Understanding Future Earthquake Hazard and Precursory Seismicity Associated with March 28, 1999 Chamoli Earthquake of Uttarakhand India

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On March 28, 1999 at 00.35 a.m., a moderate size earthquake (mb = 6.4) shook most part of the Garhwal and Kumaon Himalaya and caused considerable damage and loss of lives in the Hill district of Chamoli and its vicinity. The earthquake was located 07 km northeast of Chamoli town in the close vicinity of Main Central Thrust (MCT). An attempt has been made to forecast earthquake using spatial and temporal distribution of earthquakes and clustering. A time series of earthquake which occurred in the area between 28o-31o N and 78.8o-82.2o E were analyzed and Seismicity patterns before and after this earthquake were studied using seismicity data from 1963-2006. Daily number of events as well as cumulative number of earthquake with time for total events, and the events with mb $\geq$ 4.3 (cut-off magnitude) has been considered as basis for identification of anomalous seismicity. The Chamoli earthquake was found to be associated with a well defined anomalous seismic activity both in space and time during 27.11.1995 to 18.06. 1996, some three years and four months prior to the mainshock. The seismicity fluctuated in the order of low-high-low in two characteristics phases from 1981 to 1999, and 1999 to 2006. The preparatory zone delineated based on considering the spatio- temporal distribution of events in background, anomalous and gap phases is oriented in north-south direction in which no large earthquake has occurred so far even after lapse of ~ 6.5 years since the onset of quiescence phase.The anomalous seismic phase within the preparatory zone was characterized by considerably high seismicity (~14 folds) as compared to its preceding background seismicity phase (1981- 26.11.1995) and the following precursory gap phase (19.06.1996-27.03.1999). Clustering of these events and associated aftershocks in all the phases was observed with depth also. After the Chamoli earthquake, the analysis of seismicity data from 1999 to 2006 indicates eastward migration of seismicity ~150 km away and clustered between MCT and MBT forming an anomalously high seismicity phase during 15.04.2001 to 04.06.2002. This phase was preceded by extremely low background seismicity till April 4, 2001, and currently is being followed by a precursory gap period of low seismicity. A medium term forecast was proposed, for a possible future shallow

focus (h30 km) earthquake of about M 6.5 ± 0.5 may occur at any time in the delineated preparatory area (29.4o-30.6o N and 81.3o-81.8o E) in its southern part, Since the anomalous low seismicity quiescence phase is still continuing. This forecast was based on the concept that moderate to large magnitude earthquakes in the region are found to be preceded, generally by precursory swarms and quiescence periods. This information may warrant certain future potential earthquake hazards in this region. However, the attempt is made in an isolated manner and it is therefore necessary to integrate the region in a coordinated manner.