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“Earthquake swarms and reactivation of seismicity associated with the 2015 Mw 7.8 Gorkha earthquake in Nepal.”

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CTBT: Science and Technology Conference

Vienna Austria

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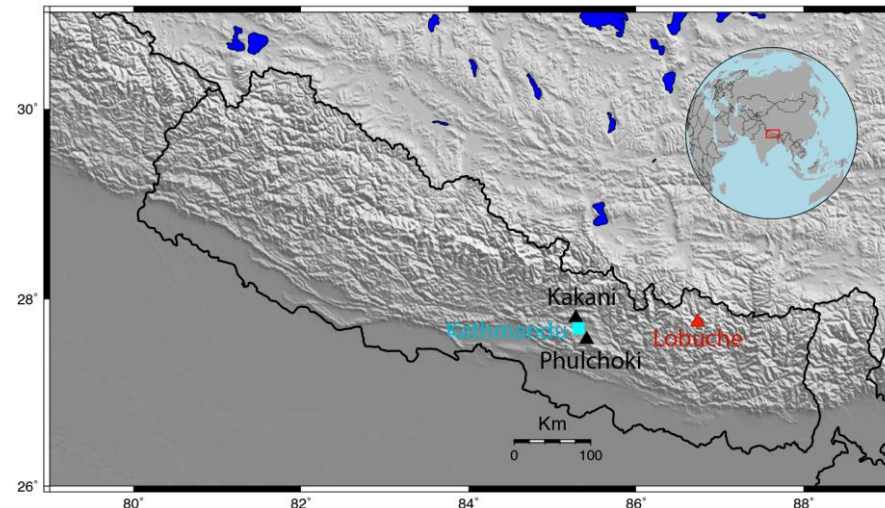
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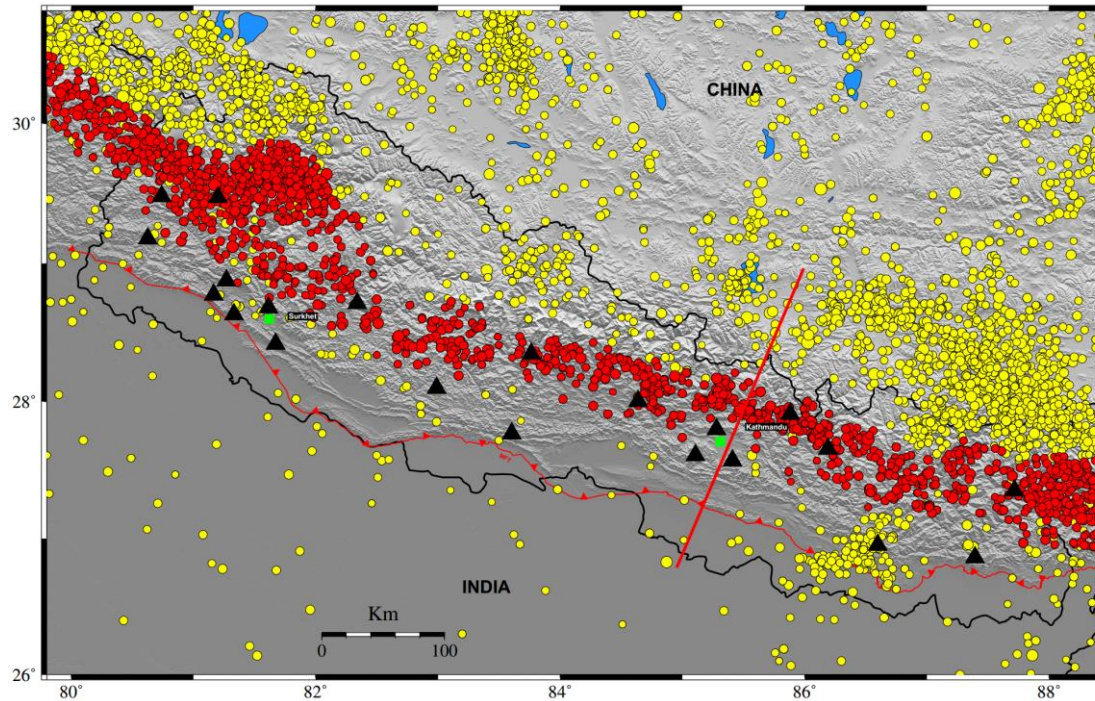
- CTBTO in Nepal: present status
- Introduction: Background seismicity
- Gorkha earthquake 25 April 2015
- Aftershocks of Gorkha earthquake
- Kathmandu cluster and Himalchuli swarm
- Conclusions

Present status of CTBTO in Nepal

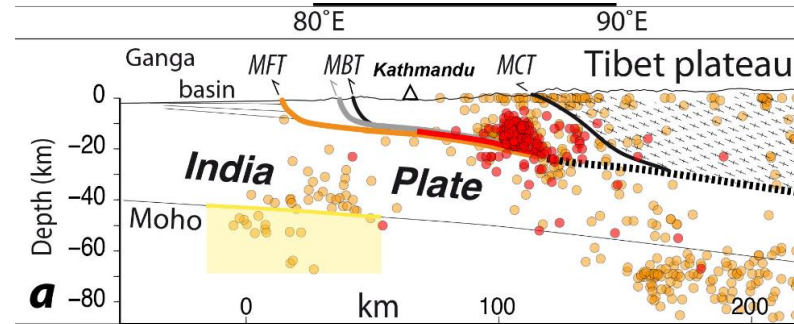
1. Treaty was signed by Nepal in 9th October 1996 but not ratified yet.
2. CTBTO had proposed a Auxiliary Seismic station AS68 in Lobuche.
3. Executive Secretary of CTBTO Dr. Wolfgang Hoffman and his team along with Nepalese counterpart have visited Lobuche site October 2001.
4. This site was not suitable to run the station at the state of health(97%) defined by the CTBTO. Presently this site has been abandoned due to difficulty of maintaining the station as per the pre-requisite of CTBTO.
5. Two sites were selected as PHULCHOKI or KAKANI.
6. KAKANI was found to be a suitable site for the station by different technical points of view (e.g. bed-rock, low noise, easy access for maintenance etc).
7. Ministry of Education, Science and Technology (MOEST) has designated MOEST as a focal point and National Seisological center of Department of Mines and Geology (DMG) as a NDC.



Background Seismicity in Nepal



(Total events recorded >59,000 events)

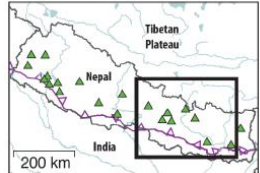
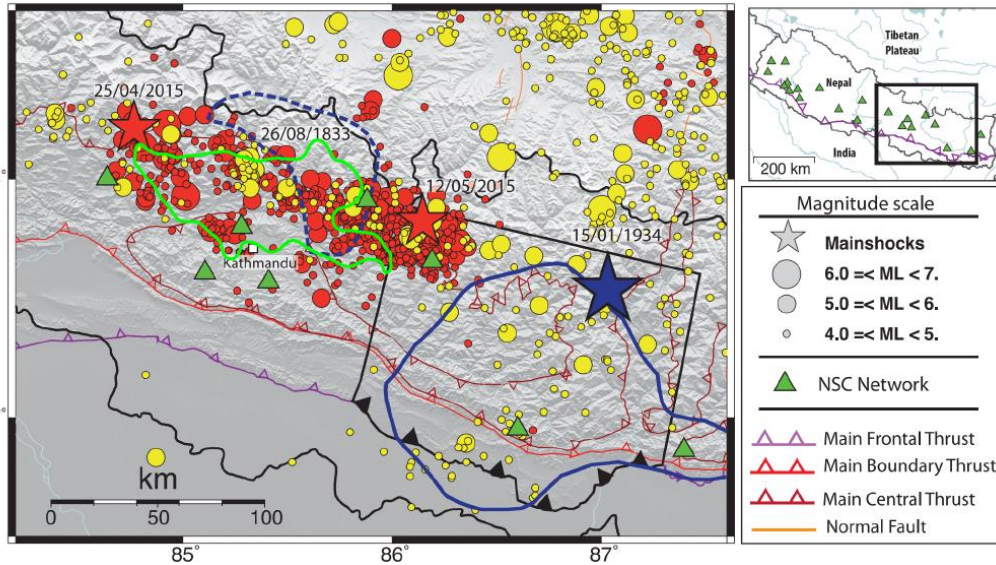


Kathmandu crosssection
(modified from Bollinger et al., 2014)

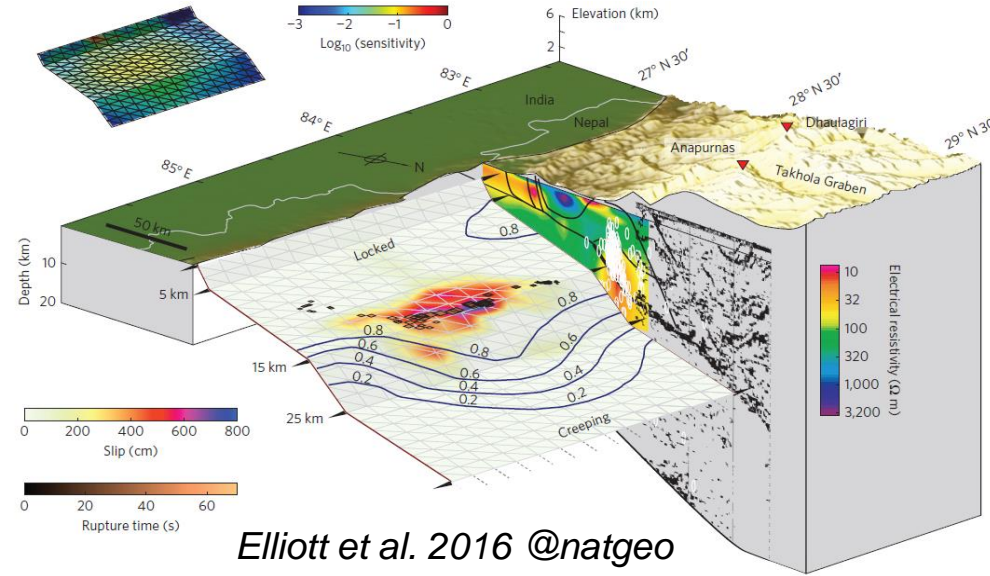
Instrumental Seismicity
($ML \geq 3.5$) during 1994-2014
AD.

Midcrustal seismic cluster develops at the downdip end of the locked portion of the Main Himalaya Thrust (MHT).

Gorkha earthquake April 25, 2015

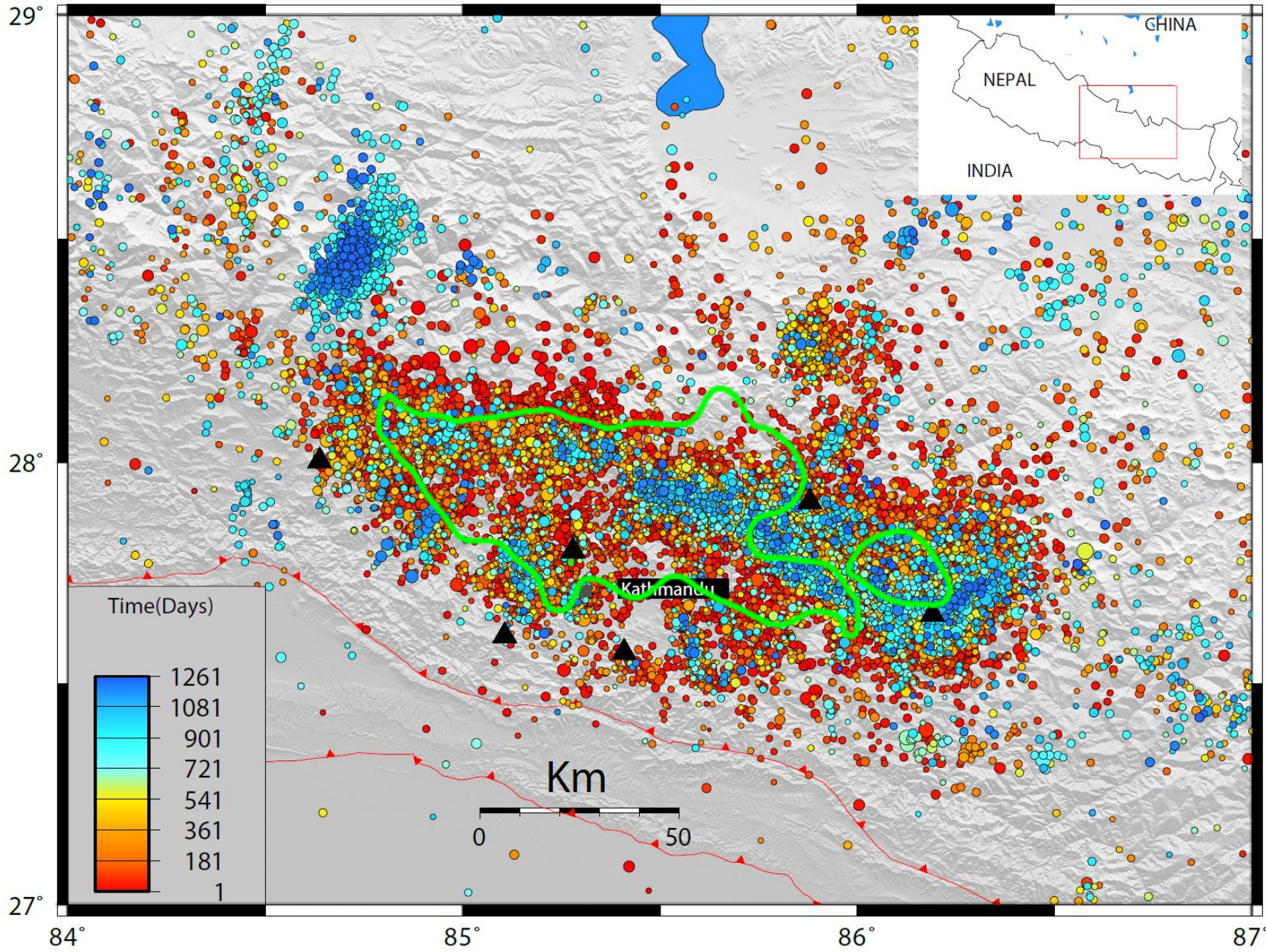


Modified after Adhikari et al 2016 @ GJI

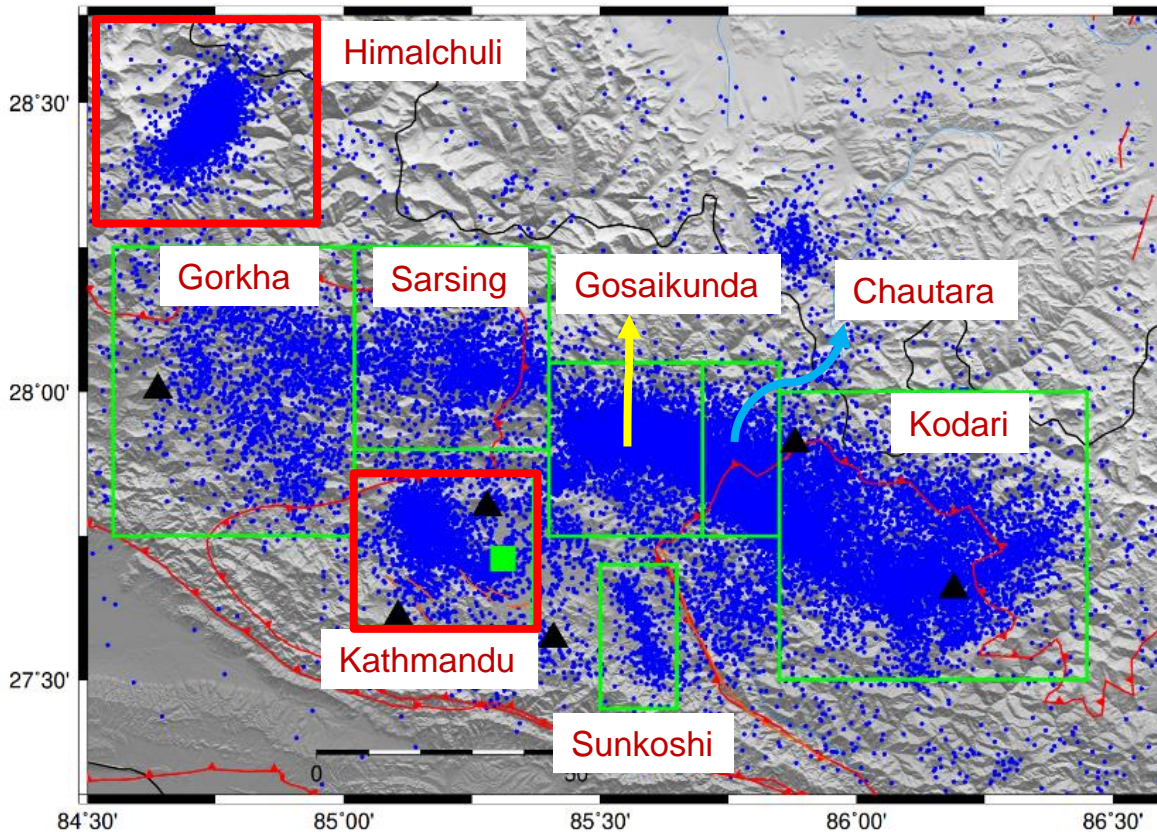


Elliott et al. 2016 @natgeo

48 months of the seismicity after Gorkha earthquake



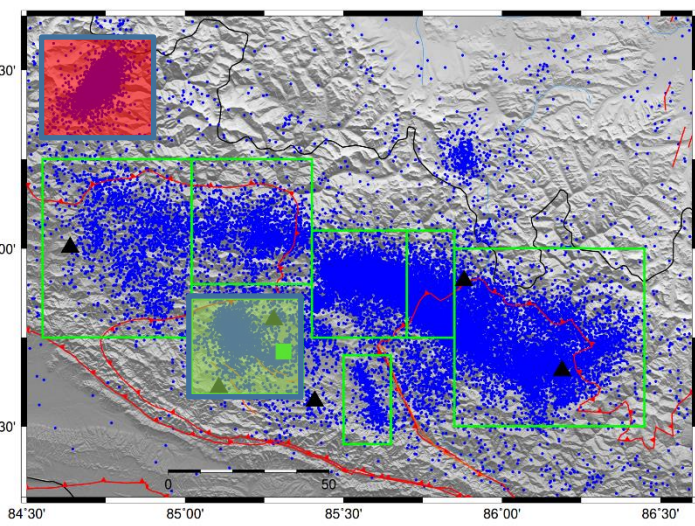
Characteristics of aftershocks clusters



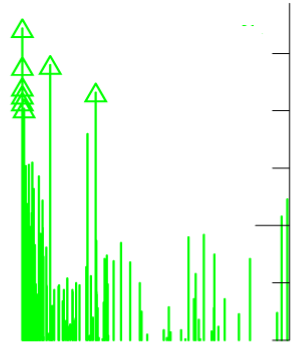
Cluster	Completeness Magnitude	b-value
Kodari	2.4	0.73
Gosaikunda	2.3	0.82
Sarsing	2.5	0.73
Sunkoshi	2.5	0.79
Kathmandu	2.3	0.76
Chautara	2.3	0.78
Gorkha	2.5	0.71
Himalchuli	3.0	2.2

Some new earthquake clusters appeared after the Gorkha earthquake at places where no earthquakes were seen in the past since 1994.

Behavior of Seismicity

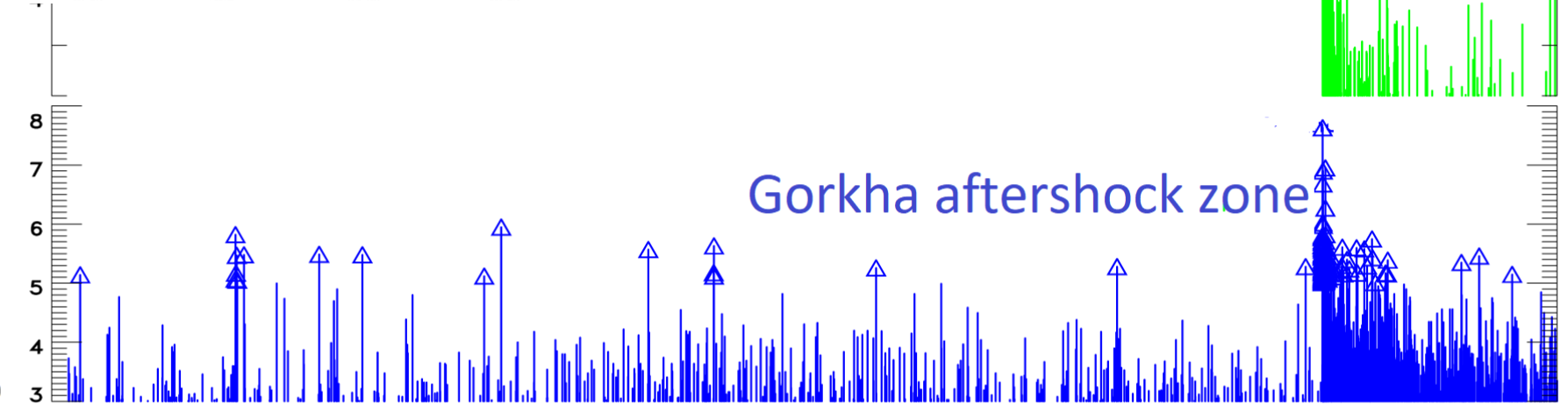


Kathmandu

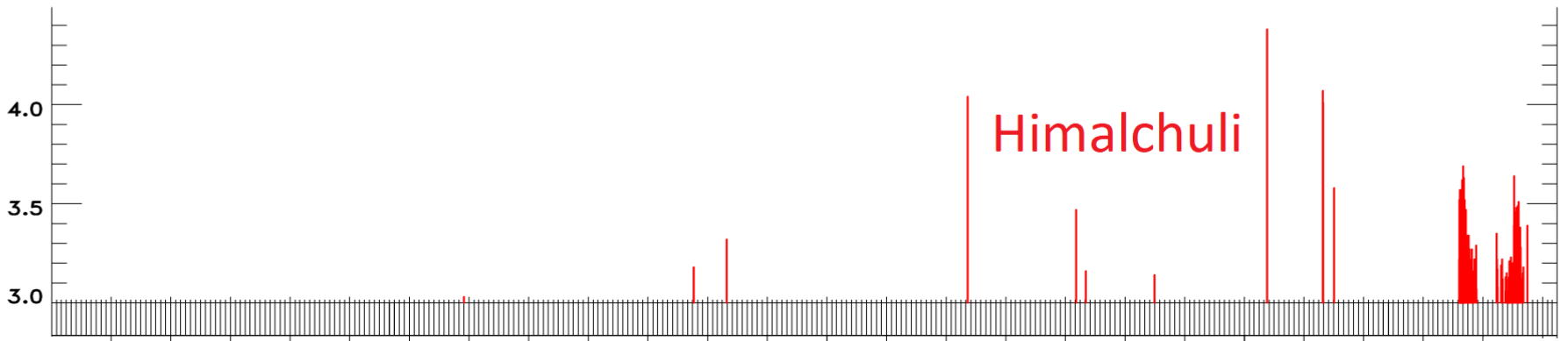


Magnitude $ML > 3.0$

Gorkha aftershock zone



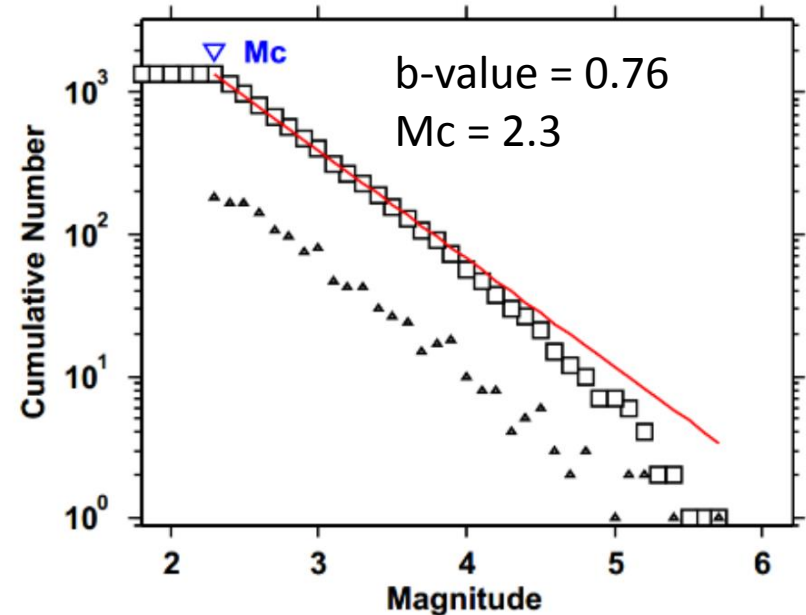
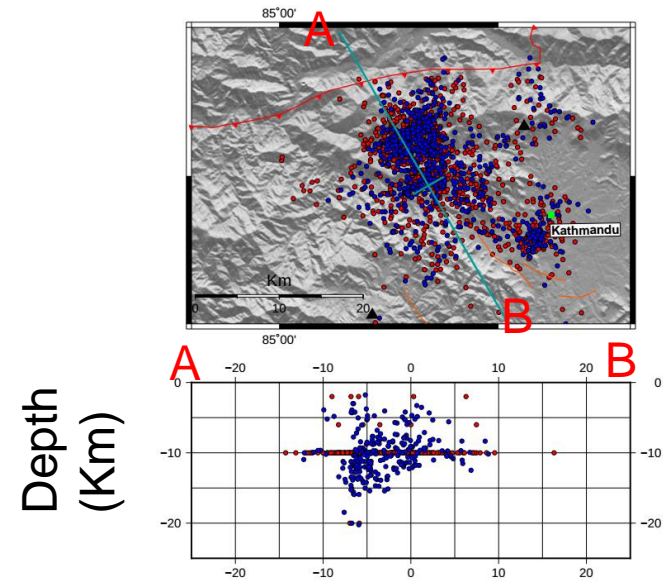
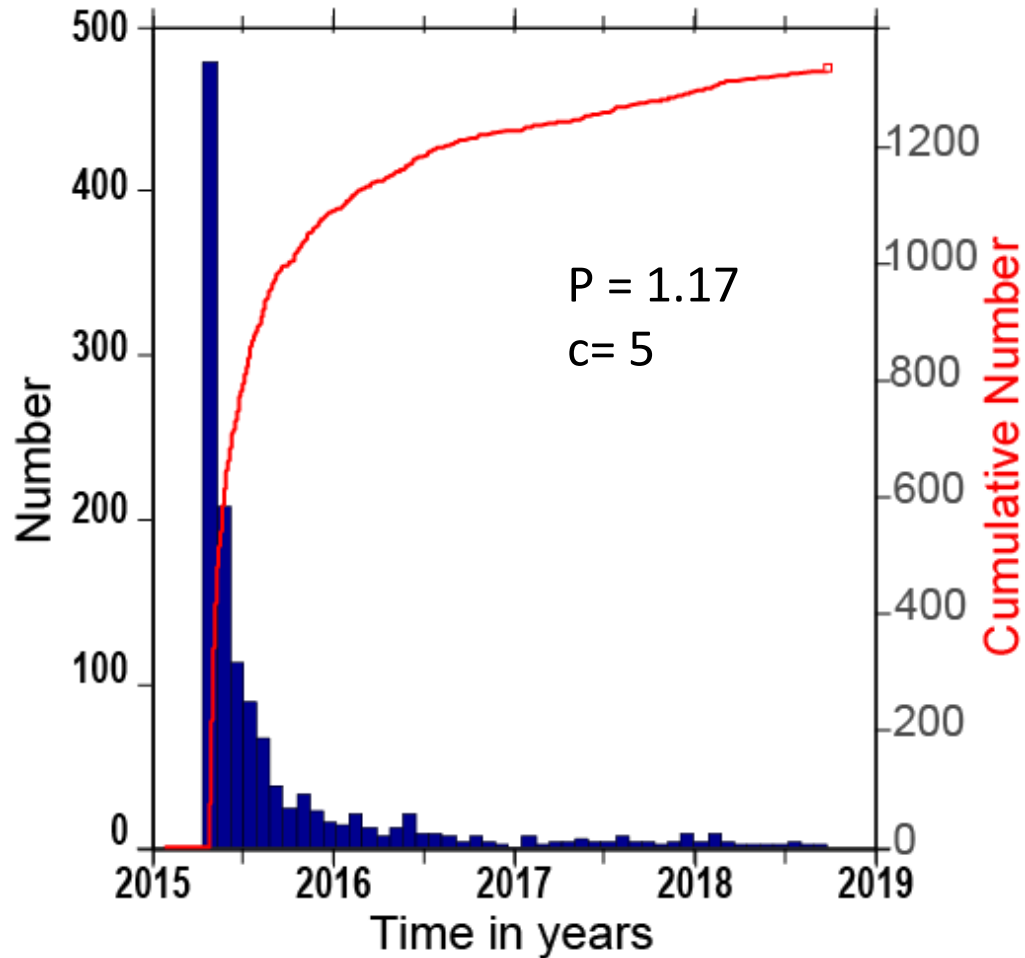
Himalchuli



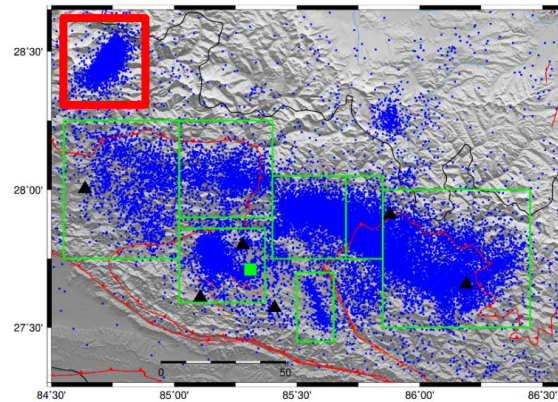
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

Kathmandu Area

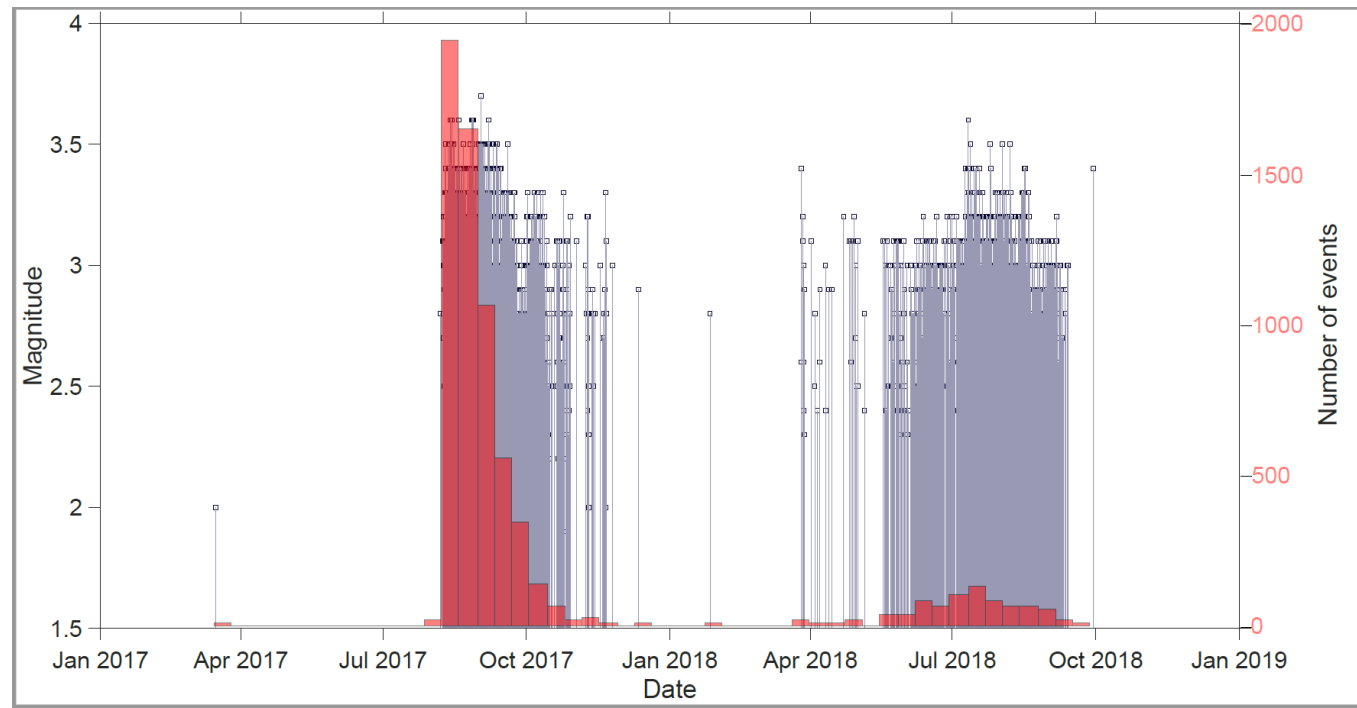
- Active since the Gorkha Earthquake
- < 6 magnitude



Time structure of the Himalchuli Swarm

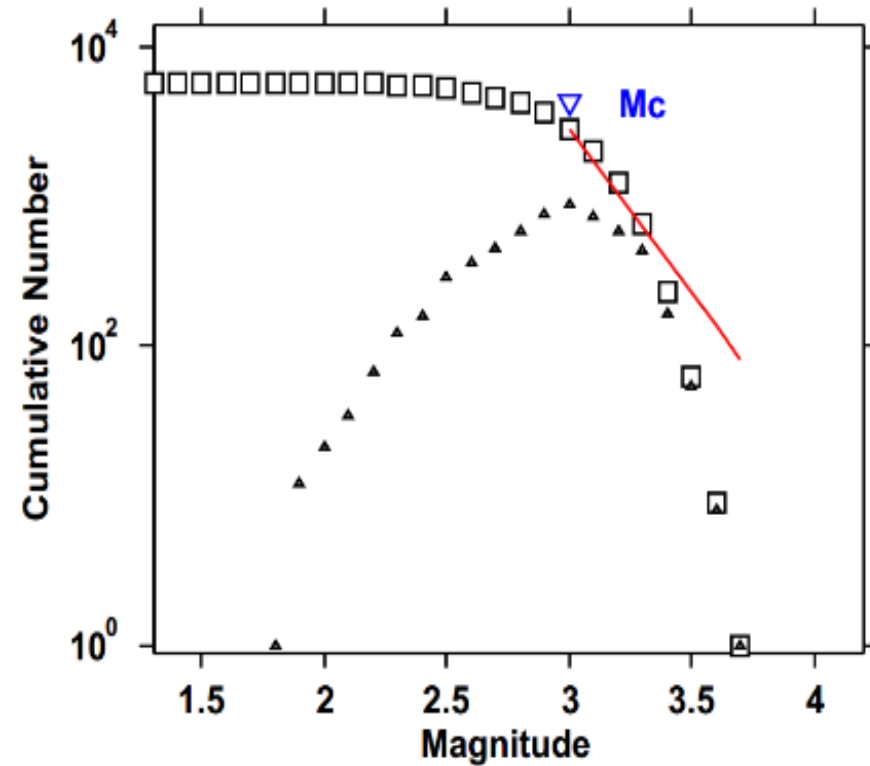


Time and Magnitude Histogram



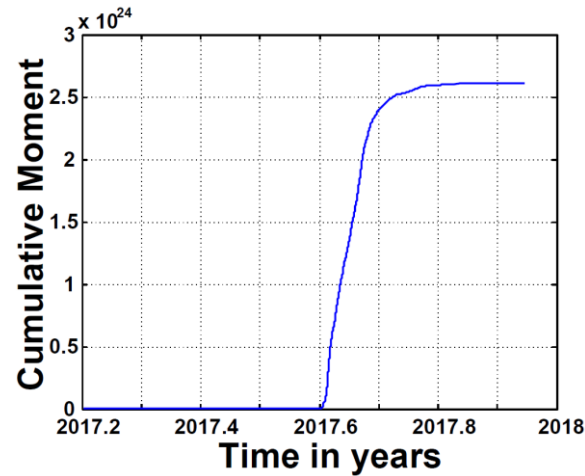
- Started abruptly in August and ended in October
- The events were more than 8 times less this year.
- No similar activity in the past.
- 6,506 events

Himalchuli Swarm

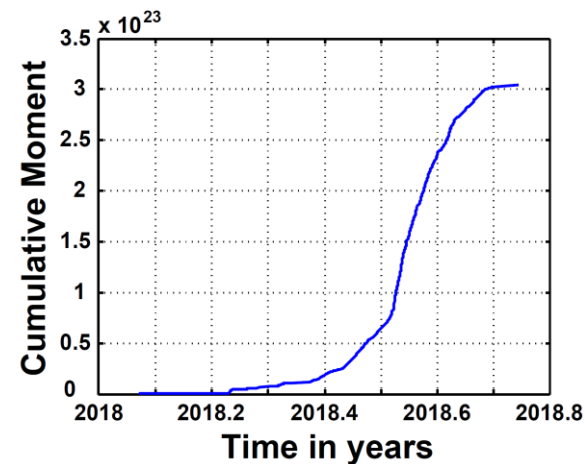


b-value > 2.2

Completeness Magnitude (M_c) = 3



- Cumulative Moment increases almost constantly. Different from Mainshock-aftershock crisis.

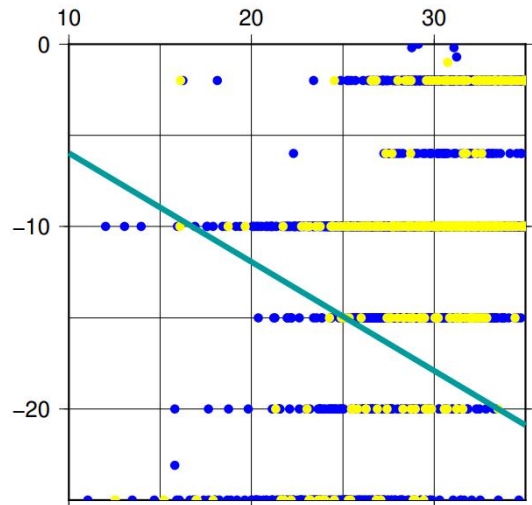
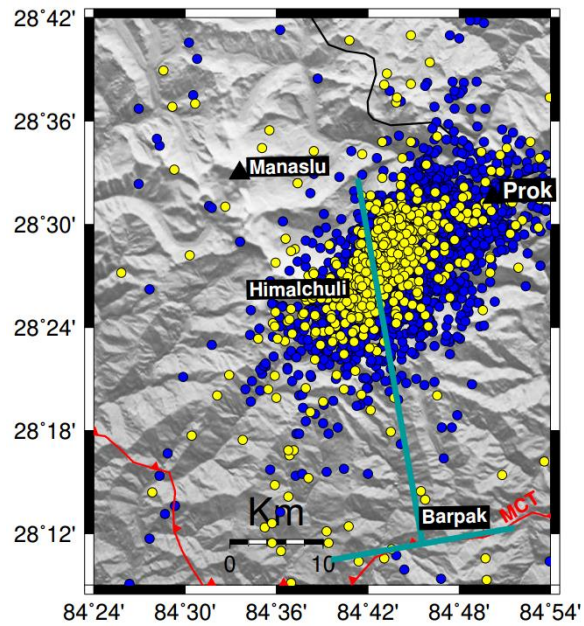


- b-value is more than 2.

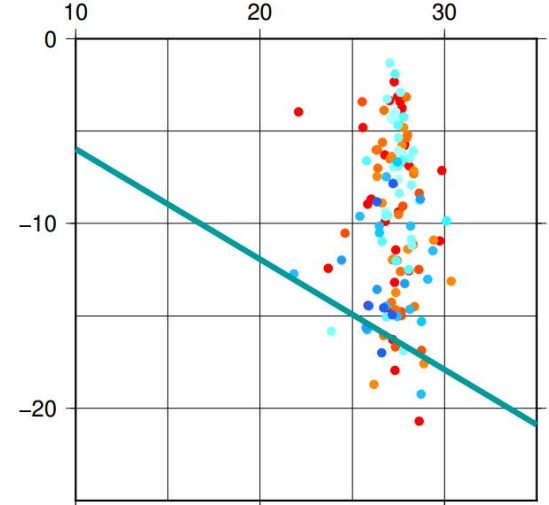
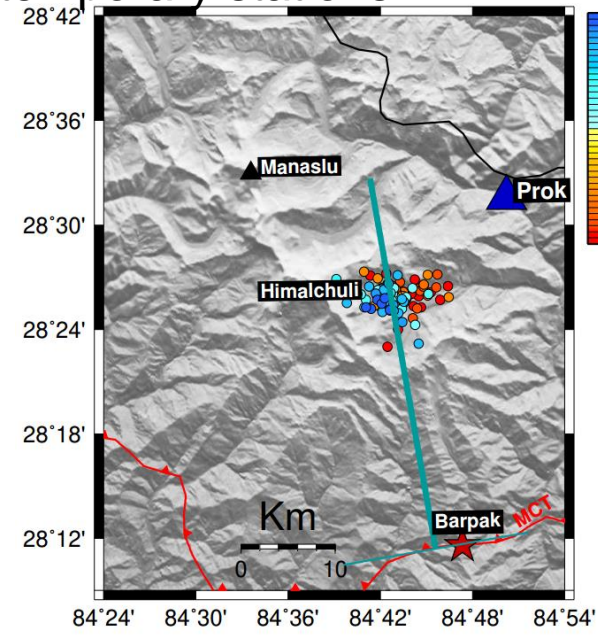
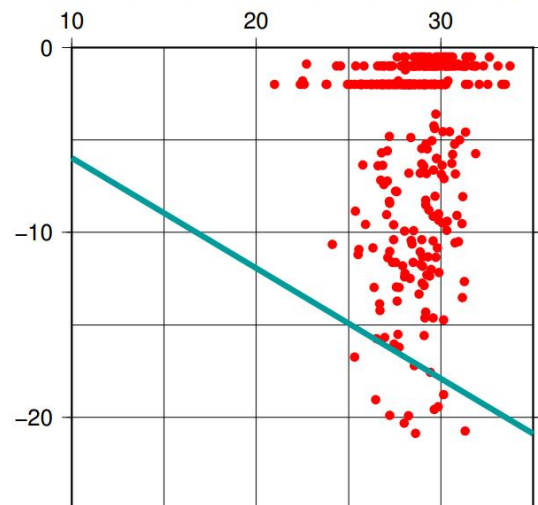
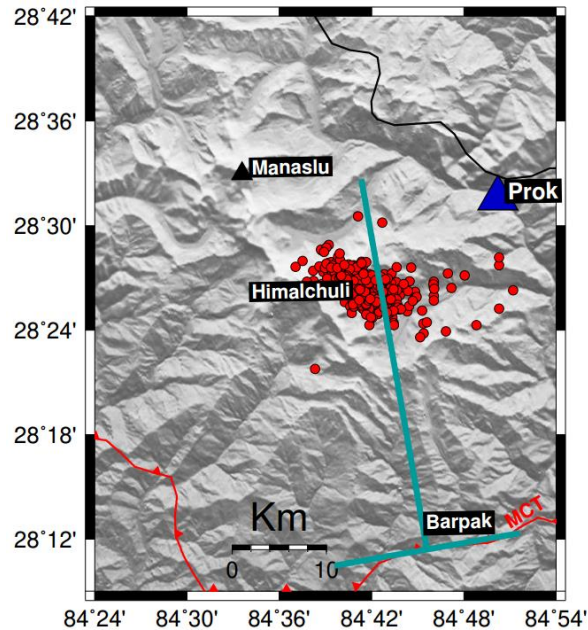
~ to Mag
5.0

Impact of adding a local station on locations

Permanent stations

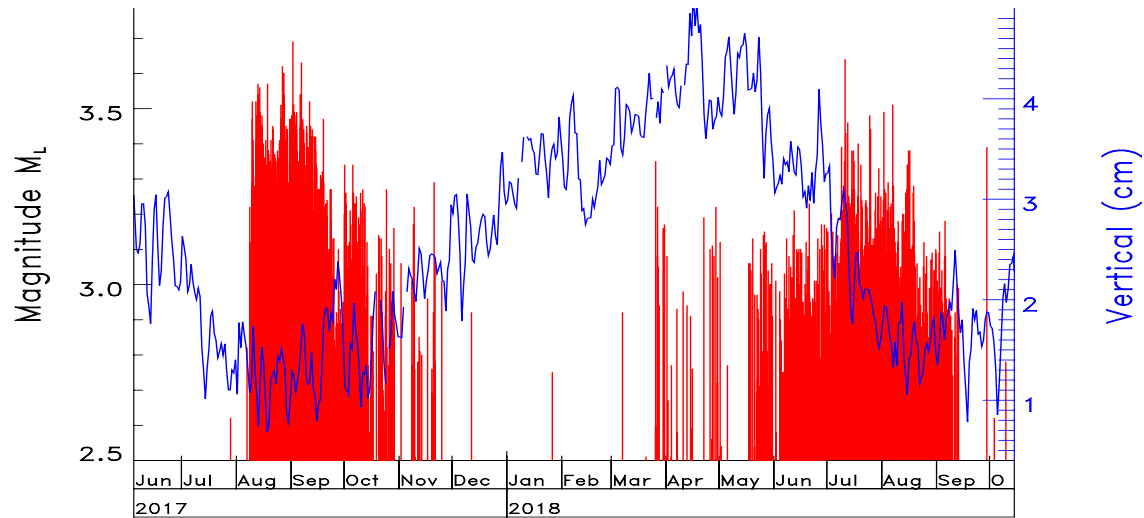


Including temporary stations

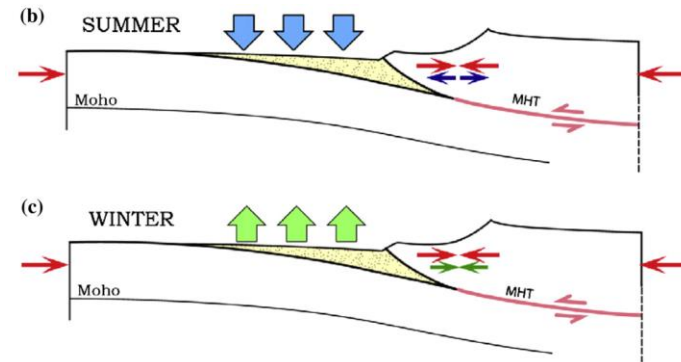
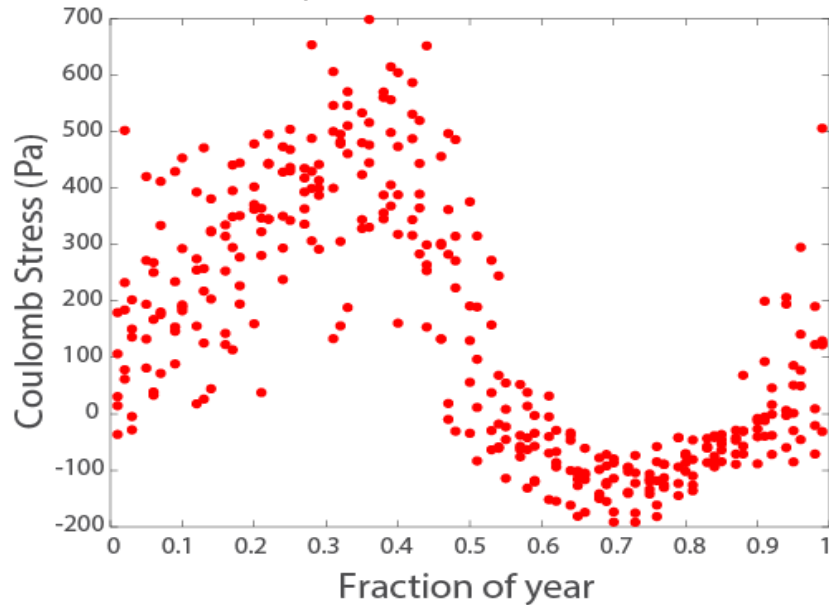


Preliminary interpretation

Zone=Manaslu/Himal Chuli from 04/06/2017 to 15/10/2018



LON:84.73-LAT:28.23, dip 70N, strike N090, friction coeff 0.4, 20km depth

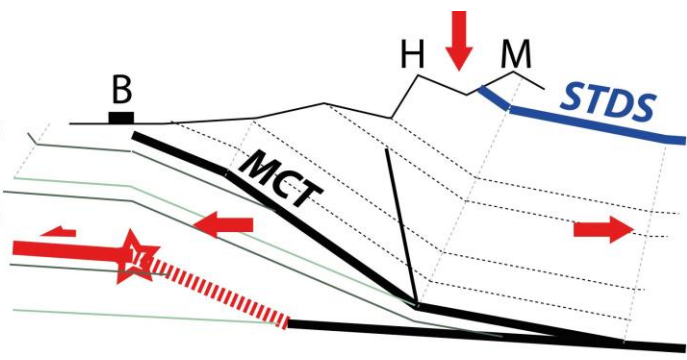


Bettinelli et al, 2008

Courtesy: C. Chanard

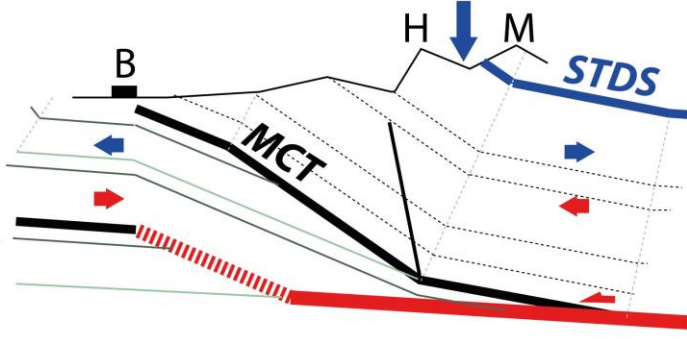
25 /04/2015

Gorkha earthquake
Extension/subsidence
of the high range

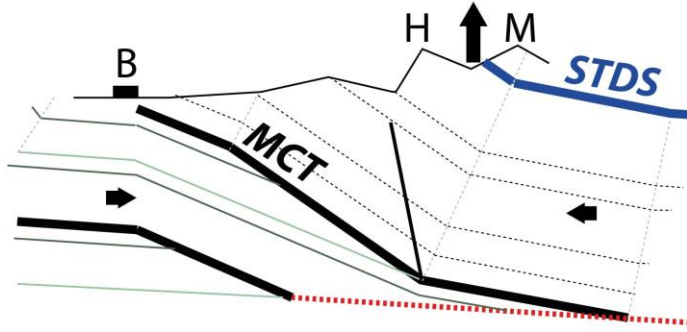


Summer 2015
and 2016

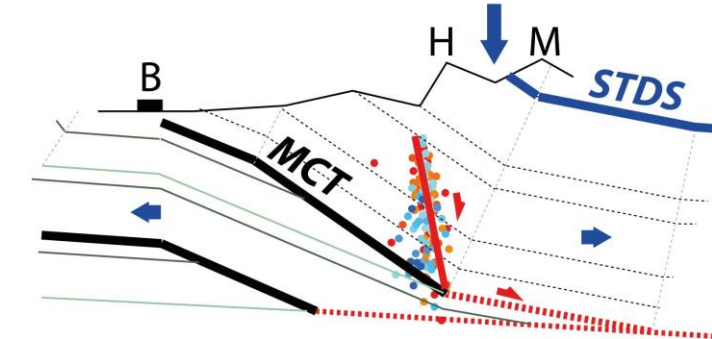
Afterslip and monsoon



Winters 2015
to 2018



Summer 2017
and 2018

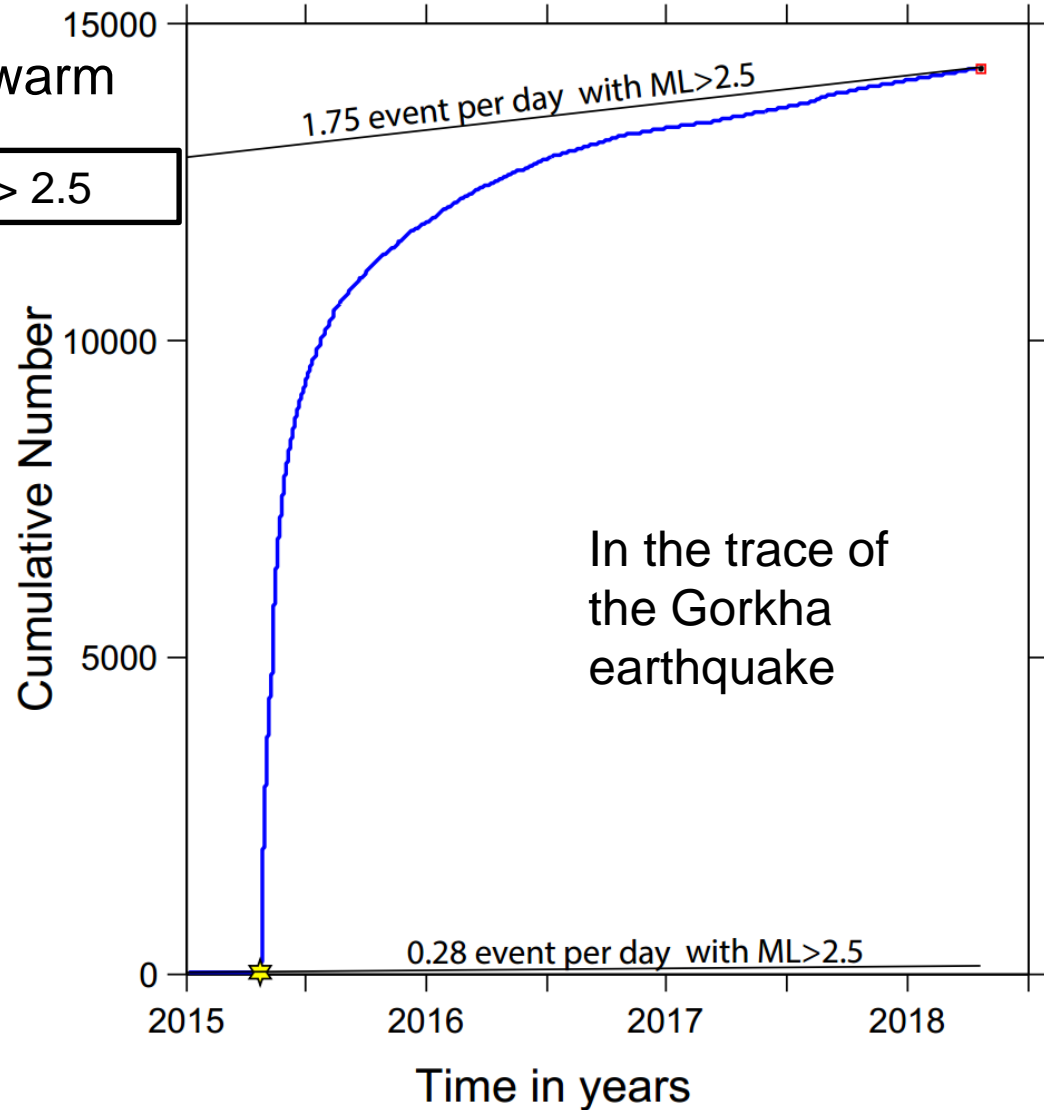
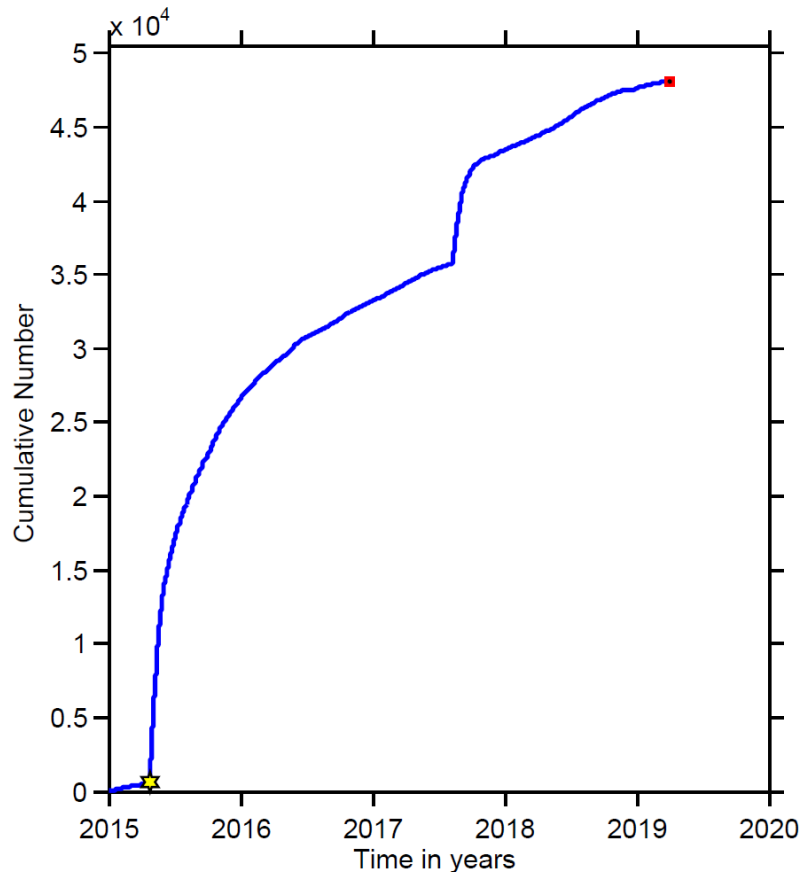


Cumulative number of earthquakes

48,156 events were picked

6,506 events in the Himalchuli swarm

14,300 aftershocks Aftershocks of ML > 2.5



Discussion and Conclusion

- Mw7.8 Rate of Gorkha aftershocks decreases progressively. The rate of earthquake is still 6 times higher than before the Gorkha earthquake.
- Earthquake clusters are located at the periphery of the rupture. Lateral variations are related to the structures at depth.
- A large swarm developed outside the rupture zone, in 2017 and again in 2018.
- Probably this swarm is related to the collapse of the Himalchuli and triggered after a first period of deep afterslip.



Thank you