Geophysical Research Abstracts
Vol. 15, EGU2013-8897, 2013
EGU General Assembly 2013

Radar-imaged internal layering in the Weddell Sea sector of West Antarctica

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Radio-echo sounding (RES) across polar ice sheets reveals extensive, isochronous internal layers, whose stratigraphy, and especially their degree of continuity over multi-km distances, can inform us about both present ice flow and past ice-flow histories. Here, we bring together for the first time two recent advances in this field of cryospheric remote sensing to analyse ice flow into the Weddell Sea sector of West Antarctica. Firstly, we have developed a new quantitative routine for analysing the continuity of internal layers obtained over large areas of ice by airborne RES surveys – we term this routine the “Internal-Layering Continuity-Index (ILCI)”. Secondly, in the austral season 2010-11 we acquired, by airborne RES survey, the first comprehensive dataset of deep internal layering across Institute and Möller Ice Streams, two of the more significant feeders of ice into the Filchner-Ronne Ice Shelf. Applying the ILCI to SAR-processed (migrated) RES profiles across Institute Ice Stream’s catchment reveals two contrasting regions of internal-layering continuity behaviour. In the western portion of the catchment, where ice-stream tributaries incise deeply through the Ellsworth Subglacial Highlands, the continuity of internal layers is most disrupted across the present ice streams. We therefore interpret the ice-flow configuration in this western region as predominantly spatially stable over the lifetime of the ice. Further east, towards Möller Ice Stream, and towards the interior of the ice sheet, the ILCI does not closely match the present ice flow configuration, while across most of present-day Möller Ice Stream itself, the continuity of internal layers is generally low. We propose that the variation in continuity of internal layering across eastern Institute Ice Stream and the neighbouring Möller results primarily from two factors. Firstly, the noncorrespondence of some inland tributaries with internal-layering continuity acts as evidence for past spatial migration of those tributaries, with likely consequences for the relative positions of Institute and Möller Ice Streams over recent history. Secondly, the subglacial roughness, in part a function of the underlying geology across the region, imposes a strong influence on the continuity of the overlying deep internal layers, though whether it controls, or is a function of, ice flow, remains undetermined. We conclude that in the subglacially mountainous Ellsworth Subglacial Highlands sector, there is long-term stability in the spatial configuration of ice flow, but that elsewhere across Insitute and Möller Ice Streams, the ice-flow configuration is not stable.