Ground Deformation in New Jersey due to Groundwater Withdrawal

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Background

- The objective of this study is to determine whether groundwater pumping from aquifers in the New Jersey Coastal Plain region causes measurable ground subsidence, a process where the level of the ground is lowered due to movement of materials in the subsurface.
- The sand and gravel sediments underlying the Coastal Plain region of New Jersey (Fig. 1) are ideal for groundwater storage and withdrawal (pumping via a well). According to the USGS, the aquifers in the Coastal Plain region of New Jersey provide water for 3.5 million people at rates of ~190 million gallons a day. Most of these aquifers are confined, meaning there is an impermeable rock layer above the layer containing water.
- Surface deformation due to groundwater withdrawal can be measured and has been observed worldwide.
- The coastal plain of New Jersey is primarily made up of sandstones. When water is extracted from these aquifers the pore spaces fill with air and collapse, which limits how much the aquifer can recharge (Fig. 2).
- InSAR uses two different satellite passes to measure ground deformation (Fig. 2).

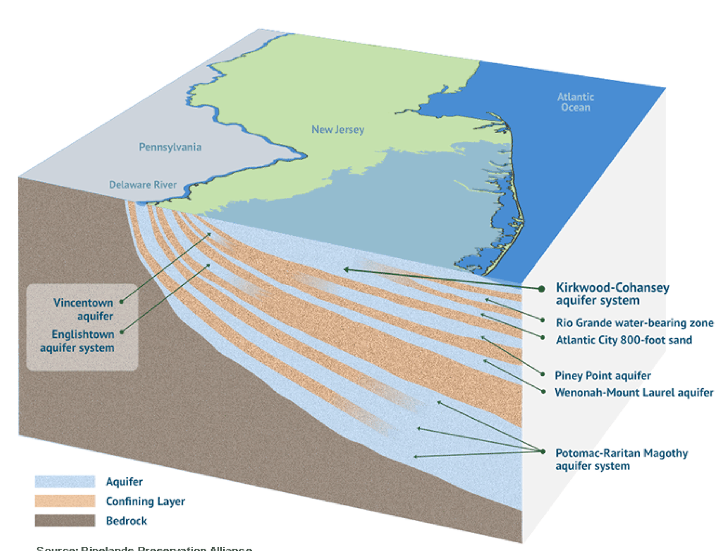

Figure 1: 3D map of the aquifer system in the coastal plain region of New Jersey. (*Pinelands Preservation Alliance*)

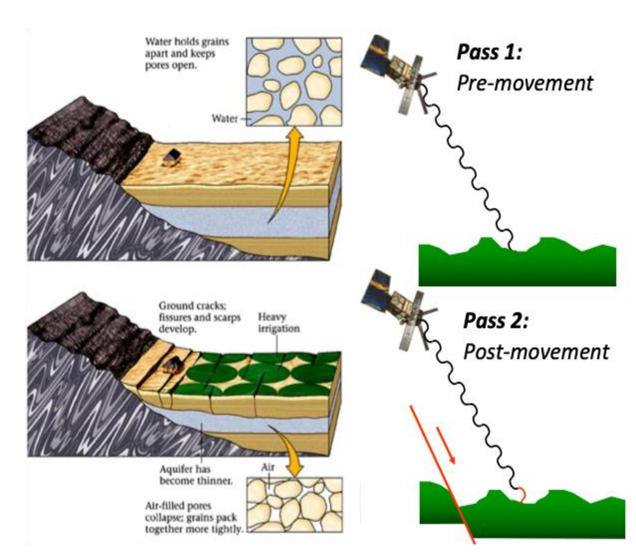

Figure 2: (Right) The diagram depicts ground subsiding as a result of groundwater withdrawal out of a porous space. (Left) InSAR uses two satellite passes to measure ground deformation.

Methods

- **InSAR:** The data is generated through the comparison of images taken during two satellite passes over a location. The first image is essentially subtracted from the second to create an interferogram image, which shows the change in surface topography, or deformation during the time interval between images (Fig. 2). We create interferograms over a time interval of 2015 to 2025 using the processing tools available at ASF Vertex.
- **GPS:** We calculate the vertical velocity of GPS data from stations in New Jersey to compare with InSAR results. We took the raw data (for the vertical component) then smoothed it using a Savitzky-Golay filter with a third degree polynomial and removed the seasonal signal.
- **Wells:** Water table height data from wells throughout NJ is monitored by the USGS. Data for these wells were downloaded from the National Water Dashboard and fit with a linear trendline.

Results

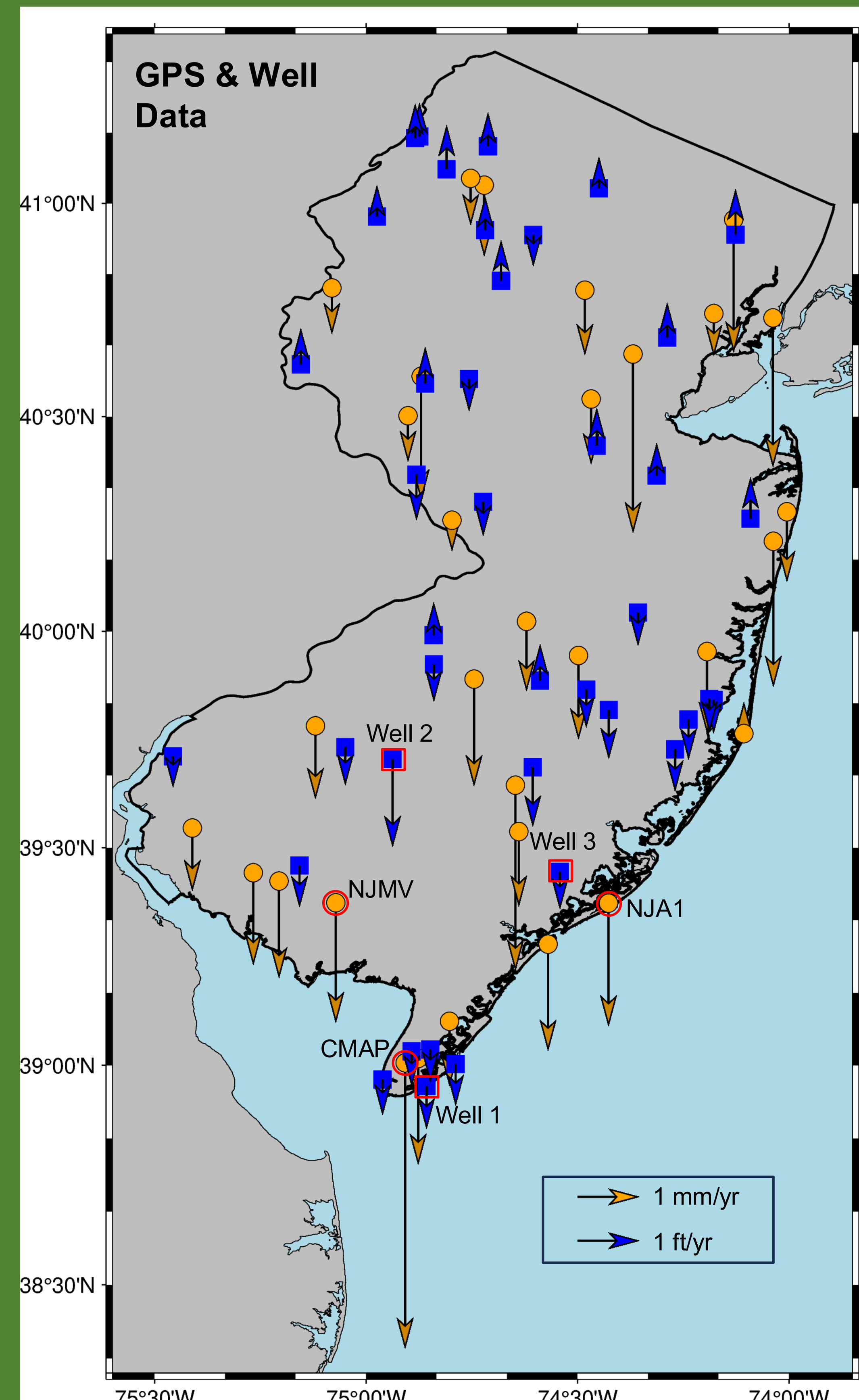

Figure 3: Map of GPS stations (orange circles) and wells (blue squares) across NJ and their vertical velocities and water level changes respectively.

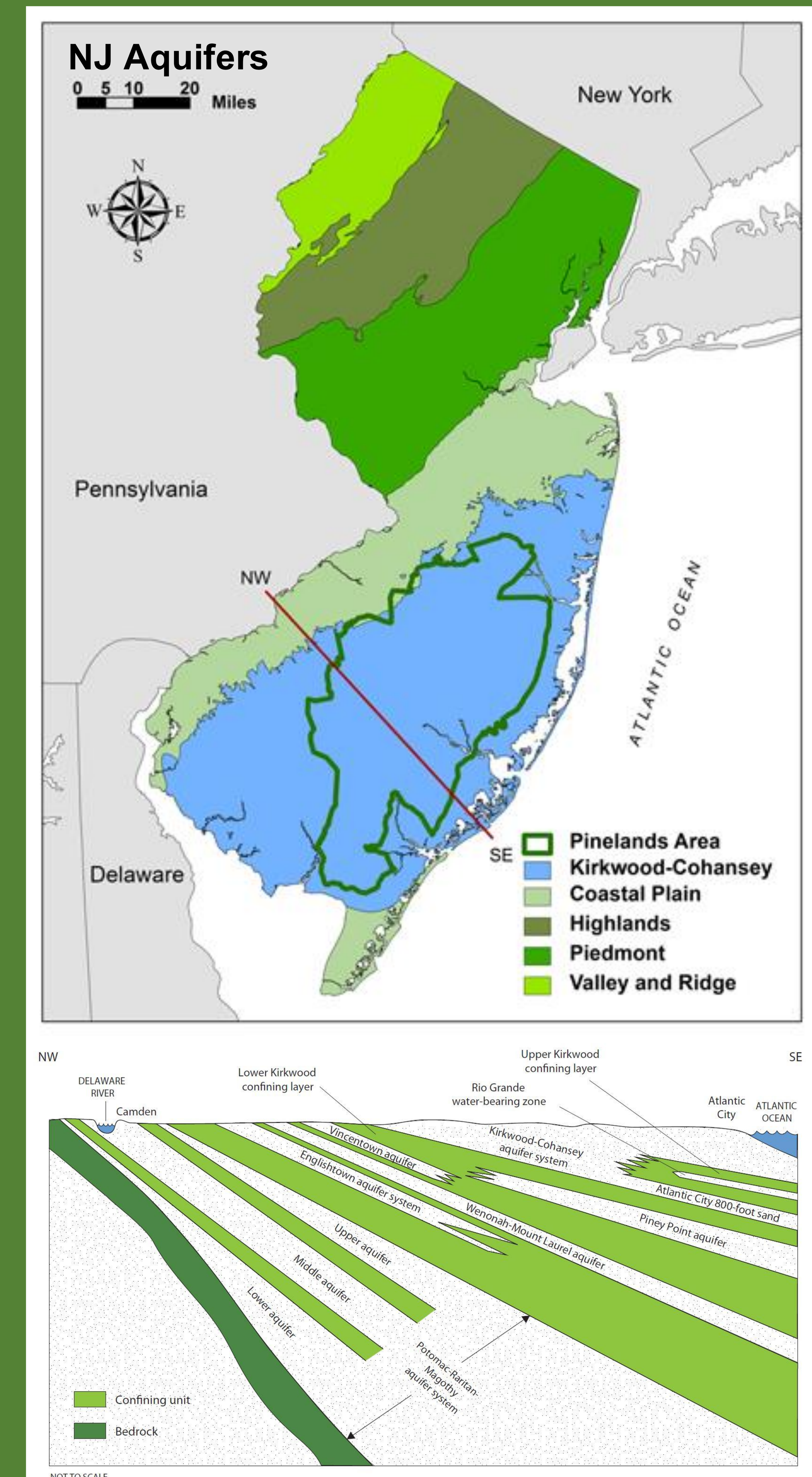

Figure 4: Map of the geographic regions of NJ highlighting the Kirkwood-Cohansey aquifer system and a sideview of the aquifer layers. (*Pinelands Preservation Alliance*)

Example Interferogram

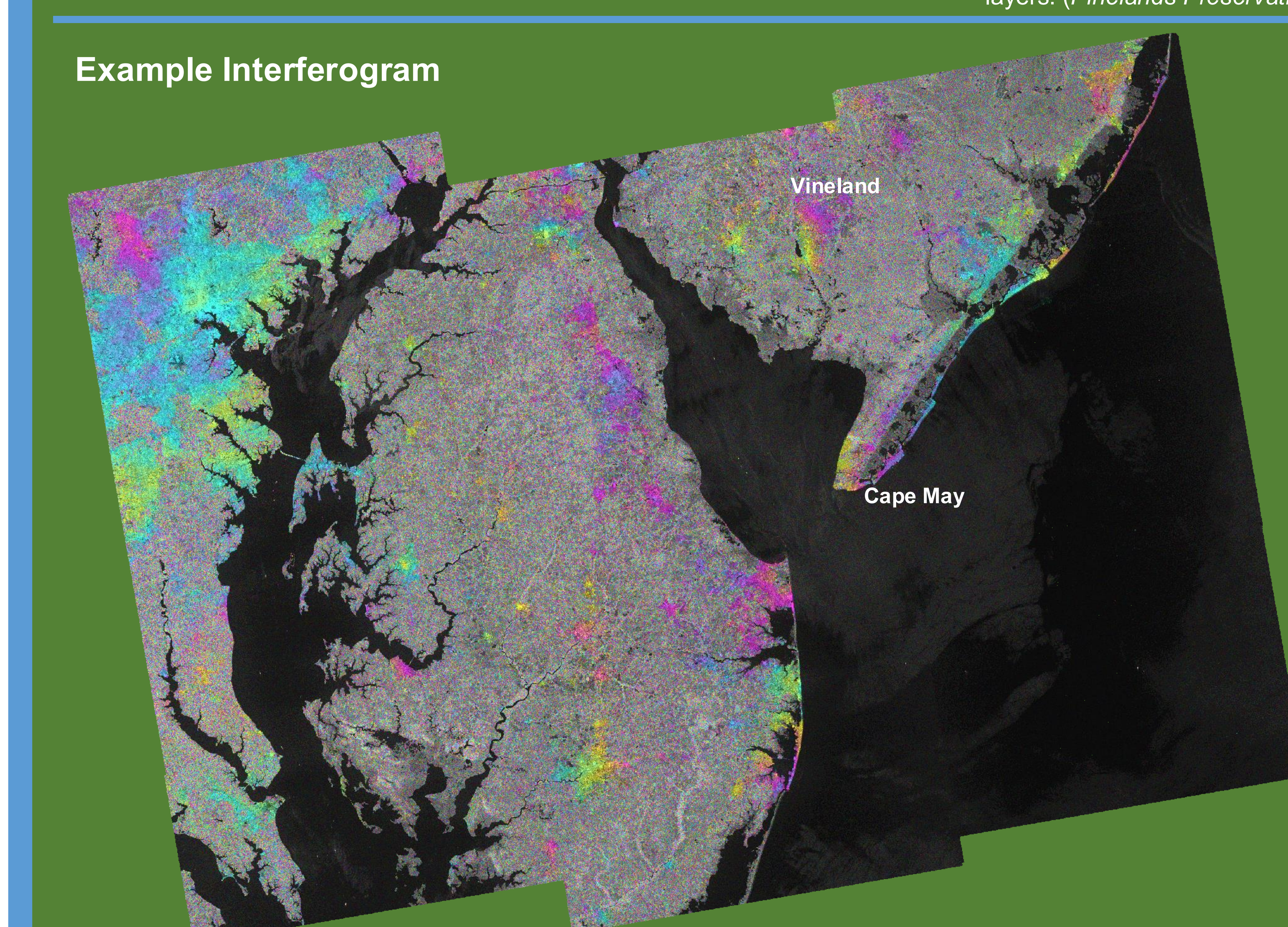

Figure 5: Example interferogram of the southern and coastal region of New Jersey (upper right corner) showing deformation between 11/21/2020 and 10/19/2024. The area around Vineland and the coast, particularly Cape May, shows evidence of subsidence. The lack of coherence elsewhere is likely due to atmospheric effects.

GPS and Well Data

Cape May

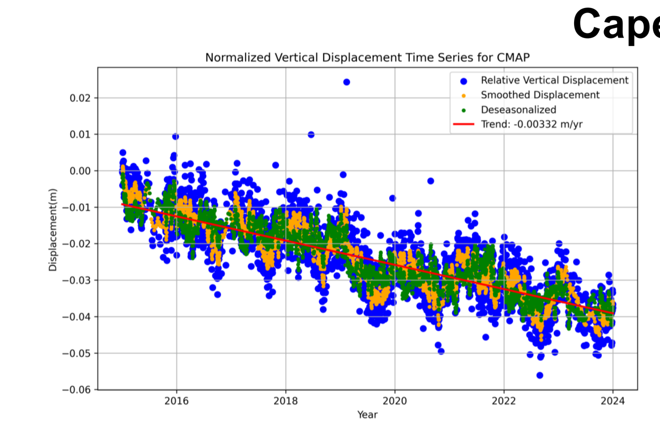

Figure 6: CMAP is a GPS station in Cape Map with an average vertical velocity of -3.32 mm/yr.

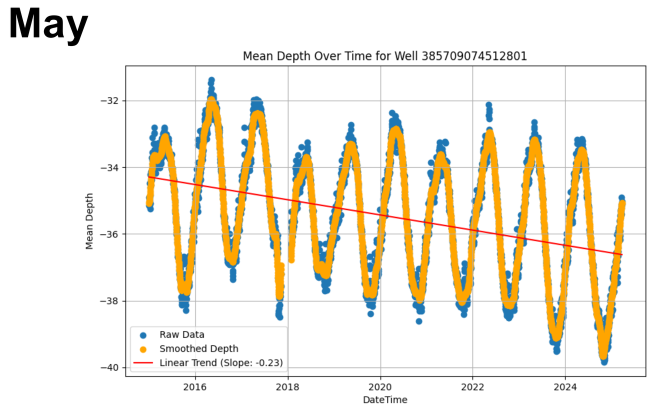

Figure 7: Well 1, denoted in Fig. 3 by a red square, has a downward trend of 0.23 ft/yr.

Vineland

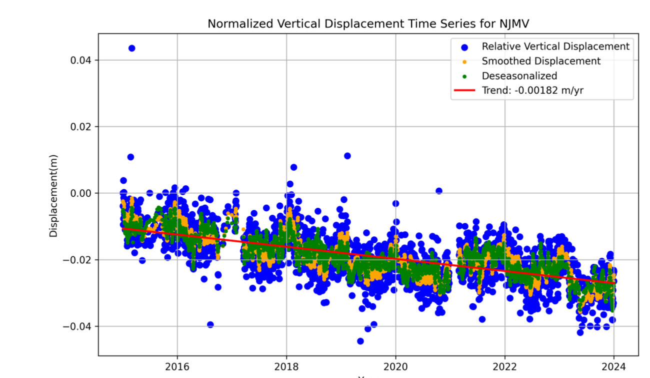

Figure 8: NJMV is a GPS station in Vineland with an average vertical velocity of -1.82 mm/yr.

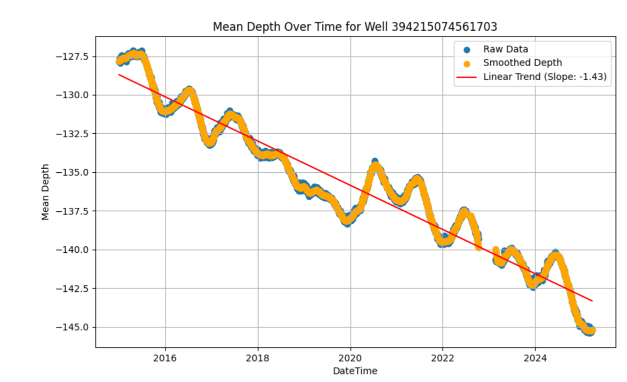

Figure 9: Well 2, denoted in Fig. 3 by a red square, has a downward trend of 1.43 ft/yr.

Atlantic City

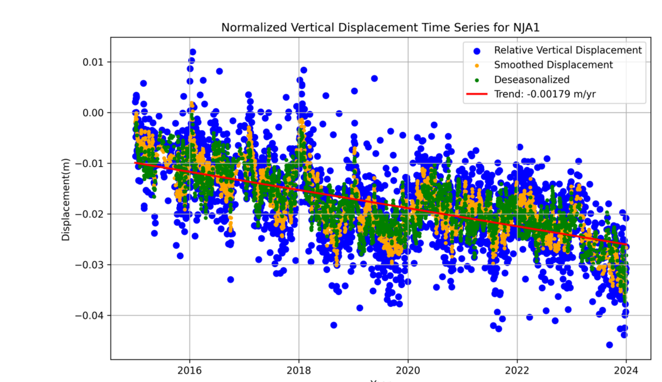

Figure 10: NJA1 is a GPS station in Atlantic City with an average vertical velocity of -1.79 mm/yr.

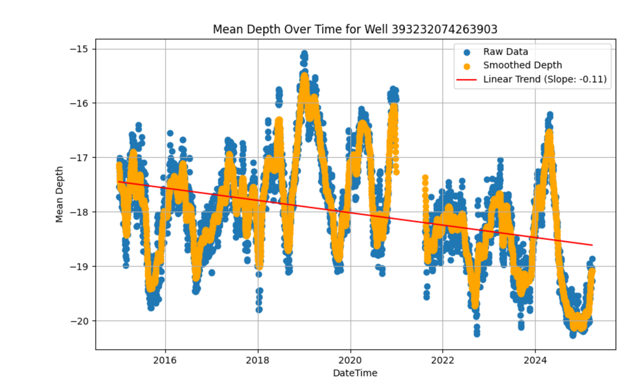

Figure 11: Well 3, denoted in Fig. 3 by a red square, has a downward trend of 0.11 ft/yr.

Conclusions & Future Work

- Preliminary analysis suggests that there is subsidence occurring in Southern New Jersey especially in the regions near Vineland and Cape May.
- The measured vertical displacement in these areas is significantly larger than the local estimates for Glacial Isostatic Adjustment.
- Moving forward we will create more interferograms to cover more regions and time periods.
- We will also create a time series of interferograms covering longer time scales.

References

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Acknowledgments:
The authors collaborated with Enrique Fernandez and Enrique Cabral-Cano at UNAM. The authors acknowledge use of the ELSA high performance computing cluster at The College of New Jersey for conducting the research reported here. This cluster is funded in part by the National Science Foundation under grant numbers OAC-1826915 and OAC-1828163.