1. INTRODUCTION

The 30-60 day Madden and Julian Oscillation (MJO, Madden and Julian 1994) dominates the time-variance of convection and wind in the tropics, especially in the eastern hemisphere and during austral summers. The origin and maintenance of the oscillation is the subject of much debate. The author observes that a westward group velocity and quasi-standing oscillations are associated with the MJO and that these observations are related to the development of new eastward propagating disturbances. Zhang and Hendon (1997) refuted the possibility of pure standing waves eastward propagating disturbances. These observations revealed that they are generated by cooperation of the eastward propagating portion of the standing oscillations often occur near barriers such as the Andes Mountains. Patterns in the MJO filtered observations reveal interesting interaction between the eastward and the westward propagating disturbances. The quasi-standing wave patterns are visible in the structural differences between the eastward and the westward propagating parts. Simple theoretical model waves roughly approximate the behavior of these wave types, and theory based on these waves describe how they interact. Matsuno (1966) found solutions to a linearized shallow water model in the equatorial beta plane. These solutions include Rossby, gravity, and Kelvin modes. The Kelvin mode is most similar to the MJO, but significant differences between the two modes occur in phase speeds and meridional winds. Nevertheless, the Kelvin wave is the simplest approximation for horizontal MJO structure available. The model of Matsuno predicts that the westward propagating portion of the frequency range of the MJO is dominated by equatorial Rossby modes. MJO filtered data (not shown) does reveal that the westward propagating portion of the standing oscillations often has the structure of low order Rossby modes. Some of the Rossby and Kelvin-like waves that occur in the atmosphere are interrelated because of interactions with land and because of feedbacks from moist convection. If one of these waves impinges on a barrier, the other may be produced as a reflection (McPhadden and Gill 1987, Park and Schubert 1993, and Kleeman 1989). As these waves interact with their reflections, quasi-standing behavior results. A similar theory has been developed to describe sea-surface temperature variations in the El-ninõ or Southern Oscillation (ENSO, Battisti 1988). Waves in the atmosphere could behave in the same way, but on different timescales.

The Rossby modes do not have the same dispersion statistics as the MJO, nevertheless the eastward and the westward propagating disturbances...
cooperate to organize convection into standing patterns. This cooperation involves interaction with land and convection. Further analysis (not shown) reveals that the apparent westward group velocity in MJOe is forced by interaction with Rossby gyres that are discernible in MJOw filtered data. These results imply that MJOe and MJOw disturbances cooperate in such a way that neither should be used independently.

ACKNOWLEDGMENTS

This work was supported by National Science Foundation grant ATM0003351 and by a supplemental NASA Spacegrant Fellowship. Mr. Roundy is and advisee of Dr. W.M. Frank.

WORKS CITED


Figure 1 A, Group velocity analysis of MJOe filtered PW. Heavy line approximates group velocity. B: PW anomaly smoothed with 17-day moving average. Dashed lines represent phase speeds of both eastward and westward propagating anomalies.

Figure 2 Distribution of westward group velocities for 10 degrees south measured from the 1988-1997 precipitable water climatology.

Figure 3 Example of MJObal filtered OLR at 15 degrees south. Contours are at integer local standard deviations.