IV ROSS SEA CONFERENCE 2023

Università degli Studi di Napoli "Parthenope"
Via Amm. F. Acton, 38 - 80133 Napoli, ITALY
3-7 July 2023, Via Acton 38, Naples-Italy

PHYSICAL OCEANOGRAPHY

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ABSTRACT Subject :

Stratification Breakdown in Antarctic Coastal Polynyas

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This study examines the process of water-column stratification breakdown in Antarctic coastal polynyas adjacent to an ice shelf with a cavity underneath. The goal is to quantify the influence of winds, air temperature, initial ambient stratification, neighboring ice tongue and headland on the timescales of polynya destratification through combining process-oriented numerical simulations and analytical scaling. In particular, the influence of wind-driven circulation on the lateral transport of dense water in polynyas, a process often neglected in the literature, is systematically examined here. An ice-shelf/sea-ice/ocean coupled numerical model is adapted to simulate the process of dense water formation in polynyas of various configurations. The simulations highlight that i) before reaching the bottom, majority of the dense water is actually carried away from the polynya by katabatic wind-induced offshore outflow, diminishing water-column mixing in the polynya; ii) alongshore coastal easterly winds, through inducing onshore Ekman transport, reduce offshore loss of the dense water and enhance polynya mixing; iii) an ice tongue next to a polynya tends to break the alongshore symmetry in the lateral return flows toward the polynya, creating a relatively stagnant region in the corner between the ice tongue and polynya where horizontal outflow of the dense water in the water column is suppressed and vertical mixing is enhanced; and iv) a headland to the other side of the polynya tends to restore the alongshore symmetry in the lateral return flows, which increases the offshore dense water transport and slows down destratification in the polynya. This work stresses the importance of resolving small-scale local processes in simulating vertical mixing in the polynya. It also provides insights into the mechanisms that drive temporal and cross-polynya variations in stratification and dense water formation in Antarctic coastal polynyas, and establishes a framework for studying differences among the polynyas in the ocean.