PhD thesis – E. BERTHIER

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Dynamics & mass balance of mountain glaciers (Alps, Himalaya, Iceland). Contribution of satellite imagery.

In this study, satellite optical images are used to assess the volumetric and dynamic changes of mountain glaciers. Original methodologies are developed to estimate glacier surface flow and thickness change from space data. So far, our main study area has been the French Alps, where numerous ground data are available to validate the satellite measurements. These methodologies have then been applied to monitor remote glaciers in Iceland and Himalaya.

By using differential Digital Elevation Models (DEM), we monitor the rapid thinning of glaciers in the Mont Blanc area during the last 25 years. From pairs of satellite images, we compute DEM in 1979, 1994, 2000, and 2003. Subtracting and adjusting the DEM yields the thickness change of glaciers. Comparisons with topographic profiles indicate an overall accuracy of 1-2 m on each altitude range. Below 2100 m, we measure thinning rate of the *Mer de Glace* evolving from 1±0.4 m/a (years 1979-1994) to 4.1±1.7 m/a (2000-2003). All glaciers in the Mont Blanc area experienced strong negative mass balance since 1979. The same methodology also indicates important ice losses for the Vatnajökull ice cap in Iceland and glaciers in Himalaya during the last 5 to 6 years. These two areas may contribute significantly to present day sea level rise.

A complete and detailed map of the velocity field of Mont Blanc glaciers is obtained by cross-correlating two SPOT5 images acquired a few weeks apart. The accuracy of our measurement is assessed by comparison with nearly simultaneous differential GPS surveys and is on the order of ±0.5 m (or ±7 m/a), *i.e.* one fifth of the pixel size. The high accuracy and the large spatial coverage of our measurements allow monitoring the glacial acceleration due to high summertime surface melting during the 2003 heat wave in Europe. On a long term basis, we observe a 30 to 40% deceleration of the *Mer de Glace,* which can explain part of the rapid thinning of this glacier.