MOSAiC

Multidisciplinary drifting Observatory for the Study of Arctic Climate

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On behalf of

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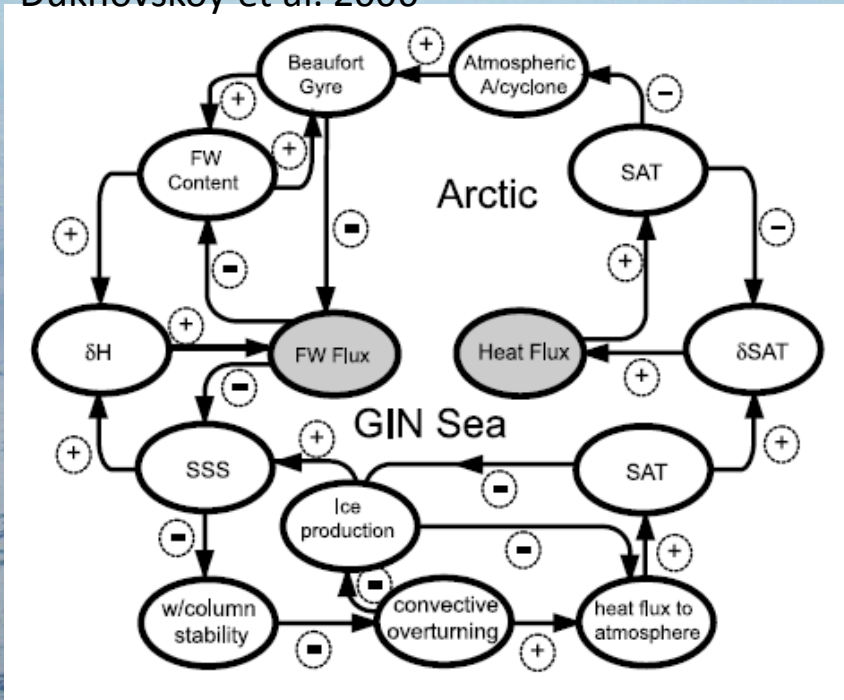
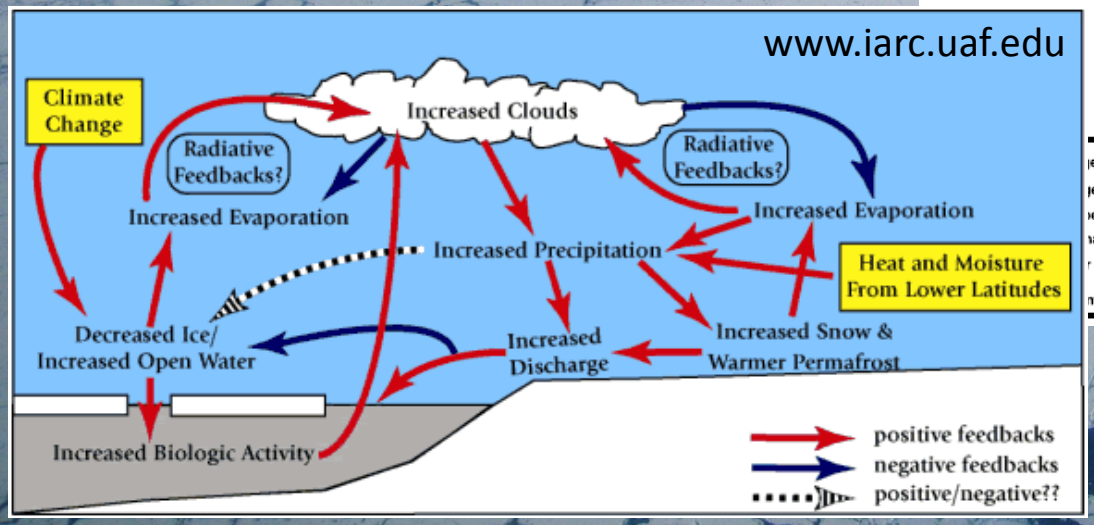
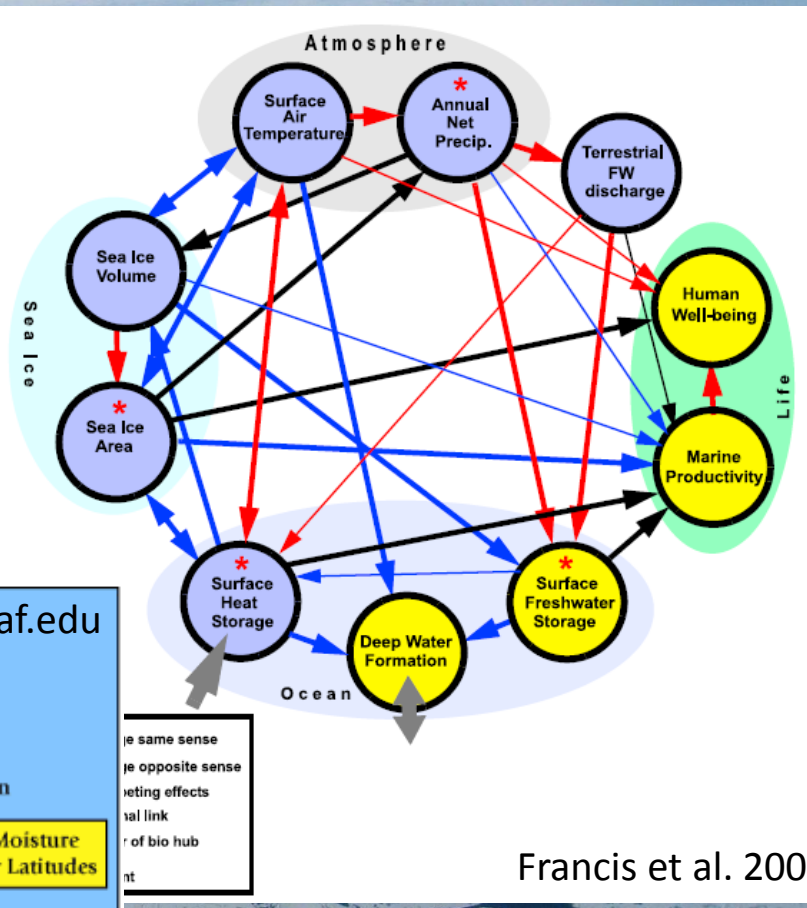
Dukhovskoy et al. 2006





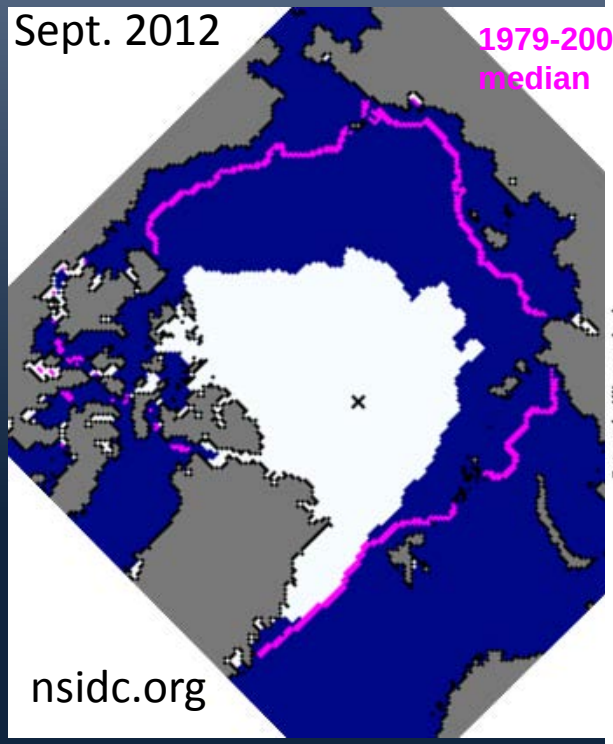


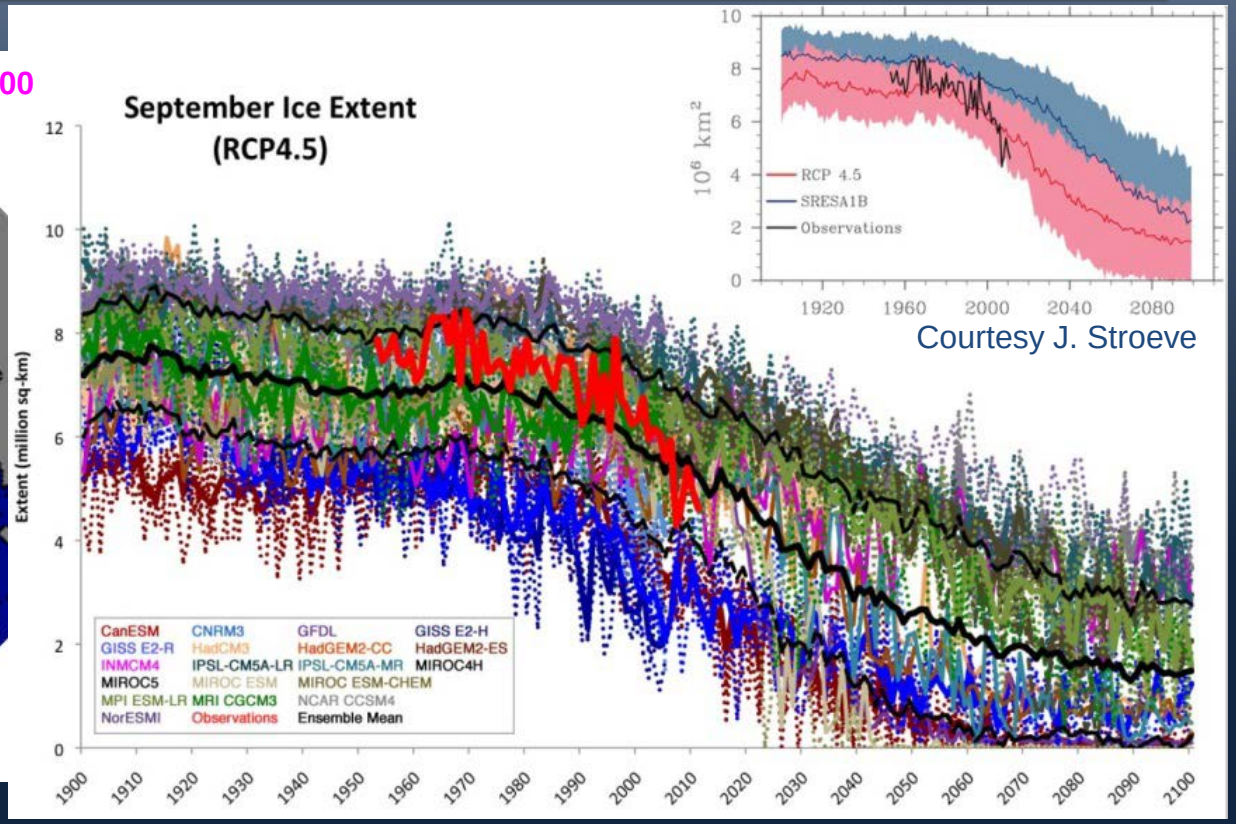
Francis et al. 2009

Arctic in Transition

The central Arctic is changing dramatically,
characterized by major sea-ice decline & more younger ice.

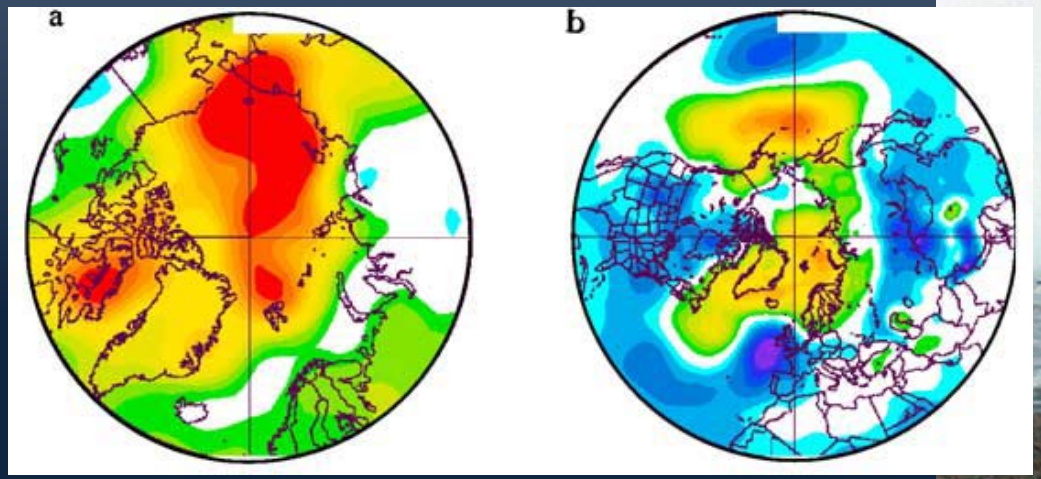
Do we know why? and (importantly) how?





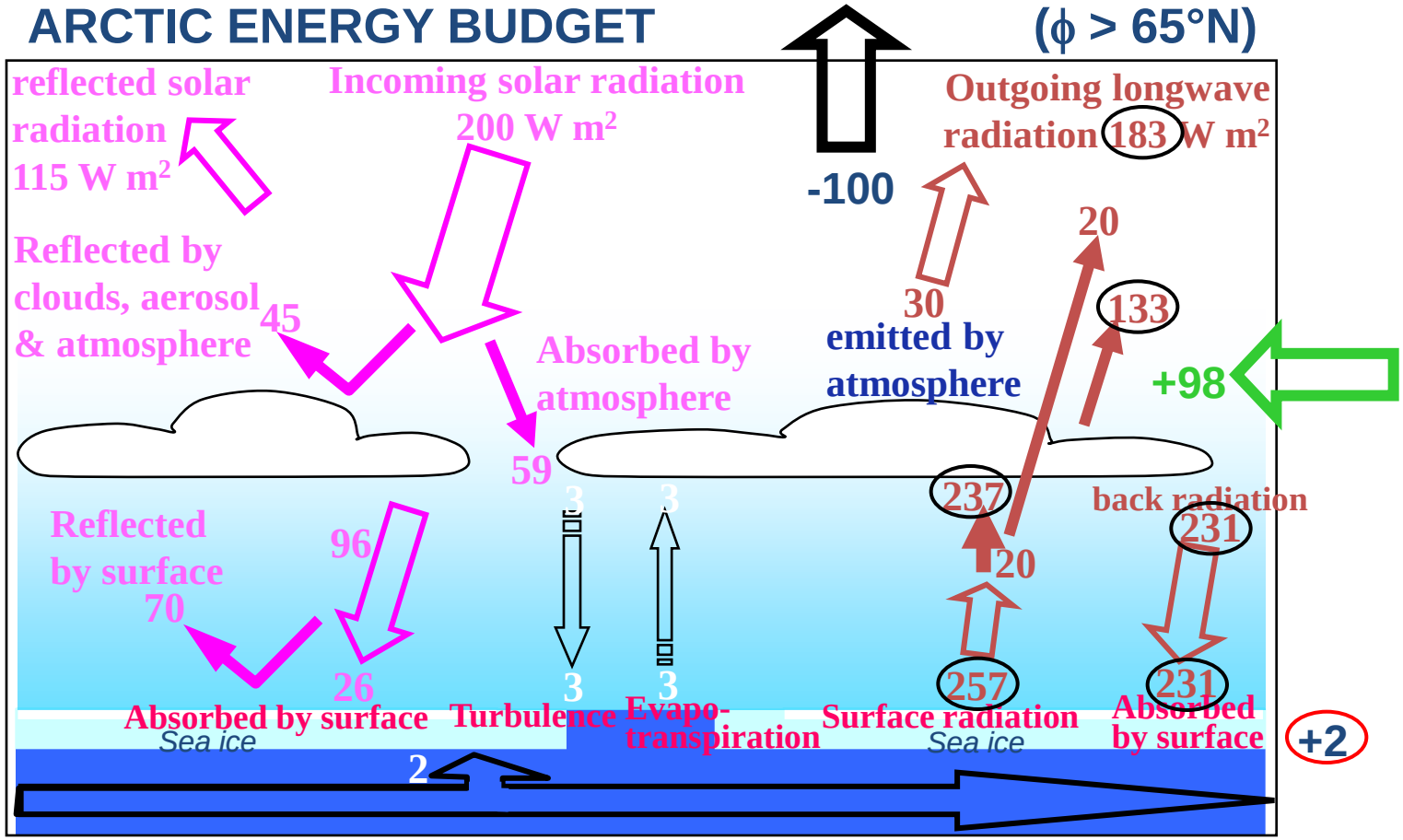
Implications of Change

- We lack a system- and process-level understanding of change, due to a lack of observations!
- Potential emergence of new processes, tipping points
- Feedbacks with “globally significant consequences” (IPCC)
- Implications for regional and lower-latitude weather
- Implications for resource development, commerce, ecosystems, productivity, communities



Francis et al. 2009

Sea-Ice Energy Budget



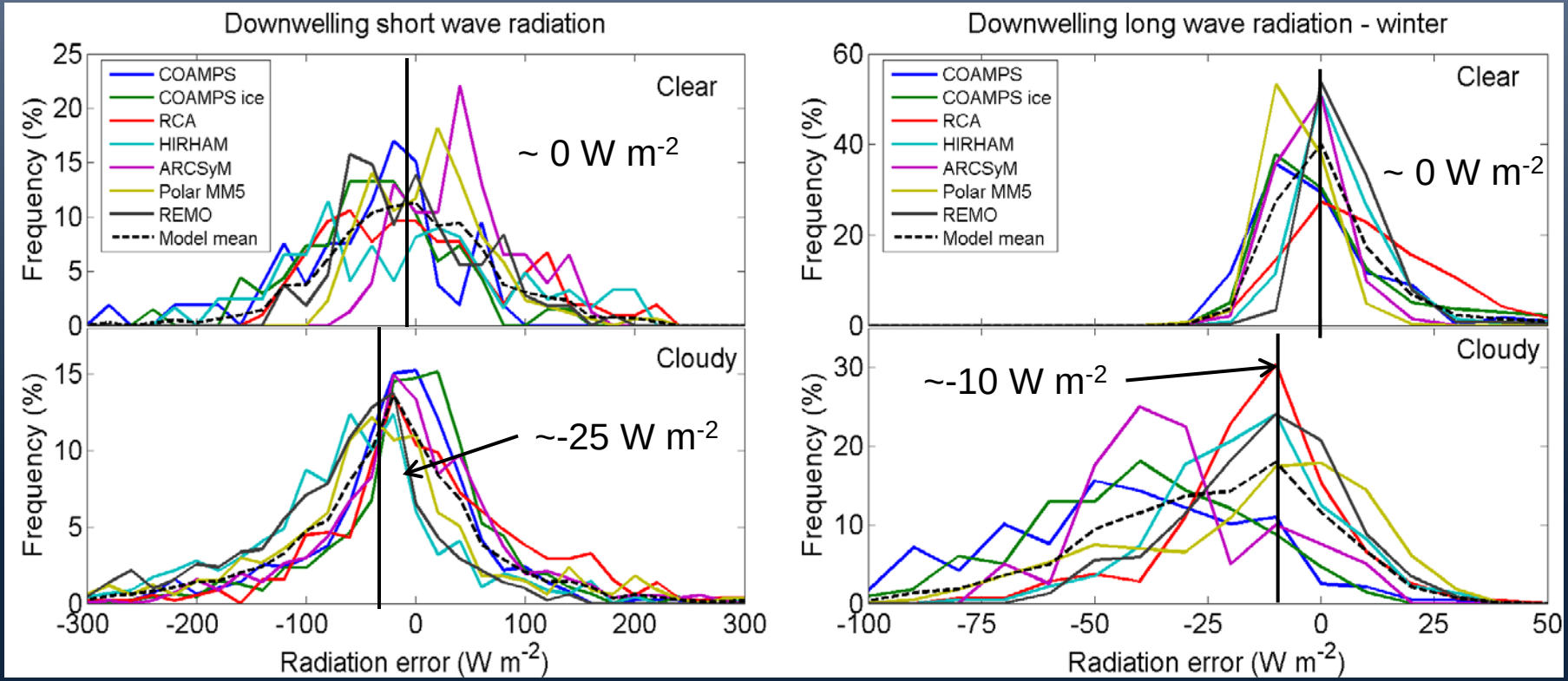
Decadal decline can be explained by ~1 W/m² excess.
Kwok and Untersteiner 2011

Persson et al. 2013

Critical Model Shortcomings

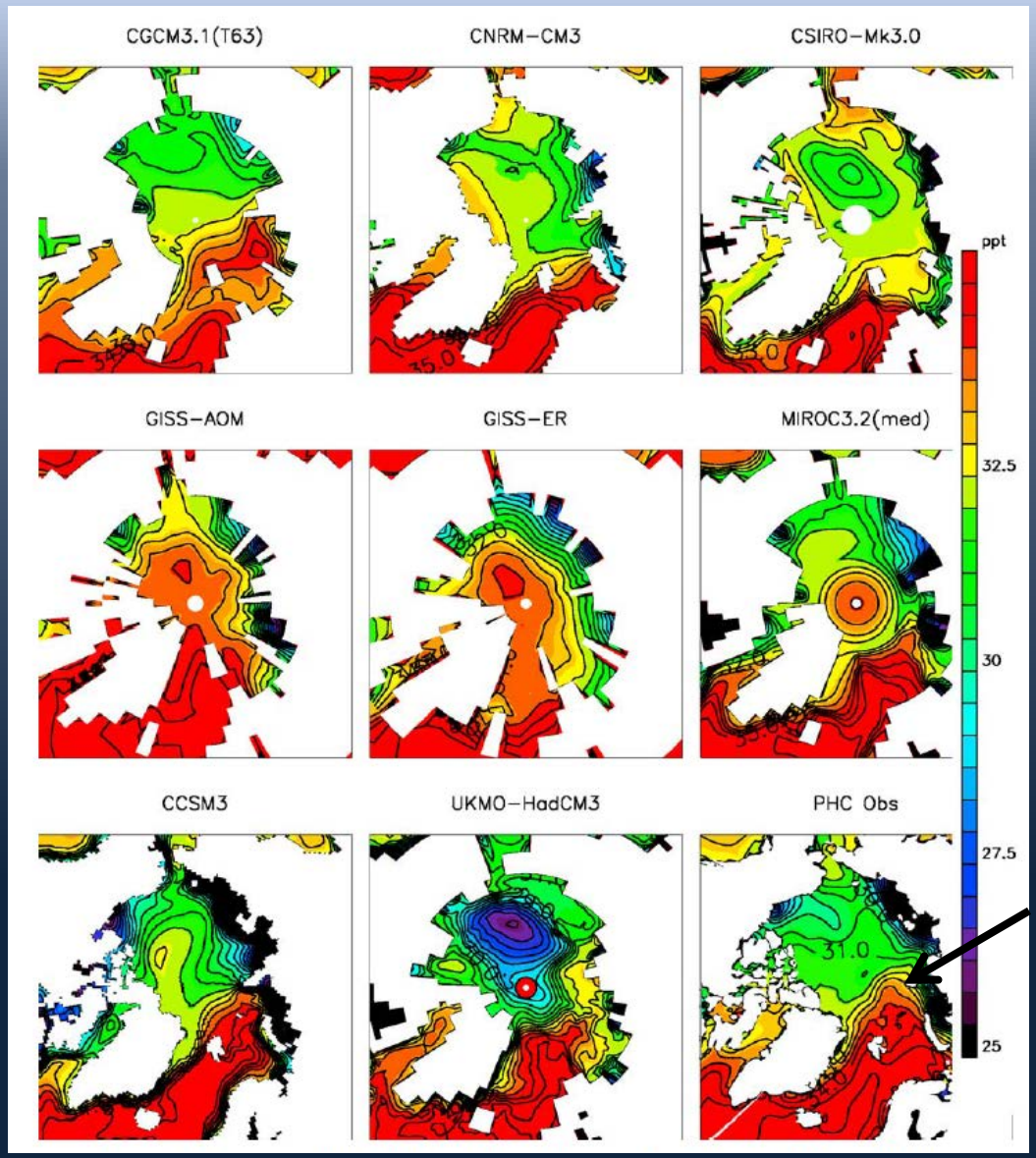
Regional Climate Models evaluated against SHEBA radiative fluxes reveal major biases and spreads, especially under clouds.

Such biases can have serious implications for sea-ice concentrations.



Tjernström et al. 2008

Critical Model Shortcomings



Comparison of IPCC AR4 models of sea-surface salinity:

Major differences suggest lack of consistency in important processes such as ocean mixing, dynamics, sea-ice processes, freshwater input, and/or others.

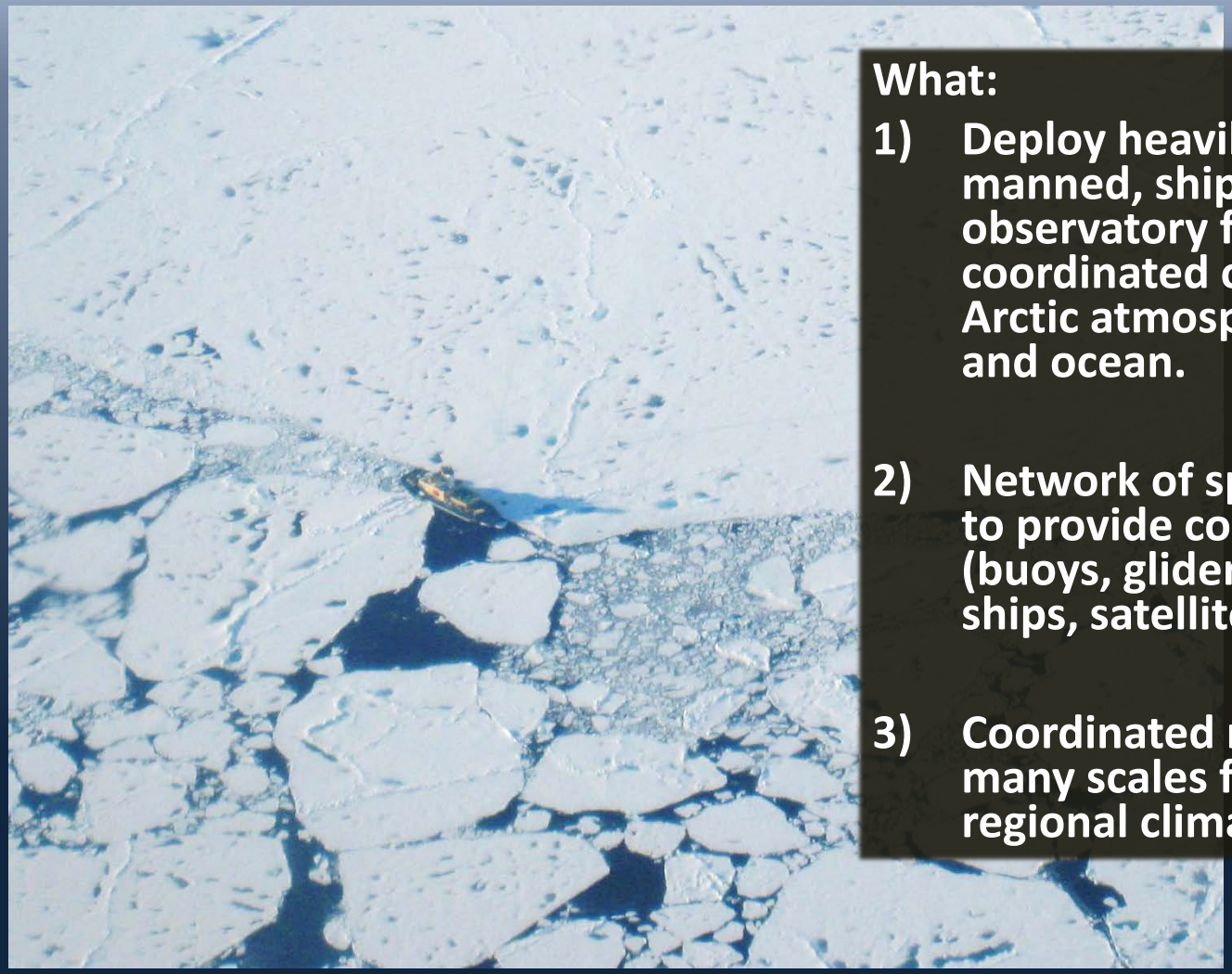
Best estimate of actual field based on observations

Holland et al. 2007

The MOSAiC Plan

Multi-year, coordinated, and comprehensive measurements, extending from the atmosphere through the sea-ice and into the ocean, are needed in the central Arctic Basin to provide a process-level understanding of the changing central Arctic climate system that will contribute towards improved modeling of Arctic climate and weather, and prediction of Arctic sea-ice concentrations.

The MOSAiC Plan



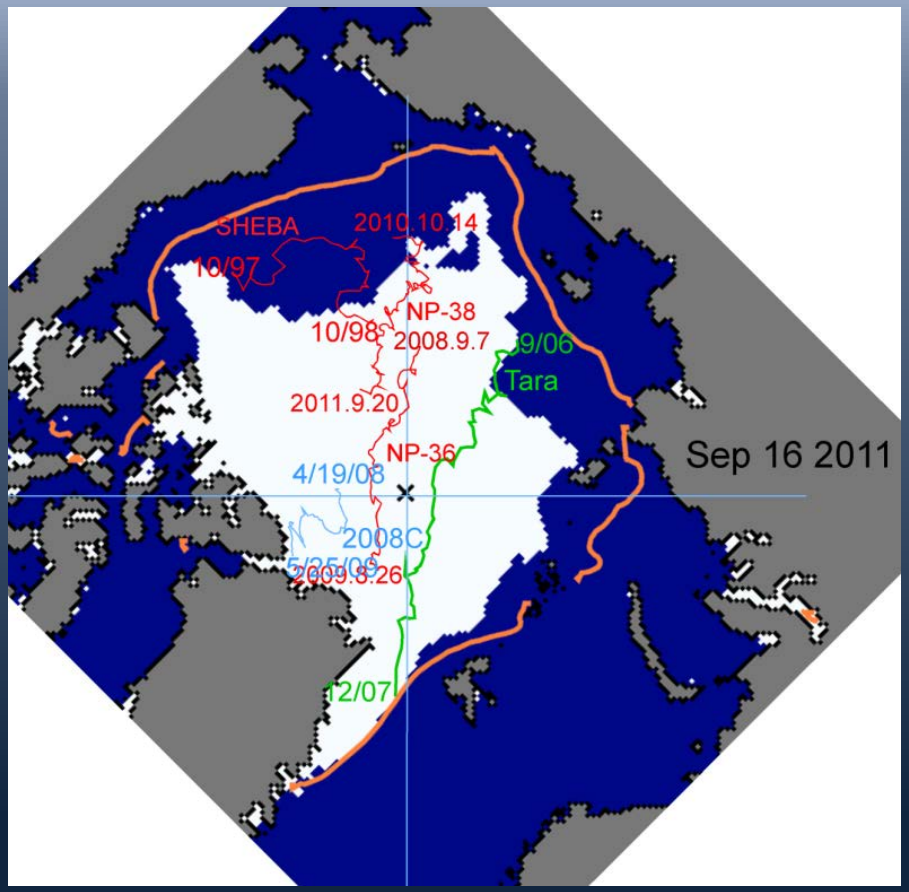
What:

1) Deploy heavily instrumented, manned, ship-based, Arctic Ocean observatory for comprehensive, coordinated observations of the Arctic atmosphere, cryosphere, and ocean.

2) Network of spatial measurements to provide context and variability (buoys, gliders, UAVs, aircraft, ships, satellites, ice stations).

3) Coordinated modeling activities at many scales from process-study to regional climate models.

The MOSAiC Plan



September 2011 sea ice extent (courtesy NSIDC). Numerous drift tracks of stations suggest possible observatory tracks

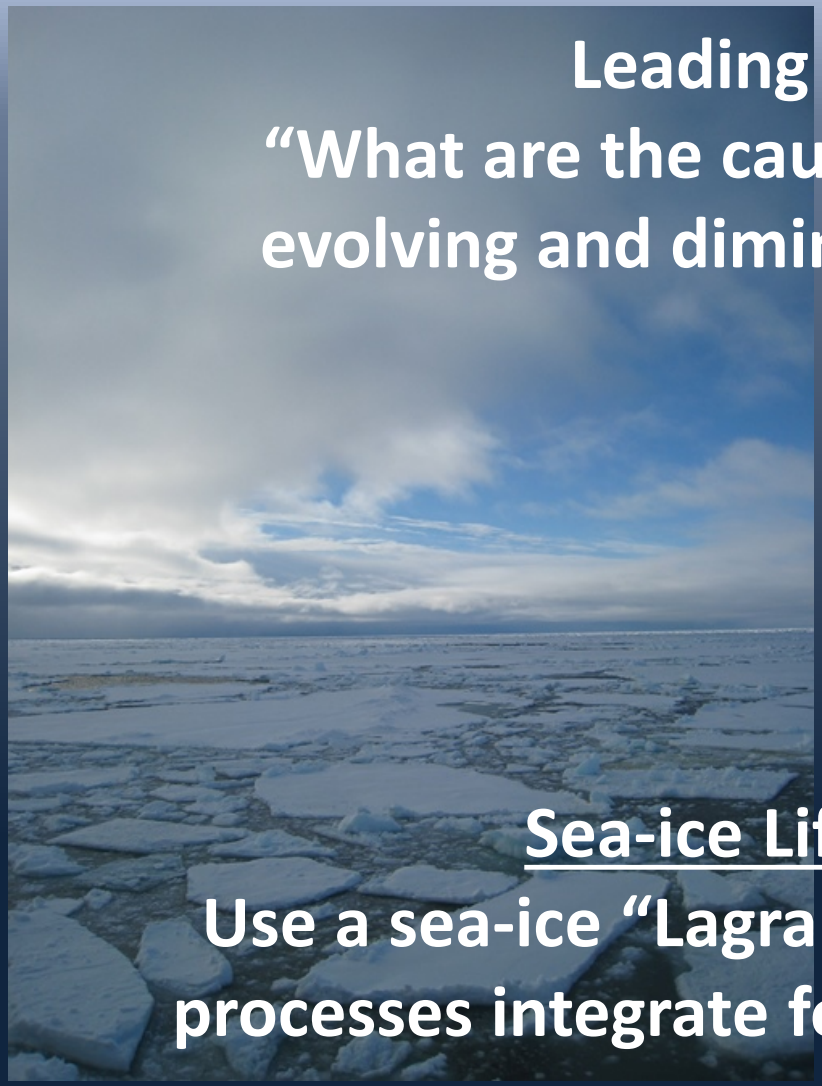
When: Autumn 2018 > Autumn 2019

Where: Central Arctic Basin ice pack

Who:

- **Coordinated through IASC**
- **International participation (e.g. US, Germany, Sweden, France, Russia, Finland, Norway, Canada, Korea, Japan, China,….)**
- **International infrastructure**
- **Synchronized international funding**

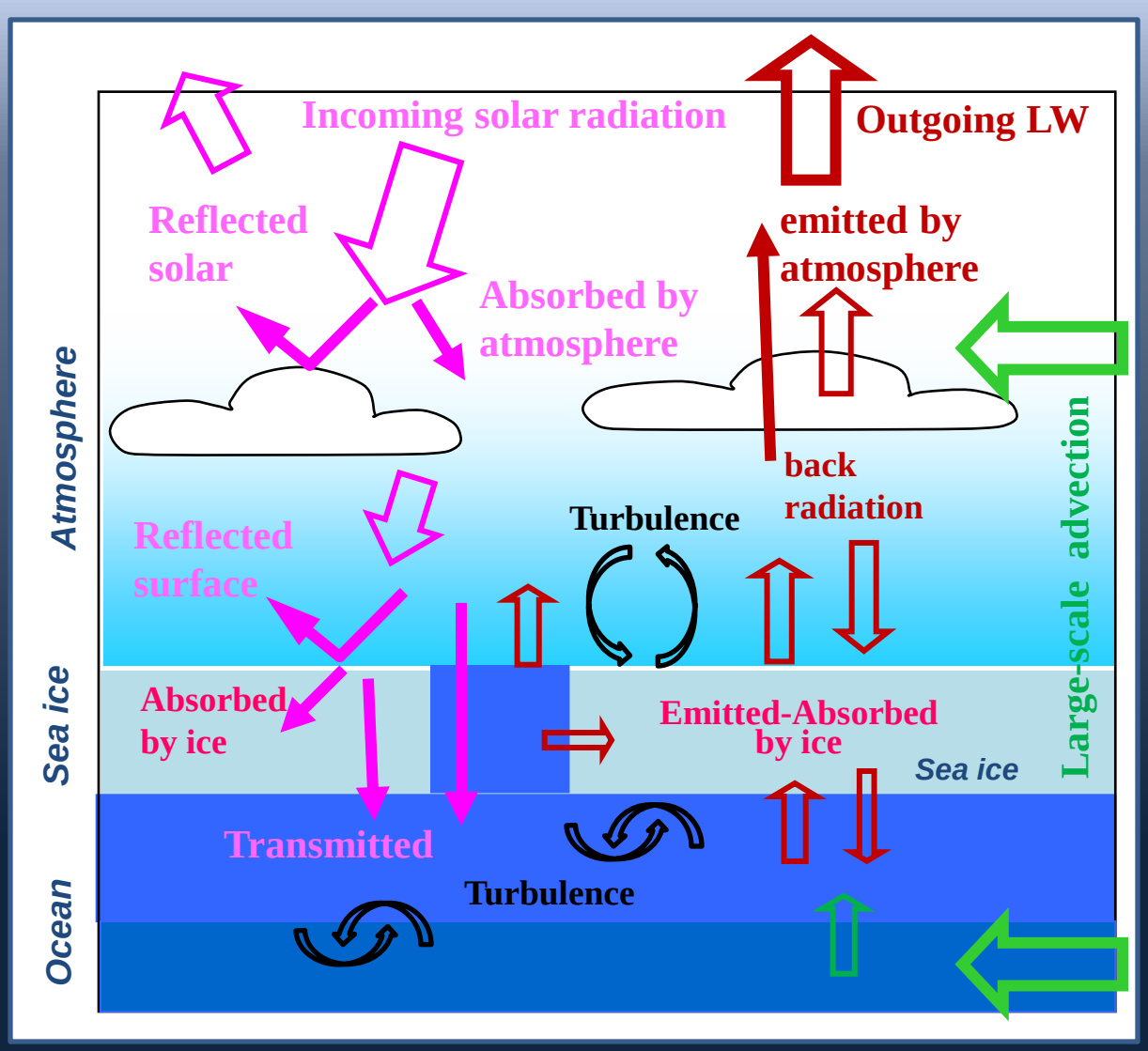
MOSAiC Science Drivers



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

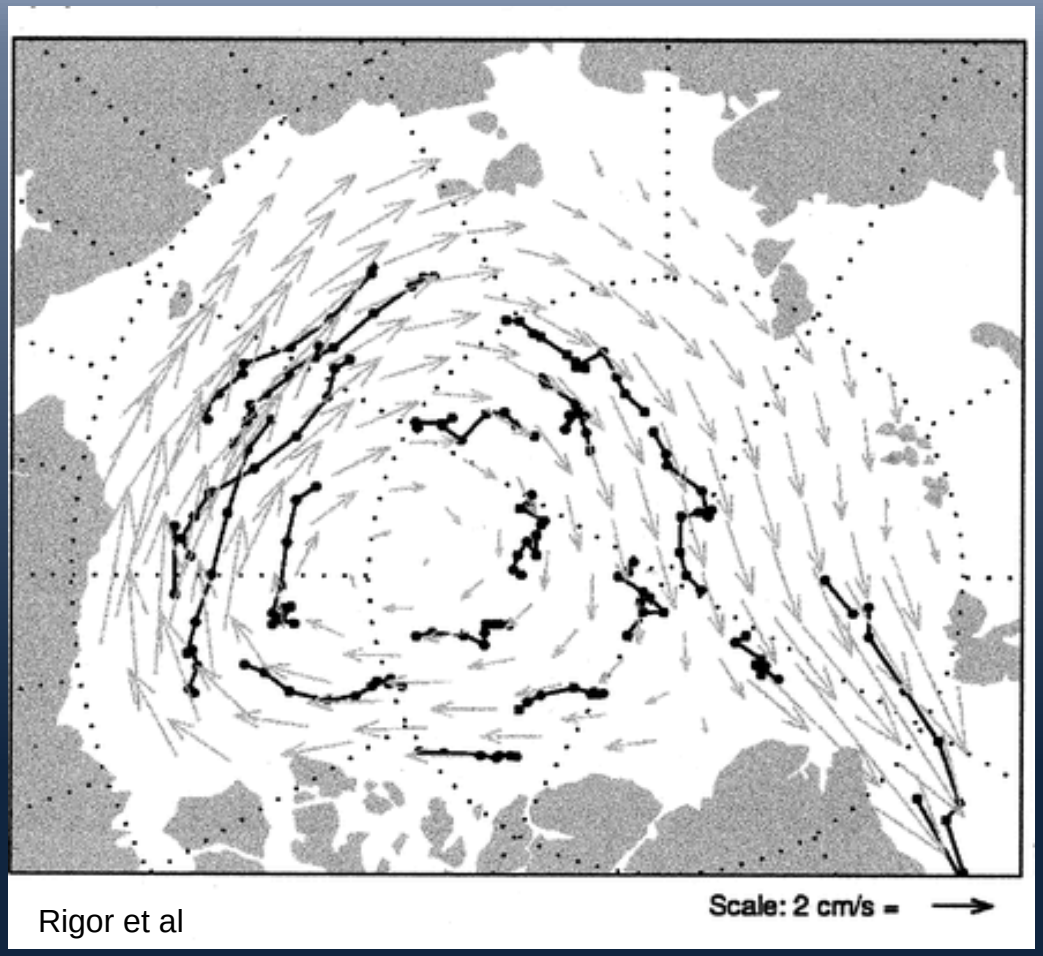
Sea-ice Lifecycle as a Theme.
Use a sea-ice "Lagrangian" perspective, where ice processes integrate forcings from atmos and ocean.

Sea-Ice Energy Budgets



- Energy Budgets
- Radiation
- Upper Ocean Heat Storage
- Mixing Processes
- Turbulence
- Stratification
- Boundary Layers
- Momentum Fluxes

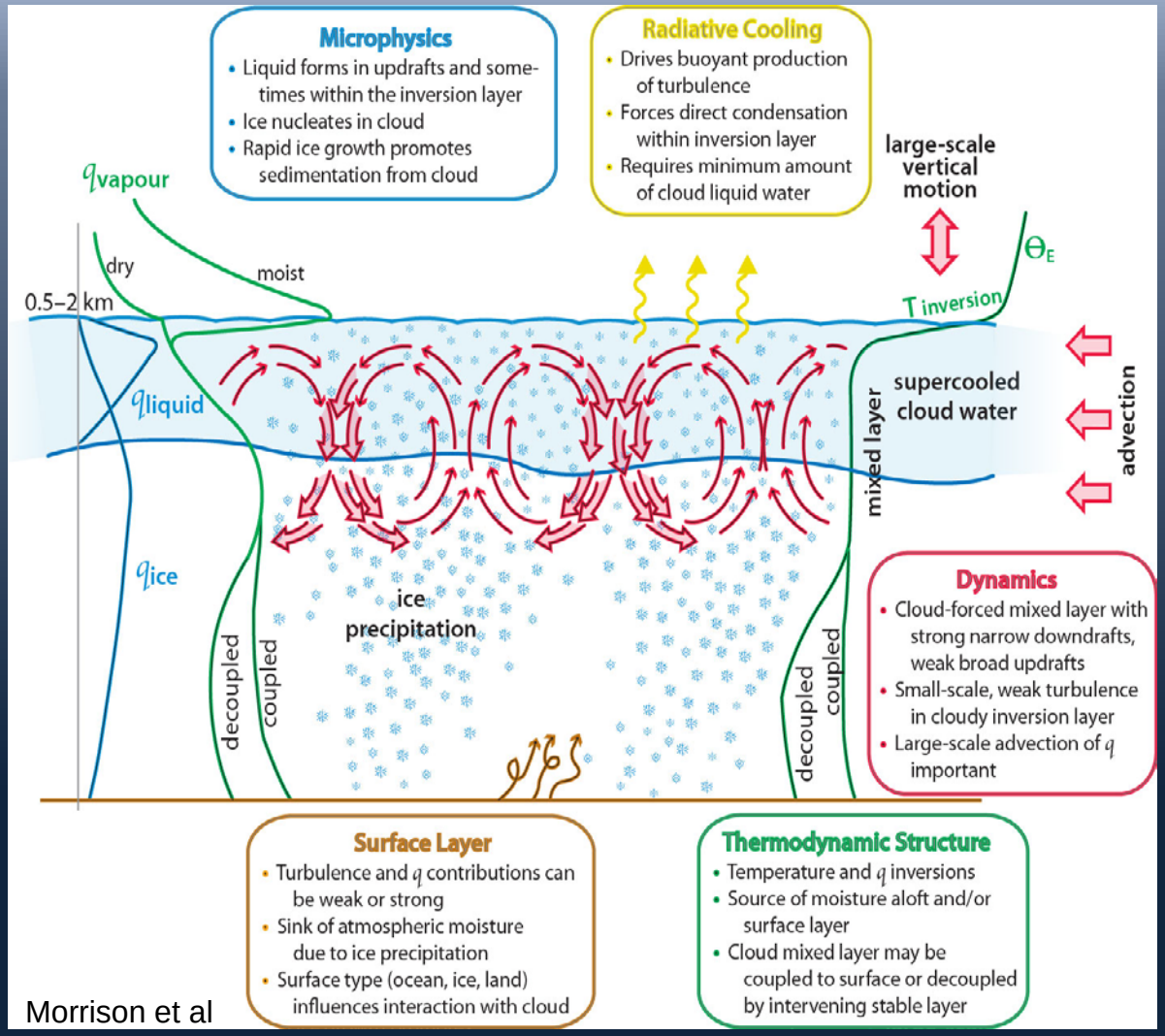
Ice Motion / Deformation



Rigor et al

- Ice Age
- Ice Thickness Dist'n
- Floe Size Dist'n
- Ridging / Leads
- FYI Roughness / Drag
- Dynamics / Velocity
- Ice –Wave Interactions

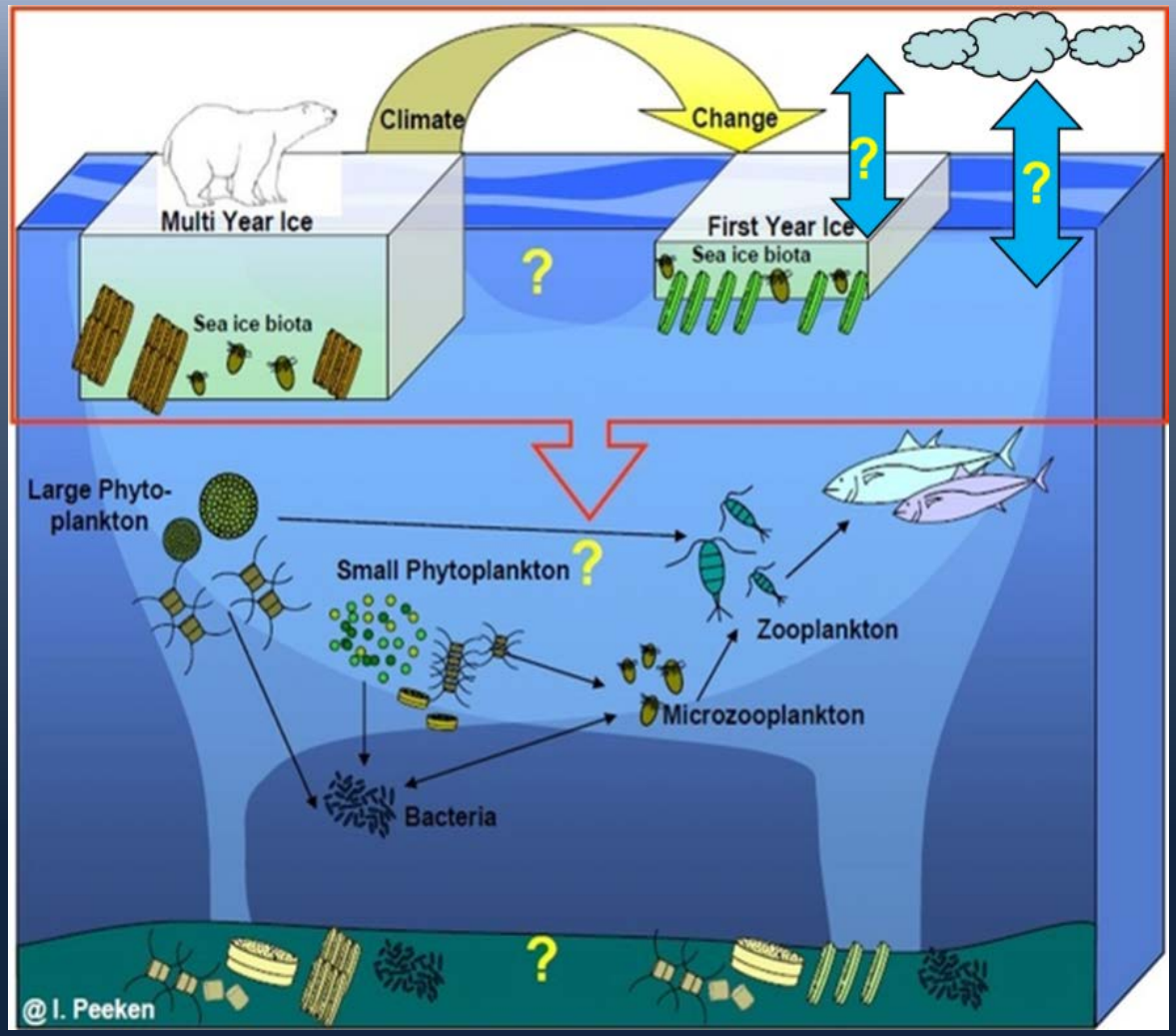
Clouds/Precip/Aerosols



Morrison et al

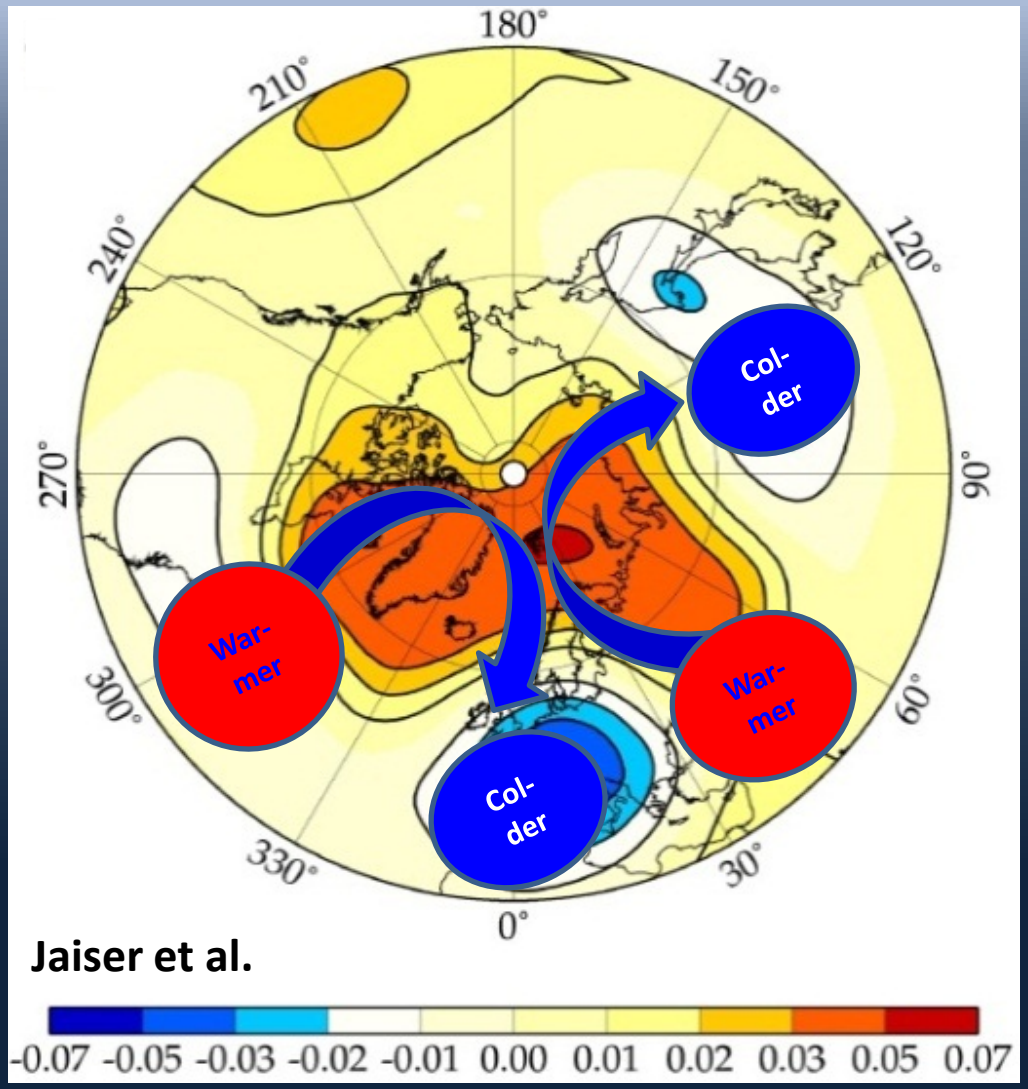
- Phase Partitioning / Mixed-phase
- Radiative Processes
- Cloud dynamics / Turbulence
- Spatial Organization
- Cyclogenesis
- Aerosol Conc. / Source attribution
- Precipitation

BioGeoChem Processes



- Surface Gas Exchange
- Carbon Cycle
- Nutrient Transfer
- Ice Algae / Biota
- Sea Ice Ecosystems
- Primary Productivity
- Aerosol Precursors

Large-Scale Implications

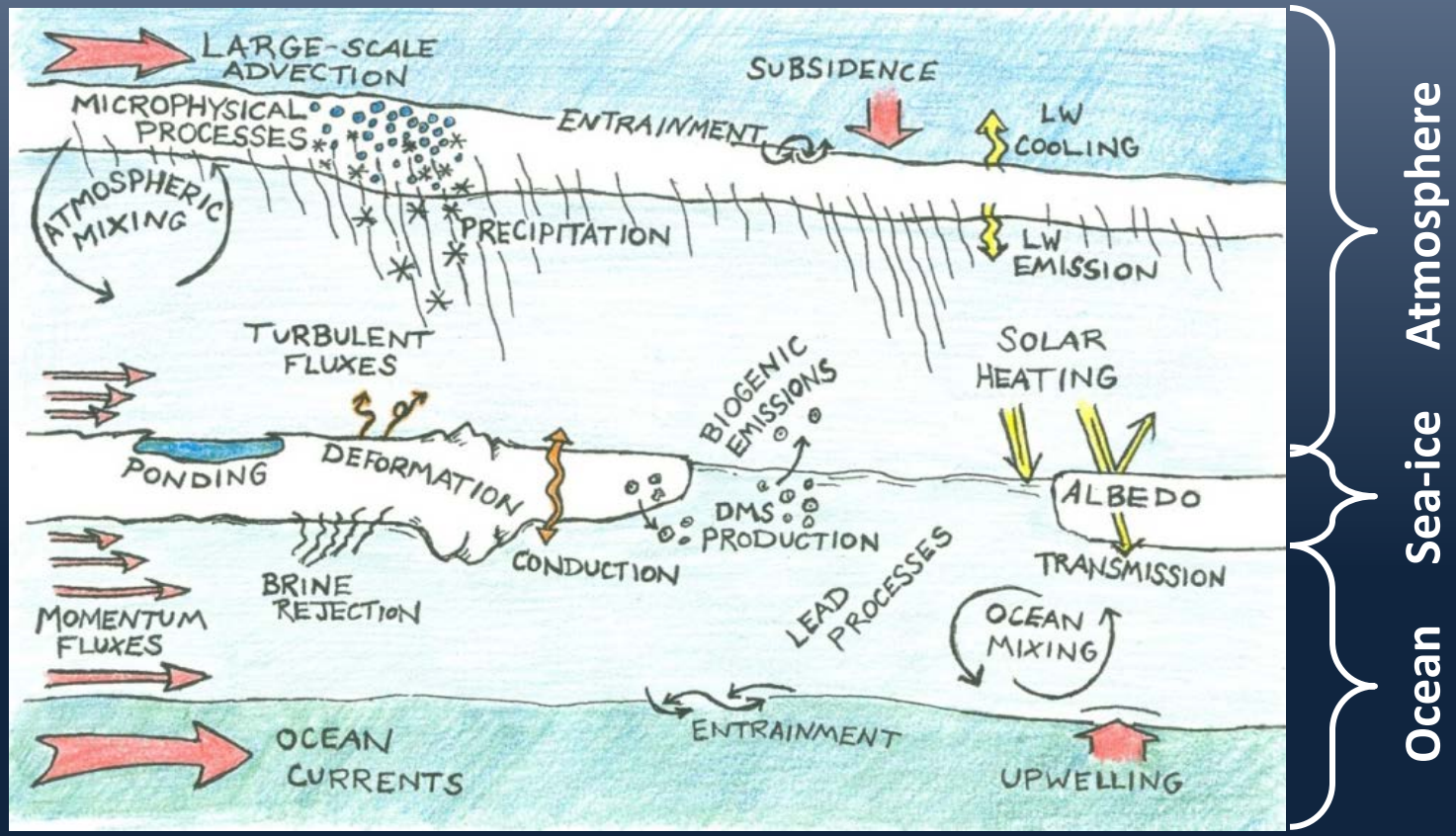


Jaiser et al.

- Large-scale Transport
- Synoptic variability
- Linking local processes & hemispheric patterns
- Upscaling
- Implications of regional change

Process Perspective

- Process-study vs. climatology
- Process perspective suited to parameterization evaluation & development
- Requires complex measurements to characterize interdependent processes
- Distributed measurements for spatial variability & context on key parameters



Measurements

atmospheric profiling, BL, & dynamics

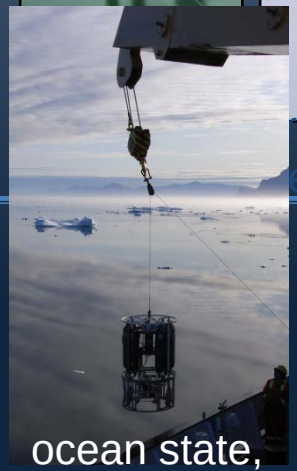
gases, aerosols, clouds & precip.

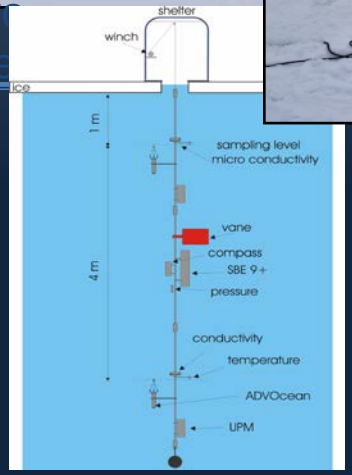
aircraft + UASs

ocean and ice bio/chem

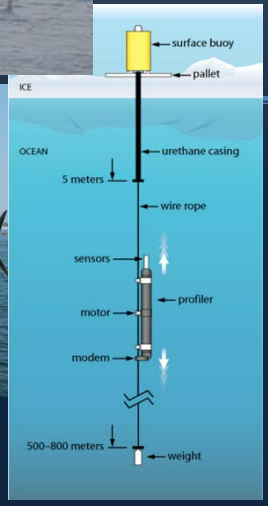
surface energy budget

buoys, AUVs, gliders





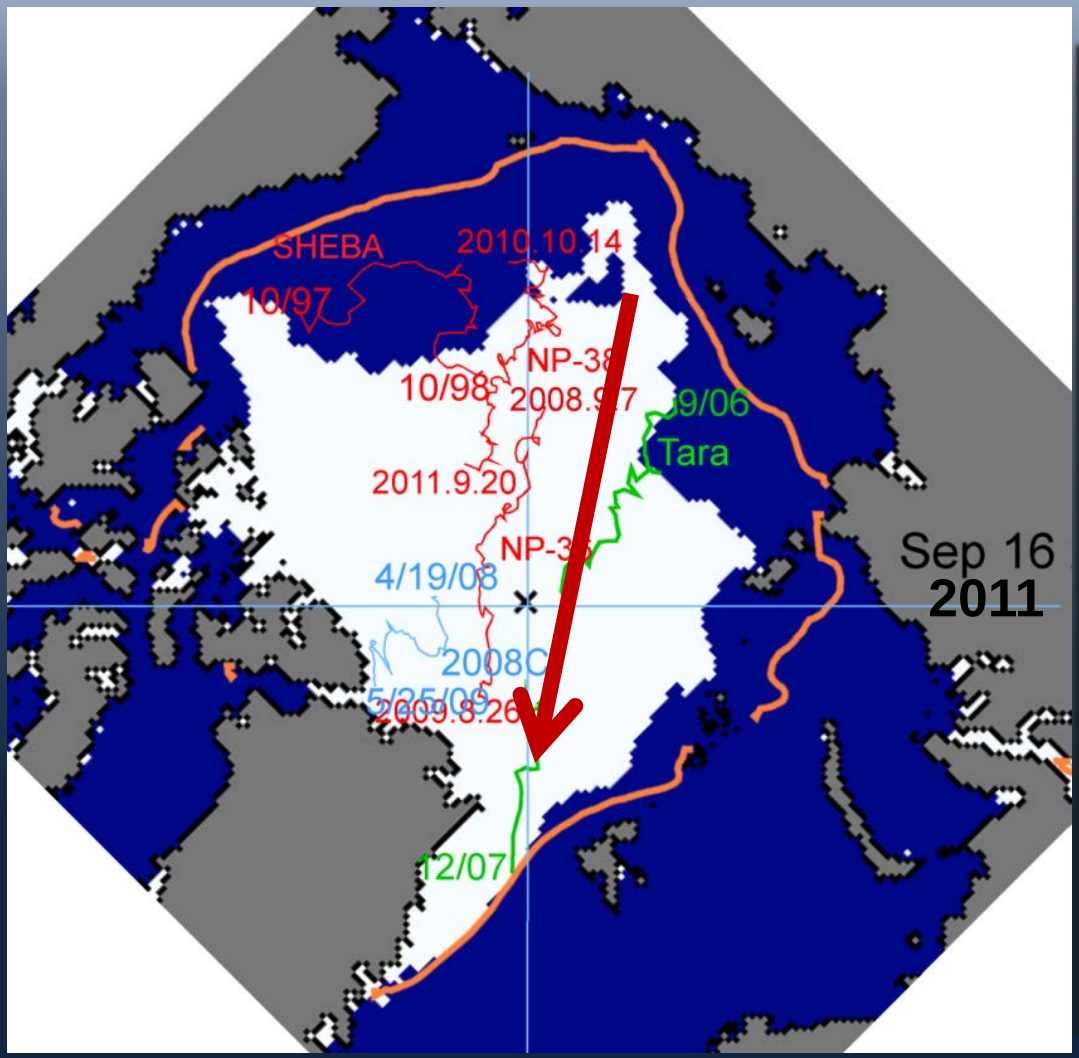
ice profiling, thermodynamics, mass budgets



ocean state, profiling, & dynamics

leads & ocean surface

Planning the Drift Track



Transpolar Drift track

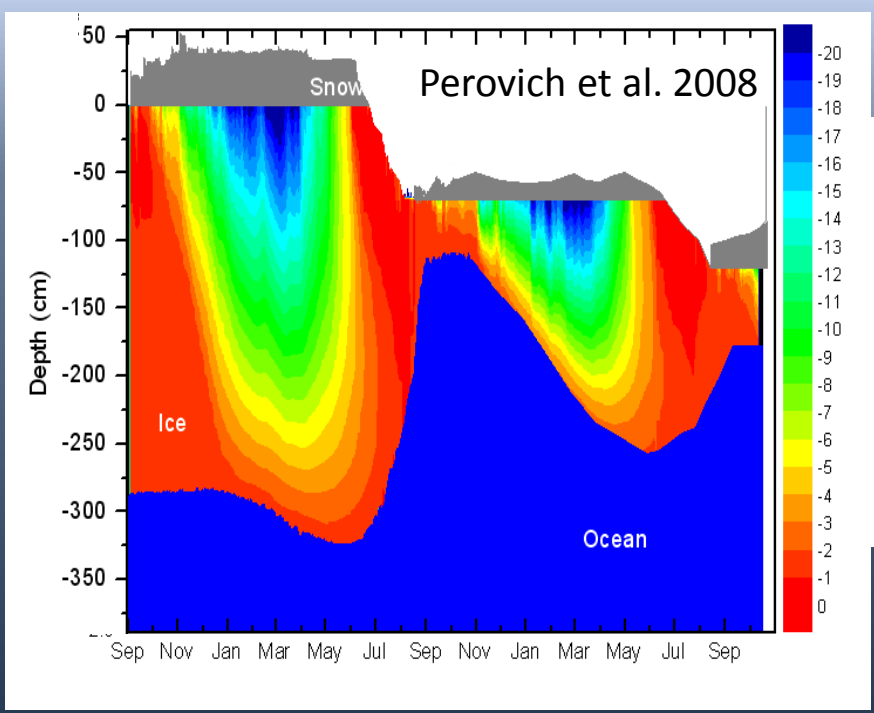
Objectives:

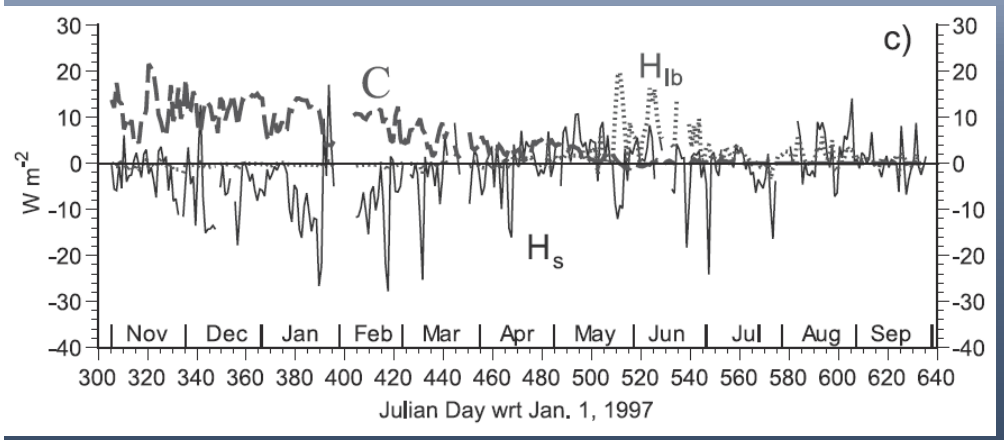
- Observe full sea-ice "life cycle," starting in new ice.
- Trajectory that will last for at least (more than) 1 year
- Observe an understudied region

Challenges:

- Central Arctic is isolated
- First year ice will be difficult

Full Annual Cycle





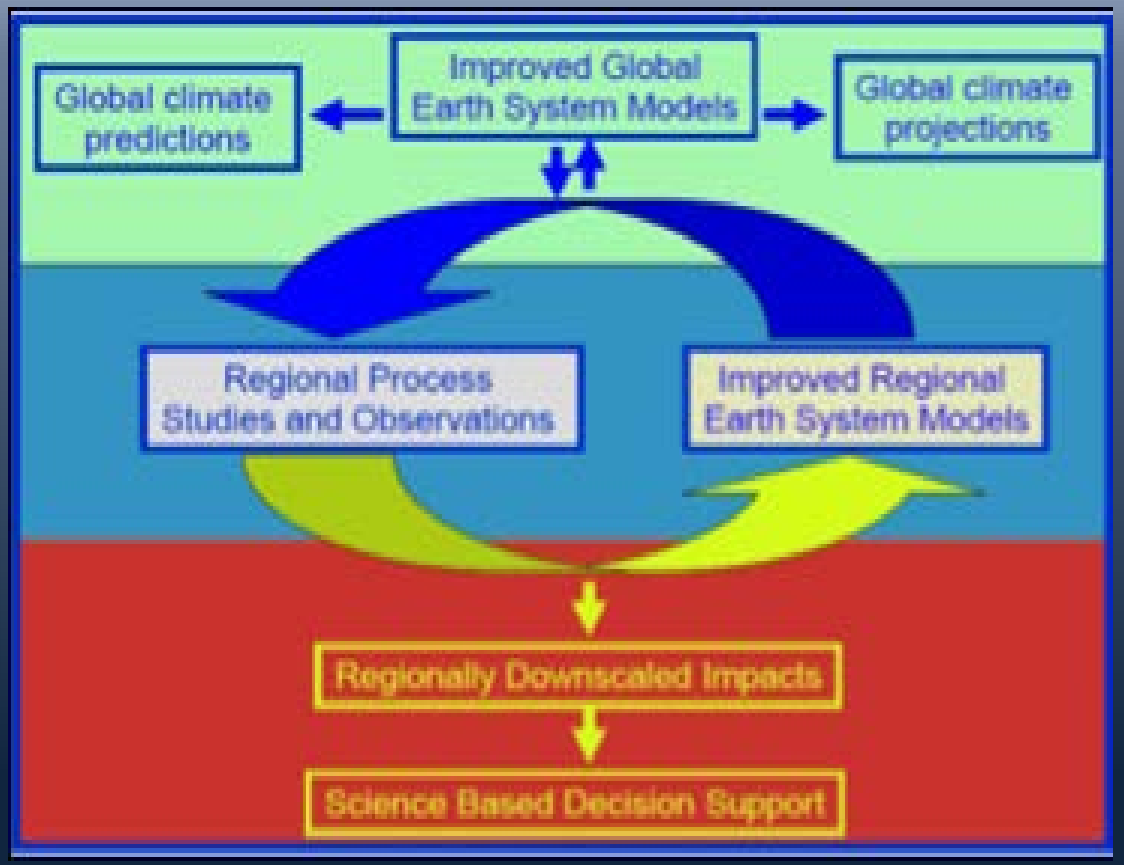
Persson et al. 2002

- Arctic climate system has memory. Sea-ice integrates energy budgets.
- Processes vary over the annual cycle.
- Important to understand all phases of the sea-ice life cycle:
  Formation > growth > transport/deformation > melt/decay/export
- Past observations biased towards summer (warm, easy);
  Relatively little understanding of winter processes.

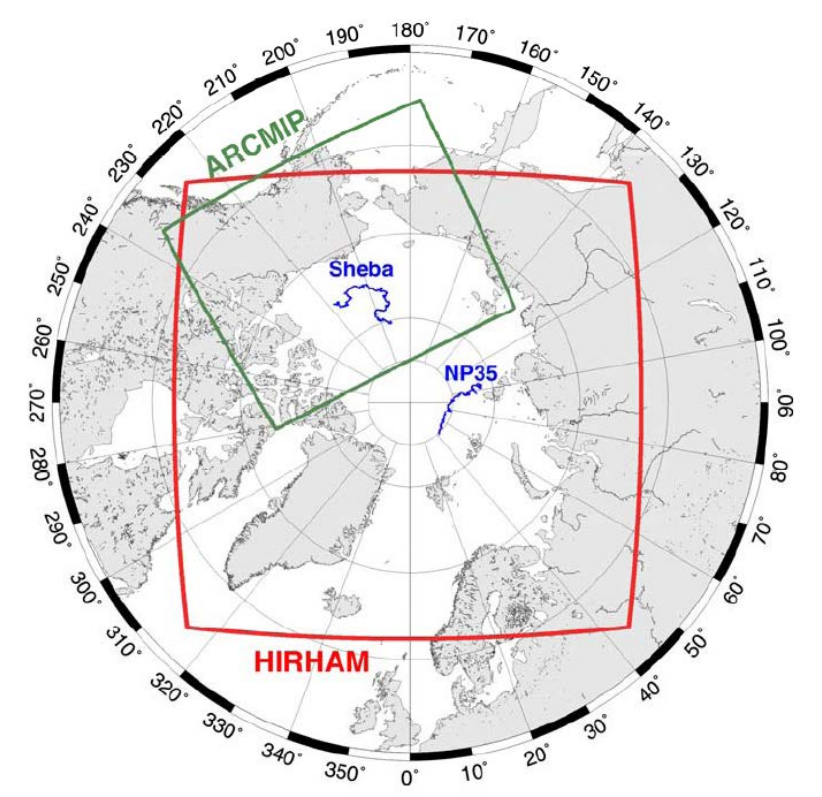
Central Model Role

Models play critical roles:

- **Identify important measurements, processes**
- **Guide drift track**
- **Integrate process information**
- **Provide spatial context**
- **Linkage w/ lower latitudes**



Central Model Role



Model considerations:

- **Hierarchy of model activities: process, regional, global**
- **Regional model intercomparison project**
- **Model "testbed" > Critical data for parameterization evaluation & development**
- **Strong ties with WWRP Year of Polar Prediction (YOPP)**

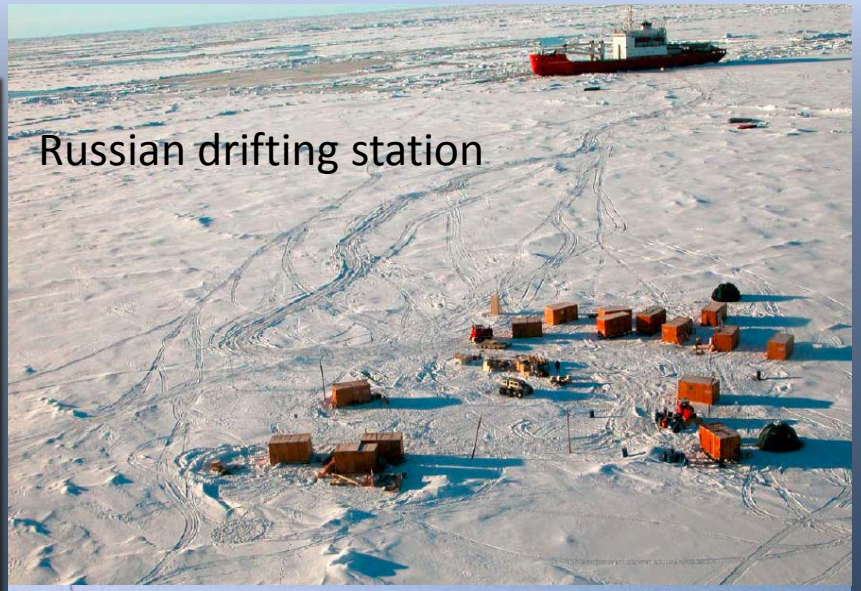
Building off the Past

Previous experiences within the Arctic ice pack:

- Russian drifting stations
- SHEBA
- Shorter-term campaigns
- Many disciplinary obs.
- Some inter-disciplinary obs.

Each of these has key limitations:

- Length of time
- Comprehensiveness
- Spatial context
- Not in the “new” Arctic



Broad Support

Strong linkages with identified international priorities:

- **IASC broad support > ICARPIII**
- **WWRP – Polar Predictability Project**
- **WMO Climate and Cryosphere**
- **US Arctic Observing "Showcase Project"**
- **NASA Arctic priorities workshop**
- **ECMWF modeling priorities workshop**
- **Links to US IARPC priorities**
- **Links to US SEARCH 5-year goals**

Key Milestones

- Planning workshops: Potsdam 2011, Boulder 2012, Potsdam 2013
- Polarstern feasibility acceptance, 2013
- Polarstern full proposal submitted, 2014
- DOE ARM proposal supported, 2014
- Initial Science Plan released, 2014
- Funders meeting, April 2015

MOSAiC into the Future

Tentative MOSAiC Schedule

- "Finalize" Science Plan – 2015
- Logistics planning - Ongoing
- Implementation Workshop and Plan – spring/summer 2015
- US interagency proposal(s) – Autumn 2015
- EU Proposal - 2016
- Preparatory modeling & instrument development 2015>
- MOSAiC Open Science Meeting – 2016?
- Field deployment September 2018

Thanks!

www.mosaicobservatory.org