UNESCO/IOC – NOAA ITIC Training Program in Hawaii (ITP-Hawaii)
TSUNAMI EARLY WARNING SYSTEMS
AND THE PACIFIC TSUNAMI WARNING CENTER (PTWC) ENHANCED PRODUCTS
TSUNAMI EVACUATION PLANNING AND UNESCO IOC TSUNAMI READY PROGRAMME
7-18 August 2023, Honolulu, Hawaii USA

TWC Operations
Sea Level Monitoring – Instruments, Limitations, Challenges

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Pacific Tsunami Warning Center

Why Sea Level Gauges are Needed

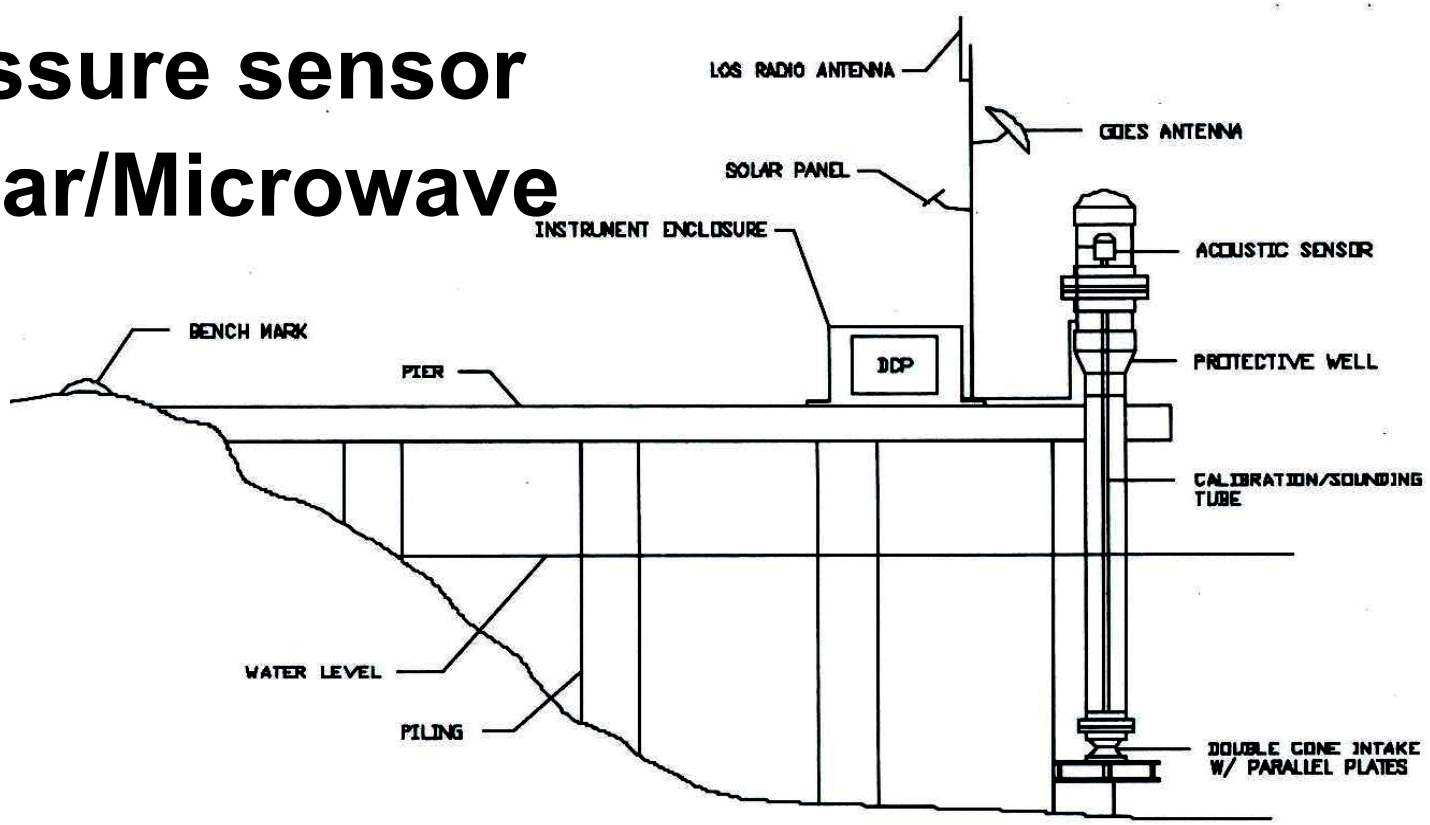
- **To verify if a tsunami exists or not**
- **To measure tsunami size for decision-making**
  - Compare with historical data
  - Constrain forecast model
- **To aid in response**
  - How bad was it?
  - Is it safe to go in?

Two Basic Types of Sea Level Gauges

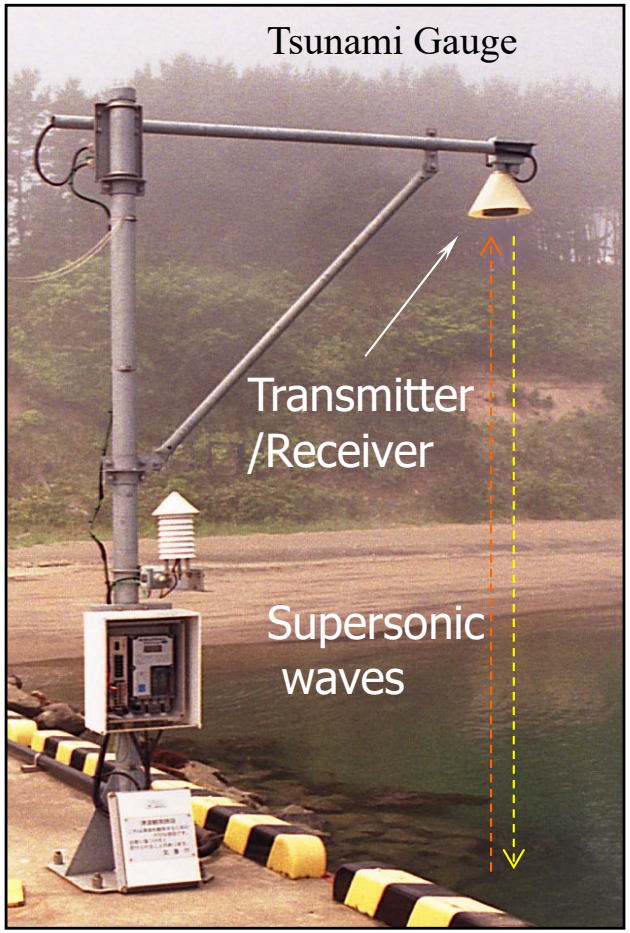
- **Coastal**
  - Good for comparison with historic events
  - Observation at coast
    Used to authoritatively cancel events
  - Heights sensitive to local effects (coastal shape, bathymetry, etc)
- **Deep Ocean**
  - Best for constraining forecast models. Heights not affected by local effects –'pure' tsunami signal
  - Observations in deep water. Not likely to be destroyed by wave
  - Forecast models required to interpret deep-ocean observations

Typical Coastal Gauge

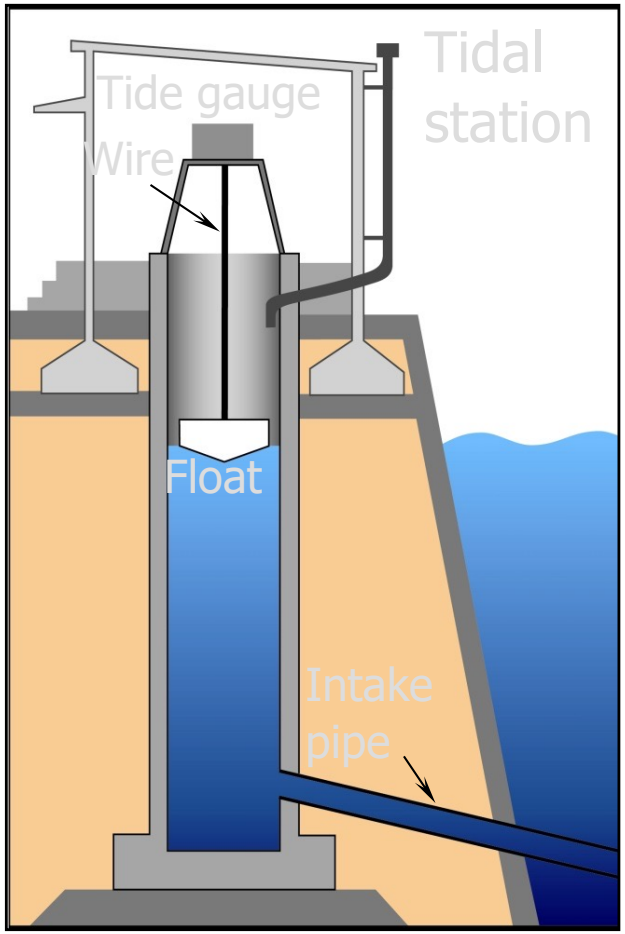
- Mechanical level
- Acoustic sensor
- Pressure sensor
- Radar/Microwave



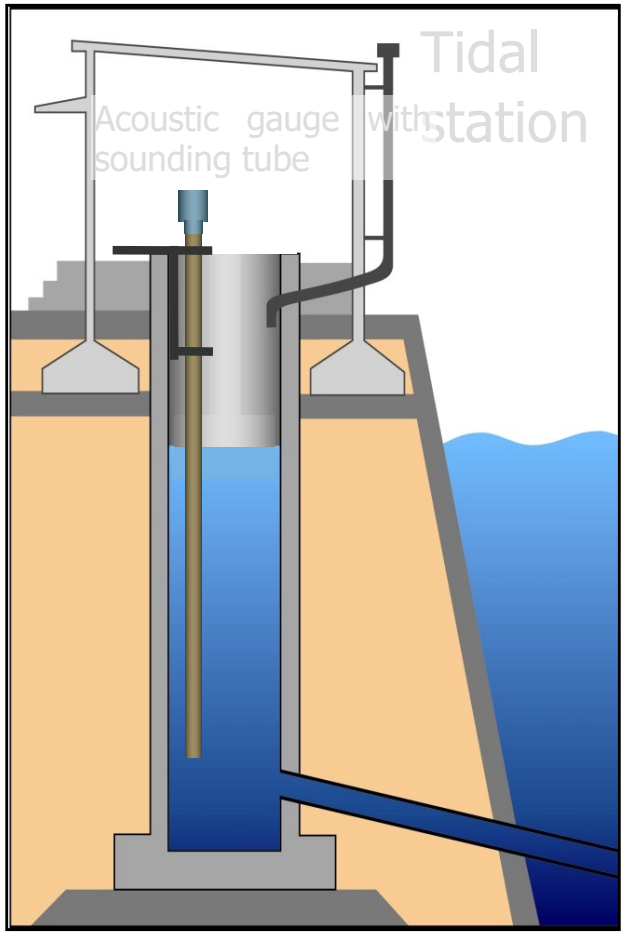
Tidal observation equipment in JMA



Microwave/Radar
in the Open Air



Float gauge
in the Stilling Well

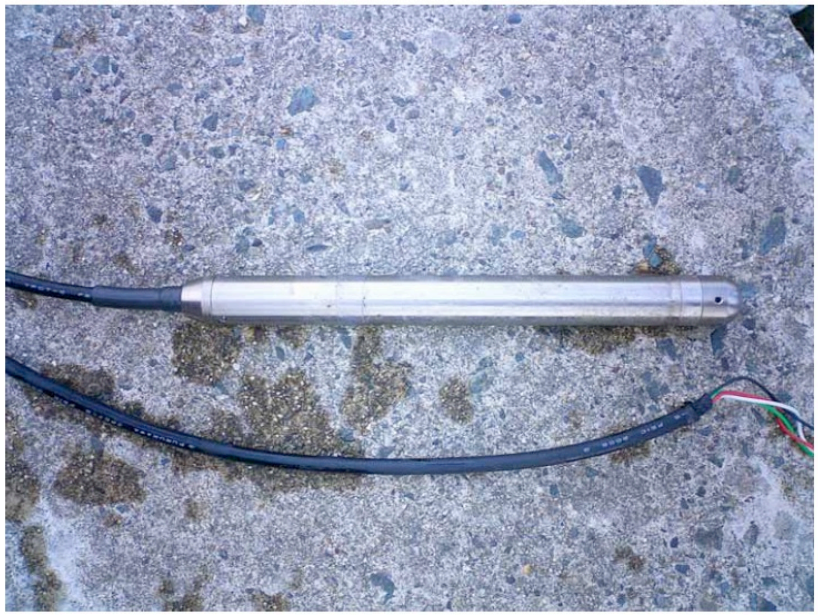


Acoustic gauge
with Sounding Tube

Instruments

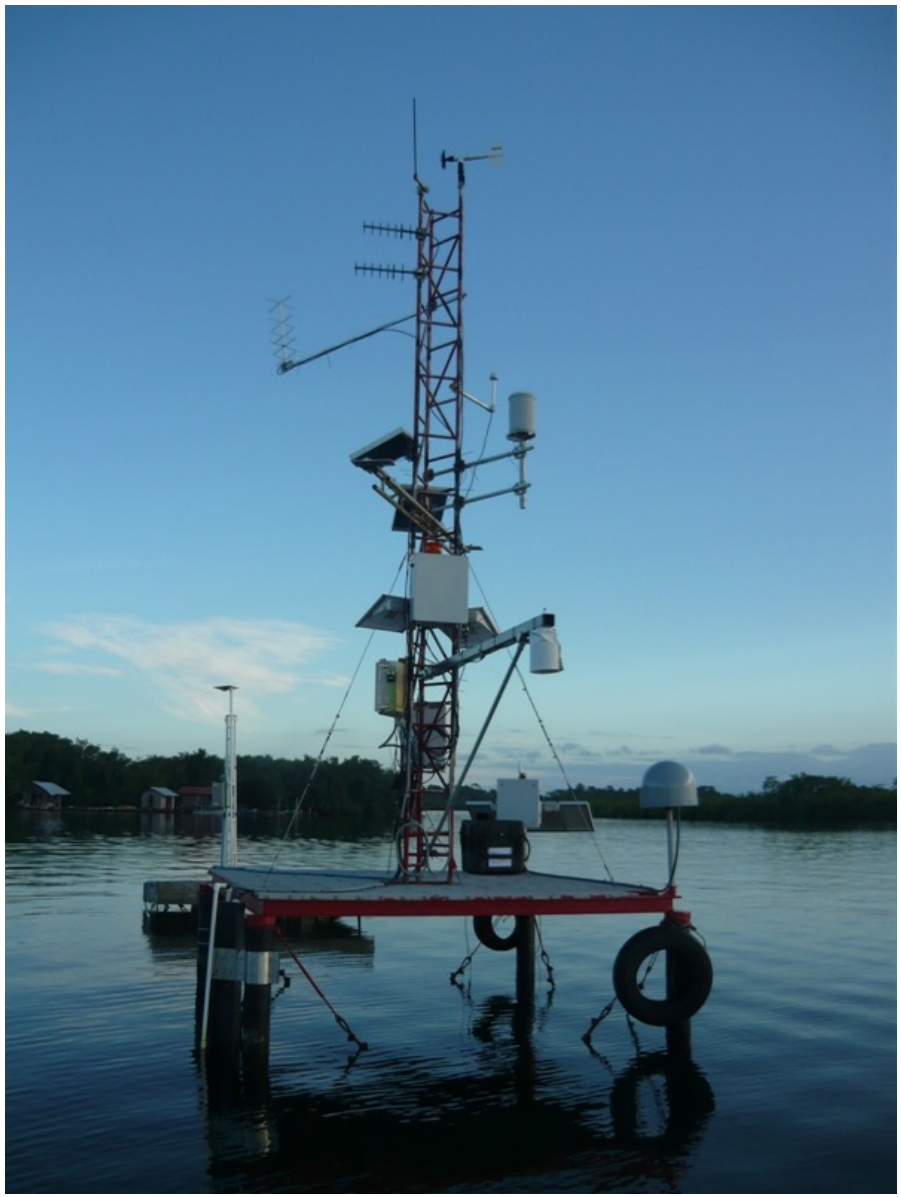
Fuess type gauge

Microwave/
Radar
gauge



Pressure sensor

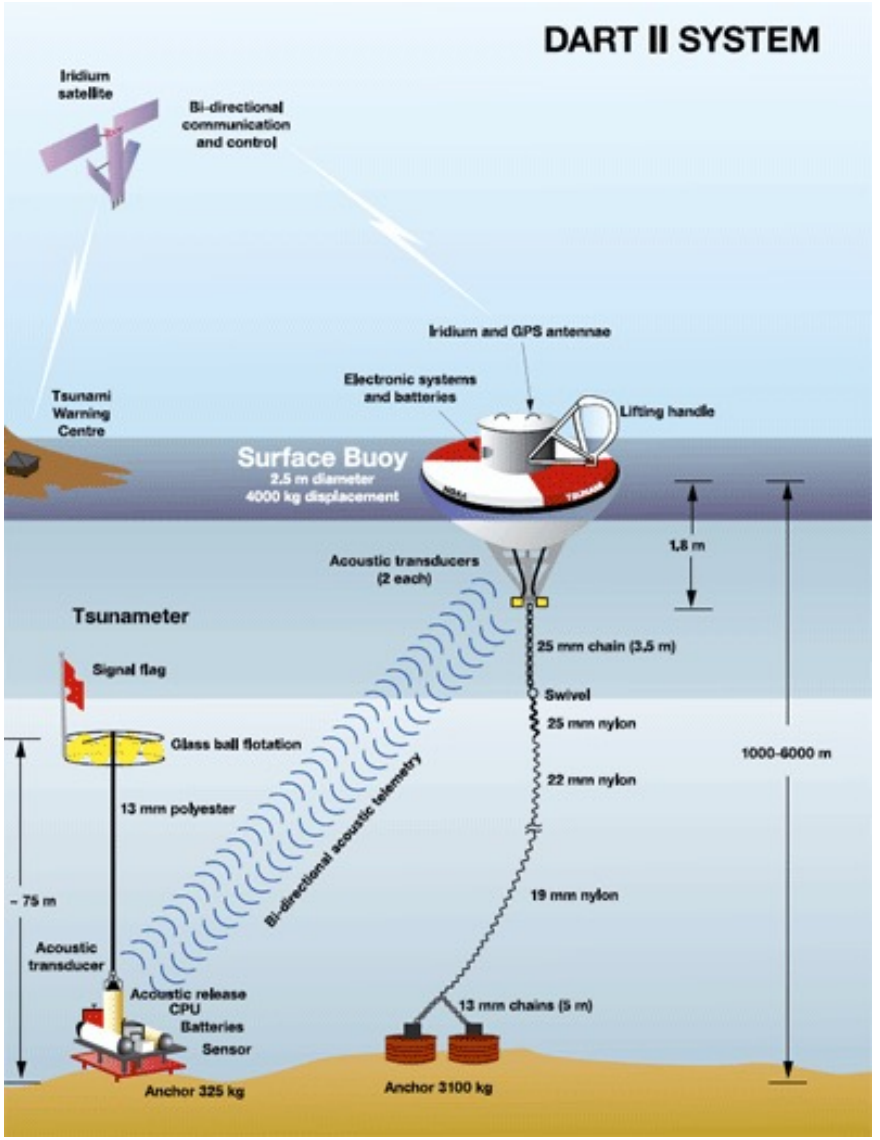
Examples of Caribbean Stations



Example of Stations in the Caribbean

Deep-Ocean Gauge

The tsunami signal is detected by a pressure sensor on the ocean floor. That signal is relayed by acoustic telemetry to the buoy. The buoy in turn transmits the signal via satellite back to the warning centers.



In case of big Tsunami?

Sea Level Gauge Data Streams

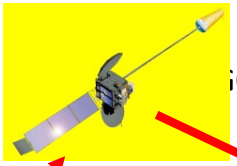
- **Sample Rates**
  - 15s — Optimal For TWS
  - **1 minute** — Good For TWS
  - 2 minute — OK For TWS
  - 6 minute — Can be Used
  - 15 minute — Not useful for TWS
- **Transmission Rates**
  - Real-time — Optimal
  - 3-6 minute — Very Good
  - 15 minute — Good
  - 1 hour — Poor
  - 3 hours — Not useful

Concept of the Tidal Data Collection System using the Geostationary Satellite of USA

Acoustic gauge

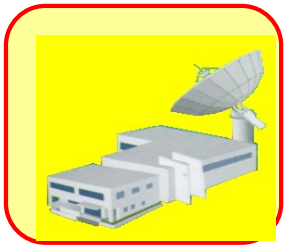
Pressure sensor

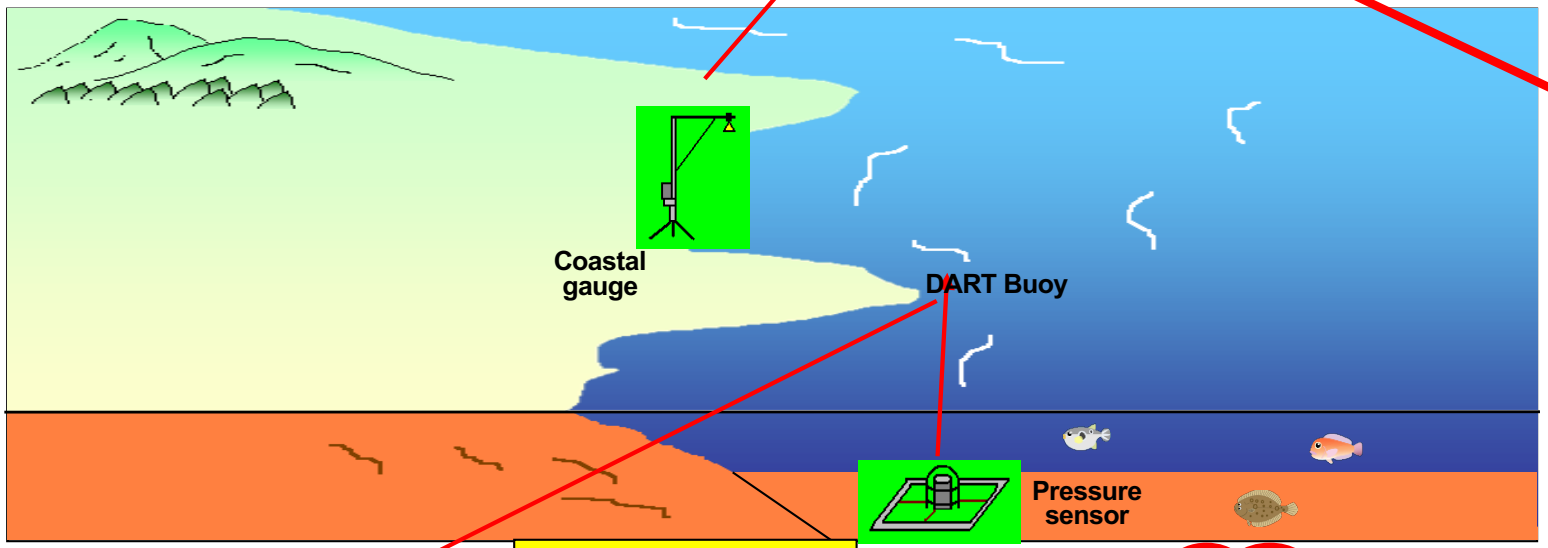
Transmission of Data
- Transmission Interval:
  5 min., 6 min, 15 min or 1 hour.
- Transmission Period:
  Within 1 min

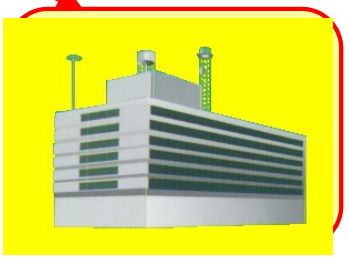


GOES

Acquisition of Tidal Data
1.6 GHz band







NOAA NESDIS – Wallops Island

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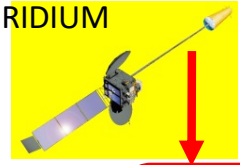
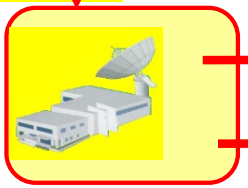


IOC Sea Level Monitoring Facility

Met Services

GTS)



NOAA Data Buoy Center

US NTWC

PTWC

NOAA PORT

GTS in the Indian Ocean region

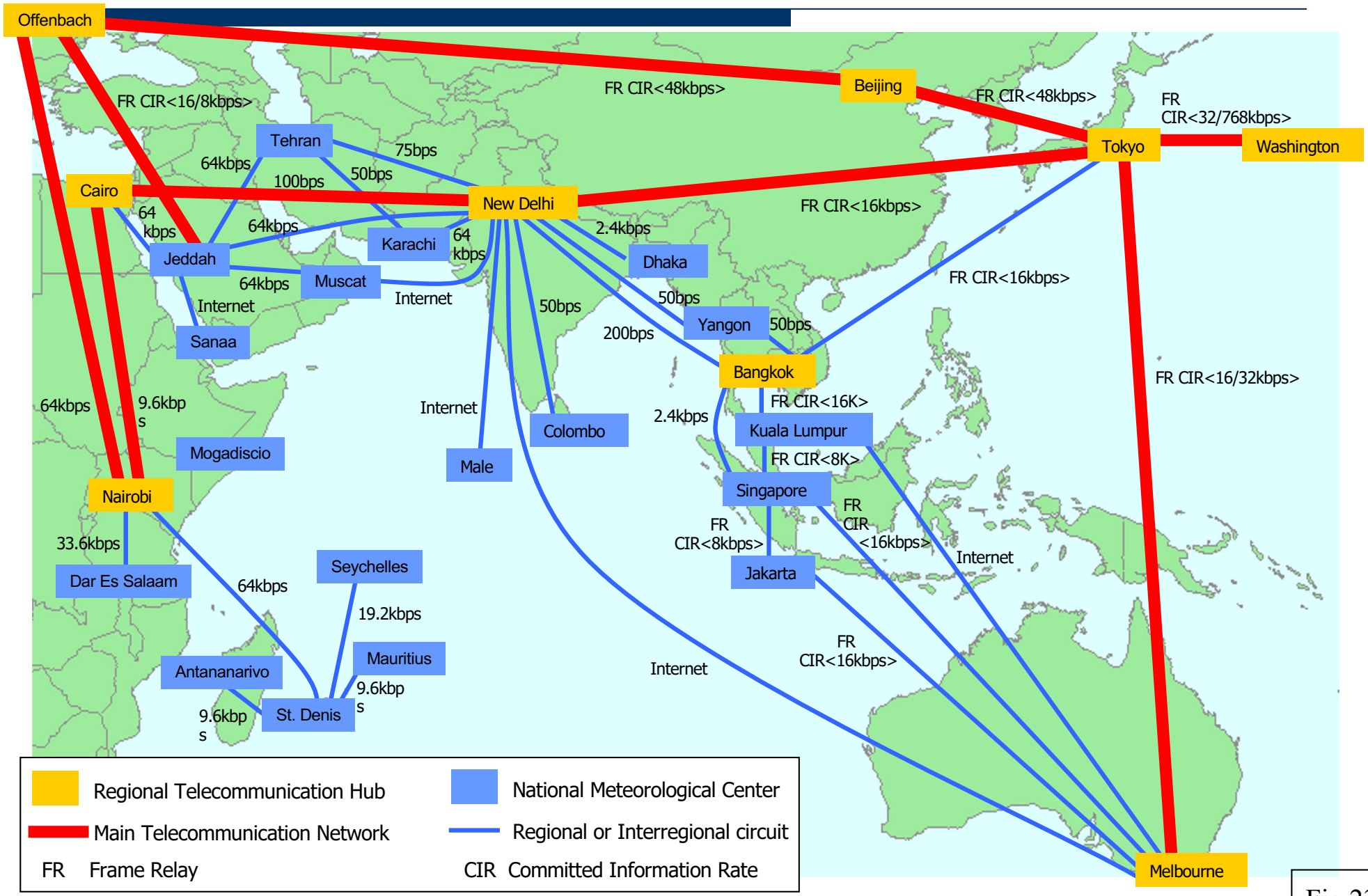
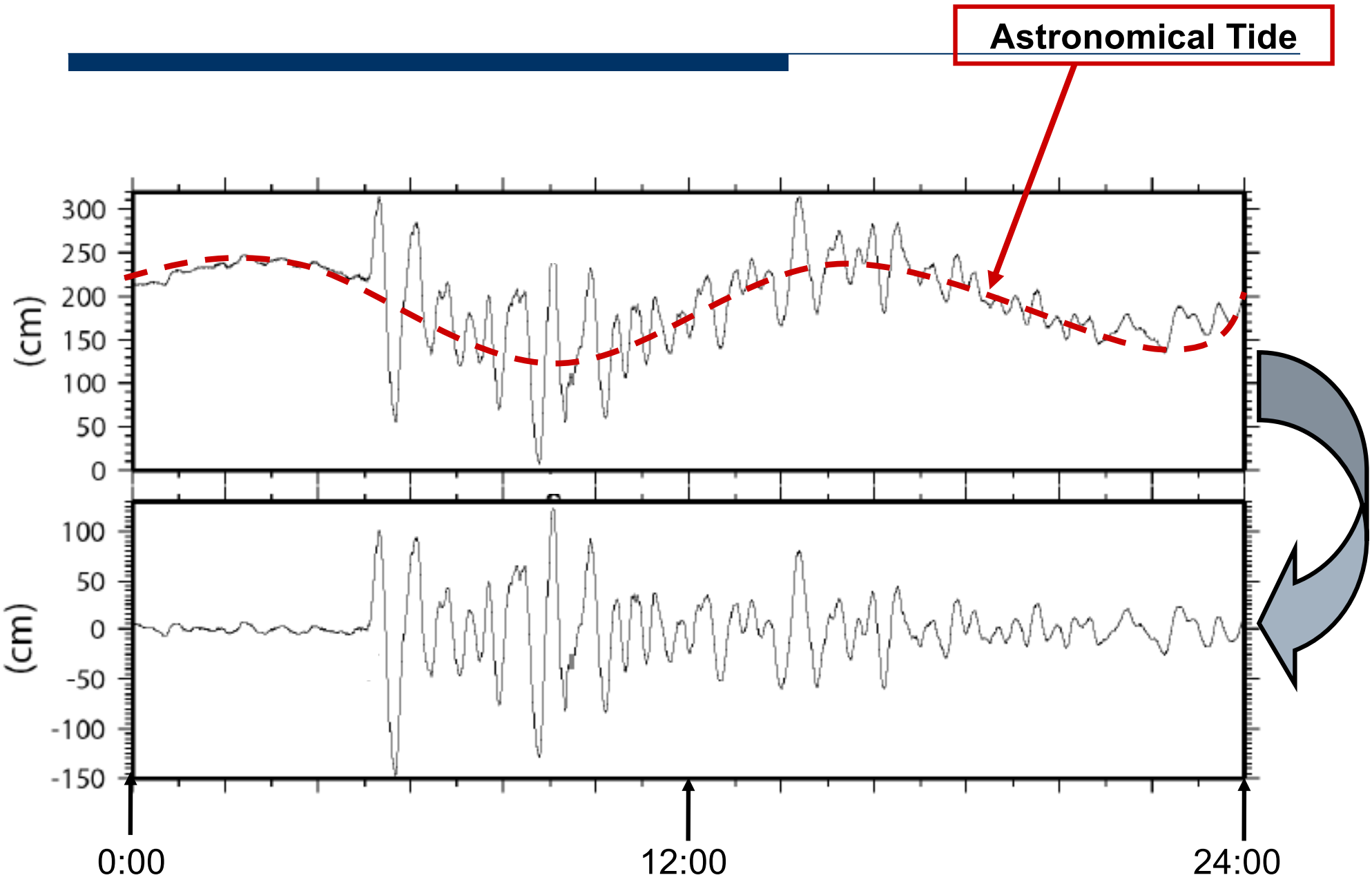
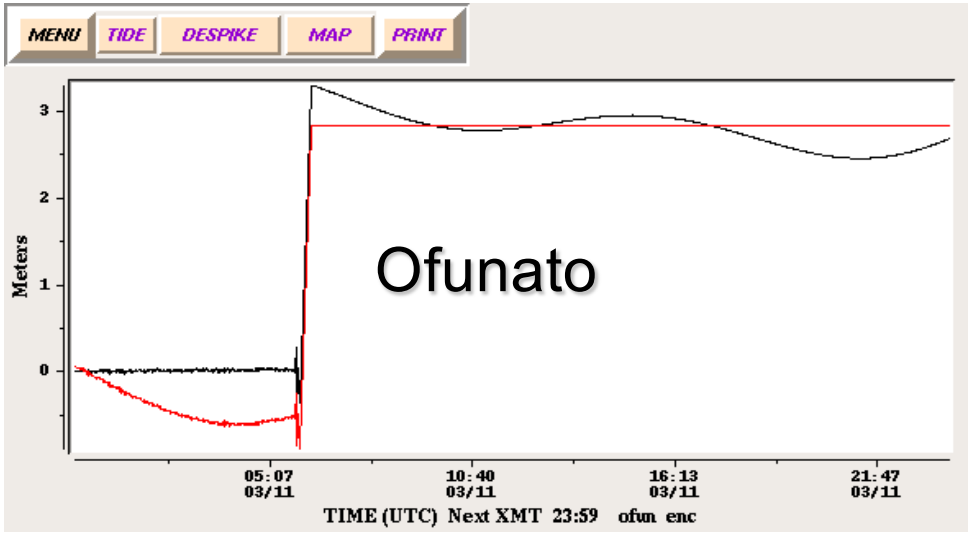


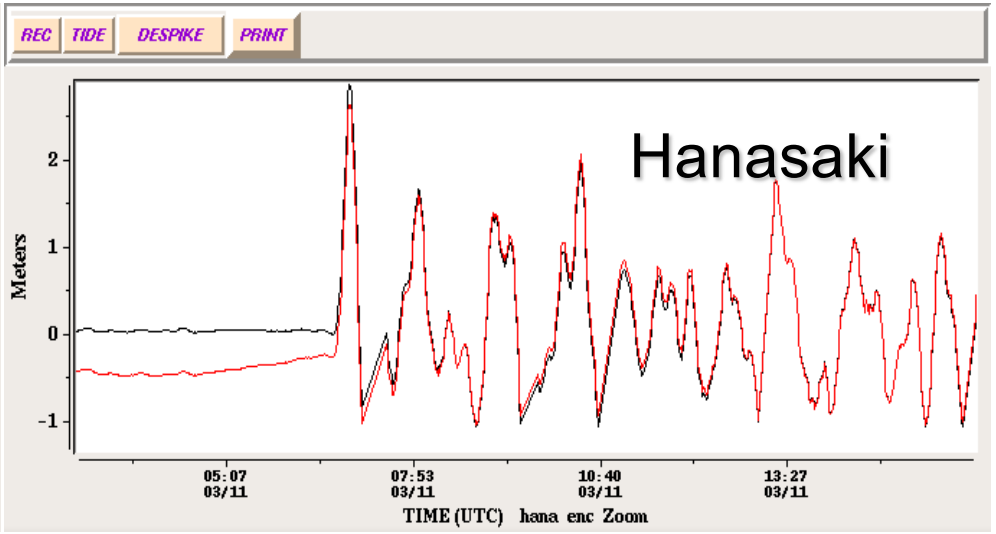
Fig.23

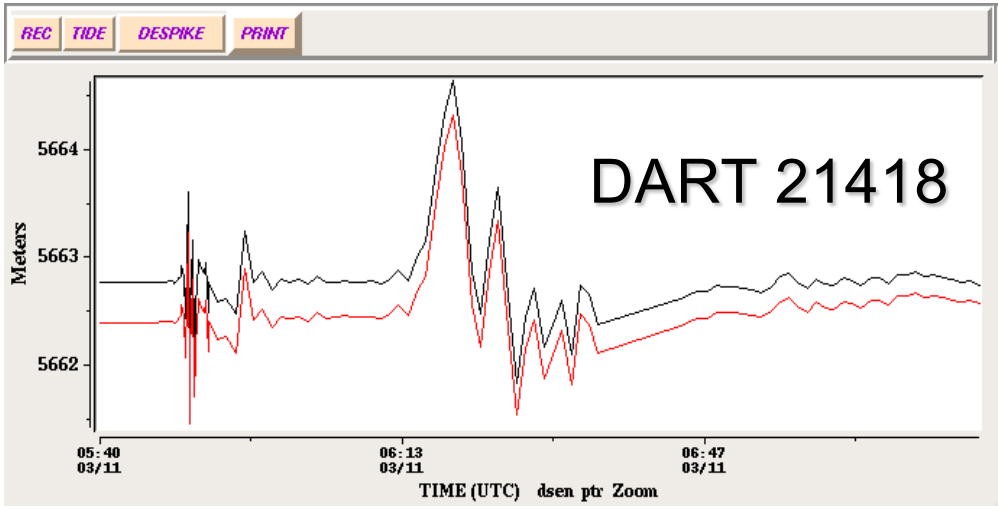
Removal of Astronomical Tide Signal

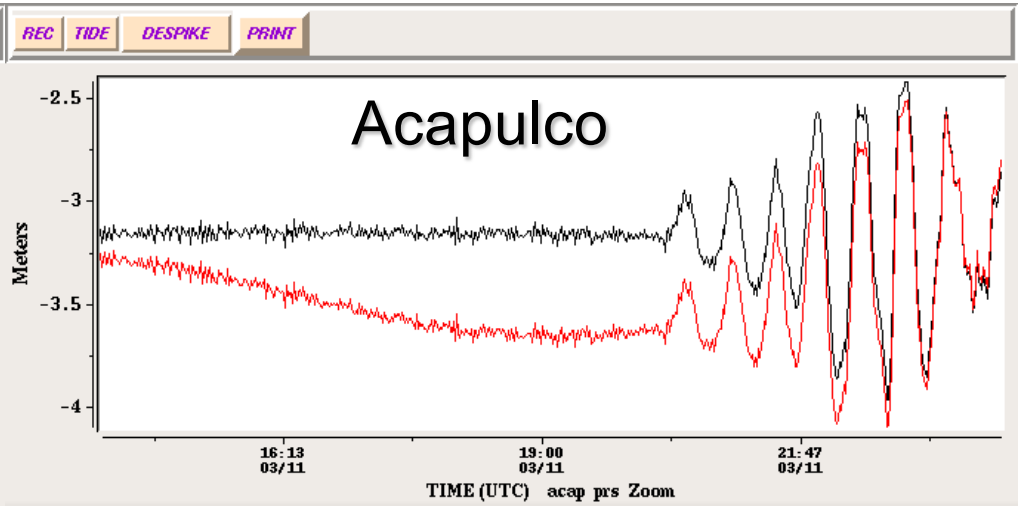


Tohoku Tsunami Marigrams



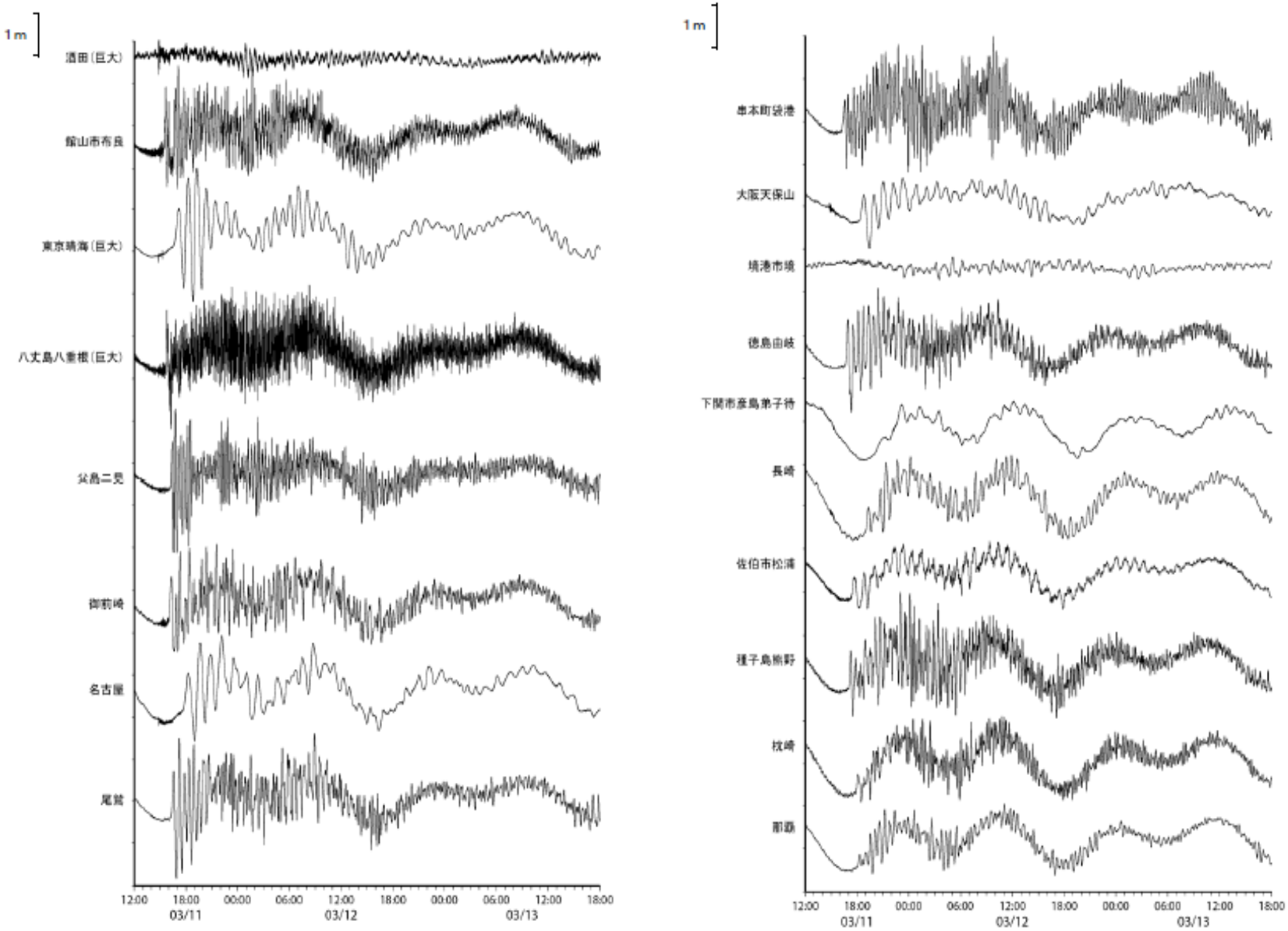






2 days tsunami records - 2011

(Western part of Japan)



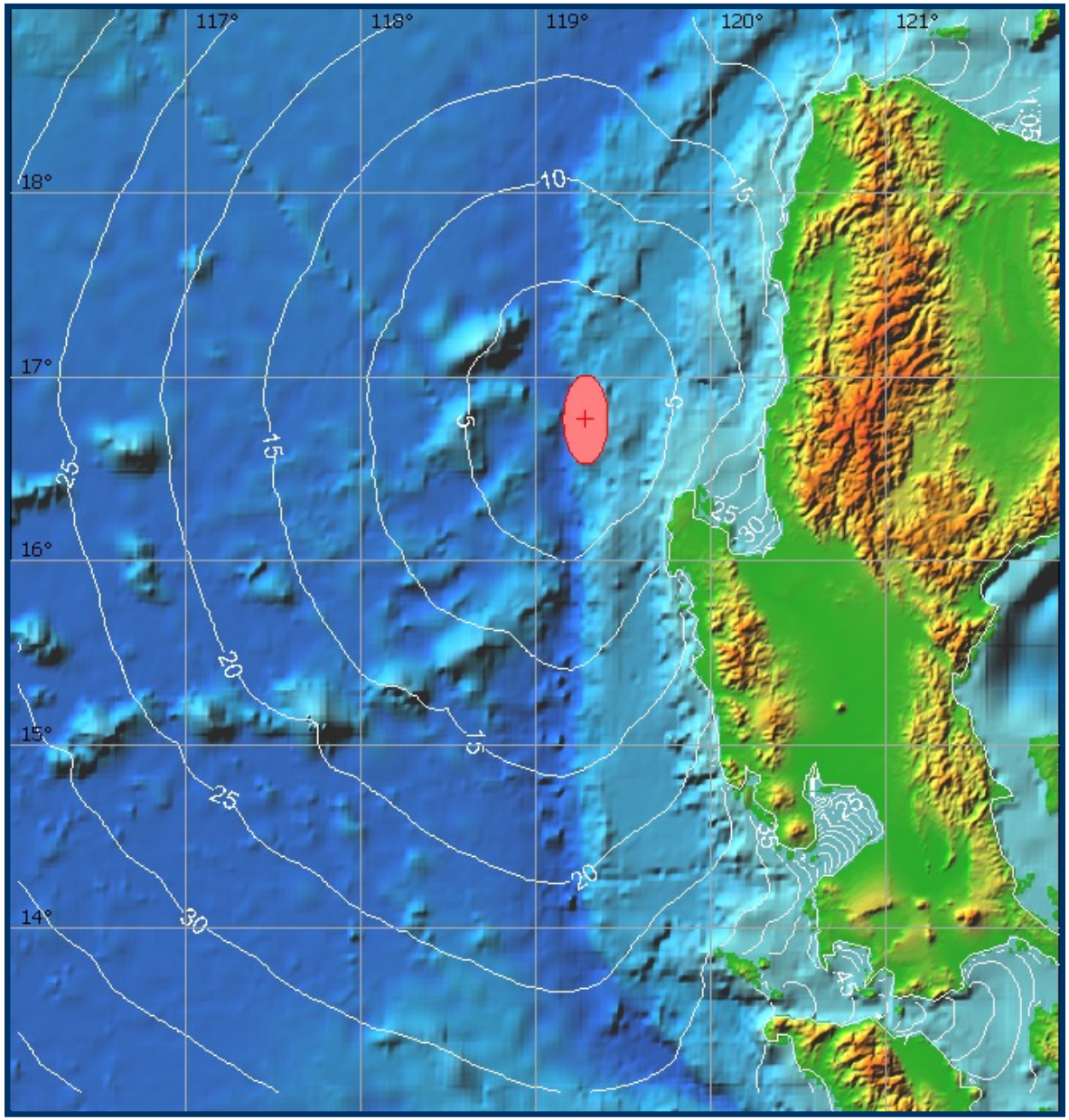
Limitations of Sea Level Data Analysis

- **Type of Sea Level Measurements**
  - Coastal Gauge
    - Most common
    - **Signal highly modified by coastal effects**
    - **May be destroyed by large tsunami**
  - Deep Ocean Gauge
    - Less common
    - Most expensive
    - **Pure tsunami signal to constrain forecast**
  - Wet Sensor
    - On land
    - Less expensive
    - Only indicate if flooding has occurred

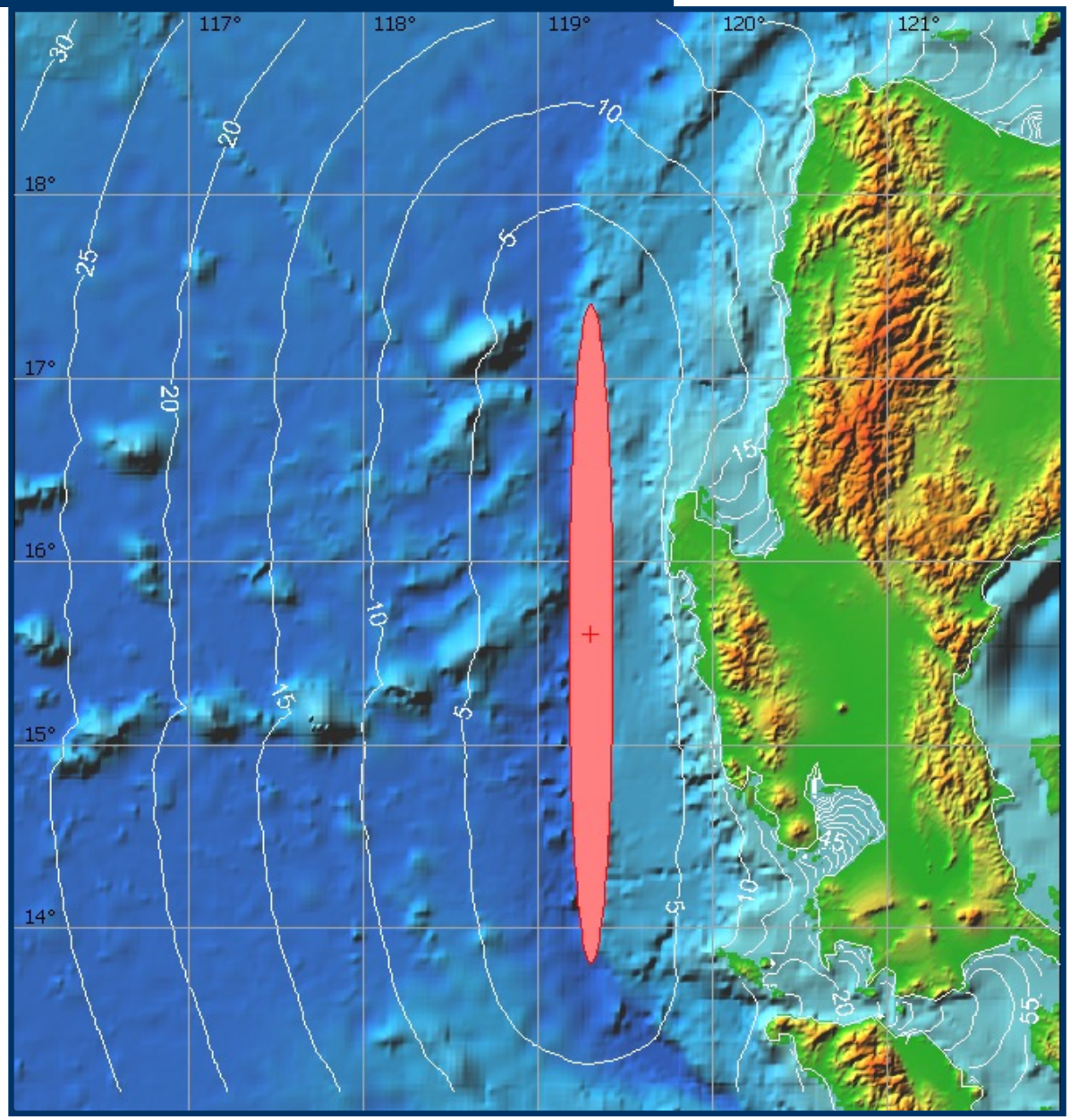
Limitations of Tsunami Forecasting

- **Estimated Arrival Time Forecast**
  - Based on initial seismic analysis
  - Point source or assumed finite fault
- **Initial Threat Level Forecast**
  - Based only on initial seismic analysis and general geophysical/oceanographic contraints
  - Least accurate
- **Sea Level Constrained Forecast**
  - Too late for local tsunami
  - Deep ocean measurements best constraint
  - More accurate

Tsunami Travel Times from Small Source



Tsunami Travel Times from Large Source



Limitations of Tsunami Forecasting

- **Historical Comparisons**
  - Historical record is very short and incomplete in most areas
  - No repeat events
  - May be okay to identify coastal sensitivities

PTWC Reporting of Tsunamis

- Expected Time of Arrival
- Maximum Wave Amplitude – above normal sea level and time of measurement

Thank You

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