Geophysical Research Abstracts
Vol. 21, EGU2019-18675, 2019
EGU General Assembly 2019

Effect of subshelf melt variability on sea level rise contribution from Thwaites Glacier, Antarctica

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Theory, modeling, and observations indicate that marine ice sheets on a retrograde bed, including Thwaites Glacier, Antarctica, are only conditionally stable. Previous modeling studies have shown that rapid, unstable retreat can occur when ice-shelf basal melting causes the grounding line to retreat past restraining bedrock bumps. In this presentation, we explore the initiation and evolution of unstable retreat of Thwaites Glacier when the ocean-induced ice-shelf basal melt forcing includes temporal variability mimicking realistic climate variability. We use an ice sheet model (MALI) forced with a new ice shelf basal melt parameterization based on melt plume theory and easily applied within an ice sheet model. We add idealized sinusoidal temporal variability to the ocean temperature profile forcing the melt parameterization that represents shoaling and deepening of modified Circumpolar Deep Water within the subshelf cavity. We perform a 72-member ensemble of 500-year duration simulations with different values for the amplitude, period, and phase of the variability. Results show that variability leads to slower grounding line retreat and less contribution to sea level rise than simulations without variability. Ocean temperature variability leads to modeled delays in glacier mass loss at 500 years of 9 to 18 years for amplitudes of variability comparable to recent ocean temperature profile observations, and delays up to 43 years for amplitudes twice that of recent observations (corresponding to a 10% decrease in sea level contribution at 500 years). Delay in mass loss is larger for longer period variability. The primary mechanism causing delayed glacier retreat under variable oceanic forcing is a nonlinear ice flux response to changing buttressing induced by ice shelf basal melting. This mechanism acts continuously, but is amplified during the onset of episodes of marine ice sheet instability. A secondary factor is the decreased sensitivity of melt rates to ocean thermocline depth as the subshelf cavity saturates with isothermal modified Circumpolar Deep Water. While the results are sensitive to the form of the melt parameterization and its variability, we conclude that decadal period ocean variability could potentially delay marine ice sheet instability by up to many decades.