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Does the tropical atmosphere support Doppler shifted MRG waves?

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MRG wave belongs to one of the major synoptic scale modes of tropical atmospheric variability and they exhibit the properties of both slowly evolving Rossby and quickly evolving gravity type wave disturbances. Since the MRG waves bridges the gap between the low-frequency and high frequency modes of variability, it is crucial to understand the underlying dynamics of the MRG waves to improve the tropical weather and extended range forecasts. Many previous studies reported the observation of Doppler shifting of MRG waves in the western Hemisphere (e.g. Yang et al. 2003, 2007, Yang and Hoskins 2016 etc). Nevertheless, a comprehensive study of eastward propagating Doppler shifted MRG (E-MRG) waves and their frequency of occurrence relative to the westward propagating MRG waves is missing. In this study, we investigate the E-MRG wave events at 200 hPa pressure level using the wave fitting and Empirical Mode Decomposition (EMD) based wave event identification methodology. We have found 743 E-MRG wave events for the period 1979-2022 and a large fraction of them occur in the westerly duct during boreal winter seasons. It is noteworthy that E-MRG wave events account 33% of the total MRG wave events in the western Hemisphere during boreal winter seasons. As expected from the linear wave theory, 75% of the E-MRG wave events occur when the background winds are westerly. On the contrary, a notable fraction of the E-MRG events occur when the background winds are easterly. Detailed analysis reveals that westerly phase of the large-scale Kelvin waves setup the conducive environment for MRG wave events to be Doppler shifted and explain more than 75% of the E-MRG wave events that occur when the background winds are easterly. In addition to that the observation of strong link between the intrusion of eastward propagating extratropical disturbances and the E-MRG wave events support the extratropical-tropical interaction theory of Hoskins and Yang, 2016. The study underscores the importance of multiscale interactions and its realistic representation in the climate and numerical weather prediction models.