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Formation of melt channels on ice shelves

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Melt channels have been observed on ice shelves experiencing strong melting in both Greenland (Petermann Glacier) and Antarctica (Pine Island Glacier). Using a fully-couple ice-shelf/sub-ice-shelf-ocean flow model, it is demonstrated that these channels can form spontaneously in laterally confined ice shelves. These channels have transverse extent of a few kilometers and a vertical relief of about a few hundred meters. Meltrates and sea-water transport in the channels are significantly higher than in between the channels on the smooth flat ice bottom. In circumstances where an ice shelf has no-slip conditions at its lateral boundaries, the ice-shelf/sub-ice-shelf-cavity system exhibits equilibrium periodic states, where the same configurations repetitively appear with a periodicity of about 30-35 years. This peculiar dynamics of the system has strong implications on the interpretation of the remote and in-situ observations and inferences of the system parameters (e.g., melt rates) based on these observations. For instance, the persistent temporal changes in the ice-shelf thickness are caused by internal dynamics of the melt channels, and, in contrast to traditional interpretation, can be independent of the oceanic forcings.