

Variations in subsidence patterns in the Gulf of Mexico passive margin from Airborne-LiDAR data and Time Series InSAR: Baton Rouge Case Study

Hurtado-Pulido, C., Amer, R., Ebinger, C., Holcomb, H.

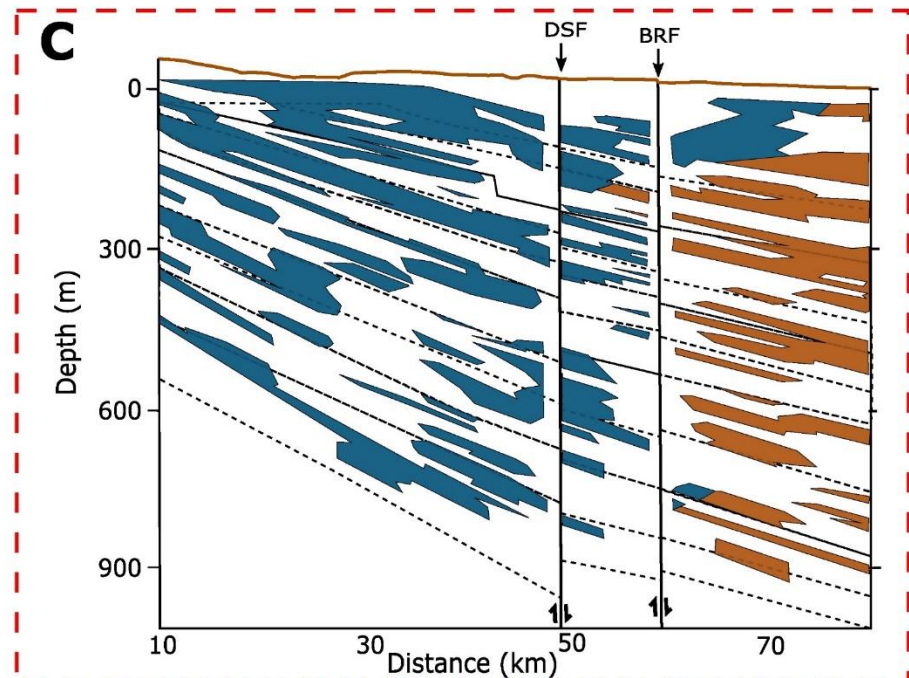
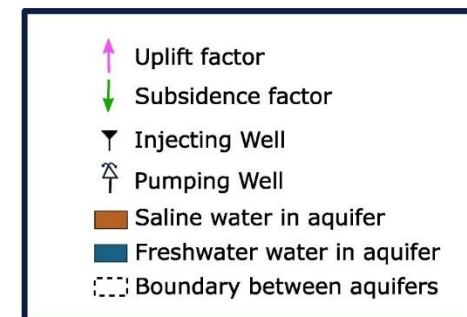
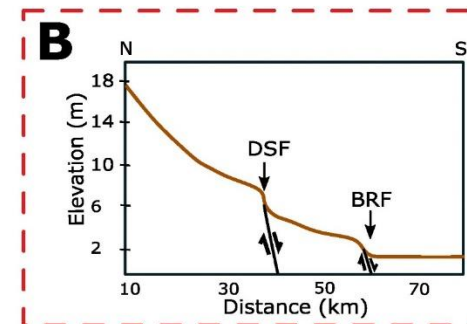
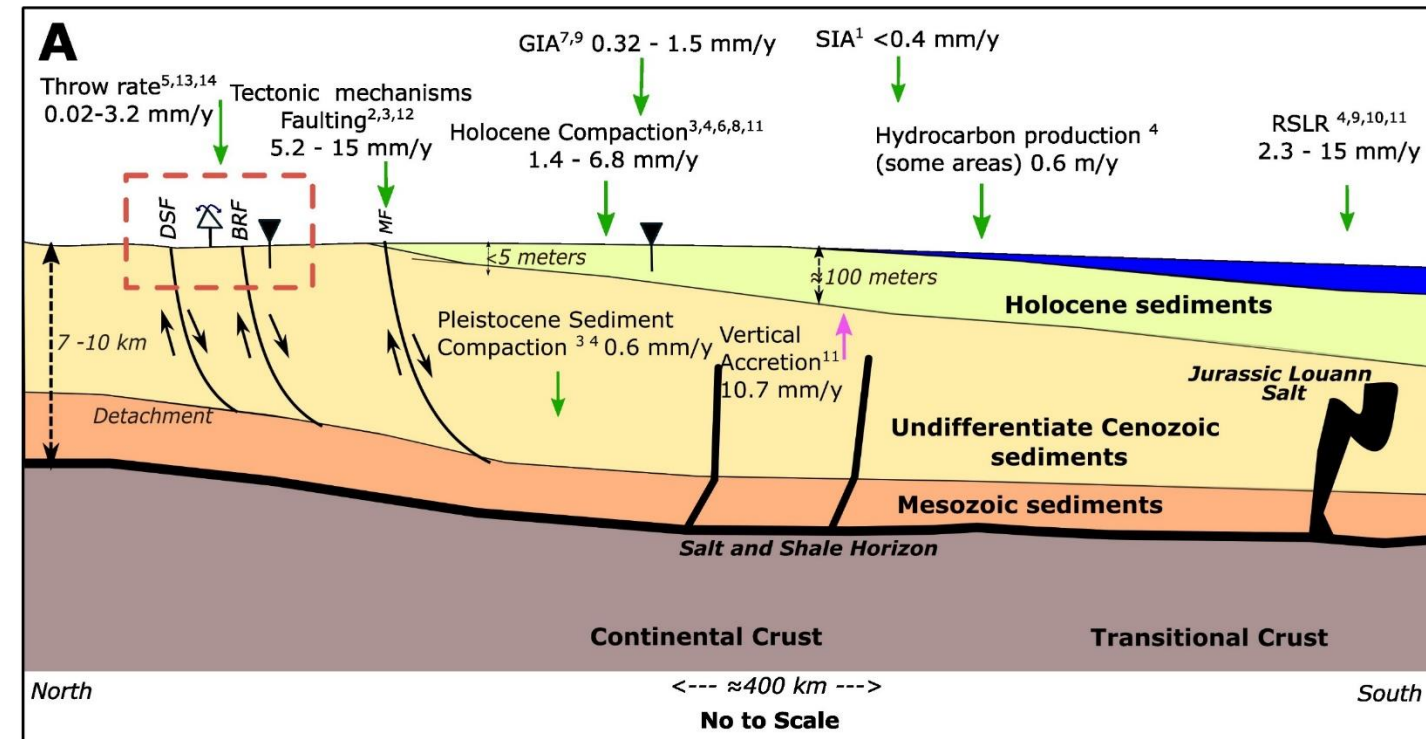
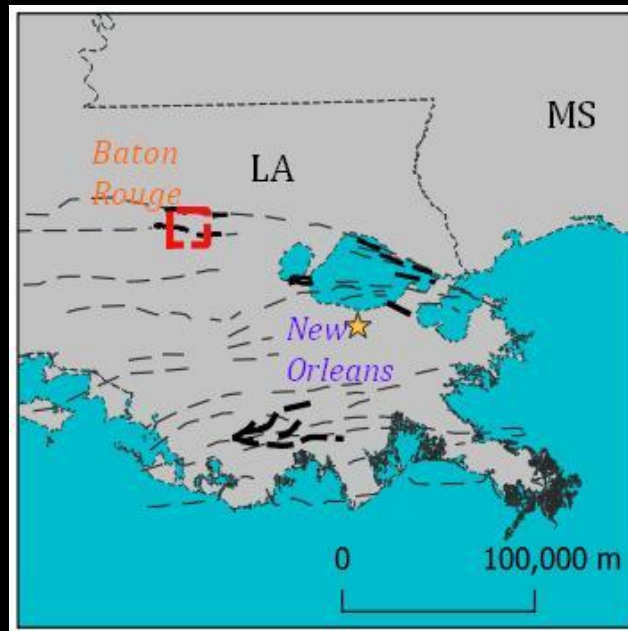
December 12, 2023

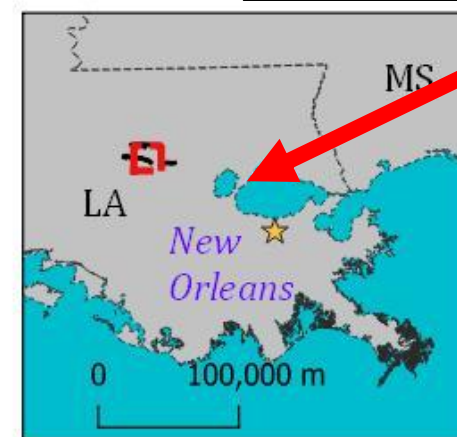
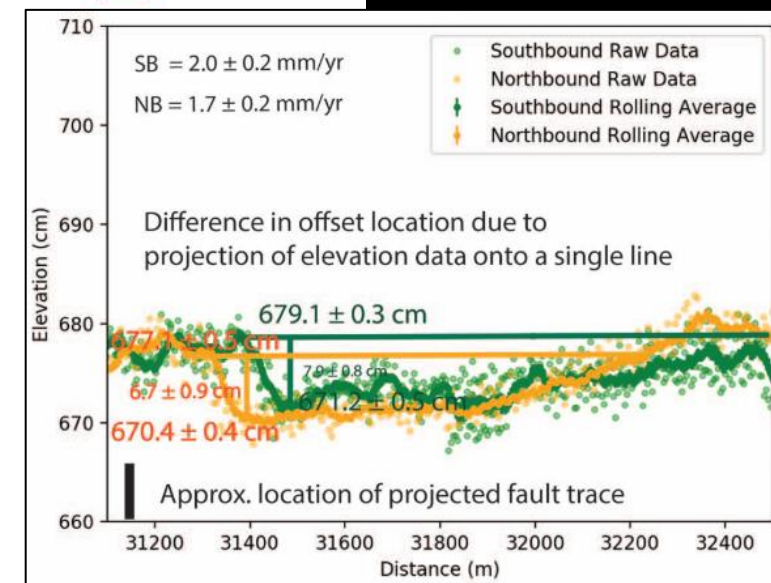
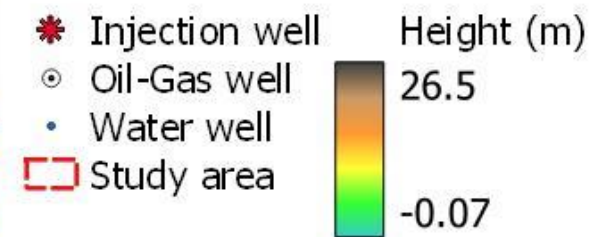
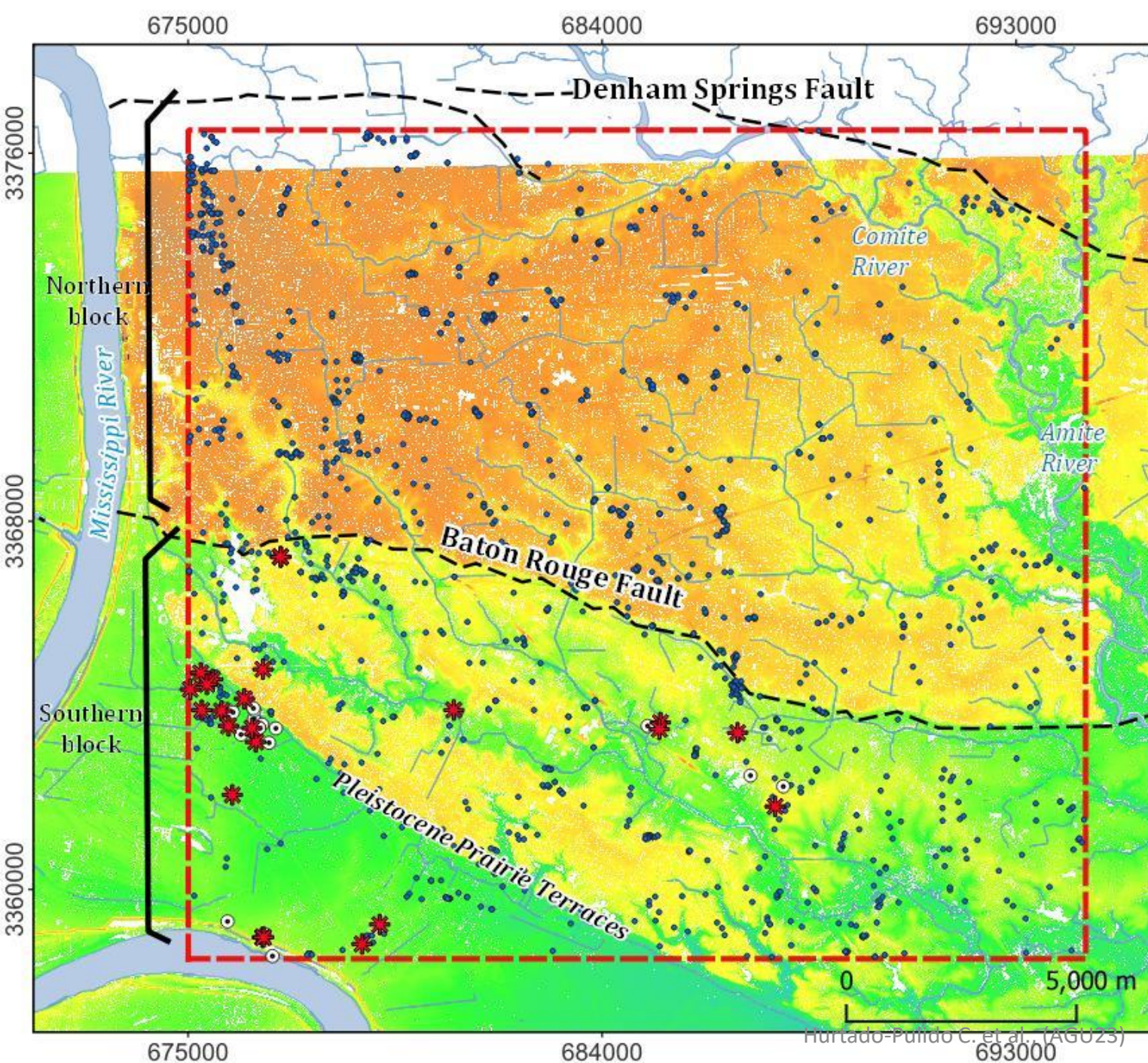


Context

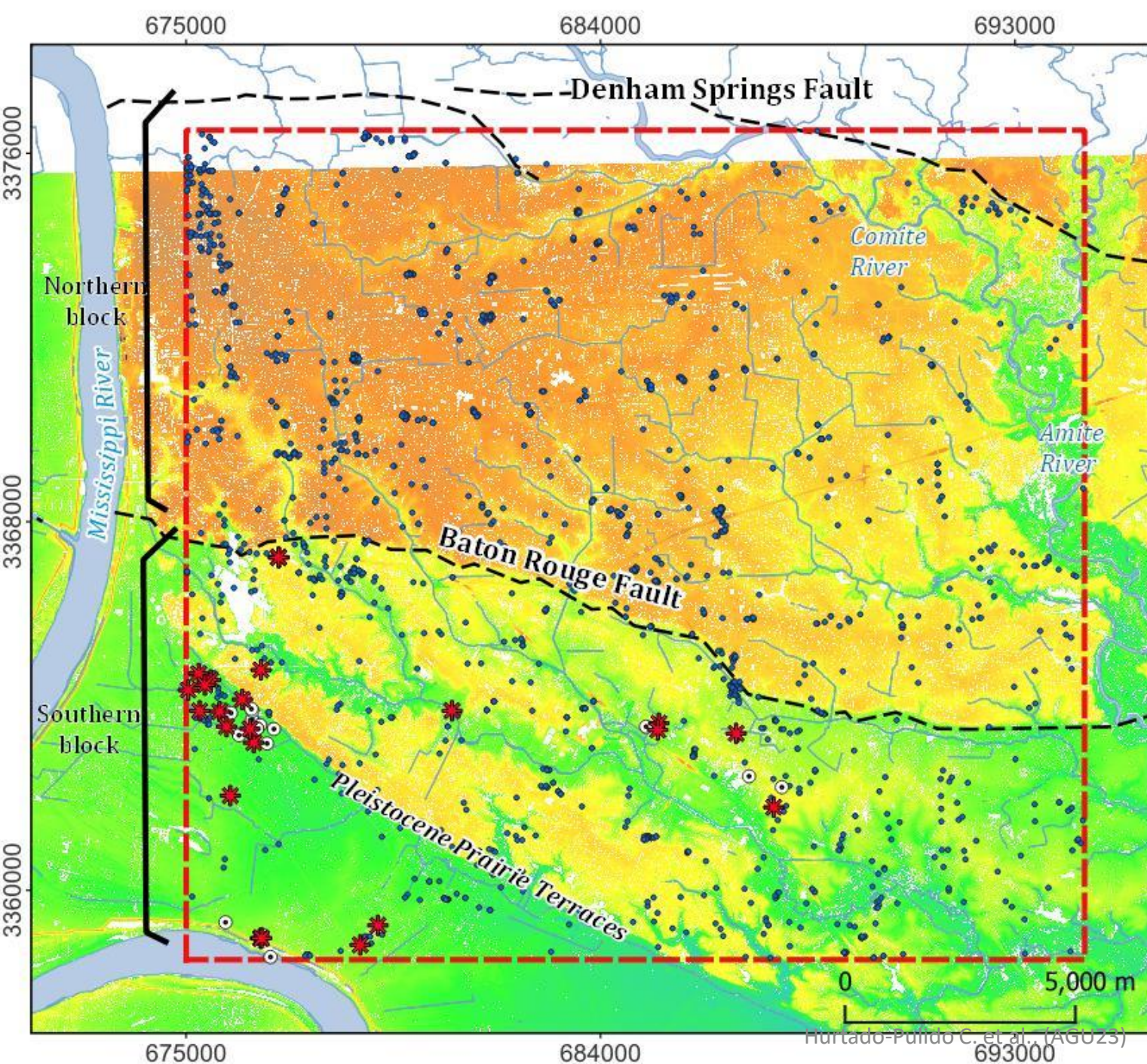
Coastal Louisiana is affected by high rates of sea level rise exacerbated by subsidence.

Human activities such as fluid extraction/injection can increase subsidence.





Hopkins et al., (2021)



Questions and Hypothesis

- 1) Are subsidence rates caused by fault slip significant and **measurable using one or both LiDAR and SAR?**
- 2) What areas are affected by **fault-controlled subsidence** in the Baton Rouge area?
- 3) Do patterns of **vertical crustal movements** correlate with **fluid extraction and/or urban development?**

InSAR

DATA

EnviSAT (2004-2010)

Sentinel-1 (2017-2020)

METHODS

Persistent Scatterer
Interferometry time
series.

Coherence: 0.66

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LiDAR

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Survey 1999 (RMSE= 15 cm, PS= 4 m)

Survey 2018 (RMSE= 3.6 cm, PS=0.33 m)

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Iterative Closest Point (ICP)

Vertical DEM differencing (GCD)

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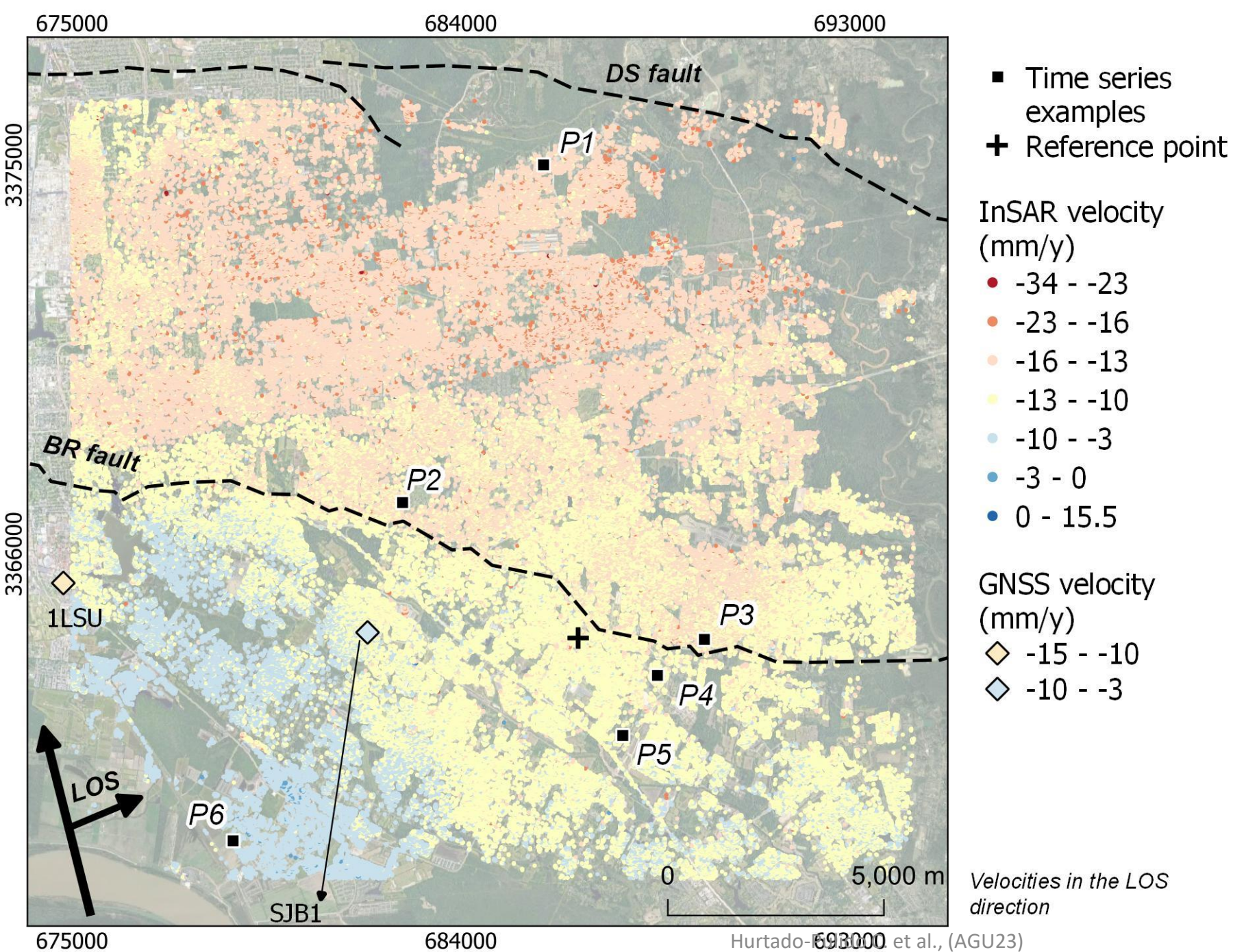
Hurtado-Pulido C. et al., (AGU23)

Well data

DATA

Injection and extraction of fluids on the area.

| | GW | Oil-gas | Injection |
|-------------|-----|---------|-----------|
| Total | 821 | 368 | 24 |
| 1999 – 2021 | 592 | 47 | 13 |
| Vol info | | 23 | 9 |

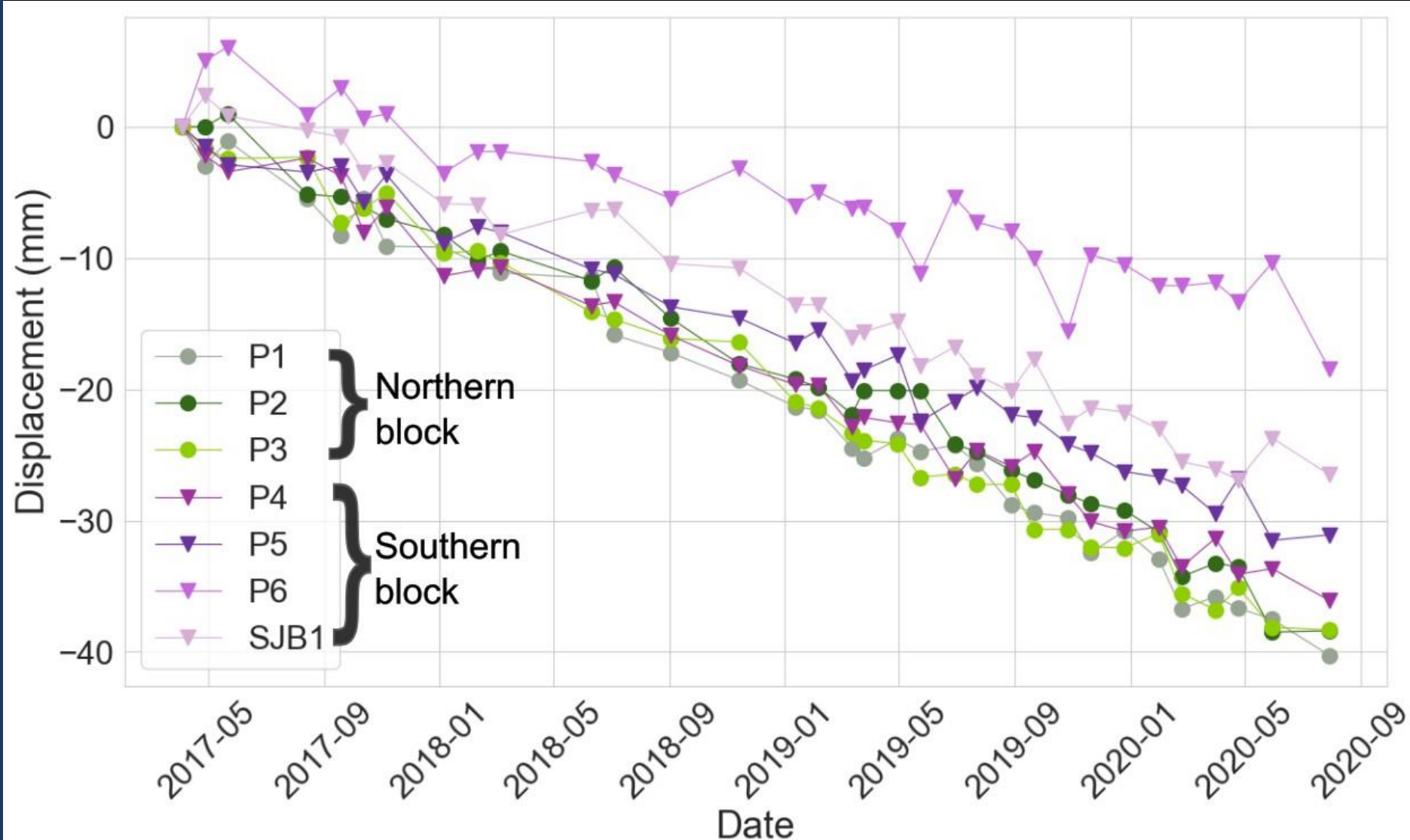


Results 1 -

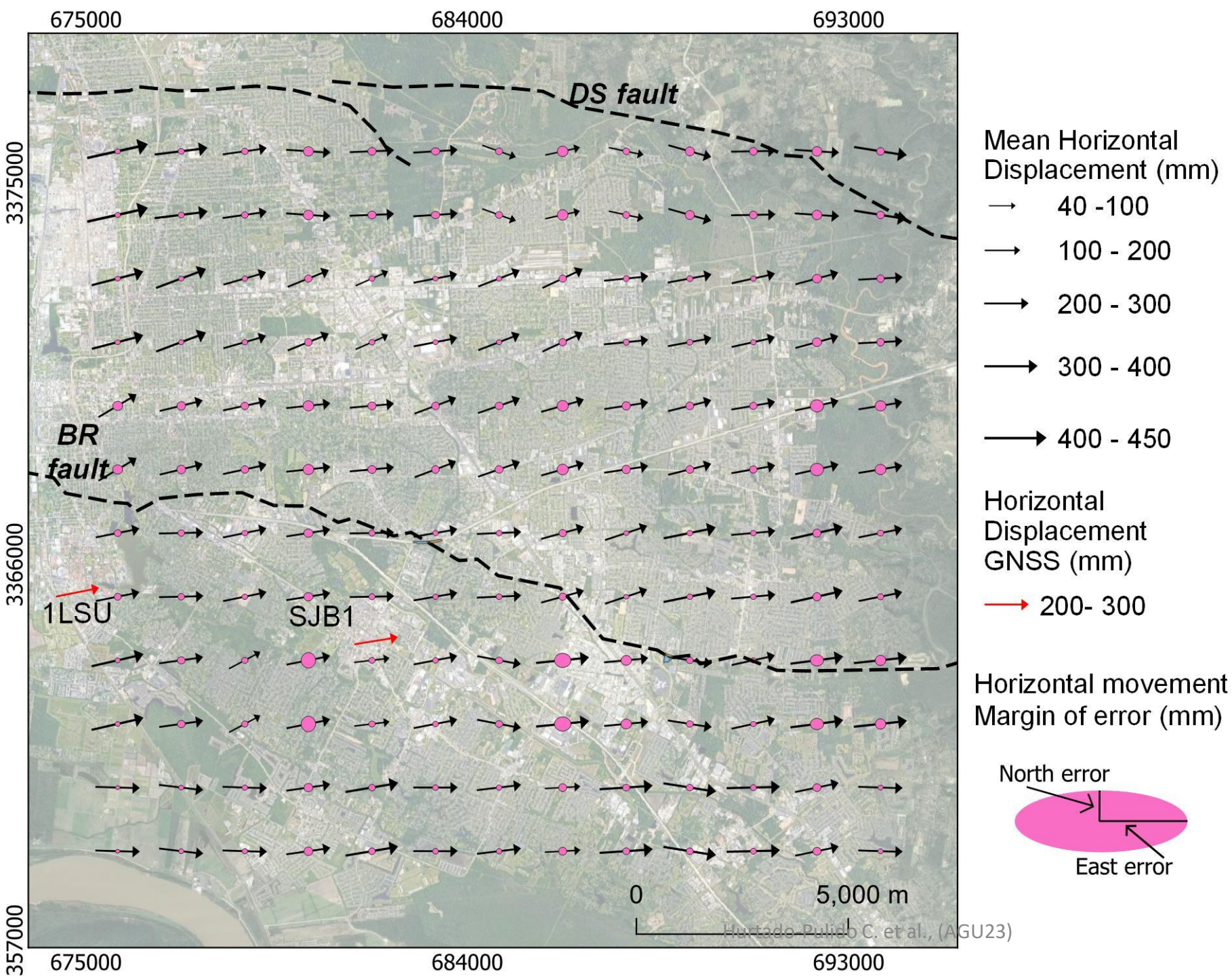
InSAR velocities show more “subsidence” in the northern block than the southern block, with the BRF as a boundary between the blocks

InSAR Velocities
2017-2020

Results 1 -
InSAR time
series near BRF
are similar.
Time series
near injection
wells have
slower
displacement.



InSAR Velocities
2017-2020



Results 2 -

Horizontal motion from LiDAR agree with GNSS stations in the area.

The area “moved” mostly E-NE.

LiDAR ICP with ground points

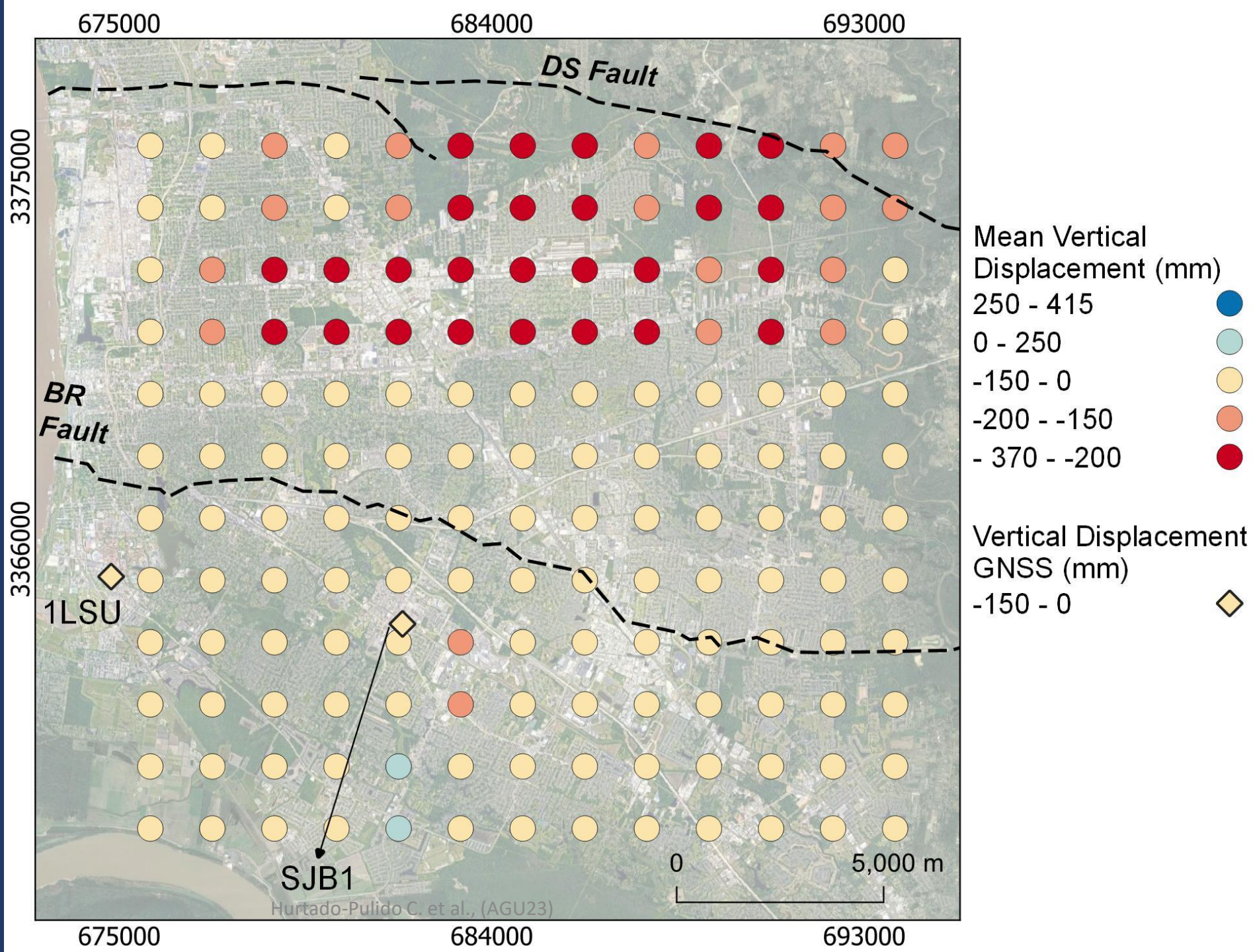
1999-2018

Results 2 -

Vertical motion
from LiDAR
agree with
GNSS.

Northern block
is subsiding
faster and there
is deceleration
in the southern
block.

LiDAR ICP with ground
points



Discussion -

The northern block is subsiding faster than the southern block during the last decades.

This contradicts the long-term displacement.

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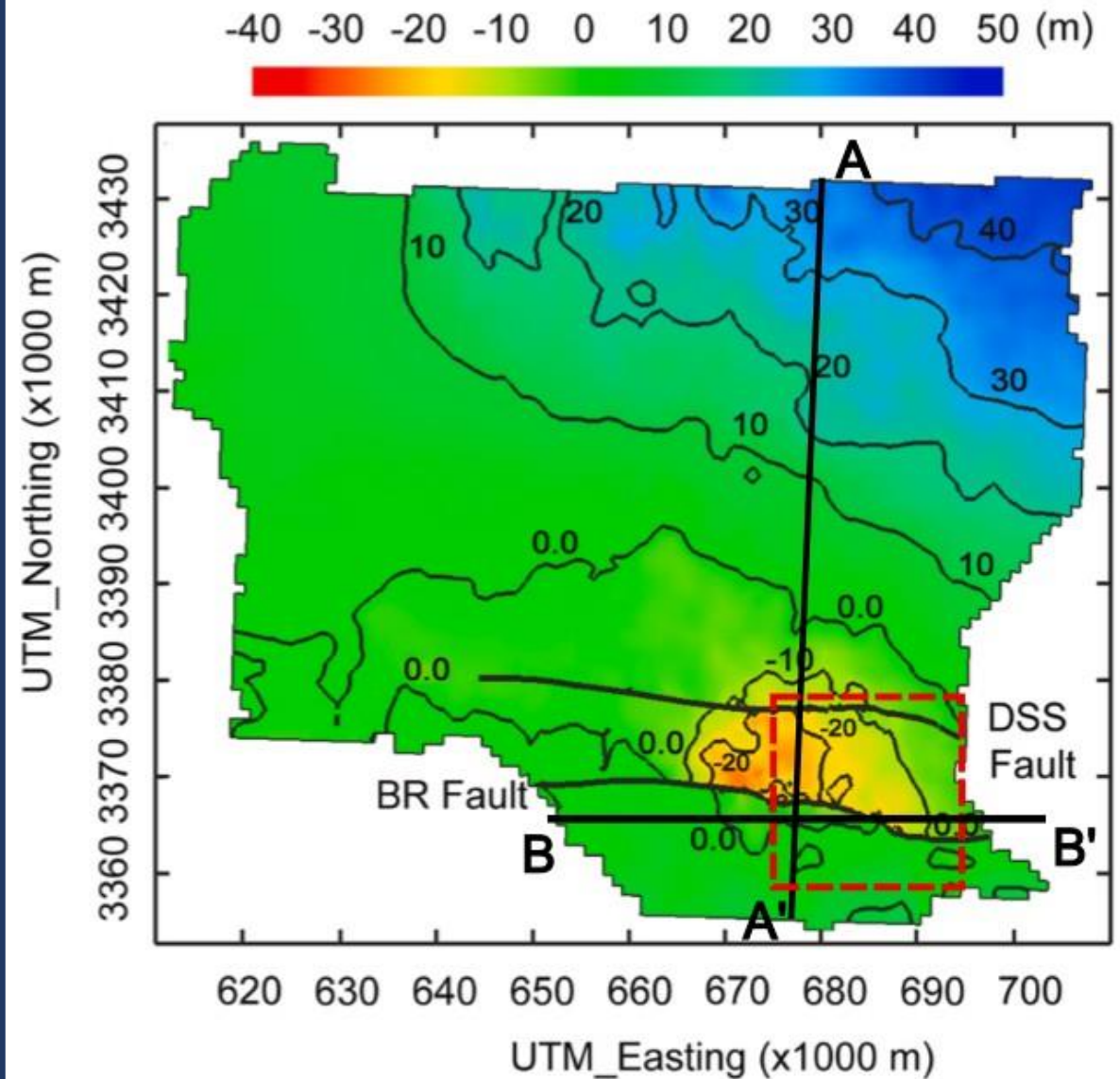
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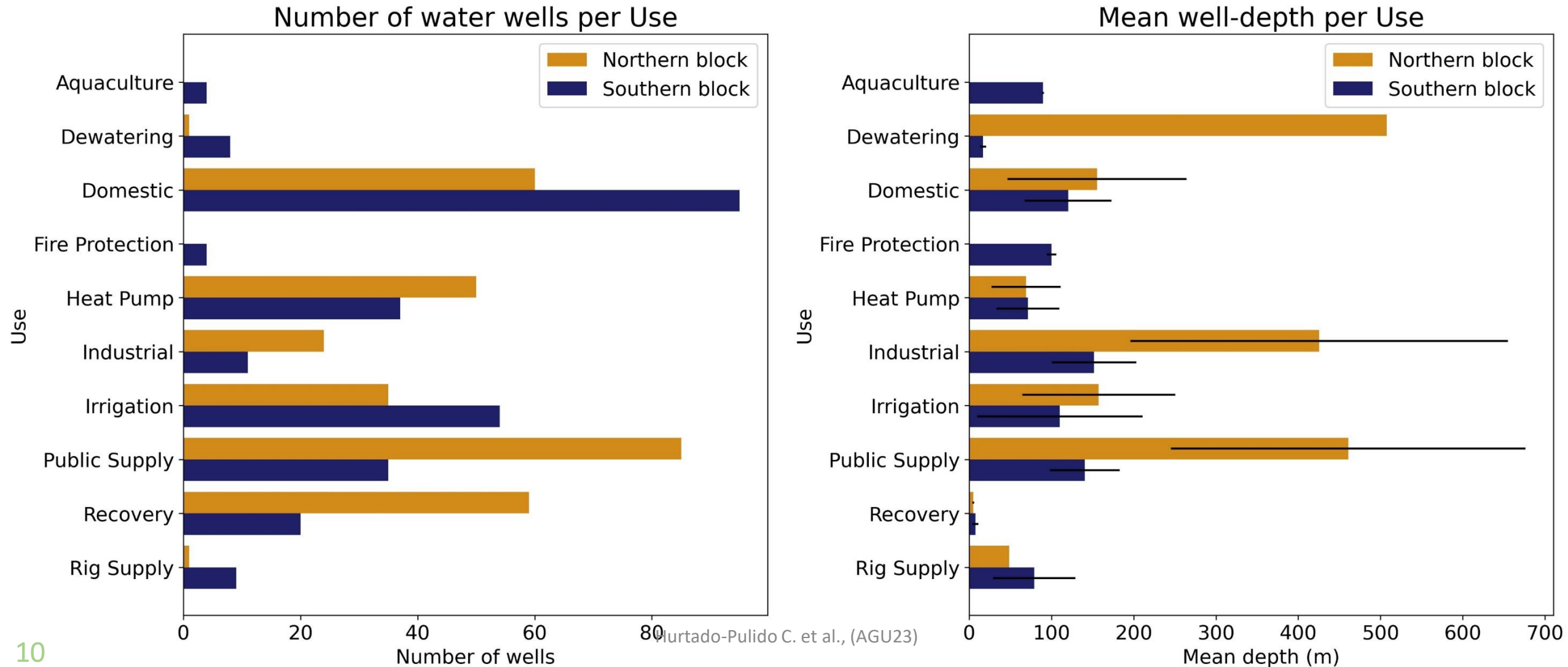
Groundwater levels are low in the area between the faults.

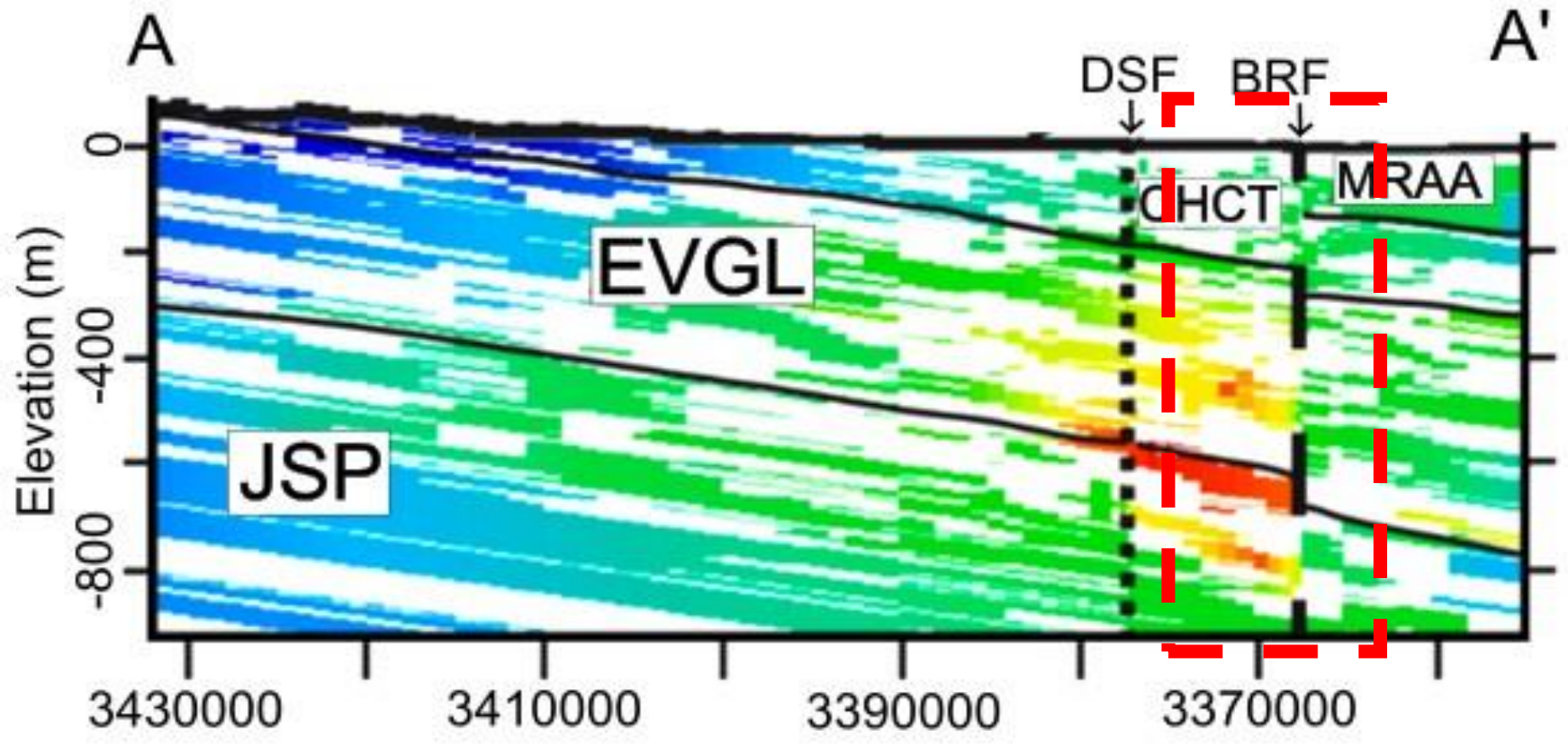
There is a large cone of depression due to high pumping.

Groundwater levels averaged from 2004 to 2020



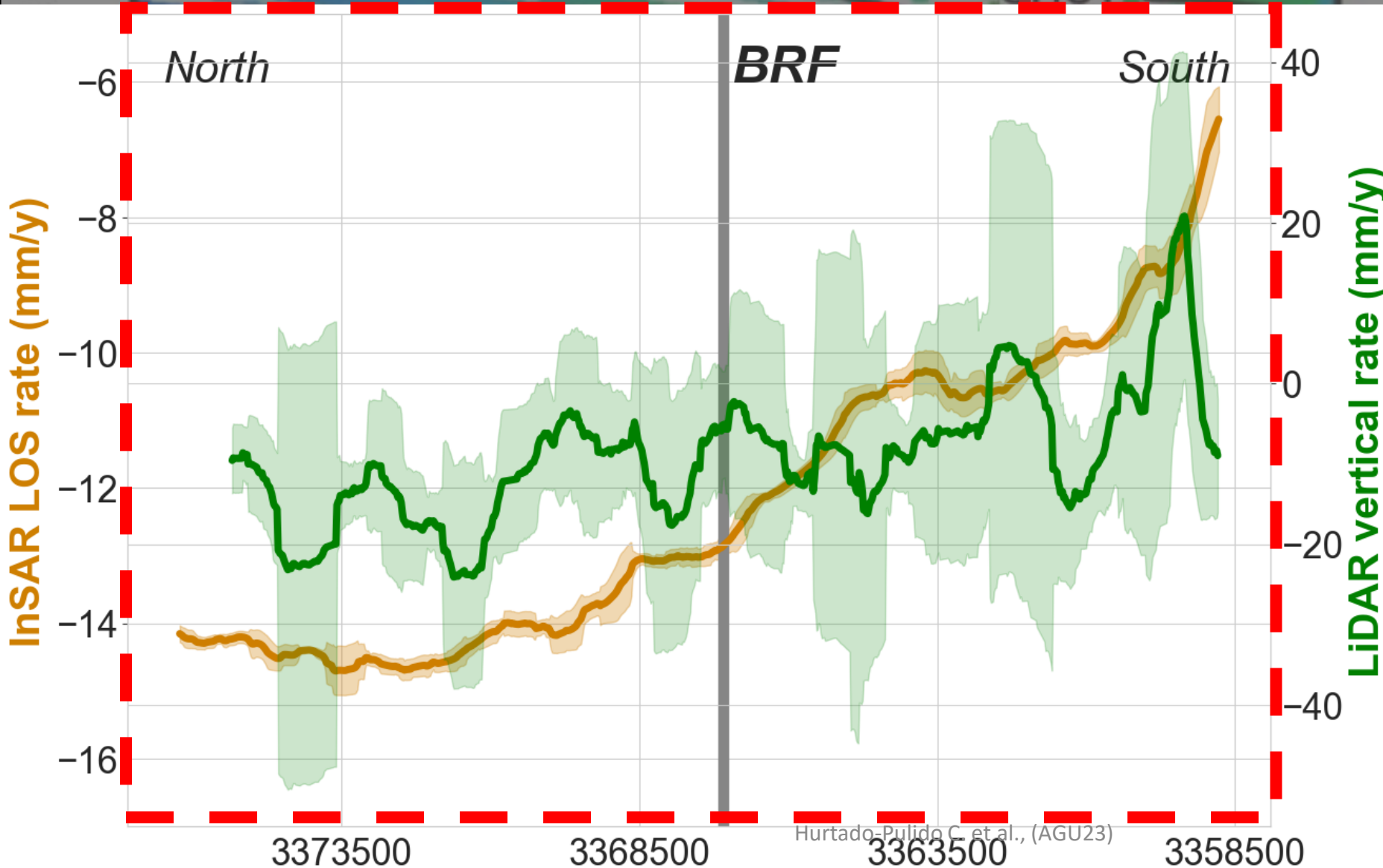
Discussion - Northern block has more and deeper wells than the southern block.





Modified from Chen et al., (2023)

Discussion -
Low
groundwater
level at deep
aquifers.



Discussion -

Low groundwater level at deepest aquifers.

Coincides with higher subsidence rates.

Main conclusions

Fluid extraction/injection are dominant processes driving surface displacement in East Baton Rouge.

The BRF divides the area into 2 regions of human-controlled subsidence.

- Northern block controlled by groundwater level changes
- Southern block influenced by injection at shallow depths

There is subsidence in the entire area, ***but it is reversing the long-term down-to-the-south displacement.***

LiDAR is a powerful geodetic tool to estimate 3D slow motion agreeing with GNSS and InSAR time series.

Next Steps

1. Analysis of subsidence caused by seasonal variation caused by hydrological loadings.
2. Numerical model for future predictions (*with Pritom Sarma, Hebrew University*)

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Contact

***I am looking for a
Job/postdoc!***

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Website