

Clce2Clouds SCOR Annual Report

July 21, 2023

1. Working group name and number

Working Group #163: Clce2Clouds (Coupling of ocean-ice-atmosphere processes: from sea-ice biogeochemistry to aerosols and Clouds)

2. Brief summary with the main highlights (200-300 words)

Clce2Clouds has been actively working on our five TORs. A key goal of Clce2Clouds is to improve communication and understanding among ocean, sea-ice and atmospheric scientists with respect to the exchange processes between interfaces and their impacts on clouds in the polar regions. Hence, a key output is a series of tutorial talks and a tutorial-style review paper to bridge knowledge gaps among our communities. The tutorial material targets both early career researchers and senior scientists with expertise in only one of the domains. Throughout our first meetings tutorial talks have been developed and recorded to share via the Clce2Clouds website. Based on the content of those talks a manuscript is in preparation. In addition, discussions in the three Clce2Clouds subgroups (sulfur cycle, nitrogen cycle, primary aerosols) have evolved to develop coupled conceptual models, considering both poles as well as different seasons. Manuscripts to describe these conceptual models are now in preparation.

3. Activities since the previous report to SCOR (e.g., virtual or in-person meetings, email discussions, special sessions). (Limit 1000 words)

- A successful hybrid meeting was held in September 2022 in Cape Town, linked to the SOLAS Open Science Conference. The meeting included a series of recorded tutorial talks which are available at <https://www.cice2clouds.org/tutorials>. These tutorials include four talks on a range of topics that cover (1) Atmospheric Processes, (2) Ocean & Sea Ice Processes, and (3) Exchange Processes.
- Initiated writing of a Clce2Clouds tutorial paper (TOR5, Deliverable #3): “From Sea Ice to Clouds: Fundamental Processes Underpinning Particle and Gas Exchange between the Polar Oceans and Atmospheres” at our September 2022 meeting in Cape Town, with continued drafting following this original scoping and planning meeting.
- Tutorial videos from the 2022 CATCH online workshop (May 2022) were also made available at <https://www.cice2clouds.org/tutorials>. These talks focus on: (1) Algal Functional Groups and the Polar Sulfur Cycle, (2) What We Know About the Chemistry & Physics of Snow that is Relevant to Snow on Sea-ice, and (3) Aerosol as Cloud Nuclei for Cloud Formation in Polar Ocean Environments.
- The sub-working groups on specific chemical/biological systems ((a) sulfur cycle, (b) nitrogen cycle and (c) primary aerosol), which were initiated in 2022, are meeting online regularly, and are working offline using a Slack workspace and shared documents. Sub-working groups also met during the hybrid meeting in Cape Town, South Africa to further efforts on conceptual models and related publications detailed below.
- Working group organization activities include communications through a Slack workspace that has expanded in the past year and is open to contributing members of the Clce2Clouds broader community, a Google Team Drive, and a working group website with support from IGAC (www.cice2clouds.org).

4. Documents published since previous report to SCOR (e.g., peer-reviewed journal articles, reports, Web pages) and should be limited to publications that resulted directly from WG activities and which acknowledge SCOR support

1. *Differences and commonalities in air-ice-ocean processes in the Antarctic and Arctic, Discussion session report, SOLAS OSC event report series: Nadja Steiner, Jessie Creamean, Jennie Thomas, Lisa Miller, Megan Willis, [SOLAS OSC2022 - Event Report Issue27.pdf \(solas-int.org\)](#)*
 2. *Coupling of ocean-ice-atmosphere processes: from sea-ice biogeochemistry to aerosols and Clouds (Clce2Clouds) Nadja Steiner, Jessie Creamean, Jennie Thomas, Megan Willis, Lisa Miller, Clce2Clouds workshop report, SOLAS OSC event report series, [SOLAS OSC2022 - Event Report Issue27.pdf \(solas-int.org\)](#)*
- No peer-reviewed documents have been published so far

5. Progress toward achieving the group's terms of reference. List each term of reference separately and describe progress on each one. (Limit 1000 words)

Clce2Clouds is presently working toward four publications that span TORS 1 - 3. These papers and their relevance to each TOR are described further below. Working titles for these publications are as follows:

1. "From Sea Ice to Clouds: Fundamental Processes Underpinning Particle and Gas Exchange between the Polar Oceans and Atmospheres"
2. "Sulfur cycle in coupled ocean-sea ice-atmosphere systems"
3. "Nitrogen cycle in polar ocean-sea ice-atmosphere systems"
4. "Overview of primary aerosol processes at the ocean-sea ice-snow-atmosphere interfaces in polar regions"

(TOR1) To prioritize key coupled biological and chemical systems that drive atmospheric reactive trace gas, aerosol, and cloud properties in polar ocean environments. Synthesize expertise from ocean, sea-ice, snow, and atmospheric chemistry communities to provide a hierarchy of chemical species that reflect common overlapping science questions (Objective O1).

- Progress toward TOR1:
 - Continued work in sub-working groups on (a) sulfur cycle, (b) nitrogen cycle and (c) primary aerosol, which continue to meet 4 - 5 times/year since January 2022
 - Synthesis publications outlining current knowledge, knowledge gaps and observational/modeling recommendations are being drafted by each of the above working groups
 - In addition, we have identified a need for a fourth sub-working group focused on secondary aerosol precursors and processes

(TOR2) To identify similarities and differences in controls on exchange processes between the Arctic and Antarctic O-SI-S-A systems. Compare and contrast common sea-ice and snow properties at both poles. Use this polar ocean comparison to describe how sea-ice properties control exchange processes, and constrain projections of future changes (Objective O2).

- Progress toward TOR2:
 - Established sub-working groups on (a) sulfur cycle, (b) nitrogen cycle and (c) primary aerosol, which have each met several times online as well as at the hybrid meeting in Cape Town, South Africa. Sub-working groups are framing their discussions and draft publications in the context of TOR2 Arctic-Antarctic comparison.
 - Scoping began for a focused publication comparing and contrasting the Arctic and Antarctic from the perspective of Clce2Clouds processes at the hybrid meeting in Cape Town, South Africa.

- We held a discussion session on differences in ocean-ice-snow-atmosphere processes between the Arctic and Antarctic at the SOLAS Open Science Conference (Sept. 2022, South Africa) and a summary published in the SOLAS newsletter (see above).

(TOR3) To develop a conceptual model of exchange processes in O-SI-S-A systems, focusing on key reactive trace gas and aerosol species prioritized in O1. Conceptual model evolution will be based on existing observational and numerical expertise, and will reflect the impact of heterogeneity in sea-ice environments at present and under future climate change scenarios (Objective O3).

- Progress toward TOR3:
 - Each sub-working group ((a) sulfur cycle, (b) nitrogen cycle and (c) primary aerosol) are currently refining bi-polar and seasonal conceptual schematics on relevant processes. These schematics will inform the basis of conceptual models of known and constrained processes, and point toward knowledge gaps to inform future research.

(TOR4) To develop interdisciplinary campaign planning recommendations to guide future studies and address model and measurement gaps. Building on the conceptual model (O3), we will identify future needs in observations and model parameterisations, and outline requirements for fully integrated, multidisciplinary and collaborative O-SI-S-A field, laboratory, and modeling research (Objective O4).

- Progress toward TOR4:
 - Community open forum and discussion on joint campaign & experiment planning held at the Clce2Clouds annual hybrid meeting Cape Town, South Africa (September 2022). Scoping began for a short, focused perspective-type paper that describes our community's vision for future interdisciplinary observational efforts.
 - Collaboration between Clce2Clouds and PICCASSO (<https://www.piccaaso.org/>; Partnerships for Investigating the biogeochemistry of the Atmosphere in Antarctica and the Southern Ocean) on a white paper resulted in a publication in Elementa (<https://doi.org/10.1525/elementa.2022.00130>). This paper describes the need for focused interdisciplinary studies of the ocean - sea-ice - snow - atmosphere interface in the Southern Ocean while this region remains the most pristine region of the globe.

(TOR5) To facilitate community and capacity building opportunities for sustainable multidisciplinary science at the O-SI-S-A interface. Engage scientifically emerging countries and early career scientists in both observational and modeling communities (Objective O5).

- Progress toward TOR5:
 - Progress on Deliverable #3 (openly available introductory talks on fundamental topics in atmospheric chemistry and sea-ice biogeochemistry) includes the following recorded lectures, which are available from the Clce2Clouds website.
 - Publicly available introductory talks from the Cape Town, South Africa workshop in September 2022. This set of introductory talks covers topics across atmospheric processes, ocean and sea ice processes, and exchange processes that have informed the development of our tutorial review paper (TOR 5, Deliverable #3).
 - Publicly available introductory talks from the CATCH Open Science Workshop in May 2022. The first three talks in this series focused on: (1) Algal Functional Groups and the Polar Sulfur Cycle, (2) What We Know About the Chemistry & Physics of Snow that is Relevant to Snow on Sea-ice, and (3) Aerosol as Cloud Nuclei for Cloud Formation in Polar Ocean Environments.
 - All tutorial talks are available at <https://www.cice2clouds.org/tutorials>
 - Our September 2022 Hybrid Clce2Clouds Workshop focused largely on initial scoping and writing of the tutorial-style review paper in Deliverable #3. Progress on drafting this paper is ongoing following this workshop.

- Active planning is underway for the co-development of a sea-ice field school focusing on ocean-sea-ice atmosphere interactions jointly with BEPSII and CATCH. The school is to be held at Saroma-Ko Lagoon in Japan (host: Daiki Nomura) towards the end of Clce2Clouds lifetime.

6. WG activities planned for the coming year. (Limit 500 words)

- Second Hybrid Clce2Clouds workshop prior to the Horizon2020 CRiceS meeting in Grenoble, France, and online (September 10 - 11, 2023).
Workshop Goals & Outcomes: This working meeting will move forward several Clce2Clouds efforts, including synthesis papers from our working groups (TOR1-3, Deliverable #1) on the sulfur cycle, nitrogen cycle and primary aerosol, our tutorial paper (TOR5, Deliverable #3), and an emerging synthesis paper on Arctic-Antarctic differences in the context of Clce2Clouds processes (TOR2). The meeting will also develop plans for modeling projects that have emerged from efforts in our working groups, and provide an opportunity for working group and community input around future observational planning (TOR4).
- Completion of the above tutorial-style review paper (TOR5, Deliverable #3)
- Continued regular virtual meetings of sub-working groups, and finalizing synthesis article(s) (Deliverable #1, covering TORs 1-3)

7. Is the group having difficulties expected in achieving terms of reference or meeting the original time schedule? If so, why, and what is being done to address the difficulties (Limit 200 words)

Despite limitations in travel and online meetings, we feel the working group is on track.

8. Any special comments or requests to SCOR. (Limit 100 words.)

Additional information can be submitted and will be included in the background book for the SCOR meeting at the discretion of the SCOR Executive Committee Reporter for the WG and the SCOR Secretariat.