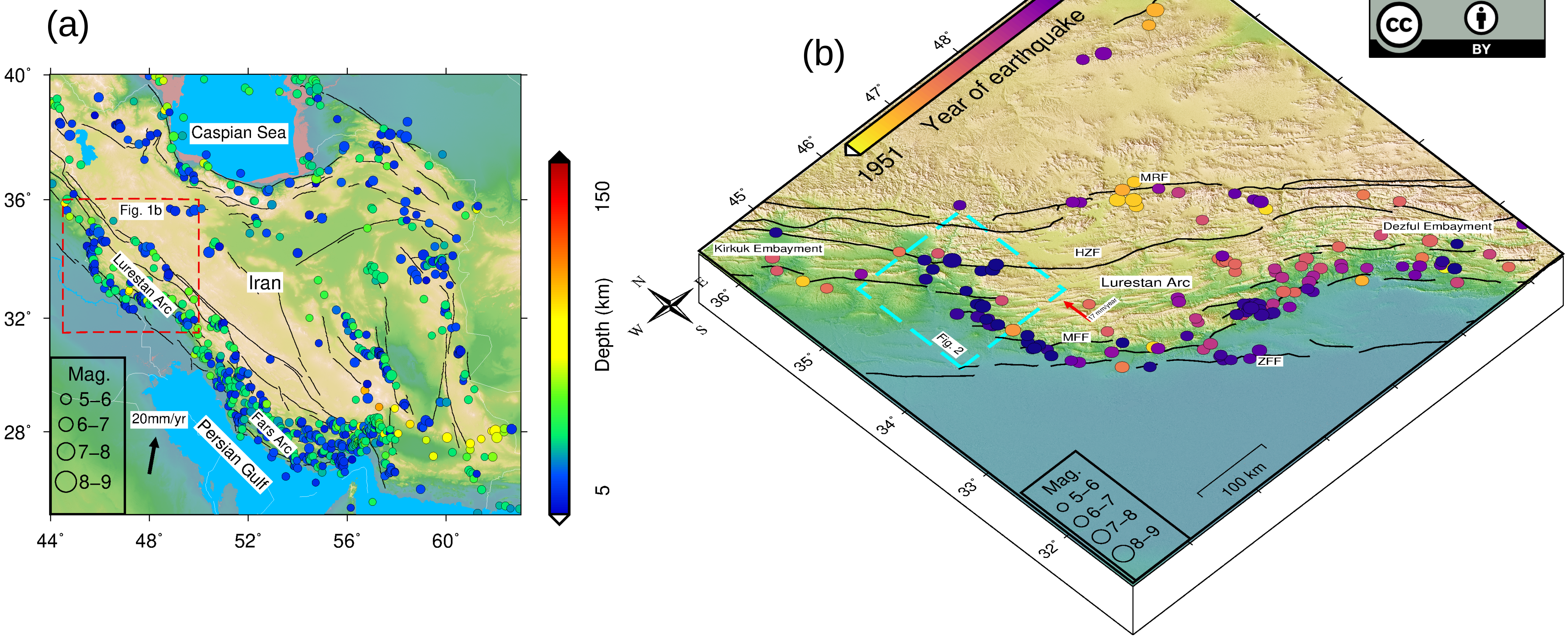
The 2017 November 12 Mw 7.3 Sarpol-Zahab (Iran-Iraq border region) earthquake: source model, aftershock sequence, and earthquakes triggering

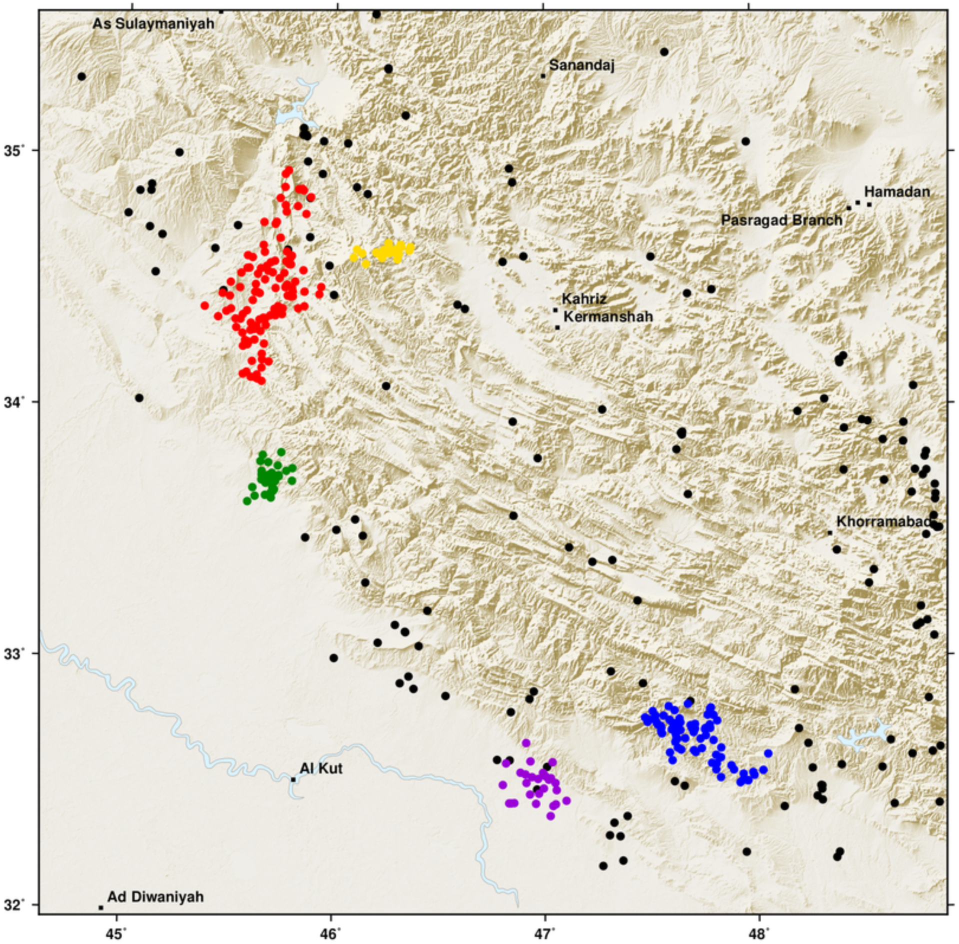
Mohmmadreza Jamalreyhani[1], Mehdi Rezapour[1], Simone Cesca[2], Sebastian Heimann[2], Hannes Vasyura-Bathke[3], Henriette Sudhaus[2,4], Marius Paul Isken[2,4] and Torsten Dahm[2,3]

[1] Institute of geophysics, University of Tehran, Iran
[2] GFZ German research centre for geosciences, Potsdam, Germany
[3] Institute for Geosciences University of Potsdam, Germany
[4] Christian-Albrechts-University Kiel, Department of Geosciences, Kiel, Germany

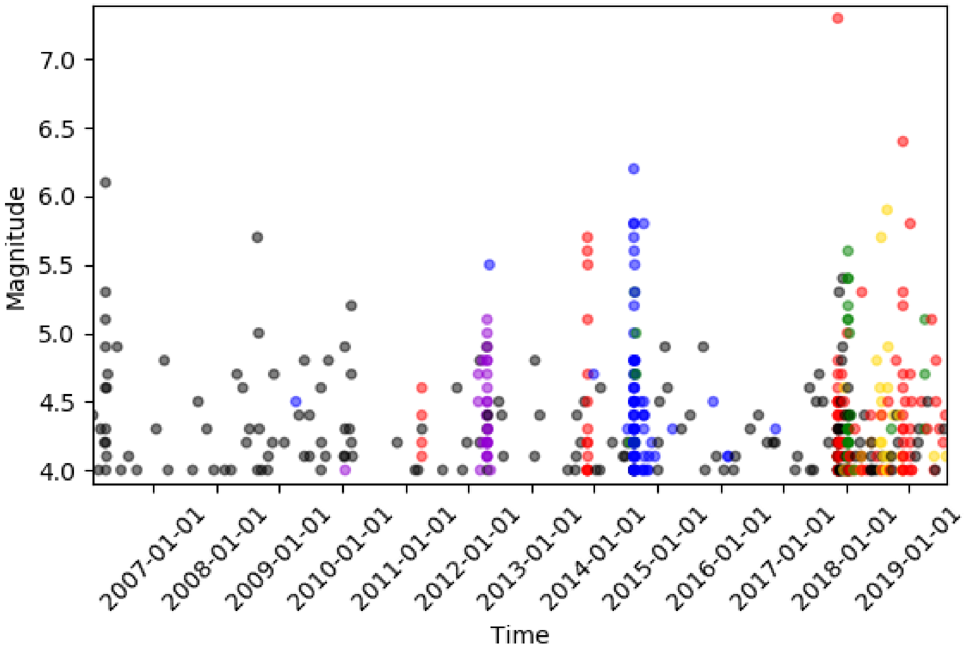
Introduction



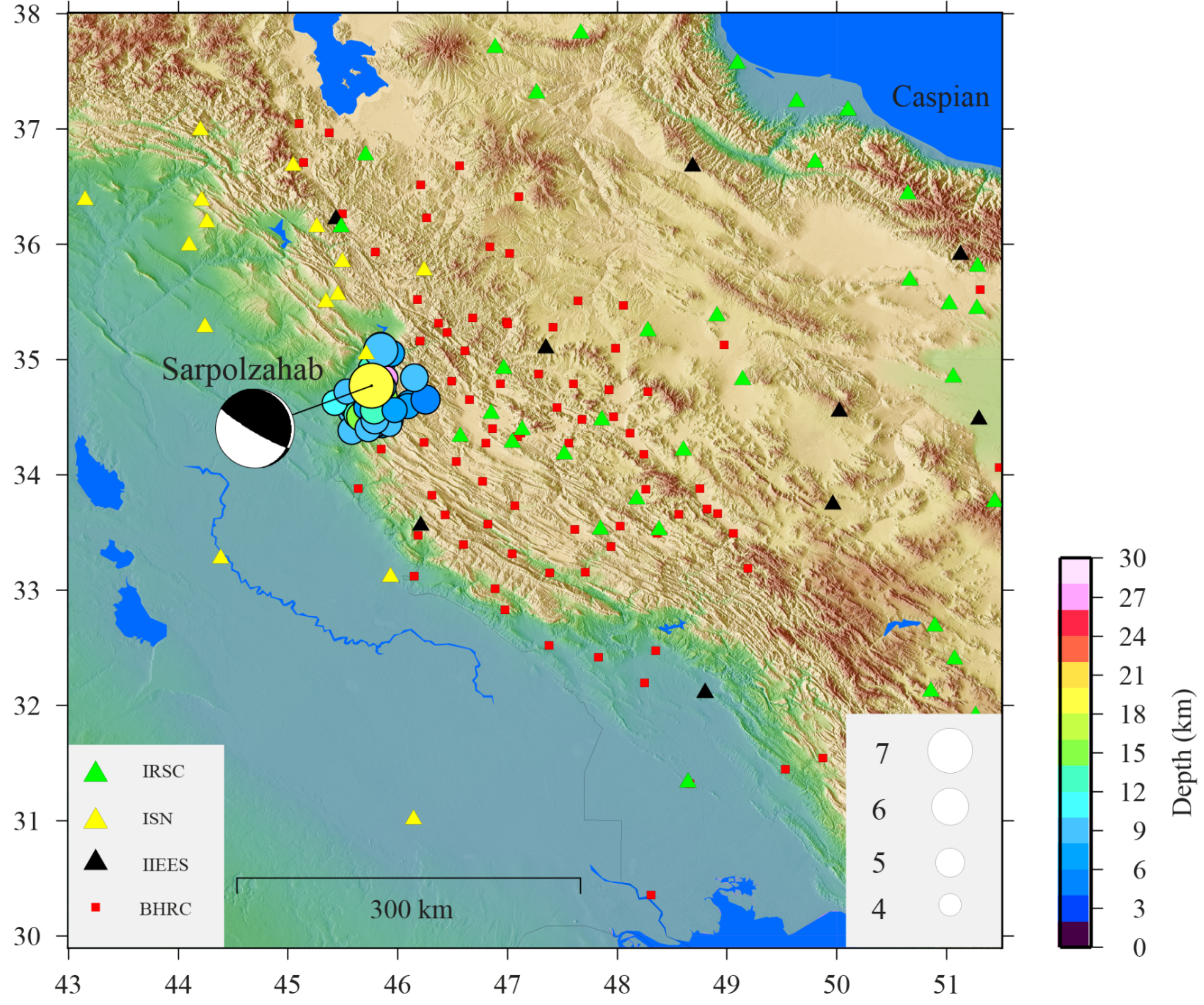
a) Seismicity of the Iran (1905-2020 form USGS catalog, M 5+). b) The Lurestan arc of the Zagros (seismicity during 1951-2019, M 5+). MRF: Main Recent Fault, HZF: High Zagros Fault, MFF: Montain Front Fault, ZFF: Zagros Foredeep Fault



Temporal evolution of seismicity clusters



L: Clustering of the Lurestan arc earthquakes (2006-2019, M 4+). R: Temporal evolution of seismicity clusters.

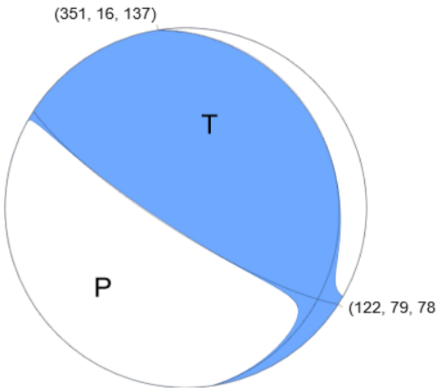


W-phase Moment Tensor (Mww)

Moment	1.124e+20 N-m
Magnitude	7.3 Mww
Depth	21.5 km
Percent DC	95 %
Half Duration	12.07 s
Catalog	US
Data Source	US[1]
Contributor	US[1]

Nodal Planes

Plane	Strike	Dip	Rake
NP1	351°	16°	137°
NP2	122°	79°	78°



USGS

EGU General Assembly 2020

Location of the 2017 Sarpolzahab Mw 7.3 E.Q. and station distribution

Result of the previous co-seismic studies on 2017 Mw 7.3 Sarpolzahab Earthquakes

Source	Data	Method	Strike	Dip	Rake	Depth (km)	Seismic Moment (NM)	Mw	Number of Asperity	Max Slip (m)	V (Km/Sec)
GFZ	Global waveforms	Waveform Modeling	349	17	136	25	9.7e+19	7.3	-	-	-
GCMT	Global waveforms	Waveform Modeling	351	11	140	17.9	1.6e+20	7.4	-	-	-
USGS	Global W phase	W-Phase	351	16	137	21.5	1.12e+20	7.3	-	-	-
USGS	Global body waves	Waveform Modeling	33	19	178	19	1.12e+20	7.3	-	-	-
Kobayashi et al. (2017)	ALOS-2	InSAR	-	-	-	-	1.4e+20	7.3	1	3	-
Barnhart et al. (2018)	Sentinel-1A/B	InSAR	351	15	128	12-22	1.09e+20	7.3	2	5	-
Kuang et al. (2018)	ALOS-2, Sentinel-1A/B	DInSAR	353.5	16.3	137	10-17	1.01e+20	7.3	1	3.8	-
Feng et al. (2018)	ALOS2, Sentinel-1, RADARSAT-2	InSAR	353.5	14.5	141.5	14.5±4	1.08e+20	7.3	2	6	-
Ding et al. (2018)	Teleseismic, ALOS-2, Sentinel-1A/B	Joint inversion of InSAR and Teleseismic waveform	354.7	16.3	137.3	15-20	1.10e+20	7.3	2	5	2.5
Vejrdian et al. (2018)	Alos-2, Sentinel-1	InSAR	354.4	17.5	141.5	14-20	1.06e+20	7.3	1	5	-
Chensheng et al. (2018)	Sentinel-1A	InSAR	356	17	126.4	20	1.16e+20	7.34	2	2.5	-
Chen et al. (2018)	Teleseismic, ALOS-2, Sentinel-1	Joint inversion of Teleseismic and InSAR	351	15	135	15	1.35e+20	7.4	1	5	1.5 and 3.2
Yang et al. (2018)	ALOS-2, Sentinel-1	InSAR	337.5	11.2	135	11-14	1.34e+20	7.36	2	4.9	-
Nissen et al. (2019)	Teleseismic and Sentinel-1A/B	Backprojection and InSAR	353.5	15	128	12-18	1.09e+20	7.3	2	5-6	2
Gombert et al. (2019)	Sentinel-1, Strong motion	Joint inversion of the strong motion and InSAR	351	14	131.5	13	-	-	1	5.5±5	3±0.25
USGS (first update)	Teleseismic P wave	Finite Fault	352	16	137	25	1.3e+20	7.3	1	6	-
USGS (second update)	Teleseismic P wave	Finite Fault	352	16	137	15	1.3e+20	7.3	2	6	-
Yin et al.	Teleseismic P wave	multi-time window	351	16	125	25	0.9e+20	7.3	1	5.2	2.6

Motivations of this study:

1- The coseismic slip distribution of the 2017 Mw 7.3 has been further investigated by several dedicated studies but different researchers have presented different results for the rupture process of this earthquake.

2- Earthquake faulting and seismicity of the Lurestan arc need more detailed study and interpretation.

3- In this study, we complement previous studies for the Mw 7.3 and we analyze the aftershocks sequence of this event.

4- We apply joint inversion technique by InSAR, teleseismic seismograms and strong motion data to image the rupture processes of the 2017 Mw 7.3 Sarpolzahab, the 2018 Mw 6.0 Tazehabad and 2018 Mw 6.4 Sarpolzahab earthquakes.

Aftershocks:

- 133 aftershocks exceeding Ml 4.0 until December 10, 2019.

- Due to occurrence of most aftershocks shortly after large mainshock, overlapping the waveform and coda of mainshock, most case can not be well filtered.

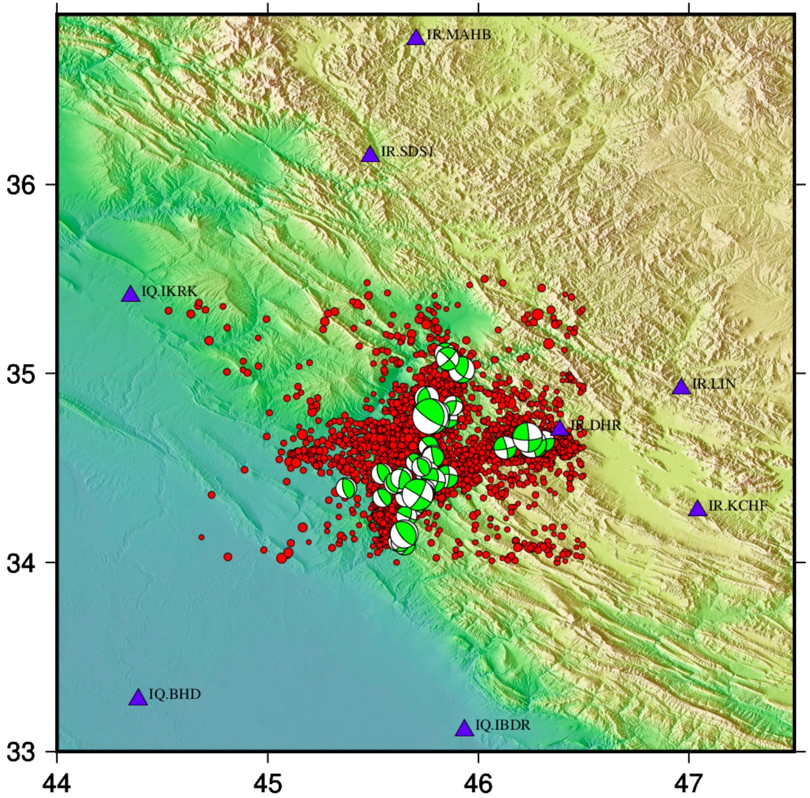
- Moment tensor inversion of the 75 aftershocks down to Ml 4.0 using Iran and Iraq networks.

-We use magnitude-dependent frequency filtering:

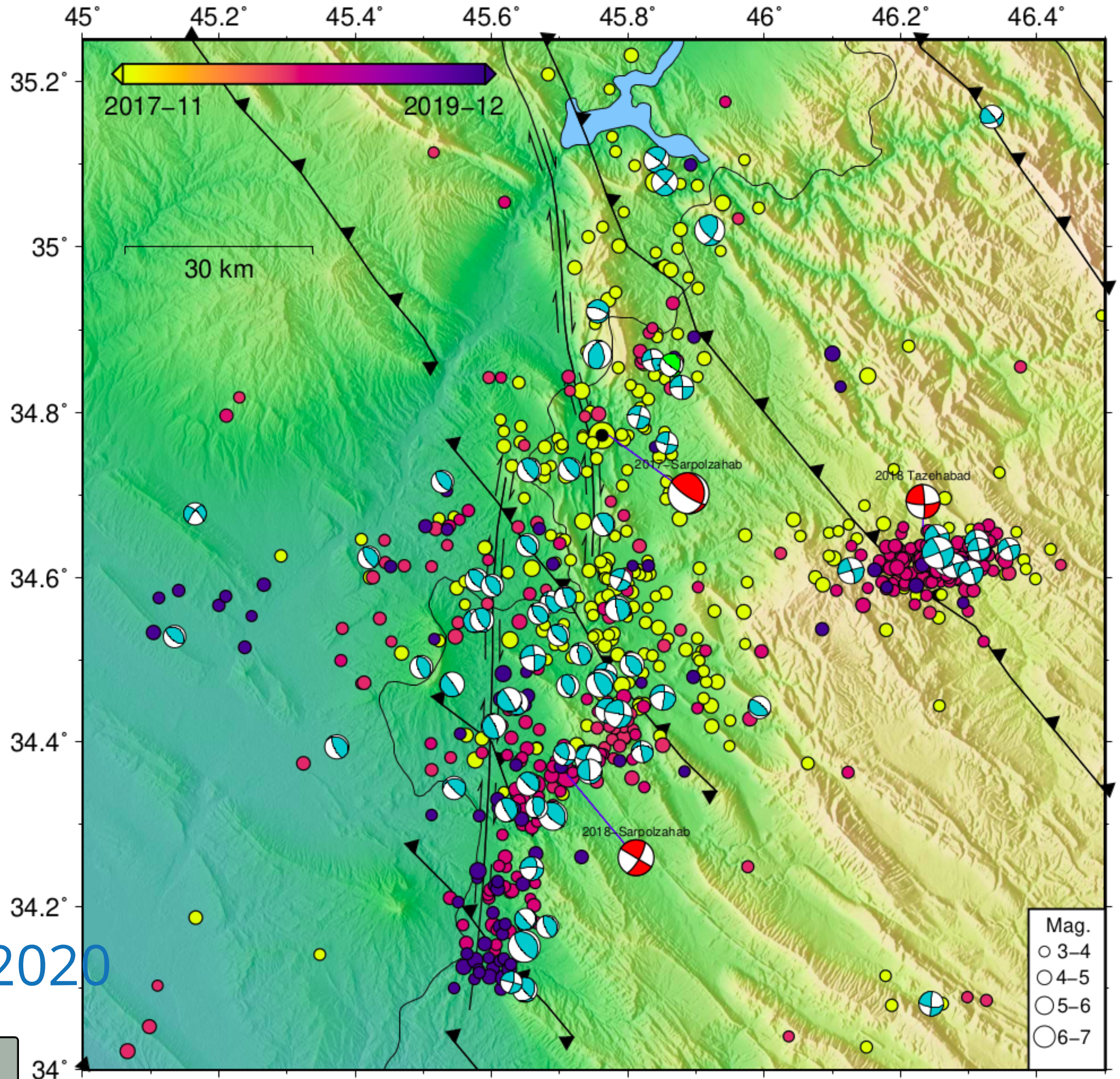
For 4.2<Ml<4.7 the bandpass filter is 0.03-0.07 Hz (14-33 sec)

For 4.8<Ml<5.7 bandpass is 0.02-0.05 Hz (20-50 sec)

For larger events (5 events), bandpass of 0.01-0.06 Hz (16-100 sec), tele

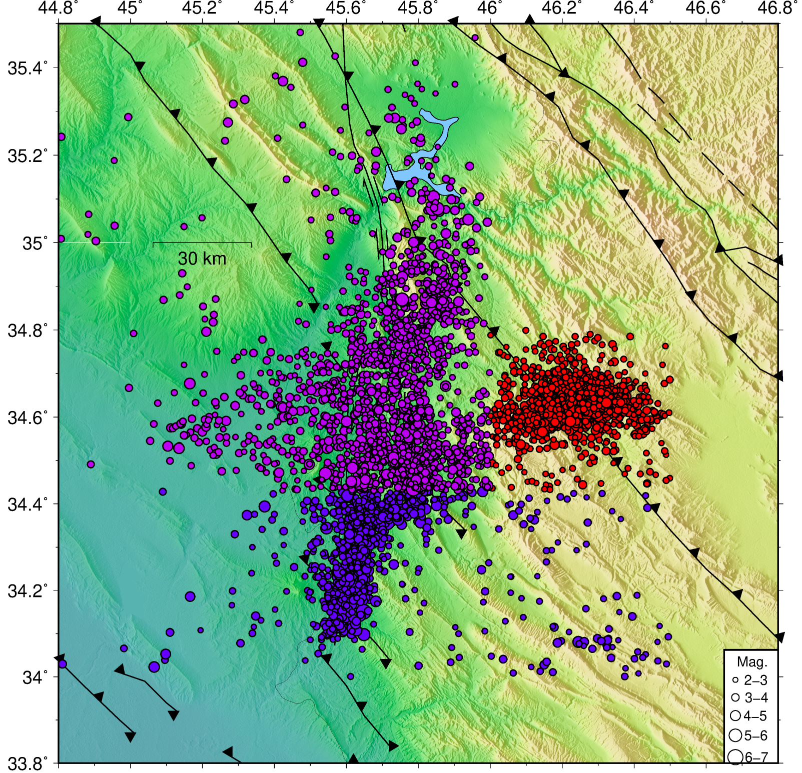


Study Area



Seismicity during Nov. 2017-Dec. 2019, Ml 3+, from IRSC catalog. Color scale show temporal evolution of the seismicity.
Three large earthquakes shown by red focal mechanism; **The 2017 Mw 7.3 Sarpolzahab, The 2018 Mw 6.0 Tazehabad and 2018 Mw 6.4 Sarpolzahab**. For these three events we apply finite fault model by combination of near-field strong motions along with InSAR surface deformation using probabilistic earthquake source inversion framework Grond (Heimann et al., 2018).

For all focal mechanism solutions (75 events Ml 4+) we apply the Grond (Heimann et al., 2018) using Iran and Iraq permanent seismic networks.



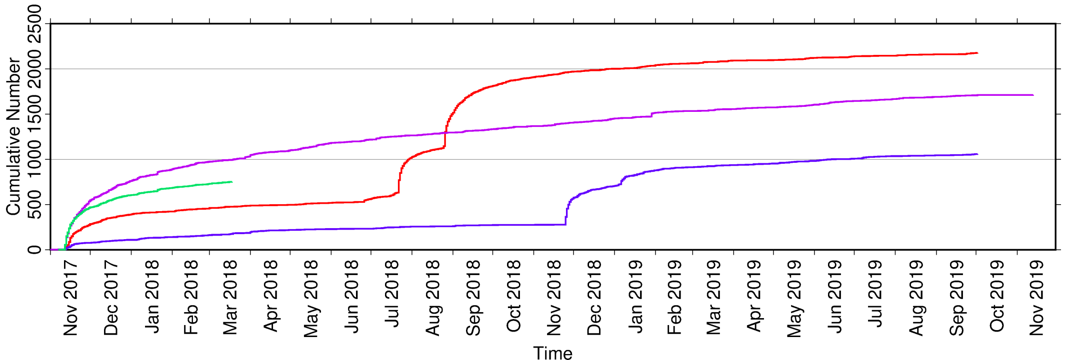
Cumulative number with temporal evolution of aftershocks in three clusters:

Purple: The 2017 Mw 7.3 and its aftershocks.

Red: The 2018 Mw 6.0 Tazehabad E.Q. (Activation just after the Mw 7.3 with small activity and later larger earthquakes of cluster occurred).

Blue: The 2018 Mw 6.4 E.Q.

Green: Aftershocks in Liu and Xu (2019) study.



EGU General Assembly 2020

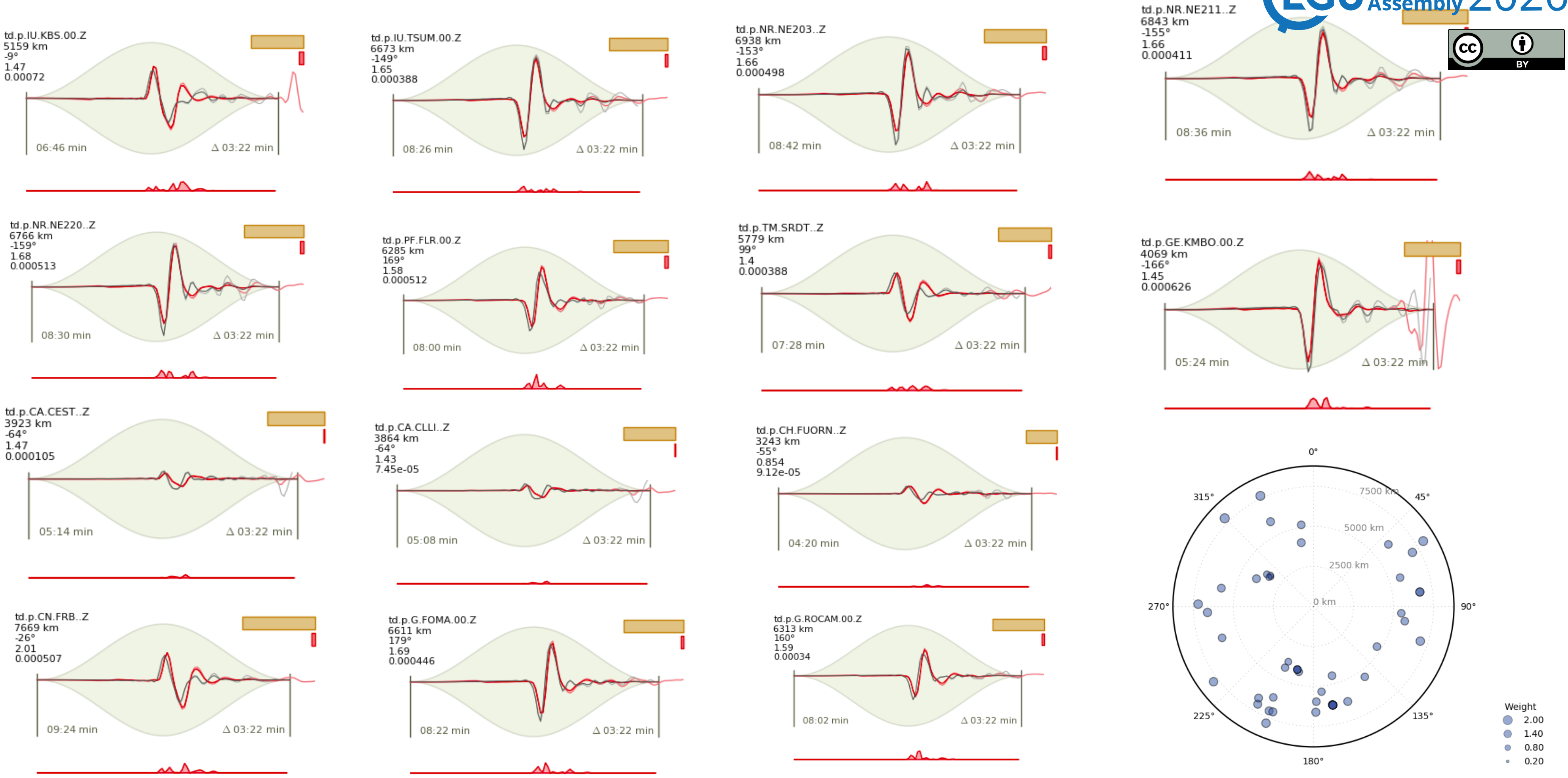
Source model for Mw 7.3 E.Q.:

By joint inversion of seismic and geodetic (InSAR) data with rectangular source model and uniform slip.

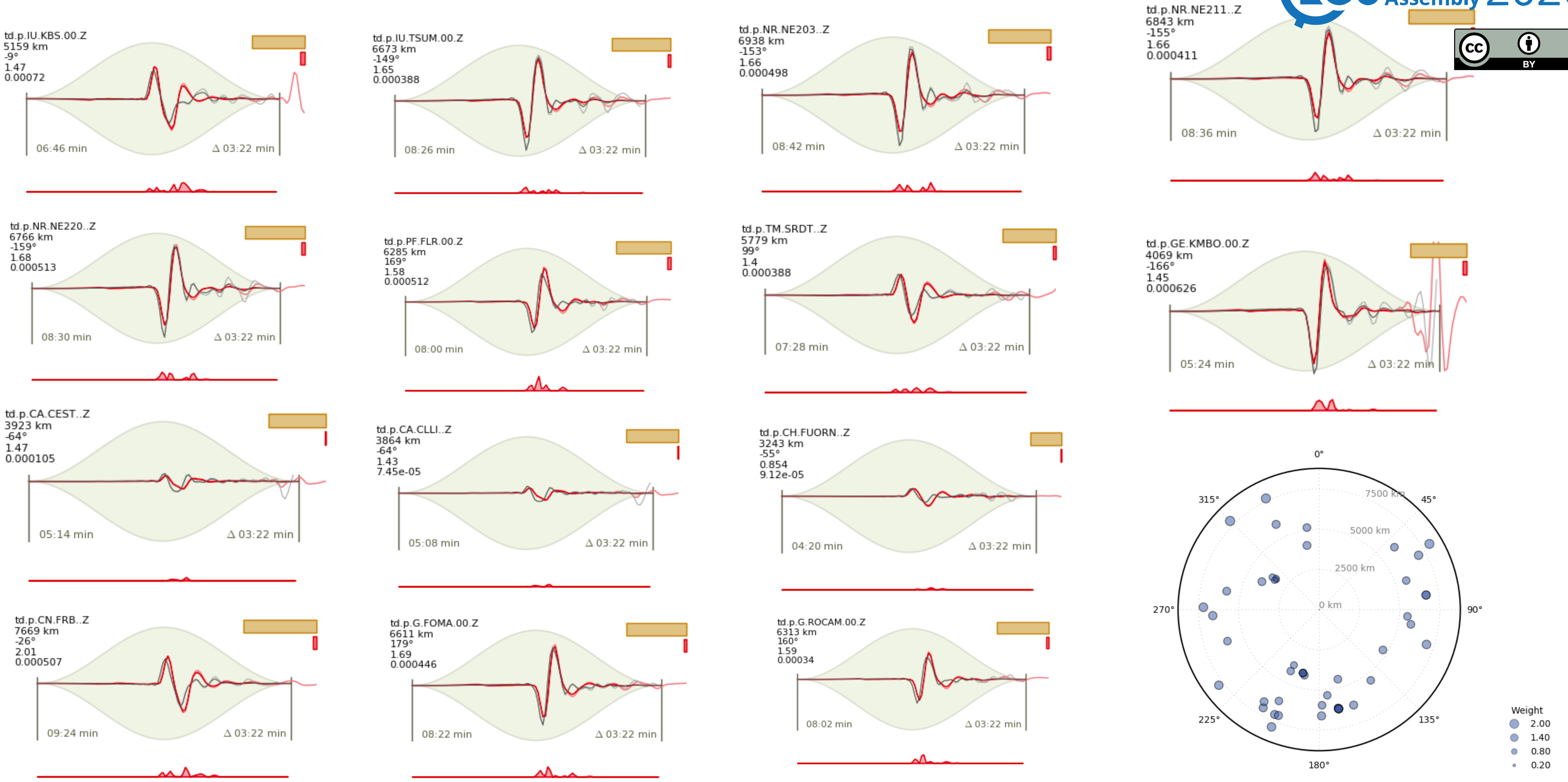
Using the open source software tool, **Grond (Heimann et al., 2018)**

Waveform fit for Mw 7.3 E.Q. in teleseismic distance (30-80 Degrees): P wave, 0.01-0.1 Hz.

EGU General Assembly 2020

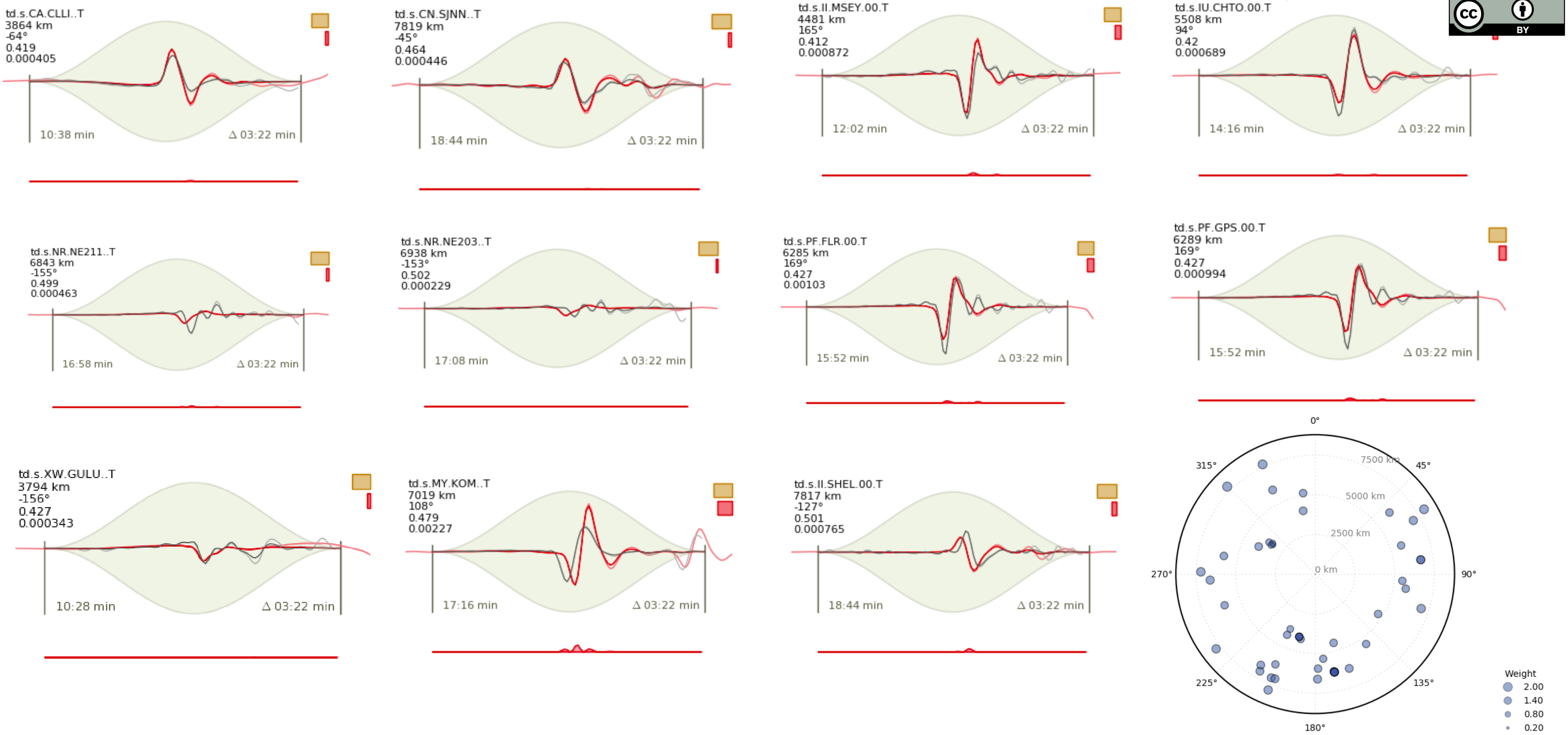


Waveform fit for Mw 7.3 E.Q. in teleseismic distance (30-80 Degrees): P wave, 0.01-0.1 Hz.

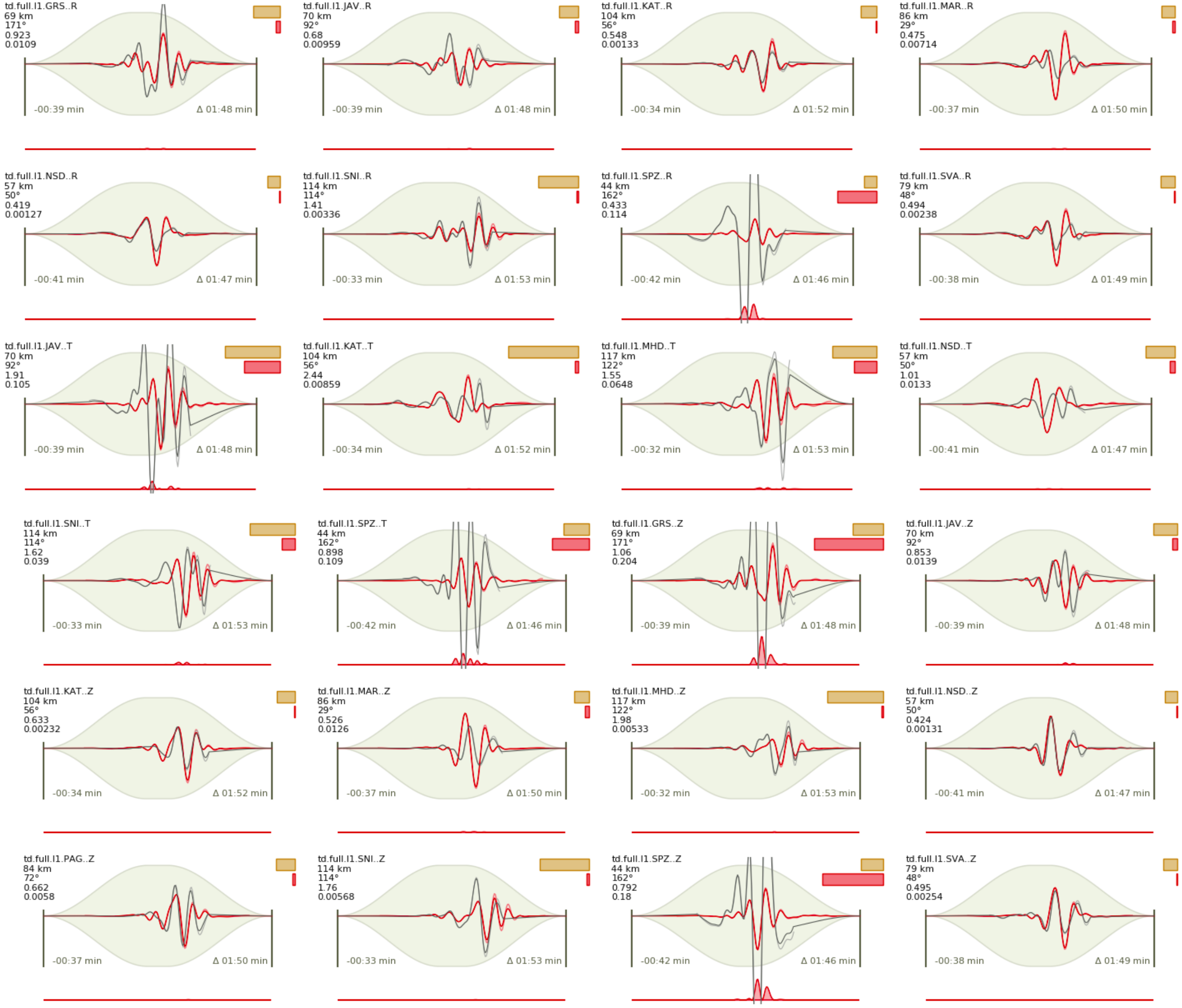


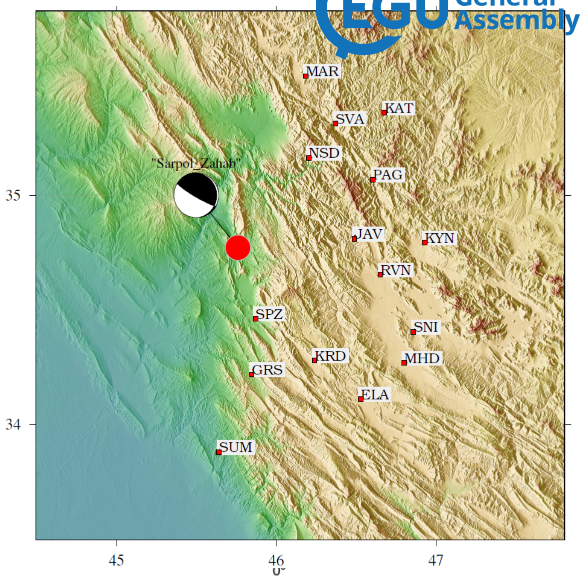
Waveform fit for Mw 7.3 E.Q. in teleseismic distance (30-80 Degrees): SH wave, 0.01-0.1 Hz.

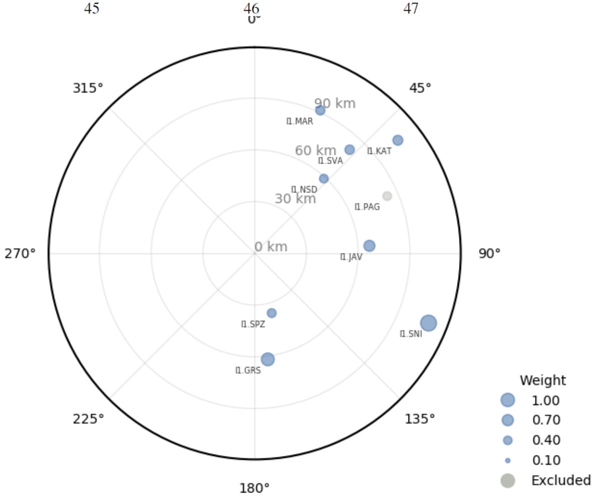
EGU General Assembly 2020



Strong motions fit: full waveform, all components, velocity and filtered in 0.05-0.15



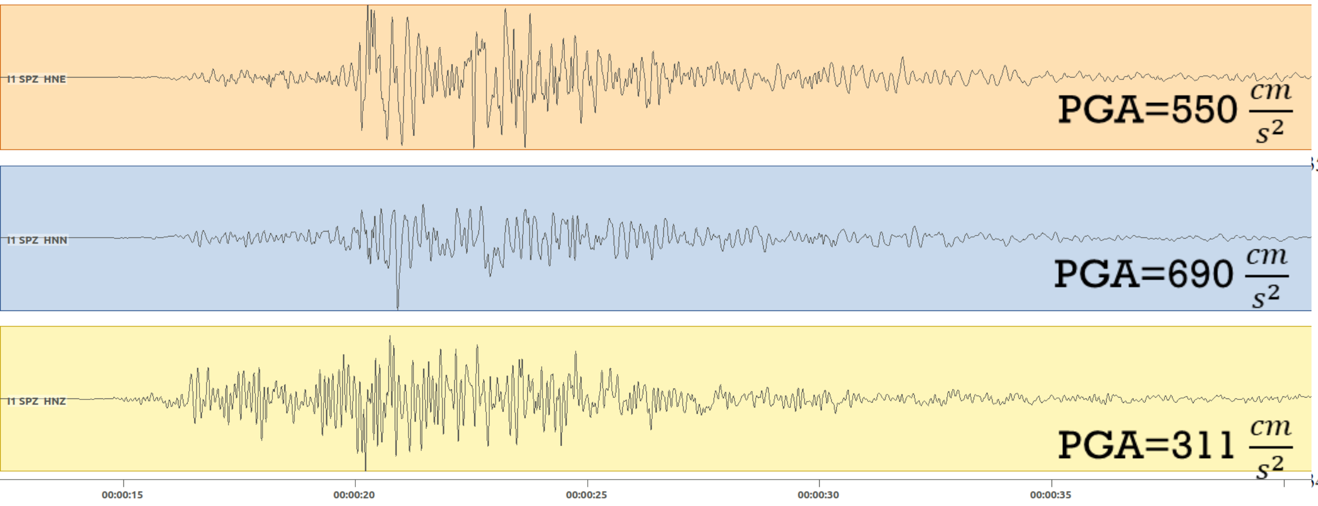


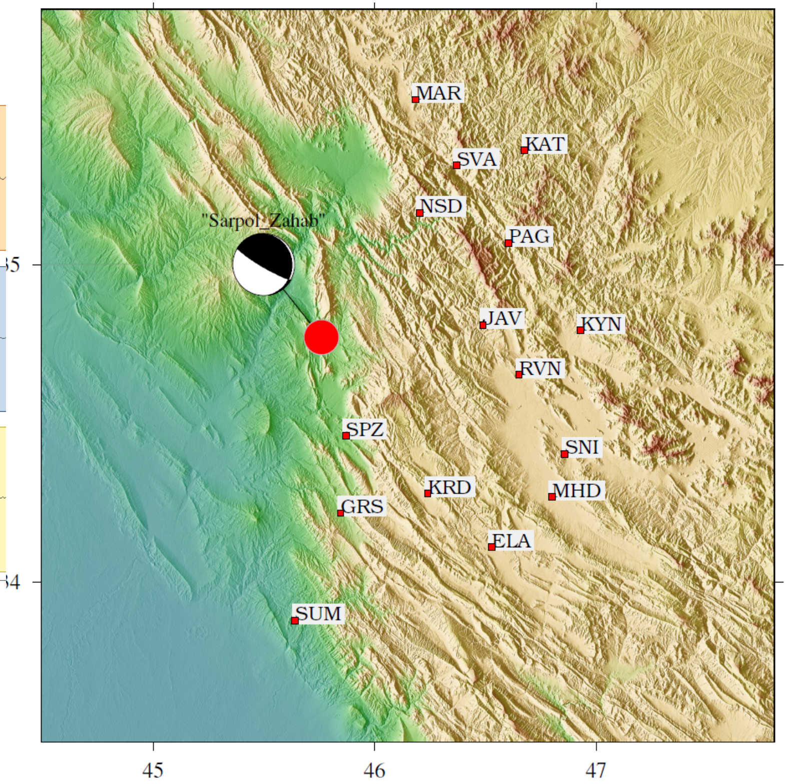


SPZ station

-At epicentral distance of the 40 km to the southeast of the main shock.

- Recorded the maximum PGA

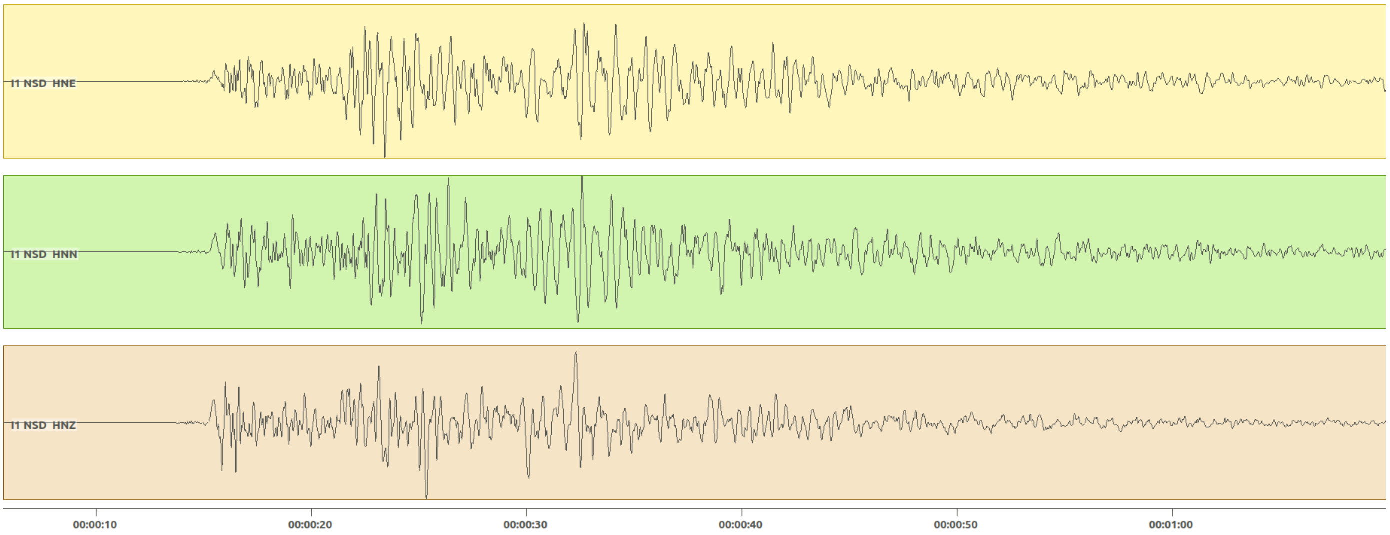


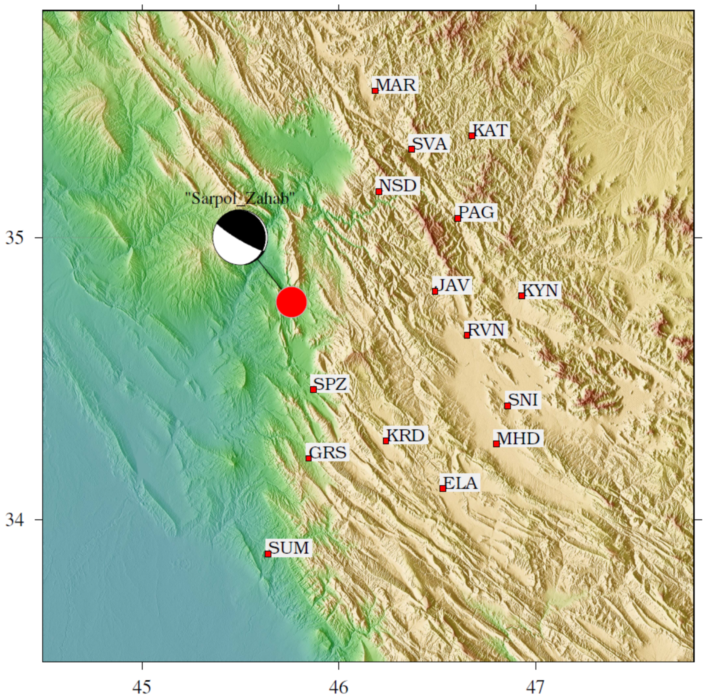


NSD station

-Epicentral distance of 45 km to the northwest of the Mainshock

- Maximum PGA 55 on Z component

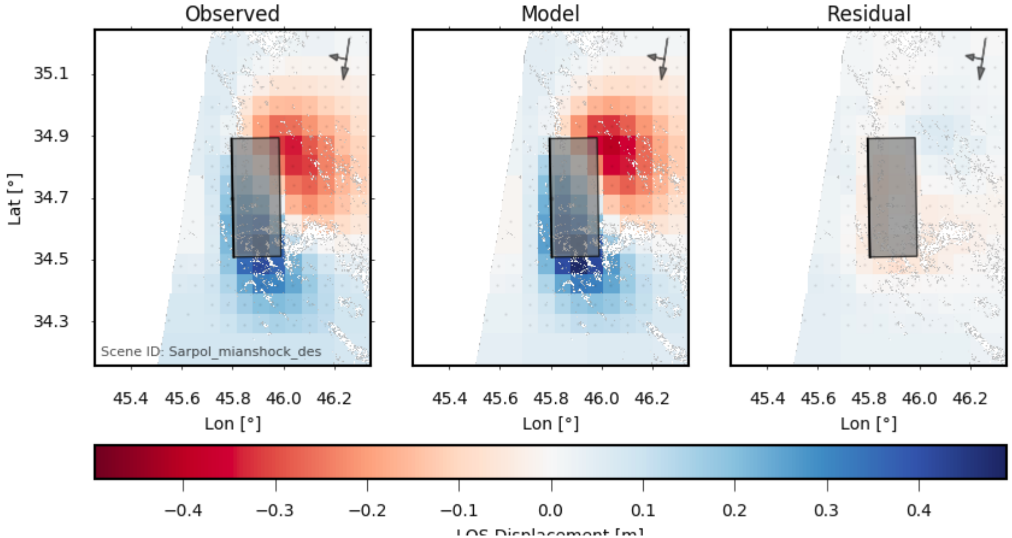


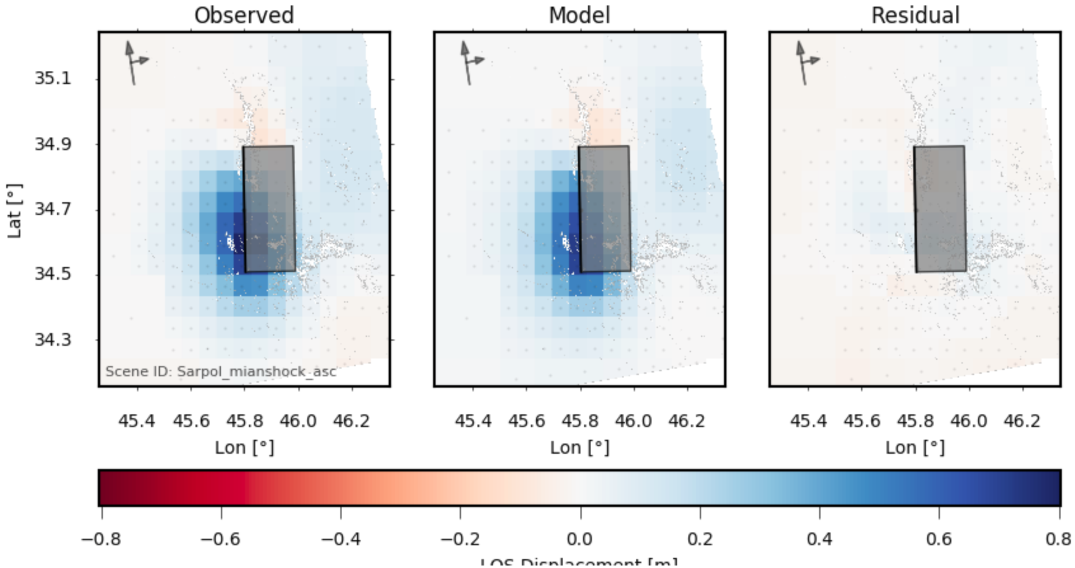


InSAR modeling:

Ascending track: 2017-10-02_2017-12-01

Descending track: 2017-10-2_2017-12-01

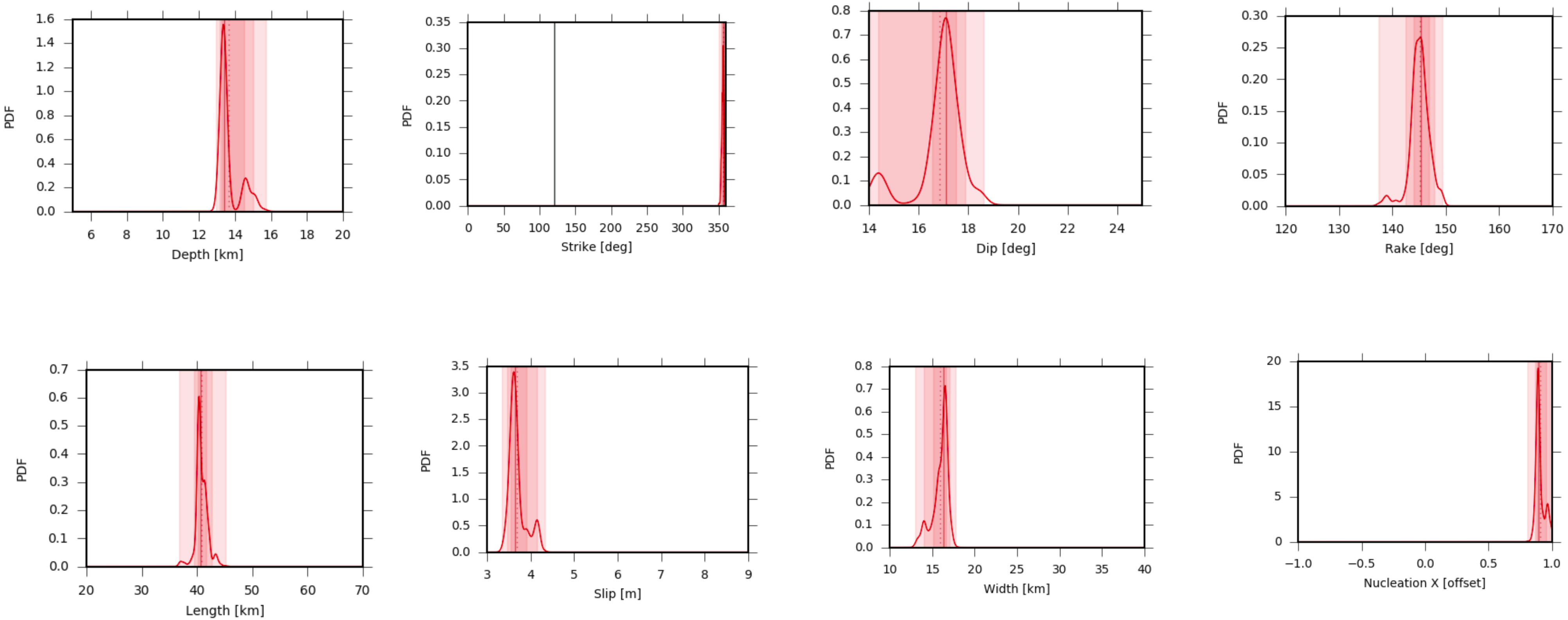




EGU General Assembly 2020

Distribution of the some source parameters:

EGU General Assembly 2020



Conclusion:

EGU General Assembly 2020

1- The 2017-2018 earthquakes sequence in the Lurestan arc, activated low-angle thrust faults and shallower strike-slip structures.

2- Both thin- and thick-skin deformation take place in the fold-thrust belts in the Lurestan arc of the Zagros.

3- Most of aftershocks of 2017-2018 Sarpolzahab and Tazehabad earthquakes have shallow centroid depths between 5 and 12 km, so that they occurred in the uppermost part of the basement and/or in the lower sedimentary cover.

4- We found the new evidence for activation of the ~NS right-lateral strike-slip Khanaqin fault, and another hitherto unknown ~EW left-lateral strike-slip fault, herein termed as Tazehabad fault.

Thank You