Towards comprehensive probabilistic tsunami hazard assessment in the Arabian and Red Seas and in Persian Gulf

Andrey Babeyko

German Centre for Geosciences GFZ, Potsdam, Germany

From Summary

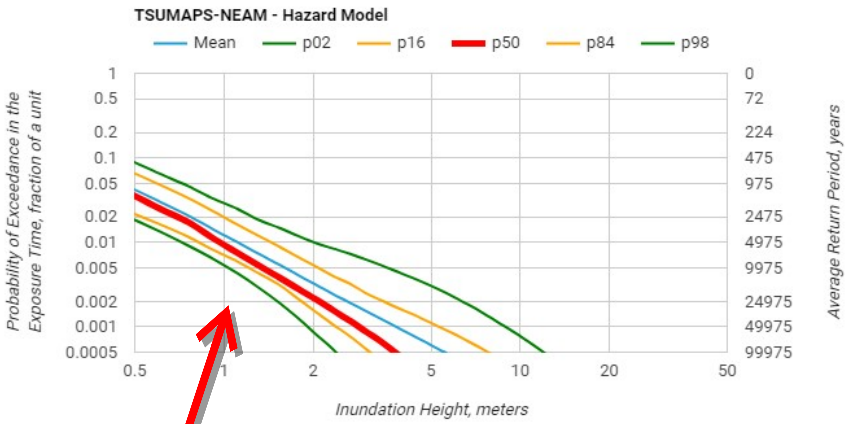
of Session-3 *“Tsunami Hazard Assessment in the Makran Subduction Zone”*
during Expert Consultation Meeting, Kish Island, Iran, 08.03.2019

Future Priorities:

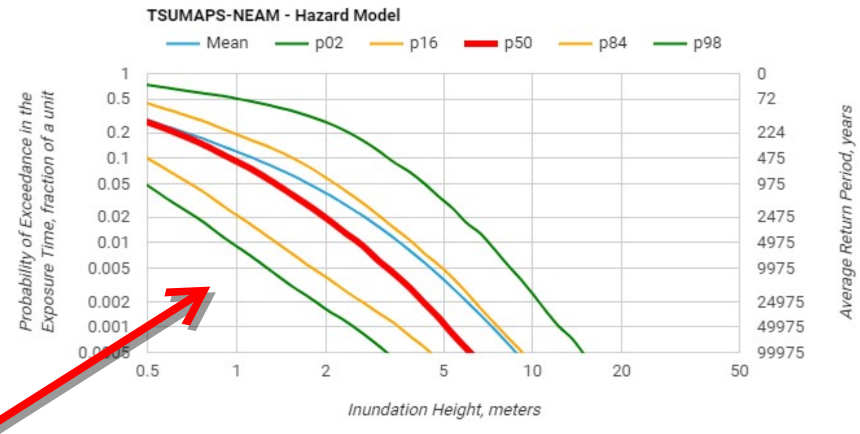
- Produce a probabilistic tsunami hazard assessment for the Makran region.
- Undertake tsunami risk assessments in coasts bordering the Makran region incorporating available data on vulnerability and exposure.
- Constrain the run-up and inundation using the 1945 event and produce a database.
- Reach a consensus on the seismic character of the Western Makran subduction zone.
- Encourage field studies in the Makran (and Persian Gulf) region including geophysical (e.g. seismic and geodesy) and geological (e.g. paleo-tsunami studies).

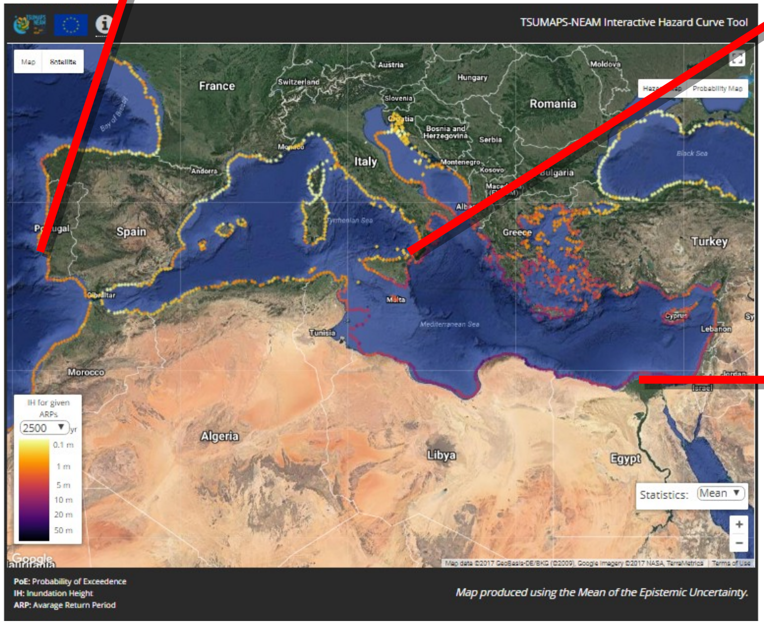
http://tsumaps-neam.eu

Lisbon, Portugal

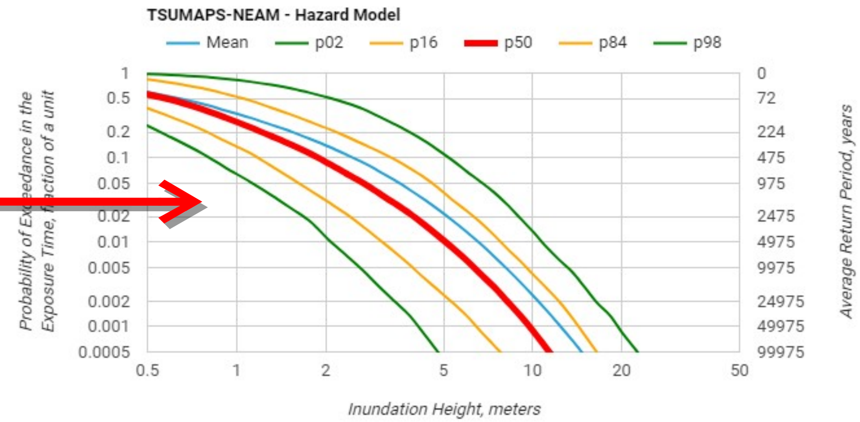


Messina, Italy



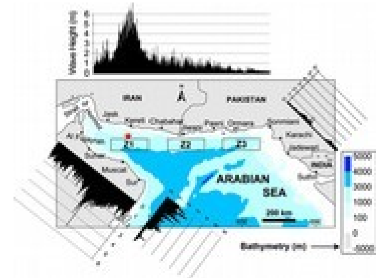


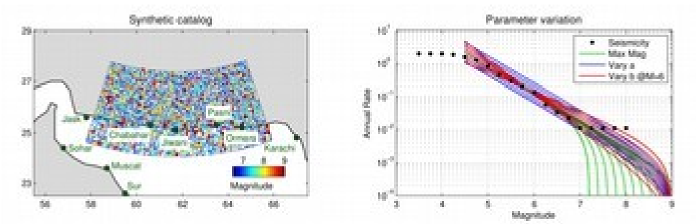
Alexandria, Egypt



Previous PTHA studies in the Makran region

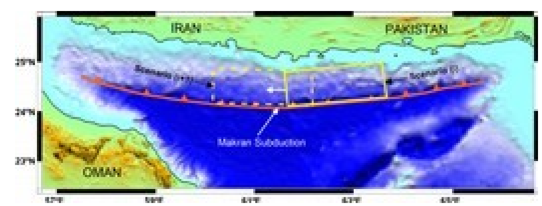
Heidarzadeh & Kijko (2011)
A probabilistic tsunami hazard assessment for the Makran subduction zone at the northwestern Indian Ocean
Nat Hazards (2011) 56:577–593 (doi: 10.1007/s11069-010-9574-x)

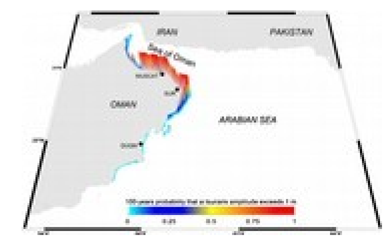


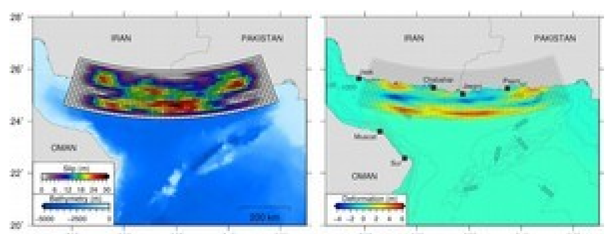


Hoechner et al. (2016)
Probabilistic tsunami hazard assessment for the Makran region with focus on maximum magnitude assumption.
Nat. Hazards Earth Syst. Sci., 16, 1339–1350 (doi: 10.5194/nhess-16-1339-2016)

El-Hussain et al. (2016)
Probabilistic tsunami hazard assessment along Oman coast from submarine earthquakes in the Makran subduction zone
Arab J Geosci (2016) 9: 668 (doi: 10.1007/s12517-016-2687-0)

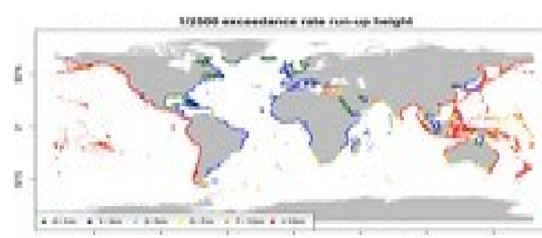






Rashidi et al. (2018)
Tsunami hazard assessment in the Makran subduction zone
ArXiv:1803.11481v1 [physics.geo-ph] 30 Mar 2018

Davies et al. (2017)
A global probabilistic tsunami hazard assessment from earthquake sources
Geological Society, London, Special Publications, 456, https://doi.org/10.1144/SP456.5,



Arabian Journal of Geosciences (2018) 11: 435
https://doi.org/10.1007/s12517-018-3797-7

ORIGINAL PAPER

CrossMark

Developing a seismic source model for the Arabian Plate

I. El-Hussain[1] • Y. Al-Shijbi[1] • A. Deif[1,2] • A. M. E. Mohamed[1,2] • M. Ezzelarab[1,2]

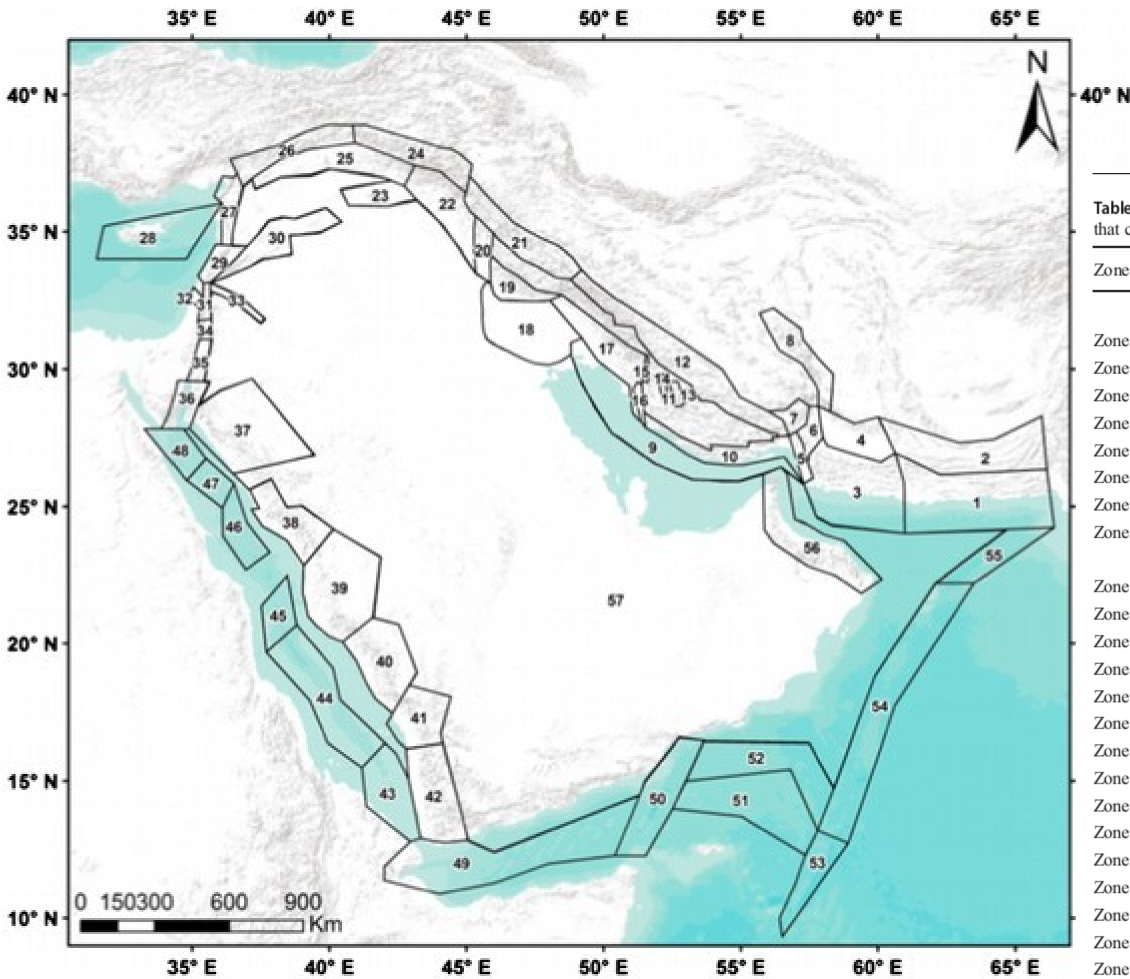
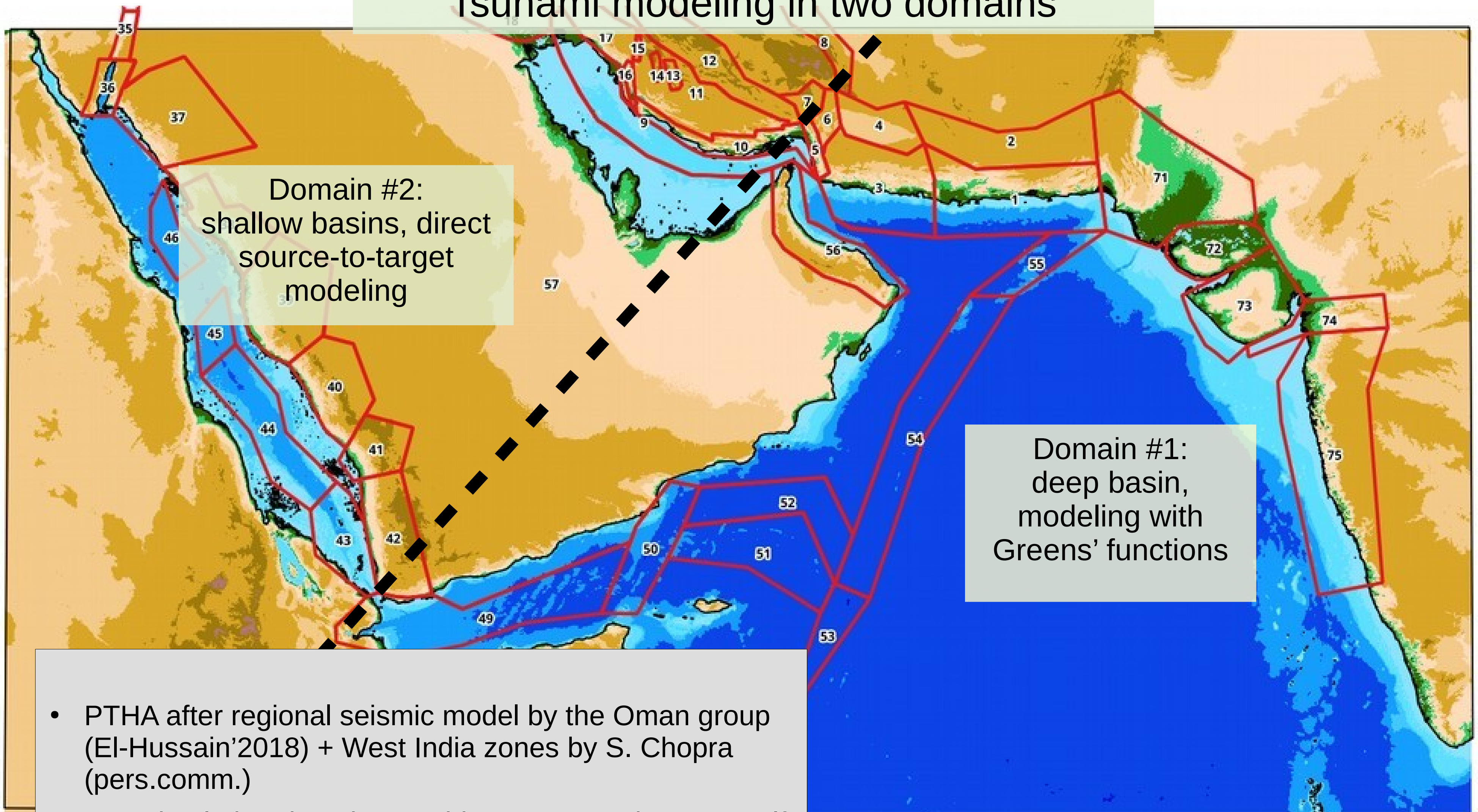


Table 1 Earthquake recurrence parameters for the delineated seismic sources. Italic font are the recurrence parameters for t[...]
that contains the delineated seismic sources (All Makran, All Zagros, All Gulf of Aqaba-Dead Sea Fault, All Red Sea, All A[...]

Zone No.	Zone Name	M_{max}	σ M_{max}	M_{min}	M_{max}obs	β	σβ	b	σb
	All Makran	*8.4*	*0.27*	*4*	*8.1*	*1.67*	*0.07*	*0.73*	*0.03*
Zone 1	Makran East	8.4	0.1	4	8.1	1.57	0.14	0.68	0.06
Zone 2	Makran Intraplate	7.8	0.3	4	7.3	1.49	0.16	0.65	0.06
Zone 3	Makran West	6.2	0.23	4	5.9	1.65	0.19	0.72	0.08
Zone 4	Jaz Murian	6.8	0.82	4	6.1	1.56	0.2	0.68	0.09
Zone 5	Zendan Fault	6.3	0.22	4	6.1	1.30	0.2	0.57	0.09
Zone 6	Jiroft Fault	6.0	0.14	4	5.8	1.70	0.17	0.74	0.07
Zone 7	Ali Abad	6.8	0.18	4	6.6	1.52	0.14	0.66	0.06
Zone 8	Gowk Fault	7.5	0.34	4	7.2	1.68	0.13	0.73	0.06
	All Zagros	*7.5*	*0.12*	*4*	*7.4*	*1.84*	*0.04*	*0.8*	*0.02*
Zone 9	Arabian Gulf	6.2	0.26	4	6.1	1.74	0.16	0.76	0.07
Zone 10	Zagros Foredeep	6.8	0.21	4	6.7	1.83	0.11	0.79	0.05
Zone 11	Zagros Simple Fold	6.9	0.21	4	6.8	1.82	0.07	0.79	0.03
Zone 12	High Zagros	7.6	0.24	4	7.4	1.75	0.1	0.76	0.04
Zone 13	Sabz Pushan Fault	6.3	0.34	4	6.1	1.69	0.19	0.73	0.08
Zone 14	Karebas Fault	5.8	0.46	4	5.4	1.81	0.22	0.78	0.09
Zone 15	Kazerun Fault	6.0	0.21	4	5.9	1.60	0.19	0.69	0.08
Zone 16	Borazgan Fault	5.8	0.22	4	5.7	1.61	0.19	0.7	0.08
Zone 17	Dezful Embayment	6.8	0.12	4	6.7	1.86	0.1	0.81	0.04
Zone 18	Mesopotamia	6.5	0.3	4	6.4	2.15	0.18	0.93	0.08
Zone 19	MFF	6.4	0.22	4	6.3	1.59	0.15	0.69	0.06
Zone 20	Khanagin Fault	7.3	0.32	4	7.2	1.76	0.16	0.76	0.07
Zone 21	Posht-E Kuh Arc	7.0	0.31	4	6.9	1.86	0.14	0.81	0.06
Zone 22	Kirkuk Embayment	6.6	0.3	4	6.5	1.68	0.17	0.73	0.07
Zone 23	Abdelaziz-Sinjar	5.4	0.36	4	5.2	1.91	0.22	0.83	0.1
Zone 24	Bitilis	6.9	0.32	4	6.8	1.91	0.2	0.83	0.09
Zone 25	Karacadag Extension	6.9	0.31	4	6.8	1.72	0.23	0.75	0.1

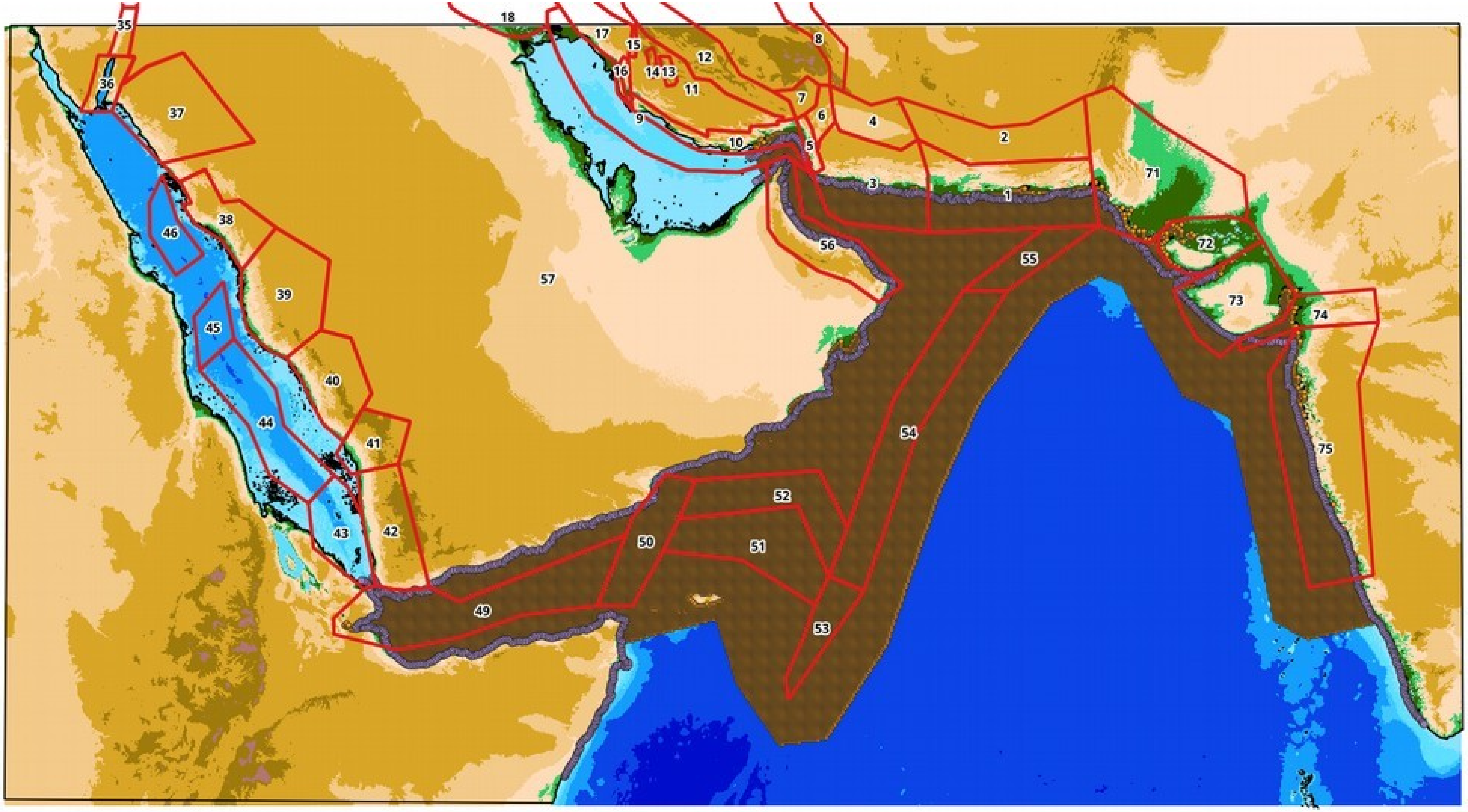
Probabilistic Tsunai Hazard Assessment extended over the whole region and all earthquake sources

Tsunami modeling in two domains

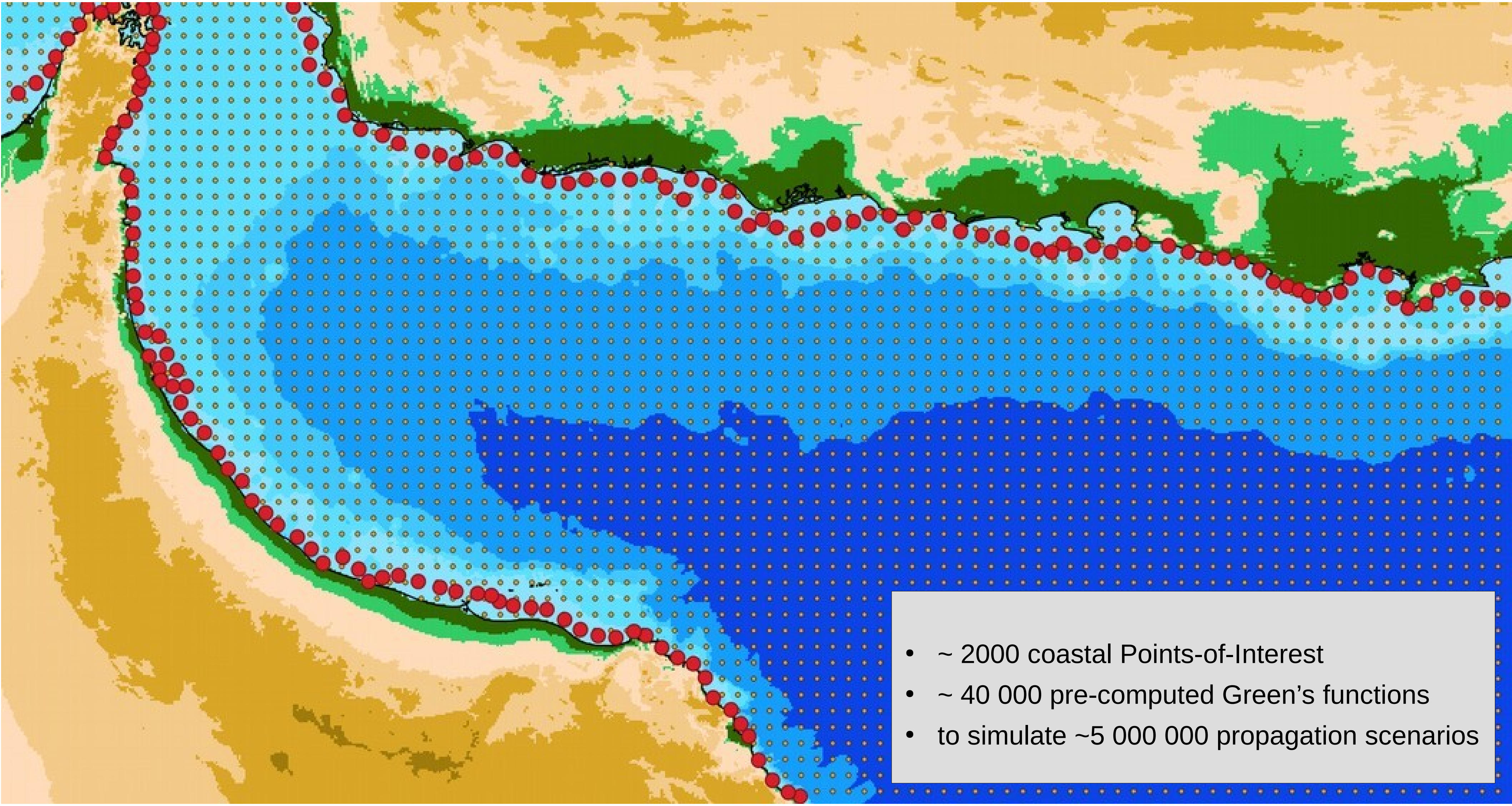


- PTHA after regional seismic model by the Oman group (El-Hussain’2018) + West India zones by S. Chopra (pers.comm.)
- Two simulation domains: Arabian Sea + Red Sea & Gulf
- ~ 2000 coastal Points-of-Interest
- ~ 40 000 pre-computed Green’s functions
- to simulate ~5 000 000 propagation scenarios

Greens’ functions area and coastal POIs

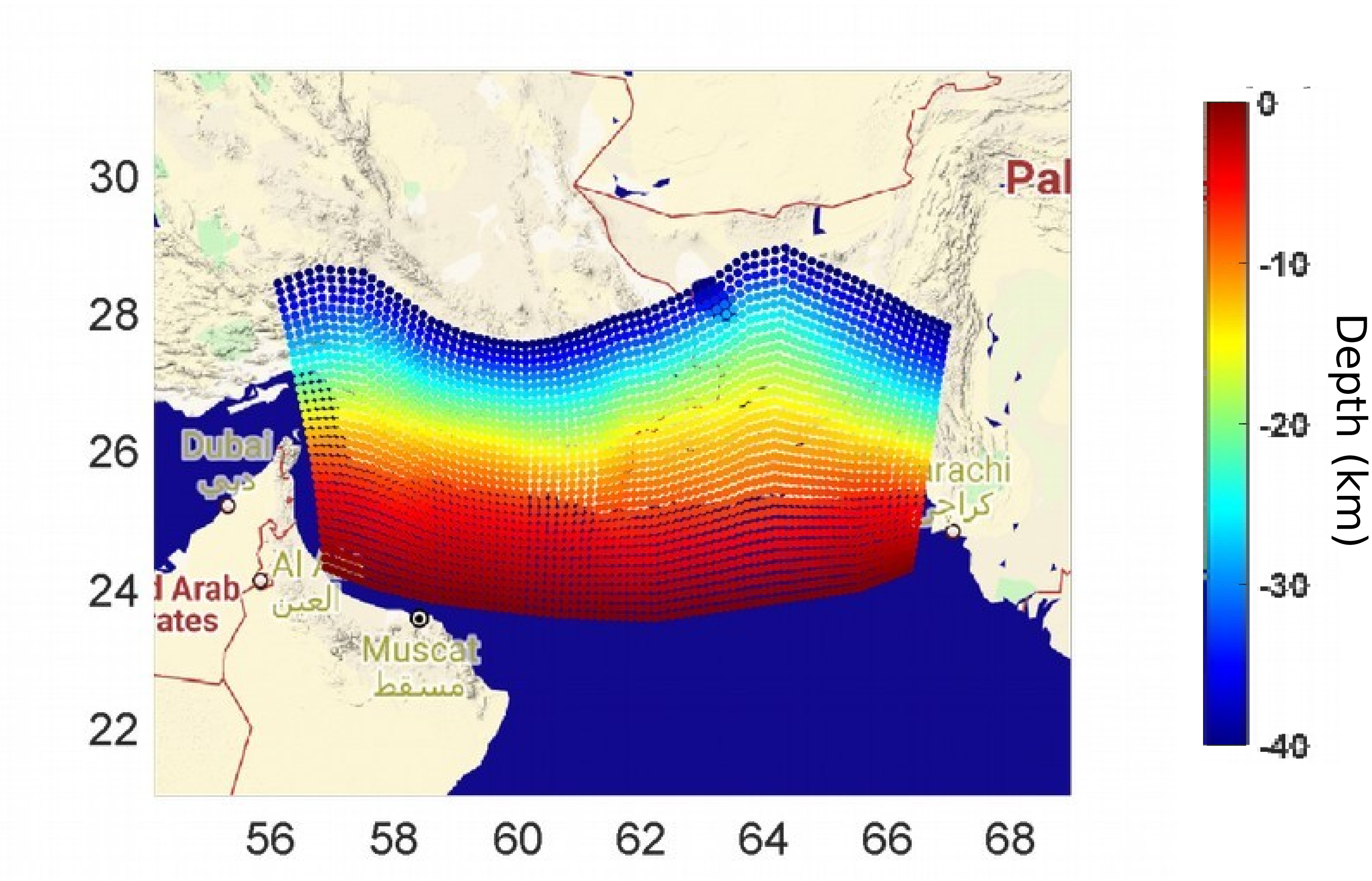


Greens' functions area and coastal POIs (zoom)



- ~ 2000 coastal Points-of-Interest
- ~ 40 000 pre-computed Green's functions
- to simulate ~5 000 000 propagation scenarios

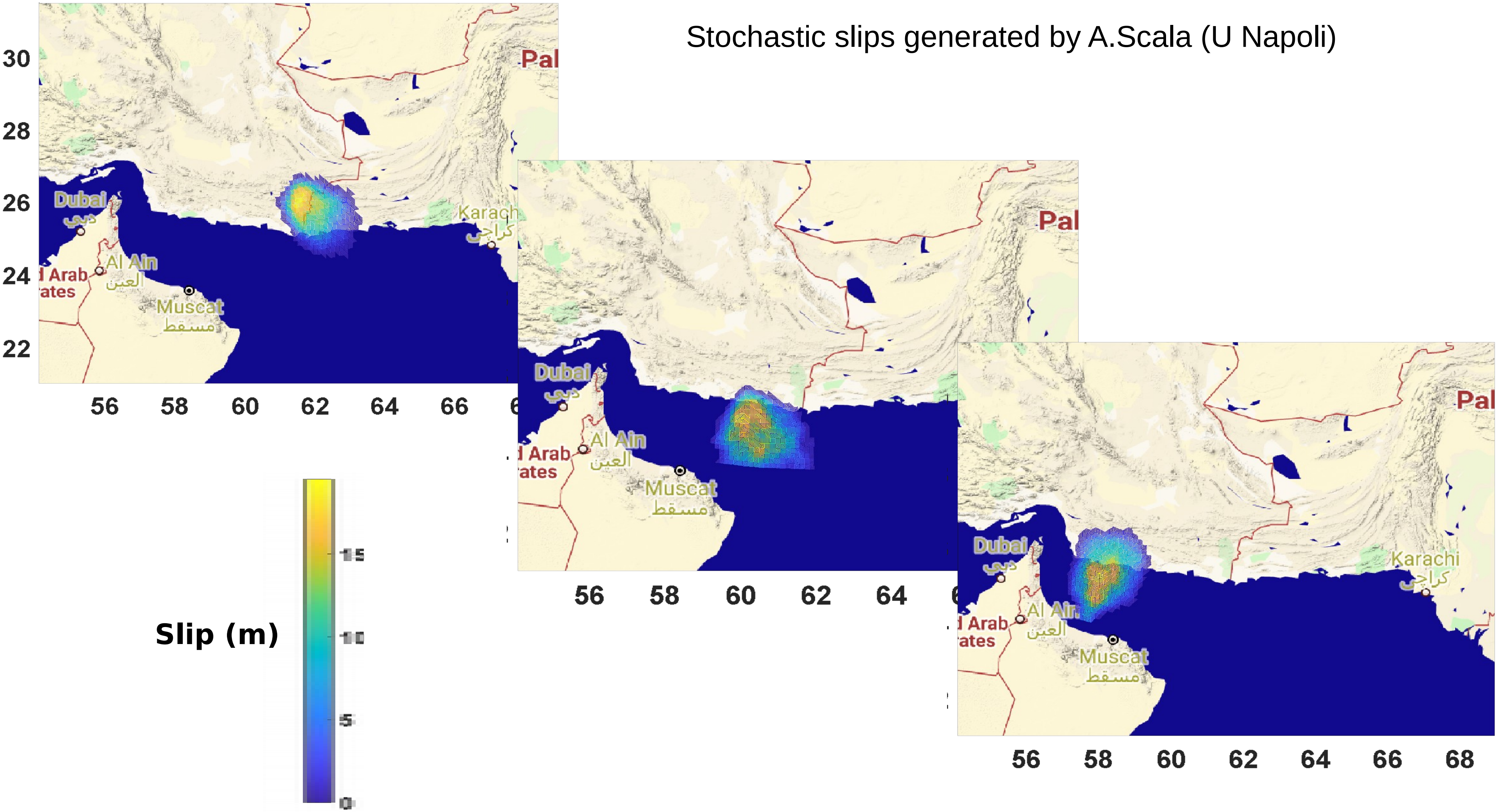
Makran subduction geometry mesh (seismic zones 1-4)



MSZ geometry model after G.Davis (Geoscience Australia) triangulated by A.Scala (U Napoli)

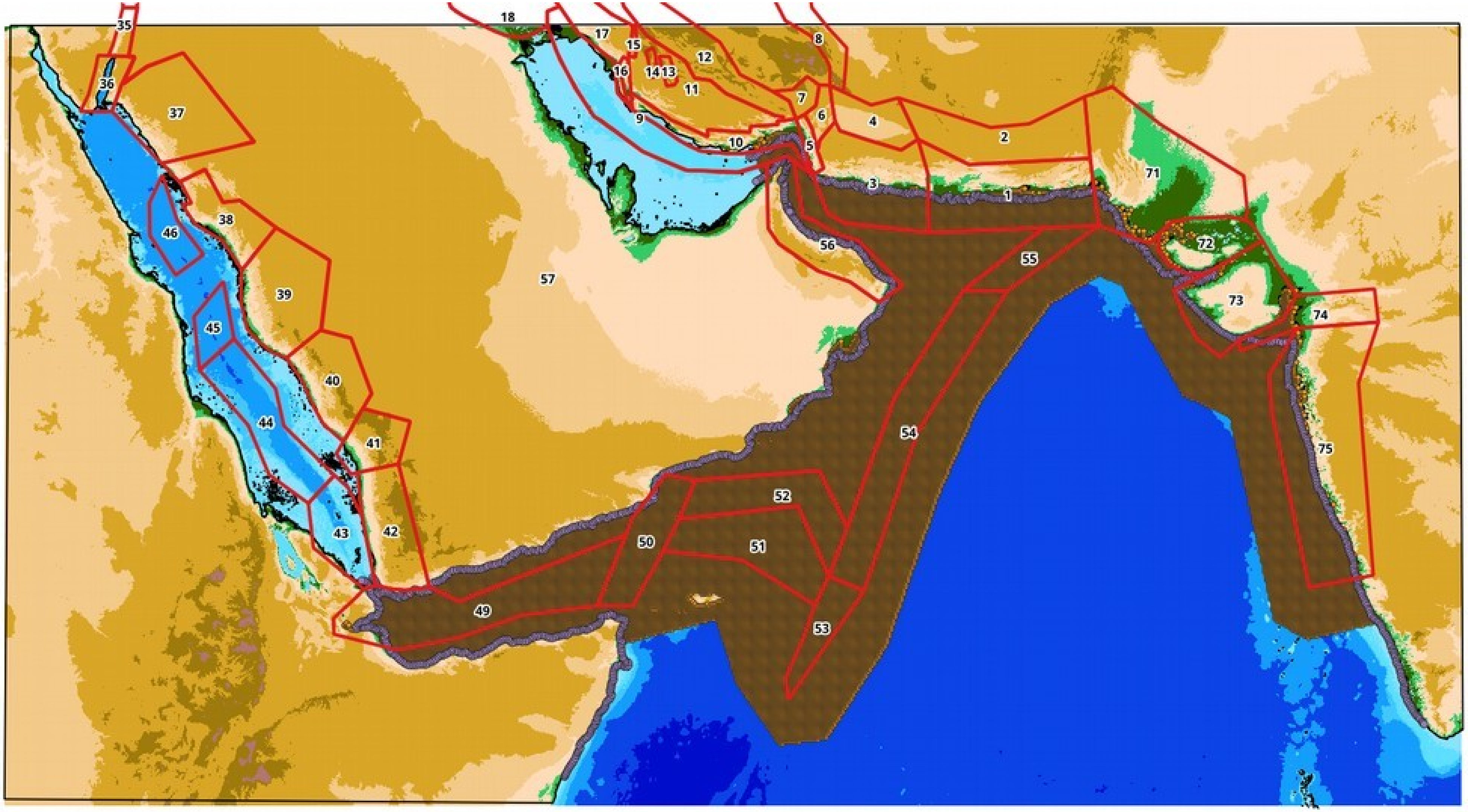
Makran subduction M8.5
slip distribution examples

Stochastic slips generated by A.Scala (U Napoli)

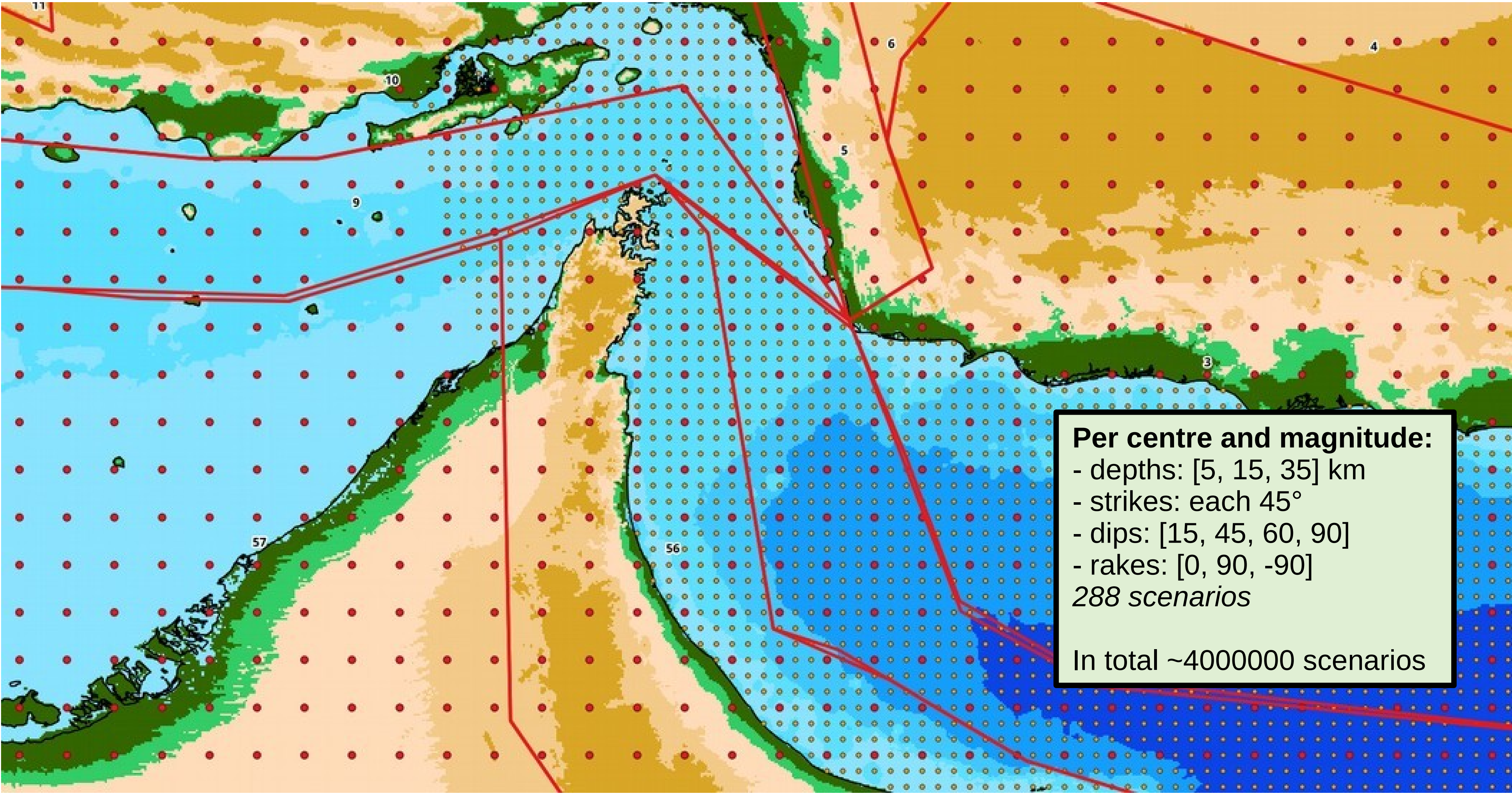


In this study seismicity is not restricted to MSZ (zones 1-4)!

Many other seismic zones have to be considered as well.



Modeling of volume-distributed (background) seismicity

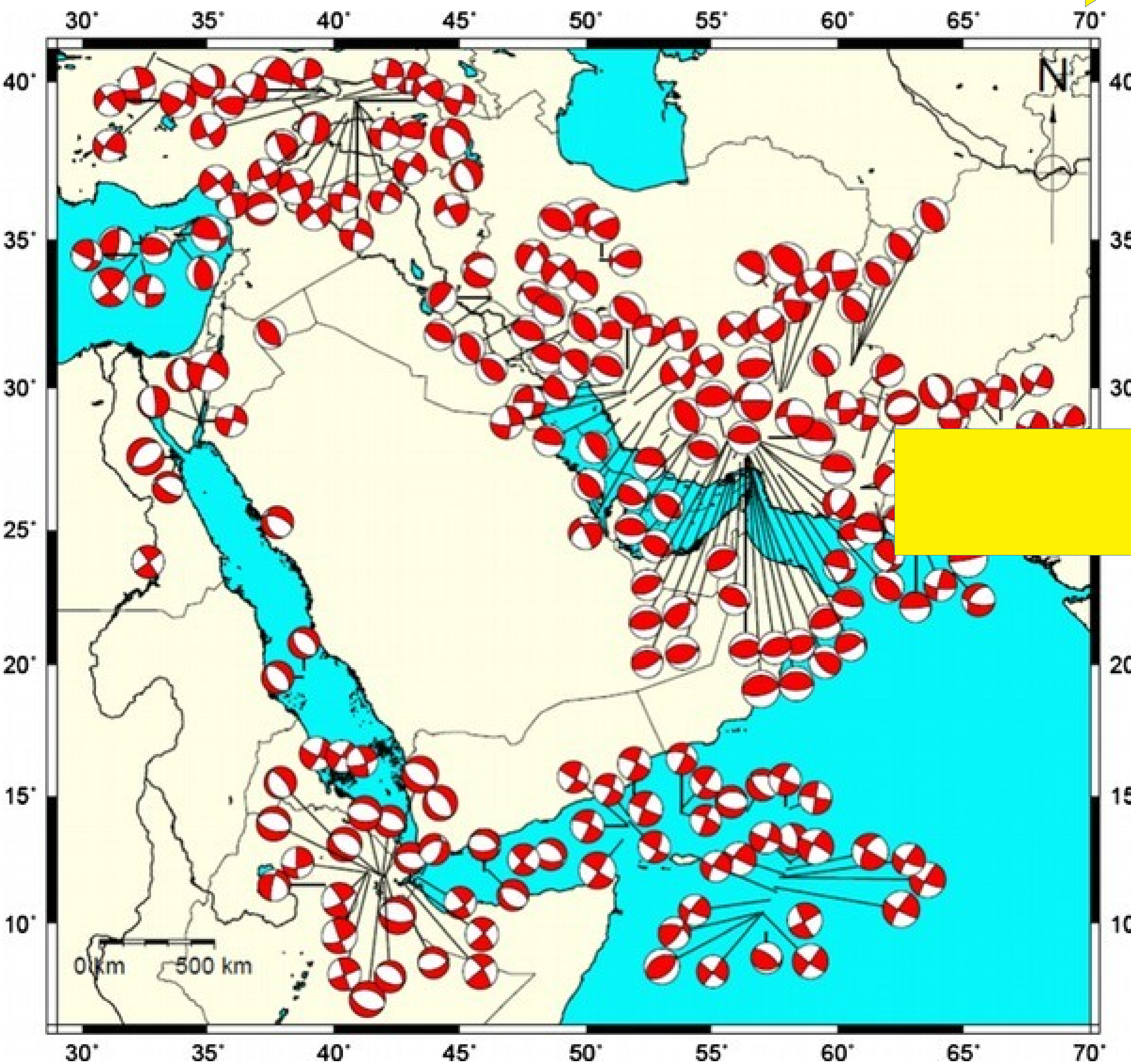


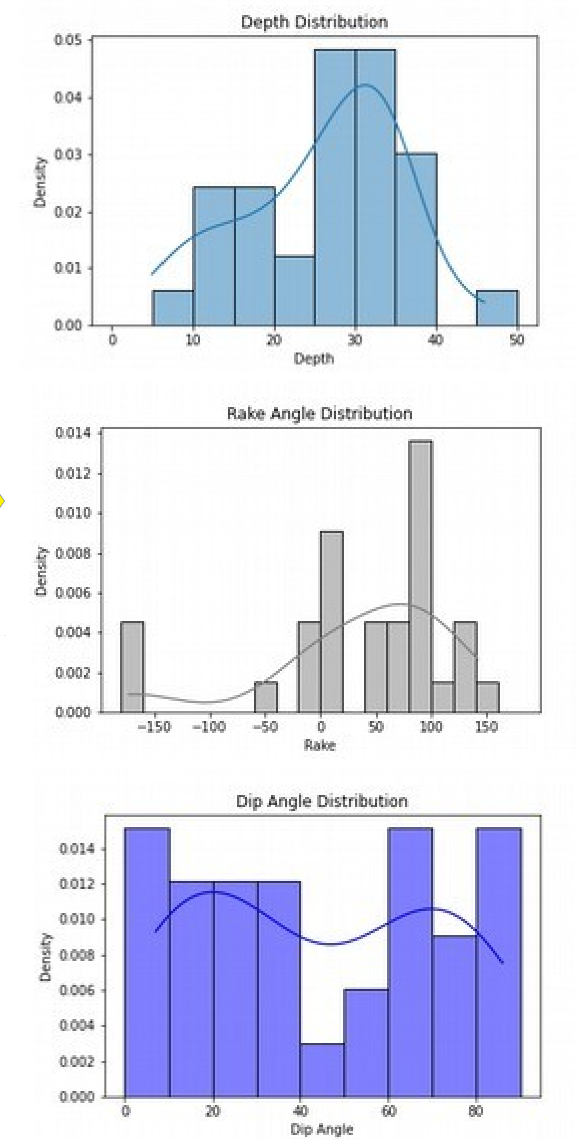
● - centres of back-ground seismicity (distance ~**25 km**)

Modeling of volume-distributed (background) seismicity

Focal mechanisms compilation (El-Hussain et al.'2018)

PDFs of fault parameters (Sunanda, pers.comm.)





Discussion points

- Most PTHA-construction blocks already prepared and available (see also following presentation of the INCOIS team)
- But we need to move faster

- To speed up PTHA-assessment:
  1) Hackathons in DE/IT? – should work
  2) Expand implementation team? – for pilot study probably not, if moving to an extended version- necessary
  3) Alternative leadership? – may work