FIJI SEISMOLOGY UNIT

MINERAL RESOURCES DEPARTMENT

Saula Mule

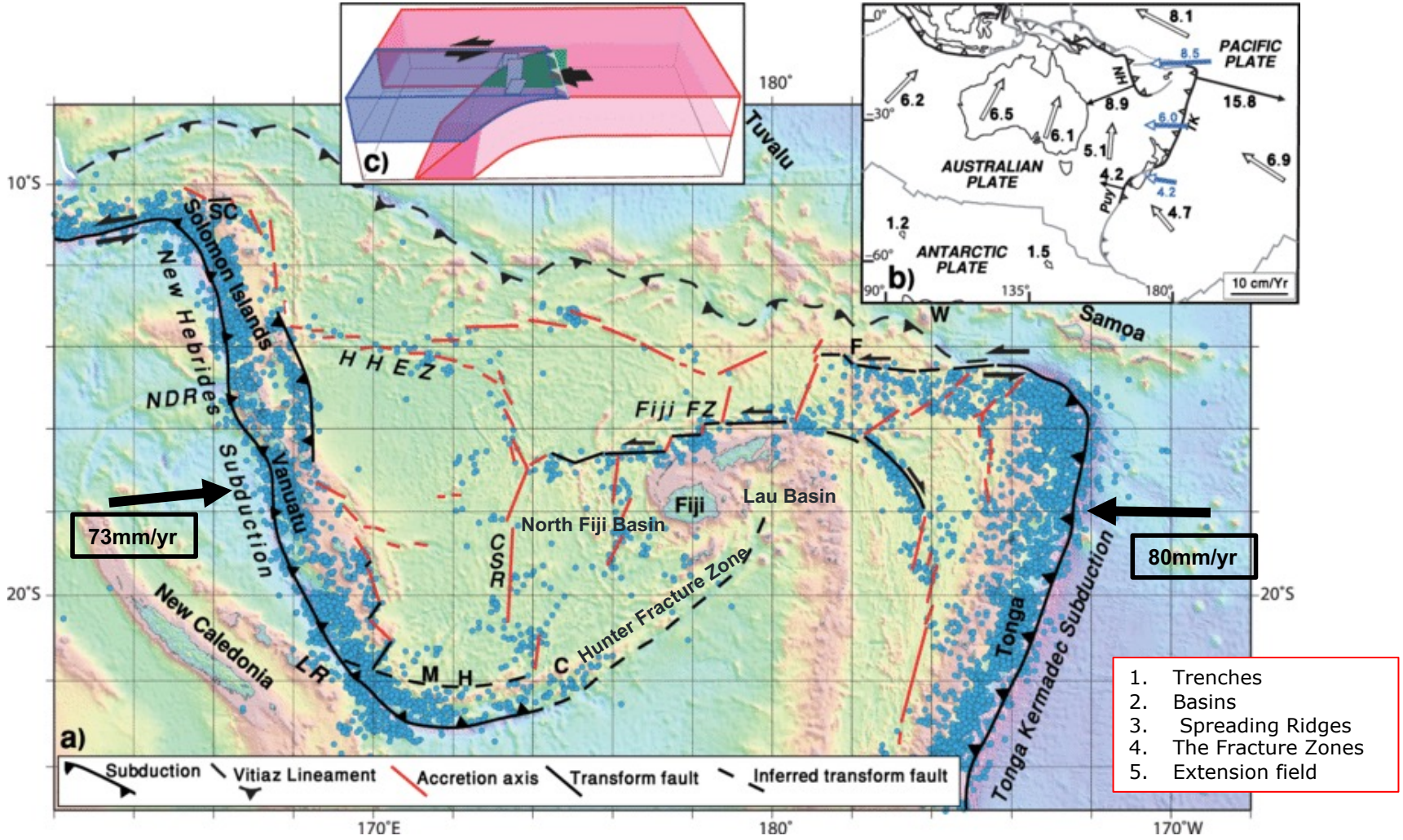
OUTLINE

1. Introduction
2. Tectonic Setting
3. Earthquakes
4. Volcanoes
5. Fiji National Tsunami Warning System
6. Great East Japan Earthquake
7. Past, Presentation and Future Plans
8. Collaboration Partners

INTRODUCTION

- **Fiji** is located in the southwest Pacific Ocean at the midpoint of the opposing potential tsunami sources, the Tonga Trench and New Hebrides Trench, therefore is vulnerable to tsunamis.
- **Earthquake Generated Tsunami** in 1953, a 6.7 M September 14th at 12.26 pm and has been the most destructive earthquake in Fiji's history.
  - A 2 m wave height was seen from the Suva Port.
  - The earthquake killed eight people, and there were 20 cases of serious injuries
- **Volcano Generated Tsunami** from Hunga Tonga-Hunga Ha'apai Volcano on 15th January
  - Generated a 20meter wave that killed 4 people in Tonga
  - This tsunami inundated coastal areas of Lau and Lomaiviti Group Kadavu and southern coast of Viti Levu.
  - This tsunami follow a leading sonic boom (sound-wave) heard across the Fiji Group.

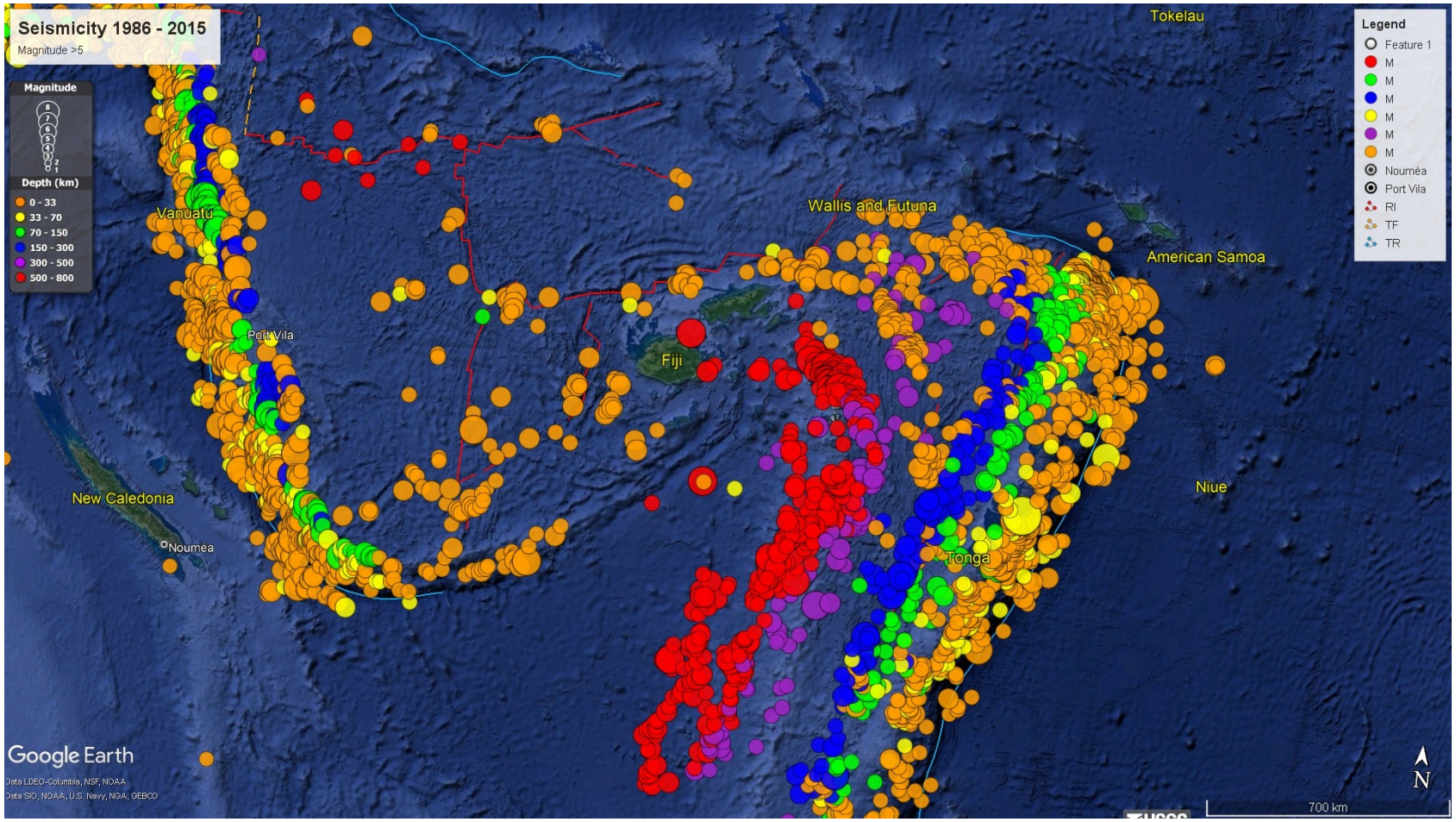
The tectonic setting of the Fiji region



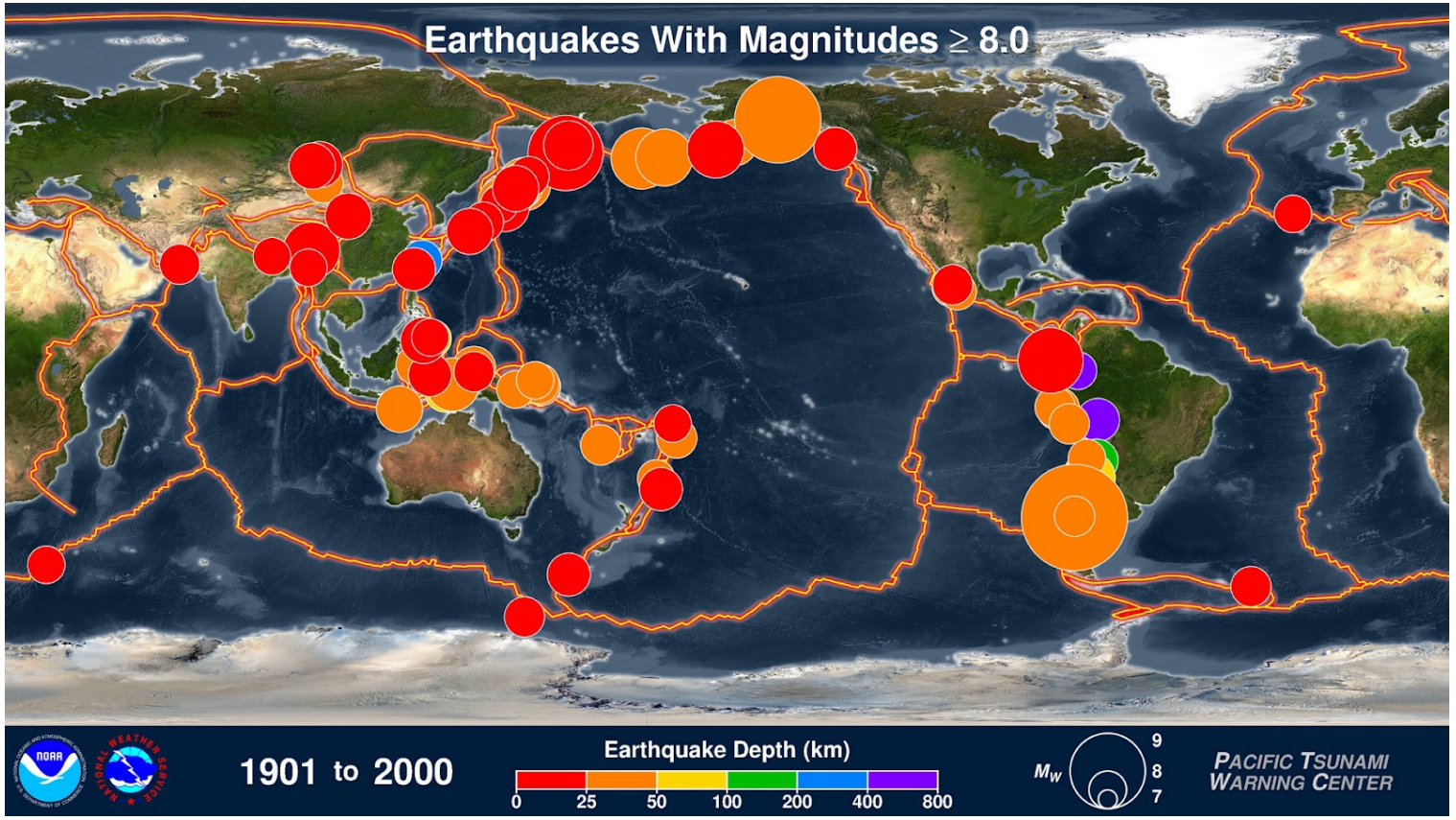
Relative plate motions adopted from http://ofgs.aori.u-tokyo.ac.jp/~okino/platecalc_new.html

Patriat, Martin & Collot, Julien & Fabre, Maud & Danyushevsky, Leonid & Meffre, Sebastien & Falloon, Trevor & Rouillard, Pierrick & Pelletier, Bernard & Roach, M. & Fournier, Marc. (2015). Propagation of back-arc extension into the arc lithosphere in the southern New Hebrides volcanic arc. Geochemistry, Geophysics, Geosystems. 16. 10.1002/2015GC005717.

SEISMICITY MAP (1986-2015)

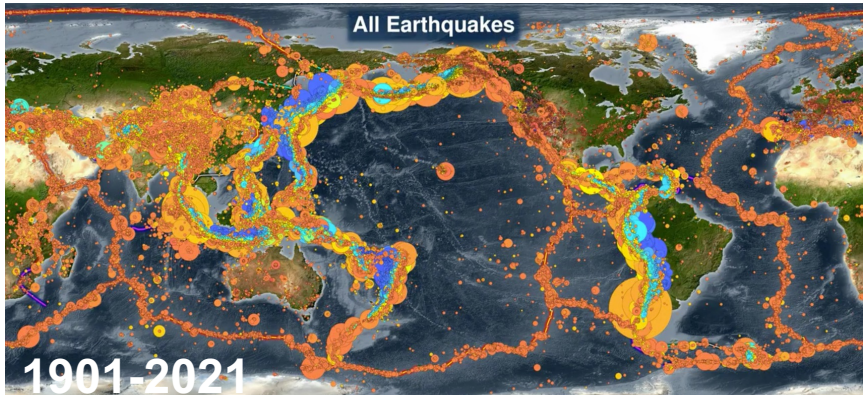


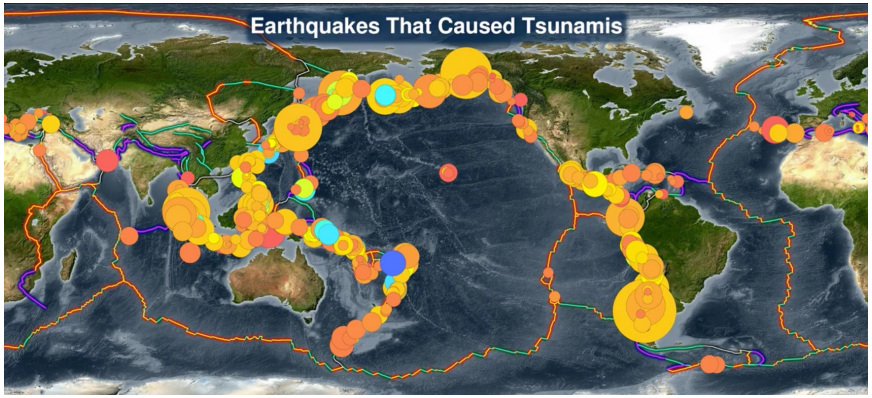
DANGEROUS EARTHQUAKES - GLOBAL

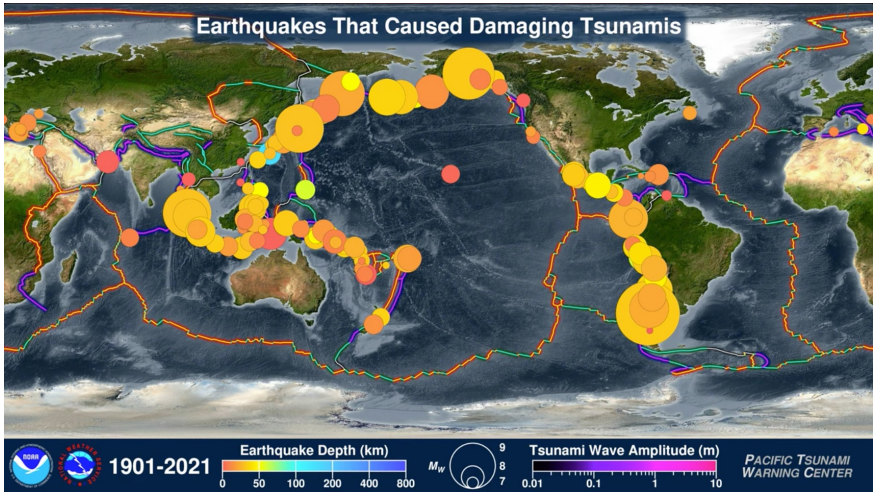


Click below for video EQ-Tsunami 1901-2021

DANGEROUS EARTHQUAKES & TSUNAMIS

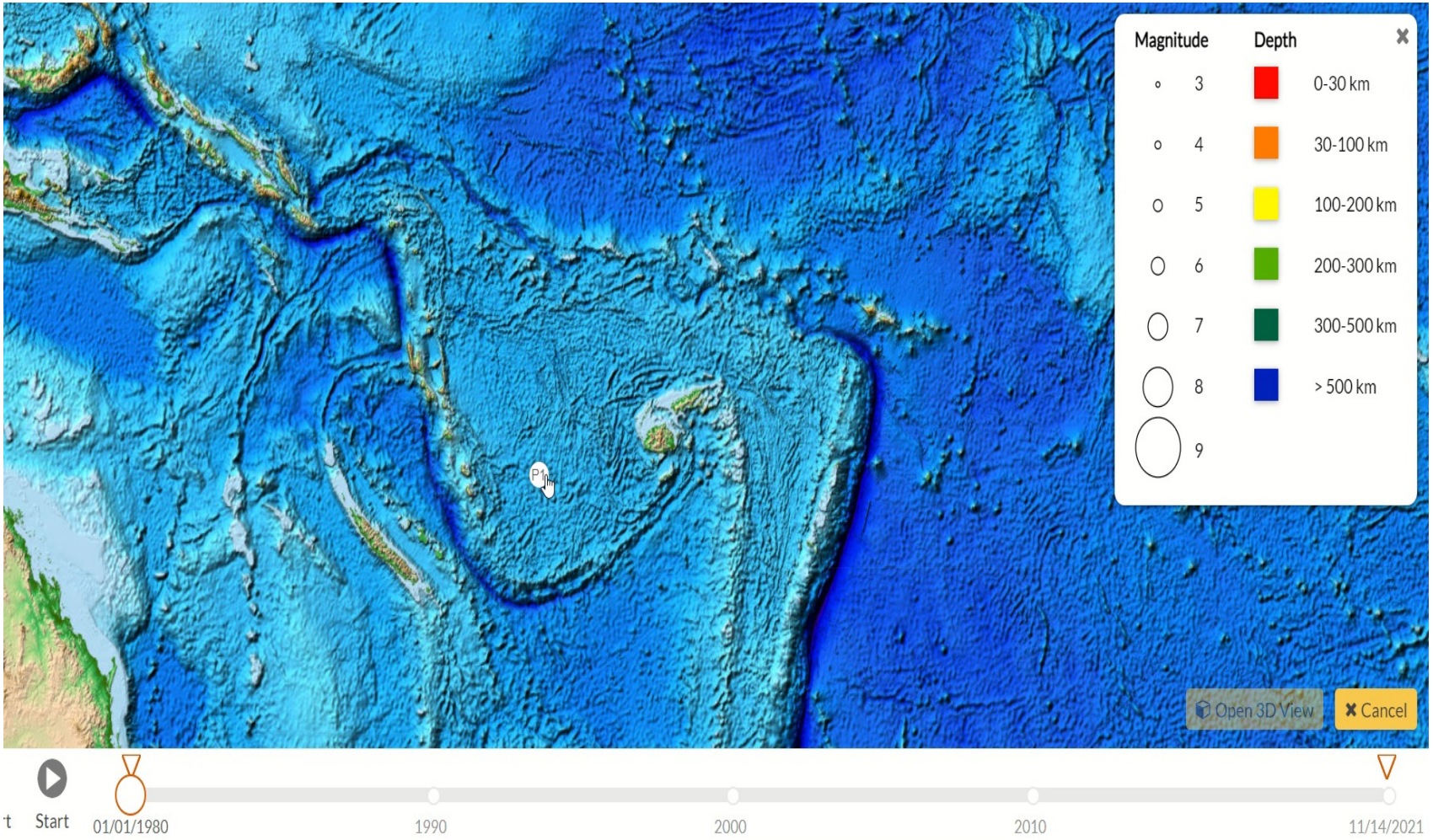






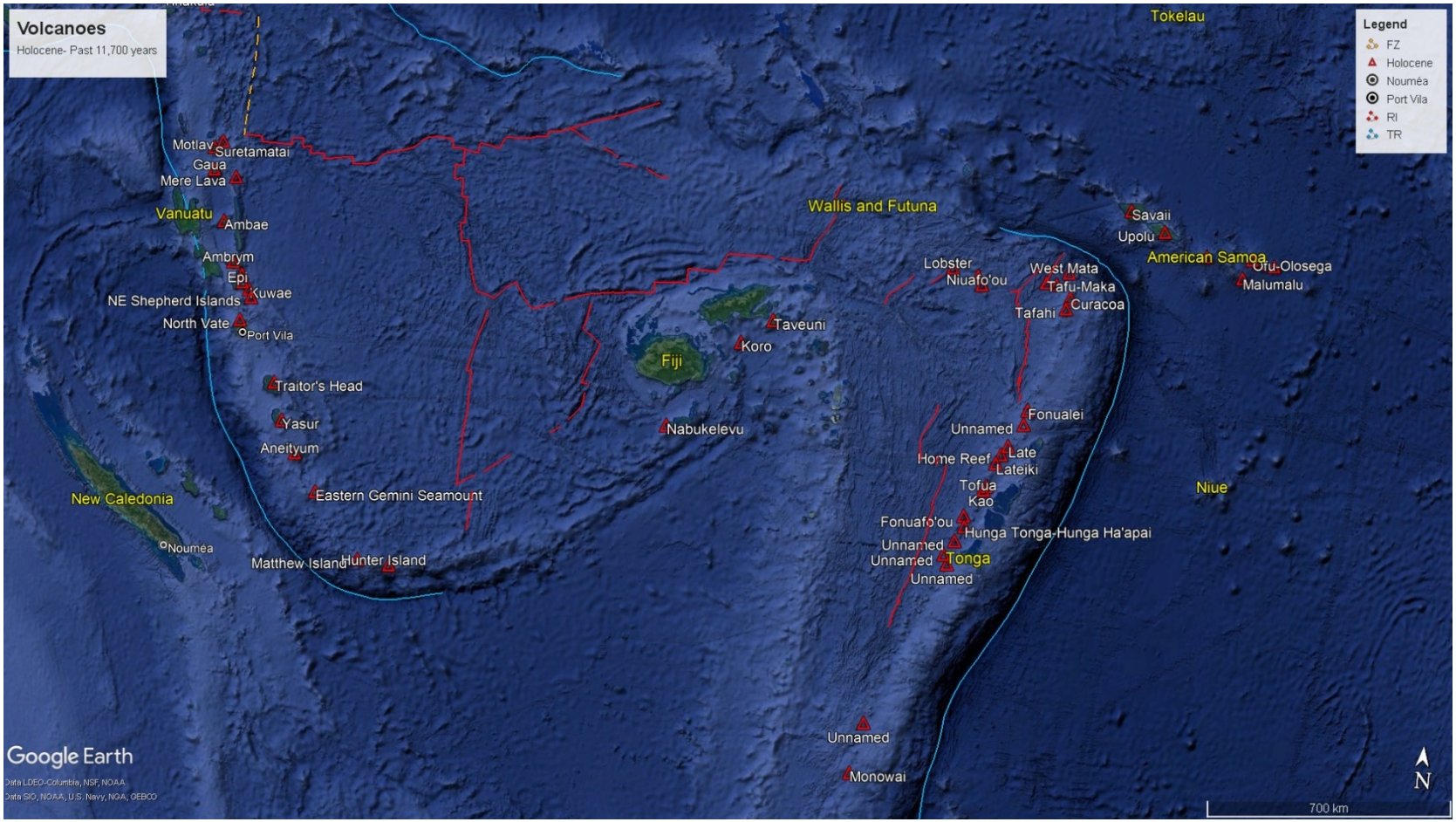
- 80% caused by earthquakes
- Shallow, undersea/near coast
- Magnitude 8+ (M7+)

EARTHQUAKE DATA

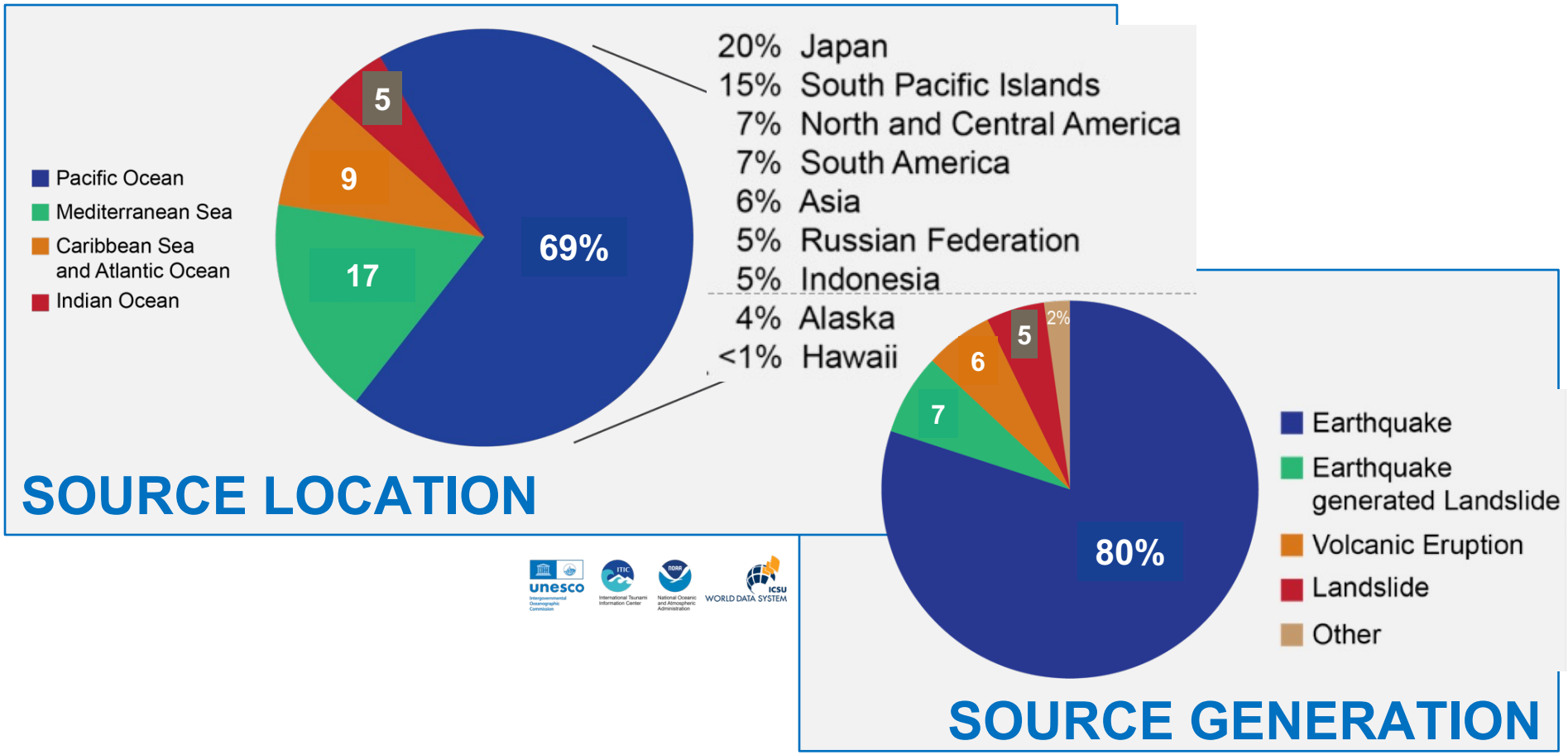


- Earthquake data provided by USGS
- Seismic Explorer is based on Seismic Eruption, a program created by Alan L. Jones at the State University of New York at Binghamton
- https://seismic-explorer.concord.org/

VOLCANOES


Volcanoes
Holocene- Past 11,700 years
Legend
FZ
Holocene
Nouméa
Port Vila
RI
TR
Tokelau
Wallis and Futuna
Vanuatu
Motlav
Suretamatai
Gaua
Mere Lava
Ambae
Ambrym
Epi
Kuwae
NE Shepherd Islands
North Vate
Port Vila
Traitor's Head
Yasur
Aneityum
New Caledonia
Eastern Gemini Seamount
Nouméa
Matthew Island
Hunter Island
Fiji
Taveuni
Koro
Nabukelevu
Savaii
Upolu
American Samoa
Lobster
Niuafo'ou
West Mata
Tafu-Maka
Curacoa
Tafahi
Ofu-Olosega
Malumalu
Fonualei
Unnamed
Home Reef
Late
Lateiki
Tofua
Kao
Niue
Fonuafo'ou
Hunga Tonga-Hunga Ha'apai
Unnamed
Unnamed
Tonga
Unnamed
Unnamed
Monowai
Google Earth
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
700 km
N

DEADLY TSUNAMIS – GLOBAL (1620 B.C to A.D. 2022)



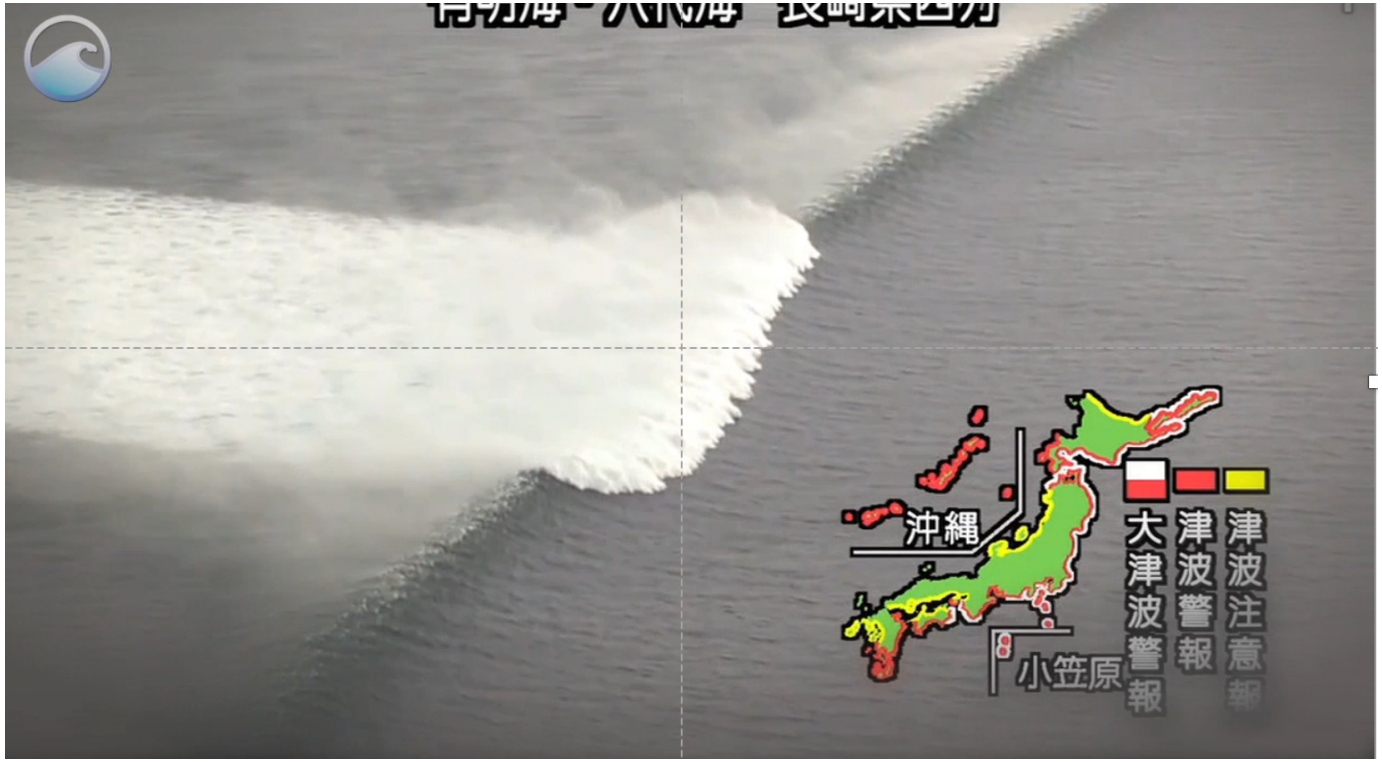
Deciding to issue warnings – Facts

- **JMA Warning timely,** incl wave forecast 3+ m
  (but was underestimate)
- **Small waves can be dangerous**
  Laboratory expts show waves 30 cm flow depth cause people to lose balance / cars to float
- **Swift-moving waves are dangerous**
  especially later waves as debris-laden rivers and/or walls of water.
- **Most people evacuated. Some did not.**
  Only 5% died, nonetheless, it was ~18,000

⇒ **NTWC DECISIONS MUST BE CONSERVATIVE (ENSURE SAFETY)**

⇒ **FOR LOCAL, PUBLIC SELF-EVACUATES - DO NOT WAIT FOR NTWC**

11 MARCH 2011: JAPAN TSUNAMI



Click below for video

11 MARCH 2011: KESENUMA, JAPAN

Click below for video


宮城県女川町（2011 年 3 月 29 日撮影）
PASCO
World's Leading Geospatial Group


Koshimura, 2011

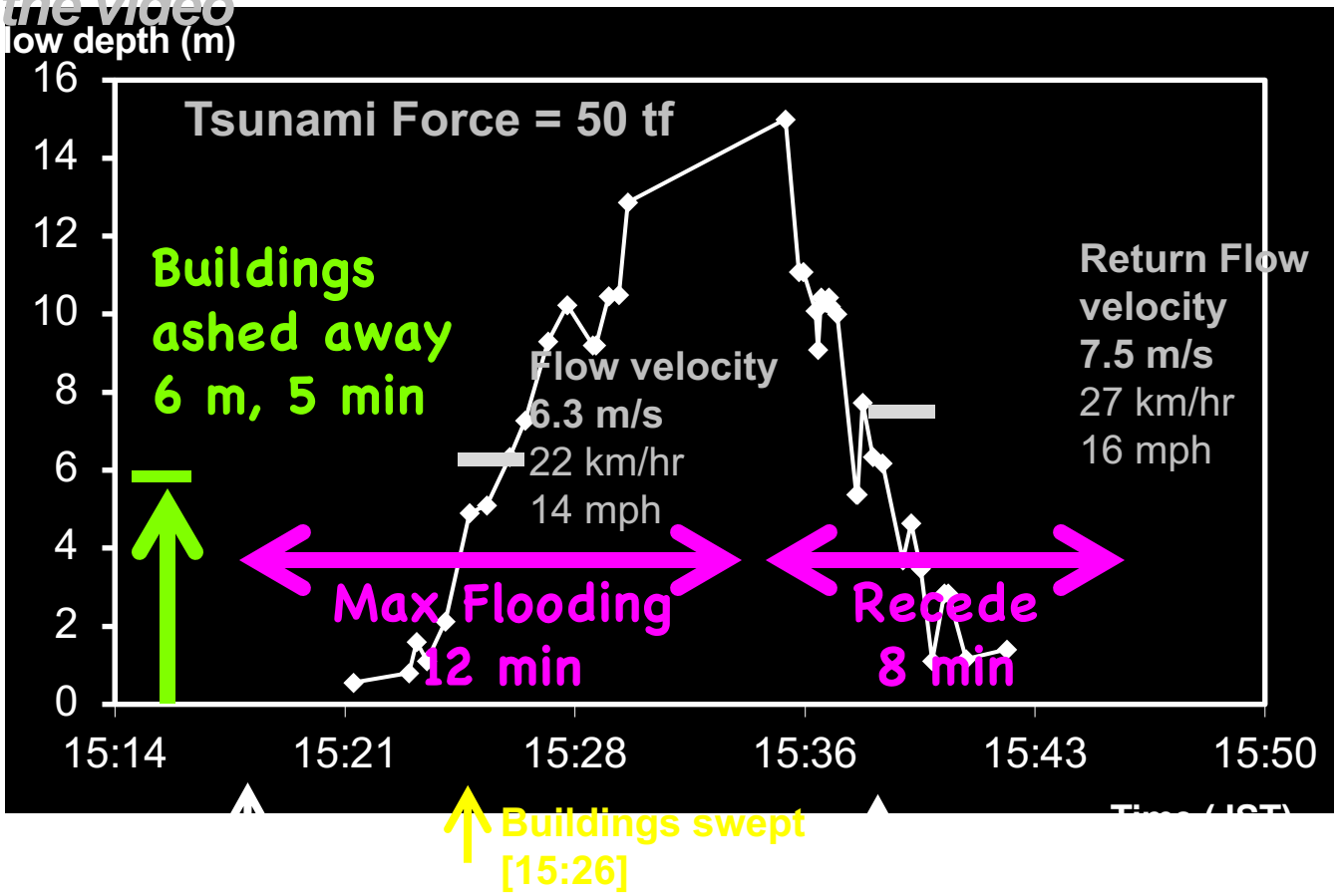
Onagawa, Japan

Koshimura, 2011

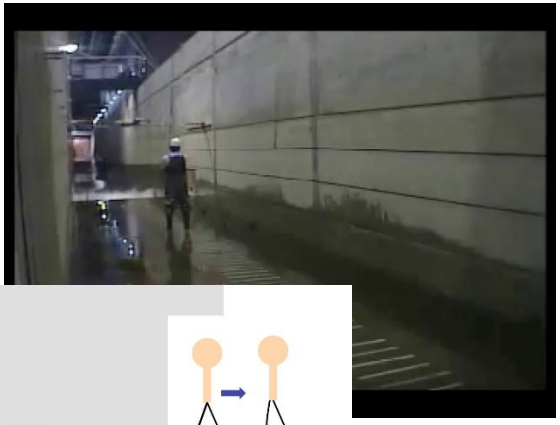
Expect Fast Flooding - Have a Personal Plan

Sendai, Japan, March 11, 2011

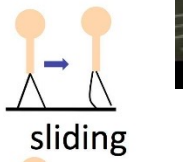
Time series of tsunami inundation interpreted from the video

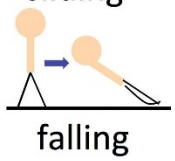


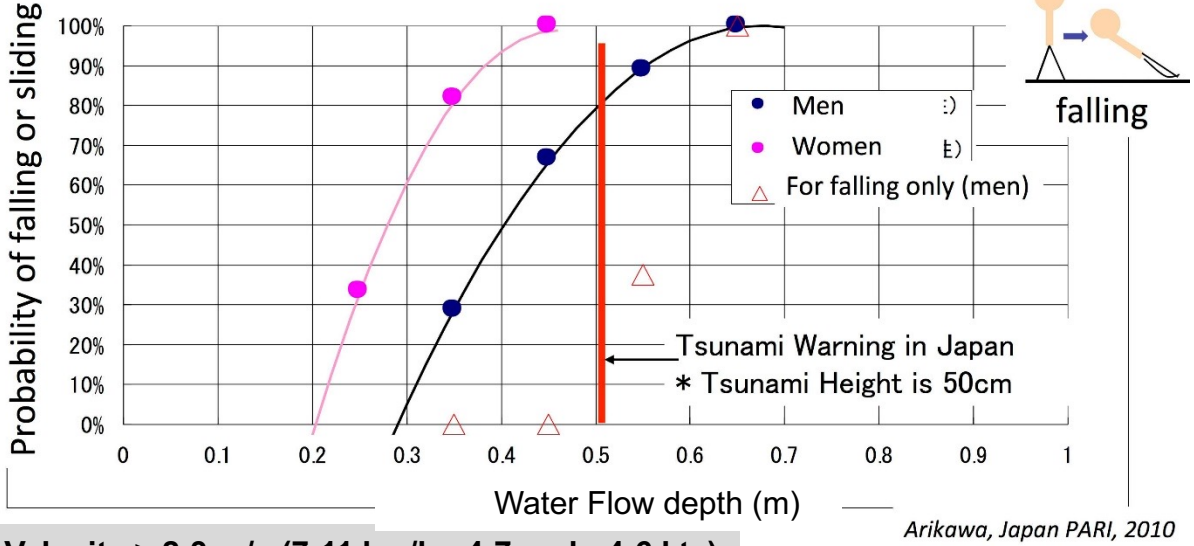
Flow Depth – Humans



Preliminary Results:
Probability of falling or sliding
=> lose balance at 0.3 m (1 ft) depth







Arikawa, Japan PARI, 2010

Velocity > 2-3 m/s (7-11 km/hr, 4-7 mph, 4-6 kts)

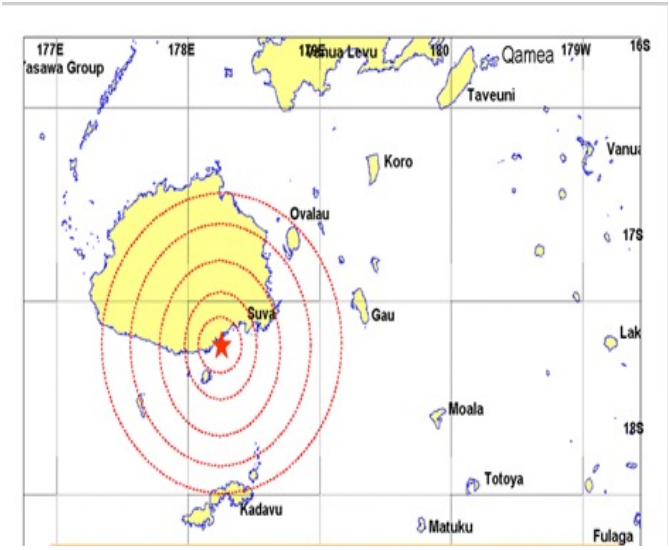
FIJI SEISMOLOGICAL NETWORK

- **Local Broadband Seismic Stations -** Tailevu, Dogotuki, Taveuni, Lakeba, Kadavu & Yasawa
- **Auxiliary Station** – Monasavu

Local Source

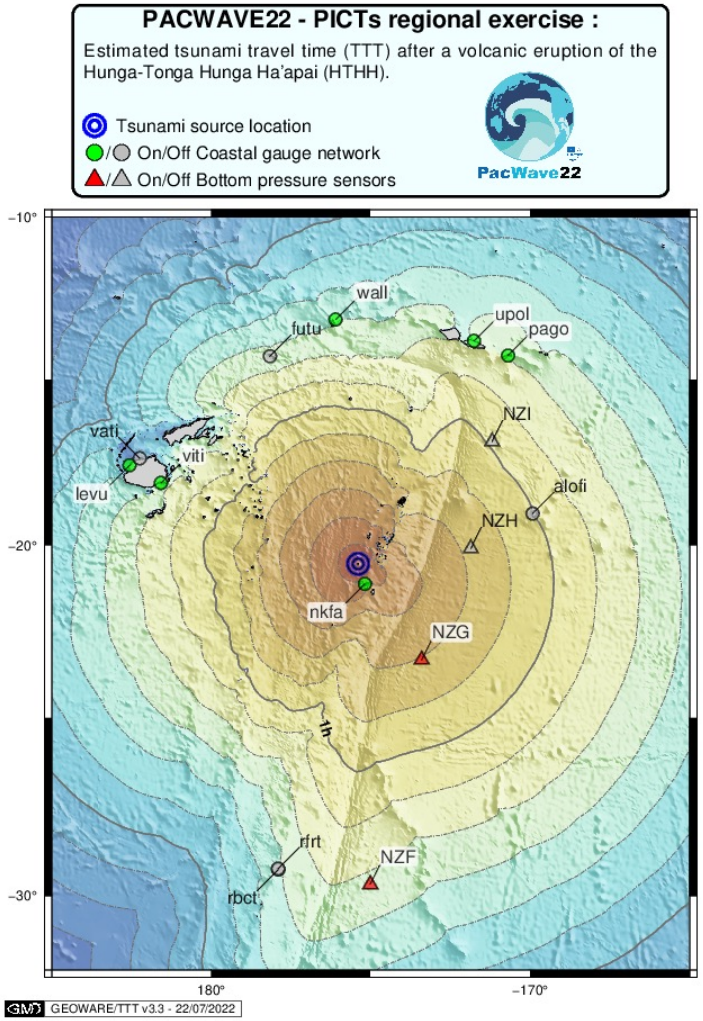
- Earthquake Generated
- Vanuatu-Fiji-Tonga source– Estimated time of arrival is less than 1.5 hours for Fiji

- Eg. September, 14th 1953 –Suva Earthquake
  - Magnitude-6.7 Ms, Depth- 21km
  - Wave height ;
    - Nakasaleka- 5m
    - Suva- 5m
    - Levuka & Savusavu- 3m
  - 8 fatalities & 20 cases of serious injuries
  - The Suva Wharf, bridges, buildings, and water reticulation facilities in southeast Viti Levu faced severe damages.



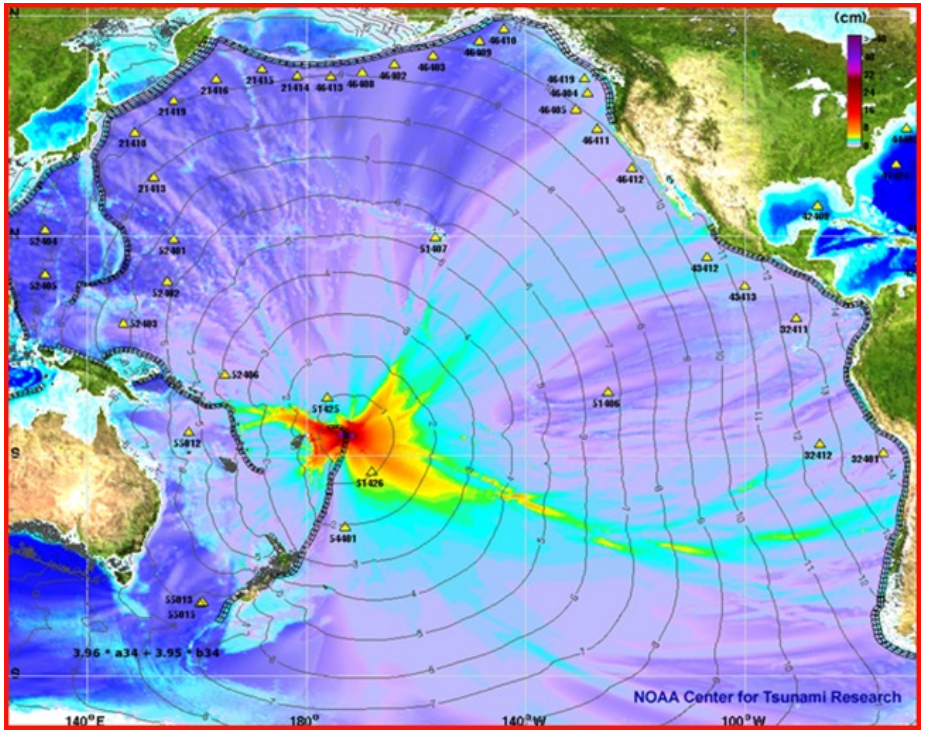
Local Source

- Volcano Generated
- Hunga Tonga Hunga-Ha'pai Volcano on the 15th of January
- Generated a 20meter wave that killed 4 people in Tonga
- This tsunami inundated coastal areas of Lau and Lomaiviti Group Kadavu and southern coast of Viti Levu.
- This tsunami follow a leading sonic boom (sound-wave) heard across the Fiji Group.



Regional Source

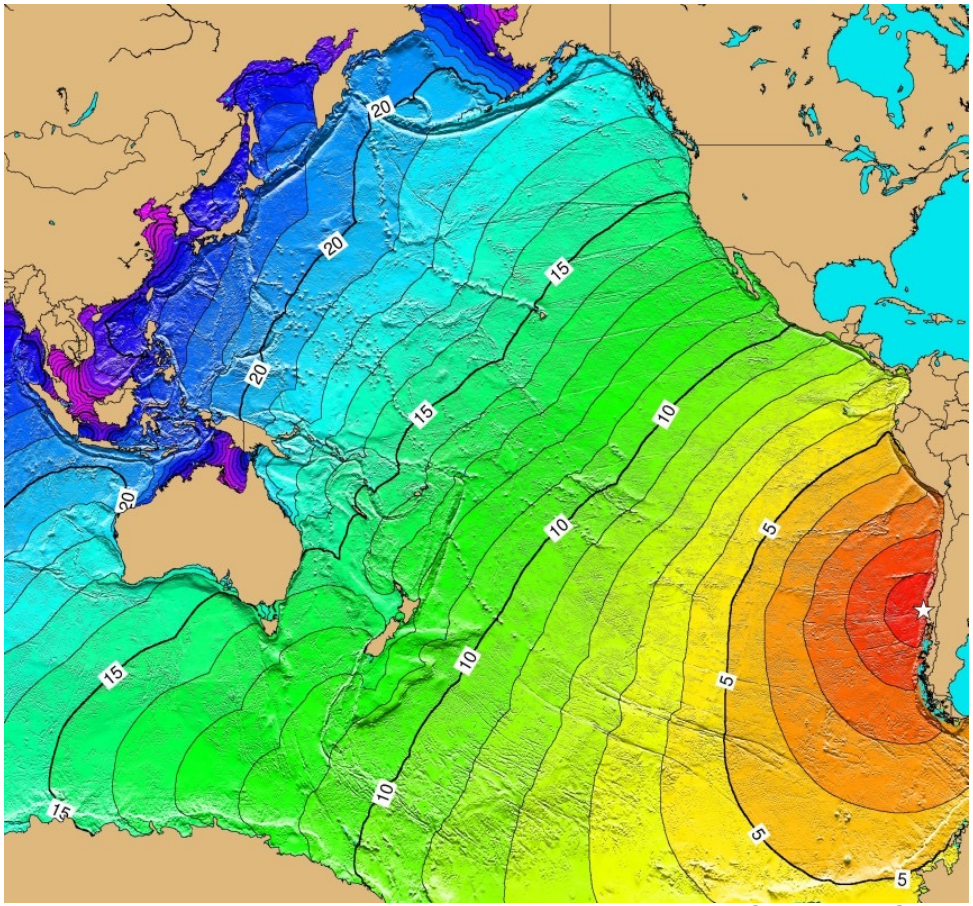
- A tsunami generally within 1,000 km or 1.5-3 hours tsunami travel time from its source.
- Eg -29th September, 2009 in the Samoa Region.
- Mag- 7.9, Depth- 15km
- Casualties- 189 in Samoa
- This tsunami was reported to have inundated Savusavu, Natewa Bay and a few coastal areas in Vanua Levu.



Source: PTWC

Distant Source

- A tsunami generally more than 1,000 km or more than 3 hours tsunami travel time from its source.
- Eg- 25th May, 1960- Great Chile Earthquake
- Mag- 9.6, Depth- 33km
- Casualties- 6,000
- This tsunami was reported to have inundated Savusavu, Natewa Bay and a few coastal areas in Vanua Levu.



Source: NOAA

FIJI NATIONAL TSUNAMI WARNING SYSTEM

STEP 1

DETECTION
Seismic Network/ V-SAT Stations

STEP 2

Data Transmission to the Suva Central Hub/ Fiji's National Tsunami Warning Center

STEP 3

Data Acquisition

STEP 4

ANALYSIS
- Automated Analysis - ORSNET/USGS/IRD/CISN/EMSC
- Manual Analysis- ATLAS/Seiscomp

STEP 5

DISSEMINATION
Release of Earthquake Information

STEP 6

RISK KNOWLEDGE
- Historic EQ Database- TSUCAT/TSUDIG analysis
- Tsunami Travel Time/ Tide Tool

STEP 7

MONITORING
- Pacific Tsunami Warning Center (PTWC)
- Tide Gauge

STEP 8

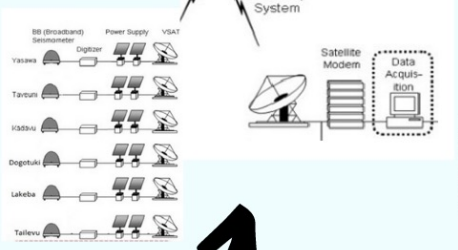
DISSEMINATION
Issuing of Tsunami Information, Advisories, Watch, & Warning

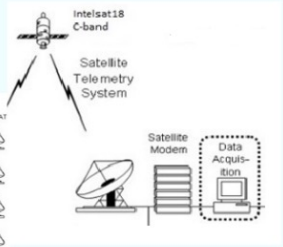
STEP 9

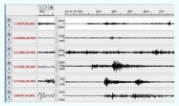
RESPONSE
NDMO & Relevant Stakeholders
- Activation of Tsunami Tsunami Siren
- Publicize the evacuation

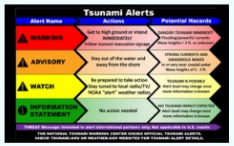
1: SEISMIC ACTIVITY & VSAT STATIONS — 1 Sec — **2: OBSERVATORY ROOM** — 5- 10 min — **3: OBSERVATORY (SIREN) & NDMO** — 10-15min

Dissemination (SOP)- 10-15 MIN









WARNING PRODUCTS/ ALERT LEVELS

Warning Products	Alert Level	Public Action	Potential Hazard
Tsunami Information	Information Statement	No action suggested at this time	No threat or very distant event for which hazard has not been determined
Tsunami Watch	Watch	Be prepared to take action Stay tuned to local radio/TV	Tsunami Possible Alert level may change once more information is known
Tsunami Advisory	Advisory	Stay out of the water and away from the shore	Strong currents and waves dangerous to those in or very near coastal waters
Tsunami Warning	Warning	Move to high ground or inland immediately	Dangerous coastal flooding and powerful currents

VINAKA VAKALEVU