P1.44 LOW FREQUENCY OSCILLATIONS IN ASSIMILATED GLOBAL DATASETS USING TRMM RAINFALL OBSERVATIONS

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1. INTRODUCTION

Low frequency oscillations (LFOs) such as the Madden-Julian Oscillation (MJO) exhibit the phenomenon of equatorial eastward propagation of convective anomalies (Madden and Julian, 1994). It is the prominent mode of the boreal winter tropical intraseasonal oscillation. Although the MJO is relatively weak during the boreal summer, it is still an important feature, especially over summer monsoon regions. There have been numerous investigations on its structure, propagation, mechanism, and its relationship to the Indian summer monsoon and the East-Asian Monsoon. For example, the rainfall active-break period during Indian summer monsoon has a 30-50-day oscillation that is closely associated with the northward propagation of the MJO (Yasunari, 1980). The rain belt movement over the Asian summer monsoon region is clearly connected to MJO activity (Murakami et al., 1984; LinHo and Wang, 2002), The linkage between the MJO and El Niño has been identified in many investigations (e.g., Teng and Wang, 2003).

Simulating the MJO with General Circulation Models (GCM's) has been difficult; however, GCM reanalysis and data assimilation products could produce realistic MJO phenomena. Although the improvement of GCM assimilations using precipitation estimates from satellite measurements has been demonstrated (e.g., Hou et al., 2000), the impact of rainfall assimilation on the representation of the MJO in GCM's has not been fully explored.

In this study, we will use the Goddard Earth Observing System (GEOS) data assimilation system (DAS) to investigate the influence of Tropical Rainfall Measuring Mission (TRMM) precipitation products on the structure and underlying physics of the MJO in a GCM assimilation system.

2. DATA AND METHODS

Global datasets for the period May-August 1998 from the GEOS DAS with/without TRMM surface rainfall estimates are the primary data in this study. TRMM official daily and monthly rainfall products, the NOAA observed outgoing longwave radiation (OLR), and output from European Center for Medium-Range Weather Forecast (ECMWF) analyses are used for comparison

A wavenumber-frequency analysis is applied to the data in this study because more wave properties are revealed in the wavenumber-frequency domain. A complex EOF analysis is also used to study MJO space-time patterns.

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3. PRELIMINARY RESULTS

In a preliminary analysis of the data, the dynamical fields resulting from the GEOS assimilation with TRMM rainfall data compare more favorably to those of the ECMWF diagnostic products, relative to the GEOS assimilation without TRMM rainfall. Also, the GEOS OLR agrees better with NOAA satellite measurements in the former case.

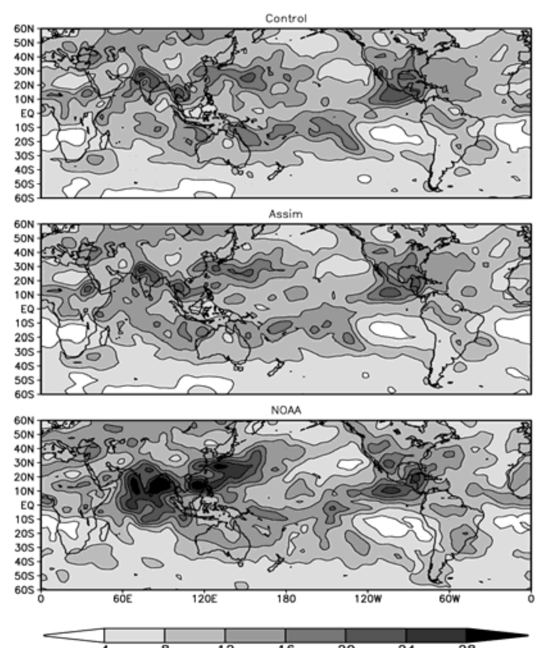

Fig.1. Distribution of the standard deviation of 20-70-day band-filtered OLR. The top, middle and bottom panels are from assimilations without/with TRMM rainfall, and NOAA observed OLR, respectively. Units are W m^{-2}.

Shown in Fig. 1 are the horizontal distributions of the standard deviation of 20-70-day band-filtered OLR from assimilations without/with TRMM rainfall and NOAA satellite measurements. The distribution of relative maxima indicates LFO activity. It may be inferred from this plot that the dominant LFO activity is in boreal Indian and East Asian summer monsoon areas. Another relatively active LFO region is at 30°S-10°S from the eastern Indian Ocean to the east-central Pacific Ocean. Active LFO features are also found at Eq-10°N over the eastern Pacific Ocean and in the North American monsoon region.

Although the magnitude of the NOAA OLR standard deviation is relatively large, spatial patterns of the GEOS and NOAA OLR are similar. It is also evident that the GEOS OLR variation with assimilated TRMM rainfall is closer to the NOAA OLR variation than the GEOS without TRMM rainfall, especially over the Asian summer monsoon region. Analyses of other state variables lead to similar conclusions.

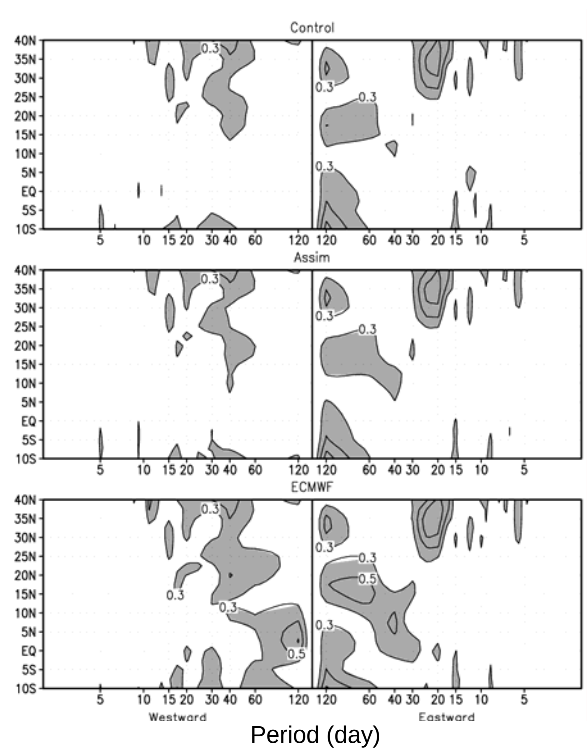

Fig. 2. V_{200mb} spectra as functions of latitude and period for zonally propagating wavenumber 1 in the interval 40-180°E for May-August 1998. The top, middle and bottom panels are derived from assimilations with/without TRMM rainfall, and ECMWF analysis, respectively.

Since LFO activity is more evident over the Asian monsoon region, the wavenumber-frequency analysis is applied to data in the interval 40-180°E. Shown in Fig. 2 is the spectral distribution of V_{200mb} wavenumber 1. For westward propagating waves, the ECMWF MJO is evident in the Tropics and 10°N-40°N, while the 20-30-day oscillation is at 25°N-40°N. For eastward propagation waves, the ECMWF MJO is the primary feature over boreal summer monsoon latitudes (10°N-25°N) and boreal tropics (Eq-10°N), while 20-30-day oscillations are active over 25°N-40°N latitudes. In addition, the MJO is evident in Southern Hemisphere tropical areas. Comparing spectral distributions from assimilations without/with TRMM rainfall to ECMWF analyses, we can conclude that westward propagating waves have very similar spectral characteristics; however, differences are seen in the spectra of eastward propagating waves. The spectra of eastward propagating waves from GEOS with the assimilation of TRMM rainfall show better agreement with those derived from the ECMWF diagnostic output. These results indicate that the satellite-measured precipitation (and associated latent heating) in the GEOS assimilation system has little impact on westward propagating Rossby waves while it has an impact on eastward propagating Kelvin waves. The MJO is strongly associated with Kelvin wave propagation. Therefore, the results here supply further evidence to support the theory originally proposed by Lau and Peng (1987) that the role of latent heating is in bridging the MJO and Kelvin waves.

We are in the processes of conducting a thorough investigation into how the TRMM rainfall measurements in the GEOS assimilation system impact the characteristics of LFOs. Detailed results will be presented at the conference.

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4. REFERENCES

Hou, A., and co-authors, 2000: Assimilation of SSM/I-derived surface rainfall and total precipitable water for improving the GEOS analysis for climate studies. *Mon. Wea. Rev.*, **128**, 509-537.

Lau,K.-M., and P.H. Peng, 1987: Origin of low frequency (intraseasonal) oscillations in the tropical atmosphere. Part I: The basic theory. *J. Atmos. Sci.*, **44**, 950-972.

LinHo and B. Wang, 2002: The time-space structure of the Asian-Pacific summer monsoon: A fast annual cycle view. *J. Climate*, **15**, 2001-2019.

Madden, R.A., and P.R. Julian, 1994: Observations of the 40-50-day tropical oscillation-A review. *Mon. Wea. Rev.*, **122**, 814-837.

Murakami, T., T. Nakazawa, and J. He, 1984: On the 40-50 day oscillation during the 1979 Northern Hemisphere summer. *J. Meteor. Soc. Japan*, **62**, 440-468

Teng, H., and B. Wang, 2003: Interannual Variations of the Boreal Summer Intraseasonal Oscillation in the Asia_Pacific Region, *J. Climate*, **16**, 3572-3584.

Yasunari, T., 1980: A quasi-stationary appearance of 30 to 40 day period in the cloudiness fluctuations during the summer monsoon over India. *J. Meteor. Soc. Japan*, **58**, 225-229.