

NCEI Tsunami Data: Capturing Tsunami Stories Through Global Observations

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ABSTRACT Tsunamis have caused a considerable number of fatalities, inflicted major damage, and significant economic loss around the globe. The NOAA National Centers for Environmental Information (NCEI) and co-located World Data Service for Geophysics (WDS) provides long term archive, data management, and access to global tsunami data. The NCEI's online and searchable global historical tsunami database contains over 31,000 tsunami wave observations from over 2,800 tsunami events. The database includes global observations of tsunami sources and tsunami runup records (locations where tsunami waves were observed by eyewitnesses, field reconnaissance surveys, tide gauges, or deep-ocean sensors). The database's robust and reliable historical tsunami runup data, known tsunami source zones, and limited geological data has facilitated the development of qualitative tsunami hazard assessments. Complementary to these records, NCEI archives analog (historical tide gauge marigrams) and high-resolution digital coastal water level data and ocean-bottom pressure data, and performs quality-control and tidal analysis of these data. Additionally, the NCEI/WDS Natural Hazards Image Database contains images related to geologic hazards including earthquakes, tsunamis, and volcanic eruptions. Because images illustrate physical and societal impacts of natural hazard events not always reflected in instrumental and numerical data, collecting and archiving these data supports a more complete understanding of natural hazard events. Combined, these historical resources help communicate the full story of tsunami events with free and open access to historical tsunami information that is key to supporting planning and decision making in the fields of tsunami mitigation, warning, response, and research.

Historical Tsunami Database

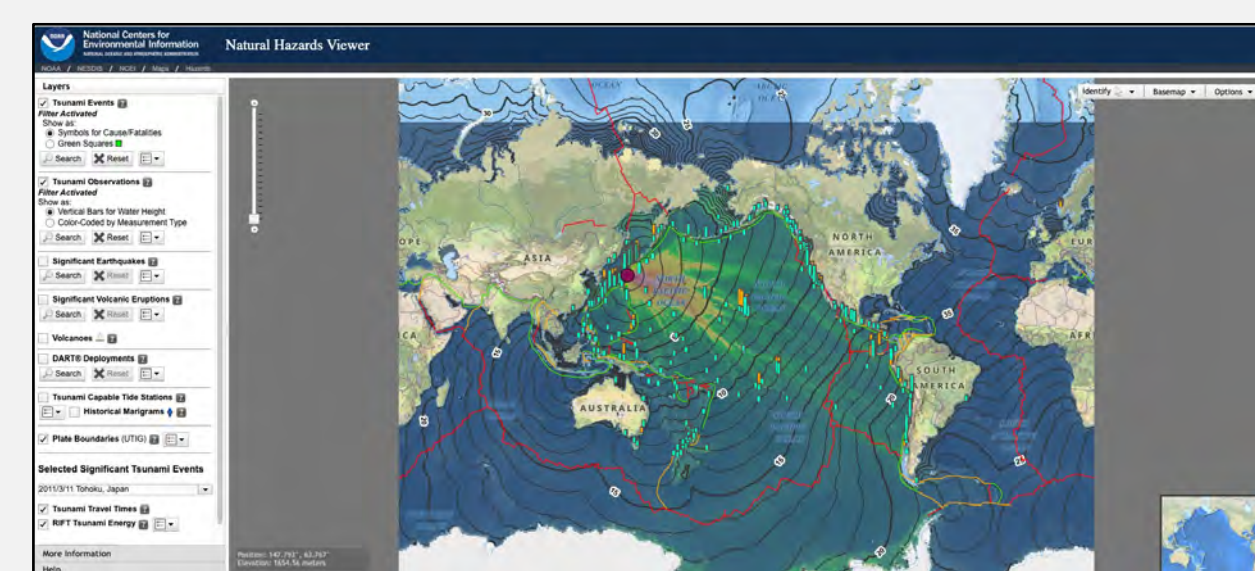
The NCEI/World Data Service Global Historical Tsunami Database is a scientifically curated list of historical tsunami source events and tsunami water height locations throughout the world that range in date from 2000 B.C. to the present. Tsunami source information comes from approximately **8,500** publications dating from the 15th century. The earliest known tsunami described was on a Syrian cuneiform tablet from 2000 B.C. The database lists more than **2,800** global tsunami events, including over **1,400** confirmed events. The historical database is an authoritative source for historical tsunami event data as it is continuously updated based on new sources. In addition to numerical wave/runup information, the database includes economic and human impacts. Long-term data from these events are used to establish the past record of natural hazard event occurrences. These data are important for planning, response, and mitigation of future events.

Data is downloadable and accessible via:

- Traditional forms
- REST API
- Map Viewers and Services

Year	Mag	Lat	Lon	Depth	Country	Location Name	Latitude	Longitude			
1902	8	11	4	400	USA	STURTON BAY, AK	68.800	-157.000			
1901	3	3	7	80	USA	MONTREY BAY, N. CALIFORNIA	36.500	-120.500			
1903	11	24	4	4	USA	SPENCERHAYNE BAY, NZ	60.000	-139.500			
1904	4	18	13	12	0	USA	N. CALIFORNIA	37.500	-122.500		
1907	3	24	12	50	0	USA	SEASIDE, N. CALIFORNIA	39.500	-124.500		
1908	9	21	6	31	4	USA	HAWAII	19.000	-155.000		
1914	8	16	12	50	4	USA	TRAWEE, CANADIAN PACIFIC	52.250	-124.167		
1919	10	2	2	4	7	USA	ALUHA, HAWAII	19.250	-155.900		
1925	3	23	28	93	36	3	USA	GULF OF ALASKA, AK	60.000	-148.000	
1925	10	4	16	43	4	1	USA	CALIFORNIA	36.500	-120.500	
1927	10	24	15	160	44.8	3	3	USA	CALIFORNIA	36.500	-120.500
1927	11	4	13	50	4.3	1	1	USA	CALIFORNIA	36.500	-120.500
1929	3	7	1	34	37.8	4	1	USA	CALIFORNIA	36.500	-120.500
1930	8	31	0	40	38	3	3	USA	CALIFORNIA	36.500	-120.500
1938	10	27	16	160	0	4	8	USA	CALIFORNIA	36.500	-120.500
1938	11	10	20	18	41.2	4	1	USA	CALIFORNIA	36.500	-120.500
1948	8	16	12	50	4.3	1	1	USA	CALIFORNIA	36.500	-120.500
1949	4	13	10	56	3	3	3	USA	CALIFORNIA	36.500	-120.500
1949	4	13	10	56	3	3	3	USA	CALIFORNIA	36.500	-120.500

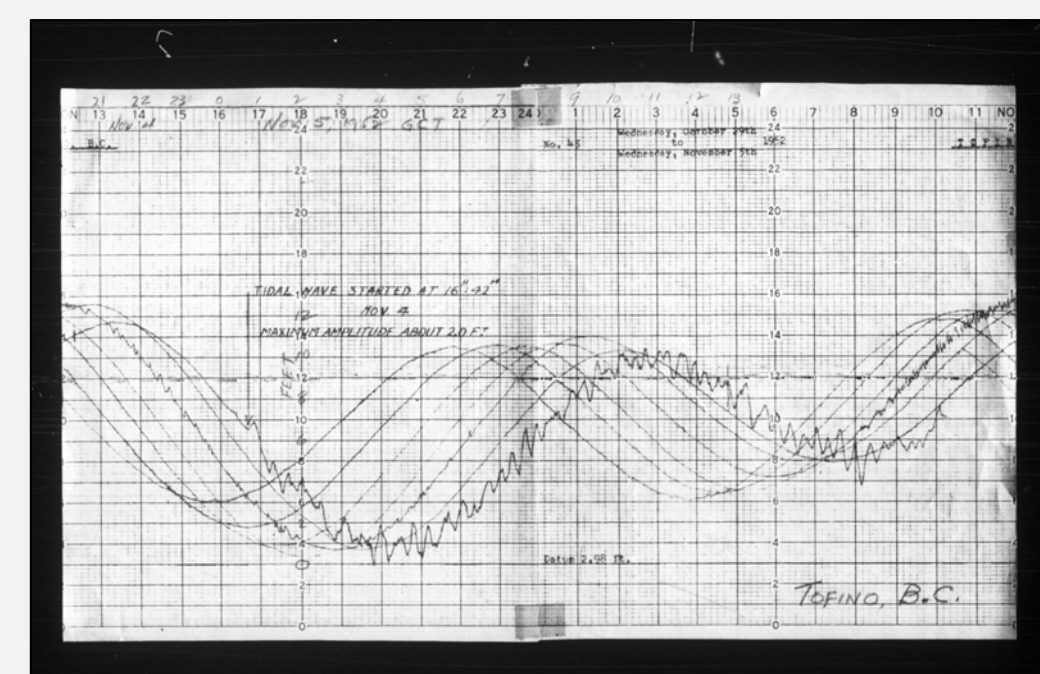
The NCEI/WDS historical tsunami data is discoverable through a public facing interface, known as Hazard Event Lookup (HazEL). The interface provides robust search capabilities, including geospatial searches to allow users to visually select an area to search. Flexible sorting and filtering of data also make the NCEI/WDS historical tsunami data more discoverable. Additionally, HazEL uses a REST API for programmatic access. A separate interactive mapping application, the Natural Hazards Viewer, exists to allow geospatial searching and visualization of the NCEI/WDS databases.



The map viewer (left) allows users to discover and view historical tsunami data on a map, in context with other spatial layers (i.e. plate boundaries, volcanoes, DART deployments, tide stations, marigrams, and selected tsunami energy plots). Credit: NOAA/NCEI

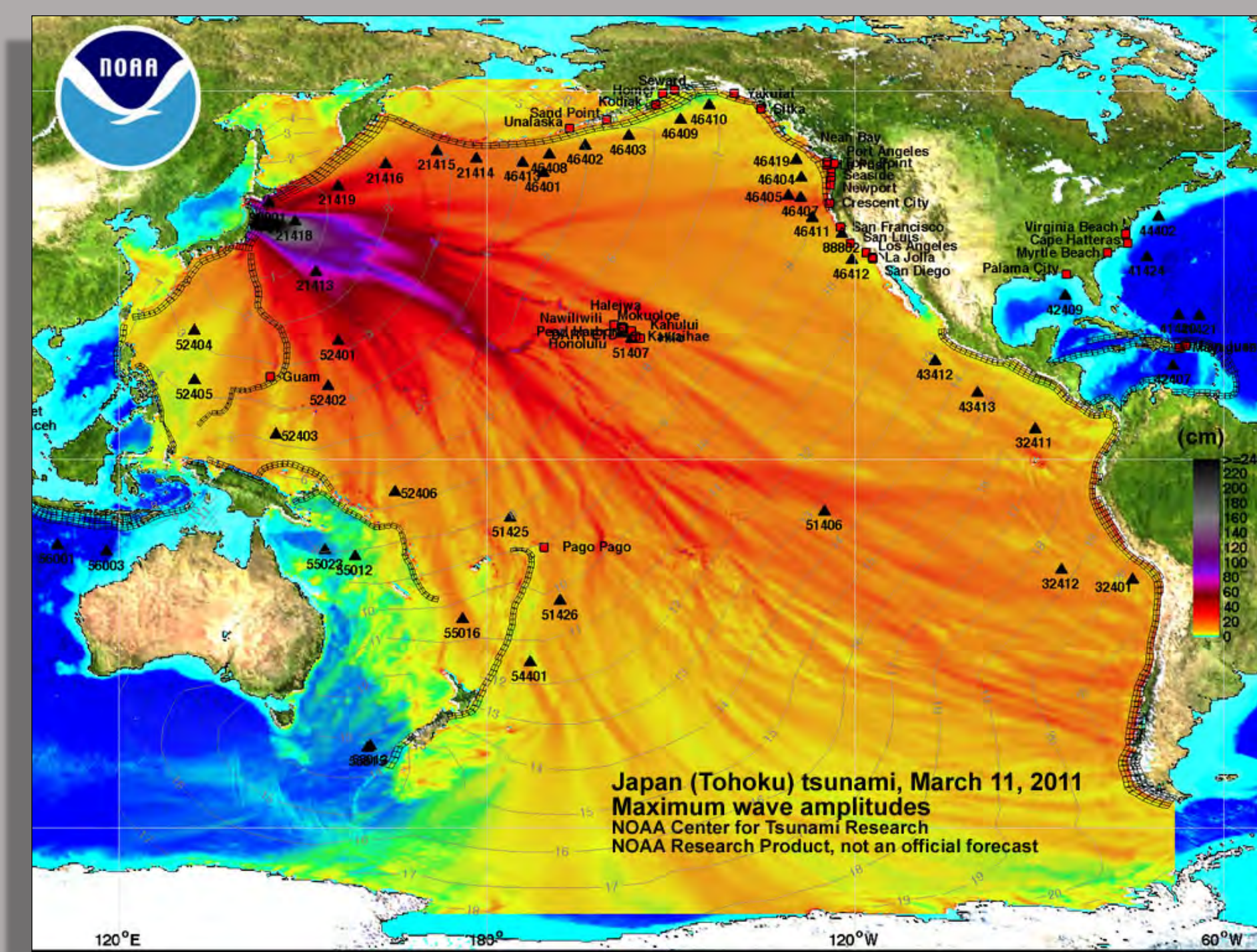
Tsunami Water Level Data

NCEI archives analog and high-resolution digital coastal water level data and ocean-bottom pressure data, digitizes select analog data, and performs quality-control and tidal analysis of these data. The digital tide gauge data, primarily U.S. stations, have been collected at 1-minute sampling since 2008 and ocean-bottom pressure data have been collected since 1983.



Scan of the Tofino, B.C. tide gauge marigram showing the arrival of the 1952 Kamchatka tsunami. Credit: NOAA/NCEI

The collection of scanned images of paper water level records (marigrams or mareograms) includes over **3,000** historic paper records (between 1854 and 1994), covering observations of more than **390** tsunamis. These records were retrieved from U.S. and international stations, and are a few days to a few weeks long -- capturing conditions before and after the tsunami arrival. These scanned records often contain handwritten, instrument specific details that can explain data gaps, instrument damage, and other data anomalies.



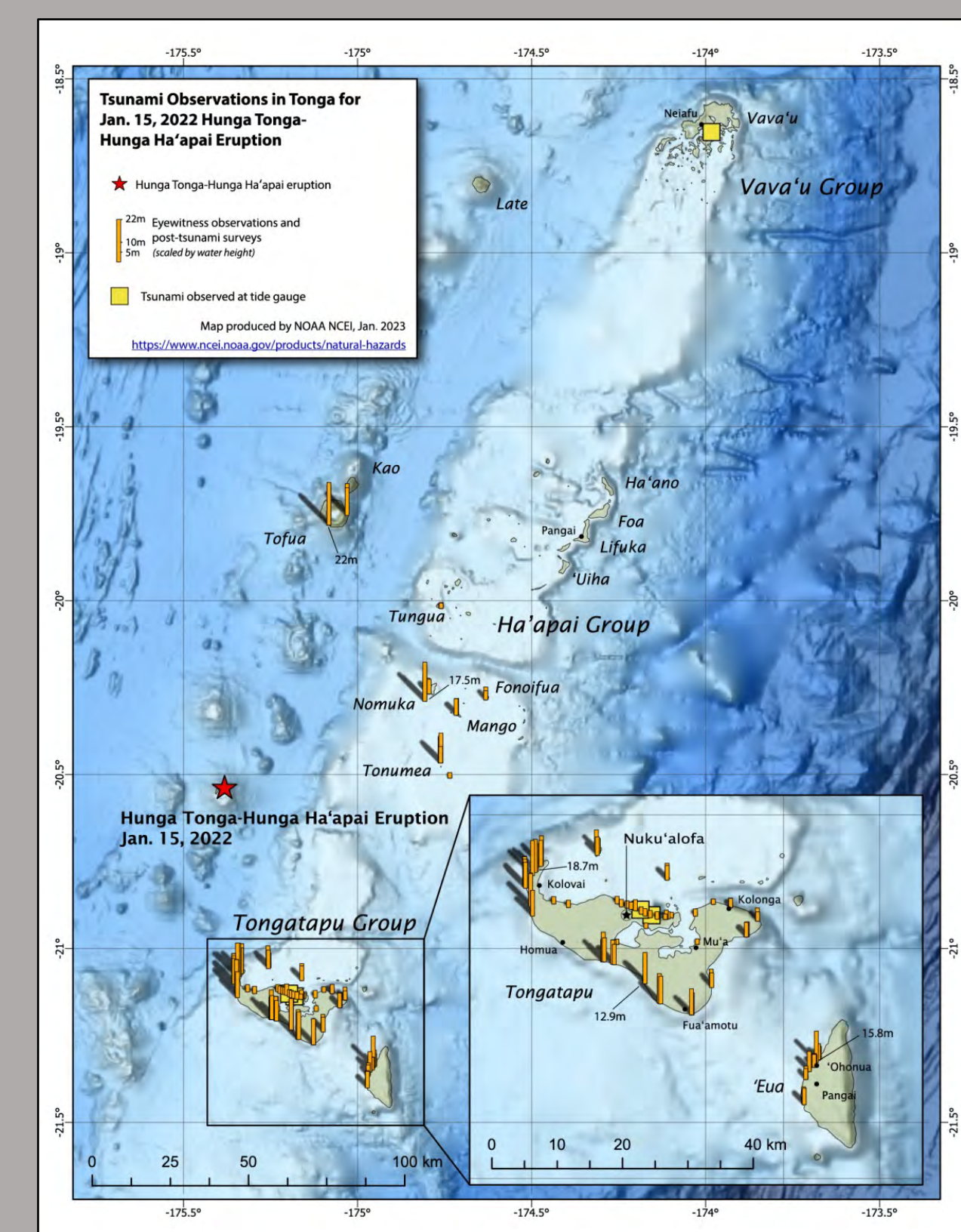
Forecasts

NCEI's retrospective high-resolution water-level data has proven invaluable for validation of tsunami forecast and inundation models as well as evacuation map development. Sea level records play a critical role in tsunami forecast model development.

NOAA Pacific Marine Environmental Laboratory's (PMEL) tsunami numerical simulation of the March 11, 2011 tsunami. PMEL acquires tsunami runup and sea level measurements data from NCEI for modeling and other scientific applications. Credit: NOAA/PMEL.

Warnings

During an event, Tsunami Warning Centers consult the NCEI tsunami database for similar (source) historical tsunamis to assist in determining potentially vulnerable areas. Tsunami runup data and water level records have proven invaluable for tsunami researchers and operational agencies with a responsibility for issuing alerts during a tsunami event. Further, emergency response agencies may use the historic occurrences to explain evacuation decisions. National Tsunami Warning Centers may establish local tsunami warning criteria based solely on earthquake magnitude, determined after examining a country's historical tsunamigenic earthquake hazard.



Map generated using observation data from the NCEI Global Historical Tsunami Database summarizing tsunami observations in Tonga following the January 15, 2022 Hunga Tonga-Hunga Ha'apai eruption. Credit: NOAA/NCEI

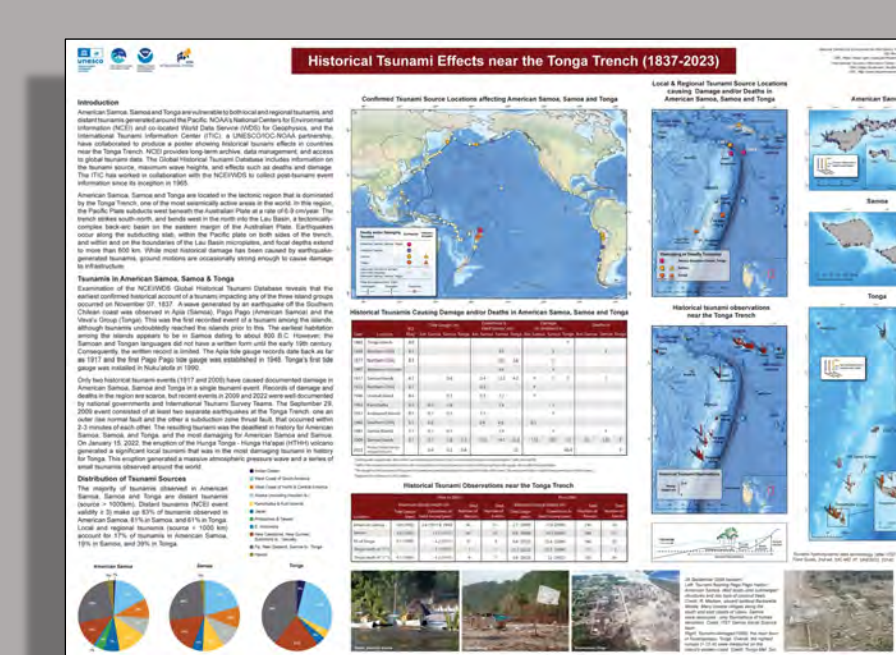
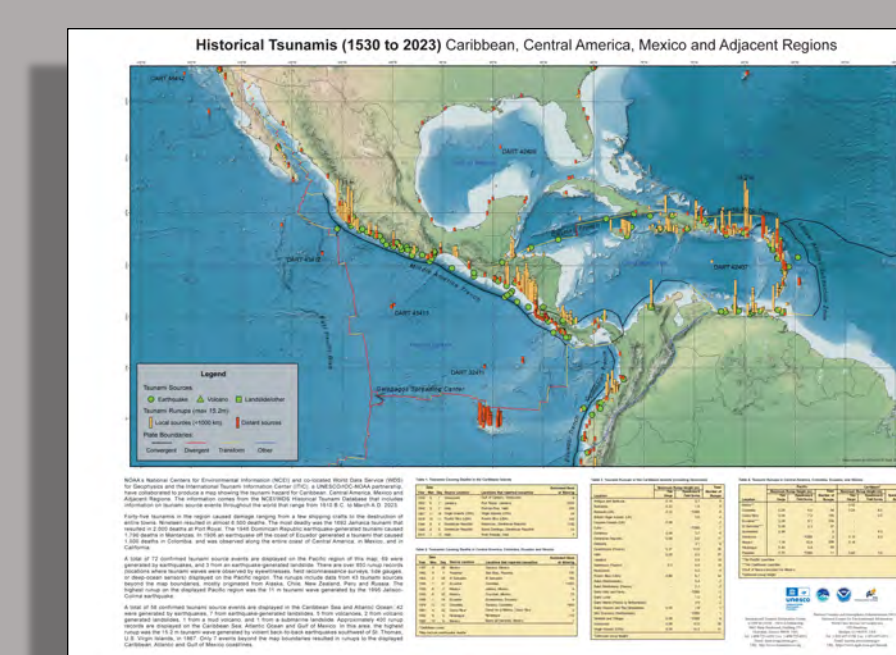
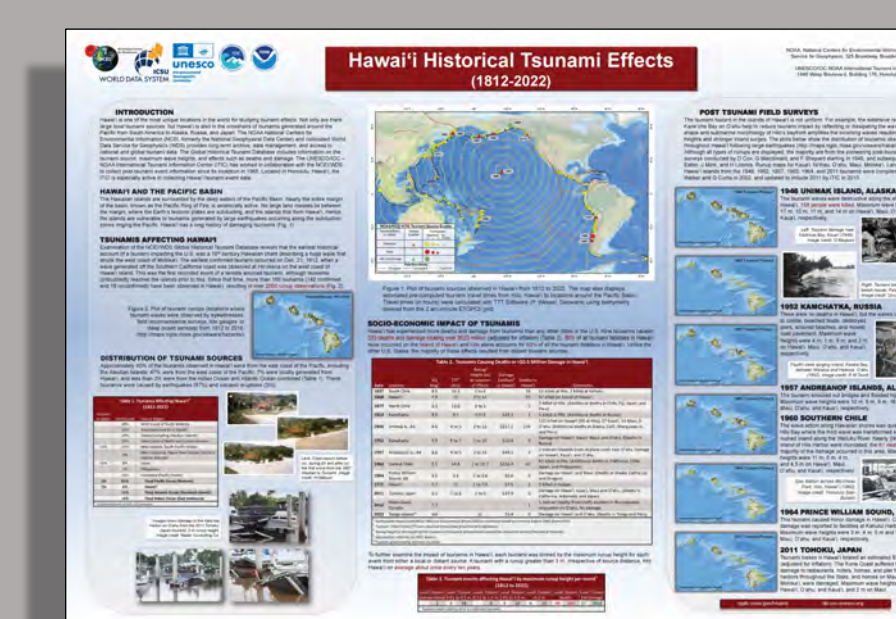
Research

NCEI's long-term archive of Deep-ocean Assessment & Reporting of Tsunamis (DART) bottom pressure data and high-resolution, coastal tide gauge data provides evidence of sea-level fluctuation and possible inundation events. Researchers use the quality-controlled data to validate tsunami propagation and storm surge models. NCEI's quality control and verification of retrospective data are required for model validation and improvement, maximizing siting considerations, and research into better understanding tsunami dynamics. The ongoing digitization of historic water level data and discovery of historic tsunami records will continue to provide new information and greatly increase the number of observations available for tsunami model validation. NCEI has a complete digital archive of all the analog records used to compile the database, allowing tsunami researchers to analyze the original source material for a historic tsunami event and associated water heights.

Risk Assessment

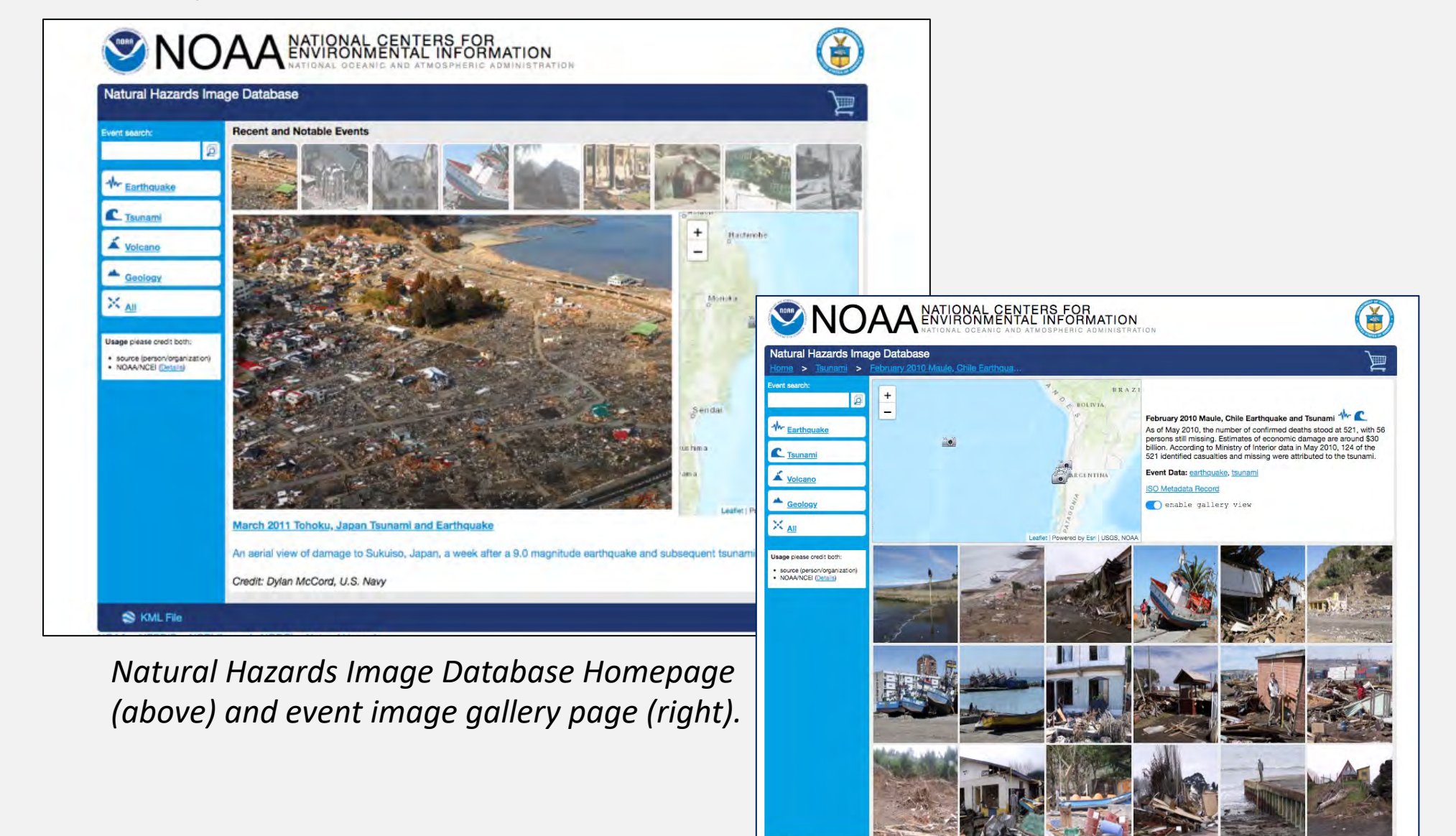
The first step in a hazard assessment involves estimating the probability of the occurrence of a potentially damaging tsunami of a given magnitude within a specified time. To undertake this assessment, the historical record of occurrence of the tsunami is analyzed. The U.S. National Tsunami Hazard and Mitigation Program (NTHMP) continues to rely on NCEI historical records as a key component of the National Tsunami Hazard Assessment. Other users developing tsunami hazard and risk assessments with the NCEI historical tsunami database include the U.S. Nuclear Regulatory Commission and IOC/UNESCO Member States. Stakeholders involved in the development of land use and engineering criteria consult historical tsunami effects, in particular NCEI's publicly available geospatial version of the data. Historical data alone are insufficient to accurately assess the long-term hazard of low frequency hazards, such as tsunamis. Therefore, use of geologic deposits can extend or fill in the record significantly. NCEI has built a foundational tsunami deposit database to foster the extension of an area's tsunami hazard profile.

Regional historical tsunami effects posters for Hawaii (top); Caribbean, Central America, Mexico and adjacent areas (middle); and countries near the Tonga Trench (bottom). Posters created in collaboration with the International Tsunami Information Center (ITIC), a UNESCO/IOC-NOAA partnership.



Natural Hazards Image Database

The NCEI Natural Hazards Image Database contains one of the largest collections of images related to geologic hazards including earthquakes, tsunamis, and volcanic eruptions. Through a searchable, sortable, and dynamic web-based user interface, the database provides free and public access to more than **1,750** images from **100** historical and recent natural hazard events. Photographs of natural hazards effects represent a unique form of data that capture the transient consequences of Earth's periodic upheavals.



Natural Hazards Image Database Homepage (above) and event image gallery page (right).

The photographs taken of damage caused by these events are a permanent record that would otherwise be erased forever by cleanup and reconstruction projects. Scientific research, mitigation, and forecasting rely on visual data for risk analysis, inundation mapping and historic records. Photographic timelines of events can also be cross-referenced with eyewitness accounts. Because images explicitly illustrate the physical and societal impacts of natural hazard events not always reflected in instrumental and numerical data, collecting and archiving these data supports a more complete understanding of natural hazard events.



The Pacific Tsunami Museum of Hilo, HI is installing informational signs at tsunami landfall sites across the Hawaiian Islands featuring NCEI Natural Hazard Image Database photographs, tsunami facts, tsunami safety, and survivor stories. Credit: Pacific Tsunami Museum

2022 Hunga Tonga-Hunga Ha'apai Eruption and Tsunami



Credit: Dr. Shane Cronin and Tonga Geological Services/NCEI

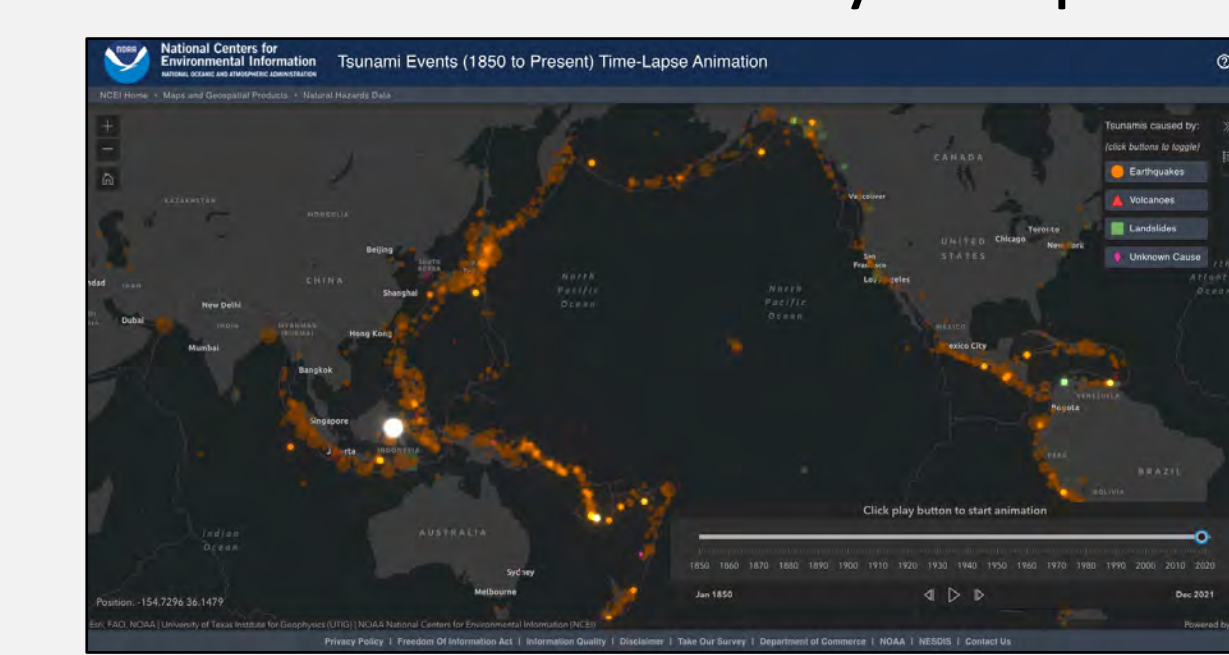
1929 Grand Banks Tsunami



Credit: Archives and Special Collections (MF 391.1.06), Queen Elizabeth II Library, Memorial University of Newfoundland, St. John's, NL/NCEI

Outreach & Education

In response to requests for basic science and data products for educational settings, NCEI and CIRES scientists developed the Tsunami Events (1850 to Present) Time-Lapse Animation, a tool that allows the "story" of historical tsunamis to be told to users new to tsunamis and tsunami data, and encourages interaction for data discoverability. To support educators in incorporating this tool into the classroom, a user guide outlines basic use and navigation of the tool. The guided activity is designed to supplement science lessons but, data accessed with the animation tool have relevance to many academic topics (math, social science, history, English, etc.) and questions could be modified to use in many disciplines.



Tsunami Events (1850 to Present) Time-Lapse Animation



Tsunami Events (1850 to Present) Time-Lapse Animation Teacher Guide and Tsunami Worksheet