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On the use of the point-mass modeling technique for assessing ice-mass variations in alpine glacier systems

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Most scientific studies dealing with gravity-based ice-mass balance estimations focus on the Earth's continental glacier systems, namely the Greenland and the Antarctica ice sheets. Alpine glacier regions such as the Alps, Himalaya or Patagonia, on the other hand, seem to be less considered. According to the most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC), however, glacier shrinkage is one of the most dominant contributors to global sea level rise. In this context we investigate the capability of the point-mass modeling technique to assess ice-mass variations in small-scale alpine regions from space-borne gravimetric data. Two different approaches of this method can be distinguished: point-mass modeling with (i) predefined and fixed positions and (ii) with unknown locations of the surface mass changes. Approach (i) yields a linear functional model in which only the magnitudes of the point-masses are considered unknown. A highly non-linear optimization problem needs to be solved for approach (ii), since both the magnitudes and the coordinates of the point-masses are introduced as unknown parameters. In addition to that, owing to the effect of downward continuation, this problem is categorized as ill-posed and needs to be remedied by introducing regularization. The L-curve criterion or the generalized cross-validation method are typically used for selecting a suitable regularization factor. We conducted a series of close-loop simulation tests for various alpine glacier systems to compare the two approaches. In order to solve the global optimization problems in (i) and (ii), we make use of genetic algorithms.