

Toward Strengthened Forecasting Services for Polar Regions

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PCAPS Open Session: Forecast value cycles for Polar Research Operations

What: A workshop was held as part of the annual Steering Group meeting of the WMO World Weather Research Program project "Polar Coupled Analysis and Prediction for Services" (PCAPS). The Open Session gathered about 50 Arctic and Antarctic stakeholders to share perspectives on polar forecasting challenges, operational needs, and opportunities for collaboration.

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1. Introduction and background

The Polar Coupled Analysis and Predictions for Services (PCAPS) project is one of the World Meteorological Organization's World Weather Research Program (WWRP) new flagship projects. Running from 2024 to 2028, PCAPS is dedicated to enhancing environmental forecasting in the Arctic and Antarctic regions for human and environmental well-being. Recognizing the complexity of interactions in polar socioecological systems, PCAPS aims to enhance environmental forecasting services with diverse user contexts in mind by facilitating the provision of more accurate, reliable, and usable prediction services (Jung et al. 2025; Lamers et al. 2024). Guided by user needs and service provision capabilities (Heinrich et al. 2024), PCAPS involves work to improve models, particularly in predicting small-scale processes essential for accurate forecasting. Also, by emphasizing the integration of social and natural scientific endeavors, along with interdisciplinary engagement, PCAPS aims to facilitate the exchange of knowledge at the science-policy-service-user interface to improve the fidelity, actionability, and impact of environmental forecasting services.

PCAPS recognizes the need for collaborative inter- and transdisciplinary researchers to understand operational decision-making and user needs. With this framework in mind, an Open Session was held as part of the PCAPS Steering Group meeting at the British Antarctic Survey in Cambridge, on Tuesday, 15 April 2025.

2. Objectives and approach

The objective of this Open Session was to enable channels of communication and explore opportunities for collaboration between the PCAPS project and polar research communities, as well as establishing long-term (inter- and trans-)disciplinary partnerships. As such, this Open Session was an opportunity to (i) seek input from Antarctic and Arctic stakeholders and experts on the PCAPS workplan and mission, (ii) share perspectives around research and operational challenges and opportunities, experienced bottlenecks, and best practices in information provision and use, and (iii) map forecast information needs.

The concept of the PCAPS Open Session originates from earlier Open Sessions that were organized under the umbrella of the WWRP Year of Polar Prediction and the Polar Prediction Project by the PPP Societal and Economic Research Applications (PPP-SERA) Task Team (Lamers et al. 2024; Jung et al. 2025; Thoman et al. 2017). A central idea behind the Open Sessions is to engage with stakeholders that are located in the geographical proximity of where a PCAPS meeting is held. As such, the thematic theme of an Open Session aligns with this locally relevant context and is very much aimed at enhancing dialogues that are

relevant from the stakeholders' perspective. This successful approach has subsequently been adopted by the PCAPS Open Sessions.

For the PCAPS Open Session, taking place at the British Antarctic Survey (BAS) in Cambridge, a thematic scope was framed around the various research operations that take place in the polar regions, and how these are depending on, as well as feeding into, environmental forecasting value cycles. A comprehensive list was created of possible participants that are based in the proximity of Cambridge by the organization committee of the Open Session, and invitations were sent accordingly. Invitations to participate in the Open Session were also sent to various U.K.-based organizations involved in polar research and forecasting, including BAS, the U.K. Met Office, and departments of various universities.

3. The PCAPS Open Session

The Open Session consisted of a hybrid part with keynote presentations and an interactive in-person-only part with breakout group discussions. The breakout group discussions evolved around a tabletop mapping exercise, using a value-cycle framework, with the goal to map gaps and challenges in providing polar forecast information services. The first hybrid part was attended in-person by almost 50 people, plus about 15 online participants. The second, in-person-only part was attended by about 45 people. Participants consisted mostly of researchers with a background in natural sciences, as well as several social science researchers and people working in operations, forecasting, and polar logistics. In addition, all the PCAPS Steering Group members attended the Open Session, as well as representatives from the WMO World Weather Research Program.

a. Keynote presentations. The keynote session was opened by PCAPS Cochair Daniela Liggett, who gave an introductory talk about the PCAPS project, its aims, and opportunities for stakeholders to get involved. This was followed by three keynote speakers who highlighted the different ways that polar forecasts are used by stakeholders and end users. James Wake (BAS) discussed the integration of forecast information with Antarctic science operations, highlighting the harsh and highly variable conditions in which such operations take place. Aidan Hunter (BAS) addressed ecosystem forecasting needs. He emphasized the need for detailed information on habitat (weather and climate) conditions to be able to research how plants and animals interact with and respond to their environment. Finally, Ed Blockley and Nick Silkstone (Met Office) discussed the forecasting and modeling activities that the Met Office undertakes for the polar regions. Next to an overview of the portfolio of polar services, they noted the extreme topography being a forecasting challenge as many details are not picked up in NWP models, for example, around the edges of the Antarctic continent. Several strengths on which the service provision is built include the orbital satellite imagery, a high number of manual observations, and the ongoing postprocessing work to fill gaps in NWP models.

b. Breakout sessions. The second part of the Open Session was in-person only, consisting of breakout group discussions. The participants were split up into six groups and engaged in tabletop mapping exercises to identify key value-cycle gaps, related research priorities, opportunities, and ways forward.

As a first step to familiarize themselves with the value-cycle framework and to get to know the other people around the table, participants in each group positioned themselves on the value cycle according to their professional affiliation with various phases. While most participants positioned themselves around the “upstream” phases (observations, modeling), there were several affiliated with more “downstream” phases (communication, decision-making). Interestingly, there were several participants who positioned themselves at multiple points,

which confirms the multidimensional and interconnected nature of providing and using environmental data and information services.

Breakout groups then turned to a mapping exercise, where each participant identified key bottlenecks and gaps within and between value-cycle phases in addition to mapping other challenges around the provision and use of environmental forecast information services for polar regions. This individual exercise was followed by group discussions about these bottlenecks and, in turn, a prioritization of the two most important that need urgent attention and should be addressed within the PCAPS project.

4. Outcomes

The following four key bottlenecks emerged, along with several opportunities to overcome them.

a. Data overload and inaccessibility. There is a paradoxical relationship with polar environmental data. While participants acknowledged the existence of a huge amount of data that are currently available, it was also emphasized that it is difficult to find, access, and apply the right kinds of data and information for a given purpose. Several groups mentioned especially challenges around in situ and high-resolution data. The bottleneck is even more urgent because often such kinds of data add value and enable model improvement as well as facilitate decision-making.

Can be alleviated by

- 1) Development of metadata repositories and data platforms that should be findable and accessible to all;
- 2) Investment in creating awareness about and trainings for data repositories;
- 3) Continued investment in effective observation-oriented collaborations, based on clear use value and concrete opportunities (e.g., vessels of opportunity, local community monitoring programmes), tailored toward specific user needs and contexts.

b. Disconnect between value-cycle phases. There are disconnections between different phases in the value cycle, especially at the stage where research output (e.g., on modeling) needs to convert to dissemination and the development of services. As such, this bottleneck aligns with the disconnect often referred to as research to operations (R2O). In addition, there is a limited degree of provider–user interaction. Many users (from ship captains to local communities) lack the tools or training to interpret complex information, whereas many providers still have limited awareness of user needs.

Can be alleviated by

- 1) Improvement of communication, codevelopment, and dedicated training aimed at strengthening provider–user interactions;
- 2) Stronger focus on codevelopment of both upstream and downstream products;
- 3) The creation of interdisciplinary training programs (including, for example, summer schools) that enable bridging of gaps between scientific disciplines as well as across various professional career stages;
- 4) Stimulating involvement of people at all stages of their careers to get involved in the International Polar Year (IPY) planning groups.

c. Limited trust. Trust in both people and products was mentioned by most groups as a key challenge and was related to several parts and phases of the value cycle. For example, trust issues can arise from disciplinary divides, relate to concerns about data quality, limited

understanding about the intended purpose of a product, or emerge from a lack of in-person interaction between service providers and users.

Can be alleviated by

- 1) Creating meeting places where conversations can be had, e.g., about data, observations, and user needs;
- 2) Enabling collaboration with local monitoring initiatives;
- 3) Investment in feedback mechanisms throughout the value cycle, allowing for knowledge based on experience and model output to complement each other;
- 4) Enabling dedicated training for sectoral decision-makers on how to interpret and use meteorological information.

d. Institutional constraints. Structural issues, such as funding mechanisms and institutional silos, were mentioned as impacting various aspects of the value cycle. Many groups noted the difficulty of ensuring long-term funding, for example, for research projects, but also for the operational implementation of research output. Incompatibility of short-term funding with the need to establish long-term monitoring, training, and cross-sectoral collaborations limits the provision and use of polar forecasting services. Other structural issues that emerge on the institutional level (relating to the first theme) are the absence of standardized data formats, metadata, and explanations in understandable language about how to use data portals.

Can be alleviated by

- 1) Rebalancing resources away from technological development toward the (relatively under-supported but vital) phases of communication, interpretation, and decision-making;
- 2) Standardization of data and enabling improvements to the interfaces of data centers;
- 3) Encouraging funding bodies to require the use of existing databases in research projects, as well as to strengthen data sharing aspects of the funding requirements;
- 4) Development of public–private solutions for sustainable service delivery.

4. Conclusion and next steps

The findings from the PCAPS Open Session show that the format of the gathering was a successful opportunity to identify research and operational challenges in service provision and use, to map experienced known bottlenecks and best practices, as well as exploring potential ways to meet forecast information needs.

While technical challenges like data gaps and model uncertainties persist, the most significant issues pertained to human and institutional issues: lack of communication, coordination, and understanding between people, institutions, and disciplines, and how these issues are tackled within the context of specific roles and stages across the value cycle. Addressing these not just requires new tools, but most of all, more integrated ways of working together. The PCAPS project remains committed to facilitating research-based activities that account for these bottlenecks and implement the identified opportunities across the polar regions. In particular, we envision that the key bottlenecks and opportunities as emerged in the Open Session may form relevant input for ongoing planning activities toward the 5th International Polar Year (IPY-5) in 2032–33.

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