Hydrostatic and non-hydrostatic simulations of the East Greenland Spill Jet

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ABSTRACT

The cascade of dense waters off the East Greenland shelf during Summer 2003 is investigated with two very high-resolution (0.5 km) regional simulations. The first simulation is non-hydrostatic. The second simulation is hydrostatic and about 3.75 times less expensive. Both simulations are compared to a previous 2-km hydrostatic run (about 30 times less expensive as the 0.5 km non-hydrostatic case).

All runs compare well with observations and confirm the persistence and the causes of the East Greenland Spill Jet: In some cases, a local perturbation results in dense waters descending over the shelfbreak into the Irminger Basin (Type I spilling). In other cases, surface cyclones associated with Denmark Strait Overflow (DSO) deep domes initiate the spilling process (Type II spilling).

Differences among runs are quantified in terms of the surface energy spectra and the Okubo-Weiss parameter. These diagnostics are sensitive to the change in resolution and dynamics among the runs. The volume transports of Denmark Strait Overflow Water and the Spill Jet are insensitive to these configuration differences, however.

1. MODEL SETUP

- •Regional MITgcm, 97 levels
- •2-km and 0.5-km horizontal resolution
- •Nested open boundary conditions
- •Scatterometer wind forcing
- •NCEP radiation forcing
- •Leith and KPP dissipation schemes

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2. SURFACE FIELDS

Cold cyclones (Fig. 1) cause spilling of shelf waters as in *Magaldi et al.* (2011) and are more detailed in the 0.5-km runs (middle row). Timeseries of the deep water volume transports at the Spill Jet section are very similar for all three runs (top right). Small-scale strain features appear in the middle of the basin for the non-hydrostatic case (bottom row). It is unclear why. The Okubo-Weiss parameter, Q (see box), is dominated by strain S^2.

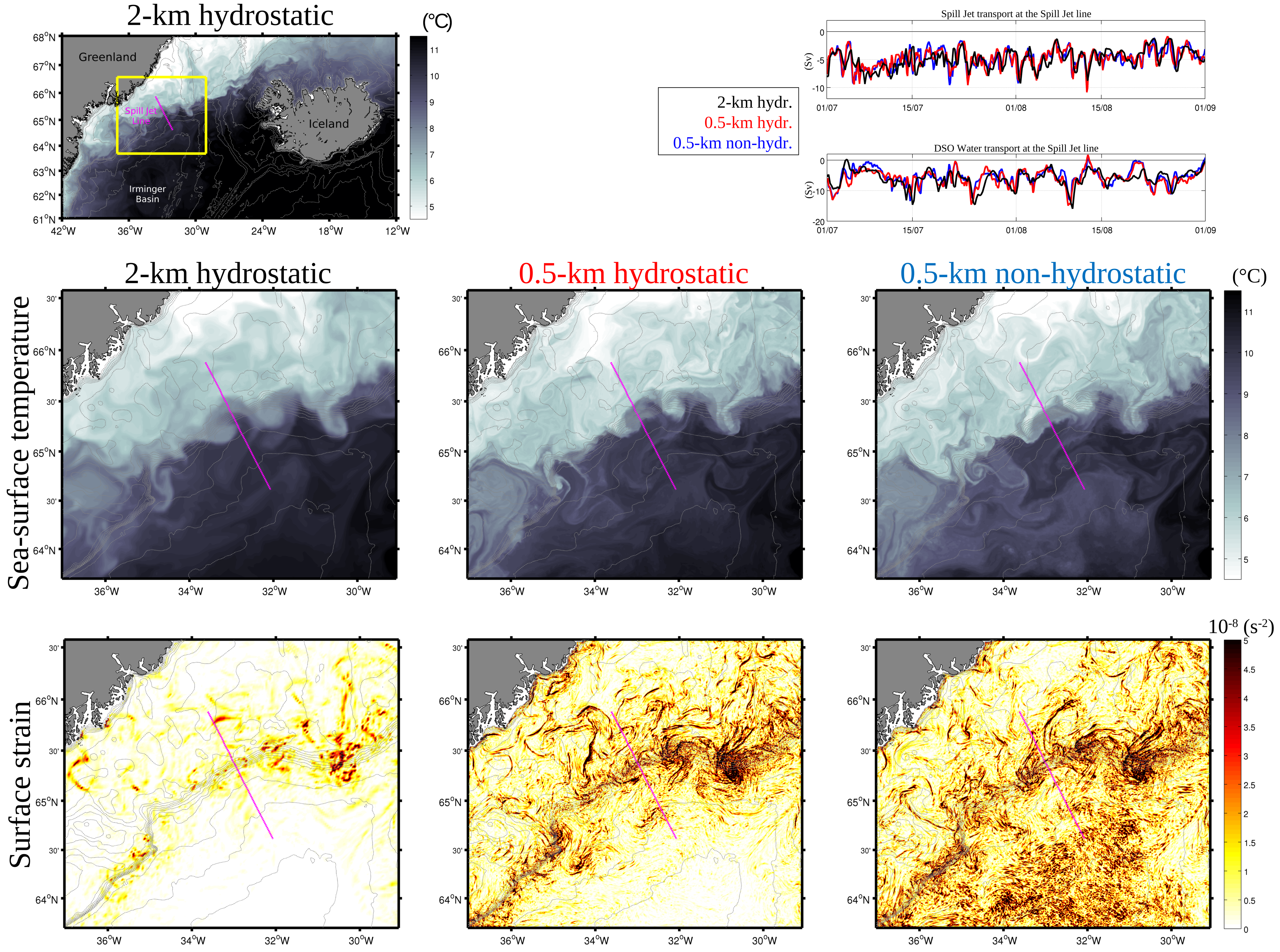

Fig. 1: Top left panel: large-scale view of sea surface temperature for the 2-km run. The yellow box is the 0.5-km domain which is nested in the 2-km domain. Top right panel: time series of volume transport for the Spill Jet and DSO Water at the Spill Jet section (magenta line). Middle and bottom rows: sea surface temperature and surface strain S^2 for the three runs.

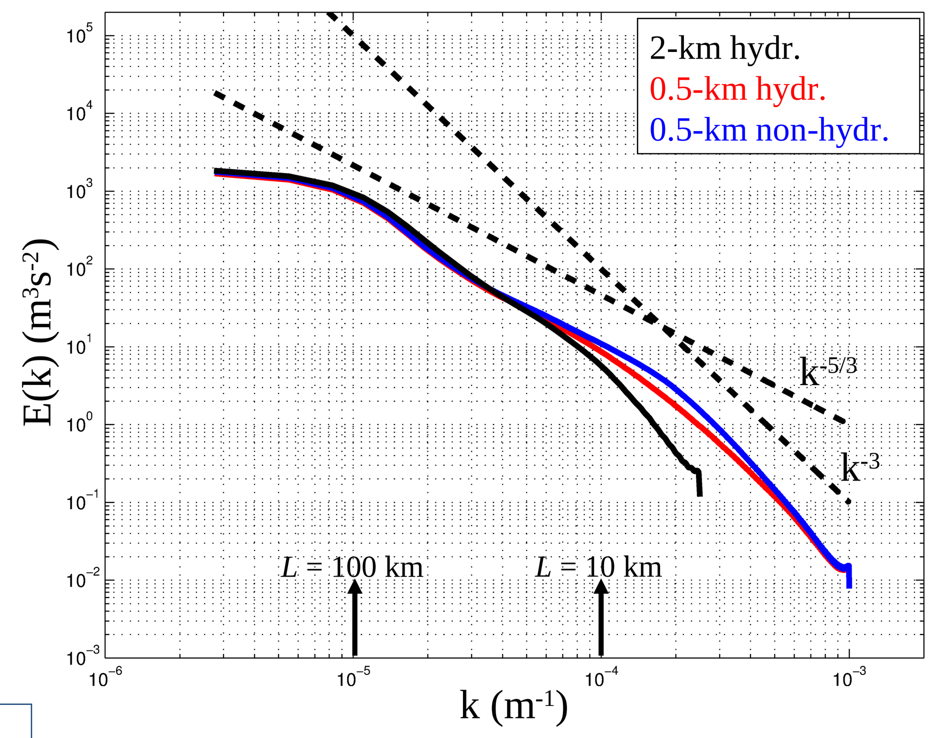

Fig. 2: Time-averaged surface horizontal kinetic energy spectra.

OKUBO-WEISS DIAGNOSTICS

Strain-squared:

$$S^2 = (\partial u/\partial x - \partial v/\partial y)^2 + (\partial v/\partial x + \partial u/\partial y)^2$$

Vorticity-squared:

$$\omega^2 = (\partial v/\partial x - \partial u/\partial y)^2$$

Okubo-Weiss parameter, Q:

$$Q = S^2 - \omega^2$$

$$\langle Q^+ \rangle = A^{-1} \int \sqrt{Q}\, dA \quad \text{for } Q > 0,$$

	2-km hydr.	0.5-km hydr.	0.5-km non-hydr.
$<\bar{Q}^+>/<\bar{Q}^+>_{2km}$	*1*	*8.6*	*10.7*
Spill Jet (Sv)	*4.9±1.7*	*4.8±1.7*	*4.8±1.7*
DSOW (Sv)	*6.1±2.8*	*6.0±2.8*	*5.5±2.7*

Table. 1: Hyperbolicity and dense water transports.

3. COMPARISON

Surface spectra coincide for scales L > 50km (Fig. 2). For smaller scales the 2-km spectrum is steeper. The non-hydrostatic spectrum is influenced by strain in the middle of the basin (Fig. 1) and is the most energetic. Quantification via $<\bar{Q}^+>$ (*Poje et al.* 2010; box) shows that the non-hydrostatic run is about ten times more hyperbolic than the 2-km run while time-averaged transport values for dense deep waters are indistinguishable (Table 1).

4. CONCLUSIONS

Deep water transports are insensitive to increasing resolution from 2 to 0.5-km, but dispersion diagnostics, especially surface strain, are sensitive. Non-hydrostatic dynamics substantially increases strain in the deep basin.

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