Modelling the Flow and Variability of Ice through the Canadian Archipelago

Preliminary Results

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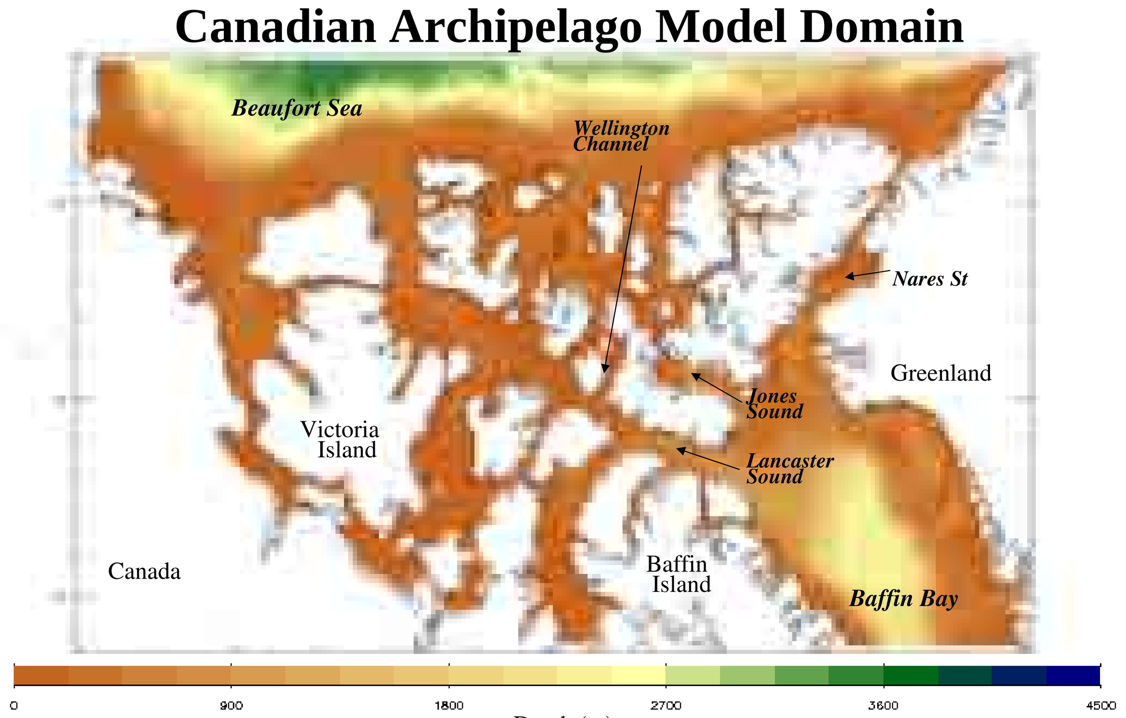
Project Description and Methodology

- **Motivation**: Ice in the Canadian Archipelago is important to local people and ecosystems, and plays a key role in freshwater export to the Labrador Sea.

- **Project**: Model Canadian Archipelago ice from 1950 to 2005 and assess historical variability and change. Use GCM forcing to provide a quantitative future projection.

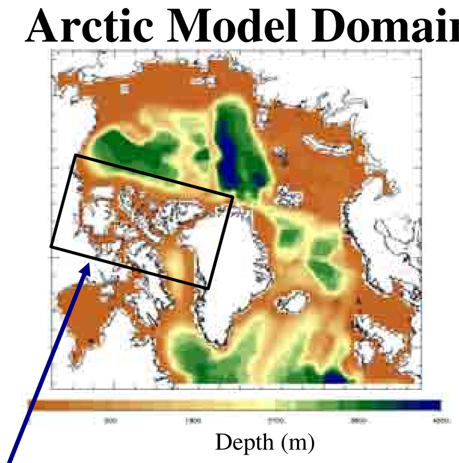
- **Model**:
  - Resolution: ~22 km in the horizontal (0.2º)
  - Ice model: Dynamics are from Hibler (1979), and thermodynamics are from Parkinson and Washington (1979). A snow model is included.
  - Ocean model: MOM2.2 (Pacanowski, 1995), 24 vertical layers
  - Open boundaries: Beaufort Sea, Baffin Bay

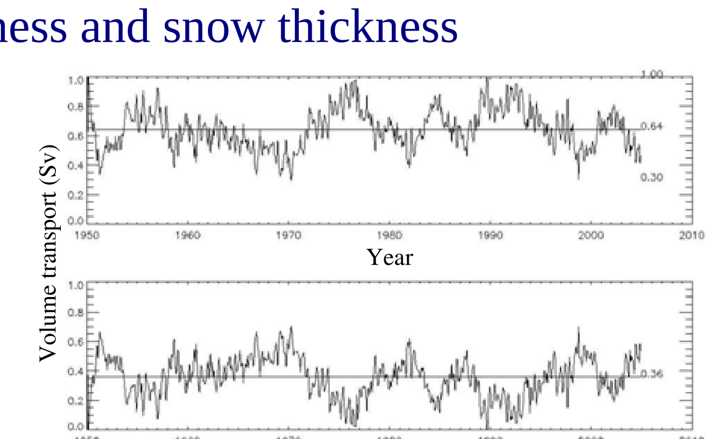
Canadian Archipelago Model Domain

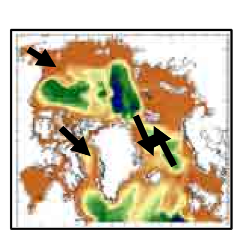


- **Forcing**:
  - Monthly varying time series, except for wind (daily varying) and precipitation (monthly climatology).
  - Atmosphere: Air temperature, humidity, pressure, windspeed, and wind-stress from NCEP (Kalnay, 1996). Air temperature is corrected using POLES (Rigor *et al*., 2000). Precipitation is from Serreze (2003). Clouds and radiation are parametrized. Mackenzie river forcing is from R-ARCNET.
  - Open boundary: from an Arctic model, with 0.5º horizontal resolution and similar set up to the Archipelago model. One way nesting of:
    - ocean temperature, salinity, velocities, streamfunction
    - ice velocities, thickness and snow thickness

Arctic Model Domain



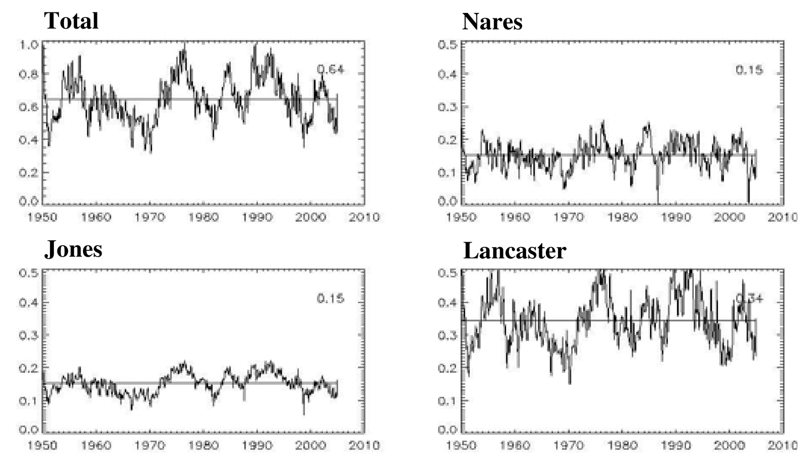


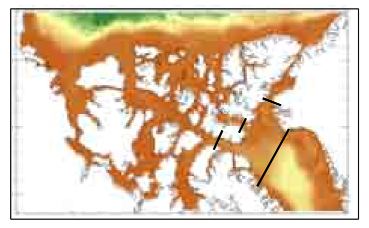


Arctic model oceanic volume fluxes (Sv) to Baffin Bay (upper panel) and to the Nordic Seas (lower panel). The Bering Strait through flow is set to 1 Sv. Arctic model transport is used to assign the oceanic transport through Canadian Archipelago model.

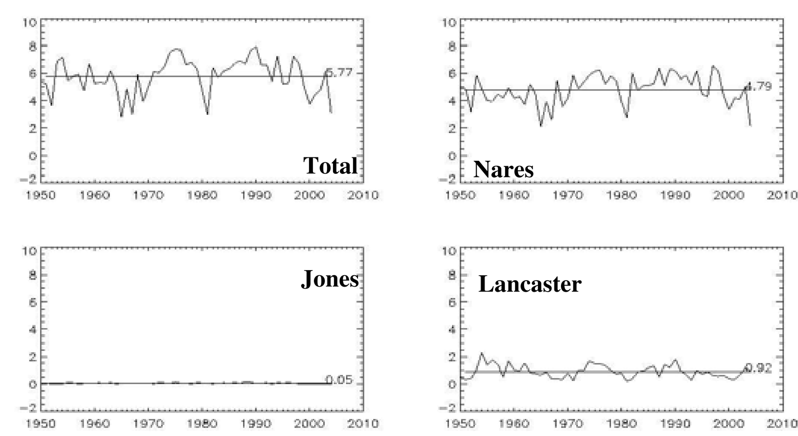
Historical simulation model results

- **Oceanic volume transport (Sv):** It is estimated that 1.5-2 Sv flows through the Archipelago. Observations at Lancaster Sound indicate a flow of 0.75 Sv (Prinsenberg & Hamilton, 2005). This model underestimates the transport, possibly as a result of an assigned Bering Strait transport of 1.0 Sv. Other model simulations show Lancaster Sound represents 40-50% of the total flow; this model suggests 53%.

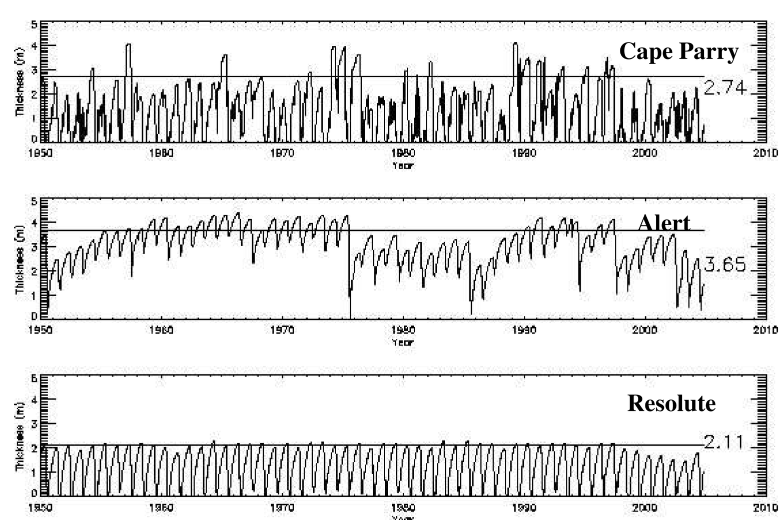


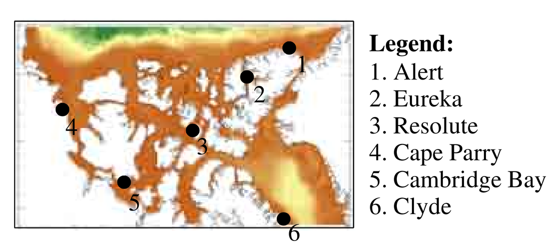


- **Ice volume transport (milli Sv):** There are very few observations of ice transport through these channels. The model shows a similarity between ice and oceanic transport variability.

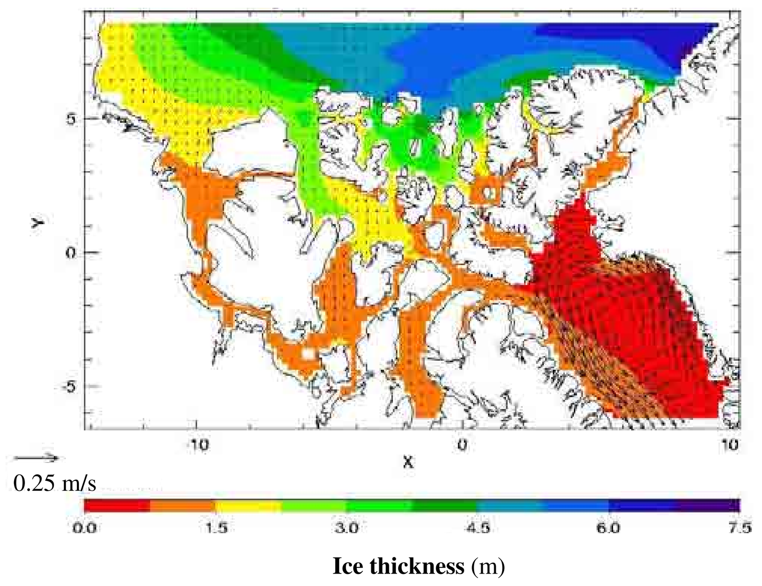


- **Modelled ice thickness at CIS stations:** Modelled ice thickness is similar to observations, except for Alert; Alert Bay is not resolved by the model and so, because of its exposed location, the model is more representative of adjacent offshore pack ice, which is thicker. Of all the stations, Cape Parry and Alert have the most interannual variability.



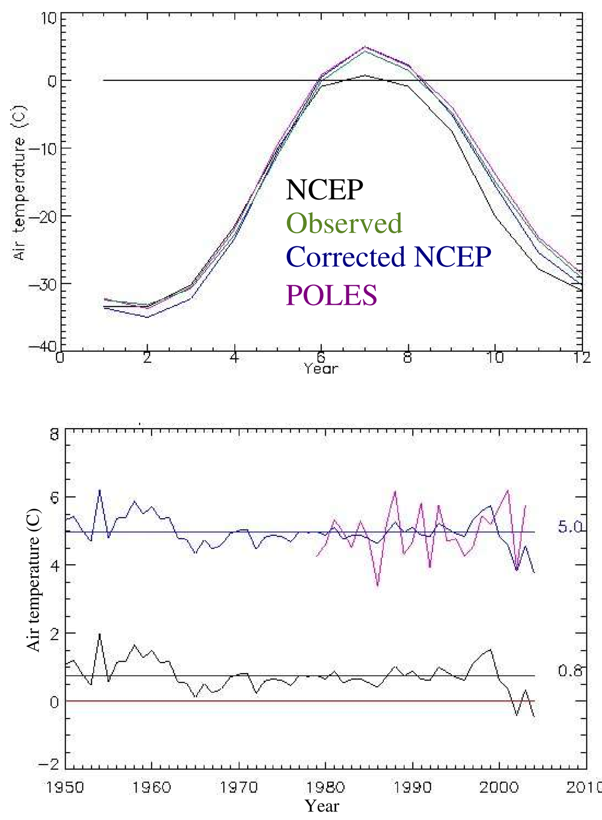


- **Annually averaged modelled ice thickness and binned ice velocities (1950-2004) :** Ice thickness for the domain shows observed characteristics with thick ice (4-6m) in the north-east and thinner (0-2m) in the south. On average, ice moves southward through the Archipelago and moves in a cyclonic direction in Baffin Bay.

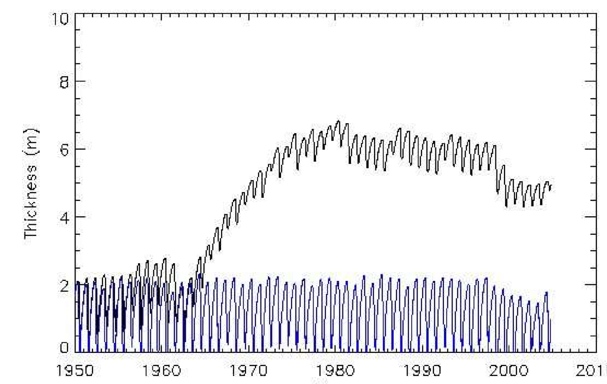


Ice sensitivity to air temperature: An example at Resolute

- **Air temperature forcing data:** NCEP summer air temperatures are unrealistically cold in the Canadian Archipelago, compared to observations. The upper panel shows the monthly seasonal cycle and the lower panel shows the time series of July air temperature. The POLES 1979-2003 air temperature data is used to correct the NCEP 1950-2005 time series The correction is largest over the summer, ranging from 0.5 to 5 degrees warmer.



- **Ice thickness response to corrected air temperature forcing:** If the summer air temperatures are less than about 0.5ºC (Flato&Brown, 1996), the modelled ice equilibrium thickness is too thick, especially in enclosed regions where the ice is not removed by advection. In the case at Resolute, a series of cold summers leads to unrealistic ice thickness. Under the corrected air temperature, the ice thickness is similar to observed.



Legend:
Ice thickness (NCEP)
Ice thickness (Corrected NCEP)

Future work

- **Sensitivity studies:** Apply high (18km) resolution daily wind, and modify open boundary conditions (eg. total oceanic volume transport)
- **Future scenario:** Combine historical forcing data with GCM (CCCma model) data and run for 2041-2060.

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