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Full Stokes ice-flow modeling of the high-Alpine glacier saddle Colle Gnifetti, Monte Rosa

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The high-Alpine glacier saddle Colle Gnifetti (CG), Monte Rosa massif, is a unique drilling site in the European Alps offering continuous ice-core records on the millennial time-scale. However, the full interpretation of the ice-core time series is challenging due to the highly irregular (spatial and temporal) snow deposition pattern and, together with a complex flow regime, upstream effects. In this context, we present results of a new three-dimensional full Stokes ice-flow model of the CG saddle. The main objectives of the modeling tool concern (a) the calculation of backward trajectories of existing ice-core drill sites, which is required in order to evaluate potential upstream effects, and (b) provide a reliable age–depth relation, in order to support experimental methods in ice-core dating.

The established full Stokes model is fully thermo-mechanically coupled. The model includes firn rheology and firn densification. The temperature field is calculated using the enthalpy method, with consideration of atmospheric temperature changes of the last century, strain heating and surface meltwater refreezing. The simulations are performed using the state-of-the-art Finite Element software Elmer/Ice. The CG full Stokes model is validated by comparison with glaciological measurements of surface velocities, snow accumulation, borehole inclination angles, density and englacial temperatures.

Using the calculated backwards trajectories, the locations on the glacier surface of the ice-core source points are identified with an uncertainty of $\sim$10% of the distance to the corresponding drill site. Moreover, the three-dimensional age field of the glacier is calculated with an uncertainty of $\sim$20%. The calculated ice-core chronologies are consistent with experimental dating results, based among others on annual layer counting and ^{14}C measurements.