Determination of Groundwater Withdrawal and Subsidence – Fort Bend County in 2024

by
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Fort Bend Subsidence District Report 2025-01

Fort Bend Subsidence District
Richmond, TX
Published in 2025

MICHAEL J. TURCO
GENERAL MANAGER

The Fort Bend Subsidence District (District) has been monitoring water use, groundwater levels, and subsidence in Fort Bend and adjacent counties since 1989. Subsidence, the lowering of land-surface elevation, is caused by the depressurization of our aquifers due to the widespread use of groundwater as a primary water source. The mission of the District is to cease ongoing subsidence and prevent the occurrence of future subsidence. As part of this effort, it is important for the District to provide consistent, high-quality information to the public regarding groundwater use, aquifer water levels, and subsidence.

The information contained within this report is the compilation of the largest multi-agency effort in the State of Texas that leverages the resources of both the Fort Bend and Harris-Galveston Subsidence Districts with the City of Houston, the Lone Star Groundwater Conservation District, the Brazoria County Groundwater Conservation District, and the United States Geological Survey. This year local, county, regional, and federal partnerships will publish the 35th volume of this important data compilation. This report is intended to exceed the requirements of section 8834.104 of the District's enabling legislation.

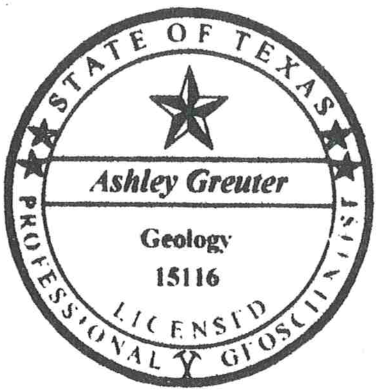
On behalf of the Board of Directors of the Fort Bend Subsidence District, I would like to thank you for your interest in the District. We look forward to continuing to provide timely, accurate, high-quality data and research to inform the District's Regulatory Planning and water planning throughout the region.

Sincerely,

Michael J. Turco
General Manager

Professional Geoscientist Seal

The contents of this report (including figures and tables) document the work of the following Licensed Professional Geoscientist:



Ashley Greuter, P.G. No. 15116

Ms. Greuter was responsible for working on all aspects of the subsidence section of the report including preparation of report figures, tables, and written text. The groundwater level data collection and interpretations were performed by the USGS and are included in the report for informational purposes. The subsidence data were processed and analyzed by Dr. Guoquan Wang at the University of Houston.

Ashley Greuter

Signature

May 28, 2025

Date

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Acknowledgments

The compilation of the data and analysis contained within this report would not be possible without the concerted effort of many who contributed to the 2024 Annual Groundwater Report. The author would like to thank the staff of the Fort Bend Subsidence District, including Veronica Osegueda, Vivian Jones, Elizabeth Giglio, and Noe Veldanez for their diligent work in managing, collecting and reviewing water use information and raw GPS data in the field; Dr. Guoquan Wang (University of Houston) for processing and archival of all raw GPS data; and the permittees and owners that submitted detailed water use information for over 1,600 pumpage reports contained in this report.

Public Hearing Notice was posted on:	February 27, 2025
Draft Presentation Posted on District Website on:	April 28, 2025
Public Hearing held on:	April 29, 2025
Hearing Examiner:	Helen Truscott
Hearing Record held open for public comment until:	May 7, 2025
Approved by the Board of Directors:	May 28, 2025

Conversions Factors and Datum

Multiply	By	To obtain
inch (in)	2.54	centimeter (cm)
foot (ft)	0.305	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
gallon (gal)	3.785	liter (L)
million gallons per day (MGD)	3785.41	cubic meter (m^3)
million gallons per day (MGD)	3.0688	acre-feet (acre-ft)

List of Acronyms

BCGCD	Brazoria County Groundwater Conservation District
CORS	Continuously Operating Reference Station
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRP	Groundwater Reduction Plan
HGSD	Harris-Galveston Subsidence District
InSAR	Interferometric Synthetic Aperture Radar
LSGCD	Lone Star Groundwater Conservation District
MGD	Million Gallons per Day
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PAM	Periodically Measured Station
POR	Period of Record
TxDOT	Texas Department of Transportation
UH	University of Houston
USGS	United States Geological Survey

Executive Summary

Groundwater was the primary source of water for municipal, agricultural, and industrial users over the last century. The reliance on groundwater and subsequent subsidence that was caused by its regional development resulted in the creation of the Fort Bend Subsidence District (District) in 1989. The District's mission is to regulate the use of groundwater in Fort Bend County to cease ongoing and prevent future subsidence that can lead to infrastructure damage and contribute to flooding.

This report comprises the 35th Annual Groundwater Report for the District. Pursuant to District Resolution No. 25-487 passed on February 26, 2025, the Board of Directors held a public hearing at 2:00 p.m. on April 29, 2025, which was attended by 25 people including members of the public, District Board Directors, and District staff. This report provides an overview of the information presented during the Public Hearing, including precipitation, water use, groundwater levels and subsidence within the District from January 1, 2024, through December 31, 2024.

Climate

Annual variations in precipitation can significantly impact the amount of water used (i.e., total water demand) in the District. Groundwater use patterns fluctuate based on total rainfall received, which results in changes in aquifer water levels and, potentially, in land subsidence. During periods of excessive rainfall, total water demand can decline; conversely, during periods of drought, water use can increase, resulting in declining water levels in the aquifer and increased land subsidence. The 2024 calendar year began with above normal rainfall for all eight of the National Weather Service (NWS) climate stations analyzed for the region. The year progressed with the majority of climate stations measuring above average rainfall that increased with intermittent summer and fall events. The lowest cumulative precipitation was recorded at Katy with about 26 inches, which places it almost 23 inches below normal. The climate station at Sugar Land Regional Airport ended the year with total precipitation of 51 inches, which is about 1.5 inches above normal.

Water Use

Since 1989, water users in the District have been working to change their source water from primarily groundwater to alternative sources of water that will not contribute to subsidence, like treated surface water. The four primary groundwater use types in the District are public supply, industrial, agricultural, and other (such as lake/pond make-up). The total amount of groundwater withdrawal for 2024 was 81.3 million gallons per day (MGD). Groundwater used for public supply remains the largest use category at 67.8 MGD and accounts for 84 percent of groundwater used in the District. Additionally, the majority of groundwater use in Fort Bend County occurs within Regulatory Area A where about 71.1 MGD was used in 2024, which accounts for 87 percent of all the groundwater used within the District. Groundwater withdrawal in Regulatory Area B was reported to be about 10.2 MGD in 2024 where groundwater is primarily used for agriculture.

The District's Regulatory Plan requires permittees in certain areas to convert to alternative water supplies to reduce their reliance on groundwater sources. The main alternative water supply used in our region is surface water sourced from three river basins, the Brazos River Basin, the San Jacinto River Basin and the Trinity River Basin. Total alternative water usage for

2024 was 100.1 MGD, with the Brazos River as the largest source of alternative water, providing a total of 73 MGD, which comprises 73 percent of the total alternative water supply. Groundwater is the single largest source of water supply within the District, comprising 45 percent of the total water used in Fort Bend County, followed by alternative water sourced from the Brazos. The total water use for the District is reported to be 181.4 MGD in 2024, which is a 3.6 percent decrease from the previous year that is most likely attributed to the above-average rainfall experienced in portions of the District as both Regulatory Areas reported decreases in agricultural use greater than 20 percent from the previous year.

Groundwater Levels

Annually, since 1990, the United States Geological Survey (USGS) has measured the water level in hundreds of wells throughout the region in cooperation with the District through a joint funding agreement along with additional cities, Harris-Galveston Subsidence District (HGSD) and groundwater conservation districts to monitor and provide reports on groundwater level altitude data for the Chicot/Evangeline (undifferentiated) aquifer. Since aquifer water-level is the best measure of the pressure in the aquifer, this information is also of vital importance to understanding the impact that changes in water use have on the aquifer system and subsidence.

The change in water-levels in the Chicot and Evangeline (undifferentiated) aquifer from 1990 to 2025 include areas of rise of over 40 feet within the northwestern portion of Regulatory Area A, such as Sugar Land, Stafford, and Missouri City, as these areas began utilizing alternative water in compliance with the District's Plan. In northeastern Fort Bend County including Cinco Ranch, Katy, and Fulshear, the change in water-levels during this time period show declines ranging from 120 to over 200 feet as these areas have experienced rapid growth in recent years. The District's Plan requires additional reduction in groundwater withdrawal in Area A to 40% of total water demand for permittees with approved groundwater reduction plans beginning in 2027.

Subsidence

Since the mid-1990s, the District has utilized global positioning system (GPS) technology to monitor the land surface deformation in the area. Working collaboratively with University of Houston researchers, the subsidence monitoring network has grown to over 180 GPS stations throughout the region. These stations are operated by the District, the Harris-Galveston Subsidence District (HGSD), the University of Houston (UH), the Texas Department of Transportation (TxDOT), and other local entities such as Groundwater Conservation Districts.

The average annual subsidence rate is a useful measure to show the current land surface changes at a GPS station. Subsidence rates presented in this report are calculated as the best fit line from GPS data collected from 2020 to 2024. Subsidence rates greater than 1.5 centimeters (cm) per year were measured in northern Fort Bend County, near the Fulshear and Katy areas as well as southeastern Fort Bend County, close to Brazoria County near Fresno. Some southern portions of Regulatory A near the Richmond and Rosenberg area and all of Regulatory Area B show very little subsidence at under half a centimeter per year.

Since 2019, the District has sponsored research conducted by Southern Methodist University in collaboration with the Harris-Galveston Subsidence District that utilizes a novel remote sensing methodology to evaluate land-surface changes in the greater Fort Bend County region. This project involves interferometric synthetic aperture radar (InSAR) to estimate changes in the land surface from a regional scale and complements the District's subsidence monitoring network by providing data in between the GPS stations. Results from InSAR-derived subsidence rates closely resemble rates calculated from the GPS stations such that the northernmost portion of Regulatory Area A shows subsidence rates greater than two centimeters per year and Regulatory Area B has subsidence rates less than half a centimeter per year.

Introduction

The greater Houston region, including Fort Bend County, has relied on groundwater as a primary source of water since the early 1900s. During and following the economic boom of the 1940s, rapid population expansion and increased water use resulted in potentiometric water level declines in the Chicot and Evangeline (undifferentiated) aquifer of 250 to 300 feet (76 and 91 meters) respectively from 1943 to 1977 (Gabrysch, 1982). The potentiometric surface is the level to which water rises in a well. In a confined aquifer, this surface is above the top of the aquifer unit; whereas, in an unconfined aquifer, it is the same as the water table.

The reliance on groundwater and subsequent subsidence that was caused by its regional development resulted in the creation of the Fort Bend Subsidence District (District) in 1989. The District's mission is to regulate the use of groundwater in Fort Bend County to cease ongoing and prevent future subsidence that can contribute to flooding and lead to infrastructure damage.

Purpose and Scope of Report

This document comprises the 35th Annual Groundwater Report for the District. Pursuant to District Resolution No. 25-487 passed on February 28, 2025, the Board of Directors held the Annual Groundwater Hearing beginning at 2:00 p.m. on April 29, 2025. The Public Hearing was held as an in-person meeting. The public hearing fulfills the requirements of Section 8834.104, Texas Special Districts Local Laws Code, which states that each year, the Board of Directors shall hold a public hearing for the purpose of taking testimony concerning the effects of groundwater withdrawals on the subsidence of land within the District for the preceding year.

The 2024 Annual Groundwater Report Public Hearing was attended by 25 people including members of the United States Geological Survey (USGS) staff, along with members of the District's staff, District Board members, representatives from cities, regional water authorities, and municipal utility districts, and the public. Those giving testimony were Ashley Greuter, Director of Research and Water Conservation of the District, and Jason Ramage, Hydrologist, Gulf Coast Programs Office, Texas-Oklahoma Water Science Center, USGS. District staff submitted 14 exhibits including topics on precipitation, groundwater withdrawal, alternative water usage, and subsidence data. Mr. Ramage presented nine exhibits including topics of water-level altitudes, water-level changes, and aquifer compaction.

The record was left open until May 7, 2025. Ms. Truscott asked for additional testimony and comments at the end of the Public Hearing. Public testimony and comments are provided in **Appendix C**.

This report provides an overview of the information presented during the Public Hearing, including climatic conditions, water use, groundwater levels and subsidence within the District from January 1, 2024, through December 31, 2024. Appendix **A** of this report includes the exhibits presented at the public hearing held on April 29, 2025.

Description of Study Area

The following section provides an overview of the study area, including the hydrogeology and the District's regulatory planning areas.

Hydrogeology

The Gulf Coast Aquifer exists as an accretionary wedge of unconsolidated sediments composed primarily of sand, silt, and clay. Indicative of a transgressive-regressive shoreline, the interbedded sands and clays are not horizontally or vertically continuous at larger than a local scale. From youngest to oldest, these hydrogeologic units include the Chicot, Evangeline, Burkeville Confining Unit, Jasper, and Catahoula Sandstone aquifers (**Figure 1**).

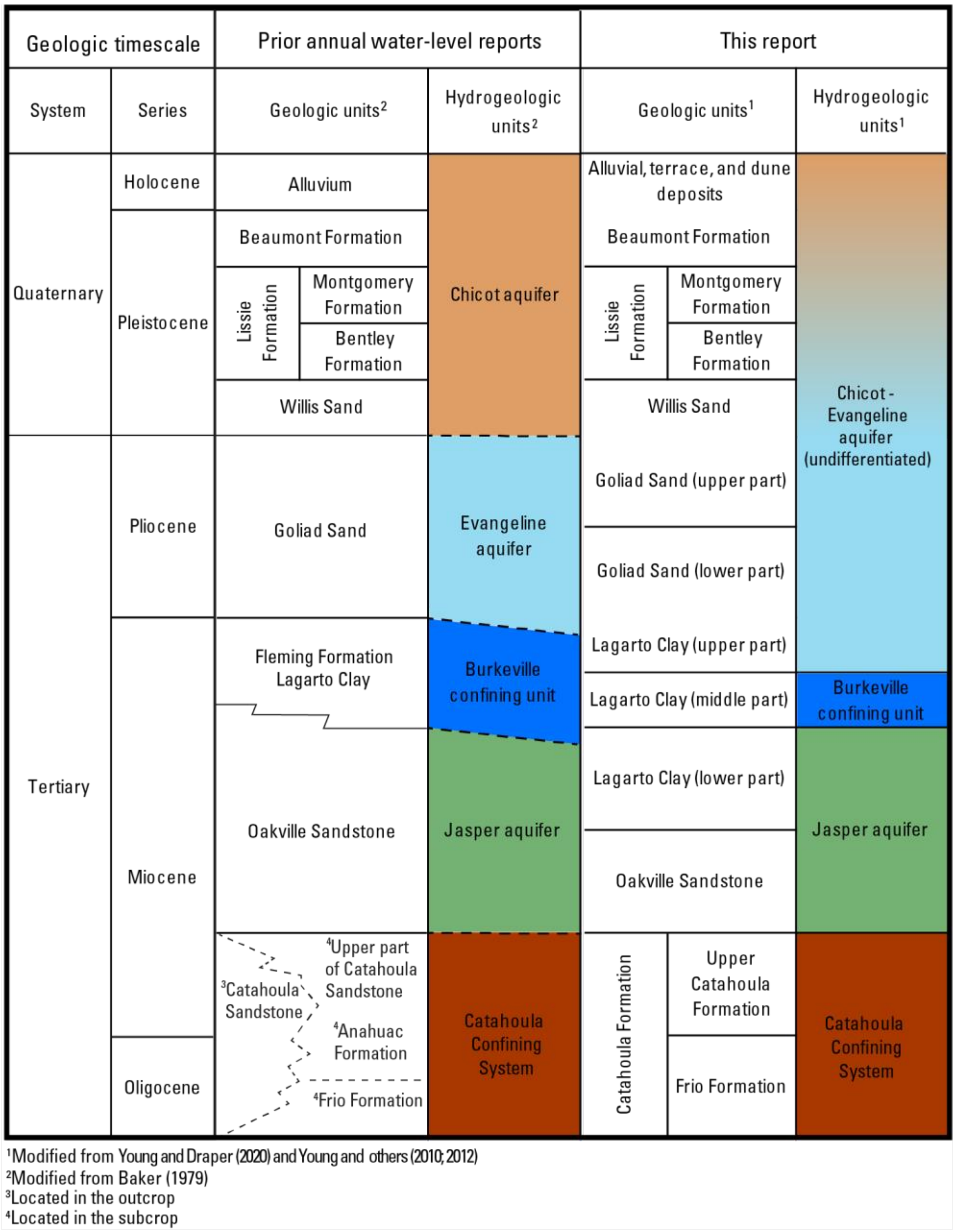

Figure 1. Updated stratigraphic column of the Gulf Coast Aquifer System in Fort Bend and adjacent counties, Texas (Ramage, et al., 2022).

The two primary water-bearing units most widely utilized within the District are the Chicot and Evangeline (undifferentiated) aquifers. The Chicot and the Evangeline aquifers comprise the shallow system of the Gulf Coast Aquifer. They are hydrologically connected such that groundwater can flow between the two units. The Chicot and Evangeline aquifers have been combined into an undifferentiated shallow aquifer system called the Chicot/Evangeline (undifferentiated) aquifer in this report (**Figure 1**).

The Jasper aquifer is the deepest primary water-bearing unit, is isolated by the Burkeville confining unit and is mostly undeveloped in Fort Bend County. Currently, one well is completed in the Jasper aquifer in the District and has only been in use on a limited basis. In the region, the Catahoula Sandstone, the deepest water-bearing unit in the Gulf Coast Aquifer system, and the Burkeville confining unit are not utilized as a groundwater supply within the District.

Most of the subsidence that has occurred in the District can be sourced to clay compaction in the shallow water-bearing units associated with long-term water use. Because of the significant amount of clay material in the primary water-bearing units of the aquifer, the risk of compaction is high in areas where the developed portions of the aquifers are within about 2,000 feet of land surface (Yu, et al., 2014) under high stress from groundwater development, and have had sustained water-level declines when compared to pre-development levels.

Regulatory Planning

The District's Plan was developed to reduce groundwater withdrawal to a level that ceases ongoing subsidence and prevents future subsidence within the District. The District utilizes a novel approach to regulating groundwater withdrawal to prevent subsidence by allowing a portion of the total water demand of a groundwater user to be sourced from groundwater. Total water demand is defined as the total amount of water used by an entity from all sources, including groundwater, treated surface water, reclaimed water, etc. The District adopted the most recent Plan on January 23, 2013, and it was subsequently amended on June 22, 2022.

The District has historically used regulatory areas to guide groundwater conversion deadlines and regulations. The 2013 Plan has subdivided Fort Bend County into two regulatory areas (**Figure 2**). Regulatory Area A includes the northeastern portion of the county, including all of the major cities in Fort Bend County such as Sugar Land, Katy, Missouri City, Rosenberg, and Richmond. Permittees in this area may source no more than 40 percent of their total water demand from groundwater unless operating under a District approved groundwater reduction plan (GRP). Since 2013, permittees operating under an approved GRP can source no more than 70 percent of their total water demand from groundwater and in 2027 this percentage will reduce to no more than 40 percent.

Regulatory Area B comprises the western portion of Fort Bend County, including cities like Simonton, Needville, Beasley, Pleak, and Orchard. Permittees located in Regulatory Area B are not subject to groundwater reduction requirements at this time.

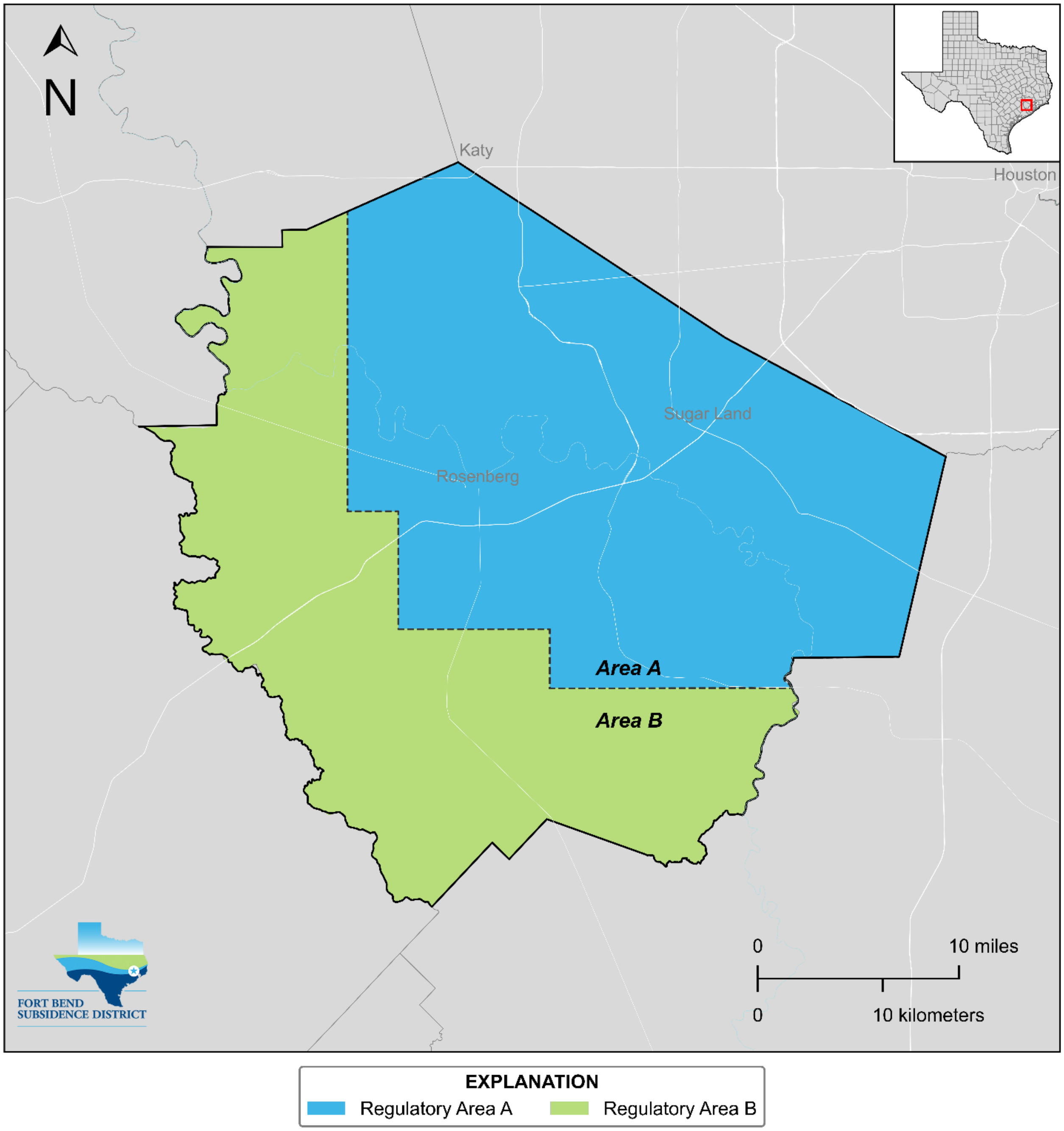

Figure 2. Location of the Fort Bend Subsidence District's Regulatory Areas.

Surficial Hydrology

The District's Plan requires permittees to utilize alternative water supplies in order to reduce their reliance on groundwater sources. The primary alternative water supplies used in our region is treated surface water sourced from three river basins: the Brazos River Basin, the San Jacinto River Basin and the Trinity River Basin (**Figure 3**)**.**

The Brazos River Basin is the second largest river basin in Texas, covering over 45,500 square miles according to the Texas Water Development Board (TWDB). The headwaters of the Brazos River are located near the Texas-New Mexico border and the river travels over 800 miles to discharge into the Gulf of Mexico near Freeport, Texas. The Brazos River Authority manages the eleven reservoirs within this basin, eight of which are owned by the Brazos River Authority and three are owned by the U. S. Army Corps of Engineers (Region H Water Planning Group, 2016).

The San Jacinto River Basin is the smallest river basin in Texas, covering almost 4,000 square miles (Texas Water Development Board, 2024). Lake Conroe and Lake Houston are the two water supply reservoirs located within the San Jacinto River Basin. Lake Conroe is jointly owned by the City of Houston and the San Jacinto River Authority. The San Jacinto River Authority operates Lake Conroe and provides water supply to Harris and Montgomery Counties. Lake Houston is owned by the City of Houston and operated by the Coastal Water Authority.

The Trinity River Basin covers almost 18,000 square miles with headwaters of the basin located in north central Texas (Texas Water Development Board, 2024). The Trinity River flows through the Dallas-Fort Worth metroplex, traversing 550 miles until the river discharges into Trinity Bay near Anahuac, Texas. There are numerous reservoirs located on the Trinity River which are owned and operated by several different agencies, including Lake Livingston which is owned and operated by Trinity River Authority.

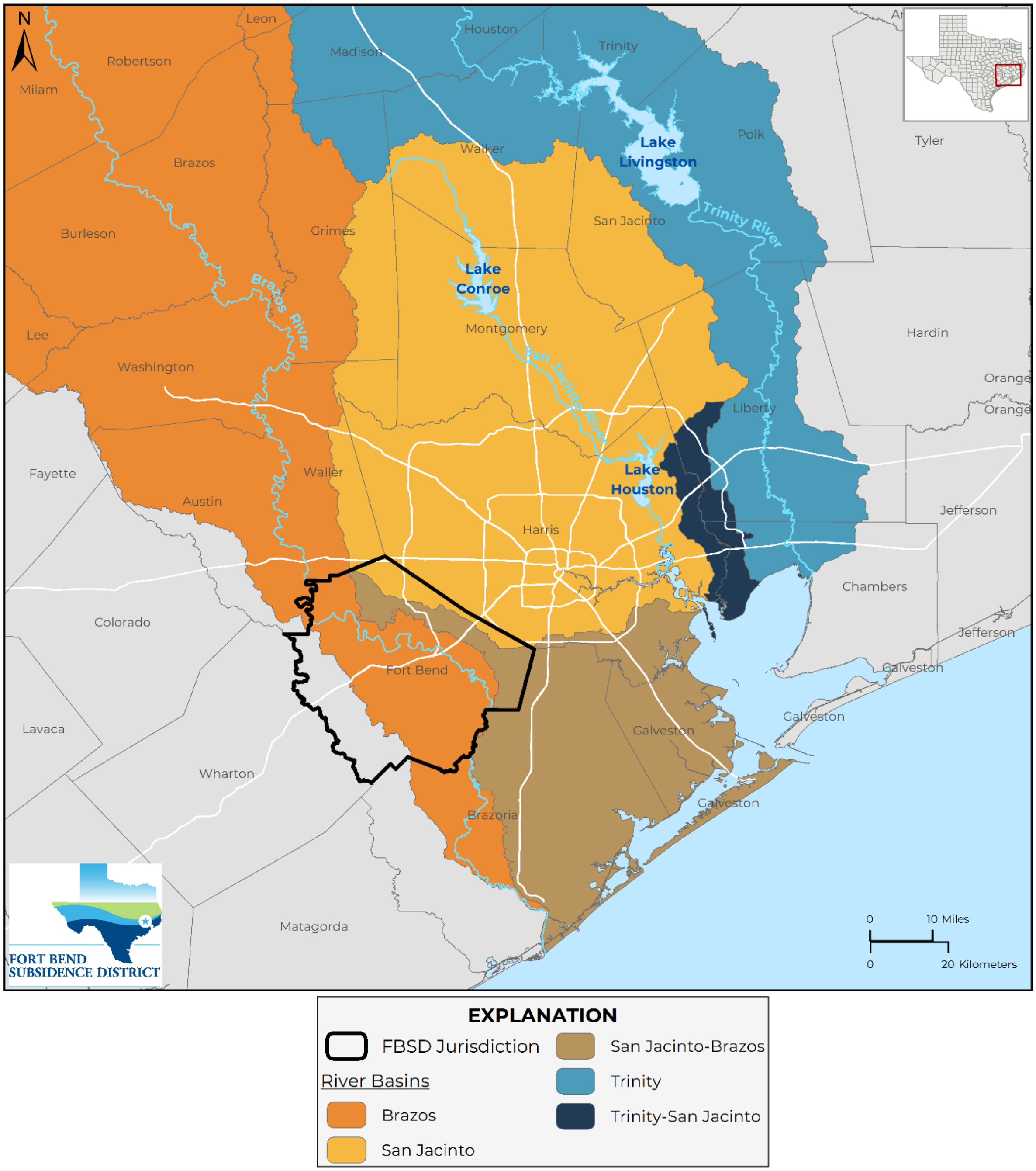

Figure 3: River basins that supply alternative water to Fort Bend and surrounding counties.

Alternative Source Waters

In the 1950s, the City of Houston along with other entities in the region began the development of several water supply reservoirs to provide water for the rapidly growing region within the Brazos, San Jacinto and Trinity River Basins. The water treatment plants served by these surface water sources are operated by the City of Houston, City of Sugar Land, City of Missouri City, City of Richmond, the Gulf Coast Water Authority, the Brazosport Water Authority, and others.

Two projects are currently underway to develop the necessary alternative water supply and distribution infrastructure to facilitate the District's future conversion requirements:

- Northeast Water Purification Plant Expansion provides 400 million gallons per day (MGD) of treated surface water conveyed by the Luce Bayou Interbasin Transfer Project. This expansion of the existing plant was completed in 2024 (Greater Houston Water, 2025).
- The Surface Water Supply Project will convey treated water from the expanded Northeast Water Purification Plant into western Harris County and northeastern Fort Bend County (Surface Water Supply Project, 2025).

In addition to the two projects described above, the City of Houston and the Water Authorities are each designing and constructing their own distribution systems to convey the treated surface water to their customers. These interrelated regional projects are planned to be completed by 2025, prior to when the next conversion requirements of the District go into effect in 2027. **Figure 4** shows the extent of these projects. Additionally, the Luce Bayou Interbasin Transfer is operational as of 2024 and pumps untreated surface water from the Trinity River through a series of canals and water pipelines along Luce Bayou to Lake Houston.

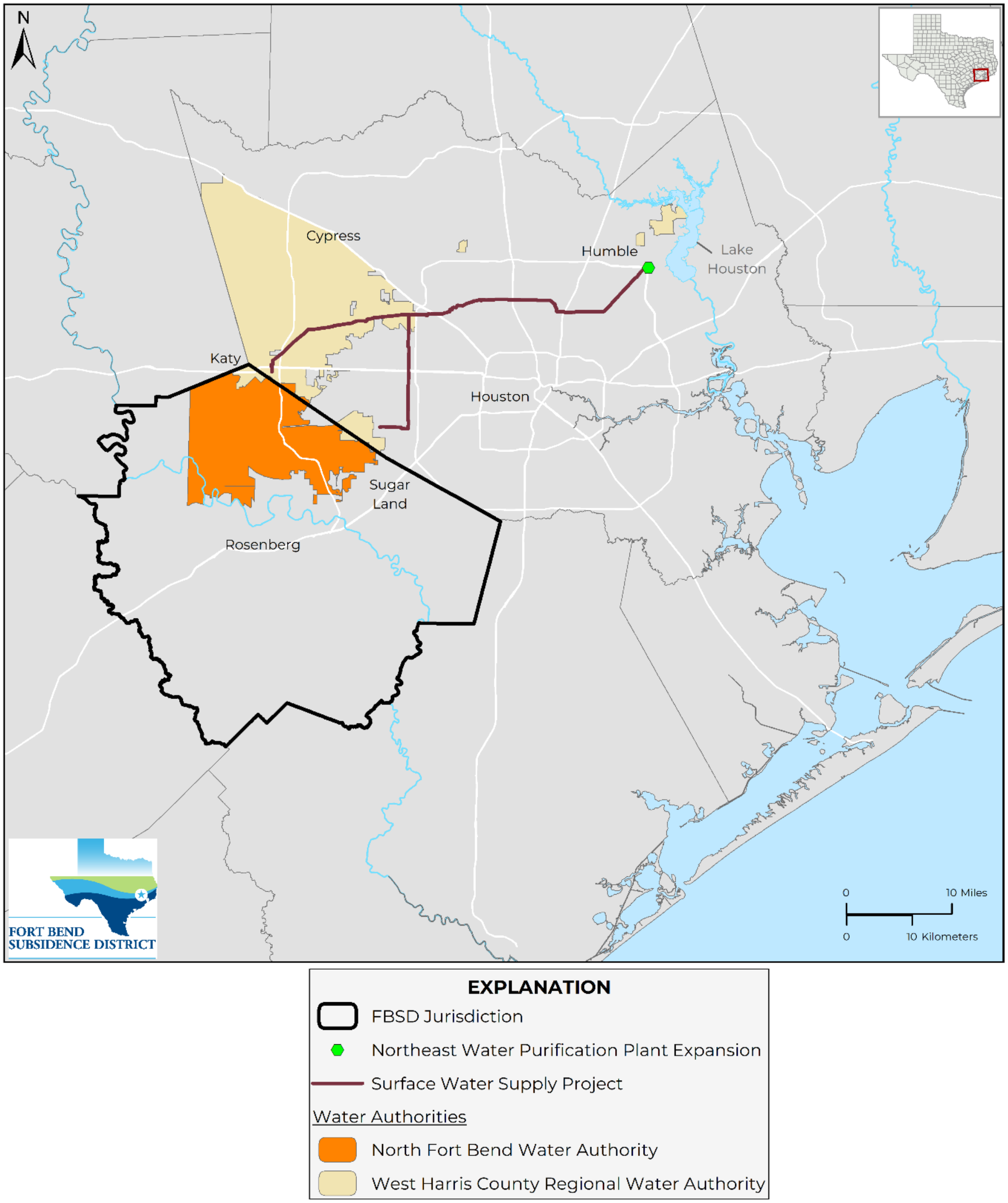

Figure 4: Alternative water supply and infrastructure distribution projects in Fort Bend County and the greater Houston region.

2024 Climate Summary

The District reviews local climatic data provided by the National Oceanic and Atmospheric Administration (NOAA) – National Weather Service (NWS) climate stations within and around the District (**Figure 5**). Variation in local precipitation, specifically deviation from historical normal, is important to the District because it has a direct impact on the magnitude of the total water demand of water users in the region and the availability of alternative water supplies, such as surface water. During periods of above normal precipitation in the region, total water demand remains typically near normal or below normal due to reduced outdoor irrigation and agricultural needs. Conversely, during periods of below normal precipitation, the total water demand of the region will typically increase due to increased water use to supplement the reduced rainfall.

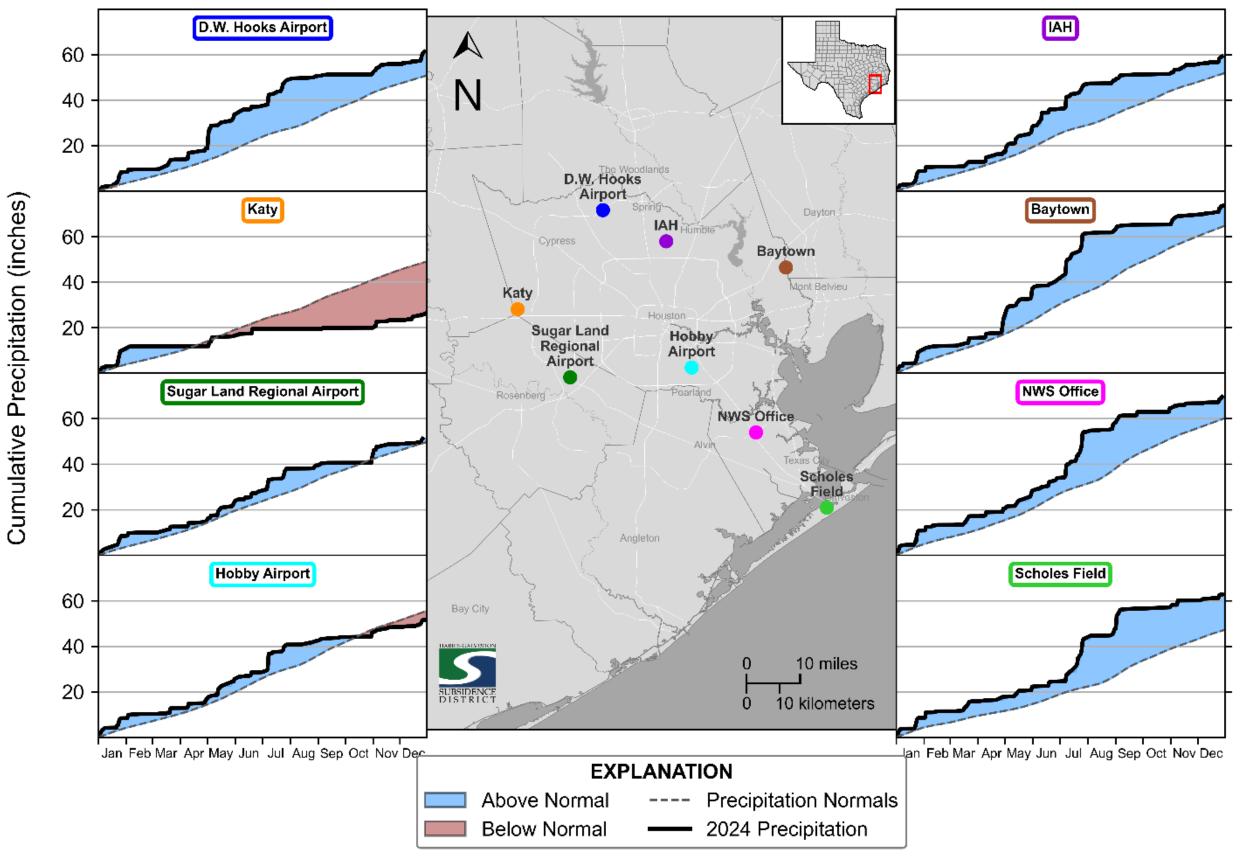

Figure 5. Location of National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) climate stations in southeast Texas analyzed for the 2024 calendar year. Graphs contain individual station cumulative precipitation, in inches, as the solid black line compared to the 1991-2020 normal precipitation shown as the dashed line.

As shown in **Figure 5**, precipitation for the 2024 calendar year at the Sugar Land Regional Airport started above normal and remained above normal for the rest of the year. Rainfall measured at the Katy climate station also began the year above average but went below normal from May through December (**Figure 5**). Overall, seven of the eight NWS climate stations recorded total rainfall above normal in 2024.

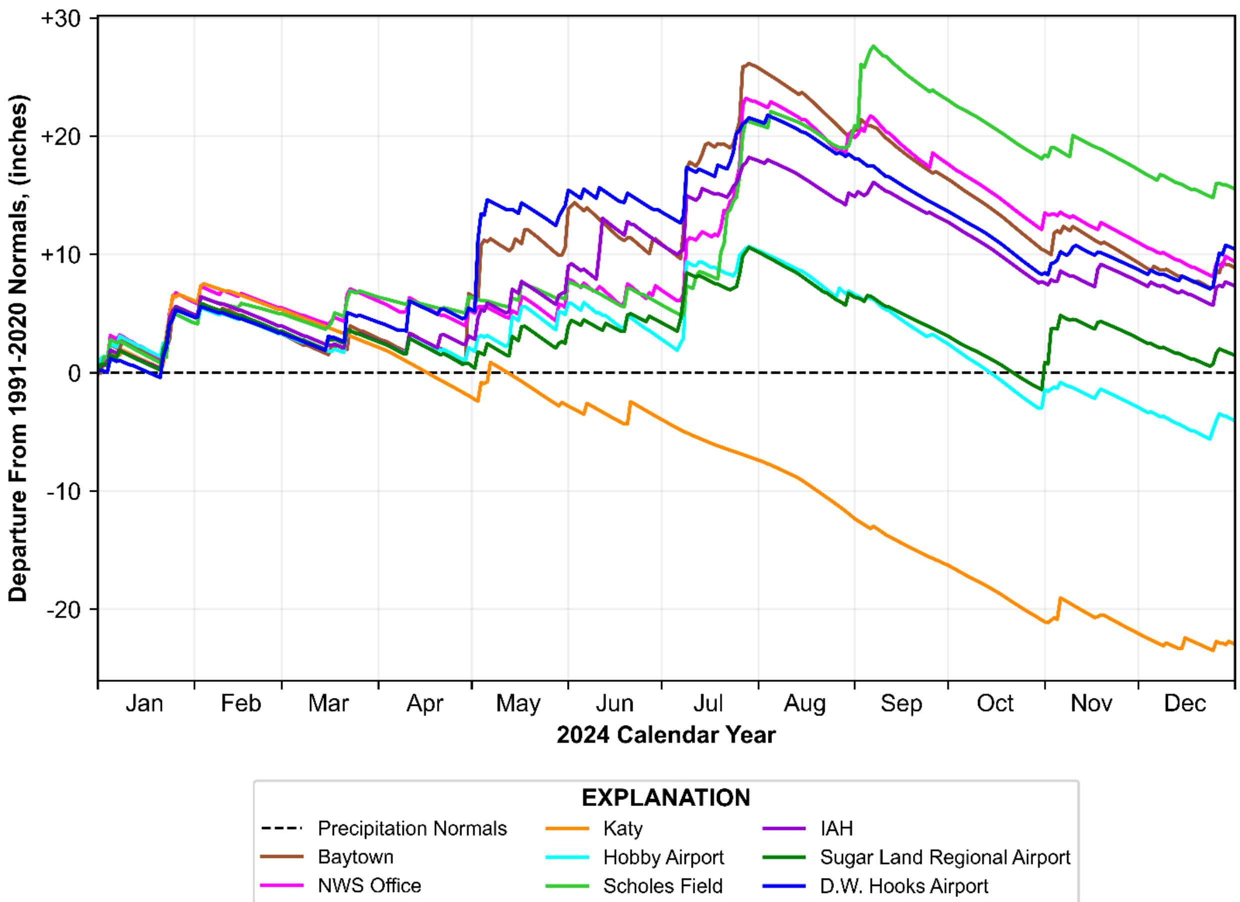

Figure 6. Cumulative 2024 precipitation, in inches, departure from 1991-2020 normal precipitation at NOAA-NWS Climate Stations within and around the District. Source: https://www.ncei.noaa.gov/access.

The smallest cumulative rainfall recorded at the selected NWS climate stations was measured at Katy with only 26 inches, placing it nearly 23 inches below normal **Figure 6**. Sugar Land Regional Airport total precipitation was about 51 inches, which was about 1.5 inches below normal. Further east of Fort Bend County, the Hobby Airport, located in Houston, reported nearly 52 inches of cumulative precipitation for 2024, which makes it 4 inches below normal. The largest total rainfall measured in the greater Fort Bend region was at Scholes Field, in Galveston, with almost 63 inches, placing it over 15.5 inches above normal (**Figure 6**).

2024 Water Use

The District collects groundwater and alternative water use annually from permittees and other water providers in the area. This information provides an understanding of how much groundwater is being used within the District, how permittees are using groundwater and a perspective on the conversion from groundwater to surface water for the regulatory areas.

For the 2024 reporting year, there were a total of 2,027 permitted wells in the District. As of April 2025, a total of 1,631 of these permittees had submitted their annual water use data for the District to compile and use in this report. The groundwater withdrawals associated with missing reports were estimated based on permitted allocations to be 2.2 MGD, which is under two percent of the reported withdrawals.

In addition to providing water use data for 2024, this report also provides updated groundwater withdrawal totals for the previously reported year of 2023. These changes are made during the normal permitting and reporting process as part of the exchange between the District and its permittees. The changes include updating estimated amounts with actual amounts, correction of data entry errors, and inclusion of annual reports that were not submitted by the deadline date. There was an increase of 0.08 MGD, which is less than one percent increase from the previous 2023 reported value.

The following sections provide a summary of the information presented at the Public Hearing held on April 29, 2025. The exhibits used to provide testimony during the hearing are included in **Appendix A – Exhibits Presented at Public Hearing held on April 29, 2025**.

Total Groundwater Use

The four primary water uses in the District are public supply, industrial, agricultural, and other (e.g., lake/pond makeup). The total amount of groundwater withdrawal for 2024 is 81.3 MGD, a 15 percent decrease from the previous year (**Table 1**), with public supply being reported to be 84 percent of the overall use. Groundwater withdrawals had increased slightly since the District's inception in 1989 (**Figure 7**) with a 30 percent increase from 62.6 MGD in 1990 to 81.3 MGD in 2024. The largest decreases (e.g., over 20 percent) in groundwater use were reported for agricultural use and other (i.e., lake/pond makeup) is most likely attributed to the above-average rainfall experienced in some areas like Sugar Land. Additionally, patterns in groundwater use have shifted over time, resulting in reduced groundwater use for industrial and agricultural needs compared with the 1990s and 2000s.

Table 1. *Summary of Reported Groundwater Use (in MGD) by Regulatory Area.*

Groundwater Use Category	Area A			Area B			Total		
	2023	**2024**	**1-Year Change**	**2023**	**2024**	**1-Year Change**	**2023**	**2024**	**1-Year Change**
Public	74.70	63.21	-15%	3.59	4.59	28%	78.29	67.80	-13%
Industrial	4.09	4.13	1%	0.07	0.08	10%	4.16	4.21	1%
Agricultural	0.50	0.20	-60%	6.59	4.89	-26%	7.09	5.09	-28%
Other	5.58	3.55	-36%	0.49	0.63	27%	6.08	4.18	-31%
Total	**84.87**	**71.09**	**-16%**	**8.42**	**10.74**	**28%**	**95.62**	**81.28**	**-15%**

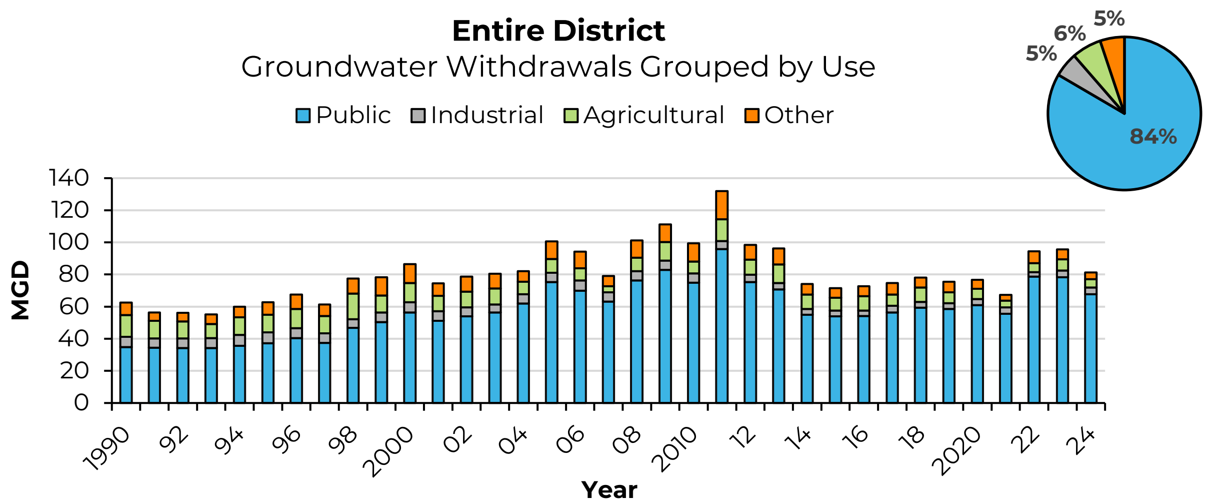

Figure 7: Groundwater withdrawals, in million gallons per day, by water use category from 1990 to 2024. The total groundwater used in the District was 81.3 MGD in 2024, with 84 percent used for public supply as shown in the pie chart (inset).

The District is divided into two regulatory areas that define how much groundwater may be utilized as a percentage of the total water demand (**Figure 2**). The total annual groundwater withdrawals are categorized by regulatory area in **Figure 8**. This graph shows the impact of the District's Plan, requiring conversion from groundwater to surface water over time and as a result the reduction in groundwater withdrawals in Regulatory Area A. Currently, wells located within Regulatory Area B have no restrictions on groundwater use.

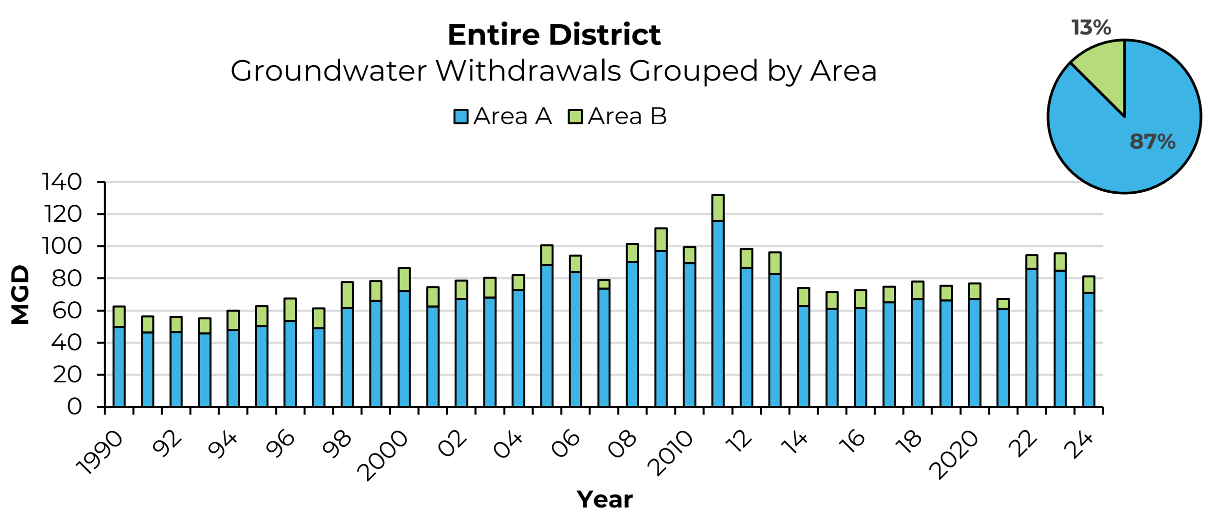

Figure 8: Groundwater withdrawals, in million gallons per day, by regulatory area from 1990 to 2024. In 2024, a total of 71.1 MGD of groundwater was used in Regulatory Area A and 10.2 MGD used in Regulatory Area B. As shown in the pie chart (inset), the majority of groundwater is being used within Regulatory Area A.

Regulatory Area A

Regulatory Area A covers the northeastern portion of Fort Bend County. Cities and entities include Arcola, Cinco Ranch, Fulshear, Houston, Katy, Meadows Place, Missouri City, Pearland, Pleak, Richmond, Rosenberg, Sienna Plantation, Sugar Land, and Thompsons. This area began its conversion to alternate water sources back in 2011, when the North Fort Bend Water Authority began taking water from the City of Houston.

In 2024, total groundwater withdrawal in Regulatory Area A was 71.1 MGD, a 16 percent decrease from the previous year (**Figure 9**). The majority of groundwater used in Regulatory Area A is associated with public supply, which comprises over 89 percent of the total. Industrial use is almost 60 percent less than what it was in 1990. Agricultural use is typically correlated to rainfall patterns. The amount of groundwater used for agriculture decreased by 60 percent in 2024 to 0.2 MGD, when compared to the previous year, and it is 96 percent less than what was used in 1990 as the land use in Regulatory Area A has changed from farmland to city centers over this time period.

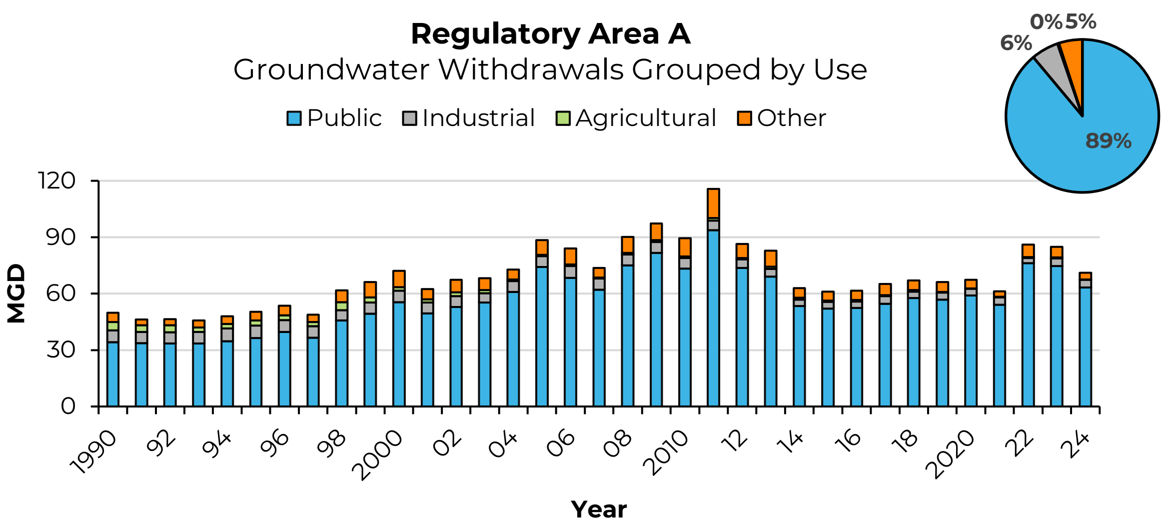

Figure 9: Groundwater withdrawals for Regulatory Area A, in million gallons per day, by water use category from 1990 to 2024. A total of 71.1 MGD of groundwater was used in Regulatory Area A in 2024, with 89% of the withdrawals being used for public supply as shown in the pie chart (inset).

Regulatory Area B

Regulatory Area B covers the western and southern areas of the District. Cities, villages and entities include Beasley, Fairchilds, Kendleton, Needville, Orchard, Simonton, and Weston Lakes.

Total groundwater withdrawal decreased by five percent in Regulatory Area B from 10.7 MGD in 2023 to 10.2 MGD in 2024 (**Figure 10**). Public supply groundwater use increased by 28 percent from the previous year to 4.6 MGD. Agricultural use was reported to be 4.9 MGD, which represents a 26 percent decrease in use from the previous year; while other use, such as lake/pond makeup, increased by 27 percent from 0.5 MGD in 2023 to 0.6 MGD in 2024. Groundwater withdrawals have generally fluctuated between 10 to 12 MGD in Regulatory Area B with the exception of the 2011 drought, which comprised 16.3 MGD (**Figure 10**).

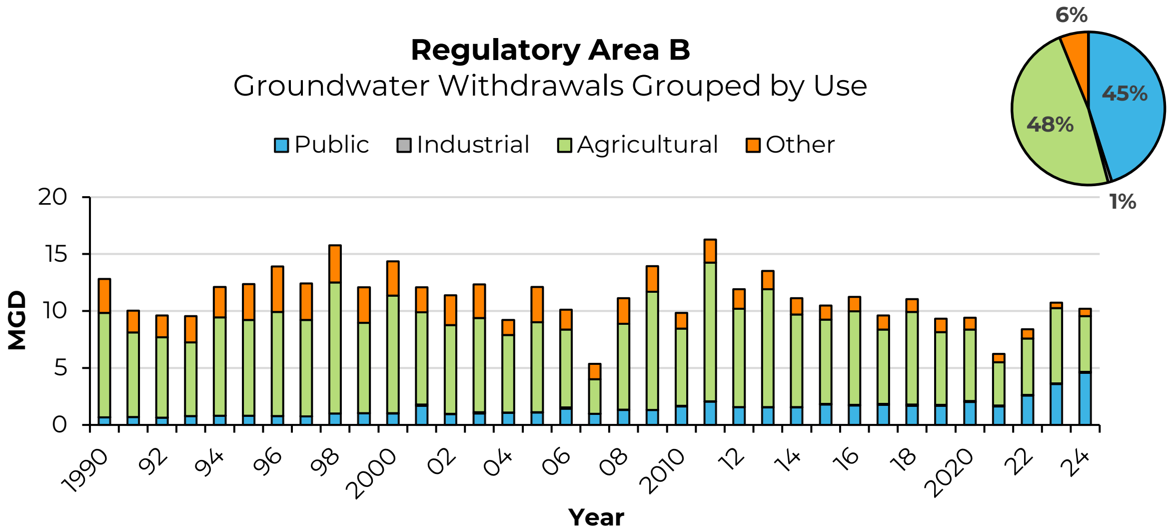

Figure 10: Groundwater withdrawals for Regulatory Area B, in million gallons per day, by water use category from 1990 to 2024. A total of 10.2 MGD of groundwater was used in Regulatory Area B in 2024, with 48% used for agricultural purposes as shown in the pie chart (inset).

Alternative Water Supply and Total Water Use

The District's Plan requires permittees to convert to alternative water supplies in order to reduce their reliance on groundwater sources. The primary alternative water supply used in our region is surface water sourced from three river basins: the Brazos River Basin, the San Jacinto River Basin and the Trinity River Basin (**Figure 3**). Alternative water use from these basins are provided in **Table 2**. The San Jacinto and Trinity River totals have been lumped together because it is not possible to get the exact number by basin.

Groundwater remains the largest source of water supply within the District as a whole. The Brazos River, as it has been since 1990, is still the single largest source of alternative water used within the District. Reclaimed water is also used as an alternative water supply, but to a much smaller degree. In 2024, all alternative water supplies were reported to be 100.1 MGD, which is an eight percent decrease from the previous year (**Table 2**).

***Table 2**. Summary of One-Year Change in Reported Alternative Water Use, Groundwater Use, and Total Water Demand (in MGD)*

Source		2023	2024	1-Year Change
Alternative Supplies	Brazos River Basin	67.1	73.0	9%
	San Jacinto/Trinity River Basin	18.7	19.7	5%
	Reuse	6.8	7.4	10%
	Alternative Supply Subtotal	*92.6*	*100.1*	*8%*
Groundwater		95.6	81.3	-15%
Total Water Demand		**188.3**	**181.4**	**-4%**

Use of alternative water sourced from the Brazos River Basin has increased by 75 percent from 41.6 MGD in 1990 to 73 MGD in 2024 (**Figure 11**). The total water demand for the District was determined to be 181.4 MGD in 2024, which is about four percent less than the previous year.

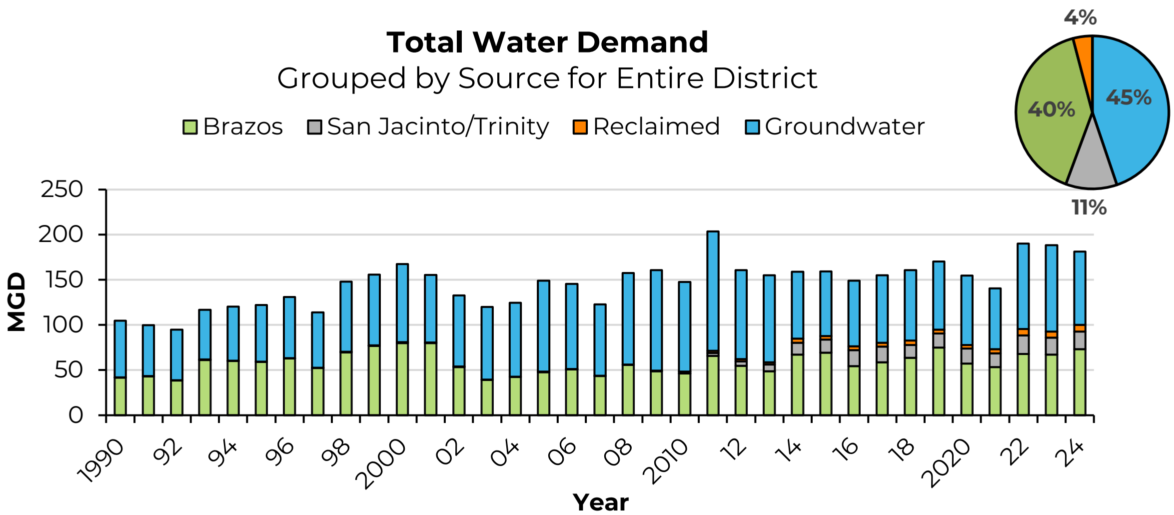

Figure 11: Total water use for the District, in million gallons per day, by source from 1990 to 2024. The total water use for the District in 2024 was 181.4 MGD with 45% sourced from groundwater as shown in the pie chart (inset).

2024 Groundwater Level Summary

All groundwater used in the District is sourced from the Gulf Coast Aquifer System, which is composed of three primary water-bearing units. Units most widely used in the District are the Chicot and Evangeline (undifferentiated) aquifers. The Chicot aquifer is the shallowest aquifer in the District which is hydrologically connected to the Evangeline aquifer immediately below. The Burkeville confining unit lies beneath the Chicot and Evangeline (undifferentiated) aquifer and isolates the third primary aquifer, the Jasper aquifer. The Jasper aquifer is not widely used in the District but is a primary source of water for other counties.

Annually, since 1990, the USGS has measured the water level in hundreds of wells throughout the region in cooperation with the Fort Bend Subsidence District through a joint funding agreement along with additional cities, HGSD, and groundwater conservation districts to monitor and provide reports on groundwater level altitude data for the primary aquifers. Since aquifer water-level is the best measure of the pressure in the aquifer, this information is important to understand the impact of changes in water use on subsidence.

The 2024 potentiometric surface (i.e., the interpolated surface created from water-level data) from the Chicot and Evangeline (undifferentiated) aquifer show the areas of primary stress on the aquifer occurs in northeastern Fort Bend County (**Figure 12**). The potentiometric surface represents an imaginary surface based on measured water-level data in tightly cased wells and essentially is the level that water would rise in a groundwater well that's drilled into the aquifer. Generally, Regulatory Area A has seen a large decline in the water-level ranging from 150 to 250 feet below datum (i.e., North American Vertical Datum (NAVD) 1988) in the Chicot and Evangeline (undifferentiated) aquifer in the northeastern portion of Fort Bend County including Fulshear, Katy, and Cinco Ranch as well as some areas in eastern Fort Bend County such as Sugar Land, Stafford, and Four Corners (**Figure 12**).

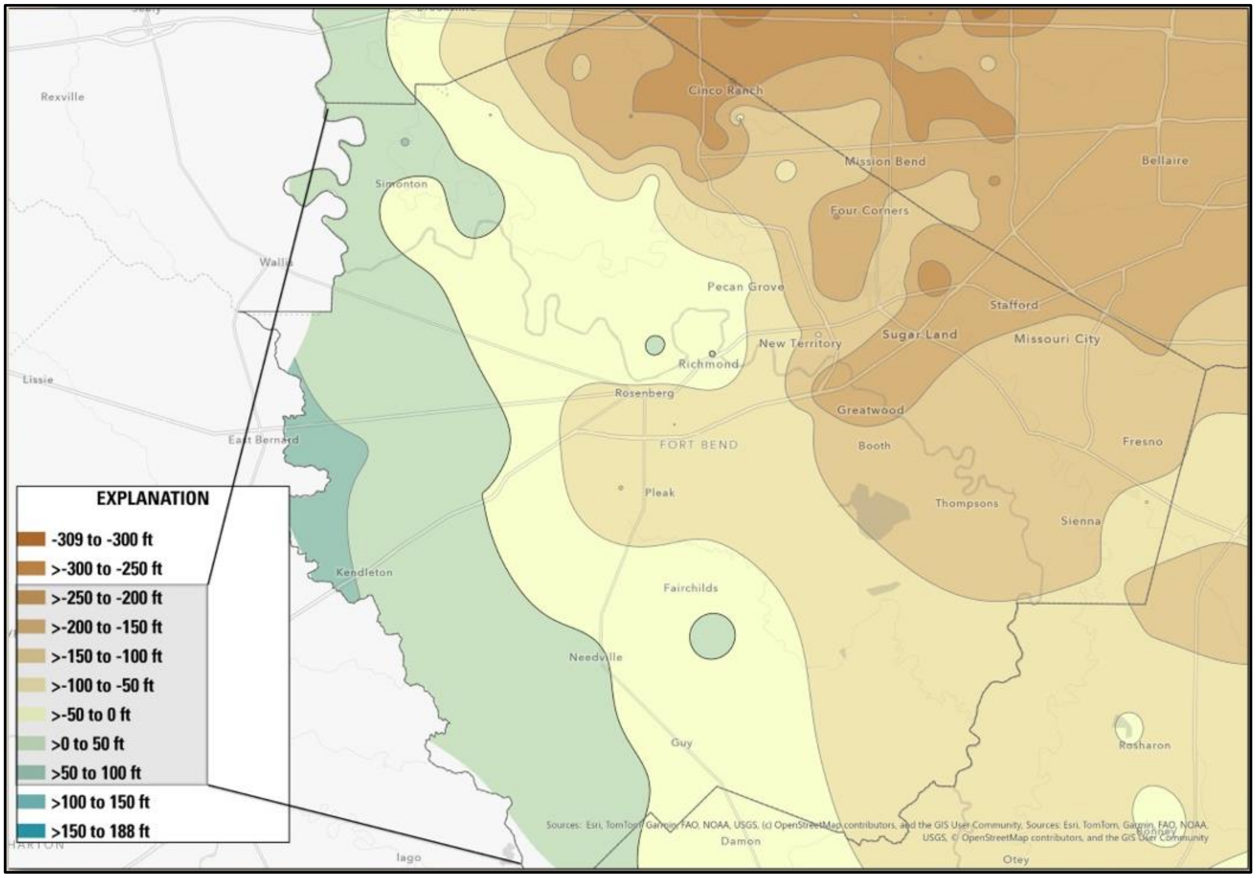

Figure 12: Altitude of the potentiometric surface determined from water-levels measured in 2025 within tightly cased wells screened in the Chicot and Evangeline (undifferentiated) aquifer, Fort Bend County, Texas, and referenced from North American Vertical Datum (NAVD) 1988 (Source: USGS provisional data – preliminary and subject to change).

The change in water-levels from 1990 to 2025, as shown in **Figure 13**, include areas of rise within Regulatory Area A such as Sugar Land and Richmond with over 40 feet as well as Missouri City with over 80 feet in the Chicot and Evangeline (undifferentiated) aquifer as these areas began utilizing alternative water in compliance with the District's Plan. Water-level declines were measured in northern Fort Bend County with as much as 200 feet in the Katy area (**Figure 13**).

The information presented in this section is a summary of the provisional data presented at the Public Hearing held on April 29, 2025. The exhibits used to provide testimony during the hearing as well as supplemental data not shown are included in **Appendix A – Exhibits Presented at Public Hearing held on April 29, 2025**. A USGS Scientific Investigation Report will be released later this year documenting the status of groundwater level altitudes and the long-term changes in the aquifers.

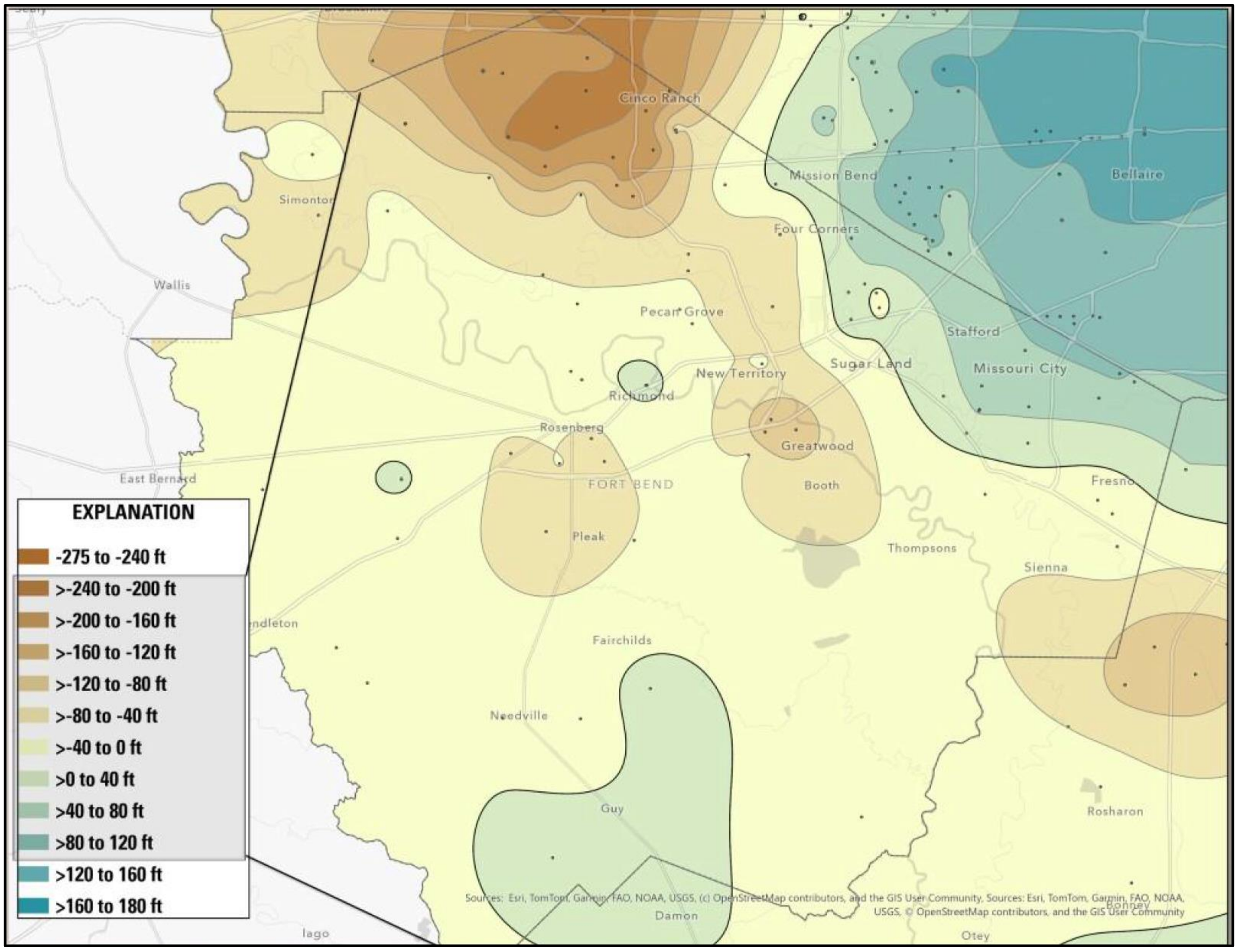

Figure 13: Water-level change at wells screened in the Chicot and Evangeline (undifferentiated) aquifer, Fort Bend County, Texas, from 1990 to 2025 (Source: USGS provisional data – preliminary and subject to change).

2024 Subsidence Trend Analysis

Subsidence is the lowering of land surface elevation. In the greater Fort Bend County area, subsidence occurs from the compaction of clays in the subsurface due to groundwater withdrawal. As the water-level of the aquifer declines, fine-grained sediments, such as silt and clay, in the aquifer depressurize and compact. This compaction results in the lowering of overlying stratigraphic units and is observed at the surface as subsidence.

Global positioning system (GPS) stations have been installed across southeast Texas in order to track changes in the land surface since the mid-1990s. This GPS network consists of a collaboration between the District, HGSD, UH, TxDOT, BCGCD, and other agencies. The GPS network had 42 active stations located inside and within a five-mile radius of Fort Bend County that collected data in 2024 and were analyzed for this report (**Figure 14**).

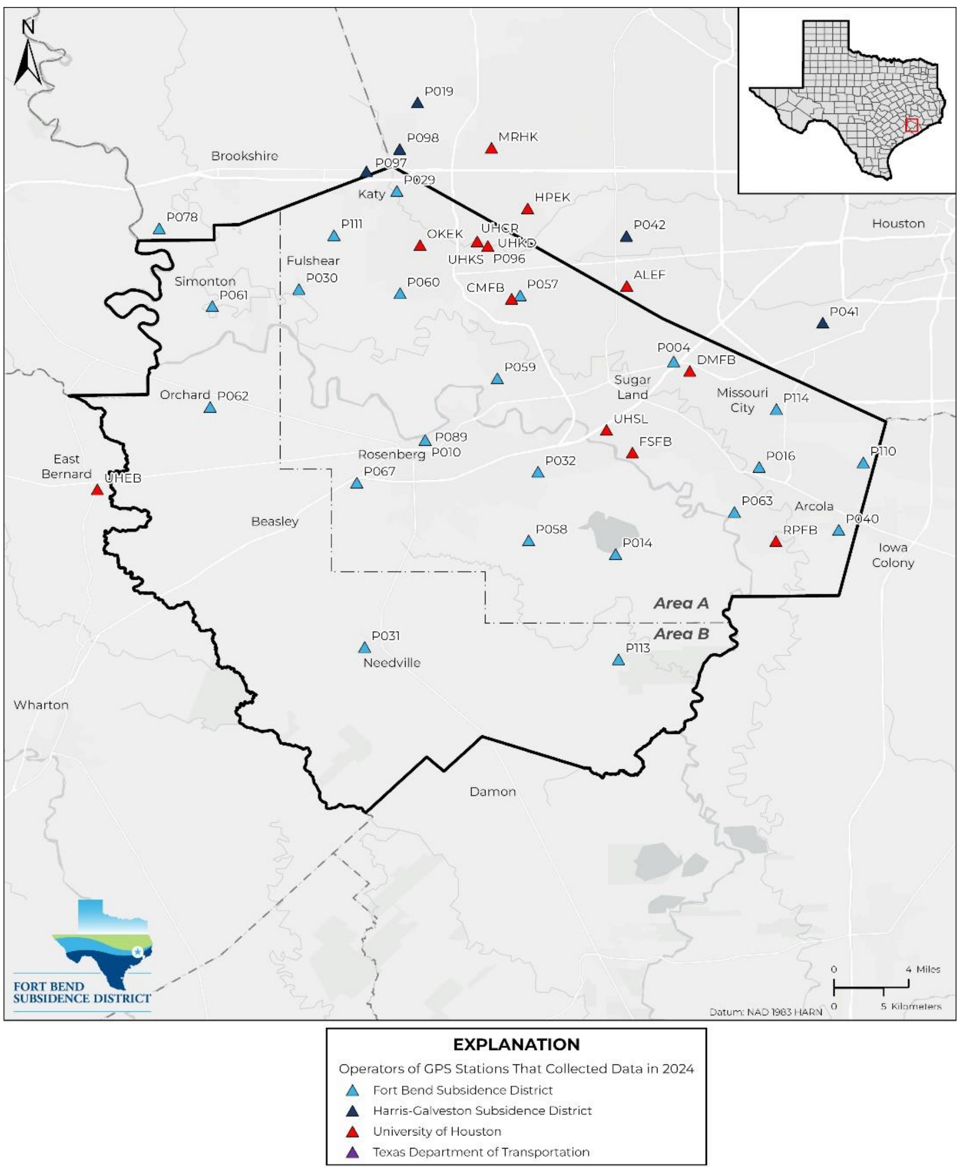

Figure 14. Subsidence monitoring network designated by operator for GPS stations that were actively collecting data in 2024 within Fort Bend County and within a five-mile radius of Fort Bend County.

The District collects raw GPS data from the active stations in the network and collaborates with Dr. Guoquan Wang at UH for processing. Aspects of GPS processing include upload to archives, data conversions, transformations to a stable reference frame designated as Houston20 to remove natural movements such as plate tectonics (Agudelo, et al., 2020) and identification and removal of outliers (Wang, et al., 2022). The District uses these GPS data to evaluate long-term subsidence trends at each location over the entire period of record and to determine the average annual subsidence at each location over the most recent 5-year period.

This analysis allows the District to determine the impact of the District's Plan on the occurrence and magnitude of subsidence as well as identify impacts of management strategies (or lack thereof) in adjacent counties on subsidence within the District. Additional information on the average annual subsidence rate and period of record data for each GPS station are provided in **Appendix B – Period of Record Data**. Active GPS stations were also located in Harris, Galveston, and Montgomery counties that are not included in this report as the focus is on Fort Bend County. Additionally, some GPS stations in Brazoria County were not actively monitoring in 2024 and are therefore excluded from the analysis.

Average Annual Subsidence Rate

The average annual subsidence rate is a useful measure to show the recent change in land surface deformation at each GPS station. The subsidence rate, presented in this report, is determined by using linear regression (i.e., the statistically determined best fit straight line through a scatter plot of data points) of the last five years of data for GPS stations with at least three years of monitoring and were actively monitoring in 2024. **Figure 15** depicts the average annual subsidence rate from 2020 through 2024 from over 20 GPS stations located in Fort Bend County as well as additional GPS stations in the subsidence monitoring network. Additionally, the subsidence rate map shown in **Figure 15** includes a hyperlink to an interactive map with these data. To access the interactive map, simply click on the figure.

Regulatory Area A has the highest subsidence rates (greater than two centimeters per year) in the northeastern area of Fort Bend County near the county border between Waller and Harris counties as well as the eastern portion of the county near the border to Brazoria County. The southern areas of Regulatory Area A and all of Regulatory Area B show very minor subsidence with subsidence rates below half a centimeter per year.

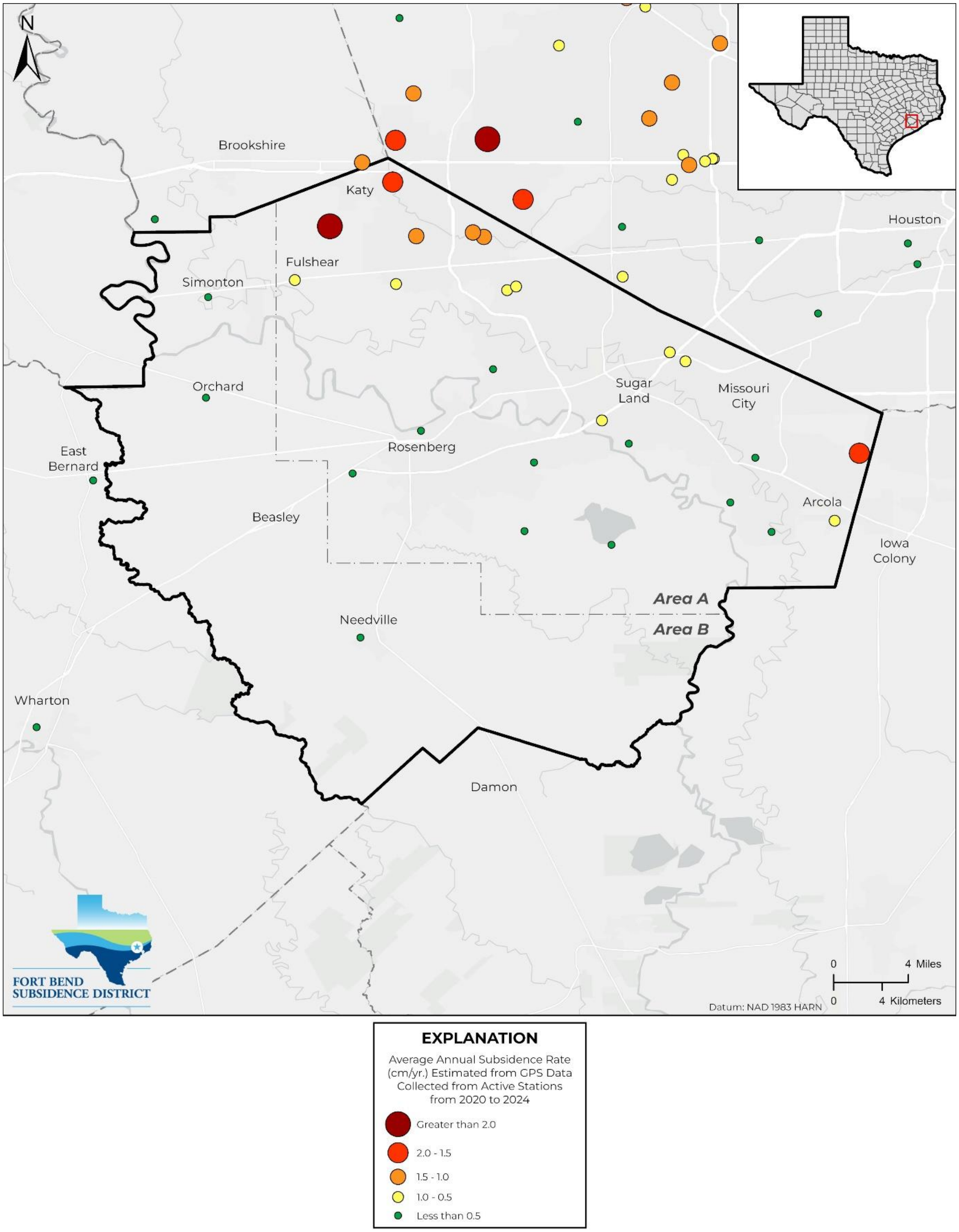

Figure 15: Annual subsidence rate, measured in centimeters per year, referenced to Houston20 and estimated from three or more years of GPS data collected from GPS stations in Fort Bend and surrounding counties that were actively collecting data in 2024, Texas, averaged from 2020 to 2024.

Period of Record Data

The period of record includes GPS measurements of the ellipsoidal height that are collected over the lifespan of each GPS station. It is used to track the full history of land-surface deformation and is represented as a vertical displacement time series scatter plot. The vertical displacement is determined by the change in ellipsoidal height, which is the distance from a point on the earth's surface to the reference ellipsoid. The reference ellipsoid is a mathematical representation of the earth's surface as a smoothed ellipsoid. Although the ellipsoid height is not the same as elevation, or the orthometric height, research has shown that linear trends of vertical displacement at GPS stations over the same time interval were the same for both ellipsoidal and orthometric heights (Wang & Soler, 2014). Therefore, ellipsoidal heights are used to estimate changes in the land surface. The period of record plots give a historical context to understand local to regional subsidence trends and are provided in **Appendix B**.

Regulatory Area A contains GPS station P111, located east of Fulshear, that has measured a cumulative subsidence of 10.7 cm since monitoring began in 2021. **Figure 16** includes the POR plot and five-year rate for P111 that shows an annual subsidence rate of 3.31 cm per year, which is the greatest rate calculated in the monitoring network.

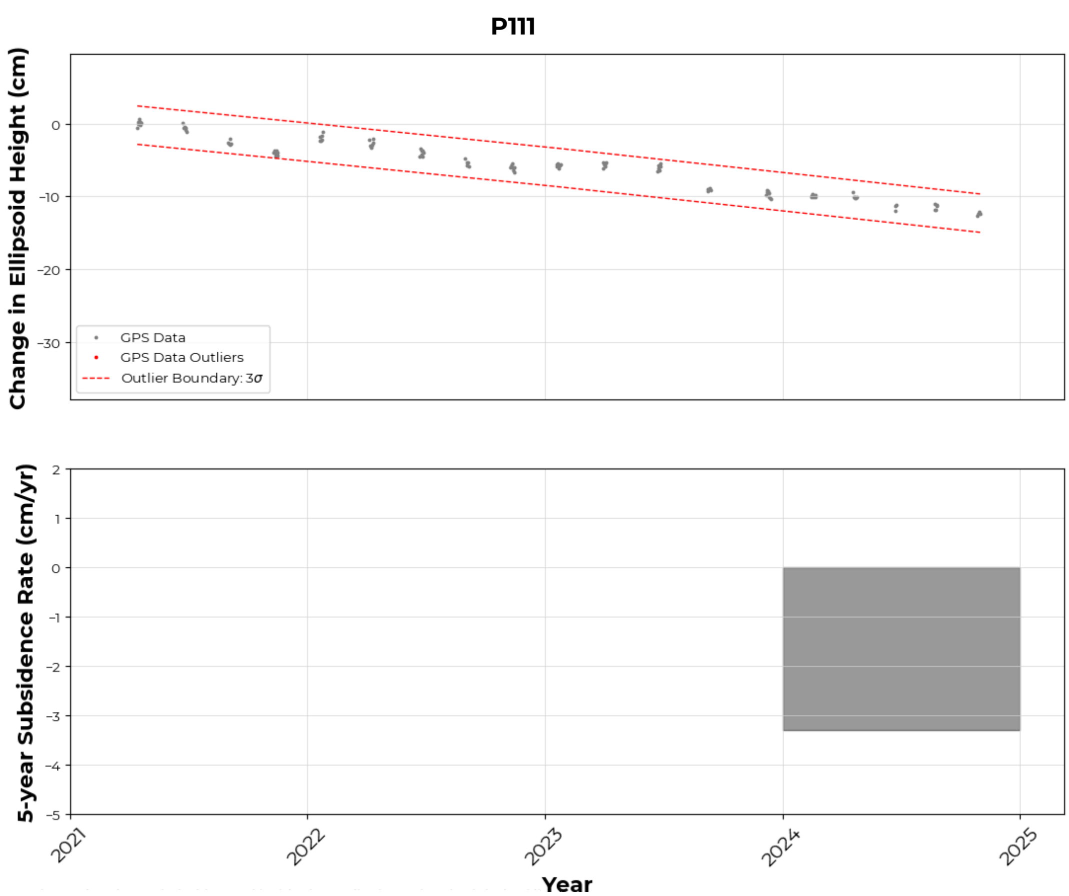

Figure 16: Period of record plot for P111 located near Fulshear, Texas, 2021 to 2024. This station measured 10.7 cm of subsidence over 4 years and the 2020-2024 annual subsidence rate is 3.31 cm per year. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by FBSD when calculating subsidence rates and are shown for informational purposes only.

Interferometric Synthetic Aperture Radar

Since 2019, the District has sponsored research conducted by Southern Methodist University that utilizes a novel remote sensing methodology to evaluate land-surface changes in Fort Bend and adjacent counties. This project involves multi-temporal interferometric synthetic aperture radar (InSAR) to estimate changes in the land surface from a regional scale and complements the District's subsidence monitoring network by providing data in between the GPS stations. Synthetic aperture radar (SAR) scenes are created through the transmission of electromagnetic radiation (i.e., radio waves) that are sent from the sensor to the ground surface and bounce back up to the sensor. The sensor circles the earth in precise orbit and time called passes. It takes about 12 days for the sensor to revisit an area previously captured. Experts use information gleamed from these different passes to detect small changes in the distances between them. This processed pair of SAR images is called an interferogram and shows if the land is moving up or down (Helz, 2005). This process was applied to the greater Fort Bend region and using state-of-the-art processing techniques achieved accuracy in millimeters.

This report marks the first year that InSAR-derived subsidence rates were analyzed and presented at the Public Hearing. The District worked with technical experts from SkyGeo, Inc. to estimate the annual subsidence rate averaged from 2020 through 2024 across Fort Bend and surrounding counties. Approximately 202 SAR scenes were analyzed from January 5, 2020, through December 21, 2024, from the descending track of Sentinel-1 and processed using the persistent scatterers technique to create an interferogram of the velocities in the vertical direction.

Results from InSAR-derived subsidence rates are shown in **Figure 17** and these rates closely resemble rates calculated from the GPS stations. For example, green colors indicate very minor subsidence to uplift and warmer colors, ranging from yellow to red, indicate higher subsidence. As presented in **Figure 17**, southern portions of Regulatory Area A near Richmond/Rosenberg as well as Regulatory Area B show minor subsidence to uplift. Conversely, the northeastern portion of Regulatory Area A contains subsidence rates greater than two centimeters per year near Katy and Cinco Ranch and this continues into western Harris County and southeastern Waller County. Some isolated areas of higher subsidence rates were also detected in northwestern Brazoria County near Iowa Colony and Manvel.

The combination of multiple monitoring methodologies, which includes traditional surveying such as the work performed by the HGSD available at https://hgsubsidence.org/science-research/2022-global-navigation-satellite-systems-gnss-survey/ and remote sensing like GPS and InSAR, compared over multiple time intervals (e.g., annual to decadal) provides a comprehensive approach to understanding the impacts of changes in groundwater use on subsidence in Fort Bend County.

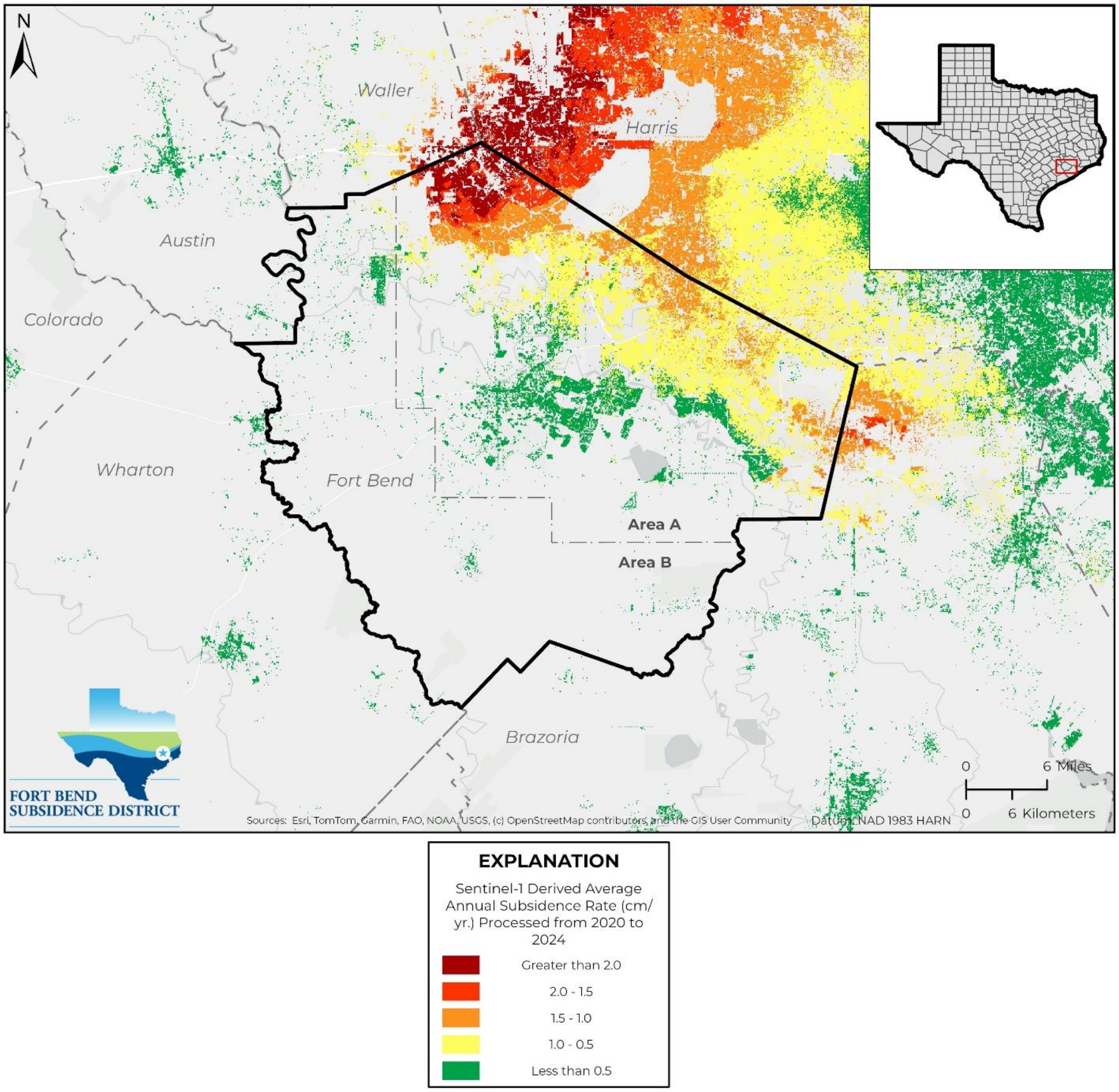

Figure 17: Interferometric Synthetic Aperture Radar (InSAR)-derived annual subsidence rate, calculated in centimeters per year, estimated from Sentinel-1 data and averaged from 2020 through 2024. Processed SAR scenes were analyzed using persistent scatterers methodology from 202 scenes on the descending track. Source: SkyGeo.

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Appendix A – Exhibits Presented at Public Hearing held on April 29, 2025

2024 Annual Groundwater Report

Public Hearing
April 29, 2025

FORT BEND
SUBSIDENCE DISTRICT

Fort Bend Subsidence District

The Fort Bend Subsidence District (FBSD) is a special-purpose district created by the Texas Legislature in 1989 to prevent further land subsidence in Fort Bend County.

GROUNDWATER REGULATION

Collaborate with local to state water entities and providers to manage groundwater use through water planning and well permitting.

RESEARCH & MONITORING

Utilize the highest quality data to monitor groundwater usage, aquifer characteristics, and land surface changes.

WATER CONSERVATION

Provide permittees, businesses, and educators with water conservation tools to reduce water use and empower the community to value water.

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Exhibit 1

Location of National Weather Service (NWS) climate stations used for rainfall data for the 2024 calendar year.

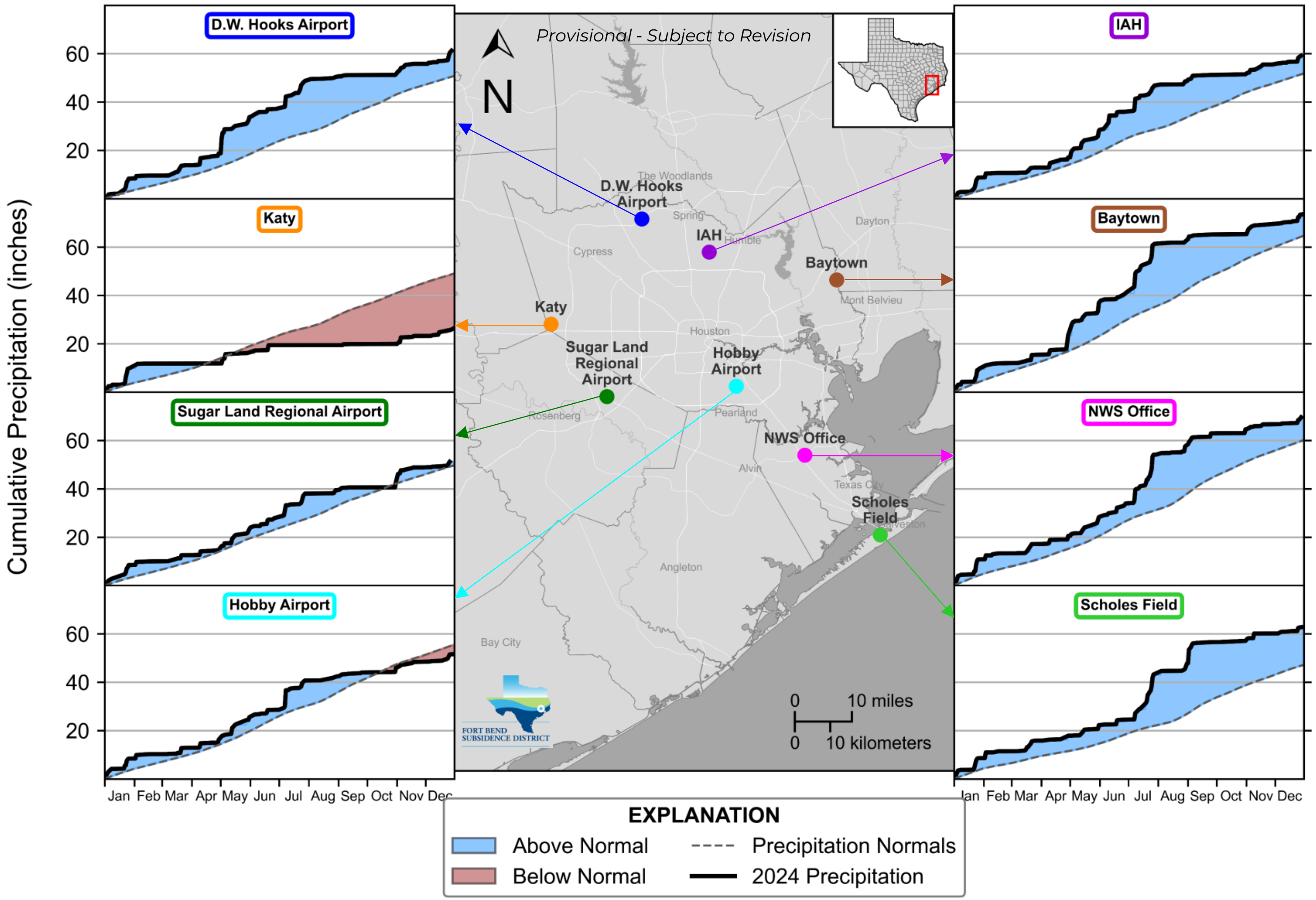
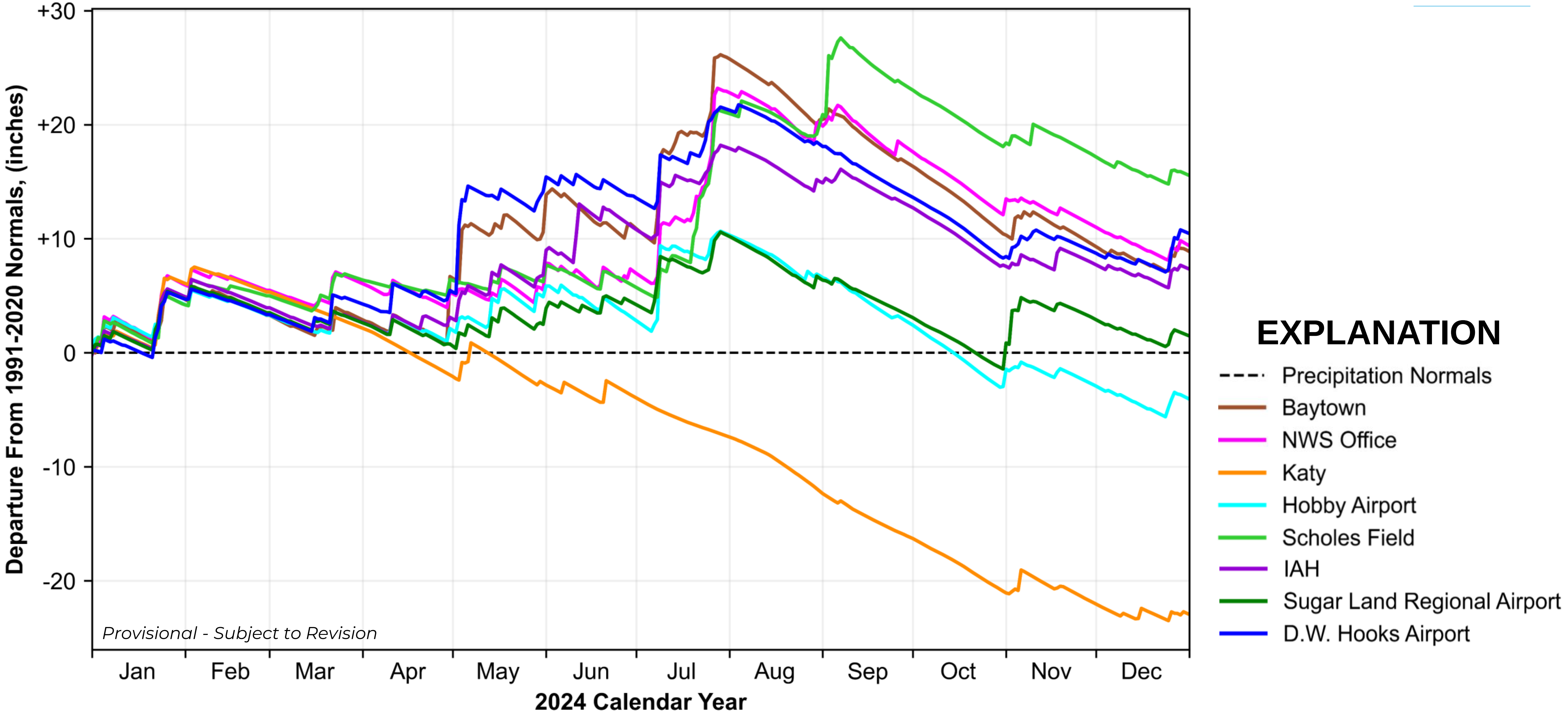


Exhibit 2 2024 Precipitation Data



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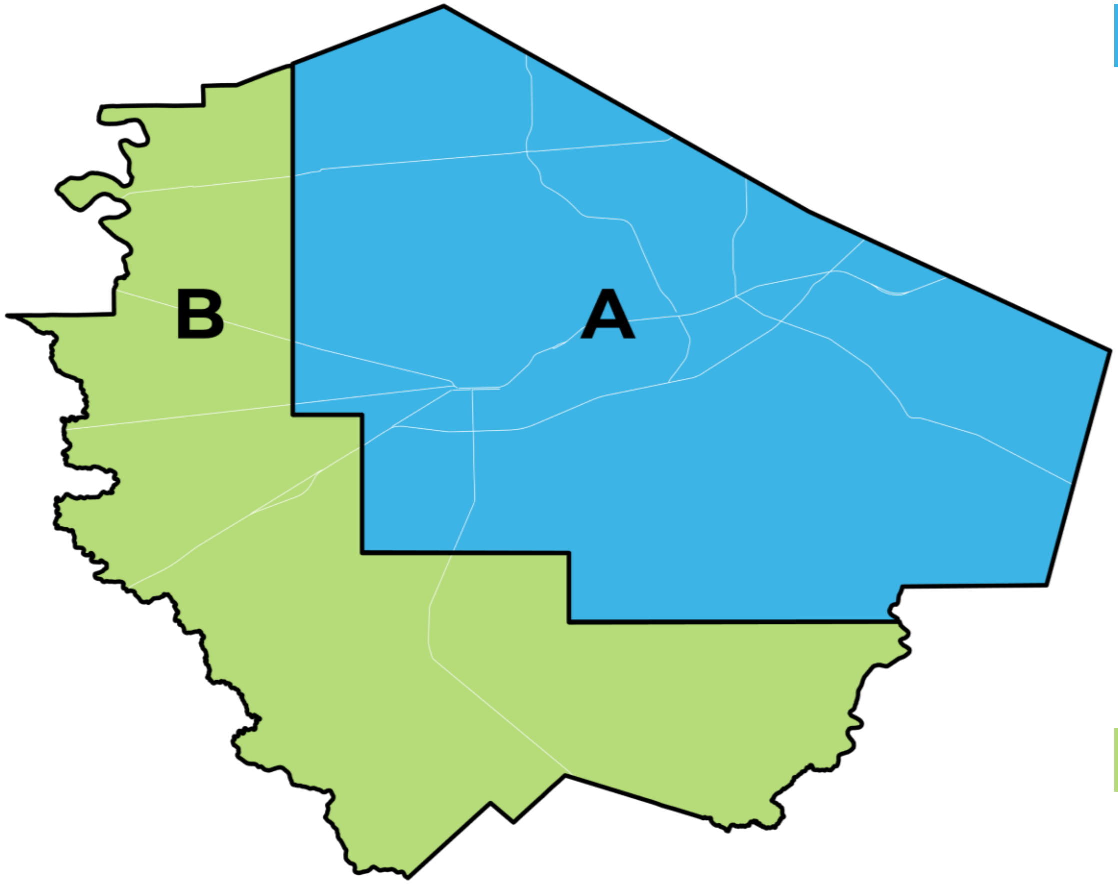
FBSD Regulatory Areas

FORT BEND SUBSIDENCE DISTRICT

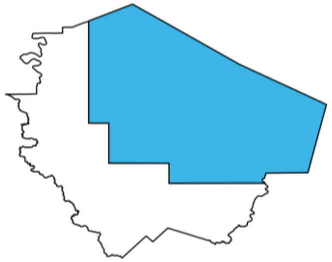


Area A: no more than 40% of Total Water Demand (TWD) may be sourced from groundwater.

- Permittees operating within an approved Groundwater Reduction Plan have the following requirements:
  - 2013 – no more than 70% of TWD from groundwater
  - 2027 – no more than 40% of TWD from groundwater

Area B: not subject to groundwater reduction requirements.

Exhibit 3 Regulatory Area A



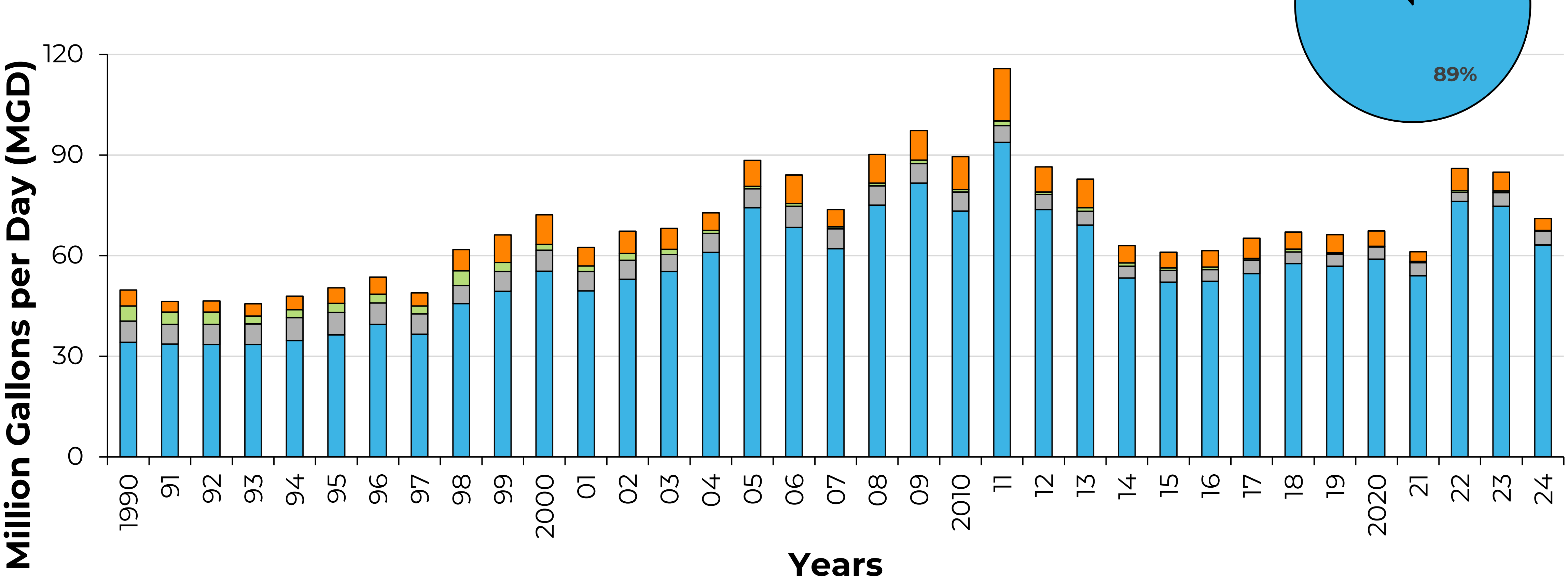
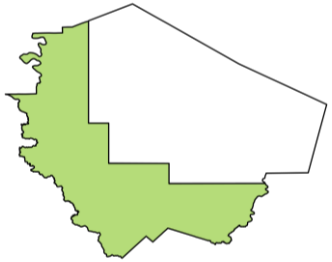
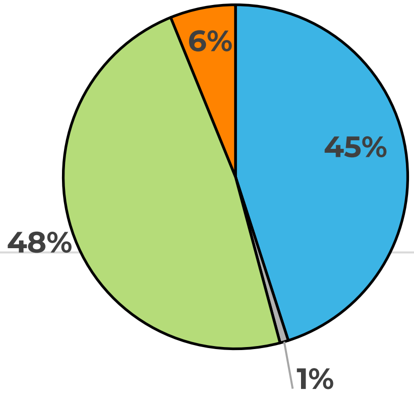


Exhibit 4 Regulatory Area B

FORT BEND SUBSIDENCE DISTRICT



2024: 10.2 MGD



Groundwater Withdrawals Grouped by Use

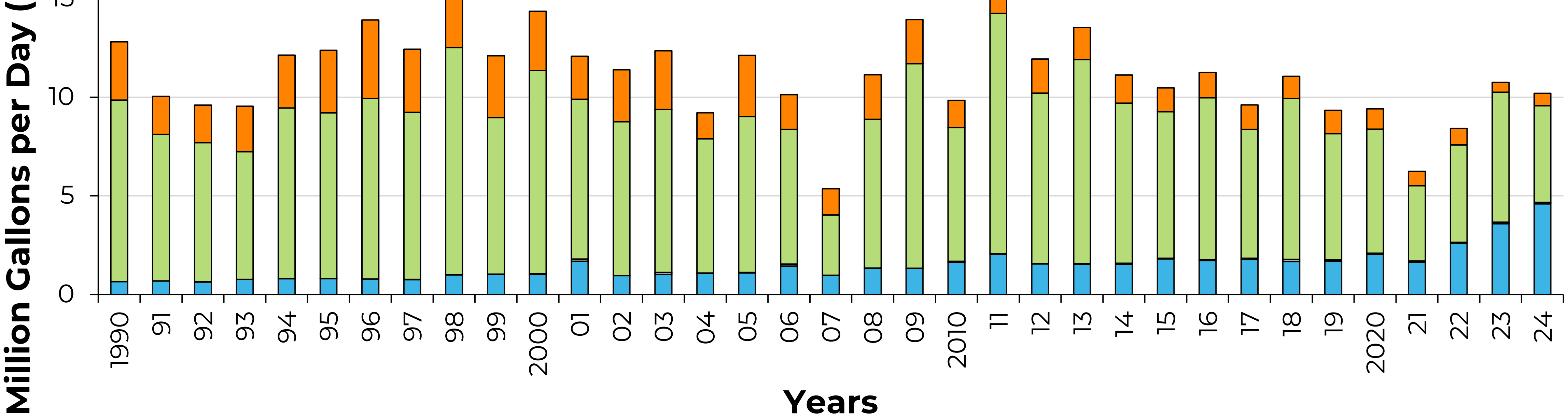
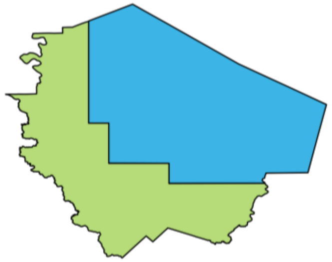
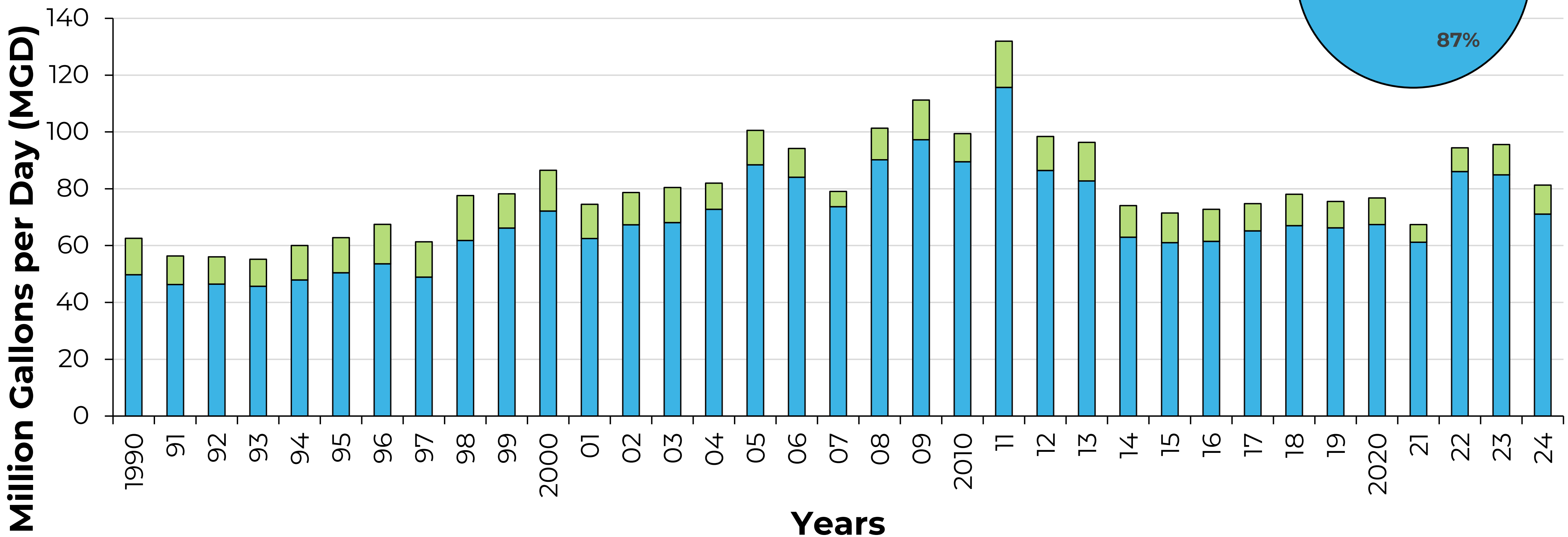
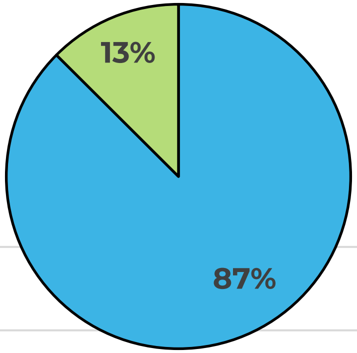


Exhibit 5 Entire District by Regulatory Area





2024: 81.3 MGD



Provisional – Subject to Revision

Exhibit 6 Entire District by Use Type

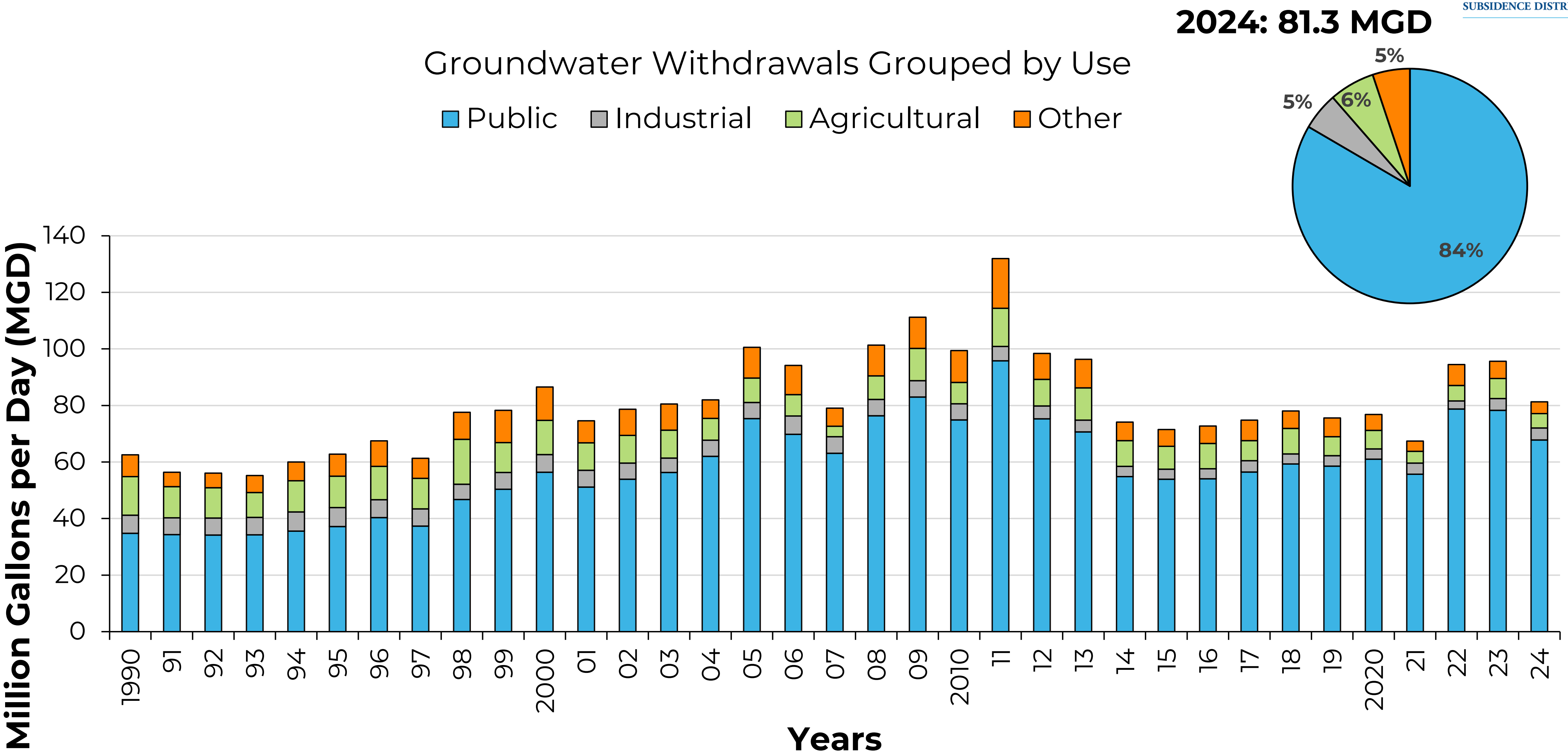
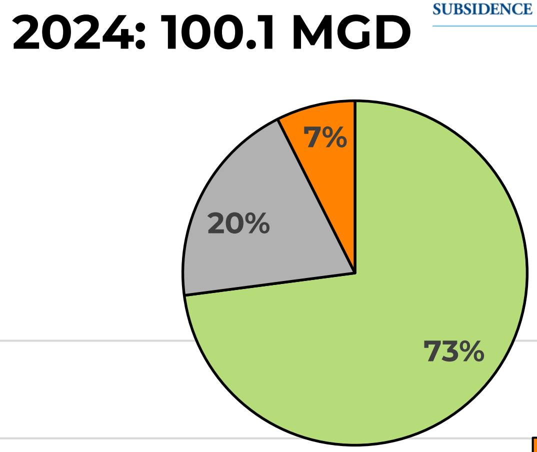


Exhibit 7 Alternative Water Use



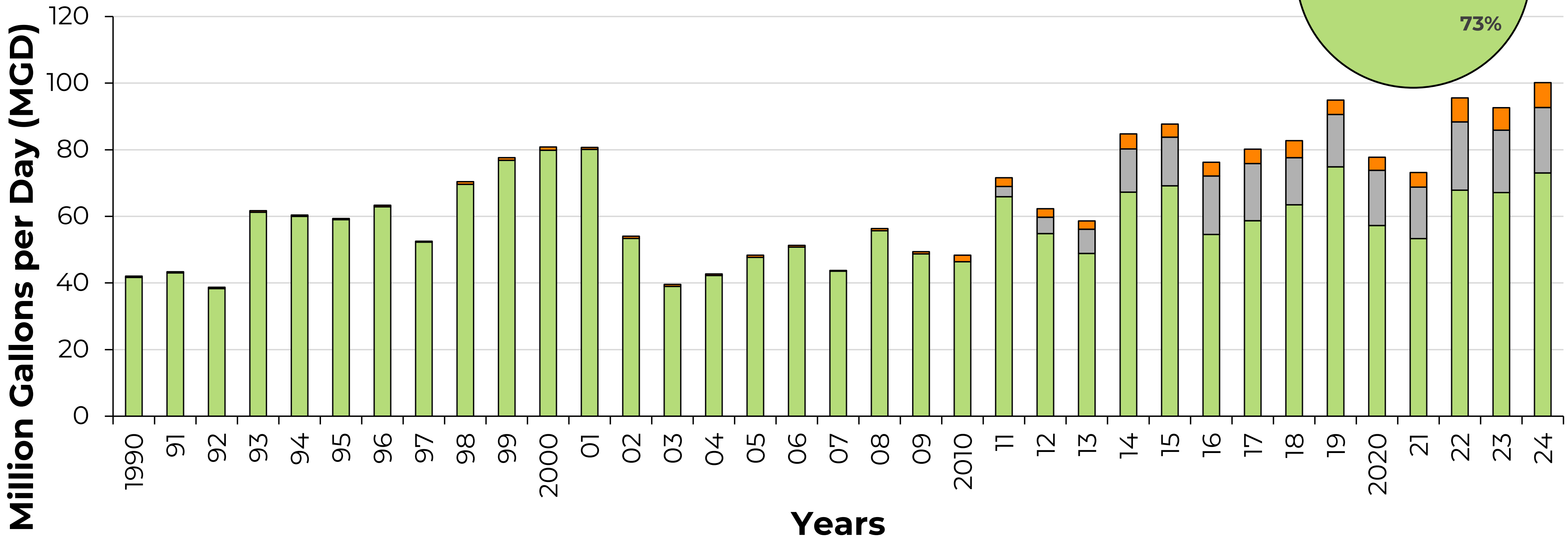
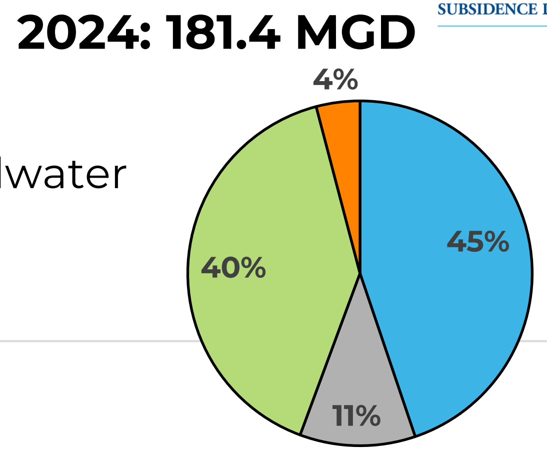
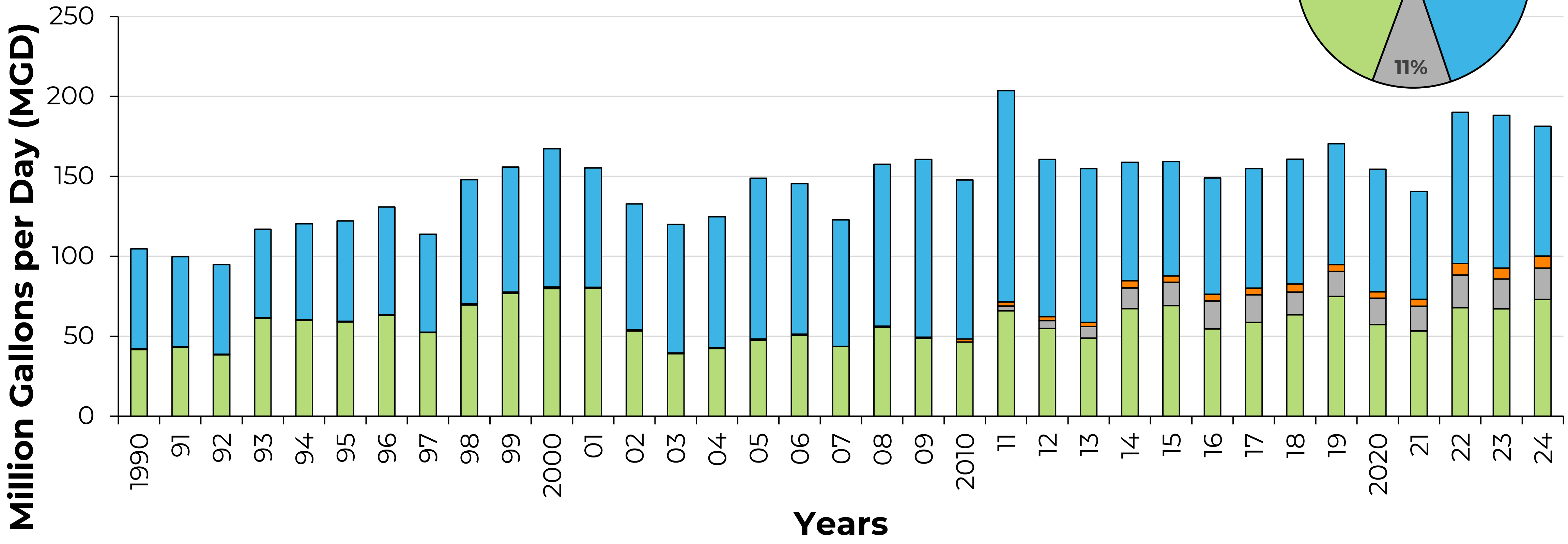


Exhibit 8 Total Water Demand





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USGS
science for a changing world

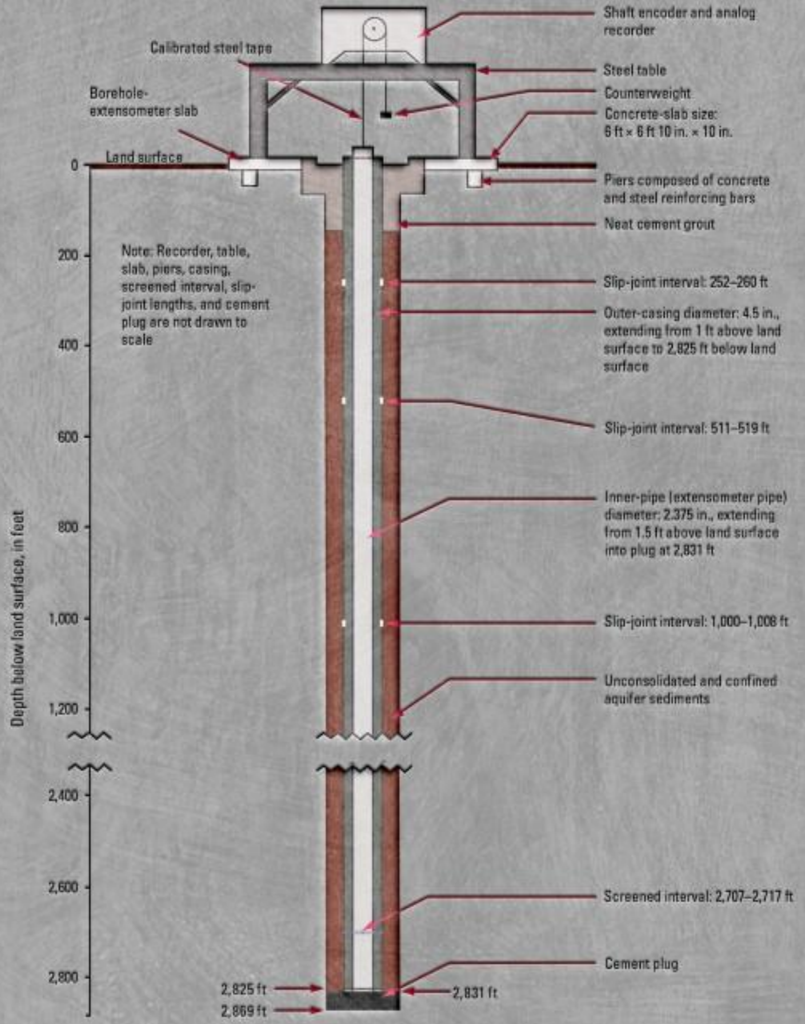


Diagram of a Borehole extensometer

Groundwater-level Altitudes, Long-Term Change & Compaction

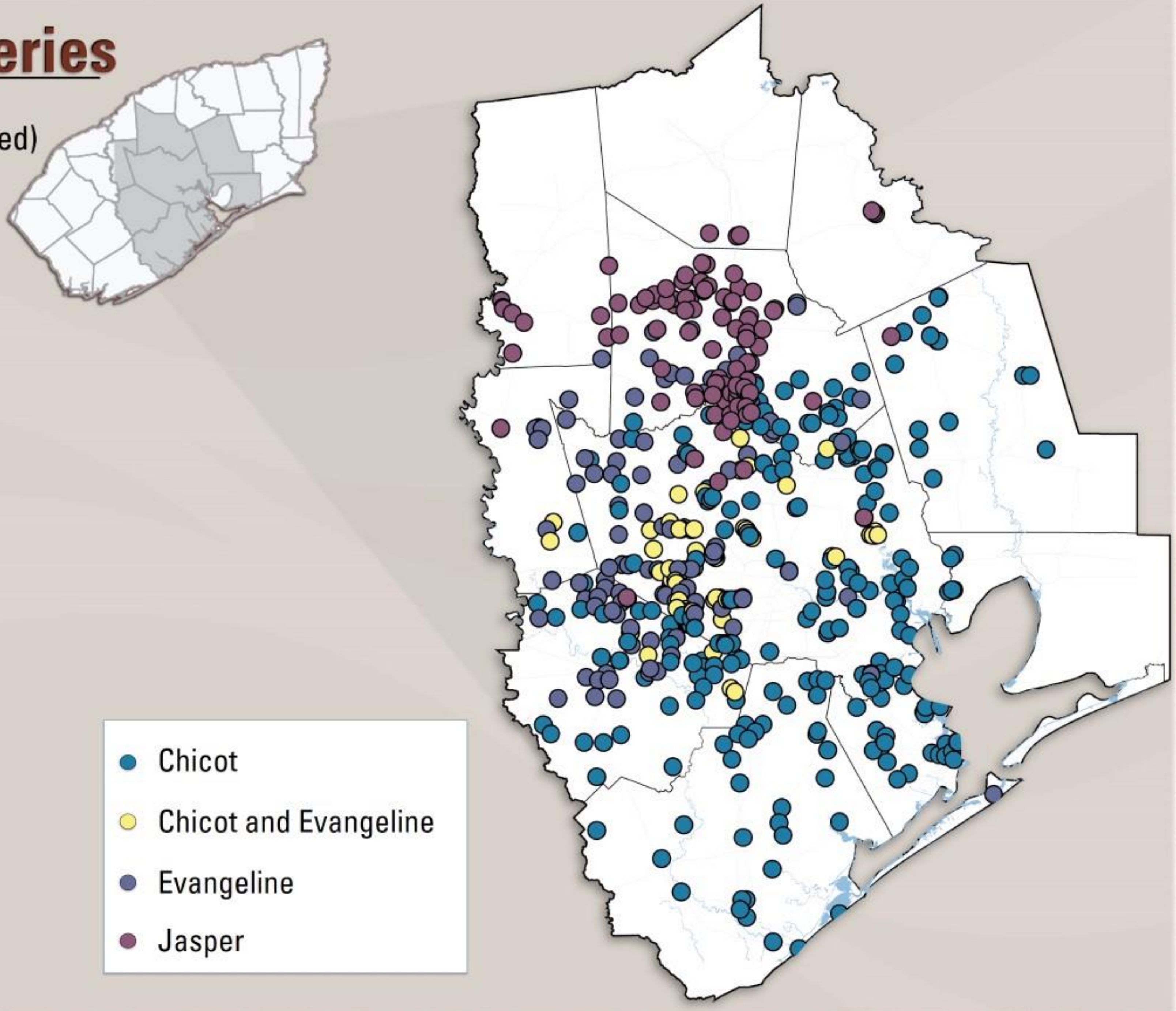
Chicot/Evangeline and Jasper Aquifers

Research in cooperation with the Harris–Galveston & Fort Bend Subsidence Districts Brazoria Groundwater Conservation District, The City of Houston and Lone Star Groundwater Conservation District

2025 Water-Level Map Series

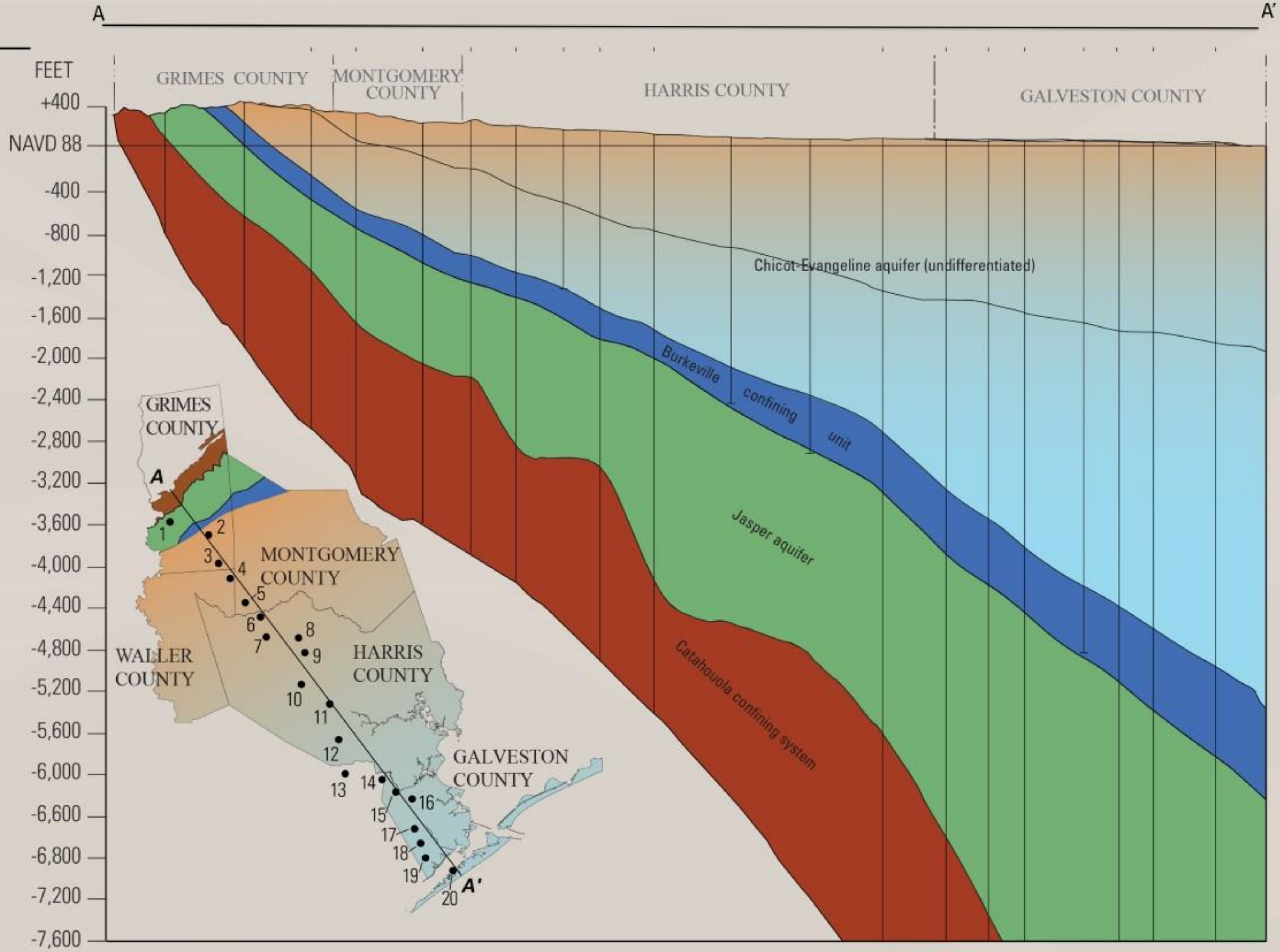
- Chicot and Evangeline Aquifers (undifferentiated)
  - 2025 Water-Level Altitude
  - 2024 to 2025 Water-Level Change
  - 2020 to 2025 Water-Level Change
  - 1990 to 2025 Water-Level Change

- Compaction 1973 to 2024
  - Compaction Data from 14 Extensometers



Geology and Hydrology

In 2021 and Moving Forward		
Geologic units[1]		Hydrogeologic units[1]
Alluvial, terrace, and dune deposits		Chicot-Evangeline aquifer (undifferentiated)
Beaumont Formation		
Lissie Formation	Montgomery Formation	
	Bentley Formation	
Willis Sand		
Goliad Sand (upper part)		
Goliad Sand (lower part)		
Lagarto Clay (upper part)		
Lagarto Clay (middle part)		Burkeville confining unit
Lagarto Clay (lower part)		Jasper aquifer
Oakville Sandstone		
Catahoula Formation	Upper Catahoula Formation	Catahoula Confining System
	Frio Formation	

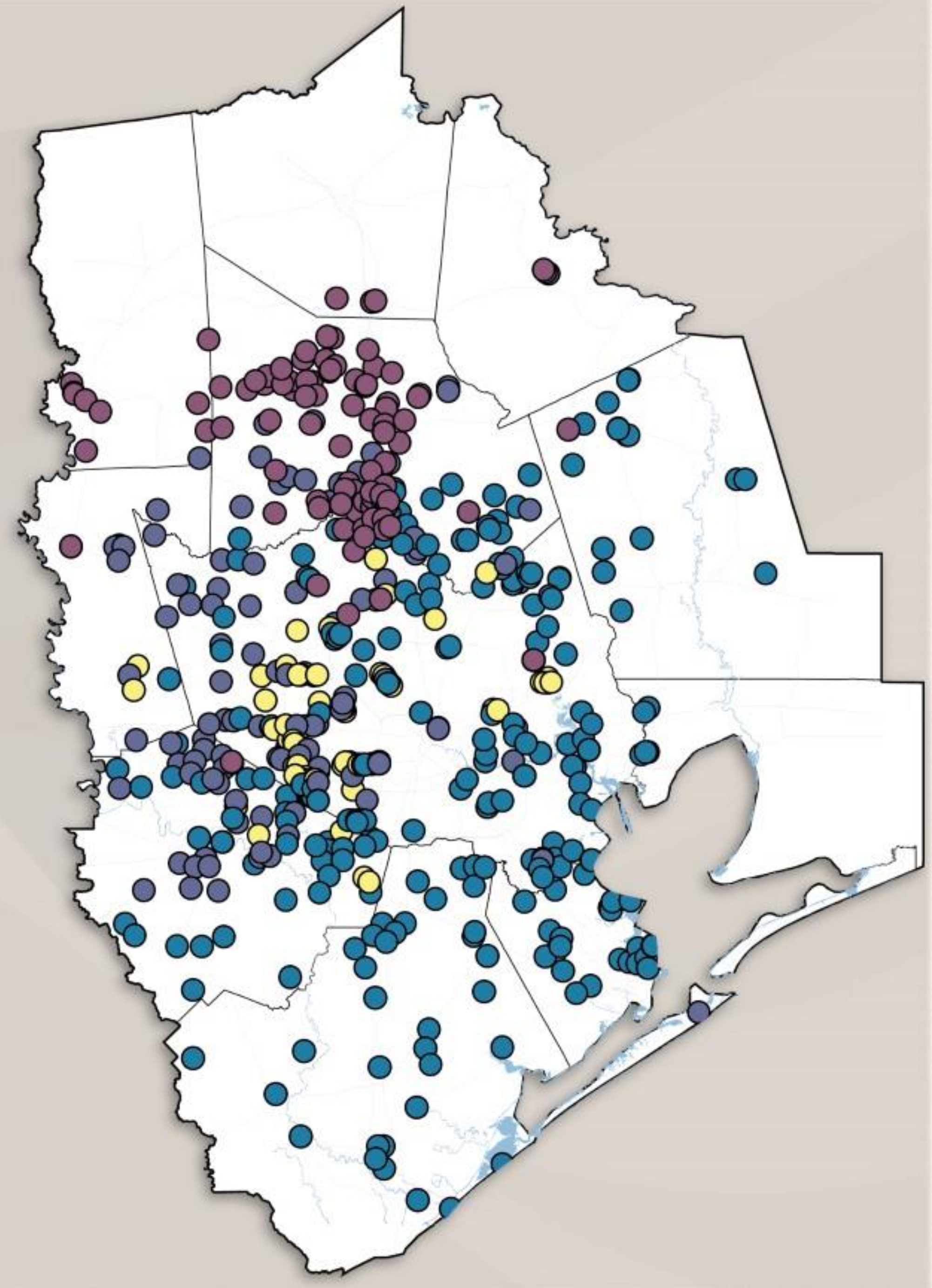


[1]Young, S.C., Kelley, V.A., Deeds, N., Hudson, C., Piemonti, D., Ewing, T.E., Banerji, D., Seifert, J., and Lyman, P., 2017

[1]Modified from Young and Draper, 2020 and Young and others (2012, 2014)

Network

- Data collected across 11 counties
- Data collection from 12-03-2024 to 3-13-2025
- Well Types:
  - Public Supply, Irrigation, Industrial, Observation
- Chicot and Evangeline (undifferentiated) water-levels: **562**
- Jasper water-levels: **112**
- Number of wells used to create the 2025 altitude maps
  - Chicot and Evangeline (undifferentiated): *525*
    - *Data from 39 wells were estimated*
  - Jasper: *108*
    - *Data from 15 wells were estimated*



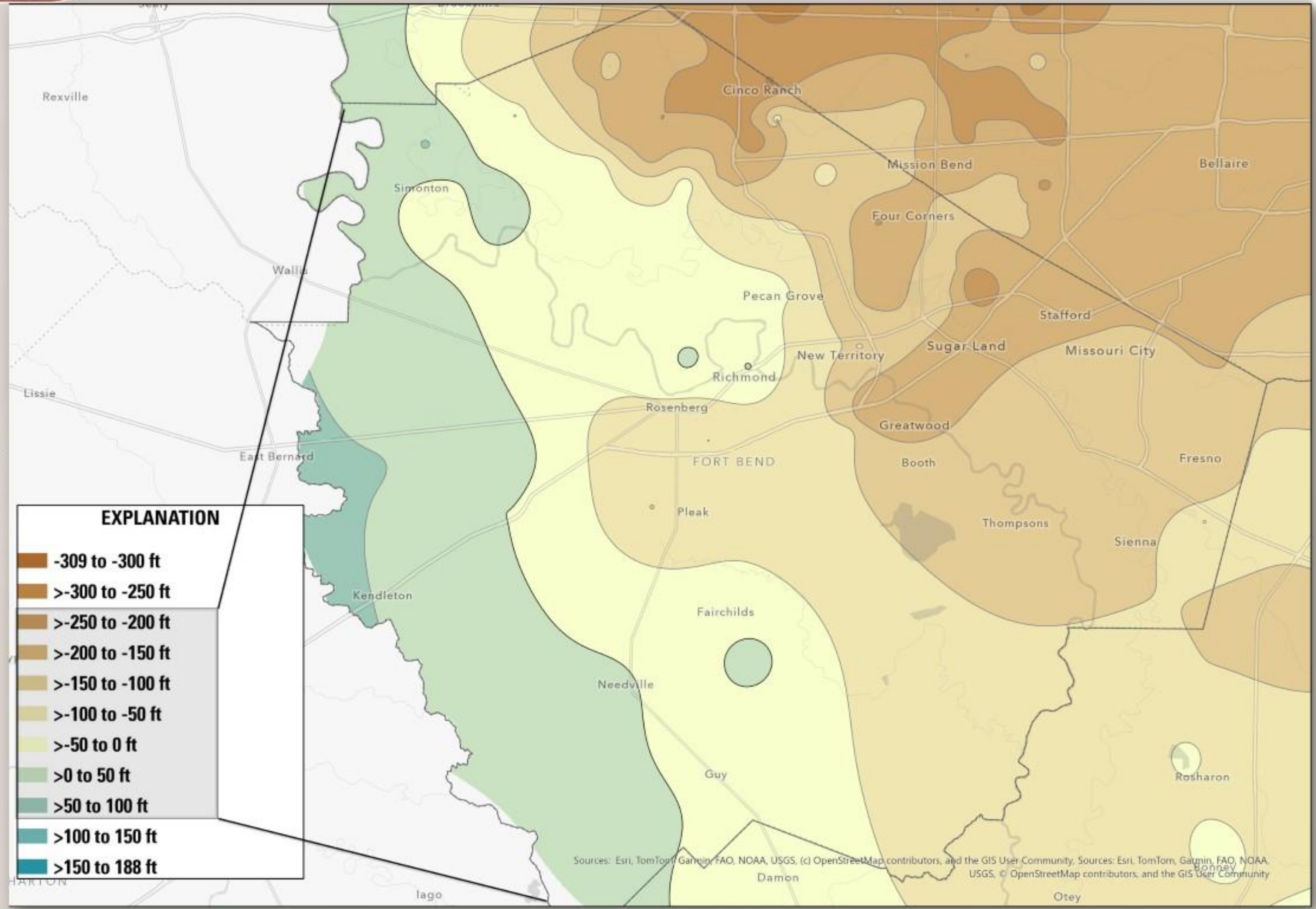
Water-Level Altitude

Chicot and Evangeline (undifferentiated)

Altitudes are referenced from NAVD 88

Lowest altitudes in south-central portion of Montgomery County and west and west-central Harris County

Highest altitudes in portions of south-eastern Grimes County, and northern Montgomery County

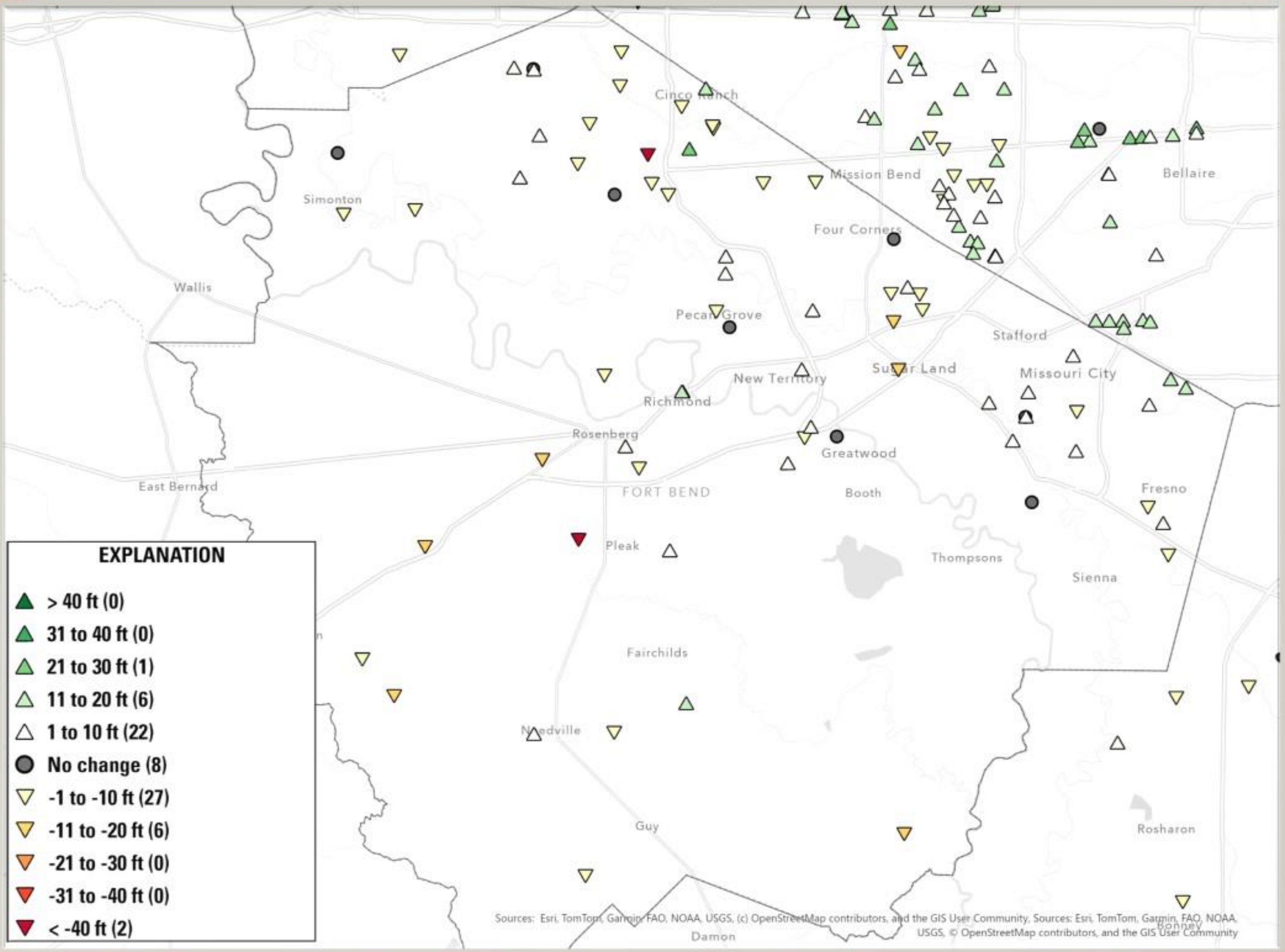


USGS
science for a changing world

2024 to 2025 Water-Level Change

Chicot and Evangeline (undifferentiated)

- 72 water-level pairs
  - About 48.6% were declines
    - Mostly in the 1 to 10 ft range
    - Largest declines (>40 ft):
      - Northern and central Fort Bend County (2)
  - About 40.2% were rises
    - Mostly in the 1 to 10 ft range
    - Largest rise (>20ft):
      - Northern Fort Bend County

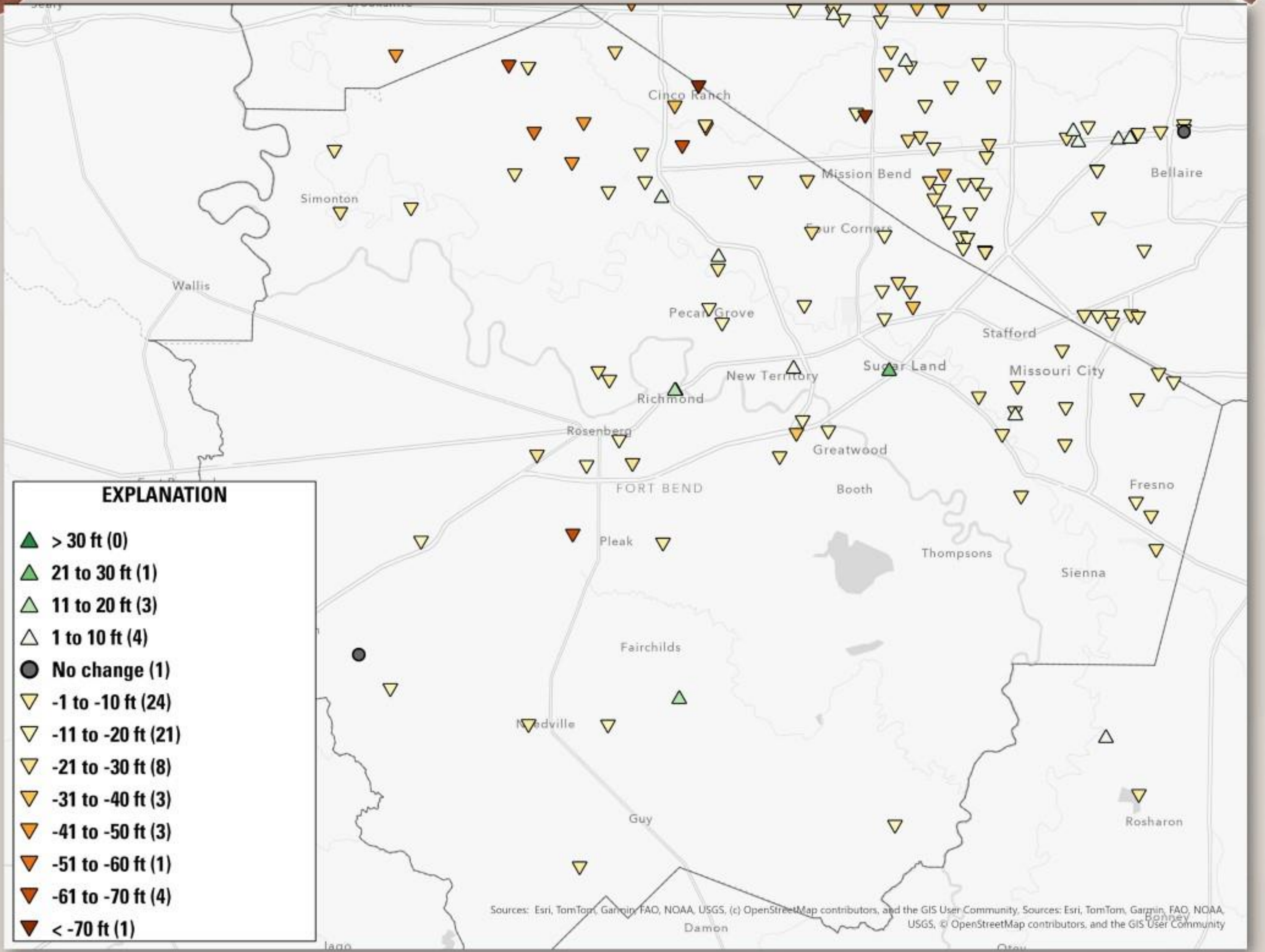


USGS science for a changing world

2020 to 2025 Water-Level Change

Chicot and Evangeline (undifferentiated)

- 74 water-level pairs
  - Mostly declines (~87.8%)
    - Most are declines of less than 20 ft.
    - Largest decline (>70 ft):
      - (1) central Fort Bend County
  - About 10.8% were rises
    - Largest rise (> 20 ft):
      - (1) near Sugar Land area



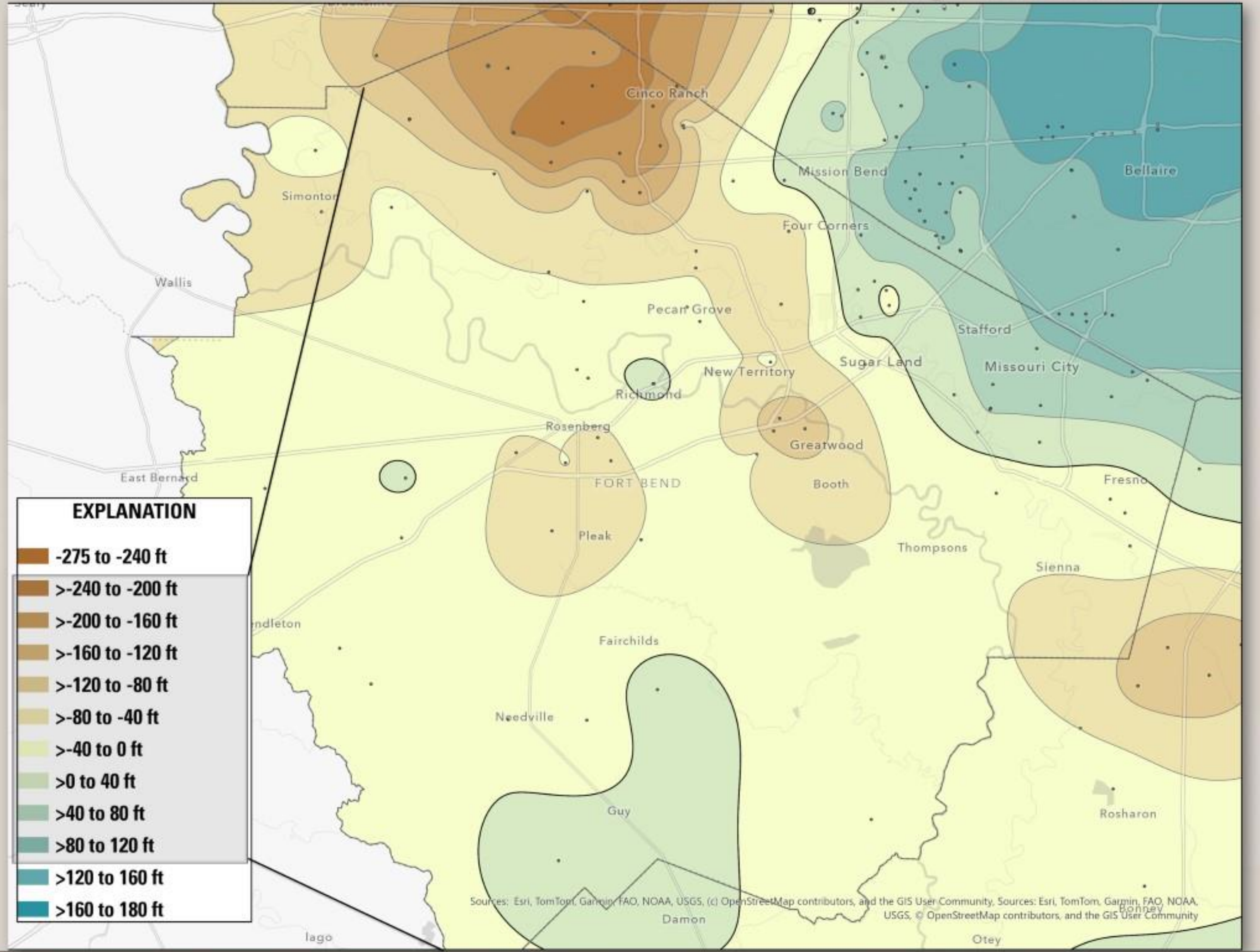
USGS
science for a changing world

Long term change

Water level rises along the north-eastern border with Harris County and the eastern border of Brazoria County

Water-level declines across much of the county with larger declines in the northern portion of the county

Chicot and Evangeline (undifferentiated) Water-Level Change 1990 to 2025



USGS
science for a changing world

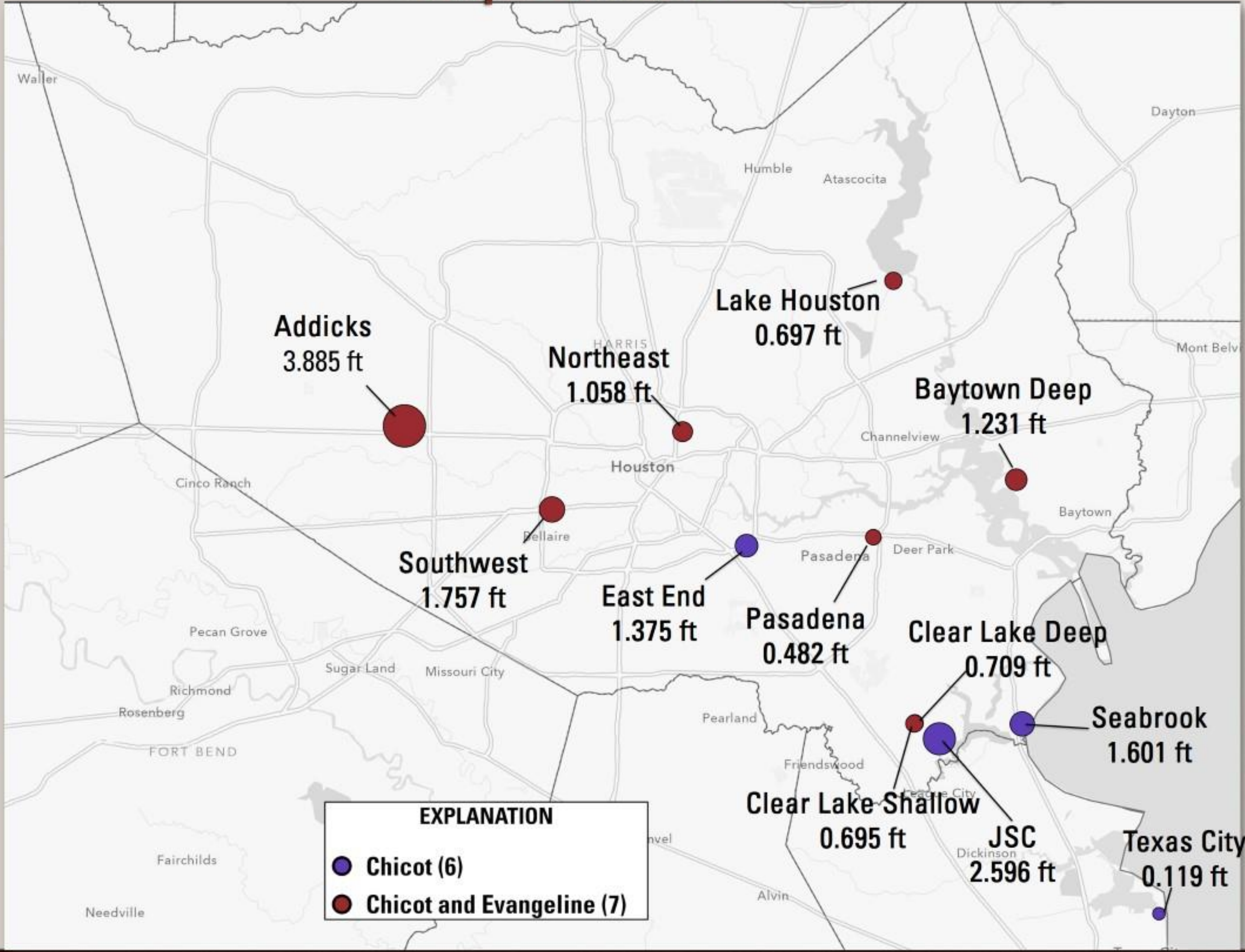
Compaction 1973 - 2024

Compaction Interval:
Chicot

1. 1973 | Baytown Shallow 1.032 ft.
2. 1973 | East End 1.375 ft.
3. 1962 | Johnson Space Center 2.596 ft.
4. 1973 | Seabrook 1.601 ft.
5. 1973 | Texas City 0.119 ft.
6. 1976 | Clear Lake Shallow 0.695 ft.

Compaction Interval:
Chicot and Evangeline

7. 1973 | Baytown Deep 1.231 ft.
8. 1974 | Addicks 3.885 ft.
9. 1974 | Pasadena 0.482 ft.
10. 1976 | Clear Lake Deep 0.709 ft.
11. 1980 | Lake Houston 0.697 ft.
12. 1980 | Northeast 1.058 ft.
13. 1980 | Southwest 1.757 ft.
14. 2017 | Cinco MUD --- ft.



2024 Compaction Summary

- Northeast recorded expansion for the period
- All other sites recorded compaction
- Compaction ranged from -0.070 ft (expansion) to 0.063 ft (compaction)

Compaction December 2023 to December 2024

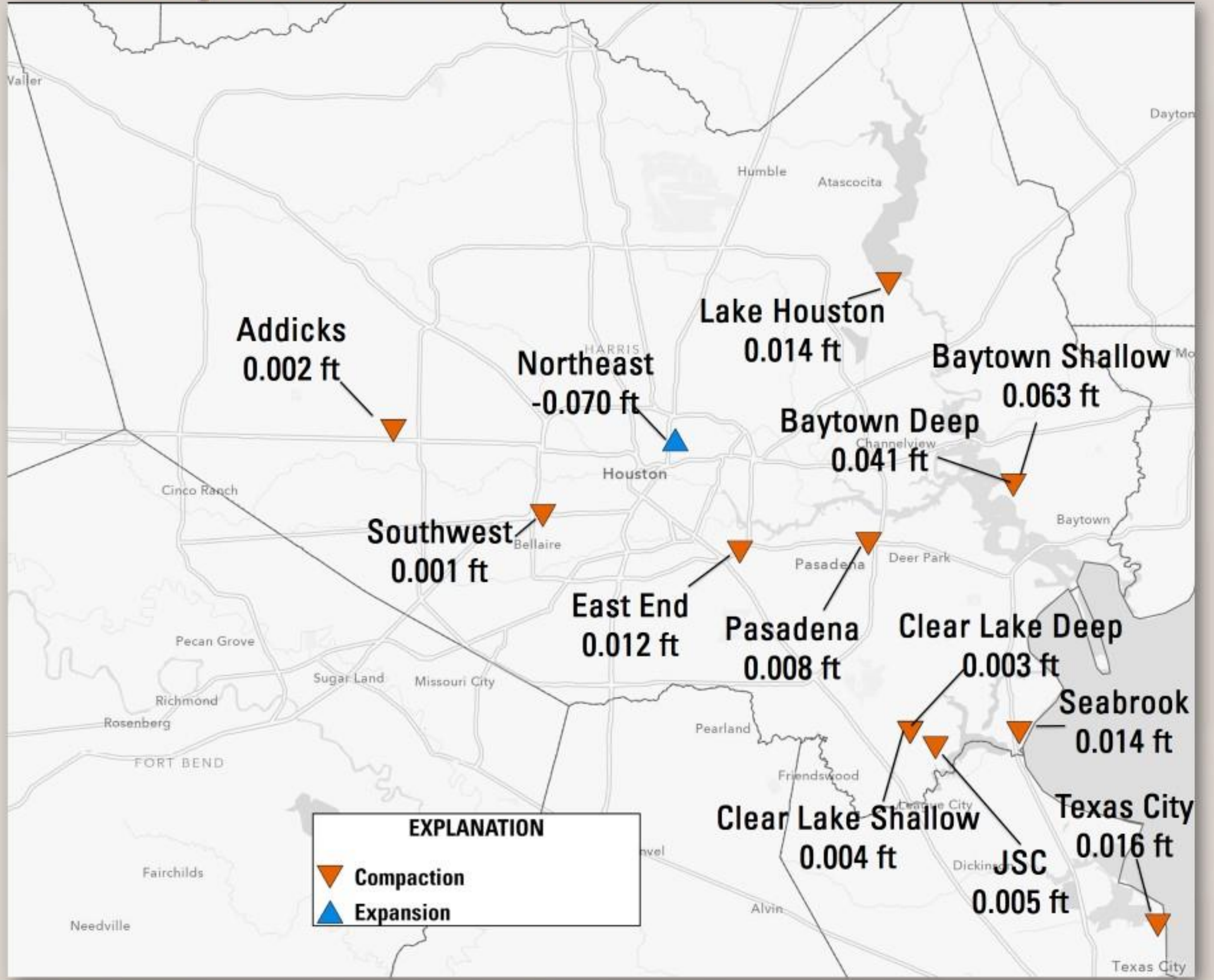
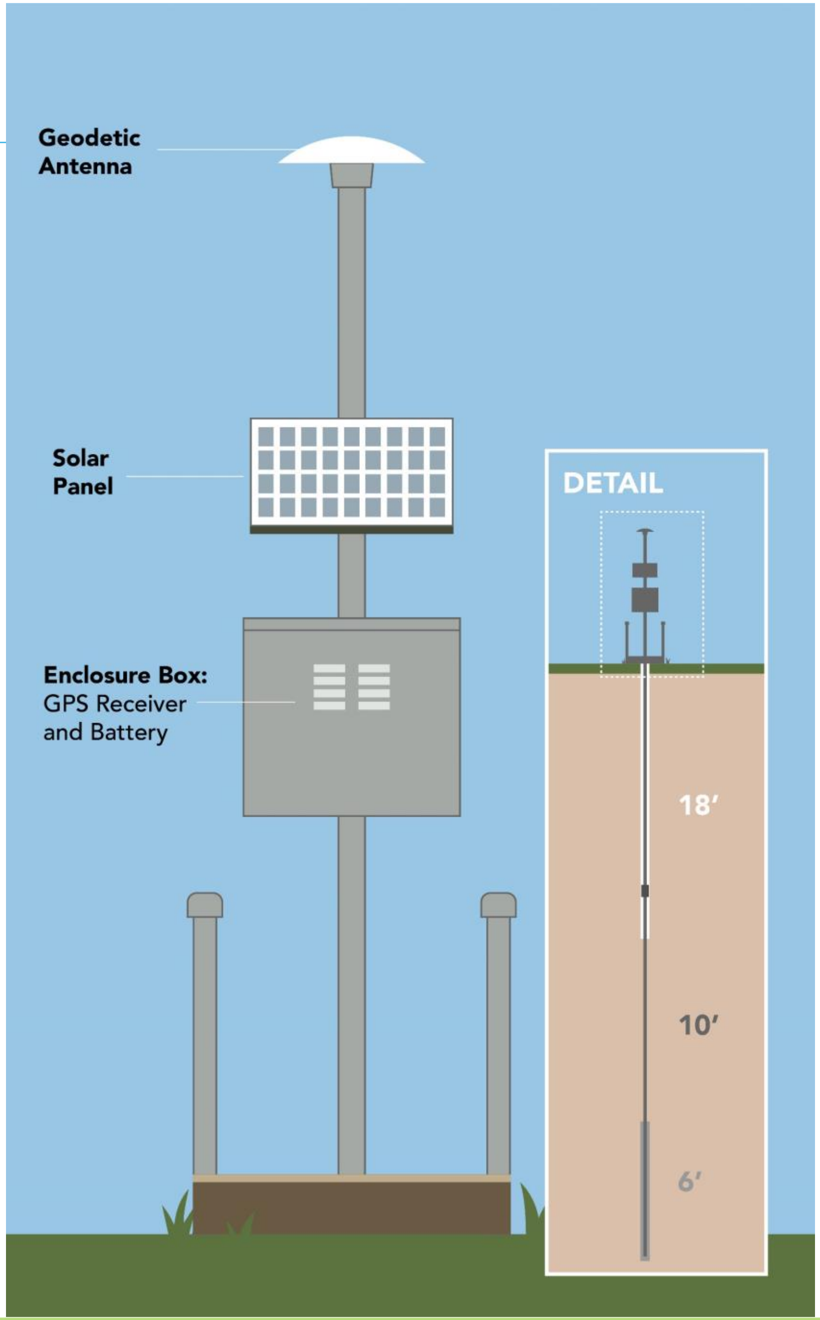


Table of Contents

Subsidence Monitoring

All FBSD operated global positioning system (GPS) stations are constructed in a custom design.

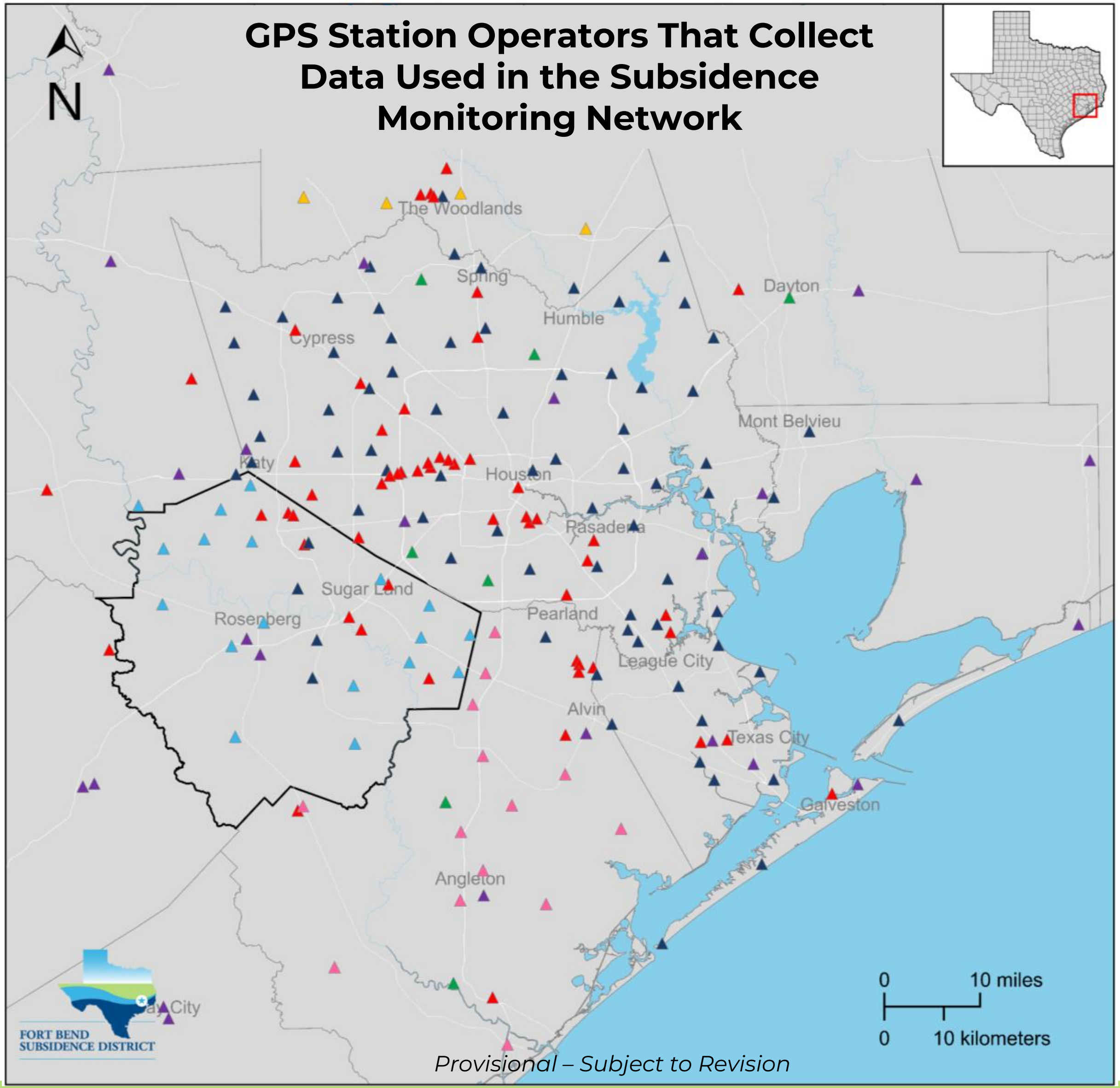
GPS data are collected for one week every two months. A conversion to continuous monitoring (data collection every day of the year) began in 2023 and will continue through 2027.



FORT BEND SUBSIDENCE DISTRICT

Exhibit 9 Subsidence Monitoring Network

Location and operator of GPS stations that monitor land surface deformation periodically or continuously within southeast Texas in 2024.



EXPLANATION

- FBSD Jurisdiction
- Harris-Galveston Subsidence District
- Fort Bend Subsidence District
- University of Houston
- Texas Department of Transportation
- Brazoria County Groundwater Conservation District
- Lone Star Groundwater Conservation District
- Other Operators

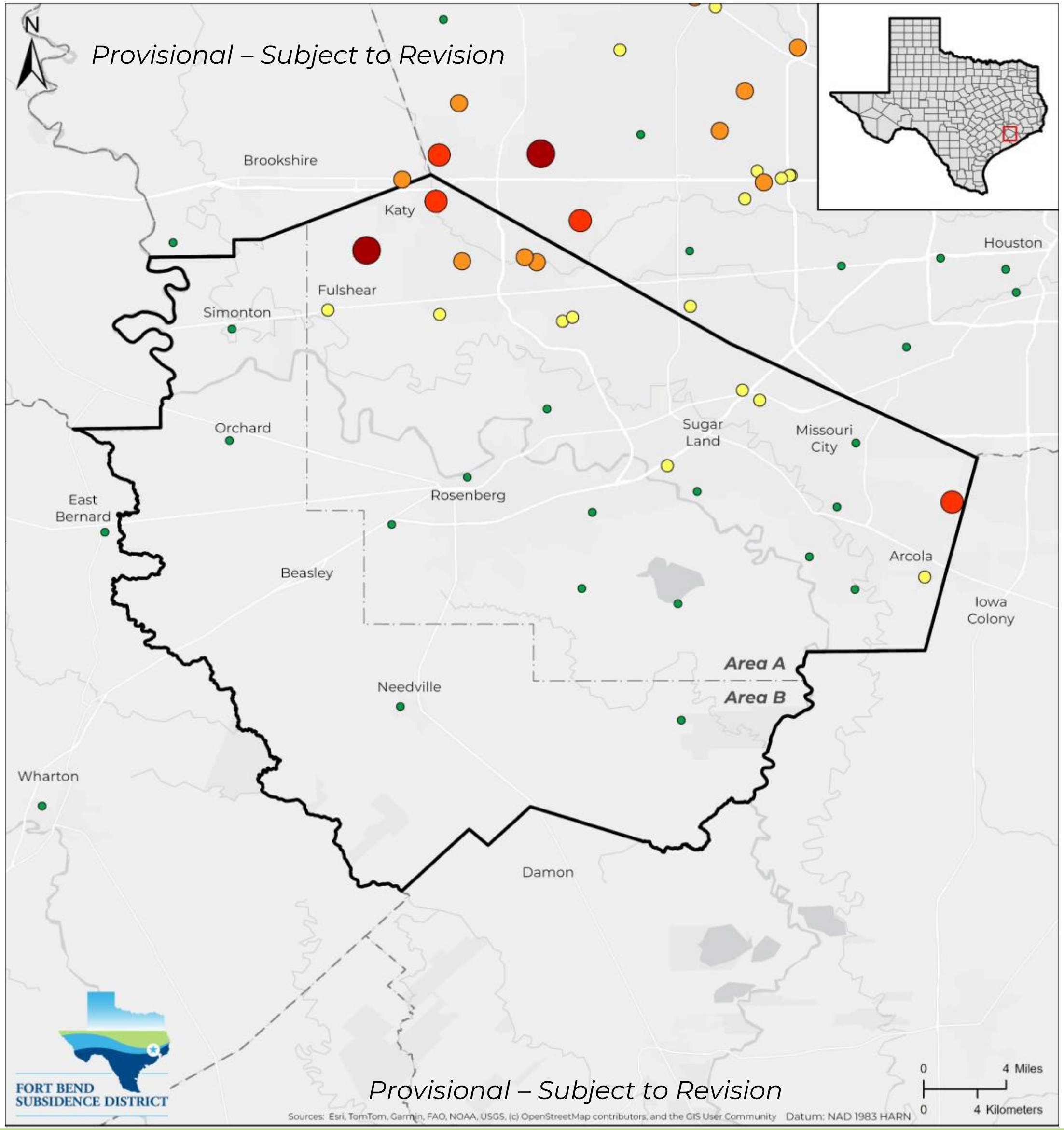
FORT BEND SUBSIDENCE DISTRICT

Provisional – Subject to Revision

Exhibit 10 Subsidence Rates in Fort Bend

FORT BEND SUBSIDENCE DISTRICT

Annual subsidence rate, in centimeters per year (cm/yr.), estimated from GPS data collected at active stations with three or more years of data averaged from 2020 to 2024.



EXPLANATION

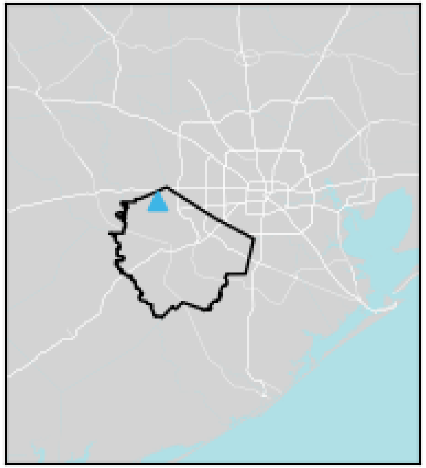
Average Annual Subsidence Rate (cm/yr.) Estimated from GPS Data Collected from Active Stations from 2020 to 2024

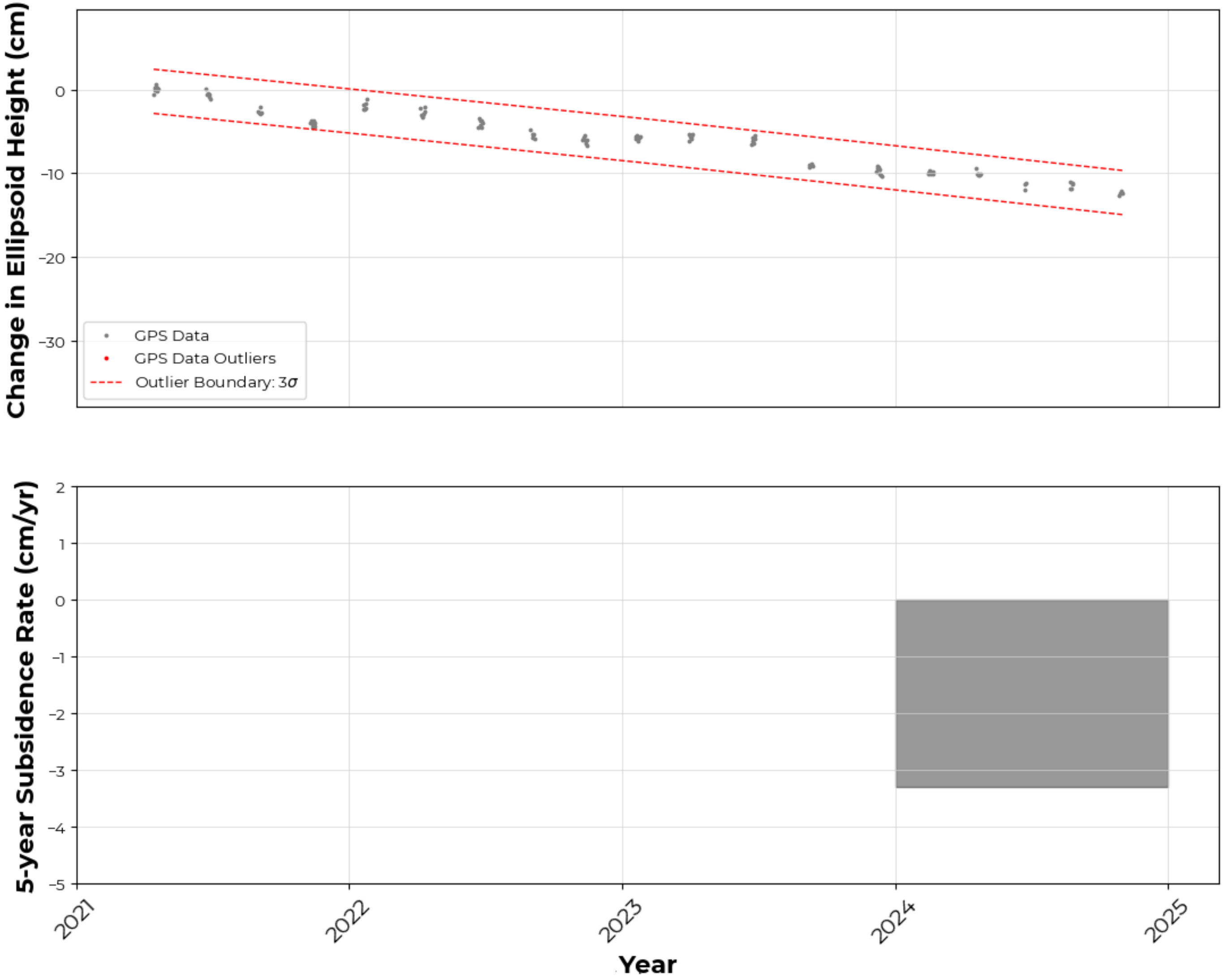
- Greater than 2.0
- 2.0 - 1.5
- 1.5 - 1.0
- 1.0 - 0.5
- Less than 0.5

Provisional – Subject to Revision

Exhibit 11 Subsidence Data in Katy/Fulshear

- GPS station P111, located in Katy, has measured a total of approximately 10.7 cm of subsidence since 2021.
- 2020-2024 average annual subsidence rate is 3.31 cm/yr.



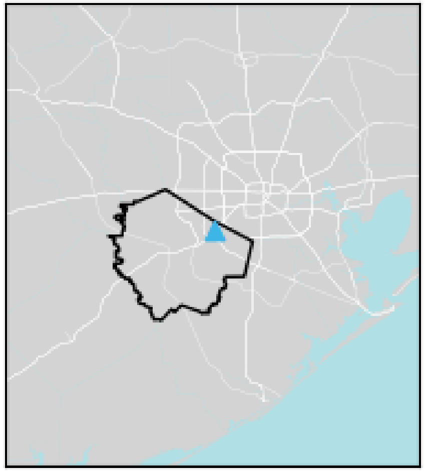


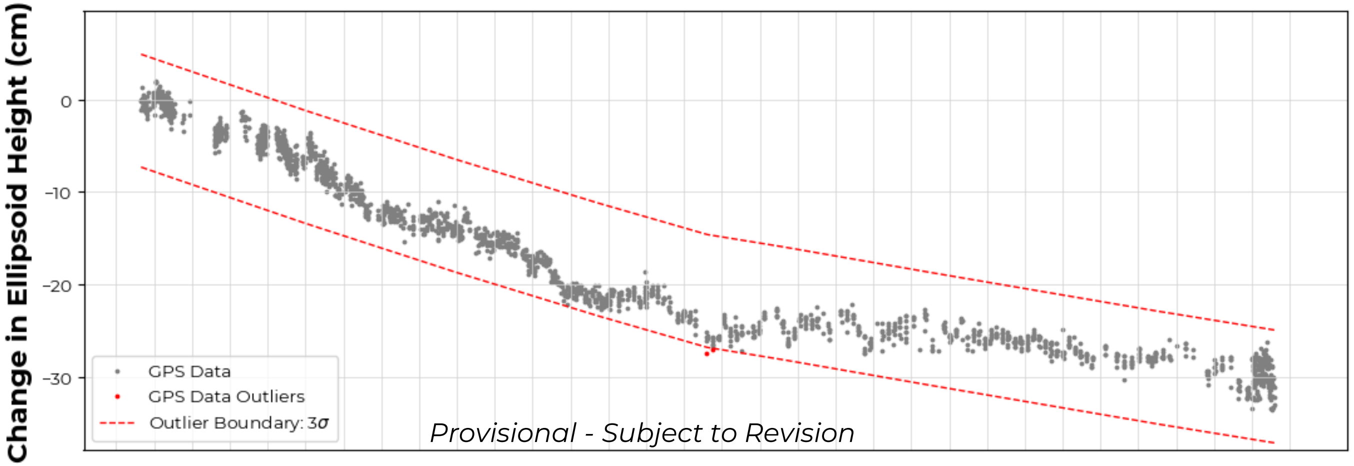
Processed GPS data (source: UH) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by the District when calculating subsidence rates and are shown for informational purposes only.

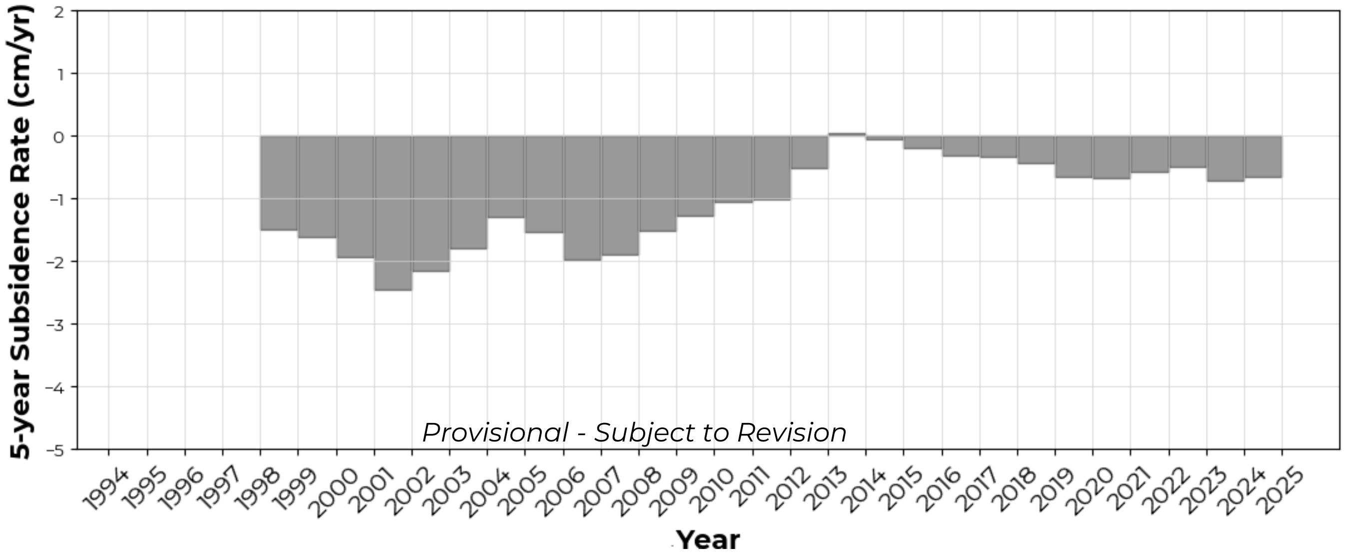
Exhibit 12 Subsidence Data in Sugar Land

FORT BEND SUBSIDENCE DISTRICT

- GPS station P004, located in Sugar Land, has measured a total of approximately 30.9 cm of subsidence since 1994.
- 2020-2024 average annual subsidence rate is 0.61 cm/yr.



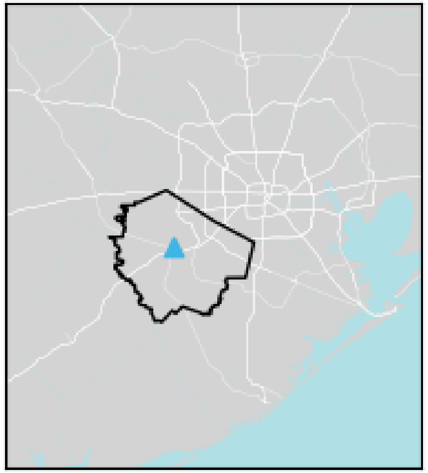




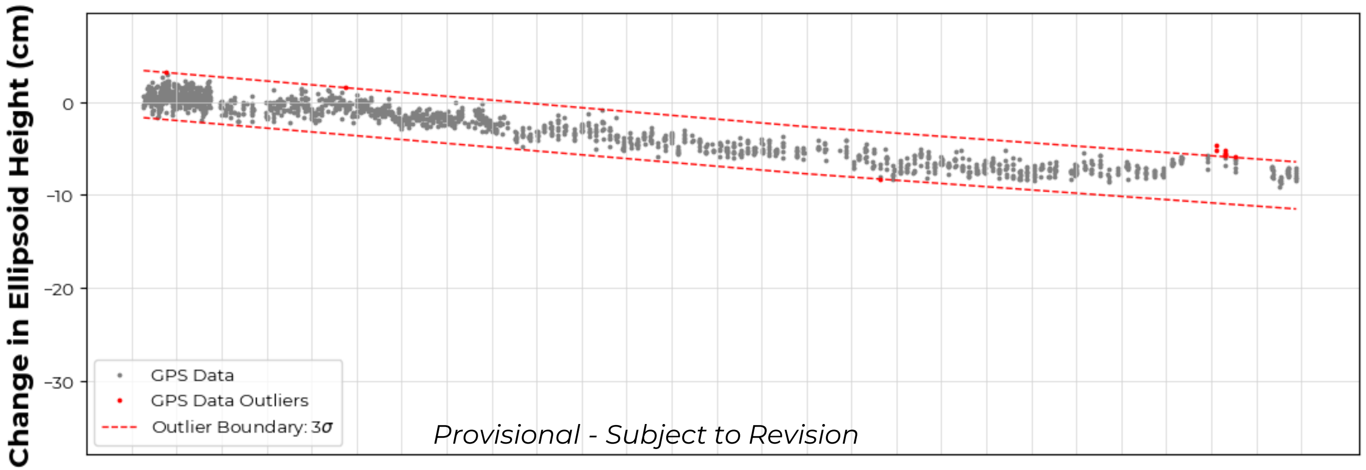
Processed GPS data (source: UH) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by the District when calculating subsidence rates and are shown for informational purposes only.

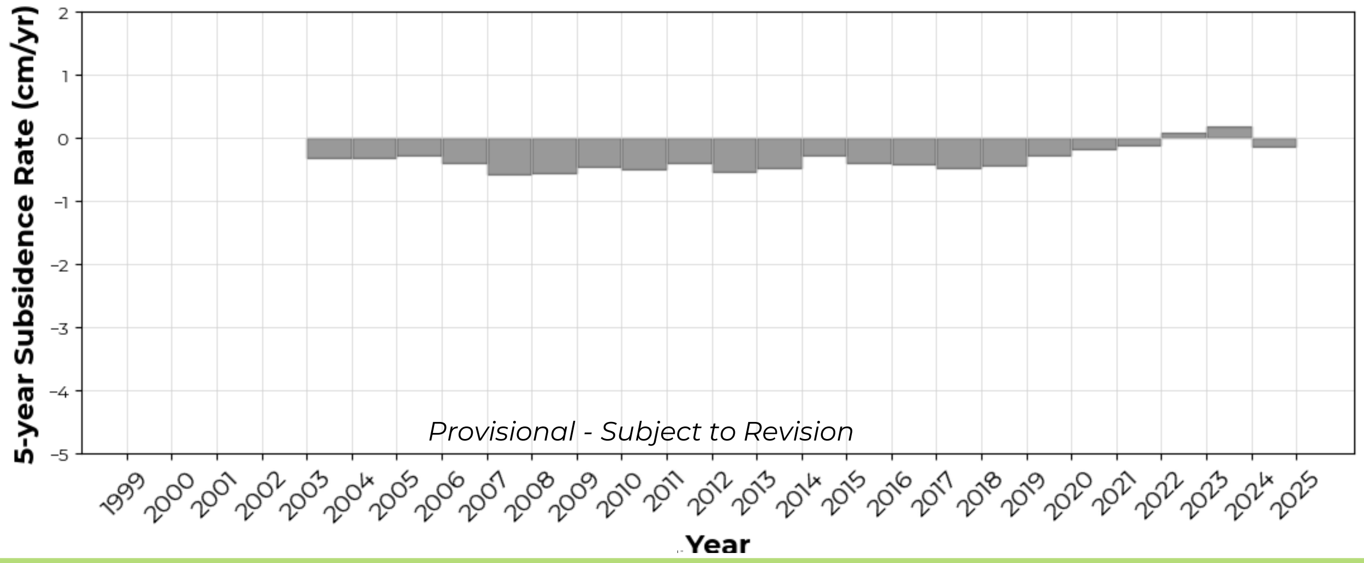
Exhibit 13 Subsidence Data in Rosenberg

- GPS station P010, located in Rosenberg, has measured a total of approximately 8.1 cm of subsidence since 1999.
- 2020-2024 average annual subsidence rate is 0.09 cm/yr.



Processed GPS data (source: UH) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by the District when calculating subsidence rates and are shown for informational purposes only.

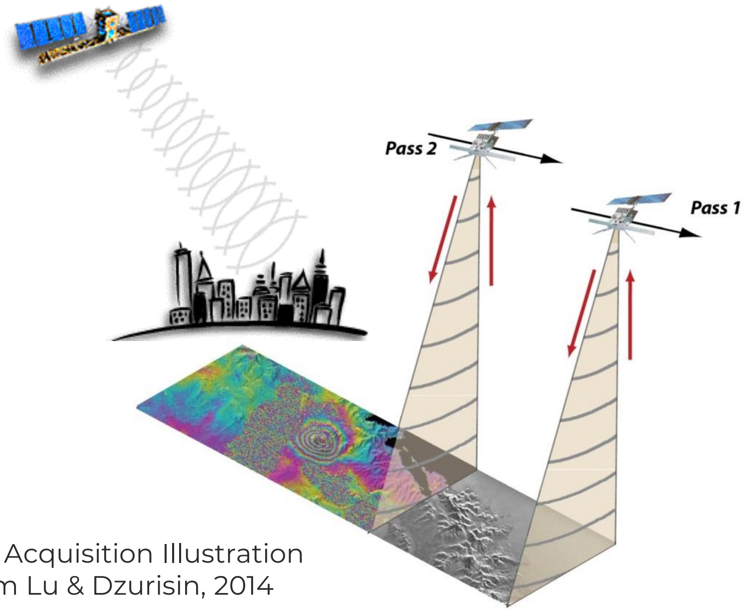




Interferometric Synthetic Aperture Radar (InSAR)

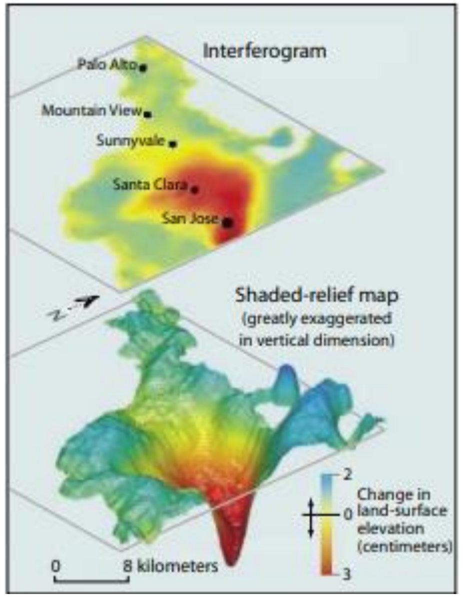
FORT BEND SUBSIDENCE DISTRICT

- Synthetic aperture radar (SAR) data are generated by transmitting radio waves from the sensor to the ground and back to the sensor.
- InSAR compares two SAR images of the same area at different times to detect small changes in distances between them. This processed pair of SAR images is the interferogram.
- Processing techniques can be used to achieve an accuracy of millimeters.



InSAR Acquisition Illustration from Lu & Dzurisin, 2014

Processing



Interferogram (top) and 3-D topography (bottom) from USGS Fact Sheet 2005-3025

Exhibit 14 Subsidence Rates from InSAR

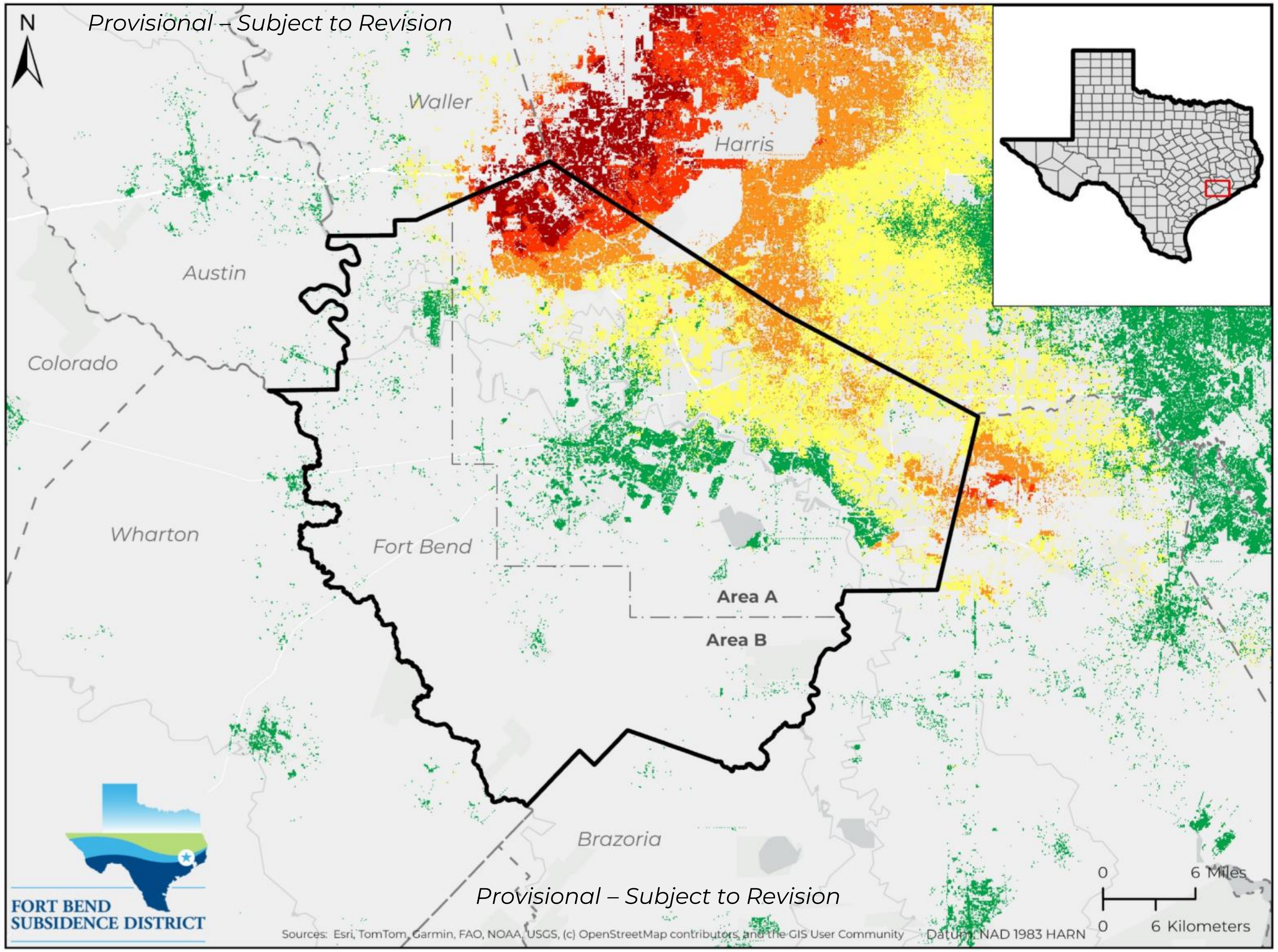
Annual subsidence rate, in centimeters per year (cm/yr.), estimated from Sentinel 1A derived time-series interferograms averaged from 2020 to 2024.

EXPLANATION

Sentinel-1 Derived Average Annual Subsidence Rate (cm/yr.) Processed from 2020 to 2024

- Greater than 2.0
- 2.0 - 1.5
- 1.5 - 1.0
- 1.0 - 0.5
- Less than 0.5

Gray areas show no data as the accuracy of InSAR decreases in rural areas due to tropospheric errors and seasonal vegetative growth.



Testimony and Public Comment

FORT BEND SUBSIDENCE DISTRICT

Any person who wishes to present testimony, evidence, exhibits or other information may do so in person, by counsel, via email to **fbinfo@subsidence.org**, or any combination of these options.

Thank You for Attending the 2024 Annual Groundwater Report Public Hearing

- The record will be open until **May 7, 2025**. You may provide comments by sending an email to **fbinfo@subsidence.org**
- The 2024 Annual Groundwater Report will be presented for approval to the Fort Bend Subsidence District Board of Directors at their next meeting on **May 28, 2025.**
- Upon Board approval, the 2024 Annual Groundwater Report will be posted on our website, **fbsubsidence.org**, located within the Science & Research section.

Scan the QR code to visit the Annual Groundwater Reports page on our website. →

Contact Information

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Richmond, TX 77469

(281)342-3273

fbinfo@subsidence.org

www.fbsubsidence.org

FORT BEND
SUBSIDENCE DISTRICT

Appendix B – Period of Record Data

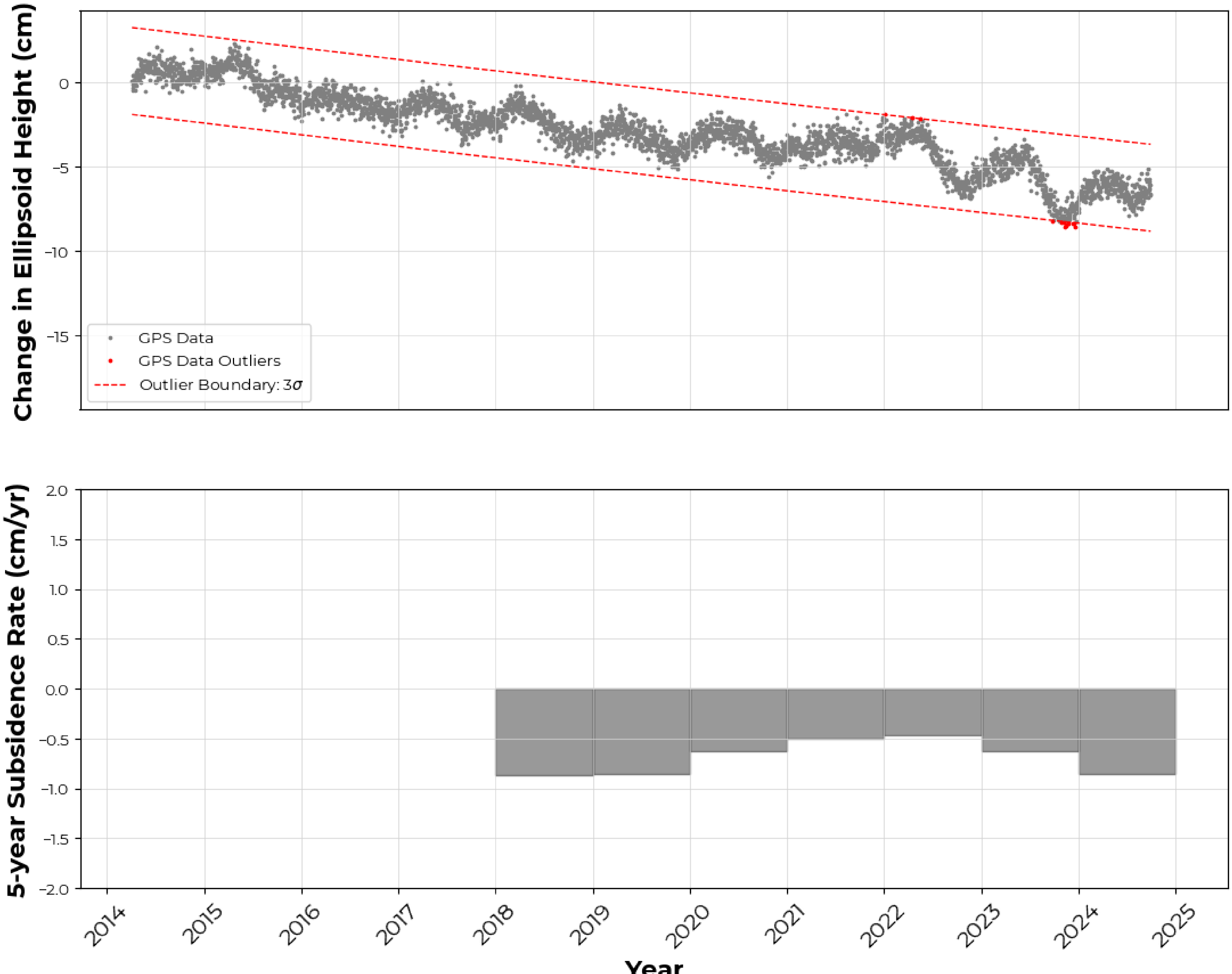
A comprehensive table is provided which includes the GPS station name, coordinates in decimal degrees, dates of operation, length of monitoring in decimal years, total vertical displacement over the period of record, and annual rate of change in ellipsoidal height from 2020 to 2024. A period of record plot and five-year rate bar graph are also included for each GPS station that was actively monitored in 2024 as well as located within Fort Bend County and within a five-mile radius of Fort Bend County.

Site Name	Latitude (Decimal degrees)	Longitude (Decimal degrees)	Start of POR (Decimal year)	End of POR (Decimal Year)	Length of POR (Years)	Number of Samples (Days)	Total Vertical Displacement over POR (cm)	Annual Rate of Change in Ellipsoidal Height 2020-2024 (cm/yr.)
ALEF	29.692	-95.635	2014.259	2024.742	10.483	3825	-6.0	-0.93
CMFB	29.681	-95.729	2014.409	2024.742	10.333	3738	-5.2	-0.72
DMFB	29.623	-95.584	2014.771	2024.742	9.971	3640	-5.3	-0.80
FSFB	29.556	-95.630	2014.371	2024.742	10.371	3644	-1.3	-0.45
HPEK	29.755	-95.716	2014.396	2024.082	9.687	2365	-15.1	-1.86
OKEK	29.725	-95.803	2014.575	2024.819	10.244	3247	-7.9	-1.15
P110	29.548	-95.442	2021.189	2024.988	3.799	149	-6.4	-1.60
P111	29.733	-95.873	2021.285	2024.832	3.548	137	-10.7	-3.31
P113	29.388	-95.642	2023.339	2024.939	1.600	76	-0.0	n/a
P114	29.592	-95.513	2023.411	2024.999	1.589	79	-0.2	n/a
P004	29.630	-95.597	1994.660	2024.591	29.932	2414	-30.9	-0.61
P010	29.566	-95.799	1999.266	2024.890	25.624	1764	-8.1	-0.09
P014	29.474	-95.644	2000.879	2024.942	24.063	1331	-5.8	-0.23
P016	29.544	-95.527	2000.860	2024.964	24.104	1361	-7.6	-0.37
P019	29.841	-95.805	2000.892	2024.578	23.685	1301	-23.0	-1.19
P029	29.769	-95.822	2007.320	2025.002	17.682	1099	-28.8	-1.62
P030	29.689	-95.902	2007.350	2024.777	17.427	909	-7.2	-0.55
P031	29.398	-95.848	2007.350	2024.881	17.531	799	4.8	0.69
P032	29.541	-95.707	2007.350	2025.002	17.652	814	-0.4	-0.05
P040	29.493	-95.462	2007.353	2024.819	17.465	833	-9.3	-0.53
P041	29.662	-95.476	2007.337	2025.002	17.665	983	-8.6	-0.41
P042	29.732	-95.635	2007.334	2024.923	17.589	836	-10.5	-0.43
P057	29.684	-95.722	2009.137	2024.816	15.679	667	-7.3	-0.94
P058	29.485	-95.715	2010.591	2024.903	14.312	641	-2.4	-0.16
P059	29.617	-95.740	2010.572	2024.890	14.318	627	-3.5	-0.22
P060	29.686	-95.820	2012.068	2025.002	12.934	601	-8.4	-0.78
P061	29.675	-95.972	2011.129	2025.002	13.873	697	-3.1	0.11
P062	29.593	-95.974	2011.129	2024.851	13.723	572	-4.2	-0.07
P063	29.508	-95.547	2011.432	2025.002	13.569	693	-2.5	-0.32
P067	29.532	-95.855	2011.109	2025.002	13.892	652	-2.1	-0.03
P078	29.739	-96.016	2014.331	2024.832	10.501	486	-3.3	-0.12
P089	29.566	-95.799	2015.766	2024.197	8.431	345	-0.8	-0.13
P096	29.724	-95.748	2017.624	2024.944	7.320	2479	-1.7	-1.07
P097	29.785	-95.847	2018.104	2025.002	6.898	701	-13.1	-1.24
P098	29.803	-95.820	2018.120	2025.002	6.882	484	-13.9	-1.83
RPFB	29.484	-95.514	2014.773	2024.742	9.969	3633	-1.0	-0.35
SISD	29.762	-96.174	2015.176	2024.742	9.566	3365	0.0	0.02
TXWH	29.325	-96.112	2010.426	2024.742	14.316	5169	-0.9	0.03
UHCR	29.728	-95.757	2014.123	2025.002	10.879	3677	-12.8	-1.35
UHEB	29.526	-96.066	2014.595	2024.646	10.051	3370	-1.3	-0.02
UHKD	29.724	-95.748	2018.969	2024.934	5.964	2102	-5.5	-1.13
UHKS	29.724	-95.748	2018.411	2024.936	6.526	2379	-4.7	-0.92

Notes:

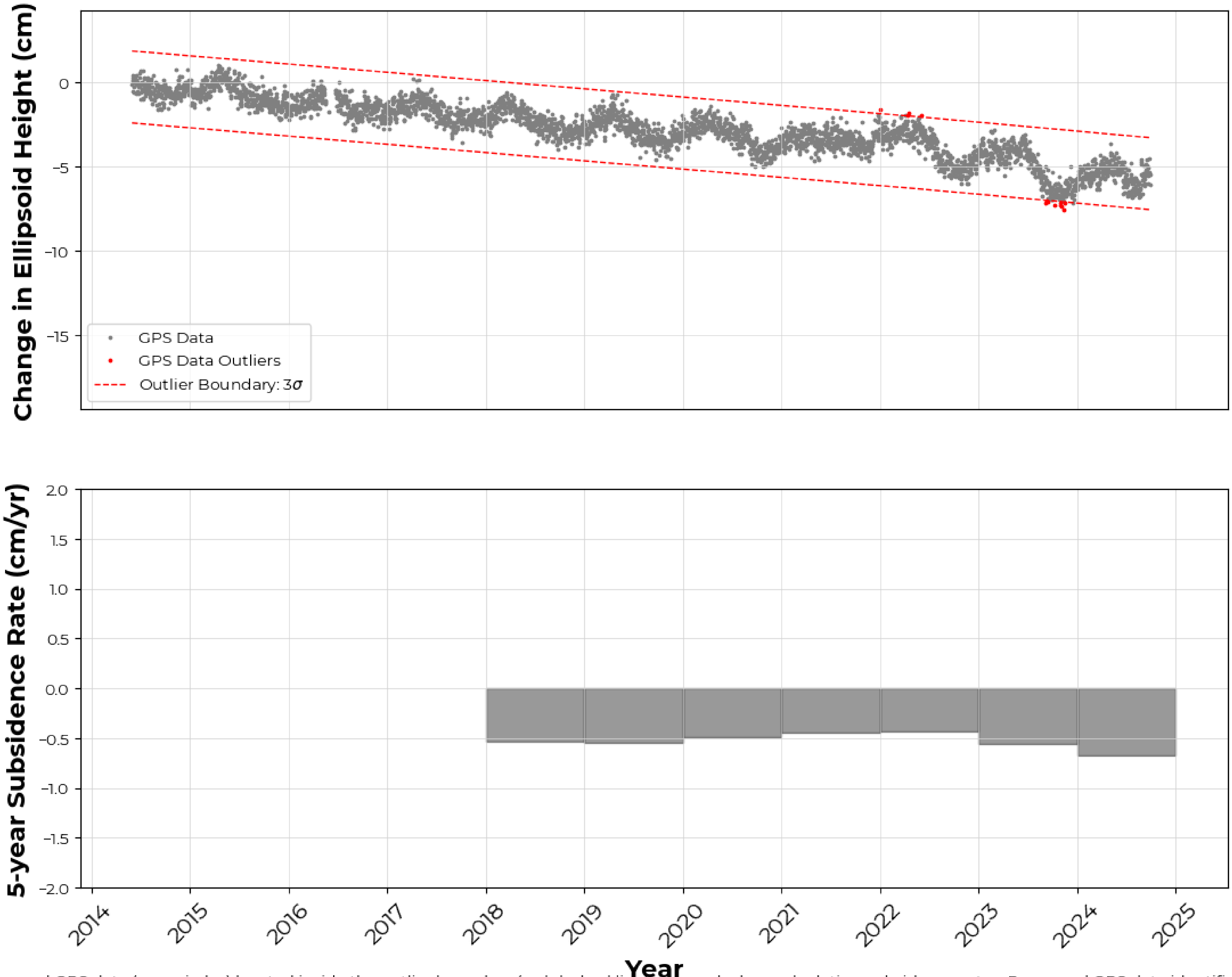
n/a: rate of change in ellipsoidal height not calculated.

ALEF



Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

CMFB



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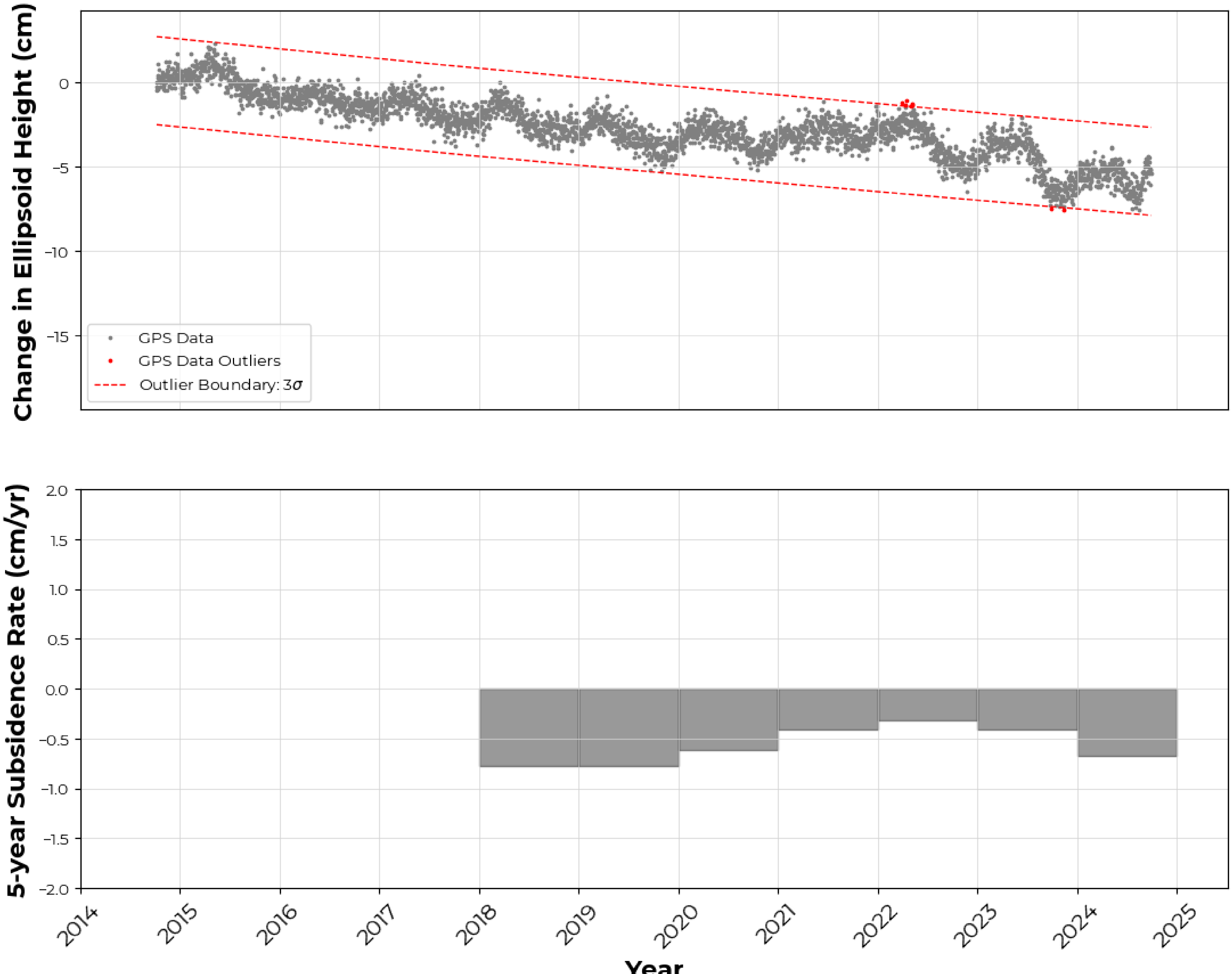
DMFB



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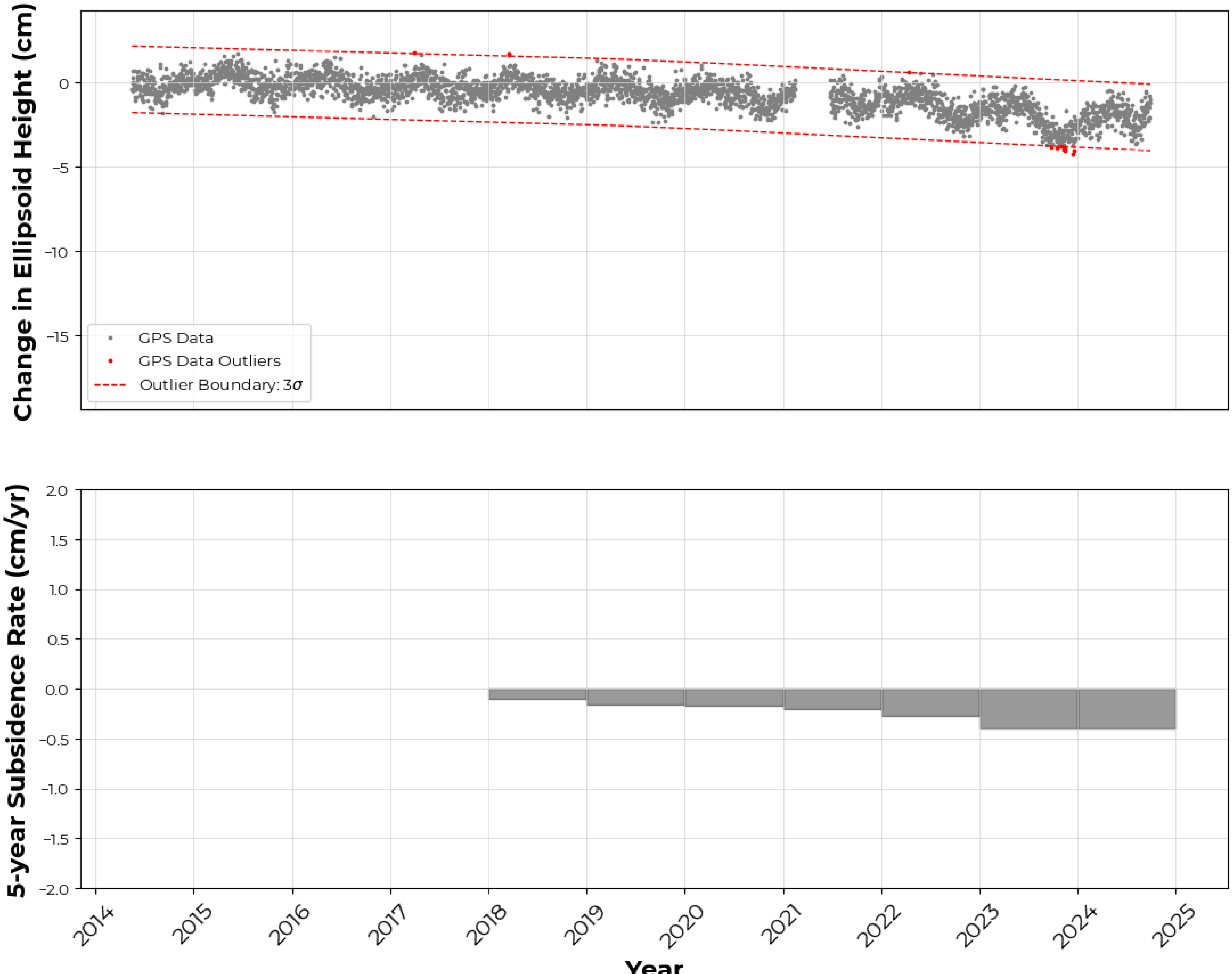
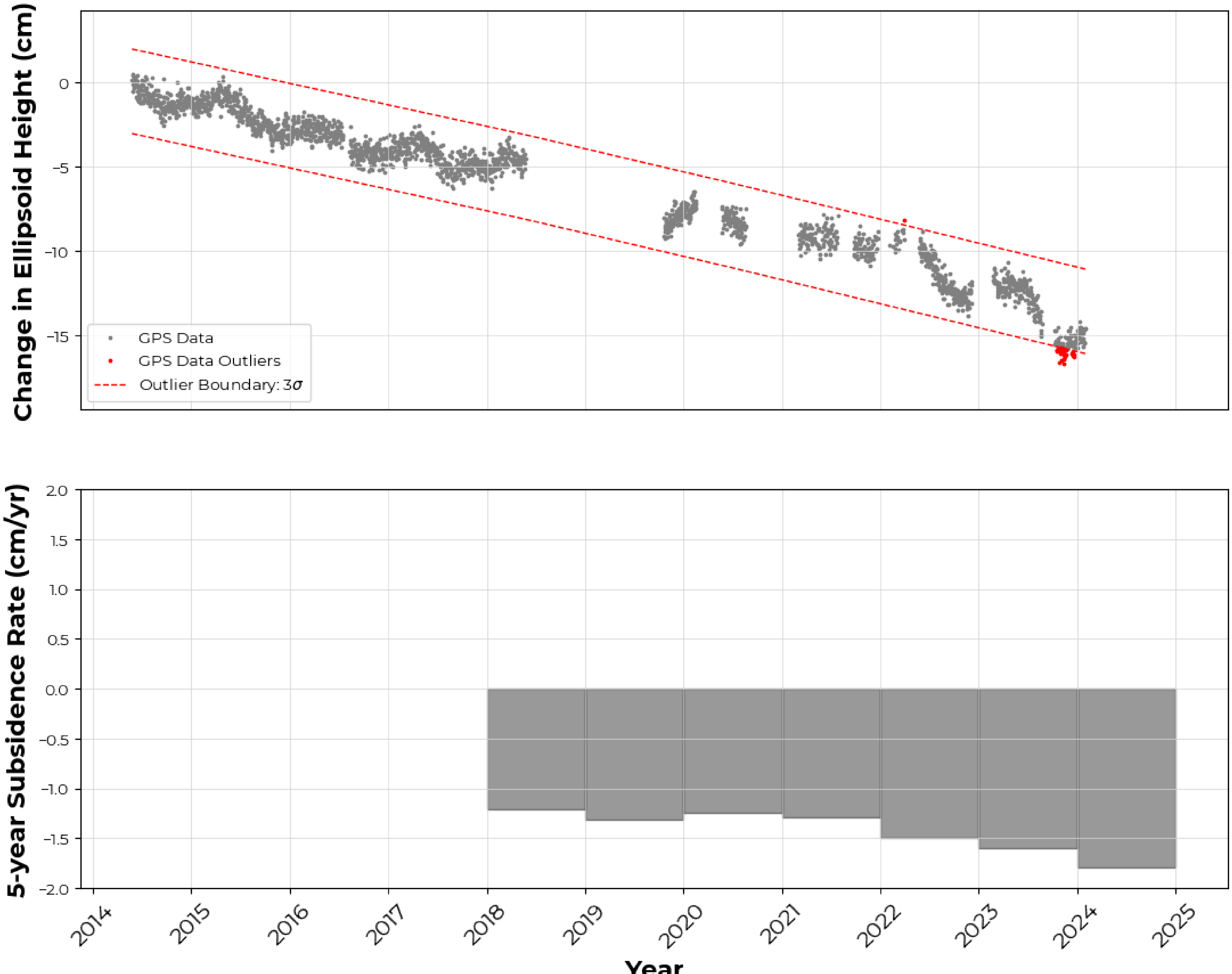
FSFB



Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

HPEK



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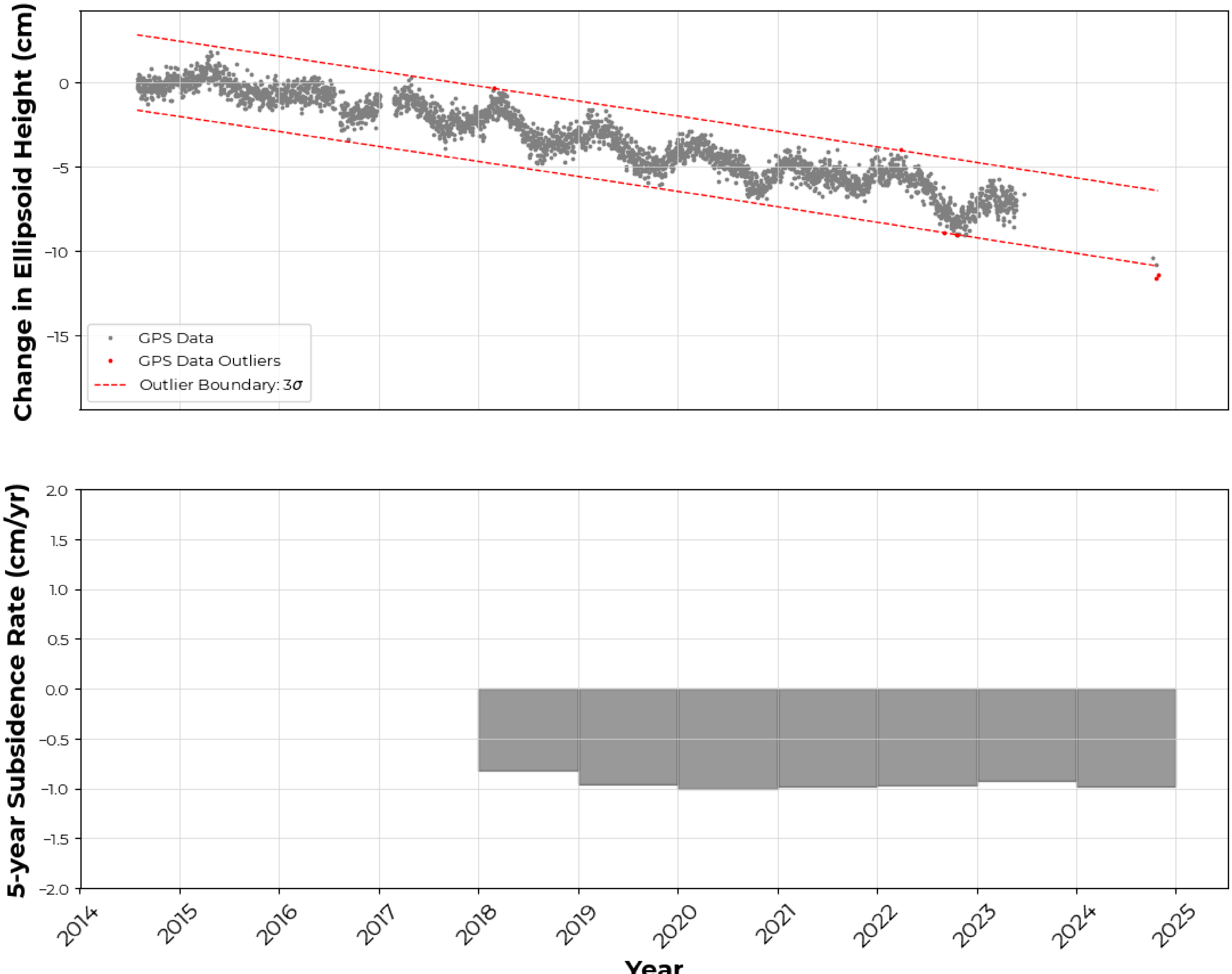
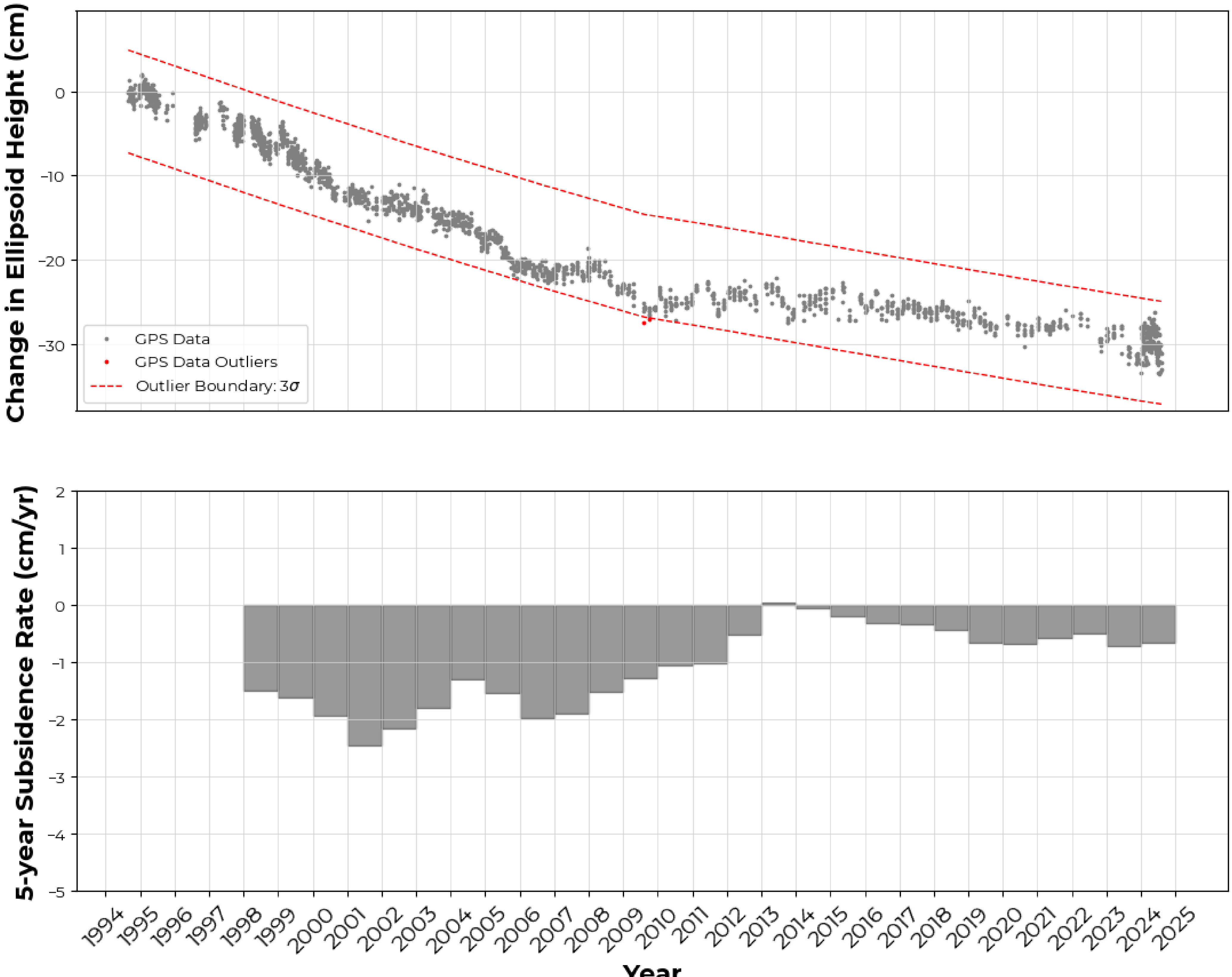
OKEK



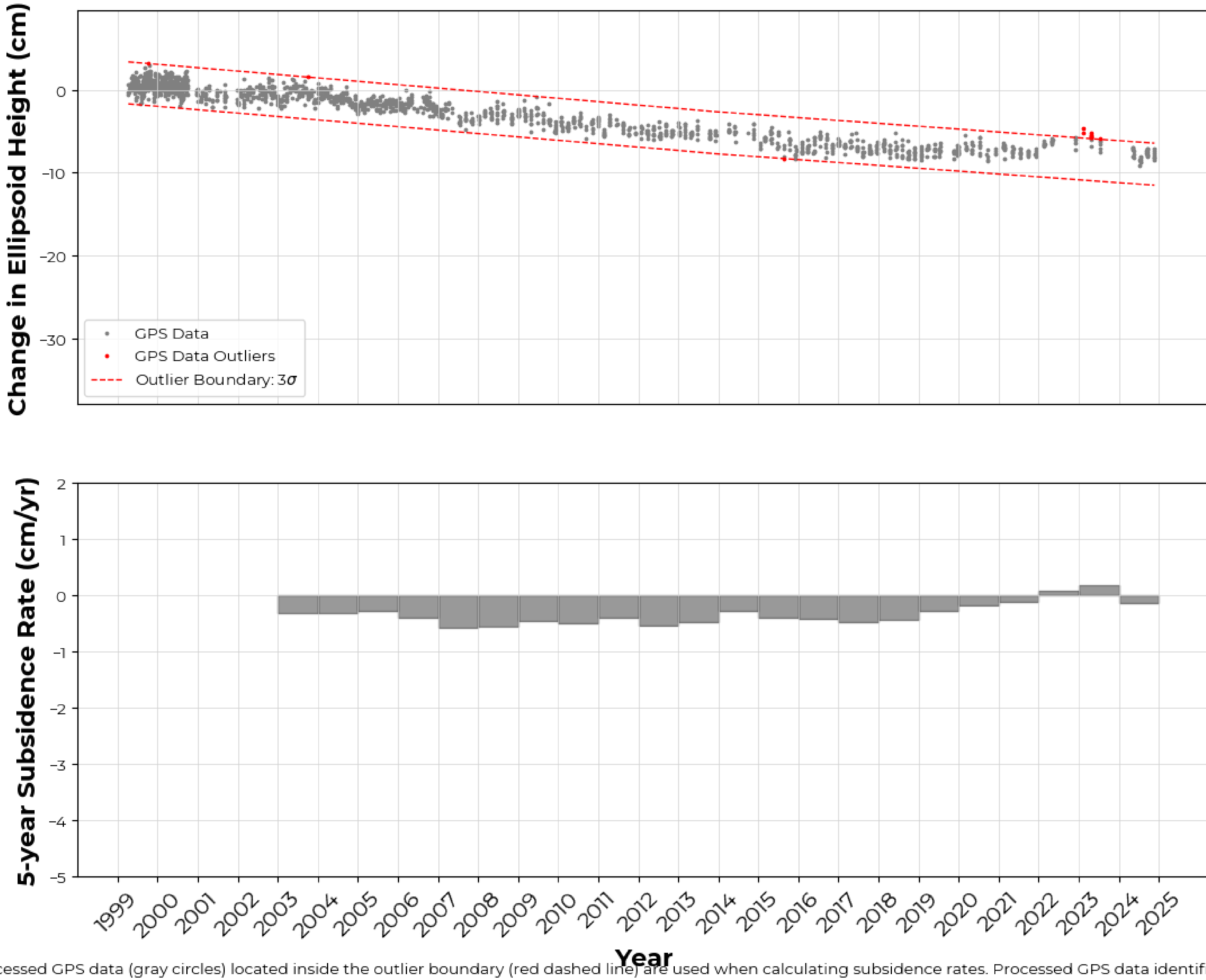
Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P004



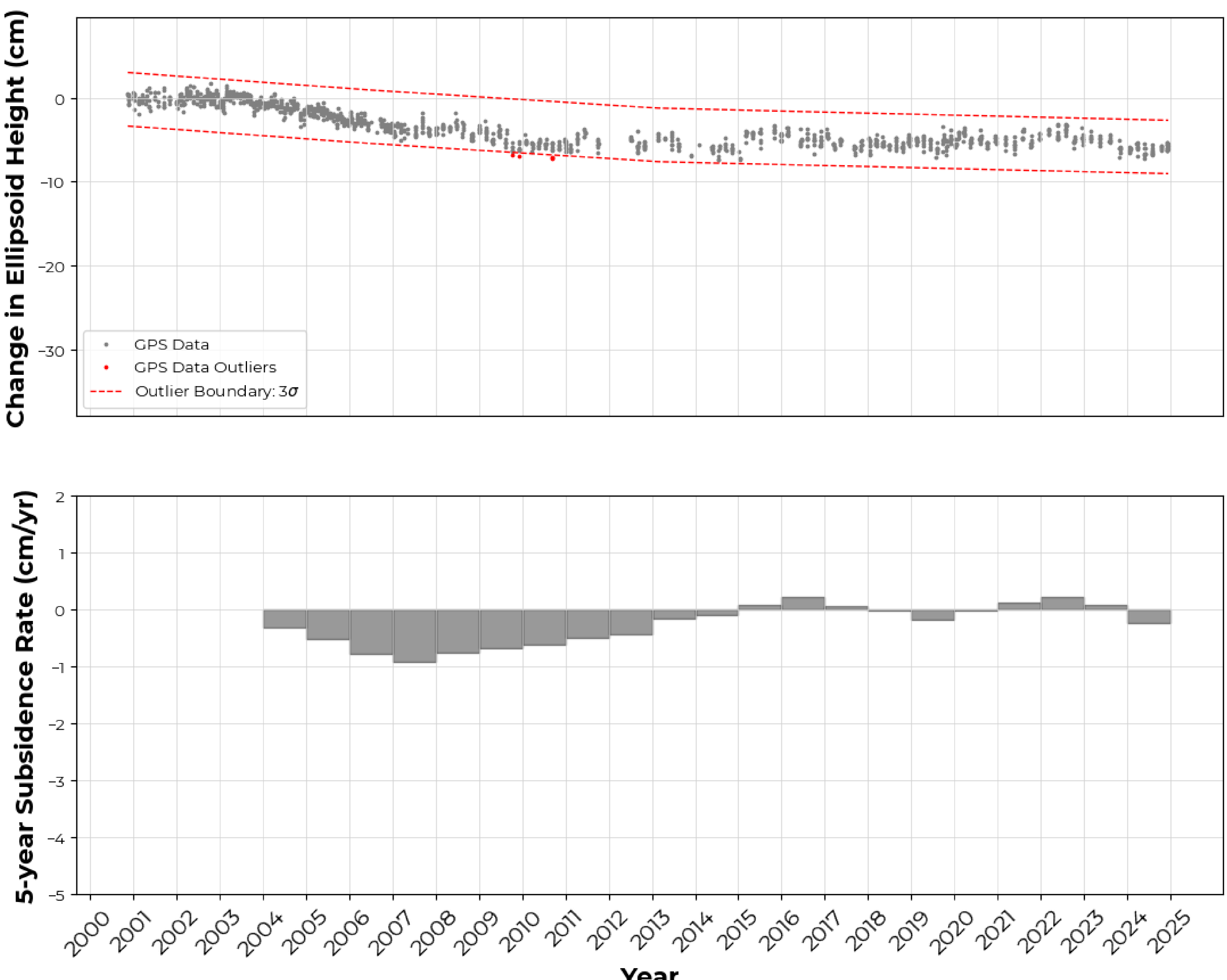
Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P010



Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P014

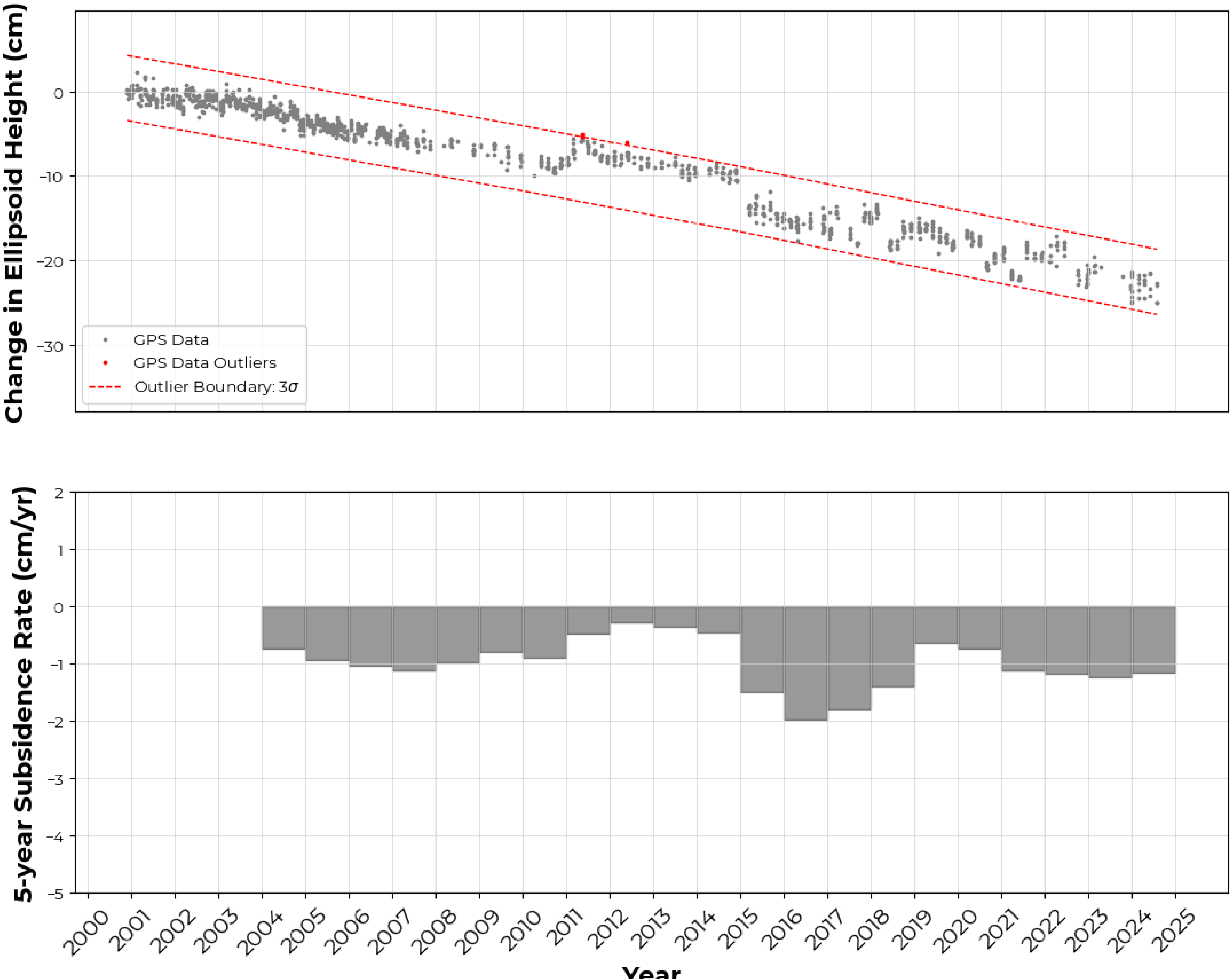


Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P016

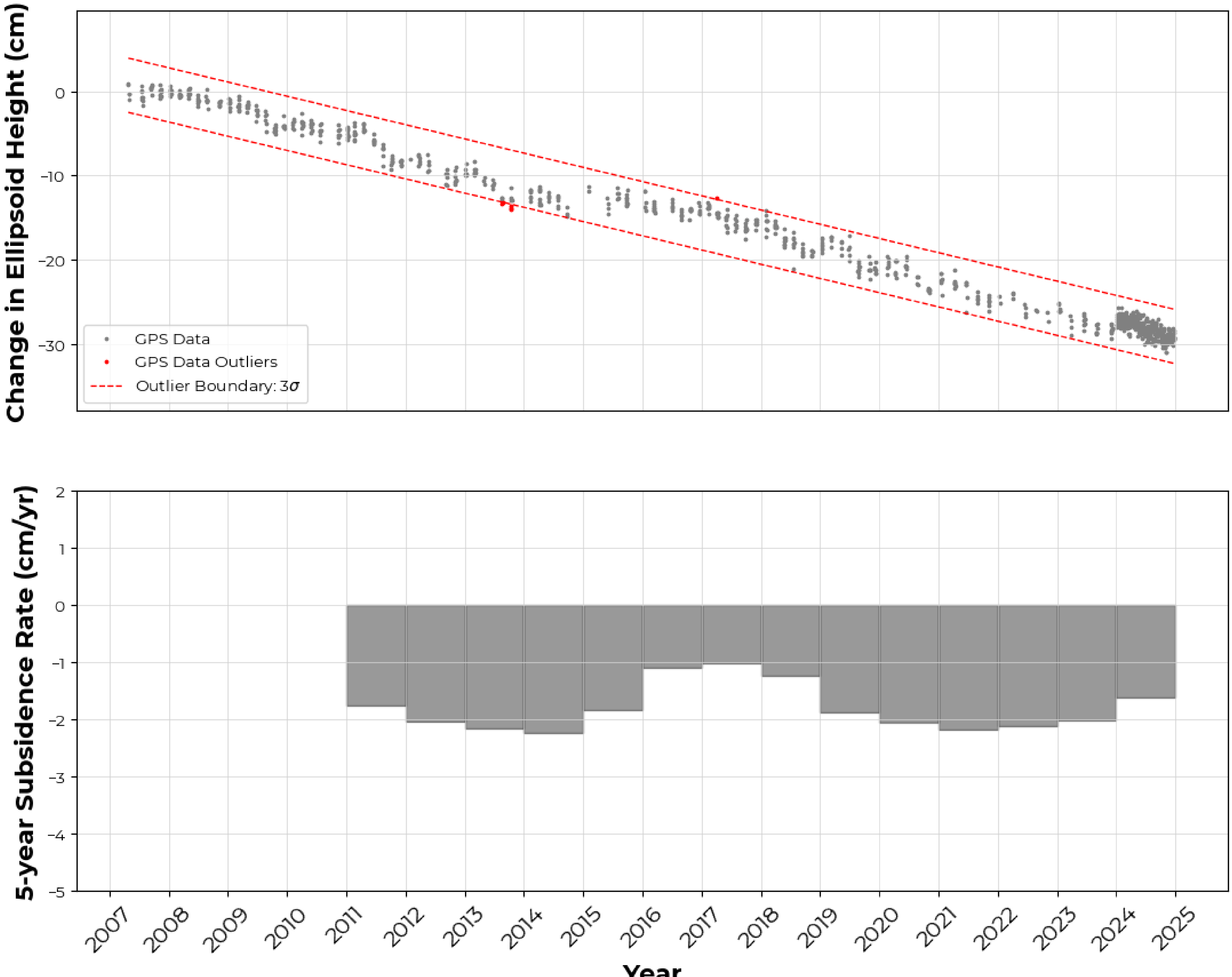
Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P019



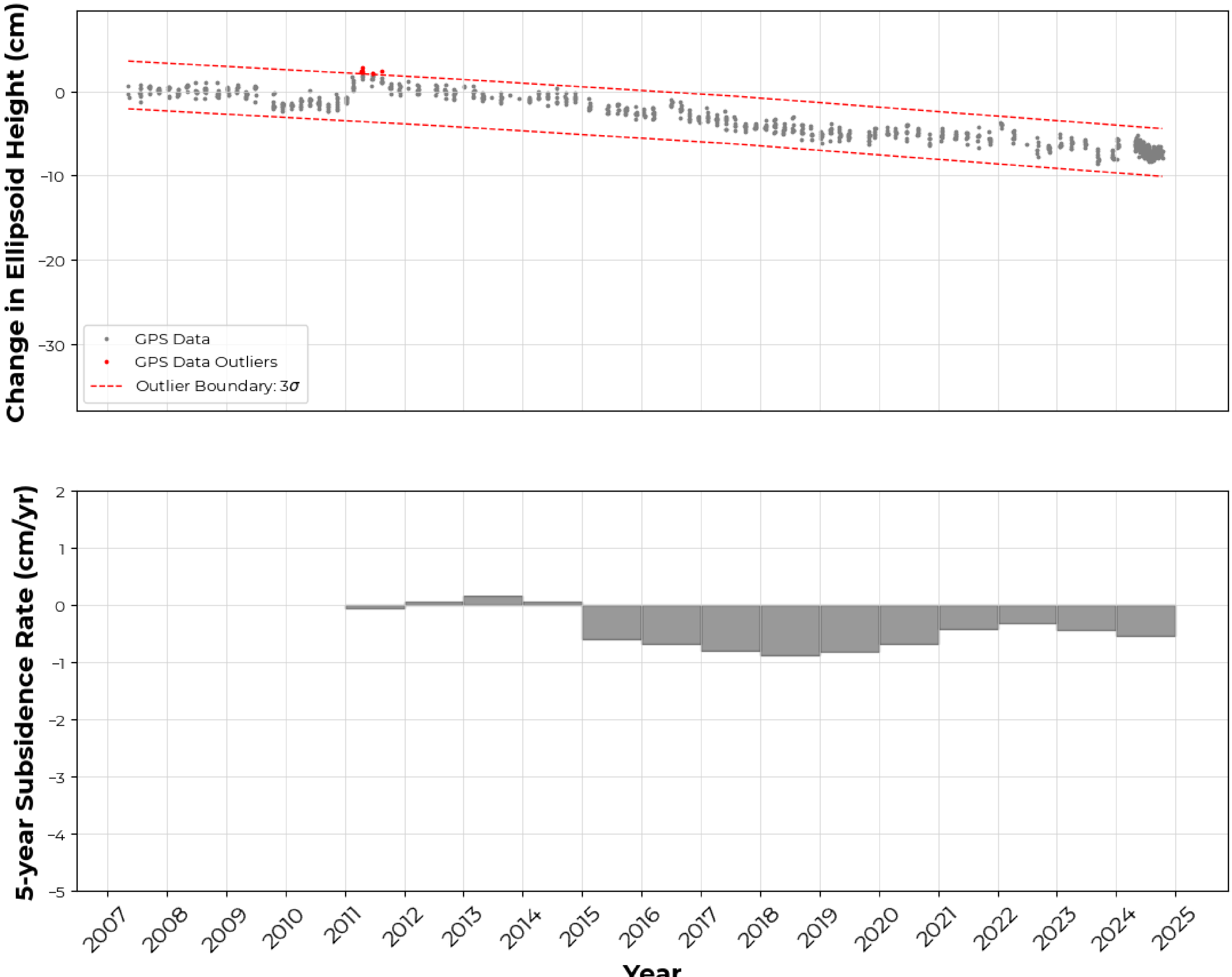
Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P029



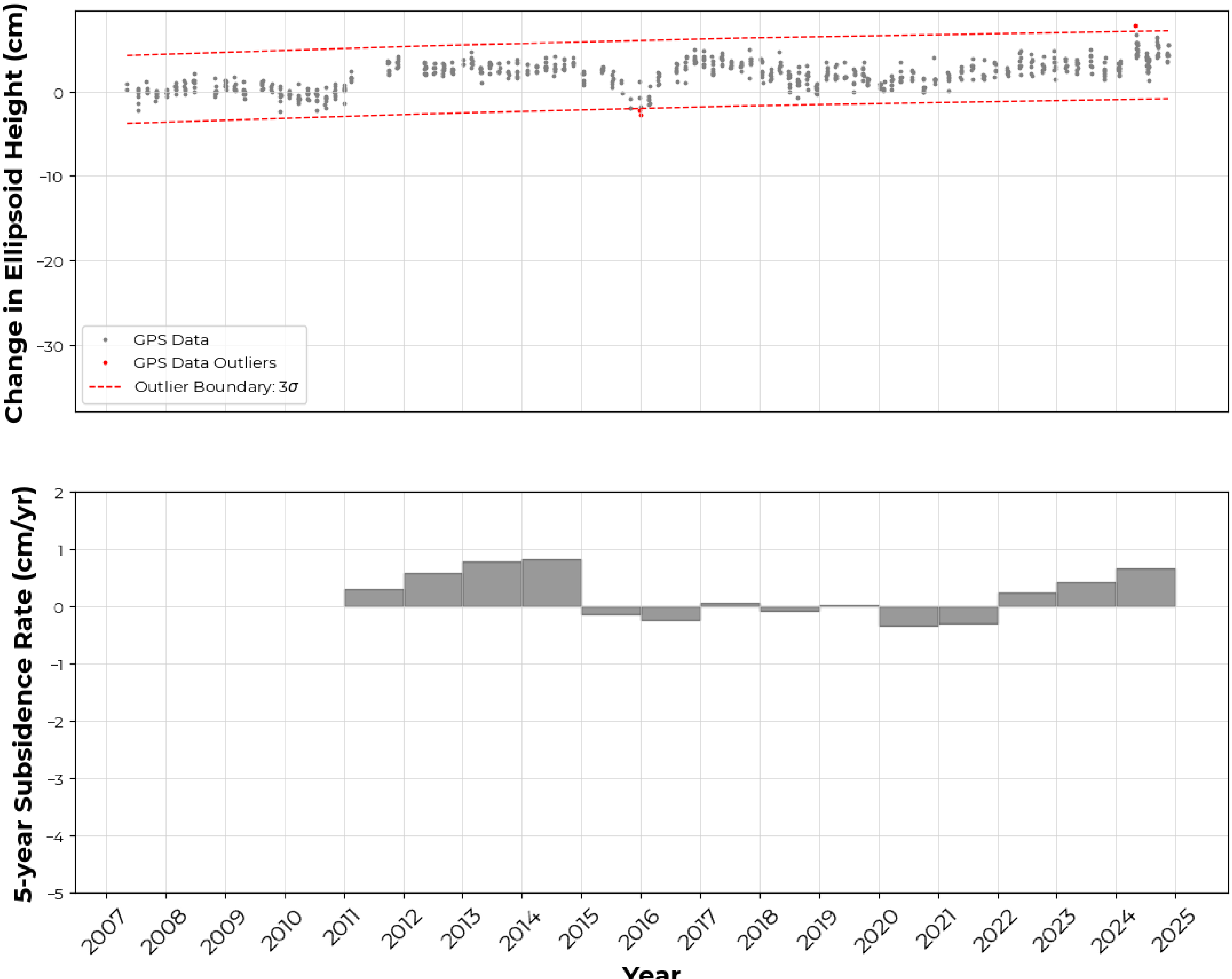
Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P030



Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered when calculating subsidence rates and are shown for informational purposes only. Source: University of Houston

P031



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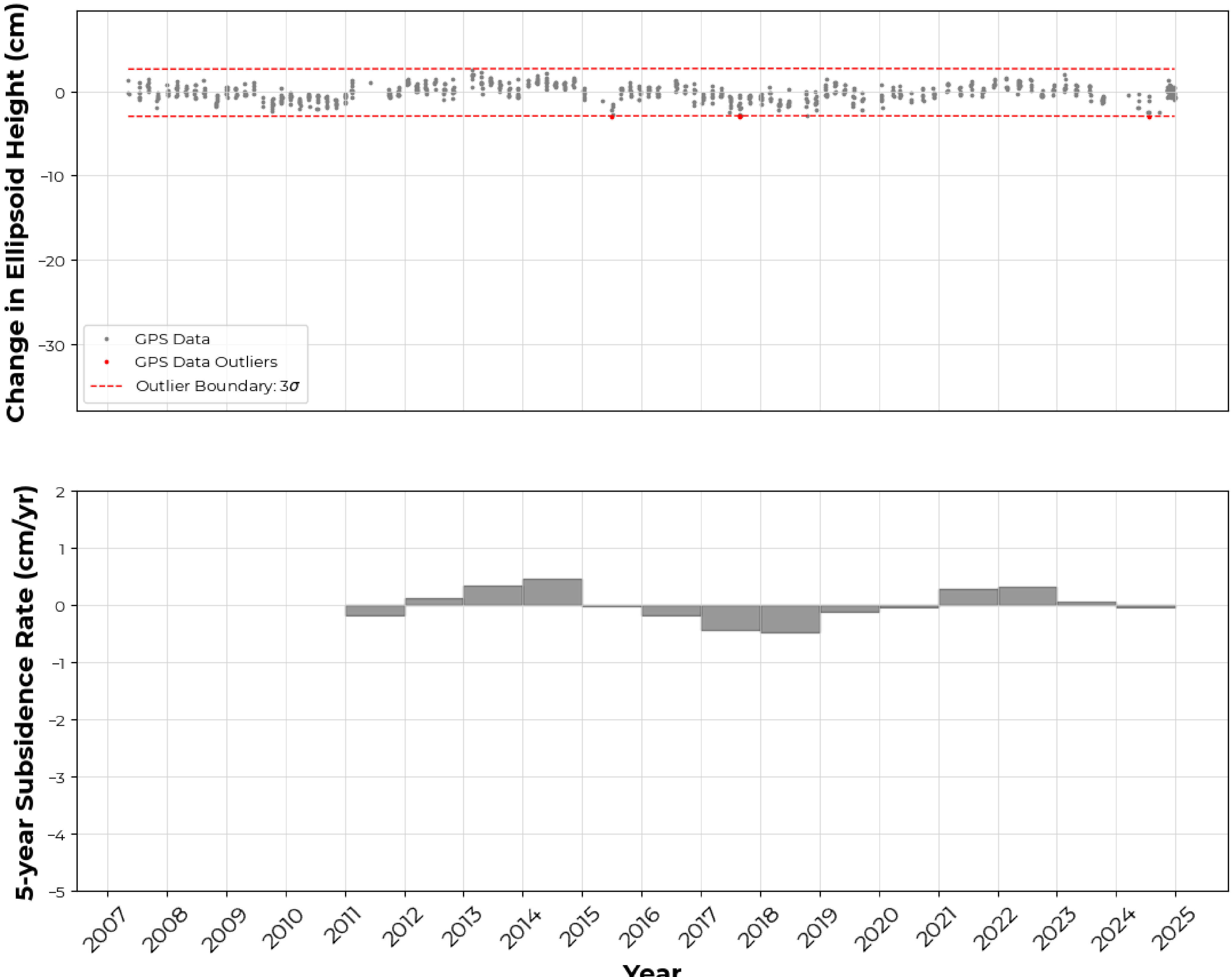
P032



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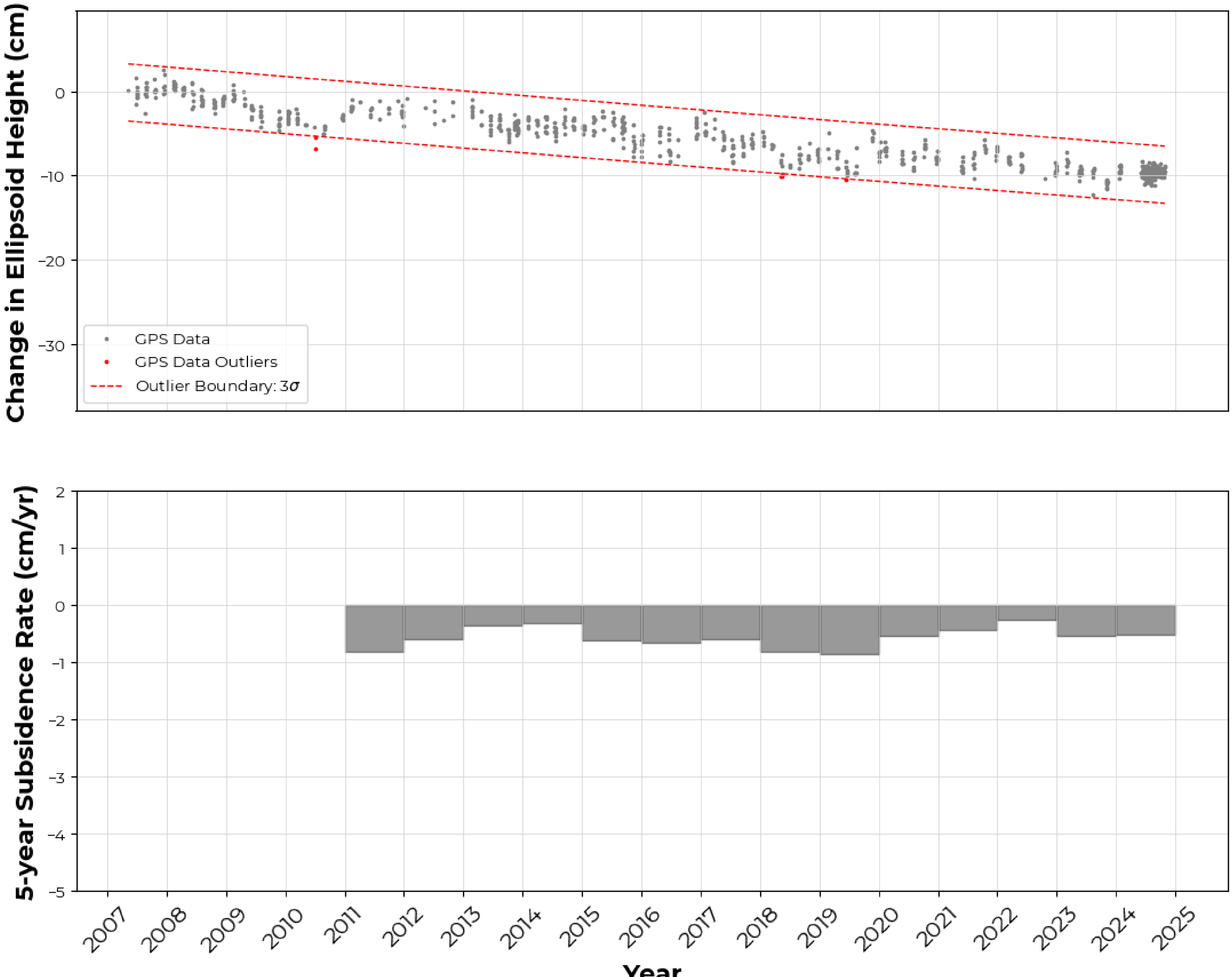
P040



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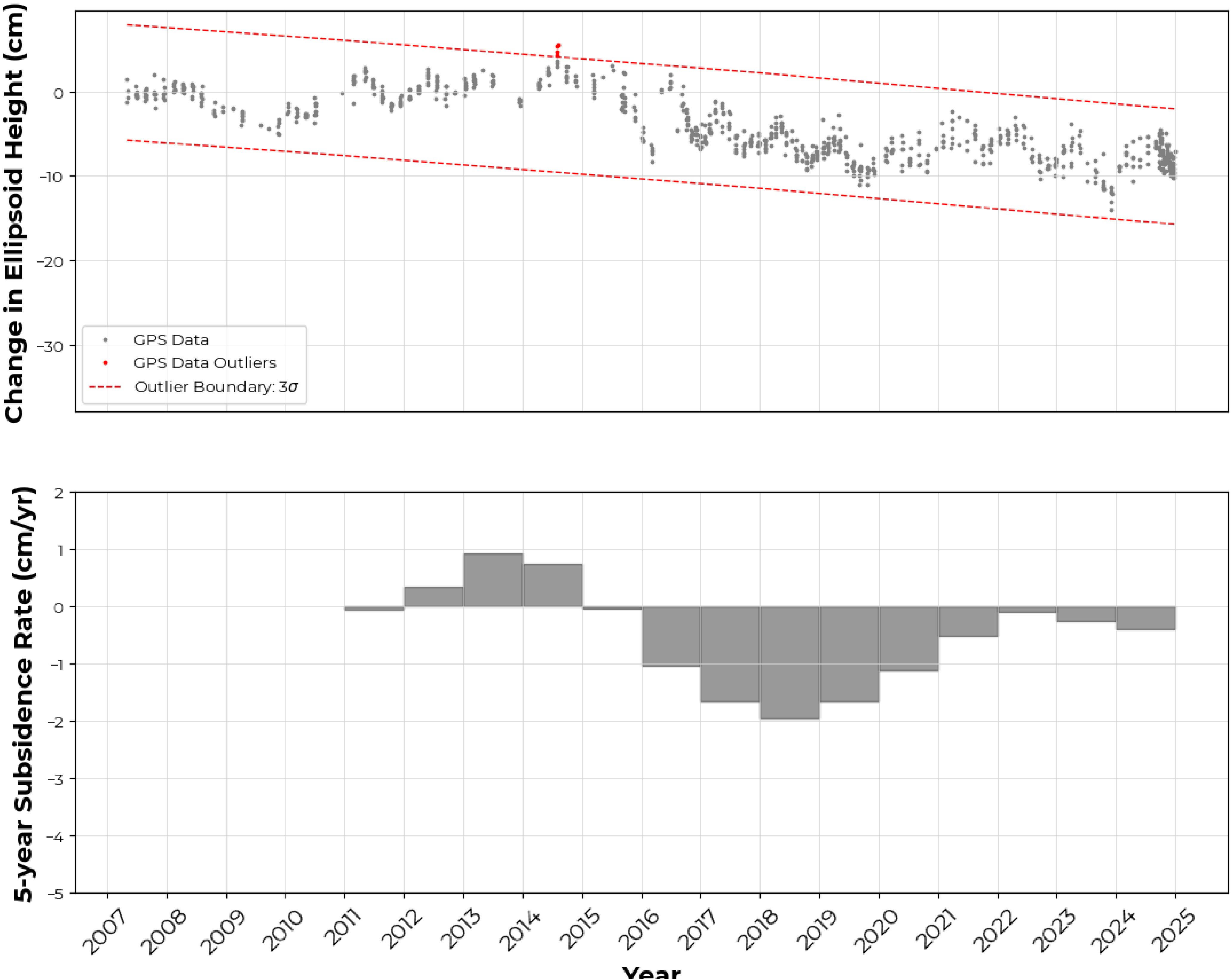
P041



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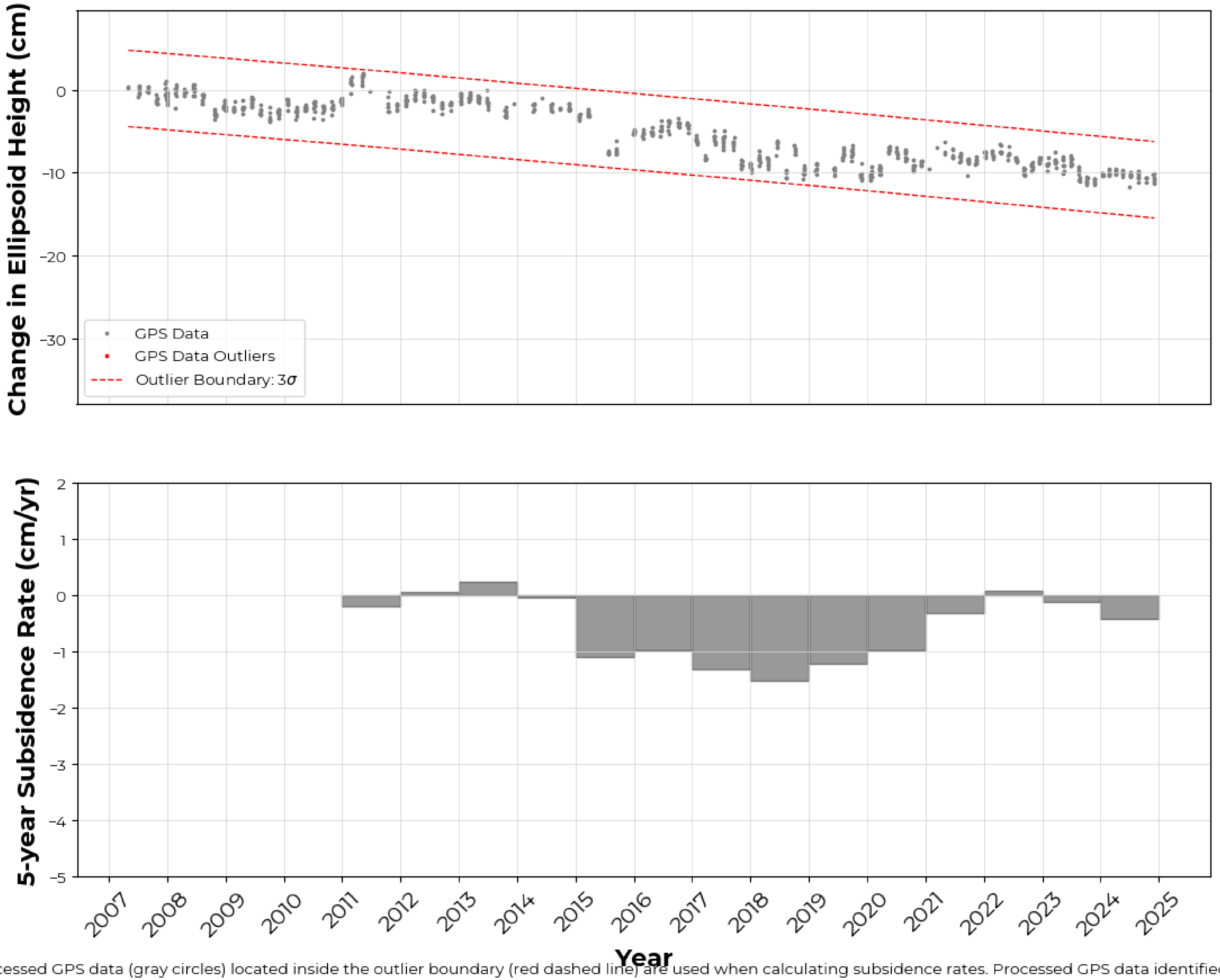
P042



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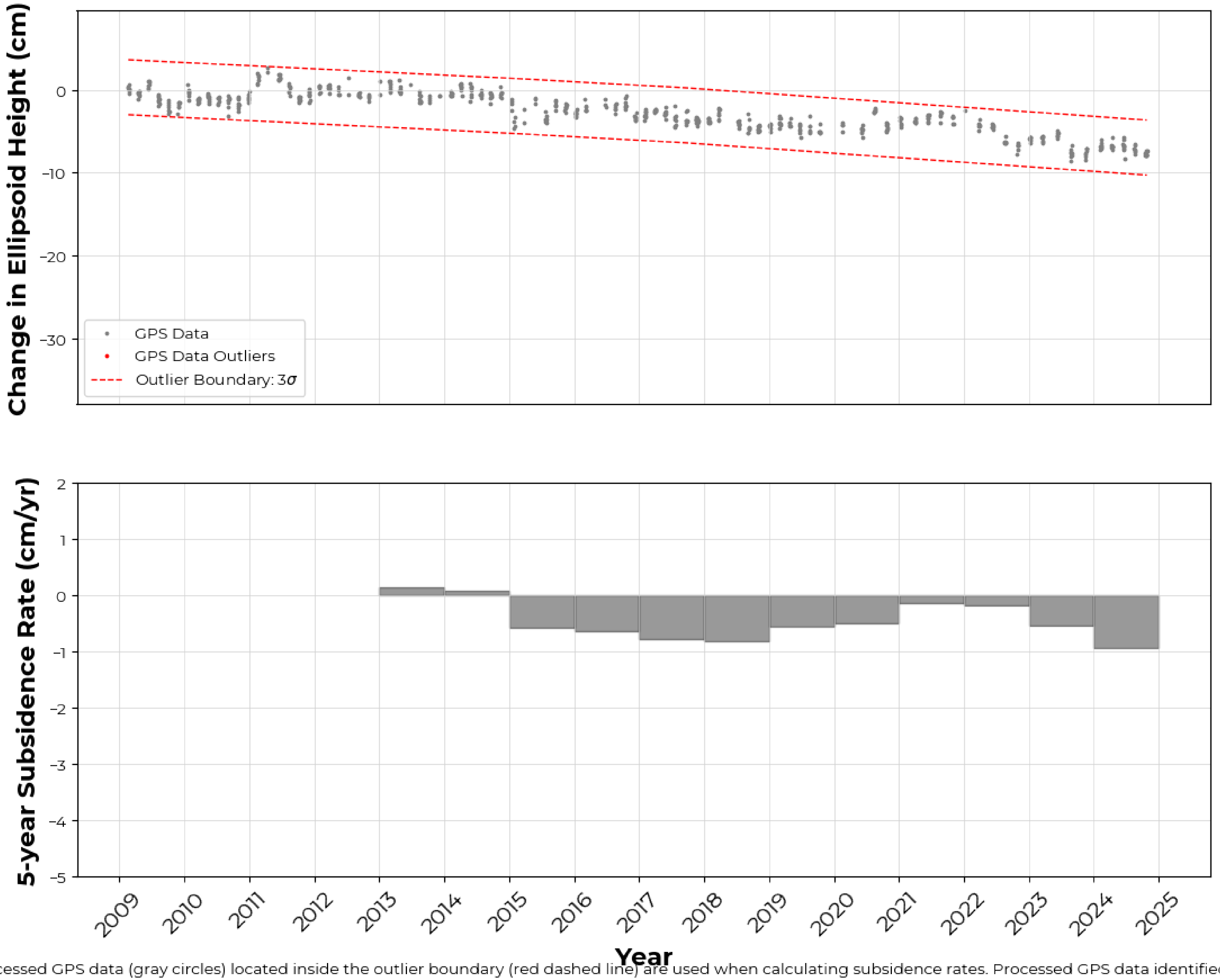
P057



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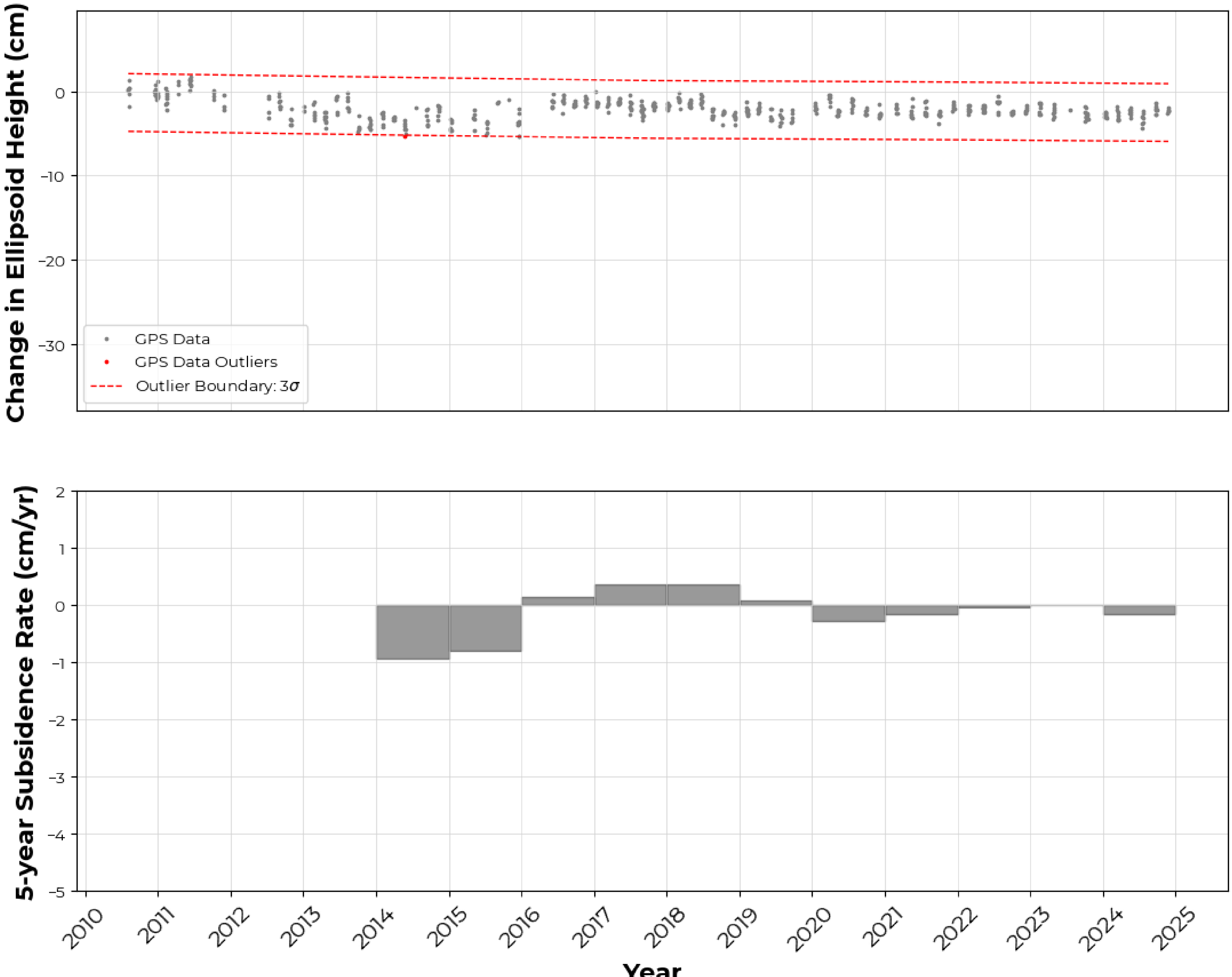
P058



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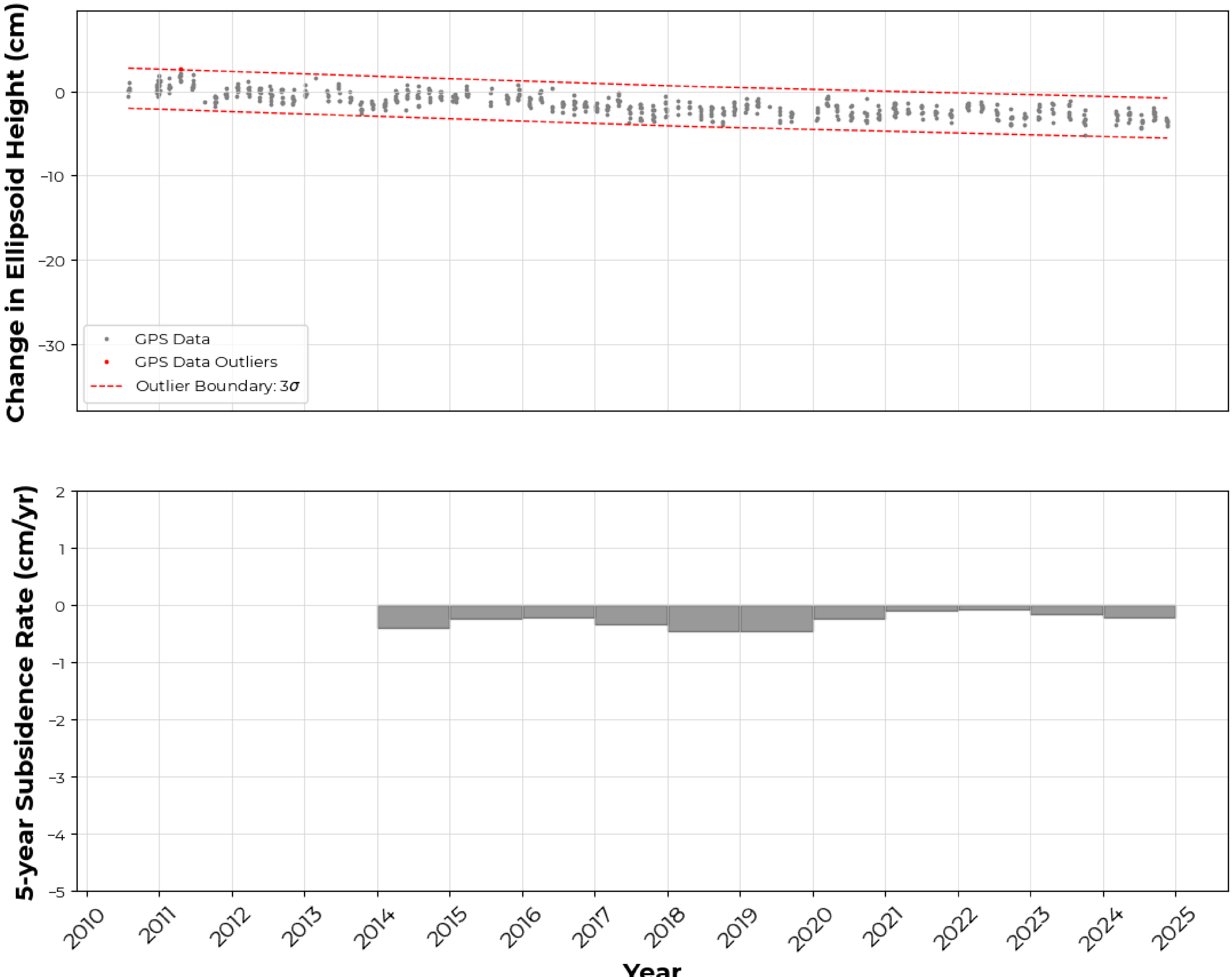
P059



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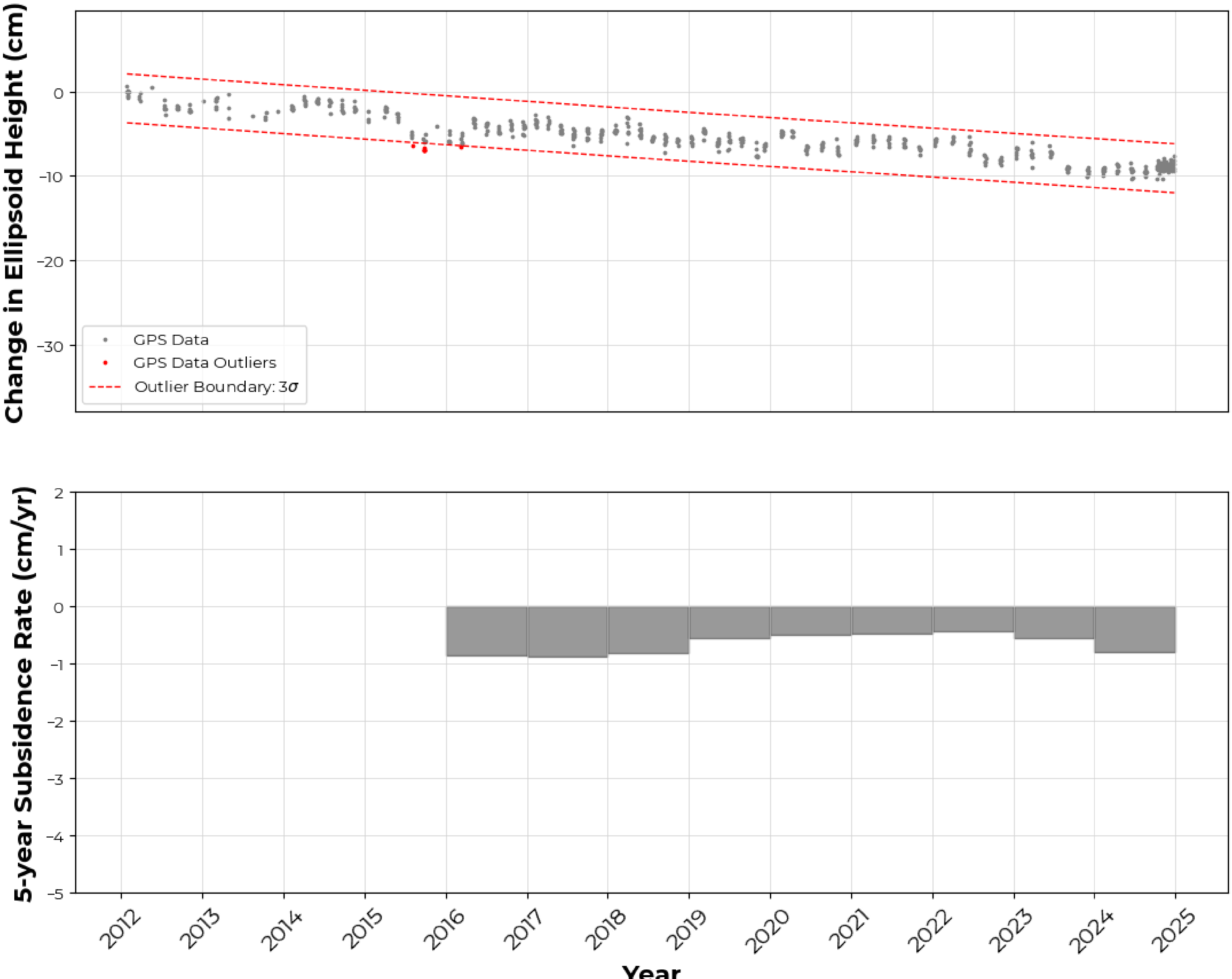
P060



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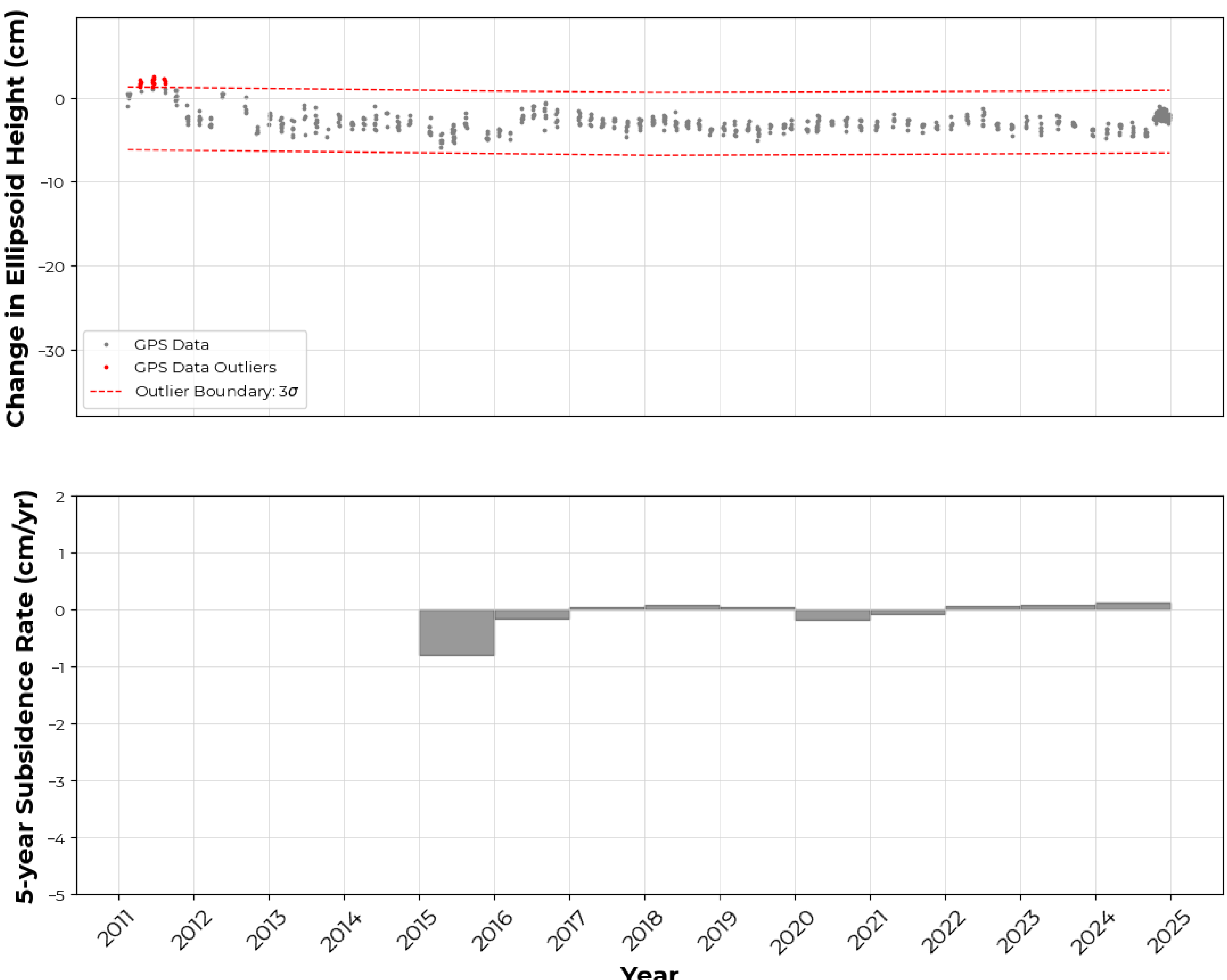
P061



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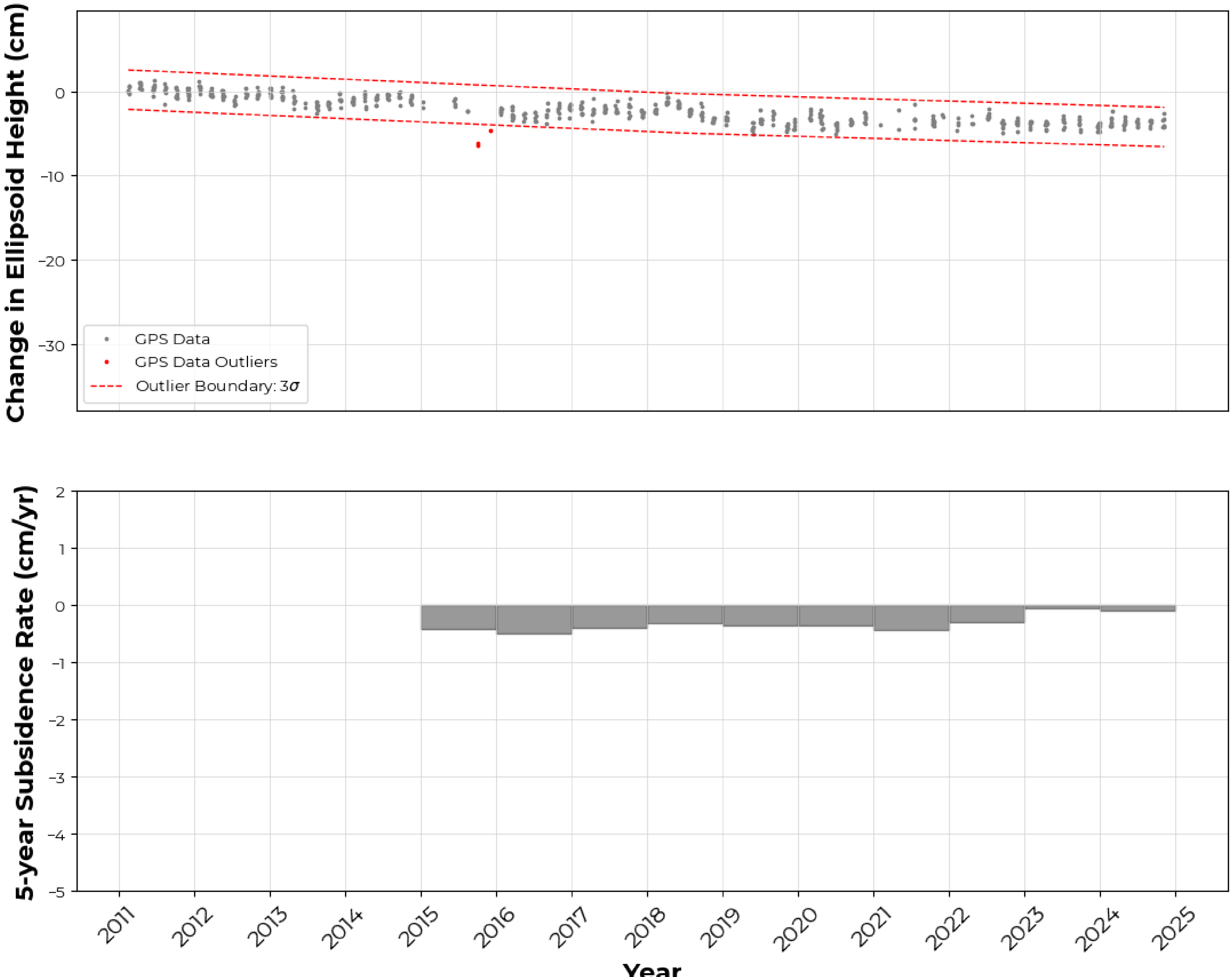
P062



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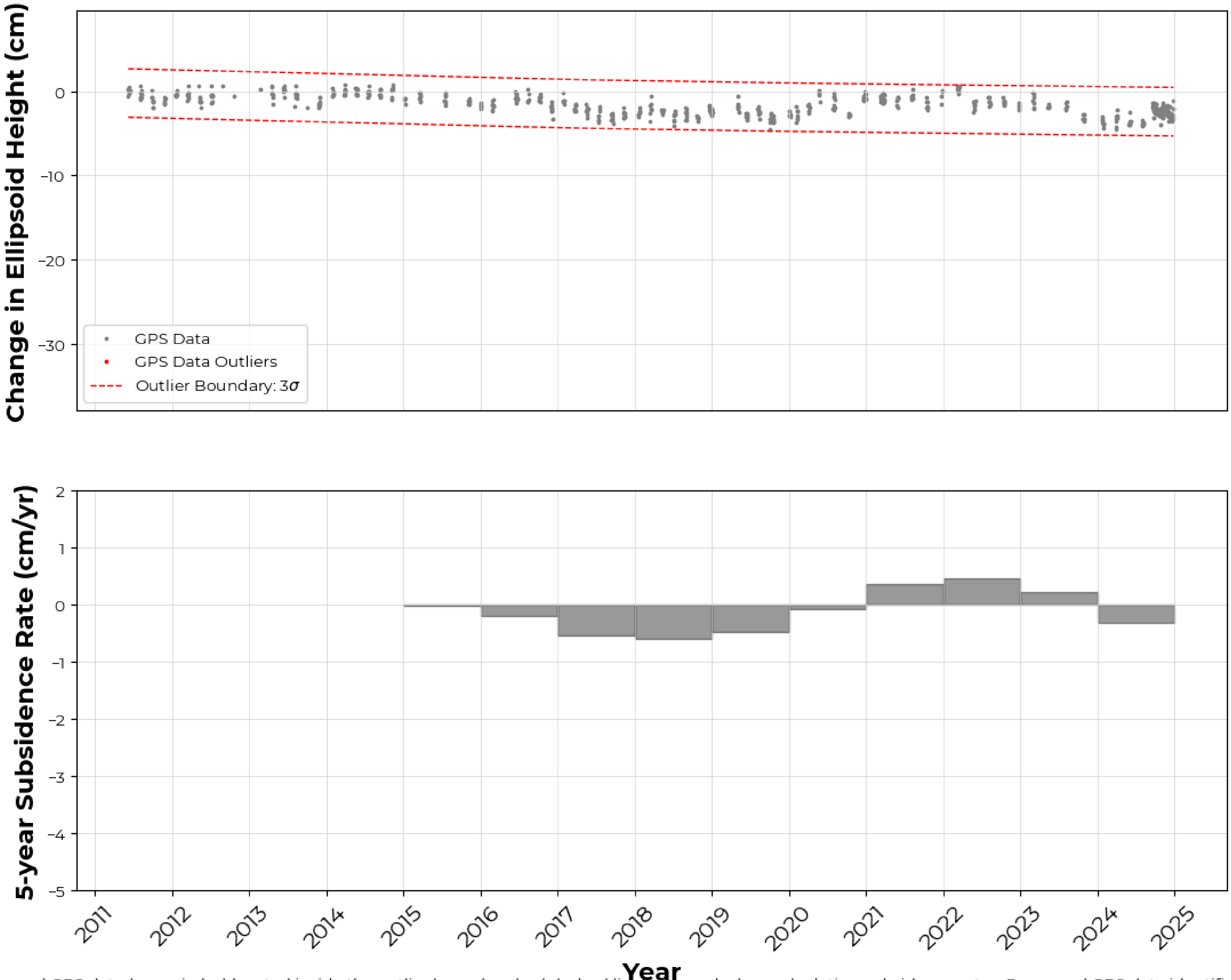
P063



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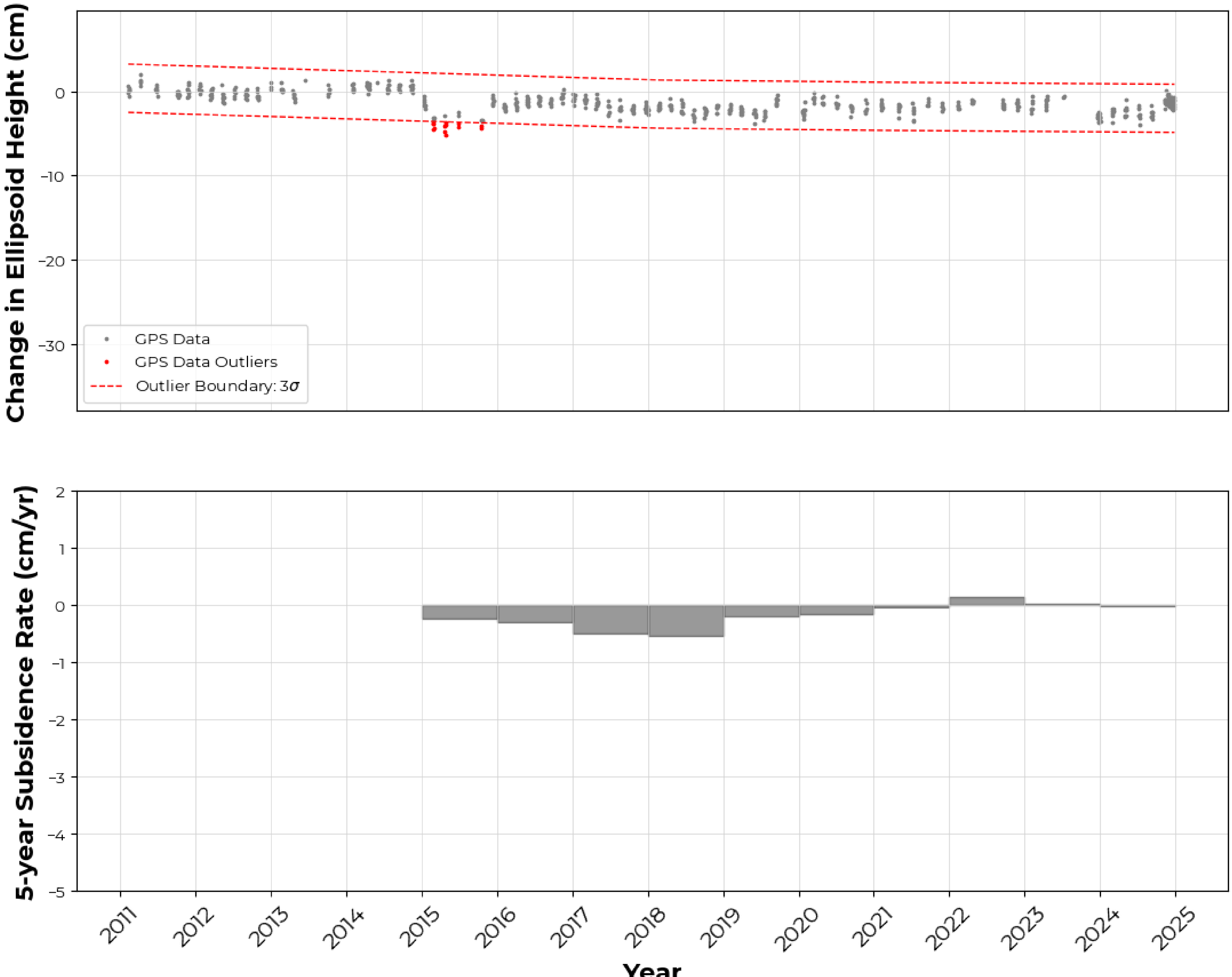
P067



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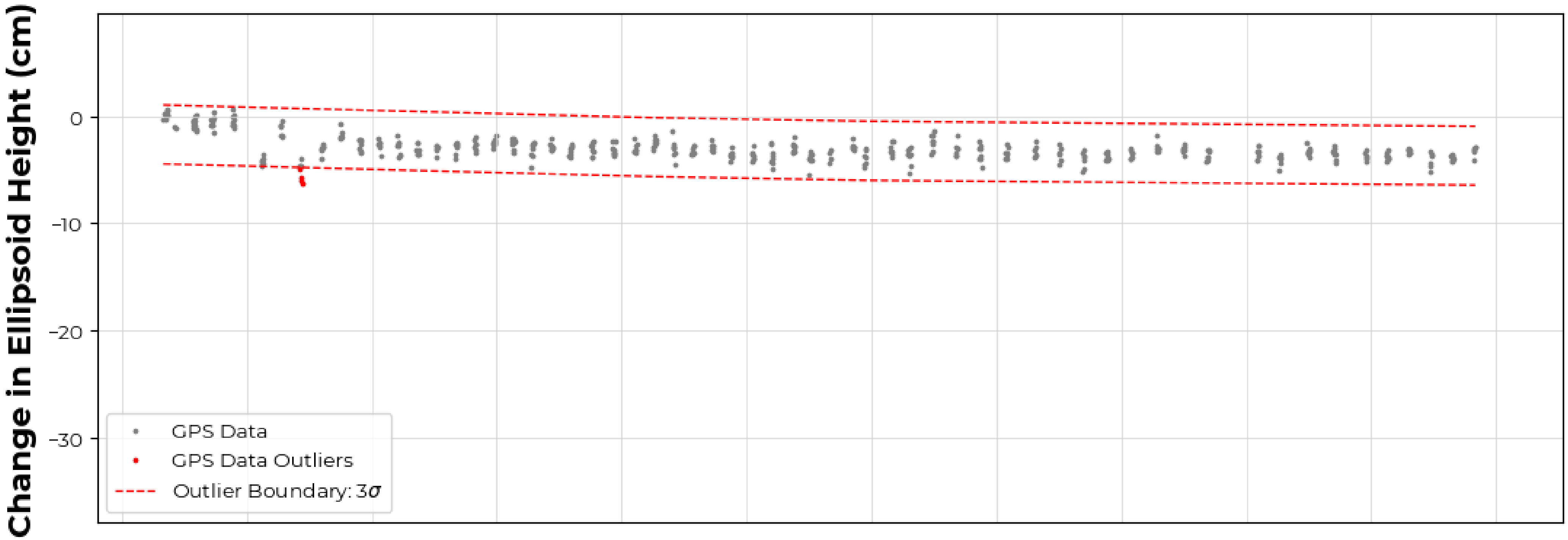
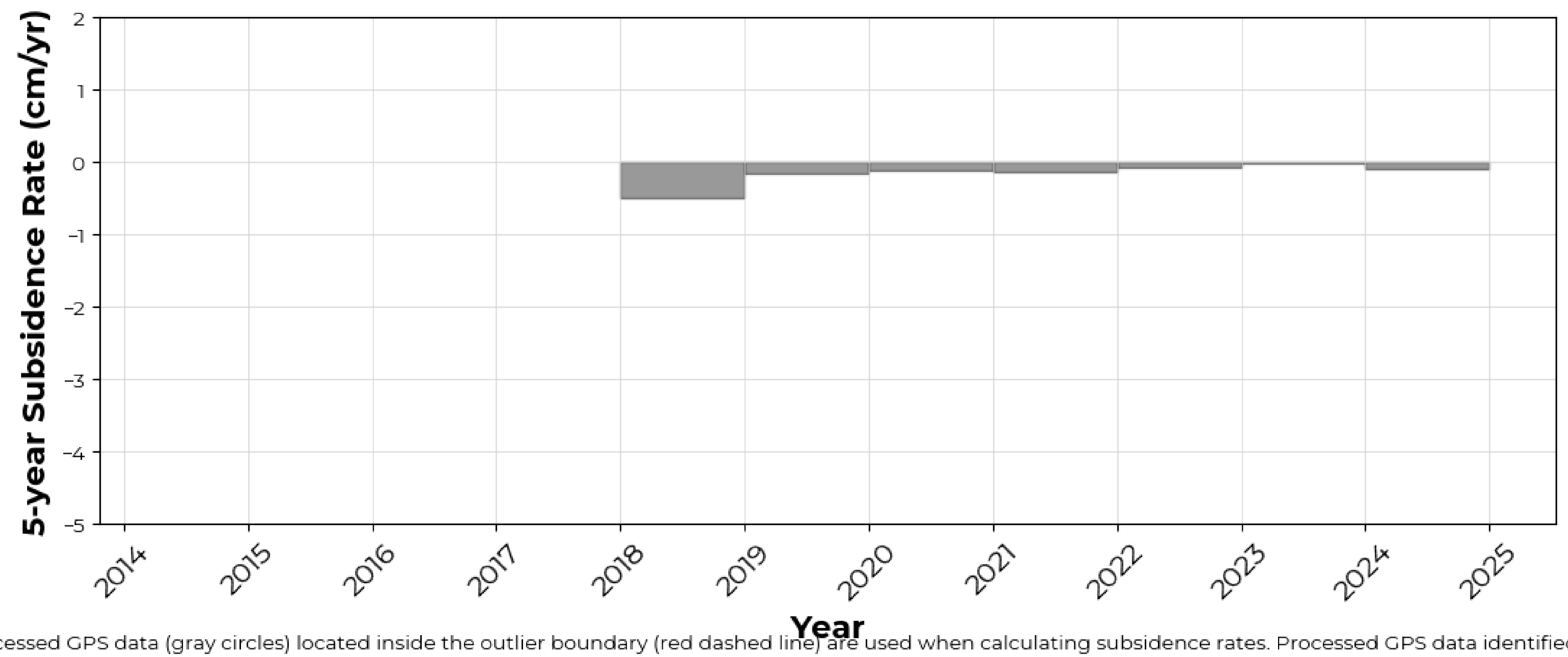
P078





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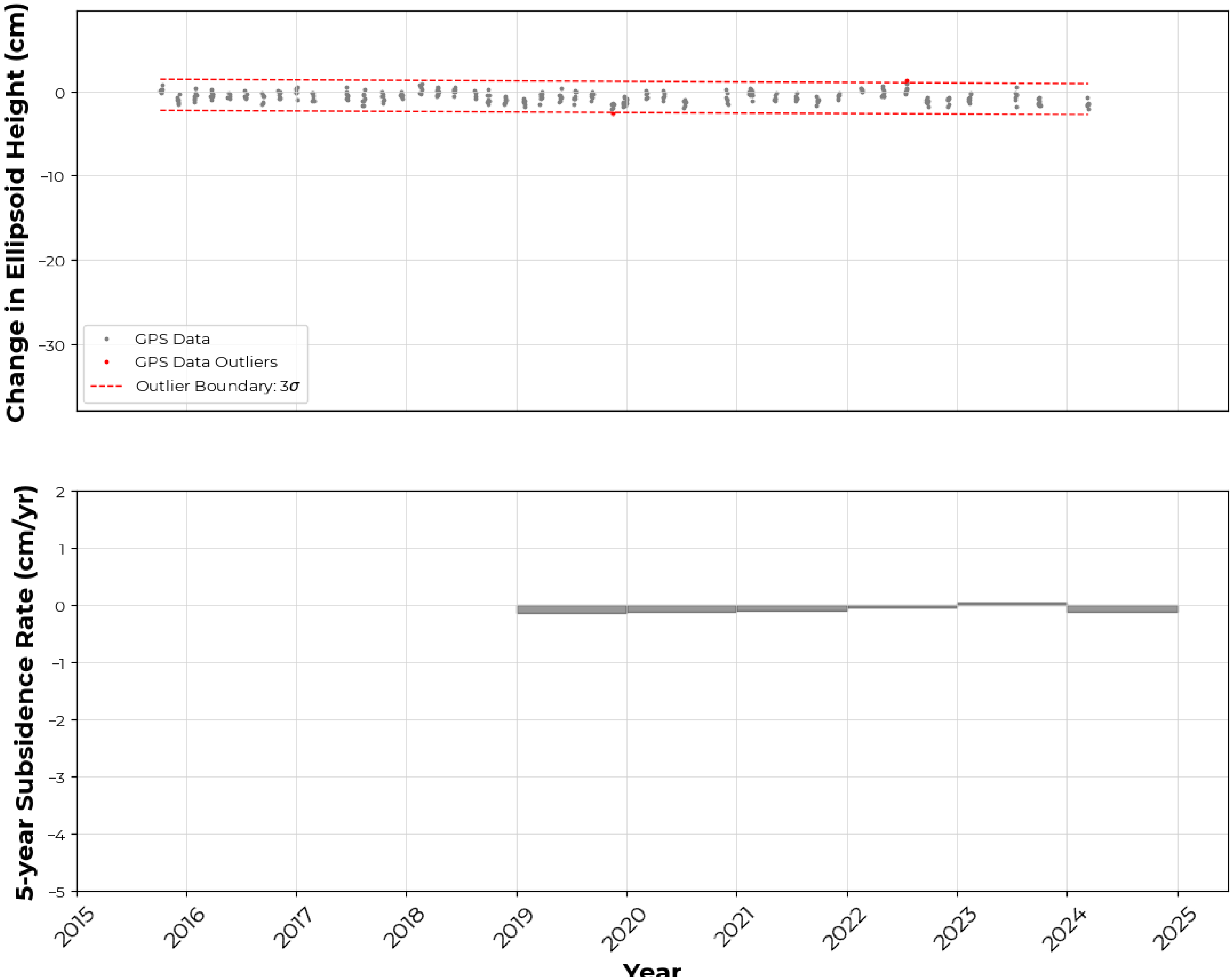
P089



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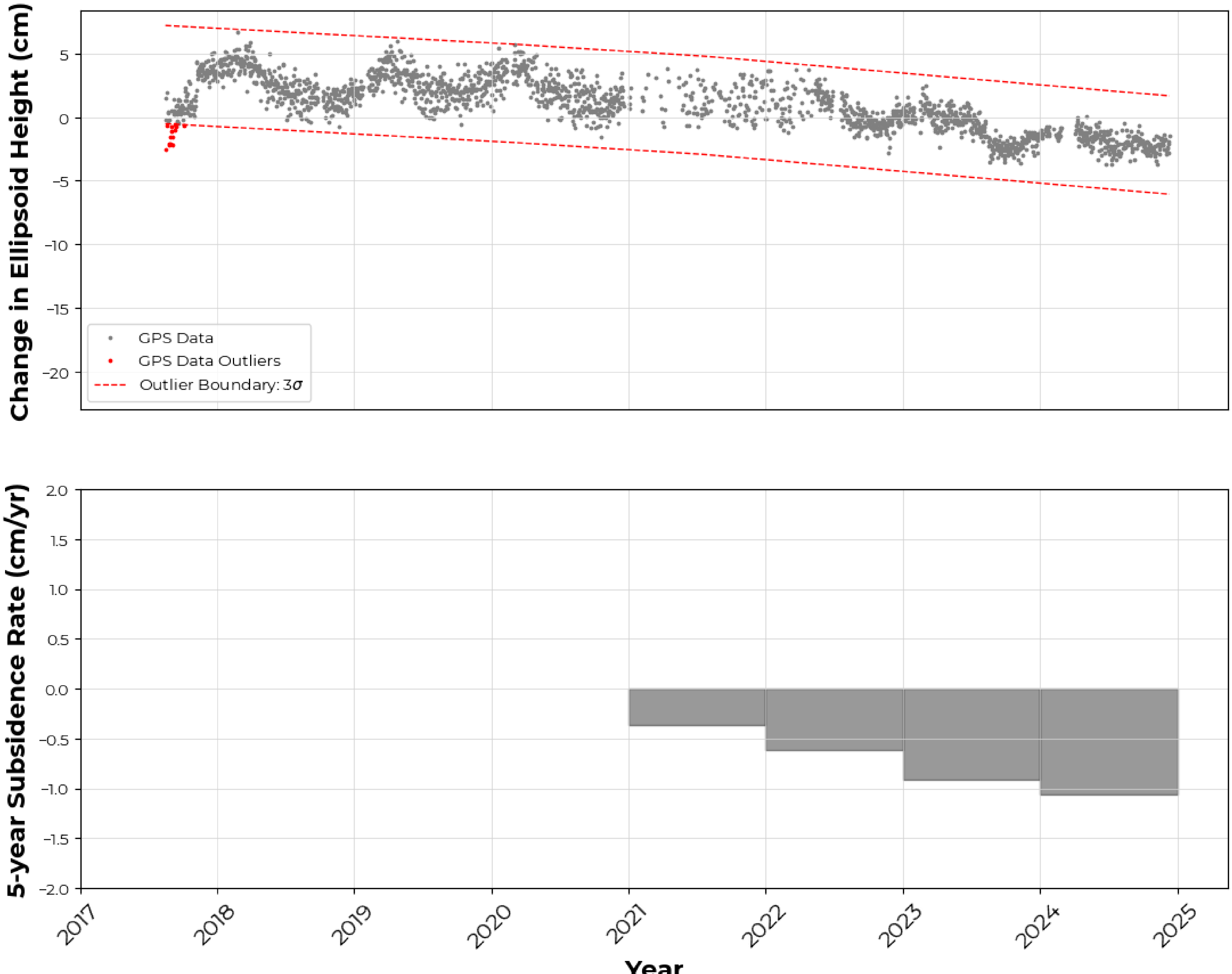
P096



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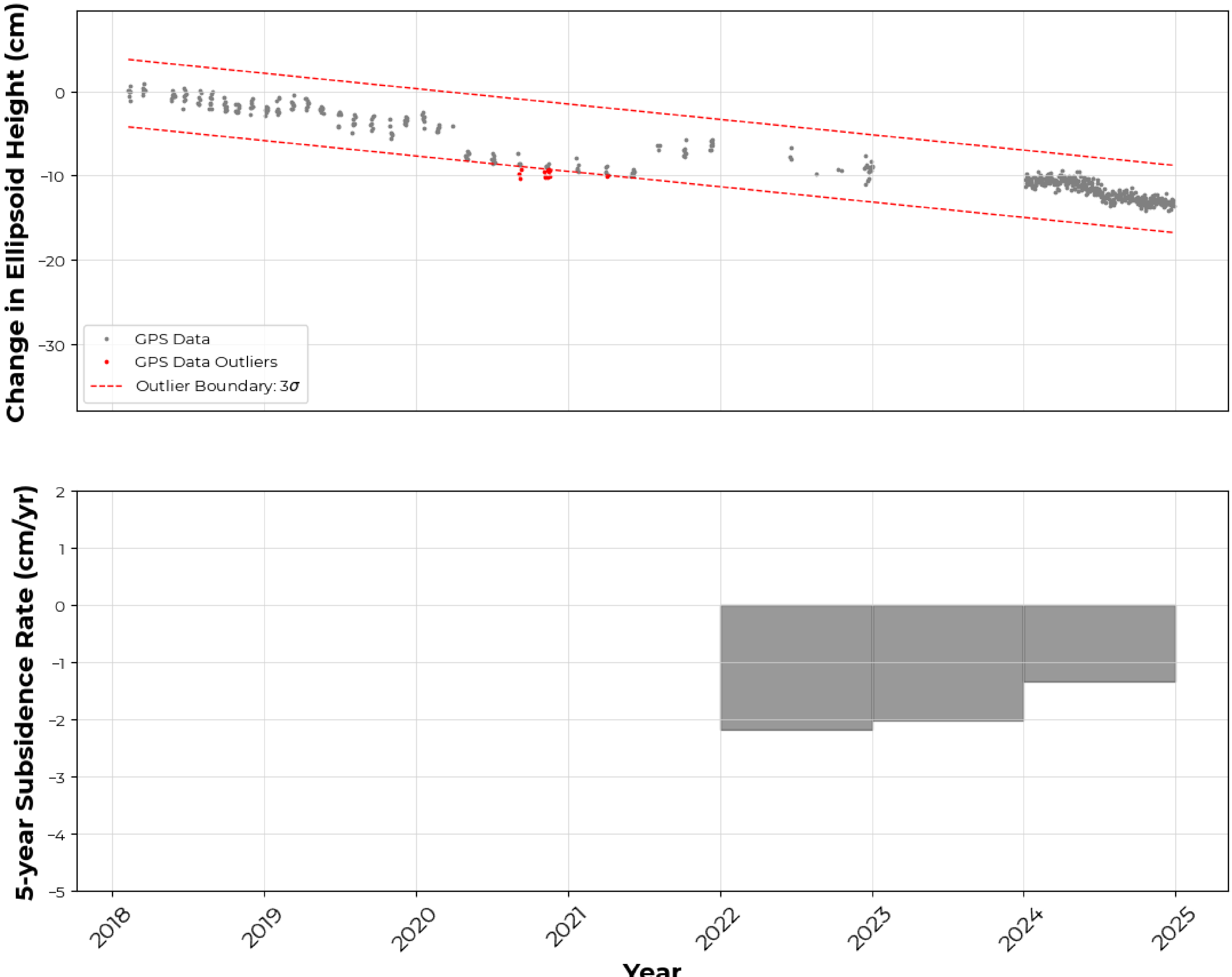
P097



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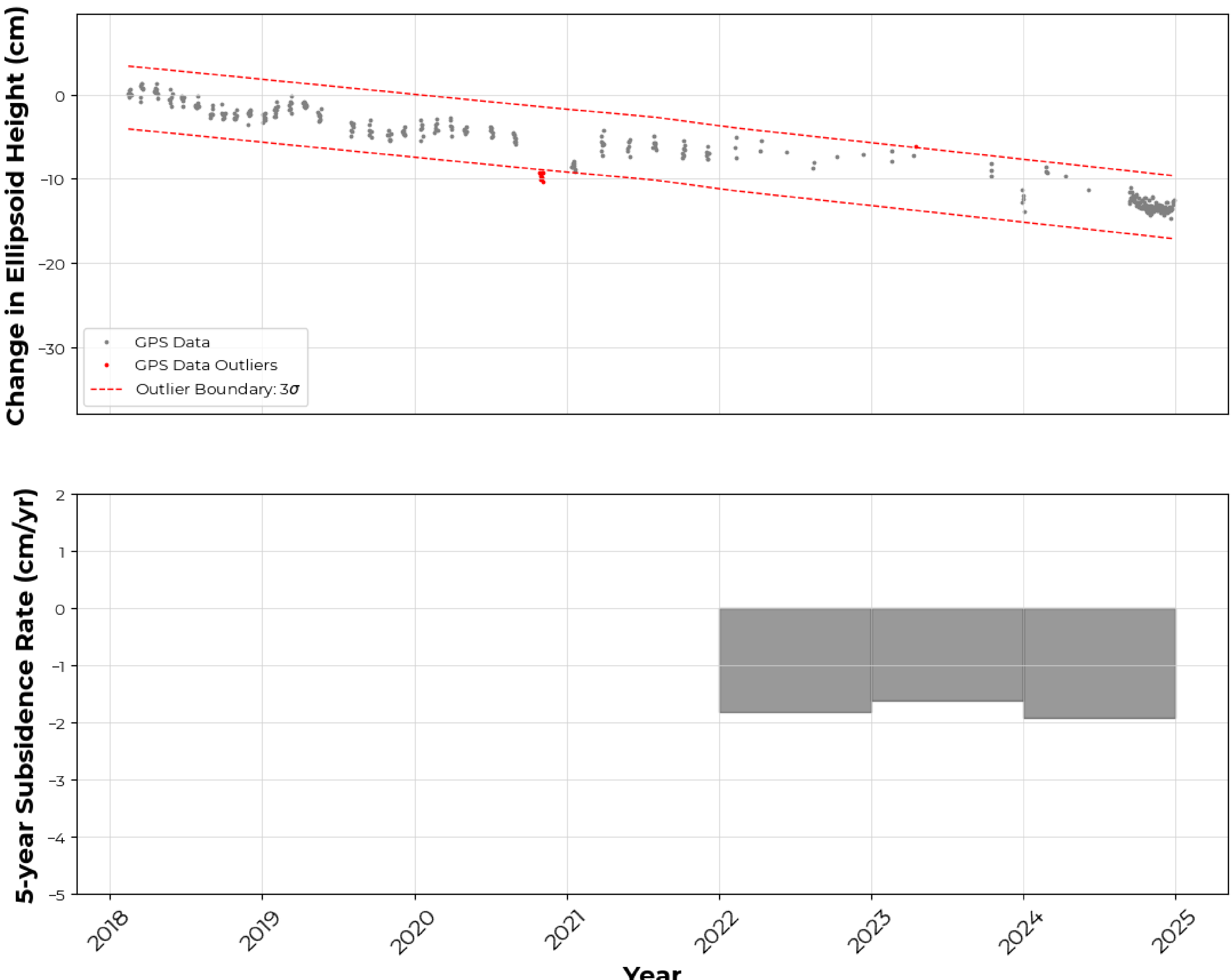
P098



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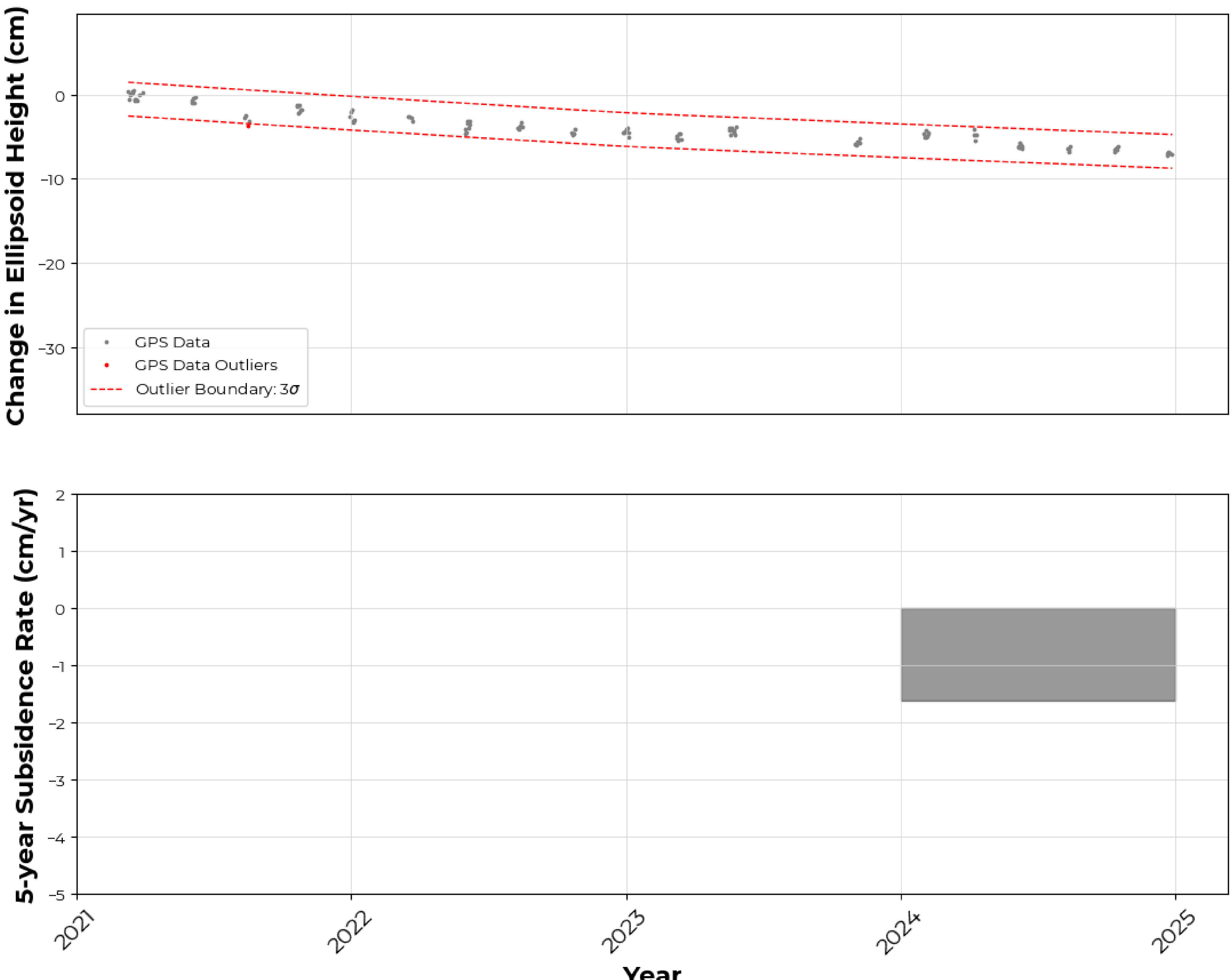
P110



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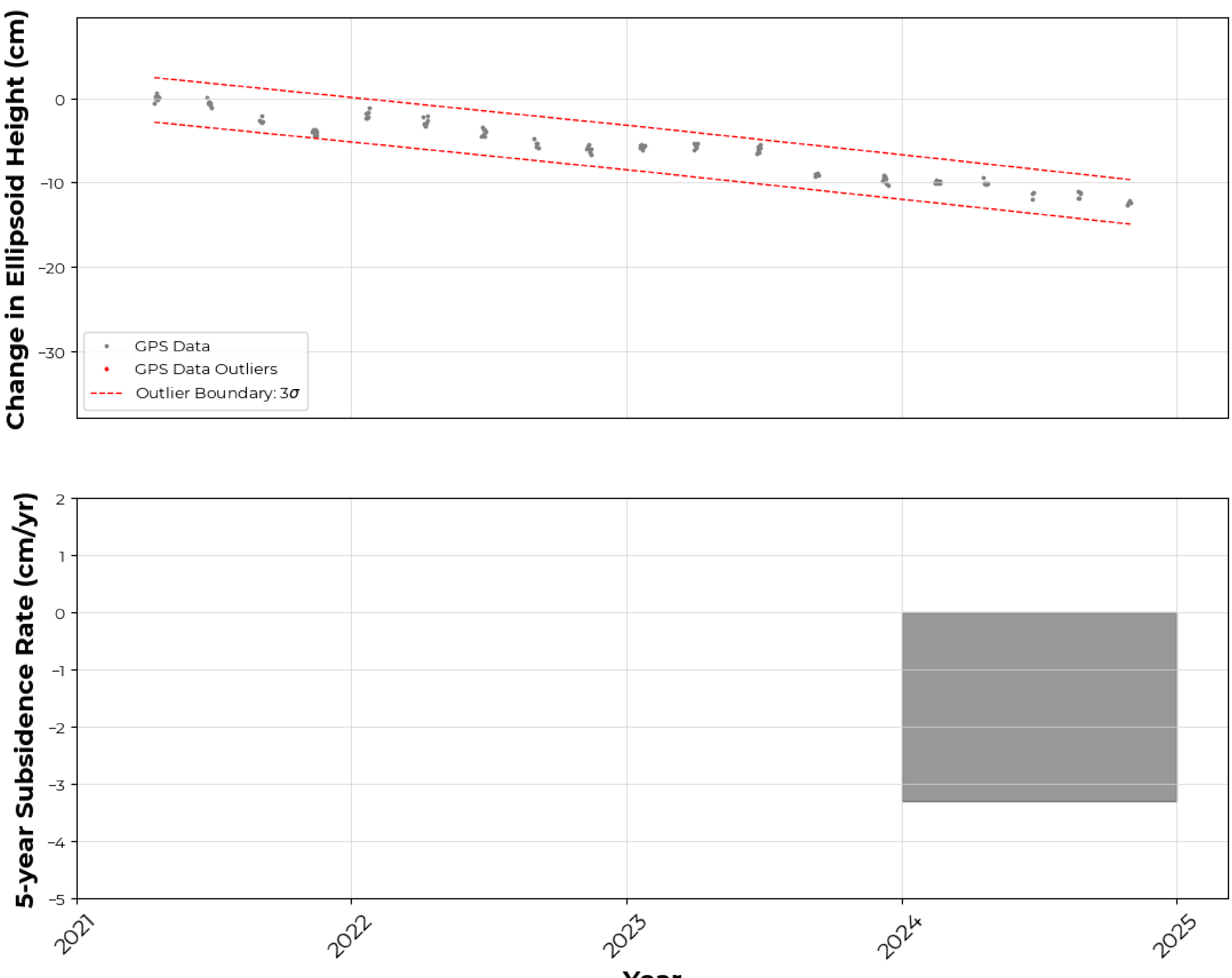
P111



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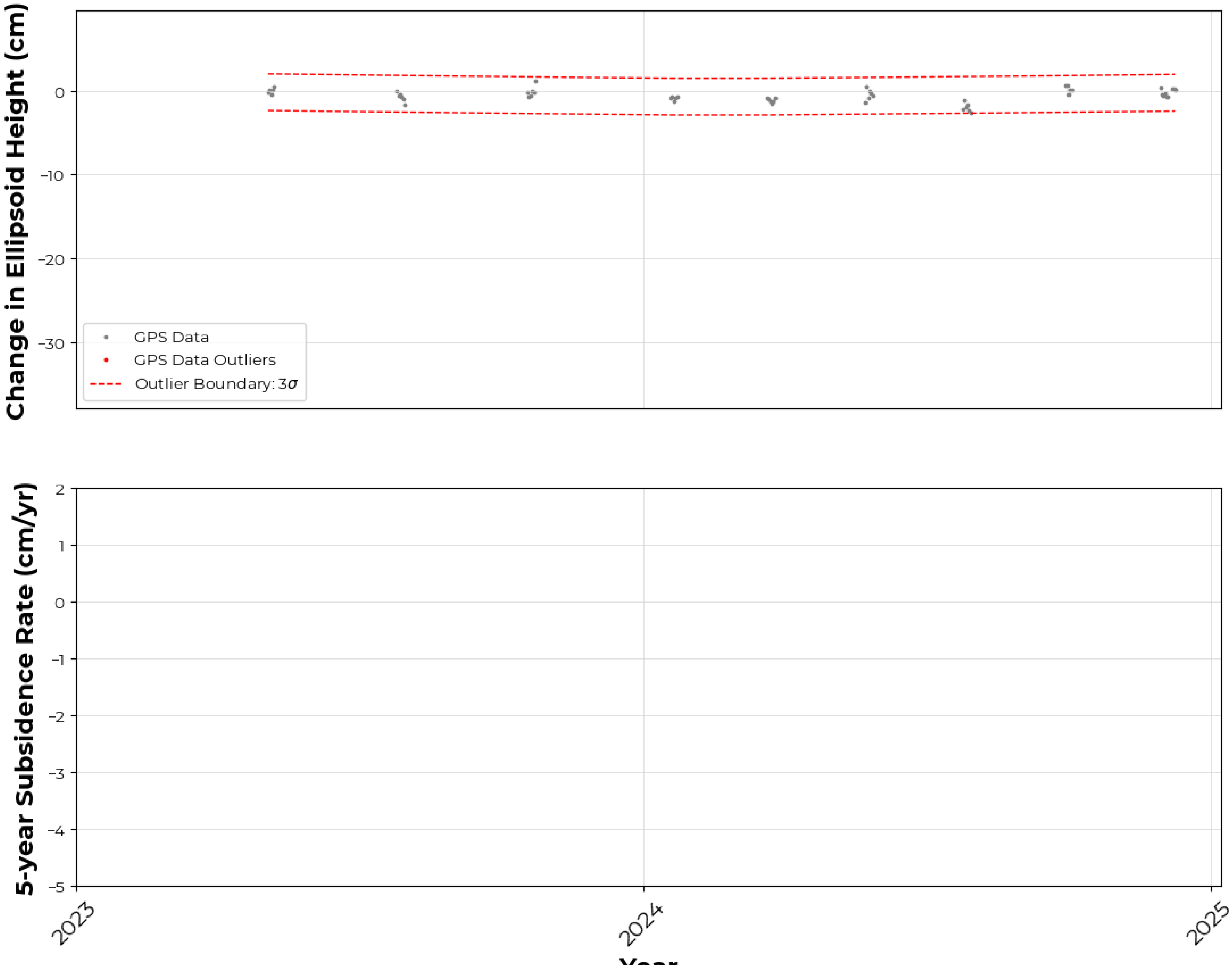
P113



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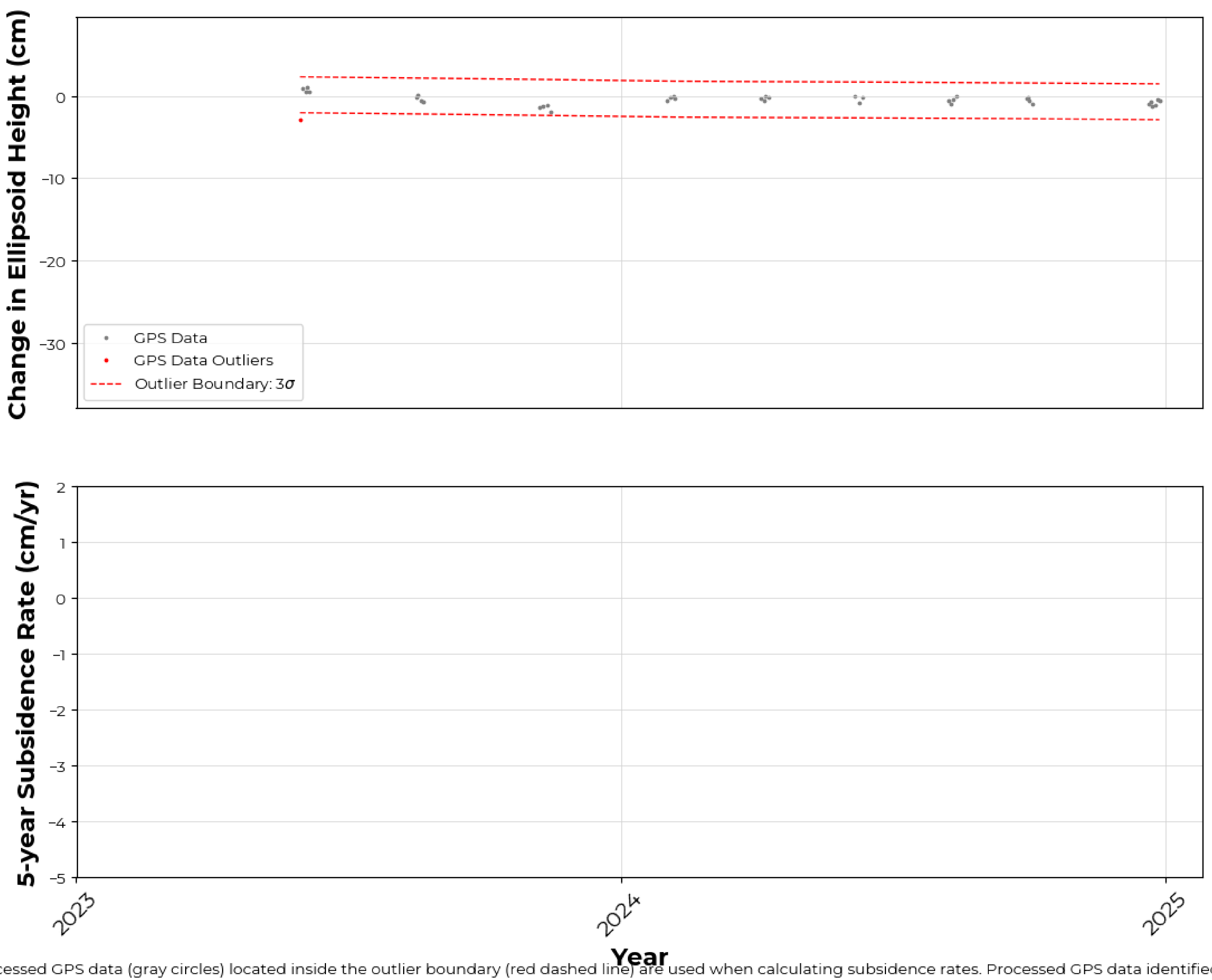
P114



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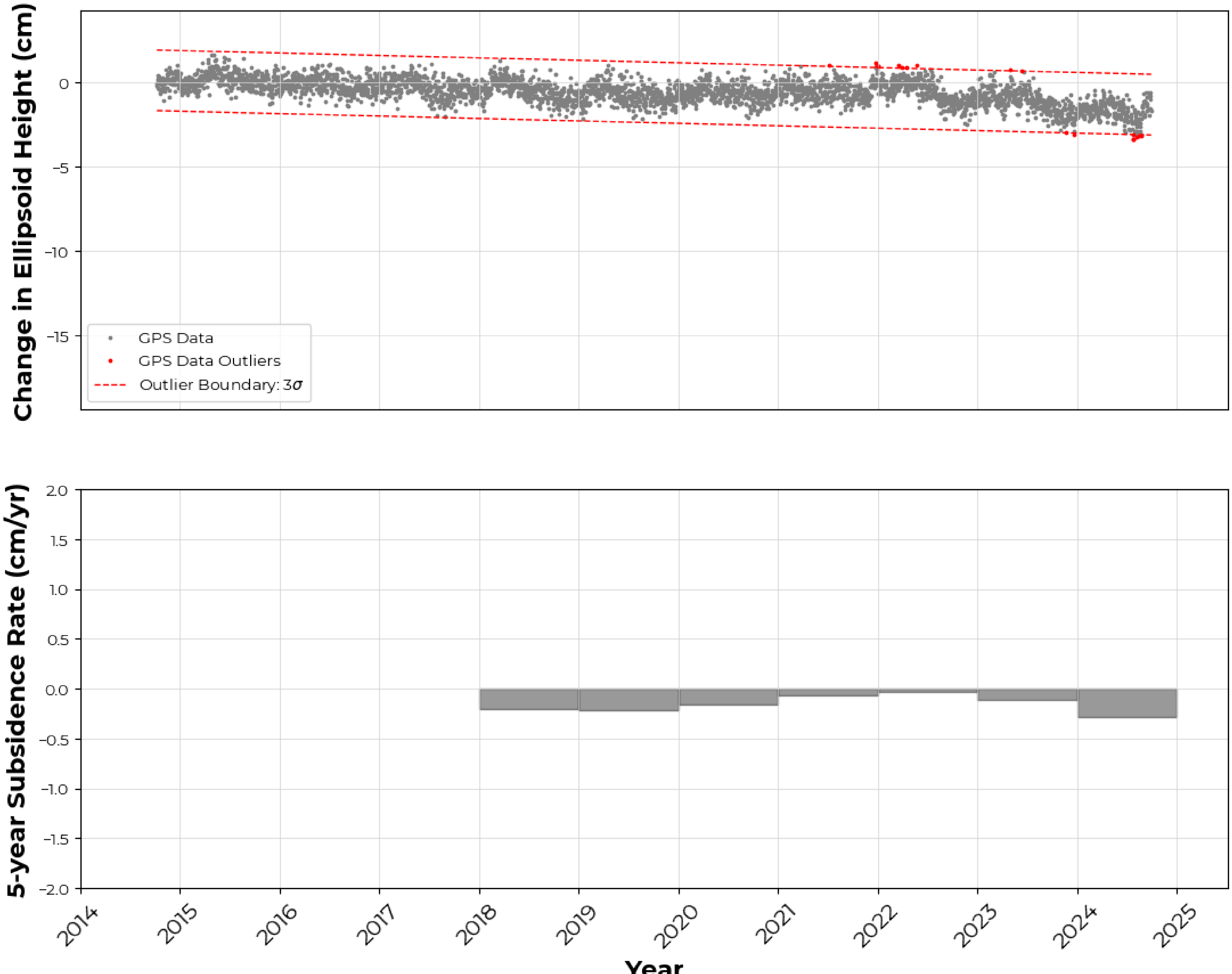
RPFB



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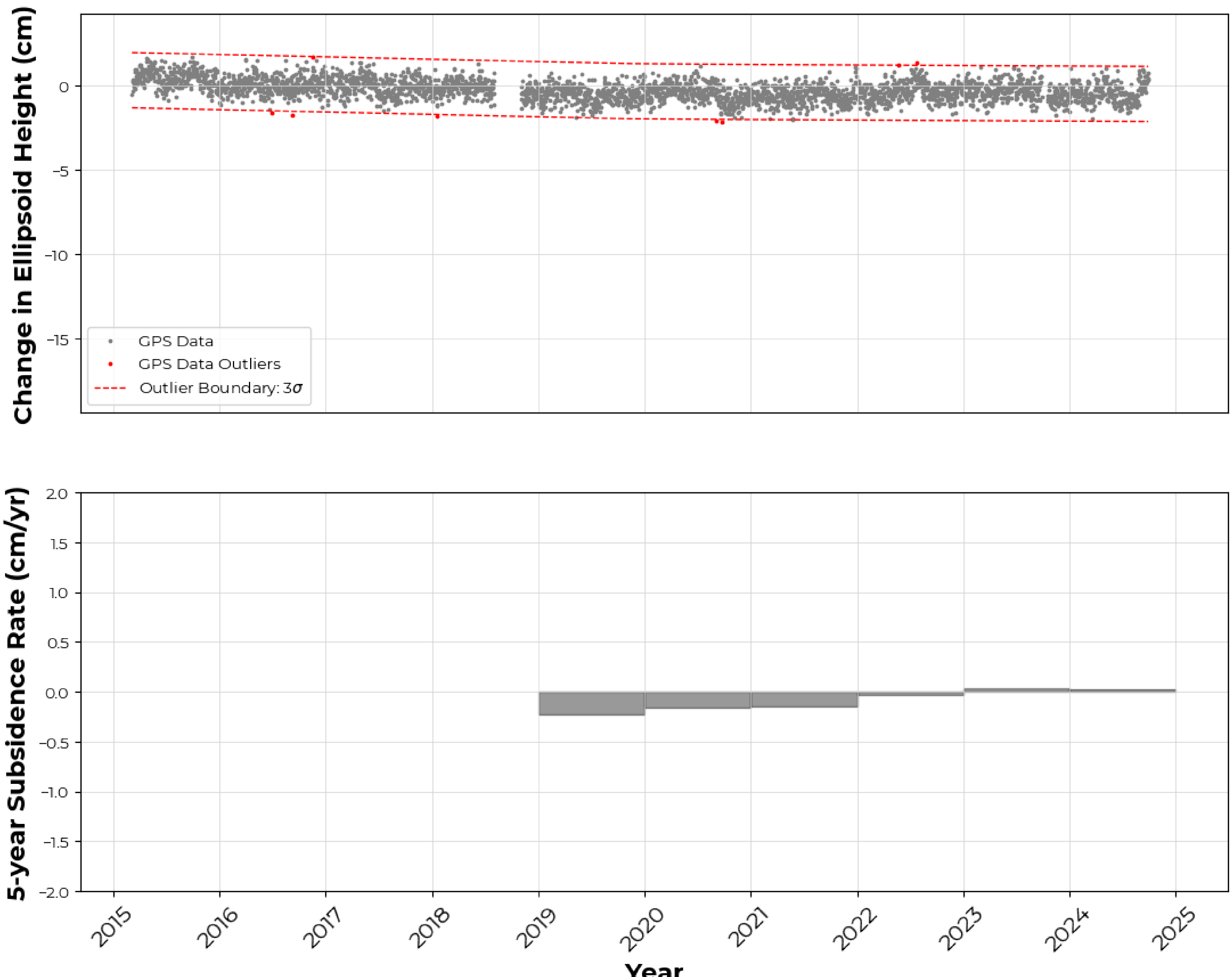
SISD



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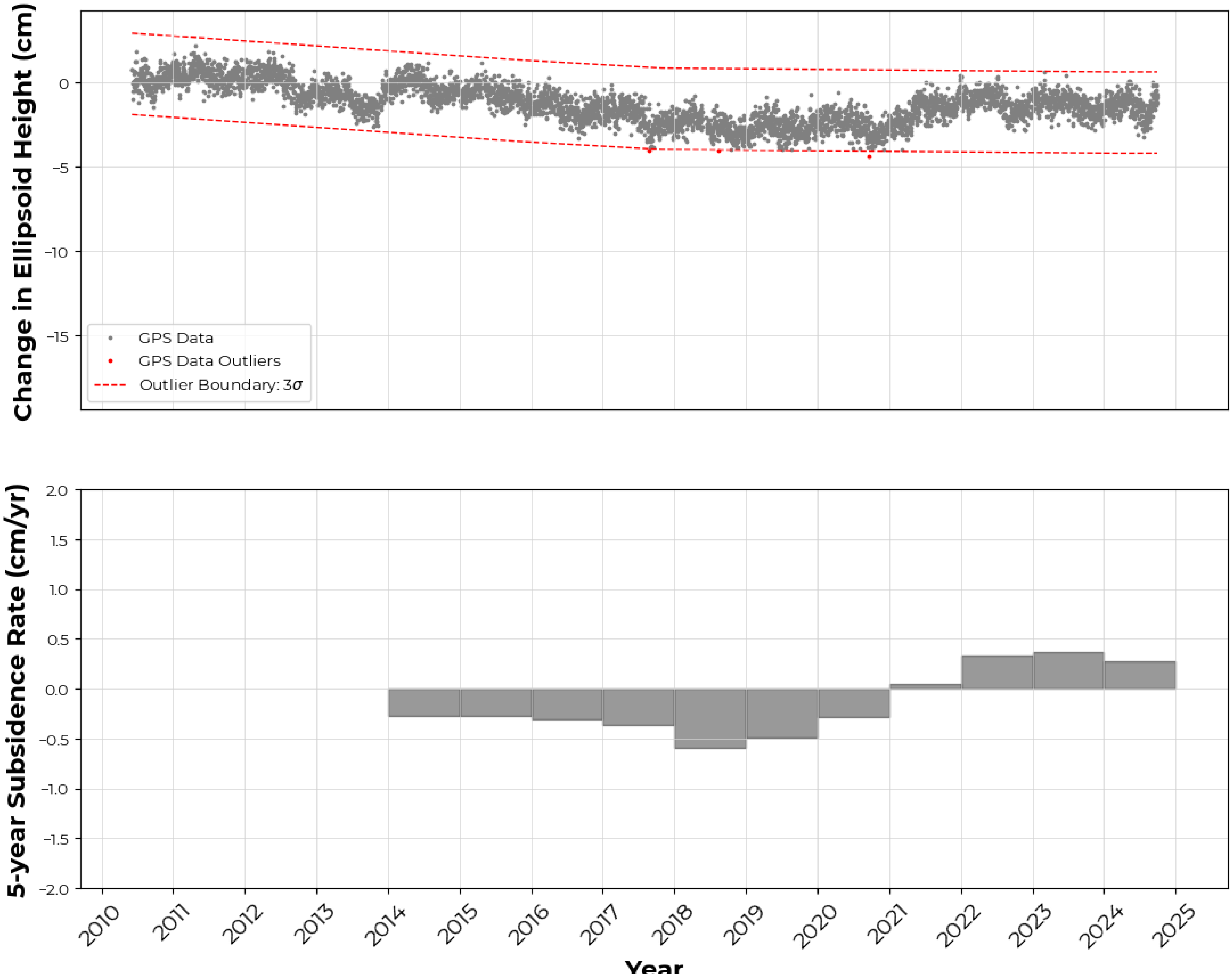
TXWH



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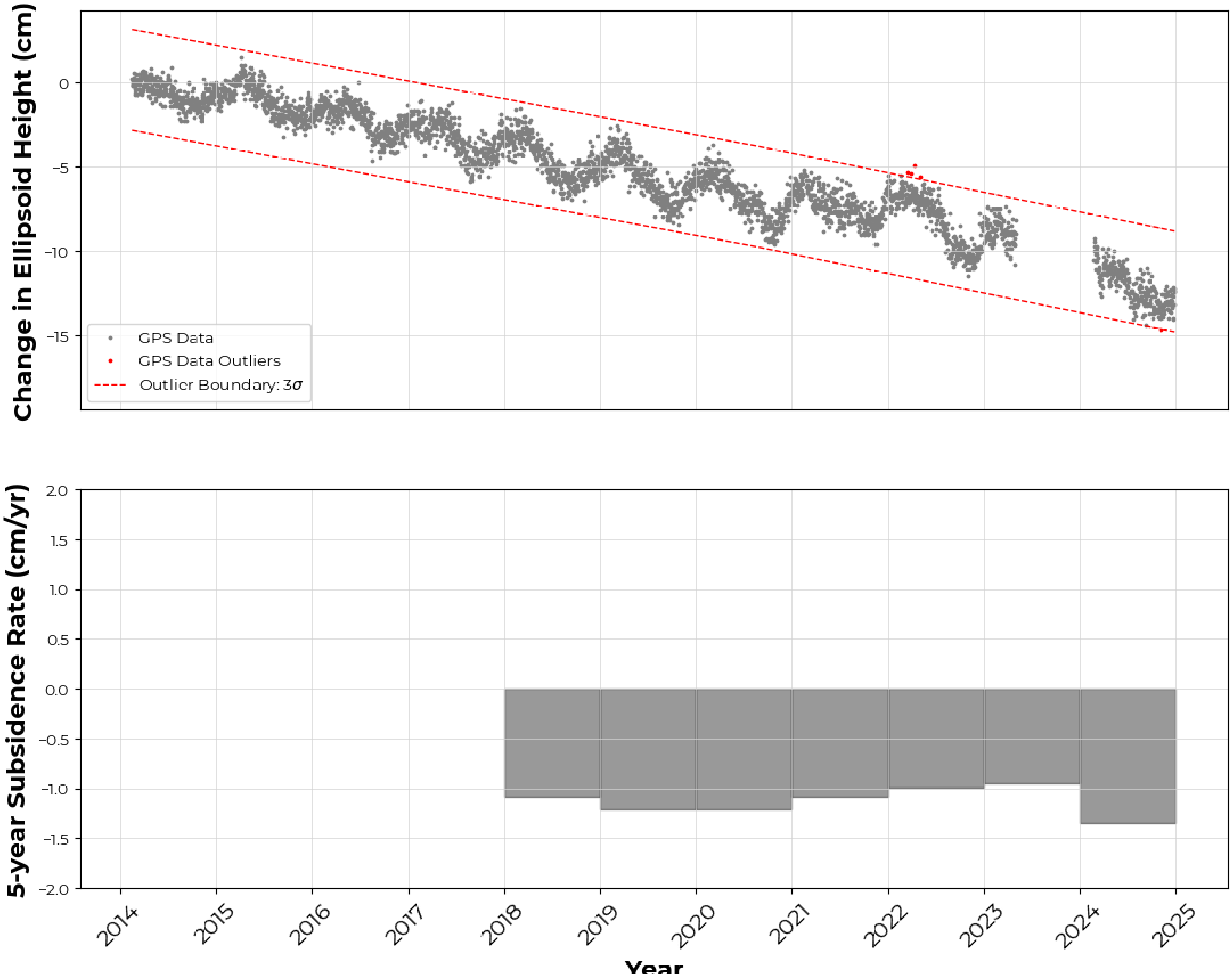
UHCR



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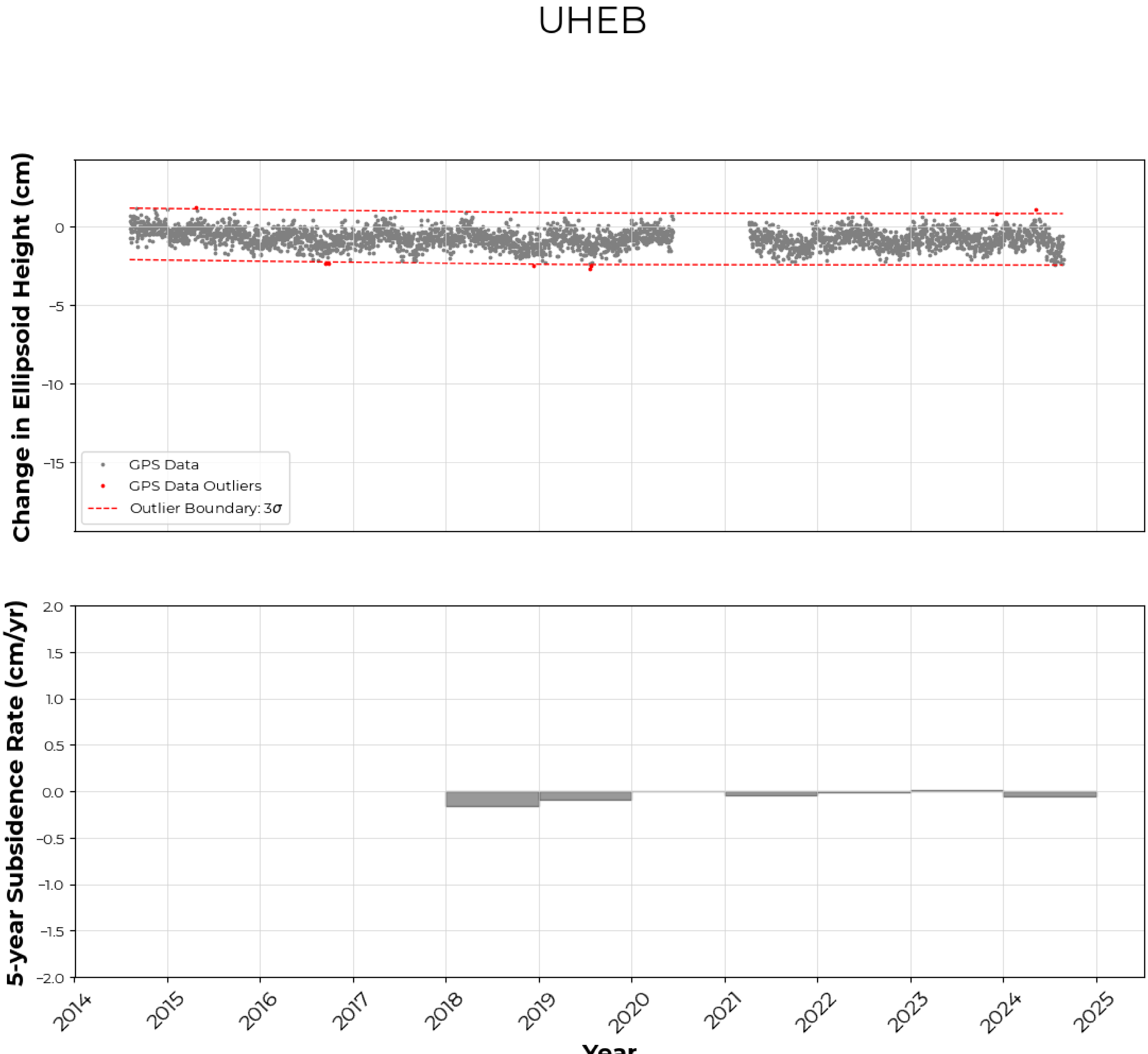

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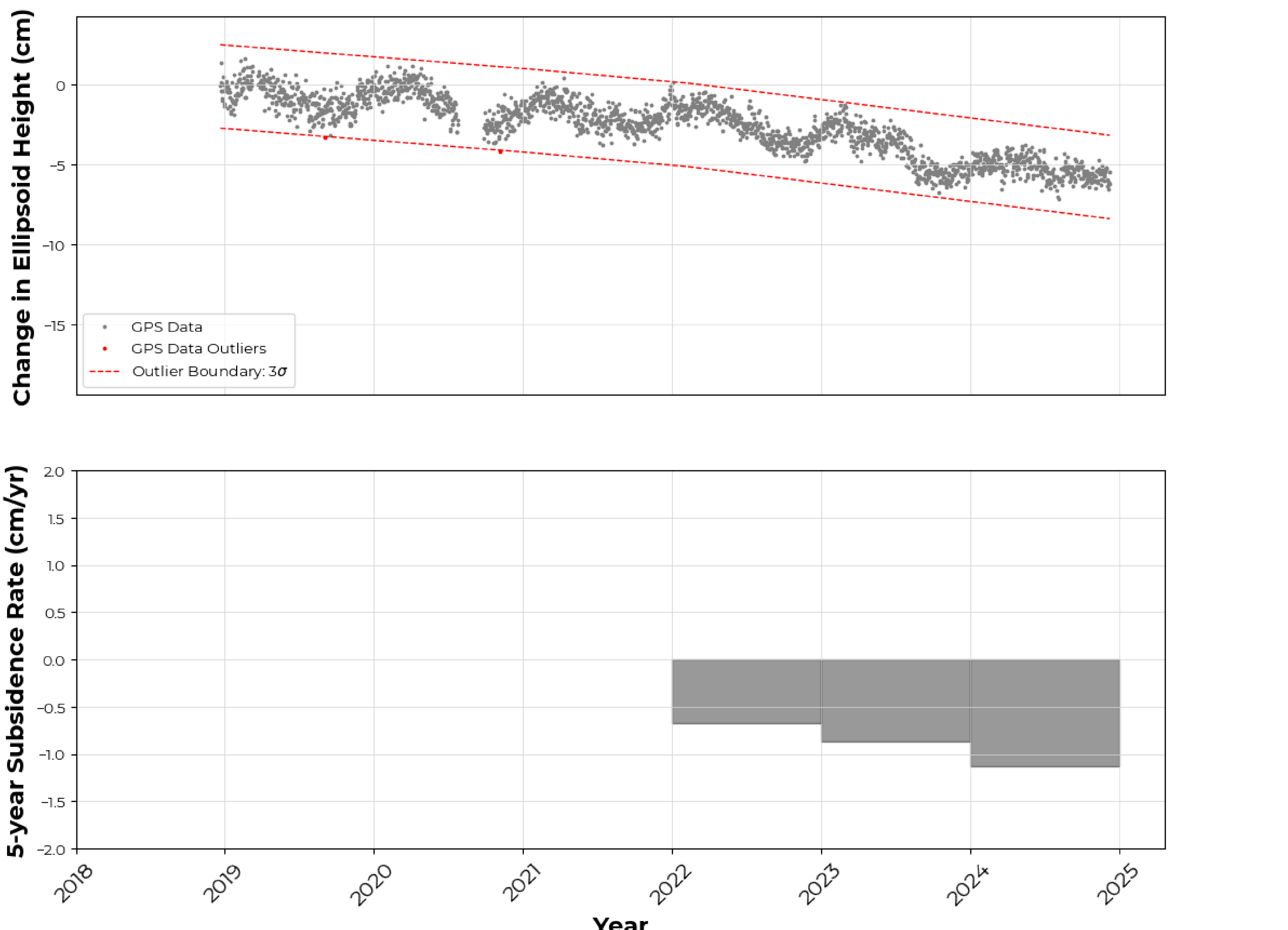
UHKD



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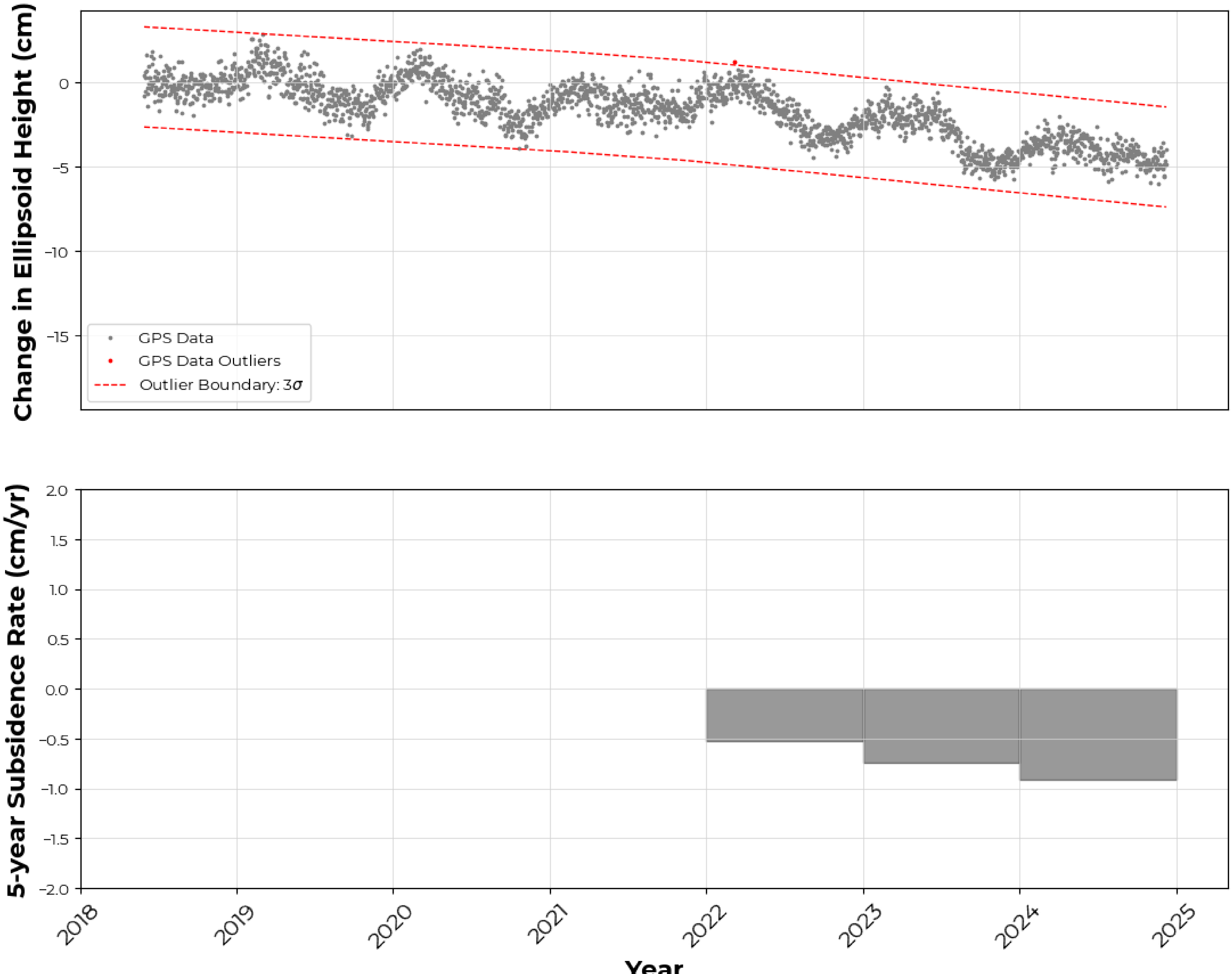
UHKS



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Appendix C – Public Testimony and Comment

The public hearing for the 2024 Annual Groundwater Report was held on April 29, 2025, and the record remained open for public testimony and comment until May 7, 2025. Five questions were received and answered at the public hearing and are summarized below.

Question 1: Why wasn't the extensometer in Fort Bend shown?

Response: *Mr. Jason Ramage (Hydrologist, USGS) answered that the data from the Cinco MUD extensometer are in review as some issues were identified and are being analyzed.*

Question 2: How are the GPS stations calibrated?

Response: *The GNSS receiver is manufactured by Trimble and has firmware that is updated on an annual basis or as applicable based on Trimble's release of new versions of firmware. Additionally, data collected from the GPS stations are processed using a stable reference frame that removes some noise from geologic processes and outliers are omitted prior to the calculation of subsidence rates. For additional information on the GPS station data methodology, please see https://doi.org/10.1061/(ASCE)SU.1943-5428.0000399.*

Question 3: How does FBSD determine the basin distinction?

Response: *The watershed basins provided in the report are taken from the Texas Water Development Board as referenced in the Surficial Hydrology section of the main report.*

Question 4: The Cinco Ranch MUD data was not shown during the presentation. If the meter data is deemed accurate and acceptable, will there be an amendment to the report that'll be published? I would like to see the compaction data for Fort Bend County.

Response: *Mr. Jason Ramage (Hydrologist, USGS) responded that at this time, the data from the Cinco MUD extensometer are in review. An issue regarding the stability of the extensometer inner stem is being evaluated. If after the evaluation period, the data are deemed to be accurate, those data will be included in the report.*

Question 5: Does the subsidence district utilize this compaction data in any decisions during the JRPR process? If so, why aren't there more study sites in FB County?

Response: *The District reviews compaction data as reported by the USGS every year as part the Annual Groundwater Report. Compaction data are incorporated within the updated groundwater flow and subsidence model (i.e., GULF 2023) upon calibration up to 2018 as part of the Joint Regulatory Plan Review (JRPR) process. Please see https://doi.org/10.3133/pp1877 to access the model utilized in the JRPR project. Extensometers are expensive, for example over one million dollars, to install because of the depth and design. Extensometers were originally installed in the region back in the 1970s to understand the mechanism of subsidence. As the data confirmed that subsidence was occurring due to aquifer compaction, additional extensometers were not installed.*