WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR ATMOSPHERIC SCIENCES (CAS)
WORLD WEATHER RESEARCH PROGRAMME (WWRP)

WWRP/THORPEX POLAR PREDICTION PROJECT STEERING GROUP KICKOFF MEETING

GENEVA, SWITZERLAND

30 November-1 December 2011

FINAL REPORT

WMO OMM

1 OPENING

The “kickoff” meeting of the WWRP/THORPEX Polar Prediction Project Steering Committee (WWRP-PPP SG) was opened at 0900 on Wednesday 30 November 2011, at WMO headquarters in Geneva, Switzerland, by Thomas Jung, Chair of the Steering Group.

The Assistant Secretary-General of WMO, Elena Manaenkova,welcomed members of the Steering Group to Geneva. In view of her past roles in providing leadershipfor the implementation of THORPEX, as well as WMO’s contribution to the International Polar Year (IPY), she was very supportive and pleased about this Project. She noted that Congress-XVI had passed important resolutions on polar matters, including the establishment of the Global Integrated Polar Prediction System (GIPPS), which provided an overarching mandate for the Project. She thanked all members for their willingness to volunteer to work on the Steering Group, and wished them all success for their deliberations.

Thomas Jung added his welcome to the group, and thanked everyone for their willingness to contribution time and energy to this important initiative.

Each participant briefly introduced himself or herself. Thomas Jung noted that four members of the Steering Group were not able to be present at this first meeting – Marika Holland, Peter Lemke, Pertti Nurmi, andDavid Bromwich – although Keith Hines was participating on behalf of David. Brian Mills and Greg Smith were also not able to be present in Geneva, but would join the meeting by web conference from 1400 to 1730 on the first day. The full list of participants in the meeting is given as Annex 1 to this report.

2 ORGANIZATION OF THE MEETING

The meeting agenda was adopted with minor amendments, and is given as Annex 2 to this report.The meeting discussed and agreed to working arrangements for its session.

3 BACKGROUND TO THE POLAR PREDICTION PROJECT&RELATED INITIATIVES

3.1 Oslo Workshop

Gilbert Brunet, the Chair of the WWRP Joint Scientific Committee (WWRP/JSC) briefed the meeting on the outcomes of the WWRP, THORPEX, WCRP Workshop “Improvement of Weather and Environmental Prediction in Polar Regions”, which had taken place from 6 to 8 October 2010, in Oslo, Norway.

He recalled that the 15th Session of CAS (November 2009) recommended, as a legacy of the International Polar Year (IPY) to establish a THORPEX Polar Research project to improve:

- understanding of the impact of polar processes on polar weather;
- assimilation of data in Polar Regions;
- prediction of high impact weather over Polar Regions.

Gilbert also recalled that the Executive Council Panel of Experts on Polar Observations, Research, and Services (EC-PORS) had recommended thatefforts be made to further polar prediction for weather and climate and to extend efforts to snow, ice, carbon, and ecosystem modelling and analysis.

He noted that the full report of the Oslo meeting was available on the web at http://www.wmo.int/pages/prog/arep/wwrp/new/documents/Polar_NWP_Meeting_Outcomes_FINAL.pdf, and it contained conclusions and recommendations that were very pertinent to the project which was now underway.

In terms of related work in Canada, Gilbert reported on the successful implementation of an air-sea-ice coupled model for the Gulf of St Lawrence. A dynamic representation of sea surface conditions improved the meteorological forecast locally, with time-evolving ice cover in coupled model allowing vast stretches of ice-free water to open up, buffering atmospheric temperatures. The use of a coupled model had resulted in significantly improved forecasts all around the Gulf of St Lawrence, demonstrating the importance of air-sea-ice coupling even for short-range weather forecasts.

He also informed the meeting that, by 2015, Environment Canada would have complete coverage over Canada and up to the North Pole with an unprecedented convection permitting and non-hydrostatic high-resolution (Δx = 2.5 km) numerical weather prediction system. This would predict out to 24-36 h, 2-4 times a day, with full data assimilation system of atmospheric measurements, a land data assimilation system (Δx = 250 m) for detailed initial conditions of surface fields, and an associated ensemble prediction system to provide forecast uncertainties.

3.2 THORPEX ICSC-9

Tetsuo Nakazawa, the Chief of WWR, advised that the ninth session of the THORPEX International Core Steering Committee, held from 21-22 September 2011, had in its Decision/Action ICSC (9) 24"… endorsed the polar prediction project. It encouraged the WWRP and WCRP steering groups to co-ordinate their respective Implementation Plans and in particular to identify those activities that should be implemented jointly and those that are best tackled separately."

He also noted that the sixth session of the CAS Management Group, held in Madrid Spain from 15-17 November 2011, had in its CASMG06/Action 6 " …advised that the WWRP/THORPEX Polar Prediction Project should include the study of the influence of atmospheric contaminants on polar weather and climate, the role of Black Carbon (BC) and the role of aerosols in general in the modification of Arctic fog and cloud prevalence, being specific examples. The Open Area Group on Environmental Pollution and Atmospheric Chemistry in particular through its Science Advisory Group on aerosols, chaired by John Ogren, is prepared to contribute to the planning of the environmental (pollution) aspects of the THORPEX Polar Prediction Project."

3.3 EC-PORS and GIPPS

Thomas Jung covered this item on behalf of Peter Lemke, who was not able to be present, and is an ex-officio member of the Steering Group as a member of the Executive Council Panel of Experts on Polar Observations, Research and Services (EC-PORS).

EC-PORS had been established in 2008 to assist the WMO Executive Council in its oversight of WMO Polar activities. In its second meeting held in Hobart in October 2010 it had formulated proposals for a Global Integrated Polar Prediction System (GIPPS), which were subsequently endorsed by the 16th WMO Congress in May/June 2011 through the adoption of Resolution 57 (Cg-XVI). Thomas noted that the system was "Global" because it was an international effort, and poles affect systems (weather, climate, biological chemical etc.) globally; and "Integrated" to reflect interconnections between the systems, and that the System itself will be integrated (research, observations and services).

The meeting recognised the importance of this resolution, and noted that in effect it provided a mandate from Congress for the establishment of the WWRP/THORPEX Polar Prediction Project, which would constitute (together with the WCRP Polar Initiative) the research component of GIPPS.

3.4 WCRP Polar Initiative

Vladimir Ryabinin from WMO's WCRP office advised the meeting of the development of the WCRP Polar Predictability Initiative, which was proposed in the result of the science-driven WCRP Workshop held in Bergen, Norway from 25-29 October 2010. WCRP Informal Report No. 2/2011 (available at www.wcrp-climate.org/documents/Polar_WCRP_Report.pdf) provided the results of the Workshop.

One immediate recognition from the workshop was that there was a notable gap between scientific communities, as most people knew only a small minority of the other participants. It therefore seemed apparent that progress in polar predictability would require crossing disciplinary boundaries to understand the feedbacks between the troposphere and the stratosphere, ocean, land, and sea ice.

In April 2011, WCRP-JSC-32 had endorsed the plan to hold a follow-on workshop to develop an implementation plan for the initiative. It will be held on 2-4 April 2012 in Toronto, Canada. The ideas were further discussed at the IASC Atmosphere Working Group meeting in Denver, USA on 23 October 2011, which is led by Dr. James Overland. Specific activities where international coordination makes a difference (the WCRP role) – the added value versus existing activities – are being expected and identified. At the Toronto workshop the target group will include 30-35 participants, will represent the required science topics and partner activities, and the meeting outcome will be a draft implementation plan to be considered at the WCRP/JSC meeting in July 2012.

Vladimir noted that there were many areas of commonality between the WCRP and WWRP initiatives. The meeting fully agreed on the need for close coordination, and to avoid overlaps and duplication of effort.

4 IMPLEMENTATION PLAN OVERVIEW

4.1 Existing Draft and Key Project Objectives

Thomas Jung provided an overview of the current draft Implementation Plan.

Following discussion, the meeting agreed on the following Mission for the project:

> **"Promote cooperative international research enabling development of improved weather and environmental prediction services for the polar regions, on time scales from hourly to seasonal."**

The meeting also agreed that it was important to note along with the Mission that:

> **"This constitutes the hourly to seasonal research component of the WMO Global Integrated Polar Prediction System (GIPPS)."**

The meeting felt that it was very important that the project should add value. It was agreed that the key points of difference included:

- the polar focus
- providing leadership on science challenges and goals
- helping to create coordination of existing efforts
- enabling improved prediction services

4.2 Agreement on Overall Structure and Chapters

The meeting agreed to the followingoutline structure of the Implementation Plan:

- Introduction
- Mission statement
- Benefits
- Research plan goals
- Strategies to achieve goals
- Governance and management
- Financial plan
- Implementation schedule
- Contributing institutions and organisations
- References
- Abbreviations
- Annexes

The meeting agreed on the following eight Research Goal areas:

1. Societal and Economic Research Applications (SERA)
2. Verification
3. Predictability and forecast error diagnosis (especially on longer time scales)
4. Nonpolar-polar linkages
5. Physical, dynamical and chemical processes
6. Ensemble forecasting
7. Data assimilation
8. Observations

The meeting agreed on the followingseven Strategies to achieve the goals:

1. Enhance international and interdisciplinary collaboration
2. Strengthen linkages between academia, research institutions and operational centres
3. Establish and exploit special research data sets: TIGGE, YOTC, reforecasts etc.,
4. Linkages with space agencies and other data providers
5. Promote interaction and communication between research and stakeholders
6. Maintain strong linkages with other initiatives
7. Foster education and outreach

5 RESEARCH PLAN GOALS

For each of the following goals, it was recognised in the first instance that the Implementation Plan should take full account of recommendations contained in the Oslo Workshop report.

5.1 Societal and Economic Research Applications (SERA)

It was agreed that Brian Mills (with assistance from others from the Working Group on SERA) would be the key Steering Groupcontributor to this section of the Plan.

In a presentation provided by web conference, Brian Mills noted that:

- Costs (of developing, providing, and using enhanced predictions) are as important to understand as are the potential benefits
- Longitudinal analysis/perspective and comparison across social, institutional and cultural geography is critical
- Value accrues in use (decision-action-consequence web) and is highly dependent on the context, situation and capacity of the individual, group or organization
- Primary entry point should be through National Meteorological and Hydrometeorological Services (NMS) (i.e., those presently providing services)

In terms of benefit areas (which is also relevant to the proposed Plan chapter on benefits) he saw a useful distinction betweenpurely regional benefits to residents and indigenous communities; extra-regional benefits such as safety, security, sovereignty and the environment, as well as improved prediction in other regions; and benefits which overlapped these (e.g., energy, minerals, fisheries, water, transportation, tourism, R&D, environment, worker/visitor safety).

He felt that key elements of SERA research would include:

- literature review and survey of a cross-section of users to establish and confirm weather-related sensitivities/risks, and benefit areas
- evaluation of prediction/service costs and benefits through an analysis of the risks, opportunities, constraints, and decision problems confronting users (and developers/producers) and their approaches to decision-making
- consideration of unique traditional and local knowledge perspectives

It would be important to recognise,exploit and link to completed and ongoing R&D such as that carried out for IPY, by ArcticNet (http://www.arcticnet.ulaval.ca/), the Arctic Climate Impact Assessment (http://www.acia.uaf.edu/), and research to be carried out to document the expected benefits of the Canadian Polar Communications and Weather Satellite mission (http://www.asc-csa.gc.ca/eng/satellites/pcw/overview.asp).

SERA research should be conductedin collaboration with the International Social Sciences Research Council (ISSC) (http://www.worldsocialscience.org/) and member associations, the Arctic Council (http://www.arctic-council.org/index.php/en/), counterpart Antarctic organizations, WMO Public Weather Services, and of course WCRP.

5.2 Verification

It was agreed that Pertti Nurmi (for atmosphere) and Greg Smith (for sea ice) would be the key Steering Group contributors to this section of the Plan.

In additional to traditional verification statistics (e.g., of Z500) there will bethree kinds and purposes of verification needed:

- Model-improvement(or diagnostic) oriented– verifications to assist in understandingerrors in order to improve process modelling. This is related to use of diagnostics to improve modelling. It could, for instance, verification of near-surface conditions to guide improvements in the modelling of boundary layer processes.
- Satellite-oriented – because satellite data will dominate the assimilation process, one major aspect of verification will be the use of in situ observations to improve/verify satellite retrievals. Satellite observations will also dominate the verification statistics.
- User oriented (including specific polar factors such as fog, visibility, blowing snow). Input from SERA is required to help specify what users are interested in. Verifications will be different over land, snow, ice and sea. New verification metrics will likely be required.

Verification in polar regions is made more difficult by the paucity of observations (particularly ground-based), their error characteristics, and by model analyses being thus largely influenced by the model itself rather than constrained by observations. Reanalysis data sets in the Arctic primarily represent the model physics rather than observations, especially in the lower troposphere.

For model-improvement oriented verifications, there may be value in forecast verification in observations space, by applying observation operators to the forecasts and comparing them with observations (including satellite radiances). But current satellite observations are not sensitive to the most important features in polar regions(e.g., snow/ice conditions, 2m temperature, boundary layer structure, lower level moisture, low-level clouds).

To provide an integrated measure of model accuracy for clouds, verification using ground-based radiation measurements would be ideal. Peter Bauer also cited as an example the impact of the revised ECMWFcloud scheme on mixed phase clouds directly affectingcloud radiative properties, and causing excessive night-time cooling, and amplified 2m temperature biases in the Arctic including Scandinavia. Additionally, verification is needed at the moderate resolution typically used for numerical forecasts, not just at the fine scale often used for process studies of clouds.

Existing figures and research results from Concordiasi could be useful to show the unique problems in the polar regions, including model biases. An existing presentation by Peter Bauer to WGNE on “normal” verifications but applied just to polar regions could also be useful as a baseline for both existing skill and available verification measures. However, verification metrics tailored to polar areas need to be defined.

The importance of verifying ensemble means (or medians) as well as spread/probability characteristics for ensemble forecasts was stressed. In general, detailed verification or probabilistic forecasts is required.

Verification of sea ice would be an important component of the project. Sea ice is important for users, particularly in coastal regions, and also integrates the past history of atmospheric and ocean changes. Sea ice analysis will be an important resource, and the GlobIce project (http://globice.mssl.ucl.ac.uk/) was noted, as well as an initiative on sea ice data by JCOMM.

5.3 Predictability and forecast error diagnosis

It was agreed that the following would be the key Steering Group contributors to this section of the plan:

- Short Range: Trond Iversen
- Medium Range: Peter Bauer
- Seasonal, and Sea Ice: Marika Holland (subject to confirmation)

It will be important to distinguish between uncertainty related to modelling versus that related to initial uncertainty. Much of the discussion on this research goal was around "predictability" studies to understand what is important to include in prediction systems. This will depend on what needs to be included for short, medium and seasonal range, and incorporates studies of flow dependence, and processes.

Potential predictability experiments will be carried out with coupled models to further our understanding of the predictability of the polar weather and climate on longer time scales.

The Canadian experience (see Section 3.3) is that moving to a full atmosphere/sea ice/ocean coupling was a key reason for predictability improvements. A figure from Gilbert Brunet on this could be useful for the Plan.

Predictability of sea ice itself needs to be covered, as well as atmospheric predictability. But there may also be a specific focus on sea ice impacts on atmospheric predictability. For instance, Peter Bauer referred to ECMWF studies on the impacts of having correct sea ice representation on predictability in the medium range, by running hindcasts using observed sea ice (the current ECMWF model persist sea ice for 10 days).

There could be merit in a specific focus on short-term predictability of polar lows – it is unclear why some are more predictable than others, and they have unique characteristics. This could be partly related to initialization, since 4DVAR is done at around four times the grid spacing of the prediction model for computational effort and linearity reasons. However, the lows can spin up very rapidly throughout the integration of the high-resolution forecast model.

Predictability in relation to model resolution could be studied, noting the results of other initiatives such as Project Athena, whichwas an indirect outcome of the World Modelling Summit (see, for example, http://www.cisl.ucar.edu/dir/CAS2K11/Presentations/miller/CAS2K11-web.pdf).

It was stressed that a lot of polar predictability studies could be carried out by exploiting existing data sets such as TIGGE and YOTC, although there may be a need to obtain additional variables which are unique to polar regions.

There remains a question on the impact on predictability of the diagnosis/initialization of the subsurface ocean.

5.4 GlobalLinkages or Interactions

It was agreed that Thomas Jung would be the key Steering Group contributor to this section of the plan.

In some respects this research goal area is again about predictability, but specifically about the influence of the polar regions on predictability in the rest of the globe, and of conditions in lower latitudes (especially the tropics) on predictability in polar regions. Flow-dependence of this linkage should also be investigated.

For polar influences on the rest of the globe, a Canadian study on the value of one extra radiosonde in the north for predictions over southern Canada was cited. Cold-air outbreaks are also important.

MJO influences on the Arctic Oscillation and the Southern Annular Mode (SAM) could be further researched.

It was also noted that any global model bias towards storm tracks being too meridionalcould potentially have implications for heat transport between middle and higher latitudes.

5.5 Physical, Dynamical and Chemical Processes

It was agreed that Chris Fairall, Ian Renfrew, Keith Hines/David Bromwich, Gunilla Svensson and Greg Smith would be the key Steering Group contributors to this section of the Plan.

The meeting noted that in polar regions, perhaps more so than in other parts of the globe,all the processes are highly interactive – so if possible an integrated approach involving all processes was important, rather than addressing them in isolation.An error in one process could quickly compound and affect all other processes and either amplify the overall error or compensate for the initial error, thereby hiding it. Hence, it is important to validate with process-level observations and avoid solely using basic integrating parameters, such as surface temperature. Furthermore, innovative validation techniques, such as process validation, often provide more insight into error sources and whether the process interactions in the models are similar to those in the observations.

Other special characteristics of polar regions include the long winter night with no diurnal cycle, the ubiquitous Arctic inversion and large atmospheric stability, and the prevalenceof mixed-phase low-level clouds in all seasons (even at temperatures below -30°C). Other difficulties for modelling in polar regions includethe tendency of the few Arctic data sources for assimilation, verification, and user impacts to be biased towards coastal areas. Interior land areas and sea ice regions are clearly underrepresented, and the spatial representativity of these coastal sites, many of which are also in complex terrain, is unknown.

Many weather forecast models also use a too-diffusive scheme for the stable boundary layer in contrast to what local observations show. This is motivated by meso-scale variability, terrain heterogeneity, etc., but is not yet understood and might also partly compensate for errors in downwelling long-wave radiation. Furthermore, sensitivity experiments on drag over land show a direct impact on the planetary scales in terms of storm track position and blocking frequency. The uncertainty in the momentum budget is large in models and needs further attention.

The meeting considered whether there was a specific need for additional chemistry expertise on the Steering Group. Since clouds are so important and need to be correct in the polar regions, and aerosols and microphysical process are therefore important, the research plan needed to account for enoughchemistry to handle that as a first order effect. The aerosol-cloud interactionis not well understood and not properly represented in models and should receive very high priority. The meeting also notedthe view of the CAS Management Group (see section 3.2) that the WWRP/THORPEX Polar Prediction Project should include the study of the influence of atmospheric contaminants on polar weather and climate, the role of Black Carbon (BC) and the role of aerosols in general in the modification of Arctic fog and cloud prevalence, being specific examples.

Given the importance of stratospheric ozone and chemistry to the time scales involved in the WCRP Polar Initiative, it was agreed that it could be best to leave WCRP to have this expertise, while this Steering Group concentrated on ensuring enough expertise in tropospheric aerosol.

While the meeting recognised the issue of Black Carbon for Arctic regions, it was a lower order effect by comparison to tropospheric aerosol, so it would be a matter of priorities for the project as to how much effort could be expended on it. It was also noted as an example that the existing ECMWF model did not even handle snow on sea ice, so any albedo impacts of deposited BC was certainly lower order.Furthermore, recent observational analyses suggest that surface albedo effects of BC on snow are less than albedo uncertainties produced by other poorly understood processes, such as snow-grain metamorphosis and cloud spectral effects. BC could perhaps be included in the second half of the ten year plan.

The meeting noted the inclusion of "environmental prediction" in the agreed Mission (see section 4.1) and confirmed the implication that chemical weather prediction, including air pollution issues, should therefore be covered under the plan, even if they had a lower priority initially.

Inclusion of the water cycle (also required for environmental prediction)is needed in coupled model forecasts – water balance, soil moisture, fresh water runoff all need to be taken into account. There are unique Arctic issues of fresh water outflowfrom rivers into the sea, which can then quickly freeze. Thisis not well handled in models, and information on the river flow is also lacking.

The meeting agreed that a good first step could be to document the current status of commonly used models and how they treat some key processes which are important in polar regions – a kind of gap analysis, to show where improvements could be made. It was also noted that processes are an integral part of the data assimilation and need to be correctly represented there as well as for the prediction model. A few process-level data sources/sites are available for such model process evaluations. Long-term sites are generally located in coastal regions and/or complex terrain (e.g., Barrow, Eureka, Alert, Ny Aalesund, Summit, Tiksi, Sodankylä), but some shorter-term field programs have provided useful data of similar breadth and quality over sea ice (e.g., SHEBA, AOE-2001, ASCOS, Russian drifting stations).

Resolution is also an issue for this research goal. How relevant are process studies on sub-km scales to typical horizontal model resolutions of 10 km or so? What are the "grey zone" issues of the treatment of convection for polar prediction, or are other than convection grey zone issue more important in polar areas? What are the resolution issues for dealing with coupled sea ice modelling where very fine resolution may be needed for the representation of leads, etc.?

The meeting agreed that the overall goal would be to improve modelling systems. Metrics would be needed to track progress, and should be designed as part of the Verification Goal (see 5.2). Some of the research strategies to achieve this overall goal are:

- Develop integrated parameterization schemes to account for the strong interaction between different processes, which is special to polar regions

- Develop forecasting systems which can deal with the special physics of polar regions, rather than being simplified as presently to be suitable for the rest of the globe

- Improve representation of key processes in models:
    - Boundary layer (especially stable boundary layers) and mixed phase clouds
    - Representation of surface characteristics (ice, snow, melt ponds) and implications for fluxes and albedo

    - Aerosol-cloud interactions (e.g., cloud condensation nuclei (CCN), ice nuclei (IN), aerosol sources),
    - Ocean mixing and entrainment (e.g., lack of breaking wave-induced mixing under ice, very strong barrier layers, complexities of ice mechanics)

- Develop parameterization[1] schemes which take into account the special characteristics of model uncertainty in polar regions

- Improve models and data assimilation systems to account for issues which are quite special to polar regions – in particular, coastal observations in regions of high gradient of weather elements, orography, and surface characteristics

- Encourage innovative sources of operational synoptic data over the Arctic Ocean, such as regular dropsonde flights with unmanned aerial vehicles e.g., Unmanned Aircraft System (UAS)– GlobalHawk

- Running operational modelling systems in fully coupled mode (atmosphere, land, snow, ocean and sea ice) to enable seamless prediction from days through to a season

In order to make progress on these various research strategies, the concept of a testbed approach was raised. This was further explored under Agenda Item 6.

Polar parameterization issues are common for models on all time scales. Thus, close collaboration with the WCRP Polar Initiative is expected concerning these issues.

5.6 Ensemble Forecasting

It was agreed that Francisco (Paco) Doblas-Reyes and Trond Iversenwould be the key Steering Group contributors to this section of the plan.

The overall goal is to develop methods for reliably representing both initial and model uncertainty in ensemble forecasting, which work well specifically for the polar regions. Uncertainty will be considered in the atmosphere, ocean and sea ice. As with other research goal areas, there will be a need to focus on what is specific about these regions. Some factors that need to be considered are:

(1) Instability sources
(2) Model error characteristics
(3) Observational error characteristics
(4) Lack of knowledge of ice edge, snow, ice thickness, etc., all of which have very nonlinear impacts
(5) Representation of initial uncertainty (from,e.g., ensemble data assimilation, singular vectors suitable, breeding, two day model errors, estimates of observational uncertainty)
(6) Representation of model uncertainty (e.g., stochastic physics, stochastic kinetic energy backscatter– see also discussion in section 5.5)
(7) Potential predictability in polar regions

The meeting recognised that ensemble systems,including multimodel ensembles, are becoming increasingly used and of interest to NMHSs in support of operational prediction.Furthermore,

[1] The meeting noted the different motivations for stochastic parameterizations – they may be intended to provide ensemble spread, or to recognize the true uncertainty in the actual parameterization

ensembles lend themselves to the provision of probabilistic forecasts, which can provide more value for decision making.

The TIGGE database could be a resource to be exploited to assess the value of multi-model approaches in polar regions. However, there may be the need for additional variables in the TIGGE database specifically of polar interest.

5.7 Data Assimilation

It was agreed that Peter Bauer, David Bromwich/Keith Hines, Greg Smith (for ocean/sea ice) and Thomas Jung would be the key Steering Group contributors to this section of the Plan.

The meeting discussed some of the unique aspects of polar regions in terms of data assimilation. Some of these are related to other research goal areas.

- The need for coupled data assimilation, including assimilation ofmulti-category sea ice, and water salinity
- Paucity of observations
- Unique character of observations (many are coastal in the Arctic)
- Limited sensitivity of satellite observations to atmosphereabove snow and ice (see Oslo report)
- Model error is important and not well known (and error formulation represents polar areas less well)

A specific and focussed research goal could simply be phrased as : “Better utilization of coastal observations”.

It was also noted that many near surface observations are of little use to data assimilation due to detachment from the free atmosphere, especially with the winter inversion. For the free atmosphere, radiosondesor other means of gaining vertical profiles are especially useful for DA. AMDAR reports from commercial aircraft are also helpful.

The meeting discussedthat there are many challenging issues having to do with the water cycle, and ocean and ice data assimilation, with strong links to the WCRP Polar Initiative and to CLIVAR’s Global Synthesis and Observation Panel (GSOP). Existing models tend to use climatological river discharge. Salinity is near zero for the fresh water discharge which then forms stratified layers which can rapidly freeze.In this regard, the meeting noted the existence of an Arctic HYCOS project involved the circumpolar countries, as well as the Global Runoff Data Centre under the auspices of GEWEX(http://www.gewex.org/grdc.html) which includes Arctic components.

5.8 Observations

It was agreed that David Bromwich/Keith Hines and Chris Fairall would be the key Steering Group contributors to this section of the Plan.

The meeting discussed the merits of special field campaigns for additional observations. They agreed that any such observations should be primarily aimed at better understanding and improved modelling of physical processes, since the aim of the project is to improve prediction systems, with a secondary goal of better model initialisation (to thereby assess the impact of additional observations on forecast accuracy).Ideally, a new campaign should extend over at least a year. Such a campaign could be modest, or it could be much more extensive if the benefits were clear and well supported by funding agencies.

Lessons could be learned from previous projects such as Concordiasi (http://www.cnrm.meteo.fr/concordiasi/) and SHEBA (http://data.eol.ucar.edu/codiac/projs?SHEBA).

The meeting noted that the establishment of a long-term (1+ years), international, interdisciplinary drifting station in the Arctic Ocean is currently being recommended by the International Arctic Science Committee Atmospheric and Cryospheric working groups (IASC-AWG,CWG), and the U.S. National Science foundation has shown interest. Such a station would provide the data necessary to understand the new and changing sea-ice environment with a recent change to primarily first-year ice, evaluate processes and process interactions in current models, and foster improvements to atmosphere-ice-ocean models on all time scales.

Whether or not there was a special campaign as part of *this* project, the meeting recognised that there would be other groups planning field observational campaigns anyway, and if possible there should be coordination toencouragea focus on observations which were useful for process studies and improved modelling, and with access to data in a timely manner. It was also recognised that there needed to be full coordination with WMO initiatives on observations under the auspices of bodies such as the Commission for Basic Systems (CBS) and the WMO/IOC Joint Commission for Marine Meteorology and Oceanography (JCOMM). This could include potential ASAP observations as shipping opened up in the Arctic. And, in general, there should be an effort to make sure that additional observations were made available in real-time via the GTS and WIS so they could be utilised in operational prediction systems.

Because of the current significant model biases in polar regions, Observing System Simulation Experiments (OSSEs) were not seen as a useful way of assessing the impacts of new observations, but could be useful later in the ten year period of the Project.

On the other hand, creative use of Observing System Experiments (OSEs) can help us understand the value of individual observations – for example, it was discovered that most Arctic Summer Cloud Ocean Study (ASCOS) data failed to get into the GTS in a timely manner, thus it was not assimilated by operational prediction services). This also emphasised the point that, ideally, any measurements

In terms of sea ice, observations of ice type, ice thickness, ice age, and snow on ice were seen as crucial. For this, and in general for observations in polar regions, the role of satellites was clearly pivotal.

Finally, the meeting was joined by Barry Goodison from the WMO Secretariat, who would welcome input on observational requirements for the Global Cryosphere Watch (GCW). This would assist in encouraging countries to compile and make cryospheric data more available.

6 STRATEGIES TO ACHIEVE & PROMOTE THE GOALS

The meeting discussed seven strategies for achieving progress in the research goal areas covered in the previous section. A recurring theme was that establishing a testbed could be an overarching strategy that would focus efforts and thereby facilitate many of these seven strategies. This is explored further in section 6.8.

6.1 Enhance international and interdisciplinary collaboration

Incentives for such collaboration could include the testbed proposal, which would bring scientists together to focus on improvements, as well as making use of existing and new datasets resulting from the project.

The meeting noted that integrated effort across different scientific disciplines was especially important for prediction in polar regions, because the community is relatively small and field campaigns are expensive.

To some extent, collaboration would naturally increase as a result of consultation on the Plan and shared goals for the research.

6.2 Strengthen linkages between academia, research institutions & operational centres

The meeting discussed some UK, USA and Canadian examples of explicit incentives from funding agencies for such collaboration, as well as other strong linkages in Sweden.

It was felt that using the Implementation Plan to explain and promote the benefits of these linkages could inspire funding agencies to adopt this approach, and ensure that research results are implemented in operational centres.

Other incentives for collaboration could include operational centres making computer time and other resources available for students and researchers, although operational constraints on resources and the complex nature of some operational systems could be an issue. ECMWF makes available computing resources for special Member State projects that could be used in Europe.

It was again noted that the testbed approach could facilitate these linkages, with academia and research institutions invited to collaborate on operational system development.

6.3 Establish and exploit special research data sets: TIGGE, YOTC, reforecasts etc.,

The meeting first discussed the use of existing datasets, and agreed on the need to compile a list of what was already available and potentially useful for pursuing the research goals. Some examples were the data from Project Athena (http://wxmaps.org/athena/home/), GlobIce (see section 5.2), IPY data (see the catalogue at http://ipycoord.met.no/).

In terms of new datasets, it was first suggested that one role of the Project could be to recommend what data should be archived and made available in reforecast experiments, for example under the auspices of the Working Group on Seasonal to Interannual Prediction (WGSIP). WGSIP will also provide the IceHFP experiment data from the CHFP dataset.

Ideally, any new special data sets should be of sufficient length to allow systematic investigation of forecast quality, verification, etc., and be openly accessible and sustainable. If an observational component (field campaign or Intensive Observing Period) of a testbed concept evolves, then this should be supported by relatively long-term reforecasts (etc.) encompassing this period.

It was recalled that ECMWF had made some special reforecasts to support YOTC, and could be requested to carry out a similar exercise in support of this project.

The Plan could perhaps include high level guidance on model experiments for establishing such new datasets, given the special nature of polar prediction, and also the importance of coupled models including sea ice. (Reanalysis of both the atmosphere and sea ice is essential.)

6.4 Linkages with space agencies and other data providers

Given the paucity of observations in polar regions, satellite information will be a key component of improved polar predictions. Linkages with them may best be via EC-PORS, which has a Space task Group.

6.5 Promote interaction and communication between research and stakeholders

Although more work was required to identify stakeholders, the meeting felt that examples included:

(1) NMHSs
(2) Arctic Council (IASC)
(3) SCAR
(4) WMO Technical Commissions
(5) Private sector service providers

Interactions would vary with the stakeholder group. For instance, briefings and feedback on the project should be provided to the annual meeting of the Executive Council, and to sessions of the WMO and other bodies. Interactions with the private sector might be through participation in existing conferences which they attended, or through the holding of special workshops.

It was noted that IPY2012 in Montreal in April 2012 would bring together many stakeholders and scientists. Arrangements had already been made for Thomas Jung to make a presentation in his role as Chair of the Steering Group, but he could make use of other opportunities to meet with stakeholders.

6.6 Maintain strong linkages with other initiatives

The meeting discussed many other related initiatives, and how strong the linkages should be with them. A tentative list of Working Groups, and of Projects, is provided in Annex 3. This list needs to be further elaborated. Each of these entities should be consulted and kept up to date on progress on this Plan.

6.7 Foster education and outreach

In general, the meeting felt that this should be an important part of the project, and much could be learned from the experiences of IPY.

In particular, it would be useful to engage strongly with the Association of Early Career Polar Scientists (http://www.apecs.is/) and to have a presence at the annual Antarctic Meteorological

Observation, Modelling and Forecasting Workshop. The sixth one http://www.cawcr.gov.au/events/amomfw_2011/ was held in Australia, and the seventh is planned for Boulder, Colorado, USA during 9-12 July 2012.

Summer schools provide an excellent opportunity, and it was noted that WWRP was planning one in 2013 on Earth System Modelling that could have a polar prediction component.

ECMWF could potentially hold a seminar on polar prediction, co-organised by WWRP/THORPEX.

6.8 Testbed Concept

The meeting felt that there were many potential advantages to setting up a testbed or testbeds as part of the Polar Prediction Project. It was likely to be at least two, in order to cover both southern and northern polar regions.

A testbed would foster relationships with partners, provide common focussed objectives, and perhaps be held over a one year period in association with a field campaign providing additional observations. It could be established to coordinate with any existing planned activities. A one year Intensive Observing Period (IOP) could provide data for denial experiments to show the impact on forecast accuracy, but the observations would likely be primarily aimed at improving modelled processes and satellite retrievals. Also, the currently assimilated data has limited sensitivity to near-surface processes (boundary layer, low-level clouds, snow) so that the denial experiments would not necessarily provide all the information required.

Given the timescales extend out to a season, there should be coordination with WCRP Transpose-AMIP (Atmospheric Model Intercomparison Project) and WGSIP.

The meeting decided that this concept should be explored further, taking into account existing WWRP guidance on Research Development Projects and testbeds, and in accordance with the WWRP Strategic Plan.

7 GOVERNANCE, MANAGEMENT & FINANCES

7.1 Project Office

Establishment and hosting of a project office should be an integral part of the plan. A host institution would normally provide office facilities and administration support, and sometimes also salary support. The arrangements used for YOTC and SPARC should be explored as a possible model. Thomas Jung was requested to explore one possible host institution.

7.2 Steering Group Operation

It was agreed that after the initial meetings to complete the Implementation Plan, the Steering Group would probably need to meet about once per year to review progress and ensure momentum. All other Steering Group work would be by email and other electronic communication.

7.3 Steering Group Terms of Reference

The meeting reviewed draft terms of reference, and requested the Chair and Secretariatto further revise them to ensure consistency with other WWRP/THORPEX groups.

7.4 Monitoring and Review

The meeting recognised the need to establish Key Performance Indicators and other measures of success of the project upfront as part of the Implementation Plan.

7.5 Funding

The meeting discussed four types of activities for which funding would be needed for the project, and potential funding sources. These will need to be further elaborated in the plan:

(1) Steering Group meetings
(2) Project office IPO salary and operation
(3) Workshops/seminars – some funding could come from WMO regular budget+
(4) Science campaigns – external funding sources.

The meeting decided that the establishment of a Polar Prediction Project Trust Fund should be explored, which could be used to support at least some of the requirements for the first three items above, during the ten year duration of the Project.

8 FUTURE PROCESS

8.1 Composition of Steering Group

The meeting discussed whether the current composition (including members who had not been able to be present) was appropriate. It was agreed that it was for now, although there could be a need in future for invited experts on particular topics. (e.g., for additional expertise on tropospheric aerosol). The WMO Consultant was also requested to seek input and comments from other Southern Hemisphere colleagues as the Implementation Plan was further developed.

8.2 Next Steps

The WMO Consultant, Neil Gordon, will continue to work on the draft Implementation Plan in close coordination with the Chair, Thomas Jung.

Discussions recorded in Section 5 of this report had covered many aspects of the eight research goal areas. These discussions, together with information from prior meetings, in particular the Oslo Workshop (see section 3.1), will assist in formulating the relevant sections of the Implementation Plan. Key inputs will be provided by members of the Steering Group as detailed in Section 5.

The final draft of the Implementation Plan will be considered by the next meeting of the Steering Group, tentatively planned for Montreal in the last two weeks of March.

9 CLOSING

Following the customary exchange of courtesies, the meeting closed at 1445 on 1 December 2011.

ANNEX 1: LIST OF PARTICIPANTS

BELAND Michel President of CAS	Environment Canada 2121 Trans-Canada Highway 5th floor DORVAL, QC H9P 1J3 Canada email: michel.beland@ec.gc.ca
JUNG Thomas Chair	Alfred Wegener Institute for Polar and Marine Research in the Helmholtz Association Am Handelshafen 12 27570 BREMERHAVEN Germany email: thomas.jung@awi.de
BRUNET Gilbert Chair of WWRP/JSC	Environment Canada 2121 Trans-Canada Highway 5th floor DORVAL, QC H9P 1J3 Canada email: gilbert.brunet@ec.gc.ca
BAUER Peter	ECMWF Shinfield Park READING, RG2 9AX United Kingdom email: p.bauer@ecmwf.int
DOBLAS-REYESFrancisco Javier	Institut Catala de Ciencies del Clima (IC3) Doctor Trueta 203 BARCELONA 08005 Spain email: f.doblas-reyes@ic3.cat
FAIRALLChristopher	NOAA/Office of Oceanic and Atmospheric Research Physical Sciences Division 325 Broadway Room 3B 117 BOULDER, CO 80305-3328 USA email: chris.fairall@noaa.gov
HINESKeith	Ohio State University 108 Scott Hall 1090 Carmack Road COLUMBUS, OH USA email: hines.91@osu.edu
IVERSENTrond	Norwegian Meteorological Institute Present affiliation: ECMWF

	Shinfield Park READING Rg2 9AX United Kingdom email: trondi@met.no
MILLSBrian (Participated by web conference, 1400-1730, 30 November 2011)	Adaptation and Impacts Research Environment Canada C/- University of Waterloo WATERLOO ON N2L 3G1 Canada email: bmills@uwaterloo.ca
RENFREWIan	University of East Anglia NORWICH, NR4 7TJ United Kingdom email: i.renfrew@uea.ac.uk
SMITHGregory (Participated by web conference, 1400-1730, 30 November 2011)	Environment Canada 2121 Trans-Canada Highway DORVAL QC H9P 1J3 Canada email: gregory.smith@ec.gc.ca
SVENSSONGunilla	Department of Meteorology Stockholm University 106 91 STOCKHOLM Sweden email: gunilla@misu.su.se
TOLSTYKHMikhail	Institute of Numerical Mathematics Russian Academy of Sciences 8 Gubkina street MOSCOW Russia email: tolstykh@inm.ras.ru
WMO SECRETARIAT	
TERBLANCHEDeon D/ARE	DTerblanche@wmo.int
NAKAZAWATetsuo C/WWR	TNakazawa@wmo.int
RYABININVladimir, WCRP	VRyabinin@wmo.int
TOURNIERNathalie, WWR	NTournier@wmo.int
GORDONNeil WMO Consultant	Neil.D.Gordon@gmail.com

ANNEX 2: AGENDA

1. OPENING *[0900-0915]*
1.1 Welcome and introductions

2. ORGANIZATION OF THE MEETING *[0915-0930]*
2.1 Adoption of the agenda
2.2 Working arrangements

3. BACKGROUND TO THE POLAR PREDICTION PROJECT & RELATED INITIATIVES *[0930-1100]*
   3.1 Oslo Workshop (Gilbert Brunet)
   3.2 THORPEX ICSC-9 (Tetsuo Nakazawa)
   3.3 EC-PORS and GIPPS (Thomas Jung on behalf of Peter Lemke)
   3.4 WCRP Polar Initiative (Vladimir Ryabinin)

4. IMPLEMENTATION PLAN OVERVIEW *[1100-1300]*
   4.1 Existing Draft and Key Project Objectives (Thomas Jung)
   4.2 Agreement on Overall Structure and Chapters

   Lunch [1300-1400]

5. RESEARCH PLAN GOALS *[1400-1730]*

   Thursday 1 December (continue with Item 5 if required)

6. STRATEGIES TO ACHIEVE & PROMOTE THE GOALS [0830-1100]

7. GOVERNANCE, MANAGEMENT & FINANCES [1100-1230]

   Lunch [1230-1330]

8. FUTURE PROCESS *[1330-1445]*
   8.1 Confirmation of lead authors
   8.2 Process for collaborative editing
   8.3 Timeline and milestones
   8.4 Next Steering Group meeting
   8.5 Composition of Steering Group

9. CLOSING [1445-1500]

ANNEX 3: TENTATIVE LIST OF RELATED WORKING GROUPS AND PROJECTS/INITIATIVES

Each entity has a star rating giving the approximate level of interaction required.

LINKAGES WITH WORKING GROUPS:

WCRP

- Polar Initiative – *****
- Subseasonal to Seasonal Prediction Project (joint WWRP/WCRP) - *****
- GEWEX – Global satellite datasets; boundary layer; regional projects. GASS/GABLS ****
- CHFP (Coupled Historical Forecast Project) ***
- SPARC - *** (focus on polar vortex; link at subseasonal scales, including stratospheric warmings)
- CliC - Arctic Sea Ice WG - **

WWRP/THORPEX Working Groups

- Mesoscale WG - ***
- Nowcasting WG - *
- PDP WG (mostly mid-latitudes and tropics – could be encouraged to consider polar regions) - **
- SERA WG - *****
- Verification WG (Joint WWRP/WCRP) - *****
- TIGGE/GIFS - ****
- DAOS WG - ****
- Regional THORPEX Committees - **

WGNE (joint CAS/WCRP) - *****

EPAC/GAW - ***

GCW - *****

IASC Atmosphere Group (ice floe experiment) – not formally connected to WMO - *****

LINKAGES WITH KNOWN HIGHLY RELEVANT PROJECTS/INITIATIVES

ACCESS (FP-7 Climate change impacts polar areas)

SEARCH (sea ice parallel to THORPEX; funded by NOAA and NSF)

Sustaining Arctic Observing Network (SAON)

GODAE (Global Ocean Data Assimilation Experiment) Oceanview. Providing ice/ocean forecast intercomparison similar to TIGGE.