Determination of Groundwater Withdrawal and Subsidence in Harris and Galveston Counties – 2021

by
Ashley Greuter, P.G.

Harris-Galveston Subsidence District Report 2022-01

Harris – Galveston Subsidence District
Friendswood, TX
2022

MICHAEL J. TURCO

GENERAL MANAGER

The Harris-Galveston Subsidence District (District) has been monitoring water use, groundwater levels, and subsidence in Harris, Galveston, and adjacent counties since 1975. Subsidence, the lowering of land-surface elevation, is caused by the depressurization of our aquifers due to wide-spread use of groundwater as a primary water source. The mission of the District is to cease on-going 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 ground water 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 Harris-Galveston and Fort Bend Subsidence Districts with the City of Houston, the U.S. Geological Survey, the Brazoria County Groundwater Conservation District, and the Lone Star Groundwater Conservation District. This year this multi-agency partnership will publish the 46th volume of this important data compilation. This report is intended to exceed the requirements of section 8801.117 of the District's enabling legislation.

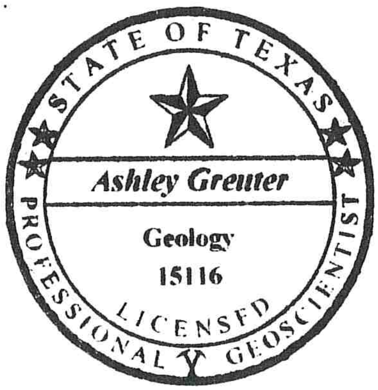
On behalf of the Board of Directors of the Harris-Galveston Subsidence District, I would like to thank you for your interest in the District. We look forward to continuing to provide timely, accurate, high-quality data and research to inform the District's Regulatory Planning efforts to prevent subsidence 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 report including preparation of report figures, tables, and writing sections. 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 5/11/22

Ashley Greuter

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Acknowledgements

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Public Hearing Notice was posted on:	March 14, 2022
Draft Presentation Posted on District Website on:	April 25, 2022
Public Hearing held on:	April 28, 2022
Hearing Examiner:	Ms. Helen Truscott
Hearing Record held open for public comment until:	May 6, 2022
Approved by the Board of Directors:	May 11, 2022

Conversions Factors and Datums

Multiply	By	To obtain
inch (in)	2.54	centimeter (cm)
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
FBSD	Fort Bend Subsidence District
GNSS	global navigation satellite system
GPS	global positioning system
GRP	groundwater reduction plan
HGSD	Harris-Galveston Subsidence District
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 the municipal, agricultural, and industrial users over the last century. Rapid increase in population in the 1950s, due to the expansion of the industrial complex in the Houston Ship Channel area, led to a dramatic increase in water demand and groundwater withdrawal. The reliance on groundwater and subsequent subsidence that was caused by its regional development resulted in the creation of the Harris-Galveston Subsidence District (District) in 1975 and the Fort Bend Subsidence District in 1989. The District's mission is to regulate the use of groundwater in Harris and Galveston counties to cease ongoing and prevent future subsidence that can lead to infrastructure damage and contribute to flooding.

This report comprises the 46th Annual Groundwater Report for the District. Pursuant to District Resolution No. 2022-1081 passed on February 9, 2022, the Board of Directors held a public hearing at 10:00 a.m. on April 28, 2022 to present climatic conditions, groundwater use, groundwater levels and measured subsidence within the District through December 31, 2021. This report provides an overview of the information presented during the Public Hearing.

Climate

Annual variations in precipitation can significantly impact the total water demand in the District. Groundwater use patterns fluctuate during periods of climatic variation, which results in changes in aquifer water-levels and potentially in subsidence rates. 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 rates of subsidence. The 2021 calendar year began with normal to below normal rainfall accumulations, followed by Winter Storm Uri that resulted in prolonged, record-breaking freezing temperatures and wintry precipitation affecting power grids across the Galveston, Harris, and Fort Bend counties in mid-February. From late spring through summer, the majority of climate stations experienced above normal precipitation alleviating some minor dry conditions in the District. Hurricane Nicholas made landfall as a Category 1 hurricane in southern Harris and Galveston counties in late September bringing several inches of rain and gusty winds. For the remainder of the year, rainfall accumulations averaged above normal for the majority of the District.

Water Use

Since 1976, water users in the District have been working to change their source water from primarily groundwater to alternative sources of water, primarily treated surface water in an effort to prevent subsidence. The percent of total water demand sourced from groundwater has dropped from about 60 percent in 1976 to about 21 percent in 2021. Most of the current groundwater use occurs in Regulatory Area Three where the regulatory compliance timeline will not be completed until 2035. The three-primary water uses in the District are public supply, industrial, and irrigation. The overall groundwater use within the District in 2021 is 203.6 MGD, which is a four percent decrease in pumpage from 2020. Public supply groundwater use remains the largest single use category at 187.2 million gallons per day (MGD), a three percent decrease from 2020, and accounts for 92 percent of groundwater used in the District.

The District's Regulatory Plan requires permittees to convert to alternative water supplies in order to reduce their reliance on groundwater. 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. In 2021, the total alternative water use was 783 MGD, with the Trinity River remaining the single largest source of alternative water providing a total of 535.9 MGD in surface water supply. Groundwater remains the second largest source of water supply within the District as a whole. The total water use for the District was 986.7 MGD in 2021, which is half a percent higher than the reported water use in 2020.

Groundwater Levels

Annually, since 1975, the United States Geological Survey (USGS) has measured the water level in hundreds of wells throughout the Houston region in cooperation with the District through a joint funding agreement along with additional cities, subsidence districts and groundwater conservation districts. These data are used to monitor the groundwater level altitude data for the Chicot/Evangeline and Jasper aquifers and evaluate the temporal change in water-level. 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 of changes in water use on subsidence.

The change in water-level in the Chicot and Evangeline (undifferentiated) aquifers since 1977 clearly shows the impact of District regulation on the aquifers. Generally, Regulatory Areas One and Two have seen a significant rise in the potentiometric water-level over 230 feet (70 meters) in the Chicot and Evangeline (undifferentiated) aquifers. The area of rise is a result of the reduction of groundwater use required by the District's Regulatory Plan. Conversely, in Regulatory Area Three and in southern Montgomery County, water-levels continue to be significantly lower than the historical benchmark, declines of over 250 feet (76 meters) in the Chicot and Evangeline (undifferentiated) aquifers. These areas are growing rapidly and the conversion to alternative sources of water will not be completed in the District until 2035.

Subsidence

Since the 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 220 GPS stations throughout the region. These stations are operated by the District, the Fort Bend Subsidence District (FBSD), the University of Houston (UH), the Lone Star Groundwater Conservation District (LSGCD), the Brazoria County Groundwater Conservation District (BCGCD), Texas Department of Transportation (TXDOT), and other local entities.

The average annual rate of vertical movement is a useful measure to show current conditions at a GPS station. The annual rates of subsidence observed in Regulatory Areas One and Two are stable, since both areas have reached their full regulatory conversion level (1990 and 1995, respectively) and Chicot/Evangeline water-levels have risen. Subsidence rates are generally above 0.5 centimeters (cm) per year throughout Regulatory Area Three as groundwater is still the primary source water in this area, and groundwater levels are significantly below the historical benchmarks. Regulatory Area Three is actively developing water infrastructure to reduce groundwater use in those areas by 2025 and 2035 as specified in the District Regulatory Plan.

Introduction

The Houston region 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 aquifers of 250 and 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 regional development resulted in the creation of the Harris-Galveston Subsidence District (District) in 1975 and the Fort Bend Subsidence District in 1989. The District's mission is to regulate the use of groundwater in Harris and Galveston counties in order to cease ongoing and prevent future subsidence that can contribute to flooding, faulting, and lead to infrastructure damage.

Purpose of Report

This document comprises the 46th Annual Groundwater Report for the District. Pursuant to District Resolution No. 2022-1081 passed on February 9, 2022, the Board of Directors held the Annual Groundwater Hearing beginning at 10:00 a.m. on April 28, 2022. The public hearing was held at the District office and also offered virtually for viewing purposes only. The public hearing fulfills the requirements of Section 8801.117, 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 during the preceding year.

The hearing was attended by 31 people, which includes both in person and virtual participants, registered for the Hearing including members of the USGS staff, members of the District's staff, two Directors, representatives from neighboring groundwater conservation districts and the public. Those giving testimony were Ms. Ashley Greuter, Program Manager – Monitoring and Research, of the District and Mr. Jason Ramage, Hydrologist, Gulf Coast Programs Office, Texas-Oklahoma Water Science Center, of the United States Geological Survey, Department of the Interior. Ms. Greuter submitted 16 exhibits including topics of precipitation, groundwater withdrawal, alternate-water usage, and subsidence measurements. Mr. Ramage presented 20 exhibits including topics of water-level altitudes, water-level changes, and aquifer compaction. The record for testimony and public comment was open from April 28, 2022 through May 6, 2022. One (1) comment was received and is included in its entirety in **Appendix D – Testimony and Public Comment from the Public Hearing**.

This report provides a general description of the District, which includes hydrogeology, alternative water sources, and regulatory planning, as well as an overview of the information presented during the Public Hearing, including climatic conditions, reported groundwater use, groundwater levels and measured subsidence within the District from January 1, 2021 through December 31, 2021. **Appendix A** of this report includes the exhibits presented at the public hearing held on April 28, 2022.

Description of the Study Area

The following section provides an overview of the study area, including the hydrogeology and an overview of 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.

The three-primary water-bearing units located within the District include the Chicot, Evangeline, and Jasper aquifers. The Chicot and the Evangeline aquifers comprise the shallow system of aquifers. These aquifers are hydrologically connected, allowing for the free flow of water between the two units. Historically, nearly all of the groundwater production in the Gulf Coast Aquifer System in the District occurred in the shallow system. Recently, an updated stratigraphic approach incorporated new data from approximately 650 geophysical logs and adjusted the bottom of the Chicot aquifer by extending it deeper (Young & Draper, 2020). This updated approach changed aquifer designations such that wells that were previously defined as screened in the Evangeline are now considered to be screened in the Chicot. As a result of this modification, the USGS has combined the Chicot and Evangeline aquifers into an undifferentiated shallow aquifer system called the Chicot and Evangeline (undifferentiated) in this report as shown in **Figure 1**.

The Jasper aquifer is the deepest of the three primary water bearing units and is isolated by the regionally persistent Burkeville confining unit. In the region, the Catahoula Sandstone, the deepest water bearing unit in the Gulf Coast Aquifer system and the Burkeville confining unit are utilized as a groundwater supply in areas to the north and west of the District where these units may produce appreciable amounts of water.

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 and the decline in the aquifers' potentiometric surface. 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 under high stress from groundwater development, and have had sustained potentiometric water-level declines (Yu, et al., 2014).

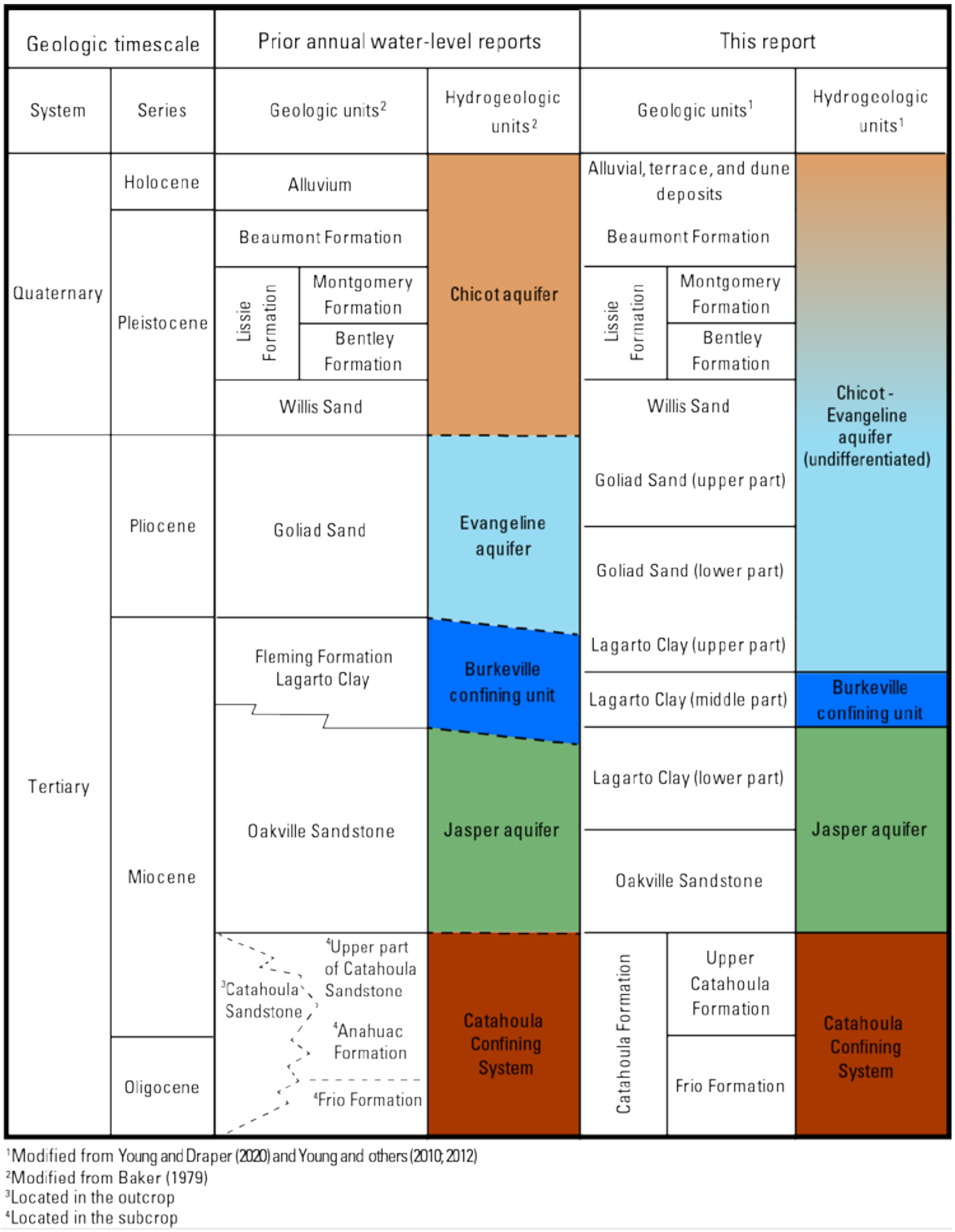

Figure 1. Updated stratigraphic column of the Gulf Coast Aquifer System in Harris and adjacent counties, Texas (Source: Braun and Ramage, 2022 [*in Press – to be published in June 2022*]).

Surficial Hydrology

The District's Regulatory Plan requires permittees to convert to alternative water supplies in order to reduce their reliance on groundwater sources. The primary alternative water supplies used in the Houston region is surface water sourced from three river basins: the Brazos River Basin, the San Jacinto River Basin and the Trinity River Basin (**Figure 2**).

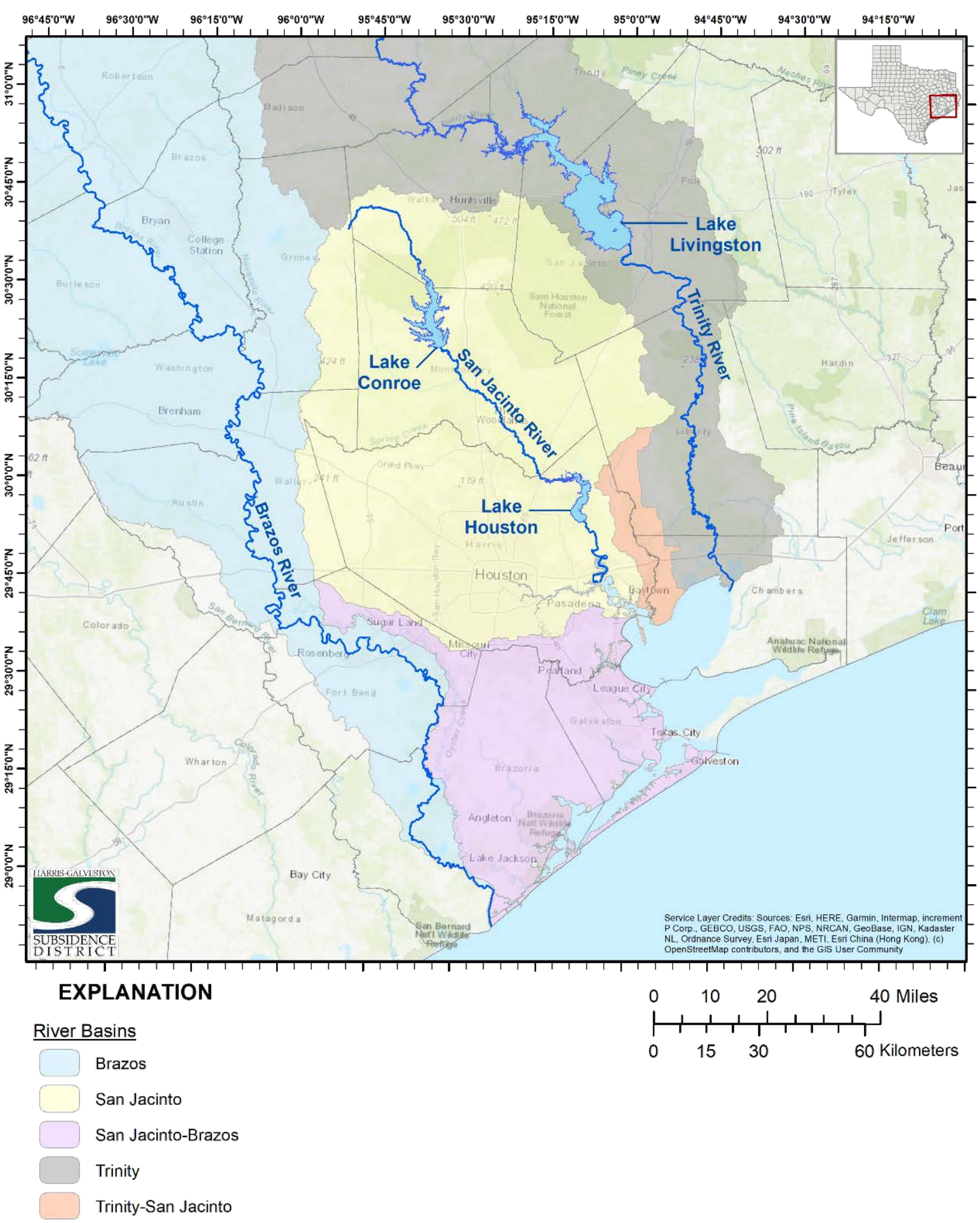

Figure 2: River basins that supply alternative water to Harris and Galveston counties, Texas.

The Brazos River Basin is the second largest river basin in Texas, covering over 45,000 square miles (116,550 sq km) (TWDB, 2020). The headwaters of the Brazos River are located near the Texas-New Mexico border and the river travels over 800 miles (1,287 km) to discharge into the Gulf of Mexico near Freeport, Texas. The Brazos River Authority manages the 11 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 (10,360 sq. km) according to Texas Water Development Board (2020). 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 (46,619 sq. km), with headwaters of the basin located in north central Texas (TWDB, 2020). The Trinity River flows through the Dallas-Fort Worth metroplex, traversing 550 miles (885 km) until the river discharges into Trinity Bay near Anahuac, Texas. There are numerous reservoirs located on the Trinity River that are owned and operated by several different agencies, including Lake Livingston which is owned and operated by Trinity River Authority.

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 within the San Jacinto and Trinity River Basins to provide water for the rapidly growing region. Today, water treatment plants served by these surface water sources and the Brazos River Basin are operated by the City of Houston, City of Sugar Land, City of Richmond, the Gulf Coast Water Authority, the Brazosport Water Authority, and others.

To meet the Harris-Galveston and Fort Bend Subsidence Districts' regulatory requirements to convert from groundwater to surface water, the City of Houston and four regional water authorities—the Central Harris County Regional Water Authority, North Fort Bend Water Authority, North Harris County Regional Water Authority, West Harris County Regional Water Authority, and Coastal Water Authority (collectively, the Water Authorities) – began working together to plan, design, finance, and construct several major infrastructure projects.

Four projects are underway to develop the necessary alternative water supply and distribution infrastructure to facilitate the District's future conversion requirements (**Figure 3**):

- Luce Bayou Interbasin Transfer: will pump untreated surface water from the Trinity River through a series of canals and water pipelines along Luce bayou to Lake Houston.
- Northeast Water Purification Plant Expansion: will expand the existing surface water treatment plant located on Lake Houston from 80 MGD up to 400 MGD, in order to treat the raw surface water conveyed by the Luce Bayou Interbasin Transfer project.
- Northeast Transmission Line Project: will provide for the conveyance of the additional treated surface water from Lake Houston into central and northern Harris County.
- 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.

In addition to the four 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, when the next conversion requirements go into effect.

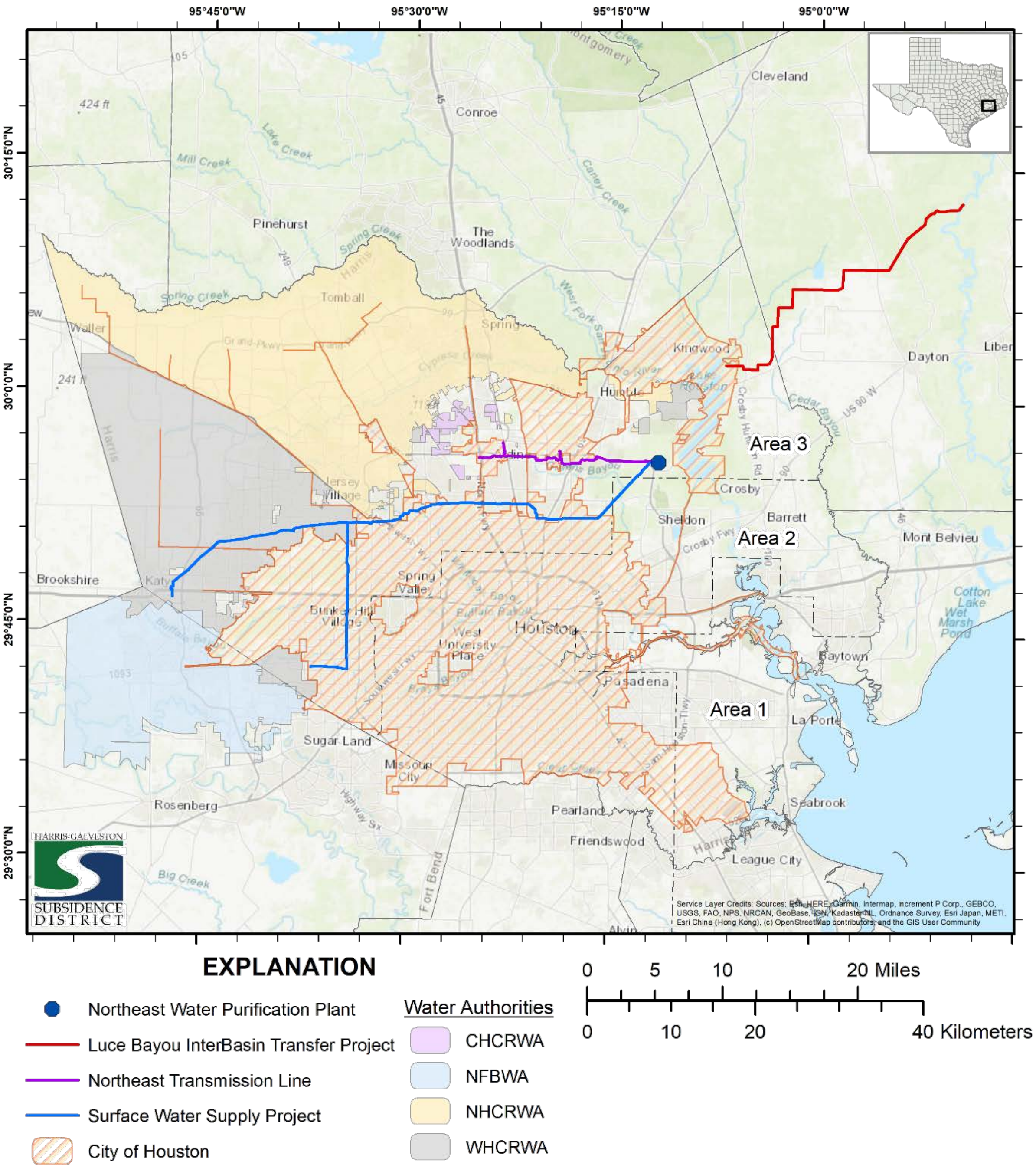

Figure 3: Alternative water supply and infrastructure distribution projects in the greater Houston region.

Regulatory Planning

The District's Regulatory 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 regulate groundwater withdrawal in order to prevent subsidence by allowing a portion of the total water demand of a water 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 Regulatory Plan on January 9, 2013 and it was subsequently amended on May 08, 2013 and April 14, 2021 (Harris-Galveston Subsidence District, Amended 2021).

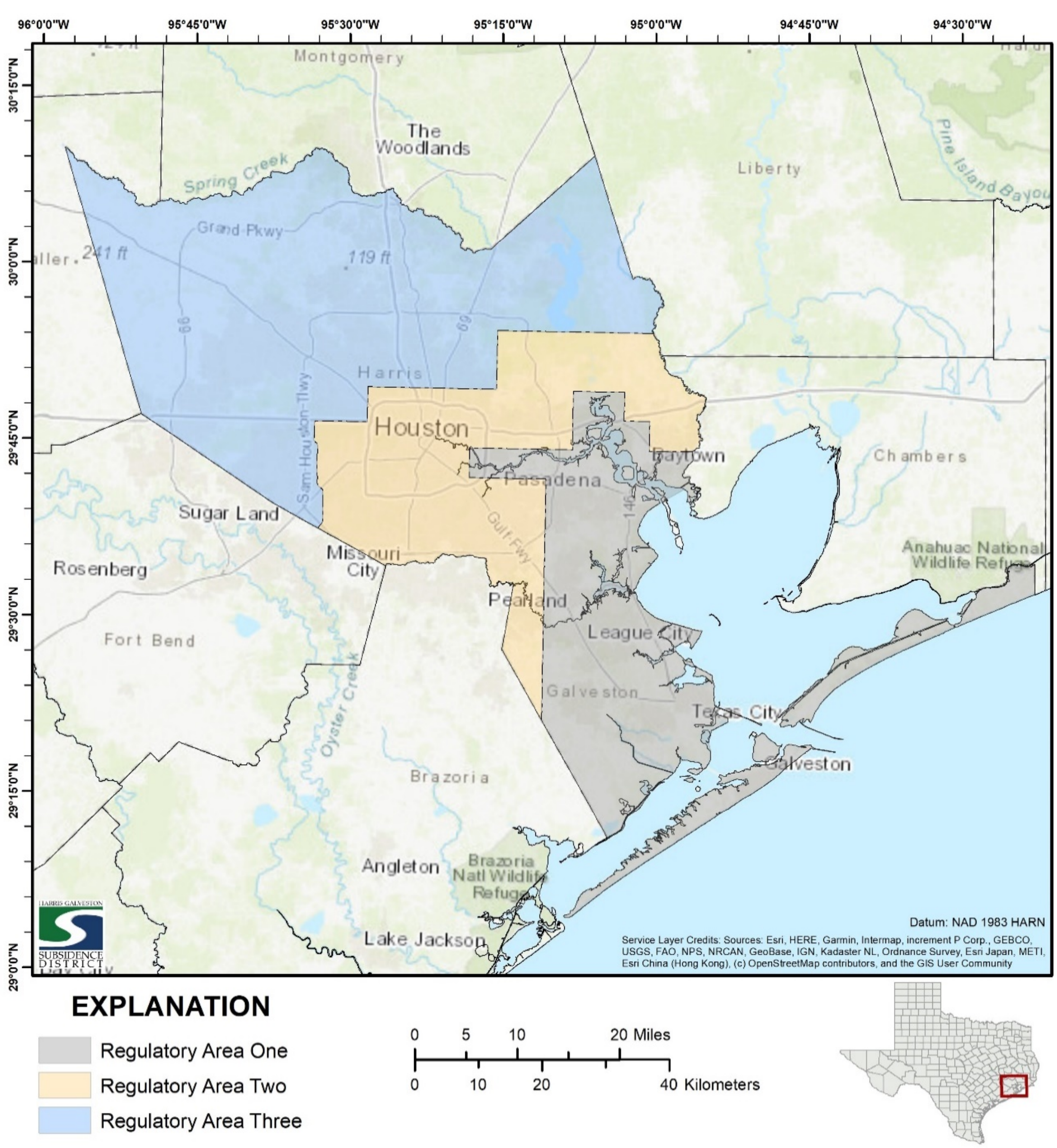

Figure 4. Location of the Harris-Galveston Subsidence District Regulatory Areas.

The District has historically used regulatory areas to guide groundwater conversion deadlines and regulations. The 2013 Regulatory Plan has subdivided Harris and Galveston counties into three regulatory areas (**Figure 4**). Regulatory Area One includes the Houston Ship Channel, Industrial Corridor, and coastal areas of Galveston and Harris Counties. Regulatory Area Two is primarily an urban intermediate area that includes downtown, the Texas Medical Center, and parts of eastern Harris County. Regulatory Area Three covers the remaining areas of the District in northern and western Harris County

Permittees in Regulatory Area One are required to have no more than 10% of their total water demand come from groundwater sources. Permittees in Regulatory Area Two must have no more than 20% of their total water demand come from groundwater sources. Reduction in groundwater use for both Regulatory Area One and Two began once the District was created in 1975, and by 1990 most of those areas had been fully converted to using alternative sources of water.

Regulatory Area Three is still undergoing conversion from groundwater to surface water sources. This area completed its first conversion in 2010 reducing groundwater use from 100% to 70% of total water demand. The District's Regulatory Plan allows permittees with more than ten million gallons per year of total water demand the option to establish groundwater reduction plans (GRPs) that provide a phased approach to conversion in Area Three with additional conditions in Area Two. For those permittees operating under a GRP in Area Three, permittees are required to adhere to the following future conversion deadlines:

- In 2025, groundwater withdrawals must not comprise more than 40 percent of the permittee's total water demand.
- In 2035, groundwater withdrawals must not comprise more than 20 percent of the permittee's total water demand.

All other permittees in Regulatory Area Three (i.e., those without GRPs) are required to reduce their groundwater withdrawals so that no more than 20 percent of their total water demand was sourced from groundwater.

2021 Climate Summary

The District reviews local climatic data provided from the National Oceanic and Atmospheric Administration (NOAA) – National Weather Service (NWS) climate stations within and adjacent to the District boundary (**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 from water users in the region as well as the availability of alternative water supplies, such as surface water. During period of above normal precipitation in the region, total water demand remains typically near normal or below normal due to reduced municipal and agricultural water uses. Conversely, during period of below normal precipitation, the total water demand of the region will typically increase due to increased water use. Additionally, during prolonged periods of below normal precipitation, natural limits on alternative supplies may require additional groundwater use – and subsequently result in additional lowering of groundwater levels, compaction of the aquifer materials, and subsidence observed at land surface.

Figure 5. Location of National Oceanic and Atmospheric Administration (NOAA)-NWS climate stations analyzed in the greater Houston region.

As shown in **Figure 6**, precipitation throughout 2021 is marked by below normal rainfall followed by prolonged above normal rainfall in the early summer through fall months for the majority of NWS climate stations analyzed. The cumulative precipitation departure from 1991-2020 normal precipitation is referenced against each NWS climate station displayed in **Figure 6**. Generally normal to below normal precipitation in the winter through spring was observed at all climate stations.

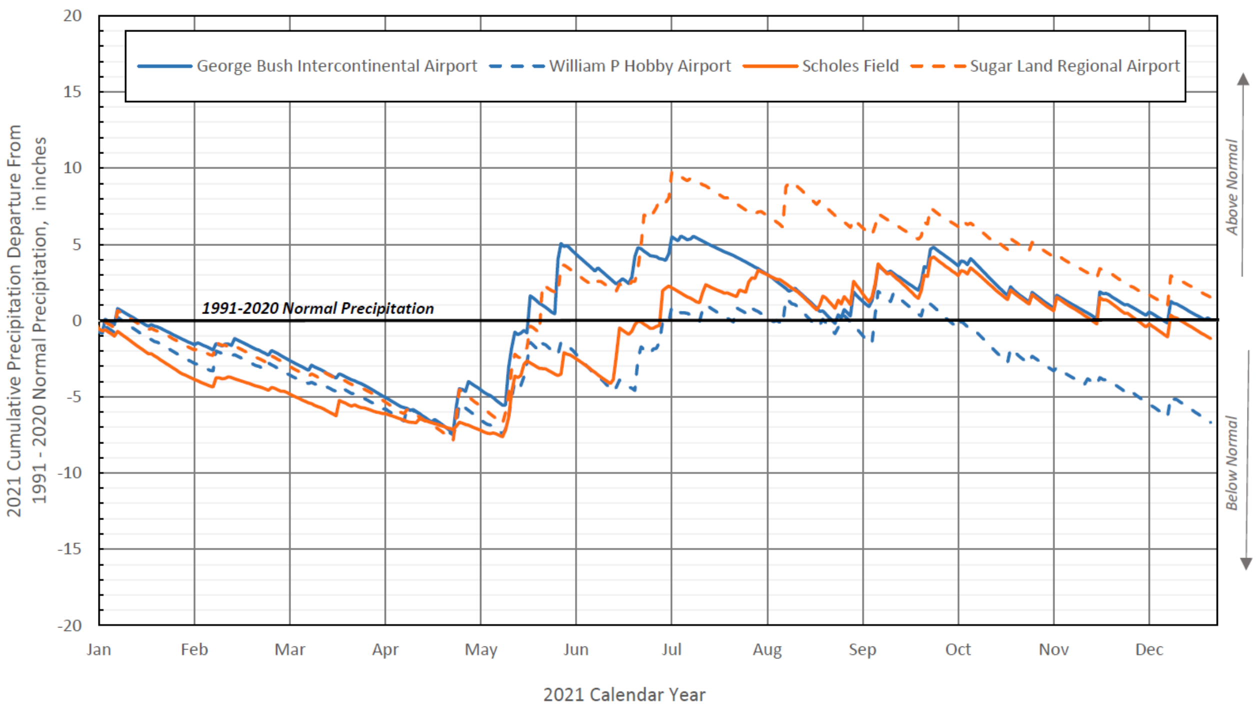

Figure 6. Cumulative precipitation departure, in inches, from 1991-2020 normal precipitation (sourced from https://www.ncei.noaa.gov/data/normals-daily/1991-2020/access/) at selected NOAA-NWS Climate Stations in the Houston region. Individual climate station data are sourced from NOWData – NOAA Online Weather Data accessed via https://www.weather.gov/wrh/Climate?wfo=hgx.

Winter Storm Uri moved onto southeast Texas from February 12 through February 18 bringing snow, sleet, and freezing rain that had tremendous impact in the District and the entire state of Texas. The winter storm, combined with a large trough from a shift in the polar vortex, brought prolonged periods of freezing temperatures and wintry precipitation which broke numerous snowfall and minimum temperature records (Fowler, 2022). The winter storm created freezing conditions that shut down the power grids and resulted in one of the largest blackout events in the recent history of the United States (Douglas, 2021). Millions of residents in southeast Texas were left without power, water pipes ruptured for both residents and businesses, and over 200 people in Texas, including 43 in Harris County, died as a result of the winter storm (Weber, 2021). Travis County officials estimated that Winter Storm Uri caused approximately $195 billion in damages in Texas (HSEM, 2021).

As the Houston-Galveston area was over 5 inches below normal precipitation totals for the majority of April, intermittent storms produced large amounts of rainfall over much of the region. Additionally, Hurricane Nicholas, a category 1 storm, made landfall at Sargent Beach in Matagorda County on

September 14, 2021 bringing several inches of rain to Harris and Galveston counties. From summer through fall, the majority of climate stations measured rainfall totals above normal (**Figure 6**).

Precipitation was generally above normal through the remainder of 2021. The largest cumulative rainfall recorded at the selected NOAA-NWS climate stations was 51.2 inches (130.16 cm) at Sugar Land Airport, which is 1.5 inches (4.15 cm) above the 1991-2020 normal annual precipitation. The lowest cumulative rainfall of 46.06 inches (116.94 cm) was recorded at Scholes Field on Galveston Island, which is 1.18 inches (3.0 cm) below normal. At the end of the year in December, the William P. Hobby airport measured the greatest departure from normal at approximately 6.7 inches below normal (**Figure 6**).

2021 Water Use Summary

The District collects groundwater and alternative water supply use annually from permittees. This information provides an understanding of how much groundwater is being used, how permittees are using groundwater, and perspective on the conversion from groundwater to surface water.

As of April 2022, a total of 7,370 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 3.18 MGD, which equates to about 1.6 percent of withdrawals.

In addition to providing water use data for 2021, this report also provides updated groundwater withdrawal totals for the previously reported year of 2020. 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 errors in the submitted data. The reported 2020 groundwater withdrawal total increased by 3.3 MGD to a new total of 211.39 MGD.

The following sections provide a summary of the information presented at the Public Hearing held on April 28, 2022. The exhibits used to provide testimony during the hearing are included in **Appendix A – Exhibits Presented at Public Hearing held on April 28, 2022.**

Overall Water Use

The three primary water uses in the District are public supply, industrial, and irrigation. The total amount of groundwater withdrawal for 2021 is 203.6 MGD, about four percent decrease over 2020, with public supply reported to be 92 percent of the overall use (**Table 1**). As a result of the District's Regulatory Plan, groundwater withdrawals have decreased since the District's inception in 1975, with a 55 percent decline from 456.3 MGD in 1976 to 203.6 MGD in 2021 (**Figure 7**). Patterns in groundwater use have shifted over time, resulting in reduced groundwater use for industrial and agricultural needs compared with the 1970s and 1980s.

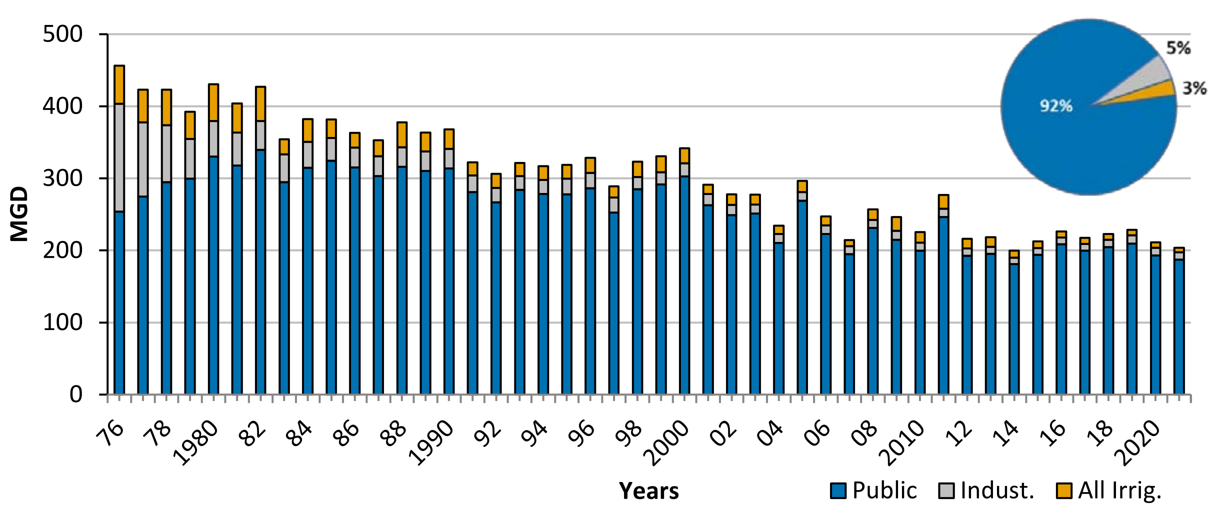

Figure 7: Groundwater withdrawals, in million gallons per day, by water use category from 1976 to 2021. The total groundwater used in the District was 203.6 MGD in 2021, with 92 percent as public supply.

The District is divided into three regulatory areas that define how much groundwater may be utilized as a percentage of the total water demand. The groundwater withdrawals are grouped by regulatory area in **Figure 8**. This chart shows the impact of the District's Regulatory Plan, requiring conversion from groundwater to alternative water over time and as a result the reduction in groundwater withdrawals in regulatory areas that have fully converted to alternative water (i.e., Regulatory Areas One and Two). As a result, the majority of groundwater use within the District is occurring within Regulatory Area Three. The following sections provide additional information regarding groundwater withdrawals in each Regulatory Area.

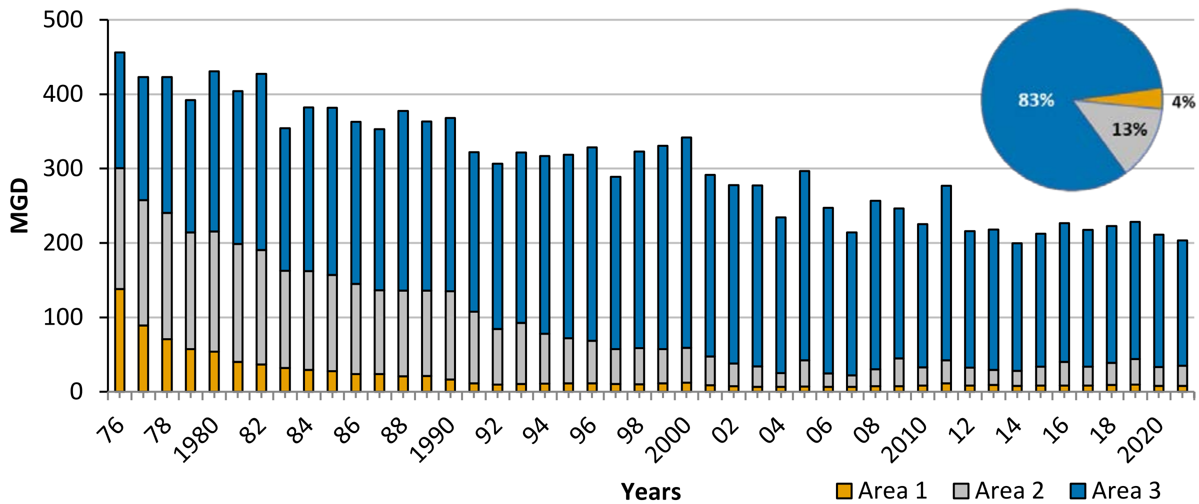

Figure 8: Groundwater withdrawals, in million gallons per day, by regulatory area from 1976 to 2021. In 2021, a total of 7.9 MGD of groundwater was used in Regulatory Area One, with 27 MGD used in Regulatory Area Two and 168.7 MGD used in Regulatory Area Three.

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

Water Use Category	Area 1			Area 2			Area 3			Total		
	2020	2021	1-Year Change	2020	2021	1-Year Change	2020	2021	1-Year Change	2020	2021	1-Year Change
Public	2.4	2.3	-4%	21.7	23.9	10%	169.2	161.0	-5%	193.3	187.2	-3%
Industrial	5.5	5.4	-3%	2.7	2.5	-7%	2.2	2.4	9%	10.4	10.3	-1%
All Irrigation	0.13	0.16	23%	0.87	0.72	-17%	6.7	5.3	-21%	7.7	6.2	-20%
Total	8.1	7.9	-3%	25.3	27.1	7%	178.1	168.7	-5%	211.4	203.7	-4%

Regulatory Area One

Regulatory Area One covers most of Galveston County and the southeastern portion of Harris County. Cities and villages included are Bacliff, Baytown, Bayou Vista, Channelview, Clear Lake Shores, Deer Park, Dickinson, El Lago, Galena Park, Galveston, Highlands, Hitchcock, Kemah, La Marque, La Porte, League City, Morgan's Point, Nassau Bay, Pasadena, San Leon, Santa Fe, Texas City, Seabrook, Shoreacres, Taylor Lake Village, Tiki Island, and Webster. Also included are Clear Lake, Johnson Space Center, and

Bolivar Peninsula Areas. This area converted to alternate water sources back in the 1970s, 1980s and early 1990s.

In 2021, total groundwater withdrawal in Regulatory Area One was 7.9 MGD, a three percent decrease from the previous year (**Table 1**). The majority of groundwater use in Regulatory Area One is associated with industrial use, which comprises 69 percent of the use in the area. Industrial use has been relatively stable since 1990 and groundwater use for public supply has remained generally stable since 2001 (**Figure 9**). Irrigation water use is typically correlated to climate and rainfall patterns. The amount of groundwater used for irrigation increased by 22 percent in 2021 to 0.16 MGD. Historically, groundwater withdrawals have declined in Regulatory Area One from a maximum of 138.1 MGD in 1976 to 7.9 MGD in 2021 (**Figure 9**).

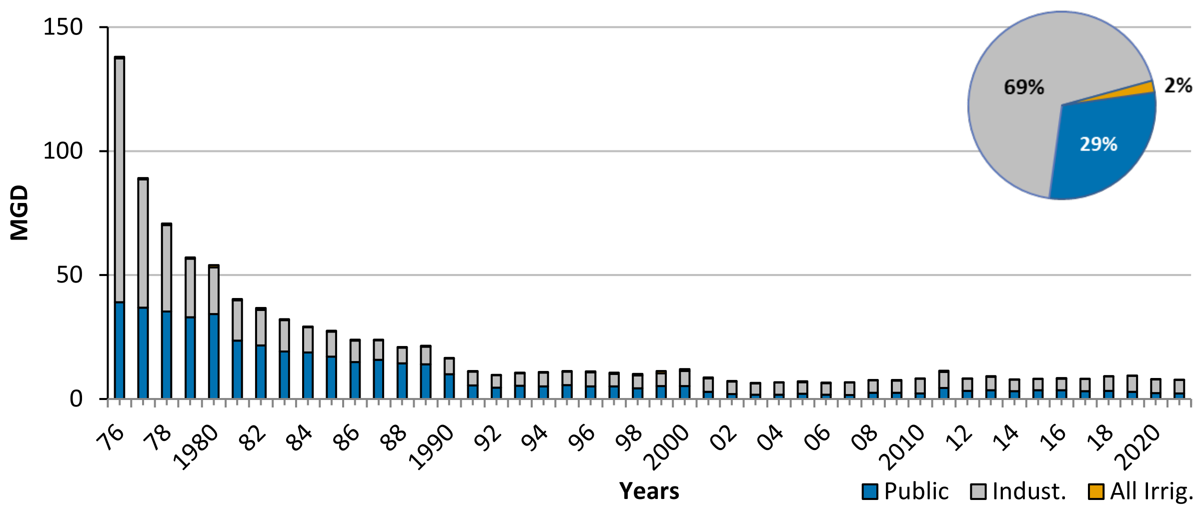

Figure 9: Groundwater withdrawals for Regulatory Area One, in million gallons per day, by water use category from 1976 to 2021. A total of 7.9 MGD of groundwater was used in Regulatory Area One in 2021, with 69% of the withdrawals being used for industrial use.

Regulatory Area Two

Regulatory Area Two covers a small northwestern slice of Galveston County and southern and eastern Harris County. Cities, entities, and areas included are Bellaire, Cloverleaf, Crosby, Friendswood, Highlands, Hobby Airport, Pasadena, Sheldon, South Houston, the Villages, West University, and large portions of the City of Houston. Regulatory Area Two has been converted to alternate water sources since the early 2000s, where possible.

In 2021, total groundwater withdrawal in Regulatory Area Two was 27 MGD, a seven percent increase from the previous year (**Table 1**). Public supply continues to be the dominant use and has decreased by 83 percent from the maximum of 143.5 MGD in 1980 to 23.9 MGD in 2021 (**Figure 10**). Overall, groundwater use in Regulatory Area Two has declined from above 150 MGD in the 1970s to below 30 MGD since 2002.

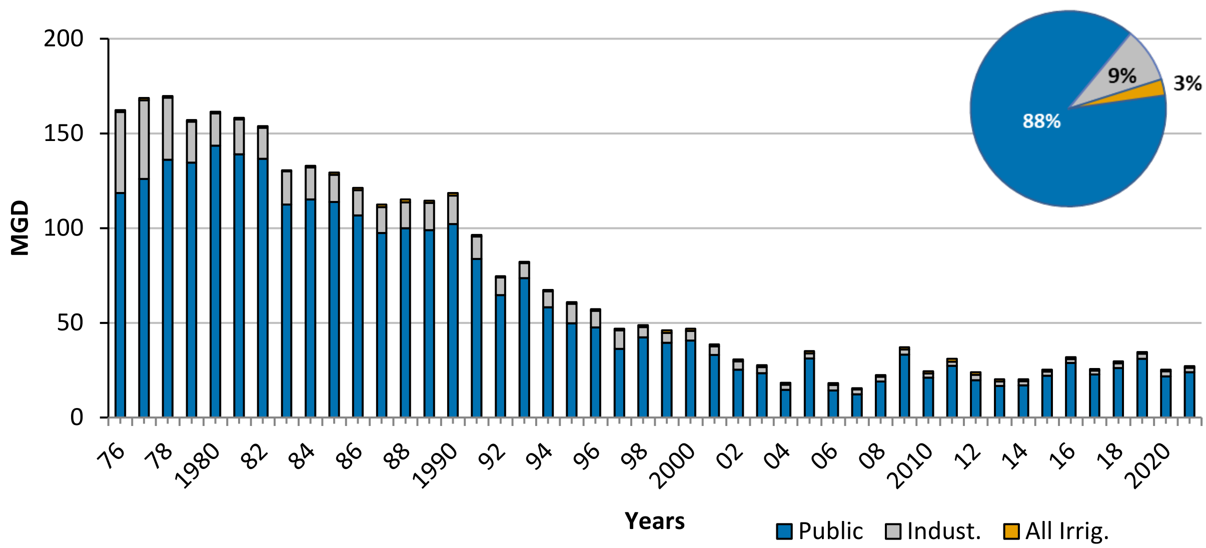

Figure 10: Groundwater withdrawals for Regulatory Area Two, in million gallons per day, by water use category from 1976 to 2021. A total of 27 MGD of groundwater was used in Regulatory Area Two in 2021, with 88% of the withdrawals being used for public supply.

Regulatory Area Three

Regulatory Area Three covers north and west Harris County. Cities, entities and areas included are the Jersey Village, Humble, Kingwood, Huffman, Tomball, Cypress, Hockley, Spring, and parts of Katy. Entities in this regulatory area were required to convert to alternate water beginning in 2010, with this conversion facilitated by the City of Houston and the Regional Water Authorities. Two subsequent conversion deadlines in 2025 and 2035 remain for permittees with groundwater reduction plans.

In 2021, total groundwater withdrawal in Regulatory Area Three was 168.7 MGD, a five percent decrease from the previous year (**Table 1**). Similar to Regulatory Area Two, the largest category of water use is public supply use, which was reported at 161 MGD and accounts for 96 percent of the groundwater use in the area (**Figure 11**). Industrial water use has been below 4 MGD since 2010, while irrigation water use remained below 10 MGD since 2014.

Groundwater withdrawals in Regulatory Area Three show a generally increasing trend beginning in 1976 through 2000, reflecting the impacts of climate and population increase as development progressed in northern and western Harris County. As shown in **Figure 11** , groundwater use has remained relatively constant since 2012, varying between 171.4 MGD and 188.8 MGD.

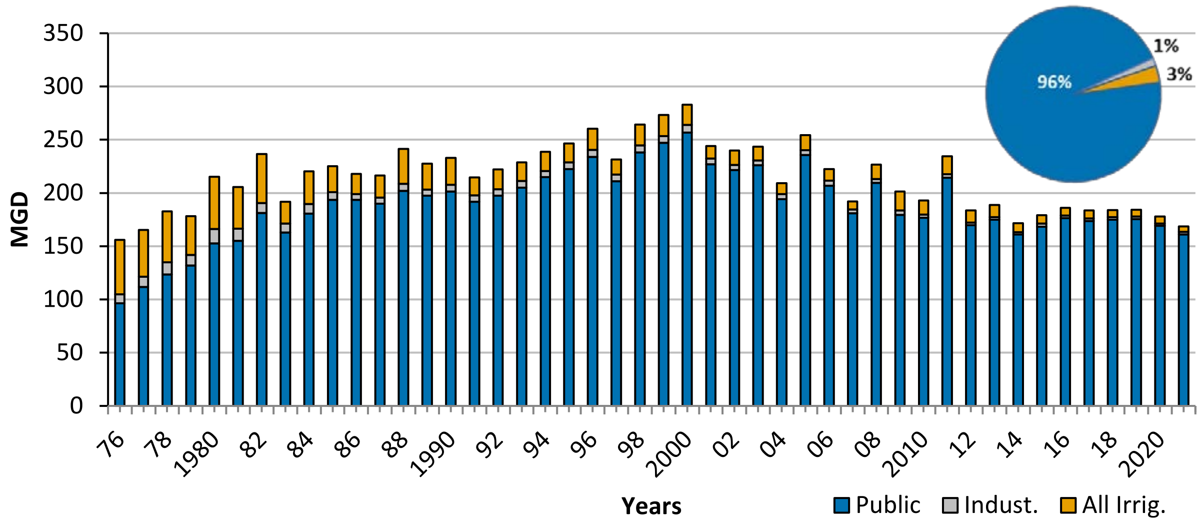

Figure 11: Groundwater withdrawals for Regulatory Area Three, in million gallons per day, by water use category from 1976 to 2021. A total of 168.7 MGD of groundwater was used in Regulatory Area Three in 2021, with 96% of the withdrawals being used for public supply.

Alternative Water Supply and Total Water Use

The District's Regulatory 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 (**Table 2**).

Table 2. Summary of Reported Alternative Water Supply Use and Total Water Use (in MGD)

Source		2020	2021	1-Year Change
Alternative Supplies	Brazos River Basin	68.8	70.9	3%
	San Jacinto River Basin	164.6	172.8	5%
	Trinity River Basin	534.7	535.9	0%
	Reclaimed Water	2.4	3.5	46%
	Alternative Subtotal	770.5	779.9	1%
Groundwater		211.4	203.6	-4%
Total Water Use		981.9	986.7	0.5%

Since 1992, the Trinity River Basin is still the single largest source of alternative water used within the District. Groundwater remains the second largest source of water supply within the District as a whole. Compared with 2020, the use of both the San Jacinto River Basin and Brazos River Basin supply increased by five and three percent, respectively. The total water use for the District was determined to be 986.7 MGD in 2021, which is half a percent increase from 2020 (**Figure 12**).

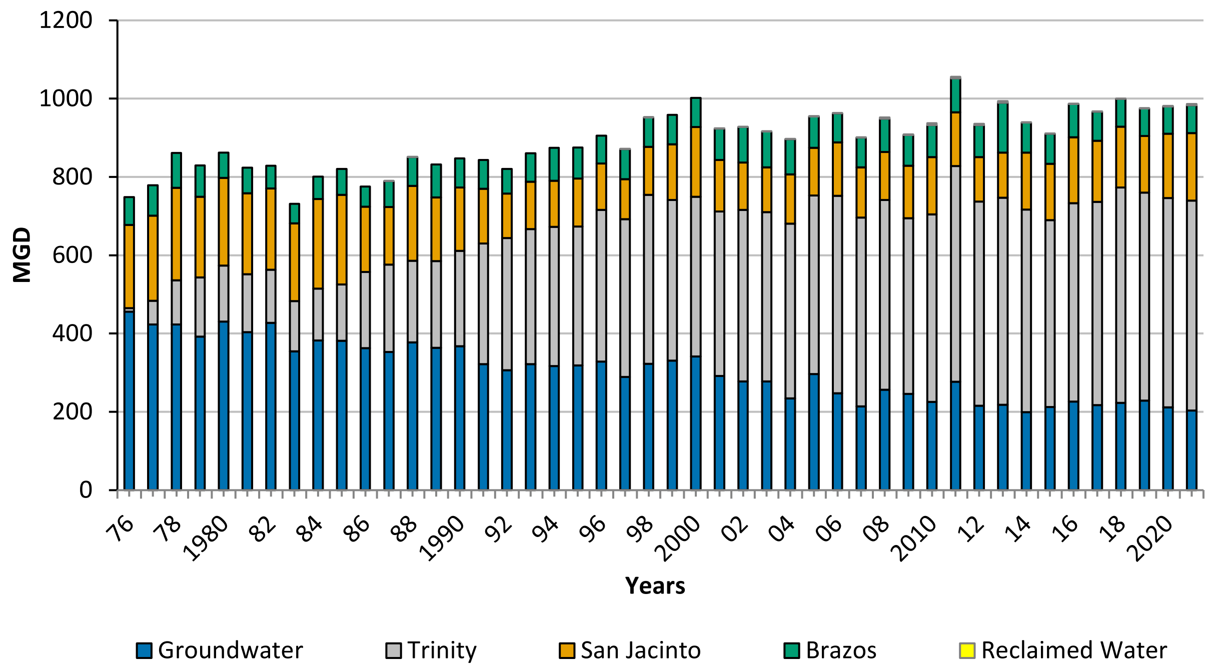

Figure 12: Total water use for District, in million gallons per day, by source water, from 1976 to 2021. The reported total water use for the District in 2021 was 986.7 MGD.

2021 Groundwater Level Summary

All groundwater used in the District is sourced from the Gulf Coast Aquifer System, which is comprised of three primary water bearing units. The two units most widely used in the District are the Chicot and Evangeline aquifers. The Chicot is the shallowest aquifer in the District which is directly connected to the Evangeline aquifer immediately below. The Burkeville confining unit lies beneath the Evangeline 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 Montgomery County.

Annually, since 1975, the USGS has measured the water level in hundreds of wells throughout the Houston region in cooperation with the District through a joint funding agreement along with additional cities, subsidence districts and groundwater conservation districts to monitor and provide reports on groundwater level altitude data for the Chicot/Evangeline and Jasper aquifers. Since aquifer water level is the best measure of the pressure in the aquifer, this information is essential to understand the impact of changes in water use on subsidence.

In 2020, the hydrostratigraphy of the Gulf Coast Aquifer was updated as part of the Joint Regulatory Plan Review (Young & Draper, 2020). This information was used to support the development of an updated groundwater-flow model, named GULF 2023, for southeastern Texas in a project funded by the District and the Fort Bend Subsidence District (FBSD), incorporated new data from approximately 650 geophysical logs, and resulted in an adjustment to the bottom of the Chicot aquifer by extending it deeper. As a result of this work, the USGS has reviewed, approved, and incorporated the updated hydrostratigraphy and has classified the update as the Chicot and Evangeline (undifferentiated) as the shallow aquifer system of the Gulf Coast Aquifer. This updated approach also changed aquifer designations for several wells measured annually as part of the groundwater level survey.

The 2022 potentiometric surface (i.e., the interpolated surface from water level data) for the Chicot and Evangeline (undifferentiated) aquifer shows the areas of primary stresses occur in northern and western Harris County, southern Montgomery County, and small portions of northern Fort Bend County (**Figure 13**). The change in water-level in the Chicot/Evangeline aquifer since 1977 clearly demonstrates the impact of District regulation on the aquifers (**Figure 14**). Generally, Regulatory Areas One and Two have seen a significant rise in the potentiometric water-level up to 274 feet (83.5 meters) in the Chicot and Evangeline (undifferentiated) aquifer. The areas of rise are a result of the reduction of groundwater use required by the District's Regulatory Plan. Conversely, in Regulatory Area Three water-levels continue to be significantly lower than the historical benchmark as these areas are growing rapidly and the conversion to alternative sources of water will not be completed in the District until 2035. The maximum declines for the Chicot and Evangeline (undifferentiated) aquifer occur in southern Montgomery County with 341 feet (104 meters) change from 1977 to 2022 (**Figure 14**).

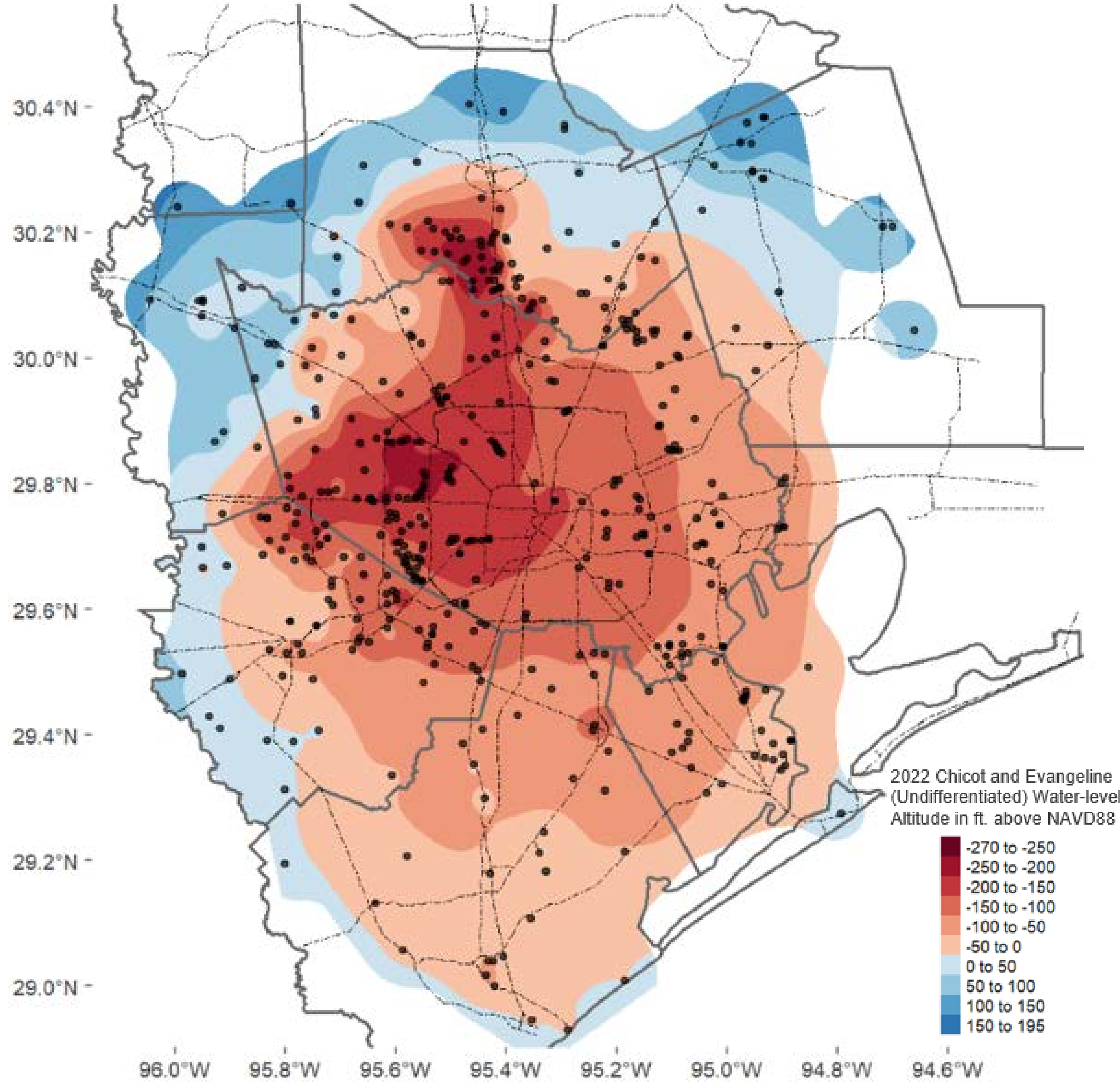

Figure 13: Altitude of the potentiometric surface determined from water-levels measured in tightly cased wells screened in the Chicot and Evangeline (Undifferentiated) aquifer, Houston region, Texas, 2022 (Source: USGS provisional data – preliminary and subject to change, WL – Water-Level).

Groundwater levels in southern Montgomery County are of particular concern. The cone of depression with the greatest water level declines in the Chicot and Evangeline (undifferentiated) aquifer exists in southern Montgomery County near The Woodlands (**Figure 14**). Recent changes in the management plan of Montgomery County's LSGCD de-regulates the use of groundwater in Montgomery County. This area is an important area of interest as continued population growth and expanded groundwater use may result in an expansion of the area of decline into northern Harris County.

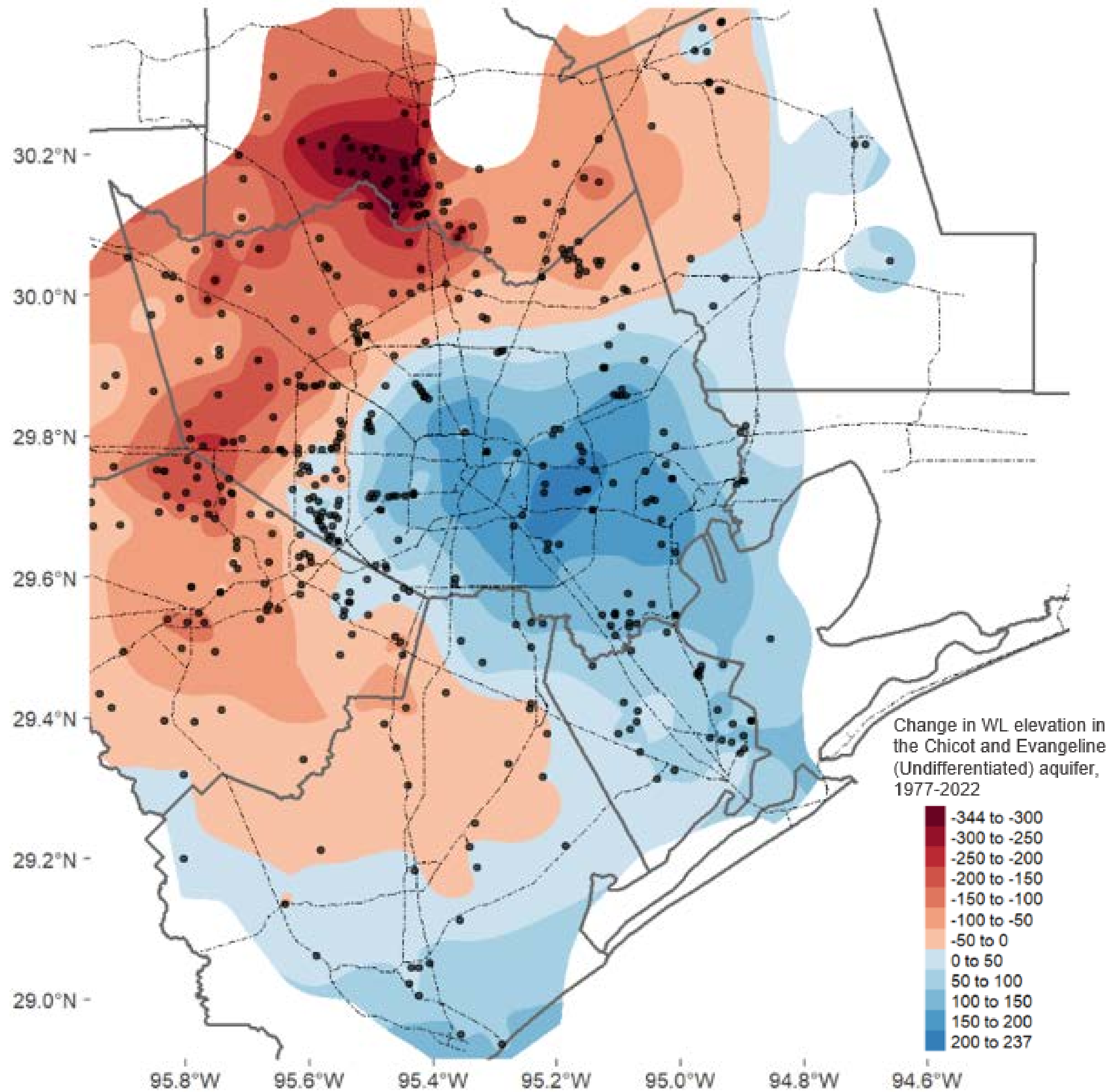

Figure 14: Potentiometric water-level change at wells screened in the Chicot and Evangeline (Undifferentiated) aquifer, Houston region, Texas, from 1977 to 2022 (Source: USGS provisional data – preliminary and subject to change).

The information presented in this section are a brief summary of the provisional data presented at the Public Hearing held on April 28, 2022. The exhibits used to provide testimony during the hearing are included in **Appendix A**. A USGS Scientific Investigation Report should be released later in 2022 documenting the status of groundwater level altitudes and the long-term changes in the Chicot and Evangeline (undifferentiated) and the Jasper aquifers.

2021 Subsidence Trend Analysis

Subsidence is the lowering of land surface elevation. In the Houston-Galveston region, subsidence occurs from the compaction of clays due to groundwater withdrawal for municipal, industrial, and irrigation water supply. 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 as subsidence at the land surface.

Global positioning system (GPS) stations have been installed in various locations across southeast Texas in order to track subsidence since the 1990s. This GPS network consists of a collaboration between the District, FBSD, UH, LSGCD, Brazoria County Groundwater Conservation District (BCGCD), the National Geodetic Survey (NGS), the USGS, the City of Houston, and the Texas Department of Transportation (TXDOT). The GPS network has grown to over 220 sites throughout the region. Additional information on the GPS network is provided in **Appendix B – Subsidence Monitoring Network Overview and Data** and **Appendix C – Period of Record Data.**

Satellite signals are collected every thirty seconds and averaged over 24 hours by global navigation satellite system (GNSS) antenna and receiver into one (1) raw daily data file. Raw data files are processed by Dr. Guoquan Wang at the UH and are compared to a stable regional reference frame designated as Houston20 that uses 25 continuously operating GPS stations which have a long history (greater than eight years) and are located outside the greater Houston area (Agudelo, et al., 2020). Additional details on the GPS data processing methodology are provided in **Appendix B**.

The District uses these GPS data in two ways: 1) period of record and 2) as an average annual subsidence rate in order to understand subsidence trends within the subsidence monitoring network. Additional information on the average annual subsidence rate and period of record data for each GPS station are provided in **Appendix C**.

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 the land-surface deformation and is represented as a vertical displacement time series. 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 as 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 vertical displacement of the land surface. Period of record plots give a historical context to understand local to regional subsidence trends. Period of record plots for each GPS station in the subsidence monitoring network are provided in **Appendix C**.

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 station with at least three years of GPS data. **Figure 15** depicts the average annual subsidence rate from 2017 to 2021 for 201 GPS stations in the greater Houston area.

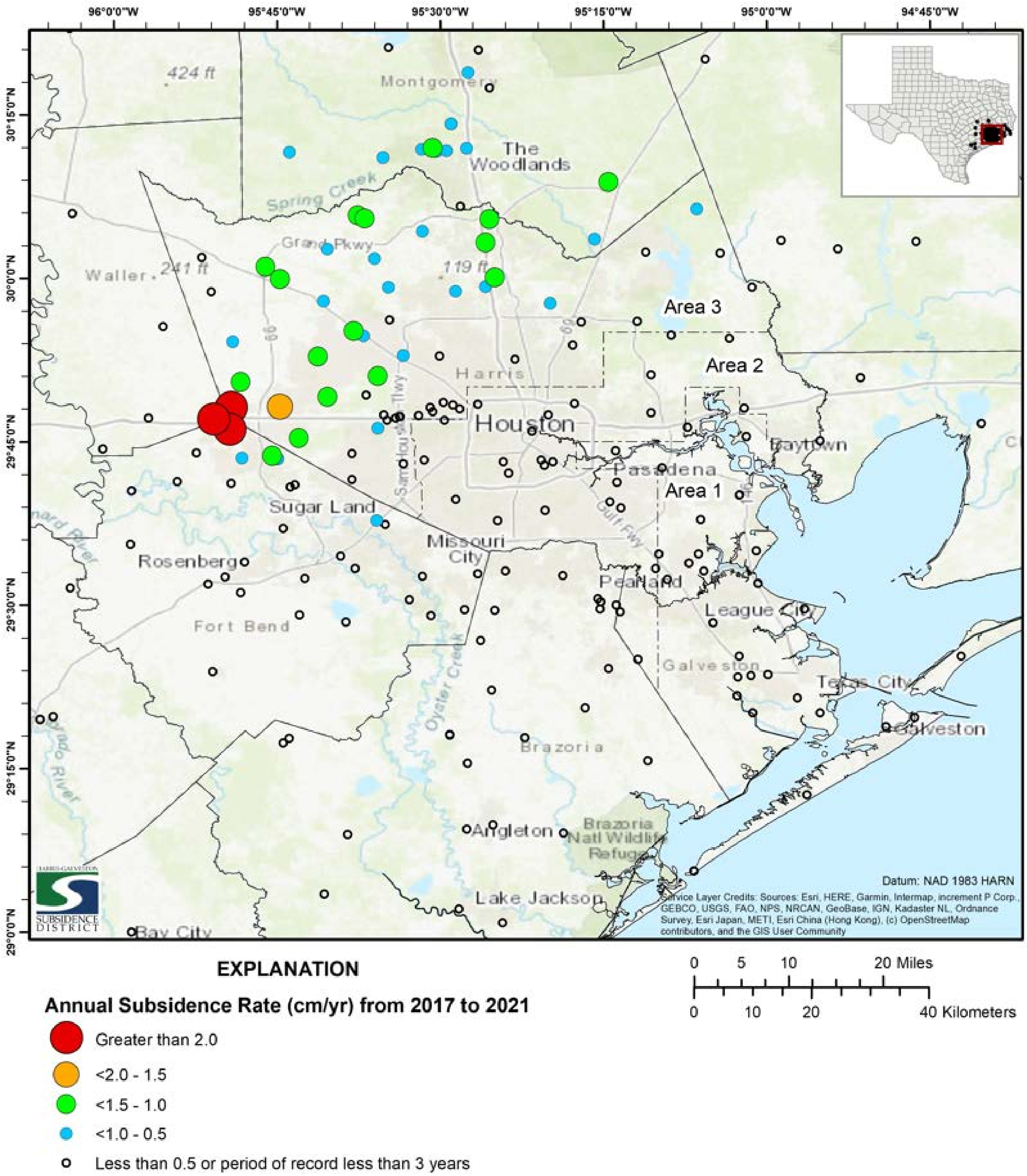

Figure 15: Annual subsidence rate, measured in centimeters per year, from 2017 to 2021, referenced to Houston20 and estimated from three or more years of GPS data collected from GPS stations in Harris and surrounding counties, Texas.

Regulatory Areas One and Two show similar subsidence rates as both areas have been fully converted since the 1990s and USGS groundwater level monitoring data show that potentiometric water levels have risen. The majority of the GPS stations in Regulatory Areas One and Two show little to no subsidence with rates under 0.5 centimeters per year and even some uplift is observed such as GPS station, P039, which is located in southeast Houston (**Figure 16**).

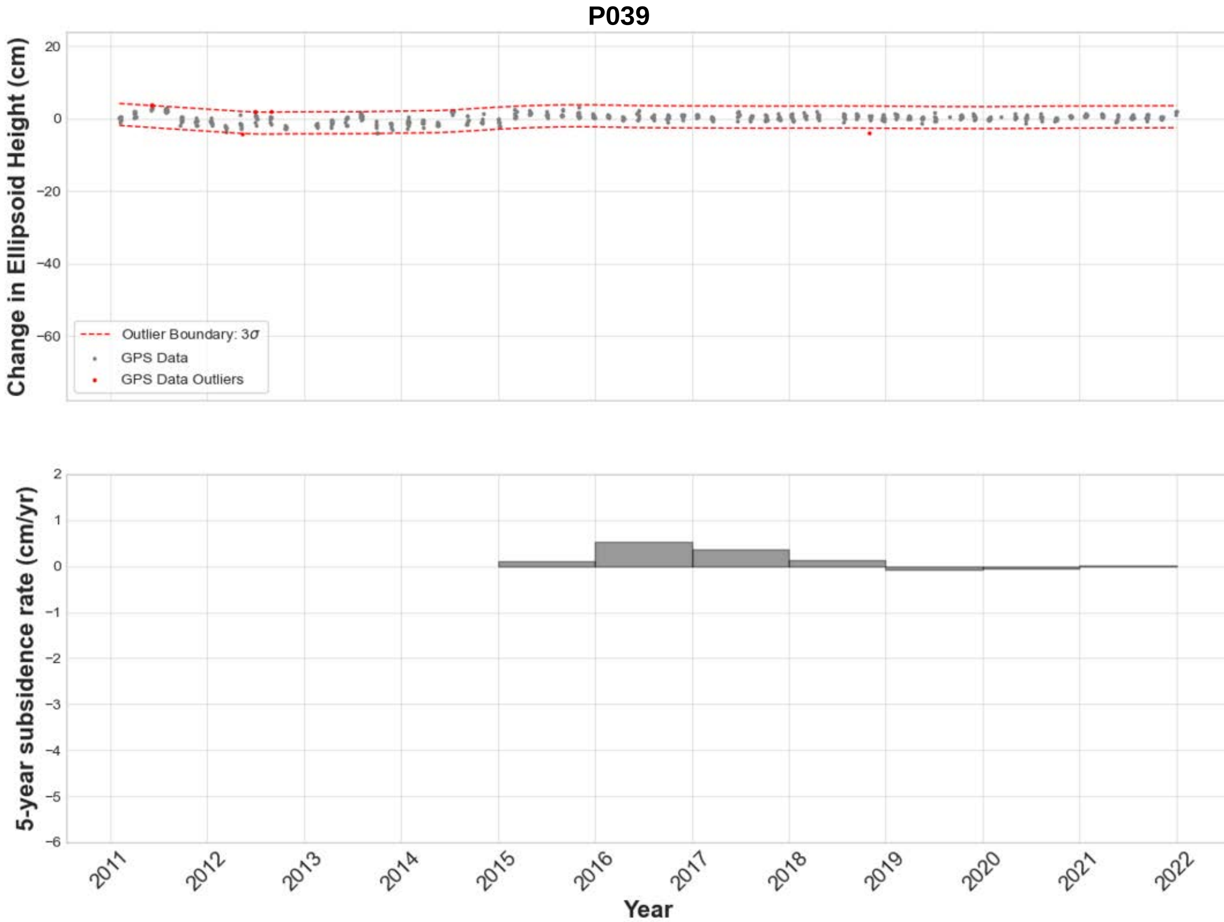

Figure 16: Period of record data from GPS station P039 located in southeast Houston, 2011 to 2021. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating subsidence rates and are shown for informational purposes only.

The highest subsidence rates (greater than 2 centimeters per year) occur in Regulatory Area Three within western Harris County as well as southeastern Waller County and northeastern Fort Bend County. GPS station P097, located in Katy within Waller County, has the highest subsidence rate estimated at 2.67 centimeters per year (**Figure 17**). Other GPS stations in the Katy area (e.g., P029, P098, P097) also show an annual subsidence rate greater than two (2) centimeters per year. Other areas in Regulatory Area Three such as Jersey Village, Addicks, Cypress, Tomball, and Spring have subsidence rates ranging from 1.69 to 1.01 centimeters per year. Based on the GPS data collected in the greater Houston area, subsidence is occurring in Regulatory Area Three, as this area is still undergoing conversion to alternative water supplies.

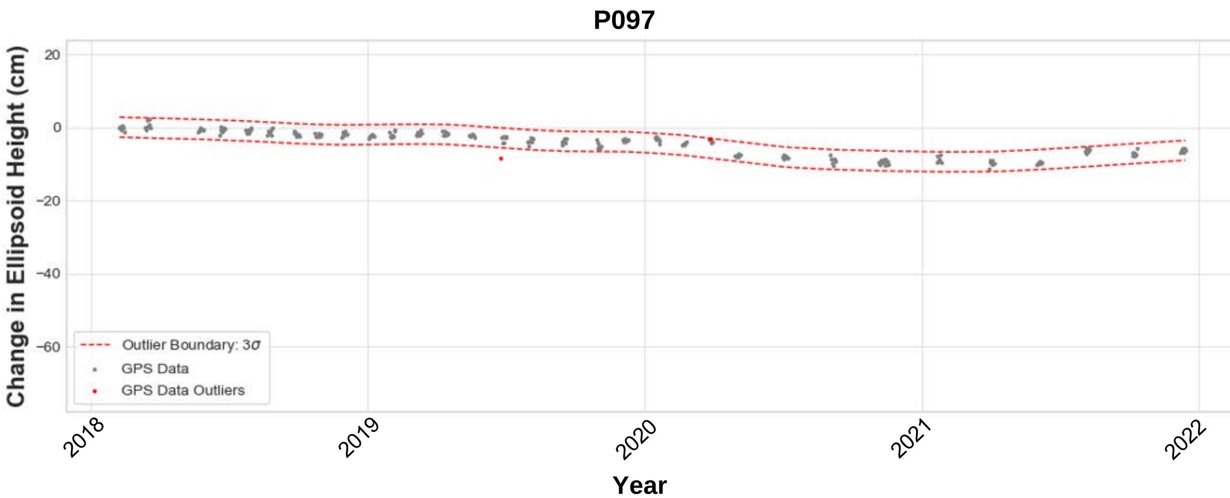

Figure 17: Period of record data from GPS station P097 located in Katy, Texas, 2018-2021. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating subsidence rates and are shown for informational purposes only.

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Appendix A – Exhibits Presented at Public Hearing held on April 28, 2022

Welcome to the Public Hearing for the 2021 Annual Groundwater Report

- Participants will be muted for the entire hearing.
- Public testimony will be available for participants at the end of the hearing. The hearing is presented virtually for viewing purposes only.
- The webinar is being recorded including all chat between participants.
- For any problems, please chat with the organizer.

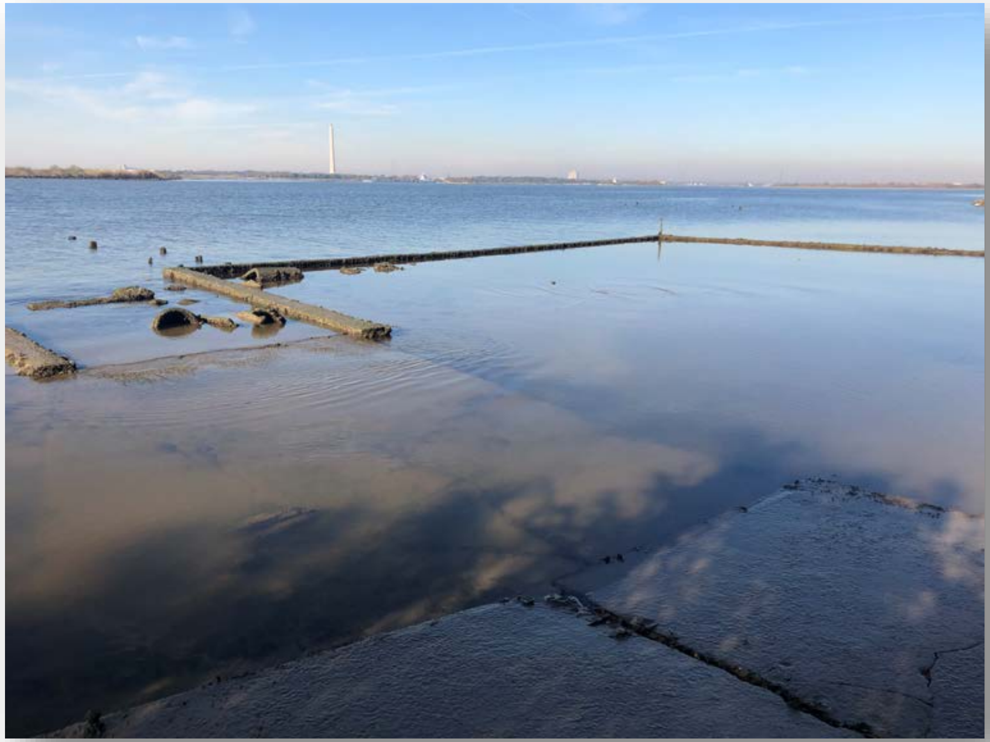
HARRIS-GALVESTON SUBSIDENCE DISTRICT

2021 Annual Groundwater Report

Public Hearing – April 28, 2022

Harris-Galveston Subsidence District Mission

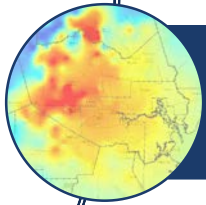
- The Harris-Galveston Subsidence District was created in 1975 to prevent land subsidence in Harris and Galveston counties through the regulation of groundwater.
- Land subsidence contributes to flooding, threatening the economic health of the area.
- Efforts to prevent subsidence by the District and the regulated community have required significant investment to create a more resilient infrastructure while securing reliable water sources for future needs.
- An annual groundwater hearing is required by enabling the act to receive testimony regarding the effects of groundwater withdrawals on subsidence.



Agenda

Climate

Groundwater Use



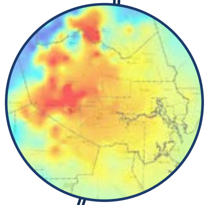
Groundwater Levels

Subsidence Data

Agenda

Climate

Groundwater Use

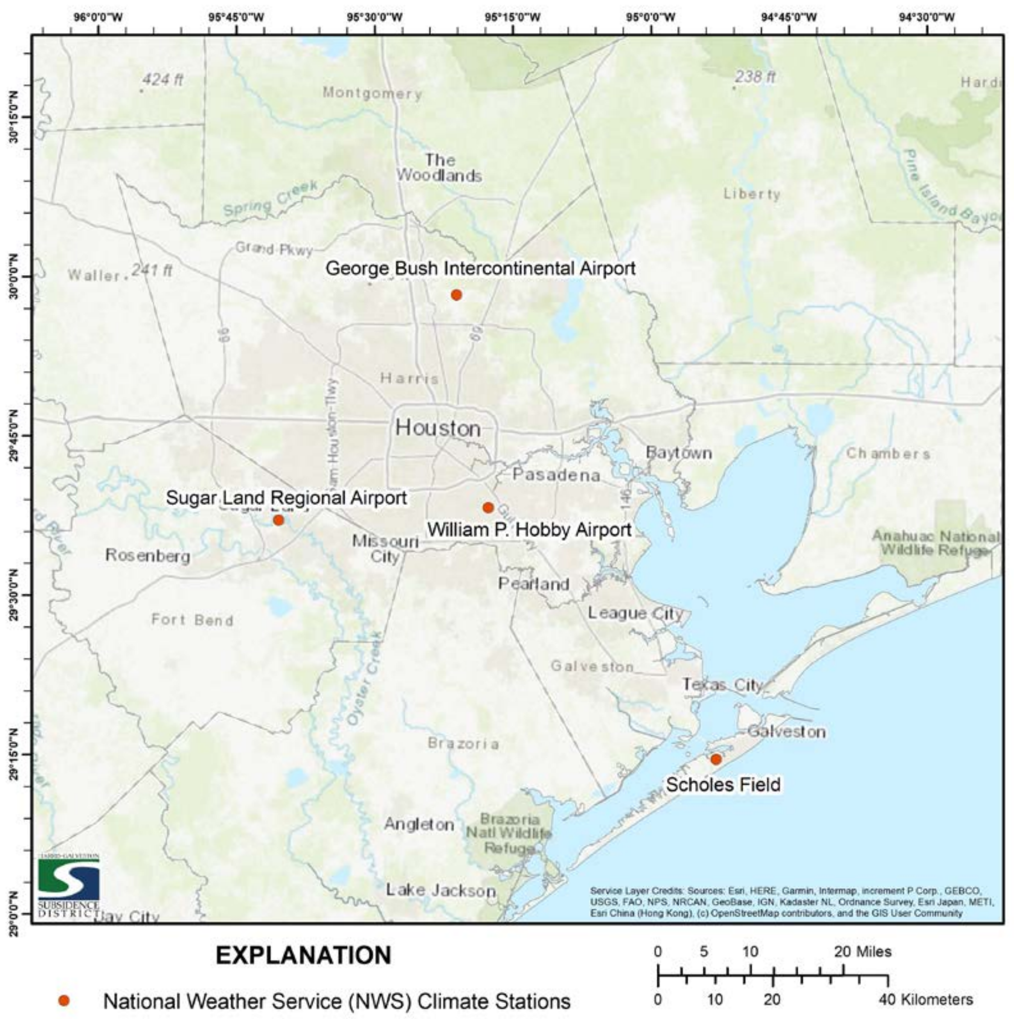


Groundwater Levels

Subsidence Data

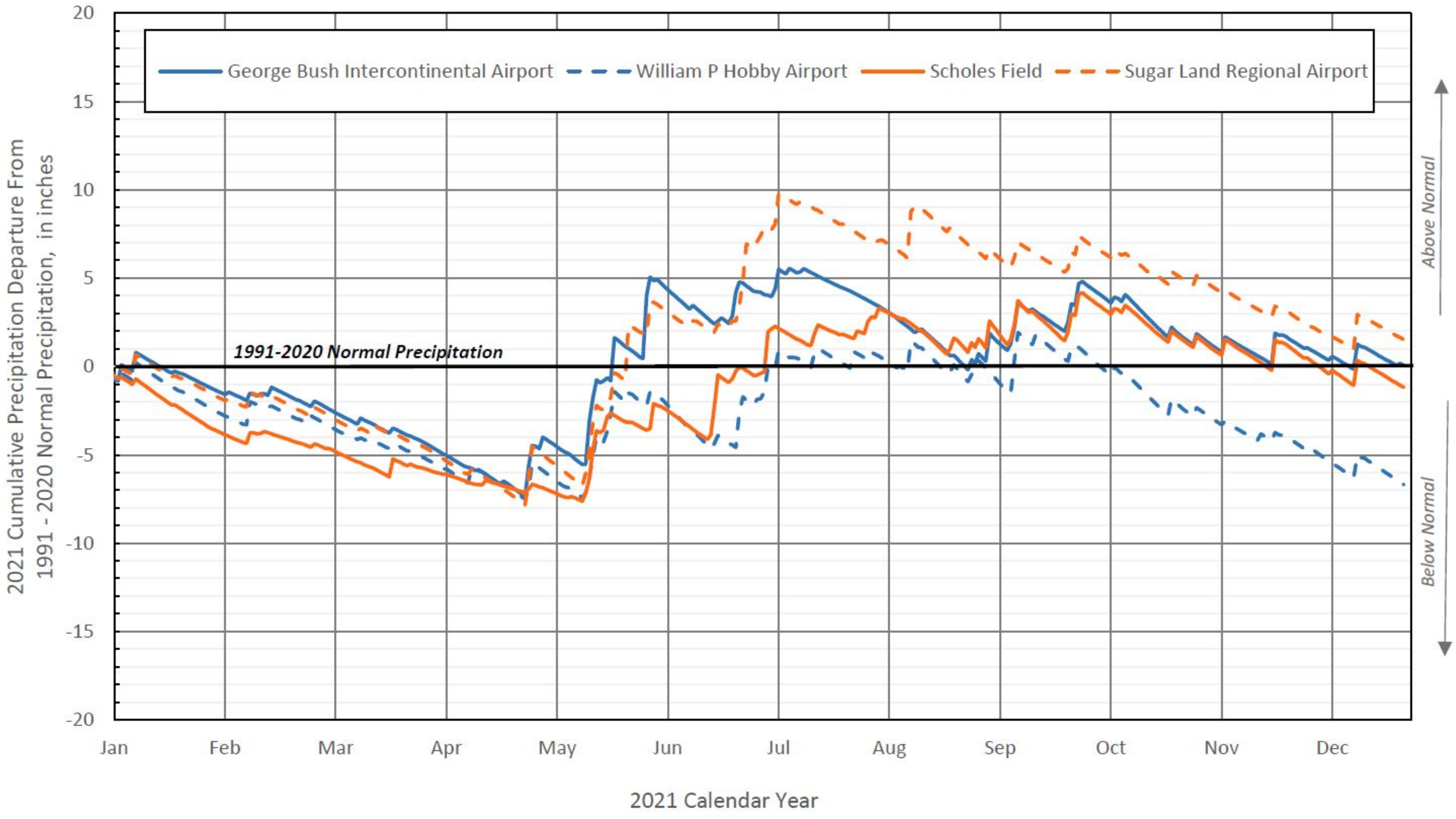
NWS Climate Stations | Exhibit 1

Location of National Weather Service (NWS) climate stations used for precipitation data for the 2021 calendar year.



(Provisional - Subject to Revision)

2021 Precipitation Data| Exhibit 2



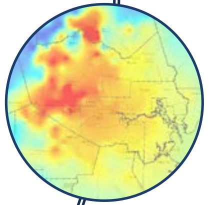
HARRIS-GALVESTON SUBSIDENCE DISTRICT

(Provisional - Subject to Revision)

Agenda

Climate

Groundwater Use



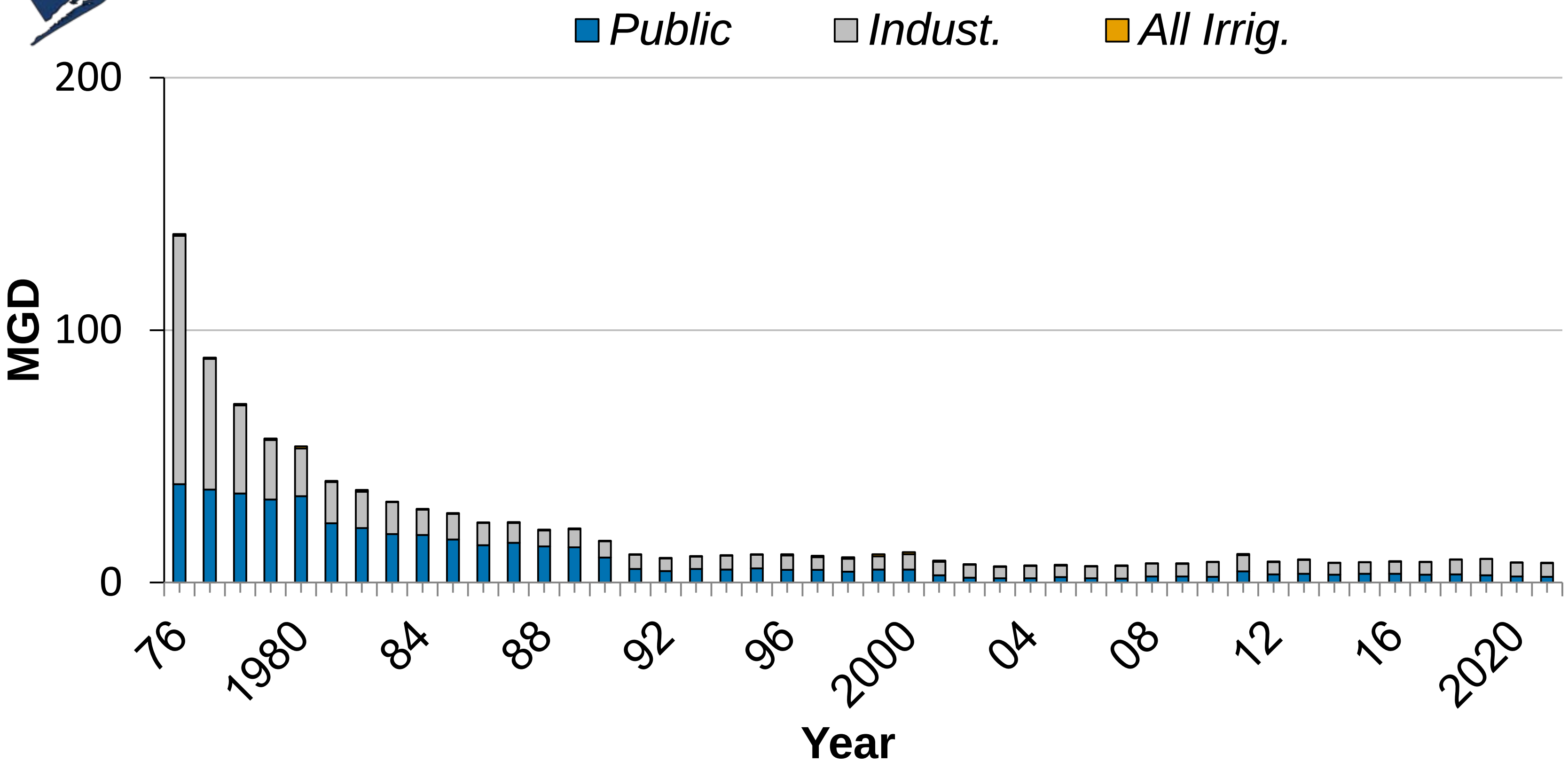
Groundwater Levels

Subsidence Data

Groundwater Withdrawals | Exhibit 3

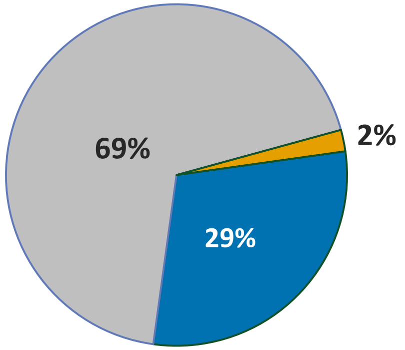
Regulatory Area One

Groundwater Withdrawals - Grouped by Use



2021 - 7.9 MGD

(2020 – 8.1 MGD; -4% change)



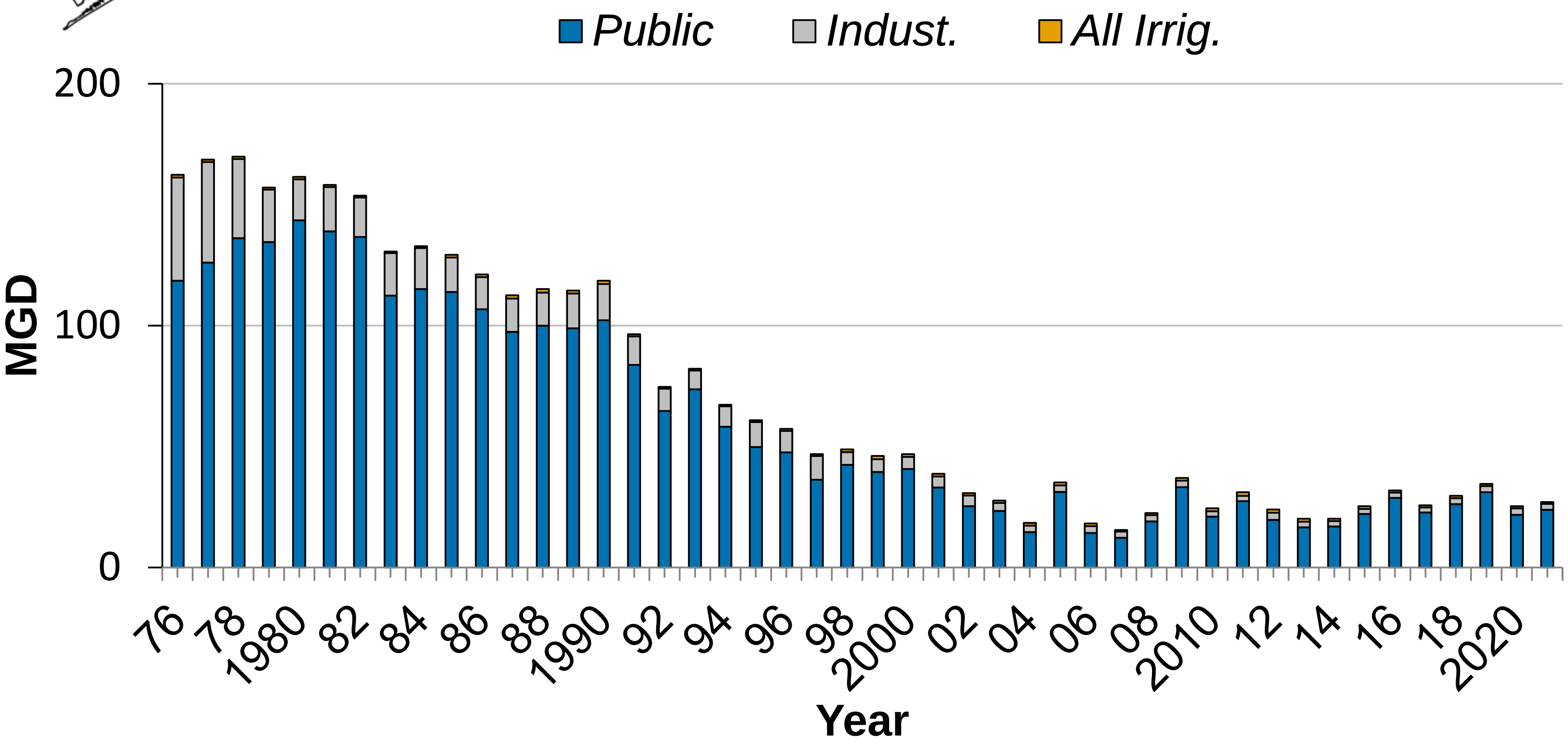
HARRIS-GALVESTON SUBSIDENCE DISTRICT

(Provisional - Subject to Revision)

Groundwater Withdrawals | Exhibit 4

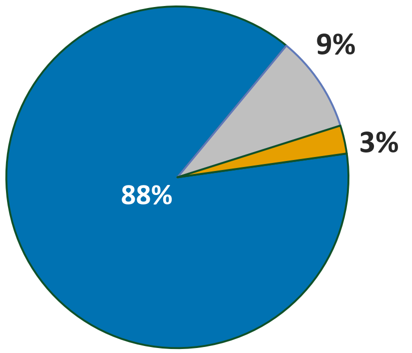
Regulatory Area Two

Groundwater Withdrawals - Grouped by Use

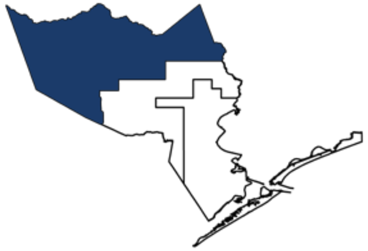


2021 - 27 MGD

(2020 – 25.3 MGD; 7% change)

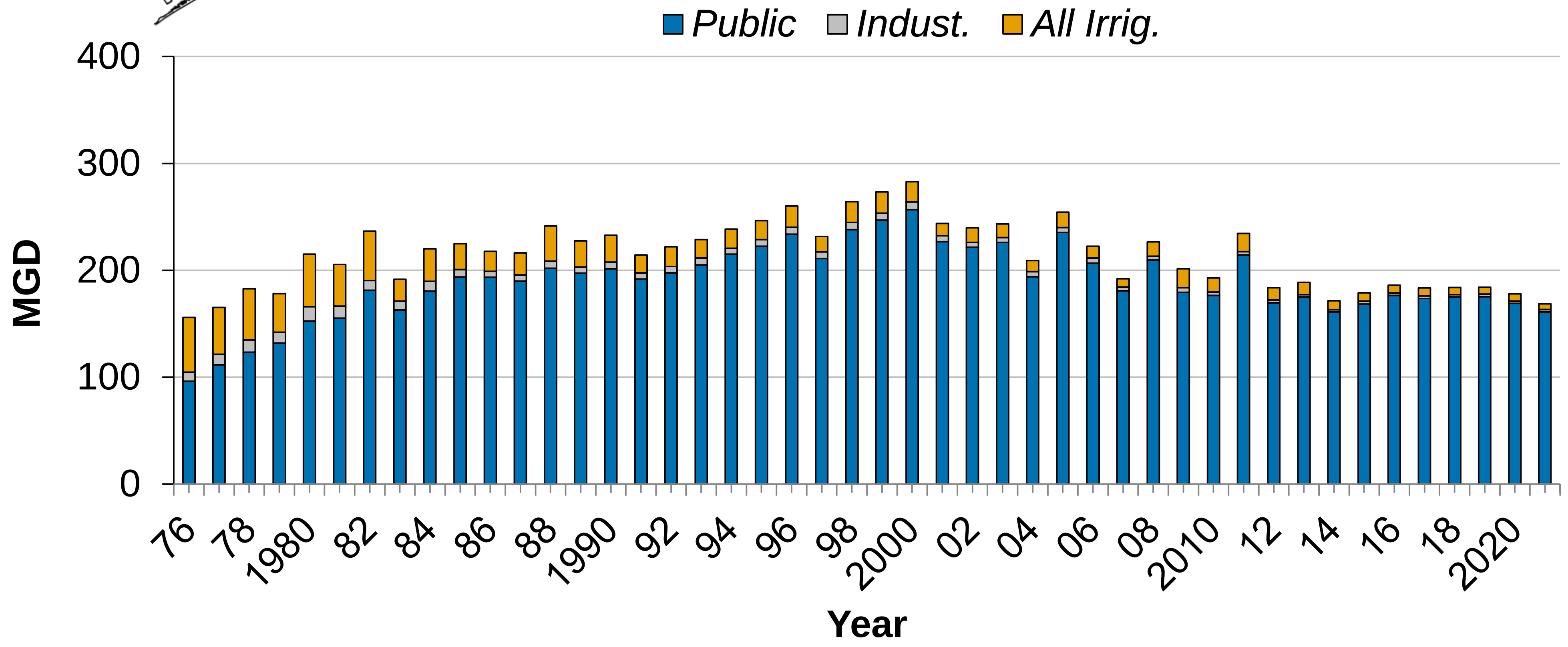


Groundwater Withdrawals | Exhibit 5



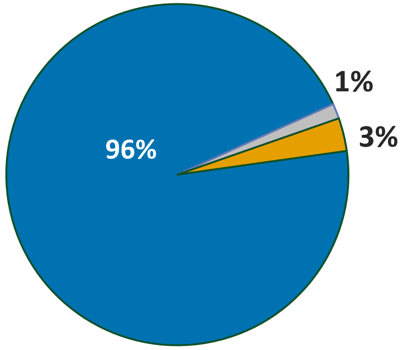
Regulatory Area Three

Groundwater Withdrawals – Grouped by Use

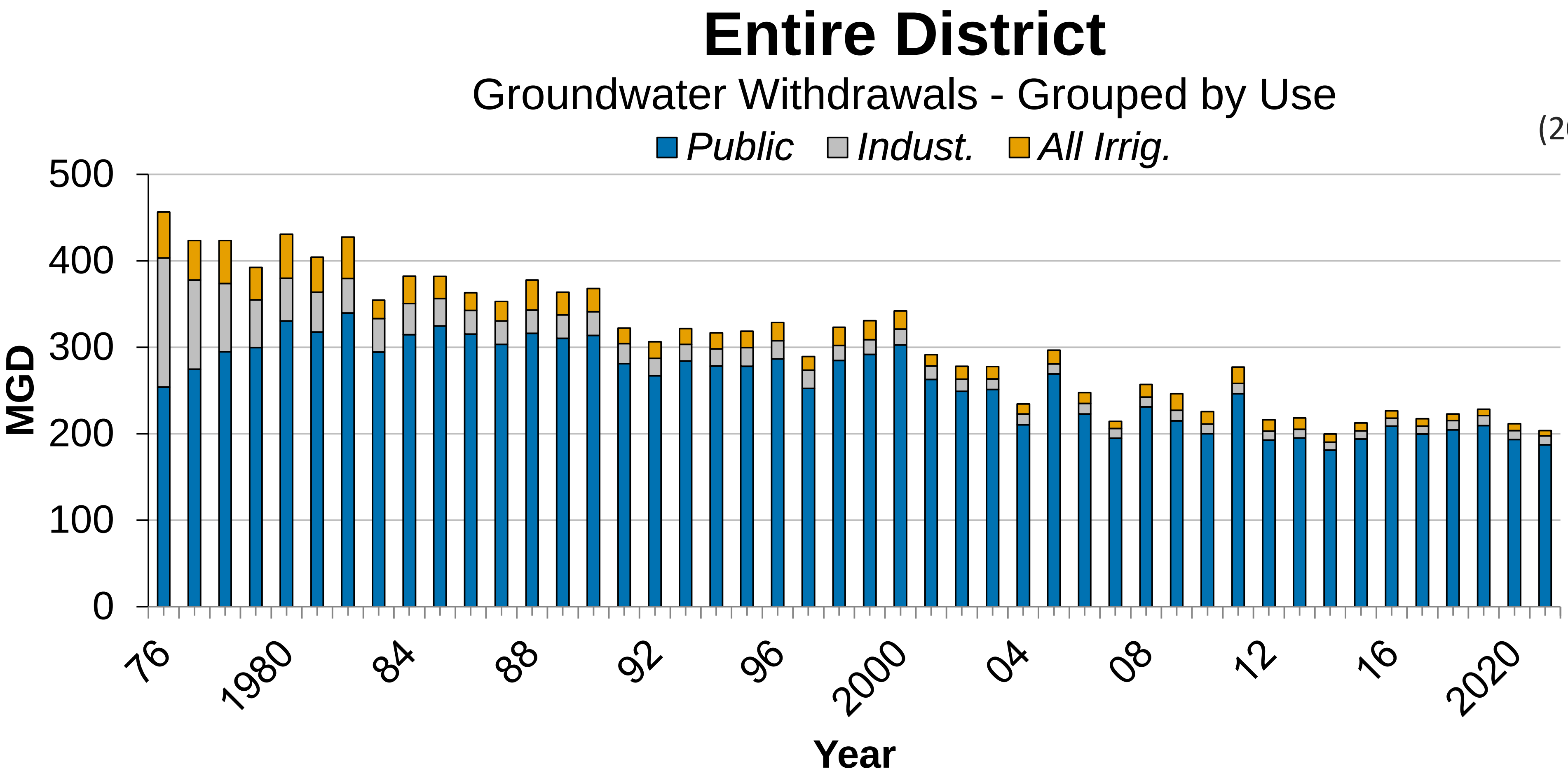


2021 - 168.7 MGD

(2020 – 178 MGD; -5% change)

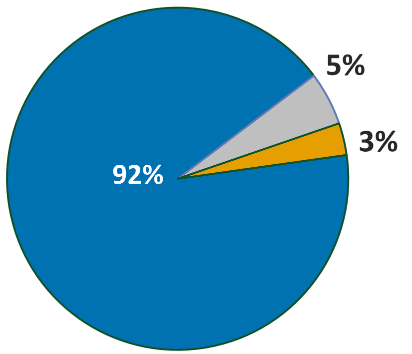


Groundwater Withdrawals | Exhibit 6

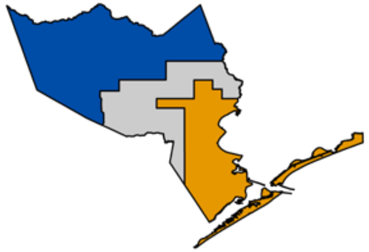


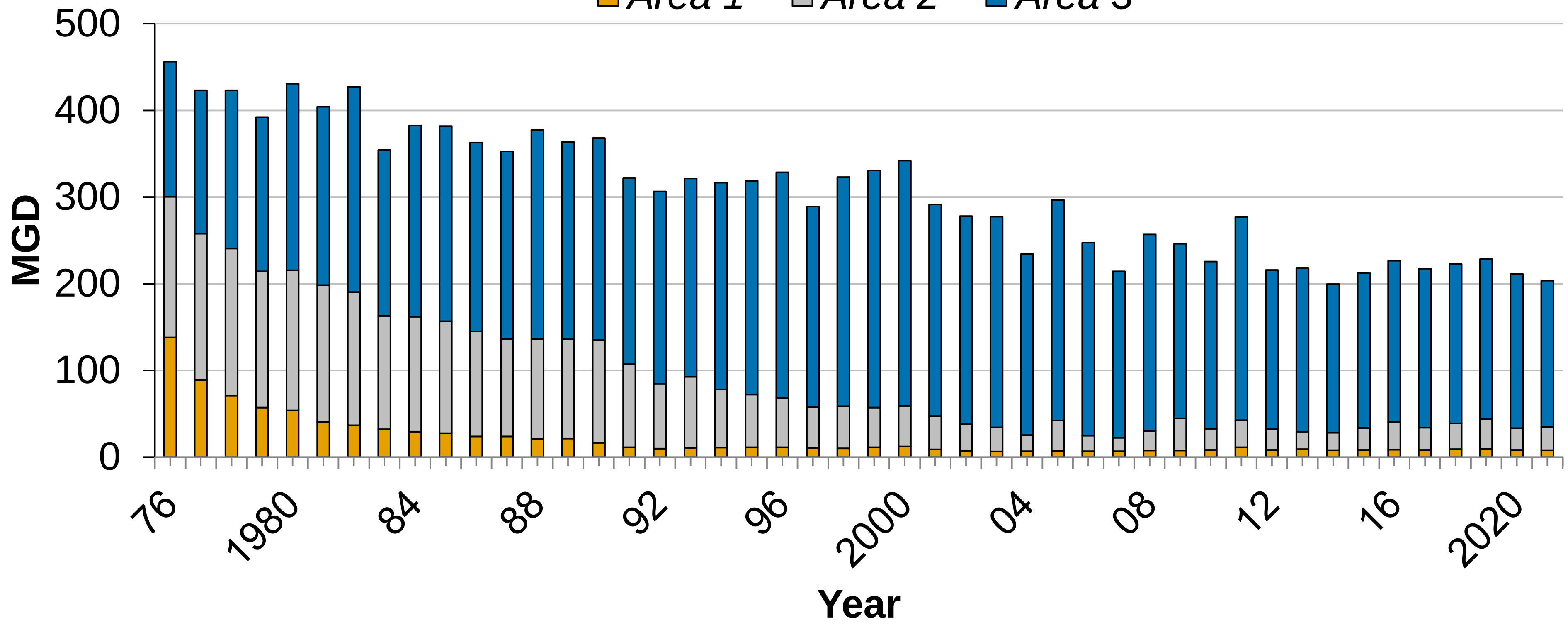
2021 - 203.6 MGD

(2020 – 211.4 MGD; -4% change)



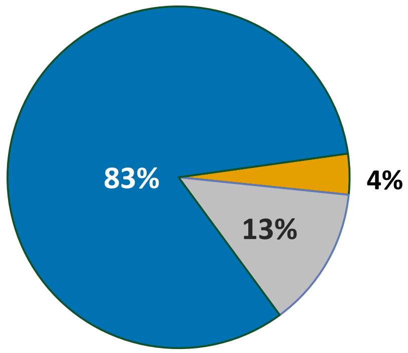
Groundwater Withdrawals | Exhibit 7





2021 - 203.6 MGD

(2020 – 211.4 MGD; -4% change)



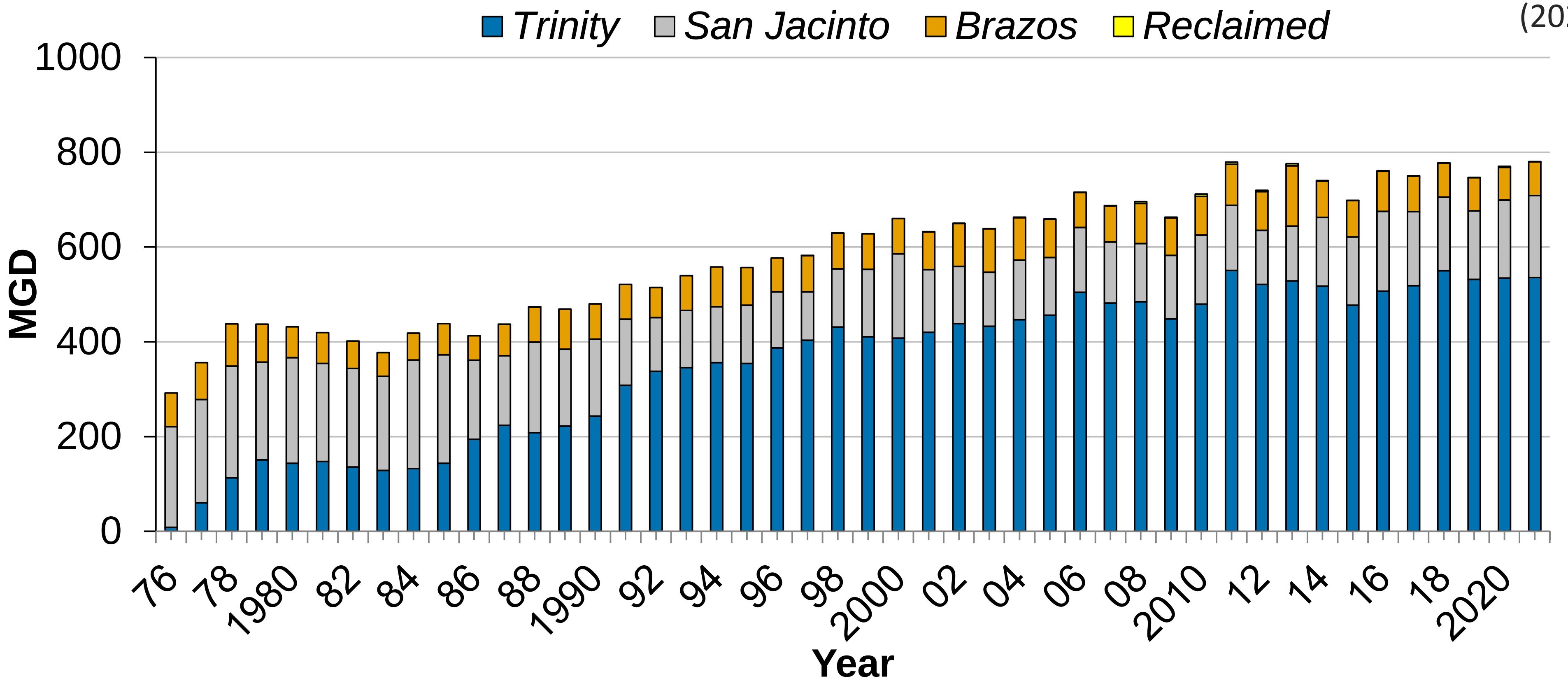
HARRIS-GALVESTON SUBSIDENCE DISTRICT

(Provisional - Subject to Revision)

Alternative Water Utilized | Exhibit 8

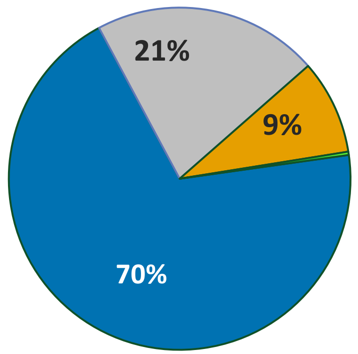
Surface and Reclaimed Water Used

Grouped by Source - Entire District

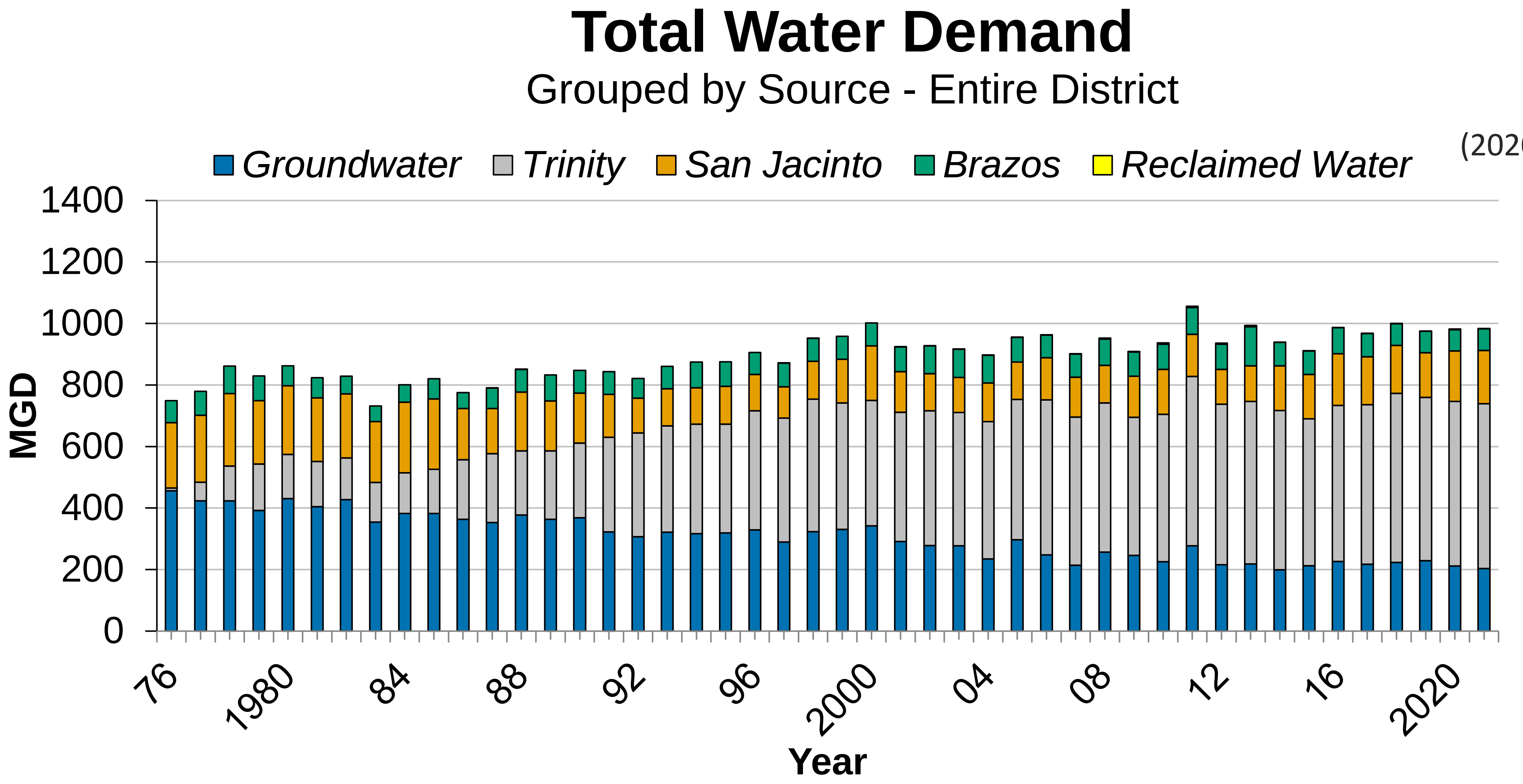


2021 - 779.9 MGD

(2020 – 770.5 MGD; 1% change)

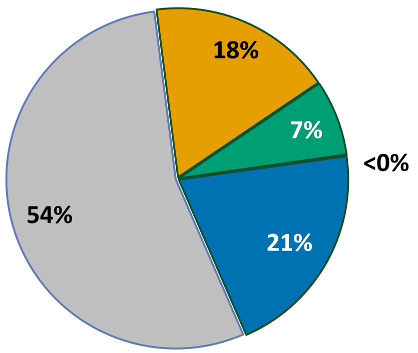


Total Water Demand | Exhibit 9



2021 - 983.4 MGD

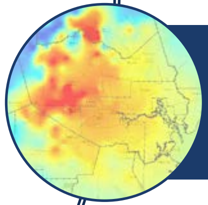
(2020 – 981.9 MGD; 0.2% change)



Agenda


Climate


Groundwater Use


Groundwater Levels


Subsidence Data

Groundwater-level Altitudes (2022) and Changes Over Time in the Chicot and Evangeline (Undifferentiated) and Jasper Aquifers and Compaction in the Chicot and Evangeline Portions of the Undifferentiated Aquifer (1973-2021)

science for a changing world

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Brazoria County Groundwater Conservation District

FORT BEND SUBSIDENCE DISTRICT

HARRIS-GALVESTON SUBSIDENCE DISTRICT

Lone Star Groundwater Conservation District

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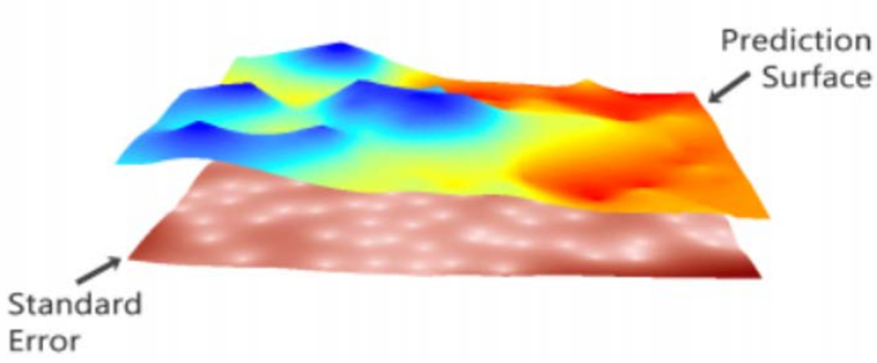
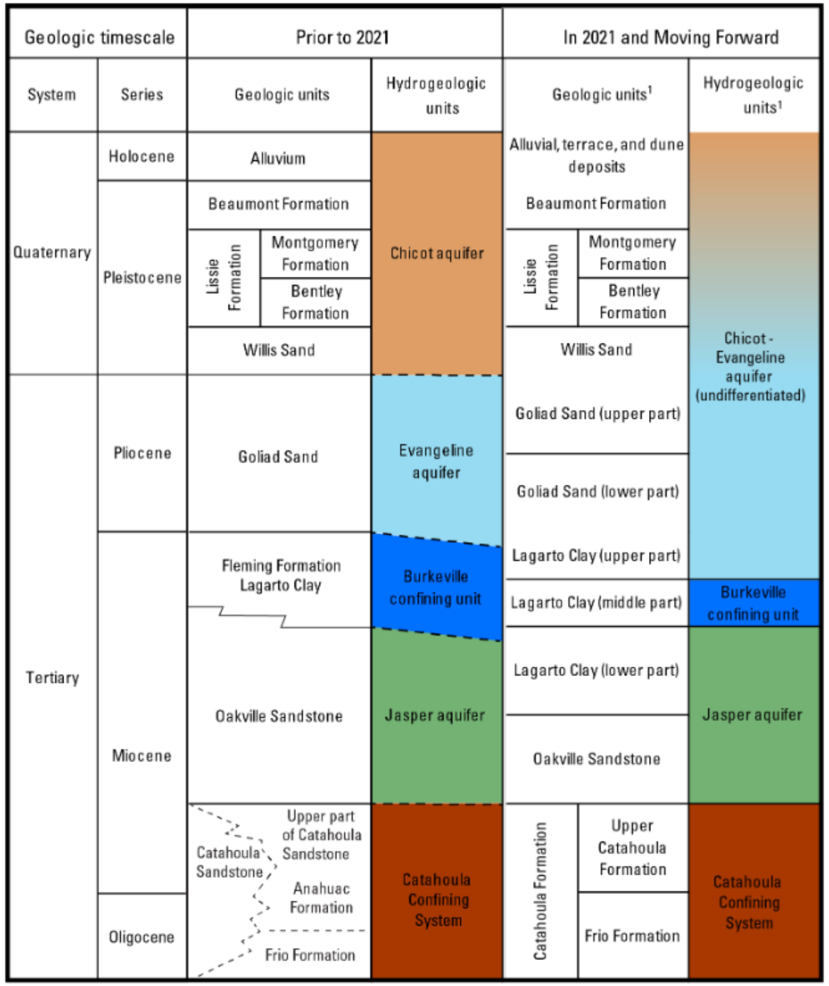
2022 Water-Level Altitude Map Series

- Chicot and Evangeline Aquifer (undifferentiated)
  - 2022 Water-Level Altitude
  - 2021 to 2022 Water-Level Change
  - 2017 to 2022 Water-Level Change
  - 1990 to 2022 Water-Level Change
  - 1977 to 2022 Water-Level Change
- Jasper Aquifer
  - 2022 Water-Level Altitude
  - 2021 to 2022 Water-Level Change
  - 2017 to 2022 Water-Level Change
  - 2000 to 2022 Water-Level Change
- Compaction 1973-2021
  - Compaction Data from 14 Extensometers

Geology and Hydrogeology

- Chicot and Evangeline aquifers (undifferentiated) have been combined into a “shallow” aquifer system
  - GULF 2023 model – updated tops and bases
  - Chicot thickened significantly in much of the region, particularly in central and southeast Harris County.
  - Many of the wells previously designated as Evangeline are now designated as Chicot.
- Altitude and long-term change maps are now represented by shaded grids (Kriging)



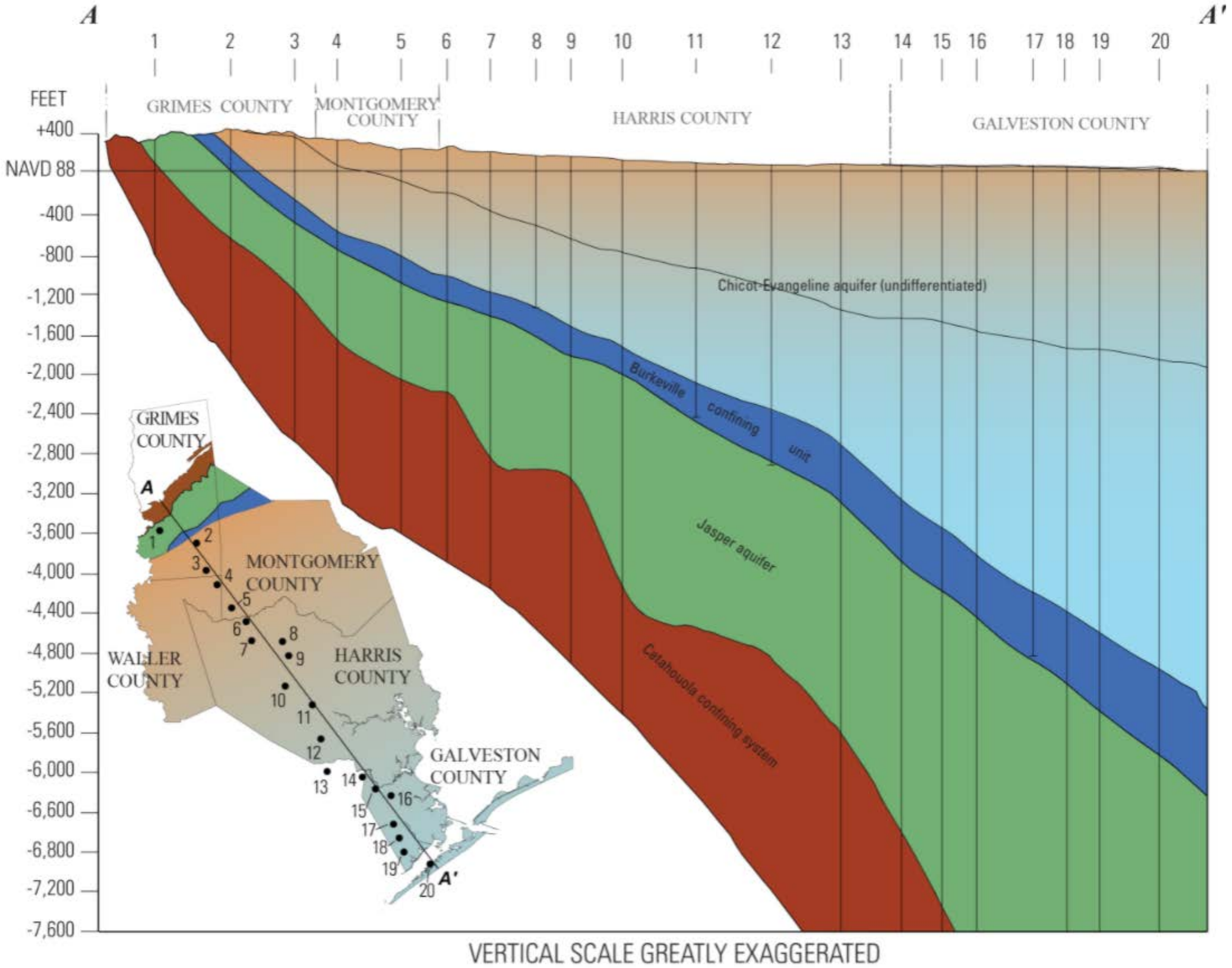


From Braun and Ramage, 2022 (in press) to be published in June 2022

Groundwater Well Network

- Data were collected across 11 counties (Harris and surrounding) from 11-29-2021 to 3-11-2022
- Requires collaboration and agreements with well owners and operators (MUDs)
- Variety of well types including public supply, irrigation, industrial, and observation
- Number of Chicot and Evangeline water-levels collected: **537**
- Number of Jasper water-levels collected: **104**
- Number of wells used to created 2021 Altitude maps
  - Chicot and Evangeline: **498**
  - Jasper: **104**

Stratigraphic Cross Section

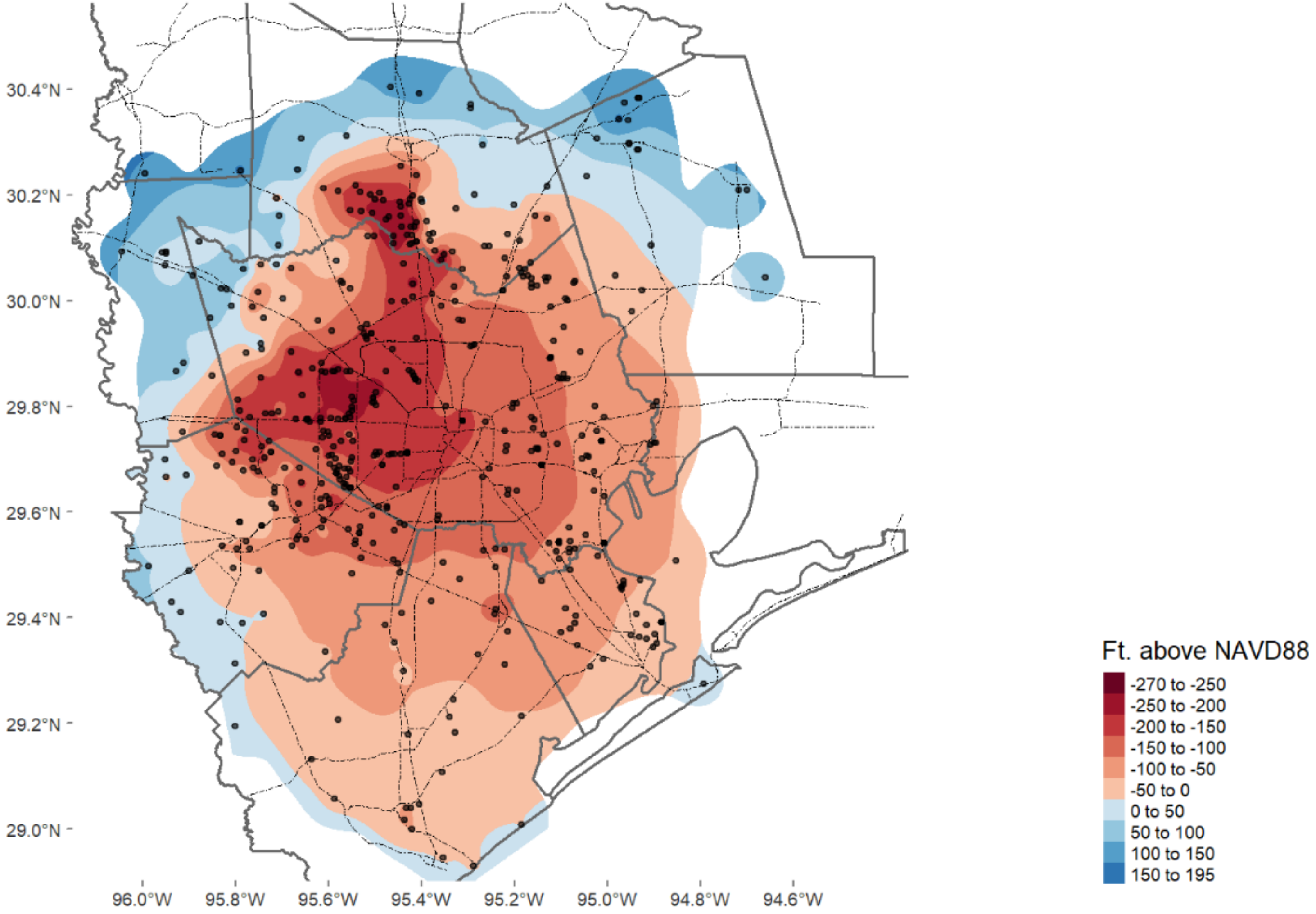


From Braun and Ramage, 2022 (in press) to be published in June 2022

USGS science for a changing world

2022 Chicot and Evangeline (Undifferentiated) Water-Level Altitude

- Data summary:
  - Min: **-270**
  - Mean: **-42**
  - Max: **195**
- Highest areas of usage in western Harris County, and the south-central portion of Montgomery County

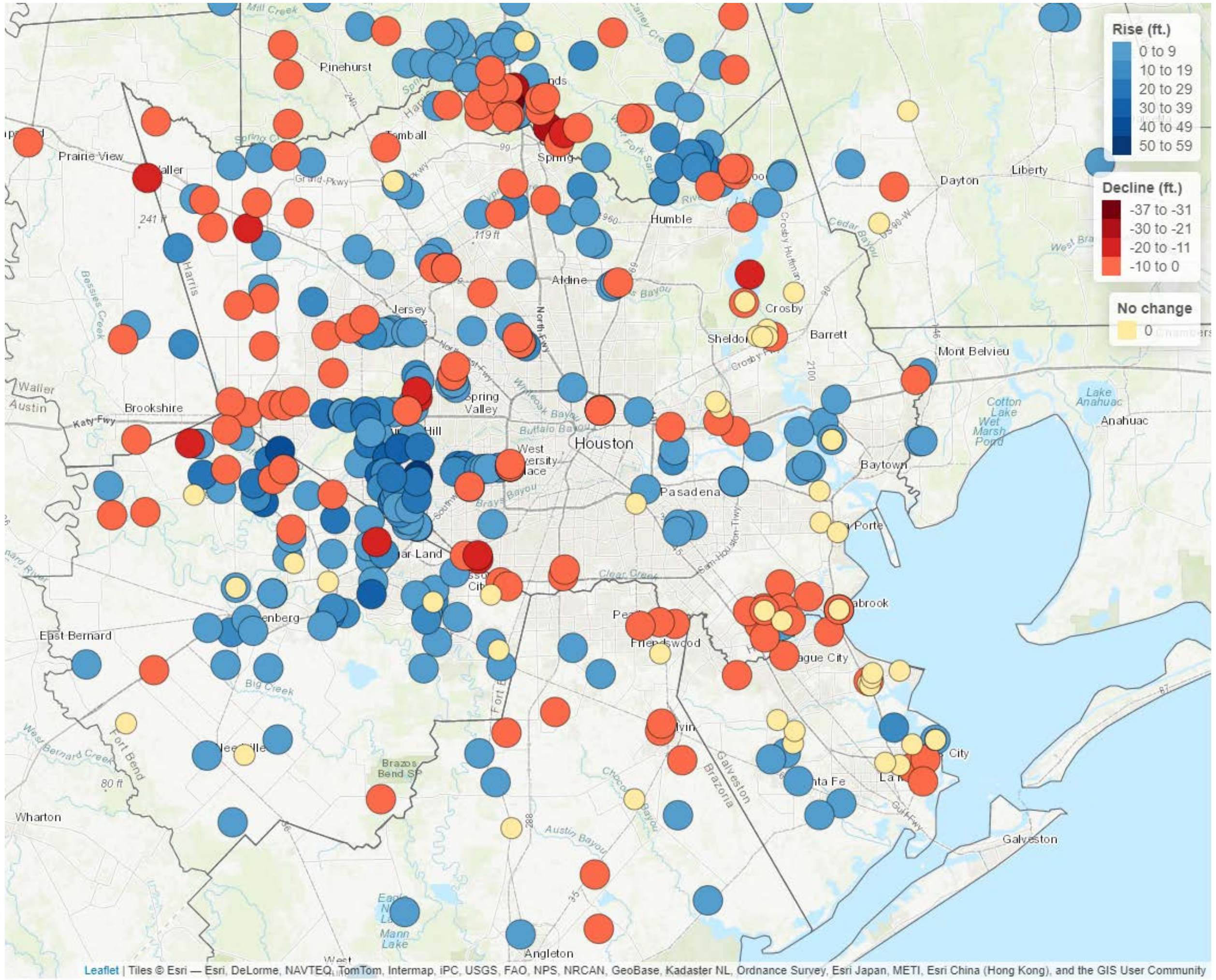


Chicot and Evangeline (Undifferentiated) 1-Year Change

- Number of wells: **457**
- Rises: **56.7%**
- Declines: **30.4%**
- No change: **12.9%**

- More than 20 ft. rise: **32**
- More than 30 ft. rise: **7**

- More than 20 ft. decline: **3**
- More than 30 ft. decline: **1**

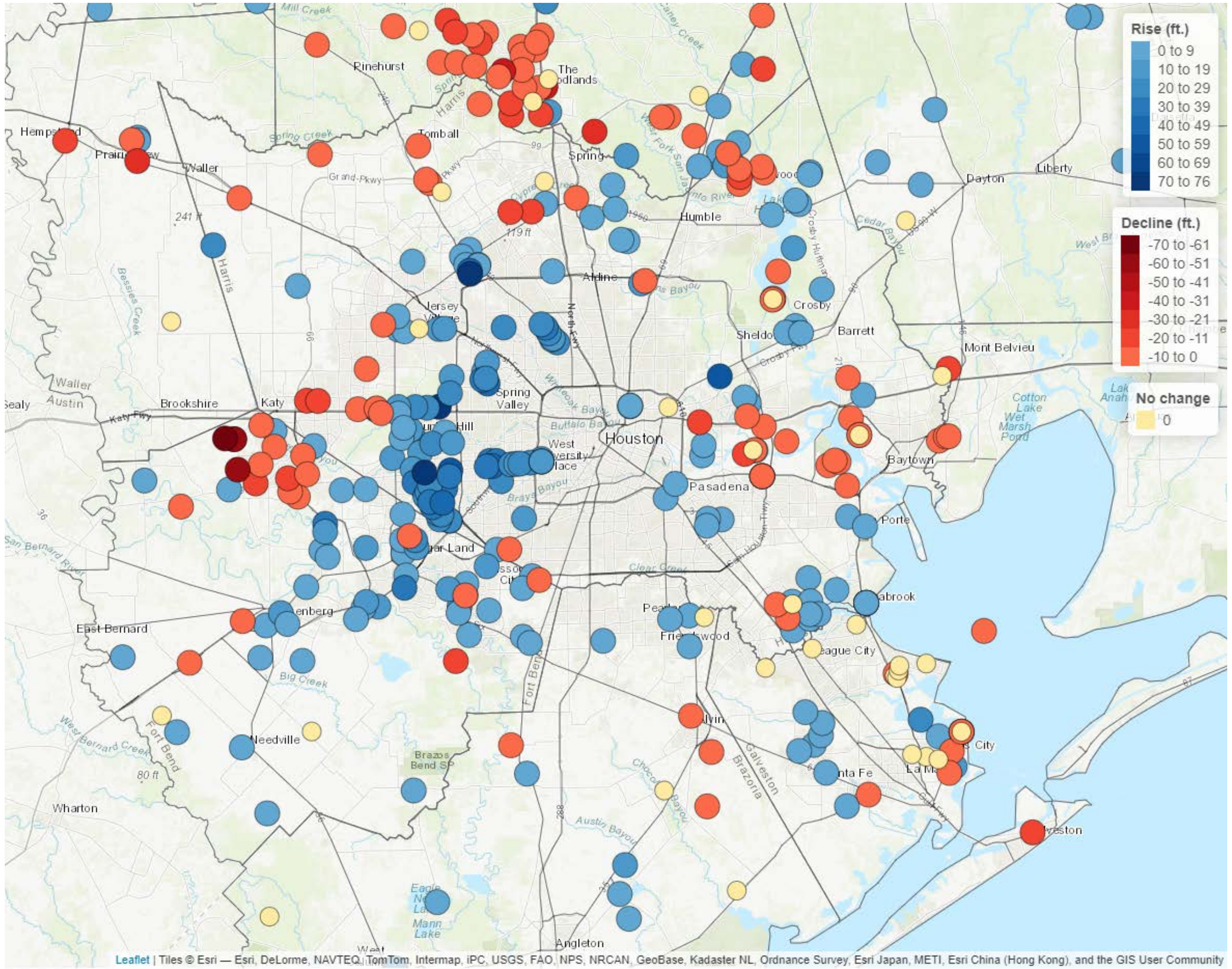


Chicot and Evangeline (Undifferentiated) 5-Year Change

- Number of wells: **388**
- Rises: **58.8%**
- Declines: **31.2%**
- No change: **10.1%**

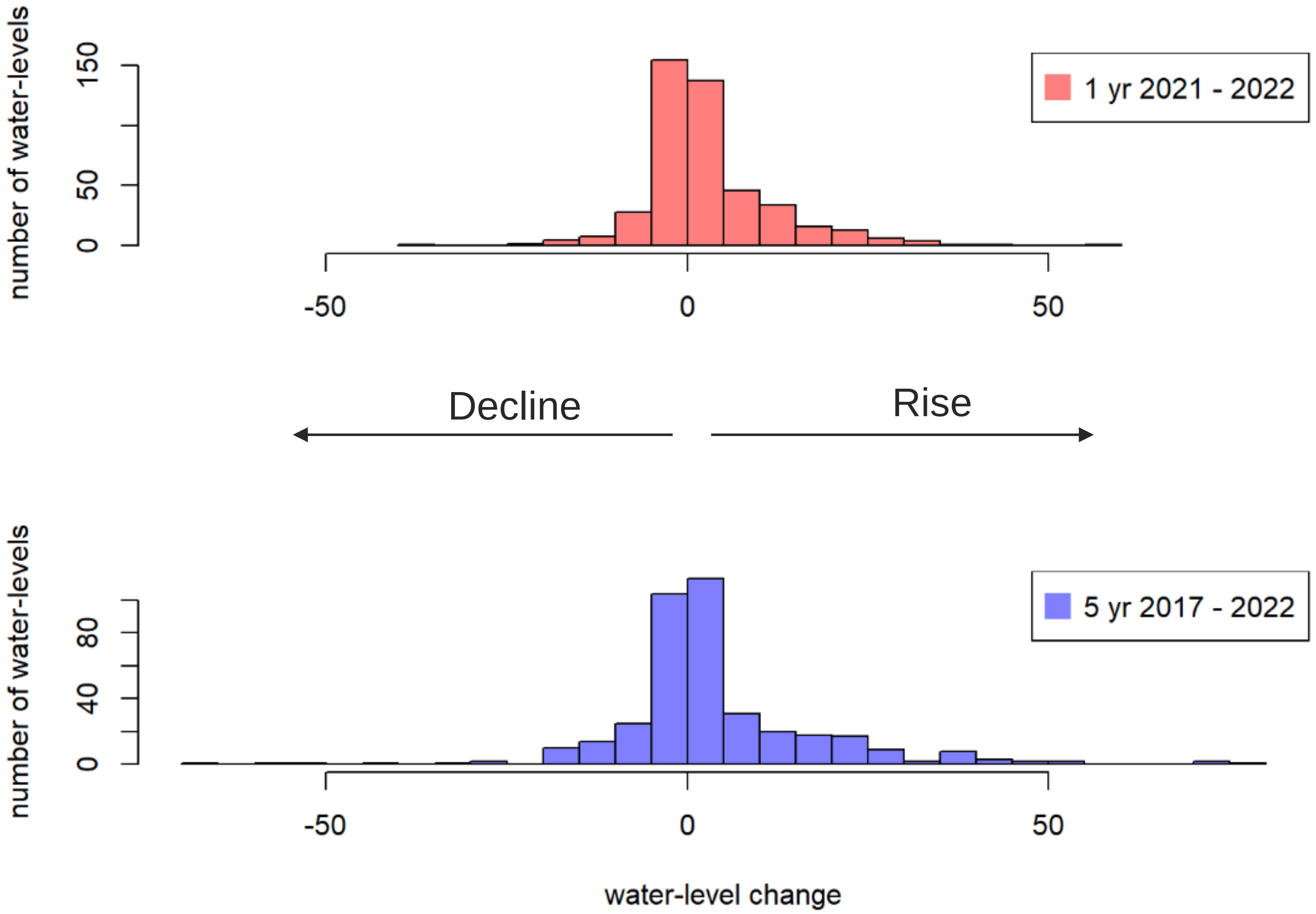
- More than 30 ft. rise: **22**

- More than 30 ft. decline: **5**



Chicot and Evangeline (Undifferentiated)
1 and 5 Year Comparison

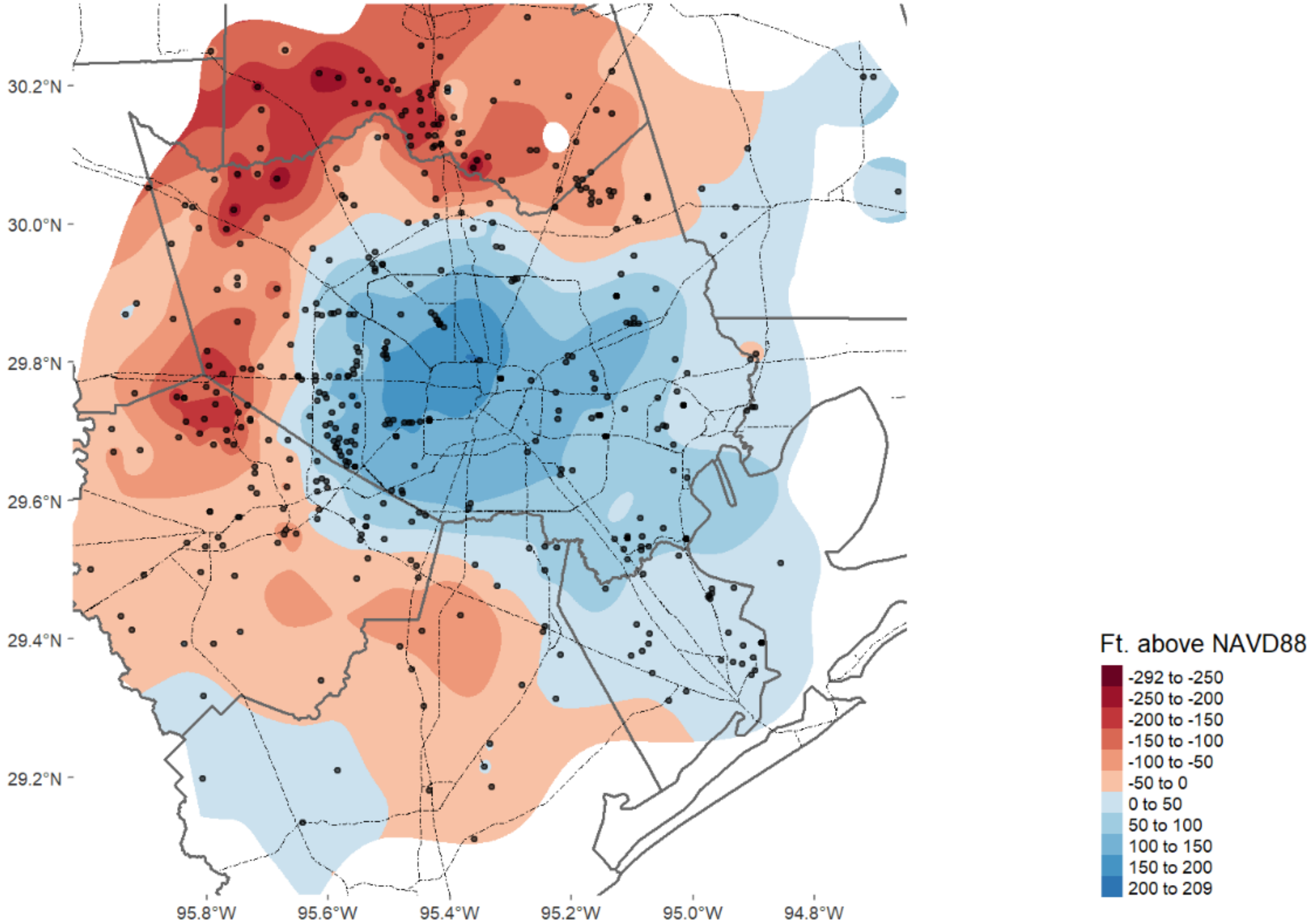
- 2021-2022 Changes
  - Rises: **57%**
  - Declines: **30%**
  - No change: **13%**
  - Rises in the 0-5 ft. range: ~**53% (137)**
  - Declines in the 0-5 ft. range: ~**73% (102)**
- 2017-2022 Changes
  - Rises: **59%**
  - Declines: **31%**
  - No change: **10%**
  - Rises in the 0-5 ft. range: ~**50% (113)**
  - Declines in the 0-5 ft. range: ~**60% (73)**



USGS science for a changing world

Chicot and Evangeline (Undifferentiated) Water-Level Change Since 1990

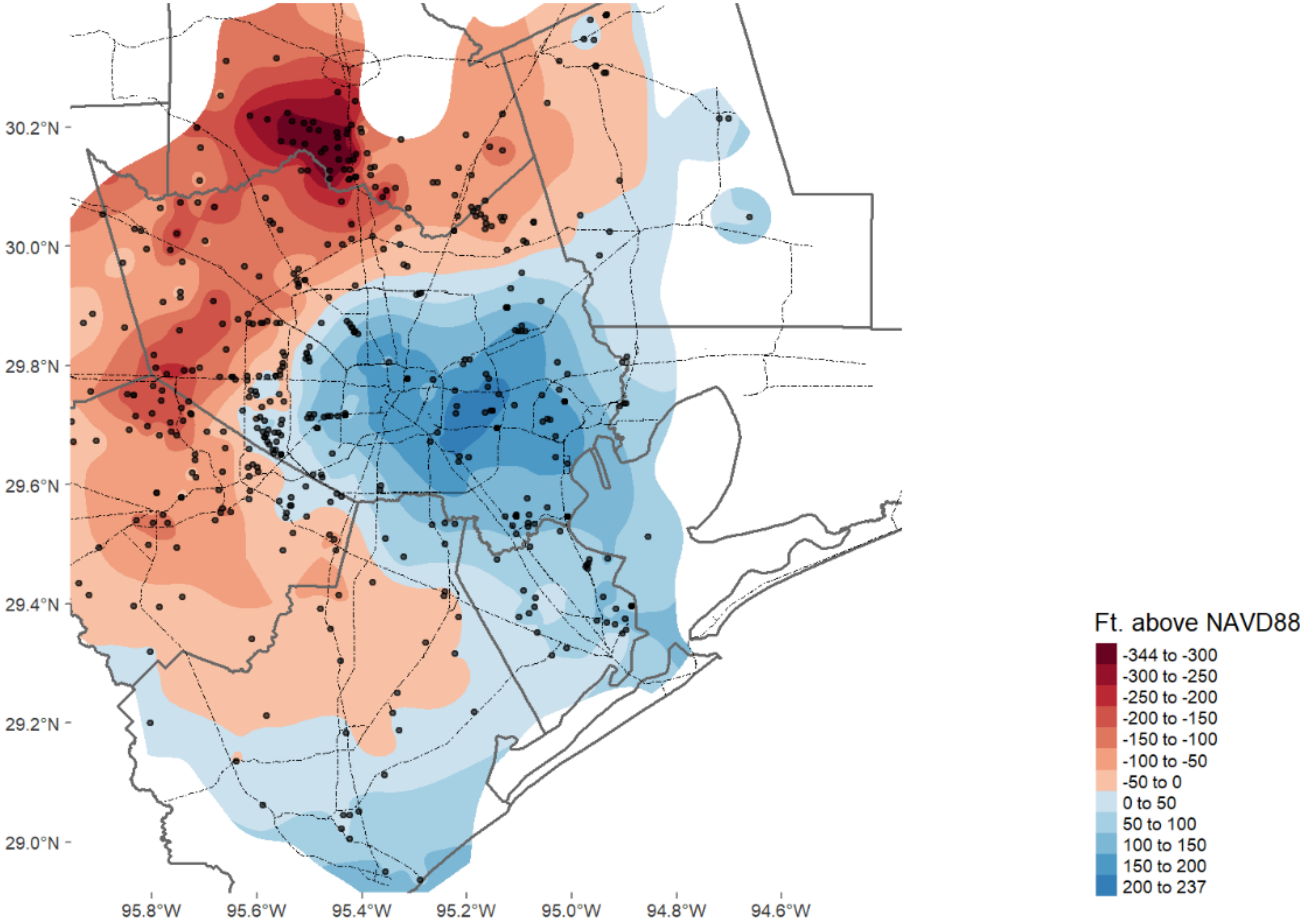
- Data summary:
  - Min: **-292**
  - Mean: **-6**
  - Max: **209**
- Water-level rises across most of central and eastern Harris County as well as Galveston County
- Water-level declines in the northern part of Fort Bend County, NW portions of Harris County, and Montgomery County



USGS
science for a changing world

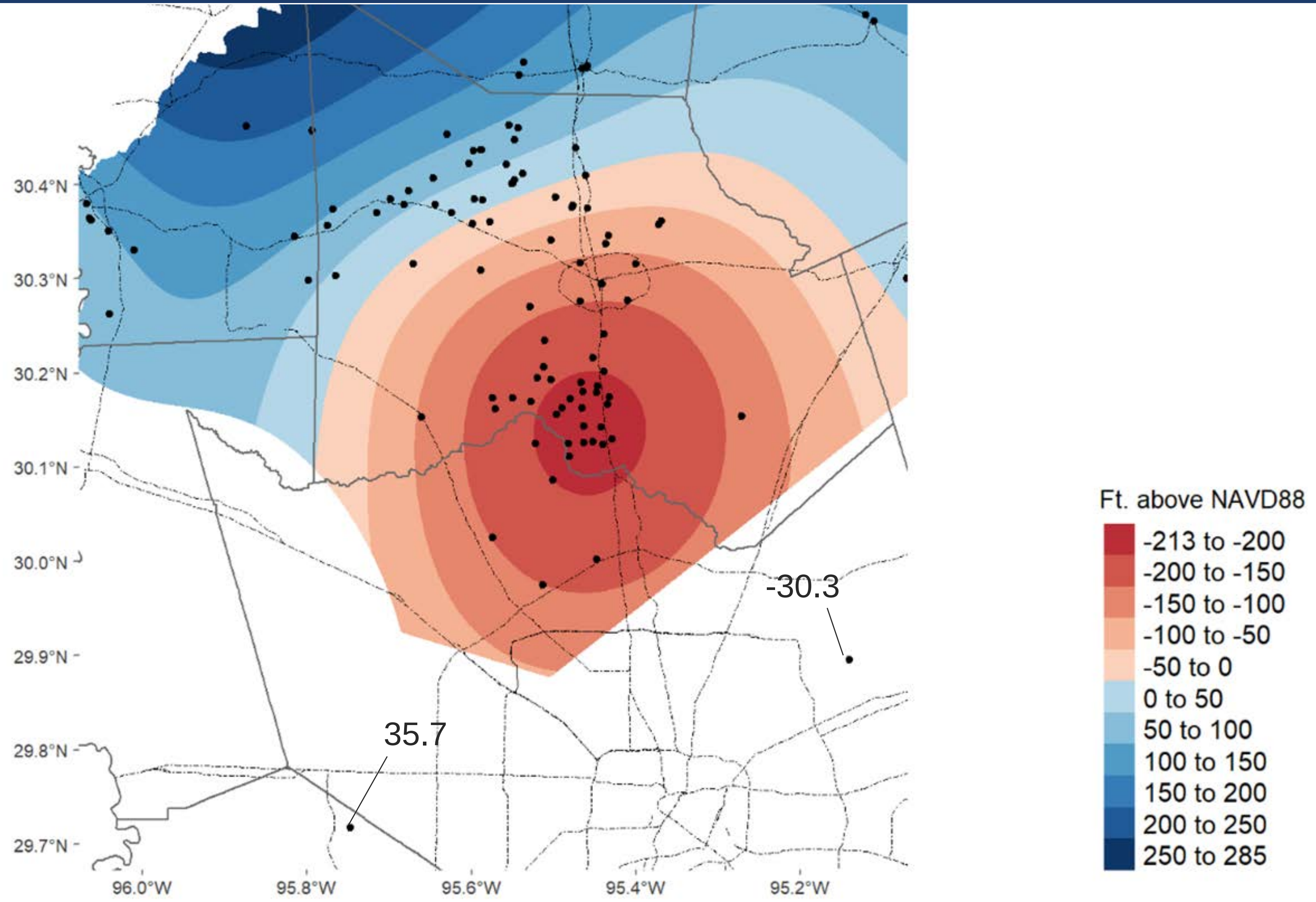
Chicot and Evangeline (Undifferentiated) Water-Level Change Since 1977

- Data summary:
  - Min: **-344**
  - Mean: **-7**
  - Max: **237**
- Water-level rises across most of central and eastern Harris County as well as Galveston County
- Water-level declines in the northern part of Fort Bend County, NW portions of Harris County, and most of Montgomery County



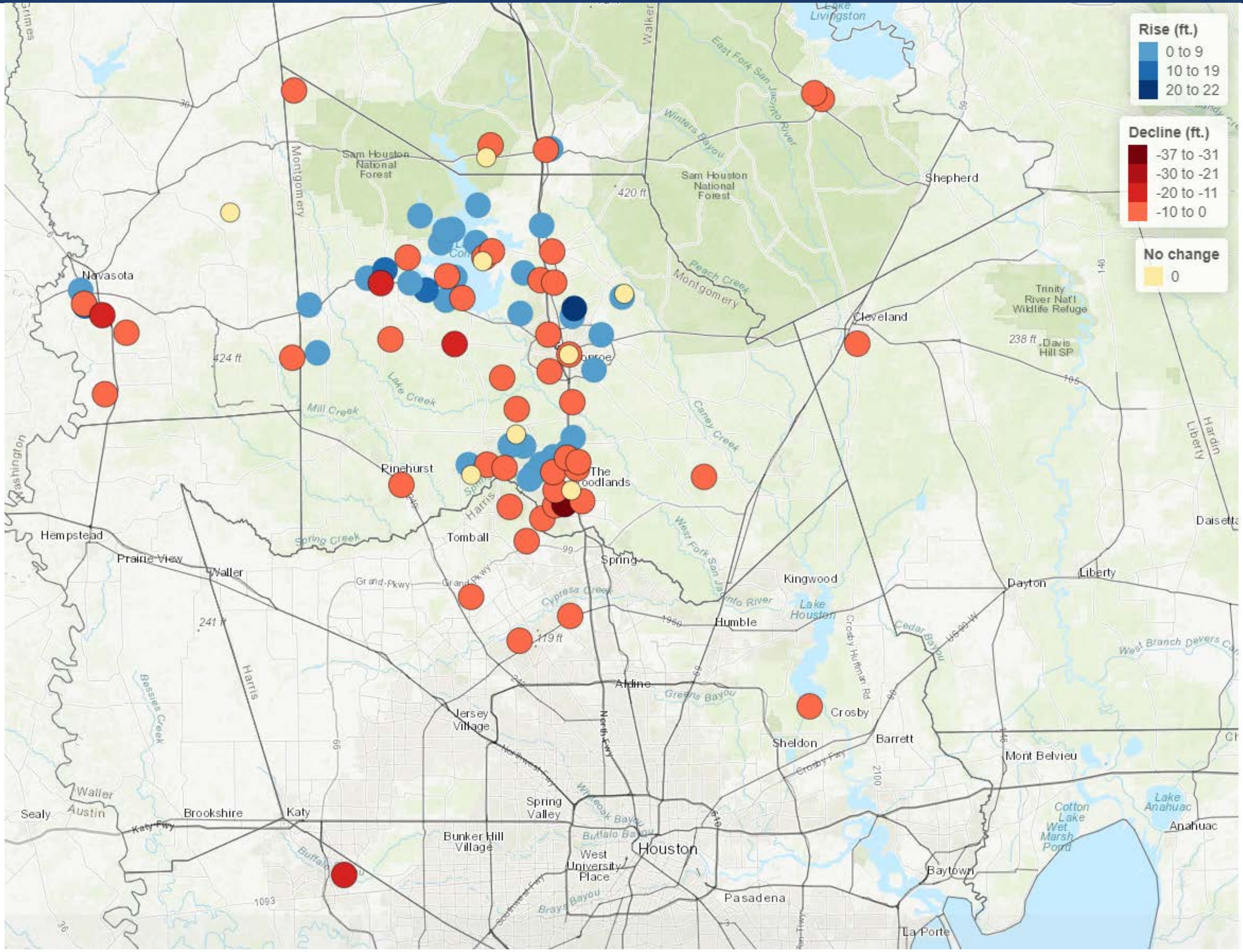
2022 Jasper Aquifer Altitude

- Data summary:
  - Min: **-213**
  - Mean: **10**
  - Max: **285**
- General trend of deepening water levels in downdip (NW-SE) direction
- Deepest water levels in south-central Montgomery County near border with Harris County



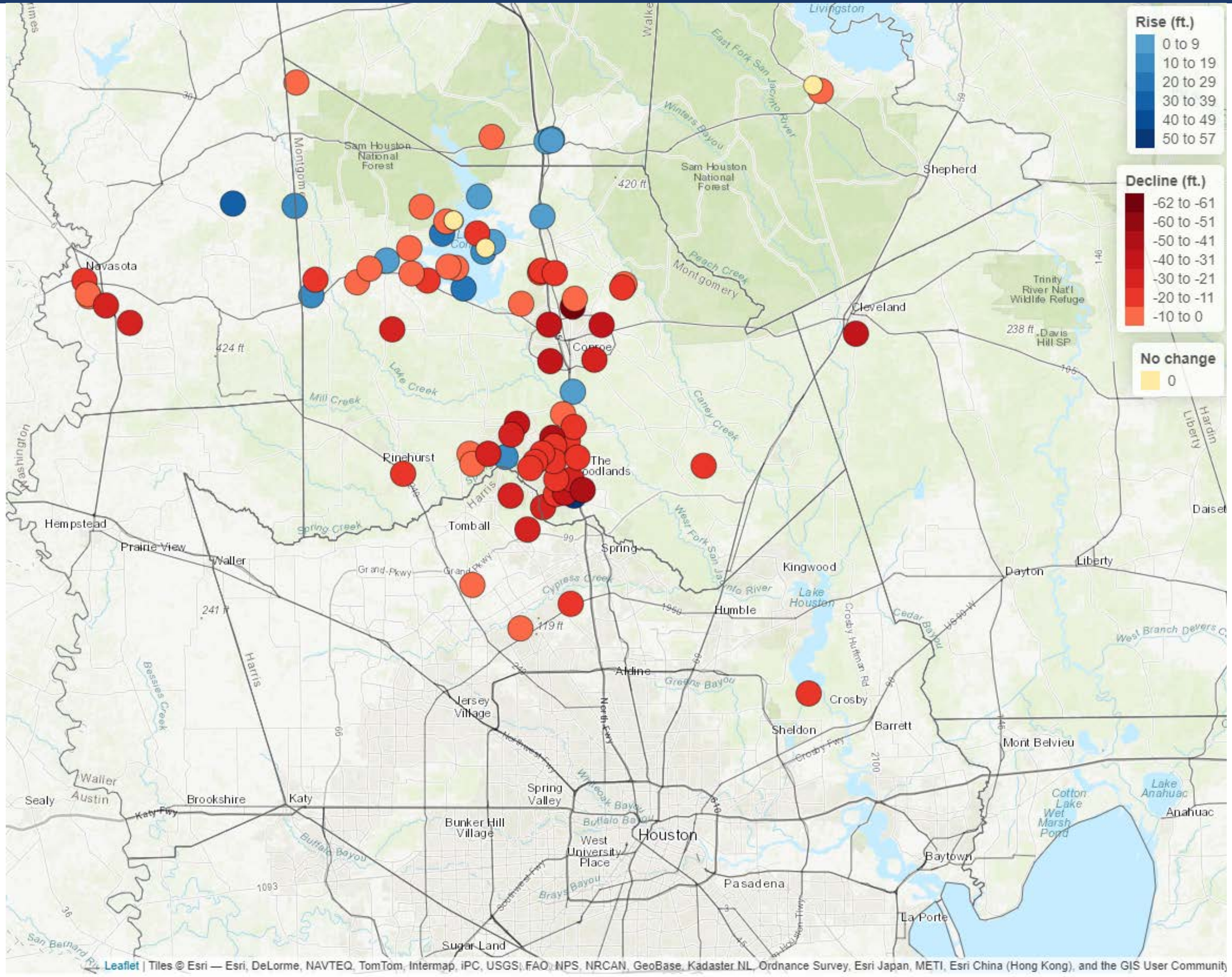
Jasper Aquifer 1-Year Change

- Number of wells: **91**
- Rises: **38.5%**
- Declines: **52.7%**
- No change: **8.8%**



Jasper Aquifer 5-Year Change

- Number of wells: **82**
- Rises: **19.5%**
- Declines: **75.6%**
- No change: **4.9%**



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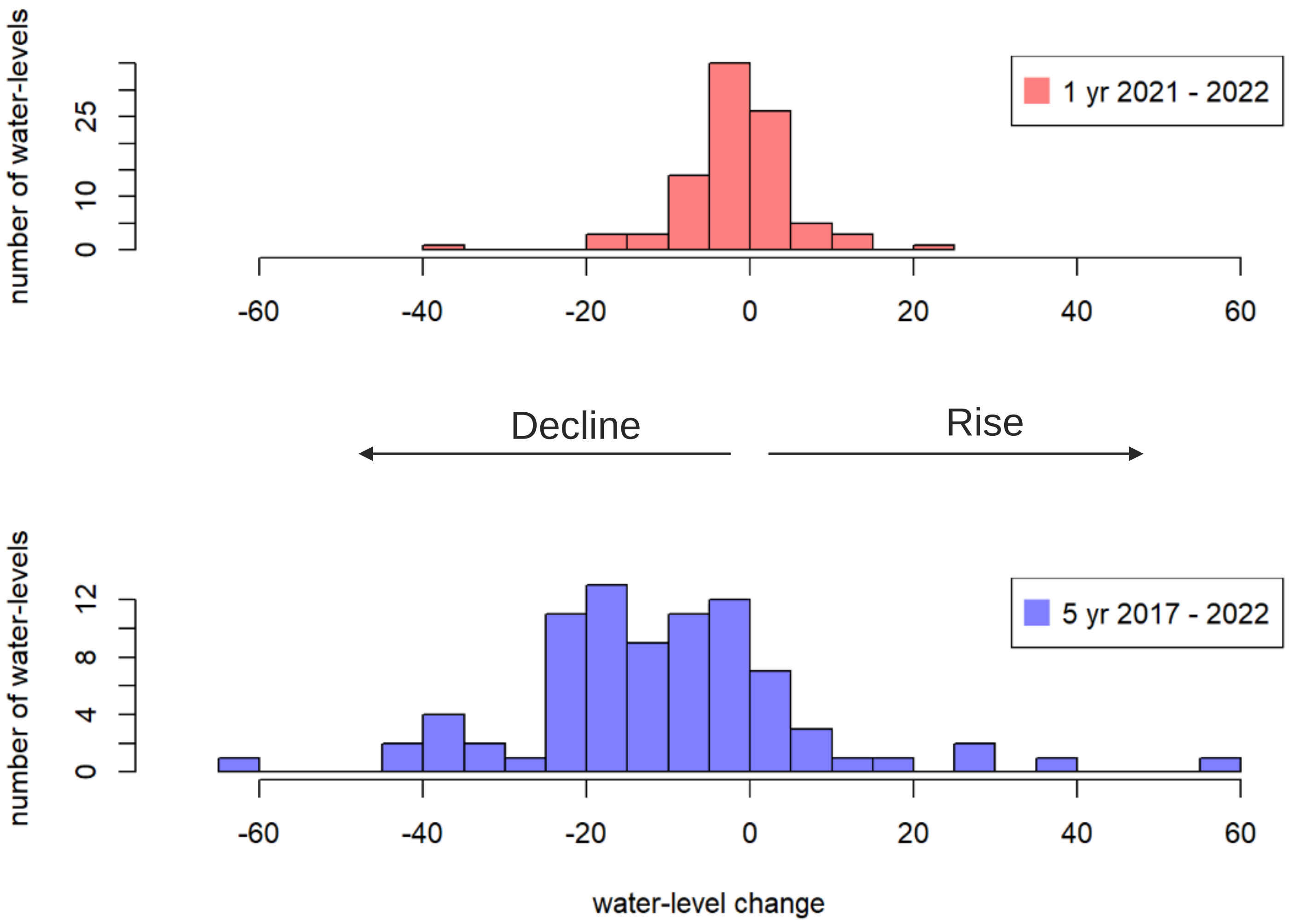
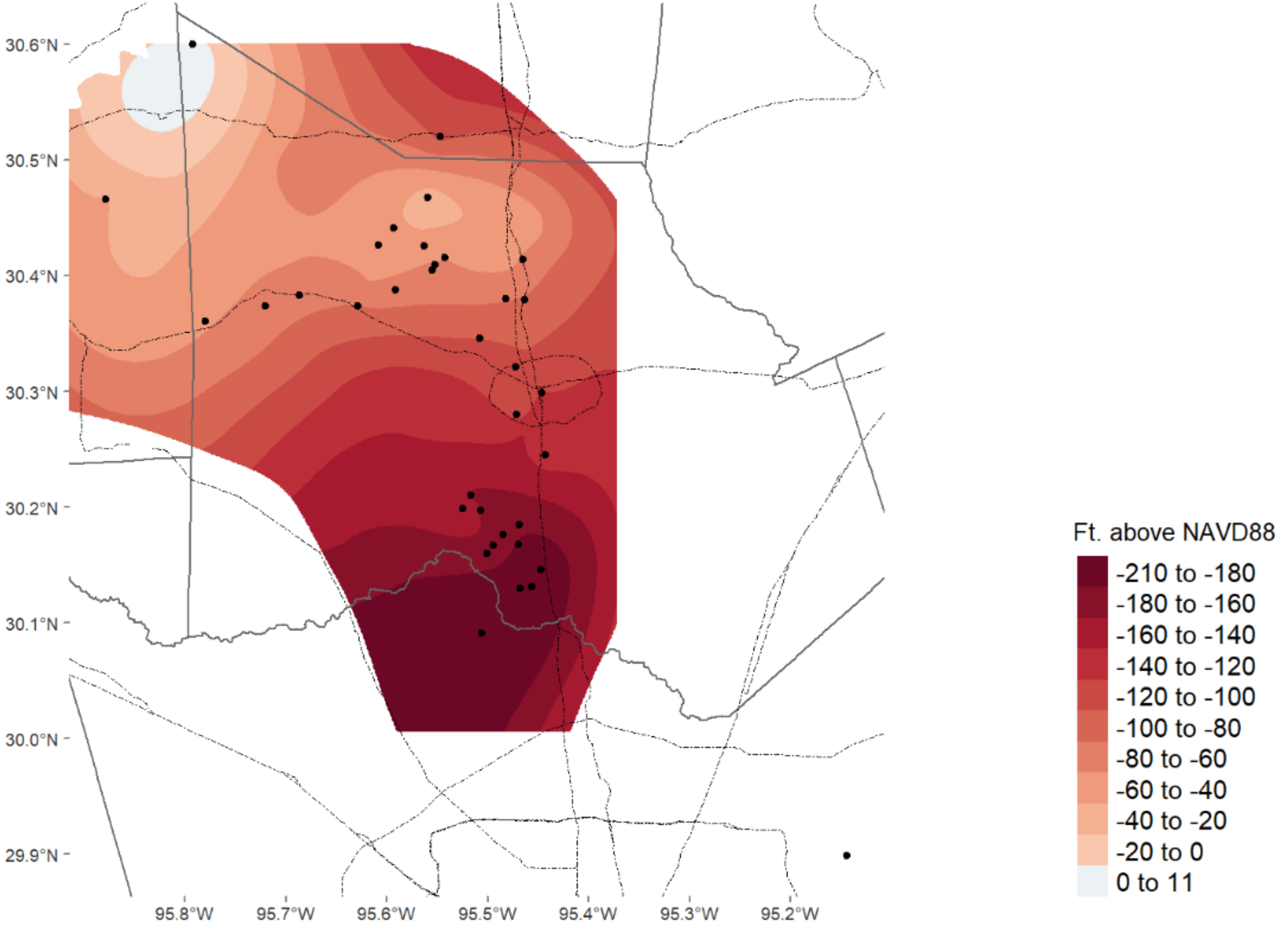
Jasper Aquifer 1 and 5 Year Comparison

- 2021-2022 Changes
  - Rises: **38%**
  - Declines: **53%**
  - No change: **9%**
  - Rises in the 0-5 ft range: ~**74% (26)**
  - Declines in the 0-5 ft range: ~**69% (33)**
- 2017-2022 Changes
  - Rises: **19%**
  - Declines: **76%**
  - No change: 5%
  - Rises in the 0-5 ft range: ~**43% (7)**
  - Declines in the 0-20 ft range: ~**69% (43)**

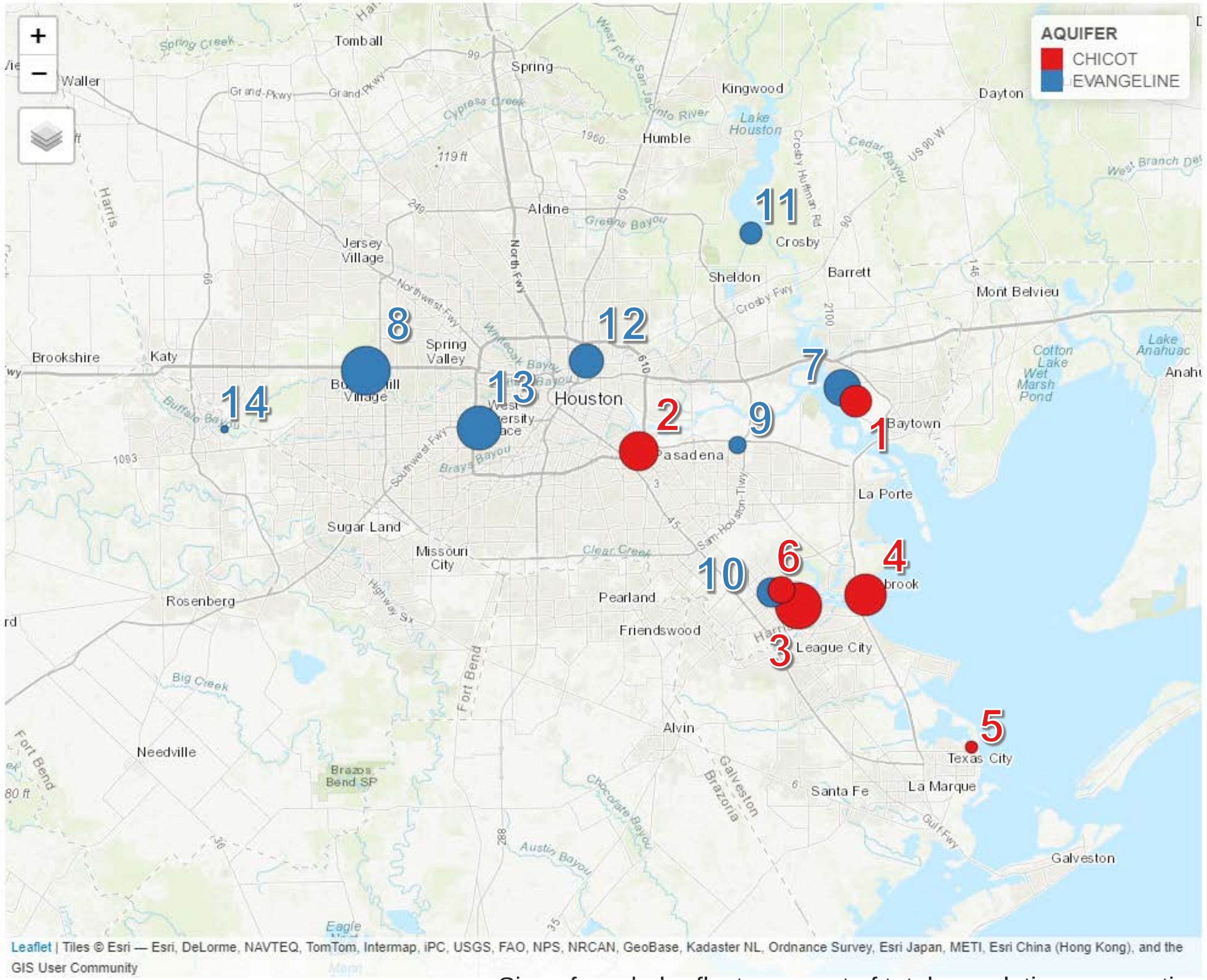


Jasper Aquifer Water-Level Change Since 2000

- Data summary:
  - Min: **-210**
  - Mean: **-98**
  - Max: **11**
- General trend of declining water levels in downdip (NW-SE) direction
- Area with greatest declines along Harris – Montgomery County border



Cumulative Compaction Recorded at Each Location as of December 2021



Size of symbol reflects amount of total cumulative compaction

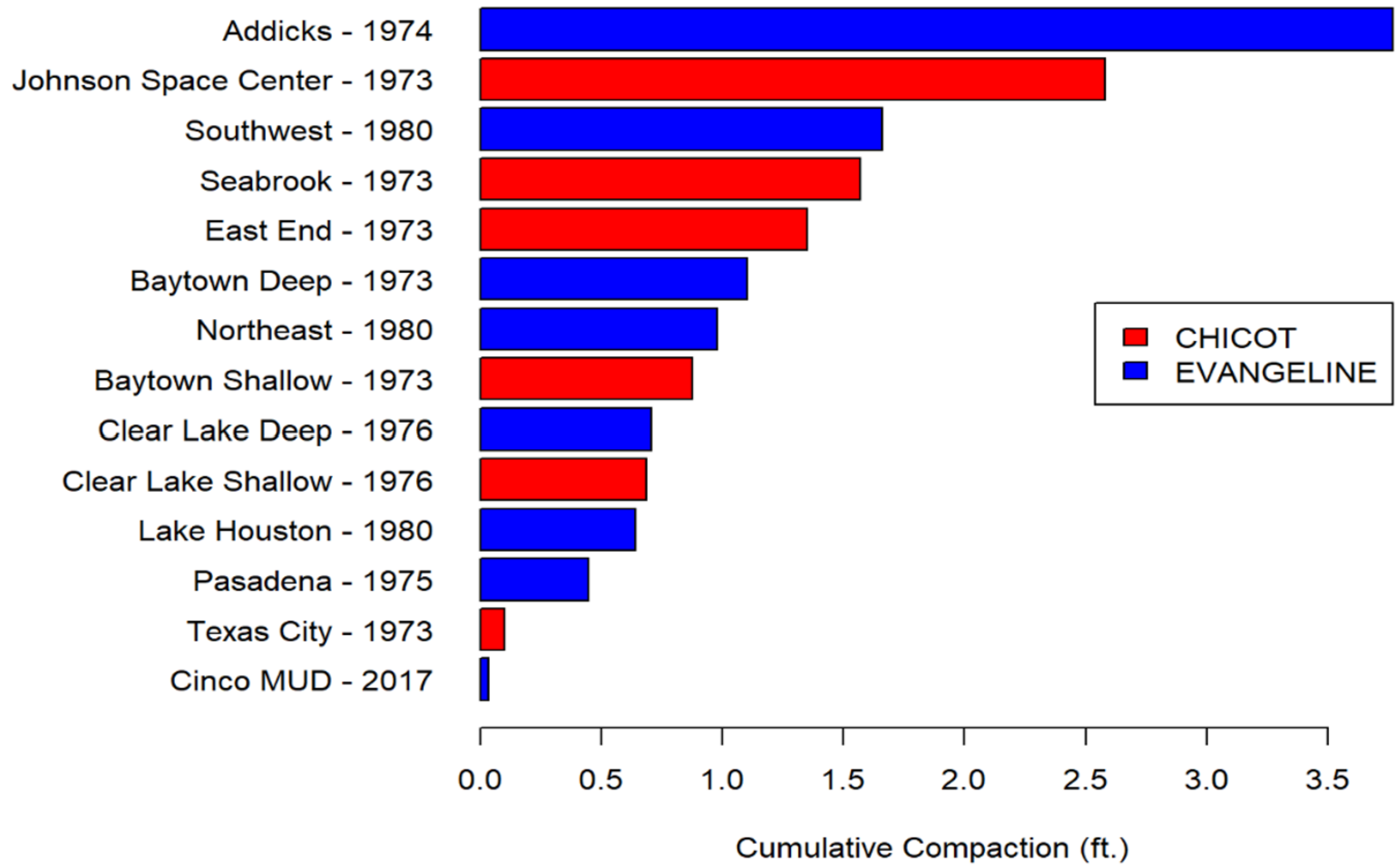
Chicot Aquifer

1. 1973 | Baytown Shallow – 0.875 ft.
2. 1973 | East End – 1.350 ft.
3. 1973 | Johnson Space Center – 2.580 ft.
4. 1973 | Seabrook – 1.570 ft.
5. 1973 | Texas City – 0.096 ft.
6. 1976 | Clear Lake Shallow – 0.685 ft.

Evangeline Aquifer

7. 1973 | Baytown Deep – 1.100 ft.
8. 1974 | Addicks – 3.770 ft.
9. 1975 | Pasadena – 0.446 ft.
10. 1976 | Clear Lake Deep – 0.705 ft.
11. 1980 | Lake Houston – 0.640 ft.
12. 1980 | Northeast – 0.978 ft.
13. 1980 | Southwest – 1.660 ft.
14. 2017 | Cinco MUD – 0.031 ft.

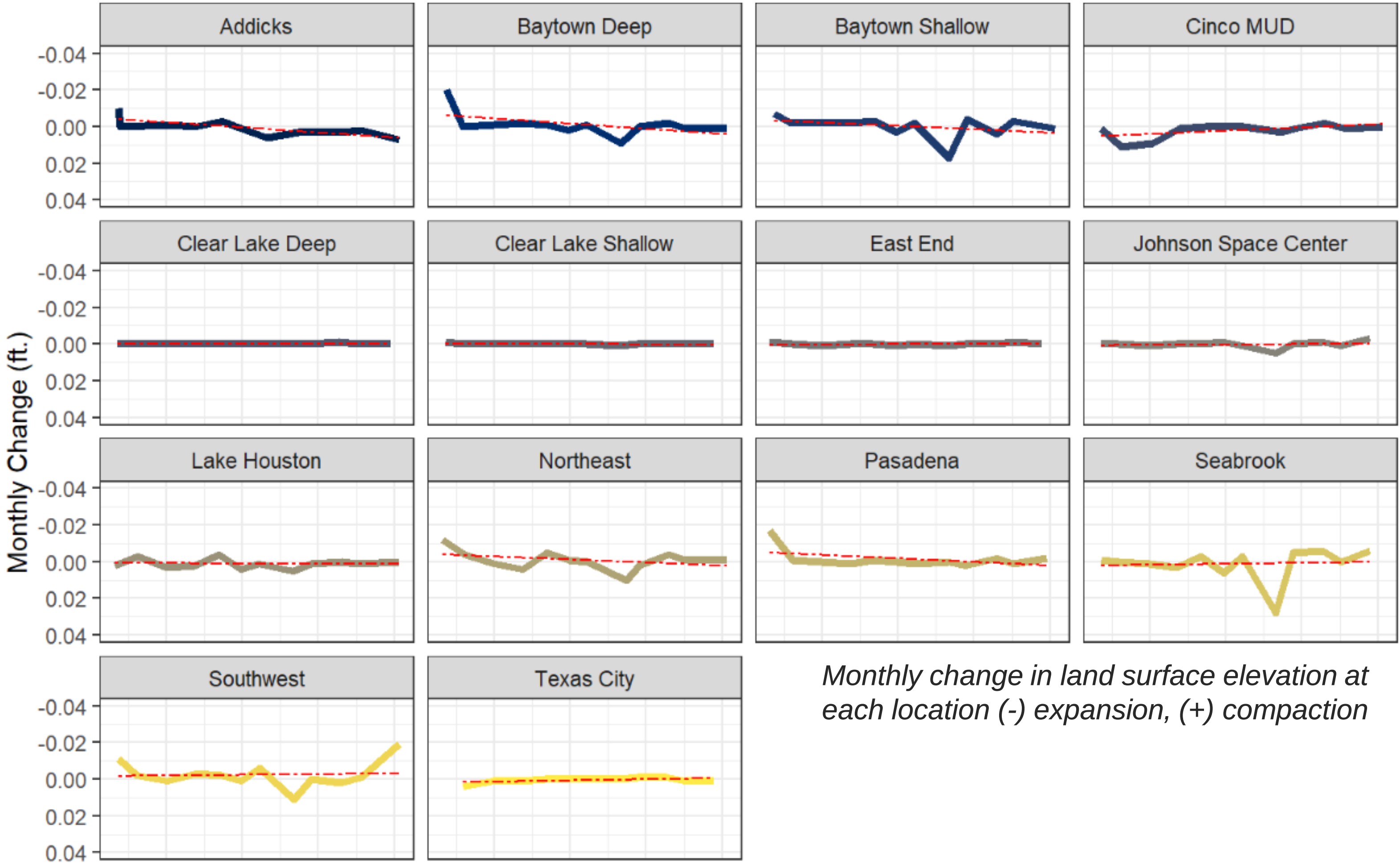
Total Compaction Recorded Since Date of Initial Recording through December 2021



Compaction 1-Year Monthly Changes

- Slight increase in trend (compaction)
  - Addicks
  - Baytown Deep
  - Baytown Shallow
  - Northeast
  - Southwest
- Slight decrease in trend (expansion)
  - Cinco MUD
  - Northeast
  - Pasadena
  - Seabrook

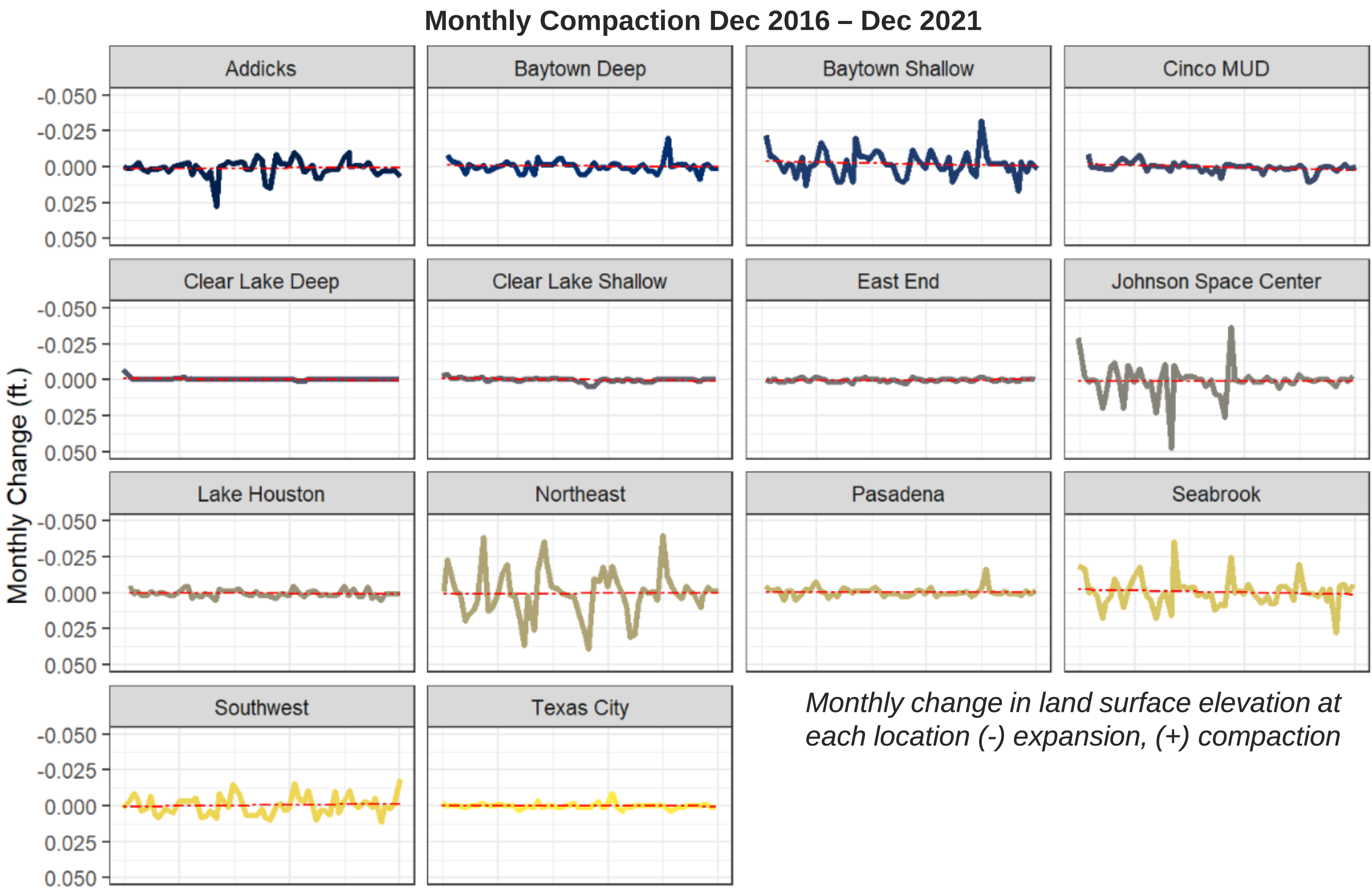
Monthly Compaction Dec 2020 – Dec 2021



Monthly change in land surface elevation at each location (-) expansion, (+) compaction

Compaction 5-Year Monthly Changes

- Slight increase in trend (compaction)
  - Baytown Shallow
  - Cinco MUD
  - Seabrook
- Slight decrease in trend (expansion)
  - Southwest

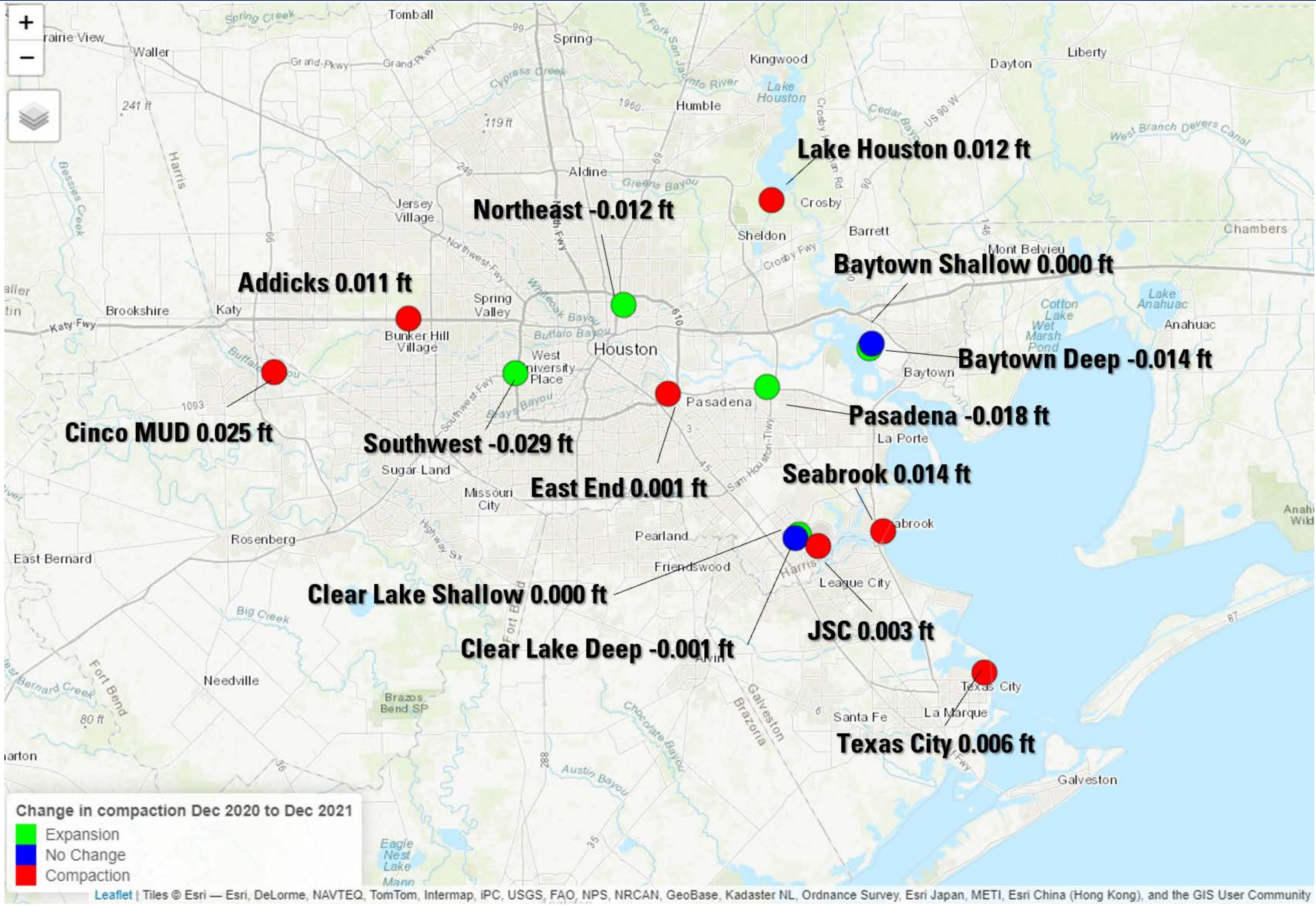


Monthly change in land surface elevation at each location (-) expansion, (+) compaction

USGS science for a changing world

Compaction Summary | Absolute changes for the period December 2020 through December 2021

- 5 sites recorded expansion ranging from 0.001 ft. to 0.029 ft.
- 7 sites recorded compaction ranging from 0.001 ft. to 0.025 ft.
- 2 sites recorded no change



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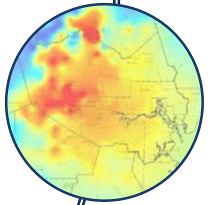
Agenda


Climate


Groundwater Use


Groundwater Levels


Subsidence Data

Subsidence Measurement Method | Exhibit 10

All Subsidence District operated Global positioning system (GPS) station are constructed in the Port-a-Measure (PAM) design and collect GPS data periodically.

Photo shows P051 located in Humble, TX.

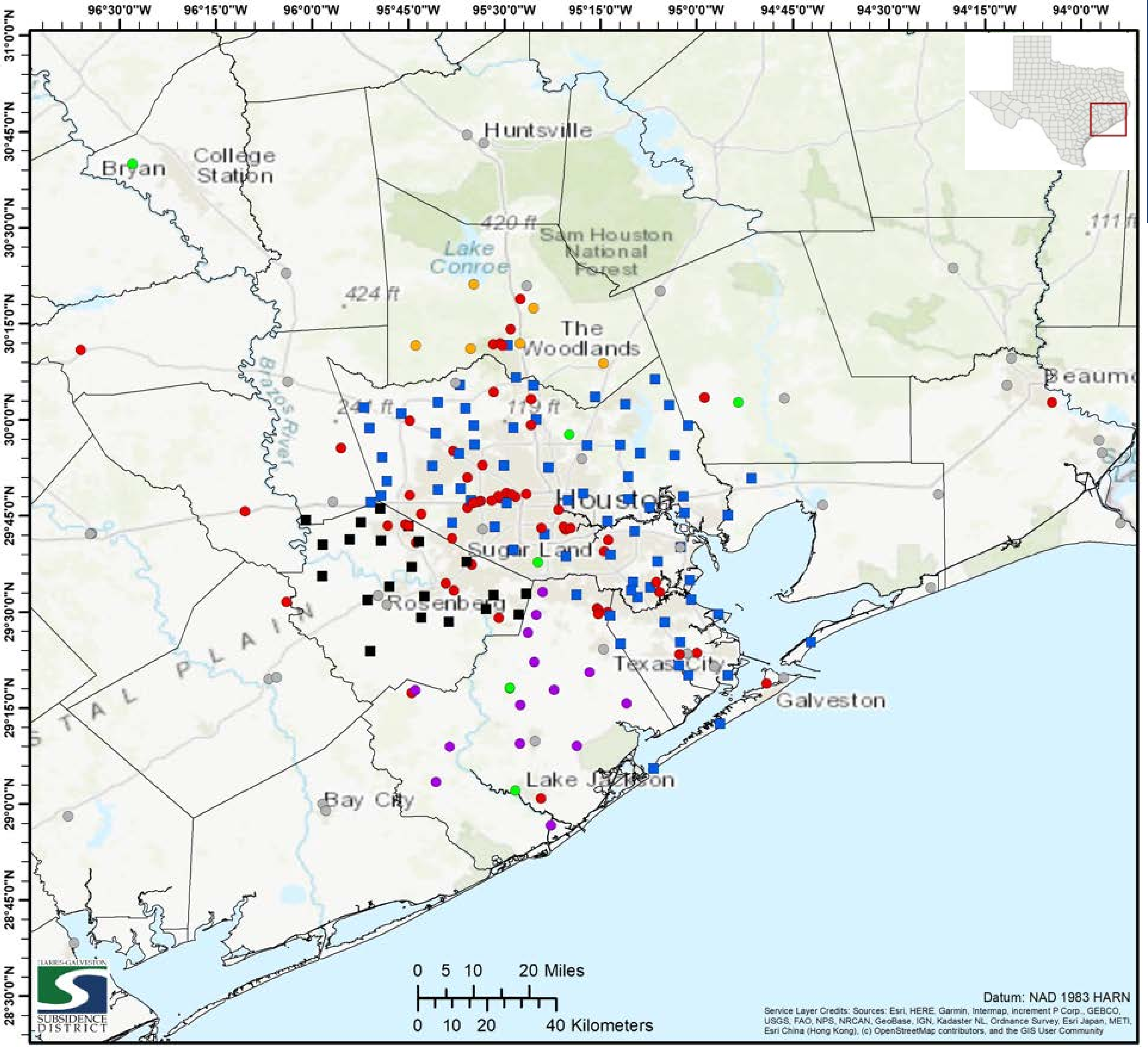
Subsidence Monitoring Network | Exhibit 11

Location and operator of GPS stations that monitor land-surface deformation periodically or continuously within the greater Houston-Galveston region 2021.

EXPLANATION

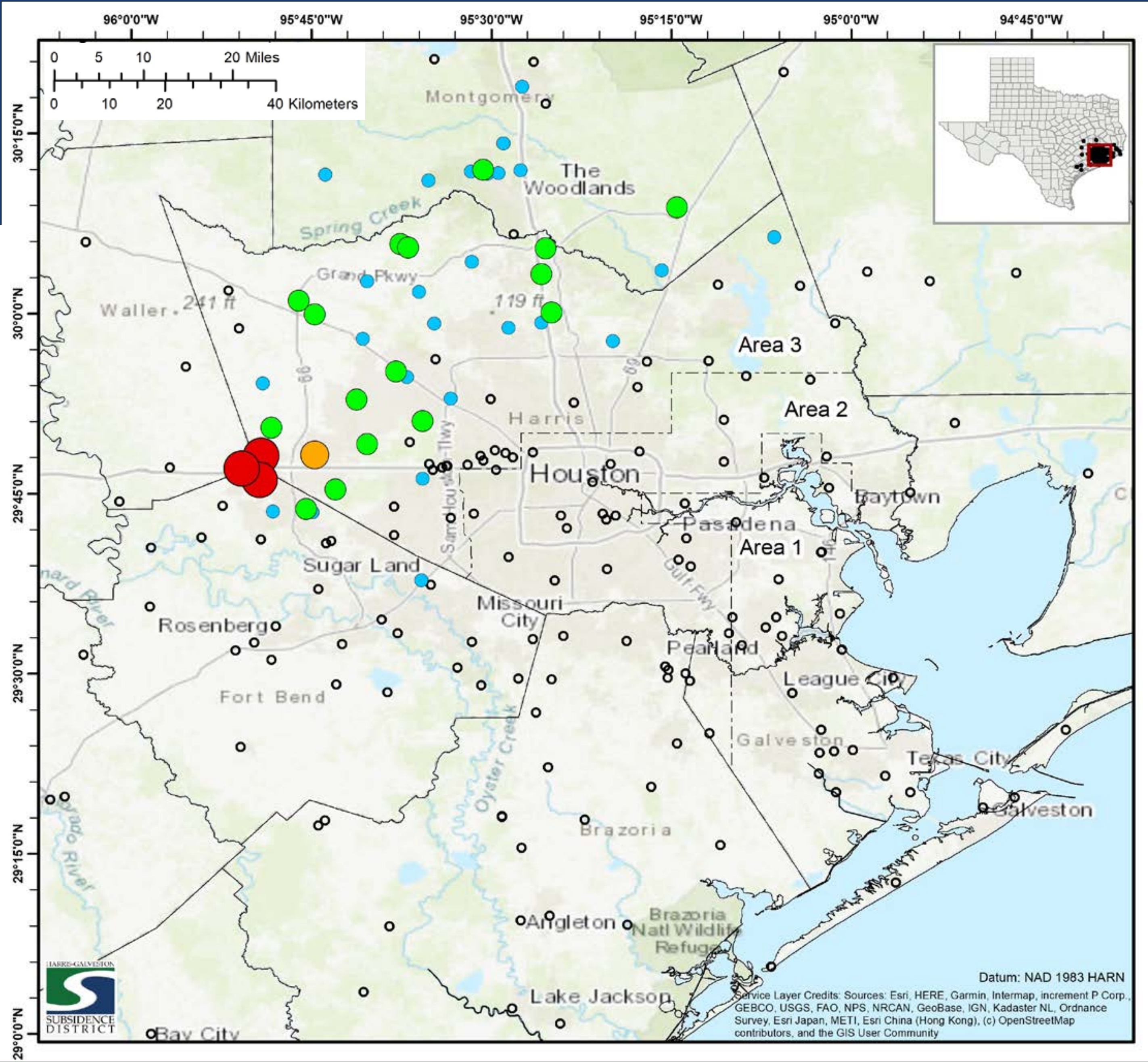
GPS Station Operators

- ■ Harris-Galveston Subsidence District
- ■ Fort Bend Subsidence District
- ● Brazoria County Groundwater Conservation District
- ● Lone Star Groundwater Conservation District
- ● Texas Department of Transportation
- ● University of Houston
- ● Other Agencies



2017-2021 Subsidence Rate | Exhibit 12

Annual subsidence rate, in centimeters per year (cm/yr), measured at GPS stations with three or more years of GPS data in Harris and surrounding counties, averaged from 2017 to 2021.



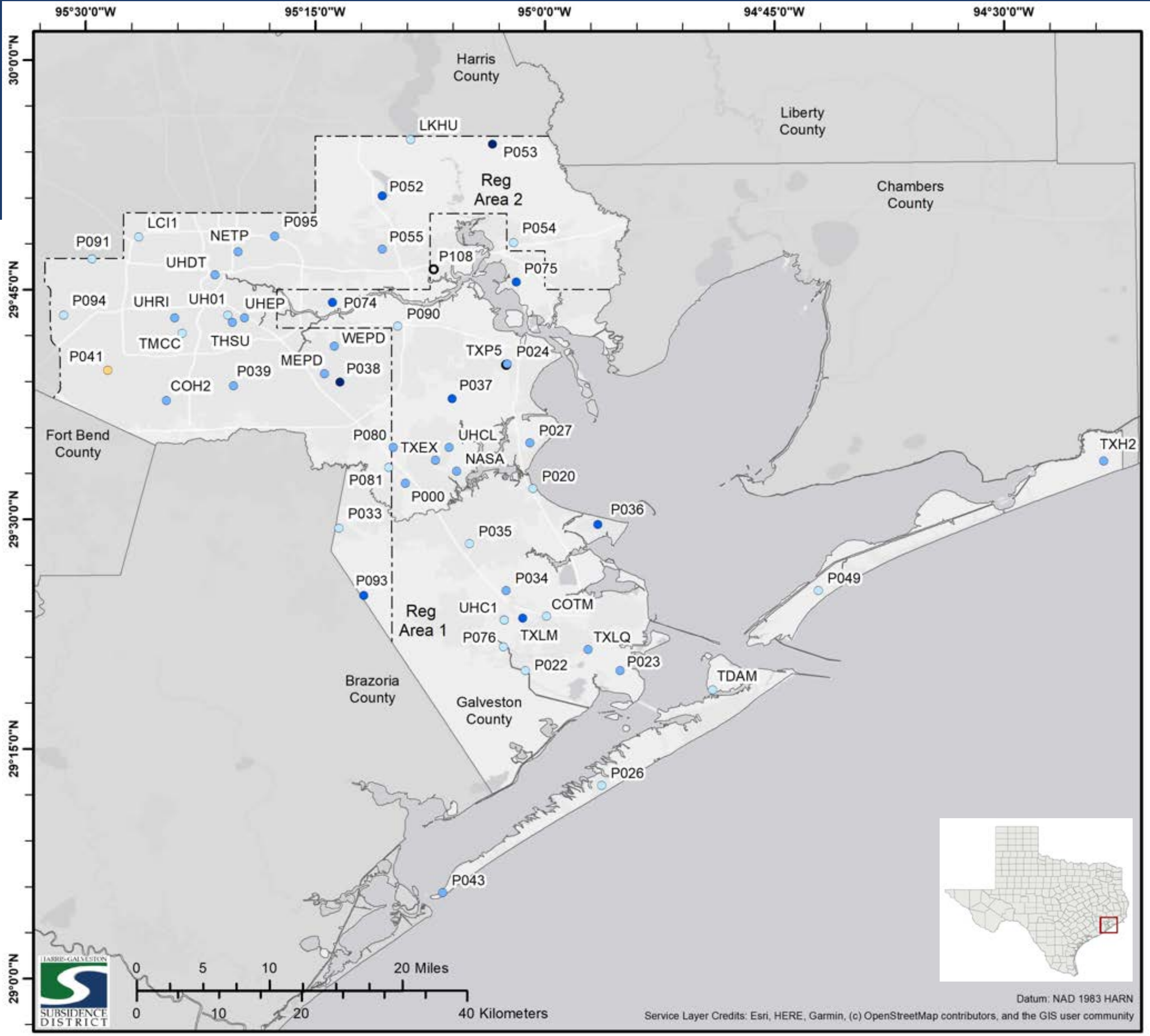
EXPLANATION

Annual Subsidence Rate (cm/yr) from 2017 to 2021

- Greater than 2.0
- <2.0 - 1.5
- <1.5 - 1.0
- <1.0 - 0.5
- Less than 0.5 or period of record less than 3 years

Regulatory Areas One and Two | Exhibit 13

Annual vertical displacement rate (cm/yr) estimated from three or more years of GPS data measured at GPS stations in Harris and Galveston counties, averaged from 2017 to 2021.



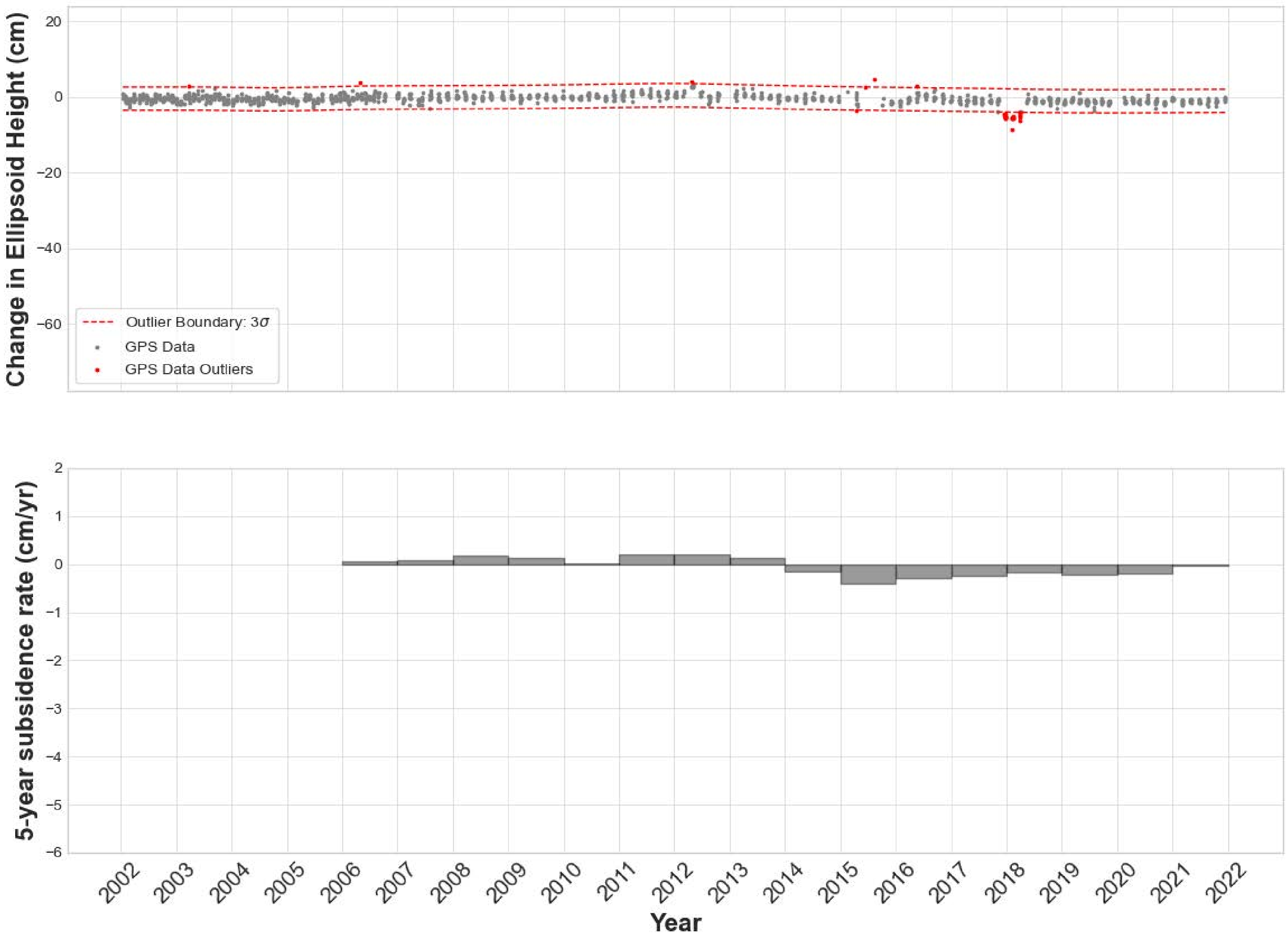
EXPLANATION

Annual Vertical Displacement (cm/yr) from 2017 to 2021 in HGSD Regulatory Areas 1 and 2

- -0.5 - -0.35
- -0.35 - 0
- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 1.0
- GPS stations monitoring less than 3 years

P020 POR Plot | Exhibit 14

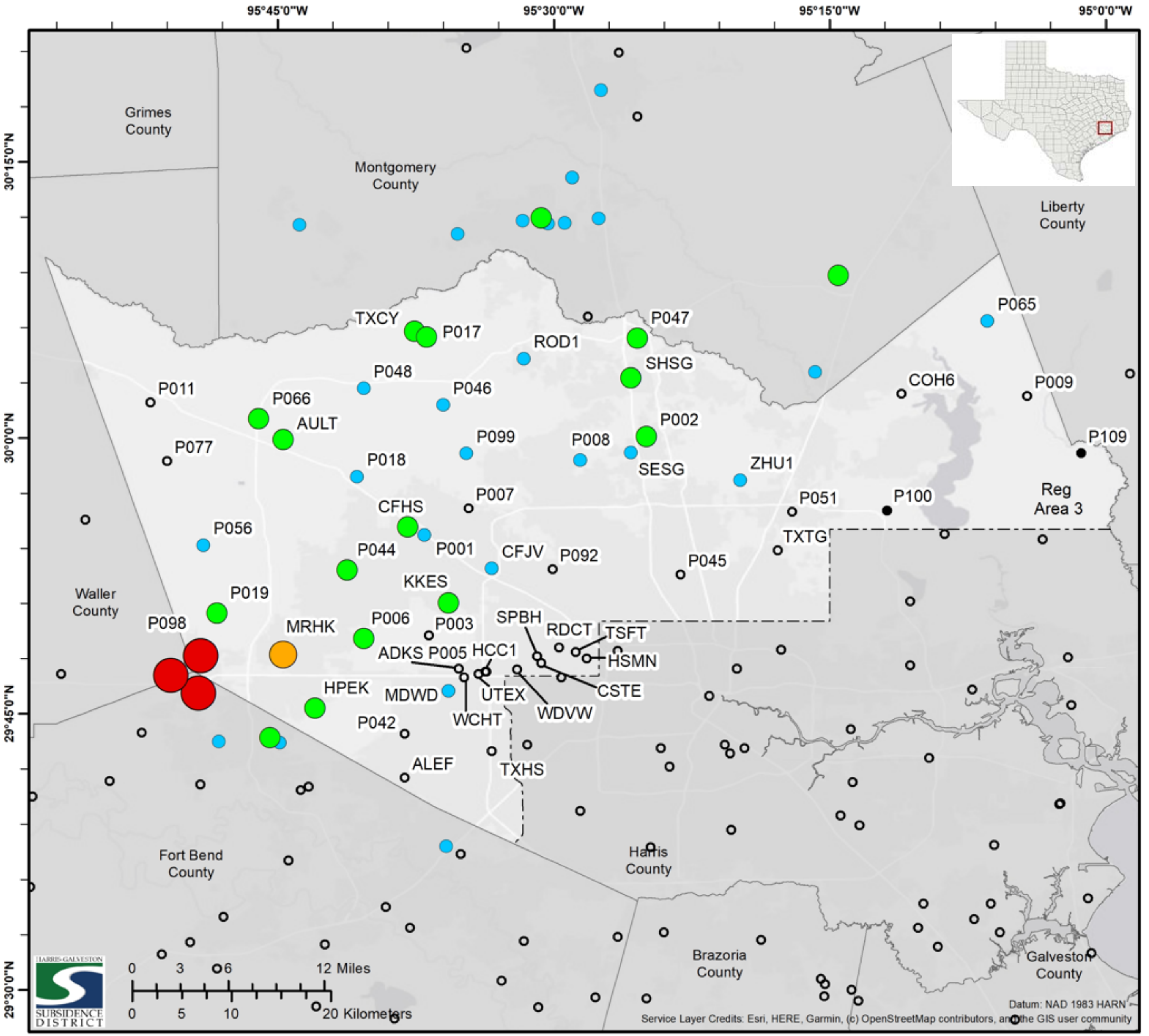
GPS station P020, located in Kemah, has measured a total of approximately 0.7 cm of subsidence since 2002.



Processed GPS data (source: UH) over period of record. Processed data (grey circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are excluded from subsidence rate calculations and are shown for informational purposes only.

Regulatory Area Three | Exhibit 15

Annual subsidence rate (cm/yr) estimated from three or more years of periodic or continuous GPS data measured at GPS stations in Harris County, Texas, from 2017 to 2021.



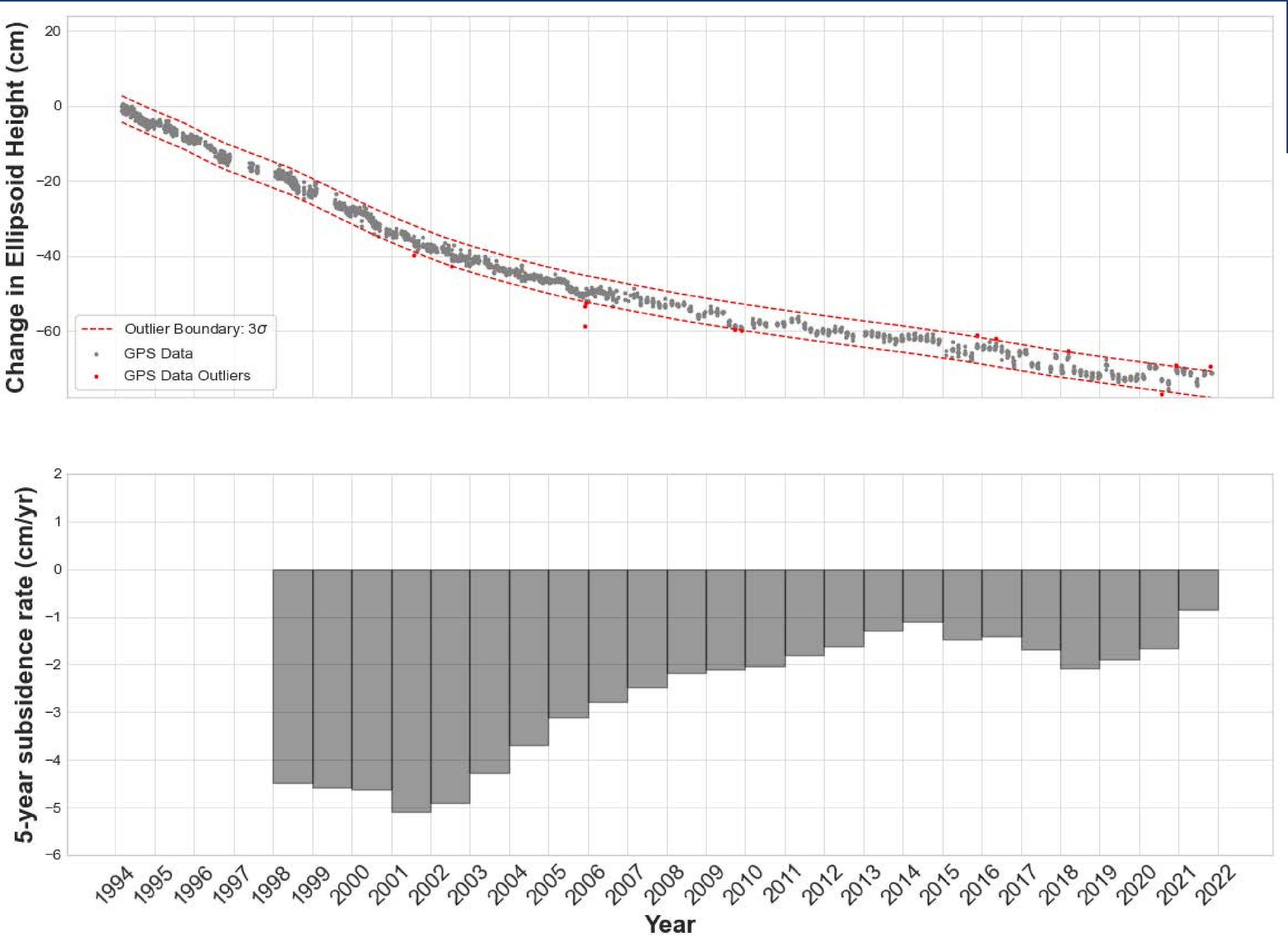
EXPLANATION

Annual Subsidence Rate (cm/yr) from 2017 to 2021

- Greater than 2.0
- <2.0 - 1.5
- <1.5 - 1.0
- <1.0 - 0.5
- Less than 0.5 or period of record less than 3 years

P001 POR Plot | Exhibit 16

GPS station P001, located in Jersey Village, has measured a total of approximately 71 cm of subsidence since 1994.



Processed GPS data (source: UH) over period of record. Processed data (grey circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are excluded from subsidence rate calculations and are shown for informational purposes only.

Testimony and Public Comment

Any person who wishes to appear at the hearing and present testimony, evidence, exhibits or other information may do so in person, by counsel, via email to info@subsidence.org or any combination of these options.

Thank you for attending the Public Hearing for the 2021 Annual Groundwater Report

- Record will be open until May 6, 2022. You may provide comments by sending an email to info@subsidence.org.
- The 2021 Annual Groundwater Report will be presented to the Harris-Galveston Subsidence District Board of Directors on May 11, 2022.
- The 2021 Annual Groundwater Report will be posted on the District's website (www.hgsubsidence.org) upon approval of the District's Board of Directors.

HARRIS-GALVESTON
SUBSIDENCE DISTRICT

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Appendix B – Subsidence Monitoring Network and Data

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List of Figures

Subsidence Monitoring Network

GPS Station Overview

The subsidence monitoring network comprises a collaboration of local to state to federal agencies who operate and maintain global position system (GPS) stations in the greater Houston-Galveston region. In 2021, the Harris-Galveston Subsidence District (the District) collected raw data from 227 GPS stations to assess and understand changes in the land-surface elevation in the region. The analysis of such data, including details on data processing and uncertainty, is provided in subsequent sections.

The District currently operates and maintains 73 GPS stations in the greater Houston region with approximately 66 stations located in Harris and Galveston counties and the remaining seven stations within Brazoria, Waller, Montgomery, and Chambers counties. Fort Bend Subsidence District (FBSD) operates and maintains 22 GPS stations with 21 stations in Fort Bend County and one in Waller County. Surrounding groundwater conservation districts (GCDs) such as Brazoria County GCD and Lone Star GCD operate and maintain 14 and six GPS stations, respectively. The University of Houston (UH) operates 66 GPS stations and the Texas Department of Transportation (TXDOT) operates 39 GPS stations spread across southeast Texas. **Figure 1** includes the location and operators of GPS stations within the greater Houston-Galveston area.

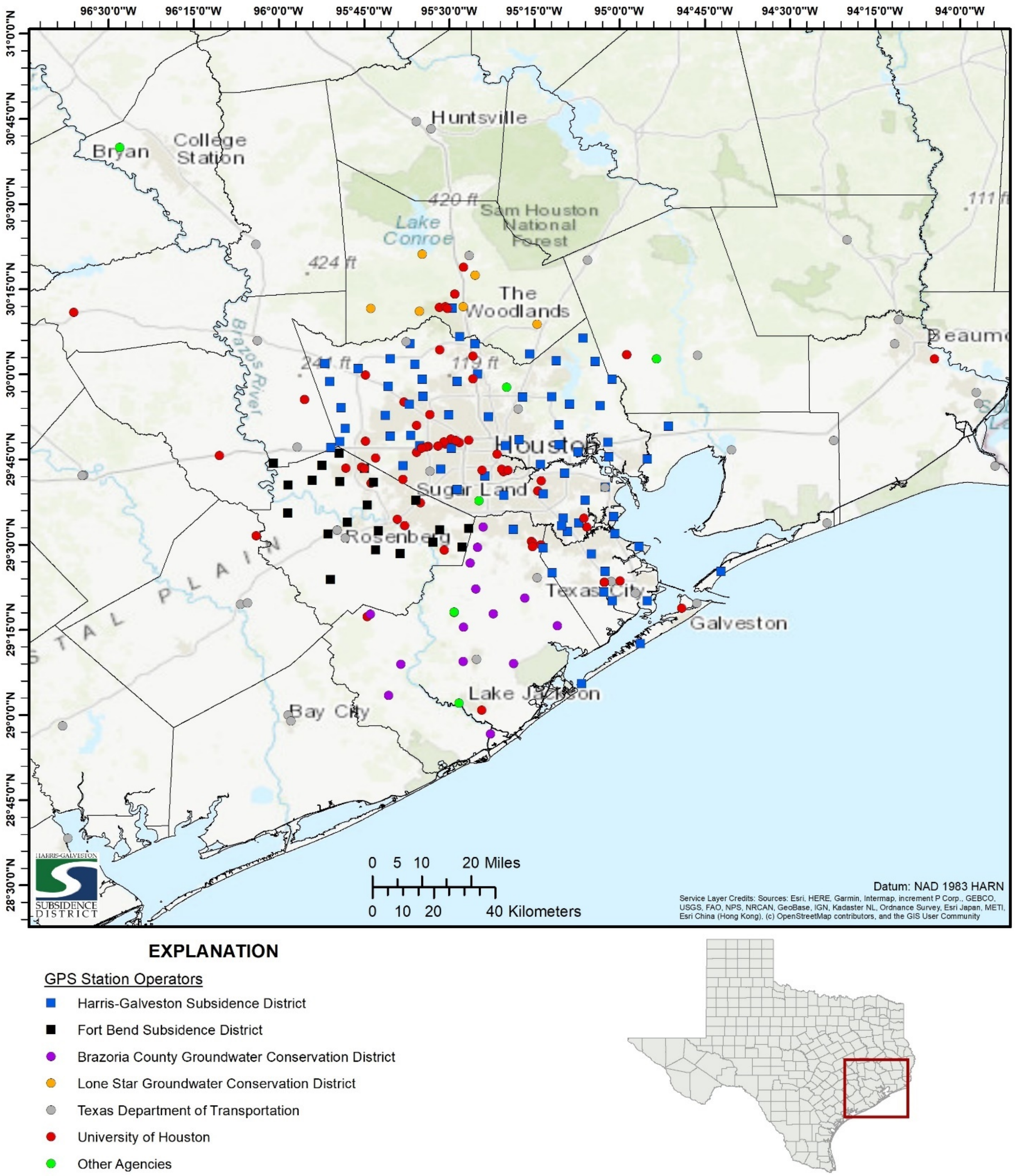


Figure 1: Location of GPS stations designated by operator in the greater Houston region.

The GPS stations are constructed in different ways based on when they were installed and operator preferences. The monitoring types are described in the section below. Two main designs of permanent GPS stations utilized by the District are a periodically measured (PAM) GPS station and an extensometer. Another type of permanent GPS station is a building mount, which is primarily used by UH.

The District designed a permanent GPS station in the mid-1990s to apply a consistent measurement method across multiple counties. This design is known as a PAM and is named after the original port-a-measure method utilized by the District in the early 1990s when the GPS station was not a permanent structure and each location collected data periodically. The PAM design consists of two-inch galvanized pipe drilled approximately 34 feet below ground surface and extends eight feet above the ground surface. The pipe is anchored in a concrete plug at the base and enclosed by centering bands and PVC pipe near the surface to reduce movement. The exposed pipe (i.e., the section of pipe that extends eight-feet above the ground surface) is mounted with an antenna adapter to secure the global navigation satellite system (GNSS) antenna. A separate two-inch pipe is installed within a few feet from the antenna pipe in order to hold an enclosure box, which stores a battery and GNSS receiver, and a mounted solar panel. Both pipes are surrounded by four bollards and encased in a concrete slab for protection. **Figure 2** depicts a schematic of the District's PAM design.

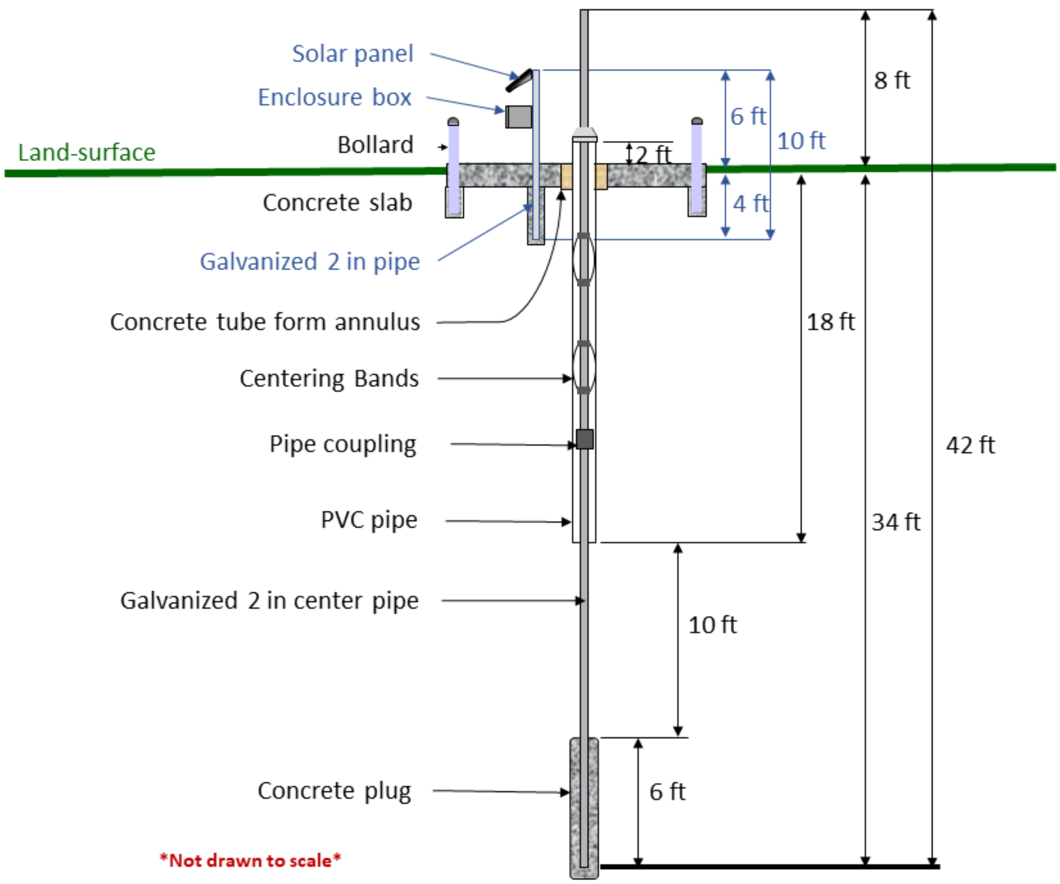


Figure 2: Schematic of the District's PAM design for a permanent GPS station. Note the schematic is not drawn to scale and is intended for visual purposes only. All numbers are provided in US standard measurement.

The USGS operates and maintains 14 borehole extensometers, which are wells drilled to various depths (650 to 3,300 feet below ground surface) and anchored with a concrete plug in order to measure compaction within different aquifers (Kasmarek, et al., 2015). **Figure 3** illustrates the extensometer design that includes an outer casing equipped with slip-joints to maintain well integrity by preventing damage from subsidence and the inner pipe attached to a concrete plug at the bottom of the borehole.

Such extensometers use digital recorders, which are connected to the inner pipe, to continuously measure the change between the inner pipe and the land-surface elevation. The District operates four GPS stations (i.e., ADKS, LKHU, NETP, and TXEX) that include a GNSS antenna mounted on the extended inner pipe.

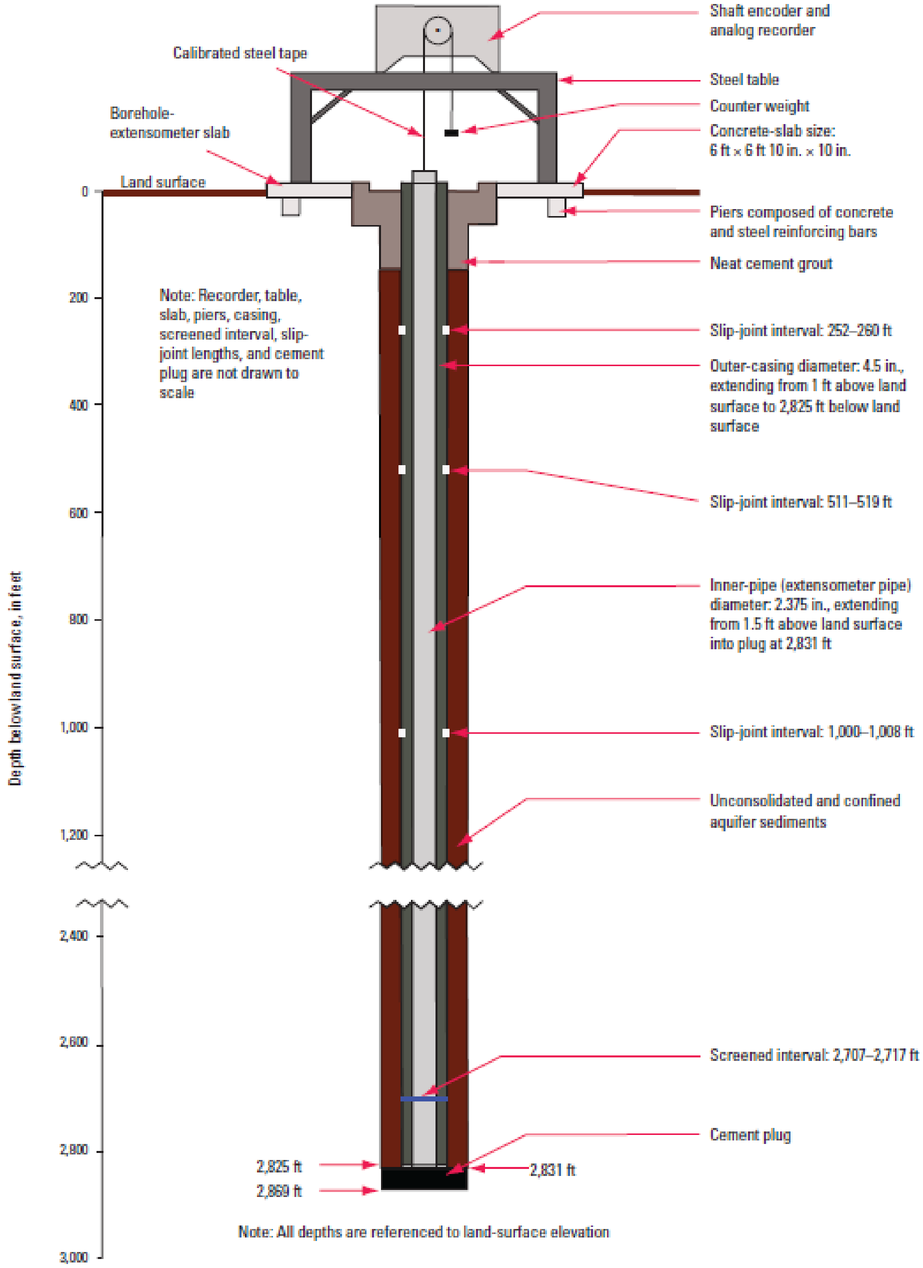


Figure 3: Cross-sectional view of an extensometer adapted from (Kasmarek, et al., 2016).

The building mount is another design for a GPS station. Building mounts have a GNSS antenna mounted on or near the building's roof. Buildings with deep foundation as well as clear sky views are selected as optimal locations to measure land-surface elevation change and limit interference. This building mount design is used by UH throughout the greater Houston area.

Subsidence Monitoring Types

GPS data are collected at each of the GPS stations every thirty seconds during the duration of monitoring, which varies from periodic to continuous. The District operates both periodic and continuous monitoring GPS stations. Other operators, such as UH and TXDOT, operate continuous monitoring stations.

Periodic monitoring stations collect GPS data for approximately seven days every two months at the GPS station. These stations are constructed in the PAM design and use a Trimble GNSS antenna and receiver to gather land-surface data.

Continuous monitoring stations collect GPS data every day of the year and some are designated as continuously operating reference stations (CORS). CORS are designed in two ways: 1) the PAM design or 2) mounted on preexisting structures. The District operates seven CORS (i.e., P026, P034, P043, P049, P080, P081, and YORS) that are constructed in the PAM design. Additionally, the District operates four CORS (i.e., ADKS, LKHU, NETP, and TXEX) that are mounted to the extended inner stem of an extensometer.

Subsidence Data

As of 2021, the District uses GPS data from 227 GPS stations spread across 20 counties in southeast Texas. The District collects GPS data from other agencies like FBSD, Brazoria County GCD, Lone Star GCD, and TxDOT as well as the UH to understand local to regional subsidence trends. **Figure 4** depicts the subsidence monitoring network with a map identification number for each GPS station and two map insets to provide greater detail in the denser areas. Additional information for each map identification number is included as a table within **Appendix C.**

The GPS data collected by the District measure the land-surface as a three-component displacement time series involving the horizontal (East-West), vertical (North-South), and the ellipsoidal height (up-down) components. GPS data are processed and converted to the Stable Houston Reference Frame 2020 (Houston20). Additional methods of GPS data processing include identification of outliers and estimations of site velocities and associated uncertainties.

Outliers are identified through a series of steps that include applying a locally weighted scatterplot smoothing (LOWESS) algorithm to obtain a time-series trend with two (2) iterations, removing the residual time-series trend, and estimating the median of absolute deviations (MAD) of the residual time-series (Wang, et al., 2022). The subsidence rate of a GPS station is estimated using the linear regression of the most recent five-year ellipsoidal height data (i.e., 2017-2021), at stations that have a minimum of three years of data. The root mean square (RMS) accuracy of the GPS data provided in this report is approximately 5-8 millimeters for the vertical direction or ellipsoidal height (Wang, et al., 2022).

The entire GPS dataset from all contributors are reprocessed every few years as improvements in positioning software, updates to global to regional reference frames, and other data processing analysis tools, such as orbital clock updates, are disseminated to users. Caution should be applied when attempting to mix or compare old GPS datasets with newer versions as GPS data processing is both a complex and a dynamic procedure.

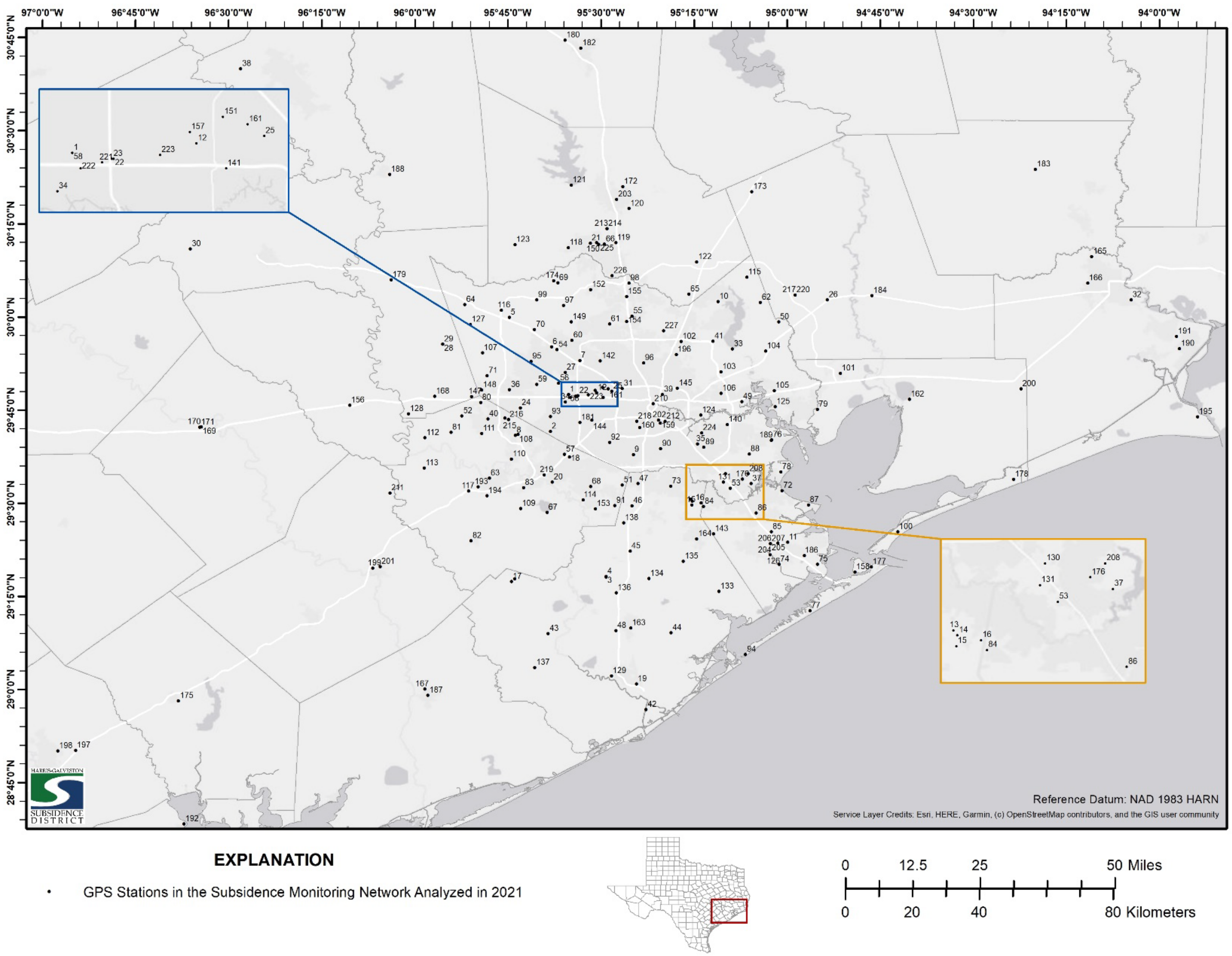


Figure 4: Location and map identification number of GPS stations that monitor periodically or continuously within Harris and surrounding Counties, Texas, 2021. The map insets show the map identification number of the higher density areas to provide greater detail.

Regulatory Areas One and Two

Regulatory Areas One and Two achieved full regulatory level conversion in 1990 and 2000, respectively. GPS stations have been operating since 1993 within this area to measure subsidence. Regulatory Area One contains 30 GPS stations with about 17 stations that measured minor uplift, 11 stations that measured extremely minor subsidence, and 2 stations that have been monitoring less than three years so no rate of change was applied (**Figure 5**). Regulatory Area Two includes 25 GPS stations with 15 stations that measured minor uplift and 10 stations that measured very minor subsidence (**Figure 5**).

According to recent research, rates of natural subsidence along the Texas Gulf Coast, particularly in Texas City and Galveston area, range from 1.5 – 3.5 millimeters per year (Zhou, et al., 2021). Based on this research, GPS stations within the range of natural subsidence has been classified as the light blue points in **Figure 5**. GPS stations that measured uplift (i.e., positive change in ellipsoidal height from 2017 to 2021) are also displayed in **Figure 5** in visually distinguish the data from the main overview subsidence rate map provided in previous sections.

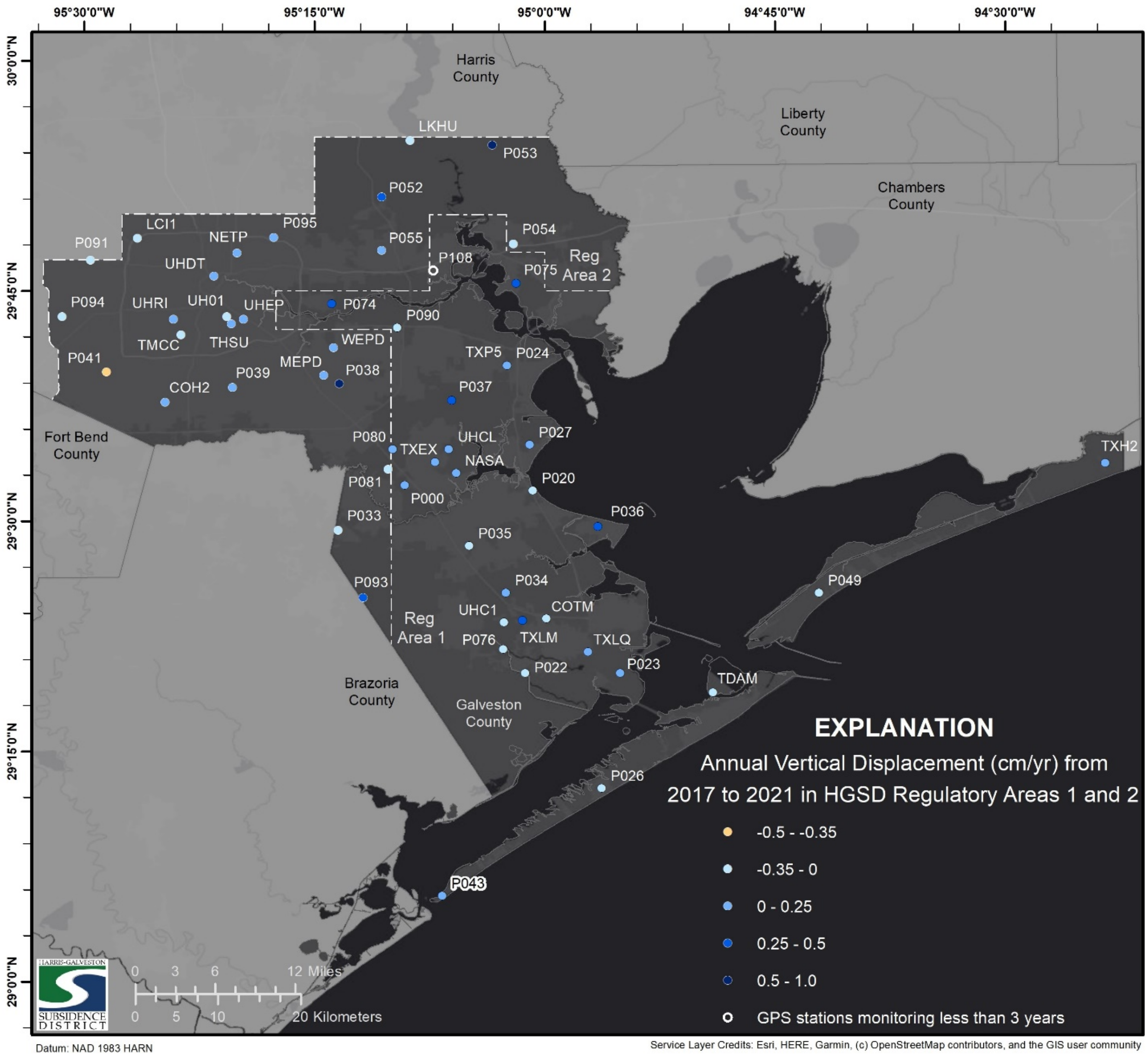


Figure 5: Annual subsidence rate in cm per year estimated from periodic and continuous GPS data measured from GPS stations within Regulatory Areas One and Two in Harris and Galveston Counties, Texas, 2017-2021.

A representative sample time-series displacement plot and five-year subsidence rate graph for a GPS station in these Regulatory Areas is P020. P020, which is located in Kemah, shows a gradually stable trend with a recent subsidence rate of 0.02 cm per year and has measured approximately 0.7 cm (0.28 inches) over 19 years (**Figure 6**).

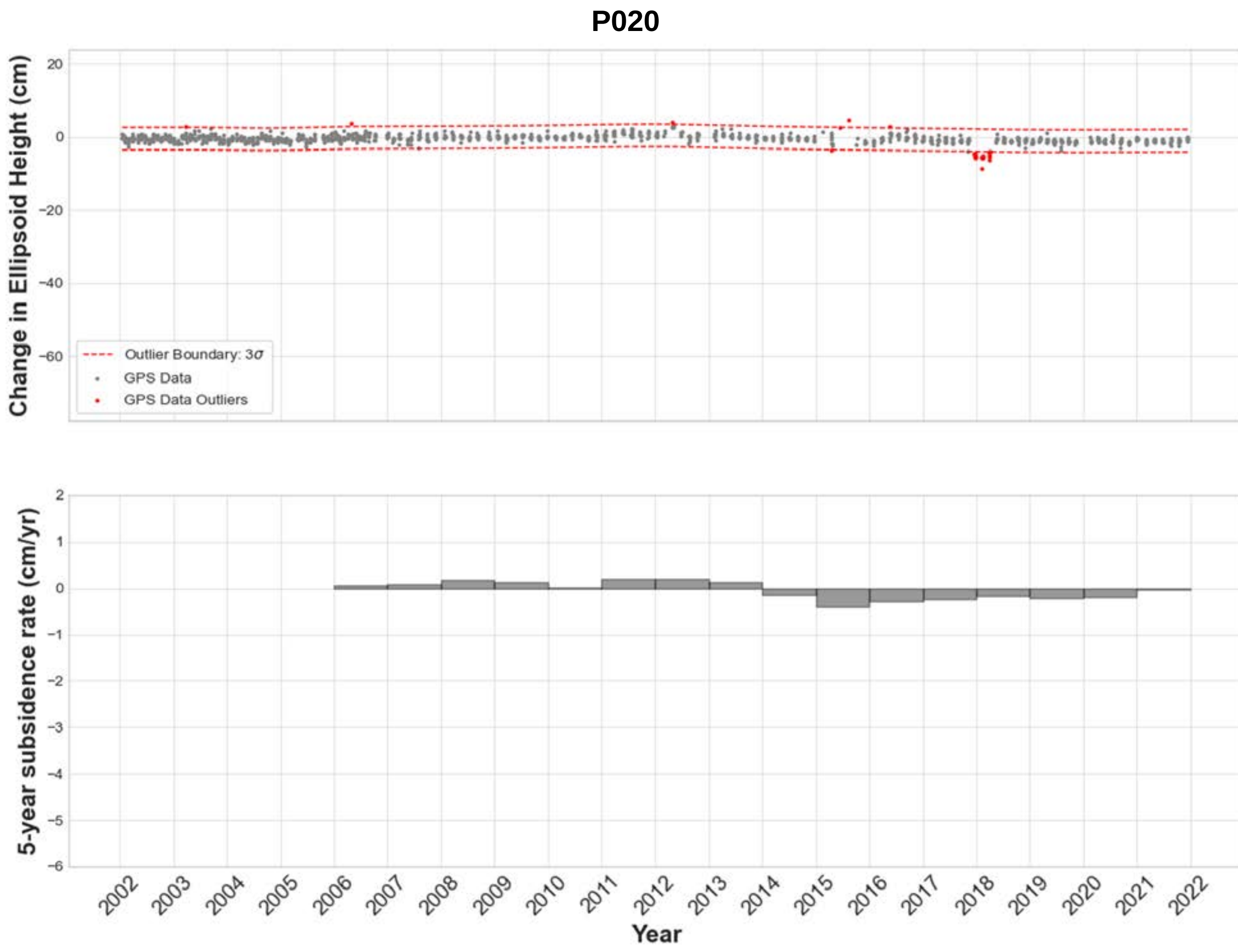


Figure 6: Period of record data for GPS station P020 located in Kemah, Texas, with a 2017-2021 subsidence rate of 0.02 cm/yr. Processed GPS data (source: UH) over period of record. Processed data (grey circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are excluded from subsidence rate calculations and are shown for informational purposes only.

Regulatory Area Three

Regulatory Area Three has not been fully converted; although some entities such as the City of Houston and Regional Water Authorities have been transitioning to alternative water sources since 2010. Regulatory Area Three contains 53 GPS stations primarily operated by the District and the UH. **Figure 7** displays the GPS stations in Regulatory Area Three with labels identifying the name of each station.

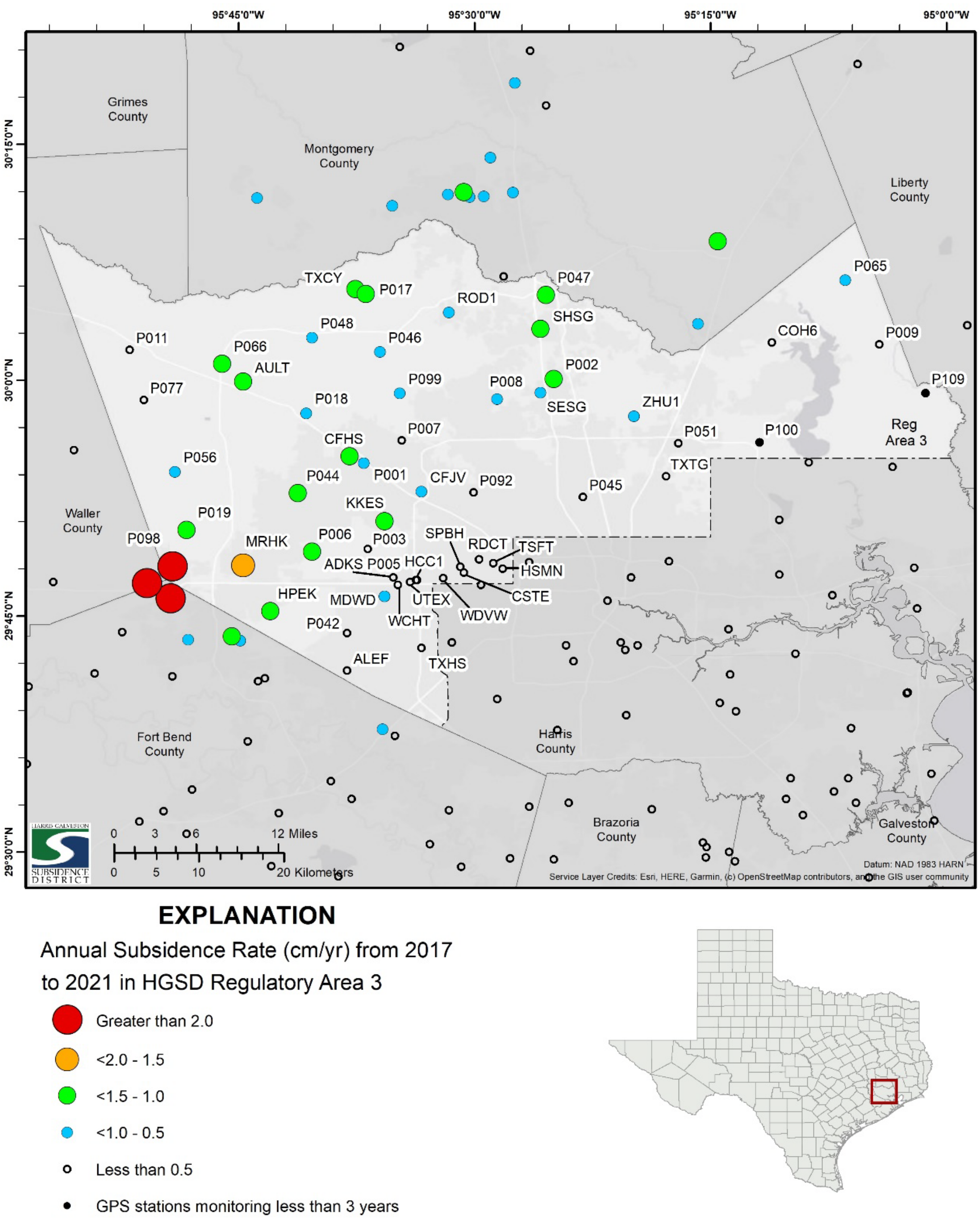


Figure 7: Annual subsidence rate in cm per year estimated from periodic and continuous GPS data measured from GPS stations within Regulatory Area Three in Harris and Galveston Counties, Texas, 2017-2021.

GPS station P001, located in Jersey Village, has measured the greatest total subsidence with approximately 71 cm over 27 years. **Figure 8** contains the period of record plot for P001 that shows a subsidence rate of 0.85 cm per year from 2017 to 2021. P001 began monitoring in the mid-1990s and measured high subsidence rates from over 4 cm per year in the late 1990s then gradually lessened to under 2 cm per year in recent years.

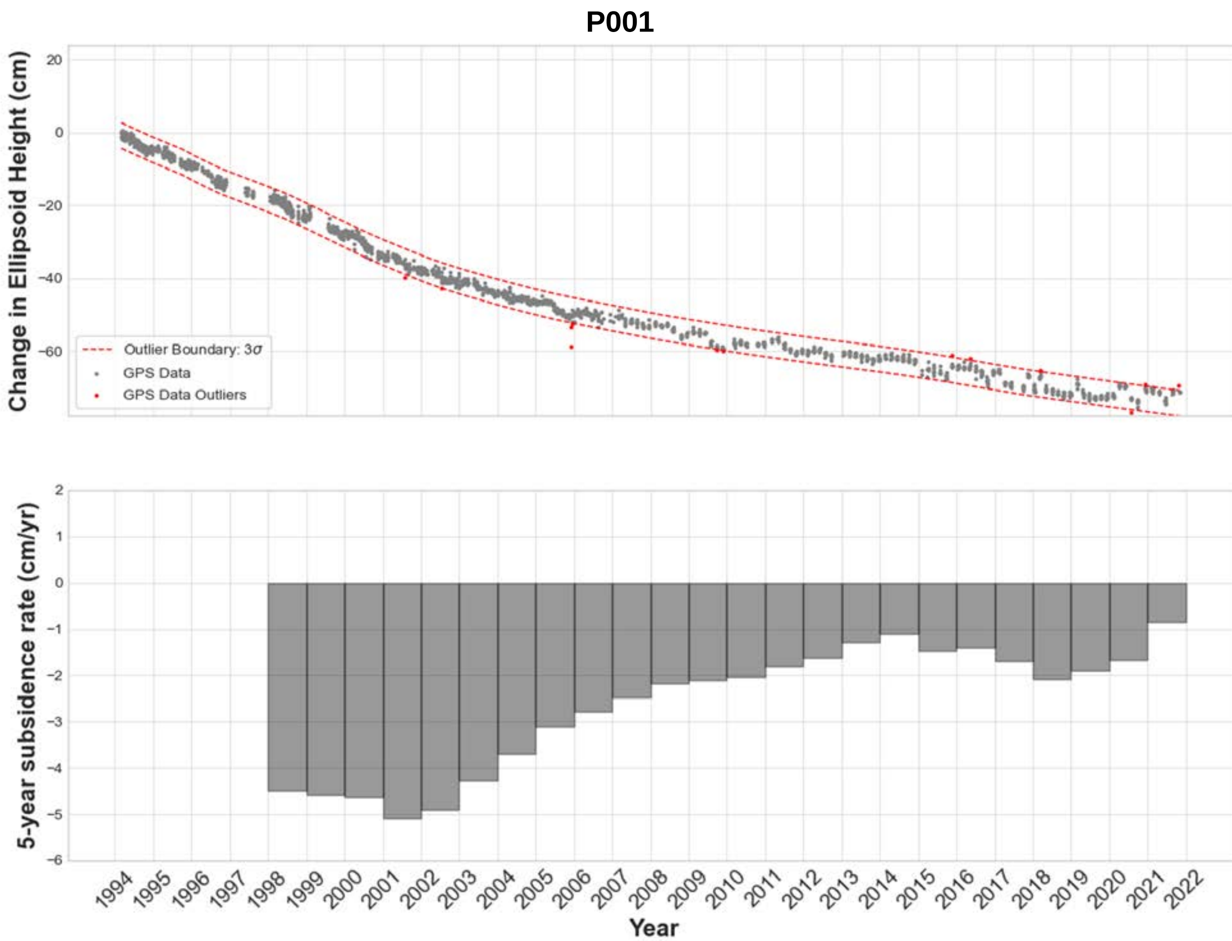


Figure 8: Period of record plot for GPS station P001 located in Jersey Village, Texas, 1994-2021. This station measured 71 cm of subsidence over 27 years and the annual subsidence rate is 0.85 cm per year from 2017 to 2021. Processed GPS data (source: UH) over period of record. Processed data (grey circles) located inside the outlier boundary (red dashed lines) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are excluded from subsidence rate calculations and are shown for informational purposes only.

References

Kasmarek, M. C. et al., 2015. *Water-Level Altitudes 2015 and Water-Level Changes in the Chicot, Evangeline, and Jasper Aquifers and Compaction 1973-2014 in the Chicot and Evangeline Aquifers, Houston-Galveston Region, Texas.* s.l.:U.S. Geological Survey Scientific Investigations Map 3337.

Kasmarek, M. C., Ramage, J. K. & Johnson, M. R., 2016. *Water-level altitudes 2016 and water-level changes in the Chicot, Evangeline, and Jasper aquifers and compaction 1973–2015 in the Chicot and Evangeline aquifers, Houston-Galveston region, Texas,* Reston: U.S. Geological Survey.

Wang, G., Greuter, A., Petersen, C. M. & Turco, M. J., 2022. Houston GNSS Network for Subsidence and Faulting Monitoring: Data Analysis Methods and Products. *Journal of Surveying Engineering.*

Zhou, X. et al., 2021. Rates of Natural Subsidence along the Texas Coast Derived from GPS and Tide Gauge Measurements (1904–2020). *Journal of Surveying Engineering,* 147(4).

Appendix C – Period of Record Data

A comprehensive table is provided which includes the Map ID (Figure 4 in Appendix B), GPS station name, coordinates, dates of operation, sample count, total vertical displacement, and annual rate of change in ellipsoidal height from 2017 to 2021. A period of record time-series plot and a five-year subsidence rate graph are also included for each GPS station.

Map ID (Figure 1)	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 2017-2021 (cm/yr)*
1	ADKS	29.7910	-95.5864	1993.520	2021.991	28.471	8462	-1.8	-0.11
2	ALEF	29.6918	-95.6351	2014.259	2022.021	7.762	2834	-3.0	-0.41
3	ANG5	29.3015	-95.4851	2003.447	2019.518	16.071	5148	-4.5	-0.26
4	ANG6	29.3017	-95.4849	2003.428	2019.518	16.090	5260	-3.9	-0.08
5	AULT	29.9978	-95.7447	2015.557	2022.021	6.464	2293	-5.5	-1.12
6	CFHS	29.9192	-95.6319	2015.595	2022.021	6.426	2292	-8.0	-1.23
7	CFJV	29.8817	-95.5558	2015.773	2022.021	6.248	2280	-4.2	-0.71
8	CMFB	29.6814	-95.7288	2014.409	2022.021	7.611	2746	-2.7	-0.42
9	COH2	29.6285	-95.4116	2009.005	2022.018	13.013	4210	-1.6	0.03
10	COH6	30.0397	-95.1848	2004.249	2021.999	17.750	3153	-4.2	0.04
11	COTM	29.3938	-94.9982	2015.097	2022.021	6.924	2271	-1.1	-0.18
12	CSTE	29.7956	-95.5107	2015.387	2021.854	6.467	2360	-4.0	-0.22
13	DEN1	29.5104	-95.2580	2011.778	2021.728	9.949	3464	-1.9	-0.26
14	DEN2	29.5049	-95.2540	2011.778	2021.728	9.949	2269	-0.5	-0.06
15	DEN3	29.4937	-95.2546	2011.778	2019.666	7.888	2679	-0.3	-0.19
16	DEN4	29.5002	-95.2296	2015.825	2021.728	5.903	1745	-0.6	-0.12
17	DISD	29.2893	-95.7404	2015.480	2022.021	6.541	2247	1.4	0.11
18	DMFB	29.6227	-95.5837	2014.771	2022.021	7.250	2647	-2.7	-0.31
19	DWI1	29.0136	-95.4037	2009.399	2022.021	12.621	4231	-1.6	-0.05
20	FSFB	29.5562	-95.6305	2014.371	2022.021	7.650	2665	-0.4	-0.26
21	GSEC	30.1973	-95.5281	2015.756	2022.021	6.264	2288	-3.1	-0.85
22	HCC1	29.7879	-95.5612	2012.914	2022.021	9.106	3315	-5.1	-0.33
23	HCC2	29.7884	-95.5620	2013.139	2021.670	8.531	2767	-6.3	-0.42
24	HPEK	29.7549	-95.7157	2014.396	2021.974	7.578	1848	-9.8	-1.29
25	HSMN	29.8004	-95.4696	2013.298	2022.021	8.723	3180	-2.1	-0.13
26	JGS2	30.0454	-94.8905	2012.463	2022.021	9.558	3218	-1.3	0.06
27	KKES	29.8503	-95.5949	2015.598	2022.021	6.423	2260	-6.7	-1.20
28	KPCD	29.9260	-95.9240	2016.441	2021.593	5.153	1839	-2.2	-0.39
29	KPCS	29.9260	-95.9240	2016.441	2021.593	5.153	1627	-1.6	-0.38
30	LCBR	30.1824	-96.6019	2010.538	2021.960	11.422	2557	-1.2	-0.14
31	LCI1	29.8075	-95.4425	2012.463	2021.892	9.429	3001	-2.9	-0.06
32	LGC1	30.0446	-94.0746	2013.531	2022.021	8.490	2620	-11.5	-1.49
33	LKHU	29.9135	-95.1458	1996.071	2021.998	25.927	8980	2.4	-0.01
34	MDWD	29.7714	-95.5952	2013.303	2022.021	8.717	3145	-5.4	-0.62
35	MEPD	29.6581	-95.2396	2014.040	2022.021	7.981	2914	1.8	0.15
36	MRHK	29.8041	-95.7452	2014.396	2022.021	7.625	2693	-11.9	-1.67
37	NASA	29.5520	-95.0962	2014.201	2021.621	7.420	2551	-0.1	0.04
38	NBRY	30.6664	-96.4671	2012.463	2021.336	8.873	3149	-1.7	-0.18
39	NETP	29.7912	-95.3342	1993.517	2021.991	28.474	8079	0.7	0.02
40	OKEK	29.7250	-95.8033	2014.576	2022.021	7.444	2652	-4.8	-0.96
41	P100	29.9341	-95.1982	2019.309	2021.890	2.580	178	0.1	n/a
42	P101	28.9446	-95.3781	2019.714	2021.482	1.767	64	0.8	n/a
43	P102	29.1487	-95.6408	2019.641	2021.408	1.767	74	-77.2	n/a
44	P103	29.1512	-95.3112	2019.712	2021.662	1.951	56	-0.1	n/a
45	P104	29.3698	-95.4205	2019.980	2021.879	1.899	39	-0.3	n/a
46	P105	29.4918	-95.4157	2019.660	2021.873	2.214	100	-1.7	n/a
47	P106	29.5524	-95.3996	2019.695	2021.884	2.189	99	-0.8	n/a
48	P107	29.1567	-95.4595	2019.616	2021.701	2.085	86	5.3	n/a
49	P108	29.7720	-95.1210	2021.244	2021.914	0.671	48	0.7	n/a
50	P109	29.9860	-95.0220	2021.148	2021.969	0.821	55	-0.5	n/a
51	P110	29.5480	-95.4420	2021.189	2021.999	0.810	39	-1.7	n/a
52	P111	29.7333	-95.8730	2021.285	2021.876	0.591	28	-1.3	n/a

Map ID (Figure 1)	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 2017-2021 (cm/yr)*
53	P000	29.5386	-95.1522	1996.003	2021.892	25.890	1668	-1.9	0.11
54	P001	29.9119	-95.6166	1994.164	2021.835	27.671	2121	-71.1	-0.85
55	P002	30.0007	-95.4159	1994.318	2021.969	27.652	2128	-63.9	-1.22
56	P003	29.8208	-95.6134	1994.328	2021.972	27.643	1693	-54.4	-0.26
57	P004	29.6304	-95.5969	1994.660	2021.835	27.175	1993	-27.3	-0.58
58	P005	29.7912	-95.5859	1996.698	2021.873	25.175	1682	-31.4	-0.09
59	P006	29.8185	-95.6719	2014.276	2021.972	7.695	384	-7.6	-1.26
60	P007	29.9363	-95.5767	1999.115	2021.972	22.857	1454	-57.0	-0.22
61	P008	29.9797	-95.4763	1999.610	2021.969	22.359	1369	-39.9	-0.83
62	P009	30.0381	-95.0715	1999.345	2021.977	22.633	1438	-3.6	-0.07
63	P010	29.5664	-95.7992	1999.266	2021.931	22.665	1690	-8.2	-0.11
64	P011	30.0322	-95.8652	1999.345	2021.892	22.548	1502	-9.0	-0.25
65	P012	30.0597	-95.2631	2000.895	2021.999	21.104	1386	-12.8	-0.52
66	P013	30.1948	-95.4900	2000.914	2021.983	21.068	1311	-25.6	-0.92
67	P014	29.4737	-95.6441	2000.879	2021.972	21.093	1212	-4.7	0.13
68	P016	29.5445	-95.5272	2000.860	2021.999	21.140	1277	-5.0	0.21
69	P017	30.0912	-95.6153	2000.895	2021.860	20.964	1217	-34.2	-1.24
70	P018	29.9649	-95.6782	2000.862	2021.988	21.126	1222	-34.1	-0.70
71	P019	29.8411	-95.8054	2000.892	2021.931	21.038	1160	-19.9	-1.09
72	P020	29.5329	-95.0132	2002.041	2021.953	19.912	1205	-0.7	-0.02
73	P021	29.5455	-95.3121	2002.082	2021.873	19.791	1139	-0.2	-0.09
74	P022	29.3345	-95.0207	2002.041	2021.931	19.890	1164	-5.0	-0.14
75	P023	29.3351	-94.9178	2002.060	2021.934	19.873	1236	1.6	0.06
76	P024	29.6688	-95.0408	2002.118	2021.988	19.871	1197	3.9	0.18
77	P026	29.2103	-94.9383	2002.194	2021.999	19.805	2563	-0.1	-0.07
78	P027	29.5831	-95.0156	2002.367	2021.969	19.602	1171	-4.6	0.02
79	P028	29.7512	-94.9176	2002.194	2021.934	19.739	1154	1.6	0.13
80	P029	29.7690	-95.8222	2007.320	2021.857	14.537	671	-23.8	-2.19
81	P030	29.6893	-95.9019	2007.350	2021.876	14.526	653	-5.5	-0.42
82	P031	29.3980	-95.8484	2007.350	2021.969	14.619	659	2.6	-0.31
83	P032	29.5406	-95.7073	2007.350	2021.950	14.600	668	0.2	0.28
84	P033	29.4899	-95.2236	2006.323	2021.876	15.553	828	-1.4	-0.03
85	P034	29.4222	-95.0417	2010.356	2021.999	11.643	4087	-2.7	0.15
86	P035	29.4726	-95.0824	2006.621	2021.887	15.266	687	2.7	-0.14
87	P036	29.4942	-94.9416	2006.966	2021.950	14.984	710	-1.0	0.54
88	P037	29.6307	-95.1010	2007.372	2021.972	14.600	754	4.8	0.27
89	P038	29.6493	-95.2230	2007.356	2021.999	14.643	753	3.9	0.54
90	P039	29.6453	-95.3393	2011.093	2021.999	10.906	548	-0.8	0.01
91	P040	29.4933	-95.4625	2007.353	2021.988	14.635	603	-7.7	-0.43
92	P041	29.6619	-95.4755	2007.337	2021.892	14.556	738	-5.7	-0.44
93	P042	29.7325	-95.6354	2007.331	2021.873	14.542	687	-8.3	-0.30
94	P043	29.0933	-95.1106	2006.545	2021.999	15.454	2262	0.0	0.06
95	P044	29.8801	-95.6869	2007.320	2021.991	14.671	690	-16.3	-1.01
96	P045	29.8759	-95.3855	2007.331	2021.950	14.619	729	-4.7	-0.06
97	P046	30.0300	-95.6001	2007.323	2021.999	14.676	711	-21.3	-0.85
98	P047	30.0896	-95.4235	2007.339	2021.988	14.649	698	-24.9	-1.37
99	P048	30.0454	-95.6717	2007.320	2021.876	14.556	684	-15.0	-0.53
100	P049	29.4225	-94.7015	2006.279	2021.939	15.660	1943	-2.4	-0.20
101	P050	29.8483	-94.8560	2006.835	2021.934	15.099	757	-0.8	-0.07
102	P051	29.9325	-95.2842	2007.339	2021.895	14.556	703	-8.8	-0.20
103	P052	29.8520	-95.1767	2007.339	2021.914	14.575	688	0.1	0.35
104	P053	29.9080	-95.0573	2007.339	2021.969	14.630	654	-1.0	0.77

Map ID (Figure 1)	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 2017-2021 (cm/yr)*
105	P054	29.8015	-95.0344	2006.816	2021.953	15.137	763	-0.5	-0.01
106	P055	29.7942	-95.1772	2006.799	2021.912	15.112	724	3.3	0.21
107	P056	29.9026	-95.8168	2007.320	2021.909	14.589	630	-7.0	-0.51
108	P057	29.6841	-95.7218	2009.137	2021.838	12.701	560	-3.4	-0.12
109	P058	29.4848	-95.7149	2010.591	2021.953	11.361	521	-2.1	-0.17
110	P059	29.6167	-95.7404	2010.572	2021.914	11.342	520	-2.9	-0.10
111	P060	29.6859	-95.8196	2012.531	2021.854	9.323	415	-4.2	-0.50
112	P061	29.6754	-95.9724	2011.129	2021.890	10.761	512	-4.1	-0.08
113	P062	29.5933	-95.9742	2011.126	2021.917	10.791	460	-3.8	-0.44
114	P063	29.5079	-95.5474	2011.432	2021.986	10.553	493	-0.8	0.36
115	P065	30.1065	-95.1069	2012.432	2021.991	9.559	451	-7.8	-0.94
116	P066	30.0172	-95.7667	2011.167	2021.892	10.725	522	-14.5	-1.06
117	P067	29.5318	-95.8548	2011.109	2021.912	10.802	489	-2.3	-0.04
118	P068	30.1848	-95.5868	2011.799	2021.966	10.167	605	-10.5	-0.91
119	P069	30.1990	-95.4589	2011.747	2021.991	10.244	613	-11.3	-0.92
120	P070	30.2911	-95.4243	2011.761	2021.914	10.153	541	-4.4	-0.19
121	P071	30.3530	-95.5789	2011.780	2021.934	10.153	618	-4.0	-0.27
122	P072	30.1470	-95.2425	2011.994	2021.999	10.005	445	-7.8	-1.15
123	P073	30.1934	-95.7302	2012.052	2021.953	9.901	636	-7.6	-0.73
124	P074	29.7356	-95.2312	2011.972	2021.912	9.940	482	-0.6	0.33
125	P075	29.7578	-95.0306	2012.432	2021.953	9.520	478	-1.5	0.51
126	P076	29.3609	-95.0455	2012.643	2021.914	9.271	430	-4.6	-0.34
127	P077	29.9790	-95.8504	2013.197	2021.912	8.715	429	-2.3	-0.24
128	P078	29.7387	-96.0157	2014.331	2021.895	7.564	376	-3.3	-0.15
129	P079	29.0348	-95.4713	2014.827	2021.999	7.172	1885	0.1	-0.15
130	P080	29.5781	-95.1651	2014.862	2021.999	7.137	2468	1.4	0.12
131	P081	29.5558	-95.1698	2014.854	2021.955	7.101	2457	0.1	-0.04
132	P082	29.2957	-95.7314	2015.714	2021.857	6.142	240	1.6	0.26
133	P083	29.2624	-95.1815	2016.014	2021.652	5.638	221	-1.5	-0.22
134	P084	29.2969	-95.3703	2016.052	2021.824	5.772	260	2.5	0.66
135	P085	29.3426	-95.2782	2016.033	2021.676	5.643	227	0.1	-0.05
136	P086	29.2577	-95.4585	2016.071	2021.802	5.731	211	1.8	0.18
137	P087	29.0581	-95.6768	2016.090	2021.851	5.761	237	0.1	0.08
138	P088	29.4456	-95.4379	2016.131	2021.873	5.742	236	-0.0	-0.33
139	P089	29.5664	-95.7992	2015.931	2021.542	5.611	279	0.1	-0.09
140	P090	29.7102	-95.1596	2015.975	2021.991	6.016	401	3.5	-0.02
141	P091	29.7832	-95.4932	2016.320	2021.999	5.679	387	-2.5	-0.23
142	P092	29.8814	-95.5008	2016.320	2021.999	5.679	355	-2.4	-0.25
143	P093	29.4168	-95.1974	2017.241	2021.912	4.671	254	-1.0	0.34
144	P094	29.7217	-95.5240	2017.296	2021.890	4.594	318	-1.6	-0.28
145	P095	29.8079	-95.2944	2017.200	2021.950	4.750	334	0.1	0.09
146	P096	29.7243	-95.7481	2017.553	2021.999	4.446	1502	2.1	-0.34
147	P097	29.7850	-95.8470	2018.104	2021.953	3.849	250	-6.8	-2.67
148	P098	29.8032	-95.8199	2018.120	2021.934	3.813	249	-6.9	-2.08
149	P099	29.9864	-95.5786	2018.140	2021.999	3.860	250	-1.1	-0.80
150	PWES	30.1990	-95.5106	2015.220	2022.021	6.801	2485	-6.5	-1.11
151	RDCT	29.8104	-95.4947	2013.561	2022.021	8.460	2849	-1.8	-0.18
152	ROD1	30.0724	-95.5268	2007.003	2022.021	15.017	5187	-16.3	-0.86
153	RPFB	29.4842	-95.5137	2014.773	2022.021	7.247	2647	0.3	-0.01
154	SESG	29.9875	-95.4296	2014.678	2022.021	7.343	2679	-5.5	-0.92
155	SHSG	30.0536	-95.4301	2014.721	2022.021	7.299	2666	-7.8	-1.30
156	SISD	29.7622	-96.1739	2015.176	2022.021	6.845	2410	-0.2	-0.11

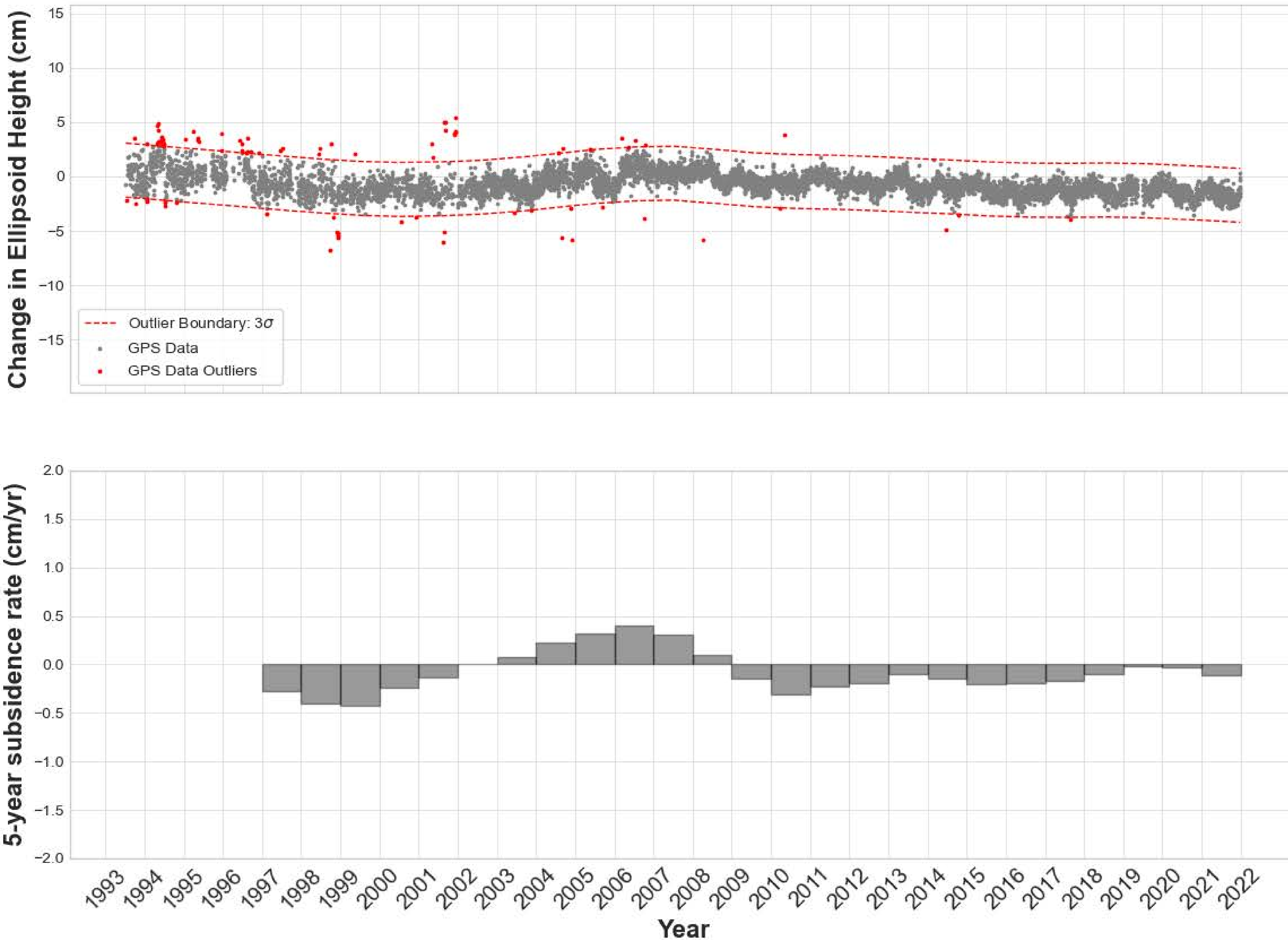
Map ID (Figure 1)	Site Name	Latitude (Decimal degrees)	Longitude (Decimal degrees)	Start of POR (Decimal year)	End of POR (Decimal Year)	Length of POR (Years)	Number of Samples (Days)	Total Vertical Displacement over POR (cm)	Annual Rate of Change in Ellipsoidal Height 2017-2021 (cm/yr)*
157	SPBH	29.8019	-95.5150	2013.303	2022.021	8.717	3183	-3.6	-0.23
158	TDAM	29.3141	-94.8170	2013.435	2022.021	8.586	2906	-1.7	-0.13
159	THSU	29.7140	-95.3399	2012.953	2022.021	9.068	3021	1.1	0.11
160	TMCC	29.7023	-95.3952	2003.271	2021.999	18.728	4546	-0.1	-0.04
161	TSFT	29.8063	-95.4800	2013.380	2022.021	8.641	3110	-4.1	-0.15
162	TXAC	29.7778	-94.6715	2011.124	2022.021	10.897	3923	2.5	0.24
163	TXAG	29.1642	-95.4190	2005.580	2020.558	14.979	5422	-1.8	-0.10
164	TXAV	29.4031	-95.2420	2017.147	2022.021	4.873	1323	-0.3	-0.25
165	TXB1	30.1614	-94.1809	2013.191	2022.021	8.829	2924	2.3	0.23
166	TXB2	30.0898	-94.1918	2012.463	2022.018	9.555	3146	-9.3	-0.33
167	TXBC	28.9998	-95.9724	2009.405	2022.021	12.616	4539	-2.0	-0.15
168	TXBH	29.7858	-95.9455	2017.150	2022.021	4.871	1719	-1.2	-0.40
169	TXC5	29.7035	-96.5725	2017.213	2022.021	4.808	1718	0.4	-0.05
170	TXCF	29.7035	-96.5725	2017.065	2022.021	4.956	1760	0.7	-0.05
171	TXCM	29.7028	-96.5773	2010.437	2022.021	11.584	4193	1.0	0.23
172	TXCN	30.3490	-95.4412	2005.580	2022.021	16.441	5986	-15.1	-0.37
173	TXCV	30.3351	-95.0936	2012.665	2021.468	8.802	2936	-3.8	-0.30
174	TXCY	30.0964	-95.6259	2017.391	2022.021	4.630	1526	-4.7	-1.12
175	TXED	28.9682	-96.6340	2009.429	2022.021	12.591	2965	0.3	0.09
176	TXEX	29.5637	-95.1192	2010.881	2021.999	11.118	3688	4.4	0.15
177	TXGA	29.3279	-94.7726	2005.580	2022.021	16.441	5795	-1.5	0.15
178	TXH2	29.5635	-94.3909	2016.090	2022.021	5.930	1907	1.2	0.07
179	TXHE	30.0990	-96.0635	2005.580	2022.021	16.441	5971	-2.1	1.28
180	TXHN	30.7424	-95.5962	2010.584	2021.810	11.225	3762	0.9	0.13
181	TXHS	29.7161	-95.5555	2012.463	2021.092	8.630	2937	-4.8	-0.41
182	TXHV	30.7207	-95.5526	2015.463	2021.810	6.346	2273	1.4	0.19
183	TXKO	30.3955	-94.3324	2011.770	2022.021	10.250	3695	0.7	0.11
184	TXLI	30.0559	-94.7710	2005.580	2022.021	16.441	5926	2.9	0.41
185	TXLM	29.3922	-95.0237	2005.580	2022.021	16.441	5963	-2.1	0.33
186	TXLQ	29.3580	-94.9529	2013.059	2022.021	8.961	3137	1.0	0.02
187	TXMG	28.9829	-95.9636	2013.309	2022.021	8.712	2790	-1.5	-0.16
188	TXNV	30.3816	-96.0667	2012.463	2022.021	9.558	3406	-2.4	-0.09
189	TXP5	29.6675	-95.0424	2019.181	2022.021	2.839	905	1.2	n/a
190	TXPH	29.9145	-93.9450	2015.313	2021.810	6.497	2294	-0.8	-0.07
191	TXPT	29.9474	-93.9529	2011.264	2021.810	10.546	3813	0.9	0.02
192	TXPV	28.6382	-96.6185	2010.292	2022.021	11.729	4253	1.9	0.30
193	TXRN	29.5425	-95.8285	2015.206	2022.021	6.814	2447	-0.1	-0.03
194	TXRS	29.5192	-95.8053	2011.447	2021.711	10.264	3707	-2.7	-0.28
195	TXSP	29.7309	-93.8972	2016.454	2021.810	5.355	1687	0.3	0.02
196	TXTG	29.8975	-95.2974	2015.466	2022.021	6.554	2330	-0.8	-0.24
197	TXVA	28.8350	-96.9100	2005.092	2021.810	16.717	5926	1.1	-0.04
198	TXVC	28.8340	-96.9580	2015.310	2021.810	6.500	2331	-0.4	0.11
199	TXWH	29.3246	-96.1118	2010.426	2022.021	11.595	4179	-0.5	0.25
200	TXWI	29.8058	-94.3715	2015.480	2022.021	6.541	2200	-0.8	-0.23
201	TXWN	29.3288	-96.0921	2015.003	2022.021	7.017	2507	1.0	0.01
202	UH01	29.7225	-95.3454	2012.745	2020.077	7.332	2619	0.1	-0.12
203	UH02	30.3152	-95.4572	2015.003	2022.021	7.017	2395	-3.7	-0.77
204	UHC0	29.3904	-95.0439	2014.138	2022.021	7.882	2755	-2.7	-0.48
205	UHC1	29.3904	-95.0440	2014.138	2022.021	7.882	2815	-1.3	-0.18
206	UHC2	29.3904	-95.0439	2014.138	2022.021	7.882	2814	-1.7	-0.17
207	UHC3	29.3904	-95.0439	2014.155	2022.021	7.866	2708	-2.9	-0.31
208	UHCL	29.5777	-95.1042	2014.242	2022.021	7.778	2634	0.8	0.08

Map ID (Figure 1)	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 2017-2021 (cm/yr)*
209	UHCR	29.7281	-95.7568	2014.125	2021.569	7.444	2717	-7.9	-1.11
210	UHDT	29.7660	-95.3594	2013.563	2022.021	8.457	3089	0.6	0.05
211	UHEB	29.5263	-96.0660	2014.595	2022.021	7.425	2411	-0.3	-0.04
212	UHEP	29.7195	-95.3271	2014.365	2021.782	7.417	2669	-0.8	0.01
213	UHF1	30.2363	-95.4831	2014.390	2021.484	7.094	2344	-5.1	-0.66
214	UHJF	30.2363	-95.4831	2014.393	2021.703	7.310	2129	-5.3	-0.66
215	UHKD	29.7242	-95.7481	2018.971	2021.719	2.749	930	-2.3	-0.67
216	UHKS	29.7243	-95.7481	2018.412	2021.719	3.307	1207	-1.8	-0.53
217	UHL1	30.0577	-94.9785	2014.365	2021.142	6.776	2357	1.7	-0.06
218	UHRI	29.7192	-95.4025	2014.330	2022.021	7.691	2796	-0.8	0.07
219	UHSL	29.5747	-95.6515	2014.185	2021.955	7.770	2625	-1.8	-0.23
220	UHWL	30.0576	-94.9784	2014.357	2021.142	6.784	2105	-0.6	-0.12
221	UTEX	29.7859	-95.5678	2012.496	2021.629	9.133	3120	-5.3	-0.39
222	WCHT	29.7828	-95.5814	2013.295	2022.021	8.725	3074	-6.5	-0.27
223	WDVW	29.7904	-95.5331	2013.320	2022.021	8.701	3114	-3.8	-0.30
224	WEPD	29.6877	-95.2287	2014.075	2022.021	7.945	2817	1.9	0.14
225	WHCR	30.1943	-95.5054	2014.779	2022.021	7.242	2643	-3.7	-0.86
226	YORS	30.1100	-95.4695	2020.827	2021.991	1.164	428	-1.0	n/a
227	ZHU1	29.9619	-95.3314	2003.042	2022.021	18.979	6582	-15.1	-0.51

Notes:

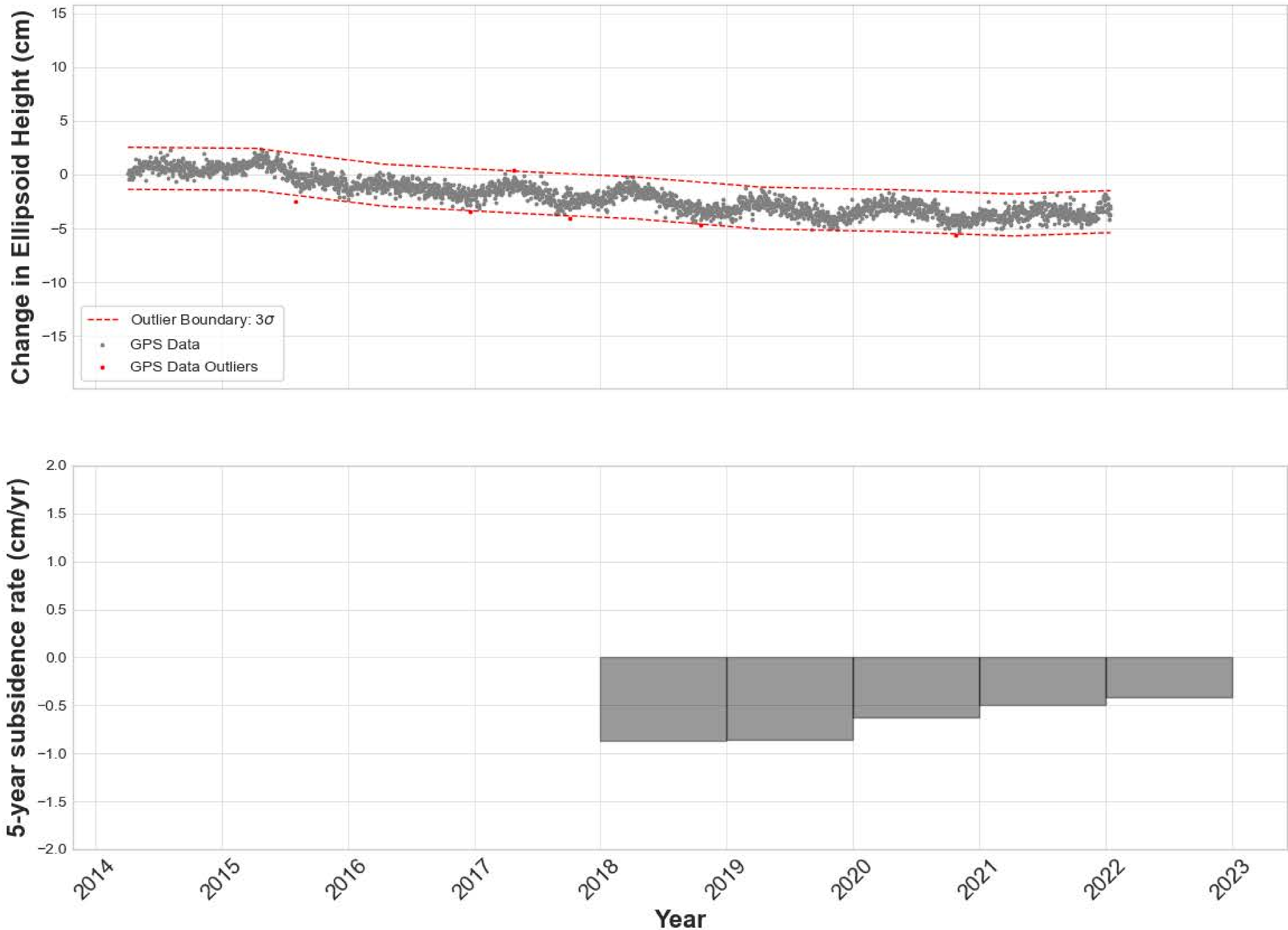
n/a: rate of change in ellipsoidal height not calculated

ADKS



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

ALEF



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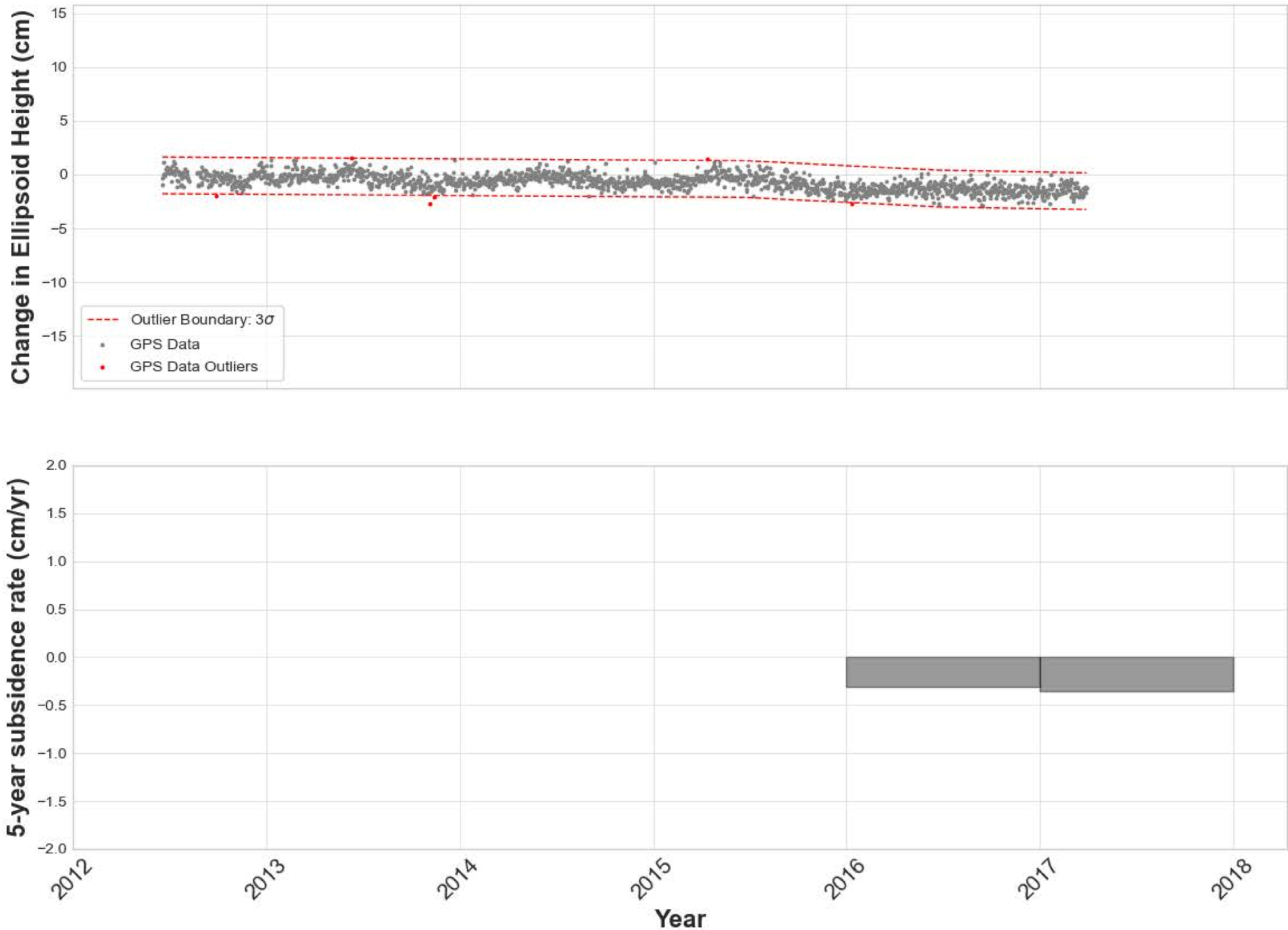
ALVN



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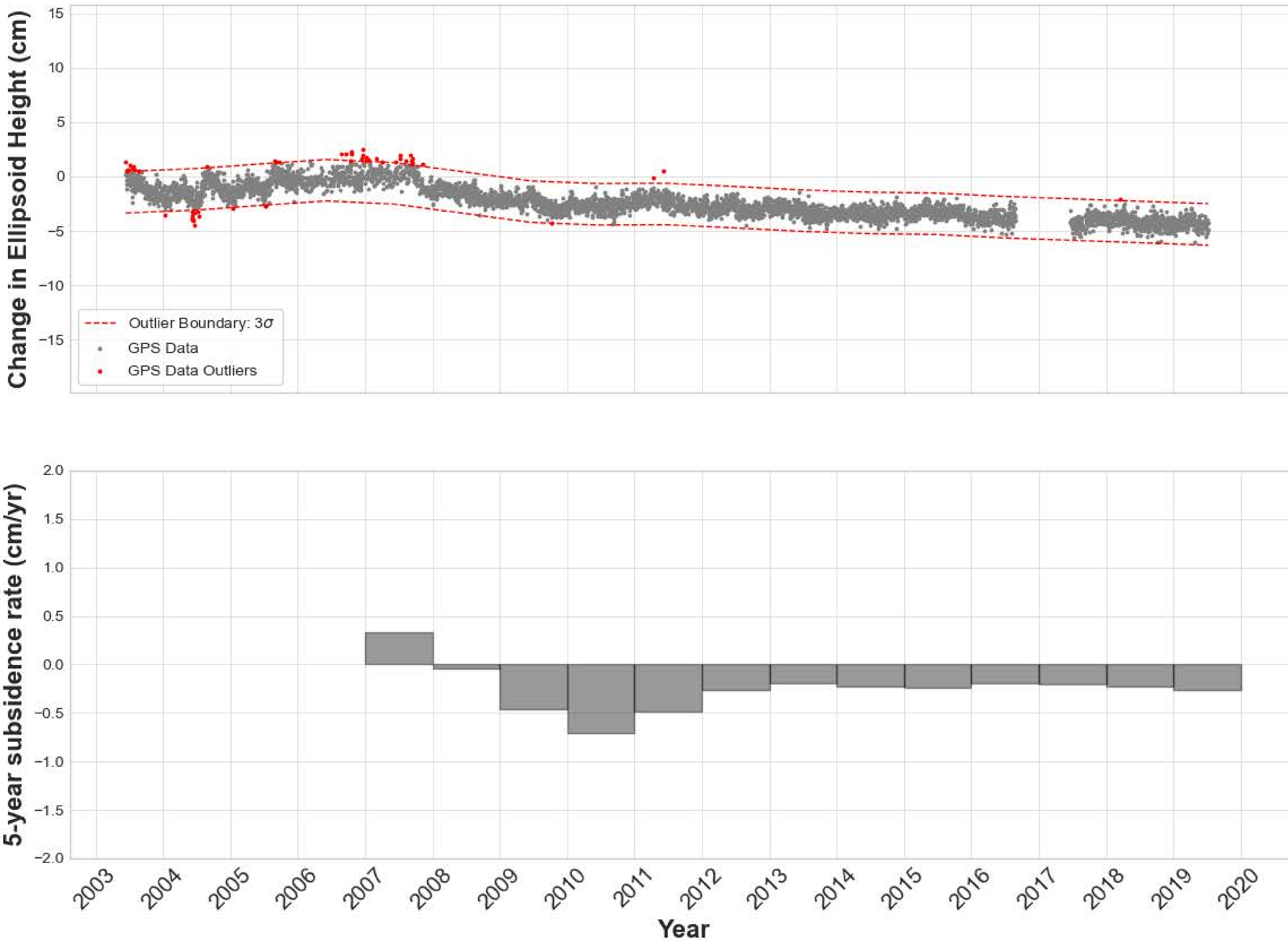
ANG5



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ANG6

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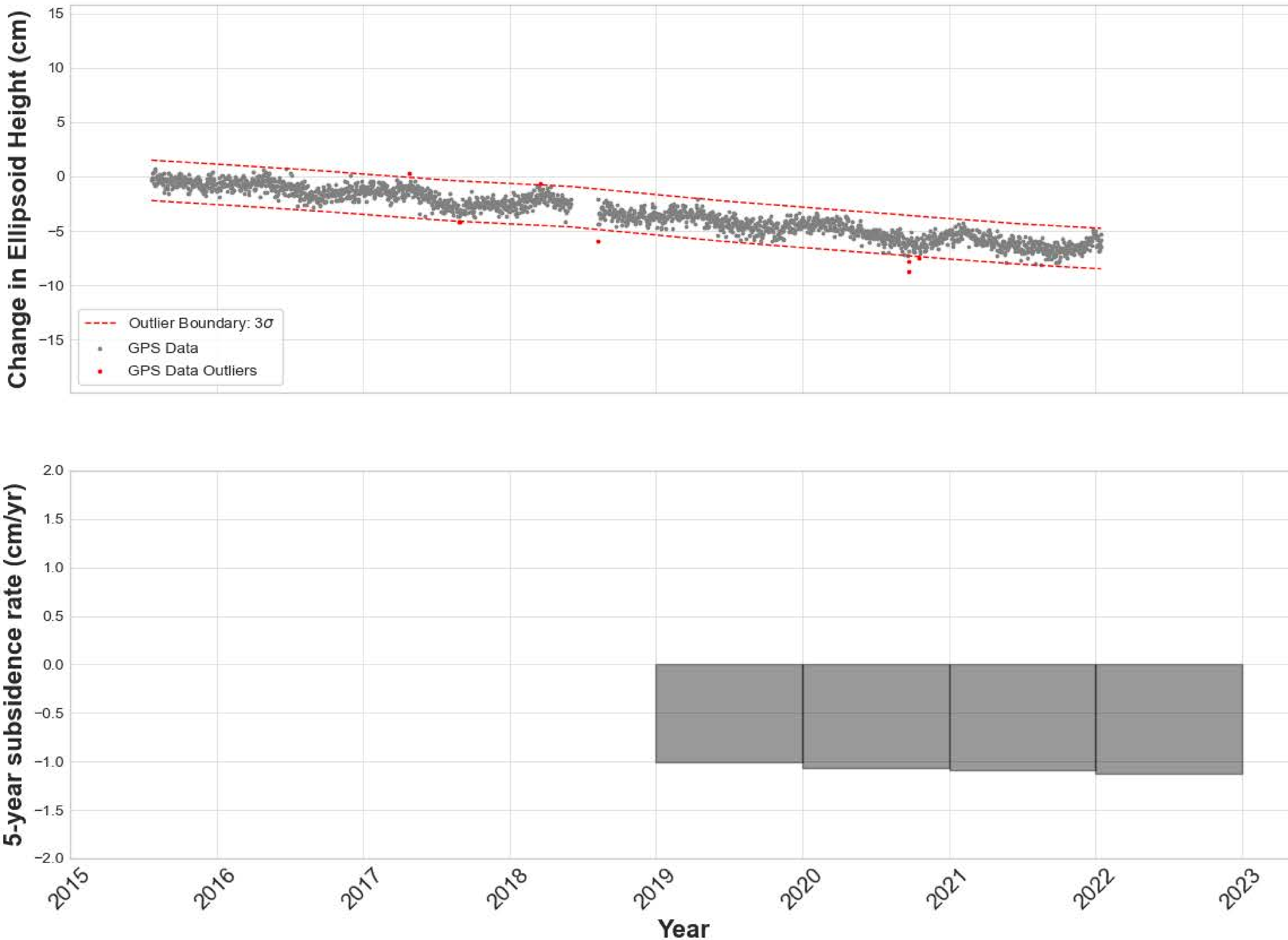
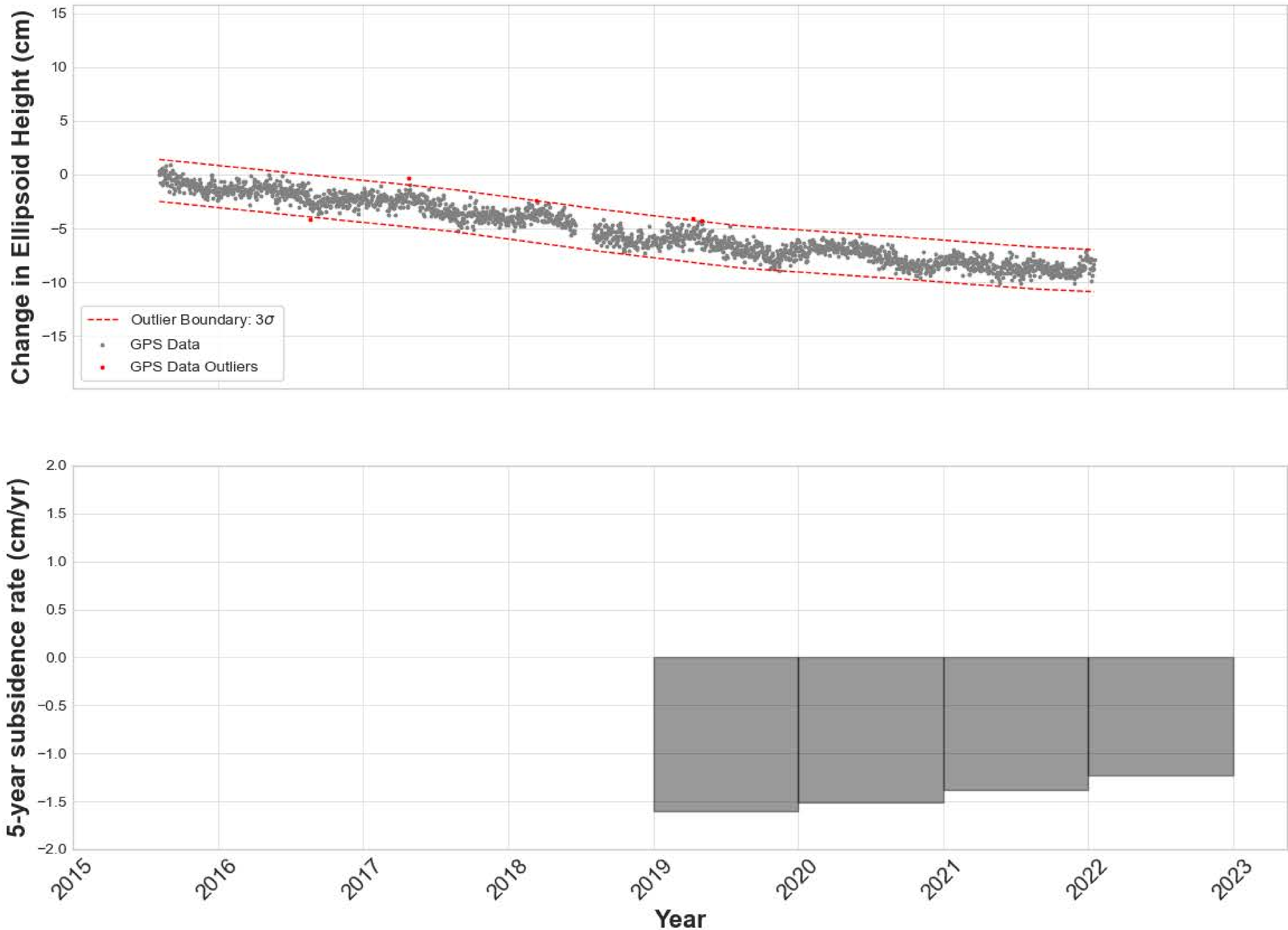
AULT



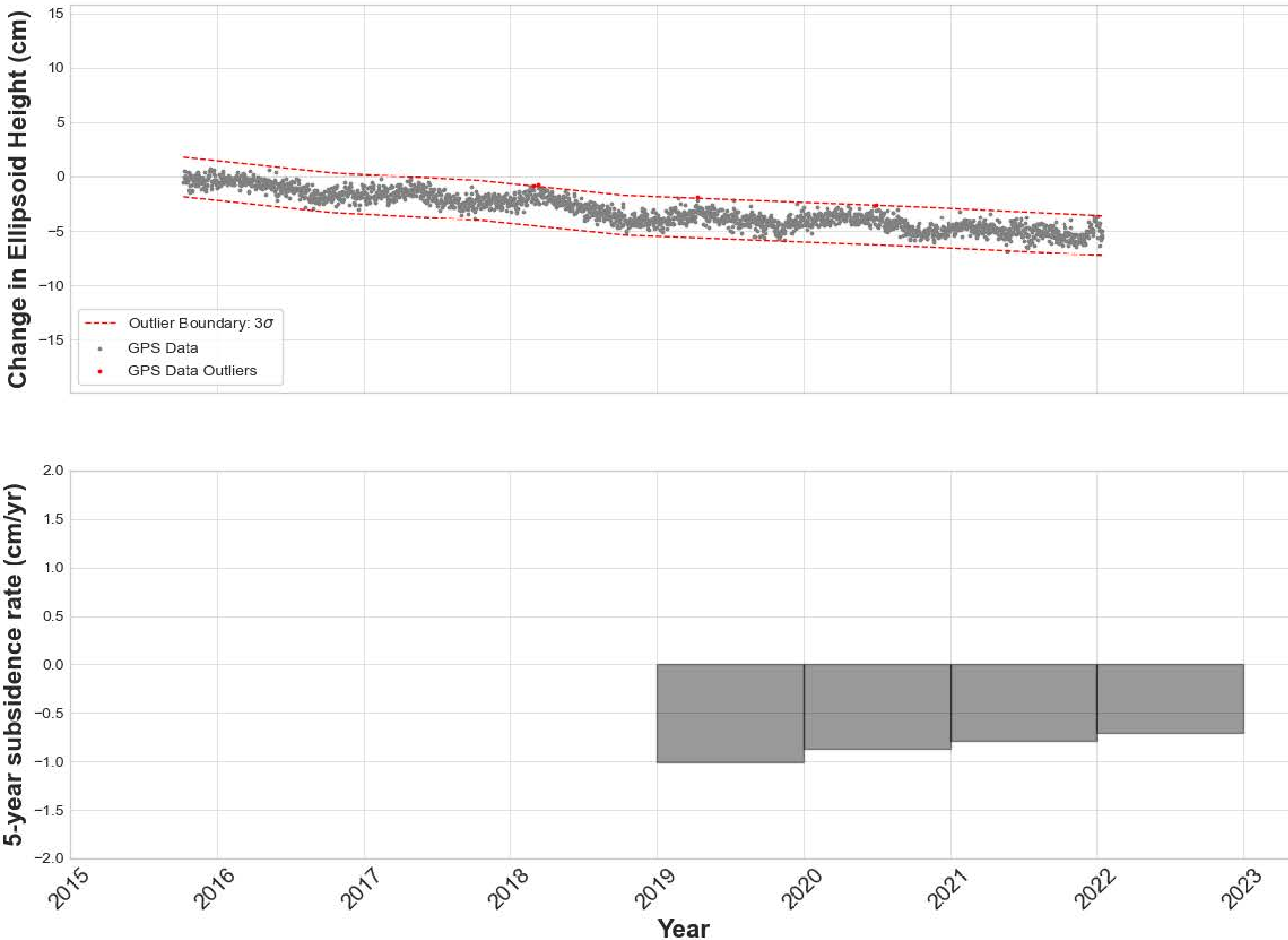
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

CFHS



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

CFJV



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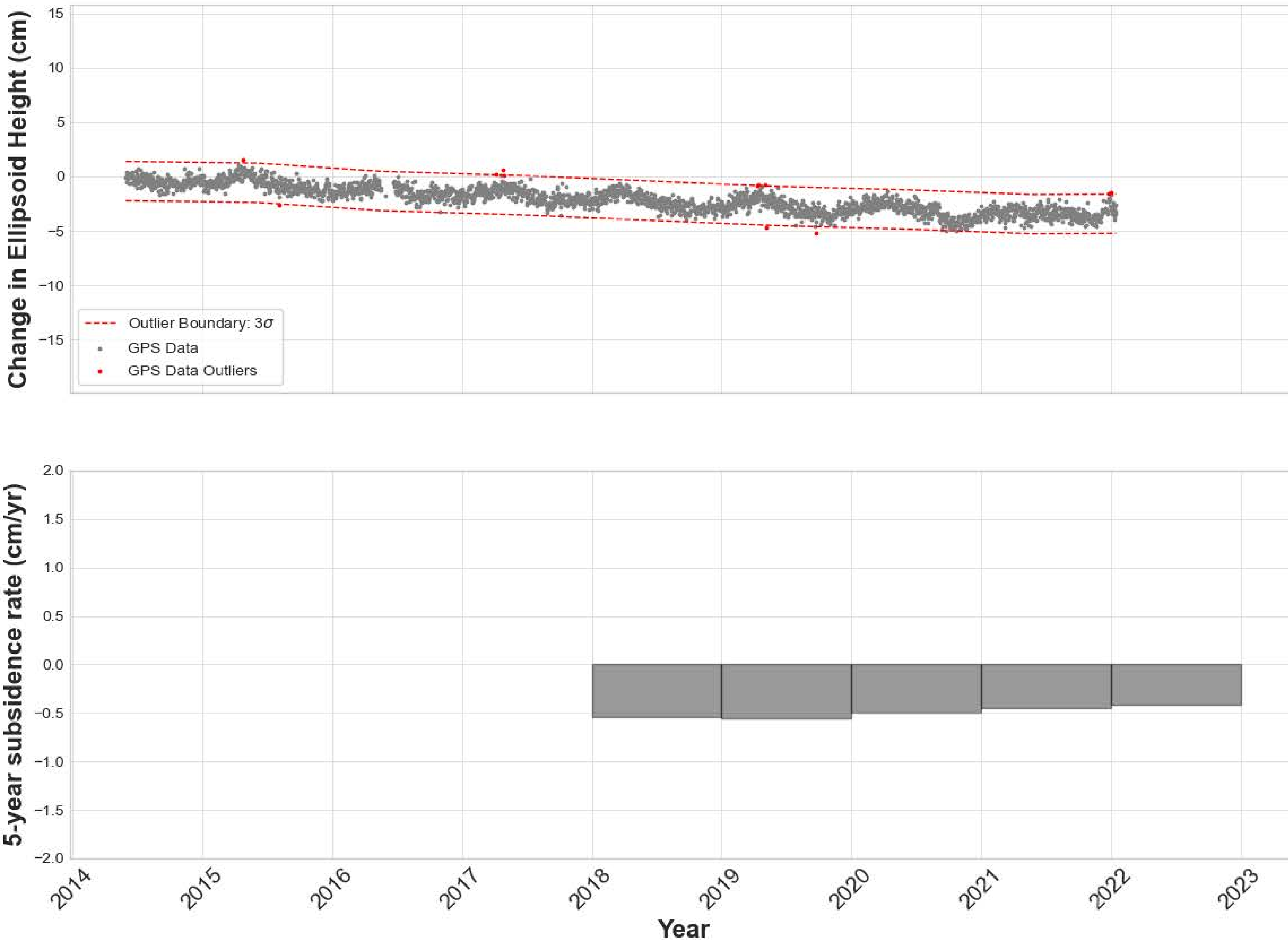
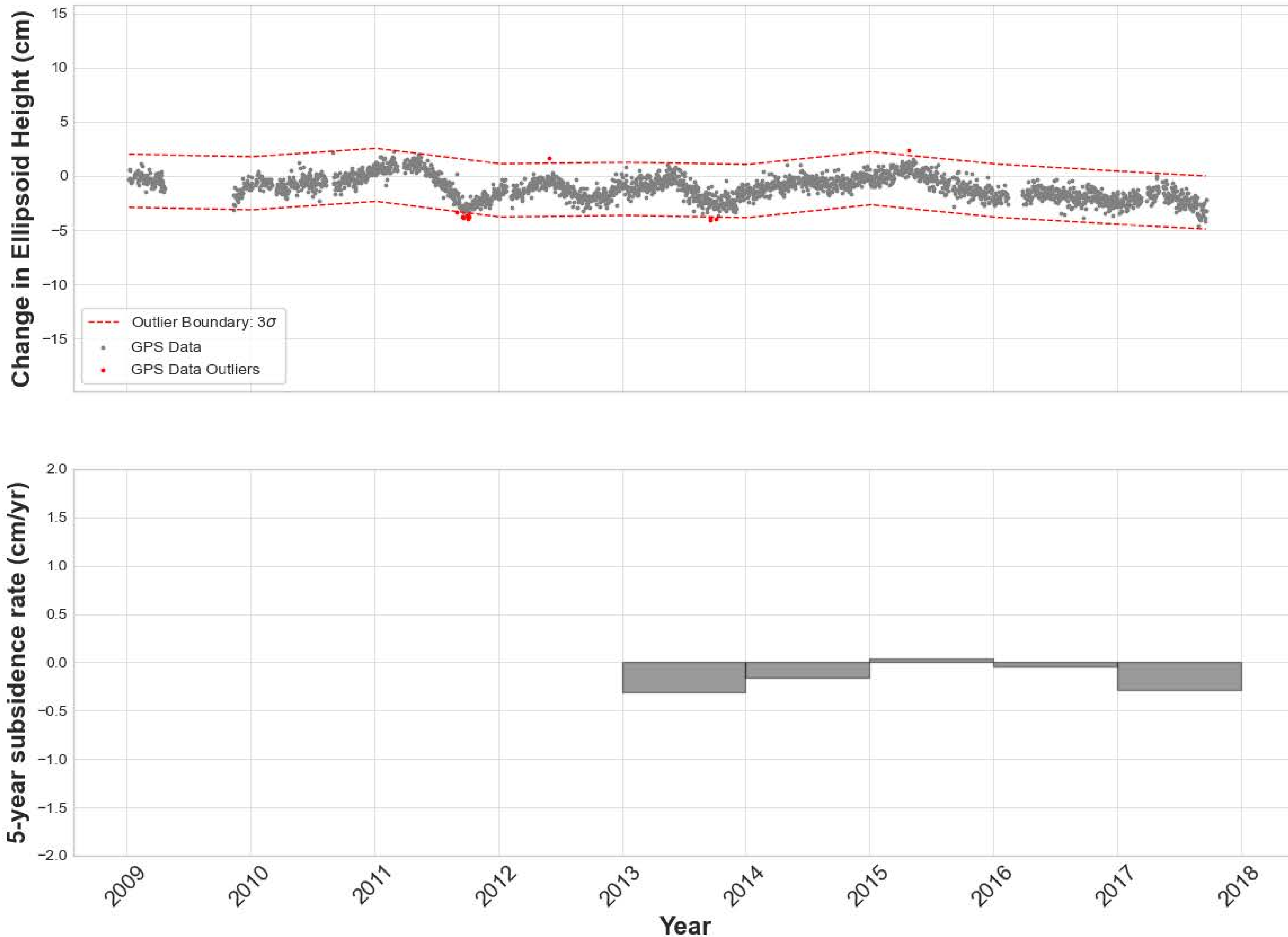
CMFB



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

COH1



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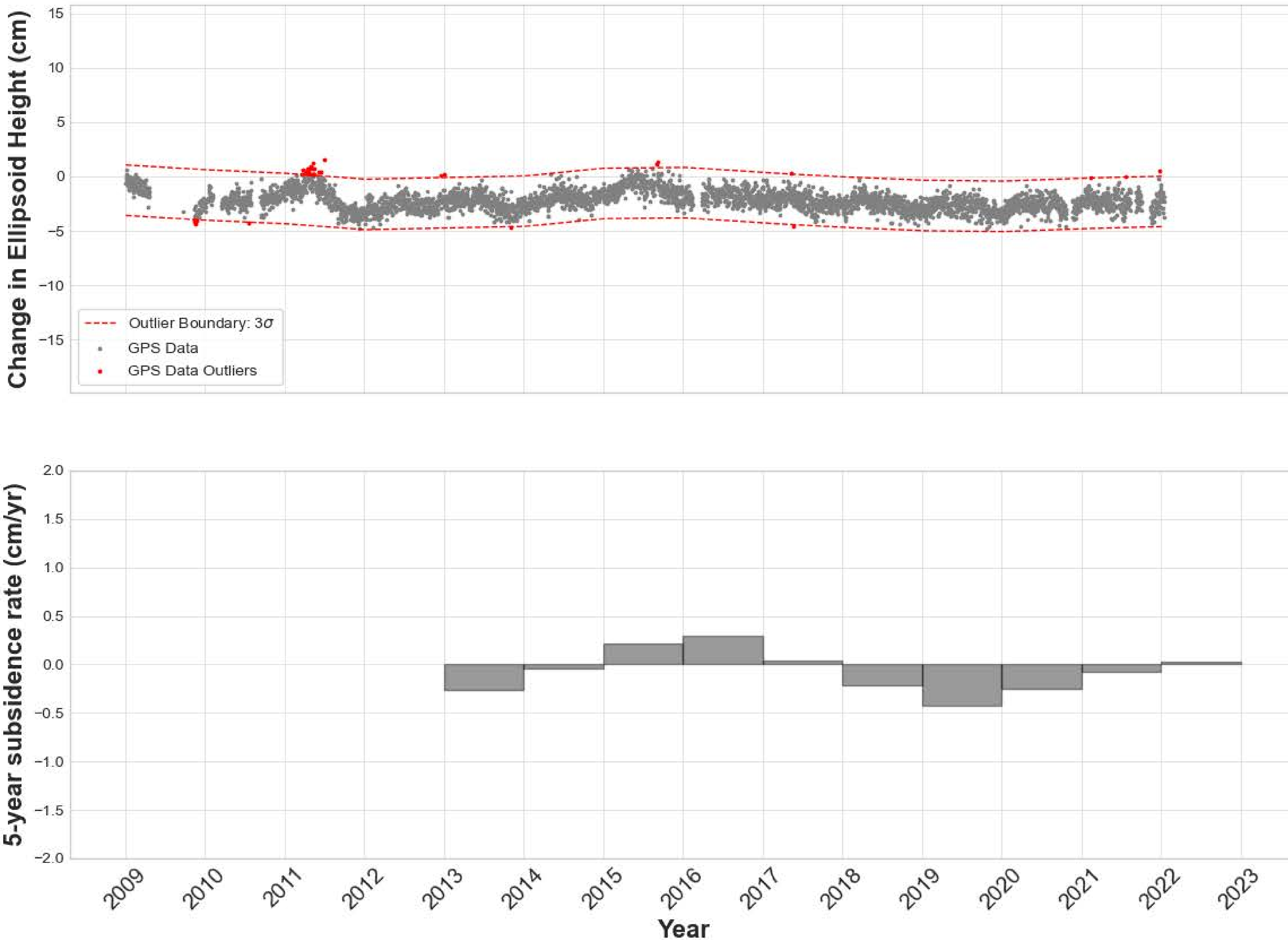
COH2



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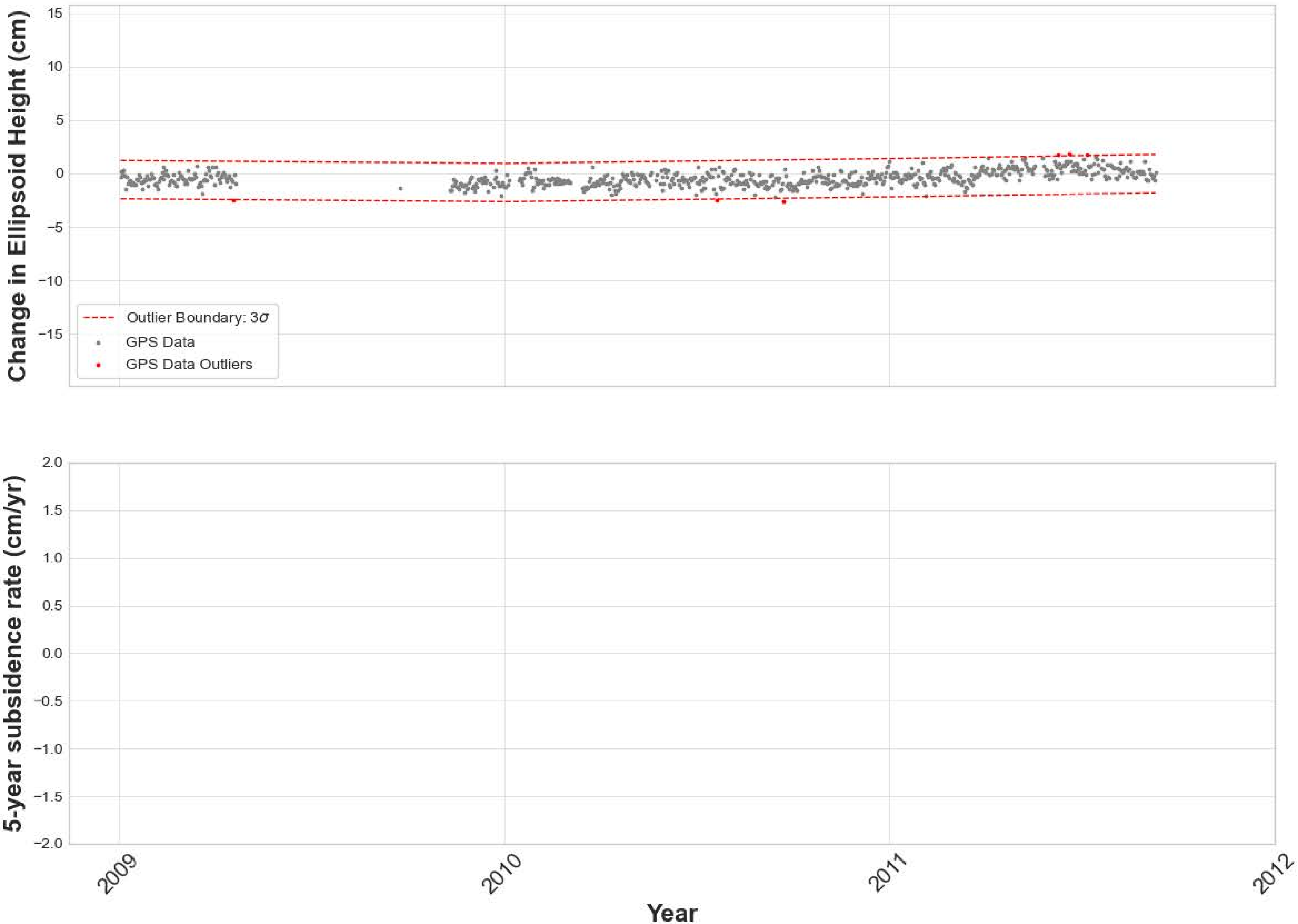
COH4



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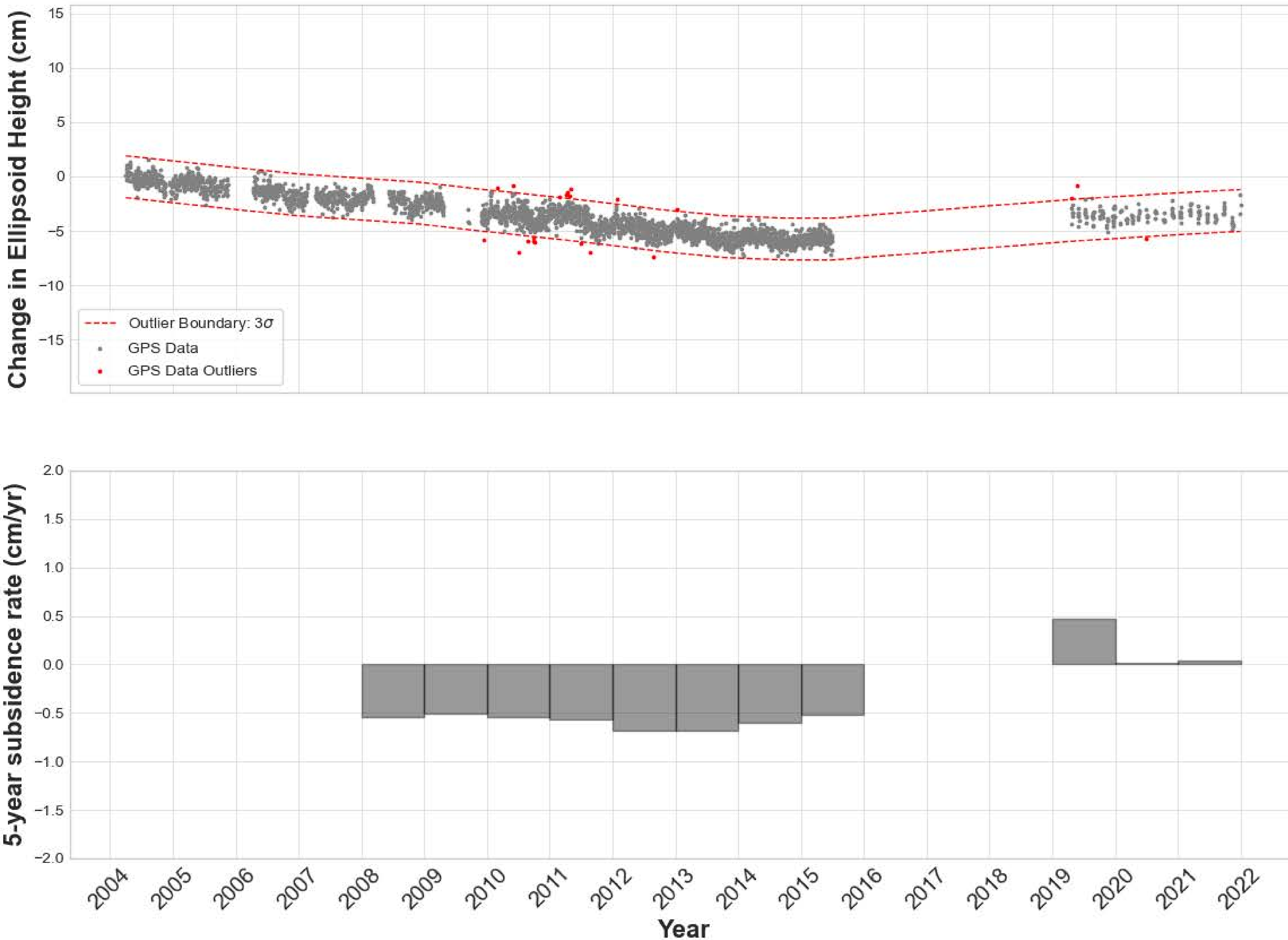
COH6



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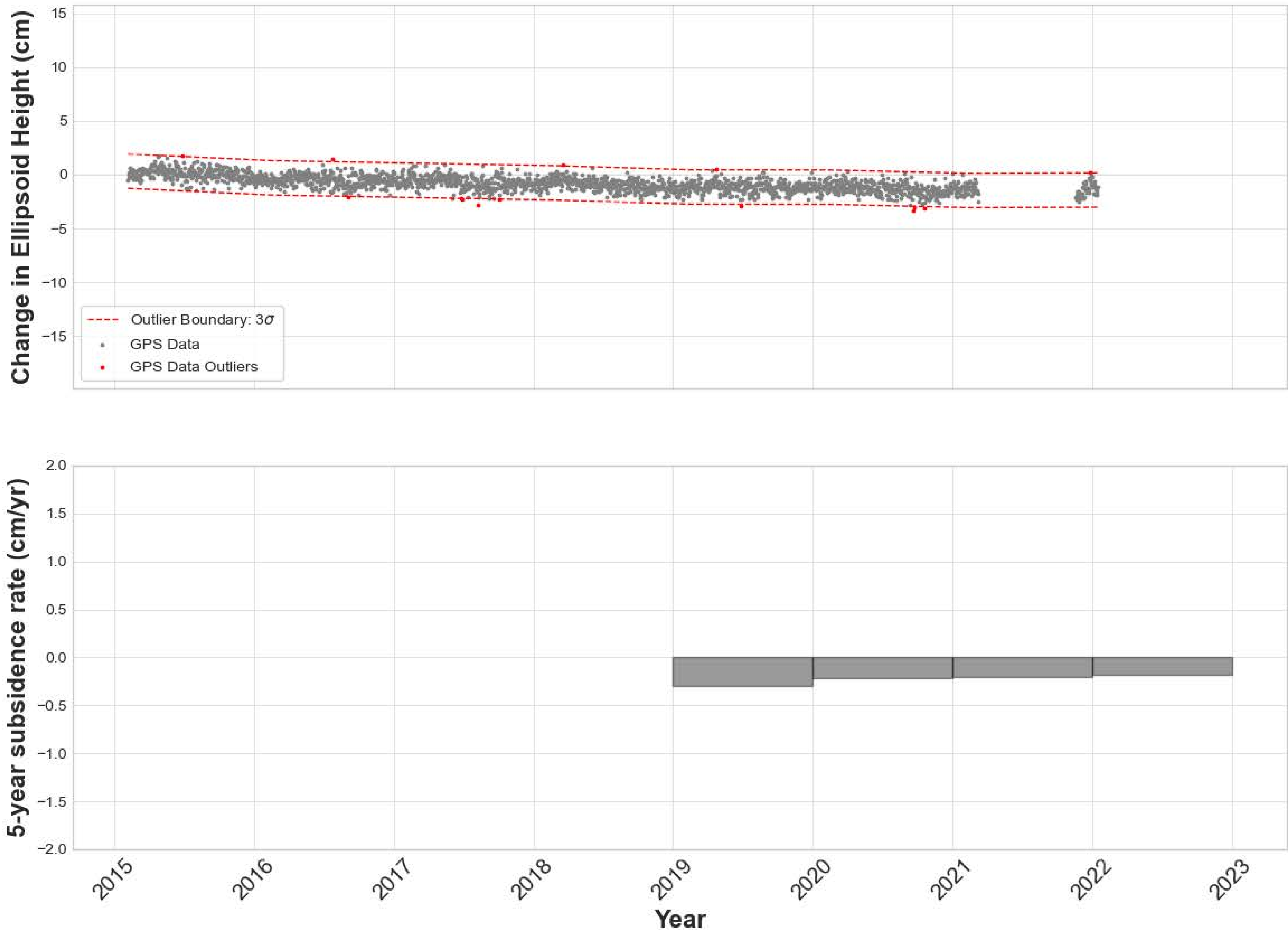
COTM



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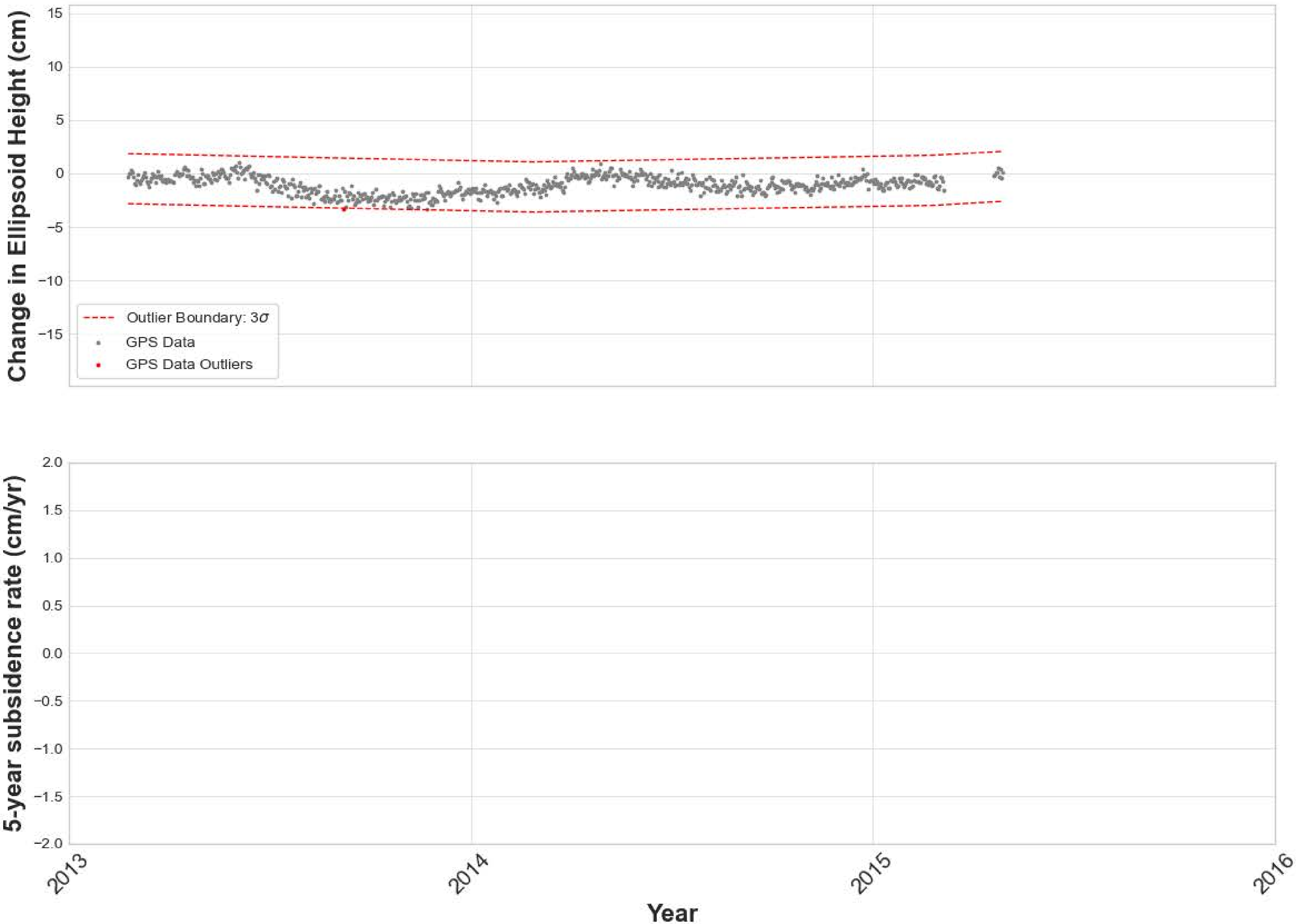
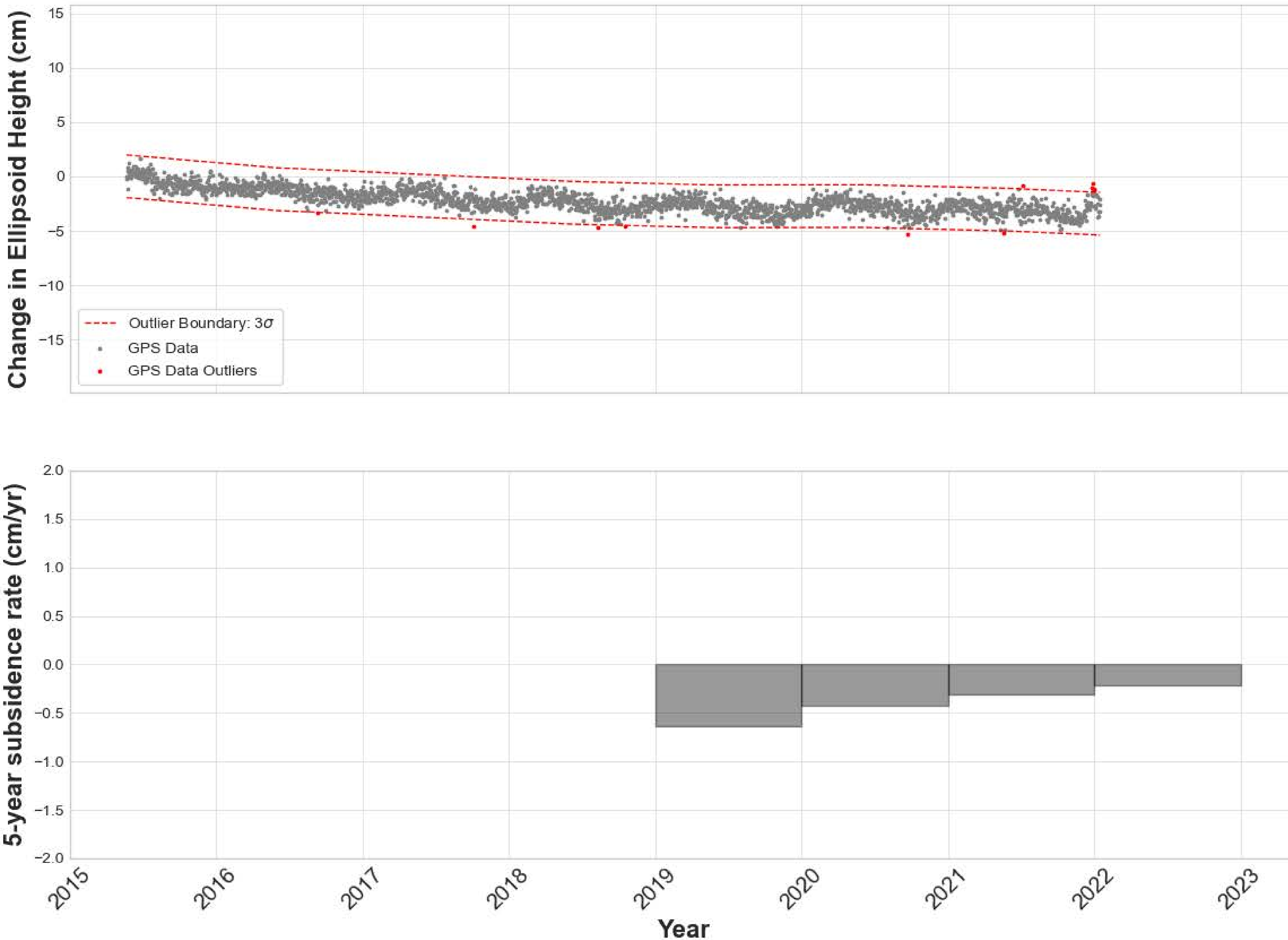
CSTA



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

CSTE



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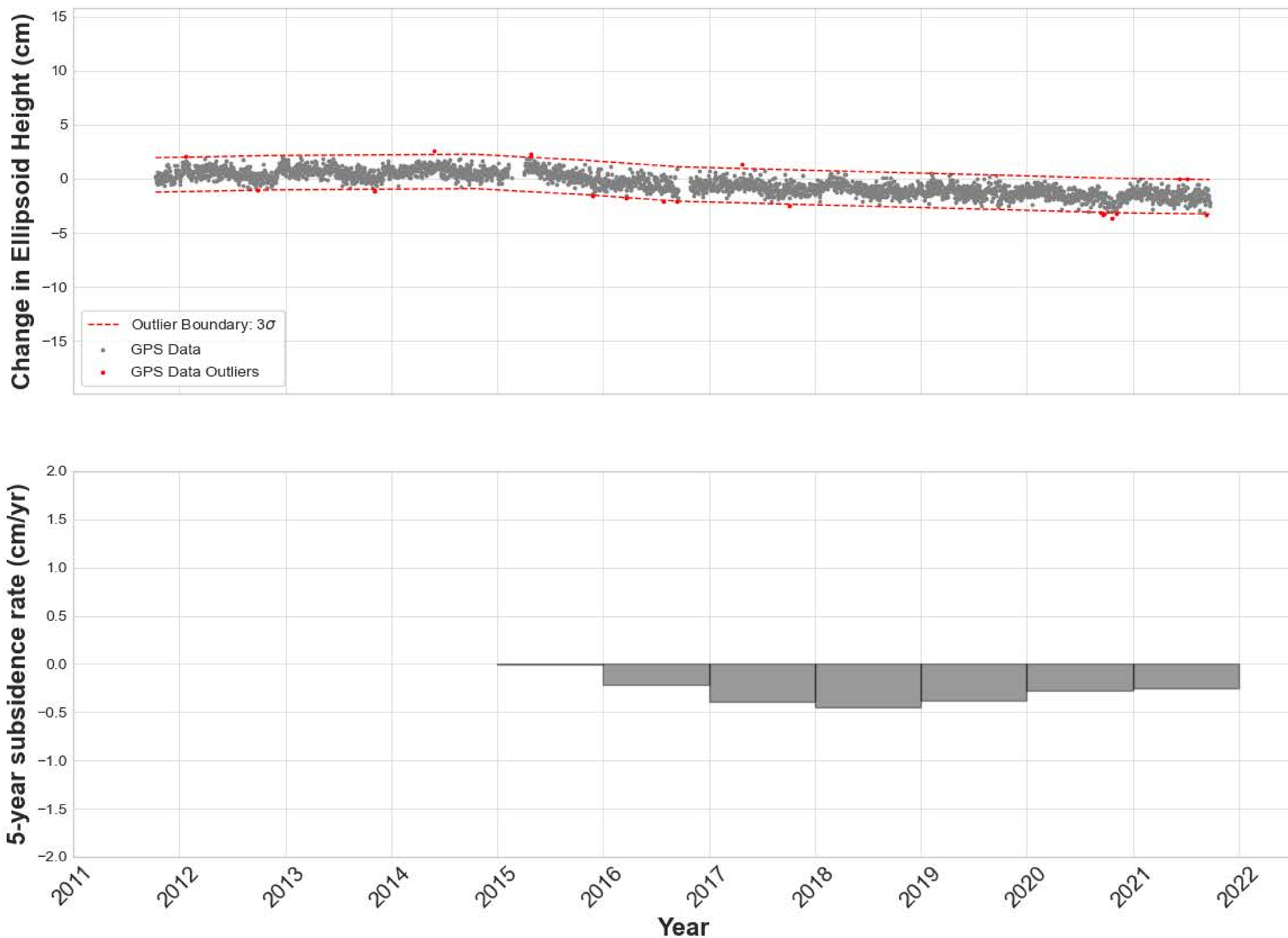
DEN1



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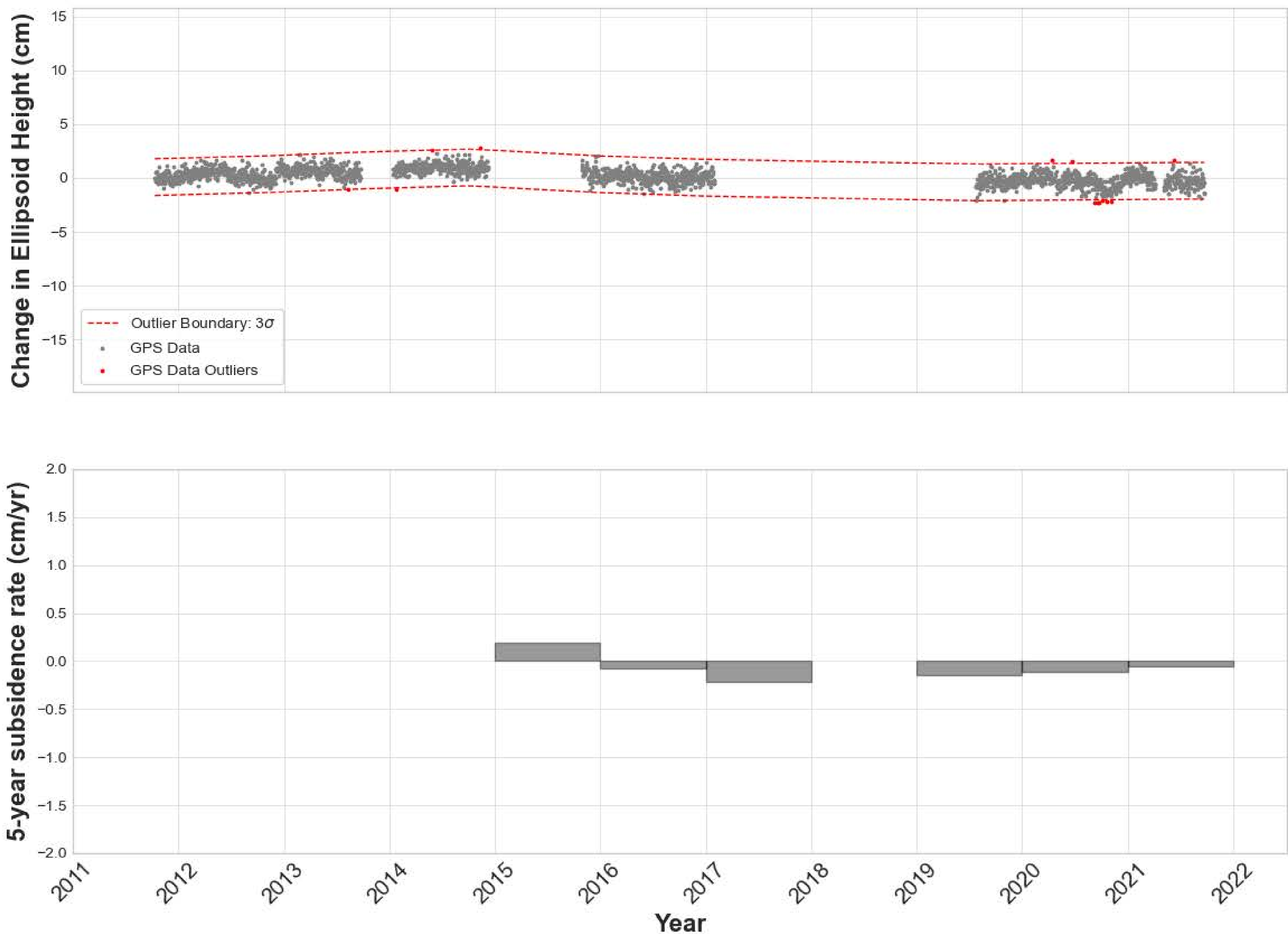
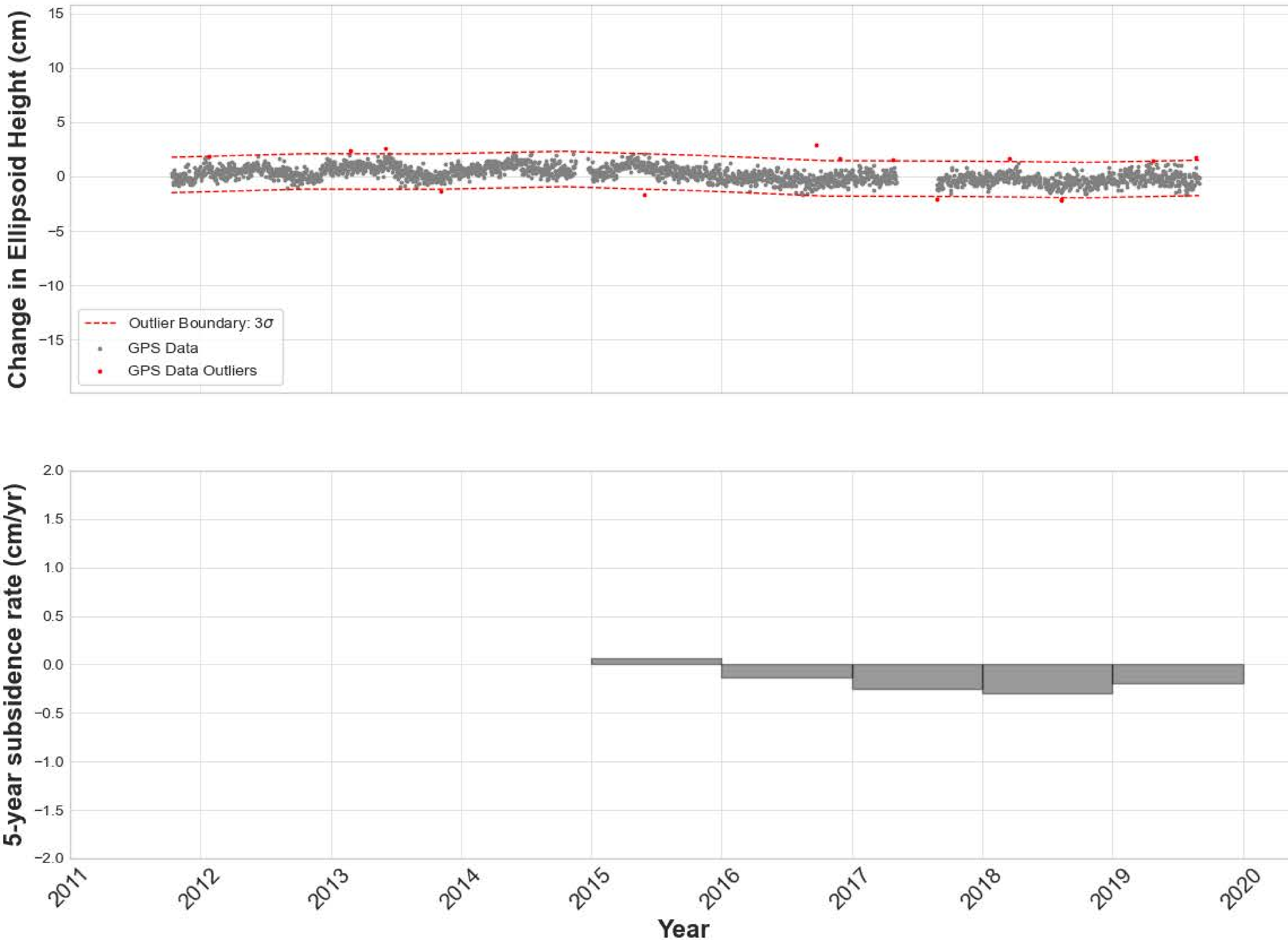
DEN2



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

DEN3



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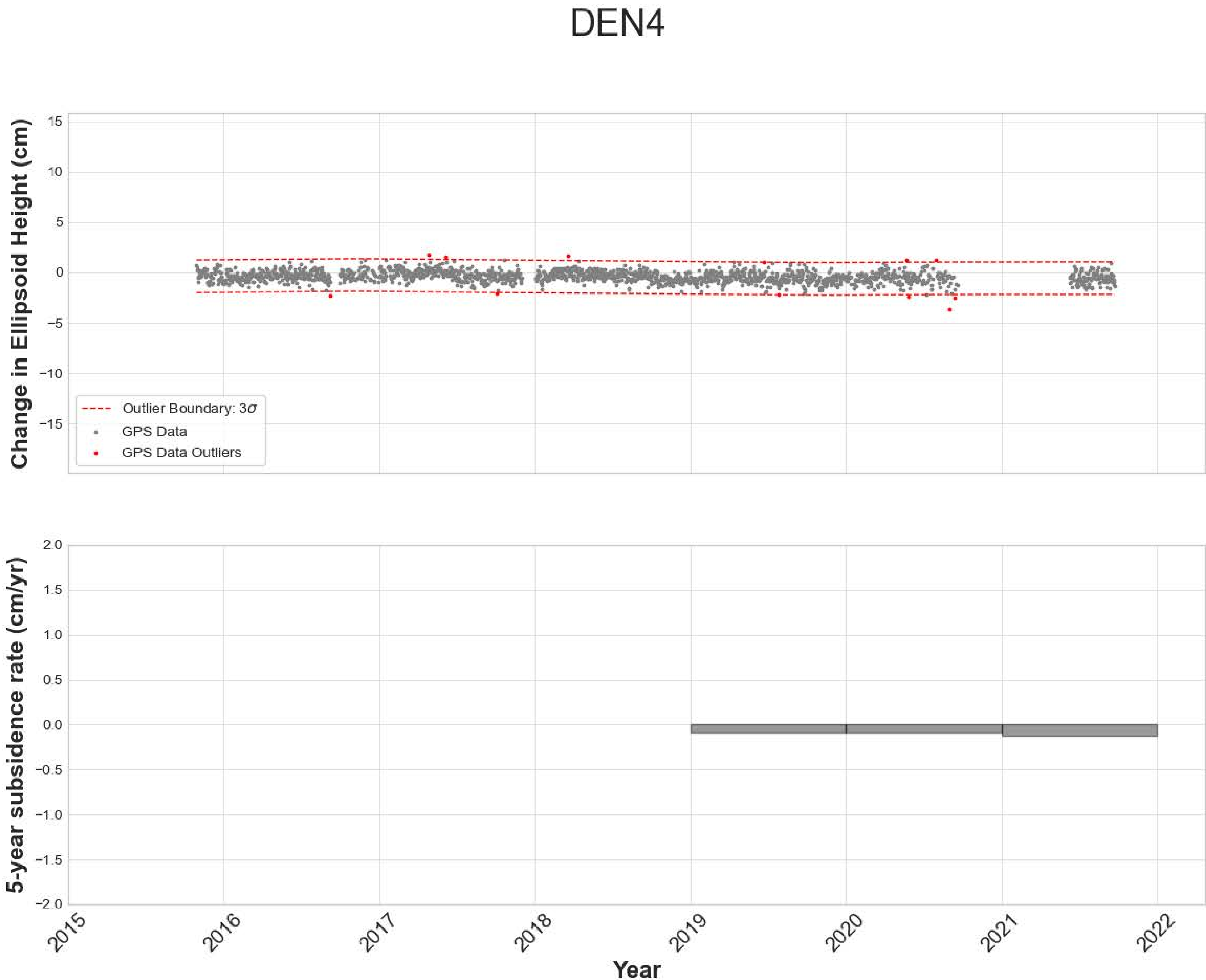
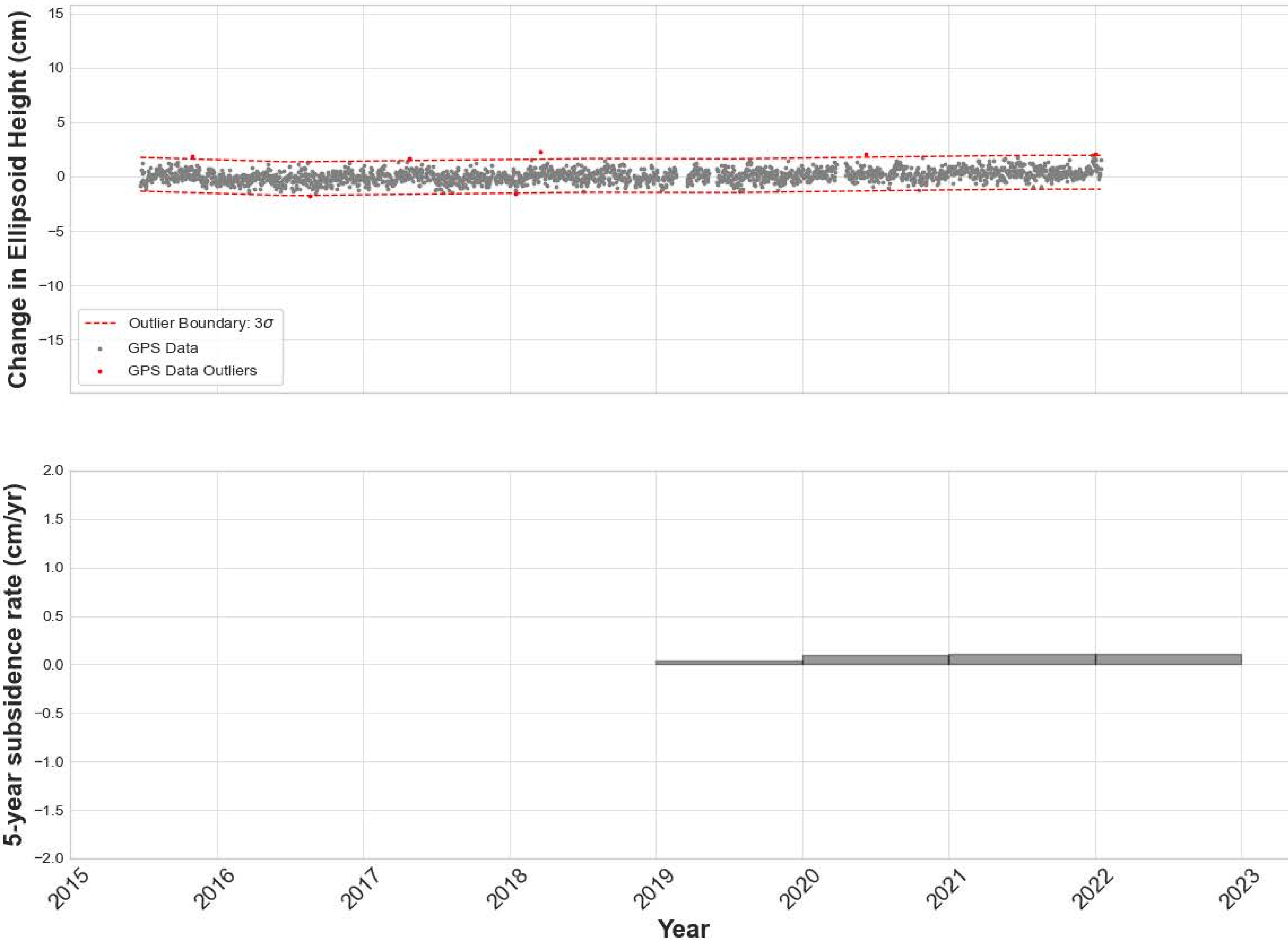


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

DISD



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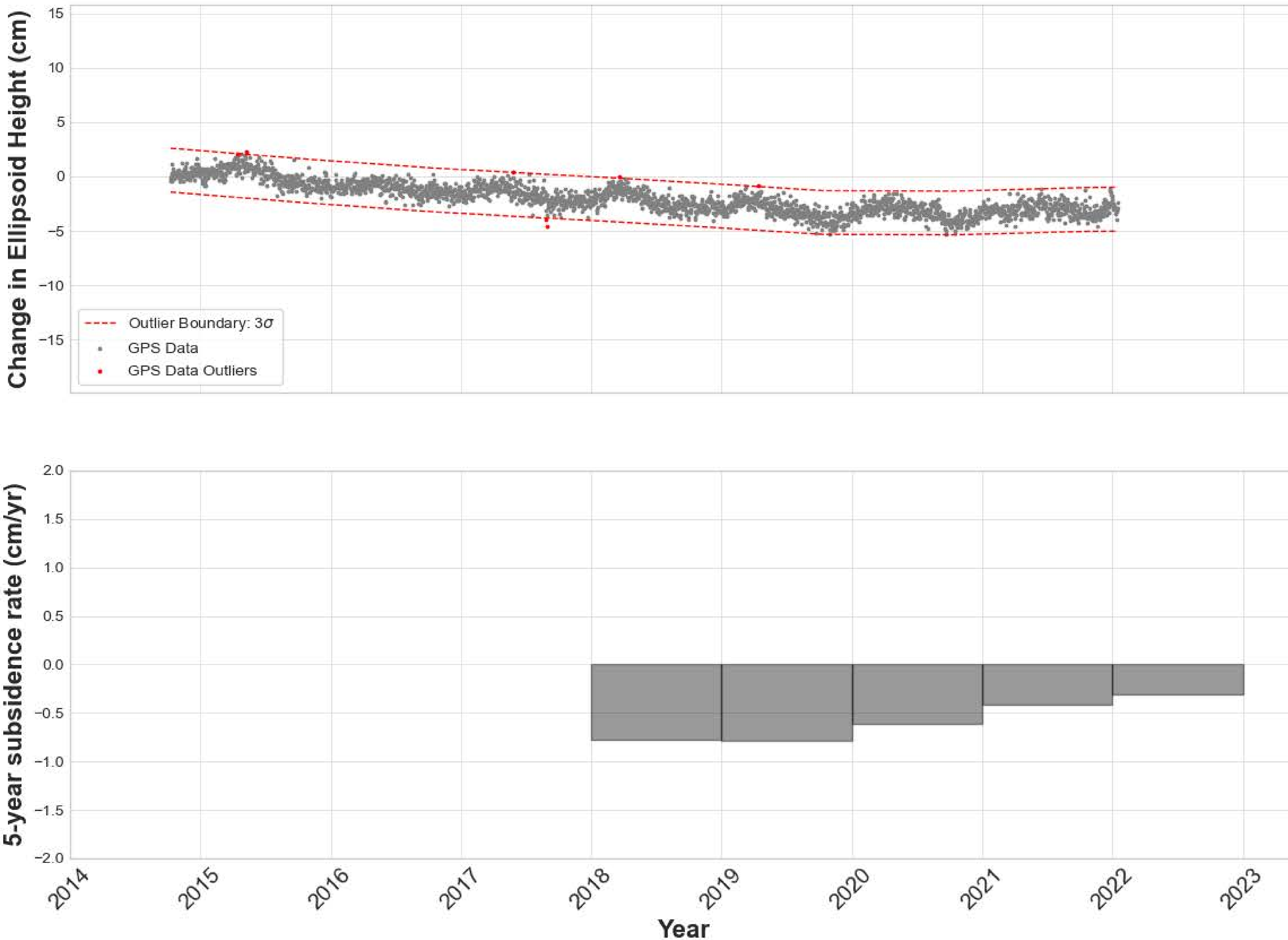
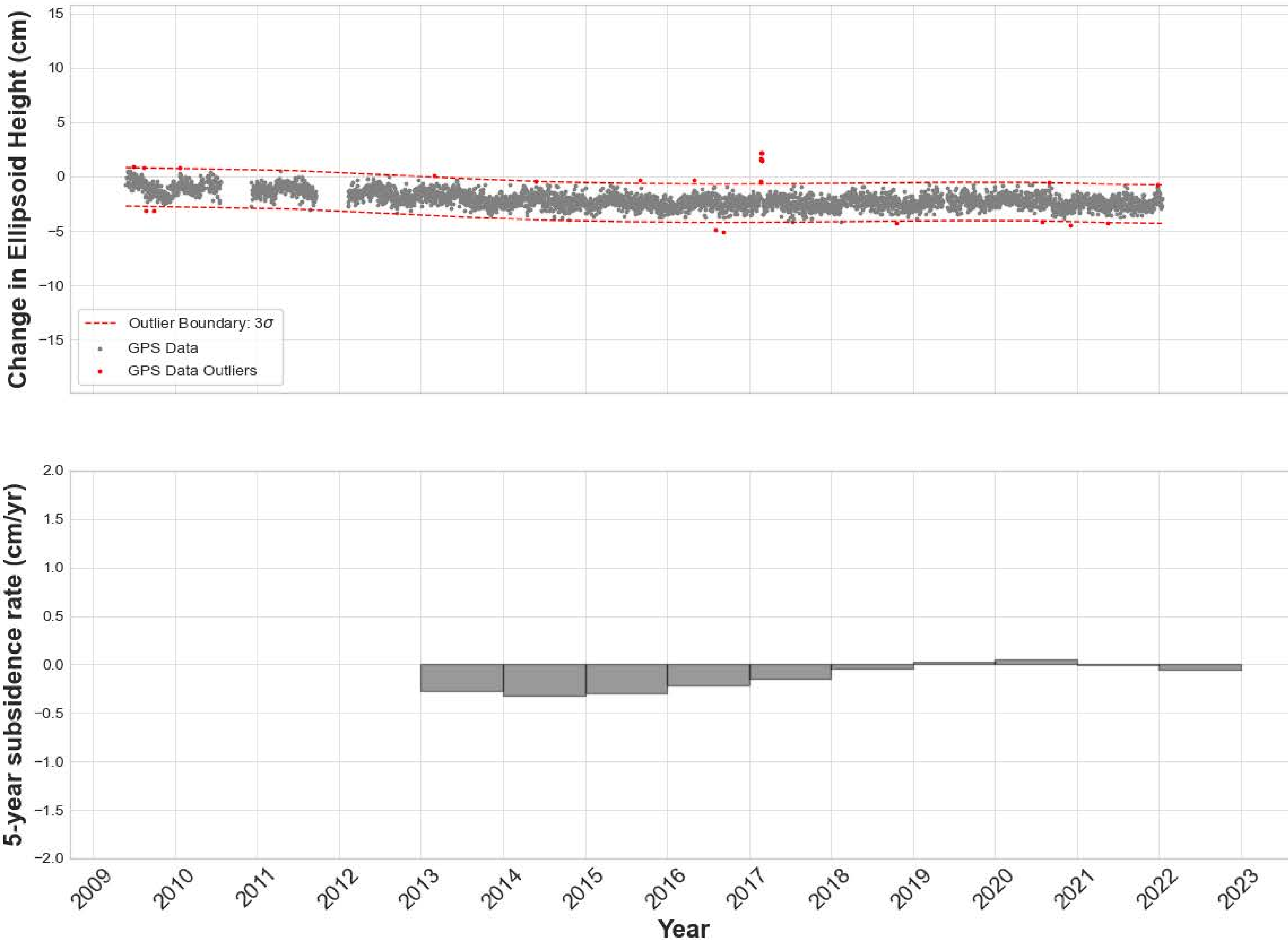
DMFB



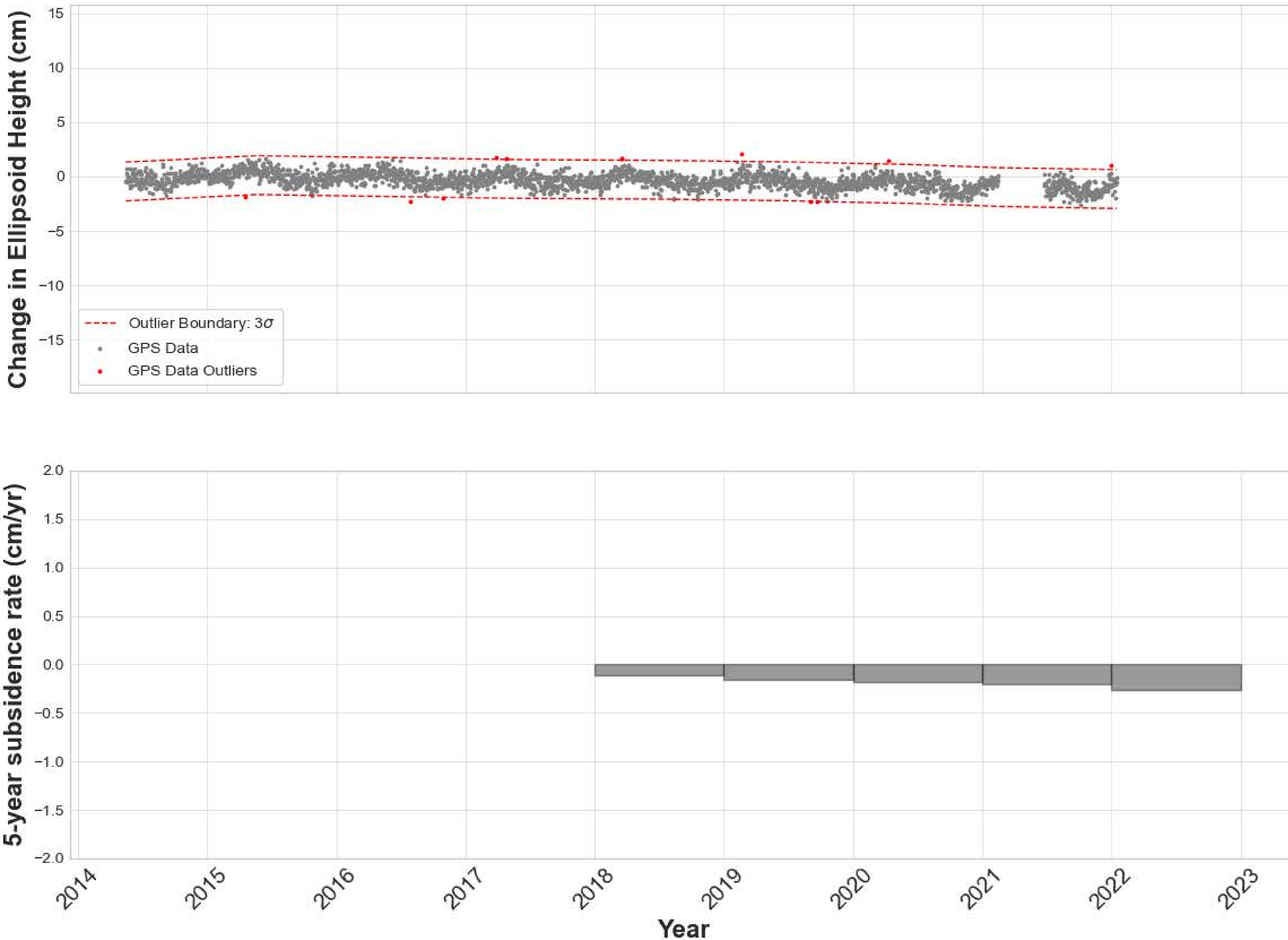
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

DWI1

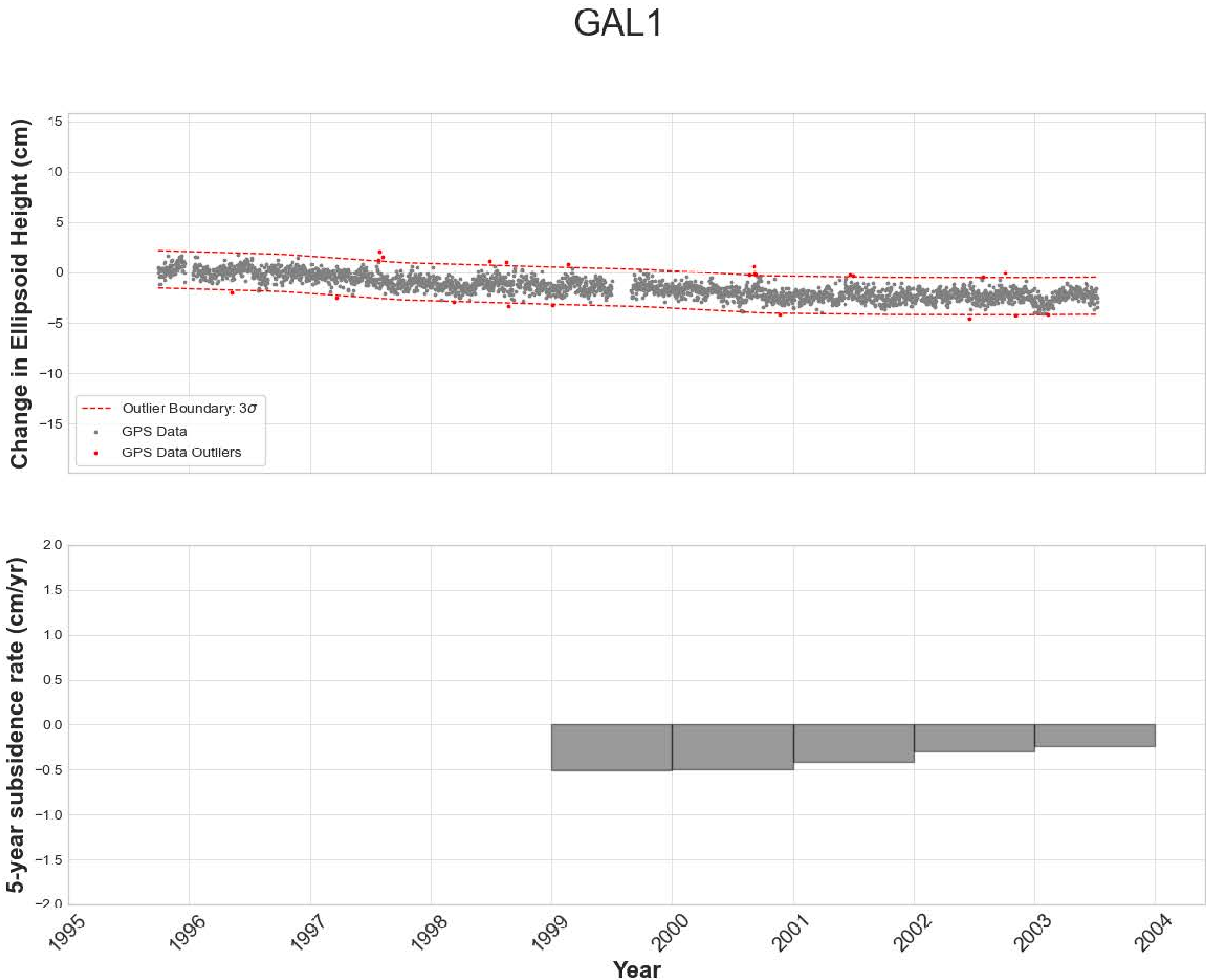


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

FSFB

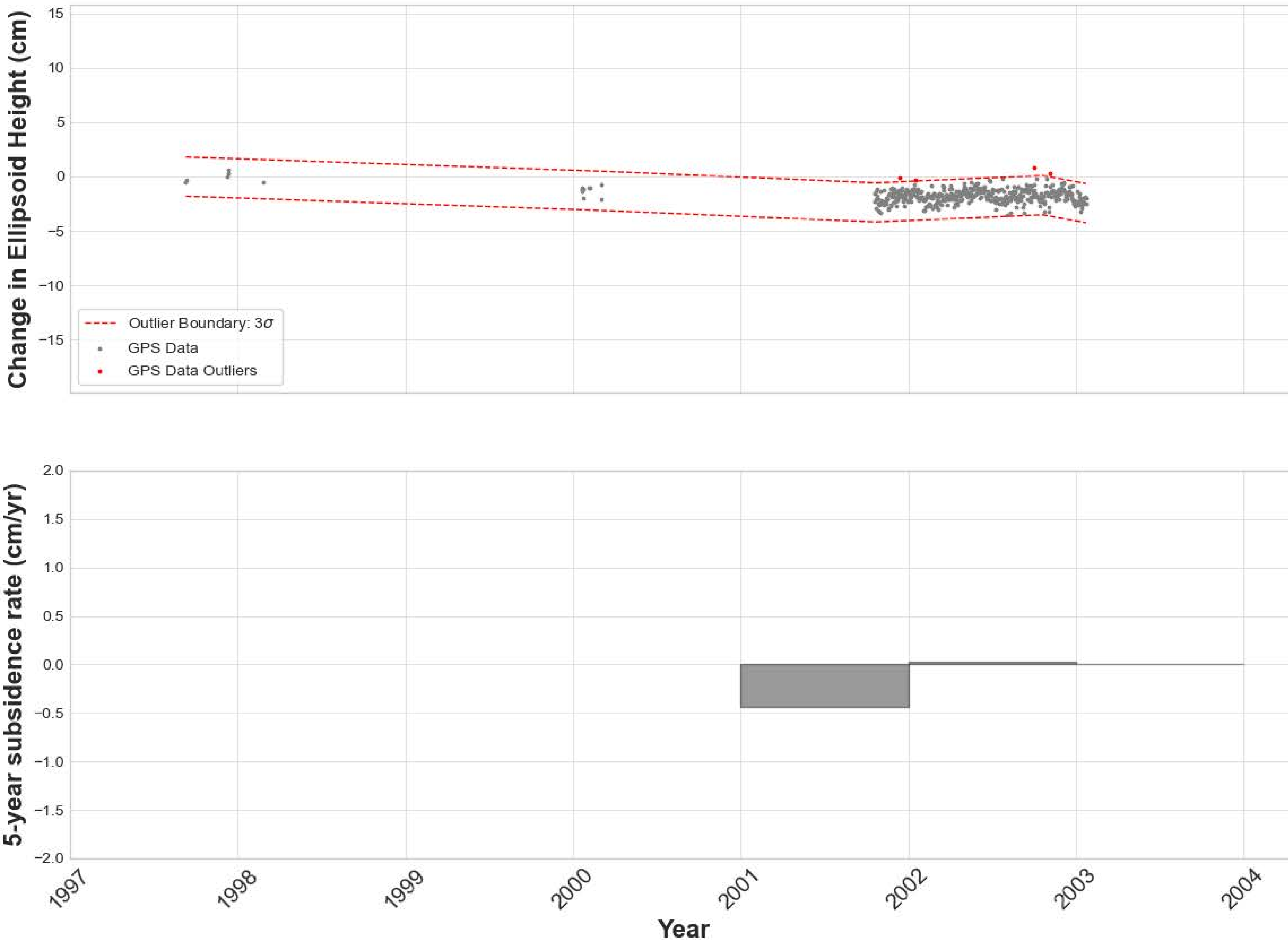


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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



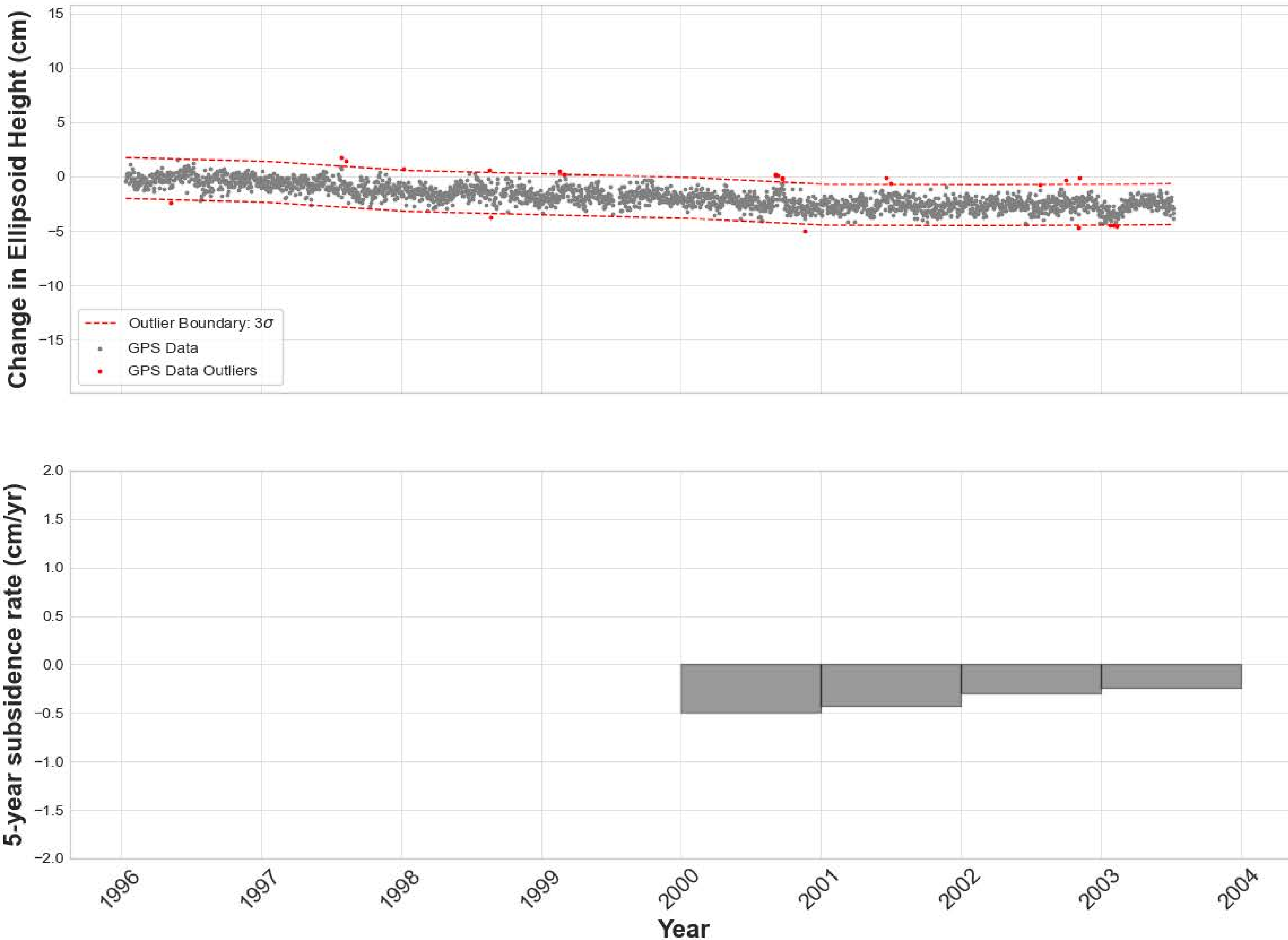
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

GAL2



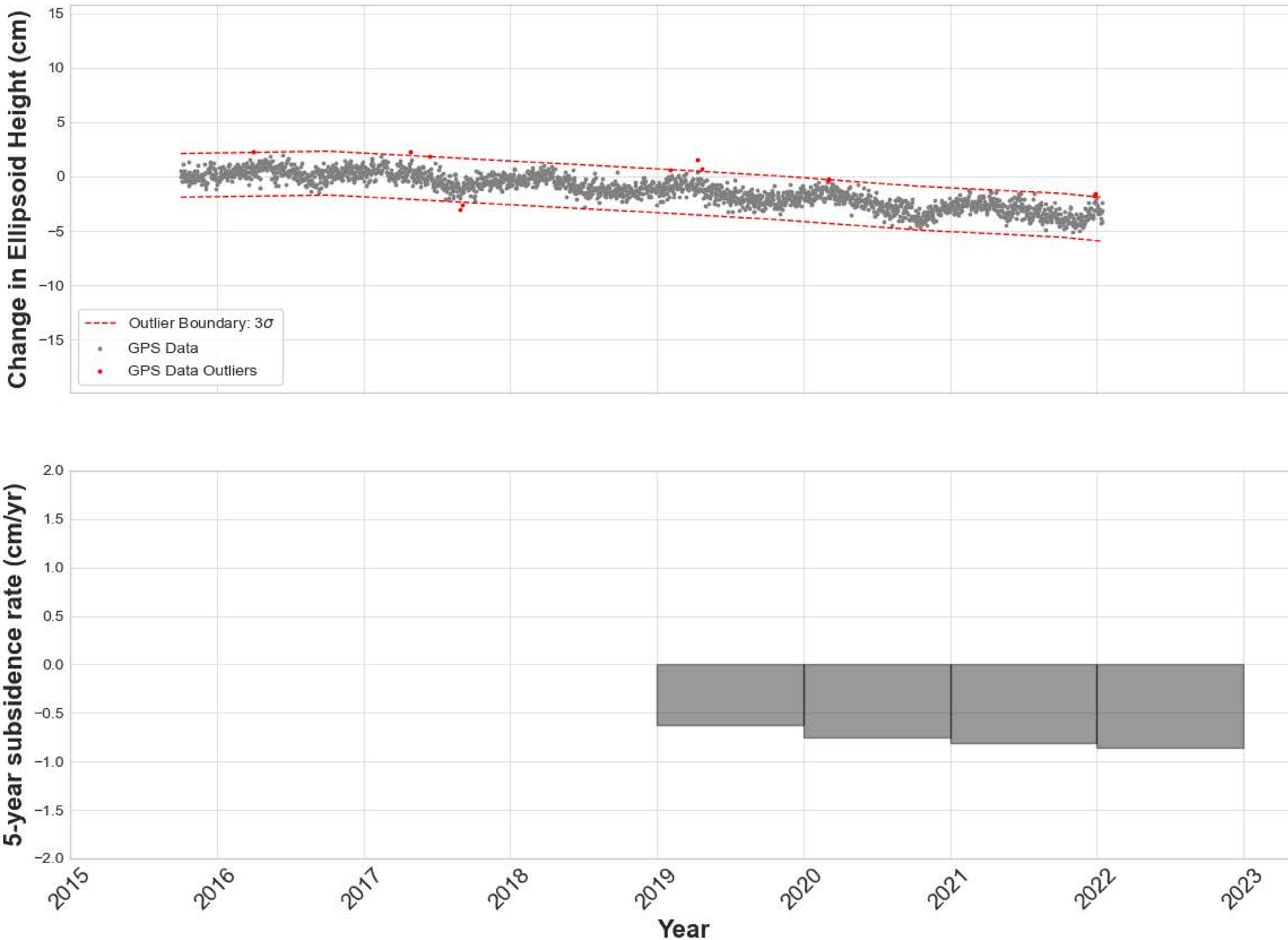
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

GAL7



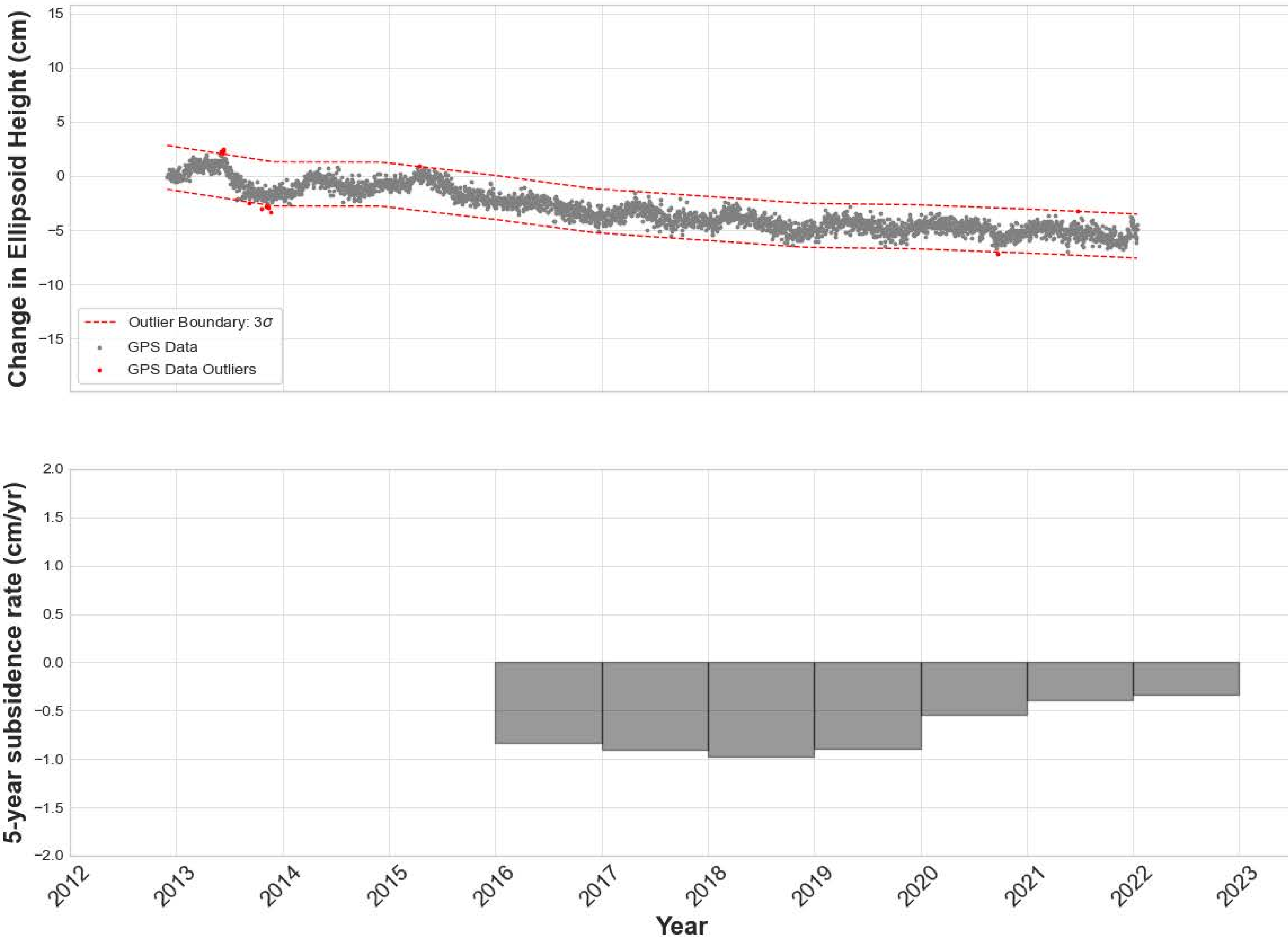
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

GSEC



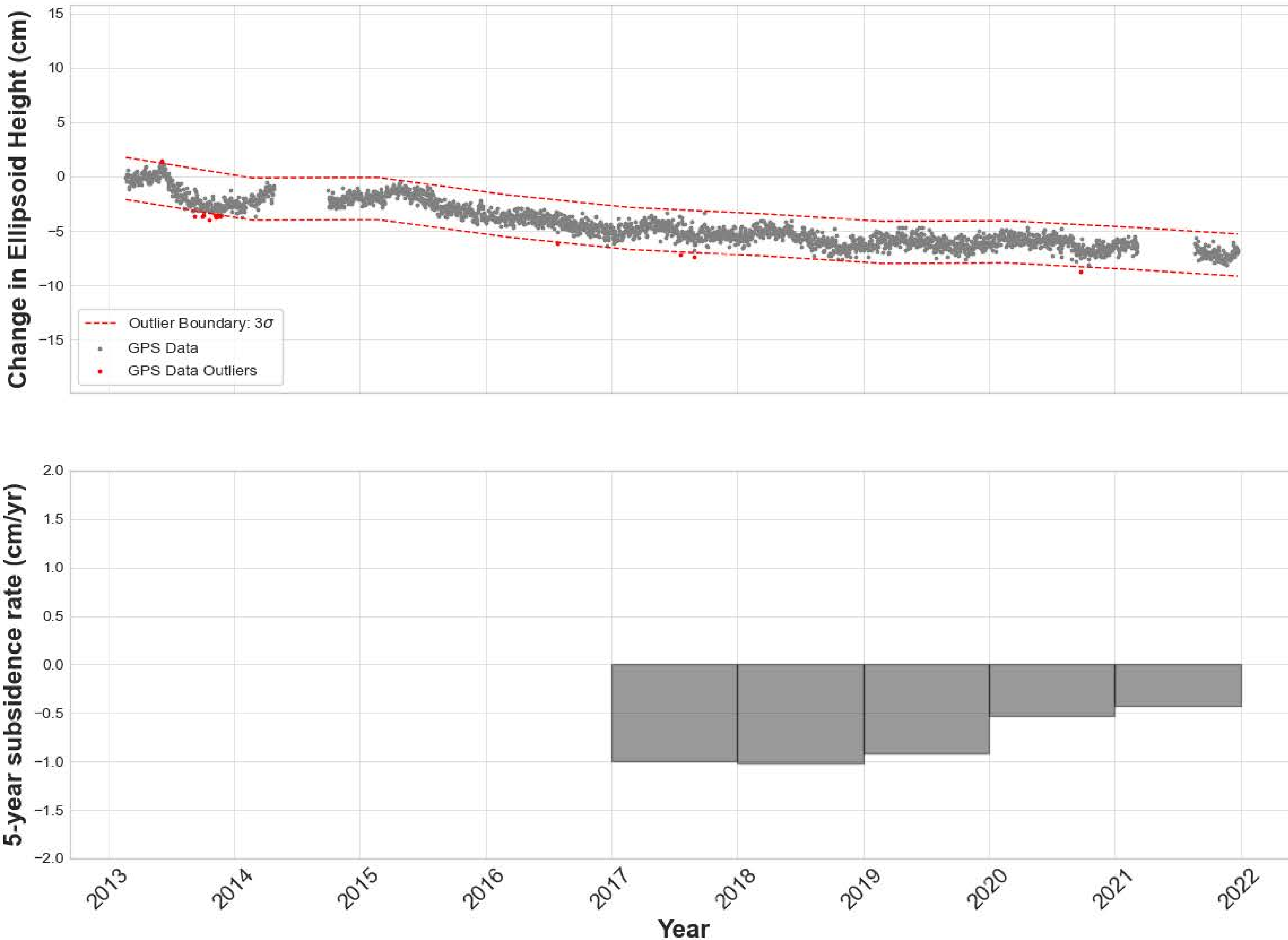
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

HCC1



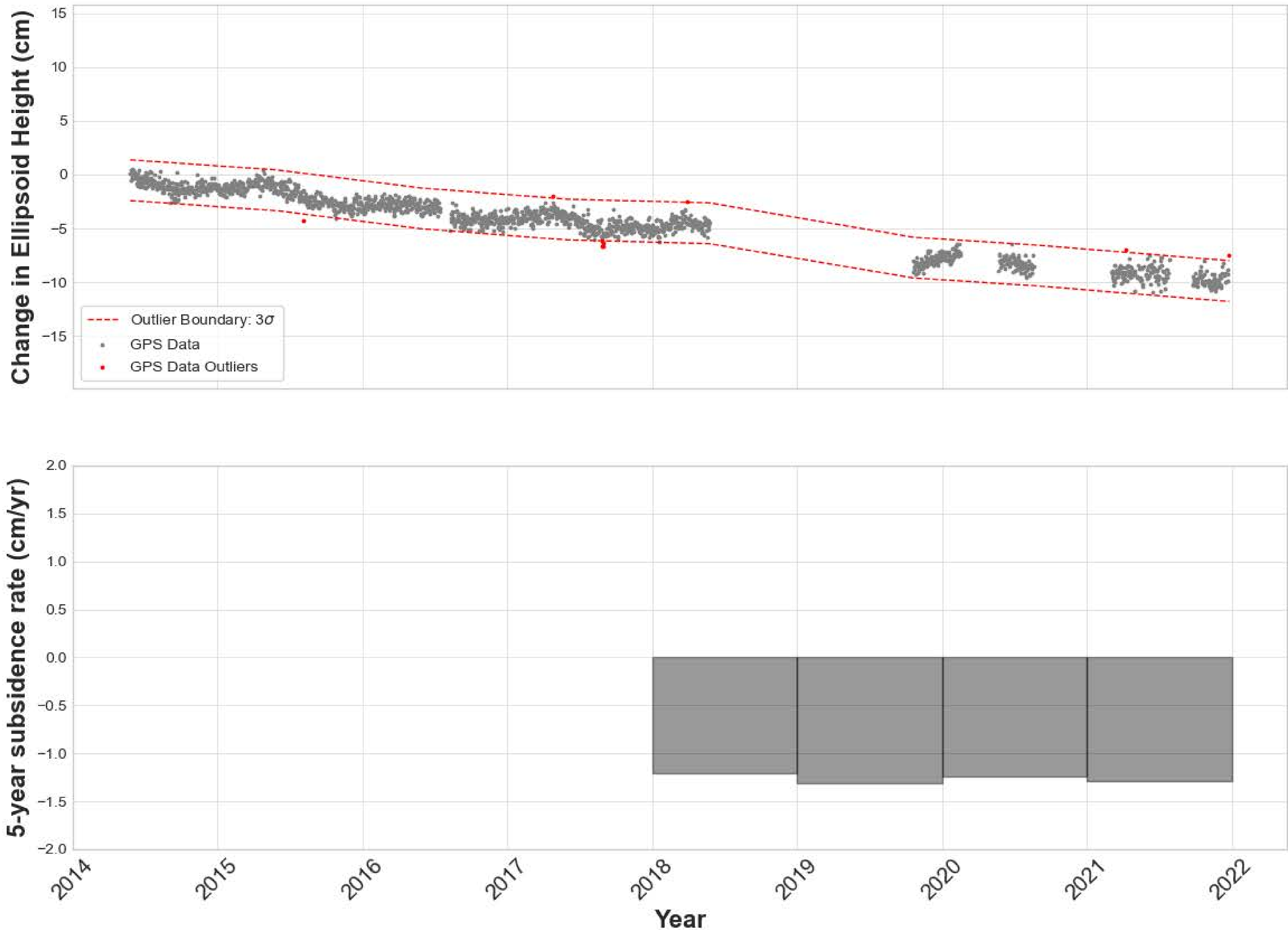
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

HCC2



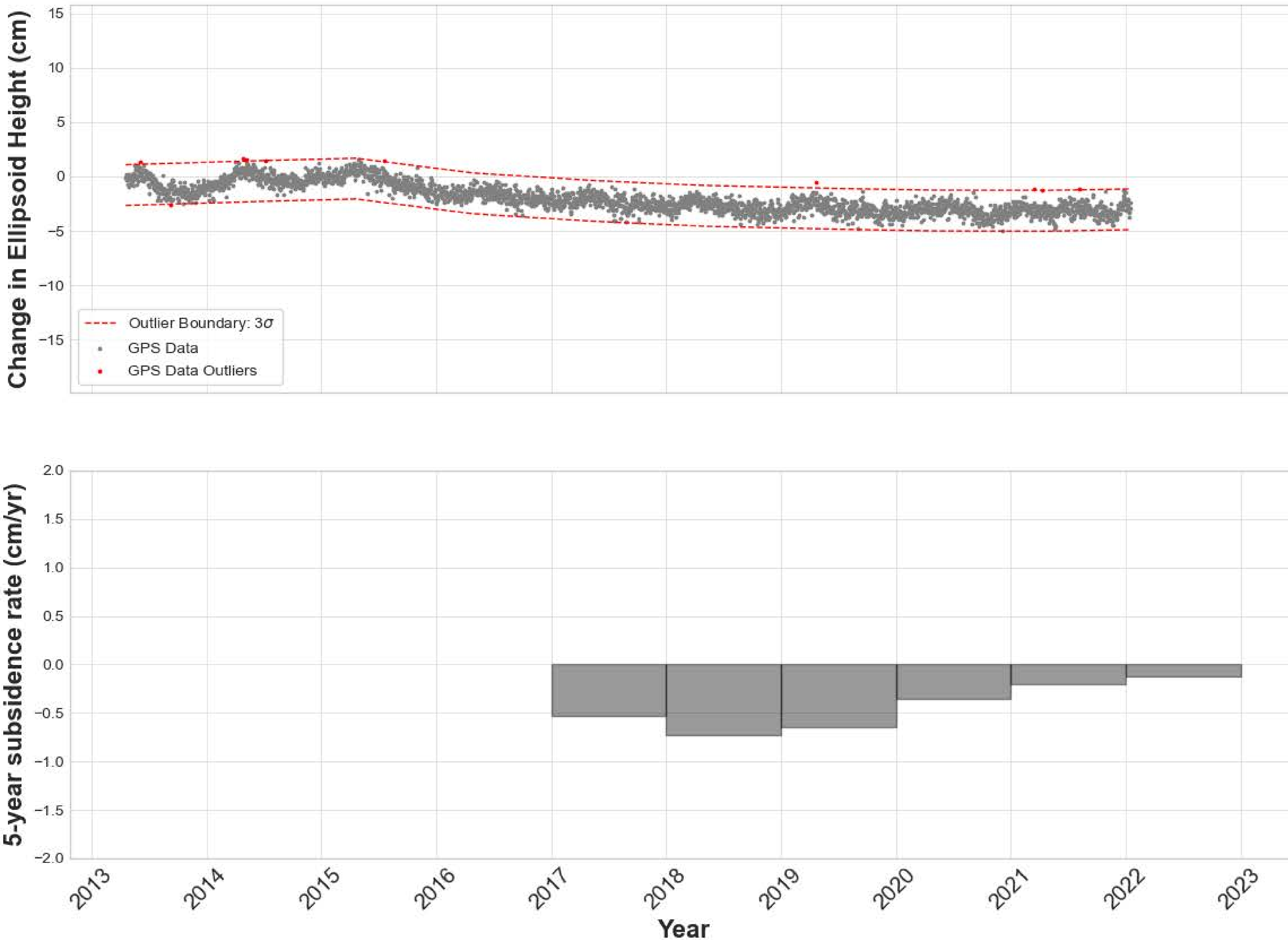
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

HPEK



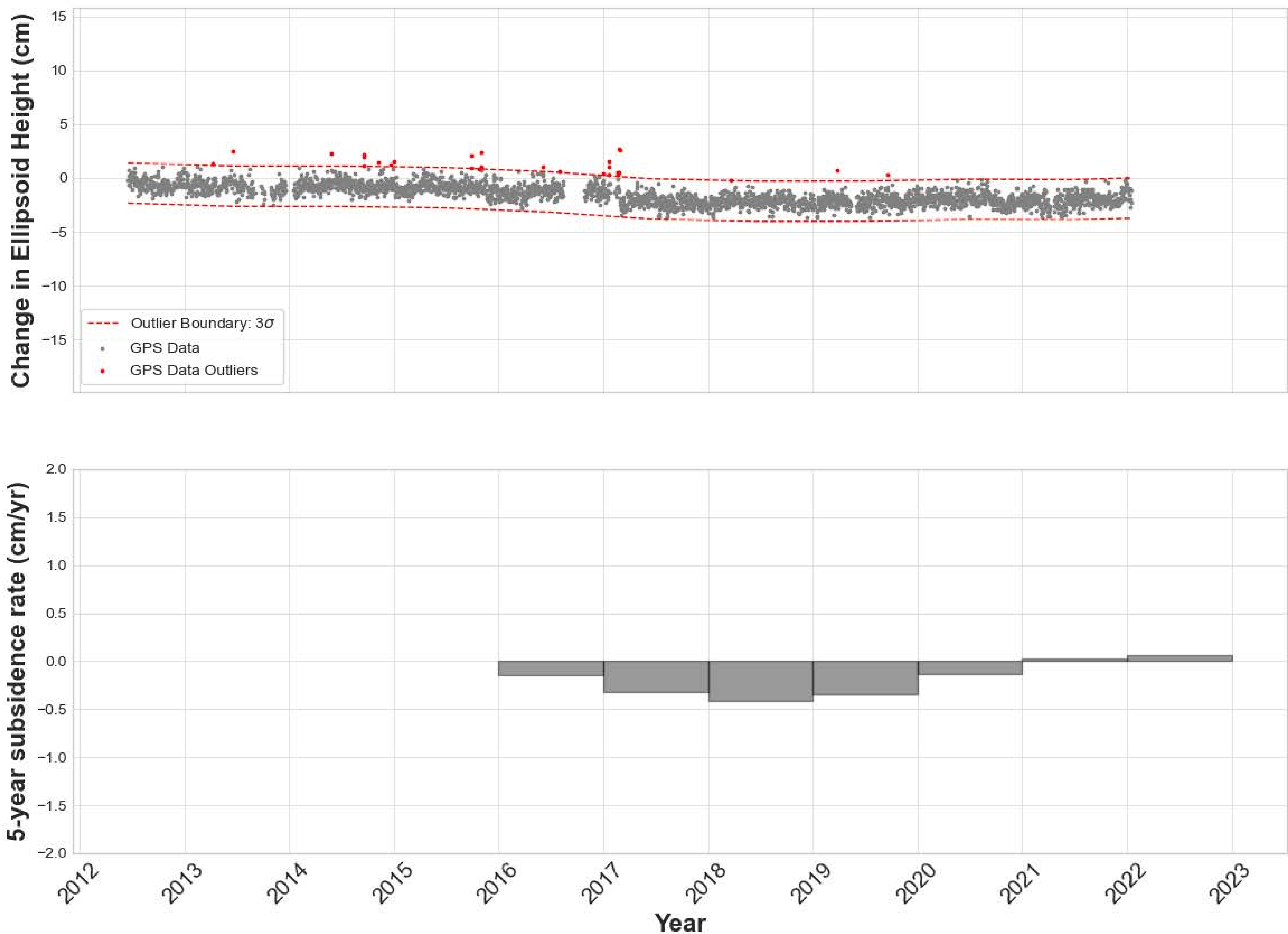
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

HSMN



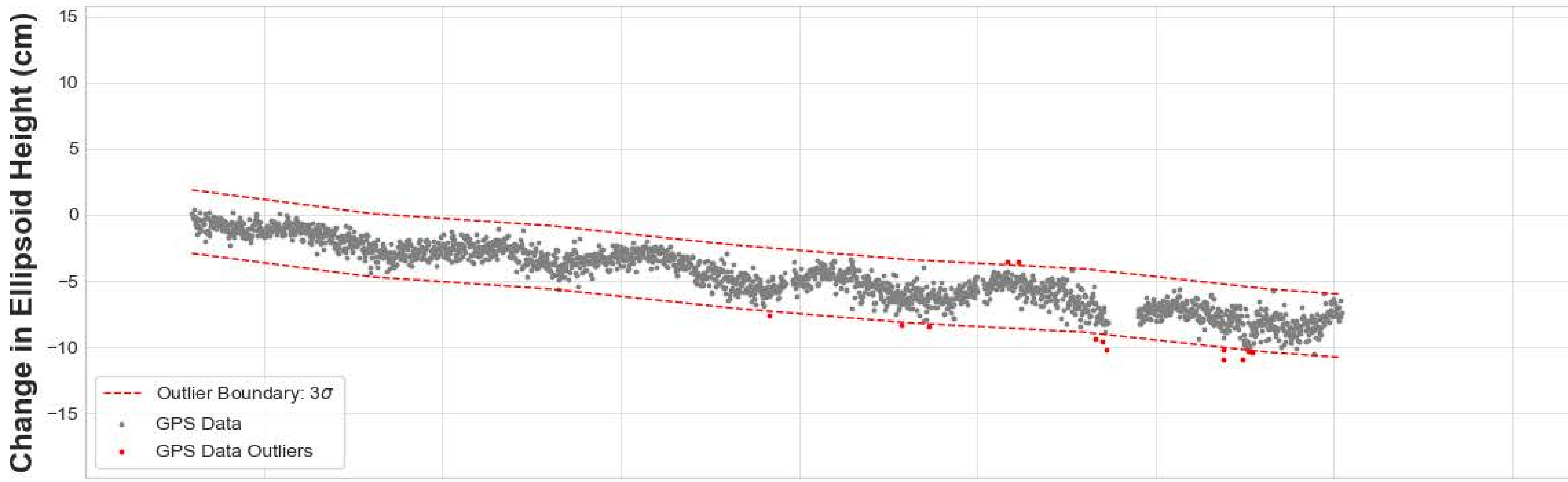
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

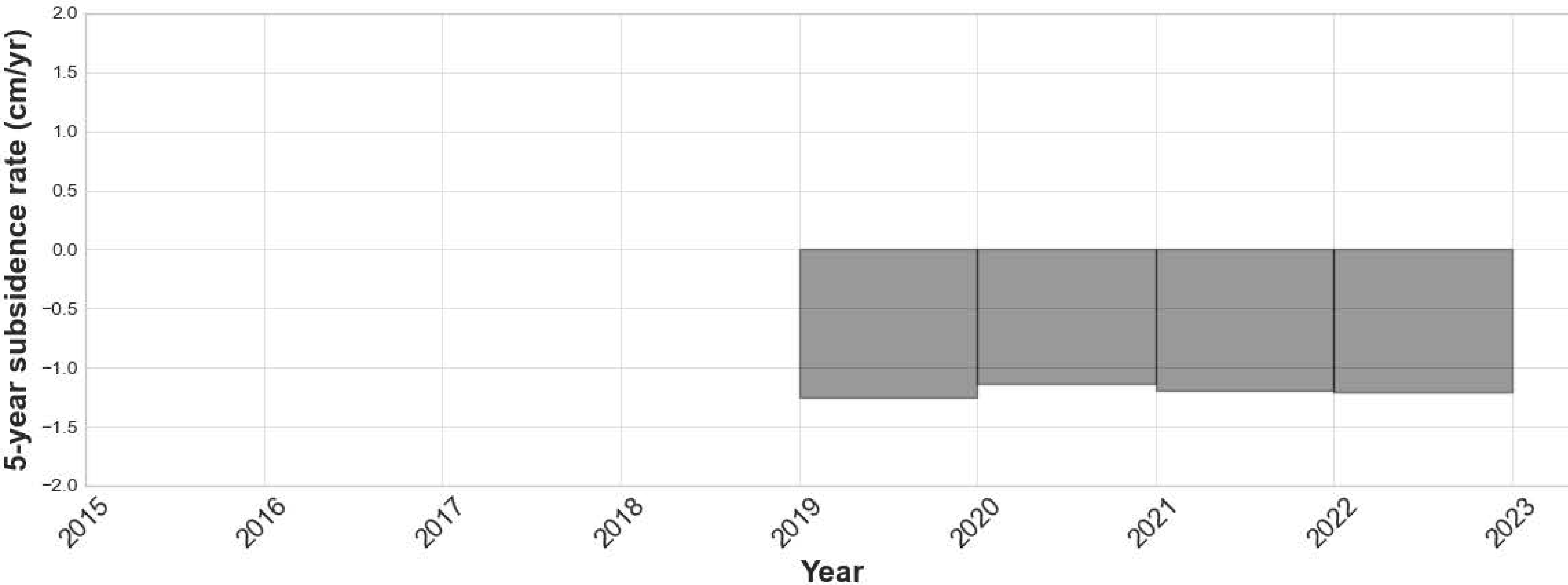
JGS2



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

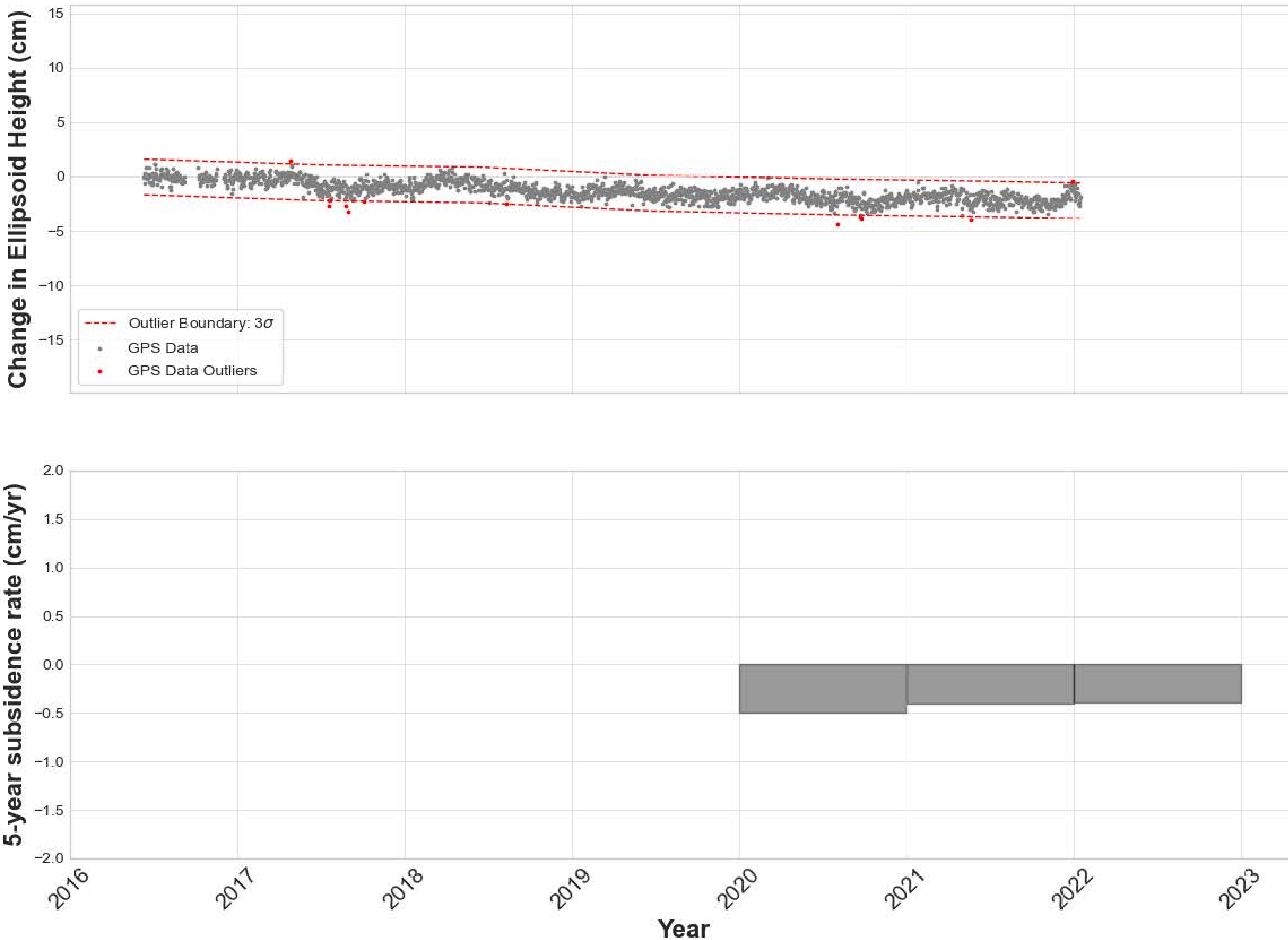
KKES





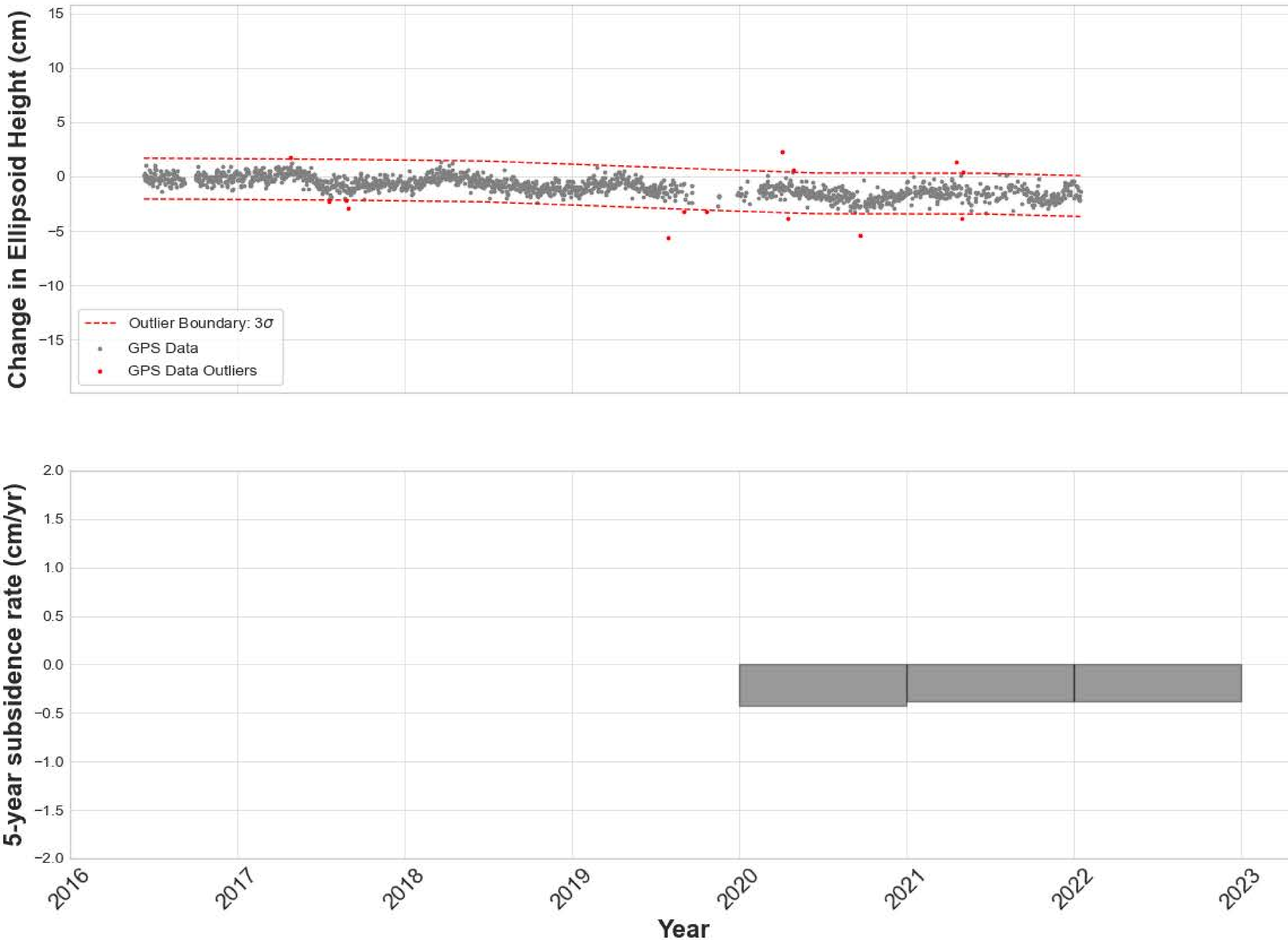
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

KPCD



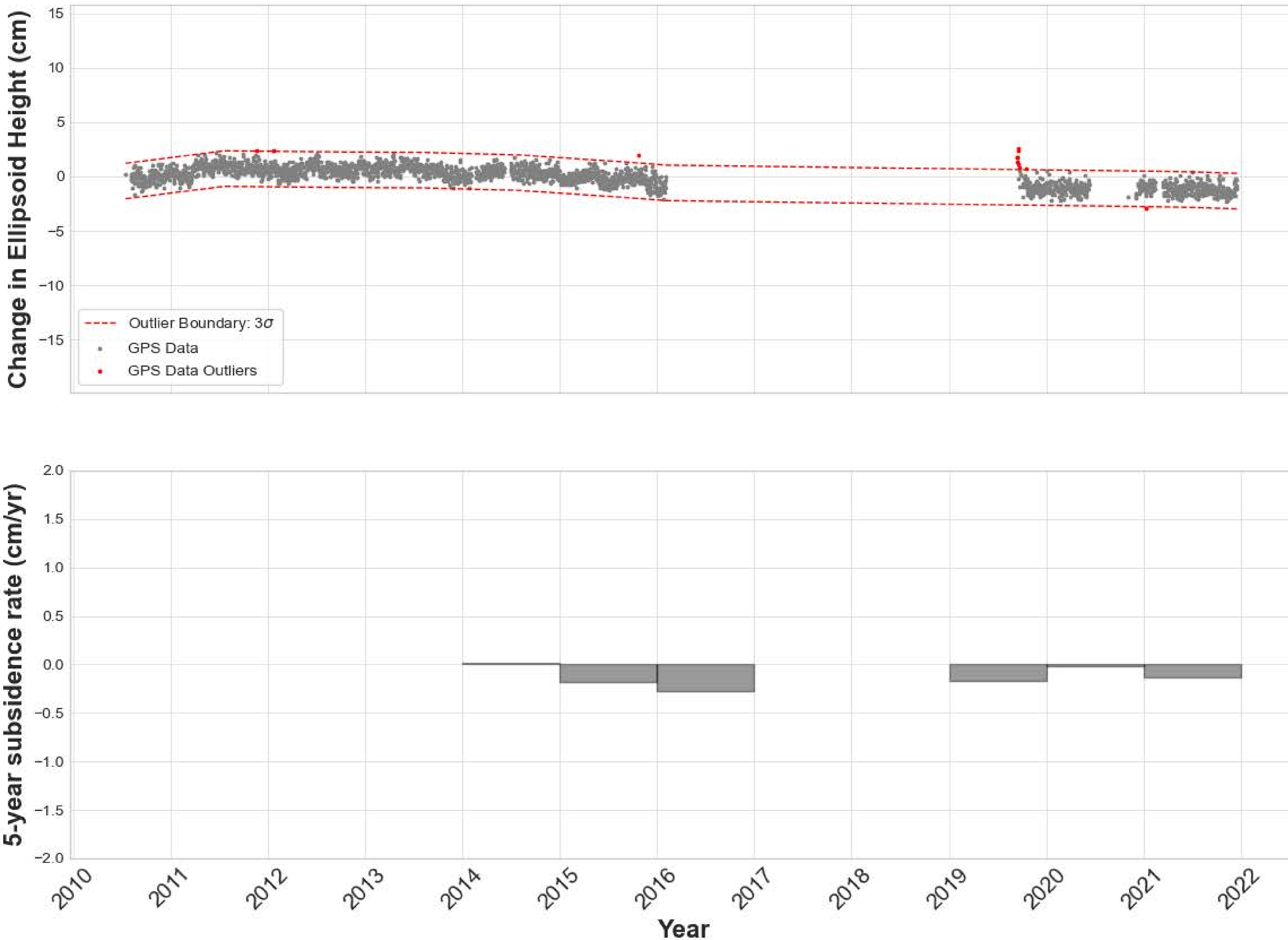
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

KPCS



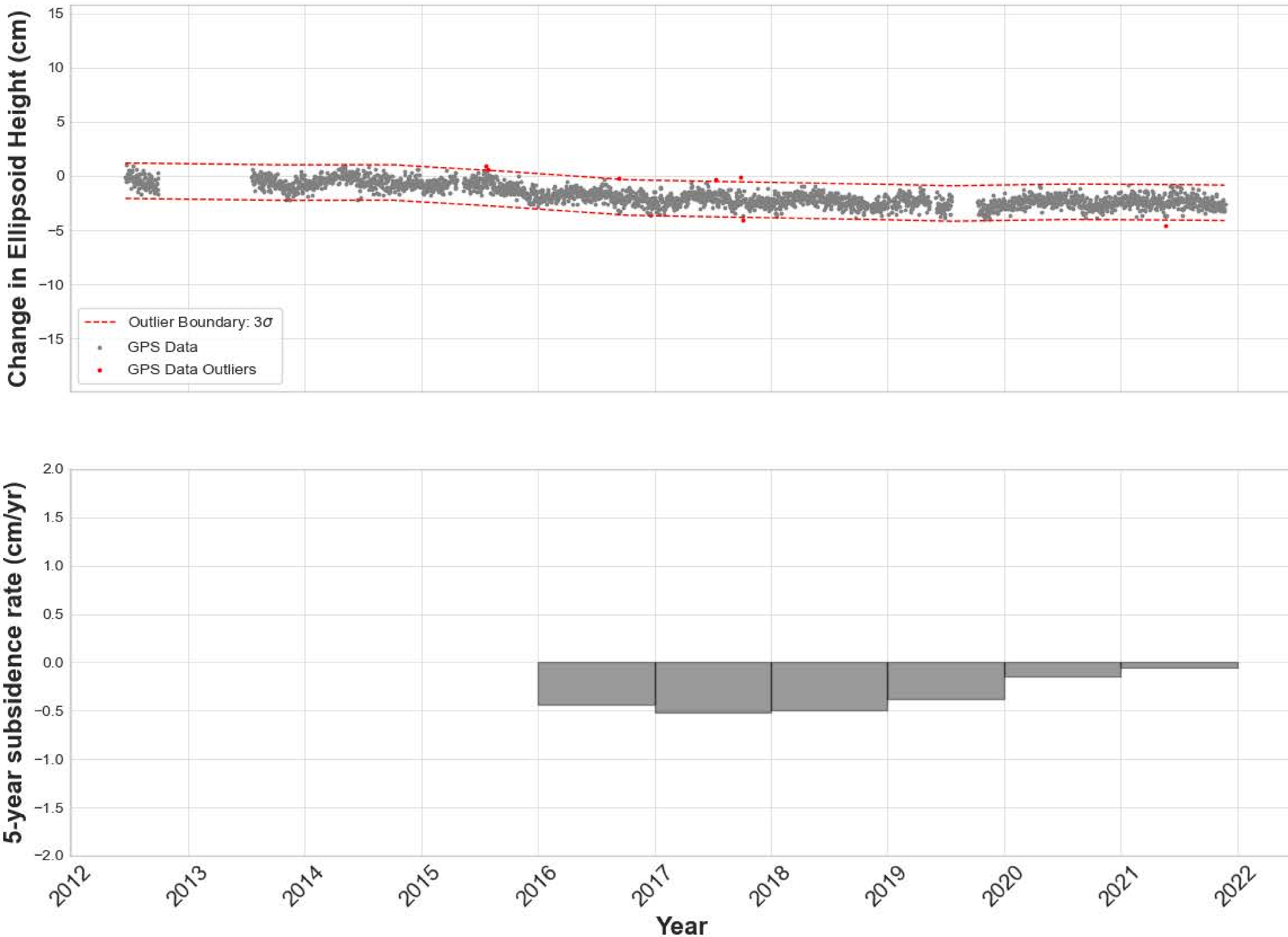
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

LCBR



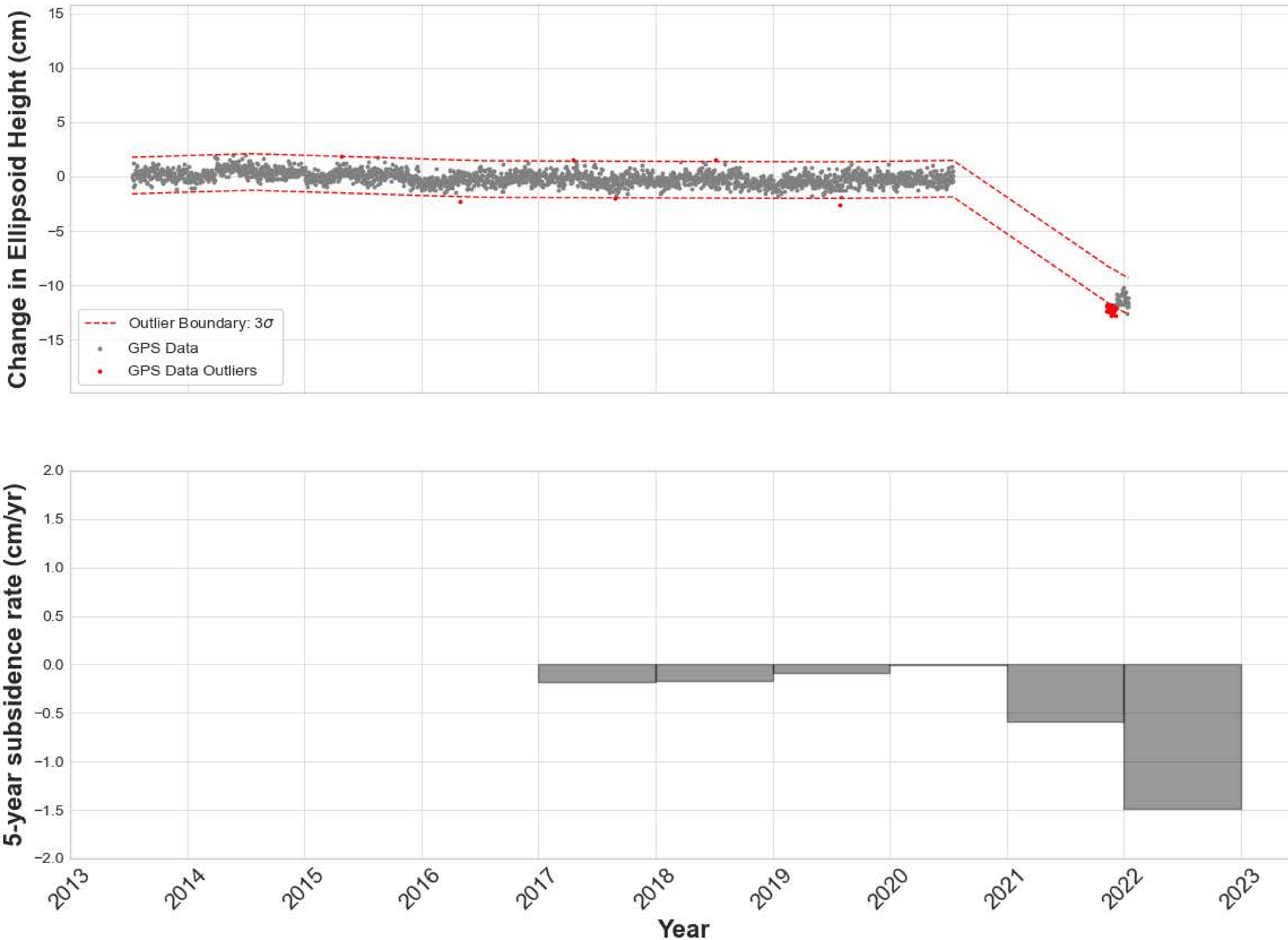
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

LCI1



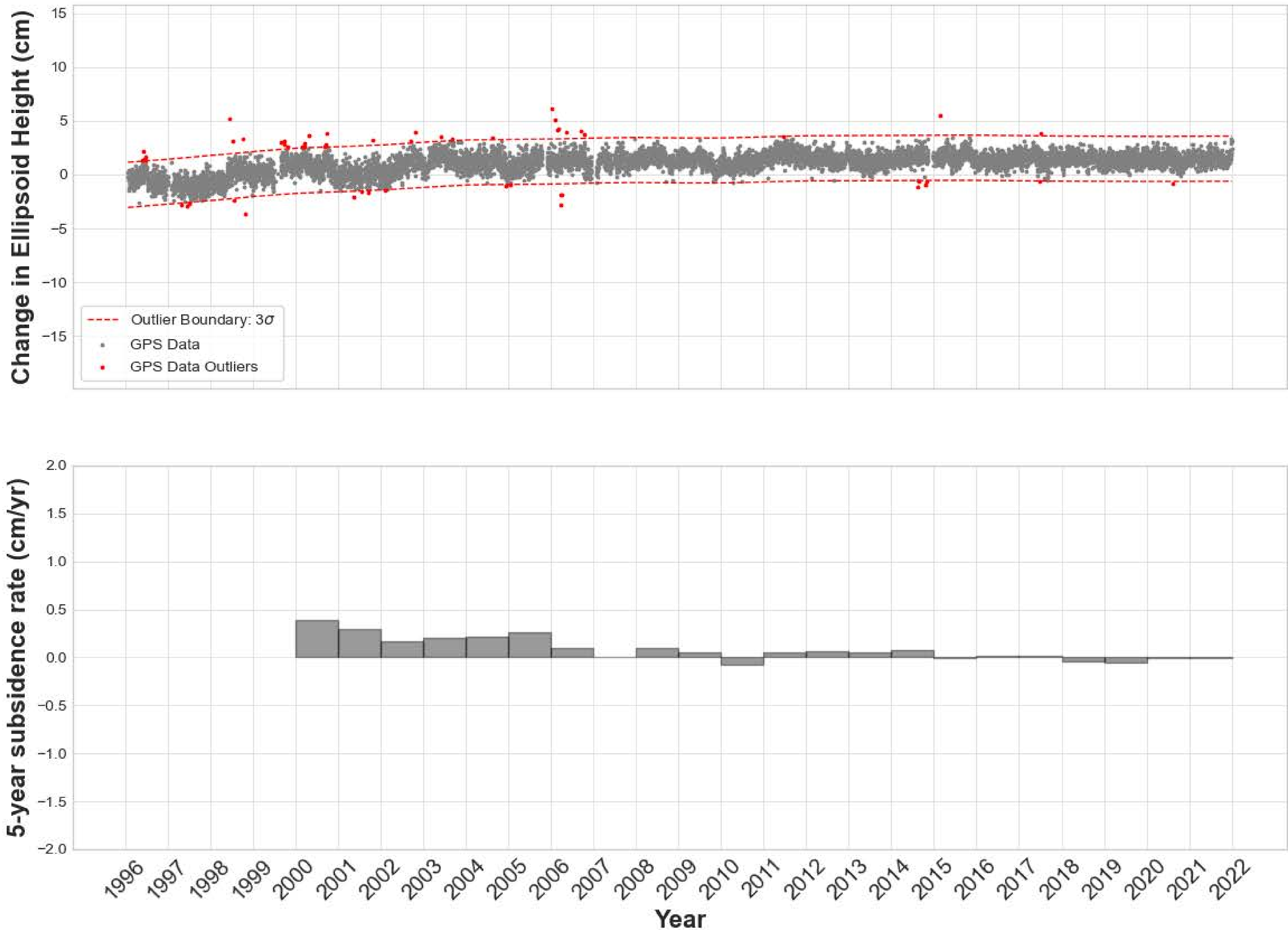
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

LGC1



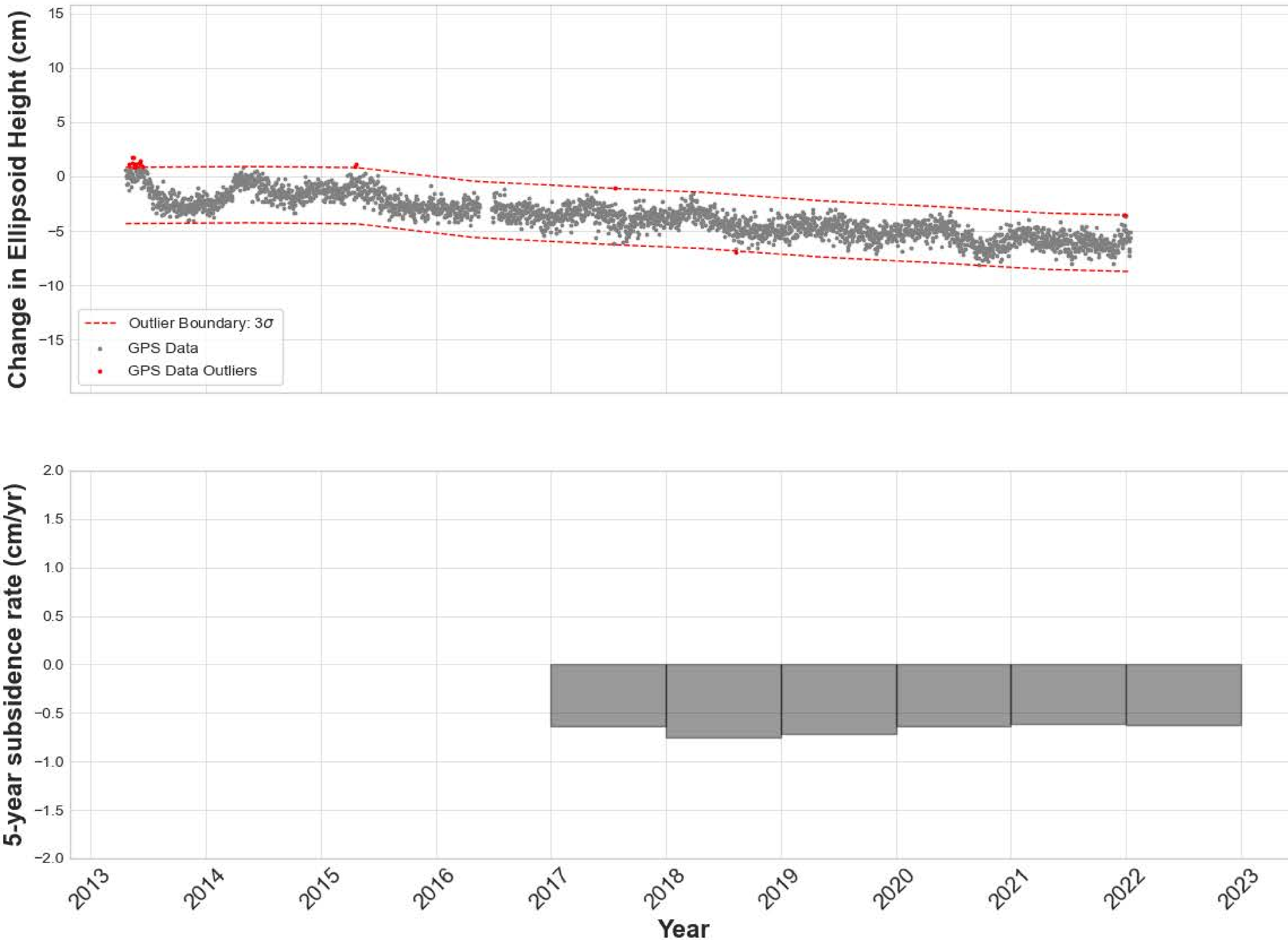
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

LKHU



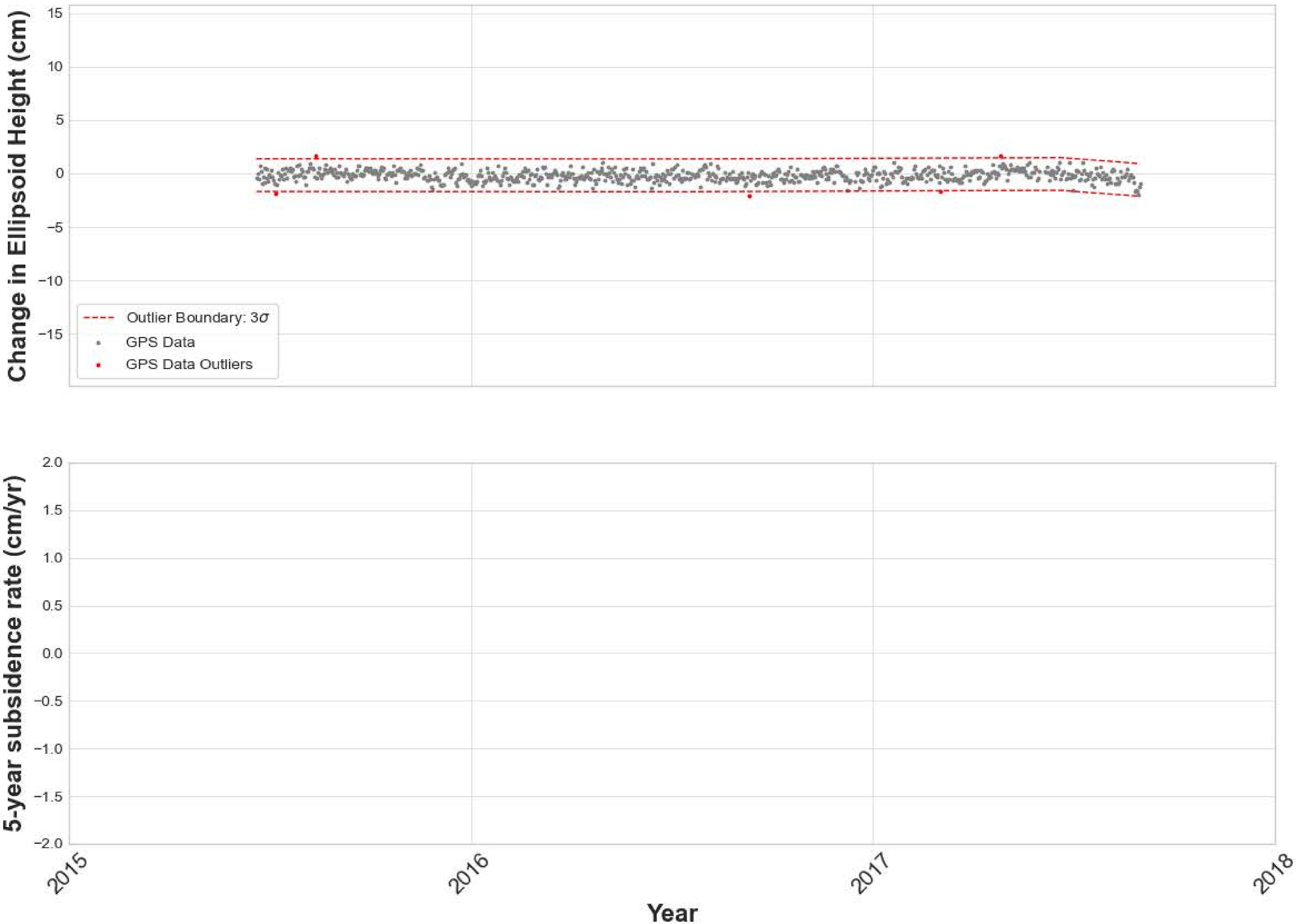
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

MDWD



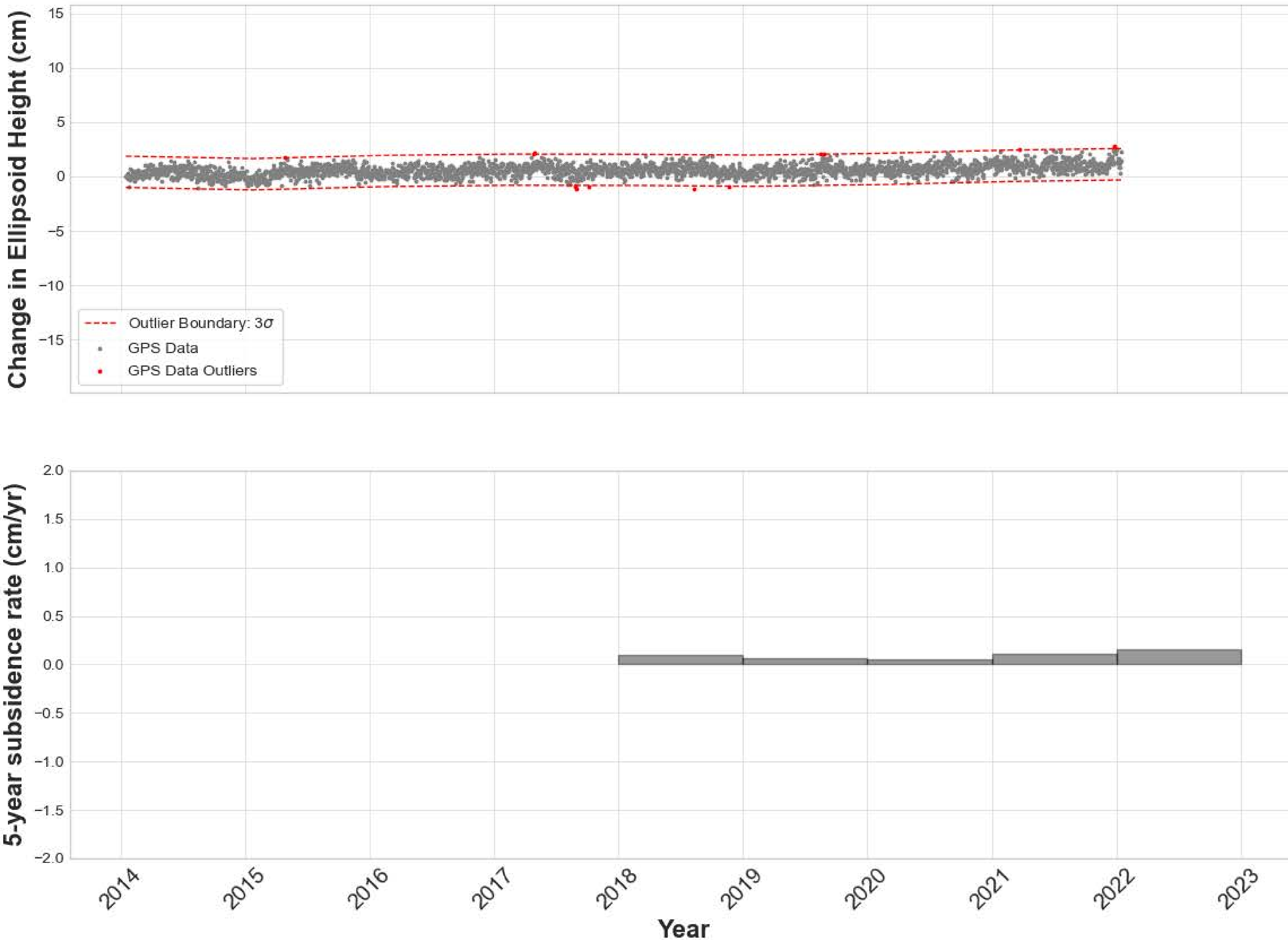
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

ME01



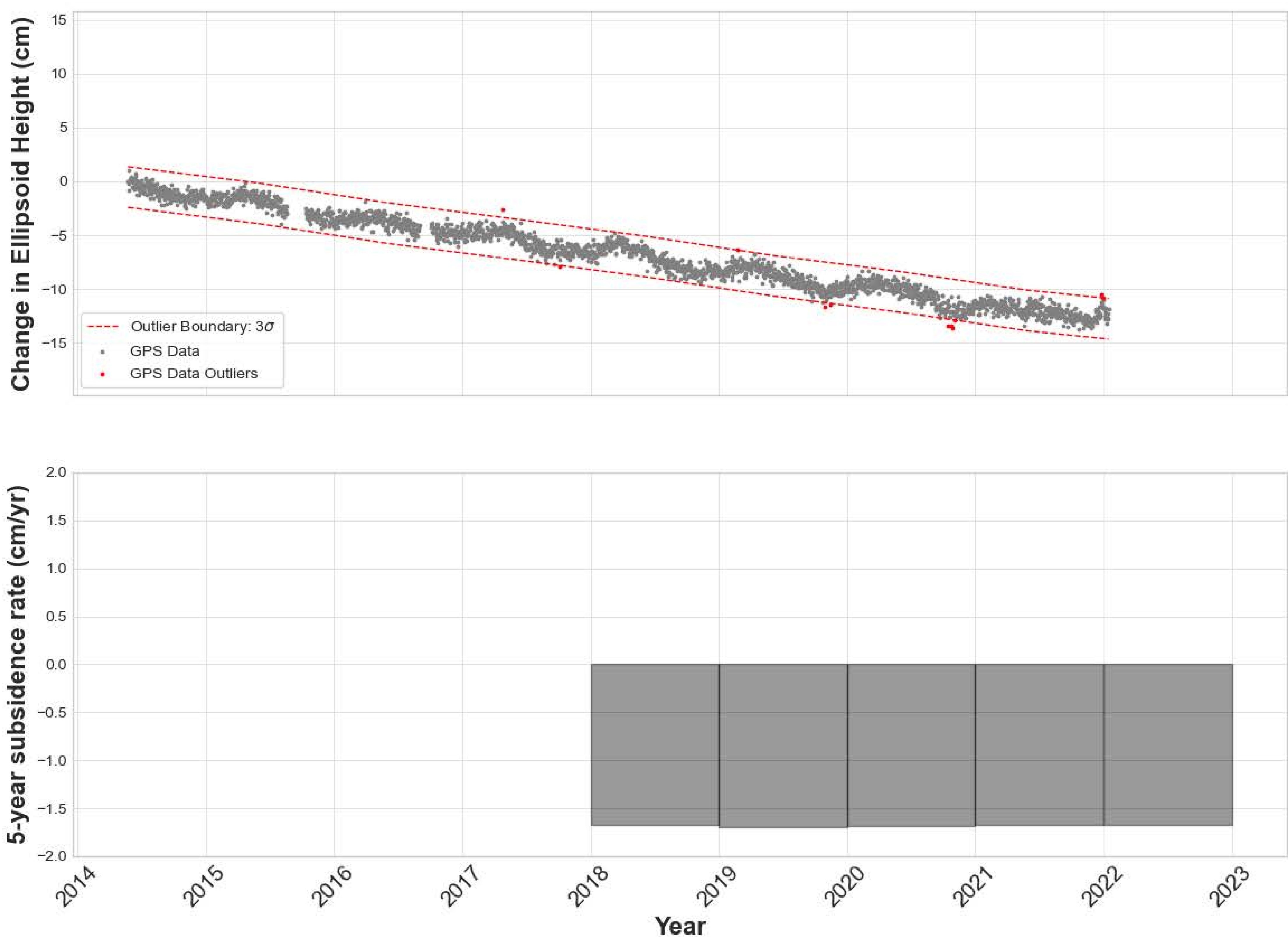
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

MEPD



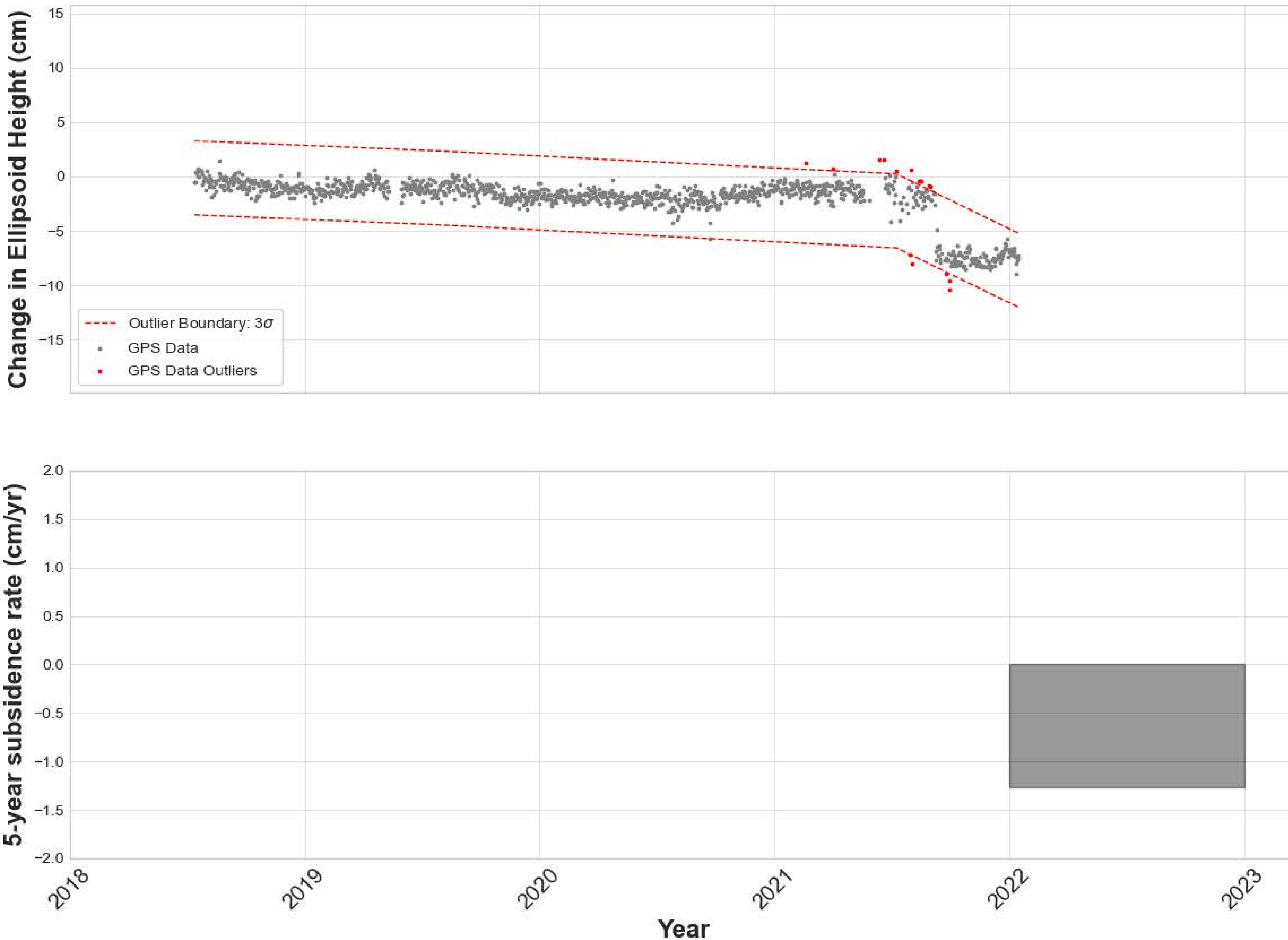
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

MRHK



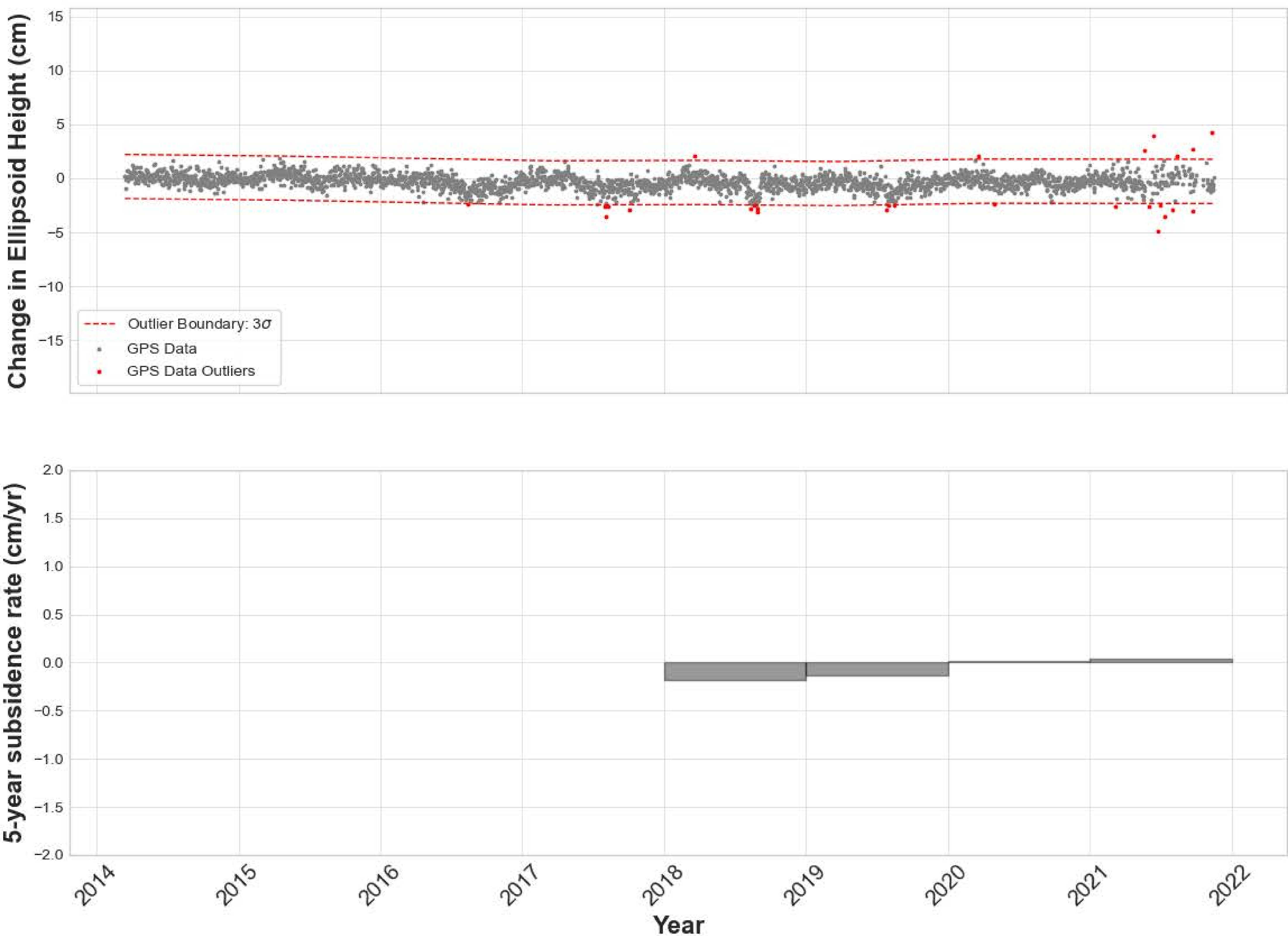
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

N301



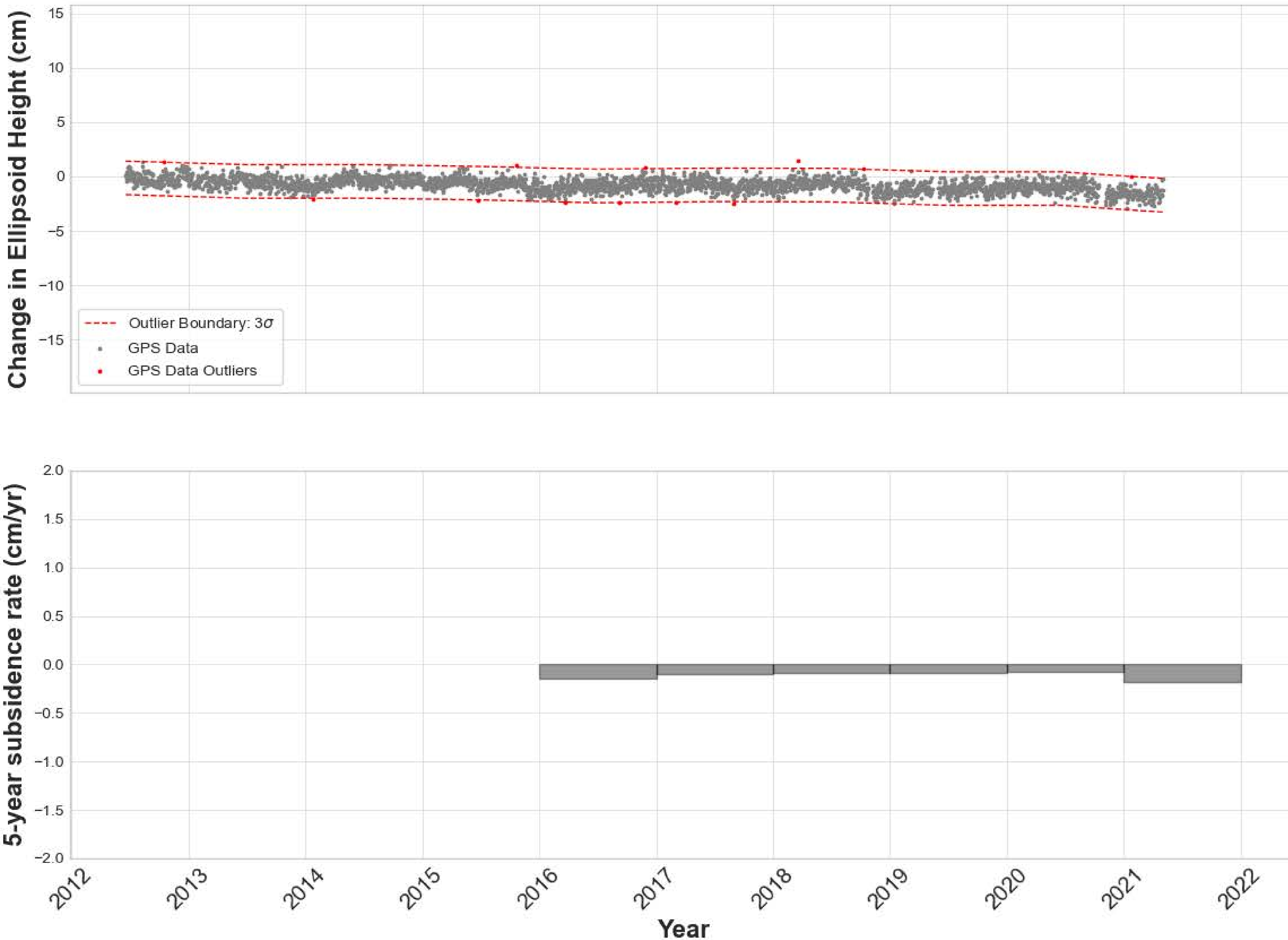
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

NASA



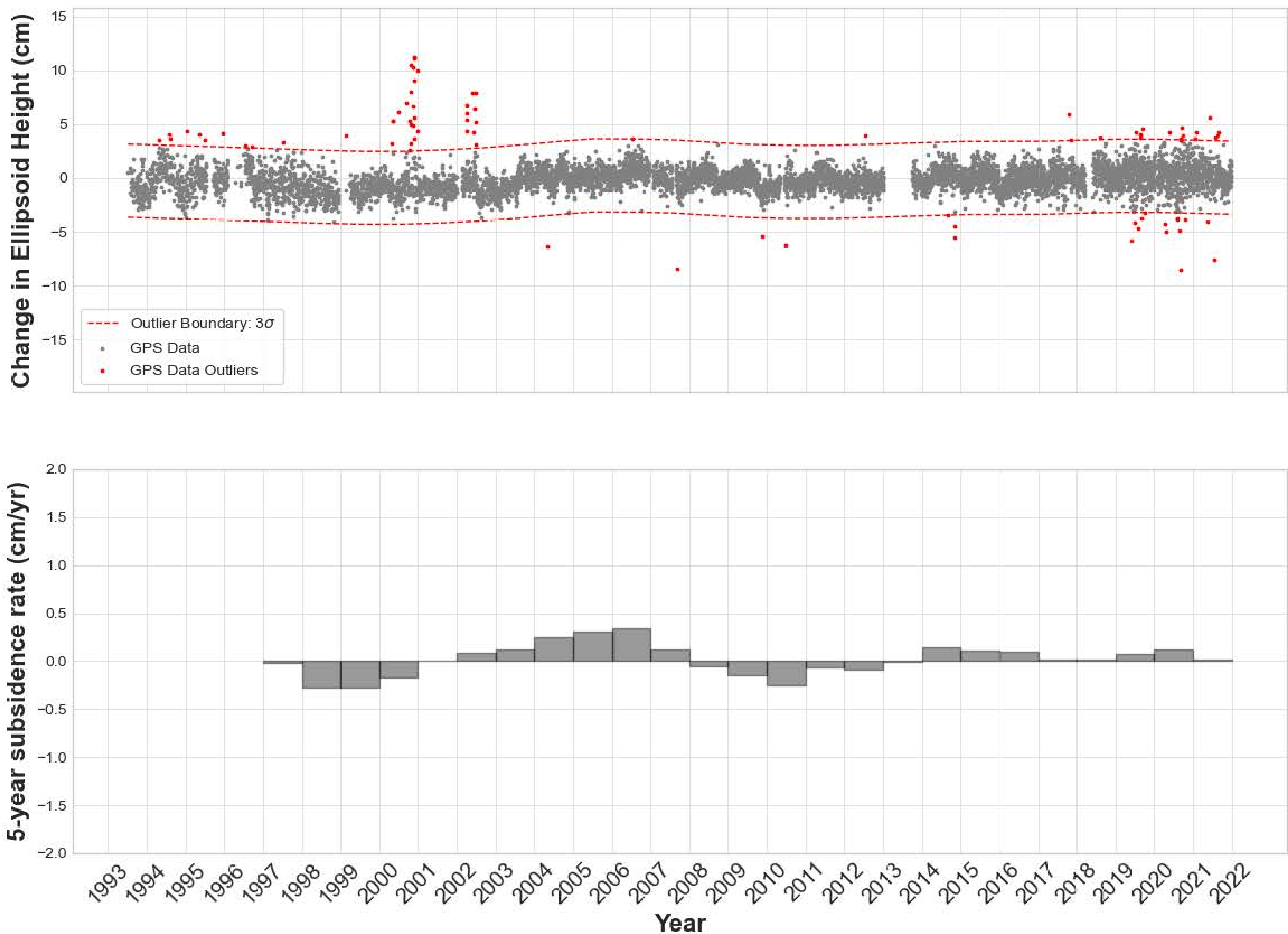
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

NBRY



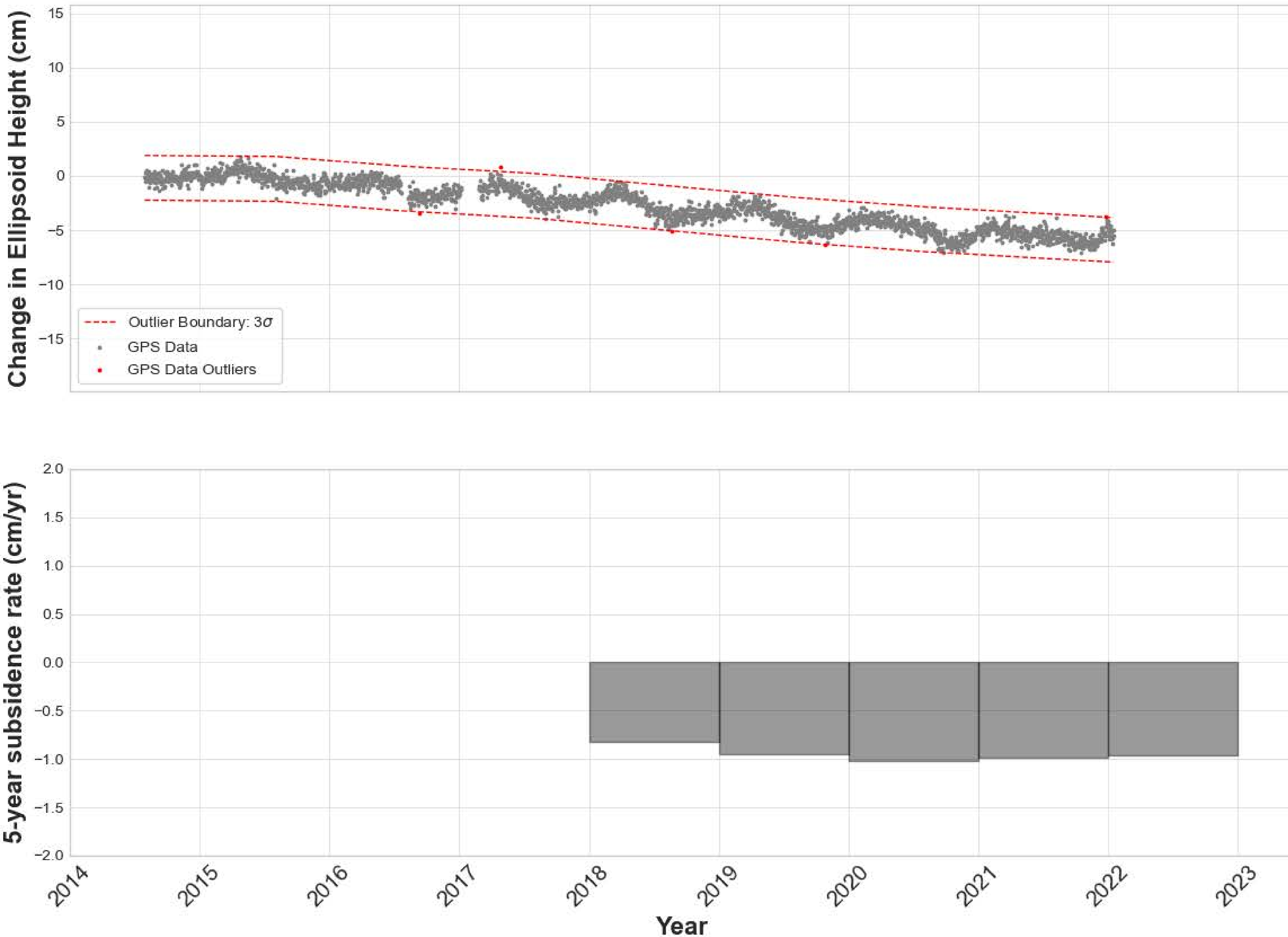
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

NETP



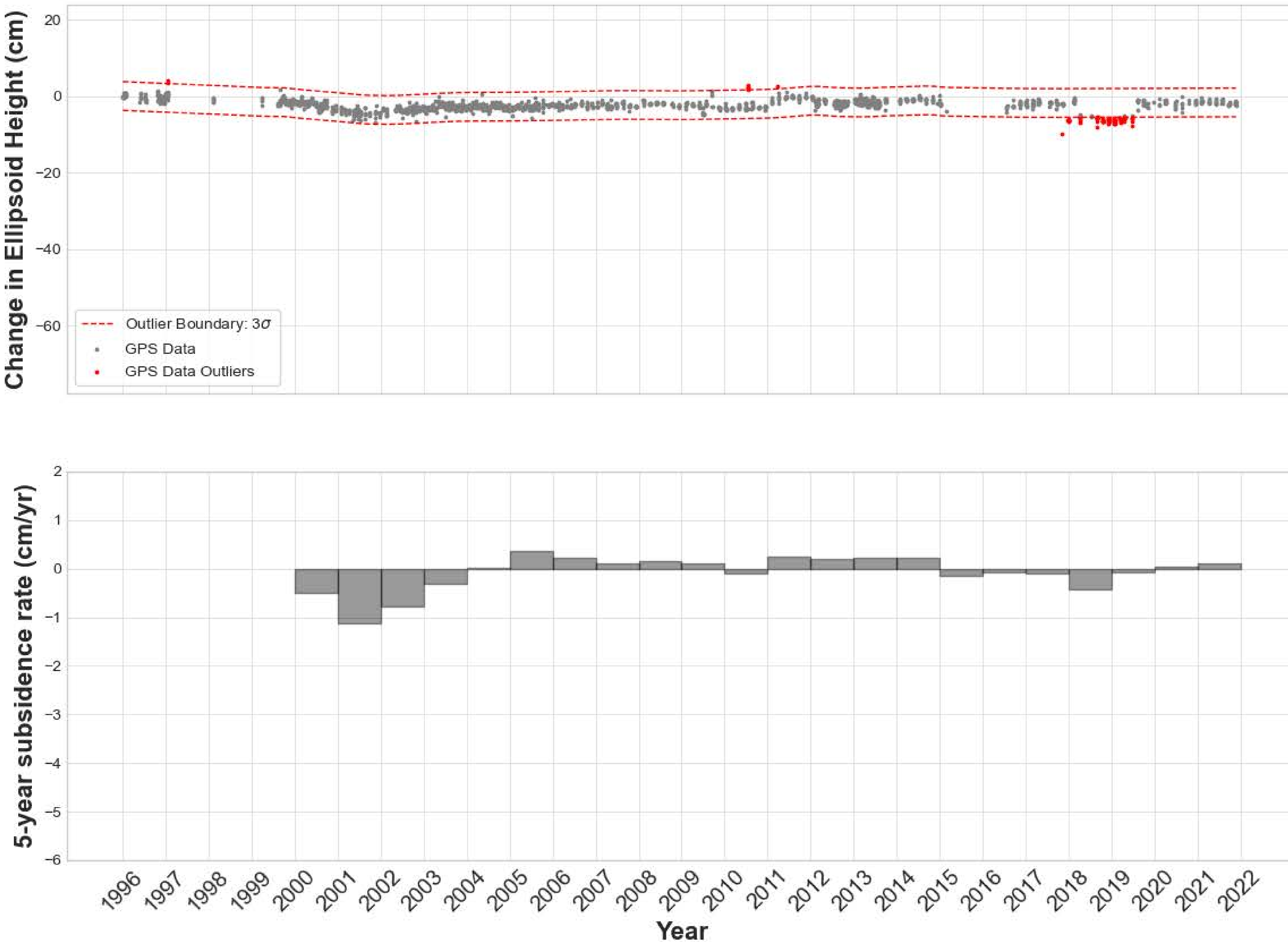
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

OKEK



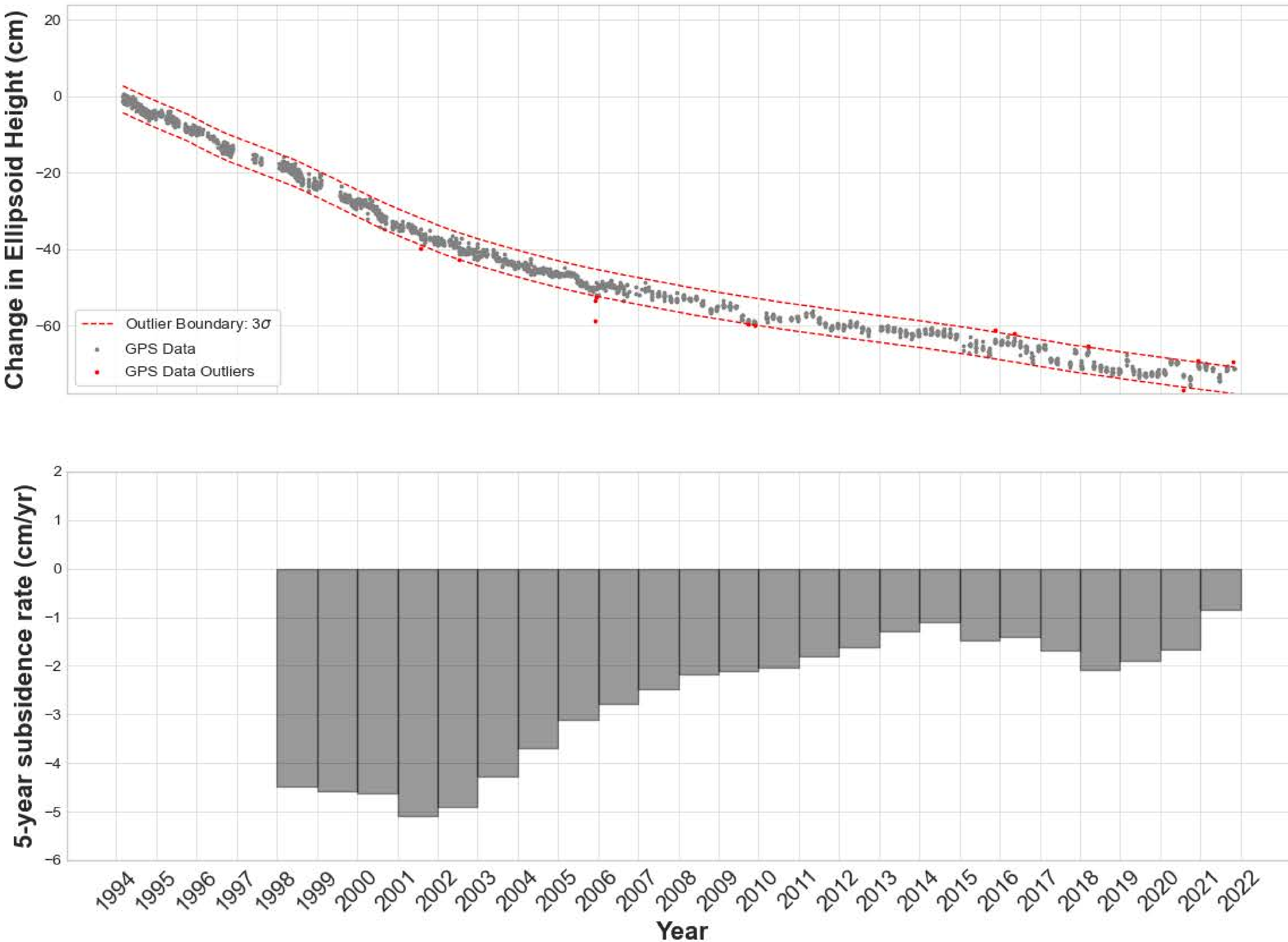
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P000



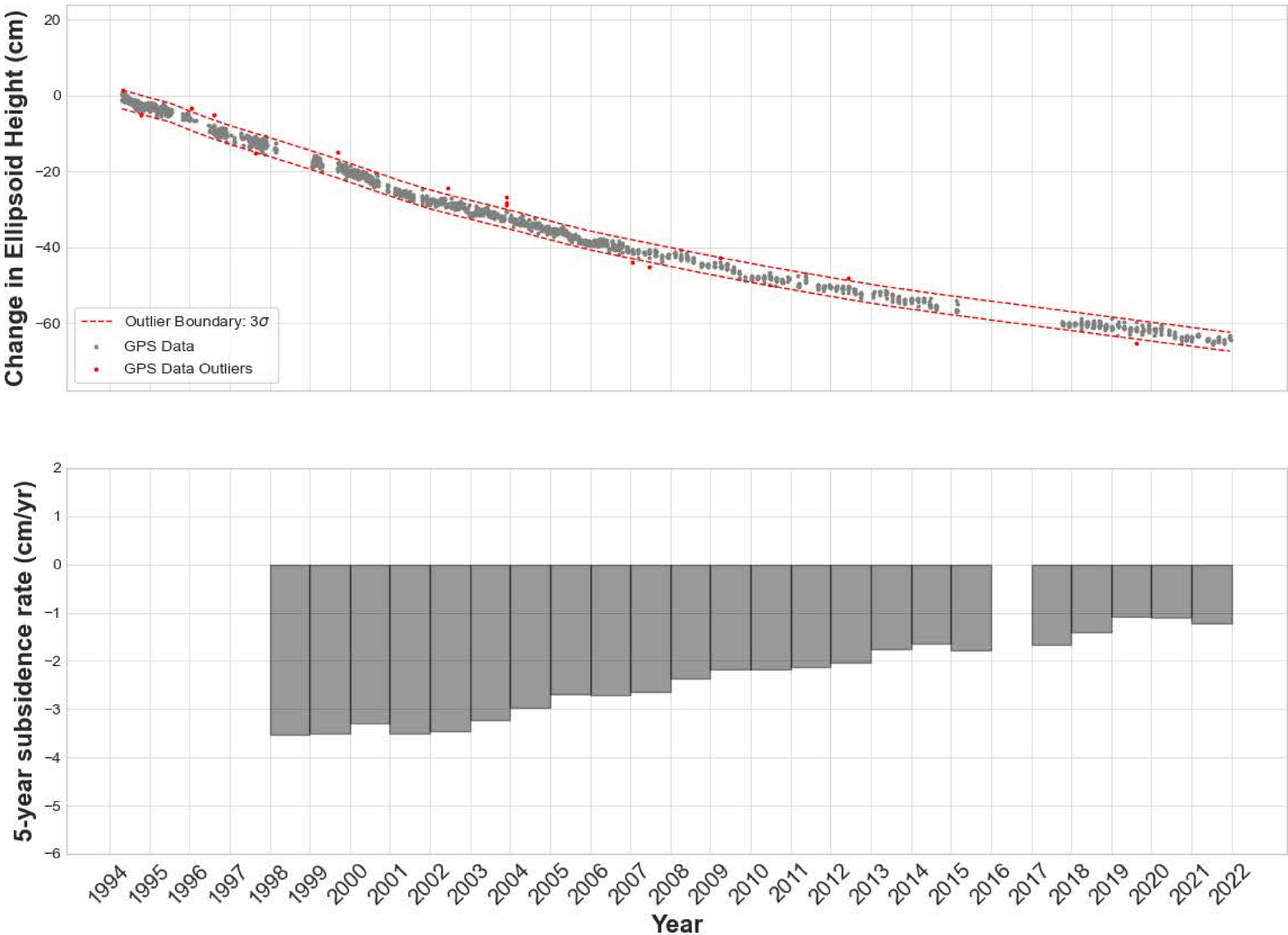
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P001



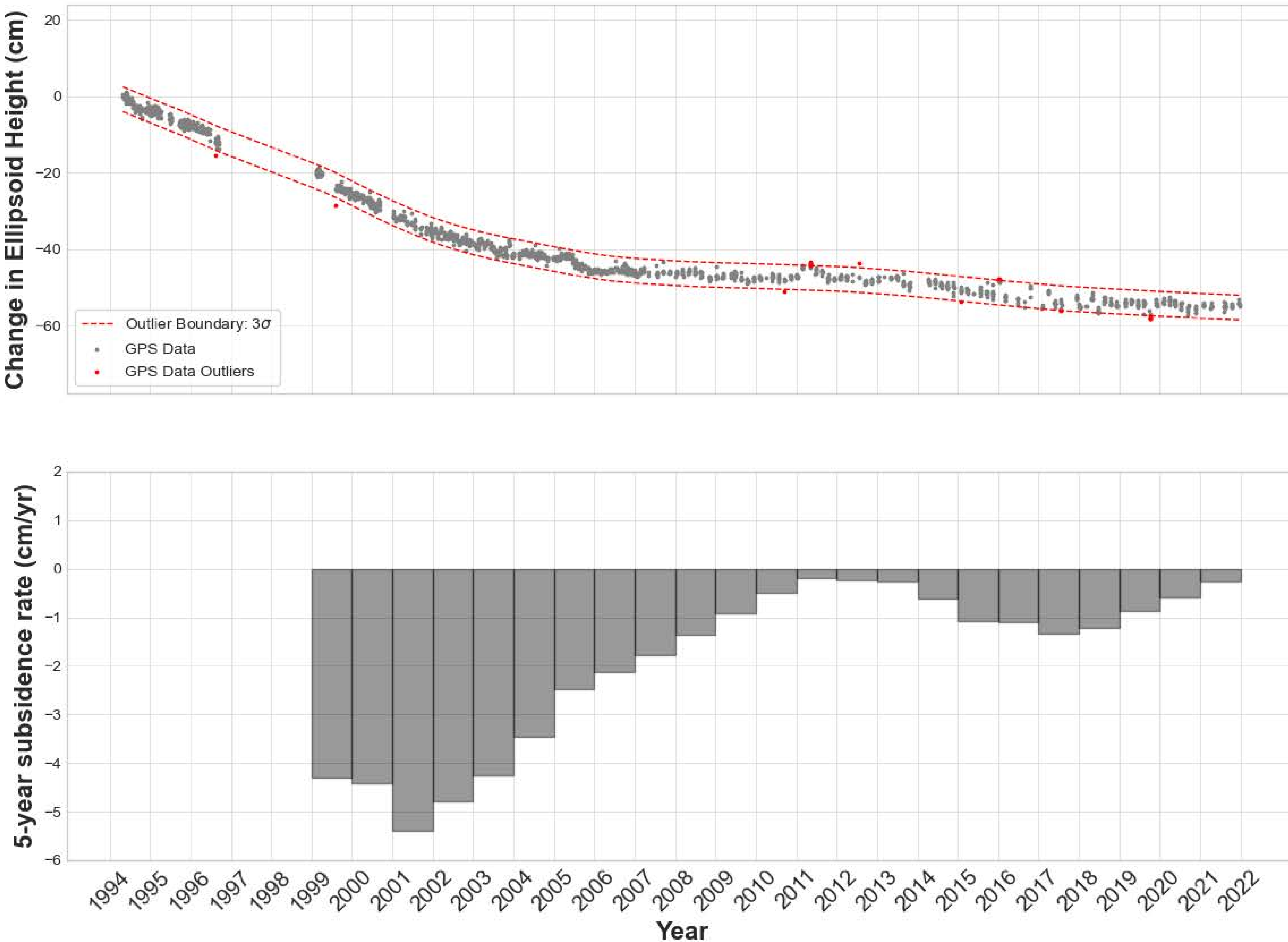
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P002



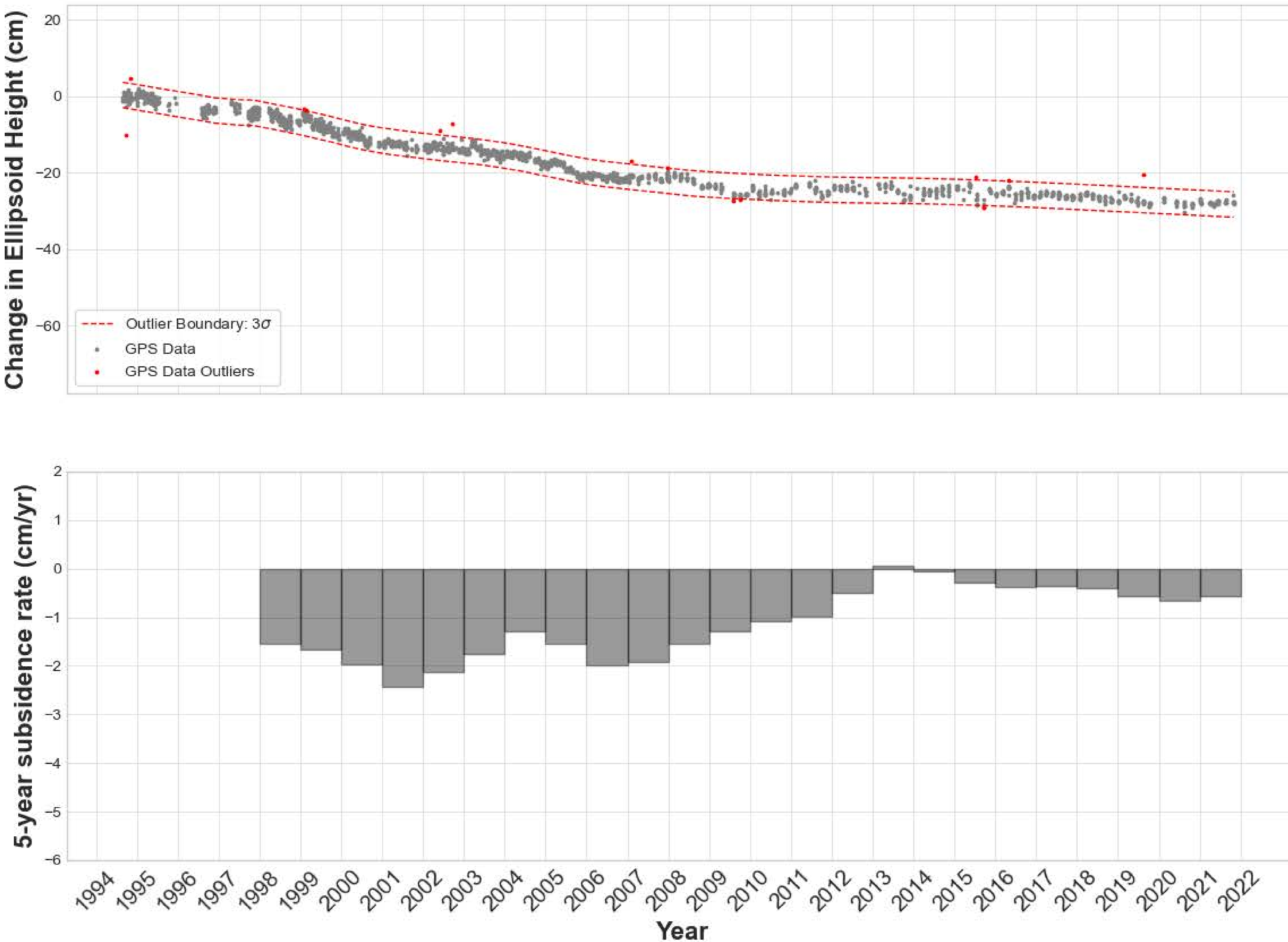
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P003



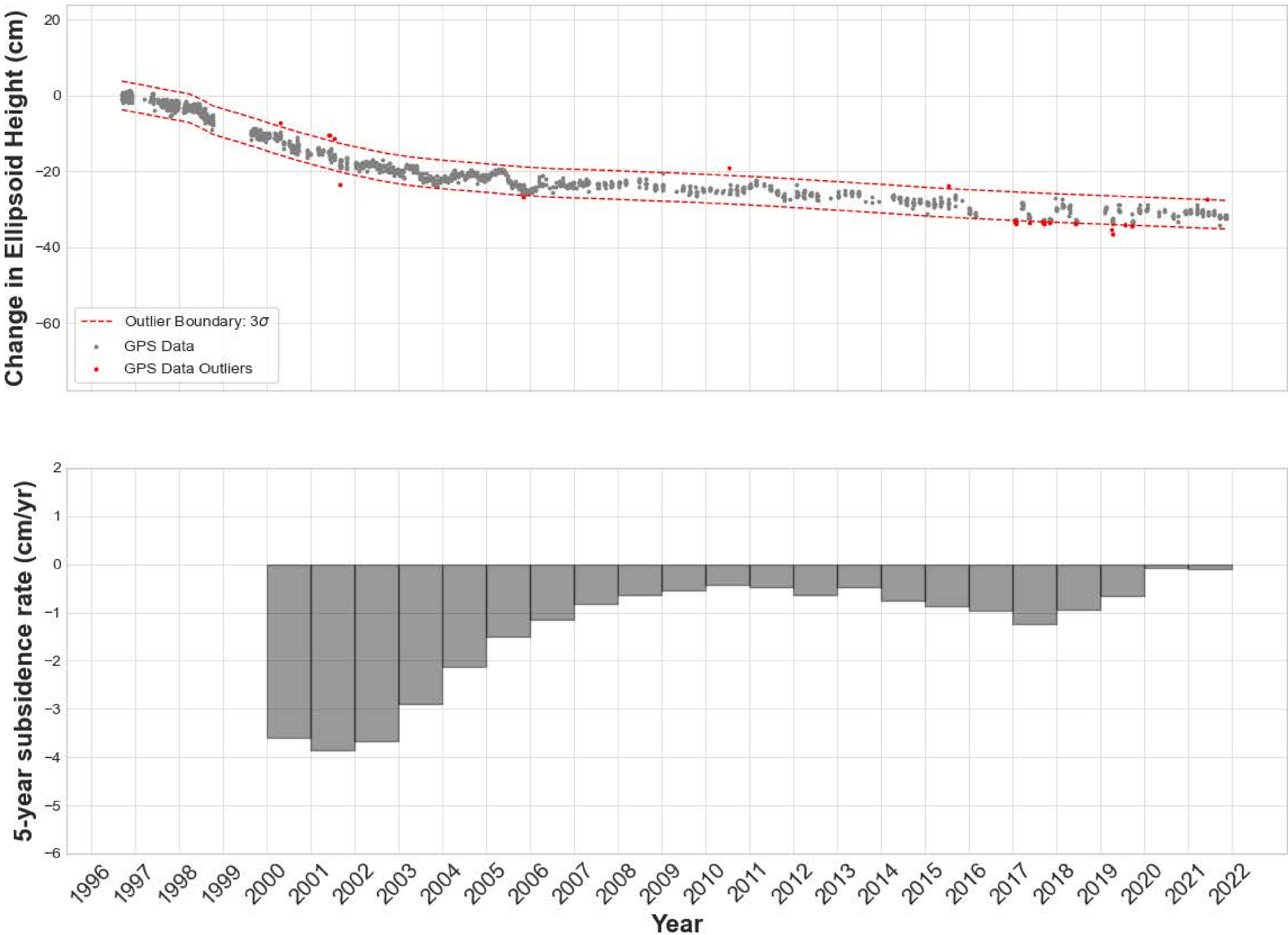
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P004



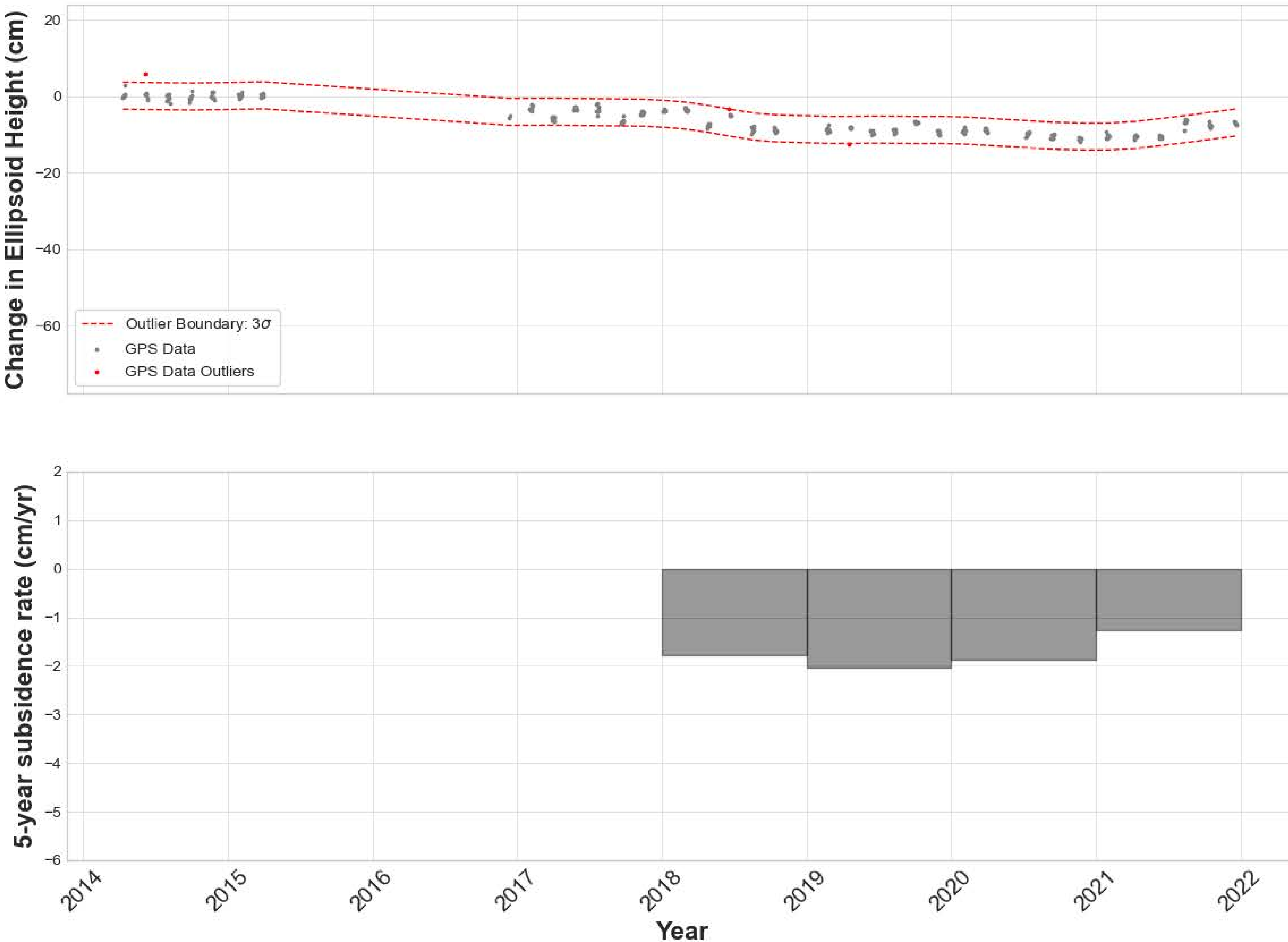
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P005



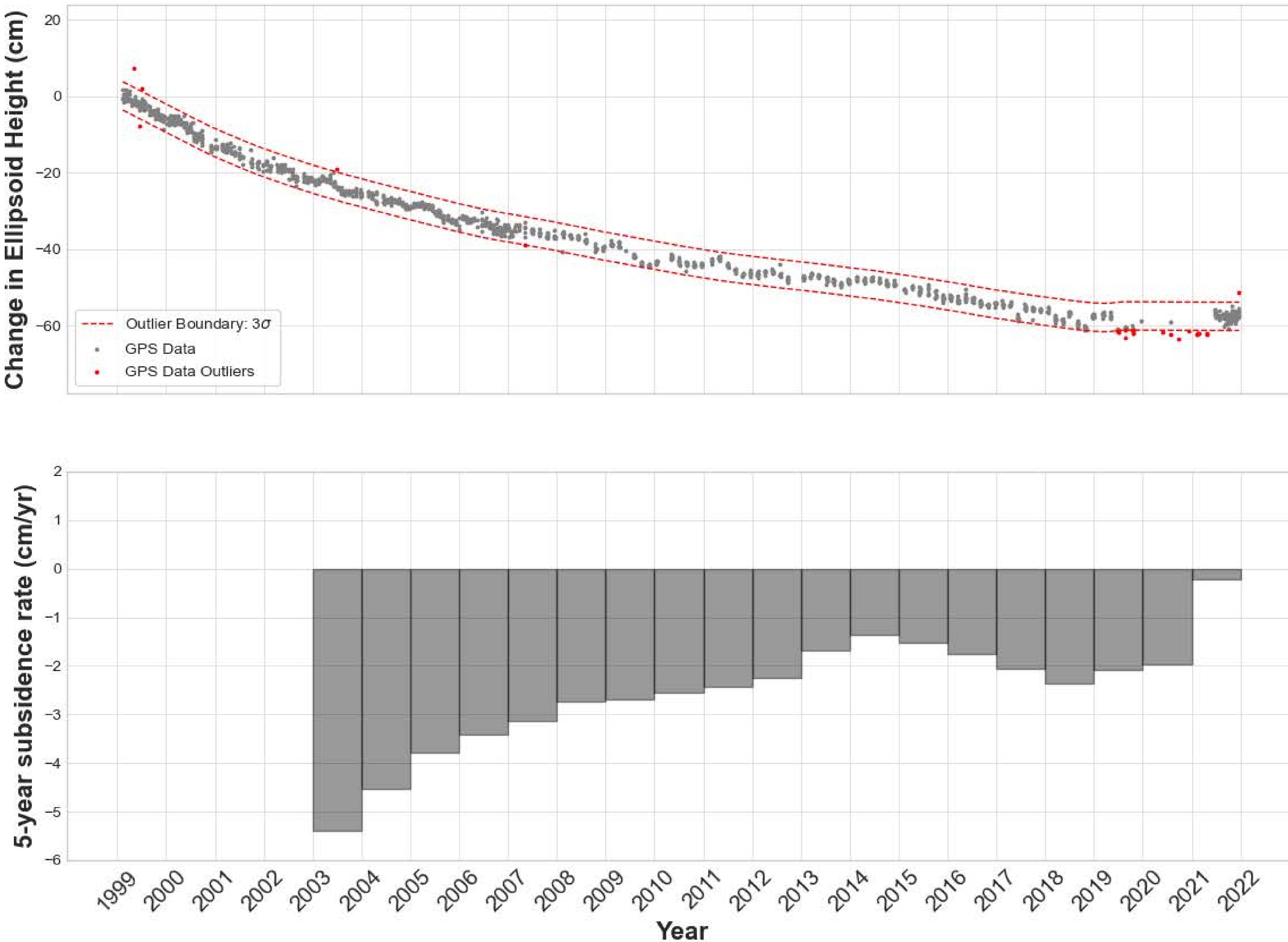
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P006



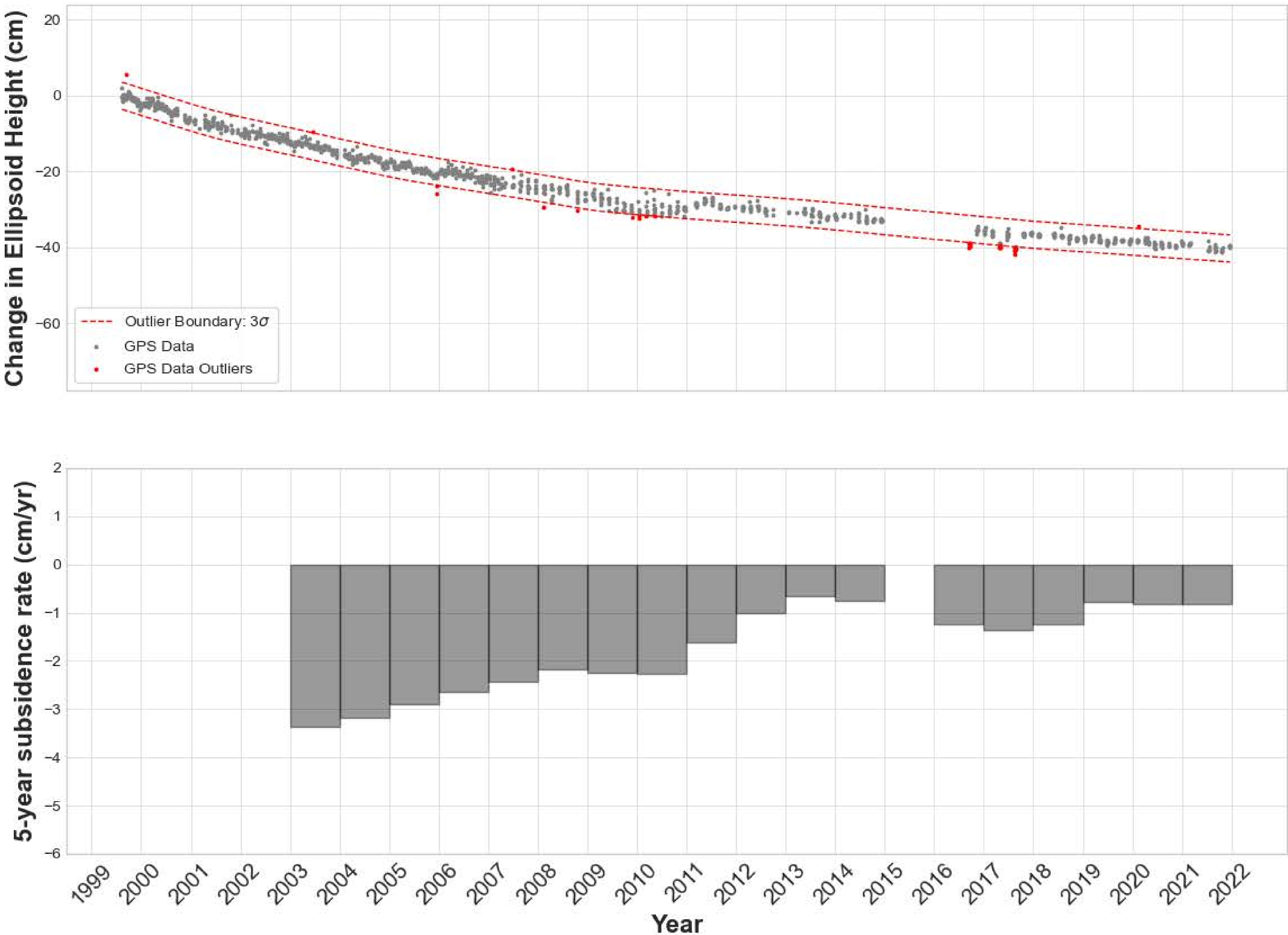
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P007



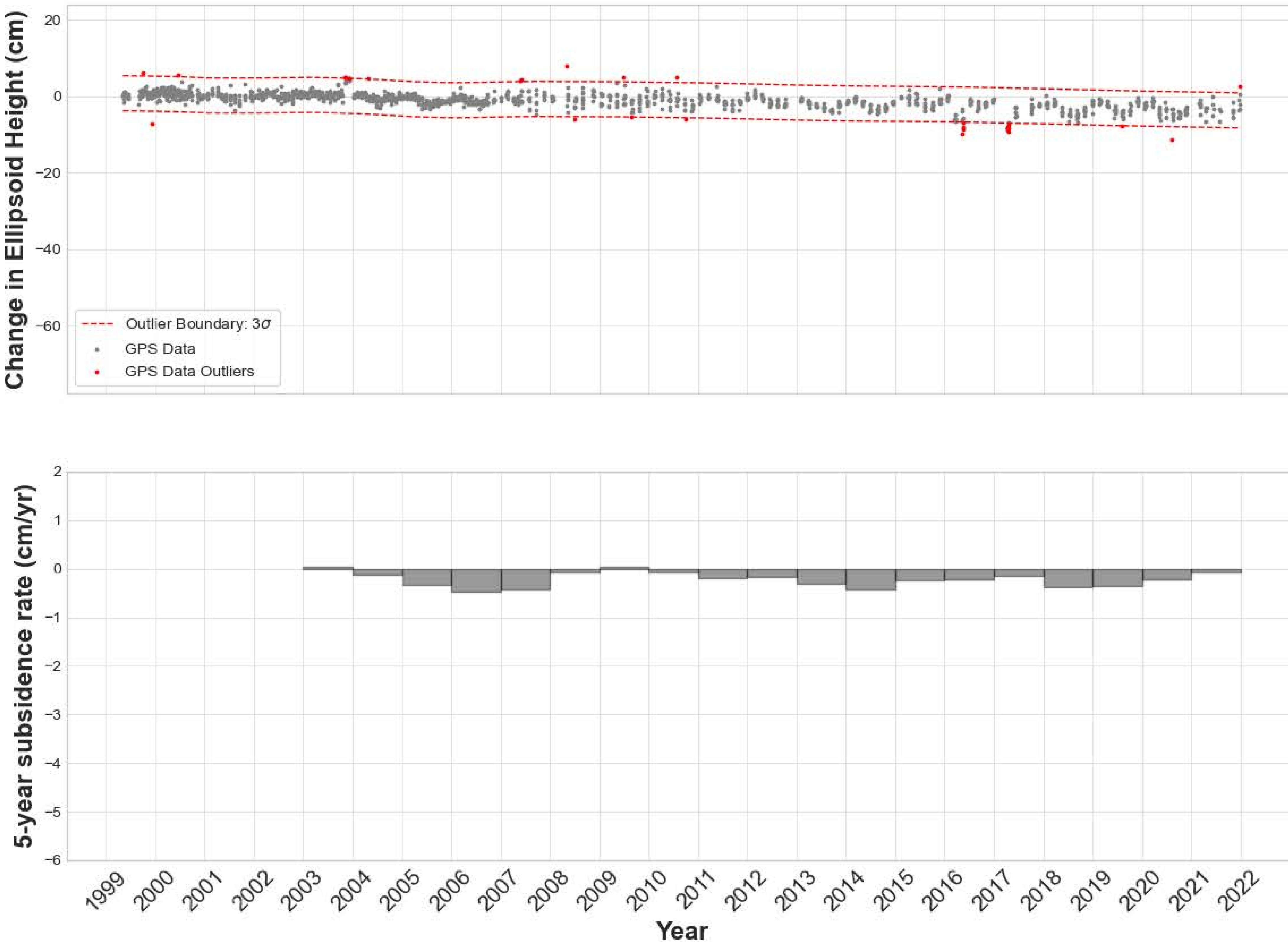
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P008



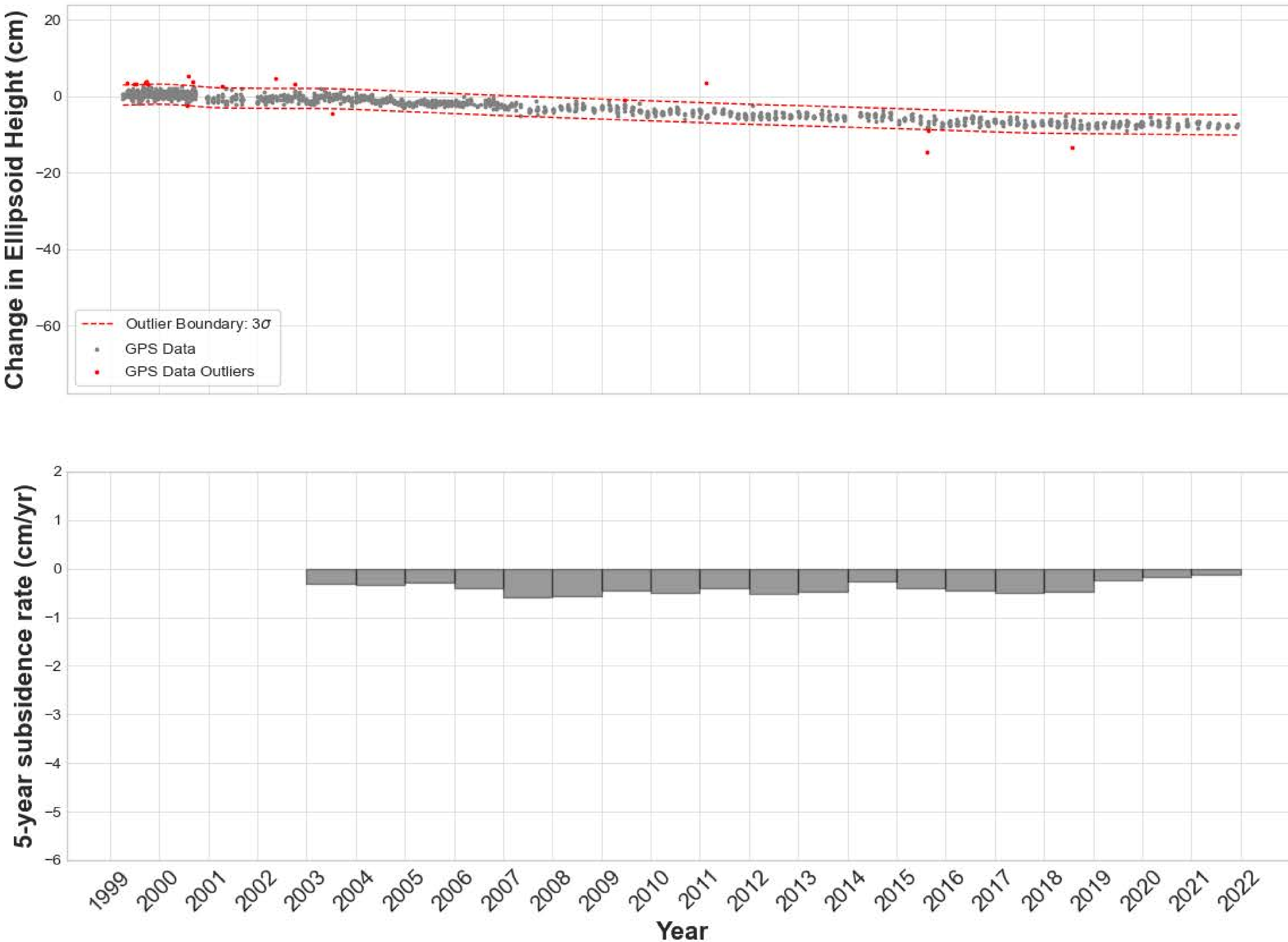
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P009



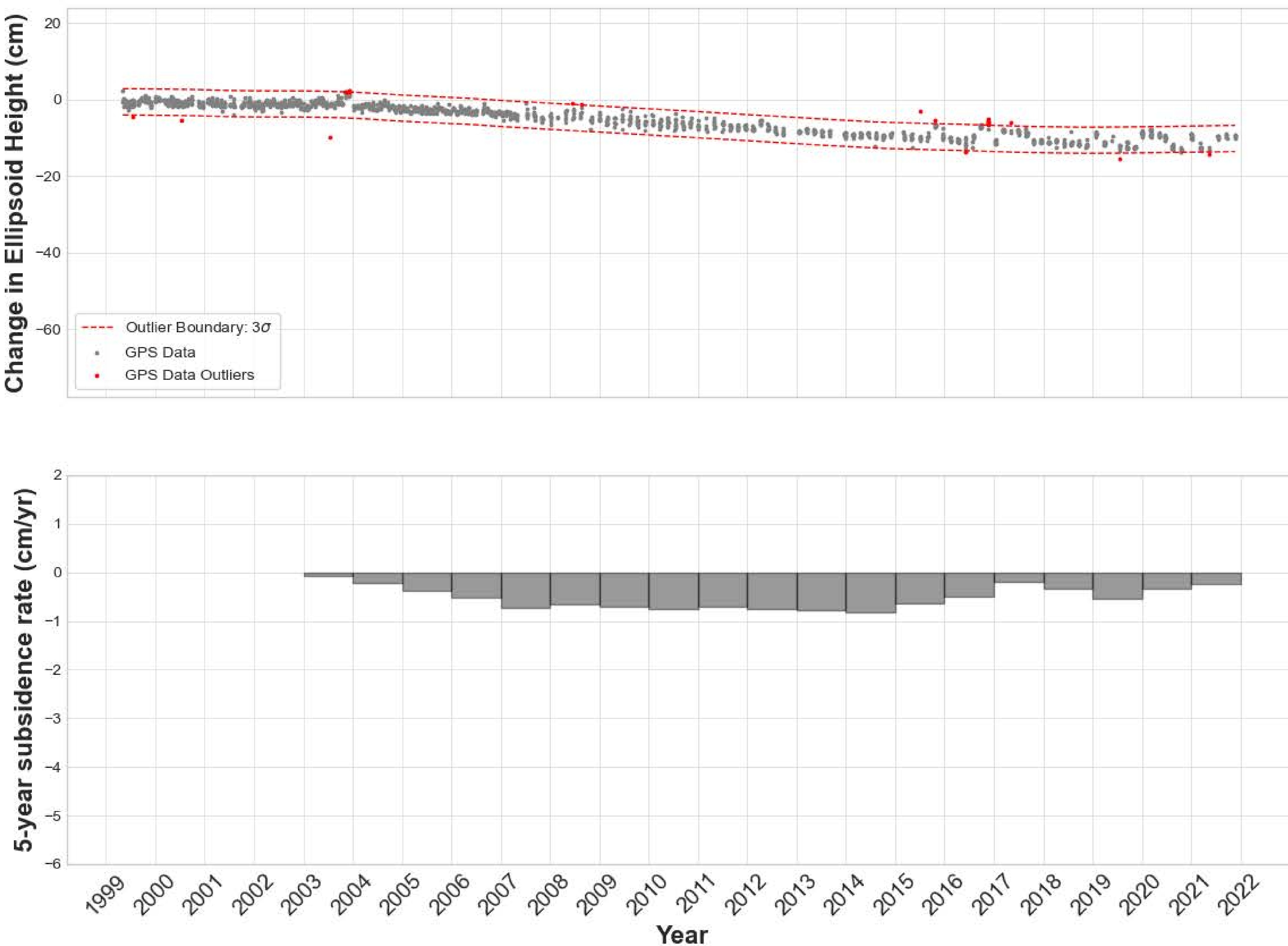
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P010



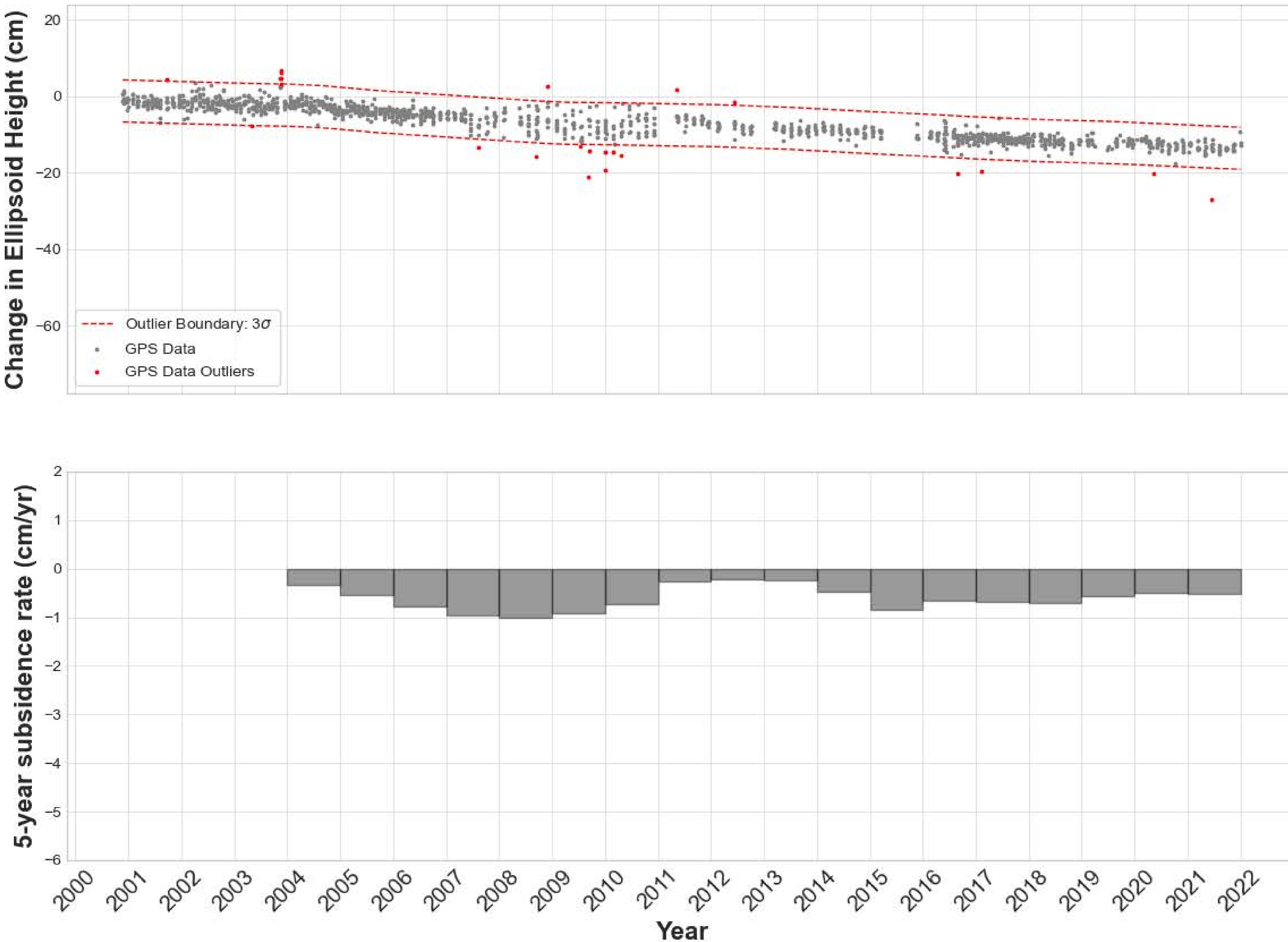
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P011



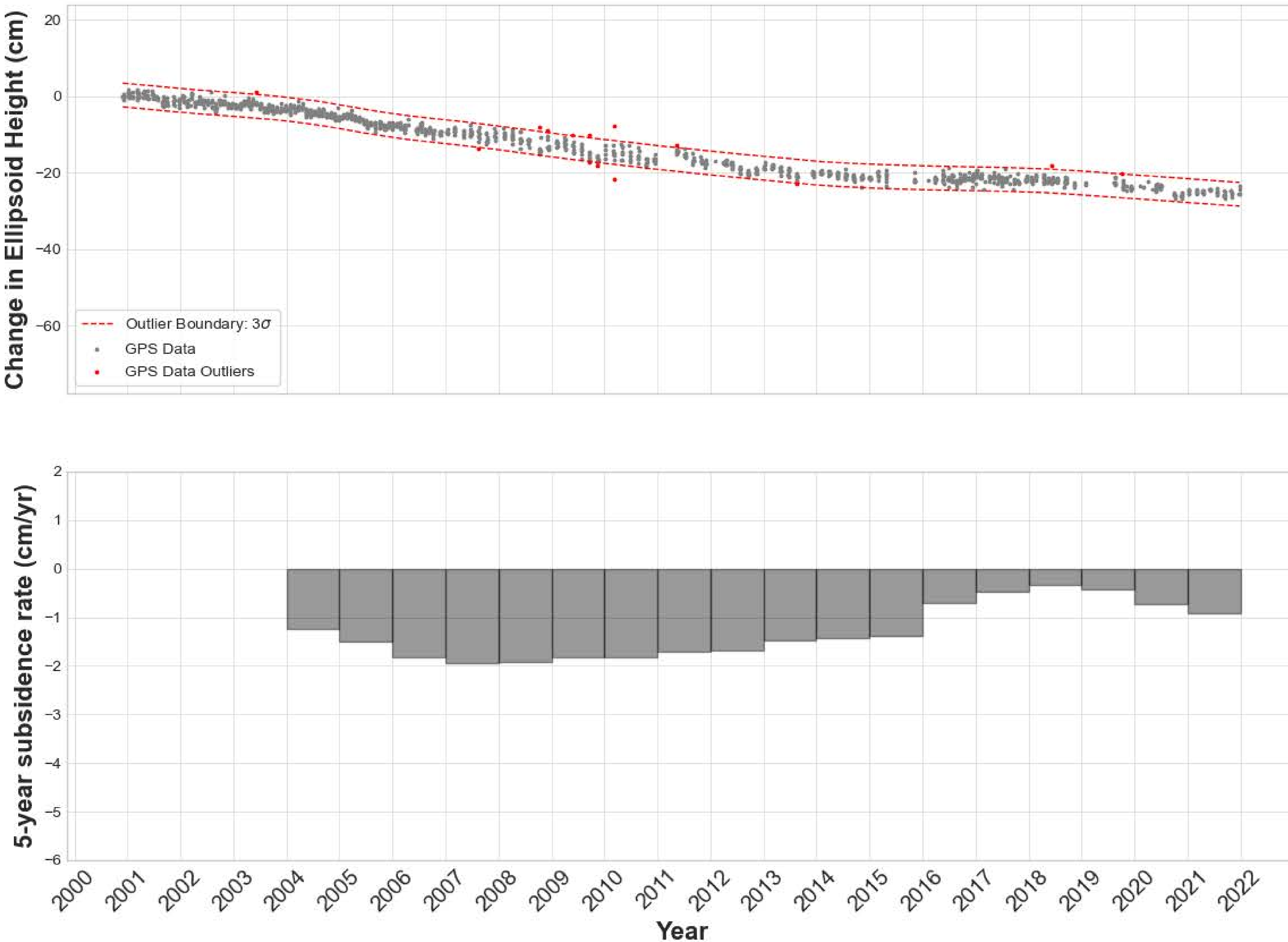
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P012



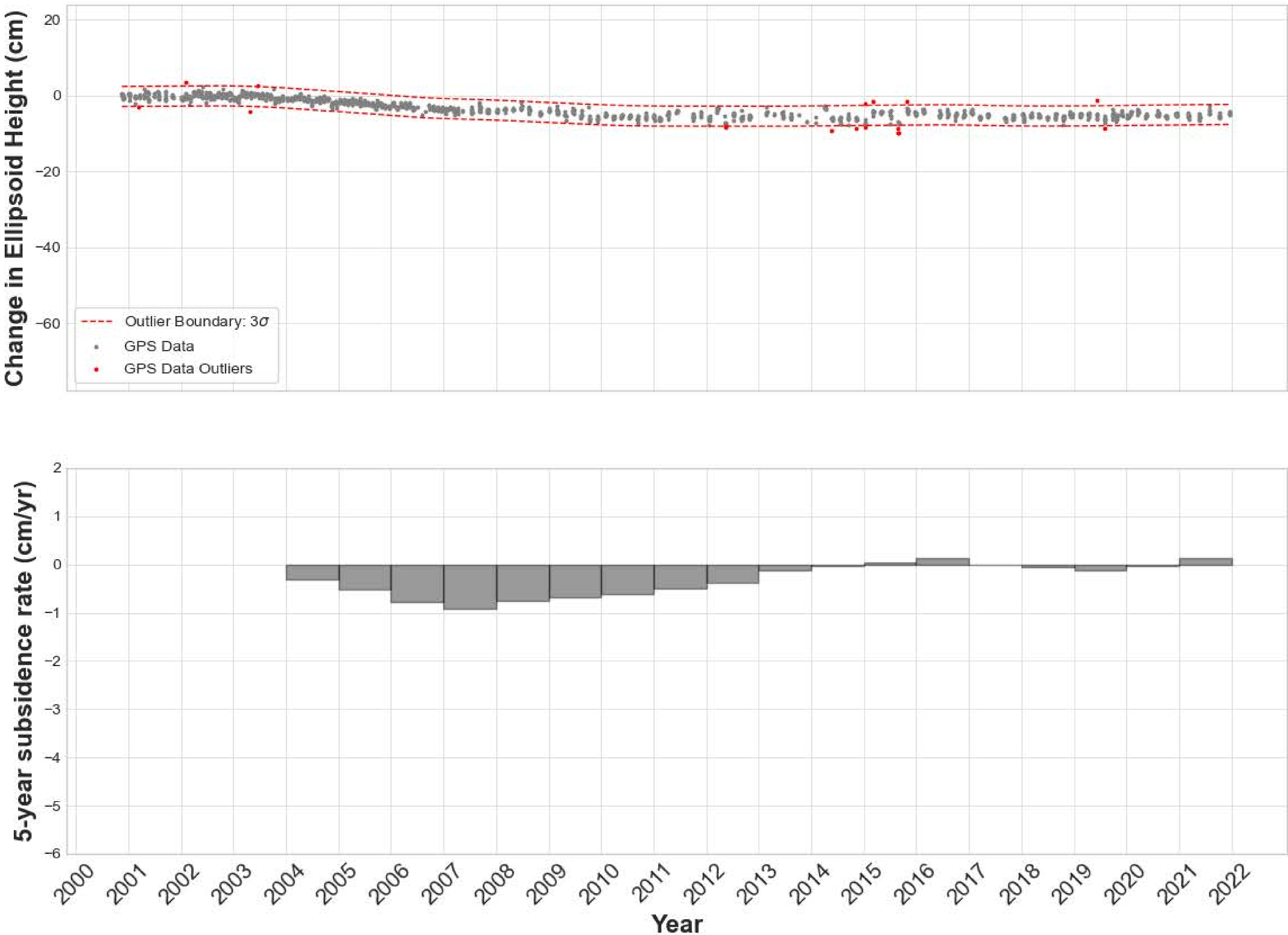
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P013



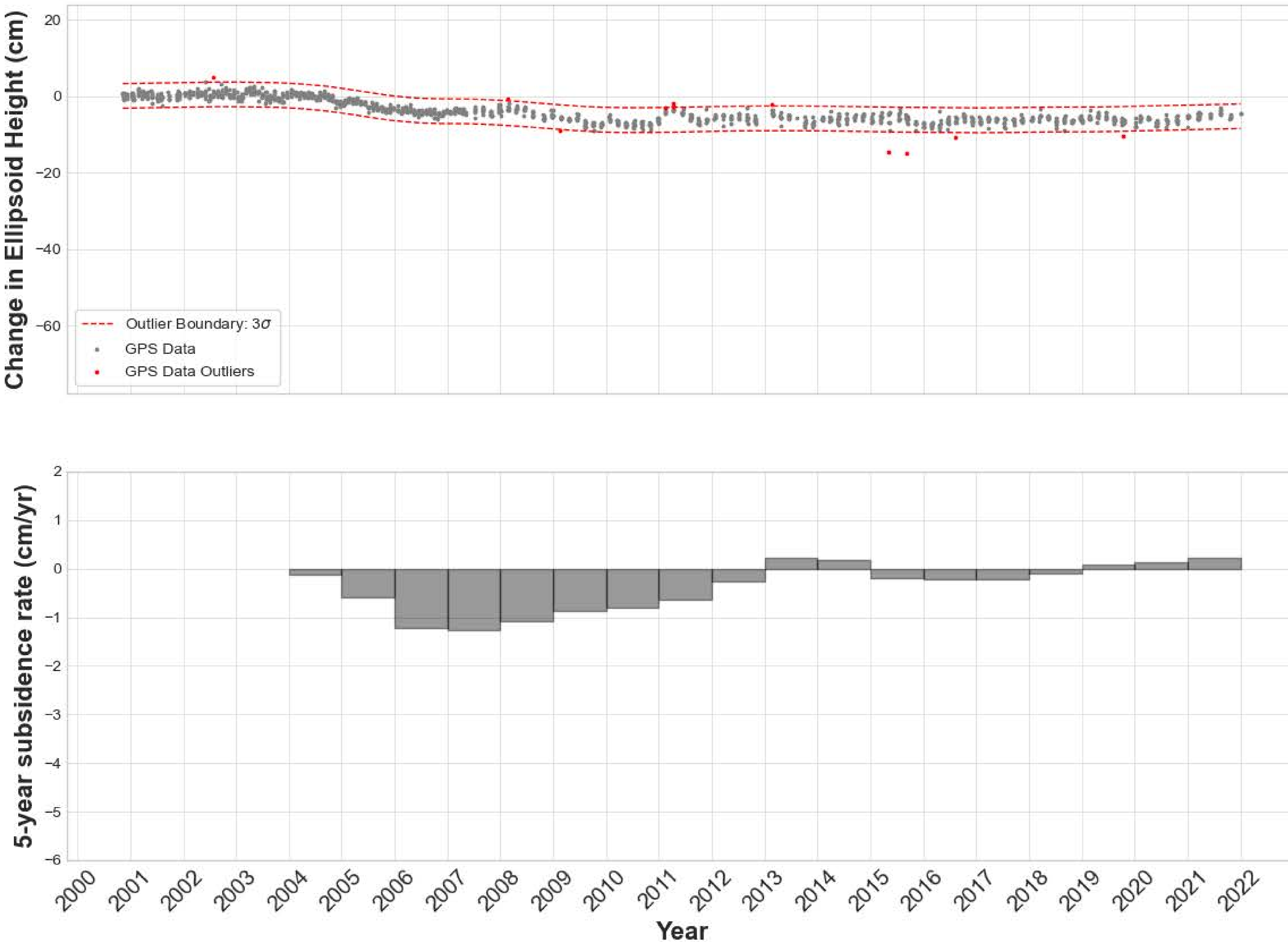
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P014



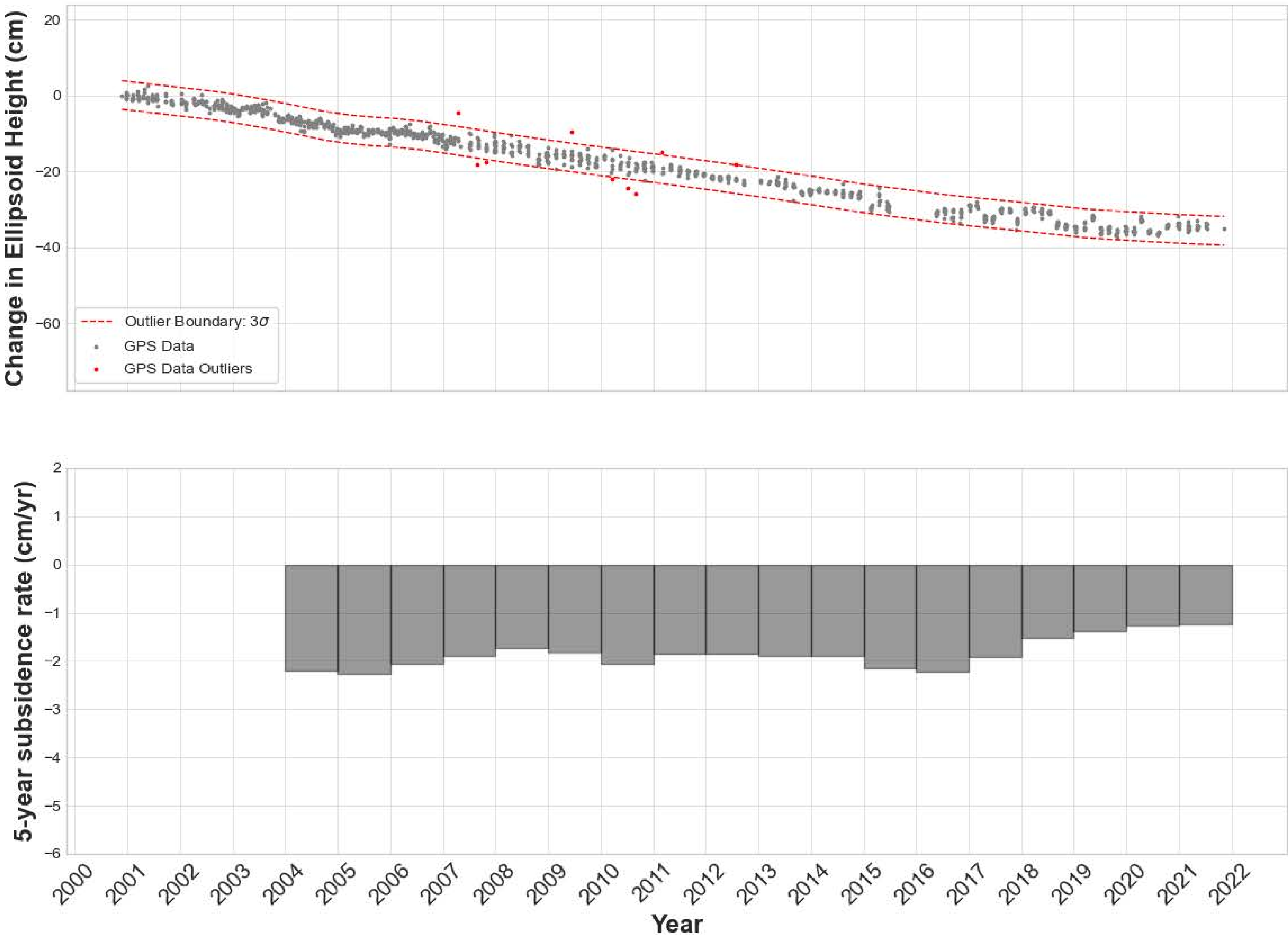
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P016



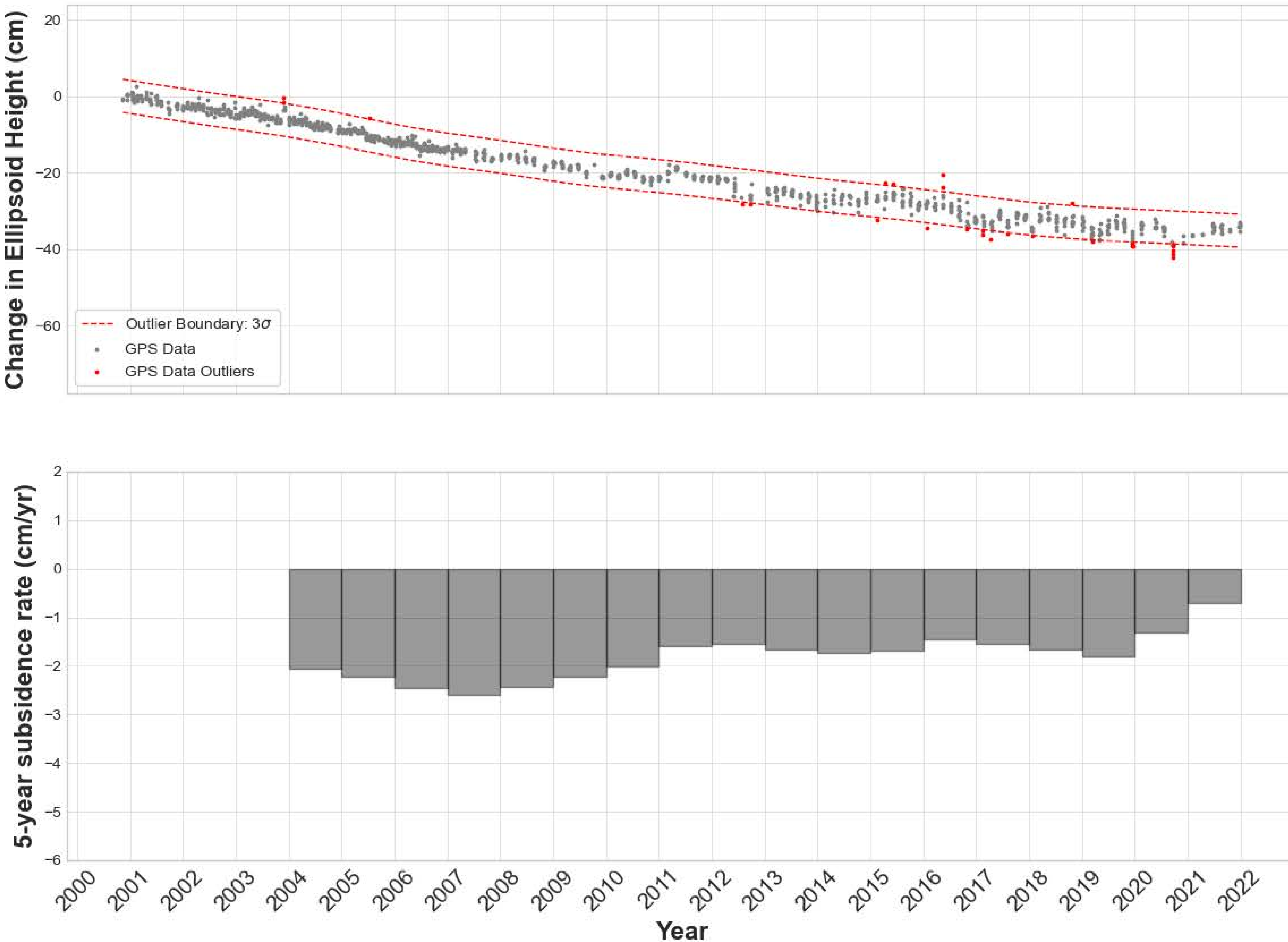
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P017



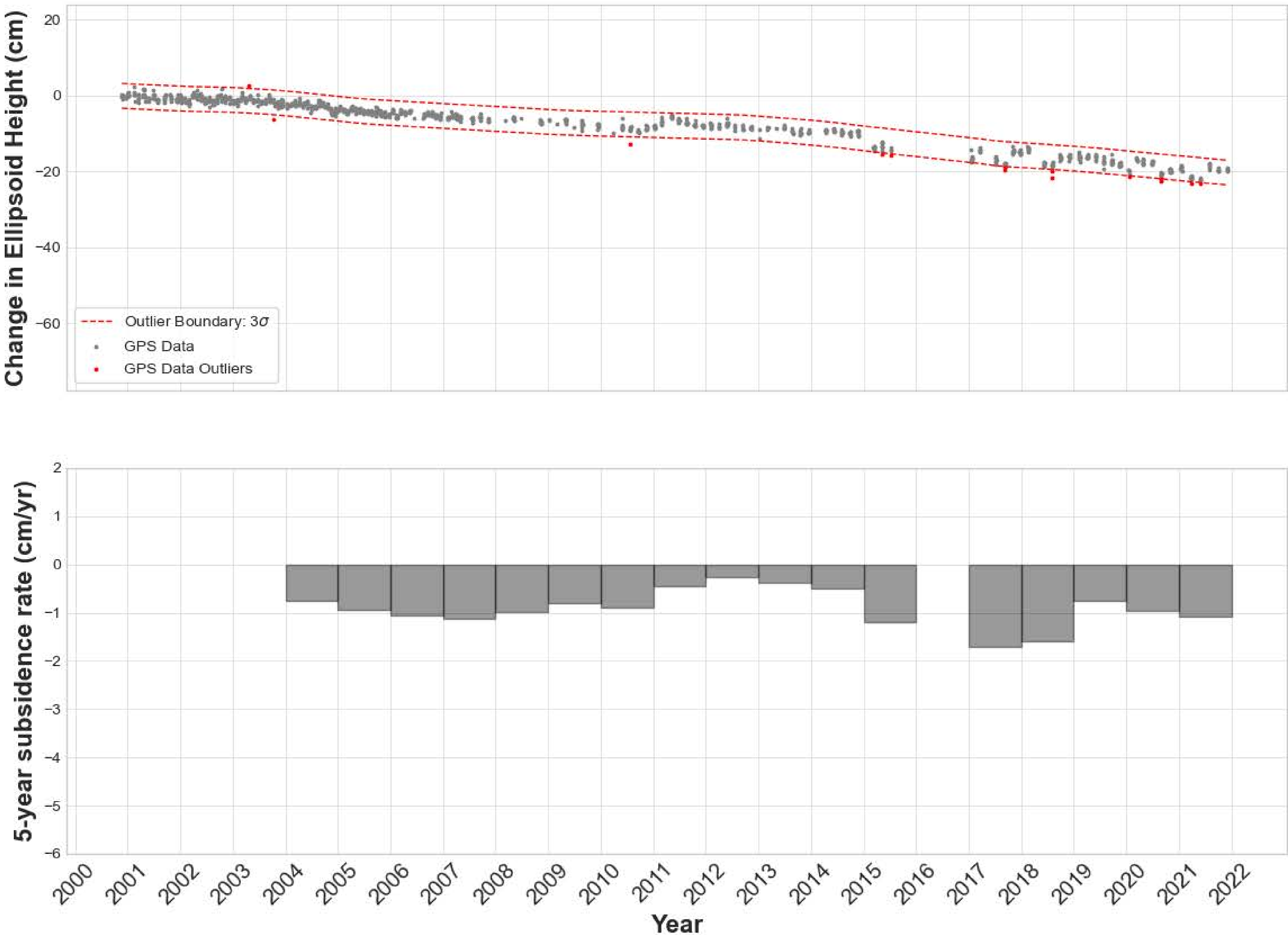
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P018



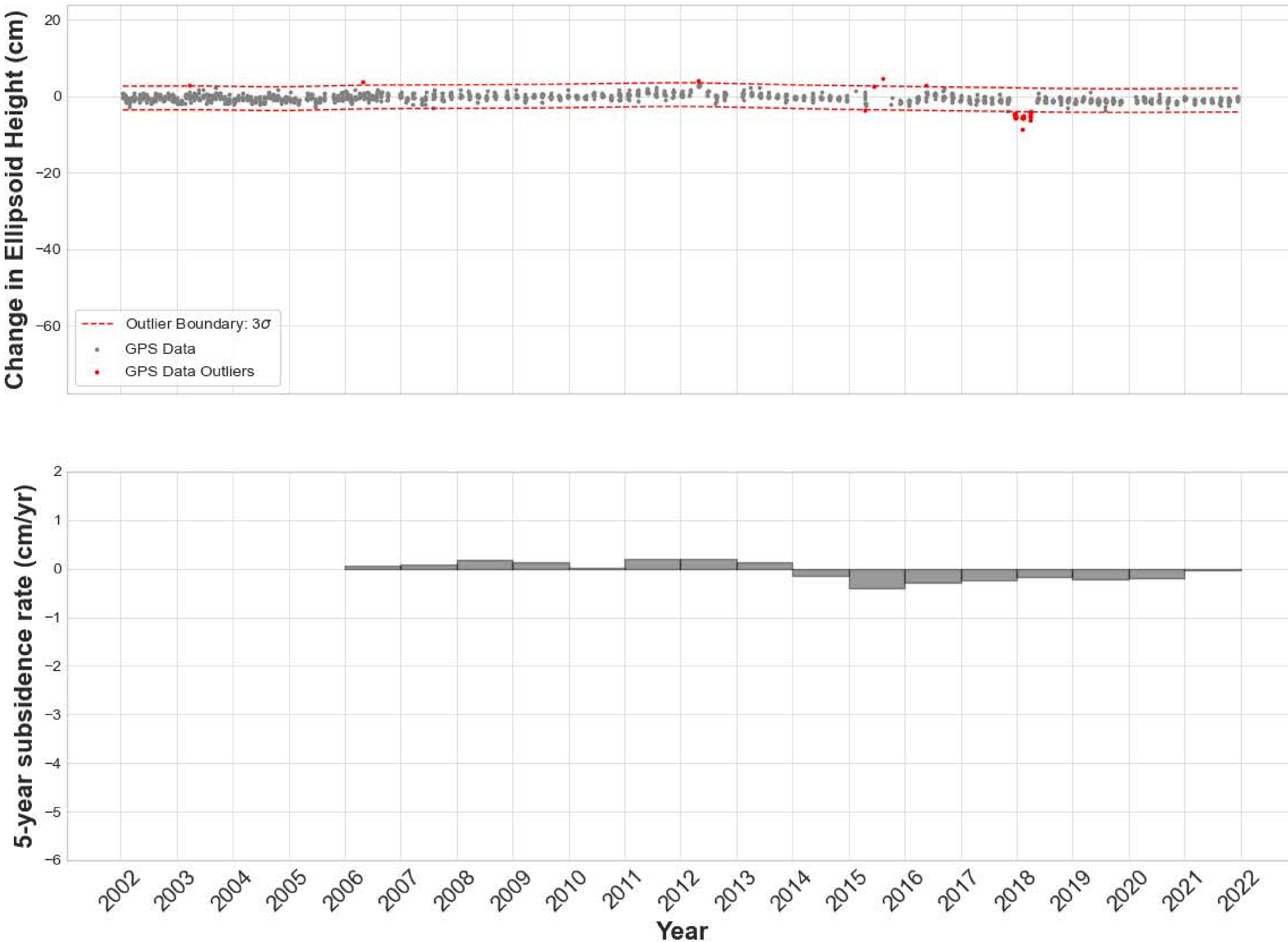
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P019



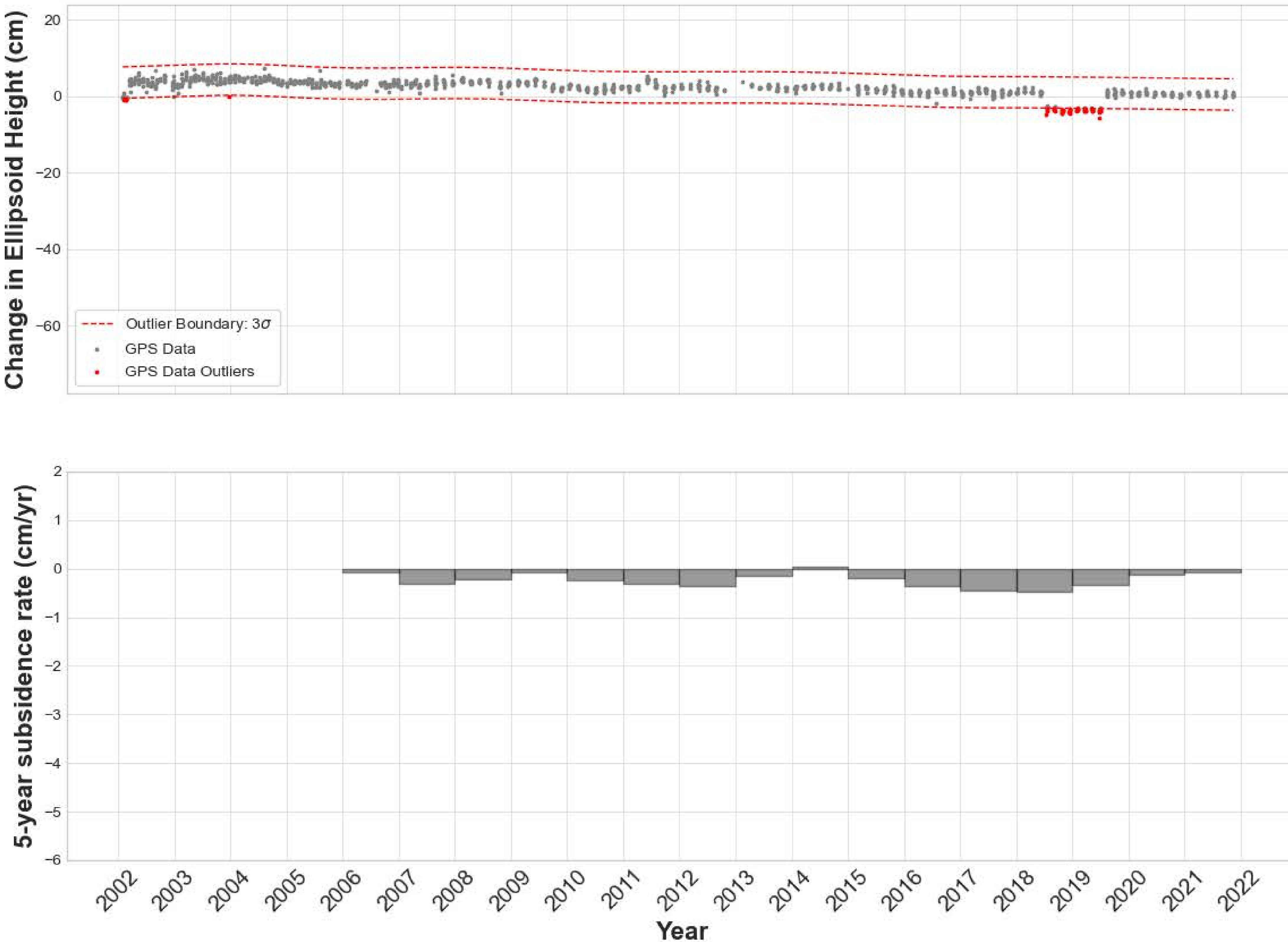
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P020



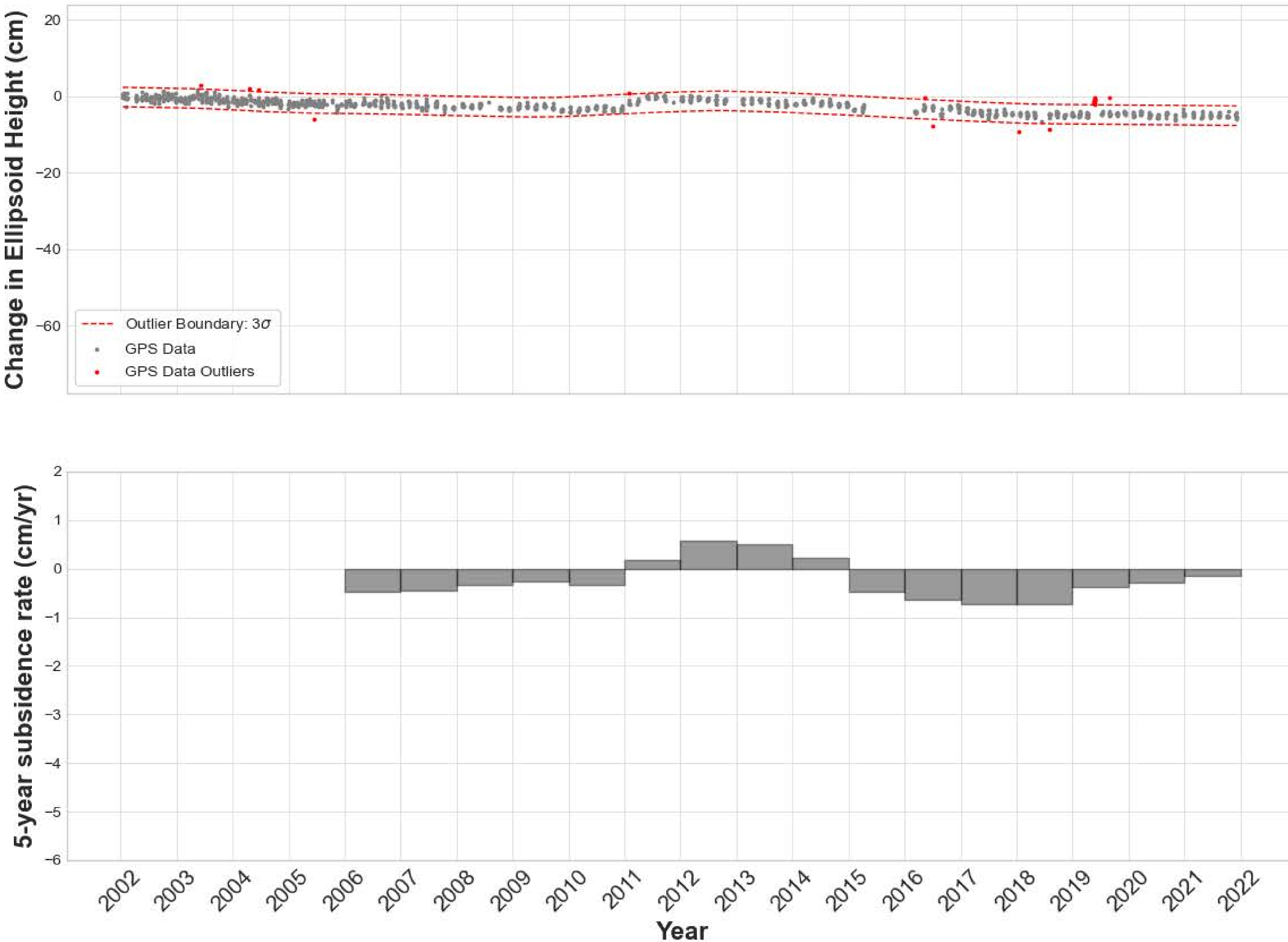
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P021



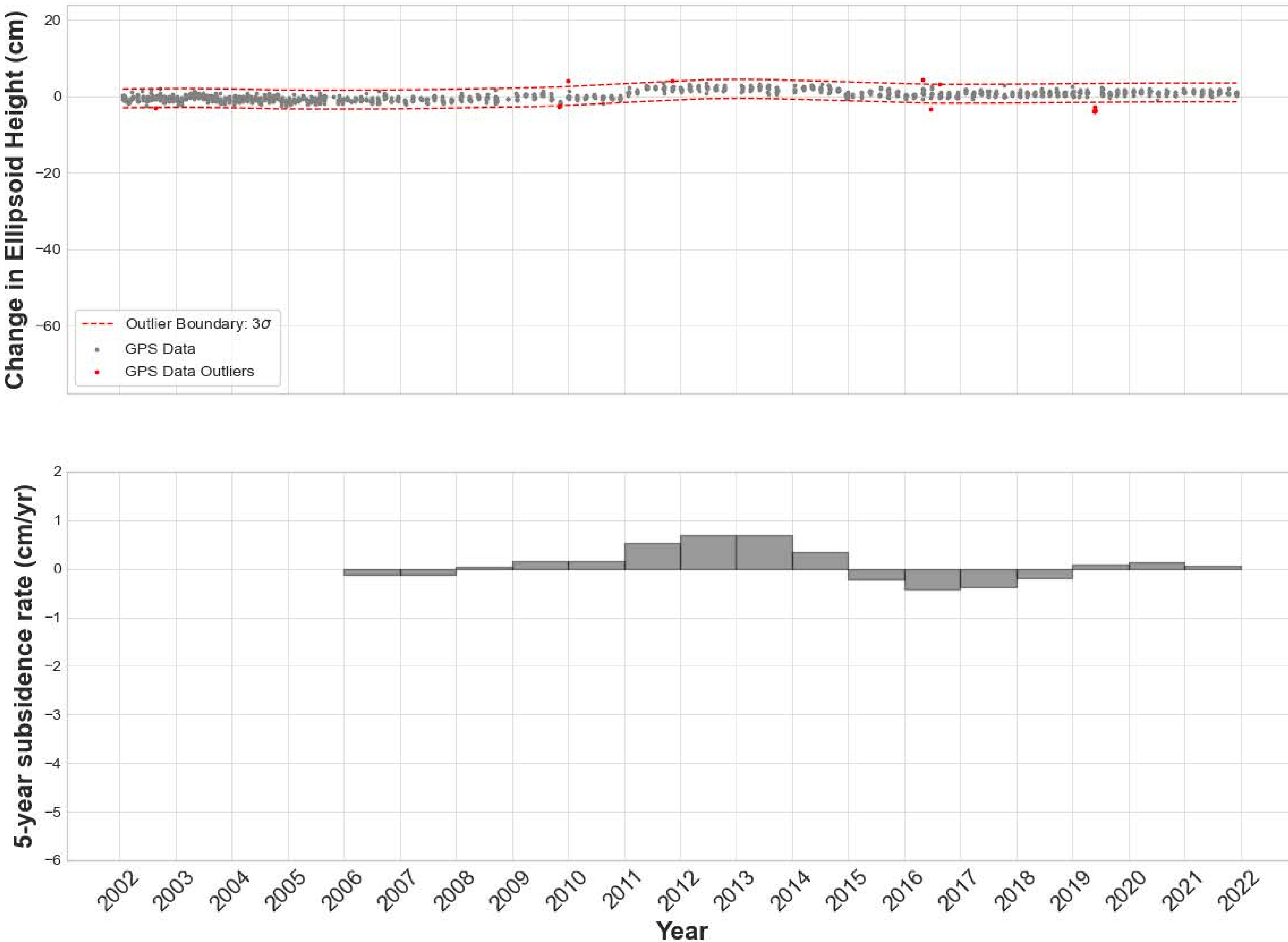
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P022



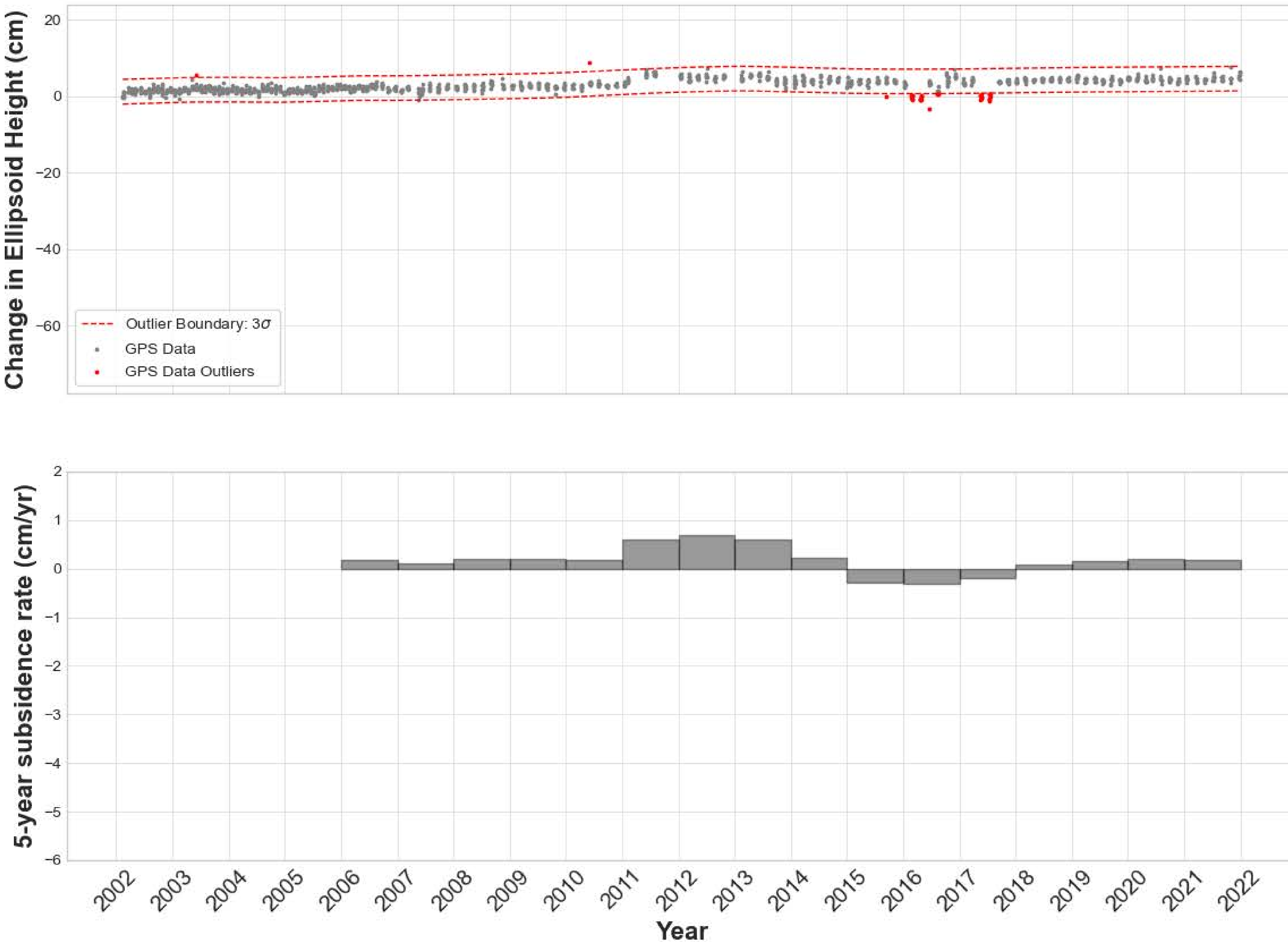
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P023



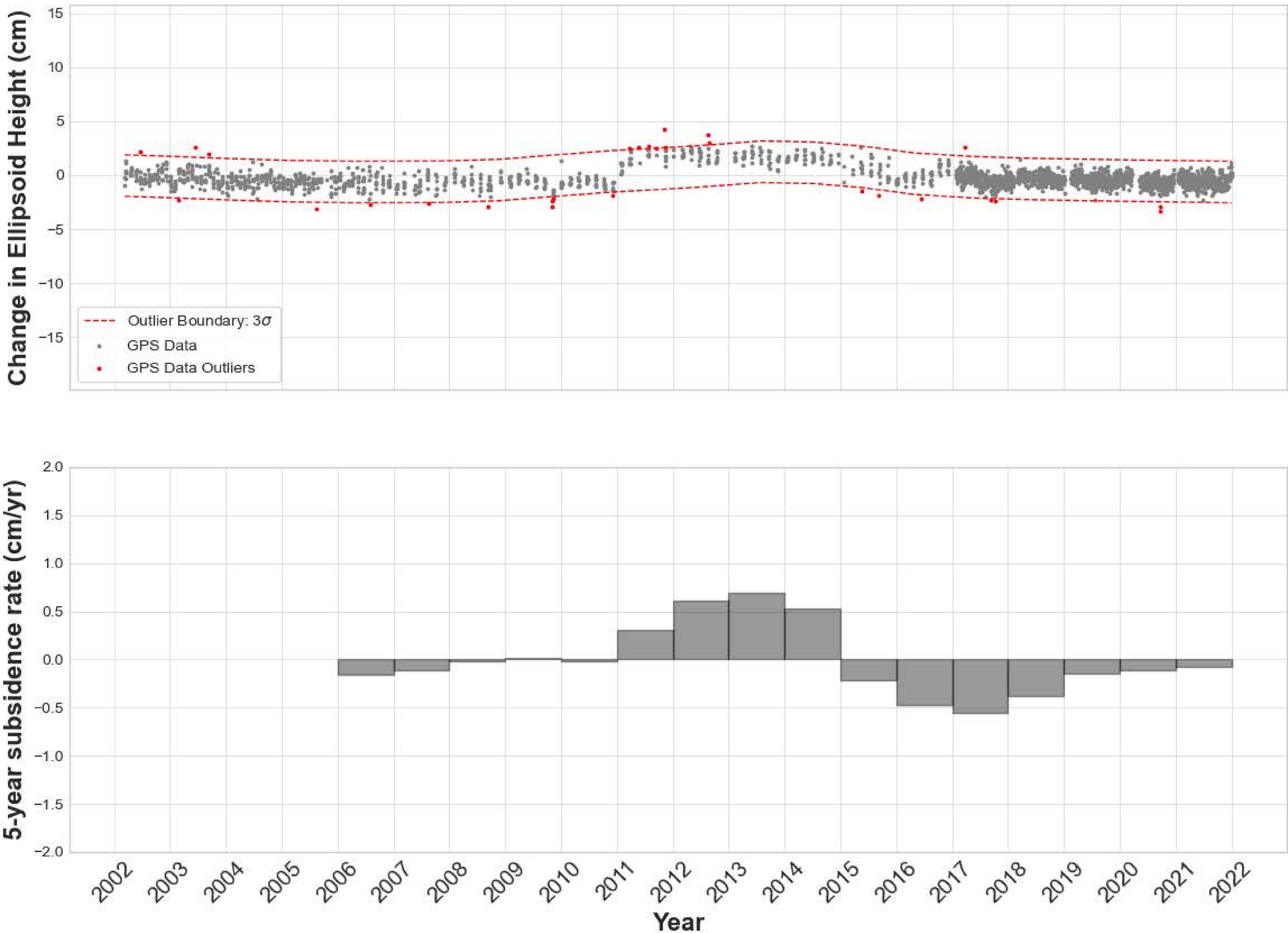
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P024



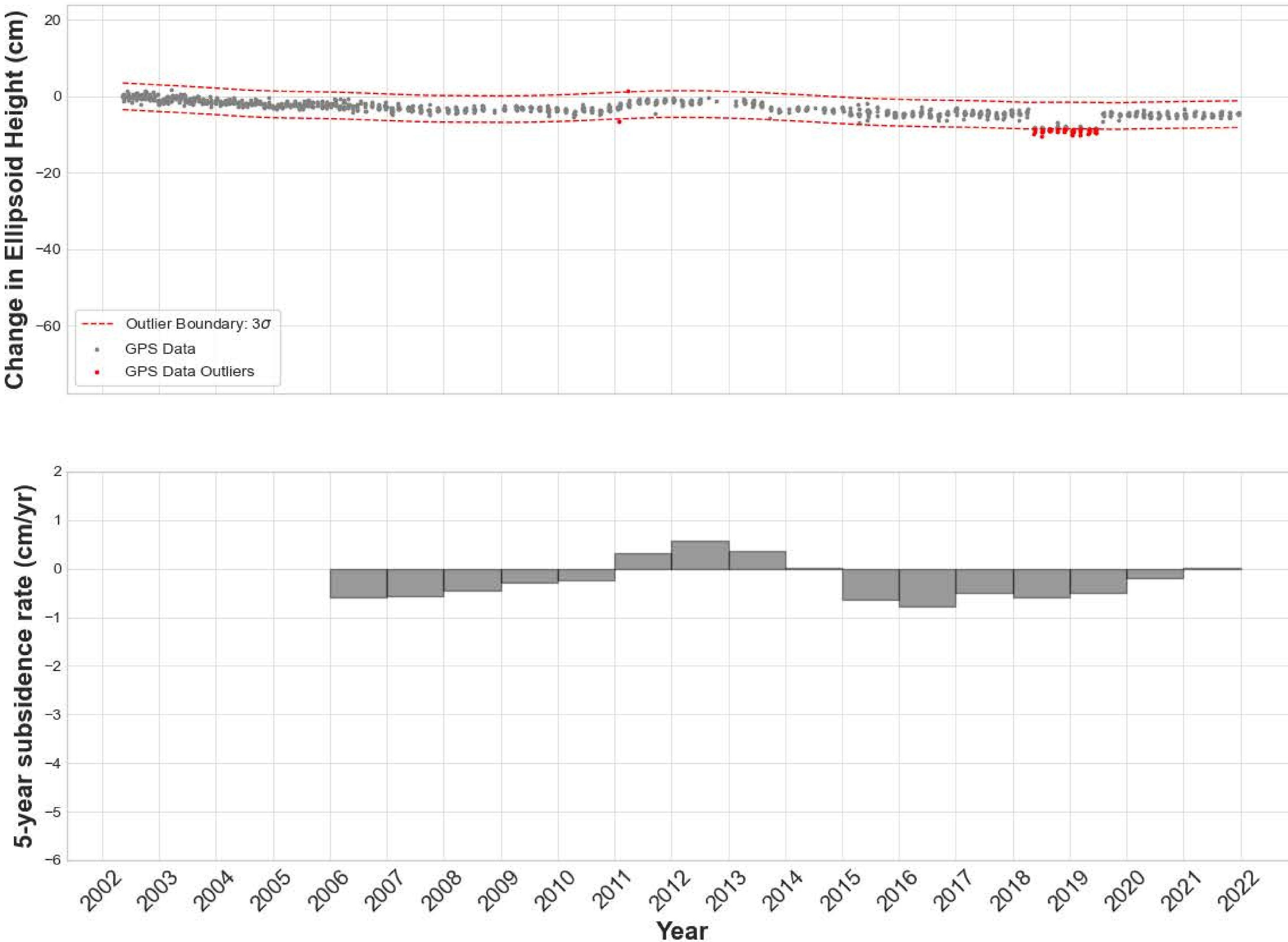
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P026



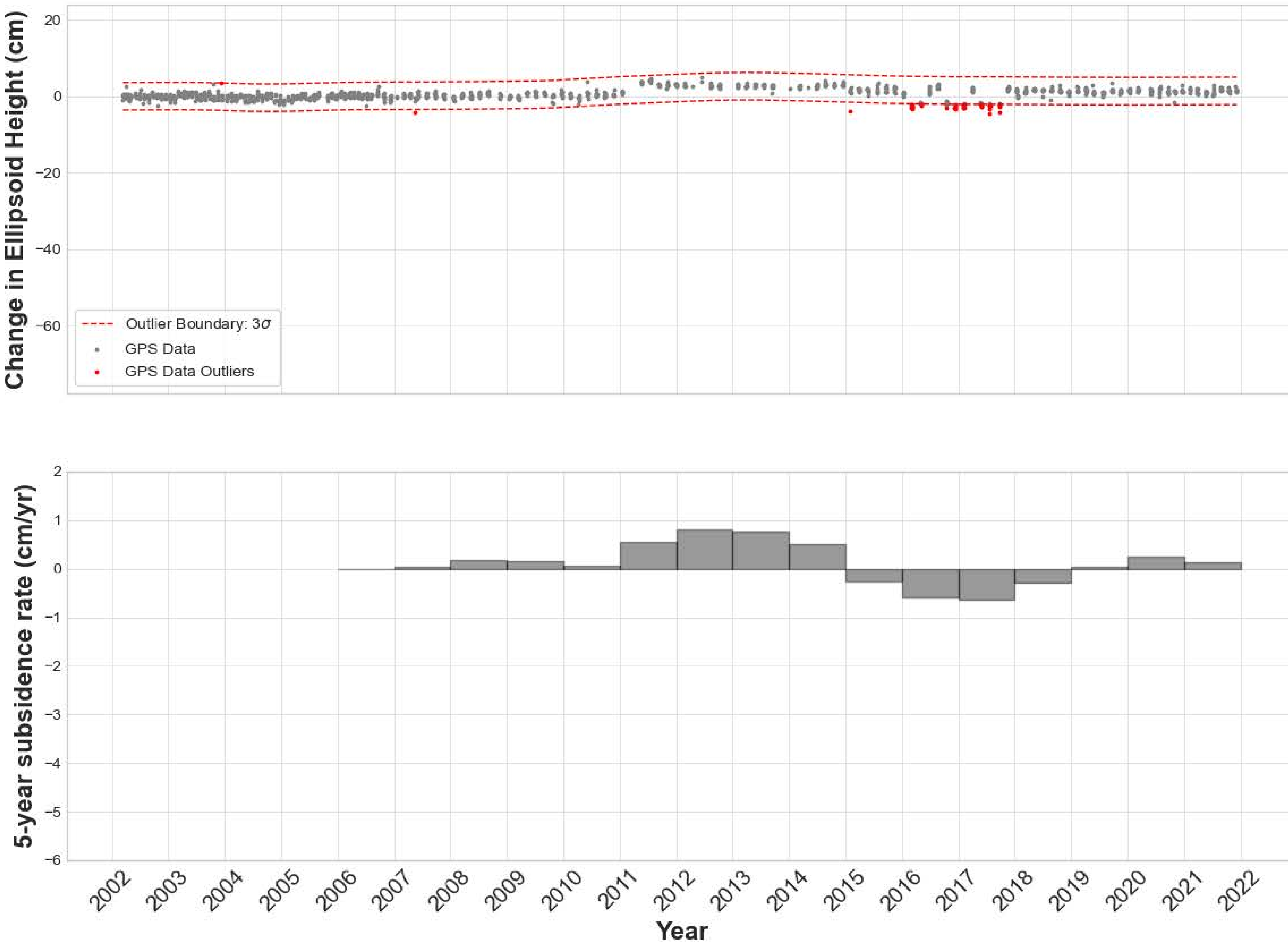
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P027



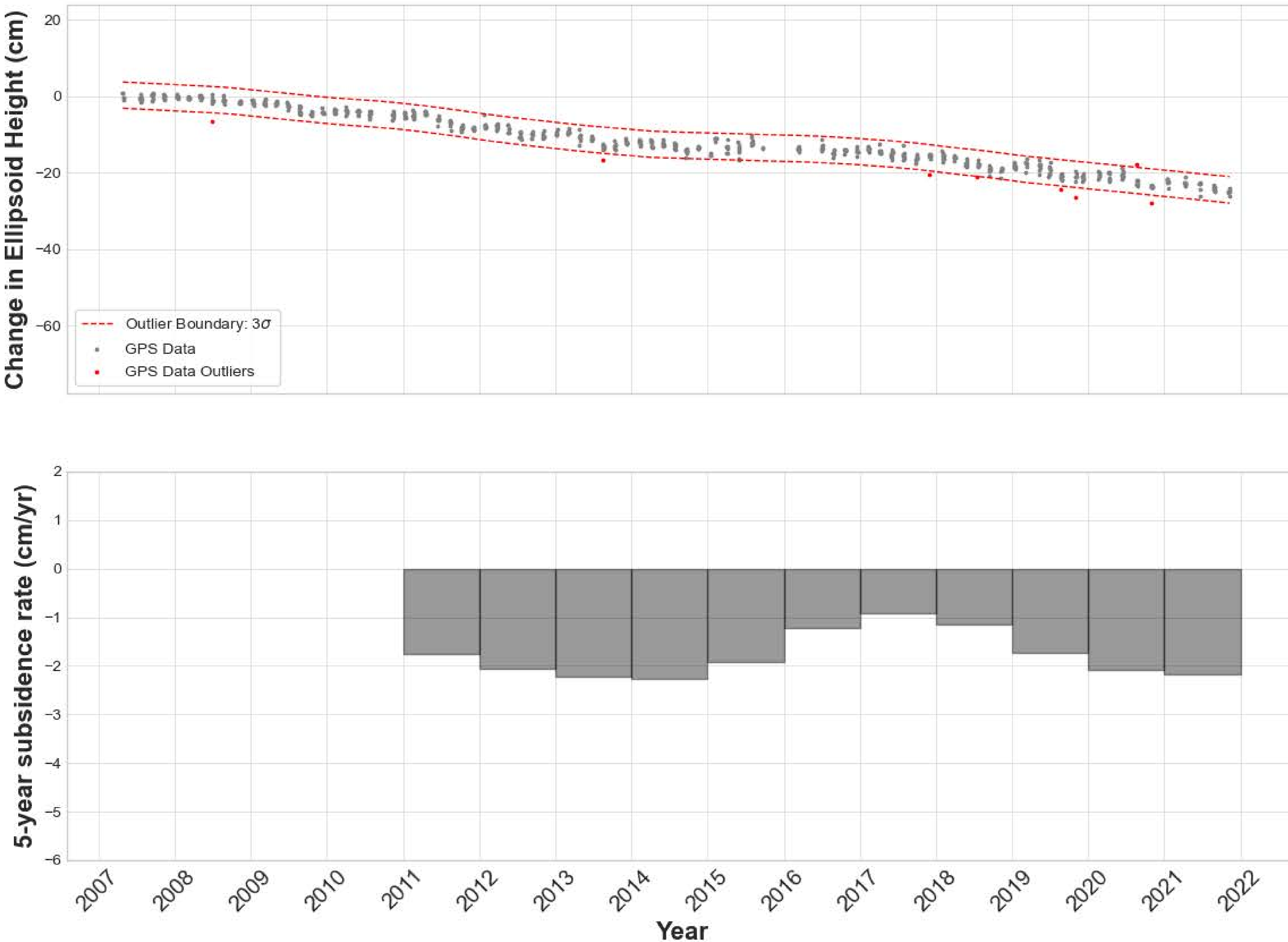
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P028



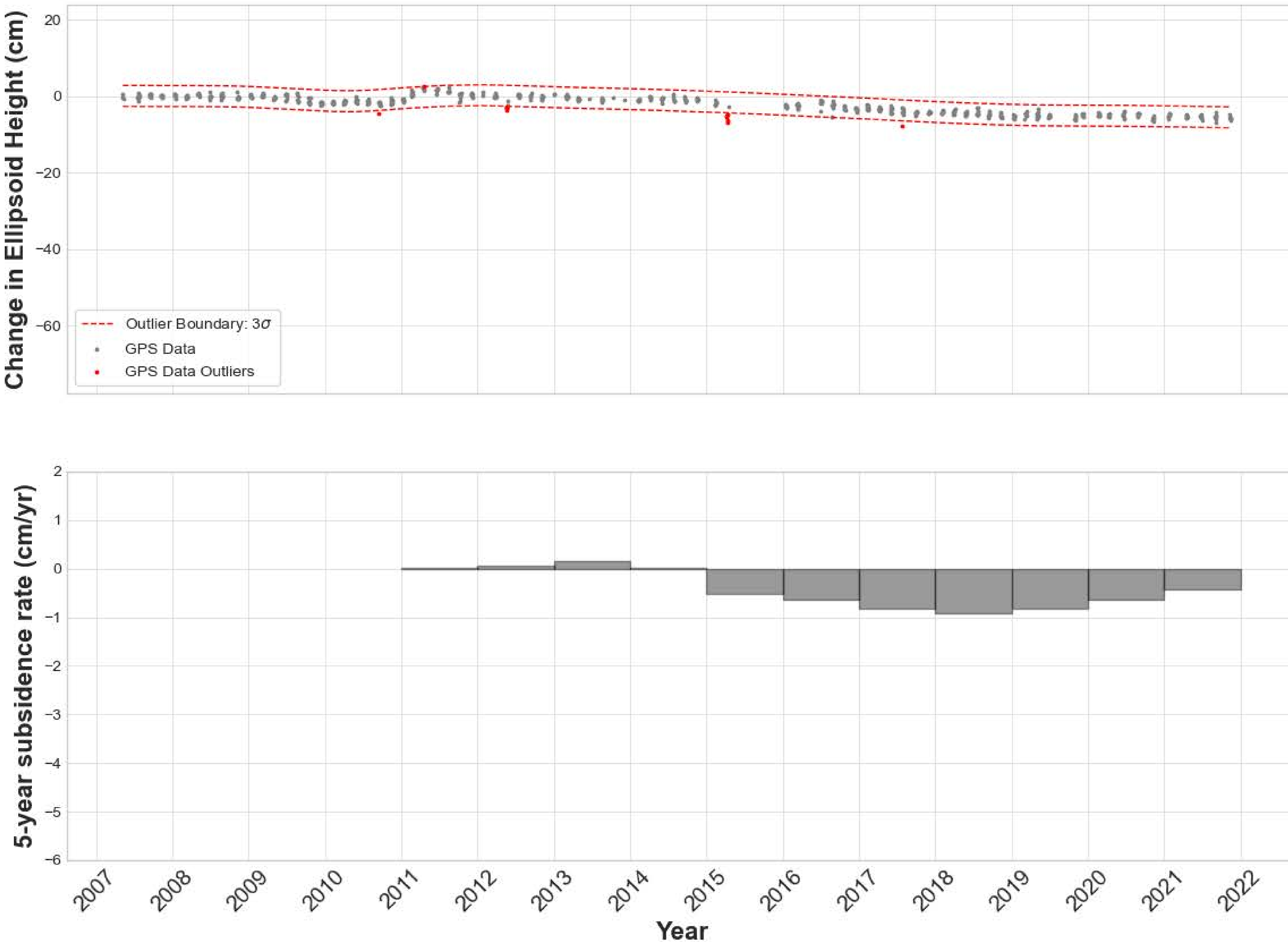
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P029



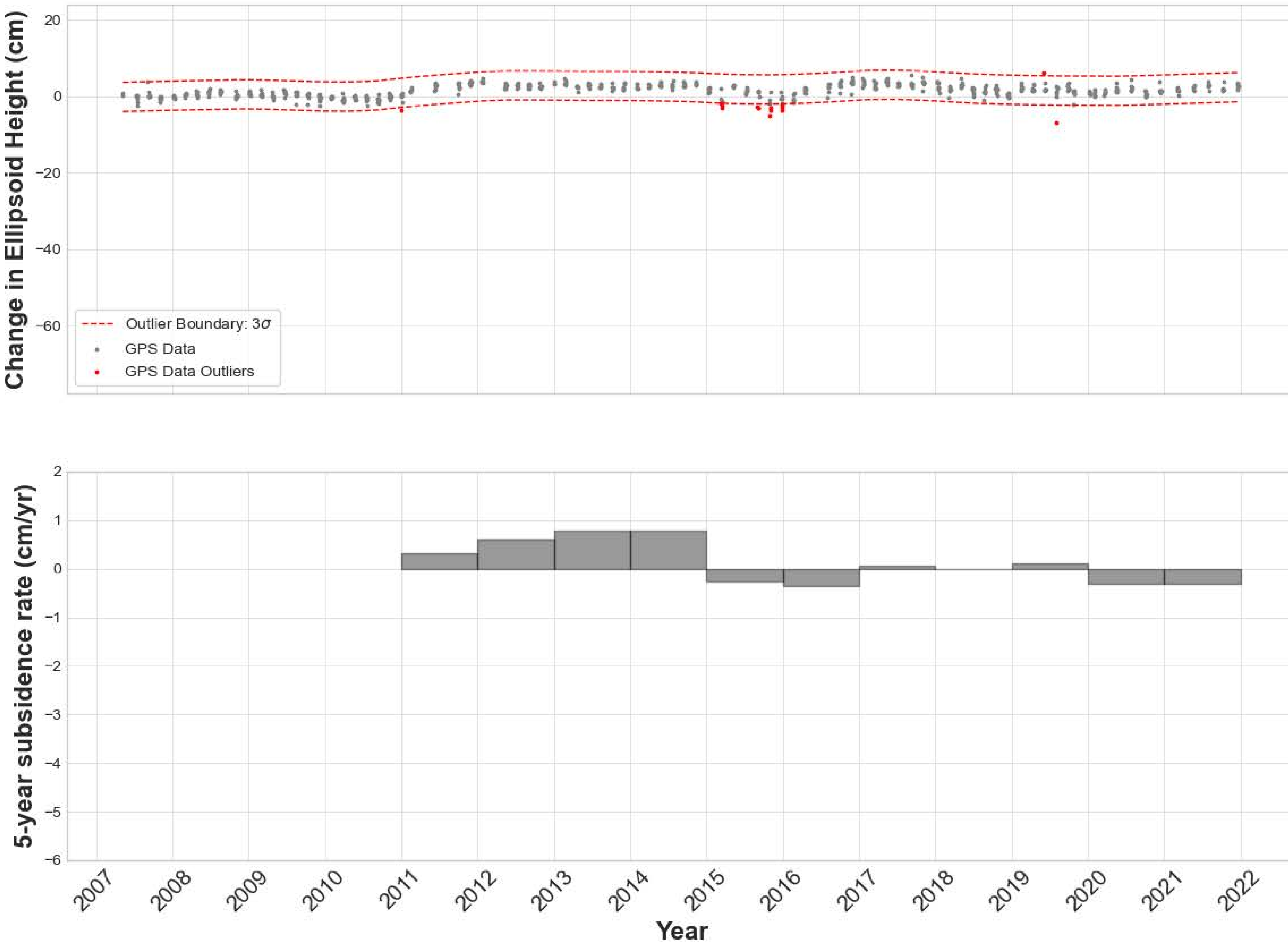
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P030



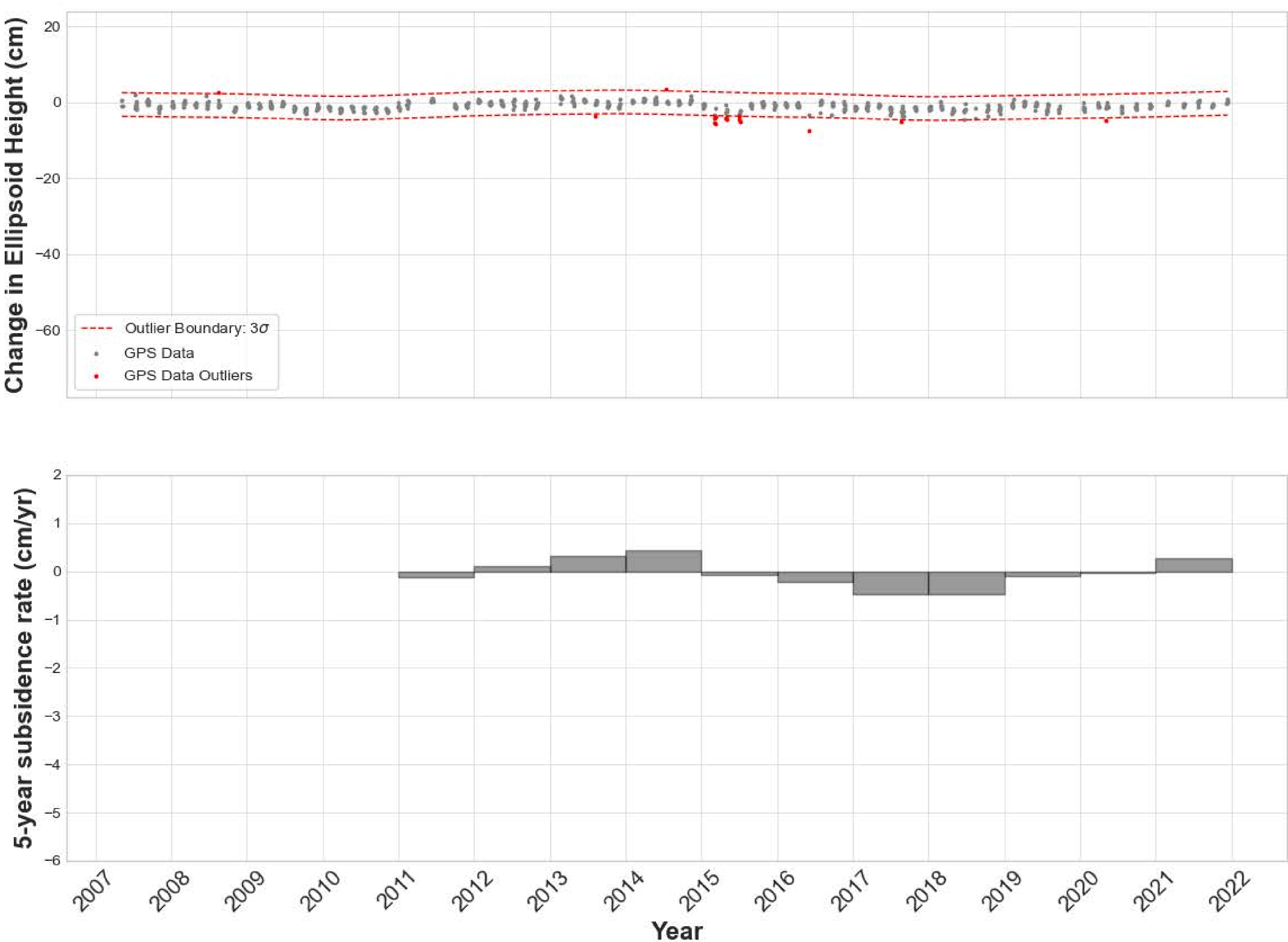
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P031



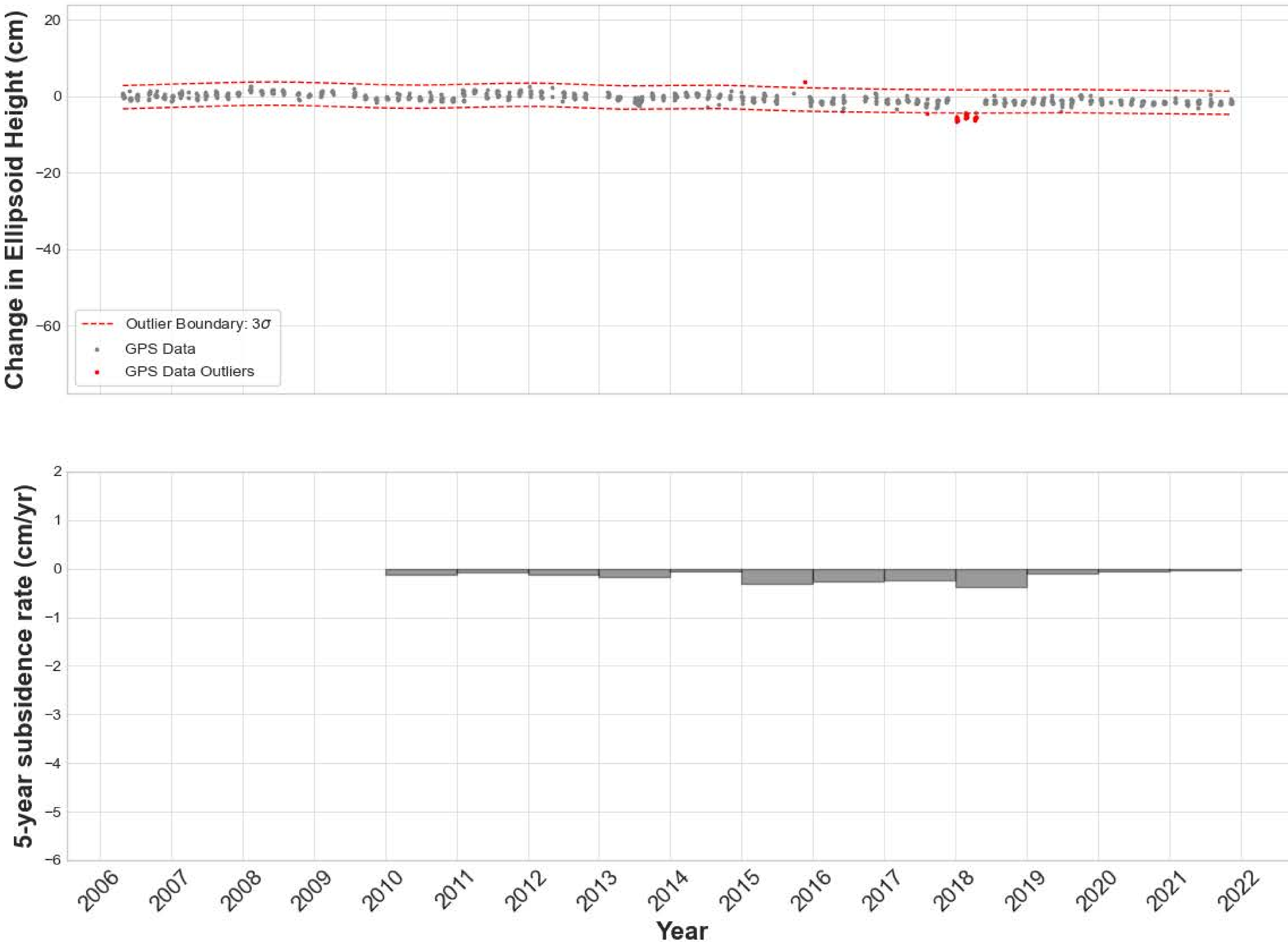
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P032



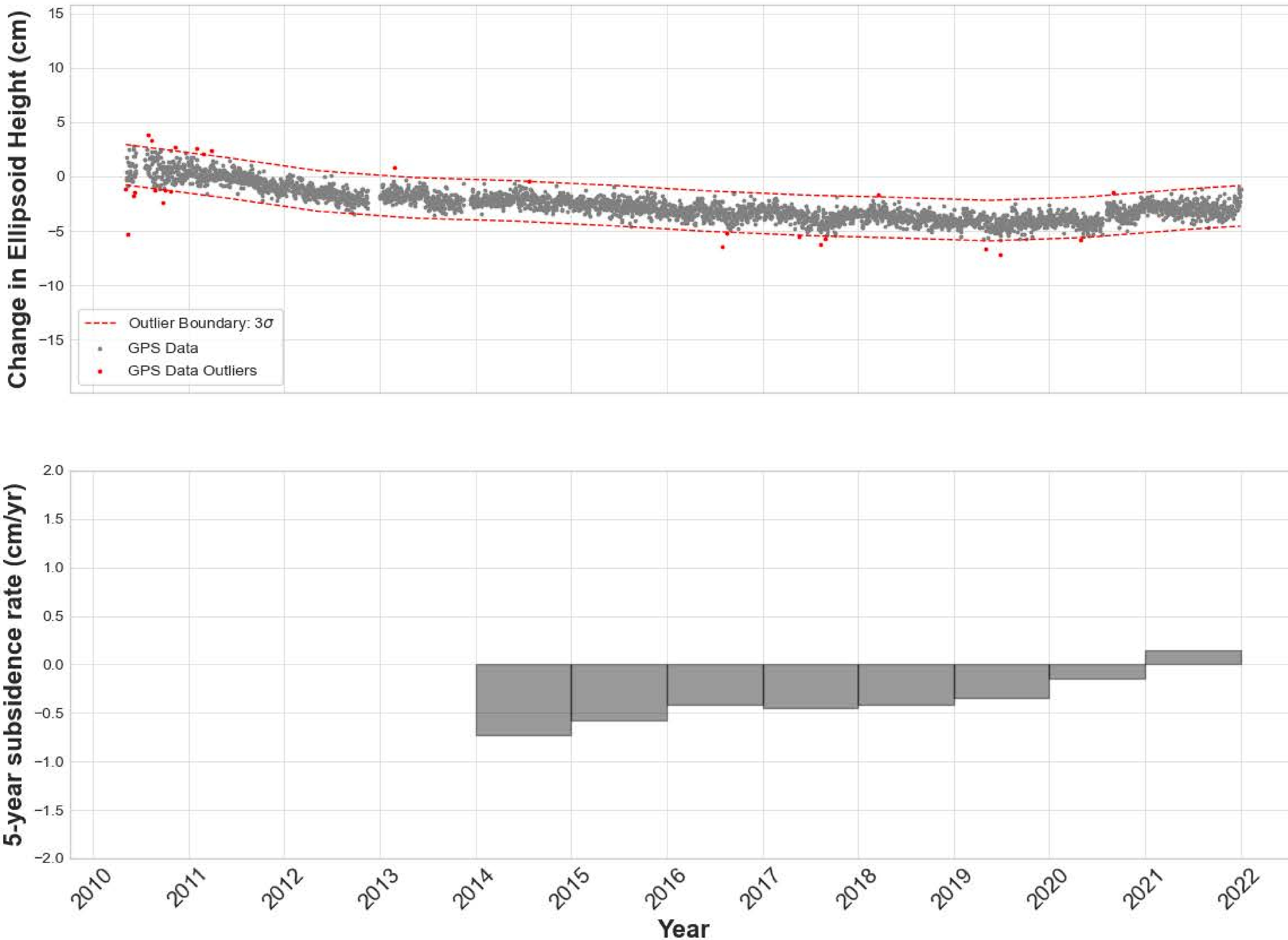
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P033



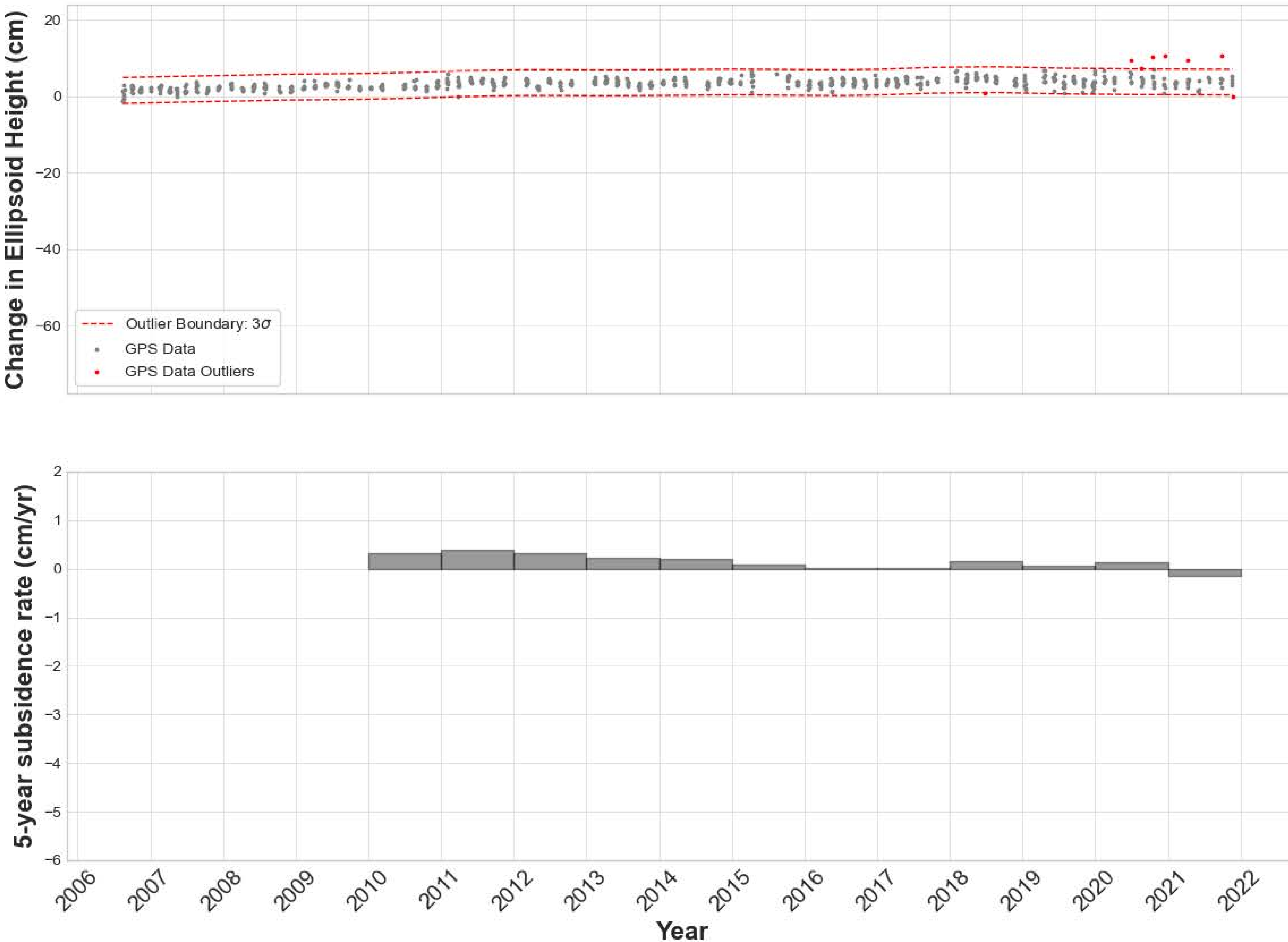
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P034



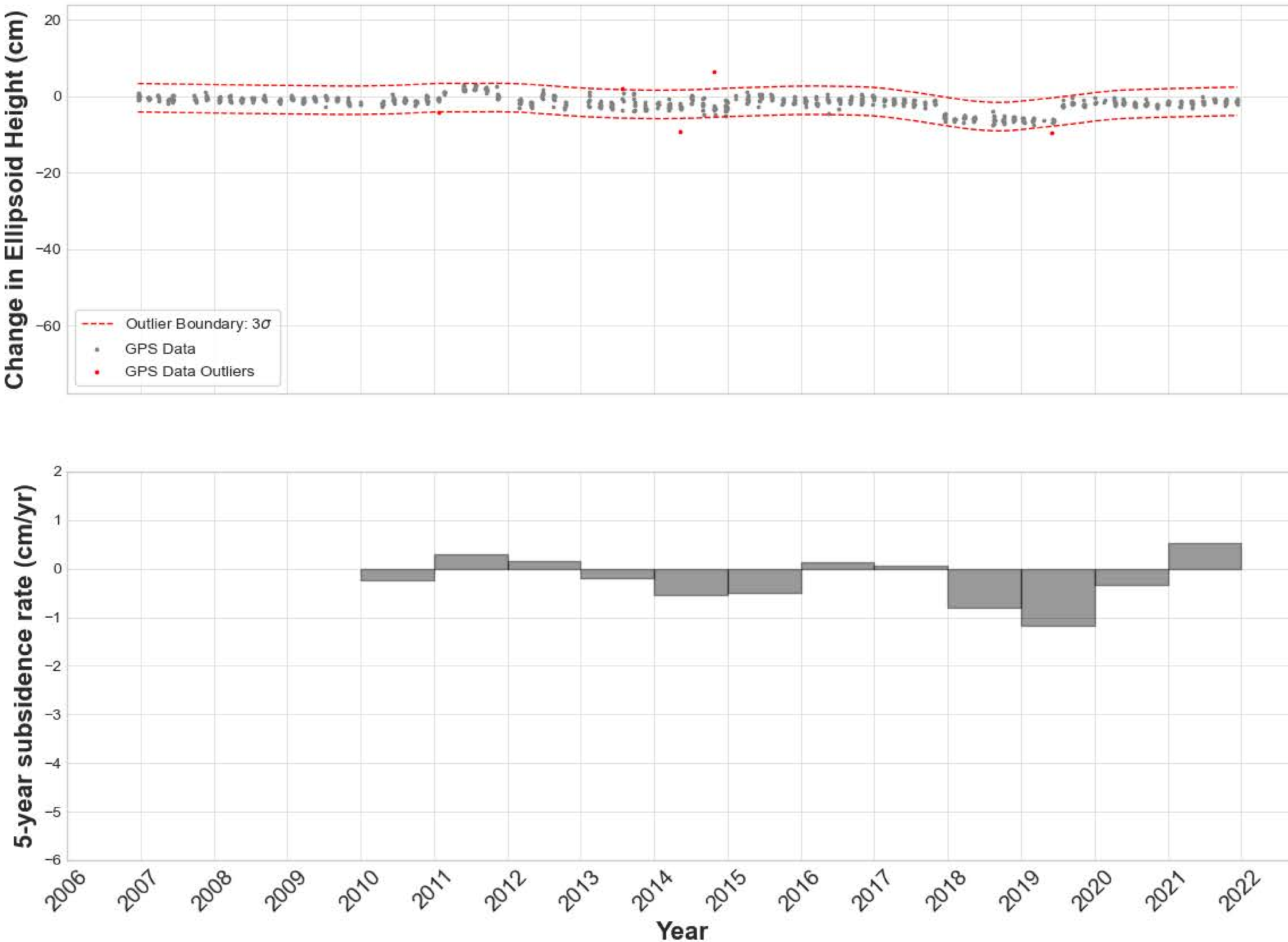
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P035



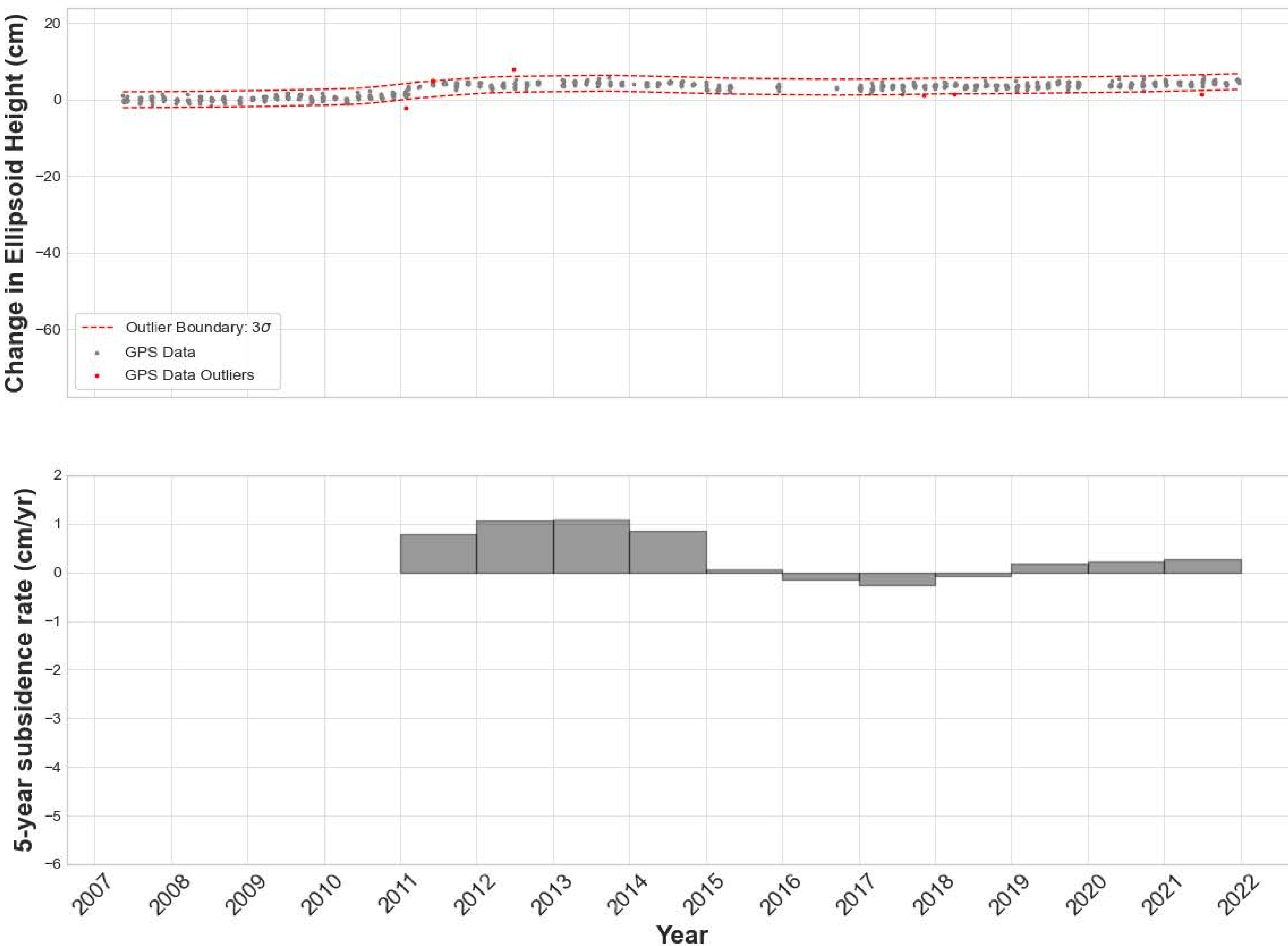
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P036



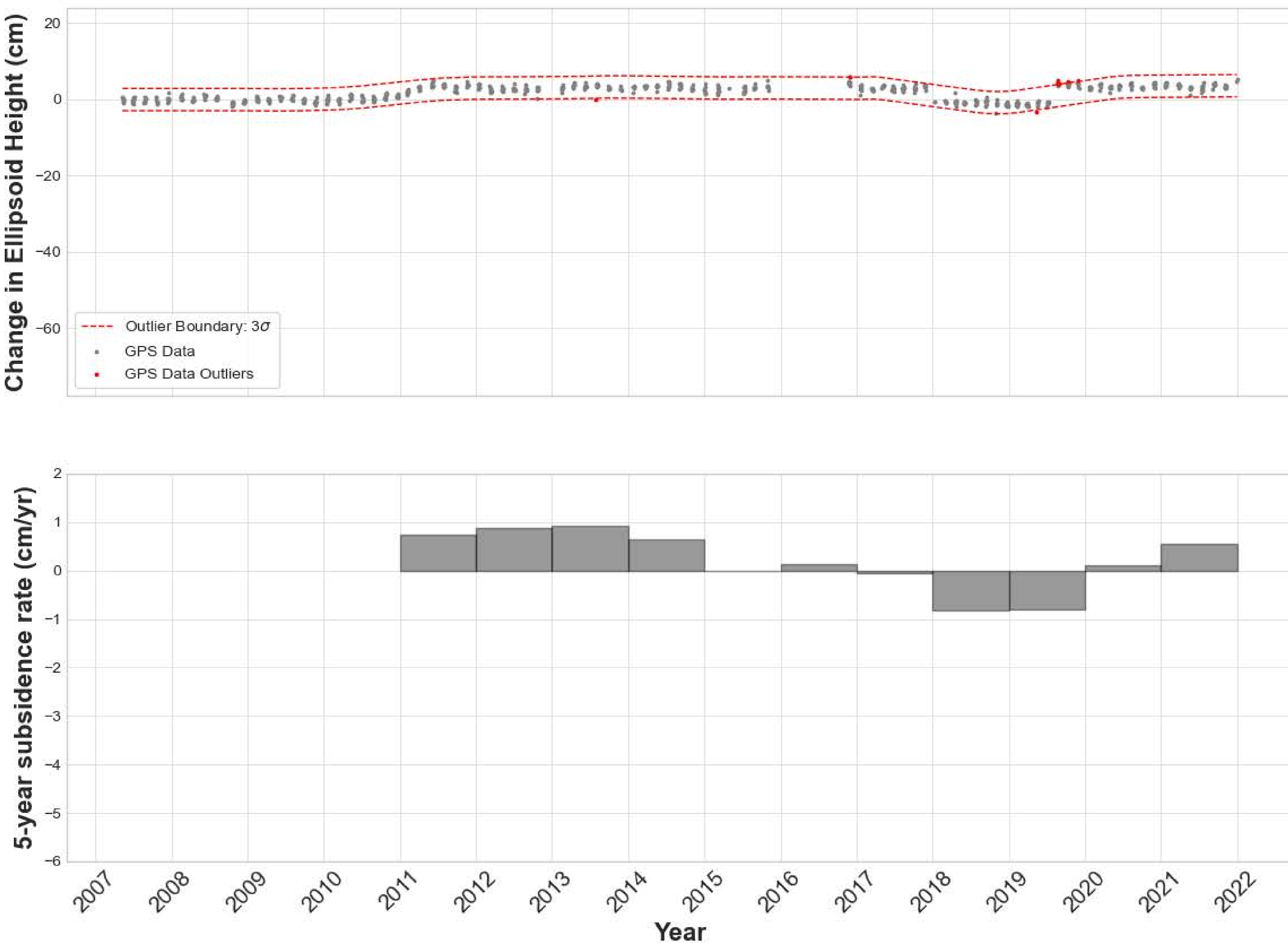
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P037



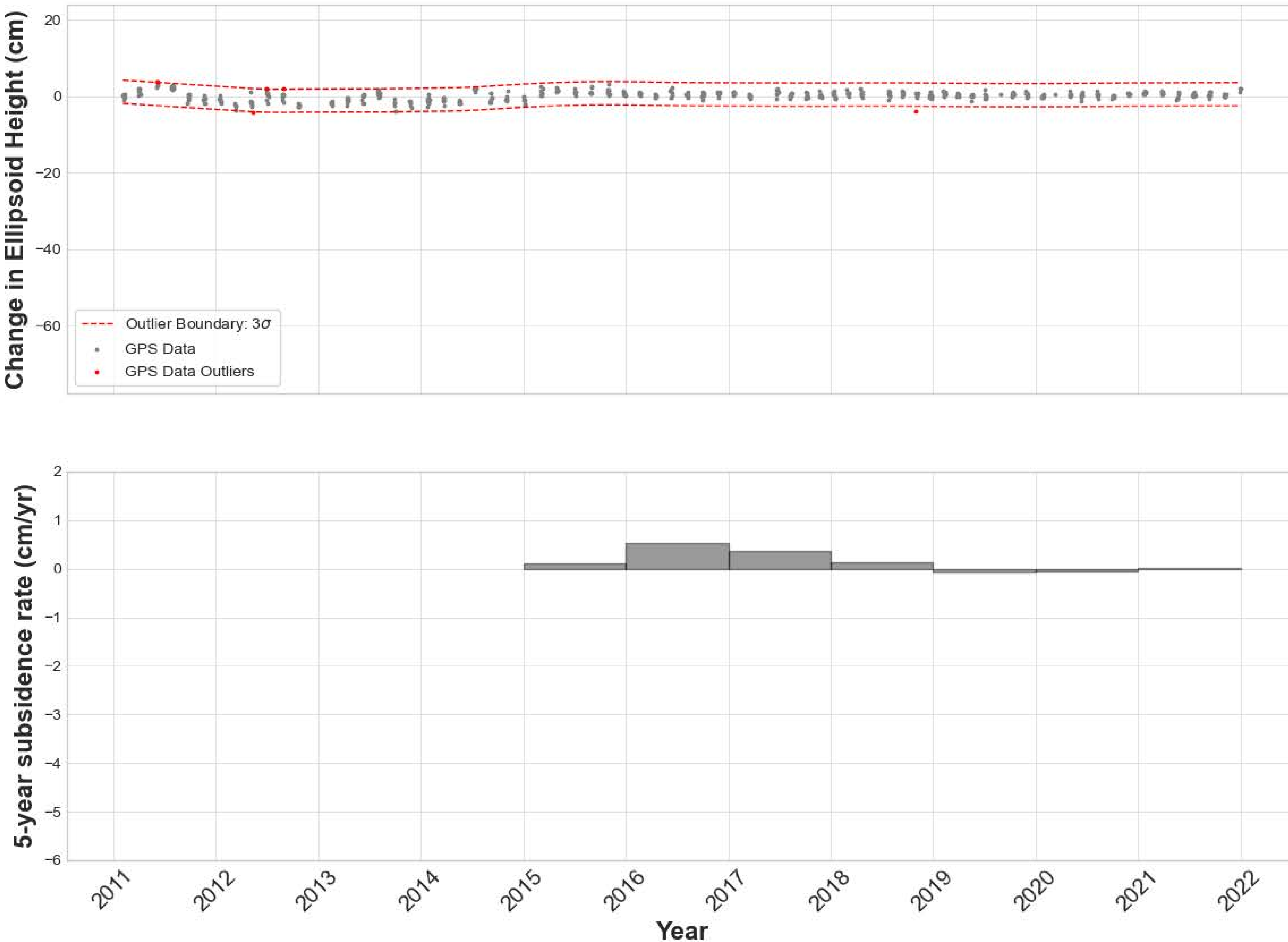
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P038



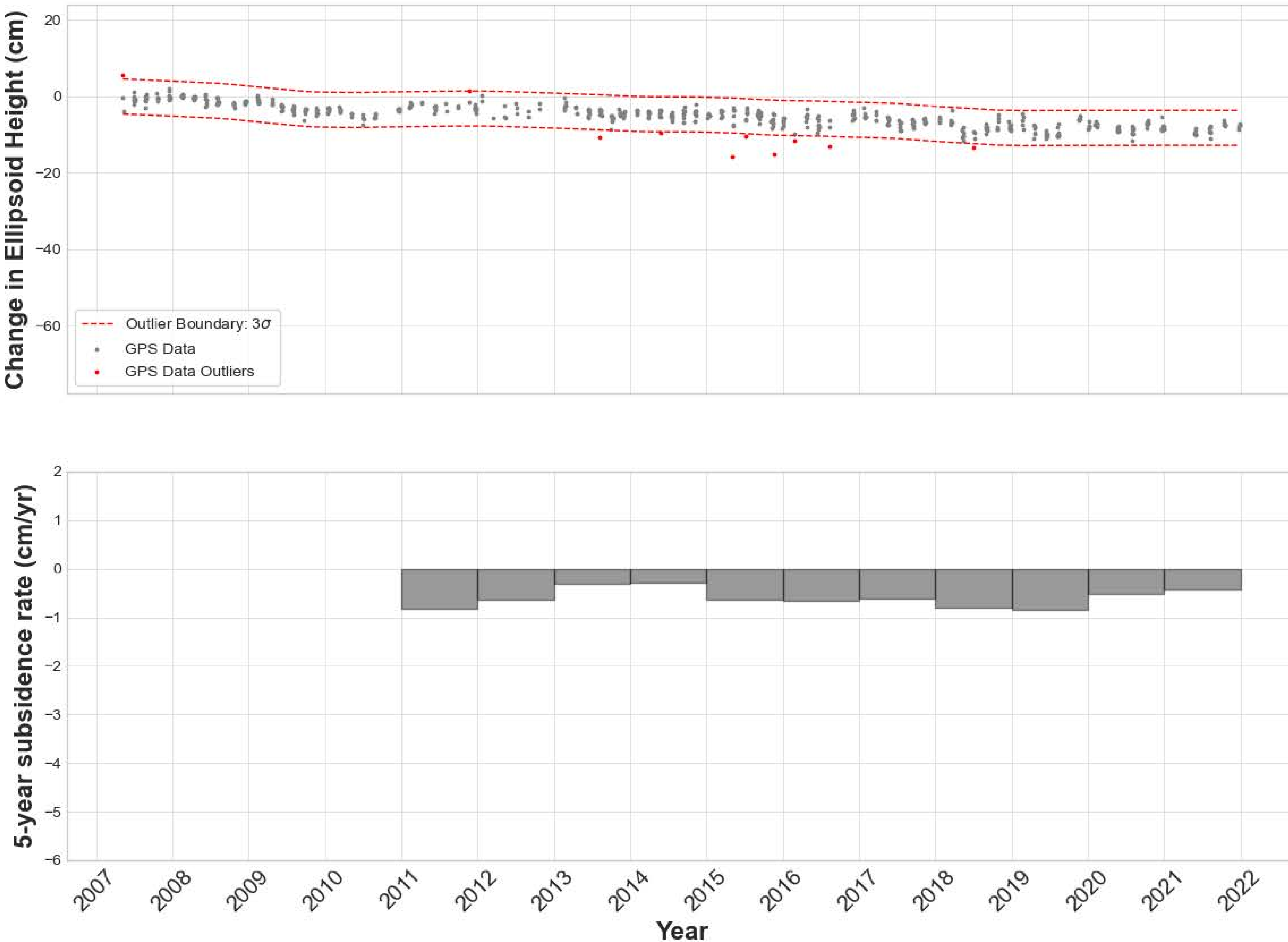
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P039



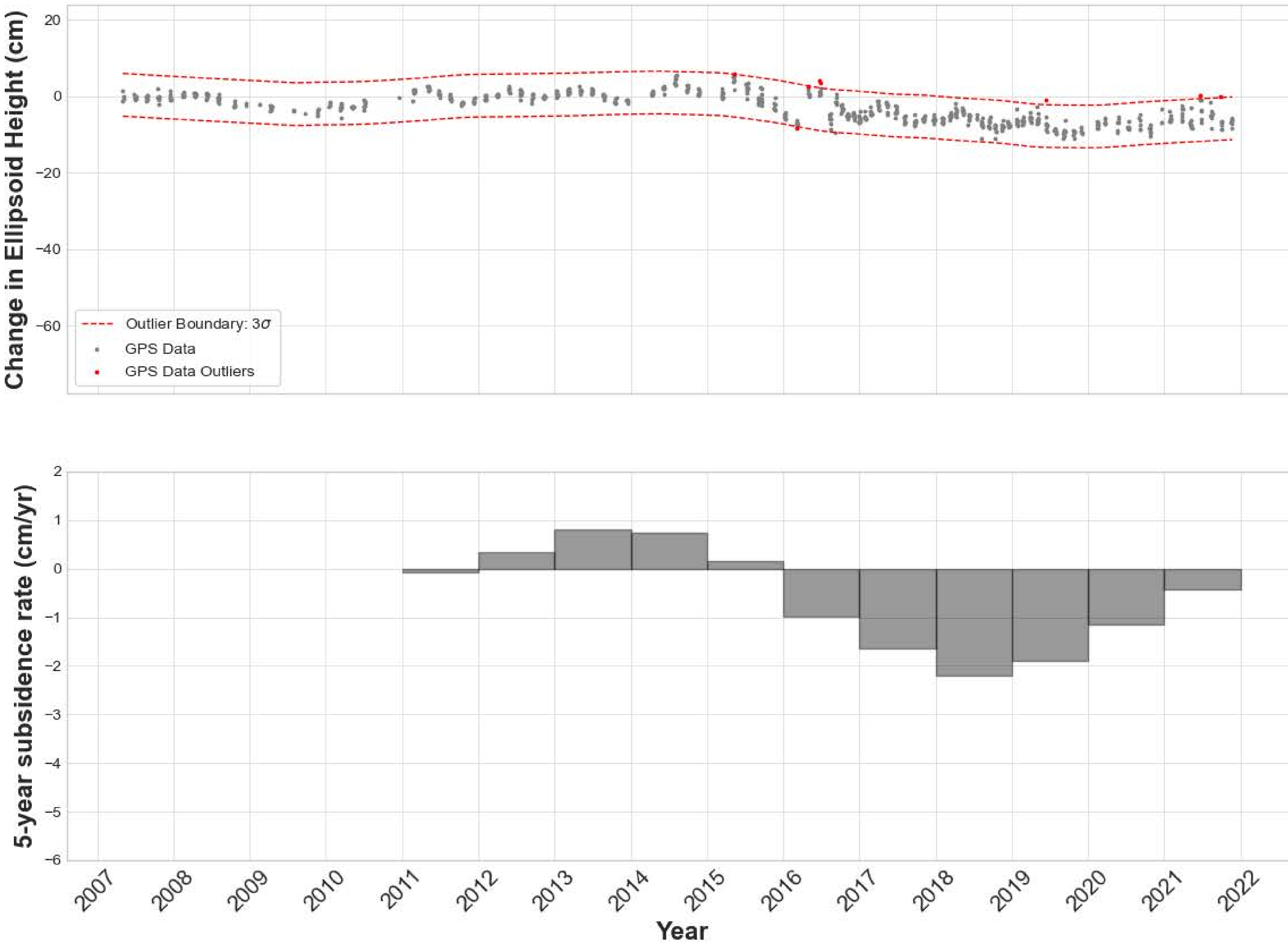
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P040



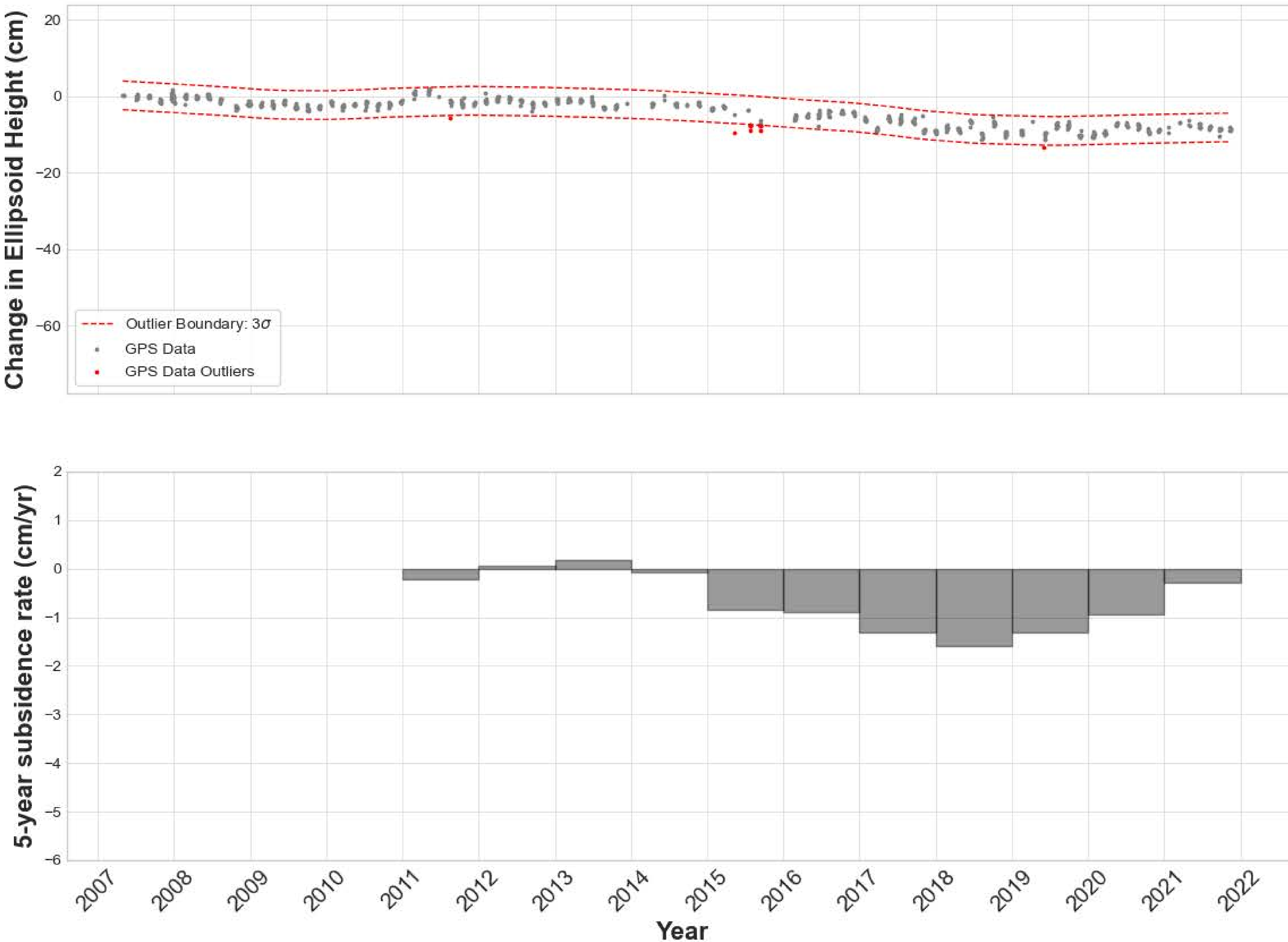
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P041



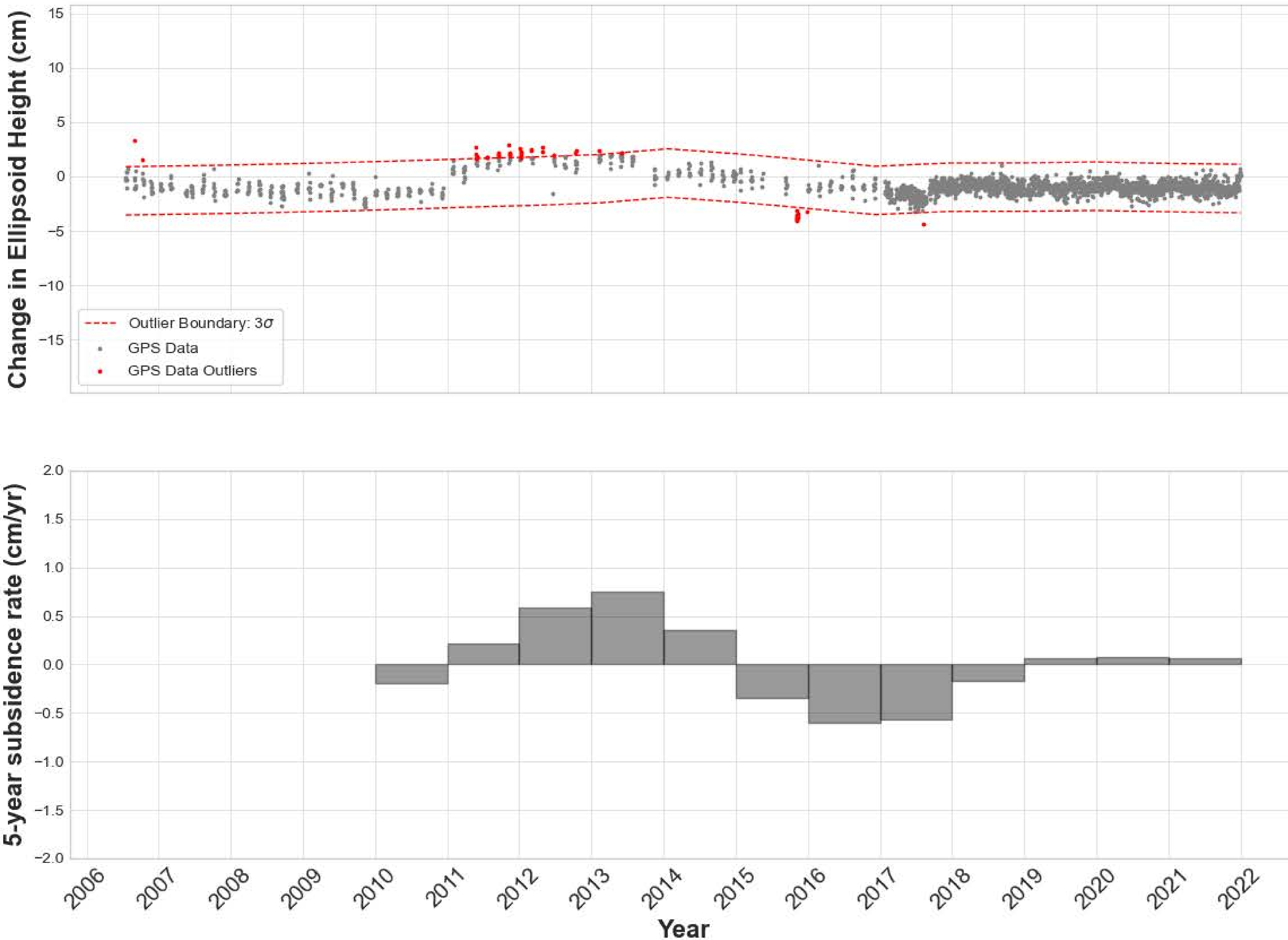
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P042



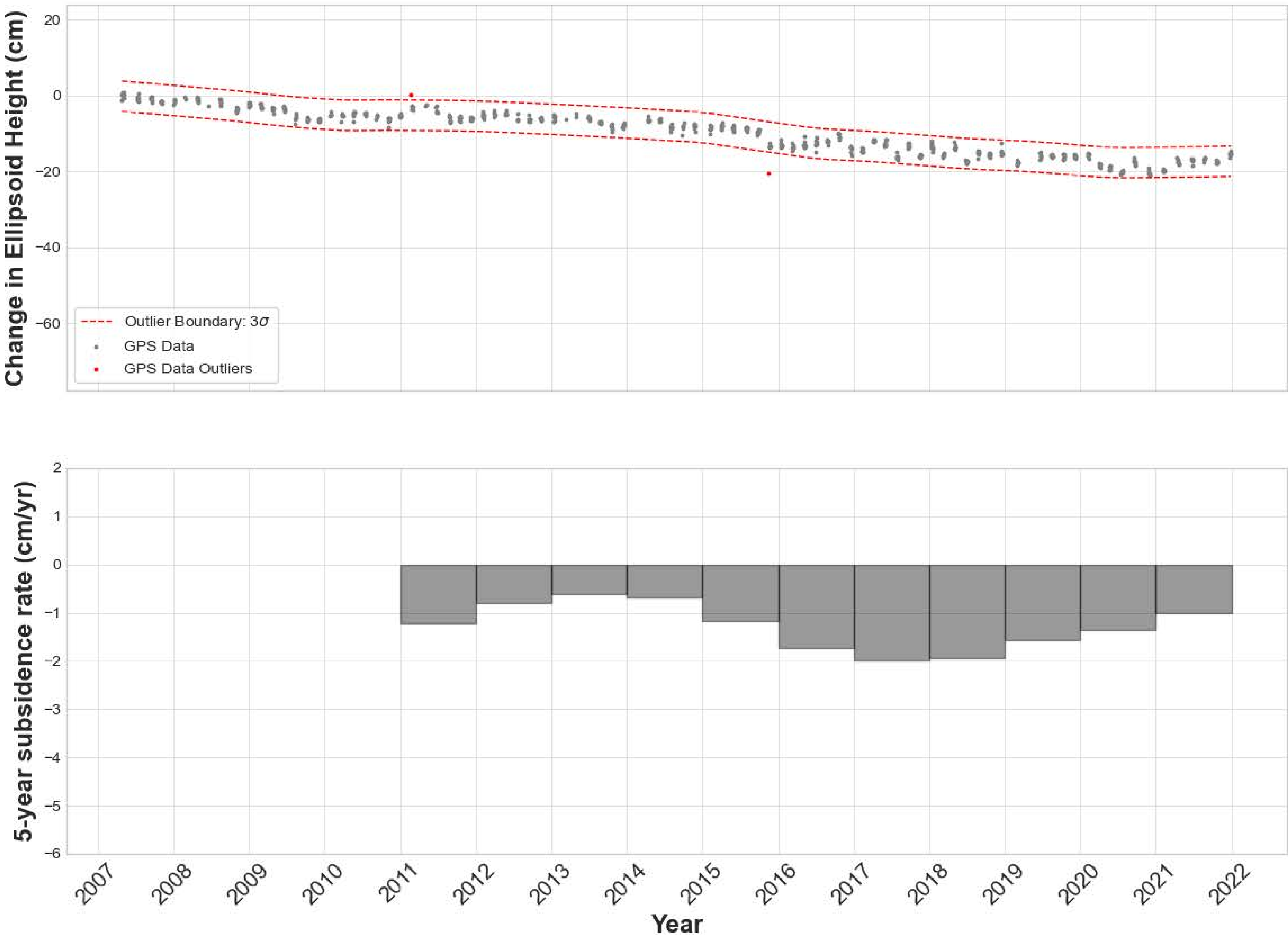
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P043



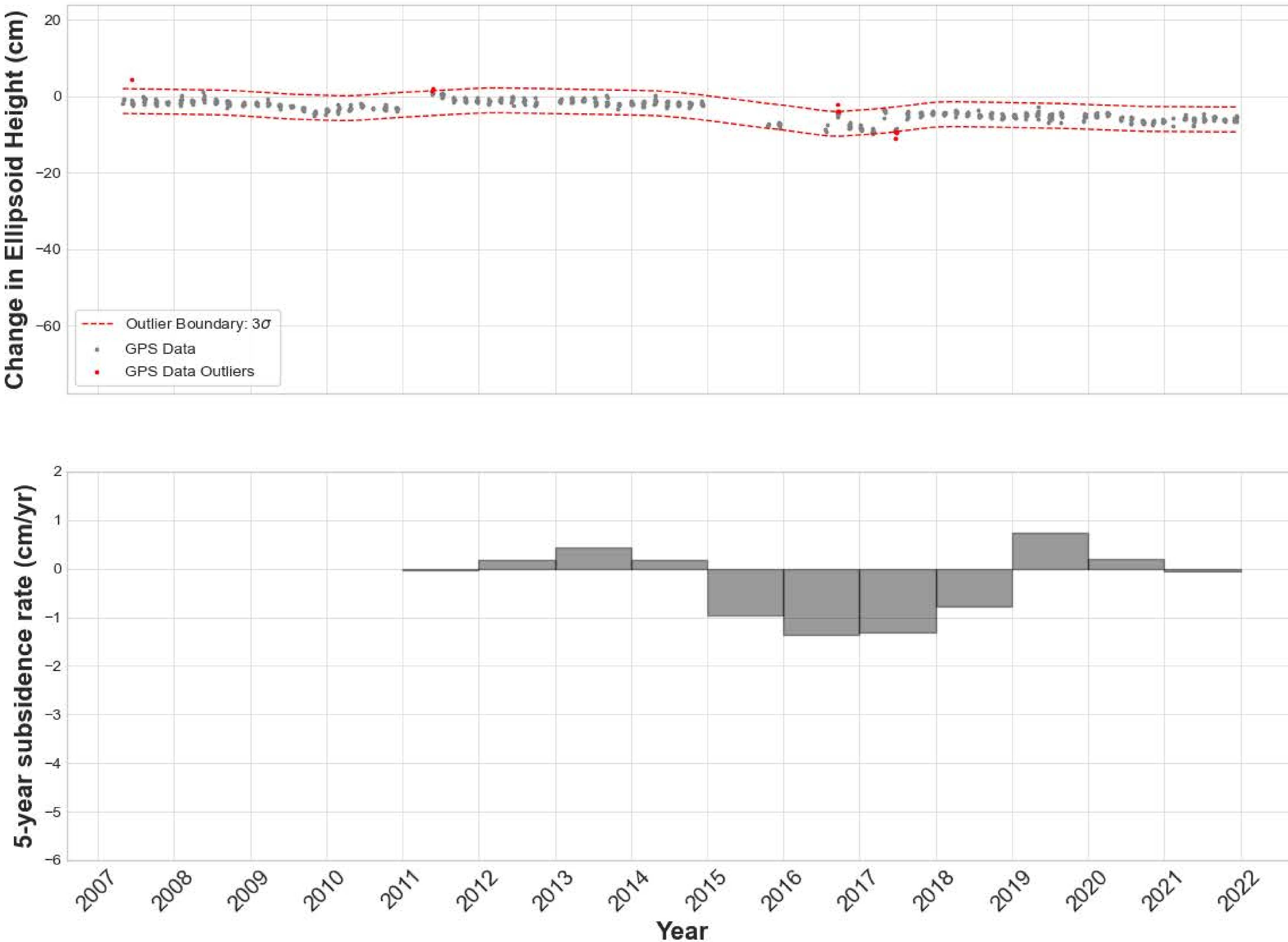
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P044



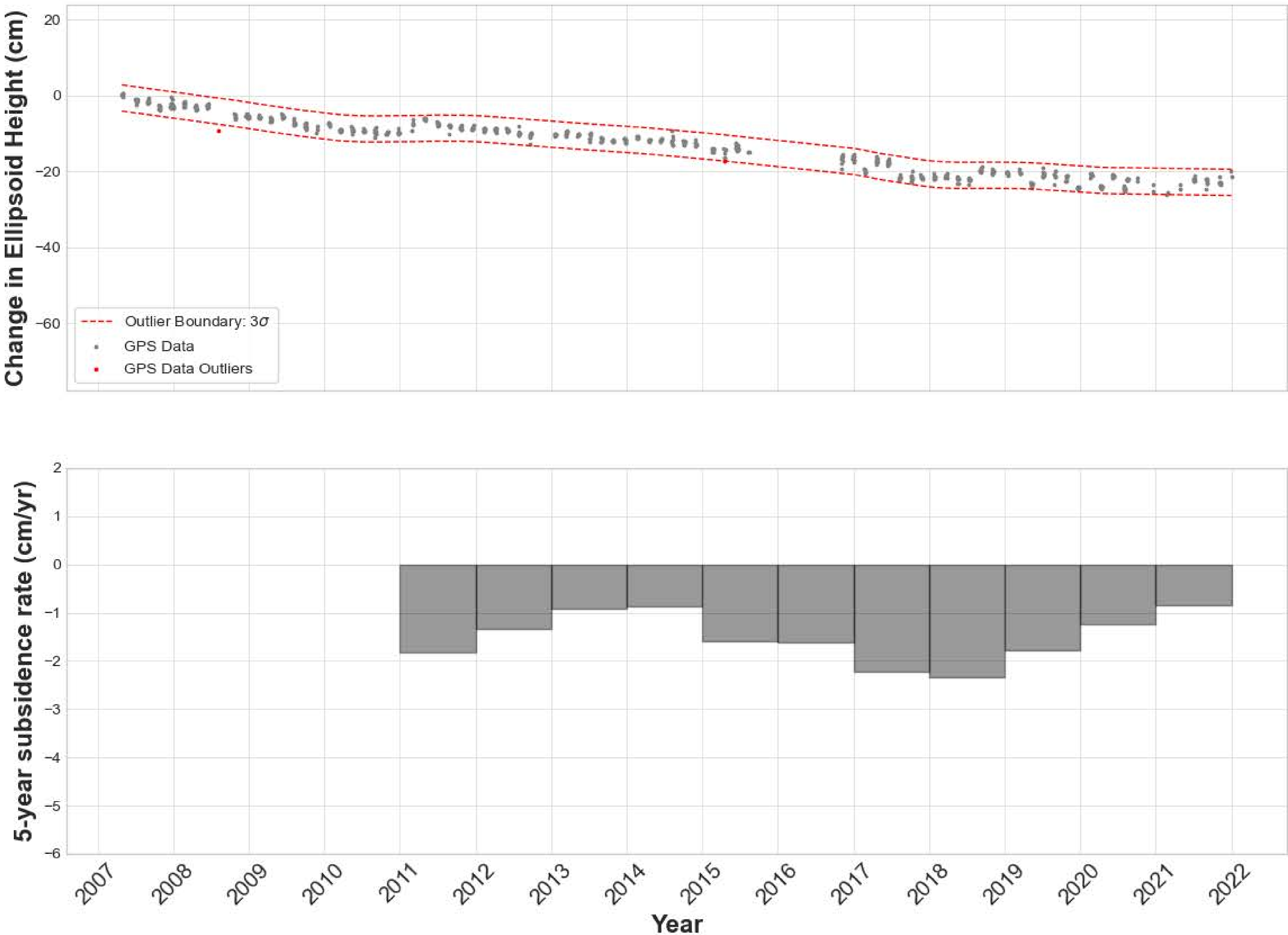
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P045



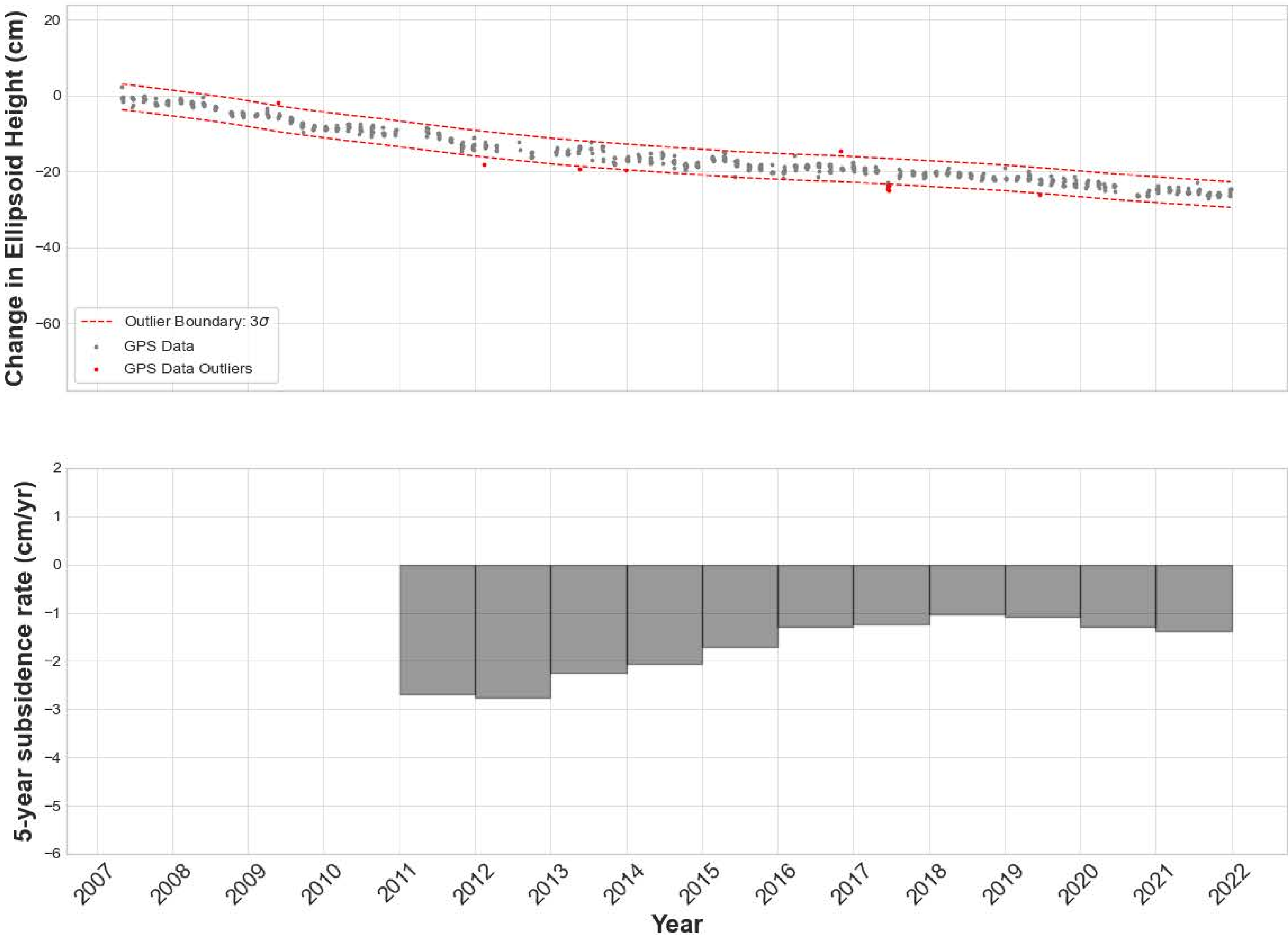
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P046



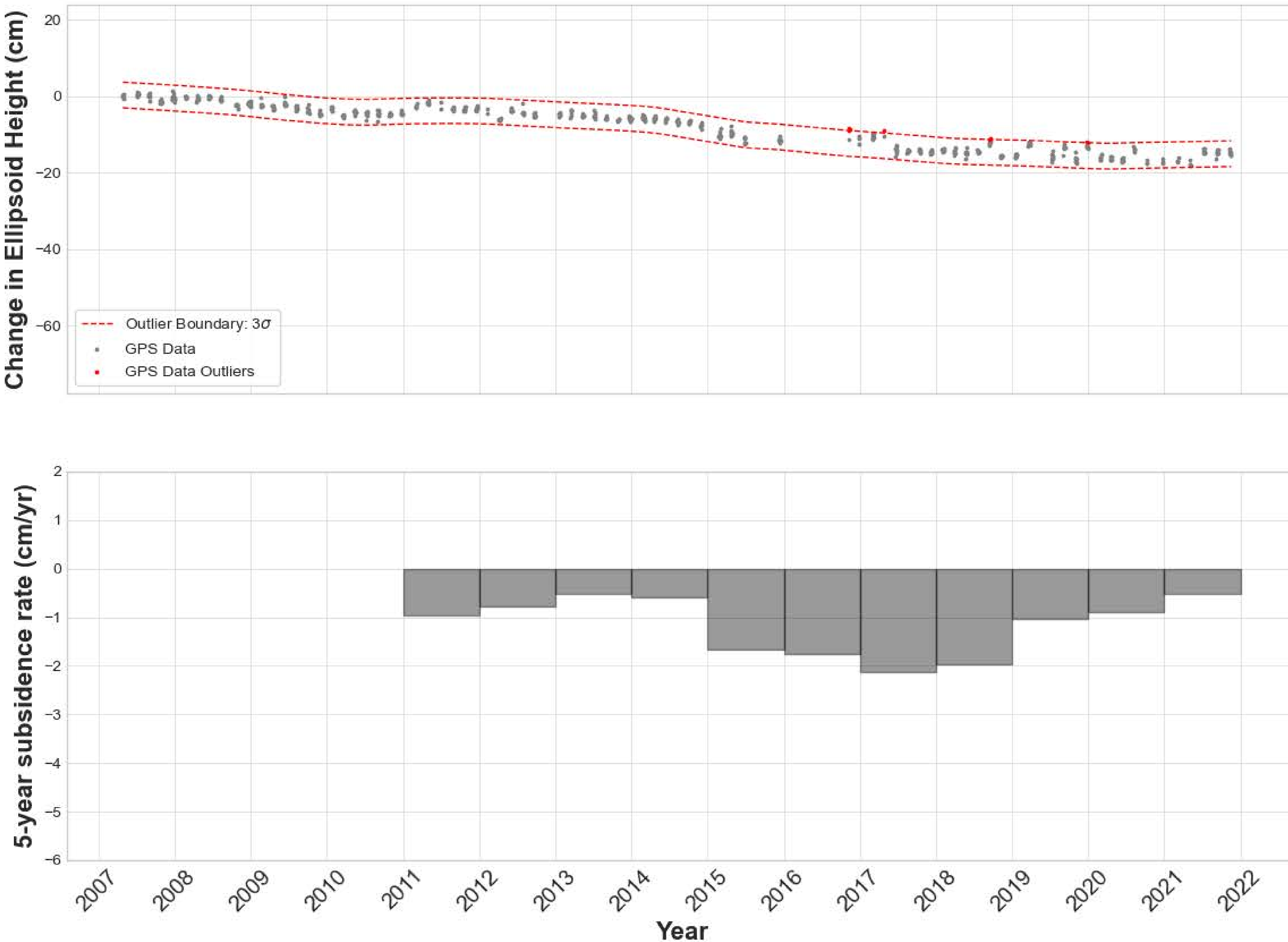
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P047



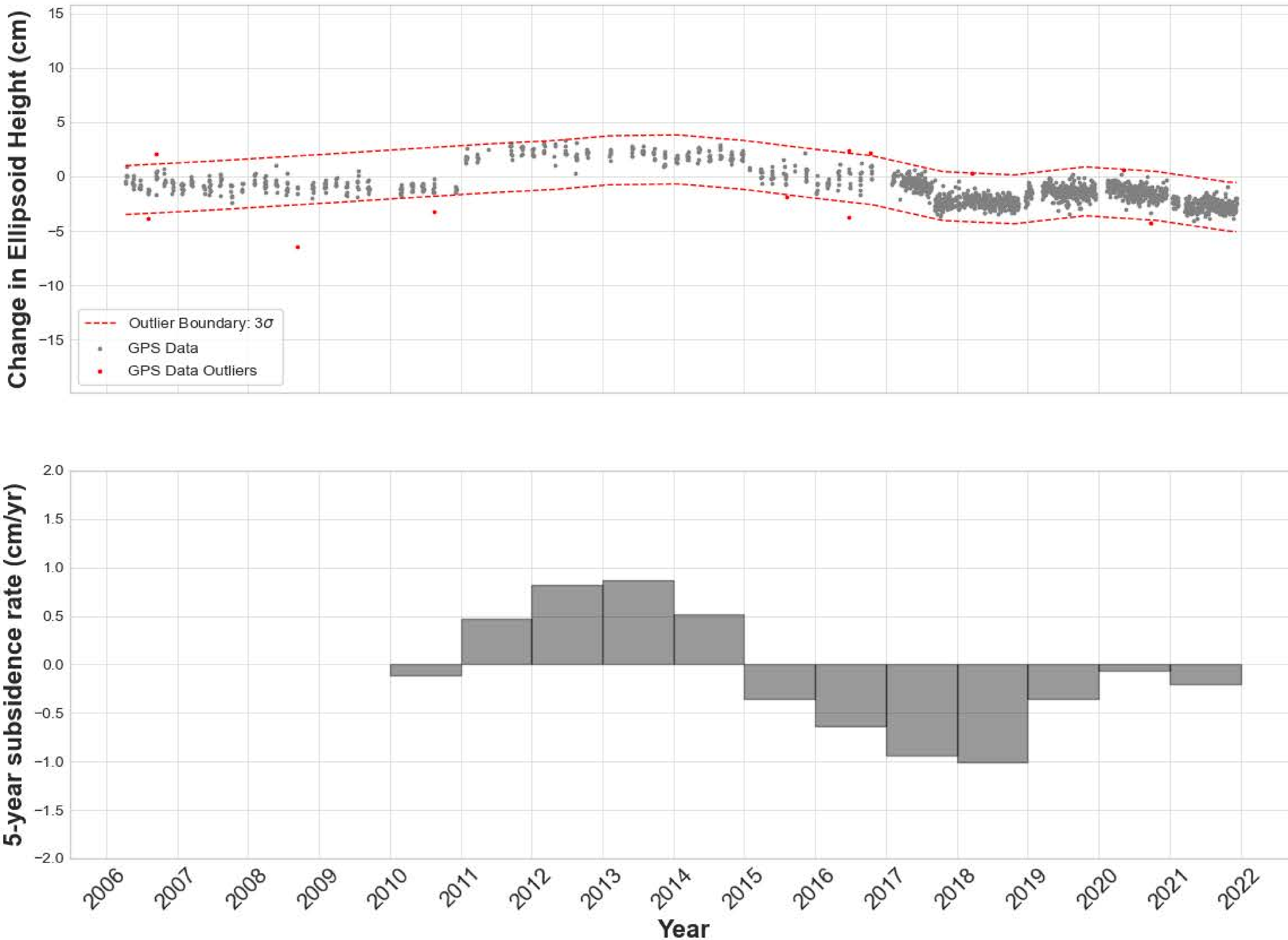
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P048



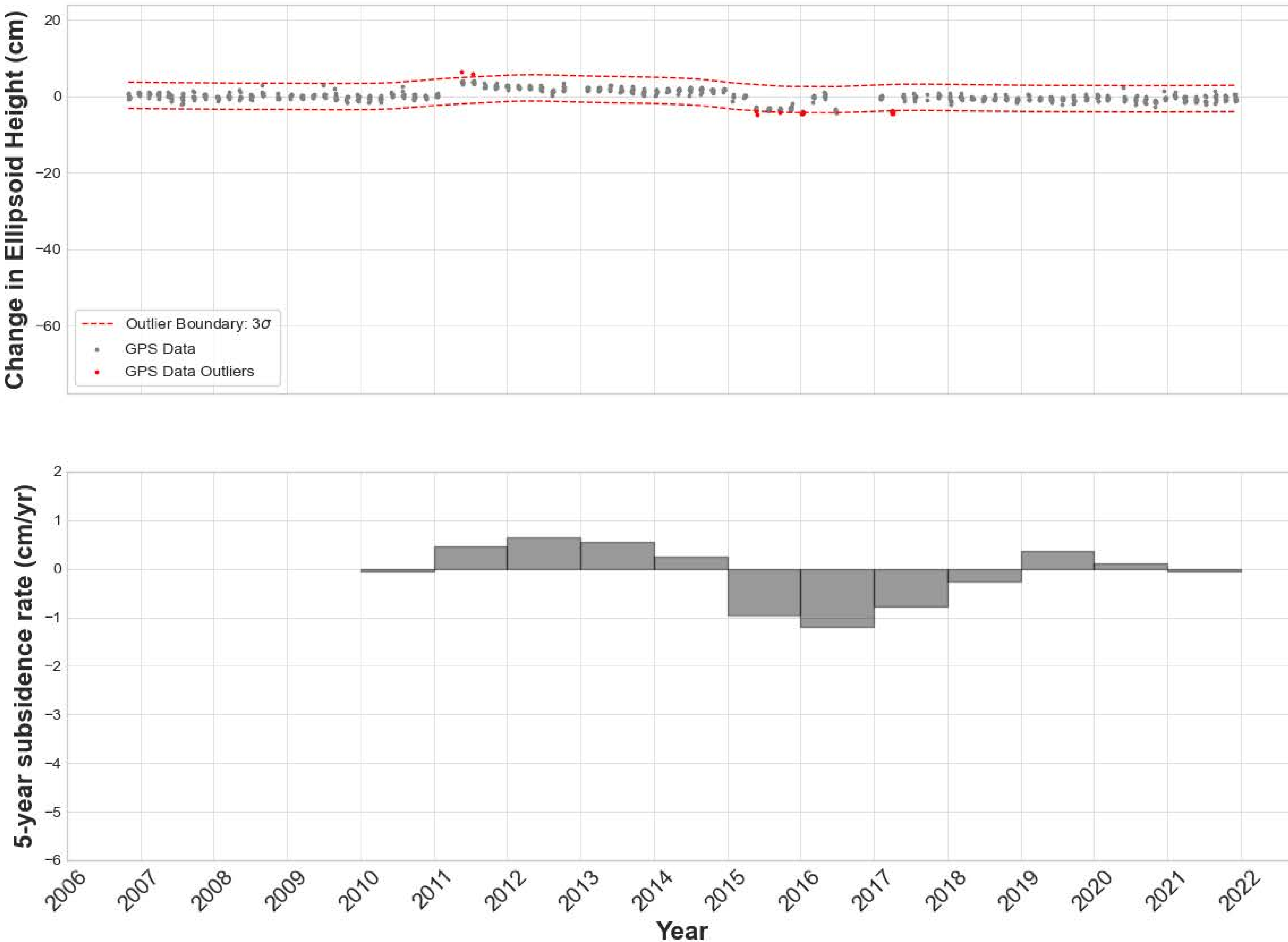
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P049



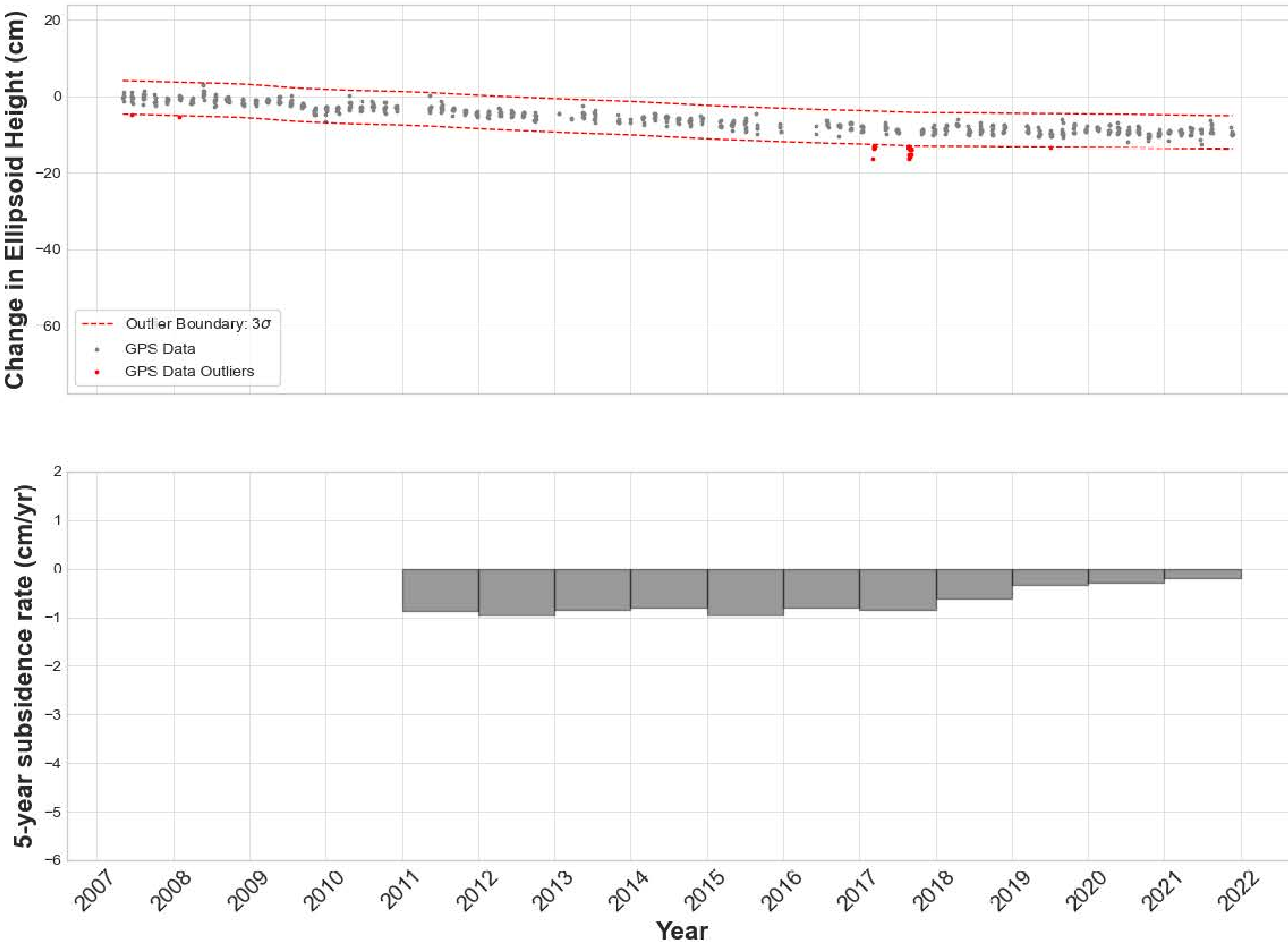
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P050



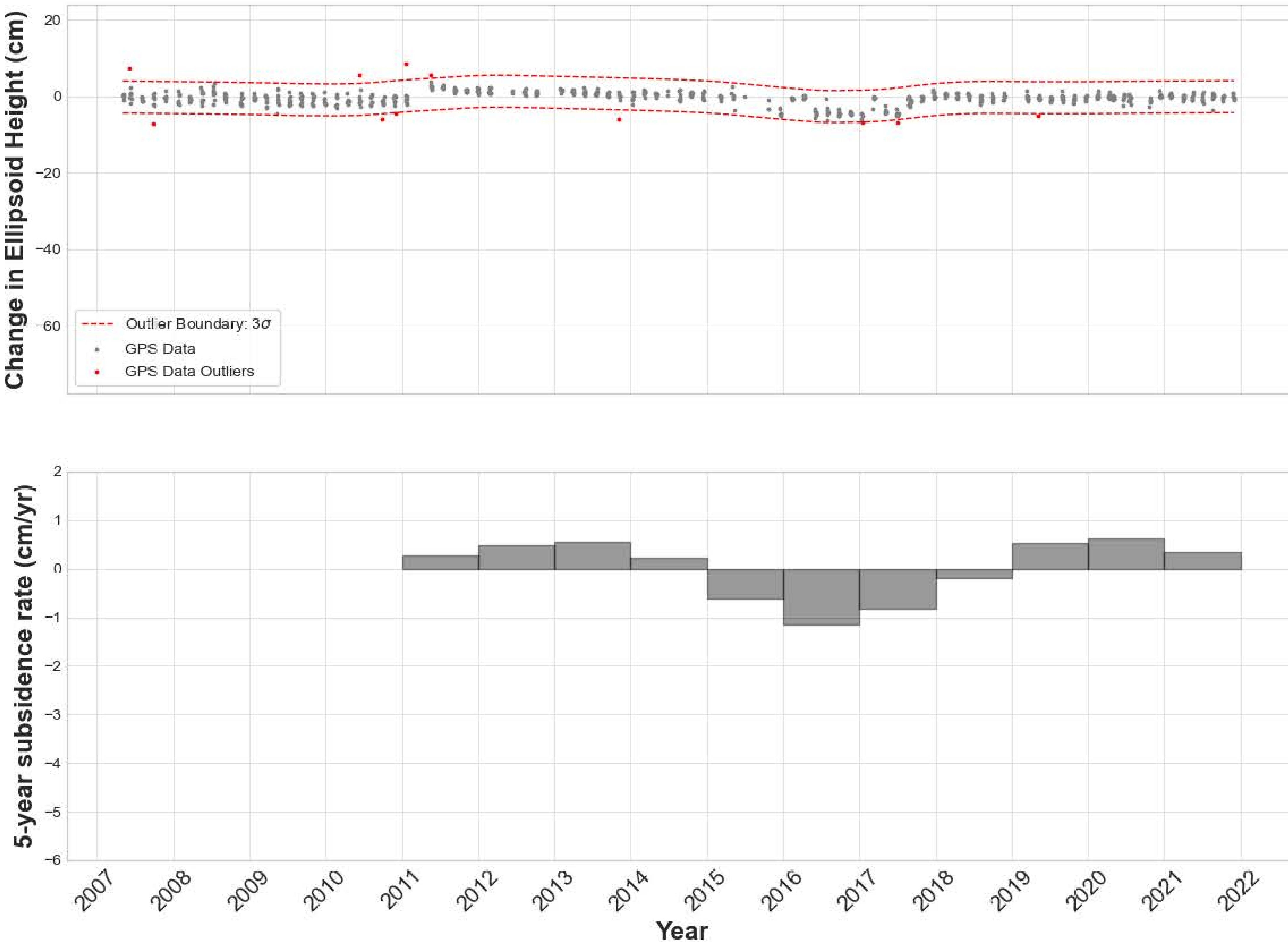
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P051



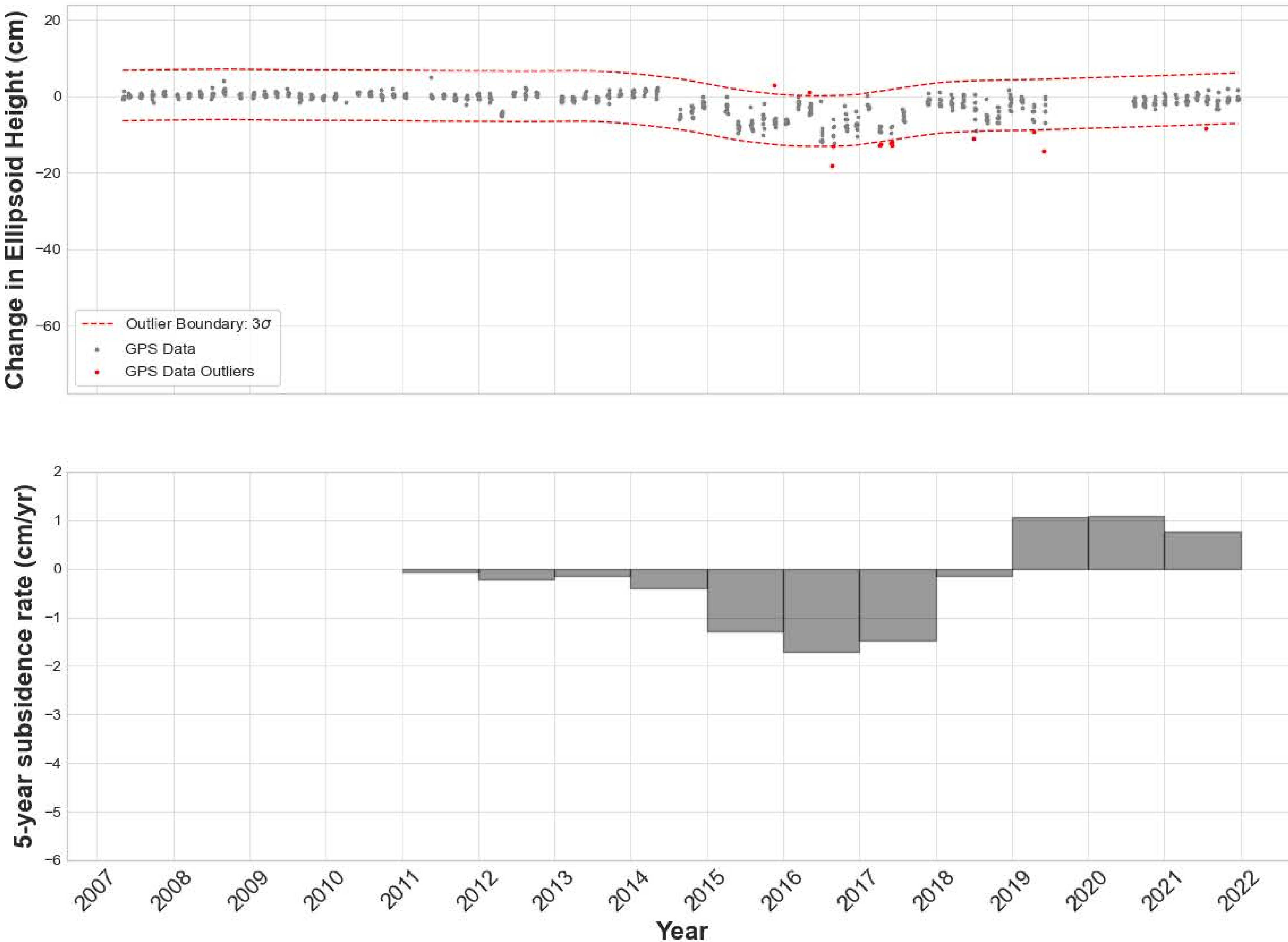
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P052

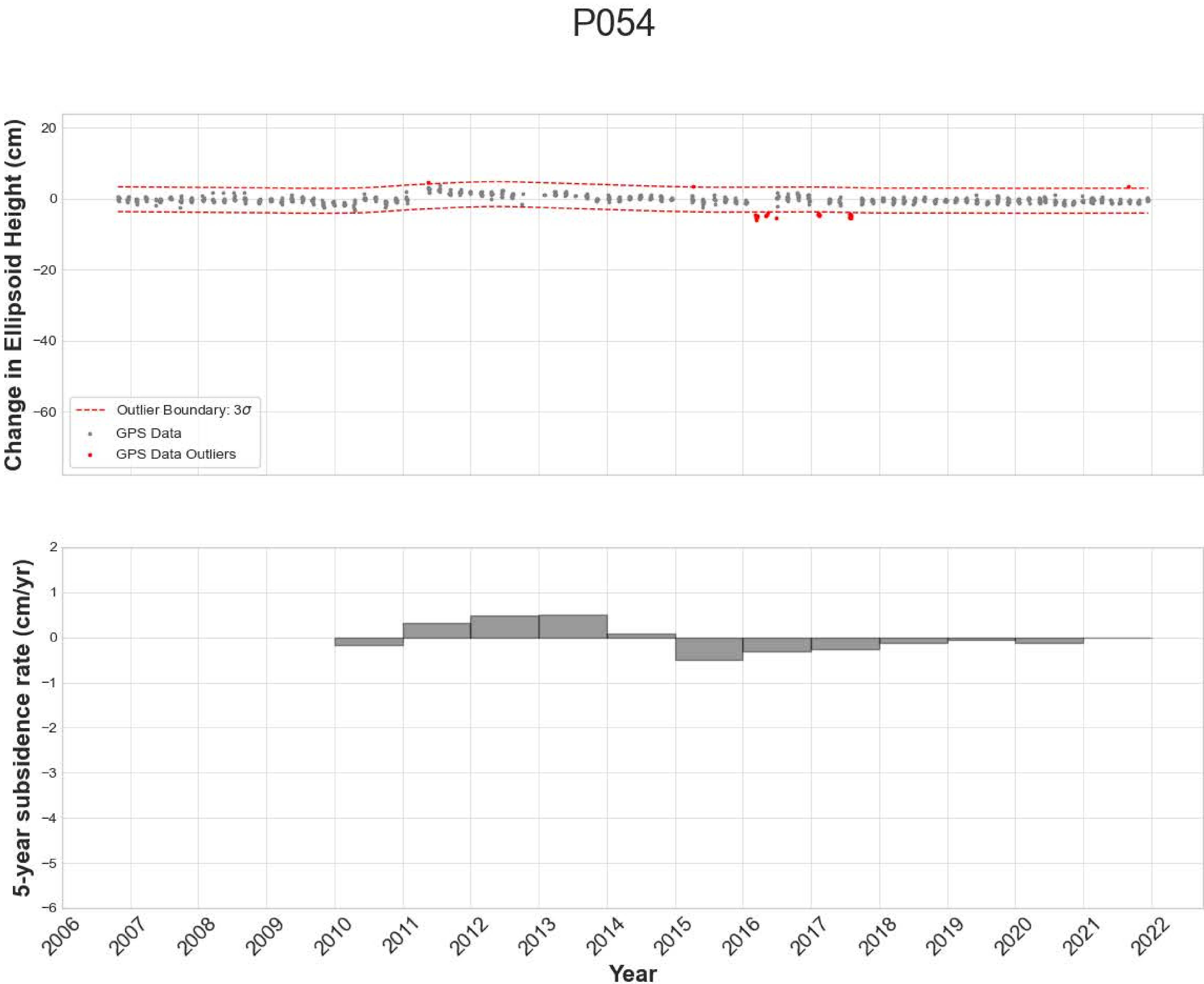


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P053

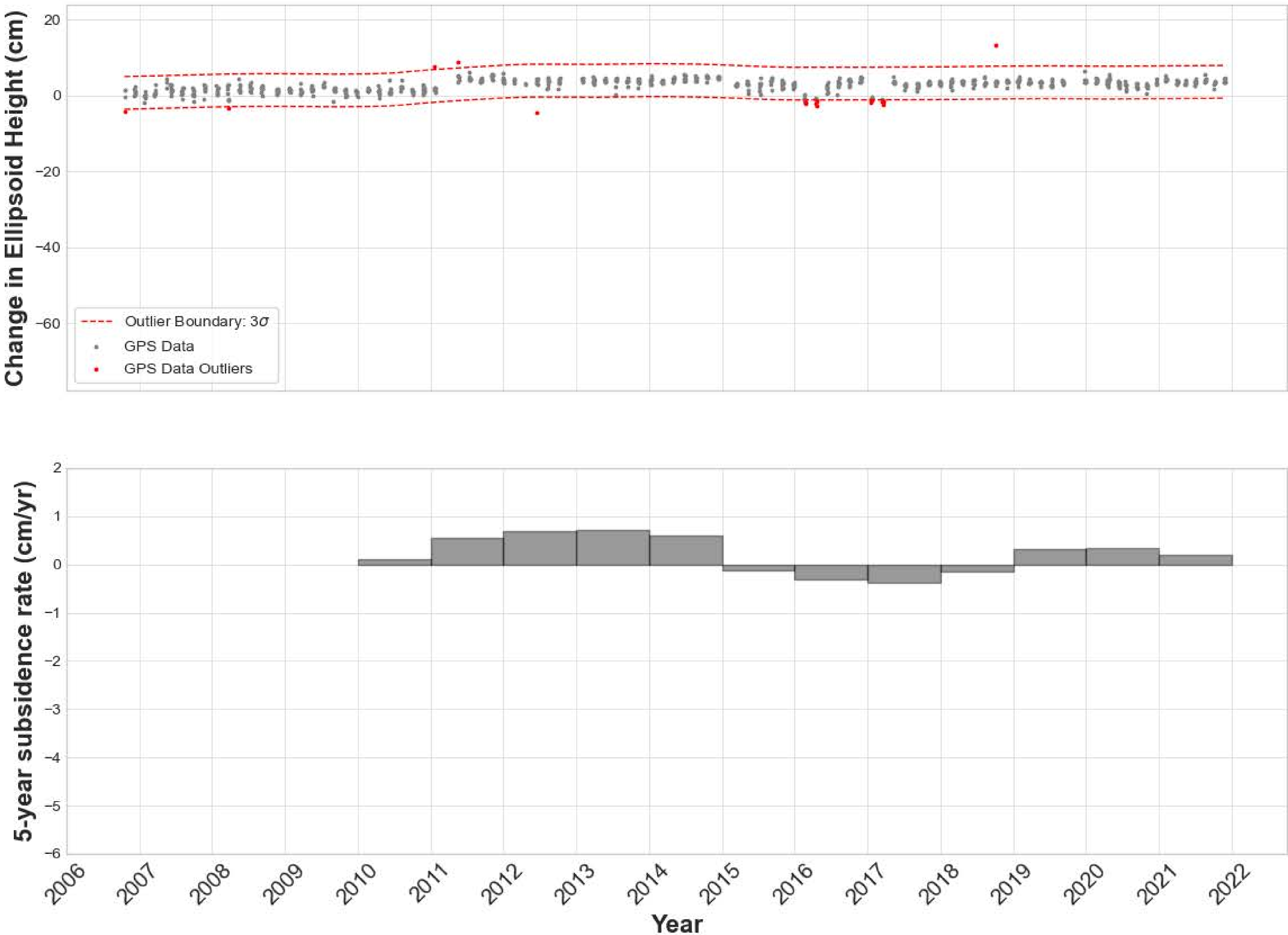


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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



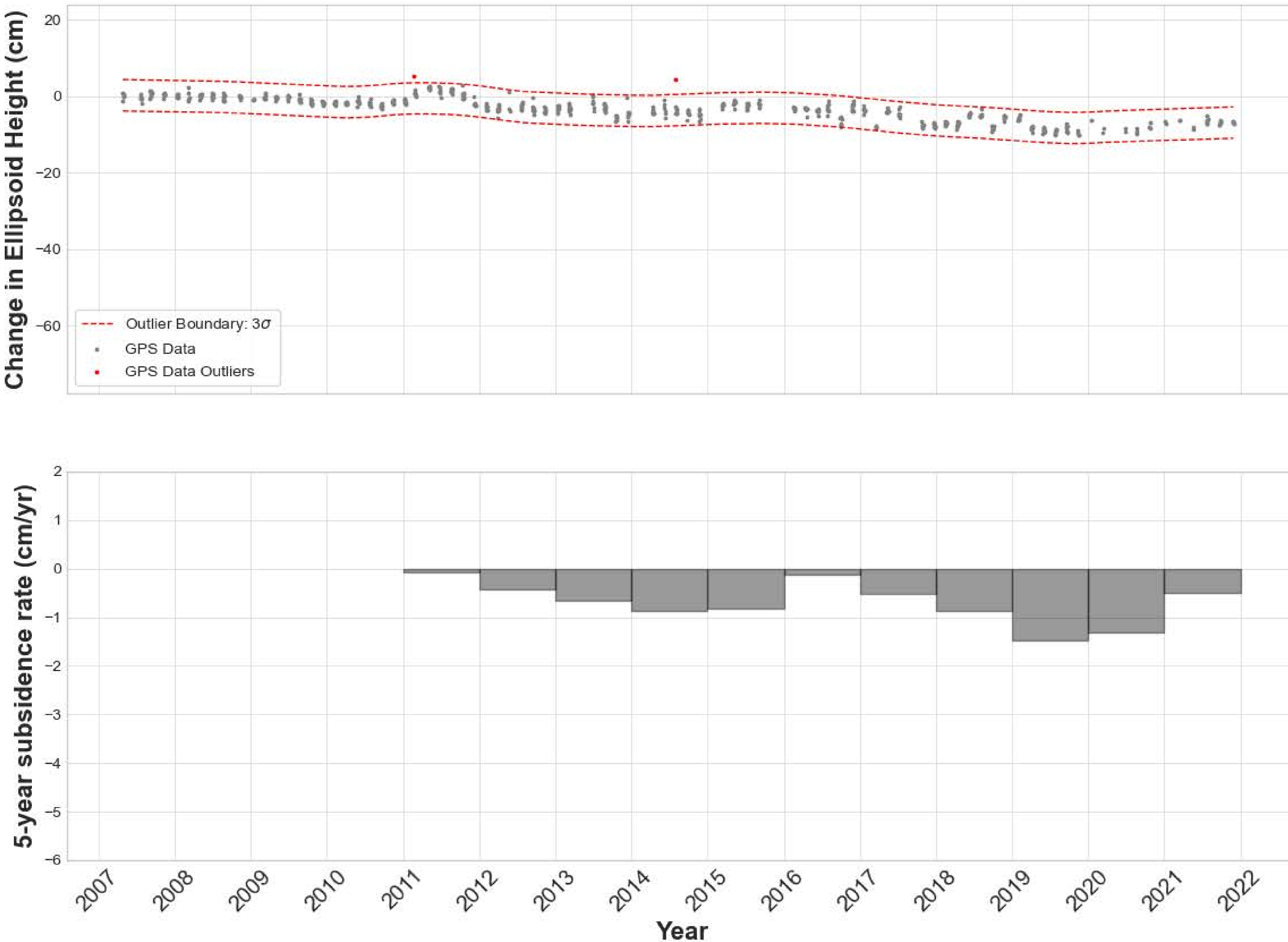
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P055



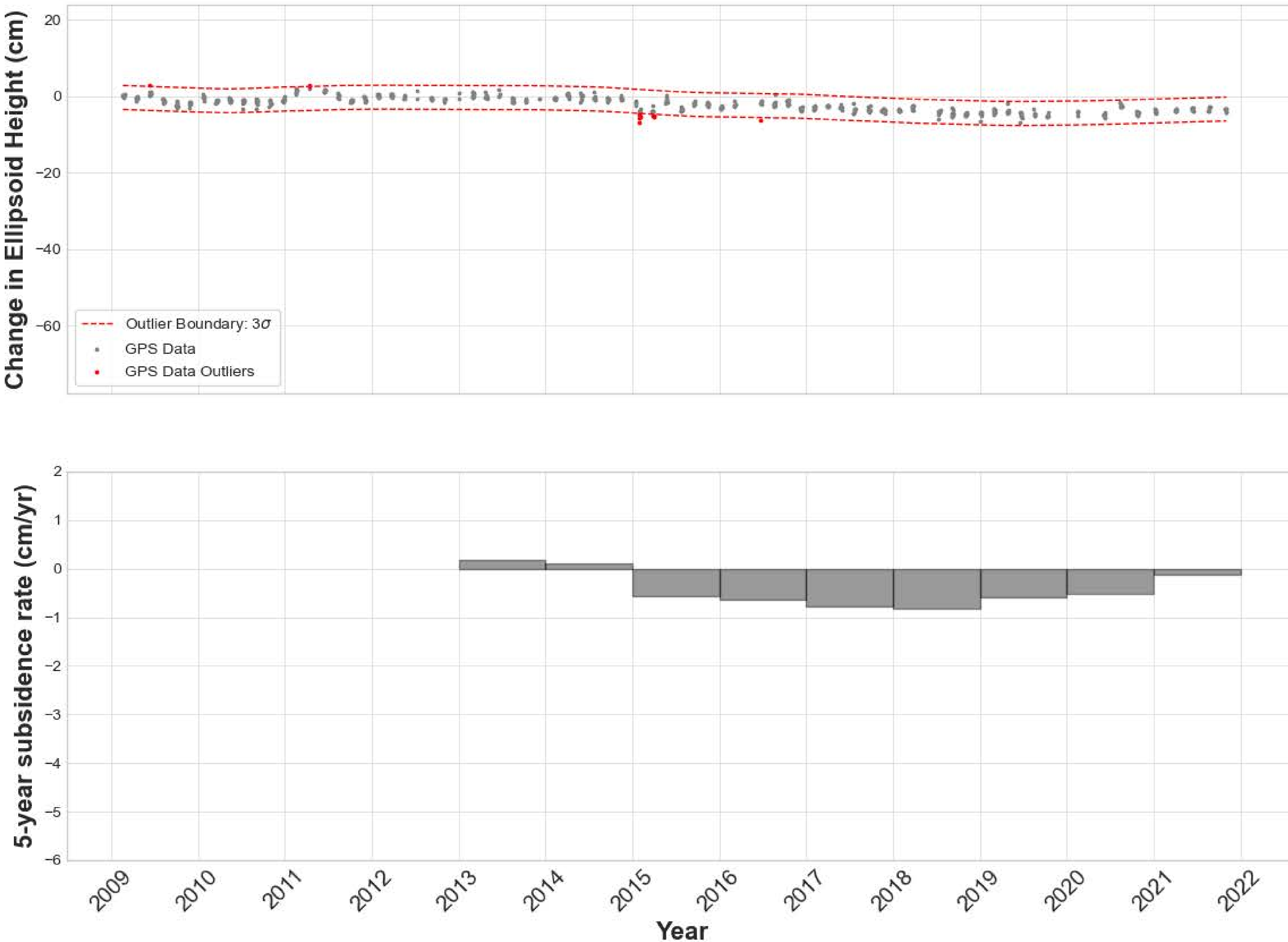
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P056



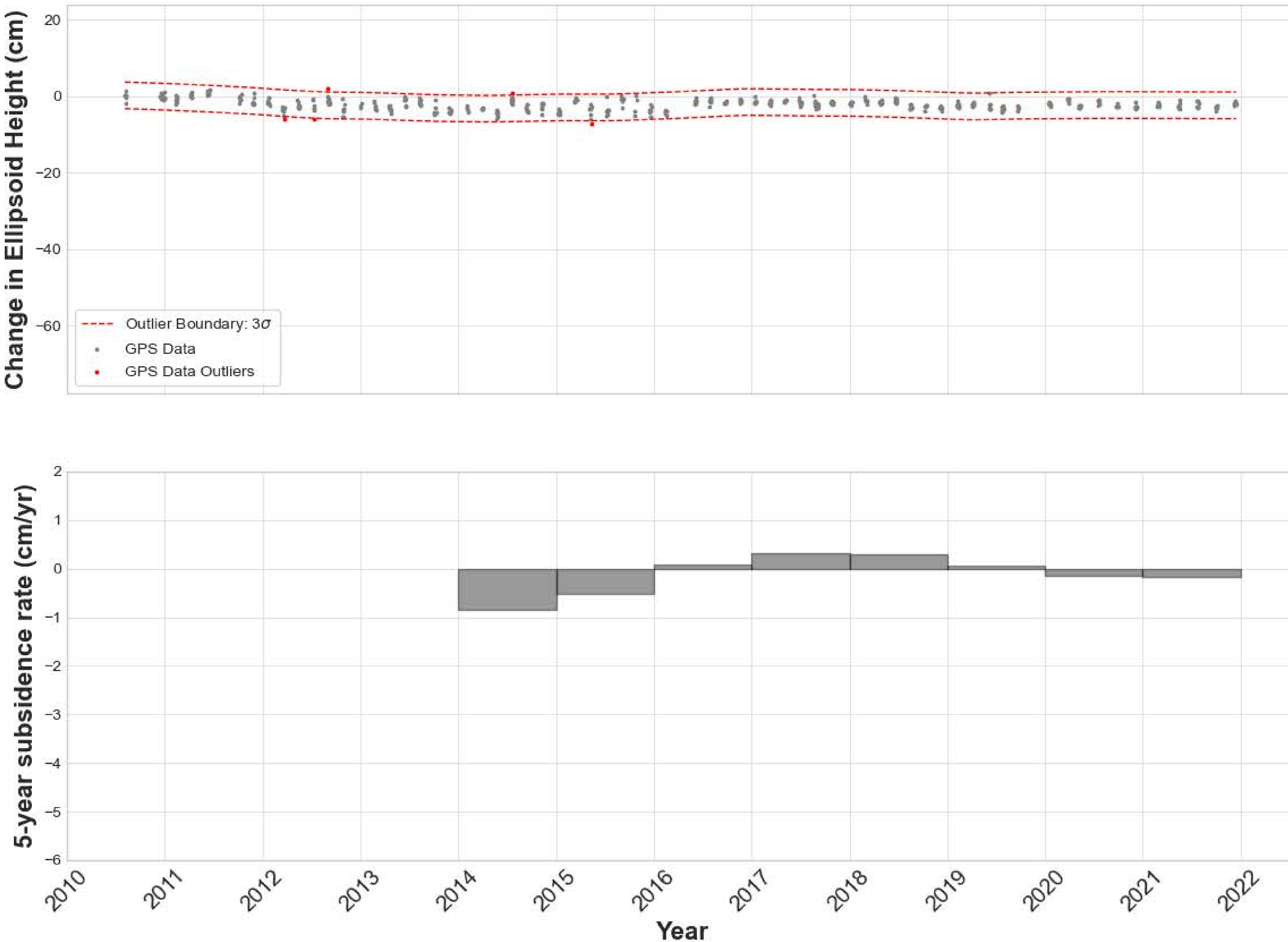
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P057



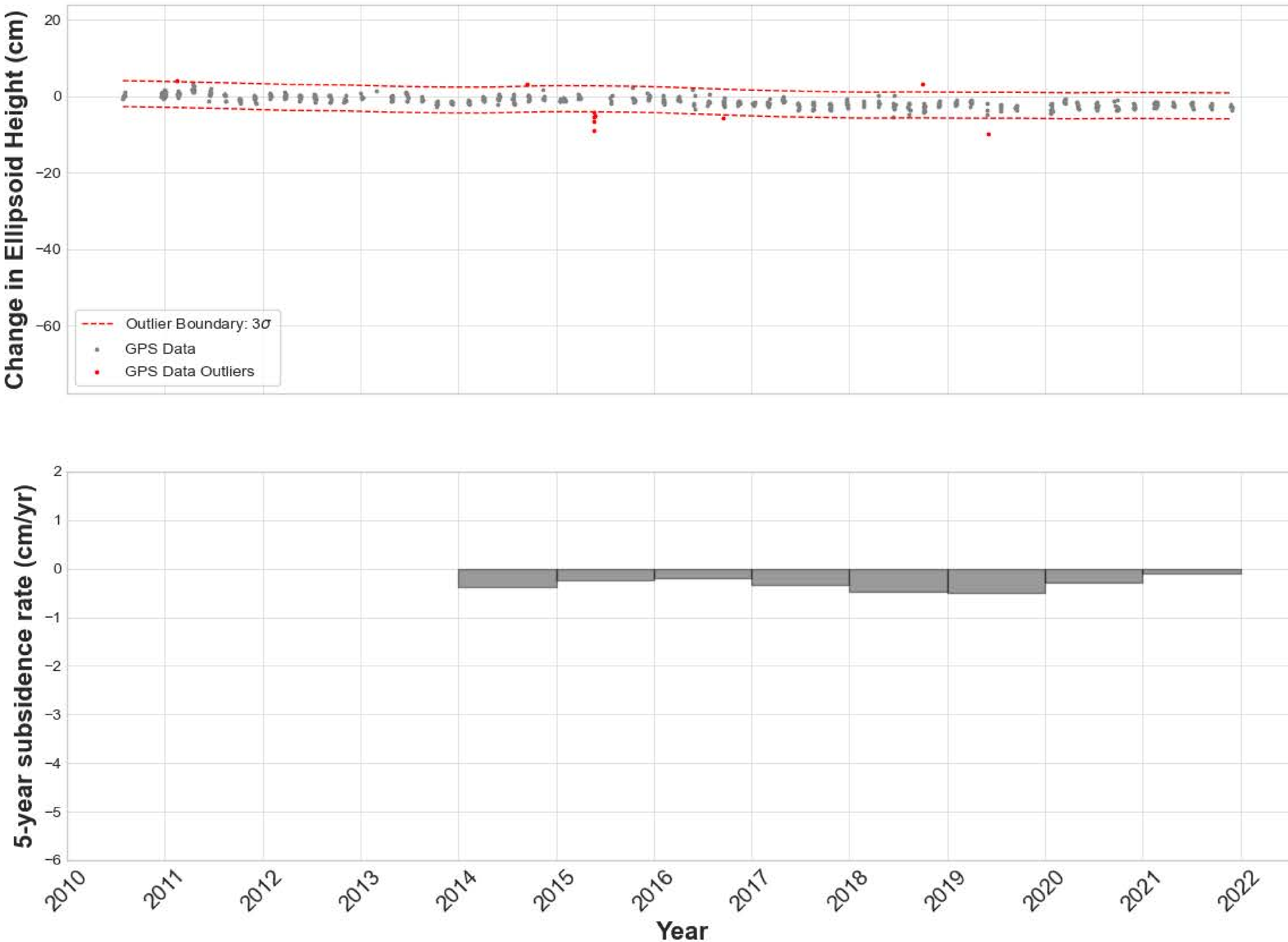
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P058



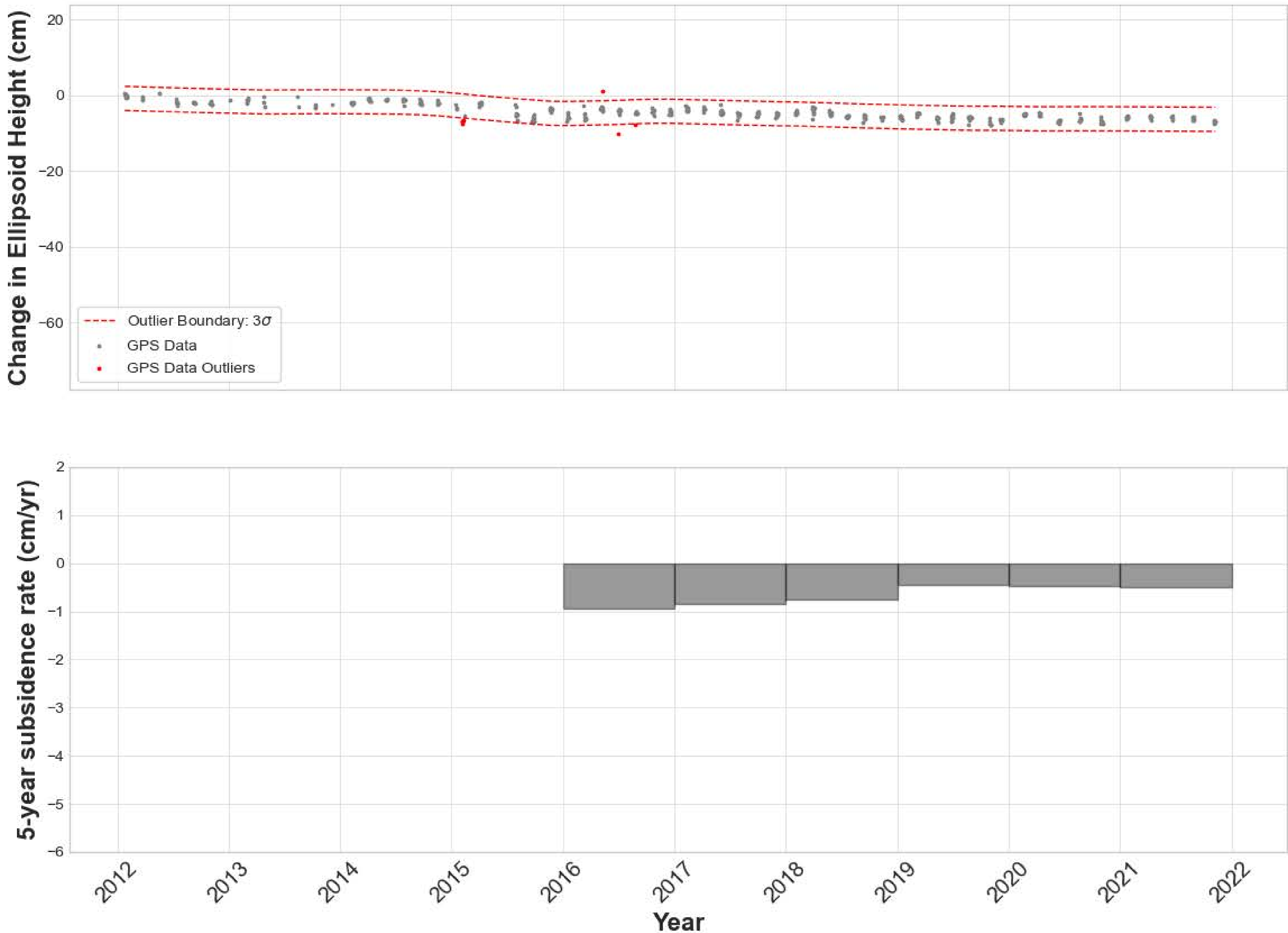
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P059



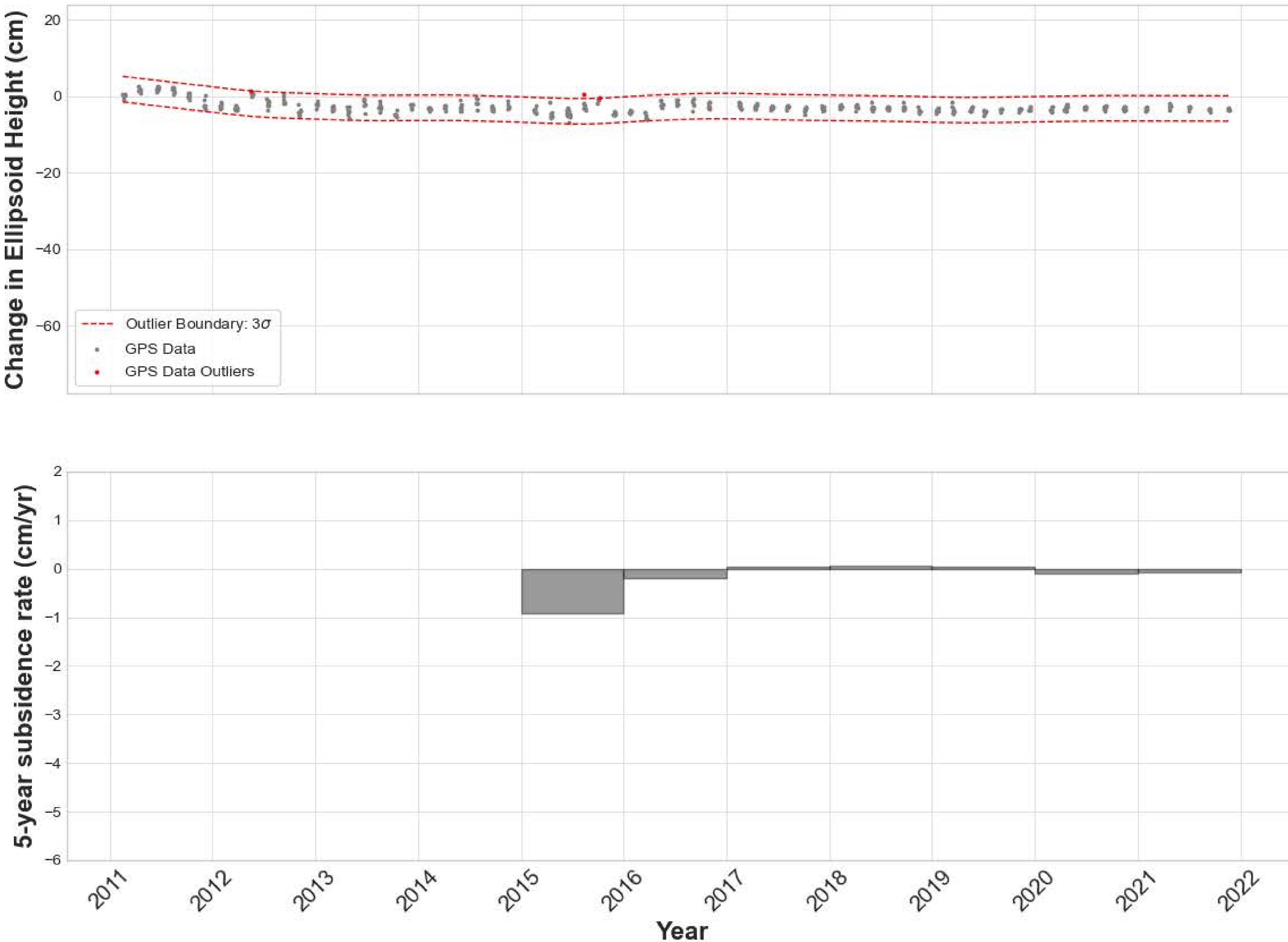
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P060



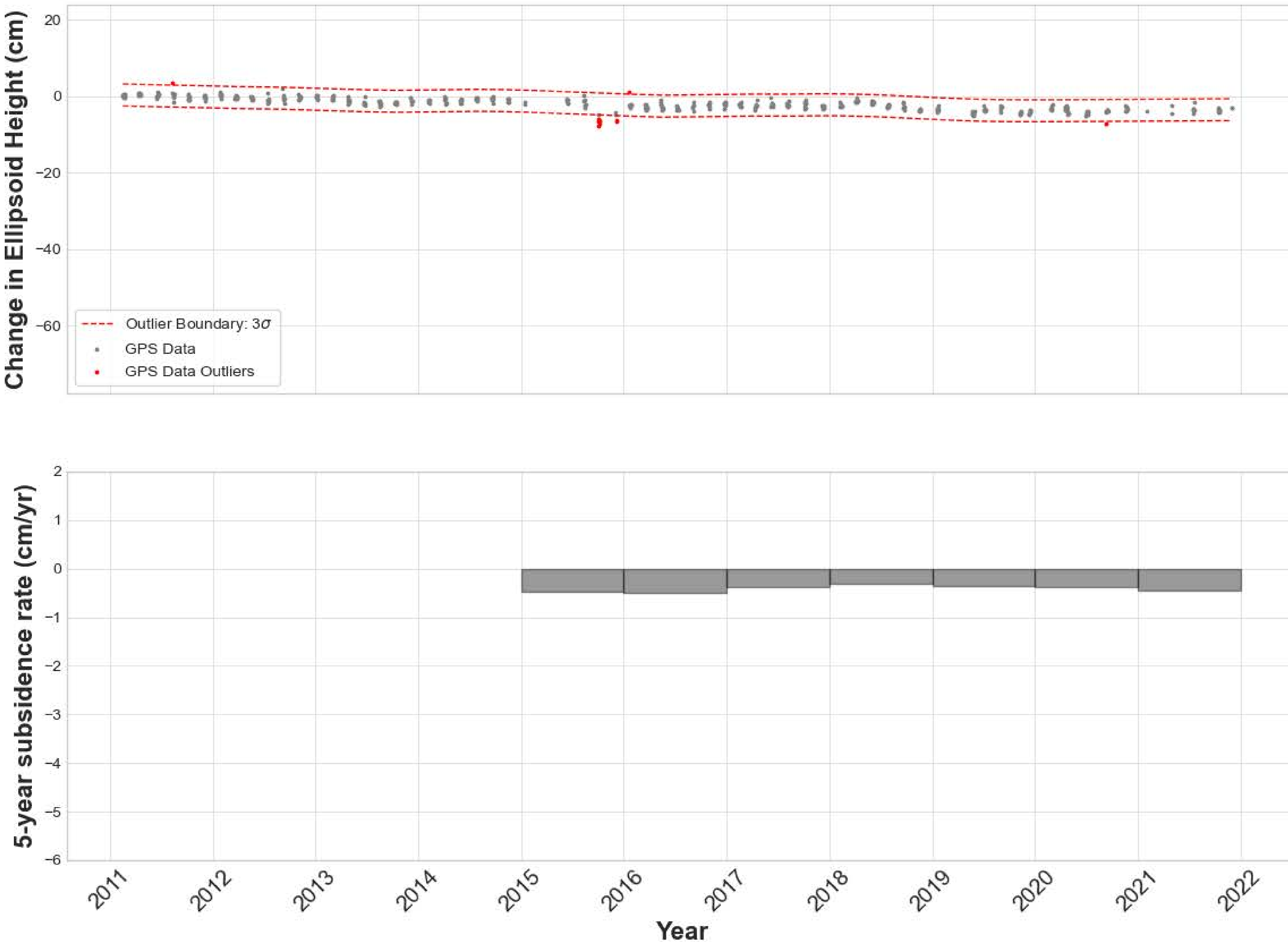
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P061



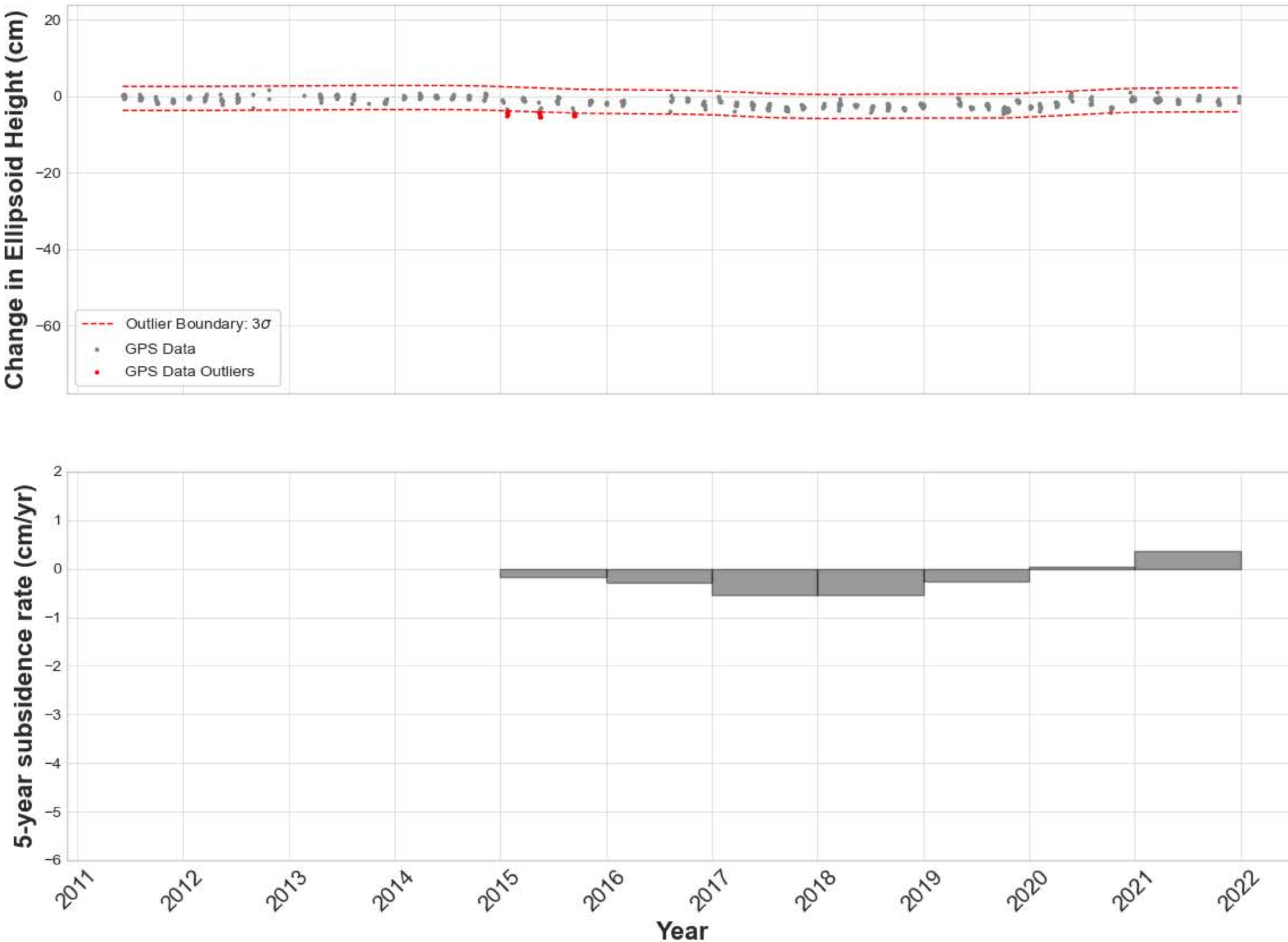
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P062



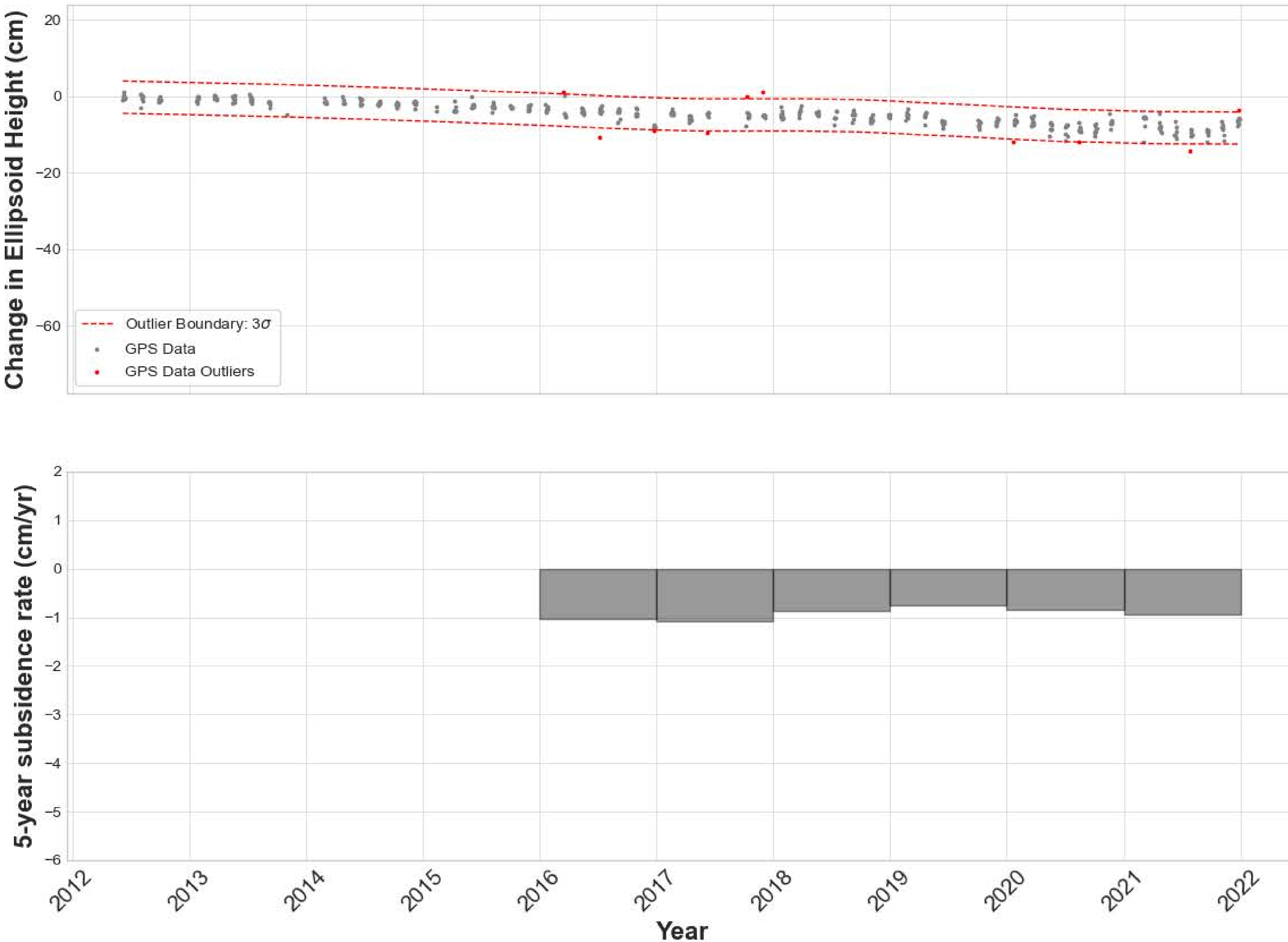
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P063



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

P065



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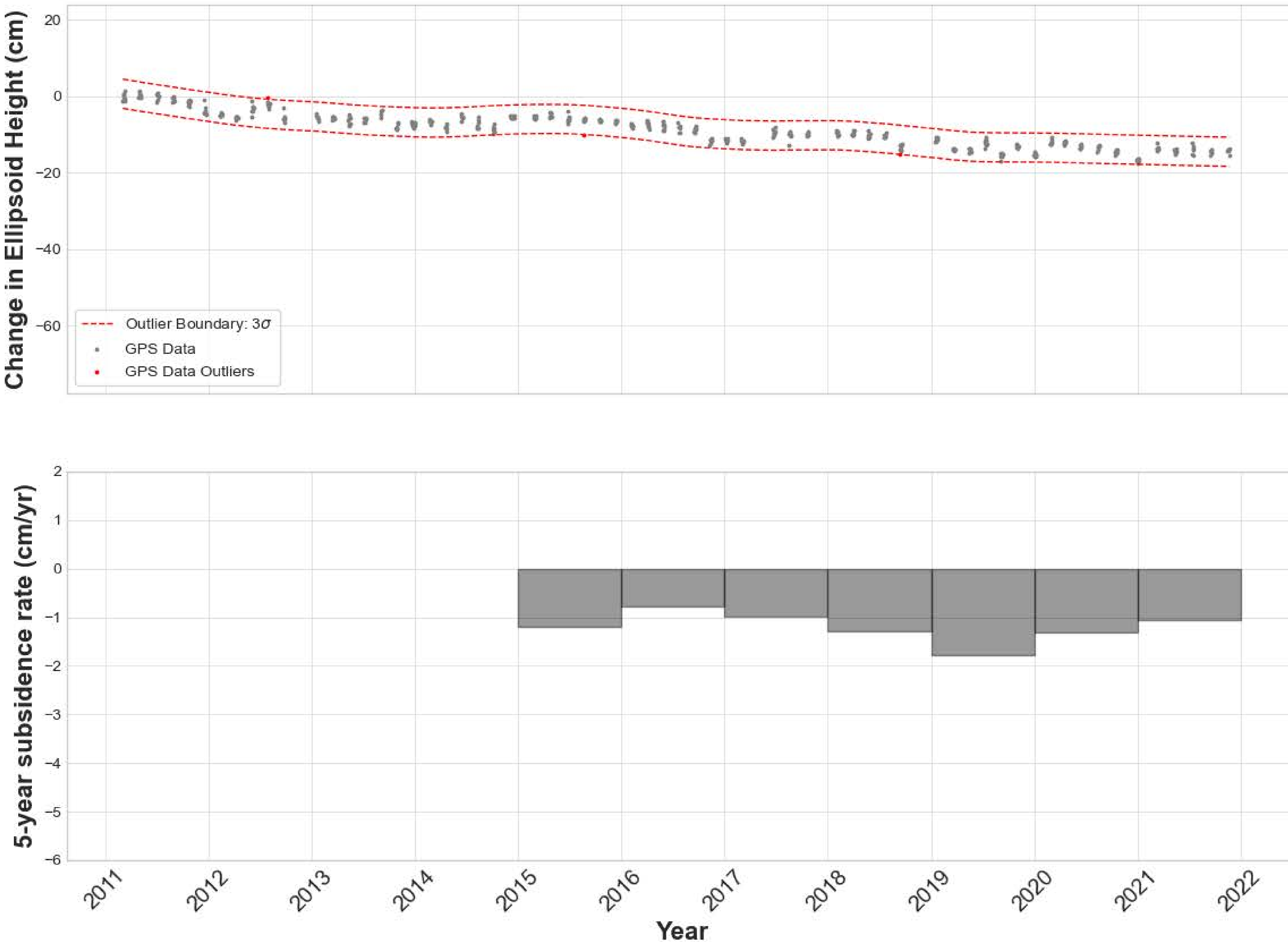
P066



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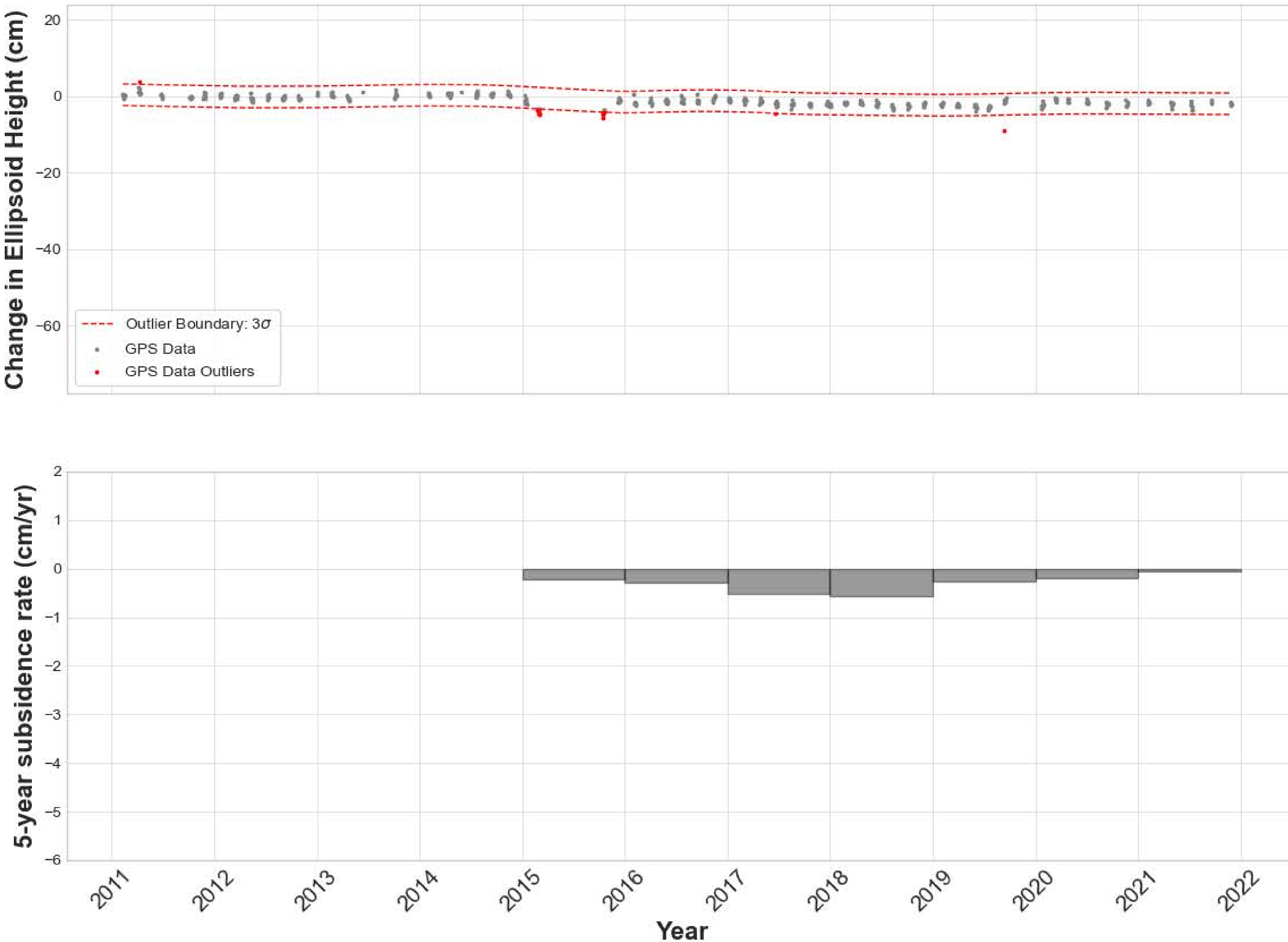
P067



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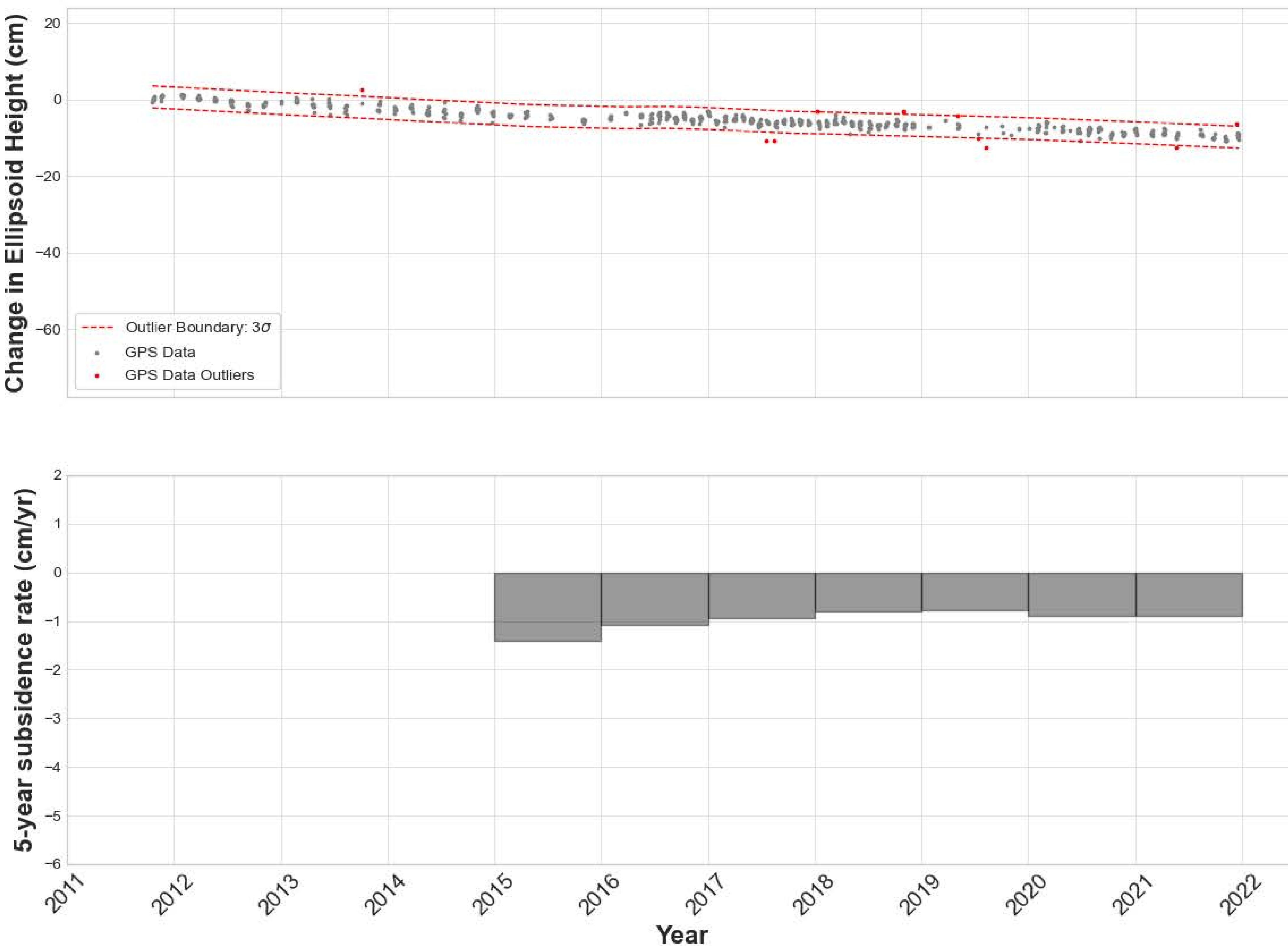
P068



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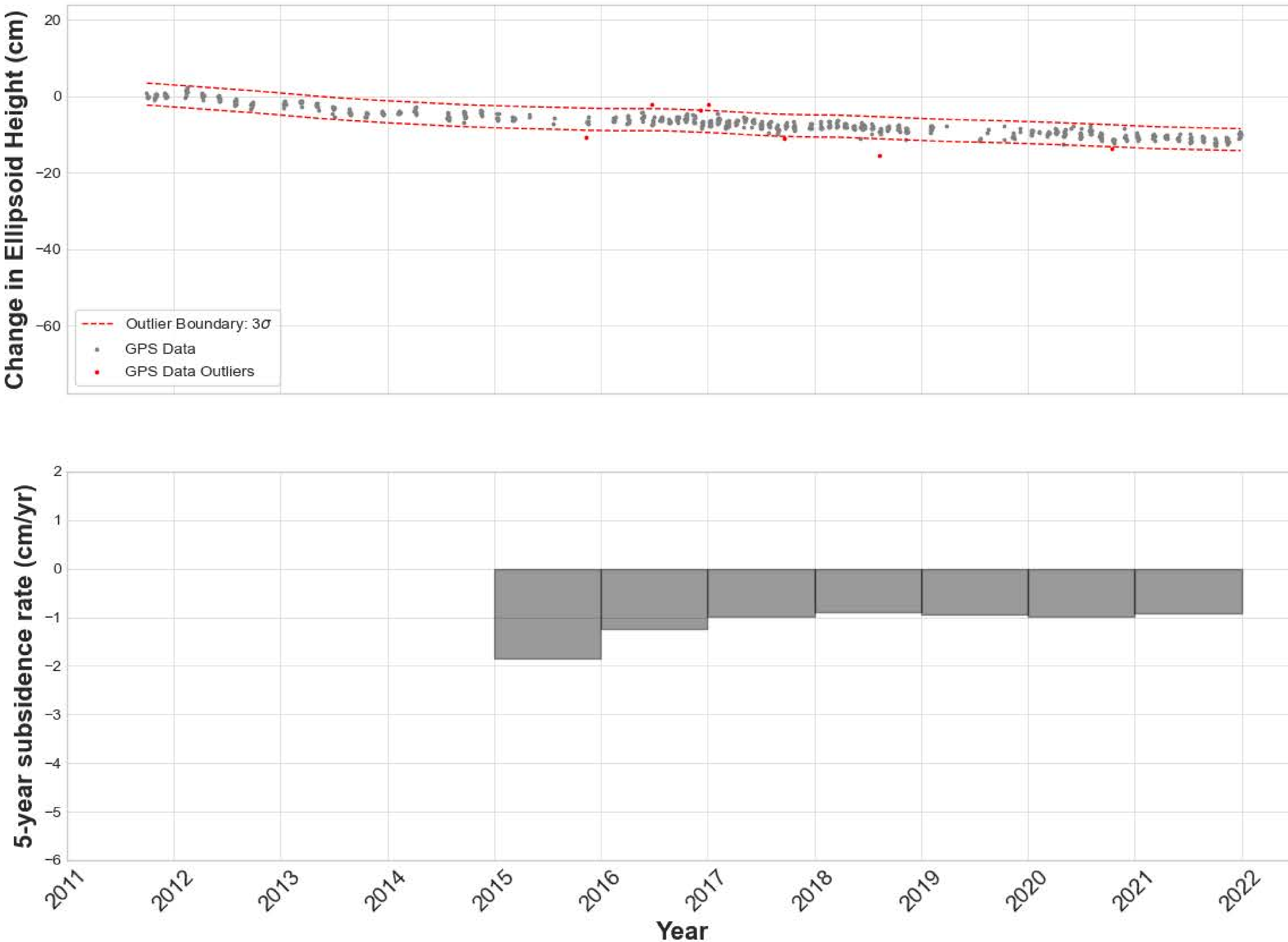
P069



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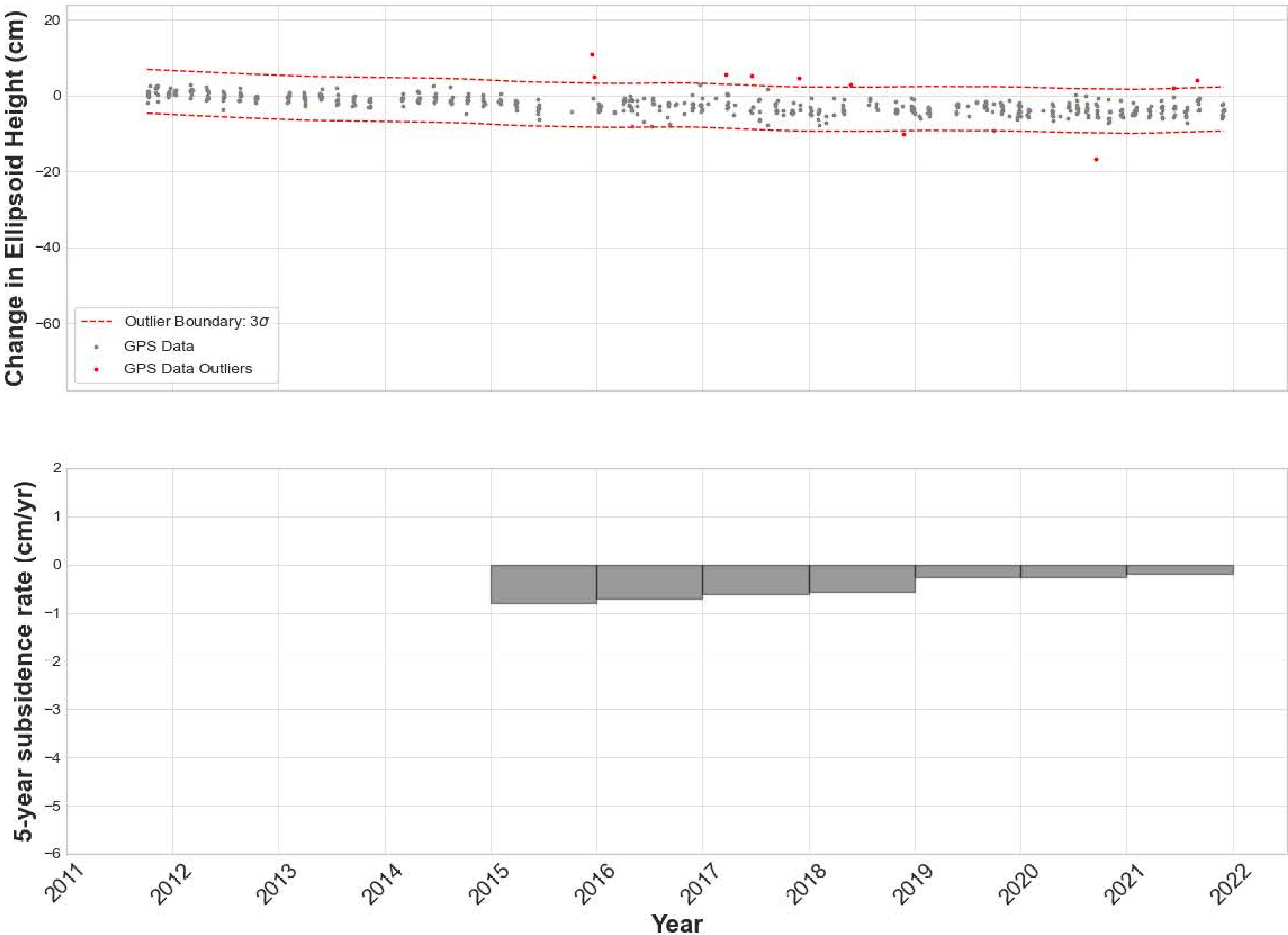
P070



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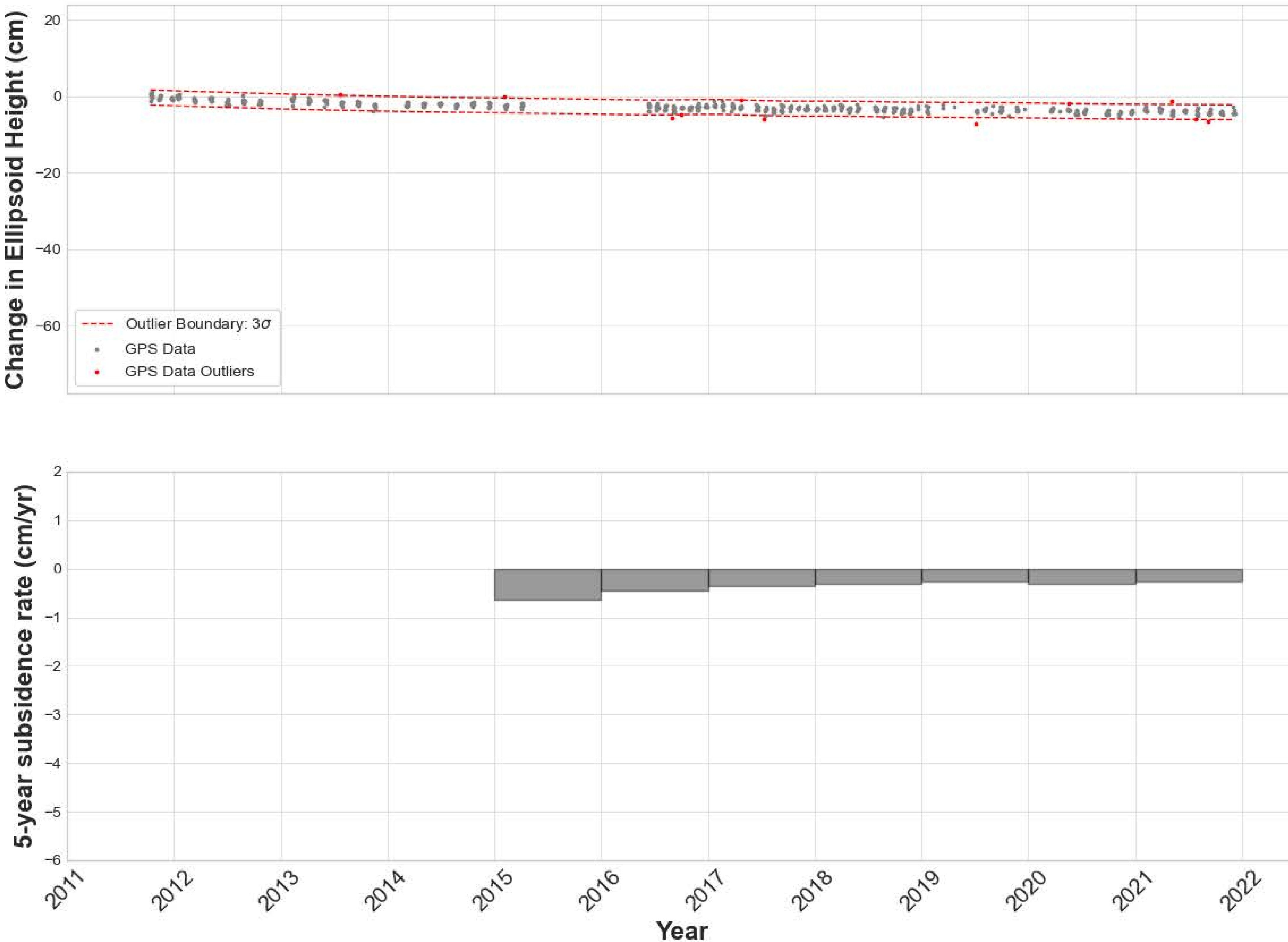
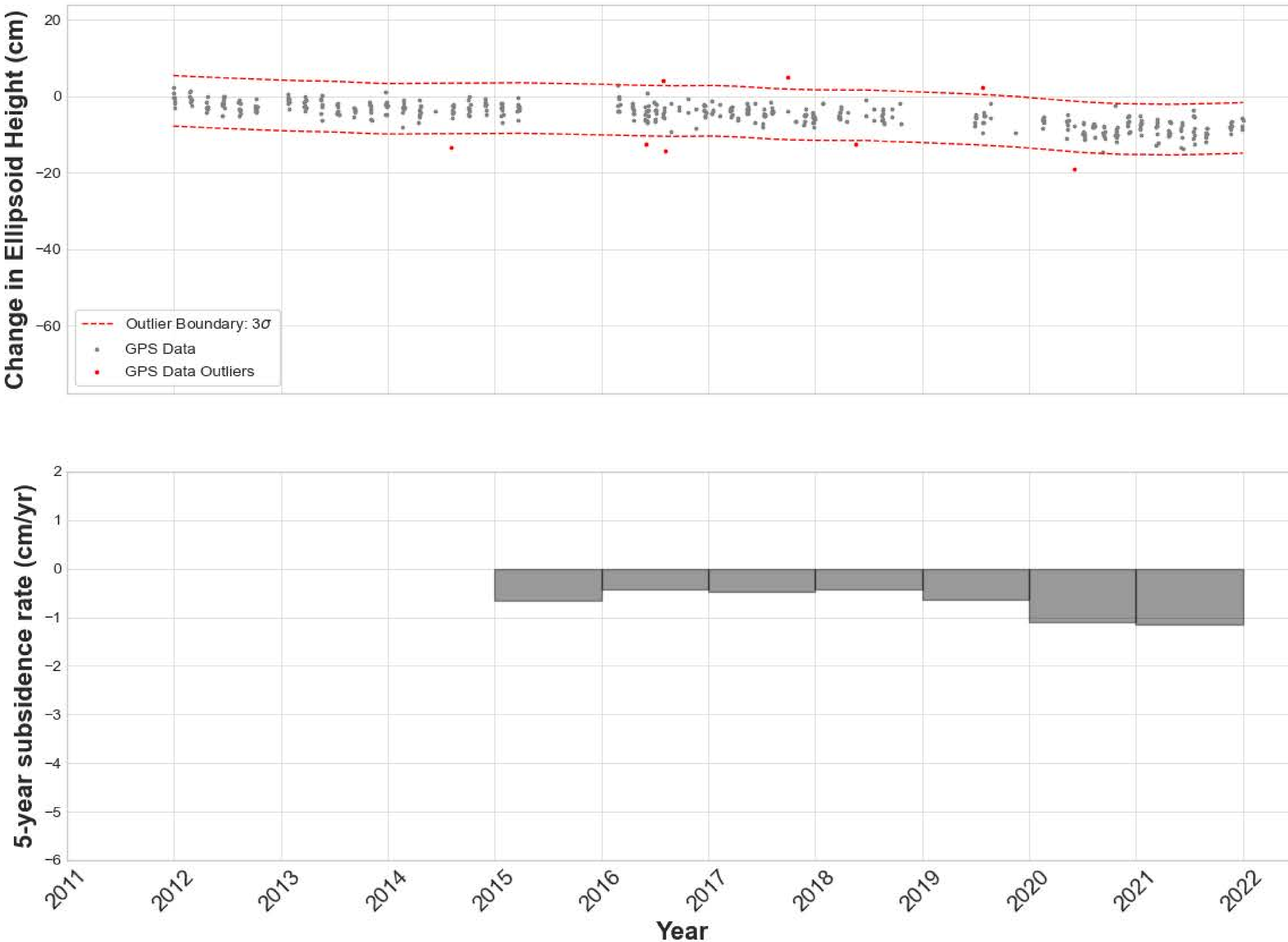
P071



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

P072



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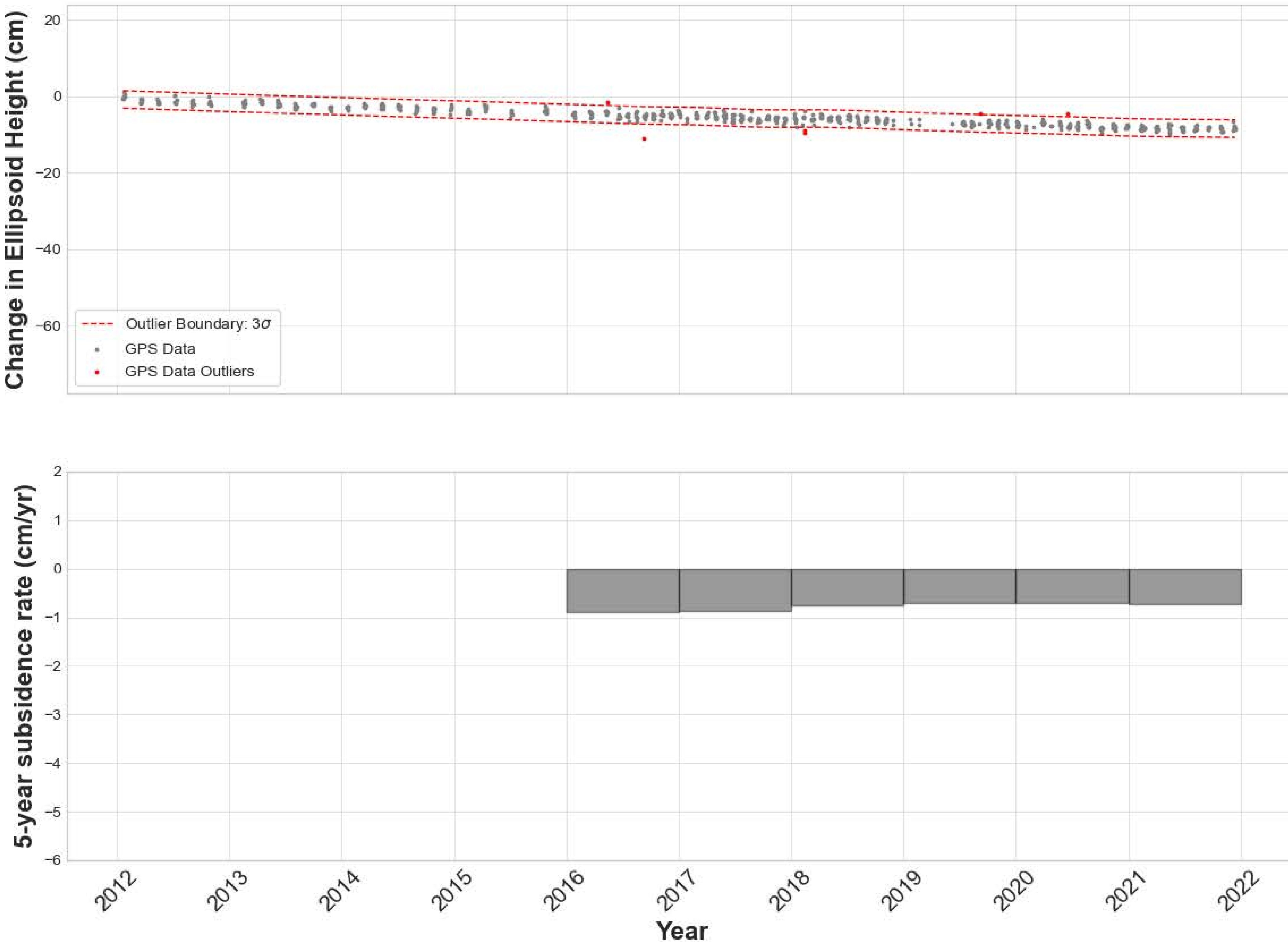
P073



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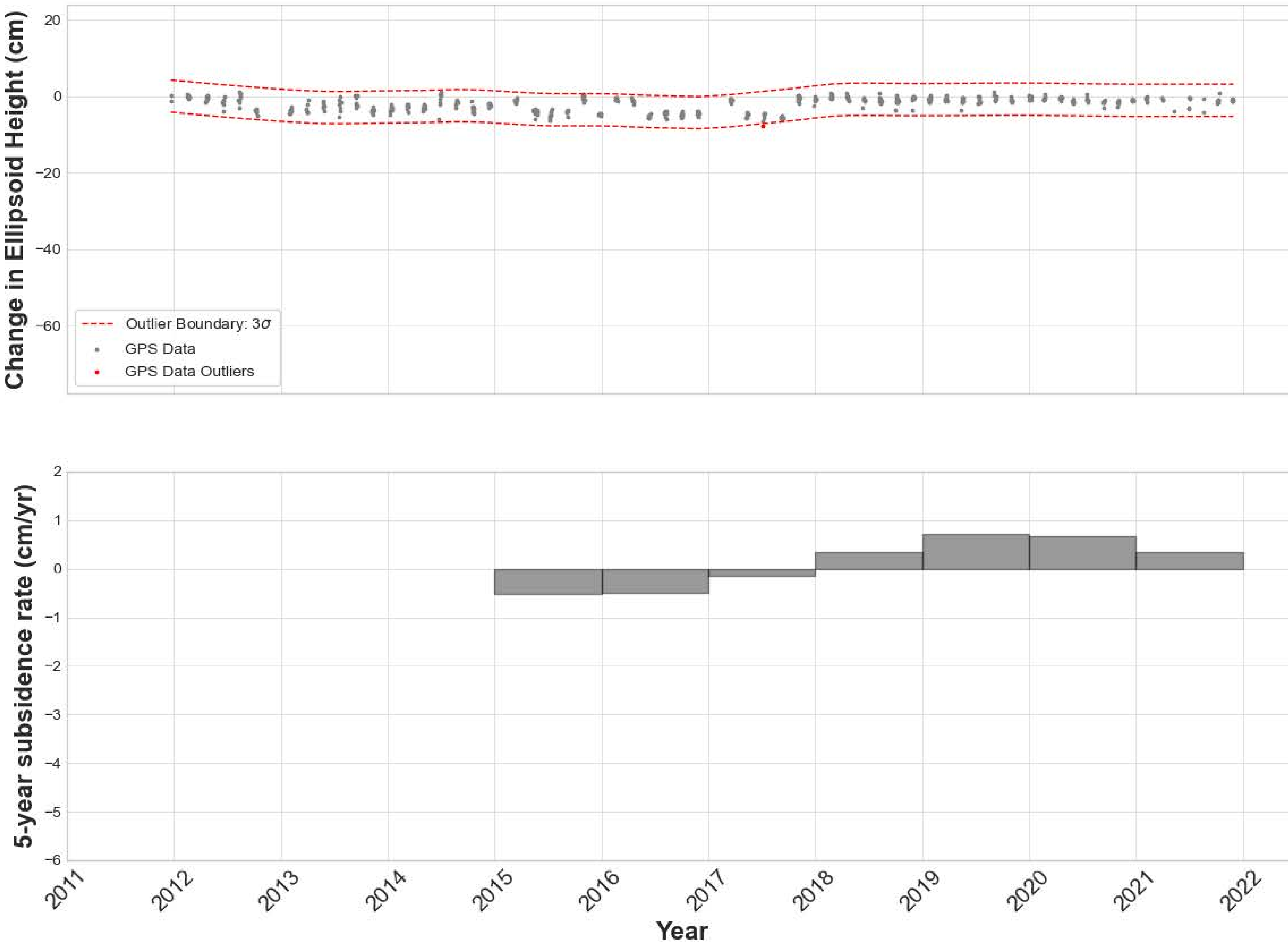
P074



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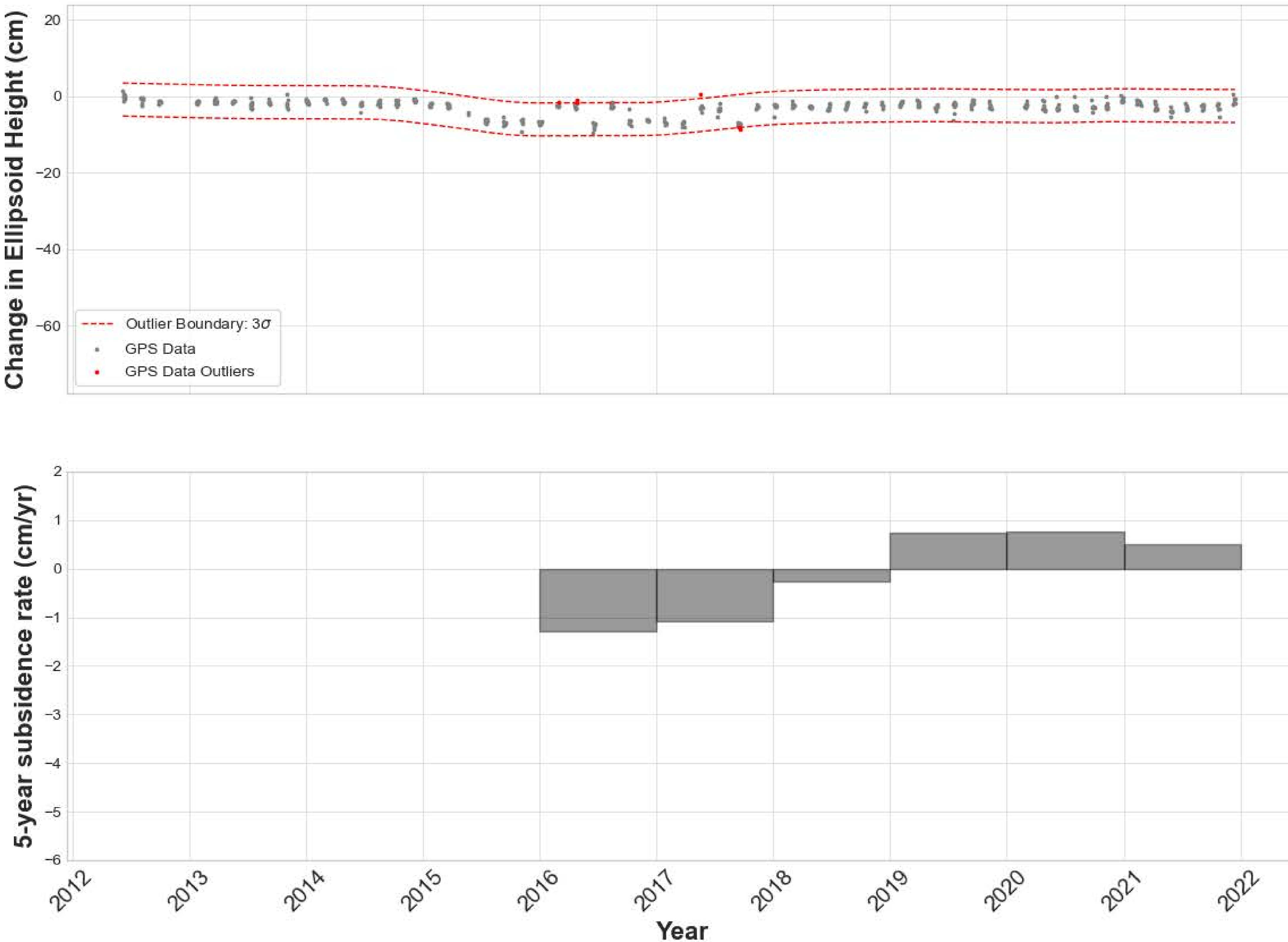
P075



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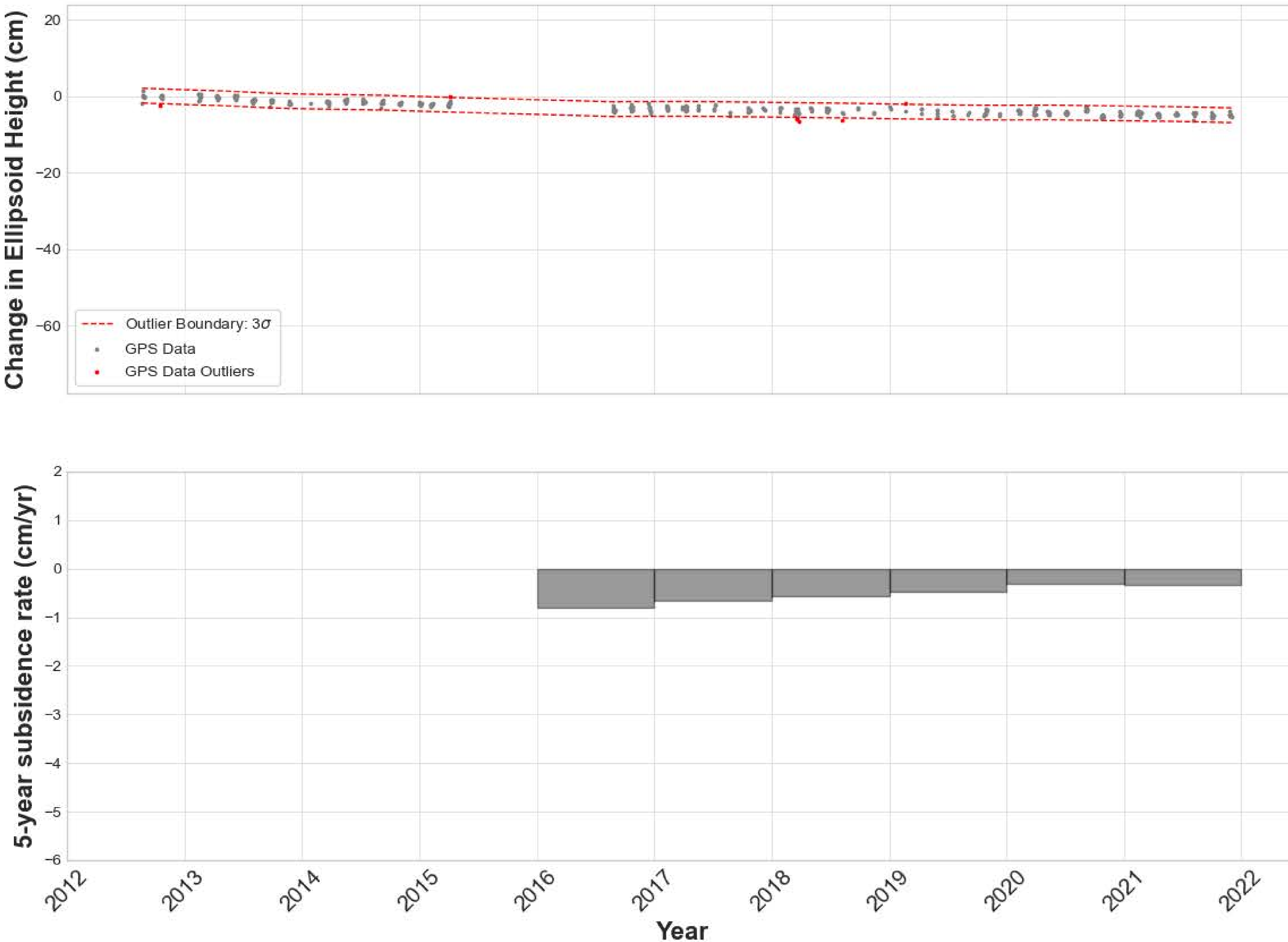
P076



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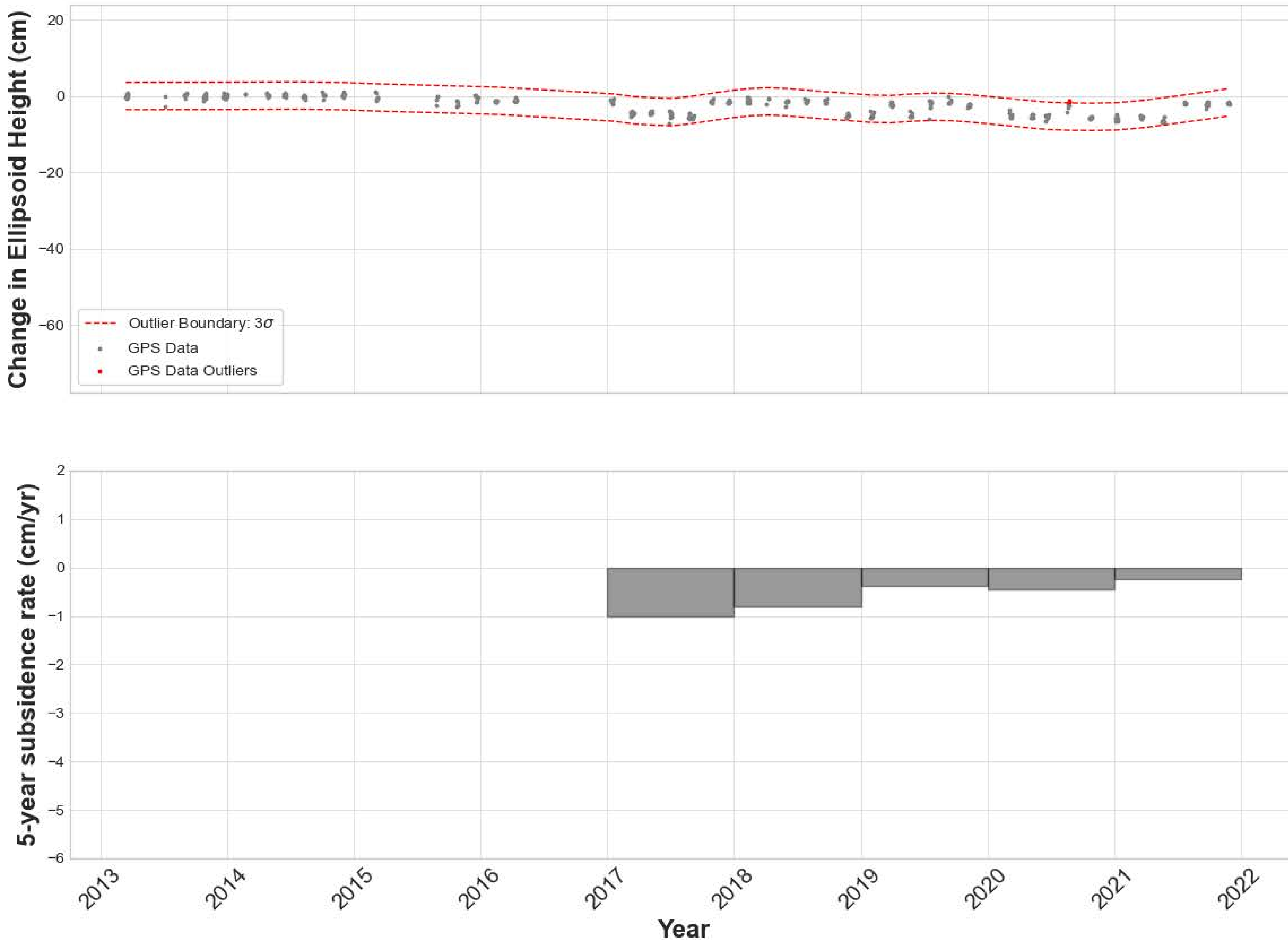
P077



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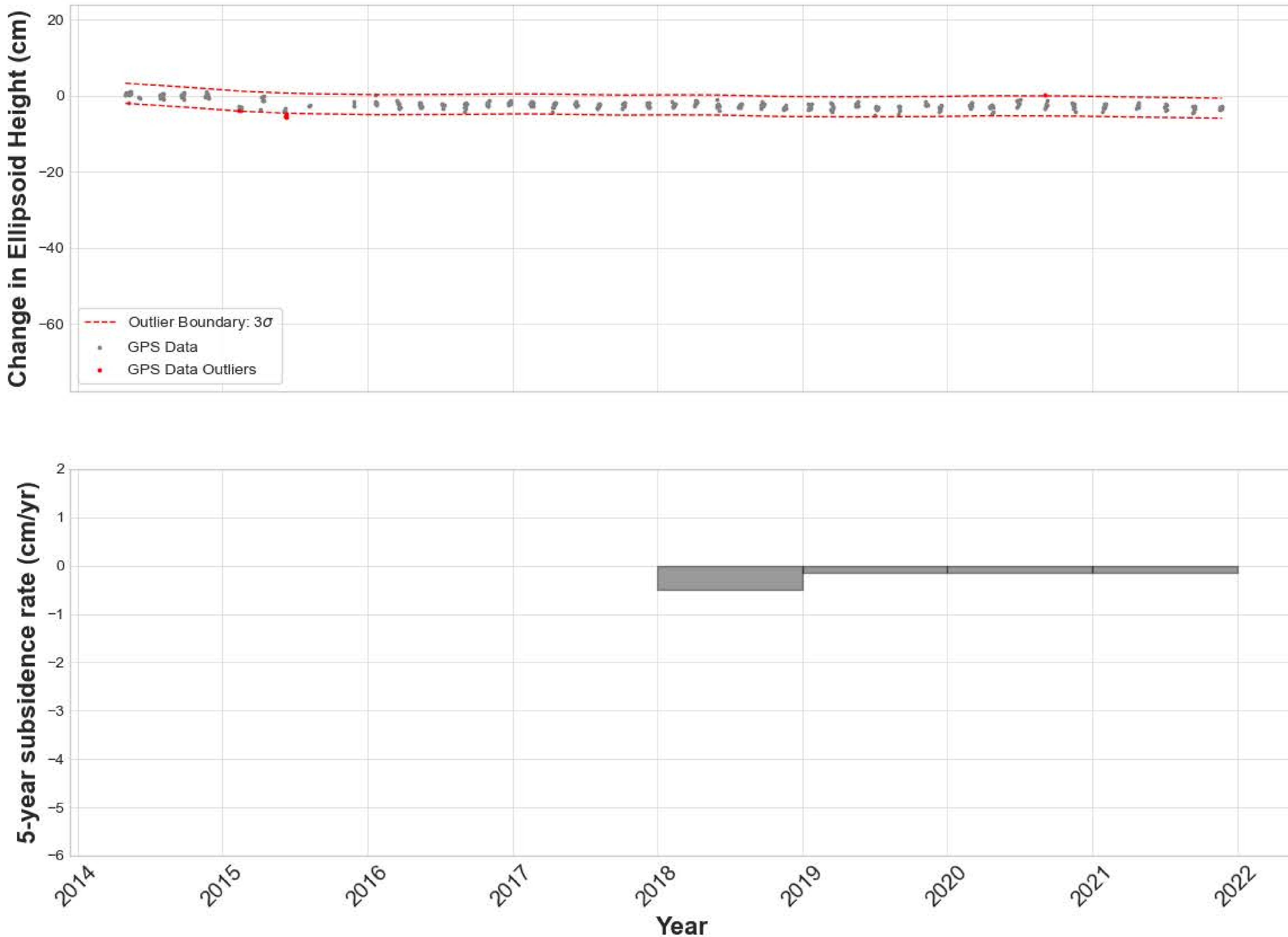
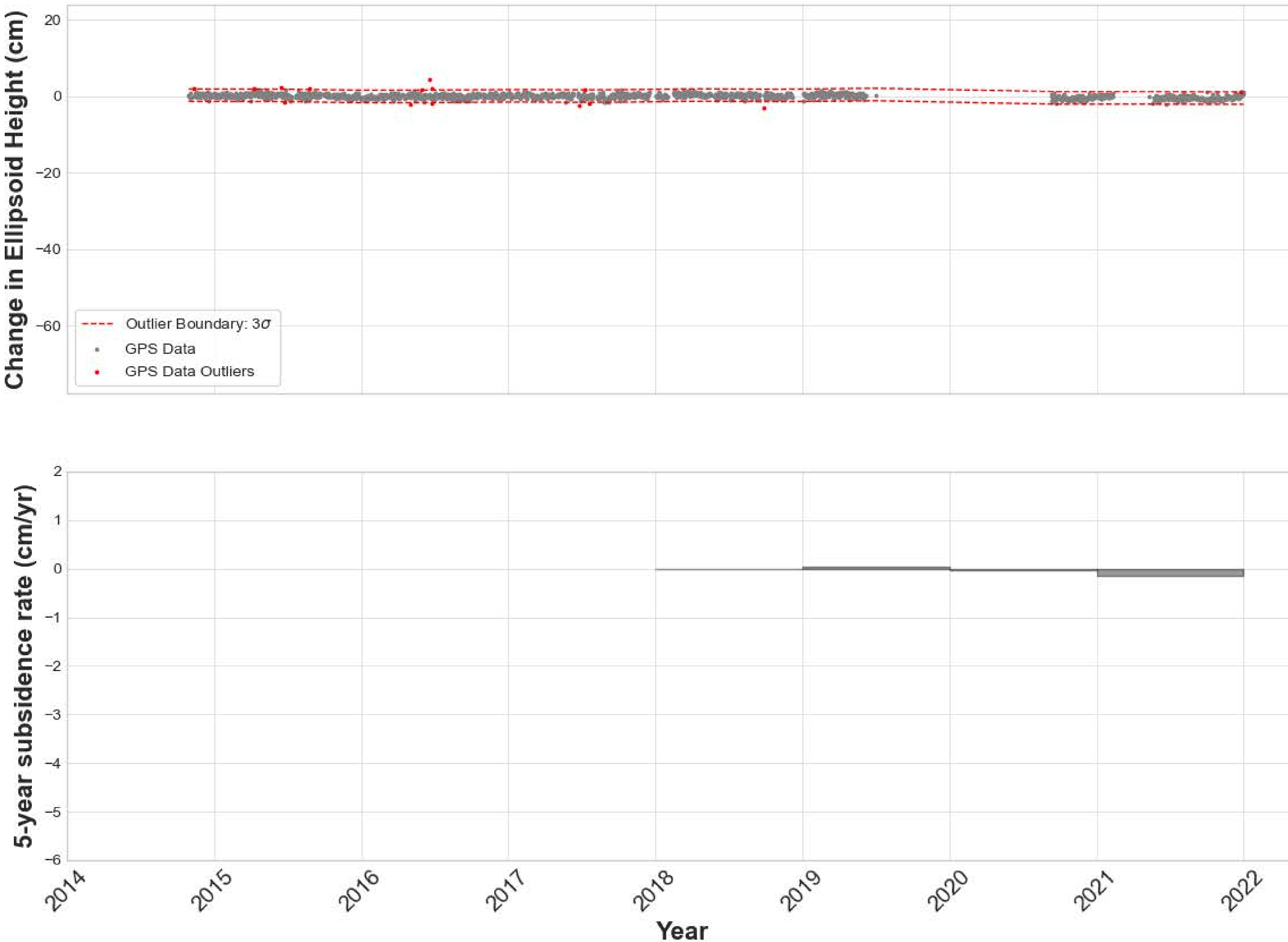
P078



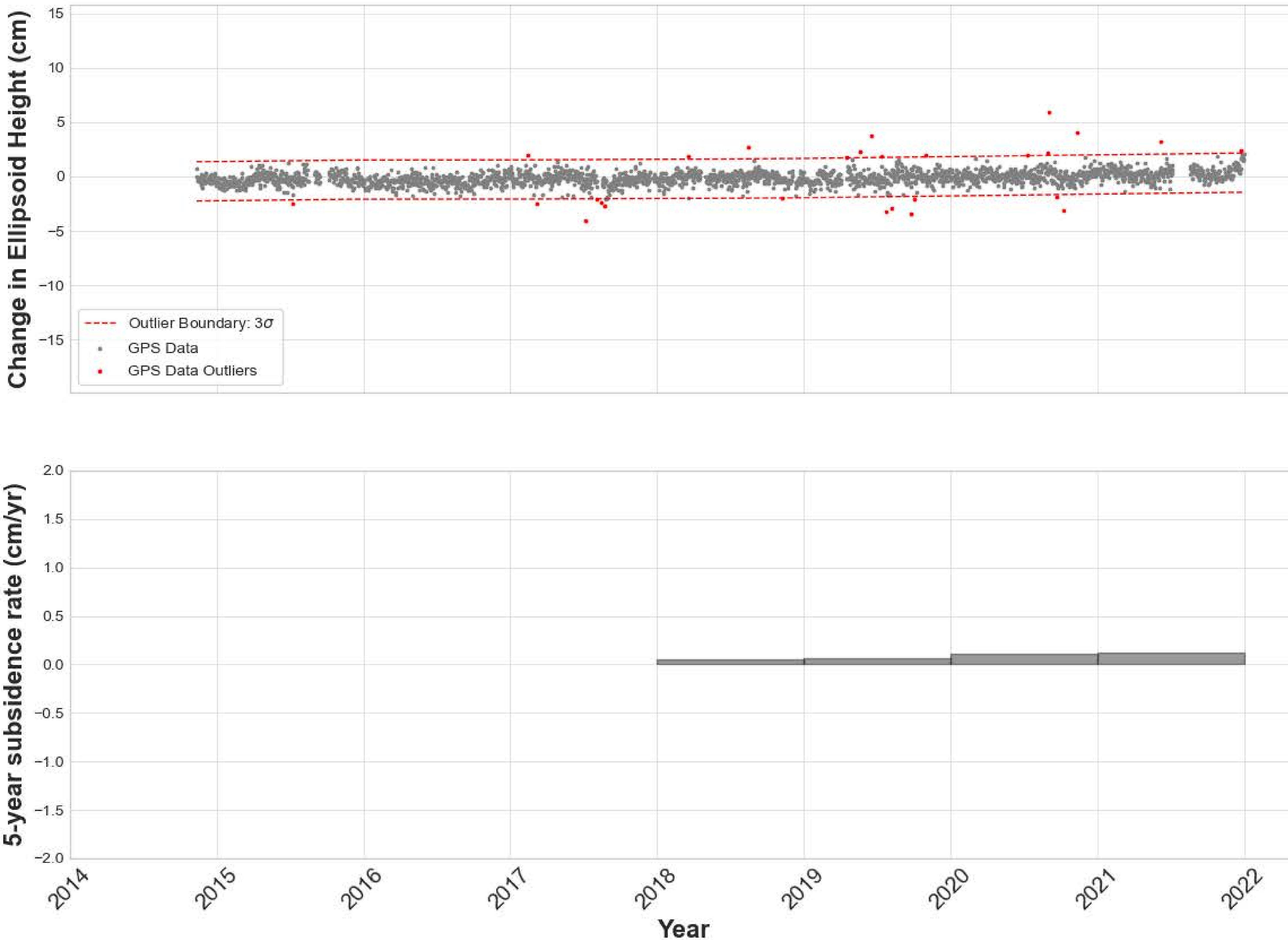
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P079



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

P080



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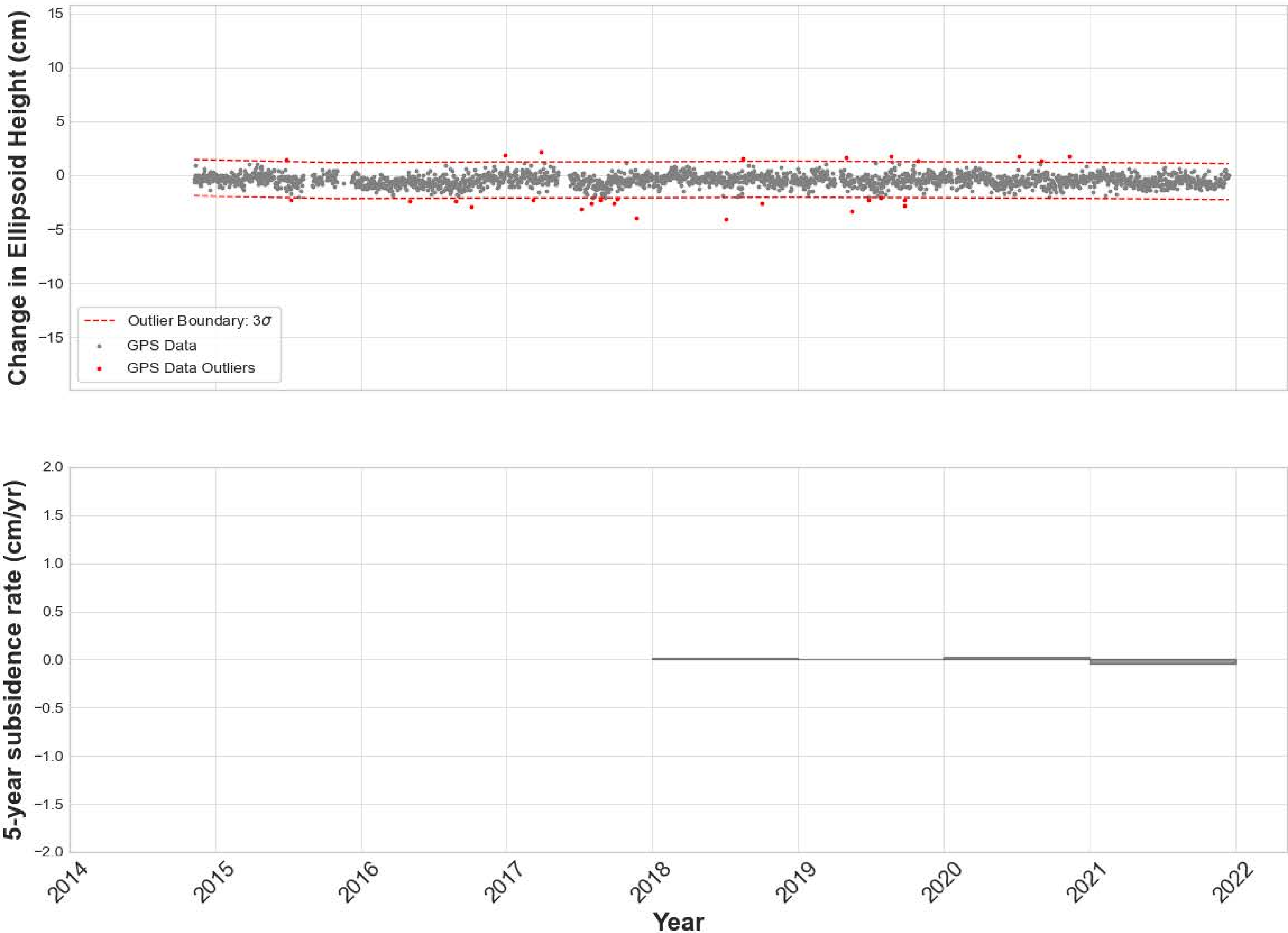
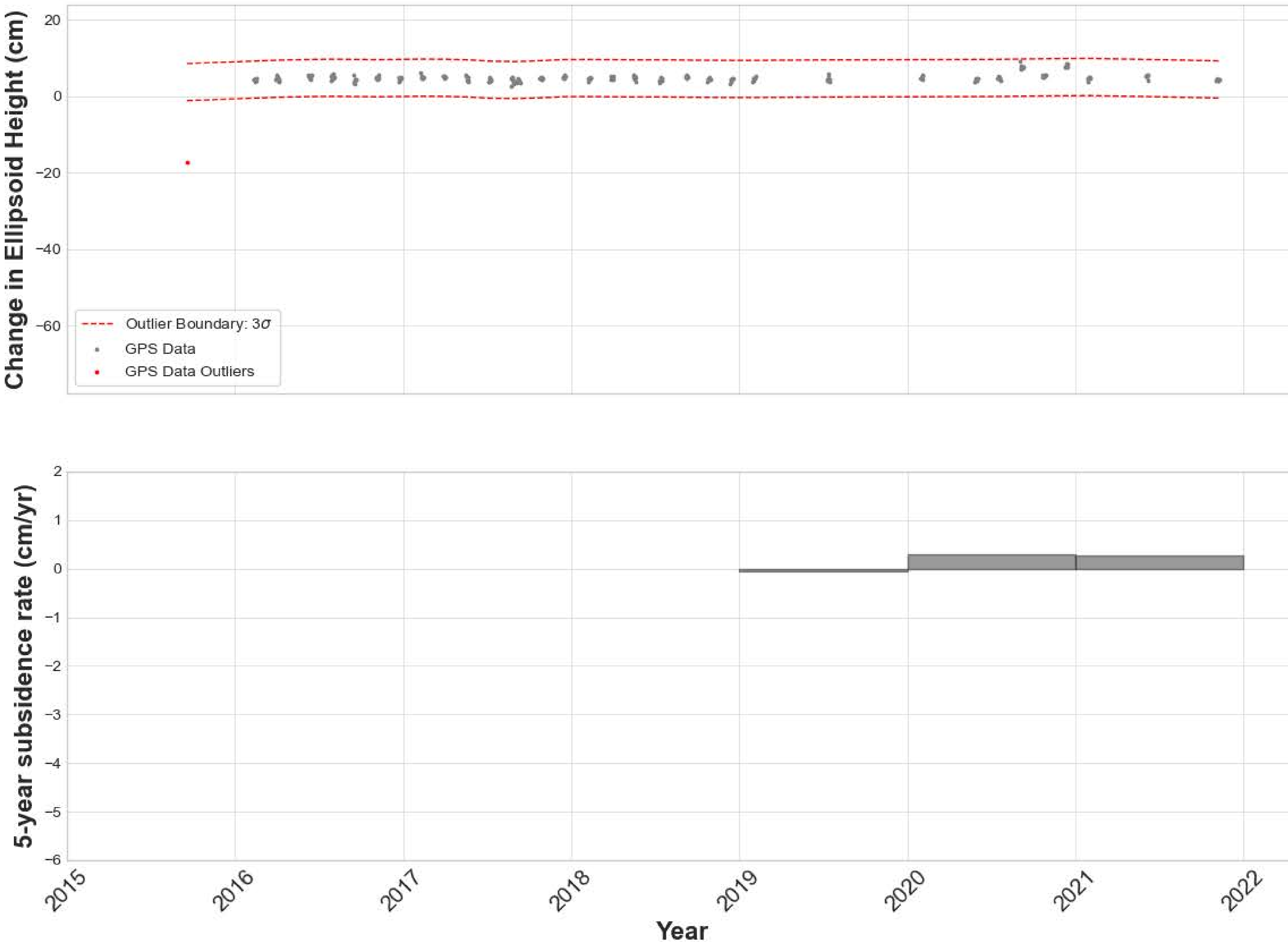
P081



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

P082



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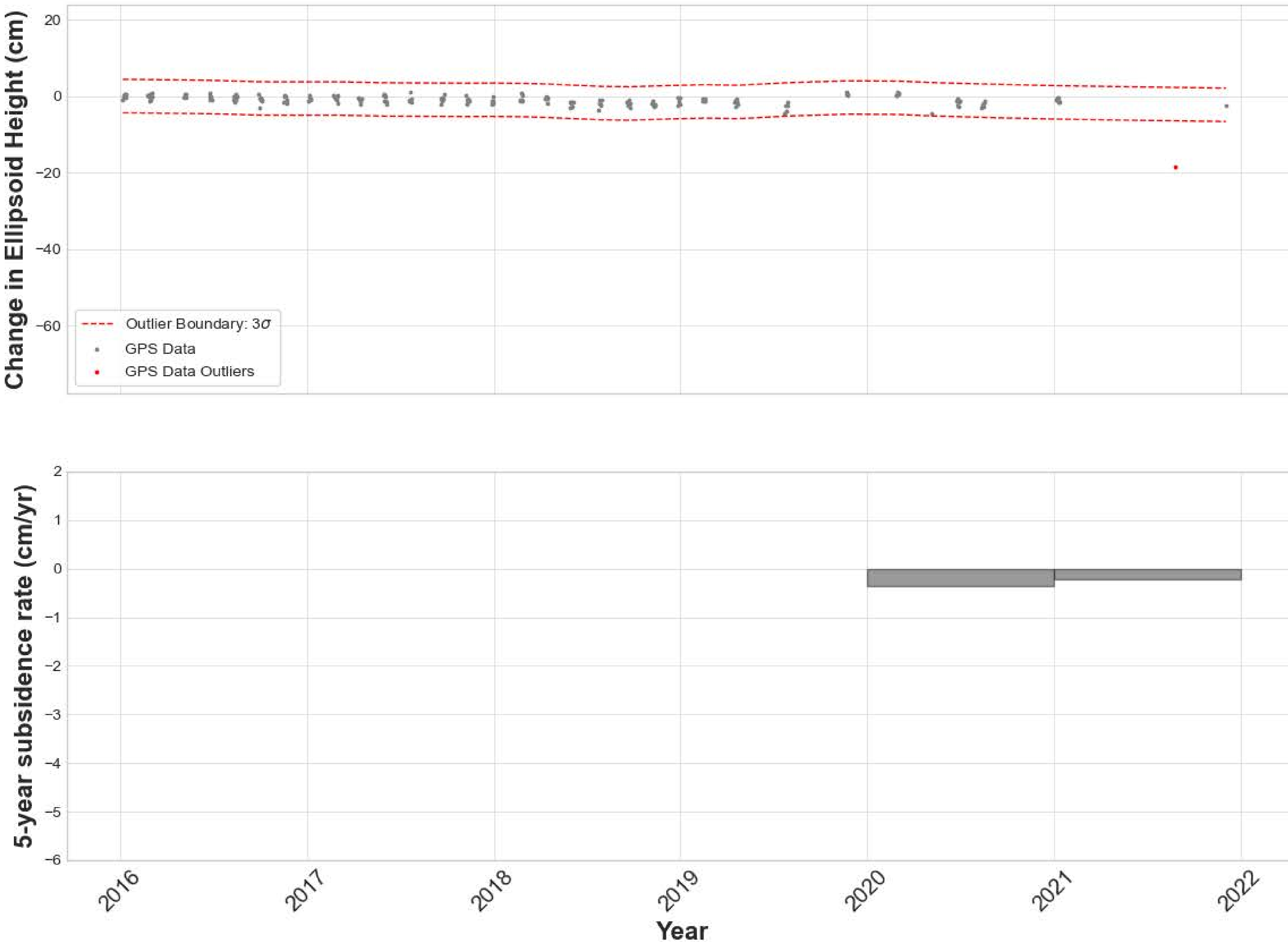
P083



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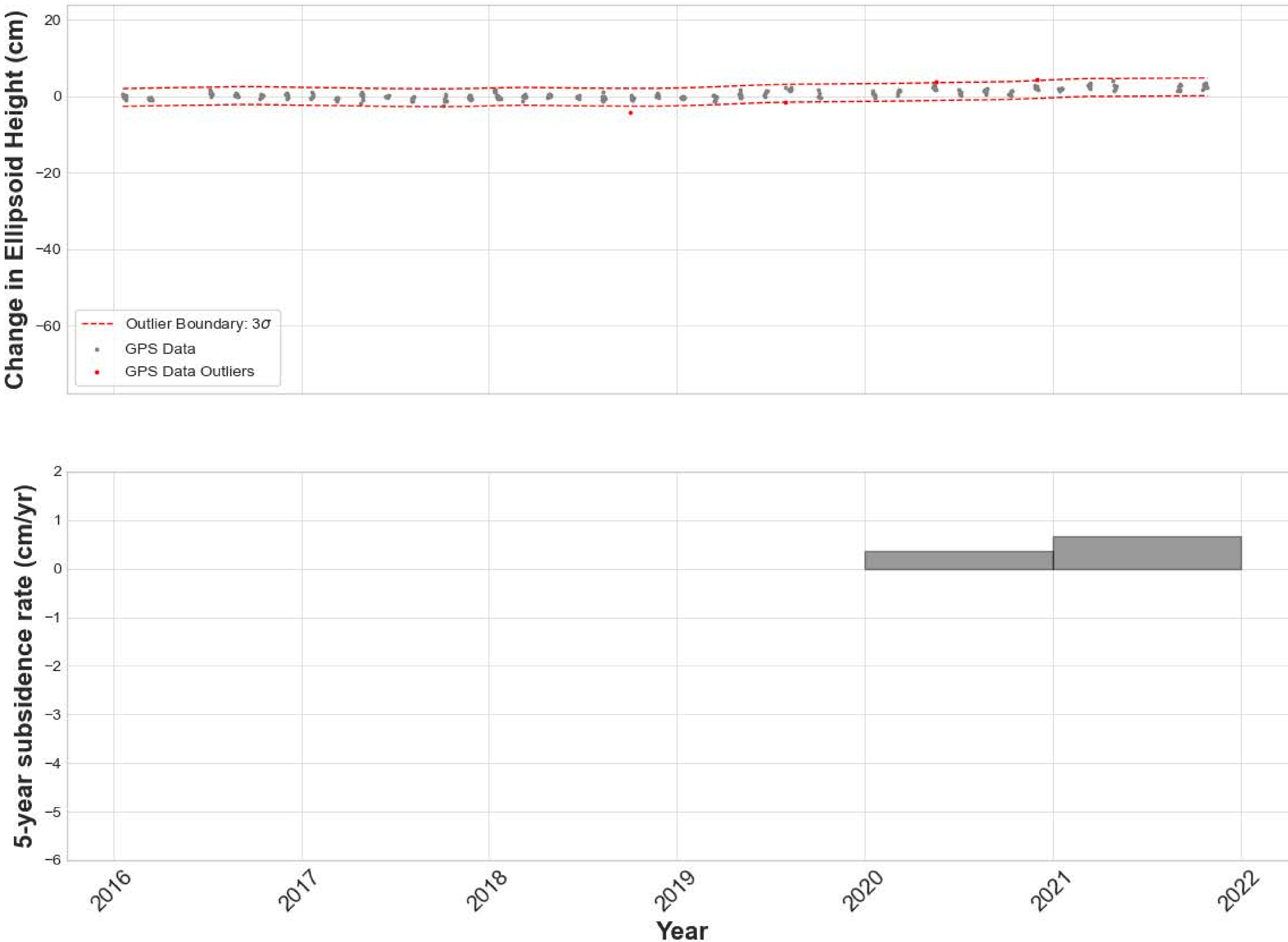
P084



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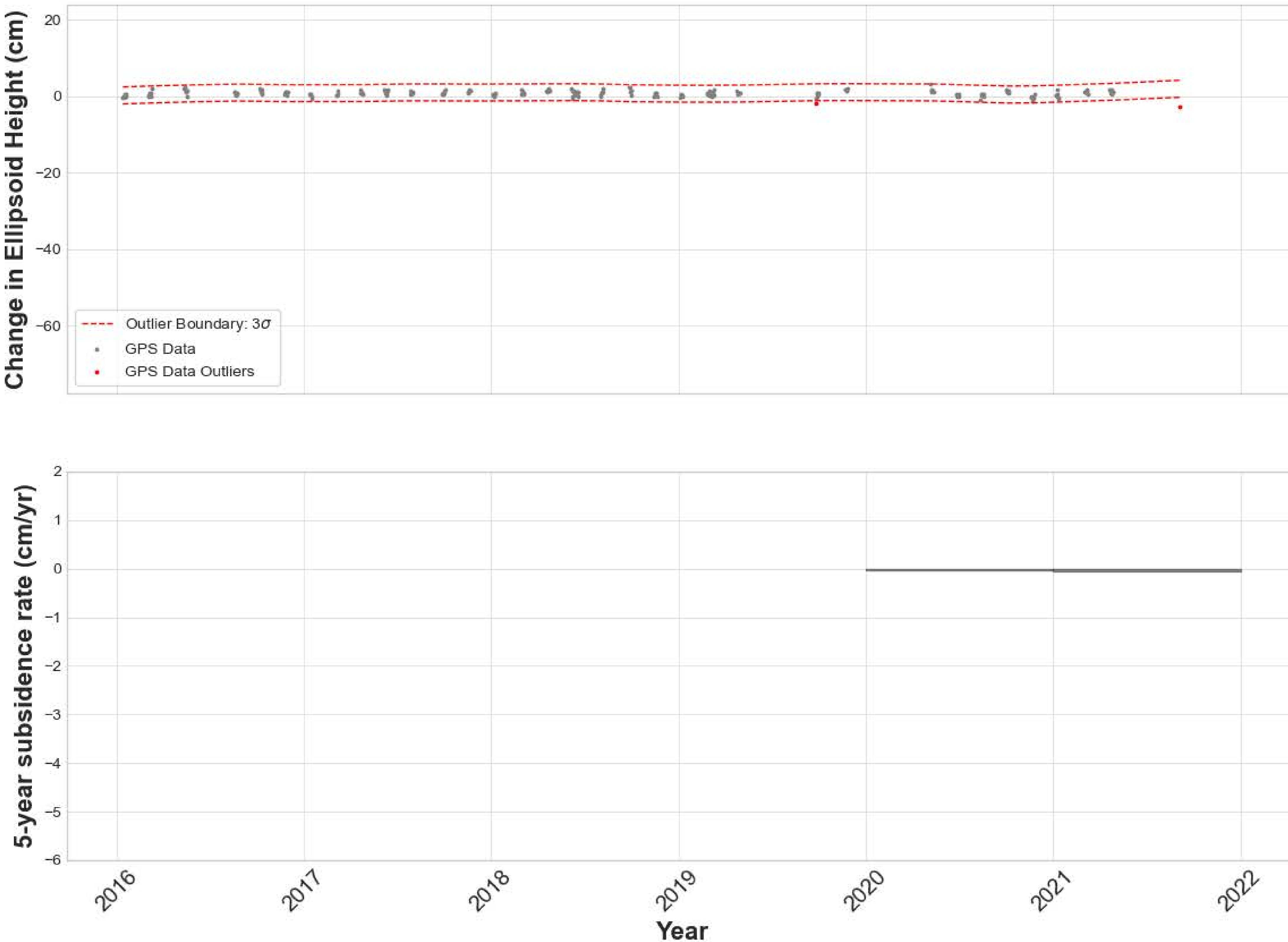
P085



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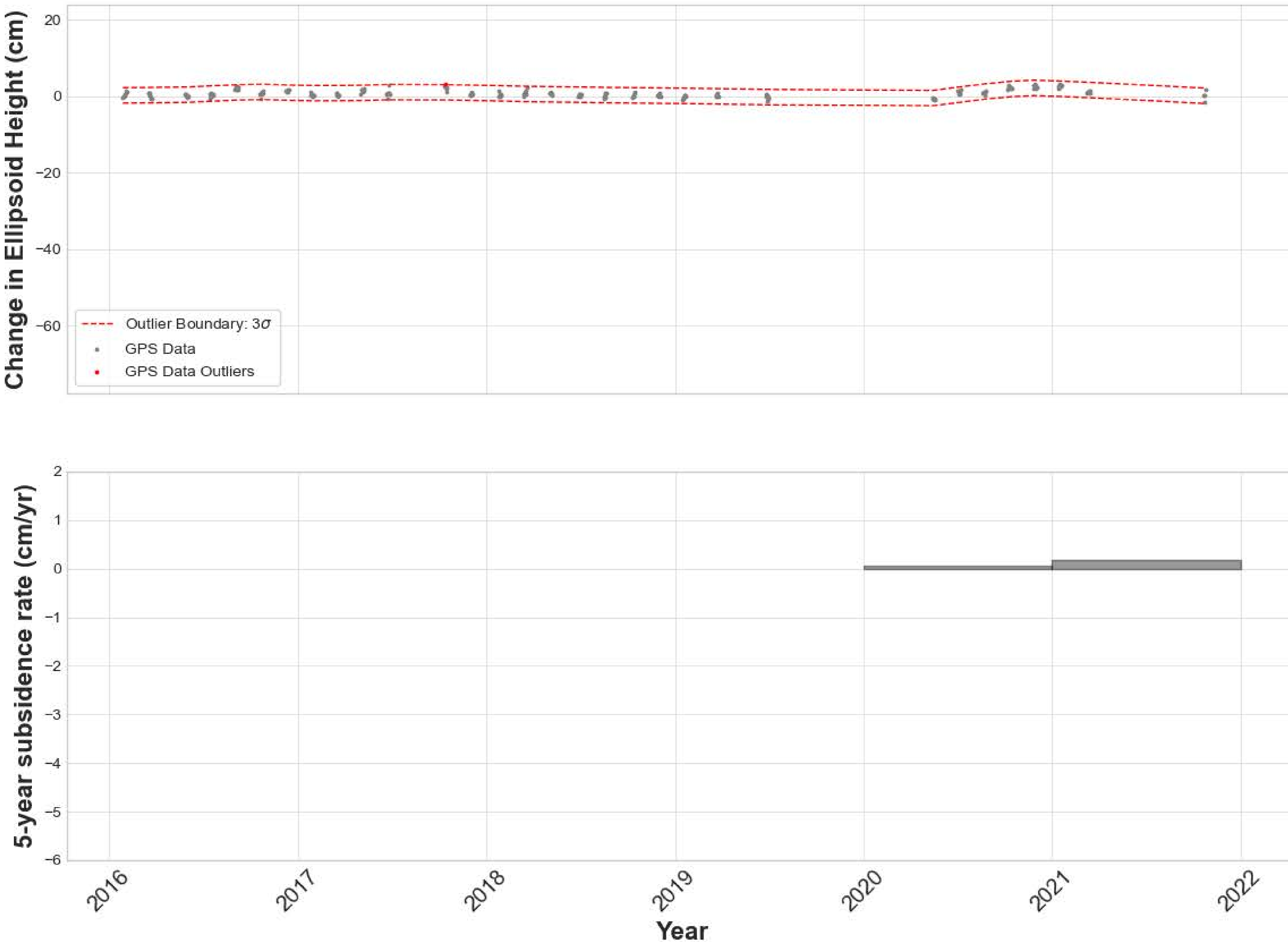
P086



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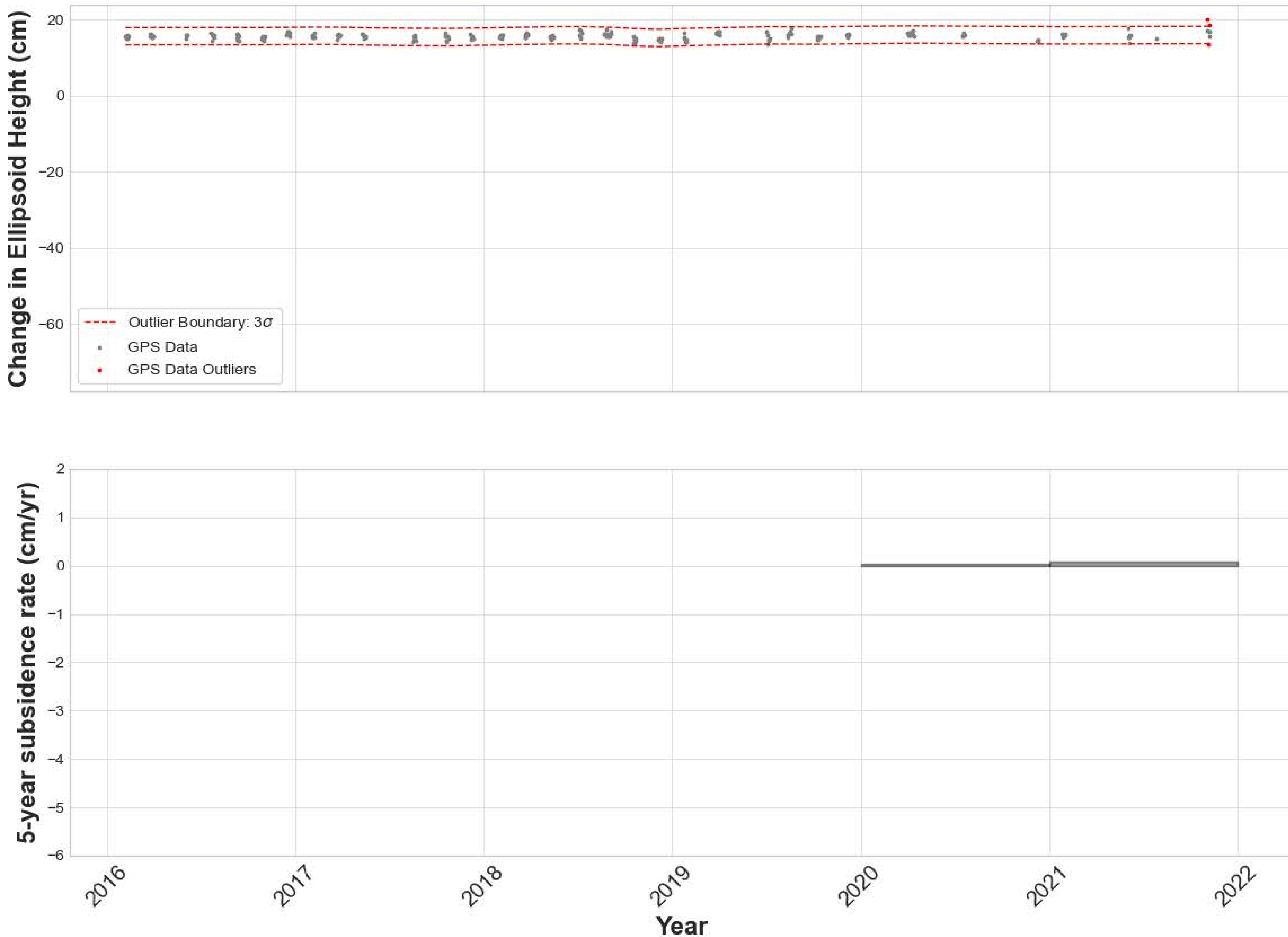
P087



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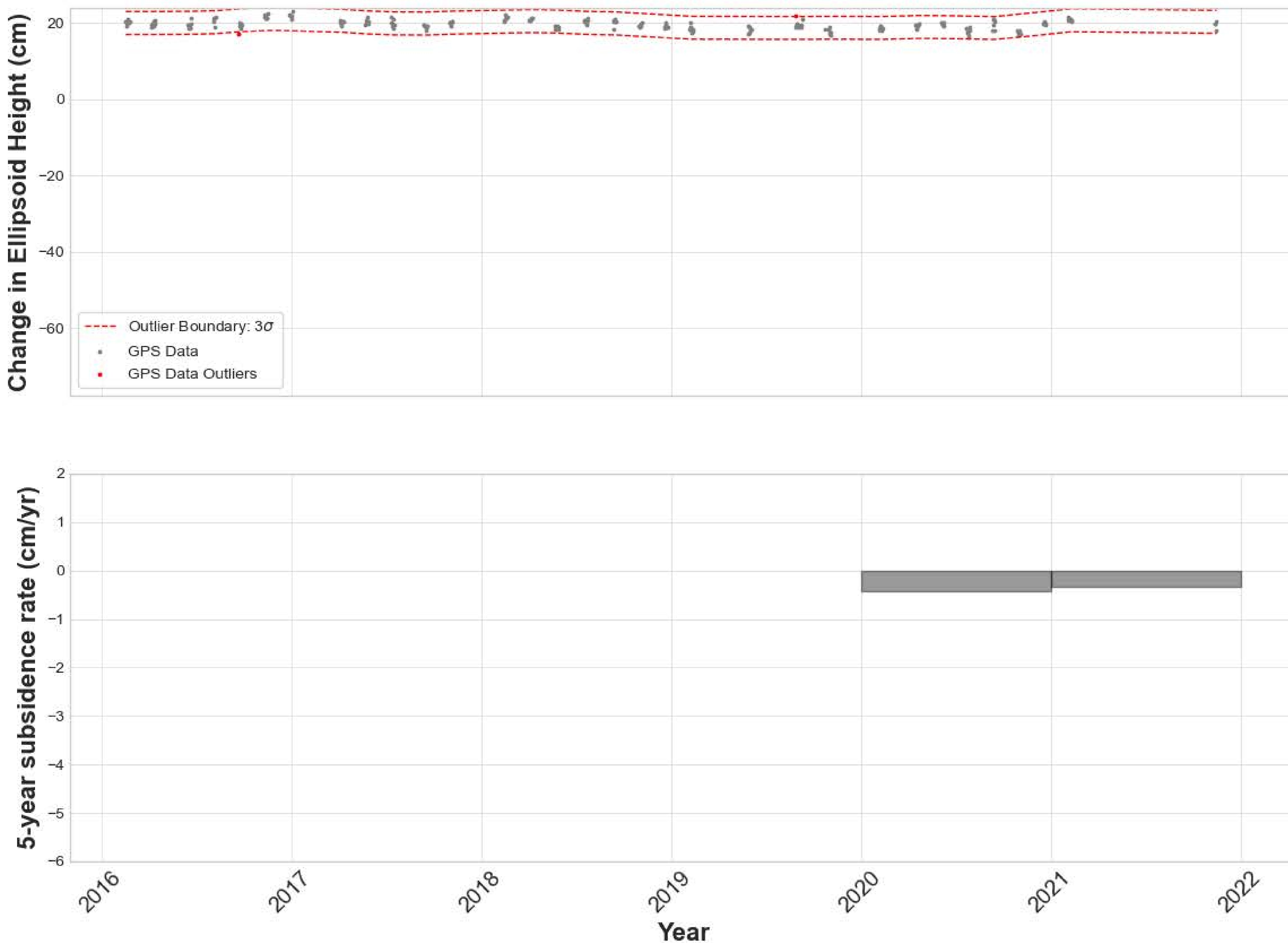
P088



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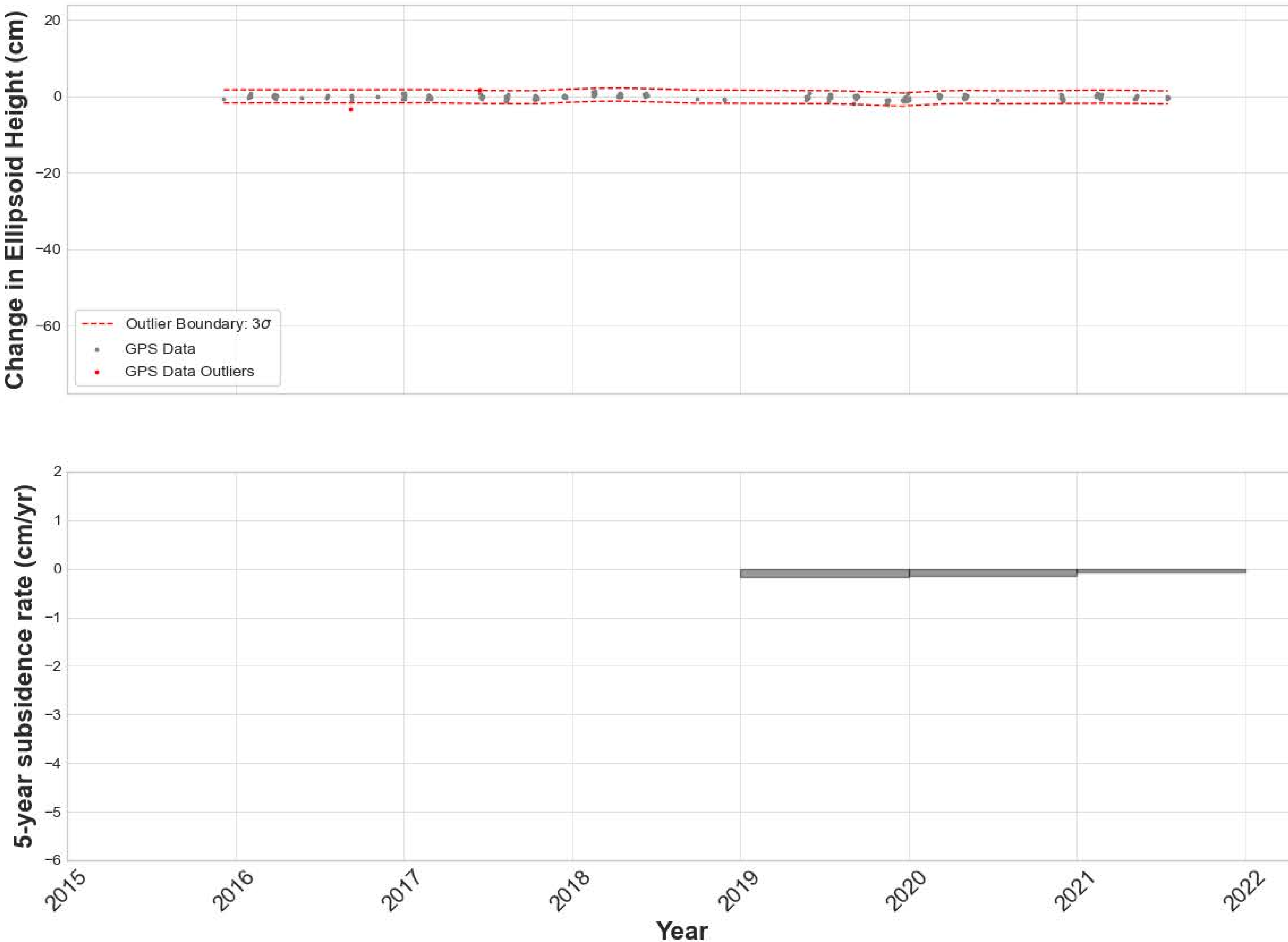
P089



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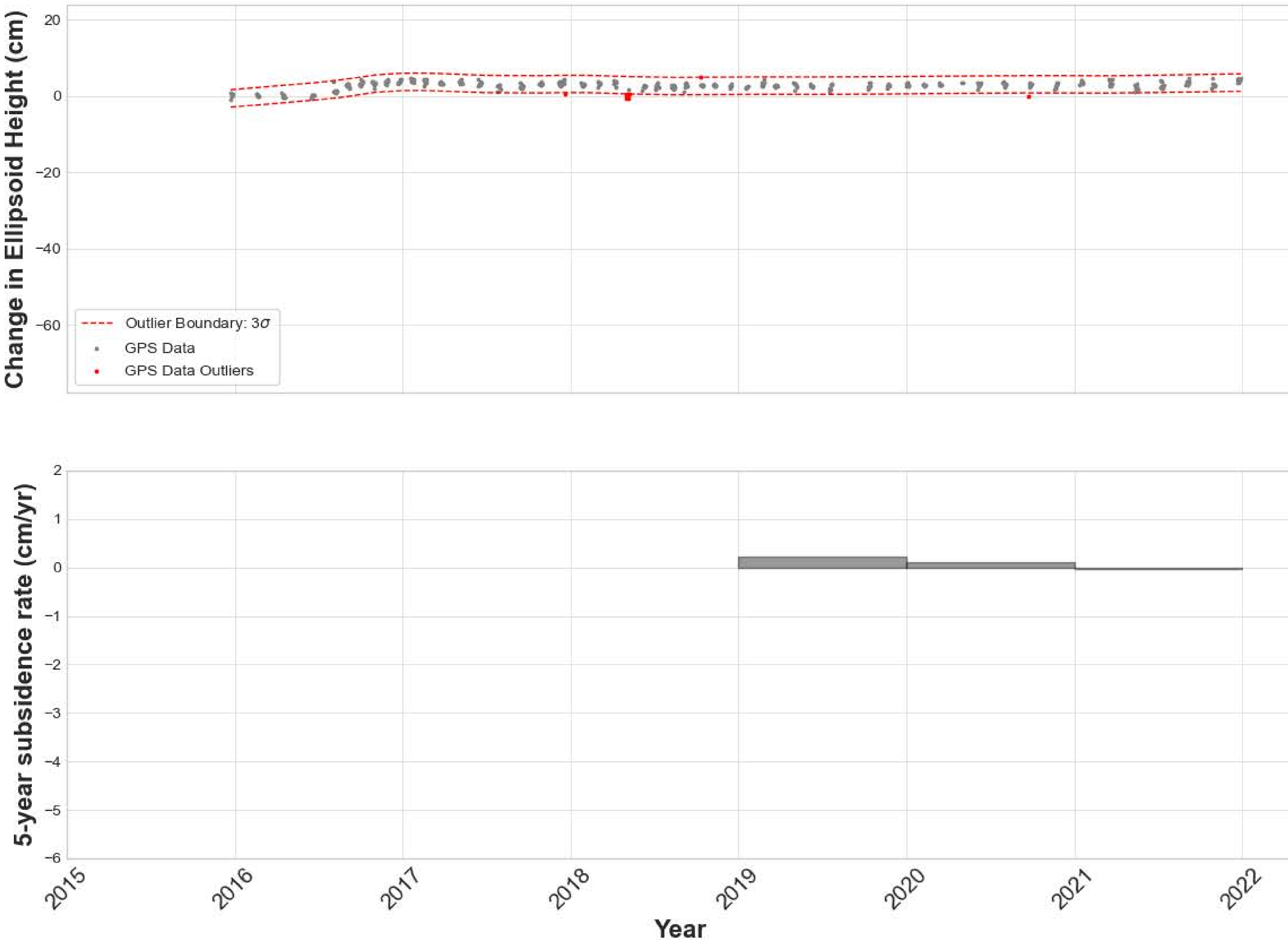
P090



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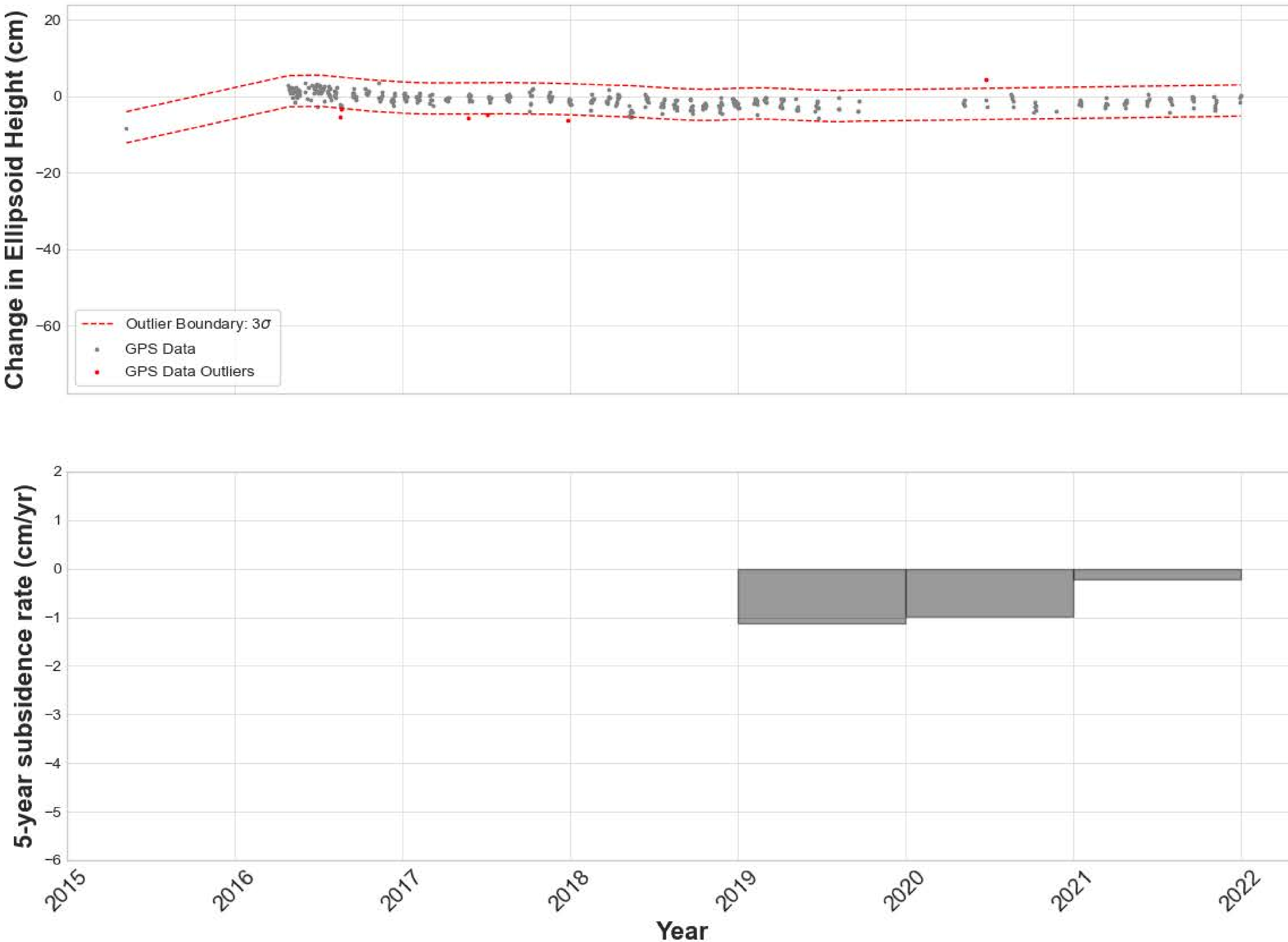
P091



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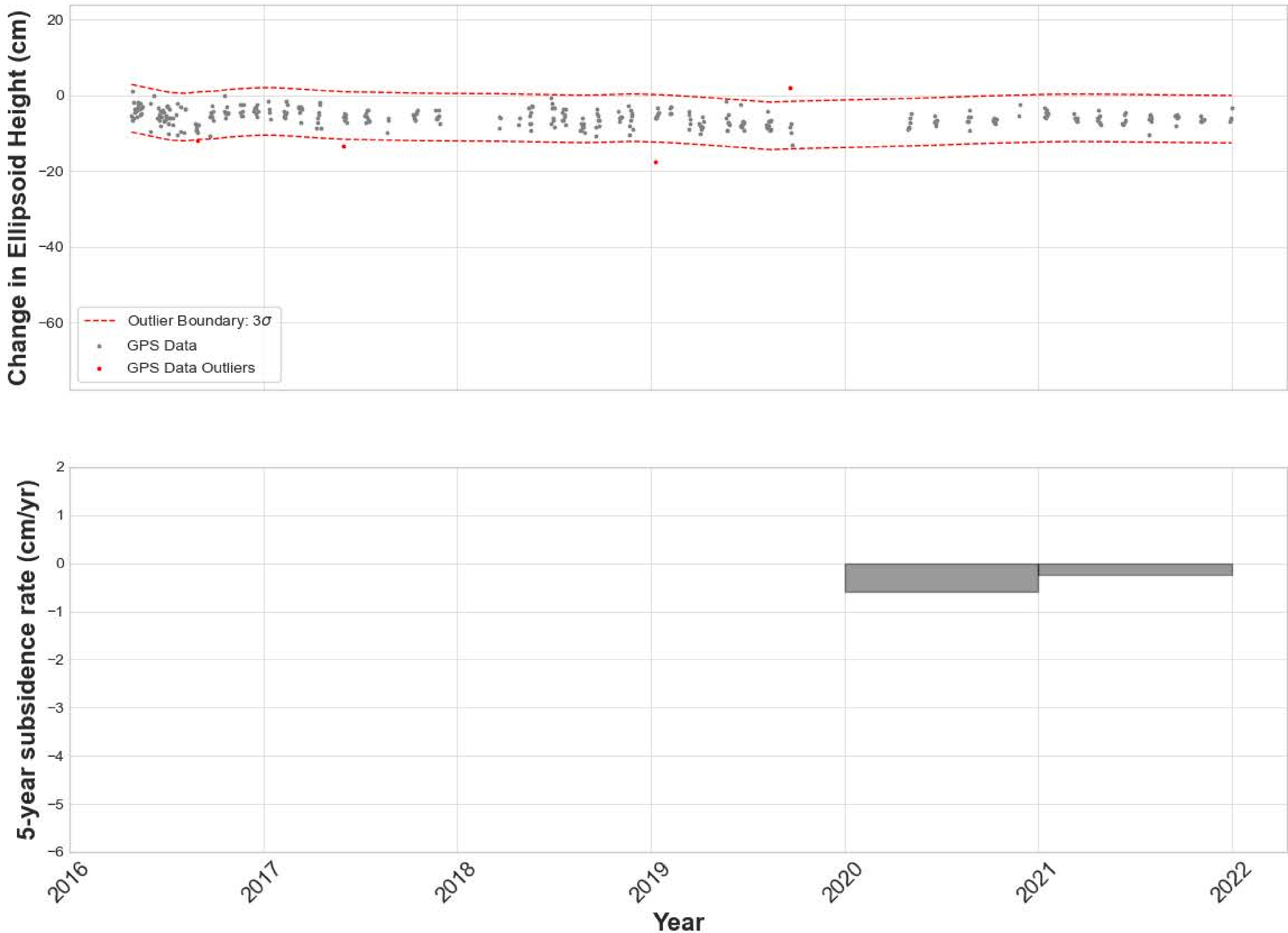
P092



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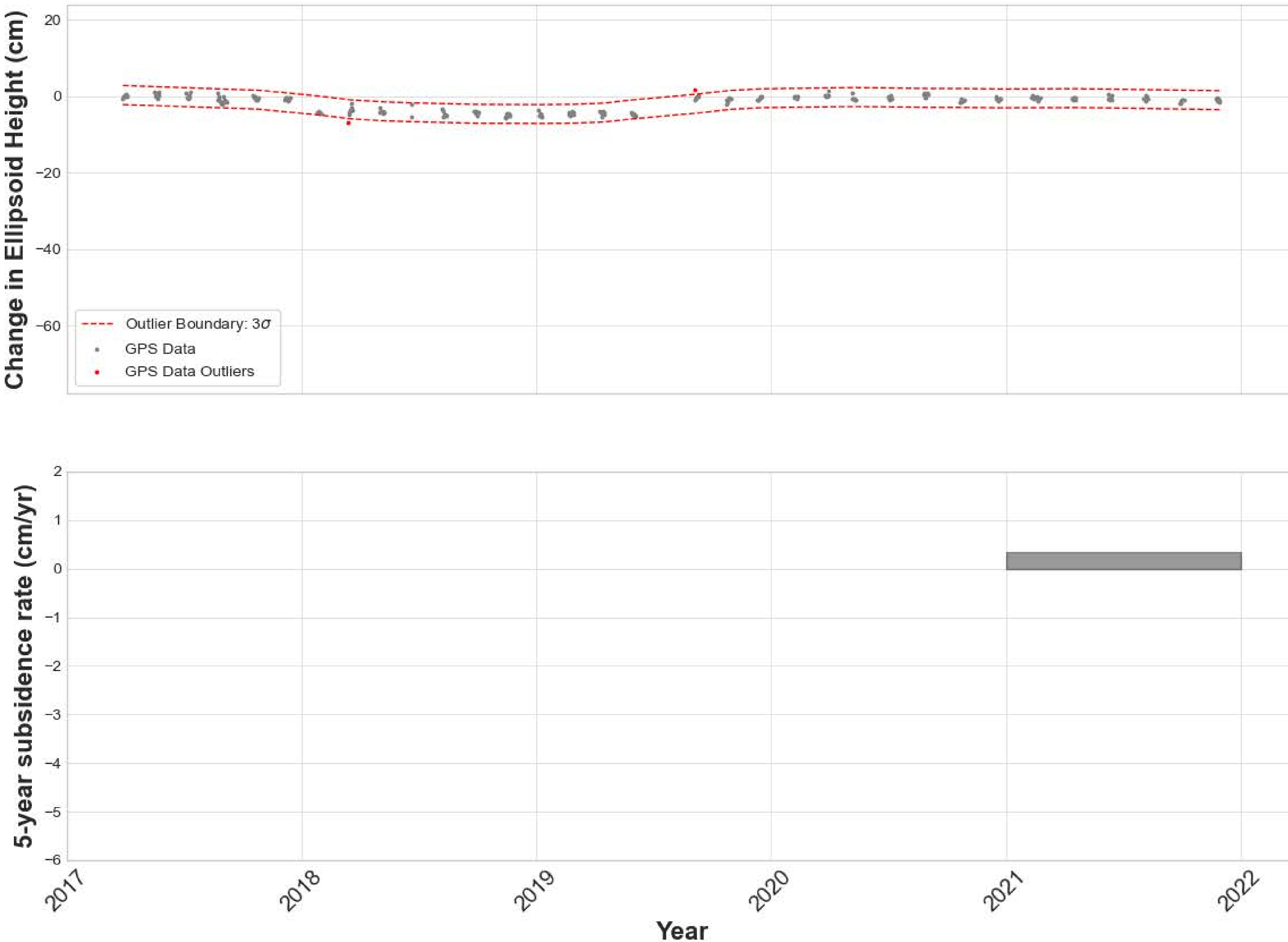
P093



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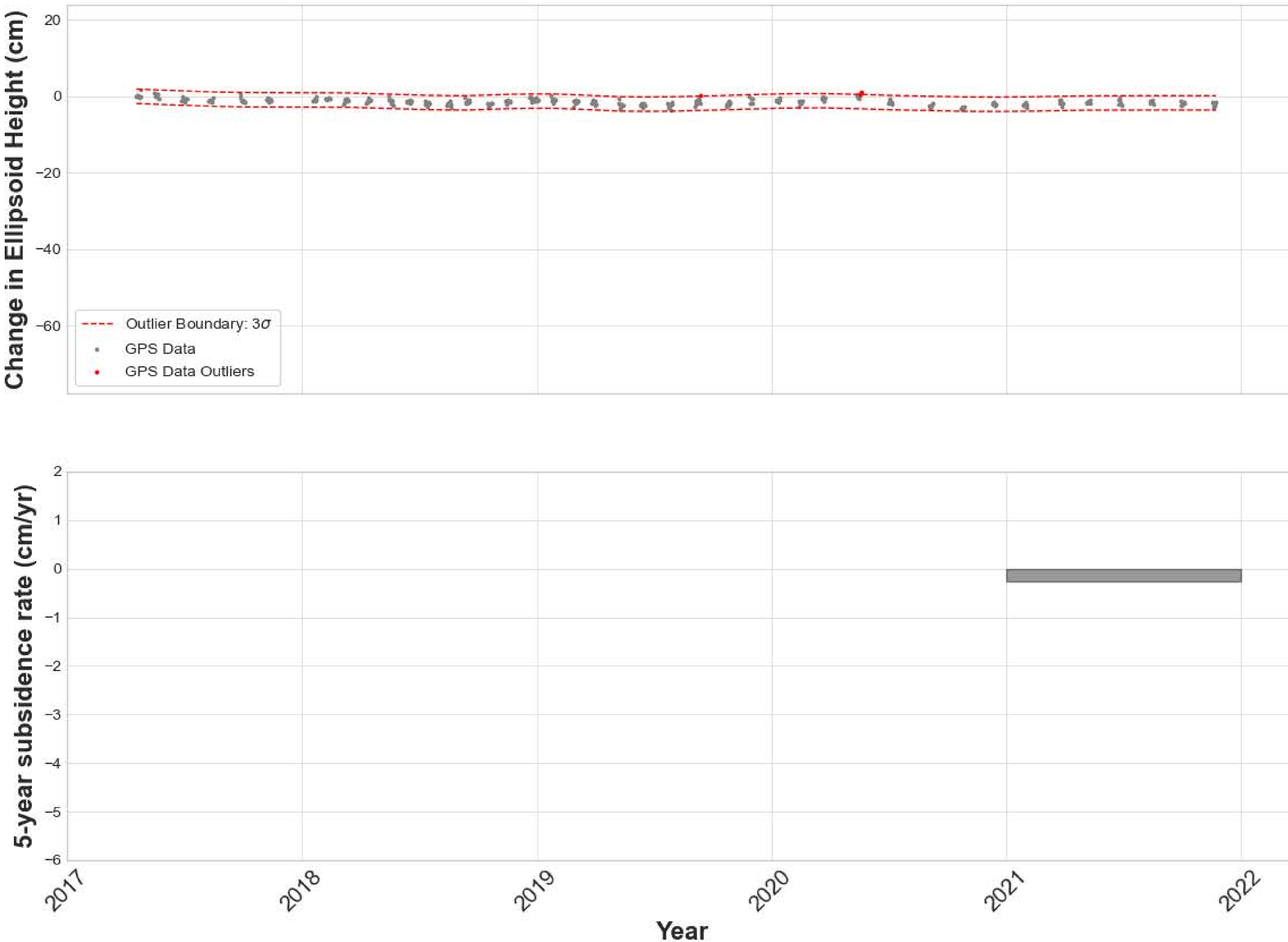
P094



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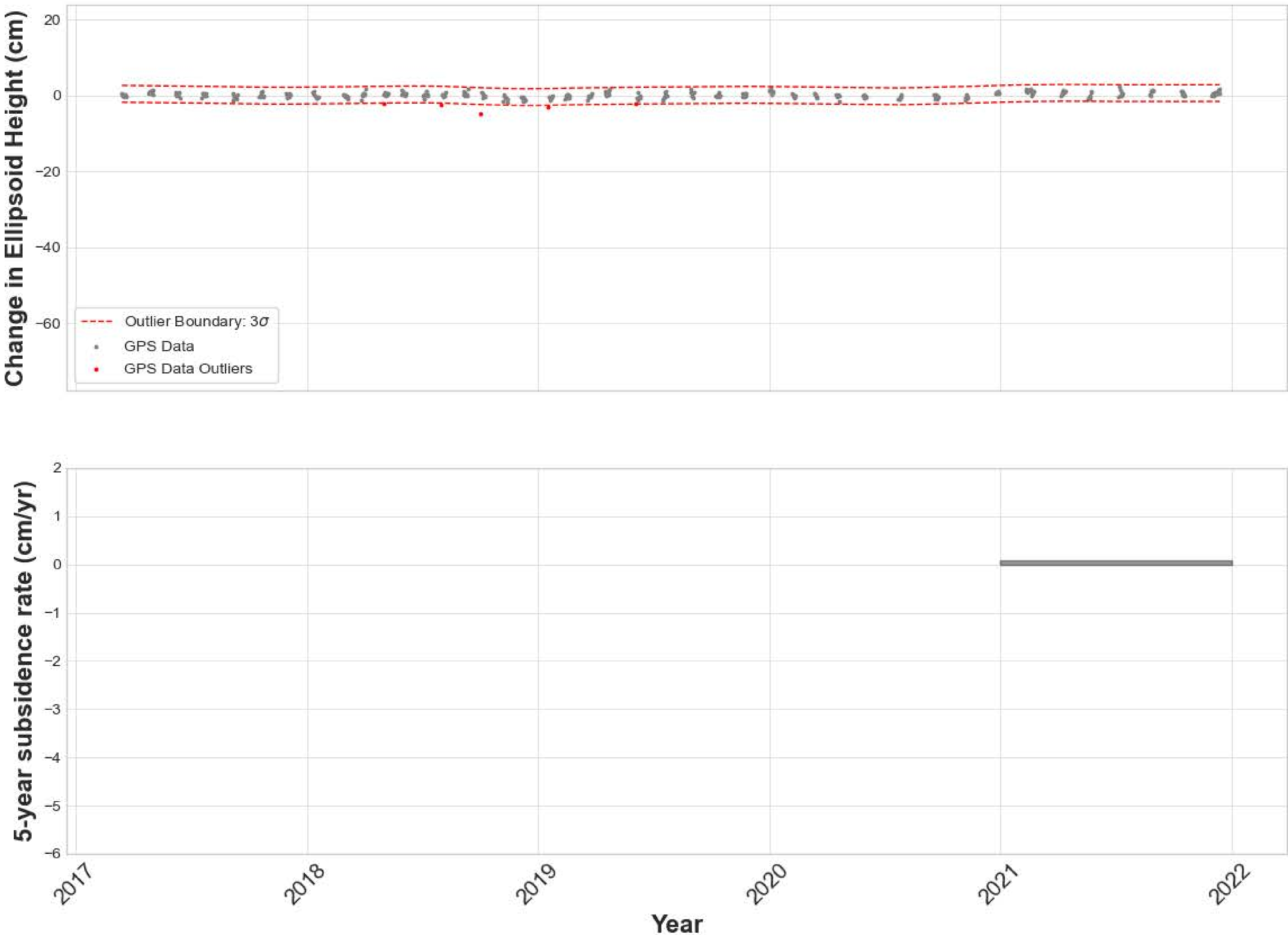
P095



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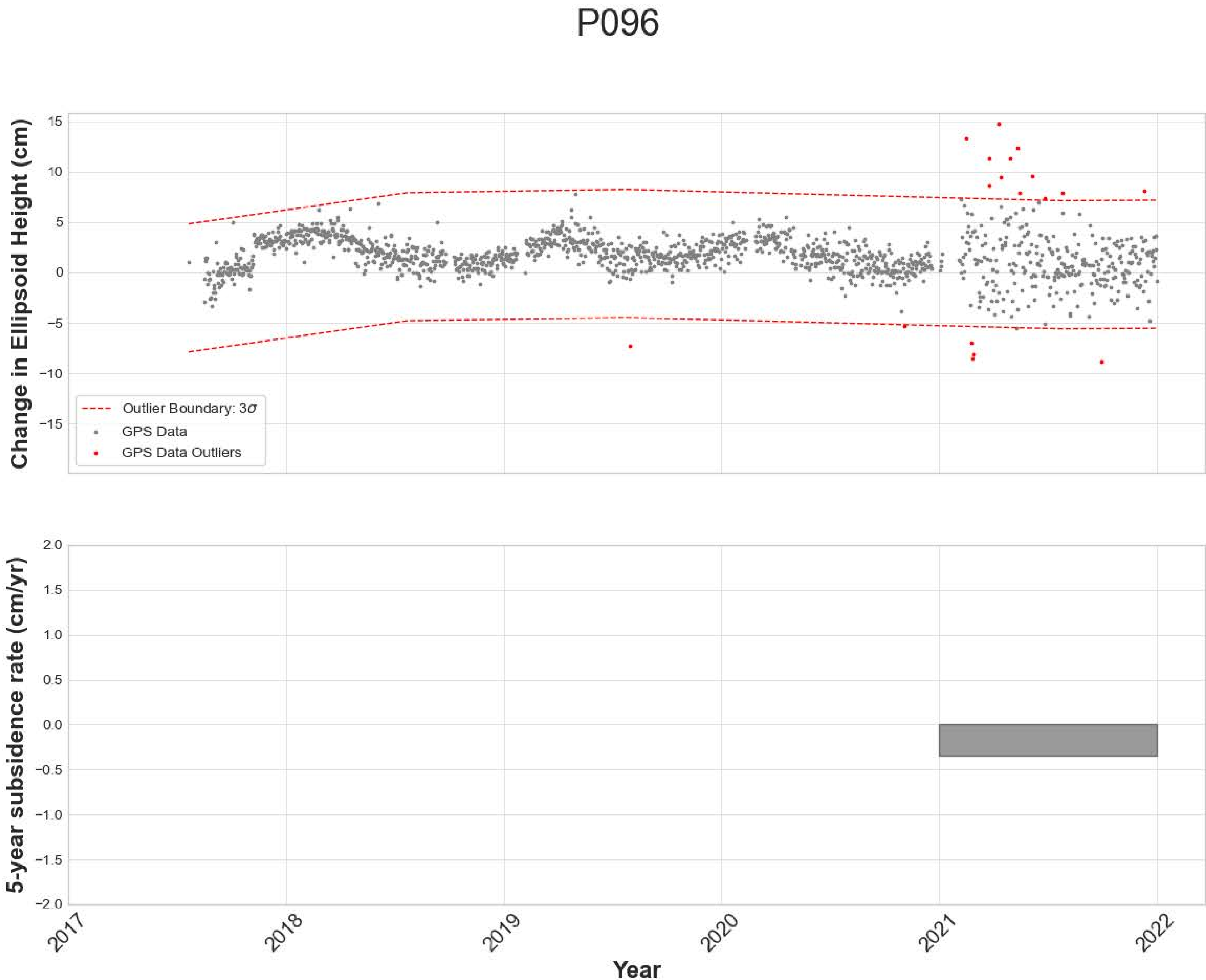

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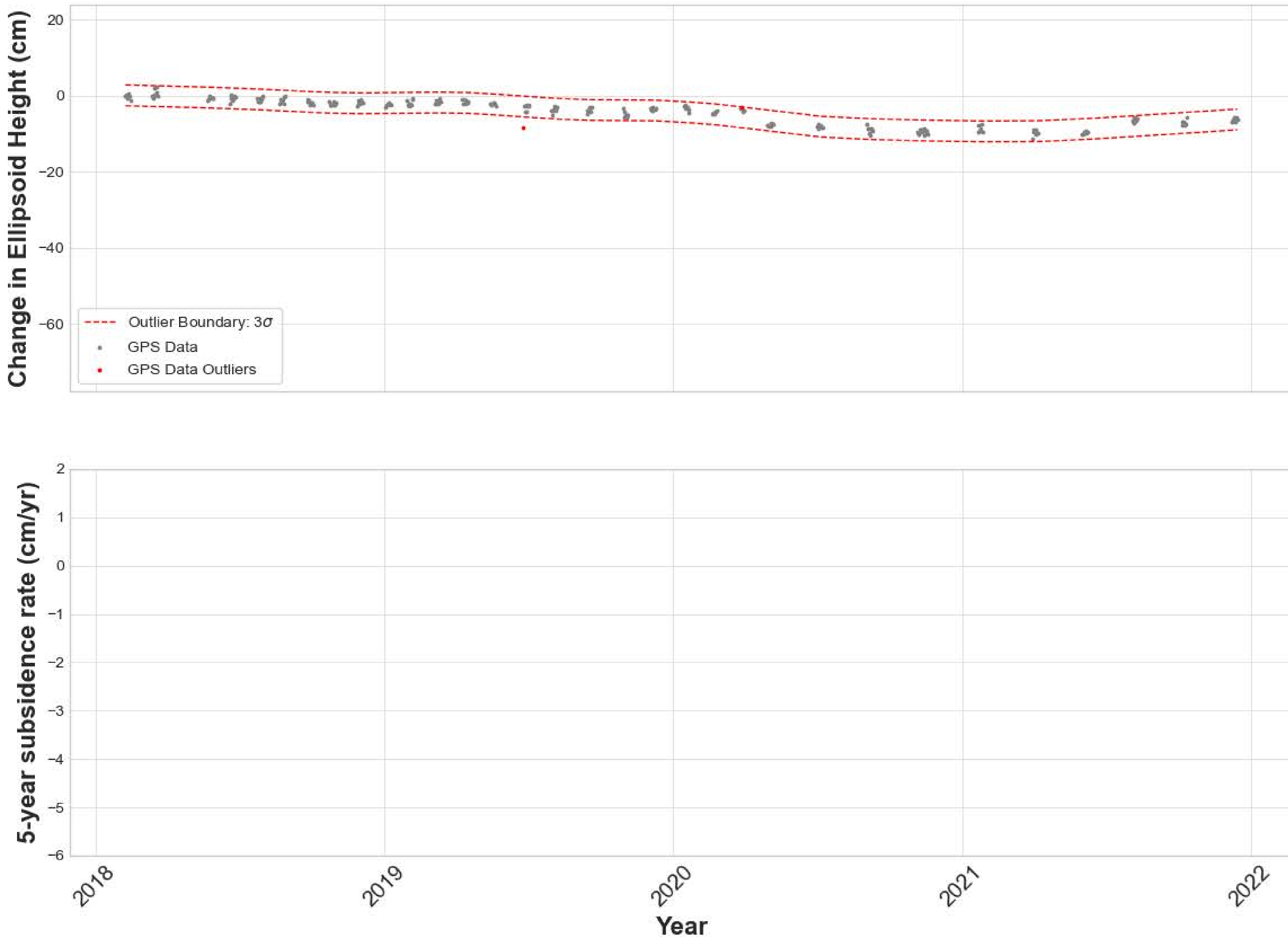
P097



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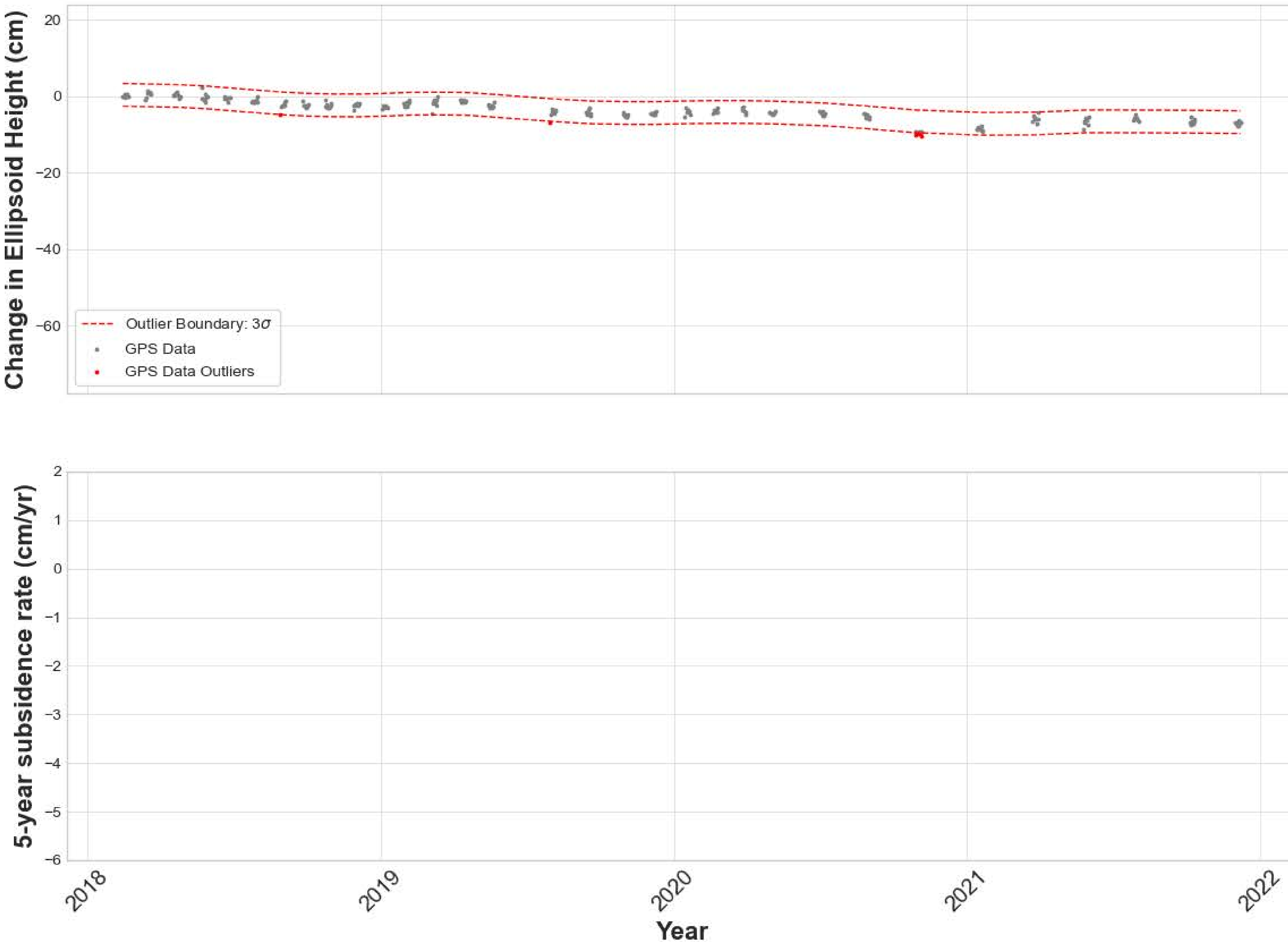
P098



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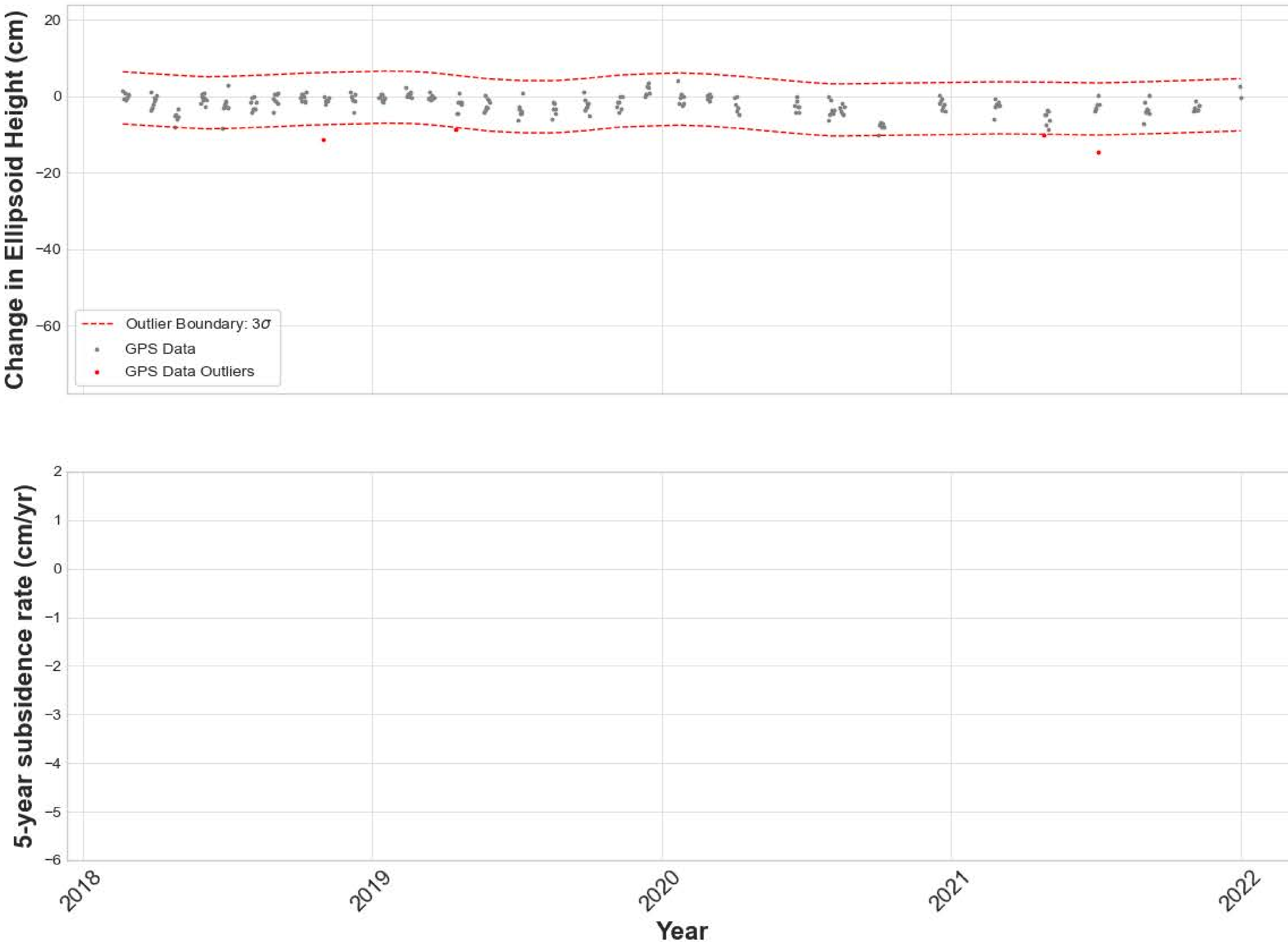
P099



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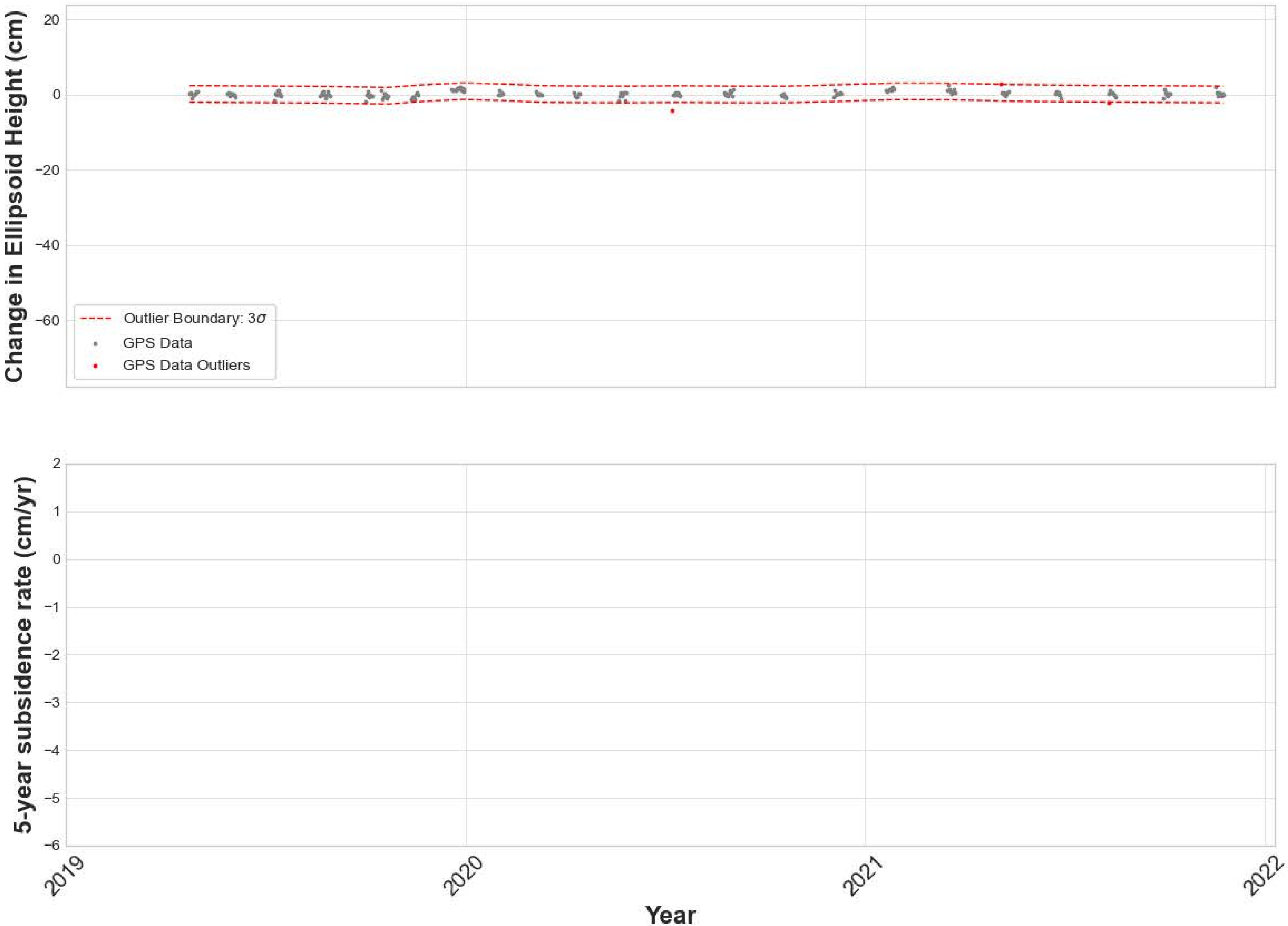
P100



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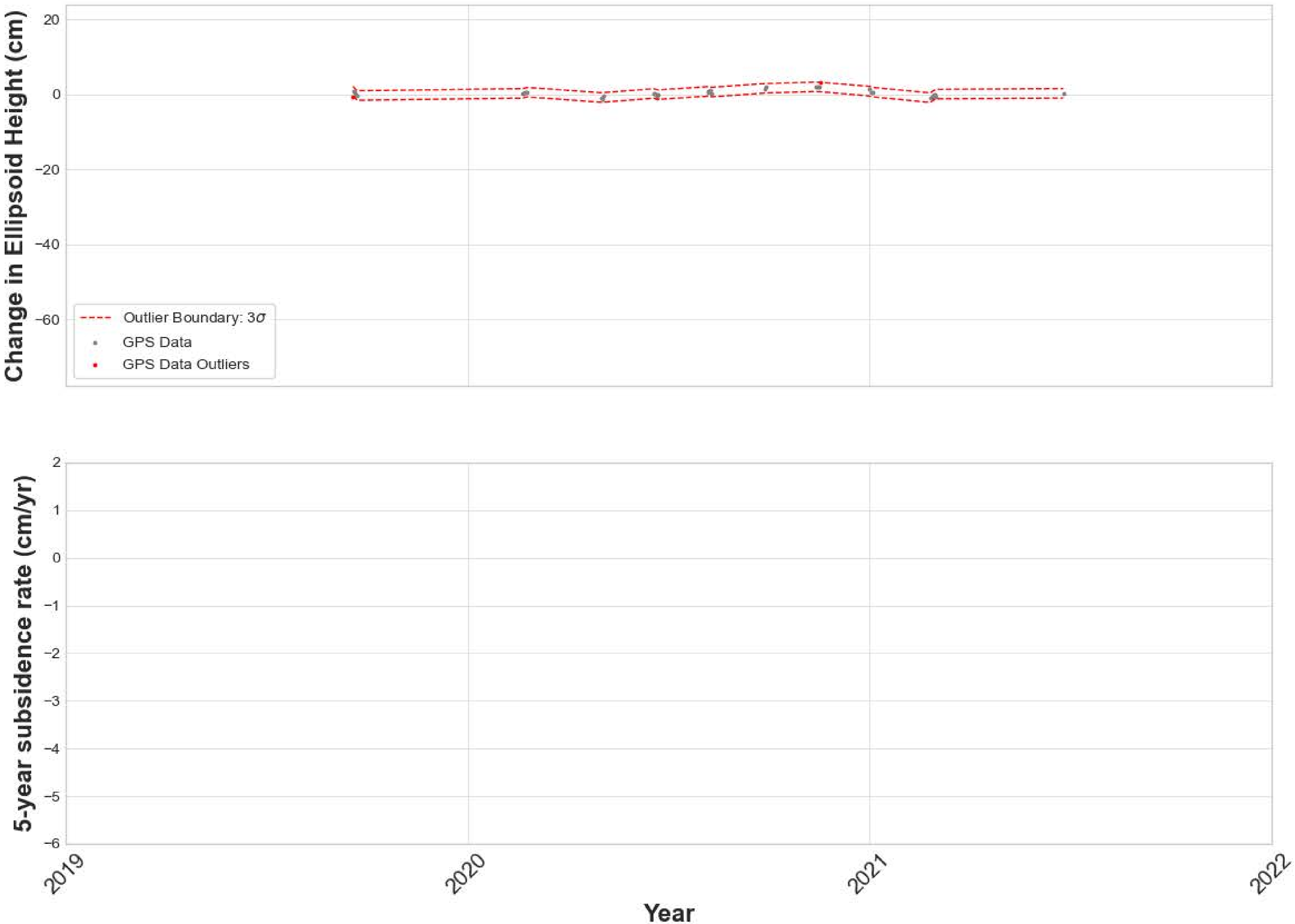
P101



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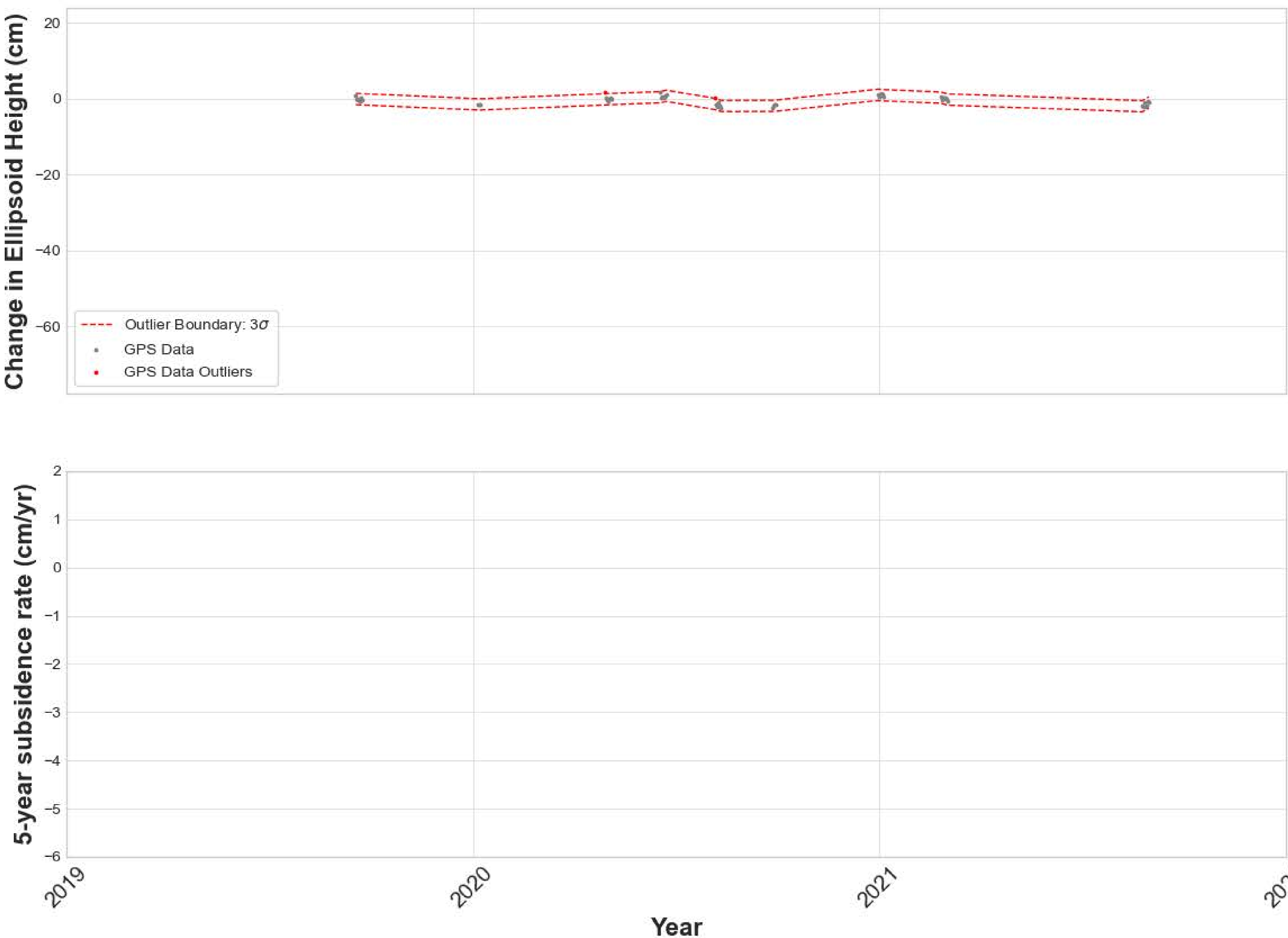
P103



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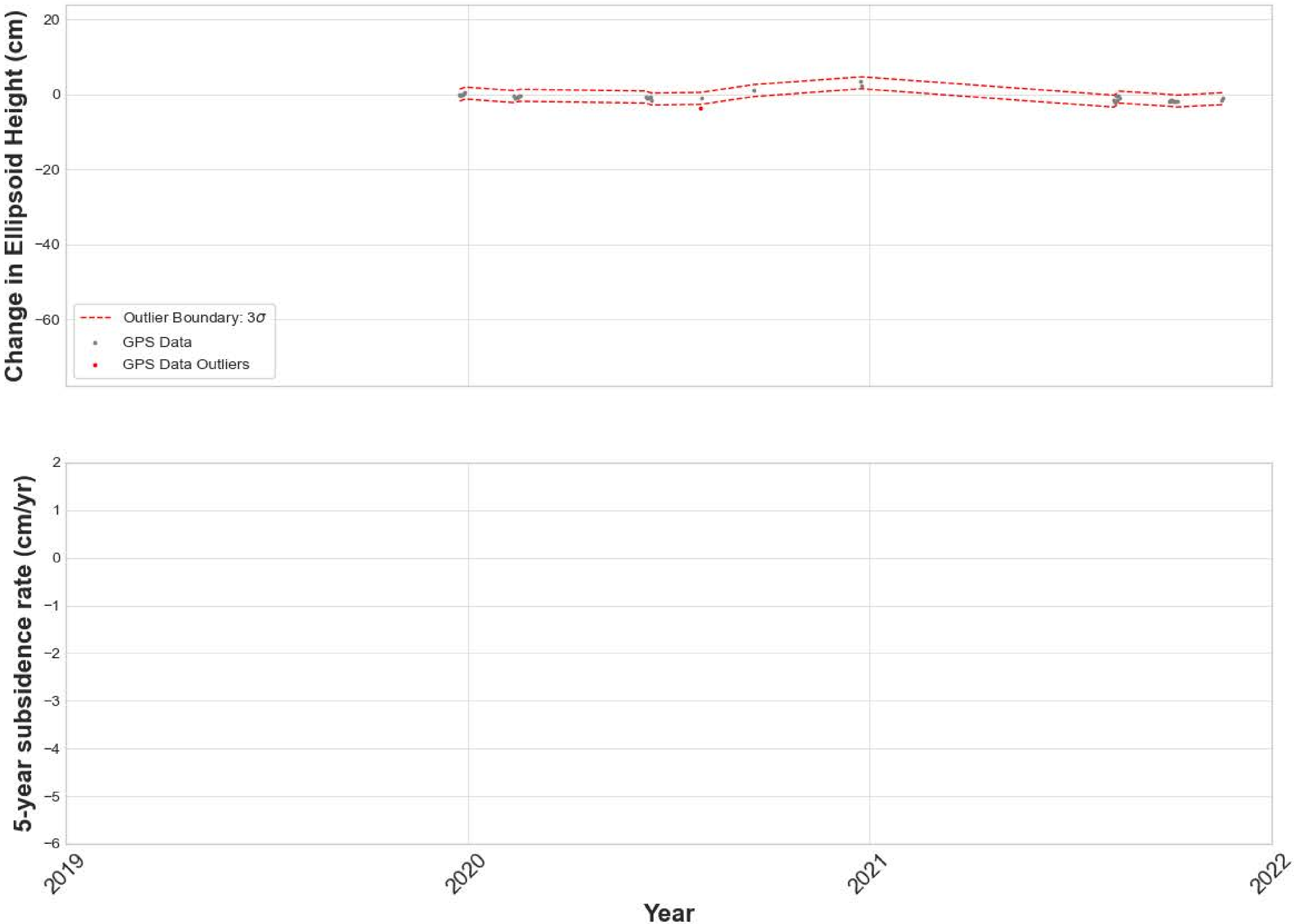
P104



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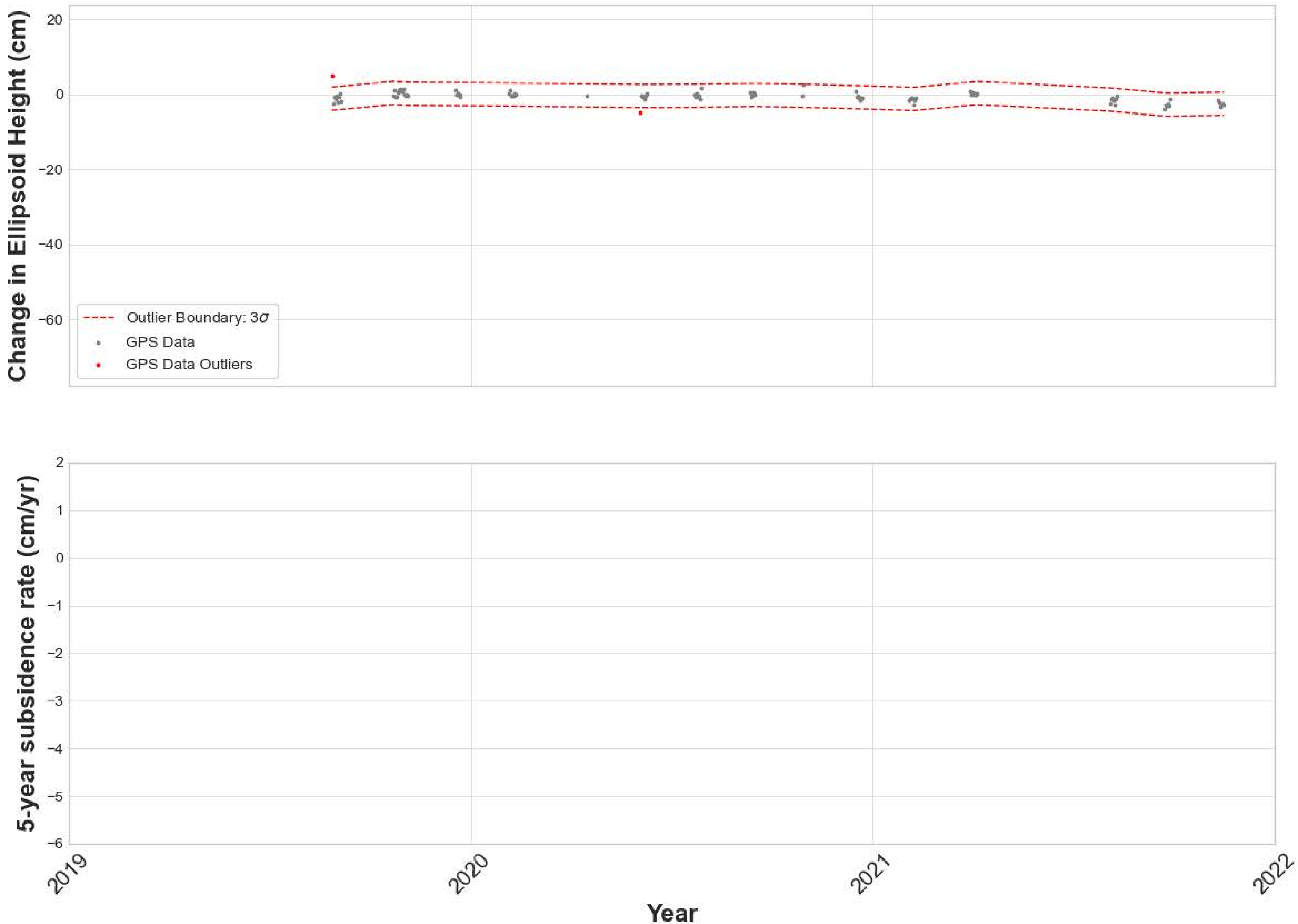
P105



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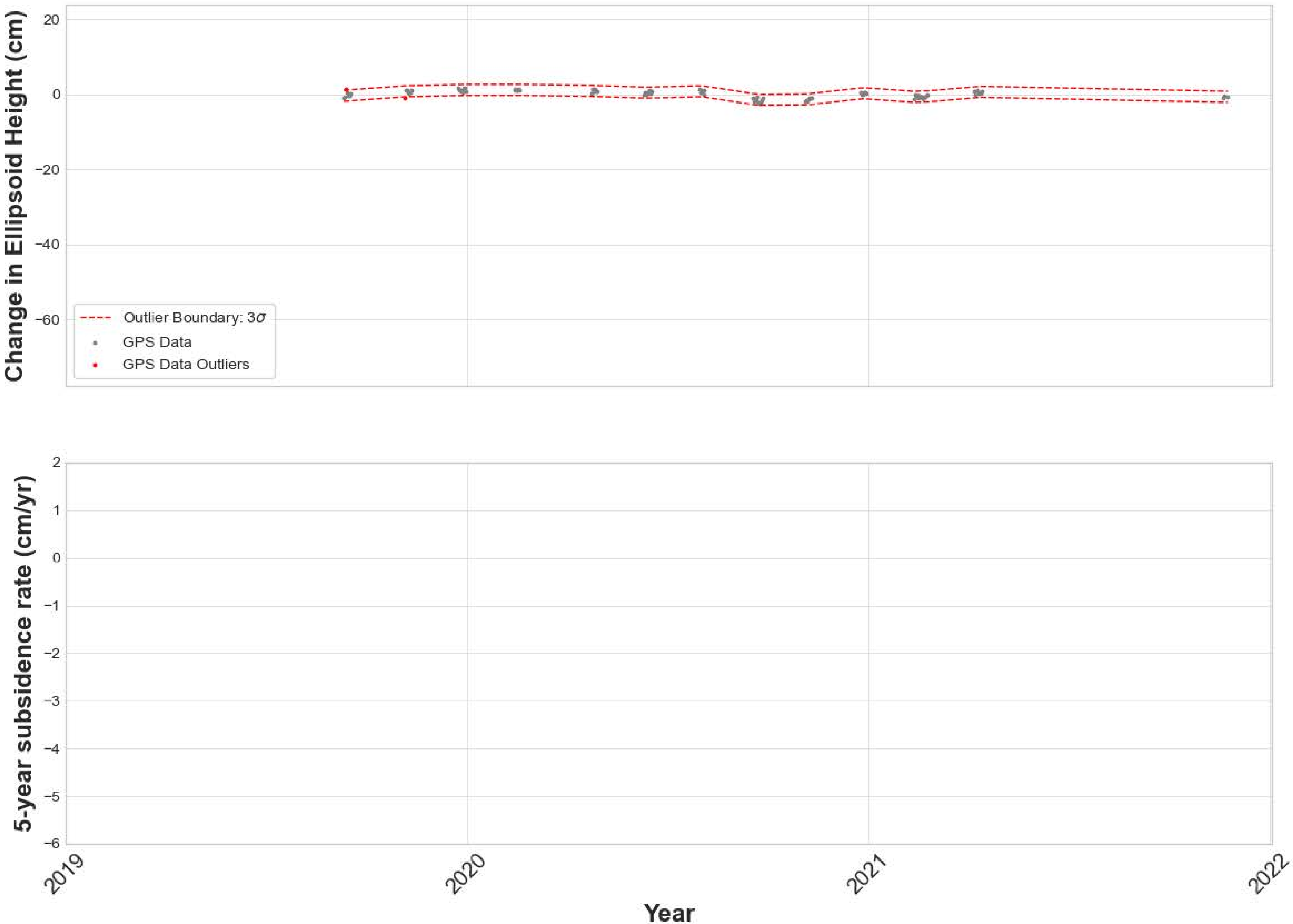
P106



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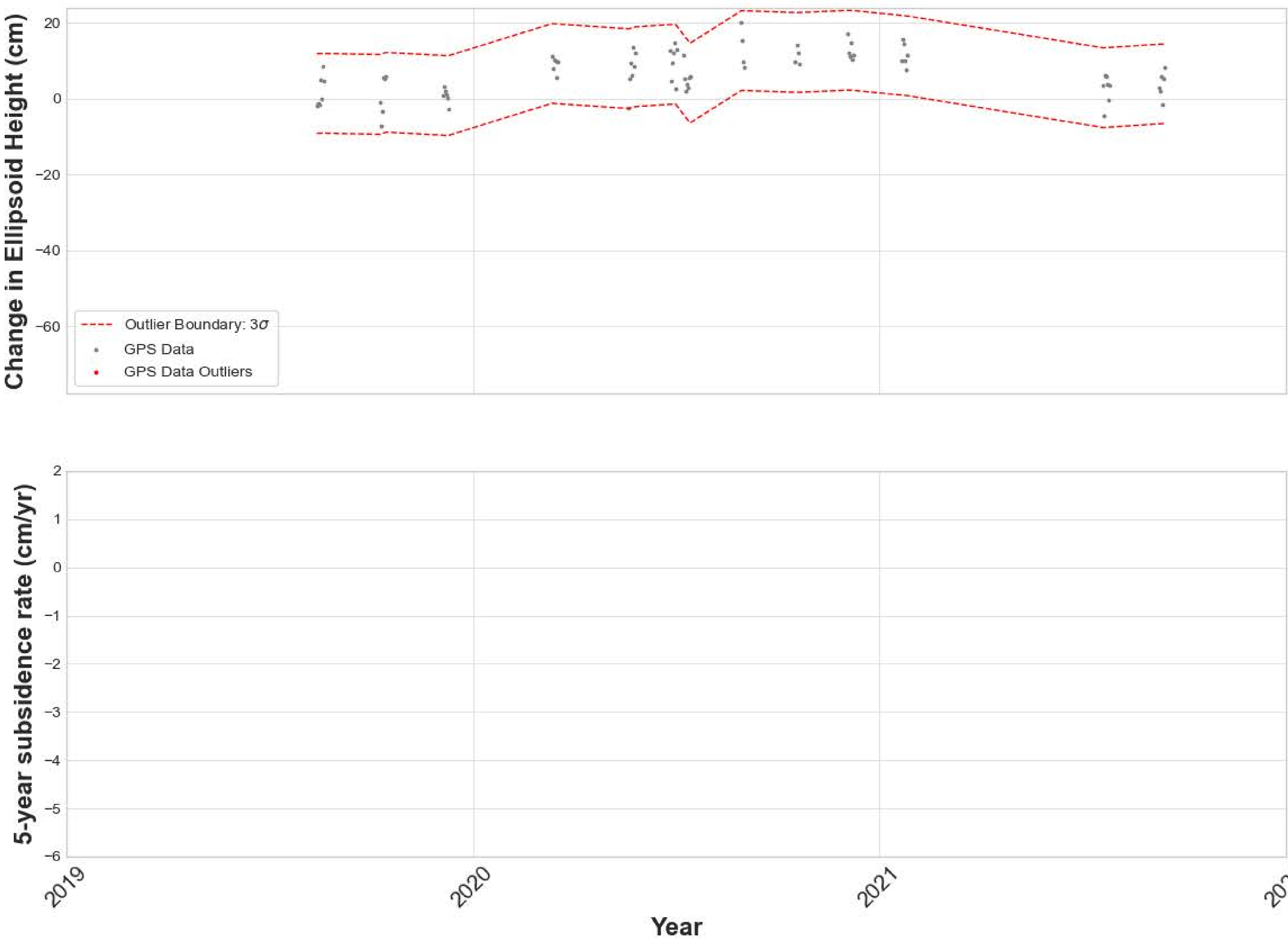
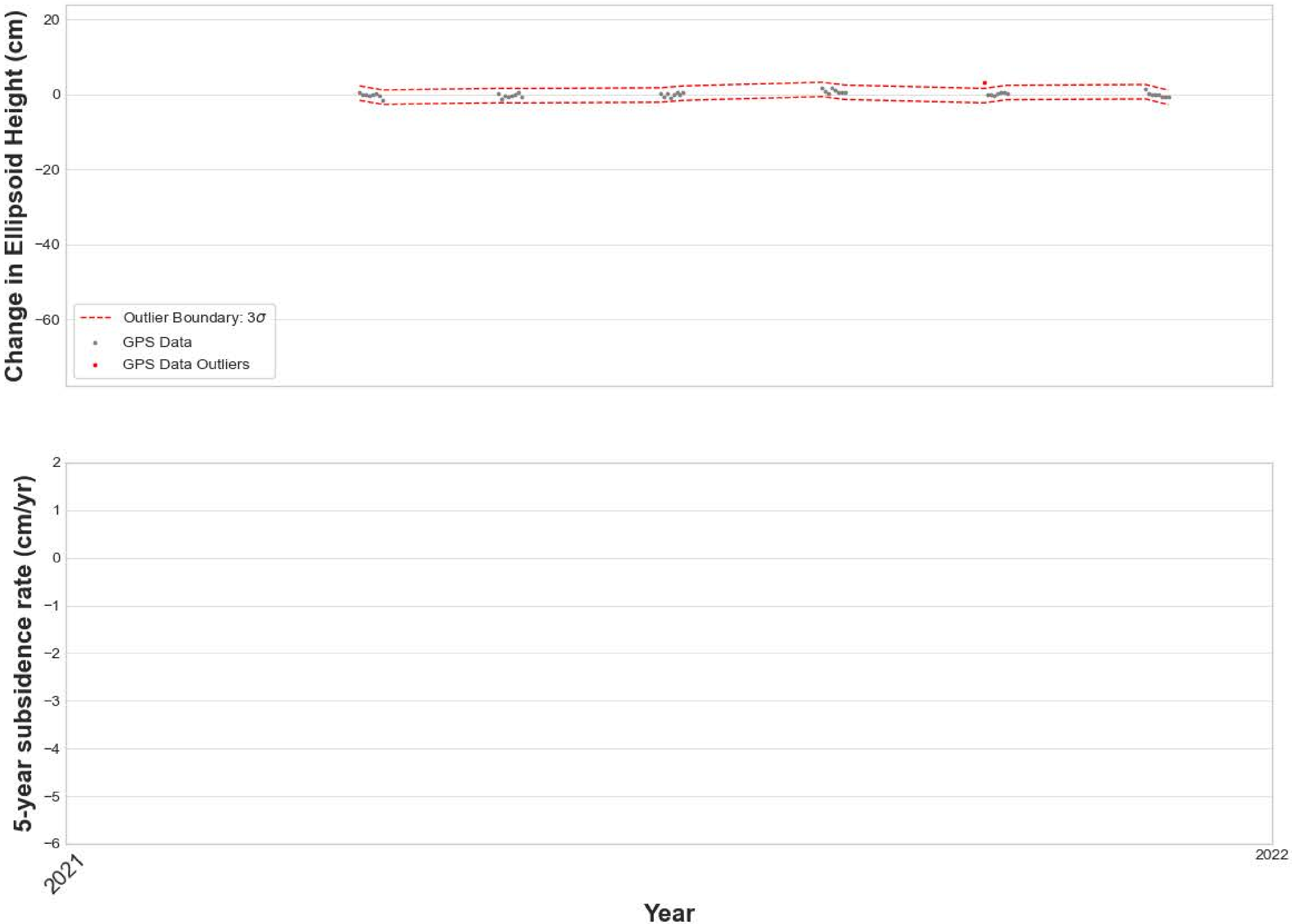
P107



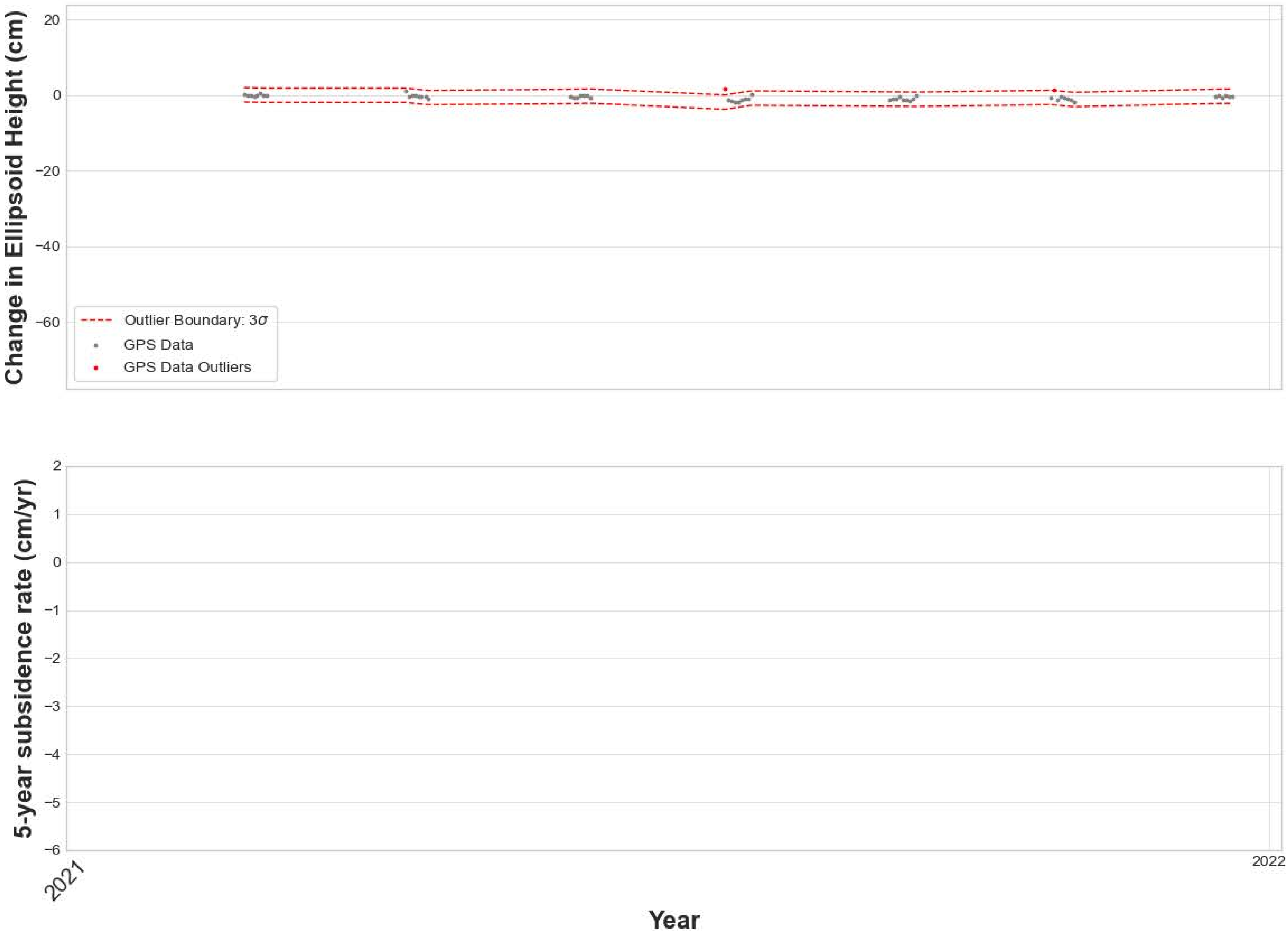
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P108



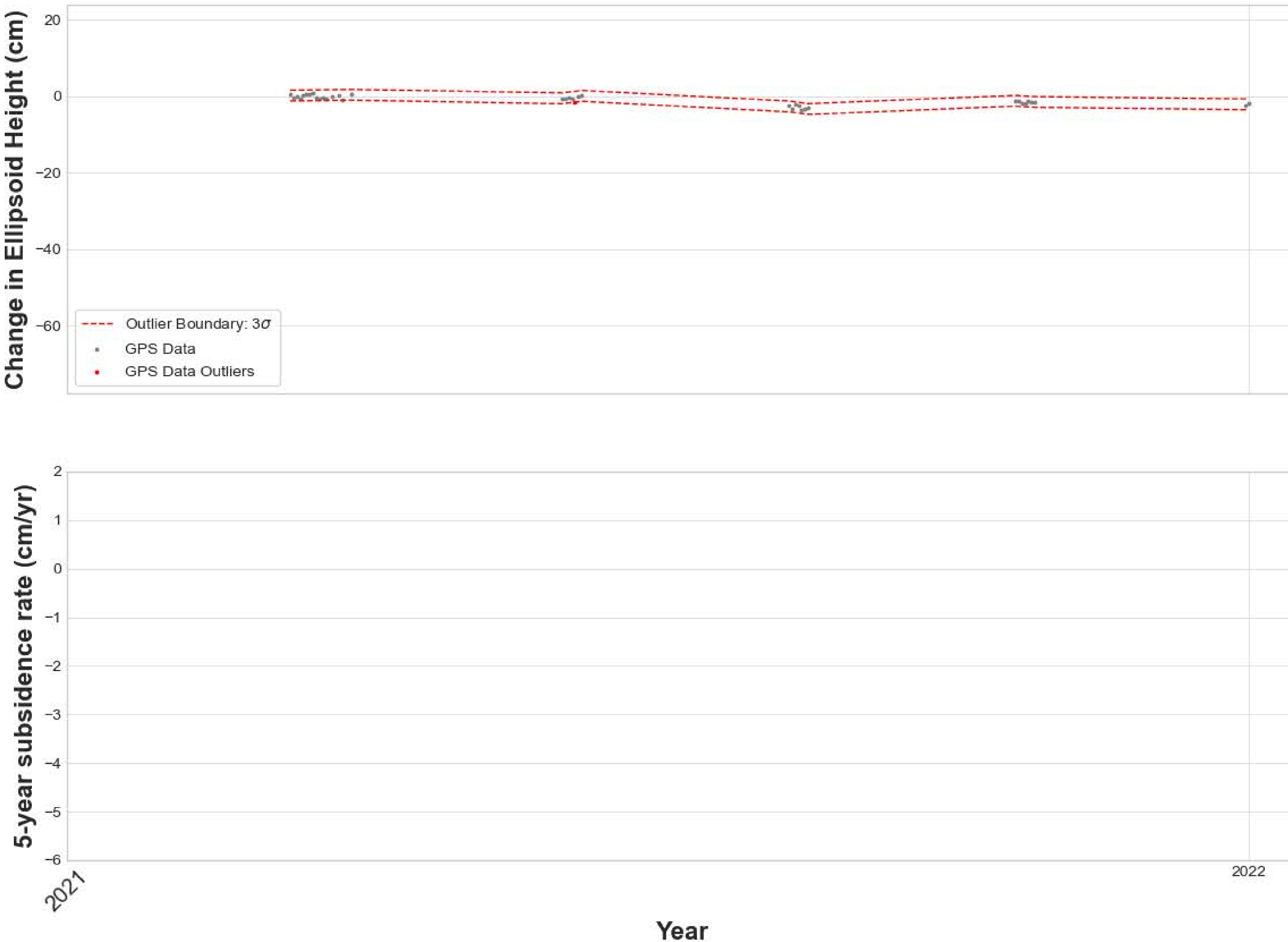
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P109



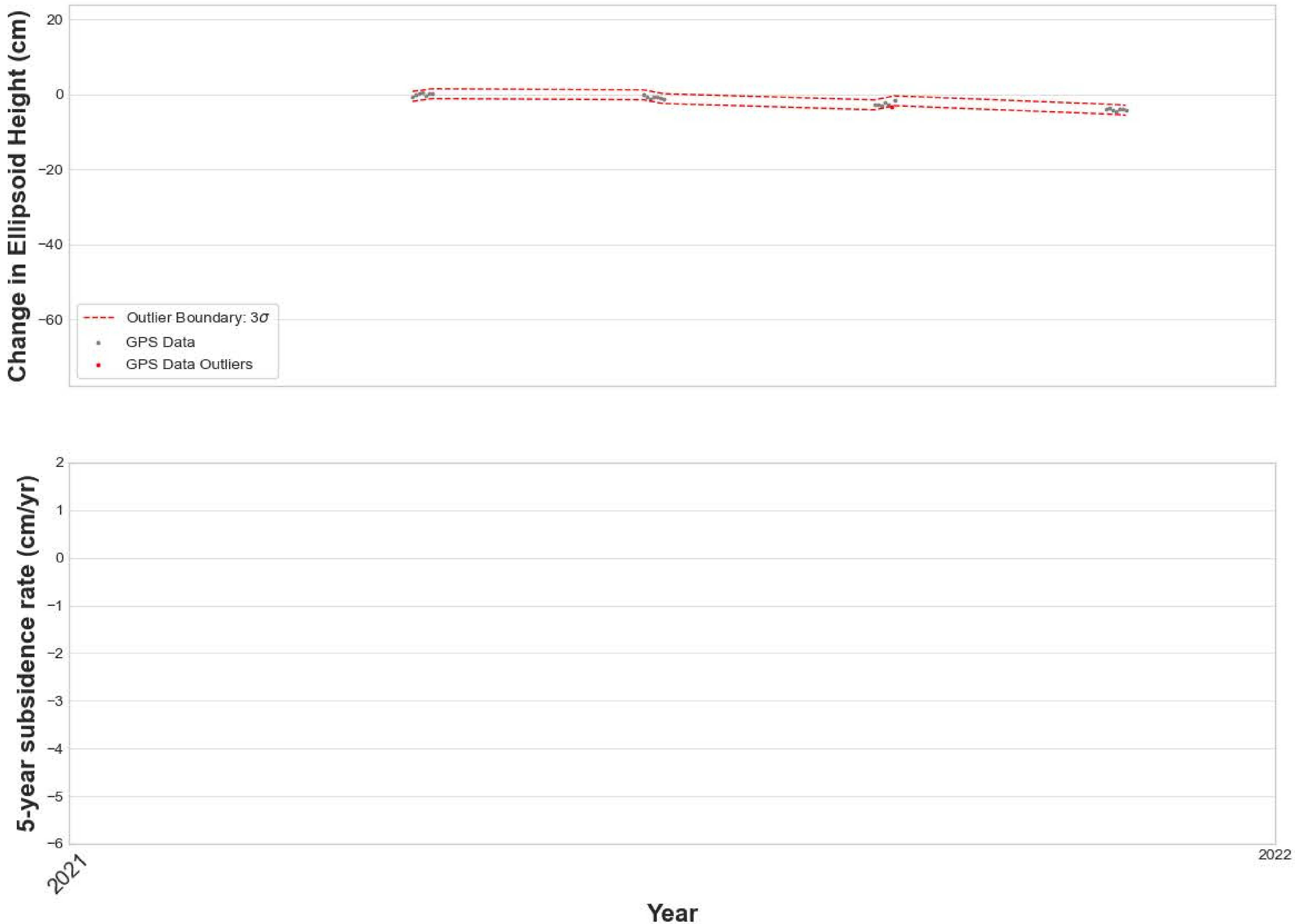
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P110



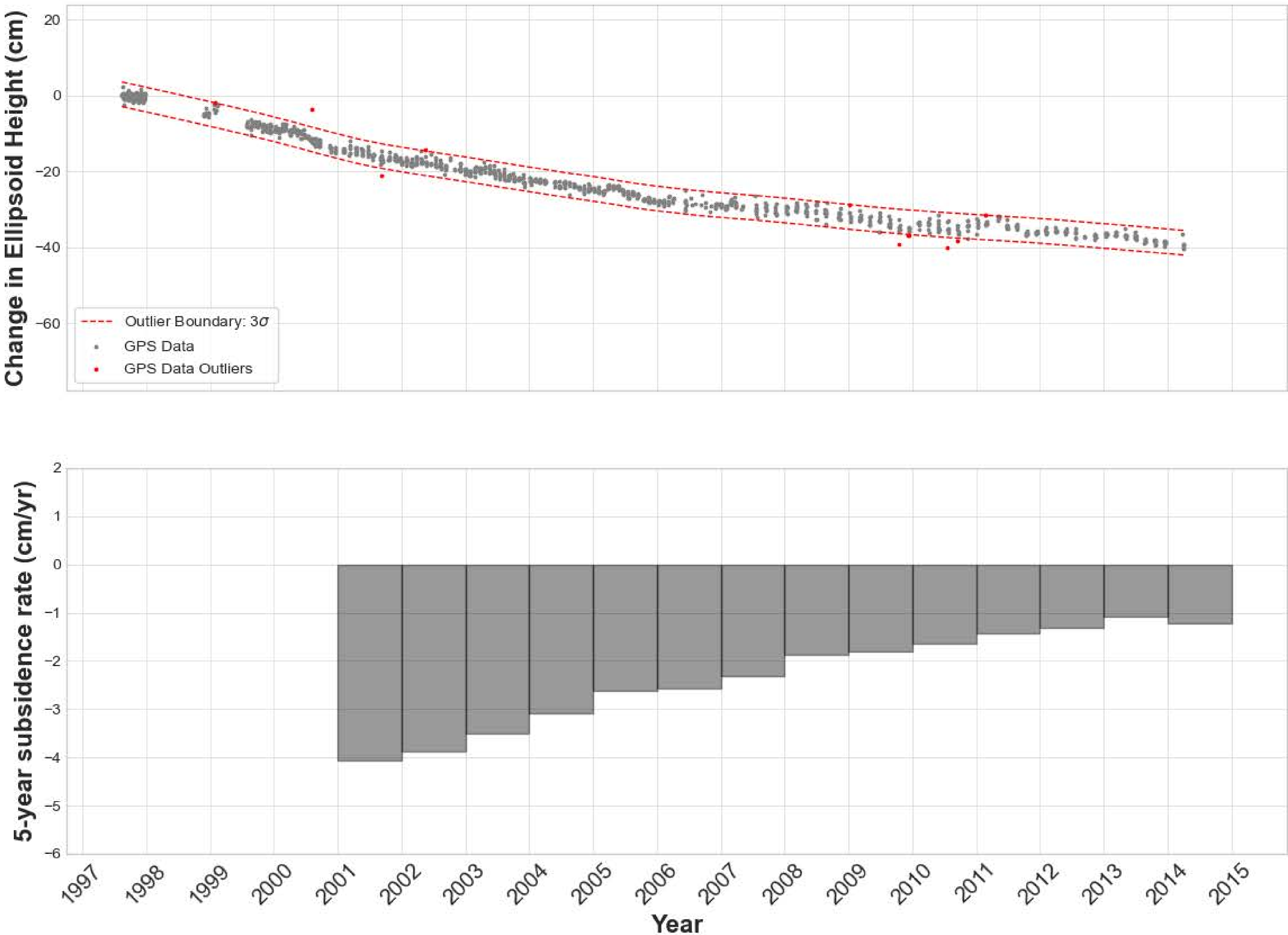
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

P111



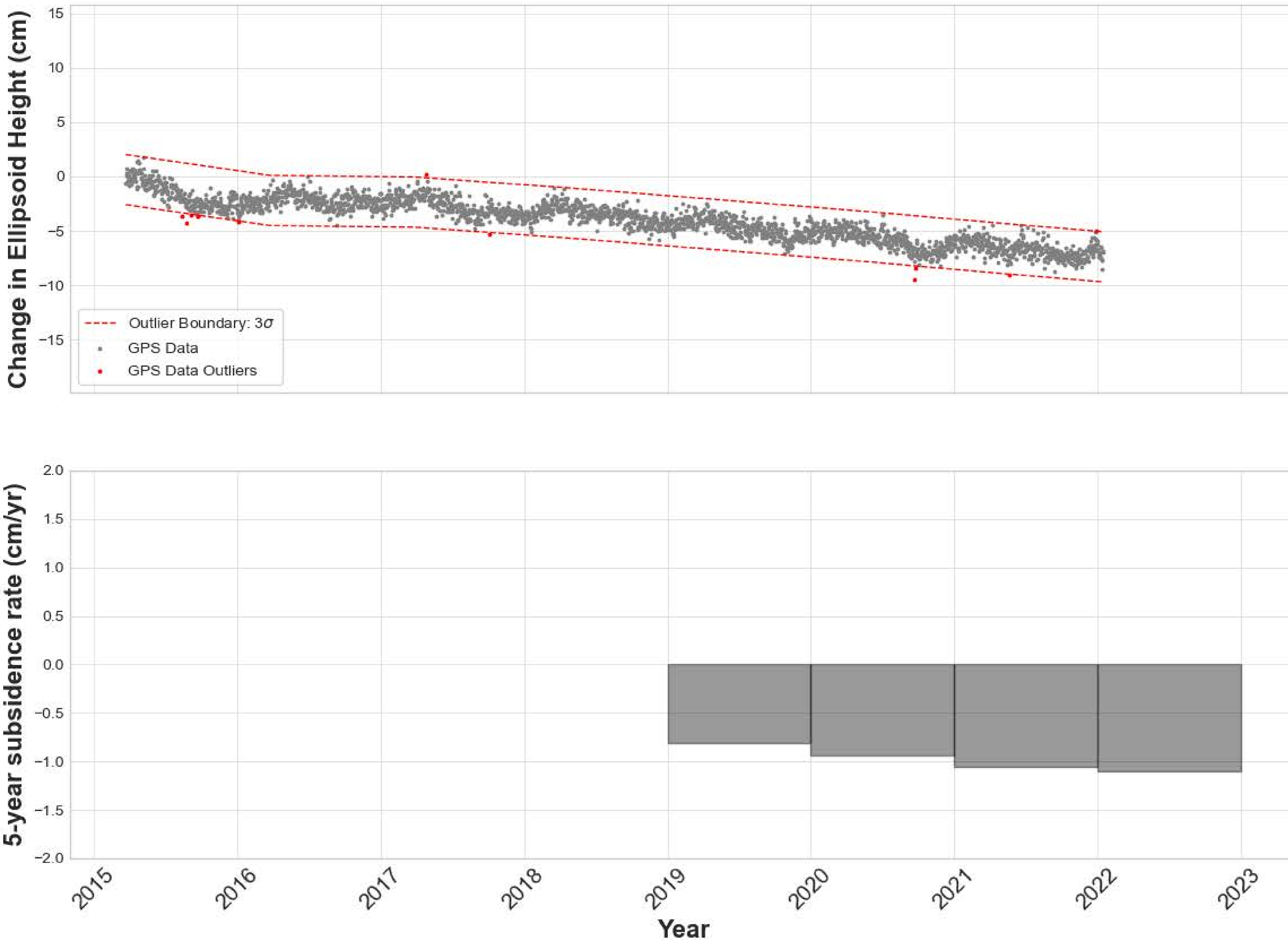
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

PAA6



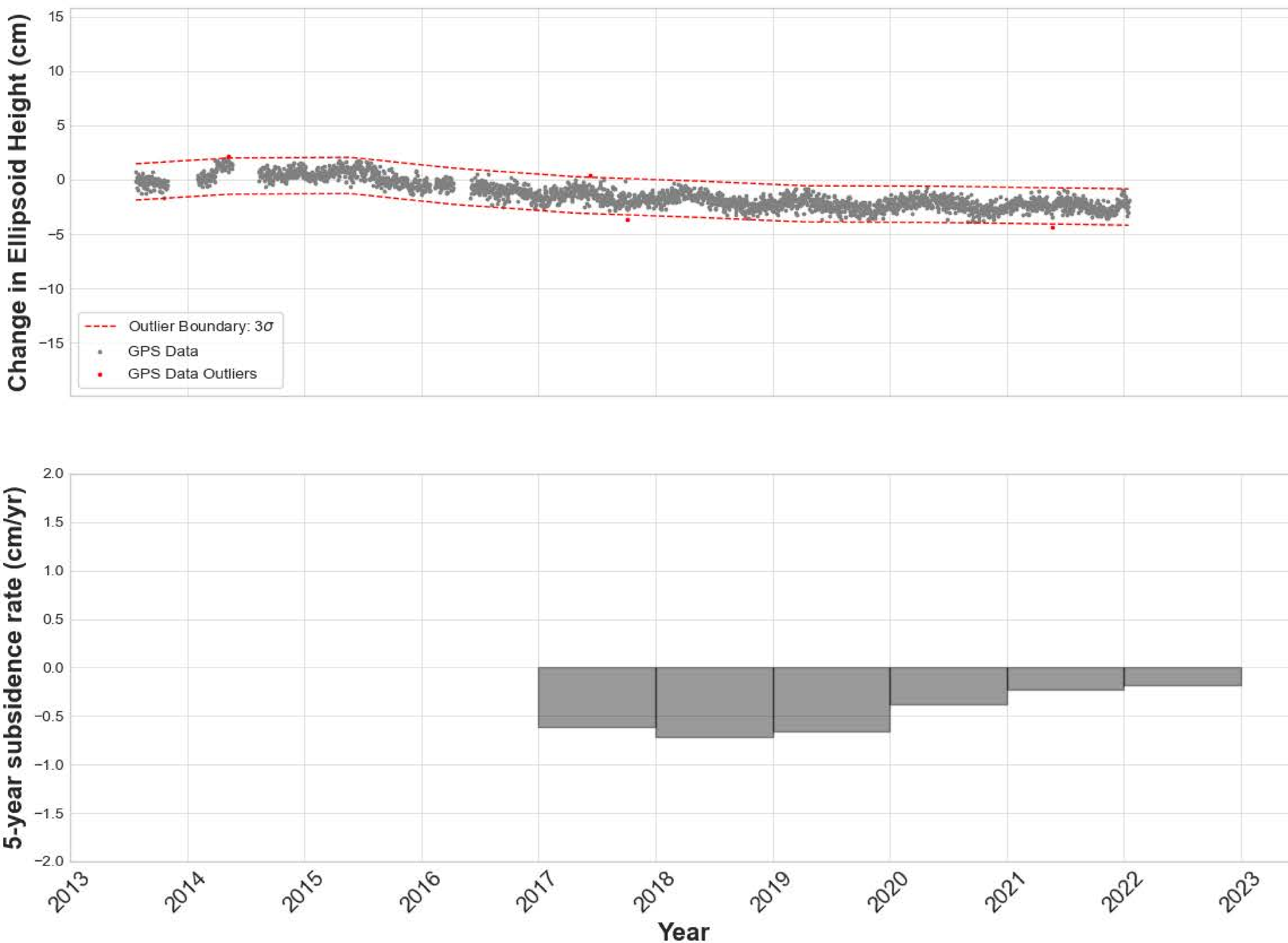
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

PWES



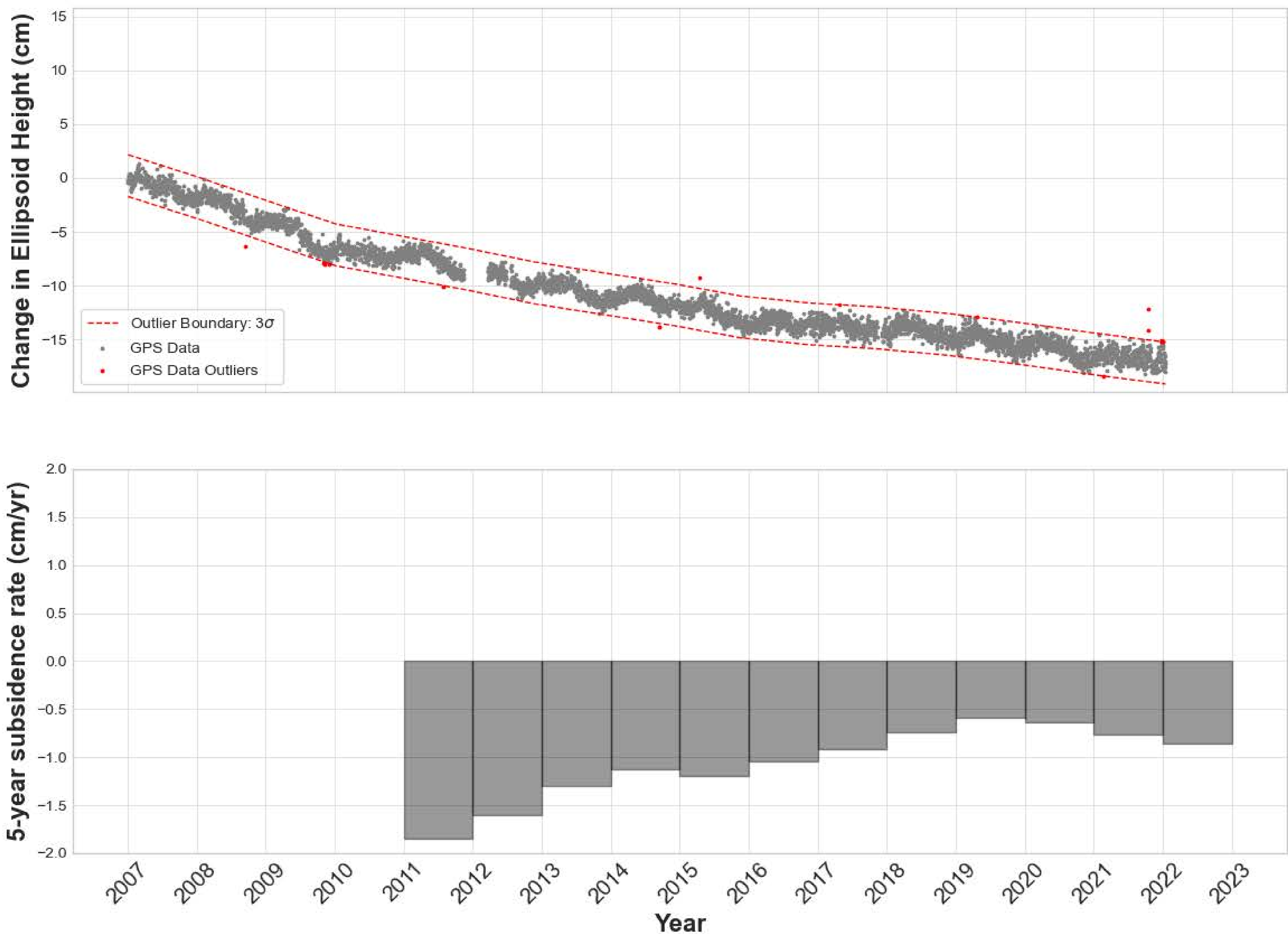
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

RDCT



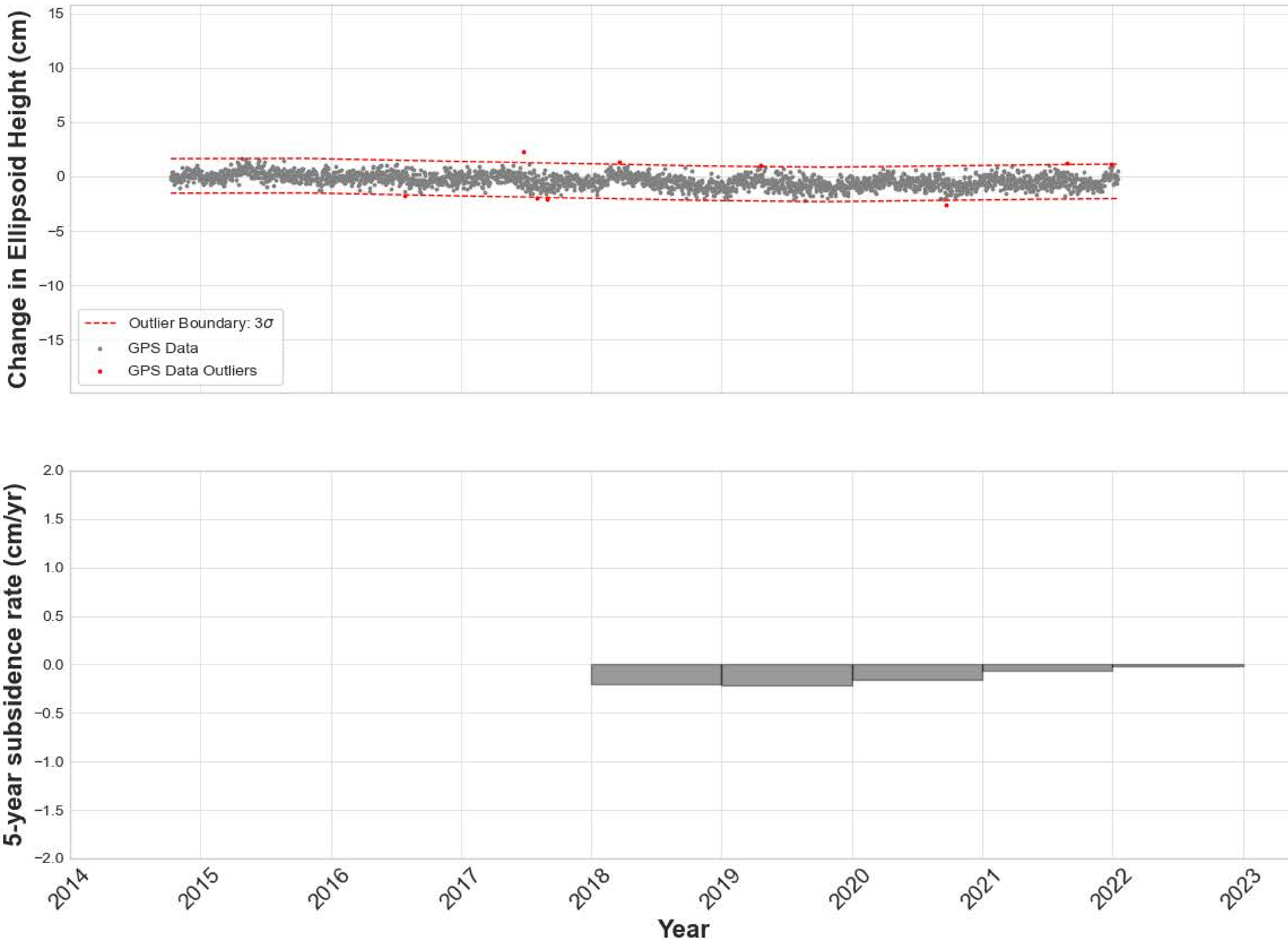
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

ROD1



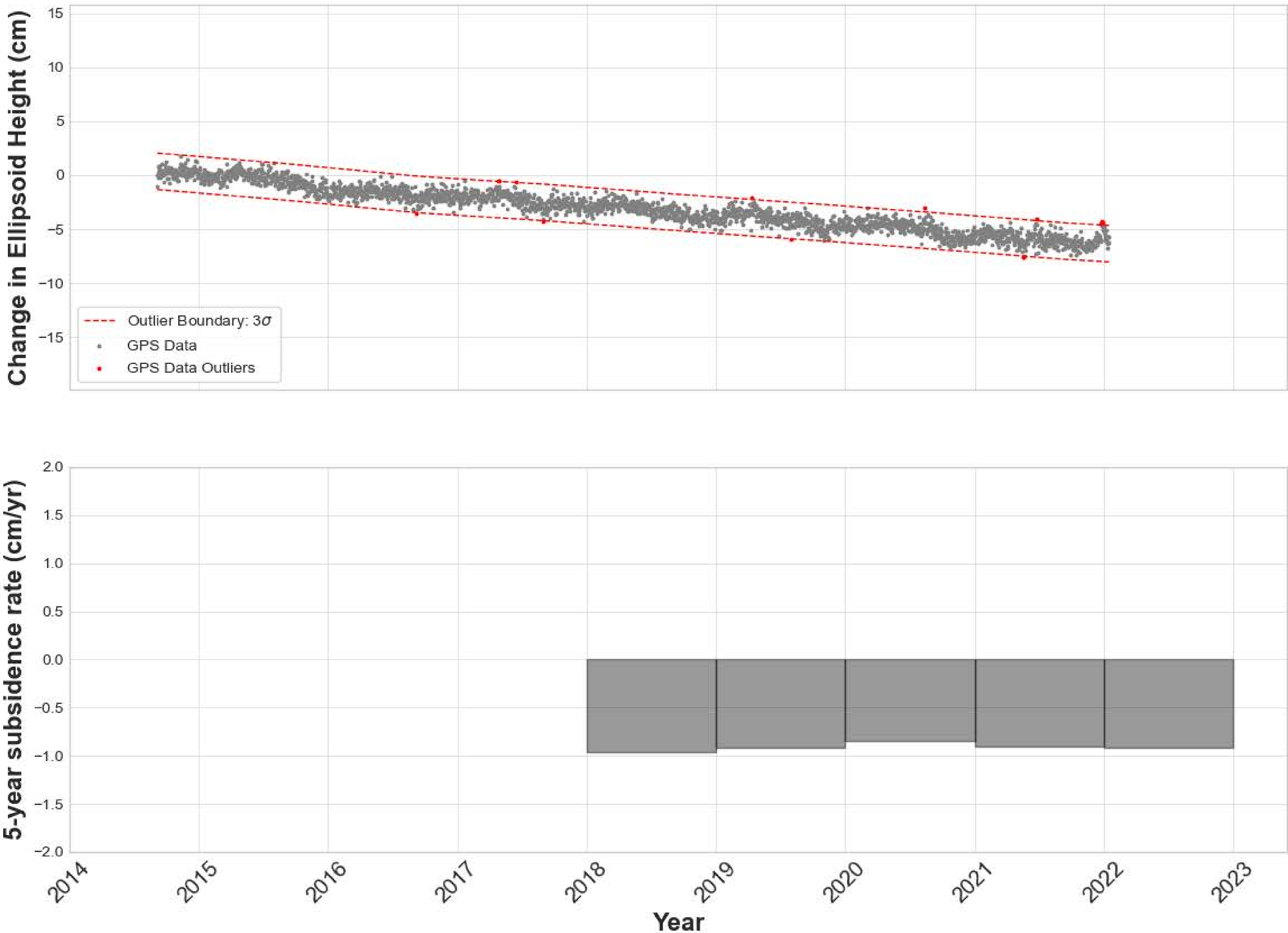
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

RPFB



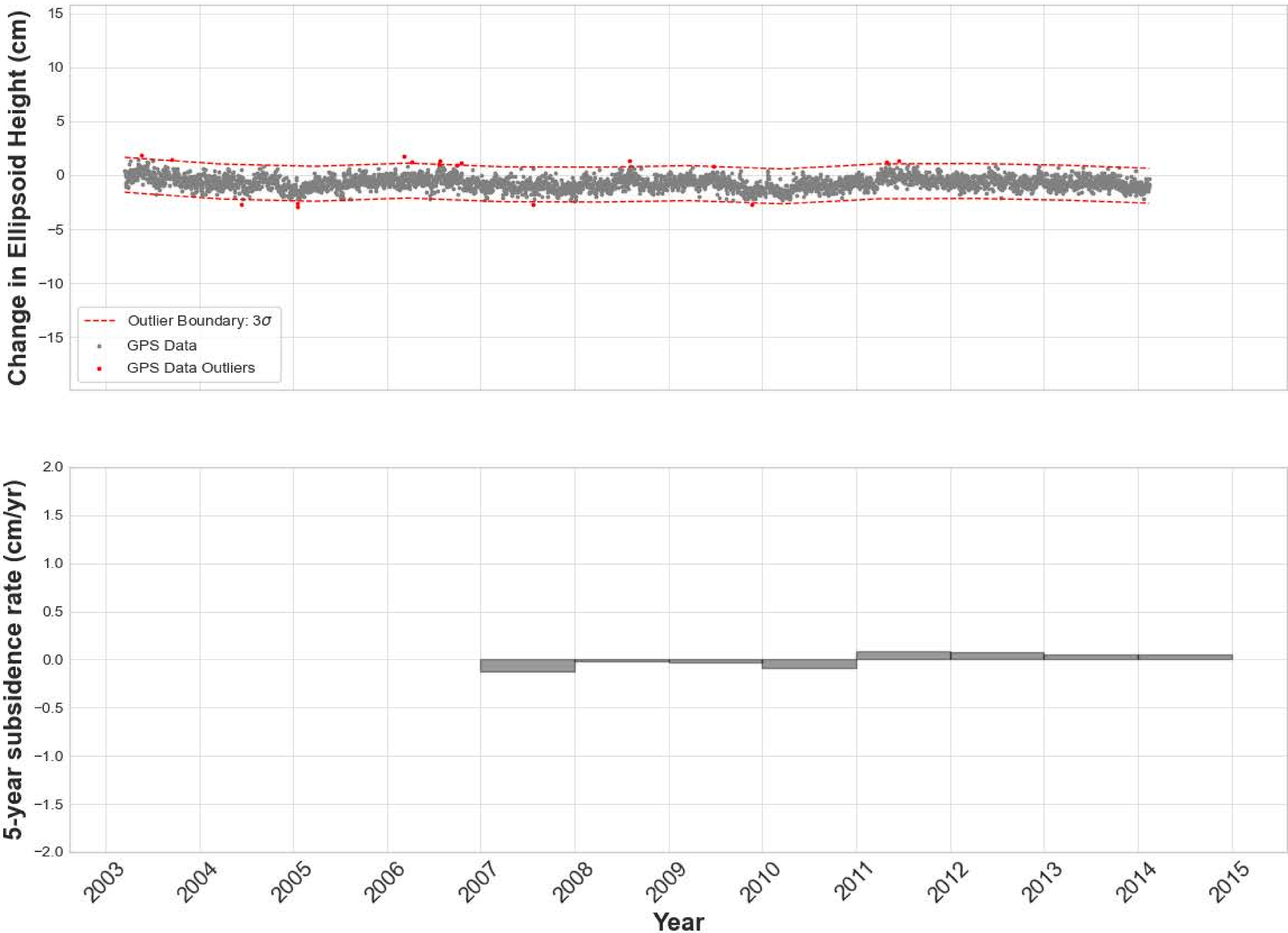
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

SESG



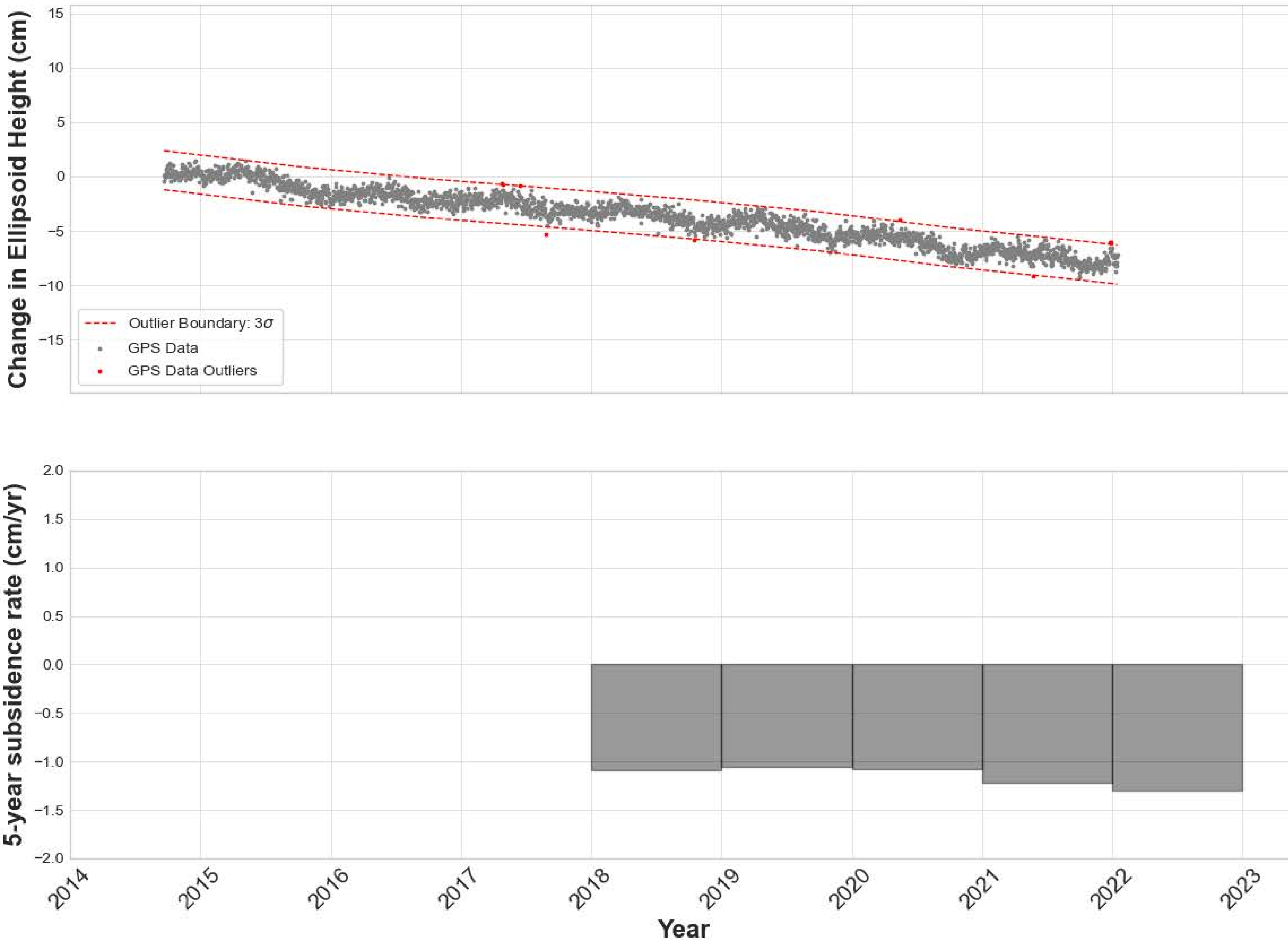
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

SG32



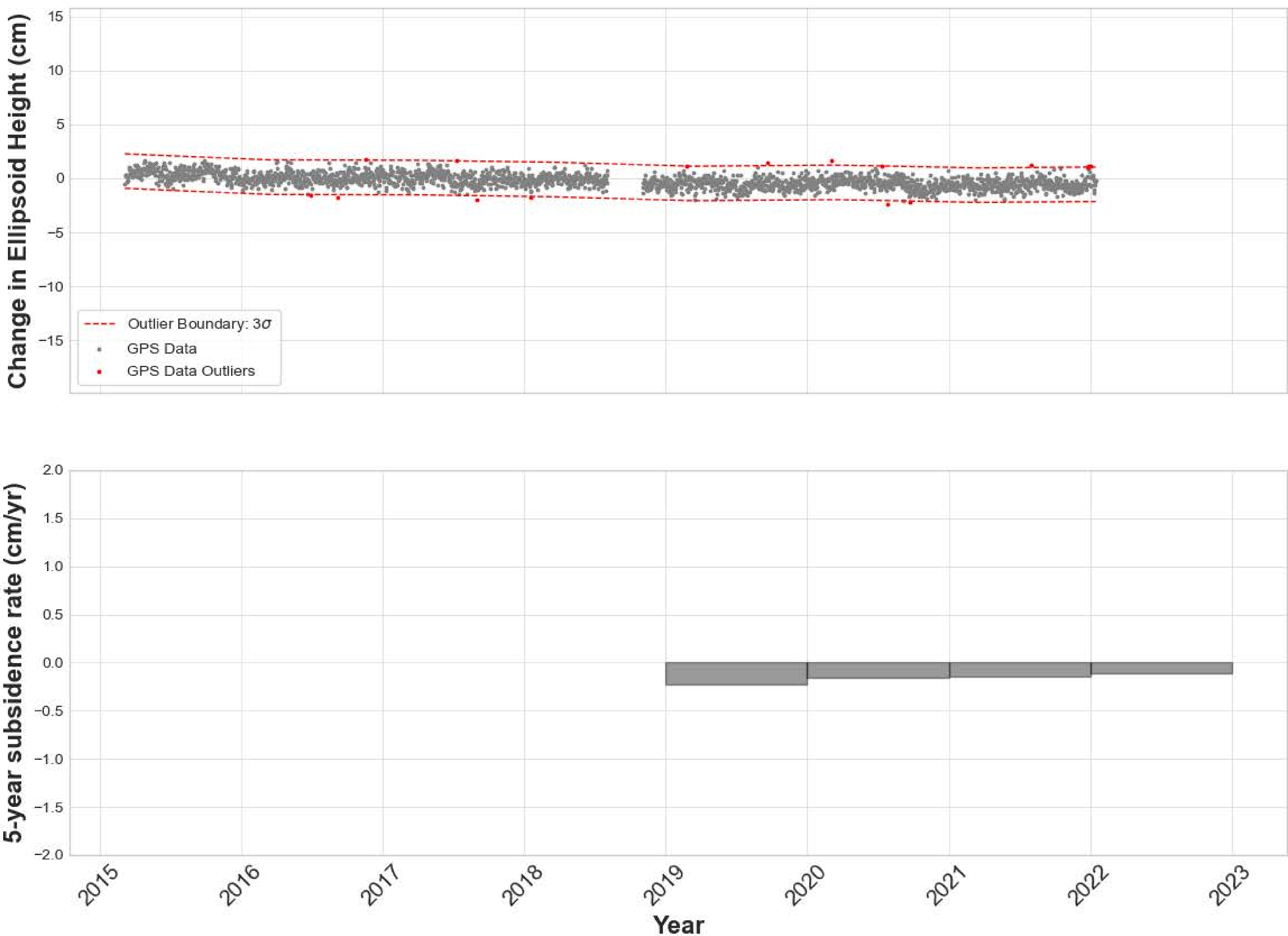
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

SHSG



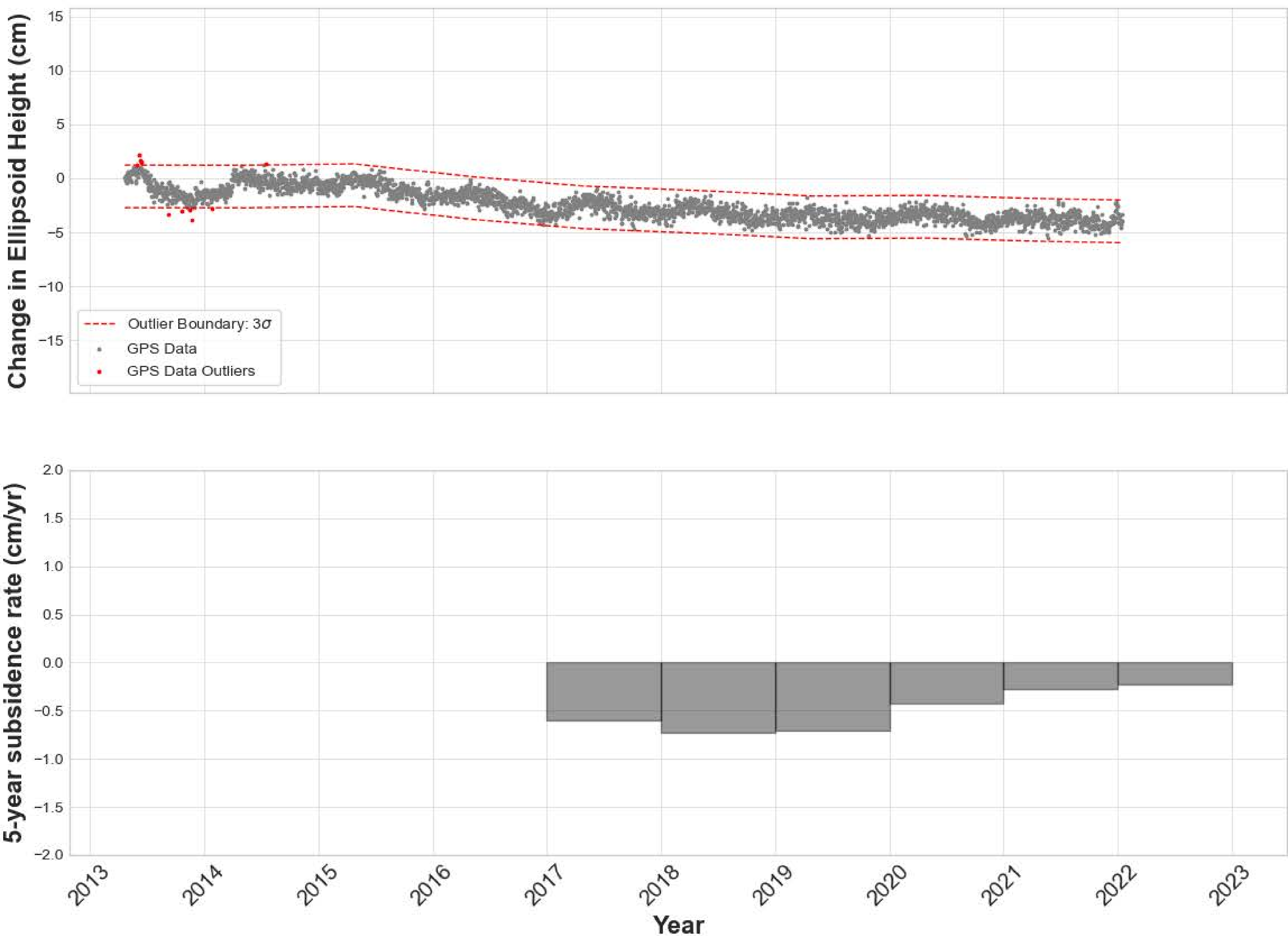
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

SISD



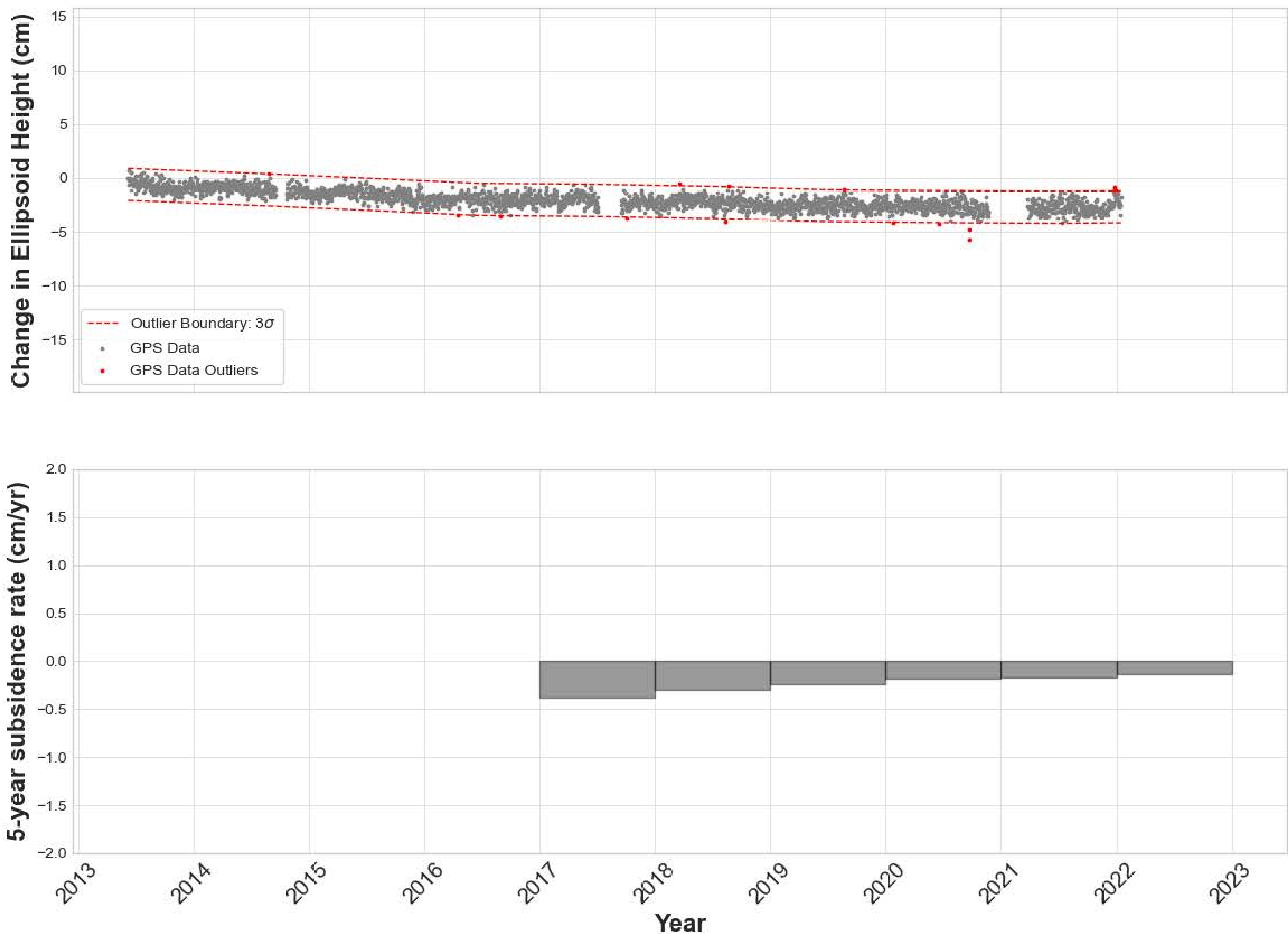
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

SPBH



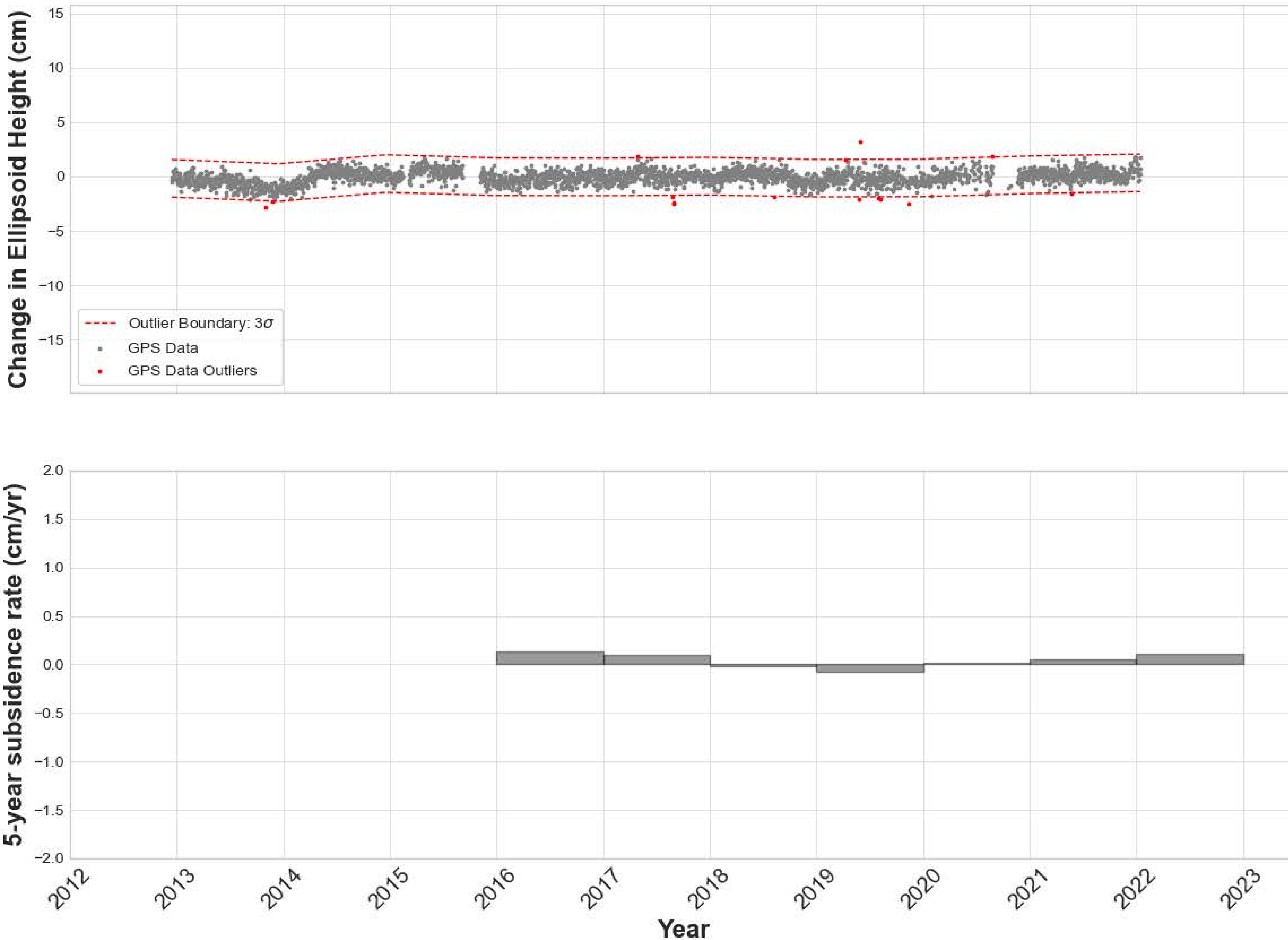
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TDAM



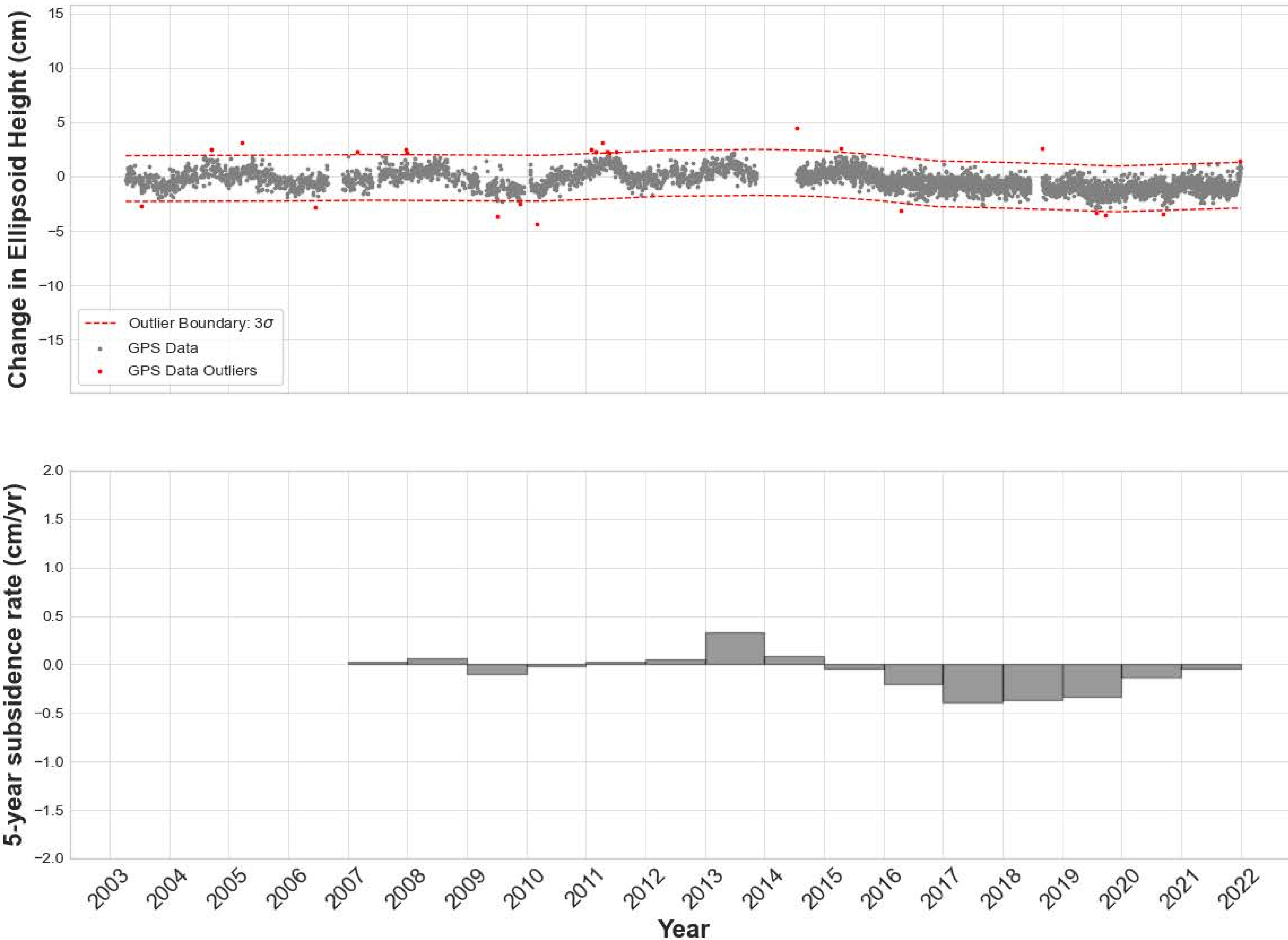
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

THSU



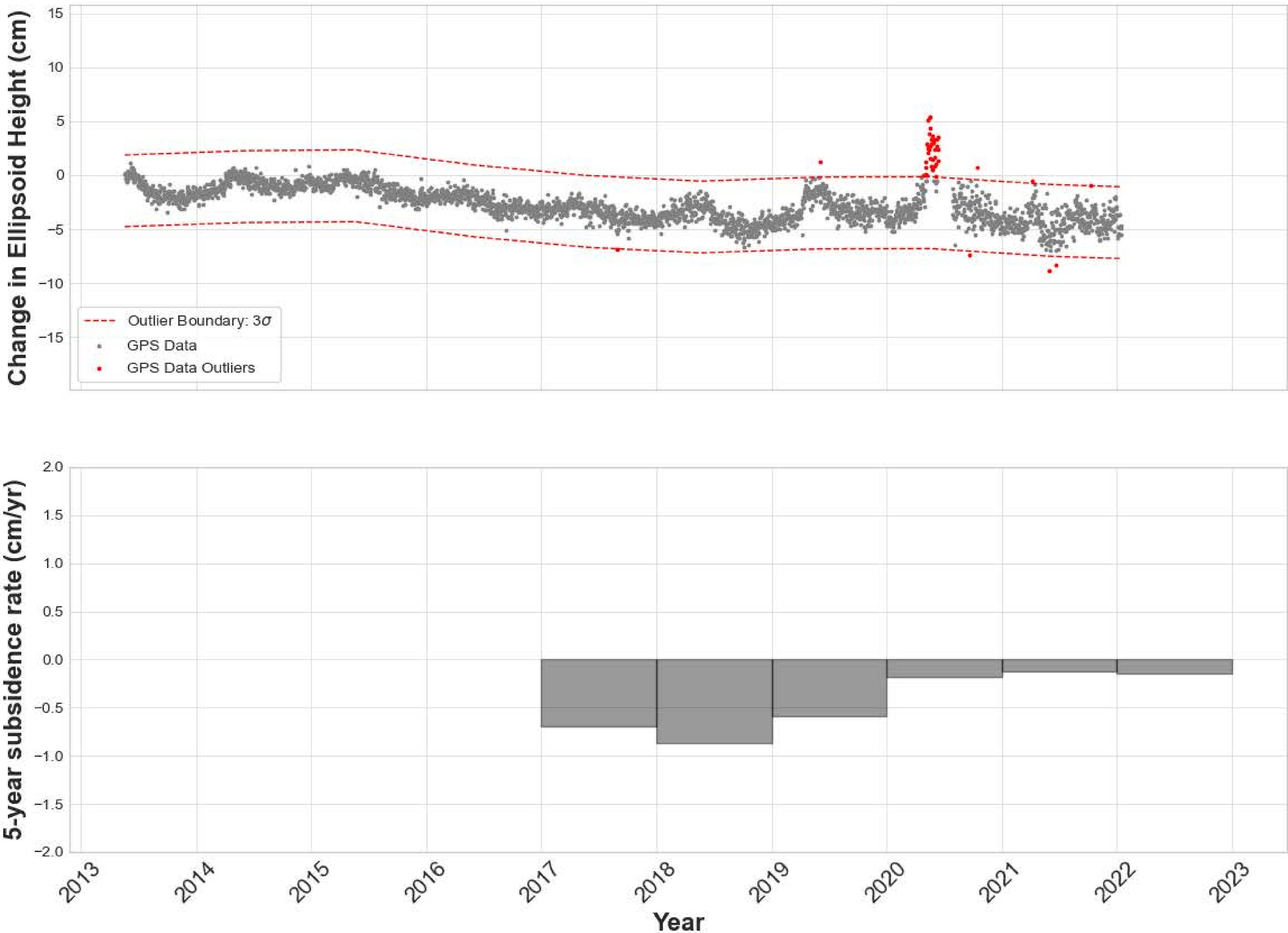
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TMCC



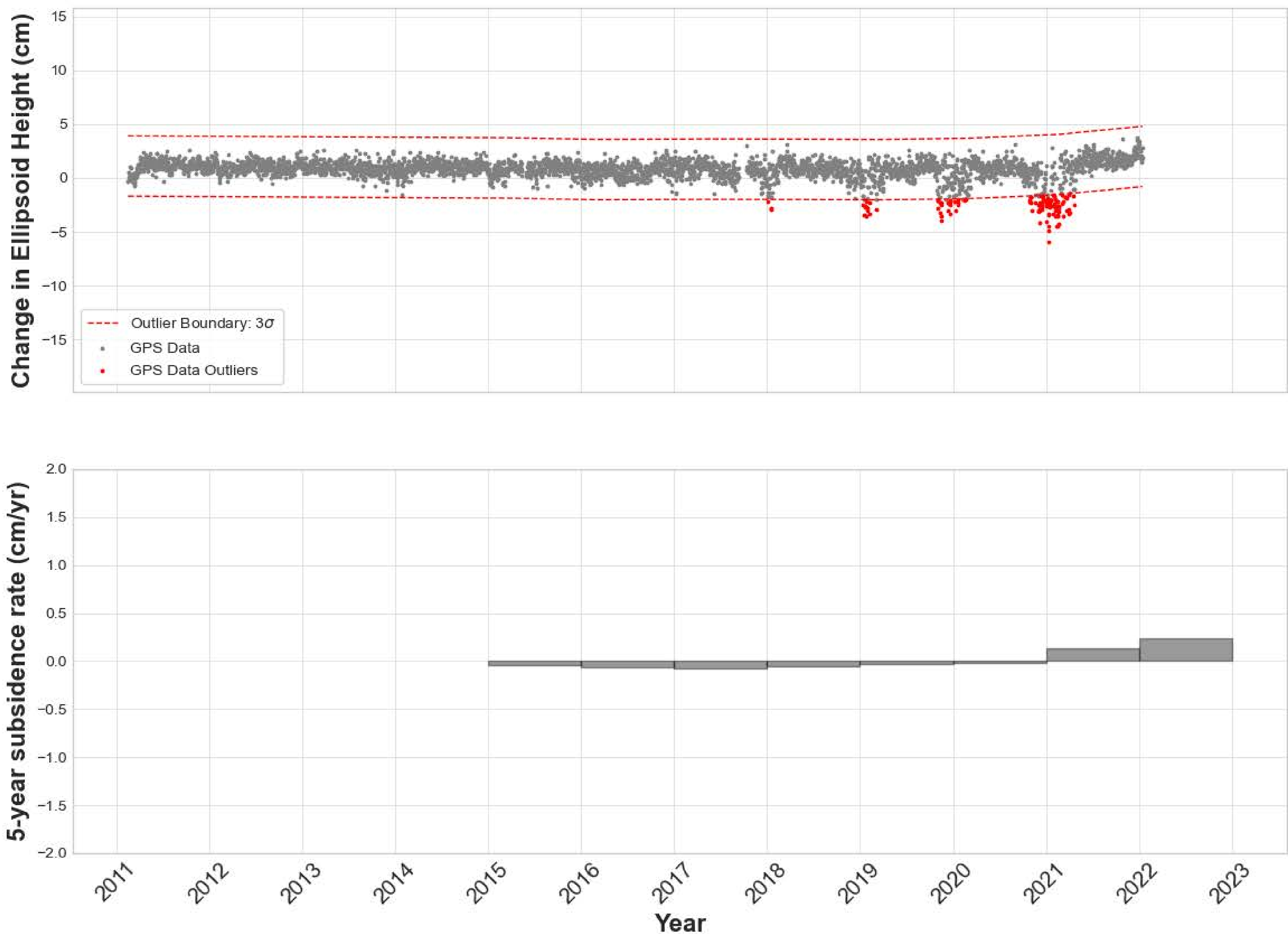
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TSFT



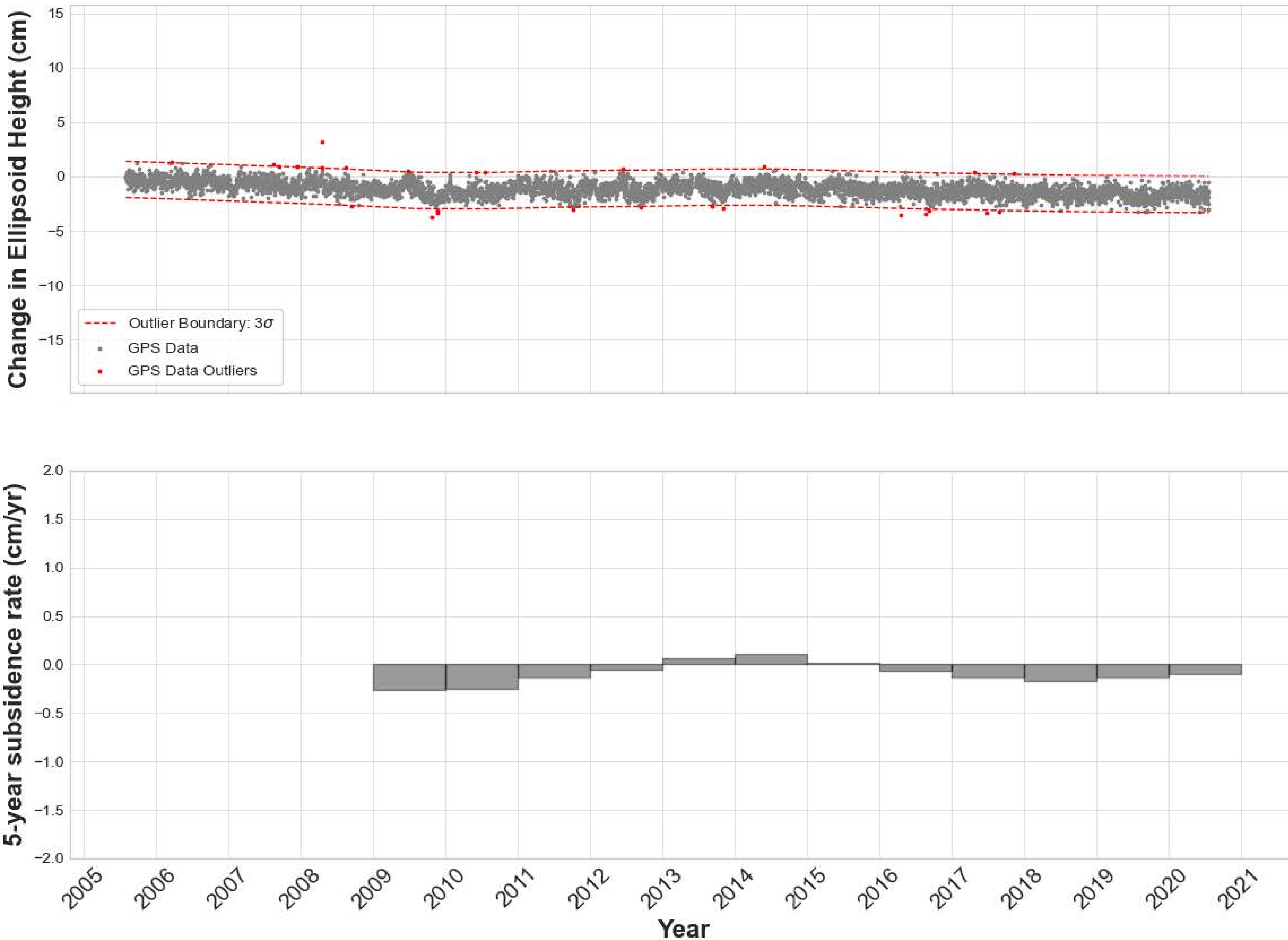
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXAC



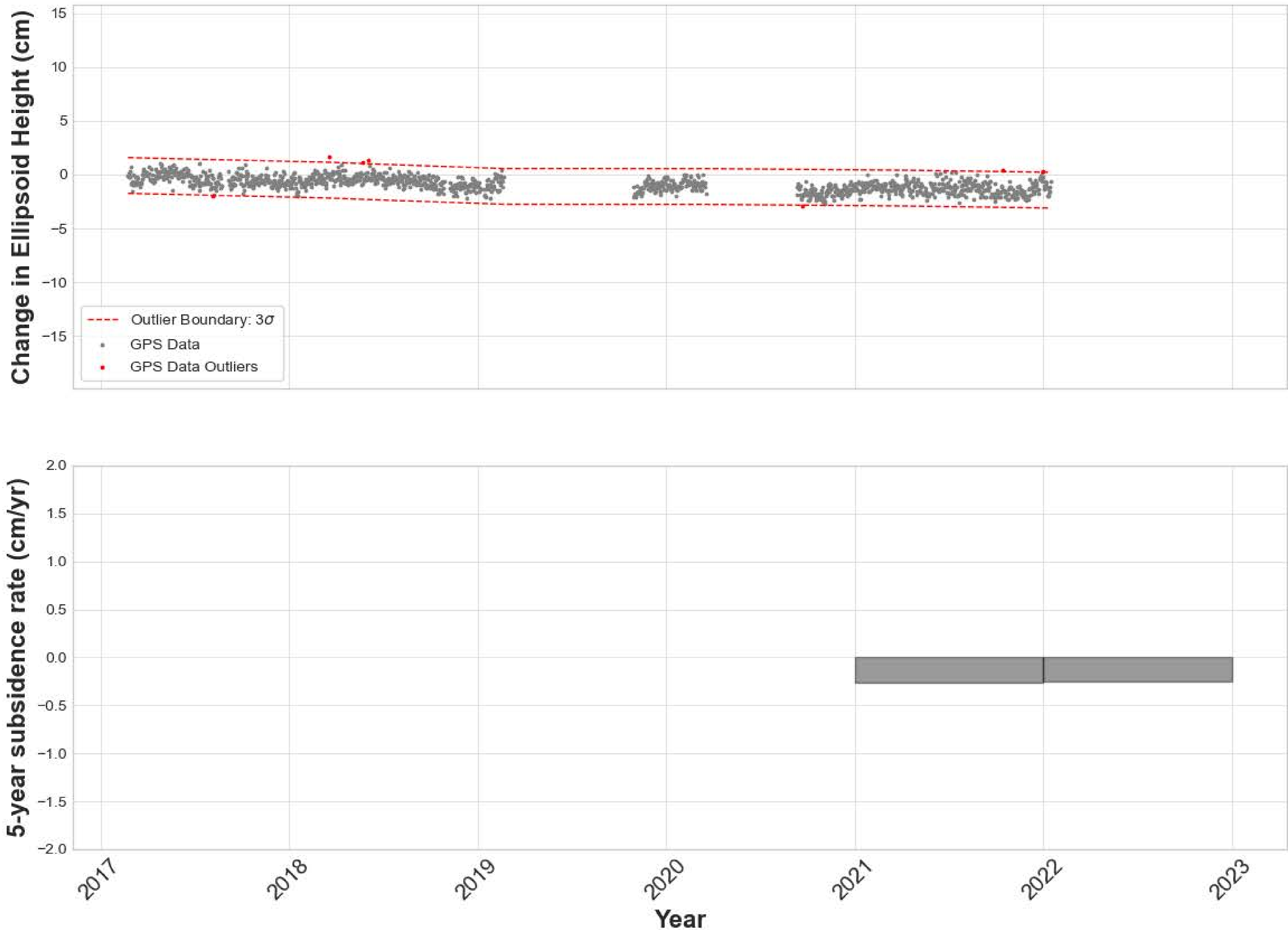
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXAG



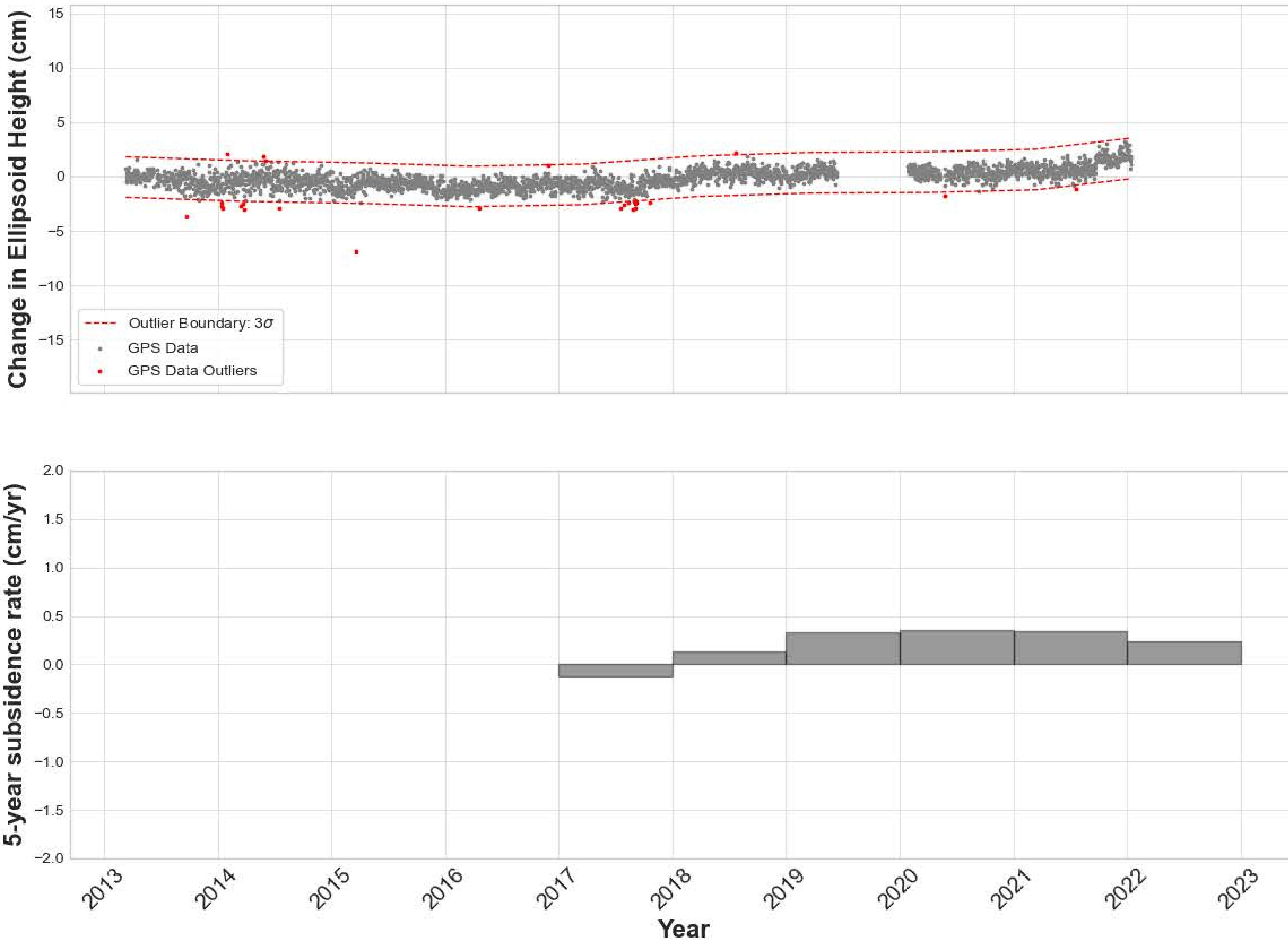
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXAV



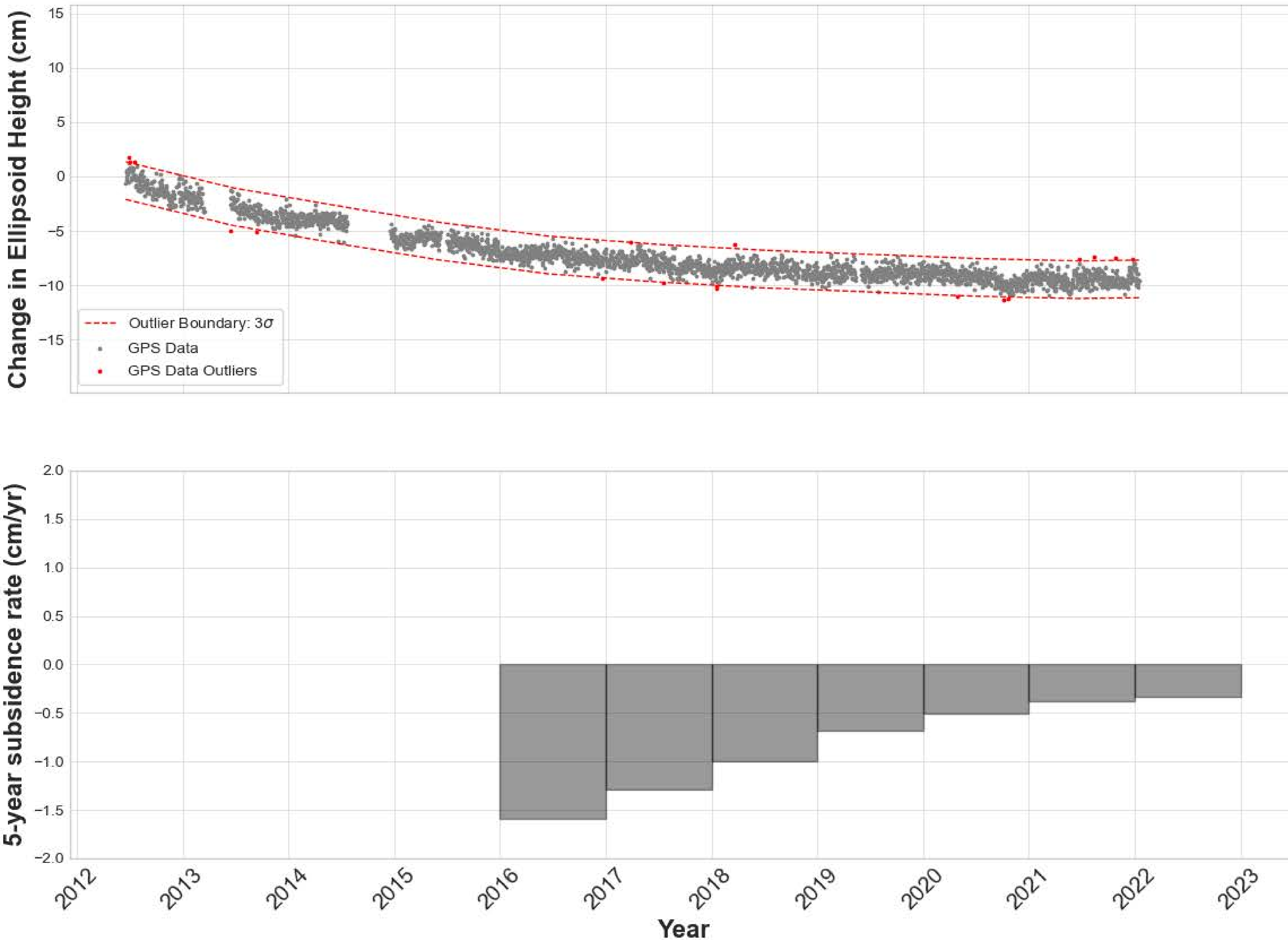
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXB1



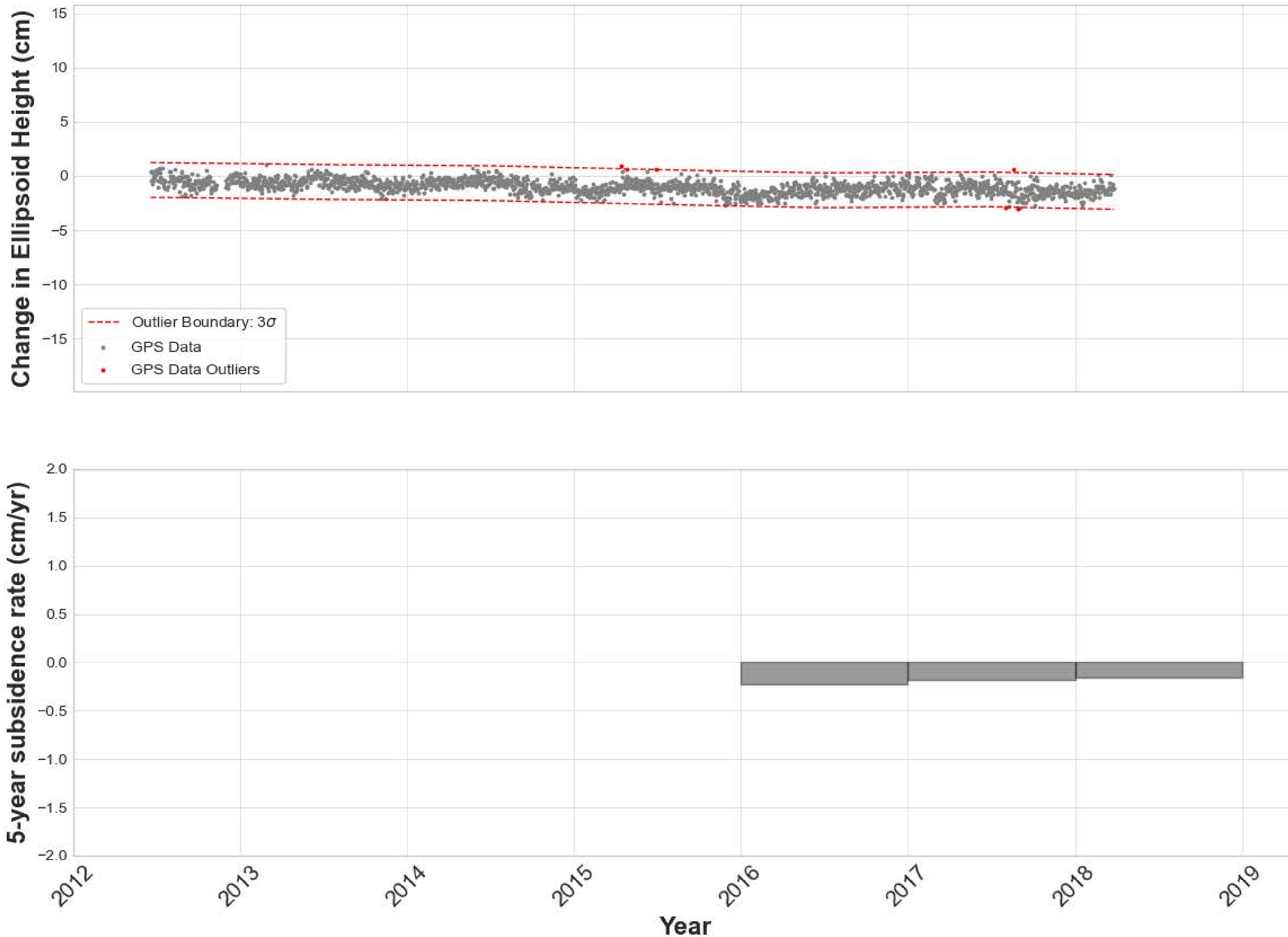
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXB2

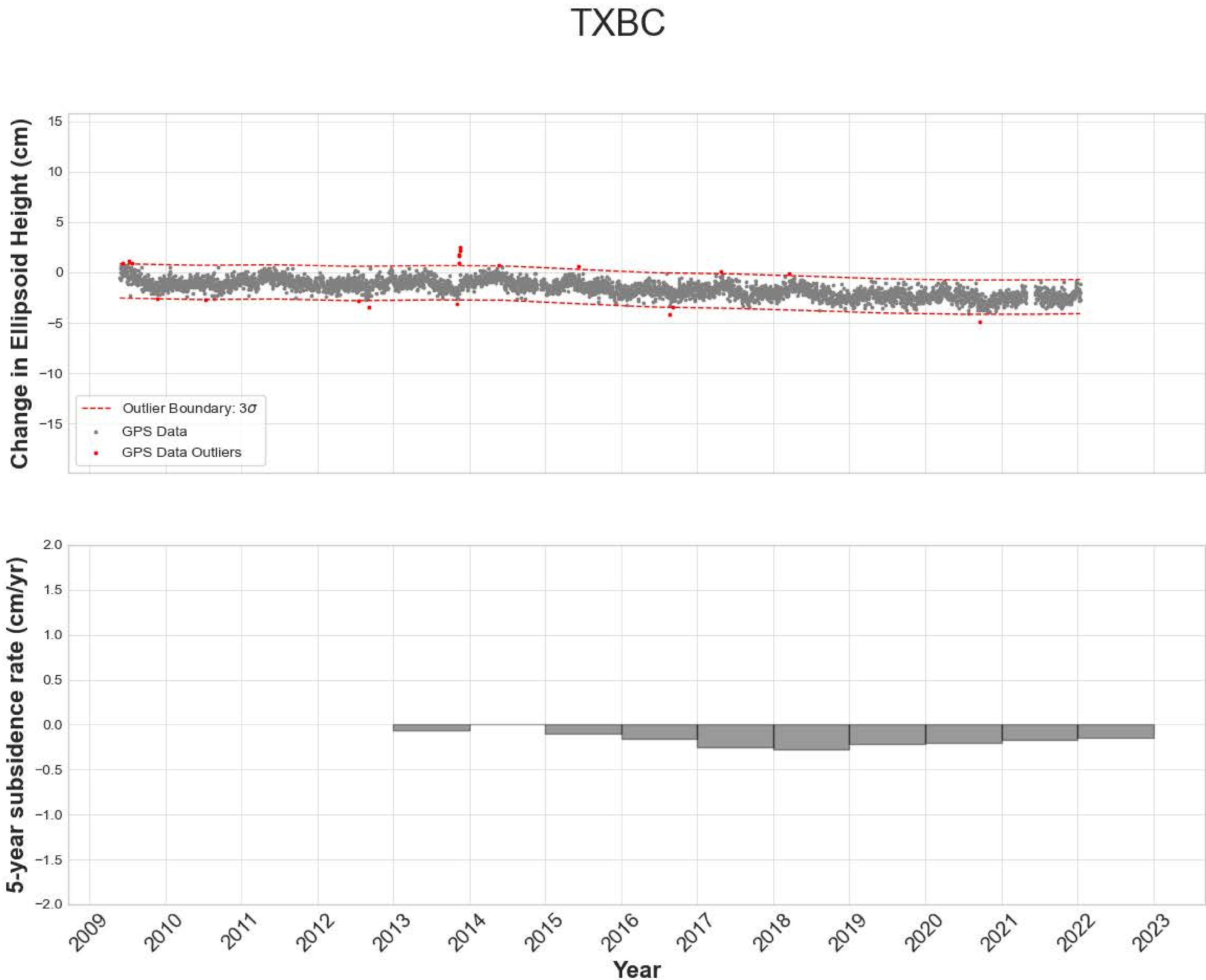


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXB6

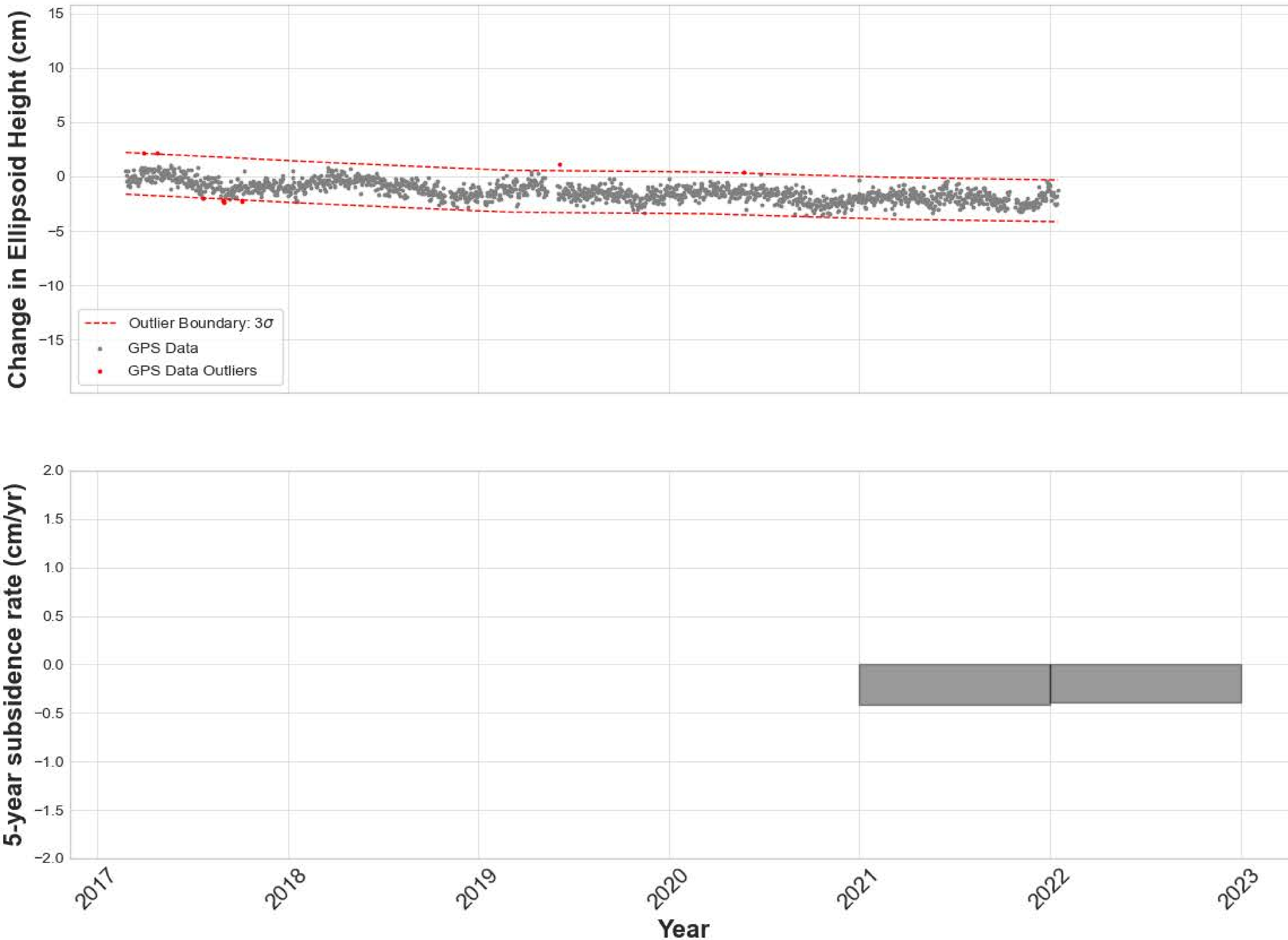


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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



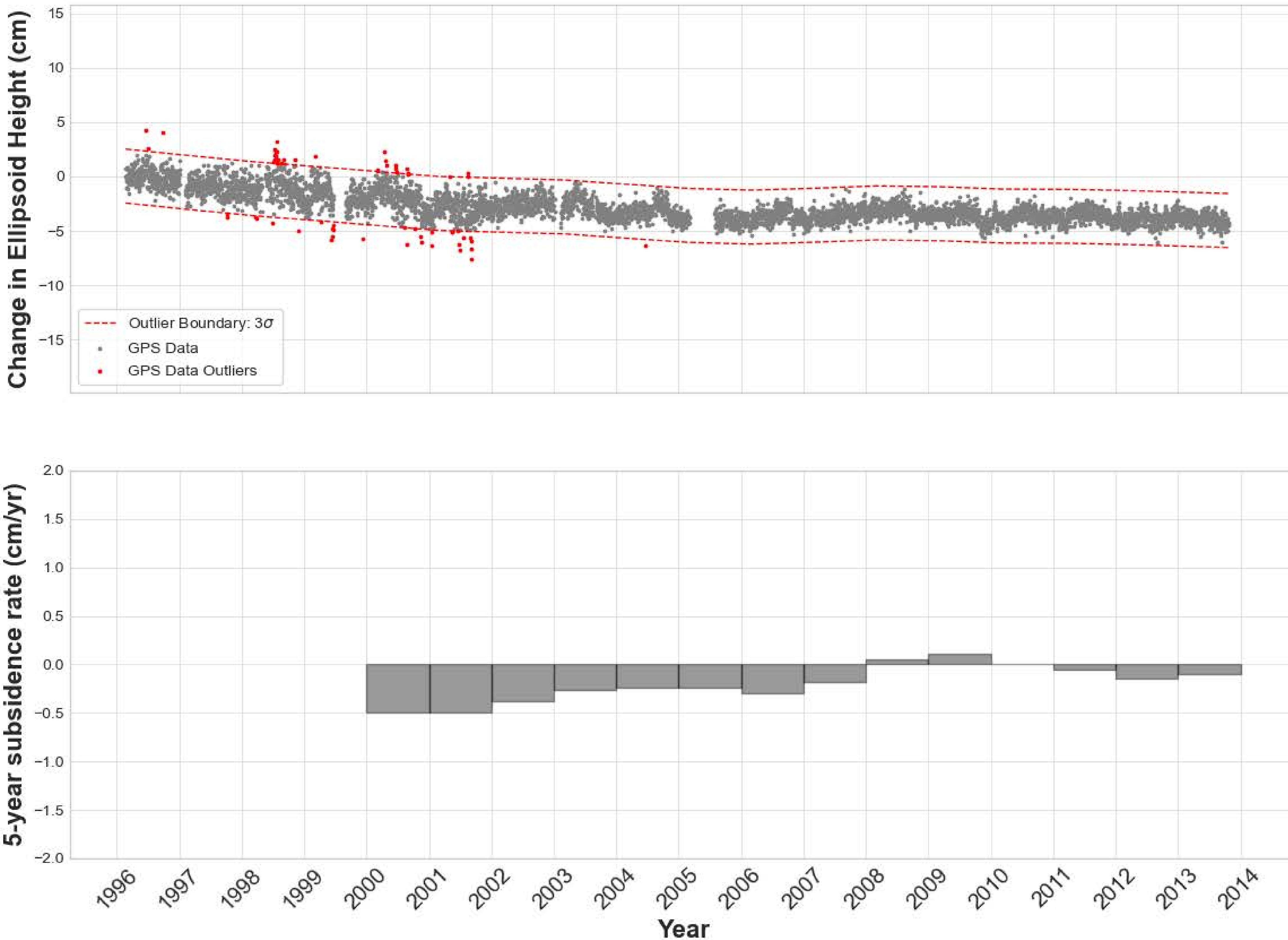
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXBH



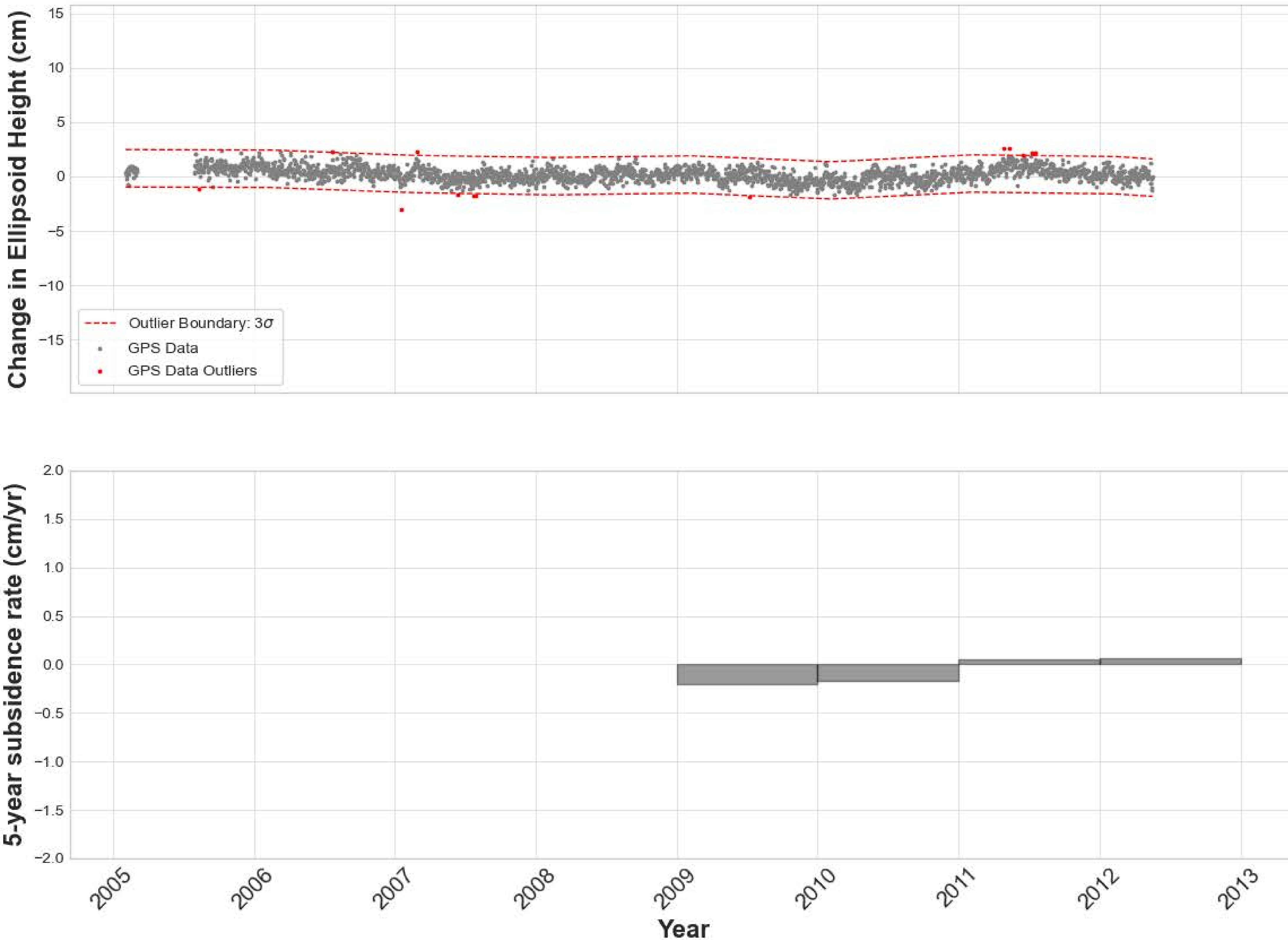
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXBM



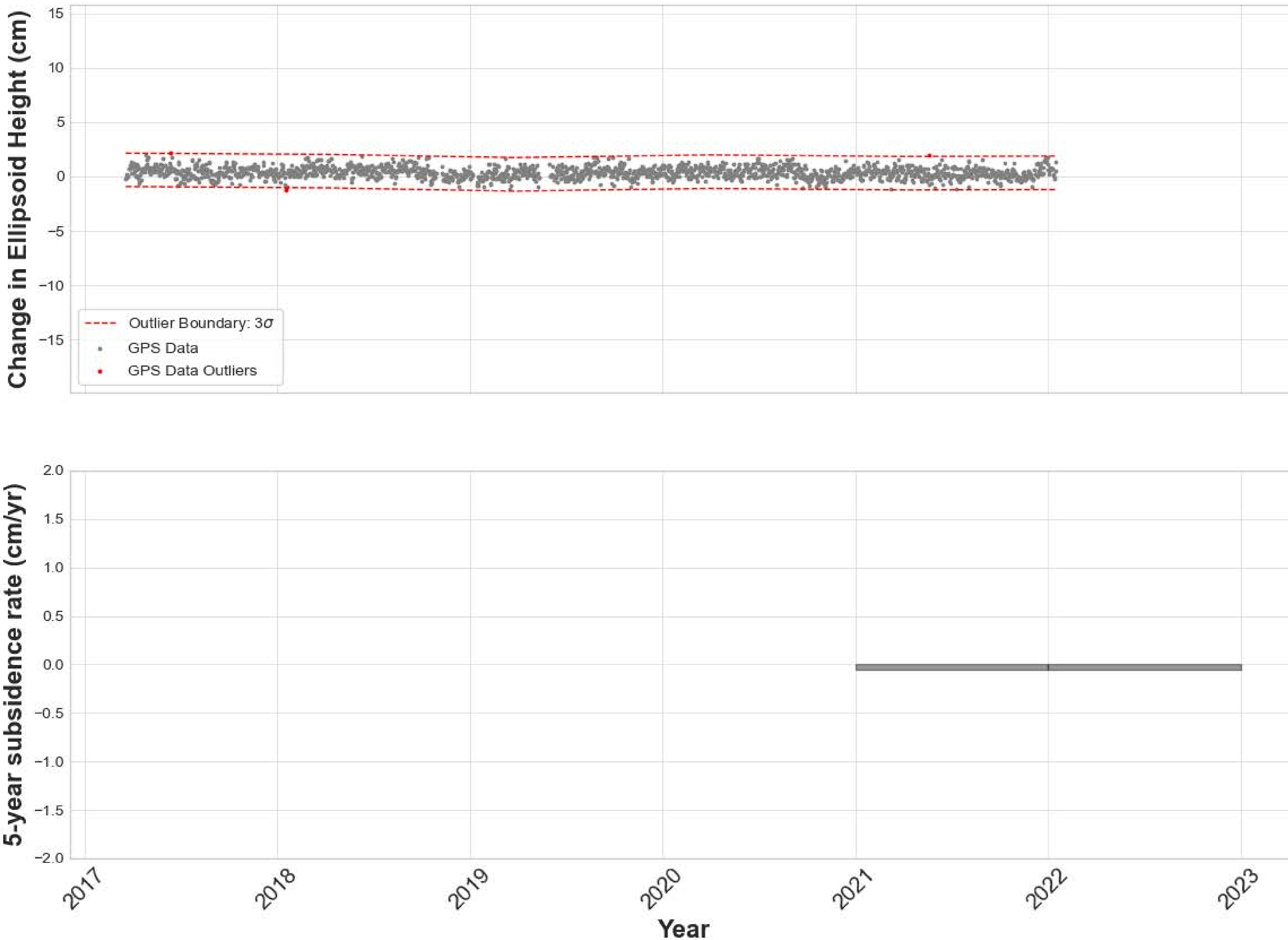
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXBY



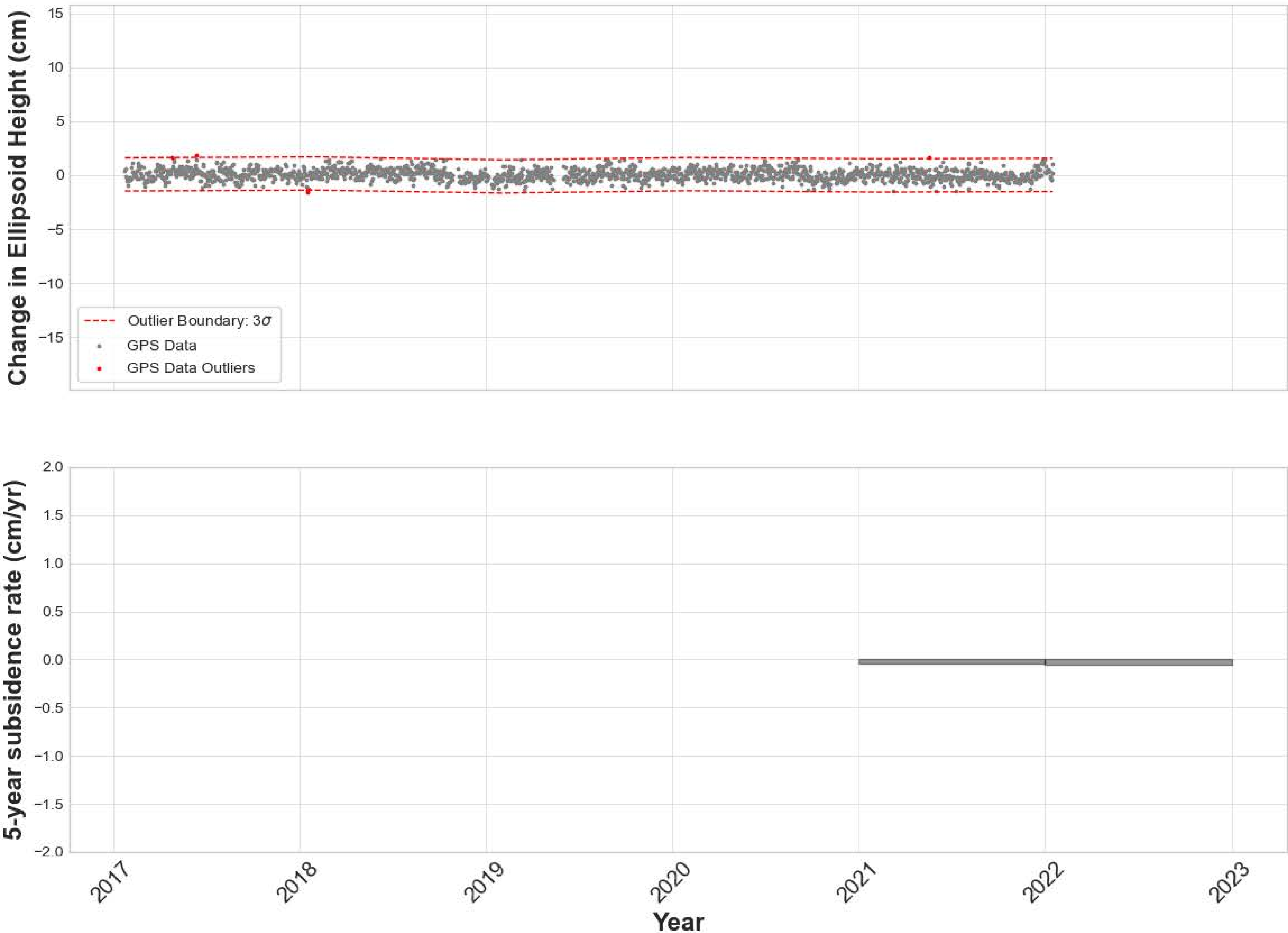
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXC5



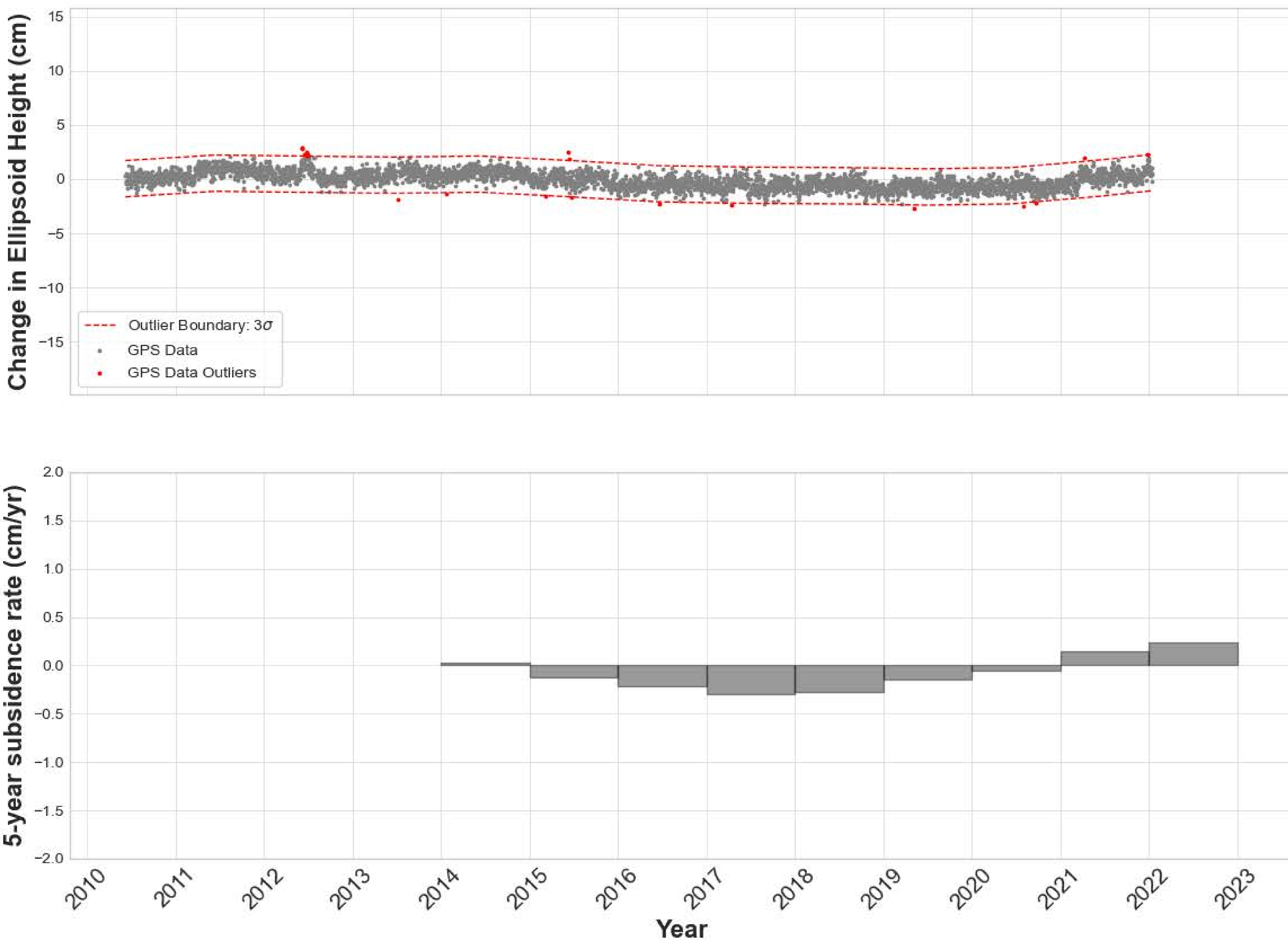
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXCF



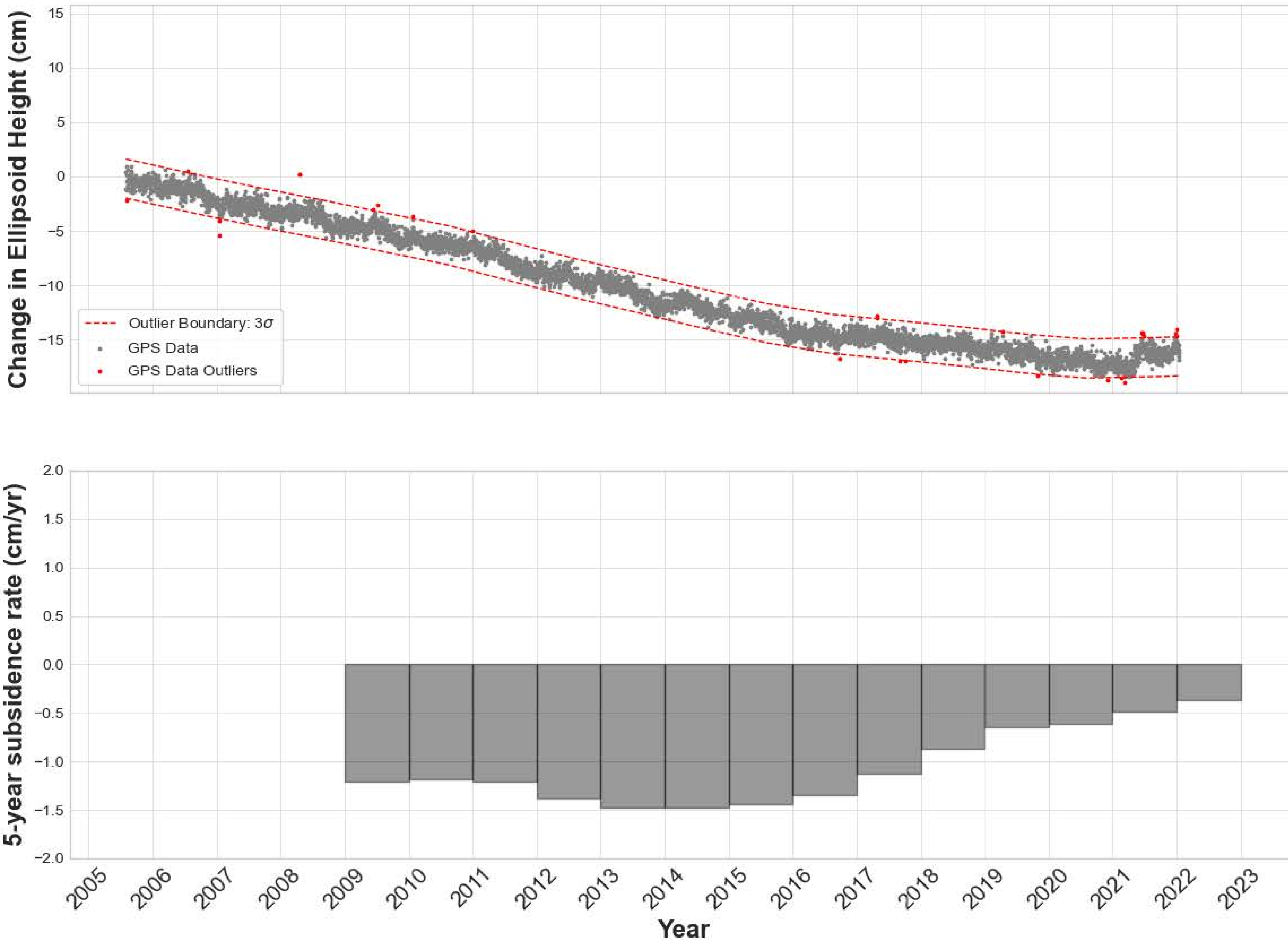
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXCM



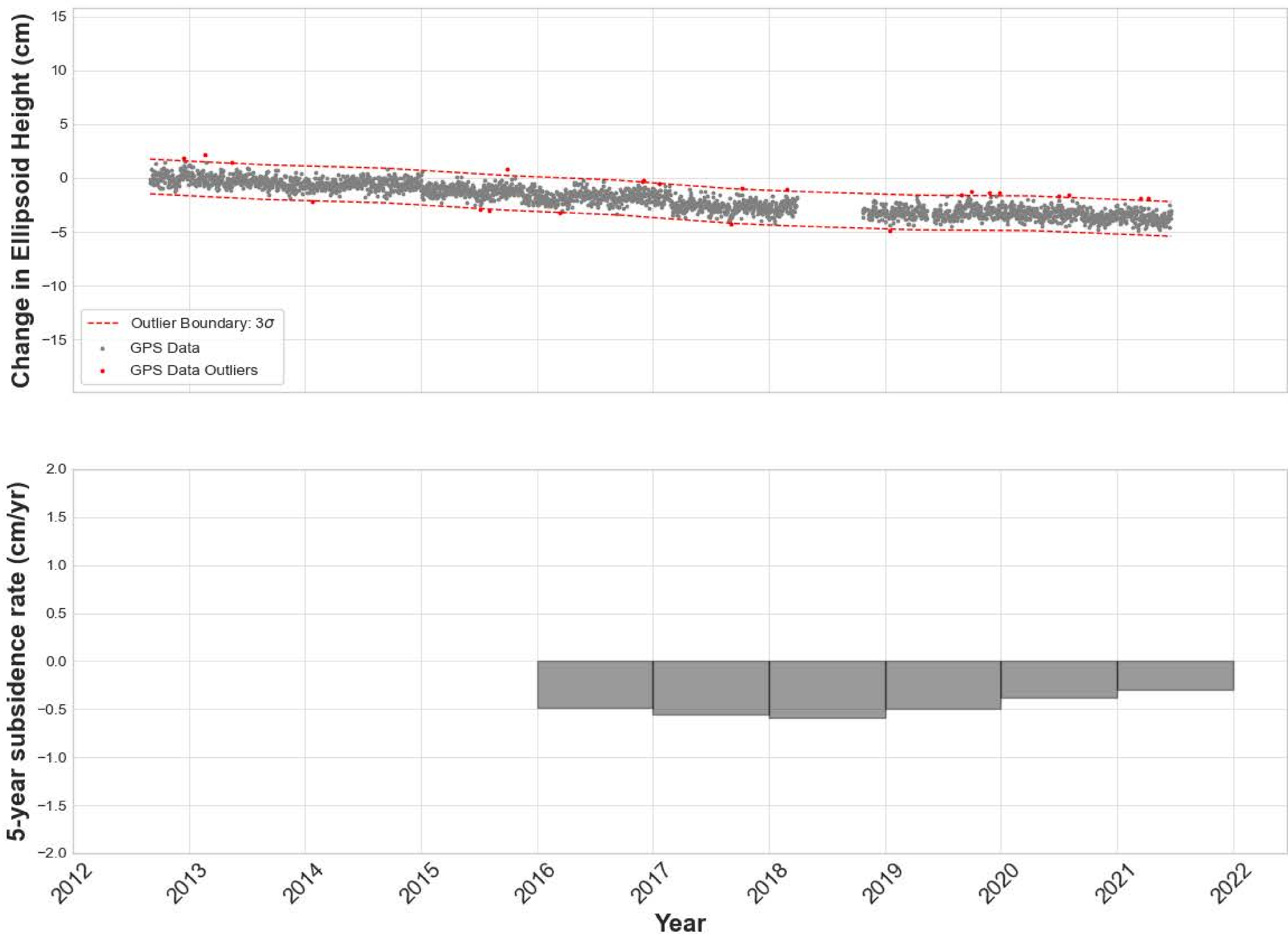
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXCN



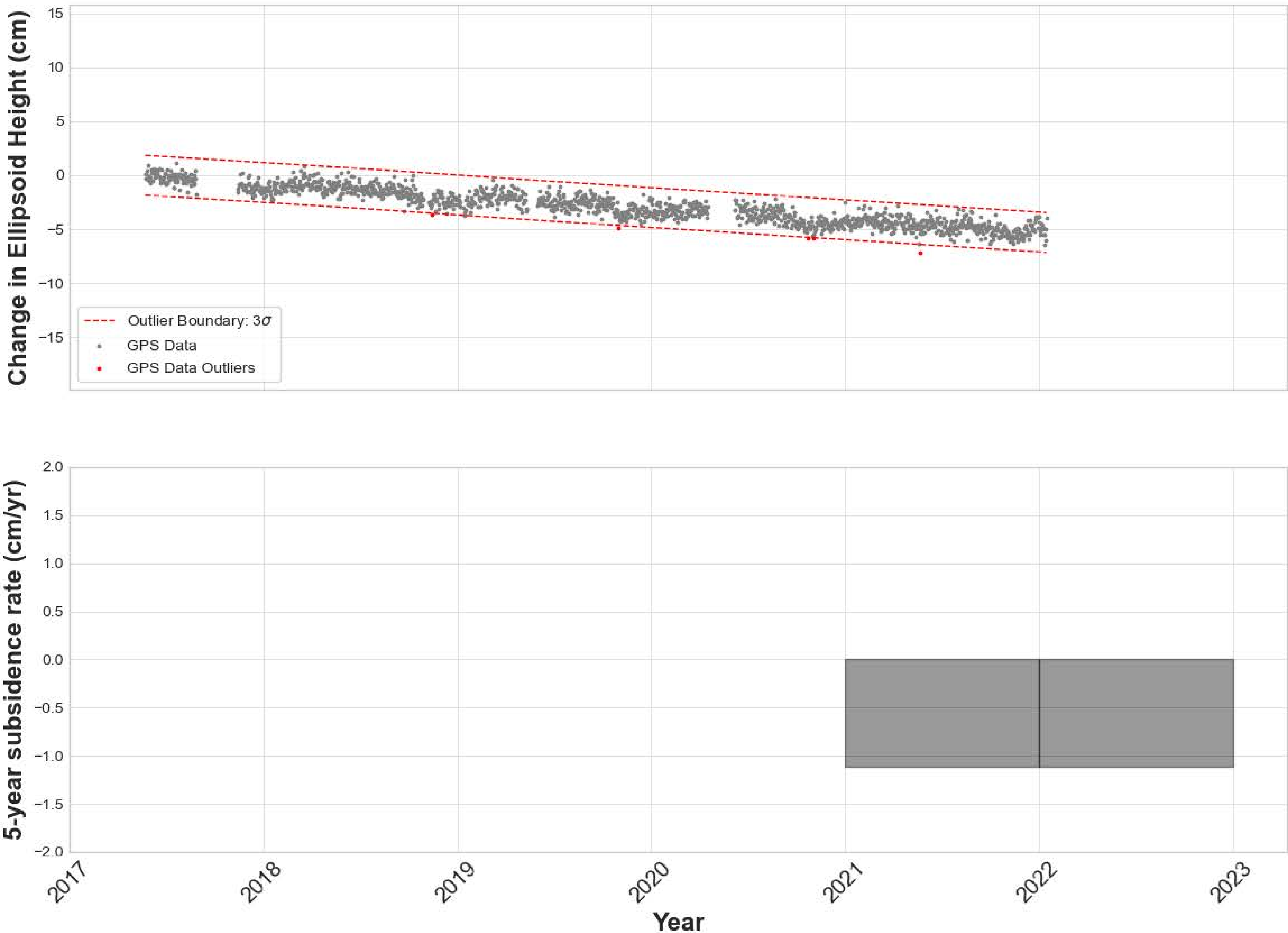
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXCV



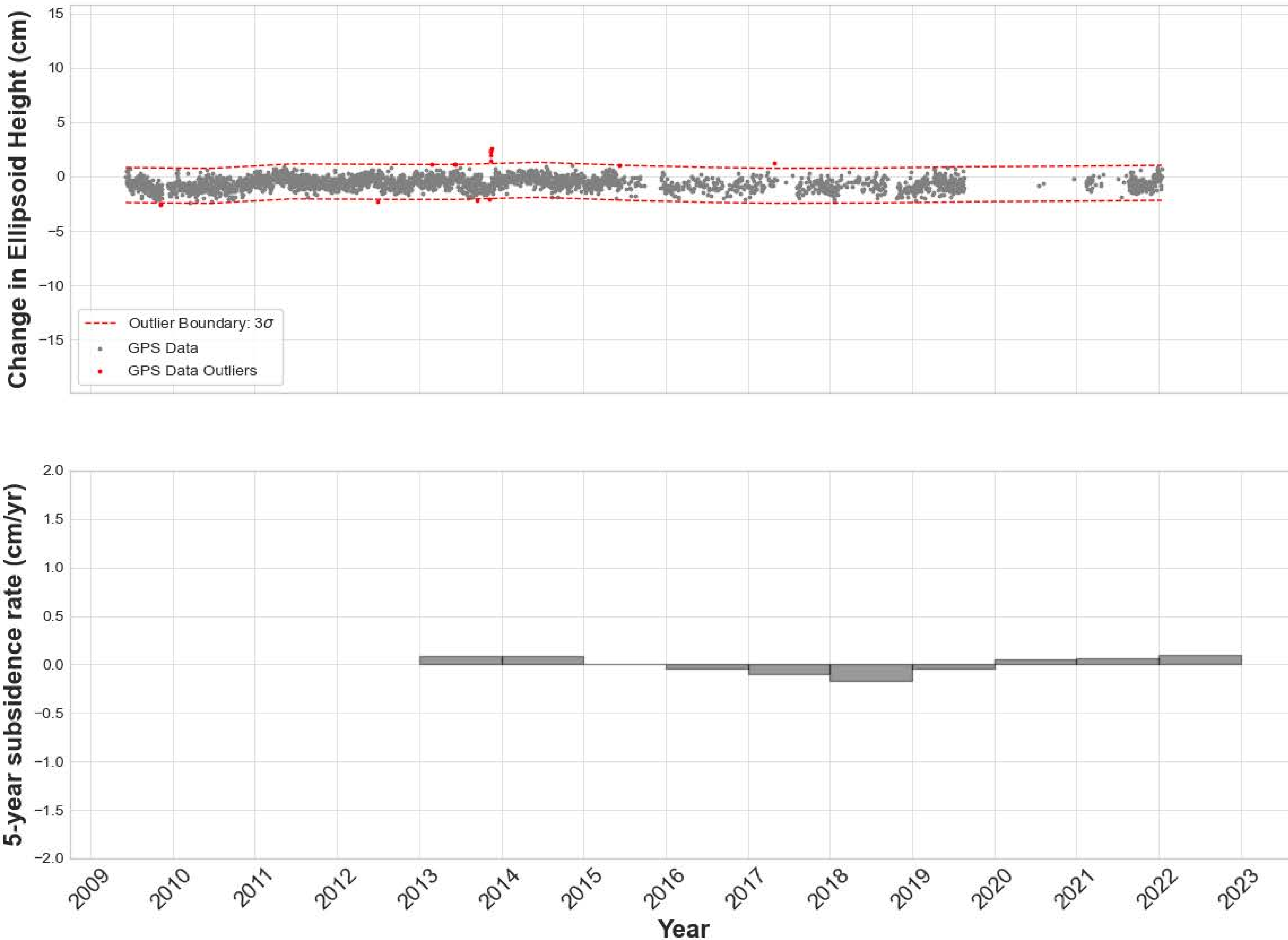
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXCY



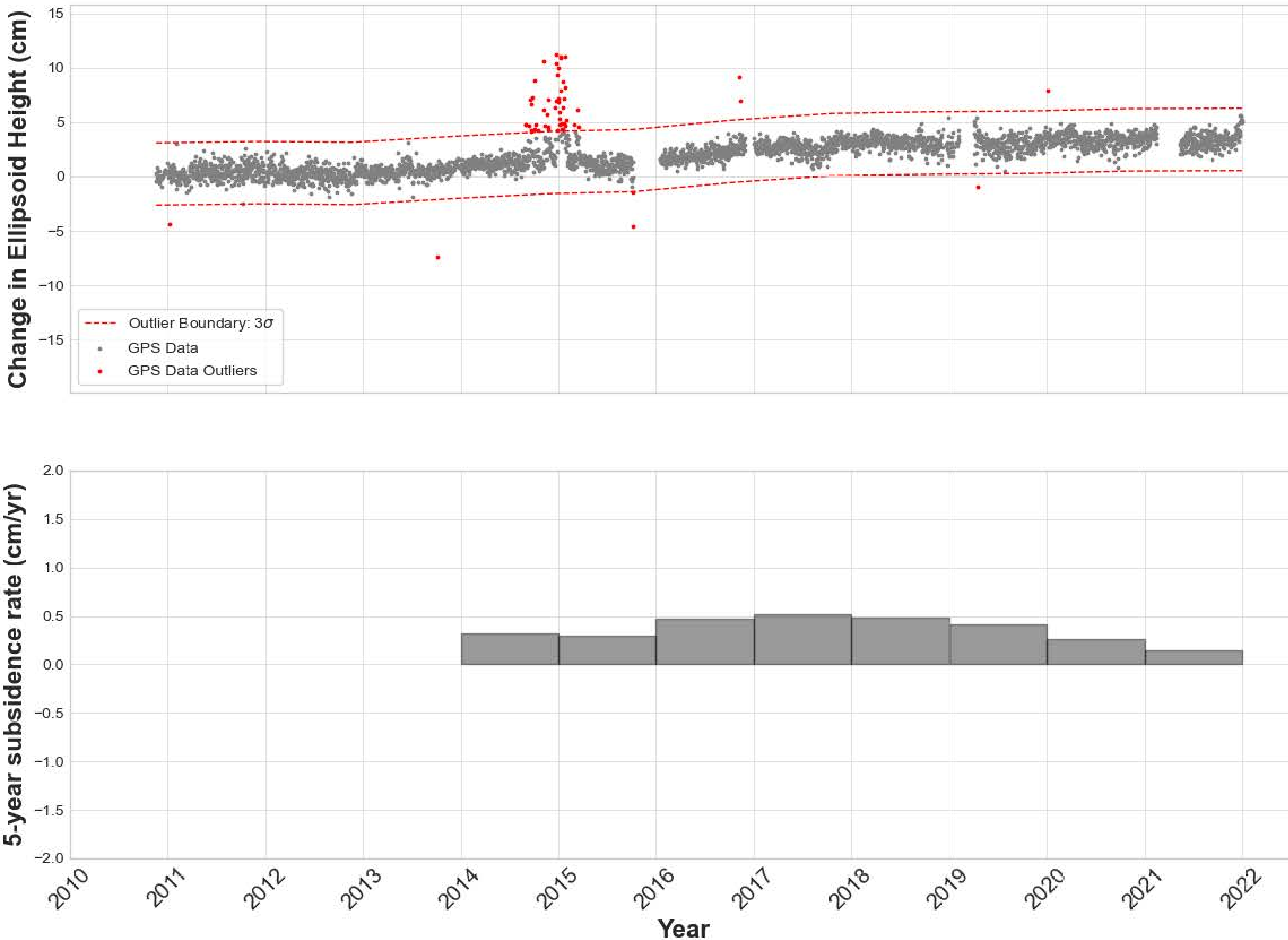
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXED



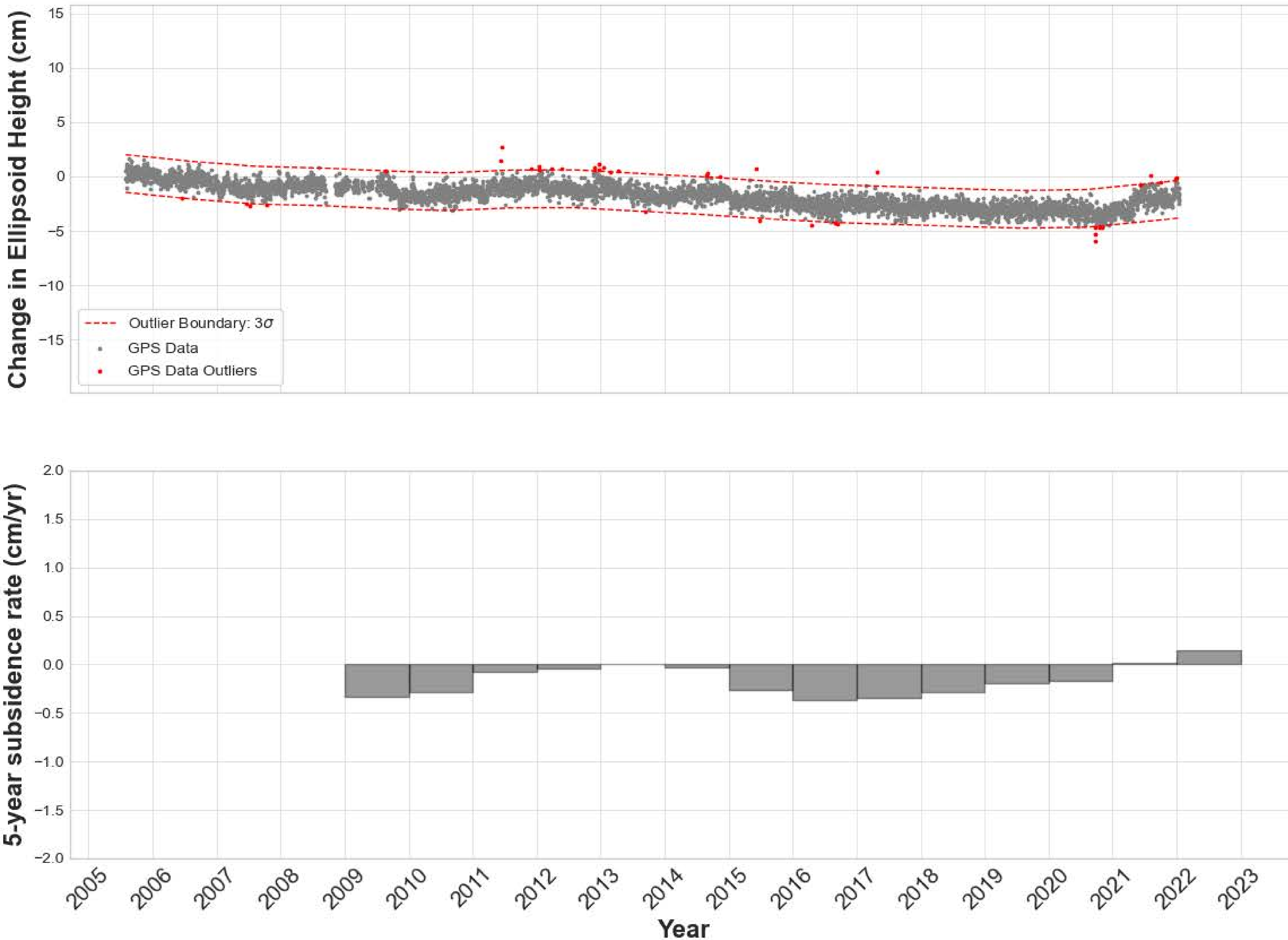
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXEX

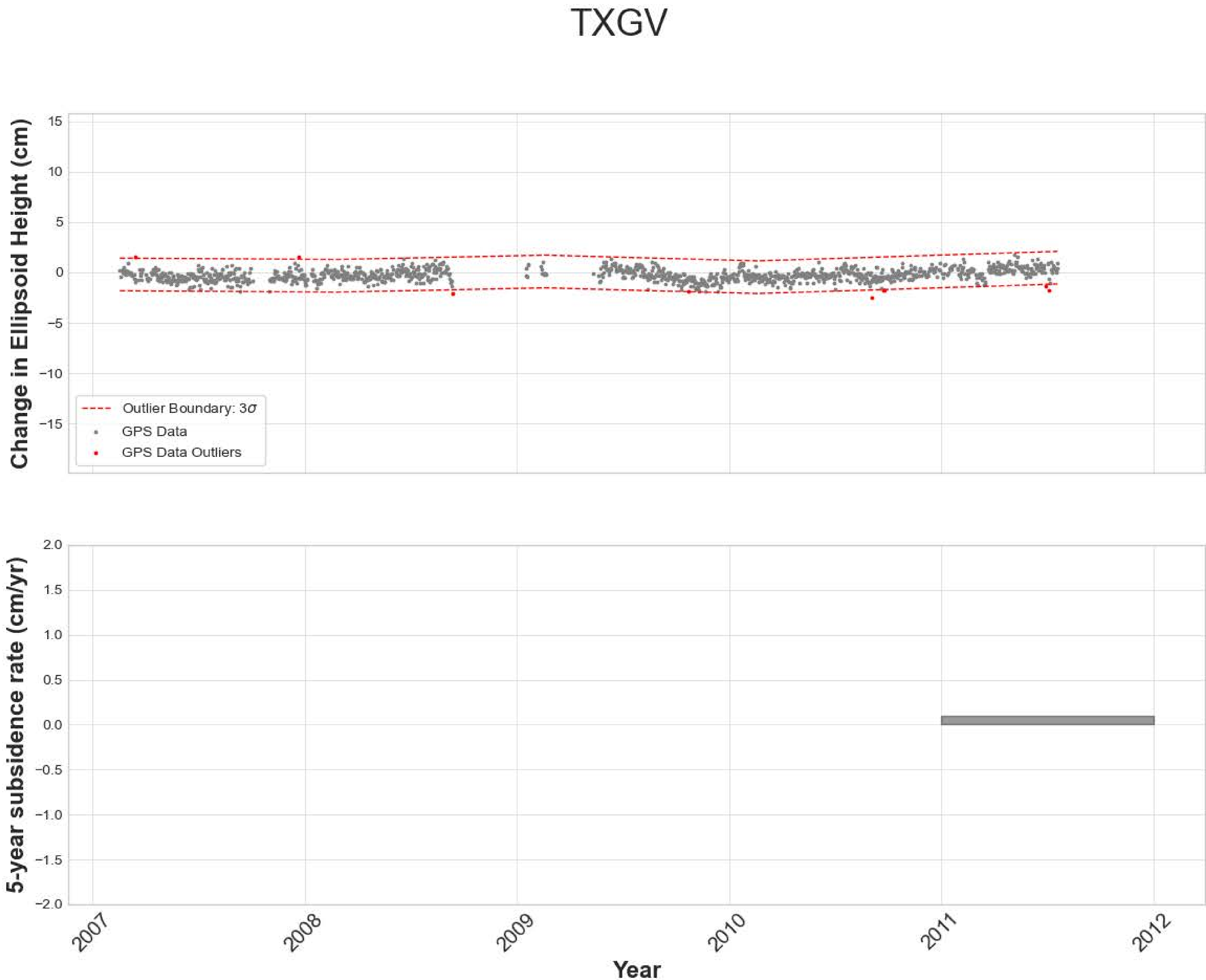


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXGA

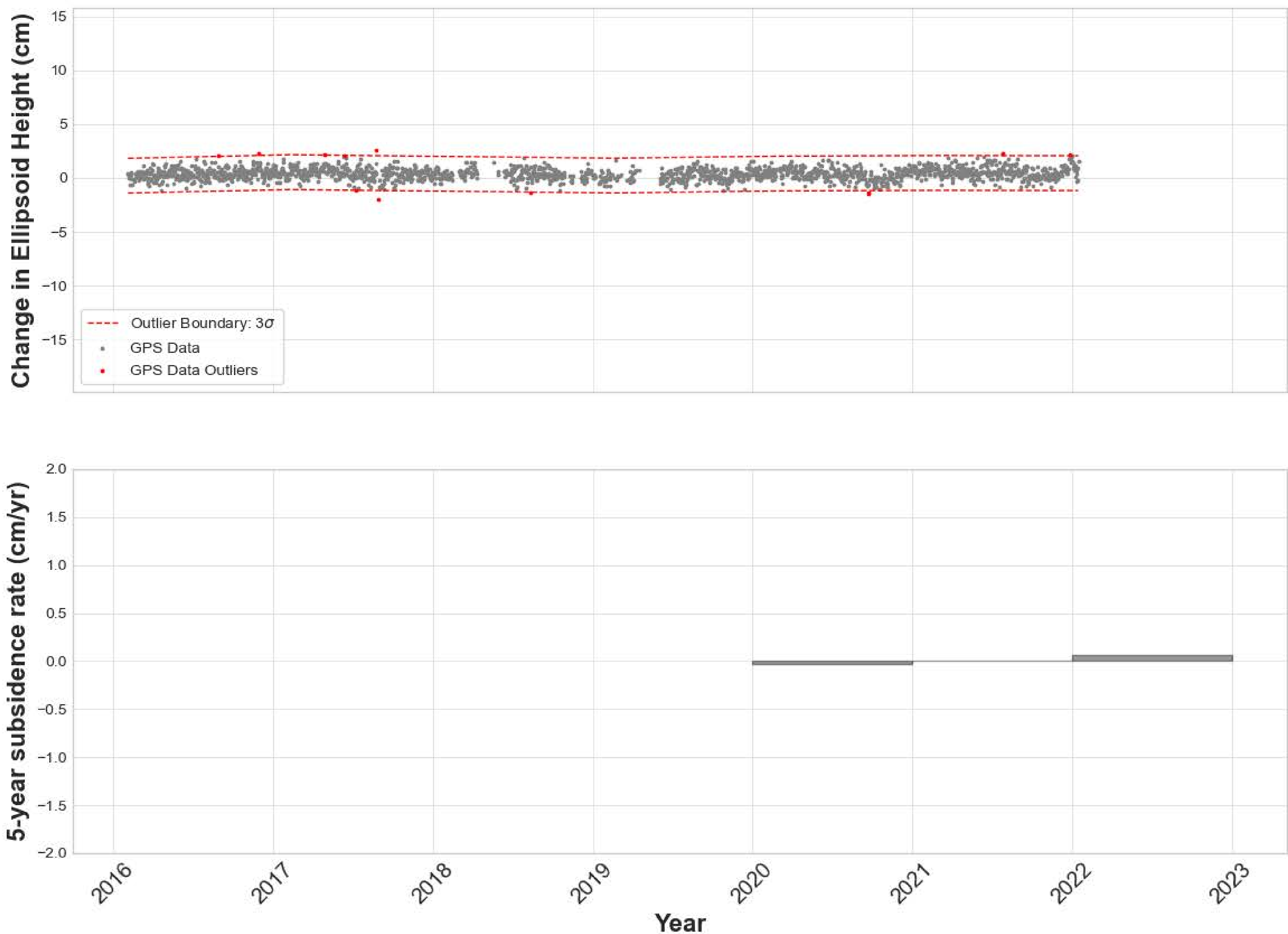


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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



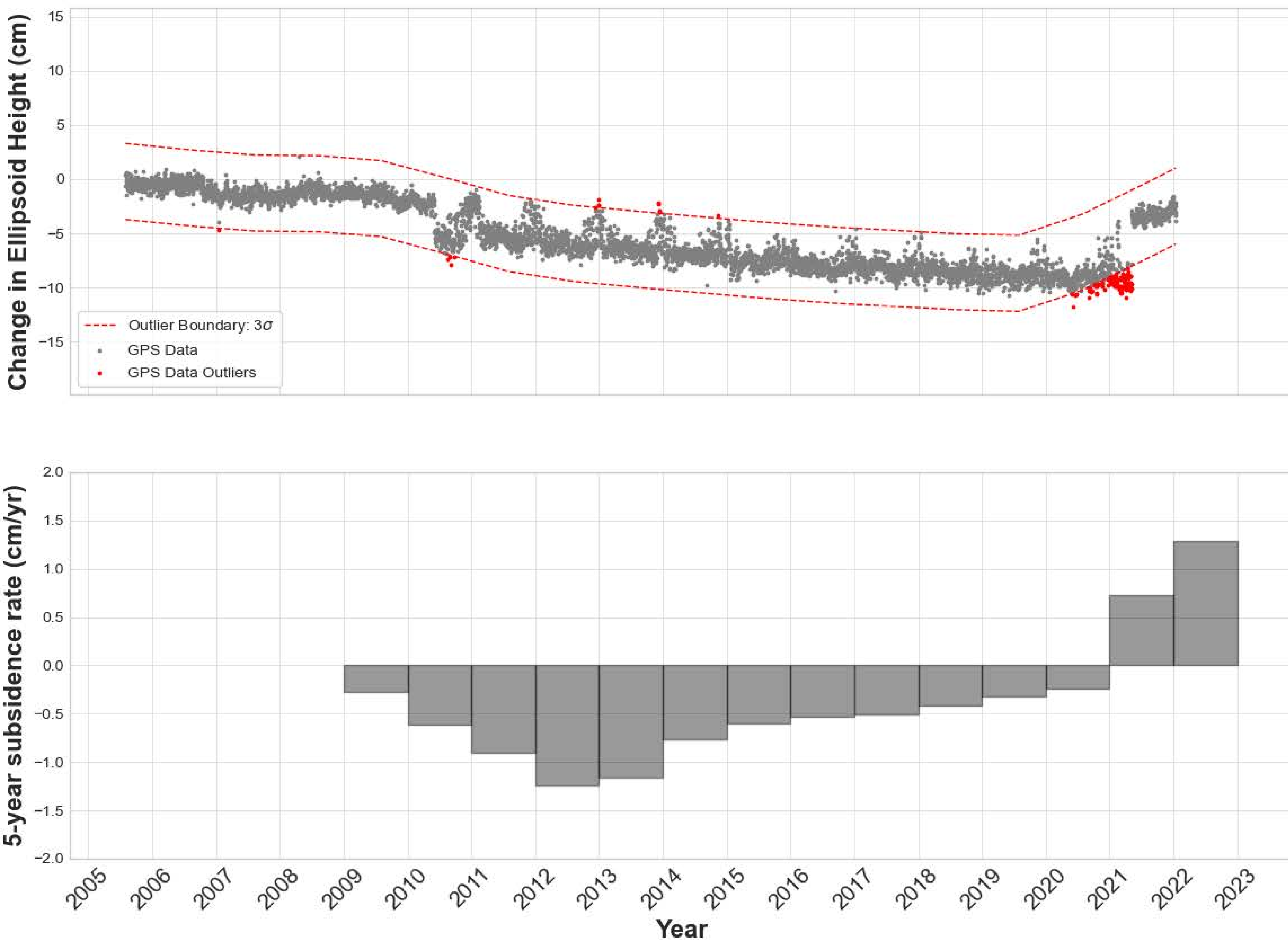
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXH2



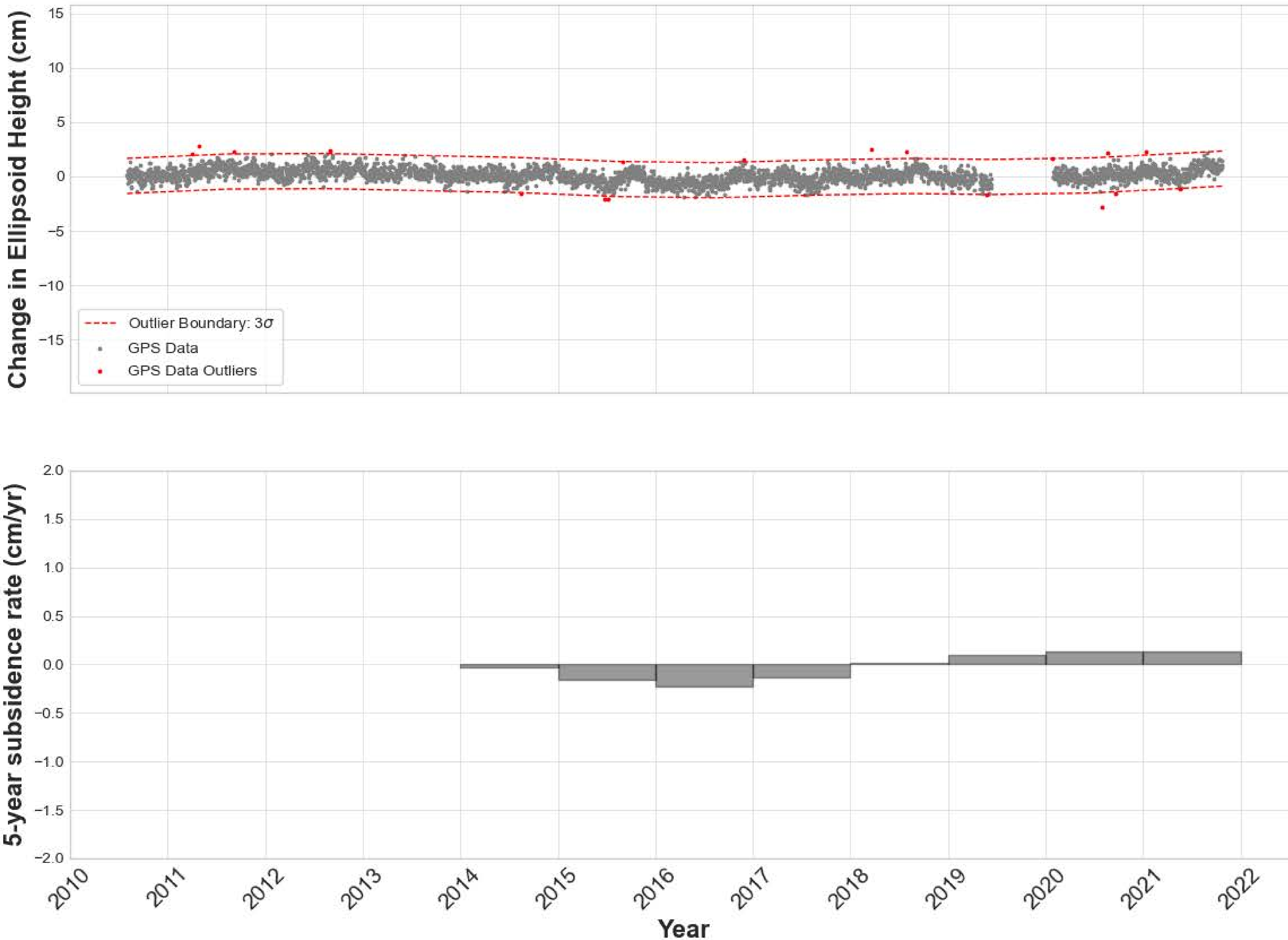
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXHE



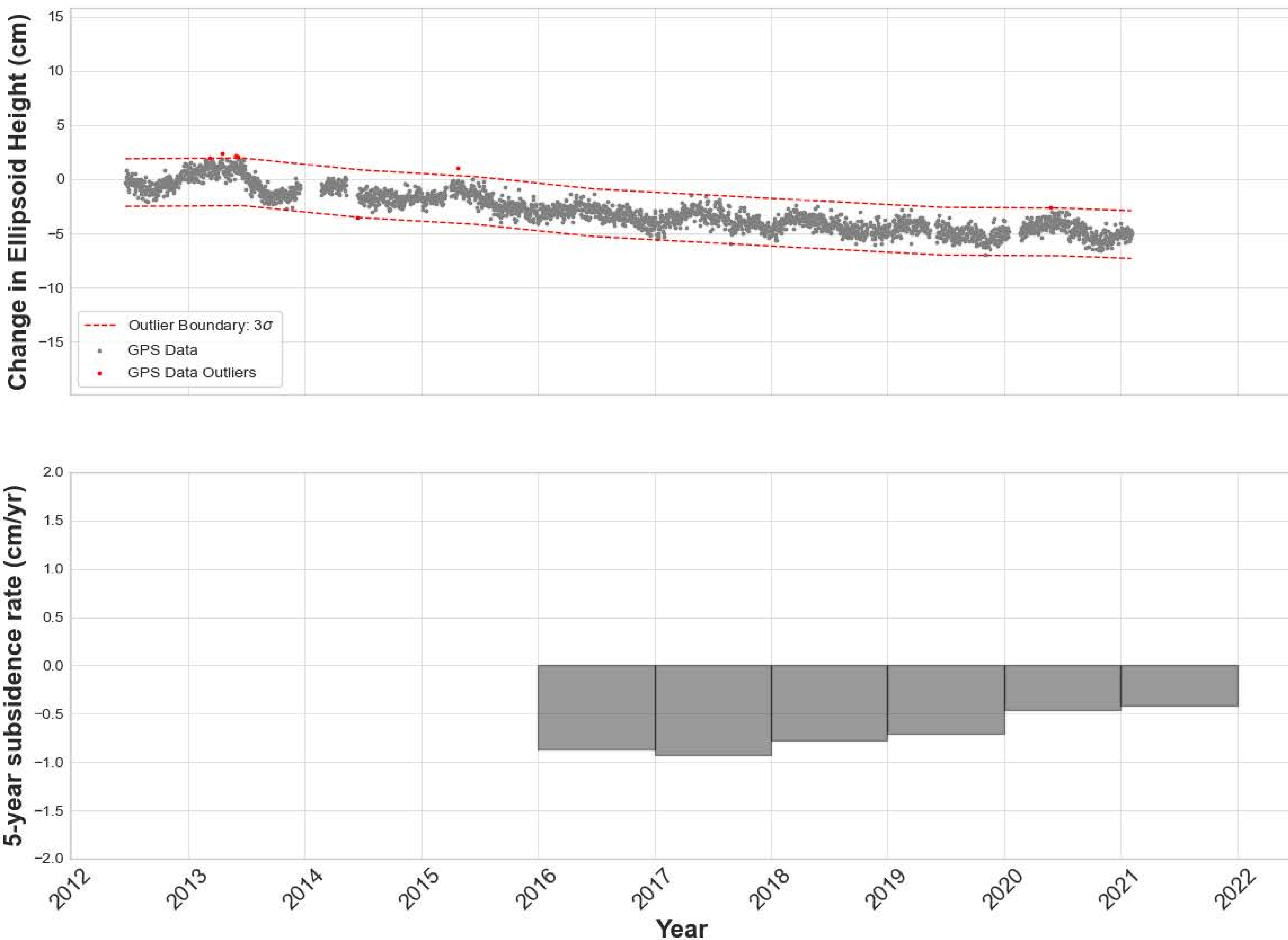
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXHN



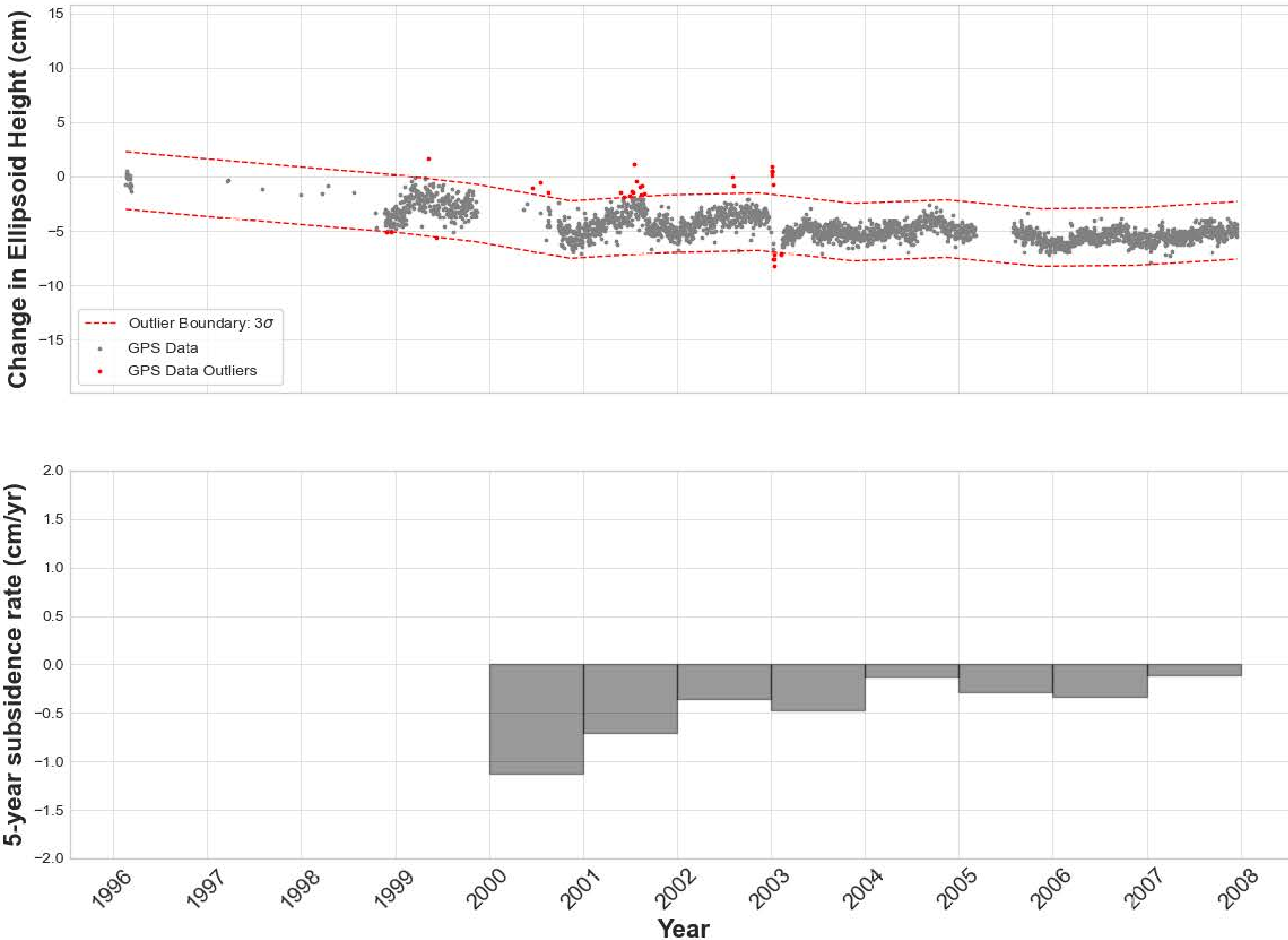
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXHS



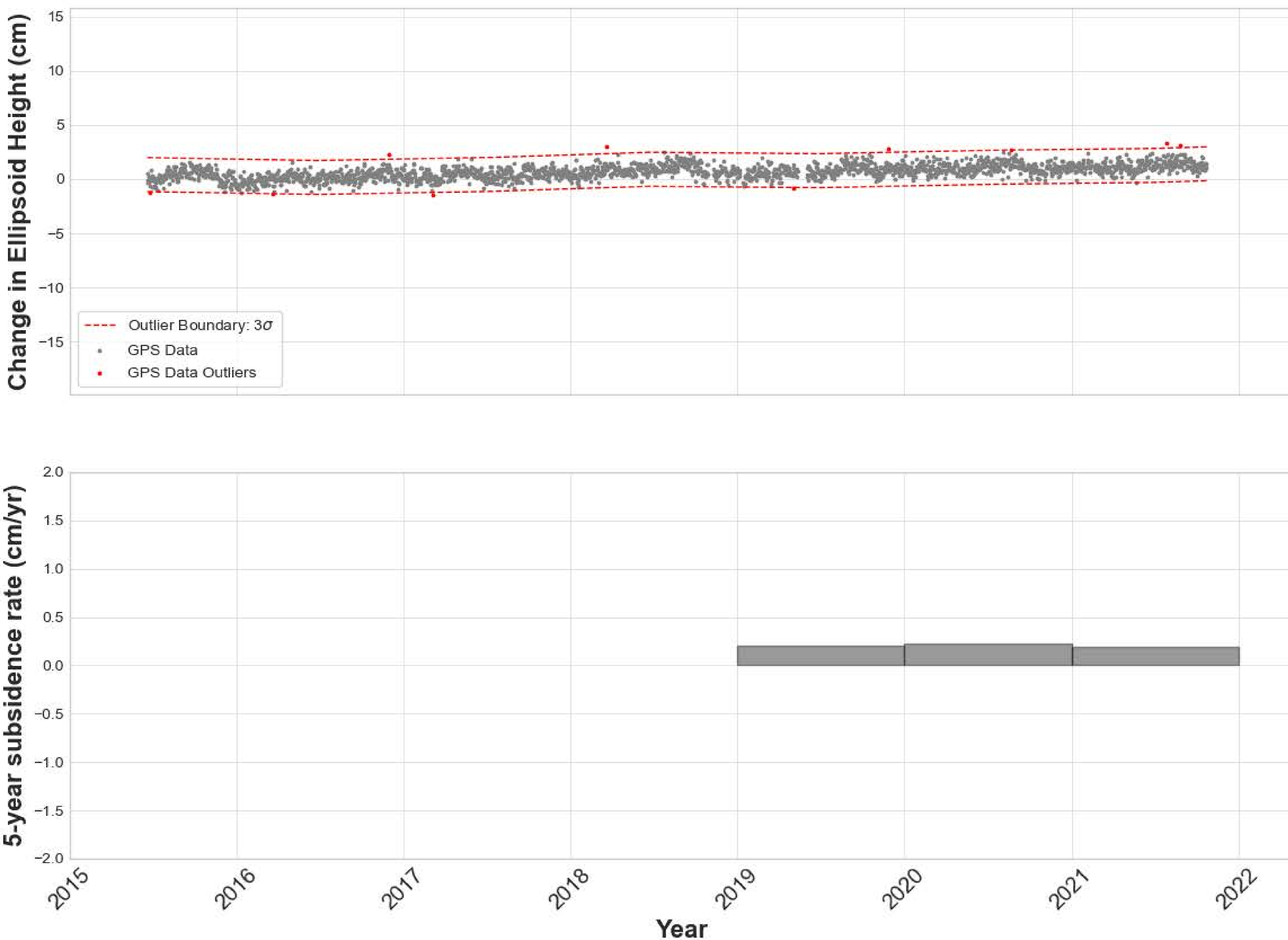
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXHU



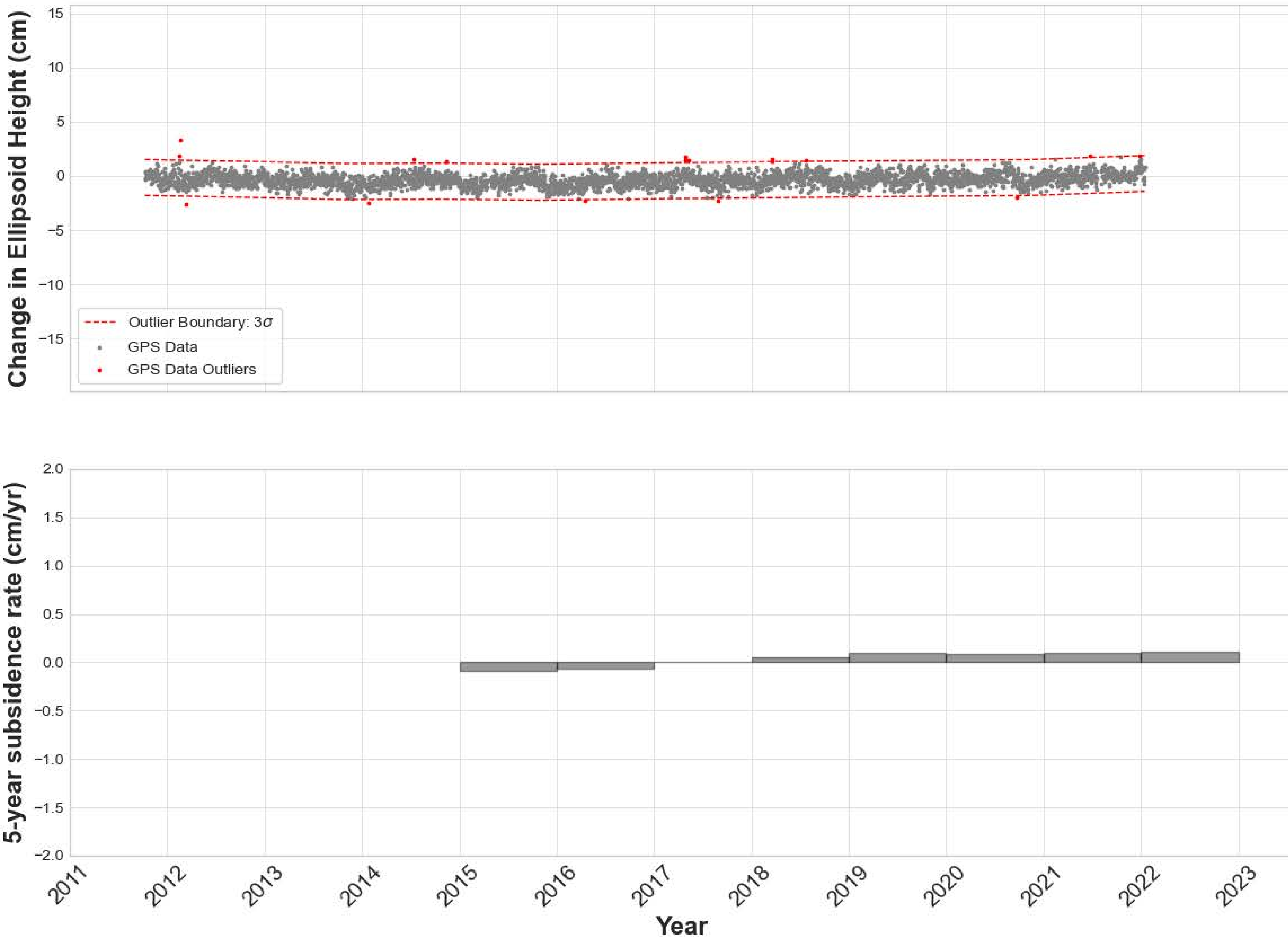
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXHV



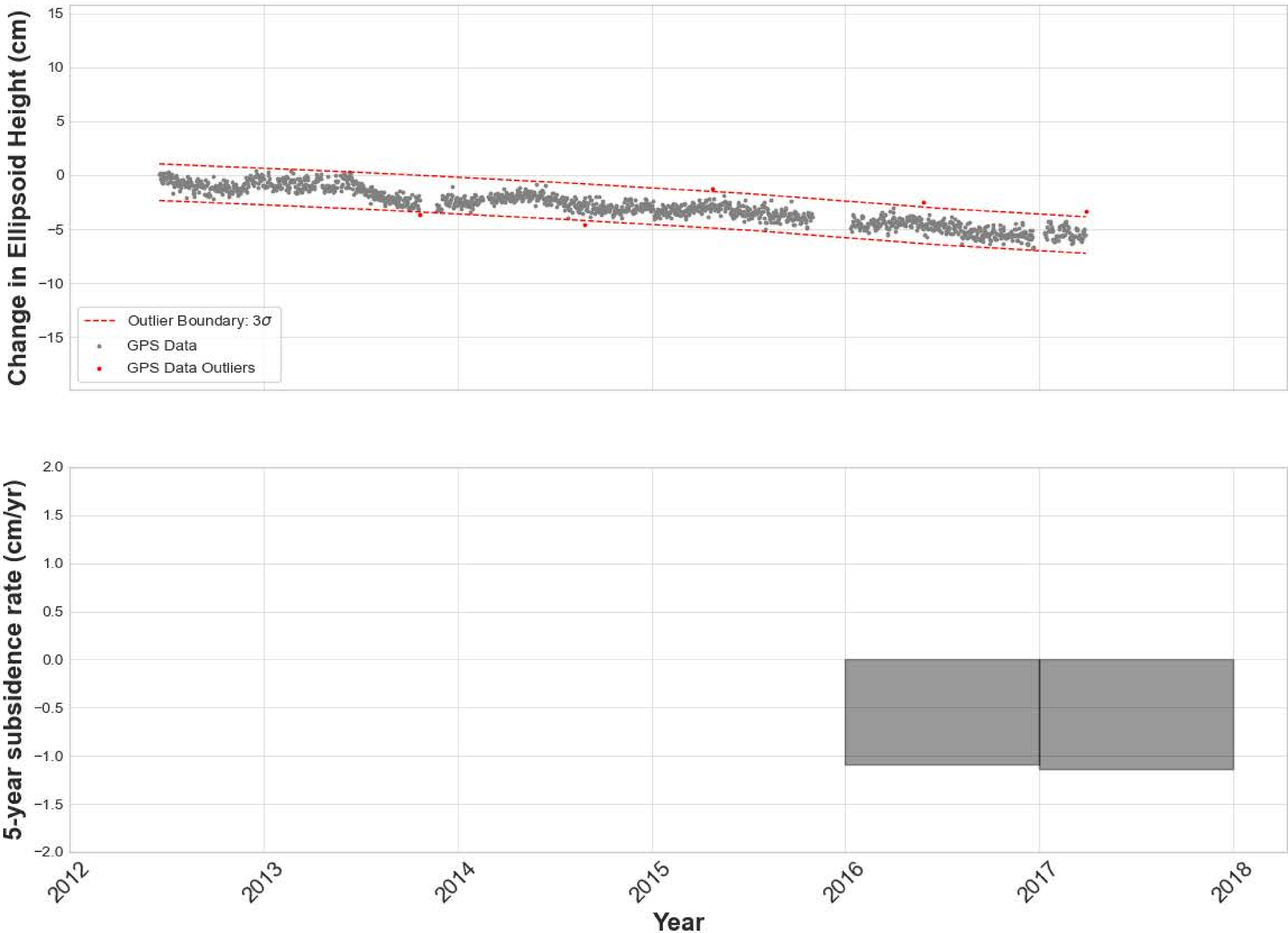
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXKO



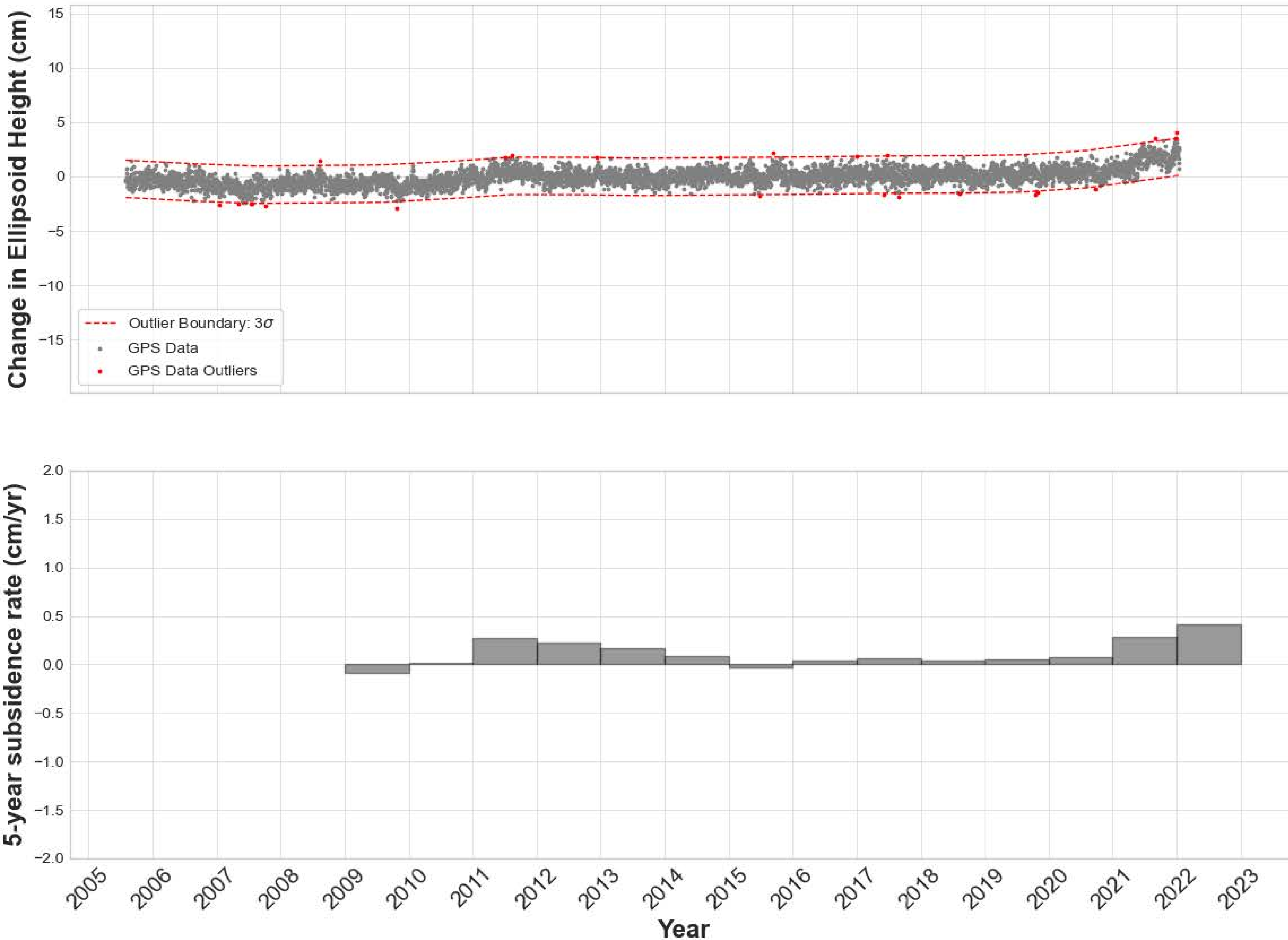
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXKY



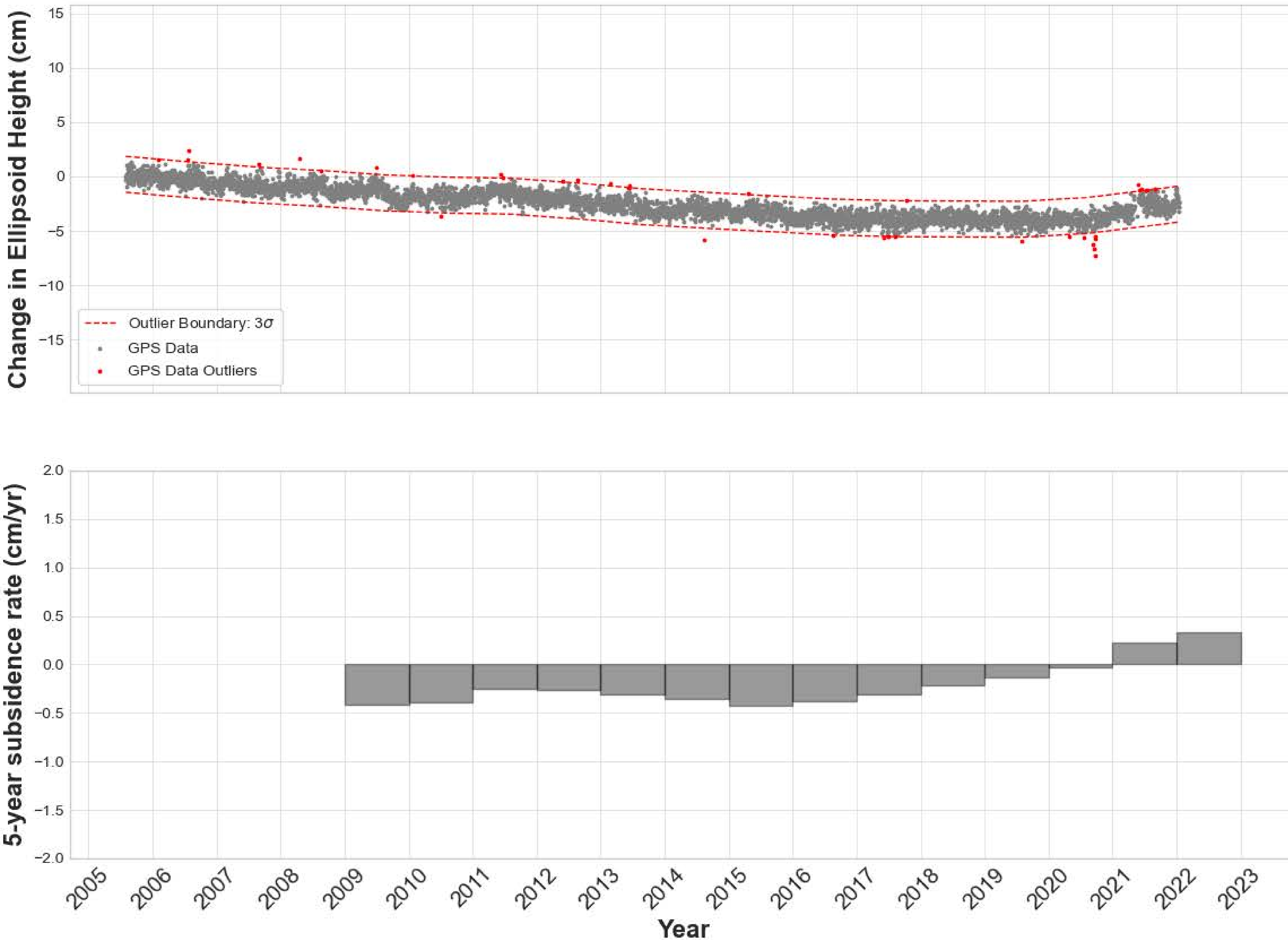
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXLI



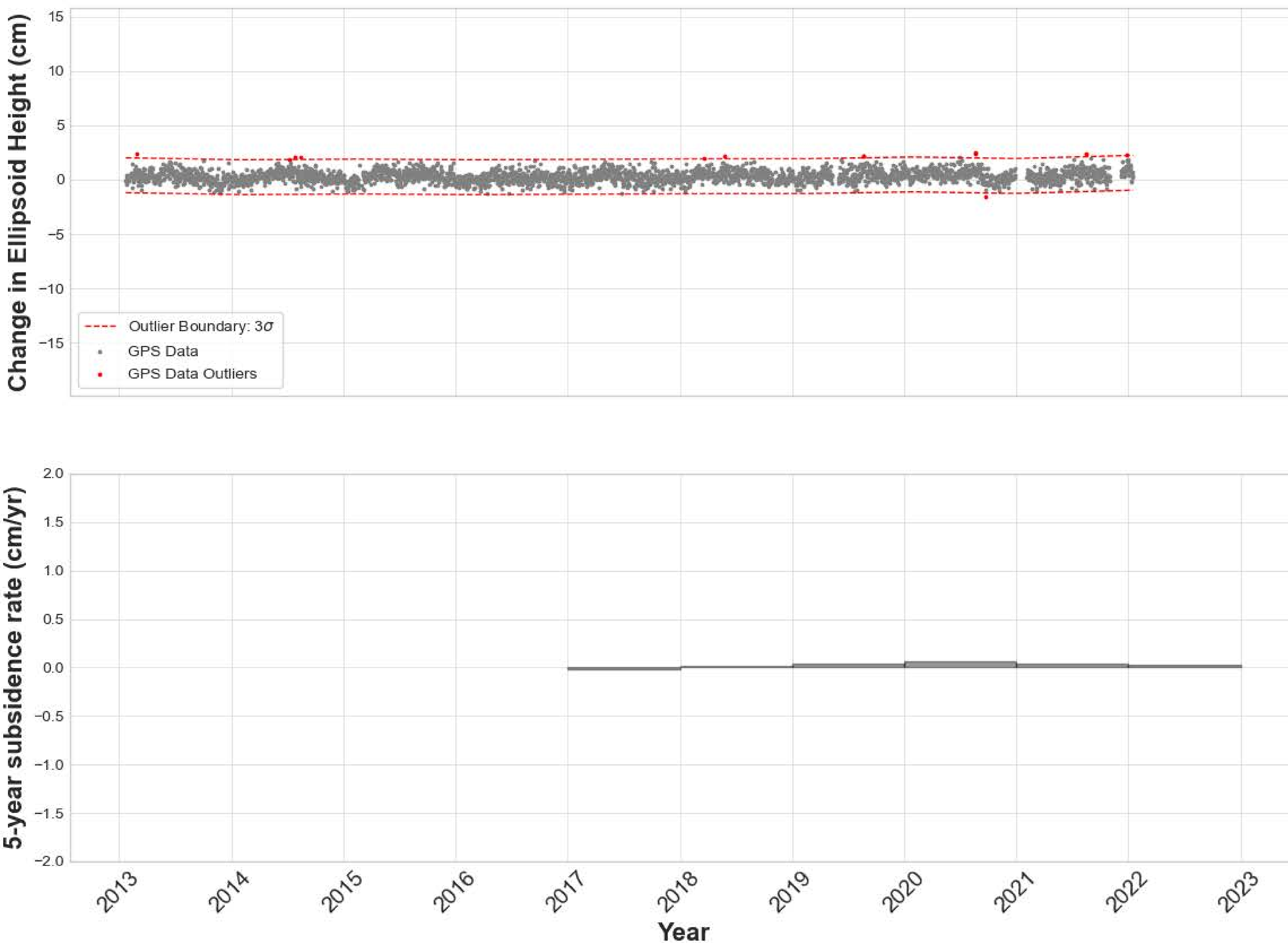
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXLM



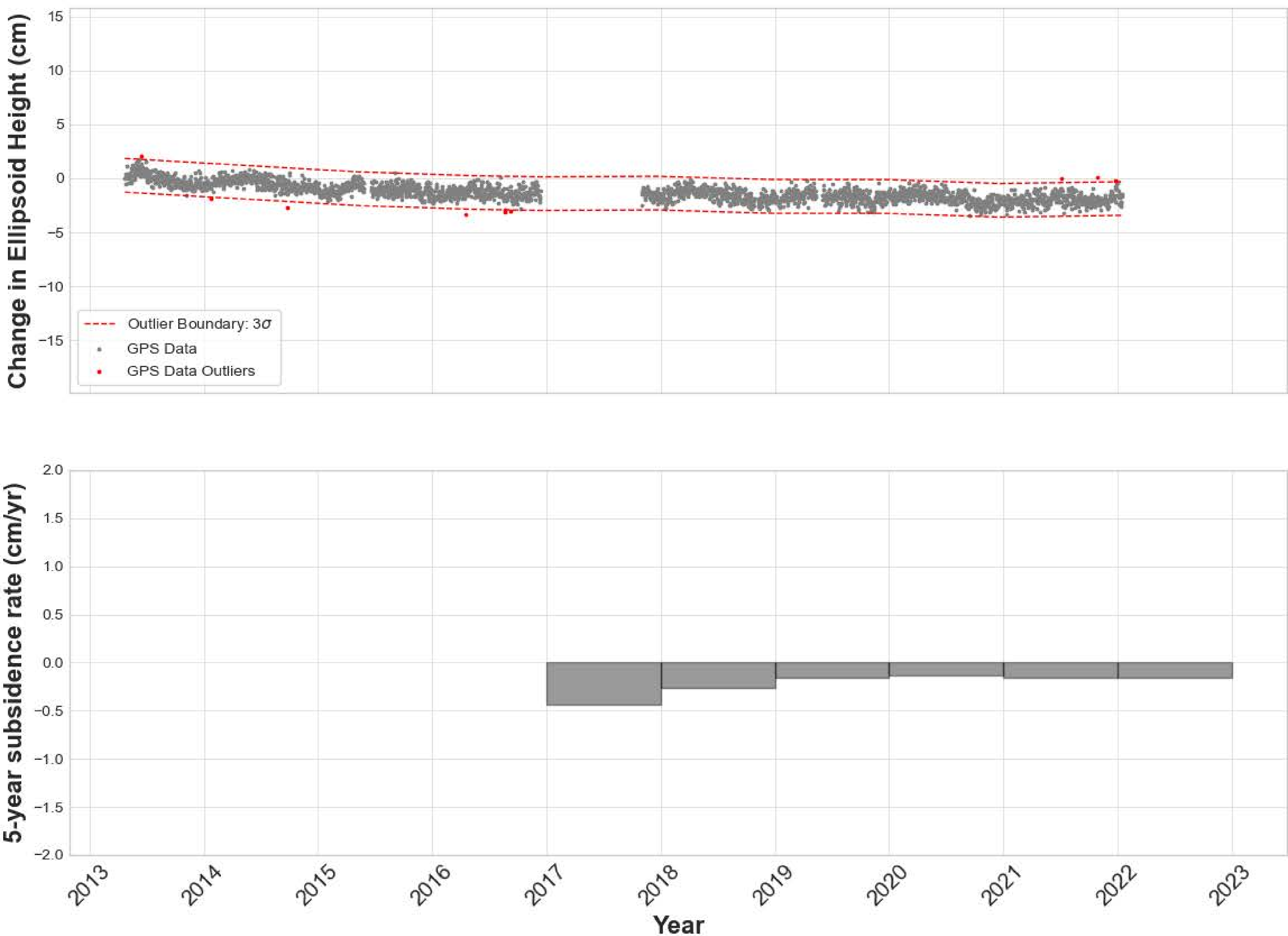
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXLQ



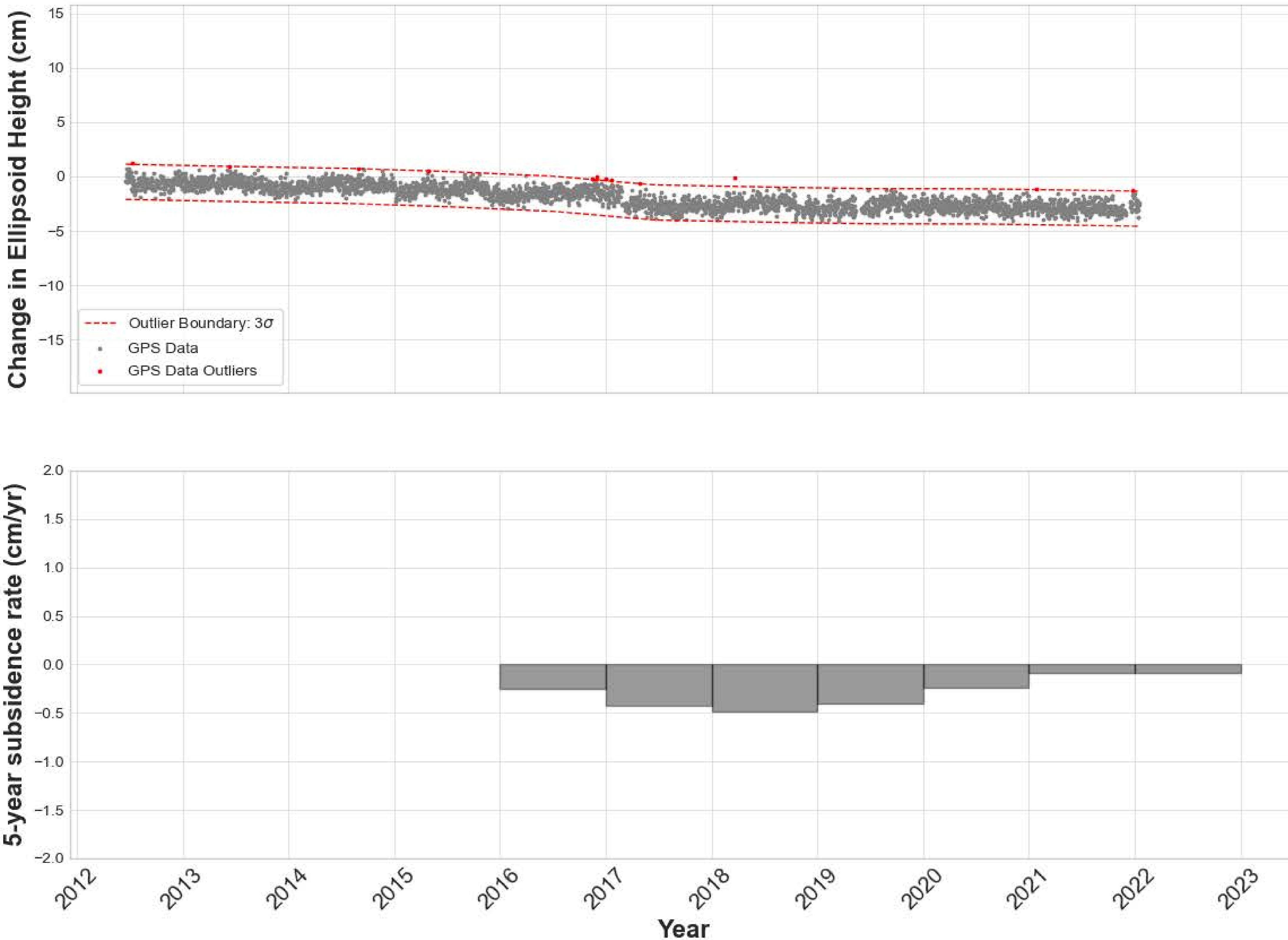
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXMG

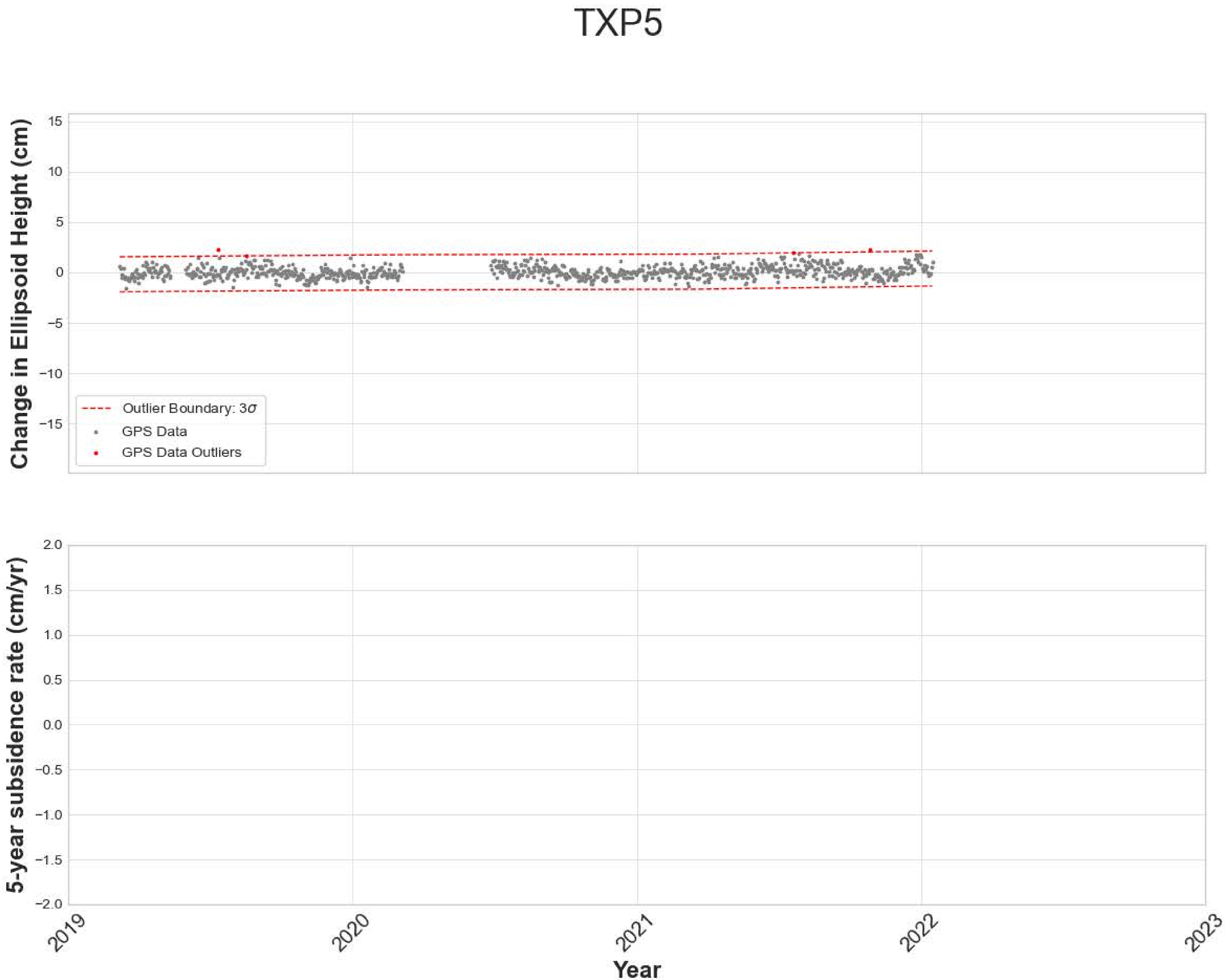


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXNV

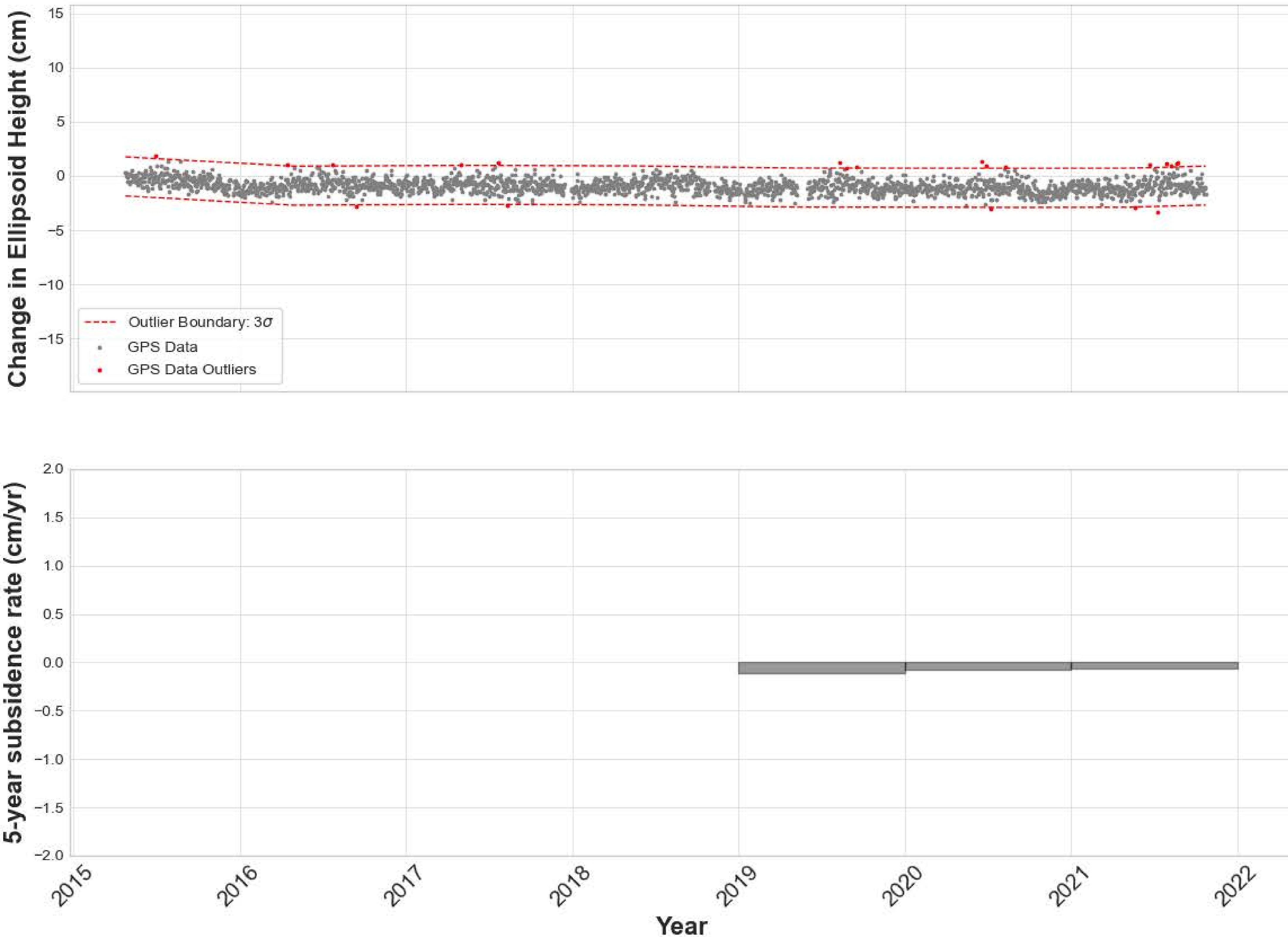


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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



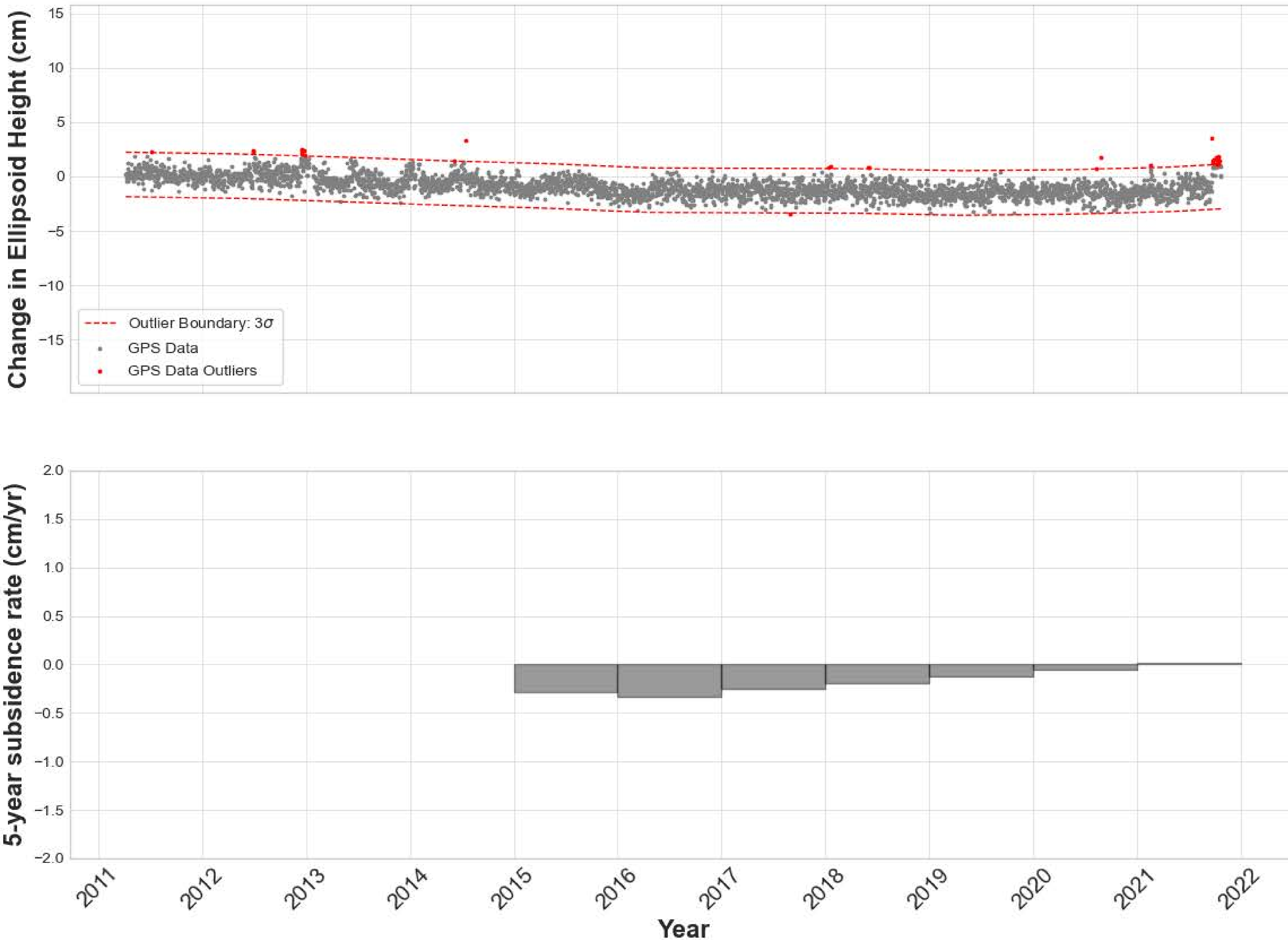
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXPH



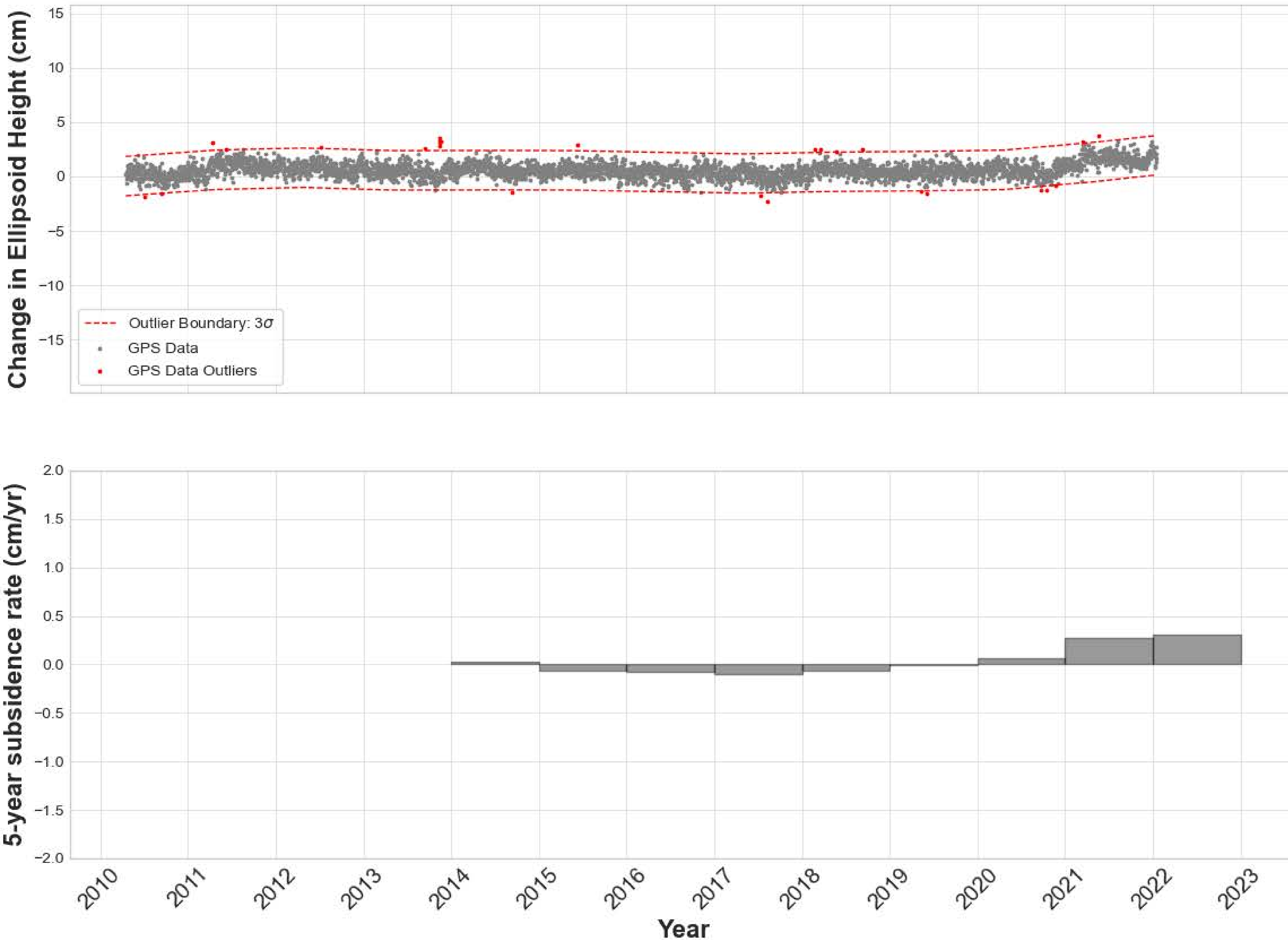
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXPT

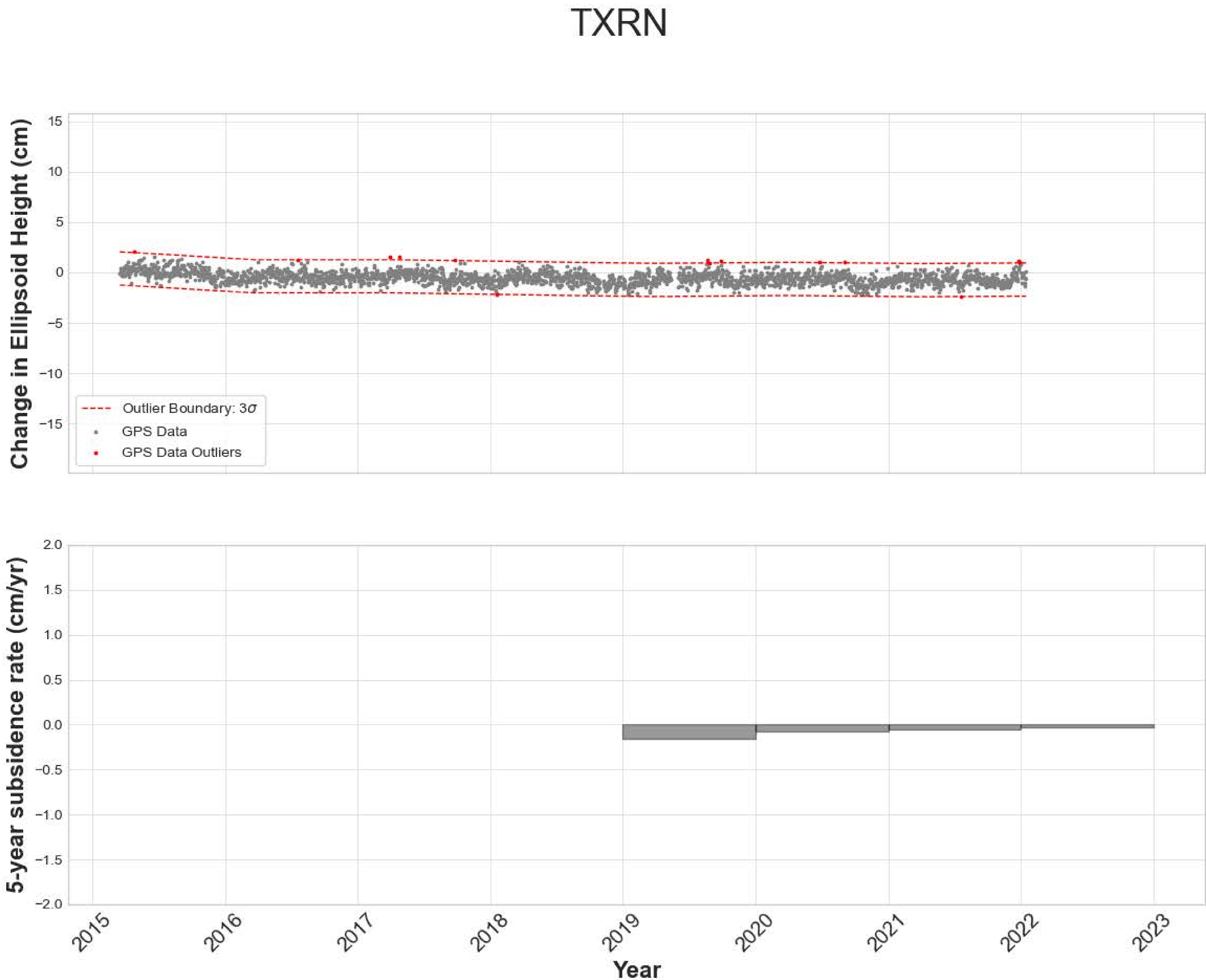


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXPV

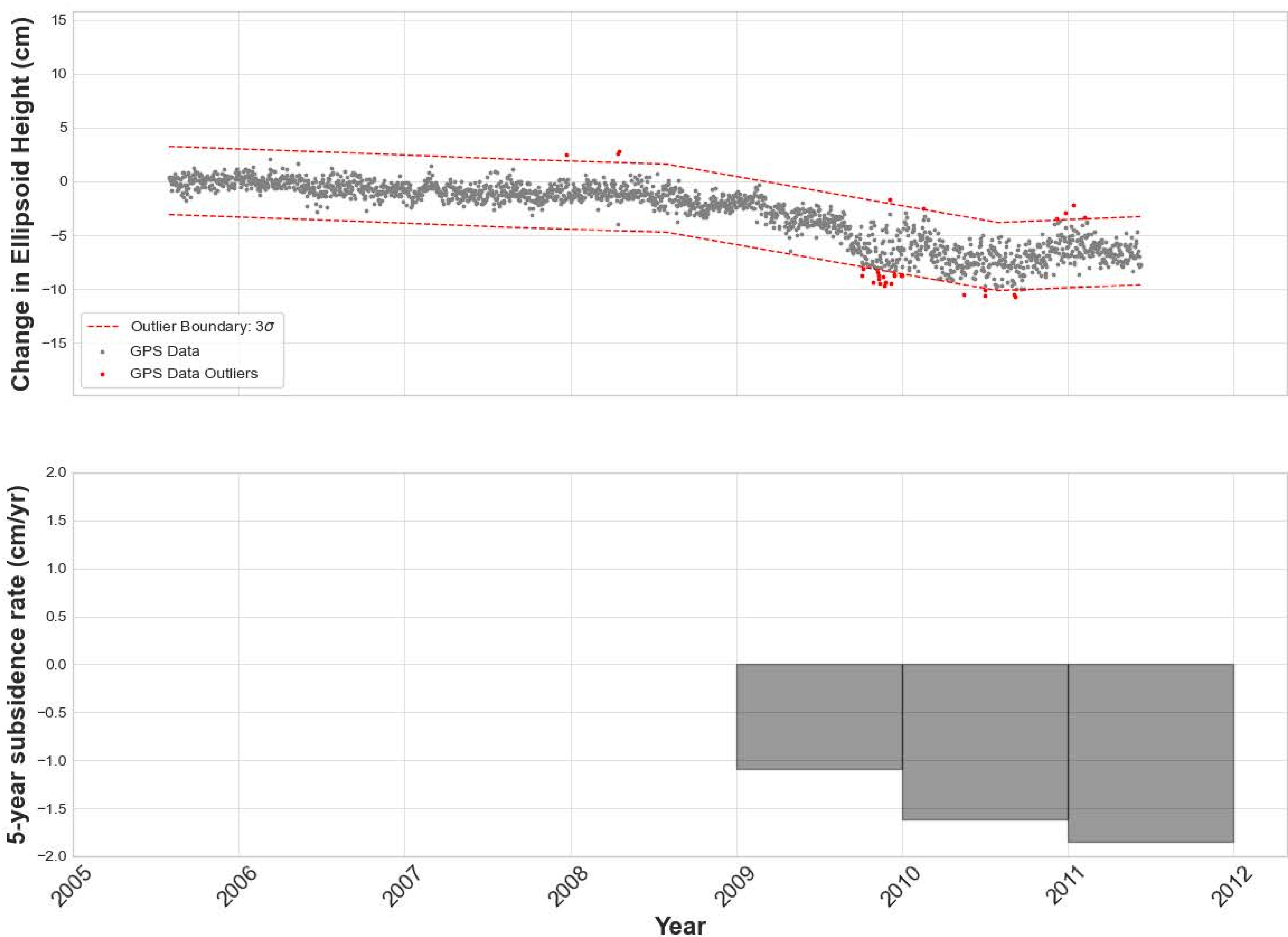


Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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



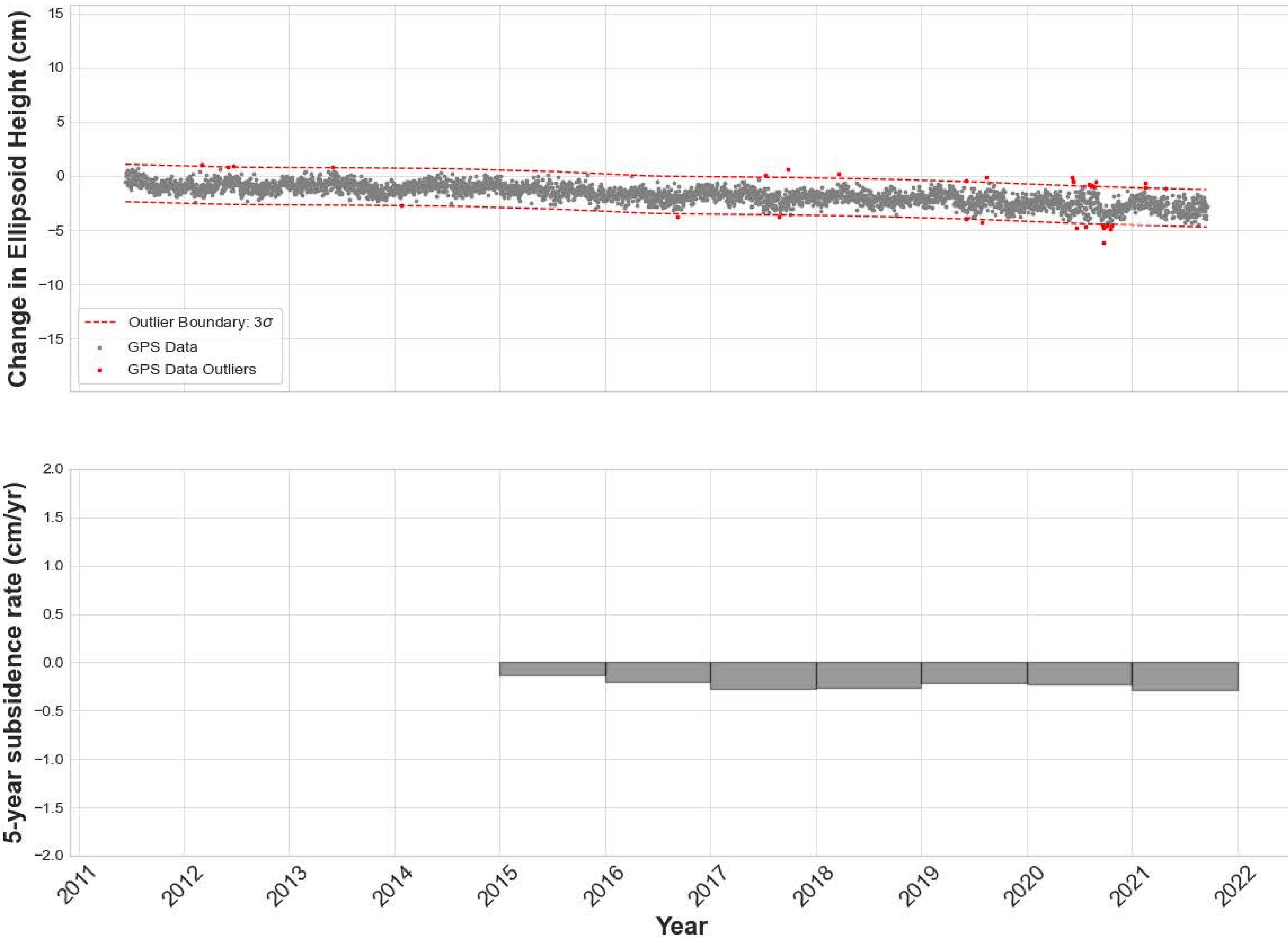
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXRO



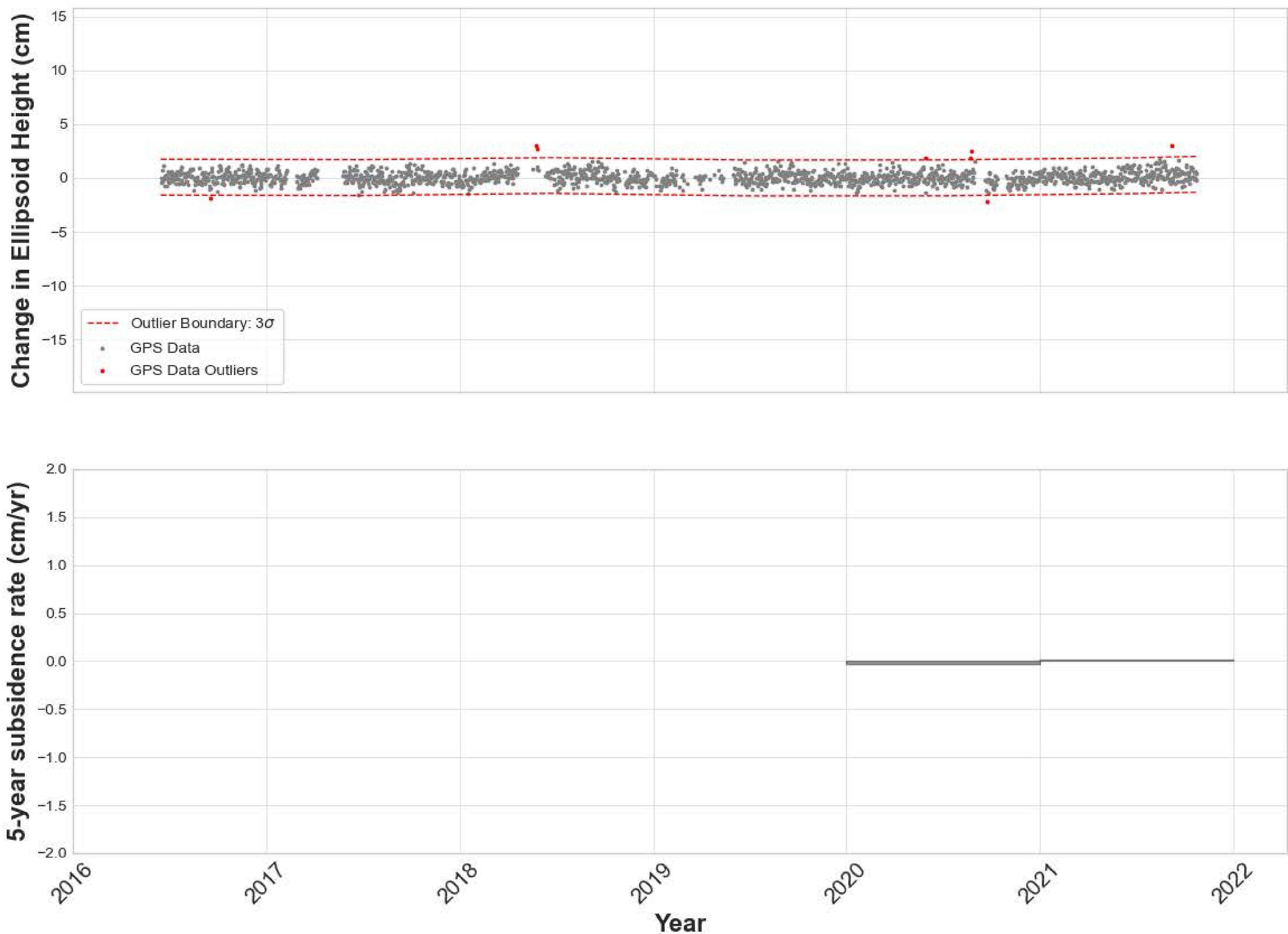
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXRS



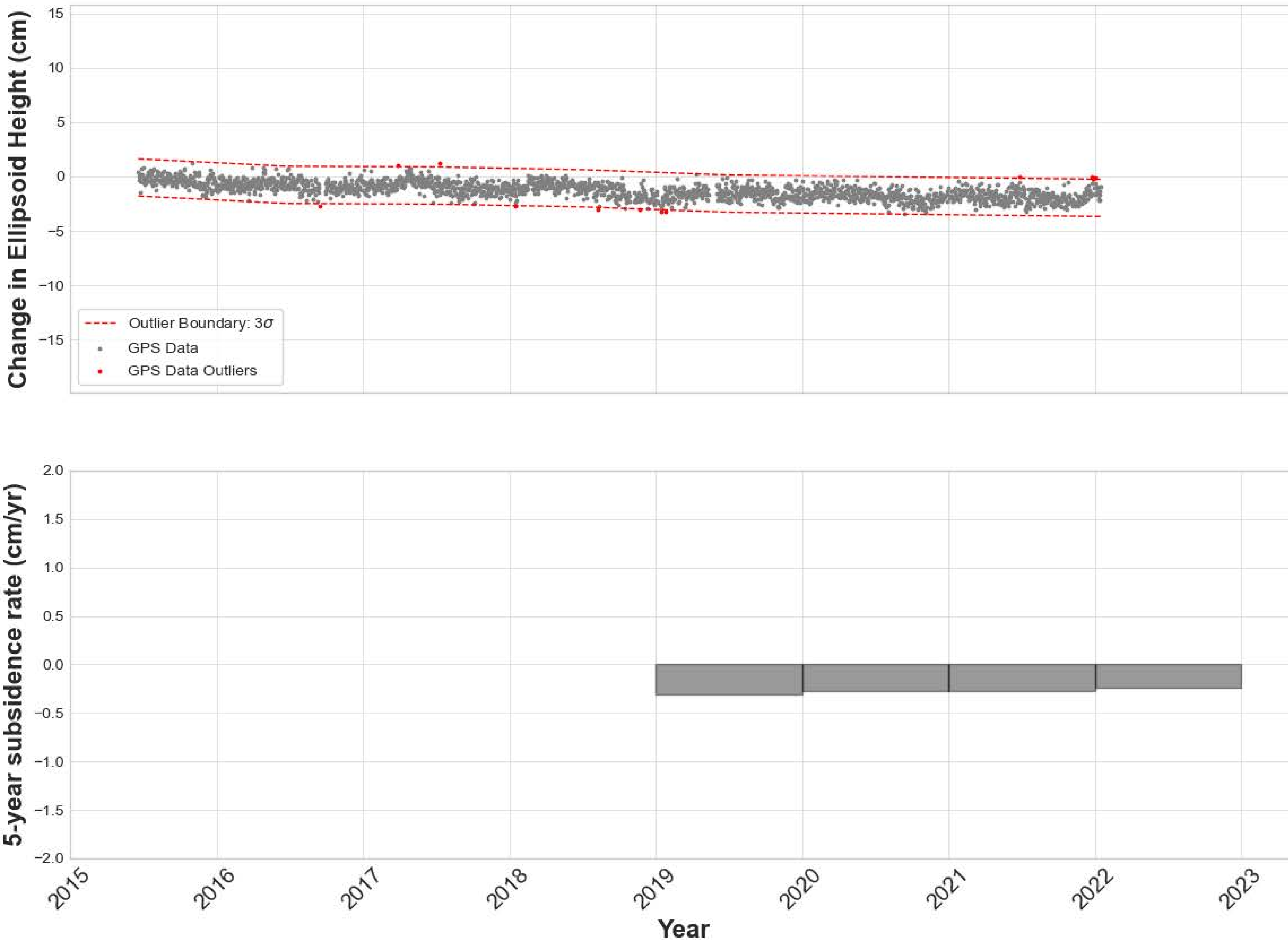
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXSP



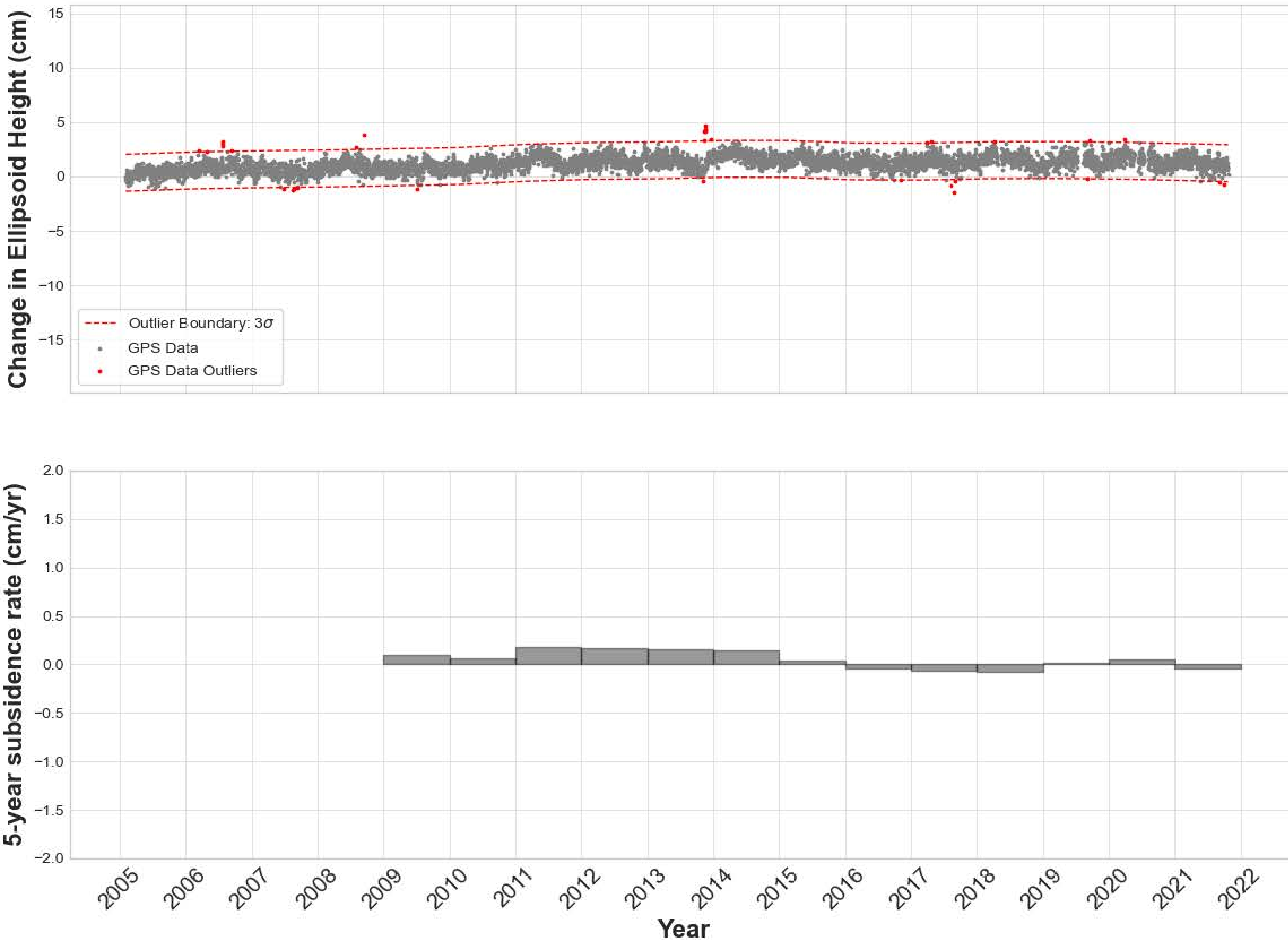
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXTG



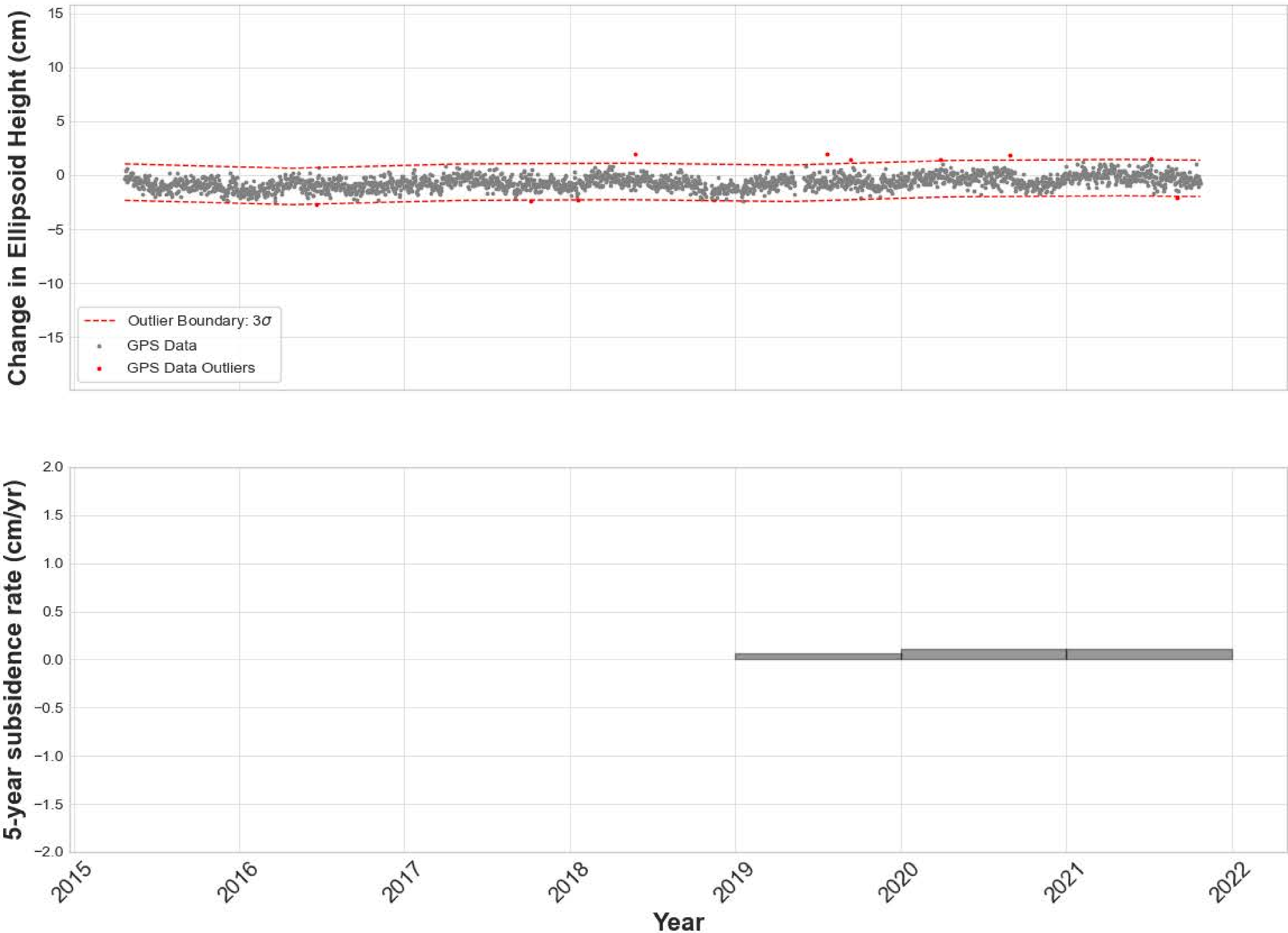
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXVA



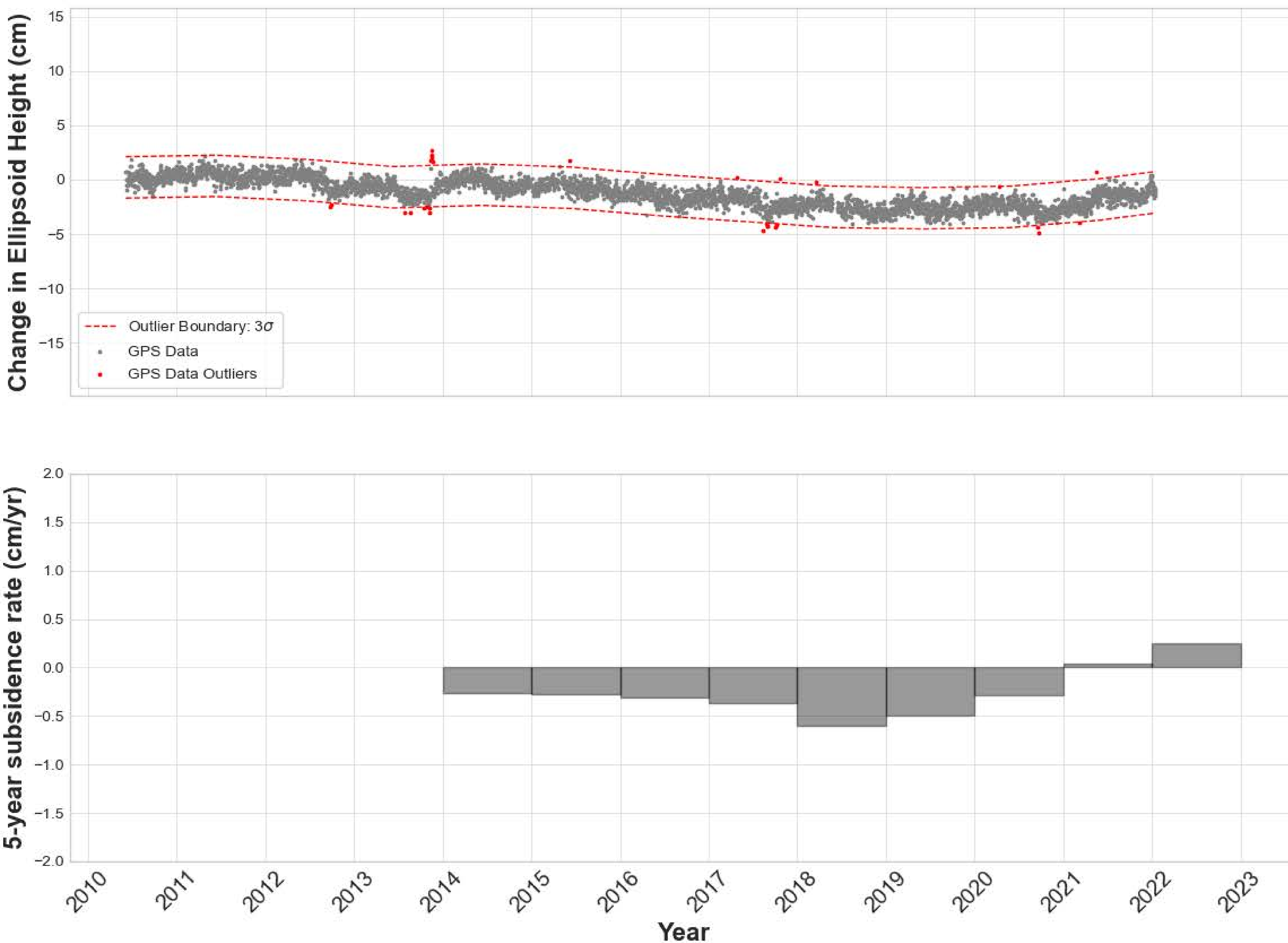
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXVC



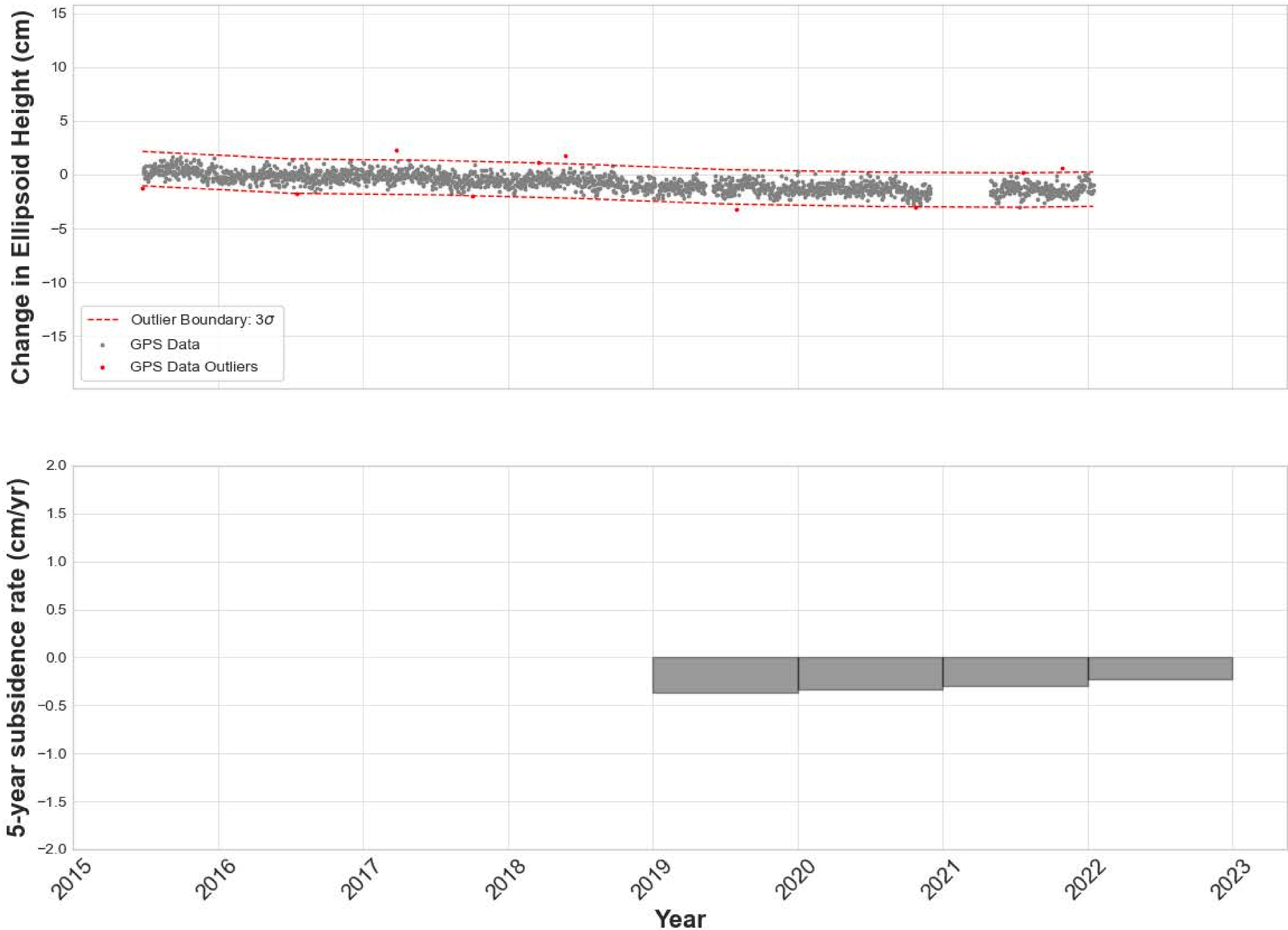
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXWH



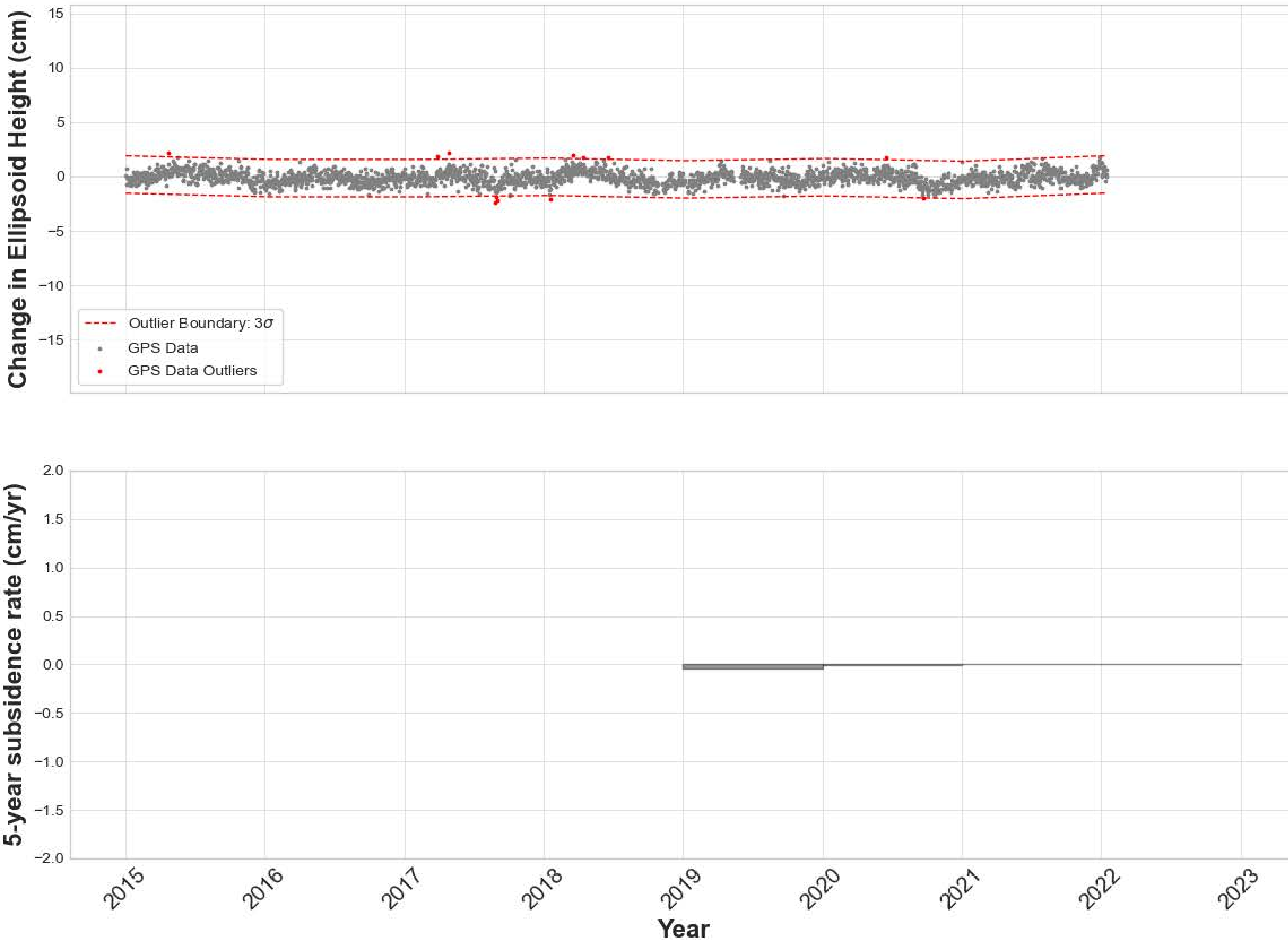
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXWI



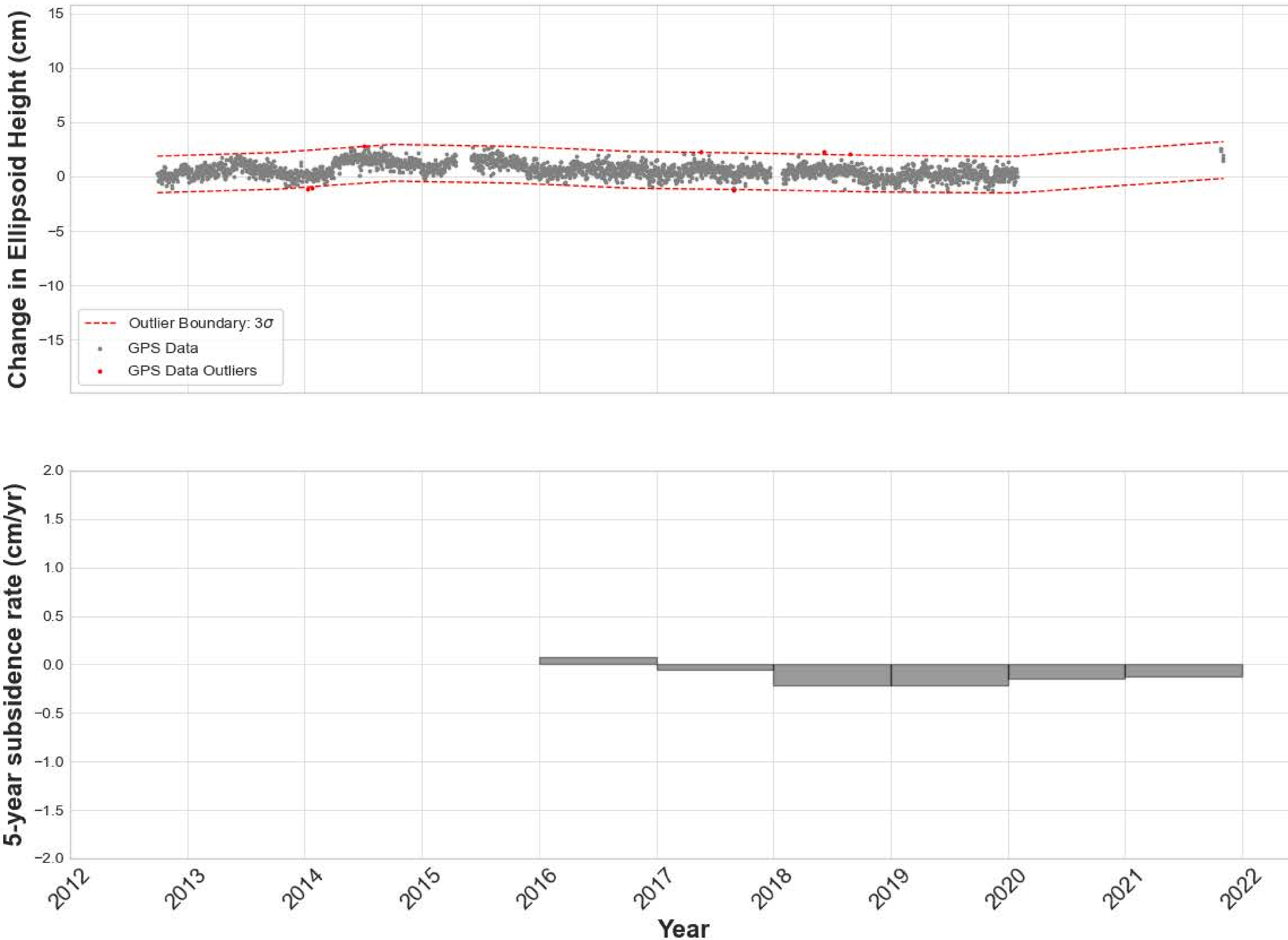
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

TXWN



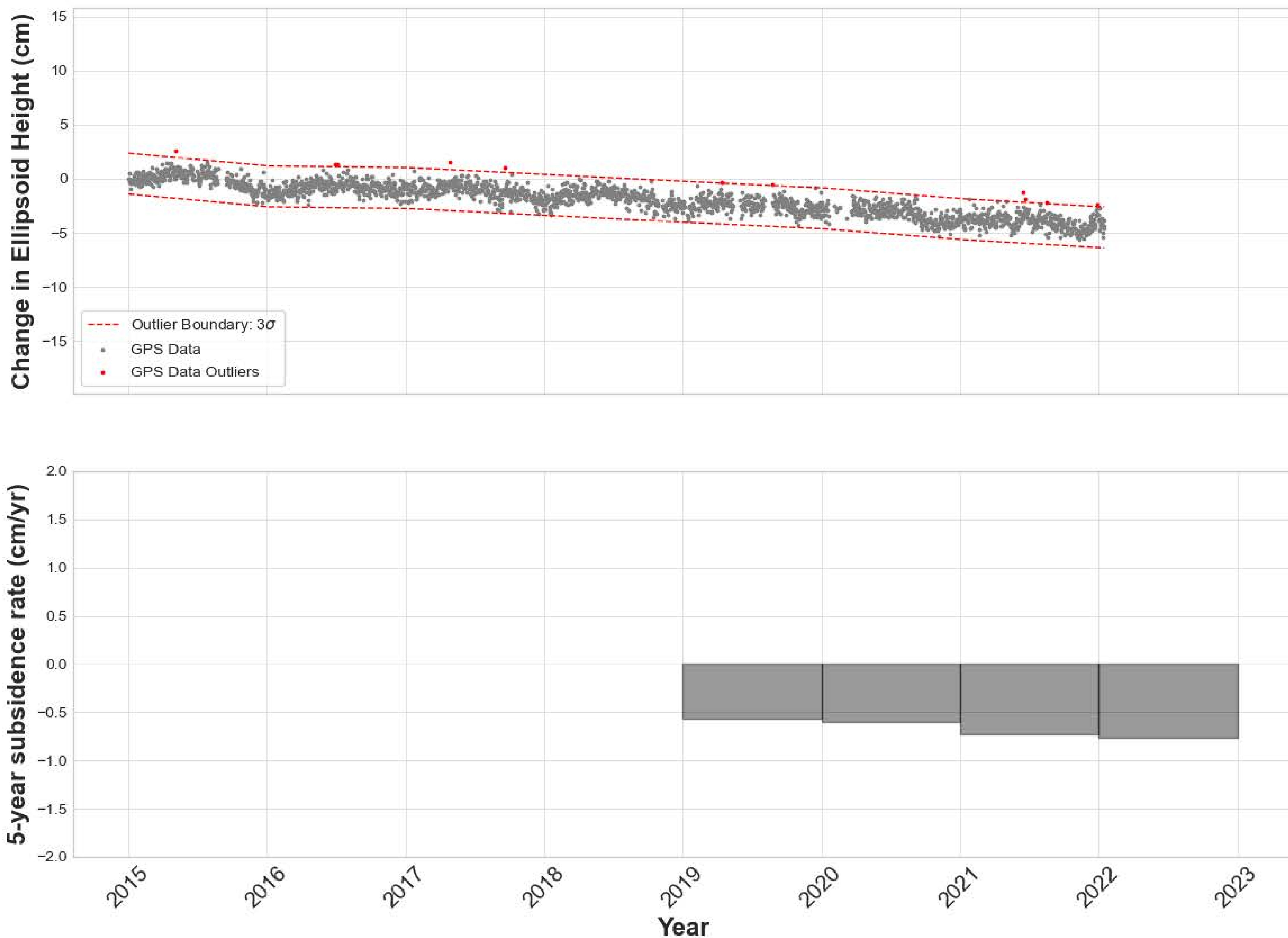
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UH01



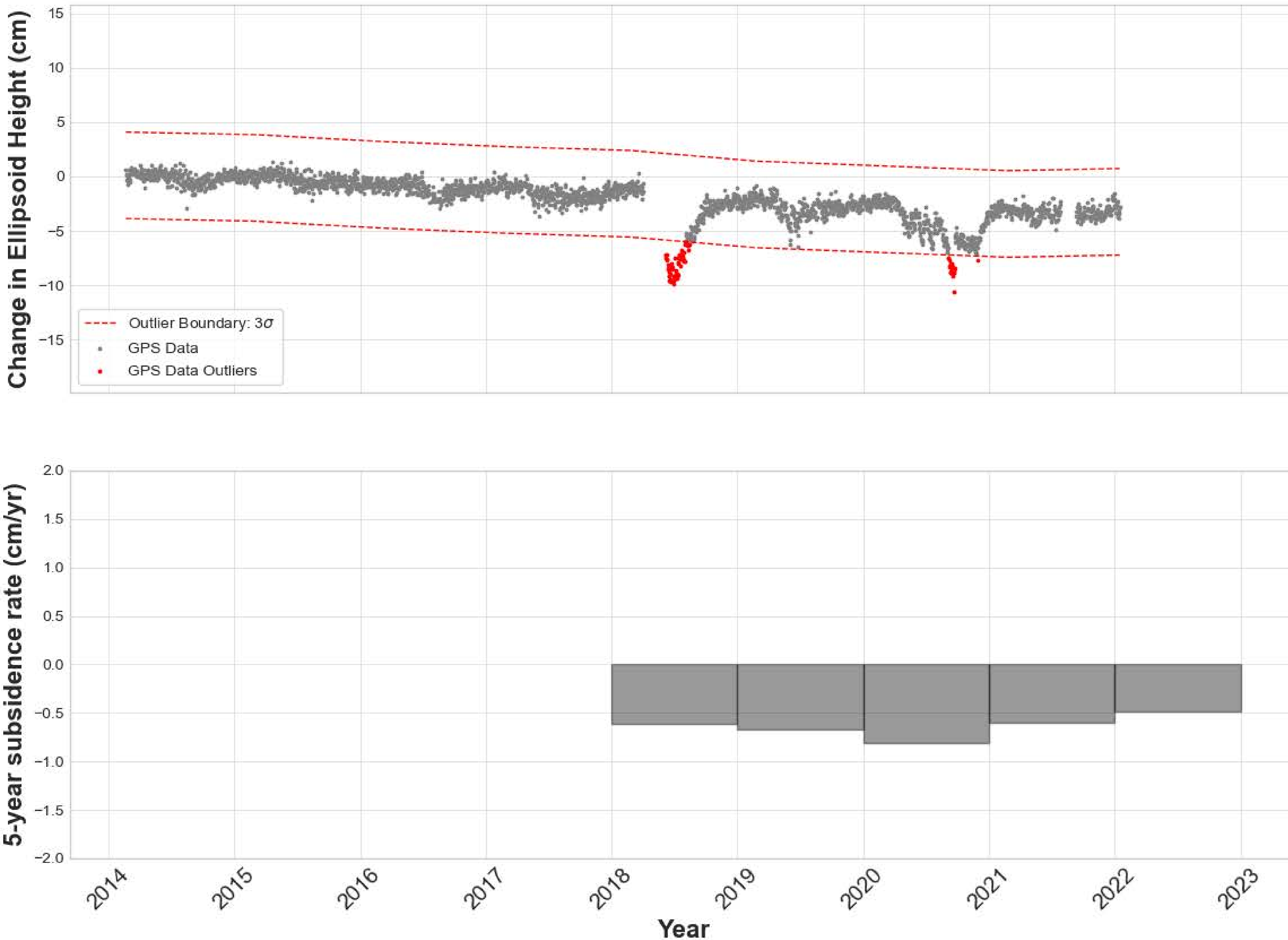
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UH02



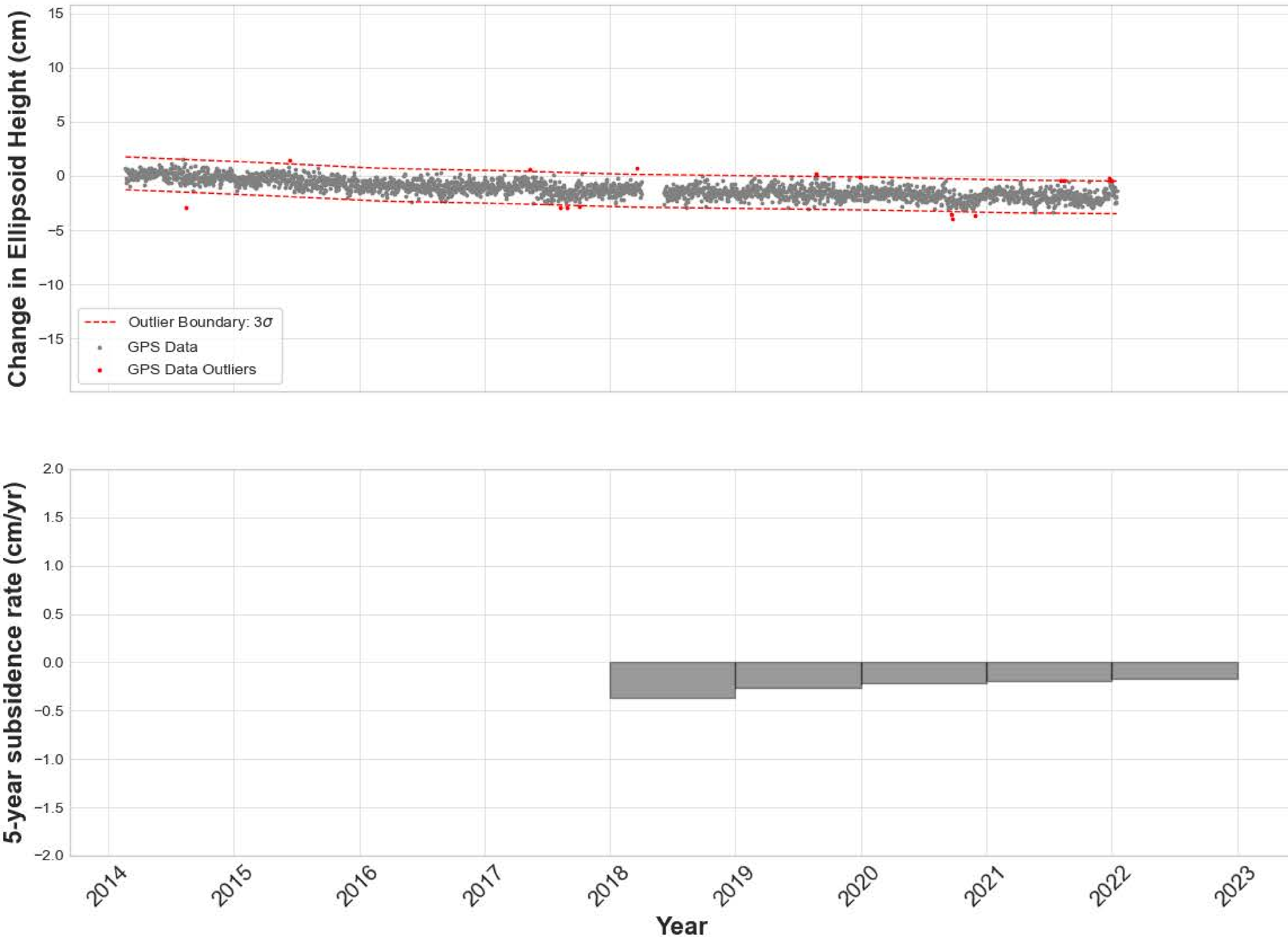
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHC0



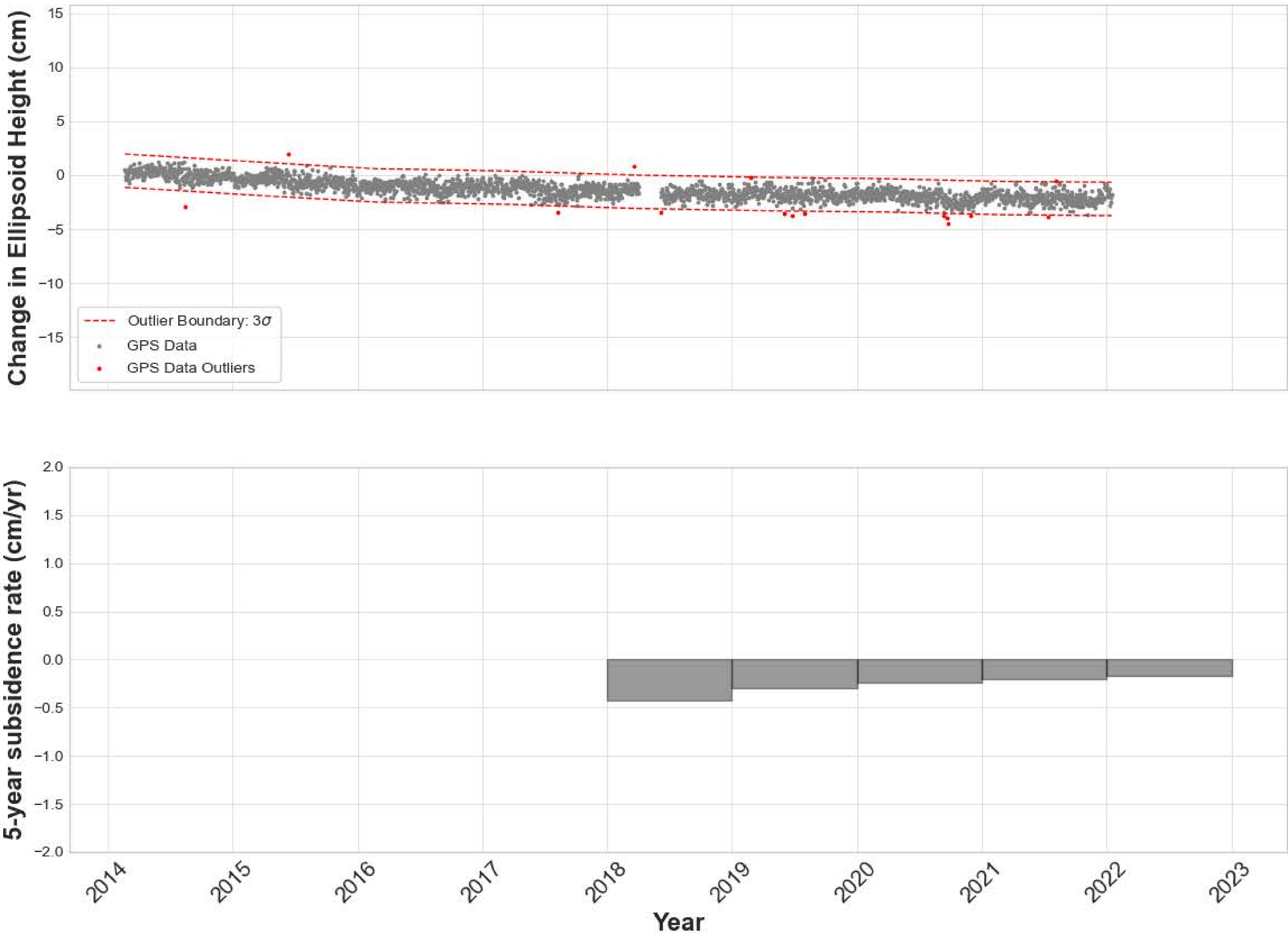
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHC1



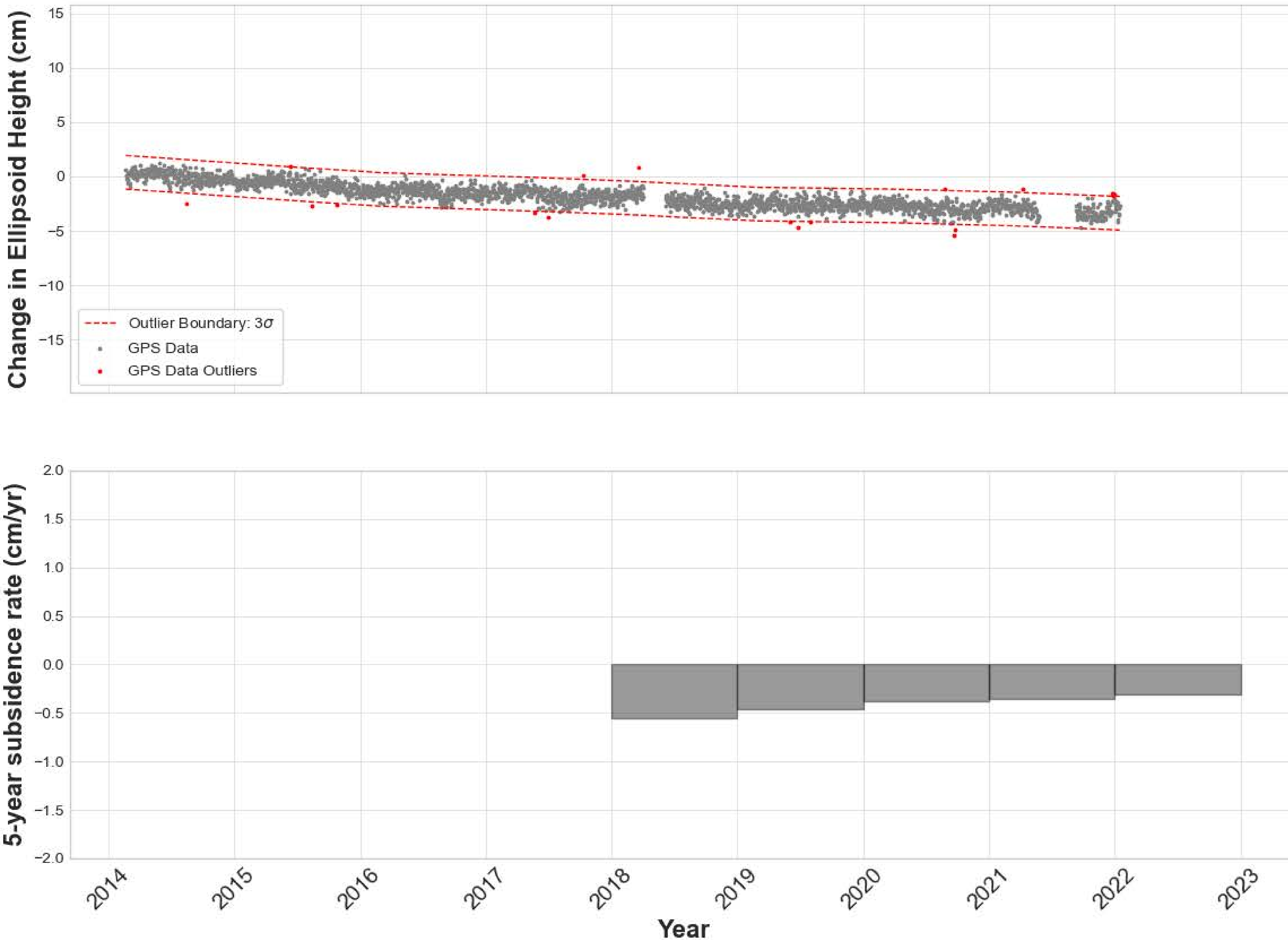
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHC2



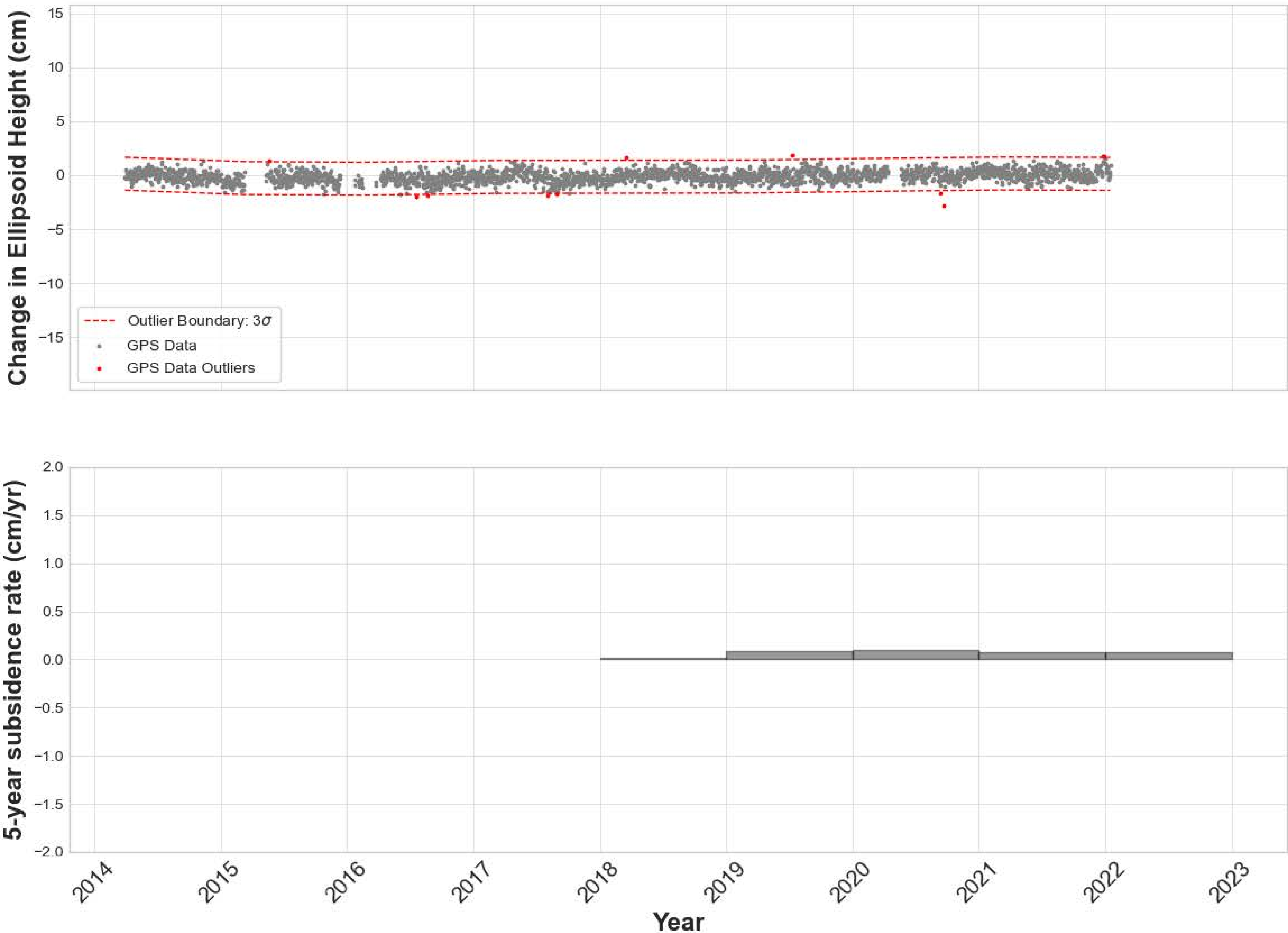
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHC3



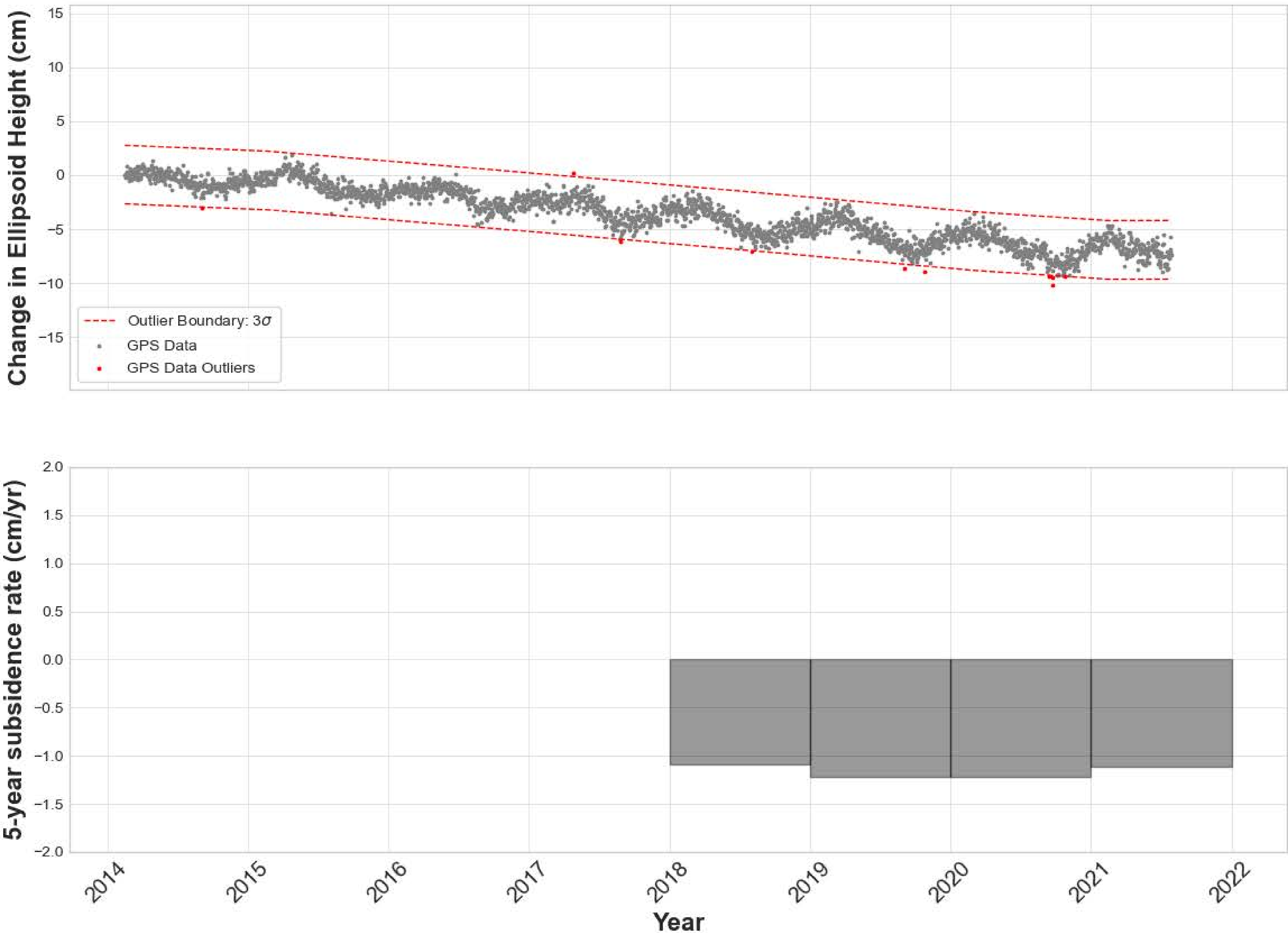
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHCL



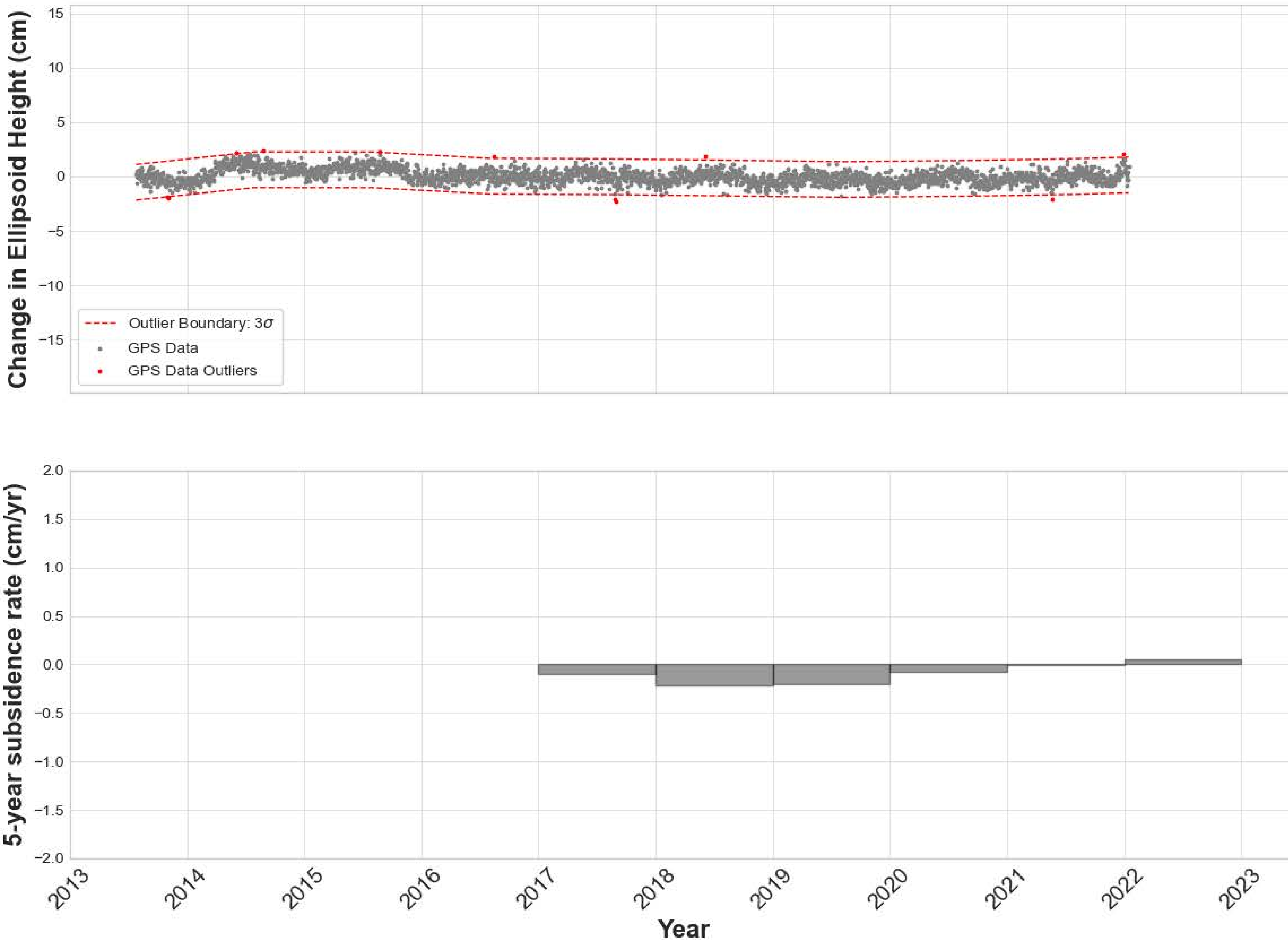
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHCR



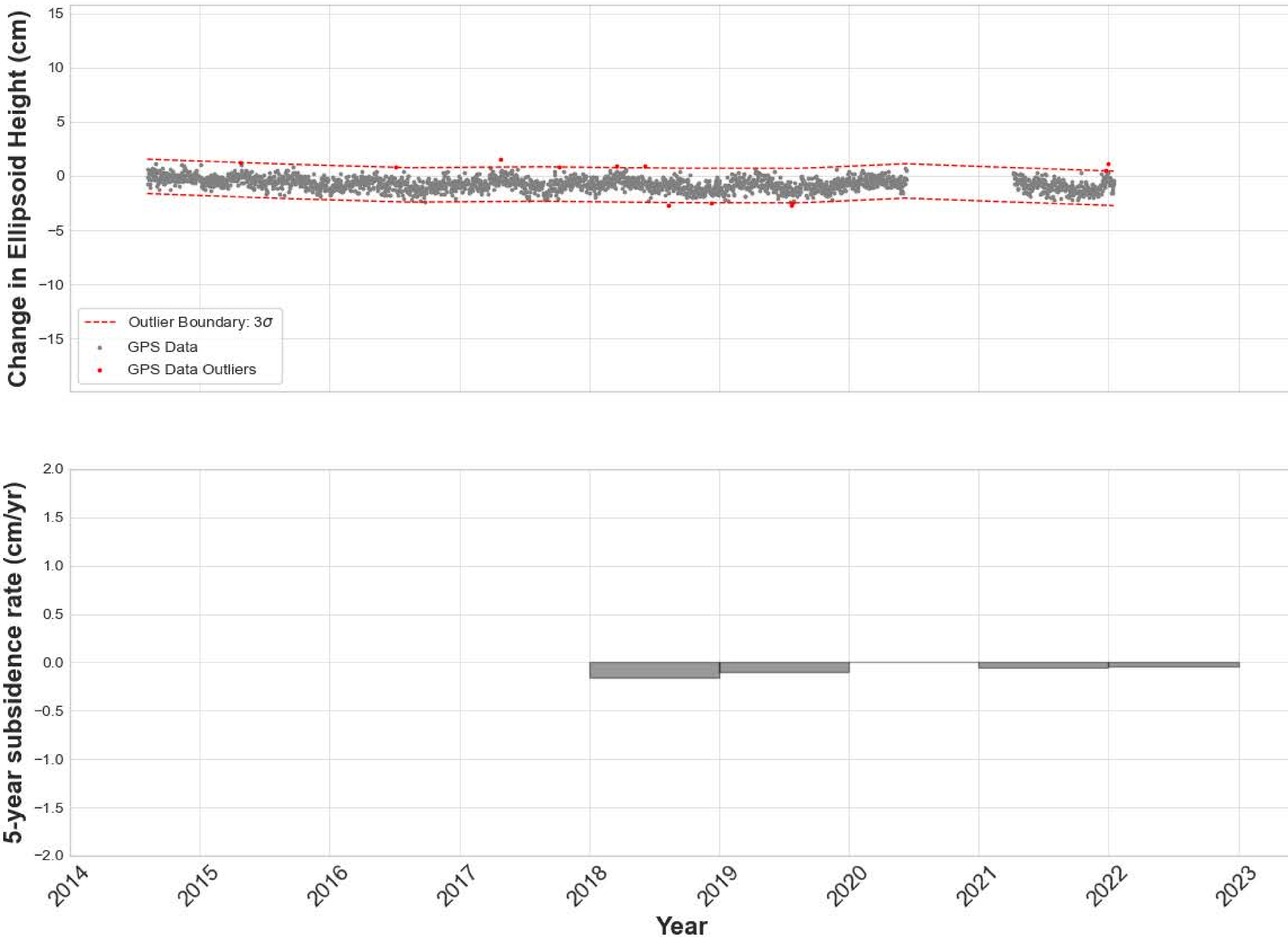
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHDT



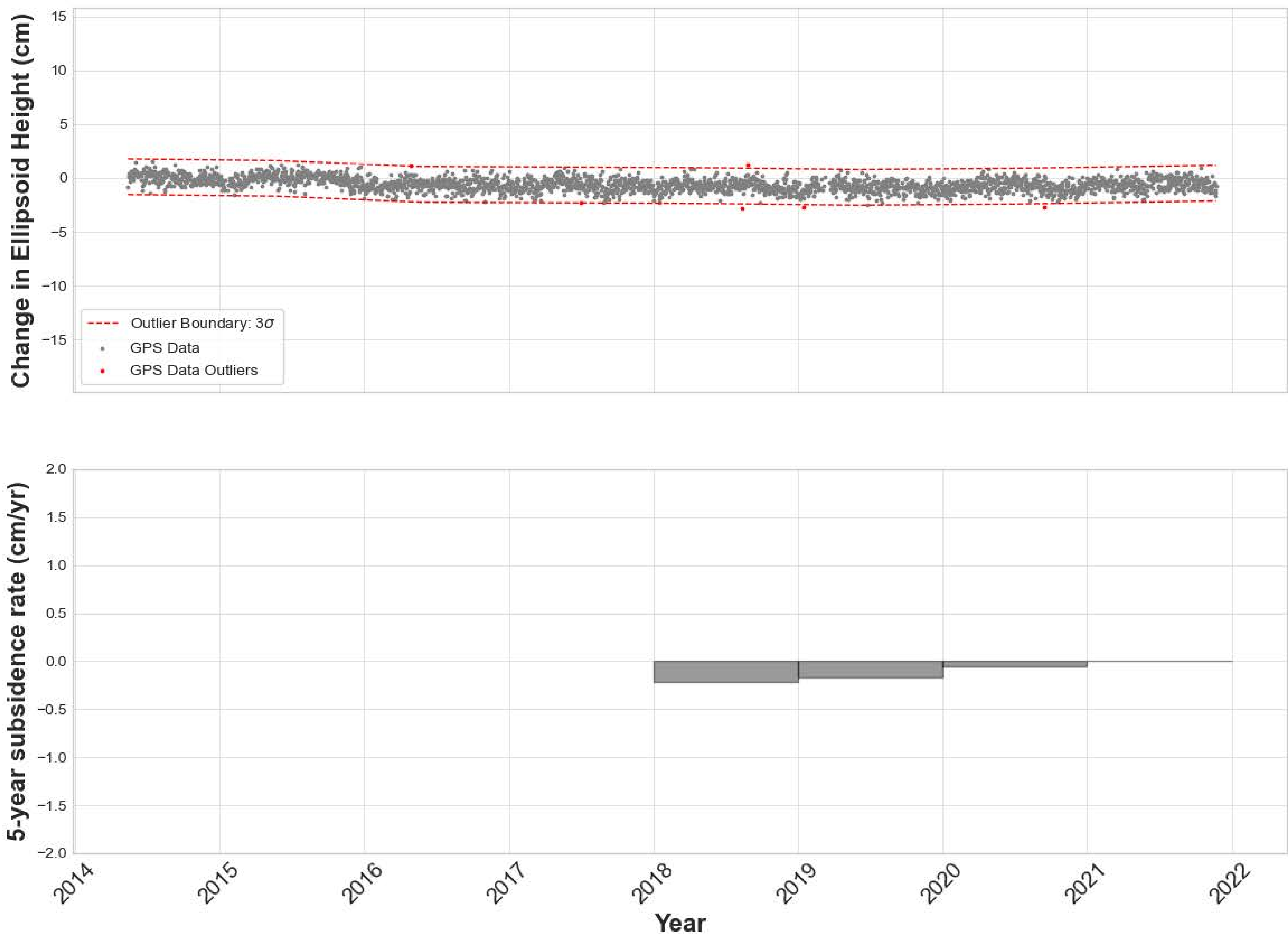
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHEB



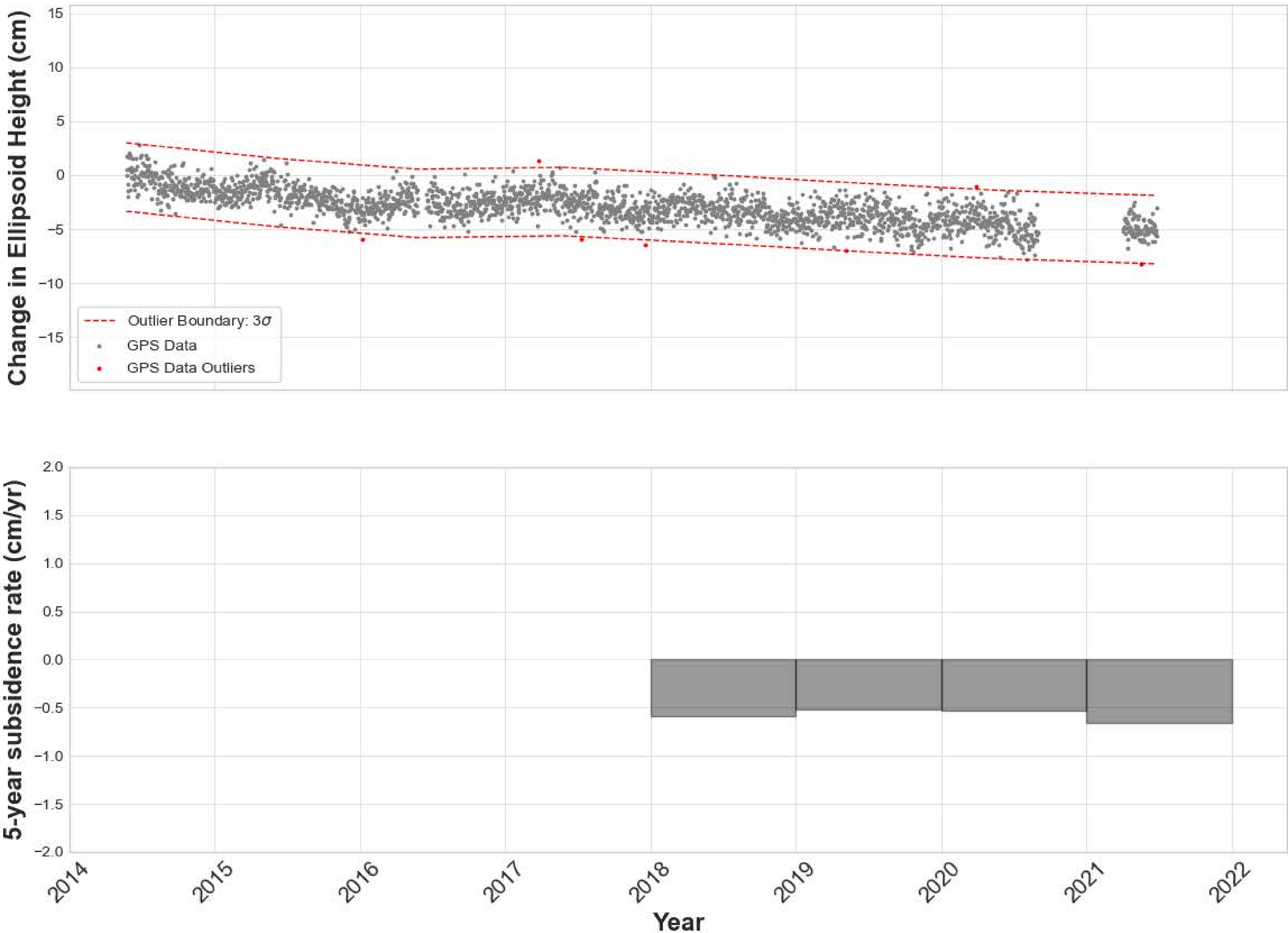
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHEP



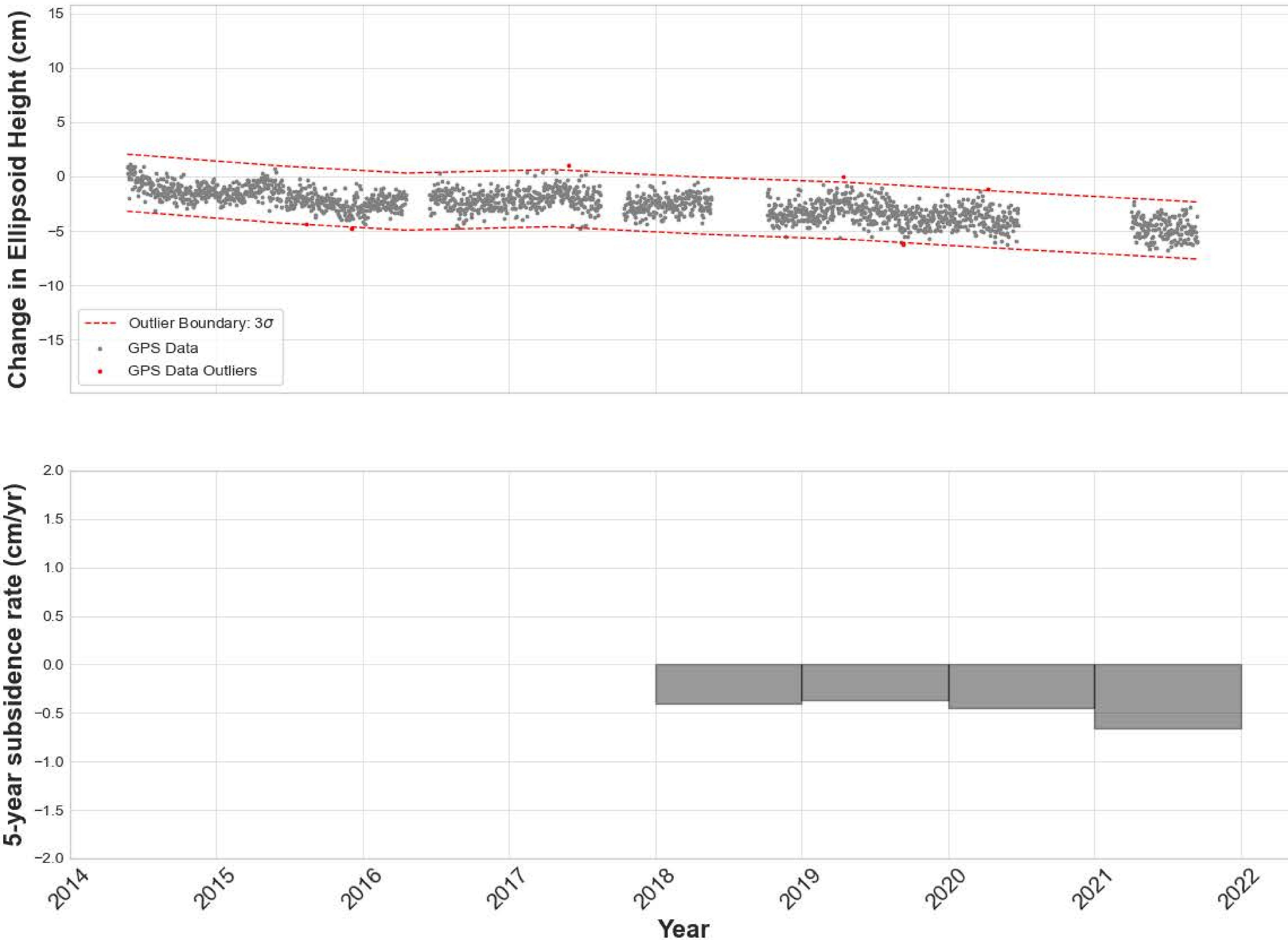
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHF1



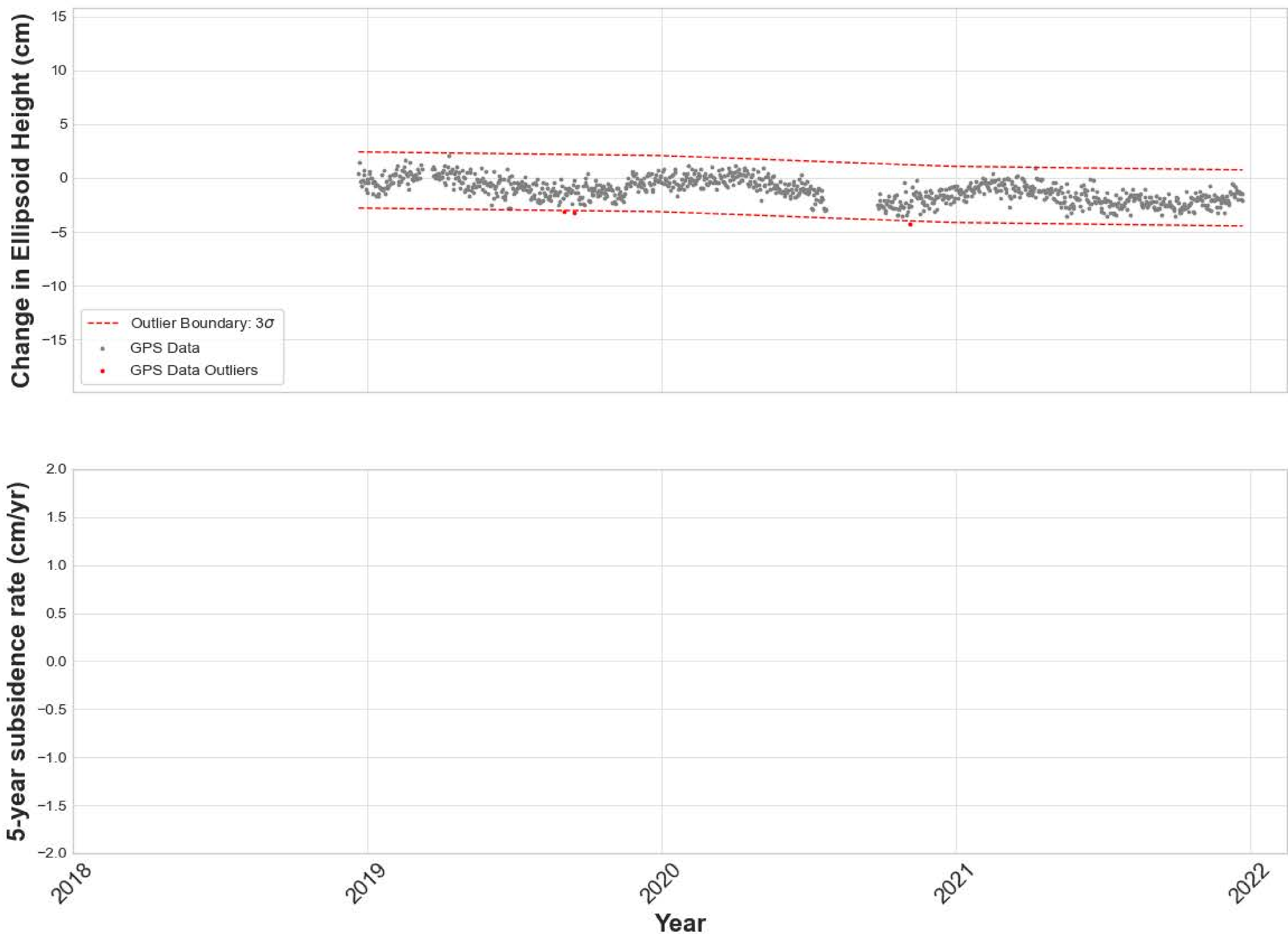
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHJF



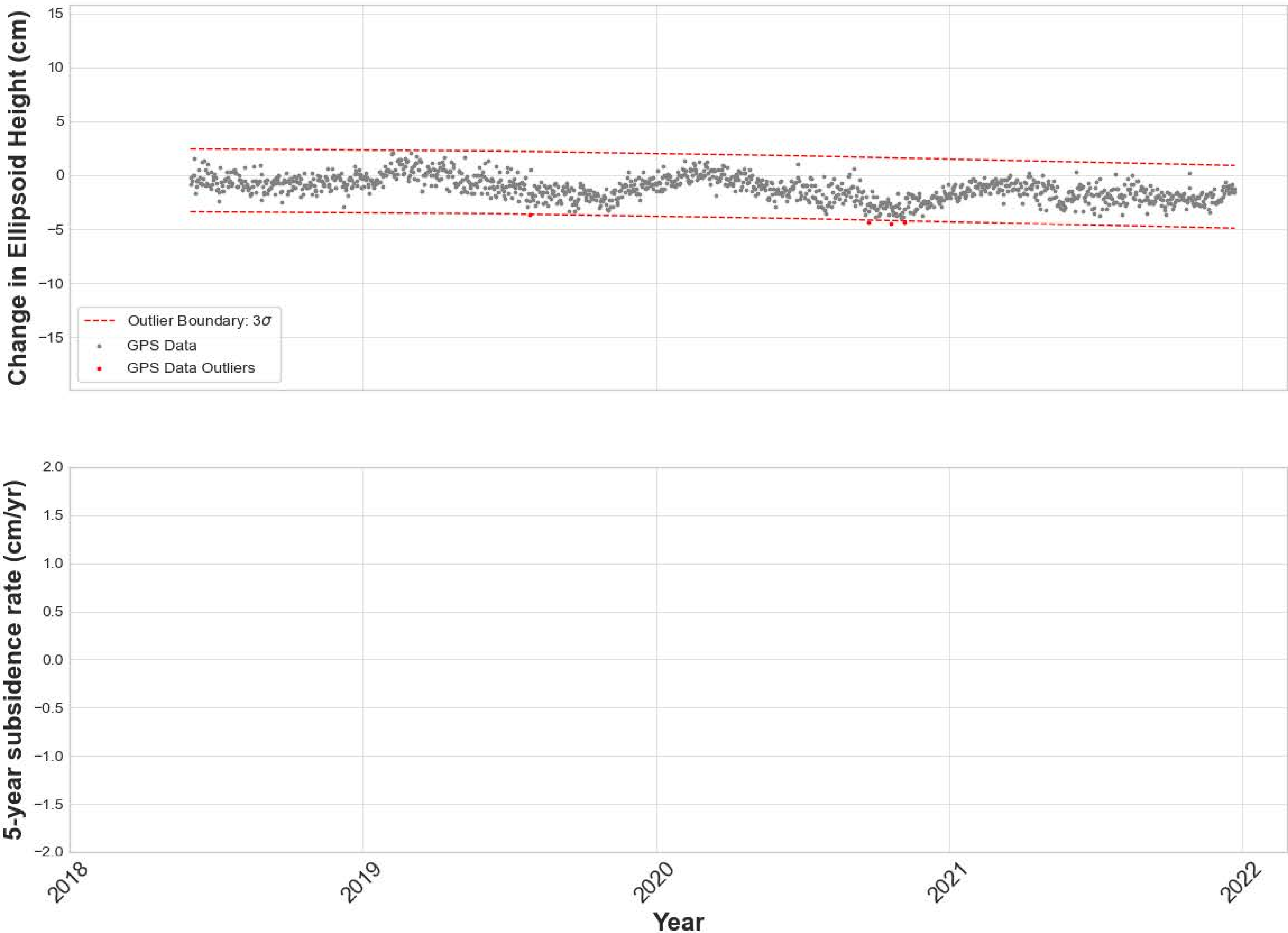
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHKD



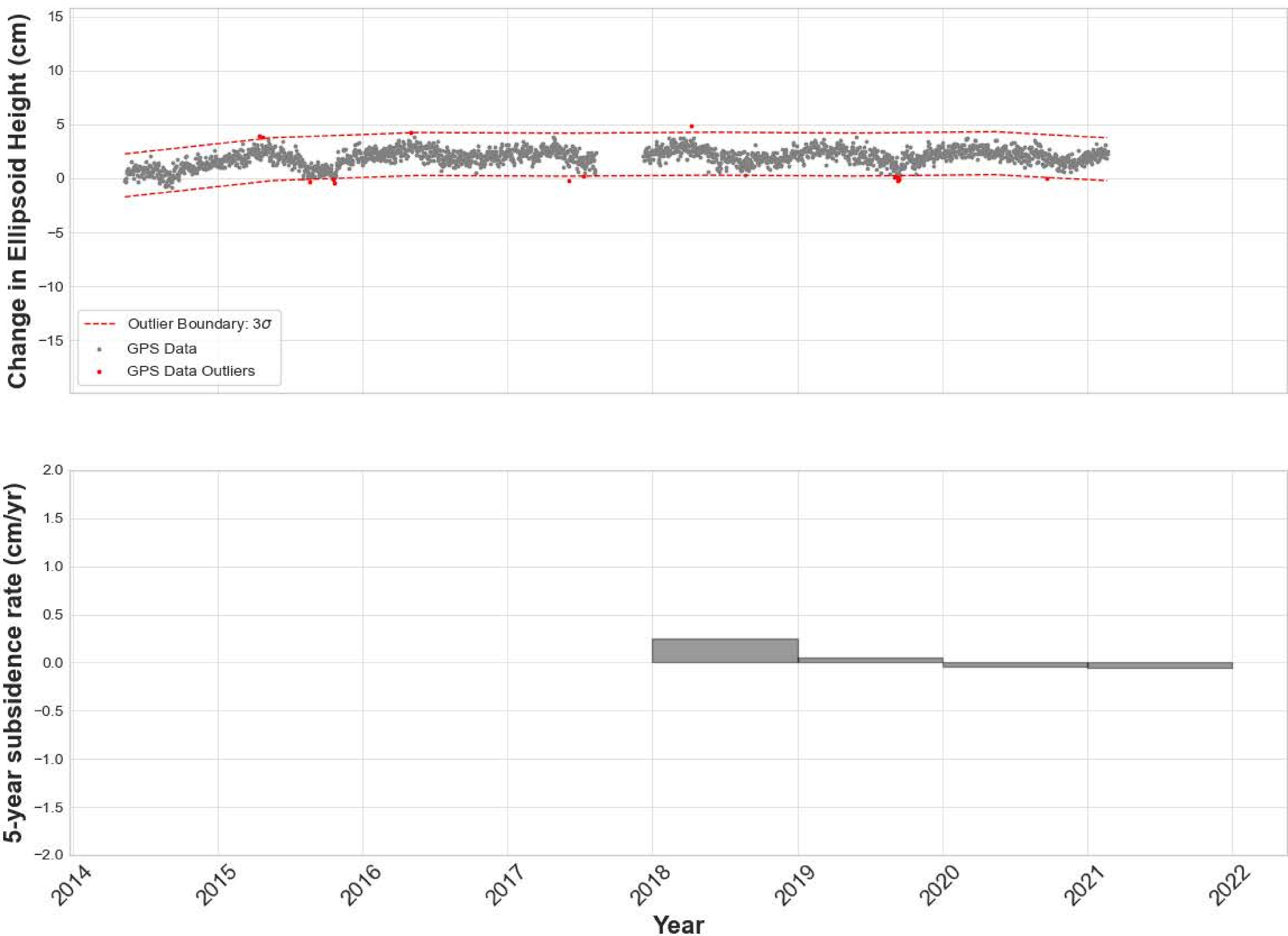
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHKS



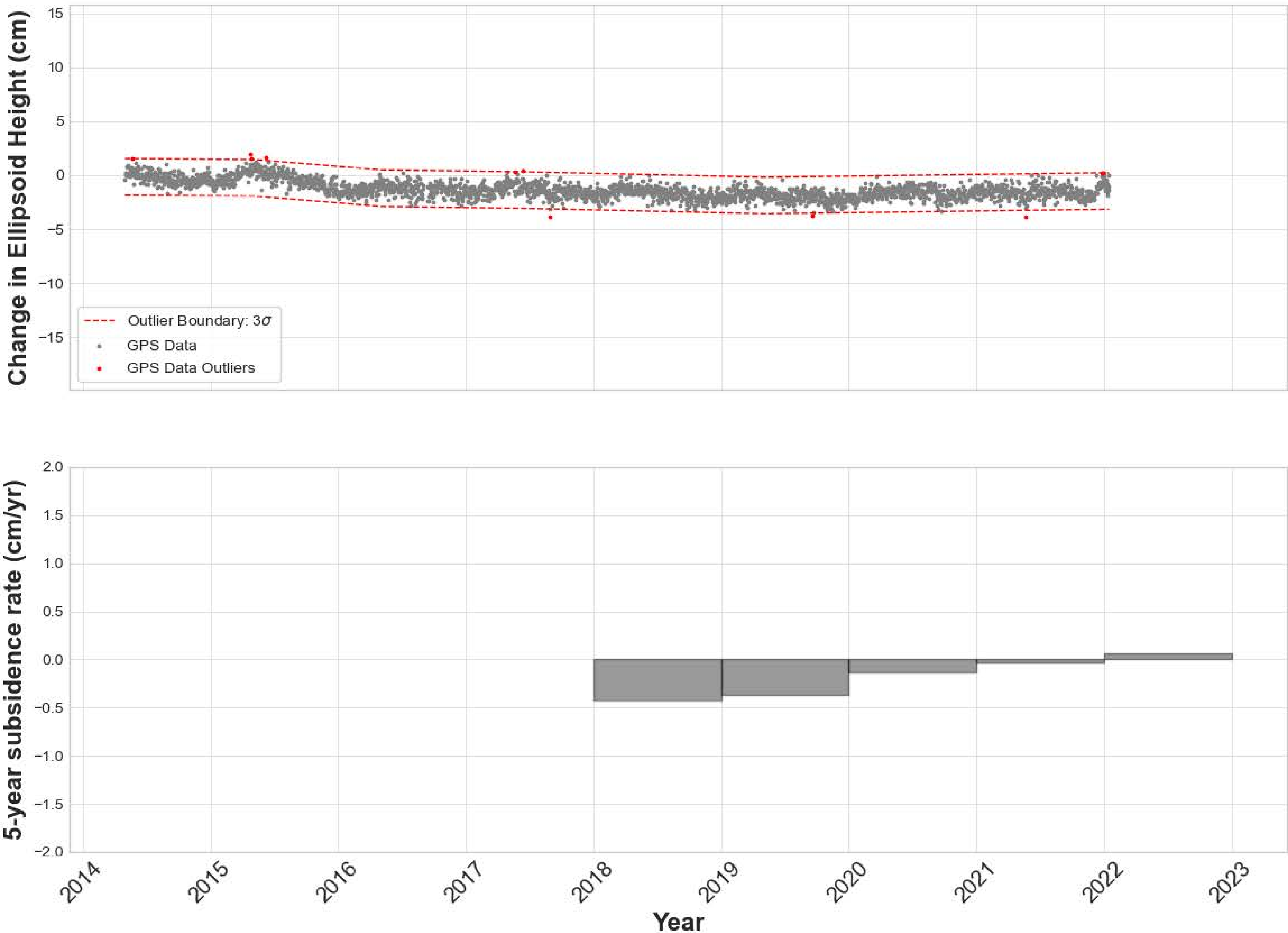
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHL1



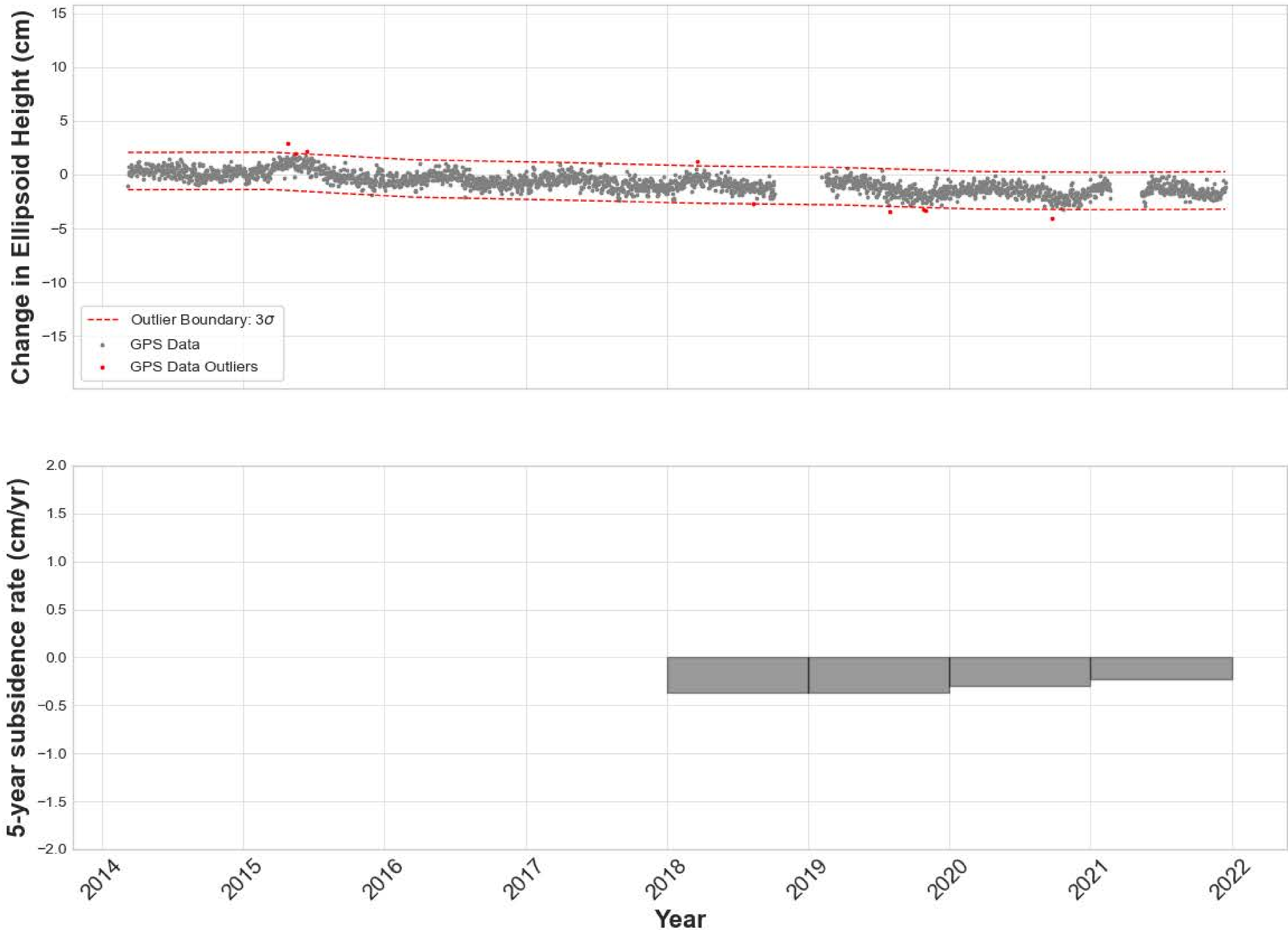
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHRI



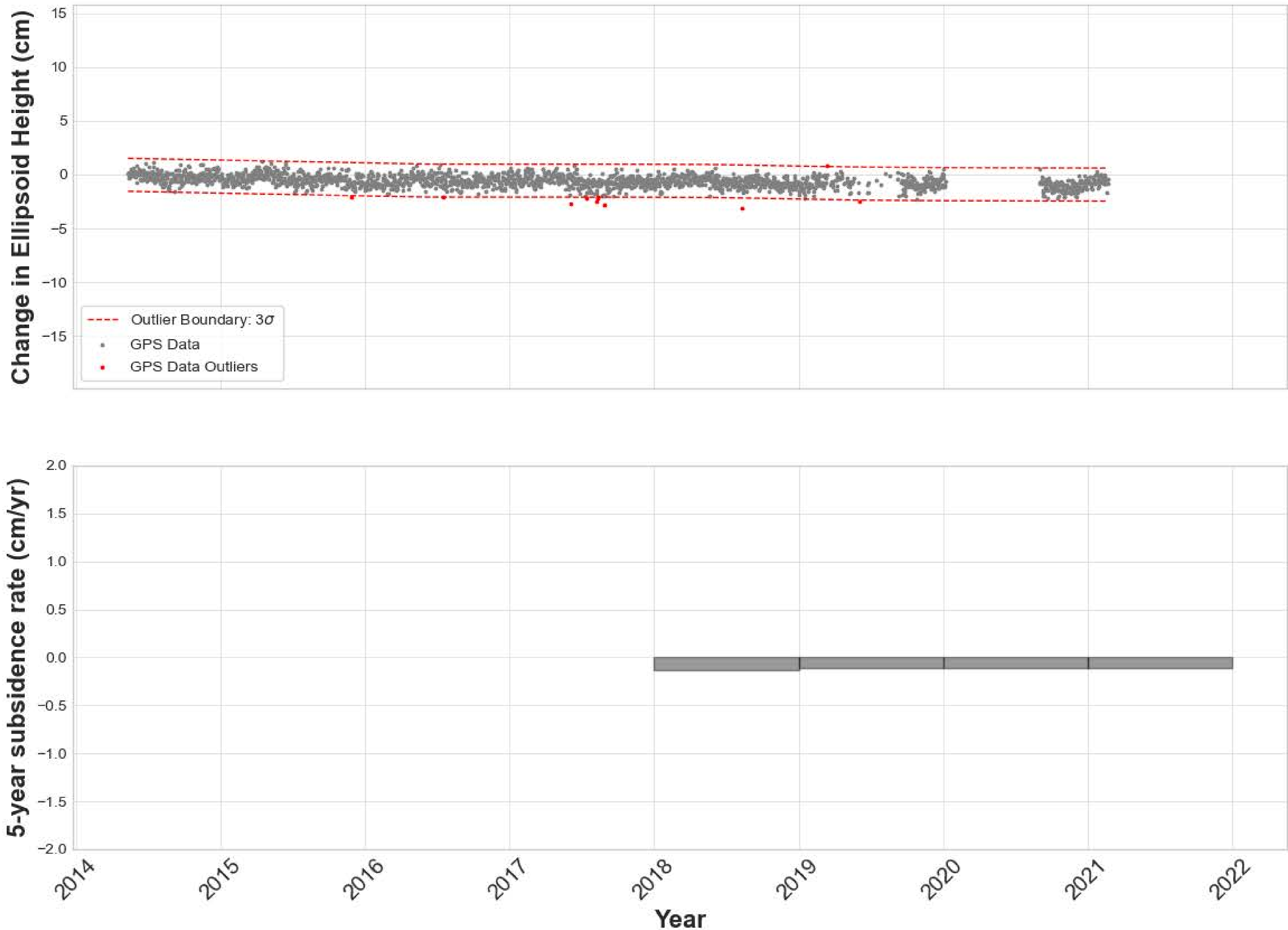
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHSL



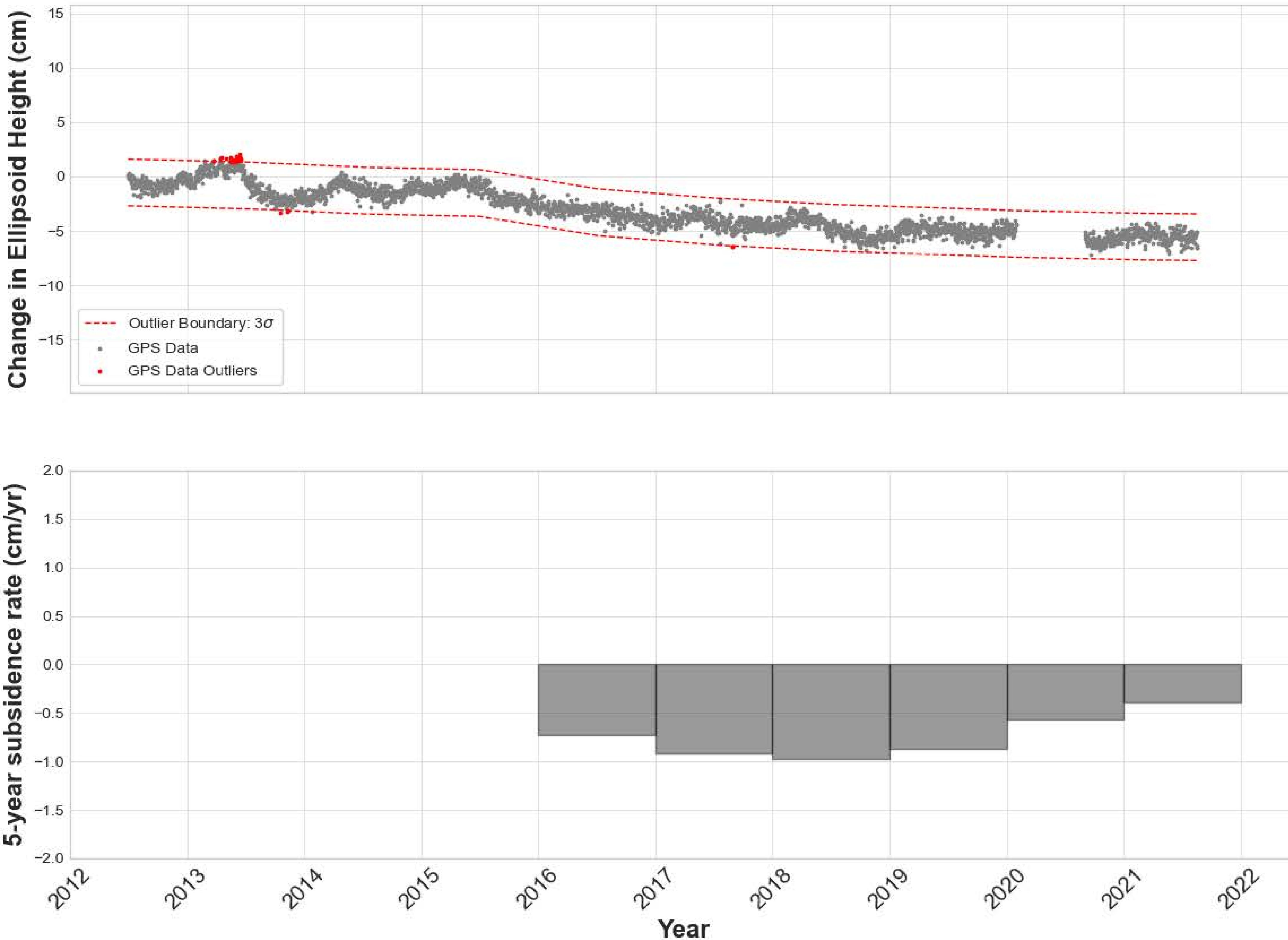
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UHWL



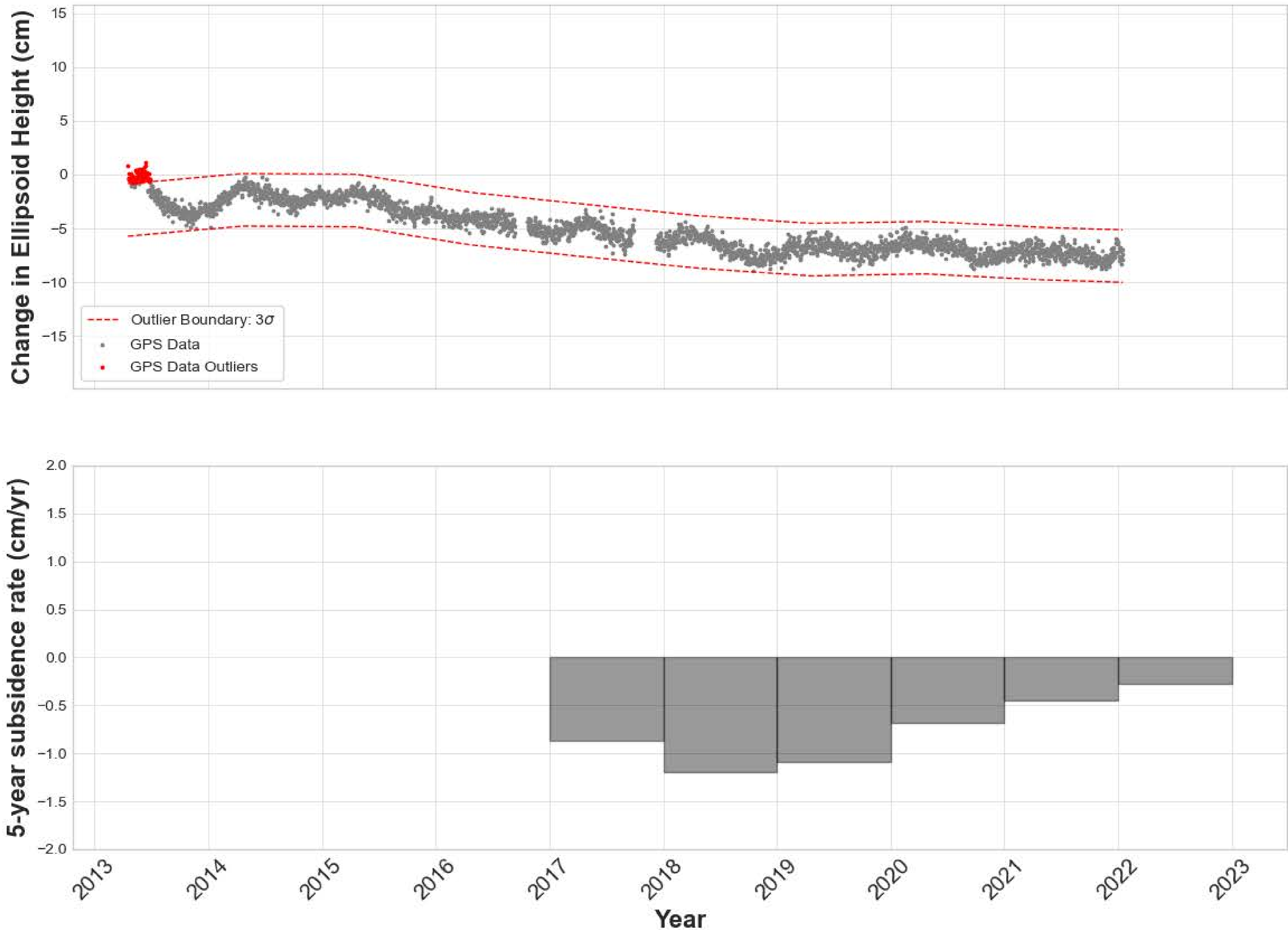
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

UTEX



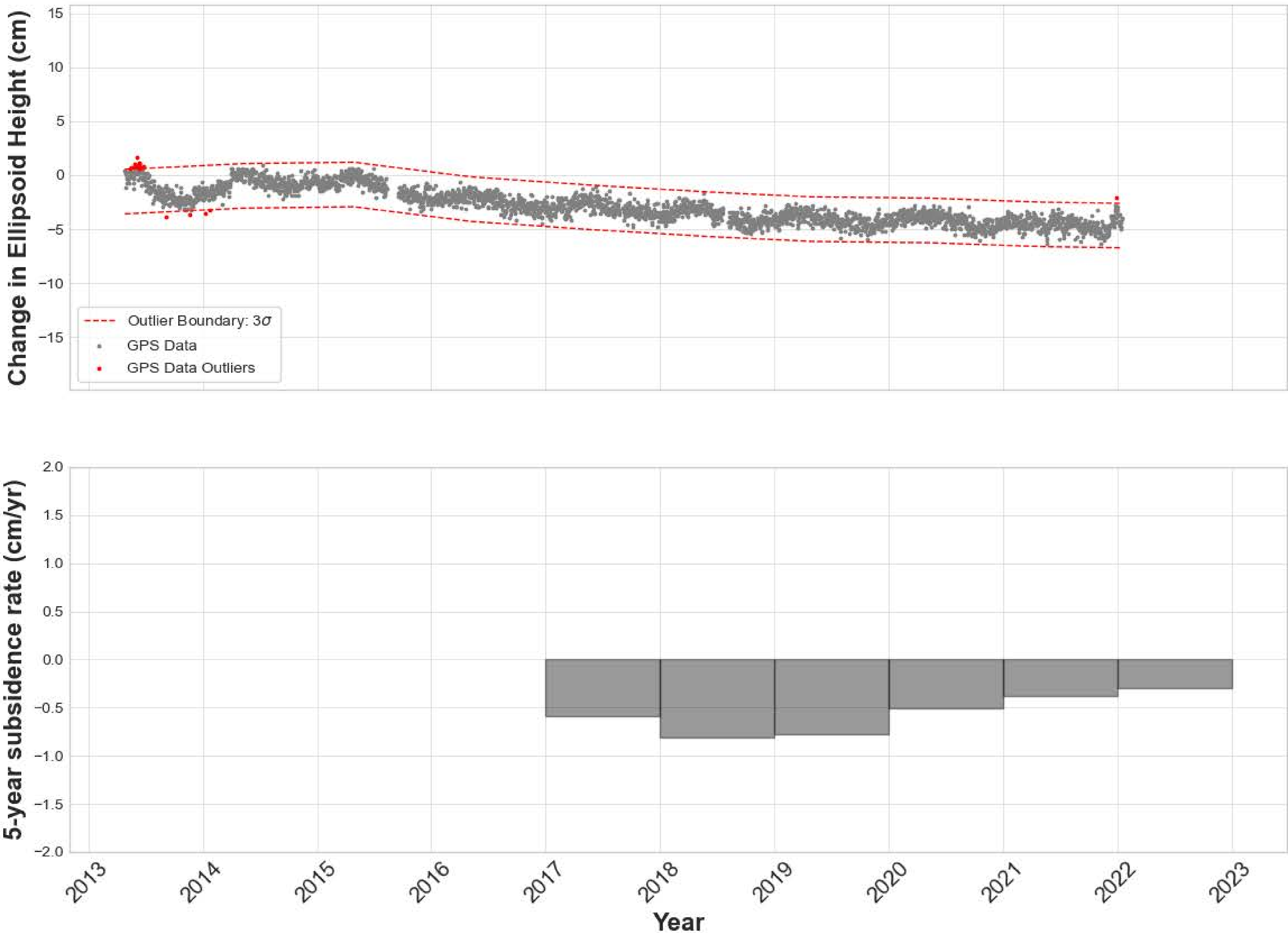
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

WCHT



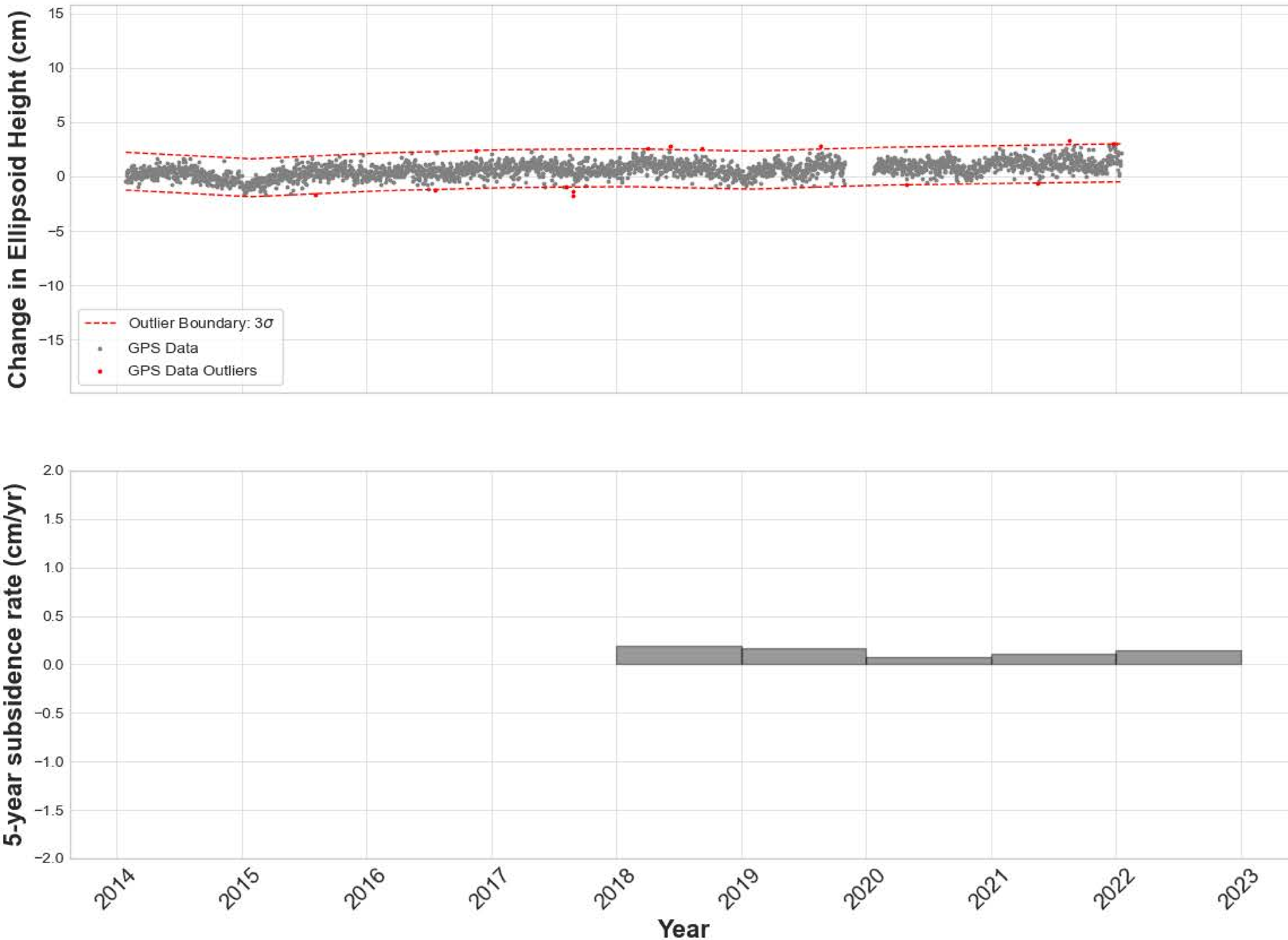
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

WDVW



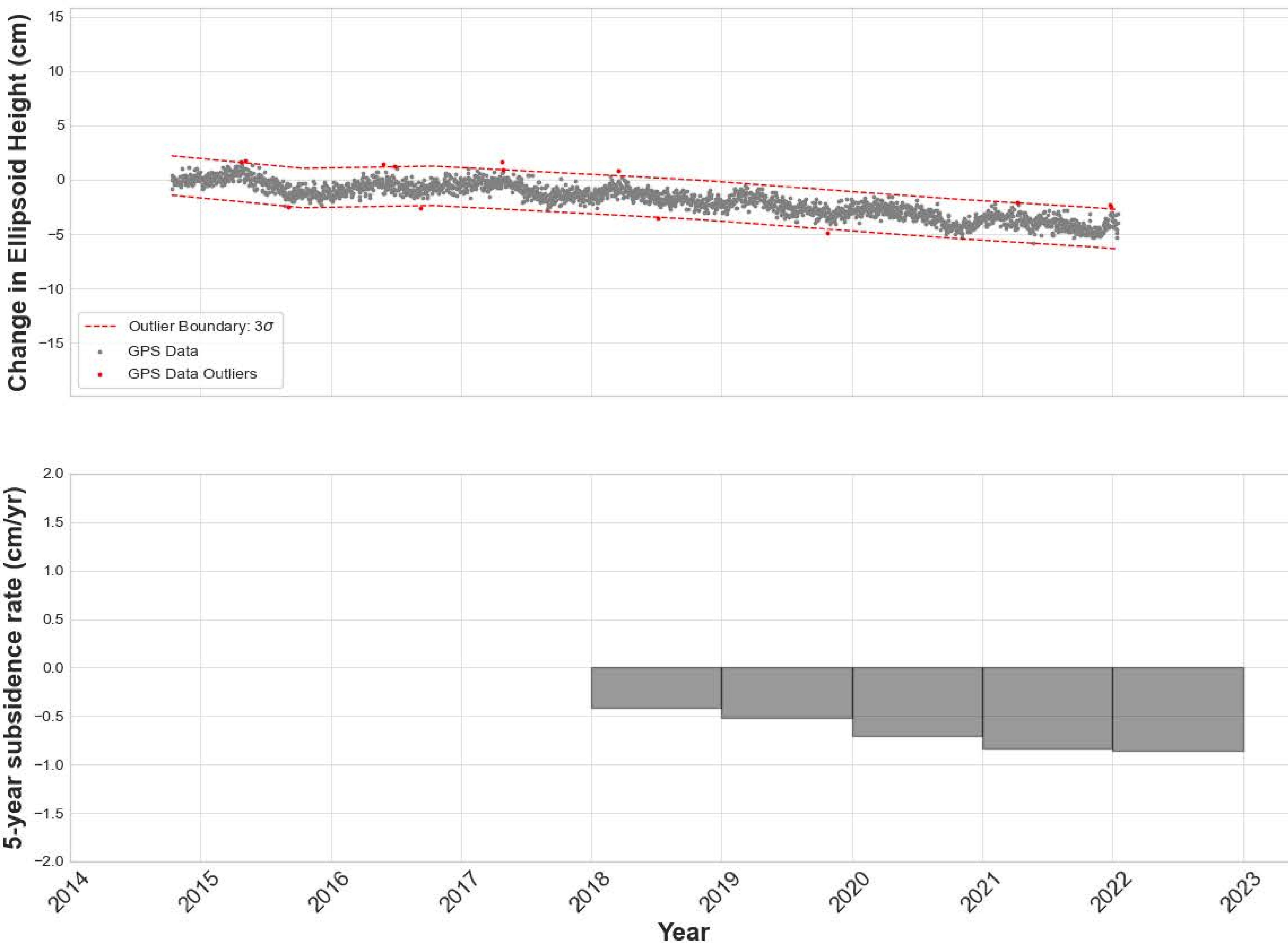
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

WEPD



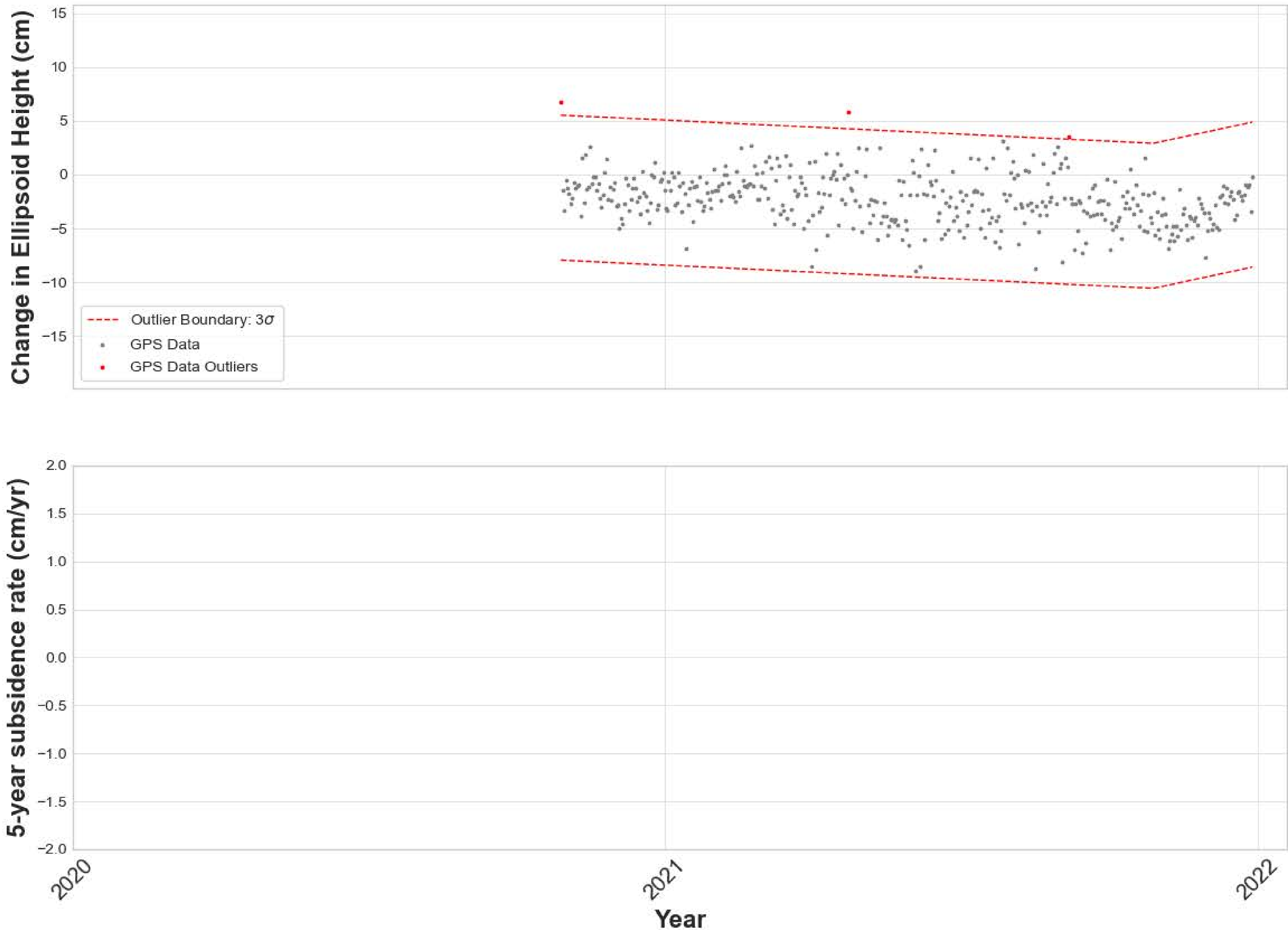
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

WHCR



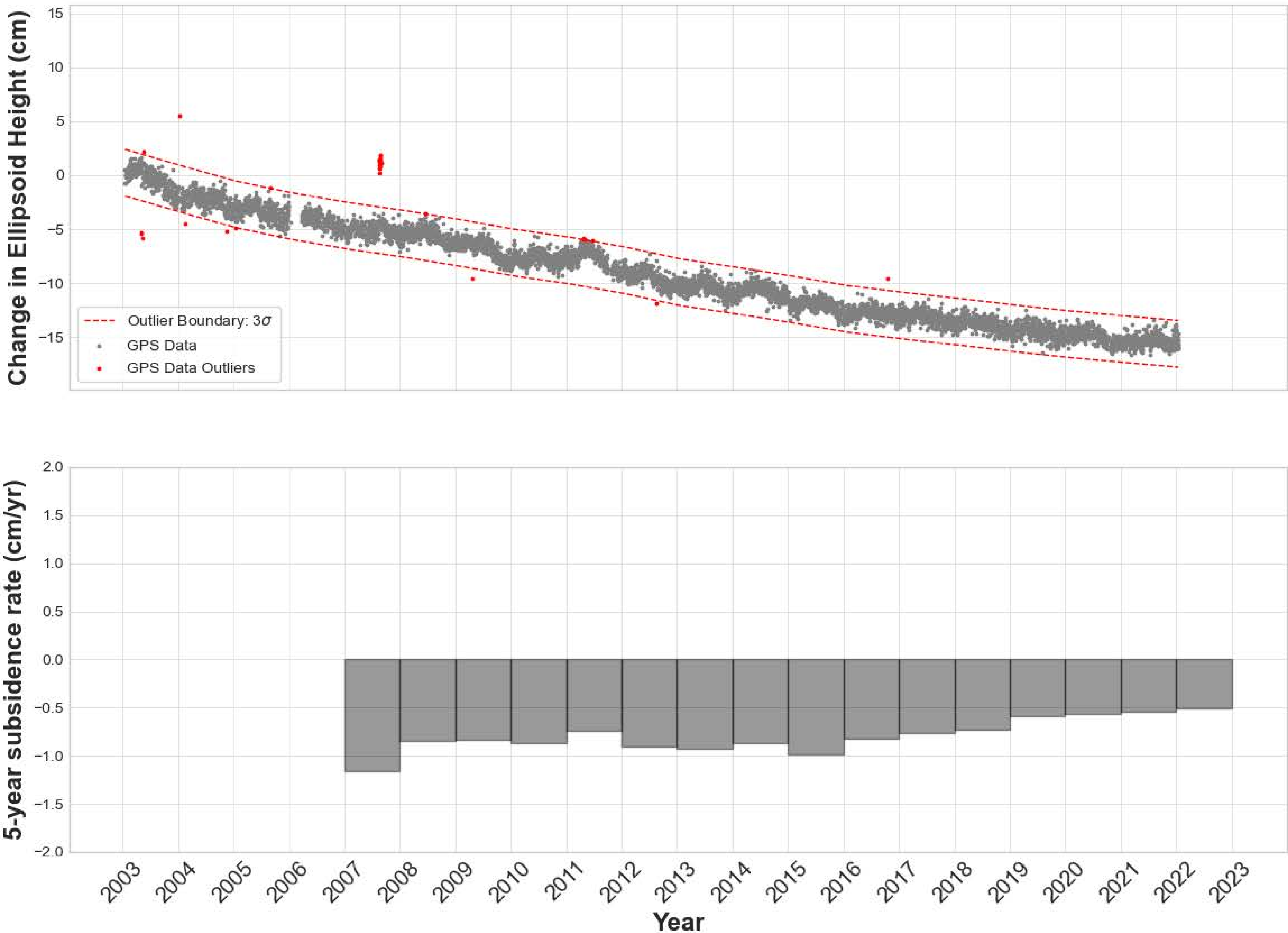
Processed GPS data (Source: University of Houston) over period of record. Processed GPS data (gray circles) located inside the outlier boundary (red dashed line) are used when calculating subsidence rates. Processed GPS data identified as outliers (red circles) are not considered by HGSD when calculating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

YORS



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

ZHU1



Processed GPS data (Source: University of Houston) over period of record. 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 HGSD when calculating subsidence rates and are shown for informational purposes only.

Appendix D – Testimony and Public Comment from the Public Hearing

The U. S. Geological Survey (USGS) has begun using a Chicot and Evangeline Aquifer "Undifferentiated" designation that combines the Chicot Aquifer and Evangeline Aquifer into one "shallow" aquifer system for the purpose of illustrating the altitudes of annual static water levels and historical changes in static water levels in water wells located in Harris County and parts of surrounding counties. USGS personnel presented information regarding the Chicot and Evangeline "Undifferentiated" aquifer system as part of the Harris-Galveston Subsidence District (HGSD) public hearing for the 2021 Annual Groundwater Report that has held on Thursday, April 28, 2022 and related information and comments follow.

Within the past fifty years or more, the differences in the aquifer pressures or heads, the static water levels in water wells and many of the hydrogeologic properties between the Chicot Aquifer and Evangeline Aquifer have been studied and documented in published and unpublished data, reports and publications prepared by the USGS and other state agencies, scientists, consultants, geologists, hydrogeologists and engineers. In addition to differences in the aquifer depths and the aquifer pressures or heads and static water levels in wells completed in the Chicot Aquifer and Evangeline Aquifer, there also can be measurable or observable differences in the geophysical log signatures, sand thickness, grain size distributions, sand to clay ratios, permeabilities, hydraulic conductivities, aquifer transmissivities and/or groundwater quality of the two aquifers.

In many areas in southeast Texas, including Harris County and surrounding counties, there is some groundwater movement between the sands and formations in the overlying Chicot Aquifer and the Evangeline Aquifer beneath it and these two aquifers have been called "leaky" aquifers, as groundwater in the aquifers is not normally under confined conditions. There are clay layers in both aquifers and the clays slow but don't prevent the movement of some groundwater between the two aquifers due to the differences in the heads or pressures in the formations. Generally, the groundwater movement or leakage is from the Chicot Aquifer, which normally has higher heads in the aquifer and shallower static water levels in water wells, into the Evangeline Aquifer, which normally has lower heads and deeper static water levels in wells versus those in the Chicot Aquifer.

The USGS verbal report and presentation on April 28, 2022 indicate that the Gulf 2023 model surfaces are comprised of updated aquifer tops and bases, which results in significant increases in the total Chicot Aquifer depths and Chicot Aquifer thickness for much of Harris County and Galveston County to the south toward the coast. In addition, many water wells that were previously designated as Evangeline Aquifer wells are now reclassified as Chicot Aquifer wells for the USGS water well and groundwater monitoring program.

Although the Chicot and Evangeline "Undifferentiated" aquifer system has now been combined into a "shallow" aquifer system, it is our understanding that water well data and properties based on the updated aquifer designations will be utilized in the corresponding individual Gulf 2023 model layers.

Based on review of the available aquifer, hydrogeologic and water well records, data and logs, a Chicot and Evangeline "Undifferentiated" aquifer designation that combines the Chicot and

Evangeline Aquifers is not a shallow aquifer system and the undifferentiated aquifer does not reflect the aquifer heads or the static water levels in wells in the vertical depth range of the combined aquifer.

The aquifer thickness of the combined Chicot and Evangeline (Undifferentiated) aquifer system can range from about 900 to 1,300 feet in northwest Harris County to more than approximately 2,600 to 2,900+ feet in southeast Harris County. These moderate to deep depths for the base of the Chicot and Evangeline "Undifferentiated" aquifer shouldn't be categorized as shallow.

Per the previous USGS designations for the Chicot Aquifer and Evangeline Aquifer wells, the historical static water level data for some wells that have been measured periodically by the USGS show modest to substantial differences in the static water levels in wells completed in the Chicot Aquifer and those completed in the Evangeline Aquifer. In addition, historical static water level data for many other water wells that are not monitored by the USGS show generally similar modest to substantial differences in the static water levels and seasonal water level changes in the Chicot Aquifer wells and Evangeline Aquifer wells. The static water level differences and seasonal water level changes in the two aquifers are driven by the differences in the depths of the well screens, the aquifer properties, the pressure heads in the aquifers and the different responses in the aquifers to short-term and long-term changes in local and regional groundwater pumping.

Depending on the well locations and depths of the well screens in Harris County and surrounding counties, the static water levels in water wells that were previously designated as completed in the Chicot Aquifer may be less than 50 feet shallower than the static water levels in some wells in the same general area with screens that were previously designated as being in the Evangeline Aquifer. However, the static water levels in some water wells completed in the Chicot Aquifer are more than 50 feet to more than 150 feet shallower than the static water levels in wells in the general vicinity with screens in the Evangeline Aquifer.

Water well and static water level data for three sets of closely spaced wells that screen sands in the Chicot Aquifer or Evangeline Aquifer and have moderate to significant differences in their static water levels follow in a table at the end of this document. The locations of these water wells are in the southwest or west parts of Harris County. In the past and currently, the USGS designation for the shallower wells listed was and remains the Chicot Aquifer and the designation for the deeper wells listed was and remains the Evangeline Aquifer. Comparison of the well and static water level data for the three sets of closely spaced wells at the end of this document shows that there are static water level differences that range from about 85 to 160 feet for these wells, which screen different depths in the Chicot Aquifer and Evangeline Aquifer as listed in the table.

In summary, the Chicot and Evangeline "Undifferentiated" aquifer designation runs contrary to the previous well-established understanding of the distinct differences between the Chicot Aquifer and Evangeline Aquifer along the upper part of the Texas Gulf Coast. The information outlined is provided due to concerns that: 1) combining the two aquifers results in a mischaracterization of the aquifers; and 2) it is possible that the static water level data or water level contouring for the undifferentiated aquifer may not accurately reflect the moderate to large differences between the Chicot Aquifer and Evangeline Aquifer in parts of Harris County and surrounding counties.

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5/06/2022; Sent via e-mail to: info@subsidence.org

Examples of Closely Spaced Water Wells Completed in the Chicot Aquifer or Evangeline Aquifer

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LJ-65-11-809
City of Houston Park Ten Well 5
Screen Interval: 300 to 533 feet
Aquifer: Chicot Aquifer
Date & Depth to Water:

12/16/2020	166 feet
1/18/2022	162.97 feet

LJ-65-11-803
City of Houston Park Ten Well 1
Screen Interval: 616 to 1,384 feet
Aquifer: Evangeline Aquifer
Date & Depth to Water:

12/16/2020	338.88 feet
1/18/2022	314.69 feet

LJ-65-12-801
Lakeside Country Club
Screen Interval: 280 to 467 feet
Aquifer: Chicot Aquifer
Date & Depth to Water:

12/16/2020	165.02 feet
1/5/2022	162.8 feet

LJ-65-20-104
City of Houston District 71
Screen Interval: 1,045 to 1,435 feet
Aquifer: Evangeline Aquifer
Date & Depth to Water:

12/1/2020	327.89 feet
1/20/2022	292.69 feet

LJ-65-20-814
City of Houston Park Glen Well 3
Screen Interval: 550 to 697 feet
Aquifer: Chicot Aquifer
Date & Depth to Water:

12/7/2020	202.18 feet
1/25/2022	196.26 feet

LJ-65-20-813
City of Houston Park Glen Well 2
Screen Interval: 1,039 to 1,733 feet
Aquifer: Evangeline Aquifer
Date & Depth to Water:

12/7/2020	305.74 feet
1/25/2022	282.92 feet