Andreas Köhler,Tormod Kværna & Steven J. Gibbons

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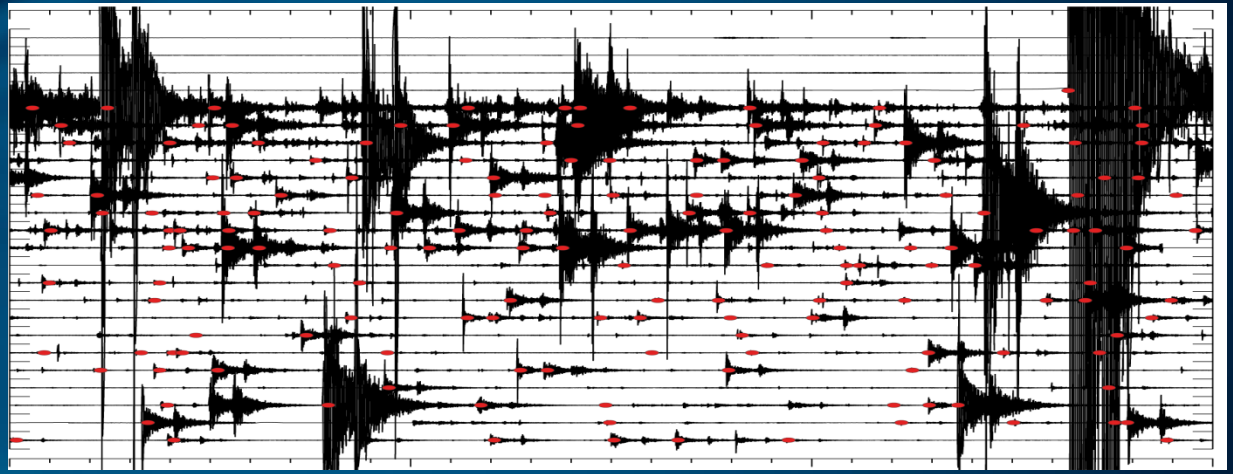
Exploring the Earth

Assessment of the empirical matched field processing algorithm for autonomous tracking of aftershock sequences



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EGU 2020

Overview

- Background:
  Reducing work load of analysists during processing of aftershock sequences of large earthquakes
- Concept:
  Use signals from the main event as templates for automatic processing of aftershocks and other recurring events
- Method:
  Empirical Matched Field (EMF) detector
- Application presented here:
  Nepal: April 25, 2015 (Mw = 7.8)
  (processing of 7 days following the main event)
- Evaluation:
  Comparison with IDC event bulletins: REB (reviewed) and SEL3 (automatic)

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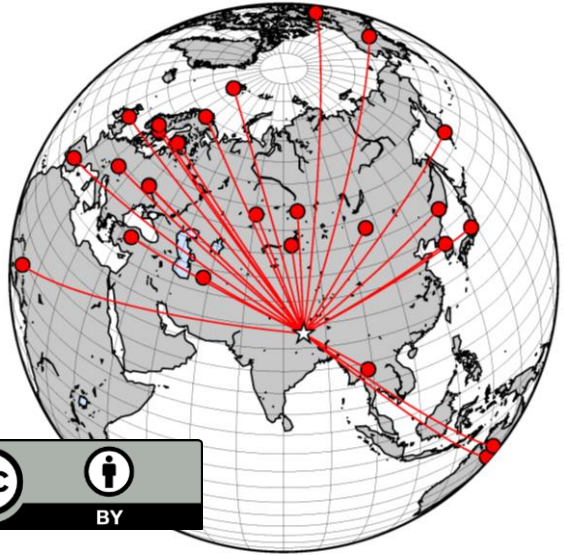
How this works:

- Pick main shock on all arrays to define steering vectors for EMF
- Detect signals using EMF statistic
- Get accurate phase onsets
- Estimate back-azimuth & slowness



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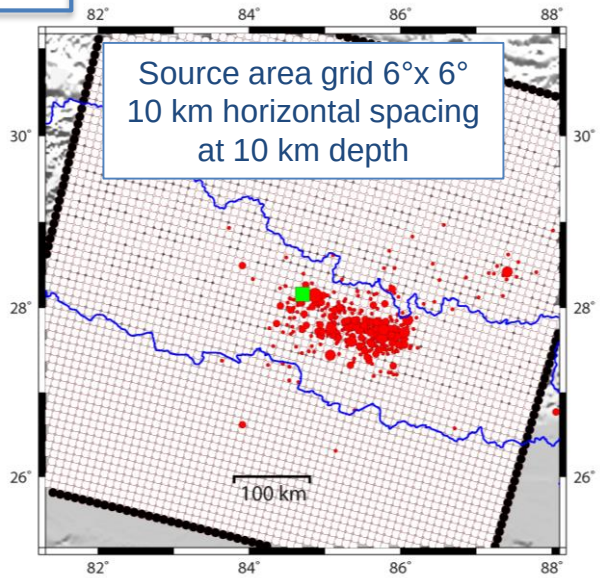


Construct grid system

Associate arrivals

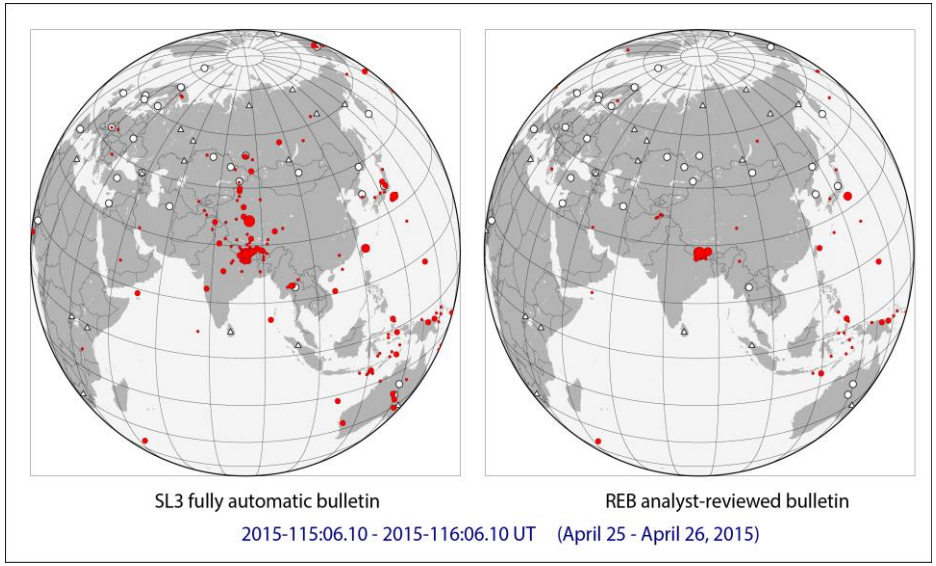
Aftershock event bulletin

Relocations from BayesLoc

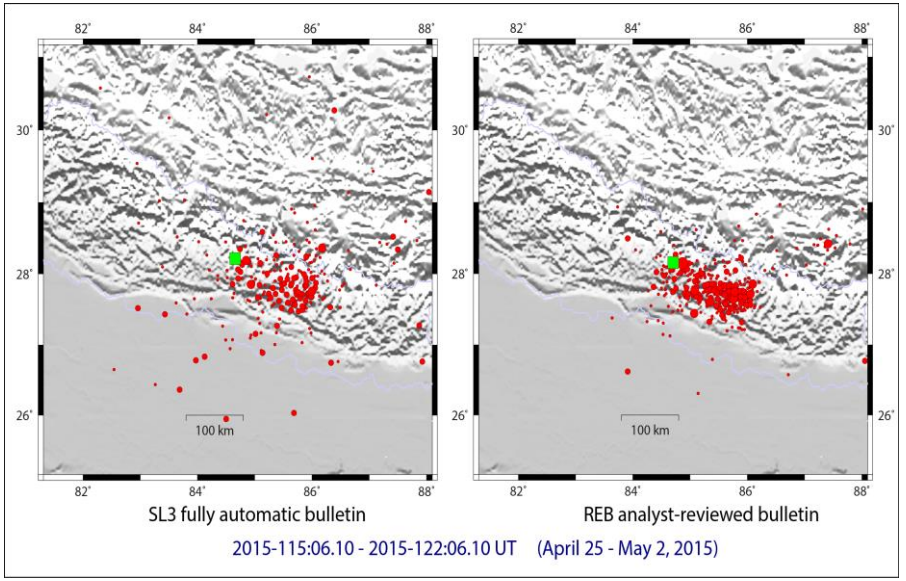
IDC bulletins

Nepal: April 25, 2015 (Mw = 7.8)

SEL3 – REB, first 24 hours



SEL3 – REB, 7 days



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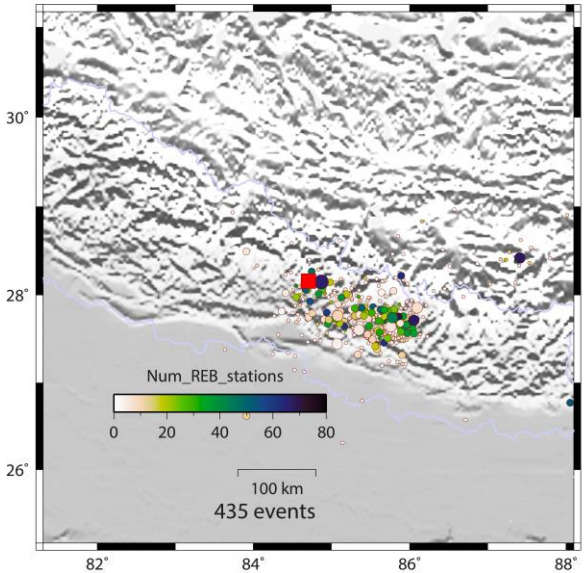
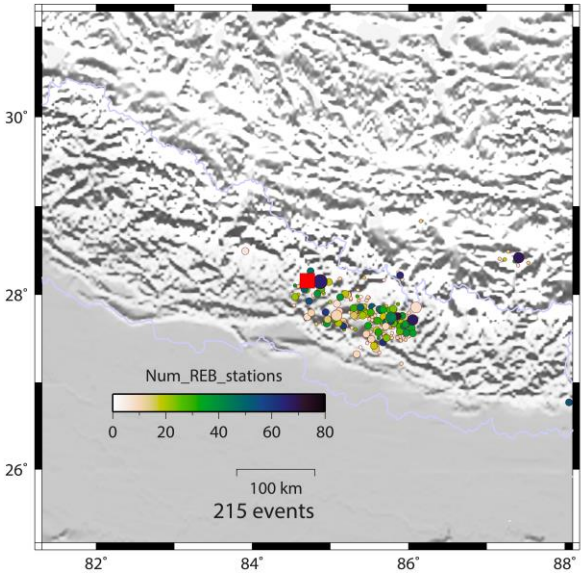
EMF evaluation results

Nepal: 215 (49.4%) of 435 REB events found by EMF
Tolerances: 150 km, 30 seconds

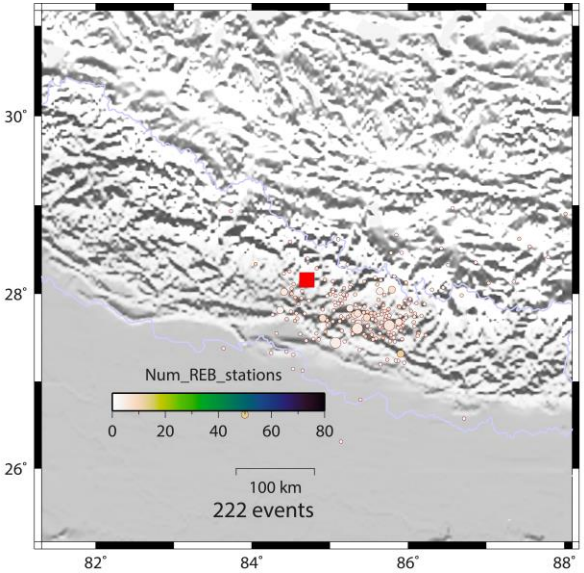
Events in REB



REB events found by EMF



REB events NOT found by EMF



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All low number of defining stations!

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EMF evaluation results

Nepal: 215 (49.4%) of 435 REB events found by EMF
Tolerances: 150 km, 30 seconds

#REB events inside box	435	
#matching EMF events	215	49.4%
#matching SEL3 events (same eventID)	284	65.3%
#matching SEL3 events (same eventID and within box)	232	53.3%
#matching REB, SEL3 and EMF	194	44.6%
#EMF events not matching any REB event	40	To be addressed

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EMF events not matching any REB event

Events with only 4 station detections, split events, additional event

Origin time	#phases	Latitude	Longitude
2015-115:06.27.14.948	6	28.9442	83.3324
~~2015-115:06.34.23.301~~	~~4~~	~~27.7931~~	~~85.4439~~
~~2015-115:06.35.20.305~~	~~4~~	~~27.9362~~	~~84.8485~~
2015-115:06.37.46.598	7	28.9456	82.9041
~~2015-115:06.46.51.698~~	~~4~~	~~28.9897~~	~~88.1990~~
2015-115:06.50.54.626	5	27.1867	84.8333
2015-115:07.30.36.166	9	29.6486	83.5397
2015-115:08.17.18.536	15	29.1595	84.0406
2015-115:08.57.46.675	**11**	**27.7534**	**85.2186**
2015-115:09.17.06.525	11	27.2097	85.9000
~~2015-115:09.18.24.964~~	~~4~~	~~29.0097~~	~~83.4588~~
~~2015-115:09.24.08.229~~	~~4~~	~~25.4089~~	~~85.5542~~
~~2015-115:10.51.25.396~~	~~4~~	~~26.6207~~	~~85.6111~~
2015-115:12.47.38.855	8	27.4424	85.3354
2015-115:23.40.50.088	5	28.7355	86.6005
2015-116:02.21.14.777	5	26.8825	84.5306
2015-116:02.48.32.403	6	29.1429	83.2831
~~2015-116:02.55.02.497~~	~~4~~	~~29.6679~~	~~87.7776~~
~~2015-116:07.13.11.333~~	~~4~~	~~29.7061~~	~~85.7228~~
~~2015-116:07.14.21.742~~	~~4~~	~~27.9201~~	~~85.6968~~
~~2015-116:07.23.44.004~~	~~4~~	~~26.1329~~	~~84.5178~~
~~2015-116:10.34.31.614~~	~~4~~	~~26.2879~~	~~86.5611~~
~~2015-117:13.23.17.005~~	~~4~~	~~27.9362~~	~~84.8485~~
~~2015-118:02.55.13.482~~	~~4~~	~~25.9435~~	~~85.2987~~
2015-118:05.01.55.281	5	29.6908	85.3925
~~2015-119:00.30.05.875~~	~~4~~	~~26.3219~~	~~82.4802~~
2015-119:05.50.29.895	7	29.4086	82.9304
~~2015-120:19.21.56.160~~	~~4~~	~~27.7111~~	~~82.5526~~
~~2015-121:05.43.11.631~~	~~4~~	~~27.3869~~	~~86.7002~~
~~2015-121:09.00.22.725~~	~~4~~	~~26.5639~~	~~82.2334~~
~~2015-122:08.01.54.607~~	~~4~~	~~29.9451~~	~~84.7122~~

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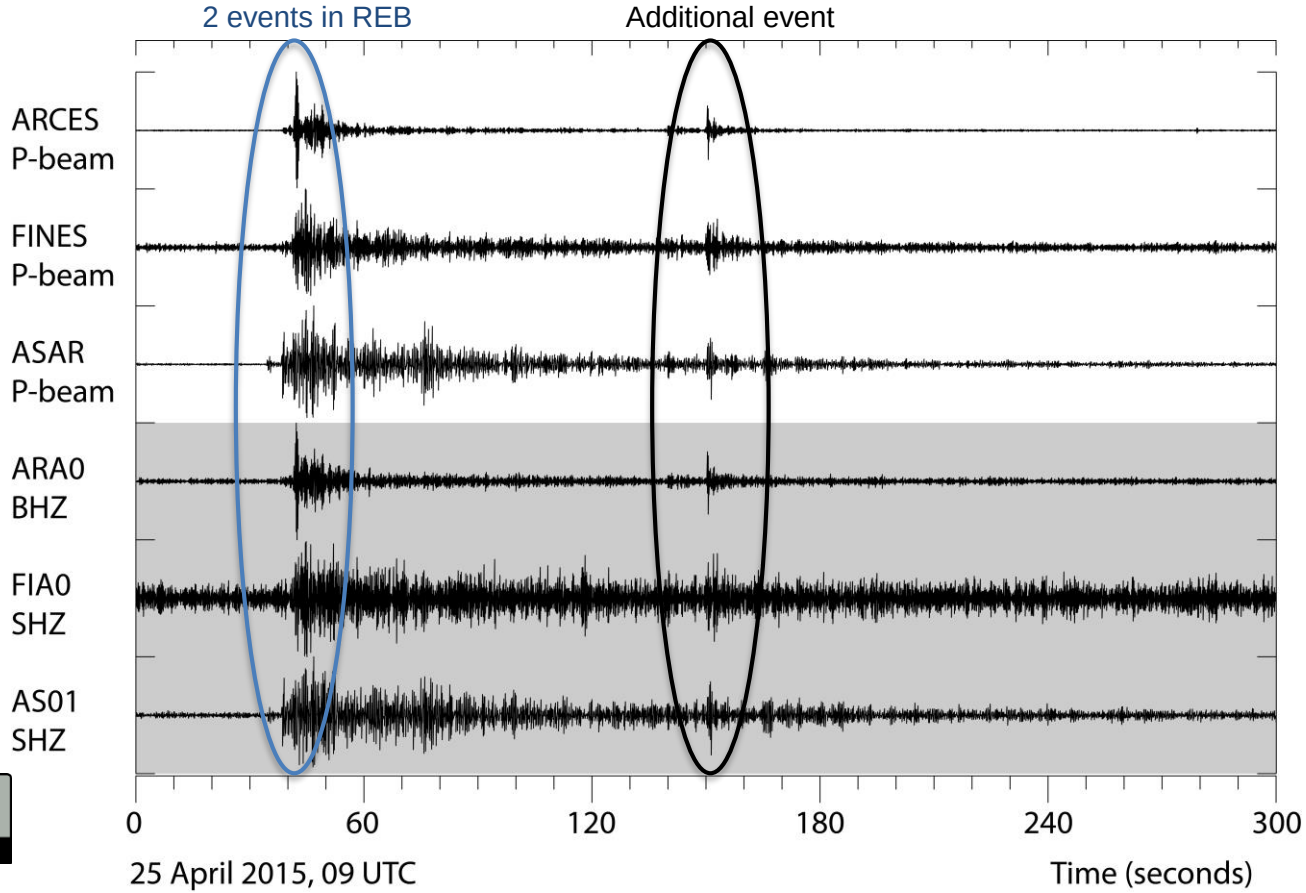
EMF events not matching any REB event

Events with only 4 station detections, split events, additional event



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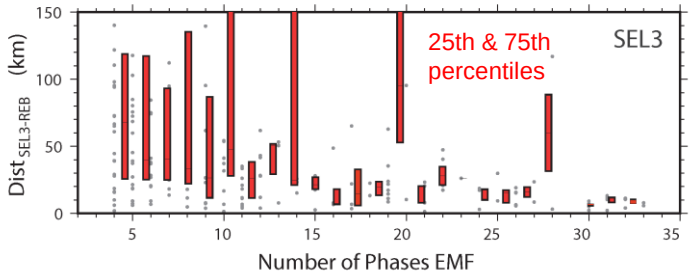
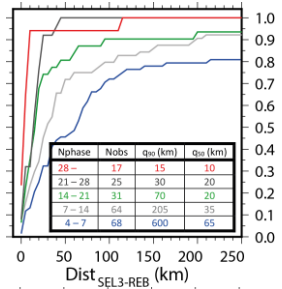
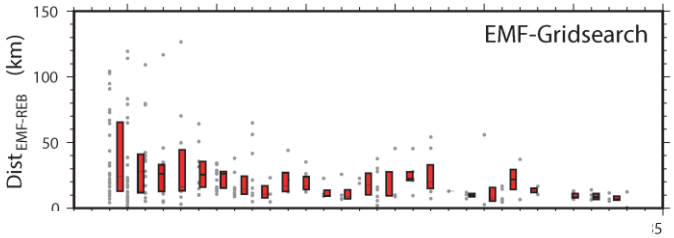
EMF evaluation results

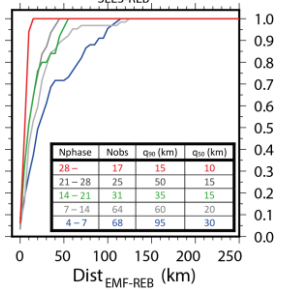
Location differences of SEL3 and EMF relative to the REB

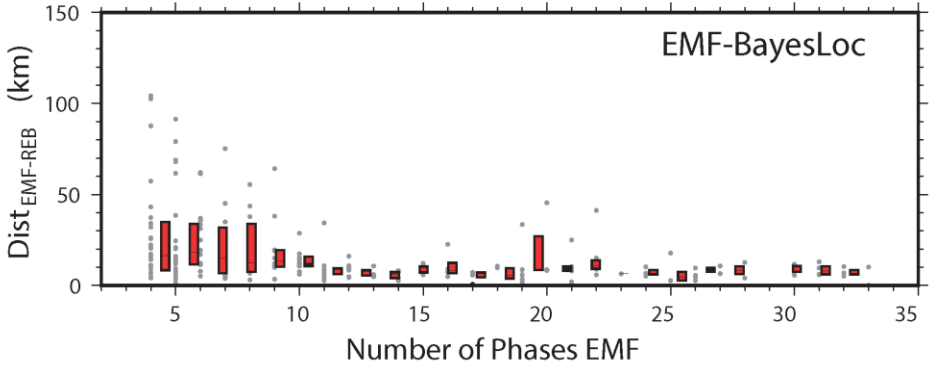
(1) EMF events are closer to REB events

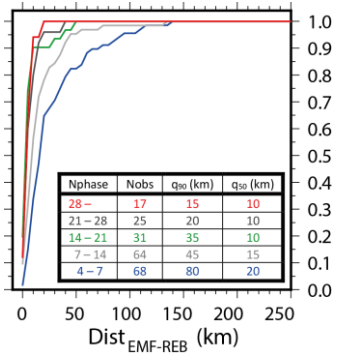












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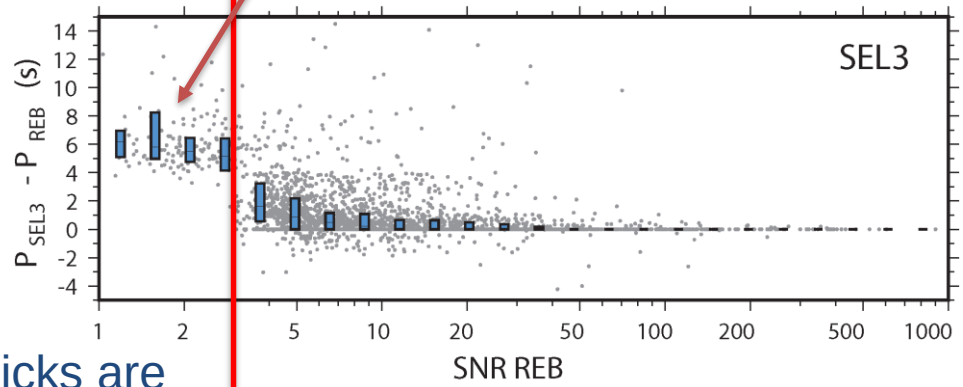
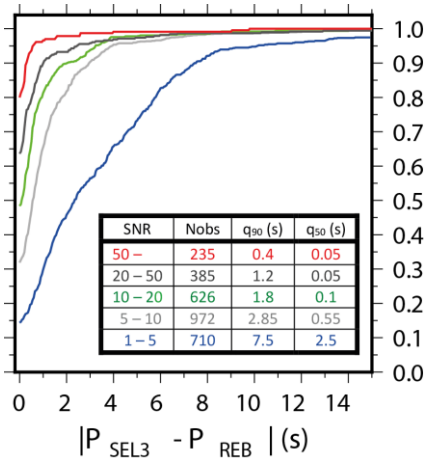
EMF evaluation results

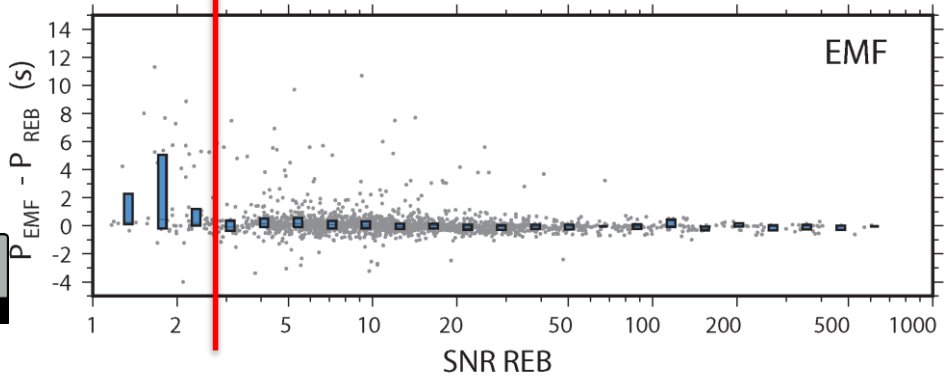
Differences of SEL3 and EMF arrival times relative to REB

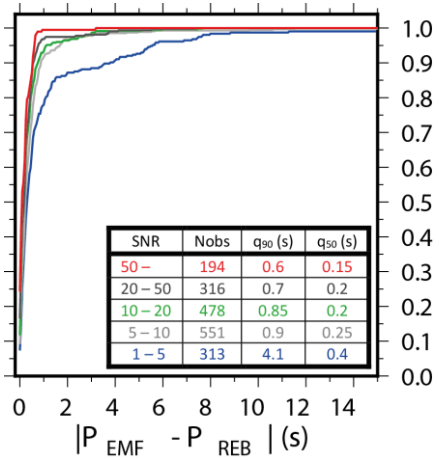
SEL3 has no SNR<3: These are phase IDs of later phases reassigned by the analyst to weak first arrival





(2) EMF picks are closer to REB picks





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Summary

- For the NEPAL earthquake sequence false event definitions are of minor concern
- The automatic EMF-based processing algorithm is picking up 50-60% of the events found in the REB. Those not found have low number of associated arrivals in REB.
- For matched events, the EMF-based processing algorithm is performing significantly better than the current automatic processing algorithms used at CTBTO, as reported in the SEL3. This applies both to location accuracy and onset time estimates.
- Application of the EMF-based processing methodology is likely to provide a more accurate starting point for the human analyst, and thus reduce the labor burden.
- Other aftershock sequences are under investigation.

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