



Intrinsic low-frequency variability in ice sheets, glaciers and ocean dynamics and its relation to the observed 20th century sea level rise

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The observed 20th century sea level rise represents one of the major consequences of anthropogenic climate change. However, superimposed on any anthropogenic trend there are also considerable decadal to centennial signals linked to intrinsic natural variability in the climate system. Here, we systematically analyze the contributions from 18 major glacier regions, the Greenland ice sheet, and ocean dynamics to the observed 20th century sea level rise and provide evidence for significant long-term correlations in each individual component. This intrinsic low frequency variability enhances previous estimates of the causal uncertainties of observed trends (based on the assumption that natural variations do not persist longer than a few years) in sea level by an average factor of 2.3. Gravitational effects and ocean dynamics further lead to regionally varying imprints of low frequency variability. In the Arctic, for instance, the causal uncertainties are even up to 8 times larger than previously thought. This result is consistent with recent findings that beside the anthropogenic signature, a non-negligible fraction of the observed 20th sea level rise still represents a response to pre-industrial natural climate variations such as the Little Ice Age.