The Year of Polar Prediction

White Paper submitted to the Arctic Observing Summit 2016

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Executive Summary:

The Year of Polar Prediction (YOPP) has the mission to enable a significant improvement in environmental prediction capabilities for the polar regions and beyond, by coordinating a period of intensive observing, modelling, prediction, verification, user-engagement and education activities. The YOPP Core Phase will be from mid-2017 to mid-2019, flanked by a Preparation Phase and a Consolidation Phase. YOPP is a key component of the World Meteorological Organization – World Weather Research Programme (WMO-WWRP) Polar Prediction Project (PPP).

The objectives of YOPP are to:

1. Improve the existing polar observing system (better coverage, higher-quality observations);
2. Gather additional observations through field programmes aimed at improving understanding of key polar processes;
3. Develop improved representation of key polar processes in coupled (and uncoupled) models used for prediction;
4. Develop improved (coupled) data assimilation systems accounting for challenges in the polar regions such as sparseness of observational data;
5. Explore the predictability of the atmosphere-cryosphere-ocean system, with a focus on sea ice, on time scales from days to seasons;
6. Improve understanding of linkages between polar regions and lower latitudes and assess skill of models representing these linkages;
7. Improve verification of polar weather and environmental predictions to obtain better quantitative knowledge on model performance, and on the skill, especially for user-relevant parameters;
8. Demonstrate the benefits of using predictive information for a spectrum of user types and services;
9. Provide training opportunities to generate a sound knowledge base (and its transfer across generations) on polar prediction related issues.

The PPP Steering Group provides endorsement for projects that contribute to YOPP to enhance coordination, visibility, communication, and networking. This White Paper is based largely on the much more comprehensive YOPP Implementation Plan (WWRP/PPP No. 3 – 2014), but has an emphasis on Arctic observations.

1. Introduction

There has been growing interest in the polar regions in recent years due to the opportunities and risks associated with anthropogenic climate change. Increasing economic, tourism, transportation, and scientific activities in polar regions are leading to more demands for enhanced environmental prediction capabilities to support decision-making. Furthermore, there is increasing evidence that weather and climate in the polar regions have a substantial influence on the lower latitudes. However, forecasting capabilities in the polar regions are lagging behind compared to mid- and low-latitude predictions. The probably most important reason for this is the sparseness of polar observations (Figure 1), posing challenges to data assimilation, forecast initialization, process understanding, model development, and forecast verification.

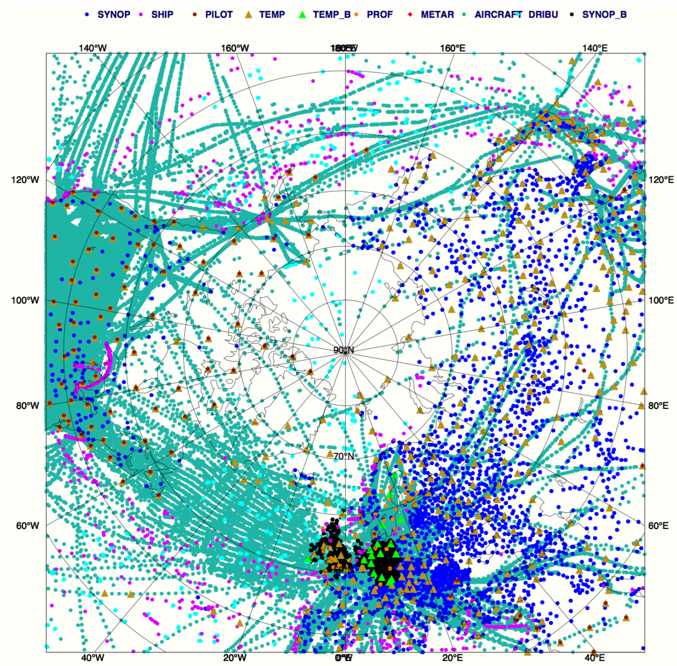

Figure 1: Conventional observations that were assimilated by the operational forecasting system at ECMWF on 15 April 2015. Different colors are used for different observation types (see legend). The strinking observational gap in the Arctic exists also for other important data types, in particular Argo floats in the ocean. Figure from Jung et al. (2016).

Recognizing this, the World Meteorological Organization – World Weather Reasearch Program (WMO-WWRP) has decided to embark on a decade-long Polar Prediction Project from 2013 to 2022. The key element of PPP is the Year of Polar Prediction (YOPP) with a Core Phase taking place between mid-2017 and mid-2019.

The YOPP Mission is to:

Enable a significant improvement in environmental prediction capabilities for the polar regions and beyond, by coordinating a period of intensive observing, modelling, prediction, verification, user-engagement and education activities.

In other words, YOPP is an extended period of coordinated intensive observational and modelling activities, aimed at improving prediction capabilities for the Arctic, the

Antarctic, and beyond. This concerted effort will be augmented by research into forecast-stakeholder interaction, verification, and a strong educational component. Being part of the Polar Prediction Project, YOPP concentrates on time scales from hours to seasons. With its clear focus on polar prediction rather than a very broad range of polar science topics, YOPP is quite different from IPY (the International Polar Year 2007-2008). Prediction of key variables such as visibility, wind, precipitation, and in particular sea ice, is central to YOPP. The presence of linkages between polar and non-polar regions suggests that the benefit of YOPP will extend beyond the polar regions.

Extra observations will be crucial to YOPP in order to (i) optimize the polar observing system, (ii) generate the knowledge necessary to improve the representation of key polar processes in models, and (iii) provide ground-truthing that it is so important to exploit the full potential of the space-borne satellite network. YOPP will provide an opportunity for testing new observational activities, and will encourage research, development and employment of innovative systems.

Another important aspect of YOPP will be a strong virtual component through involvement of the numerical modelling community, encompassing models of the atmosphere, ocean, sea ice, and land. Operational model runs will cover time scales from hours to seasons. A particular focus will be on sea ice, since for polar regions this medium is both a critically important environmental variable to be predicted, and a strong modulator of other weather-related predictands (Figure 2).

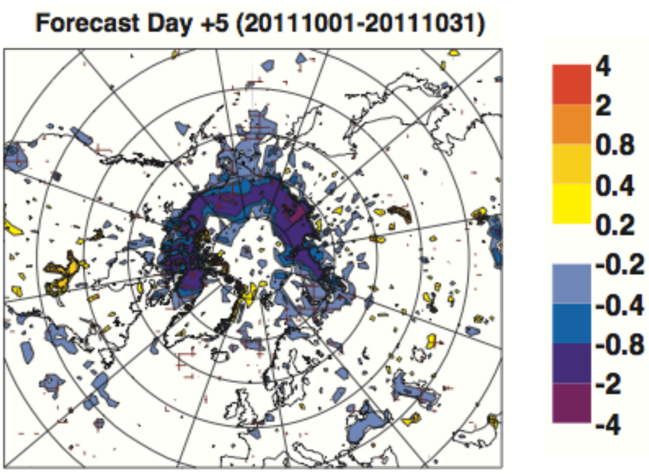

Figure 2: Mean 2-m temperature difference (in K) between hindcast experiments using observed and persisted sea ice and sea surface temperature at 5 days lead time with the ECMWF forecasting system for October 2011. The large errors along the ice edge highlight the importance of coupled processes even for near-term prediction in polar regions. Figure from Jung et al. (2016).

Striving to improve polar predictions, the additional observations collected during YOPP will be utilized in several ways. The observations will be used (i) in data assimilation systems to improve forecast initialization, assess the relative merits of different observation types, locations, and frequencies (by means of observing system (simulation) experiments, i.e., data denial experiments), and further develop coupled data assimilation techniques, (ii) as basis for forecast verification, and (iii) to study processes that are key to improved polar predictions, for example processes related to the stable boundary layer, sea ice, mixed-phase clouds, and polar lows. YOPP-related data from observations and models will be shared using standardised interfaces and documentation standards, also enabling long-term data preservation. A dedicated YOPP Data Portal will provide a unified framework of the data hosted by the data centres contributing to YOPP.

YOPP will also explore largely uncharted territory in the area of polar forecast verification; YOPP will contribute to our understanding of the value of improved polar prediction capabilities; and YOPP will help to educate the next generation of scientists. YOPP will be carried out in three phases: a Preparation Phase from 2013 to mid-2017, a Core Phase from mid-2017 to mid-2019, and a Consolidation Phase from mid-2019 to 2022 (Figure 1). Each of these phases is discussed in the following Sections.

In order to achieve the research objectives listed in the executive summary, strategic aspects of YOPP are to:

A. Strengthen linkages between academia, research institutions and operational forecasting centres;
B. Establish and exploit special research data sets that can be used by the wider research community and forecast product users;
C. Establish a common virtual data archive through integration of contributing archives;
D. Link with space agencies;
E. Promote YOPP with funding agencies;
F. Develop strong linkages with other initiatives;
G. Promote interactions and communication between research and stakeholders;
H. Foster education and outreach.

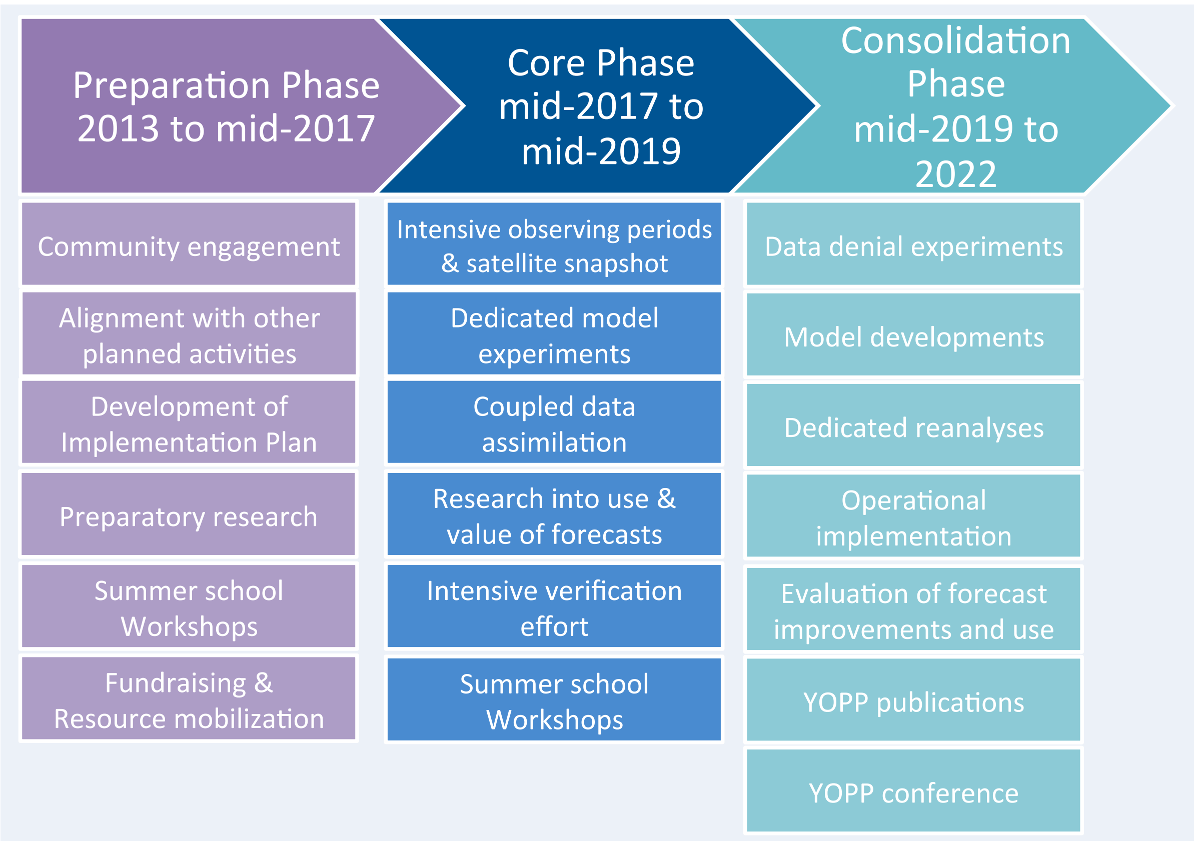

Figure 3: The phases of YOPP and key activities therein

2. YOPP Preparation Phase (2013 to mid-2017)

The current Preparation Phase is crucial for the success of YOPP. It involves a number of aspects – overall planning, engagement with stakeholders, coordination of observations and related field programmes, promotion of modelling activities, establishment of data archive systems, preparatory research, and involvement of funding agencies.

YOPP was devised following the first meeting of the PPP Steering Group in Switzerland in December 2011. The initial concept for YOPP is outlined in the PPP Implementation Plan (WWRP/PPP No. 2 – 2013). The International Coordination Office (ICO) for Polar Prediction, hosted at the Alfred Wegener Institute in Germany and responsible for the overall management of PPP, is also in charge of the overall management of YOPP.

YOPP Planning Meetings involving members of the WWRP-PPP Steering Group as well as participants representing important partners (Table 1) were held 2013 in the UK, 2014 in Finland and Canada, and 2015 in Switzerland. The last of these – the YOPP Summit - was special in that about 120 scientists, stakeholders, and representatives from operational forecasting centers, international bodies, and funding agencies were assembled to make major progress in the planning of the approaching YOPP Core Phase. The outcomes of extensive discussions held at the YOPP Summit are the basis for a final revision of the YOPP Implementation Plan which will be published ahead of the Arctic Observing Summit 2016.

Table 1: Selected YOPP Partners (coordinating bodies; acronyms are explained in the appendix of the YOPP Implementation Plan).

Group	Role
APECS	Implementation of educational component of YOPP
CBS / Integrated Observing Systems	Facilitating the improvement of polar observing systems
EC-PHORS	Overall policy perspective
EUCOS	Additional observations over northern polar regions
GASS	Coordination of polar model intercomparison projects
GCW	Cryospheric observations, and potential use of the GCW portal
GODAE Oceanview	Development and implementation of the intensive modelling campaign (ice-ocean)
IASC	Planning of YOPP for northern polar regions
IASOA	Contributing observations and research based on pan-Arctic atmospheric observatories
IICWG	Coordination of operational ice services
MOSAiC	Gathering data from and around the drifting observatory to improve coupled models and coupled data assimilation, and for ground

	truthing of satellite data
PCPI	Close coordination of related activities
PSTG	Supporting the exploitation of satellite data (“satellite snapshot”)
S2S	Sub-seasonal to seasonal aspects of polar predictions
SAON	Coordination of Arctic Observations
SCAR	Planning of YOPP for southern polar regions
Sea Ice Prediction Network	Collaboration on Arctic sea-ice prediction
SOOS	Coordination of Southern Ocean Observations
WCRP/CliC	Close coordination of related activities of CliC and its working groups
WGNE	Development and implementation of the intensive modelling campaign (atmosphere)
WGSIP	Encouraging institutions with prediction capability to use initial conditions that take advantage of the new available data from YOPP to rerun some sub-seasonal and seasonal predictions

The identification of, and engagement with, key partners for YOPP is an important element of the Preparation Phase (Table 1). Another crucial element at a slightly different level is the excitation of, support for, and coordination of individual projects and initiatives that fill YOPP with life. In the past, a number of scientists seeking funds from different funding agencies for projects potentially contributing to YOPP have been supported with individual letters of support. At the YOPP Summit it was decided to establish an endorsement process that fulfils these tasks in a more systematic manner. For projects and initiatives to be endorsed, criteria include, among others, the contribution to the general YOPP objectives, willingness for close coordination with other YOPP activities, and open data sharing. Requests for endorsement are reviewed by the PPP Steering Group. During the first four weeks, more than 10 projects and initiatives have requested YOPP endorsement. Among the earliest endorsed are for example: a project contributing additional upper air soundings from Neumayer Station (Antarctica) and RV Polarstern; the Forum for Arctic Modelling and Observational Synthesis (FAMOS); a project conducting an Arctic Earth Observation Impact Assessment; and the Group on Earth Observations Cold Regions Initiative (GEO-CRI). Details on the endorsement process and an up-to-date list of endorsed projects and initiatives is given at <http://www.polarprediction.net/yopp/yopp-endorsement.html>.

A number of important science workshops has already been co-organized by PPP, for example a Polar Prediction Workshop held in the UK (2013), a PPP Science Workshop held in the US (2013), a Polar-Lower Latitude Linkages Workshop held in Spain (2014), a SERA Workshop held in Canada (2015), and a Workshop on the Dynamics of Atmosphere-Ice-Ocean Interactions in the High-Latitudes held in Norway (2015).

Another important outcome of the YOPP Summit was the establishment of additional sub-committees that take the lead in fostering certain aspects of YOPP. The existing sub-committees on (i) Sea-Ice Prediction, (ii) Societal and Environmental Research and Applications (SERA), and (iii) Education are complemented with committees on (iv) Southern Hemisphere aspects, (v) Coordinated Model Experiments, (vi) the YOPP Data Component, and (vii) Arctic Observations and Intensive Observing Periods. Most of these are now in the process of being established (as of November 2015). A substantial part of the further YOPP planning will take place within these sub-committees and on pre-YOPP workshops they are organizing, focussed on their respective themes.

3. YOPP Core Phase (mid-2017 to mid-2019)

The main YOPP activities are planned to take place during the period mid-2017 to mid-2019 – centred on the year 2018. The YOPP Core Phase encompasses four major elements: an intensive observing period, a complementary intensive modelling and forecasting period, a period of enhanced monitoring of forecast use in decision making including verification, and a special educational effort. Here we only sketch aspects of observational activities in the Arctic.

YOPP will take advantage of the existing operational data gathered under WMO auspices for the globe, including polar regions. Additional observations promoted during the YOPP Preparation Phase will fall into the following categories: (i) comprehensive reference stations, (ii) field campaigns, (iii) aircraft campaigns, (iv) shipping, (v) free troposphere, (vi) sea ice and upper ocean, (vii) open ocean, (viii) deeper ocean, (ix) autonomous sensor systems, (x) snow, (xi) land, (xii) boundary layers and clouds, and also (xiii) stakeholders. All of these categories are discussed in detail in the YOPP Implementation Plan.

It has been realized that maintaining certain types of Polar observations (e.g., four radiosonde launches daily) over two full years is not feasible. Therefore, extra observations will concentrate on Intensive Observing Periods (IOPs) within the YOPP Core Phase. Taking into account operational feasibility, physical processes, benefit for data assimilation systems, and socio-economic relevance, the timing of Arctic IOPs has tentatively been determined as follows.

There will probably be two Arctic IOPs, with one covering a full open-water season (June to November 2018) and one focusing on winter (January to March 2019). 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.

It is important to note that the temporal focus on IOPs does not imply that observations taken outside IOPs but within the YOPP Core Phase, or even in the late Preparation Phase or early Consolidation Phase, would not be useful for YOPP. For example, some observation types will be more continous in nature (e.g., extra automatic weather stations and floats), and some relevant observational campaigns will not be able to comply with IOPs for practical reasons (e.g., MOSAiC).

Given the strong involvement of operational forecasting centers, YOPP will not only benefit from additional observations *per se*, but also from additional efforts to provide observational data in (near-)real-time via the WMO Information System / Global Telecommunication System (WIS/GTS). The revised YOPP Implementation Plan will include a "How-To" chapter to facilitate real-time data provision for the research community.

4. YOPP Consolidation Phase (mid-2019 to 2022)

The Consolidation Phase will be as important as the earlier phases in that it will ensure to provide a legacy of YOPP. Beside the holding of synthesis workshops and conferences, implementation of YOPP findings into operational forecasting systems, and evaluation of forecast improvements and their use by stakeholders, it will be crucial to ensure proper archiving, availability, and traceability (Digital Object Identifiers) of the additional observational data generated during YOPP. To this end, a YOPP Data Portal, building on the experience of the Global Cryosphere Watch (GCW) Portal, will be implemented to enable an efficient exploitation of YOPP data. GCW data management is based on achievements in distributed data management systems during the International Polar Year and alignment of these achievements with relevant WMO activities like WMO Information System (WIS) and WMO Integrated Global Observing System (WIGOS) as well as the combined SAON/IASC Arctic Data Committee and SCAR Standing Committee on Antarctic Data Management (SCADM). The foundation of this is standardised documentation of datasets using metadata describing who measured/modelled/analysed what, where and when, as well as the access mechanisms to data and potential constraints. Integration of YOPP data management with WIS ensure that YOPP data are exposed through the GEOSS Common Infrastructure as well as for other WMO programmes (e.g., the emerging Polar Regional Climate Centre). WIGOS metadata describes instrumentation, procedures and facilities used to collect observational data and ensures proper understanding of quality, comparability and how representative data are. It is also the basis for WMO programmes network design.

The additional data collected during YOPP will be used during the Consolidation Phase to evaluate the benefit of extra observations for polar predictions. This includes data denial experiments which will provide guidance for optimizing the polar observing system. Furthermore, the extra observations along with the high-resolution numerical experiments will benefit model development and the enhancement of value of satellite data in a prediction context.

In order to synthesize the available YOPP data and to exploit them in models, it will be desirable to carry out special (high-resolution) reanalyses for the Arctic (as for the Antarctic). This will be an ongoing activity during the Consolidation Phase. Such reanalyses along with the availability of reforecast data sets will provide the basis for probabilistic forecast calibration and for diagnostic and verification studies that are expected to advance polar prediction across a wide range of time scales. Finally, in particular the strongly involved of observational centers will enable a seamless legacy of

YOPP by utilizing an optimized polar observing network and improved forecasting systems for better polar predictions beyond 2022.

5. Final Remarks

This White Paper has barely touched on some aspects that are important ingredients for a successful YOPP, including coordinated model experiments, education and outreach efforts, funding aspects, verification, data assimilation, satellite data, and more. If you want to learn more, and want to stay informed, about YOPP, the website of the International Coordination Office for Polar Predicion at <http://www.polarprediction.net> hosts all relevant information, including workshop and meeting reports, the PPP and YOPP Implementation Plans, a frequently updated news section, and information on upcoming events (including the pre-YOPP workshops) and on the endorsement process. Another way to get more information is to follow @polarprediction on Twitter, and/or to subscribe to the polar prediction mailing list by sending an email to <office@polarprediction.net>.

The remaining one and a half years of the Preparation Phase are crucially important to making YOPP a fruitful endeavor. Ultimately, the success of YOPP depends on the enthusiasm and willingness of scientists to contribute with their projects and initiatives. The Arctic Observing Summit 2016 is a prime opportunity to inform on YOPP, discuss Arctic observations needed for YOPP, and to excite corresponding contributions to YOPP. We invite requests for YOPP endorsement not only for already funded projects to maximize coordination and mutual benefits, but also to support planned projects in their efforts to obtain funding.

Selected publications:

PPP Steering Group and Coauthors: Implementation Plan for the Year of Polar Prediction, WWRP/PPP No. 3, 2014 (newer version available by the time of the Arctic Observing Summit 2016)

Goessling, H. and Coauthors: Paving the Way for the Year of Polar Prediction, Bull. Am. Met. Soc., 2015

Jung, T. and Coauthors: Advancing polar prediction capabilities on daily to seasonal time scales, Bull. Am. Met. Soc., 2016

Jung, T. and Coauthors: Polar-lower latitude linkages and their role in weather and climate prediction, Bull. Am. Met. Soc., 2015