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Analytical solutions for the effect of topography, accumulation rate and flow divergence on isochrone layer geometry

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The effect of disturbances in ice thickness, accumulation rate and flow-line divergence on radar-detected isochrone geometry in ice sheets are examined. Under an assumption of a steady-state ice sheet geometry and a spatially homogeneous velocity profile, an analytical expression for the slope of the isochrones can be derived. In terms of normalised depth of the isochrones, a change in accumulation rate is almost equivalent to a change in ice thickness, the only difference being that the accumulation rate also affects the total ice flux. Over wavelengths long compared with the ice thickness, disturbances propagate very long distances downstream. These disturbances manifest themselves as dips in the isochrones. If a dip is caused by a hill in the bedrock (or by an increased surface accumulation), the dip is upwards and vice versa. For plug flow, the dip depends only on the initial and final thickness/accumulation rate ratios. For internal deformation, the situation is more complex, but the basic patterns remain the same. Finally, we show that these patterns can be used to deduce the vertical velocity profile from isochrone layers.