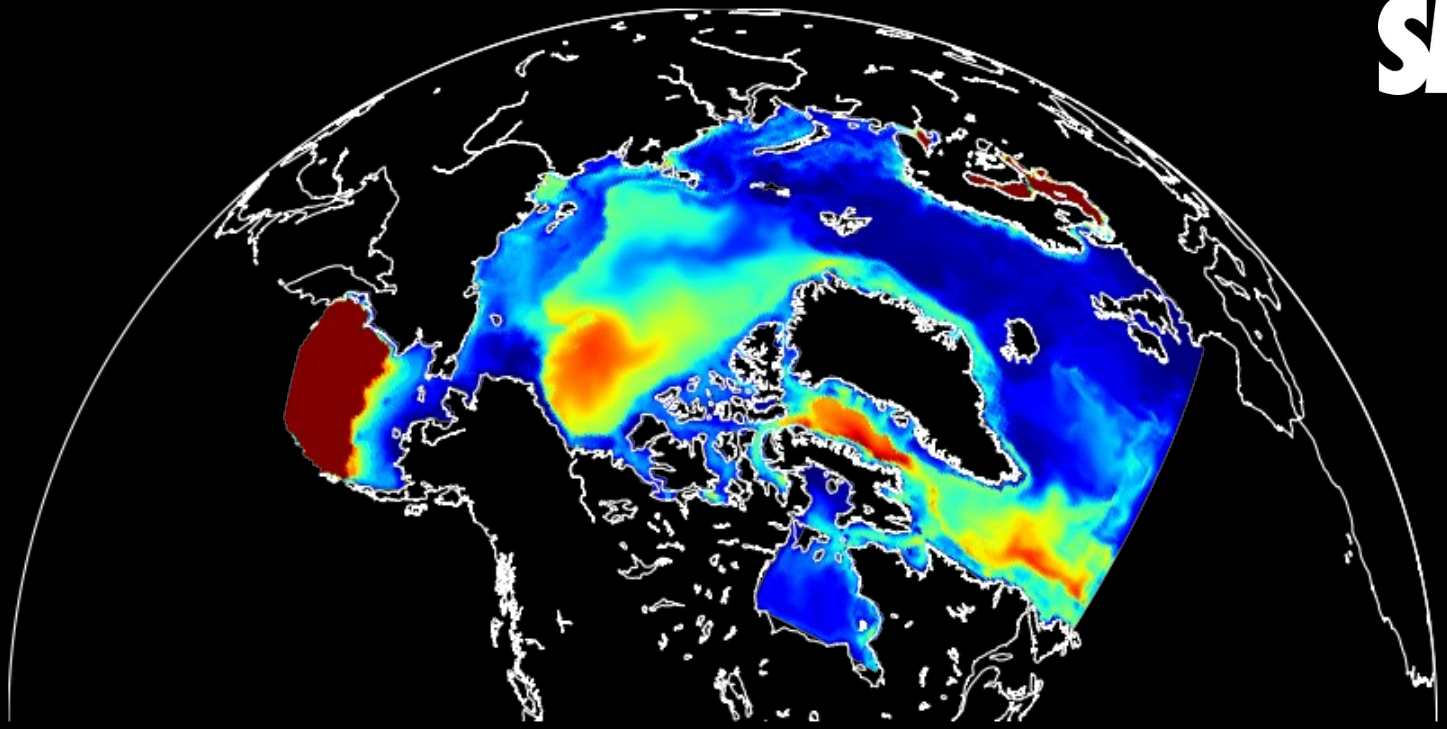

Beaufort Gyre freshwater experiments with the RCO model: Effects of mixing and FW variability

Per Pemberton and Markus Meier
Swedish Meteorological and Hydrological Institute

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Overview

- First results of the AOMIP Beaufort Gyre Freshwater experiment with RCO model
- Sensitivity to mixing parametrization in the RCO ocean model, in the experiment
- Model assessment of Beaufort Gyre Region Freshwater variability

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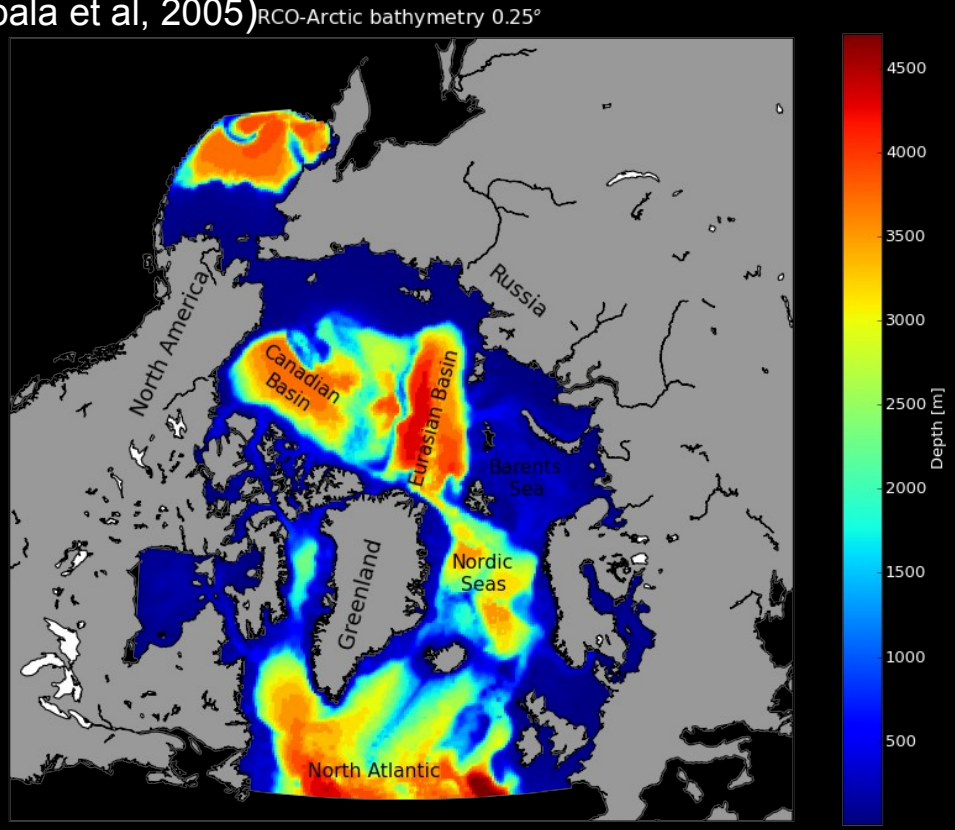
RCO model

- Based on OCCAM
- RCO Rossby Centre Ocean model (Meier et al., 2003)
- Regional coupled ocean/sea ice model
- Multi-category sea ice model (Haapala et al, 2005)
- Rotated spherical 0.25º grid
- 59 z-levels
- Open BC North Atlantic
- FCT advection scheme
- Vertical mixing : k-ε, k-model or Ri dependent (Pacanowski & Philander)
- Horiz. mixing: Harmonic
- Restoring t=240 days
- ERA-40/Interim forcing



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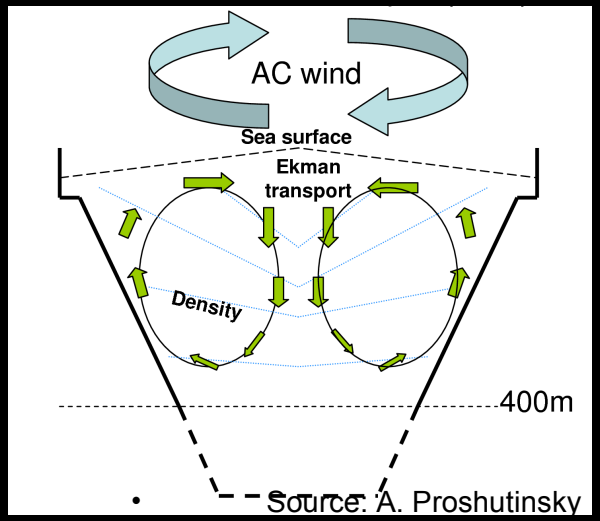
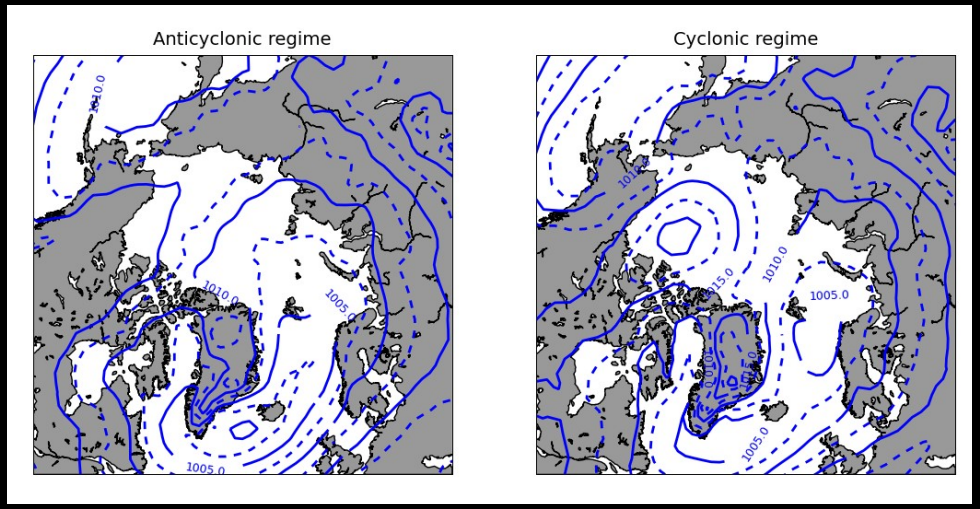
Beaufort Gyre Freshwater Exp.

- Study the role of Ekman Pumping in in Beaufort Gyre Freshwater pool
- Only forced by wind stress, i.e no heat, runoff, sea-ice, inv. barometric effect ...
- Closed boundary
- Vertical stratified, horizontally uniform temp and sal initial conditions
- Two regimes cyclonic and anticyclonic
- Winds, drag coefficient and windstress accord. AOMIP algorithm



Source: A. Proshutinsky



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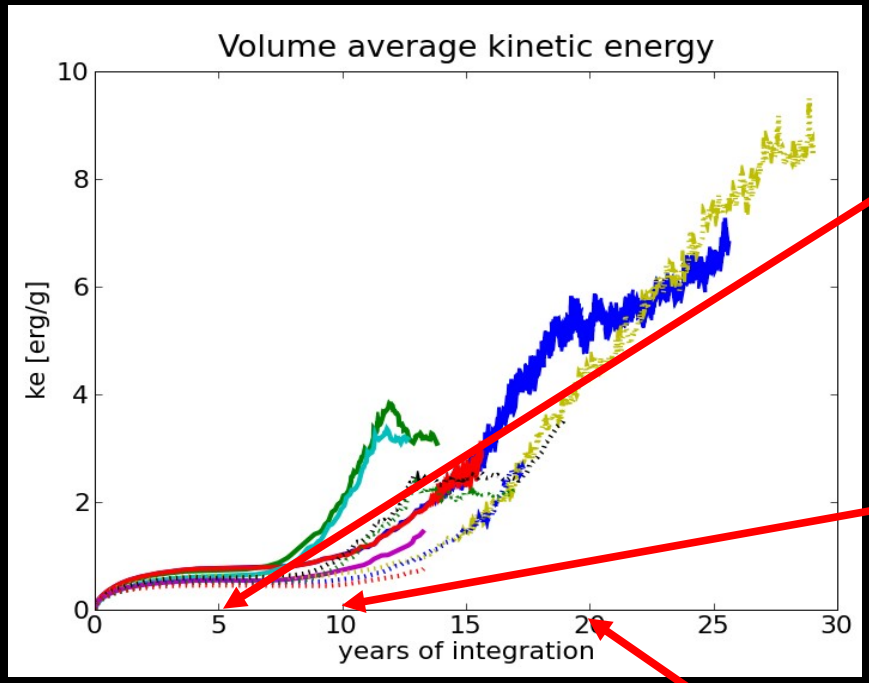
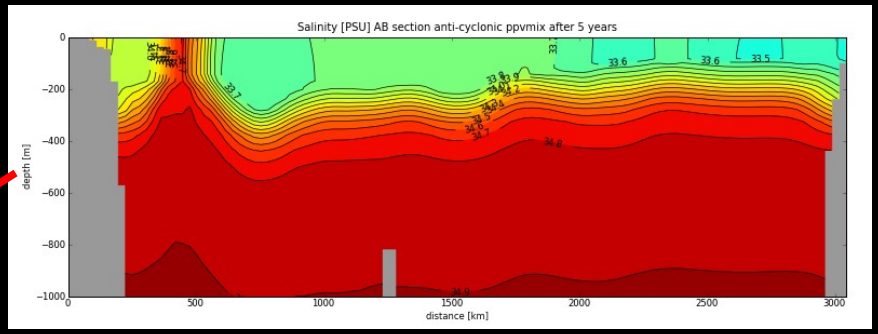
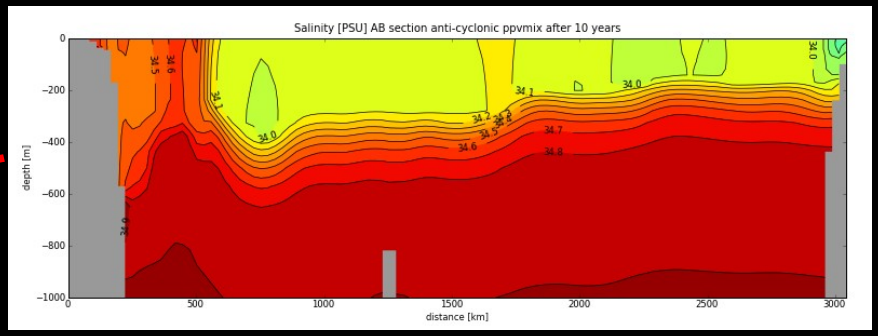
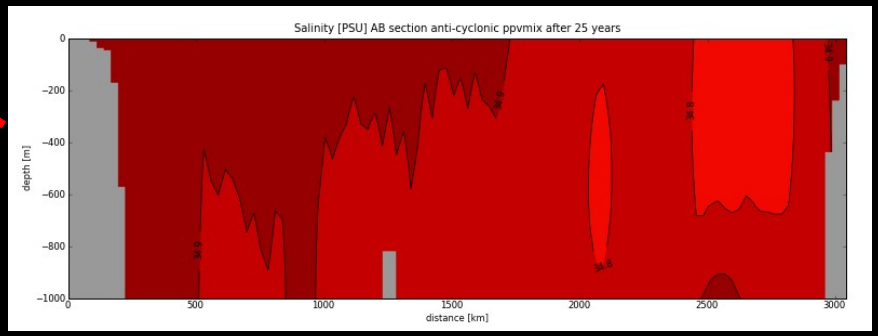
Steady-state?









- Stratification deteriorates
- Grows unstable after 10-20 years depending on simulation type/regime
- Well-mixed after +20 years
- Analyze experiments after 7 years

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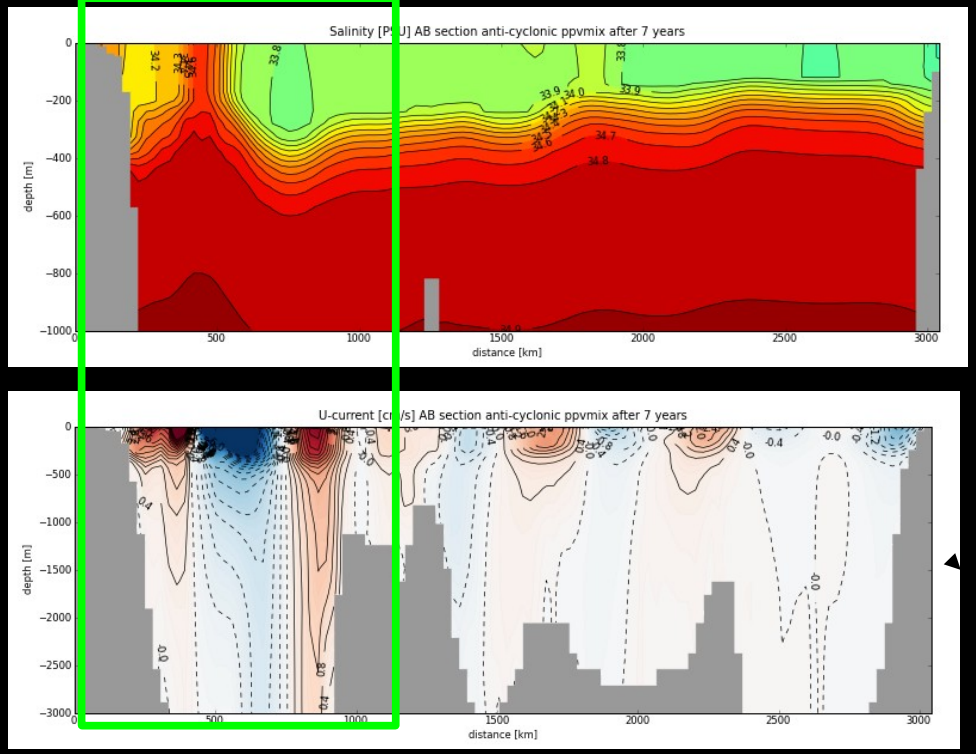
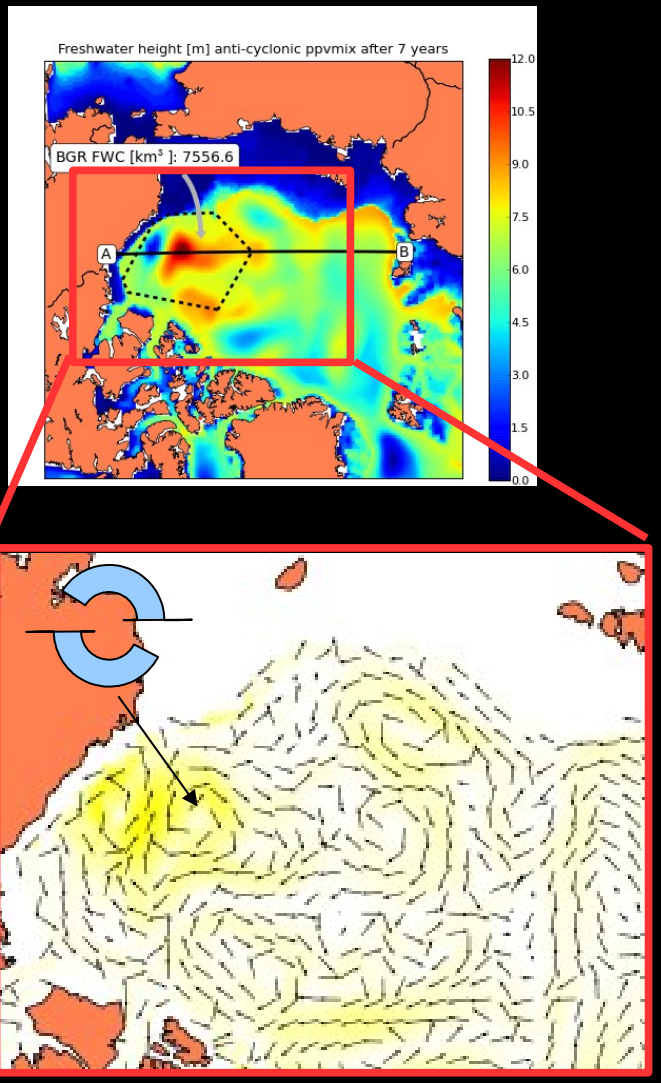
Anticyclonic regime

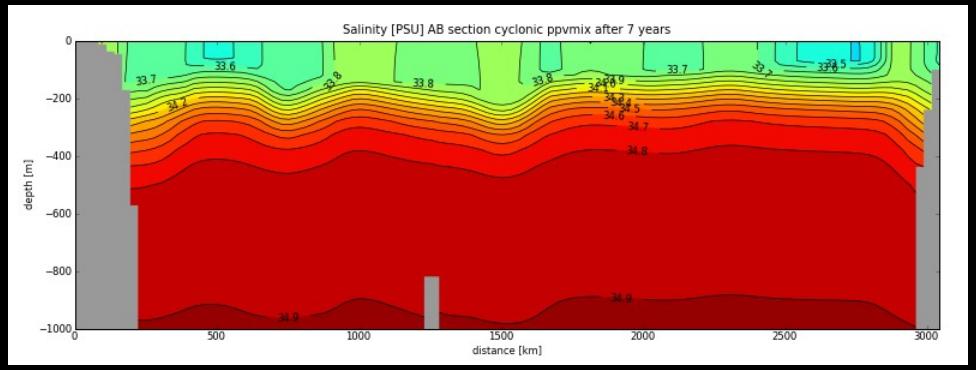
BG region

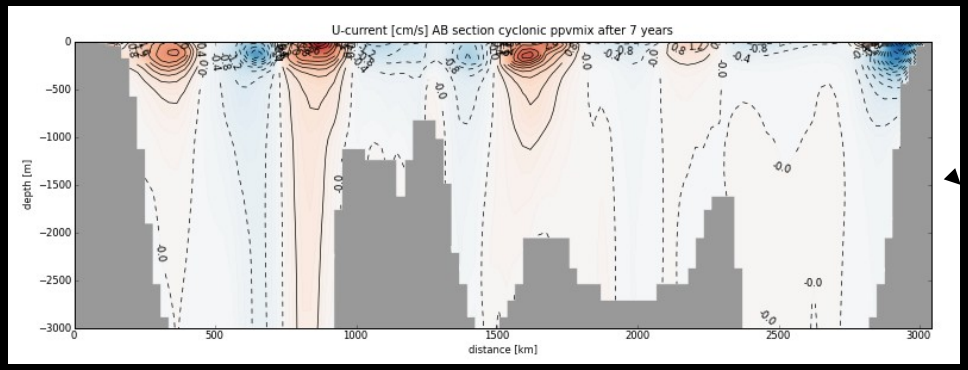


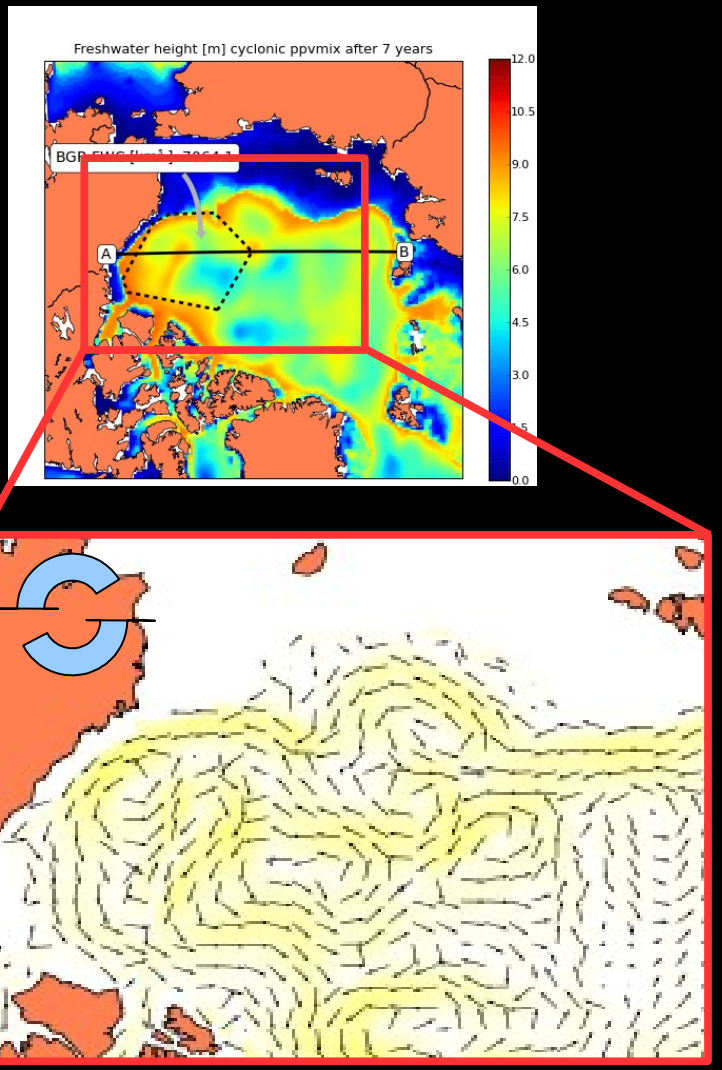


- Strong Ekman Pumping
- Accumulation of FW in central BG region
- Anticyclonic gyre with strong currents in upper ocean layer
- Upwelling on coastal side

Cyclonic regime







- Reduced Ekman Pumping
- More FW accumulated along Alaskan coast and Canadian Archipelago
- Weaker anticyclonic circulation in central Beaufort Sea

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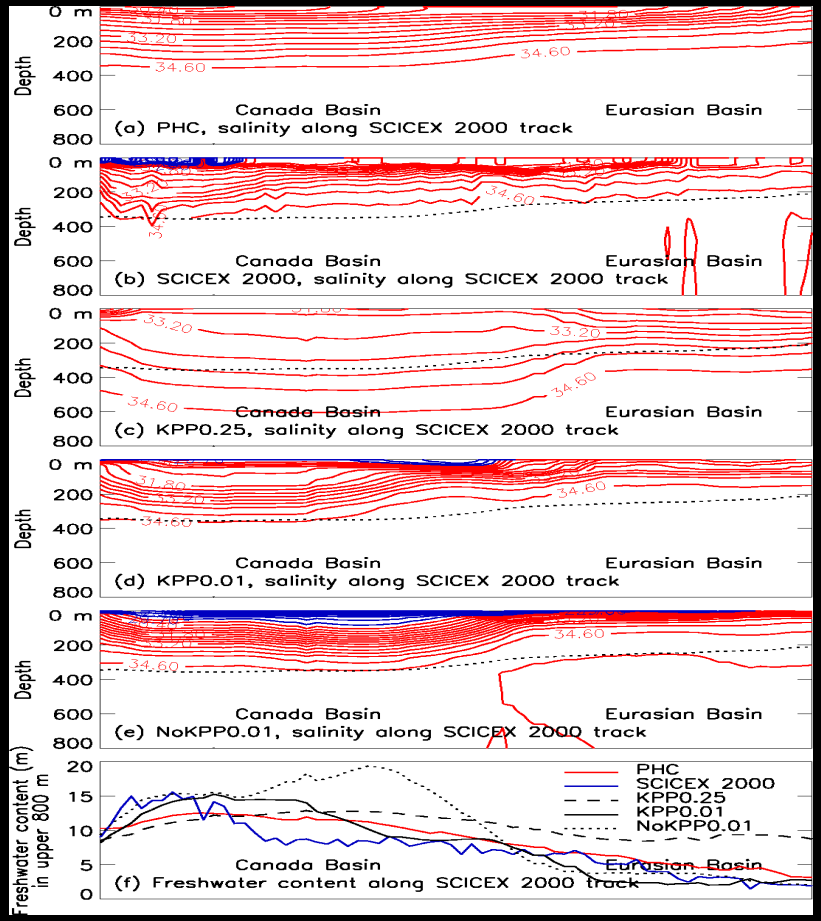
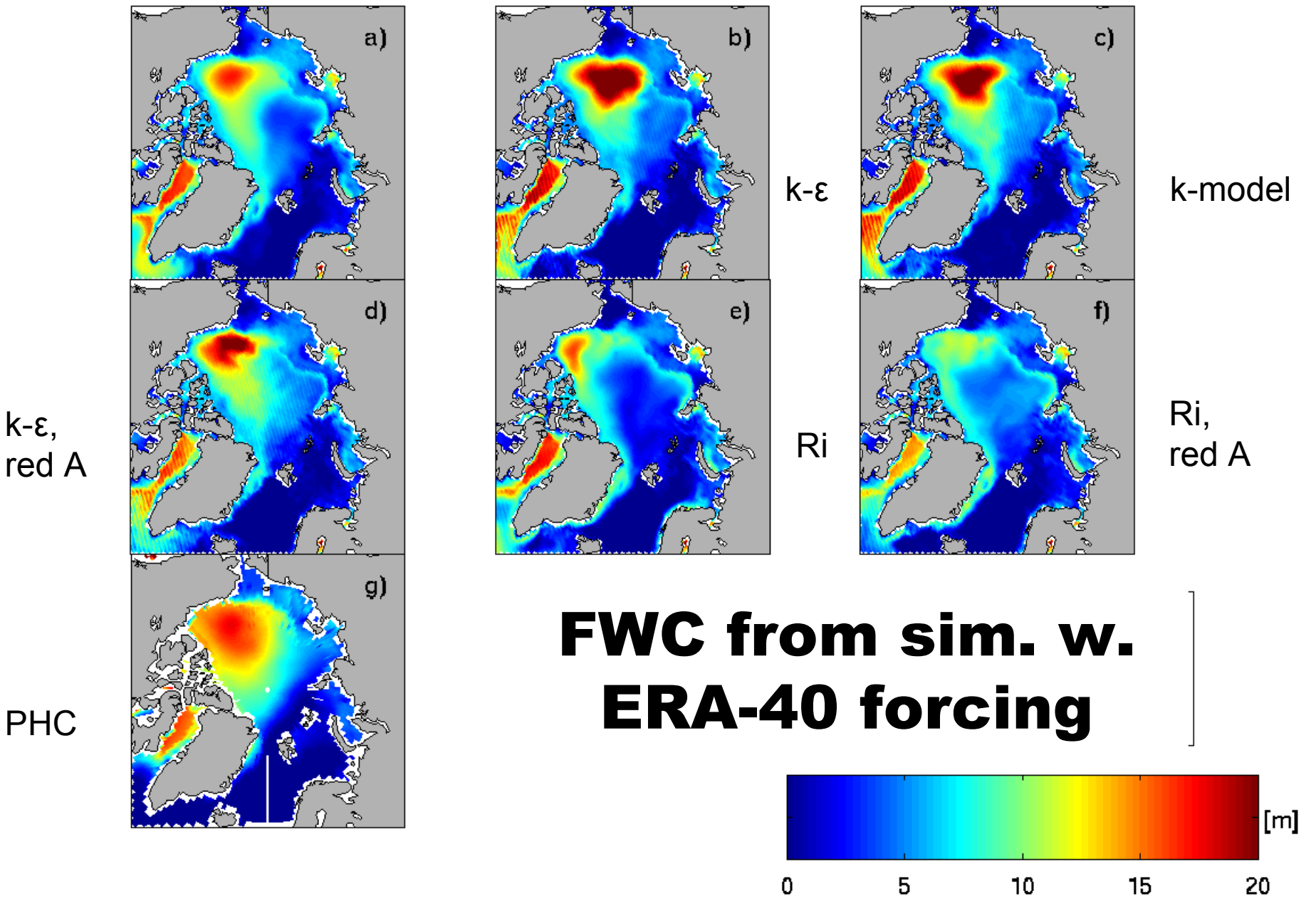
Mixing parametrization impact on FW



Zhang & Steele, 2007:


Freshwater content 0 - 800 m, average period=2000
a)
b)
c)
d)
e)
f)
g)
k-ε
k-model
k-ε,
red A
Ri
Ri,
red A
PHC
FWC from sim. w.
ERA-40 forcing
[m]
0
5
10
15
20

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Sensitivity tests of mixing parameters

- Vertical mixing parametrization:
  - k-epsilon
  - Pacanowski-Philander (PP)

- Explicit horizontal mixing:
  -increased horizontal viscosity
  -increased horizontal diffusivity

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Salinity Anticyclonic regime (7 years)

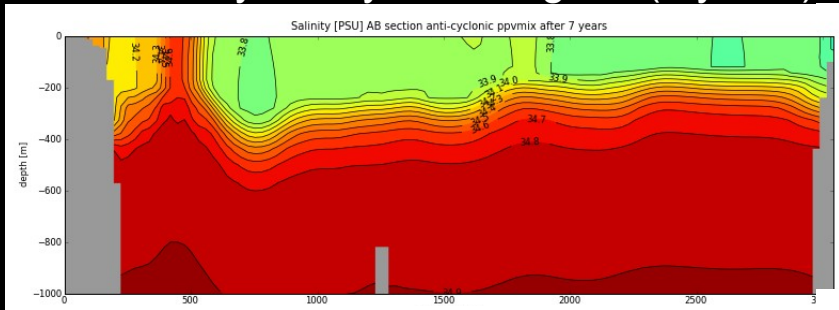
Cyclonic regime

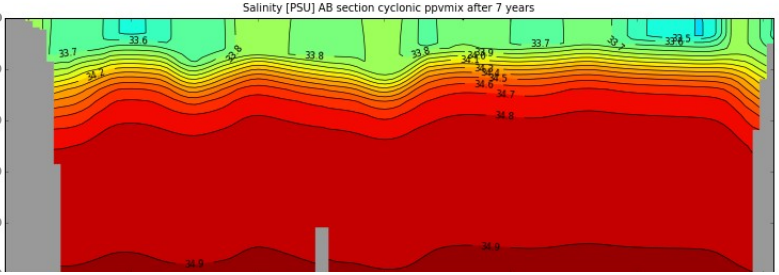
PP

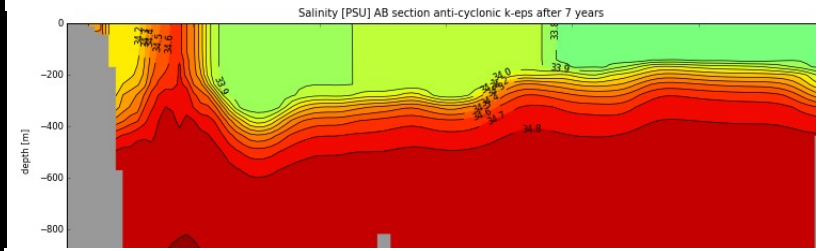
k-ε

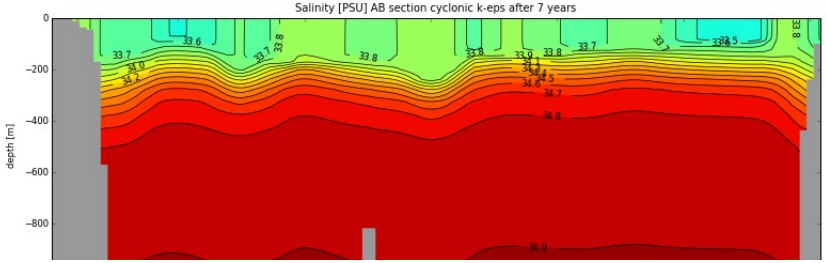
high hor. visc

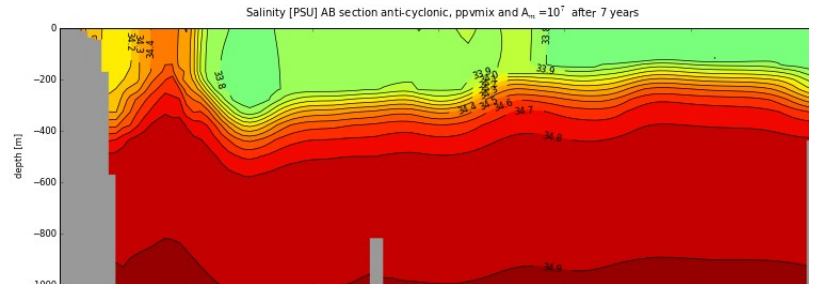
high hor. diff

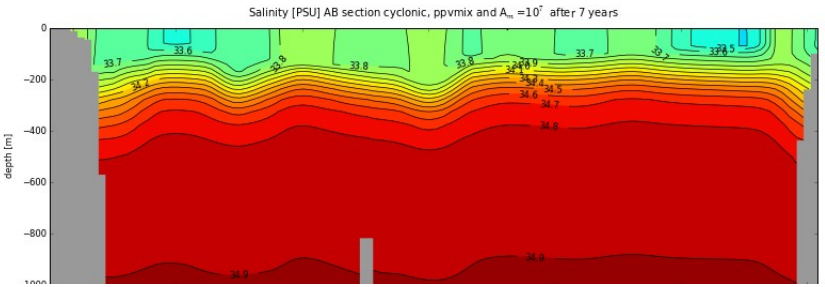


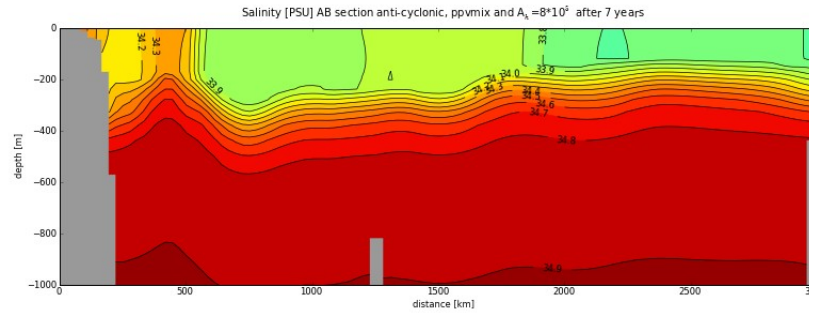


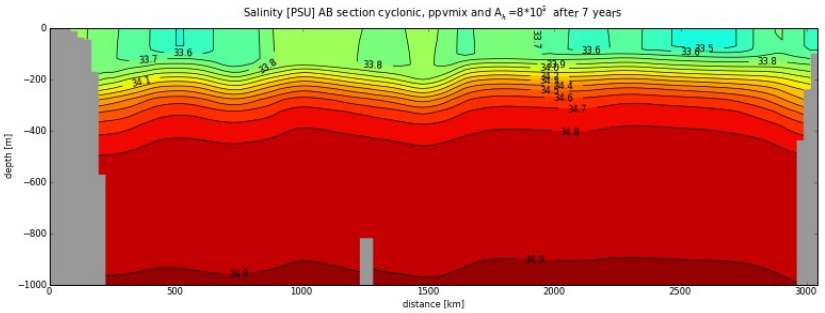












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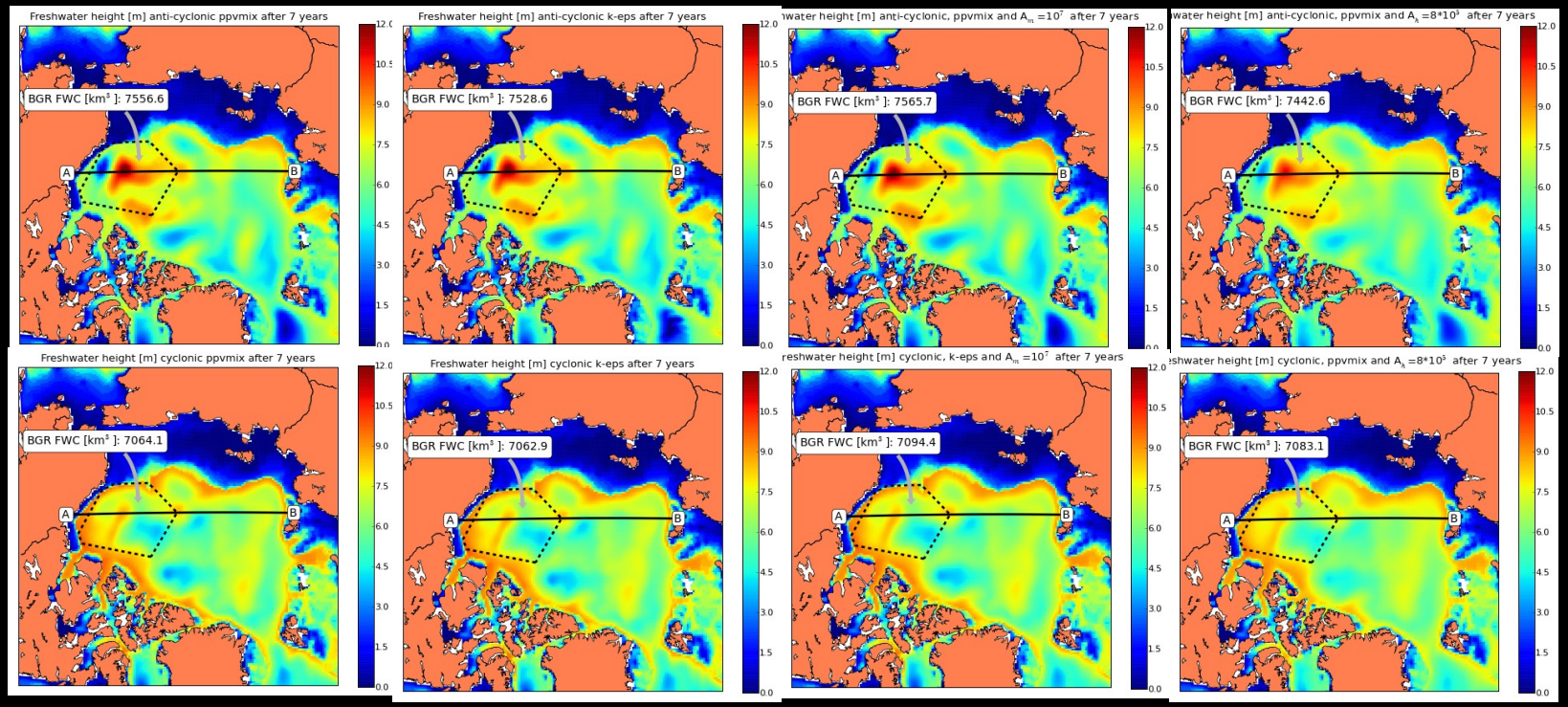
Freshwater Content

PP | k-ε | High hor. visc | High hor. diff

Anti cycl

Cycl



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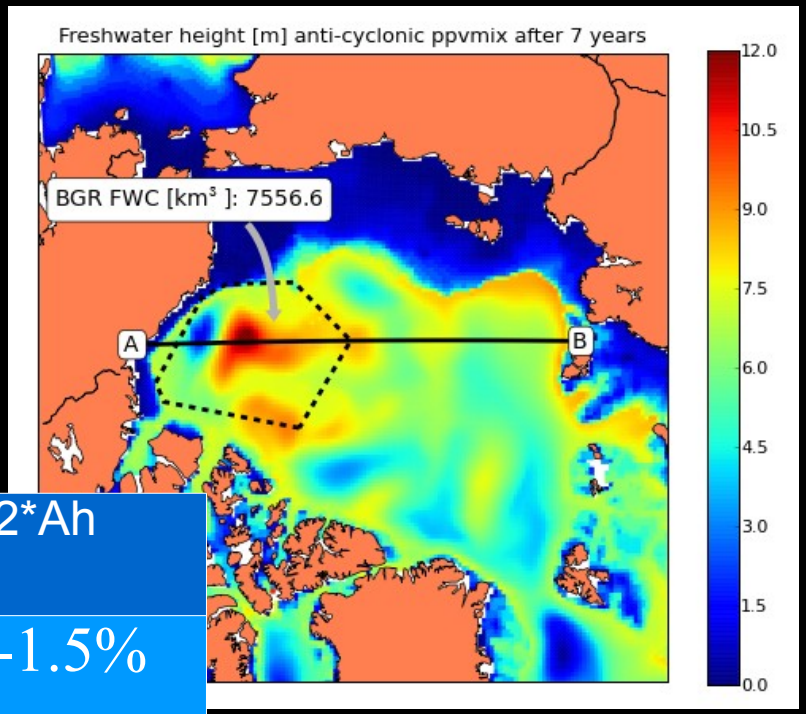
Total FW volume in BGR

- Anticyclonic regime 7,600 cubic km PP-mix after 7 years
- Cyclonic regime 6% lower
- Sensitivity to mixing is low



Regime	pp	k-eps	2*Am	2*Ah
Anticyc	0%	-0.3%	0.1%	-1.5%
Cyc	-6.5%	-6.5%	-6.5%	-6.3%

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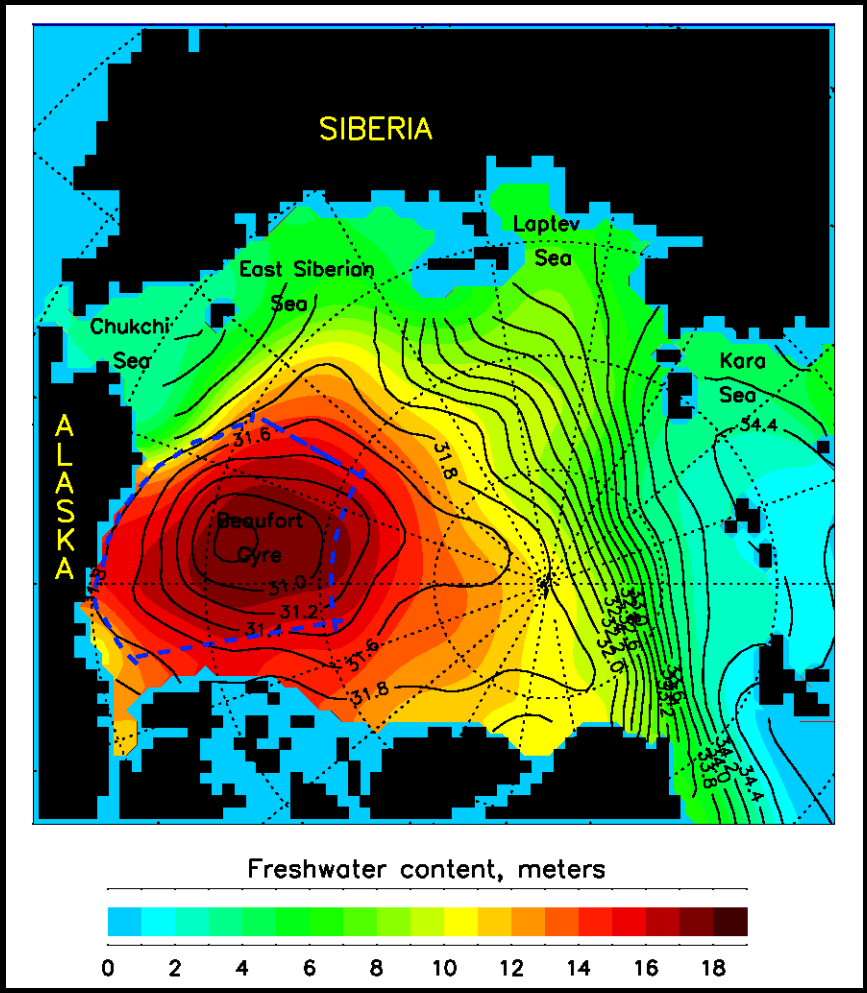
Freshwater Variability in BGR



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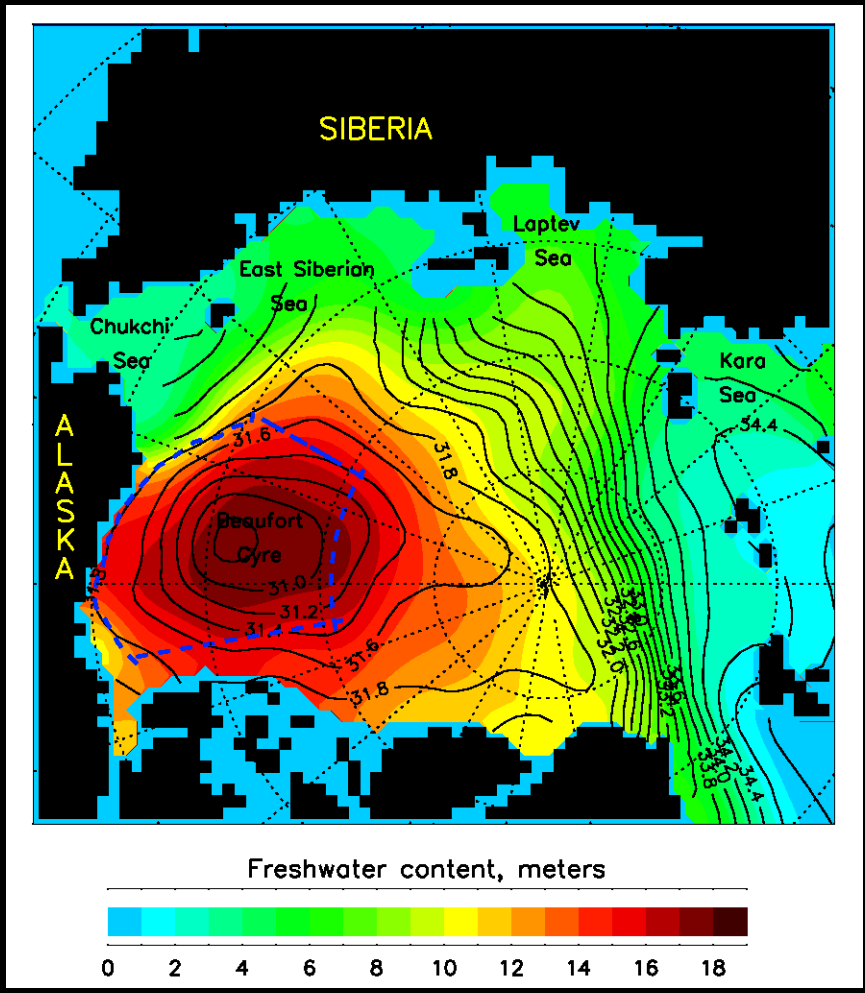
Freshwater Variability in BGR

Proshutinsky et al (2009) :

- FWC vol 20,000 cub. km
- Positive FWC trends (2003-2007)
- Seasonal variability 2 max peaks
- Thermodynamic peak (ice melt) June-July
- Dynamic (EP) peak in Nov-Jan



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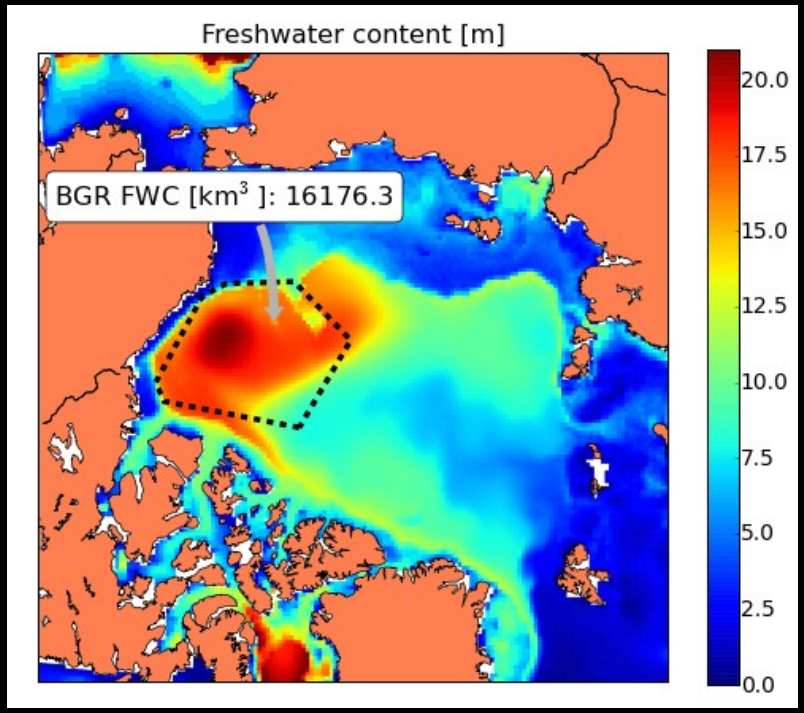
Modeled Freshwater Variability with RCO

- ERA-40/ECMWF forcing
- Now forced with all atmos fluxes and restoring,
- Runoff (climatology)
- Open North Atlantic BC (PHC)
- Multi-category sea-ice
- Simulation period 1958 – 2007
- Analysis of Beaufort Gyre Region (BGR) according to Proshutinsky et al



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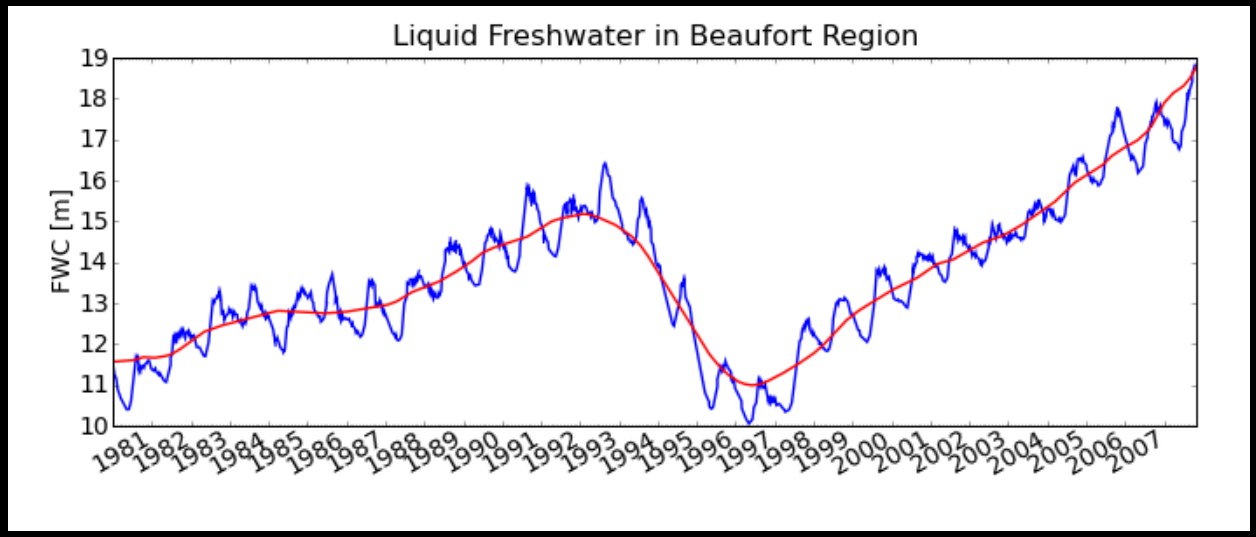
Liquid Freshwater Variability 1980-2007



- Positive trend (1980-2007)
- 2 regimes
- Regime shift during 1990s

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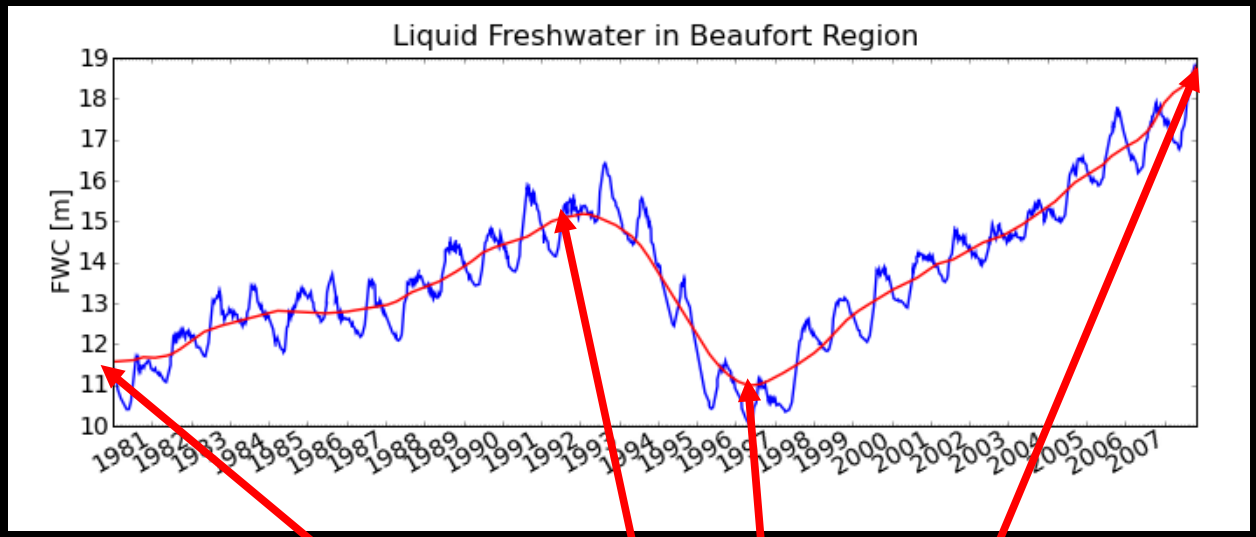
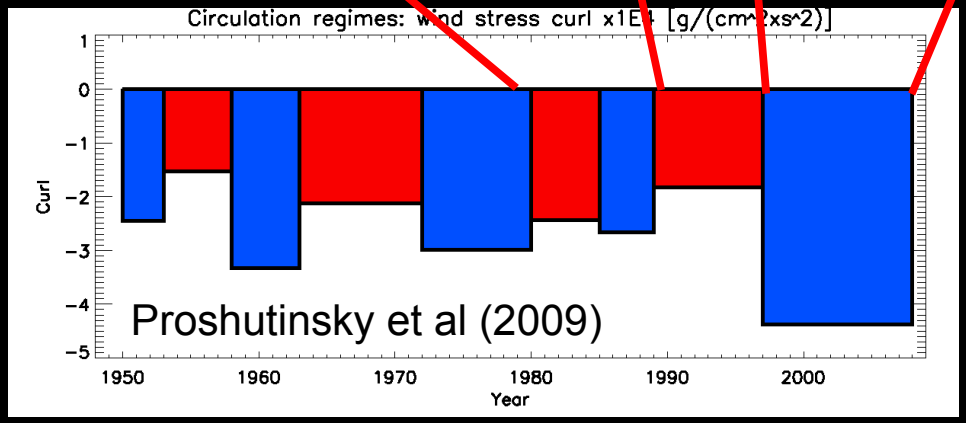
Liquid Freshwater Variability 1980-2007





- Positive trend (1980-2007)
- 2 regimes
- Regime shift during 1990s
- Regime shift in accord with changed windstress curl in the region and with AOO

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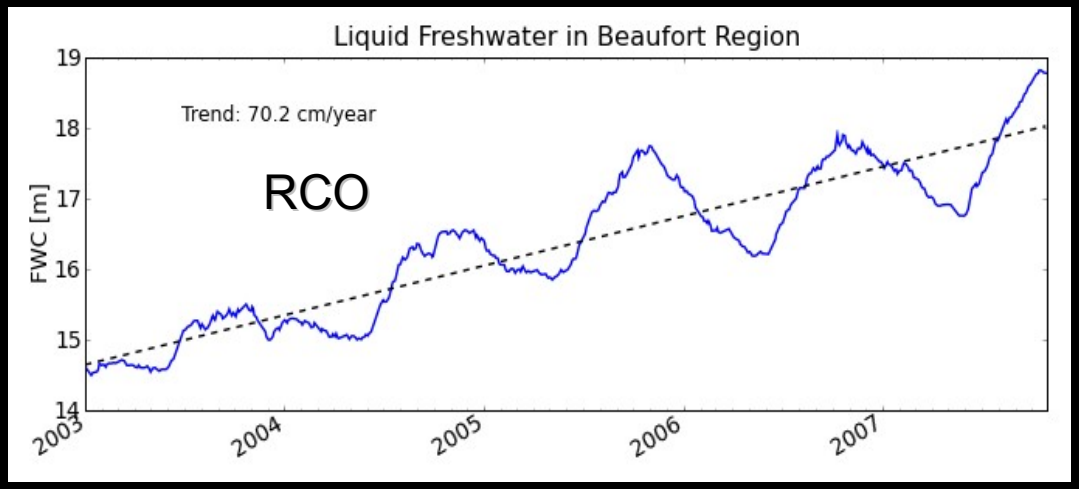
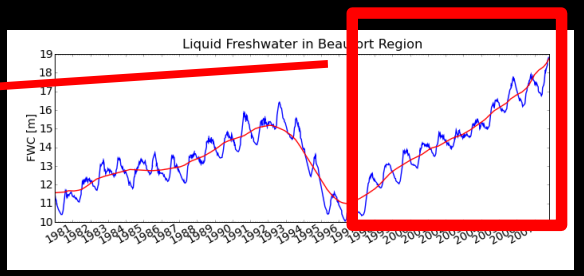
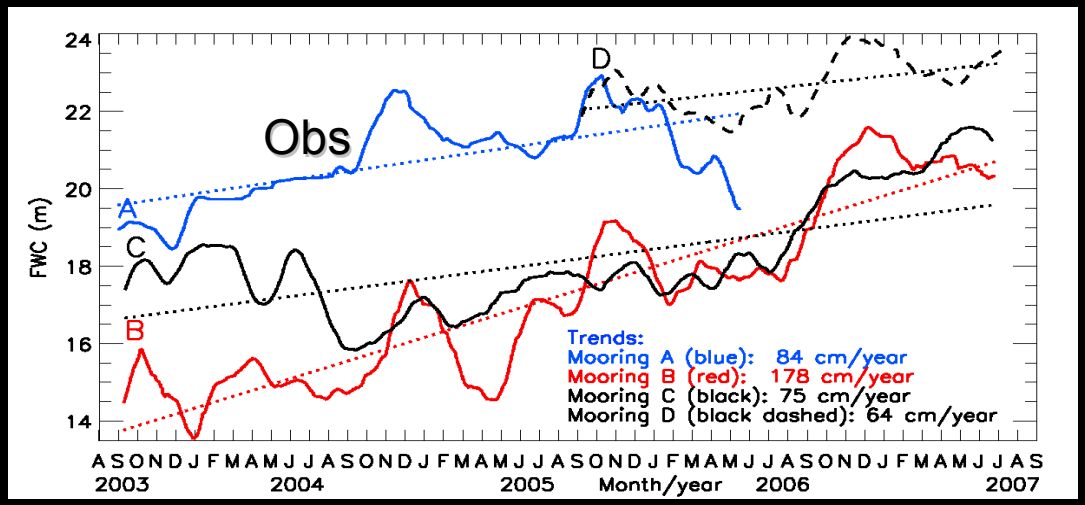
Liquid Freshwater Variability 2003-2007







- Model trend 70 cm/year
- Obs 64-178 cm/year depend on mooring site
- Larger annual peaks during 2004, 2005 and 2007 when stronger EP has been observed

Proshutinsky et al (2009)

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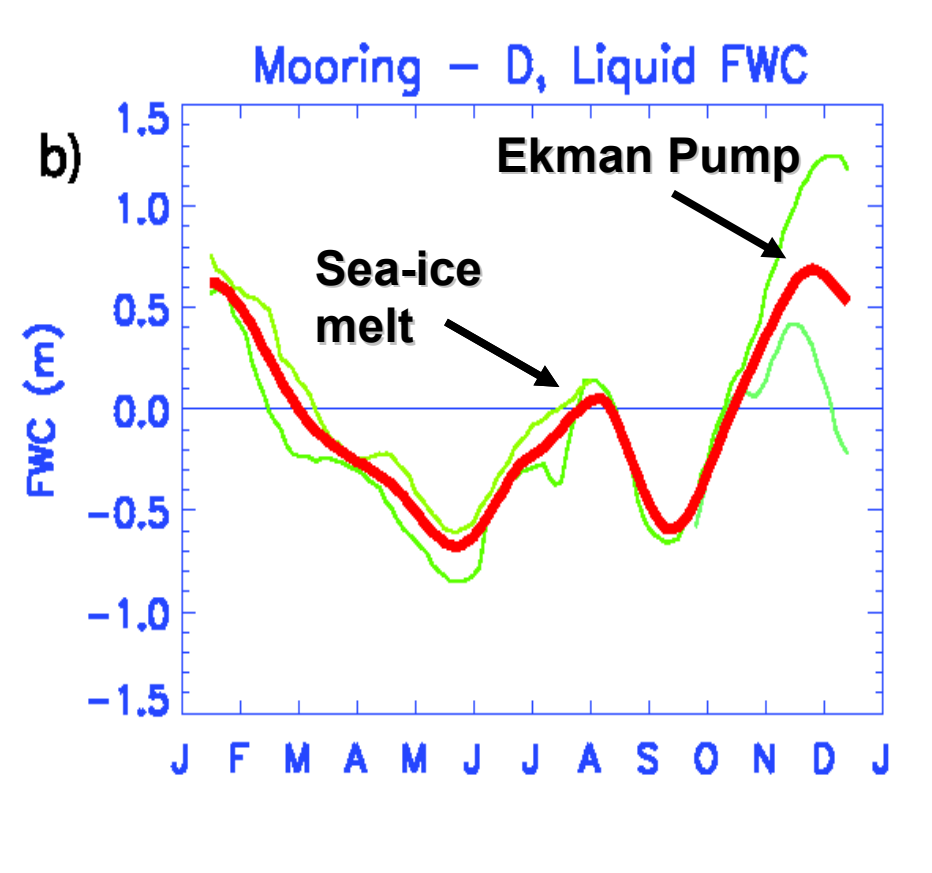
Observed Freshwater Seasonal Variability in BGR



Proshutinsky et al (2009)

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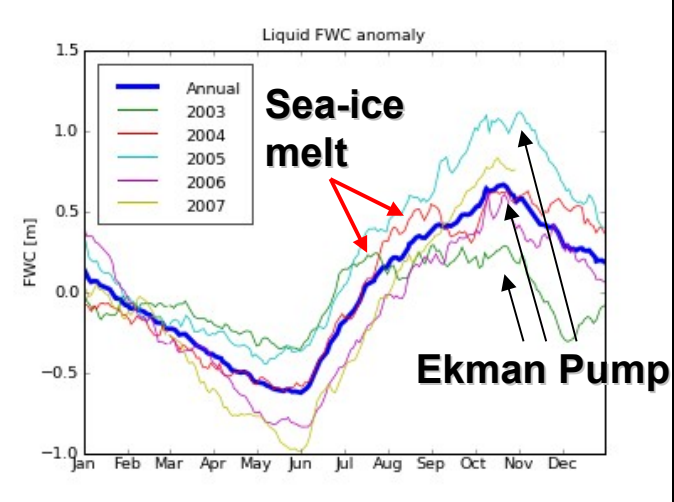
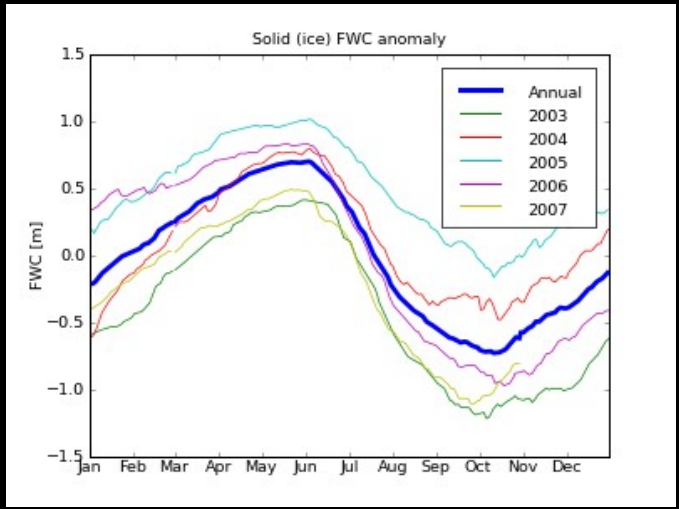
Seasonal Variability 2003-2007





- Modelled mean seasonal FWCL max peak in Nov (max EP)
- Year to year variations are large
- 2003 and 2004 have 2 max peaks, first max occur during melt season, second max in Nov
-

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Conclusions

- Parametrized turbulent mixing plays a minor role in the BG experiment, wind driven up/downwelling plays a major role
- Liquid FW variability in the BG region has positive trend which is in accordance with observations of the 2000s
- The modeled seasonal variability has a maximum in November and some years a secondary max in June-July

THANK YOU!