Large-Scale Environment and Diurnal Variation of Warm Season Precipitation Episodes over the U.S.
Case Study of July 23-29, 1998

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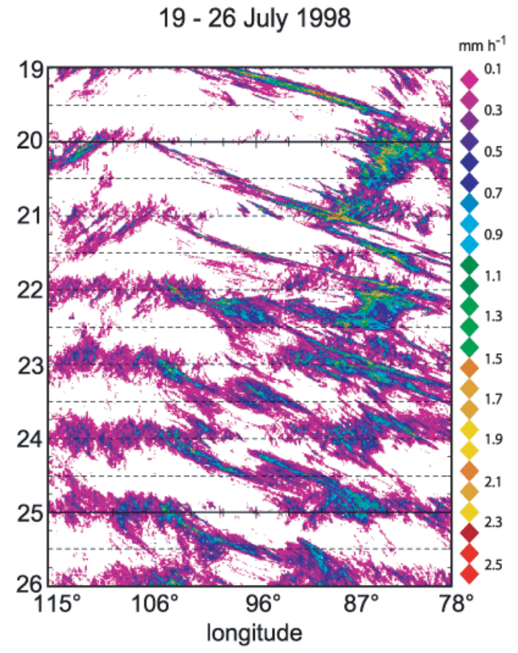
Background

Warm season rainfall is notoriously difficult to predict. However, recent findings by Carbone et al. (2002) suggest that the 6- to 24-hour quantitative precipitation forecast (QPF) time frame may be ripe for improvement.

Time-longitude sections (Hovmoller diagrams) of estimated rainfall rate over the continental U.S. indicate long-lived, coherent precipitation structures during the warm season which tend to occur in the absence of significant upper-level forcing. These precipitation structures appear as "rain streaks" in time-longitude diagrams. The rain streaks were characterized in terms of zonal span and duration using an objective "rain streak" recognition algorithm by Carbone et al. for 4 warm seasons (1997-2000). An example Hovmoller diagram is shown below.



Example of a Hovmoller diagram. This diagram shows radar-estimated rainfall rate areally-averaged from 30 to 48 N as a function of longitude and time. Time increases downward. The 7-day time interval overlaps the July 23-30 period described in the poster. Note several eastward-propagating "rain streaks," mostly initiating near 106 W. The daily afternoon thunderstorm maximum over the Rocky Mountains (west of 106 W) is also apparent. These thunderstorms are embedded within the North American monsoon and exhibit very little zonal movement.

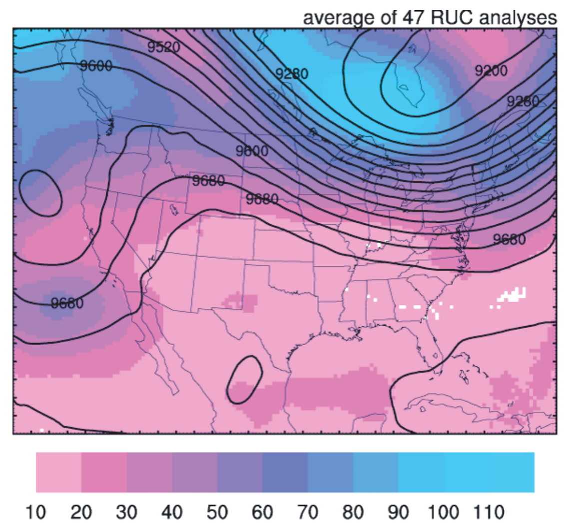
Span and duration statistics suggested a high number of precipitation episodes with lifetimes far exceeding that of a typical mesoscale convective system (MCS). In fact, the 1997-2000 warm season climatology featured rain streaks which persisted 40+ h at a recurrence frequency of once per week.

This study aims to characterize the large-scale environment of these precipitation episodes using archived ETA and experimental RUC-2 (MAPS) analyses. Both models used 40-km grid spacing.

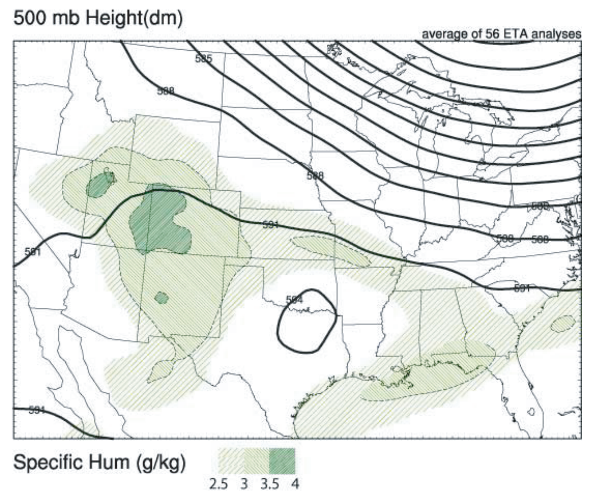
Objective

Document mean conditions and diurnal variation of large-scale environment for warm season period with a static weather pattern and strong diurnal signal in precipitation.

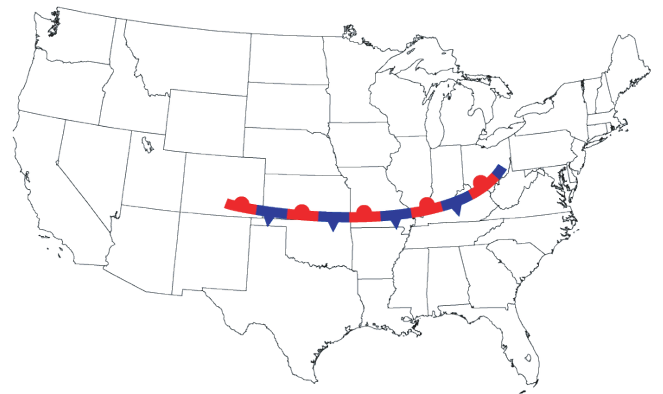
Mean Conditions



Mean geopotential height (m; solid contours) and standard deviation (colors) of analyzed MAPS 300-mb pressure surface for 23-29 July 1998. There is little height (and hence geostrophic wind) variation south of the mean polar jet stream position. The precipitation episodes that propagate across the Central U.S. are not closely tied to traveling disturbances in the westerlies.

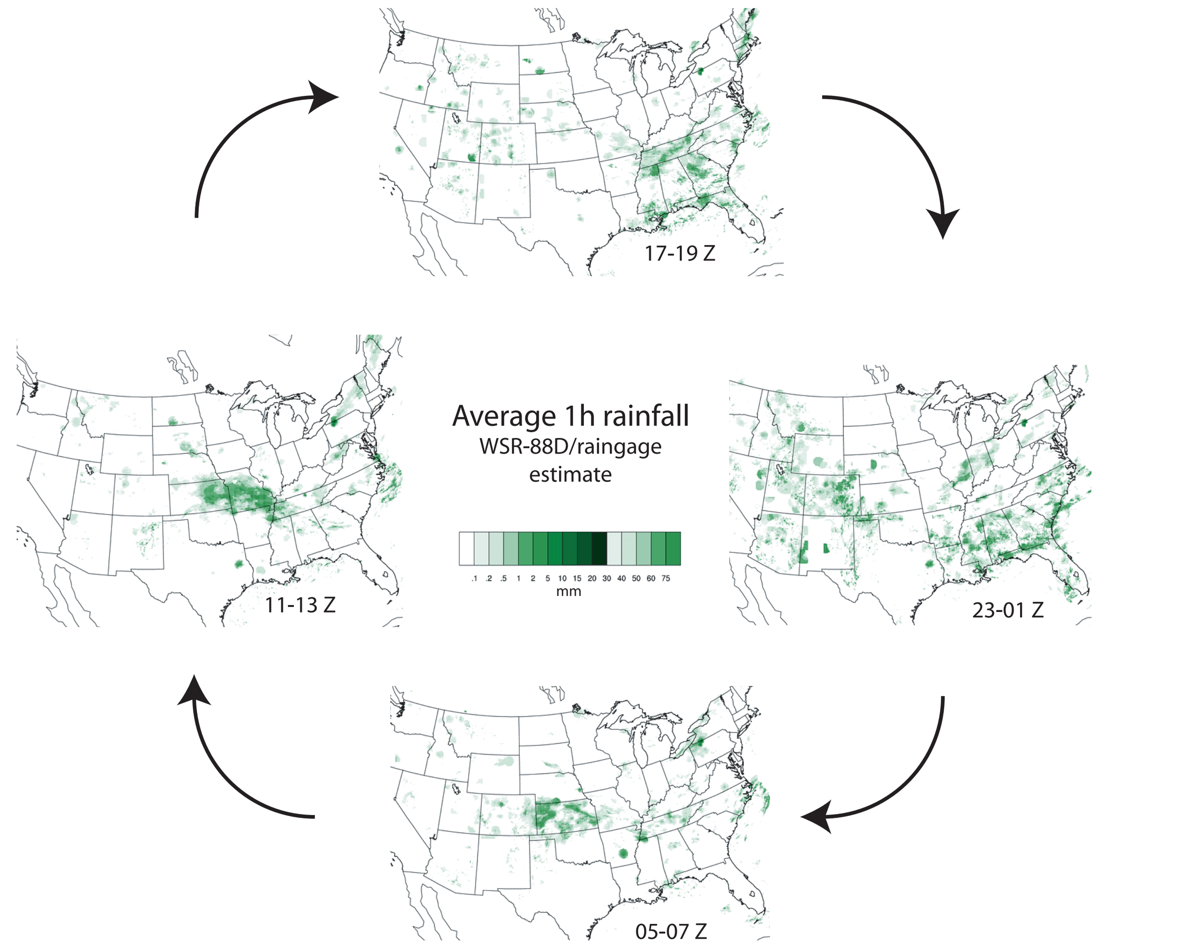


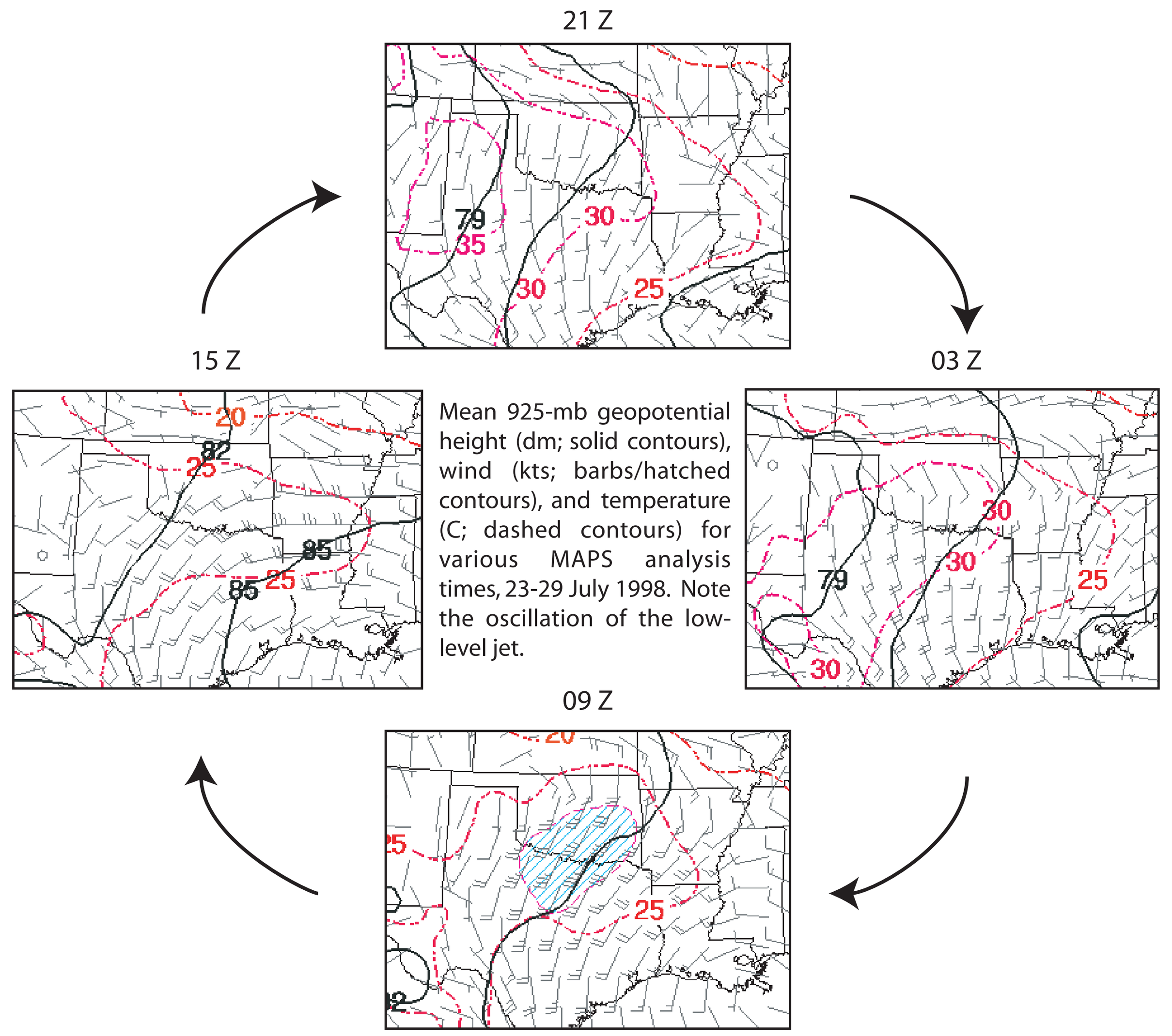
Mean height of analyzed ETA 500-mb pressure surface for 23-29 July 1998. Specific humidity is hatched in green. Higher mid-tropospheric moisture values are within the monsoon circulation over the western U.S. and along the Central U.S. storm track.



Artist's depiction of the surface front draped across the nation's midsection from 23-29 July 1998.

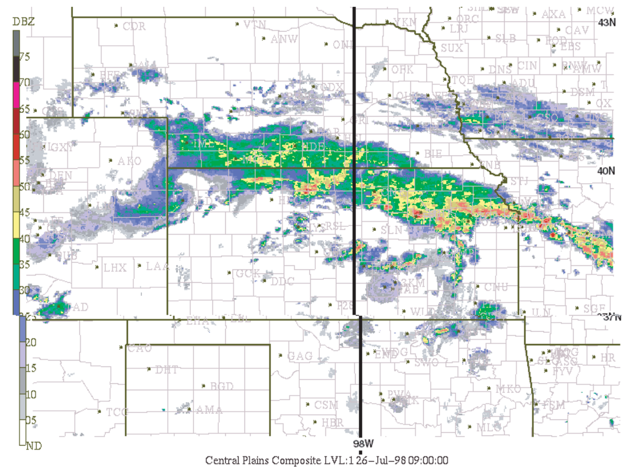
Diurnal Signal

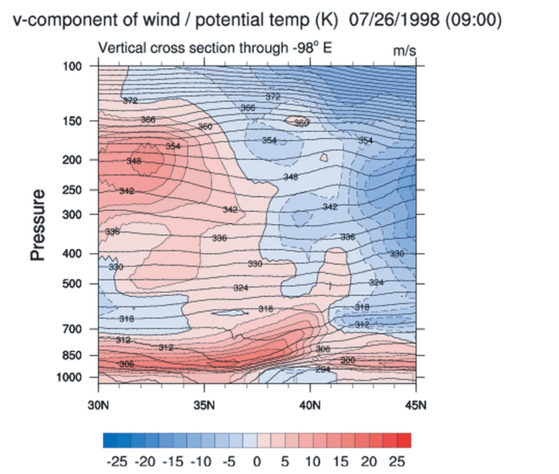




Mean 925-mb geopotential height (dm; solid contours), wind (kts; barbs/hatched contours), and temperature (C; dashed contours) for various MAPS analysis times, 23-29 July 1998. Note the oscillation of the low-level jet.

Nocturnal MCS and Low-level Jet





The above left figure shows NIDS reflectivity associated with the early morning MCS on July 26, 1998. The above right figure is a vertical cross-section through 98 W at the same time from the MAPS analysis. Contours of potential temperature and meridional wind speed are shown. The elevated convection north of the surface front (~38 N) lies at the nose of a strong low-level jet.

Conclusion

The upper-level flow was relatively static from 23 to 30 July 1998, showing little variation near the primary track of the precipitation episodes. The track was anchored within a deep confluent zone north of a mid-tropospheric ridge centered over Texas. The weather pattern was highly analogous to a case study described by Trier and Parsons (1993) in which the low-level jet fueled successive MCSs along and north of a zonally-oriented surface boundary over Kansas/Oklahoma.

Multi-day composites of rainfall and low-level wind exhibited a strong dependence on the diurnal cycle. However, the signal was less apparent in upper-level wind composites. There are several likely reasons. For one, the important forcing is probably shallow and near the surface. Second, the numerical models probably have a difficult time representing deep convection and conveying its up-scale influence on the large-scale environment. Furthermore, upper-air observations are sparse, owing to twice-daily rawinsondes and fewer aircraft taking observations near active convection. This decreases the likelihood of mesoscale convection affecting the analyzed fields.

Better understanding of precipitation episode dynamics should improve quantitative precipitation forecasts, especially downstream from ongoing events. Further exploration via cloud resolving models and detailed case-studies is planned.

References

Carbone, R. E., J. D. Tuttle, D. A. Ahijevych and S. B. Trier, 2002. Inferences of predictability associated with warm season precipitation episodes. *J. Atmos. Sci.* **59**, 2033-2056.
Trier, S. B. and D. B. Parsons, 1993. Evolution of environmental conditions preceding the development of a nocturnal mesoscale convective complex. *Mon. Wea. Rev.* **121**, 1078-1098.

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