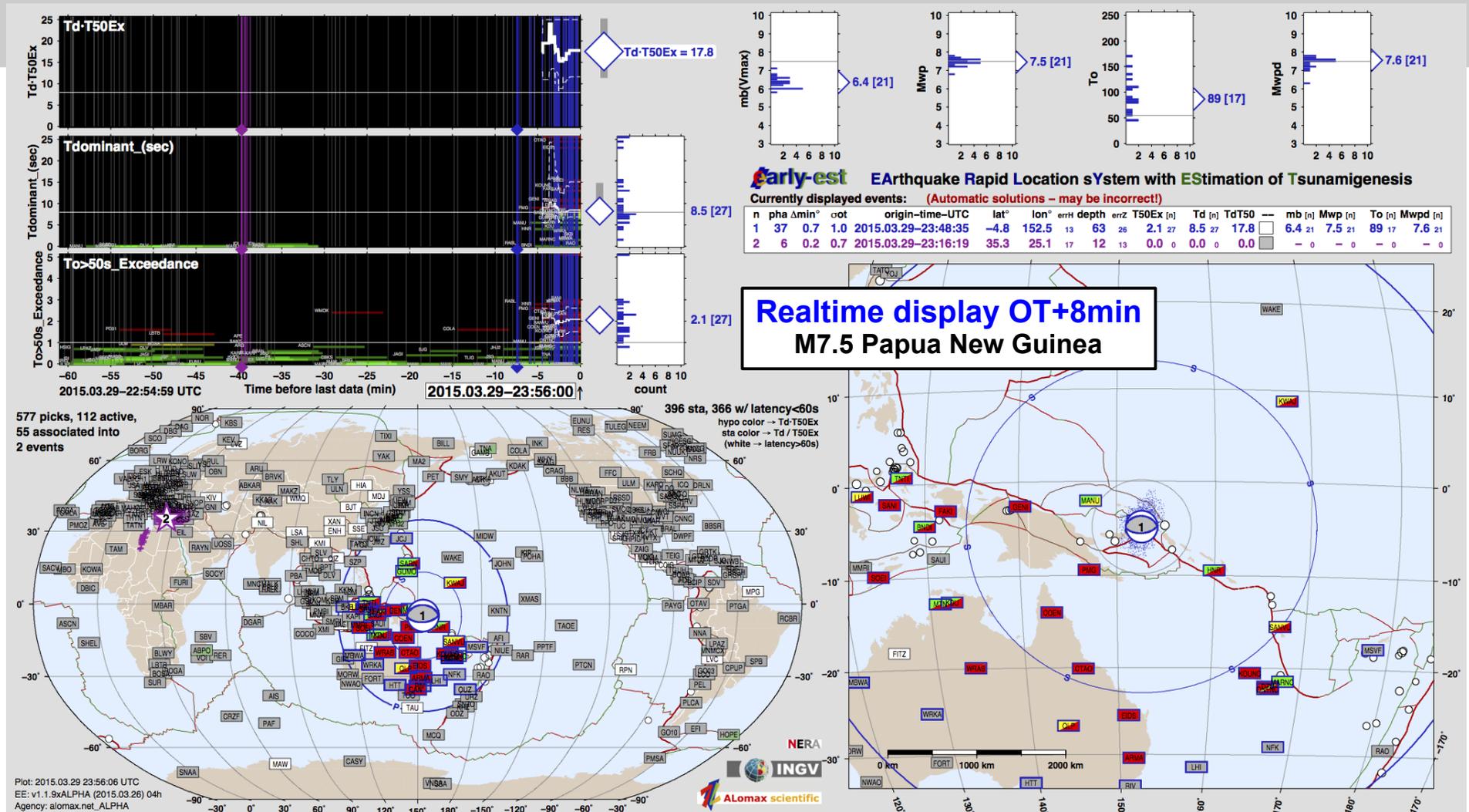




# Early-est: rapid, fully automatic determination of the location, magnitude, mechanism and tsunami potential of an earthquake

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

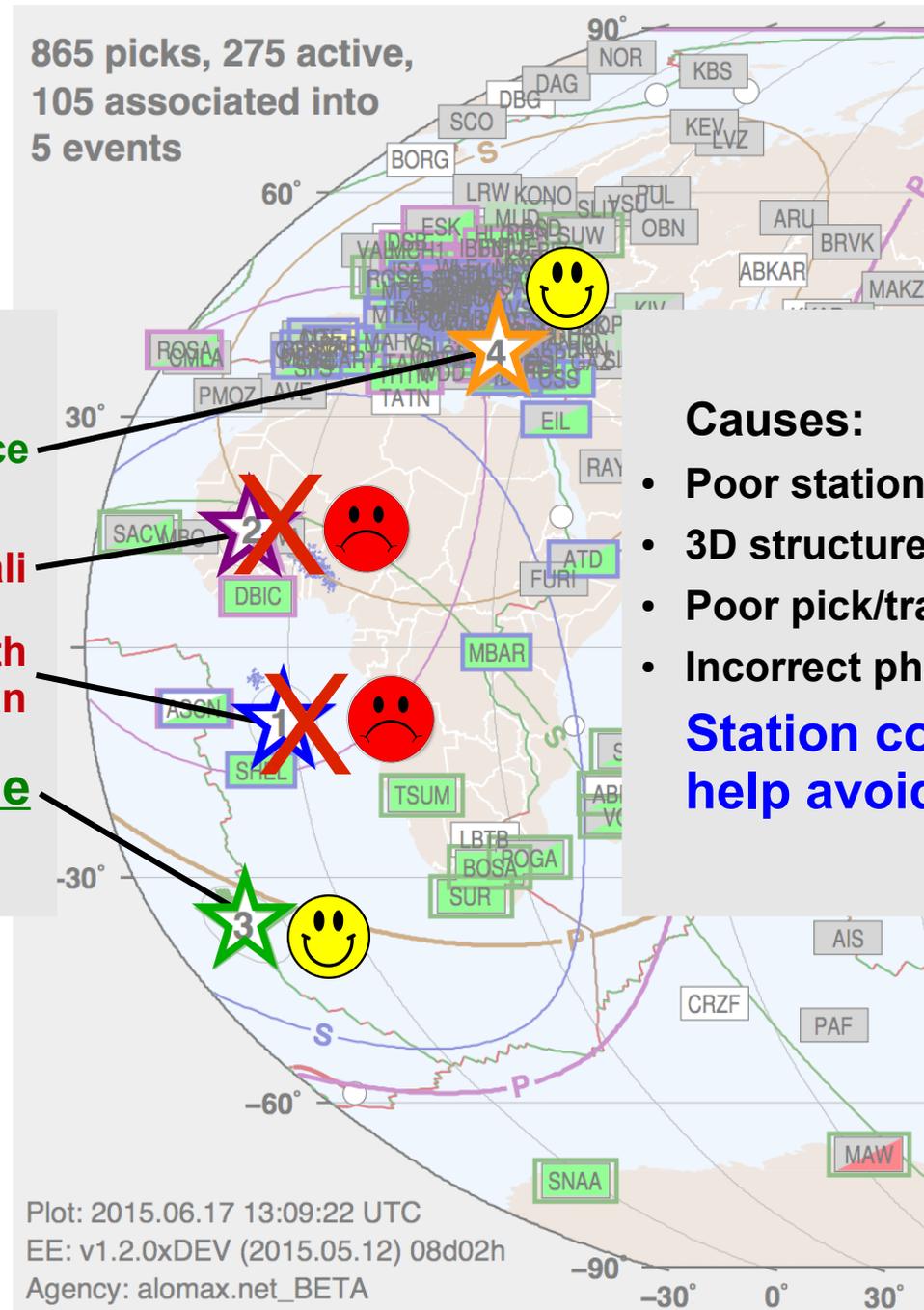
**EarlyEst (EE):** Rapid earthquake analysis module at INGV CAT tsunami alert center:



# Station corrections not just for better locations, but also for stable, robust and reliable rapid locations

Example:  
False events

865 picks, 275 active,  
105 associated into  
5 events



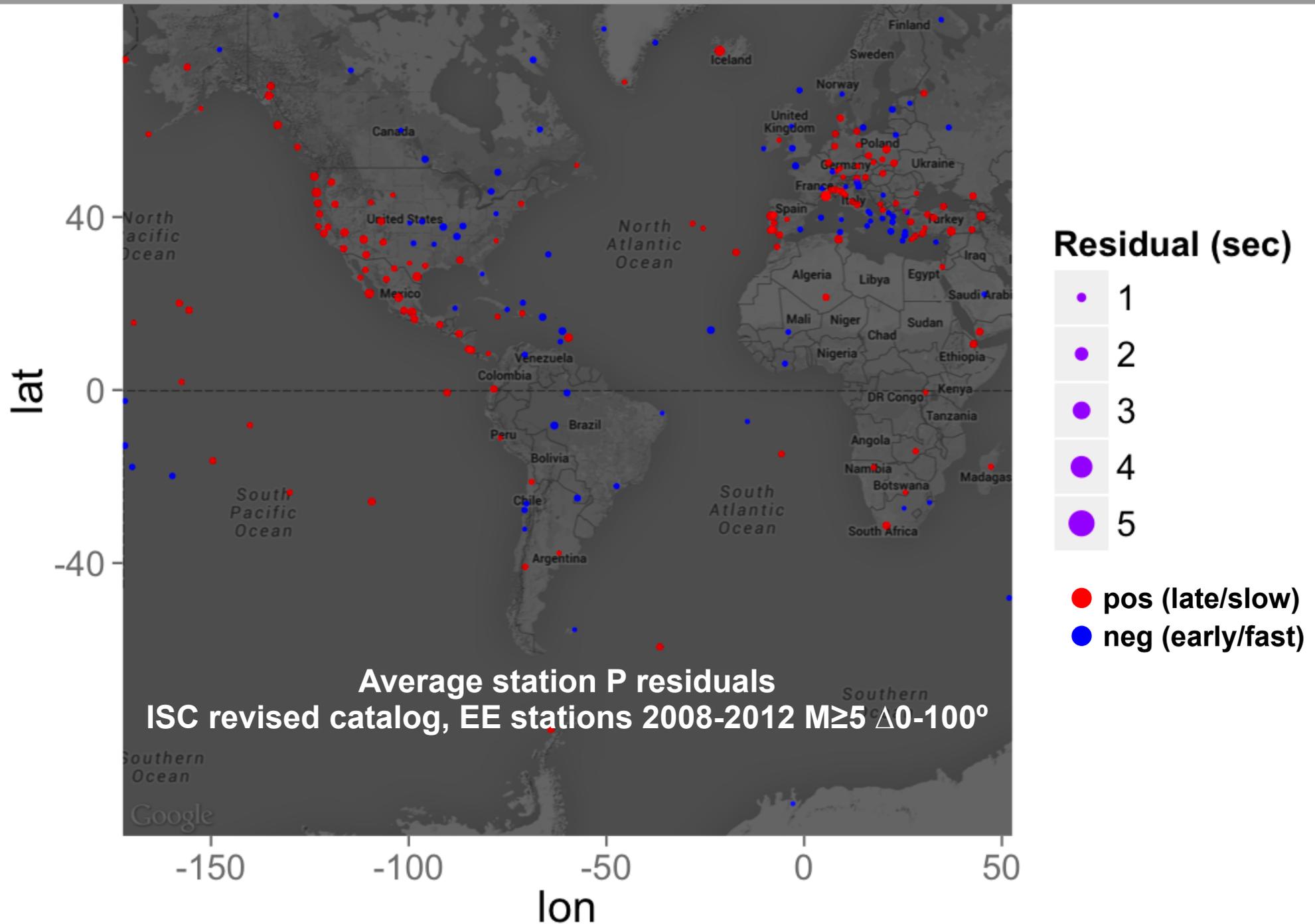
## Causes:

- Poor station distribution
- 3D structure but 1D velocity model
- Poor pick/travel-time error model
- Incorrect phases association

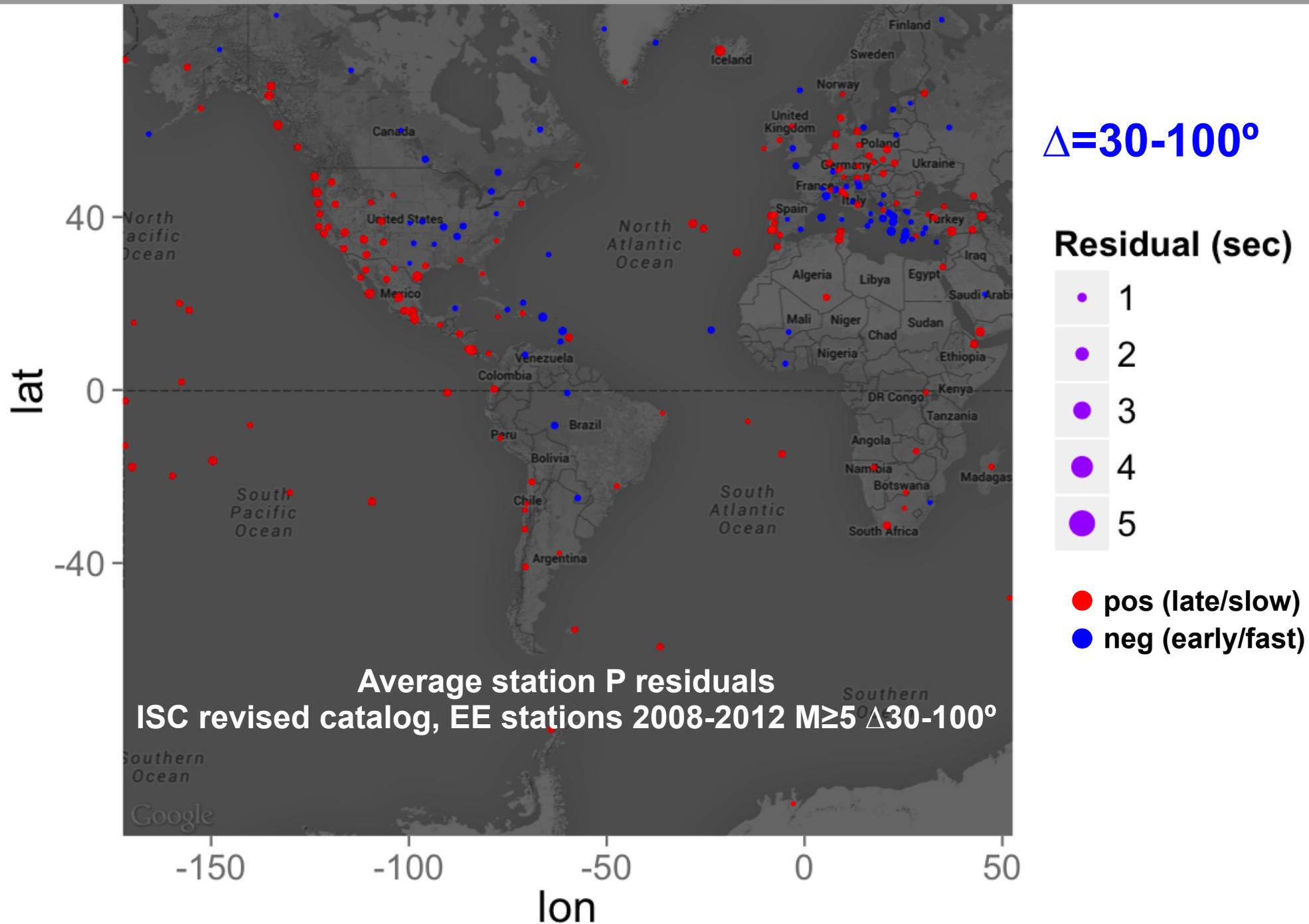
**Station corrections can help avoid this problem.**

Plot: 2015.06.17 13:09:22 UTC  
EE: v1.2.0xDEV (2015.05.12) 08d02h  
Agency: alomax.net\_BETA

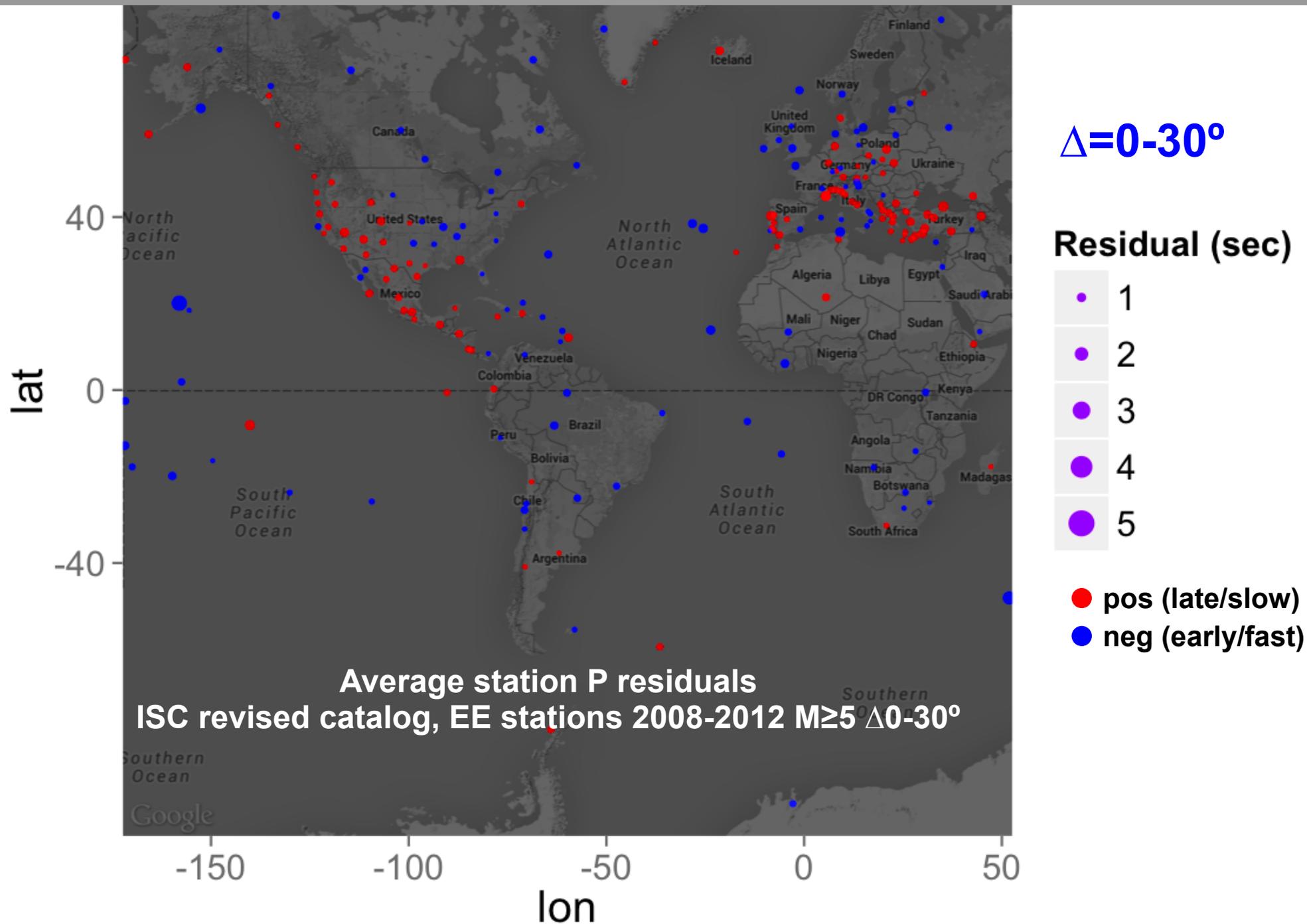
# Average station P residuals ISC 2008-2012 reflect large-scale tectonics



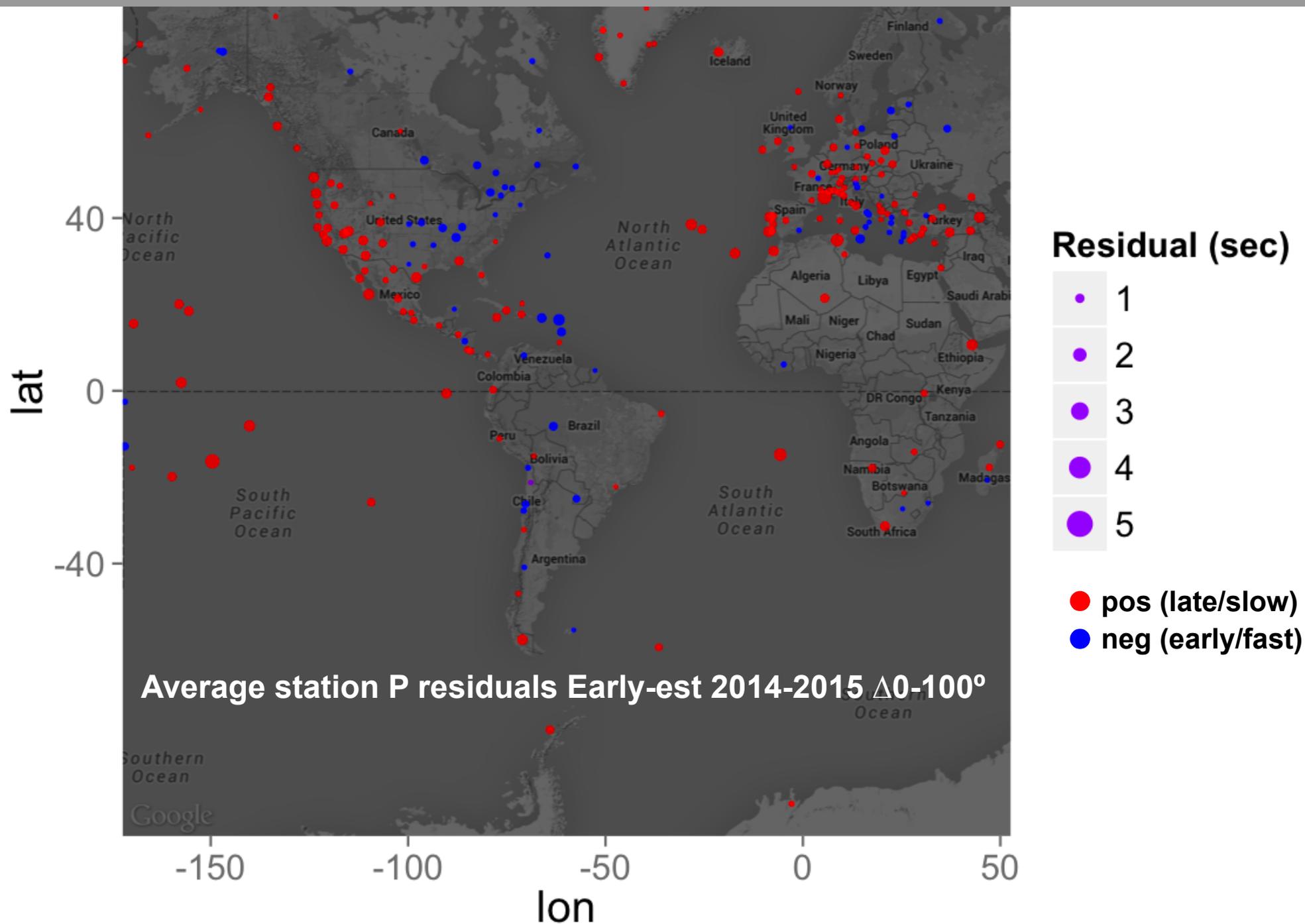
# Average station P residuals for distant events show lithosphere / upper mantle tectonic most clearly



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



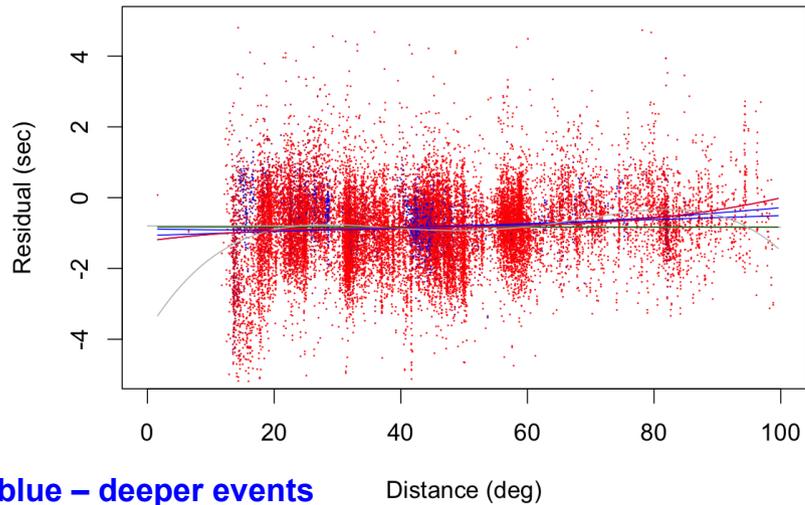
# Average station P residuals for Early-est similar, but not identical: larger than ISC, local differences → use EE for EE!



# 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

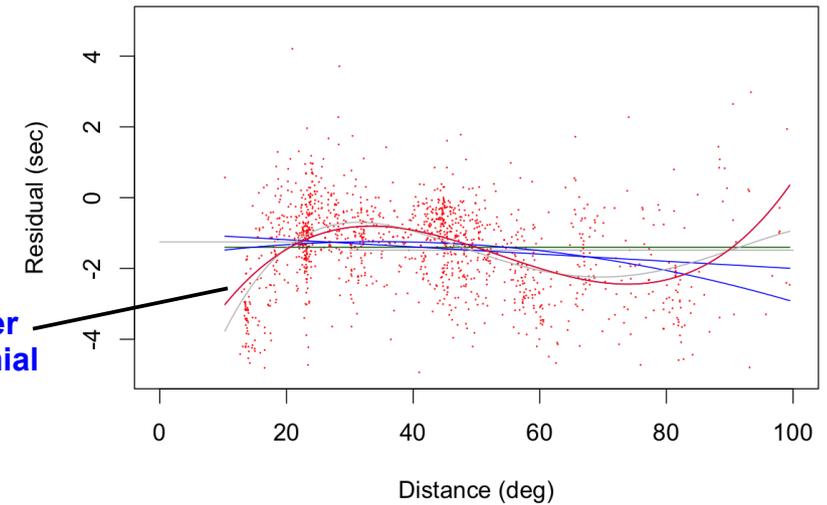


## Early-est 2014-2015

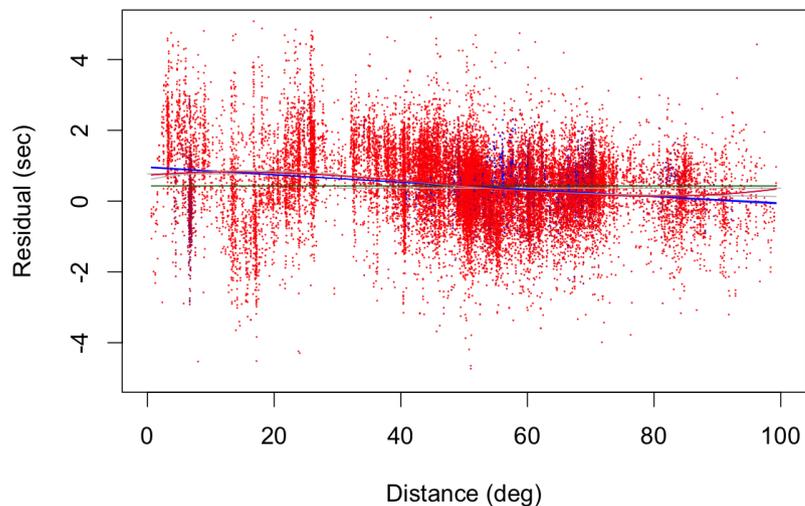
P residuals II\_WRAB\_00\_BHZ n15\_2gap180\_P\_5s\_d0-100\_z0-999

Station WRAB

3<sup>rd</sup> order polynomial

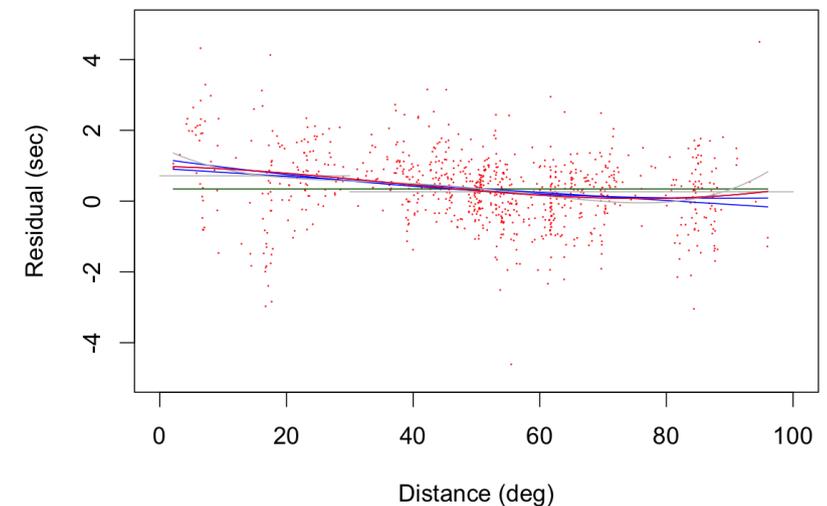


P residuals AAK ISC\_rev\_EE\_2008-2012\_M5\_EESta\_5s\_d0-100\_z0-999

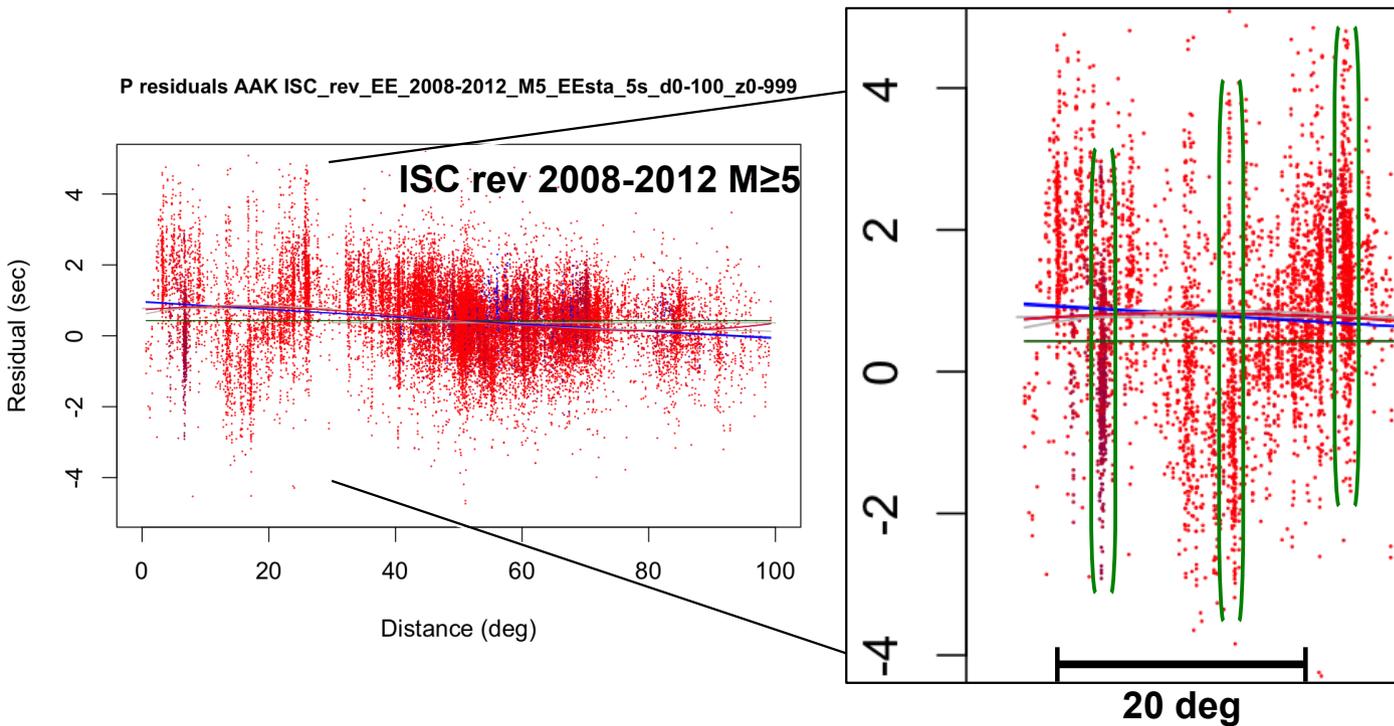


Station AAK

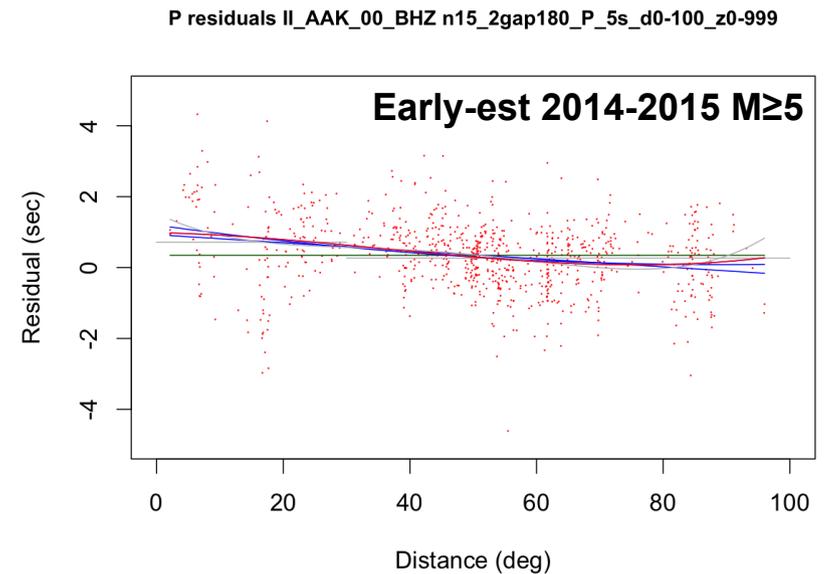
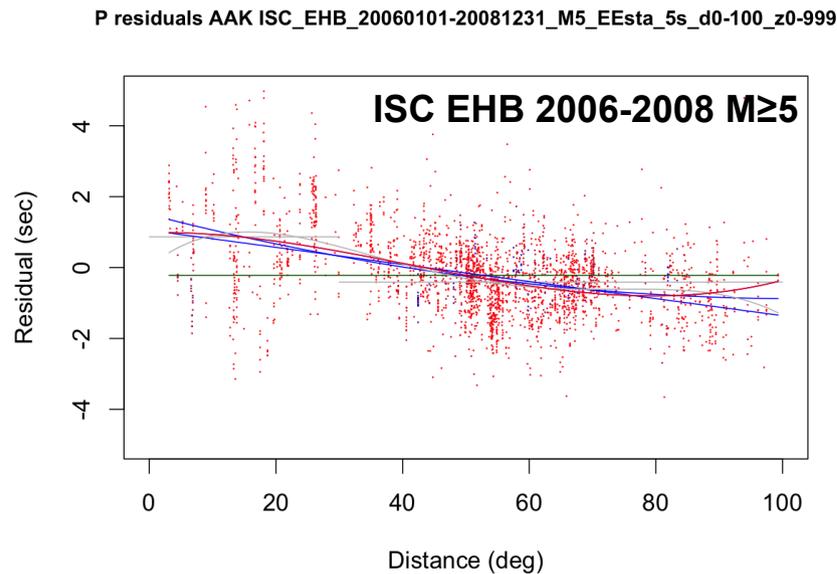
P residuals II\_AAK\_00\_BHZ n15\_2gap180\_P\_5s\_d0-100\_z0-999



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



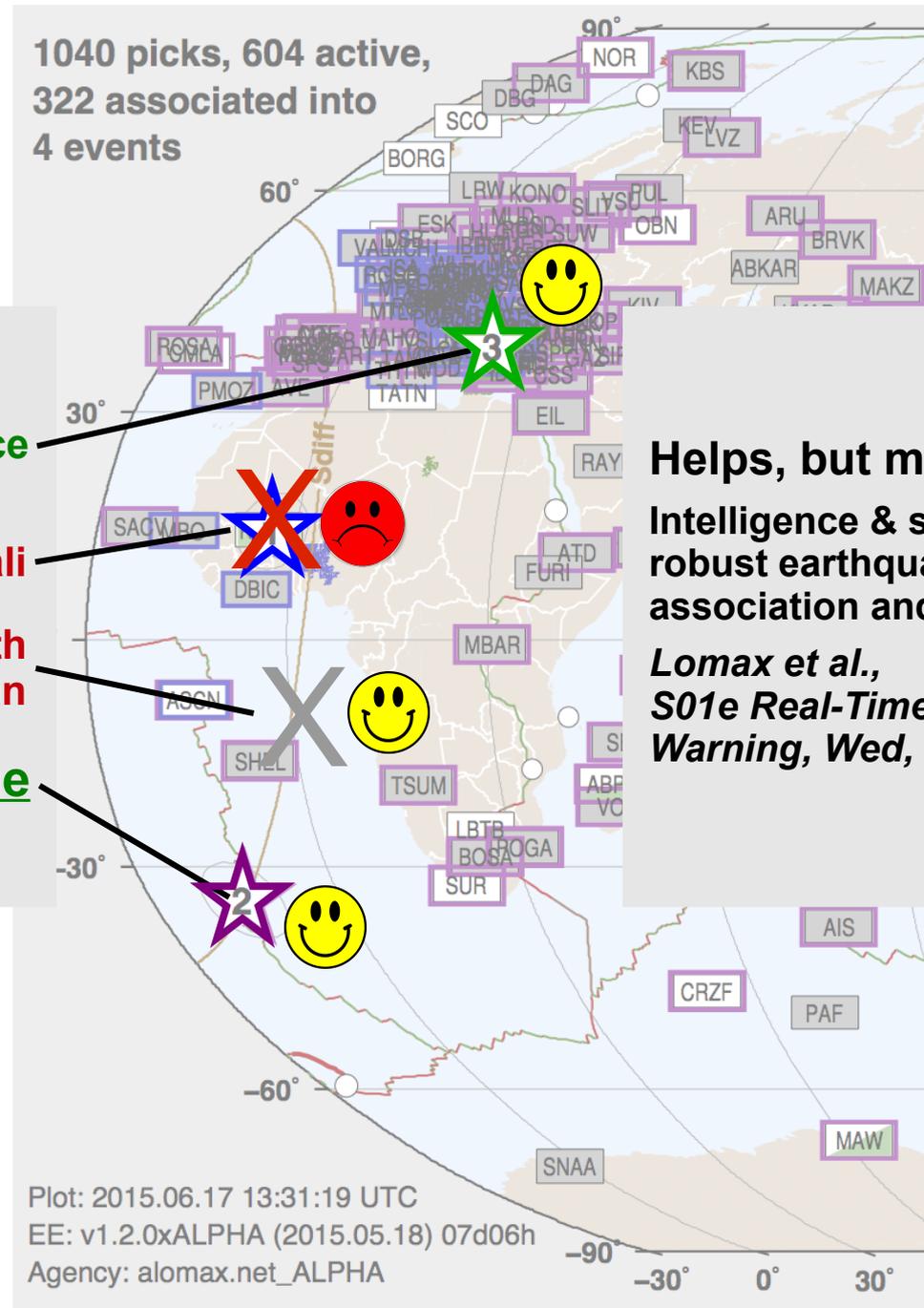
- Depth-OriginTime trade-off?
- Different station sets used? (sta availability, magnitude)
- ... combined with 1D velocity model
- Mis-identified phases?
- ???





# 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*

Plot: 2015.06.17 13:31:19 UTC  
EE: v1.2.0xALPHA (2015.05.18) 07d06h  
Agency: alomax.net\_ALPHA

# 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](http://ingv.it), [geofon.gfz-potsdam.de](http://geofon.gfz-potsdam.de), [geosbud.ipgp.fr](http://geosbud.ipgp.fr), [resif.fr](http://resif.fr), [ird.nc](http://ird.nc), [iris.washington.edu](http://iris.washington.edu), [usgs.gov](http://usgs.gov)*
- *Analysis Software: R statistics and graphics language; Python: [pandas.pydata.org](http://pandas.pydata.org), [matplotlib.org](http://matplotlib.org)*

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