Introduction

Deep convection in the open ocean can occur when a unique set of oceanic and atmospheric conditions—a preconditioned water column, cyclonic circulation and strong atmospheric forcing—are satisfied. Among the few locations where these requirements are met is the Labrador Sea, where the intermediate water mass known as Labrador Sea Water (LSW) originates. Recently the hypothesis that LSW is also formed in the southern Irminger Sea has been rekindled\(^1\). Indirect evidence indicates that deep convection may have taken place there during sufficiently strong, high-NADW events. Cyclonic circulation and a preconditioned water column are features of the Irminger Sea, and a mechanism capable of enhancing the heat fluxes from the southern Irminger Sea exists in the form of a strong, but narrow and intermittent wind pattern called the Greenland tip jet\(^2,3\) (Fig. 1). This study seeks to elucidate the atmospheric conditions leading to tip jet events using the ERA-40 reanalyses data and a trajectory model. The impact of the events in dictating the evolution of the wintertime mixed-layer in the southern Irminger Sea is investigated using in-situ moored profiler data and application of a one-dimensional mixed-layer model. A second source of LSW would influence our understanding of the ventilation of the North Atlantic and its branch of the meridional overturning circulation.

Backward trajectories

The 3D trajectory model Lagrang\(_3\) was used to compute backwinds air parcel trajectories terminating above the southern Irminger Sea, a region of weak water column stratification where deep convection is believed to occur during high-NADW winters\(^4\). The winters 1994 to 2002 were considered for this analysis, resulting in 2819 trajectories from 101 tip jet events (Fig. 3).

Oceanic response

A moored profiler (MP) programmed to obtain twice-daily profiles of temperature and salinity between 60 and 1800 m was deployed in the southeast Irminger Sea (Fig. 1) for the winter of 2002-3. Mixed-layers below 60 m were observed between November and April (Fig. 5).

Bulk heat fluxes were computed for the mooring site using timeseries of wind, humidity and air and sea surface temperatures from various sources in order to include the effect of the tip jet events. The resulting “best estimate” turbulent heat flux timeseries were used to force a 1D oceanic mixed-layer model\(^5\) (hereafter PWP). Figure 5 shows timeseries of mixed-layer depth from the MP and from the PWP model. For comparison, the model was also forced with NCEP fluxes (green) as well as the best estimate timeseries with the tip jets removed (red). Driven with the best estimate fluxes, the mixed-layer model simulates the envelope of the observed mixed-layer depth fairly well, including the rapid deepening during February associated with the integrated effect of 7 tip jets occurring in quick succession that month. The final depth of convection for the winter of 2002-3 (~400 m) also agrees well with the MP data. Removal of the tip jet events from the forcing timeseries resulted in a 20% shallower mixed-layer and indicates that they contributed significantly to its deepening.

Conclusions

- Tip jets are intense, but narrow and intermittent wind phenomena that commonly occur east of Cape Farewell during winter
- Tip jets cause elevated turbulent heat fluxes and are important for the seasonal evolution of the mixed-layer of the southern Irminger Sea
- 1D mixed-layer model results add to the growing body of studies supporting the hypothesis that deep convection can take place in the Irminger Sea during high-NADW winters

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The Greenland Tip Jet and its Effect on the Irminger Sea

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