New Synthesis of Arctic Freshwater Budget & Fluxes

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Cape Farewell, Greenland, Aug 2004
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Reservoirs in km³,
Fluxes in km³/yr
1000 km³/yr = 0.032Sv

Serreze et al., 2008.
Arctic Freshwater Budget 1980-2000

- The budget of FW:
  - Meteoric + Pacific inputs = Marine + sea ice (SI) outputs to the Atlantic

Box size proportional to: reservoir volume or 1 year's total flux.
Arctic freshwater is accumulating in the 2000s

Canada basin is 1-3psu fresher than pre-1990s climatology
Morison et al., 2012

1992-1999

2006-2008

Rabe et al., 2011
Arctic freshwater is accumulating in the 2000s

Canada basin is 1-3 psu fresher than pre-1990s climatology
Morison et al., 2012

- **Climatology to 2008:**
  - 8,500 km$^3$ in Canada/Makarov Basins.
  - McPhee et al., 2009.

- **'92-'99 to '06-'08:**
  - 8,400 km$^3$ in the Arctic ocean.
  - Rabe et al., 2011.

- **1995 to 2010:**
  - 8,000 ± 2,000 km$^3$ in the W. Arctic Ocean.
  - Giles et al., 2012.

- **1992 to 2012:**
  - 12,000 km$^3$ in the Arctic ocean.
  - Rabe et al., 2013.
Sea ice volume changes in the 2000s

PIOMAS (Pan-Arctic Ice-Ocean Modeling and Assimilation System) data from UW-APL
Sea ice volume changes in the 2000s

- PIOMAS sea ice volume loss: -22% (4300 km$^3$) for '00-'10 average minus '80-'00
- 3800 km$^3$ for Oct-Nov '10-'12 minus '03-'08

(Laxon et al., 2013) – PIOMAS has 3600 km$^3$

1980-2000 average = 19.9x10$^3$ km$^3$

Aagaard & Carmack (1989) = 17.3x10$^3$ km$^3$

2000-2010 average = 15.6x10$^3$ km$^3$

PIOMAS (Pan-Arctic Ice-Ocean Modeling and Assimilation System) data from UW-APL
Import flux changes in the 2000s

- P-E increases by 10%
- Runoff increases by 8%

for '00-'10 average cf. '80-'00
Import flux changes in the 2000s

- P-E increases by 10%
- Runoff increases by 8%
- Bering Strait increases by 4%?

for '00-'10 average cf. '80-'00
Export flux changes in the 2000s

- Fram Strait liq. increases 4%?
- Fram Strait SI decreases 9%?

for '00-'10 average cf. '80-'00
Export flux changes in the 2000s

- Fram Strait liq. increases 4%?
- Fram Strait SI decreases 9%?
- Davis Strait decreases 6%?
  for '00-'10 average cf. '80-'00
Net flux change in the 2000s

- Imports increase by 7%
- Exports decrease by 4%
  for '00-'10 average cf. '80-'00
Net flux change in the 2000s

- Imports increase by 7%
- Exports decrease by 4%
  for '00-'10 average cf. '80-'00

1980-2000 average = -100\,\text{km}^3/\text{yr}

2000s average = 800\,\text{km}^3/\text{yr}

600\,\text{km}^3/\text{yr} = 9000\,\text{km}^3\text{ in 15yr,}
  as observed in W. Arctic
Net flux change in the 2000s

- Imports increase by 7%
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for '00-'10 average cf. '80-'00

No change in fluxes cf errors (?)

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2000s average = 800km³/yr

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No change in fluxes cf errors (?)

Rudels (2010) model of baroclinic liquid export fluxes: relaxation from initial fw volume anomaly: not yet seen!
Budget analysis can't identify source of W. Arctic freshwater:
- MY sea ice melt?
- Internal redistribution by wind?
- Flux changes?
- Unforced variability?

2000–2010

| Component     | Change
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff</td>
<td>-35%</td>
</tr>
<tr>
<td>Multiyear ice</td>
<td></td>
</tr>
<tr>
<td>Seasonal ice</td>
<td>+4%</td>
</tr>
<tr>
<td>Beaufort Gyre</td>
<td>+30%</td>
</tr>
<tr>
<td>Liquid fw</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- During the 2000s freshwater accumulated in the western Arctic (~9000km$^3$ in ~15yr).
- Import & Export fluxes are not obviously different in 2000s. Perhaps a freshening of ~ 800km$^3$/yr occurred relative to 1980-2000.
- Source of extra freshwater is unclear from budget: multiple sources are possible.