# The Diurnal Cycle of Precipitation over the Americas based on CMORPH

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## 1. Introduction

The diurnal cycle of precipitation over the region of the American monsoon is studied using the CMORPH precipitation analysis technique. Retrievals from passive microwave (PMW) sensors provide a more direct and accurate source of precipitation estimation than IR retrievals, from which rainfall is indirectly derived from cloud-top temperature. However, temporal sampling from PMW sensors relegated to polar-orbiters is sparse relative to frequent IR imaging provided from geostationary satellites. CMORPH takes advantage of the more accurate precipitation estimation provided by the PMW sensors and frequent rainfall propagation derived from geostationary satellite IR to provide complete precipitation analyses. CMORPH also includes data from AMSU-B instruments along with data from TMI (TRMM satellite) and SSMI (DMSP satellites).

CMORPH provides high spatial (maximum 8 km) and temporal (30 minutes) resolution precipitation analyses that are ideal for documenting the diurnal cycle of precipitation.

## 2. Results

Major features of the summertime diurnal cycle, as depicted by CMORPH for the South American Monsoon, include an afternoon maximum in precipitation over the Andes and the high terrain in central and eastern Brazil, a nocturnal maximum in precipitation over areas just east of the Andes (western Argentina, central Bolivia and western Paraguay), and a nocturnal maximum over the Atlantic in the vicinity of the South Atlantic Convergence Zone during the southern summer (Fig. 1). A remarkable diurnal cycle in precipitation occurs in coastal areas of northern and northeastern South America. With the daytime heating, precipitation rapidly forms along and just inland from the coast (Fig. 1, lower left panel). This precipitation advances westward and southward, producing a nocturnal maximum in areas approximately 500 km inland from the coast (Fig. 1 upper left panel). The inland propagation of sea-breeze-induced rainfall systems is a feature most frequently found during late SH summer (December-February) and fall (March-May). The seasonal average diurnal cycle for equatorial South America (Eq. – 5ºN) for March-May 2003 indicates that sea-breeze-induced precipitation systems propagate westward, reaching the western Amazon Basin in about two days (see dashed lines in Fig. 2). As these systems propagate inland they contribute to a nocturnal precipitation maximum in some areas and a diurnal precipitation maximum in other areas. A nocturnal or early morning precipitation maximum also occurs along the immediate coast and offshore in the vicinity of the Atlantic ITCZ and over the Pacific near the west coast of South America.

A remarkable feature of the North American monsoon is the very large amplitude to the diurnal cycle of precipitation in the vicinity of the Sierra Madre Occidental (SMO) in northwest Mexico (Fig. 3). Convective precipitation develops over the Sierra Madre Occidental (SMO) during the early afternoon (1230-1300 LST, lower right panel), reaches maximum intensity just to the west of the

SMO in early evening (1830-1900 LST, upper left panel), and weakens during the night (0030-0100 LST, upper right panel). The convective systems primarily move westward with time producing a nocturnal maximum along the coastal plain (Fig. 4). At 28ºN there is also some indication of eastward propagation just to the east of the crest of the SMO.

Another interesting feature of the North and Central American monsoons is the strong diurnal cycle in precipitation that occurs over nearby oceanic regions, sometimes extending hundreds of miles out to sea, especially west of Central America and to the east of the East Coast of the United States. Convection develops along the east coast of Central America (Fig 5) early in the day, propagates to the west coast by evening and then continues westward over the ITCZ region of the Pacific, where a significant diurnal cycle in precipitation is evident several hundred miles from land. Over the southeastern United States precipitation is greatest during the late afternoon and early evening, while over the Atlantic the maximum occurs during the late night early morning 200-300 miles east of the coast. For this region there is no propagation of precipitating systems, but rather a distinct out-of-phase relationship in the strength of precipitation between land and the nearby Atlantic Ocean.

**3. Conclusion**

CMORPH analyses of precipitation provide an excellent opportunity to document the diurnal cycle of precipitation over the entire globe (60ºN-60ºS). The diurnal cycle of precipitation is largest over the Americas in regions of steep topography and in the vicinity of coastal boundaries. Convection initiated along the northeast coast of South America propagates inland, reaching the western Amazon basin two days later. There is a distinct late night-early morning maximum in precipitation over oceanic regions, such as the equatorial Atlantic, tropical eastern North Pacific and western North Atlantic (near the Southeast United States coast).

CMORPH analyses of precipitation provide an excellent data set for validating the simulated diurnal cycle and the frequency of occurrence of precipitation systems in numerical models.

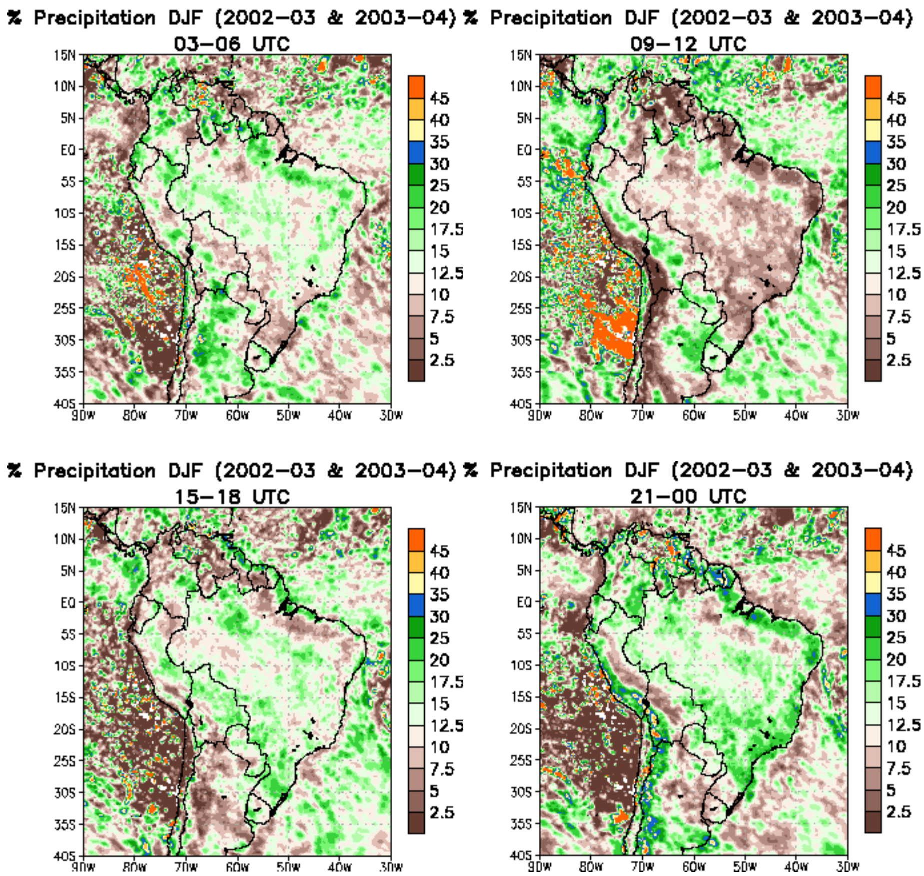


**Figure 1.** Mean percent of daily total precipitation for 03-06 UTC, 09-12 UTC, 15-18 UTC, and 21-00 UTC. The mean is computed for the combined December-February periods for 2002-03 and 2003-04. Note: if rainfall were distributed equally throughout the 24-h period then 12.5% would be the expected percentage of the daily total for each 3-h interval. Percentages should be ignored in regions where rainfall is infrequent, such as over the eastern subtropical Pacific and over the subtropical North Atlantic.

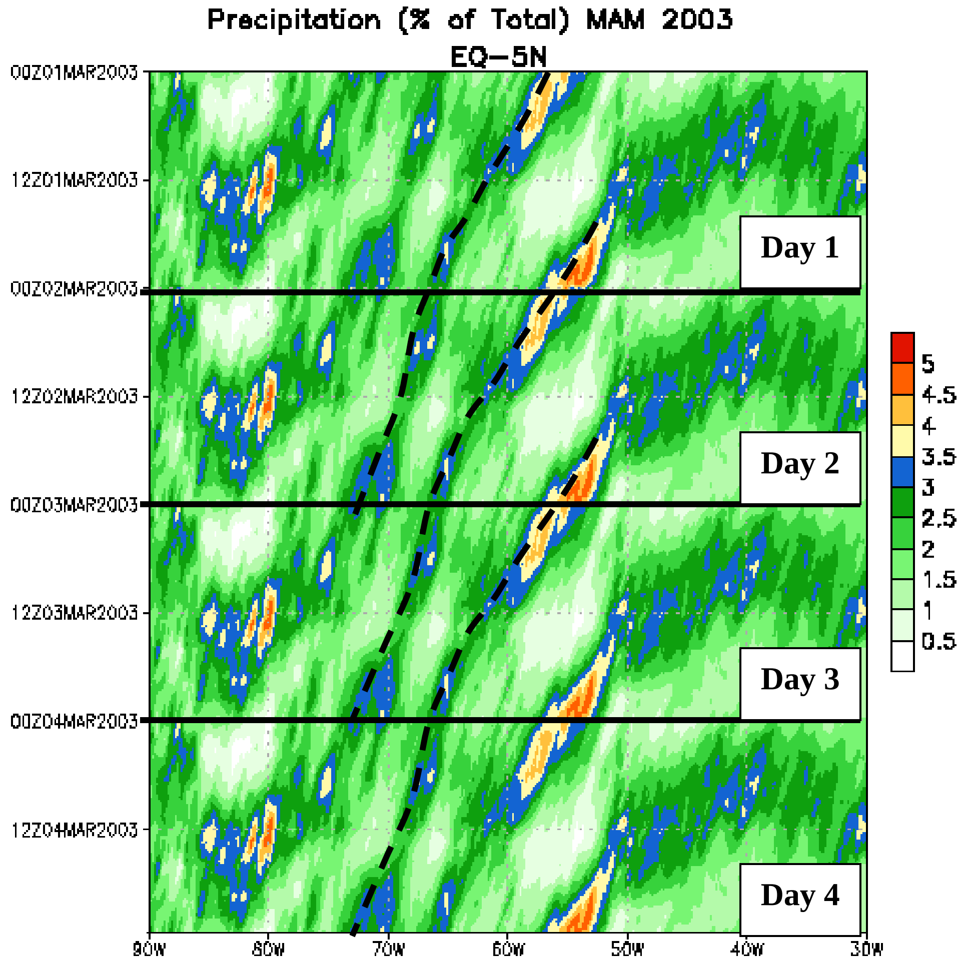


**Figure 2.** Time-longitude section of the mean (March-May 2003) percent of daily precipitation for the latitude band 0º-5ºN. The mean diurnal cycle has been repeated 4 times (Day1 – Day 4). The dashed lines indicate the westward-propagation with time associated with sea-breeze-induced convection along the northeast coast of South America (near 50ºW). The mean diurnal cycle was computed based on analyses at 30-minute intervals (48 per day). Thus, in the absence of any diurnal cycle the expected percentage is 2.1 for each 30-minute interval.

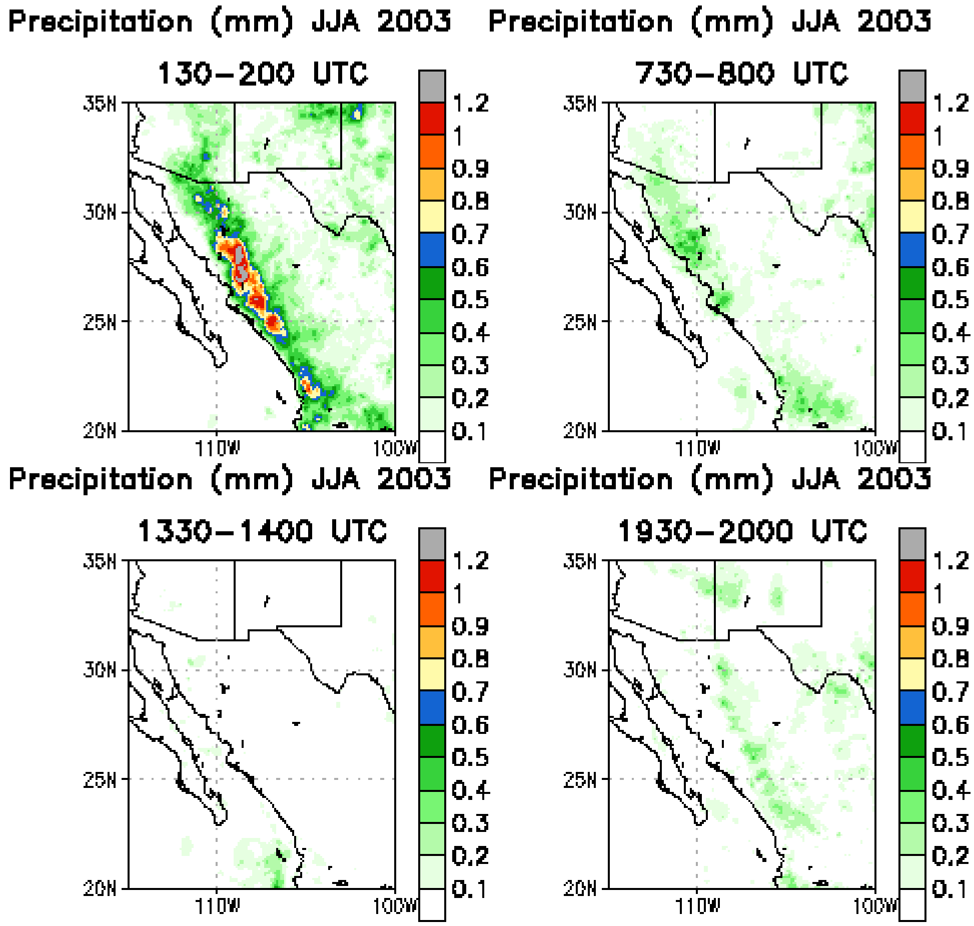


**Figure 3.** Mean June-August 2003 precipitation for the 30-minute periods indicate above each panel. Local standard time is UTC – 7.

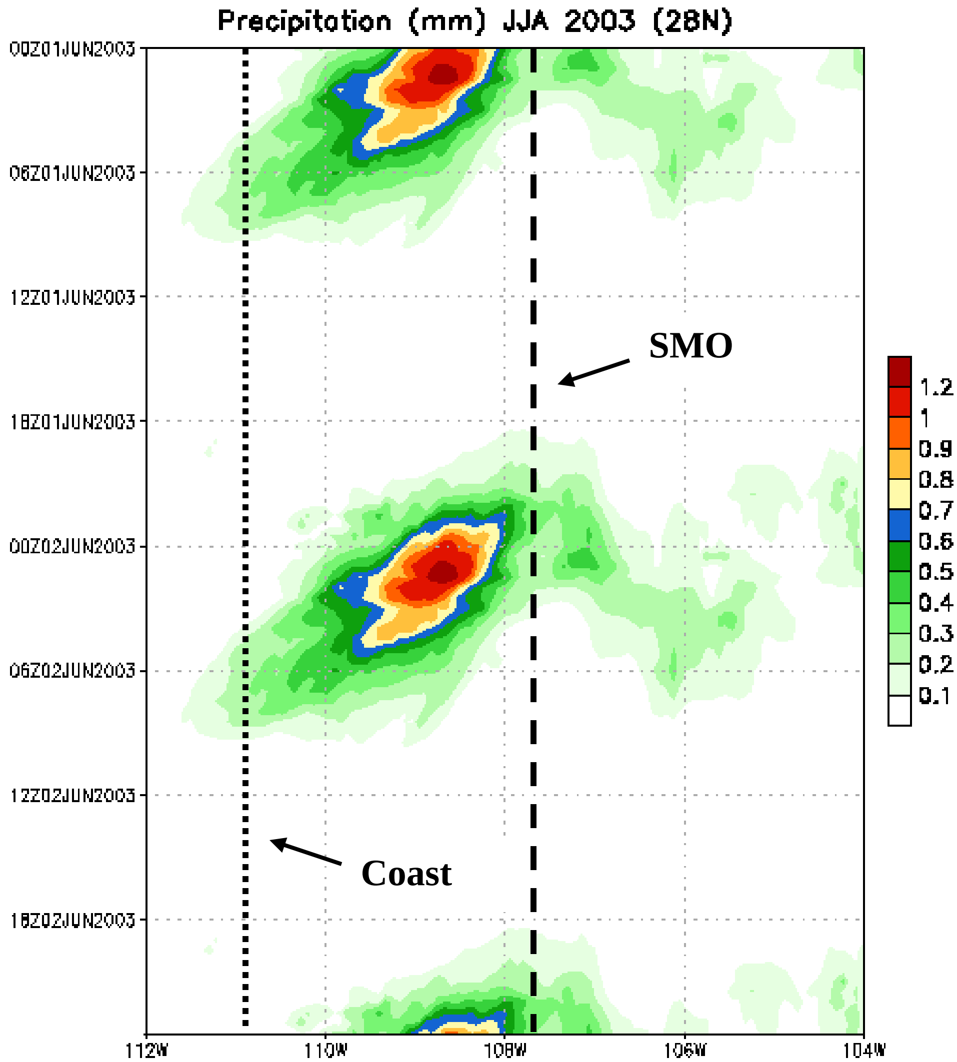


**Figure 4.** Time-longitude section of mean precipitation (30-minute amounts in mm) for 28ºN. The mean diurnal cycle is repeated twice. The approximate longitudes of the crest of the Sierra Madre Occidental (SMO) and Gulf of California coast are indicated by the dashed and dotted lines, respectively.

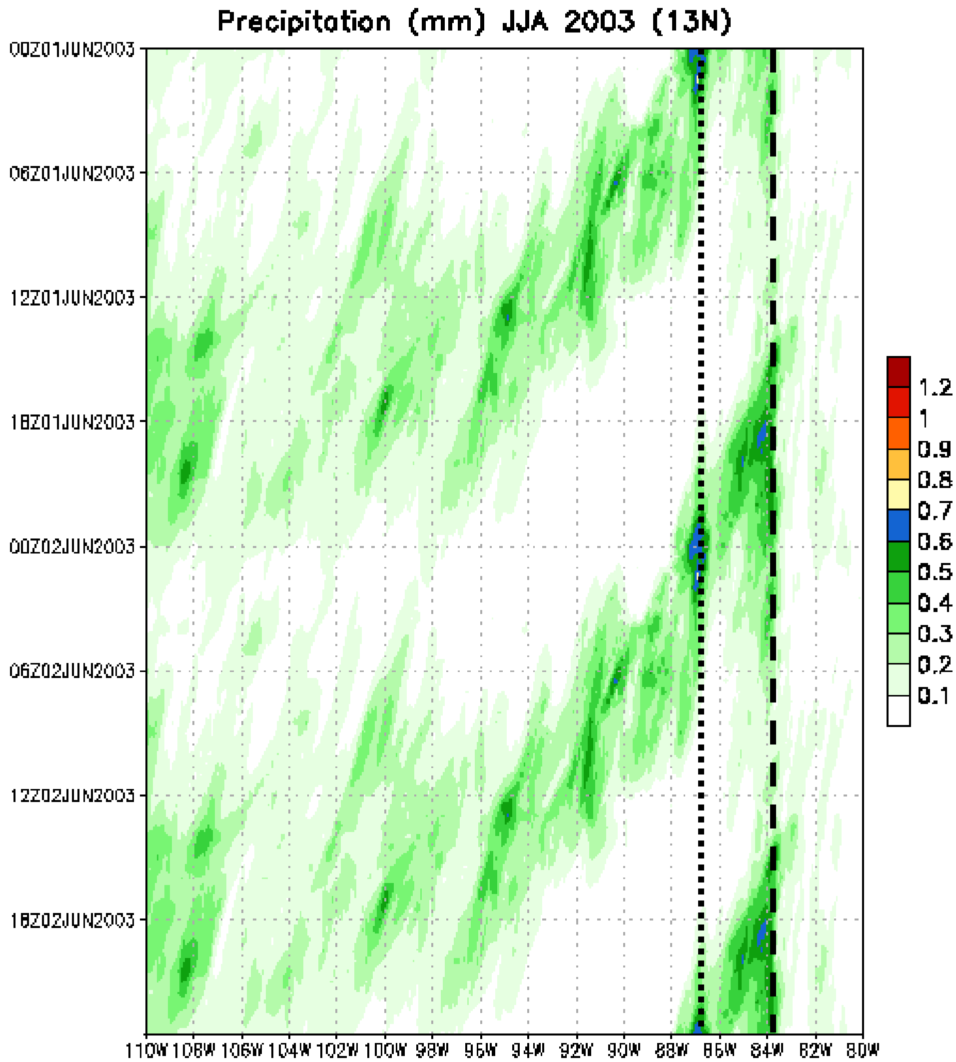


**Figure 5.** Time-longitude section of mean precipitation (30-minute amounts in mm) for 13ºN. The mean diurnal cycle is repeated twice. The dashed (dotted) line indicates the east (west) coast of Central America.

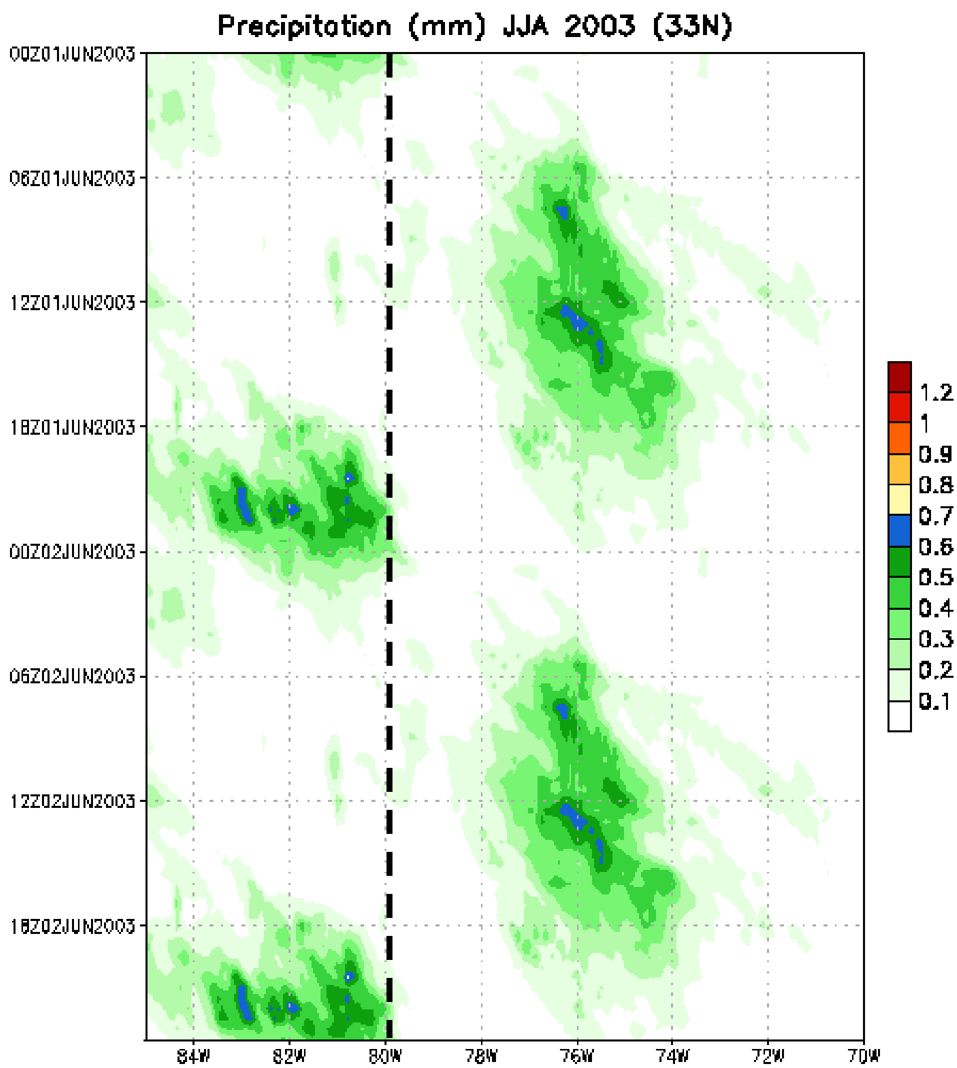


**Figure 6.** Time-longitude section of mean precipitation (30-minute amounts in mm) for 33ºN. The mean diurnal cycle is repeated twice. The dashed line indicates the East Coast of the United States.