Geophysical Research Abstracts
Vol. 20, EGU2018-11696, 2018
EGU General Assembly 2018

Forcing of Convective Gravity Waves during the Madden-Julian-Oscillation

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(1) Yonsei University, Department of Atmospheric Science, South Korea, (2) Deutsche Forschungsgemeinschaft (DFG), grant KA4222/2-1, (3) Korea Meteorological Administration (KMA) Research and Development Program, grant KMIPA 2015-6160

Weather systems in the tropical Indian Ocean region are prominently influenced by the Madden-Julian-Oscillation (MJO) (Madden and Julian, 1972). Although understanding of the MJO has improved over the last decade, MJO still considerably degrades forecasting skill, particularly in the Asian Monsoon region (Kim et al. 2014). This is especially true for seasonal prediction. The interaction of gravity waves (GW) from convection during MJO active phases is one of the various sources of uncertainties in MJO modeling.
We developed a coupled model of convective gravity wave (CGW) forcing and propagation to evaluate the entire life-cycle of GWs from their convective excitation to their dissipation in the upper stratosphere / lower mesosphere region. CGW forcing at source level was calculated using the Song & Chun (2005) model. Simulations were performed for all respective MJO phases for MJO cycles between 1979 and 2010 using CFSR data for the full spectrum of CGWs.
Our results show a strong correlation between momentum flux at cloud top height and 850 hPa zonal wind anomalies. Wavelength spectra show maximum momentum flux for 80 km horizontal wavelength – a challenge for limb- and nadir-sounding satellite instruments. Furthermore, GW momentum flux phase-speed spectra show a strong dependence on MJO phase with more prominent eastward directed cloud top momentum flux during MJO wet phases and lower cloud top momentum flux during MJO dry phases.
We also calculated GW upward propagation using a column model (Song et al. 2006). Here, results show maximum absolute momentum flux between 10°S and 10°N at altitudes from 15 km to 45 km with increasing amplitude from MJO phases 1 to 4 and decreasing amplitude from MJO phase 5 to 8. Zonal means of eastward directed momentum flux also show this correlation. Eastward gravity wave drag (GWD) consistently shows a maximum at altitudes below 40 km and prominent westward GWD at altitudes higher than 40 km. Additionally, we will demonstrate the impact of the QBO phase on our findings with GWD found stronger during the easterly phase of the quasi-biennial oscillation (QBO) compared to the westerly QBO phase.