United Nations
Educational, Scientific and
Cultural Organization

Intergovernmental
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Commission

PacWave11 Summary Brief
October 2011

Exercise Pacific Wave 11 Scenarios:
PTWC RIFT Energy / Coastal Forecasts

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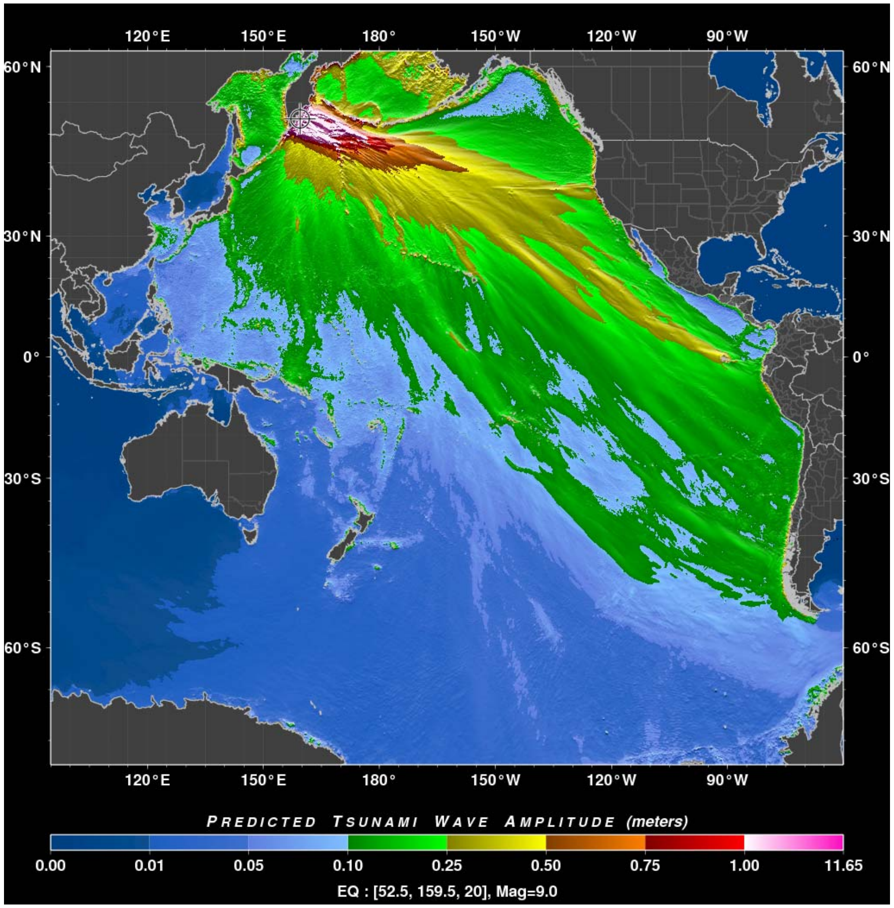
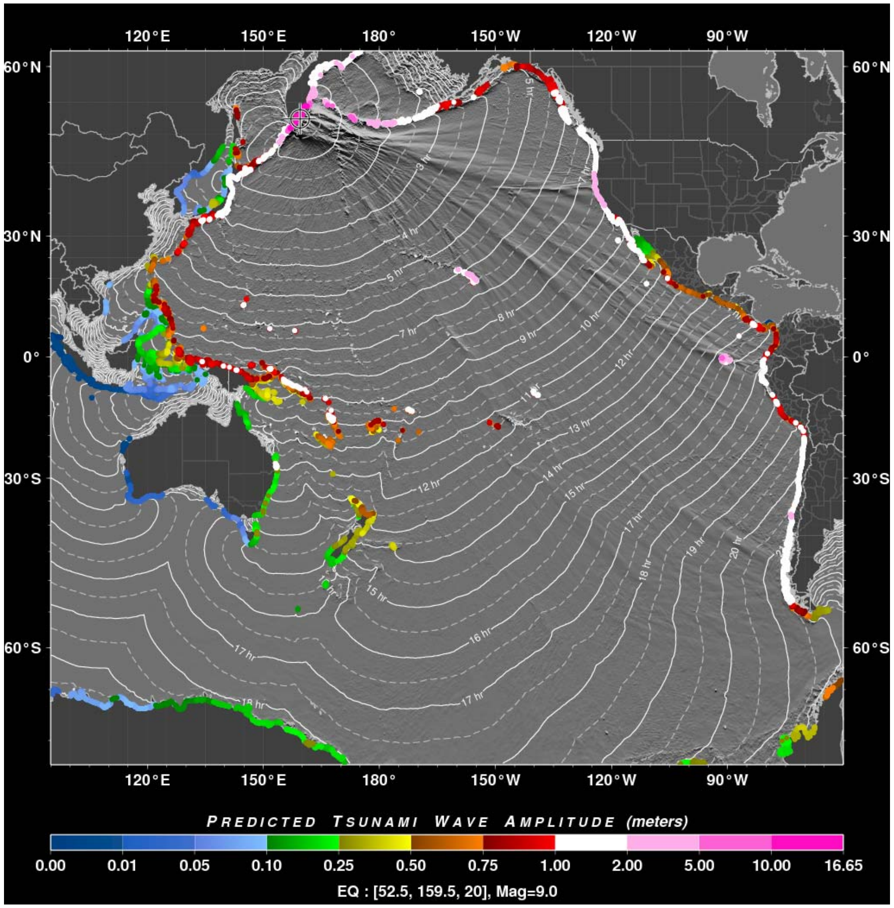
PacWave11 Tsunami Scenarios (PTWC RIFT): Kuril-Kamchatka Trench

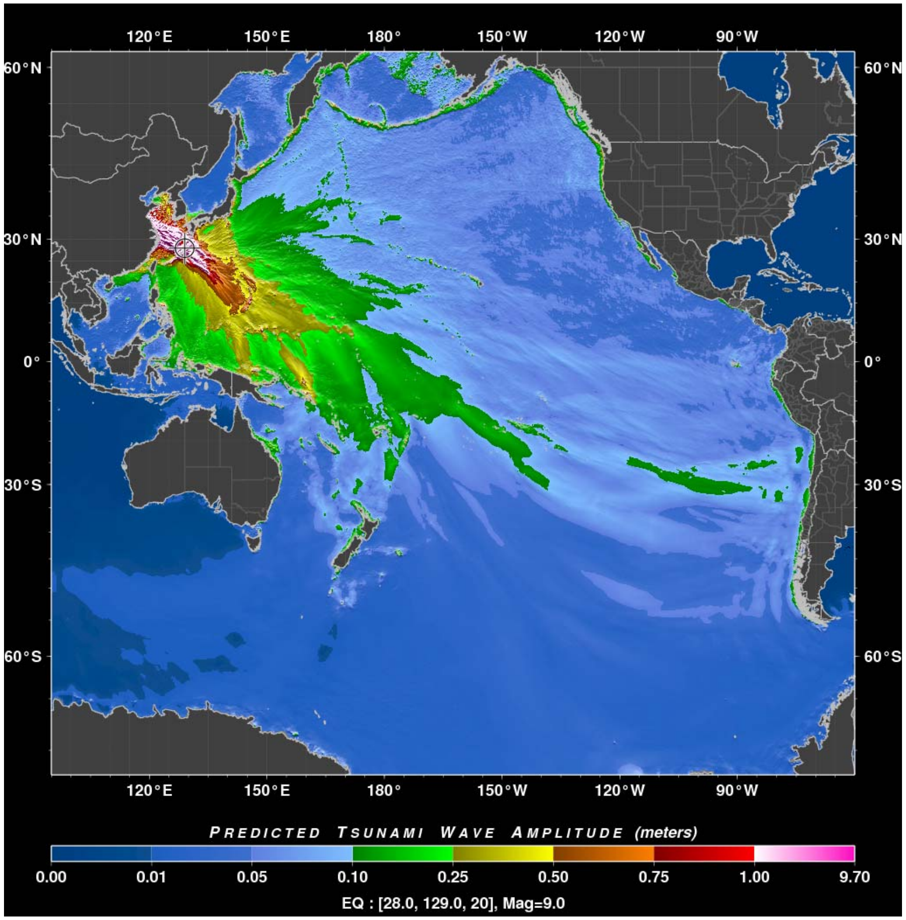




Energy

Coastal Forecast

PacWave11 Tsunami Scenarios (PTWC RIFT): Nansei-Shoto Trench



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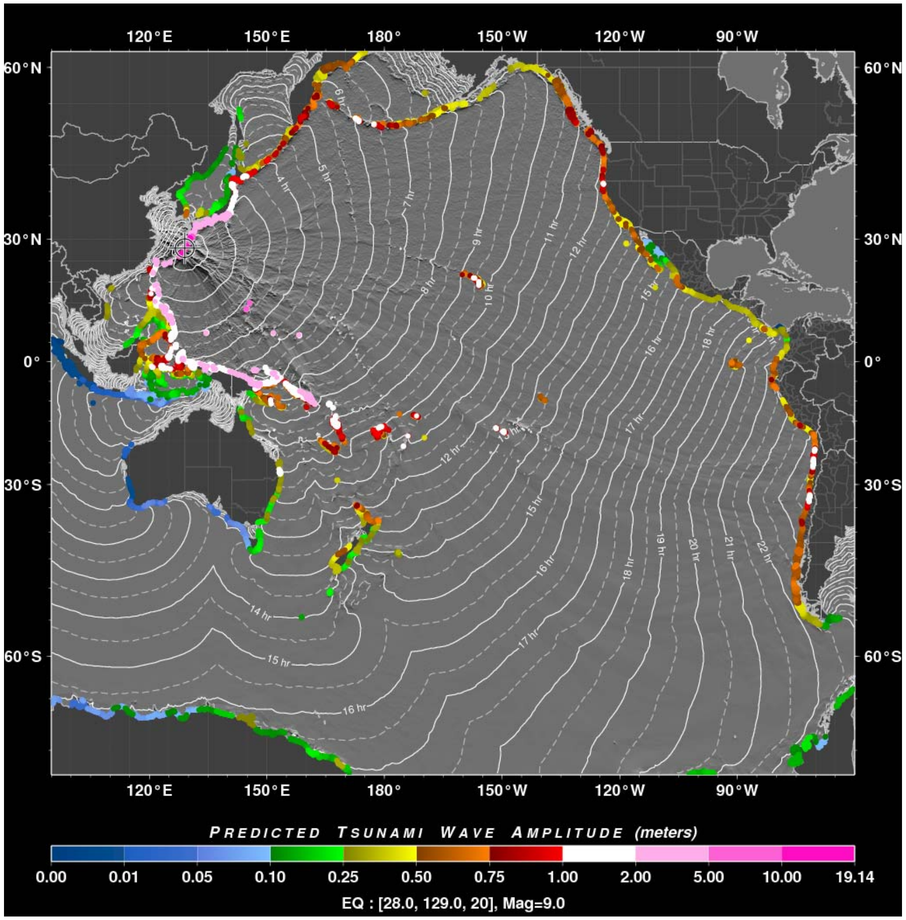
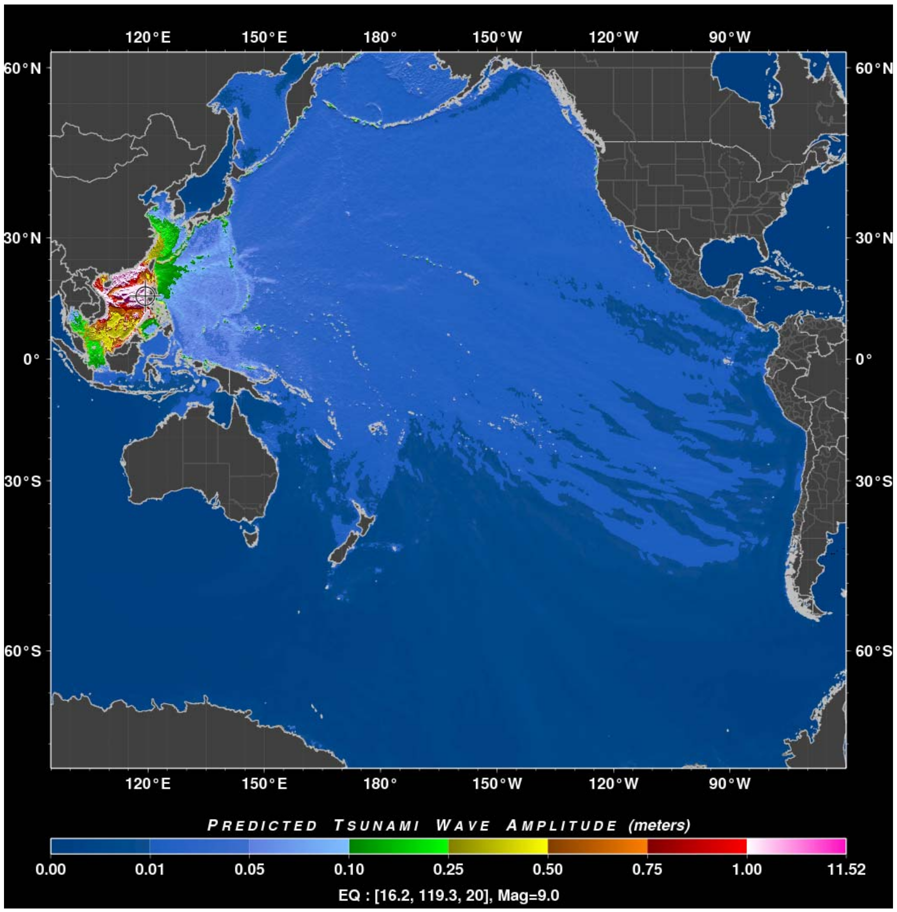


Coastal Forecast

PacWave11 Tsunami Scenarios (PTWC RIFT): Manila Trench



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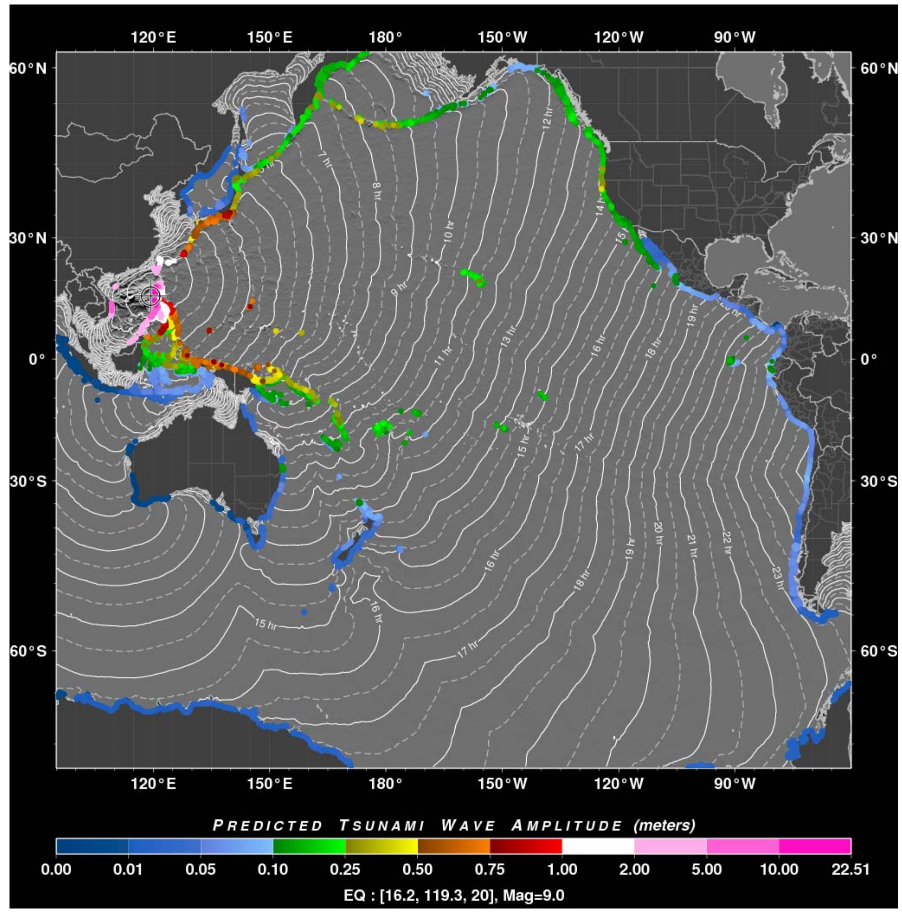

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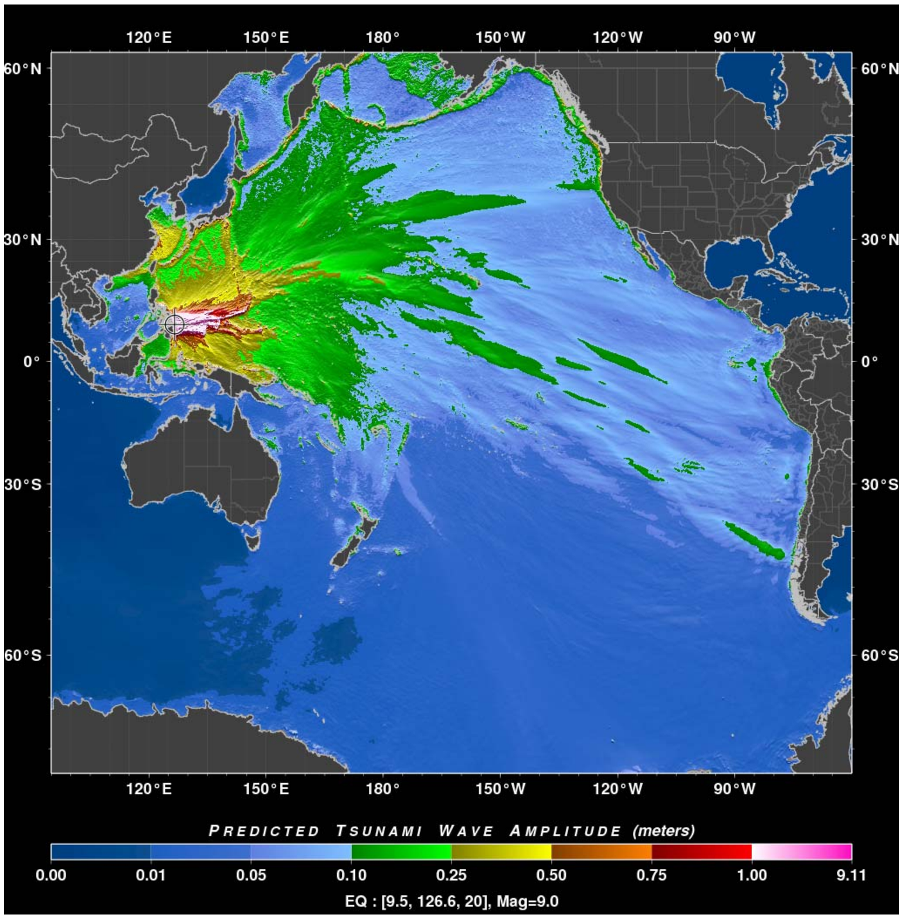
PacWave11 Tsunami Scenarios (PTWC RIFT): Philippines Trench



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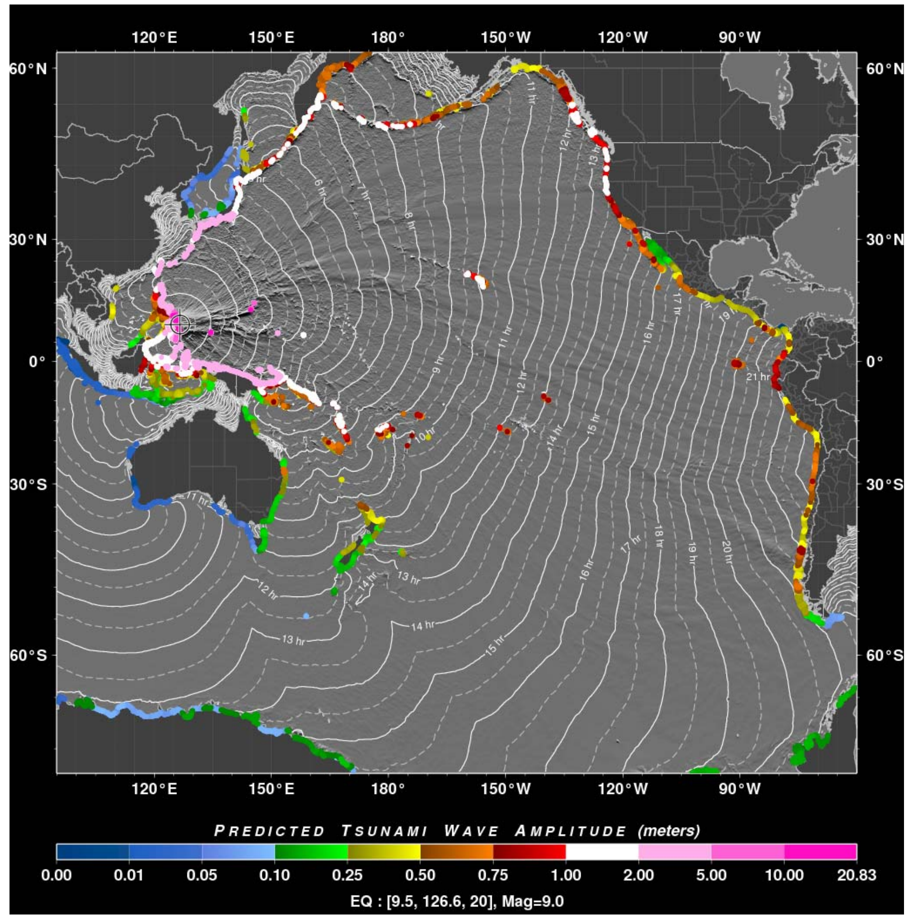

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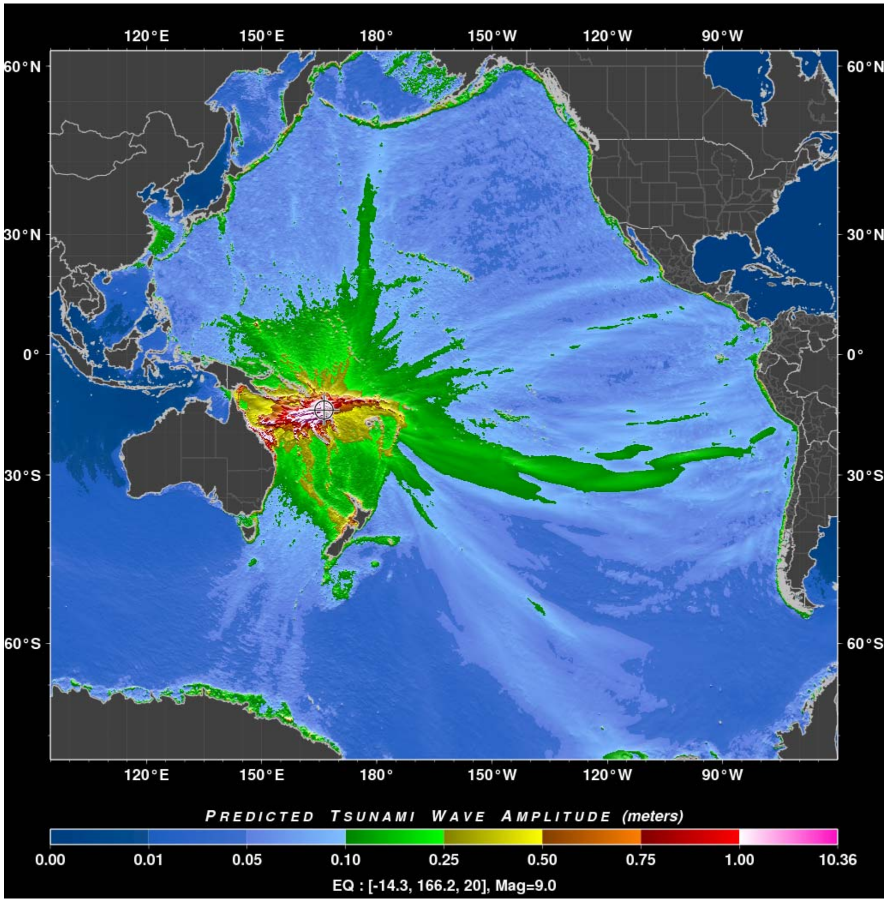
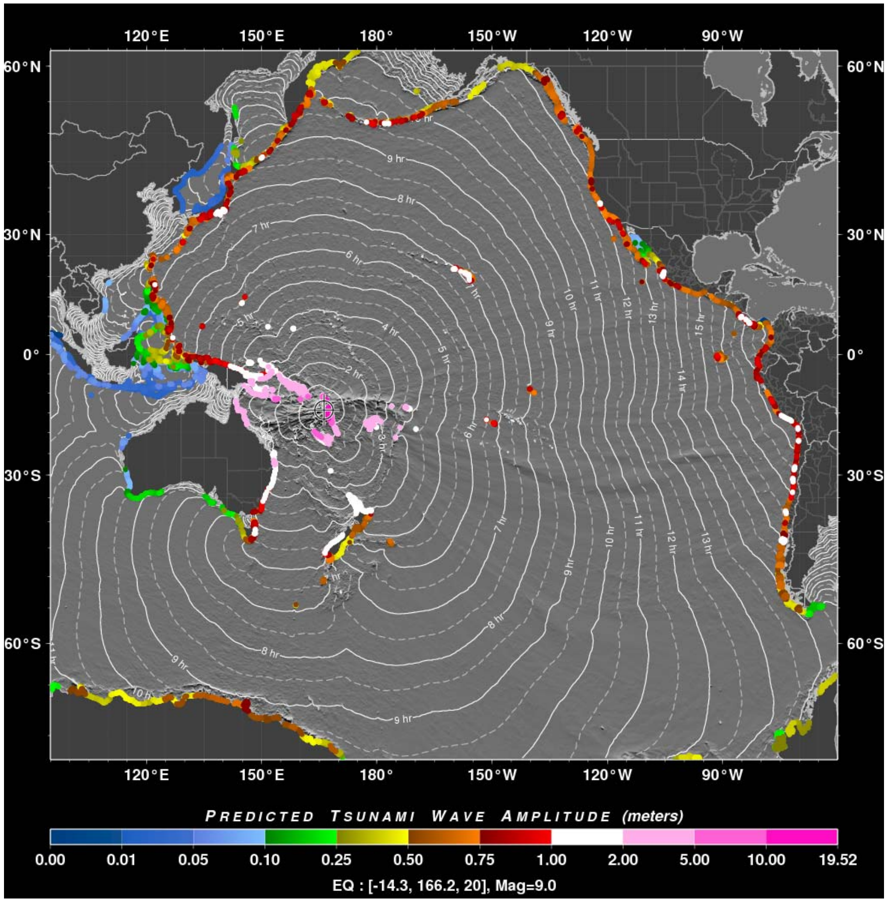
PacWave11 Tsunami Scenarios (PTWC RIFT): New Hebrides Trench





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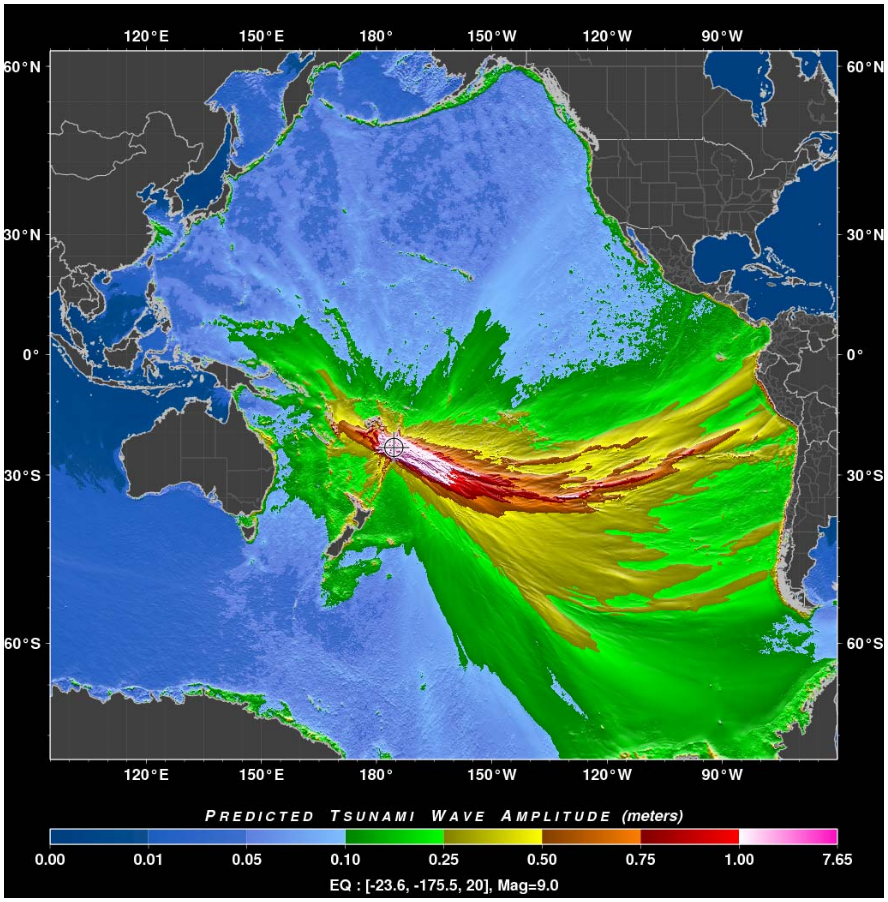
PacWave11 Tsunami Scenarios (PTWC RIFT): Tonga Trench



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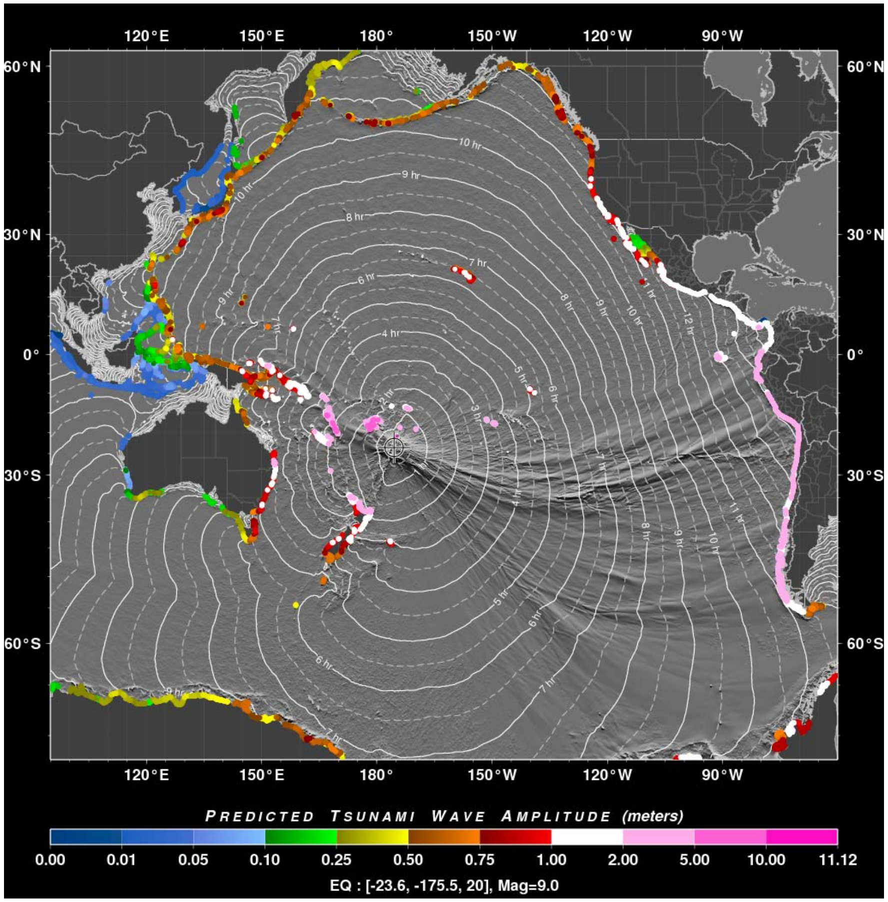

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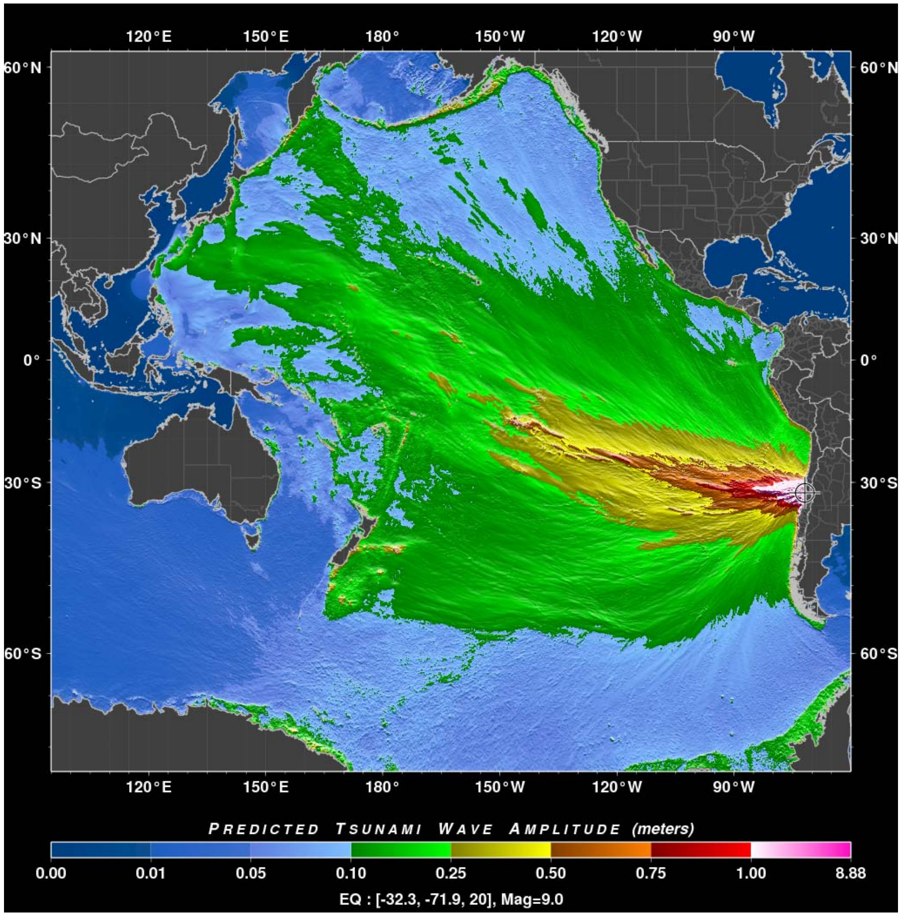
PacWave11 Tsunami Scenarios (PTWC RIFT): Peru-Chile Trench



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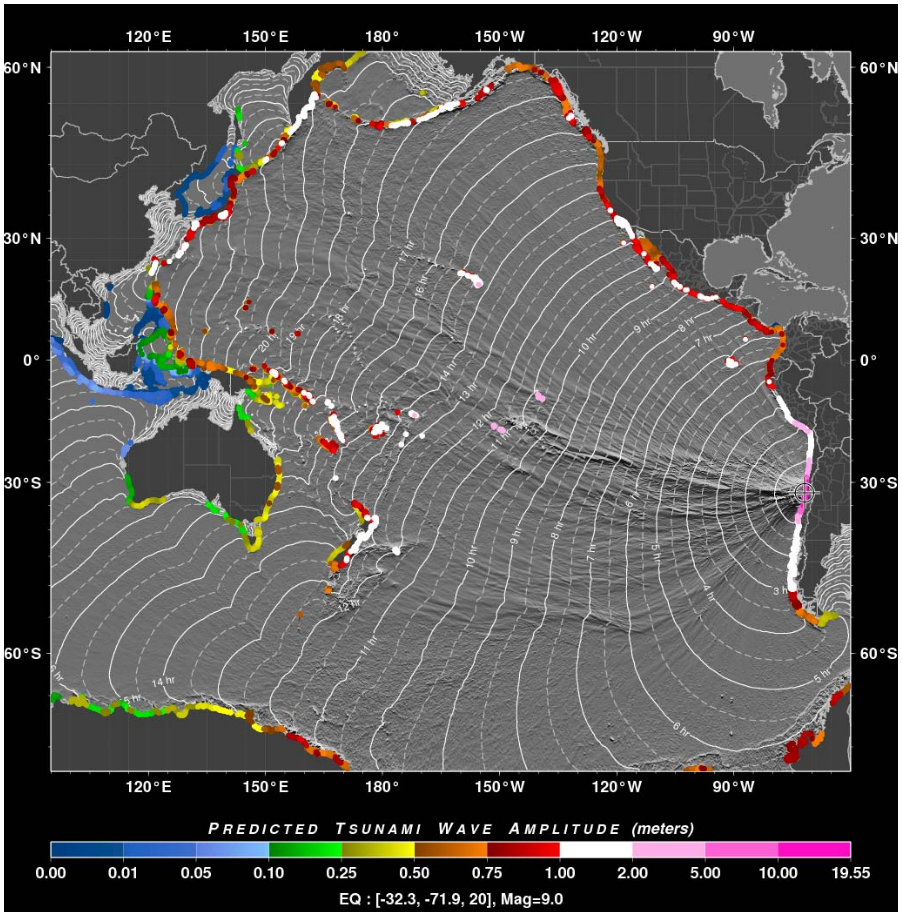

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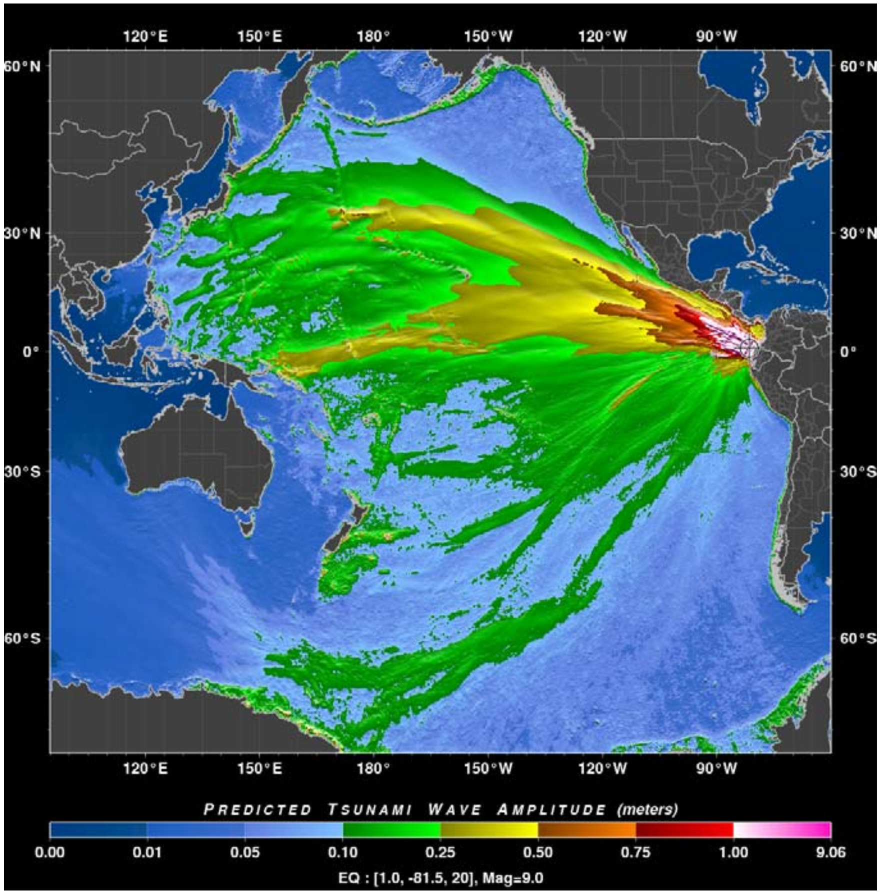
PacWave11 Tsunami Scenarios (PTWC RIFT): Colombia-Ecuador Trench



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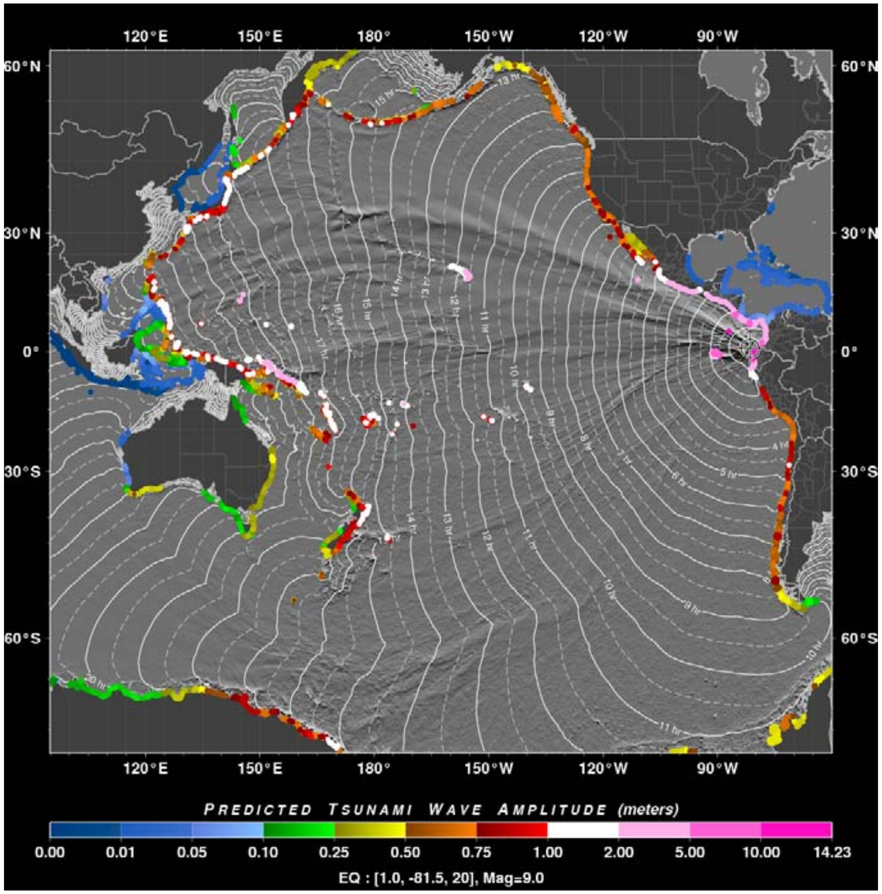

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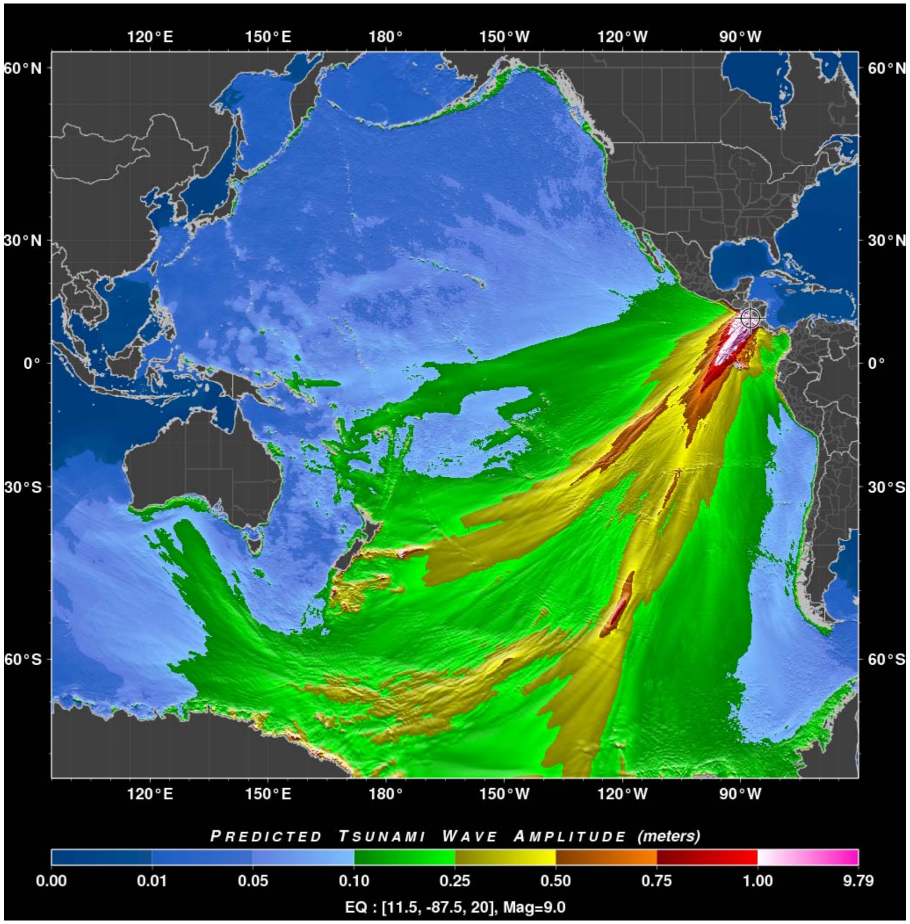
PacWave11 Tsunami Scenarios (PTWC RIFT): Middle America Trench



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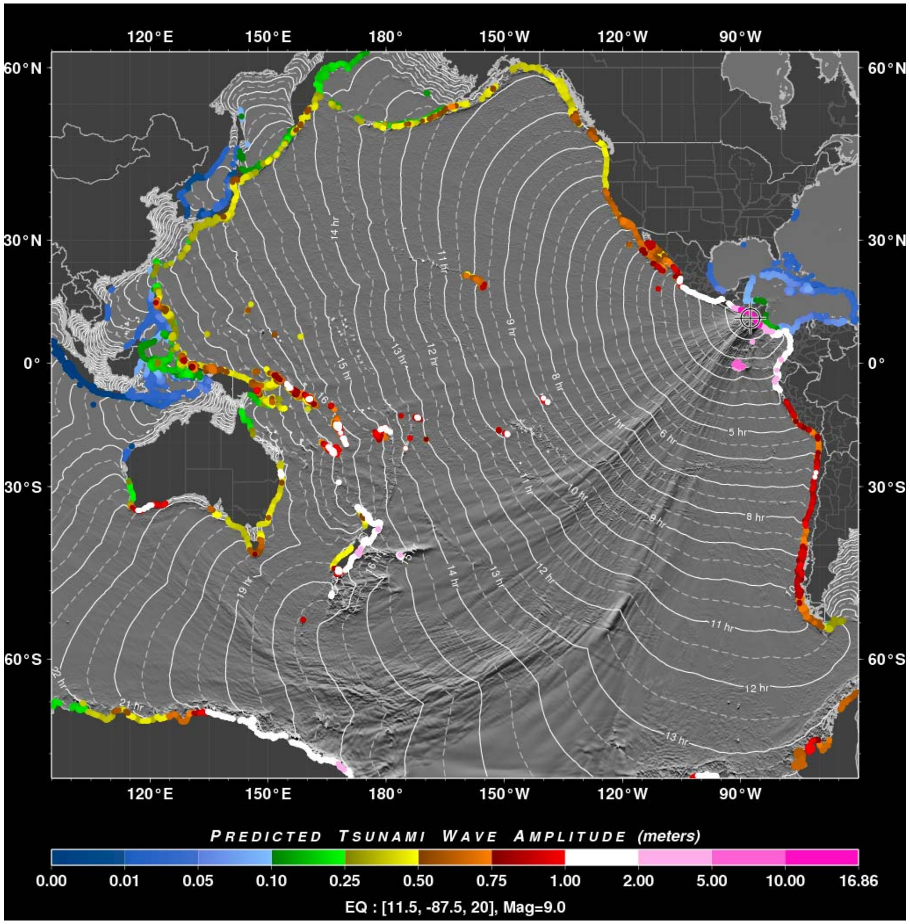

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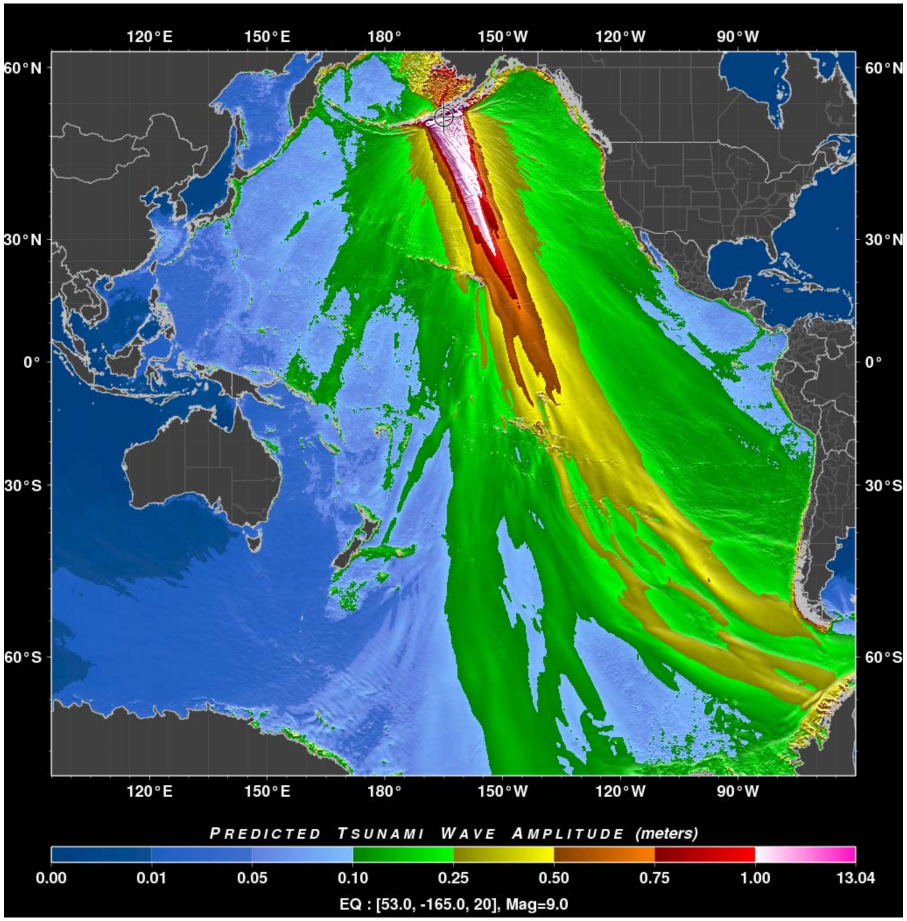
PacWave11 Tsunami Scenarios (PTWC RIFT): Aleutian Trench



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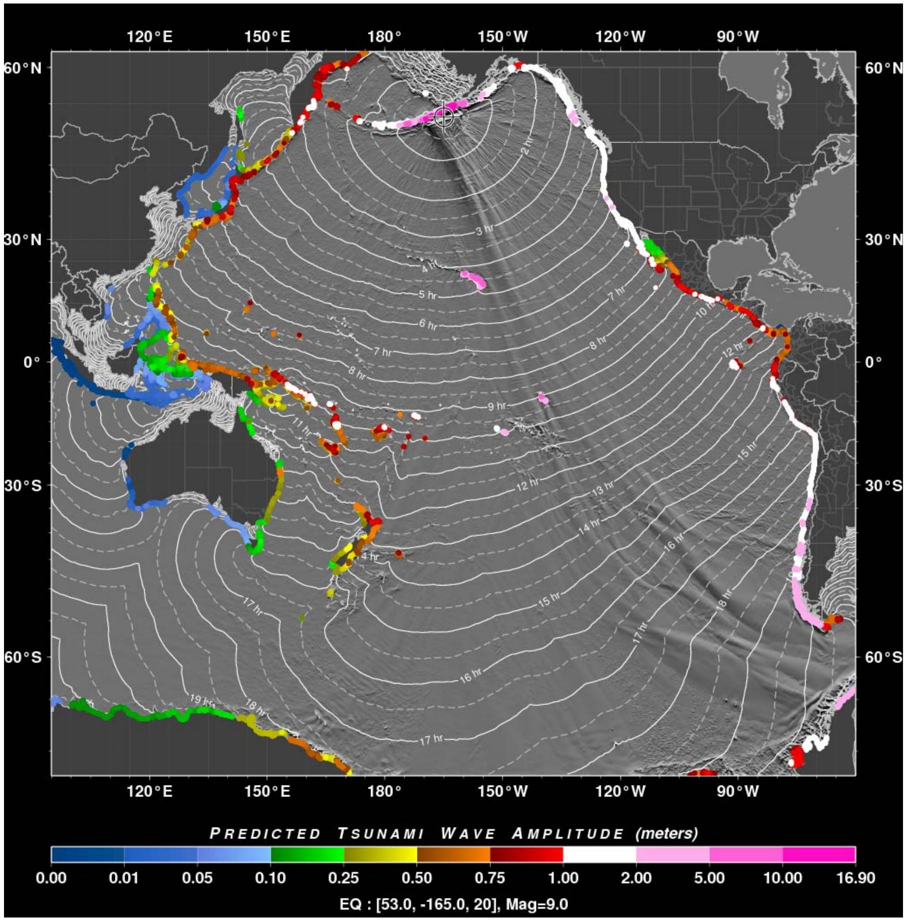

Coastal Forecast

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PTWC RIFT Brief
October 2011

PTWC Tsunami Wave Forecasts: RIFT Model

Charles McCreery, PTWC
Dailin Wang, PTWC

Forecast Models at PTWC

1. **PMEL's SIFT (pre-computed database/unit source models with a real-time component of inundation models). Database: computed at 4-arc-min. resolution and archived at 16-min. resolution (about two thousands unit sources).**

Method: fit the sources to DART observations and then run inundation models (for selected US locations, goal: 70+ inundation models).

2. **WCATWC's ATFM (pre-computed database models with nested grids near coast, for US locations). Fewer sources than in SIFT but presumably better coastal forecast than the SIFT database.**

3. **PTWC's RIFT (completed computed in real-time). No inundation component at the present time, although resolution as fine as 30-arc-sec can be used for local/ regional tsunamis.**

Why is there a need for real-time tsunami forecasting?

- **Pre-computed database approach cannot exhaust all possible earthquake scenarios (location and focal mechanisms). Currently, the sources in database models are all shallow thrust earthquakes (Kuril 2007 M8.1 and Samoa 2009 M8.0 are outer-rise normal fault earthquakes).**
- **Smaller earthquakes not well represented by database models**
- **As real-time earthquake location and focal mechanisms becomes available, tsunami forecast can be refined using these real-time parameters, which may or may not agree with the pre-defined sources in the database models. For the same magnitude EQ, database model gives the same answer even if the location and/or depth change. There is no depth sensitivity in the database models.**

  Examples:

  - **Jul 23, 2010, M7.3 EQ in Moro Gulf (z=575km), Mindanao, Philippines.**
  - **Sep 30, 2009, M7.5 EQ in Sumatra (z=80 km). Amp at Padang varies from 2.5 m to 0.5 m for shallow vs. deep.**

Why is there a need for real-time tsunami forecasting?

- **For small earthquakes (e.g., mag < 7.9), it is not necessary to integrate the tsunami model for the whole basin (e.g., the whole Pacific). Smaller domain can be used and propagation results can be obtained quickly.**

- **Cannot always rely on DART inversion, because the nearest DART might be too far away or might not in the main energy beam (e.g., Oct. 25, 2010 Mentawai Destructive Tsunami)**

- **Quick centroid moment tensor (CMT) solution might be faster than waiting for DART data, thus potentially generating more accurate forecast in less time.**

PTWC Real-Time Tsunami Model: RIFT

- **Physics: linear shallow water equations in spherical coordinates**
- **Numerics: staggered grid in space and leap-frog in time**
- **Initial condition: Okada (1985) elastic deformation formula.**
- **Fault size: continuous function of the EQ magnitude.**
- **Topography: Gebco 30-arc-sec resolution (typically, 4-arc-min. sampling of the Gebco grid is used for whole basins. For Hawaii-basin and other smaller basins 30-arc-sec. grid is used)**
- **Model domain: pre-defined basins or dynamically configured on the fly based a given tsunami travel time range or a given radius to the epicenter.**
- **Coastal forecast is based on the so-called Green's law (a theoretical result of inferring coastal wave height from off-shore wave height).**

Operation Scenarios

1. **Local Tsunami (mag <=7.5) (Indian/Caribbean)**
   Initial real-time tsunami forecast in 10-20 seconds after location and magnitude determination, using 30-sec or 1-min. resolution.

2. **Regional Tsunami Warning (Mag <=7.8)**
   Initial real-time tsunami forecast in 10-20 seconds using 2-4 min. resolution/

3. **Expanding Tsunami Warning (Mag >= 7.9)**
   Initial forecast for regions within 3-hour tsunami arrival time in 10-20 seconds, then whole basin run to follow, giving areas beyond the 3-hour arrival time forecast well in advance of the tsunami arrival. Refine forecast based on observations and refinement of EQ parameters.

Challenges and Limitations

- **Real-time forecasting is of limited use for local warning, even warning based on magnitude alone might not be adequate, if the EQ location is very close to the coast. Self-evacuation might be the only way to avoid the loss of lives.**

  Dense seismic network is needed.

- **Uncertainties of EQ parameters. Real-time forecast is only as good as the EQ parameters. Initial EQ mag can be off by 0.2 or more (recent Vanuatu event: initial mag was 0.4 too high).**

  Forecast at Vanuatu tide gauge:

  amp=0.75 m (Mw=7.5)

  amp=0.25 m (Mw=7.1, GCMT)

  Observed: 0.20 m (z2p)

  PTWC WCMT=7.3 and 7.1 for the 16:55Z (18.4S, 168E) and 18:19Z (18.2S, 168E) event:

Currently, Wphase takes about 25-30 min. come up with a good magnitude, this is too slow for local warning but useful for areas further away from the epicenter.

Challenges and Limitations

- **Tsunami wave height is sensitive to EQ depth, especially if the magnitude is small, therefore there is substantial uncertainty of tsunami forecast.**

  For the 1st Vanuatu event (M7.1):
  Amp=0.25 m, if z=33km
  Amp=0.63 m, if z=10km

- **Ingestion of DART data in propagation model does not always yield the best results. It's more art than science. Ingestion of tide station observations in forecast models is a big challenge.**

- **RIFT relies on Green's law for coastal forecast, no inundation models yet. Green's law only meant to work for linear open coast, it might not work well for small islands and harbors.**

  Future: implementing DART inversion and coupling with inundation models.

Future Plans

- **Implement inversion schemes using DART data and CMT.**
- **Use real-time forecast to provide more accurate warnings (specifically, reduce the number of over warnings based on the magnitudes alone)**
- **Longer term, replace Green's law with more accurate inundation models (super computer might be needed).**