

solas event report

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3rd Cryosphere and Atmospheric Chemistry Open Science Workshop

9-13 May 2022, Online

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The [3rd Cryosphere and Atmospheric Chemistry \(CATCH\) Open Science Workshop](#) was held online during 9-13 May 2022. [CATCH](#) is a community driven International Global Atmospheric Chemistry ([IGAC](#)) activity also sponsored by SOLAS, which aims to foster research collaborations across scientific disciplines and national boundaries to advance knowledge on the chemical, physical and biological interactions and feedbacks within the coupled cryosphere-atmosphere system and implications for climate, ecosystems and society (Thomas *et al.*, 2019).

The specific aims of this workshop were to explore five selected cross-disciplinary science themes

through online presentations and discussion taking advantage of the wide ranging expertise of participants from the CATCH community: (1) Linking biogeochemistry to aerosol-cloud interactions in the Southern Ocean and Antarctic, (2) Ocean-ice-snow-atmosphere fluxes, (3) Polar halogen chemistry and interlinked processes, (4) Cryospheric links to aerosol-cloud interactions, and (5) Coupling of ocean-ice-atmosphere processes: from Sea-Ice biogeochemistry to aerosols and Clouds.

Close to 200 scientists attended the workshop over 5 days with three 2-hour long sessions spread over each day to enable participation across many time zones at a reasonable time of

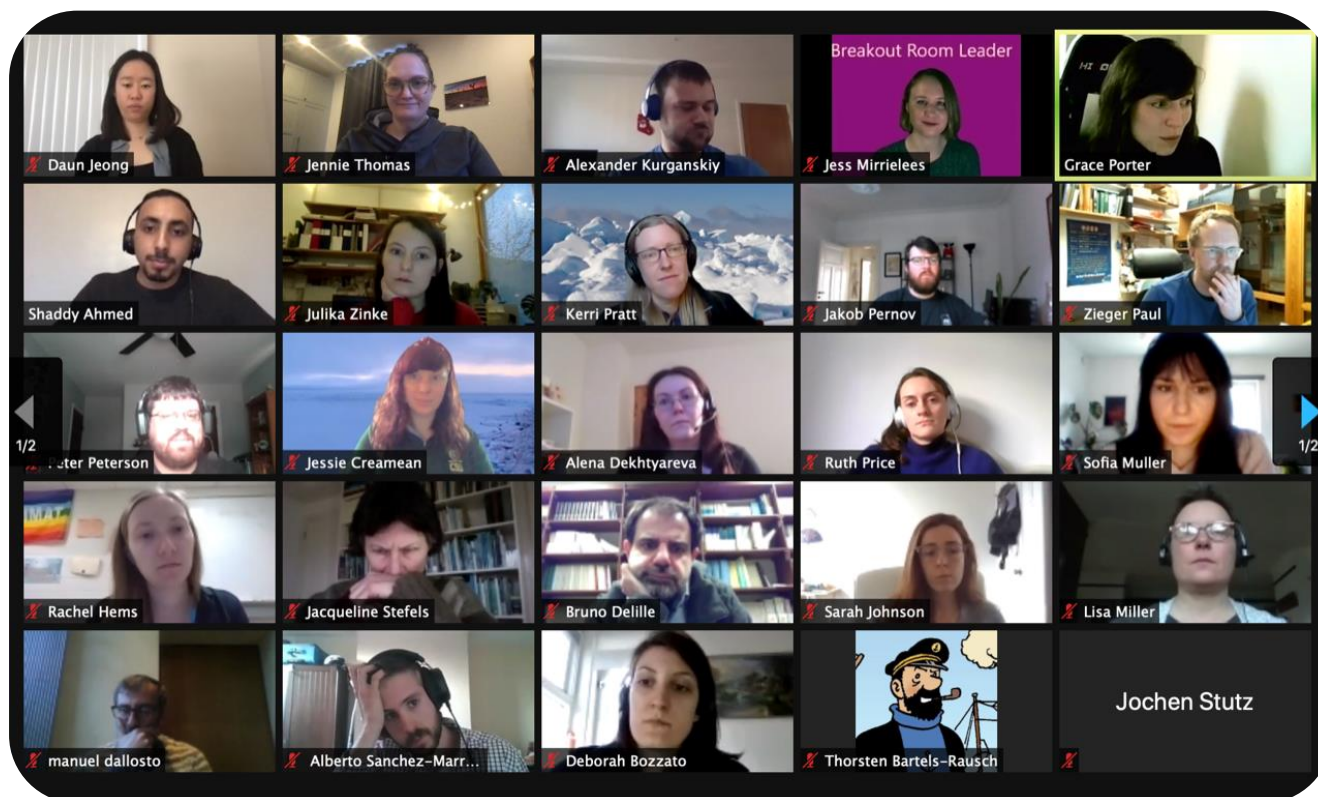


Figure 1: Screen shot of meeting attendees of the 3rd CATCH Open Science Workshop.

day. Participants, about a third being Early Career Researchers (ERCs) and a 41%:59% female-to-male gender balance, were from all continents, with the bulk from Europe, North America but also numerous scientists based in South America, Africa and Australia/New Zealand (Figure 1 & 2) and did represent a wide range of science disciplines. The [session hosts](#), which included both ECRs as well as senior scientists, had put together their respective session programme of invited short talks, longer keynote presentations followed by a moderated discussion. Talks were recorded allowing to catch up on missed sessions. A very productive feature was the use of taking interactive notes online with Etherpad, which allowed to capture discussion contributions, enhanced interaction, and enabled a continuous thread of exchanges over the three sessions on the day. In addition, each session was preceded by a poster session in Gather.Town providing more time for interactions and science exchange.

Below brief session summaries are given, whereas recorded talks and discussion protocols have been archived for future reference on the [event website](#). Session (1) on [Linking biogeochemistry to aerosol-cloud interactions in the Southern Ocean and Antarctic](#) provided a platform to present key science questions and plans of Partnerships for Investigating the Biogeochemistry of the Atmosphere in Antarctica and the Southern Ocean (PICASSO), a recently launched CATCH initiative. One major focus of talks and discussions was around open questions on the role of the Sulphur cycle for regional climate, with marine including sea ice biogenic processes driving particle precursor emissions and triggering potential feedbacks with low-level clouds. Session (2) on [Ocean-ice-snow-atmosphere fluxes](#) featured presentations describing the current approaches to quantify trace gas and aerosol fluxes above ocean, ice and snow surfaces. The discussions were centered on

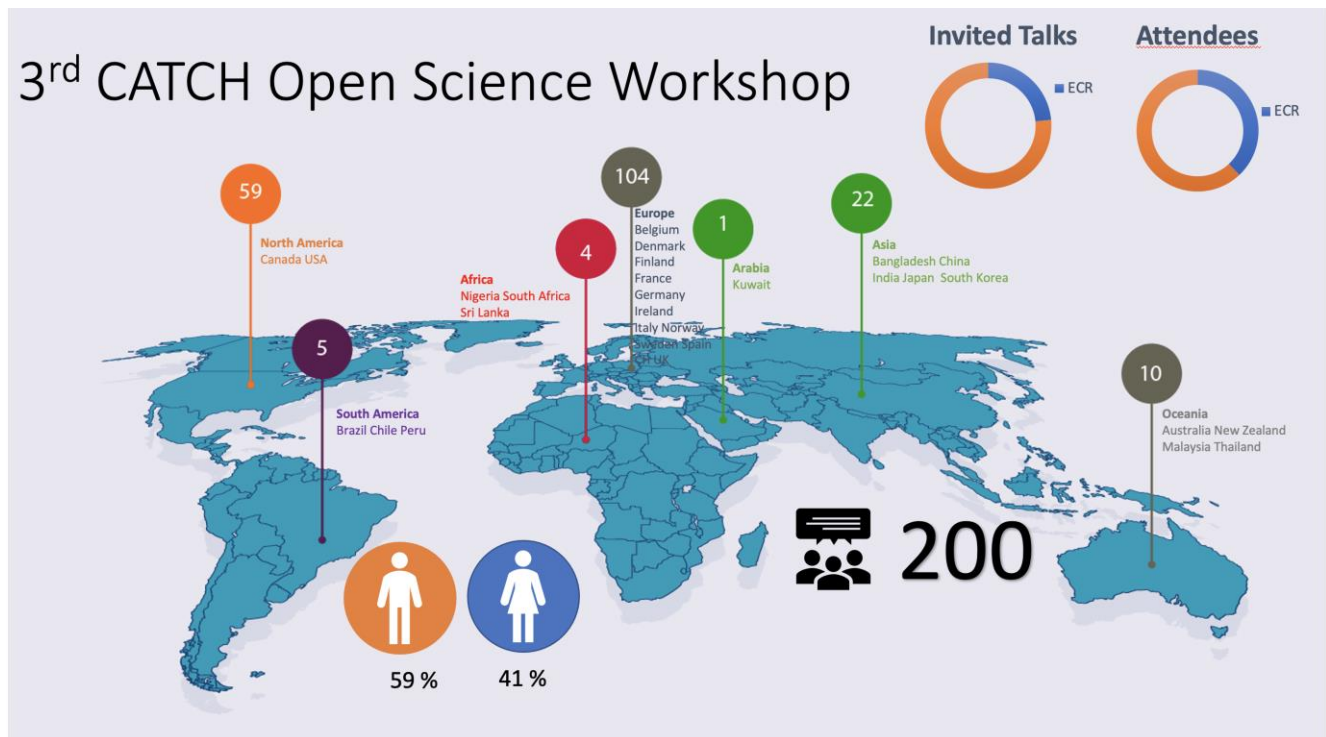


Figure 2: Geographic, gender of meeting attendees and early career researchers' engagement of the 3rd CATCH Open Science Workshop.

limitations and uncertainties in flux estimates, measurement strategies and how to use this flux information within models. It was recognised that models need more and better constrained flux parametrisations based on observations for a range of trace chemical species and aerosol. Session (3) on [Polar halogen chemistry and interlinked processes](#) discussed in particular the role of snow, including snow on sea ice, compared to sea salt aerosols in activating and sustaining halogen chemistry, as well as the main outstanding questions regarding how halogens influence atmospheric aerosols and oxidation capacity. The selection of talks reflected the current community research focus, which had shifted recently from bromine/chlorine to the rather complex iodine chemistry. Session (4) on [Cryospheric links to aerosol-cloud interactions](#) addressed potential impacts of surface aerosol sources on clouds. Discussions revolved in particular around sources and abundance of cloud forming aerosols in the polar regions and how these vary over the seasons, which processes

control aerosol emission and transport and what current modelling deficiencies are. And finally Session (5) on [Coupling of ocean-ice-atmosphere processes: from sea-ice biogeochemistry to aerosols and Clouds](#) provided a forum for discussions around the main theme and science questions of a recently funded SCOR working group, sponsored by CATCH ([SCOR WG #163: Clce2Clouds](#)). Working in silos is a common barrier of cross-disciplinary collaboration. To overcome this barrier educational talks on cross-cutting themes that link the sea-ice/ocean/atmosphere system were presented.

All who participated in a post event online survey are thanked for providing some key feedback for the planning of future CATCH meetings. In general, the workshop was rated as successful by all, including first-time participants, and fulfilled expectations as to allow to keep up to date in CATCH science topics and get inspired/ learn about research in closely related and relevant research disciplines. The scientific quality of

presentations and discussions was ranked from very good to excellent. The online format received mixed reviews: on the one hand, the combined tools of Zoom, Etherpad and Gather.Town worked well, anyone could participate in the sessions of interest at no cost and minimal carbon emissions, sessions were well organised and went smoothly with very engaging discussions. On the other hand, networking opportunities were perceived as limited, confirming that the virtual format is complementary but not a replacement for in-person meetings. The Gather.Town poster session remained under-used and its potential was not fully exploited.

We thank the workshop sponsors, who provided financial support for a fully virtual CATCH workshop enabling truly cross-disciplinary and international dialogue and scientific discussions which often require a lot more patience than talking to your specialist colleague. And finally, we thank all participants again for their engagement and hope to keep in touch via the CATCH newsletter, email list or upcoming online seminars, until the next workshop, which will be in-person.

Event sponsors



References

Thomas, J.L., Stutz, J., Frey, M.M., *et al.* (2019). Fostering multidisciplinary research on interactions between chemistry, biology, and physics within the coupled cryosphere-atmosphere system. *Elem. Sci. Anth.*, 7, 58. <http://doi.org/10.1525/elementa.396>

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Shuting Zhai is a PhD candidate studying Atmospheric Science at the University of Washington. Her research topics include modelling tropospheric halogen chemistry and their preservation in Arctic ice cores. She also investigates the role of anthropogenic emissions on the trends of ice core halogens since the pre-industrial time.

Implications of snowpack reactive bromine production for Arctic ice core bromine preservation

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Snowpack production of reactive bromine has been observed to influence tropospheric bromine abundance and is necessary to explain the depletion of surface ozone in coastal Arctic in spring (Stutz *et al.*, 2011; Swanson *et al.*, 2022). Modelling approaches based on coastal Arctic observations are conducted for short time periods in spring only (Thomas *et al.*, 2011, etc.). But the implications on snow preservation, and thus ice core bromine concentration, which has been used as a sea ice proxy (Vallelonga *et al.*, 2021), has not yet been investigated. Using bromine records from six Arctic ice cores, and a new snowpack bromine emission parameterisation in a global model, this work examines snow preservation over the course of a full annual cycle, with a focus on ice core locations, which are mostly inland.

Snowpack emission mechanism differs for the snow skin layer (top 1mm) of the snowpack and deeper layers within the snow photic zone. Heterogeneous reactions on snow grains driven by dry deposition of reactive bromine dominate

reactions for the snow skin layers, and irradiation-driven photochemical reactions occurring in the snowpack interstitial air are the major source from deeper snow. Our process-based parameterisation treats the two mechanisms separately in the GEOS-Chem model, and dynamically tracks snow bromide content for all snow types.

Change point analysis show that only the Russian Arctic ice core, Akademii Nauk (AN), has significant trends since the preindustrial time, while all the Greenland ice cores show no significant trends (Figure 3). Model results predict 32% post-depositional loss at AN, and 51%–172% loss for the inland Greenland ice cores (Figure 4), and deeper snow production dominates the total loss. Controlling factors for snowpack preservation of bromine are the snowfall rate and the dark period of the location over the course of a year. For example, high snowfall rate and long dark periods make AN the only ice core that has snow layers that are never

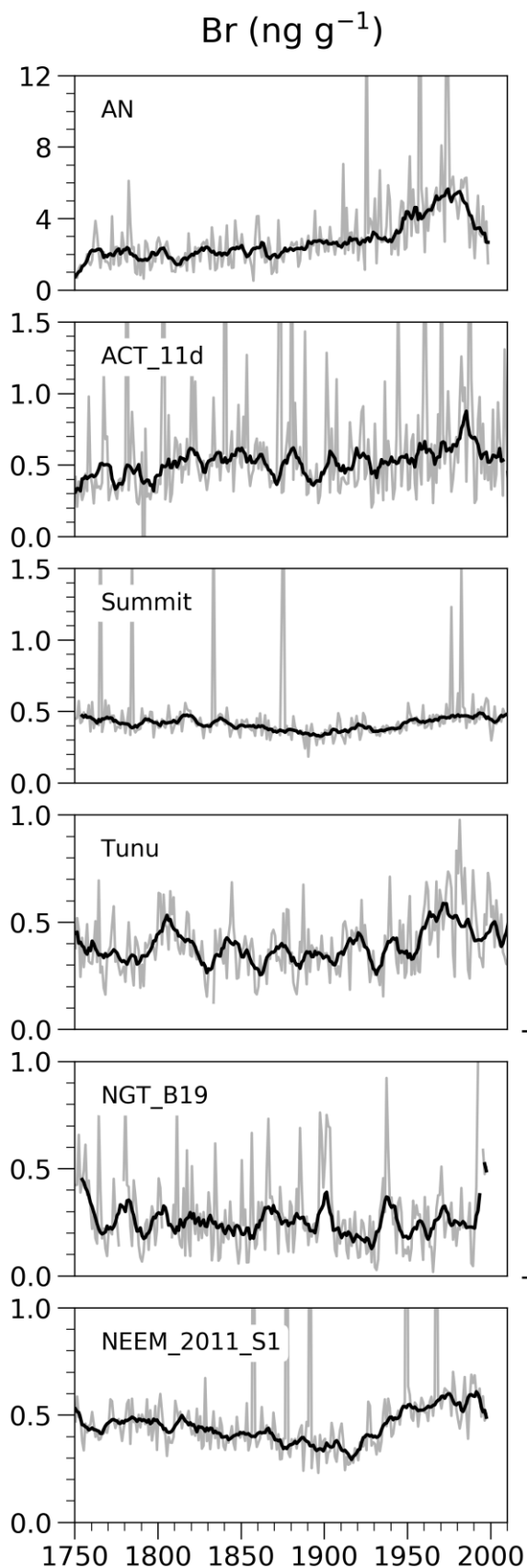


Figure 3: Time series of annual mean bromine concentration measured from the six Arctic ice cores.

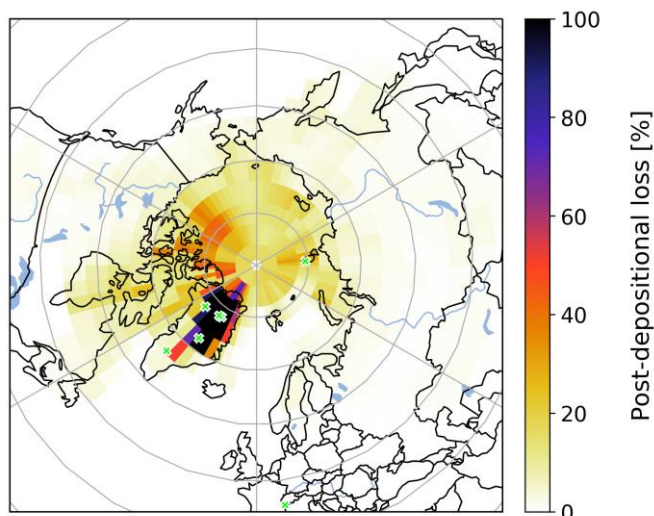


Figure 4: Modelled post-depositional loss of bromine from the snowpack, calculated as total annual mean emission flux divided by total annual mean deposition flux.

exposed to sunlight. Thus, it is likely that the observed trends in AN reflect processes occurring in late fall and early winter, and snow layers that accumulate during the dark are buried beneath the snow photic zone before polar sunrise. This conflicts with the interpretation that snow bromine is indicative of spring sea ice extent.

Total annual snow emissions are larger than total annual deposition at most Greenland sites, showing that our deeper snow parameterisation, which is based on 1-D model studies conducted during springtime, is an overestimate when applied to the late spring, summer, and early fall. Even with the overestimated bromine emissions from deeper snow in the model, the model predicts significant preservation of snow bromine at AN, consistent with the observations that only this ice core preserves trends of bromine. Our study points out the necessity of observations of snowpack bromine chemistry throughout the whole sunlit time period, especially over land snow. A detailed study of snow impurity and microphysics is also essential to fully understand the mechanisms.

This research has been published:

Zhai, S.T., Swanson, W., McConnell, J.R., *et al.* (2023). Implications of snowpack reactive bromine production for Arctic ice core bromine preservation. *J. Geophys. Res.: Atmos.*, 128(20), e2023JD039257. <https://doi.org/10.1029/2023JD039257>

References

Thomas, J.L., Stutz, J., Lefer, B., *et al.* (2011). Modeling chemistry in and above snow at Summit, Greenland – Part 1: Model description and results. *Atmos. Chem. Phys.*, 11(10), 4899–4914. <https://doi.org/10.5194/acp-11-4899-2011>

Stutz, J., Thomas, J.L., Hurlock, S.C., *et al.* (2011). Longpath DOAS observations of surface BrO at Summit, Greenland. *Atmos. Chem. Phys.*, 11(18), 9899–9910. <https://doi.org/10.5194/acp-11-9899-2011>

Swanson, W.F., Holmes, C.D., Simpson, W.R., *et al.* (2022). Comparison of model and ground observations finds snowpack and blowing snow aerosols both contribute to Arctic tropospheric reactive bromine. *Atmos. Chem. Phys.*, 22(22), 14467–14488. <https://doi.org/10.5194/acp-22-14467-2022>



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