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Towards an observation-based deterministic model for water motion beneath the Antarctic Ice Sheet Interior

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The movement and storage of water beneath the Antarctic Ice Sheet could have major implications for flow rates of the ice streams and outlet glaciers, and is one of the greatest unknowns in the mass balance equation. Currently available models for ice-sheet-wide hydrology typically use gridded data for surface elevation and ice thickness. Although this allows coverage of the entire ice sheet and facilitates interface with ice sheet models, it may miss critical characteristics of the subglacial hydrological system, as the interpolation process inevitably smoothes over real features and may even introduce artefacts. We are developing a new drainage model for large portions of the Antarctic Ice Sheet, which uses the original ice penetrating radar data on ice thickness and basal reflectivity combined recent satellite altimeter-derived surface elevation profiles. This model attempts to treat the subglacial water system as many detailed two-dimensional hydrologic paths, rather than one relatively coarse three-dimensional hydrologic grid. Part of this model employs an automated algorithm, which organizes existing ice-penetrating radar data around the inferred hydrologic system. Application of this model has revealed that a number of subglacial lakes in the Dome C region lie at the transition zone between a region where estimated discharge exceeds the carrying capacity of porous media rock and fractured rock aquifers. Detailed knowledge of the bed topography helps predict where subglacial water is capable of thermally eroding its own passage through the overlying ice versus where it is necessary for water to mechanically force open an aperture for its own transport. Knowledge of the surrounding basal morphology may allow identification of areas where water transport plays an active role in transporting and reshaping sediments. Radar reflectivity can confirm the passage of water through a given location. Similarly, the structure of the overlying ice provides information about the production of water and evidence of its transport. Although no single technique can be applied ice sheet wide, the combined assimilation of multiple techniques can be used to create comprehensive picture of water transport throughout much of the ice sheet.