Characteristics of TRMM derived Latent Heating Variability Associated with the MJO over the Indian and West Pacific Oceans

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Introduction

Barnes and Houze (2013) investigated how the precipitating cloud population associated with the Madden-Julian Oscillation (MJO) varies in the central Indian and west Pacific Oceans using the Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (TRMM PR) and suggested how that cloud population is associated with the large-scale circulation using ERA-interim reanalysis. The cloud population analyzed included isolated, shallow echoes (ISEs) and extreme echo features called deep convective cores (DCCs), wide convective cores (WCCs), and broad stratiform regions (BSRs), which represent the deepest and smallest components of the convective and stratiform portions of the precipitating cloud population. In the central Indian and west Pacific Oceans, broad stratiform regions experience the greatest variability during the MJO and strongly peak during the active stage. The deep and wide convective cores experience less variability and the timing of their maximum differs in the central Indian and west Pacific Ocean, which was related to differences in the variability of mid-latitude relative humidity and vertical wind shear between the geographic regions. Houze (1982) demonstrated that the latent heating profile in convective regions is characterized by heating at all levels which maximizes in the low-mid troposphere. The latent heat profile in stratiform regions is characterized by heating at upper levels and cooling at low levels. Additionally, Houze (1982, 1989) showed that the overall vertical structure of heating is related to the proportion of convective and stratiform precipitation. The classification technique employed by Barnes and Houze (2013) and the spectral latent heating (SLH) algorithm for the TRMM PR enables the authors to investigate how changes in the precipitating cloud population are related to variability in the latent heating profile during the MJO in the central Indian and west Pacific Ocean.

Objective

• Document latent heating produced by precipitating cloud population and its variability during the MJO.
• Investigate central Indian and west Pacific Oceans.
• Focus on yellow regions shown at right.

Methodology

• Latent heating derived using the spectral latent heating (SLH) algorithm for the TRMM PR (Shiga et al., 2004, 2007, 2009).
• Look-up tables for convective, stratiform, and anvil regions based on precipitation-top height and precipitation rate at surface and melting level. Based on numerical simulations of convection during TOGA COARE.
• Identify isolated, shallow echoes and three extreme echo features using TRMM PR and methodology described below.
• Composite around 8 phases of the MJO (Real-Time Multivariate Index), shown below.

Profile Structure & Variability of Extreme Echoes

• BSRs have heating at upper-levels and cooling at low levels. DCCs and WCCs have heating through their depth that maximizes at mid-lows.
• Consistent with previous studies such as Houze (1982,1989).
• Profile structure similar in each phase.
• Amplitude of heating increases during the active stage.

Comparing Central Indian and Southeast West Pacific Oceans

Central Indian Ocean (CIO)

- Total vertically integrated latent heating maximum in active stage (ph. 2 & 3).
- Contribution to the total vertically integrated latent heating observed by TRMM.
- Extreme echo contribution to the total heating during active stage and ~15% during suppressed stage.
- WCCs and BSRs contribute more in the active stage (ph. 2 & 3), when these echoes are more common.
- ISEs contribute more during the suppressed stage.
- BSR heating is highest in phase 3.

Southeast West Pacific Ocean (SEWP)

- Clouds in the SEWP do not peak to the same extent as the CIO.
- Total vertically integrated latent heating maximum in active stage (ph. 2 & 3).
- Contribution to the total vertically integrated latent heating observed by TRMM.
- Extreme echo contribution to the total heating during active stage and ~20% during suppressed stage.
- DCCs, WCCs, BSRs, and ISEs contribute more when these echoes are more common.
- BSRs contribute more in the active stage.
- BSR heating is highest in phase 1.

Conclusions

Changes in the precipitating cloud population have been related to variations of latent heating during the MJO in the central Indian and west Pacific Oceans.

- Extreme echoes account for more of the observed heating during the active stage.
- Broad stratiform regions account for most of the heating variability and increase the depth of the heating profile.
- Deep and wide convective cores account for less of the variability. Their profiles differ in terms of magnitude and pattern of variability in each region.
- Isolated, shallow convection account for relatively more of the observed heating during the suppressed stage.
- Greatest difference between central Indian and west Pacific Ocean observed in magnitude and pattern of variability in convective heating.
- In all geographic regions, heating from broad stratiform regions systematically maximizes in active stage and minimizes in suppressed stage.

References

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