SAND2012-7213P

SALSA3D

A Global 3D P-Velocity Model of the Earth's Mantle For Improved Event Location in Nuclear Explosion Monitoring

Sandy Ballard[1]

Mike Begnaud[2], Jim Hipp[1], Chris Young[1],

Andre Encarnacao[1], Scott Phillips[2]

[1]Sandia National Laboratories

[2]Los Alamos National Laboratory

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Nuclear Explosion Monitoring

Comprehensive Test Ban Treaty (CTBT)
Adopted by UN in 1996, ratified by 157nations
China, Egypt, Iran, Israel, United States have signed, but not ratified
India, Pakistan and North Korea have not signed

Comprehensive Test Ban Treaty Organization (CTBT) Vienna, Austria

US National Data Center, AFTAC, Patrick AFB, FL

US Dept. of Energy provides R&D support

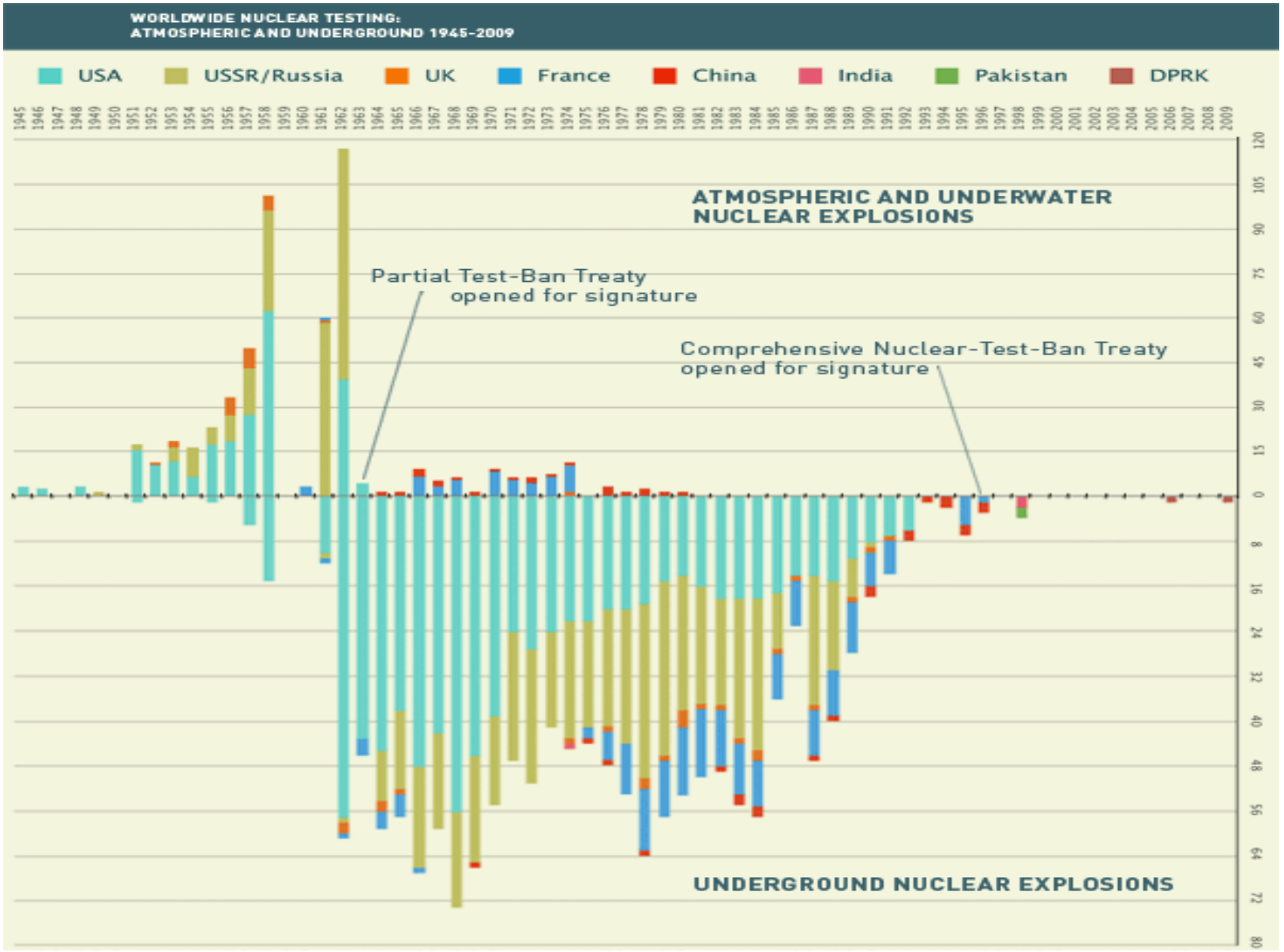
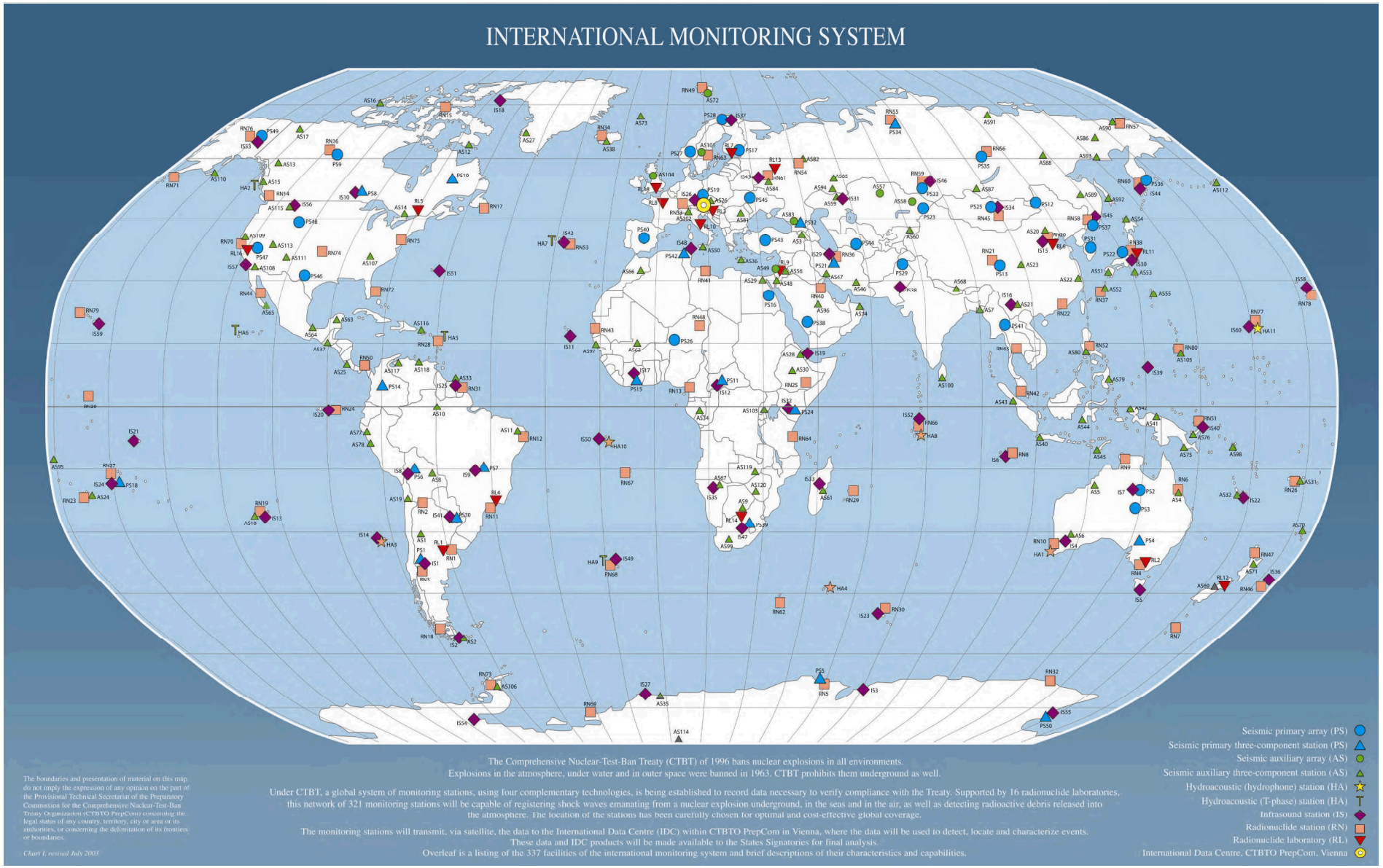
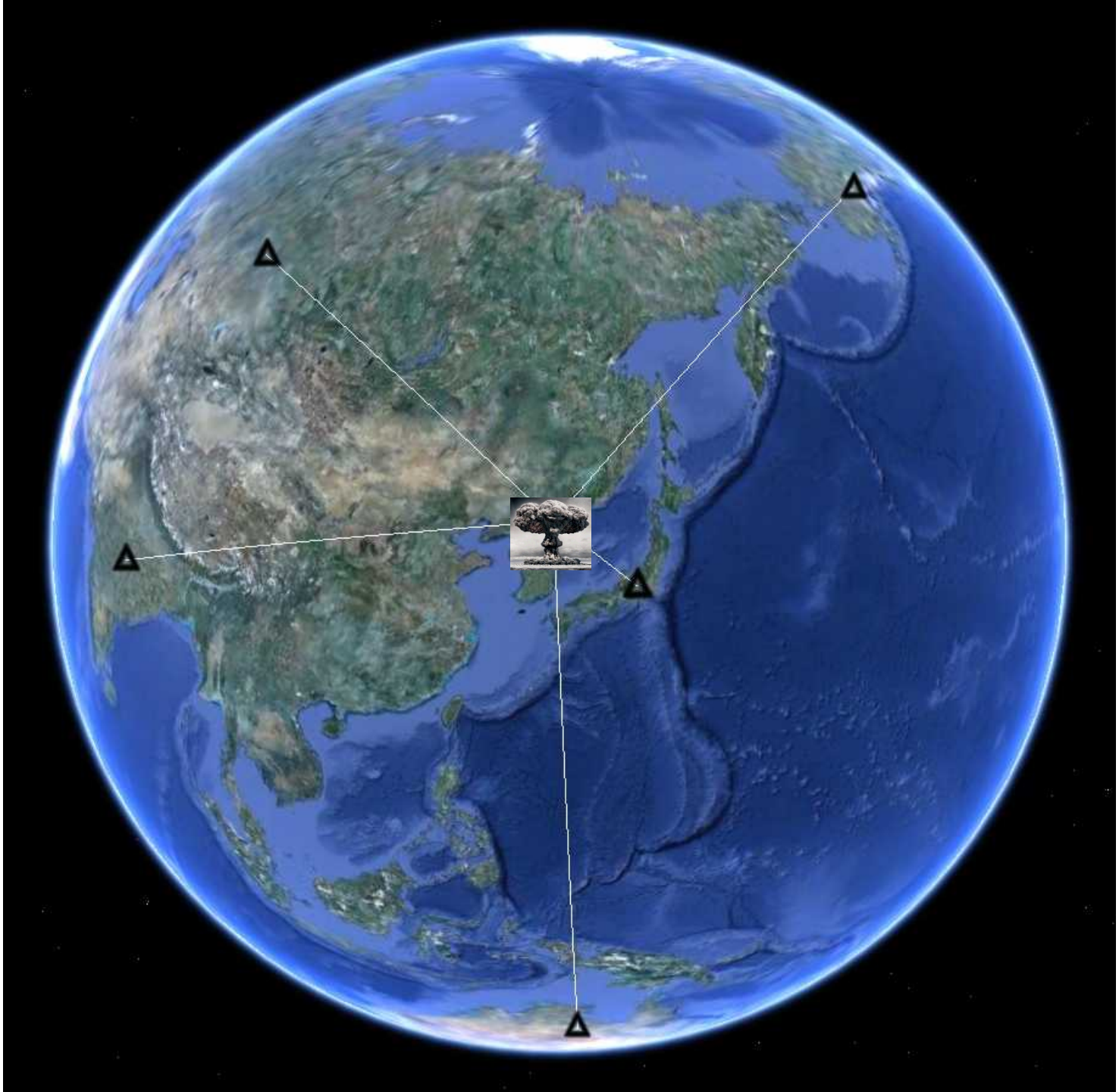


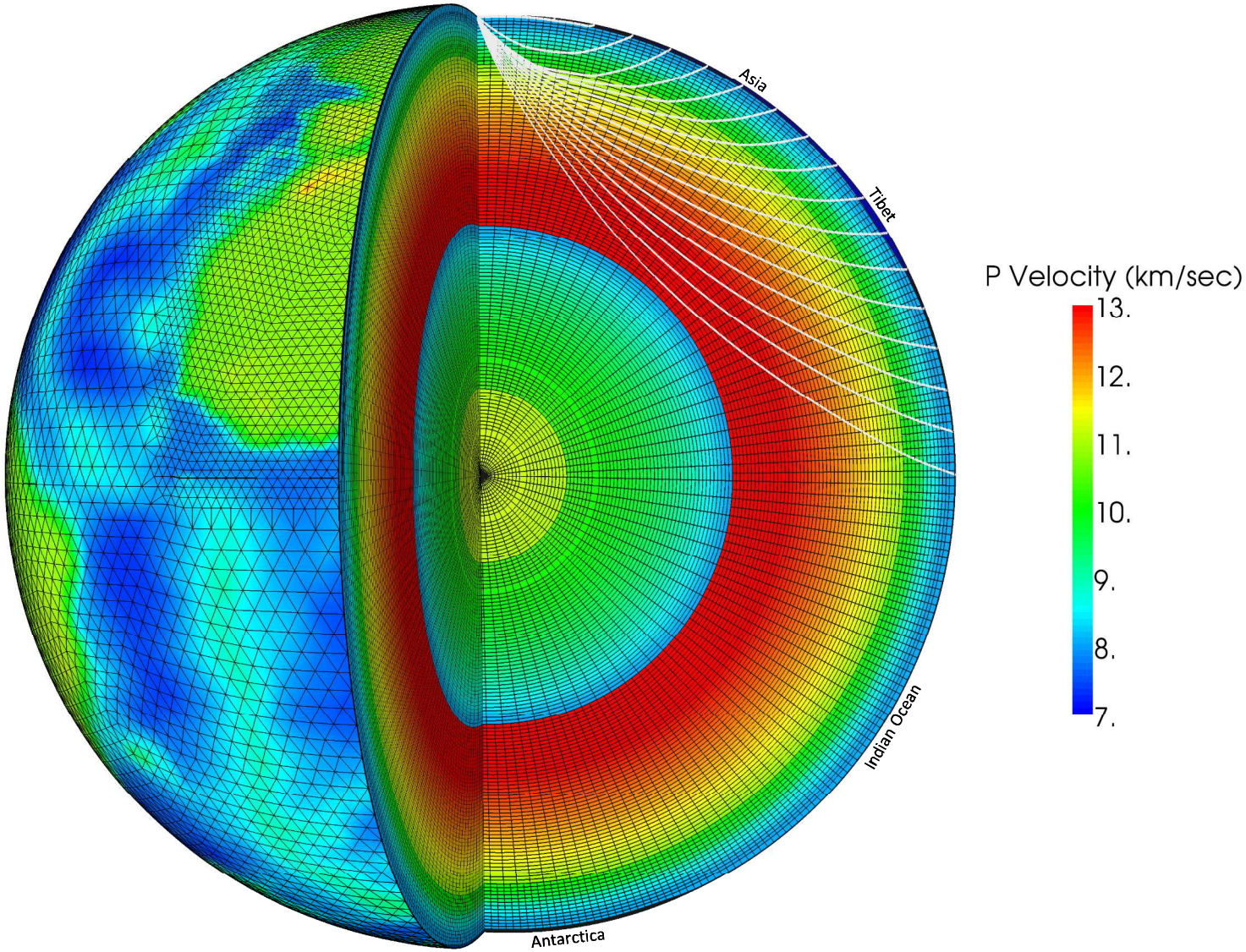
Figure from CTBTO website www.ctbto.org

CTBT International Monitoring System



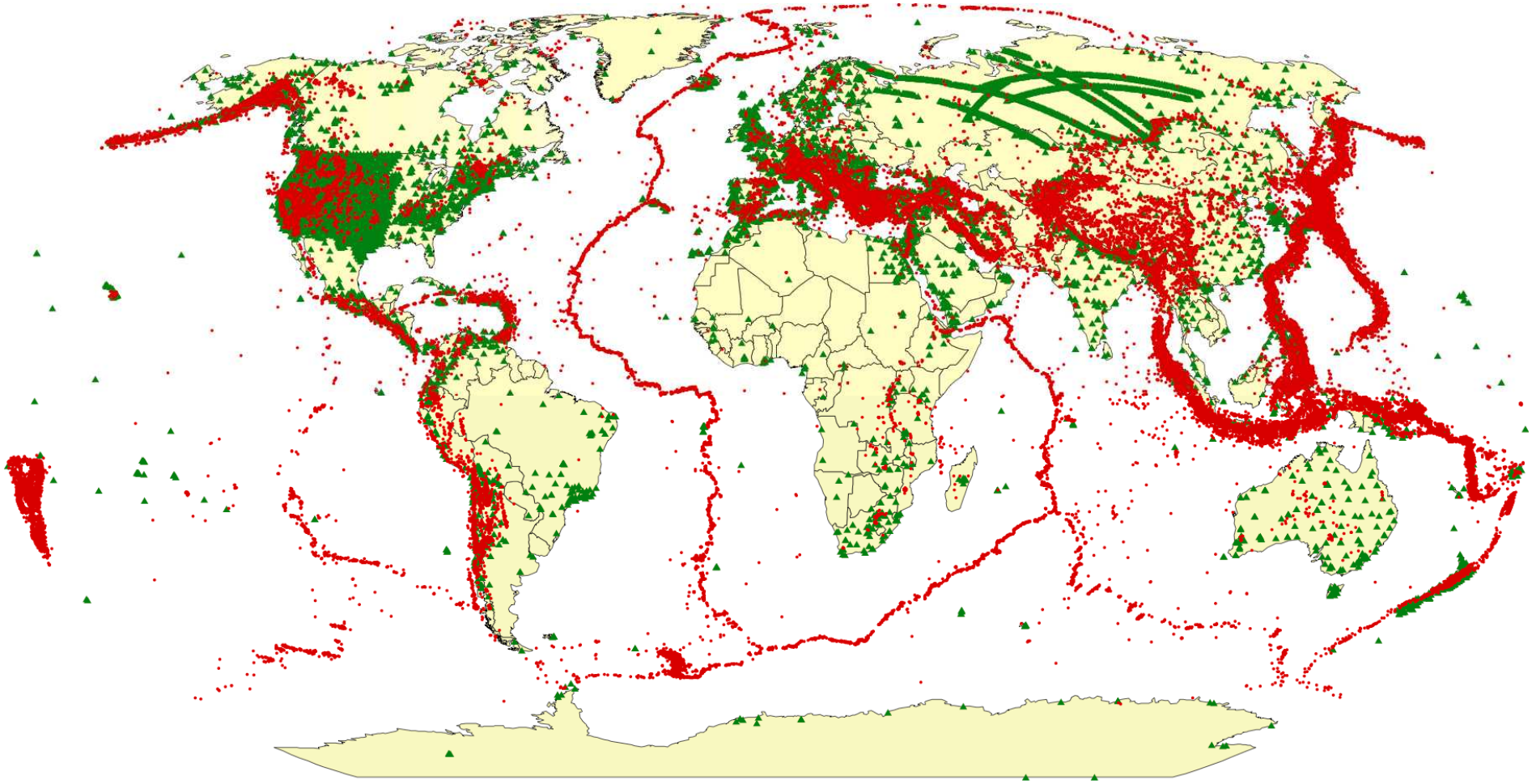


Seismic Ray Tracing Through 3D Earth Models

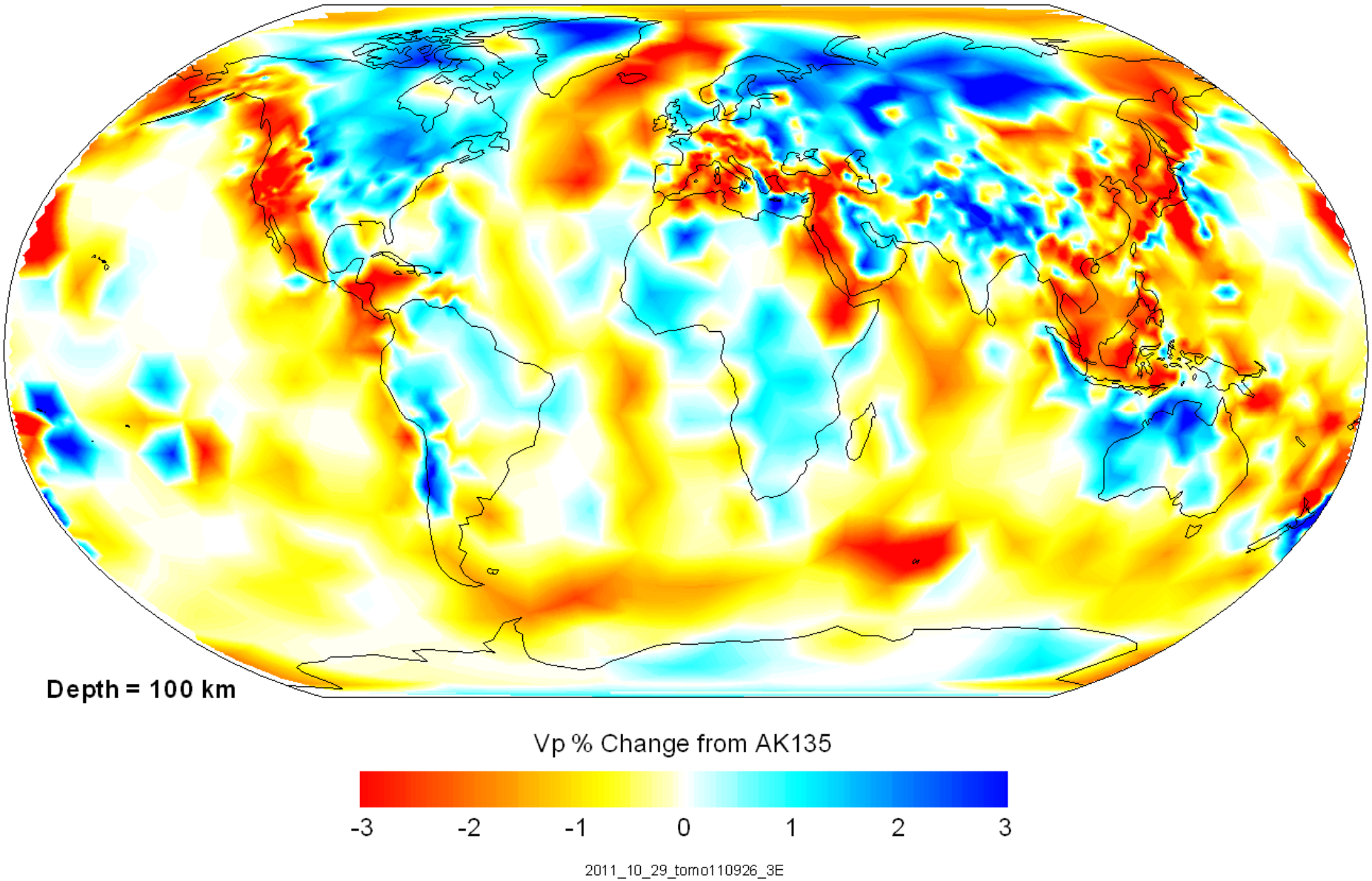


Tomography Data

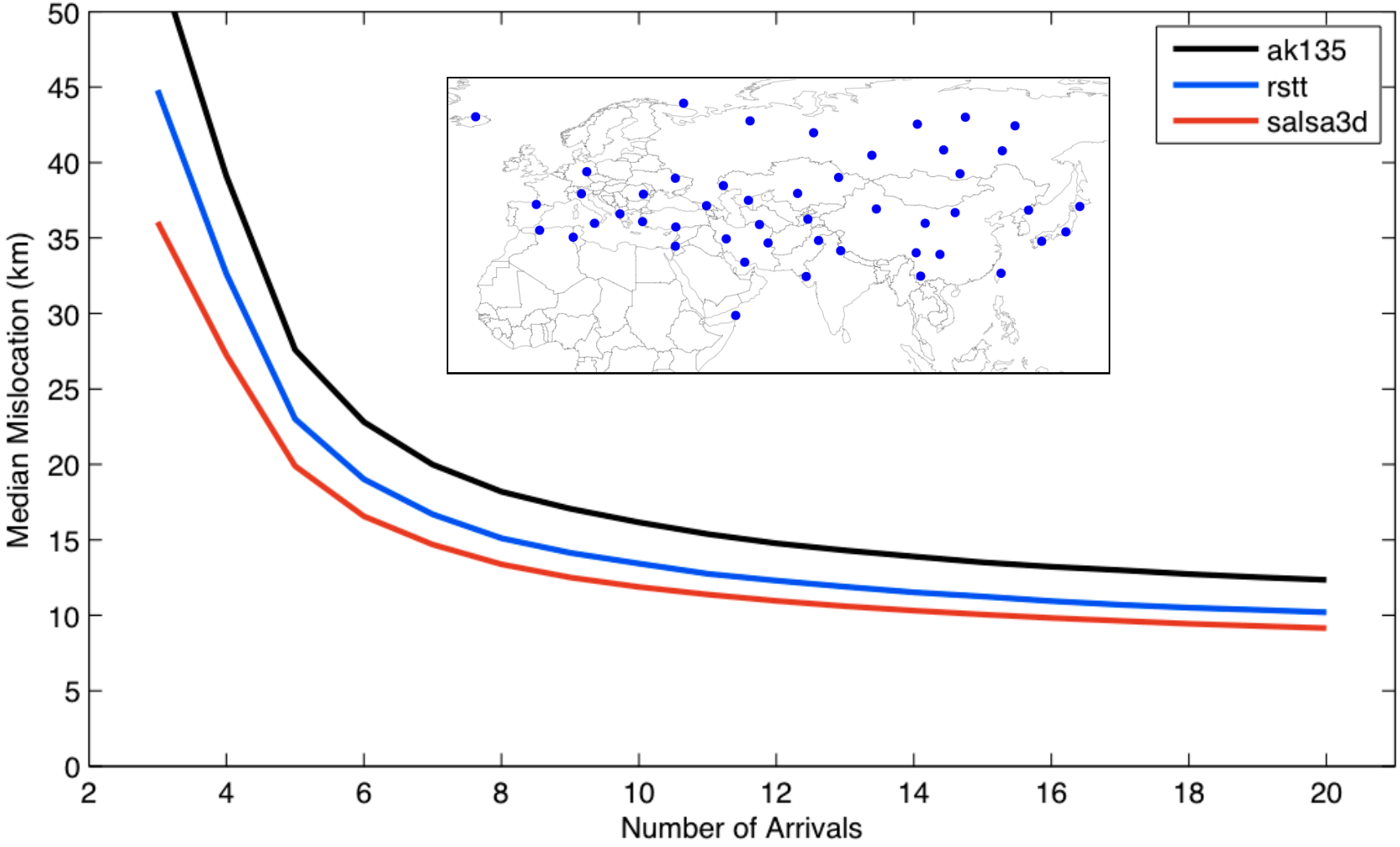
117K events **12K stations** **12M ray paths**



SALSA3D


Depth = 100 km
Vp % Change from AK135
-3
-2
-1
0
1
2
3
2011_10_29_tomo110926_3E

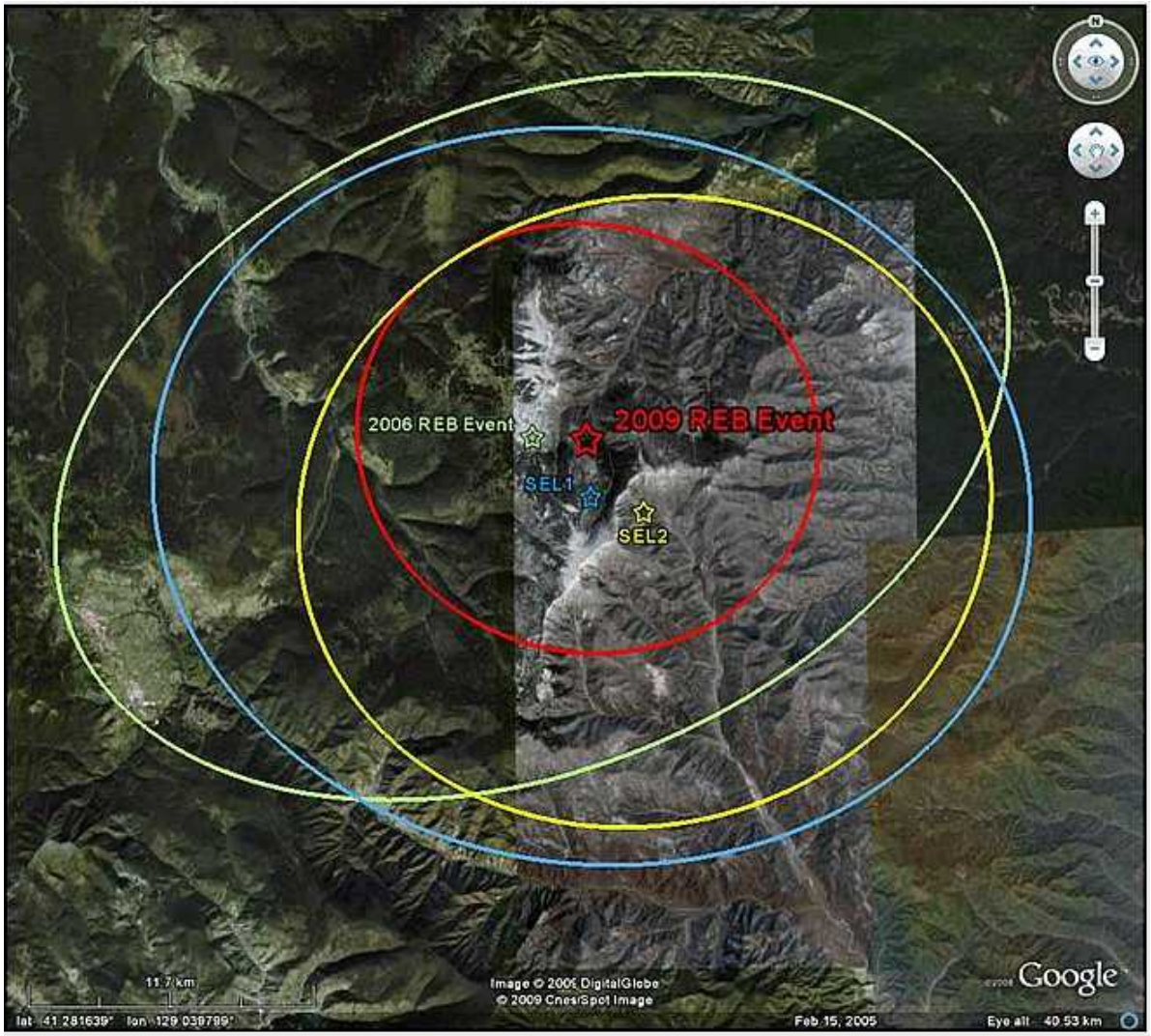
Mislocation vs. Number of Observations



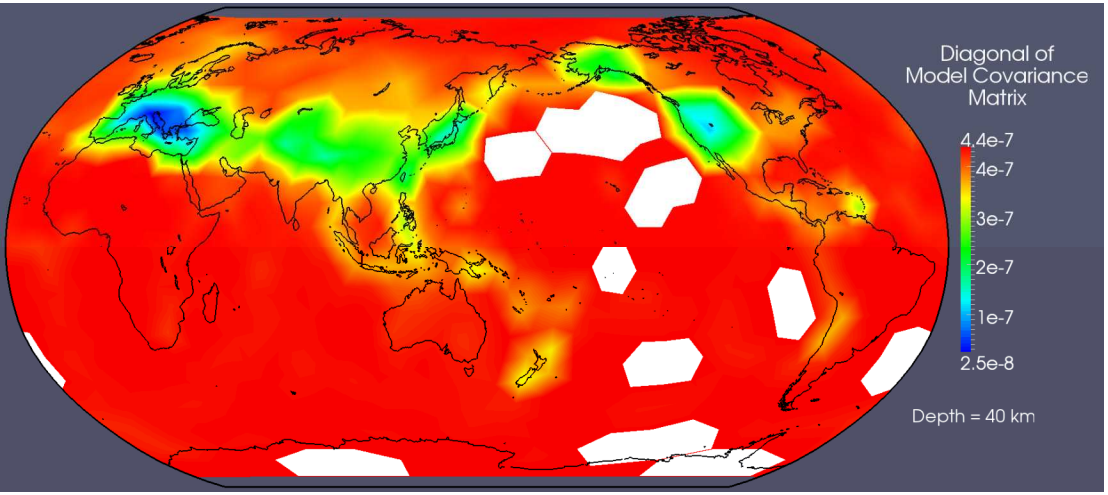
CTBTO Location of 2006 and 2009 North Korean Tests

- Origin of 2009 event (red) is much more precise than the 2006 origin (green)
- Blue and yellow ellipses show the first and second automatic location estimates
  - Sel1 = primary stations
  - Sel2 = primary + auxiliary
- 2009 bigger event, seen at more stations, error ellipse is circular due to better station coverage

From CTBTO website

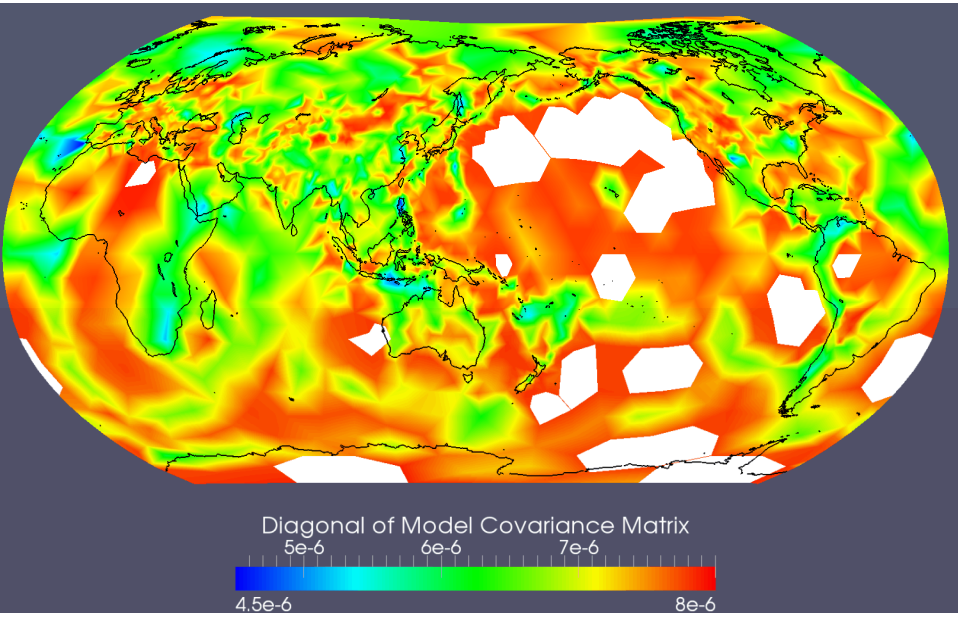


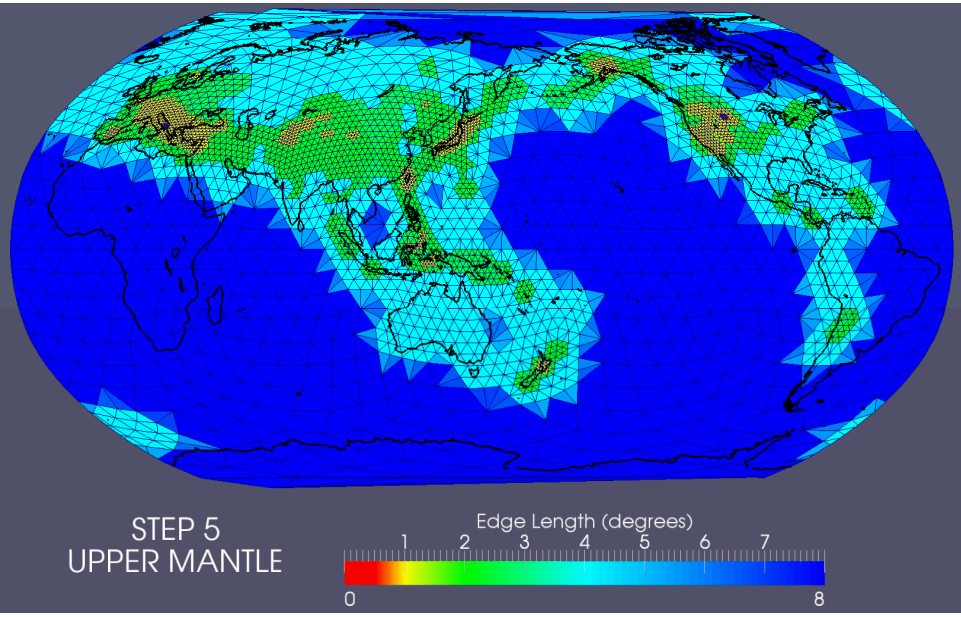
Model Covariance Matrix



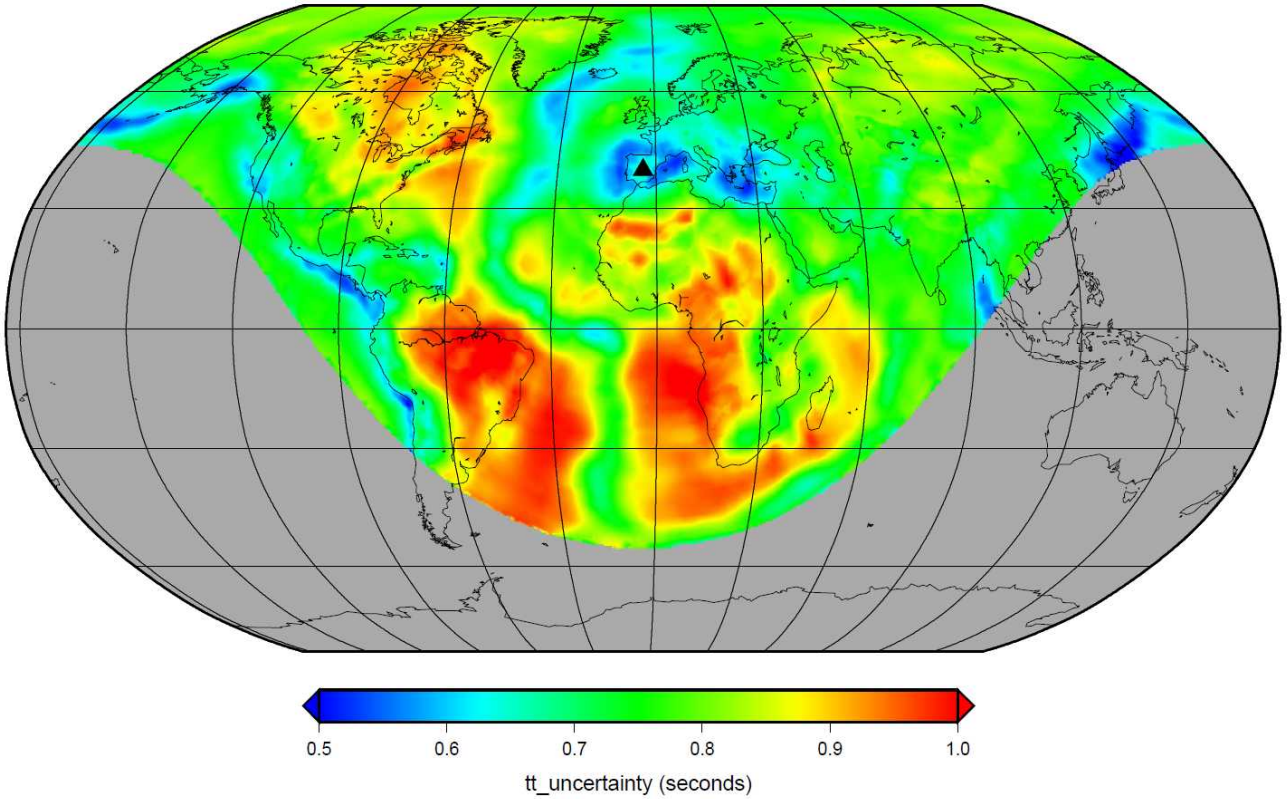
$$C_M = \left(G^T G\right)^{-1} G^T \begin{bmatrix} C_{\Delta d} & 0 \\ 0 & C_{\Delta s} \end{bmatrix} G \left(G^T G\right)^{-1}$$

15 petaflops to compute
180GB of RAM to store
computed in distributed mode

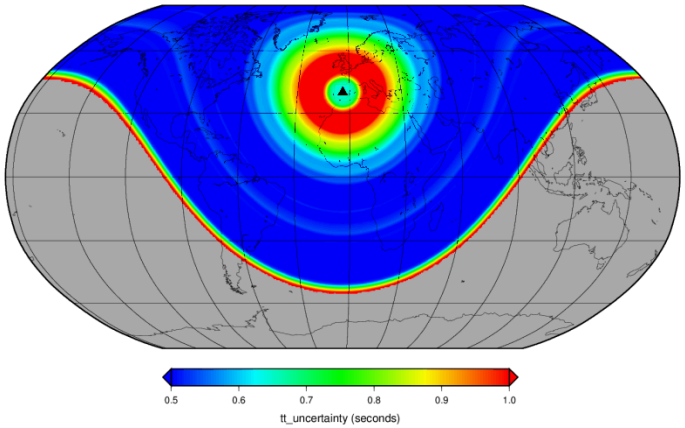




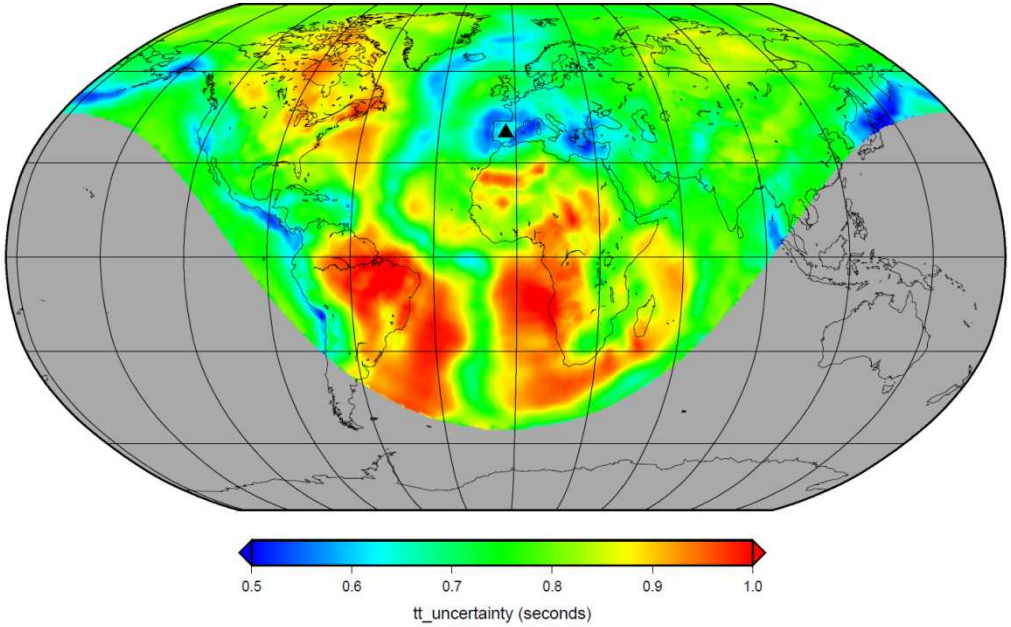
ESDC, depth=0km



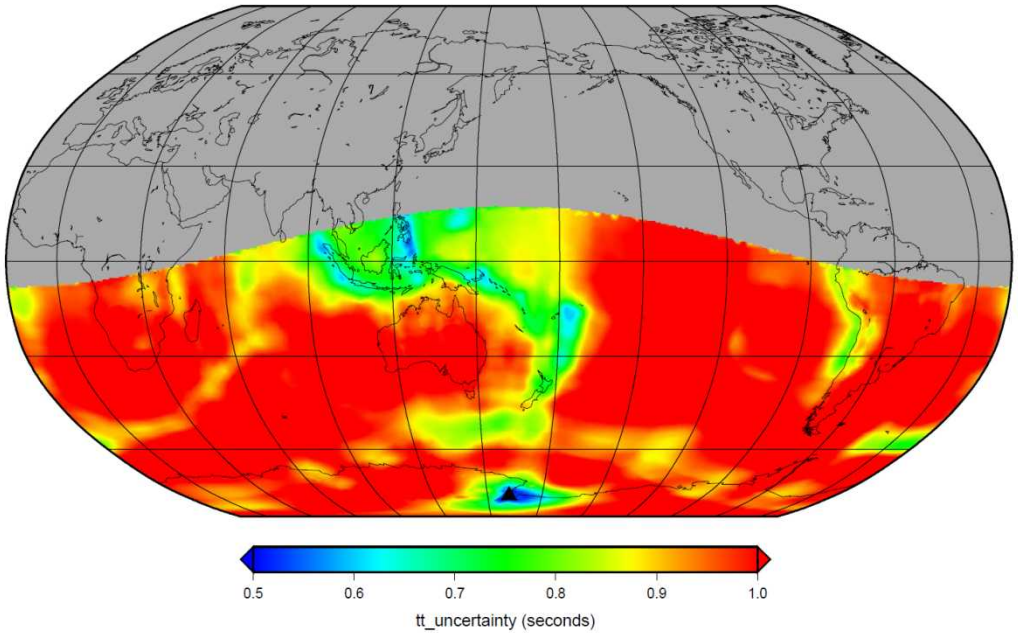
$$\sigma_T^2 = W \begin{bmatrix} C_M & 0 \\ 0 & C_{NR} \end{bmatrix} W^T$$



ESDC, depth=0km



VNDA, depth=0km



Summary

- We have developed a global 3D model of the compressional wave speed distribution in the Earth's crust and mantle.
- We successfully computed the model covariance matrix for our model which allows us to calculate path-dependent travel time uncertainty estimates.
- The model significantly improves the accuracy and precision and seismic event locations.
- We delivered 3D travel time lookup tables for USNDC network to mitigate performance issues related to the use of 3D models in operational systems
- System is currently being tested on USNDC pipeline testbed.