Sea Level Station Metadata for Tsunami Detection, Warning and Research

K.J. Stroker[1], J. Marra[2], U.S. Kari[2], S.A. Weinstein[3], L. Kong[4]

[1]NOAA/National Geophysical Data Center (NGDC) [2]NOAA NESDIS National Climatic Data Center/IDEA Center [3]NOAA NWS Pacific Tsunami Warning Center [4]UNESCO IOC International Tsunami Warning Center

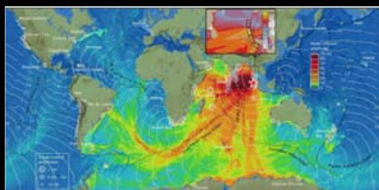
INTRODUCTION

The devastating earthquake and tsunami of December 26, 2004 has greatly increased recognition of the need for water level data both from the coasts and the deep-ocean. In 2006, the National Oceanic and Atmospheric Administration (NOAA) completed a Tsunami Data Management Report describing the management of data required to minimize the impact of tsunamis in the United States. One of the major gaps defined in this report is the access to global coastal water level data. NOAA's National Geophysical Data Center (NGDC) and National Climatic Data Center (NCDC) are working cooperatively to bridge this gap. NOAA relies on a network of global data, acquired and processed in real-time to support tsunami detection and warning, as well as high-quality global databases of archived data to support research and advanced scientific modeling. As identified in the Tsunami Data Management Report, the need also exists for long-term retention of the sea level station data. NOAA envisions that the retrospective water level data and metadata will also be available through web services, using an XML-based schema. NOAA's National Geophysical Data Center (NGDC) and co-located World Data Center for Solid Earth Geophysics (including tsunamis) would hold the archive of the sea level station data and distribute the standard metadata.

BACKGROUND

Information used to describe sea level station is distributed among databases held by multiple agencies, institutions and organizations. This information is absolutely necessary to support detection and warning. However, the global extent (Figure 1) of the Boxing Day tsunami made it clear that this information is not readily accessible.

Figure 1. Maximum computed tsunami amplitudes around the globe. Image courtesy of NOAA's Pacific Marine Environmental Laboratory (PMEL)



In early 2005, parties interested in enhancing the access and use of sea level station data united under the NOAA NCDC's Integrated Data and Environmental Applications (IDEA) Center's Pacific Region Integrated Data Enterprise (PRIDE) program to develop a distributed metadata system describing sea level stations (Kari et. al., 2006; Marra et.al., in press). This effort started with pilot activities in a regional framework and is targeted at tsunami detection and warning systems being developed by various agencies.

STATION METADATA

NOAA tsunami program relies on water level data both national and international partners (Figure 2). NOAA's Tsunami Warning Centers have developed an application to decode and display sea-level data that is transmitted from these organizations in real-time. The data arrives from coastal tide stations, as well as NOAA's DART buoys, in many different formats and is constantly changing (Figure 3).

Figure 2. Sea Level gauges and networks contributing to the Tsunami Warning System in the Pacific (TWSP).

UHSLC Format – Readable ASCII
SWIO40 RJTD 250015
:ENB 1 #1 M 3908 3908 3910 3909 3911 3909 3912 3910 3913 3913 3917 3917 3917 3917 .. …

NTC Format - Unreadable Format
91642 46/// /1205 10296 40080 22200 00287 555 77744 A0102 516`3 60029 6315B 03024 …

NOS Format - No Apparent Pattern
2.3 ^^33487552
206011307M94168411DZpQ^@@rl}0uW@1[Am@~@BsBYB\AG@BrBYBzAM@BqBZCUAB@BoBZCmA@....

NOAA DART Format – Must be decoded
D$2I 01 tt 22:53:15 ts 22:52:30 3259892
000000440000ffffffffffffffffffffffffffffffffffffeffffefffeffe01* 29
D$2I 02 tt 22:53:15 ts 22:44:00 3259897
ffffffffffefffdfffcfffcfffb000cfffafffafff9fff9fff8fff8fff701* 2C

Figure 3. Examples of real-time messages that arrive at the Tsunami Warning Center (TWC).

In the past, a considerable amount of code in the Tide Tool application was dedicated to decoding and keeping up with various changing in the methods in which data is transmitted. With the enabling of a sea-level web service that is devoted to keeping the station metadata current, Tide Tool can be more stabilized to display water-level data for real-time detection and warning.

WEB SERVICES

The NOAA IDEA Center working with the NOAA Pacific Tsunami Warning Center have developed a web service to expose station level metadata enabling real-time data mining (Figure 4). The W3C (http://www.w3.org/2002/ws/) defines a Web Service as "a software system designed to support interoperable Machine to Machine interaction over a network." Web services are frequently just Web APIs that can be accessed over a network, such as the Internet, and executed on a remote system hosting the requested services. One of the more important innovations in Web Services is "*machine-to-machine communications*." This means that a Web Service can ask another Web Service to do something, and that Web Service can ask another Web Service to do something, and so on.

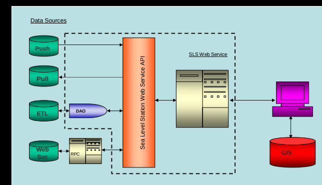


Figure 4. Four options for getting the sea level metadata to the web service

REAL-TIME DATA STREAM

The sea-level station web-service was developed for real-time applications and have a minimal list of required elements that are needed for the TWC to analyze the water-level data as it arrives at the warning center (Table 1).

SPECIFICATION	ELEMENT	DETAILS
STATION	globalID (M) localID (M) stationName (M) location status (M) operator (M) poc	lat,lon,country(M) region,horizDatum(O) person,phone,email(M)
SYSTEM	sensor systemDCP	model,sampleRate,units(M) maker,vertDatum,filters,siting,quality(O) transInterval,#Samples,start, end,constants(M) maker,model,software,length,size(O)
DATA	sampleRate(M) #Samples(M) message#(O) year,mo,day,hour,minute(O)	
PRODUCT	type(O) distribution(M) serverLocation(M)	

Table 1. List of criteria used to describe water level station specifications. These parameters are required for support of NOAA/PTWC "Tide Tool" application. (M) Mandatory Element (O) Optional Element

The schema above was developed into an XML schema. Users, such as the warning centers, can then get detailed information or transform the XML. Some of these transformations are simple XML-to-XML transformations such as the KML standard supported by Google Earth or a more complex SOAP web service applications.

LONG-TERM ARCHIVE

There is a vast difference in what is required for real-time detection and what is required for long-term archive. NOAA's National Geophysical Data Center (NGDC) will be responsible for the archive and distribution of the water-level data in support of the NOAA Tsunami Program. The goal of a long-term archive will be able to make the data available for research and modeling in 50-100 years. The user will need to retrieve data in a standard format or with all documentation or software necessary to read a format.

In order to ensure longevity of the dataset, the schema as outlined by the NOAA IDEA Center will need to be extended to include standard elements from the ISO 19115 core metadata set (Figure 6).

Figure 6. ISO 19115 Core Metadata Elements

Mandatory Elements:	Conditional Elements:
Dataset title Dataset reference date Dataset language Dataset topic category Abstract Metadata point of contact Metadata date stamp	Dataset responsible party Geographic location by coordinates Dataset character set Spatial resolution Distribution format Spatial representation type Reference system Lineage statement On-line Resource Metadata file identifier Metadata standard name Metadata standard version Metadata language Metadata character set

Incorporating the detailed work that the NOAA IDEA Center has done with a metadata standard that is supported for long-term archive will enrich the data set.

One example of how the schema might be extended would be to add the standard elements from ISO to extend the Point of Contact information (Figure 7).

poc	person,phone,email

CI_ResponsibleParty	individualName organisationName positionName contactInfo (CI_Contact) role (CI_RoleCode)
CI_Address	deliveryPoint city administrativeArea postalCode country electronicMailAddress
CI_Contact	phone address onlineResource hoursOfService contactInstructions

Figure 7. Detail needed for the long-term archive for the responsible party of a tide station data set.

Extending the schema developed by the IDEA Center would also mean adding more detail about the station history (date station first occupied, bench marks, instrument modifications), access and use constraints on the data, security constraints (proprietary or non-proprietary), data quality, processing and lineage, and online resource (CI_OnlineResource section of ISO). Of course, the data formats *MUST* be well described. If the data arrived in a binary format, the archive must have a method to decode the data. The role of the archive is to ensure that data is independently understandable and that the process has been documented from creation to user discovery (Figure 8).

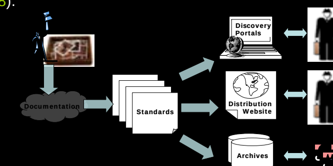


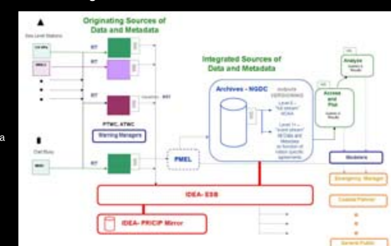
Figure 8. Creation to user discovery.

The data will not only be stored in a long-term archive at NGDC, but it will also be delivered. Delivery of the data will require an agreement between the archive and the sea level station operator. Once an agreement has been reached between the archive and the station operator, tools to access and plot the data will be standards based tools that are incorporated seamlessly into methods already in use at NGDC.

SUMMARY

To support tsunami detection and warning, as well as modeling and research requirements NOAA is working collaboratively to ensure timely delivery of water-level data both for real-time and retrospective research. The XML based schema will be enhanced for the archive, NGDC will work with station operators to distribute the data and make the data available (Figure 9). For more information, visit http://www.sealevelstations.org/.

Figure 9. Diagram showing data collected from sea level sources through to the archive.



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