The Evolution and Behavior of High-Amplitude Extratropical Wave Patterns Associated with the Madden-Julian Oscillation and Equatorial Rossby Waves

Lawrence C. Gloeckler and Paul E. Roundy
Department of Atmospheric and Environmental Sciences,
University at Albany, SUNY
1400 Washington Avenue, Albany, NY 12222

lgloeckler@albany.edu||proundy@albany.edu

Introduction

The Madden Julian oscillation (MJO) and convectively coupled equatorial Rossby (ER) waves interact to organize convection in the tropics. The release of latent heat in convection in the tropics triggers Rossby wave responses that extend into the middle latitudes. The zonal wind signals associated with the MJO through the upper troposphere interact with the background state to guide extratropical waves back into the tropics of the eastern Pacific basin, or to prevent such intrusion. Intrusion of extratropical waves into the tropics excites ER waves (e.g., Kiladis and Weickmann 1992; Meehl et al. 1996; Kiladis 1998; Slingo 1998), which then interact with the MJO to organize convection. Thus a feedback loop can develop in association with the MJO, ER waves, and the extratropical circulation. This poster provides details about this type of interaction and its associated extratropical circulation patterns.

Motivation

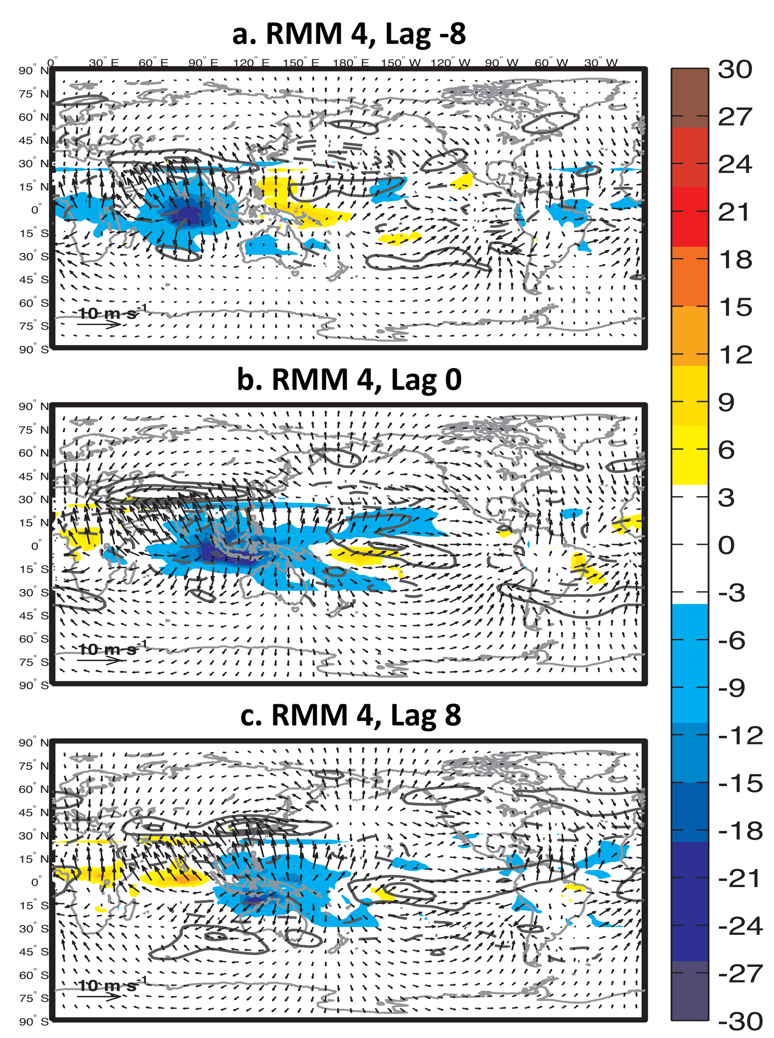

FIG. 1. Composite OLR anomalies (shaded in W m^{-2}; dark blue shading suggests convection associated with composite MJO events), 200-hPa divergent winds (vectors in m s^{-1}), and 200-hPa zonal rotational wind anomalies (dark grey contours; contour interval is 2 m s^{-1}, beginning at ±2 m s^{-1}; solid grey contours indicate positive zonal rotational wind anomalies, and dashed contours indicated negative rotational wind anomalies). N indicates the number of MJO base dates included in the composites.

- Simultaneous MJO and ER wave assessment yields more information about the extratropical circulation pattern than can be explained by either mode alone, or by a linear combination of the two modes

- **Goal:** To assess forcing of extratropical circulation pattern by tropical convective modes and vice versa
- Figure 1 demonstrates well-known response in subtropical jet (STJ) to upper-tropospheric divergent outflow associated with MJO convection
- Figure 2 demonstrates utility of simultaneous MJO and ER wave assessment to glean information about extratropical circulation pattern

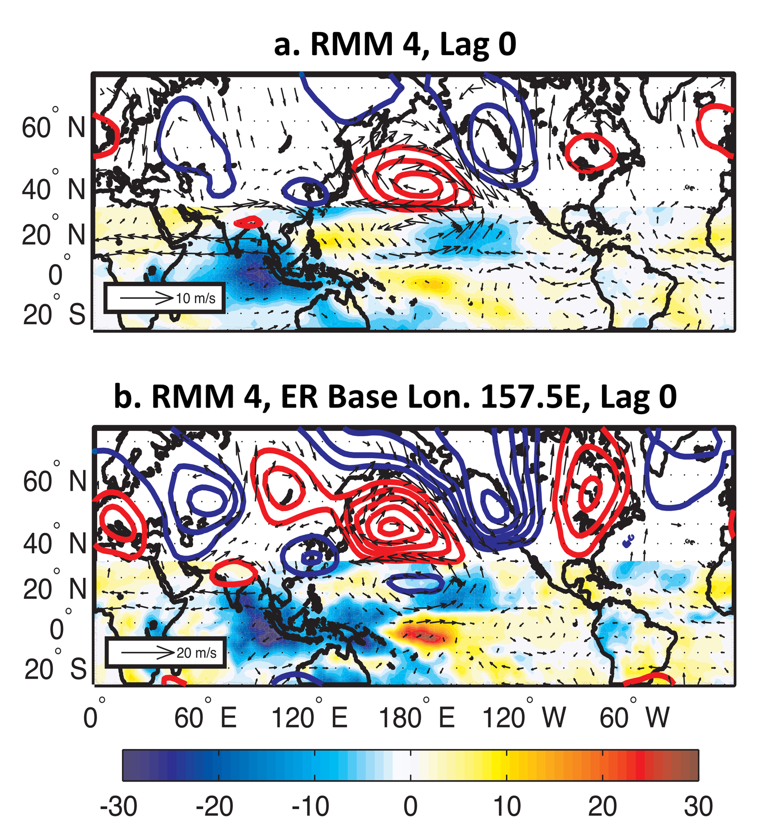

FIG. 2. Composite OLR (shaded in W m^{-2}) and 300-hPa geopotential height and wind anomalies. Composites correspond to (a) RMM phase 4, and (b) a simultaneous assessment of ER wave and MJO events with an ER wave base longitude of 157.5°E during RMM phase 4. Geopotential height anomaly contours (red=positive, blue=negative) are drawn every 20 m, beginning at +20 m and −20 m, respectively.

Results

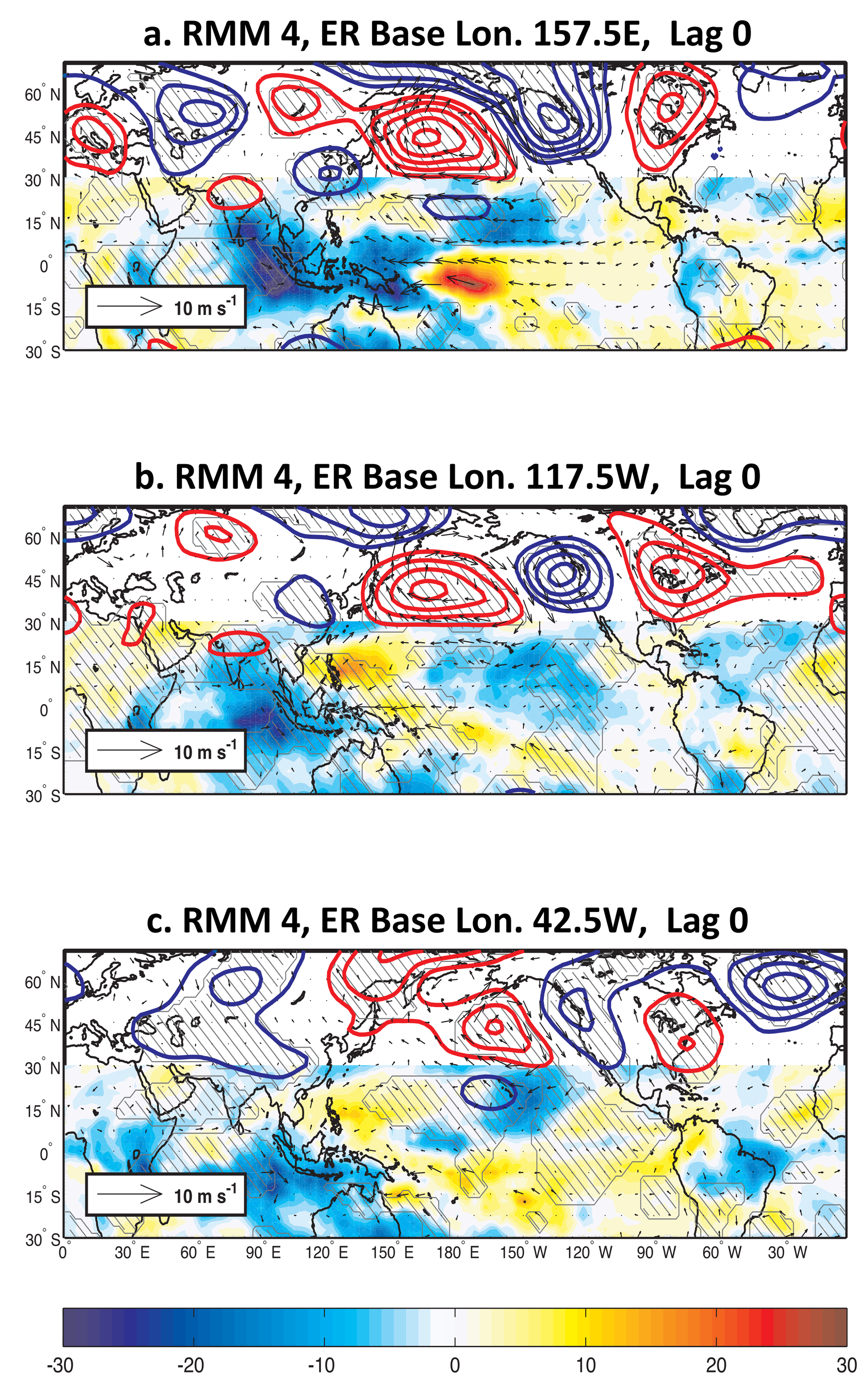

FIG. 3 Comparison of composite circulation patterns associated with RMM 4, lag 0, and ER wave base longitudes at (a) 157.5°E, and (b) 117.5°W and (c) 42.5°W. Shading and contour intervals follow the description in Fig. 2.

- Figure 3 demonstrates sensitivities of extratropical circulation pattern associated with selection of composite ER wave base longitudes
- Selection of 117.5°W yields similar height and wind anomaly patterns to 157.5°E, but subtle phase shifts are evident between composites
- Selection of 42.5°W yields much greater change in height and wind anomaly patterns compared to patterns in Fig. 3a and 3b
- Figure 4 shows variation in number of ER wave crests per 2.5 degrees of longitude that occur simultaneous with each RMM phase during boreal winter
- Highlights regions in which ER wave crests are favored for given RMM phases
- Sensitivities in extratropical circulation patterns associated with selection of composite ER wave base longitude independent of number of ER wave crests

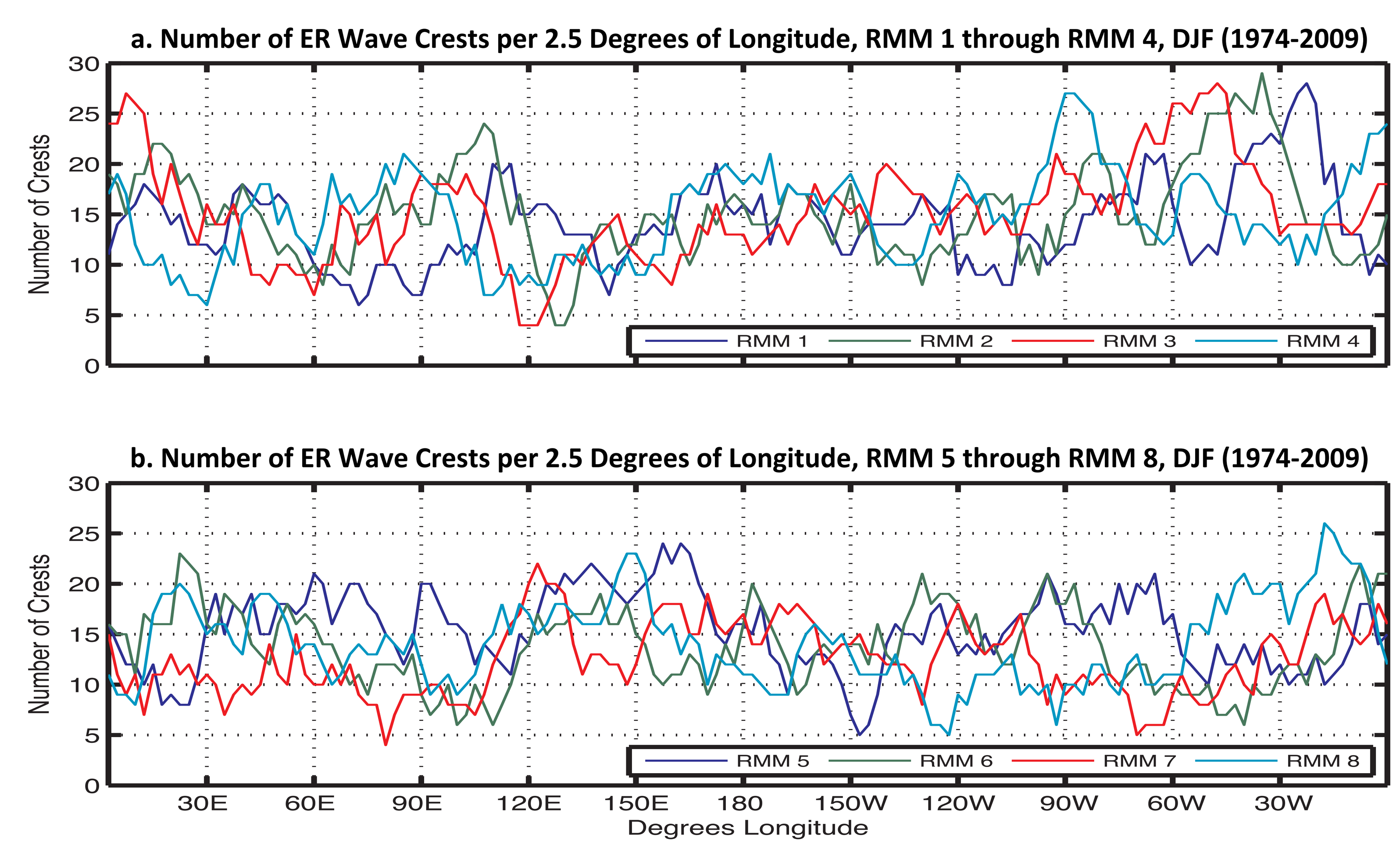

FIG. 4. Number of ER Wave crests per 2.5° of longitude during boreal winter simultaneous with (a) RMM 1 through RMM 4 and (b) RMM 5 through RMM 8.

Future Work

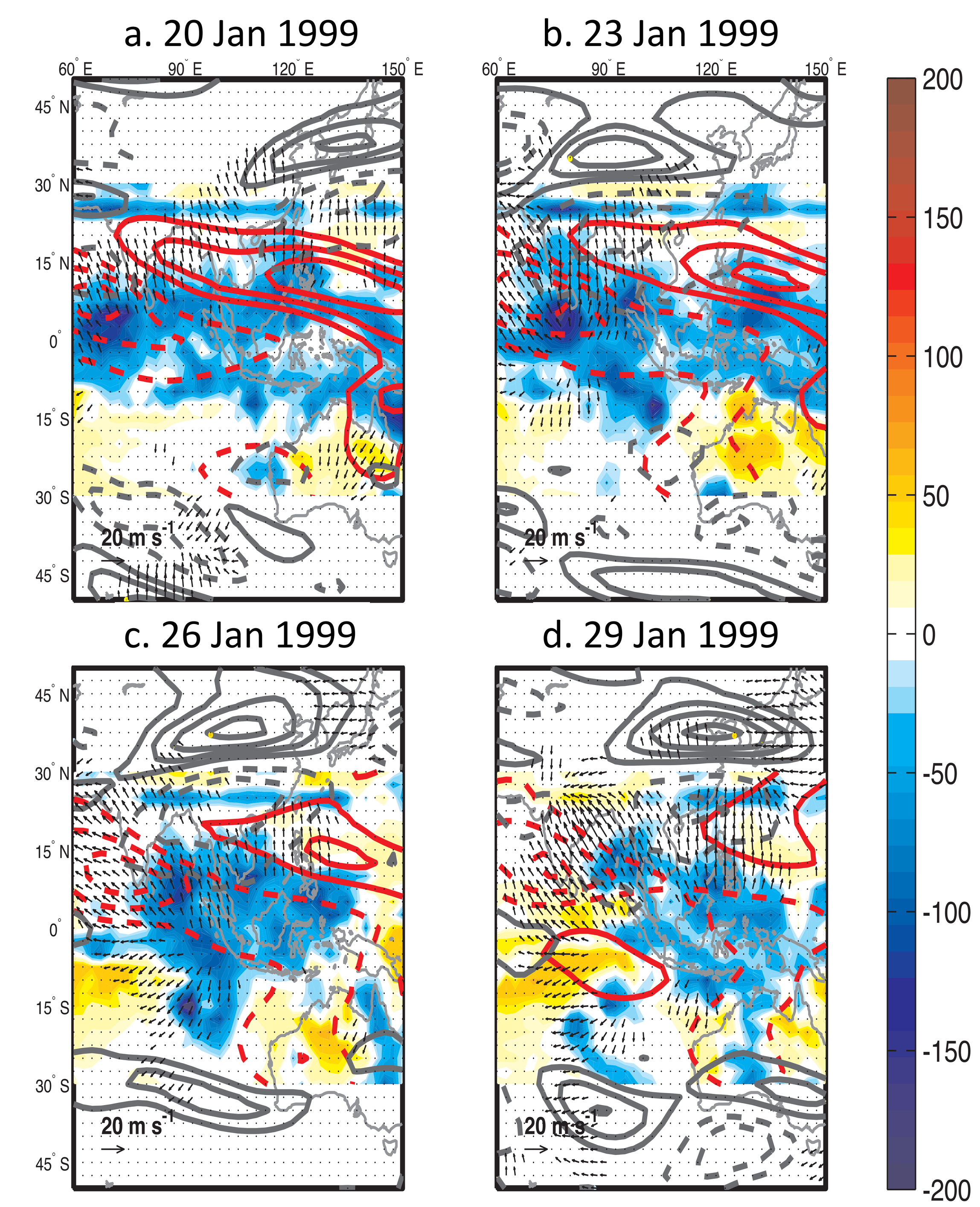

FIG. 5. Unfiltered OLR anomalies (shaded, in W m^{-2}; dark blue shading suggests deep convection), 200-hPa zonal rotational wind anomalies (dark grey contours; solid contours indicate positive anomalies, and dashed contours indicate negative anomalies; contour interval is 10 m s^{-1}, beginning at ±10 m s^{-1}), total divergent wind (vectors in m s^{-1}; only vectors exceeding 5 m s^{-1} are plotted), and MJO band OLR projections (following Roundy and Schreck 2009; red contours; contour interval is 5 W m^{-2}, beginning at ±5 W m^{-2}; solid contours indicate the active convective phase of the MJO, and dashed contours indicate the suppressed convective phase of the MJO) for an MJO event in January 1999.

- Perform case studies to assess roles of MJO and ER wave convection on modulating extratropical circulation pattern
- Figure 5 provides example of first-order assessment of extratropical circulation response associated with MJO in January 1999
- Analyses will improve understanding of evolution of high-amplitude extratropical circulation patterns associated with tropical convective modes
- Apply results in real time to create better statistical forecasts of low-frequency extratropical wave patterns linked to tropical convective modes

References

Kiladis, G. N., and K. M. Weickmann, 1992: Circulation anomalies associated with tropical convection during Northern winter. *Mon. Wea. Rev.*, **120**, 1900-1923.

——, 1998: Observations of Rossby waves linked to convection over the eastern tropical Pacific. *J. Atmos. Sci.*, **55,** 321-339.

Meehl, G. A., G. N. Kiladis, K. M. Weickmann, M. Wheeler, D. S. Gutzler, and G. P. Compo, 1996: Modulation of equatorial subseasonal convective episodes by tropical-extratropical interaction in the Indian and Pacific Ocean regions. *J. Geophys. Res.*, **101**, 15,033–15,049.

Roundy, P. E. and C. J. Schreck III, 2009: A combined wave-number–frequency and time-extended EOF approach for tracking the progress of modes of large-scale organized tropical convection. *Quart. J. Roy. Meteor. Soc.*, **135**, 161-173.

Slingo, J. M., 1998: Extratropical forcing of tropical convection in a northern winter simulation with the UGAMP GCM. *Quart. J. Roy. Meteor. Soc.*, **124**, 27-51.