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Basal Properties of the Filchner-Ronne Sector of Antarctica from Inverse Modeling and Comparison with Ice-Penetrating Radar Data

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Lubrication by subglacial water or saturated subglacial sediments is crucial to controlling the movement of fast-flowing outlet glaciers and ice streams. However, the subglacial environment is difficult to observe directly. Here, we combine inverse modeling with ice-penetrating radar observations to characterize the ice sheet bed in the Filchner-Ronne sector of Antarctica, with a specific focus on the Recovery Glacier catchment. First, we use the Ice Sheet System Model (ISSM; Larour et al., 2012) to assimilate satellite observations of ice sheet surface velocity (Mouginot et al., 2019) in order to solve for basal drag and ice rheology across the Filchner-Ronne sector of Antarctica. Next, we compare these results with ice-penetrating radar observations sensitive to the presence of ponded water at the ice sheet base (Humbert et al., 2018; Langley et al., 2011), along with remotely sensed observations of active lakes (Smith et al., 2009) and putative large subglacial lakes inferred from the ice sheet surface slope (Bell et al., 2007). We find that the main fast-flowing region of Recovery Glacier is mostly low-drag, with the exception of localized sticky spots and bands. The boundary between rugged subglacial highlands and a deep subglacial basin near the onset of the ice stream is associated with a sharp reduction in basal drag, although surface velocity changes smoothly rather than abruptly across this transition. An upstream shear margin, visible in satellite radar images of the ice surface, is associated with low basal drag. The putative large lakes have low drag but are not strongly distinguished from their surroundings, and radar evidence for ponded subglacial water within them is weak. The active lakes identified from satellite altimetry are similarly situated in areas of low basal drag, but have limited radar evidence for ponded subglacial water. An L-curve analysis indicates that our inverse model results are robust against changes in regularization, yet the radar-identified lake candidates do not have a clear relationship with low-drag areas in the fast-flowing ice stream. We conclude that the deep-bedded regions of Recovery Glacier are underlain by saturated subglacial sediments, but classic ponded subglacial lakes are much more rare. Isolated sticky spots and bands within the ice stream are either due to protrusions of bedrock out of the sediments or to localized areas of frozen and/or compacted sediments.