PAVING THE WAY FOR THE YEAR OF POLAR PREDICTION

BY HELGE F. GOESSLING, THOMAS JUNG, STEFANIE KLEBE, JENNY BAESEMAN, PETER BAUER, PETER CHEN, MATTHIEU CHEVALLIER, RANDALL DOLE, NEIL GORDON, PAOLO RUTI, ALICE BRADLEY, DAVID H. BROMWICH, BARBARA CASATI, DMITRY CHECHIN, JONATHAN J. DAY, FRANÇOIS MASSONNET, BRIAN MILLS, IAN RENFREW, GREGORY SMITH, AND RENEE TATUSKO

Polar prediction has never been as high on the international weather and climate research agenda as today. A growing human interest in the polar regions fueled by climate change and its polar amplification, and the realization that significant knowledge gaps in terms of observational coverage and process understanding exist, have stimulated the World Meteorological Organization (WMO) to address the lagging forecasting capabilities at the poles. Major efforts to increase polar environmental prediction capabilities on hourly-to-seasonal [Polar Prediction Project (PPP)] and seasonal-to-centennial [Polar Climate Predictability Initiative (PCPI)] time scales have been initiated. A key element of these activities is the Year of Polar Prediction (YOPP), a period of intensive observing, modeling, prediction, verification, user engagement, and education activities from mid-2017 to mid-2019.

YEAR OF POLAR PREDICTION SUMMIT

WHAT: 120 scientists, stakeholders, and representatives from operational forecasting centers, international bodies, and funding agencies assembled to make significant advances in the planning of the Year of Polar Prediction.
WHEN: 13–15 July 2015
WHERE: Geneva, Switzerland

To pave the way for a successful Year of Polar Prediction, a major planning event—the YOPP Summit—was held. The meeting brought together

AFFILIATIONS: GOESSLING AND KLEBE—Alfred Wegener Institute, Bremerhaven, Germany; JUNG—Alfred Wegener Institute, Bremerhaven, and University of Bremen, Bremen, Germany; BAESEMAN—Scientific Committee on Antarctic Research, Cambridge, United Kingdom, and International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, Alaska; BAUER—European Centre for Medium-Range Weather Forecasts, Reading, United Kingdom; CHEN—WMO consultant, Montreal, Canada; CHEVALLIER—CNRM, Météo France, CNRS UMR 3589, Toulouse, France; DOLE—NOAA/Earth System Research Laboratory, Boulder, Colorado; GORDON—Otaki, New Zealand; RUTI—World Meteorological Organization, Geneva, Switzerland; BRADLEY—University of Colorado Boulder, Boulder, Colorado; BROMWICH—Byrd Polar and Climate Research Center, The Ohio State University, Columbus, Ohio; CASATI, MILLS, AND SMITH—Meteorological Research Division, Environment and Climate Change Canada, Dorval, Quebec, Canada; CHECHIN—A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences, Moscow, Russia; DAY—NCAS-Climate, Department of Meteorology, University of Reading, Reading, United Kingdom; MASSONNET—Georges Lematre Centre for Earth and Climate Research, Earth and Life Institute, Université Catholique de Louvain, Louvain-la-Neuve, Belgium, and Climate Forecasting Unit, Catalan Institute of Climate Sciences, Barcelona, Spain; RENFREW—School of Environmental Sciences, University of East Anglia, Norwich, United Kingdom; TATUSKO—Alaska Region, NOAA/National Weather Service, Anchorage, Alaska
CORRESPONDING AUTHOR: Helge F. Goessling, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bussestrasse 24, D-27570 Bremerhaven, Germany
E-mail: helge.goessling@awi.de

DOI:10.1175/BAMS-D-15-00270.1

In final form 8 October 2015

120 participants from 20 countries including scientists, stakeholders, and representatives from operational weather and climate prediction centers, international bodies, and funding agencies. Up to 750 viewers at a time followed the plenary talks and discussions online, highlighting the strong interest in YOPP.

The summit started with background presentations that helped to set the scene. After a number of keynote presentations, all interested parties had the opportunity to present their expectations of, contributions to, and recommendations for YOPP. Following extensive discussions in breakout groups, recommendations were presented and discussed during a final plenary session.

Several YOPP-related outcomes and issues were elaborated during the Sixth PPP Steering Group Meeting (PPP-SG6) held directly after the summit. Where appropriate, this report takes into account the decisions made at PPP-SG6.

GENERAL OUTCOMES. The summit informed a large group of scientists, stakeholders, and organizational representatives with a shared interest in advancing predictive capacity in polar regions and beyond on the goals and priorities of YOPP. The summit revealed and furthered the enthusiasm of the community to advance polar predictions and highlighted that YOPP has grown into a well-recognized and much anticipated campaign with the potential to become a game changer for our ability to predict the weather and climate for the polar regions.

Fig. 1. The Southern Cross features prominently in the logo presented at the summit. A YOPP Southern Hemisphere committee has been initiated to ensure that the Southern Hemisphere is well represented and coordinated.

The discussions showed that the existing version of the YOPP Implementation Plan provides a sound basis for the planning of YOPP. It was pointed out that some important topics should feature more prominently in the revised plan, including land processes and the hydrological cycle. It was realized that stronger coordination could be achieved through the establishment of YOPP subcommittees and that the Southern Hemisphere needs to feature more strongly. A committee dedicated to Southern Hemisphere aspects was launched (Fig. 1) and has already gathered considerable momentum since the summit (http://polarmet.osu.edu/YOPP-SH/).

Numerous important commitments and contributions to YOPP were offered at the summit. For example, the Climate and Cryosphere Project (CliC) of the World Climate Research Program (WCRP) appointed two CliC fellows to define and oversee CliC's contributions to YOPP. Another high-level commitment was made by Met Norway, which offered to contribute to the development of a YOPP data portal (see "Data strategy"). A more comprehensive list of commitments will be gathered and made public through the PPP International Coordination Office (ICO) at www.polarprediction.net.

USER-RELEVANT ASPECTS AND VERIFICATION. Participants agreed that user-engagement and associated social science studies are necessary to serve the YOPP objectives. User-tailored products and services shall be developed, hosted, and evaluated within multidisciplinary test beds (e.g., the NOAA Arctic Test Bed, Alaska).

User-relevant verification will reflect periods aligned with user activity, exposure, and sensitivity, possibly corresponding with the intensive observing periods (IOPs; see "Observations"). However, end-user engagement and social science applications will operate independently of IOPs, starting in 2017 and extending into the YOPP consolidation phase (mid-2019 to 2022).

From a verification perspective it was argued that, ideally, YOPP data from observations and models should be made available in (near) real time, follow a mandatory standard format, and be stored in one single data archive with a structure designed in consideration of verification requirements (see "Data strategy" for the eventual data strategy in consideration of all aspects). For social science applications within YOPP, it was recommended to develop and support a dedicated repository of expertise and primary/secondary datasets or metadata.

It was argued that all YOPP observations compatible with the Global Telecommunications System/

WMO Information System (GTS/WIS) be utilized in data assimilation for forecasts and not be held back for future verification studies. Data denial experiments and/or verification against observations not assimilated could be performed during the YOPP consolidation phase. Real-time verification against GTS/WIS observations during YOPP by exploiting existing resources/facilities already available in major operational centers (e.g., the European Centre for Medium-Range Weather Forecasts) shall be encouraged. During the YOPP consolidation phase, summary verification to monitor and compare pre- and post-YOPP prediction skill (where appropriate also with respect to predefined benchmarks, e.g., climatological and persistence forecasts) should be coordinated and centralized amongst a few key centers (e.g., Environment and Climate Change Canada). Finally, the impact of enhanced polar observations and predictions during YOPP on midlatitude predictions also needs to be assessed.

OBSERVATIONS. The YOPP core phase is scheduled from mid-2017 to mid-2019. Given that it is impossible to maintain certain types of polar observations (e.g., four radiosonde launches daily) over two full years, it was recognized that IOPs within the YOPP core phase are needed, both for the Arctic and the Antarctic.

Taking into account operational feasibility, physical processes, benefit for data assimilation systems, and socioeconomic relevance, the timing of IOPs was tentatively determined as follows. For the Antarctic, given increased research capacity and the importance of accurate predictions for key stakeholders such as the logistics community and the tourism industry during austral summer, the period from October to March 2018/19 was agreed upon as a starting point for further discussion. For the Arctic, having two IOPs emerged as a consensus, with one covering a full open-water season (June to November) and one focusing on winter (January to March). The start of the Arctic summer IOP well before the sea ice minimum is required to ensure that long-term predictions for the economically relevant late summer/early autumn season can be well initialized. To improve predictions on shorter time scales (hours to days) for the same target period, on the other hand, it will be important to enhance observations in late summer and early autumn. Furthermore, it was strongly argued for extending the IOP to late autumn to capture the time of year when atmosphere–sea ice–ocean interactions are most vigorous. The shorter Arctic winter IOP will take place in operationally more challenging conditions and will be targeting phenomena such as polar lows, snow, cold-air outbreaks, and stable boundary layer processes.

An important task of the coming two years will be to coordinate different campaigns (e.g., aircraft) within the IOPs. Two new committees will focus on this task: one dedicated to the Arctic and the other to the Antarctic (the already-mentioned Southern Hemisphere committee). Generally, it was stressed that strong communication and coordination would be needed to provide a clearer view on the observational component of YOPP (which is populated bottom up with, e.g., process-study, satellite, and GTS/WIS-type data) to all involved. One important element would be the compilation of a well-structured list of planned observations, which should be accounted for in the YOPP endorsement process.

MODELING, DATA ASSIMILATION, AND FORECASTING. It was pointed out that a number of modeling activities are already taking place in projects closely related to YOPP, calling for intensive coordination. The need for leadership for every YOPP modeling aspect was highlighted. A committee has been initiated to take the overall lead in the further development of the YOPP modeling component.

It was recommended to complement the emphasis in YOPP research on fundamental polar–nonpolar latitude process linkages with applications and analyses driven by specific user problems and prediction requirements. Participants also recognized the need to put more emphasis on microphysics and radiation modeling activities, since these appear to be essential to improve models for polar prediction. Another critical modeling issue to be tackled during YOPP is the use of the classical (elastic-)viscous-plastic (EVP) rheology at very high resolution. To enable detailed diagnostic studies, modelers should also archive model tendencies, as was done by groups during the Year of Tropical Convection (YOTC), along with other variables valuable for a process-based understanding of polar predictions (e.g., www.climate-cryosphere.org/activities/targeted/simip).

A need to foster the development of coupled high-resolution prediction systems was stressed. For example, a challenging milestone could be to have a coupled pan-Arctic system, running at 10 km or finer resolution and issuing forecasts more than a few days ahead, operational by 2017. Such a system would bridge short-term and seasonal forecasting. Some participants made commitments, mentioning global and regional configurations they plan to use during YOPP. Some flexibility in the definition of regional

domains was mentioned, enabling the definition of common study areas.

Finally, advancing data assimilation systems should be a key activity within YOPP. A prerequisite for making progress will be to further our understanding of the error structure of models used for producing reanalyses, reconstructions, or initializations of predictions. It was strongly recommended that YOPP continues to leverage the activities of the World Weather Research Programme (WWRP) Data Assimilation and Observing Systems (DAOS) Working Group and data denial experiments in order to determine the value added from particular observations collected during YOPP.

DATA STRATEGY. It was decided to develop a YOPP data portal that builds on the experience of the Global Cryosphere Watch (GCW), including the use of consistent metadata and pointers to other online locations where data can be retrieved. A small number of data centers willing to archive YOPP data (and to support the process) and able to provide digital object identifiers (DOIs), such as PANGAEA, should be identified. Datasets must be open access and, where observations are suited for real-time operational use, submission through GTS/WIS should be mandatory. Special attention should be given to WMO standards including the Binary Universal Form for the Representation of meteorological data (BUFR). Finally, all datasets should be published in data journals such as *Earth System Science Data* (*ESSD*), and a YOPP special issue in *ESSD* should be created.

EDUCATION, OUTREACH, AND COMMUNICATION. Effective cross-disciplinary communication among scientists will be key to making YOPP effective and successful. The need for keeping and further building on the momentum generated by the summit was stressed. Active communication (e.g., website, Twitter, mailing list, workshops, project endorsement) and further promotion of YOPP (e.g., representation at high-level events) is mandatory.

The participants strongly supported the ongoing efforts in training early-career scientists, including the Abisko Polar Prediction School 2016 and ongoing webinar series. It was recommended to develop a broader outreach plan (science–stakeholders and science–public) for YOPP, in particular for the launch event in mid-2017 and for suitable observational campaigns.

NEXT STEPS. The outcomes of the YOPP Summit are the basis for a revision of the YOPP Implementation Plan, with the final version expected to become available by the end of 2015. Further YOPP planning will be carried out through the PPP Steering Group in cooperation with its partner initiatives and through the above-mentioned committees that will focus on the planning for each of the different YOPP key areas.

Discussions at the summit revealed that a YOPP endorsement process is urgently needed to promote activities with funding agencies and other decision makers and to provide a detailed overview of ongoing and planned activities that is mandatory to enable effective coordination. The main source for YOPP and its further planning, including the revised Implementation Plan and an endorsement form, is the YOPP website (http://polarprediction.net/yopp). Updates to the community on recent developments will also be distributed via the mailing list polarprediction@climate-cryosphere.org (to subscribe, contact office@polarprediction.net).

ACKNOWLEDGMENTS. We acknowledge Francisco J. Doblas-Reyes for verifying the accuracy of this summary. We thank all participants for their contributions and acknowledge the generous financial assistance provided by the PPP Trust Fund contributors (Canada, United Kingdom, United States, Norway, Australia), Global Framework for Climate Services (GFCS), Alfred Wegener Institute (AWI), CliC, and Earth System Knowledge Platform (ESKP), and all in-kind support. Thanks are also extended to the coorganizers (WMO, AWI, and CliC) and to WMO for hosting the event.