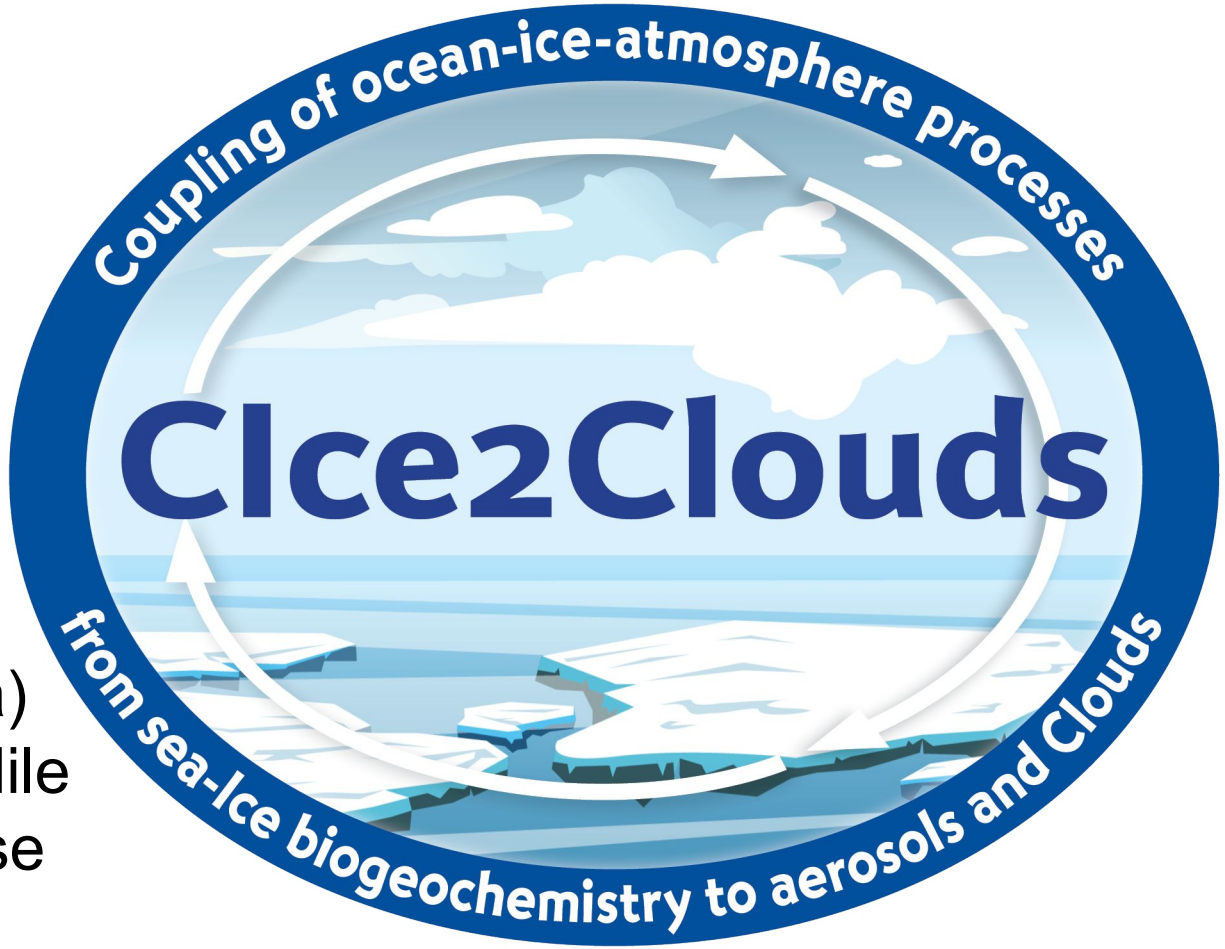
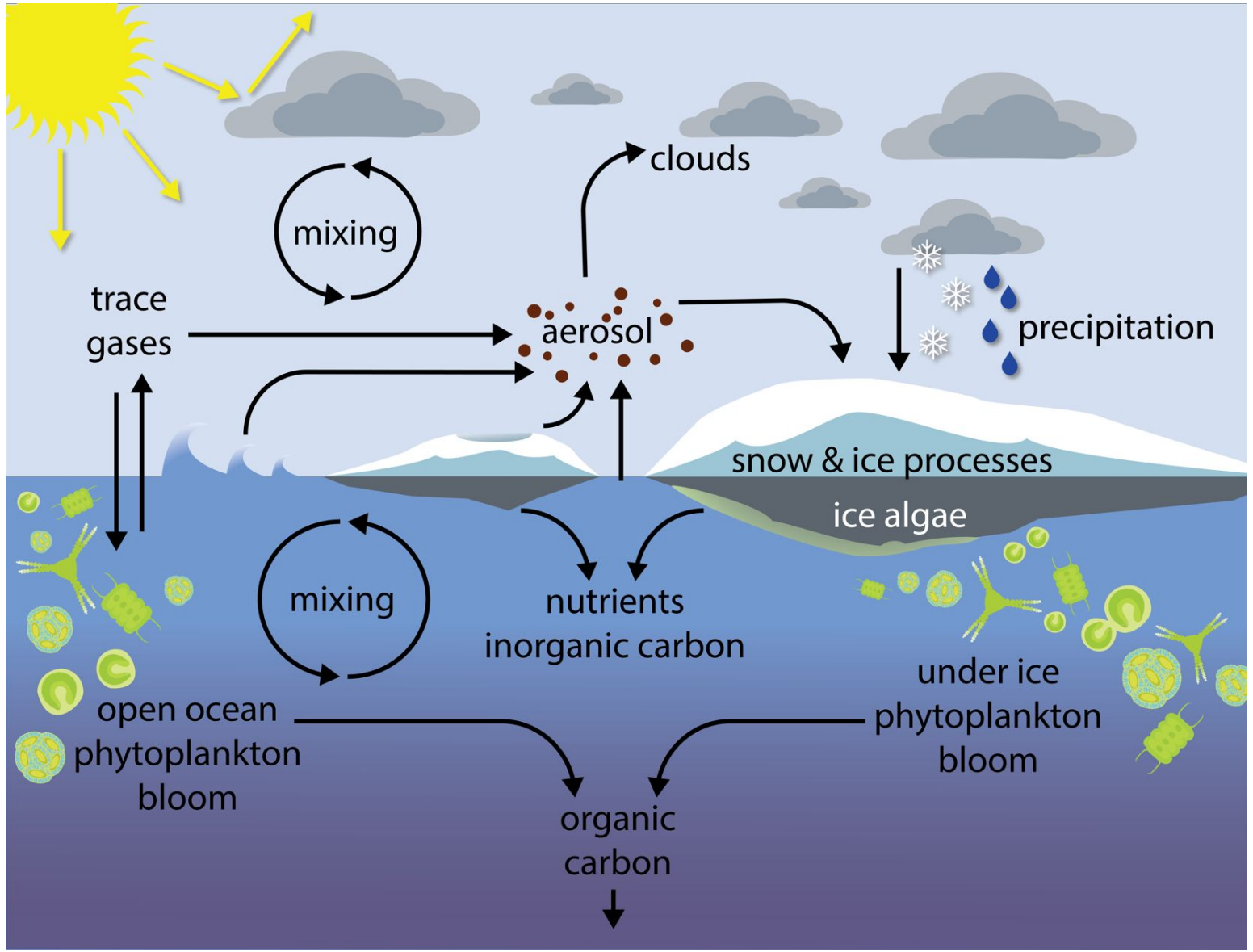
Coupling of ocean-ice-atmosphere processes: from sea-Ice biogeochemistry to aerosols and Clouds (CIce2Clouds)



Co-chairs:
Megan Willis (USA) & Nadja Steiner (Canada)
Full Members: Raul Cordero (Argentina), Odile Crabeck (Belgium), Markus Frey (UK), Hakase Hayashida (Japan), Anoop Marajan (India), Daiki Nomura (Japan), Jennie Thomas (France), Liyang Zhan (China) **+ Associate Members**

Website: www.cice2clouds.org

CIce2Clouds scientific questions



- What are the key biological and chemical systems (i.e., chemical species whose emission and deposition is driven by coupled biological, chemical, and physical processes) in polar ocean environments that control atmospheric chemistry and resulting climate feedbacks?
- How does the formation, evolution, and melt of sea-ice and snow cover in the polar oceans impact emission and deposition of climatically and biogeochemically active materials?
- In what ways are these impacts similar or different between the Arctic and Southern Oceans?

CIce2Clouds working group objectives

(O1) ***Synthesize key coupled biological and chemical systems that drive atmospheric reactive trace gas, aerosol, and cloud properties in polar ocean environments.***

(O2) ***To identify similarities and differences in controls on exchange processes between the Arctic and Antarctic ocean-ice-atmosphere (OIA) systems.***

(O3) ***To develop a conceptual model of exchange processes in OIA systems, focusing on key reactive trace gas and aerosol species prioritized in O1.***

(O4) ***To develop interdisciplinary campaign planning recommendations to guide future studies and address model and measurement gaps.***

(O5) ***To facilitate community and capacity building opportunities for sustainable multidisciplinary science at the OIA interface.***

Recent & Upcoming meetings:

October 2: Online CIce2Clouds community meeting

November 7-9: Cice2Clouds annual hybrid meeting

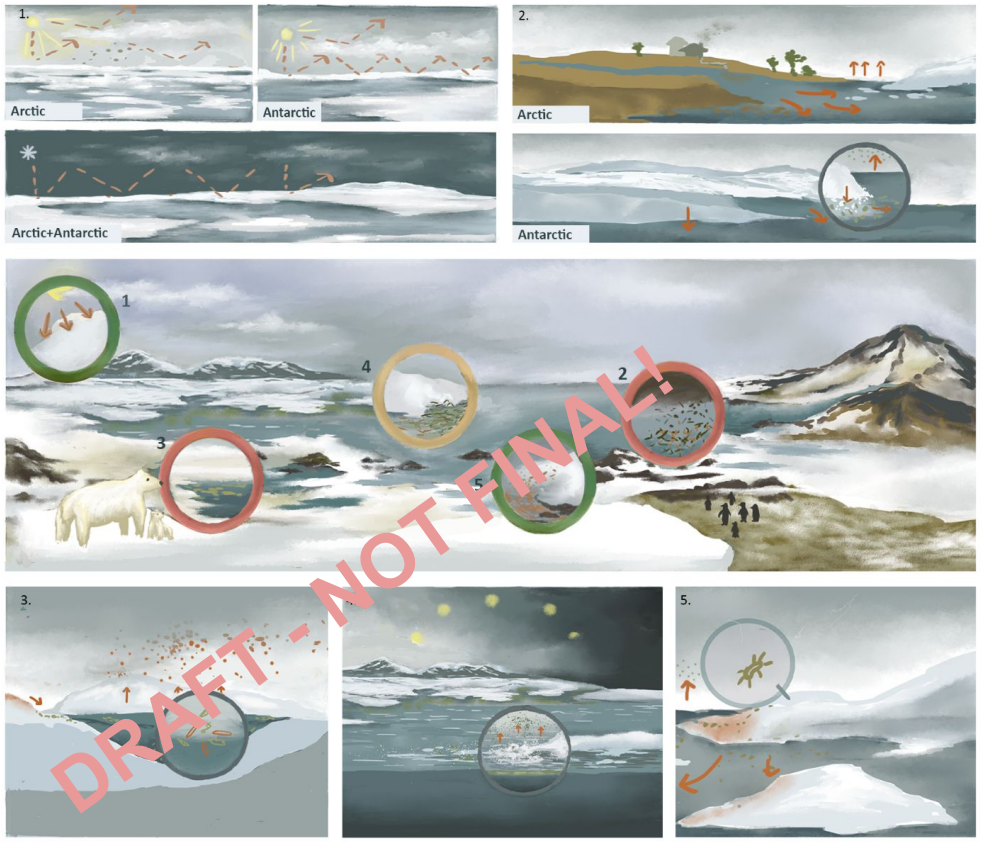
Ahead of the SOLAS science conference, Goa, India

November 17-22: IPY32-33 planning workshop

CIce2Clouds presentation (focused on O4) during orientation to ongoing community efforts

Primary aerosol conceptual model & synthesis

TOR1-3



1.Solar radiation reflecting from ice surfaces and clouds in the summer versus winter. The summer Arctic sea ice has lower albedo than the Antarctic summer sea ice due to melt ponds.

2.River discharge and thawing permafrost / coastal erosion of the Arctic and under-ice river discharge of the Antarctic.

3.Melt ponds and their ecosystems, developing on the arctic sea, emitting particulates into the air.

4.Biological cycle of both poles, changing from polar day to night, showing the difference in activity levels of phytoplankton and ice algae in context of ice cover.

5.Land ice melt introducing freshwater nutrients and glacial microbes into the ocean along coastlines in Antarctica, Greenland, and other smaller Arctic glacial areas.

Biological processes that generate primary aerosols in the polar oceans when sea ice is present

Know relatively well Know moderately well Know very little

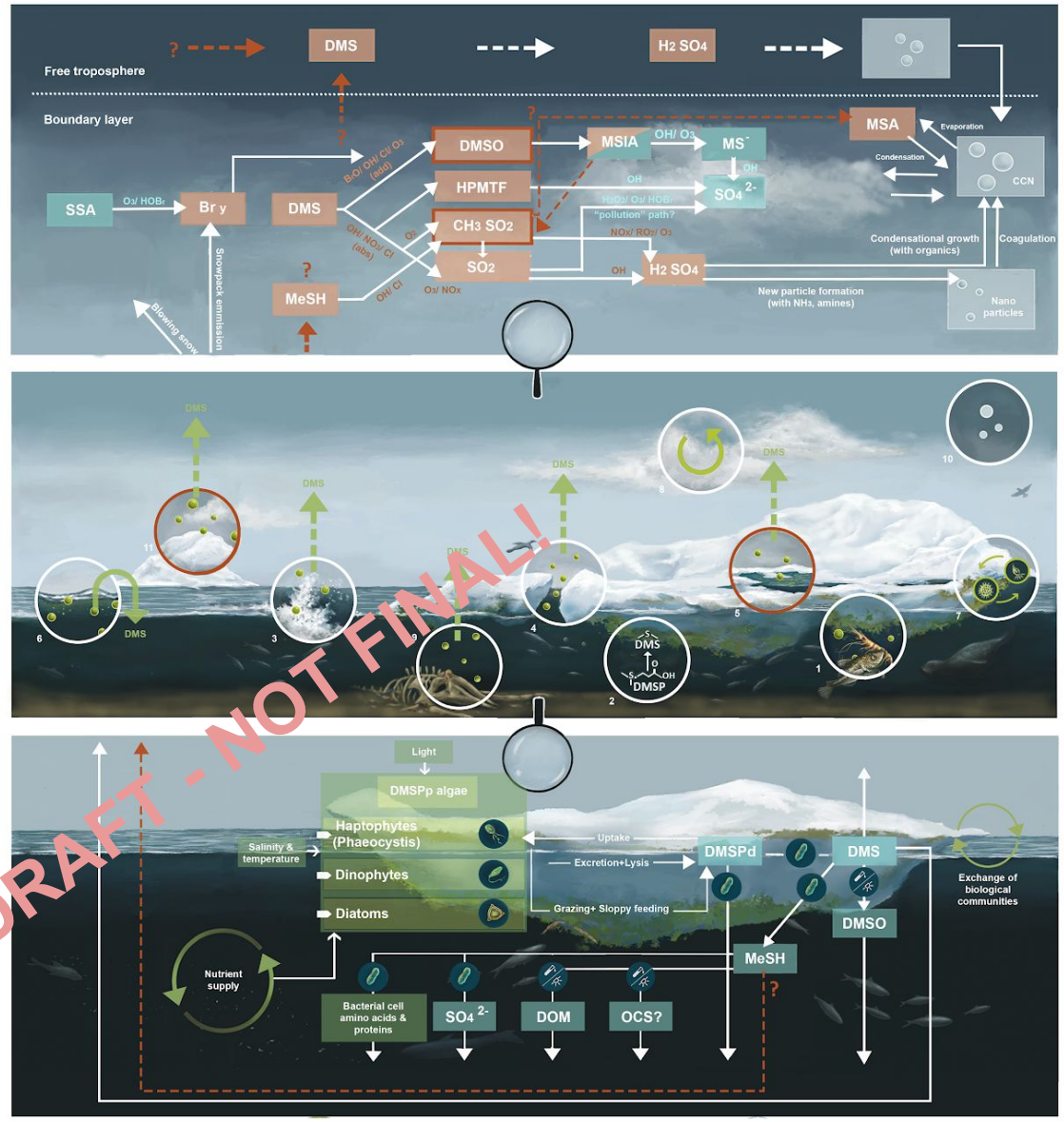
Graphic design: Mrinmayi Dalvi, India
aranyagaatha.wordpress.com

(J. Creamean et al., in prep.)

- Currently revising a draft written by all coauthors, with focused working session planned for November CIce2Clouds meeting
- Draft of a conceptual model summarizing the key biotic and abiotic aerosol emission & exchange processes in the Arctic and Antarctic
- Goal is to submit paper to Elementa special issue in April 2025

Sulfur cycle conceptual model and synthesis

TOR1-3



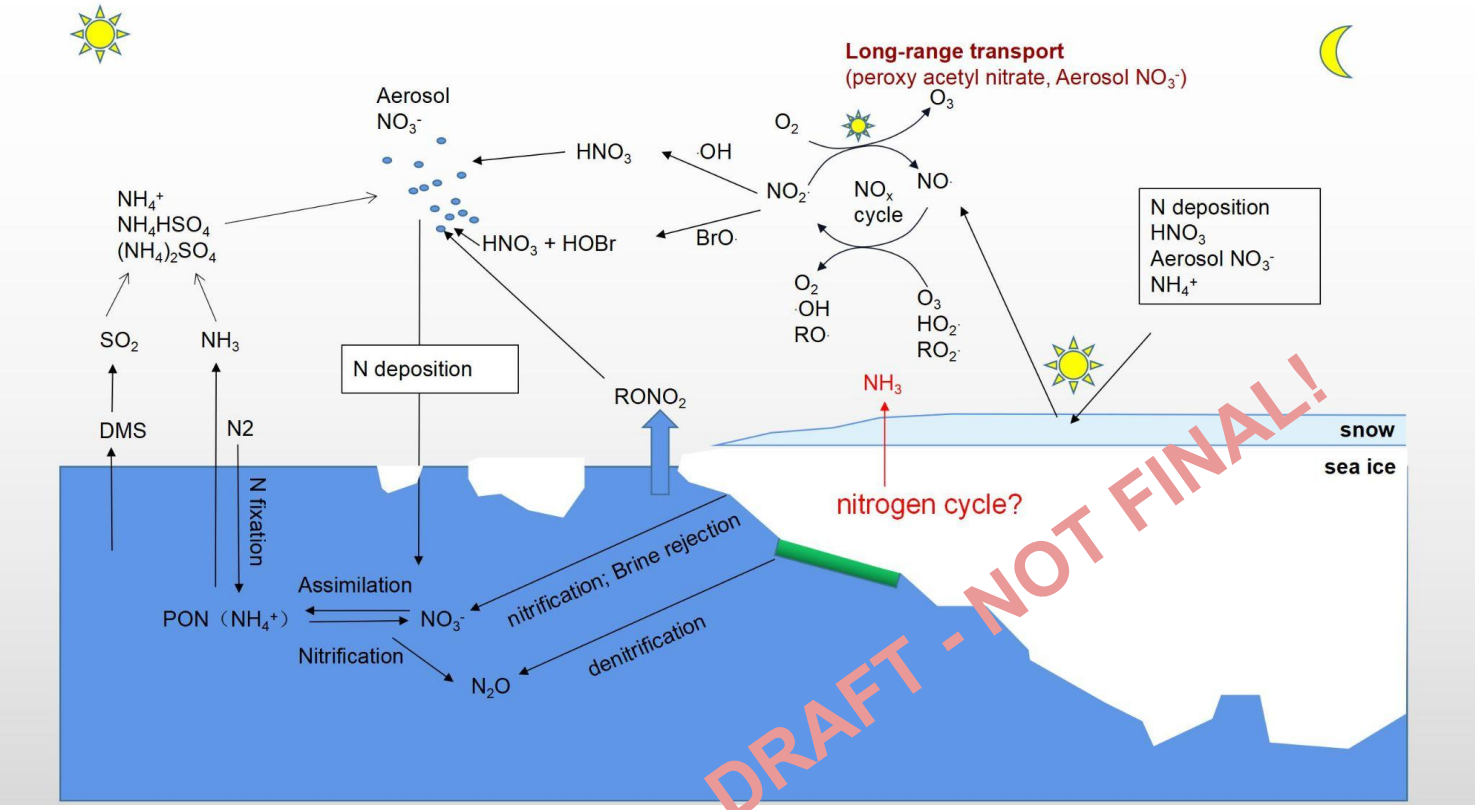
- Currently revising a draft written by all coauthors, with focused working session planned for November CIce2Clouds meeting
- Reorganizing sections: (a) detailed processes in sea-ice, interface, and atmosphere, and (b) dedicated for modeling uncertainties and needs
- Goal is to submit paper to Elementa special issue in May 2025

Graphic design: Mrinmayi Dalvi, India
aranyagaatha.wordpress.com

(***S. Ishino et al., in prep.***)

Nitrogen cycle conceptual model & synthesis

TOR1-3



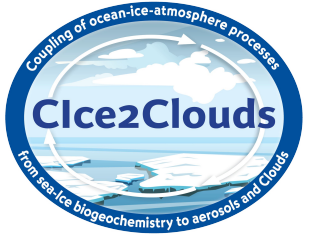
- Discussion sessions have identified major scientific gaps in knowledge of the N-cycle in sea ice, limiting our ability to build a conceptual model

(N-cycle efforts led by *L. Zhan*)

- Lack of knowledge in sea ice, and atmosphere, leads to challenges in identifying links to atmospheric oxidising capacity, aerosol and cloud processes
- Rather than a detailed literature review and synthesis, our work on the N-cycle may contribute to the CIce2Clouds introductory paper or a short commentary highlighting knowledge gaps.
- Discussion and planning at November workshop.

Community recommendations for interdisciplinary observations

TOR4



Deliverable: A **community driven framework** for designing joint observations that effectively incorporate modellers from early planning stages and provide integrated and comparable oceanic and atmospheric measurements. With focus on the following questions:

1. What ***model limitations & scientific recommendations*** arise from CIce2Clouds conceptual models?
2. What are the **key variables and processes** to observe in these systems?
   a. How do we **rank these key variables** from perspectives of: (i) **importance** to understanding these OIA chemical & biological systems and **improving models**, (ii) **effort and resources required** to incorporate specific measurements in a field expedition or focused laboratory study?
   b. What **new observations/observational strategies** are needed?
   c. How can we address potentially **conflicting logistical needs** for observations of key variables?
3. What have we **learned from past interdisciplinary/multidisciplinary OIA observations**?
   a. What do we **recommend as a community** based on this (e.g., covering observation planning and execution, funding structure)?
4. Through a **set of focused examples** (specific parts or sections of the Primary Aerosol & Sulfur Cycle conceptual models), **describe our vision for a fully-integrated observation and modelling effort** that addresses our own recommendations from the conceptual models.

Ongoing and future work CIce2Clouds online meeting in October 2024, with a major focus on this effort at our next hybrid workshop in Goa, India (November 2024) and leading up to the IPY32-33 planning workshop.

Community & capacity building

TOR5

- Overarching focus on Early Career Researcher (ECR) engagement and training in a multidisciplinary context
- Building a common language and sustainable multidisciplinary science across the OIA interface
  - *Deliverable in progress, began at the 2022 CIce2Clouds Workshop:*
    - tutorial-style review paper, focused on fundamental concepts that link sea-ice biogeochemistry with atmospheric science and chemistry
    - “what do we need to know from each other on either side of the OIA interface?”
  - Associated tutorial talks & lectures available to the community

From Sea Ice to Clouds: Fundamental Processes Underpinning Particle and Gas Exchange between the Polar Oceans and Atmospheres (L. Miller et al., in prep)

- Tutorial paper covering the basics of atmospheric chemistry, sea-ice biogeochemistry, and oceanography needed for these communities to work together

- Brief, introductory explanations & figures with references to foundational papers and textbooks

- Each section co-written by atmospheric and ocean scientists ⇒ *interdisciplinary interpretation teams*

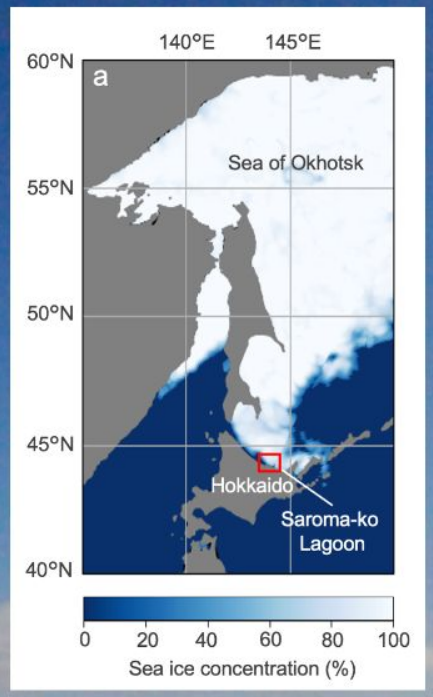
- Text is largely drafted, next: back-and-forth revisions to assure cross-disciplinary accessibility

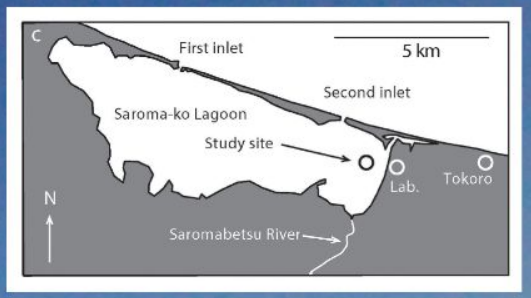
Sea Ice School 2026

Saroma-ko Lagoon, Hokkaido, JAPAN

by BEPSII-CIce2Clouds-CATCH

- Date: 10 days around end of Feb/beginning of Mar 2026
- Target: 30 early career scientist (post doc, Ph.D students etc.)
- Program: Field and Lab work, lecture, workshop
- Deadline for school and funding application: End of 2025
- Further information will be updated in the future (BEPSII site)





Sea ice school 2022 in Canada

Information for research in Saroma-ko Lagoon

Photo: Daiki Nomura

Elementa Special Feature - CIce2Clouds

Expected articles in preparation:

1. Steiner & Willis, *Coupling of ocean-ice-atmosphere processes: from sea-Ice biogeochemistry to aerosols and Clouds (CIce2Clouds)* – Introductory article
2. Ishino et al., *The biogenic sulfur cycle in a coupled ocean-sea ice-atmosphere system* – review/synthesis article
3. Creamean et al., *Overview of primary aerosol sources and processes at the ocean-sea ice-snow-atmosphere interfaces in polar regions* – review article
4. Miller et al., *From sea ice to clouds: Fundamental processes underpinning particle and gas exchange between the polar oceans and atmospheres* – tutorial-style review article
5. Zieger, Willis et al., *Vision for Interdisciplinary Observations across the Polar Ocean-Ice-Atmosphere Interface* – synthesis article/white paper
6. Haddon, Steiner et al., *Future Arctic DMS production and emissions from a regional sea ice and ocean biogeochemical model*

Additional article submissions anticipated

CIce2Clouds

Coupling of ocean-ice-atmosphere processes from sea-ice biogeochemistry to aerosols and Clouds

www.cice2clouds.org

CIce2Clouds workshop 2023
Grenoble, France & online

IGAC International Global Atmospheric Chemistry

International Science Council SCOR Scientific Committee on Oceanic Research

solas

CATCH the Cryosphere and ATmospheric CHemistry

BEPSII Biogeochemical Exchange Processes at Sea Ice Interfaces