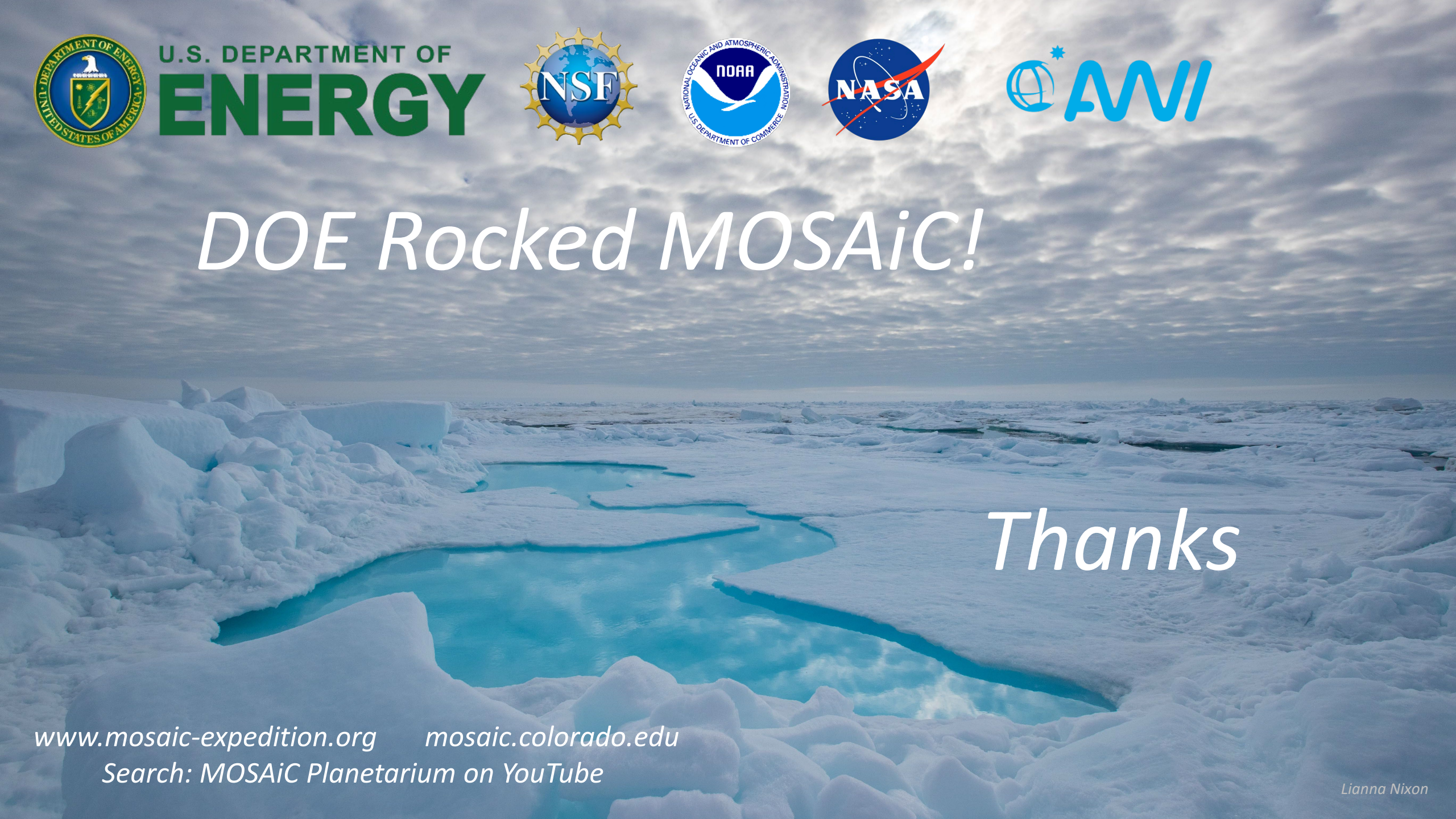
Mostly yellow because of pollution!

Scientific Pathways Forward

- Ice thermodynamics and clouds
- Winds, momentum, ice dynamics
- Dynamics vs thermodynamics for sea ice forecasting
- Aerosols, sources, processes, CCN, INPs, etc.
- Precipitation and snow on sea-ice
- Cloud microphysical and radiative properties
- JGI microbial meta-genomes and –transcriptomes
- Lots of “coupled system science”
- Development of merge data products
- High-res modeling (clouds, ABL)
- Model assessment and development

We are just getting started!

Esther Horvath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NASA
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Lianna Nixon