Richard H. Hagemeyer
Pacific Tsunami Warning Center:

Mission, Operations, and Activities

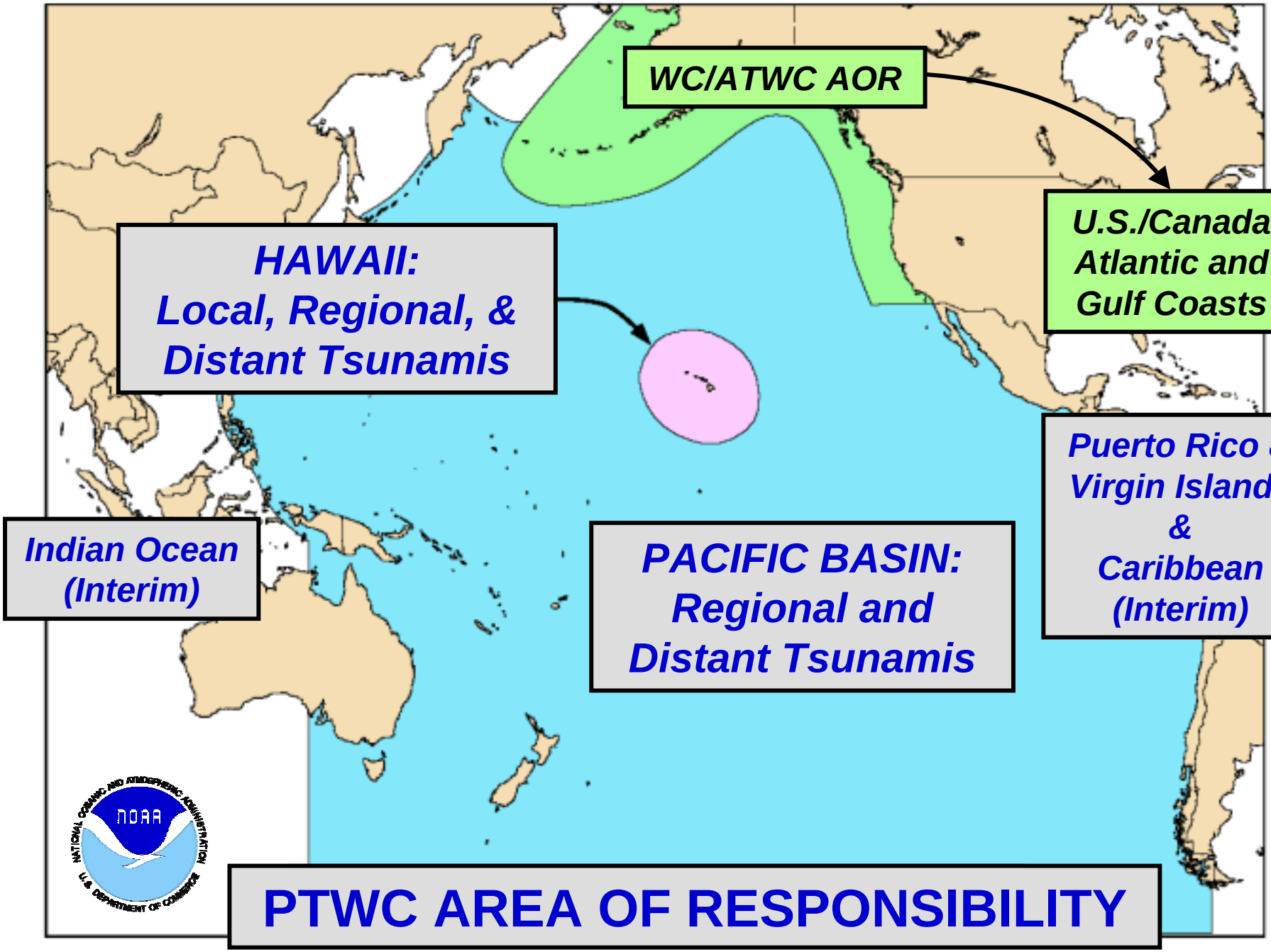
HISTORY

- U.S. TSUNAMI WARNING CENTER (PTWC) ESTABLISHED IN 1949 ...AFTER THE 1946 TSUNAMI
- IOC TSUNAMI WARNING SYSTEM IN THE PACIFIC AND ITS ICG FORMED IN 1965 ...AFTER THE 1960 TSUNAMI AND U.S. CONTRIBUTED PTWC AS ITS OPERATIONAL CENTER
- U.S. ALASKA TSUNAMI WARNING CENTER ESTABLISHED IN 1969 ...AFTER THE 1964 TSUNAMI
- IOC INDIAN OCEAN TSUNAMI WARNING SYSTEM ESTABLISHED IN 2005 ...AFTER THE 2004 TSUNAMI

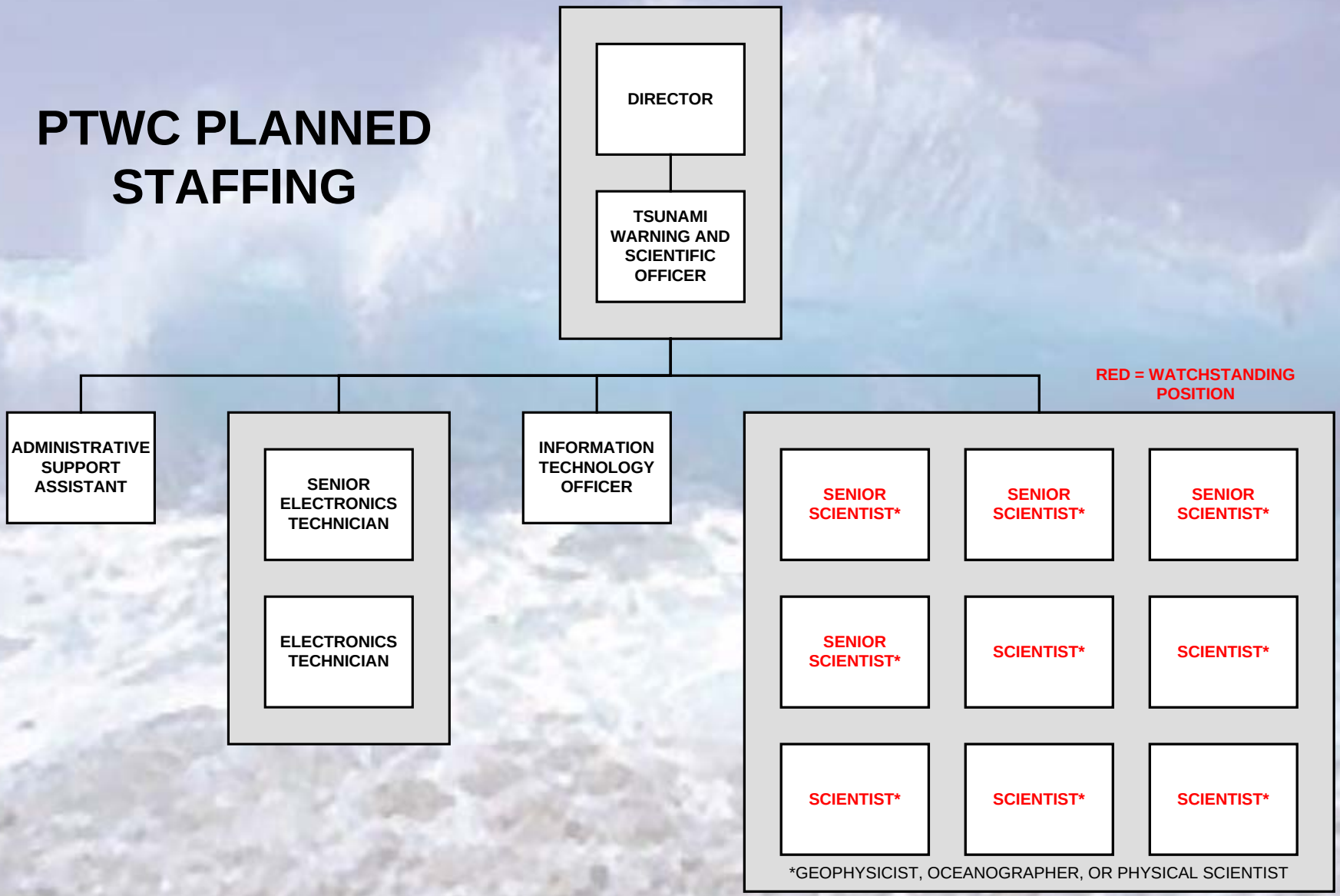
PTWC Mission

SAVE LIVES AND REDUCE PROPERTY DAMAGE BY ISSUING TIMELY AND EFFECTIVE WARNINGS FOR THE TSUNAMI HAZARD

- **LOCAL / REGIONAL TSUNAMI WARNING CENTER FOR THE STATE OF HAWAII**
- **U.S. NATIONAL CENTER FOR ALL U.S. INTERESTS IN PACIFIC OUTSIDE THE WC/ATWC AOR**
- **INTERNATIONAL CENTER FOR THE TSUNAMI WARNING SYSTEM IN THE PACIFIC (ITSU)**
- **INTERIM CENTER FOR THE INDIAN OCEAN**
- **INTERIM CENTER FOR THE CARIBBEAN**


WC/ATWC AOR
U.S./Canada Atlantic and Gulf Coasts
HAWAII: Local, Regional, & Distant Tsunamis
Puerto Rico & Virgin Islands & Caribbean (Interim)
Indian Ocean (Interim)
PACIFIC BASIN: Regional and Distant Tsunamis
NOAA
PTWC AREA OF RESPONSIBILITY

PTWC PLANNED STAFFING



Overview of PTWC Activities

- Respond to Alarms
- Respond to Readiness Problems
  - Communications Links
  - Data Sources (e.g., NEIC, HVO, WC/ATWC)
  - Hardware
  - Software
- Research
  - Internal Research to Improve Operations
  - Monitor Applicable External Research
  - Develop and Implement New Procedures
- Data Streams from Partners
  - Seek/Add New Data Streams
  - Maintain Existing Data Streams
  - Changes in Metadata
  - Changes in Formats
- Install/Maintain/Upgrade Field Sites
  - Hawaii Seismic and Sea Level Sites
  - Pacific Sea Level Sites
- Information and Computer Technology
  - System Administration Tasks
  - Security
- Software
  - Write New Operational Software
  - Maintain Existing Software

Overview of PTWC Activities

- Outreach
  - Public
  - Media
- Interface with Partners
  - NWS (PRH, HFO, AR, WR, SR)
  - NOAA (OAR-PMEL, NOS, NESDIS)
  - Hawaii Civil Defense
  - National Tsunami Hazard Mitigation Program
  - International (IOC, ICG/ITSU, ICG/IOTWS, IOCARIBE, WMO)
- WC/ATWC Backup
- Maintain Facilities
  - Grounds
  - Buildings
  - Housing
  - Antenna Farm
  - Geomagnetics
  - Kipapa Seismic Vault
- Safety Issues
- Develop/Maintain Documentation
- Develop/Maintain Web Site
- Operate Geomagnetics Observatories for the USGS and Japan
- Operate COOPS Weather Station

Overview of PTWC Activities

- **Message Dissemination**
  - **Maintain List of Contact Points**
  - **Communications Tests**
  - **Exercises**
- **Other Administrative Tasks**

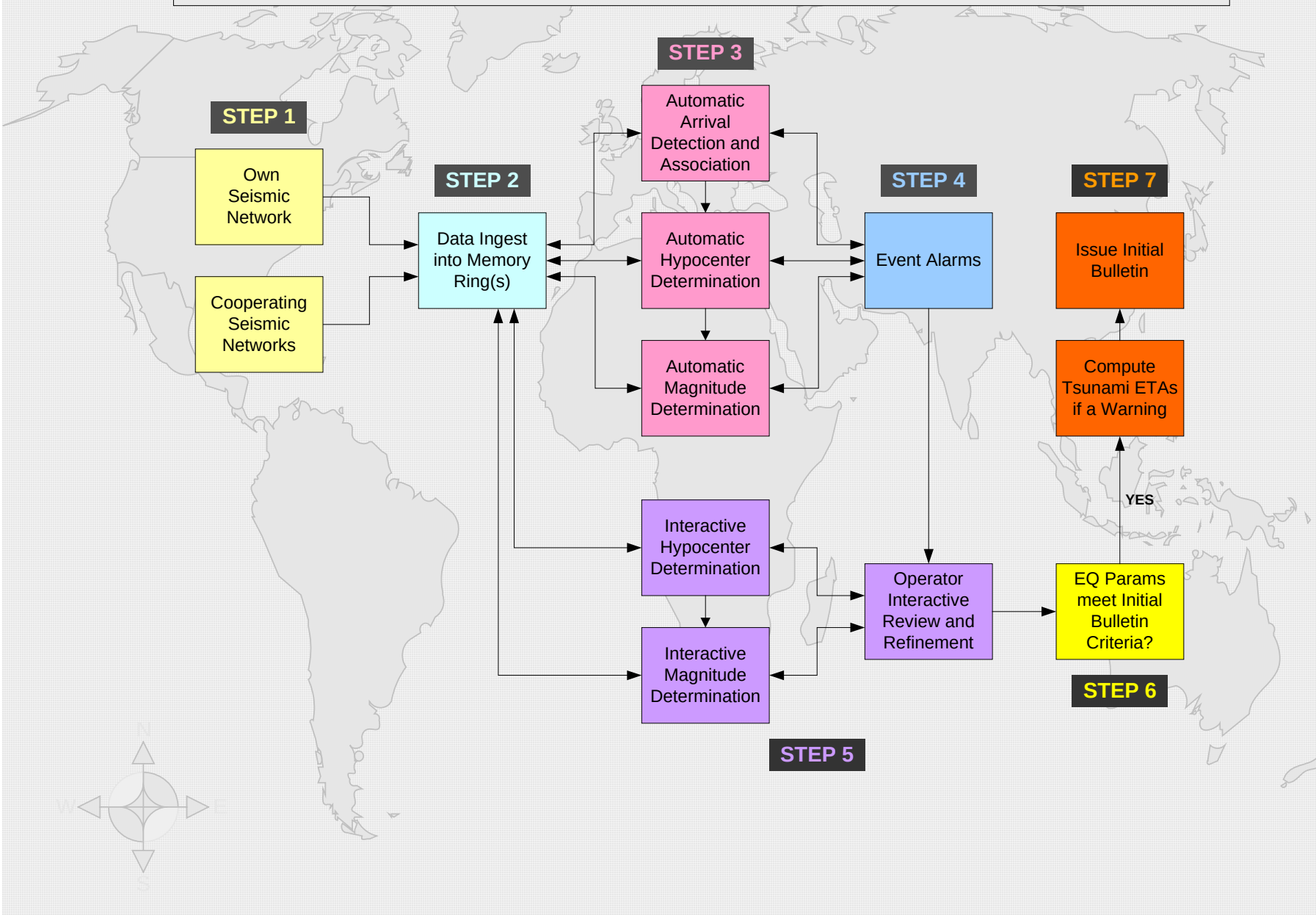
PTWC KEY OPERATIONAL ACTIVITIES

- SEISMIC DATA COLLECTION & ANALYSES
- SEA LEVEL MEASUREMENTS
- DECISION-MAKING PROCESSES
- MESSAGE CREATION & DISSEMINATION

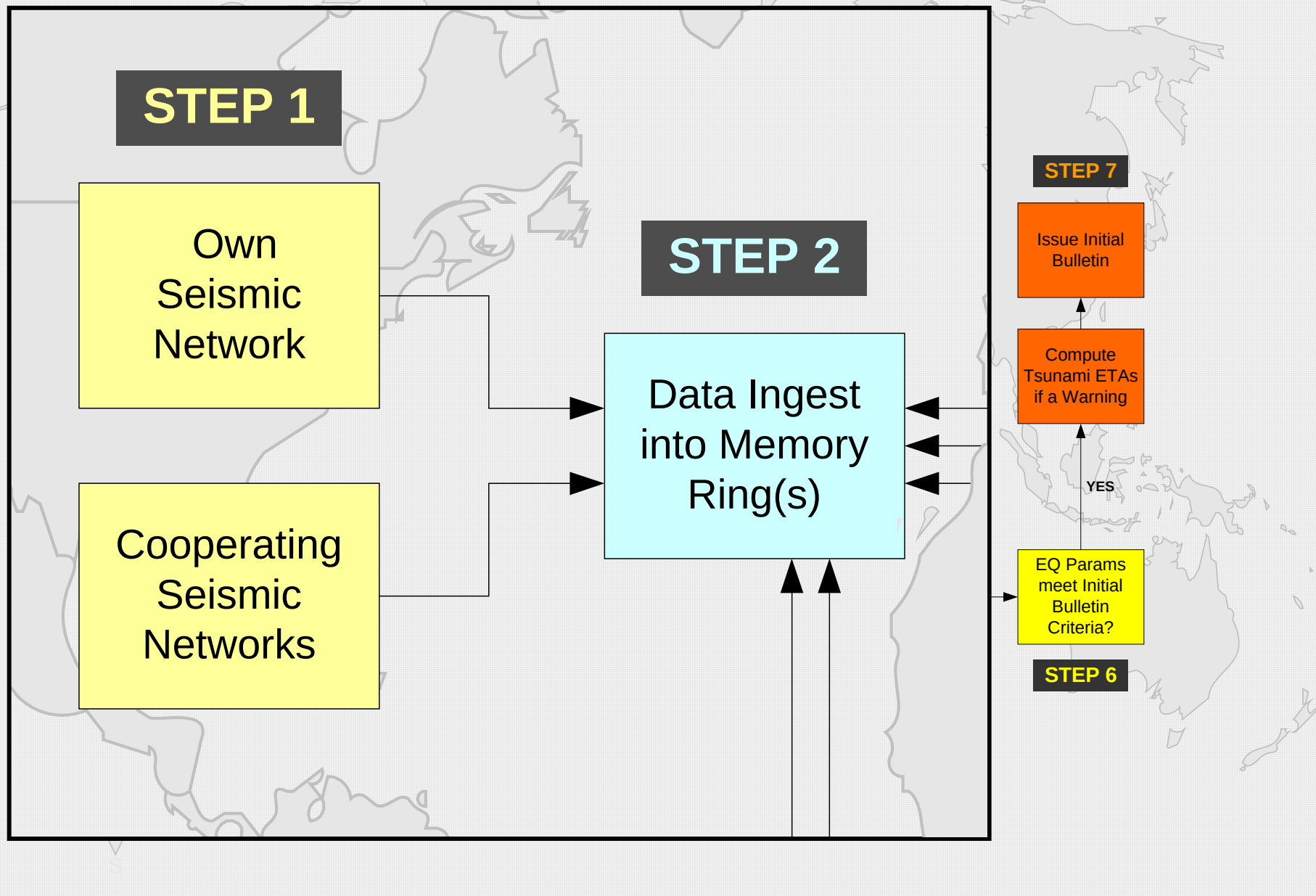
KEY OPERATIONAL GOALS

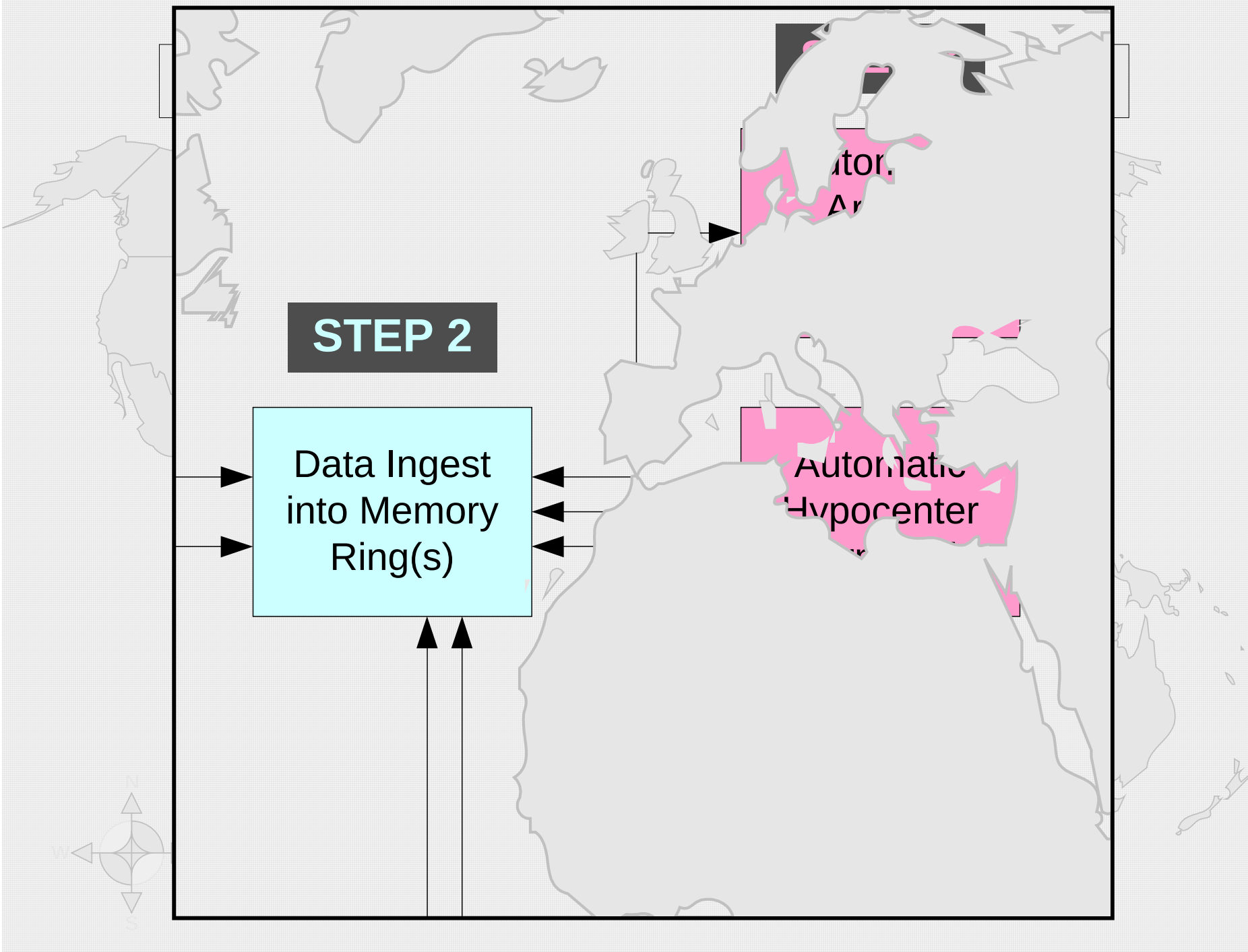
- FASTER
- MORE ACCURATE
- MORE RELIABLE

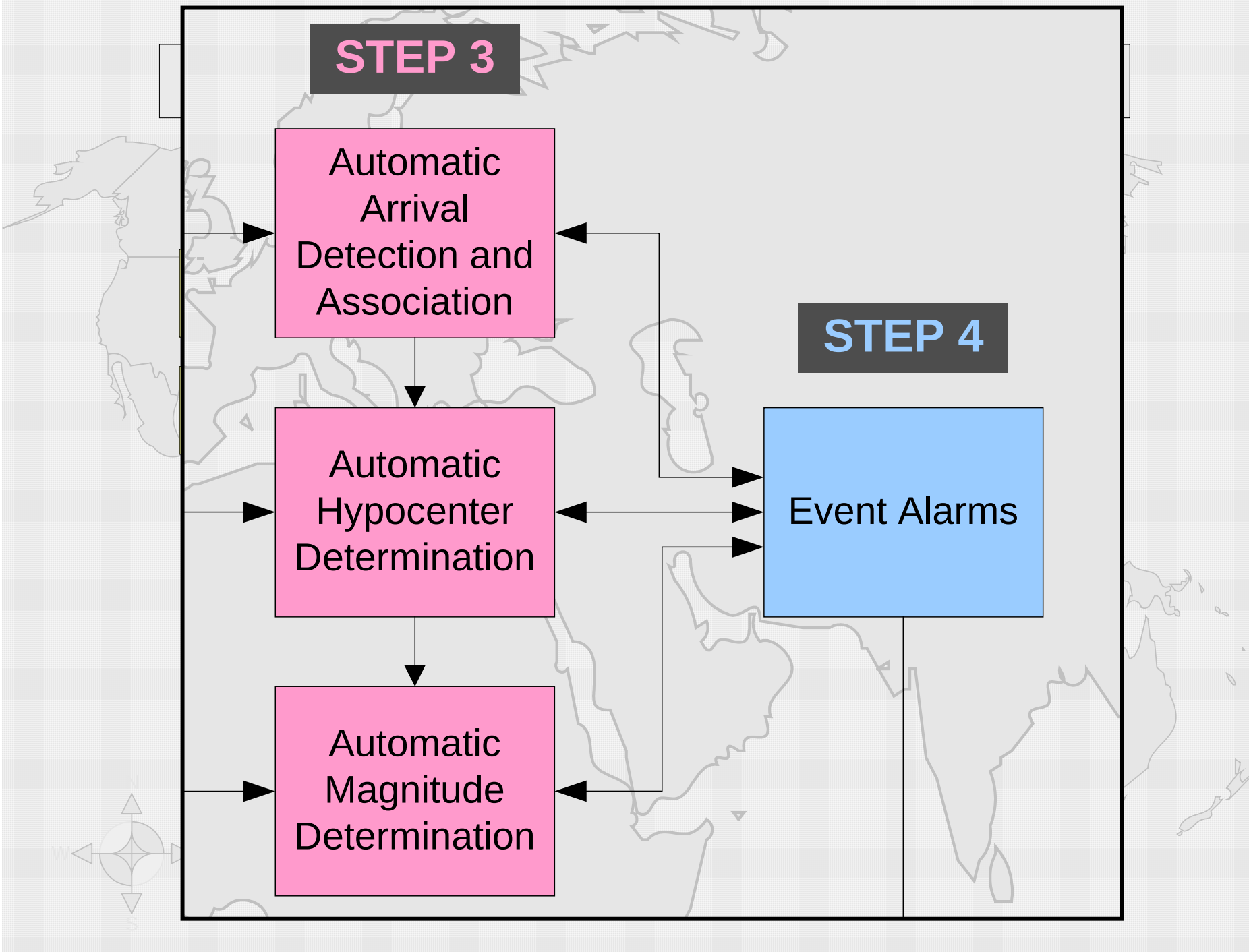
PTWC General Processes and Procedures for Initial Tsunami Bulletins



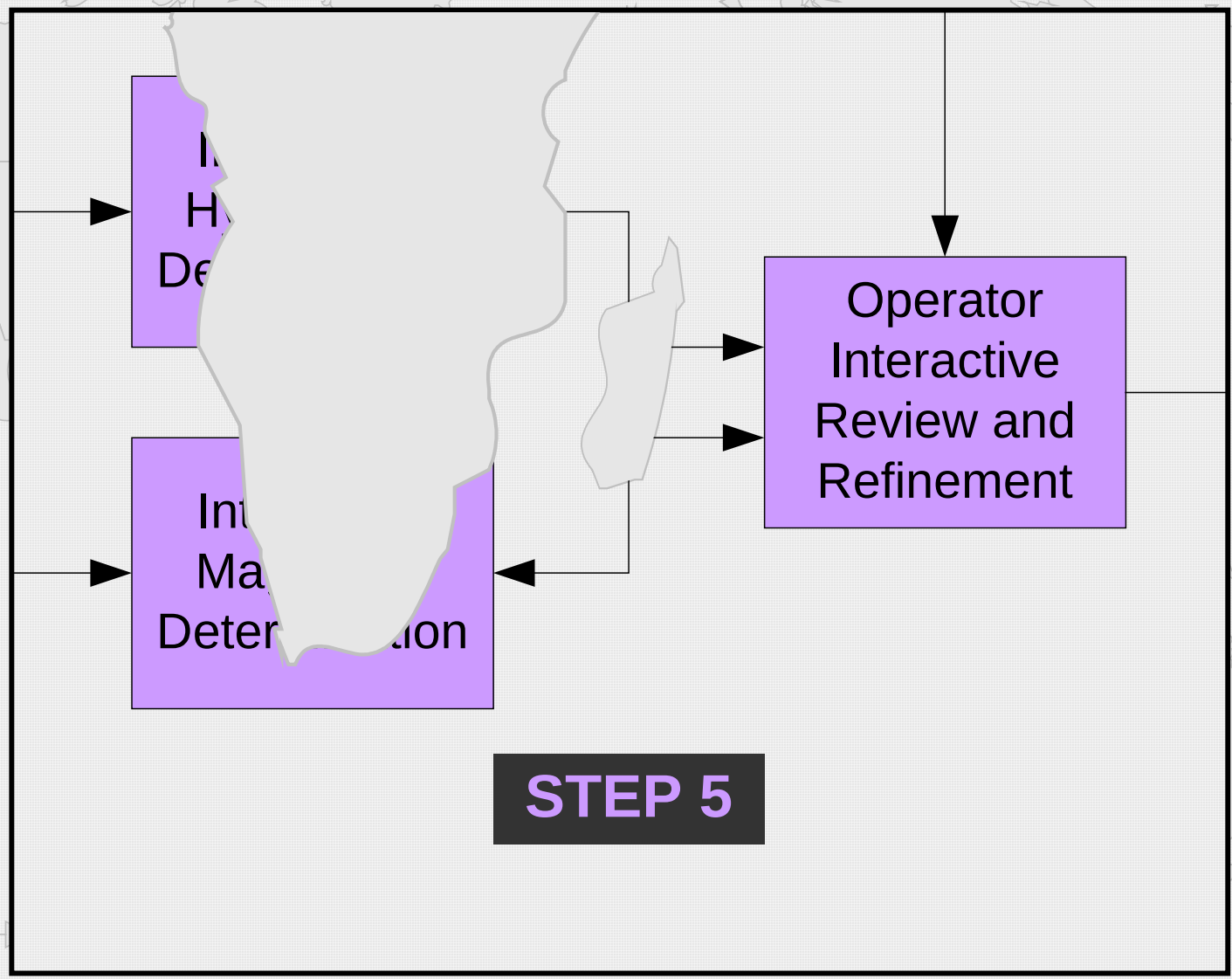
PTWC General Processes and Procedures for Initial Tsunami Bulletins



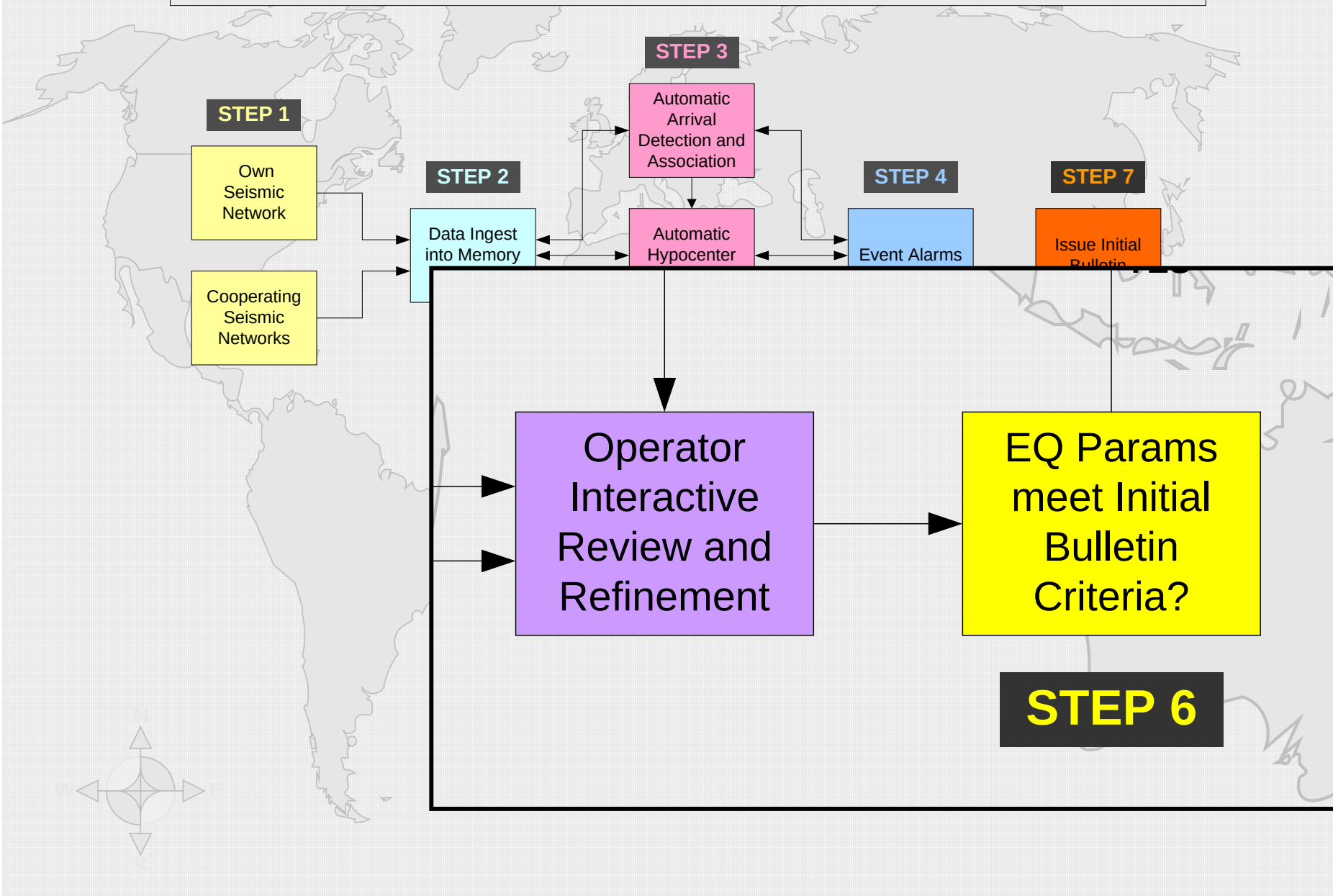

STEP 2
Data Ingest into Memory Ring(s)


STEP 3
Automatic Arrival Detection and Association
Automatic Hypocenter Determination
Automatic Magnitude Determination
STEP 4
Event Alarms

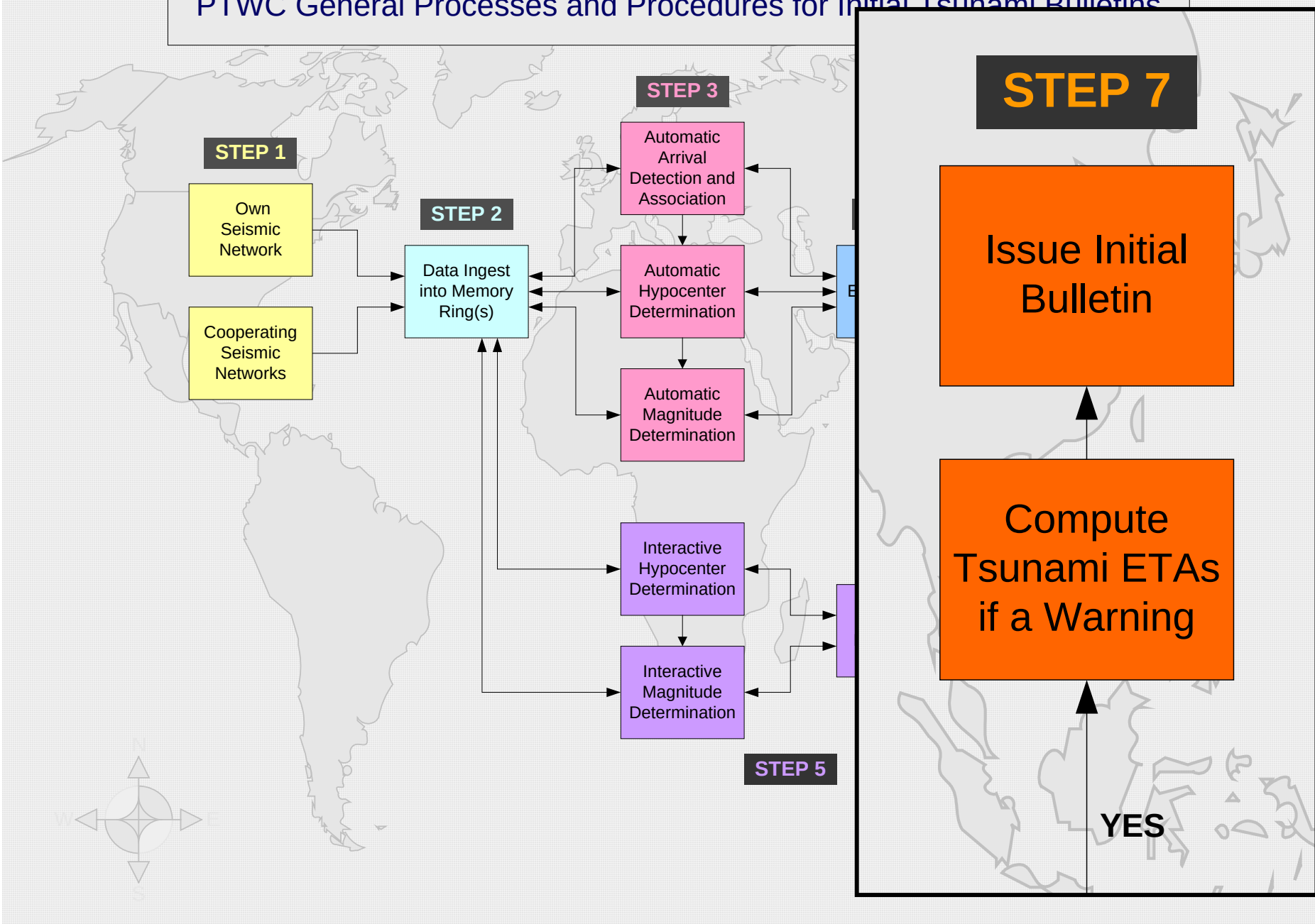
PTWC General Processes and Procedures for Initial Tsunami Bulletins



PTWC General Processes and Procedures for Initial Tsunami Bulletins



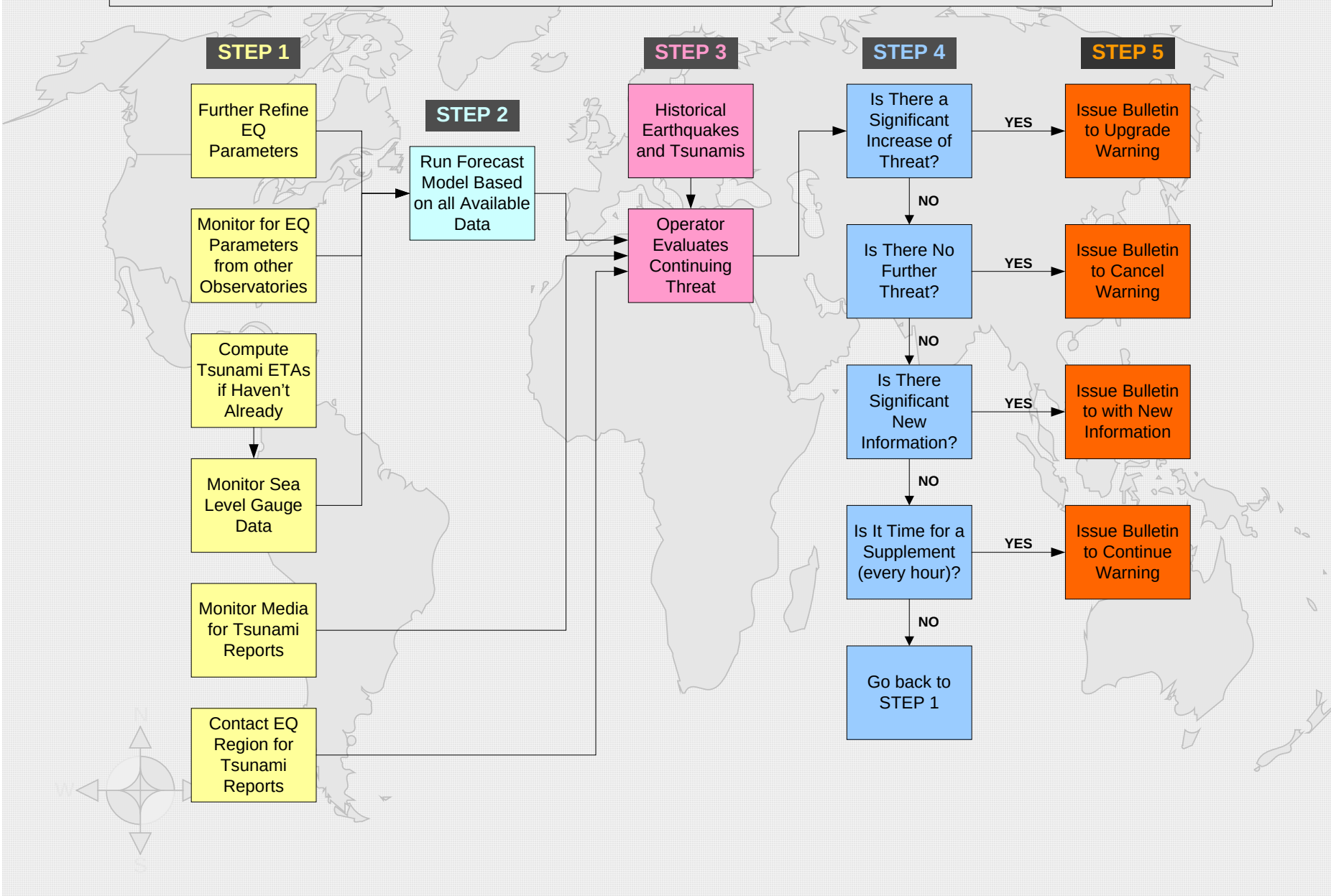
PTWC General Processes and Procedures for Initial Tsunami Bulletins

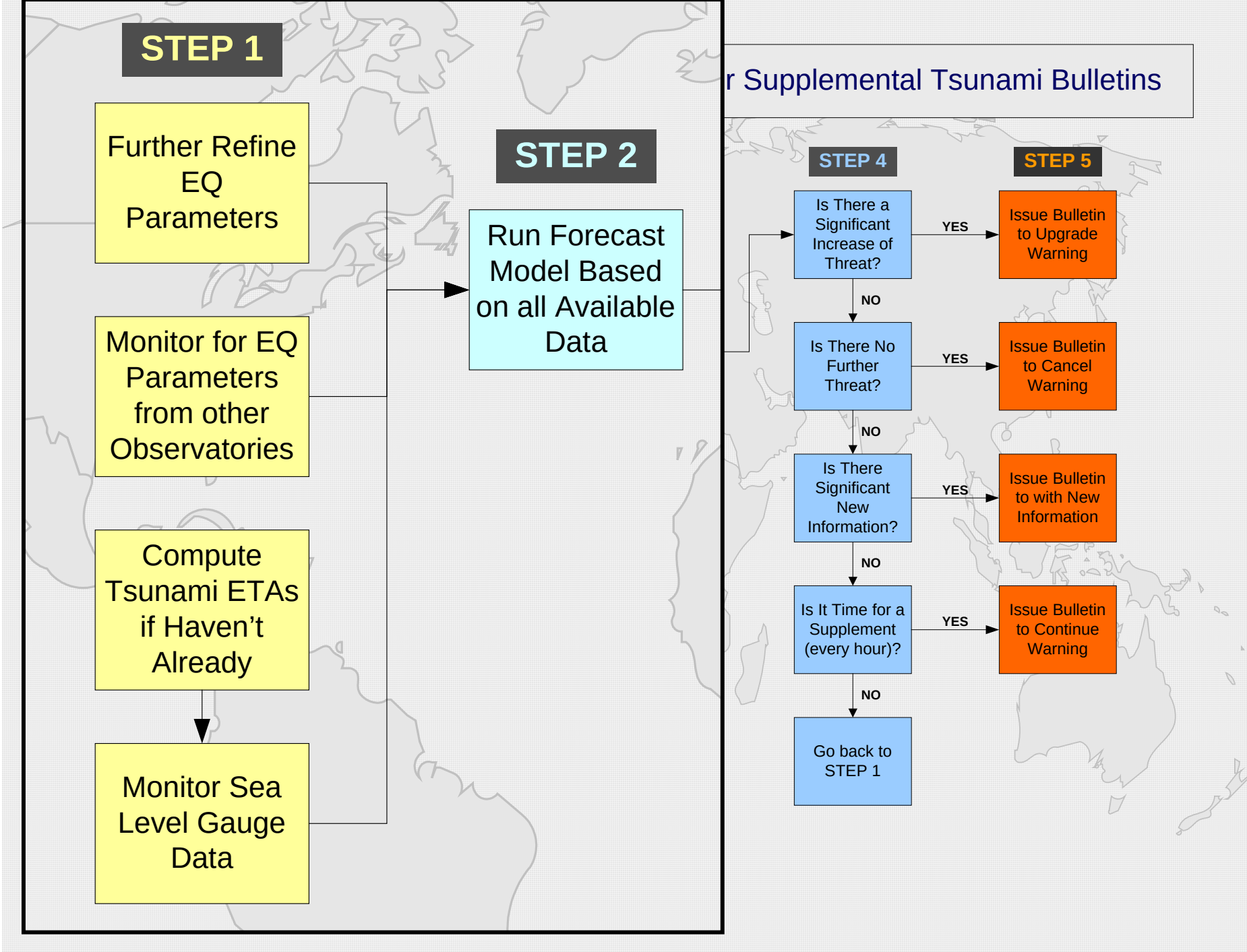


PTWC PACIFIC BULLETIN CRITERIA

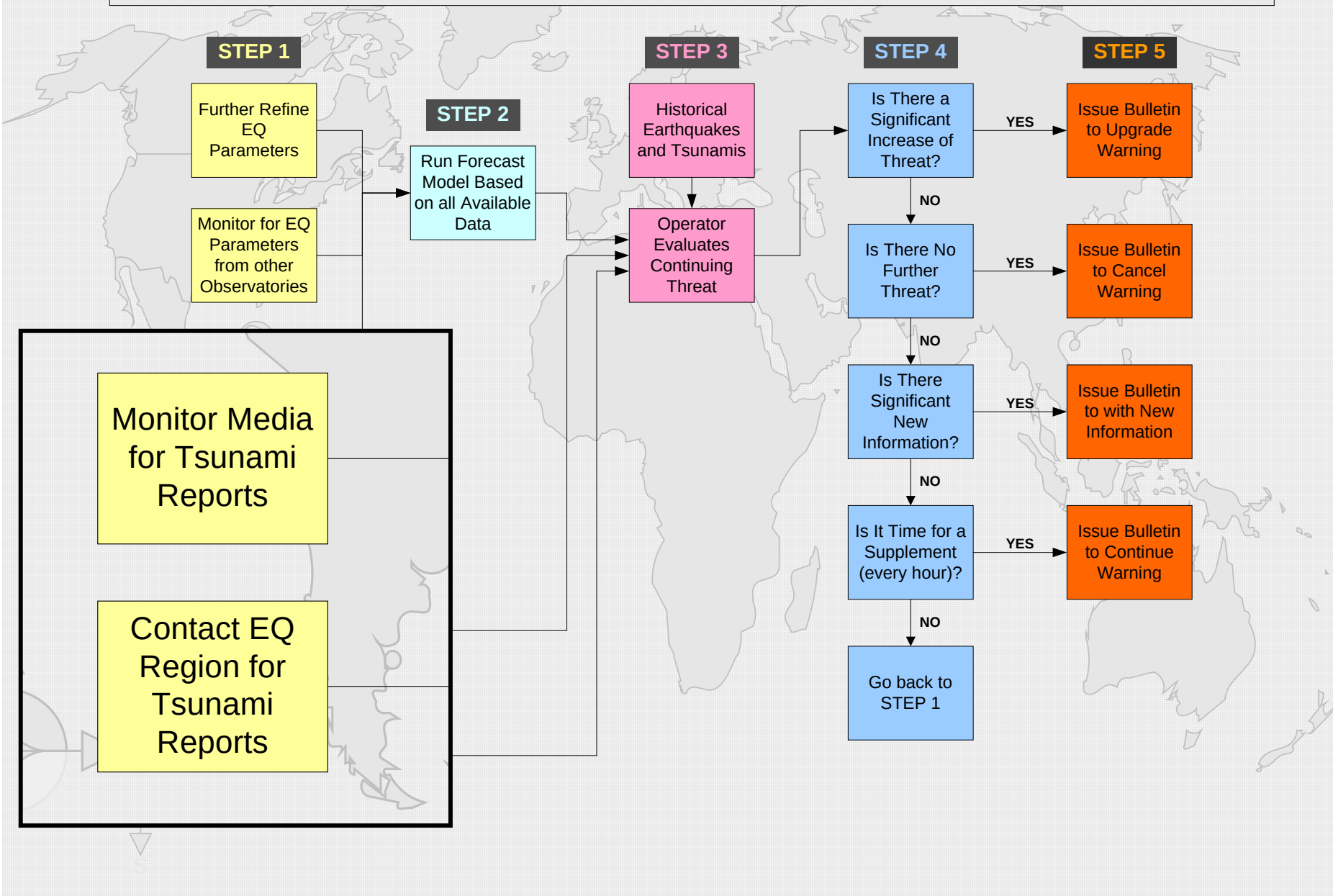
Mw less than 6.5 **(Mw: Moment Magnitude)**	**Earthquake Message Only**
Mw 6.5 to 7.5	**Tsunami Information Bulletin**
Mw 7.6 to 7.8	**Regional Tsunami Warning**
Mw > 7.8	**Expanding Warning / Watch**
Confirmed Teletsunami	**Pacific-Wide Warning**

PTWC General Processes and Procedures for Supplemental Tsunami Bulletins

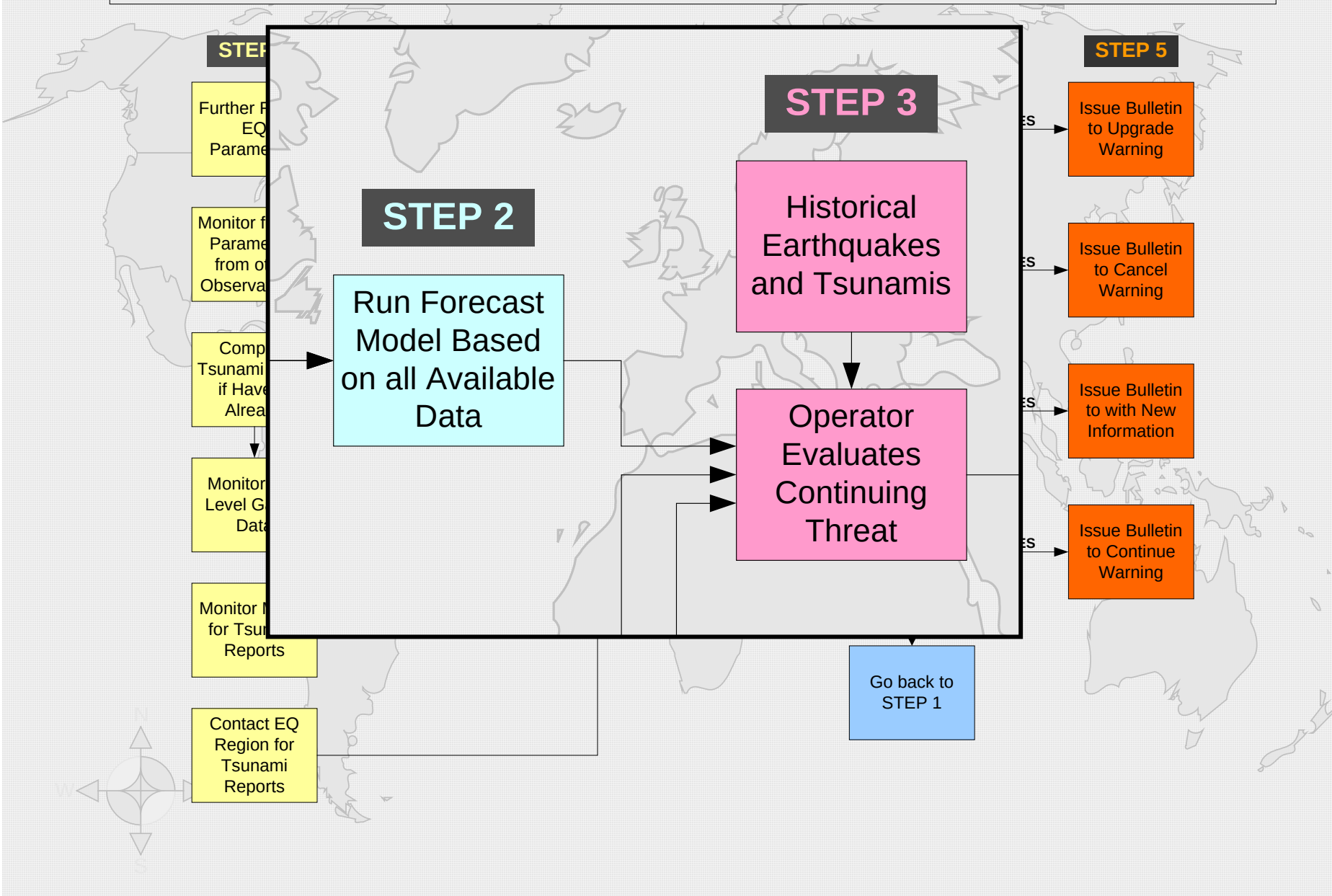



STEP 1
Further Refine EQ Parameters
Monitor for EQ Parameters from other Observatories
Compute Tsunami ETAs if Haven't Already
Monitor Sea Level Gauge Data
STEP 2
Run Forecast Model Based on all Available Data
r Supplemental Tsunami Bulletins
STEP 4
STEP 5
Is There a Significant Increase of Threat?
YES
Issue Bulletin to Upgrade Warning
NO
Is There No Further Threat?
YES
Issue Bulletin to Cancel Warning
NO
Is There Significant New Information?
YES
Issue Bulletin to with New Information
NO
Is It Time for a Supplement (every hour)?
YES
Issue Bulletin to Continue Warning
NO
Go back to STEP 1

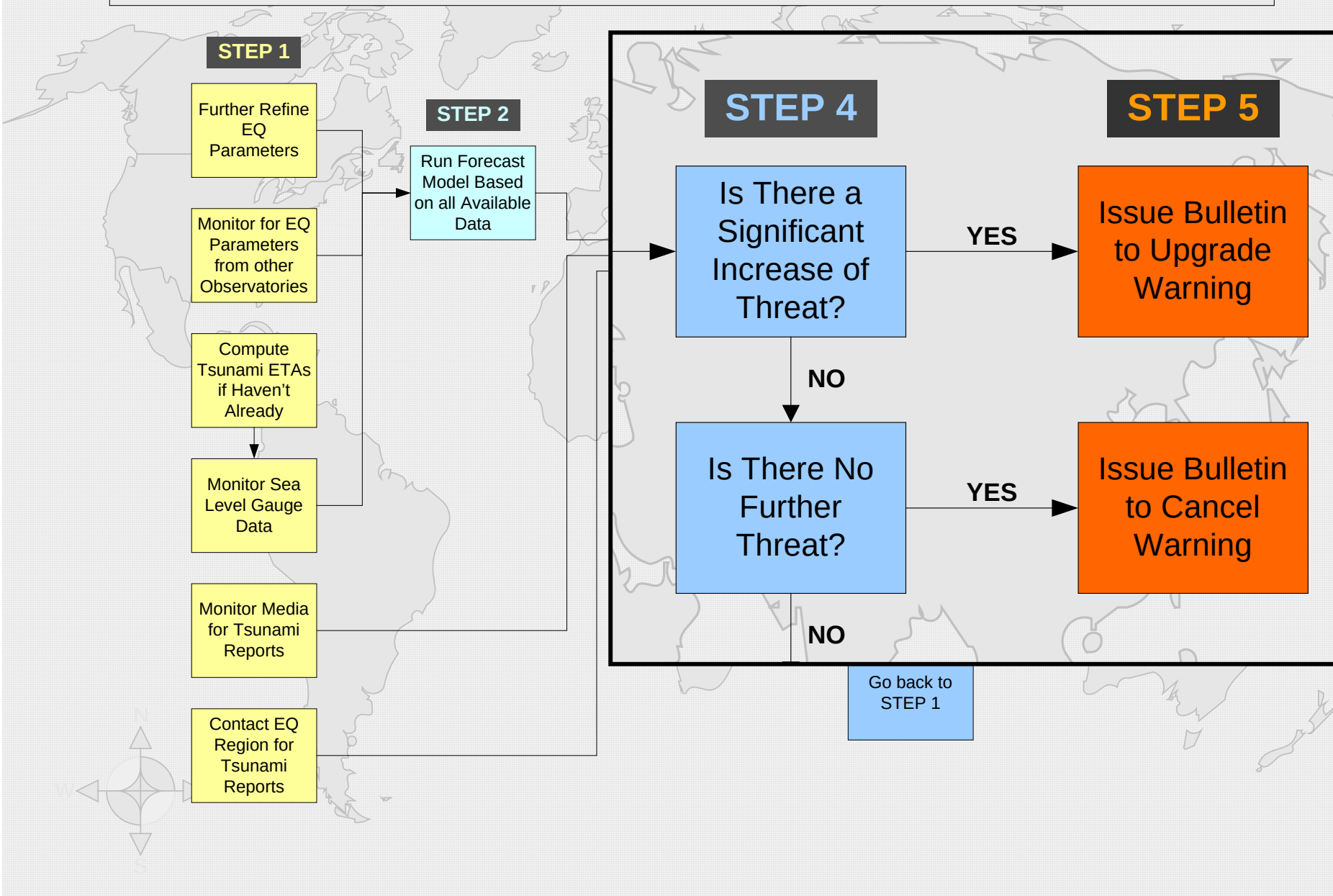
PTWC General Processes and Procedures for Supplemental Tsunami Bulletins



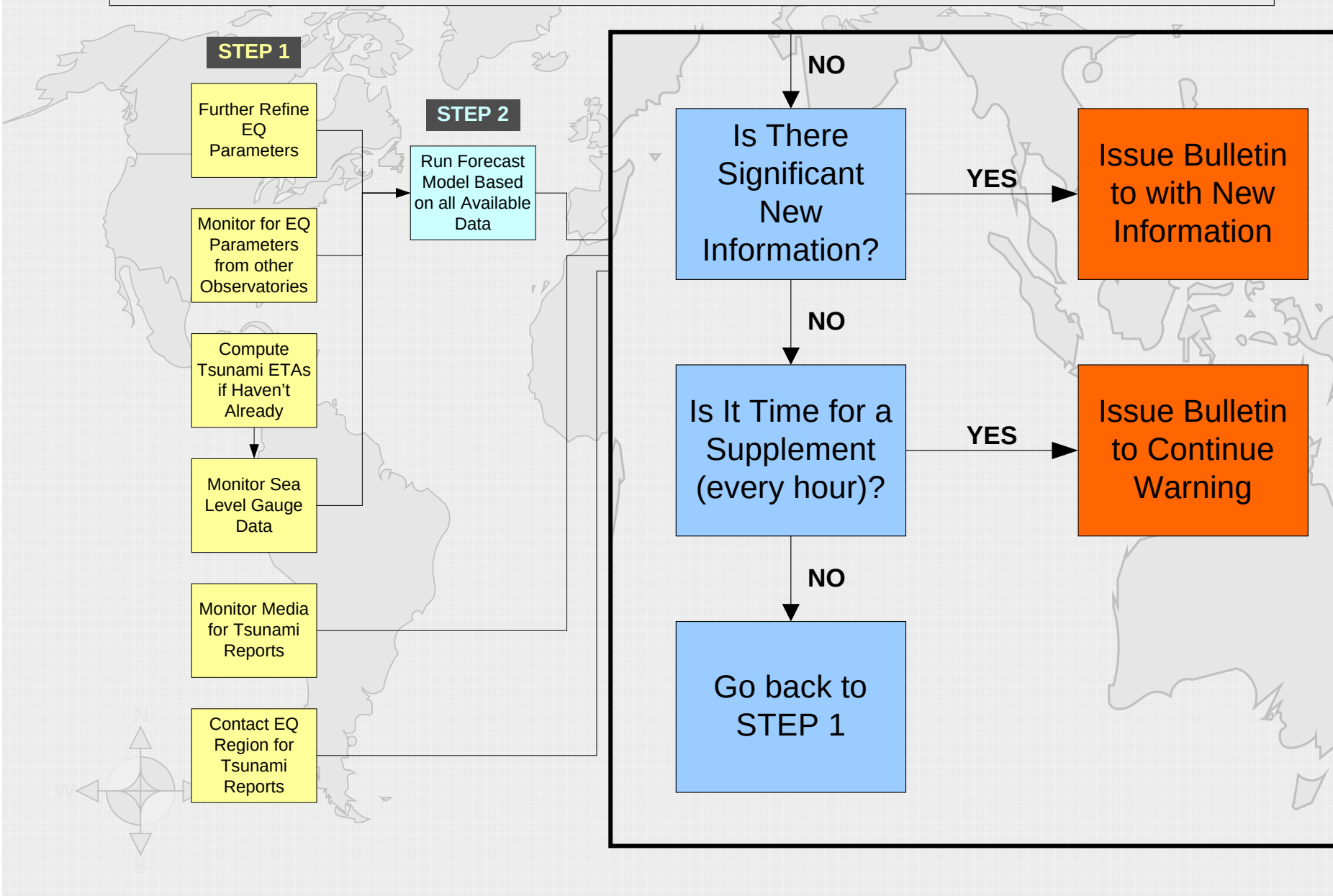
PTWC General Processes and Procedures for Supplemental Tsunami Bulletins



PTWC General Processes and Procedures for Supplemental Tsunami Bulletins



PTWC General Processes and Procedures for Supplemental Tsunami Bulletins



100% OPERATIONAL RELIABILITY

- **POWER**: All operational systems on a central UPS backed up by a generator with one week of fuel.
- **CENTER HARDWARE**: Hardware duplicated into primary and redundant systems.
- **DATA SOURCES**: Seismic and sea level data come from multiple sources.
- **DATA COMMUNICATIONS**: Data is sent to PTWC over multiple links whenever possible.

100% OPERATIONAL RELIABILITY

- **DATA PROCESSING**: Multiple algorithms for EQ detection, alerting, locations, magnitudes, and model guidance.
- **MESSAGING**: Multiple dissemination methods to reach designated contact points by multiple means.
- **DUTY PERSONS**: Two persons always on duty on the Center compound.
- **BACKUP CENTER**: PTWC and WC/ATWC provide backup service for each other.

LONG TERM SUSTAINABILITY

- **NATIONAL SUPPORT: National commitment to Center operations. As a part of the US National Weather Service, certain resources and expertise are shared with this organization that also does 24x7 monitoring of the environment and issues advisories, watches, and warnings.**
- **ORGANIZATIONAL SUPPORT: Organizations of stakeholders such as ITSU (international), NTHMP (national), and TTRC (local) that include emergency managers, warning center operators, and scientists provide authoritative sustained focus on tsunami issues**

LONG TERM SUSTAINABILITY

- **MULTI-FUNCTION SEISMIC**: Seismic stations operated by multiple organizations for multiple purposes including earthquake monitoring, volcano monitoring, and geophysical research.
- **MULTI-FUNCTION SEA LEVEL**: Sea level stations operated by multiple organizations for multiple purposes including tides, storm surge, El Niño, and long-term sea level rise.
- **MULTI-FUNCTION COMMUNICATIONS**: Data communications methods shared when possible. Message disseminations over multi-purpose circuits such as GTS, AFTN, EMWIN.

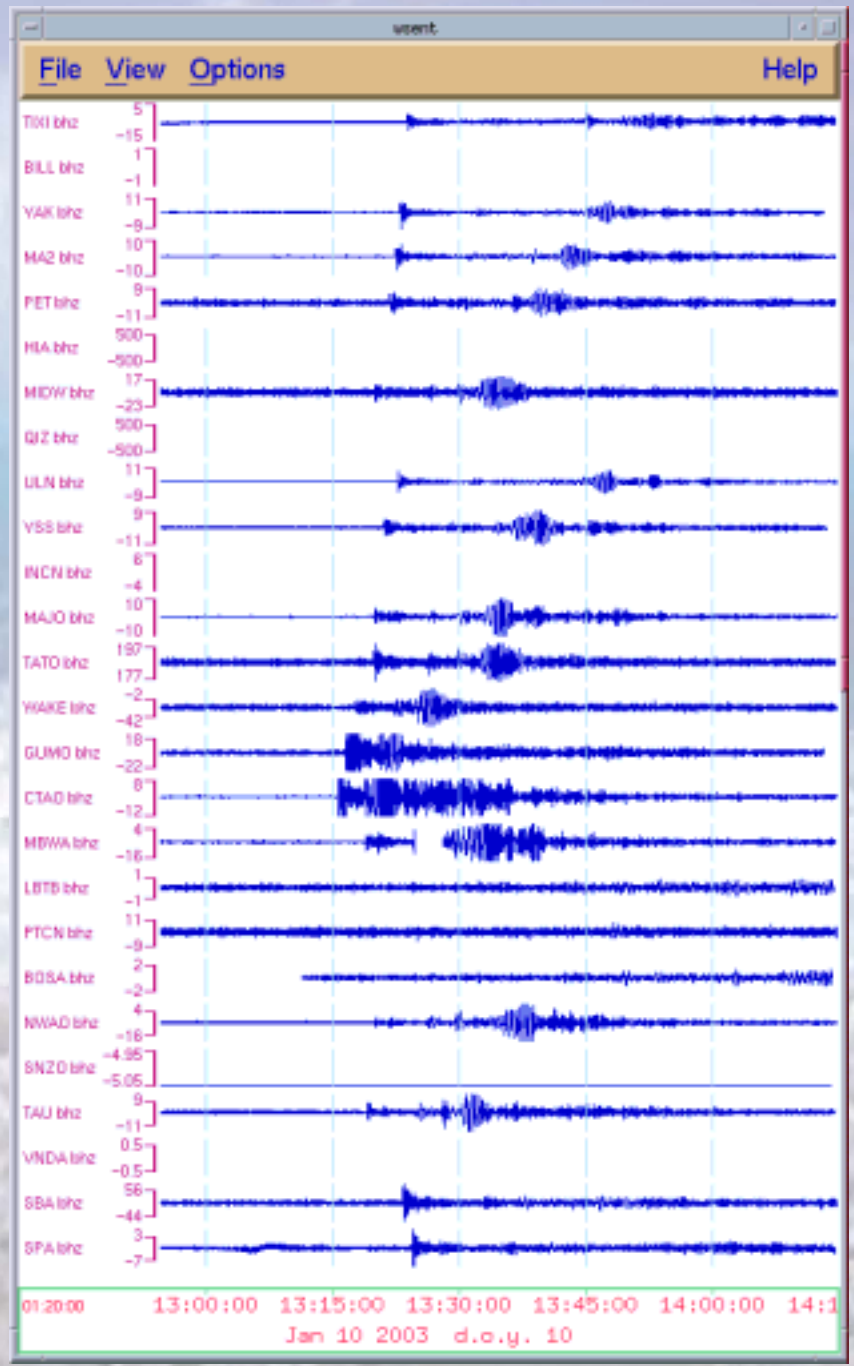
LONG TERM READINESS

- **FREQUENT ALARMS**: Duty staff respond to one or two earthquakes per day on average
- **FREQUENT BULLETINS**: Bulletin criteria set so system is exercised regularly.

Pacific:	Mw >= 6.5	~2 events/month
Hawaii:	ml > 4.0	~1 event/month

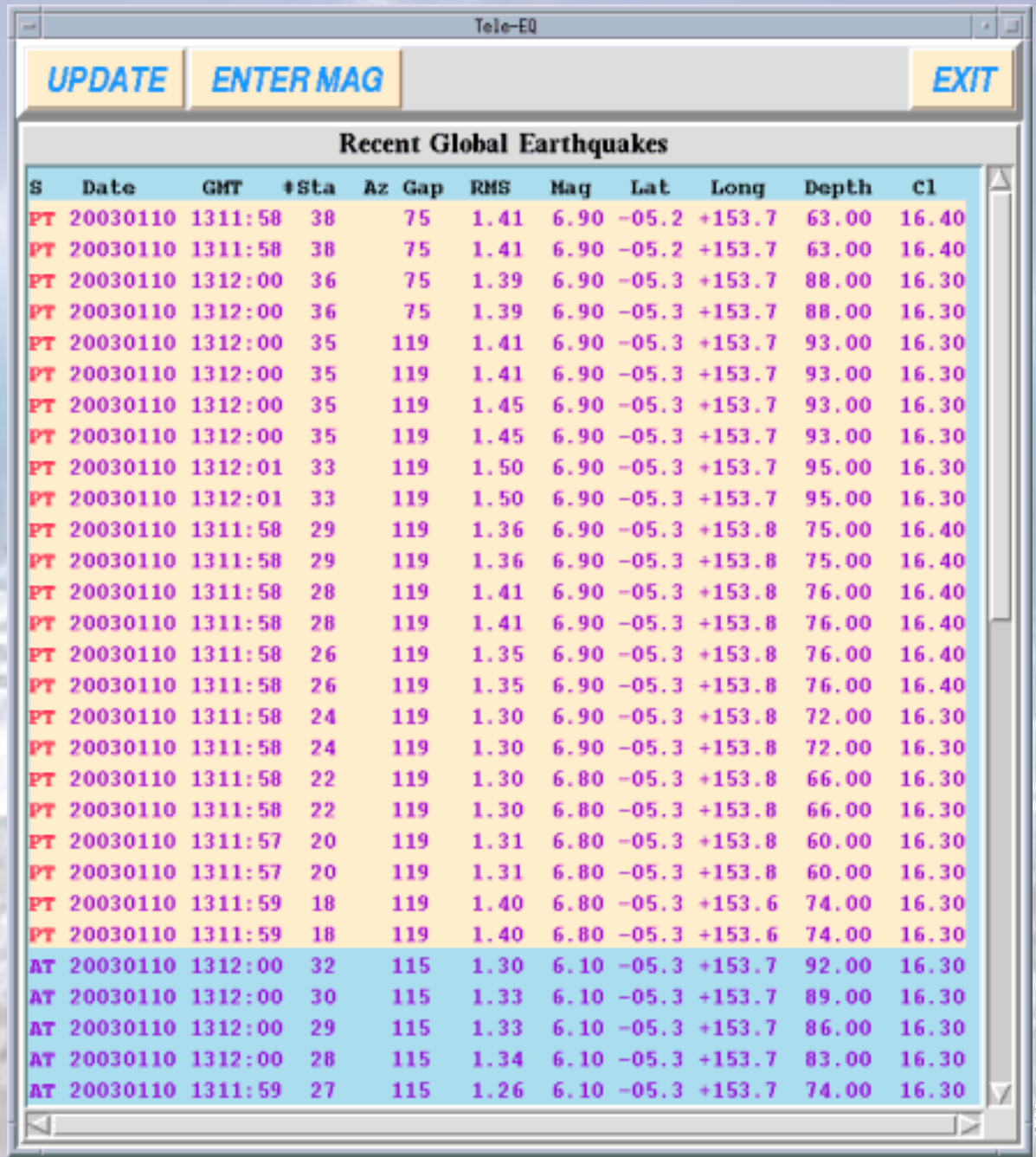
- **COMMUNICATION TESTS**: Monthly communication tests with response required ensure communication links working and reinforce readiness.
- **EXERCISES**: Tabletop and more realistic exercises expose weaknesses and provide practice.

CONTINUOUS DISPLAY OF SEISMIC TRACES

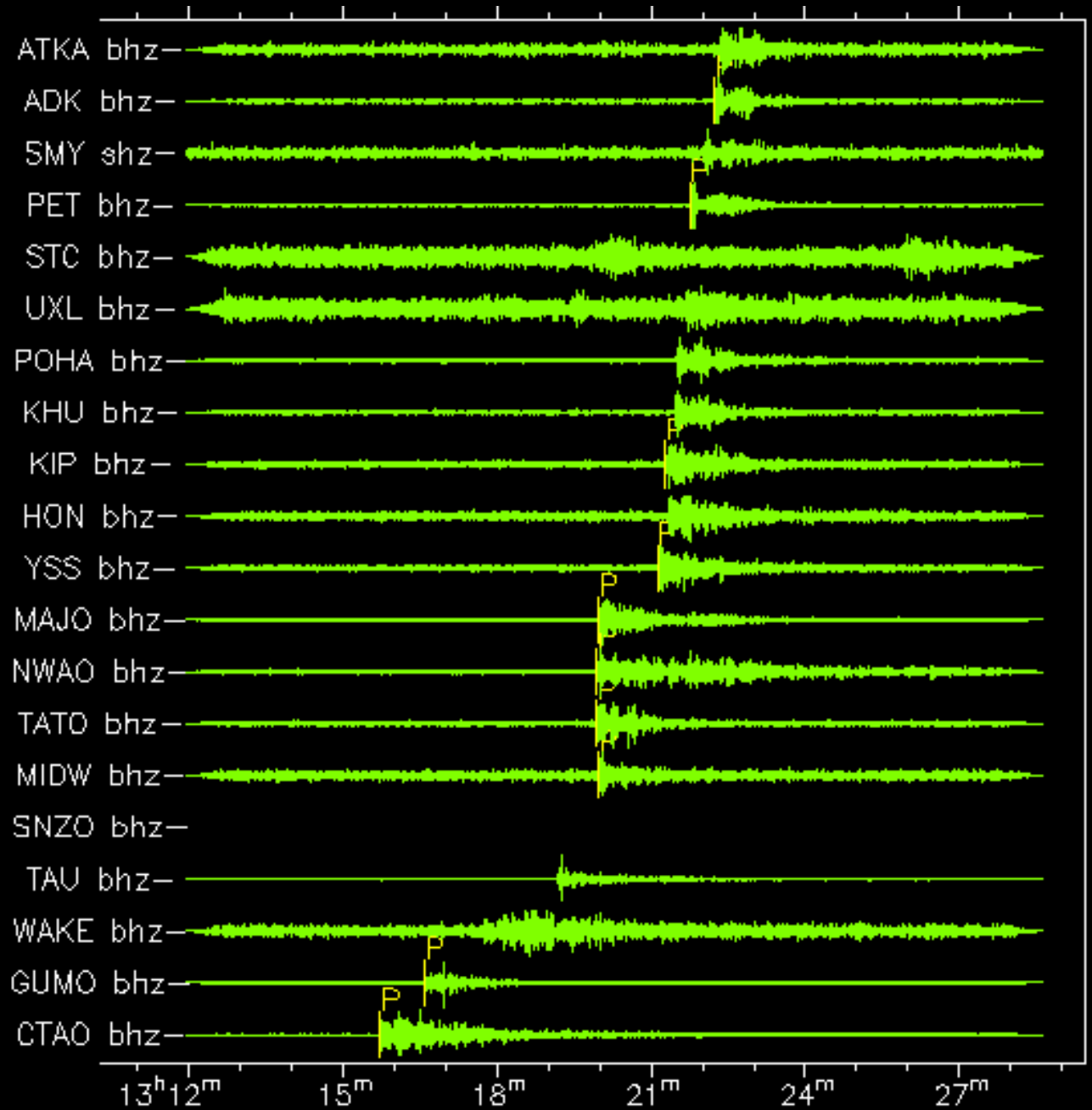


AUTOMATIC SOLUTIONS FOR PACIFIC EVENTS

INITIAL LOCATION IN 3 - 8 MIN

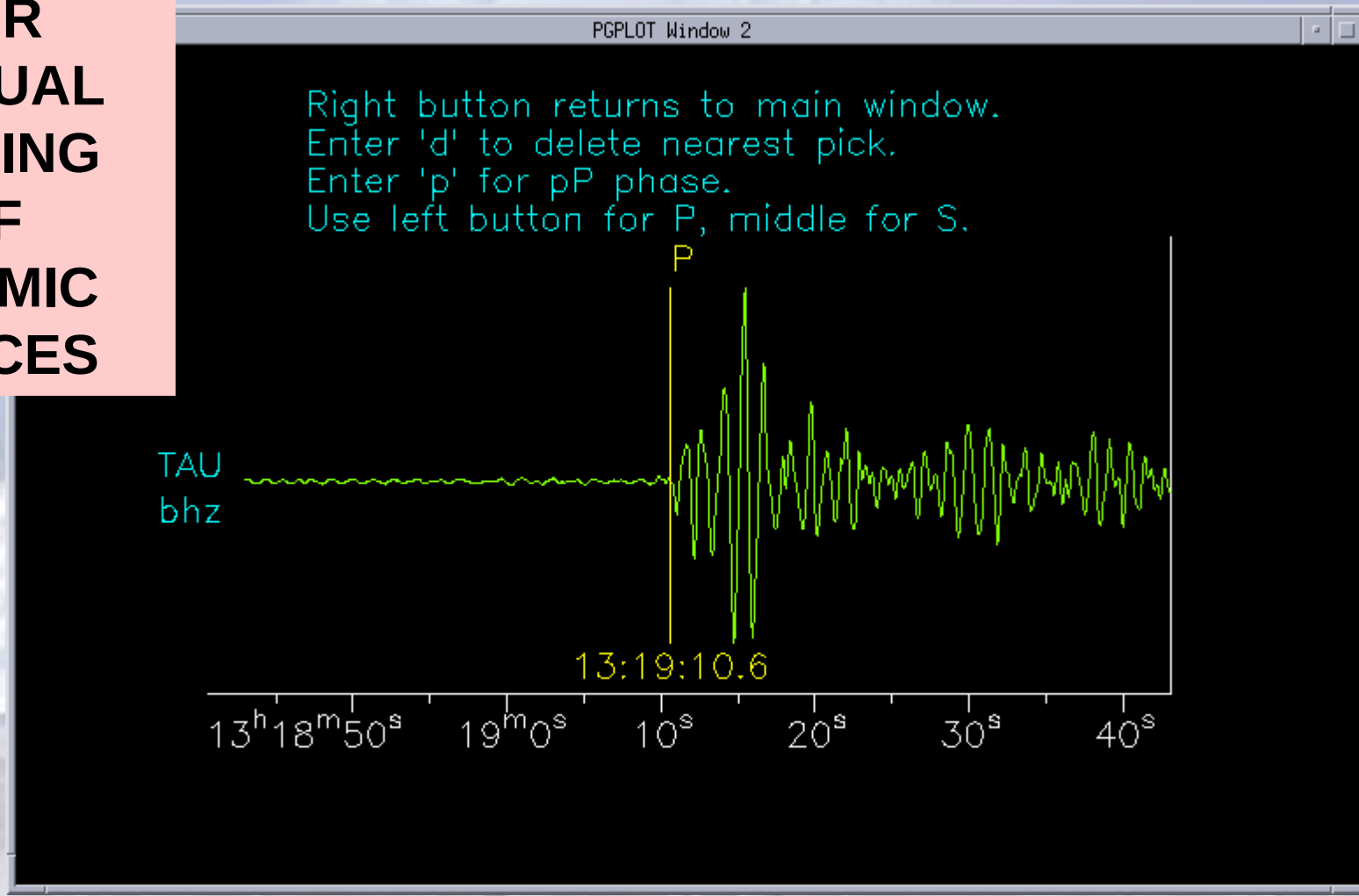


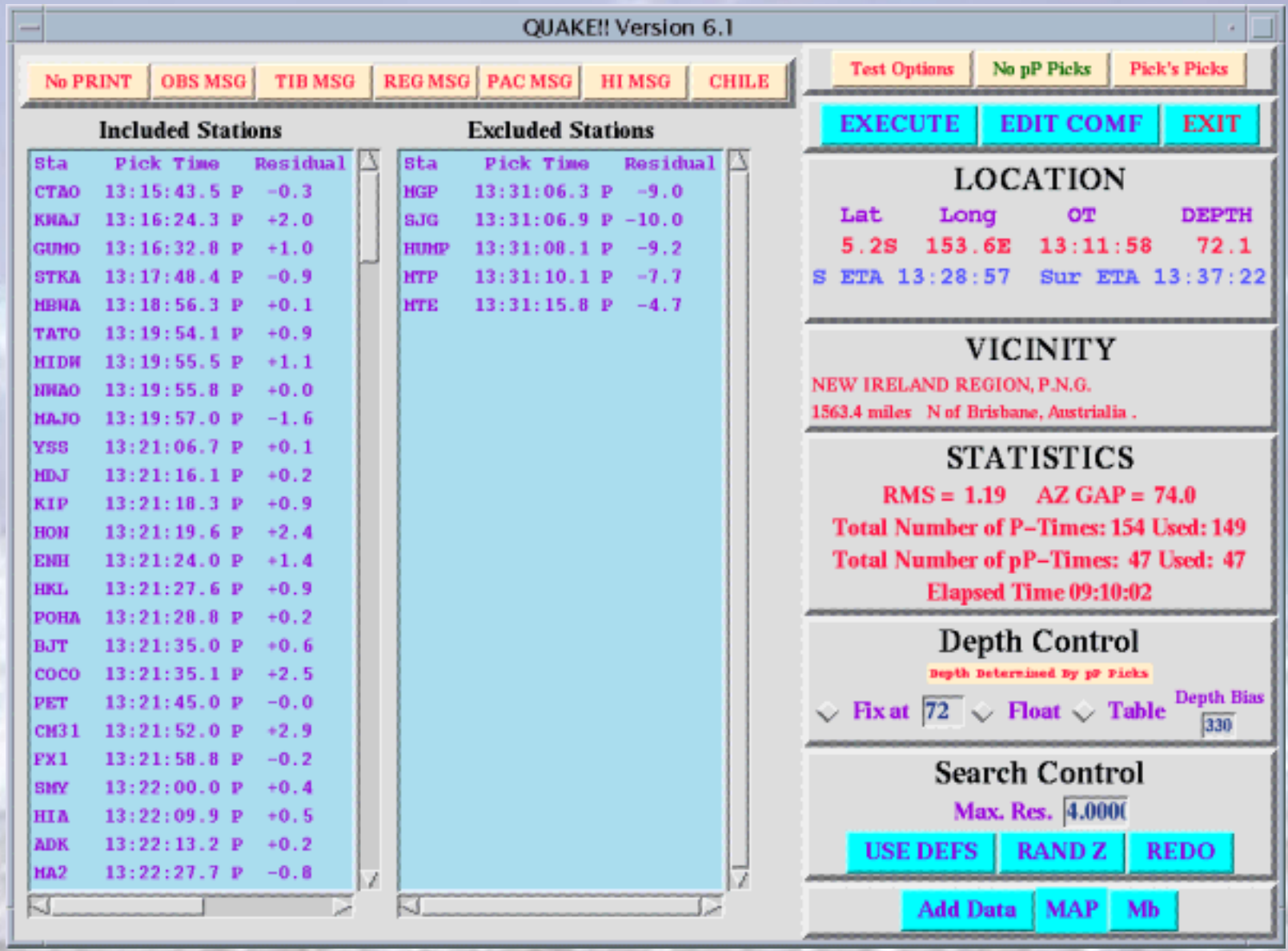
S	Date	GMT	#Sta	Az	Gap	RMS	Mag	Lat	Long	Depth	Cl
PT	20030110	1311:58	38		75	1.41	6.90	-05.2	+153.7	63.00	16.40
PT	20030110	1311:58	38		75	1.41	6.90	-05.2	+153.7	63.00	16.40
PT	20030110	1312:00	36		75	1.39	6.90	-05.3	+153.7	88.00	16.30
PT	20030110	1312:00	36		75	1.39	6.90	-05.3	+153.7	88.00	16.30
PT	20030110	1312:00	35		119	1.41	6.90	-05.3	+153.7	93.00	16.30
PT	20030110	1312:00	35		119	1.41	6.90	-05.3	+153.7	93.00	16.30
PT	20030110	1312:00	35		119	1.45	6.90	-05.3	+153.7	93.00	16.30
PT	20030110	1312:00	35		119	1.45	6.90	-05.3	+153.7	93.00	16.30
PT	20030110	1312:01	33		119	1.50	6.90	-05.3	+153.7	95.00	16.30
PT	20030110	1312:01	33		119	1.50	6.90	-05.3	+153.7	95.00	16.30
PT	20030110	1311:58	29		119	1.36	6.90	-05.3	+153.8	75.00	16.40
PT	20030110	1311:58	29		119	1.36	6.90	-05.3	+153.8	75.00	16.40
PT	20030110	1311:58	28		119	1.41	6.90	-05.3	+153.8	76.00	16.40
PT	20030110	1311:58	28		119	1.41	6.90	-05.3	+153.8	76.00	16.40
PT	20030110	1311:58	26		119	1.35	6.90	-05.3	+153.8	76.00	16.40
PT	20030110	1311:58	26		119	1.35	6.90	-05.3	+153.8	76.00	16.40
PT	20030110	1311:58	24		119	1.30	6.90	-05.3	+153.8	72.00	16.30
PT	20030110	1311:58	24		119	1.30	6.90	-05.3	+153.8	72.00	16.30
PT	20030110	1311:58	22		119	1.30	6.80	-05.3	+153.8	66.00	16.30
PT	20030110	1311:58	22		119	1.30	6.80	-05.3	+153.8	66.00	16.30
PT	20030110	1311:57	20		119	1.31	6.80	-05.3	+153.8	60.00	16.30
PT	20030110	1311:57	20		119	1.31	6.80	-05.3	+153.8	60.00	16.30
PT	20030110	1311:59	18		119	1.40	6.80	-05.3	+153.6	74.00	16.30
PT	20030110	1311:59	18		119	1.40	6.80	-05.3	+153.6	74.00	16.30
AT	20030110	1312:00	32		115	1.30	6.10	-05.3	+153.7	92.00	16.30
AT	20030110	1312:00	30		115	1.33	6.10	-05.3	+153.7	89.00	16.30
AT	20030110	1312:00	29		115	1.33	6.10	-05.3	+153.7	86.00	16.30
AT	20030110	1312:00	28		115	1.34	6.10	-05.3	+153.7	83.00	16.30
AT	20030110	1311:59	27		115	1.26	6.10	-05.3	+153.7	74.00	16.30



SEISMIC TRACES IN ORDER OF ARRIVAL FOR MANUAL PICKING

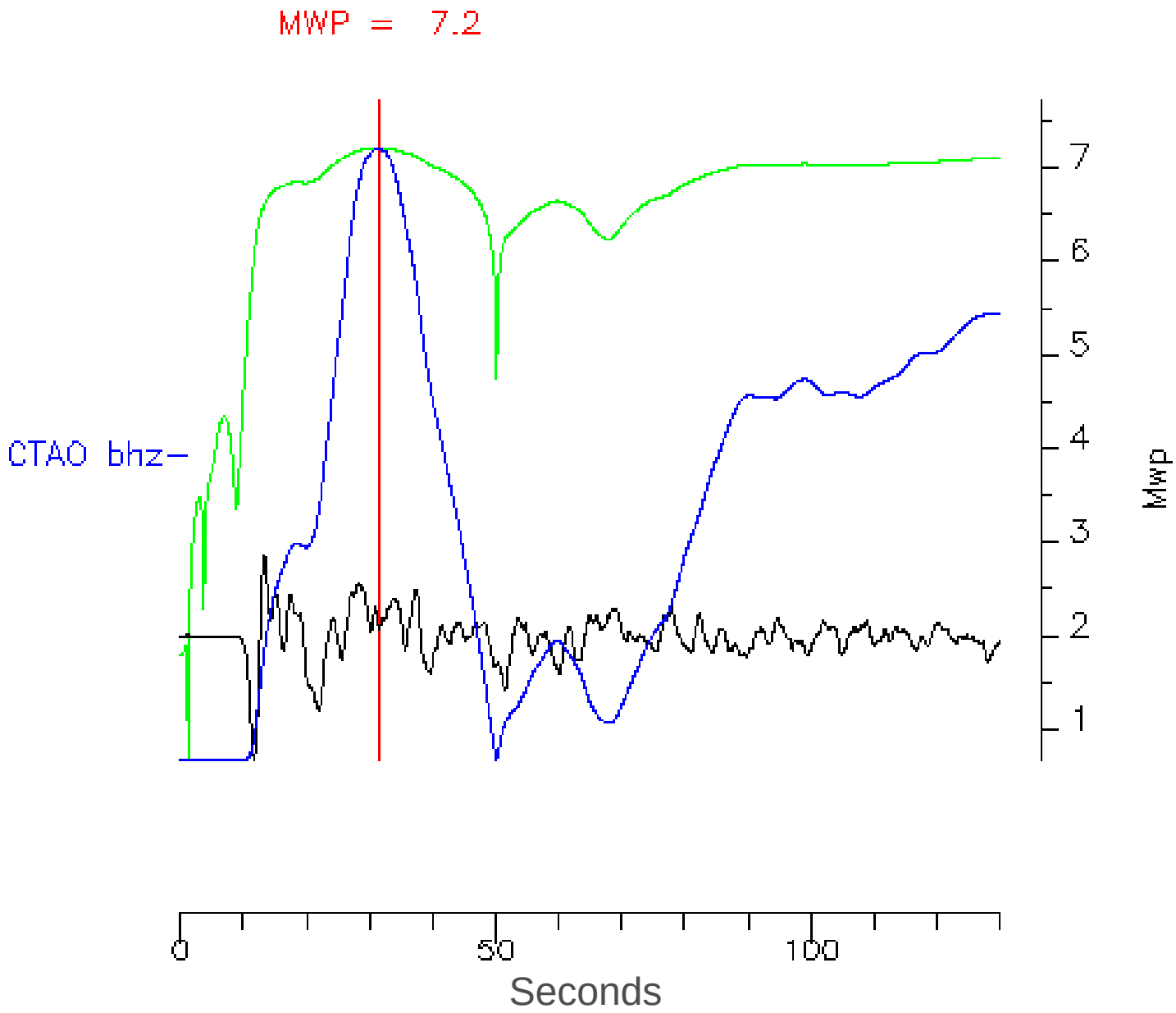
DISPLAY FOR MANUAL PICKING OF SEISMIC TRACES

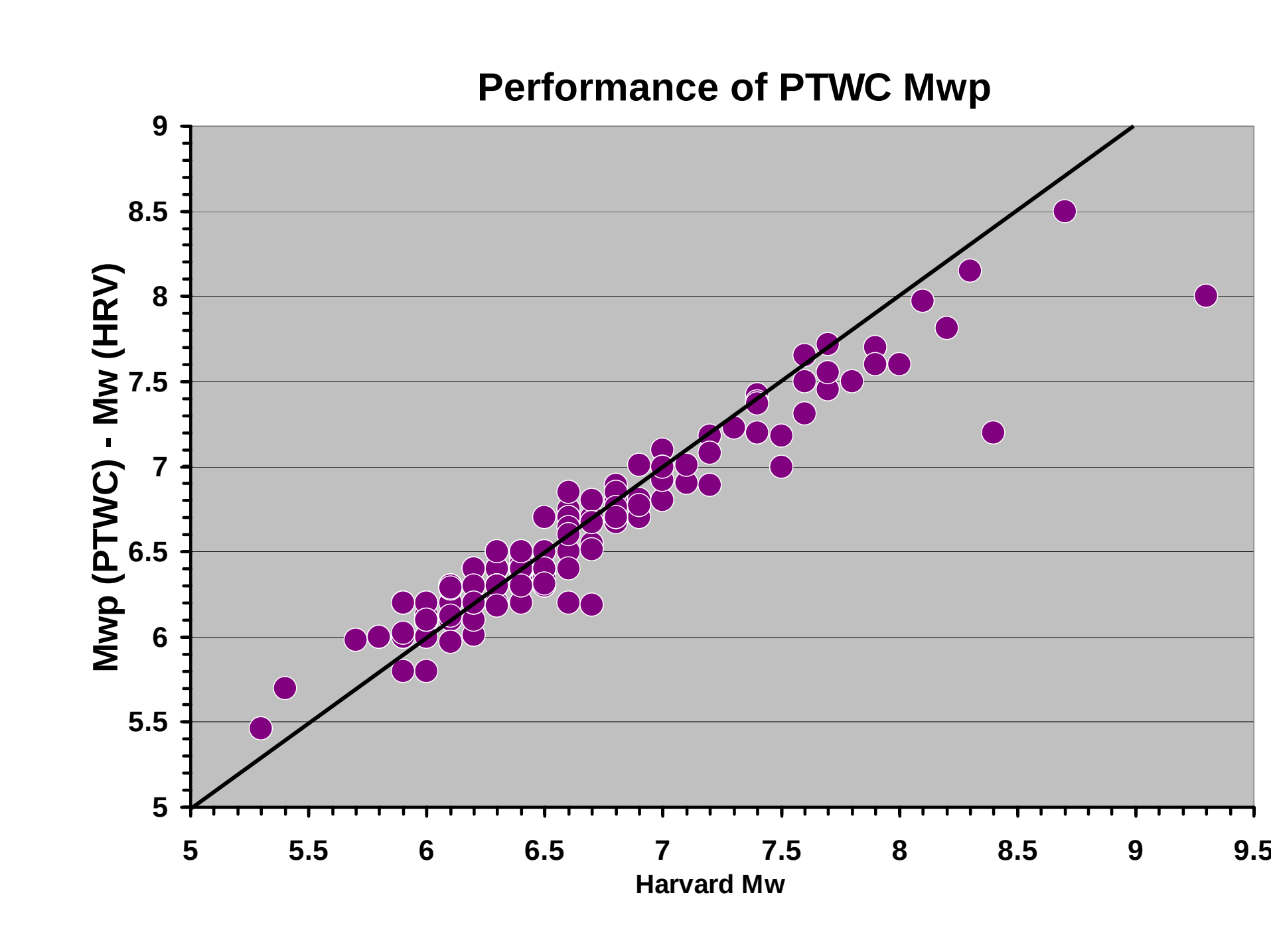




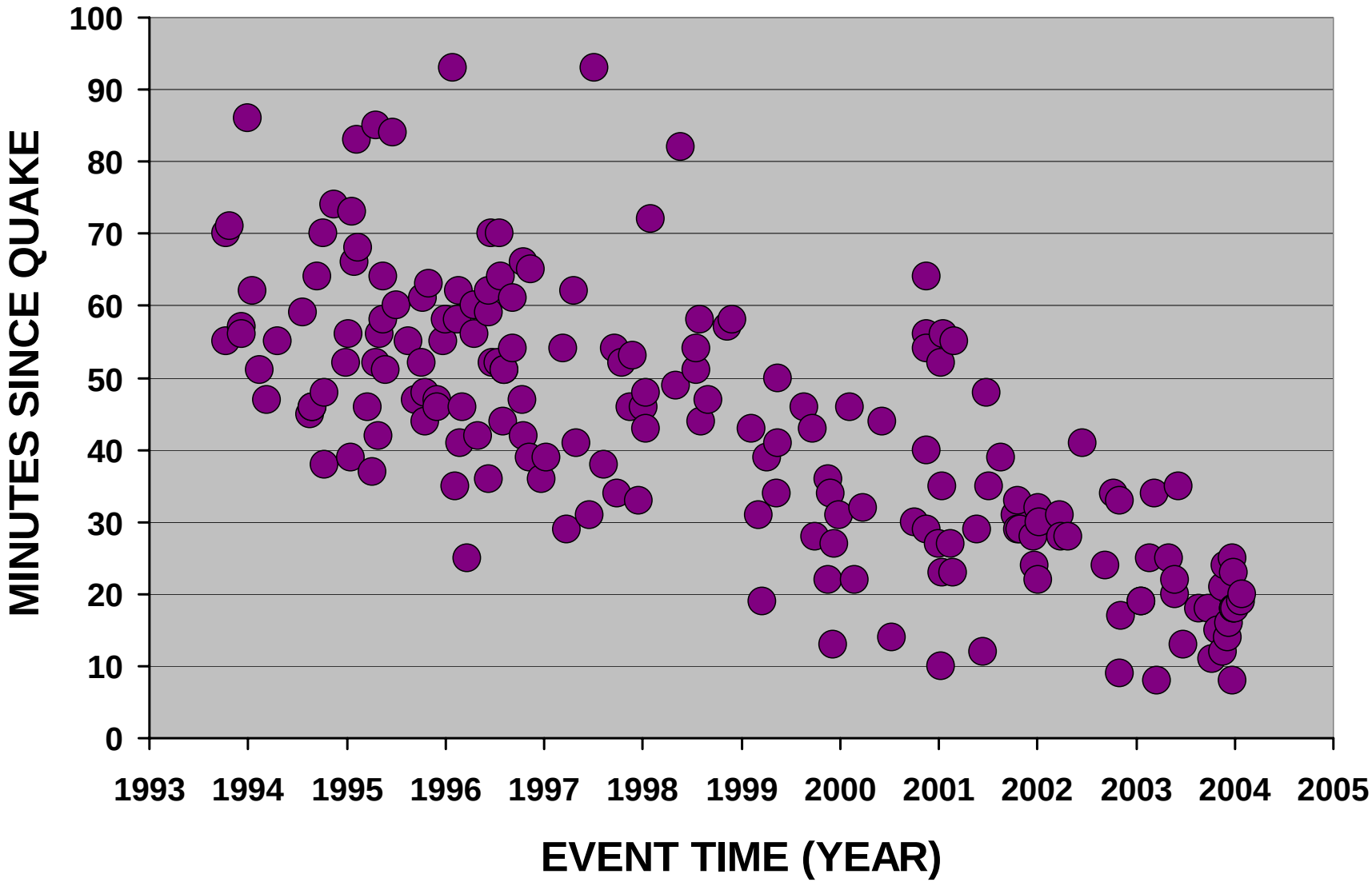
INTERACTIVE TOOL TO REFINE SOLUTION INCLUDING DEPTH

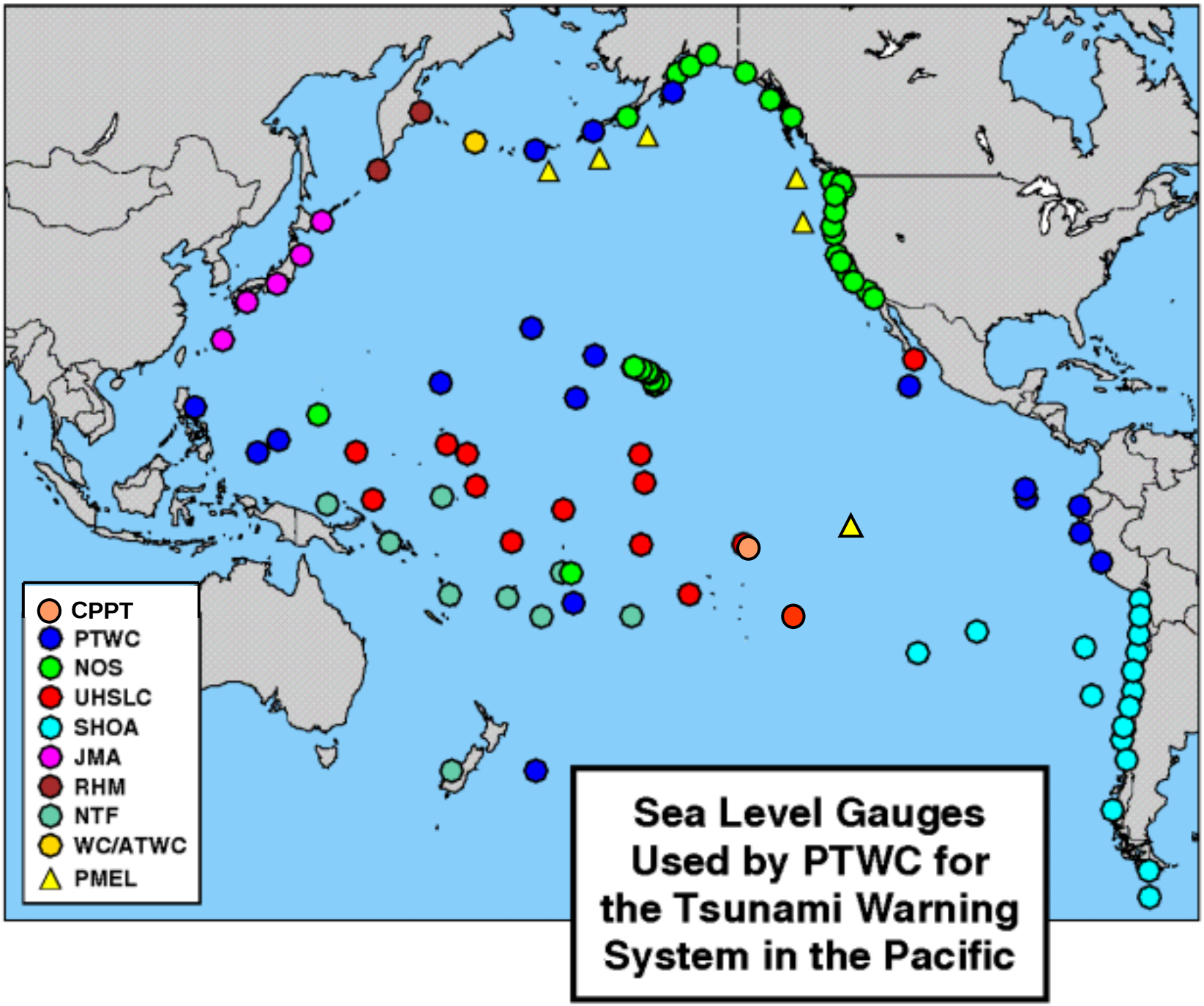
Mwp: Moment Magnitude from the P Wave



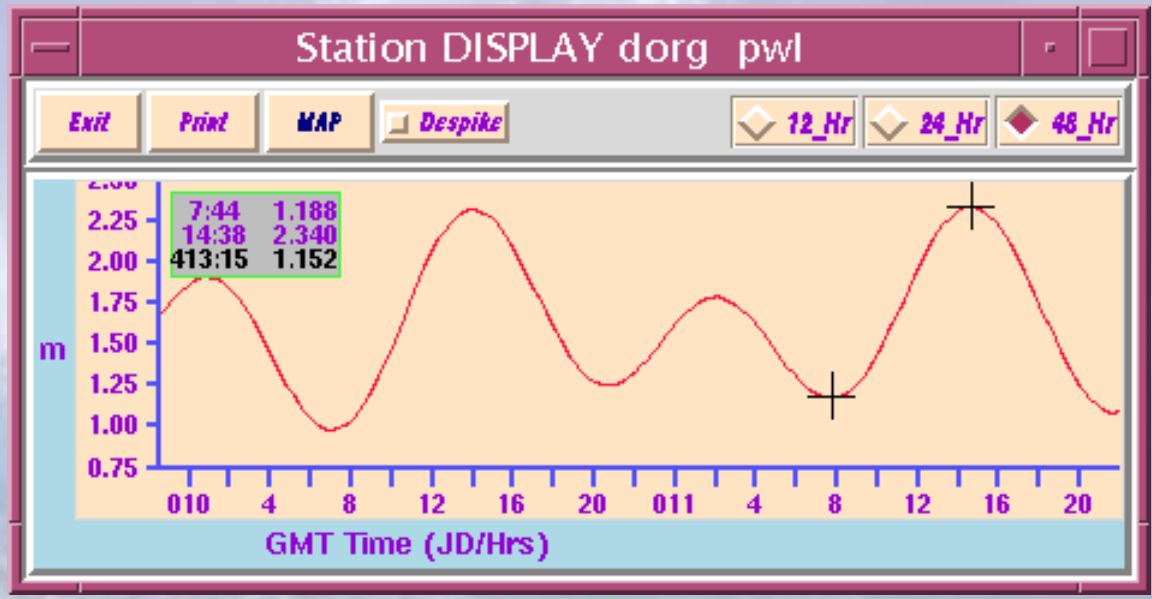

Performance of PTWC Mwp
Mwp (PTWC) - Mw (HRV)
Harvard Mw
9
8.5
8
7.5
7
6.5
6
5.5
5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5

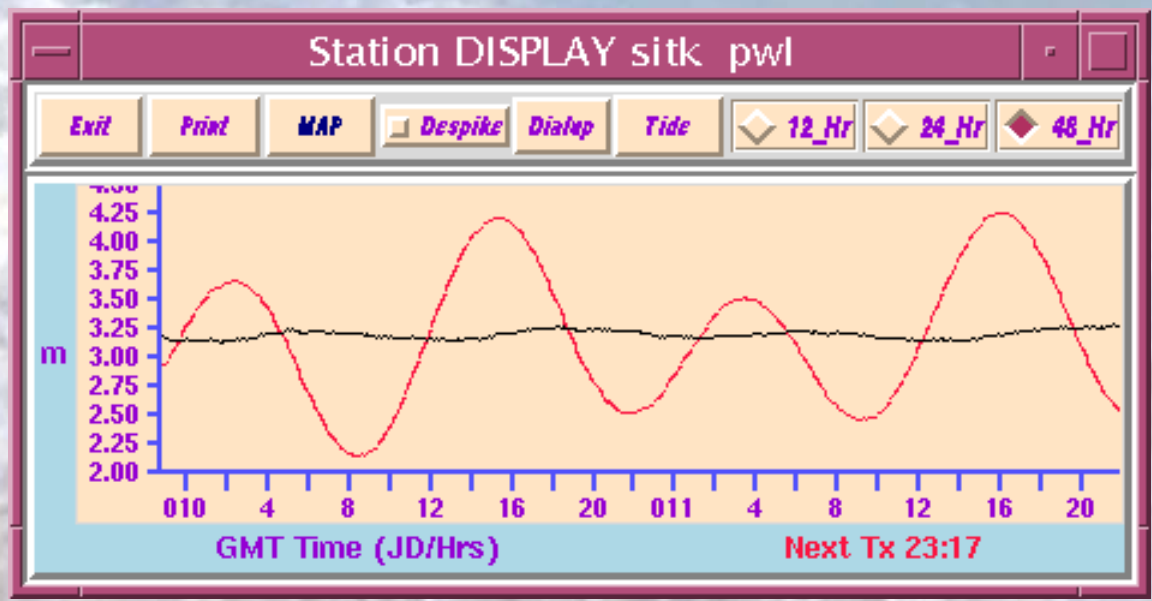
ISSUE TIME OF PTWC INITIAL BULLETINS FOR TELESEISMS



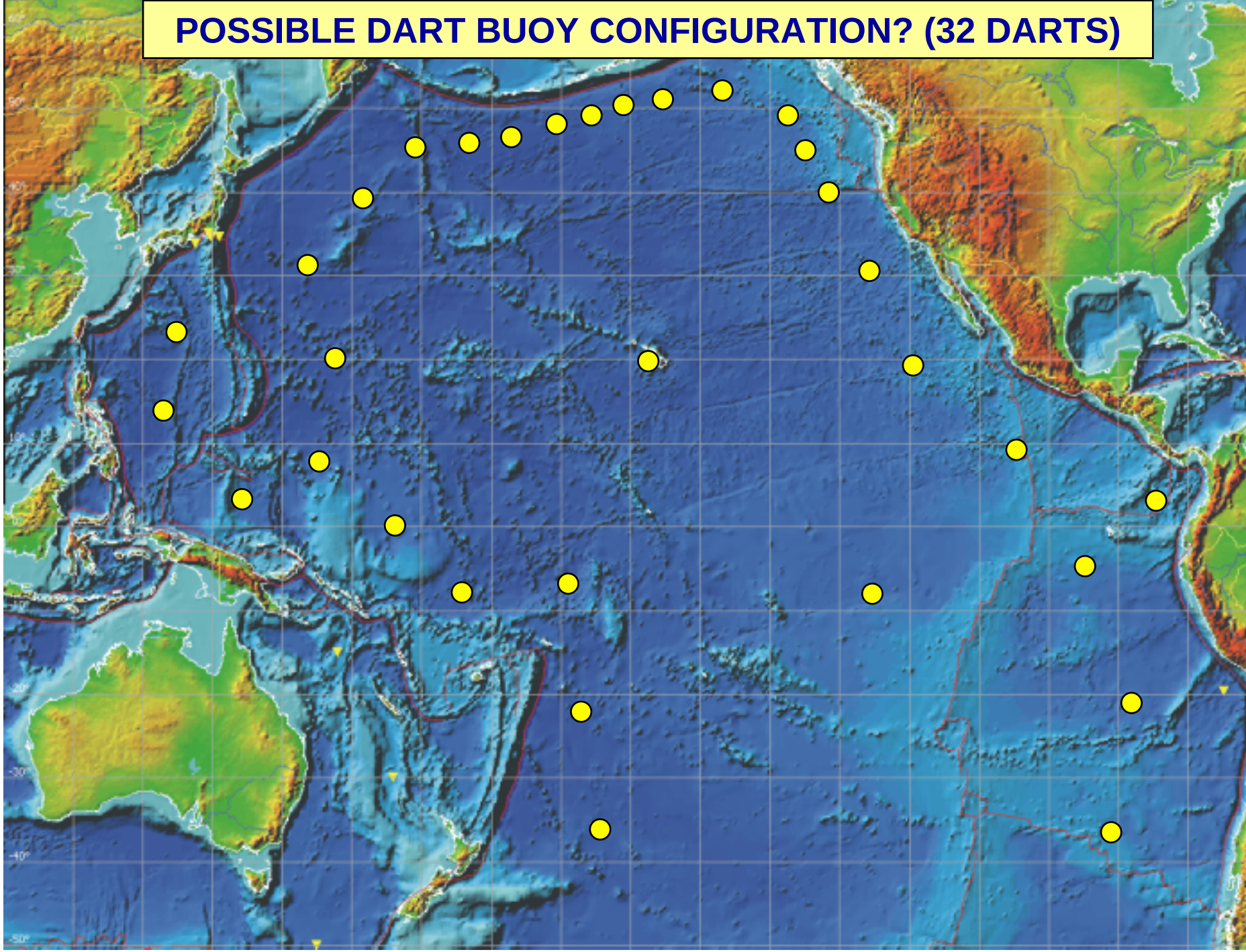

CPPT
PTWC
NOS
UHSLC
SHOA
JMA
RHM
NTF
WC/ATWC
PMEL
Sea Level Gauges Used by PTWC for the Tsunami Warning System in the Pacific

INTERACTIVE DISPLAY AND MEASURE OF SEA LEVEL DATA

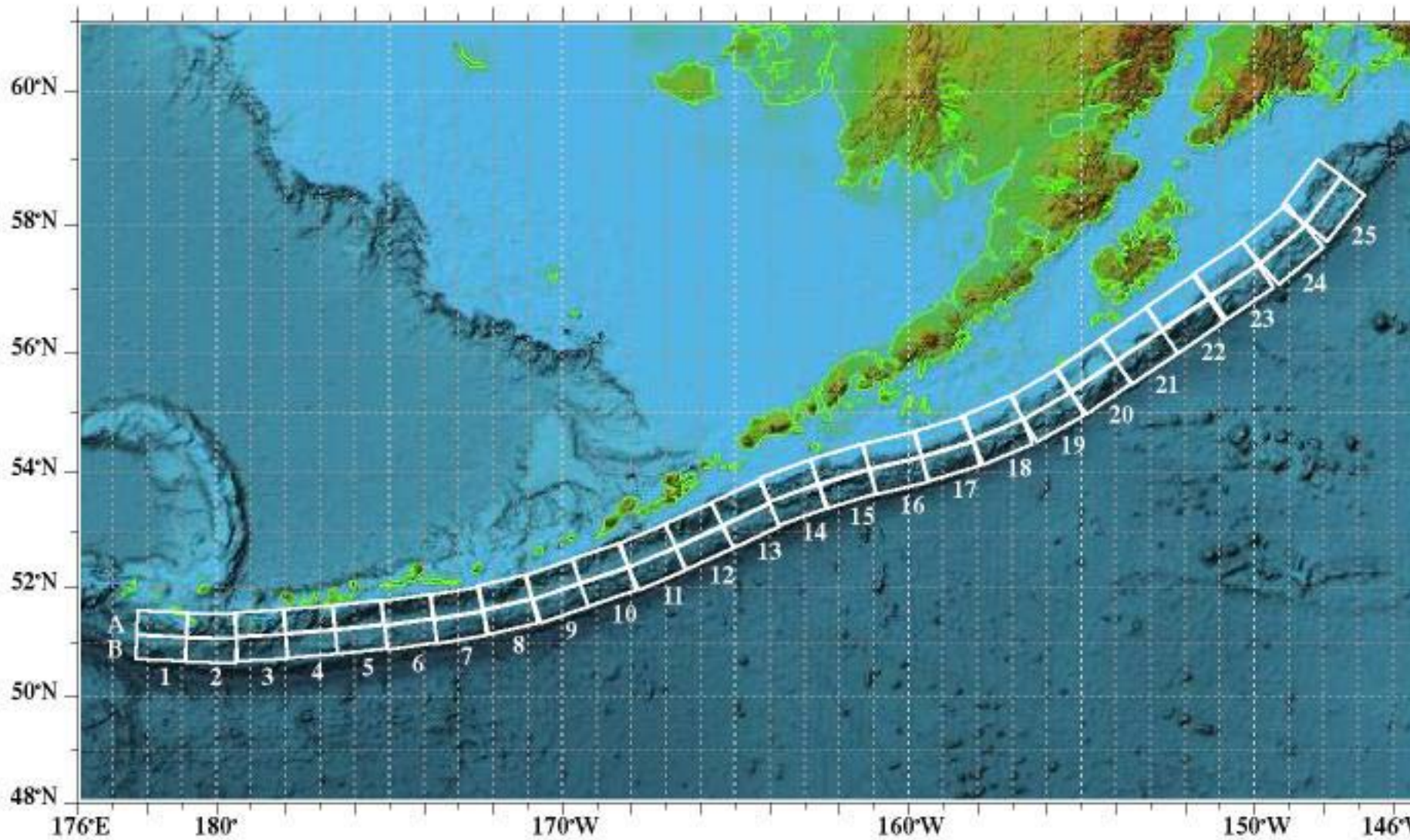




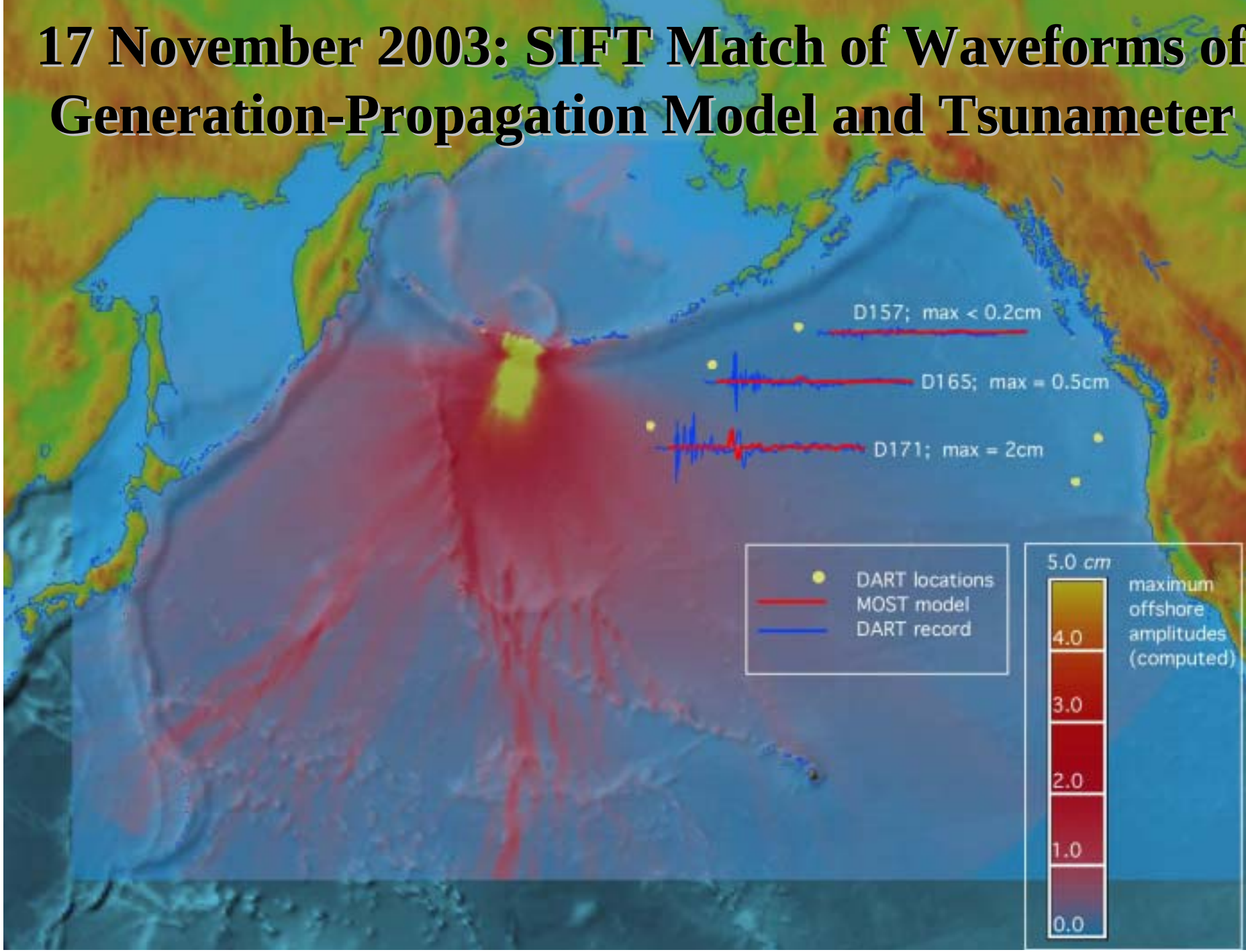
POSSIBLE DART BUOY CONFIGURATION? (32 DARTS)



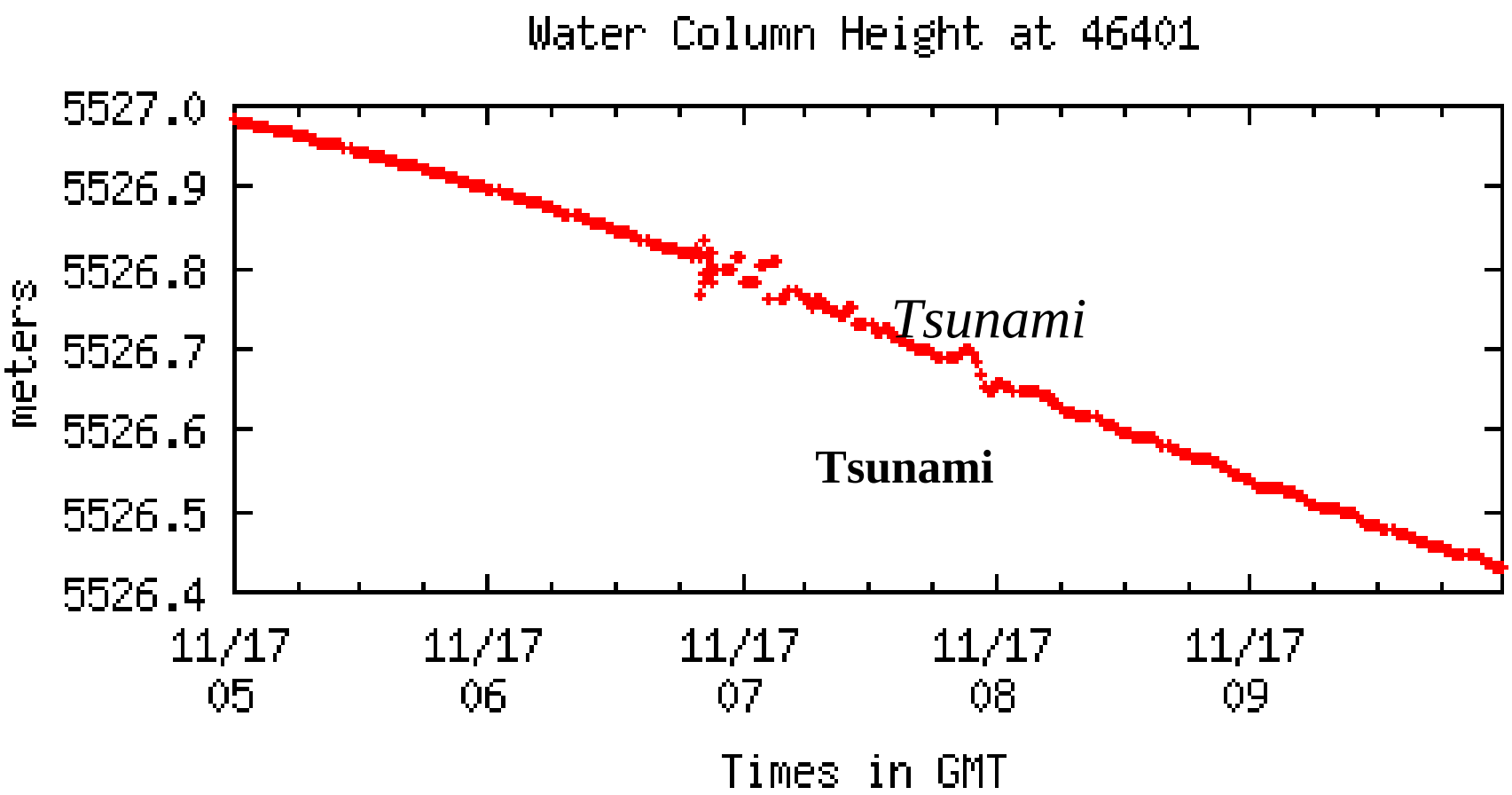
SIFT FORECAST MODEL: SOURCES

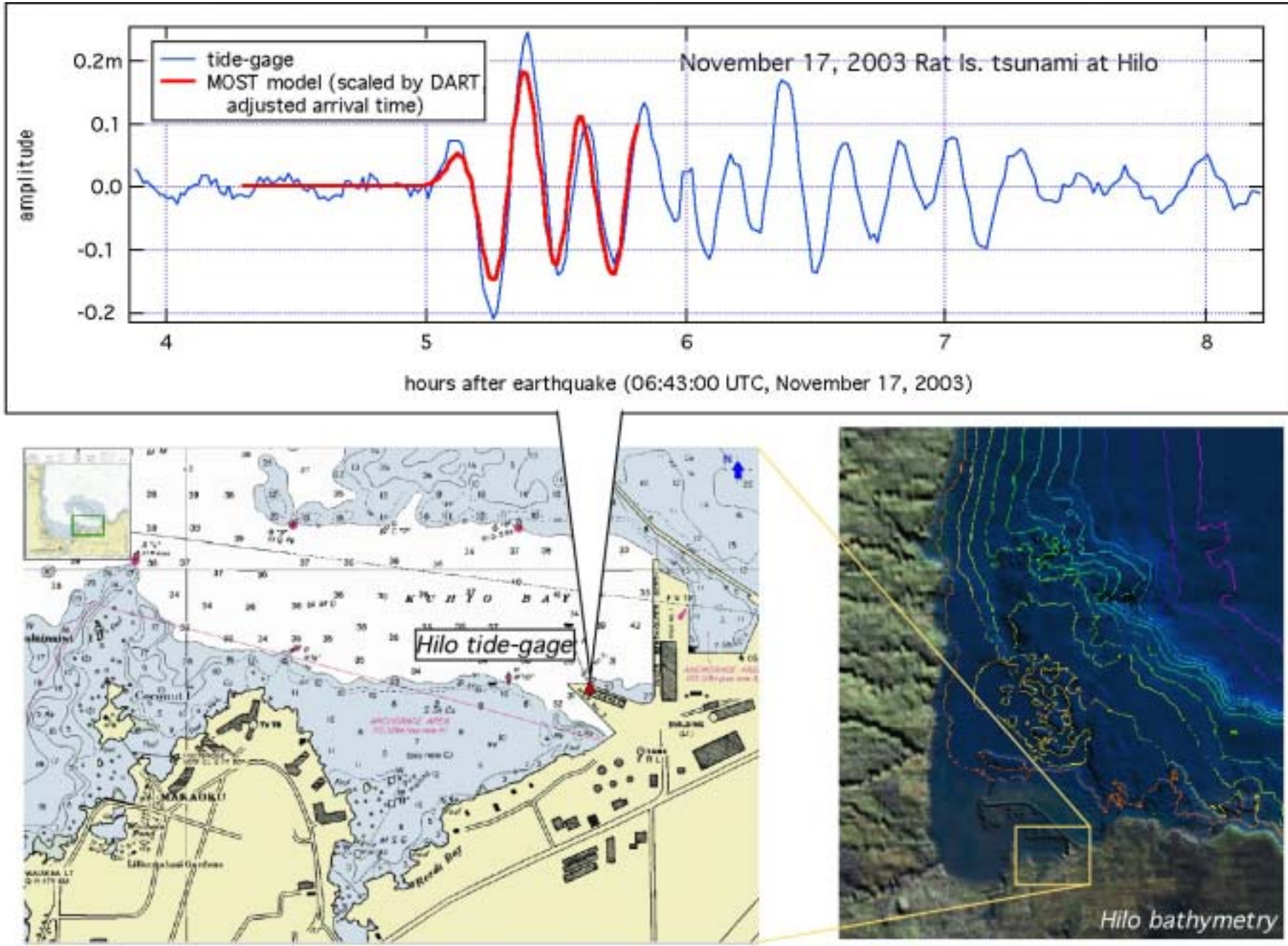


17 November 2003: SIFT Match of Waveforms of Generation-Propagation Model and Tsunameter



Real Time Detection of November 17, 2003 Tsunami




tide-gage
MOST model (scaled by DART adjusted arrival time)
November 17, 2003 Rat Is. tsunami at Hilo
amplitude
0.2m
0.1
0.0
-0.1
-0.2
4
5
6
7
8
hours after earthquake (06:43:00 UTC, November 17, 2003)
Hilo tide-gage
Hilo bathymetry


TSUNAMIS ARE RARE. KEEP THESE SAFETY TIPS IN MIND AND ENJOY THE BEACH!