Observational Analysis on Heavy Spring Rainfall in Iowa from the IFloodS Campaign

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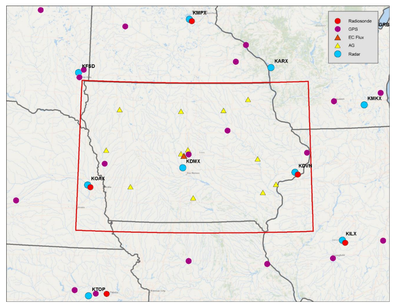
Introduction



Iowa study area

The red line indicates the analysis region. Station codes are: KMDX - Des Moines, IA, KTOP - Topeka, KS, KILX - Lincoln, IL, and KMPX - Minneapolis, MN.

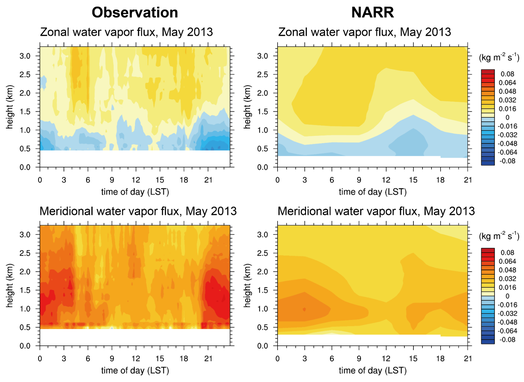
❑ Observationally-derived water vapor flux

$$Q_x(t) = \int_0^{z_{top}} \rho_v(t,z)u(t,z)dz\,, \quad Q_y(t) = \int_0^{z_{top}} \rho_v(t,z)v(t,z)dz$$

ρ_v: water vapor density

u, *v*: wind velocity

To derive water vapor flux at high temporal time scales, we utilize WSR-88D Velocity Azimuth Display (VAD) wind profiles, Global Positioning System (GPS) precipitable water and radiosonde humidity profiles, following the method suggested by Ryu et al. (2015).



Time-height variation in water vapor flux at Des Moines, IA, in May 2013 from observations (left) and NARR (right)

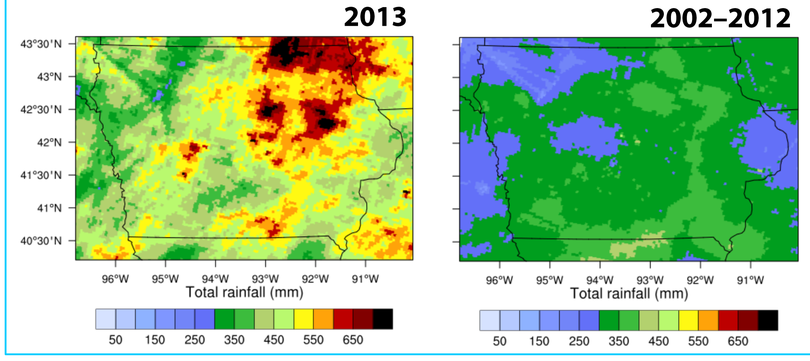
As Ryu et al. (2015) pointed out, NARR underestimates the magnitude of water vapor flux, particularly in the meridional direction.

Rainfall Characteristics

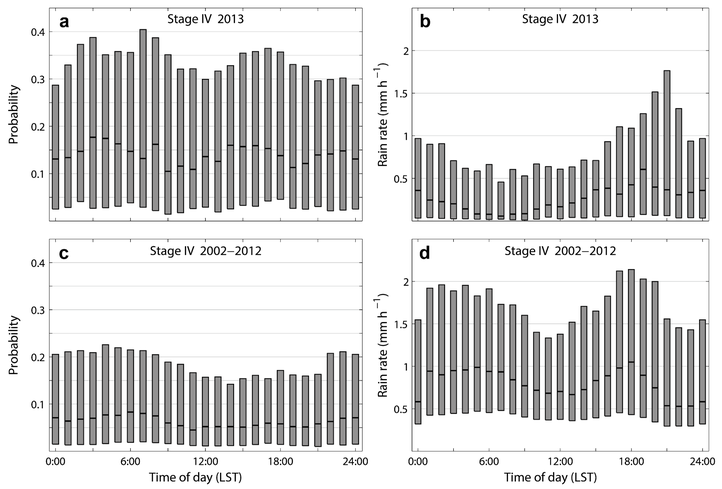
Rainfall amounts in mm during April–June for each year of 2002–2013 from Stage IV data.

2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	avg.
485	248	362	452	321	498	305	227	292	320	300	256	339

2013 is the second wettest year among 2002–2013 in terms of the 3-month spring rainfall, as can be seen from the 3-month rainfall distribution below.



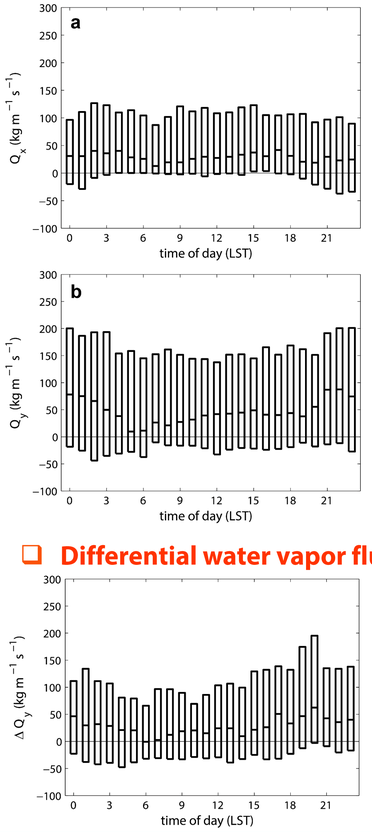
Diurnal Cycle in Rainfall



Rainfall probability in 2013 is high during the predawn hours and early morning hours (also in 2002–2012).Rain rate in 2013 is highest during the evening hours. Rain rate in 2002–2013 is high during the evening hours and predawn hours. In general, rain rate in 2013 is higher in the nighttime than in the daytime.

Diurnal Cycle in Water Vapor Flux

❑ Vertically-integrated water vapor flux



Zonal water vapor flux (top) and meridional water vapor flux (bottom), integrated up to z = 4 km at Des Moines, IA, in April–June 2013.

Unlike the zonal water vapor flux, the meridional water vapor flux exhibits a strong diurnal variation.

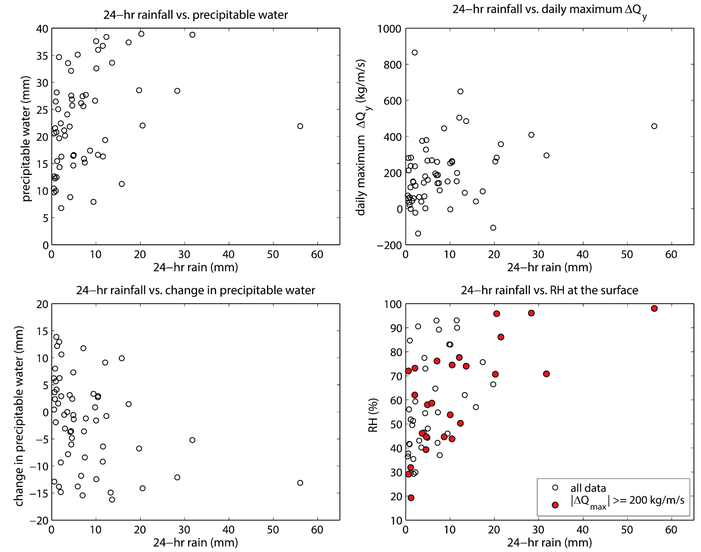
The stronger southerly water vapor flux in the nighttime reflects the influence of nocturnal low-level jets that transport moisture from the south (Helfand and Schubert 1995; Dirmeyer and Kinter 2010).

❑ Differential water vapor flux in the meridional direction

Average between Topeka, KS and Lincoln, IL minus Minneapolis, MN.

This differential flux exhibits larger values in the nighttime than in the daytime.

Relationship with Daily Rainfall



- 24-hr rain: area-average rainfall in Iowa
- Precipitable water: 00 UTC at Omaha sounding station
- Daily max. differential flux: Topeka & Lincoln minus Minneapolis
- Change in precipitable water: 24-hr difference in precipitable water at 00 UTC at Omaha
- RH: relative humidity near the surface at 00 UTC at Omaha

Precipitable water shows a positive but weak relationship with daily rainfall (top left), the daily maximum of the differential water vapor flux also shows a weak relationship (top right).

The change in precipitable water shows a negative relationship with rainfall (bottom left).

The surface relative humidity shows a slightly stronger relationship with rainfall than precipitable water or differential water vapor flux, and the relationship becomes stronger when conditioned on large values of differential water vapor flux (here, 200 kg m^{-1} s^{-1}; bottom right).

Discussion and Conclusions

- ❑ It is found that rain rate, meridional water vapor flux, and differential water vapor flux in the meridional direction all exhibit significant diurnal variations in which nighttime values are greater than daytime ones.
- ❑ The differential water vapor flux does not solely explain the rainfall amount, implying that a stronger convergence does not always yield larger rainfall.
- ❑ Large surface relative humidity and strong convergence are critcal for heavy rainfall.

References

Dirmeyer, P. A. and J. L. Kinter, 2010: Floods over the U.S. Midwest: A regional water cycle perspective. J. Hydrometeor., 11, 1172–1181.

Helfand, H. M. and S. D. Schubert, 1995: Climatology of the simulated Great Plains low-level jet and its contribution to the continental moisture budget of the United States. J. Climate, 8, 784–806.

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