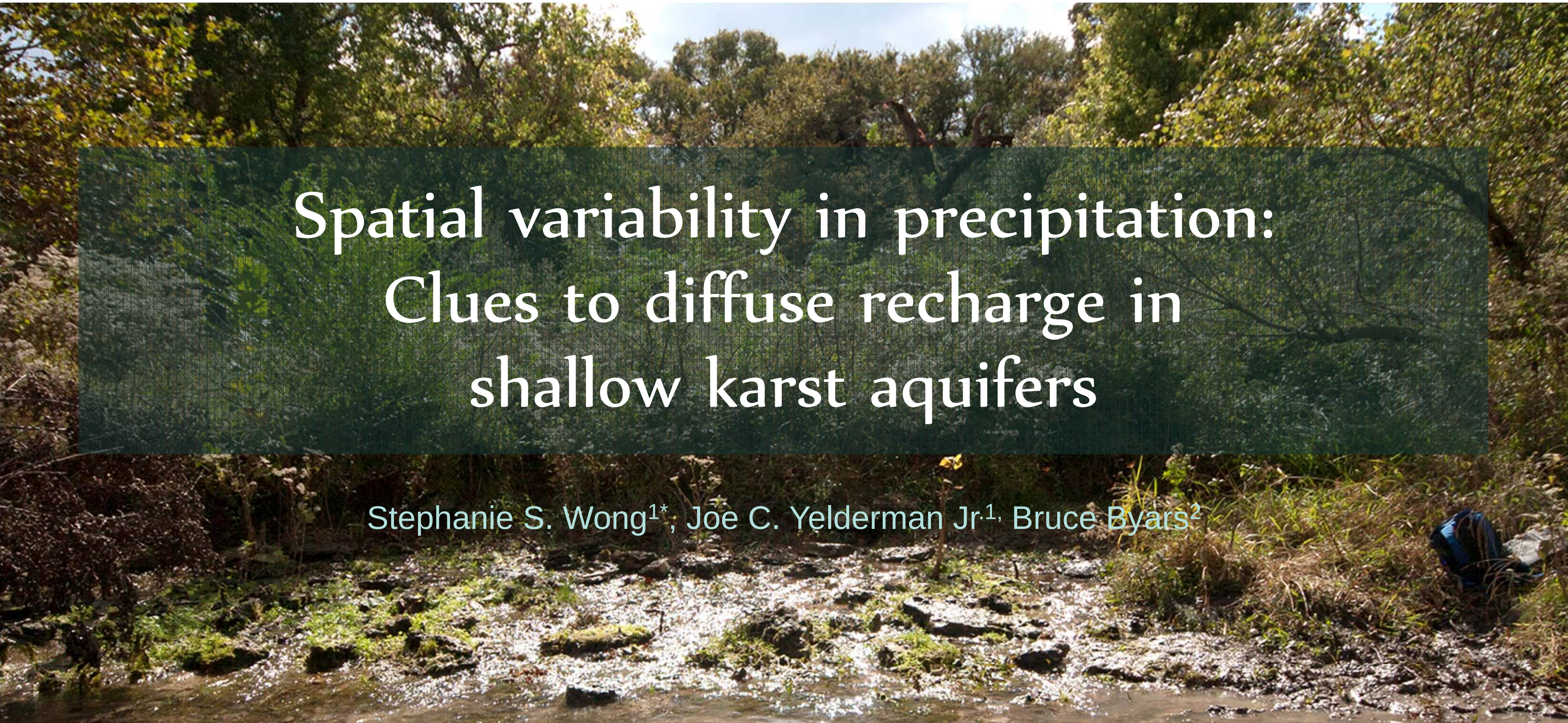

Spatial variability in precipitation: Clues to diffuse recharge in shallow karst aquifers

Stephanie S. Wong[1*], Joe C. Yelderman Jr.[1], Bruce Byars[2]

[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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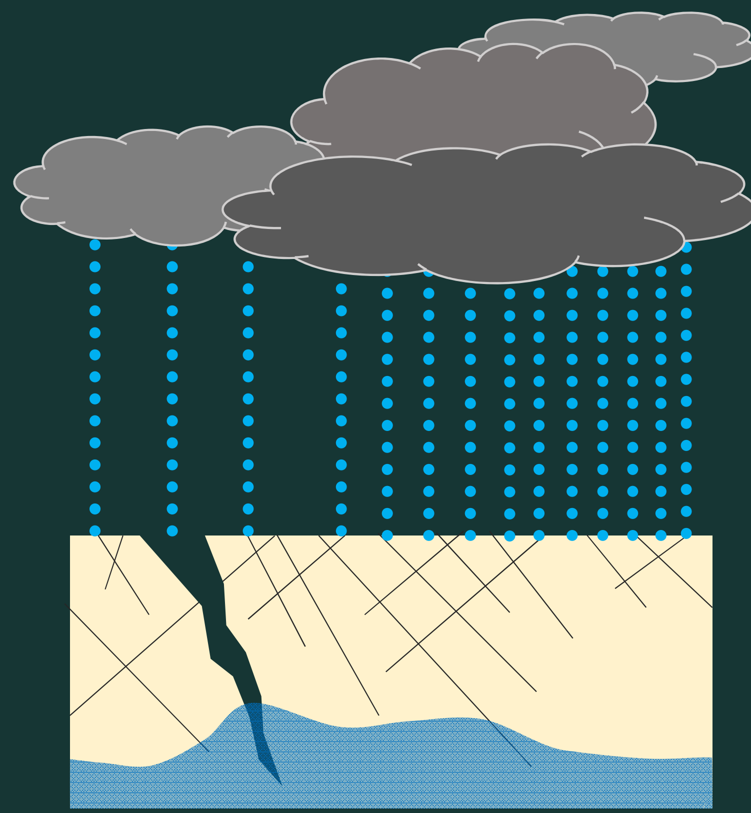
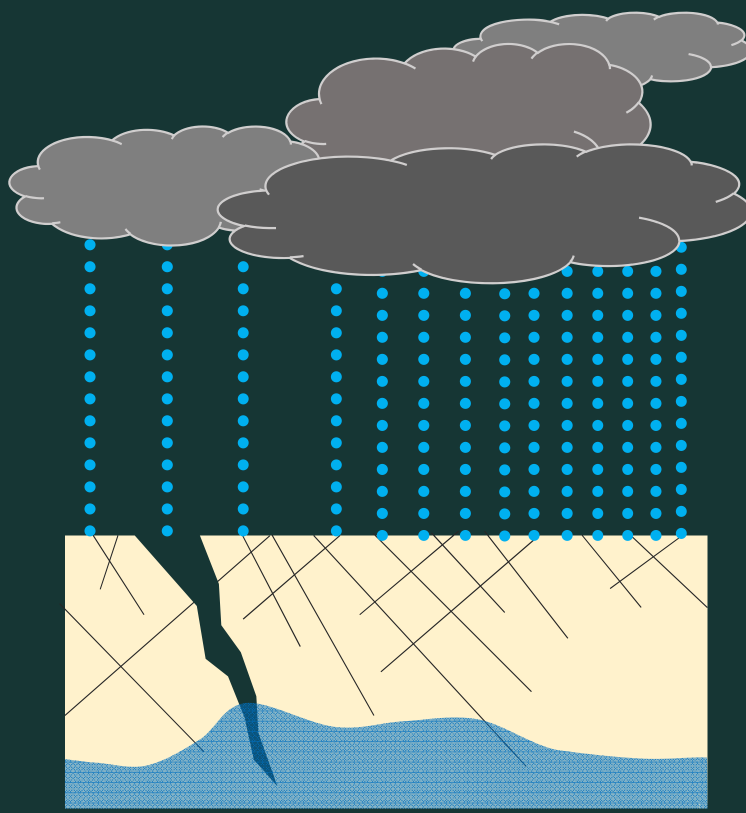
Spatial heterogeneity, karst, and precipitation

- 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



Variable precipitation??

Heterogeneous aquifer

Variable recharge

Objective:

Precipitation data

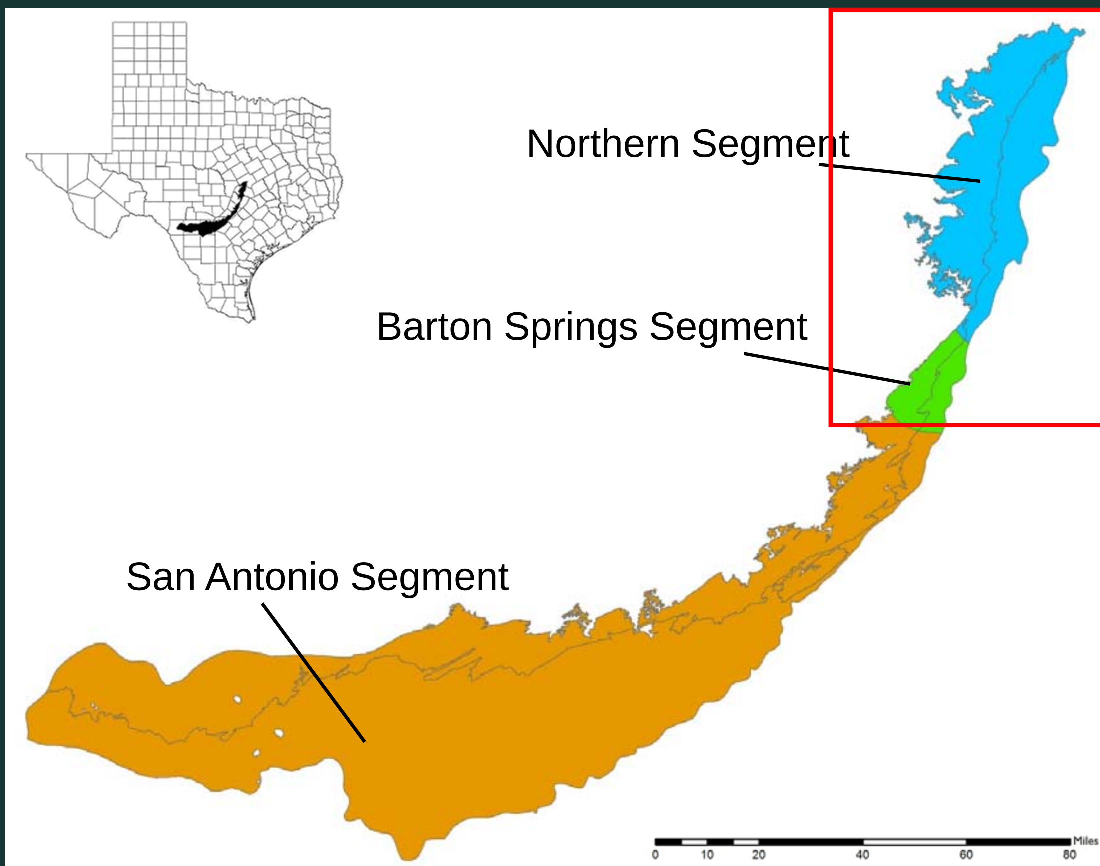
Surface geology

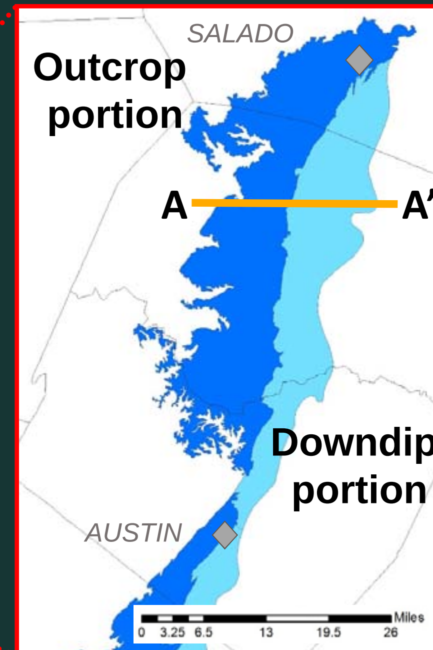
Groundwater and surface water response

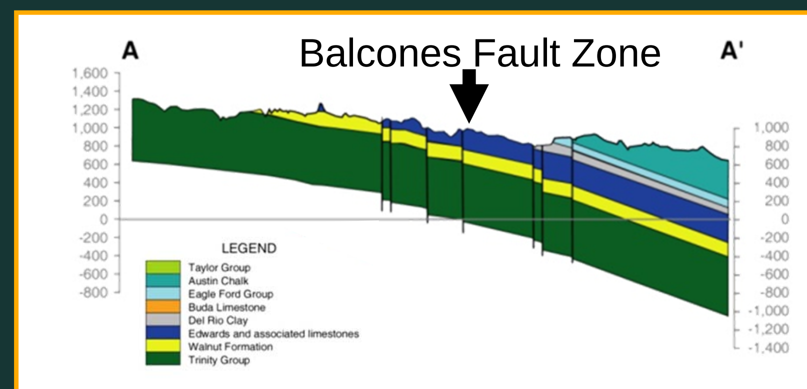
To improve understanding between **recharge**, **geology**, and **precipitation** in a shallow karst aquifer by:

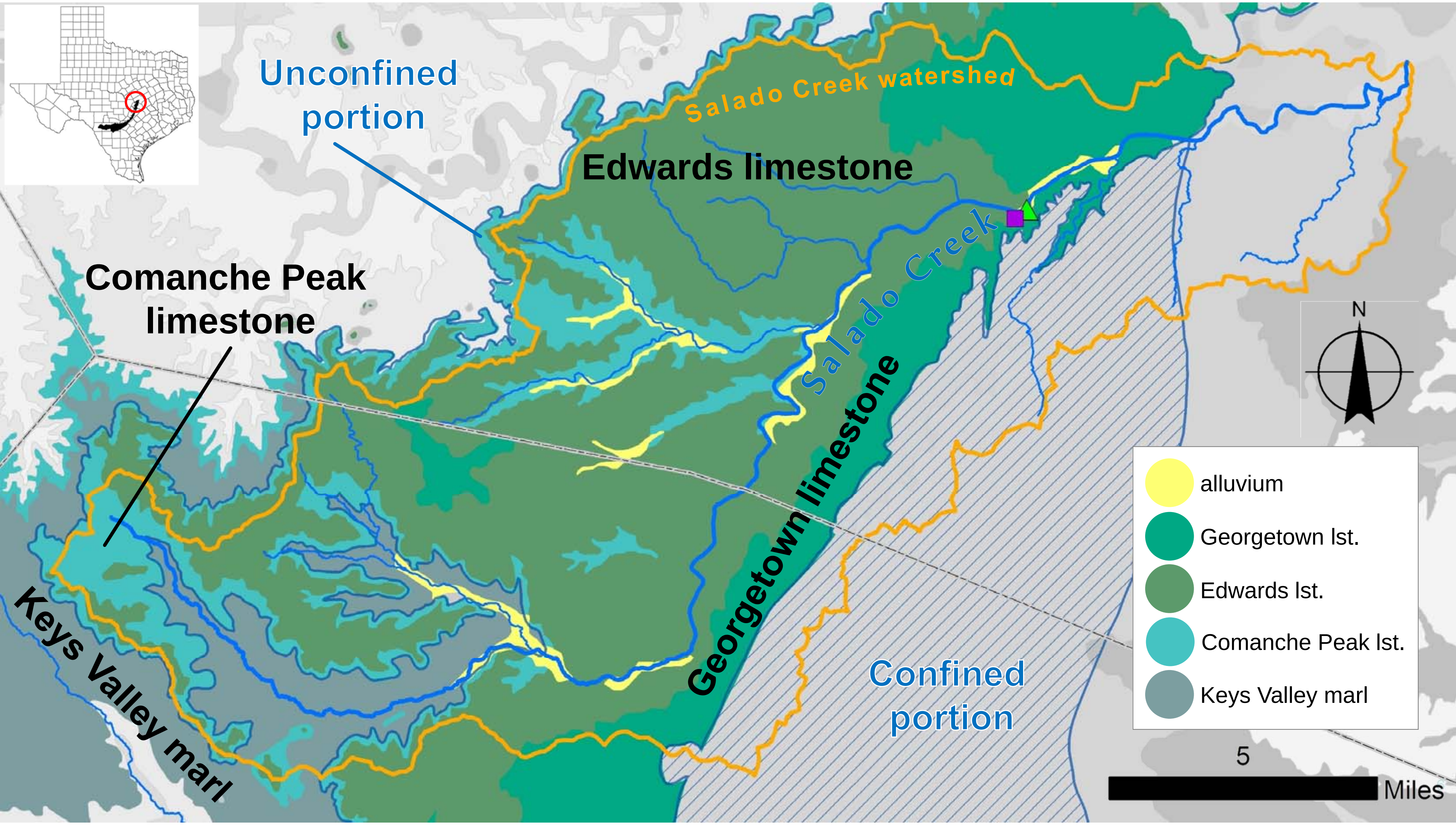
- **Describing** geologic heterogeneity
- **Documenting** spatial variability of precipitation
- **Comparing** precipitation to hydrogeologic data

The Edwards BFZ aquifer









Unconfined portion
Salado Creek watershed
Edwards limestone
Comanche Peak limestone
Salado Creek
Georgetown limestone
Keys Valley marl
Confined portion
N
alluvium
Georgetown lst.
Edwards lst.
Comanche Peak lst.
Keys Valley marl
5
Miles

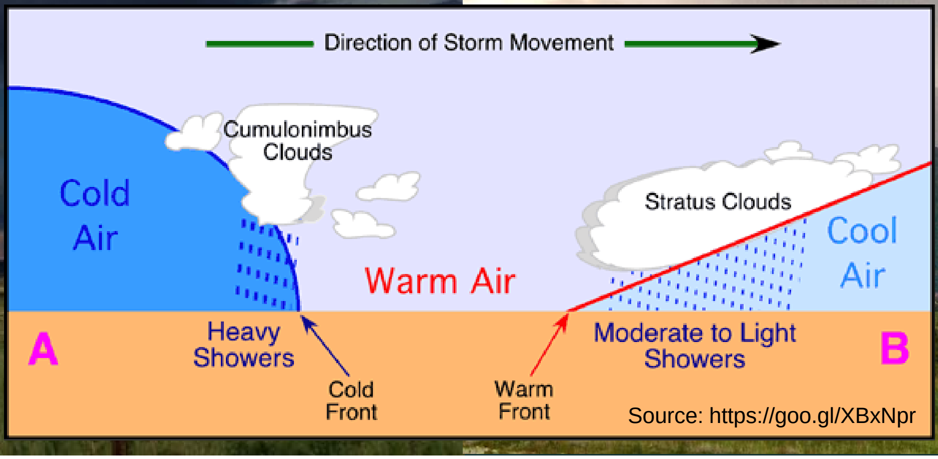
Types of precipitation

Convective rain

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

Stratiform rain

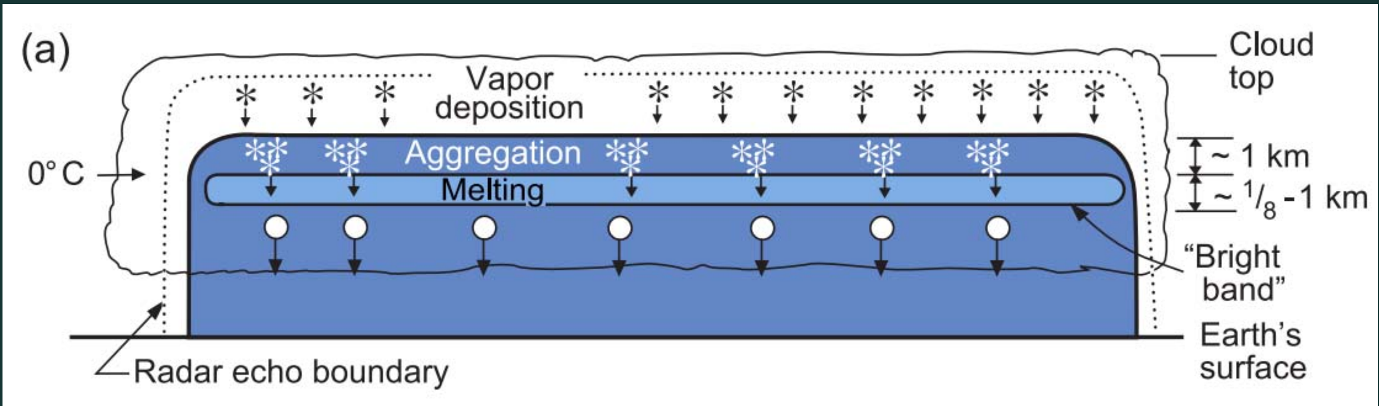
- Large air masses rise **diagonally** as larger-scale atmospheric dynamics force them to move over each other
- Rain falls from shallow, low clouds at typically low intensities (eg. drizzle, light rain)



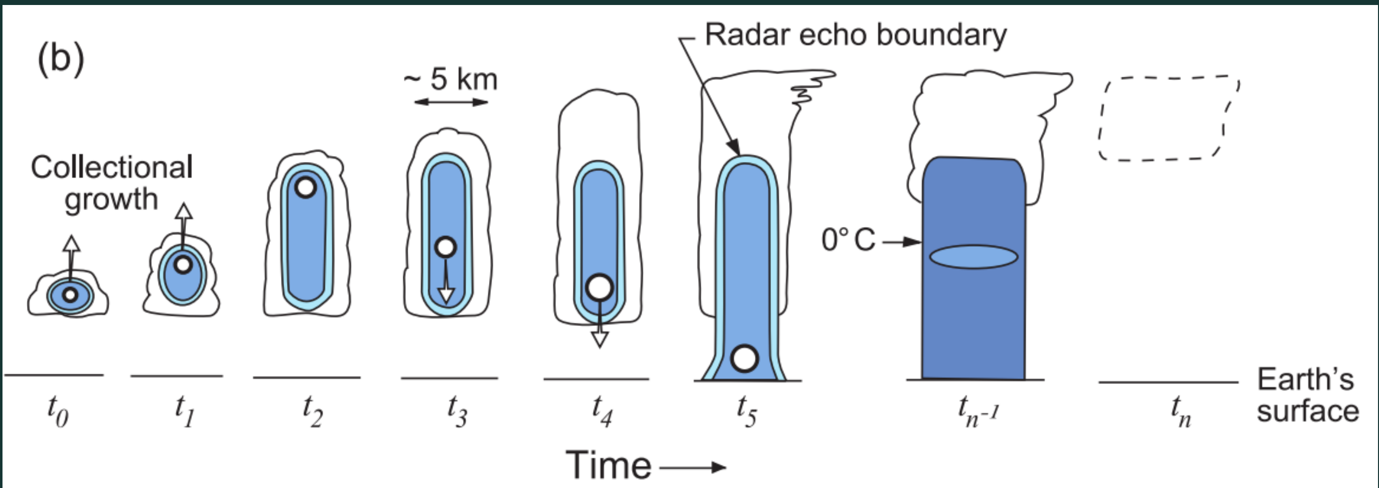
Source: https://goo.gl/U6svYF

Source: https://goo.gl/eK9Gbb

Stratiform precipitation (spatially homogenous)



Convective precipitation (spatially heterogeneous)



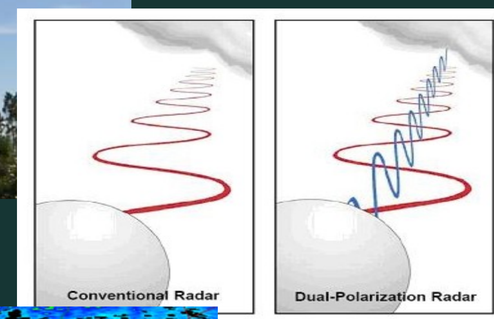
(*a* and *b* modified from University of Washington, 2017)

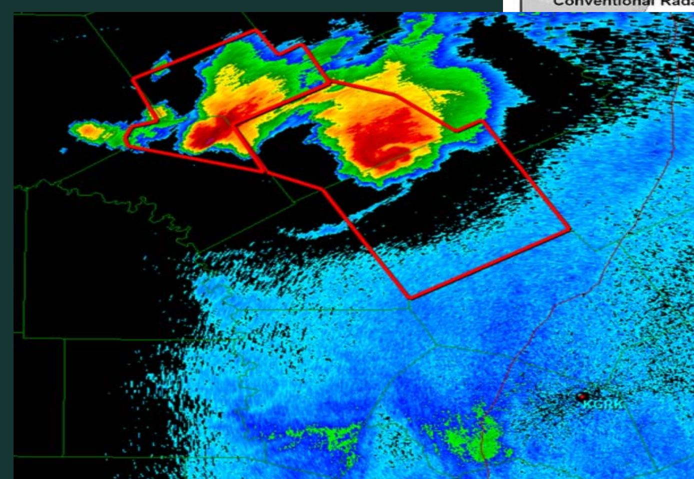
WSR-88D Precipitation Data

- 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

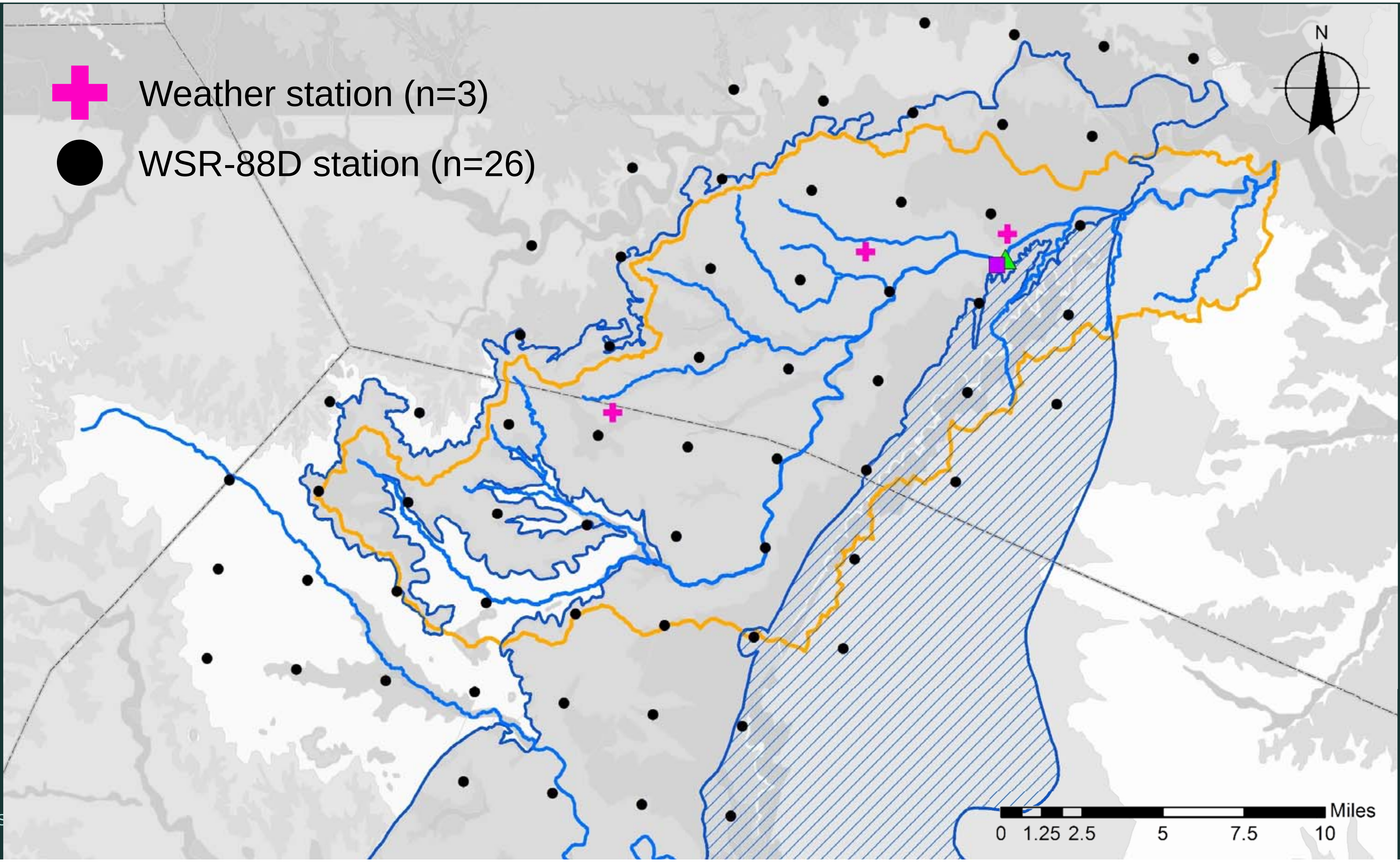
Doppler radar

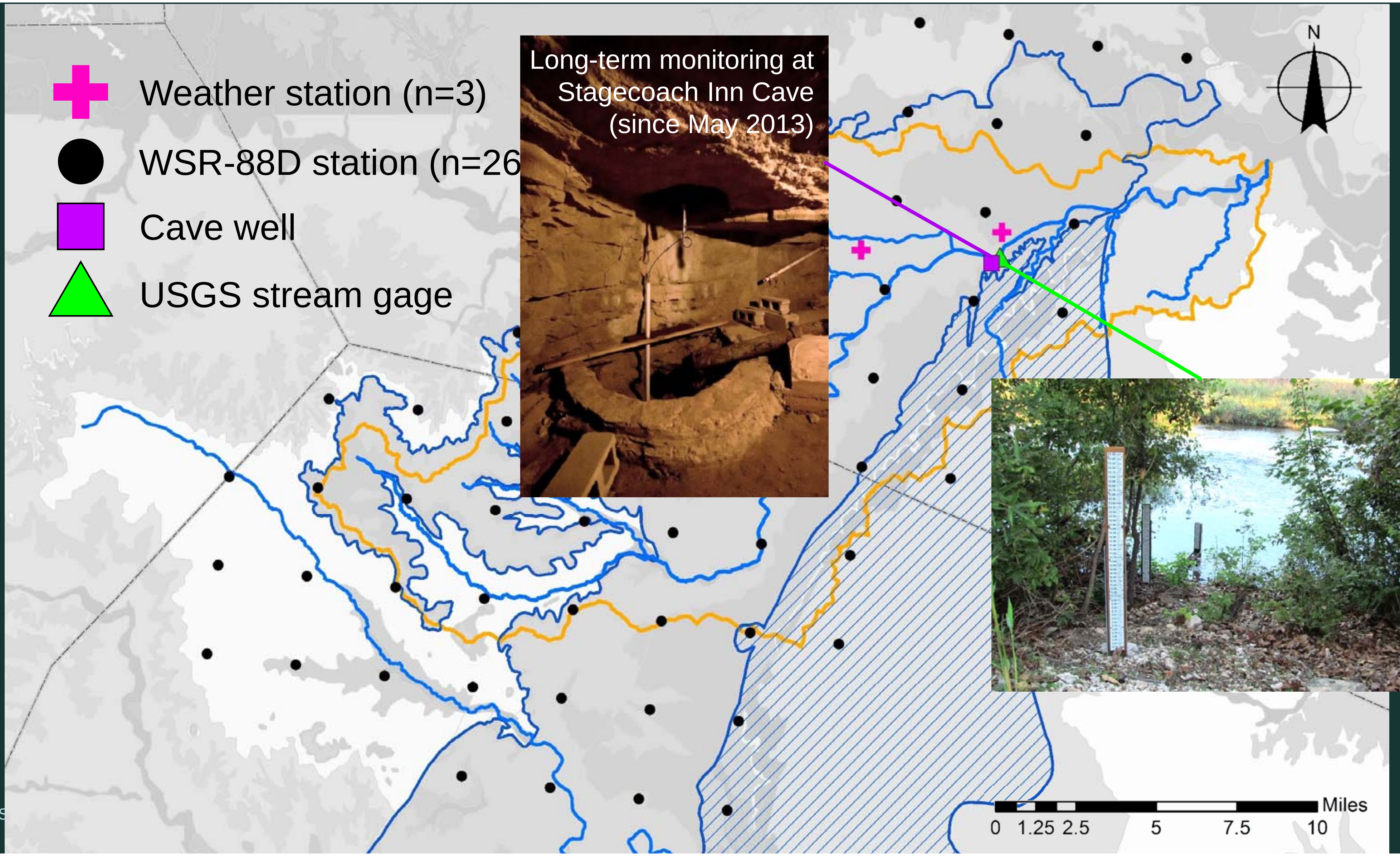
Dual-polarization



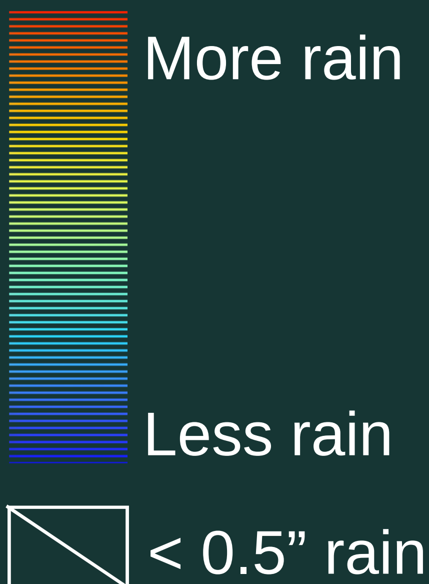


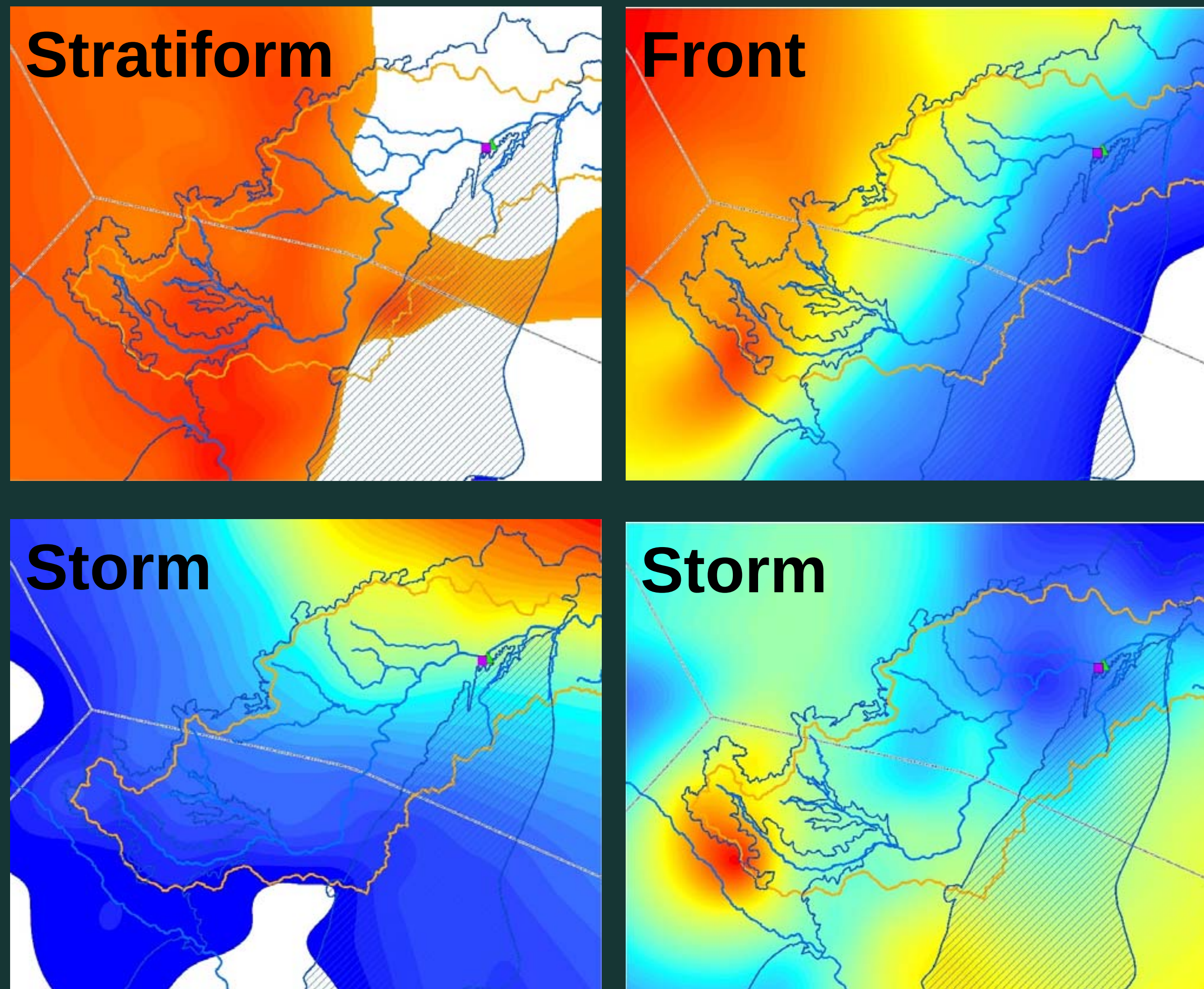
Example coverage


Weather station (n=3)
WSR-88D station (n=26)
N
Miles
0 1.25 2.5 5 7.5 10


Weather station (n=3)
WSR-88D station (n=26
Cave well
USGS stream gage
Long-term monitoring at Stagecoach Inn Cave (since May 2013)
N
Miles
0 1.25 2.5 5 7.5 10

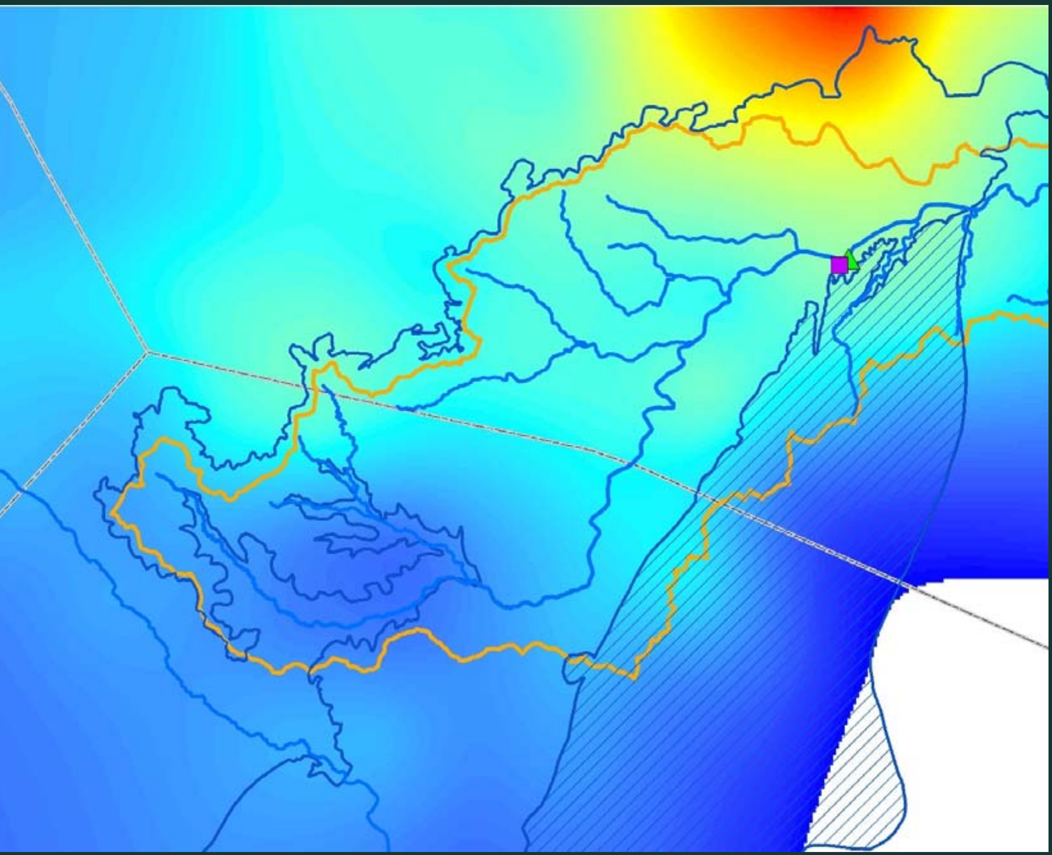
Precipitation patterns (daily total)





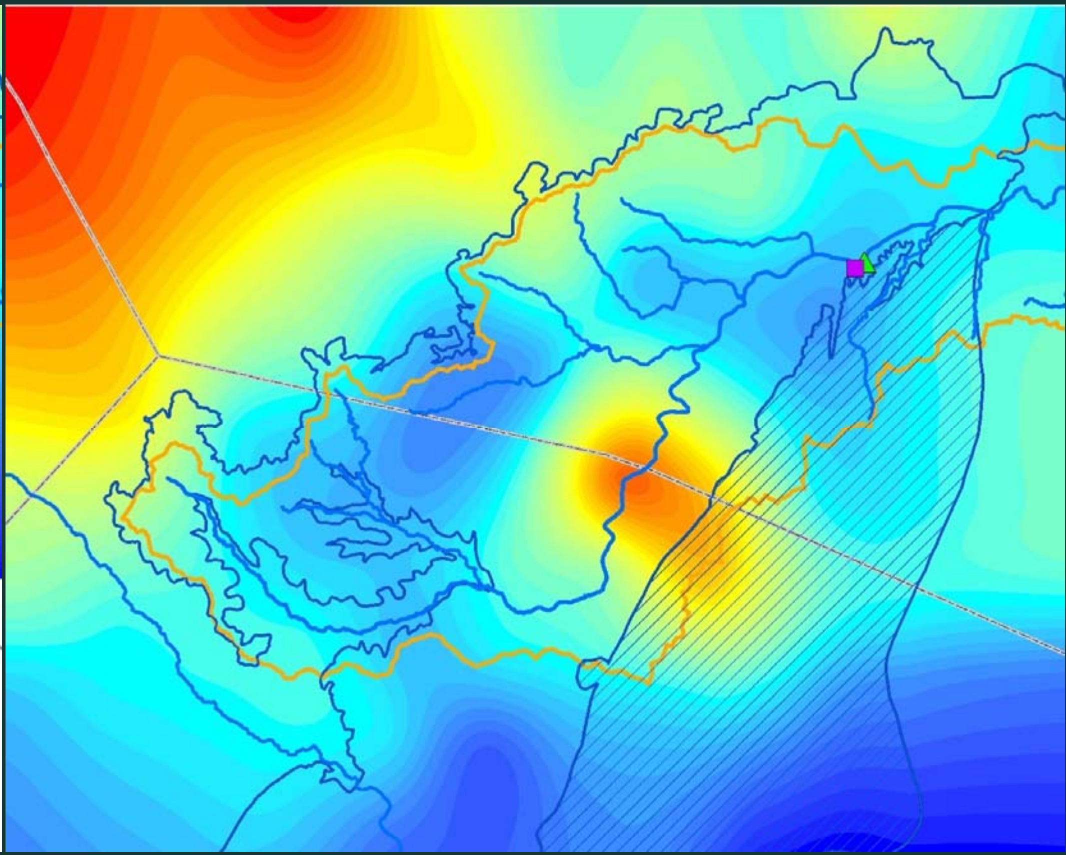
March 12, 2017

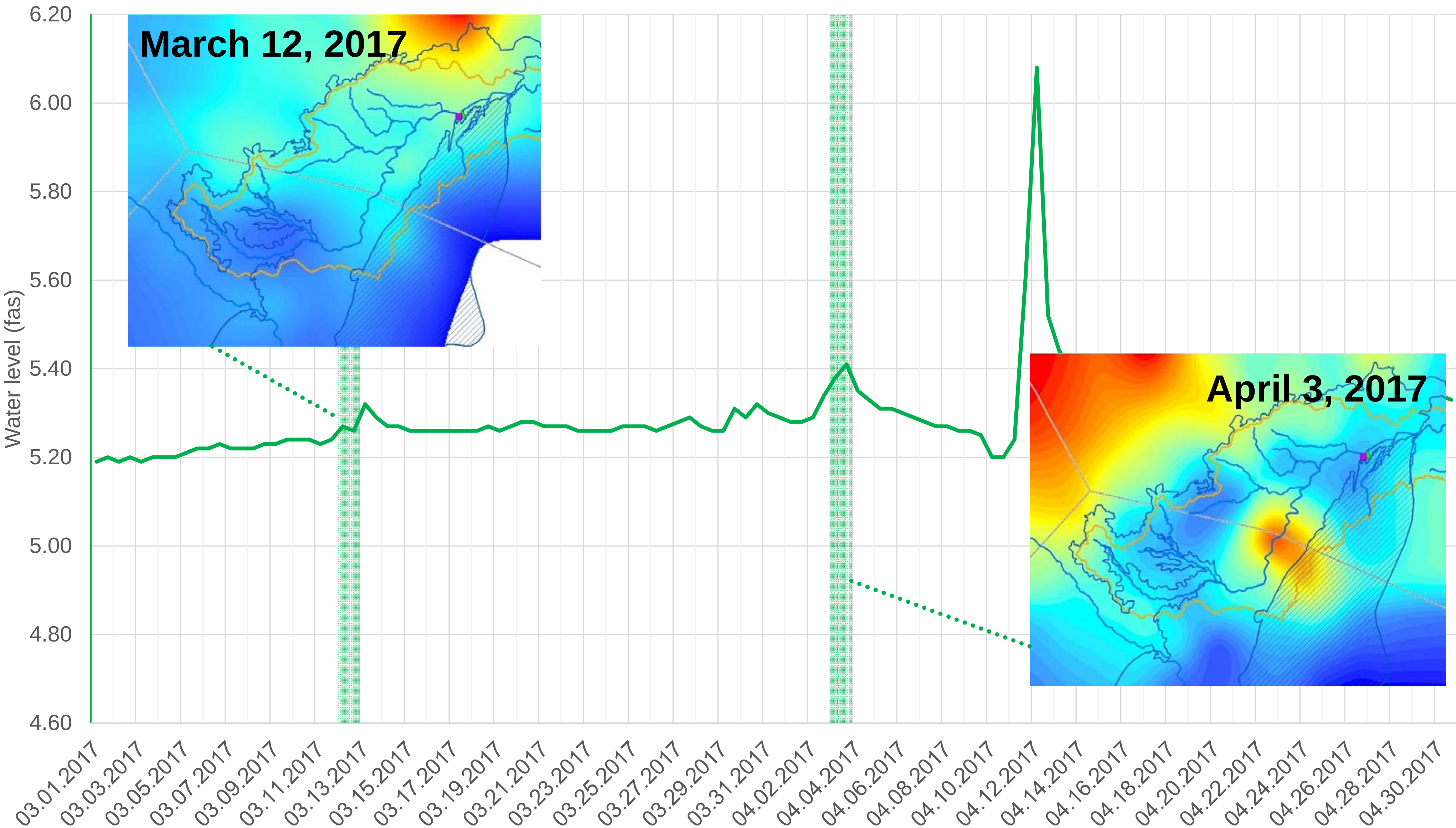
Min = 0.67 in   Avg = 0.88 in
Max = 1.09 in   Total = 23 in



April 3, 2017

Min = 0.64 in   Avg = 0.776 in
Max = 1.12 in   Total = 19.83 in



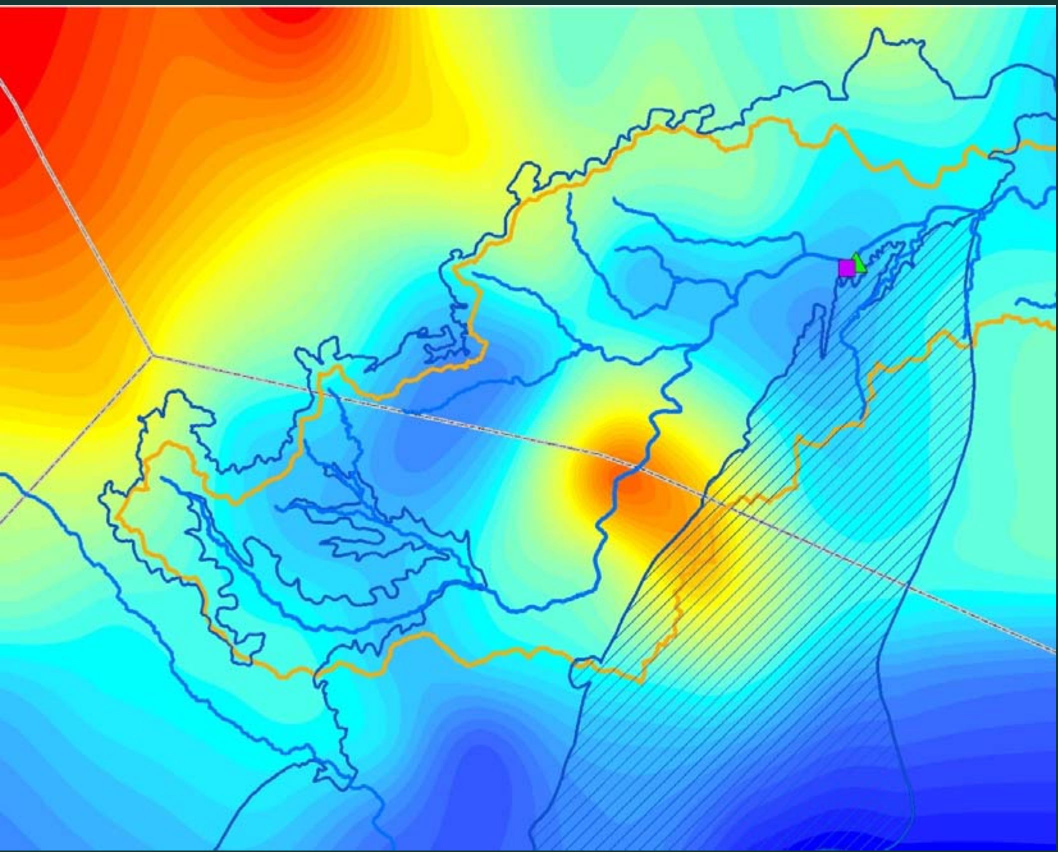

March 12, 2017
April 3, 2017
Water level (fas)
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
4.60
03.01.2017
03.03.2017
03.05.2017
03.07.2017
03.09.2017
03.11.2017
03.13.2017
03.15.2017
03.17.2017
03.19.2017
03.21.2017
03.23.2017
03.25.2017
03.27.2017
03.29.2017
03.31.2017
04.02.2017
04.04.2017
04.06.2017
04.08.2017
04.10.2017
04.12.2017
04.14.2017
04.16.2017
04.18.2017
04.20.2017
04.22.2017
04.24.2017
04.26.2017
04.28.2017
04.30.2017

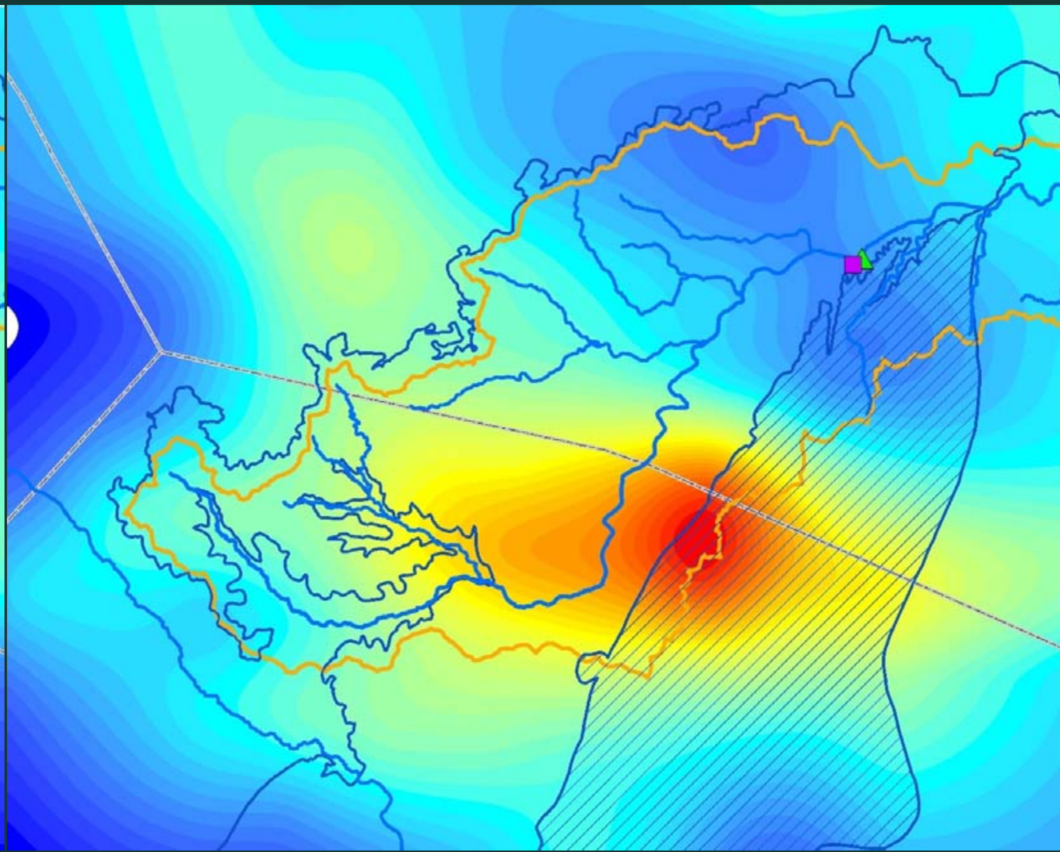
April 3, 2017

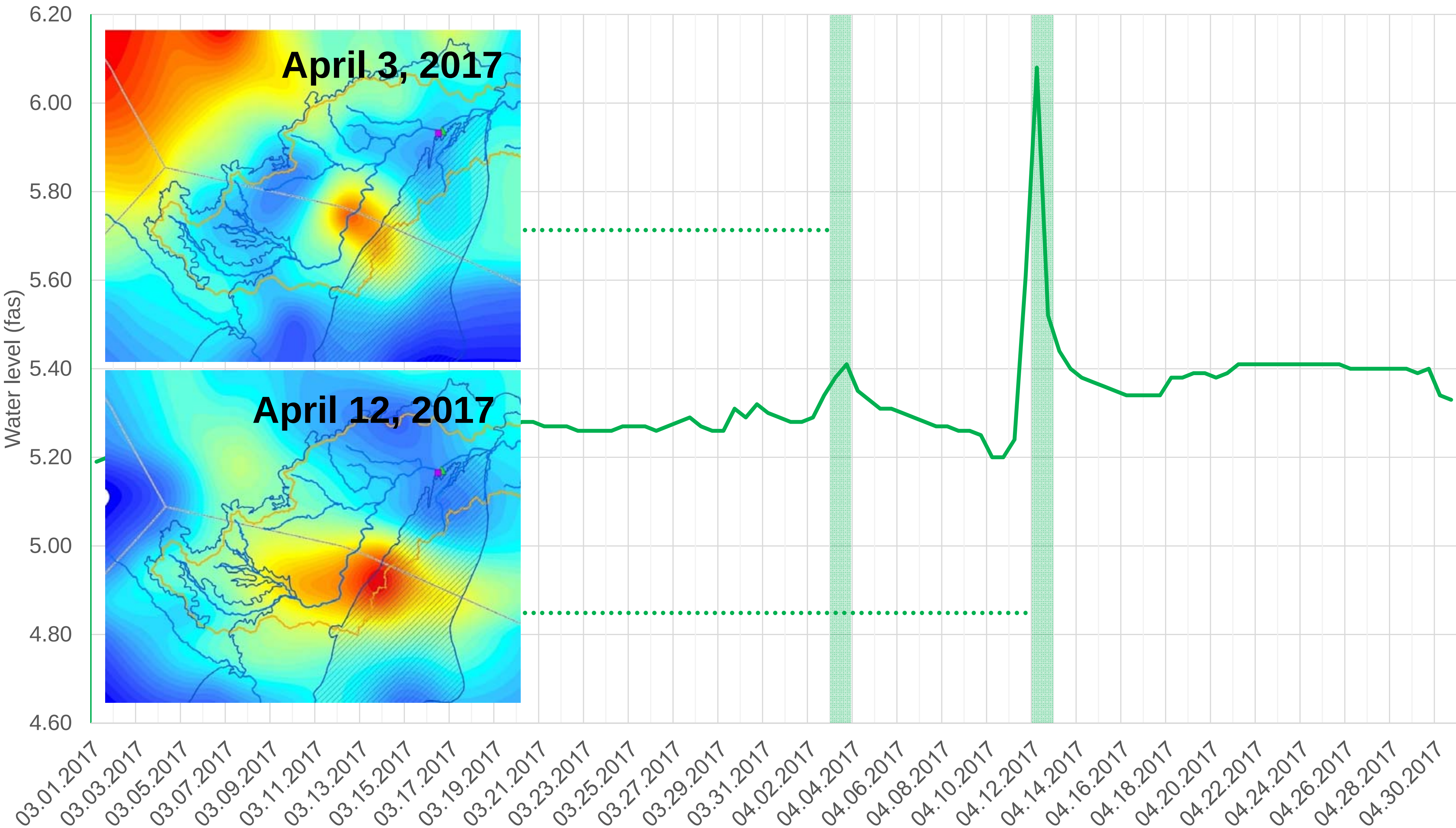
Min = 0.64 in   Avg = 0.76 in
Max = 1.12 in   Total = 19.83 in

April 12, 2017

Min = 0.84 in   Avg = 1.38 in
Max = 2.28 in   Total = 35.92 in

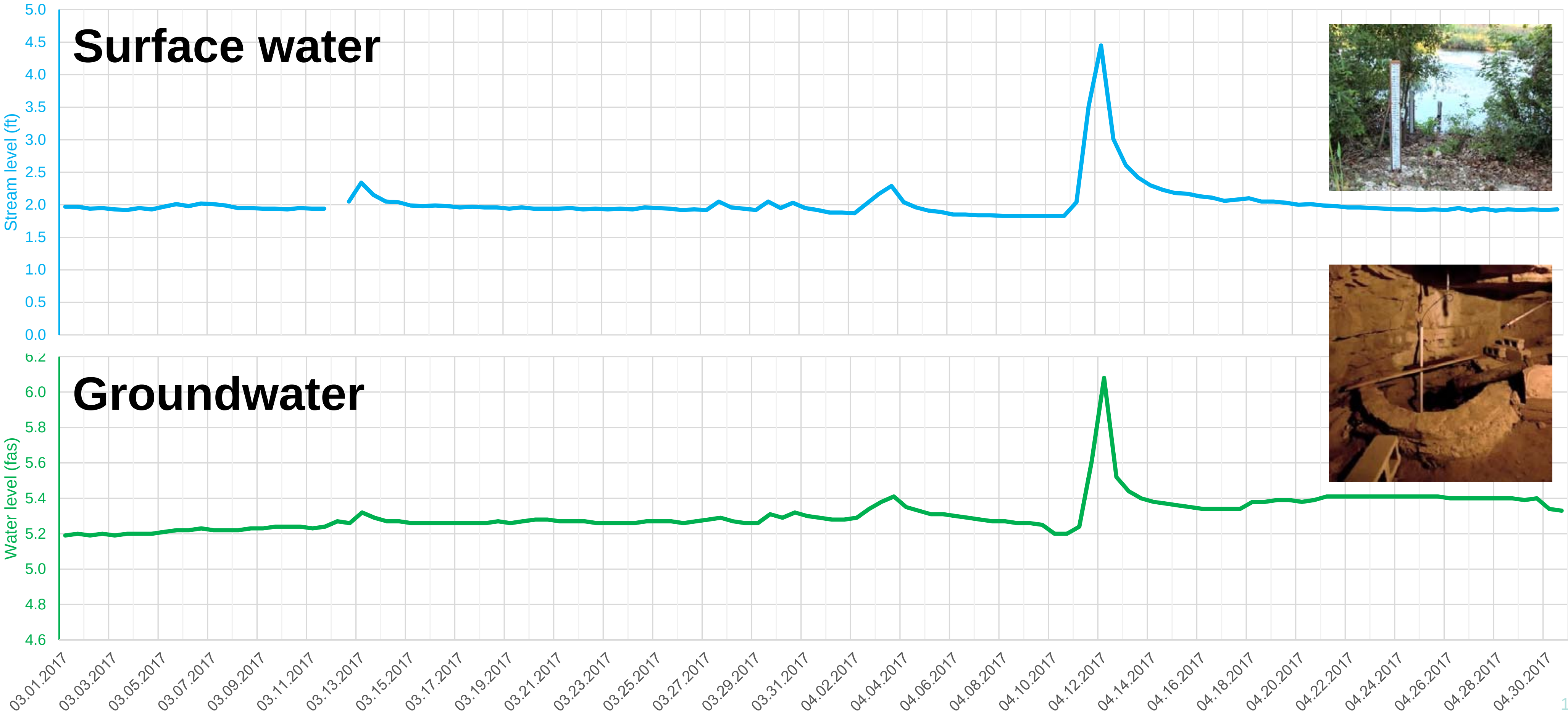






April 3, 2017
April 12, 2017
Water level (fas)
6.20
6.00
5.80
5.60
5.40
5.20
5.00
4.80
4.60
03.01.2017
03.03.2017
03.05.2017
03.07.2017
03.09.2017
03.11.2017
03.13.2017
03.15.2017
03.17.2017
03.19.2017
03.21.2017
03.23.2017
03.25.2017
03.27.2017
03.29.2017
03.31.2017
04.02.2017
04.04.2017
04.06.2017
04.08.2017
04.10.2017
04.12.2017
04.14.2017
04.16.2017
04.18.2017
04.20.2017
04.22.2017
04.24.2017
04.26.2017
04.28.2017
04.30.2017

Groundwater/surface water connection



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!

(Mr. Geary Schindel)

References

- https://image.slidesharecdn.com/satelliteobservationsofrainfallandwatervapor-13009929034985-phpapp02/95/satellite-observations-of-rainfall-and-water-vapor-12-728.jpg?cb=1300975729
- Jones, I.C., 2003, Groundwater Availability Modeling: Northern Segment of the Edwards Aquifer, Texas. Texas Water Development Board Report 358. Texas Water Development Board, Austin, Texas. 83 pp.
- Skow, K., Meteorology 432 Instrumentation and Measurements: NWS WSR-88D Radar Fundamentals (PowerPoint presentation). National Weather Service, Des Moines, Iowa. 57 pp.
- University of Washington Mescoscale Group, Separation of convective and stratiform precipitation in mesoscale systems. <https://atmos.washington.edu/MG/PDFs/NOTES_SeparationConvectStratMesoscale.pdf> *accessed 11 October 2017.*
- Wikipedia, Precipitation types <https://en.wikipedia.org/wiki/Precipitation_types> *accessed 17 October 2017.*
- Photo credits: Stephanie S. Wong, Joe C. Yelderman Jr.