European alpine glaciers lost about 35% of their total area from 1850 until the 1970s, and almost 50% by 2000 (Zemp et al., 2006). With respect to the 1970s area, there was little change until 1985 (-1%) and a strong decrease (-20%) until the year 2000 (Paul et al., 2004). This rapid decline in glacier area has been confirmed by analysis of more recent satellite data (Paul et al., 2007a). This study compared Landsat TM and ASTER imagery from 2003/04 with the earlier data sets and found similar patterns of massive glacier retreat and thinning throughout the entire Alps. Thereby, the thinning was only derived indirectly by recognizing increasing areas with rock outcrops, separation of glacier tongues and disintegrating/collapsing glacier bodies, but is confirmed by direct mass balance measurements as well (Zemp et al., 2005). At several locations pro-glacial lakes have been formed which are partly still growing.

The currently observed rapid changes are most likely a response to the sudden increase in Alpine temperature of about 1°C in the 1980s, which has shifted the equilibrium line altitude (ELA) by about 150 m upwards. From the application of simple GIS-based models (Paul et al., 2007b; Zemp et al., 2006) it could be shown that this ELA shift would reduce the overall glacier area by about 40%. About a half of this area has already disappeared and the remaining 20% is expected to disappear until 2020, even without a further temperature increase. Additionally, several positive feedbacks might have enhanced the decay, for example a gradual albedo lowering in hot and dry summers, increased turbulent heat fluxes from now ice free terrain, and surface lowering instead of a dynamic retreat towards higher elevations. Extreme events like the summer of 2003 melted most of the final firn reserves on many glaciers, which are now prone to an even faster melt (Paul et al., 2007a; Zemp et al., 2005).

If temperatures will increase even further (without a substantial increase in precipitation), the future of most glaciers in the Alps is doubtful. An increase of only 2°C would shift the ELA 300 m further upwards and could finally reduce the 1980s glacier area by about 80%, a result that has been obtained from both modelling approaches (Paul et al., 2007b; Zemp et al., 2006). Of course, due to a different ice thickness some glaciers will change their size more slowly, but the change will occur nevertheless.

References