MMM SEMINAR SERIES

Mesoscale & Microscale Meteorology
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Dependence of the Structure of Stratospheric Kelvin and Mixed Rossby-gravity waves on the Background Flow

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Equatorial Kelvin and mixed Rossby-gravity (MRG) waves are critical components in the forcing the stratospheric Quasi-Biennial Oscillation (QBO), which is in turn an important factor in modulating subseasonal tropospheric variability such as the Northern Hemisphere storm track and the Madden-Julian Oscillation. Much past work has been focused on the wave-mean flow interaction by stratospheric equatorial waves, but numerical models used for both weather and climate simulations still have great difficulty in maintaining and simulating the evolution of the QBO. Models also struggle to replicate the structure, variability, and momentum forcing associated with equatorial waves, therefore it is important to have good a priori knowledge of the characteristics of these waves in the real atmosphere. Using ERA5 reanalysis data, we examine the structure, scales, and propagation characteristics of Kelvin and MRG waves under extreme phases of the QBO. It turns out that linear theory initially developed in the 1960s and 1970s by Matsuno, Lindzen, and Holton, among others, provides a valuable guide in explaining at least the qualitative structure and basic state dependence of stratospheric equatorial waves. The equivalent depth and thus the phase speed of all waves increases with height, as expected due to the effects of damping on upward propagating wave energy. Lower stratospheric Kelvin waves are dominated by zonal wavenumber one and two structures, but with height the lower frequency and wavenumber signals are damped, so the signals become dominated by wavenumbers 3 and 4 above around 20 hPa. The structures of Kelvin and MRG waves are greatly impacted by the sign of the zonal wind and its vertical shear associated with the QBO. In general, Kelvin waves in QBO easterlies are less equatorially trapped and so have much wider meridional structures and larger vertical wavelengths than in westerlies. In QBO westerlies, MRG waves are characterized by the classical structures predicted by Matsuno (1966), but in easterlies these structures are highly altered, with the zonal scales increasing and their zonal phase speeds approaching zero. These zonally standing features become dominant in this situation, with purely downward phase speeds along with upward propagating energy dispersion. We show that these structures can be explained by consideration of the impacts of the critical level, where the phase speeds of the waves approach that of the easterly background flow, as manifested by the expected impacts of scale dependent damping.

Thursday, 10 November 2022, 2:00pm

Refreshments 1:45pm

Please also join colleagues for refreshments and informal discussion after the seminar until 3:30pm

NCAR-Foothills Laboratory, 3450 Mitchell Lane

FL2-1022, Large Auditorium

Seminar will also be live webcast

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Participants may ask questions during the seminar via Slido.

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