Geophysical Research Abstracts
Vol. 12, EGU2010-13729-1, 2010
EGU General Assembly 2010

Mapping of saltwater intrusions into the McMurdo Ice Shelf, Antarctica, using electromagnetic induction sounding and ground penetrating radar measurements

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Ice Shelves, interacting with both the ocean and the atmosphere, are a sensitive indicator of a changing environment. The repeated observation of ice shelf thickness as a result of surface and bottom mass balance and ice shelf dynamics yields insight into this sensitive balance. Ice shelf thickness is normally measured by radar, or derived from freeboard height using knowledge about ice density and sea level height. Seismic methods may also be used but are usually limited to smaller areas. In general, melting at the underside of the ice shelf is expected to be highest near the grounding line, and the rise and outflow of diluted undercooled water may result in bottom freezing. In the presence of saline ice at the ice shelf bottom the use of radar for ice thickness measurements is limited, as the radar energy is effectively absorbed. This is also the case near the ice shelf edge where saltwater intrusions may be observed. In November 2009 we conducted helicopter-borne electromagnetic induction measurements in the McMurdo Sound to measure sea ice and ice shelf thickness within a validation experiment for the CryoSat-2 satellite. The instrument used was an “EM bird”, which is more frequently operated in the Arctic to map sea ice thickness. The thickness of the ice shelf could be detected for values less than about 50 m, with a strong gradient perpendicular to the ice shelf front and significant undulations parallel to the ice shelf front. At the same time, we used a ground penetrating radar system in order to detect the transition depth between fresh water and saline ice. In this contribution we present the results of this combined airborne and ground based method, which could be further developed to a fully airborne or ground based technology detecting larger ice shelf thickness and ice shelf morphology in the presence of marine ice.