

# Factor 5: Subsidence in GMA-12

Presented to GMA-12  
March 25, 2026

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# Background and Previous Discussion

- **What is subsidence? What causes it?**
  - Lowering of land surface caused by compaction of clays
  - Typically in clastic, unconsolidated sediments
  - Sometimes from sinkholes in karst, or O&G activity
- **Is it a problem in GMA-12?**
  - TWDB subsidence study tool:
    - Brazos Valley Alluvium, Yegua-Jackson and Carrizo-Wilcox have high potential
    - Queen City and Sparta have a medium potential
  - "There have been no reported land subsidence issues in the footprint of the Carrizo-Wilcox aquifer." *Huang and others, 2012*

# TWDB Study

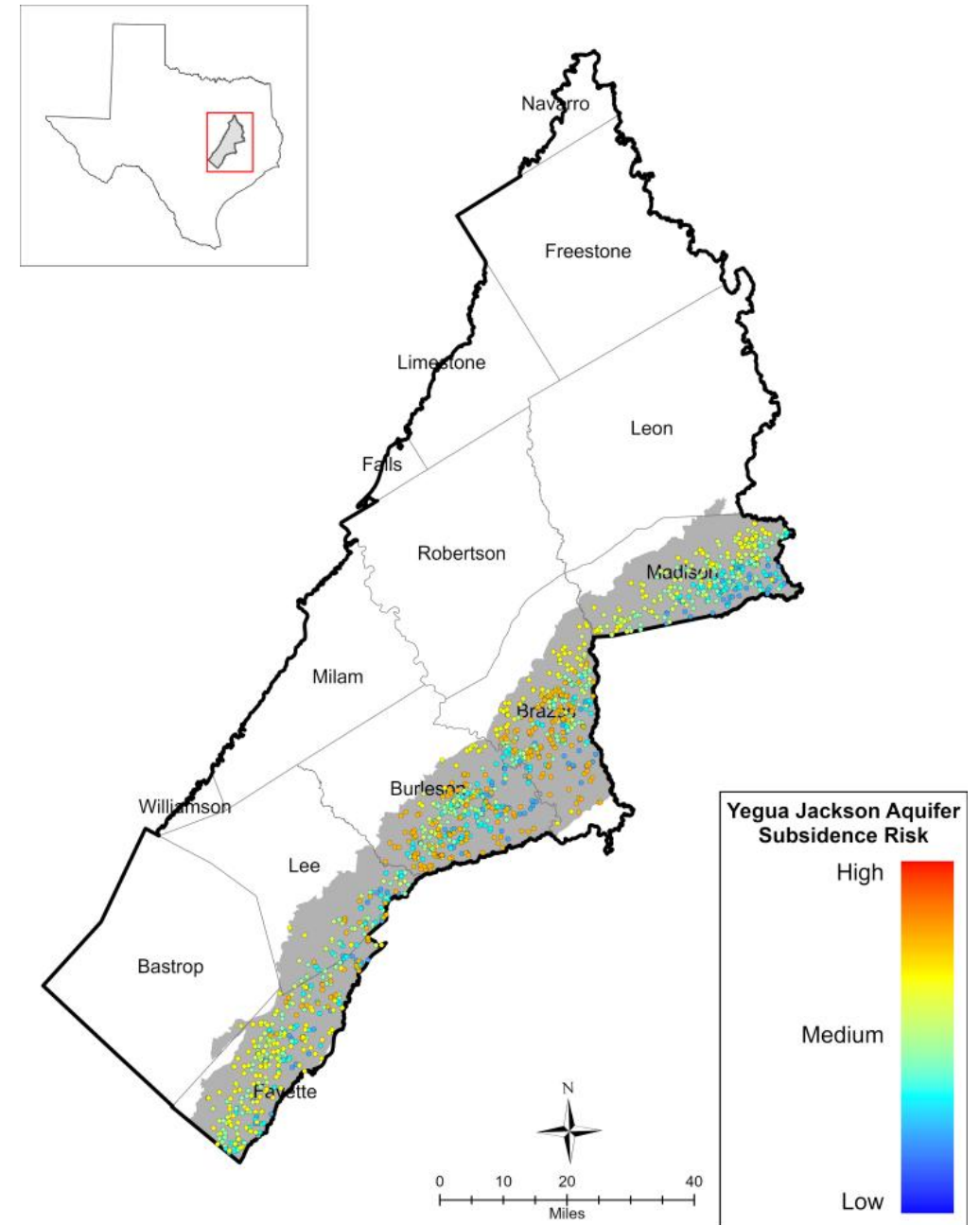
- Risk factors considered
  - Clay character
  - Lithologic type
  - Extend of sediment consolidation
  - Anticipated drawdown
- Normalized to 0-10 scale
  - Aquifer's risk classified based on 75<sup>th</sup> percentile score

| Subsidence Risk Factor<br>(Weight)                       | Subsidence Risk Factor Class                                                                                                      | Subsidence Risk Value |
|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Clay Layer Saturated Thickness and Extent (6)            | Regional Extent – Greater than 300 feet                                                                                           | 5                     |
|                                                          | Regional Extent – 200 to 300 feet                                                                                                 | 4                     |
|                                                          | Regional Extent – 100 to 200 feet                                                                                                 | 3                     |
|                                                          | Regional Extent – Greater than 0 to 100 feet                                                                                      | 2                     |
|                                                          | Local Extent or No Clay                                                                                                           | 1                     |
| Clay Compressibility (5)                                 | Plastic Clay                                                                                                                      | 3                     |
|                                                          | Stiff Clay                                                                                                                        | 2                     |
|                                                          | Hard or No Clay                                                                                                                   | 1                     |
| Aquifer Lithology (4)                                    | Unconsolidated Clastic                                                                                                            | 4                     |
|                                                          | Consolidated Clastic                                                                                                              | 3                     |
|                                                          | Carbonate/Evaporite                                                                                                               | 2                     |
|                                                          | Igneous                                                                                                                           | 1                     |
| Preconsolidation Characterization (3)                    | Current Static Water Level Less than Historic Low Water Level Plus 25 Feet                                                        | 3                     |
|                                                          | Current Static Water Level Greater than Historic Low Water Level Plus 25 Feet and Less than Historic Low Water Level Plus 50 Feet | 2                     |
|                                                          | Current Static Water Level Greater than Historic Low Water Level Plus 50 Feet                                                     | 1                     |
|                                                          | Greater than 200 feet                                                                                                             | 5                     |
| Predicted 50-Year Water Level Decline based on Trend (2) | Between 100 and 200 feet                                                                                                          | 4                     |
|                                                          | Between 50 and 100 feet                                                                                                           | 3                     |
|                                                          | Between 0 and 50 feet                                                                                                             | 2                     |
|                                                          | Less than 0 feet                                                                                                                  | 1                     |
|                                                          | Greater than 200 feet                                                                                                             | 5                     |
| Predicted DFC* Water Level Decline (1)                   | Between 100 and 200 feet                                                                                                          | 4                     |
|                                                          | Between 50 and 100 feet                                                                                                           | 3                     |
|                                                          | Between 0 and 50 feet                                                                                                             | 2                     |
|                                                          | Less than 0 feet                                                                                                                  | 1                     |

\*DFC = Desired Future Condition

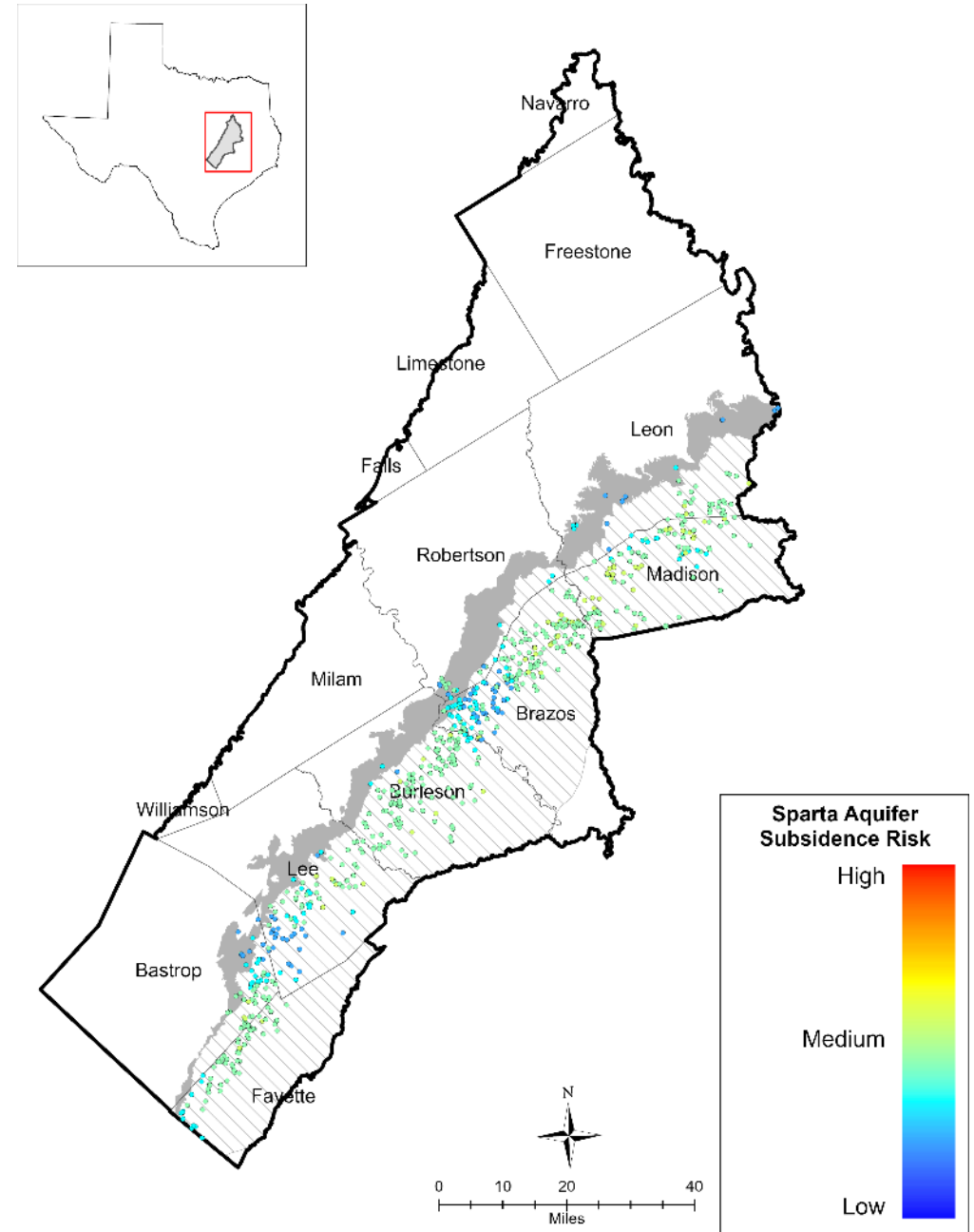
# GMA-12 Aquifers

- Yegua-Jackson
  - Most at risk
  - Youngest
  - Thickest average clay layer



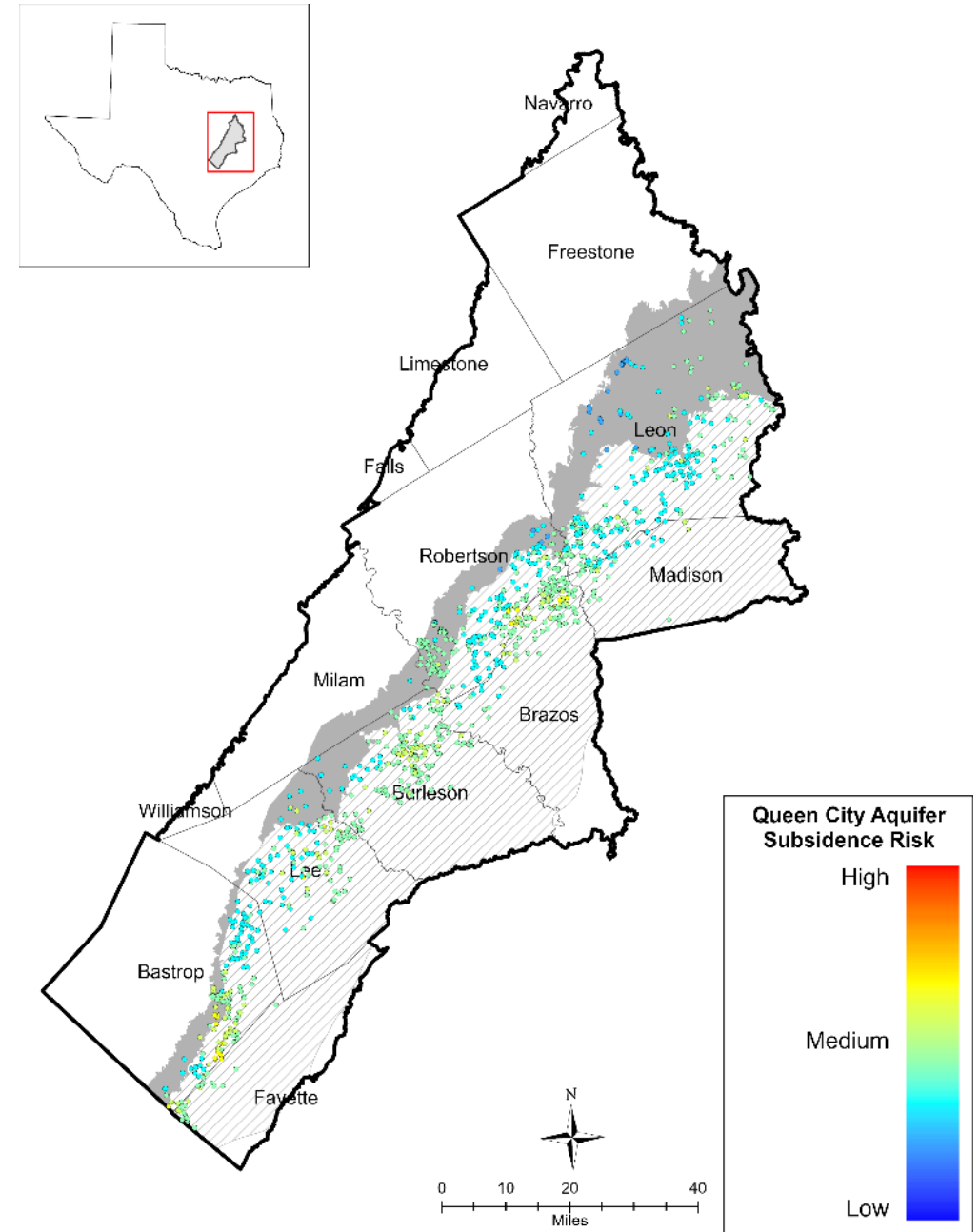
# GMA-12 Aquifers

- Sparta
  - Lower risk category
  - Thinner clays



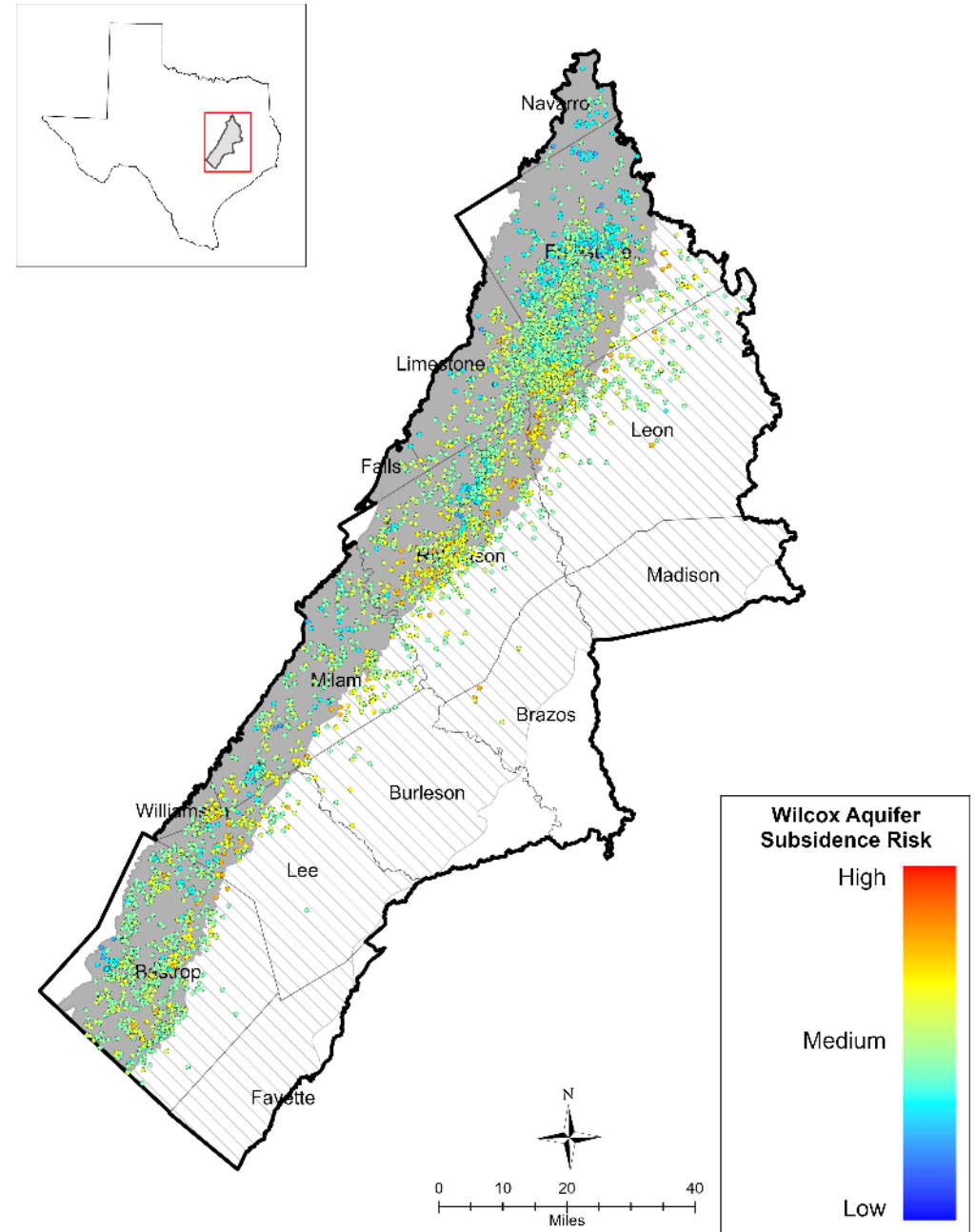
# GMA-12 Aquifers

- Queen City
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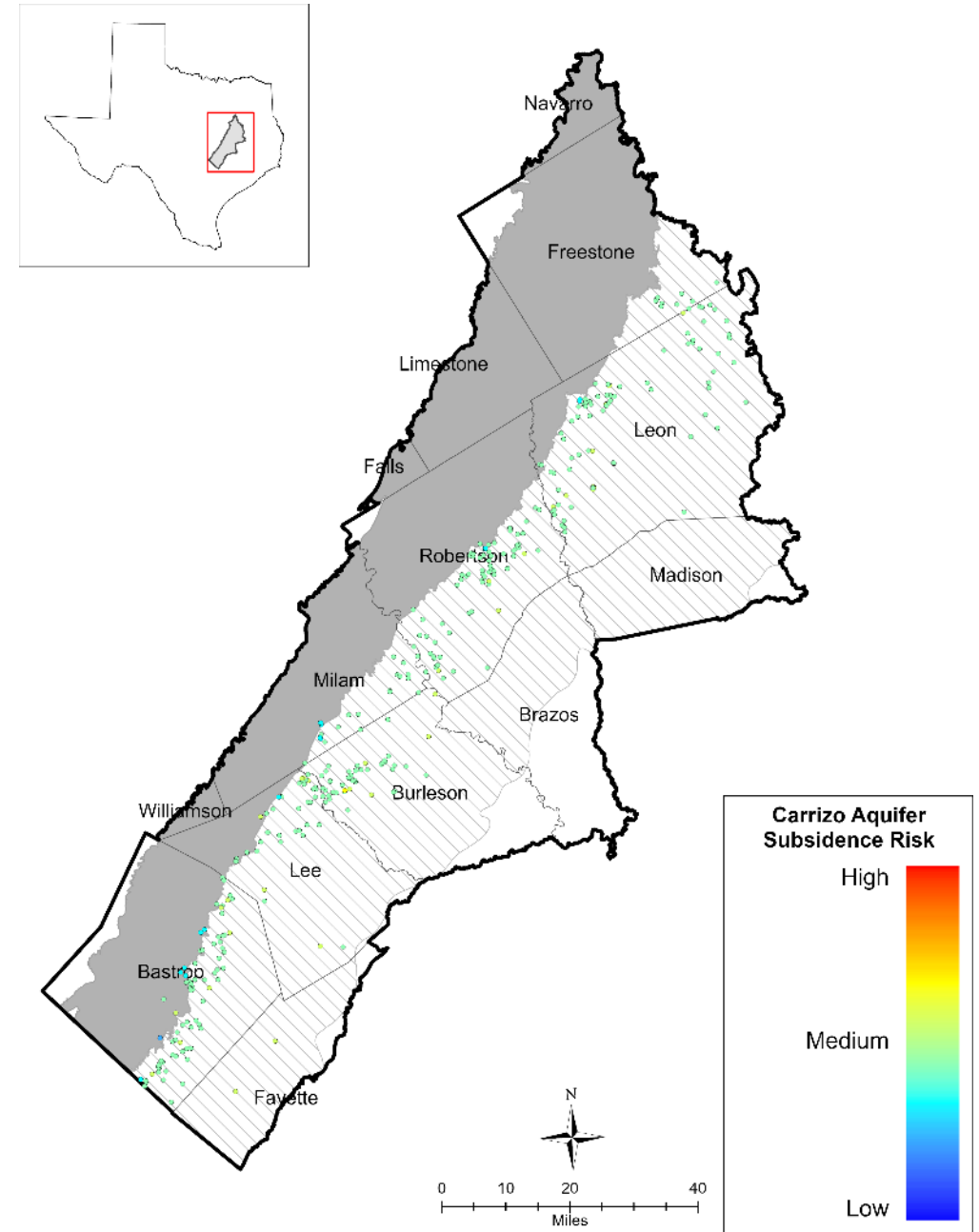
# GMA-12 Aquifers

- Carrizo-Wilcox
  - Higher risk category
  - Thicker clays
  - Highest drawdowns



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# Subsidence in Houston Metro

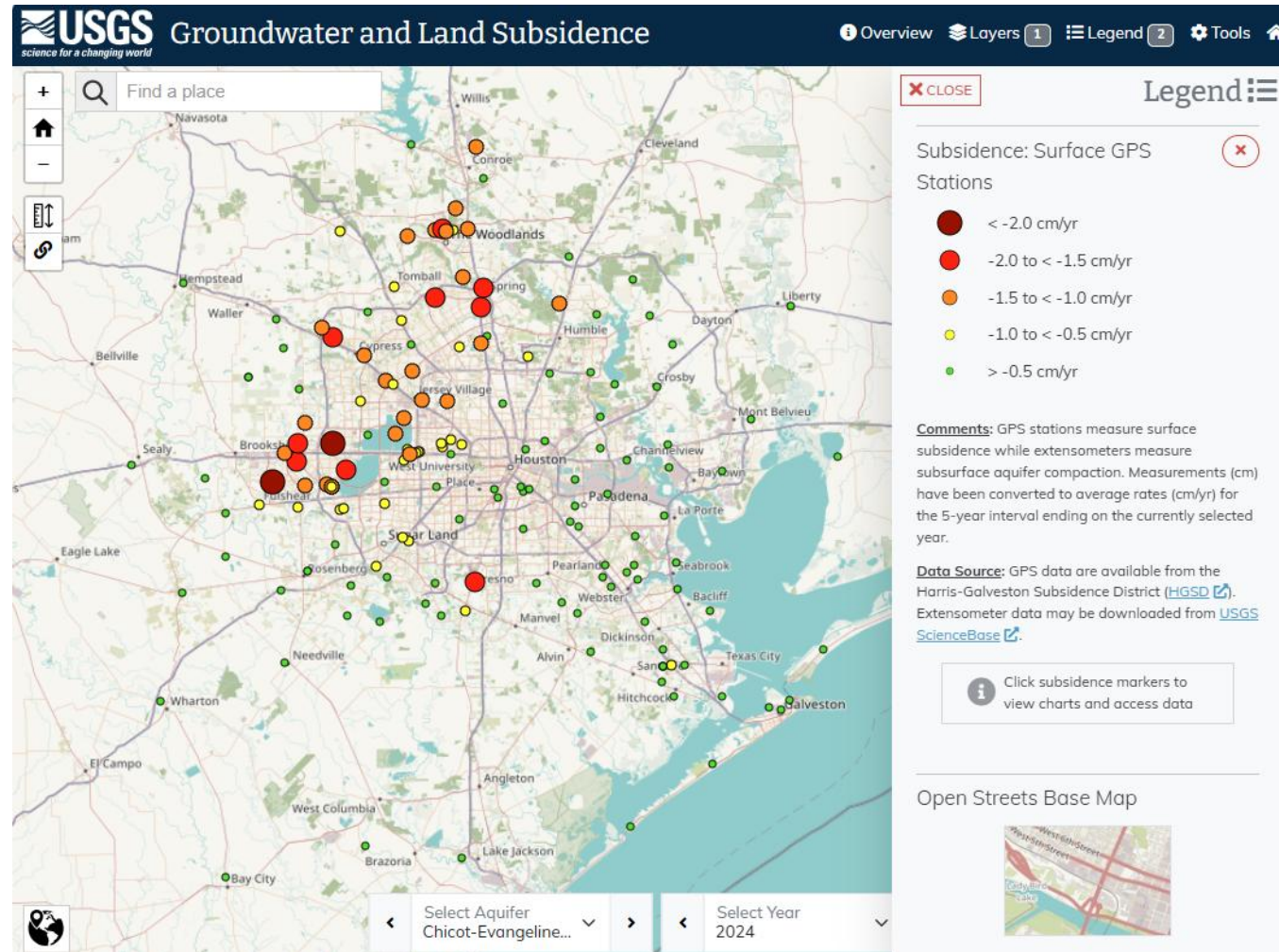
- **Well-described**
  - Large, historical dataset
  - Many stations
  - Multiple types of stations
- **Scientific Contributors**
  - HGSD/FBSD
  - USGS
  - Univ. Houston
- **Extensive!**
  - Often cited “hot spot”



*Photo courtesy USGS*

# Subsidence in Houston Metro Area

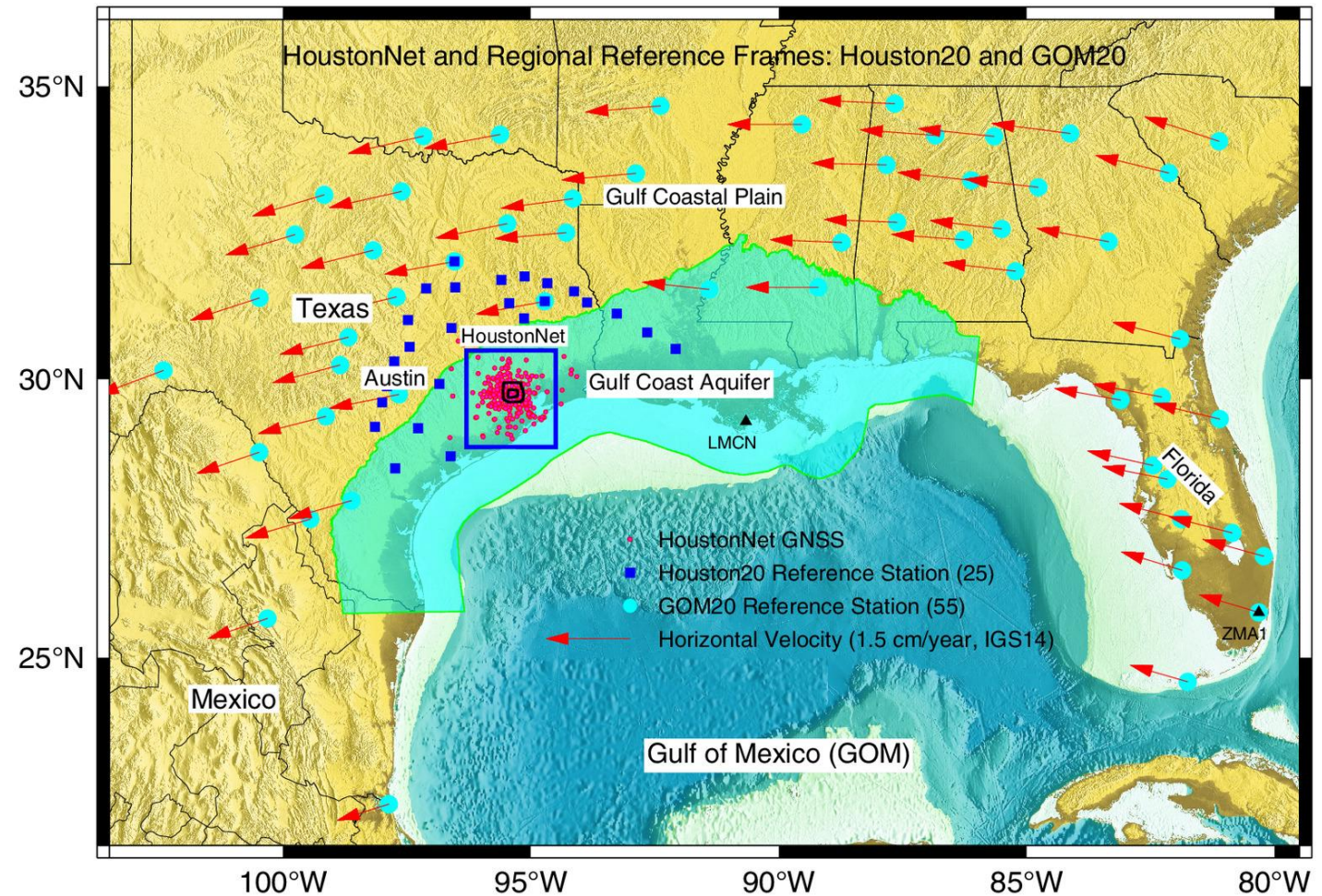
- **Well-described**
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# Regional GNSS Data Availability

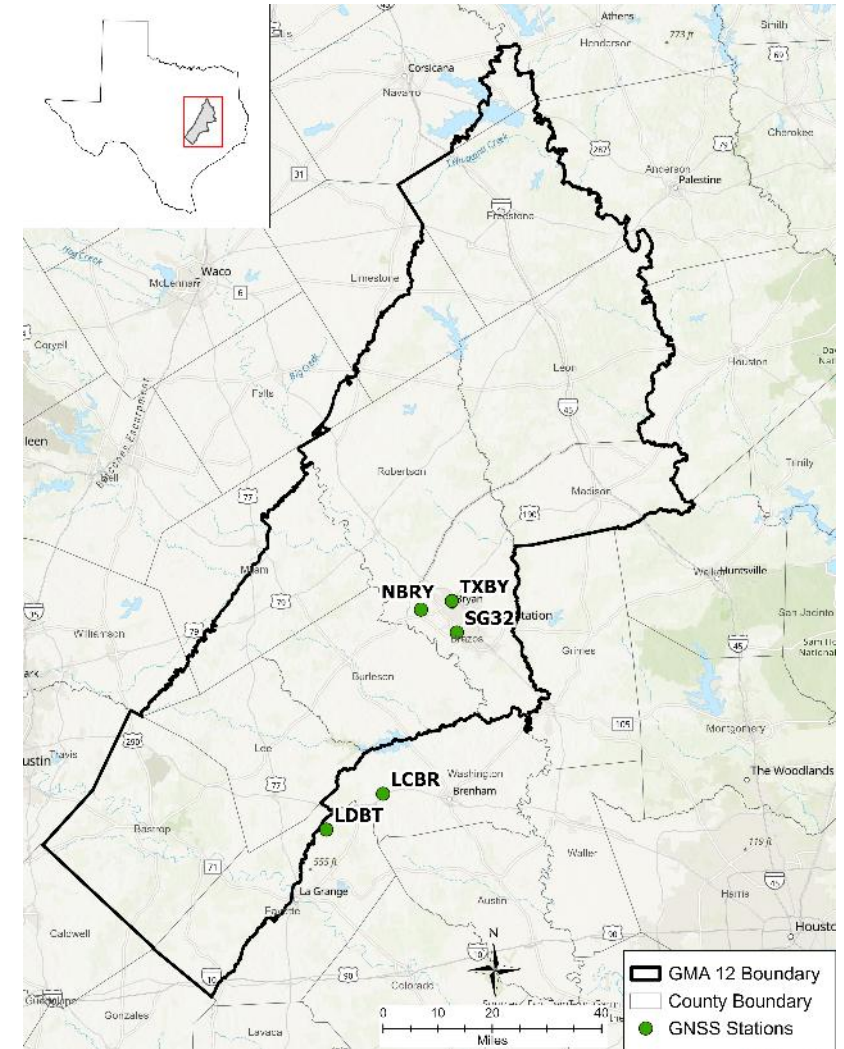
- **Global Navigation Satellite System**
  - Essential component of "GPS"
  - Stationary receivers
- **Dense Houston Subsidence Data**
  - Red Dots -> stations



Map from Wang and others (2022)

# Regional GNSS Data Availability

- **Stations in/near GMA-12**
  - Bryan/College Station
    - SG32 (TAMU W. Campus)
    - TXBY (TAMU RELLIS)
    - NBRY (TXDOT N. Bryan)
    - TXNV (TXDOT Navasota)
  - Round Top
    - LCBR (LCRA Burton)
    - LDBT (NOAA Ledbetter)
- **Obtained processed data from Wang and others (2022)**



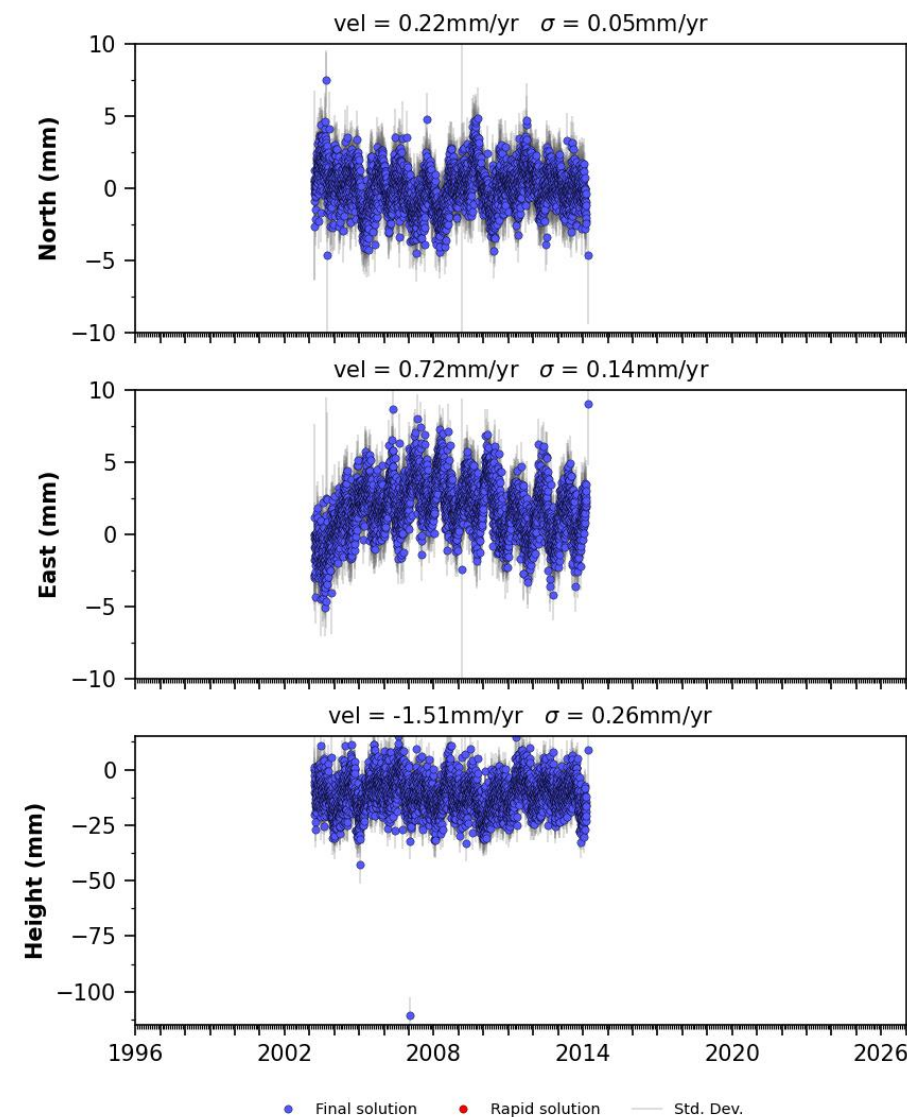


# Example from SG32

- Algorithms yield somewhat different values
  - NSF GAGE =  $1.51 \pm 0.26$  mm/yr
  - Wang 2022 = 0.85 mm/yr

## SG32 (College\_Station) NAM14

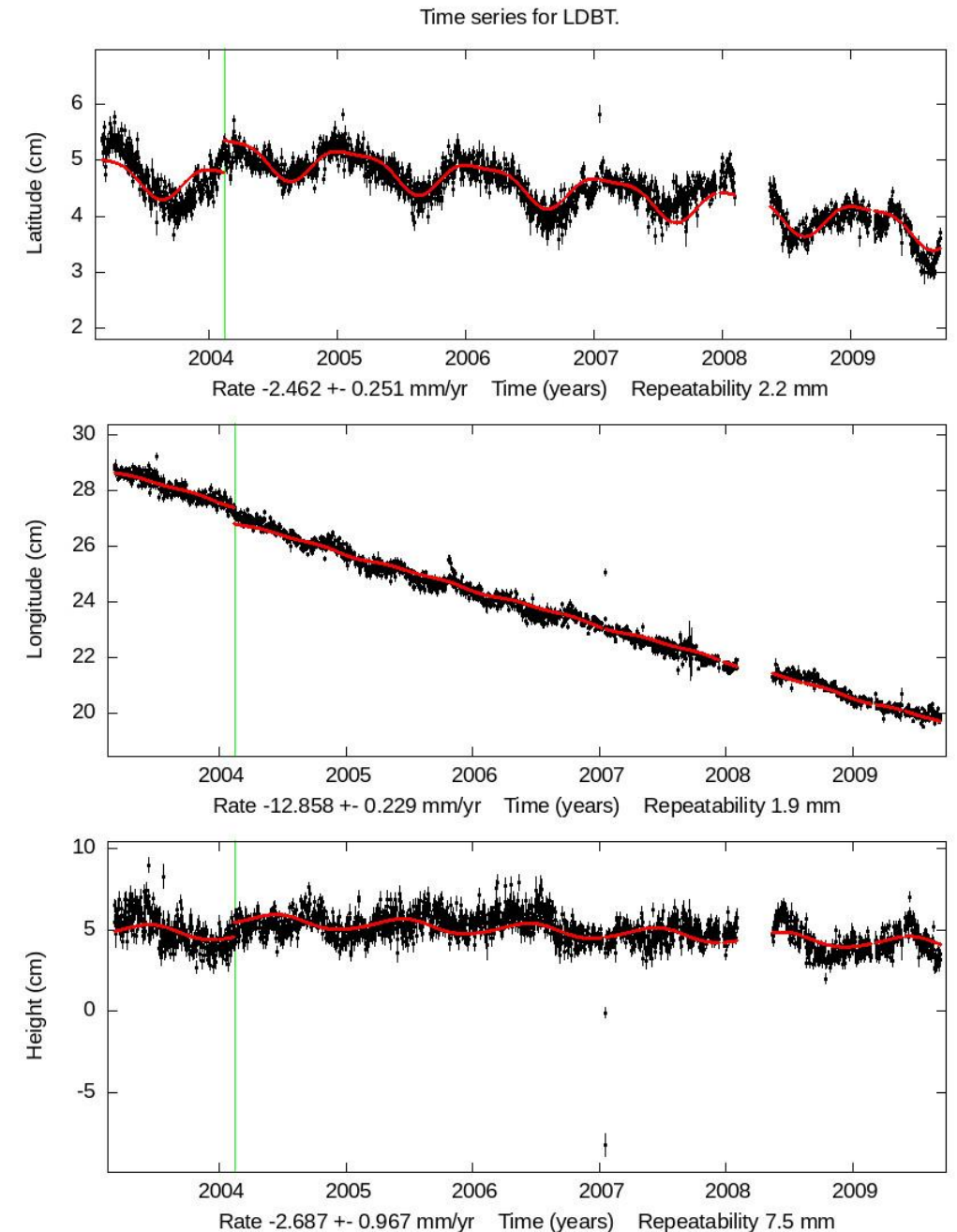
Processed Daily Position Time Series - Cleaned (SD > 20 Removed) & Detrended



Source file: SG32.cwu.nam14.pos Last epoch plotted: 2014-03-22 12:00:00

# Example from LDBT

- Algorithms yield somewhat different values
  - NASA JPL =  $2.69 \pm 0.97$  mm/yr
  - Wang 2022 = 2.31 mm/yr



<https://sideshow.jpl.nasa.gov/post/links/LDBT.html>

# Measured land surface changes

| Station | Location                | Land Surface Velocity (mm/yr)<br>Negative indicates subsidence |             |             |             |
|---------|-------------------------|----------------------------------------------------------------|-------------|-------------|-------------|
|         |                         | All Available                                                  | 2001 – 2010 | 2011 – 2020 | 2016 – 2020 |
| SG32    | TAMU West Campus        | <b>-0.85</b>                                                   | <b>-0.3</b> | <b>0.5</b>  | na          |
| TXBY    | Near TAMU RELLIS Campus | <b>-0.48</b>                                                   | <b>-0.7</b> | na          | na          |
| NBRY    | TXDOT N. Bryan          | <b>-1.99</b>                                                   | na          | <b>-1.1</b> | <b>-1.1</b> |
| LCBR    | LCRA Burton             | <b>-1.05</b>                                                   | na          | <b>-1.8</b> | <b>-0.5</b> |
| LDBT    | NOAA Ledbetter          | <b>-2.31</b>                                                   | <b>-0.4</b> | na          | na          |
| TXNV    | Navasota                | <b>-3.02</b>                                                   | na          | <b>-3.1</b> | <b>-2.1</b> |

# Summary

- **Moderate risk of future subsidence in GMA-12 area**
  - Indicated by TWDB study (Furnans and others, 2017)
  - Examined combination of lithologic factors and drawdown factors
  - Most GMA-12 aquifers are semi-consolidated
- **Small, but detectable land elevation changes have been recorded**
  - Values 0.5 to 2.0 mm/yr (0.05 to 0.2 cm/yr)
  - Order of magnitude lower than Houston area (0.5 to 2 cm/yr)
  - Very sparse, uncertain data



# Summary

- Best available data shows limited subsidence in GMA-12
  - Historical perspective only
  - Critical gaps in center of GMA-12
- Technical assessment suggests *watchful waiting*
  - Available data does not appear to indicate current issue

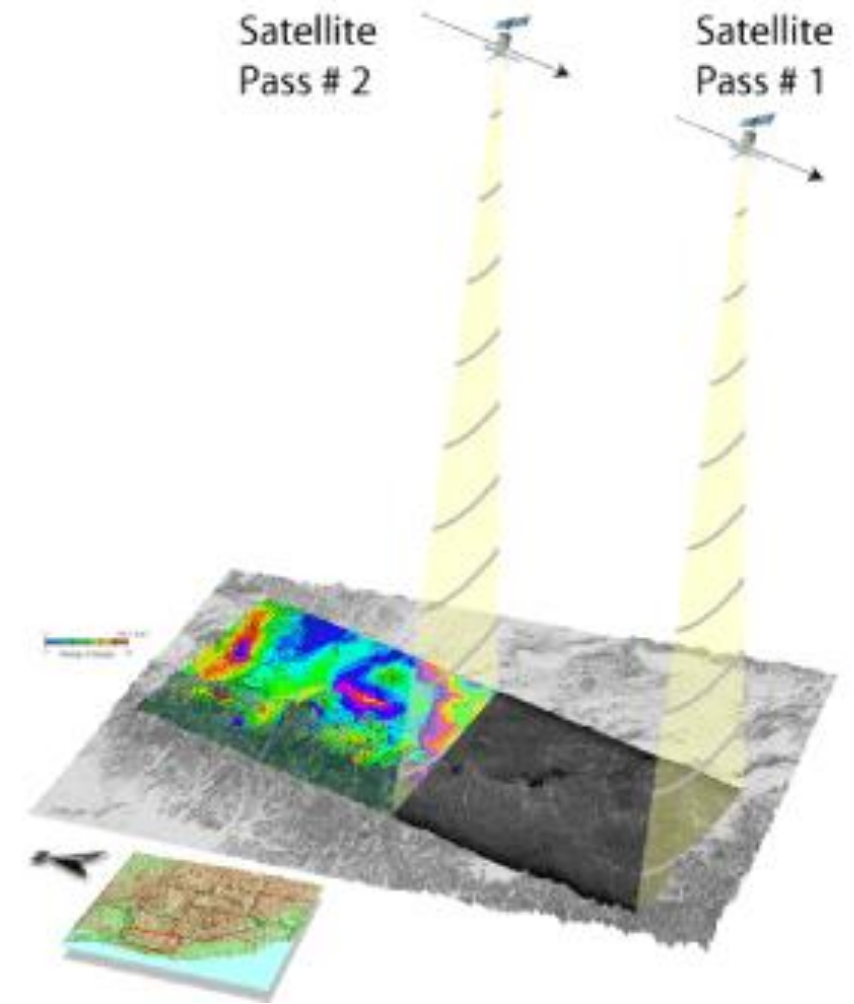


Figure from USGS