



NCEI WATER LEVEL REPORT - Tsunami

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Introduction

The NOAA National Centers for Environmental Information (NCEI) archives and provides quality-control of tsunami-related data as part of the U.S. Tsunami Warning System (Figure 1). We receive high-resolution coastal tide gauge data from the NOAA Tsunami Warning Centers and the Center for Operational Oceanographic Products and Services (CO-OPS). We receive high-resolution Deep-ocean Assessment and Reporting of Tsunamis (DART) data from the National Data Buoy Center.

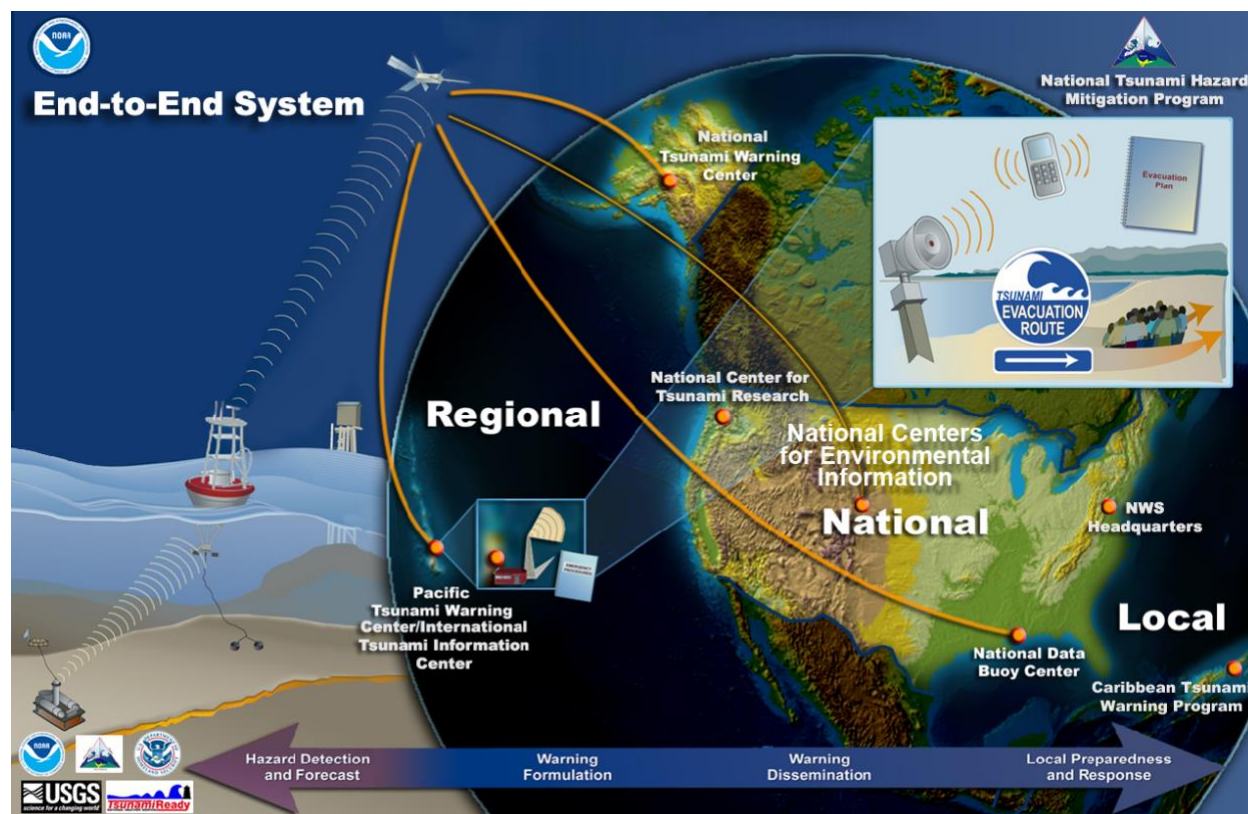


Figure 1: U.S. Tsunami Program 'End-to-End' System.

The NCEI Natural Hazards Team consists of three sub-teams: the NCEI/World Data Service (WDS) Global Historical Database Team, the Digital Elevation Model (DEM) Team, and the Water Level Team, which includes a Technical Lead, Research Lead, and a Marigram Specialist. The Water Level Team archives analog and digital coastal tide gauge data and ocean bottom pressure data, digitizes analog data as funding permits, and performs quality-control and tidal analysis of the high-resolution data. These time-series data are complementary to the maximum wave heights recorded in the NCEI/WDS Global Historical Tsunami Database.

The first section of this report describes NCEI's archival services and information used by the U.S. Tsunami Warning System; the second section describes the products NCEI has developed to support tsunami warning operations and research. We expect to provide updates to this report regularly via email containing a link to a PDF in our hazards data web-accessible folder at <https://www.ngdc.noaa.gov/hazard/data>. If you have comments or suggestions as to how we can improve this report, please contact us at [faz.info@noaa.gov](mailto:haz.info@noaa.gov).

Services

Archive

NCEI is the long-term archive for all NOAA coastal tide gauge and deep-ocean pressure data. The archival process involves assuring completeness and re-usability of metadata and data as well as performing data backup on digital tape with duplicate copies held at two or more physical locations separated by at least 50 miles. These data include:

- Coastal Tide Gauge Data: 1-minute water level data from National Ocean Service (NOS)/CO-OPS (about 225 stations, since 2008) and high-resolution water level data from the National Weather Service (NWS)/Pacific Tsunami Warning Center (PTWC) (about 12 stations, since 2013) and NWS/National Tsunami Warning Center (NTWC) (7 stations, since 2014). We also archive 6-minute, hourly, daily, and monthly mean water levels for all NOS stations, and 15-second data for tsunami events.
- Analog Tide Gauge Records (Marigrams): NCEI stewards select pre-digital-age tide gauge data (1854–1981) capturing tsunami events. (The graphic representation of water level as a function of time on paper is called a *marigram*.)
- DART Ocean Bottom Pressure Data: High-resolution 15-second data recovered from the seafloor by NWS/National Data Buoy Center (NDBC) (39 stations, since 2008, including non-DART bottom pressure recorder data from 1983 and forward).

Figure 2 shows a map of the locations of the digital tide gauge data and DART ocean bottom pressure data.

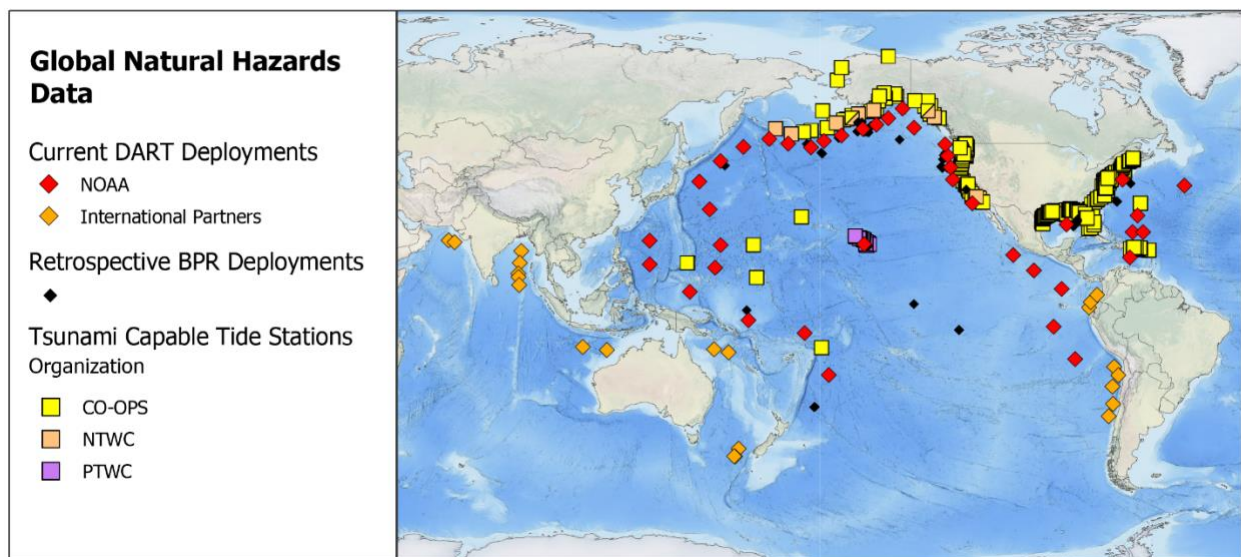


Figure 2: A map showing the locations of current and past DART deployments (including NOAA and international partners) and U.S. tsunami capable tide stations.

Rescue

NCEI is working to ensure that all U.S. coastal tide gauge data, select international tide gauge data, and ocean bottom pressure data are archived. To achieve this goal, NCEI is working with our NOS and NWS partners to eliminate gaps due to data ingest failures or delays. With the introduction of visual timeline inventories, our partners have helped us identify, recover, and backfill gaps in our archive.

Reformat

We receive coastal tide gauge data and ocean bottom pressure data in 3–4 different formats, none of which are standardized. All water level data and products are converted to standardized file formats for ease of use. These include netCDF and tab-delimited ASCII formats, with metadata embedded according to community-adopted conventions and structures.

Digitize

The archive includes 3486 high-resolution scanned marigram images. Of these, 224 are available for direct download, while the remainder are discoverable via our Marigram Search Page (<https://www.ngdc.noaa.gov/nndc/struts/form?t=102890&s=3&d=3>) and may be requested by email to haz.info@noaa.gov. Scanned marigram images that contain clear pen traces and all necessary scale and datum information are digitized into numerical time-series data by hand-selecting data points along the inked tidal curves. Though automated data point selection capabilities exist, when tested, they did not accurately detect faint traces and consistently failed to correctly select the peak and trough values. Hand-selection ensured that the maximum and minimum values important across water level research would be accurately recorded. The completed time series is exported, converted into standardized file formats, and is available for download in both netCDF and CSV formats. From 2016 to 2019, we have digitized 47 of these images, across nine tsunami events, into ready-to-use, digital time-series data (Figure 3).

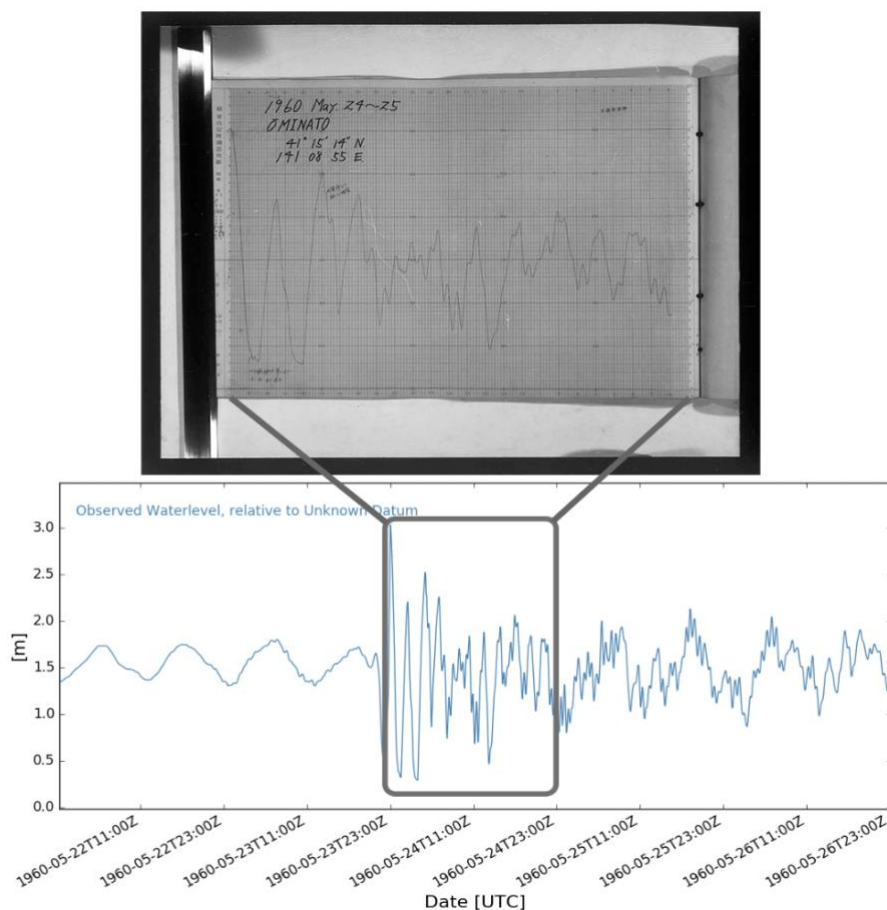


Figure 3: Top: Scanned marigram image. Bottom: Plot made from digitized time-series taken from the marigram image.

Discover

NCEI supports data discovery and access in a number of ways. By maintaining collection-level metadata in the standard ISO-19115 XML format, these data products and services are made discoverable through the NOAA catalog (<https://data.noaa.gov>) and [Data.gov](https://data.gov). We also provide more focused discovery through spatial map services (<https://maps.ngdc.noaa.gov/viewers/hazards/?layers=5> and <https://maps.ngdc.noaa.gov/viewers/hazards/?layers=4>) and temporal timeline inventories (<https://www.ngdc.noaa.gov/hazard/tide/>, <https://www.ngdc.noaa.gov/hazard/dart/>, and <https://www.ngdc.noaa.gov/hazard/bpr/>). These maps and timelines link to our Station Pages where data may be downloaded directly.

Access

All data and products are made available for direct download via our THREDDS Data Server (<https://www.ngdc.noaa.gov/thredds/enhancedCatalogWaterlevel.html>.) To help organize and showcase these data, we also provide plot previews, metadata about the station and/or deployment, and download links from our Station Pages. An example is provided at <https://www.ngdc.noaa.gov/hazard/tide/stations/9410170/?year=2019>.

As a service to NWS, we provide a RESTful API for programmatic access to NTWC data. NOS is a primary user of this service through their Tides and Currents website (<https://tidesandcurrents.noaa.gov/tsunami>). Details about this service are described at https://www.ngdc.noaa.gov/hazard/twc_waterlevel_extract_service.html.

User Engagement

We engage with NWS/NDBC and Oceanic and Atmospheric Research (OAR)/NOAA Center for Tsunami Research (NCTR) through monthly DART data check-ins to discuss the status of recent DART deployments and other issues that arise (for example, authoritative DART locations from NDBC). We engage with NOS/CO-OPS through as-needed discussions about tide gauge data issues, including data ingest failures and file formats. When data transmission issues from NWS/NTWC arise, we engage with their IT Specialist.

We address user inquiries through haz.info@noaa.gov. The types of questions we have received in the past have included the availability of paper and/or digitized marigrams for particular events of interest and questions about quality control and tidal analysis.

Products

Quality-Control and Tidal Analysis

Post-processing of water level data is a current project at NCEI. We provide quality-controlled water level data, computed astronomical tides, details on the harmonic tidal analysis results, and spectra to assess the quality of the de-tiding. Researchers use the quality-controlled data to validate tsunami propagation and storm surge models, improve forecasts and numerical models necessary for sound management, and plan coastal communities.

Common issues to ocean bottom pressure data are the typically 1–2 week period of adjustment at the beginning of the record to the full ocean depth and instrumental spikes. Common issues to coastal water level data include unexplained vertical datum shifts, 180-degree phase flips, clipping, and instrumental spikes. NCEI regularly computes up to 69 tidal harmonic constituents based on multi-year time-series, in order to produce authoritative records of tsunamis and other extreme events. These constituents consist of computed amplitudes and phases for 69 known tidal frequencies, and may be used for tidal prediction, such as by the Tsunami Warning Centers for real-time decision support. Currently, we do not consider it necessary to use more than 69 tidal constituents, as in the open ocean the amplitudes of these additional tidal constituents are very small; in the coastal zone there will be issues separating them from seiches, resonance oscillations in bays and ports, and shelf waves. No numerical filtering is applied because of the unwanted side effects, such as energy leakage and phase shifts that will introduce small changes in the tsunami wave amplitudes. If numerical filtering is needed, for example, to separate tsunami signal from seiches, this should be done by the user because the choice of the numerical filter is a matter of personal preference. Our processing is focused on providing, to the greatest extent possible, “clean” records of tsunami waves to meet the requirements of the tsunami community for high-quality data.

Tsunami Event Pages

In the event of a tsunami, we augment our holdings by collecting and processing data from the National Hydrographic Services in the affected regions and from the United Nations Education, Scientific and Cultural Organization Intergovernmental Oceanographic Commission (UNESCO IOC) Sea Level Stations Monitoring Facility. Currently, UNESCO IOC does not process these data. These data products are then made available via Tsunami Event Pages. We currently host Tsunami Event Pages for 10 events that occurred between 2006 and 2015. An example is at <https://www.ngdc.noaa.gov/hazard/dart/2015chile.html>.

