

EGU21-16419

<https://doi.org/10.5194/egusphere-egu21-16419>

EGU General Assembly 2021

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Seasonal flow variations of Ross Ice Shelf (Antarctica): from observations to modeling

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Ice mass loss from both Antarctic Ice Sheet is increasing, accelerating its contribution to global sea level rise. Interactions between the ice shelves (the floating portions of the ice sheet) and the ocean are key processes in this mass loss. The large Ross Ice Shelf is presently stable but buttresses grounded ice equivalent to about 12 m of global sea level, and geological evidence points to large and sometimes rapid past changes. Recent ocean modeling and observations show that seasonal inflows of warmed upper-ocean water under a thin-ice corridor from Ross Island to Minna Bluff and at the ice front can produce locally high melt rates each summer, suggesting that future increases in summer upper-ocean ocean warming north of the ice front could accelerate ice-shelf flow speeds and mass loss. Recent GPS observations of Ross Ice Shelf velocity have shown seasonal flow variations of several meters per year over a large part of the ice shelf, accelerating in summer and decelerating in winter. A similar seasonal variability has been observed over the floating extension of Byrd glacier (one of the major tributary glaciers of Ross Ice Shelf) by processing Antarctic image pairs in the ITS_LIVE dataset. However, ice-sheet simulations driven by realistic annual cycles of basal melt rates near the ice front produce much smaller seasonal variations than observed, suggesting that other processes could be at play. Here, we investigate a new potential mechanism for a seasonal signal in ice flow: variations of sea surface height (SSH) driven by seasonal changes in thermodynamic and atmospheric forcing of ocean state under the ice shelf. Model annual cycle of SSH under Ross Ice Shelf has an amplitude of up to ~20 cm, with substantial spatial variability. These variations of sea level, similarly to tidal signal but with a longer period, can lead to changes in driving stress over the ice shelf as well as a migration of the grounding line due to hydrostatic adjustment and visco-elastic bending of the ice shelf in the grounding zone. By simulating these SSH variations in an ice-sheet model, we more accurately reproduce the variations observed at GPS stations on Ross Ice Shelf.