Spatial variability in precipitation: Clues to diffuse recharge in shallow karst aquifers

Stephanie S. Wong¹*, Joe C. Yelderman Jr¹, Bruce Byars²

¹ Baylor Department of Geosciences
One Bear Place #97354
Waco TX 76798
* stephanie_wong@Baylor.edu

² Baylor Center for Spatial Research
One Bear Place #973541
Waco TX 76798

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Spatial heterogeneity, karst, and precipitation

- Traditionally,
  - Treat geology as **homogeneous aquifer**,
  - Use **average annual precipitation** over the whole aquifer,
  - Or both
Spatial heterogeneity, karst, and precipitation

Since we know karst is heterogeneous, it is even more important to consider precipitation variability to understand recharge.
Objective:

To improve understanding between recharge, geology, and precipitation in a shallow karst aquifer by:

• Describing geologic heterogeneity
• Documenting spatial variability of precipitation
• Comparing precipitation to hydrogeologic data
The Edwards BFZ aquifer

Northern Segment
Barton Springs Segment
San Antonio Segment
Outcrop portion
Downdip portion
Balcones Fault Zone
Edwards limestone
Comanche Peak limestone
Georgetown limestone
Keys Valley marl

Unconfined portion
Confined portion
Types of precipitation

**Convective rain**
- Air parcels rise *vertically* through the temporarily self-sustaining mechanism of convection.
- Rain falls from deep clouds at various intensities (e.g., storm).

**Stratiform rain**
- Large air masses rise *diagonally* as larger-scale atmospheric dynamics force them to move over each other.
- Rain falls from shallow, low clouds at typically low intensities (e.g., drizzle, light rain).

Source: [https://goo.gl/eK9Gbb](https://goo.gl/eK9Gbb)
Source: [https://goo.gl/XBxNpr](https://goo.gl/XBxNpr)
Source: [https://goo.gl/U6svYF](https://goo.gl/U6svYF)
Stratiform precipitation (spatially homogenous)

(a) 

Convective precipitation (spatially heterogeneous)

(b) 

Seattle

Texas

(a and b modified from University of Washington, 2017)
WSR-88D Precipitation Data

- National Weather Service product; deployed in 1990s
- Doppler radar system operating in dual-polarized mode
- Distinguishes between different hydrometeor characteristics at 4x4 km resolution
- Raw data calibrated during post-processing using field validation data
Confined portion

Unconfined portion

WSR-88D station (n=26)

Weather station (n=3)
WSR-88D station (n=26)
Cave well
USGS stream gage

Long-term monitoring at Stagecoach Inn Cave (since May 2013)
Precipitation patterns (daily total)

More rain

Less rain

< 0.5” rain

Stratiform

Front

Storm

Storm
March 12, 2017
Min = 0.67 in  Avg = 0.88 in  Max = 1.09 in  Total = 23 in

April 3, 2017
Min = 0.64 in  Avg = 0.776 in  Max = 1.12 in  Total = 19.83 in
April 3, 2017
Min = 0.64 in  Avg = 0.76 in  Total = 19.83 in
Max = 1.12 in

April 12, 2017
Min = 0.84 in  Avg = 1.38 in  Total = 35.92 in
Max = 2.28 in
Groundwater/surface water connection

**Surface water**

**Groundwater**
Summary and conclusions

• WSR-88D a rich source of high spatial and temporal data
• WSR-88D data allow for greater correlation of recharge events with surface water and groundwater monitoring data
• Especially in karst systems,
  • Similar magnitude storms can have very different groundwater response depending on where rain falls
  • Small, even rains may not result in recharge
• Better understanding of recharge over karst allows for improved management of sensitive recharge areas
Thank you!
References


• Photo credits: Stephanie S. Wong, Joe C. Yelderman Jr.