Impact of Freshwater from Arctic Rivers in a High-Resolution Model

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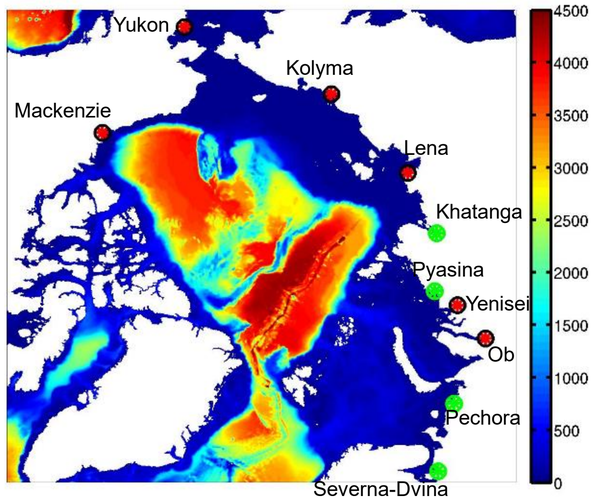
Questions

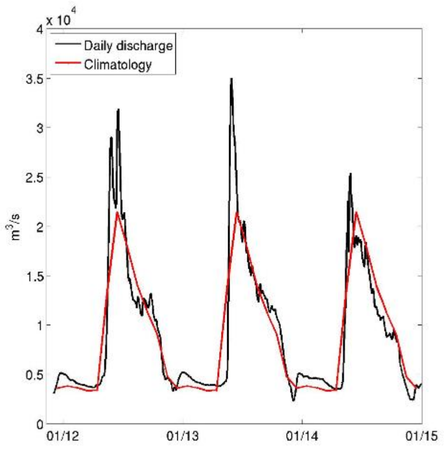
-- What is the effect of variable river discharge on the Arctic region?
-- Can the salinity signal of river discharge be tracked in the Beaufort Gyre?
-- Does river discharge affect ice breakup in the spring?
-- How far from the river mouths do the river plumes in the Arctic affect the freshwater content?

Background



Top 10 Arctic Rivers (ranged by discharge volume) are marked. Daily discharge data available for those marked in RED – only climatology available for GREEN.

Daily and climatological discharge data for the Mackenzie. Daily data show stronger, more abrupt peaks. For the three years modeled, discharge is higher than the climatological average.



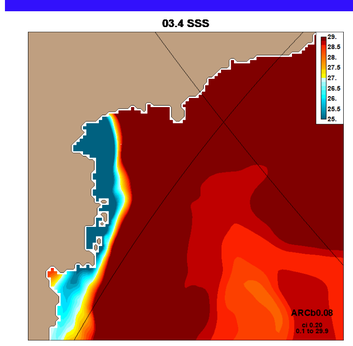
Model details

HYCOM (Hybrid Coordinate Ocean Model) run in the Arctic Cap region (shown above). Nominal resolution of 1/8 degree (~4km in this region). HYCOM is coupled with CICE.

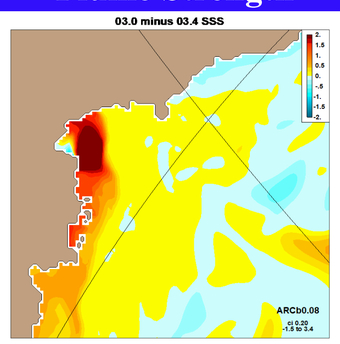
Five runs were performed:

1. "Normal" (monthly climatological river discharge, Dec 2011 through Dec 2014)
2. No rivers (all river discharge set to zero, Dec 2011 through Nov 2014)
3. Daily rivers (3.0, Dec 2011 through June 2014)
4. Daily rivers x5 (3.1, Dec 2011 through Dec 2014)
5. EPMASS on: river discharge included as a mass flux rather than as a virtual salt flux.
   -- HYCOM had some stability issues with EPMASS on, so river discharge was reduced by a factor of 10 in this run. (3.4, Dec 2011 through Nov 2012)

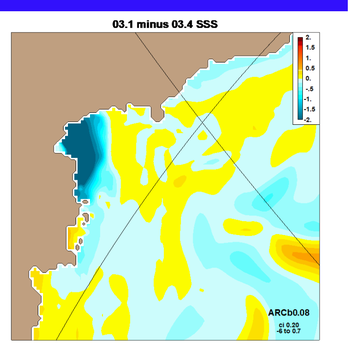
Plume Strength



In the run with mass flux, there is a strong fresh plume near the Mackenzie River, mainly confined to the shelf.

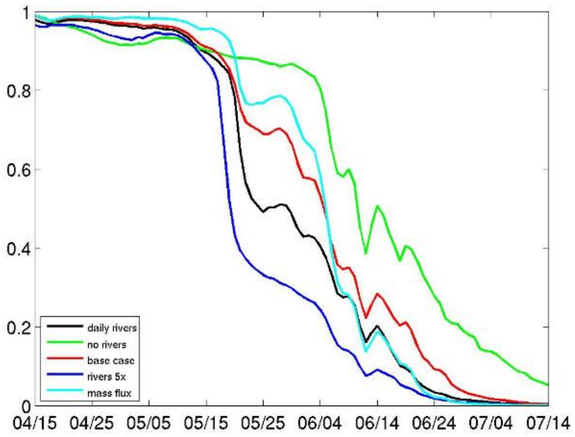


The "mass flux" plume is fresher and more extensive than the "daily rivers" plume, even though discharge is lower by a factor of 10. There is some off-shelf FW.



The plume for "daily rivers x5" is fresher than the "mass flux" plume; discharge is higher by a factor of 50. Plume location is very similar.

Ice Melt at the River Mouth

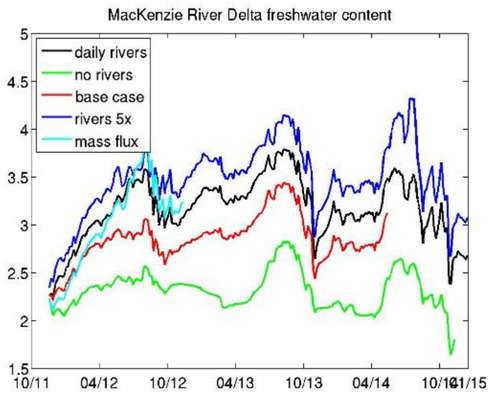


Ice concentration in a small area at the mouth of the Mackenzie (the Mackenzie River Delta) in summer 2012 (mid-April to mid-July).

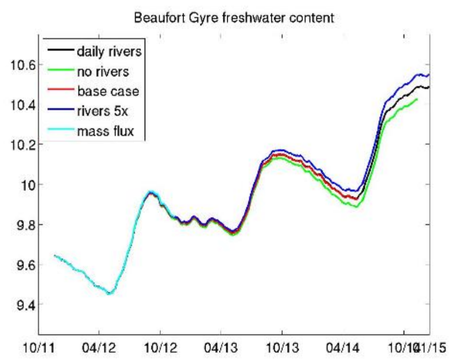
Effects of river discharge on springtime break-up of ice at the mouth of the Mackenzie River Delta:
-- **River discharge x5** melts ice first
-- **Daily discharge** melts ice earlier than **climatology**
-- Inclusion of **mass flux** melts river faster (steeper decline)
-- With **no river discharge**, ice breakup is delayed by at least a month

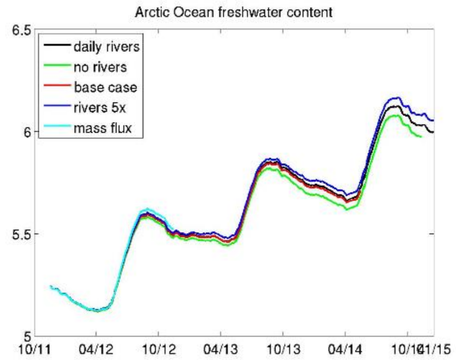
Freshwater Content

In a given column of seawater, the freshwater content (FWC) is the height (in meters) of freshwater that must be removed to bring salinity of the column to 34.8.



- Differences appear in terms of bias rather than short-term variability (which is likely wind-based)
- Strong seasonal cycle in all cases
- Springtime increase in FWC is steeper when mass flux is included





Larger spatial scales (Beaufort Gyre basin and Arctic Ocean) show long-term trend, minimal differences between runs.

Conclusions

- Changes in river discharge have distinct local effects
- Springtime ice breakup happens earlier with more river discharge
- While adjusting the volume of river discharge seems to affect biases, turning on the mass flux has significant effects; further analysis is necessary
- In the larger scale, the effect of increased river discharge on freshwater content is small.
- On the timescales and with the tools available here, pulses of freshwater from the Mackenzie river could not be traced in the Beaufort Gyre.