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Indirect inversions

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Since Doug MacAyeal's pioneering studies of the ice-stream basal traction optimizations by control methods, inversions for unknown parameters (e.g., basal traction, accumulation patterns, etc) have become a hallmark of the present-day ice-sheet modeling. The common feature of such inversion exercises is a direct relationship between optimized parameters and observations used in the optimization procedure. For instance, in the standard optimization for basal traction by the control method, ice-stream surface velocities constitute the control data. The optimized basal traction parameters explicitly appear in the momentum equations for the ice-stream velocities (compared to the control data). The inversion for basal traction is carried out by minimization of the cost (or objective, misfit) function that includes the momentum equations facilitated by the Lagrange multipliers. Here, we build upon this idea, and demonstrate how to optimize for parameters indirectly related to observed data using a suite of nested constraints (like Russian dolls) with additional sets of Lagrange multipliers in the cost function. This method opens the opportunity to use data from a variety of sources and types (e.g., velocities, radar layers, surface elevation changes, etc.) in the same optimization process.