Geophysical Research Abstracts
Vol. 15, EGU2013-5914, 2013
EGU General Assembly 2013

Non-linear rates of Antarctic ice loss under high rates of sea-level rise

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According to both deterministic and semi-empirical studies, the rate of eustatic sea-level rise is likely to reach 0.4-0.6 m / century by AD 2100, but rates of up to 1 m / century are also possible if the most extreme climate projections are realised. Rates of sea-level rise of this magnitude are typical of a long term equilibrium response to environmental change (for example through glacial-interglacial cycles), but have not been witnessed during the historical past, and thus the consequence of these conditions for existing global ice-sheets remains unknown. From recent instrumental observations alone we are therefore unable to predict whether mass loss from these ice sheets will vary linearly with changes in the rate of sea-level rise, or if a non-linear response is more likely. In an attempt to address this shortcoming, we use a three-dimensional ice-sheet model to investigate glaciological changes taking place during the most recent period of 1 m / century sea-level rise, the last deglaciation (20 ka to present). Our experiments show a clear threshold in the relationship between the rate of sea-level rise, and the rate of (sea-level contributing) ice-sheet mass loss. Based on a statistical model fitted to our data, we show that at rates of sea-level rise below 1 m / century, Antarctic ice loss is linearly related to the combined effects of oceanic warming and rising sea levels, but above this threshold, the rate of ice loss increases significantly, and is driven primarily by the rate of sea-level rise, with ocean warming playing a lesser role. Our modelled values are consistent with current rates of Antarctic ice loss and sea-level rise, and imply that accelerated mass loss from marine-based portions of Antarctic ice sheets may ensue when an increase in global mean air temperature of only 1.4-2.0 deg. C is achieved, assuming sufficient ice exists in unstable geometries.