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Monthly estimates of Antarctic Ice Sheet elevation change from a quarter-century of combined radar and laser altimetry

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Satellite altimetry provide the longest continuous record from which the mass balance of the Antarctic ice sheet can be derived, starting with the launch of ERS-1 in 1991. Accurate knowledge of the long-term mass balance is vital for quantifying Antarctica's contribution to sea-level rise and understanding the geophysical processes governing ice-sheet changes. However, this record comprises of different measurement systems, with different accuracies and resolution capabilities. This poses a major challenge for the reconstruction and interpretation of consistent elevation-change time series for determining long-term ice sheet trends and variability. In this study, we present a novel framework for seamless integration of heterogeneous altimetry records, using an adaptive least-squares time series adjustment and sensor fusion technique. The procedure allows reconstructing time series at fine spatial (<10 km) and temporal (monthly) scales, while accounting for sensor-dependent biases and heterogeneous data quality.

Our synthesized record spans the time period 1992-2018, and includes data from both the European Space Agency (ERS-1, ERS-2, Envisat and CryoSat-2) and NASA (ICESat and Operation IceBridge), with future inclusion of data from NASA's ICESat-2. We explore the major corrections applied to raw satellite altimetry data to assess their overall effect on the estimated uncertainty. We also estimate mission specific errors using crossover analysis and independent airborne measurements to derive reliable uncertainty bounds for each individual time series and its associated elevation change rate.

This methodology allows us to improve upon existing records of the long-term evolution of the Antarctic Ice Sheet, providing an invaluable dataset for advancing ice sheet assimilation efforts into climate models and for disentangling the causal mechanisms responsible for ice sheet mass change. Our 26-year analysis shows increased ice sheet thinning rates for the Amundsen Sea Sector, with the changes spreading far inland over the past decade. Further, major precipitation events in Dronning Maud Land have produced rapid thickening over the last decade compared to the beginning of the record. We also observed a strong correlation between the instantaneous elevation change rate and changes in SMB variability and ice dynamics for Totten Glacier in East Antarctica. Over Lake Vostok, we observed little-to-no change in surface elevation over the full altimetry record.