Melting of ice

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The quantitative understanding of glacial ice melting into the ocean is one of the most outstanding challenges in environmental fluid dynamics. The lack of understanding is on a fundamental level, due to the highly complex multi-scale, multi-physics nature of the problem. The process involves intricate multi-way coupling effects, including thermal convection, salinity, ocean current, and radiation, etc. As ice melts into the surrounding salty water, a decrease in local salt concentration leads to reduced water density, inducing upward buoyant forces and, consequently, upward flow. This flow dynamically interacts with the ice, resulting in a feedback loop of further melting (Stefan problem). Our investigation employs direct numerical simulations with the phase field method. To capture the intricacies of melting dynamics within turbulent flows, we implement a multiple-resolution strategy for salinity and phase field simulations [3]. The versatility of our method is demonstrated through successful applications to diverse melting scenarios, including the formation of melt ponds [2], melting in Rayleigh-Bénard convection [4], vertical convection with fresh water [1], and vertical convection with salty water [3]. In this presentation, we showcase results obtained across these various geometries. This work contributes to advancing our understanding of the complex dynamics involved in glacial ice melting within oceanic environments.

References

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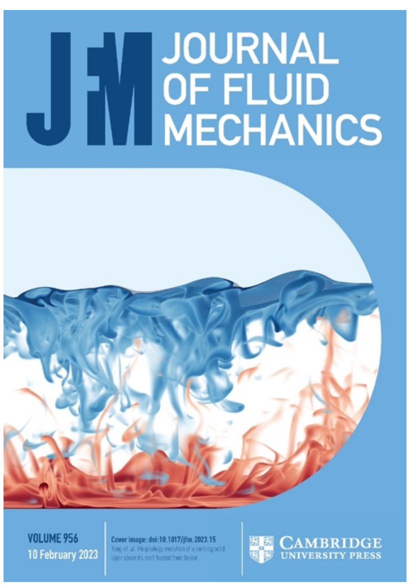

Destabilization of the Antarctic Ice Sheet and extreme sea-level rise - Europe's greatest threat from global warming

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Even if the transformation to sustainable energy would occur tomorrow, and after tomorrow global temperature would not rise any further, sea-level will continue to increase, and not by a small amount, but by many meters. With the Paris Agreement fully implemented it would eventually imply 4-16 m sea level rise in response to 2 degrees warming. Because this equilibrium response was always thought to occur on timescales of a few thousand years, politicians and media were not interested. However, in recent years it has become clear that the ocean is quickly melting floating ice-shelves surrounding the large ice caps of Greenland and West-Antarctica. Especially around the western part of the Antarctic ice cap the process progresses disturbingly fast. Moreover, ice shelves feature deepening cracks and rifts and eventually may crumble in pieces, as has been witnesses for 2 ice shelves, Larsen A and Larsen B. Recently year Larsen C lost a large fragment of 300 by 50 km, and the floating ice shelf of Thwaites glacier is quickly weakening and may accelerate sea-level rise significantly in the near future, hence its nickname Doomsday Glacier. While melting ice shelves do not raise the sea level (like melting ice cubes in a glass of soft drink), their indirect effect on sea level is large. The large ice caps are unstable and need the ice shelves to prevent them from collapsing under their own weight. In this colloquium I will review the processes that give rise to fast and extreme sea-level rise, what recent observations tell us about these processes, how we can make future projections with numerical models, and whether we should be worried about the results.