Optimization of Gravity Wave Source Parameters to Improve Seasonal Forecasts of the Quasi-Biennial Oscillation in a Stratosphere-Resolving Numerical Weather Prediction Model

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The accurate simulation of a quasi-biennial oscillation (QBO) in global climate models (GCMs) relies strongly upon the model's realistic representation of wave driving in the tropics. In recent decades, the contribution of small-scale gravity waves to the evolution of the QBO has been established, motivating the need for GCMs to incorporate a comprehensive gravity wave drag (GWD) parameterization scheme in order to augment the resolved wave driving with a significant sub-grid momentum source. Frequently, this GWD scheme requires tuning a suite of source parameters before a realistic QBO is supported by the model.

In this study, we determine the optimal parameter space configuration for the GWD scheme implemented in a prototype high-altitude numerical weather prediction (NWP) model by choosing the parameters such that hindcast errors are minimized in the equatorial lower stratosphere. By choosing this domain for the minimization, we retrieve the set of GWD source parameters that drives the NWP model to most closely agree with observations of QBO winds over each optimization time interval. We present here the empirically-determined latitudinal profiles and time evolutions of various parameters including source strength and phase speed spectrum.

Improvements to the hindcasts of QBO winds in the model over seasonal and interannual time scales due to the optimized parameter set are also ascertained. Specifically, we explore how the parameterized gravity wave drag varied during the 2015-2016 QBO disruption at all latitudes. Although it is understood that the disruption was due to large-scale, meridionally-propagating Rossby waves rather than anomalous gravity wave driving, we hypothesize that this observations-based optimization of the GWD parameterization in the subtropics may promote a wind structure more amenable to resolving and accurately hindcasting the implicated forcing of the QBO disruption at lead times of 1–3 months.

Key words: QBO, gravity waves, seasonal prediction