E1: Characteristics and Causes of Denmark Strait Overflow Transport Variability

Mattia Almansi, Thomas W. N. Haine, Robert S. Pickart,
Marcello G. Magaldi, Renske Gelderloos, and Dana Mastropole
mattia.almansi@jhu.edu

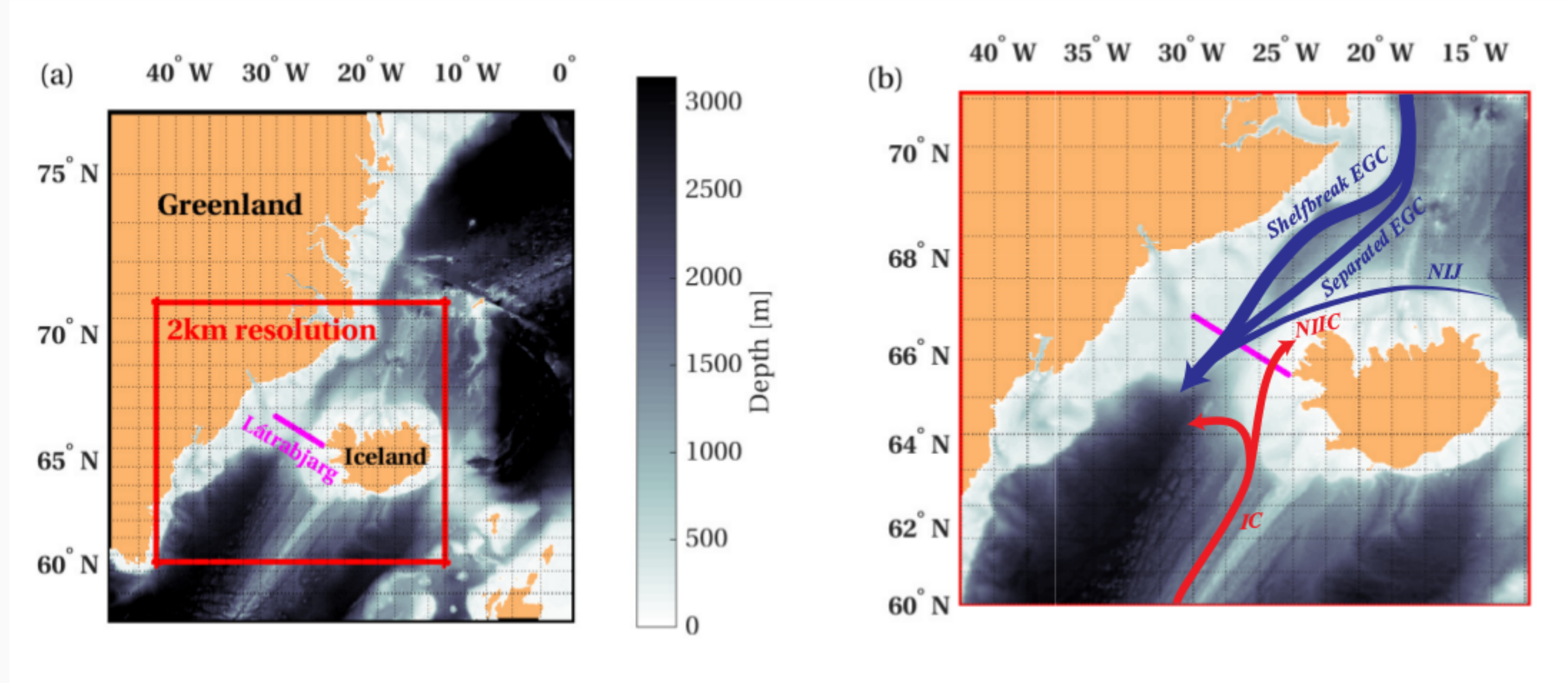
JOHNS HOPKINS KRIEGER SCHOOL of ARTS & SCIENCES

idies The Institute for Data Intensive Engineering and Science

① Abstract

Boluses and pulses are the two dominant mesoscale features in Denmark Strait. They increase the yearly mean southward volume flux of the Denmark Strait Overflow (DSO) by about 30%. We detect and characterize boluses and pulses in our high-resolution (~2 km) numerical model (MITgcm) covering the east Greenland shelf and the Iceland and Irminger Seas, and we provide a brief description of the physical processes that may be involved [1]. SciServer hosts our simulations: the goal is to build a collaborative sharing environment where users can access and process high-resolution datasets.

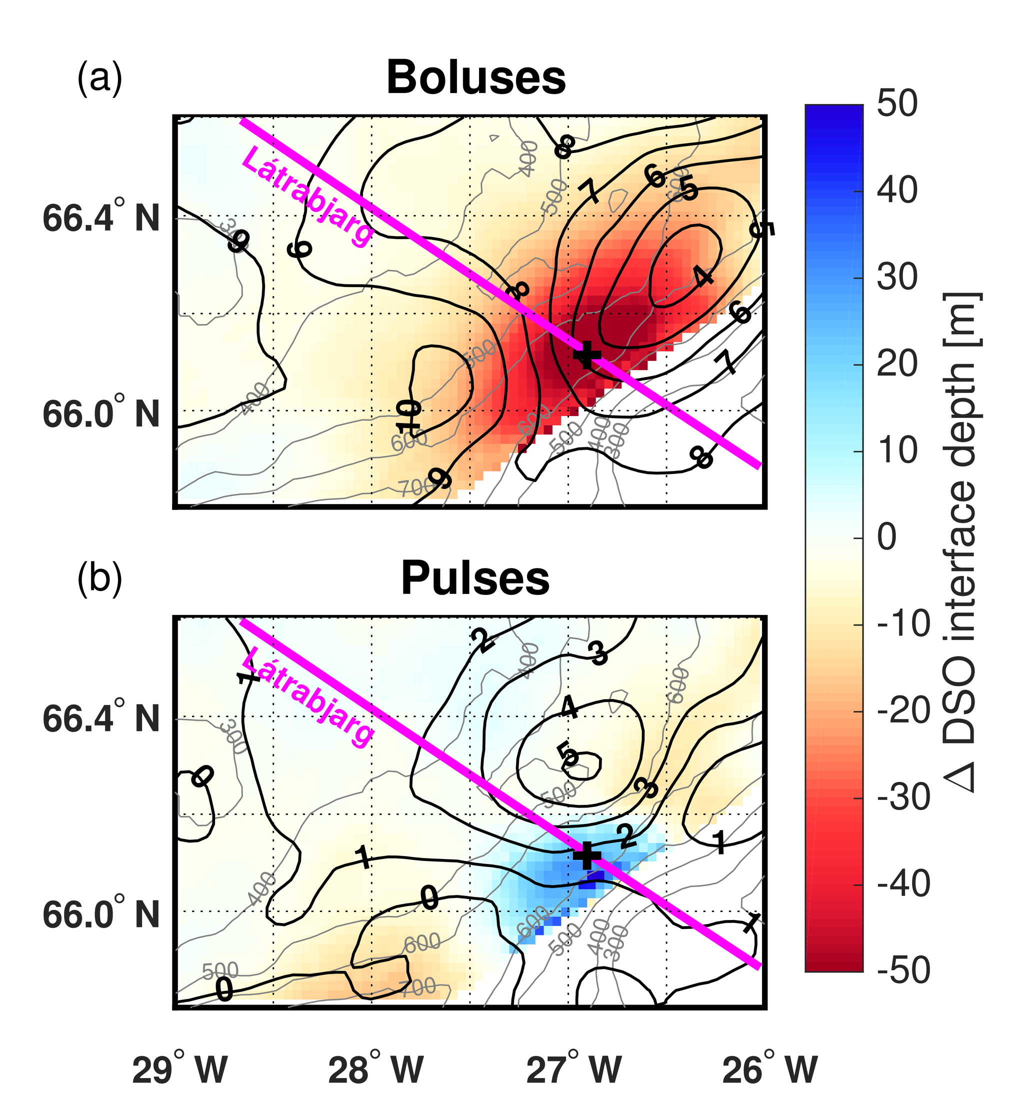
② Model domain and schematic of the currents



(a) Plan view of the numerical domain superimposed on sea-floor bathymetry. Red lines bound the 2 km resolution area. (b) Schematic of the currents flowing in the 2 km resolution area highlighted in (a). EGC = East Greenland Current; NIJ = North Icelandic Jet; NIIC = North Icelandic Irminger Current; IC = Irminger Current.

③ SSH and DSO interface

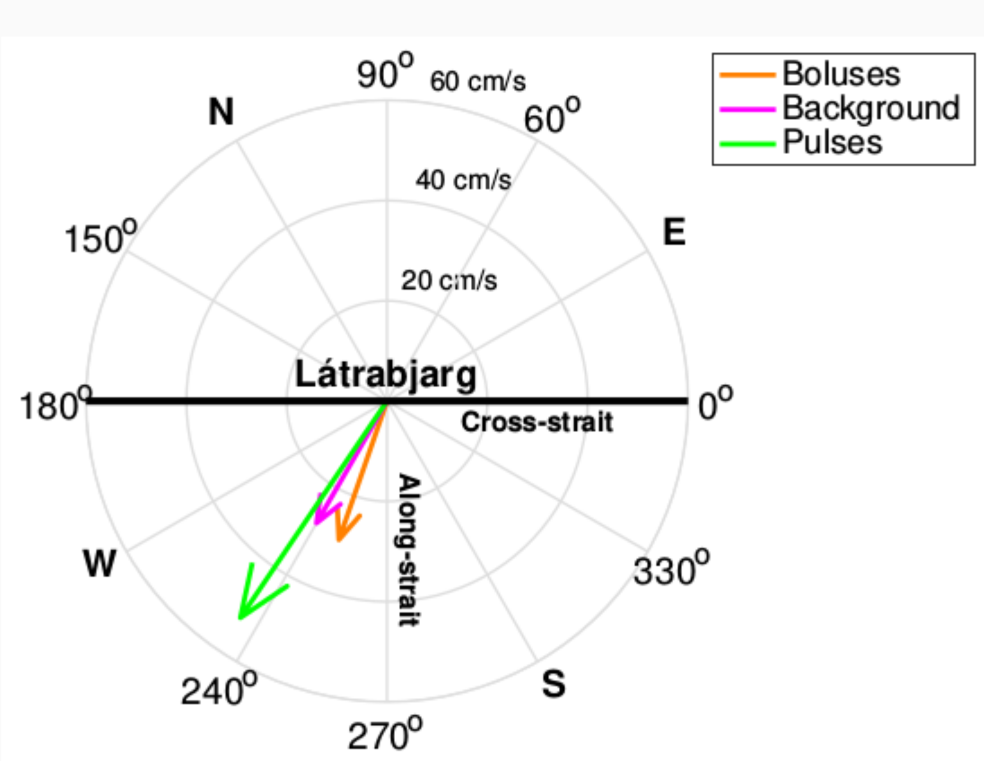
The DSO interface shoals during boluses and deepens during pulses, and the along-strait length scale of the boluses is larger. SSH rises during the passage of both mesoscale features. SSH anomaly contours form a bowl upstream of Denmark Strait during boluses, while during pulses they form a dome centered northwest of the sill.



Composite of DSO interface (shading) during (a) boluses and (b) pulses minus the background state. Black contour lines show the SSH composite during (a) boluses and (b) pulses minus the background state (cm). Negative (positive) anomalies correspond to a shallower (deeper) DSO compared to the background state.

④ DSO direction

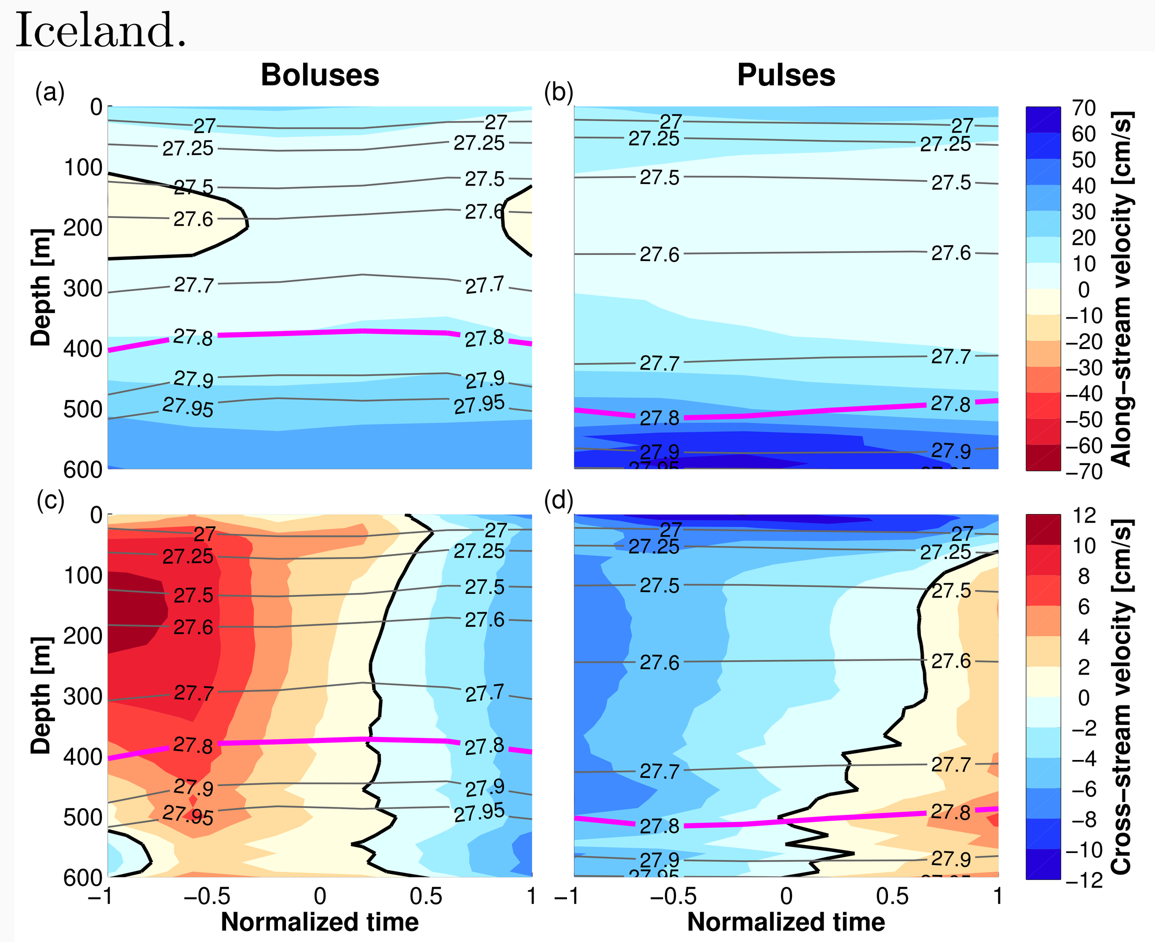
Assuming that the flow is geostrophic, SSH anomalies above imply enhanced DSO flow toward Iceland during boluses (cyclonic) and toward Greenland during pulses (anticyclonic), consistent with the flow vectors below.



Mean velocity of the DSO.

⑤ Time evolution of velocities

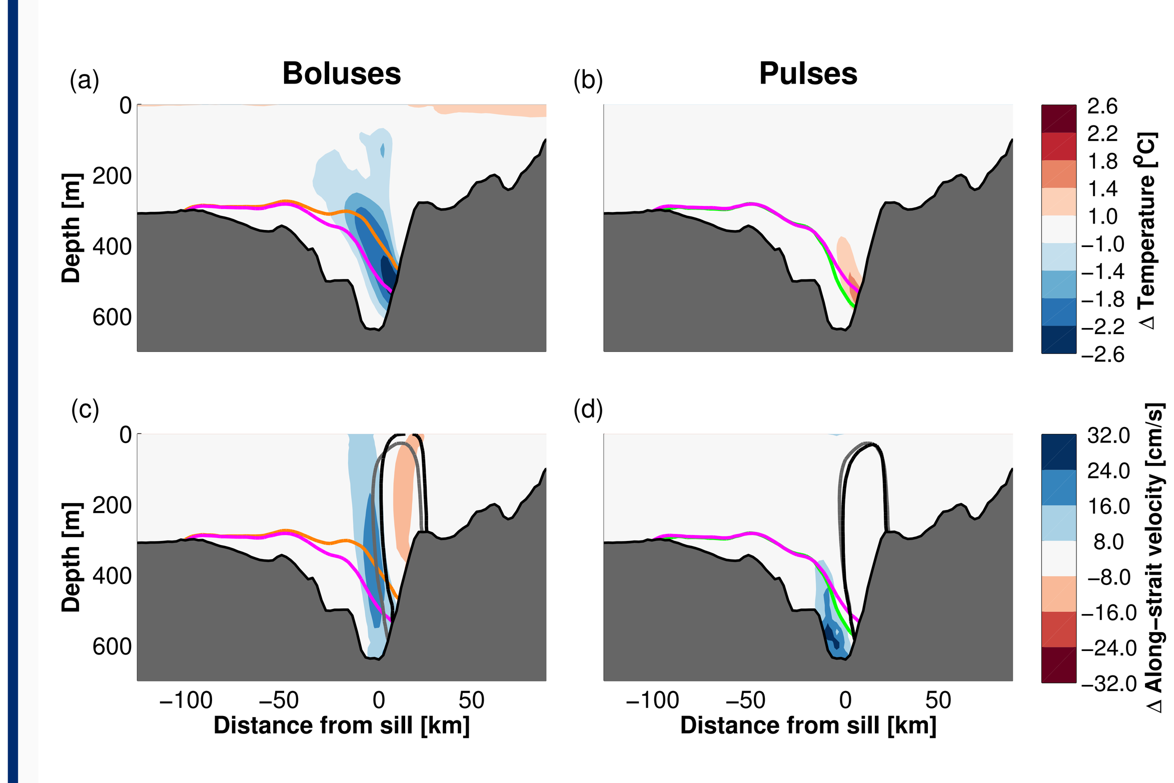
For boluses, there is a small variation in the along-stream flow of DSO water. However, there is a very clear pattern in the cross-stream velocity for the upper-layer that extends into the overflow layer as well. Specifically, the flow is towards Iceland at the leading edge of the bolus and towards Greenland at the trailing edge, indicating that boluses are associated with veering. For pulses, the along-stream flow of DSO water is significantly faster in the center of the feature, while the cross-stream flow is associated with backing: first towards Greenland, then towards Iceland.



Time evolution of the composites of representative boluses (left column) and pulses (right column) obtained by averaging (a and b) along-stream velocity, and (c and d) cross-stream velocity. Zero-velocity contours are drawn in black.

⑥ Distribution of anomalies

Temperature anomalies are strongest near the overflow interface; in particular, water near the interface of the overflow layer is colder by about 2.6°C during boluses, and warmer by about 1.8°C during pulses. The enhanced equatorward flow during pulses is confined to the overflow layer on the western side of the trough, while for boluses it extends throughout the water column in the center of the trough. Interestingly, the poleward flow of the NIIC increases during bolus events.



Composites of boluses (left column) and pulses (right column) minus the background state: (a and b) potential temperature, and (c and d) along-strait velocity. Positive velocities are equatorward. The DSO interface during boluses (orange), pulses (green), and background state (magenta) are outlined. Gray contours bound the northward flow at the Iceland shelfbreak during the background state, while black contours bound the northward flow during boluses in (c) and pulses in (d).

⑦ Conclusions

- Boluses and pulses play a major role in controlling the variability of the DSO transport.
- Fluctuations in DSO transport form upstream of Denmark Strait. Thus, coastally-trapped waves triggered by upstream downwelling-favorable winds could play a role in controlling the pulsating behavior of the DSO transport.
- Boluses are associated with an enhanced equatorward flow throughout the whole water column and may be related to the NIJ.

⑧ Reference

[1] Almansi, M., Haine, T. W. N., Pickart, R. S., Magaldi, M. G., Gelderloos, R., & Mastropole, D. (accepted). High-Frequency Variability in the Circulation and Hydrography of the Denmark Strait Overflow from a High-resolution Numerical Model. *Journal of Physical Oceanography*.

Our datasets and user-friendly post-processing tools are publicly available at `http://www.sciserver.org/integration/oceanography/`