



United Nations
Educational, Scientific and
Cultural Organization



Intergovernmental
Oceanographic
Commission

Making the Pacific Ready for the Tsunami Threat

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International Union
of Geodesy and
Geophysics

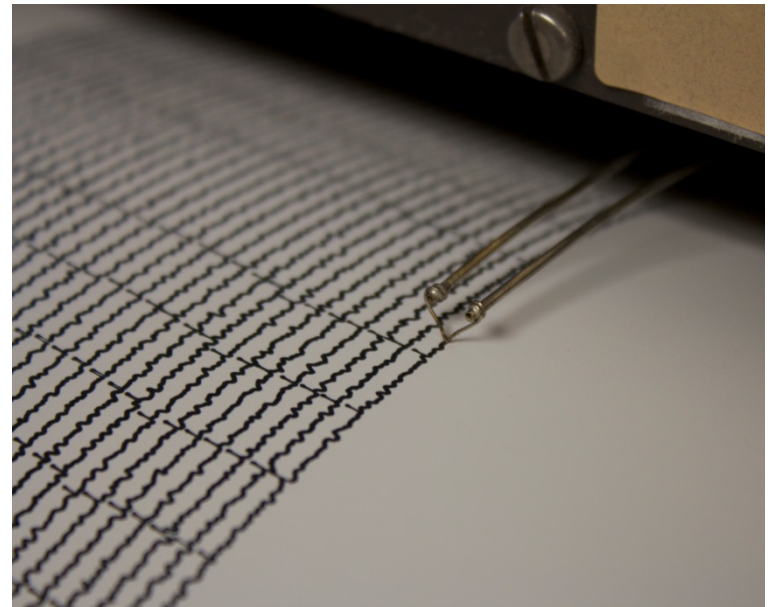
Tsunami Early Warning

Where have we been? Where are we now? Where are we going?



Charles McCreery, Director
NOAA Pacific Tsunami Warning Center

Where have we been?



Where have we been?



Where are we now?



Where are we going?

Boldly go where no Tsunami Warning Center has gone before....



Tsunami Characteristics and Warning

How, What, When, Where, Why

How

- > 85% by earthquakes
- < 15% by volcanoes, landslides, meteo

Tsunami Warning Centers have concentrated on addressing earthquake-generated tsunamis. Currently, other generation mechanisms go undetected with the tsunami only discovered after the fact.

Tsunami Characteristics and Warning

How, What, When, Where, Why

What

- **Generated by seafloor displacements**
- **Long ocean waves with 5 to 60 minutes periods**
- **Can have huge energy**
- **Small amplitudes in deep water**
- **Efficient propagation in deep water**
- **High speed in deep water**

Tsunami waves are most difficult to detect and measure near their source and as they propagate across the ocean - right where it would be most helpful to warning centers. Currently there are no practical, comprehensive, remote-sensing methods.

Tsunami Characteristics and Warning

How, What, When, Where, Why

When - Generation

- **A tsunami-genic earthquake can happen anytime**
- **Current earthquake forecasting is only probabilistic and not practical for warning**
- **Can be more than a lifetime between significant events on any coast**

Tsunami warning centers (and emergency managers and the public at risk) must be prepared to react, quickly and accurately, anytime.

Tsunami Characteristics and Warning

How, What, When, Where, Why

When - Impacts

- **Flooding can occur within minutes near the earthquake**
- **Can affect almost every coast in the Pacific in less than 24 hours**
- **Time of initial impact, time of maximum impact, duration of hazard important for warning**

Speed counts, especially for the local tsunami where biggest impacts occur. Time of initial tsunami impact for distant tsunami can be determined fairly accurately, but time of maximum impact and the duration of the tsunami hazard not as well.

Tsunami Characteristics and Warning

How, What, When, Where, Why

Where - Generation

- **Location of major subduction zones is known**
- **Location where next major earthquake will occur is unknown**

Tsunami warning centers must be prepared to respond for any source.

Tsunami Characteristics and Warning

How, What, When, Where, Why

Where - Impacts

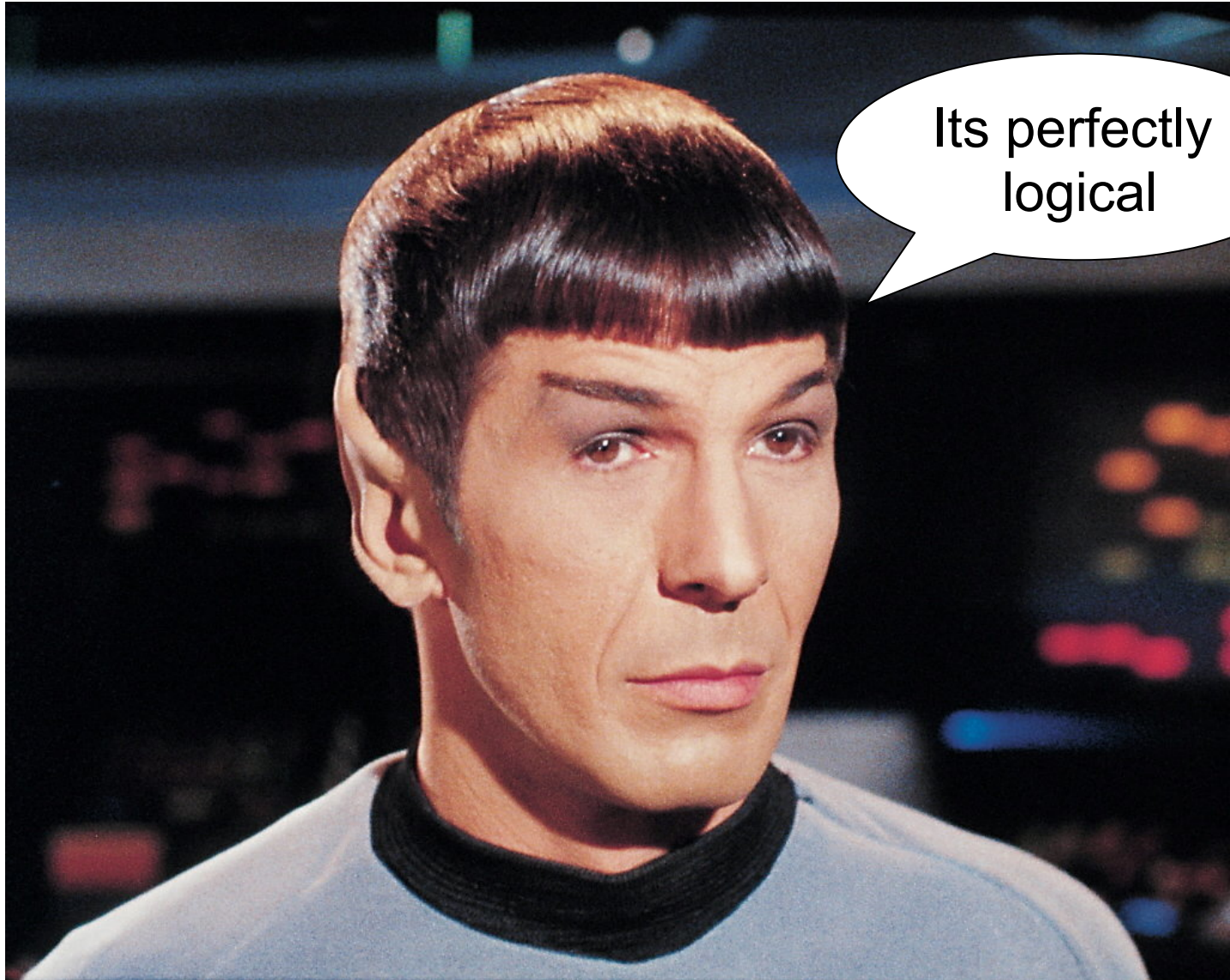
- **Biggest impacts usually near the source**
- **Tsunami energy is affected by many factors**
 - **shape and orientation of the source**
 - **focusing by refraction (bathymetry)**
 - **spreading, dispersion, friction**
- **Impacts characterized by flooding extent, current speeds, flow depths,**

Tsunami propagation forecast models are the only way to estimate tsunami propagation across oceans. Tsunami forecast inundation models are the only way to estimate coastal impacts.

Tsunami Characteristics and Warning

How, What, When, Where, Why

Why



The Ideal Tsunami Warning Center

- **Know the characteristics of an earthquake within minutes of when it occurs to know how it displaced the seafloor directly or indirectly to generate a tsunami.**
- **Be able to quickly and accurately forecast tsunami impacts for all threatened coasts including times and duration of impact, levels of flooding, and currents.**
- **Be able to quickly verify the forecast.**
- **Have the capability to disseminate this information quickly and understandably to all who need it.**

We are already part of the way there.

Seismic Networks



Quick detection preliminary earthquake parameters.

Centroid Moment Tensor

```
0.275000 -0.406853
Moment mag. : 6.57
PDE location : Lat= 2.20N; Lon= 126.90E; Dep= 64.9 km
Centroid loc.: Lat= 2.30N; Lon= 126.70E; Dep= 90.5 km
Origin time : 2012/08/26 15:05:37.00
Time delay : 4.0 sec
Half duration: 4.0 sec
```

```
Moment tensor: scale= 1.0E+26 dyn.cm
rr= 0.404 ; tt= 0.417 ; pp=-0.821
rt=-0.495 ; rp=-0.073 ; tp= 0.193
```

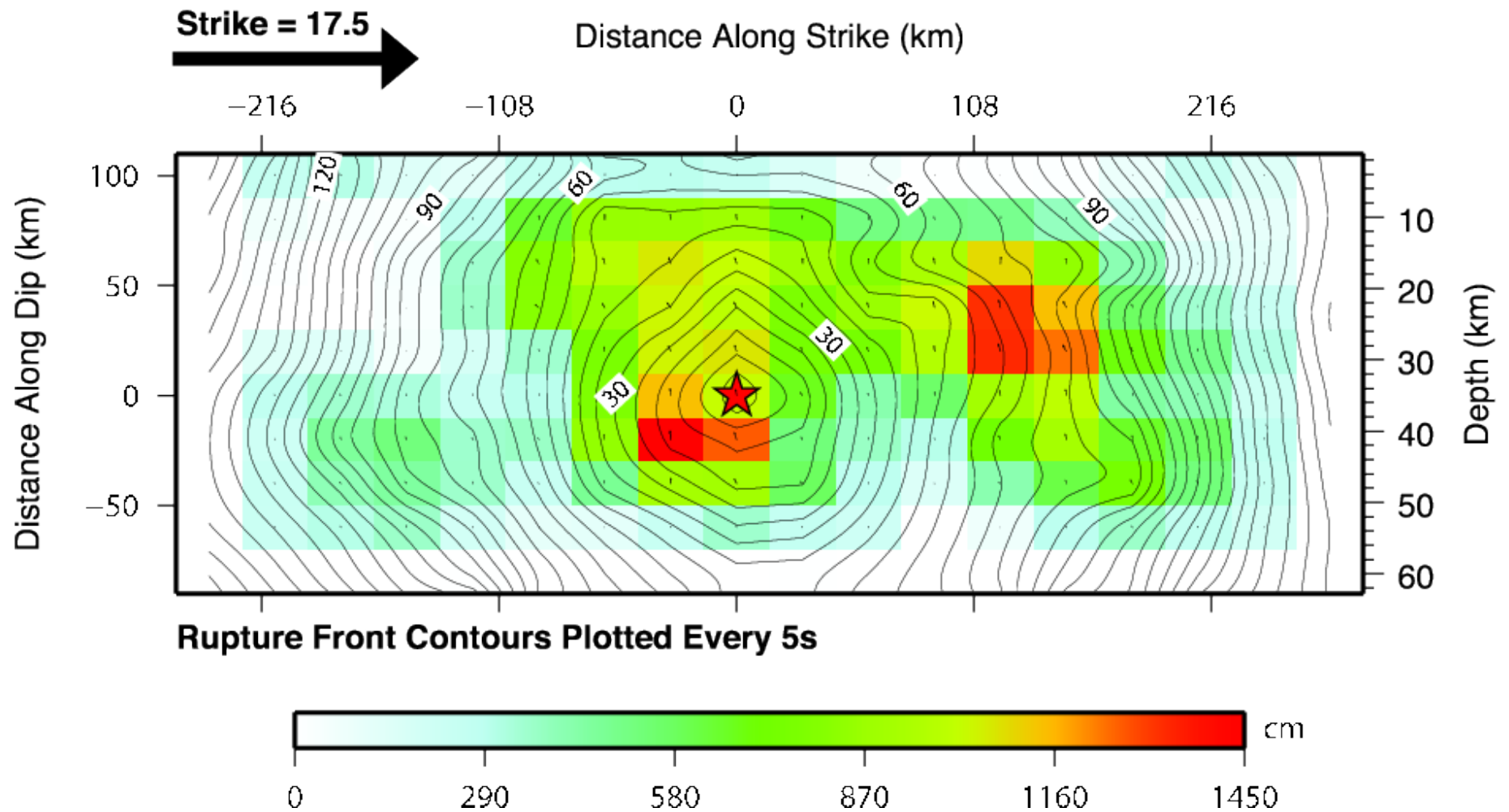
```
Principal Axes:
1.(T) Val= 0.926 ; Plg= 44 ; Azm=171
2.(N) -0.075 ; 46 ; 351
3.(P) -0.851 ; 0 ; 81
```

```
Best Double Couple: M0=8.88E+25 dyn.cm
NP1: Strike=207 ; Dip=60.5887 ; Slip=146
NP2: Strike=316 ; Dip=60.8025 ; Slip= 34
```

```
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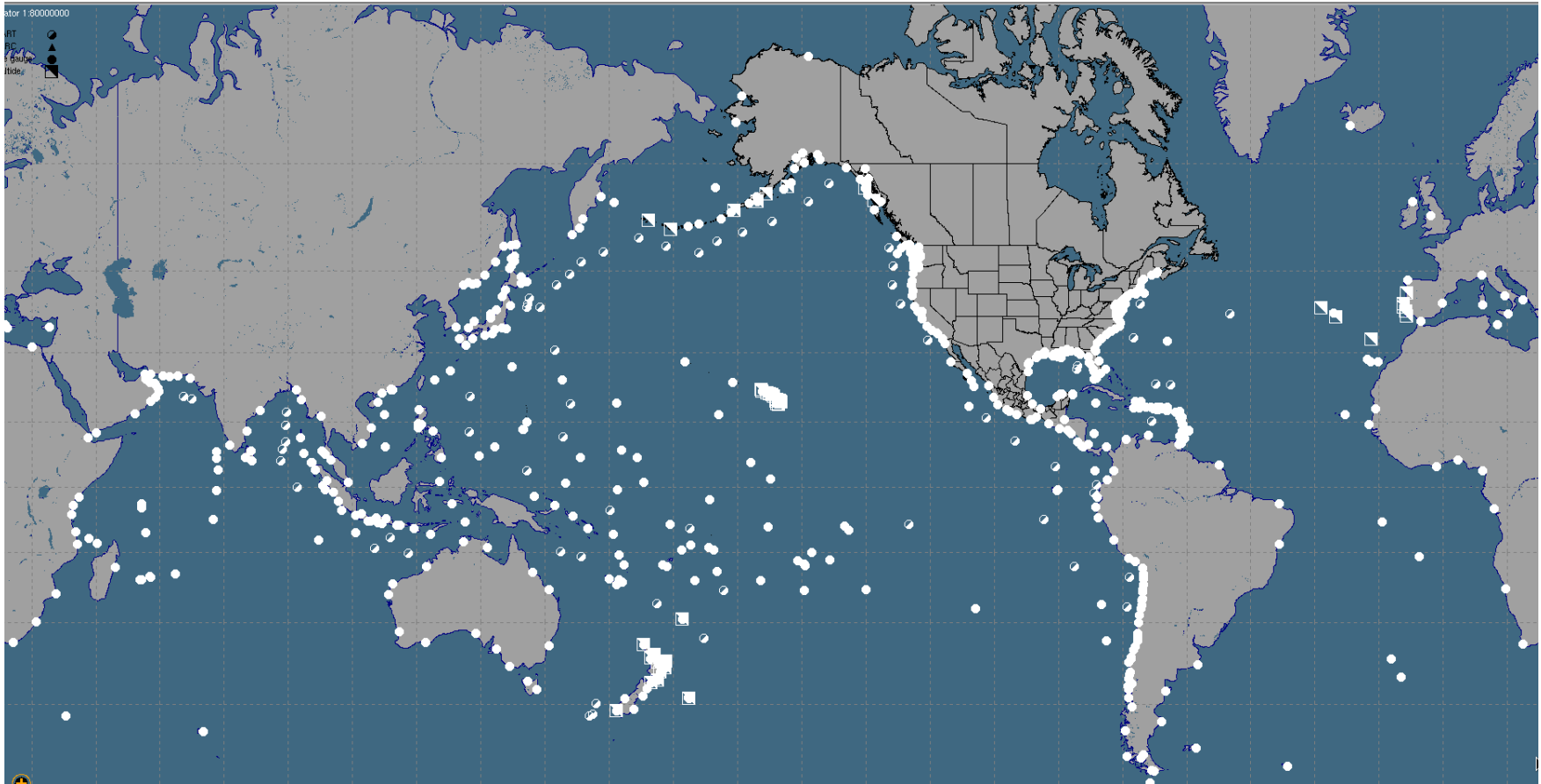
Accurate magnitude and overall earthquake mechanism.

Rapid Finite Fault



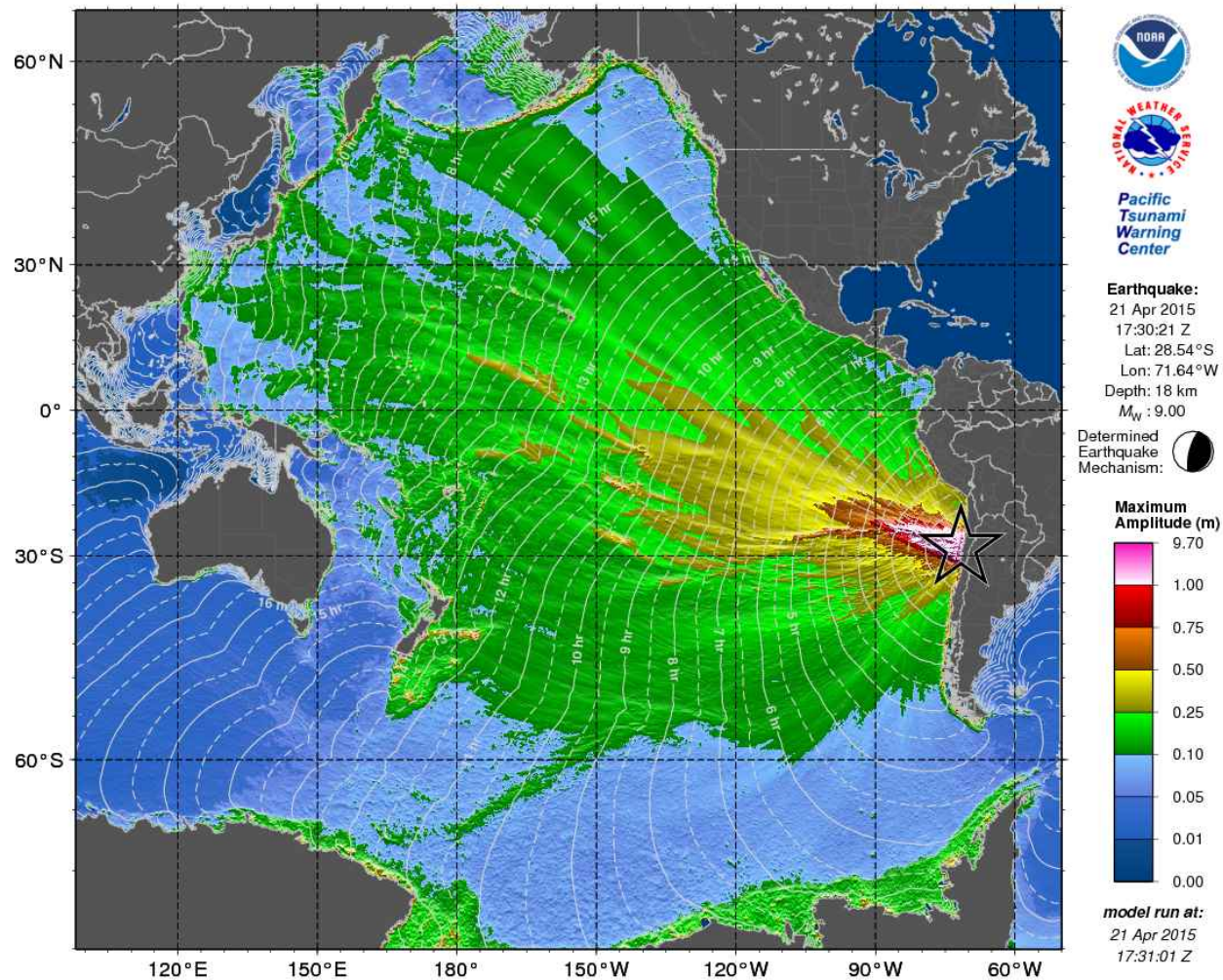
Not yet, but hopefully soon with GPS.

Sea Level Data



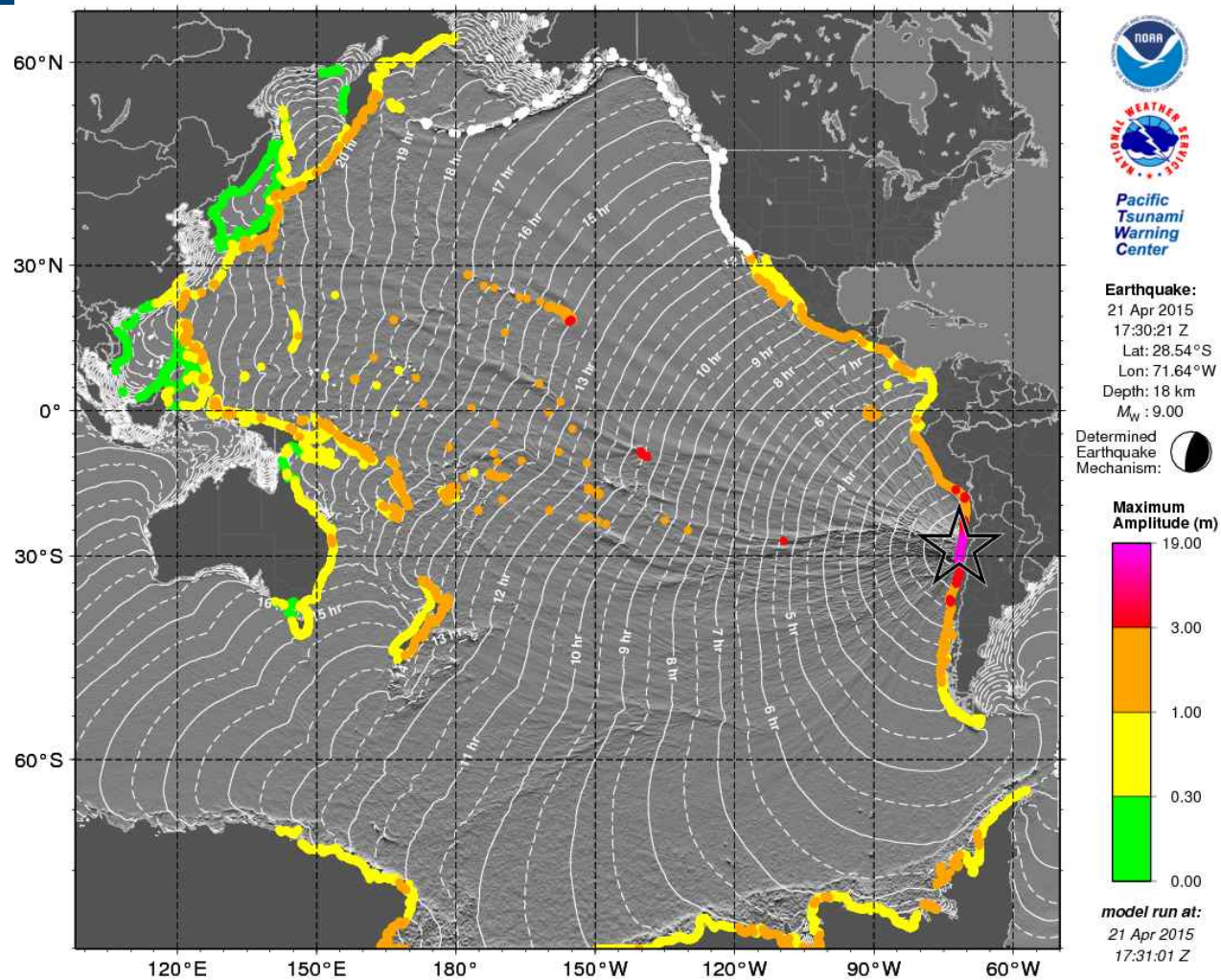
To constrain forecast, validate forecast and monitor tsunami.

Propagation Forecast



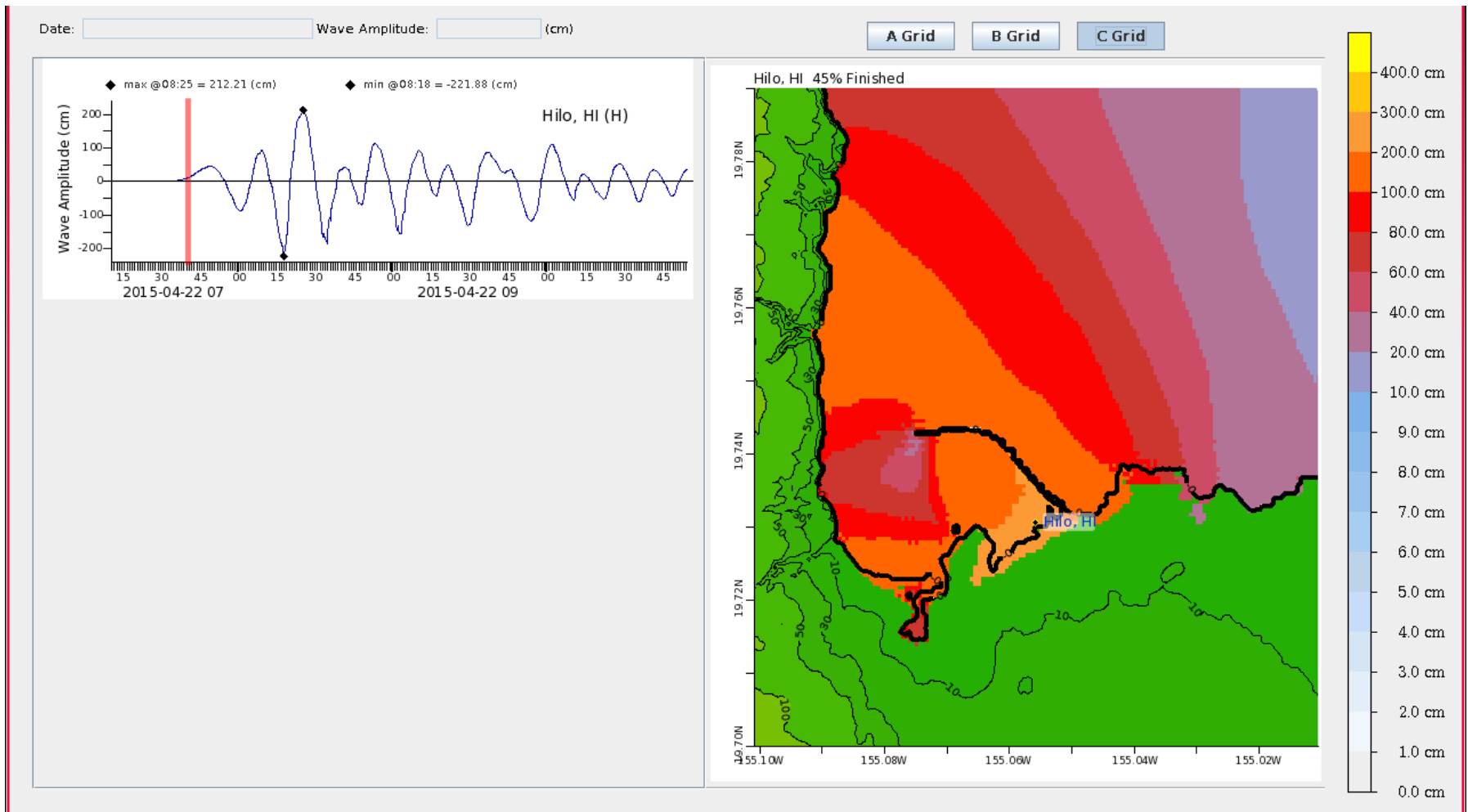
Many models. Accuracy depends on accuracy of source.

Coastal Amplitude Forecast



Comprehensive coverage with Green's Law.

Coastal Inundation Forecast



Where a coastal inundation model exists.

Conclusions

- **We already have much of the data and many of the tools we need.**
- **Make incremental improvements to those.**
- **Pursue new data and tools:**
 - **GPS for quick displacements, finite fault**
 - **Undersea cables for mid-ocean measurements**
 - **Remote sensing**
- **Pursue rapid alerting methods – e.g., CAP, mobile phone alerts.**
- **Coordinate, collaborate, share for sustainability.**

Our Wish For Every Coastal Community





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Thank You
