Multidisciplinary drifting Observatory for the Study of Arctic Climate

MOSAiC – Understanding Polar Dynamics and Physical Processes

***Matthew Shupe**, and the MOSAiC Consortium*

CIRES, University of Colorado / NOAA

2019 ARM/ASR Joint Annual Meeting

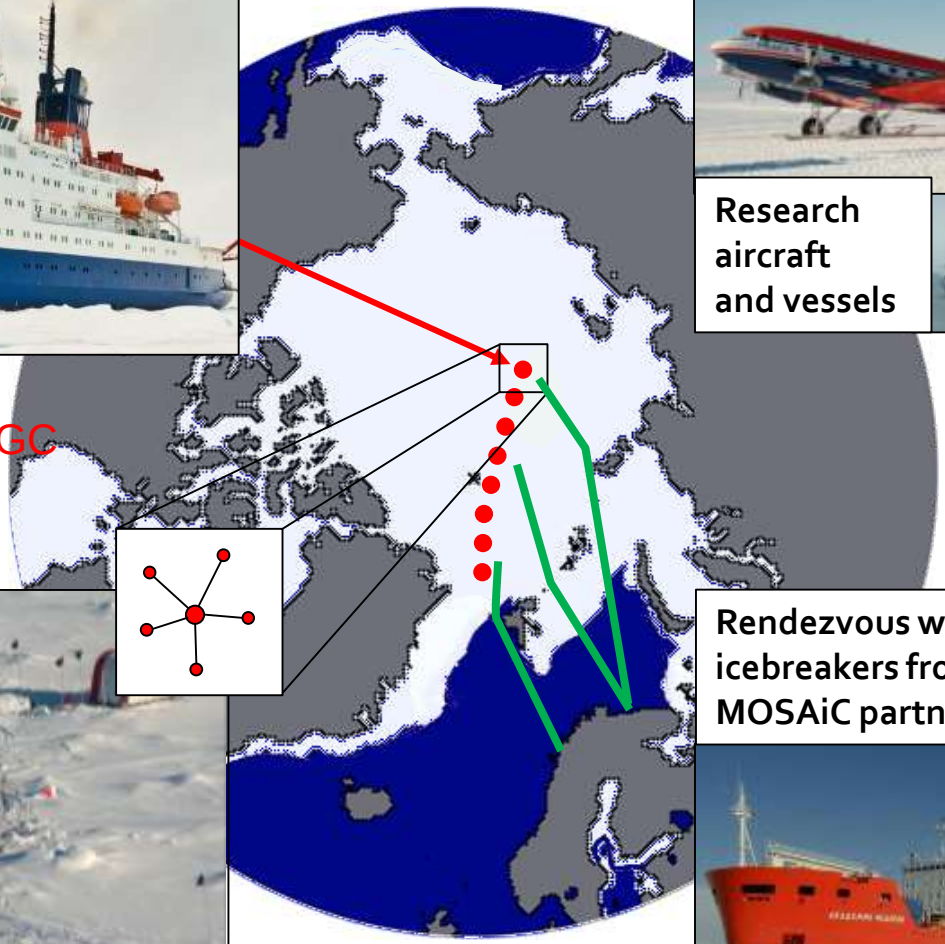
A Year in the Arctic

Fall 2019 to Fall 2020

Coupled observations
Atmos-Ice-Ocean-Eco-BGC

→
Extend vertical &
geographic coverage

Research
aircraft
and vessels



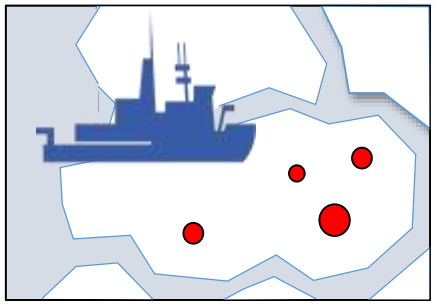
Autonomous systems,
buoys,UAS, AUV

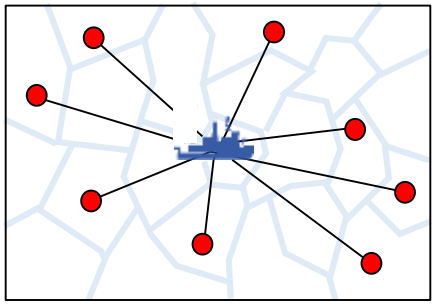
Rendezvous with
icebreakers from
MOSAiC partners

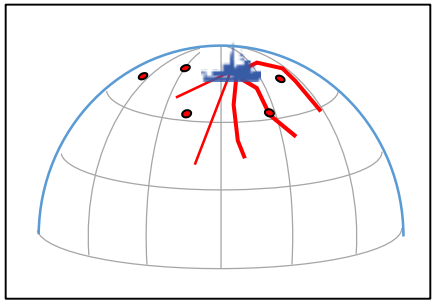
→
Broader geographic
coverage & supply

17 nations involved!

Multiscale Design







<u>Local:</u> Central Observatory
- Ship & ice camp
- Coupled measurements
- ➢ Process scale observations

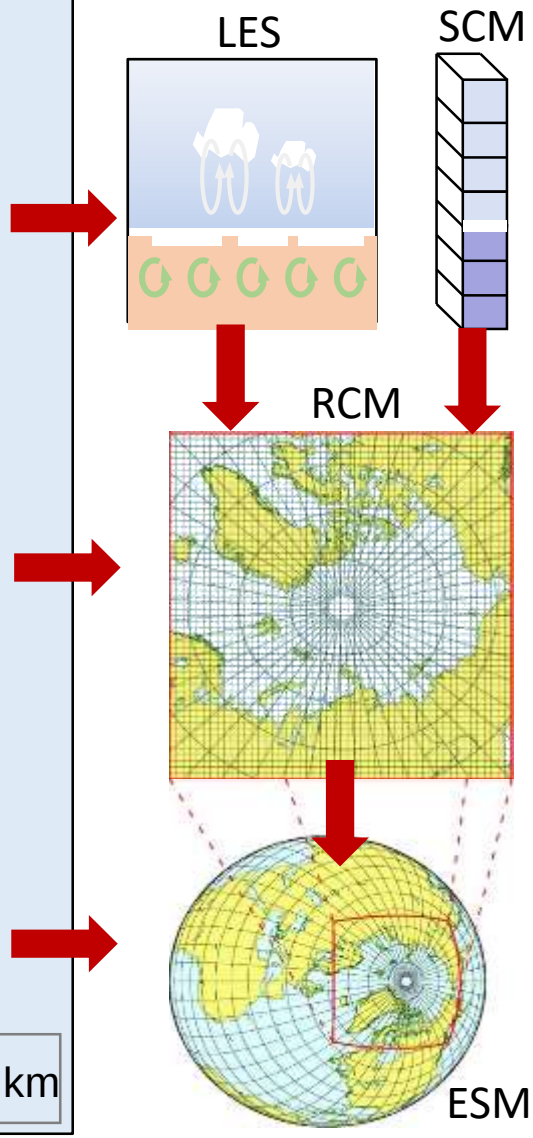
< 5 km

<u>Regional:</u> Distributed Network
- Sea ice stations
- Unmanned aircraft
- Process & regional model
- ➢ Model grid cell

< 50 km

<u>Arctic-wide</u> linkages
- Collaborating research vessels
- Aircraft (Polar 5,6)
- Arctic buoys, satellites
- Data assimilation studies
- ➢ Regional & global models

> 1000 km

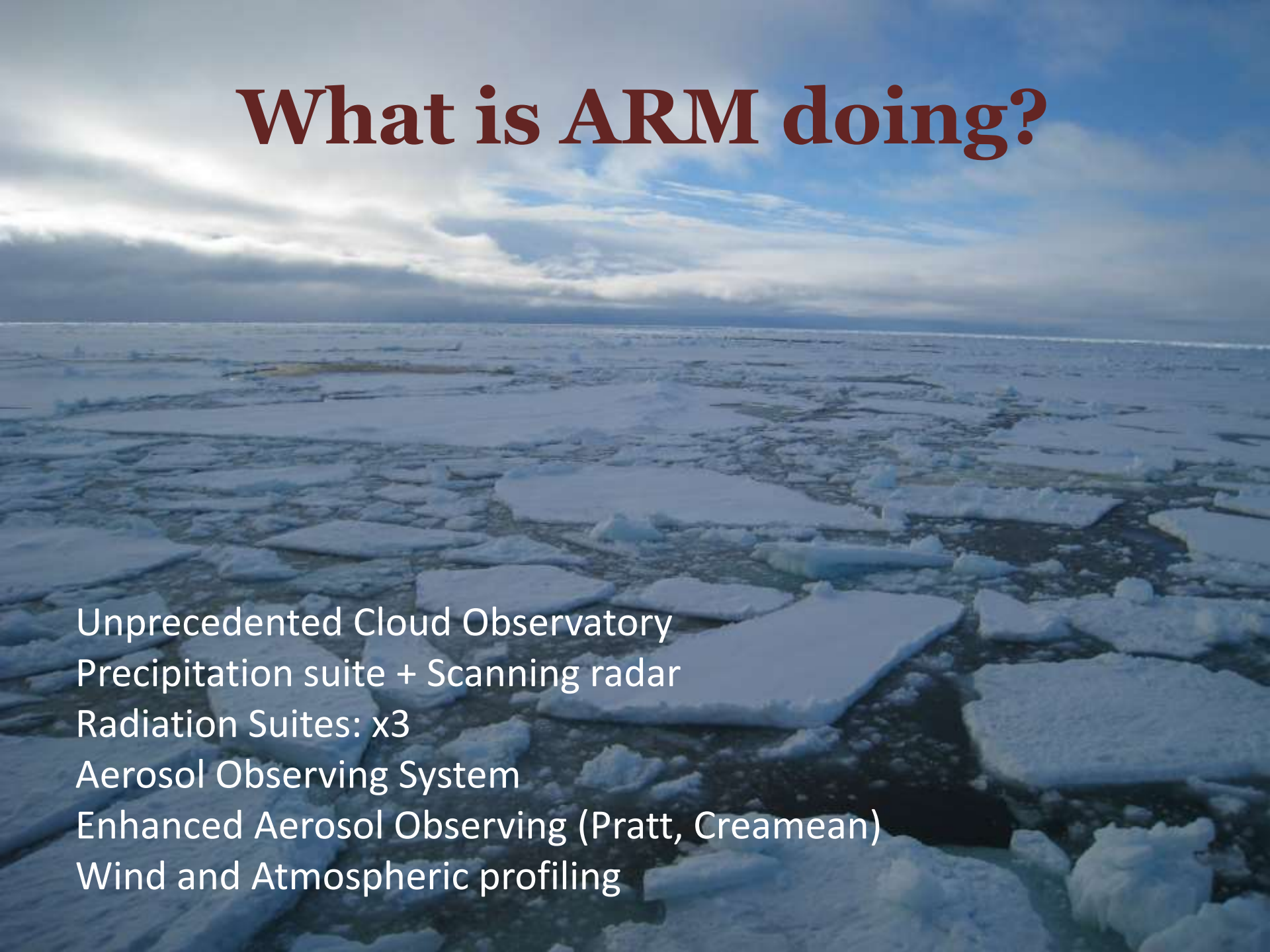


Science Priorities

"What are the causes and consequences of an evolving and diminished Arctic sea ice cover?"

- ❑ Energy/momentum budgets
- ❑ ABL & airmass transformation
- ❑ Cloud/Precip processes
- ❑ Aerosol processes
- ❑ Links to ocean and ice dynamics
- ❑ Links to Eco and BGC

What is ARM doing?

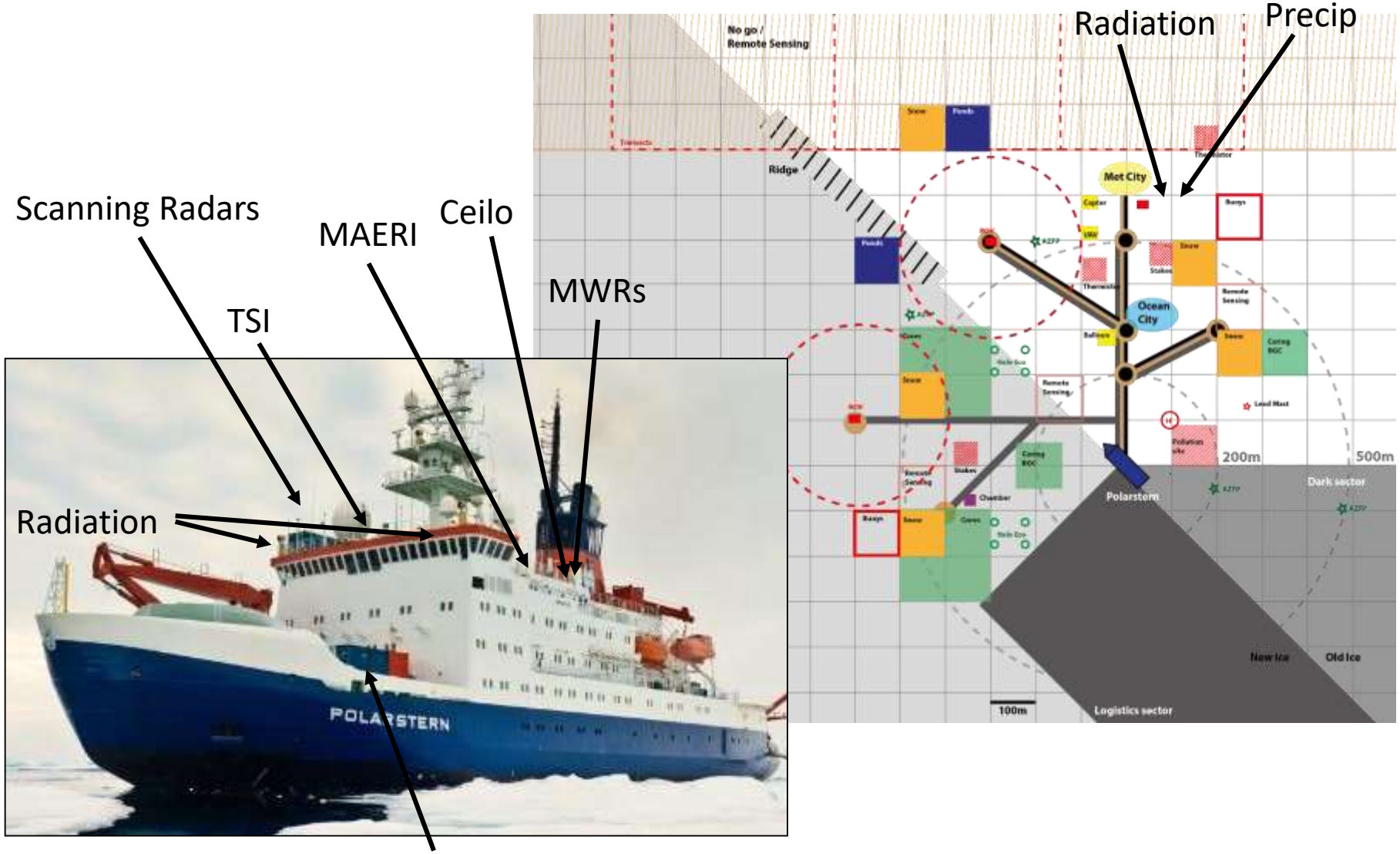


Unprecedented Cloud Observatory
Precipitation suite + Scanning radar
Radiation Suites: x3
Aerosol Observing System
Enhanced Aerosol Observing (Pratt, Creamean)
Wind and Atmospheric profiling

What are others doing?

Tethered balloon and UAS programs (multiple)
Aircraft campaigns (2xATMOS, 2xICE)
Special soundings: ozone, CFH, backscatter
Met towers and distributed surface flux stations
More wind profiling
Water isotopes, ice crystals, & other precip measurements
Aerosols: NPF, SPIN, different inlets, filters
Physical samples (ocean, ice, snow, pond, air)
Snow depth, distribution, morphology
Ice optical properties, roughness, thermodynamics, stress, etc.
Ocean state, fluxes, mixing/dynamics
BGC processes: elemental cycles, nutrients, gas fluxes, etc.
ECO processes: primary productivity, communities, etc.

ARM Installations



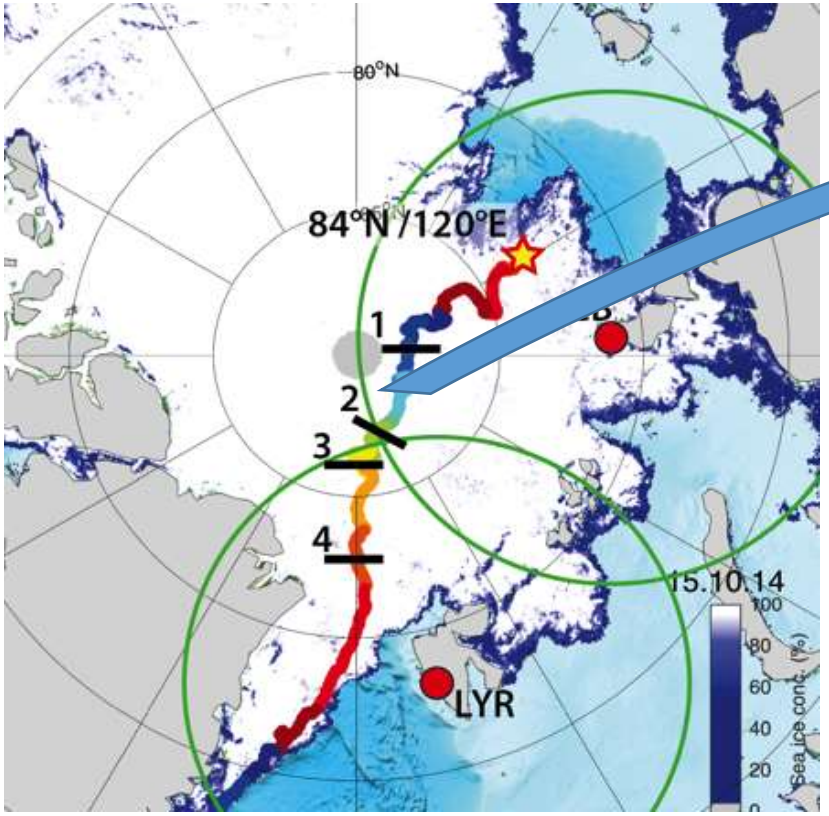
Opportunities to Engage

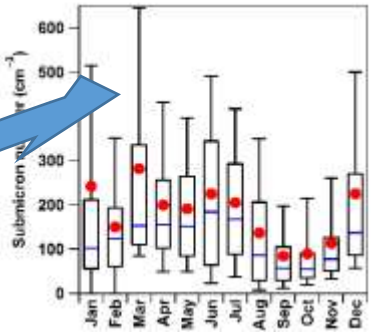
"Free Proposal Ideas"

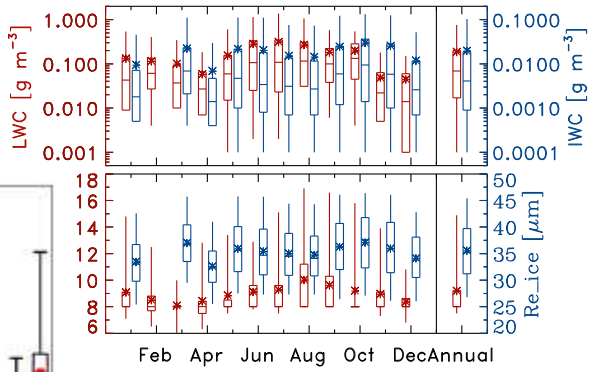
- *Snowfall link to snow accumulation on sea ice*
- *Spatial distribution of cloud-precipitation systems relative to variable surface*
- *The microphysical-dynamical structure of Arctic storms*
- *Large-scale advective impacts on the central Arctic aerosol size distribution*
- *Arctic boundary layer wind profiles and their link to surface momentum flux and sea-ice motion*
- *Assessment of how climate and operation models represent surface energy fluxes and its implication on assessing large-scale effects of Arctic change*

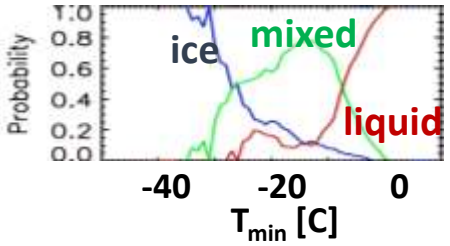
Bulk Model Evaluation

Model output along drifting MOSAiC track from YOPP or other models









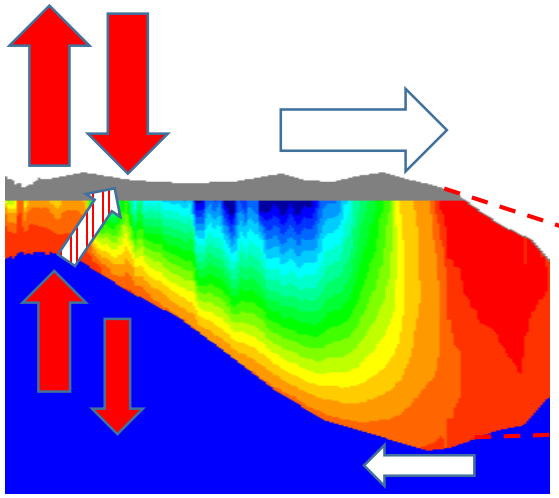
Atmospheric state
Cloud type
Radiation
Surface albedo
Mixed-layer temperature
Distinguish by regimes
Etc., etc., etc.

How well do models represent the basic state of the Central Arctic?
(unprecedented observations in the region)

Process Assessment

Closing sea ice thermo-mass & momentum budgets

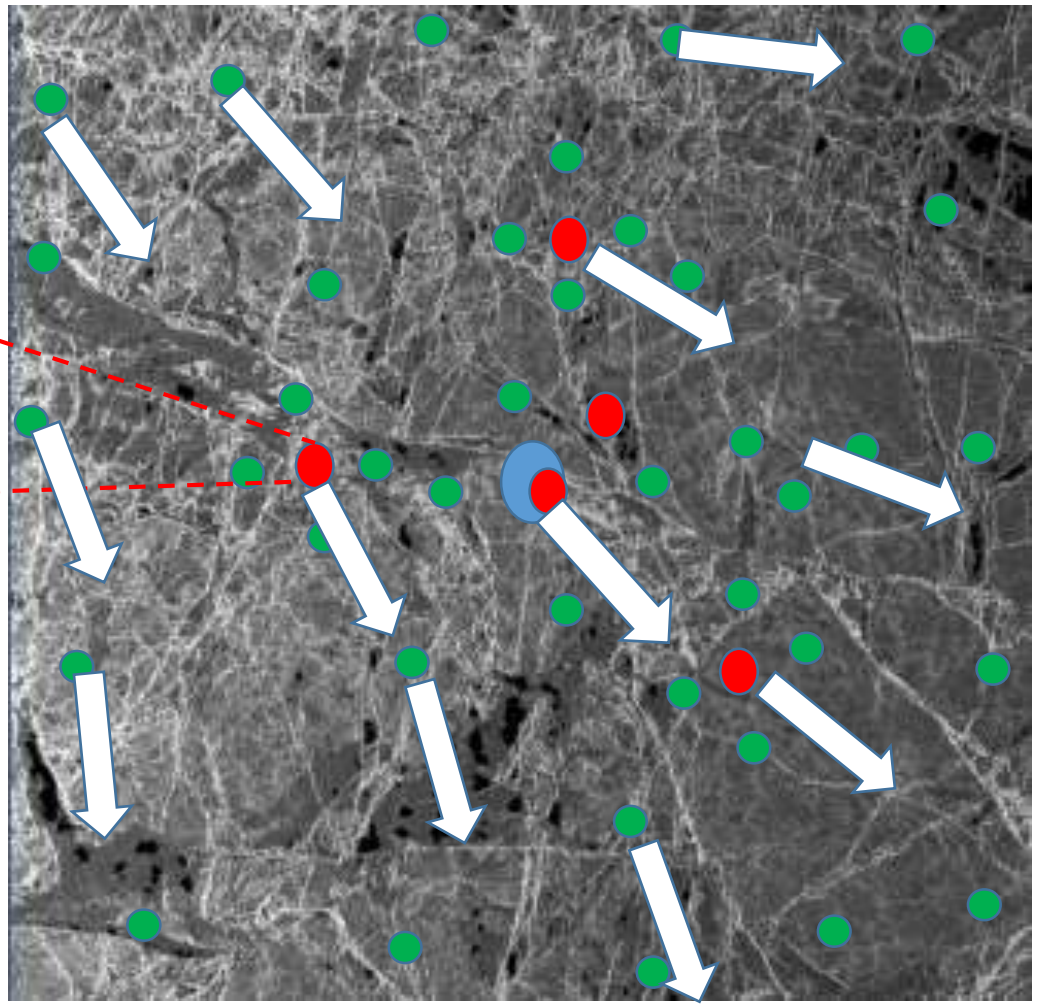
Thermodynamic balance
>> ice growth & melt



Momentum budget >>
ice motion & deformation

What processes control domain sea-ice conc. & thickness distribution? (also sea-ice drift)

MOSAiC Distributed Network



~40 km

Process Assessment

Partitioning surface energy budget

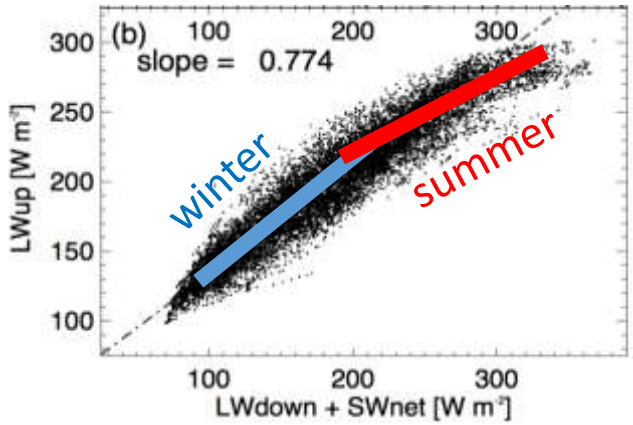
Surface Energy Budget (positive flux = surface warming)

$$SW_{down} - SW_{up} + LW_{down} - LW_{up} + SH + LH + G - \cancel{Melt} = 0$$

Forcers

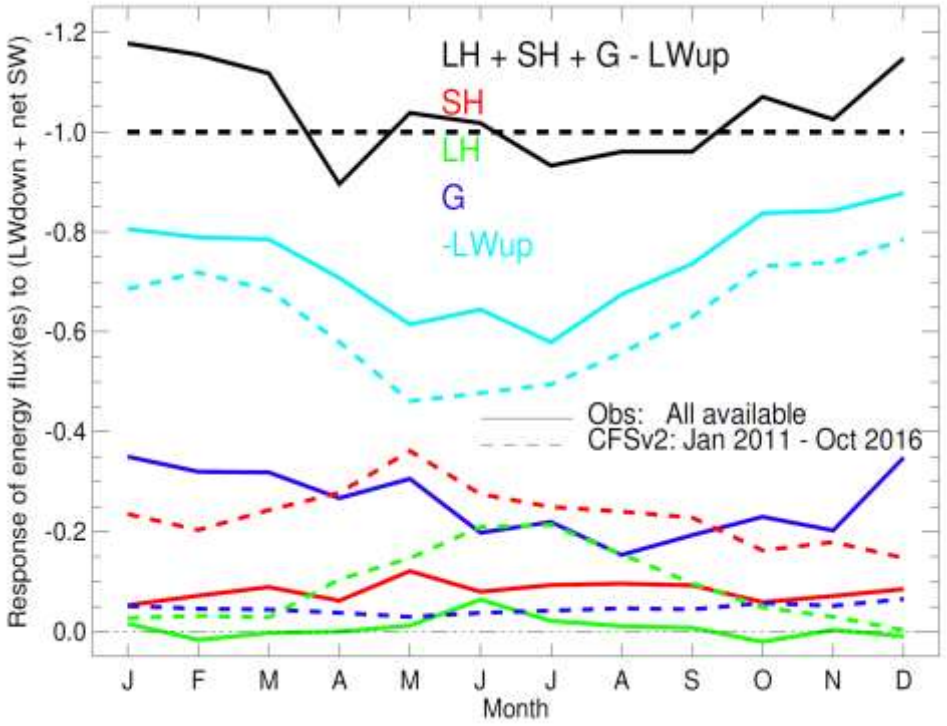
Responders

Slopes relating parameters



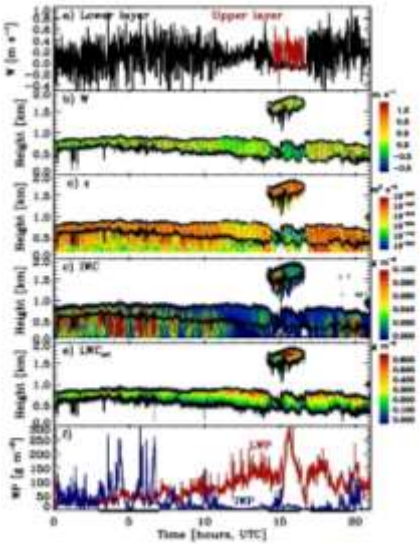
How do models partition surface energy?

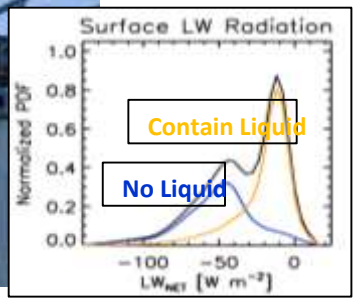
Evaluating model process relationships over full year



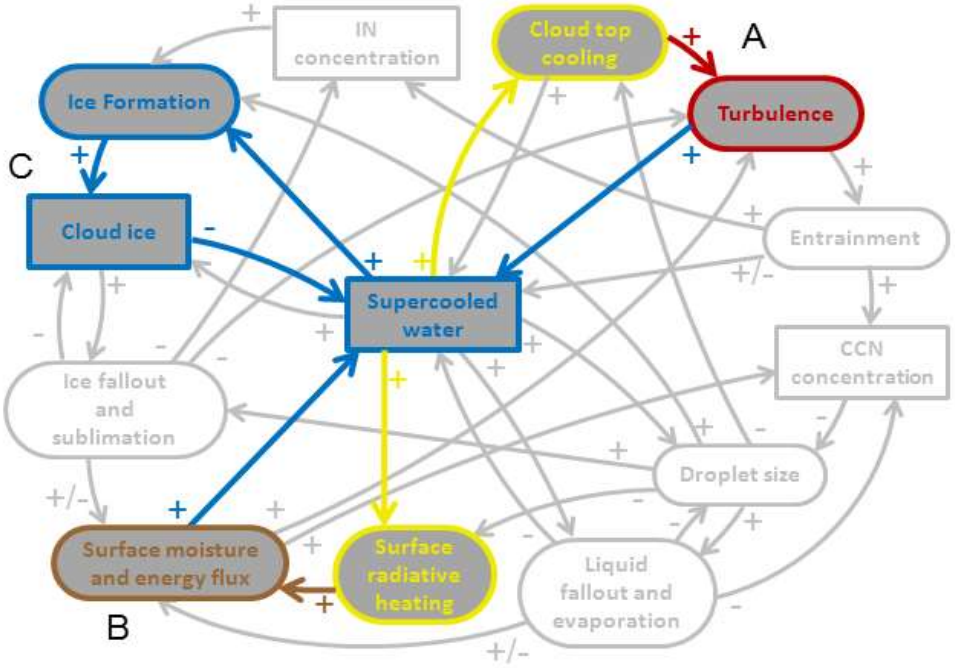
Process Assessment

Detailed cloud-radiation-precipitation processes





What controls the occurrence of supercooled liquid water?

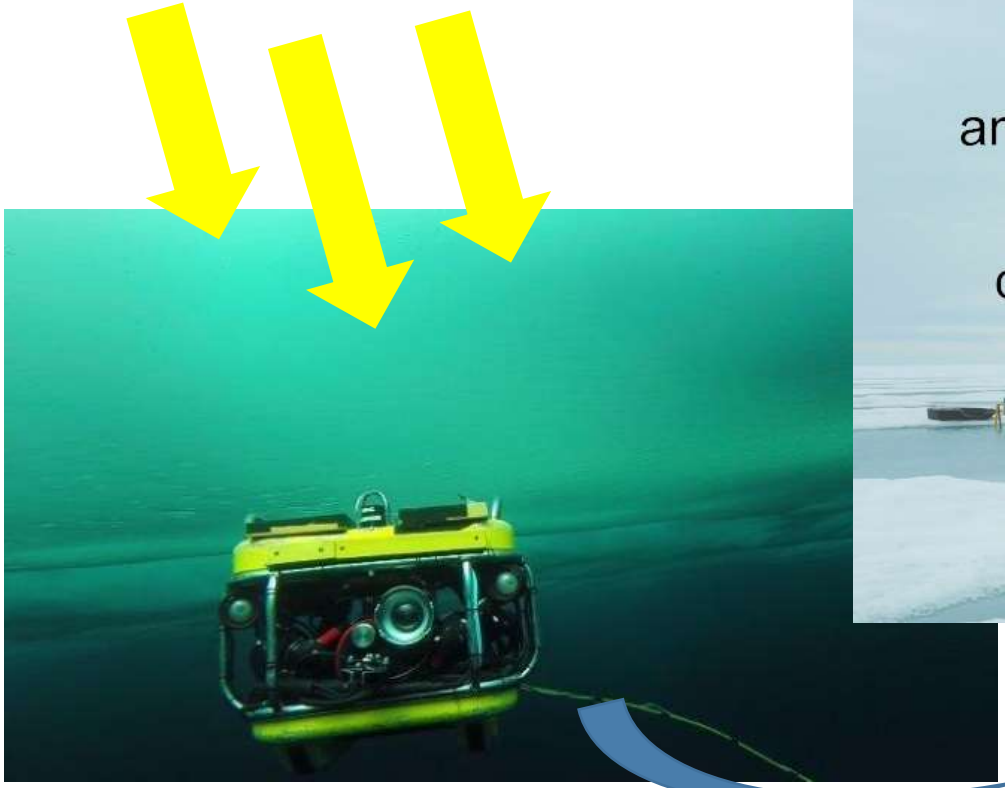


How are clouds represented in large-scale models?

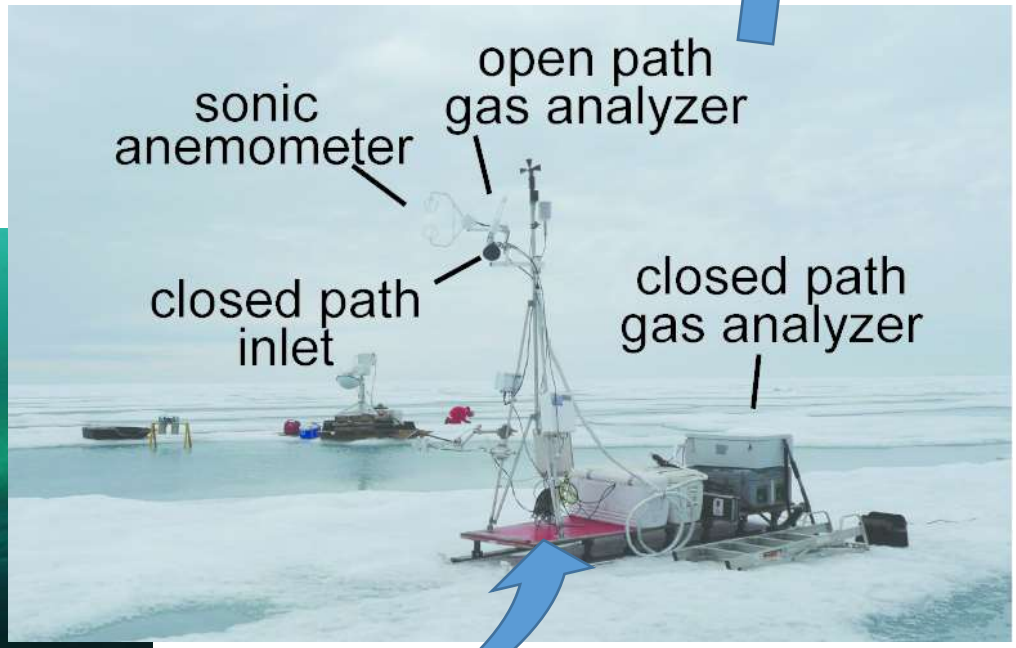
Atmos-Eco-BGC Coupling

Sun light, ice optics, biology, and aerosols

Atmosphere-ice processes determine light



Surface gas fluxes impact aerosol formation



Biological activity drives elemental cycles (C, N, S, etc.)

Forward looking: Representing coupling across physical, biological, and chemical realms

A Distinctive Opportunity

to address Arctic system modeling challenges

- Full year
- Coupled system
- Process perspective
- Multi-scale

Science and Implementation Plans

www.mosaic-expedition.org