Central Asia Quaternary Fault Database

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Bundesministerium für Bildung und Forschung

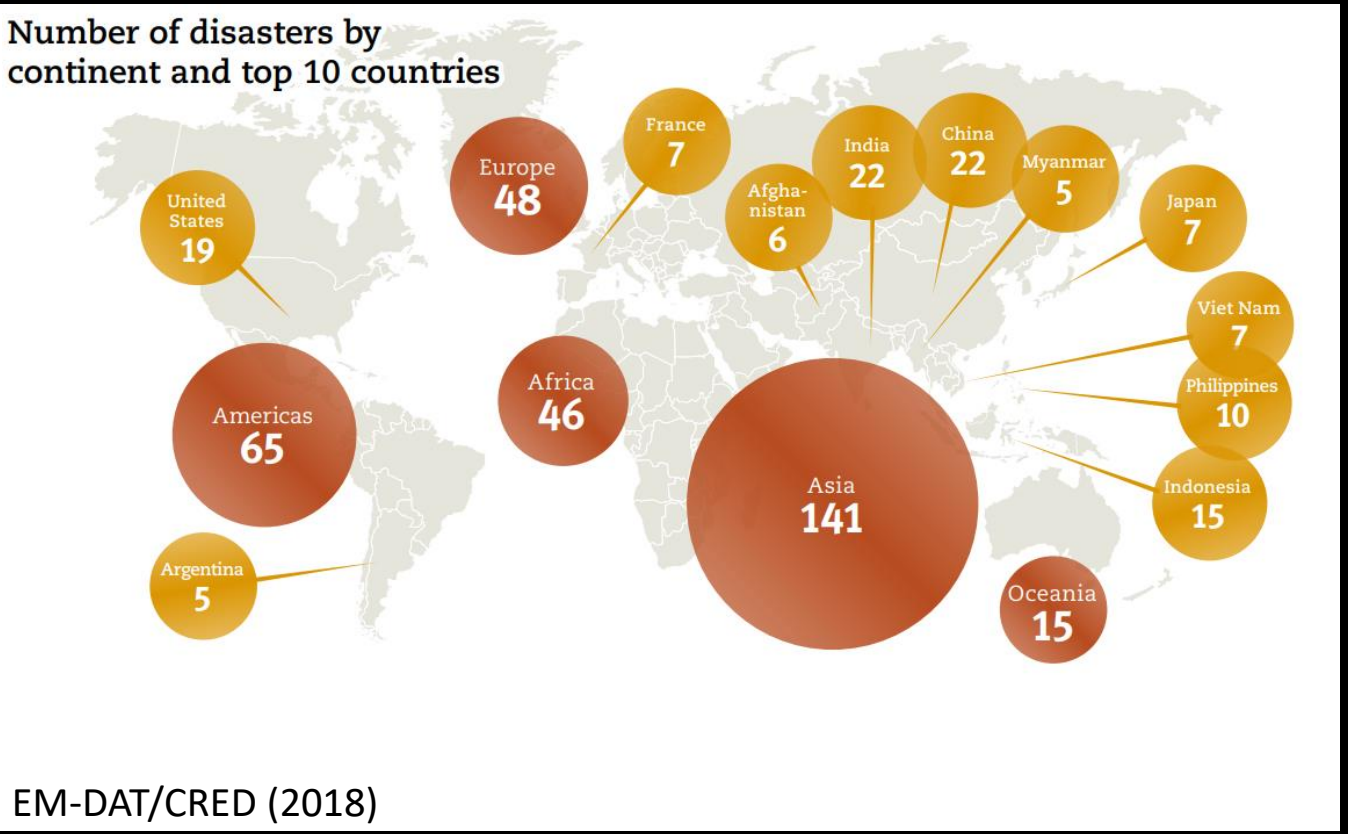
CATENA
CLIMATIC AND TECTONIC NATURAL HAZARDS IN CENTRAL ASIA

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

ESD Earth System Dynamics Research Group

UNIVERSITY OF MONTANA

Impact of Geologic Hazards



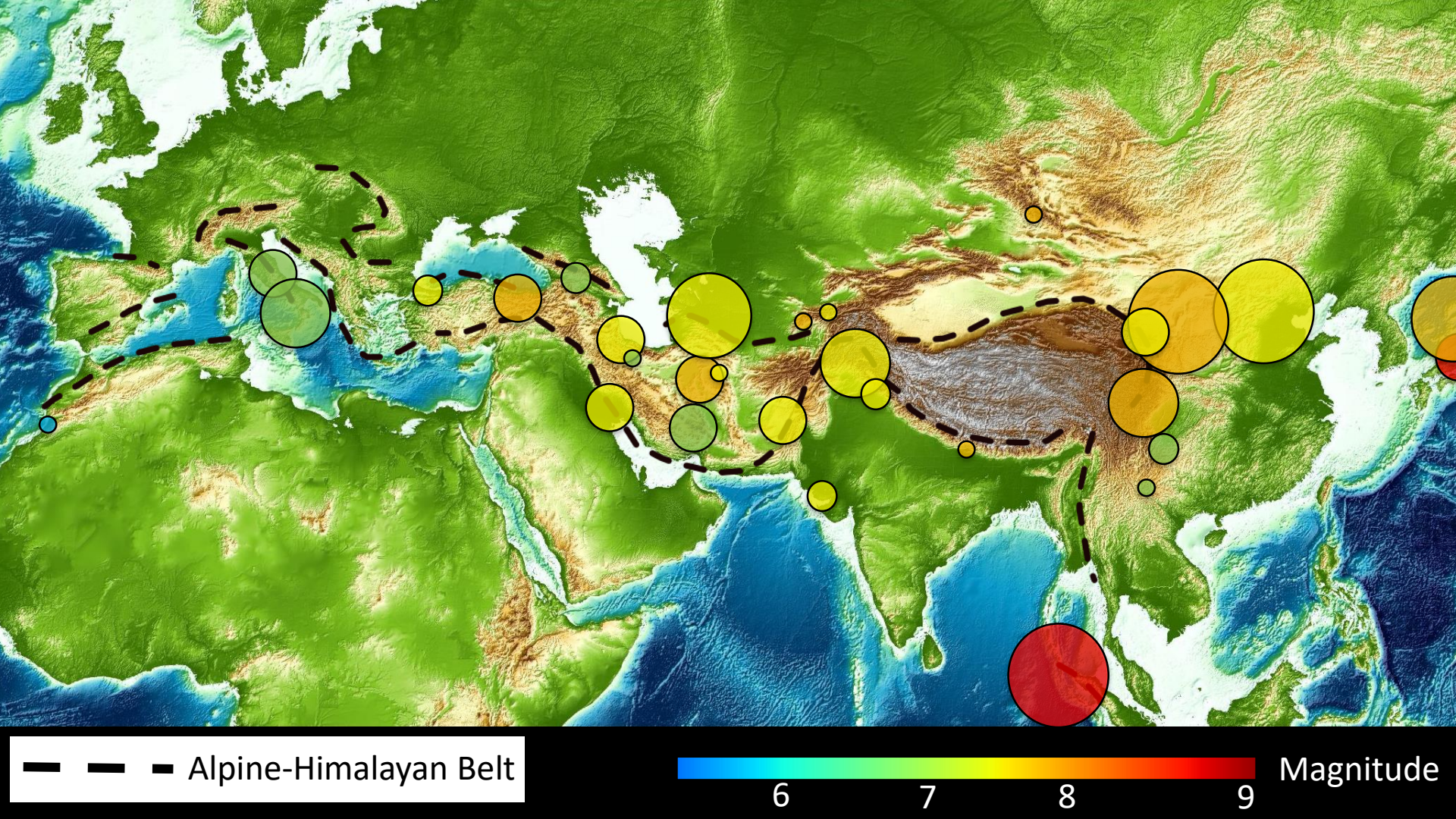
EM-DAT/CRED (2018)

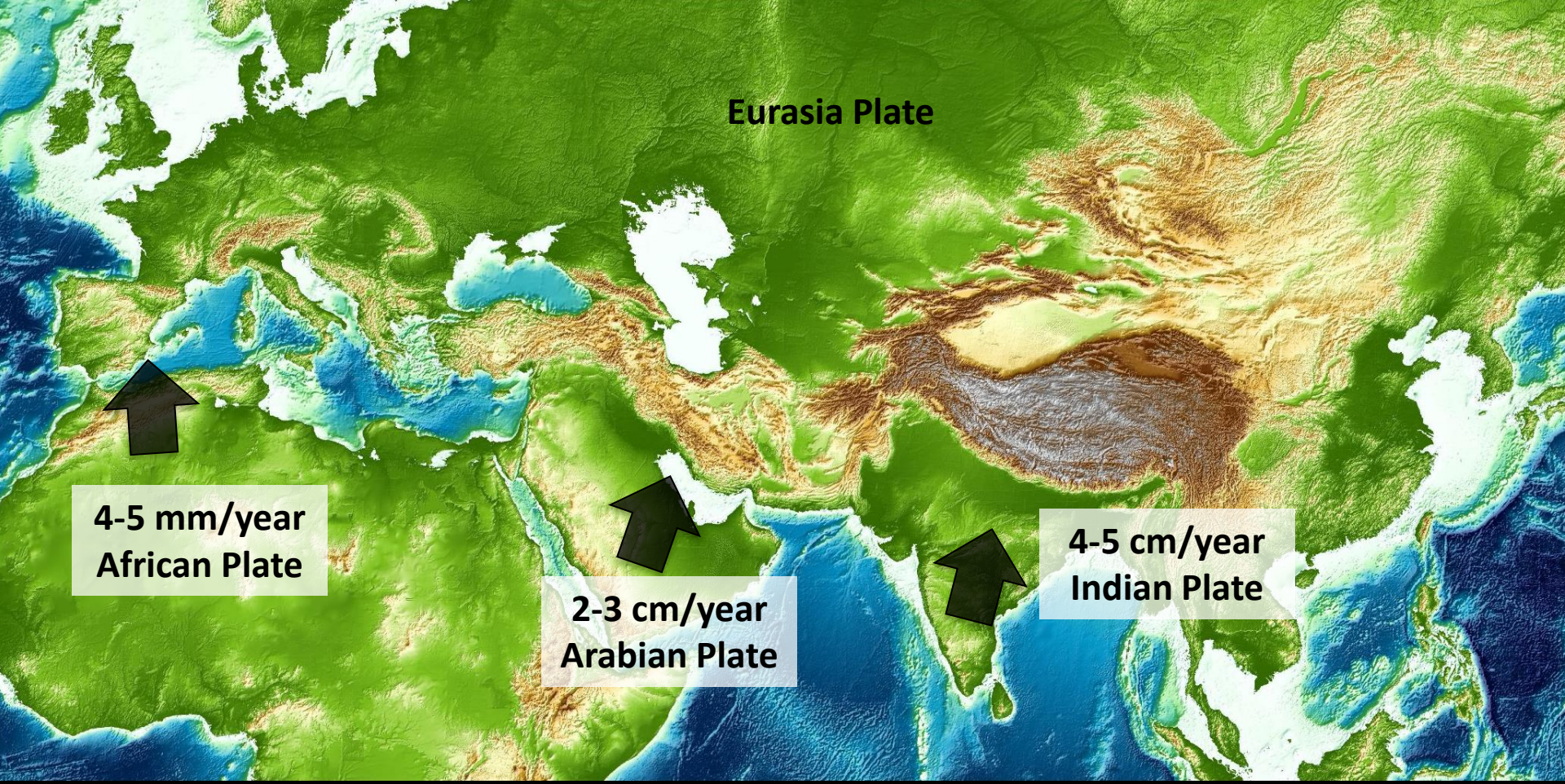
Disasters in 2018:

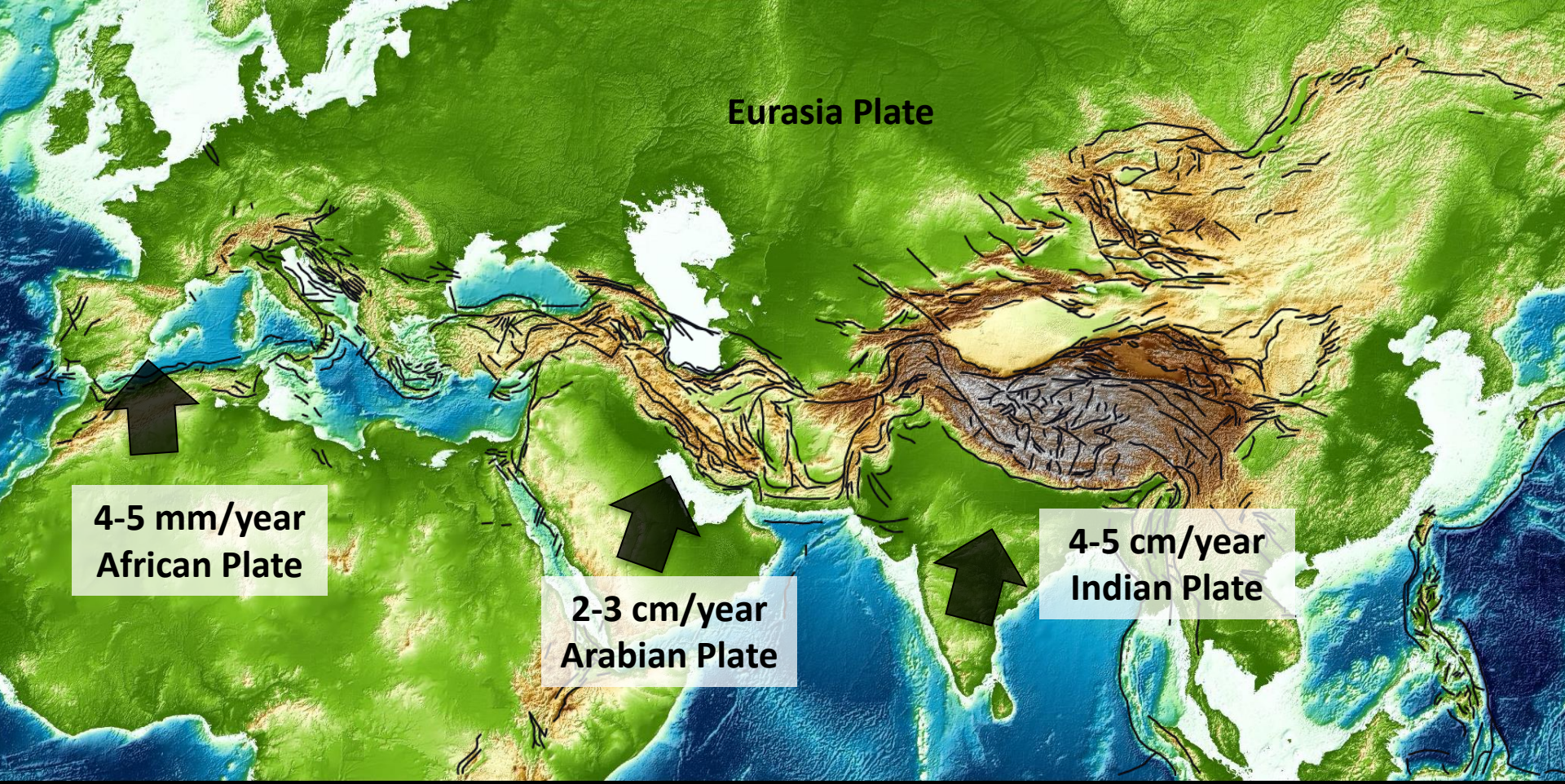
Asia suffered the most
45% of disasters
80% of deaths
76% of people affected

Earthquakes
45% of deaths


Alpine-Himalayan Belt


Alpine-Himalayan Belt
6
7
8
9
Magnitude


Eurasia Plate
4-5 mm/year
African Plate
2-3 cm/year
Arabian Plate
4-5 cm/year
Indian Plate


Eurasia Plate
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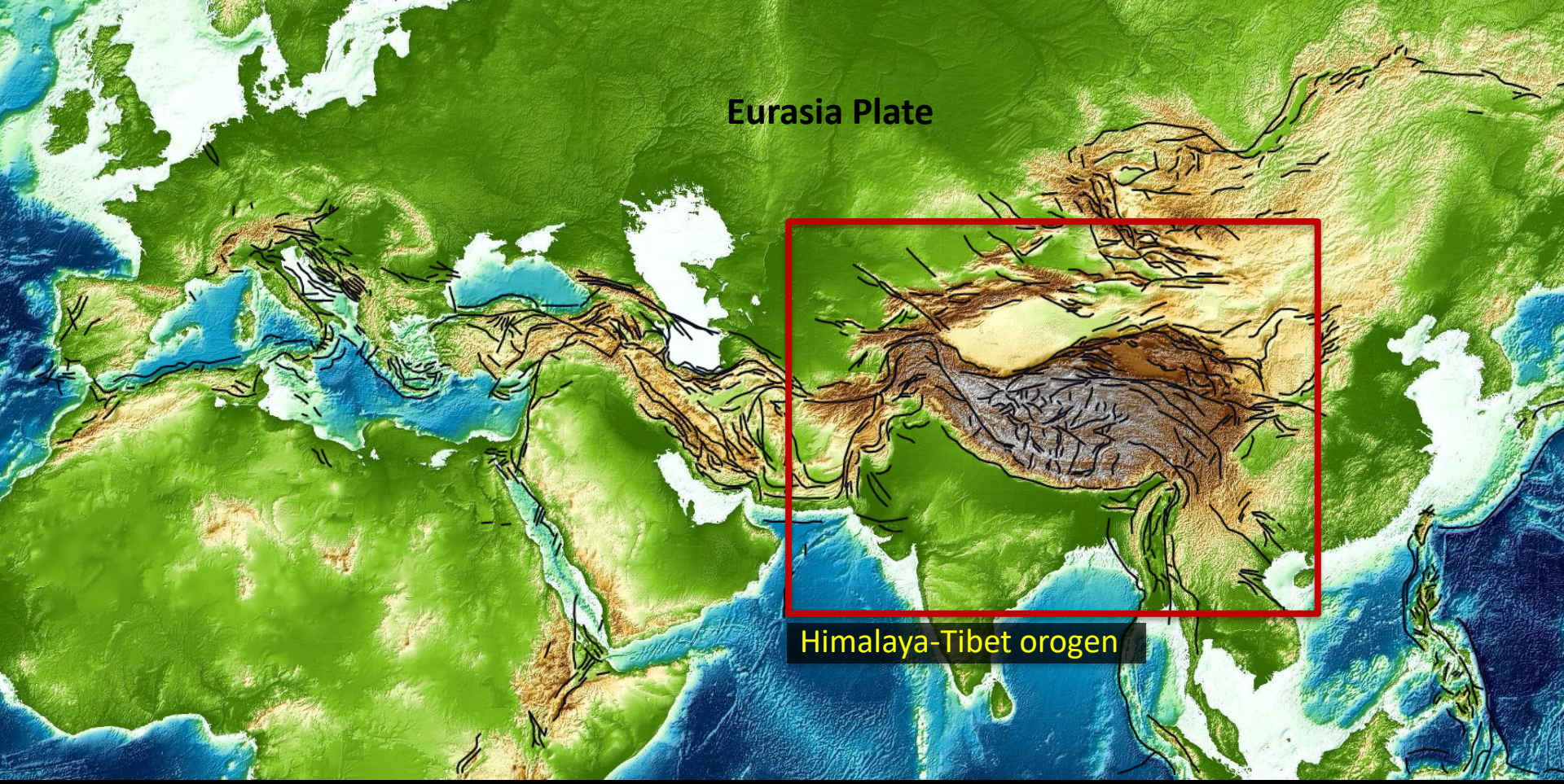
Quaternary faults


Eurasia Plate
Himalaya-Tibet orogen
Quaternary faults

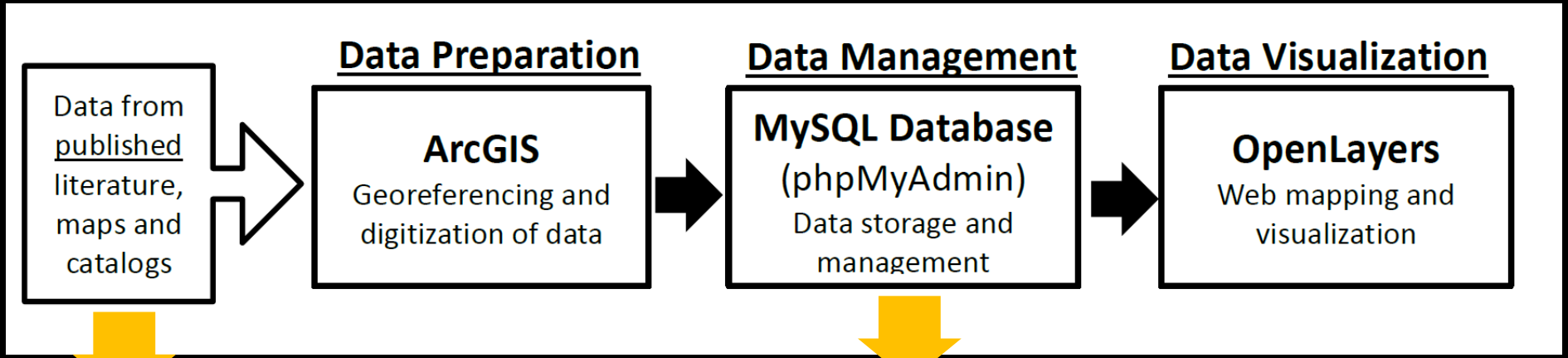
Roadmap

Motivation

To centralize and enhance public access to fault locations and characteristics for seismic hazard analysis and reducing risk.

- Database construction
- User interface: map and search tool
- Database data gaps

Database construction



Data sources:

>250 published manuscripts

HimaTibetMap

ANSS earthquake catalog

Datasets:

>1000 fault traces

>34,000 earthquakes

>100 faults with attributes

6 landslide inventories

Roadmap

Motivation

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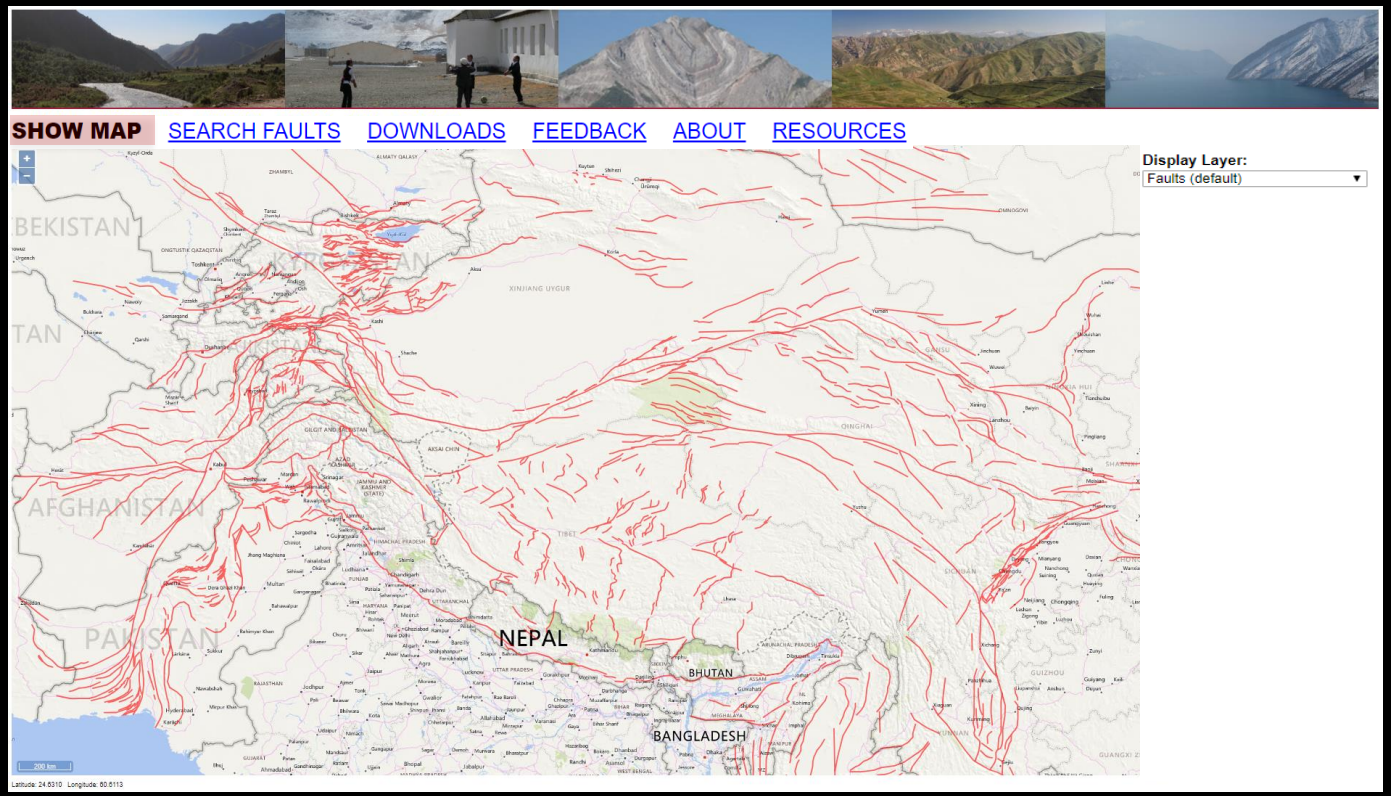
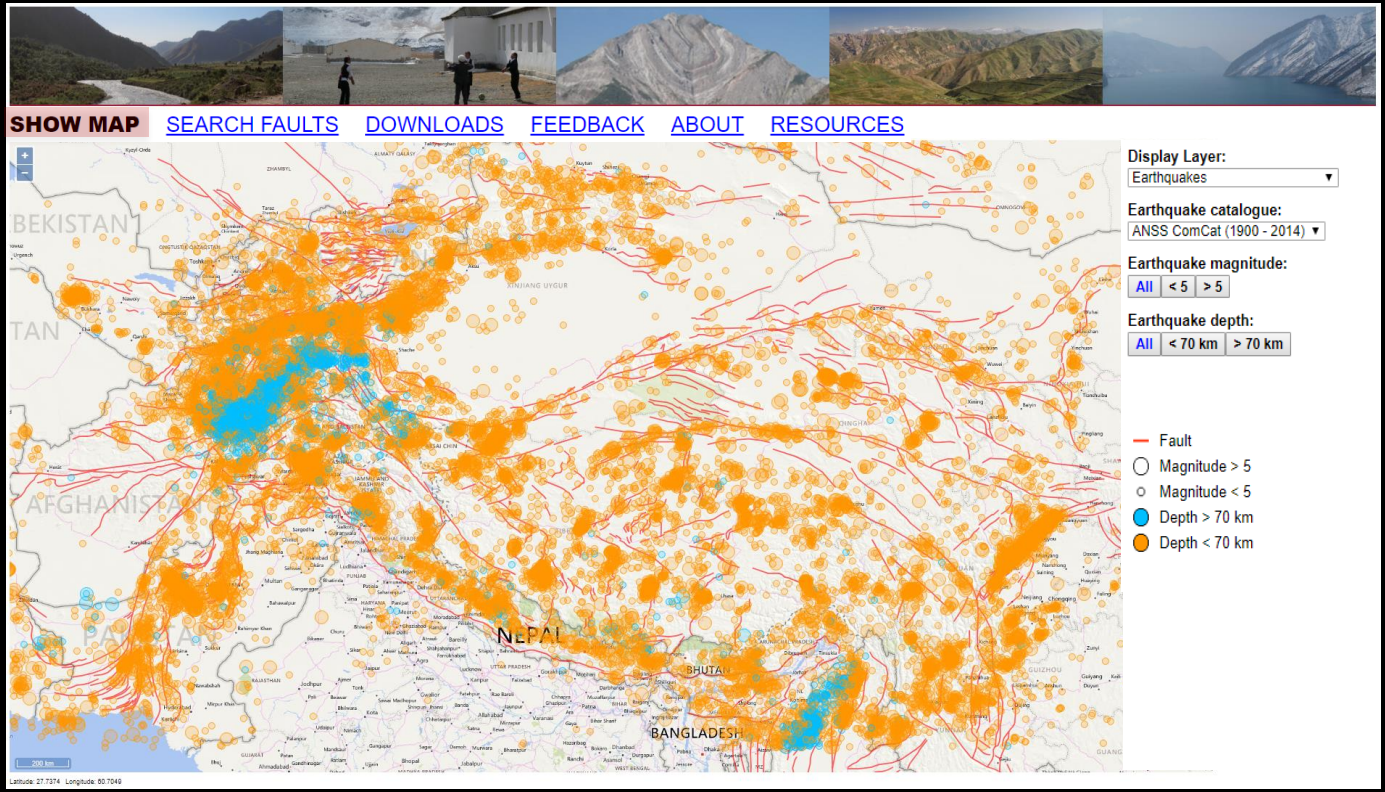
- Database construction
- User interface: map and search tool
- Database completeness and data gaps

Interactive map: fault locations



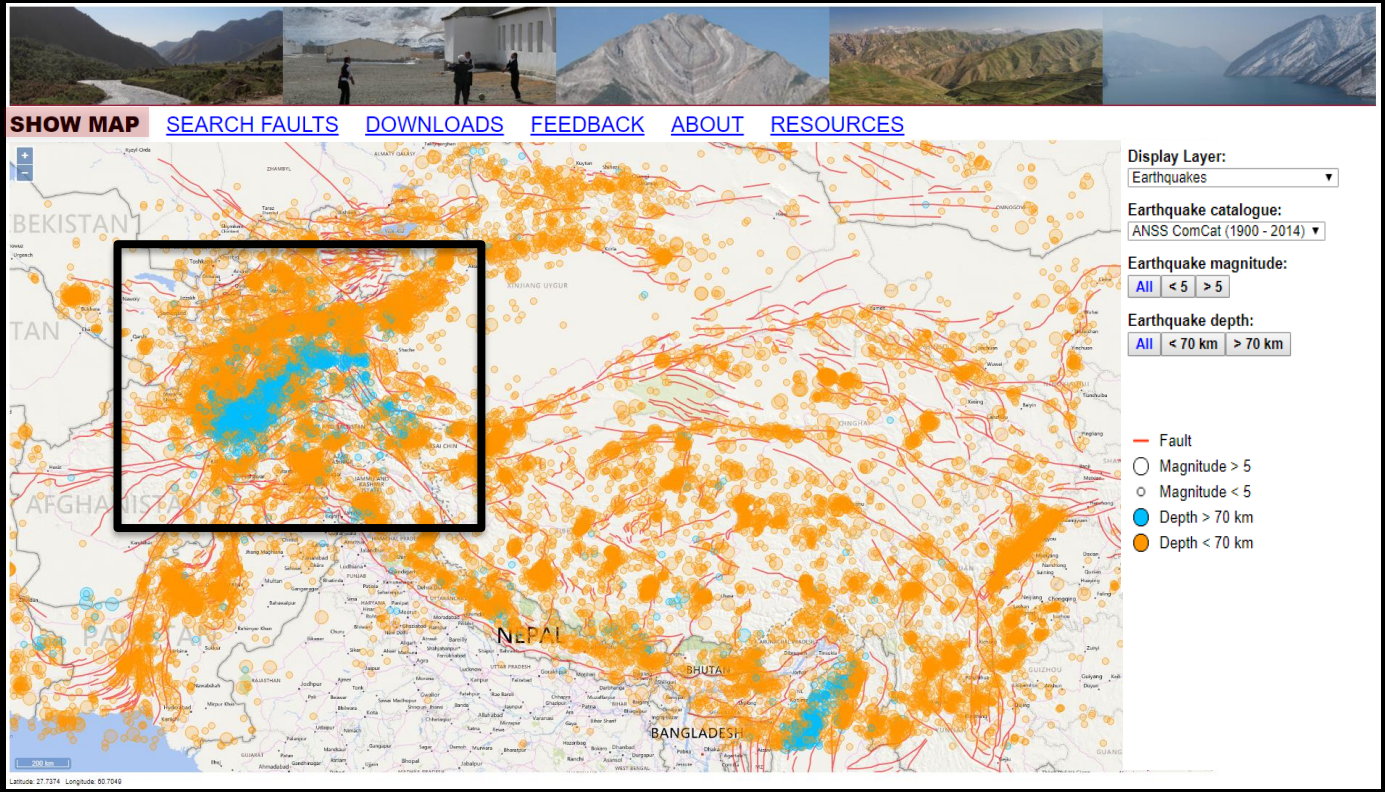
Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: seismicity



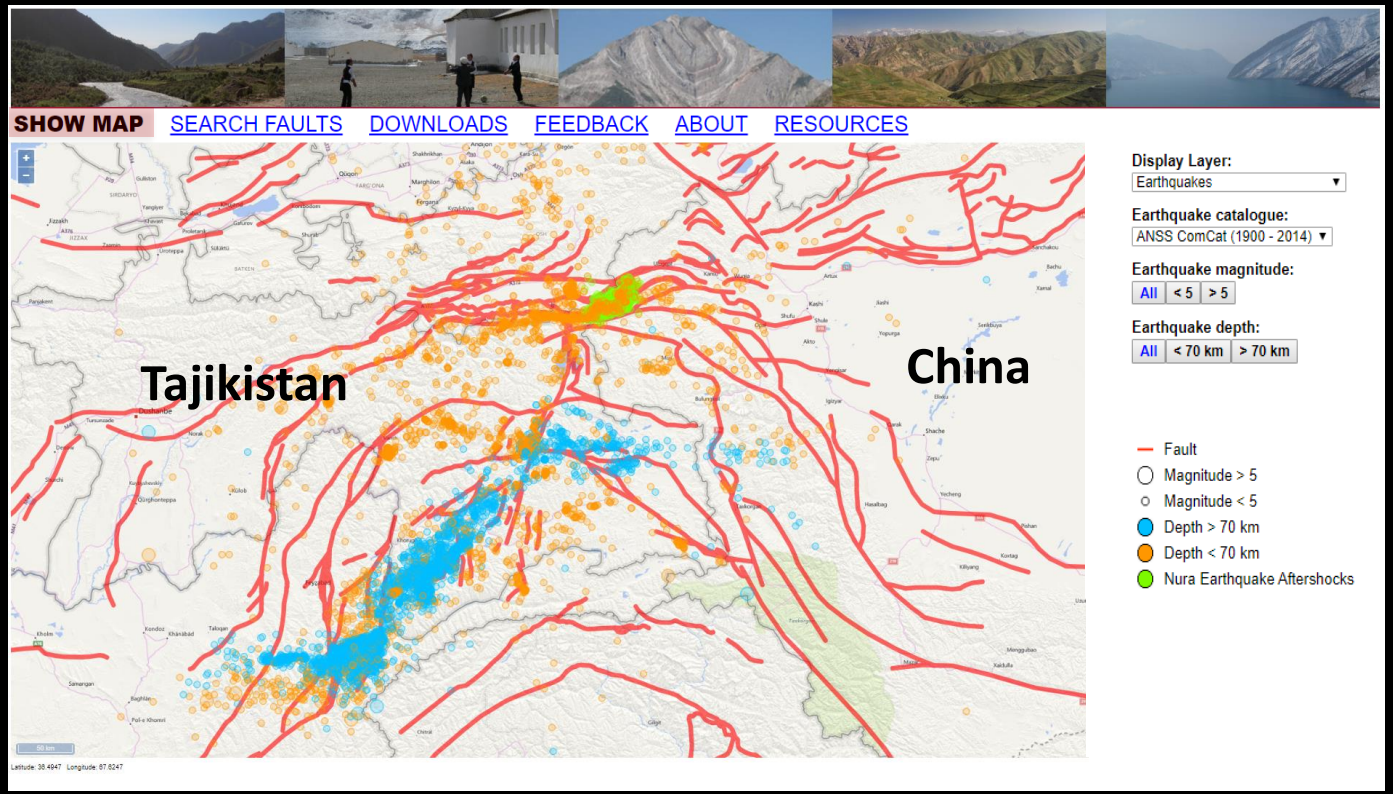
Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: seismicity



Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: seismicity



Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: landslides

Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

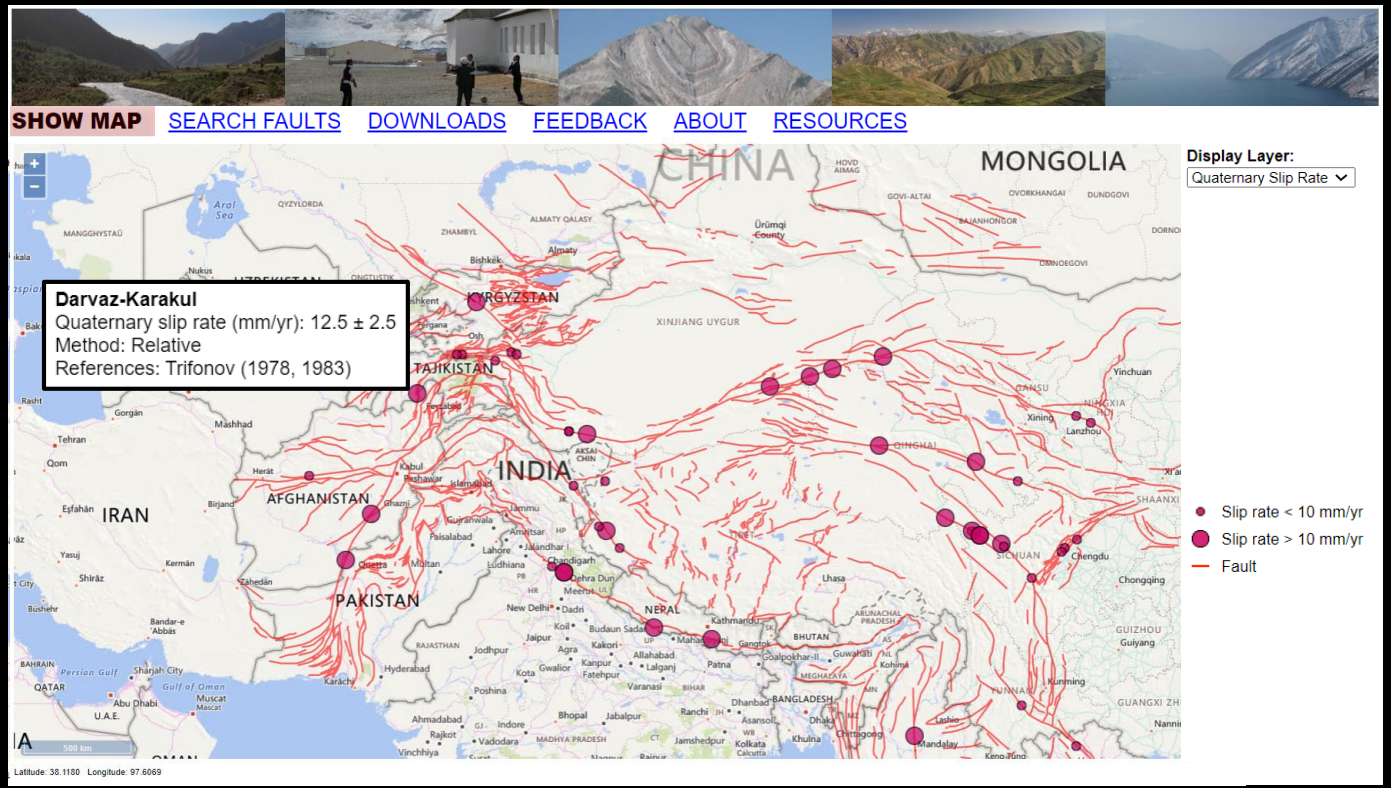
Interactive map: landslides

Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: slip rates

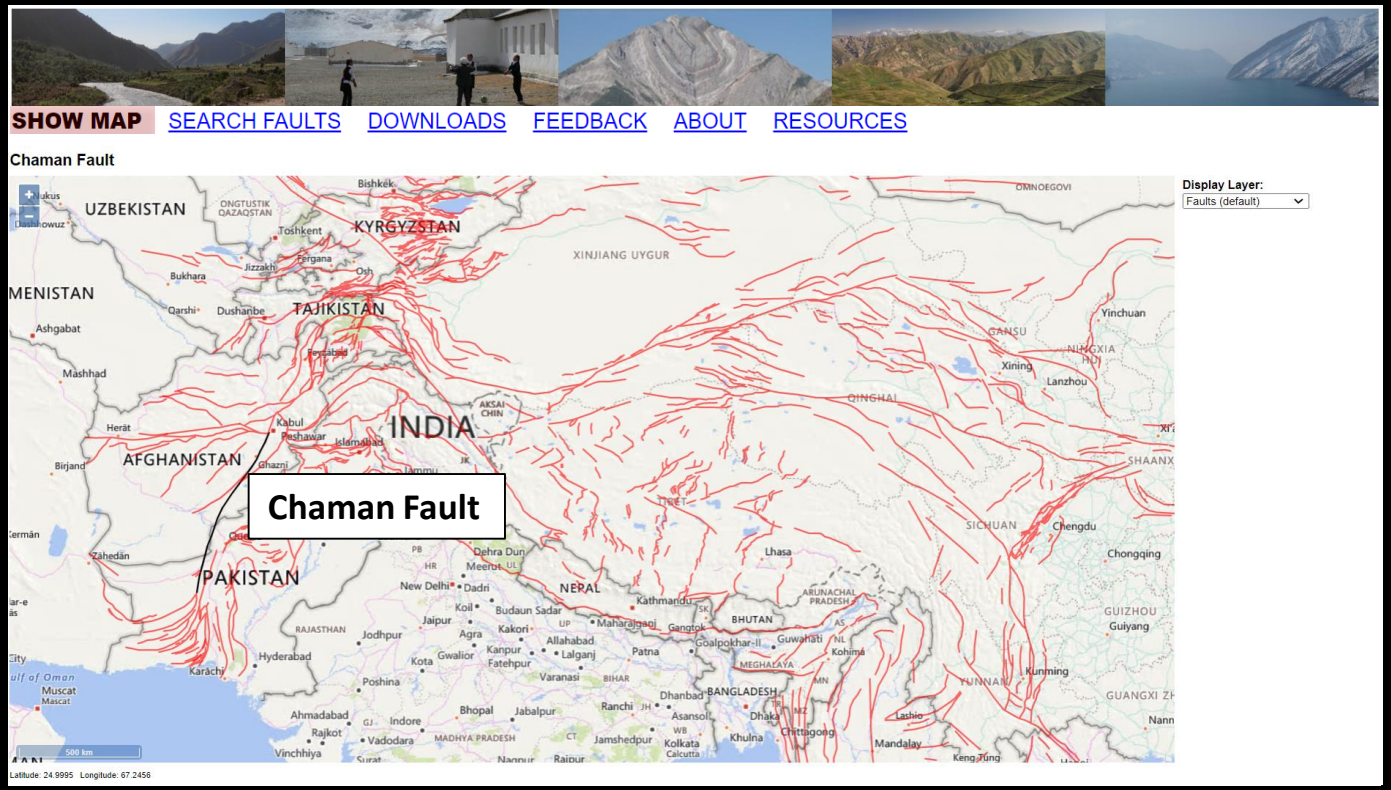
Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: slip rates



Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Interactive map: fault selection



Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Fault behavior and characteristics

Name	Chaman Fault
comments	Also known as the Chaman Fault System. Ruleman et al. (2007) subdivided the system into four subsidiary systems including Chaman fault, Mokur fault, Gardiz fault, and Paghman fault
Geographic characteristics	
Country	Afghanistan, Pakistan
Exposure	Exposed
Seismic characteristics	
Geodetic slip rate (mm/yr)	5.4 - 16.8
comments	Based on geodetic observations, E. Apel (written commun., 2006, in Yeats, 2012) reported 26 mm/yr for the Chaman fault. This rate is close to that of 29.7 mm/yr predicted for relative movement of India toward Eurasia in this region (Sella et al., 2002). Mohadjer et al. (2010) used differences in velocities between GPS sites spanning most of the northern end of the Chaman Fault and placed a lower bound on the slip rate of 18 ± 1 mm/yr across this region. Furthermore, they estimated a rate of 5.4 ± 2 mm/yr of sinistral shear across the Gardiz and Mokur faults at the northern section of the Chaman Fault zone. Continental scale geodesy indicates that India's relative velocity with respect to Eurasia at the longitude of the Chaman fault system is 24-28 mm/yr of which 15.1 mm/yr is accommodated by the Ornach Nal fault and the central and southern Chaman fault (Szeliga et al., 2012). At latitude 33 degrees N and further north, InSAR data indicate a velocity across the Chaman fault of 16.8 ± 2.7 mm/yr near Qalat, Afghanistan (Szeliga et al., 2012). Based on GPS observations, the authors also reported 16.8 ± 0.51 mm/yr of sinistral motion near Kabul, Afghanistan. Jay et al. (2017) calculated a modeled slip rate of 10 mm/yr by averaging velocity pair differences across the fault.
InSAR	At latitude 33 degrees N and further north, InSAR data indicate a velocity across the Chaman fault of 16.8 ± 2.7 mm/yr near Qalat, Afghanistan (Szeliga et al., 2012). Based on GPS observations, the authors also reported 16.8 ± 0.51 mm/yr of sinistral motion near Kabul, Afghanistan.
Geologic slip rate (mm/yr)	2 - 40
comments	Based on the degree of topographic disturbance caused by the fault, Wellman (1965) suggested a present-day average slip rate of 2-20 mm/yr. Beun et al. (1979) suggested an average slip rate of 25-35 mm/yr over the last 2 My across the whole fault zone based on the correlation of Pliocene offset of volcanic units that straddle the fault north of Ab-e-Istada in Afghanistan. Geologic and plate closure estimates suggest sinistral slip across the Chaman fault system of between 19 and 35 mm/yr over the last 25 Ma (Lawrence and Yeats, 1979). NUVEL-1 global plate motion model of DeMets et al. (1990) predicts a rate of about 40 mm/yr for the Chaman Fault. Lawrence et al. (1992) reported 19-24 mm/yr over the last 20-25 My as a minimum slip rate assuming slip began just after the end of deposition of the Khojak Flysch. Yeats (2012) concluded that the slip rate on the Chaman Fault is high enough that the next earthquake is overdue, even assuming that some of the plate boundary slip maybe aseismic or on slow earthquakes. Although poorly constrained, Molnar et al. (2010) believe that the rate of slip on the Chaman Fault is >10 mm/yr and most likely between 20 and 30 mm/yr.
Historic earthquake	There are at least four major strike-slip earthquakes with M > 6 recorded historically on the Chaman fault: the 1505 earthquake (Ms 7.3) west of Kabul, the 1892 (Ms. 6.5) earthquake near the city of Chaman, the 1975 earthquake between Chaman and Nushki and the 1978 earthquake north of Nushki in Pakistan. No major historical earthquakes are noted between the 1892 Chaman rupture to the southern terminus of the 1505 rupture which made Bernard et al. (2000) and Ambraseys and Bilham (2003b) conclude that a significant slip deficit exists along the Chaman fault, especially north of ~31 degree latitude. The region east of the Chaman fault underwent two large earthquakes, the Mach earthquake of 27 August 1931 of Ms 7.3 in the Sibi re-entrant between the Brahui and Sulaiman ranges, and the Quetta earthquake of 30 May 1935 of Ms 7.7. The epicenter of the Quetta earthquake was close to the Ghazaband fault. Ambraseys and Bilham (2003a), however, were unable to attribute the reported surface deformation to a source fault. Recent seismicity along the fault appears to be mostly small earthquakes (M 3-5), located mostly in regions with major historical seismicity. The M5 earthquake in 2005 ruptured the surface along the 6.5 km of the Chaman fault south of Kabul. The slow slip observed over a year after this event raises the possibility that other parts of the fault might rupture in slow slip events (Yeats, 2012).
Geomorphic expression	Earthquakes along the Chaman fault appear to consistently rupture to the surface. Oldham (1883) and Babur (1912) reported surface ruptures for the 1505 earthquake near Kabul. Griesbach (1893) observed surface rupture from the 1892 Chaman earthquake which offset railroad tracks crossing the fault by 0.75 m. No surface rupture has been reported for the 1975 Ms 6.7 earthquake which occurred between Nushki and Chaman in Pakistan. The 1978 Mw 6.1 earthquake near Nushki ruptured the surface (Yeats et al., 1979). Wellman (1965) reported stream offsets of 20-120 m. Active fault features consistent with the 1892 surface rupture are described by Lawrence and Yeats (1979)
Structural characteristics	
Primary sense of motion	Sinistral (left-lateral); Strike-slip
comments	Ruleman et al. (2007) reported active frontal thrust faults along western margin of the Chaman fault. These arcuate, northwest-directed, east-dipping, frontal thrusts are second-order structures that result from the combination of compression and strike-slip motion on the Chaman fault system. Some of these thrust faults are >20 km long and extend >10 km west of the main fault trace. Multiple strike-slip fault strands are proximal to these thrust faults.
Length	> 850 km

References

Ambraseys and Bilham (2003a); Ambraseys and Bilham (2003b); Babur (1912); Bernard et al. (2000); Beun et al. (1979); DeMets et al. (1990); E. Apel (written commun., 2006); Griesbach (1893); Jay et al. (2017); Lawrence and Yeats (1979); Lawrence et al. (1992); Mohadjer et al.(2010); Molnar et al. (2010); Oldham and Oldham (1883); Ruleman et al. (2007); Sella et al. (2002); Szeliga et al. (2012); Wellman (1966); Yeats (2012); Yeats et al. (1979)

Geographic characteristics

- Level of exposure

Seismic characteristics

- Geodetic slip rate
- Quaternary slip rate
- Historic earthquakes
- Trench studies

Structural characteristics

- Geometric parameters

Search tool

SHOW MAP | **SEARCH FAULTS** | DOWNLOADS | FEEDBACK | ABOUT | RESOURCES

Fill in one or more fields and start search. The search tool permits searches on fault name and location. Users can also limit their search results by making queries on seismic and structural characteristics of faults.

Fault Name

Geographic Characteristics

Country

Physiographic province

Seismic Characteristics

Geodetic Slip Rate (mm/yr) min: max:

Quaternary Slip Rate (mm/yr) min: max:

Historical Earthquakes All

Geomorphic expressions All

Paleoseismic studies All

Structural Characteristics

Sense of movement All

Search

Latitude: 16.1589 Longitude: 55.1035

Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

Search tool

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Fault Name

Geographic Characteristics
- Country
- Physiographic province

Seismic Characteristics
- Geodetic Slip Rate (mm/yr) min: max:
- Quaternary Slip Rate (mm/yr) min: max:
- Historical Earthquakes: Yes
- Geomorphic expressions: All
- Paleoseismic studies: All

Structural Characteristics
- Sense of movement: All

Search

Mohadjer et al. 2016, Nat. Hazards Earth Syst. Sci.

- 46 faults found.

Roadmap

Motivation

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- User interface: map and search tool
- Database completeness and data gaps

Data gaps

SHOW MAP | **SEARCH FAULTS** | DOWNLOADS | FEEDBACK | ABOUT | RESOURCES

Fill in one or more fields and start search. The search tool permits searches on fault name and location. Users can also limit their search results by making queries on seismic and structural characteristics of faults.

Fault Name

Geographic Characteristics

Country

Physiographic province

Seismic Characteristics

Geodetic Slip Rate (mm/yr) min: max:

Quaternary Slip Rate (mm/yr) min: max:

Historical Earthquakes No

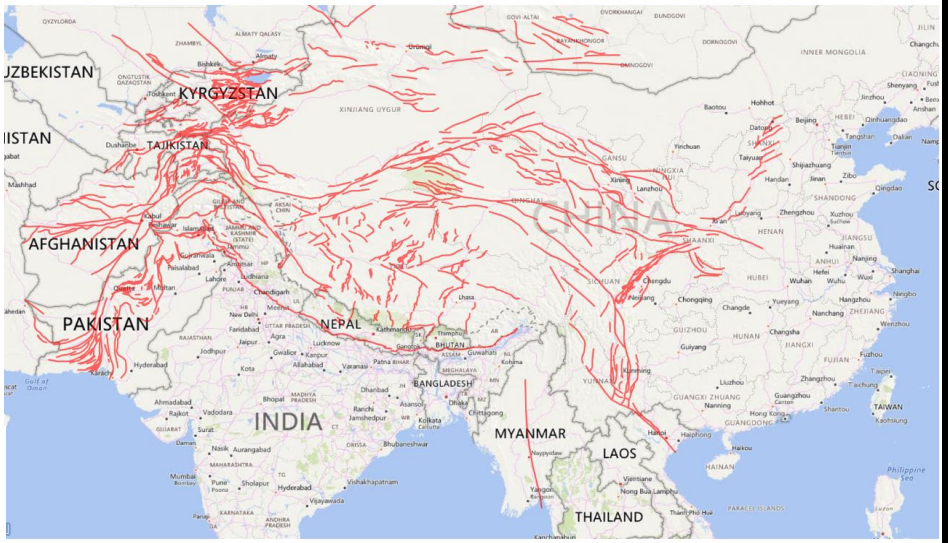
Geomorphic expressions No

Paleoseismic studies No

Structural Characteristics

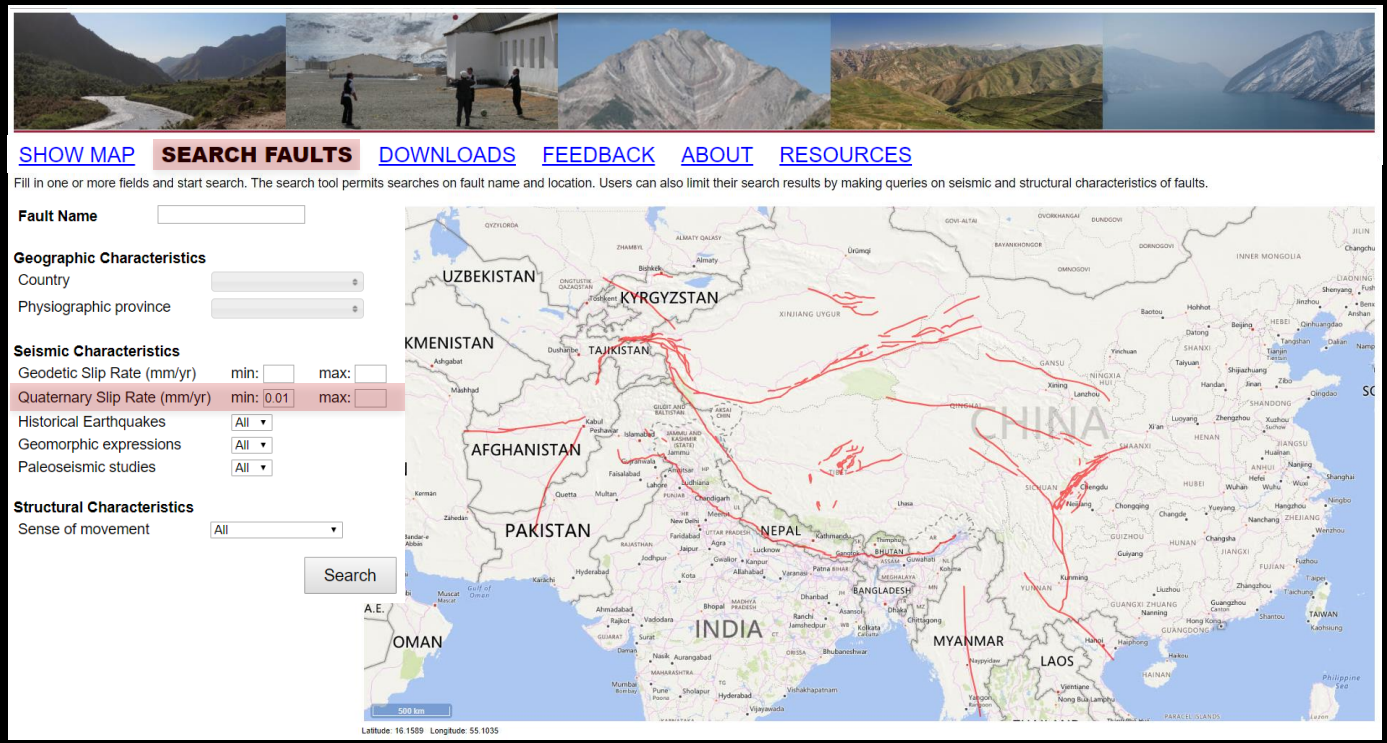
Sense of movement All

Search



- 126 faults found.

Data gaps



- 32 faults found.

Data gaps

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Fill in one or more fields and start search. The search tool permits searches on fault name and location. Users can also limit their search results by making queries on seismic and structural characteristics of faults.

Fault Name

Geographic Characteristics

Country

Physiographic province

Seismic Characteristics

Geodetic Slip Rate (mm/yr) min: 0.01 max:

Quaternary Slip Rate (mm/yr) min: max:

Historical Earthquakes All

Geomorphic expressions All

Paleoseismic studies All

Structural Characteristics

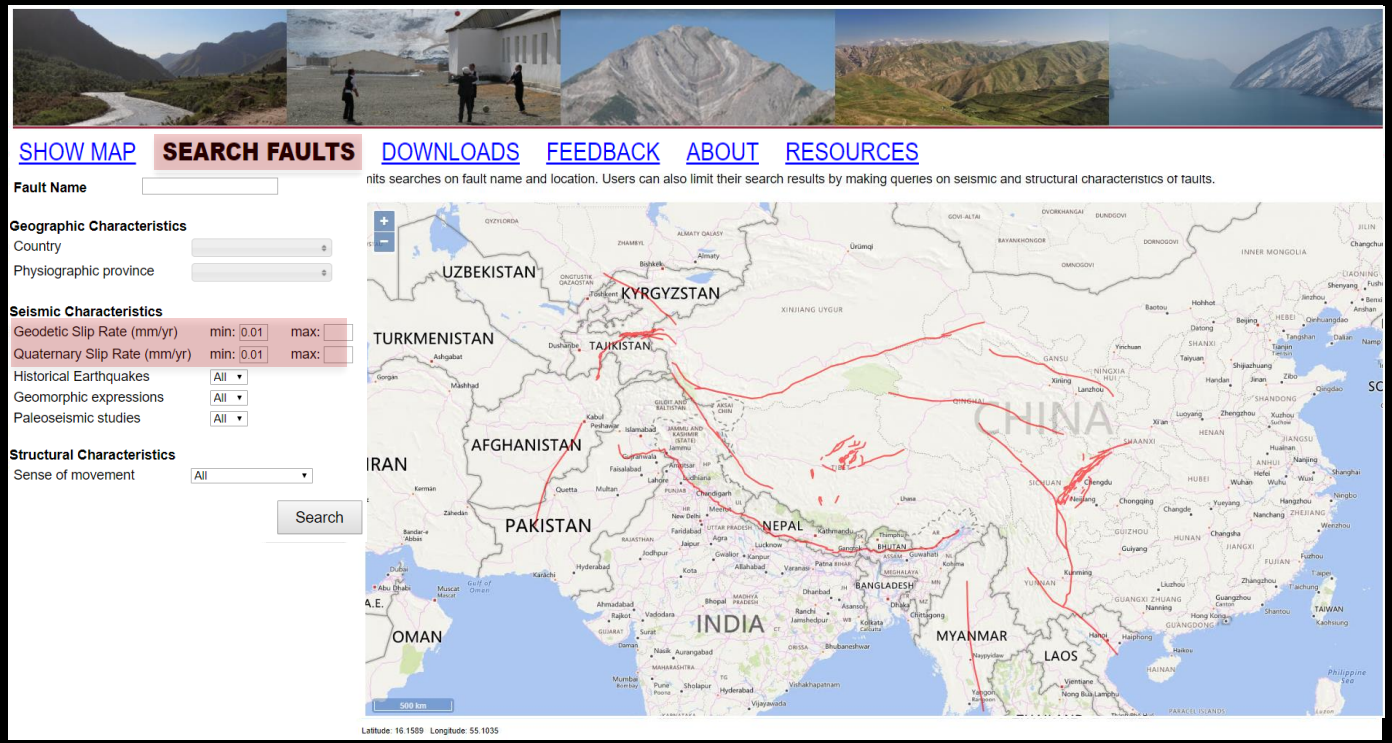
Sense of movement All

Search

Latitude: 19.0949 Longitude: 80.0648

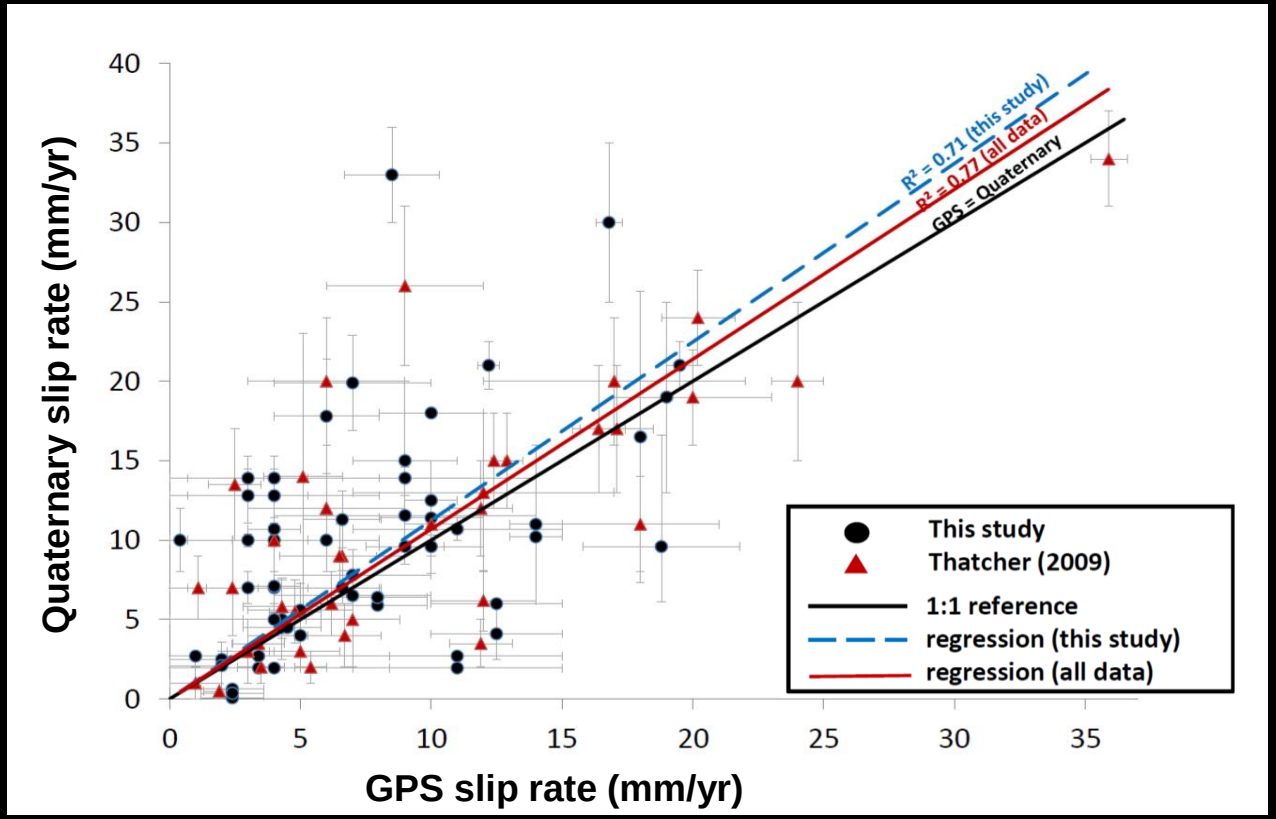
- 25 faults found.

Data gaps



- 19 faults found.

Database usage: slip rate analysis



Mohadjer et al. 2017, Earth-Science Reviews

Slip rate dataset:
97 slip pairs, 43 faults

Most rates match each other within their reported uncertainties

Summary & Conclusions

Open-Access Database Features

- Web-based interactive map & database
- Search tool and downloadable data
- Contributes to earthquake risk reduction
  - ➢ Centralizes active fault parameters
  - ➢ Identifies data gaps

What can you do?

- Access, visualize, download data
- Submit new/missing published content

https://esdynamics.geo.uni-tuebingen.de/faults/