Near-Term Climate Prediction

A Concept Note Submitted to WCRP JSC
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1. Context

Why do we need a Grand Challenge on Near-Term Climate Prediction*?*

The evolution of climate in the near term, out to a decade or two ahead, is the combination of natural climate variability and human-forced climate change. This combination both determines the shift in the mean climate over the period of interest but also affects the risk of extremes or unprecedented events, which impact human activity and well-being (*Meehl et al., 2014*). For example, natural variability can cause changes in storm paths and intensities (and hence weather risk to property and life) or in rainfall and temperature (and hence water shortages, drought and flooding). These changes in natural variability are large enough from one decade to the next to temporarily exacerbate or counter underlying anthropogenic trends. This is the case in most parts of the world as changes in circulation arising from atmospheric and oceanic natural variability such as the El Niño-Southern Oscillation and the annular modes, or the slower variations associated with Pacific and Atlantic decadal variability significantly affect regional surface climate variability and trends. Even the rate of warming of the planet as a whole under the influence of increased greenhouse gas concentrations is significantly affected by regional modes of climate variability on decadal timescales (*Kosaka and Xie, 2013*).

Climate projections out to a century ahead based on a range of potential anthropogenic greenhouse gas and industrial aerosol emission scenarios have been successfully coordinated, produced and analysed several times under the WCRP's Working Group on Coupled Modelling (WGCM) through the Coupled Model Intercomparison Project (CMIP). These projections, and the detailed information derived from them, have been used to inform governments of the long-term risks due to climate change via the Intergovernmental Panel on Climate Change. These projections provide the mean, long-term path of the anthropogenically-forced climate embedded within a wide envelope of uncertainty that the internal variability might fall within. However, the projections do not account for the actual, initial state-dependent evolution of climate in the near term. The most recent CMIP experimental protocols included *initialised climate predictions*, reflecting that the requirement is now for the time-dependent prediction of the combined impact of externally-forced and internally generated variability. This more specific and potentially more accurate information is important to a broad range of users of climate information who are engaged in near-term planning activities, and require regionally-specific *predictions* as they grapple to address the near-term risks imposed by the combination of anthropogenic climate trends and natural climate variability. Addressing this need can only be achieved by predictions initialized with the current climate state (*Smith et al., 2013*).

As an outgrowth of the WCRP/WGCM CMIP phase 5, world climate modelling centres have been seeking to harness global coupled climate models to explore the potential of initialized, multi-year to decadal climate prediction (*Smith et al., 2012; Kirtman et al., 2013*). These activities are continuing in the CMIP6-endorsed Decadal Climate Prediction Project (DCPP) and elsewhere. A Grand Challenge (GC) on NearTerm Climate Prediction (NTCP) is needed in order to support two things. First, research and development to improve multi-year to decadal climate predictions and the utility of the associated information. Second, the development of organisational and technical processes to underpin the future, routine provision of scientifically-sound, prediction services that can assist stakeholders and decision-makers. The latter will include greater international coordination and the development of recommendations on which conditions should be met prior to the

dissemination of forecasts. The Grand Challenge will include the synthesis of real-time prediction information from multiple existing, initialized prediction systems, an assessment of the confidence the scientific community has in the information, and the development of criteria that need to be satisfied before WMO would endorse and advise on how to implement the operational prototype services developed through the GC.

The Grand Challenge on Near-Term Climate Prediction will pursue the following objectives:

(1) To improve the quality of initialized decadal climate information and prediction
(2) To collect, collate, and synthesize the prediction output and tailor information to form the basis of a service that addresses stakeholders' needs
(3) *To develop processes to assess and communicate the degree of confidence and uncertainty in the predictions*

This GC on Near-Term Climate Prediction fills an important gap in the provision of seamless climate information that is bookended by seasonal-to-interannual climate predictions on the one hand, and multi-decadal and longer-term climate change projections on the other. The GC will be an important contribution to the provision of a seamless climate service, as recommended by the Global Framework for Climate Services.

2. Science Initiatives*:*

What are the main scientific Issues?

R&D to address objective (1)*:*

(a) There is a need to advance the science of decadal prediction, including the characterization and understanding of the sources of decadal predictability, the evaluation and improvement of the simulation of decadal variability in global models, the understanding of decadal variability in observations and quantifying prediction skill:

> *Essential background research is needed to identify and characterize sources of decadal predictability, and to understand the underlying mechanisms. Such research will build on activities sponsored under different WCRP Projects. The GC on NTCP will engage with the Project leadership and research groups to build on progress in existing research areas and to stimulate development of new projects which address the research gaps revealed during experimental and operational near term prediction activity.*

(b) There is a need to improve methods of model initialization and specification of external forcing agents (in particular solar variability, aerosols and volcanoes).

> *The GC on NTCP will pursue research on identification of observational needs, data assimilation and initialization and ensemble methods. It will work with WCRP model development and observational activities to improve external forcing inputs in coupled climate models.*

(c) There is a need to reduce the impact of initialization shock, model drift and model biases on the output of decadal prediction runs.

> *The GC will work with WCRP modelling groups to develop research projects that specifically assess and reduce shock, drift, and biases and statistical approaches aimed at reducing their impact on predictive skill.*

(d) Advance methods for drift and bias adjustment and downscaling necessary for region-specific, user relevant output.

Determine optimal methods to extract skillful signals from raw forecast ensembles through bias correction and statistical and dynamical downscaling or other techniques.

R&D to address objective (2):

(a) Mine and understand the value of information embedded in multi-model hindcast and forecast ensembles.

Explore the broad space of ensemble hindcast and forecast outputs in order to examine the relationship between internal variability and externally forced variations and trends. The transfer of information from predictable ocean variability to land is of particular interest, as is the information contained on extreme scenarios.

(b) Understanding how to combine forecast output and past observational statistics and scenarios (instrumental and proxy) in producing relevant near term climate outlooks.

Determine how best to use ensemble forecast output to predict the risk of extreme events on timescales out to decadal.

(c) Working with forecast providers to understand user's needs in terms of content and format.

Engage with users, national meteorological and hydrological services and WMO CBS-CCL to determine best presentation and dissemination methods.

R&D to address objective (3):

Determine and communicate forecast uncertainty, delivery of modeling products: use of single-model and multi-model ensembles.

Use multi-model ensemble hindcasts and observations to improve our ability to quantify uncertainty in collaboration with modelling centres and forecast providers.

Assess scientific opinion on the degree of confidence that scientists have in the forecasts.

Provide recommendations on what sort of information on quality and confidence should accompany forecasts provided to users.

How should these be addressed?

A plan to address these scientific challenges and issues above will be an important objective of the GC Steering Group. The first order approach should be establishing a prioritized list of the issues and opening links to the corresponding WCRP projects** and their panels (overseen by sub-groups of the GC Steering Group), as well as other groups. These could jointly develop plans to establish research goals, methods of scientific communication, and international research programs to be proposed to the WCRP JSC.

** *The scientific issues listed under the GC on NTCP are fairly comprehensive and many ongoing activities within WCRP are addressing the various aspects of these issues. One possible approach for this GC is to initiate focus groups that specifically evaluate the Near Term Prediction GC output. These focus groups could either involve or perhaps reside within existing ongoing activities.*

What are the linkages to other WCRP groups and initiatives (as well as outside of WCRP)?

There is a raft of research activity under WCRP and within WMO operational infrastructure that already contributes to the development and delivery of near-term predictions. The proposed GC will actively pursue effective communication with other WCRP projects, as indicated above, to address the relevant scientific issues.

There is a strong link to operational activities under the WMO, such as the Commission for Climatology, which already provide real time seasonal forecast information.

There are many links with research under the four core projects on climate dynamics and modes of variability (CLIVAR, SPARC) as well as climate change and the water cycle (GEWEX, CliC).

There are close links with WGSIP and WGCM and the Decadal Climate Prediction Project under CMIP6 as well as CORDEX.

The scientific issues are linked to other GCs: Clouds, Circulation and Climate Sensitivity; Weather and Climate Extremes; Melting Ice and Global Consequences.

How best to encourage involvement of early career scientist and under-represented countries?

- Develop uniform protocols and standards for delivery of decadal prediction products.
- Establish two-way communication with regional and national forecast centres in under-represented countries and train forecasters in the use of decadal climate prediction products (capacity building).
- Establish hands-on internships for early career and under-represented country scientists in leading modelling centres.
- Organize topical workshops for early career scientists.
- Involve early career scientists and under-represented countries in the production of a Global Decadal Climate Outlook each year.

3. Products/Deliverables

Proposed products and deliverables:

- A white paper (in e.g. EOS, BAMS, Science overview, etc.) that announces the creation of the WCRP GC on Near-Term Climate Prediction, its motivation, aims and research activities (2016).
- New scientific results from meetings and workshops dealing with research focussed on NTCP (ongoing).
- The production of standards, verification methods and guidance for near term predictions in collaboration with the WMO CBS/CCl Expert Team, which are seamless with long-term projections (2018).
- The achievement of WMO recognition for operational decadal predictions (2019).
- The initiation and issuance of a real-time Global Decadal Climate Outlook once each year (2016 onwards, with 2 years of dry running before issue) in consultation with CBS-CCL and following the template of the Global Seasonal Climate Update (GSCU) for seasonal predictions.

The main outcome from the GC-NTCP will be the raising of awareness within the scientific community and relevant stakeholders of *predictions* of the near-term evolution of climate due to *both* anthropogenic influence and natural variability.

Pursuing the deliverables and products listed above this GC will clarify and synthesize the predictions to address societal needs for useable climate information including key information on their limitations.

Such concerted effort on NTCP addresses present societal needs and emerging knowledge and will help define WCRP's next generation scientific objectives and research plans

4. Suggested Membership

Please suggest either some general ideas about membership (e.g. 'should include membership of XXX group') or feel free to suggest names, in particular leadership.

Adam Scaife and Yochanan Kushnir (co-leads), Joan Alexander (until Jan. 2016), George Boer, David Carlson, Francisco Doblas-Reyes, Ed Hawkins, Masahide Kimoto, Arun Kumar, Katja Matthes, Judith Perlwitz (from Jan. 2016), Scott Power, Marilyn Raphael, Akihiko Shimpo and Doug Smith
WCRP Secretariat support: Michael Sparrow and Matthias Tuma.

5. References/Appendices

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