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Reanalysis of a ten year record (2004-2013) of seasonal glacier mass balances at Langenferner, Ortler-Alps, Italy

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Records of glacier mass balance represent important data in climate science and their uncertainties affect calculations of sea level rise and other societally relevant environmental projections. In order to reduce and quantify uncertainties in mass balance series obtained by direct glaciological measurements, we present a detailed reanalysis work-flow which was applied to the ten year record (2004 to 2013) of seasonal mass balance of Langenferner, a small glacier in the European Eastern Alps. The approach involves a methodological homogenization of available point values and the creation of pseudo-observations of point mass balance for years and locations without measurements by the application of a process-based model constrained by snow line observations. We examine the uncertainties related to the extrapolation of point data using a variety of methods, and consequently present a more rigorous uncertainty assessment than is usually reported in the literature.

Results reveal that the reanalyzed balance record considerably differs from the original one mainly for the first half of the observation period. For annual balances these misfits reach the order of >300 kg m^{-2} and could primarily be attributed to a lack of measurements in the upper glacier part and to the use of outdated glacier outlines. For winter balances respective differences are smaller (up to 233 kg m^{-2}) and they originate primarily from methodological inhomogeneities in the original series. Remaining random uncertainties in the reanalized series are mainly determined by the extrapolation of point data to the glacier scale and are in the order of 80 kg m^{-2} for annual and 52 kg m^{-2} for winter balances with values for single years / seasons reaching 136 kg m^{-2}. A comparison of the glaciological results to those obtained by the geodetic method for the period 2005 to 2013 based on airborne laser scanning data, reveals that no significant bias of the reanalyzed record is detectable.