

Evaluation of NET-VISA association and location performance using Ground Truth events and RSTT model based SSSCs

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CTBTO Science and Technology Conference

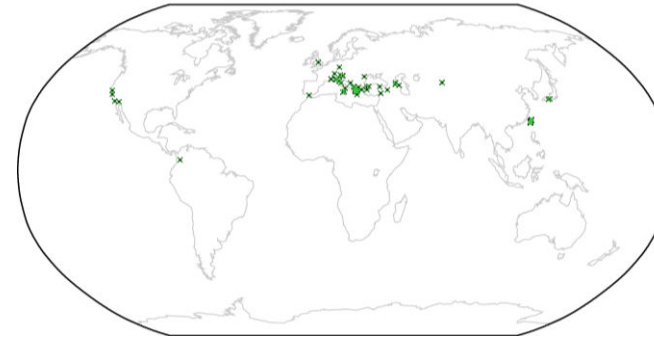
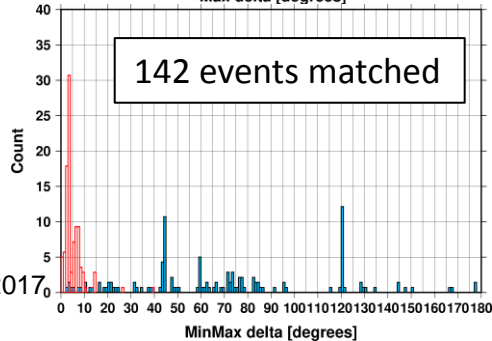
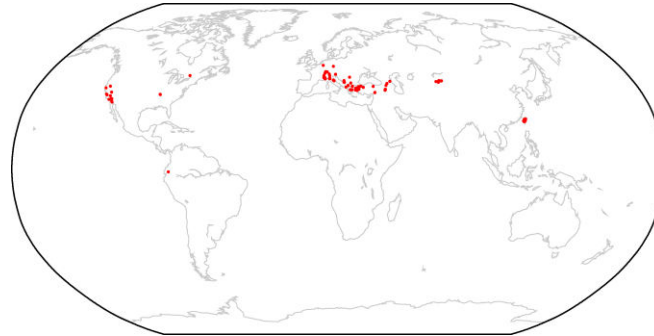
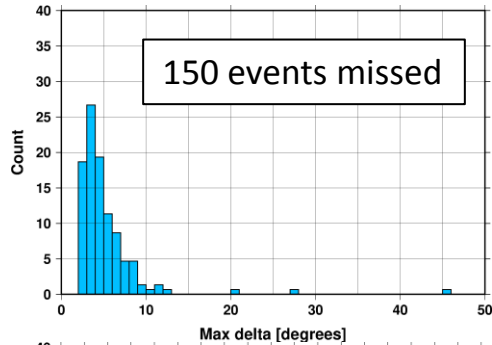
26-30 June 2017, Vienna

Motivation

- NET-VISA (Arora et al., 2013) offline automatic test-run has been completed for 2013
- The 2013 ISC Ground Truth (GT, Bondár and McLaughlin, 2009) selection can be used to measure NET-VISA performance
- Current, semi-empirical Source Specific Station Corrections (SSSCs) are incomplete as they exist for only a fraction of IMS stations
 - LEB contains a mixture of iasp91 and SSSC predictions
 - Difficult to evaluate the effect of SSSCs
- Relocation of GT events using iLoc (Bondár and Storchak, 2011) with and without Regional Seismic Travel Times (RSTT, Myers et al., 2010) offers an insight how a full set of RSTT model-based SSSCs may improve locations

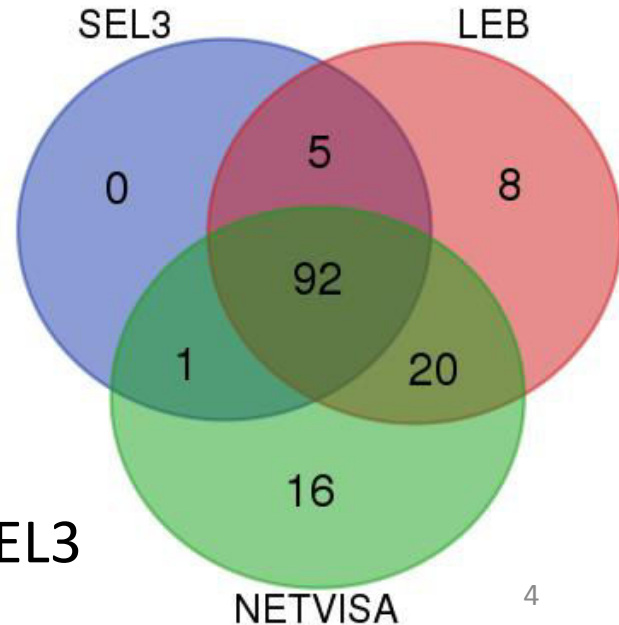
Ground truth events

- 292 GT5 events in the ISC GT selection from 2013
- 150 GT events are not found in the IDC bulletins
 - These are small magnitude local/regional events

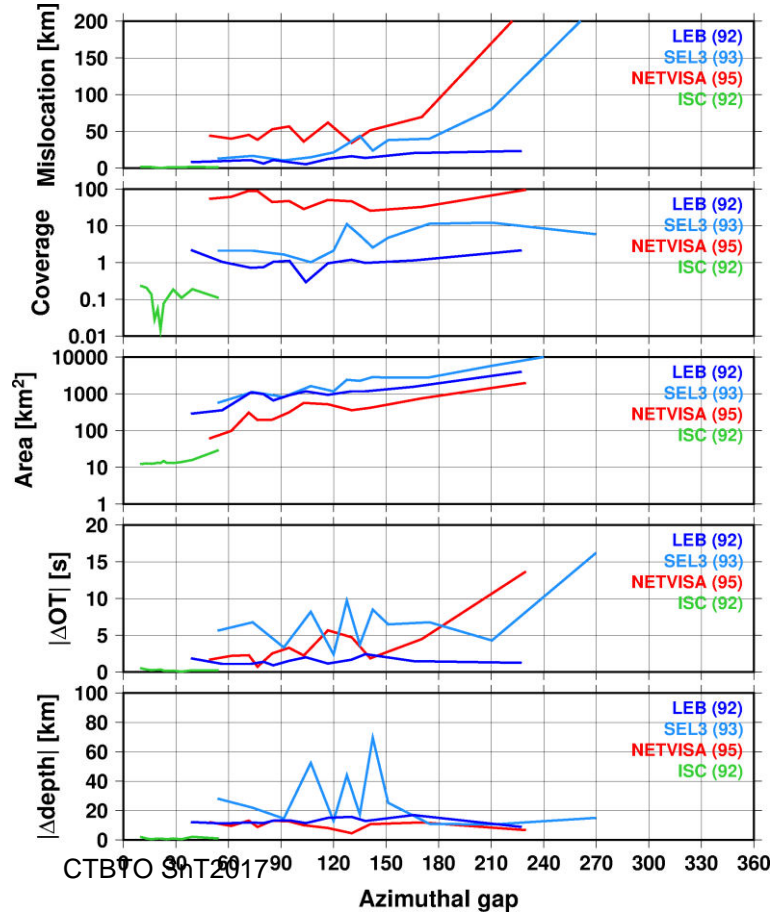


Matching GT events

- 142 GT5 events matched by SEL3, NET-VISA or LEB
- Matching criteria
 - OT: ± 2 min; Lat, lon: ± 5 degrees
 - Manual inspection for common picks at IMS stations
- LEB: 88% (125) events
- SEL3: 69% (98) events
 - 2 SEL events match to 1 GT
- NET-VISA: 91% (129) events
 - 5 NET-VISA events match to 2 GT events
- 1 event missed by LEB
- 16 events built by NET-VISA alone
- NET-VISA builds 22% more GT events than SEL3



Location comparisons



- NET-VISA suffers from larger mislocations
- NET-VISA provides better depth and origin time estimates
- SEL3 and LEB error ellipses appear to be somewhat inflated
- NET-VISA and ISC error ellipses are at the 90% confidence level
- Analyst review (LEB) significantly improves SEL3

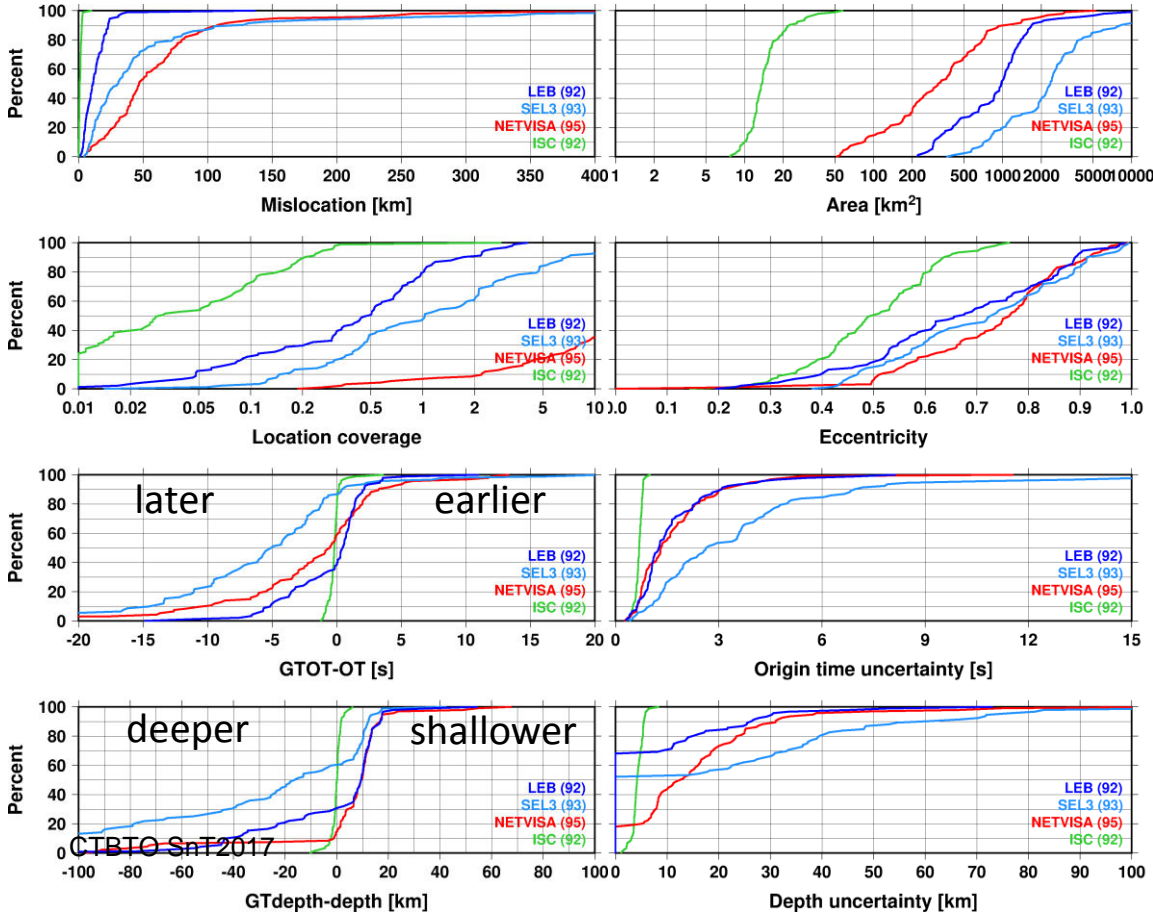
Location comparisons

NET-VISA

- 45 km median mislocation
- Smaller, less than 1000km² error ellipse
- Poor coverage
- Much better depth and OT estimation

LEB

- 10 km median mislocation
- 80% coverage



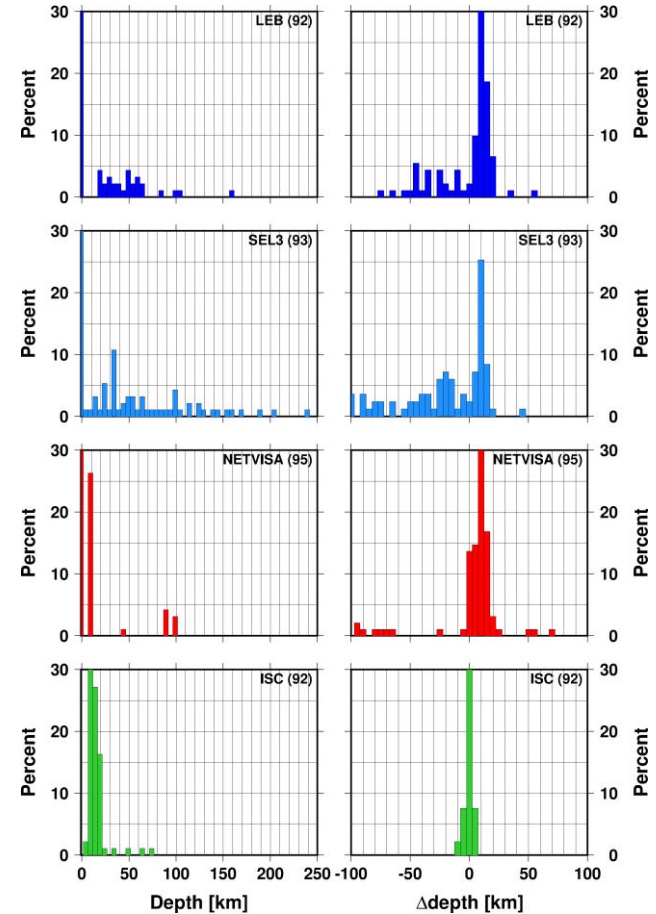
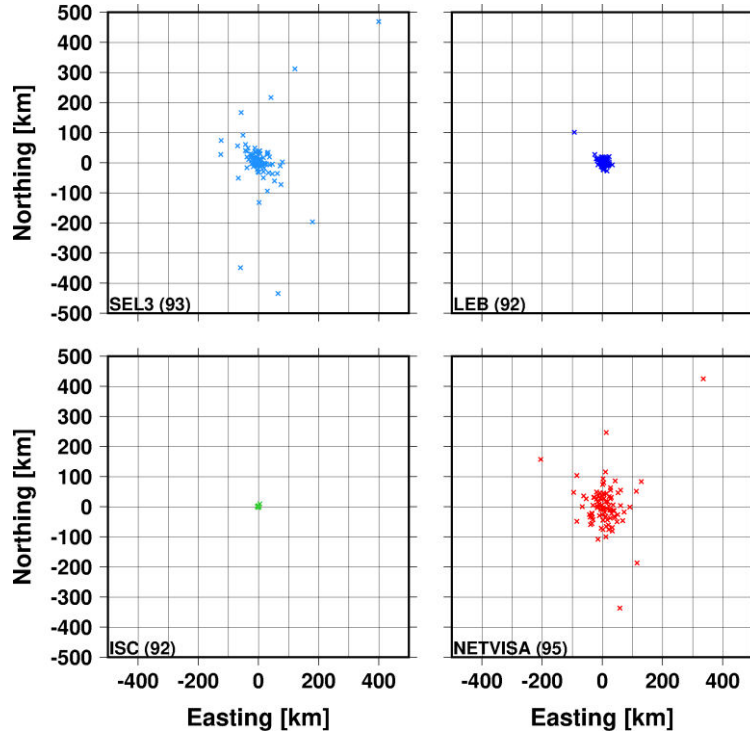
Location comparisons

NET-VISA vs SEL3

- Larger scatter, fewer terrible outliers
- Very few deep events

LEB

- Tight locations



Relocations with iLoc

- GT5 events with at least one regional phase picks in LEB are relocated with and without RSTT (Myers et al., 2010) travel-time predictions
 - iLoc is a further developed version of the ISC locator (Bondár and Storchak, 2011)
 - iLoc is capable of using RSTT predictions directly
 - No need to calculate SSSCs
- The objective is to assess the location performance of RSTT based calibrated regional travel time predictions

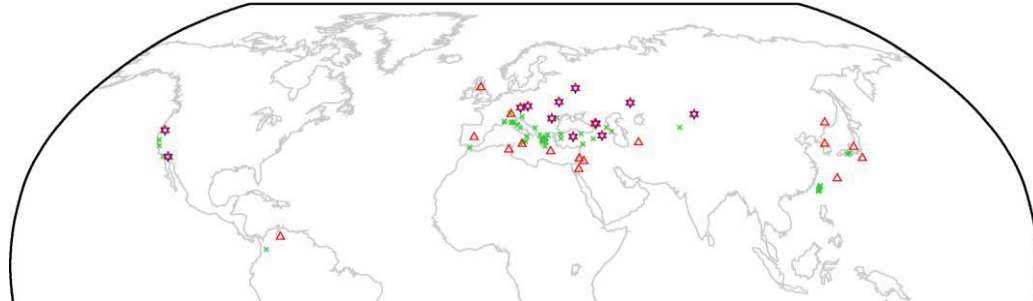
Relocations with iLoc

- 118 LEB events with regional phases
- LEB locations include current SSSCs
 - Some stations have SSSCs, some not (red triangles)

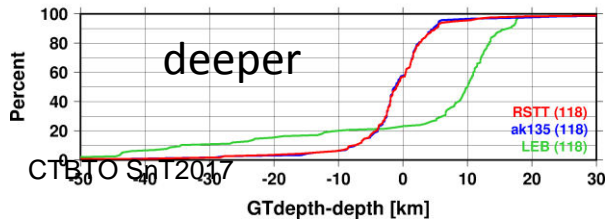
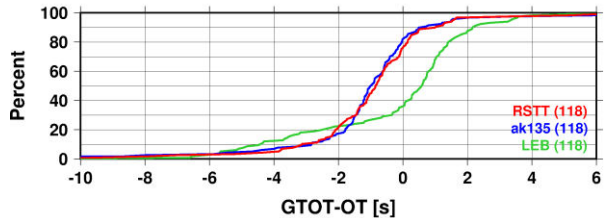
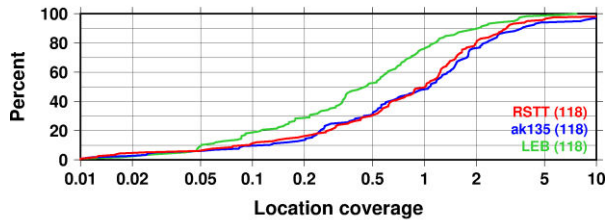
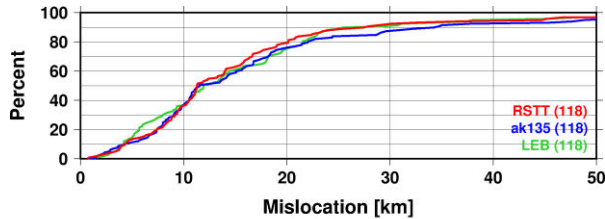
Pn stations



Sn stations



Relocations with iLoc



Mislocation

- Both LEB and RSTT outperforms iasp91

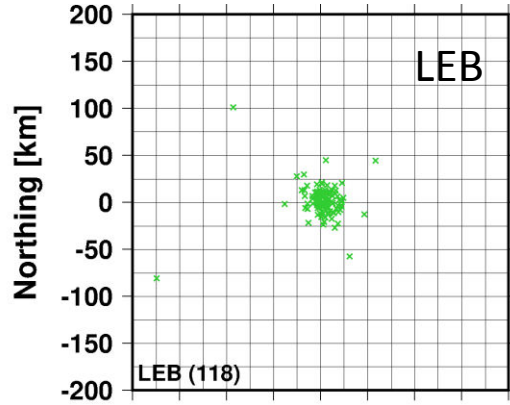
Location coverage

- 80% coverage in LEB
- LEB error ellipses are larger

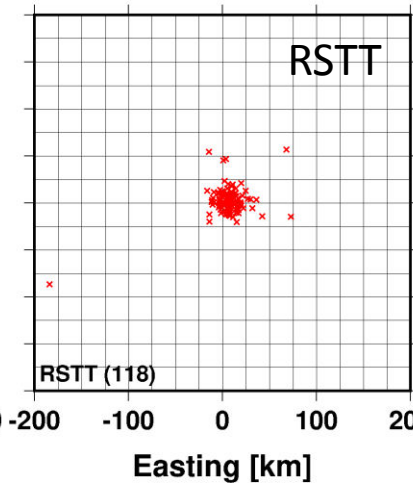
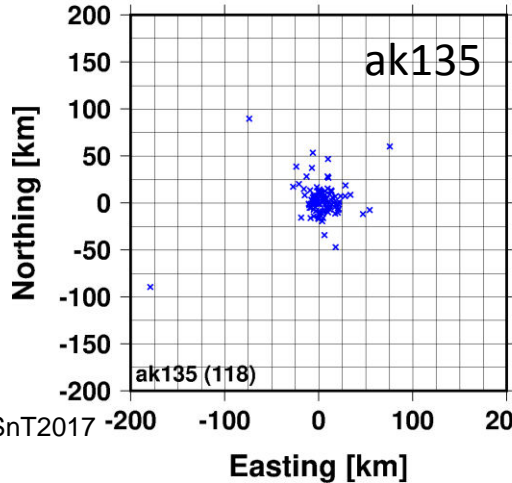
Origin time and depth

- iLoc provides better depth and origin time estimates
- LEB puts some shallow events deep

RSTT vs current SSSCs



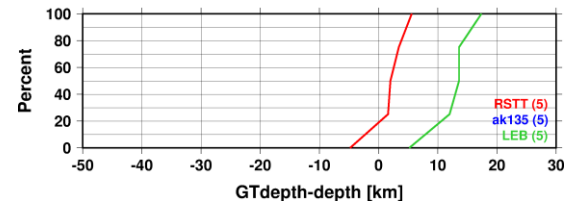
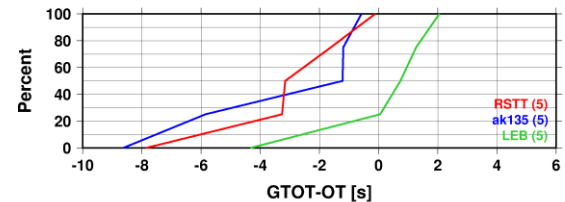
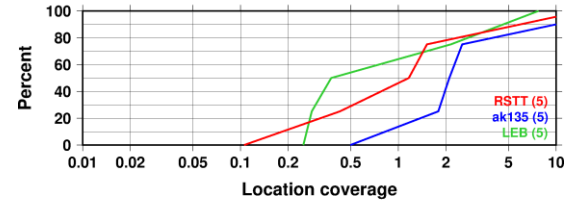
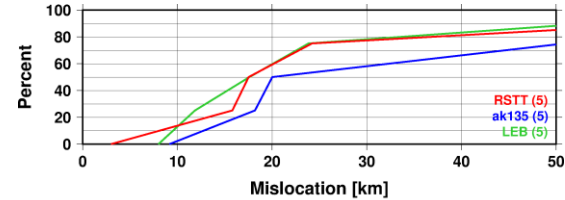
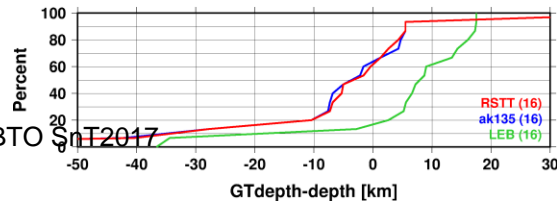
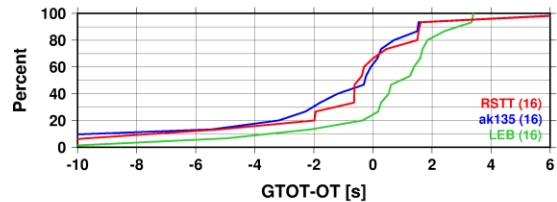
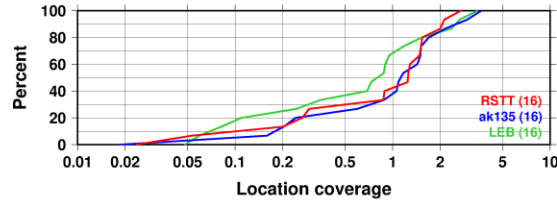
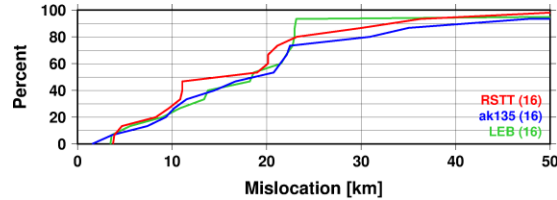
RSTT provides
smaller scatter and
fewer outliers than
LEB



RSTT vs current SSSCs

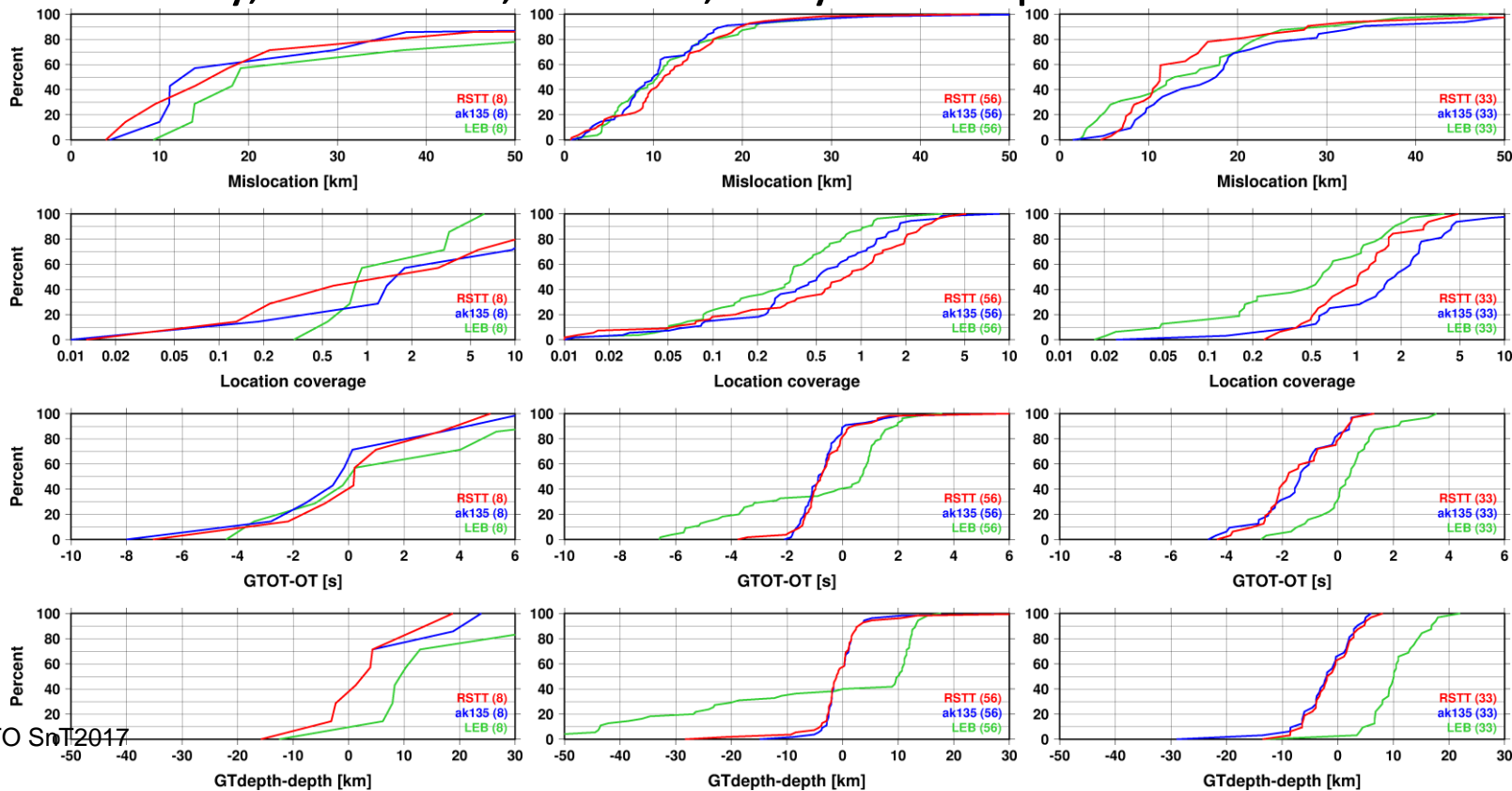
Far East: no current SSSCs

California: SSSCs exist for all stations

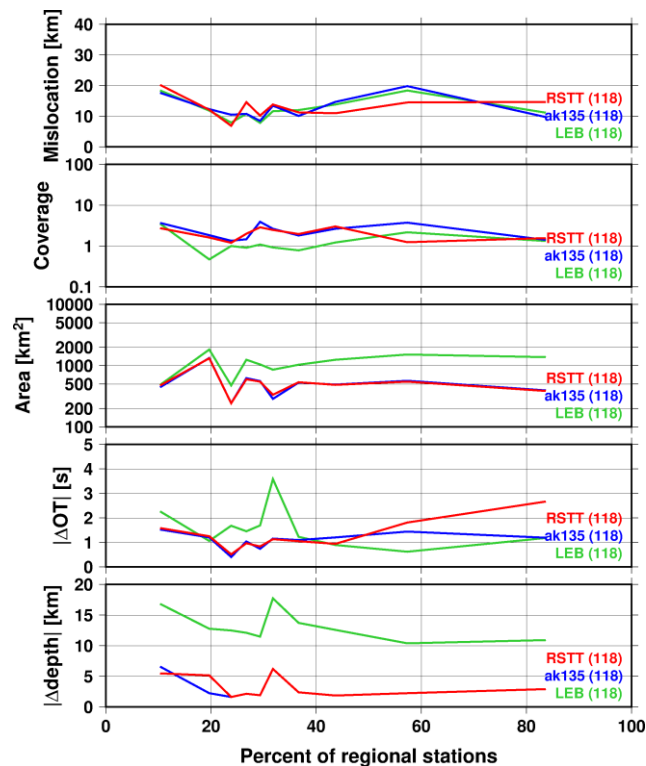
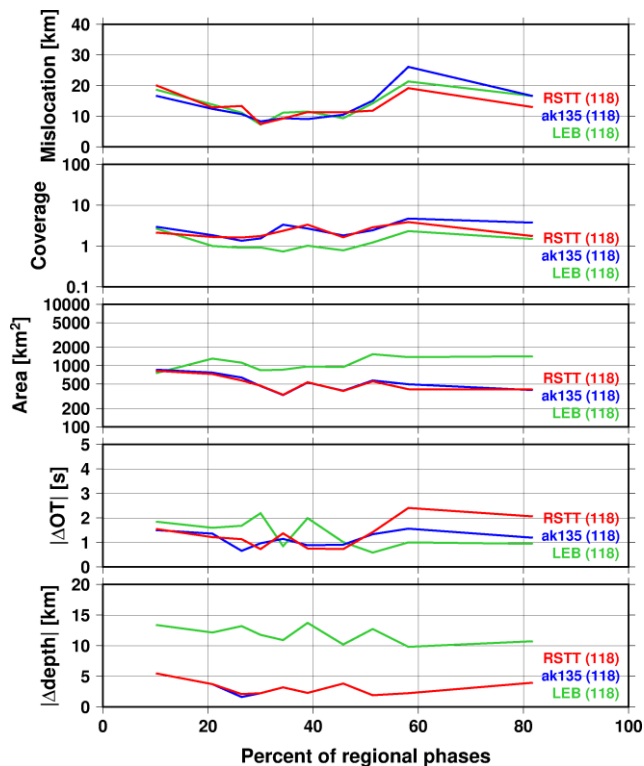


RSTT vs current SSSCs

Turkey, Caucasus, Greece, Italy: incomplete set of SSSCs

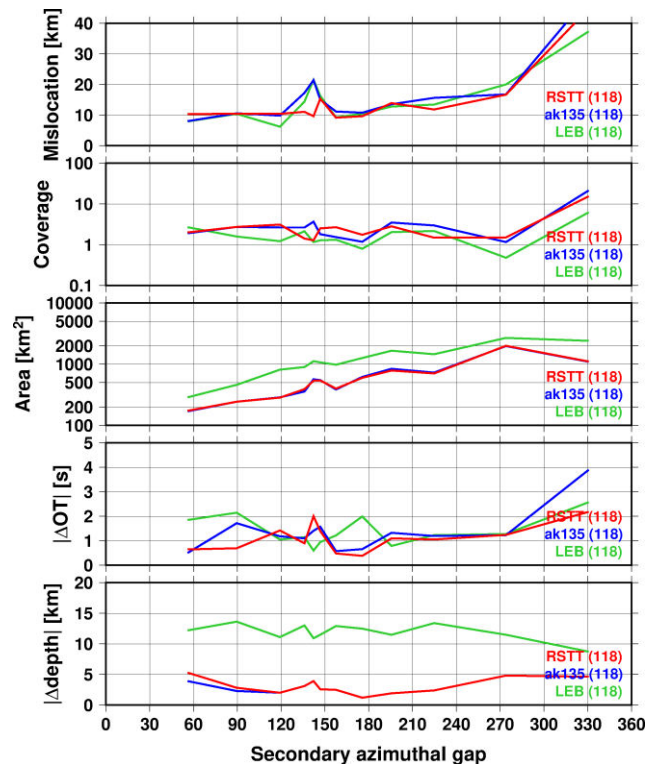
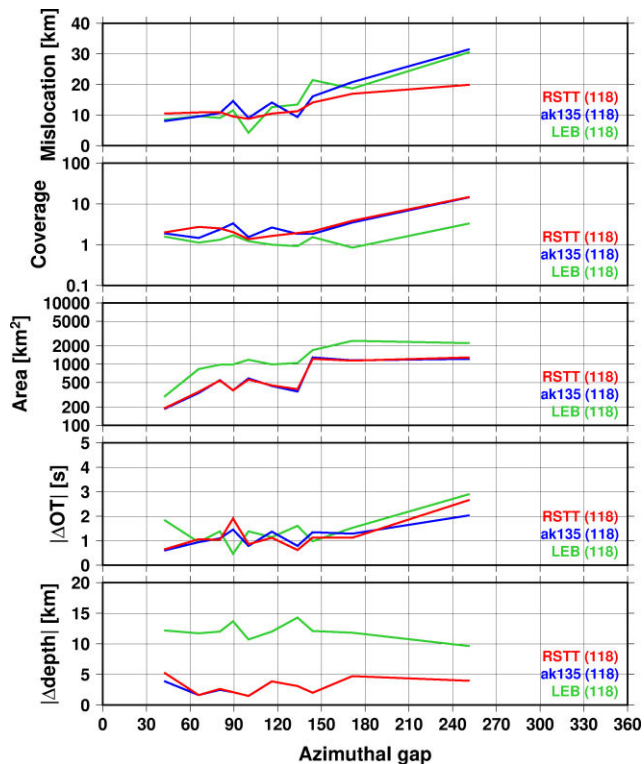


Median deviation from GT



- Median values in every 5 percentile bins of data as a function of percentage of regional phases and regional stations
- RSTT provides improvements in both location and origin time

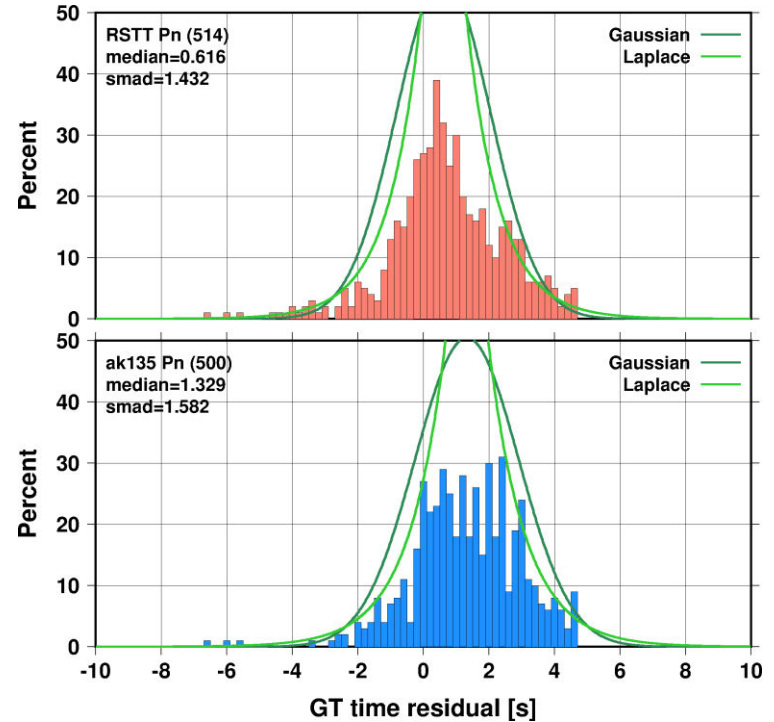
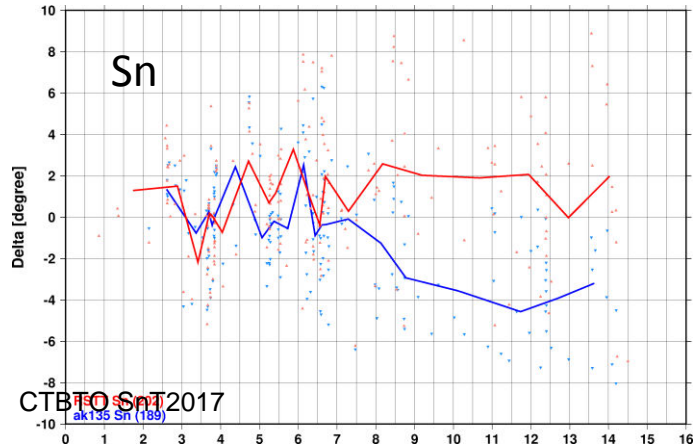
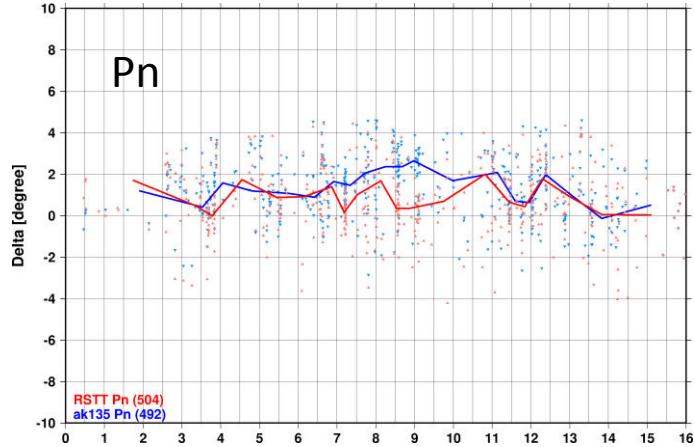
Median deviation from GT



- Median values in every 5 percentile bins of data as a function of primary and secondary azimuthal gap
- RSTT provides improvements in both location and origin time

GT residuals

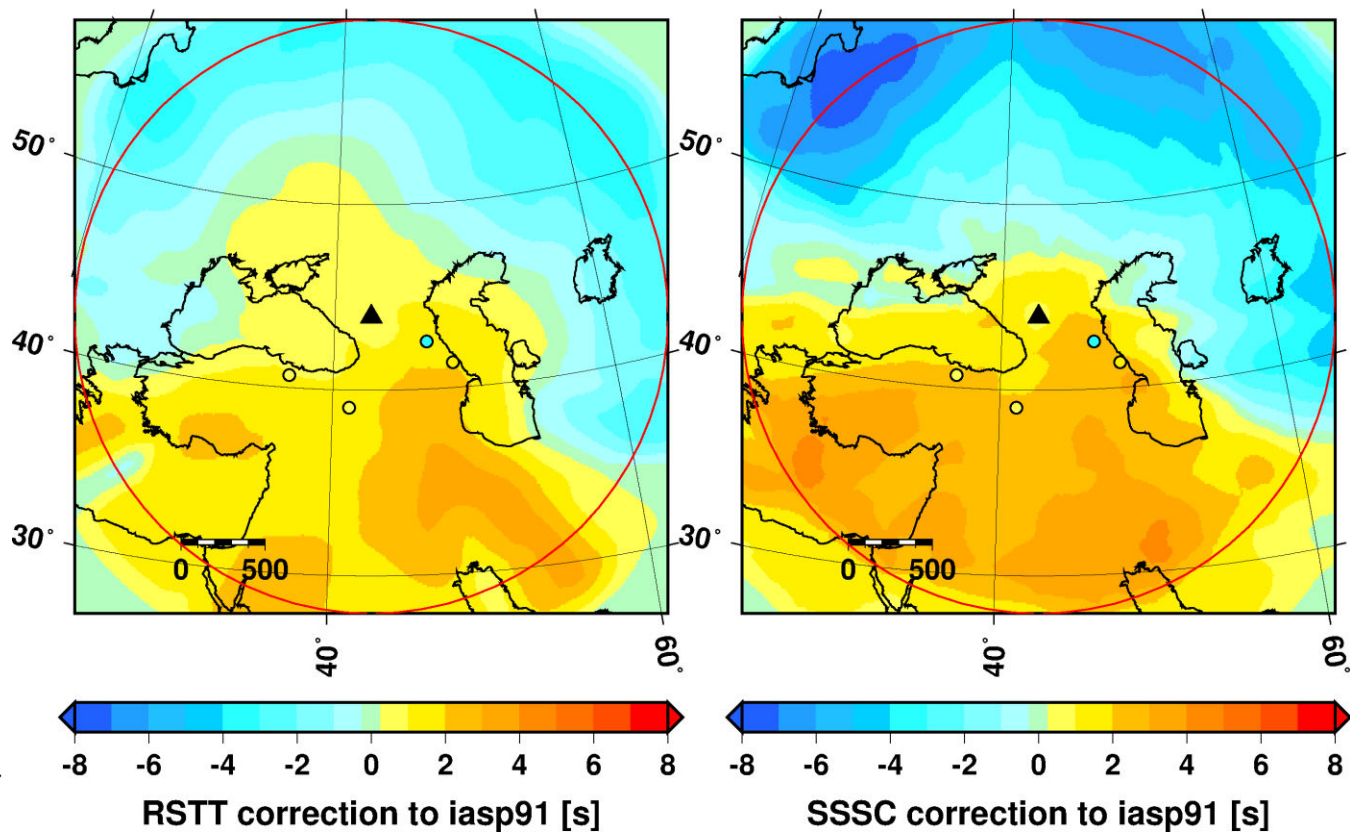
Residuals calculated w.r.t. GT locations become more zero-mean and normally distributed



RSTT vs current SSSCs

KVAR, Pn GT residuals

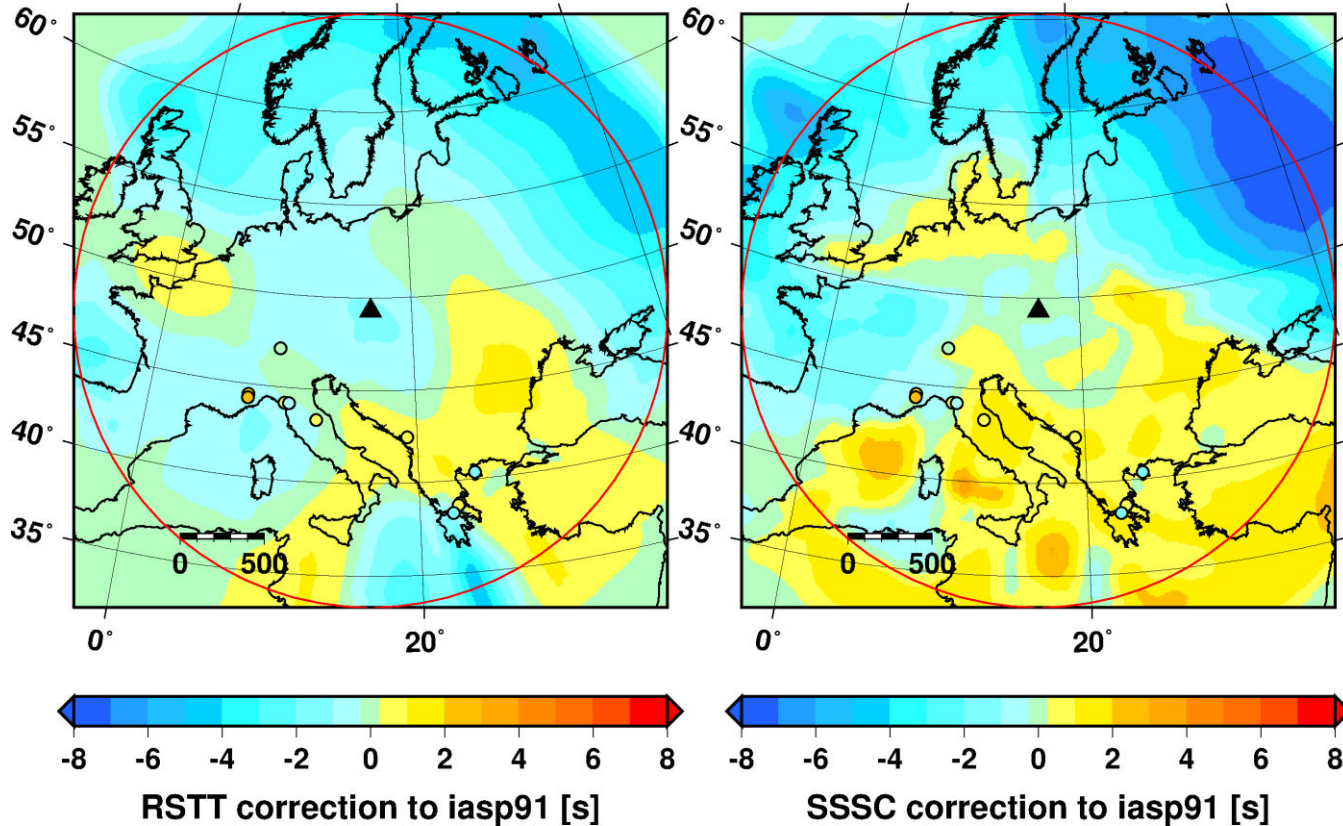
KVAR, Pn GT residuals



RSTT vs current SSSCs

VRAC, Pn GT residuals

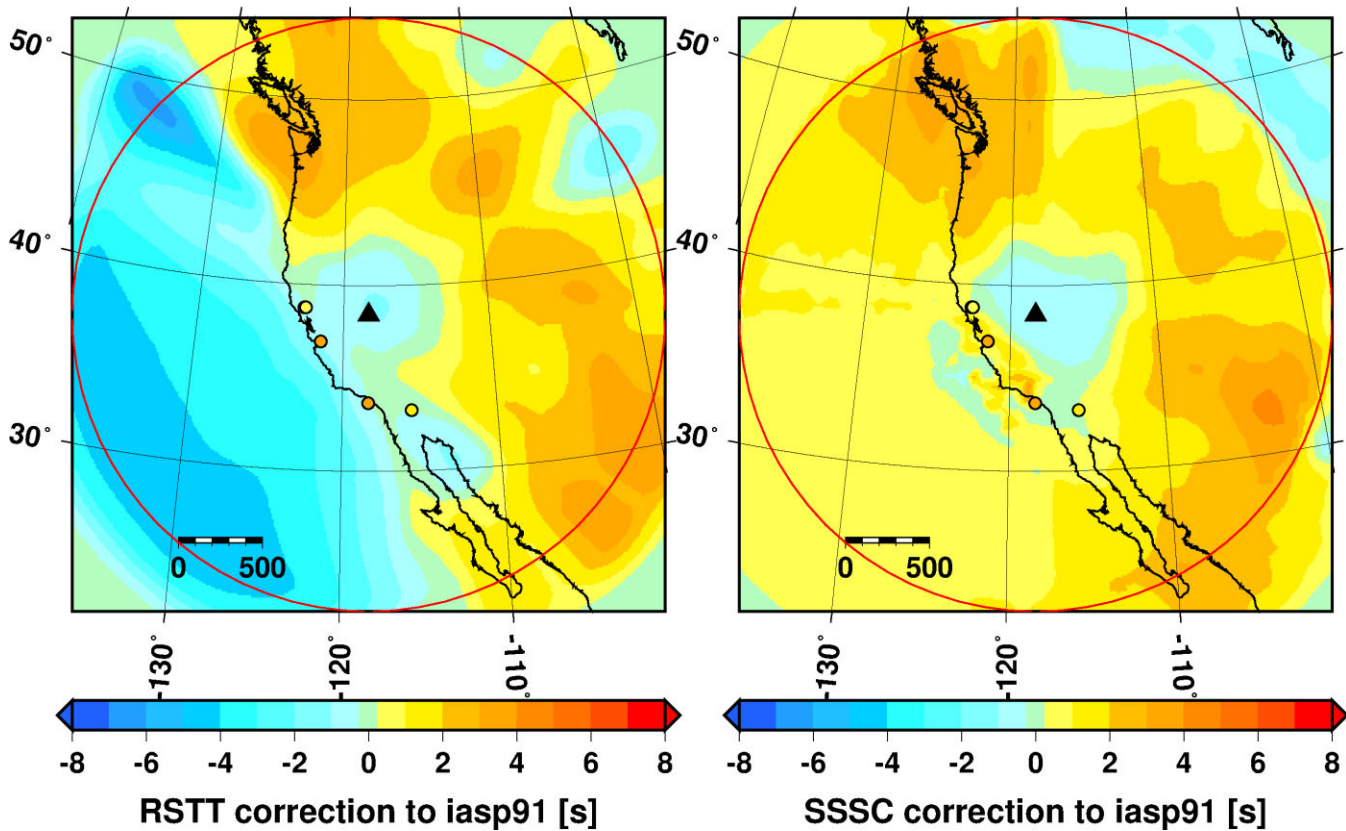
VRAC, Pn GT residuals



RSTT vs current SSSCs

NVAR, Pn GT residuals

NVAR, Pn GT residuals



Conclusions: NET-VISA

- NET-VISA built 91% of the GT events compared to 88% of LEB and 69% of SEL3
- NET-VISA does a significantly (22%) better job at building GT events than SEL3
- NET-VISA locations are somewhat poorer than SEL3
 - The latest NET-VISA run 2.2.48 shows improvements in location
 - Further improvements are expected from NET-VISA effort
 - The objective is better location accuracy with NET-VISA than with SEL3
- NET-VISA depth estimations are superior to SEL3
 - NET-VISA does not make shallow events deeper
- Analyst review significantly increases LEB quality
- Missed events in SEL3 were added by analysts
- NET-VISA will reduce analyst workload

Conclusions: RSTT

- Current SSSCs available only for a fraction of stations
- Model-based RSTT can provide SSSCs anywhere
- iLoc relocations were used to test the performance of RSTT
- On the set of GT events considered, RSTT performs consistently better than iasp91 and not worse than current SSSCs
- Residuals w.r.t. GT
 - RSTT GT residuals are closer to zero-mean
 - RSTT SSSCs explain majority of iasp91 residuals

Future Plans

- NET-VISA currently does *not* use SSSCs in the association process
- SSSCs require the integration of multi-threaded version of location library
 - Integration work is under way
- Pn and Sn picks that are currently rejected owing to their large iasp91 residuals may become available using RSTT predictions, thus changing the resulting set of events
- The NET-VISA association process using SSSCs will be evaluated using Ground Truth events