

## **Differential recession of glaciers in Nanda Devi Biosphere Reserve, Garhwal Himalaya, India**

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**Abstract** This study compares past toposheets (1955 and 1962) and ASTER satellite images (2004 and 2005) to examine the changing state and causes of varying retreat rates of glaciers in Nanda Devi Biosphere Reserve of Garhwal Himalaya. The Dunagiri, Milam and Tipra glaciers were surveyed in 2008, 2009 and 2010, respectively. The study reveals that the Milam, Tipra and Dunagiri glaciers retreated at the rates of 29.4, 12.5 and 1.3 m year<sup>-1</sup>, respectively. Such differential retreat rates can be explained by altitudes of their snouts and local physiographic conditions. The change of mean width of the Tipra, Dunagiri and Milam glacier was estimated to be -0.01, -0.005 and 0.29 km. The Tipra, Dunagiri and Milam glaciers have vacated areas of about 0.54, 0.03 and 1.66 km<sup>2</sup>, respectively. The glaciers show negative mass balance. The net mass change of the Tipra and Dunagiri glaciers was about -470 and -107 × 10<sup>6</sup> m<sup>3</sup> water equivalent (WE), respectively.

**Key words** glacial retreat; mass balance; glacial geometry; Tipra; Milam and Dunagiri glaciers; climate change; Indian Himalaya