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Basin-Wide Mass Balance of Jakobshavn Isbræ (West Greenland) during 1880-2100

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Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Muresan, I. S., Khan, S. A., Aschwanden, A., Langen, P. L., Khroulev, C., Box, J. E., & Kjær, K. H. (2015). Basin-Wide Mass Balance of Jakobshavn Isbræ (West Greenland) during 1880-2100. Abstract from 2015 AGU Fall Meeting, San Francisco, United States.

C21A-0715
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Tuesday, 15 December 2015

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Abstract:
Greenland's main outlet glaciers have more than doubled their contribution to global sea-level rise over the past decade through acceleration of ice discharge. Jakobshavn Isbræ (JI) in west Greenland is the largest outlet glacier in terms of drainage area.
Here we use a 3-D modeling approach to study the mechanisms controlling dynamic changes at the terminus of JI over a period of 220 years. Over 100 simulations are performed with different sets of parameters where the calving fronts and the grounding lines are free to evolve in time under atmospheric and oceanic forcing. We find that the thinning and the retreat that starts at the calving front and then propagates upstream is mostly controlled by a loss of resistive stresses at the terminus through glacier dynamics induced calving rather than by changes in oceanic temperatures. Three major accelerations are identified in 1928, 1998 and in the summer of 2003. The acceleration which started in 1928 slowly faded by 1948, while the accelerations in 1998 and 2003 sustain the high velocities observed at JI in the last decade. Further, we find that under atmospheric RCP 4.5 and RCP 8.5 forcing (no RCP ocean forcing included), an increase in ocean temperatures of just 0.7 °C (relative to 1880-2012) is enough to trigger a collapse of the JI's southern tributary by 2050 which further destabilizes JI and unleashes a major glacial collapse of ~25 km. JI's contribution to SLR is found to be ~2.8 mm (~1014 Gt) for the period 1880 to 2014, from which the contribution between 1997 to 2014 represents 27 %. By the end of the century contributions to SLR as high as ~11 mm (~4000 Gt under RCP 8.5 and almost 300% increase relative to 1880-2014) can be expected from Jakobshavn Isbræ only.
Our choice of ice sheet model comprises the Parallel Ice Sheet Model (PISM).