Cooling and freshening of the West Spitsbergen Current by shelf-origin cold core lenses

Zoe Koenig (zoe.koenig@uib.no), Amelie Meyer, Christine Provost, Nathalie Sennéchael, Arild Sundfjord, Laurent Beguery, Marylou Athanase and Jean-Claude Gascard

A. Introduction

The West Spitsbergen Current (WSC) is the main source of heat and salt in the Arctic. As it flows northward along the western Svalbard slope, the current cools and freshens. What are the processes at the origin of this cooling? Boyd and D’Asaro (1994): the atmosphere (less important in summer) and exchanges with waters west of the WSC. Saloranta and Haugan (2004): exchanges with shelf waters through diapycnal mixing.

In July 2017, a Sea Explorer was deployed that criss-crossed the WSC in front of Kongsfjorden 6 times down to 700 meters to investigate the shelf-slope exchanges. During the glider mission winds were weak and mainly northerlies.

Left: a) Green line is SeaExplorer glider trajectory in July 2017.
b) Zoom on the glider trajectory (purple box). Moorings at 78.5°N from the AW (Beszczynska-Mölter et al., 2015) are located with orange stars (F1 to F5). The yellow diamonds indicate the lens locations. SPC: Spitsbergen Polar Current

Right: Wind (m.s⁻¹) at 10m at 78.80°N-8°E from June to August 2017. The red dashed lines delineate the period of the glider mission.

B. Overview of the mission

Atlantic Water (AW) in the WSC : warm and salty

Lenses of cold and fresh water in the WSC

Topographically trapped waves

Cascading of cold and fresh water from the shelf

Shelf water : colder and fresher

C. Lens in transect 1a

Lens: 4 km diameter (Rossby radius around 4km). Core at 225 m depth, from 150 to 300m depth.

• Fresher, colder, depleted in DO. Enriched in CDOM and in total particle concentration.

• Water in the lens with similar characteristics to water on the bottom of the slope (around 400-450m depth).

– Similar origin: the lens detached from the bottom of the slope via isopycnal displacement.

• Lens is located in the core of the WSC hence potential influence on the cooling of the core.

• Lens with a slight anticyclonic component, with horizontal velocity difference about 4 cm/s.

• Similar characteristics are observed for the lens in transect 2a, although it is fresher, colder and deeper.

D. Origin of the lenses

TS diagram color-coded with depth (m): squares with black edges are from profiles in the cold core lens from transect 1a triangles with magenta edges are from profiles on the shelf. Small dots without edge are from profiles on the shelf (transect 2c).

• Waters on the shelf: still quite warm and salty compared to the waters in the Spitsbergen Polar Current (SPC): they probably originate from the Spitsbergen Trough Current, formed in winter by intrusions of AW onto the shelf.

• Waters on the shelf with similar properties as waters located at the bottom of the slope around 400-450m.

→ Same origin: Shelf waters cascade down the slope through diapycnal displacement

E. Conclusion

In summer: cascading of colder and fresher water than the WSC core from the shelf at the bottom of the slope

These lenses can detach as the offshore part of the WSC is baroclinically unstable and cool the core of the WSC.

Schematic of the slope-shelf exchanges documented by the Sea Explorer glider. A relaxing state with weak winds is characterized by cascading of relatively cold water from the shelf down the slope and cold core eddies in the WSC.

