BAMS
Meeting Summary

Recent Progress and Future Prospects of Subseasonal and Seasonal Climate Predictions

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2019 International Workshop on Climate Prediction: Past, Present and Future

What: Approximately 100 participants, who do research and modeling or work for operational communities, convened to share knowledge and experience, review the progress in operational practices and scientific studies related to climate prediction, and discuss current challenges and further perspectives for more reliable and useful climate forecast information.

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Where: Taipei, Chinese Taipei

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Over the last few decades, there have been tremendous advances in observing systems and improvements in understanding and forecasting capabilities of Earth's climate system. At the same time, the demand for and harnessing of climate prediction has been increasing in a range of applications. At present, weather forecasts and seasonal climate prediction are part of routine activities in operational centers across the world. In subseasonal forecasting, which had been considered a "predictability desert" (Vitart et al. 2014), there has been significant progress from both the weather and climate communities, coordinated internationally by the World Weather Research Programme (WWRP) and World Climate Research Programme (WCRP), and increased demands for operational forecasts to fill the gap between weather and seasonal climate forecasts. As a result, the Subseasonal-to-Seasonal prediction project (S2S) was launched as a joint project of the WWRP and WCRP in 2013.

To review the main operational and scientific advances and to discuss the challenges and future directions in subseasonal and seasonal climate prediction, the Asia–Pacific Economic Cooperation (APEC) Climate Center (APCC) held an international workshop[1] as a platform for operational and research communities to share their expertise, with a theme of present and future of subseasonal and seasonal climate prediction. The importance of this workshop was emphasized at the opening ceremony as a significant opportunity for sharing scientific outcomes and operational experiences to facilitate the exchange of information and knowledge between communities and as an example of the global efforts to promote international collaborations to enhance the prediction systems for more reliable and useful climate forecast information.

[1] The workshop was co-hosted by the Central Weather Bureau of Chinese Taipei (CWB). Presentations from the workshop are available online (https://apcc21.org/act/workView.do?lang=en&bbsId=BBSMSTR_000000000024&nttId=6117&pageIndex=1&recordCountPerPage=10&searchCnd=&cate1=&searchWrd=).

The main session began with the keynote speech by Francisco Doblas-Reyes, head of the department of Earth Sciences at Barcelona Supercomputing Center, focusing on the process of transitioning climate research efforts into the operational environment. He stressed that the requests for climate information come from a broad range of users and that needs should be addressed from an operational climate service perspective. To address this requirement, he emphasized a new paradigm of climate research, the "research–provider–service" chain, to be oriented both ways to promote two-way information exchange within the operational and user communities. Subsequently, Arun Kumar, principal scientist of NOAA's Climate Prediction Center, introduced the current World Meteorological Organization (WMO) operational infrastructure and activities on subseasonal to decadal prediction. He raised an issue with how hard it is to communicate climate prediction with user communities, particularly in the form of probabilities, and emphasized the importance of accessible information. In this respect, he noted that further research efforts are required to translate climate-centered information and knowledge more simply, easily, and clearly, and to provide guidance on some high-priority issues in advancing operational infrastructure, product development, and information communication.

Operational issues: Current status and progress of MME prediction systems

The multimodel ensemble (MME) technique has been considered an effective way of improving seasonal forecasts so that various MME prediction systems are currently utilized at major operational centers around the world. Through the meeting session on operational issues, speakers from APCC, North American Multi-Model Ensemble (NMME), Copernicus Climate Change Service (C3S), and the International Research Institute for Climate and Society (IRI) introduced their successful stories on the development of operational infrastructure. Particularly, APCC showed that their MME prediction system has been gradually enhancing forecast skill for the common hindcast period since its establishment, which is mainly due to increased participation in advanced forecast systems (e.g., state-of-the-art coupled models) and increased independencies between the contributing models. Most recently, C3S has developed an operational seasonal multiforecast system with five European contributor systems. MME operation groups have been striving to develop well-validated MME prediction systems for both operational and research purposes, and their efforts clearly showed better benefits than the contributing individual models. However, one speaker further pointed out that it is now time to compare the MME forecast skill with other worldwide MME groups rather than with individual contributors and then introduced ongoing research activities on this.

Most MME operational groups have been making efforts to provide free and open access to data, to move their release date earlier, and to encourage modeling groups to participate in MME for accessible, timely, and high-quality information to promote the uptake of climate information by application sectors. As such, there are lots of similarities in terms of scientific and technical challenges and opportunities faced in the MME operational centers. These common issues include bias correction, calibration, and combination; observational uncertainty; model resolution; interpretation of probabilities; and linking research, operations, and users that should be considered from both research and operational perspectives. From this point of view, the session emphasized the necessity for strong connectivity and collaborations between MME operational centers for sharing information and knowledge, and even the human and computer system resources directly or indirectly.

Modeling issues: Progress and challenges in climate modeling

Various endeavors to increase the accuracy of forecasts were presented in the modeling session. Several speakers highlighted the importance of realistic initializations and simulations of complex interactions (e.g., atmosphere–land) and processes. For example, it was reported that coupled model initialization with advanced ensemble ocean data assimilation leads to better skill at presenting seasonal sea surface temperature (SST) variation. As well, a burst ensemble with perturbed atmosphere and ocean initial conditions can provide a clear benefit in terms of greatly increased reliability compared to a time-lagged ensemble without ocean perturbation on a subseasonal time scale. One presentation on ensemble generation raised the issue that it is time to think about designing the ensembles to improve the model, instead of producing just forecasts. Also presented were issues with the interaction and consistency of physics modules: consistent treatment of total hydrometers in the cloud and radiation processes can lead to improved representation of solar radiation fluxes. The workshop noted that while these efforts have been made in operational modeling and research communities, the challenges still remain, including forecast initialization, atmosphere–ocean coupling, ensemble generation, and increasing model resolution.

Scientific issues: Validation, combination, and calibration

The meeting session on scientific issues began with a series of talks from operational and research work at APCC, CWB, IRI, and the Korean Institute of Atmospheric Prediction Systems (KIAPS) on S2S predictability, forecast verification, and product development. Several speakers addressed the predictability and prediction skill of large-scale atmospheric phenomena using the S2S database and the NOAA Subseasonal Experiment (SubX) project data. The subseasonal prediction skill is largely dependent on the amplitude and/or phase of the Madden–Julian oscillation (MJO), El Niño–Southern Oscillation (ENSO), and quasi-biennial oscillation (QBO), which are considered major sources of predictability for subseasonal forecasts. For example, it was demonstrated that subseasonal prediction skill tends to be enhanced during the easterly phase of QBO. One presentation drew attention to the verification framework for diagnosis of weather skill beyond two weeks and suggested that optimized spatial filters can detect reliable skill that far out, but they need to consider a linear spatial combination of variables as well as a spatial weight for minimizing mean square error. APCC and IRI were devoted to the emerging area of S2S forecasting for multimodel combinations, showing some promise in the development of a calibrated multimodel forecast product. However, it is still in the research stage and some issues to be considered before transition of research to operations remain, including robust results from comprehensive skill assessment with a large set of reforecasts.

On the seasonal time scale, the MMEs, widely used at major operational centers, are now broadly recognized as powerful tools in dynamical climate prediction as they account for overconfidence and uncertainties. It was highlighted that the potential benefit that can be expected by using the MME amplifies with the increase of the independence of the contributing models, showing that the Grand MME, exploiting together the MMEs independently developed by different communities, enhances significantly the skill in predicting seasonal mean temperature and precipitation. Indeed, a real-world forecast application showed significant enhancement of the potential economic value of the MME forecasts for energy demand over Italy, demonstrating the Grand MME significantly contributes to useful predictions at the seasonal time scale. It was also emphasized that increasing the ensemble size is needed to provide a probabilistic prediction of extreme events due to the fact that large ensemble size could capture the observed amplitude for tropical climate variability as well as extreme climate events.

Discussion on the way forward

Special emphasis in the discussion session was put on initiatives in developing coordination among operational centers providing MME-based seasonal climate predictions. While there are various sources of real-time seasonal prediction products based on well-validated MMEs across the world, such as Lead Center for Long-Range Forecasts MME (LC-LRFMME), APCC, IRI, C3S, and NMME, they have not converged on an optimal combination nor method for model calibration, which is mainly due to different characteristics of participating models and their datasets (e.g., model configuration, resolution, hindcast period). The issue that there are no significant improvements in multimodel systems was also raised. Therefore, a critical assessment of the current status of a multimodel system needs to be conducted, while setting the future direction so that the necessary resources can be put in place. In this regard, coordinated efforts were proposed to conduct a comprehensive forecast quality assessment of a massive dataset from various MME groups. Some consensus was formed on the need for this effort, given that there have been some studies done regarding multimodel comparisons, although it is still in the brainstorming state and needs closer discussion and more communication among related groups. It was mentioned that APCC is willing to support the efforts and take part in some activities.

There was an ongoing debate about whether the methodologies for model calibration and combination led to enhanced efficiency of the (simple) multimodel ensemble, even though many different approaches have been explored in research and operational seasonal prediction, showing some improved skill for specific targets. However, the model-weighted MME could probably improve the skill slightly, but it tends to be dependent on region, season, variables, and model, mainly due to a relatively small sample size for the estimation of conclusive and robust weightings of the individual forecast systems. Therefore, the workshop agreed that the improvement of individual models themselves in climate modeling aspects (e.g., coupling, dynamics, physics, etc.) is a more important contributor for more reliable MME prediction skill than that of model calibration and combination methods.

In the context of predictability sources, more focus needs to be on other sources of predictability for subseasonal forecasts, for example, soil moisture or the stratosphere, which has been the center of the second phase of the S2S project. Issues on the inconsistency of the initial conditions in reforecasts (or hindcasts) and a real-time forecast period were also discussed, which may be one of the reasons that predictability does not show skill improvement in real-time forecasts as compared with reforecasts.

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Reference

Vitart, F., G. Balsamo, R. Buizza, L. Ferranti, S. Keeley, L. Magnusson, F. Molteni, and A. Weisheimer, 2014: Sub-seasonal predictions. ECMWF Tech. Memo. 738, 45 pp., www.ecmwf.int/sites/default/files/elibrary/2014/12943-sub-seasonal-predictions.pdf.