NOAA Meteotsunami Project

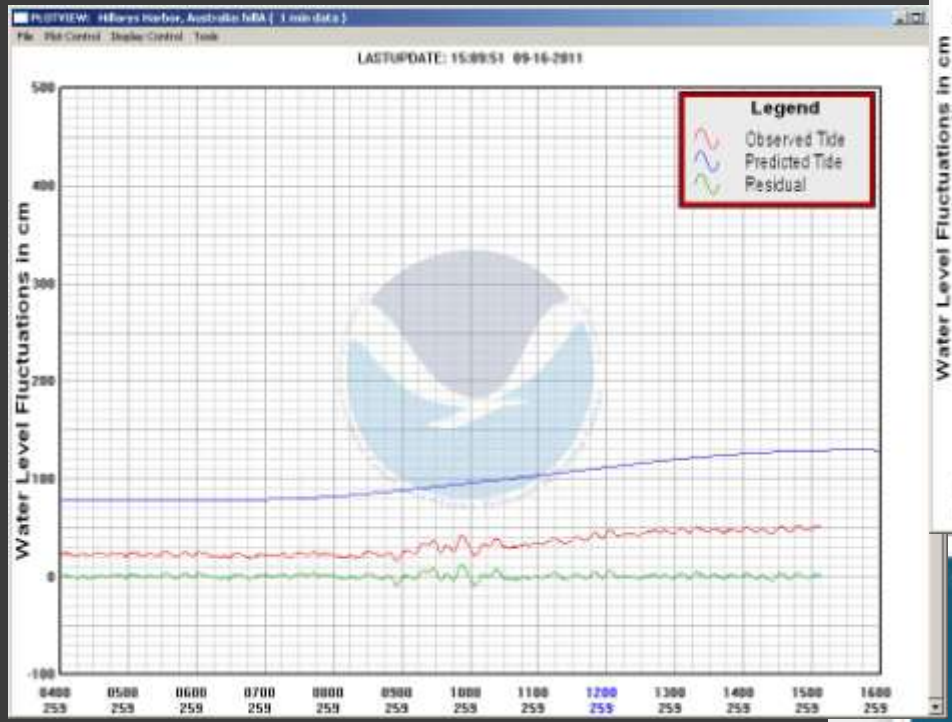
Paul Whitmore
NOAA/NWS West Coast/Alaska Tsunami Warning Center
October, 2011

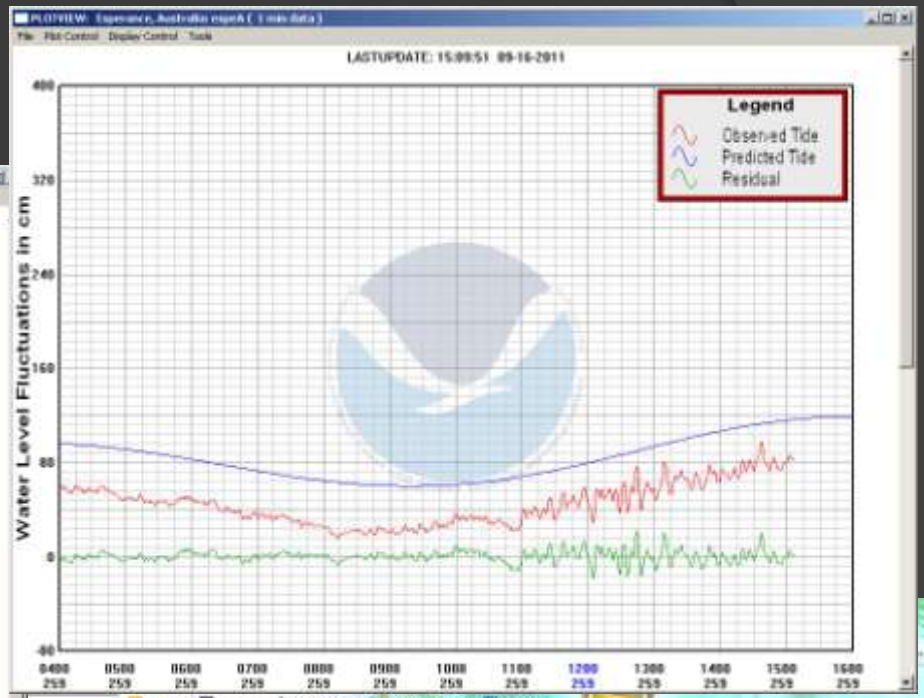
WCATWC in Palmer, Alaska

???Site of next meteotsunami project meeting???

Recent meteotsunami?

Southwest Australia September 16, 2011





Project Motivation

October 28, 2008 Boothbay, Maine

- October 28, 2008 Boothbay, Maine surprise event
- All indications point to meteorological origin
  - Other probable east coast meteotsunamis were recorded in 1994 (Maine) and 1992 (Florida)
- NWS Alaska Region – Can't we do something about these things?

Project History

2009 NOAA Tsunami Program Meeting

- September 2009 NOAA Tsunami Program meeting: the meteotsunami threat to US east coast discussed
  - Cited as a larger threat than traditional tsunami.
- Meteotsunami warning development in the Mediterranean region
- Decision made to invest in meteotsunami warning system development project

Project History

2010 Grant RFP

- Announcement for Federal Funding Opportunity issued July, 2010
  - No proposals received.
- Announcement scaled back and reissued January, 2011.
- Successful applicants led by PI Vilibic announced August, 2011

Project Deliverables

Objective 1 of 3

- Identify causative forces and precursor environmental conditions conducive to meteotsunami formation.
  - Meteorological conditions
  - Bathymetric conditions
  - Use the conditions to explain historic meteotsunamis
  - Explain basic relations used to forecast timing and impact based on causative factors

Project Deliverables

Objective 2 of 3

- Define observational and processing systems needed to forecast events.
  - Observational data necessary
    - Existing
    - New
  - Communications of data to a warning center
    - Latency
    - Bandwidth
  - Design processing to ingest and forecast
  - Work with appropriate NWS facilities

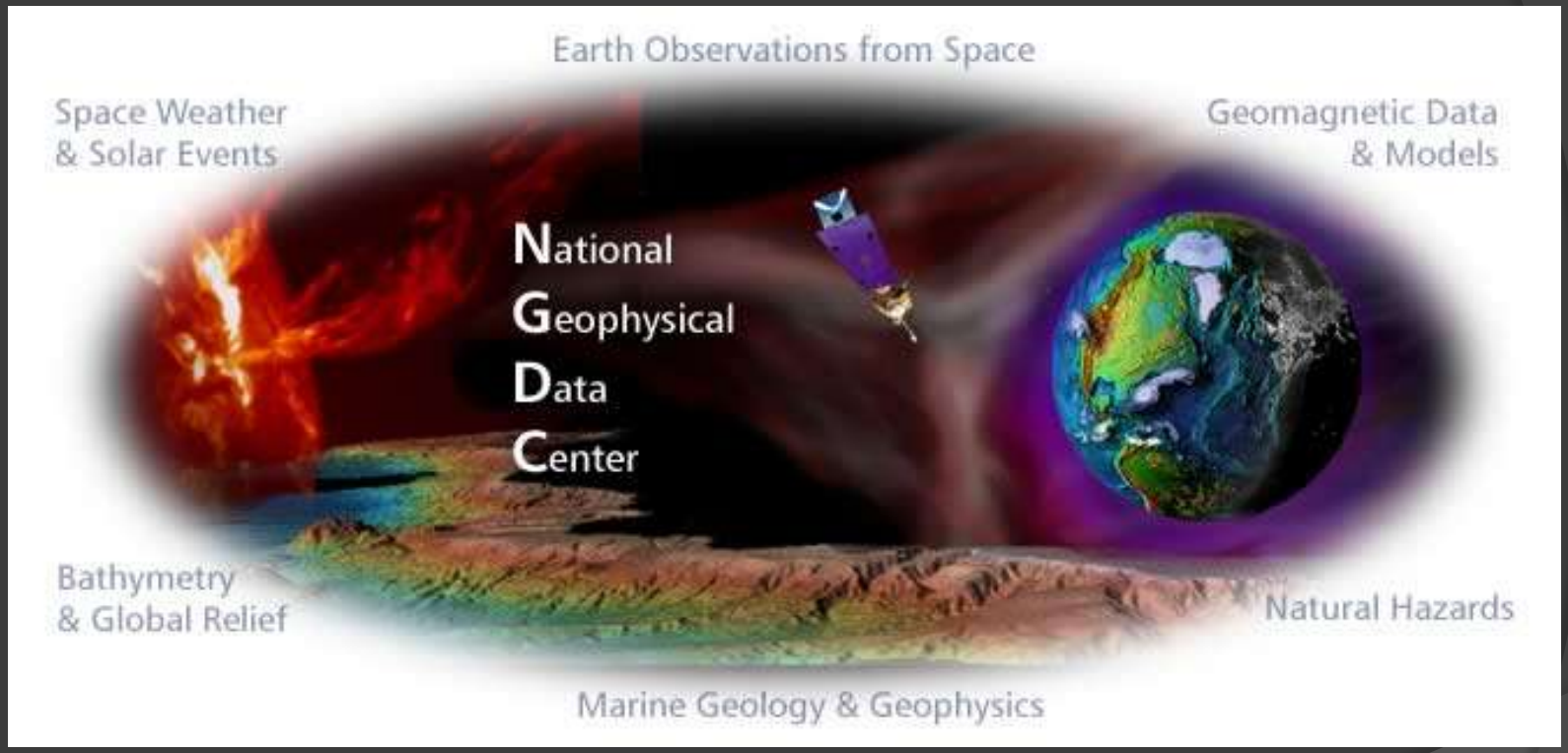
Project Deliverables

Objective 3 of 3

- Develop warning protocol for US
  - Define necessary environmental measurements
  - Develop warning procedures/protocols
  - Provide design case for historic event
  - Work with NWS facilities to determine operational constraints

U.S. Department of Commerce
National Oceanic & Atmospheric Administration

National Geophysical Data Center (NGDC)



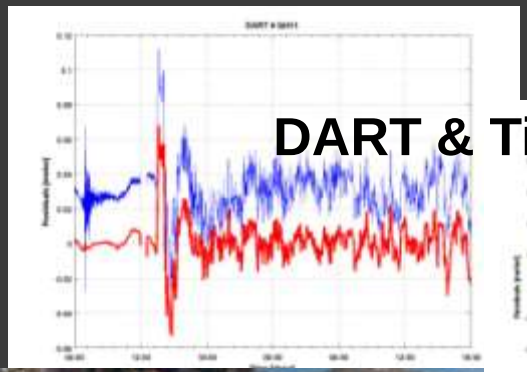
Paula Dunbar and George Mungov

http://ngdc.noaa.gov/hazards

Natural Hazards Data

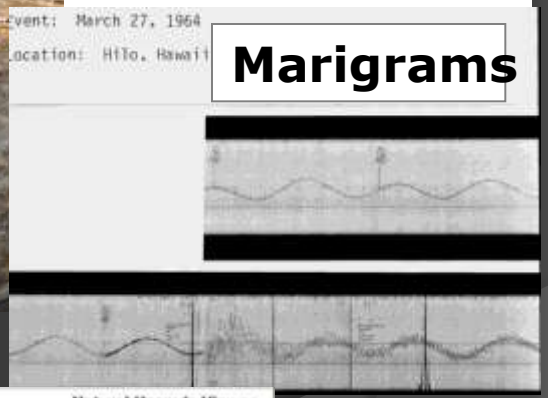
- **Global historical event databases**
  - **Tsunami event & runup databases**
  - **Earthquakes & Volcanic eruption databases**
  - **Includes damage, deaths, $**
- **Tsunami Deposits**
- **Tsunami References**
- **Damage Photos**
- **DART ® BPR data**
  - **Codes developed to extract tsunami signals**
- **High resolution tide gauge data**
- **Web Map, Feature, KMZ data delivery**

http://ngdc.noaa.gov/hazard



DART & Tide Gauge

Photos



Marigrams

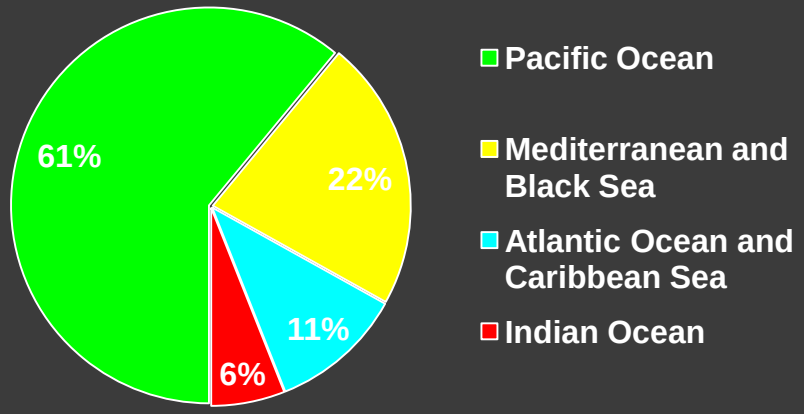
Tsunami Events

Historical Tsunami Database

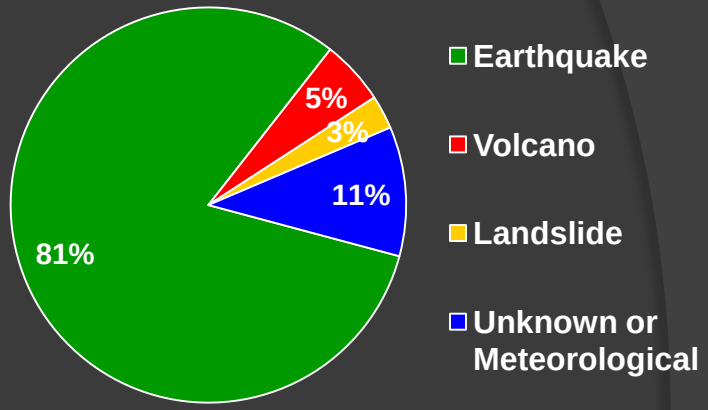
- **Tsunami Source Event**
  - Date/time, location, magnitude, validity, max water height, deaths, damage, references
- **Tsunami Runups**
  - Type of measurement, water heights, inundation distance, arrival times, wave periods, first motion, deaths, damage, references
- **Variety of Data Sources**
  - Tide gauge observations, deep ocean sensors, tsunami warning centers, field surveys, eyewitness accounts, journal articles, data catalogs, newspapers, etc.
- **Tsunami Event Validities**
  - High (validity3-4) - recorded on seismograph and tide gauge, prior to instrumental records – reported by many reliable and independent sources, many reports of deaths, damage and observations of waves in many locations
  - Low (validity 1-2) - prior to instrumental recordings, described by only source, reported to be earthquake-caused, but not listed in local earthquake catalogs, *possibly meteorologically caused*
  - Seiche or river disturbance (validity 0)
  - Erroneous (validity -1)

Distribution of Global Tsunamis

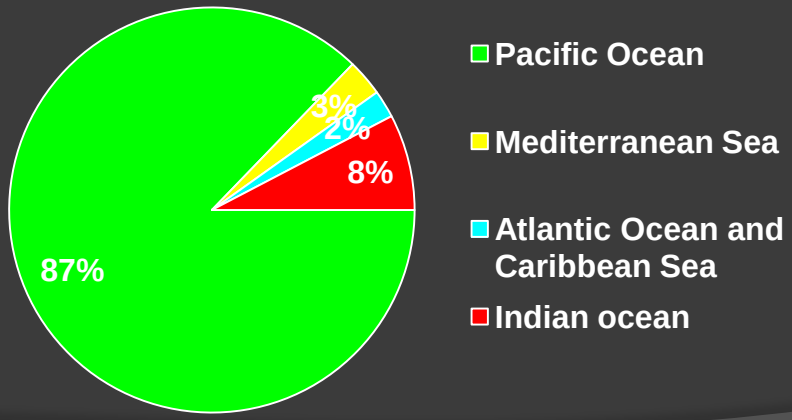
- **2,120 Tsunami Source Events**



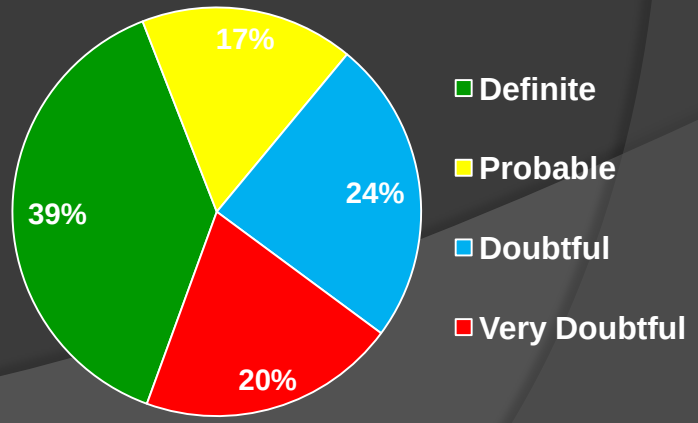
Cause of Tsunami



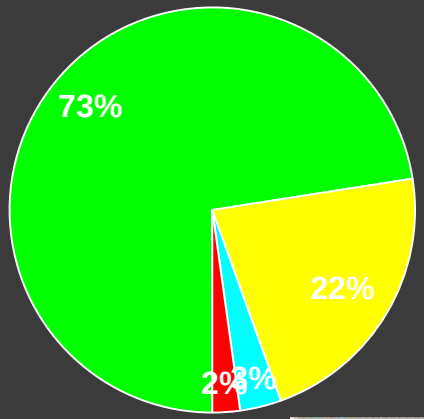
- **21,208 Tsunami Runups**
  - (27% from 2011 Tohoku, 5% from 2004 Sumatra)



Validity of Tsunami

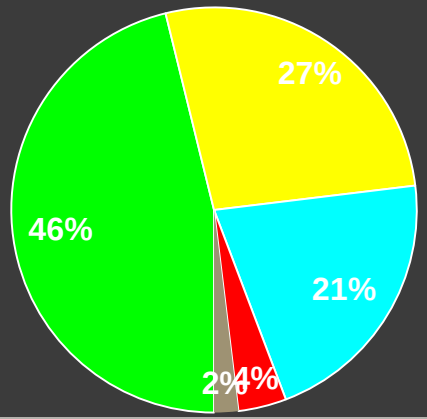


Distribution of Meteotsunamis



Global

- Pacific Ocean
- Mediterranean and Black Sea
- Atlantic Ocean and Caribbean Sea



United States and Territories

- West Coast
- Hawaii, American Samoa
- East Coast U.S.
- Alaska
- U.S. Virgin Islands

Tsunami Events Full Search, sort by ...

1909	9	20				-1	9			*		USA	LOUISIANA: GRAND ISLE				1			
1910	11	21	12	45		-1	9			*		USA	SAN FRANCISCO, CA			.30	1			-1.50
1915	2	11				1	9			*		USA TERRITORY	MARIA ISLANDS, AMERICAN SAMOA	-14.210	-169.580	2.40	1			
1921	12	16				-1	9			*		USA	HAWAII				1			
1923	2	17				-1	9			*		CHILE	CENTRAL CHILE	-35.330	-72.420	1.50	1		.60	1.50
1923	9	4				-1	9			*		USA	N. CALIFORNIA			6.10	1			
1924	5	30				-1	9		Vol	*		USA	HAWAII			5.00	3		2.30	2.00
1925	5	11				-1	9			*		ITALY	CALABRIAN ARC				0			
1925	10	4	16			1	9			*		USA	CALIFORNIA			.34	2			-1.00
1925	12	22				1	9			*		MICRONESIA, FED. STATES OF	CAROLINE ISLANDS, YAP ISLAND	10.000	138.000		1			
1926	3	31				-1	9			*		COOK ISLANDS	COOK ISLANDS				1			2.50
1927	1	1	8	17		1	9	5.7		*		USA	CALIFORNIA	32.500	-115.500		1			1.00
1928	9	13				-1	9			*		VENEZUELA	CARUPANO				1			
1929	8	9				1	9			*		CHILE	ANTOFAGASTA	-23.700	-70.400	7.50	0		2.00	
1931	8	19				1	9			*		USA	ATLANTIC CITY, NJ	39.350	-74.417	3.00	4			
1932	5	7				-1	9			*		ITALY	CALABRIAN ARC				0			
1932	11	10				-1	9	*		*		USA	WILLETTS POINT, NEW YORK			5.40	1			
1933	3	11	1	54	7.0	0	9	8.3		*		USA	S. CALIFORNIA	33.616	-117.966	.10	2		-3.30	
1934	8	21				0	9			*		USA	S. CALIFORNIA	33.700	-118.200	12.00	6			3.00
1938	11	21	11	41		1	9			*		USA	HAWAII	19.500	-155.500		1			2.00
1938	9	21				1	9			*		USA	NEW JERSEY COAST	39.950	-74.120		1			
1944	9	14				1	9			*		USA	NEW JERSEY COAST	38.933	-74.900		1			
1947	1					-1	9			*		USA	HAWAII				0			
1952	5	6				0	9			*		USA	LAKE HURON, MI	43.100	-82.400	1.52	3			
1954	6	26				0	9			*		USA	MICHIGAN CITY, IN (LAKE MICHIGAN)	41.700	-86.883	3.00	5			
1957	11	1	5	0		-1	9			*		USA	HAWAII			.10	5			-3.00
1988	4	30				-1	9			*		USA	S. CALIFORNIA				1			
1991	5	7				1	9			*		GREECE	EAST AEGEAN SEA	37.133	26.833	.50	1		-3.30	
1992	7	3				-1	9			*		USA	DAYTONA BEACH, FL			6.00	4			
1994	1	4				1	9			*		USA	COREA HARBOR, MAINE	44.400	-67.970	1.50	1			
2000	1	26				-1	9			*		PHILIPPINES	TAWI-TAWI, PHILIPPINES	5.100	120.150	20.00	4			

91 events returned

Possible US Meteotsunamis

- Selected events in the NGDC Database
- Events are on the U.S. coasts
- Another to look at is 2008 Boothbay, Maine
- 1926 Maine Event (listed as landslide)

1944 – Probable hurricane
1957 – very small
1988 - ??? Wind wave

NOAA NATIONAL GEOPHYSICAL DATA CENTER

Search NGDC Search NOAA Go

NOAA > NESDIS > NGDC > Natural Hazards privacy policy

Tsunami Events Search - sorted by Date, Country

Tsunami Events where Year >= 1940 and (Cause for the Tsunami <= 9 and Cause for the Tsunami >= 9) and Country = USA

View parameter descriptions and access statistical information by clicking on column headings.

For additional information about the tsunami, runups, associated earthquake or volcanic eruption, click on the links in the **Earthquake Mag**, **Volcano**, **Addl Tsu Info**, or **Num. of Runups** columns.

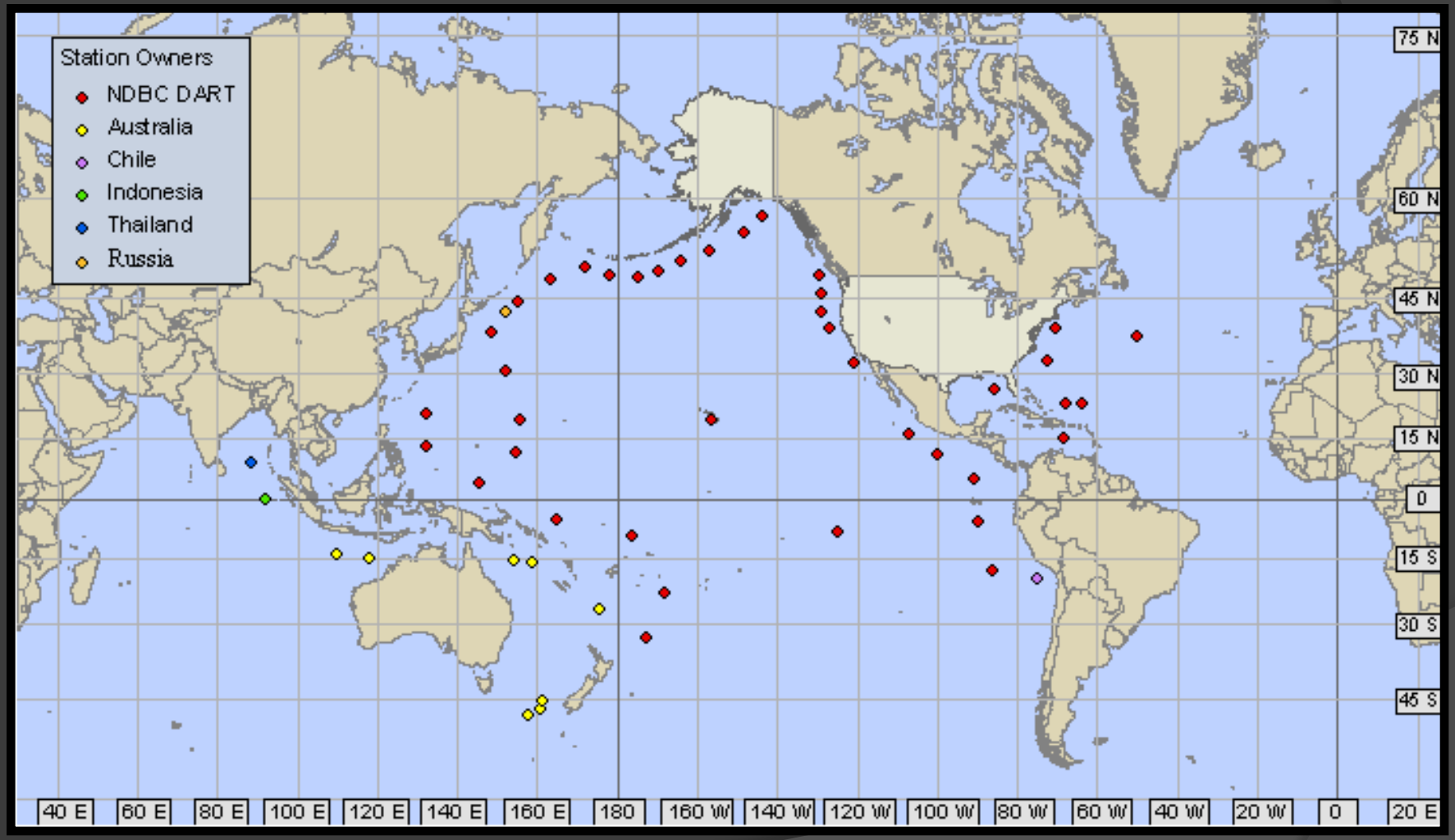
Date						Tsunami Cause				Addl Tsu Info	Deposits	Tsunami Source Location			Tsunami Parameters								
Year	Mo	Dy	Hr	Mn	Sec	Val	Code	Earth-quake Mag	Vol-cano			Country	Name	Latitude	Longitude	Max Water Height	Num. of Runups	Magnitude Abe	Magnitude Iida	Tsu Int	Warn Status	Deaths Num	Deaths De	Injurie Num	Injurie D
1944	9	14				1	9			*		USA	NEW JERSEY COAST	38.933	-74.900		1								
1947	1					-1	9			*		USA	HAWAII				0								
1952	5	6				0	9			*		USA	LAKE HURON, MI	43.100	-82.400	1.52	3								
1954	6	26				0	9			*		USA	MICHIGAN CITY, IN (LAKE MICHIGAN)	41.700	-86.883	3.00	5					8	1		
1957	11	1	5	0		-1	9			*		USA	HAWAII			.10	5			-3.00					
1988	4	30				-1	9			*		USA	S. CALIFORNIA				1								
1992	7	3				-1	9			*		USA	DAYTONA BEACH, FL			6.00	4								
1994	1	4				1	9			*		USA	COREA HARBOR, MAINE	44.400	-67.970	1.50	1								

Observational Networks and Data Sets

- Sea Level
  - Coastal tide gage
  - Deep Ocean (DART)
- Pressure/Wind
  - Ocean buoys
  - Coastal network
- Vertical Sounding
- Satellite
- Historical Observations
- Bathymetry/Elevation

Observational Networks

Sea Level - DART network



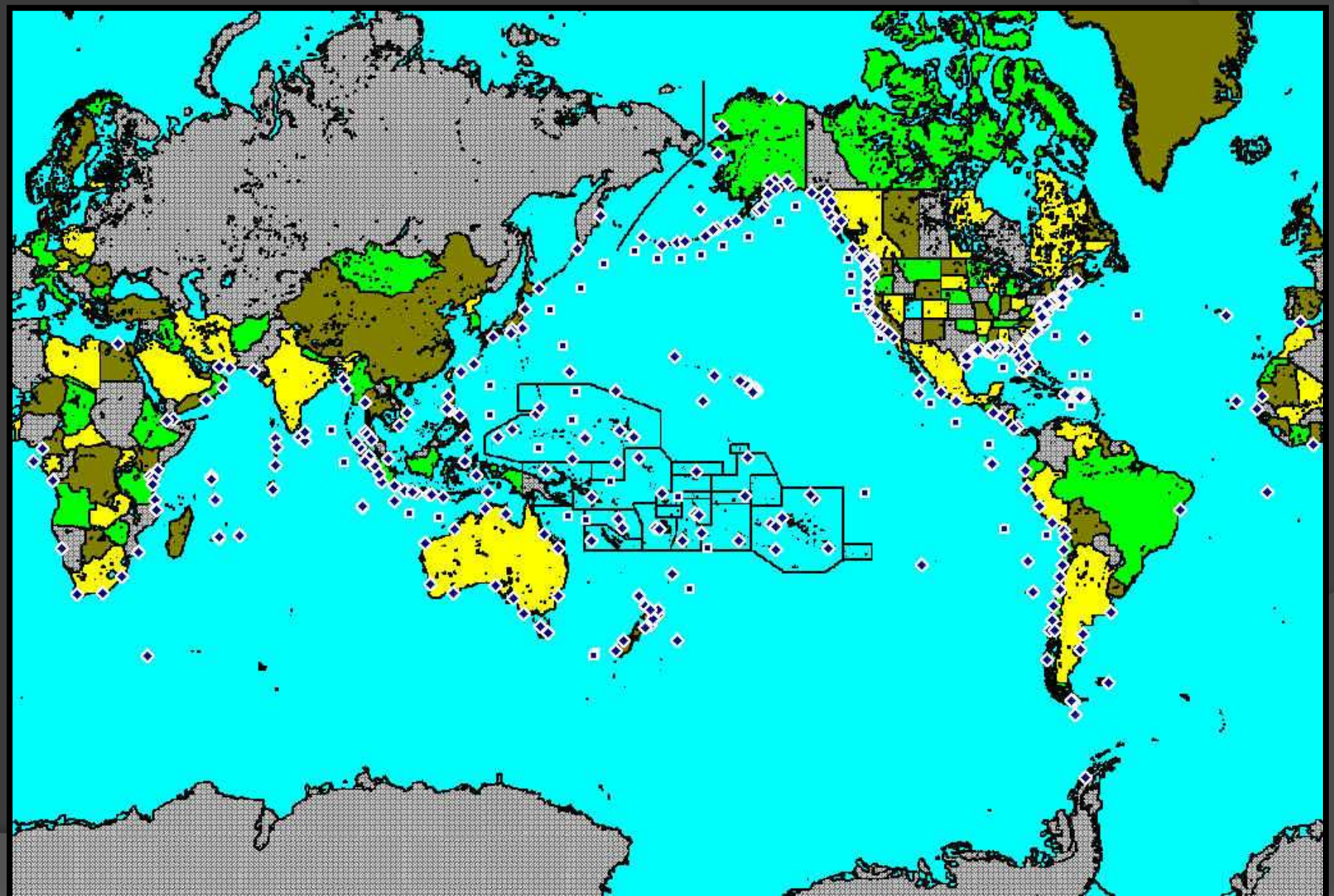
Observational Networks

Sea Level - DART network

- Data available at NGDC
  - http://www.ngdc.noaa.gov/hazard/DARTData.shtml
- OR NDBC
  - http://www.ndbc.noaa.gov/dart.shtml
- Contact:
  - Paul.whitmore@noaa.gov – will get with the correct person

Observational Networks

Sea Level – Coastal tide gage network



Observational Networks

Sea Level – Coastal tide gage network

- Data available through NOS tsunami site
  - http://tidesandcurrents.noaa.gov/tsunami/
- OR NGDC
  - http://www.ngdc.noaa.gov/hazard/tide.shtml
- Contact:
  - Allison Allen - allison.allen@noaa.gov

Observational Data Sets

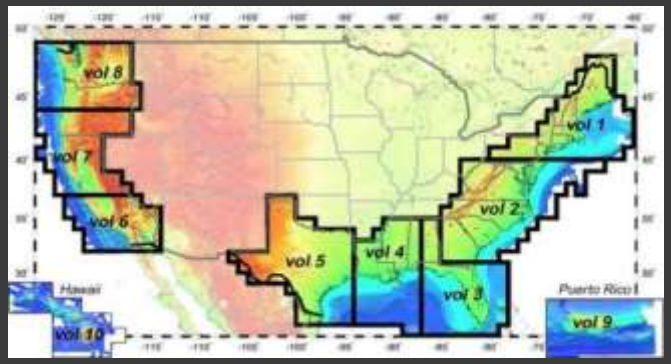
Bathymetric/Elevation Data Sets

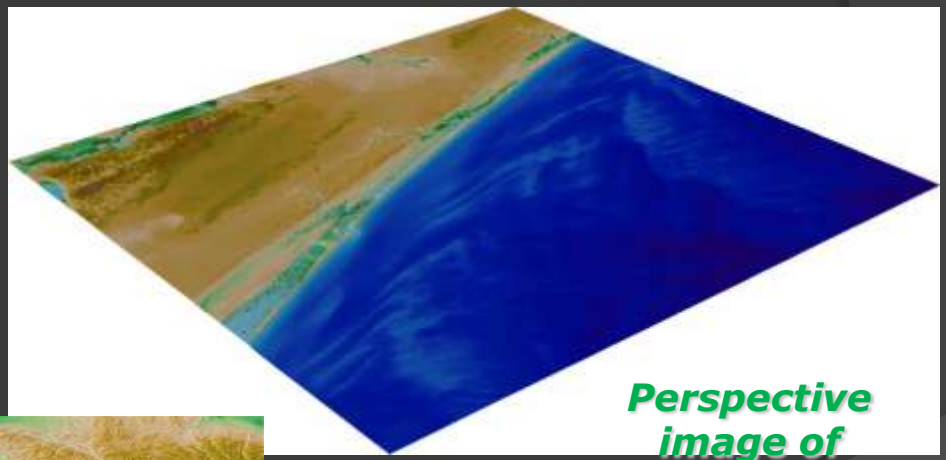
- NGDC provides access to high resolution and low resolution digital elevation models
  - http://www.ngdc.noaa.gov/mgg/dem/demportal.html - Discovery portal
  - http://www.ngdc.noaa.gov/mgg/inundation/tsunami/inundation.html - Tsunami DEMs
  - http://www.ngdc.noaa.gov/mgg/bathymetry/relief.html - All bathy/topo data sets
- Contact:
  - Paul.whitmore@noaa.gov – will get with the correct person

Marine Modeling

Develop, archive, and provide access to global, regional, and community level bathymetric-topographic digital elevation models (DEMs) and derived products

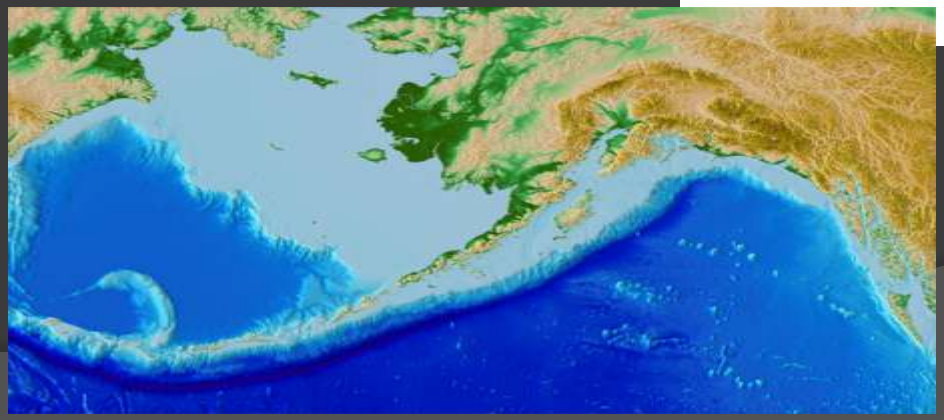
Select products include: 10-m coastal tsunami inundation DEMs, Coastal Relief Models (90m-30m) for the U.S., ETOPO1, and Great Lakes bathymetry





Perspective image of Daytona Beach tsunami inundation DEM

CRM for Southern AK



Observational Networks

Weather buoys

- Products
  - Pressure
  - Wind
  - Wave Height/Period
- Buoys operated by NDBC – see data at http://www.ndbc.noaa.gov/
- Resolution – details from Kathleen
- Kathleen.oneil@noaa.gov

Observational Networks

Ground Stations

- Products
  - Pressure
  - Wind
- All observations systems available through http://www.nws.noaa.gov/om/coop/wfo-rfcmap.htm
- Resolution - variable
- Data archive at - *http://madis.noaa.gov*
  - *Contains NWS, NOS, and many other sources*
- Contact - Paul Whitmore who will work with NWS HQ for specialist

Observational Data Sets

Air pressure chart archives

- Historic pressure charts
  - Sources – Historic and recent NWS
  - Archives – National Climate Data Center
    - www.ncdc.noaa.gov
  - Contact – Jay.Lawrimore@noaa.gov

Observational Data Sets

Vertical sounding data

- U Wyoming site - http://weather.uwyo.edu/upperair/sounding.html
- Others – National Climate Data Center
  - www.ncdc.noaa.gov
  - Best for the archived data
- Contact – see previous slide

Observational Data Sets

Meteorological Satellite Data

- Sources:
  - Polar Orbiting
  - GOES
  - Altimetry (JSON)
- Archives – NCDC
  - See previous slides for NCDC info
- Contact – NCDC slide

Successful Conclusion

- Understanding the cause of US meteotsunamis
  - Boothbay
  - Daytona Beach
- Define systems necessary to forecast
- Design procedures and protocols to forecast future events