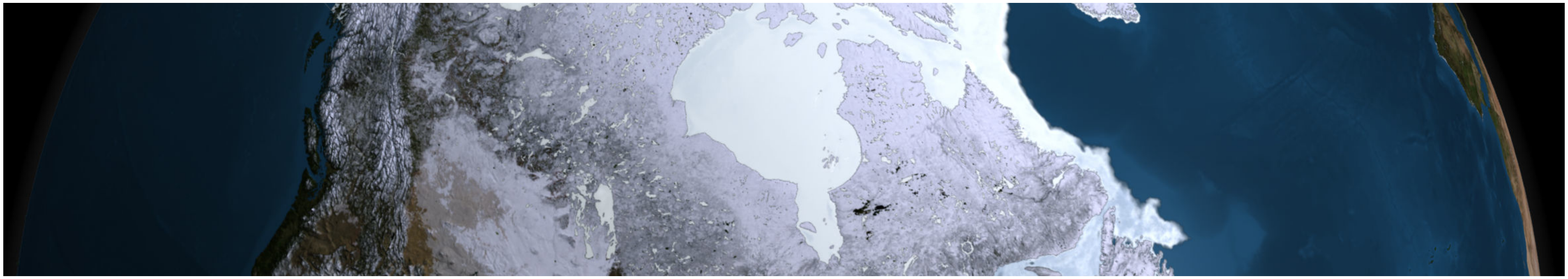

Hudson Bay Modeling

Identifying gaps in our current knowledge

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Cold-Region Estuaries Workshop
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ArcticNet

Québec Océan
Le groupe interinstitutionnel de recherches océanographiques du Québec

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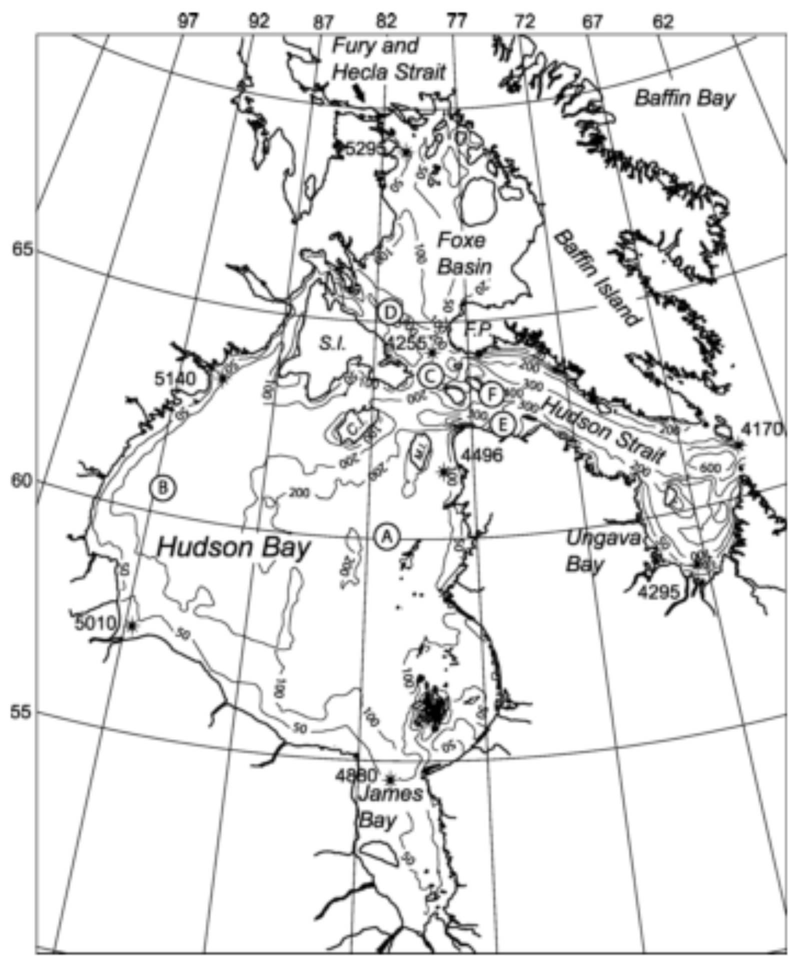
Outline

- Non-exhaustive review of recent modeling work
  - The freshwater-marine coupling cycle
- Discussion
  - Model strength and limitations
  - Where to go from here?

The HBS numerical model

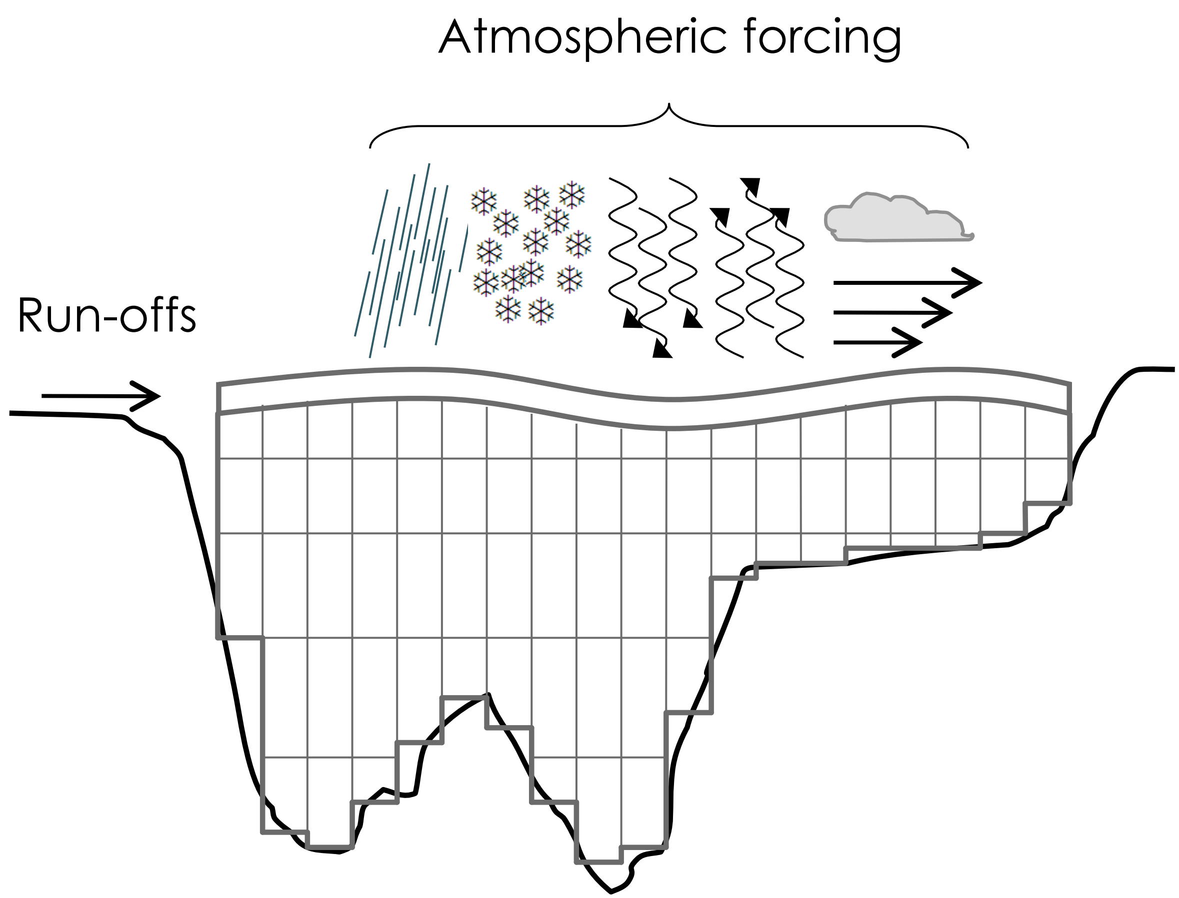


Finite difference
hydrostatic
primitive equations of
geophysical fluid dynamics are
solved numerically on a 3D grid
with geopotential vertical
coordinates (z-levels)

Δx = 10 km
Δz = 10-50 m
Δt = 300 s

Saucier et al. (2004) / Backhaus (1985)

Coupled ice-ocean modeling



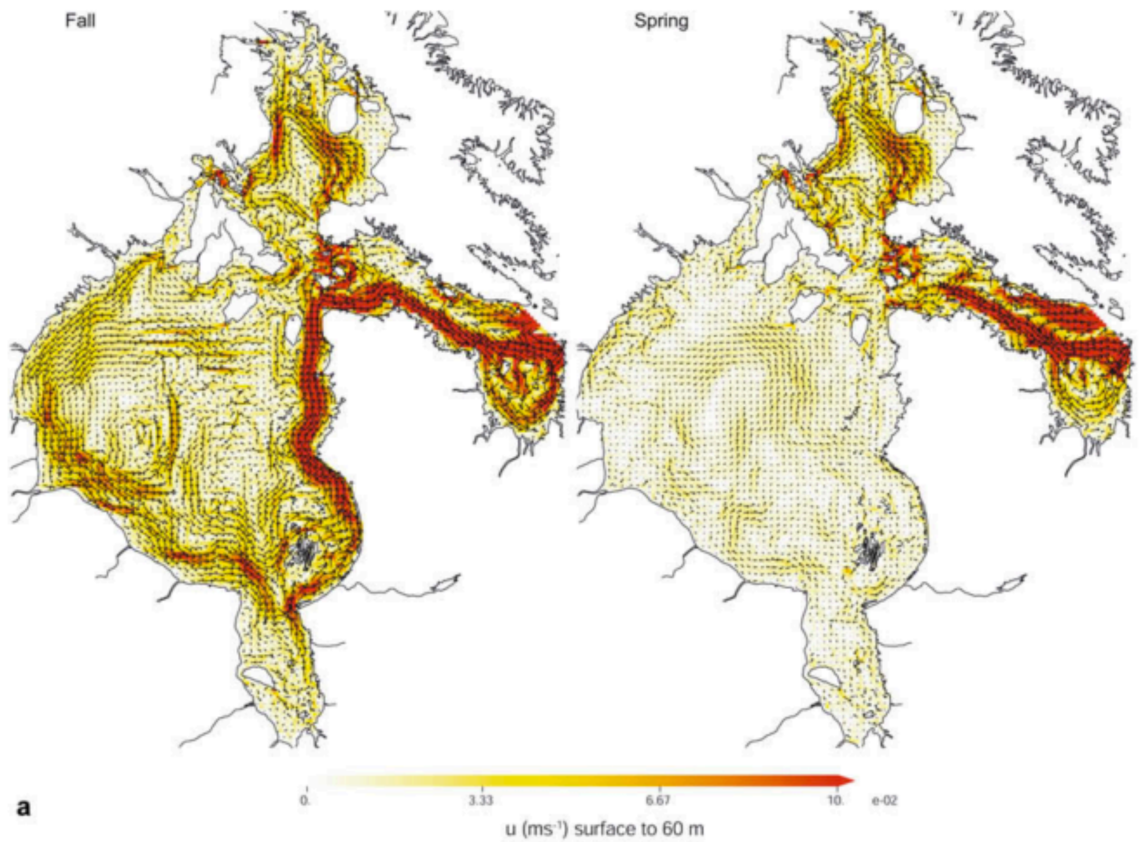
OBC: Hydrography and tides
IC: Spin-up from climatology

Circulation

The general circulation is **cyclonic**.

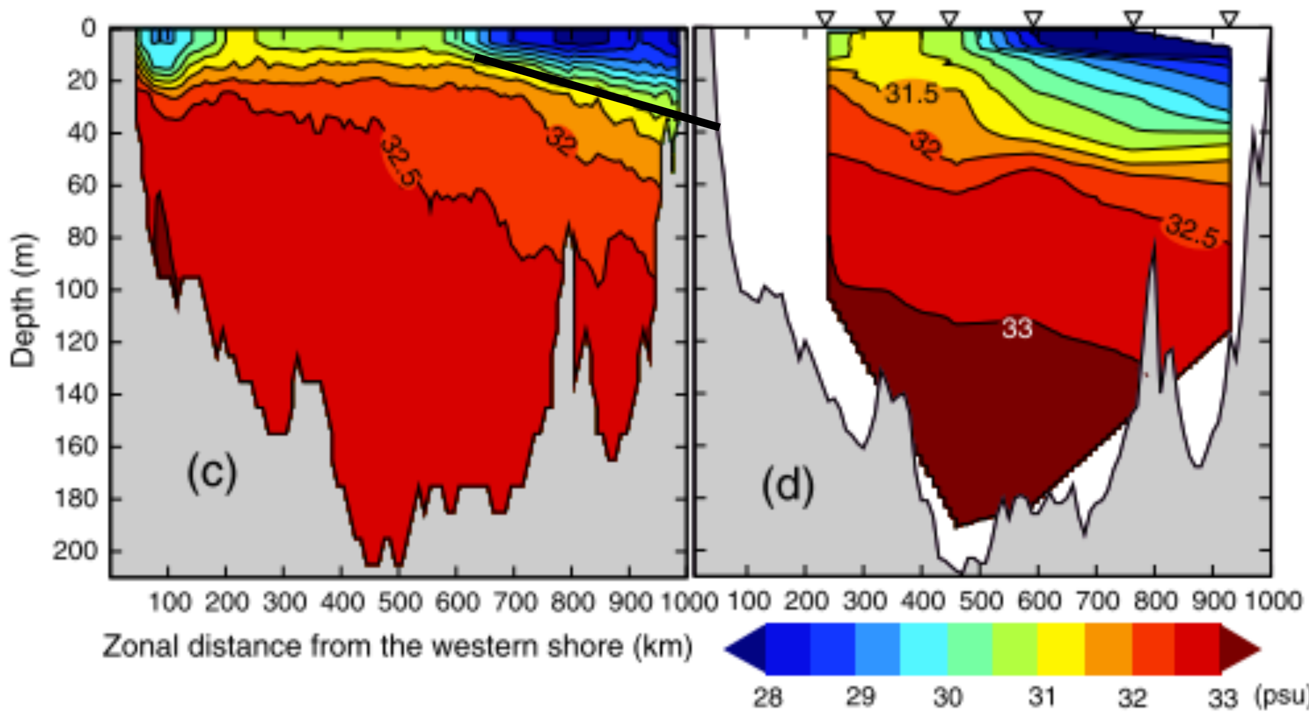
River waters transported by a **buoyancy-driven** coastal current.

Under-ice friction slows down surface currents.



Saucier et al. (2004)

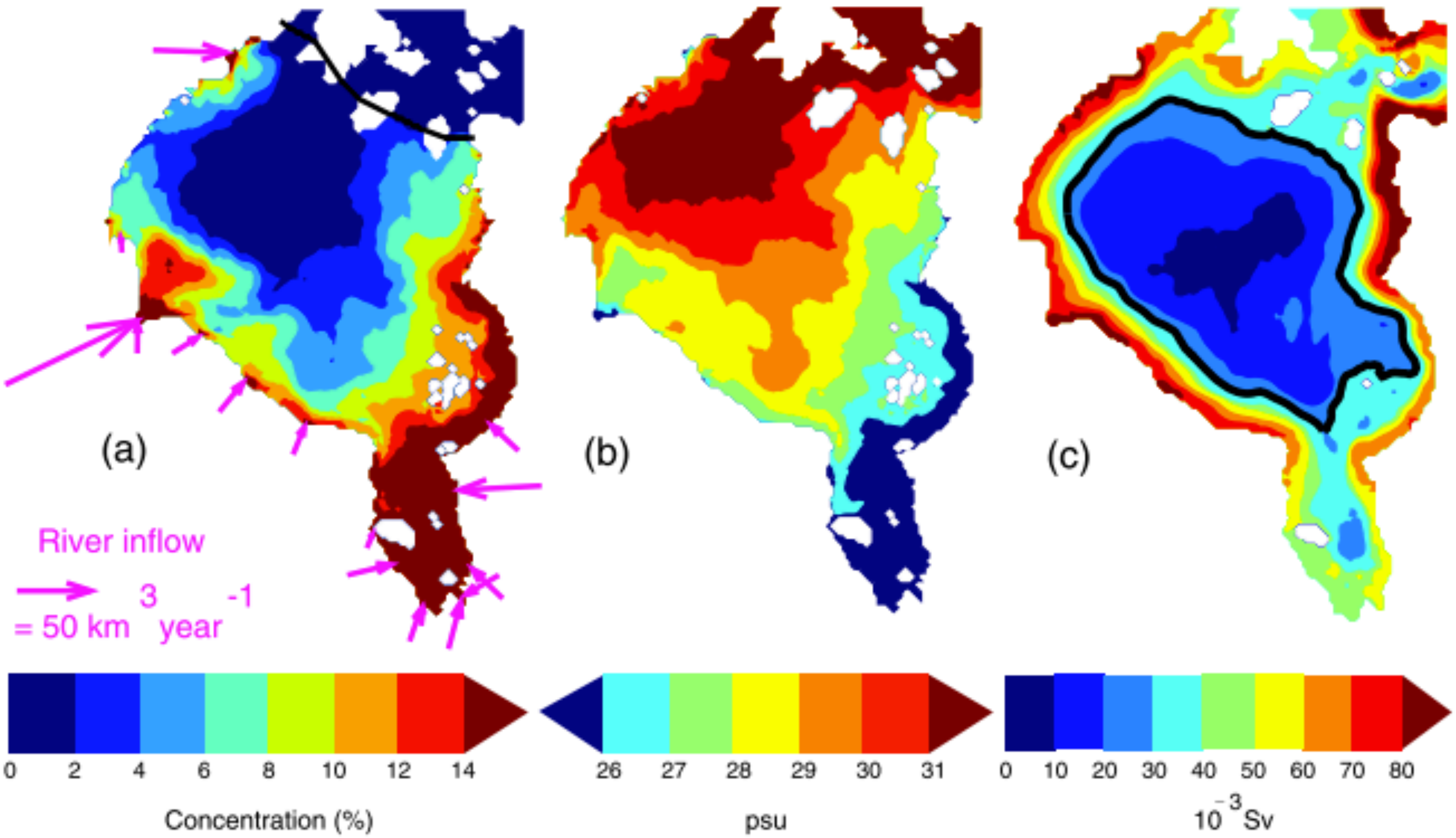
Hydrography



Baroclinic radius of deformation ~ O(5) km

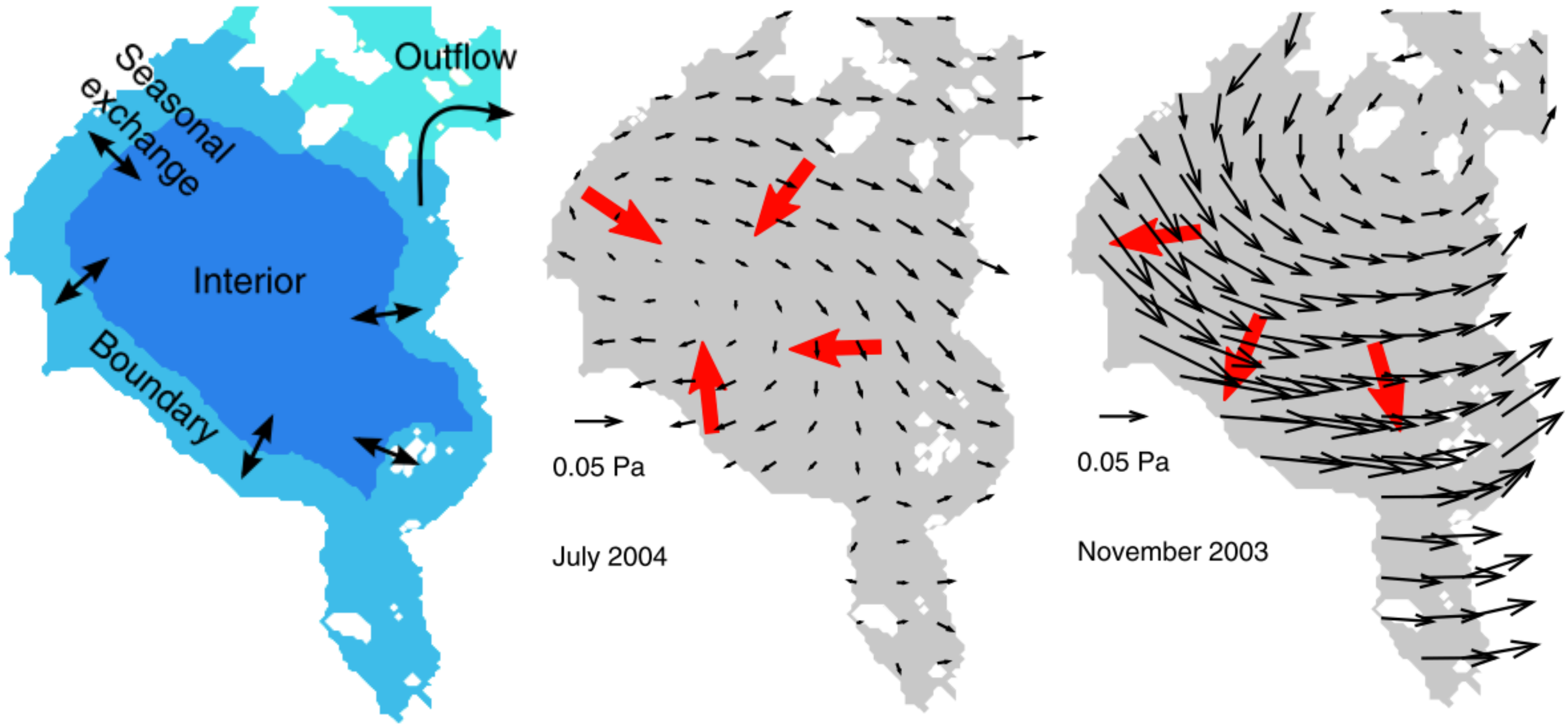
St-Laurent et al. (2011)

River influence



St-Laurent et al. (2011)

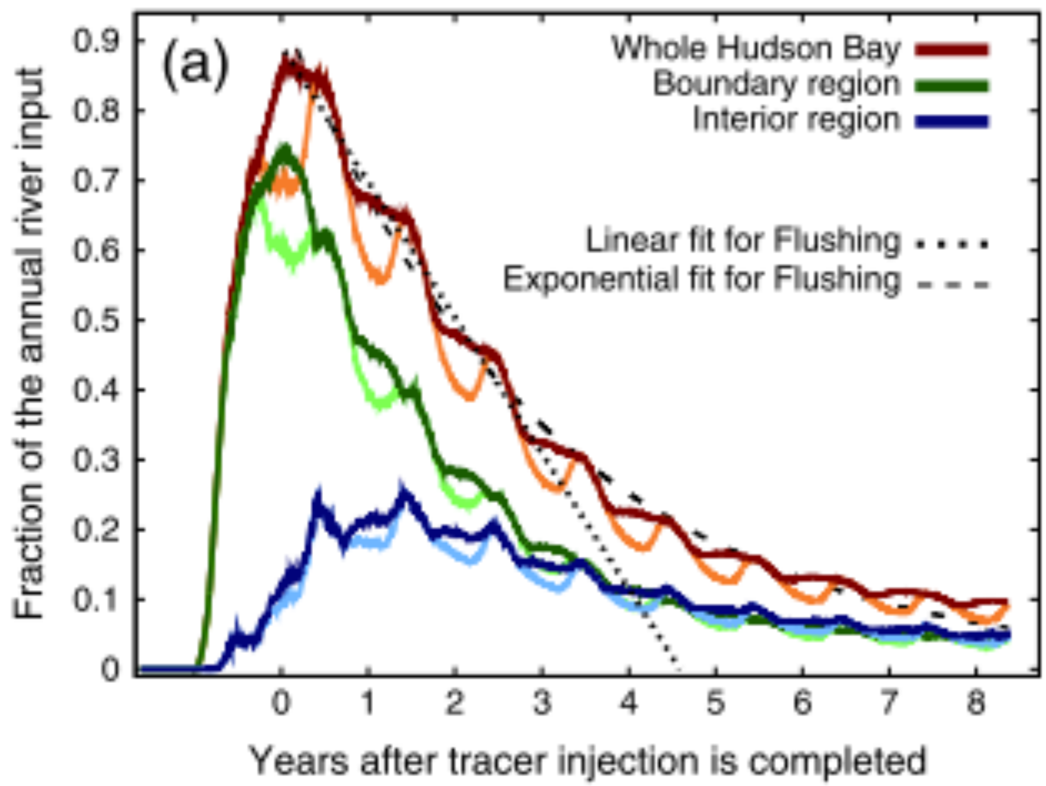
Freshwater exchanges and export



St-Laurent et al. (2011)

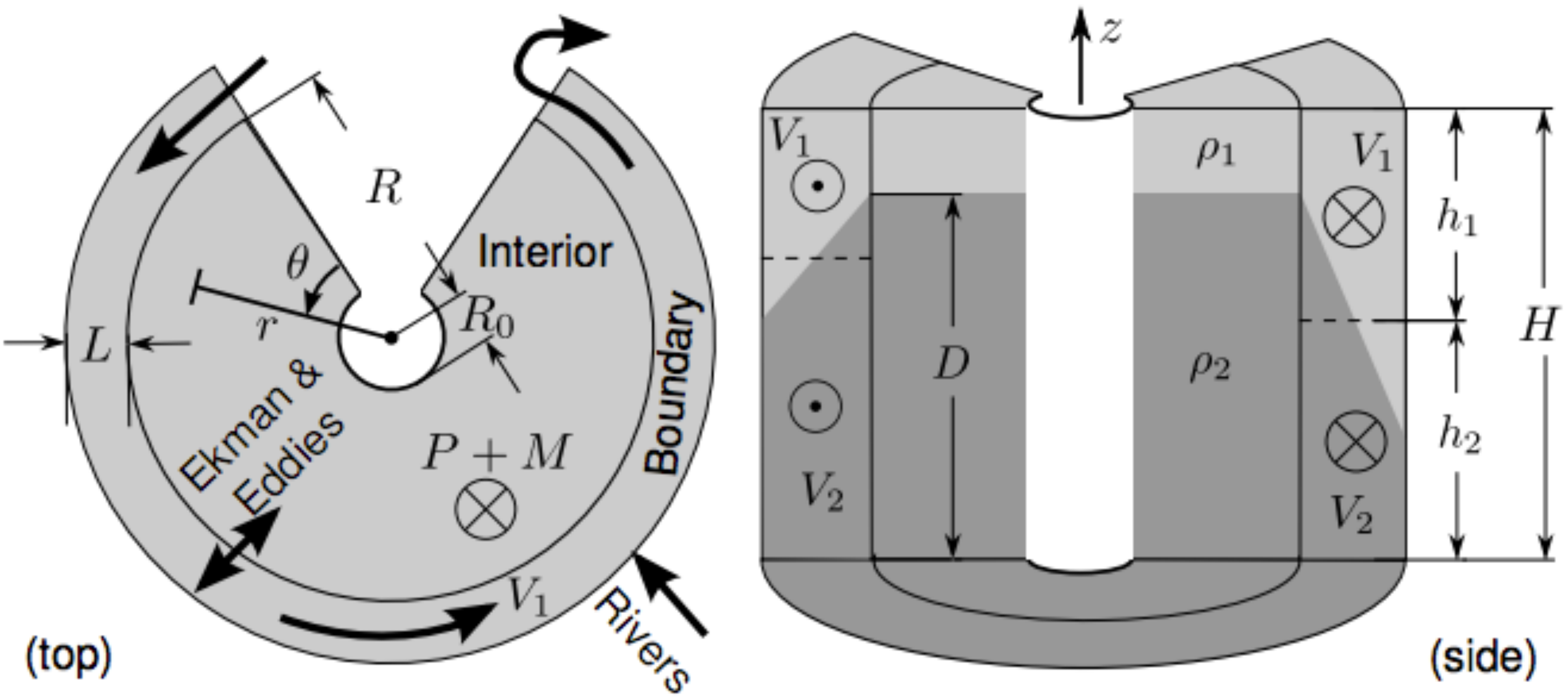
Freshwater residency time

The same year (2004) is run many times.



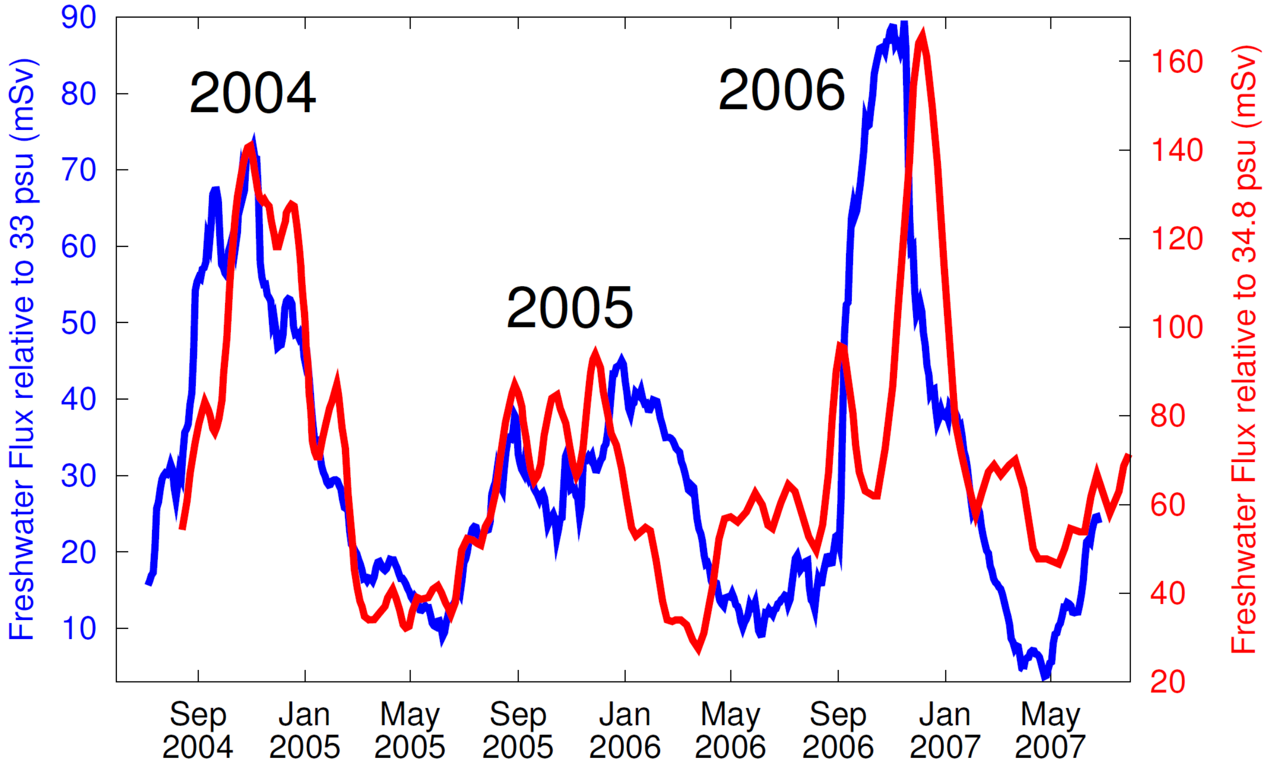
St-Laurent et al. (2011)

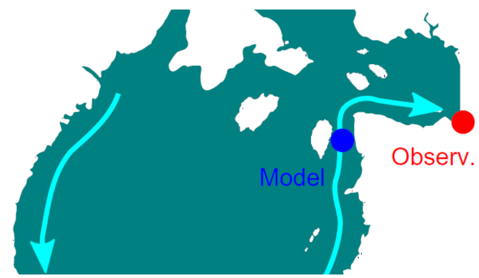
Conceptual model



St-Laurent et al. (In press)

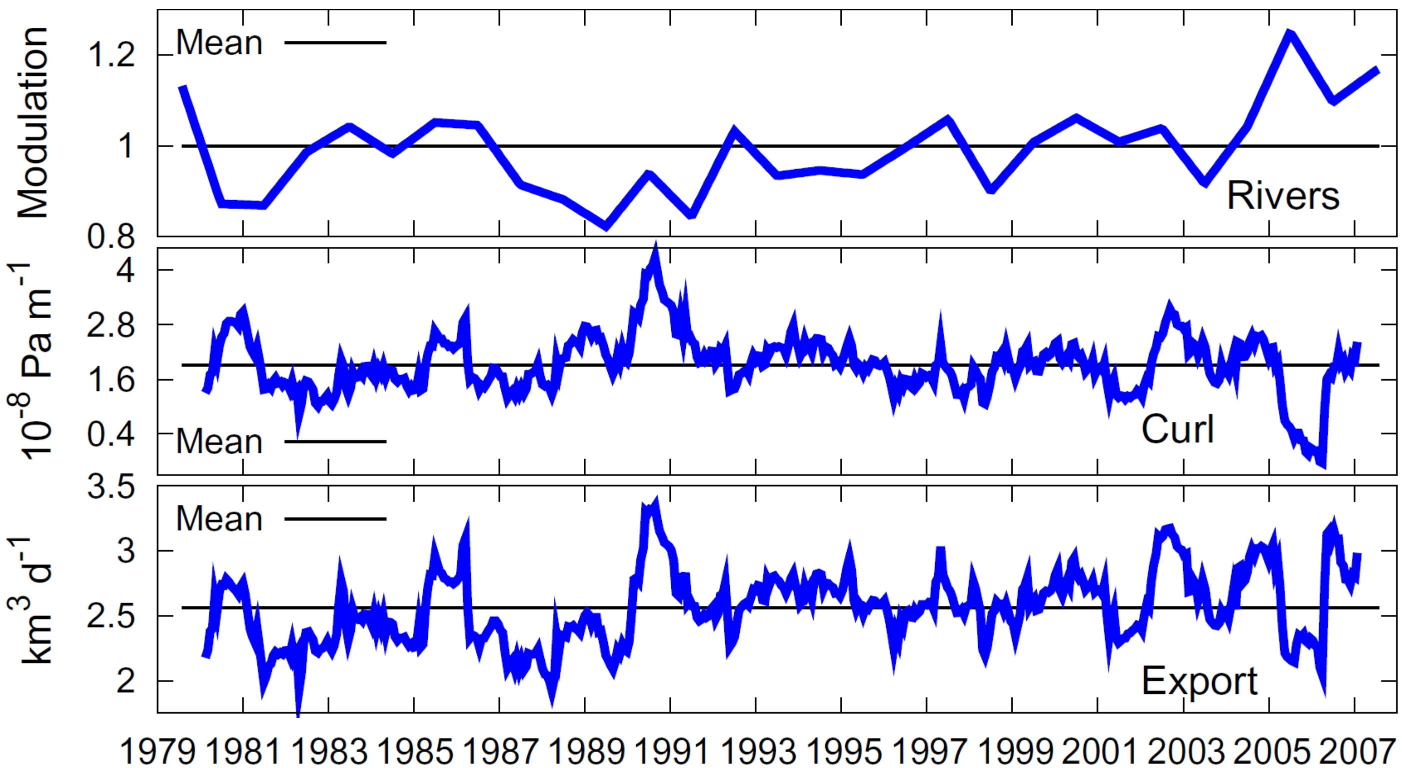
Conceptual model results



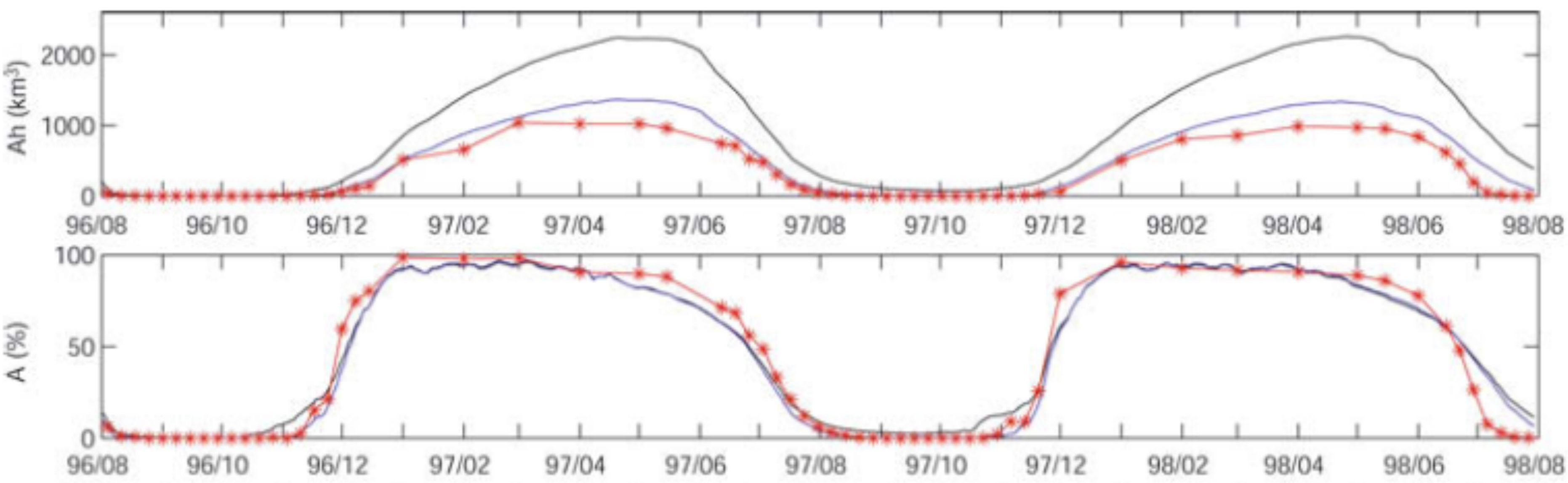


Conceptual model results

The wind-driven accumulation / release mechanism controls the export of freshwater through Hudson Strait more than rivers do.



Sea ice

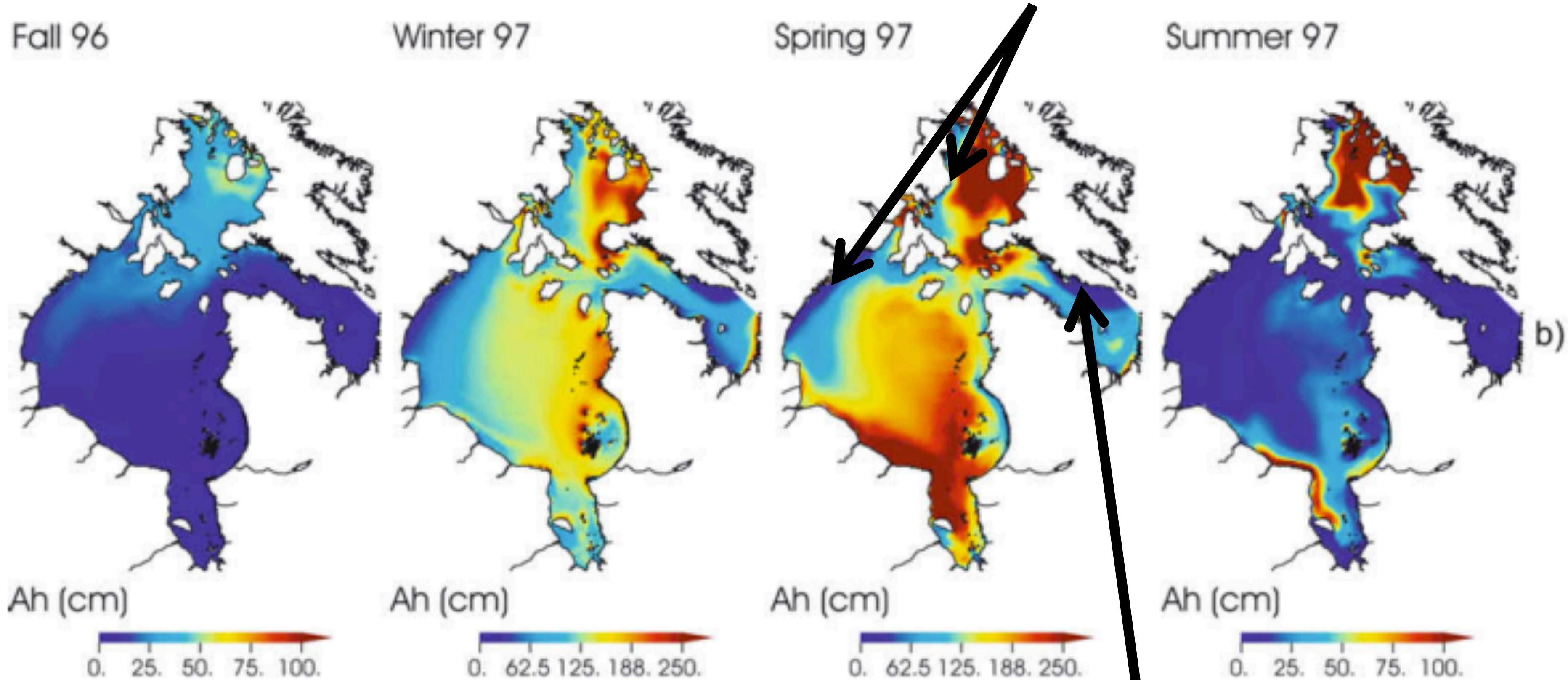


Data from ice charts (Canadian Ice Service)

Saucier et al. (2004)

Sea ice concentration and volume

Coastal polynyas



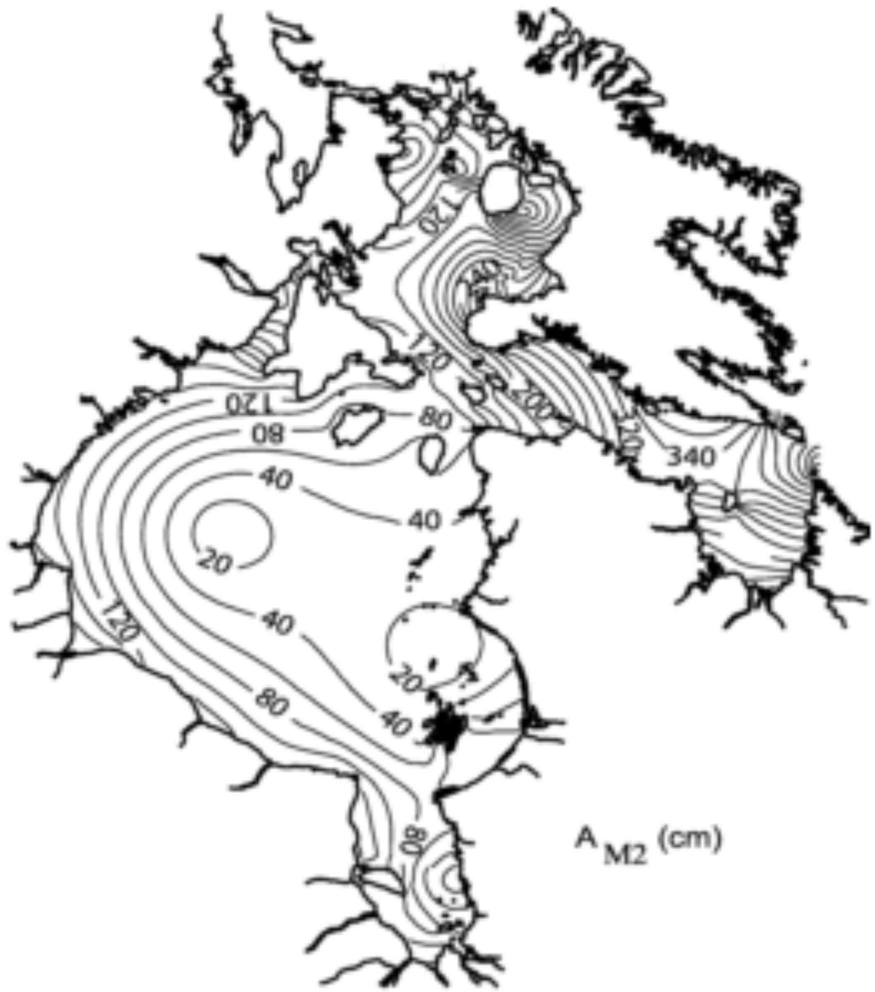
Not present in ice charts
Too close to boundaries

Saucier et al. (2004)

Tides

Tides are forced at the entrance of Hudson Strait and propagate cyclonically in the HBS.

They are responsible for the formation of sensible heat polynyas in Belcher Islands.

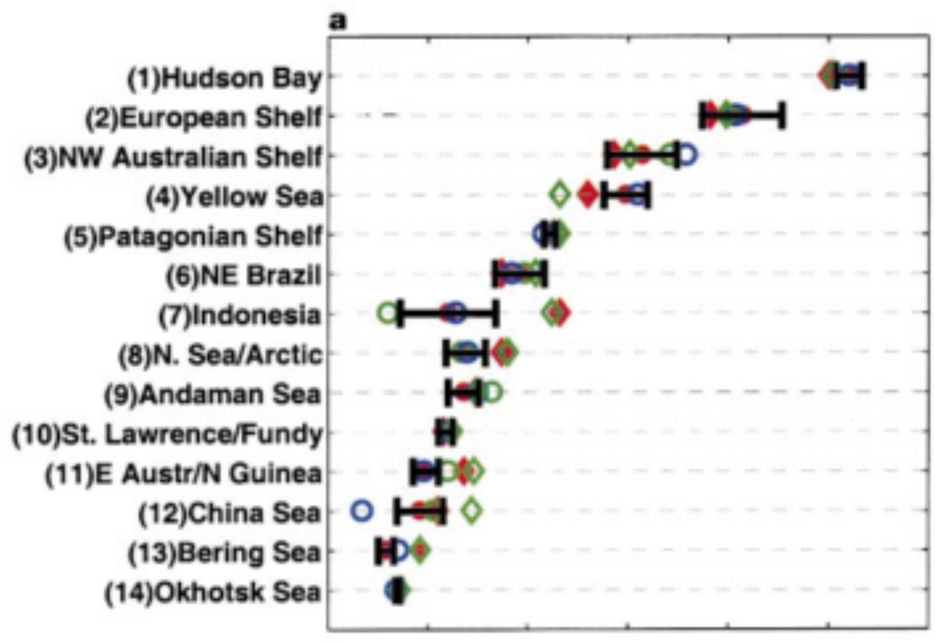


Saucier et al. (2004)

Tides

The Hudson Bay / Hudson Bay / Labrador Sea System is where tidal dissipation is highest in the world (Egbert et al. 2002).

Under-ice friction further dissipates tidal energy, modifies its phase, reduces surface currents, and affect the density field through mixing.



St-Laurent et al. (2008) / Prinsenberg (1980) / Egbert et al. (2002)

The interannual and climatic scale

Posters:

S. Senneville and S. St-Onge-Drouin, ***Modeling future sea ice conditions in Hudson Bay*** for more details (poster).

R. Wang, S. Senneville and D. Dumont, ***Interannual variability of the freshwater pathways***.

Summary

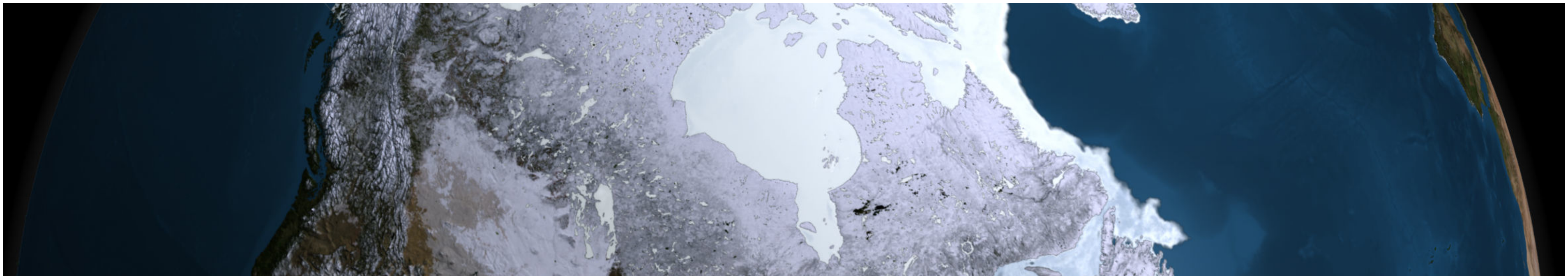
- The general circulation, freshwater pathways, sea ice cycle, polynyas, and mean transports are well represented by the model (given that we look far enough from model boundaries).
- The model helps see the big picture and understand what drives the fate of freshwater in the system.
- Ongoing work will characterize in more detail the interannual variability and the HBS climate response.

What to do next?

- First, **determine what we want to model and study**.
  - Coastal erosion
  - Sea ice dynamics around islands
  - Polynya dynamics
  - Deep water formation
  - Coastal upwelling
  - Contribution of eddies to tracer transport
  - The effect of steep bathymetric features
  - Snow and rain on ice
  - Wave-ice interactions

What to do next?

- Nesting and downscaling
  - Use the large-scale model to force a limited area on a finer grid.
  - Acquire data compatible with the finer scale for model testing.
  - Characterize the internal variabililty.
- Update the code to improve physical parameterizations
- Add further complexity to the model (biogeochemistry, sediment transport, snow blowing, black carbon, etc.)



Thank you

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