The Beaufort Gyre:
Models, Observations, & Truth

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7th AOMIP workshop
GFDL, Princeton, NJ
June 14-15, 2004

Abstract

We have performed a preliminary intercomparison of the structure of the Beaufort Gyre (BG) in AOMIP models. We find that the freshwater pool of the BG is too shallow in some models (relative to observations) and too deep in others. The large-scale currents seem to respond to this geostrophically, i.e., the overly deep BG's produce anticyclonic circulation to artificially deep levels. Total freshwater content in the BG seems reasonable in all models, indicating that it is a problem with the vertical distribution of freshwater. Two main factors may be contributing to these differences. First, the surface stress is different in each AOMIP run, even with the same atmospheric forcing, because of differences in the sea ice models. Second, the mixing schemes in each model are different. In particular, a very preliminary examination of AOMIP runs and also of different runs all using the UW model indicate that vertical diffusion may be a primary factor in controlling the depth of the BG and thus the sign of simulated Atlantic Water vorticity in the Canadian Basin.

Why is the Beaufort Gyre freshwater pool so shallow in some models, and so deep in others?

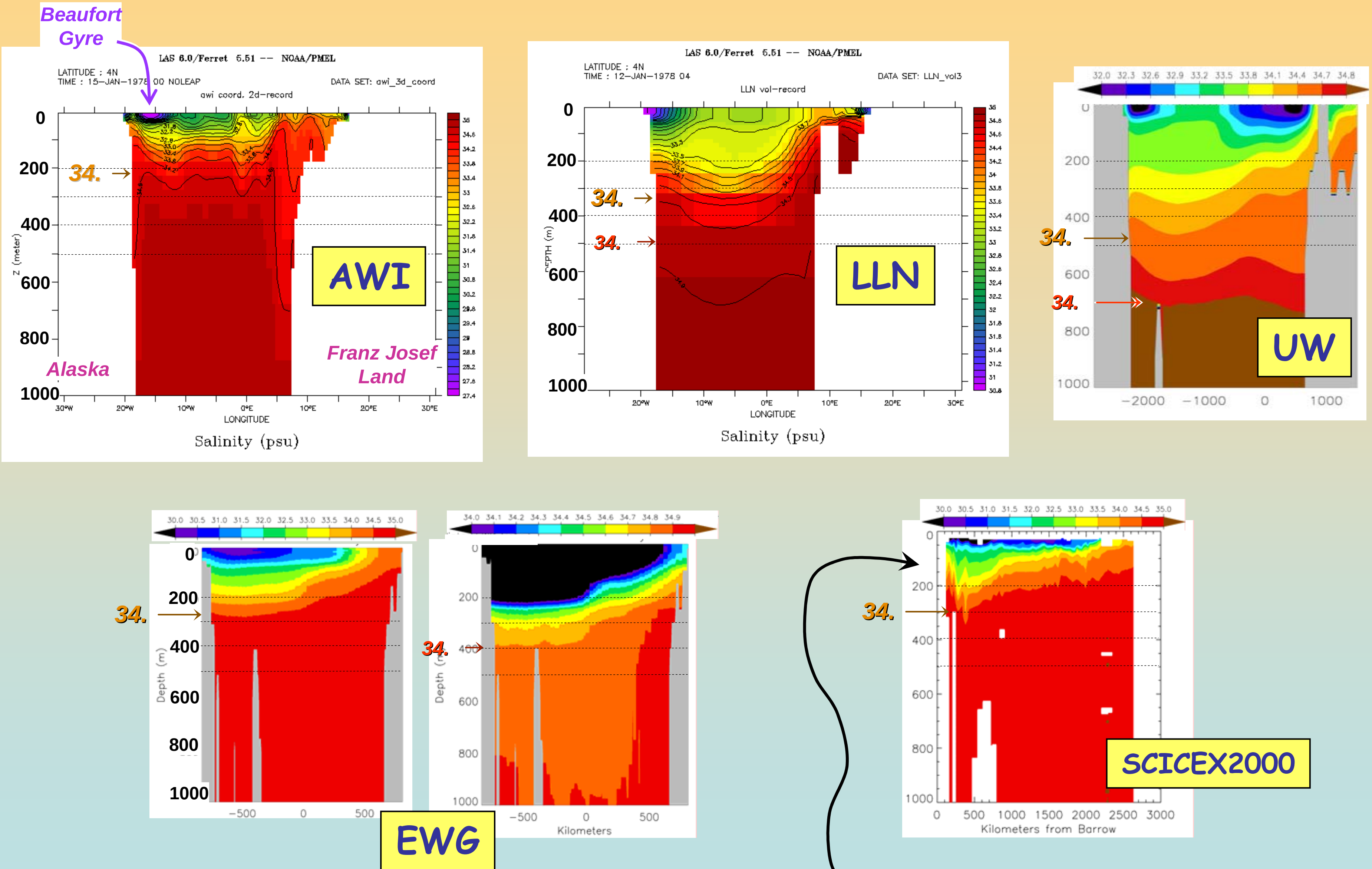
In the following slides, we first explore the extent of the problem, using model output available on the LAS before our workshop from AWI and LLN, and from our very recent UW run using our new POP ocean model configuration.

We will show:

- *vertical salinity* slices
- *horizontal salinity* slices
- maps of *freshwater* content & *SSH*
- horizontal ocean *velocity* slices

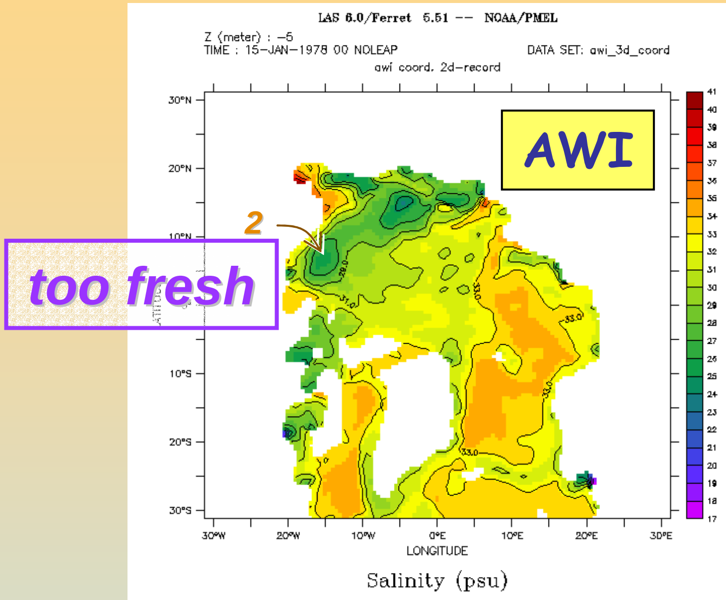
We conclude with a very brief discussion of potential mechanisms that might be causing these differences.

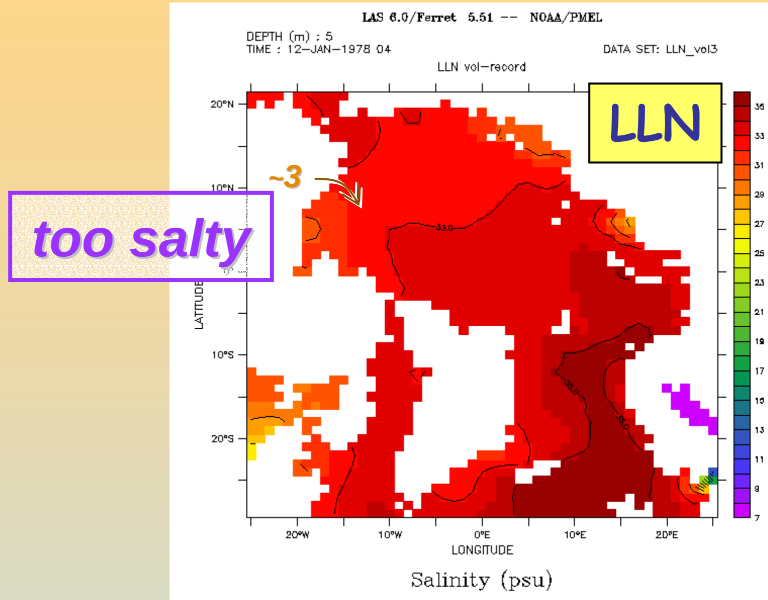
Salinity transect: Alaska - Franz Joseph Land

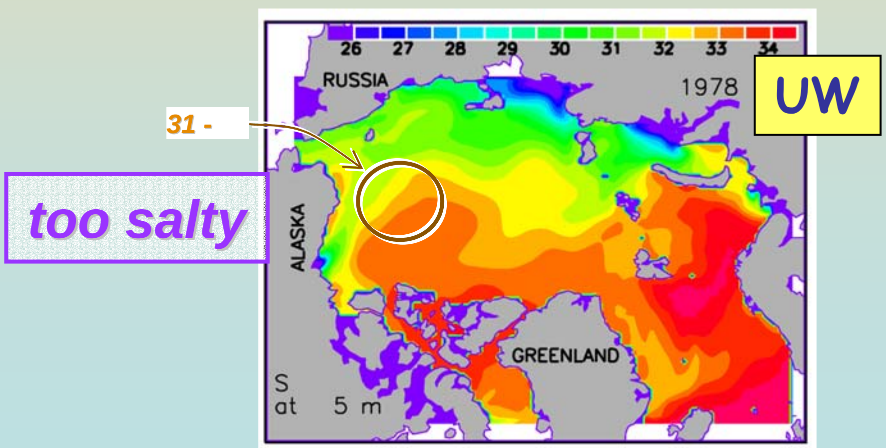


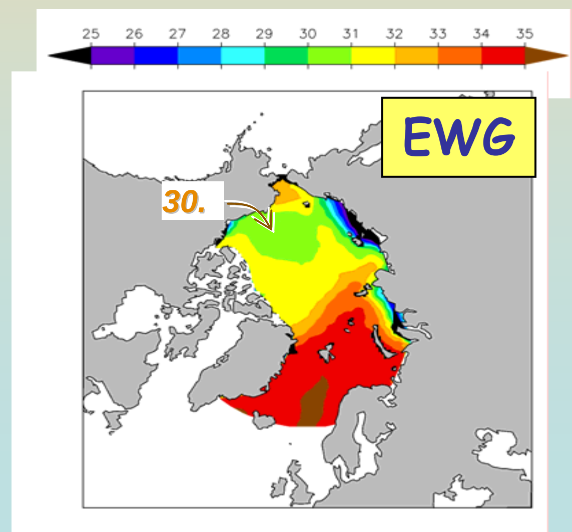
contours shoal near Alaska in

SSS

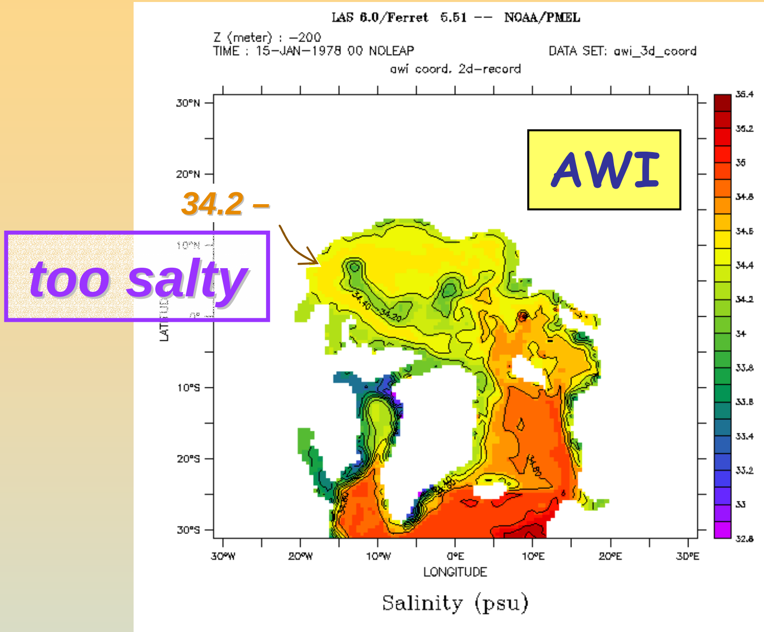

LAS 6.0/Ferret 6.51 -- NOAA/PMEL
Z (meter) : -5
TIME : 15-JAN-1978 00 NOLEAP
DATA SET: awi_3d_coord
awi coord. 2d-record
AWI
2
too fresh
LONGITUDE
Salinity (psu)

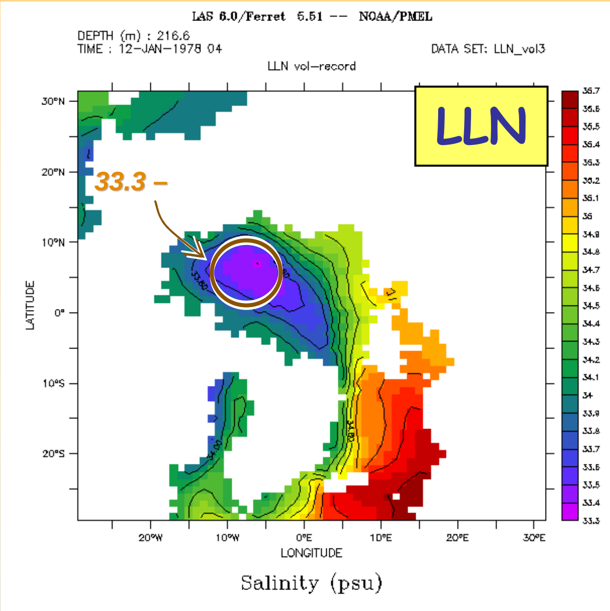

LAS 6.0/Ferret 5.51 -- NOAA/PMEL
DEPTH (m) : 5
TIME : 12-JAN-1978 04
DATA SET: LLN_vol3
LLN vol-record
LLN
~3
too salty
LATITUDE
LONGITUDE
Salinity (psu)

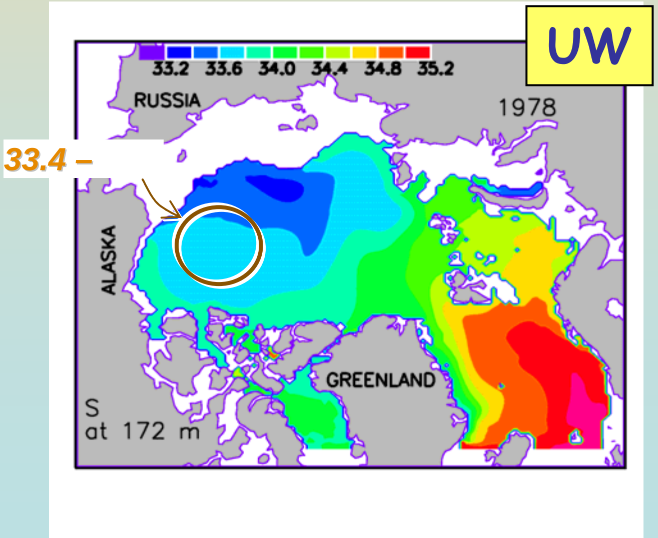

26 27 28 29 30 31 32 33 34
RUSSIA
1978
UW
31 -
too salty
ALASKA
GREENLAND
S
at 5 m

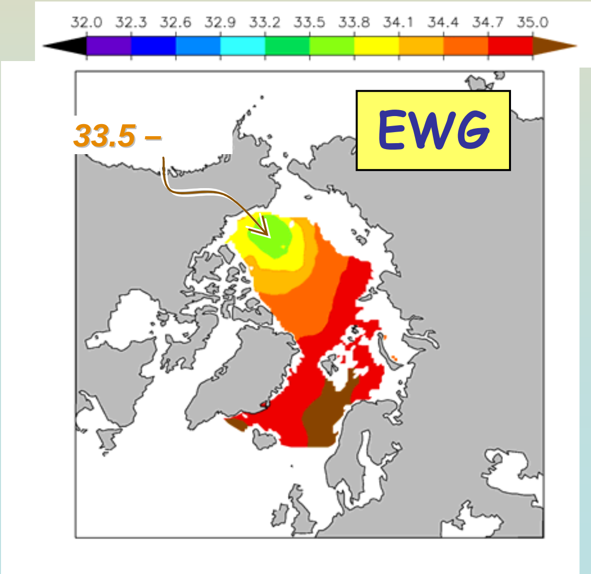

25 26 27 28 29 30 31 32 33 34 35
EWG
30.

Salinity at ~200 m

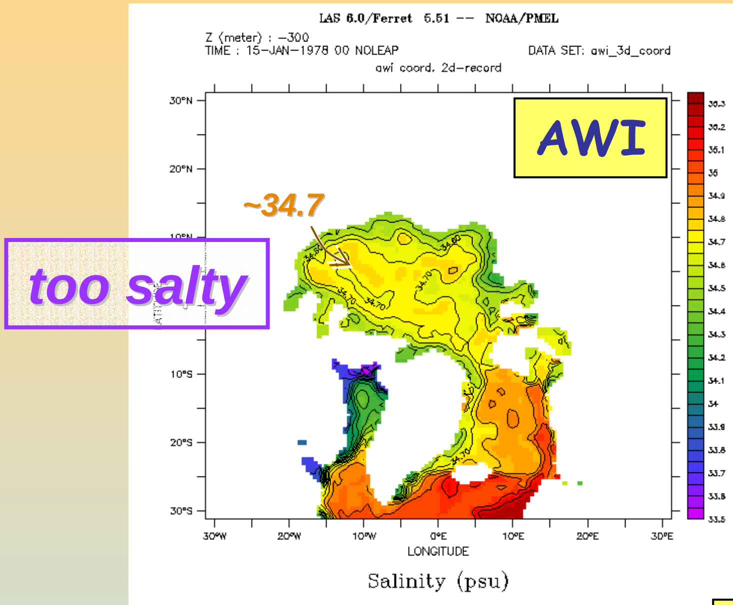


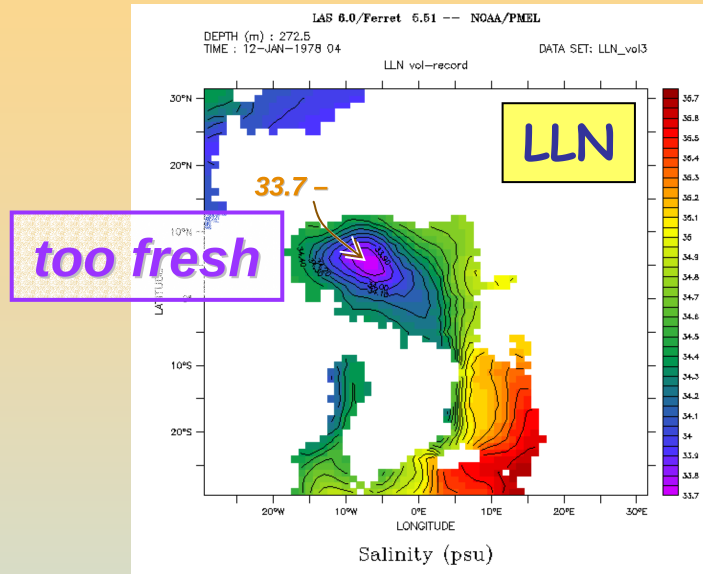


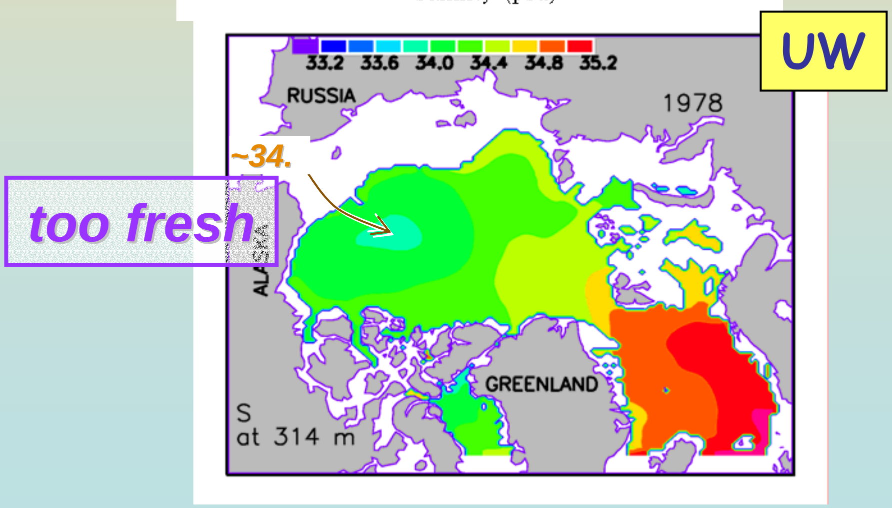


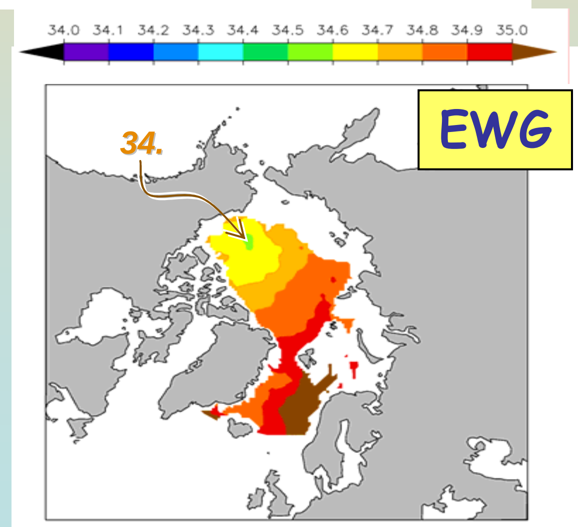


Salinity at ~300 m

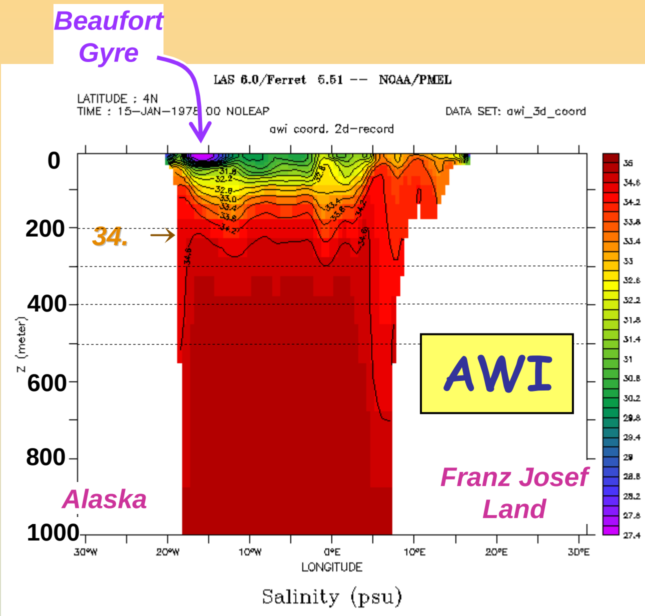


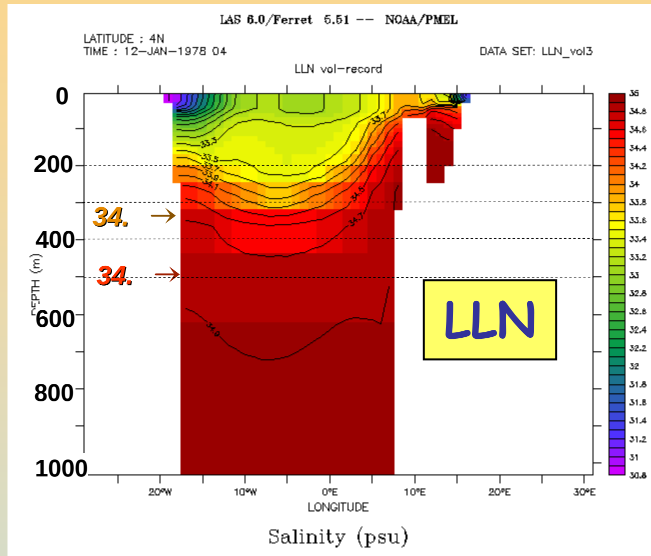


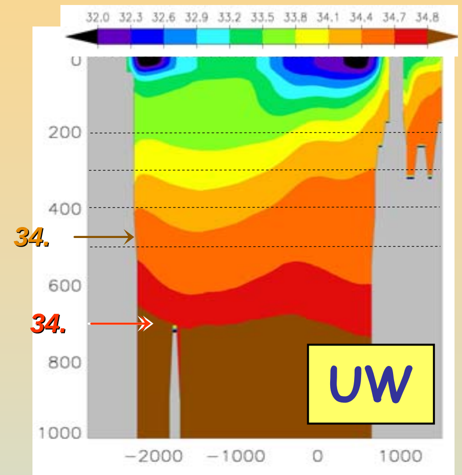




Summary of S(x,y,z)



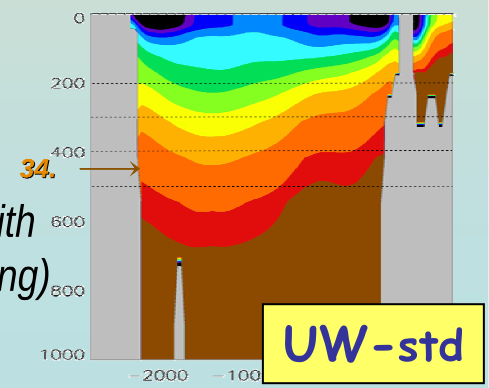




Relative to EWG:
Freshwater is too shallow

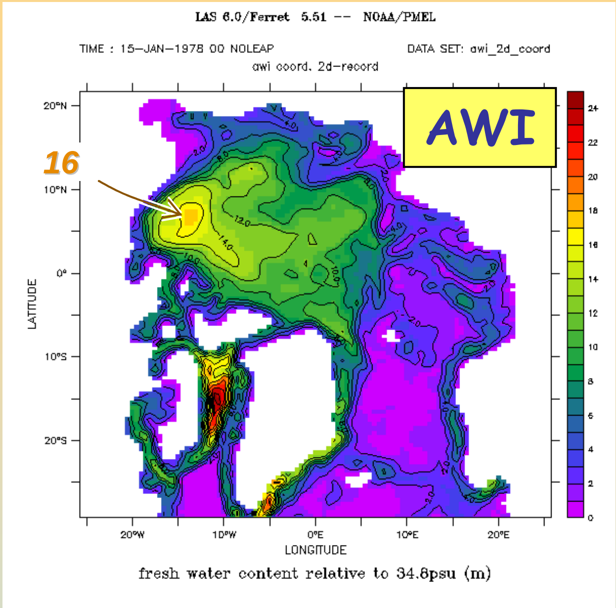
Relative to EWG:
Freshwater is too deep

Ditto, but worse!



(UW ~better with std./NCEP forcing)

Freshwater content

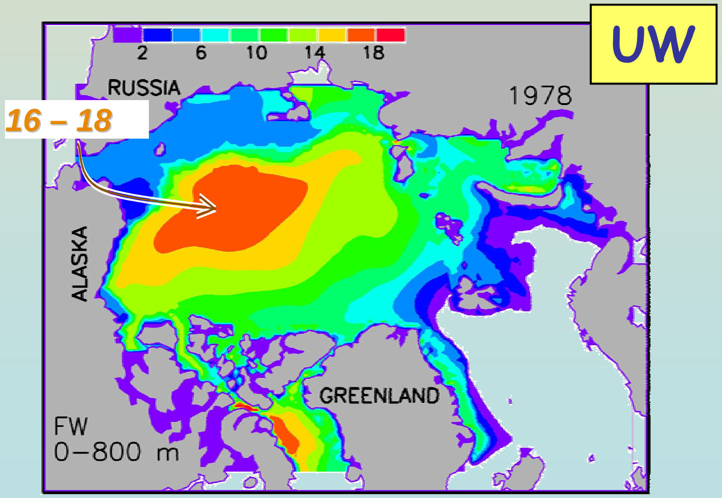


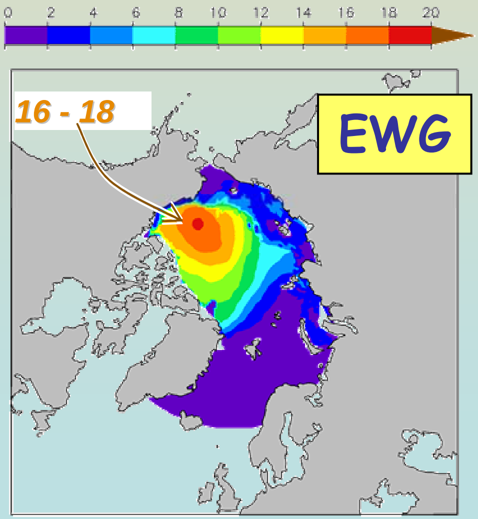
LLN

Not bad agreement!

⇒ differences are

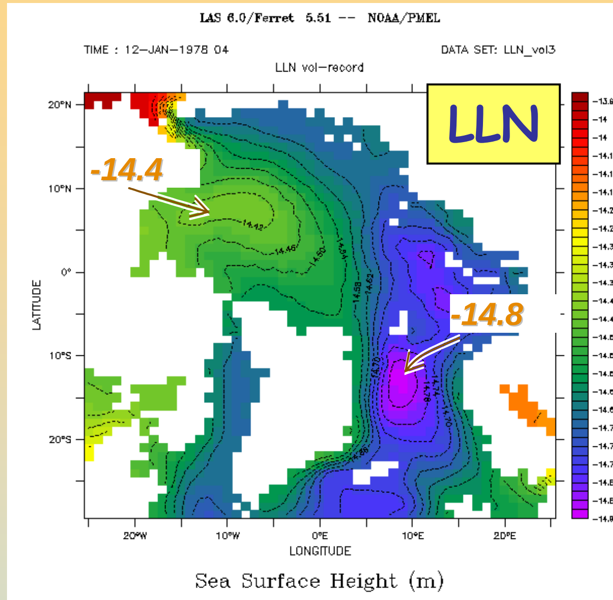
- **f.w. (z)**, & not
- **f.w. content**

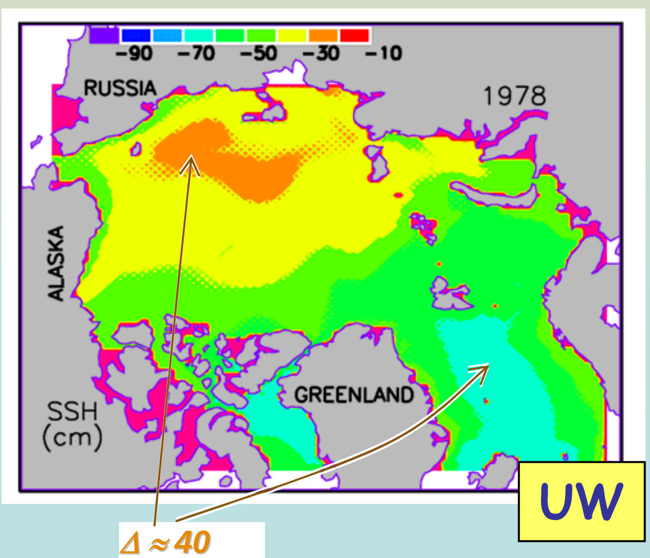


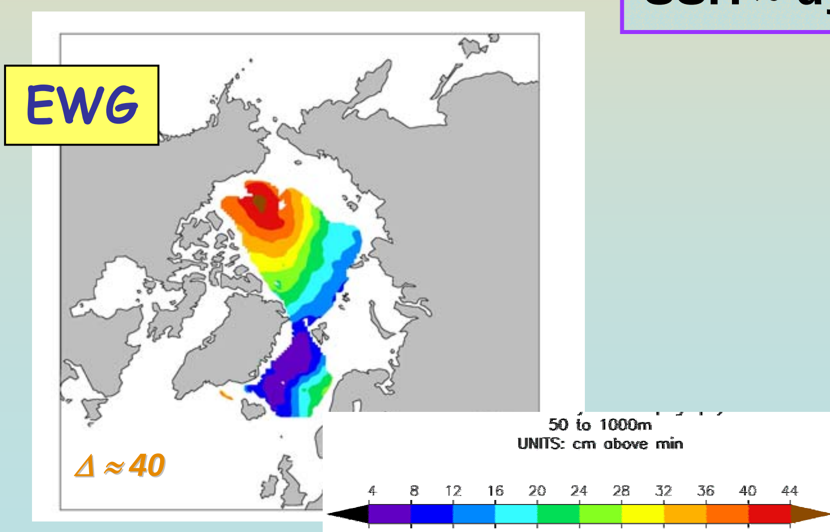


SSH

AWI





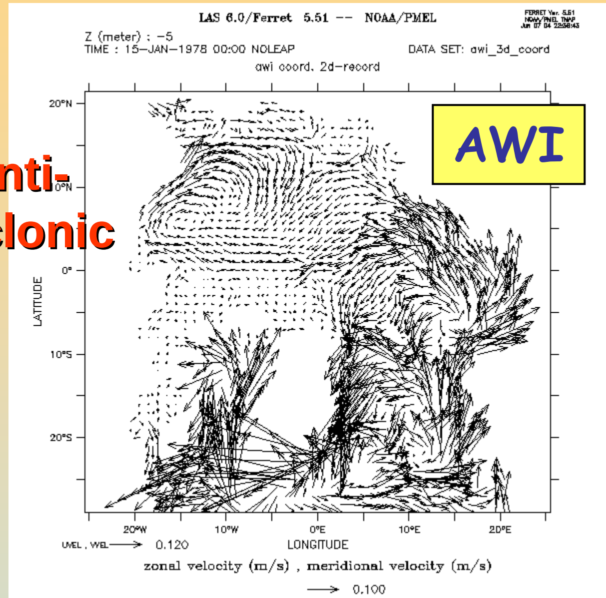


Not bad agreement

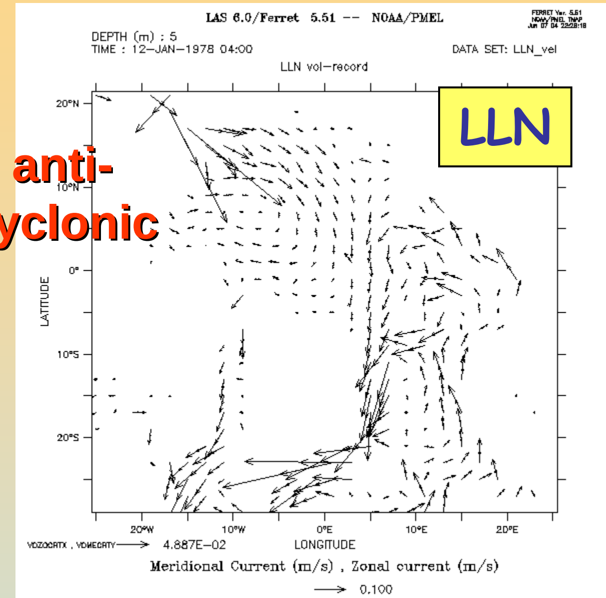
SSH ≈ dynamic topog.

Velocity at 5 or 10 m

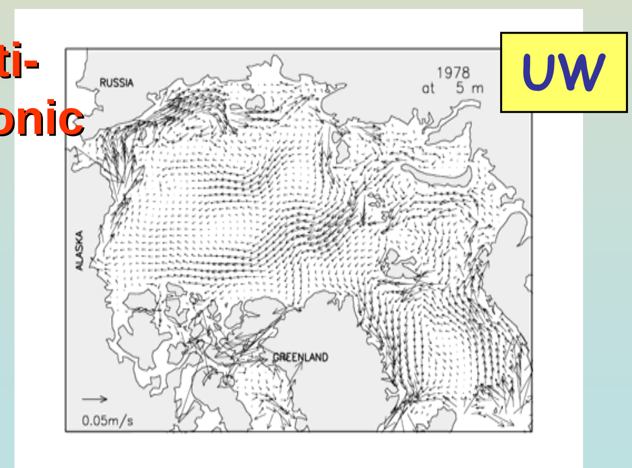
anti-cyclonic



anti-cyclonic



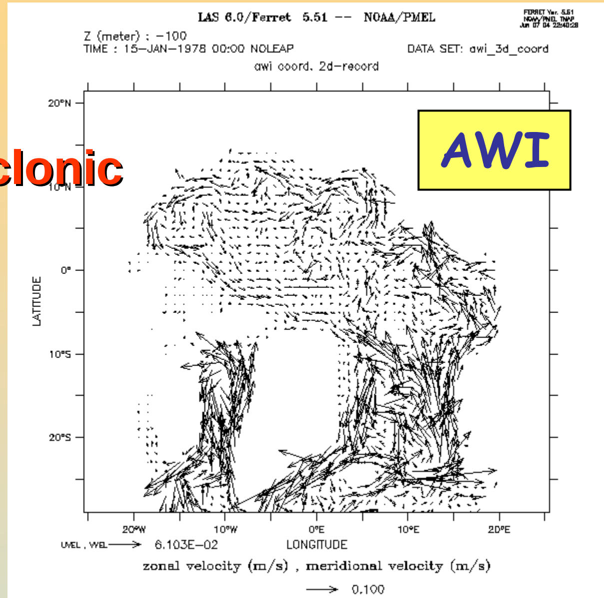
anti-cyclonic



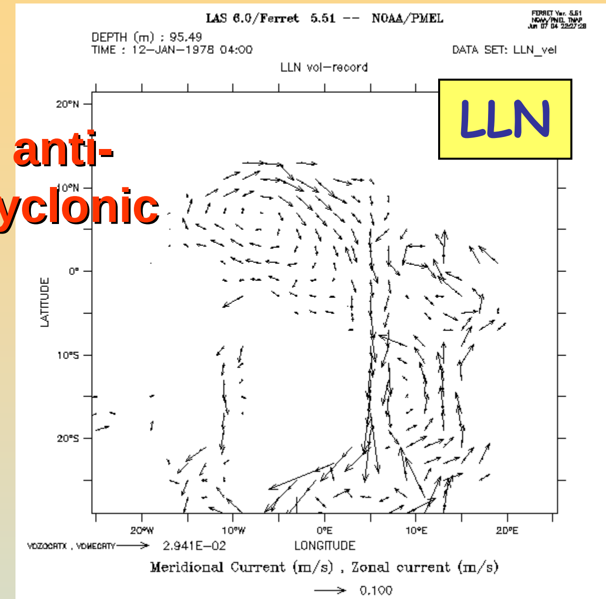
all anticyclonic @ surface

Velocity at 100 m

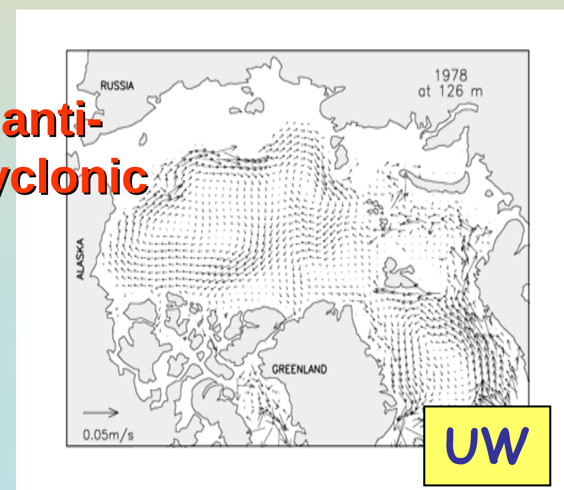
cyclonic



anti-cyclonic



anti-cyclonic

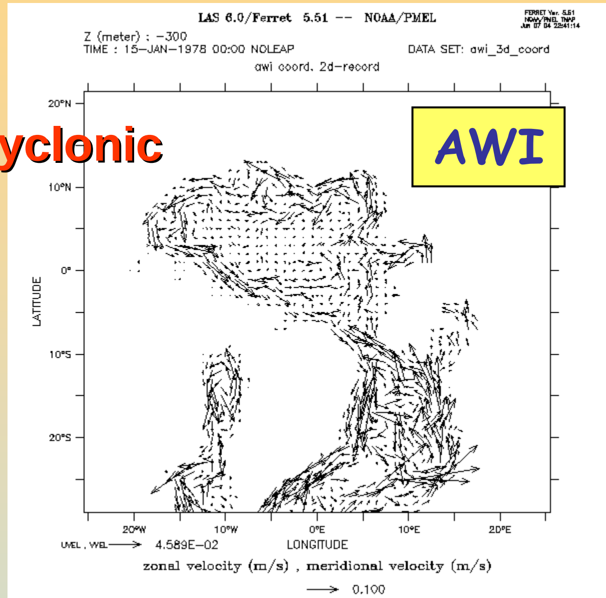


By 100 m,

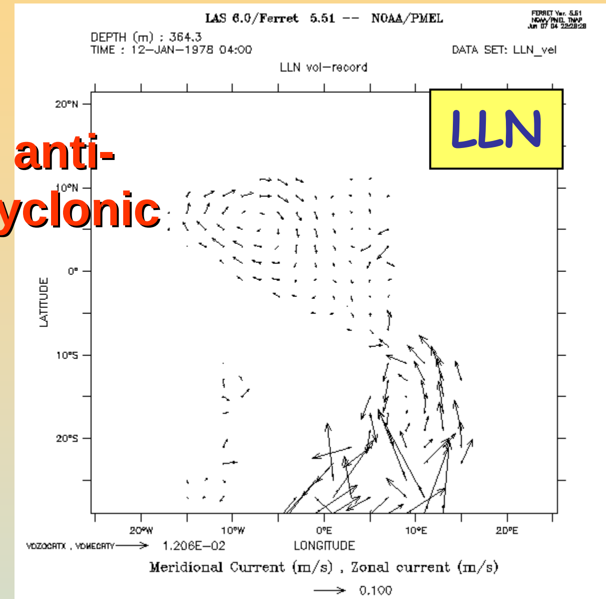
the differences are evident.

Velocity at 300 m

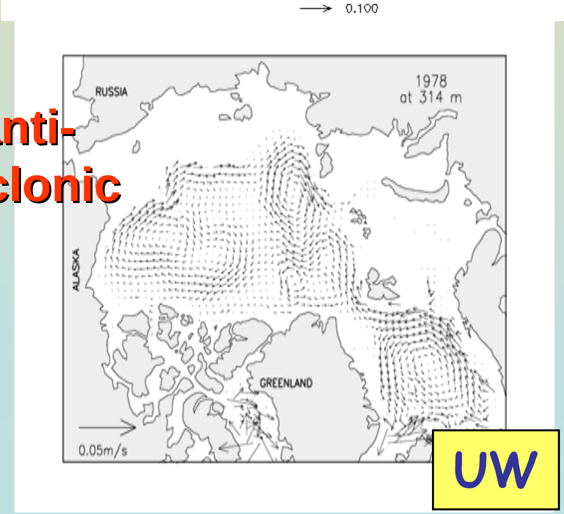
cyclonic



anti-cyclonic



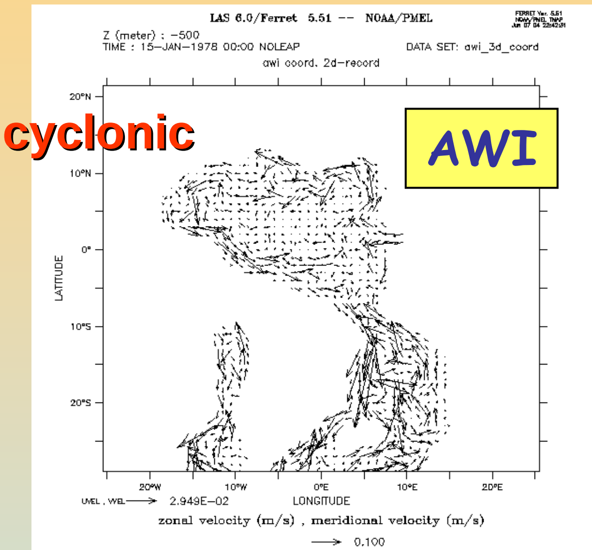
anti-cyclonic

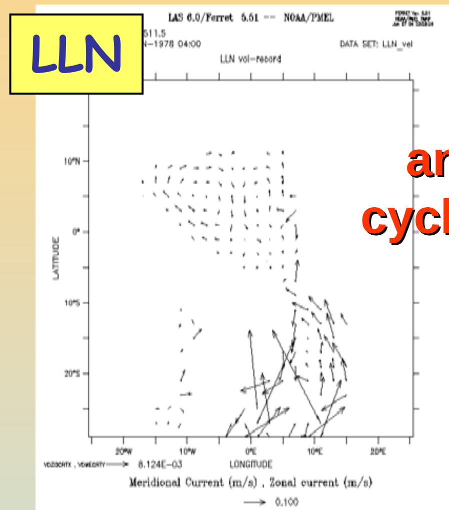


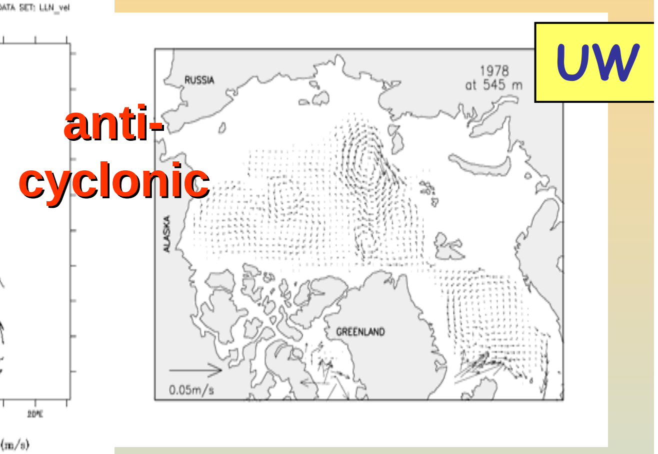
100 m – 500 m:

vorticity ~constant

Velocity at 500 m







2-layer fluid (0 – 800 m)

<u>Top</u>: *wind-driven* B.Gyre

<u>Bottom</u>: *p.v.conserving* bound. current

1-layer fluid (0 – 800 m)

***wind-driven* B.Gyre**

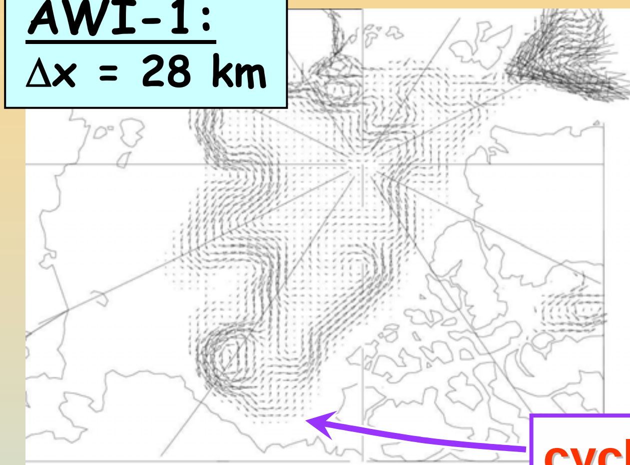
The 2 current systems are (unrealistically?) vertically decoupled!

Does the anticyclone destroy the cyclonic boundary current?

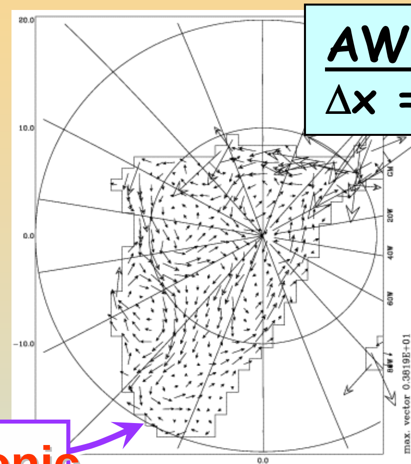
Why? Why? Why?

Hypothesis #1: It's resolution!

AWI-1:
Δx = 28 km

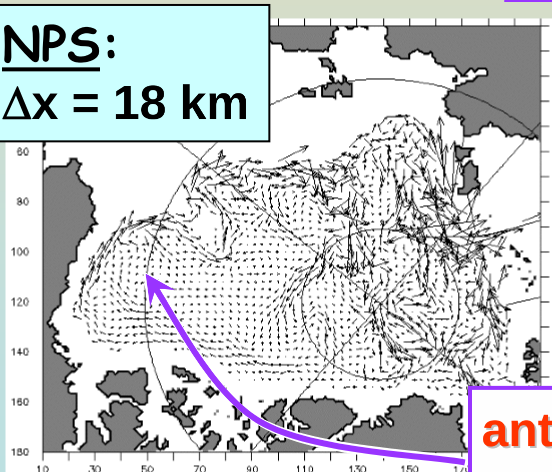


AWI-2:
Δx = 100 km

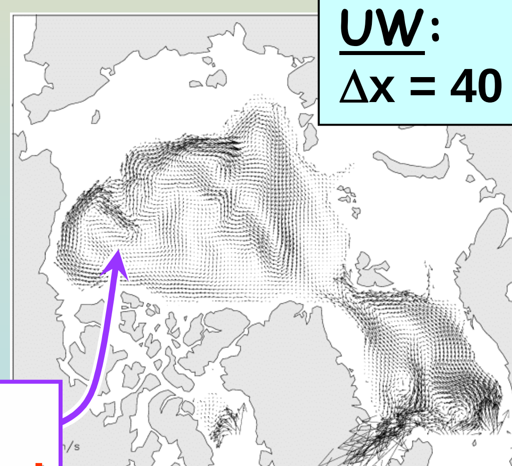


cyclonic

NPS:
Δx = 18 km



UW:
Δx = 40 km



anti-cyclonic

Nahhh…

…figures are from G. Holloway's web page: ocean velocity at 400-500m

Why? Why? Why? Hypothesis #2: It's mixing!

	AWI	LLN	UW
tracer advection	FCT	centered	centered
horiz. diffusion	none	isopycnal+GM (2e7 cm^2/s)	harmonic (0.8e6 cm^2/s)
vert. diffusion	none	1.5 turb. closure (min = 0.12 cm^2/s)	harmonic (0.25 cm^2/s)
horiz. viscosity	biharmonic (0.5e-21 cm^4/s)	harmonic (4e8 cm^2/s)	harmonic (0.8e8 cm^2/s)
vert. viscosity	harmonic (10 cm^2/s)	1.5 turb. closure (min = ?)	harmonic (0.25 cm^2/s)
mixed layer scheme	none	1.5 turb. closure	none

Uhhh…maybe! *Preliminary runs at UW with varying vertical diffusion seem to support this idea.*

Why? Why? Why?

Hypothesis #3: It's surface stress!

…i.e., *Ekman pumping*

UW

LLN

AWI

Ummm…
need to look at this!

The end… for now….