Using Physics-informed Neural Networks to Learn the Flow at Ice Rises

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Ice rises are grounded features within ice shelves with local zones of slow-moving ice. These regions are valuable for studying firn compaction, which informs paleo-climate reconstructions and ice sheet mass loss estimates in our warming world. Physics-informed neural networks (PINNs) offer a promising new method to understand firn compaction by combining a neural network with physical constraints, such as conservation of mass, to reconstruct ice parameters from sparse and noisy data. In this work, we apply PINNs to infer the ice dynamics at the Korff Ice Rise in the Ronne Ice Shelf. Our model is trained on vertical ice velocities derived from phase-sensitive Radio Echo Sounder (pRES) data. We account for the difference between pRES observed apparent depths and velocities (which assume constant ice density) and the true depths and velocities (which account for a firn layer) with a theoretical firn density profile. The PINN minimizes misfit by also satisfying the governing mass conservation equations and boundary conditions at the surface, bed, and divide. Preliminary results reveal a Raymond arch structure, which is consistent with the prior, traditional inversion method. However, further work is needed as our current boundary conditions lead to unphysical horizontal flow velocities and an unrealistic density profile.