Crustal structure, seismicity and landslide activity in Bhutan – preliminary results from a temporary seismological network

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Project GANSSER focuses on the Geodynamics ANd Seismic Structure of the Eastern-Himalaya Region. Its main tool of observation is a temporary network of 38 broadband seismological stations (Fig. 1), which was deployed in Bhutan in January 2013 and operated until April 2014. While 13 of these stations continue to acquire data in the field, preliminary results on crustal structure, seismic activity and landslide-generated seismic noise are presented here.

The structure of the crust is targeted to deduce two types of information. First, the main interfaces at which seismic properties change in space – such as the crust-mantle boundary (Moho) and the Main Himalayan Thrust (MHT) – are investigated by converted waves (receiver functions). Second, the P- and S-wave velocity structure of the crust and the underlying mantle are the aim of various seismic imaging techniques (tomography, active source seismology principles). Details of these are presented in the companion paper by Singer et al. (this volume).

The level of seismic activity in Bhutan is of interest as the region is considered a seismic gap, i.e. a segment of the Himalayan arc where fewer earthquakes happen than elsewhere in the orogen. Also, regarding very large and destructive earthquakes (magnitude M>8), there is neither instrumental nor historical record of such events in Bhutan, but palaeoseismological results suggest two M>8 events in the past 1000 years (Berthet et al. 2014). Characterizing the level of seismicity is of importance to assess seismic hazard and to understand the seismotectonics of Bhutan. With the first 9 months of the data analyzed, our preliminary results show two clusters of seismicity in the Southwestern and in the Eastern part of the country. The two M>4 events that have been detected globally were located more accurately: one of them occurred at about 70 km depth in Northern Bhutan, the other was followed by a series of aftershocks. Several other felt events in the region that have not been located by global networks were detected by our network. The processing of the full catalogue, including the now continuing monitoring, is planned to come to more representative conclusions (i.e. based on a longer time period).

Detecting landslides from seismic noise is an emerging field of seismology. Based on a seismically well-characterized debris flow event in Nepal and the applied methods there (Burtin et al., 2009), we screened the dataset acquired in Bhutan for landslide activity during the 2013 monsoon season. Compared to our expectations to detect a large number of events in such a steep country, the number of observed landslides remained relatively low. With observations made during a field campaign, we propose the following reasons to explain this: the relatively small size of events; the relatively dry 2013 monsoon season; the dense forest coverage; the strength of the rocks of the Greater Himalayan Sequence occupying most of the region; and the relatively sparse station distribution in the centre of the country. Nevertheless, a number of events could be detected and located, and some were confirmed by Landsat composite satellite image pairs (before and after the event). Many of these landslides are in: areas of geologically weaker rocks (phyllites); in the Southern part of the country where the combination of active tectonics, rainfall and steep slopes is most favourable for landslides; or near new road constructions. The ca. one dozen events reported by the media could not be located seismically: their size was large enough to cause road blocks (and due to the elementary road network trigger media appearance) but not enough to be detected by a

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sufficient number of stations. From a seismological point of view: it seems most advantageous if a landslide monitoring network is designed for a specific region (including adequate station spacing), and if it undergoes a phase of calibration with ground truth from field verifications.

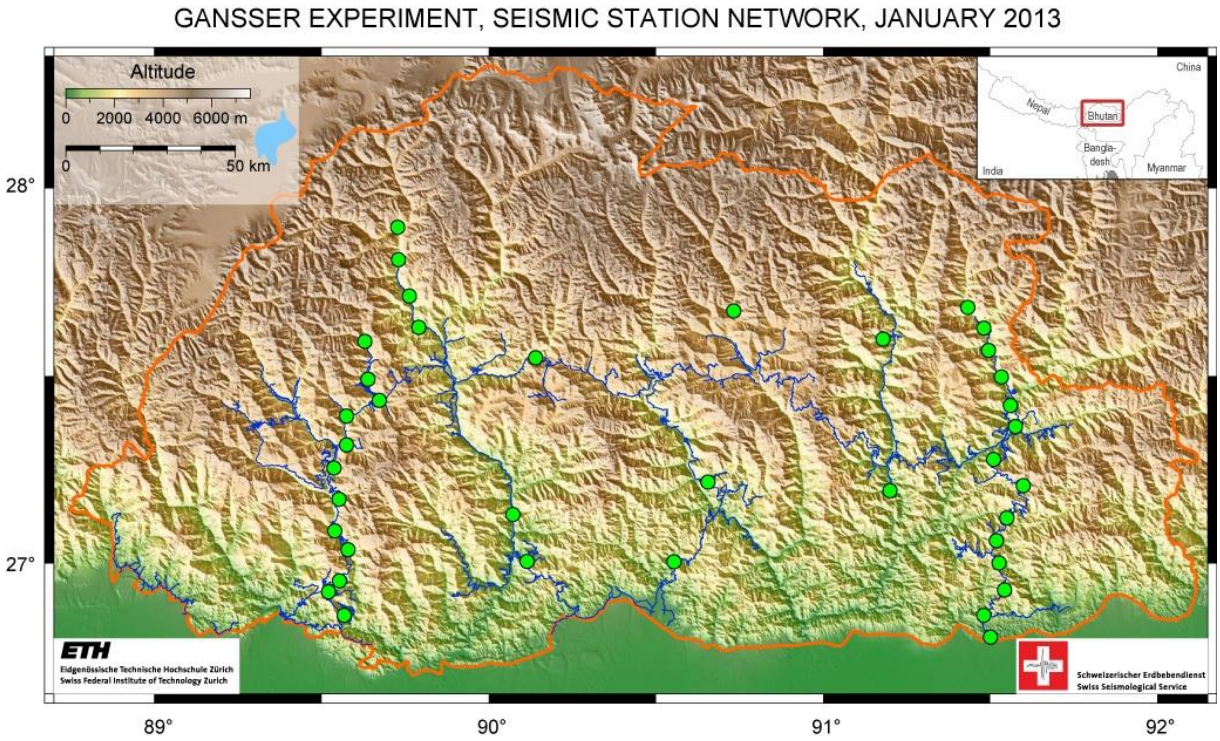

Figure 1. Station geometry of the GANSSER project's broadband seismological network in Bhutan.

References

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