WMO WGSIP INITIATIVE:

Ocean Prediction Capability
(A component of the WGSIP Prediction Capability Project)

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Context – Main goals

The application of coupled global climate and earth system models to initialized subseasonal to interdecadal climate prediction presents opportunities for predicting ocean properties across those time scales. However, there have been relatively few attempts to evaluate such capabilities apart from prediction of sea surface temperature (SST), which is well observed and fundamentally influences global surface climate both locally and remotely through teleconnections.

This project aims to address this gap by systematically evaluating prediction capabilities for ocean variables other than SST across time scales and for multiple initialized climate prediction systems. It is motivated by the relatively high potential predictability associated with the ocean, and by the essential role of the oceans in climate variability. Two main impacts are envisioned. The first is that assessing ocean prediction capabilities will potentially facilitate useful real-time forecasting of ocean properties having societal impacts, as discussed below. (Here “useful” implies reliable forecasts having demonstrable skill.) The second impact is that assessing ocean prediction capabilities of different climate prediction systems both individually and relative to each other will provide valuable information about how well those systems represent processes from which ocean predictability derives. For example, if the structure and evolution of a particular ocean variable is grossly unrealistic in the predictions, then contributions to predictability associated with that variable are likely to be degraded. Associated multi-model comparisons will highlight how well different ocean processes are represented across systems, and may provide clues as to what factors influence performance (e.g. resolution, model physics and numerics, initialization) and hence how performance may be improved.

A significant challenge for this project is that observations of ocean variables other than SST are relatively sparse over typical hindcast periods, so that uncertainties in verification datasets are relatively large. Prediction capabilities will thus be assessed using multiple datasets for verification, including purely observation-based analyses and reanalyses from models that assimilate observational data. Besides pointing to uncertainies in skill, this may potentially provide information about the quality of the verification datasets themselves (Massonnet et al. 2016). Employing multiple datasets will also enable the use of multi-product averages or other combinations, which may improve verification dataset quality in much the same way that multi-model combinations can improve forecast quality (e.g. Sospedra-Alfonso and Merryfield 2017).

This project will address WCRP Strategic Plan Objective 2, “Prediction of the near-term evolution of the climate system", including its emphasis on “Simulation capabilities”.

Research Plan

Initial efforts will focus on a pair of 2-dimensional ocean variables that are relatively well observed, provide important diagnostics of modeled ocean behavior, and have potential societal impacts.

Sea surface height (SSH). ENSO drives interannual SSH anomalies of up to several 10s of cm in the Indo-Pacific basins, and other modes of climate variability can have significant regional effects as well (Roberts et al. 2016). Such variations in combination with long-term sea level rise are large enough to have appreciable impacts on the frequency and severity of coastal flooding. Forecasts of regional SSH variability could thus hold considerable value (Widlansky et al., 2017), and while initial studies have indicated promising levels of skill (Miles et al. 2014), very few such efforts have been undertaken. This work will be anchored at CCCma, where preliminary work has found high levels of skill for multi-seasonal prediction of SSH in the Canadian seasonal prediction system (higher than for SST at longer ranges), and demonstrated advantages to combining multiple ocean reanalyses for verification. This work will be extended to consider additional models starting with those available from the CHFP, NMME and Copernicus, and consider the altimetric data record which begins in 1993 as another product for hindcast verification.

Mixed-layer depth (MLD). MLD determines the volume of seawater that is in immediate contact with the atmosphere, and thus exerts fundamental controls on air-sea interactions that shape climate variability. In addition, MLD affects ocean ecosystems through its influences on temperature, nutrient concentrations, light availability and so forth. While observations are sparse, we expect considerable value of this analysis in the intercomparison of different models. This work will be anchored at Uni Hamburg, where initial analyses with the German seasonal forecast system (GCFS) has indicated skill for MLD at seasonal time scales. These analyses suggests skill in regions with large MLD variability in the North Atlantic that goes beyond that of SST, indicating a potential for predicting atmosphere-ocean interactions in crucial regions. The initial steps in this analysis will be to obtain MLD datasets, e.g. re-analyses and ARGO-based datasets, as well as Copernicus seasonal systems and compare seasonal hindcast skill. An initial focus on seasonal timescales will take into account the limited database, and aims to establish whether such an analysis might be also feasible at longer timescales.

Expected outcomes

The joint analysis of skill of different quantities – against multiple datasets and within a multitude of models – will allow us to gain a better understanding of

- → the ocean's potential in contributing to predictability on the investigated time scales
- → ocean prediction capabilities of different prediction systems, both collectively and relative to each other
- → the suitability of different datasets and combinations thereof for ocean forecast verification
- → avenues for improving ocean initialization and verification datasets.

Deliverables will include journal publications and meeting presentations facilitating improved knowledge of the topics listed above.

Participation

In addition to the co-leads, additional WGSIP members and others in the scientific community will be engaged to draw upon their expertise, and as the project extends in scope to encompass subseasonal and decadal predictions and additional ocean variables. Assistance in obtaining hindcast datasets that are not otherwise available will be another basis for such engagement.

Initial actions

- Sep 2019-Dec 2019: Establish contacts and share plans with related initiatives
- Sep 2019-Mar 2020: Compile initial seasonal hindcast and verification datasets for monthly mean SSH (at CCCma) and MLD (at U Hamburg), perform initial verification analyses
- Sep 2019-Mar 2020: Survey possibilities and take steps toward obtaining seasonal hindcast datasets from additional current or former operational systems

Related initiatives and contact points

S2S: Yuhei Takaya (WGSIP and JMA/MRI)

OceanPredict: Yuhei Takaya (WGSIP and JMA/MRI) to advise on any GODAE OceanView prediction activities on subseasonal and longer time scales, and facilitate sharing of expertise with those working on shorter time scale predictions.

Ocean Reanalysis Intercomparison Project

Copernicus Climate Change Services (C3S): Anca Brookshaw (ECMWF and C3S) – WGSIP to advise on which ocean variables C3S should serve, and for access to C3S data

CLIVAR Global Synthesis and Observations Panel (GSOP)

References

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