The approaching Great Nepal Earthquake – 20xx !!
Need for an Earthquake Early Warning system for DRR

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Geoscientists Did not forecast 2015 Gorkha Earthquake

(we did not expect that it will come so early)

We forecasted much larger Earthquake
which is yet to come and

it may occur any time in future, sooner or latter

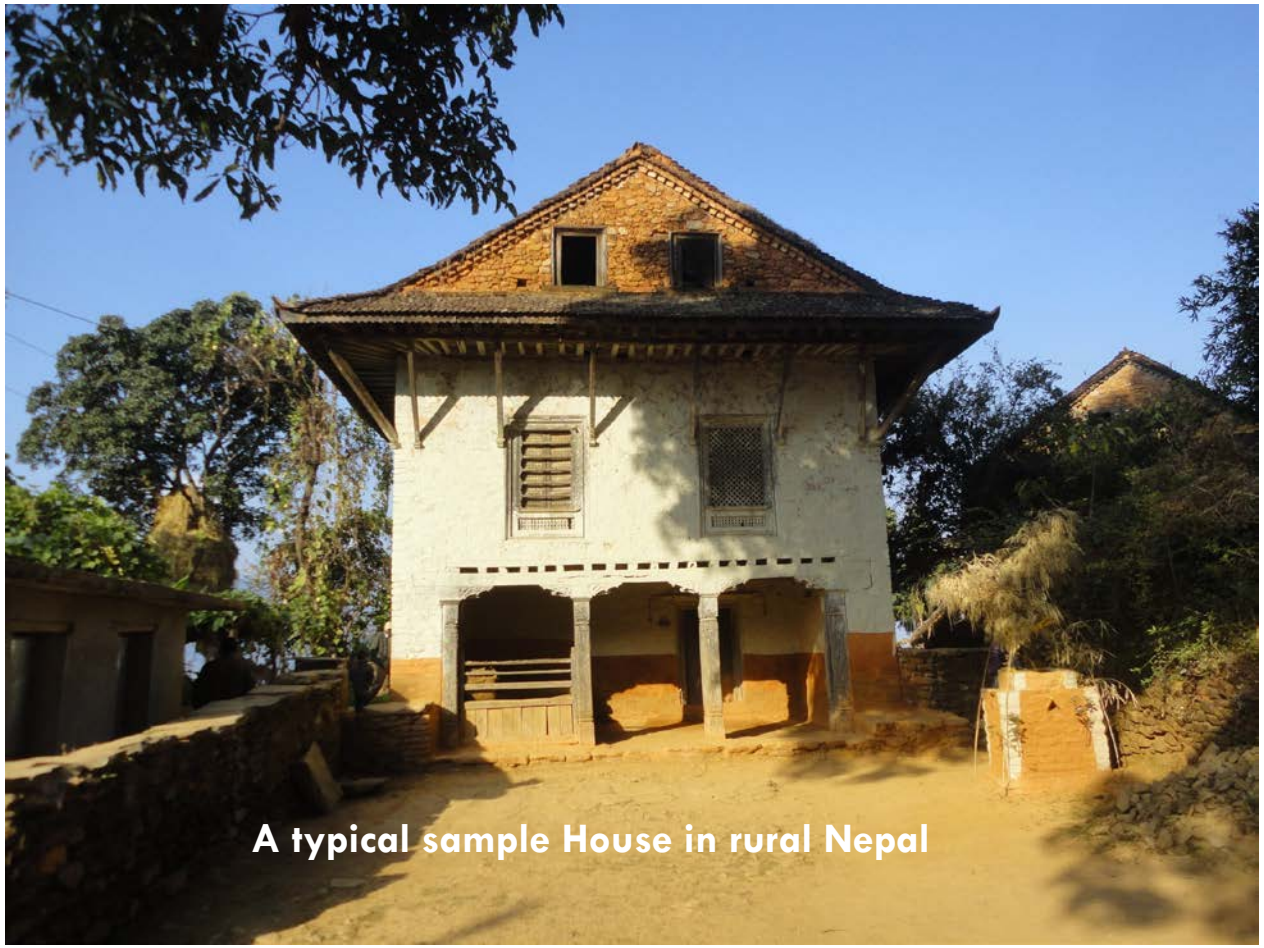
Based on the results of over 35 years of extensive geologic, geodetic and seismic studies,

We did forecast a Great earthquake with magnitude over 8 to occur any time in future (*but not the Gorkha Earthquake*), and the government and people were warned extensively for over a decade on the possible occurrence of an earthquake and to get prepared.

As a result public and government awareness campaigns were widely organized and preparedness for Earthquake rescue and relief operations were initiated.

This preparedness greatly helped for so well organized Rescue and Relief operation during the 2015 Earthquake . Most preparations were in place and were excellently executed.

Thanks to our Nepal Army, Armed Police force and Nepal Police. Also, good news is that Nepal has recently successfully completed the reconstruction work very recently just within 7 years. A great achievement.



A typical sample House in rural Nepal

The fate of the same house after the 25th April, 2015 Gorkha Earthquake

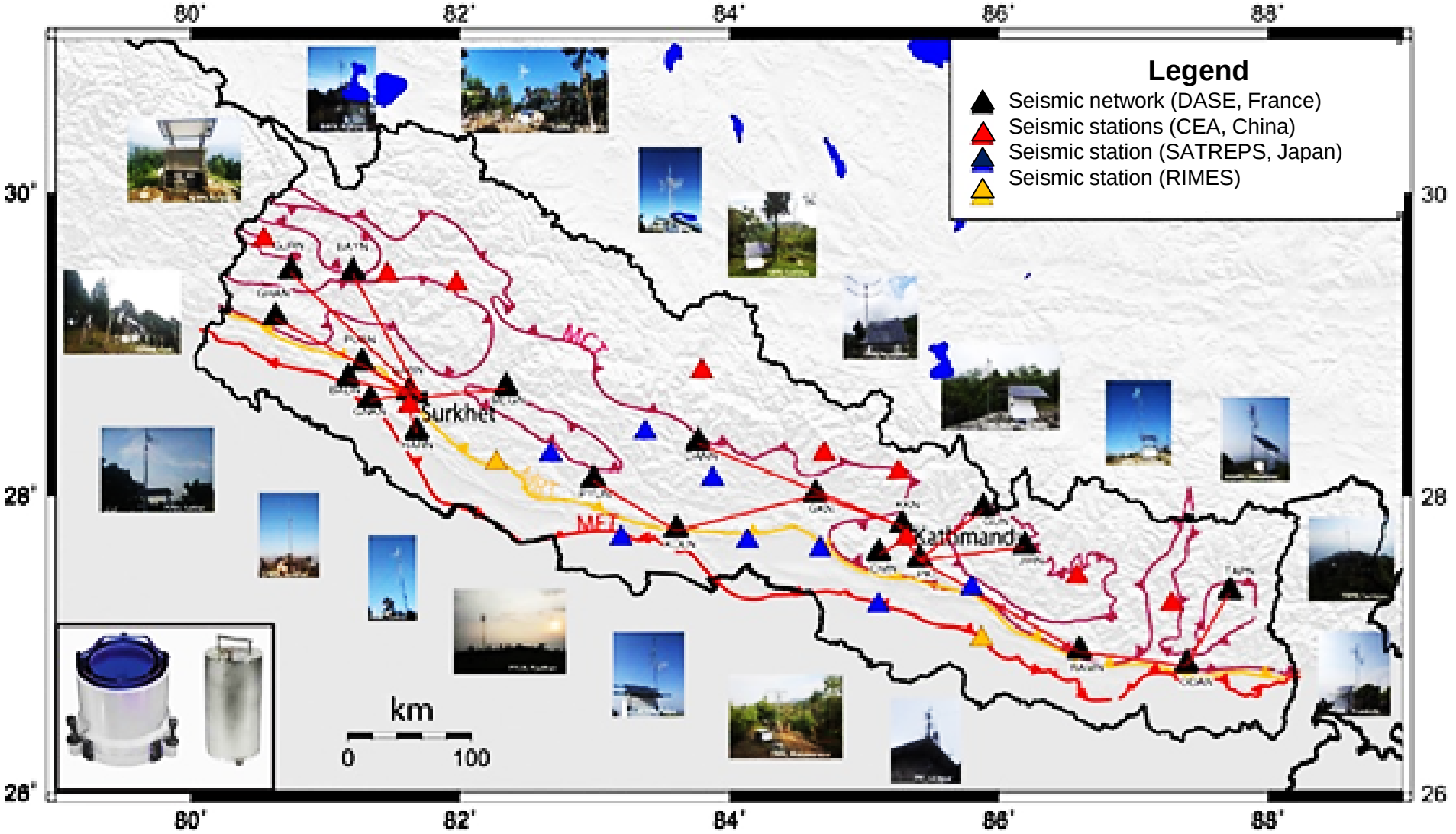
The Present Scientific Knowledge on Future Nepal Earthquake

The first seismic station in Nepal was established in 1978 under the Department of Mines and Geology in cooperation with DASE, France.

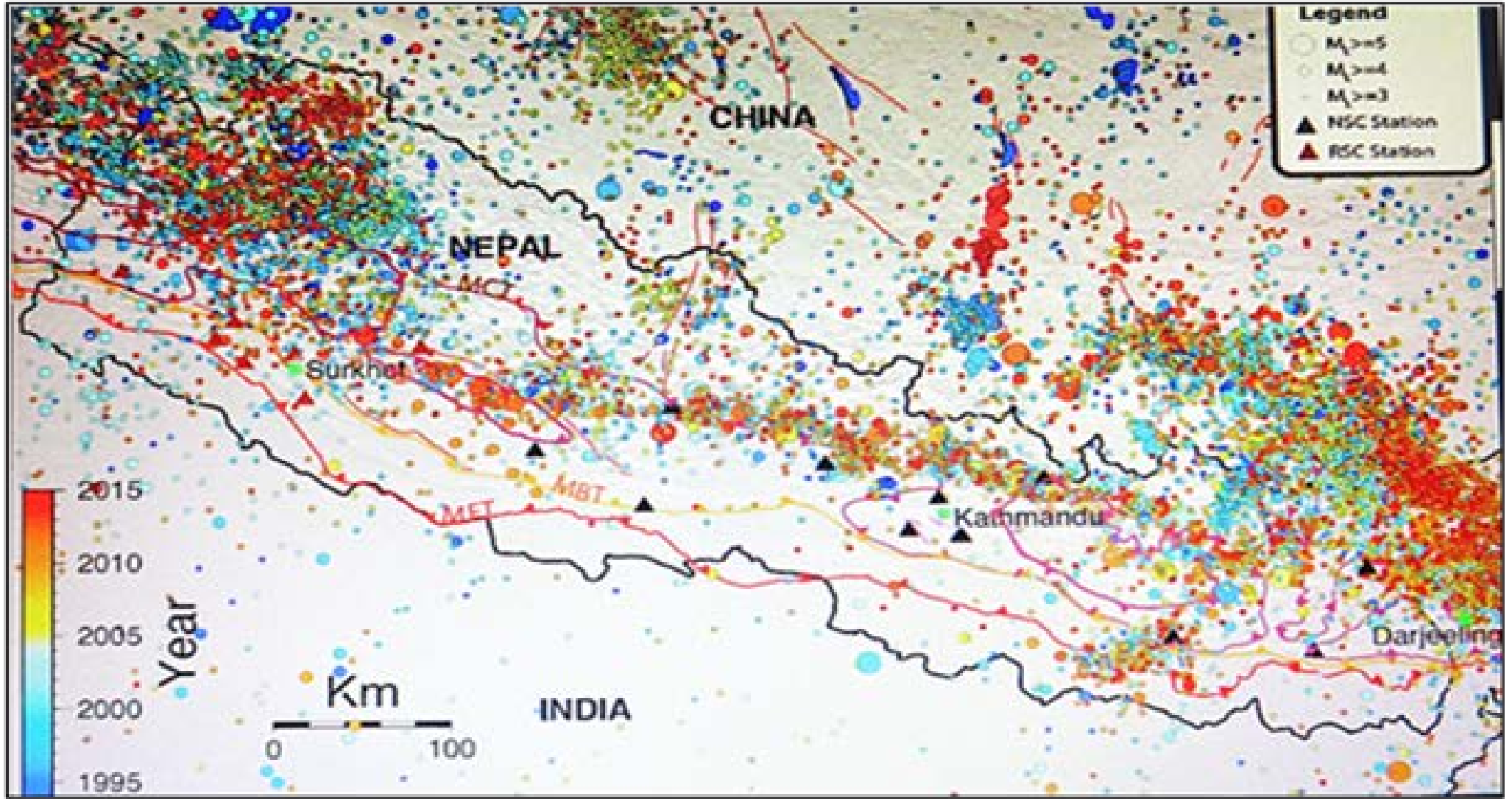
Based on the seismic data collected over ~15 years, the first model of the underlying structure of the Nepal Himalaya was published in 1995 (Pandey et al. 1995).

During the same period from Caltech, USA Prof. Avouac started establishing continuous GPS receivers, and for the first time the vertical and horizontal velocities and the stress accumulation rates in the Nepal Himalaya were established

Seismic studies in Nepal since 1978



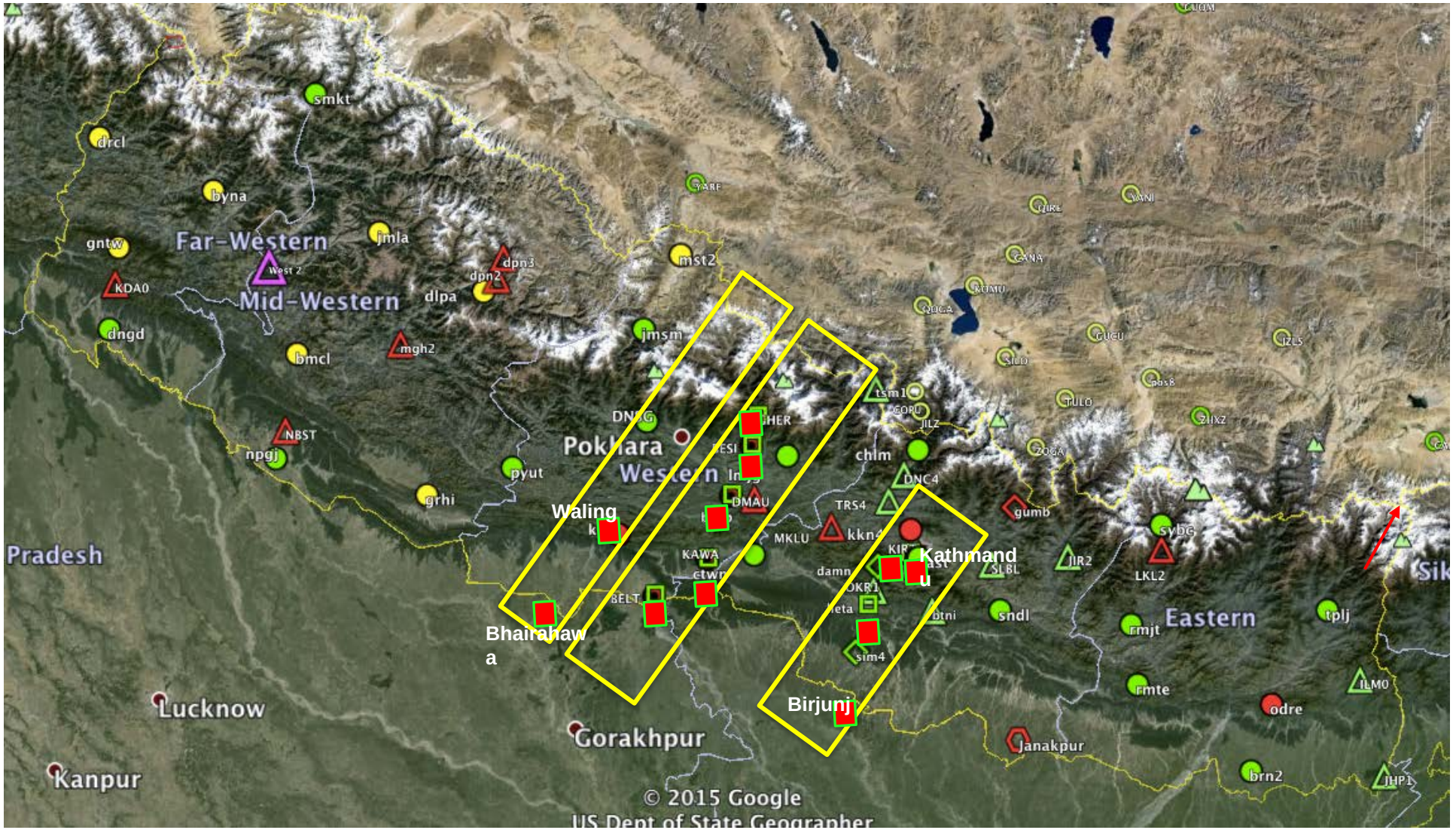
Currently operating seismic stations in Nepal (Adhikari et al., 2021) and approximate location of the "Seismology at School in Nepal" network within the yellow frame.



*Map showing microseismicity in Nepal between **1994-2014** (Adhikari, 2021).*

Currently running Nepal-Tibet GPS/GNSS stations (Caltech and NAST/TU)

- **Presently running NAST/TU GPS Stations along two transects and at Kathmandu (Total 11 stations)**

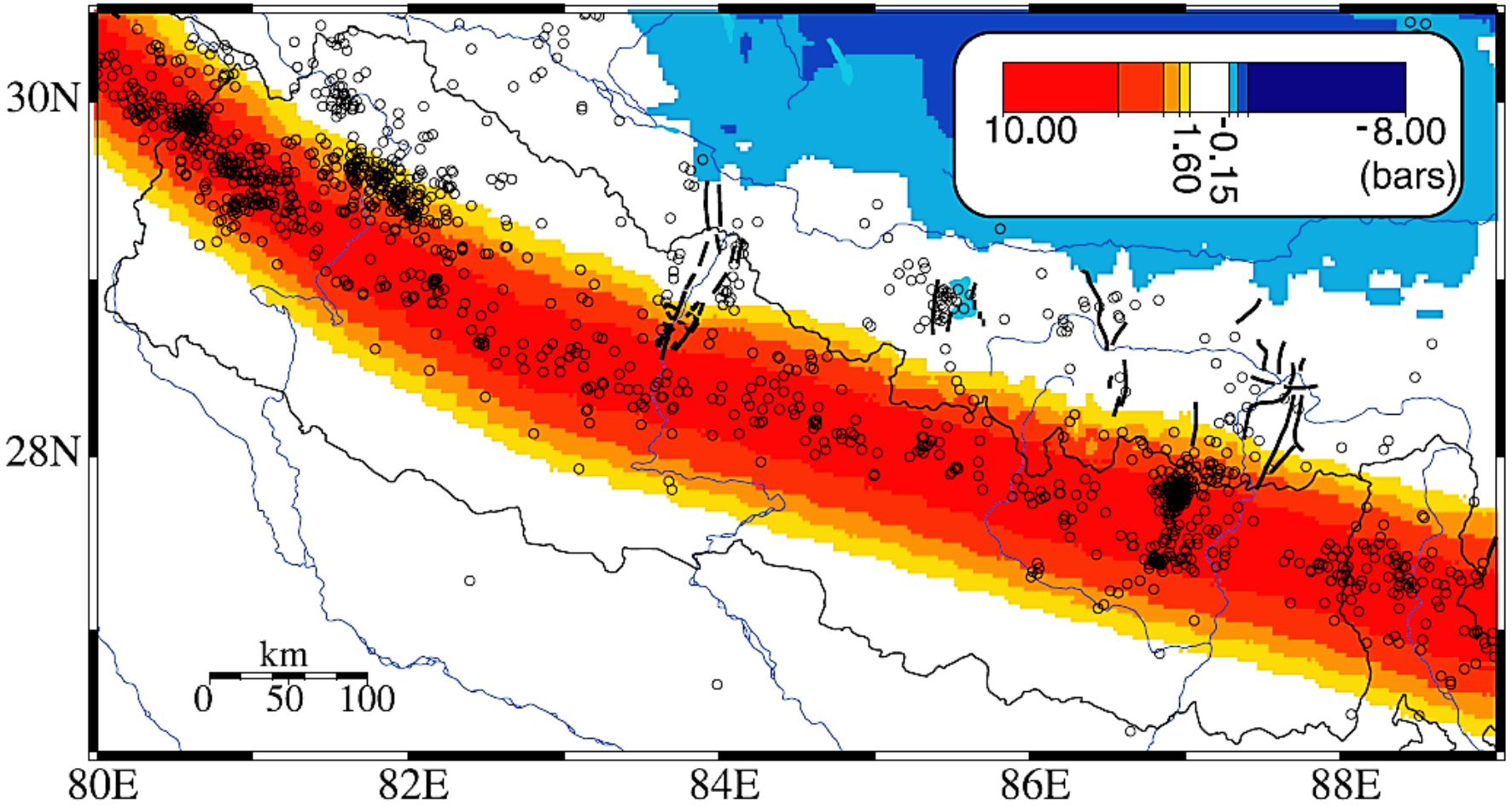


Local Capacity building
Students of Geology Department helping to establish the Temporary seismometers in the field and continuous GPS station at NAST

Continuous GPS station at NAST

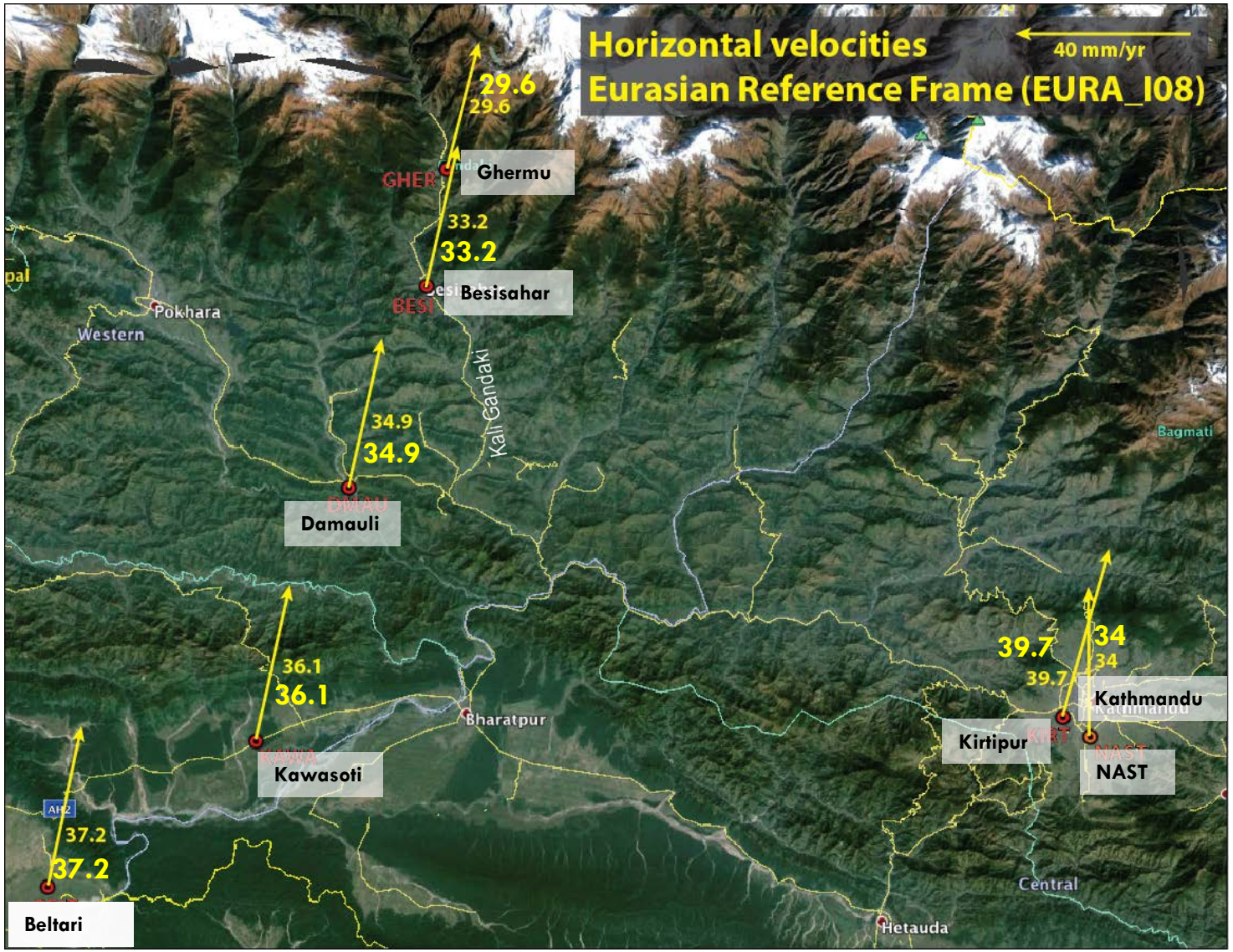
Stress accumulation rate along the Himalayan front during the interseismic period.

Coulomb stress variations were computed assuming a uniform regional stress field with σ_1 striking $N18^0E$ and $\triangle\sigma = 250.10^6$ Pa.



Bollinger et al., 2004

Horizontal movement of the Himalaya in western Nepal
NAST/ T U GPS station data before 2015 earthquake



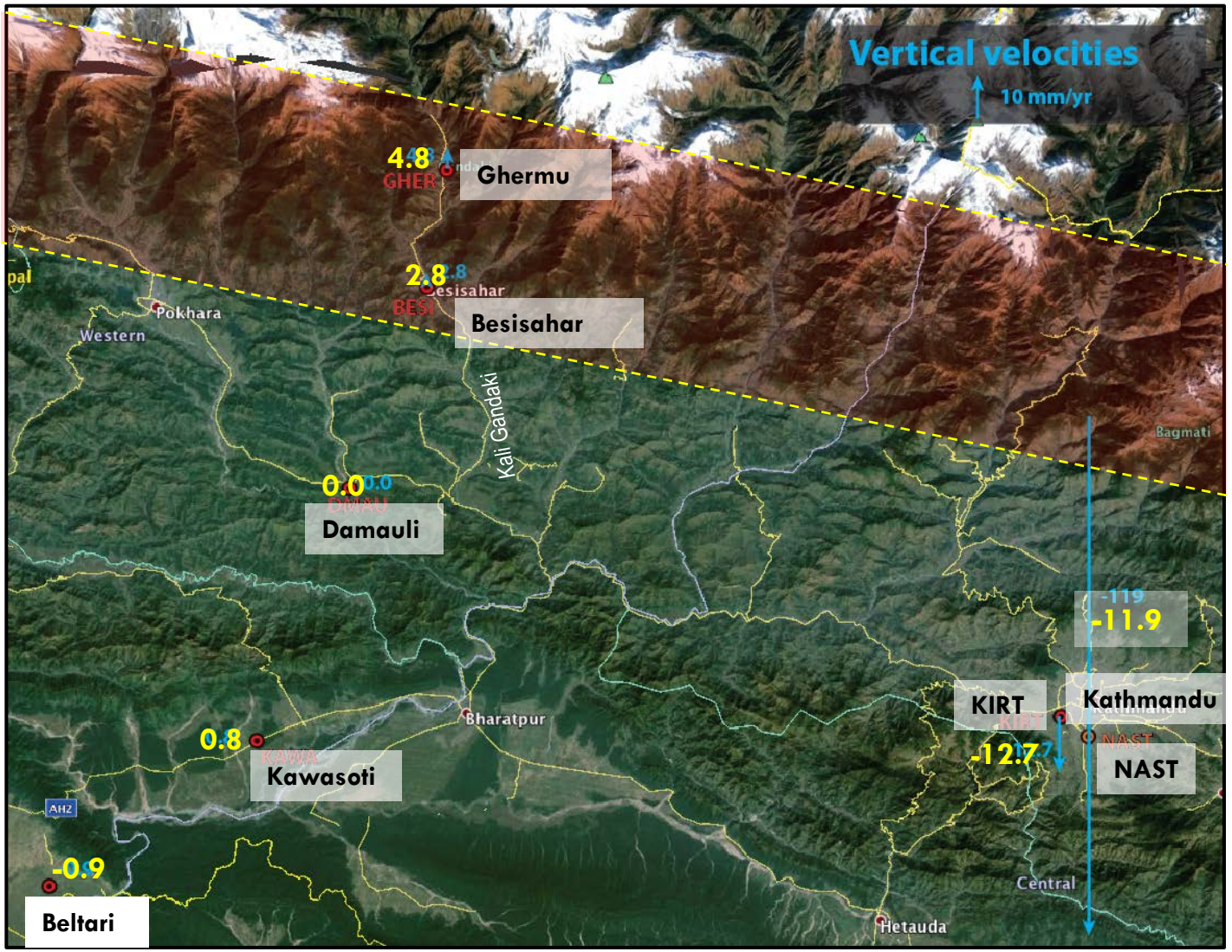
A shortening of 7.6 mm/year from south of MFT to MCT (37 to 30 mm/yr).

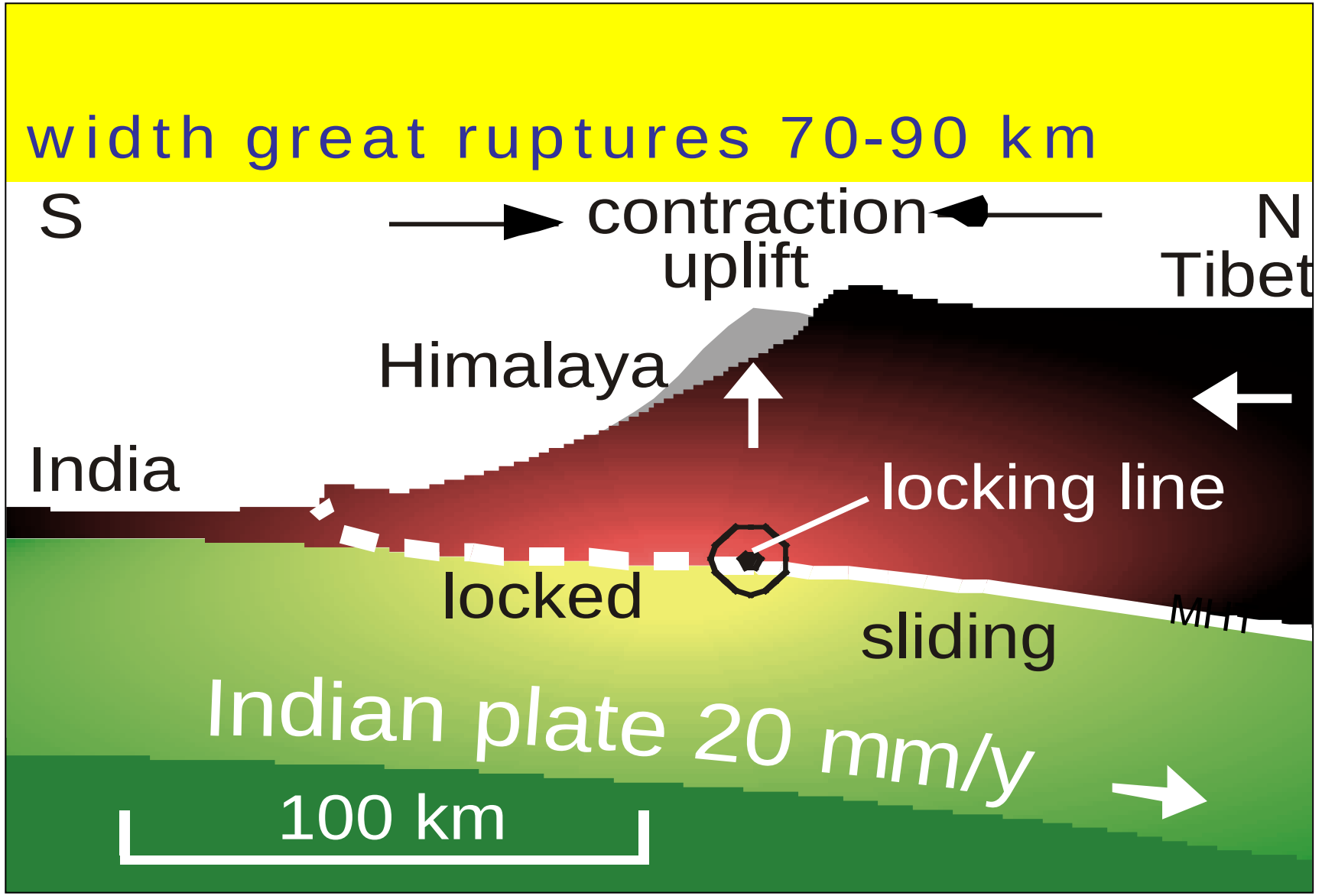
Half of this shortening occurs between the two most northern stations

No net vertical motion in the three south stations but the two northern stations show 2.8 ± 0.9 mm/yr and uplifting 4.8 ± 1.3 mm/yr.

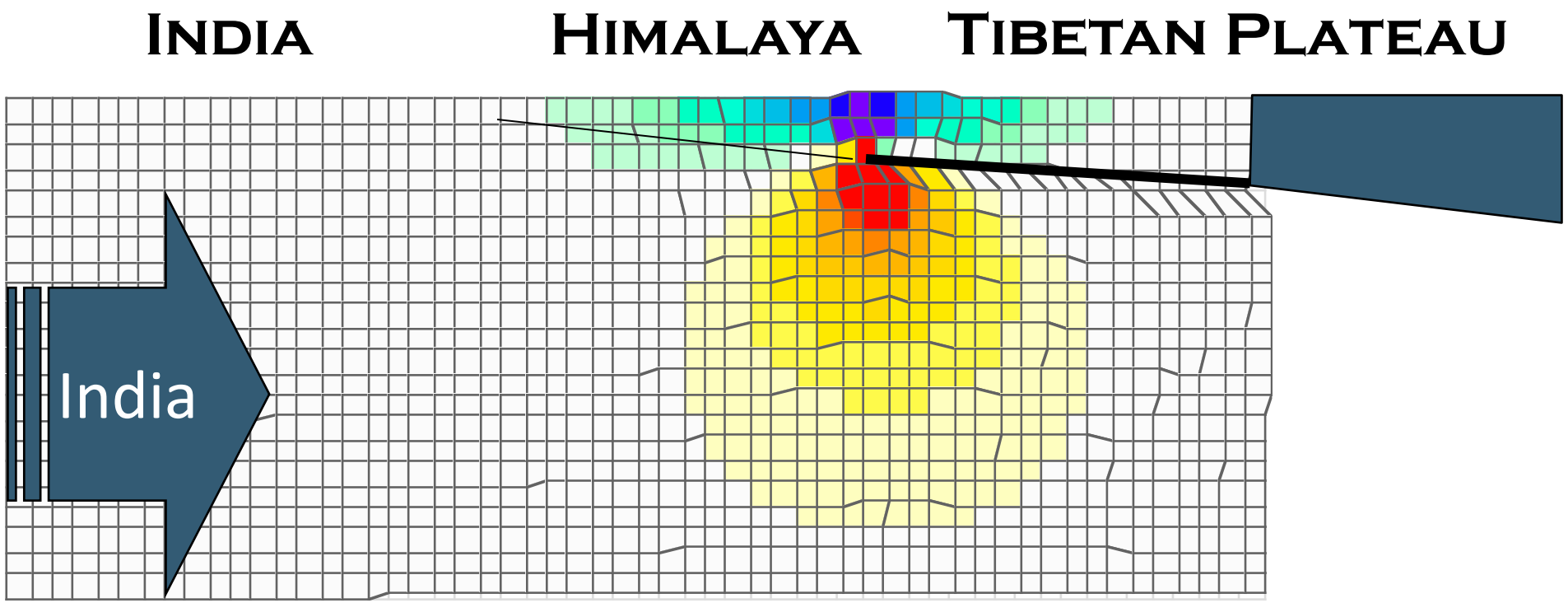
Conclusion: Interseismic strain accumulation above the crustal ramp on the MHT (to be released in the next major earthquake).

Vertical movement of the Himalaya in western Nepal
NAST/ T U GPS station data before 2015 earthquake

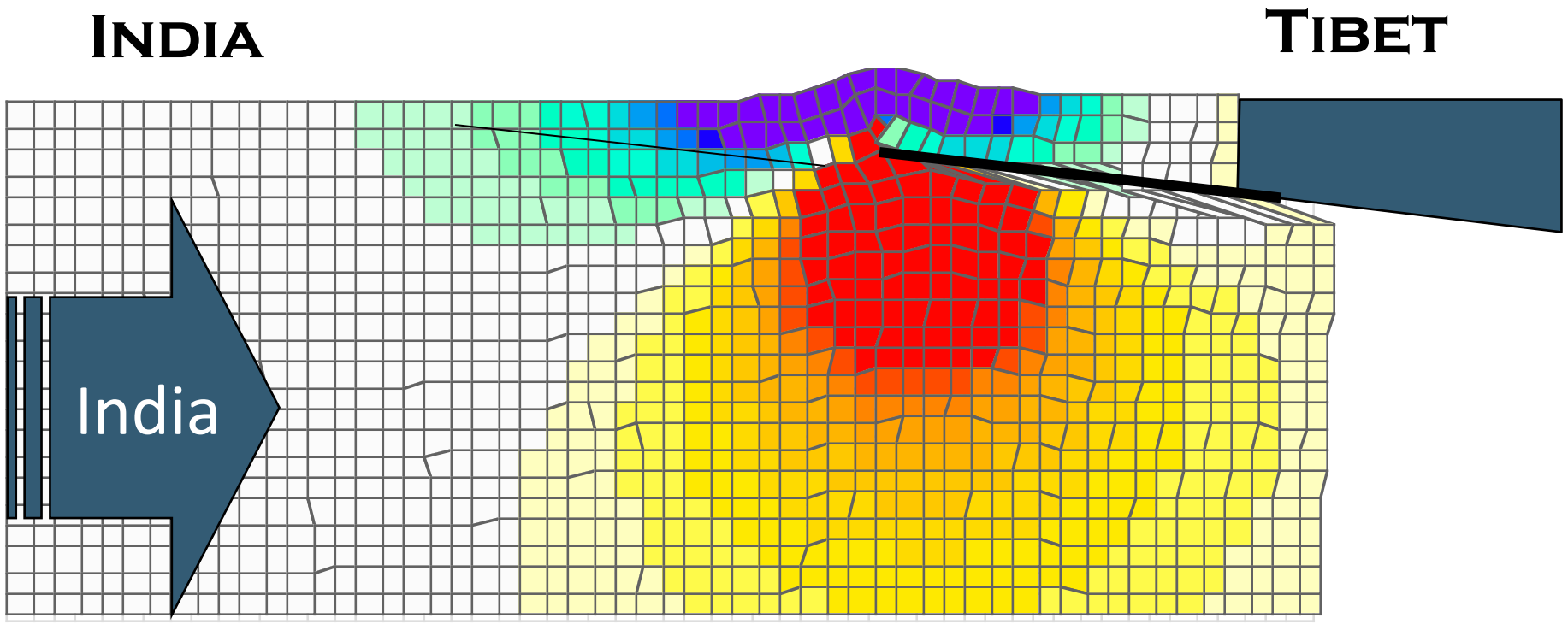




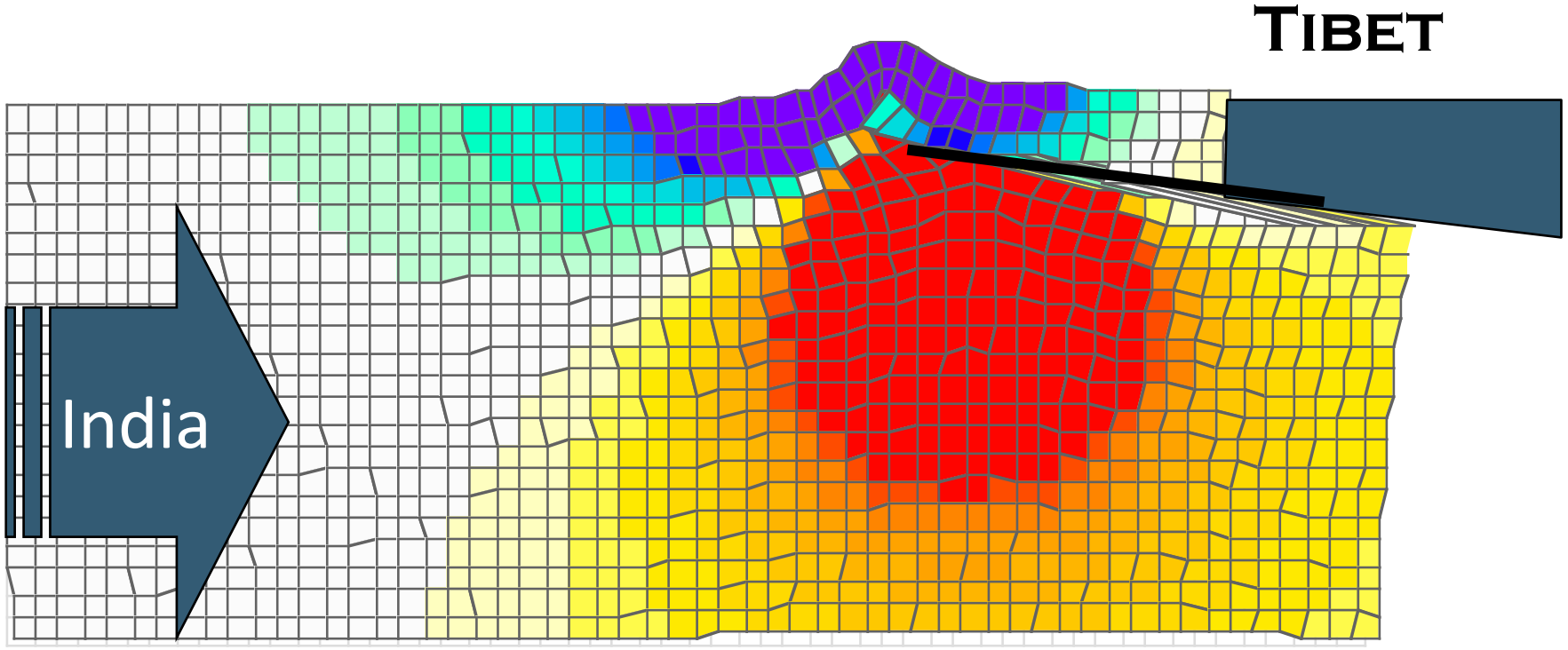
Bilham, Gaur and Molnar, 2001

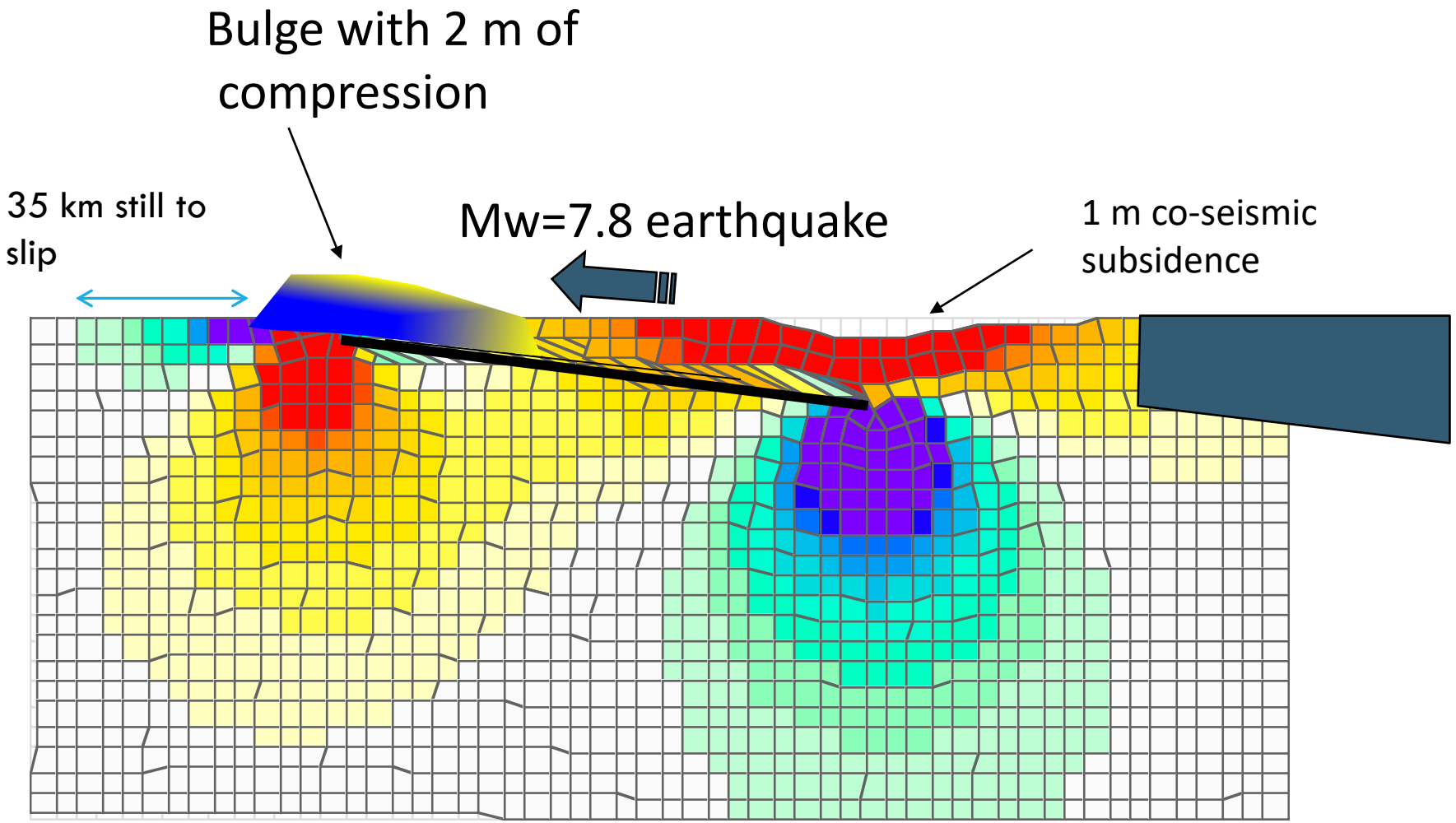


(Bilham, Personal Comm.)

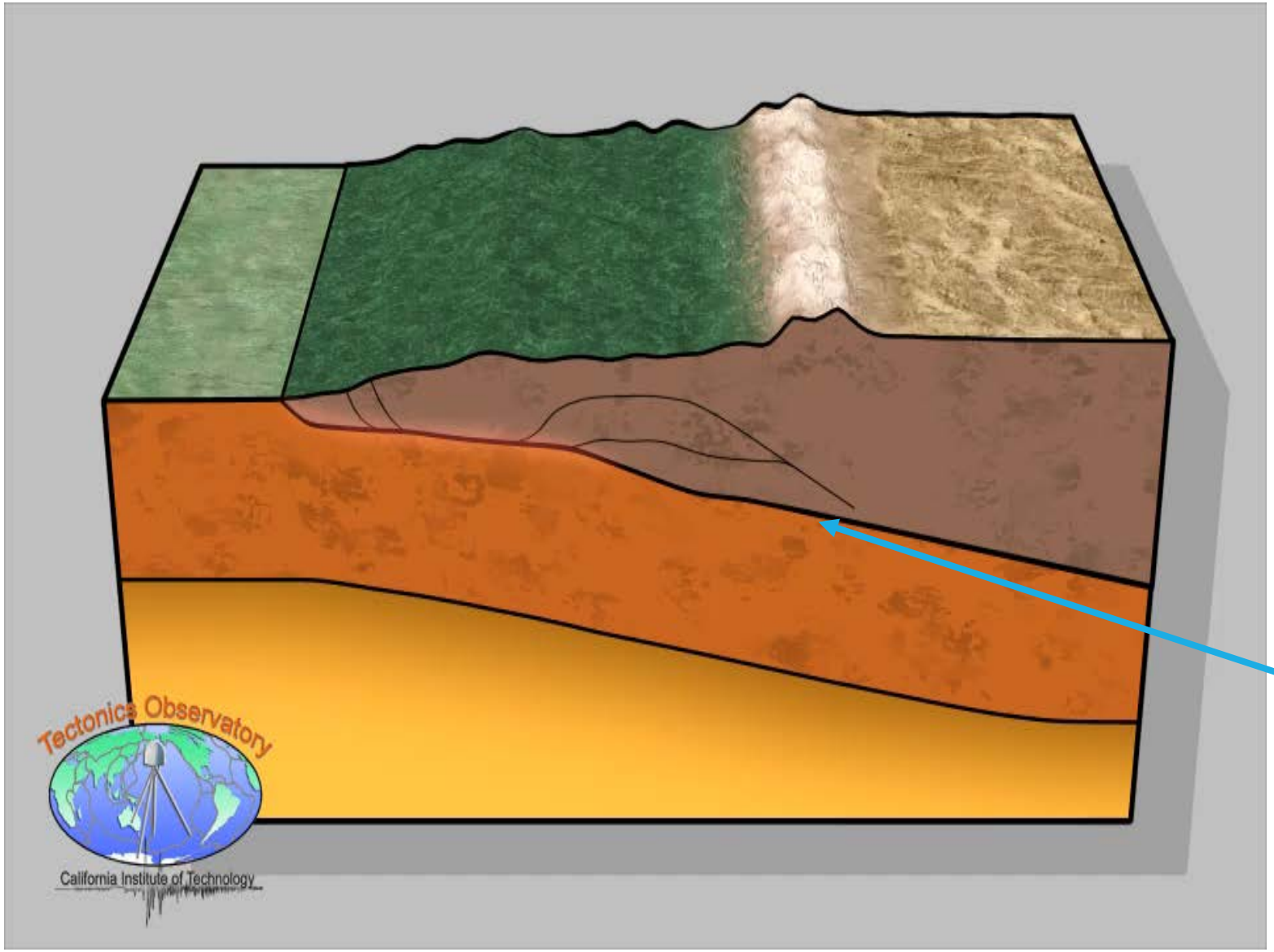

INDIA
TIBET
India

critical stress





The 2015 earthquake incompletely slipped



Courtesy, Jean Phillipe Avouac, Caltech)

The Ruptured segment of Gorkha earthquake along the MHT

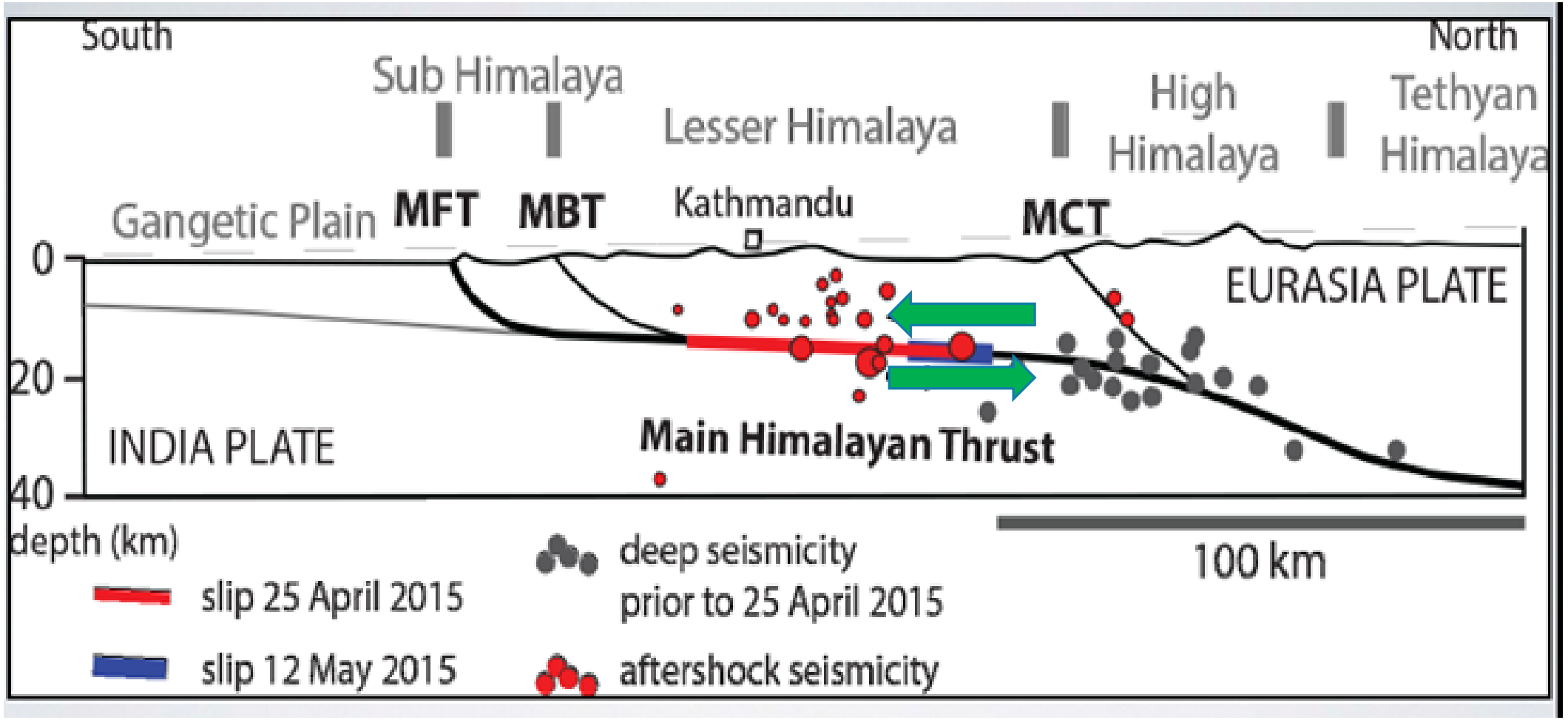
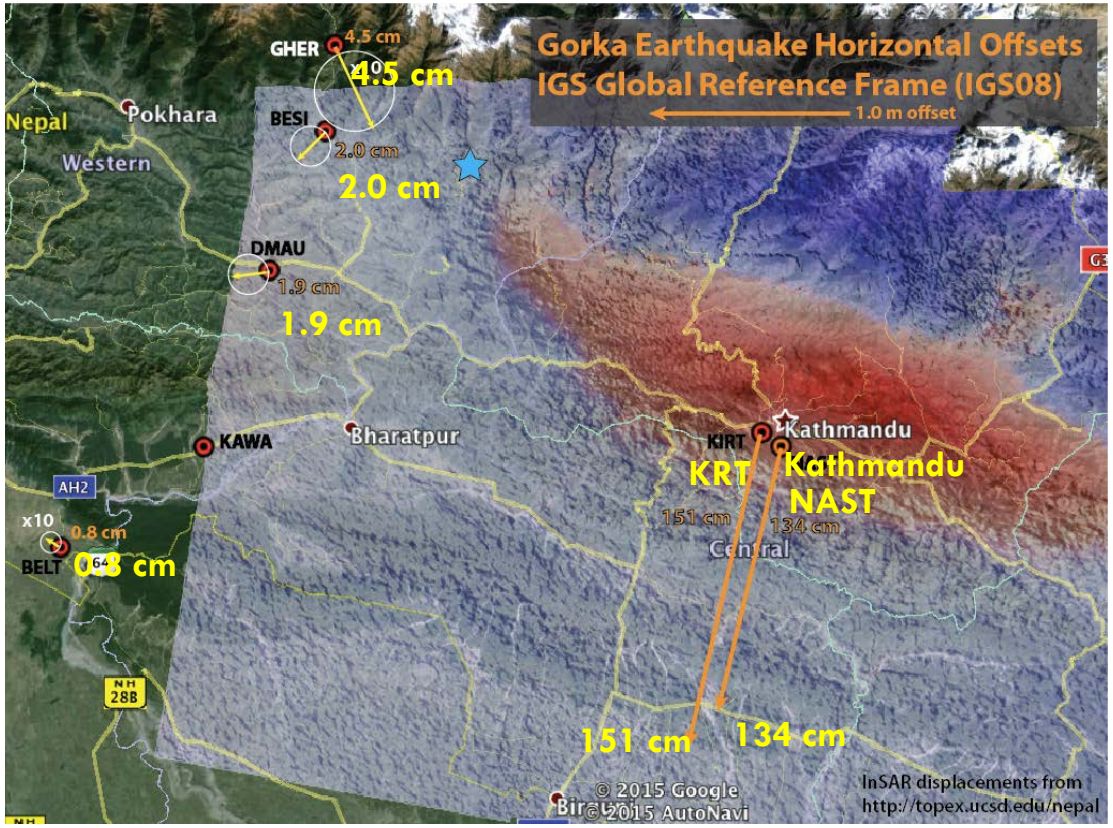
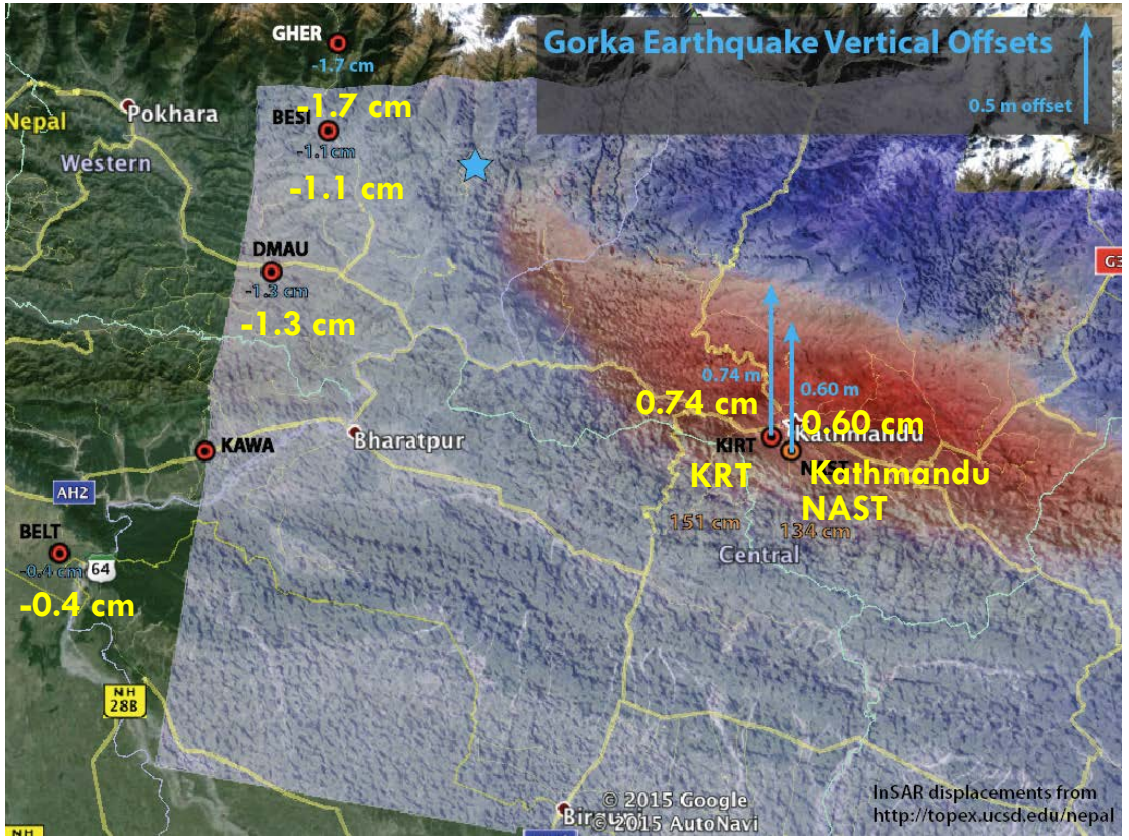


Figure 4. Generalised cross section showing the approximate locations of slip during the 25 April and 12 May 2015 ruptures on the Main Himalayan Thrust (MHT), and approximate aftershock locations of both events. (Hayes, G., USGS, 2015)

NAST-TU Station GPS data after the 2015 Gorkha Earthquake



The results of NAST/TU GPS two stations in Kathmandu Valley showing the horizontal movement of stations by 151 and 136 cm to the south



The results of NAST/TU GPS two stations in Kathmandu Valley showing the vertical movement of stations by 0.60 and 0.74 m to the south

Paleoseismological research in Nepal

Active fault research

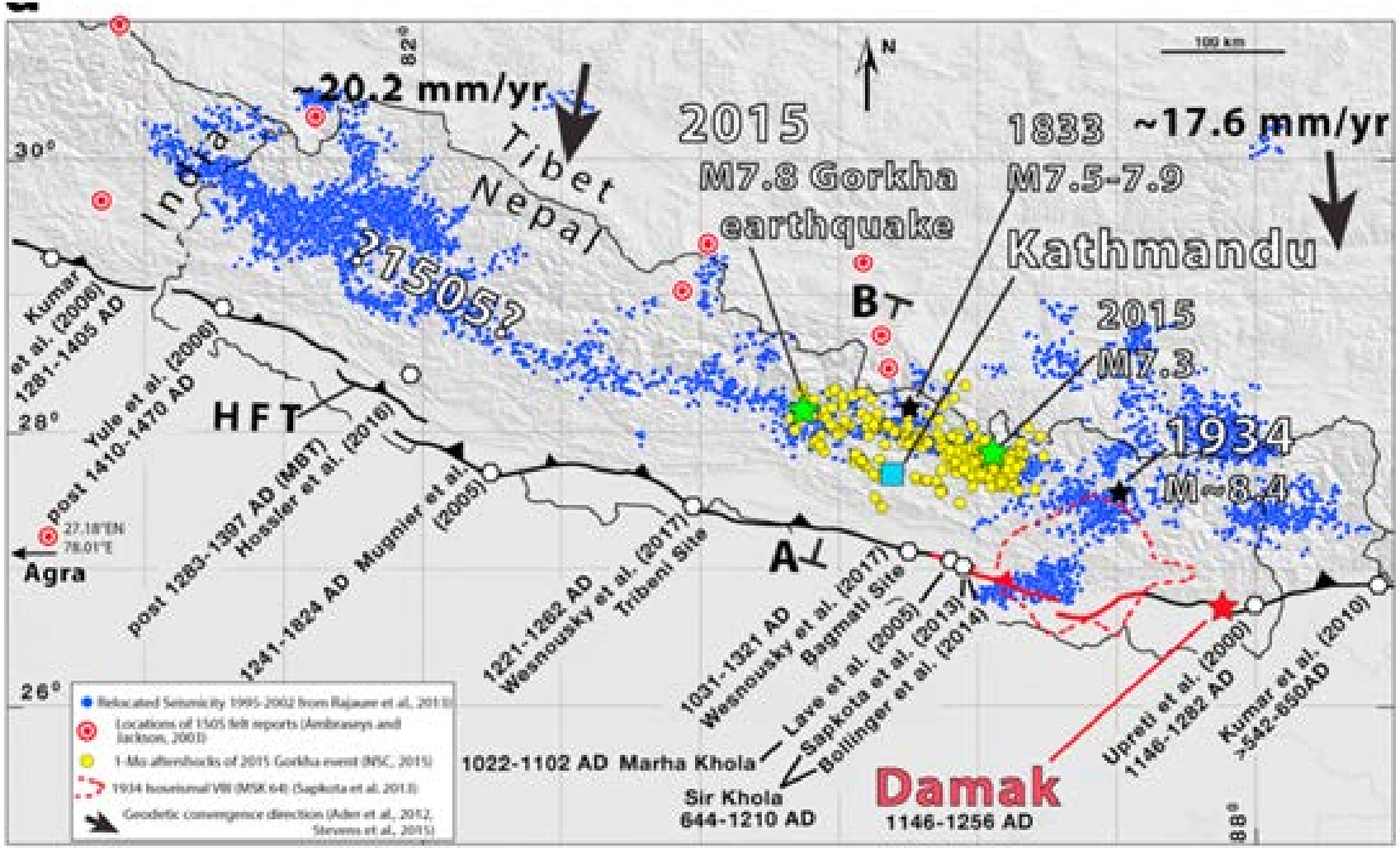
A Tool for Evaluating Earthquake Risks

Active Faults in Nepal

Trenching across active faults in western Nepal

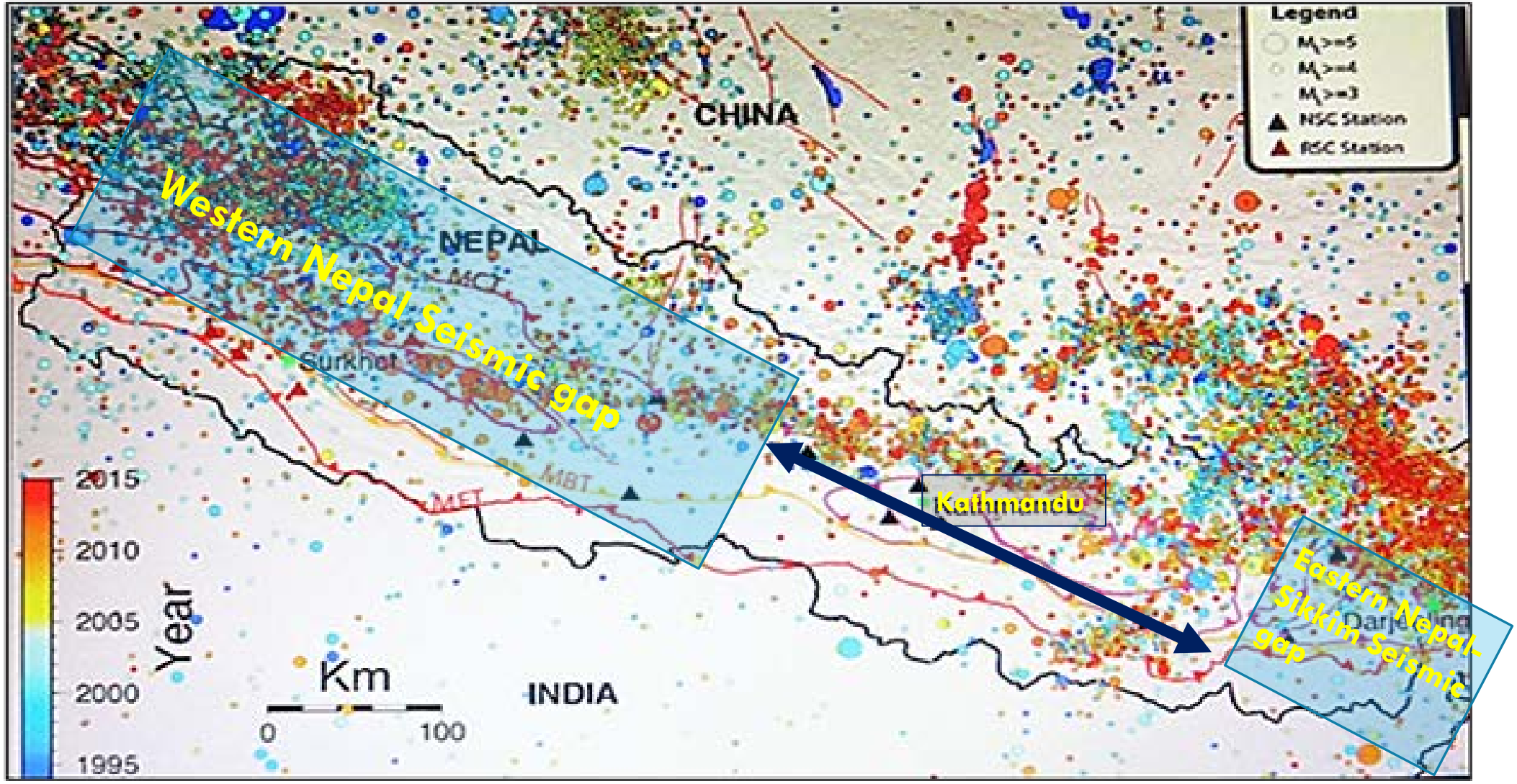
Photos: B.N. Upreti

Location of major trenching sites in Nepal and age of surface rupture earthquakes reported at sites along the Himalayan Frontal Thrust (HFT)

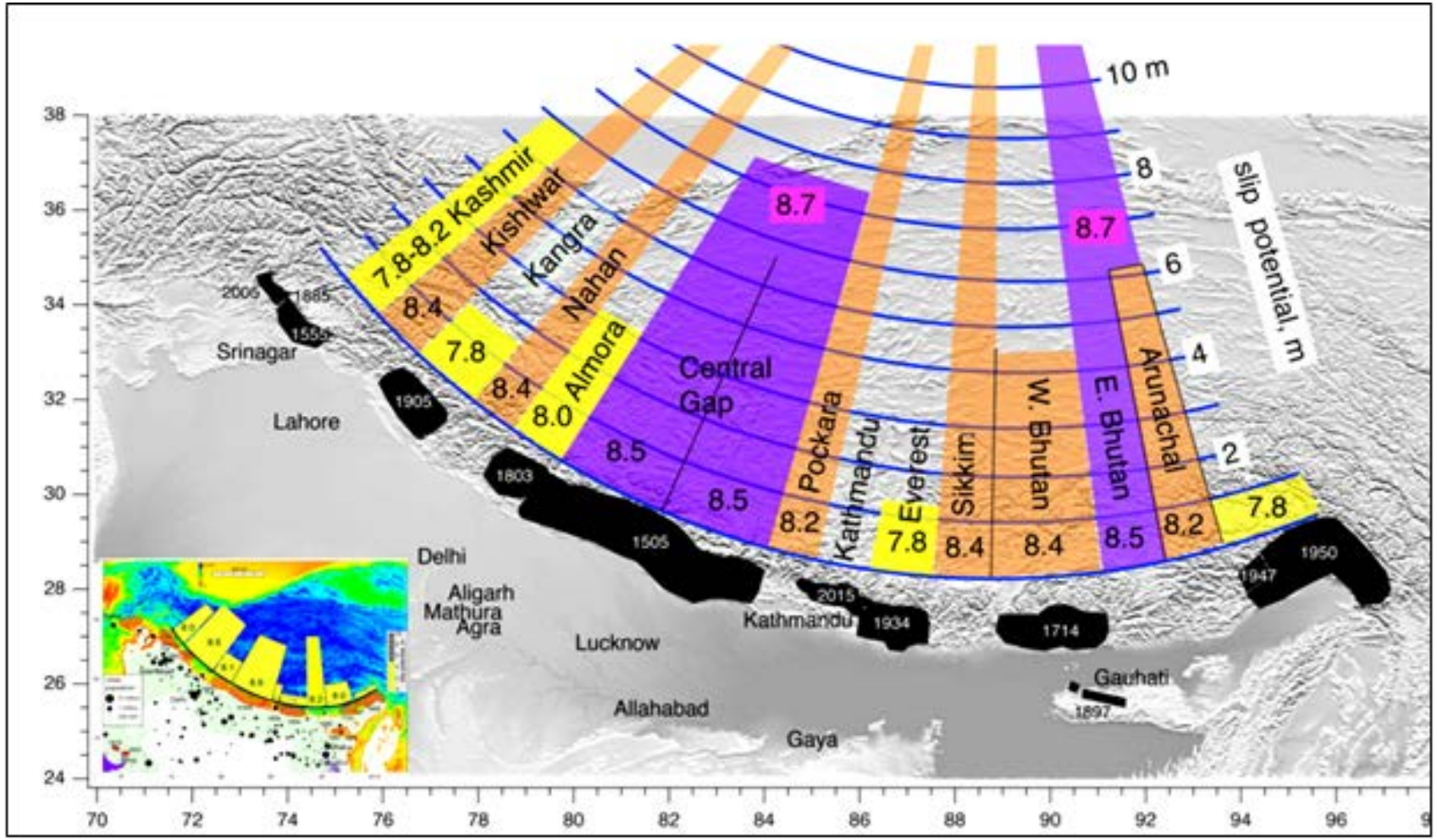


(After: Wesnousky et al., 2017

The approaching
Great Nepal Earthquake – 20xx (!!)



Map showing microseismicity in Nepal between 1978-2020 (Adhikari, 2021). The Eastern and western Nepal seismic gaps are added on the original map. Seismic gaps are the potential areas for the next large earthquakes.

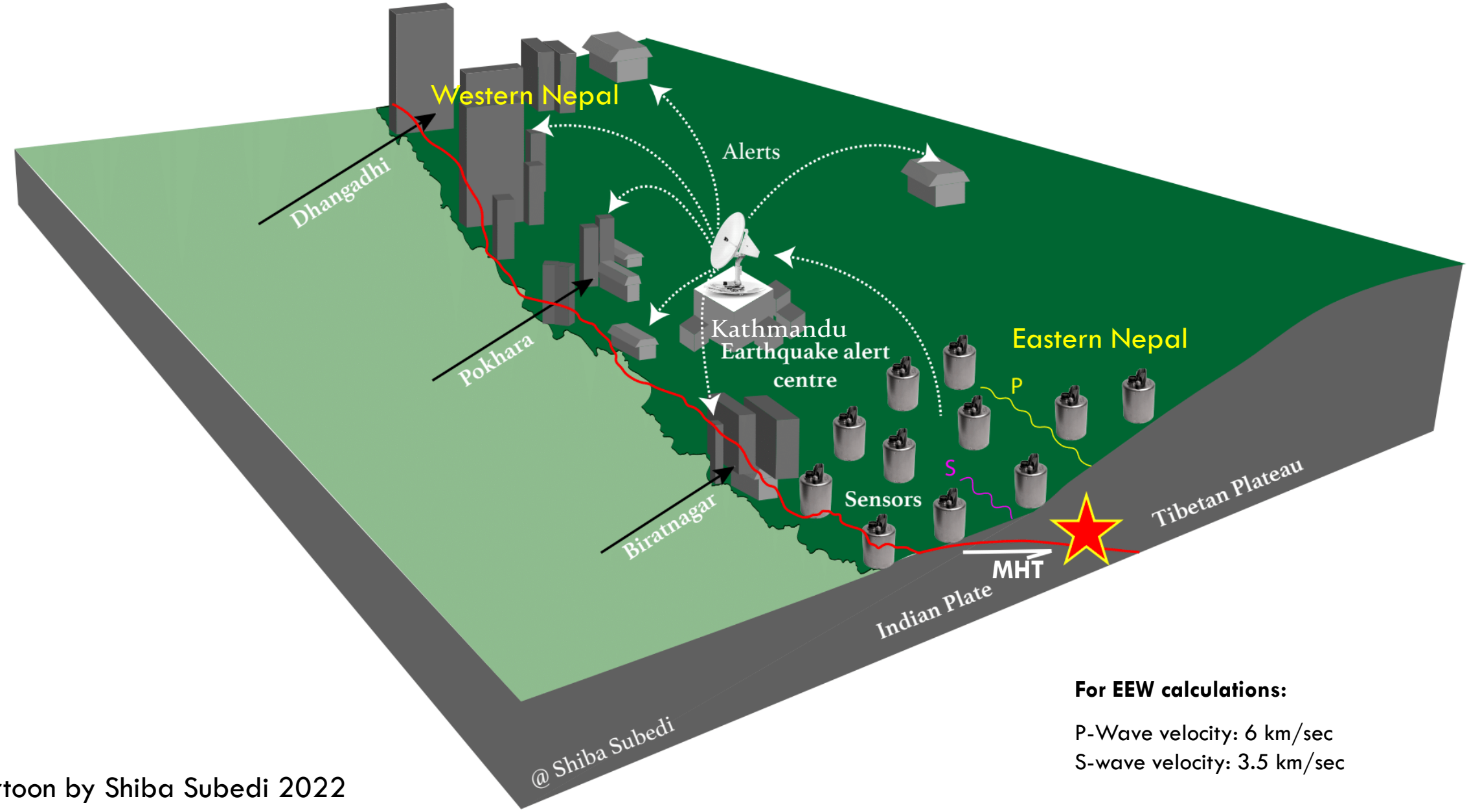


Bilham, 2019. Himalayan earthquakes: a review of historical seismicity and early 21st century slip potential. Geological Society, London, Special Publications, 483, 423-482, 5 February 2019, https://doi.org/10.1144/SP483.16

Fig. 34. Five centuries of Himalayan rupture zones (black) and current slip potential (metre scale (right)) since the last rupture in named segments. The colours indicate the maximum magnitude of an earthquake that could occur in the present time should a segment fail in a single event or as partial slip. Two areas with violet shading could host Mw > 8.7 earthquakes. Six areas with brown shading could rupture in Mw 8.4 earthquakes. Five areas, shaded yellow, could presently slip in Mw ≥ 7.7 earthquakes similar to the recent Gorkha earthquake. The Kathmandu region could experience a Mw 7.3 earthquake to its south, but I argue in the text that this is unlikely. The inset shows an earlier version of this plot made before the 2005 and 2015 earthquakes (Bilham & Wallace 2005). The 2005 earthquake occurred to the west of a Mw = 8.0 forecast region, and the 2015 earthquake occurred at the junction between Mw = 7.4 and Mw = 7.9 forecast areas north of Kathmandu. A recurrence of the 1833 earthquake was not anticipated.

Proposed

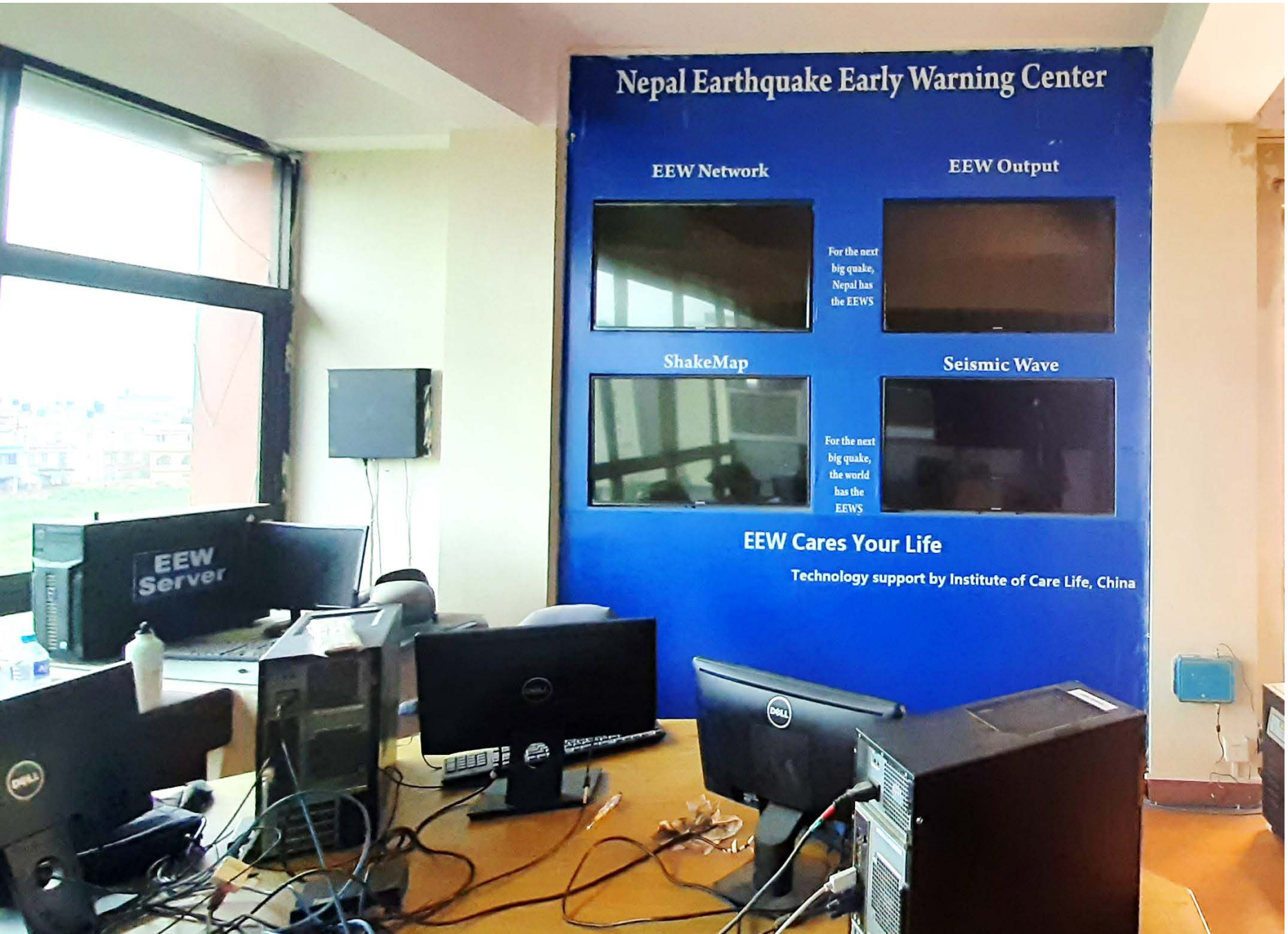
National Earthquake Early Warning (EEW) System in Eastern Nepal Under NAST



Cartoon by Shiba Subedi 2022

For EEW calculations:

P-Wave velocity: 6 km/sec
S-wave velocity: 3.5 km/sec

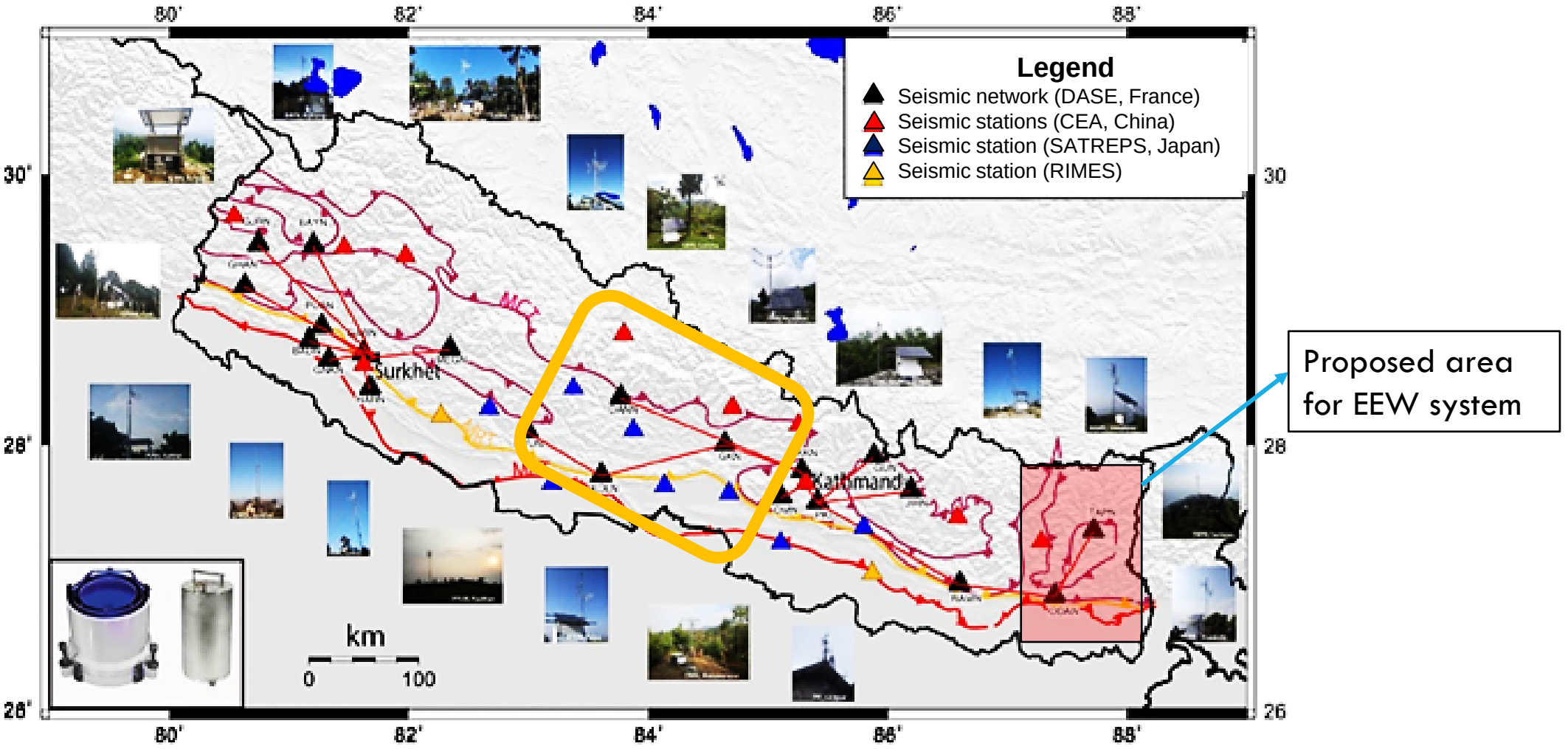


NAST has already attempted to run an EEW system for western Nepal area covering from Pokhara to Kathmandu with about 60 accelerometers.

It was established immediately after the 2015 Gorkha Earthquake with the help from a Chinese Company.

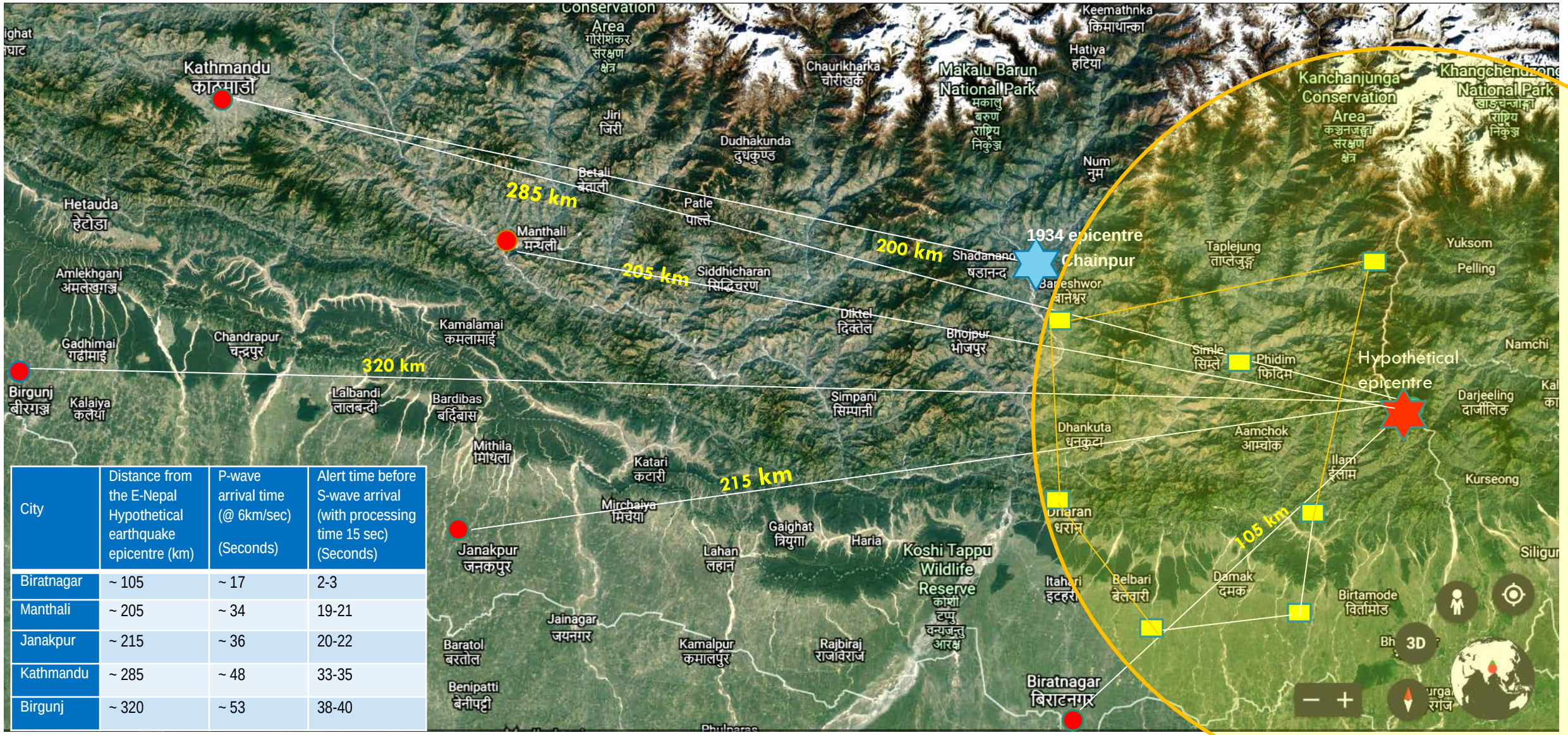
However, the Chinese involvement was short lived.

Seismic studies in Nepal since 1978



Currently operating seismic stations in Nepal (Adhikari, 2021, Unpub. PhD Thesis, (Univ of Paris)And approximate location of the “Seismology at School in Nepal” network in yellow

Proposed new seismic stations (base stations) in eastern Nepal and possible lead time for Earthquakes Early Warning (EEW) (*Yellow squares proposed new seismic stations for EEW*)



City	Distance from the E-Nepal Hypothetical earthquake epicentre (km)	P-wave arrival time (@ 6km/sec) (Seconds)	Alert time before S-wave arrival (with processing time 15 sec) (Seconds)
Biratnagar	~ 105	~ 17	2-3
Manthali	~ 205	~ 34	19-21
Janakpur	~ 215	~ 36	20-22
Kathmandu	~ 285	~ 48	33-35
Birgunj	~ 320	~ 53	38-40

One section of the technology building is set aside in the ground floor for the Seismological date centre

Way Forward

Preparedness

- Establishment of an Earthquake Early Warning System
- Massive public awareness and sensitization to the Government machinery
- Renewed preparedness on Rescue and Relief
- Advanced training to NA, APF and NP
- Establishment of a International standard National Disaster Training Centre under Nepal Army
- Strengthening NDRRMA and MoHA in disaster preparedness


THANK YOU