Breakout session reports serve as a record of discussion results from breakout and working group presentations. These reports serve as a resource for program managers when asked to provide highlights of programmatic results with short notice. They also provide information to the ARM Facility management about science needs of ARM users. In addition, they can help the program managers evaluate the progress of self-organized groups within the ARM and ASR communities.

Please provide a concise narrative discussing key findings, decisions, issues, needs, and/or future plans and action items. Not all session narratives will necessitate touching on all topics, but session report authors should aim to provide as much information as possible to address relevant points. Session reports are not expected to exceed two pages of text. It is not necessary to include a detailed list of presentations. Send completed reports by July 30, 2021 to Sally McFarlane, Shaima Nasiri, and Jeff Stehr.

Session Title: Cloud process studies needed to reduce uncertainty in extratropical cloud feedbacks in climate models: a focus on observations and modelling of high-latitude marine post-frontal clouds **Session Conveners:** Bart Geerts, Xiaohong Liu

Co-conveners: Greg McFarquhar, Mikhail Ovchinnikov, Branko Kosovic, Roger Marchand, Scott Giangrande, Ann Fridlind, Johannes Mülmenstädt, Susannah Burrows, Paul DeMott, Daniel Knopf, Po-Lun Ma, Nicole Riemer

Session Date: Thursday, June 24 Session Time: 11 a.m. – 1 p.m. EDT Number of Attendees: ~90 participants (virtual) Summary Authors:

Main Discussion

We had a very busy and packed breakout session. We had a great attendance, some outstanding presentations, as well as some thoughtful (but too brief) discussions. The chat line was busy with exchanges, providing useful input, feedback, and inspiration for future activities.

The meeting proceeded as follows:

A. <u>Extratropical cloud feedbacks in climate models</u>

11:00 am: Steve Klein (DOE LLNL) gave a very nice overview talk on *Extratropical cloud feedbacks in climate models*. The driving question is how extratropical cloud properties will change in a warmer climate, thereby exacerbating the warming (positive feedback), or reducing it (negative feedback), which depends on current cloud states (e.g., cloud phase).

11:20 am: Ann Fridlind (NASA GISS) coordinated a series of brief summaries on the relevant *extratropical cloud processes.* She started with a brief overview of relevant processes, and then invited the following brief presentations:

- o Susannah Burrows, DOE PNNL: Marine sources of CCN/INPs
- Xiaohong Liu, Texas A&M University: Secondary ice production
- o Johannes Muelmenstaedt, DOE PNNL: Rain processes

11:50 am: This was followed by a discussion of the most uncertain extratropical cloud processes and how to improve their understanding based on observation and modeling studies, led by Ann Fridlind.

12:00 pm: Photo Op: zoom snapshots were taken of the ~90 participants.

B. High-latitude marine post-frontal clouds

B.1 Brief presentations

Four talks were given summarizing the status of COMBLE, MARCUS, and MICRE experiments, as follows:

12:05 pm: Greg McFarquhar, NOAA CIMMS: *Overview of post-frontal shallow clouds over the Southern Ocean*

12:15 am: Bart Geerts, University of Wyoming: *The marine CAO cloud regime as observed in COMBLE: preliminary findings and some promising cases*

12:25 am: Scott Giangrande, DOE BNL: *Recent updates on the COMBLE and MARCUS datasets and products*

12:30 pm: Roger Marchand, University of Washington: MICRE: overview and findings

B.2 Contributed slides

12:35 pm: Two-slide summaries were presented by 10 groups, in rapid succession:

- 1. Minghui Diao et al: Mixed-Phase Cloud Processes over High Latitudes
- 2. Naruki Hiranuma et al: INP concentrations at the ENA and SGP sites
- 3. Yonggang Wang: Improving the understanding of cold-air outbreak cloud regime using COMBLE observations and numerical simulations
- 4. Stanford McKenna et al: Precipitation Occurrence Frequency over the Mid-Latitude Southern Ocean
- 5. Andrew Gettelman et al.: Evaluating Earth System Models with MICRE Data
- 6. Thomas Hill et al.: Concentrations and Characteristics of Ice Nucleating Particles (INPs) at Macquarie Island during MICRE

- 7. Steven Krueger et al: Lagrangian simulations of Arctic cold air outbreak cloud systems over Greenland and Norwegian Sea
- 8. Xue Zheng et al: Cloud field associated with MCAOs in the E3SM SCREAM simulation
- 9. Peng Wu et al: Cloud morphology evolution in Arctic cold-air outbreak: A COMBLE case study
- 10. Branko Kosovic et al: Numerical Simulations of Cold Air Outbreaks Using a Multi-Scale Modeling Framework

B.3 Discussion

12:50 pm: A brief discussion was held on COMBLE case selection, VAP data interest, plans for collaboration (moderators: Bart Geerts, Greg McFarquhar, Scott Giangrande), as well as on modeling objectives, intercomparisons, collaborations (moderators: Mikhail Ovchinnikov, Branko Kosovic).

We adjourned the meeting ~8 minutes after the hour. A recording of the meeting is available <u>on this</u> <u>google drive</u>.

Future Plans

The main outcome of this discussion is that we are planning a "working discussion" on the topic of *Observations and modelling of high-latitude marine clouds in both hemispheres, esp. as related to the recent Southern Ocean experiments, COMBLE, and other campaigns (e.g. ACTIVATE) and sites (e.g. NSA, ENA).* An announcement for this workshop (tentatively to be held in early September) will be circulated via the High-Latitudes Working Group email list.

Action Items

To the organizers: *We really appreciate the scheduling of this Breakout before the relevant Poster session*: many of the presentations referred to posters in the poster session immediately after this Breakout.



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