ABSTRACT

The NOAA National Centers for Environmental Information (NCEI) and collocated World Data Service (WDS) for Geophysics provide data management and access to global tsunami data. NCEI/WDS's Global Historical Tsunami Database includes information on over 2,600 tsunami events from 2000 B.C. to the present. The tsunami events were gathered from scientific and scholarly sources, regional and worldwide catalogs, tide gauge data, deep ocean sensor data, individual event reports, and unpublished works. Available data includes information on tsunami sources, tsunami wave heights and socio-economic impacts (i.e. death, property damages). NCEI/WDS developed an animated, interactive map (controlled with a time slider) displaying global historical tsunami events since 1850. Tsunami events with low validities (1=very doubtful tsunami) to high validities (4=definite tsunami) are displayed. The new animated web map is implemented with the ArcGIS API for JavaScript, ReactJS, and a NOAA GeoPlatform (ArcGIS Online) hosted feature layer; utilizing Esri's cloud infrastructure offers flexible visualization options and fast performance. Combined with a newly developed, educational STEM activity, this interactive web map should serve as an introduction to historical tsunami events and associated data for K-12 and general public audiences.

INTRODUCTION

The NOAA National Centers for Environmental Information (NCEI) and collocated onal Centers for ronmental Information Tsunami Events (1850 to Present) Time-Lapse Animation World Data Service (WDS) for Geophysics provide data management and access to global tsunami data. NCEI/WDS's Global Historical Tsunami Database includes unamis caused by: information on over 2,600 tsunami events from 2000 B.C. to the present. The (click buttons to toggle) Earthquakes tsunami events were gathered from scientific and scholarly sources, regional and worldwide catalogs, tide gauge data, deep ocean sensor data, individual event reports, and unpublished works. Available data includes information on tsunami sources, tsunami wave heights and socio-economic impacts (i.e. death, property damages). These data are stored in a relational database along with related tsunami runup points (locations where tsunami waves were observed by eyewitnesses, field reconnaissance surveys, tide gauges, or deep-ocean sensors), references, images, significant earthquakes, significant volcanic eruptions, and tsunami deposits. The NCEI/WDS Global Historical Tsunami Database allows national and local decisionlick play button to start animatio makers to use historical natural hazards data to determine the threats their communities have faced and understand when to issue warnings and evacuation orders. As our educational climate shifted to remote and virtual learning platforms, interest in basic tsunami science and data products for educational settings Figure 1. Screenshot of Tsunami Events (1850 to Present) Time-Lapse Animation increased. These requests highlighted the value of developing a tool that accessed the same historical tsunami data but better suited for novice users and educational https://www.ncei.noaa.gov/maps/tsunami-events/ settings. In response, NCEI developed the Tsunami Events (1850 to Present) Time-NCEI/WDS developed an animated interactive map displaying global historical tsunami Lapse Animation tool. This tool combined with a newly developed, educational events since 1850 (Figure 1). STEM activity, serves as an introduction to historical tsunami events and associated data for K-12 and general public audiences. This time range was chosen to ensure:

NCEI/WDS's Global Historical Tsunami Database

The NCEI/WDS tsunami database includes two related tables: observations of tsunami sources and tsunami runup records. The tsunami event database contains over 40 fields (e.g. date, time, maximum water height, location, etc.). An important database field for tsunami events, or runups, is the reference field that lists source documents of the data. Also, tsunami events are linked to analogous earthquake and volcanic eruption databases maintained by NCEI/WDS, lists source documents of the data. Also, tsunami events are linked to analogous earthquake and volcanic databases maintained by NCEI/WDS, thereby providing information on the tsunami source. Historical tsunami data is subject to many issues relating to reliability (e.g.

Event	Validity Key
-1	Erroneous Entry
0	Event that only caused a seiche or disturbance in an inland river
1	Very Doubtful Tsunami
2	Questionable Tsunami
3	Probable Tsunami
4	Definite Tsunami

Table 1. Tsunami event validity values are assigned to each event to indicate level of doubt regarding credibility and/or sufficiency of data for a listed tsunami event.

misinterpretation of events, typographical errors, scarcity of information, etc.). As a result, the database uses a validity key (Table 1) to assign each event a validity value to explain that doubts exist regarding the credibility and/or sufficiency of data for a listed tsunami event.

ACCESSIBILITY

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.



NOAA National Centers for Environmental Information www.ncei.noaa.gov

Discovering Historical Tsunami Data Through Time-Lapse Animation Lindsey Wright^{1,2}, Jesse Varner^{1,2}, Nicolas Arcos², Kelly J Stroker², Trinity Foreman³ 1 Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado at Boulder, Boulder, CO, USA 80309

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TSUNAMI EVENTS (1850 TO PRESENT) TIME-LAPSE ANIMATION



- good global distribution of data
- more accurate reporting of event details since 1850
- reasonable animation time length for general public (2-3 minutes)
 - Interactive features for the animation include: Clickable tsunami events to obtain more information • Timeline slider to scroll to a specific date • Zoomable and moveable map

The animation groups and displays tsunami sources into four principal and common source categories: Earthquake, Volcano, Landslide and Unknown. Also, all tsunami events with validities 1-4 are displayed to emphasize the uncertainties involved in historical tsunami data. The animation was reviewed by NOAA and United Nations Educational, Scientific and Cultural Organization (UNESCO) partners during the development process. The new animated web map is implemented with the ArcGIS API for JavaScript, ReactJS, and a NOAA GeoPlatform (ArcGIS Online) hosted feature layer. Utilizing Esri's cloud infrastructure to host the geospatial layer offers flexible visualization options and fast performance.

LINKS

Tsunami Events (1850 - Present) Time-Lapse Animation: https://www.ncei.noaa.gov/maps/tsunami-events/

Time-Lapse Viewer Teacher Guide: https://www.ncei.noaa.gov/news/ncei-supports-natural-hazards-education

> **NCEI/WDS Global Historical Tsunami Database**: https://www.ngdc.noaa.gov/hazel/view/about

NOAA Education Tsunamis: https://www.noaa.gov/education/resource-collections/ocean-coasts/tsunamis

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 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).

NEED IDENTIFIED

The HazEL interface is largely utilized by advanced and regular users such as researchers and hazard professionals, though NCEI does receive inquiries from the general public. Meanwhile, the map viewer's geospatial focus lends itself to more casual or less advanced users. Since the Spring of 2020, many more requests have been received for basic tsunami science and data products for educational settings due to the increase in remote learning as a result of the global pandemic. In response, NCEI and CIRES scientists sought to develop a tool that allows the "story" of historical tsunamis to be told in an educational setting to users new to tsunamis and tsunami data, but still allow interaction for data discoverability.



NCEI SUPPORTS NATURAL HAZARD EDUCATION The Tsunami Events (1850 to Present) Time-Lapse Animation tool and guided activity serves as an introduction to historical tsunami events and associated data suitable for grades 6-12 and general public audiences. NCEI has developed a short user guide and Tsunami Worksheet (Figures 2 & 3) that was reviewed by science educators from different states and their expertise, feedback, and suggestions were integrated into this resource prior to publication. To support educators in incorporating the Tsunami Events (1850 to Present) Time-Lapse Animation into the classroom, the user guide outlines basic use and navigation of the tool. A Teacher Guide with expanded details for each of the Tsunami Worksheet questions, additional details, tutorials, and resources can be used by educators to guide student discovery. Though the guided activity is designed to supplement science lessons, 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. The Tsunami Worksheet is available in a fillable and printable pdf format supporting use in both inperson and virtual learning environments. Further details and resources for each worksheet question are included in the Teacher Guide. Allowing students to explore the time-lapse animation tool using the prompts of the Tsunami Worksheet, students will naturally develop an understanding of science concepts including the Next Generation Science Standards MS-ESS3-2 and HS-ESS3-1. The time-lapse animation tool and its accompanying educational resources have been and continue to be promoted among teachers.



Figure 2. Tsunami Events (1850 to Present) Time-Lapse Animation Teacher Guide and Tsunami Worksheet.

> Figure 3. Tsunami Worksheet available *in printable/fillable PDF* format.

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