BAMS
Meeting Summary

The YOPP Final Summit

Assessing Past and Forecasting Future Polar Prediction Research

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The Year of Polar Prediction (YOPP) Final Summit

What: One hundred eighty-seven scientists, stakeholders, and representatives from operational forecasting centers and international bodies assembled in person and online to review the accomplishments and impacts of YOPP and make recommendations on prediction-related priorities for future international polar research projects.
Where: Montreal, Canada
When: 29 August–1 September 2022

KEYWORDS: Antarctica; Arctic; Atmosphere-ocean interaction; Forecast verification/skill; Data assimilation; Numerical weather prediction/forecasting

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The Year of Polar Prediction (YOPP) Final Summit was the final milestone in the World Meteorological Organization's (WMO) World Weather Research Programme's (WWRP) Polar Prediction Project (PPP). The PPP mission was to "promote research enabling improved prediction services for the polar regions," with PPP running for 10 years from 2013 to 2022 (Jung et al. 2016). YOPP was PPP's flagship activity (Goessling et al. 2016) including a period of intensive observing, modeling, prediction, verification, user engagement and education activities from mid-2017 to mid-2019. This was to be followed by a consolidation period ending in December 2022 to carry out the analysis, synthesize and publish the results.

The YOPP Final Summit was attended by 187 participants from 27 countries (123 in person with another 64 online) to discuss the accomplishments and impacts of YOPP and make suggestions for future international polar research programs building on the PPP. Participants included scientists across a wide range of careers stages, representatives from operational weather and climate prediction centers, international bodies, key user groups, and other stakeholders. Poster presentations and stands included endorsed projects but also new Arctic flagship projects building in part on the legacy of YOPP. An overview booklet of the Polar Prediction Project and the Year of Polar Prediction—including coordination, resource mobilization, research accomplishments (quantitative and qualitative), and science to services was launched at the YOPP Final Summit (Jung and Wilson 2022). The YOPP Final Summit was preceded by a 1-day workshop at McGill University for early-career polar scientists where more than 20 participants had the opportunity to hear from and interact with YOPP senior scientists on scientific as well as career topics.

The summit commenced with background presentations recalling the rationale and drivers for PPP and YOPP and then moved into 3.5 days of plenary and parallel presentation sessions reviewing progress and identifying future challenges for science and services. Brainstorming sessions were held at the end of each day to capture the successes of YOPP, as

well as areas where more could be done. Participants also provided ideas and suggestions for future international polar prediction research and services projects. Session themes included Modeling Advancements, Observing System Experiments (OSEs) and Satellites; Polar Processes; Polar Oceans; Processes and the YOPP Supersite Model Intercomparison Project (YOPPsiteMIP);[1] Science to Services; Polar Prediction and Societal Implications; Sea Ice; Southern Hemisphere; Polar Midlatitude Linkages; Observation Campaigns and MOSAiC;[2] and Observing Systems and Sea Ice.

[1] YOPPsiteMIP is a novel approach for testing model skill and parameterization schemes using easily accessible multivariate and high-frequency observational and model data, including model tendency and flux data, in the same file format. The MIP has recently been updated to MIIP to accommodate Model Intercomparison and Improvement Project activities.

[2] The Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC; https://mosaic-expedition.org/) expedition was a 1-yr-long foray into the central Arctic (September 2019–October 2020) and was a YOPP-endorsed project.

Outcomes

Presentations, the brainstorming discussions, the conference blog wall, and discussion during the 4 days all indicated that the YOPP Final Summit was able to capture and showcase the major advancements made as well as identify areas that should be further explored with high priority in the future (Figs. 1a–d). Given the diverse specializations

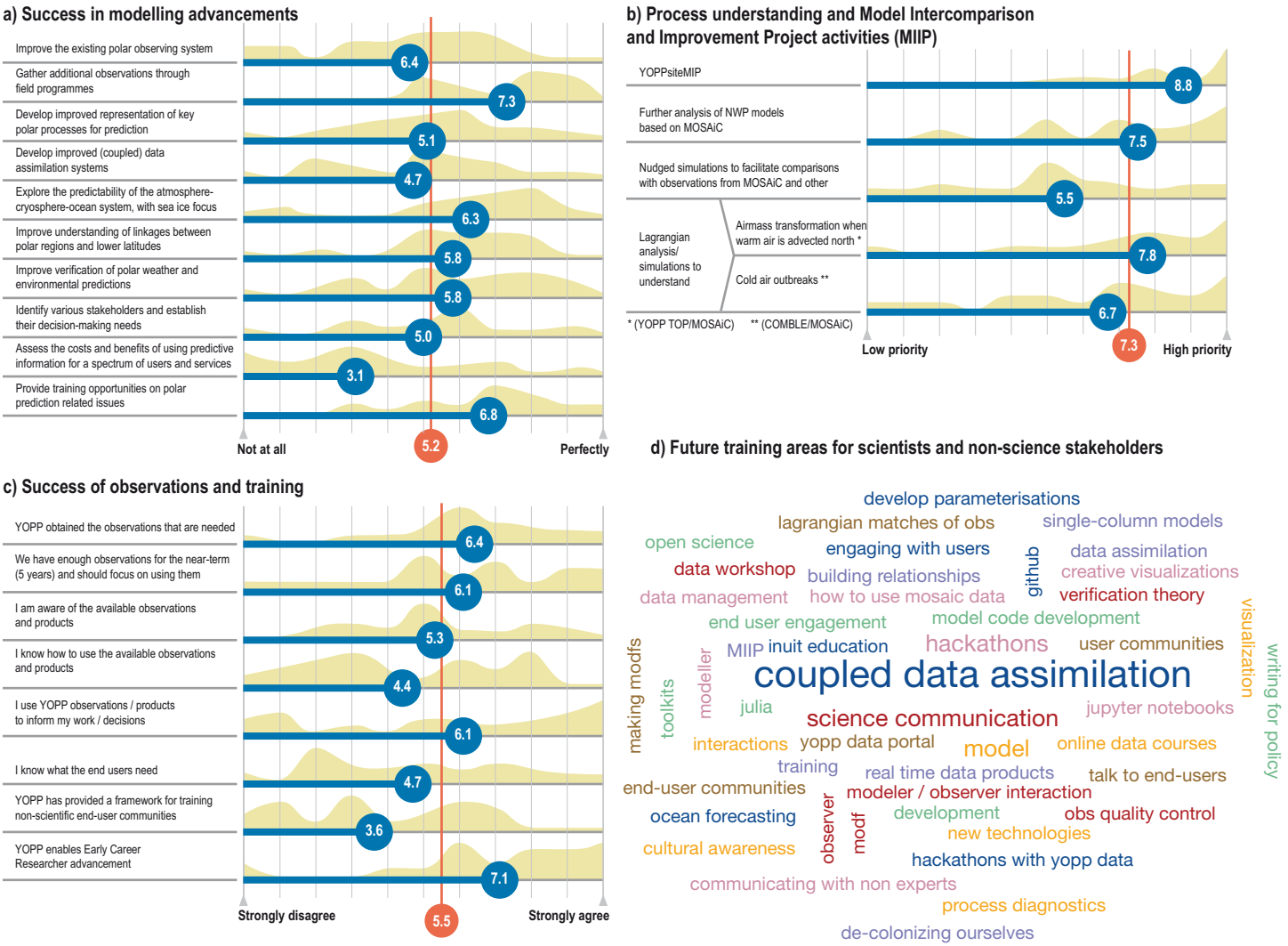

Fig. 1. Feedback from participants in parallel brainstorming sessions on (a) success of YOPP in model advancements, (b) priority areas for further activity in process understanding and MIIP activities, (c) perception of YOPP success in the areas of observations and training, and (d) a word cloud reflecting priority training areas for scientist and nonscientist stakeholders. The numbers in the (a)–(c) indicate the mean result, while the shaded areas show the spread of responses. The relative sizes of the words in (d) indicate priority.

of those participating in the YOPP Final Summit, ranging from polar processes through atmospheric and sea ice/ocean forecasting, polar monitoring and observation campaigns to the social sciences enhancing people engagement with prediction services, different groups identified differing success areas. From the brainstorming sessions, it can be seen that YOPP helped to

- obtain a large amount of data that are widely used by many researchers;
- further the use of observations to compare with model data through the YOPPsiteMIP process and links to MOSAiC;
- raise awareness about available products and services, how to use them, and who the end users are (but more needs to be done); and
- train early-career scientists (but more could be done to help train nonscientific stakeholders).

The successes of YOPP from the presentations and keynote presentations included

- a better understanding of the impact of key polar measurements (radiosondes and space-based instruments such as microwave radiometers), and recent advancements in the current NWP observing system, achieved through coordinated OSEs in both polar regions (e.g., Sandu et al. 2021);
- enhanced understanding of the linkages between Arctic and midlatitude weather (e.g., Day et al. 2019);
- advancements in the atmosphere–ocean–sea ice and atmosphere–land–cryosphere coupling in NWP, and in assessing and recognizing the added value of coupling in Earth system models (e.g., Bauer et al. 2016);
- deployment of tailored polar observation campaigns to address yet-unresolved polar processes (e.g., Renfrew et al. 2019);
- progress in verification and forecasting techniques for sea ice, including a novel headline score (e.g., Goessling and Jung 2018);
- advances in process understanding and process-based evaluation with the establishment of the YOPPsiteMIP framework and tools (Svensson 2020);
- better understanding of emerging societal and stakeholder needs in the Arctic and Antarctic (e.g., Dawson et al. 2017); and
- innovative transdisciplinary methodologies for coproducing salient information services for various user groups (Jeuring and Lamers 2021).

The YOPP Final Summit included presentations from, and discussions led by, representatives of key user groups such as SmartICE (https://smartice.org/), the International Association of Antarctica Tour Operators (IAATO), DanPilot, and Hurtigruten Expeditions. These users provided valuable perspectives about the use of environmental prediction, and challenges arising in cruise tourism, Inuit community sea ice travel hazards and subsistence activities, ice pilotage, and cargo shipping across the Arctic and into the Southern Ocean. Every day of the summit a "Science to Services" and "Polar Prediction to Societal Implications" session was organized, during which particular insights and challenges were raised and discussed by researchers and stakeholders. There were separate sessions from an Arctic (Canadian or European) or Antarctic perspective, respectively, based on YOPP-endorsed projects and stakeholder experiences. These Science to Services sessions, as well as a Services User Dinner Panel, provided important contextual information for discussing the societal value and legacy of YOPP, as well as future directions (Fig. 2).

Fig. 2. Word cloud identifying critical users and sectors for prediction-related services in the next decade.

The YOPP Final Summit identified a number of areas worthy of prioritized research in the area of environmental prediction and services for the polar regions:

- coupled atmosphere, sea ice, and ocean models with an emphasis on advanced parameterizations and enhanced resolution at which critical phenomena start to be resolved (e.g., ocean eddies);
- improved definition and representation of stable boundary layer processes, including mixed-phase clouds and aerosols; incorporation of wave–ice–ocean interactions;
- radiance assimilation over sea ice, land ice, and ice sheets; understanding of linkages between polar regions and lower latitudes from a prediction perspective;
- exploring the limits of predictability of the atmosphere–cryosphere–ocean system;
- an examination of the observational representativeness over land, sea ice, and ocean; better representation of the hydrological cycle; and
- transdisciplinary work with the social science community around the use of forecasting services and operational decision-making to name but a few.

The discussions around the Science and Service sessions identified that, while good progress had been made in identifying key user groups and their needs, more effort is needed to expand research around identifying the range of information needs of a greater diversity of user groups as well as tailoring services to their needs.

The presentations and discussions at the YOPP Final Summit identified the major legacy elements of YOPP: the YOPPsiteMIP approach to enable easy comparison of collocated multivariate model and observational outputs with the aim of enhancing process understanding, the development of an international and multi-institutional community across many disciplines investigating aspects of polar prediction and services, the YOPP Data Portal[3] (https://yopp.met.no/), and the education and training delivered to early-career polar researchers.

[3] The YOPP Data Portal allows users open access to discover and, according to copyright restrictions, to download data from the Arctic and Antarctic special observing periods and targeted observing periods.

Recordings of the plenary presentations from the YOPP Final Summit can be found on the YOPP YouTube Channel under the YOPP Final Summit playlist (www.youtube.com/@yearofpolarpredictionpolar6442/). Further information on the Polar Prediction Project

can be found on Zenodo (https://doi.org/10.5281/zenodo.7440072) and for YOPP at https://doi.org/10.5281/zenodo.7420919.

Next steps

Logistical issues, the COVID-19 pandemic, but also new scientific questions (e.g., the value of targeted observations in the Southern Hemisphere), as well as technical issues emerging toward the end of the YOPP Consolidation Phase, resulted in the decision to continue the following three YOPP activities to the end of 2023: (i) YOPP Southern Hemisphere (YOPP-SH); (ii) Model Intercomparison and Improvement Project (MIIP); of which YOPPSiteMIP is a critical element; and (iii) the Societal, Economics and Research Applications (PPP-SERA) Task Team.

The next WMO WWRP Implementation Plan will be considered by the WMO Congress in mid-2023 with an anticipated commencement date of 1 January 2024. The draft implementation plan includes a polar-related research project entitled "Polar Coupled Analysis Prediction and Services" (PCAPS) that will build upon and extend the work undertaken in the Polar Prediction Project and its flagship activity the Year of Polar Prediction.

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