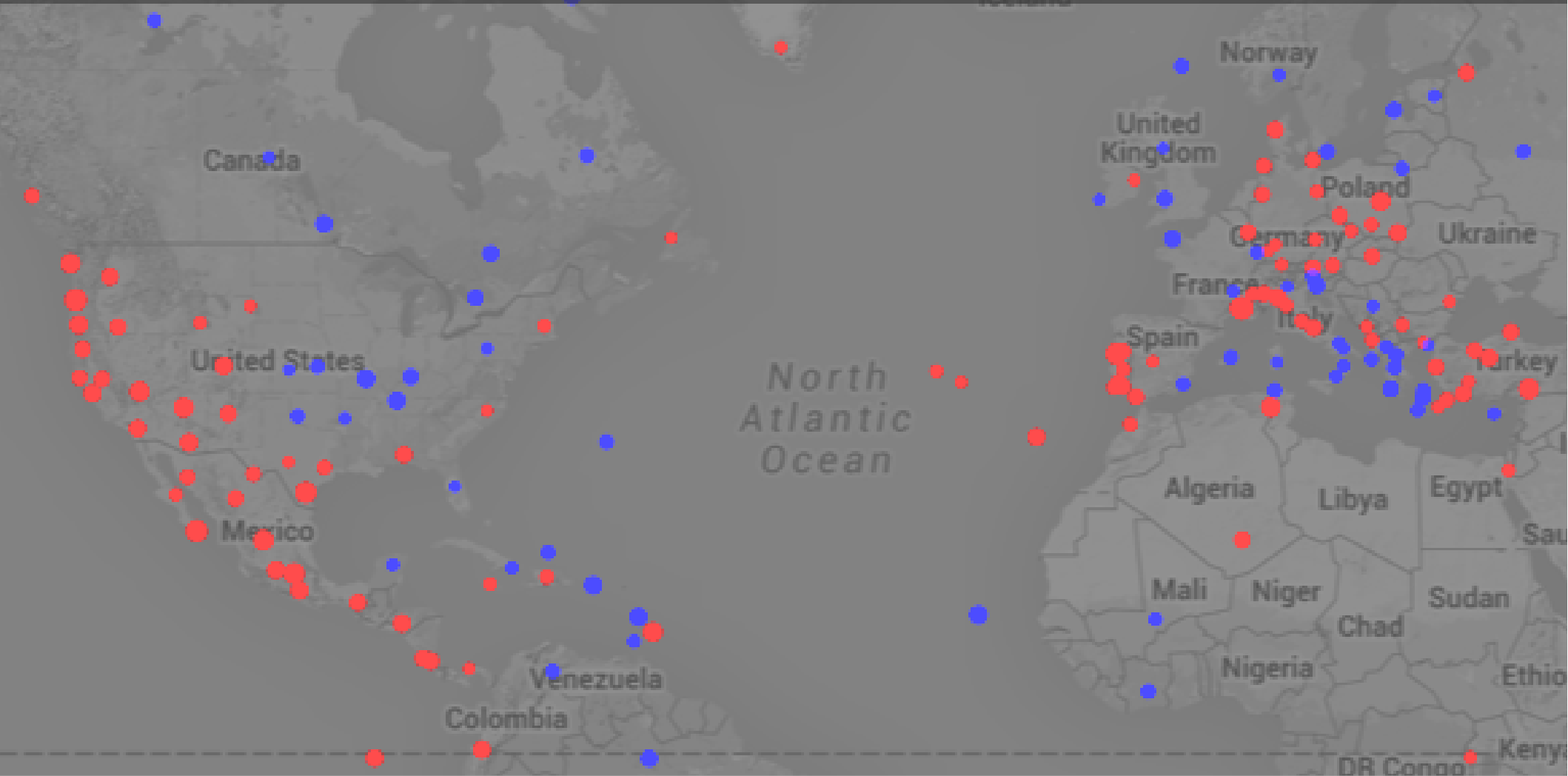
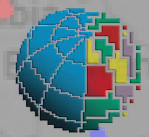


Exploring and exploiting the ISC arrivals database: station corrections for rapid and reliable earthquake location



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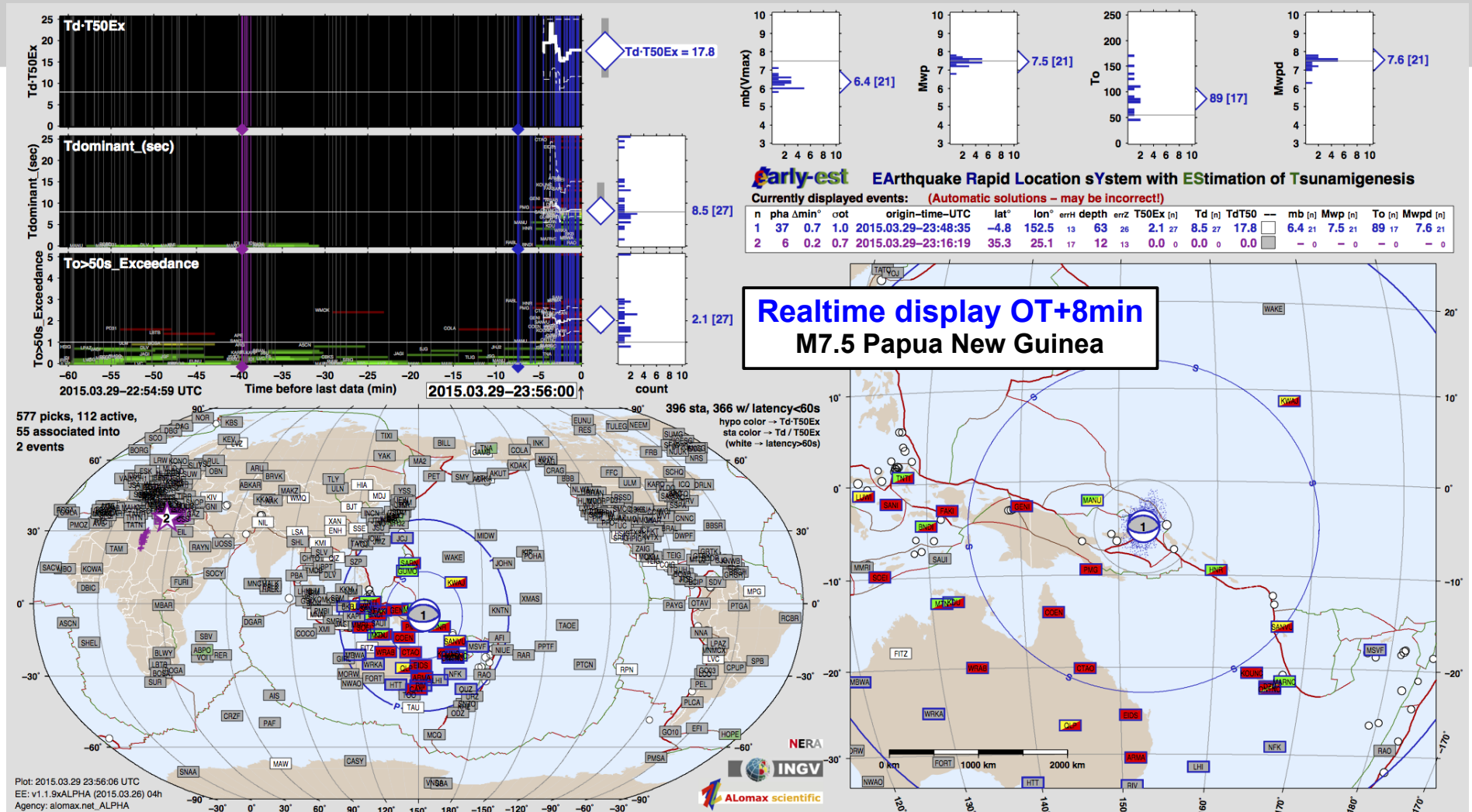
Alberto Michelini, Fabrizio Bernardi, and Valentino Lauciani
Istituto Nazionale di Geofisica e Vulcanologia, Roma, Italy



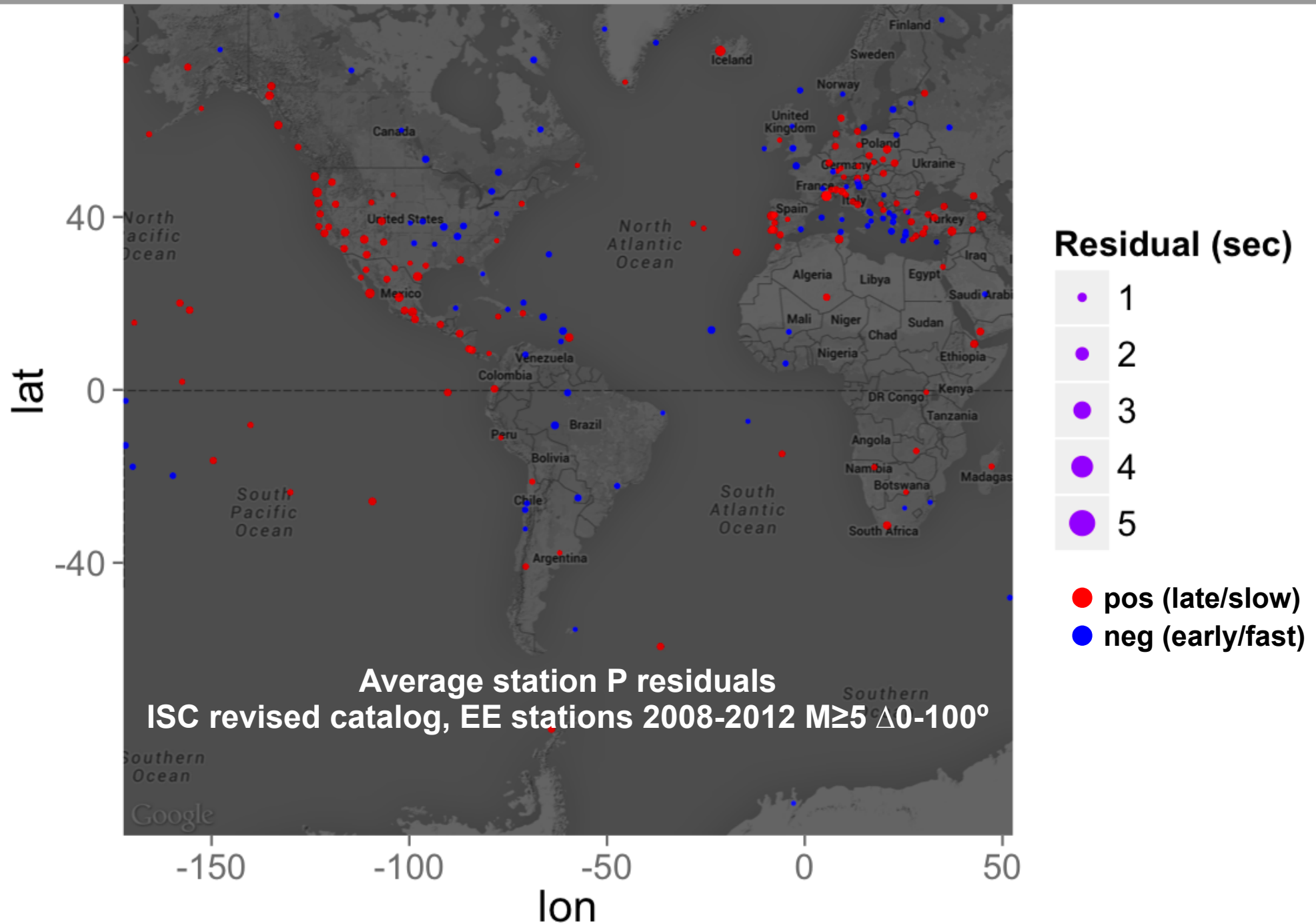
Early-est: rapid, fully automatic determination of the location, magnitude, mechanism and tsunami potential of an earthquake

For effective **earthquake and tsunami early-warning** it is crucial that key earthquake parameters are determined as rapidly and reliably as possible.

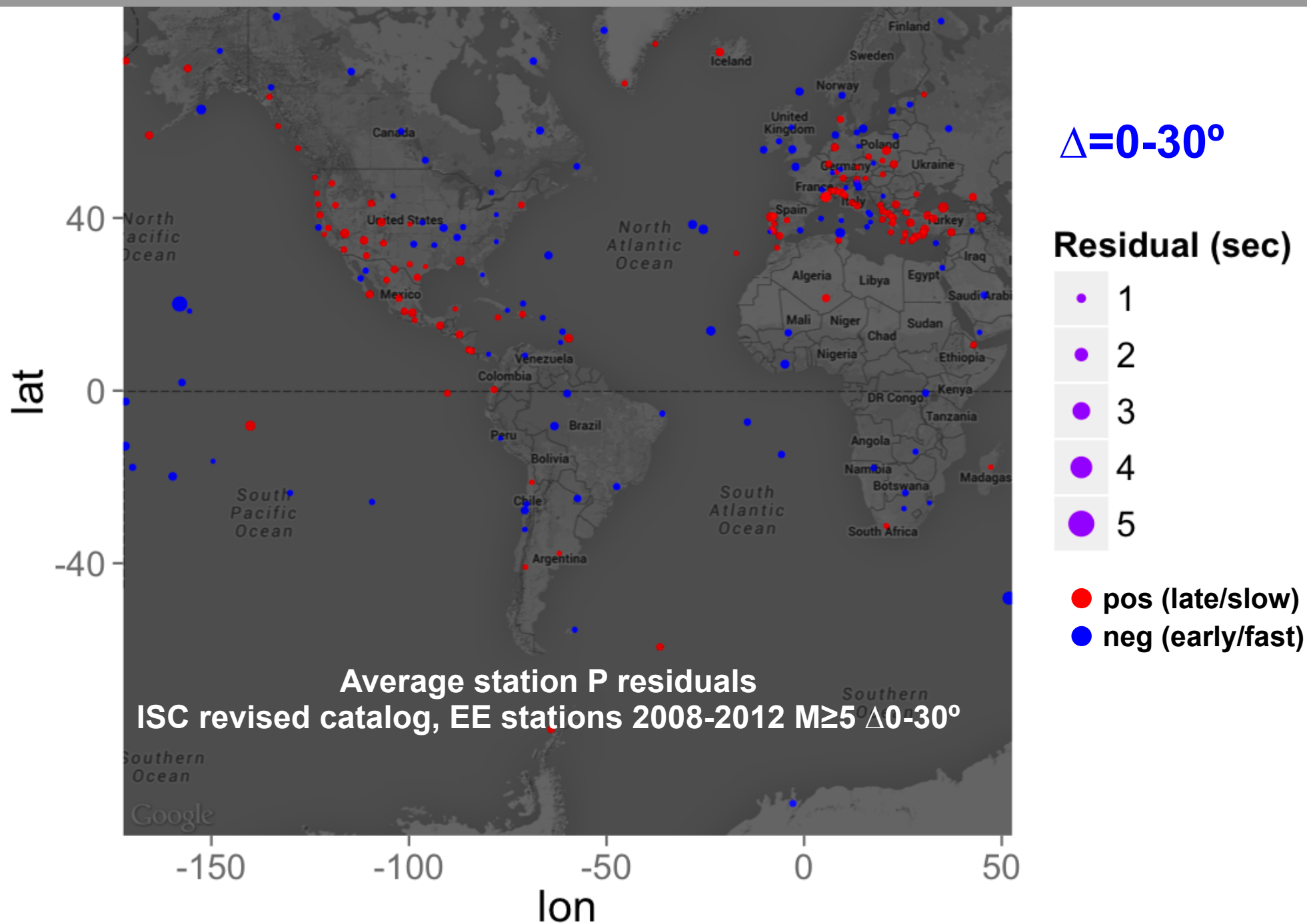
EarlyEst (EE): Rapid earthquake analysis module at INGV CAT tsunami alert center:



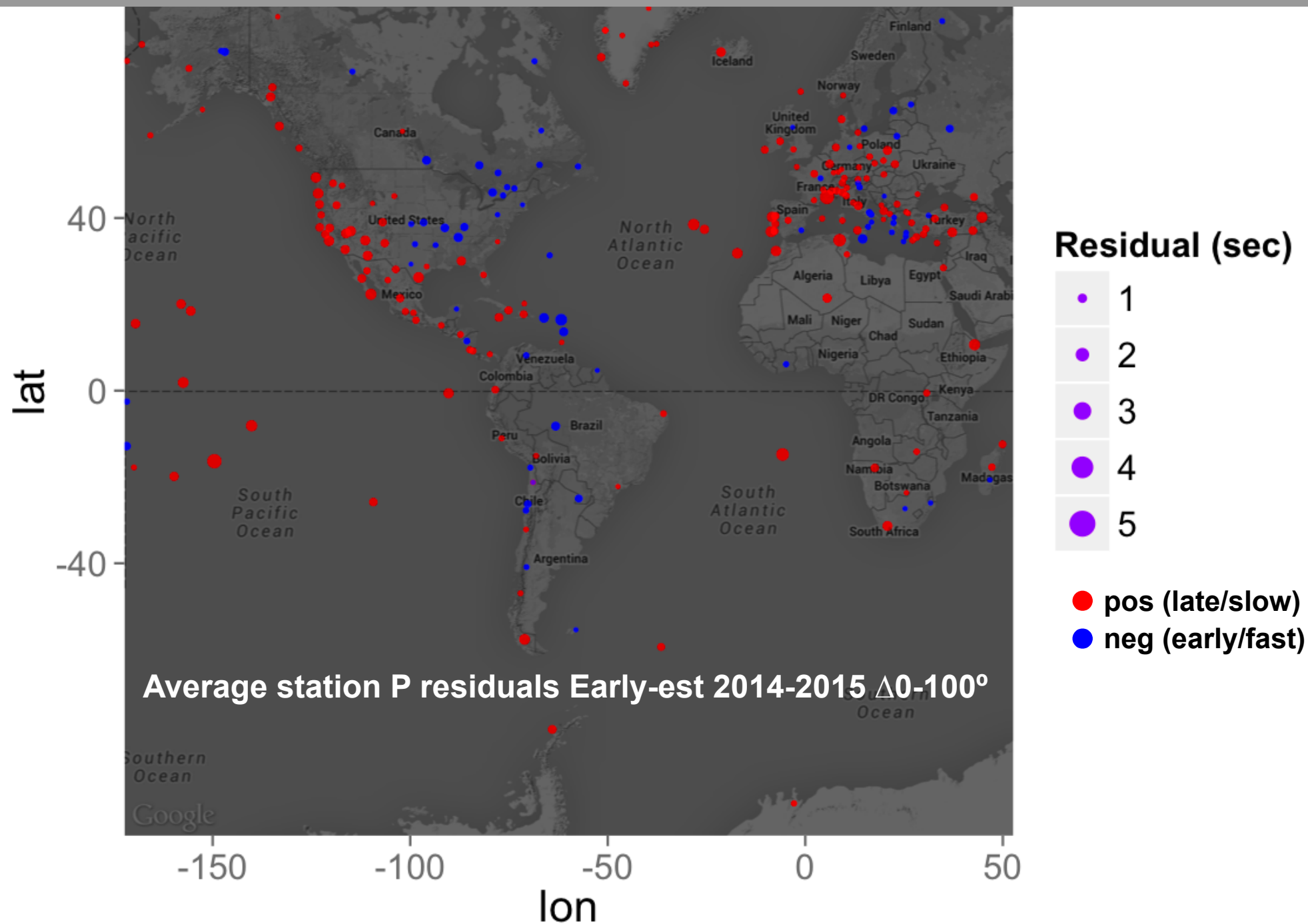
Average station P residuals ISC 2008-2012 reflect large-scale tectonics



Average station P residuals for regional events differ, reflect shallower structure



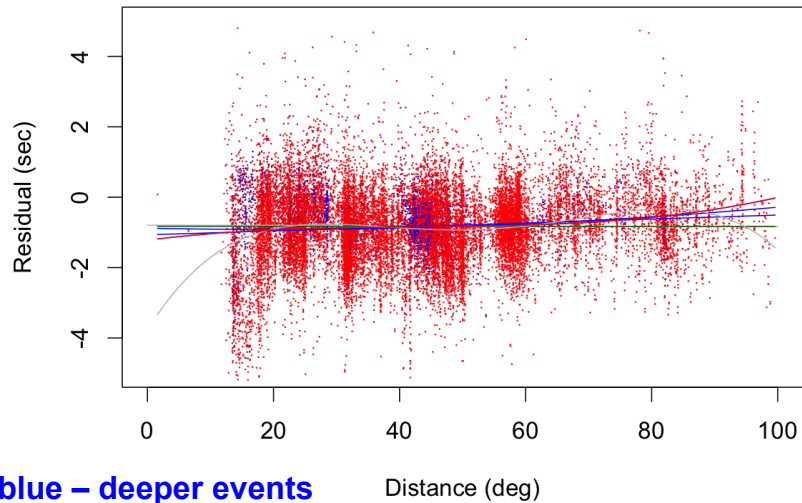
Average station P residuals for Early-est similar, but not identical: larger than ISC, local differences → use EE for EE!



Event P residuals at single stations, fit with constant and polynomial functions

ISC revised 2008-2012 $M \geq 5$

P residuals WRAB ISC_rev_EE_2008-2012_M5_EESta_5s_d0-100_z0-999

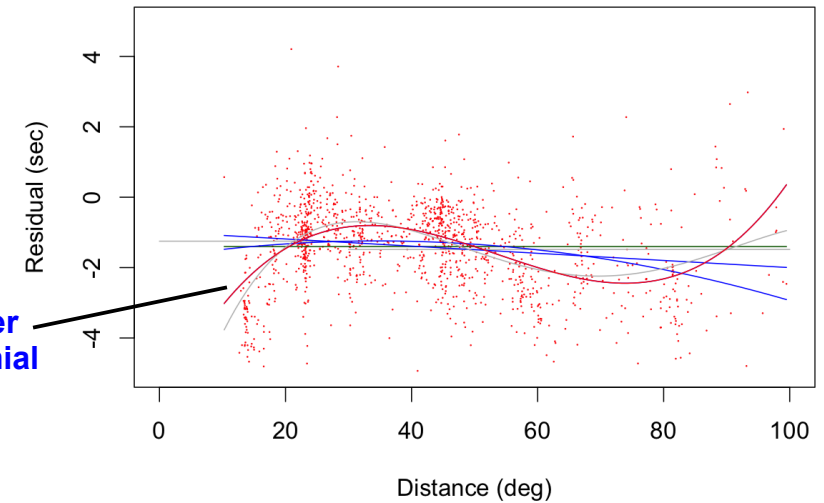


Early-est 2014-2015

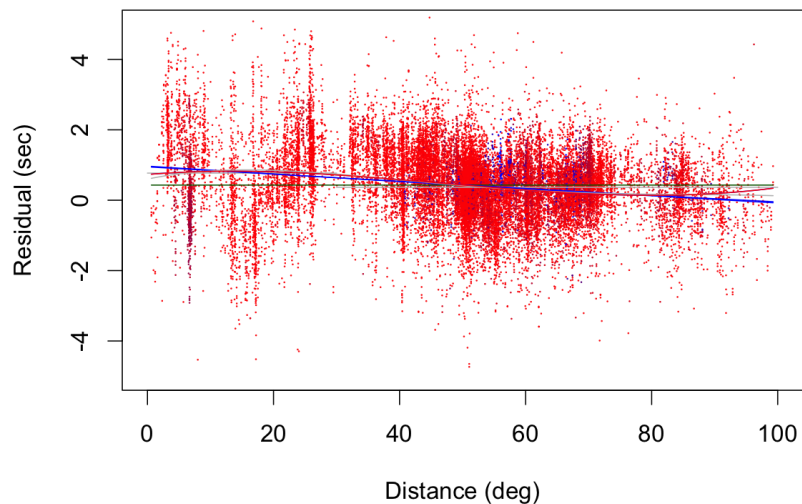
P residuals II_WRAB_00_BHZ n15_2gap180_P_5s_d0-100_z0-999

Station WRAB

3rd order polynomial

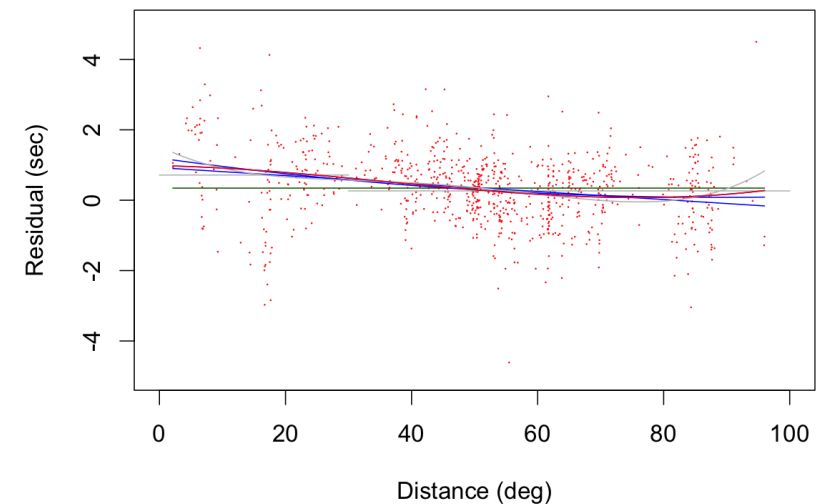


P residuals AAK ISC_rev_EE_2008-2012_M5_EESta_5s_d0-100_z0-999



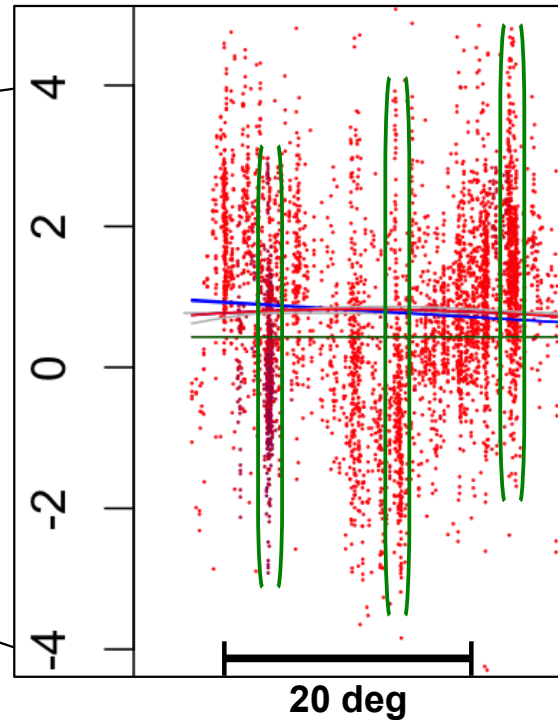
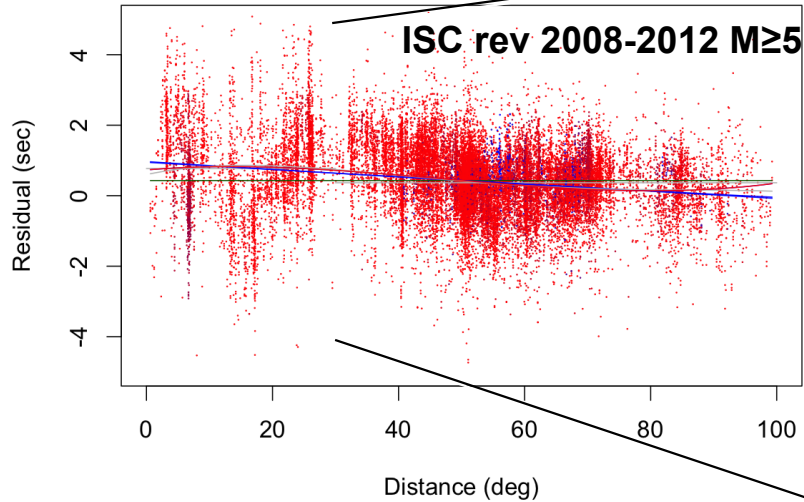
P residuals II_AAK_00_BHZ n15_2gap180_P_5s_d0-100_z0-999

Station AAK



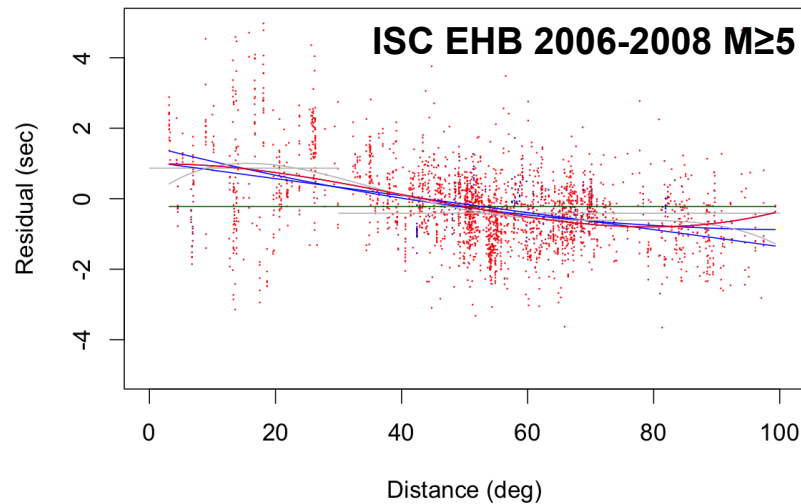
Question: Why always large variance in residual at ~constant distance (same source region)?

P residuals AAK ISC_rev_EE_2008-2012_M5_EESta_5s_d0-100_z0-999

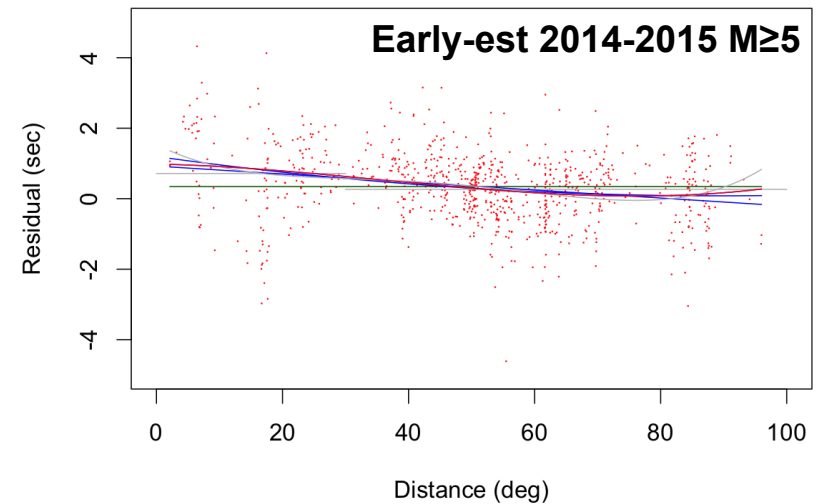


- Depth-OriginTime trade-off?
- Different station sets used? (sta availability, magnitude)
- ... combined with 1D velocity model
- Mis-identified phases?
- ???

P residuals AAK ISC_EHB_20060101-20081231_M5_EESta_5s_d0-100_z0-999



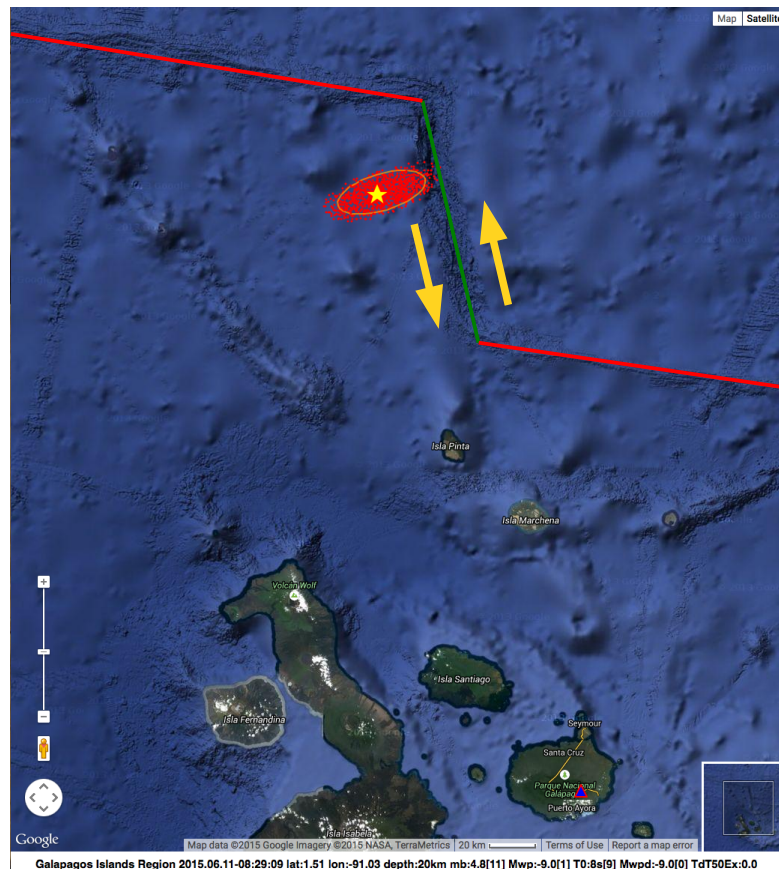
P residuals II_AAK_00_BHZ n15_2gap180_P_5s_d0-100_z0-999



Early-est locations: Station corrections should give more associations and better absolute hypocenters

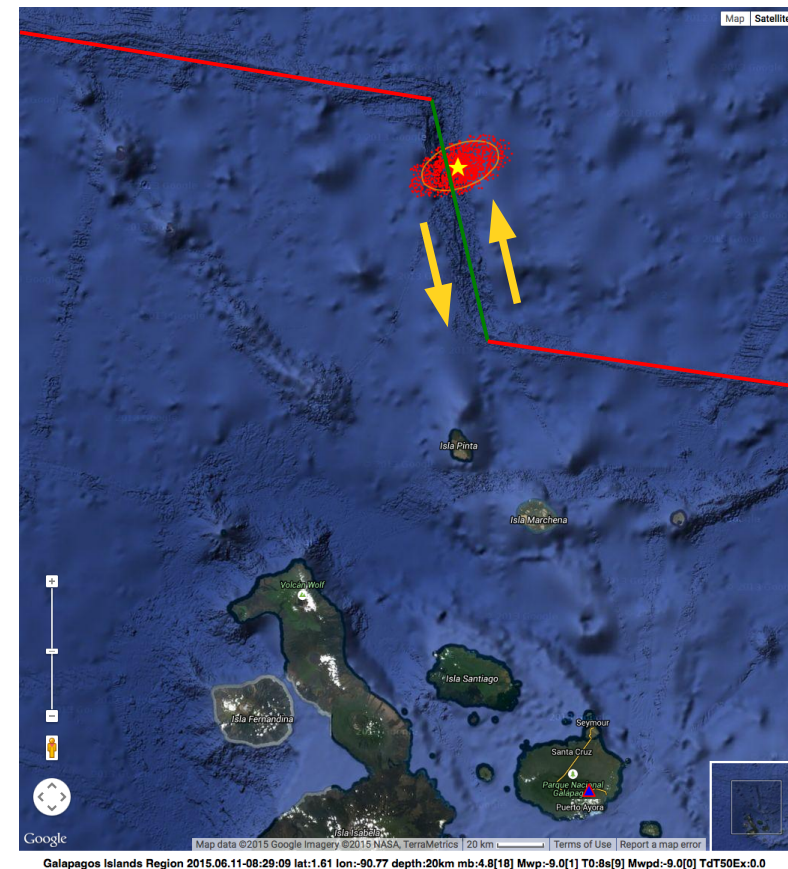
Without corrections

Magnitude:	mb: 4.8 [11] Mwp: 5.3X [1] Mwpd: - [0]
Region:	Galapagos Islands Region
Origin Time:	2015.06.11-08:29:08.92 UTC
Hypocenter:	lat: 1.51° lon: -91.03° [+/-18km] depth: 20km [+/-16km]
Location	stdErr:2.6s assocPhases: 14 usedPhases: 13



With P corrections

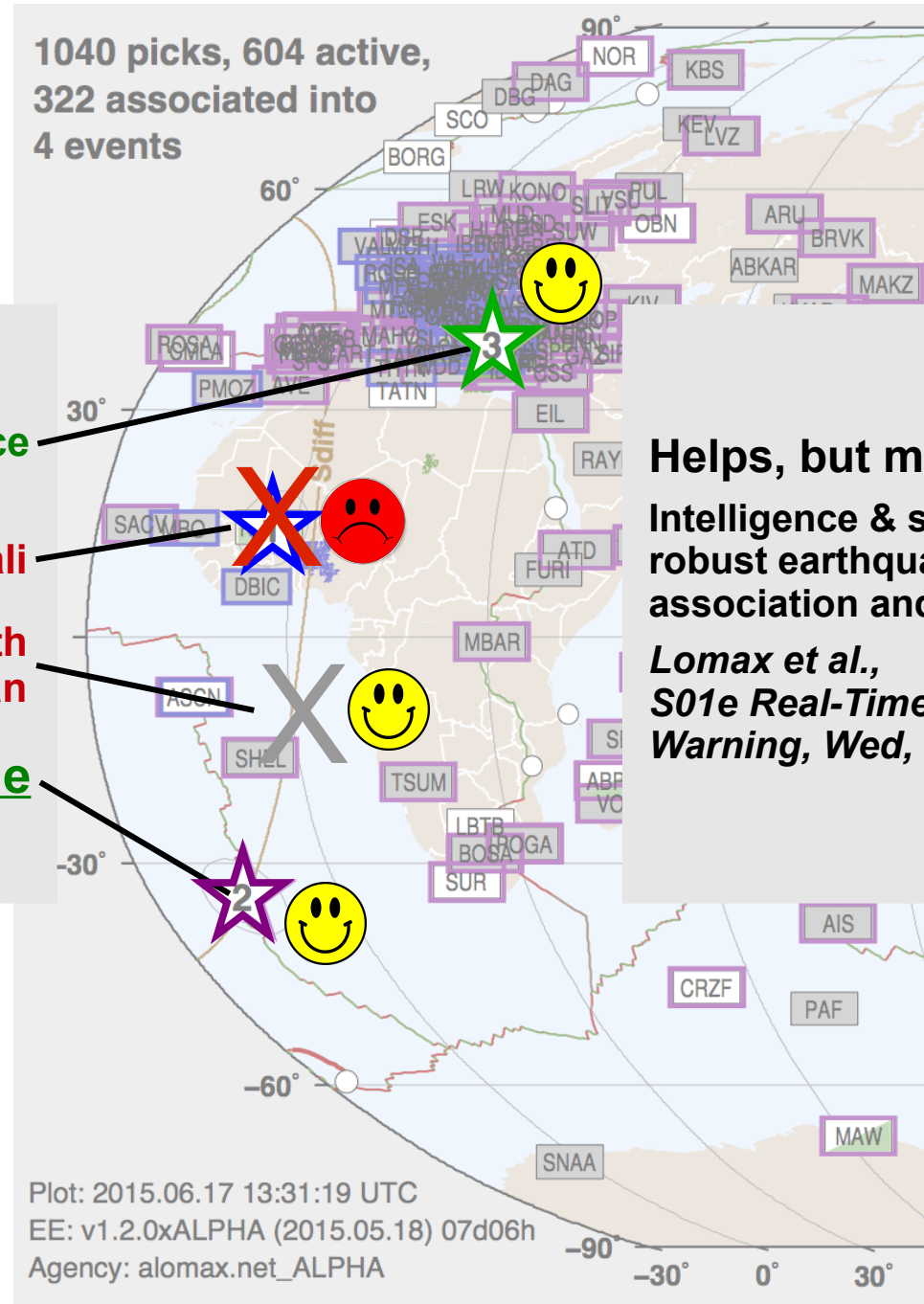
Magnitude:	mb: 4.8 [18] Mwp: 5.4X [1] Mwpd: - [0]
Region:	Galapagos Islands Region
Origin Time:	2015.06.11-08:29:09.13 UTC
Hypocenter:	lat: 1.61° lon: -90.77° [+/-16km] depth: 20km [+/-16km]
Location	stdErr:2.5s assocPhases: 26 usedPhases: 20



Early-est P corrections, 4th order polynomial fit

Early-est: P corrections + more picks help avoid false events

1040 picks, 604 active,
322 associated into
4 events



M3.5 Greece

FALSE: M6 Mali

FALSE: M6 South
Atlantic Ocean

M7 Mid-Atlantic Ridge

Helps, but more needed:

Intelligence & statistics for rapid & robust earthquake detection, association and location,

*Lomax et al.,
S01e Real-Time Seismology and Early Warning, Wed, July 1, 08:30*

Station corrections for rapid and reliable earthquake location: Conclusions

- **Empirical station corrections** give more associations, lower errors; can give more accurate absolute locations.
- Corrections should be developed and used on the **same analysis system**.
- **Polynomial fit** of residuals vs distance works well.

- Why is there a **large variance in residuals** at each distance?
- Which is better: **empirical** corrections or travel-time in **3D models**?

- More needed: **Intelligence & statistics for rapid & robust earthquake detection, association and location**, *Lomax et al.*,
S01e Real-Time Seismology and Early Warning, Wed, July 1, 08:30

- *Support: Centro Nazionale Terremoti, INGV*
- *Data: ingv.it, geofon.gfz-potsdam.de, geosbud.ipgp.fr, resif.fr, ird.nc, iris.washington.edu, usgs.gov*
- *Analysis Software: R statistics and graphics language; Python: pandas.pydata.org, matplotlib.org*

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