Can Seismologists Handle the Truth?

From Ground Truth to Calibrated Earthquake Locations

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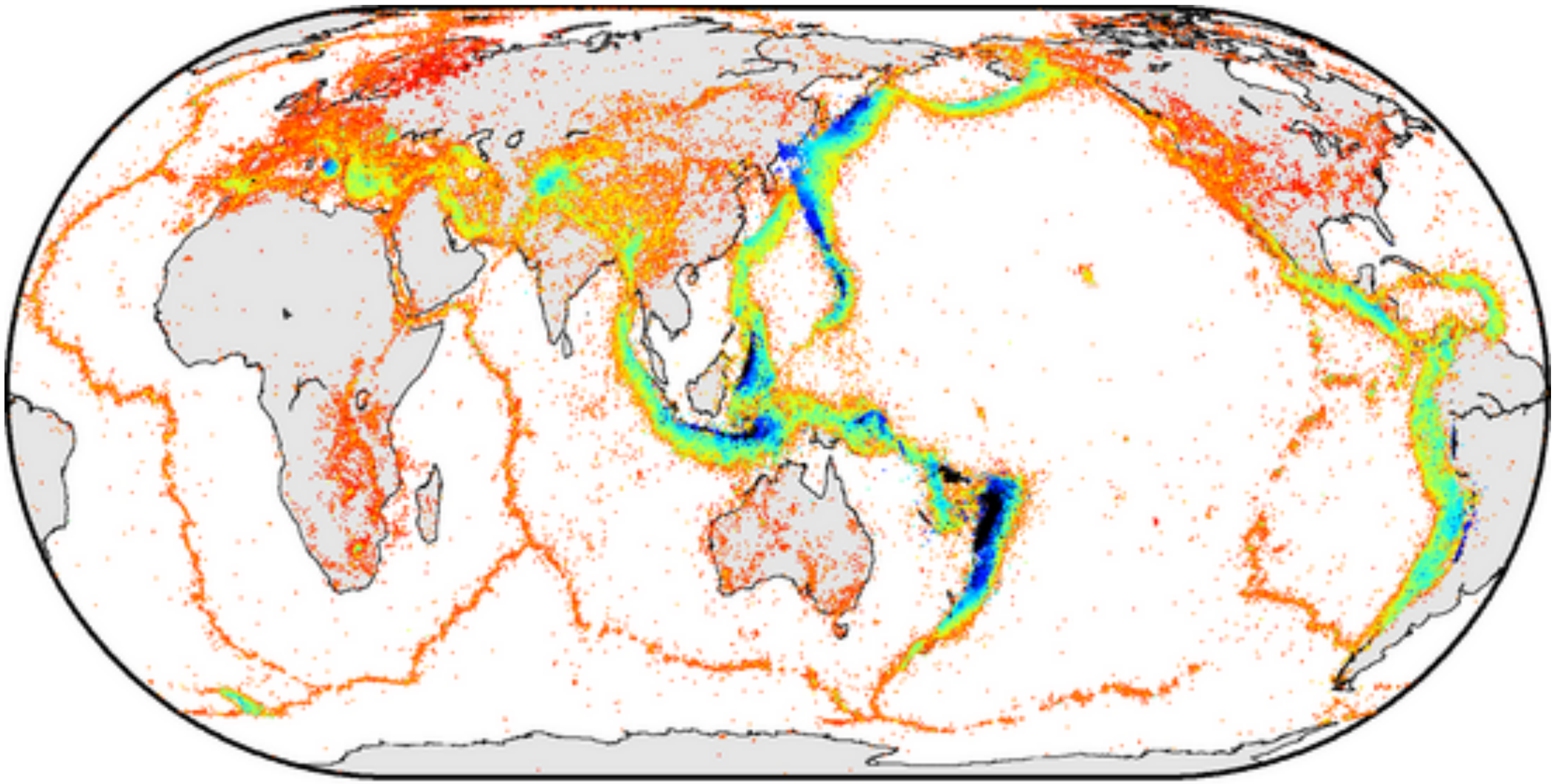
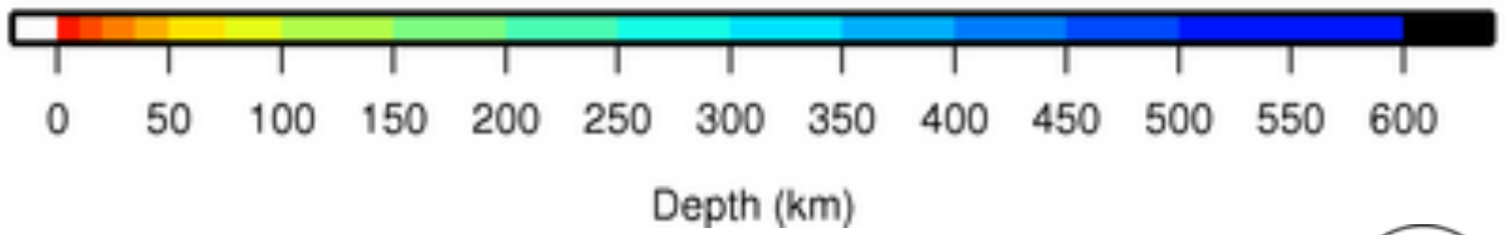
ISC 1960-2015





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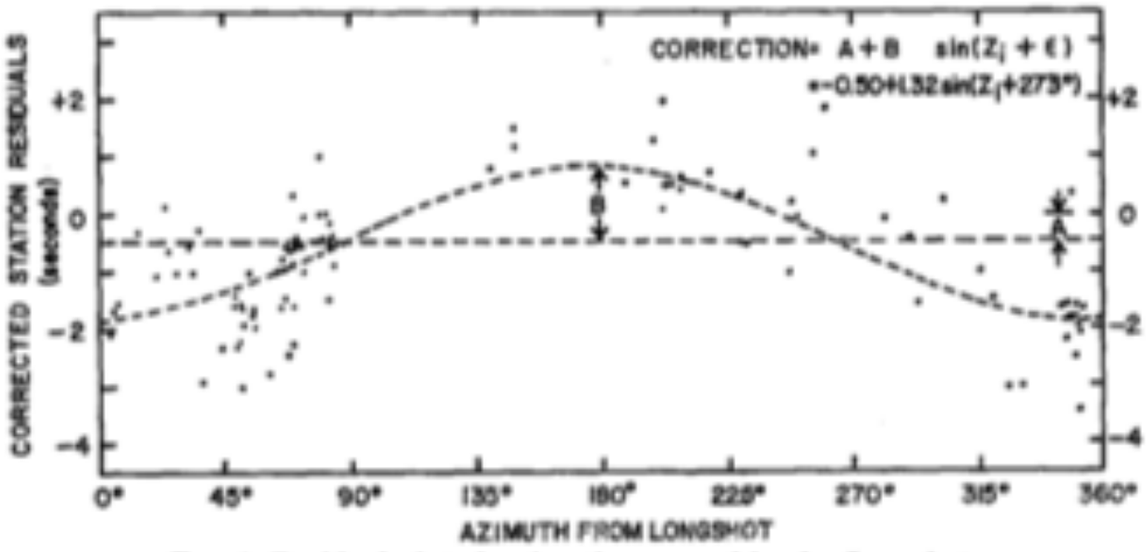


Fig. 1. Residual plot showing the source bias for Longshot.

Herrin & Taggart (1968)

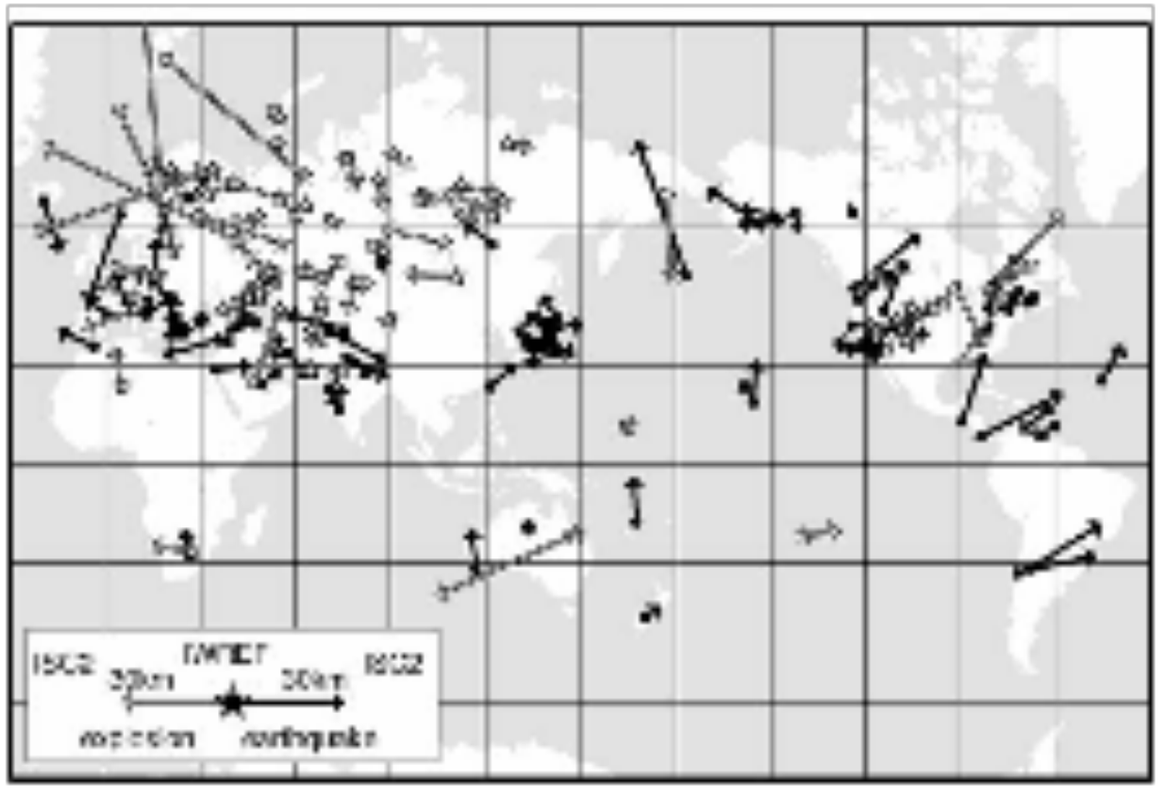


Fig. 3. Map of ISC2-IWREF epicentre mislocation vectors. The vectors point from the IWREF position towards the ISC2. Mislocation scale is different from the map scale.

Fig 3 Mislocation of intermediate-depth New Zealand earthquake of January 04 1975 Position indicated $k = 1.0$ is found from local network with standard velocity model That marked $k = 0.9$ is found allowing for higher velocities in the subducting slab USGS position is also shown

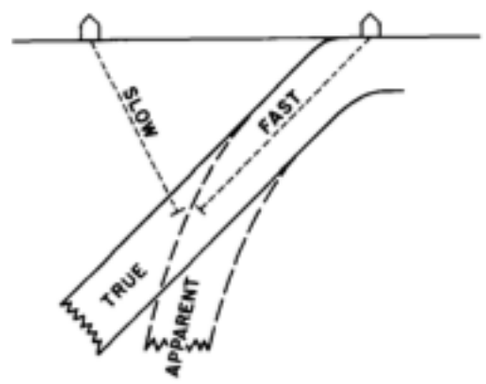


Fig 4 Apparent distortion of subducting slab due to faster velocities in slab compared with surrounding mantle

Adams (1992)

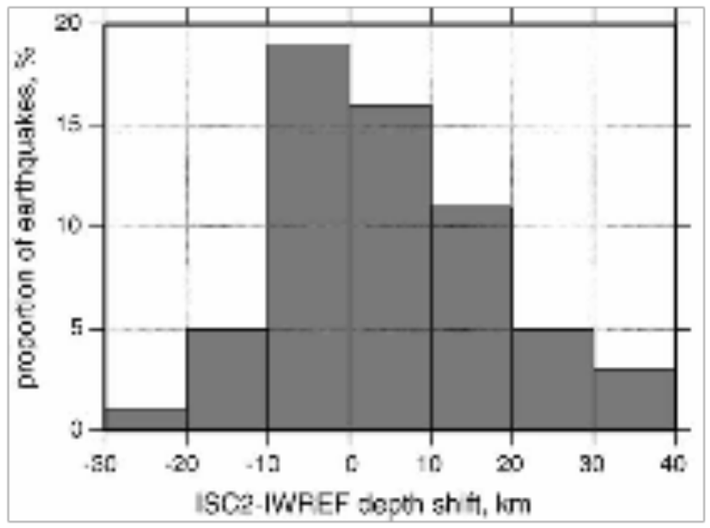
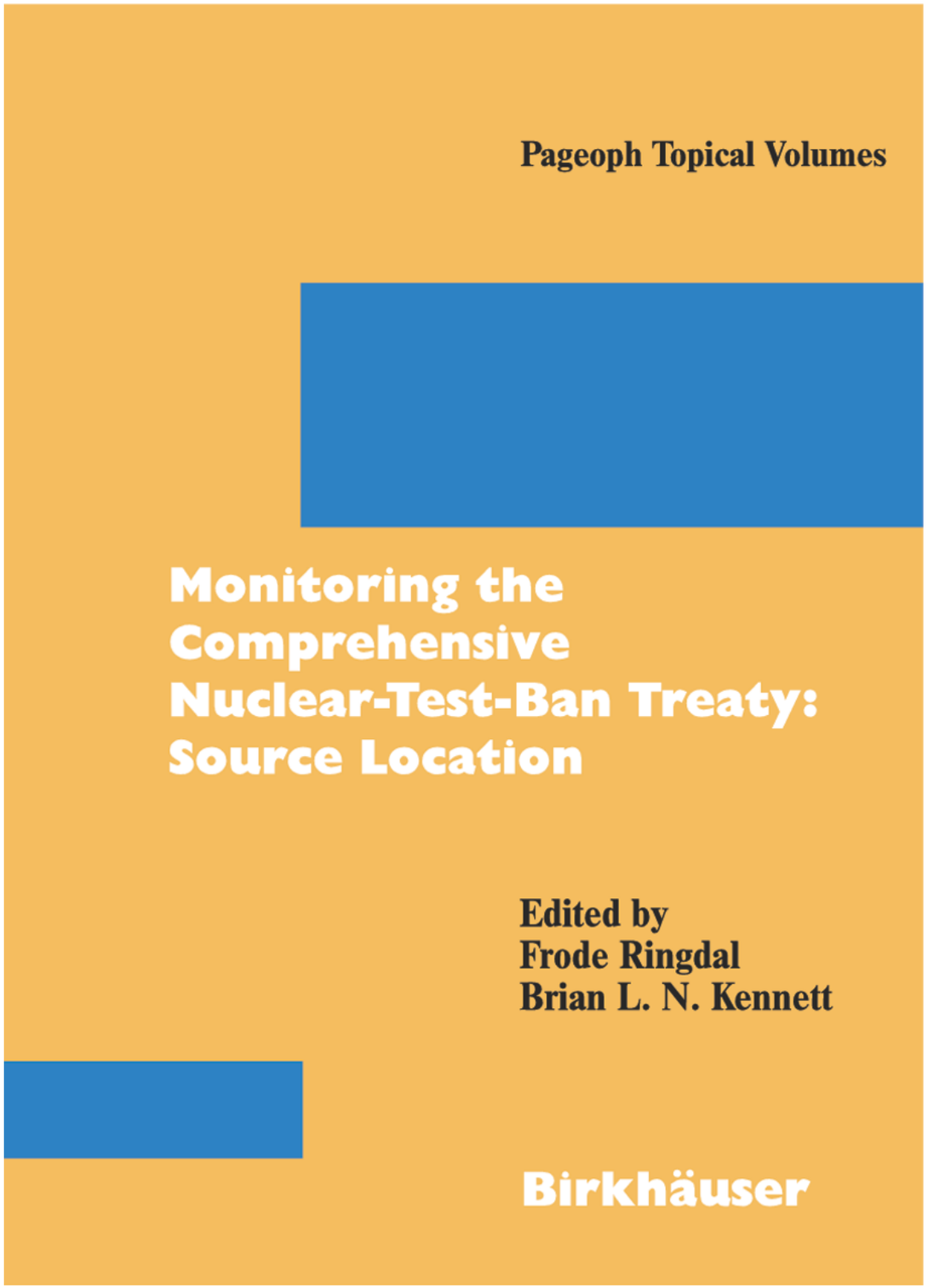


Fig. 7. Distribution of earthquakes with the size of ISC2-IWREF depth shift.

Storchak (2006)



On-Site Inspection: Main Characteristics

CTBTO PREPARATORY COMMISSION | preparatory commission for the comprehensive nuclear-test-ban treaty organization

- Defined maximum Inspection Team size (maximum of 40 inspectors at any given time - except during drilling)
- Use of approved inspection equipment by Inspection Team
- Defined maximum Inspection Area (1.000 km^2 - no linear distance greater than 50 km in any direction)
- Defined maximum duration of OSI: 60 days (from approval of OSI request) – may be extended by a maximum of 70 days

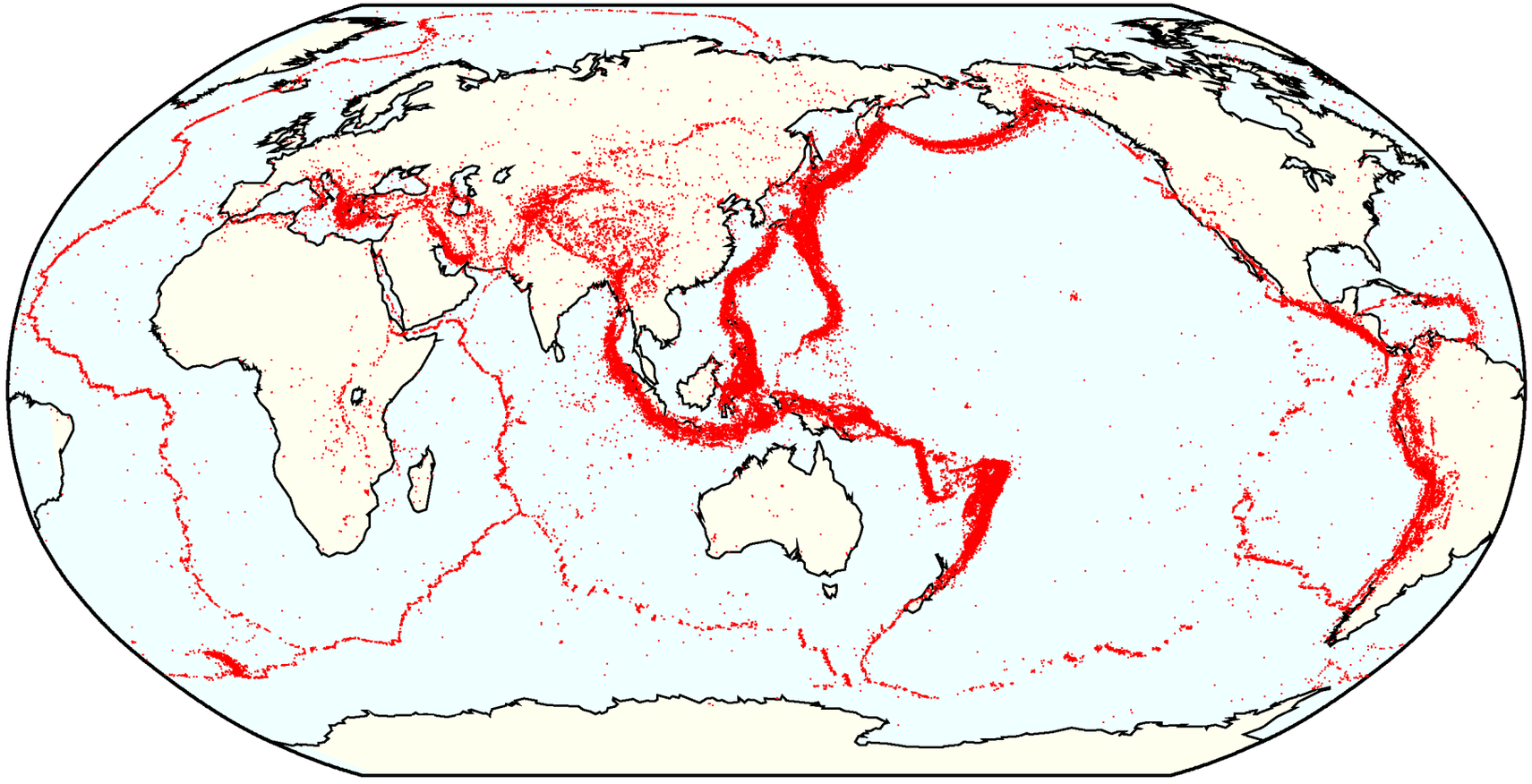
Strengthening Verification, Enhancing Security: The Scientific and Political Significance of the CTBT
Introductory Course on the CTBT
18-22 October 2010
Vienna, Austria

Matjaz PRAH
OSI Coordinator
Office of the Director
On-Site Inspection Division
Provisional Technical Secretariat (PTS), CTBTO

What makes EHB hypocenters better than ISS, ISC and PDE hypocenters?

- Use of an Improved 1-D Global Travel Time Model (ak135)
- Iterative Relocation With Dynamic Phase Identification
- Use of First Arriving P, S and PKP Phases
- Use of Teleseismic Depth Phases pP, pwP and sP (with PDF's and bounce point corrections)
- Ellipticity Corrections for ak135 Model
- Empirical Teleseismic "Station" Patch Corrections (5° x 5° patches)
- Weighting by Phase Variance as a Function of Distance
- At Least 10 Teleseismic Observations
- Teleseismic Secondary Azimuth Gap < 180°
- Most of the EHB methodology is incorporated in the new ISC locator

EHB 1960-2008, 141478 events



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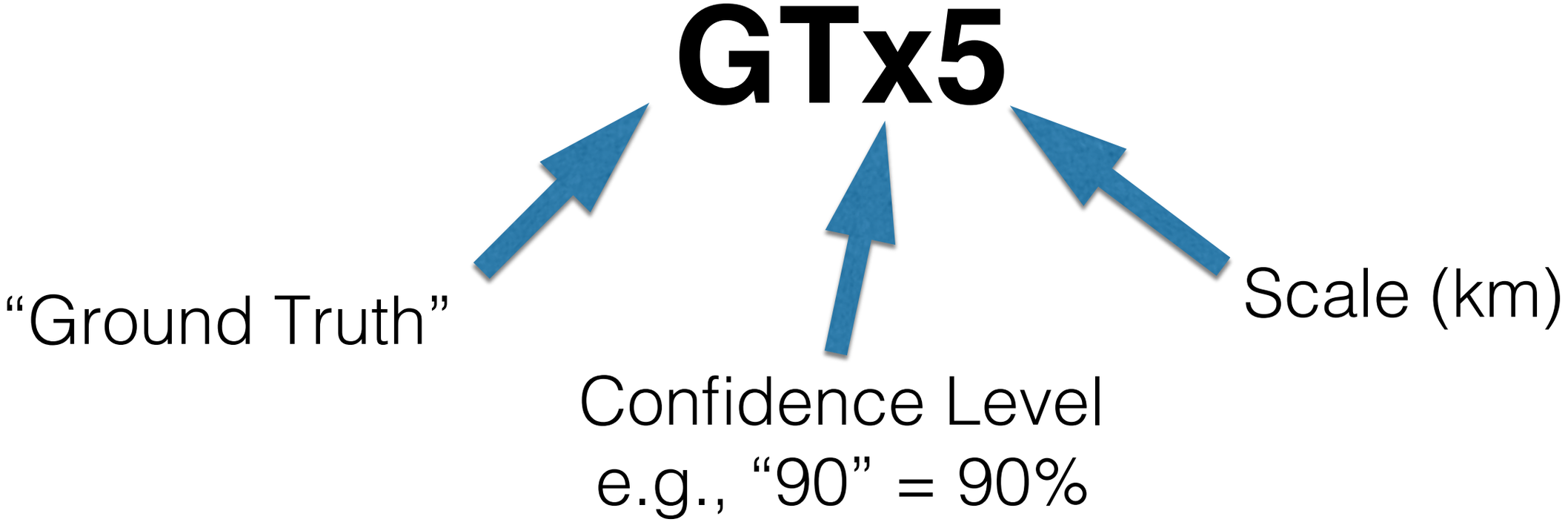
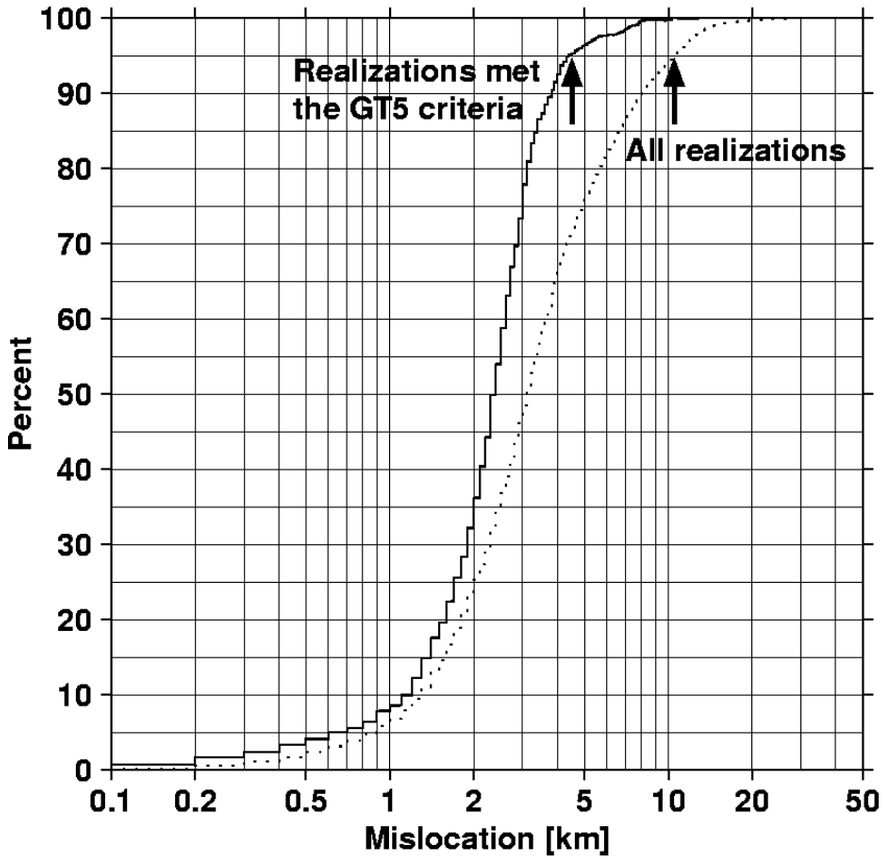
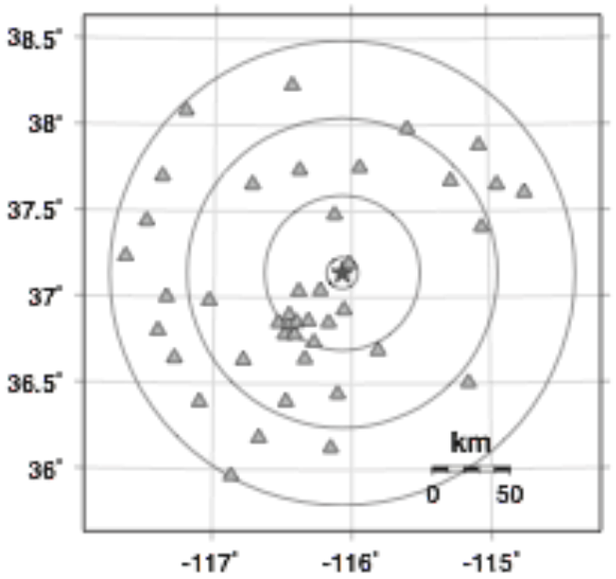
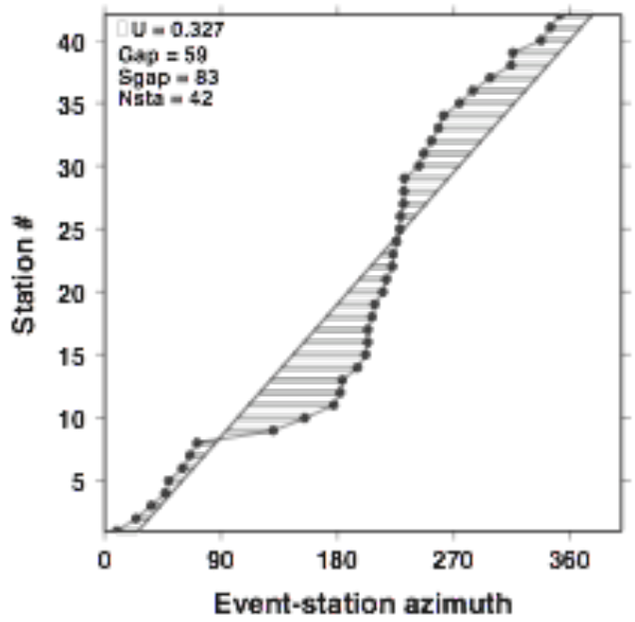
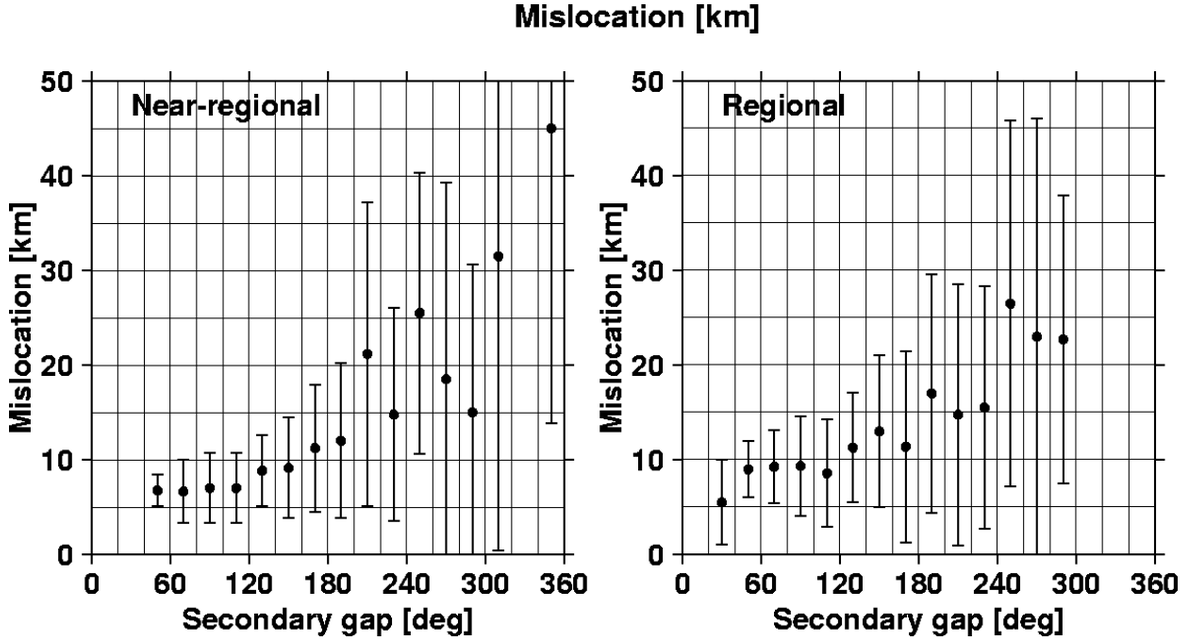
Location Accuracy Nomenclature

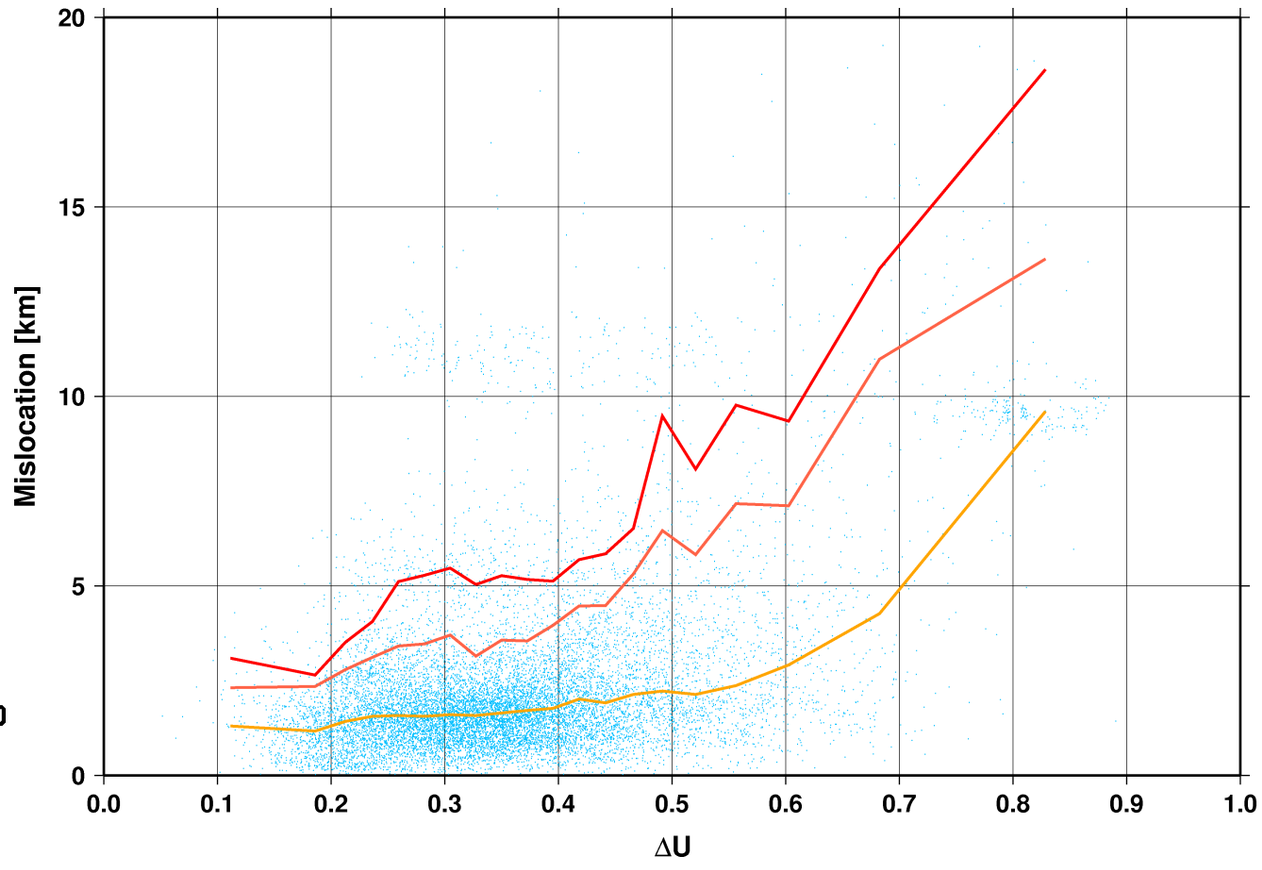






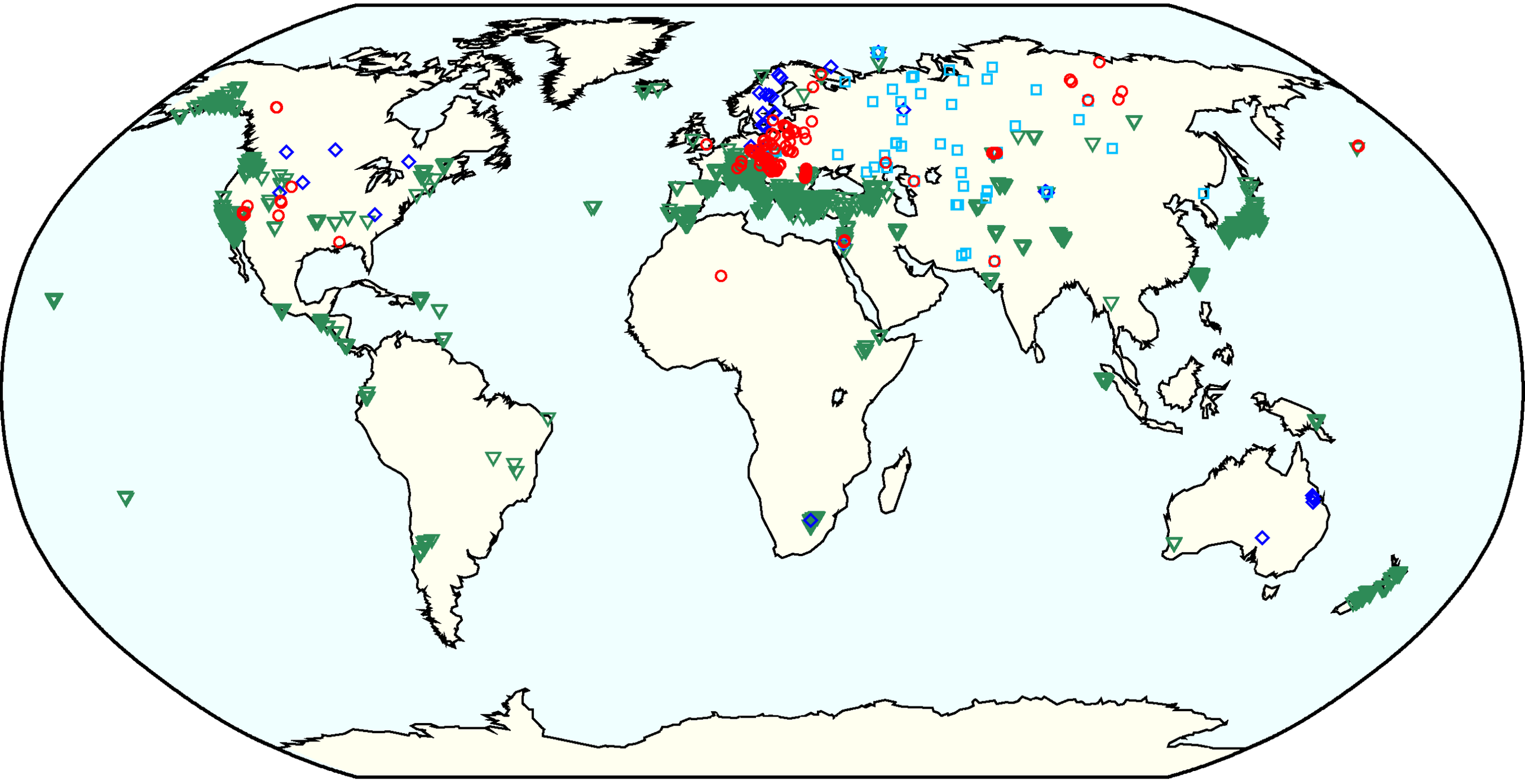






Bondar et al. (2004)

Bondar & McLaughlin (2009)



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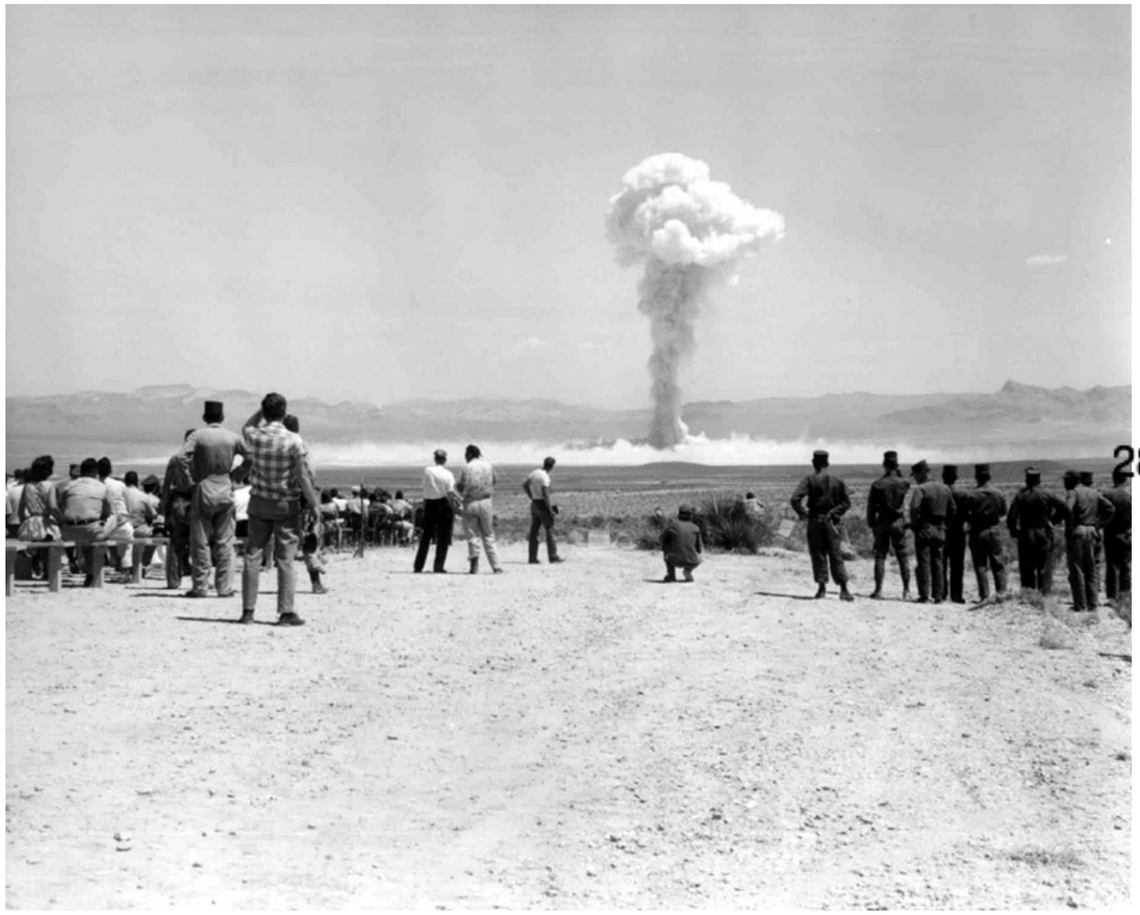
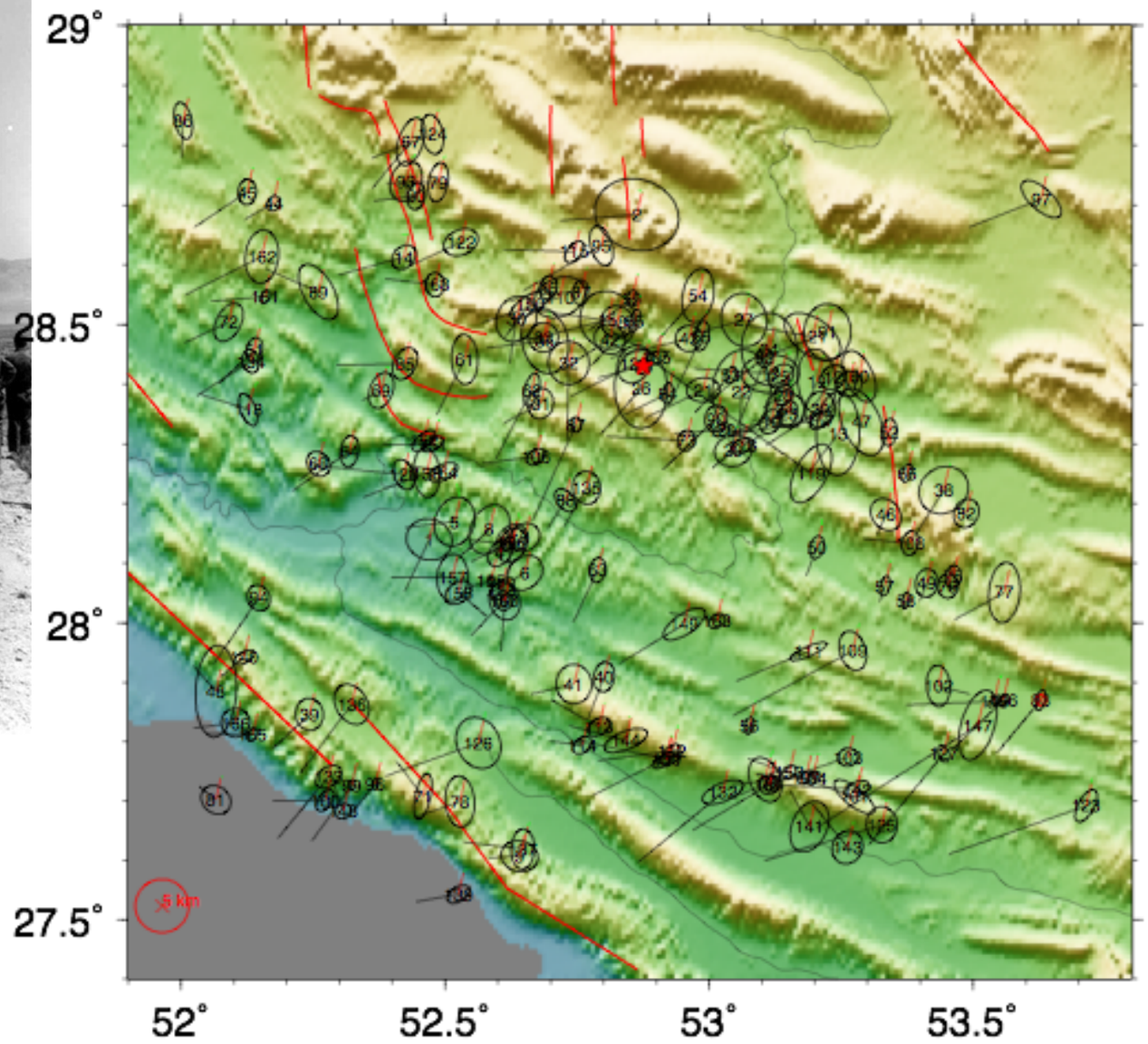
8573 events from 1959-2012



This is Ground Truth
("Small Boy", 1962)

ghir24.25



These are carefully calibrated earthquake locations,
not Ground Truth

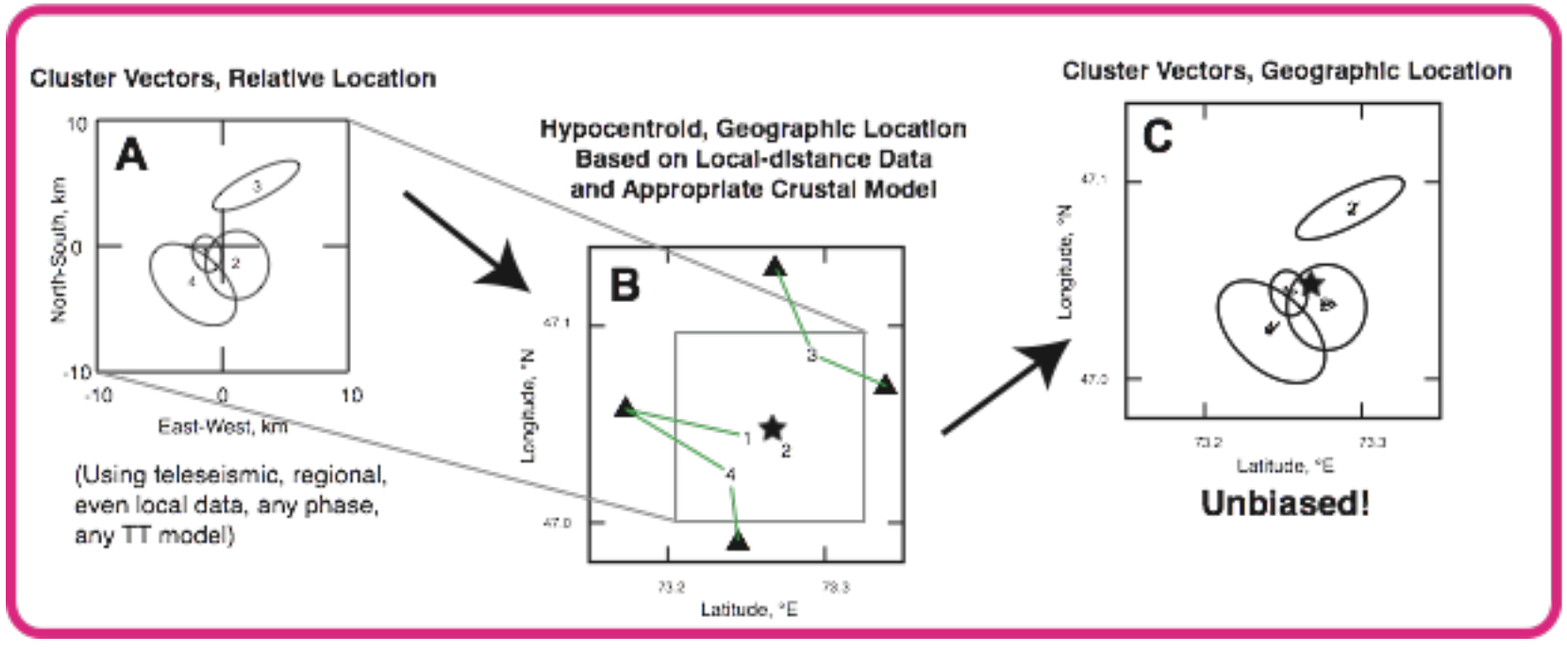
“**Ground Truth**” should be retained as a rare and distinct category in seismology, and not mixed in with the problem of estimating the uncertainties of the earthquake location process.

An appropriate terminology for the estimation of hypocentral parameters from the arrival times of seismic phases observed at a distance is “**Calibration**”

MLOC for detailed analysis of calibrated clusters

followed by

BayesLoc for extension to regional catalogs using MLOC results as prior constraints



- *Bayesian hierarchical statistical model*
- *Prior knowledge incorporated*
- *MCMC samples joint posterior distribution*

A Nomenclature for Calibrated Earthquake Locations

"Calibrated" means that some analysis of the arrival time data has been performed that is reasonably expected to result in a minimally biased estimate of the epicenter and perhaps of other hypocentral parameters. The second letter of the code conveys which parameters are calibrated.

	Epicenter	Focal Depth	Origin Time
CH	●	●	●
CT	●		●
CF	●	●	
CE	●		

A length scale for epicentral accuracy is always required.

e.g., CH02, CT08

Confidence level is assumed to be 90%.

Epicentral Uncertainty Length Scales

How to represent a 2-D uncertainty ellipse in a single number?

Nearest integer (in km) to:

- Semi-major axis length of the confidence ellipse: nint(**b**).

- Average of the two semi-axis lengths: nint((**a**+**b**)/2).

- Radius of the circle with the same area as the ellipse: sqrt(**ab**).

Furthermore

GTX nomenclature can be retained for legitimate ground truth events, there is no need for a scale length beyond GT1.

An “N” nomenclature class can be defined for location accuracies estimated from network criteria.
Scale length required.

A “U” class can be defined for events with uncalibrated epicenters.
No scale length is used.

Going Forward…

The greatest contribution of the ISC to these efforts is likely to be in the painstaking collection of data from local and regional seismic networks around the world, especially in developing countries. These data are vital to carrying out research in calibrated earthquake locations.

We thank them for their efforts!