Impact of MJO on the Diurnal Cycle of Rainfall over the Western Maritime Continent during the Northern Hemisphere Winter

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❖ Abstract

Madden-Julian Oscillation (MJO) which has 50 to 60 days of periodicity initiates over the Indian Ocean and propagates eastward passing through Maritime Continent. The Maritime Continent is one of the largest rainy regions of the globe, and it has very complex mountaineous topography. Furthermore, the Maritime Continent has dominant diurnally varying signal of rainfall. In this study, we examined the impact of the MJO on the rainfall diurnal cycle over the western Maritime Continent during the northern hemisphere winter. We mainly used CSEOF technique to extract diurnal signal from the data and investigated the modulation of its physical processes at longer time scales. We also adopted RMM (Real-time Multivariate MJO) index by Wheeler and Hendon (2004) to define MJO days. As a result, we found out that the CSEOF analysis enables us to analyze the diurnal process of the rainfall which has distinct contrasts between land and sea, and the convectively enhanced MJO affects more oceanic regions than lands by increasing rainfall amount and shifting the time of the maximum rainfall. However, during the convectively suppressed MJO days, the rainfall amount over the ocean decreases.Now, we are trying to figure out the dynamical and physical mechanism in terms of this interaction between MJO and diurnal variation of the rainfall. The detour of the winds due to the high mountain over the Maritime Continent seems to make increase of the convergence over the sea. In addition, the increase of the westerly winds during the MJO causes more evaporation and this contributes to make easier conditions to rain over the ocean.

❖Data & method

✓ Data

- TRMM 3B42: 3hr interval, 0.25°resolution
- JRA-25 Reanalysis: 6hr interval, 1.25°resolution
- NOAA OLR: pentad &1day, 2.5°resolution
- For 10 years: December through February

✓ Method

- Cyclostationary Empirical Orthogonal Function (CSEOF) Analysis

- Kim and North (1997); Kim and Chang (2001); Lim et al (2002) Seo and Kim (2003)
- space-time data *T(r,t)* are decomposed into cyclostationary loading vectors (LV) and their corresponding principal component time series (PC):

$$T(r,t)=\sum_n LV_n(r,t)PC_n(t)$$

- The represented data by CSEOF analysis have periodic and time dependent loading vectors as well as PC time series, because the loading vectors are eigenfunctions of a space-time covariance function instead of a space-only covariance function as in EOF analysis. In this study, the period, which is called nested period, of the loading vectors is chosen to be 24 hours to detect diurnally evolving physical processes. In addition to the loading vector, the PC time series enables us to understand the amplitude modulation of the physical processes at longer time scales (> 1day). For details, see Seo and Kim (2003).

- Regression Analysis

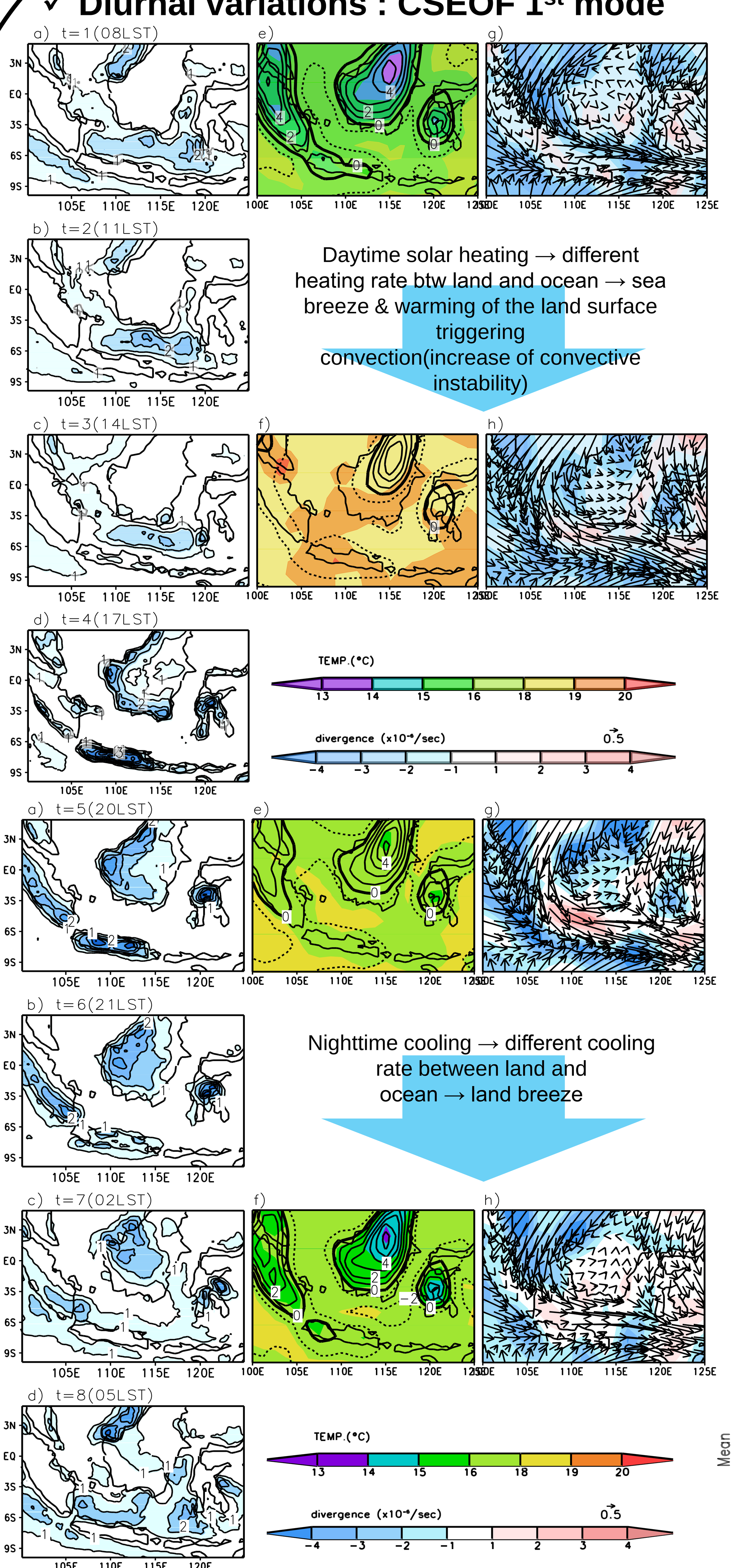
As the CSEOF analysis for individual variables are performed separately, we need to conduct regression analysis to make individual variables have physical consistencies. The PC time series of a predictor variable, such as wind, temperature, and so on are regressed onto the PC time series of the precipitation which is a target variable:

$$T_i(t)=\sum_n a_n^{(i)}P_n(t)+\varepsilon^i(t), i=1,2,3,...,$$

where T(t) are the CSEOF PC time series of the rain rate, P(t) are the CSEOF PC time series of the other variable, and a_n are the regression coefficients.

❖Results

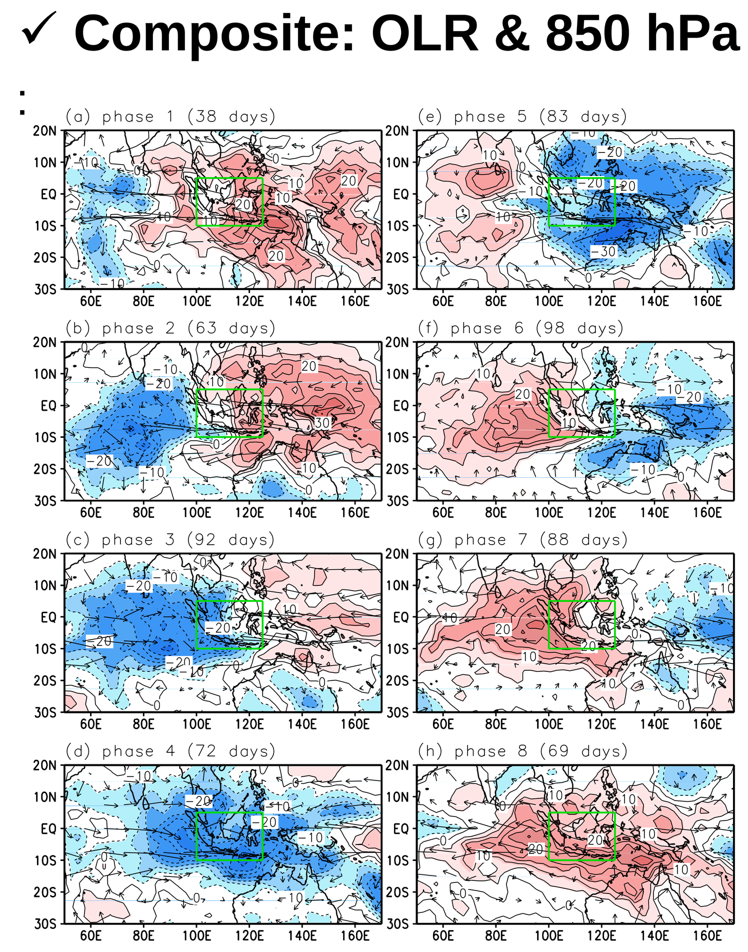
✓ Diurnal variations : CSEOF 1st mode



(a)~(d): TRMM rain rate(mm/hr), (e)~(f):shaded-temp, contour-conditional instability, (g)~(h):shaded-divergence,vector-10m winds

- Distinct land –sea contrast:
- Late afternoon/evening convection over land, and nighttime and morning convection over the surrounding ocean (Murakmi1983;Nitta and Sekine 1994; Yang and Slingo 2001)
- A morning maximum in convection: northwest coast of Borneo
- interaction between the northeast monsoon flow and the nighttime land breeze off Borneo & internal gravity wave propagation

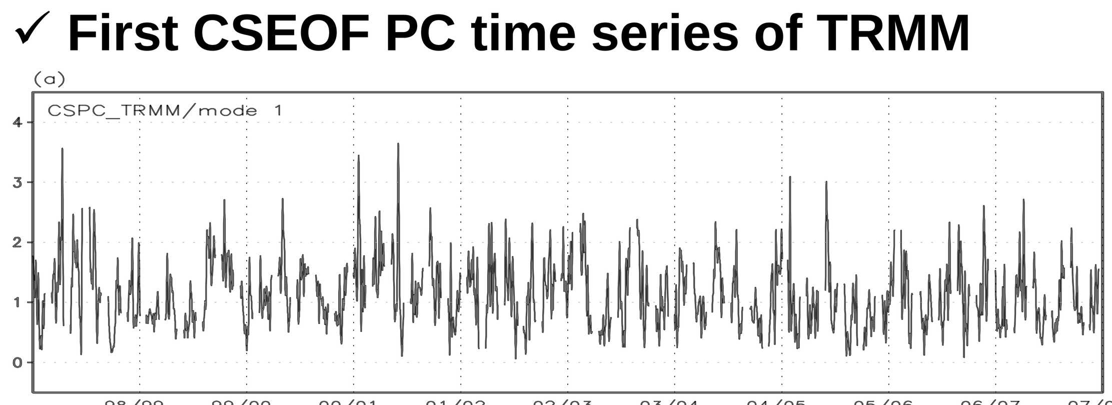
✓ Composite: OLR & 850 hPa wind anomalies

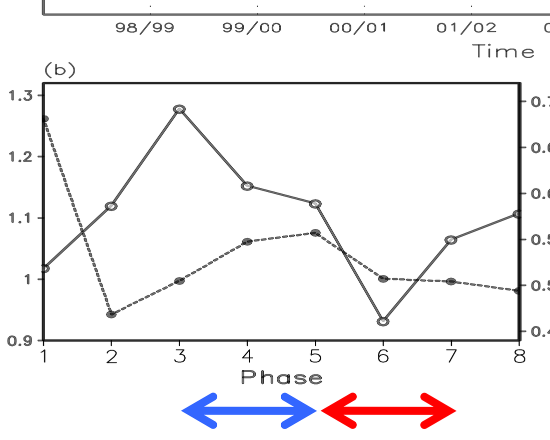


- DJFcomposite: OLR and 850hPa wind vector anomalies based on RMM index (Wheeler & Hendon, 2004) during 97/98-07/08.
- Rectangle in each phase indicates the analysis domain of this study.
- Eastward moving MJO: :

- Convectively enhanced MJO accompanying westerlies & vice versa

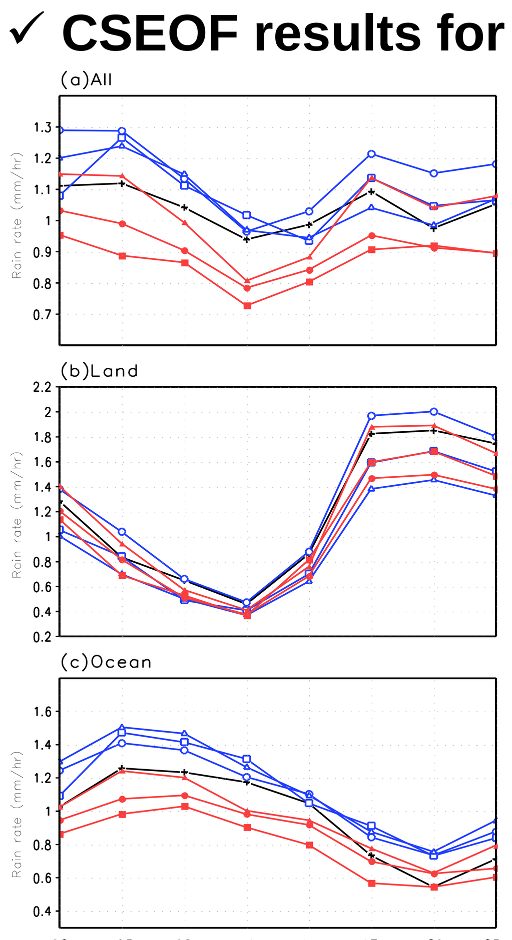
✓ First CSEOF PC time series of TRMM





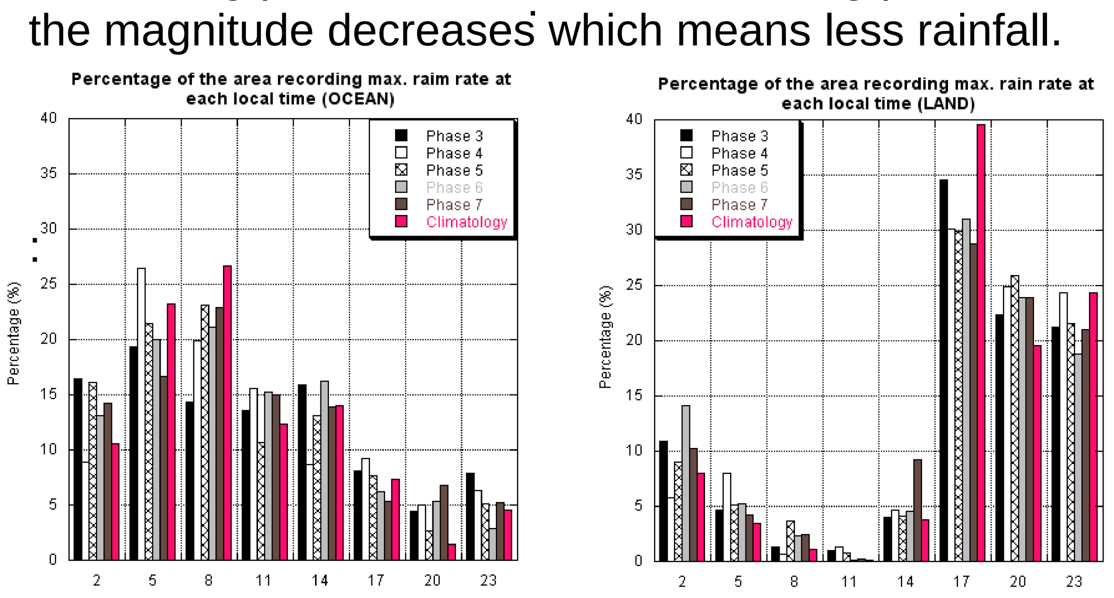
(a) First CSEOF PC time series of TRMM rain rate(mm/hr), and (b) its values of mean and standard deviation for each MJO phase

✓ CSEOF results for days of each MJO phase



- The mean diurnal cycle of TRMM rain rate (mm hr-1) in each MJO phase from 3 to 8, averaged over (a) the all area, (b) the land, and (c) the ocean within10°S-5°N, 100°E-125°E. The axis of abscissa denotes the local standard time.
- Land is relatively less affected by the MJO than ocean.

- Oceanic regions have increased magnitude of rain rate during phase 3 to 5. However, during phase 6 to 8, the magnitude decreases which means less rainfall.



- There exists time shift of max. rain on the largest area over the oceanic region (phase 3,4), no shift over the land