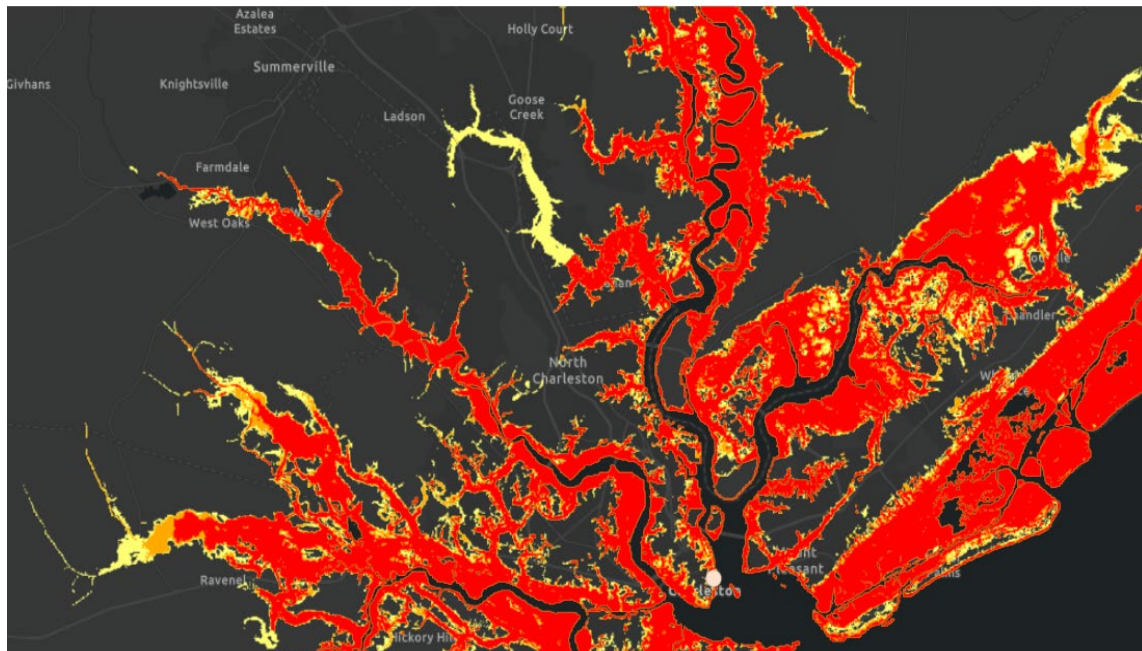


NOTICE OF SERVICES UPDATE: ANNUAL HIGH TIDE FLOODING OUTLOOK



Silver Spring, Maryland
April 2026



**Center for Operational Oceanographic Products and Services
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce**

The National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS) provides the National infrastructure, science, and technical expertise to collect and distribute observations and predictions of water levels and currents to ensure safe, efficient and environmentally sound maritime commerce. The Center provides the set of water level and tidal current products required to support NOS' Strategic Plan mission requirements, and to assist in providing operational oceanographic data/products required by NOAA's other Strategic Plan themes. For example, CO-OPS provides data and products required by the National Weather Service to meet its flood and tsunami warning responsibilities. The Center manages the National Water Level Observation Network (NWLON), a national network of Physical Oceanographic Real-Time Systems (PORTS®) in major U.S. harbors, and the National Current Observation Program consisting of current surveys in near shore and coastal areas utilizing bottom mounted platforms, subsurface buoys, horizontal sensors and quick response real time buoys. The Center: establishes standards for the collection and processing of water level and current data; collects and documents user requirements, which serve as the foundation for all resulting program activities; designs new and/or improved oceanographic observing systems; designs software to improve CO-OPS' data processing capabilities; maintains and operates oceanographic observing systems; performs operational data analysis/quality control; and produces/disseminates oceanographic products.

Notice of Services Update: NOAA's Annual High Tide Flooding Outlook

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1. OVERVIEW

High tide flooding (HTF) is the overflow or excess accumulation of ocean water on low lying land at high tide. Above-average tides can trigger high tide flooding and disrupt coastal communities. This type of flooding, which can occur on sunny days and in the absence of storms, creates public safety risks and lasting impacts. In the short-term, HTF can block roads, overflow storm drains, or cause temporary business closures. Long-term impacts are possible; frequent flooding over time can damage below-ground infrastructure and degrade wetlands, compounding future risk. Routine tidal flooding can be further exacerbated by weather events like heavy rains, strong winds, or large waves that add to coastal water levels. The National Ocean Service (NOS) has three established thresholds (Sweet et al. 2018) to record the severity of flood levels.

- **NOS Minor Threshold:** When water levels reach approximately 0.55 meters (1.8 feet) above average high tide¹. This minor flooding is mostly disruptive, causing stormwater backups, road closures and emergency services delays. NOS Minor flood thresholds were revised in 2023 to be more representative of flooding in the Pacific Islands region (Kavanaugh, et al., 2023).
- **NOS Moderate Threshold:** When water levels reach approximately 0.85 meters (2.8 feet) above average high tide. This can cause more disruption and can damage homes and businesses.
- **NOS Major Threshold:** When water levels reach more than an average of 1.20 meters (3.9 feet) above average high tide. Floods of this severity are quite destructive, may lead to evacuations, and often require repairs to infrastructure and property.

As global mean sea levels rise, many coastal communities will experience more frequent high tide flooding, with a projected national average of 55-85 days per year by 2050². Since 2014, NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) has produced annual high tide flooding assessments (hereafter, HTF Outlooks)³ using methods outlined in Sweet et al. (2018). These projections help coastal communities understand and plan for changes in flood frequency. In 2025, CO-OPS implemented the following updates to the HFT Outlook.

- Applying daily and annual flood count completeness criteria
- Adding 'Moderate' and 'Major' decadal HTF projections
- Expanding annual HTF predictions to other stations

¹ What is High Tide Flooding? <https://oceanservice.noaa.gov/facts/high-tide-flooding.html>

² Annual HTF Outlook National Summary: <https://tidesandcurrents.noaa.gov/high-tide-flooding/annual-outlook.html>

³ Archive of annual High Tide Flooding reports: <https://tidesandcurrents.noaa.gov/pub.html#popular>

2. METHODOLOGY UPDATES

Annual HTF Outlooks predict the range of high-tide flooding days a station might experience during the upcoming meteorological year (May to April). Annual HTF predictions account for cyclical and interannual variation by assessing daily and annual historical flood counts, and by collating the impacts of El Niño Southern Oscillation (ENSO) and seasonal increases in flooding during winter months (Sweet et al., 2014). Annual HTF Outlook models run in June of each year, coinciding with the release of mid-year El Niño Southern Oscillation (ENSO) forecasts from NOAA's Climate Prediction Center (CPC)/International Research Institute (IRI) for Climate and Society at the Columbia Climate School (Kavanaugh et al., 2023). Total daily flood counts for the year are compared to previous flood counts to establish overall trends and ENSO sensitivity to provide a range of expected flood days (Sweet, et al, 2018). Decadal projections for a suite of sea level rise scenarios through 2050 (Sweet et al. 2022) are produced to supplement station-specific and regional flood predictions for the upcoming year. The following documentation details 2026 methodology updates and the impact of their implementation.

NEW DAILY MAXIMUM WATER LEVEL PRODUCT

DAILY MAXIMUM REQUIREMENTS FOR ANNUAL HISTORICAL FLOOD COUNTS

Annual HTF Outlooks use historical flood counts to create data-driven statistical predictions. Daily water level maximums, "Daily Max," are one of the historical products used to calculate Annual HTF Outlooks. Methods and completeness criteria for both 6-minute and hourly-based daily max data were recently established (Jima, et al, 2025). The hourly-based daily max product was integrated into the historical High Tide Flooding statistics used to compute the 2025-26 Annual HTF Outlook. Previously, if a station experienced an outage, the highest recorded water level would be considered the daily maximum, despite significant gaps during the day. This method did not account for the possibility that peak water levels could be much greater than the recorded observation. The Daily Max product includes an additional quality control parameter, percent completeness, meaning a daily maximum is recorded and used for calculating historical high tide flood statistics only if at least 50% of hourly values in a 24-hour period are captured. Percent completeness is computed by comparing the number of available observations to the number of complete sets expected on a given day. For example, if 20 of 24 hourly observations are recorded, the day would result in 83% completeness. The Daily Max for that day can then be used for annual flood count calculation. If a water level exceeds the minor flood threshold at any point, the day is included in the computation, regardless of whether it meets the 50% completeness requirement. Days that meet neither the minor flood threshold nor the completeness threshold are excluded from historical high-tide flooding statistics.

PERCENT COMPLETE REQUIREMENTS FOR MET-YEAR FLOOD COUNTS

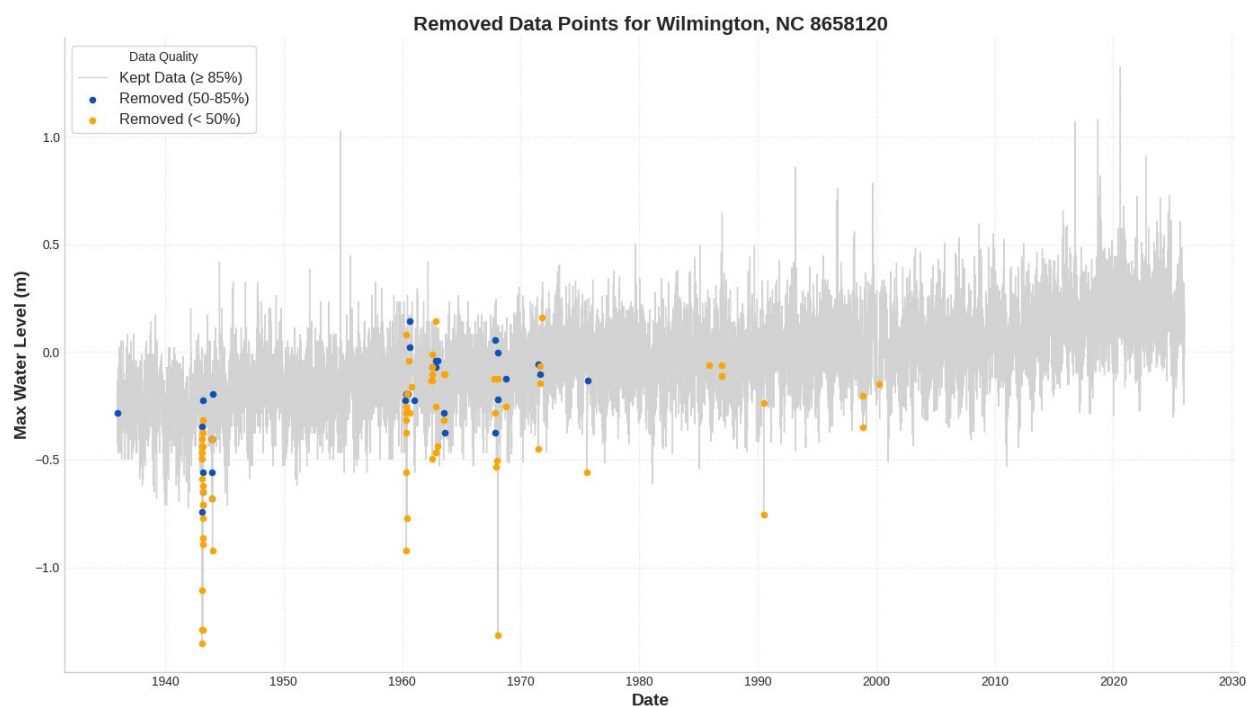
Daily HTF (DHTF) counts for historical HTF products have at least 50% of hourly values recorded, as explained above. An additional quality control measure of 85% completeness is applied to annual historical HTF counts for met-year predictions. This means that each year must have at least 310 days of observation to be included in the calculation of met-year HTF predictions. Establishing and integrating

completeness criteria improves the integrity of observational data used for calculating DHTF and annual met year flood counts.

DAILY MAXIMUM REQUIREMENTS FOR THE DECADAL PROJECTIONS

Decadal HTF projections predict average annual flood frequencies during a given ten-year period (Sweet et al., 2022). Future projections are calculated from annual flood counts averaged to create decadal estimates based on exceedance probabilities (Sweet, et al. 2022). Annual HFT Outlooks⁴ include station-based visualizations of the estimated decadal range through the year 2050. HTF projections rely on decades of past water level observations, which are used to apply empirical probability distributions to estimate the number of high tide flood days for future years and decades (Sweet and Park, 2014; Sweet et al. 2018; 2022; Kavanaugh et al. 2023). Decadal projections are now computed with 85% completeness criteria, meaning any year used for computing decadal projections must have daily maximums for 85% of the year.

Figures 1a and 1b show the impact of applying completeness criteria to the daily max data. The 50% completeness criteria eliminates several incomplete days, many of which had recorded values that weren't representative of true daily maximum water levels. Applying the additional 85% completeness criteria improves the historical data used to compute HTF decadal projections by ensuring the time series more accurately represents observed maximum water levels.



⁴ Annual High Tide Flooding Outlook on Tides & Currents: <https://tidesandcurrents.noaa.gov/high-tide-flooding/annual-outlook.html>

Figure 1a: A plot of the water level time series for Wilmington, NC, shows data points removed from the application of completeness criteria. Dates by decade are plotted on the X-axis and maximum water levels are plotted on the Y-axis in meters. Orange dots represent data points removed due to being less than 50% complete. Blue dots represent data removed for being less than 85% complete. A light gray line represents water levels in meters from 1908 to 2025. The plot shows that minimal data is removed in comparison to the total timeseries. Most removed data points coincide with short data outages.

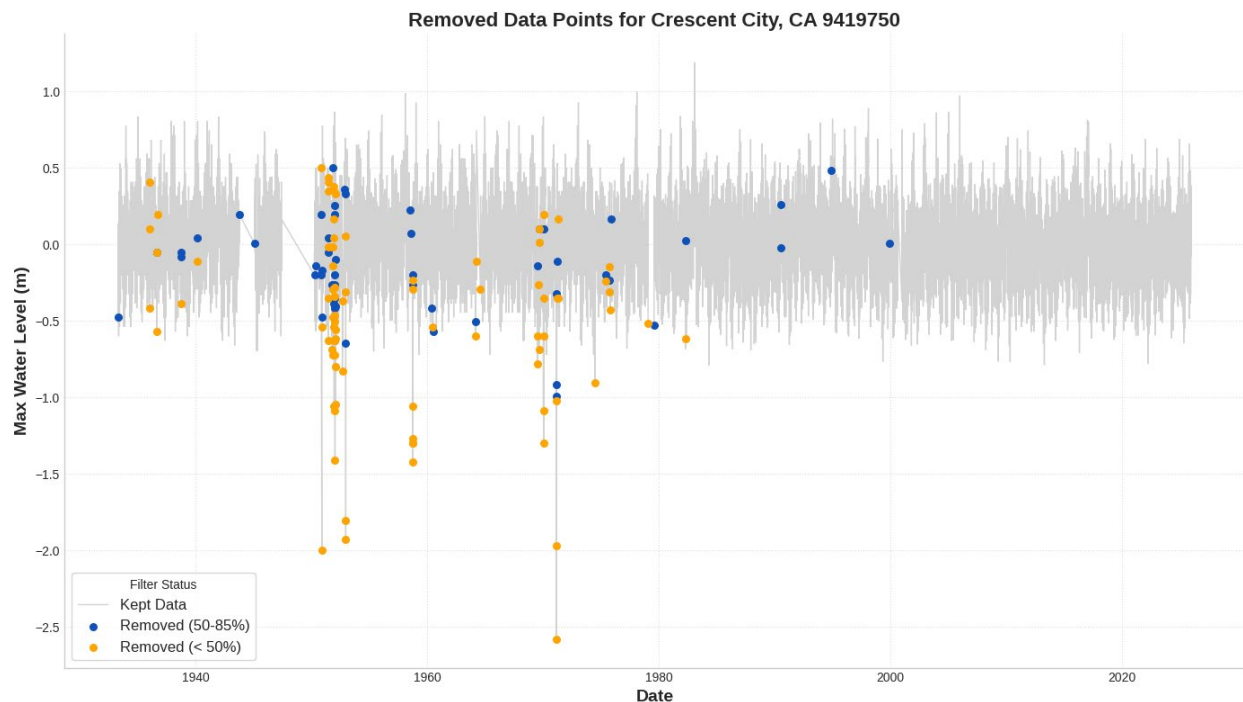


Figure 1b: A plot of the water level time series for Crescent City, CA, shows data points removed from the application of completeness criteria. Dates by decade are plotted on the X-axis and maximum water levels are plotted on the Y-axis in meters. Orange dots represent data points removed due to being less than 50% complete. Blue dots represent data removed for being less than 85% complete. A light gray line represents water levels in meters from 1933 to 2025. The plot shows that minimal data is removed in comparison to the total timeseries. Most removed data points coincide with short data outages. Despite the large gap in Crescent City's water level record, data after 1950 are complete enough to produce annual HTF predictions.

DECADAL PROJECTIONS FOR NOS MODERATE AND MAJOR FLOOD THRESHOLDS

Previously, decadal projections were only available relative to the NOS Minor flood threshold. Most established water level stations also have NOS Moderate and NOS Major flood thresholds (Sweet et al. 2018, 2022). This notice marks the application of the same methods for creating decadal projections at the NOS Minor threshold to NOS Moderate and NOS Major flood thresholds. This expands the suite of decadal HTF products that help community planners and decision makers better understand the potential

for changes in future flood frequencies in their regions. Data are available for application through the CO-OPS Derived Product API⁵.

Table 1 highlights six example stations from across the country, with varying sea level rise (SLR) scenarios (Sweet et al., 2022) to demonstrate the new projection information. Sweet et al. determined the likely decadal range by plotting decadal projections through 2100 and calculating the median between two bounding scenarios (2022). Values for NOS Minor thresholds are highlighted in red. Though this level of flooding happens at a lower threshold, it happens the most frequently and is the most impactful over time. NOS Moderate flood counts are highlighted in orange, and NOS Major flood counts are highlighted in yellow. The key message is that flood frequencies decrease as flood thresholds increase; however, lower flood counts are based on significantly higher thresholds, showing the potential for more impactful flooding within twenty years.

Station & Region	Likely SLR Scenario	NOS Minor Threshold in 2050 (Ft. above MHHW)	Flood Count (Days)	NOS Moderate Threshold (Ft. above MHHW)	Flood Count (Days)	NOS Major Threshold (Ft. above MHHW)	Flood Count (Days)
Fall River, MA, Northeast	Low	1.83	50	2.77	3	4.03	0
Sewells Point, VA, Mid-Atlantic	Intermediate	1.75	85	2.71	10	3.95	1
Virginia Key, FL, Southeast	Intermediate	1.69	35	2.66	1	3.89	0
Port Isobel, TX, Western Gulf	Intermediate High	2.06	85	2.67	3	3.89	0
San Diego, CA, Southwest Pacific	Intermediate Low	1.86	25	7.79	0	4.06	0
Toke Point, WA Pacific Northwest	Intermediate Low	2.00 ft	20	2.90	5	4.20	0

Table 1. A representation of changes in the number of projected flood days by decade based on NOS Flood Thresholds. Each station represents a different region and illustrates the way rates of flooding range by both region and threshold. It's important to note that projections shown here represent the lower bound of likely ranges (Sweet et al., 2022). A full range of decadal flood counts is available in CO-OPS Derived Products API. Column color corresponds with flood extent layers in Annual HTF Outlook product map: red for minor, orange for moderate, and yellow for major.

⁵ CO-OPS Derived Product API - High Tide Flooding - Decadal Projections:
<https://api.tidesandcurrents.noaa.gov/dpapi/prod/#htf>

NEW STATIONS

The 2025 Annual HTF Outlook marks the first expansion of the station list since the methodologies were published in 2018 (Sweet et al, 2018). To be included, stations must meet a minimum of 20 years of verified hourly water level observations, established NOS flood thresholds, and a predictable tidal range, typically within approximately 1-4 m (Sweet et al., 2018). These parameters intentionally exclude stations with extremely small or large tidal ranges, such as Berwick, LA, (mean tidal range: 0.13 m⁶) or Eastport, ME, (mean tidal range: 5.59 m.⁷ Extreme ranges, either small or large, limit the ability to make meaningful predictions and are not included.

Table 2 lists newly added Annual HTF Outlook stations, their date of establishment, NOS Minor Threshold, and data source and scenario for SLR projections. Annual HTF Outlooks include station-specific decadal projections for sea level rise (SLR) scenarios to aid long-term planning and preparation (Sweet et al., 2022). Most new stations have SLR scenarios from the nearest 1-degree grid point (Sweet et al., 2022). In prior Annual HTF Outlooks all decadal projections have been relative to the NOS Minor threshold.

⁶Station homepage for Eastport, Maine: <https://tidesandcurrents.noaa.gov/stationhome.html?id=8410140>

⁷ Station home page for Berwick, Louisiana: <https://tidesandcurrents.noaa.gov/stationhome.html?id=8764044>

Station ID	Station Name	Date of Establishment	NOS Minor Threshold (Ft. above MHHW)	SLR Scenario (Source)	SLR Scenario (Chosen Trend)
		Annual Predictions		Decadal Projections	
8447386	Fall River, MA	1999	1.83	Grid	Low
8465705	New Haven, CT	1999	1.91	Grid	Low
8551762	Delaware City, DE	2001	1.88	Grid	Low
8570283	Ocean City Inlet, MD	1997	1.73	Grid	Low
8573927	Chesapeake City, MD	1972	1.77	Grid	Low
8637689	Yorktown, USCG, Training Center, VA	2004	1.74	Grid	Low
8639348	Money Point, VA	1997	1.77	Grid	Low
8658163	Wrightsville Beach, NC	2004	1.82	Grid	Intermediate
8762075	Port Fourchon, Belle Pas, LA	2003	1.69	Grid	Intermediate
8768094	Calcasieu Pass, LA	2002	1.71	Grid	Intermediate
9419750	Crescent City, CA	1950	1.92	Station Specific	Intermediate Low
9439040	Astoria, OR	1925	1.99	Station Specific	Intermediate Low
9443090	Neah Bay, WA	1934	1.96	Station Specific	Intermediate Low

Table 2. Details for newly-added stations: ID, Location, year of establishment, chosen trend for met-year predictions, NOS minor flood thresholds, and sea level trend information (derivation and selected scenario). Stations in gray indicate metrics used for annual HTF predictions, and blue represent information used for decadal HTF projections. The likely SLR scenario is chosen based on where the time series trend falls between two bounding scenarios (Sweet et al, 2022).

3. APPLICATIONS

The application of an annual 85% completeness threshold yielded small changes to the range of met-year predictions. Of the twenty stations showed a 1-day difference in the upper or lower bound of their prediction range, sixteen showed an increase in predicted flood days. Dauphin Island, AL, had a decrease

in two flood days for both high and low bounds. Friday Harbor, WA, had an increase in two flood days for both upper and lower bounds. Four stations had a change in the method selection, including Dauphin Island and Friday Harbor.

The range of HTF days calculated during assessment were compared to observations from April 2024 through May 2025. Annual flood counts were plotted in conjunction with trend lines to illustrate inter-annual flood count variation and El Nino Southern Oscillations (ENSO) sensitivity. All but two stations included in the 2025-26 Annual HTF Outlook fell within range of observations during the testing period. Wrightsville Beach, SC, predicted fewer days on the lower range, and Neah Bay, WA, predicted slightly more on the upper range during the 2024-25 analysis. Outliers were explainable and not replicated in 2025-26 results.

Trends used to calculate annual HTF predictions can be linear, demonstrating a consistent rate of change over time, or quadratic, demonstrating an unequal increasing rate of change over time (e.g., high tide flood frequencies rising more quickly or remaining more constant than predicted). NOAA's Oceanic Niño Index⁸ (ONI) is used for a multiple regression analysis to assess the effects of both temporal change characteristics, linear vs. quadratic, as well as covariability to ENSO influences (Sweet et al. 2018). Depending on location, some stations demonstrate sensitivity to fluctuations in ENSO that create greater inter-annual variations in flood frequency.

The following figures illustrate the interannual variability of two new stations in different regions. Figure 2 plots annual flood counts for Ocean City Inlet, MD, where the linear trend with ENSO sensitivity was chosen to predict the range of HTF days for the coming meteorological year. Figure 3 plots annual flood counts for Astoria, OR, where quadratic ENSO sensitivity was chosen to predict the range of HTF days for the coming year. Although Astoria has no significant rate of long-term sea level rise, ENSO sensitivity makes annual flood count prediction meaningful⁹.

⁸ NOAA Climate Prediction Center's Oceanic Niño Index: <https://www.climate.gov/news-features/understanding-climate/climate-variability-oceanic-nino-index>

⁹ Relative Sea Level Trend for Astoria, WA:
https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=9439040

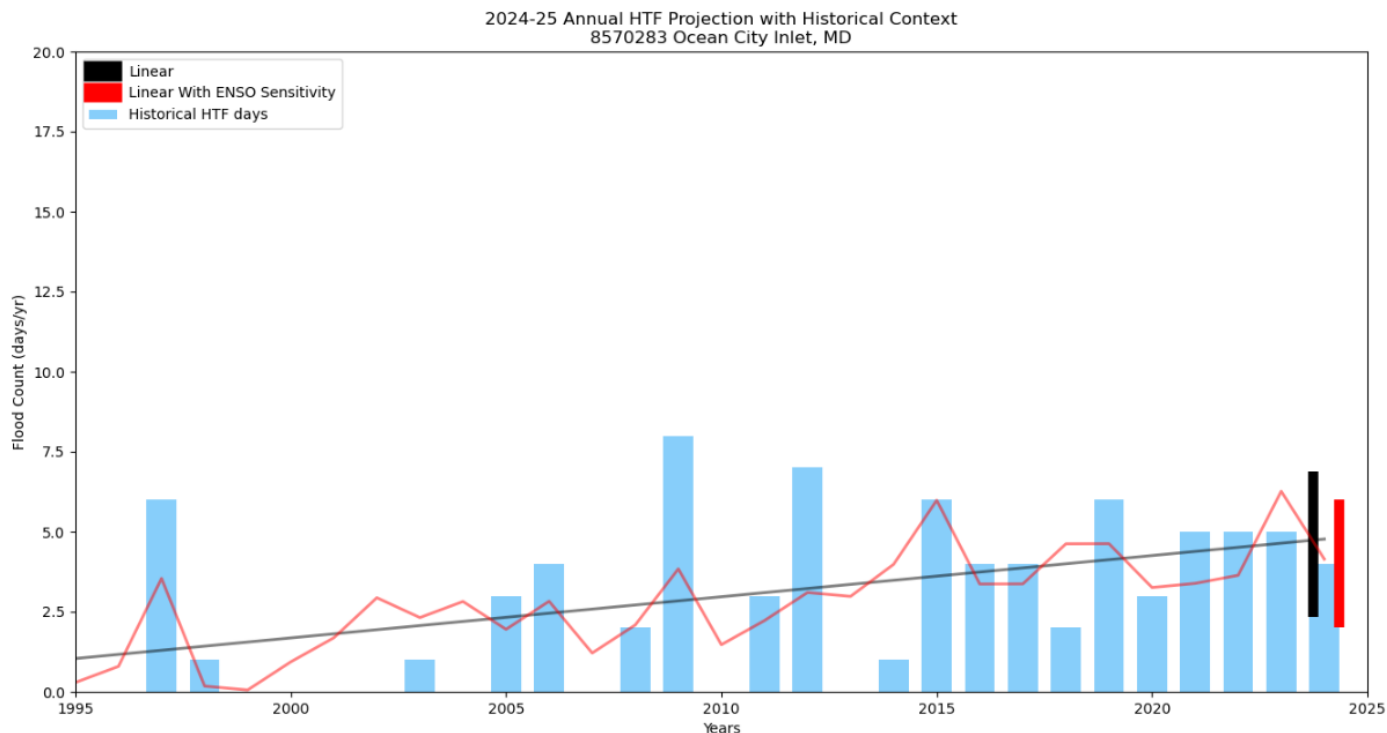


Figure 2. Historical flood counts by year at Ocean City Inlet, MD, as blue bars. The number of HTF days increases between 1995 and 2025. A black linear trend line is applied to show the potential range of HTF day. A red line shows sensitivity to ENSO cycles. The chosen trend for the 2024-25 model run matches the chosen trend in 2025-26 modeling, showing skill with consistent trend prediction, and meeting the requirements for new stations.

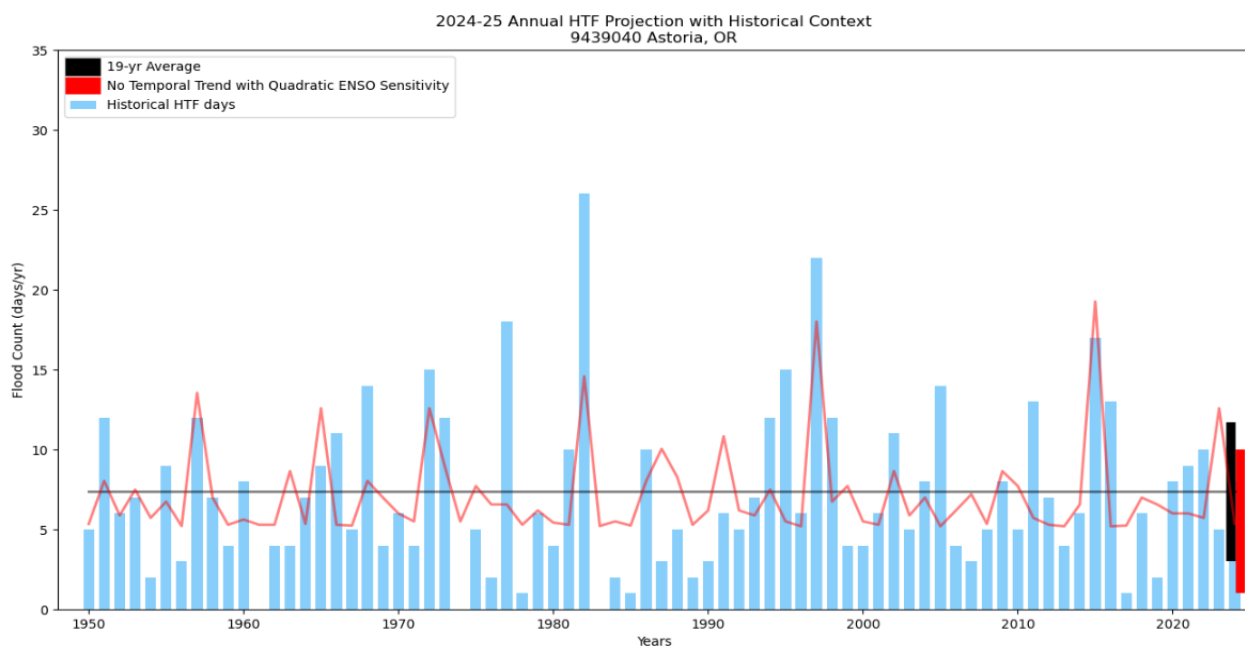


Figure 3. Annual historical flood counts for Astoria, OR, are represented in blue. The linear trend is shown in black. The red line represents the impacts of ENSO on long-term sea level. In this case, the red line indicates Astoria is

sensitive to changes in ENSO cycles that change flood rates from linear to quadratic, meaning the rate of change increases relative to time. The model predicts Quadratic with ENSO sensitivity for both the 2024-25 and 2025-26 meteorological years, consistent trend prediction for the station and region, and meeting the requirements for new Annual Outlook stations.

4. CONCLUSION

Annual High Tide Flood Outlooks are designed to help communities understand historical flooding and plan for changing flood frequencies in the future. The integration of each enhancement improves quality and spatial coverage of predictions. The addition of new stations enables more coastal communities to plan for future flood frequencies. The addition of Moderate and Major decadal flood projections gives coastal planners information to prepare for and mitigate the impacts of more extreme flood scenarios. Implementation of the completeness criteria at each step ensures that data used in Outlook models is high quality and representative of on-the-ground observations, contributing to more precise predictions and projections. All updates are now available to support long-term planning through the [interactive product website](#)¹⁰ and [NOAA's Sea Level Calculator](#)¹¹.

¹⁰ NOAA's Annual High Tide Flood Outlook: <https://tidesandcurrents.noaa.gov/high-tide-flooding/annual-outlook.html>

¹¹ NOAA's Sea Level Calculator - Changes in Flood Frequency (QV2) : <https://coast.noaa.gov/sealevelcalculator>

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