

## Monitoring of the glaciers in the Khumbu region, Himalayas by high resolution SAR satellite TerraSAR-X

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Worldwide recession of mountain glaciers is one of the key indicators for the global climate change. Significant impacts on downstream area such as GLOF (Glacial Lake Outburst Flood) and water shortage are expected as a result of glacier retreat. Glacier observation is important for the climate system monitoring as well as the prediction of the damage caused by glacier retreat. Field survey of glaciers requires significant effort since glaciers are generally located in very remote area and cannot frequently be done for every glacier although it provides detailed data. Therefore, the satellite remote sensing technique is essential for the glacier monitoring.

The Himalayas form the earth's highest mountain region, containing the highest peaks in the world which hold many sources of rivers in South Asia. Recent rapid retreat of the glaciers in the Himalayas caused the emergence of significant number of glacial lakes, some of which are in danger of outburst. Many people in South Asia largely rely on the melt water from glacier in dry season. They will be potentially affected by further retreat of the Himalayan glaciers.

A Number of observations by remote sensing satellites has been done and glacier inventories were created by some project such as GLIMS. However, most of the observations were done by optical satellites during dry season and could rarely be done during monsoon season due to the heavy cloud cover when GLOF most likely happens.

Synthetic Aperture Radar is a weather independent sensor and thus capable of observing the glaciers even in monsoon season. There have previously been observations of glaciers by SAR satellites. But they could only monitor the location of glaciers and the detailed interpretation has been difficult.

TerraSAR-X, launched in June 2007, is the X-band SAR satellite developed in a public private partnership between the German Aerospace Center (DLR) and EADS Astrium GmbH. It realized the highest spatial resolution (approx. 1m) as commercial radar satellite. TerraSAR-X imagery is distributed by Infoterra GmbH and its partners. For the Japanese customers, PASCO Corporation has the exclusive distribution right for TerraSAR-X imagery. TerraSAR-X imagery can be directly donwlinked to the ground station in Japan owned by PASCO. The spatial resolution breakthrough realized by TerraSAR-X enabled the interpretation of more detailed texture of ground surface.

In this presentation, the glaciers in the Khumbu Himalayas observed by TerraSAR-X and how the glaciers, glacial lakes and surrounding terrains such as moraine can be interpreted will be shown. Based on the observation result, how the high resolution SAR satellites can be utilized for the monitoring of glaciers and the prediction of glacier related hazards such as GLOF will be also discussed.

It is sometimes hard to interpret the surface relief of glaciers with optical imagery when they are covered with snow or dark debris. However, imagery already acquired by TerraSAR-X represents detailed relief on glaciers and showed its usefulness for glacier monitoring, which evokes us the expectation for detailed terrain interpretation with high resolution SAR satellites.