Tidal Datum Calculation Procedures

Date	Revision Description	Notes
November 2023	• Original document	• Deep dive into Hohonu's tidal datum calculation methodology and comparison to NOAA protocols and TAD calculator • Identified future upgrades to methodology to increase alignment with NOAA methods, specifically in optimizing calculation record length and the MHHW calculation

Purpose and Scope

Hohonu provides precision water level monitoring and forecasting to help communities prepare for and respond to flooding. The organization maintains a network of over 100 water level sensors located in 14 states, and it uses the latest technologies in hardware, software, and data science in order to deliver reliable and accessible water level data to its customers.

Tidal datums are standard elevations referenced to a certain tidal phase and can be used as a baseline for measuring local water levels. It is essential to accurately and reproducibly establish tidal datums for usage by both the data provider (e.g. for QA/QC of raw data, for comparison to control stations) and public stakeholders (e.g. for navigation, setting acute event thresholds, etc.). While long records (i.e. greater than 19 years) of water levels are needed to establish a primary estimate of a tidal datum, shorter records can be used given there is a control station (e.g. NWLON) with a sufficient record nearby. NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) is the authoritative source for accurate water level data, maintaining dozens of such control stations and providing methodology for calculating local tidal datums.[1] Hohonu implements these procedures within its own data program to ensure accurate datum calculation.

This document provides an overview of the calculation methodology used by Hohonu to establish tidal datums for its stations. ***It is intended as technical***

support for users of Hohonu's data, providing identification of the origin of Hohonu's public data as well as context when converting between datums. While related to tidal datums, Hohonu maintains procedures for assessing geodetic datums (e.g. NAVD 88) elsewhere. As per the NOAA technical documentation, determination and use of tidal datums can be considered independent of geodetic datums.[1]

Datum Calculation

Tidal datums for Hohonu stations are calculated once a record of at least 35 days has been established. Due to legacy limitations in server capacity, a rolling 35 day window was initially used to assess the tidal datum, where datums are reassessed on a daily basis. Hohonu is now optimizing server capacity to align record lengths with NOAA protocol and utilize the maximum data available at a station for tidal datum calculations. The procedures for calculating tidal datums are outlined below (Figure 1).

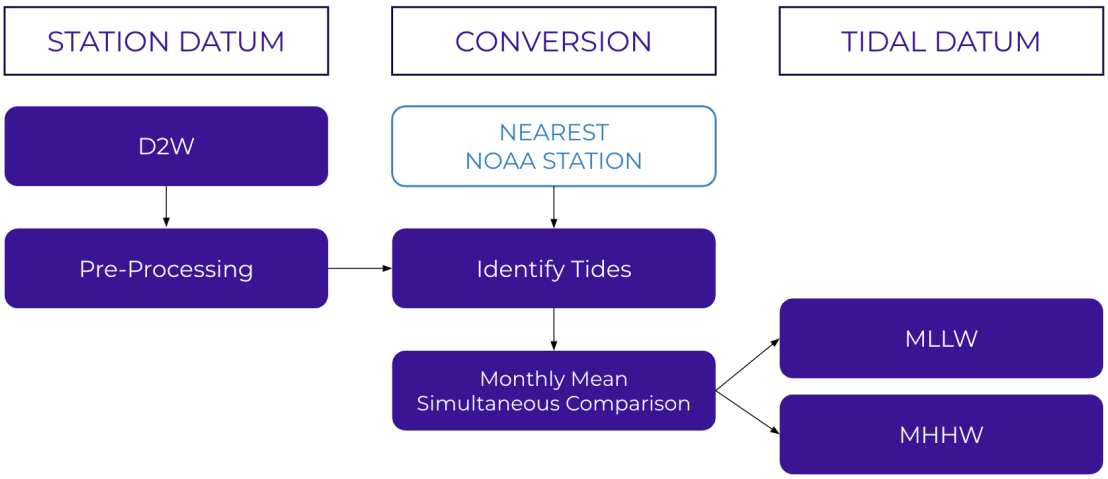

Figure 1. Overview of the Hohonu tidal datum calculation methodology

Data Pre-Processing

Data fetched from the Hohonu server are initially aligned to the station datum and measurements are referenced as raw measurement of distance to the water (D2W). For many use cases, this relative, hyper-localized measurement in locations filling gaps between NWLON stations is proving valuable to communities. Prior to performing tidal datum calculations, D2W data are first pre-processed by aligning them to the nearest six-minute mark and removing duplicate measurements. Finally,

all measurements are inverted to properly facilitate identification of high and low tides.

Identifying Tidal Signals

Estimation of tidal datums closely follows the procedures outlined by NOAA and utilized in the Tidal Analysis and Datum (TAD) calculator.[1,2] The first step in the TAD calculation involves joining the inverted D2W data with data collected at the same time at an associated NOAA control station. Control stations are matched to each Hohonu sensor based primarily on proximity and similarity of tidal conditions. Water level data from both stations are then processed using a Butterworth digital filter to remove high frequency (> 4 cycles/day) water level variability. Tidal high and low waters are then identified from the observed water level data. High and low indices that are less than 0.03 m different in height or 2 hours apart from the subsequent or preceding indices are removed per the TAD procedure.[1] Finally, the times in which high and low tides occurred in both station's signals are used to mark the original data points in the unfiltered signals.

Monthly Mean Simultaneous Comparison (MMSC)

Monthly average high high tide and low low tide are calculated for each station's daily extrema time series. The difference between the extrema of the Hohonu station and NOAA station is then calculated and averaged, providing conversion factors between the station datum and tidal datum. To yield data referenced to the mean low low water (MLLW) datum, the MLLW conversion factor is subtracted from the inverted D2W data.

The mean high high water (MHHW) datum is currently assessed independently of a NOAA control station. As stated above, internal methodologies are currently being updated to align MHHW estimates with NOAA protocol. MLLW and MHHW example comparisons between Hohonu and NOAA are shown in the below table.

Datum Usage and Review

Upon calculation, tidal datums for each station are saved in the Hohonu server to be utilized for efficient conversion of water level data and comparison to nearby stations. Users can access and manipulate the datum of sensor data via the user interface on the Hohonu Dashboard and mobile app or through the Hohonu Public API.[3] References for data access are provided below. Tidal datums undergo consistent review. Hohonu regularly performs random manual comparison to nearby control stations and to datums calculated using the online TAD calculator[2] provided by NOAA CO-OPS (Table 1).

Hohonu Node	Datum	Hohonu Procedures	NOAA TAD Calculator	Error
Kāneʻohe Bay, HI	MLLW	-1.438 m	-1.444 m	0.006 m
	MHHW	-0.741 m	-0.775 m	0.034 m
SF Tidal Marina 1, CA	MLLW	-2.901 m	-2.907 m	0.006 m
	MHHW	-1.123 m	-1.099 m	0.024 m
Portland Harbor, ME	MLLW	-5.296 m	-5.300	0.004 m
	MHHW	-2.220 m	-2.268	0.048
Fernandina 1, FL	MLLW	-3.994 m	-3.991	0.003 m
	MHHW	-1.810 m	-1.988 m	0.178 m

Table 1. Example comparisons between the Hohonu procedures and NOAA's online TAD calculator show methodology alignment. Input data for each methodology were a record of 'clean' D2W measurements collected at various Hohonu stations between September 1 and October 5, 2023. Clean data were chosen to facilitate their use in the online calculator. The NOAA control stations used were Mokuoloe (1612480), San Francisco (9414290), Portland (8418150), and Fernandina Beach (8720030), respectively.

References

1. National Ocean Service, Computational Techniques For Tidal Datums Handbook, NOAA Technical Report NOS COOPS 2, Center For Operational Oceanographic Products and Services, Silver Spring, MD, 2003. https://www.tidesandcurrents.noaa.gov/publications/Computational_Techniques_for_Tidal_Datums_handbook.pdf
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