The Diurnal Cycle of Precipitation during the NAME 2004 Field Campaign

Emily J. Becker and E. Hugo Berbery
Department of Atmospheric and Oceanic Science/ESSIC
University of Maryland, College Park, MD 20742
becker@atmos.umd.edu

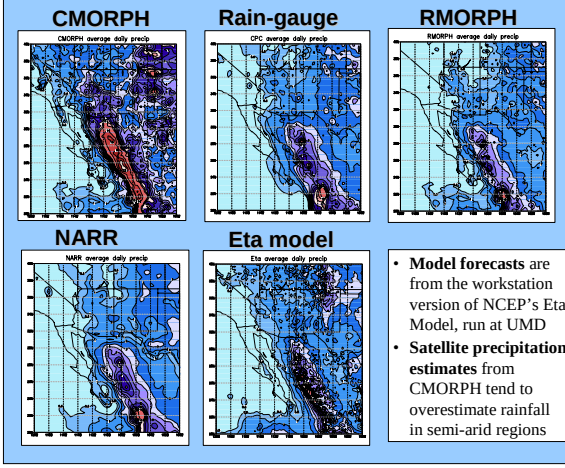
Abstract

The structure and forcings of the diurnal cycle of warm-season precipitation during the North American Monsoon are examined for the core Monsoon region and for the southwestern United States, using a diverse set of observations, analyses and forecasts from the North American Monsoon Experiment Field Campaign of 2004. Included are raingauge and satellite estimates of precipitation, Eta model forecasts, and the North American Regional Reanalysis (NARR). Similar daily averages of precipitation are obtained from the Eta model forecasts, NARR, and rain-gauge observations. However, the Climate Prediction Center (CPC) Morphing technique (CMORPH) exhibits notably higher precipitation values, but a corrected research-quality version of CMORPH reveals similar values as all the other estimates.

The diurnal cycle within the core region occurs earlier in the day at higher topographic elevations, evolving with a westward shift of the maximum. This shift appears in the observations, reanalysis, and, while less pronounced, in the model forecasts. Examination of the forcings behind this cycle, including a thermodynamic forcing in the form of convective available potential energy (CAPE) and a dynamic forcing as represented by moisture flux convergence reveals the westward shift appears more prominently in the dynamic forcing.

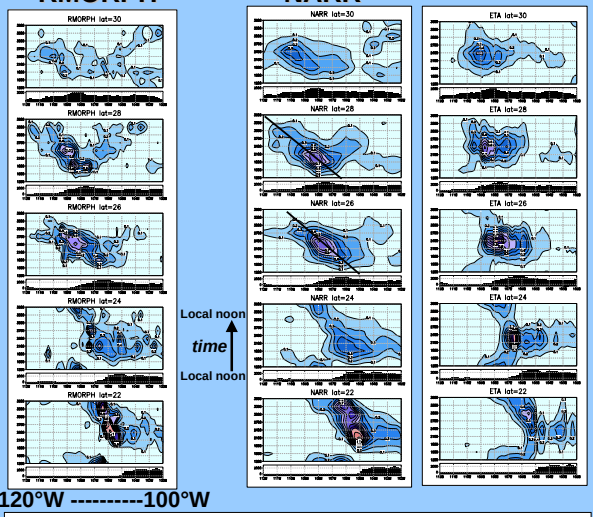
In general, precipitation in the southwestern United States, including southern Arizona and New Mexico, shows a strong effect due to northward moisture surges from the Gulf of California. The diurnal cycle of precipitation seems to respond to the thermodynamic forcings during no-surge cases, but during the occasional surges when precipitation is increased, the dynamic forcing acquires a greater role in the evolution of the precipitation.

Average daily precipitation 20°N-40°N, 100°-120°W

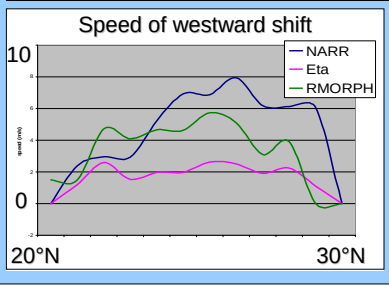


- **Model forecasts** are from the workstation version of NCEP's Eta Model, run at UMD
- **Satellite precipitation estimates** from CMORPH tend to overestimate rainfall in semi-arid regions

The diurnal cycle in the core Monsoon region: Hovmoeller diagrams



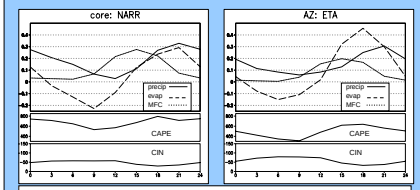
Precipitation initiates high in the SMO in afternoon, peaks over slopes of SMO in evening, diminishes over coastal plain and eastern coastal waters at night. Cycle begins and ends earlier at southernmost latitude shown. Speed of westward shift is determined by the slope of the Hovmoeller diagram.



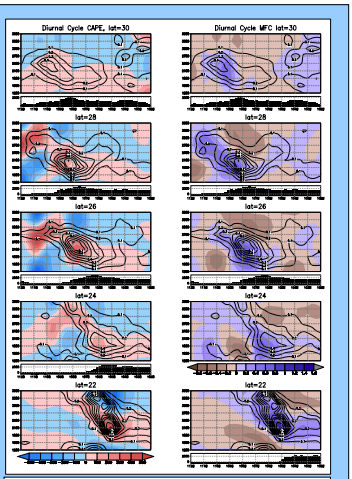
Westward shift maximum speed occurs around 24°N-28°N, where the SMO peaks are highest, and decreases to zero to the north and south of the Gulf of California.

Forcings of the diurnal cycle in the core Monsoon region

- **Thermodynamic forcing:** Convective available potential energy (CAPE) is the maximum energy available to an ascending air parcel; often a precursor to severe weather. Strong CAPE during precip max in evening; second maximum at night over GoC.
- **Dynamic forcing:** vertically-integrated moisture flux shows convergence along the western slopes of the Sierra Madres in late afternoon and evening and divergence over the Gulf of California.



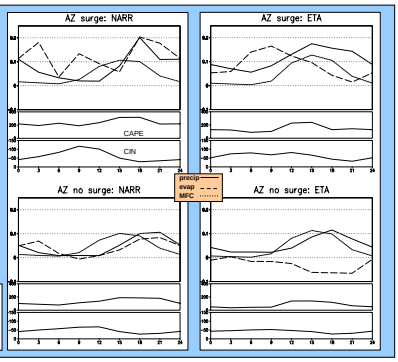
July and August 2004 precipitation, MFC, evaporation, CAPE, and CIN for land-only core monsoon area average: 20-30°N, 111-114°W.



CAPE average diurnal anomalies (left), vertically-integrated column MFC (right), precipitation contours (both), from NARR.

The diurnal cycle in the south-western U.S. and Gulf surges

Occasional northward surges of moist air from the Gulf of California affect the diurnal cycle: greater precipitation, stronger CAPE, changes to MFC cycle. Generally, diurnal cycle in non-surge cases resembles the overall average (not shown). NARR has a bias toward too-strong moisture transport by Gulf of California LLJ. (Mo et al. 2005). MFC peaks closer to precipitation peak during surges.



Precip, MFC, evap, CAPE, CIN for land-only area average: 32-36°N, 104-113°W, divided into surge (top panels) and non-surge times

Summary

- Peak precipitation intensity occurs at different times throughout the core region, e.g. 1800-2100 at 24°N vs. 2100-midnight at 28°N. Speed of westward shift varies with latitude.
- MFC exhibits a westward shift similar to that of precipitation, with the maximum occurring in the late afternoon, shortly before the precipitation maximum, and moving to the west throughout the evening.
- In the Eta model, MFC during surges peaks about six hours before peak precipitation, suggesting that MFC has a greater role in precipitation during surges. As also seen in previous studies, NARR appears to overestimate the meridional transport of water in this region.

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