海科院青年教师程晨在国际冰冻圈顶级期刊《The Cryosphere》发表最新研究成果

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近日我校海洋科学学院青年教师程晨作为第一作者在《The Cryosphere》“冰冻圈”杂志发表题为“Responses of sub-ice platelet layer thickening rate and frazil-ice concentration to variations in ice-shelf water supercooling in McMurdo Sound, Antarctica”的学术论文。

该项研究主要于程晨讲师过去一年在英国南极局（British Antarctic Survey）的访学期间完成，并与该单位两位知名教授Adrian Jenkins和Paul R. Holland、河海大学的王召民教授、我校海科院另外两名青年教师合作完成。该项成果首次给出了南极麦克默多海峡片状冰增长率与当地过冷水过冷温度间的定量关系。

片状冰是南极冰架前缘固定冰下特有的存在形式，其主要由从冰架前缘流出的过冷水羽流中悬浮的冰晶颗粒上浮至固定冰下积累而成。片状冰不但对冰架前缘海冰厚度有着不可忽略的贡献，同时也是地球上冰藻最富集的产地。麦克默多海峡有着环绕南极最丰富的片状冰资源，该研究基于一种改进的过冷水羽流模式，通过开展大量敏感性数值实验，最终确定了当地片状冰增长率与过冷水过冷温度间的定量关系，而这一关系根本上决定于悬浮冰晶颗粒的大小。

本文是我校首次以第一单位在冰冻圈及其气候变化方面顶级期刊《The Cryosphere》发文。该杂志是中科院SCIE地学一区期刊，其2018年影响因子为4.524，五年影响因子为5.558。本文也是程晨讲师2017年发表在期刊《Journal of Physical Oceanography》研究工作的后续研究，它的最终发表进一步提升了我校在南极冰架—海洋相互作用研究领域的影响力。

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Responses of sub-ice platelet layer thickening rate and frazil-ice concentration to variations in ice-shelf water supercooling in McMurdo Sound, Antarctica

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Abstract. Persistent outflow of supercooled ice-shelf water (ISW) from beneath McMurdo Ice Shelf creates a rapidly growing sub-ice platelet layer (SIPL) with a unique crystallographic structure under the sea ice in McMurdo Sound, Antarctica. A vertically modified frazil-ice-laden ISW plume model that encapsulates the combined non-linear effects of the vertical distributions of supercooling and frazil concentration on frazil-ice growth is applied to McMurdo Sound and is shown to reproduce the observed ISW supercooling and SIPL distributions. Using this model, the dependence of the SIPL thickening rate and depth-averaged frazil-ice concentration on ISW supercooling in McMurdo Sound is investigated and found to be predominantly controlled by the vertical distribution of frazil concentration. The complex dependence on frazil concentration highlights the need to improve frazil-ice observations within the sea-ice–ocean boundary layer in McMurdo Sound.

1 Introduction

Ice shelf basal melting removes more mass from the Antarctic Ice Sheet than iceberg calving does, but the three largest ice shelves, Filchner-Ronne, Ross, and Amery, contribute only 18 % of the net meltwater flux (Rignot et al., 2013). That is because the seawater-filled cavities beneath those ice shelves are dominated by high-salinity shelf water that has a potential temperature at or near the surface freezing point. Ice shelf basal melting occurs at depth because the freezing point temperature is lower under elevated pressure, and results in the formation of ice-shelf water (ISW), characterized by potential temperatures below the surface freezing point. When the buoyant ISW ascends along the ice-shelf base, the pressure relief causes it to become supercooled in situ, a necessary condition for ice crystals to persist in suspension. Those disk-shaped frazil-ice crystals accumulate under the ice shelves, leading to the formation of marine ice that is thicker and more localized than would be possible through direct freezing at the ice-shelf base (Morgan, 1972; Oerter et al., 1992; Fricker et al., 2001; Holland et al., 2007, 2009). Occasionally, frazil-ice crystals bathed in supercooled ISW are also carried out beyond the ice-shelf front and precipitated under adjacent sea ice, forming an unconsolidated, porous, sub-ice platelet layer (SIPL) (Gow et al., 1998; Hunkeler et al., 2016; Langhorne et al., 2015; Leonard et al., 2006; Robinson et al., 2014). SIPL not only harbours some of the highest concentrations of sea-ice algae on Earth (Arrigo et al., 2010) but also contributes to the sea-ice thickness when the water within the pores of SIPL freezes, due to heat loss to the atmosphere, to become incorporated platelet ice (Smith et al., 2001). Therefore, SIPL should not be ignored when investigating sea-ice thickness near an ice-shelf front.

Owing to the paucity of direct observation, our understanding of the evolution of frazil-ice-laden ISW relies heavily on numerical models. Those models are mostly derived

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