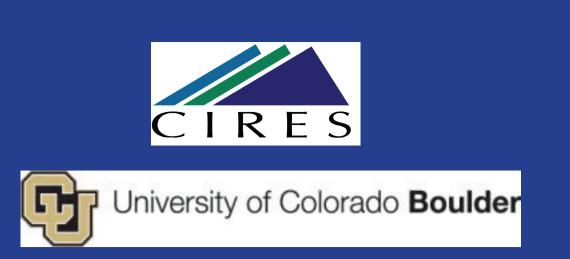
vP3.4 | EGU25-20966



# Cataloging historical tsunami marigrams from microfilm images

Aaron Sweeney<sup>1</sup>, Erik Radio<sup>2</sup>, Moukthika Gunapaneedu<sup>3</sup> <sup>1</sup> Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado Boulder <sup>2</sup> University of Colorado Boulder Libraries <sup>3</sup> University of Colorado Boulder

Contact: aaron.sweeney@colorado.edu, erik.radio@colorado.edu, moukthika.gunapaneedu@colorado.edu



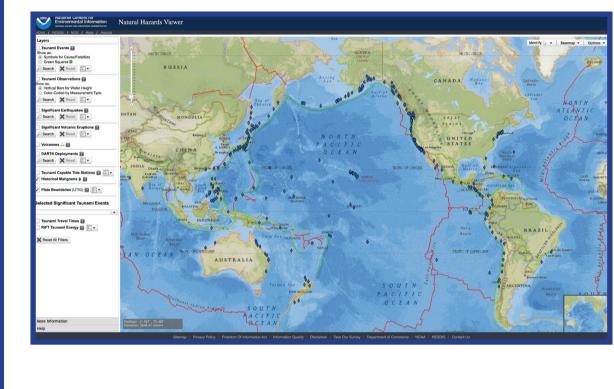
# 1. Introduction

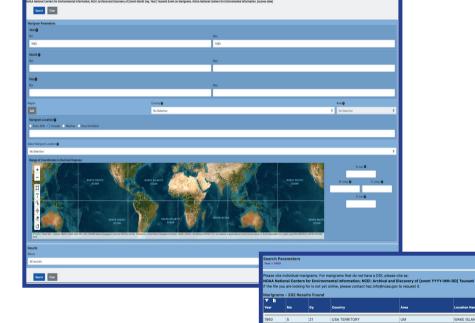
The U.S. NOAA National Centers for Environmental Information (NCEI) has more than 3,700 tsunami marigram (tide gauge) records in both image and paper format, capturing worldwide observations of more than 390 tsunami events from 1854 to 1994. The majority of these tsunami marigram records were scanned to high-resolution digital TIFF images during the U.S. NOAA Climate Data Modernization Program (CDMP) which ran from 2000 to 2011. Additional, uncatalogued physical records exist on microfilm rolls and paper at the David Skaggs Research Center (DSRC) in Boulder, Colorado, USA. For many tsunami events prior to 1994, data resides only on the marigram records, making them of great historical significance. Nine of the 12 uncatalogued microfilm rolls have been scanned by NCEI to produce over 4,000 TIFF images. During 2025, we will be working to catalog, archive, and make these images discoverable and accessible online. We will identify any duplicates by comparing to the existing catalog of marigrams already archived at NCEI. Given the large number of uncatalogued images, we are exploring automated approaches to harvesting metadata from the images to aid in cataloging. Here, we present the project background, goals, and initial results of this effort.

# 2. Background and Prior Work

# 2a. Scanned Images of Paper Marigrams (1854-1994)

NCEI has an existing collection of scanned images of paper water level records (marigrams or mareograms) that 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 images were previously cataloged to enable search by country, area name, location name, latitude, longitude, and date using NCEI's Hazards Event Lookup (HazEL) search tool: https://www.ngdc.noaa.gov/hazel/view/hazards/tsunami/marigram-search/. Preview images and high-resolution TIFF images are linked in the search results for direct download. We plan to do the same with the 4,000 microfilm images.

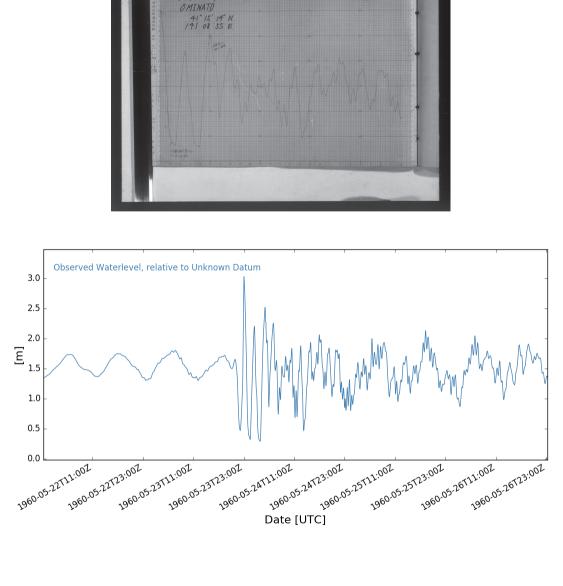






## 2b. Marigram Digitization

We received funding in 2017-2018 to digitize select marigram images. Ten events were selected based on their impacts: 1854, 1883 (Krakatau eruption), 1896, 1933, 1945, 1946 (M8.6 Alaska), 1952 (M9 Kamchatka), 1960 (M9.5 Chile), 1964 (M9.2 Alaska), and 1968 (M8.2 Japan). A total of 48 marigrams were digitized into a tabular format, improving the usability of these in situ data to validate tsunami models. Challenges included faded ink in traces and in annotations, paper creases and tears, trace wrap-around, recorder idiosyncracies, and the need for manual point-picking and sleuthing of location, time-zone, vertical da-



## 3. Methodology

To support search and discovery, the following metadata will be identified: country, area name, location name, latitude, longitude, scale factor, and record start and end dates. Descriptive text on the images will be captured in a comments field to provide historical context and support further refinement of data usefulness, for example, the identification of vertical datum and scale. Optical character recognition has been employed to aid in text capture. Not all of the images present on the microfilm are marigrams, some are tide tables, so some additional effort at image classification is

Some of the difficulties encountered include poor image contrast, poor text legibility, lack of information, and the need to identify and group images that belong to the same time-series.

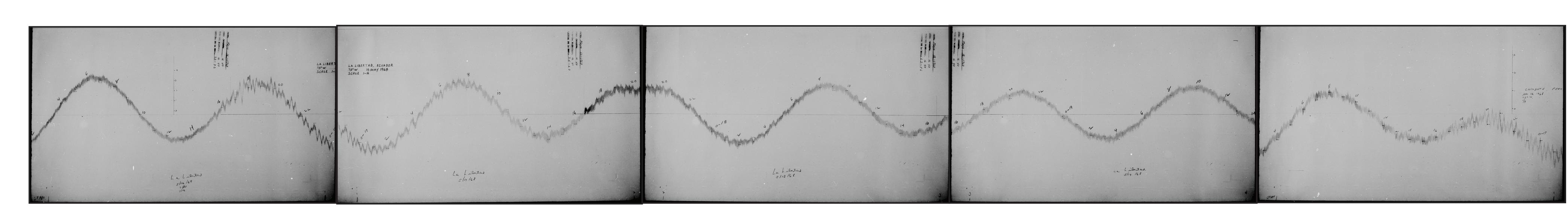


Figure 1: A sequence of images from a single roll of microfilm with good contrast. As indicated by the hand-written annotation on each image, the first four images belong to the same time-series (La Libertad, Ecuador, in May 1968), while the fifth image belongs to another time-series at another location (Chimbote, Peru, in May 1968). The vertical unit of measure and vertical datum are absent. Clock times are likely in the local time zone, but require validation against known tsunami event and runup times in UTC, as recorded in the NCEI/WDS Global Historical Tsunami Database.

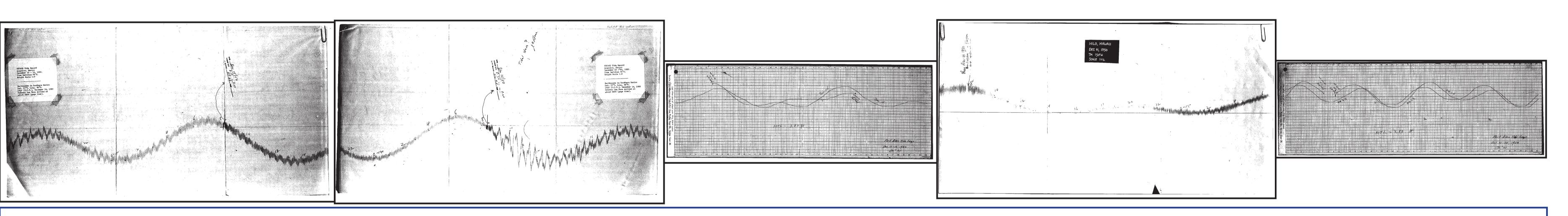


Figure 2: A sequence of images from a single roll of microfilm. The images belong to the same time-series (Acapulco, Mexico, in December 1950). Poor image contrast and "noise" presents challenges to metadata identification as well as data usability.

## 4. Initial Results

About 10% of the 4,000 images have been assigned a country, area name (state, prefecture, region, or other administrative unit), location name, latitude, longitude, and record start and end dates. Descriptive text on the images has been captured in a comments field in the resulting table. Grouping of images that belong to the same time-series has been a manual process. Tsunami event dates will be filled in by comparing the record start and end dates against the dates recorded in the NCEI/WDS Global Historical Tsunami Database.

	Hamiltonia de	THE RESERVE OF THE PARTY OF THE		arange .	-	1000 10 10	1000 10 10	1000 1011	1,31,616			110 1100 1100 1000	proprieta de la constantina della constantina de
NOS1788-1950_0002:tif	MEXICO	GUERRERO	ACAPULCO	acap2	88	1950-12-13	1950-12-15	1950-12-14	16.86	-99.89	1 OF 2	1:9 NOS1788-1950	"Earthquake in Southern Mexico. Seismic sea wave arrived at approximately 0835 (gage time)"
NOS1788-1950_0003.tif	USA	HAWAII	PORT ALLEN	pall	80	1950-12-14	1950-12-14	1950-12-14	21.89	-159.58	1 OF 1	1:11 NOS1788-1950	Writing's in the image are unclear.
NOS1788-1950_0004.tif	USA	HAWAII	HILO	hilo2	80	1950-12-14	1950-12-14	1950-12-14	19.73	-155.09	1 OF 1	1:12 NOS1788-1950	
NOS1788-1950_0005.tif	USA	HAWAII	PORT ALLEN	pall	80	1950-10-21	1950-10-25	1950-10-21	21.89	-159.58	1 OF 1	NOS1788-1950	Writing's in the image are unclear.
NOS1788-1950_0006.tif	USA	HAWAII	HILO	hilo2	80	1950-10-23	1950-10-23	1950-10-23	19.73	-155.09	1 OF 1	1:12 NOS1788-1950	
	0.64	100000000		17.00	A 2.0		E1200000000000	100000000000000000000000000000000000000	07/30	12200000	20000		"Earthquake near Guatemala. An unusual disturbance occurred between 21 and 22 hr (wave
NOS1788-1950_0007.tif	ECUADOR	LA LIBERTAD	LA LIBERTAD	lali	89	1950-10-23	1950-10-24	1950-10-23	-2.233	-80.91	1 OF 1	1:16 NOS1788-1950	time) on October 23."
NOS1788-1950_0008.tif	USA	HAWAII	HONOLULU	hono	80	1950-10-24	1950-10-24	1950-10-24	21.3069	-157.8583	1 OF 1	1:6 NOS1788-1950	
NOS1788-1950_0009.tif	GUATEMALA		PUERTO SAN JOSÉ	prsj	88	1950-10-23	1950-10-25	1950-10-24	13.9167	-90.8333	1 OF 2	1:12 NOS1788-1950	"Earthquake near Guatemala. There were several foreshocks" Readings are faint.
NOS1788-1950_0010.ttf	GUATEMALA		PUERTO SAN JOSÉ	prsi	88	1950-10-27	1950-10-28	1950-10-27	13.9167	-90.8333	2 OF 2	1:12 NOS1788-1950	"Earthquake near Guatemala. There were several foreshocks" Readings are faint.
NOS1788-1950_0011:tif		16										NOS1788-1950	No readings found in the image.
NOS1788-1950_0012.tif	DUIT IDDINES		DAVAO	davo	84	1950-10-09	1950-10-10	1950-10-10	7.0731	125.6128	2 OF 2	NOS1788-1950	No scale or event commentary visible.
NOS1788-1950_0013.tlf		15	DAVAO		84						1 OF 2		
WD31700-1230_0013.01	PHILIPPINES		DAWAG	davo	04	1950-10-09	1950-10-10	1950-10-10	7.0731	125.6128	1 OF 2	NOS1788-1950	"NOS COPY ILLEGIBLE" and No readings found in the image.
NOS1788-1950_0014.tif	USA	CALIFORNIA	LA JOLLA	lajo	80	1950-10-09	1950-10-10	1950-10-10	32.849	-117.2707	2 OF 2	NOS1788-1950	"Note: Hours marked on the curve have been interpolated in office." No readings found in the image.
NOS1788-1950_0015.tif	USA	CALIFORNIA	LA JOLLA	lajo	80	1950-10-09	1950-10-10	1950-10-10	32.849	-117.2707	1 OF 2	NOS1788-1950	"NOS COPY POOR"  "Note: Hours marked on the curve have been interpolated in office."  No readings found in the image.
NOS1788-1950_0016:tif	PHILIPPINES		CEBU	cebu	84	1950-10-09	1950-10-10	1950-10-10	10.3	123.91666	2 OF 2	NOS1788-1950	"Vertical hourly marks were interpolated in the office." No readings found in the image.
NOS1788-1950_0017.tif			CEBU	cebu	84	1950-10-09	1950-10-10	1950-10-10	10.3	123.91666	1 OF 2	NOS1788-1950	"NOS COPY ILLEGIBLE." "Vertical hourly marks were interpolated in the office." No readings found in the image.
NOS1788-1950_0018.tif		HAWAII	HILO	hilo	80	1950-10-05	1950-10-05	1950-10-05	19.7297	-155.09	1 OF 1	1:12 NOS1788-1950	remain many many many many and a many many many many many many many ma
14031740-1330_0010.01	USA	THATAN	HILO	THO	90	1950-10-05	1950-10-05	1950-10-05	19.7297	-155,09	TOFT	1.12 NOS 1700-1930	"Earthquake in NW Costa Rica."
NOS1788-1950_0019.tif	EL SALVADOR		LA UNION	laun	88	1950-10-05	1950-10-06	1950-10-05	13.4833	-87.8833	1 OF 1	1:24 NOS1788-1950	"The seiche, although small, is unusual and corresponds to a seiche which appeared on the Puritarenas record soon after the earthquake." No readings found in the image.
													"Earthquake in NW Costa Rica."
NOS1788-1950_0020.tif	EL DAUMBOO		LALIDERTAD	La De	88	4050 40 05	4050 40 00	4050 40 05	42 4402	00.000	4.05.4	4-45 NOD4700 4000	"A possible seiche is noted on the 5de record starting after 1600 (gauge time) on October 5."
			LA LIBERTAD	laib	-	1950-10-05	1950-10-08	1950-10-05	13.4883	-89.322	1 OF 1	1:16 NOS1788-1950	No readings found in the image.
NOS1788-1950_0021.tif		NAME OF THE PROPERTY OF THE PR	PUNTARENAS	punt	88	1950-10-05	1950-10-06	1950-10-05	9.9763	-84.8389	1 OF 1	1:16 NOS1788-1950	"This is the same earthquake which destroyed the tide station at Puerto Armuelles, Panama"
NOS1788-1950_0022-tif		HAWAII	HONOLULU	hono	80	1950-10-06	1950-10-06	1950-10-06	21.3	-157.87	1 OF 1	1:6 NOS1788-1950	
NOS1788-1950_0023.tif	USA	HAWAII	PORT ALLEN	pall	80	1950-10-04	1950-10-07	1950-10-05	21.9	-159.59	1 OF 1	1:11 NOS1788-1950	
NOS1788-1950_0024.tif	PANAMA	BALBOA CANAL ZONE	BALBOA HEIGHTS		88	1950-05-01	1950-06-02	1950-04-30	8.9667	-79.5667	1 OF 1	NOS1788-1950	"SEICHE PROBABLY CAUSED BY EARTHQUAKE. RECORDED AT BALBOA HEIGHTS, CANAL ZONE AT 23:50:37 G.M.T. ON APRIL 30, 1950. EPICENTER: Lat. 4" N., Long. 82" W. APPROXIMATE DISTANCE FROM BALBOA: 275 miles."
NOS1788-1950_0025.tif												NOS1788-1950	No readings found in the image.
-													No readings found in the image.
NOS1788-1950_0026.tlf	MARSHALL ISLANDS		KWAJALEIN	lowaj	80	1949-11-01	1949-11-01	1949-11-01	8.73	167.73	1 OF 1	NOS1788-1950	"No Tsunami Recorded"
NOS1788-1950_0027.tif	USA	HAWAII	HONOLULU	hono	80	1949-10-20	1949-10-20	1949-10-20	21.3	-157.87	1 OF 1	1:6 NOS1788-1950	Readings are very faint.
VOS1788-1950_0028.tlf	PAPUA NEW GUINEA		RABAUL	raba	82	1949-10-19	1949-10-20	1949-10-20	4.2	152.18	1 OF 1	1:12 NOS1788-1950	Readings are very faint. "Earthquake near Solomon Islands, 5°05'S, 154"E at 0700 October 20, 1949 (2100Z Oct. 19, 1949). Motor clock failure prevented recording of initial receipt which was computed to arrive at about 0737 Oct. 20. Vertical motion of pencil during time clock was stopped indicates an extreme range of 2.0 feet between highest and lowest points of seismic sea wave."
NOS1788-1950_0029.tif	PAPUA NEW GUINEA		DREGTER HBR, NEW GUINEA		82	1949-10-20	1949-10-20	1949-10-20	-5.5	150	1 OF 1	1:12 NOS1788-1950	"Earthquake at 5"5"S, 154"E near Solomon is, 2100Z Oct 19, 1949."
NOS1788-1950_0030.tif		HAWAII	PORT ALLEN	pall	80	1949-10-19	1949-10-22	1949-10-19	21.9	-159.59	1 OF 1	1:11 NOS1788-1950	
NOS1788-1950_0031:tif		HAWAII	HILO	hilo	80	1949-10-19	1949-10-19	1949-10-19	19.7297	-155.09	1 OF 1	1:12 NOS1788-1950	
14031740-1230_003101	USA	TOWNS	HILO	mo	00	1949-10-19	1949-10-19	1943-10-19	19.7297	+155.09	TOFT	1.12 NOS 1700-1930	Readings are very faint. Details about the location are not found.
NOS1788-1950_0032.tif			MANUEL MAGNET			1949-09-27	1949-09-27	1949-09-27				NOS1788-1950	"Severe Earthquake, 40 second duration."
NOS1788-1950_0033.tif	PHILIPPINES		MANILA YACHT BASIN	mani	84	1949-09-03	1949-09-05	1949-09-03	14.5833	120.9667	1 OF 1	1:16 NOS1788-1950	
NOS1788-1950_0034.tif	USA	HAWAII	HONOLULU	hono	80	1949-08-22	1949-08-22	1949-08-22	21.3	-157.87	1 OF 1	1:6 NOS1788-1950	
NOS1788-1950_0035.tlf	USA	HAWAII	HILO	hilo	80	1949-08-22	1949-08-22	1949-08-22	19.7297	-155.09	2 OF 2	1:12 NOS1788-1950	
NOS1788-1950_0036:tif	USA	HAWAII	HILO	hilo	80	1949-08-21	1949-08-21	1949-08-21	19.7297	-155.09	1 OF 2	1:12 NOS1788-1950	
051788-1950_0037.tif						1949-08-22	1949-08-22	1949-08-22			1 OF 1	NOS1788-1950	Partial readings can be seen. Information about the location is unavailable.  "Checking for sidal wave. Staff read 14.1 Cor. time 21:56 Zone time 21:56 Sea very calm."
NOS1788-1950_0038.tif	USA	WASHINGTON	SEATTLE	dsea2	88	1949-04-13	1949-04-13	1949-04-13	47.6	-122.33	1 OF 1	1:2 NOS1788-1950	"Wednesday"
NOS1788-1950_0039.tif		THE RESERVE OF THE PARTY OF THE	PAGO PAGO, SAMOA	100000	81	1948-09-08	1948-09-08	1948-09-08	-14.276	-170.702	1 OF 1	1:12 NOS1788-1950	
		HAWAII			80	1948-09-08	1948-09-09	1948-09-08	21.44	-158.19	1 OF 1	1:12 NOS1788-1990 1:12 NOS1788-1990	"Earthquake near Tonga Islands (Lat. 21"S. Long. 174"W) at 1509 G.C.T."
NOS1788-1950_0040.tif		HOWAII	WAIANAE, OAHU	waian	April 9				21.44	.158.19	7 7 16 7	717 2 64 15 7 7 8 9 7 16 7	

#### 5. Continued Effort

We will continue to examine the images to identify metadata to aid in search and discovery, and group images together that belong to the same time-series to prepare for long-term archive and for access via direct download.

# 6. Funding Acknowledgment

Funding for this work extends through 2025 and is provided by funding from the University of Colorado Boulder Libraries. A. Sweeney is supported by NOAA cooperative agreement NA22OAR4320151. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

## 7. References

 National Geophysical Data Center / World Data Service: NCEI/WDS Global Historical Tsunami Database. NOAA National Centers for Environmental Information. doi:10.7289/V5PN93H7