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Linking glacier annual mass balance and glacier albedo from MODIS data

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The albedo is one of the variables controlling the mass balance of temperate glaciers. Multispectral imagers, such as MODIS on board TERRA and AQUA, provide a means to monitor glacier albedo. In this study, different methods to retrieve broadband glacier albedo from MODIS data are compared. In particular, the effect of the multiple reflections due to the rugged topography and that of the anisotropic reflection of snow and ice are investigated. The methods are tested on the Saint Sorlin glacier (Grandes Rousses area, French Alps). The accuracy of the retrieved albedo is estimated using both field measurements and albedo derived from terrestrial photographs. The root mean square deviation between field measurements and the broadband albedo retrieved from MODIS pixels at 250m spatial resolution was found to be less than 0.06. One decade (2000-2010) of MODIS data were then processed to create a time series of albedo maps of Saint Sorlin glacier during the ablation season. It appears that the albedo in the ablation area of the glacier does not exhibit any marked decreasing trend during the decade under study. This contrasts with the situation observed on other glaciers in the Alps. In addition, the annual mass balance of Saint Sorlin Glacier was compared with the minimum albedo value (spatial averaged over the whole glacier) observed with MODIS during the ablation season. A high linear correlation exists between the two variables. Furthermore, the day on which the albedo reaches a minimum over the glacier closely corresponds to the day on which the snowline is found to be at its highest elevation, thus close to the glacier's equilibrium line. This indicates that the high correlation can be explained by the fact that this minimal albedo contains a high degree of information regarding the relative share of areal surfaces between the ablation zone (i.e. ice with a generally lower albedo) and the accumulation zone (i.e. snow with a relatively high albedo). This implies that monitoring the albedo of glacier with MODIS data can provide a useful means to approach the inter-annual variability of the glacier's mass balance.