Regional Training Workshop on Pacific Tsunami Warning Center
Enhanced Tsunami Products for ICG/CARIBE EWS
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TWC Operations – Tsunami Travel Time Forecasting

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Tsunami travel time computation

Wave speed: $c = \sqrt{gh}$

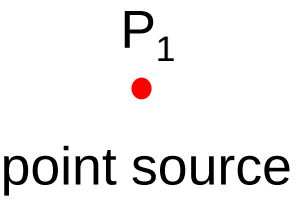
g = acceleration of gravity = 10 m / s^2

h = water depth

Since water depth varies across the ocean then the wave speed varies across the ocean

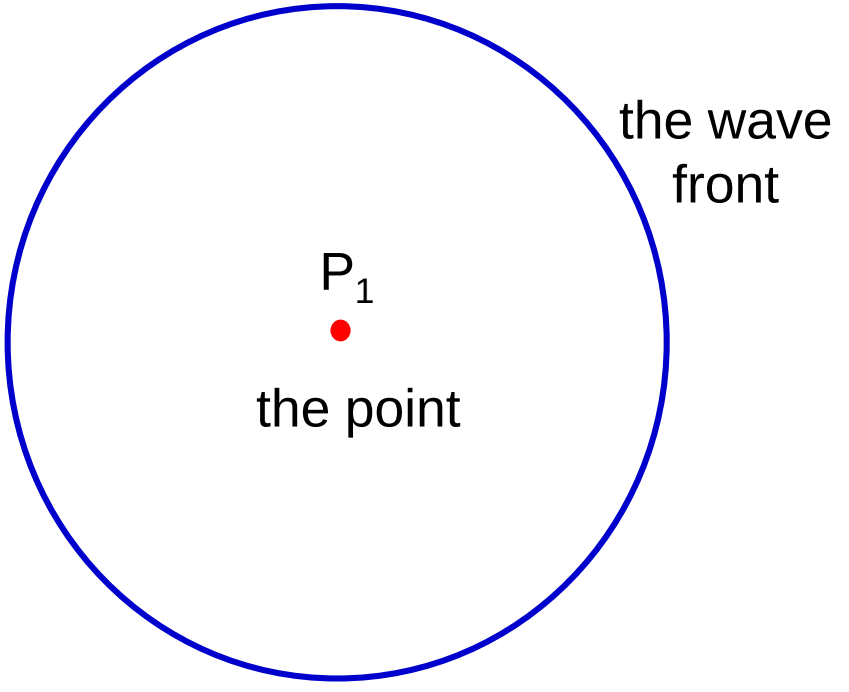
Huygens Principle: **every point on a wave front of a point source is also a point source.**

A Point Source



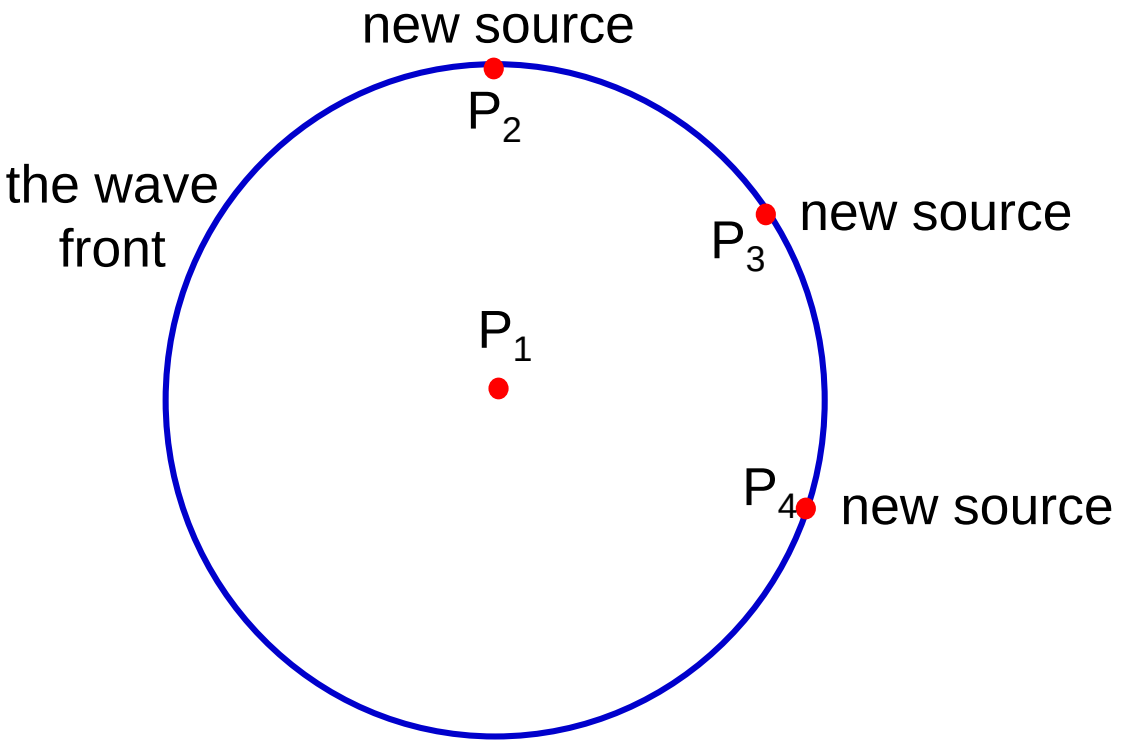
Wave speed in the vicinity of the point is C_1.

Wave Front After Increment of Time

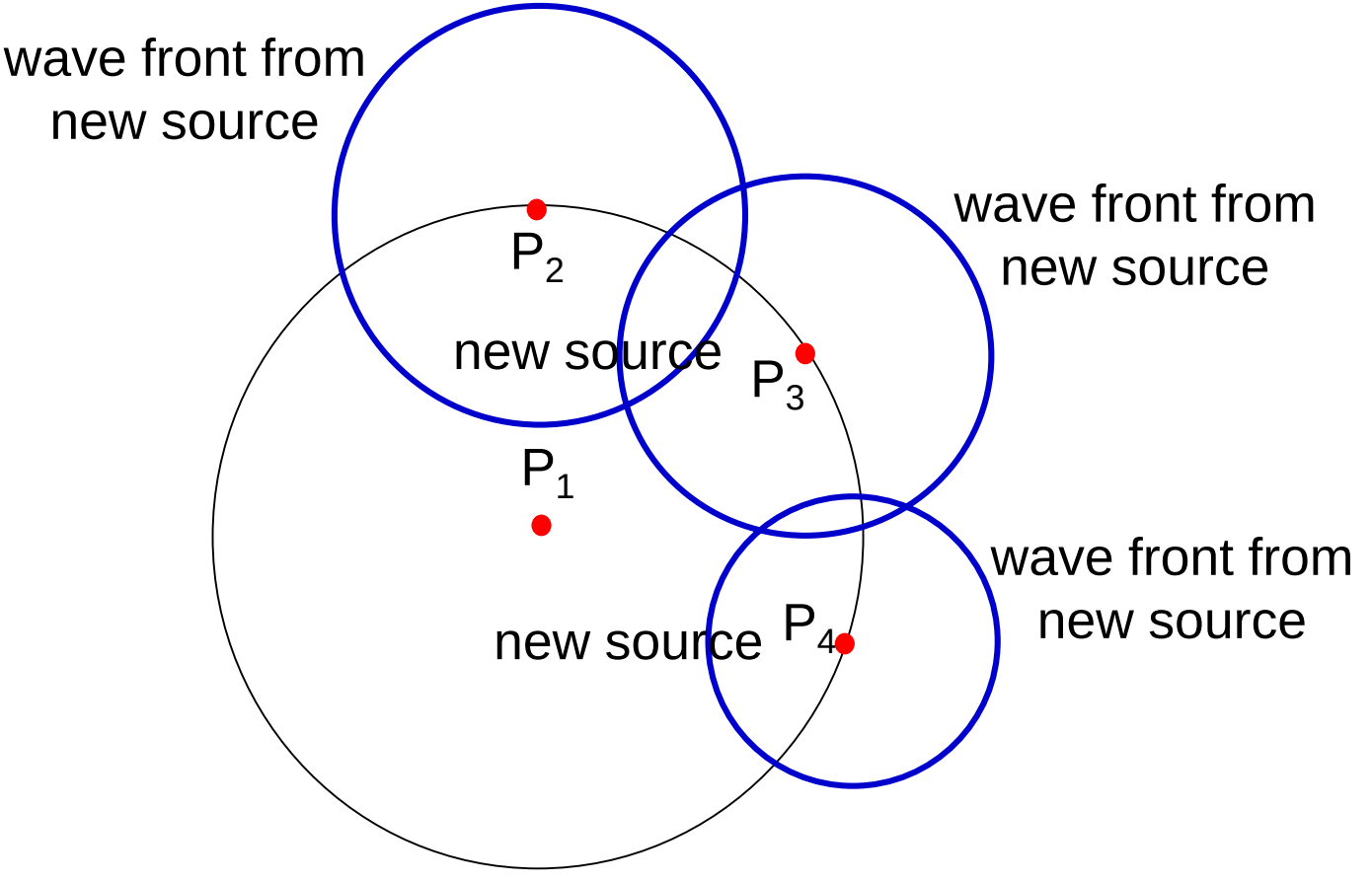


Every Point on Front is New Source

Wave speed in the vicinity of each new source may be different: C_2, C_3, and C_4

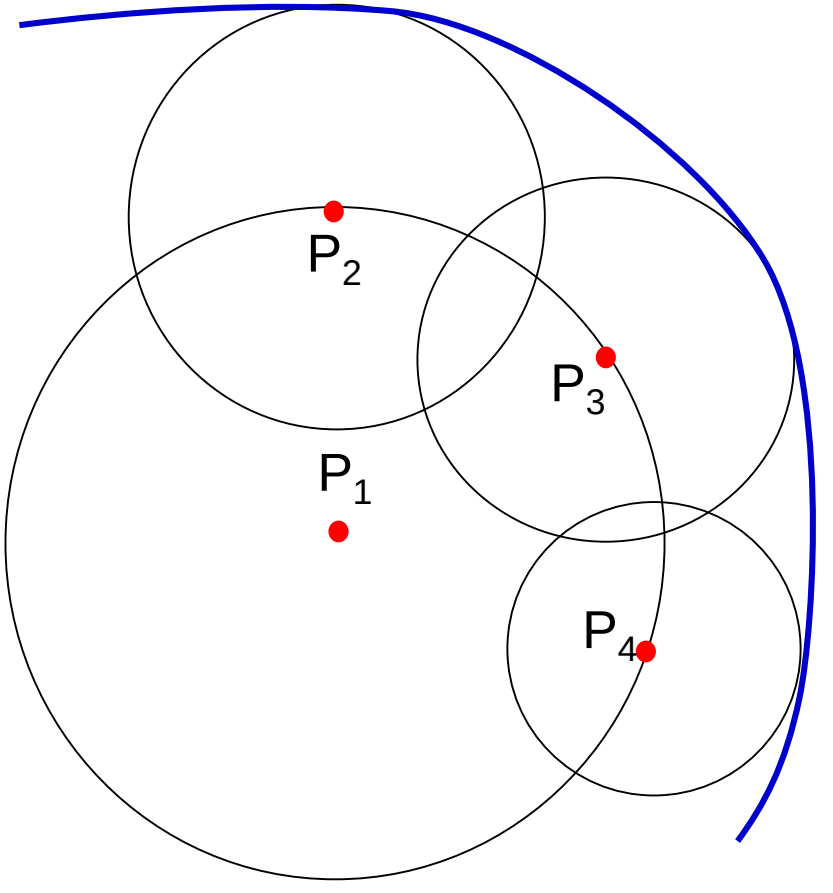


After Next Time Increment



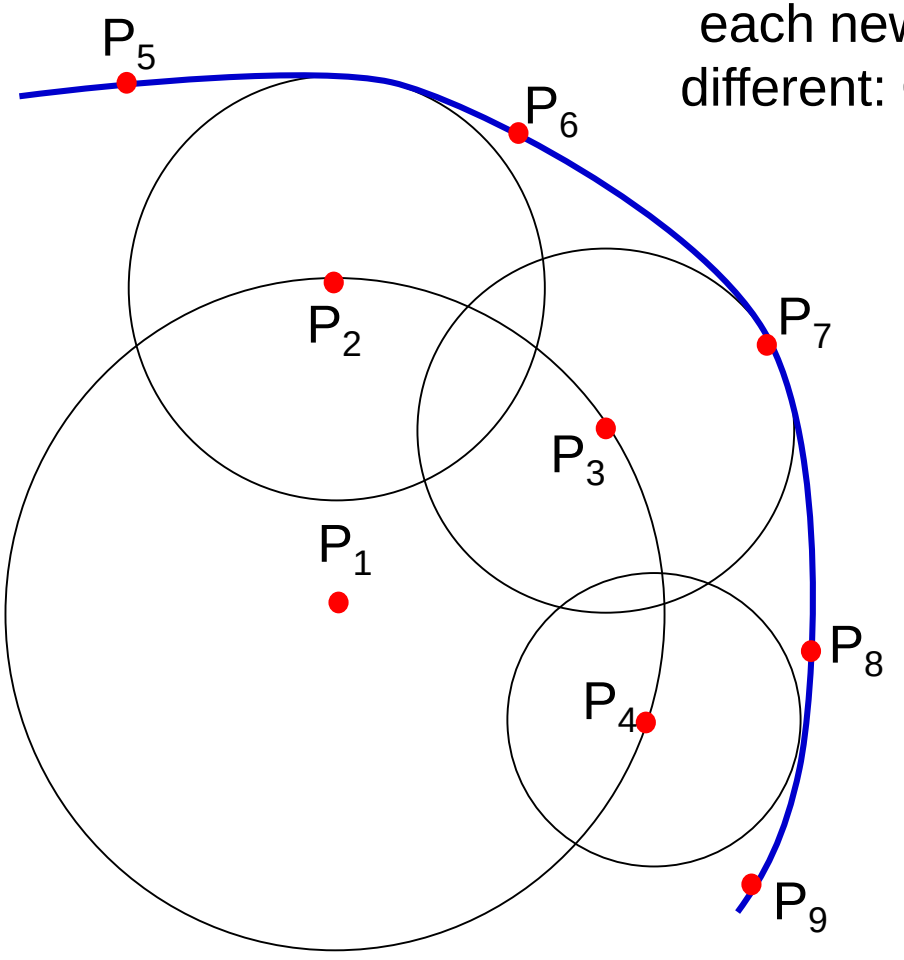
Wave speed in the vicinity of each new source is different.

Combined New Wave Front



More New Points on Wave Front

Wave speed in the vicinity of each new source may be different: C_5, C_6, C_7, and C_8



Etc., etc., etc., …

Calculating ETAs

- **EQ epicenter assumed to be point source.**
- **If epicenter on land, nearest ocean point with sufficient depth is assumed**
- **PTWC estimated tsunami arrival times (ETA)**
  - computed in real-time using GEOWARE TTT (tsunami travel time) software http://www.geoware-online.com/tsunami.html)
  - GEBCO 30-arc-second bathymetry data (http://www.gebco.net).
  - For speed of computation, lower resolution might be used (such as 5 or 10 arc-minute grid).

Reference: Wessel, P. (2009), Analysis of observed and predicted tsunami travel times for the Pacific and Indian Oceans, Pure and Applied Geophysics, vol 166, 301-324, doi:10.1007/s00024-008-0437-2.

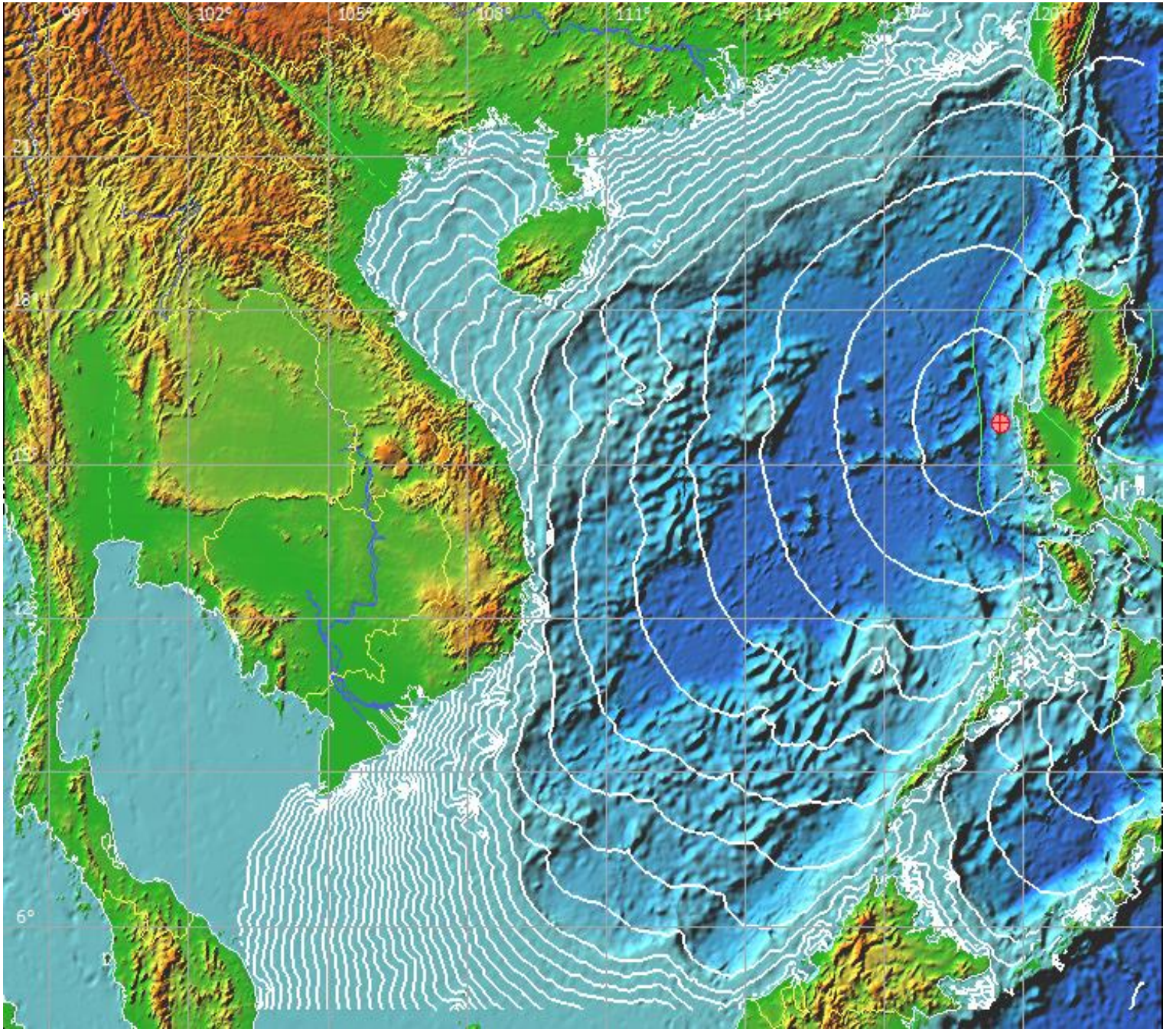
Limitations of tsunami travel computation

- **Tsunami not generated by point source**
- **Main energy propagation path might not be quickest possible path (assumed in TTT)**
- **Usually results in ETAs that are**
  - earlier than observed in far field
  - later than observed near field.

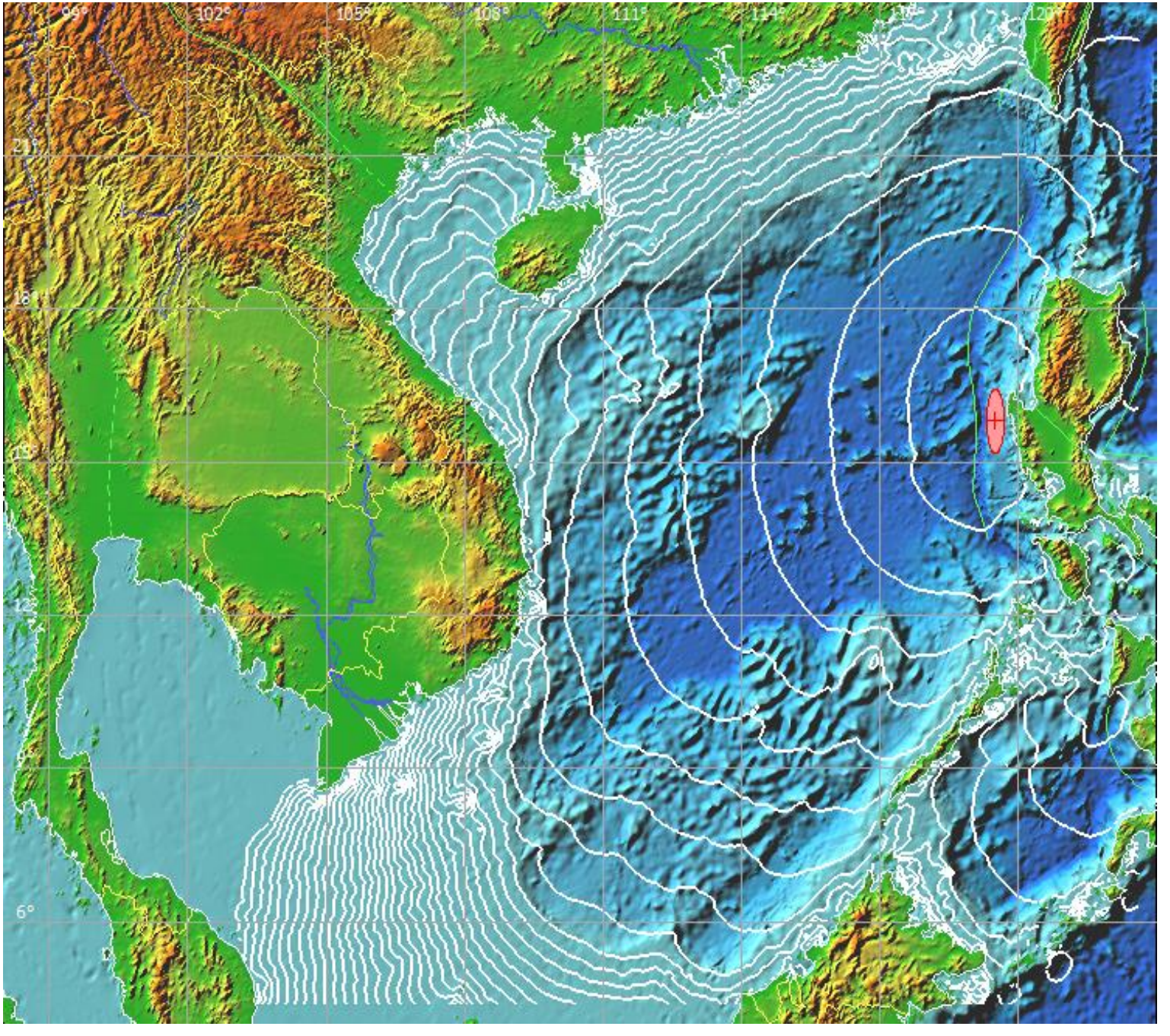
Sensitivity of ETAs to size of sources

- **Fault Size examples: Manila Trench, ETAs decrease as source size increases (note ETA contours near Taiwan)**

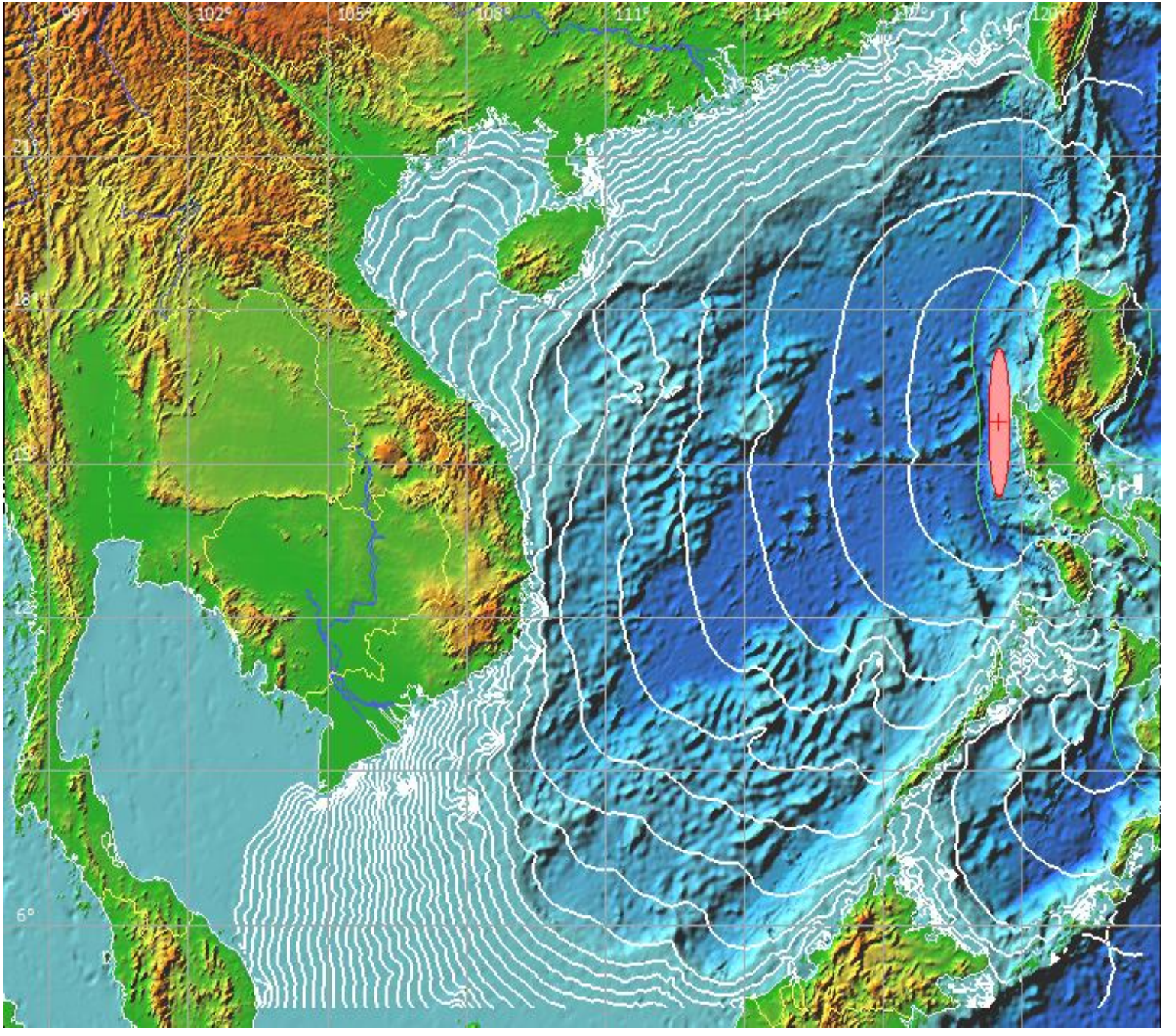
Tsunami Travel Times: 20 x 20 km Source and 15-min Isochrons



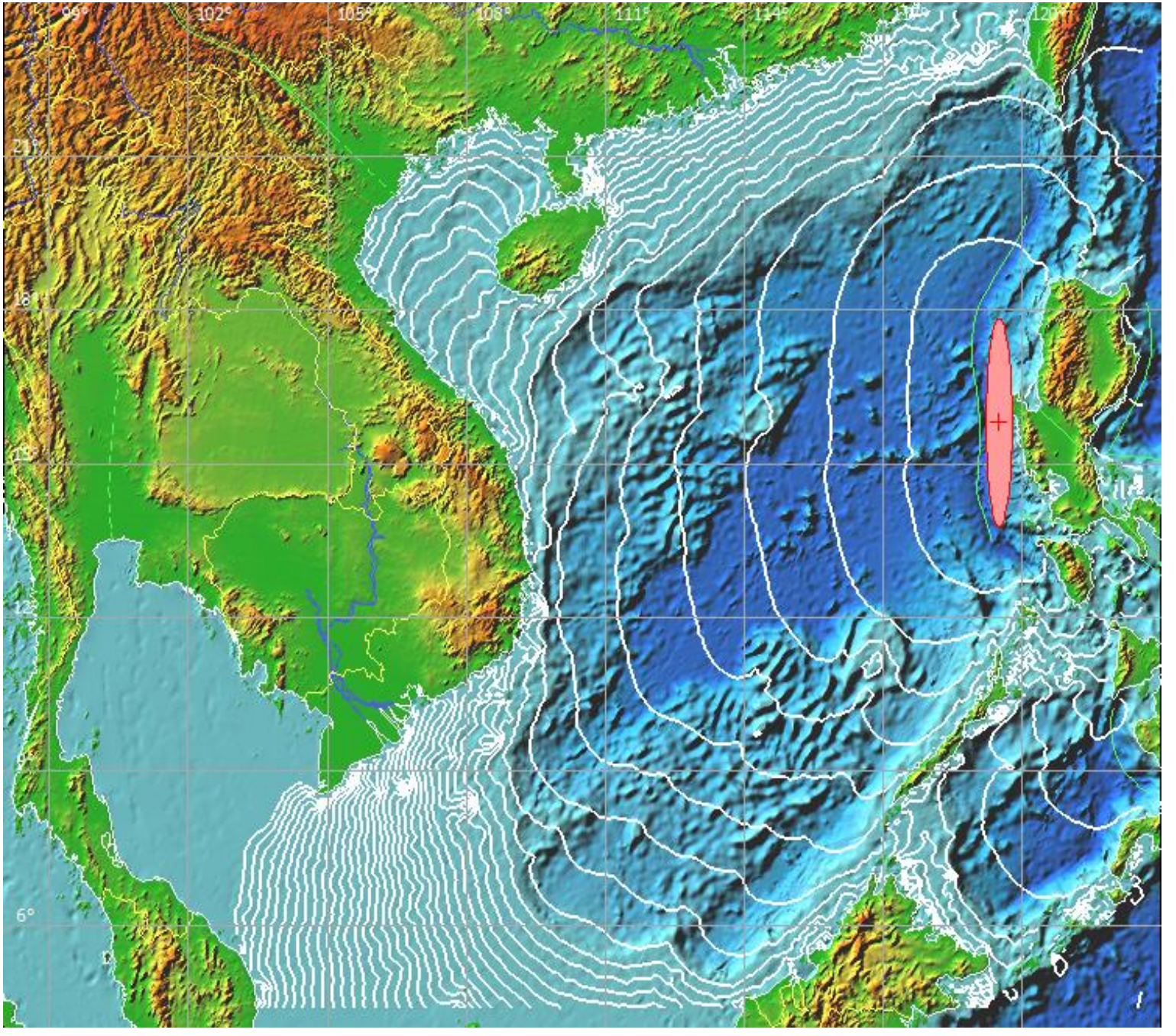
Tsunami Travel Times: 20 x 70 km Source and 15-min Isochrons



Tsunami Travel Times: 25 x 160 km Source and 15-min Isochrons



Tsunami Travel Times: 30 x 225 km Source and 15-min Isochrons



Thank You, Gracias, Merci, Mahalo

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