# Ensemble MJO Prediction with ACCESS-S1

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The Bureau of Meteorology has developed a new dynamical seasonal forecasting system, the Australian Community Climate and Earth-System Simulator (ACCESS-S1). One of the main targets of our research is to improve subseasonal prediction skill of the Madden-Julian Oscillation (MJO) and its impacts on Australian and global climate. Improving the depiction and prediction of the MJO serves to provide improved prediction of tropical and extratropical climate patterns, tropical storms and cyclones, monsoons, and global ocean surface waves. While climate models currently achieve ensemble-mean prediction skill for the MJO at lead times ranging from about two to four weeks, global teleconnections driven by the MJO are often too weak, particularly for the lower-resolution models, and thus there exists great potential for further improving our prediction of MJO impacts.

We assess the ability of ACCESS-S1 to predict the MJO using retrospective ensemble forecasts for the period 1990-2012. The ACCESS-S1 hindcast ensemble uses 11 members from 4 start dates per month. Initial perturbations are introduced only in the atmospheric initial conditions through a modified version of random field perturbations. In contrast, the POAMA-2 system uses a method of coupled breeding that generates coupled ocean and atmosphere perturbations. Nonetheless, ACCESS-S1 demonstrates improved skill in predicting the bivariate Real-time Multivariate MJO (RMM) index by about 4 days lead time in austral summer and 5 days in boreal summer compared to POAMA2. Probabilistic forecast scores further demonstrate improved skill in predicting MJO amplitude by at least 7 days, and MJO phase by about 9 days. However, the ensemble from ACCESS-S1 for the MJO is underdispersed, indicating further gains in forecast skill can still be achieved when the ensemble perturbation method is upgraded in the future.

Recent work has shown the MJO to be significantly modulated by the stratospheric Quasi-Biennial Oscillation (QBO). The MJO during boreal winter is observed to be stronger during the easterly phase of the QBO than during the westerly phase, with the QBO zonal wind at 50 hPa leading enhanced MJO activity by about one month. Using retrospective forecasts from both POAMA-2 and ACCESS-S1, we show that this strengthened MJO activity during the easterly QBO (EQBO) phase translates to improved prediction of the MJO and its convective anomalies across the tropical Indo-Pacific region by about 8 days lead time relative to that during westerly QBO (WQBO) phases. All operational models participating in the WCRP/WWRP Subseasonal-to-Seasonal (S2S) prediction project also show a higher MJO prediction skill during EQBO winters than during WQBO winters, with enhanced MJO prediction skill of up to 10 days. These improvements in forecast skill result not just from the fact that forecasts are initialized with stronger MJO events during EQBO, but also from the more persistent behaviour of the MJO for a similar initial amplitude during QBO easterly phases as compared to QBO westerly phases. The QBO is thus an untapped source of subseasonal predictability that can provide a window of opportunity for improved prediction of global climate.

Finally, we describe a new approach for presenting probabilistic forecasts of the MJO based on the RMM index. This new display overcomes the difficulty of interpreting a dispersive ensemble plume and directly quantifies the probability for the MJO to occur in each of its eight RMM-defined phases as well as the weak phase. This innovative method for accessing probability of the state of the MJO in an ensemble forecast compliments the traditional MJO ensemble forecast display and verification and will benefit global forecasting centres, international MJO working groups, and the S2S project.