Measuring skill of Arctic Ocean models in temperature-salinity space

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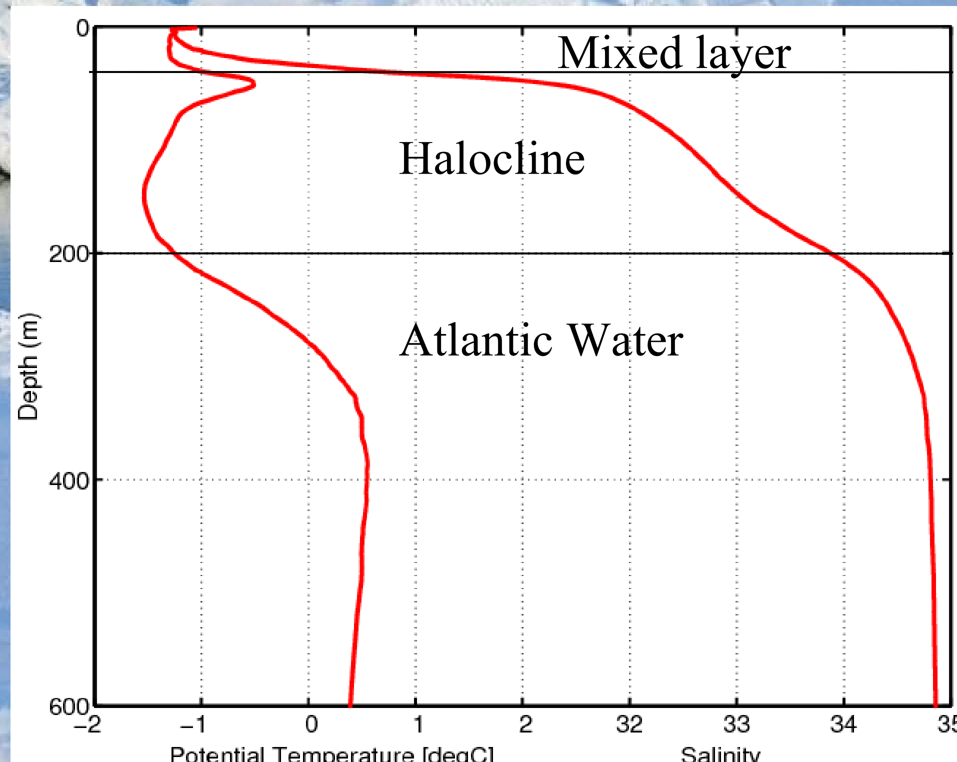
Motivation

Find a <u>simple</u> metric to measure numerical models' skills in reproducing water masses in the Arctic Ocean

Water masses:

- Atlantic Water
- Halocline
- Shelf Water
- Mixed layer

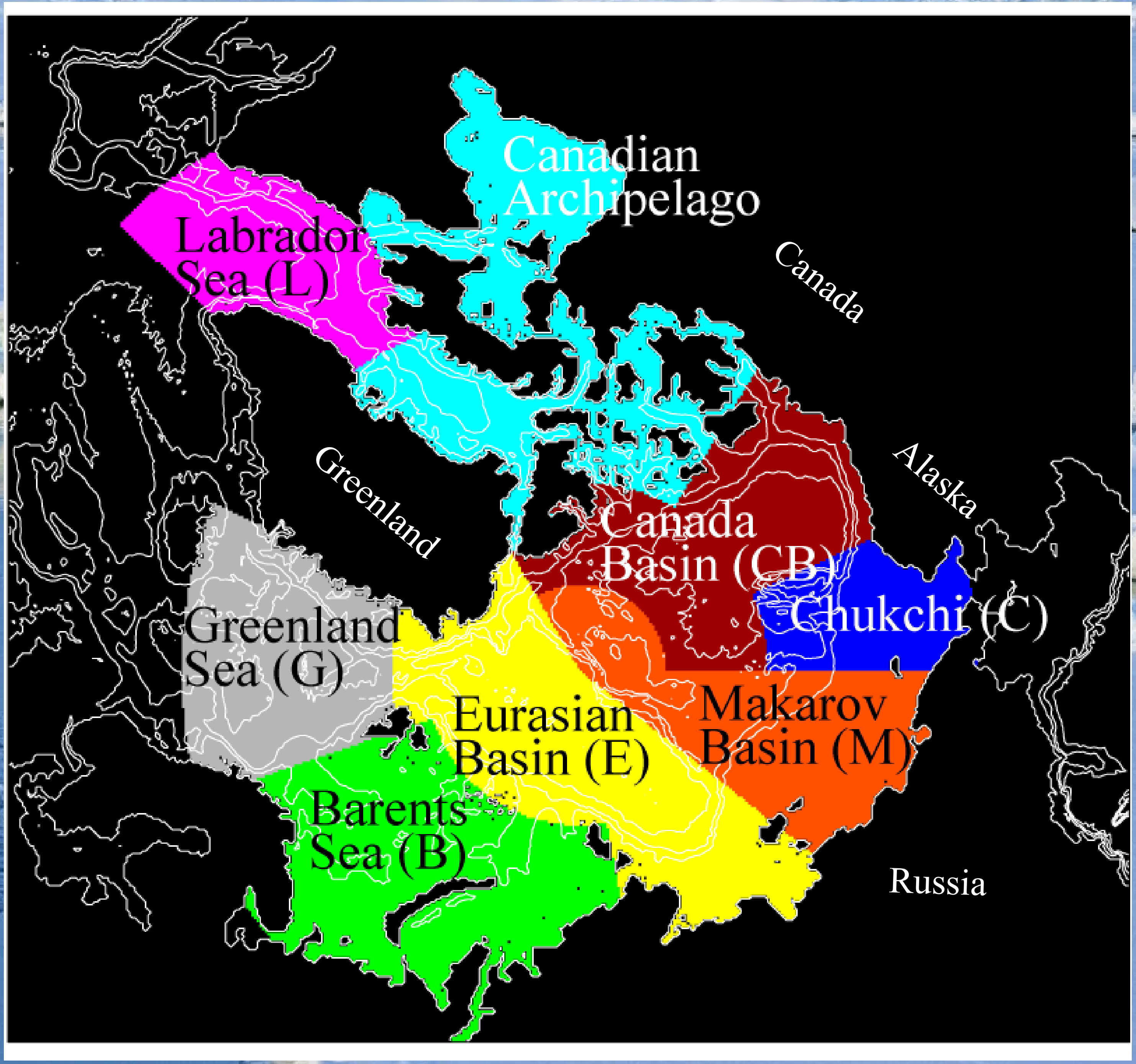


Models

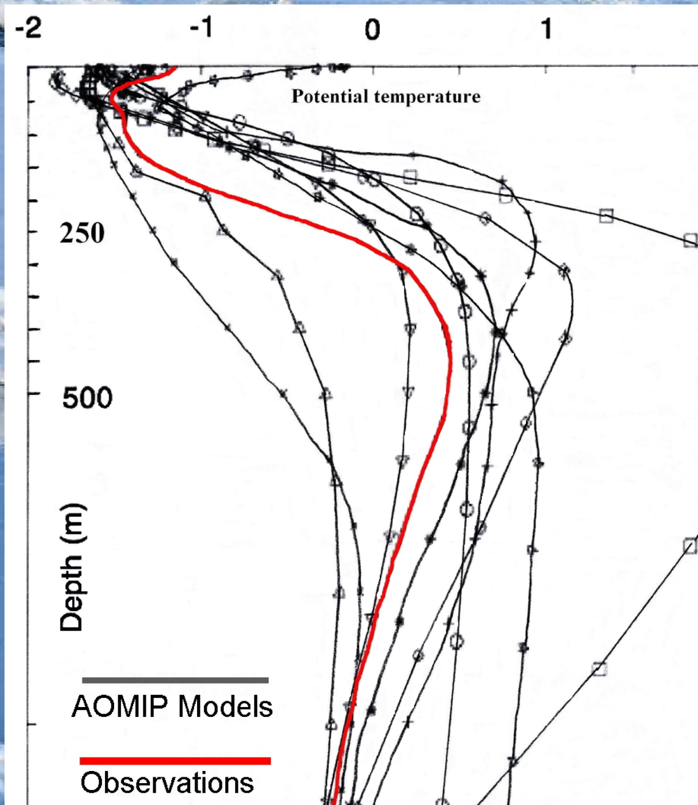
	ECCO2	ORCA025 (DRAKKAR)	ORCA1
sea-ice	MITgcm	LIM2	LIM2
ocean	MITgcm	NEMO	NEMO
spatial coverage	regional	global	global
temporal coverage	1992-2008	1970-2000, 2002-2008	10-yr climatology
horizontal (Arctic)	~18km	~12km	~45km
vertical levels	50	46, 75, 50	46
atmospheric BCs	JRA25	CORE + ERA40	ECMWF
relaxation	none	SSS	SSS
sea-ice dynamics	VP	VP, EVP	VP
river-runoff	[Winsor, 2007]	[Dai and Trenberth, 2002]	[Dai and Trenberth, 2002]

ECCO2: Nguyen et al, 2010, submitted to JGR-Oceans

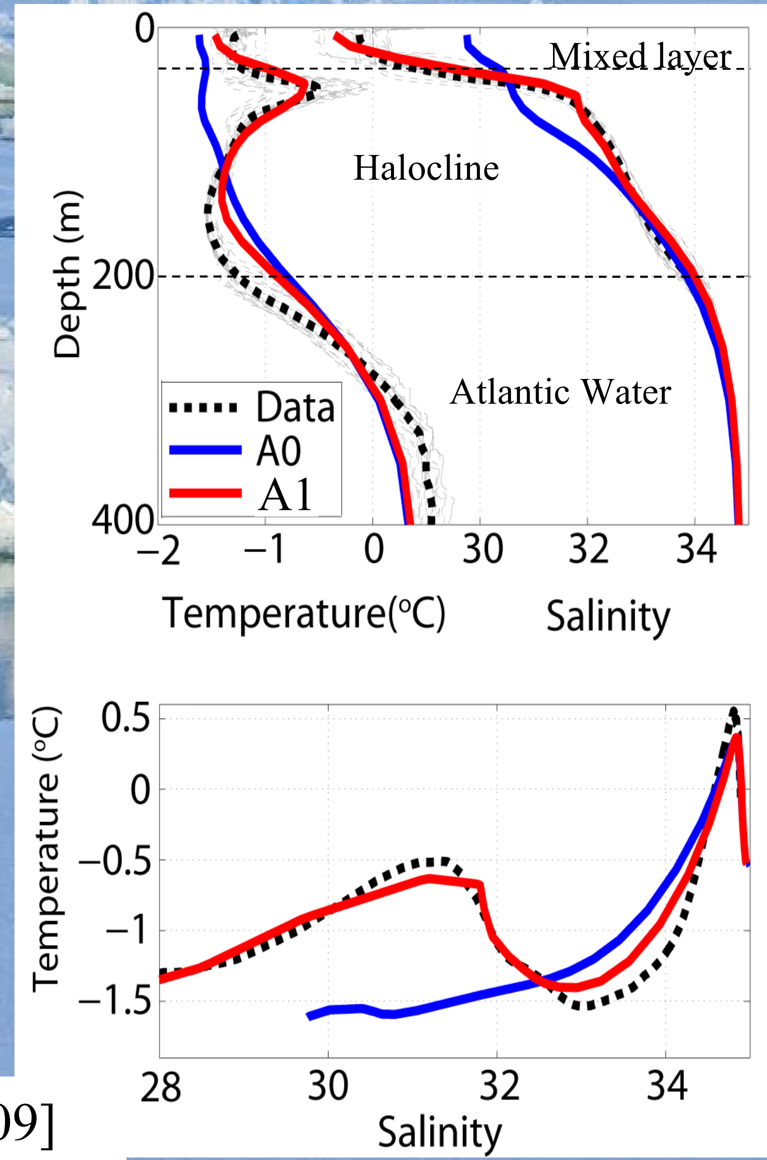
Domains


Canadian Archipelago
Labrador Sea (L)
Canada
Alaska
Greenland
Canada Basin (CB)
Chukchi (C)
Greenland Sea (G)
Eurasian Basin (E)
Makarov Basin (M)
Barents Sea (B)
Russia

Example: The Cold Halocline



[Holloway et al., 2007]



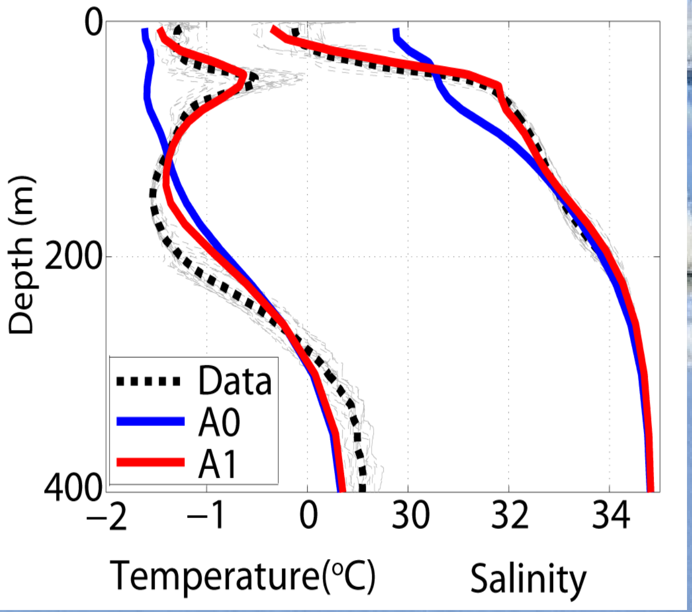
[Nguyen et al., 2009]

Skill (1): SSQ

Nguyen et al. [2009]

- Merge T and S → density
- Compared with individual CTD profiles 1992-2004
- Skill defined as:

$$I = \frac{\left(SSQ_{A0} - SSQ_{A1}\right)}{SSQ_{A0}} \times 100$$



SSQ: Sum of squares of (model – data)

$I > 0$ when $SSQ_{A1} < SSQ_{A0}$ → *A1* is better

$I < 0$ when $SSQ_{A1} > SSQ_{A0}$ → *A1* is worse

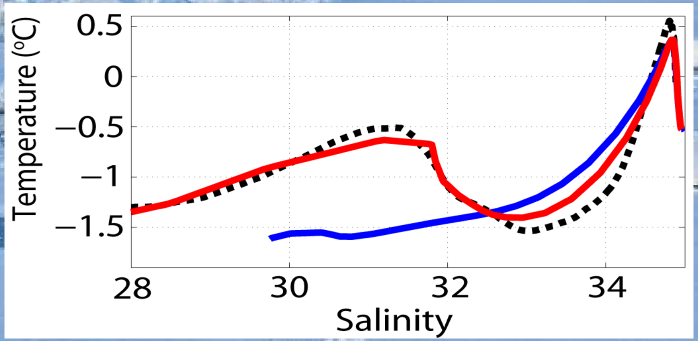
Disadvantages:

- Need full 3-D T/S fields at all time
- Not feasible for comparison between models

Skill (2): Mixing line

Idea:

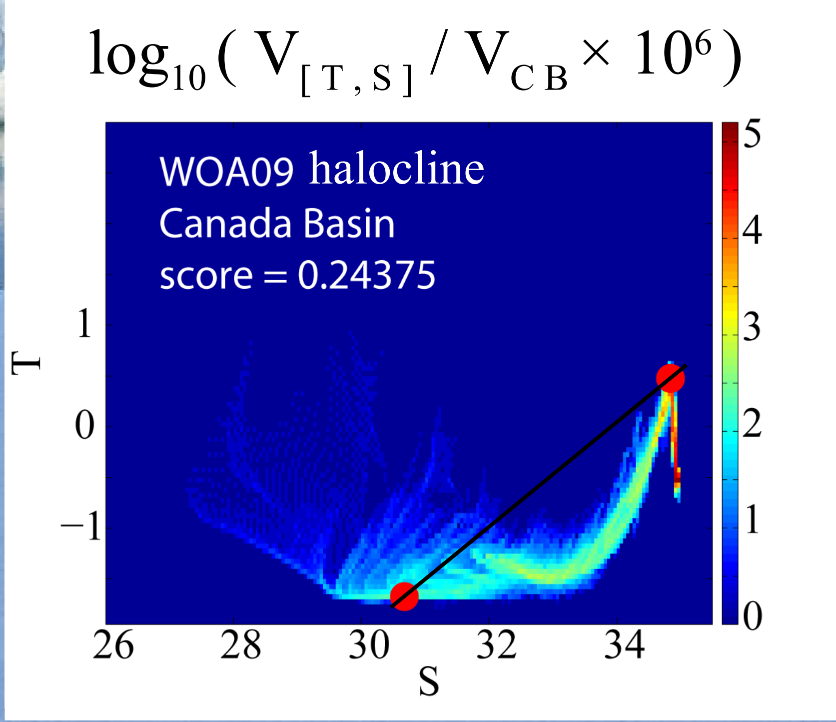
- Halocline: "scoop" in TS diagram
- Models: missing this "scoop"



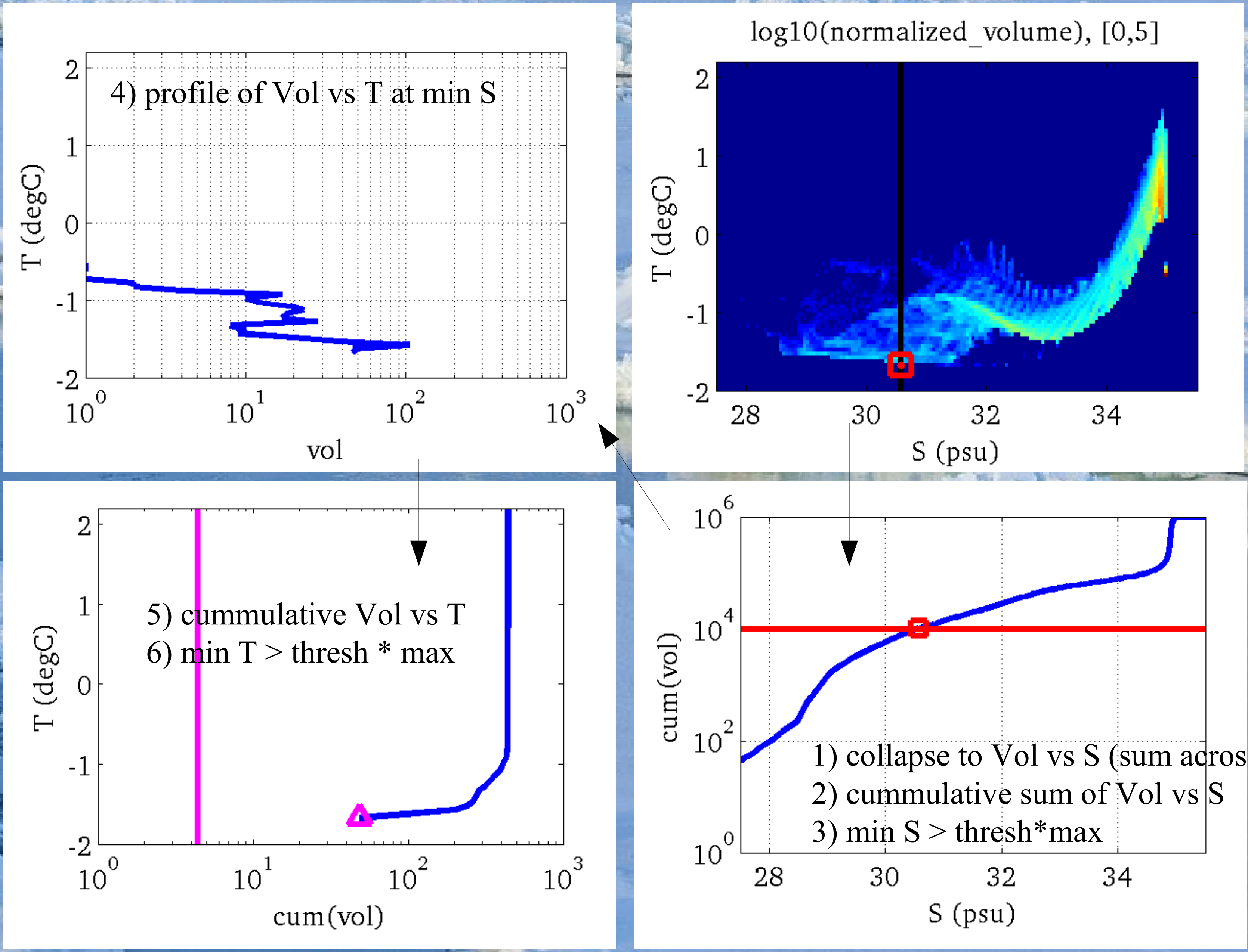
Steps:

1) Fractional volume within each T and S bin
2) Establish a mixing line:
   bottom of mixed layer
   top of Atlantic Water
3) Integrate "weighted" volume under the mixing line

→ curvatures: taken care of with weights.

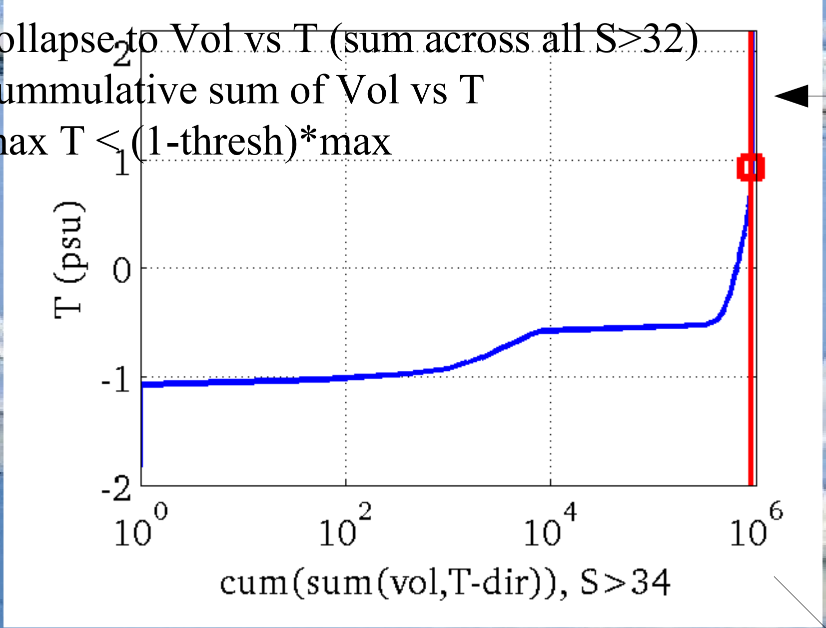


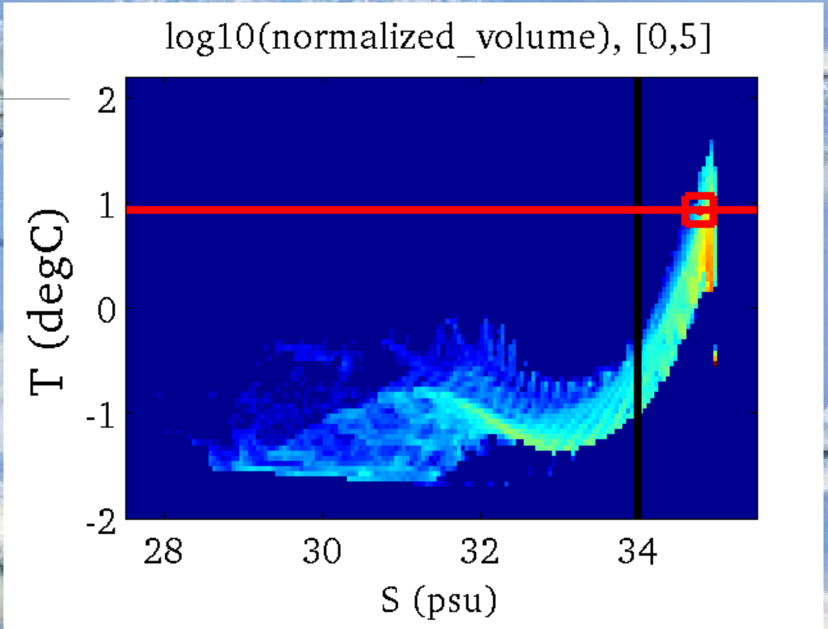
Skill (2): tie points minimum:

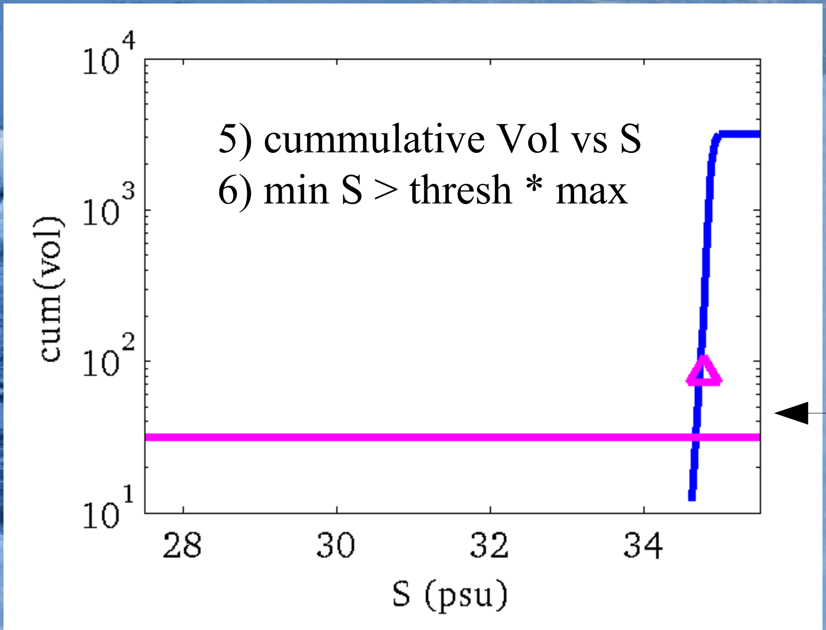


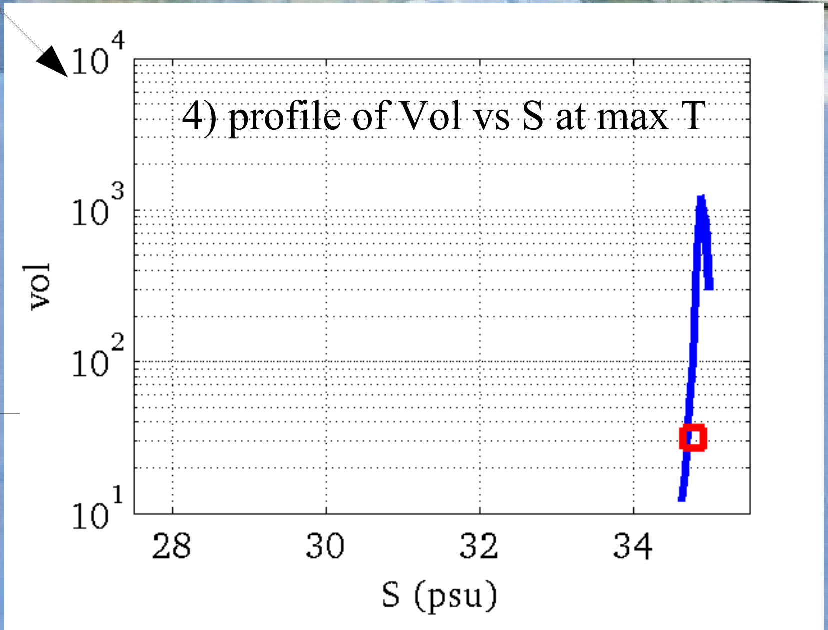
Skill (2): tie points maximum:

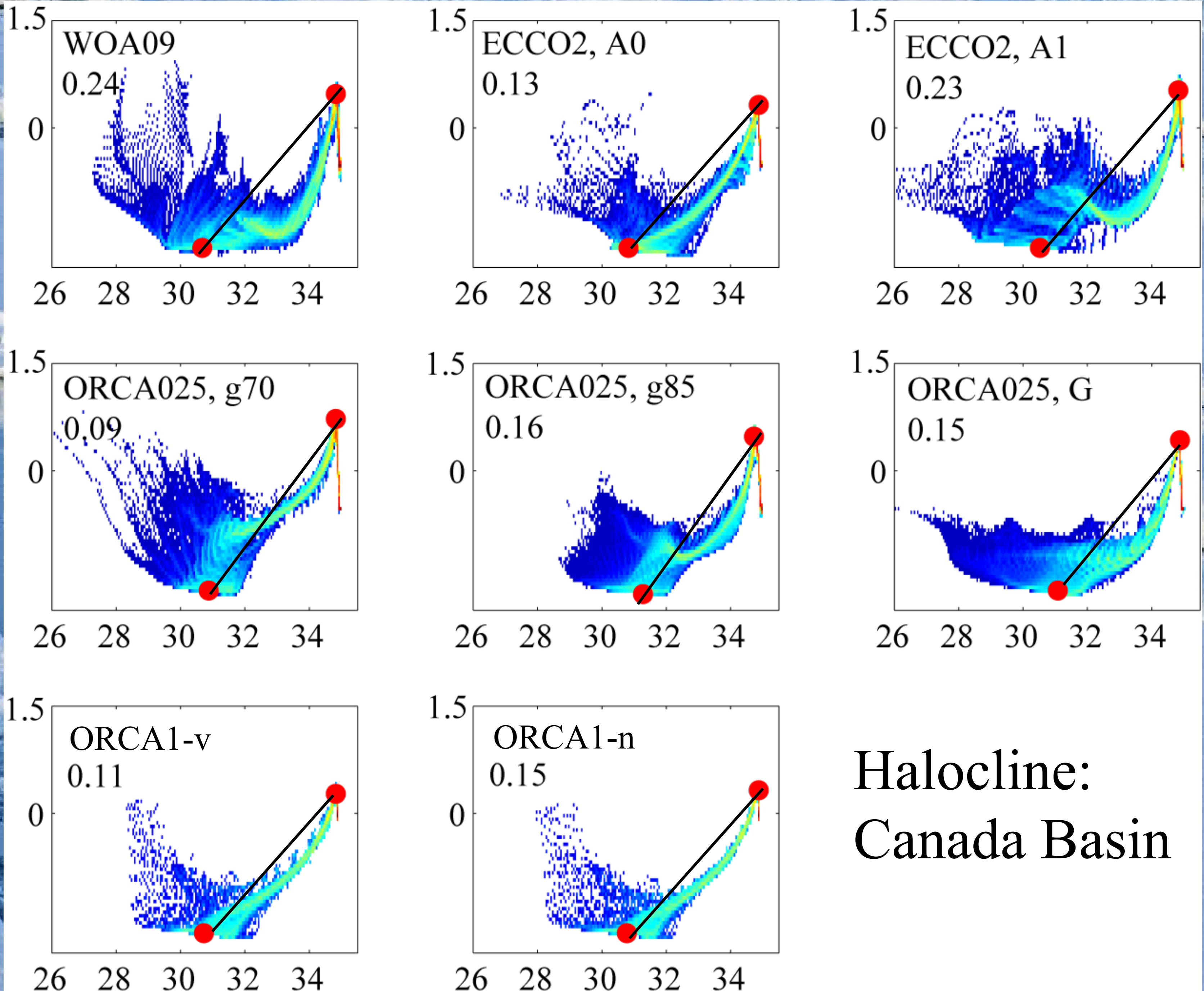
1) collapse to Vol vs T (sum across all S>32)
2) cummulative sum of Vol vs T
3) max T < (1-thresh)*max

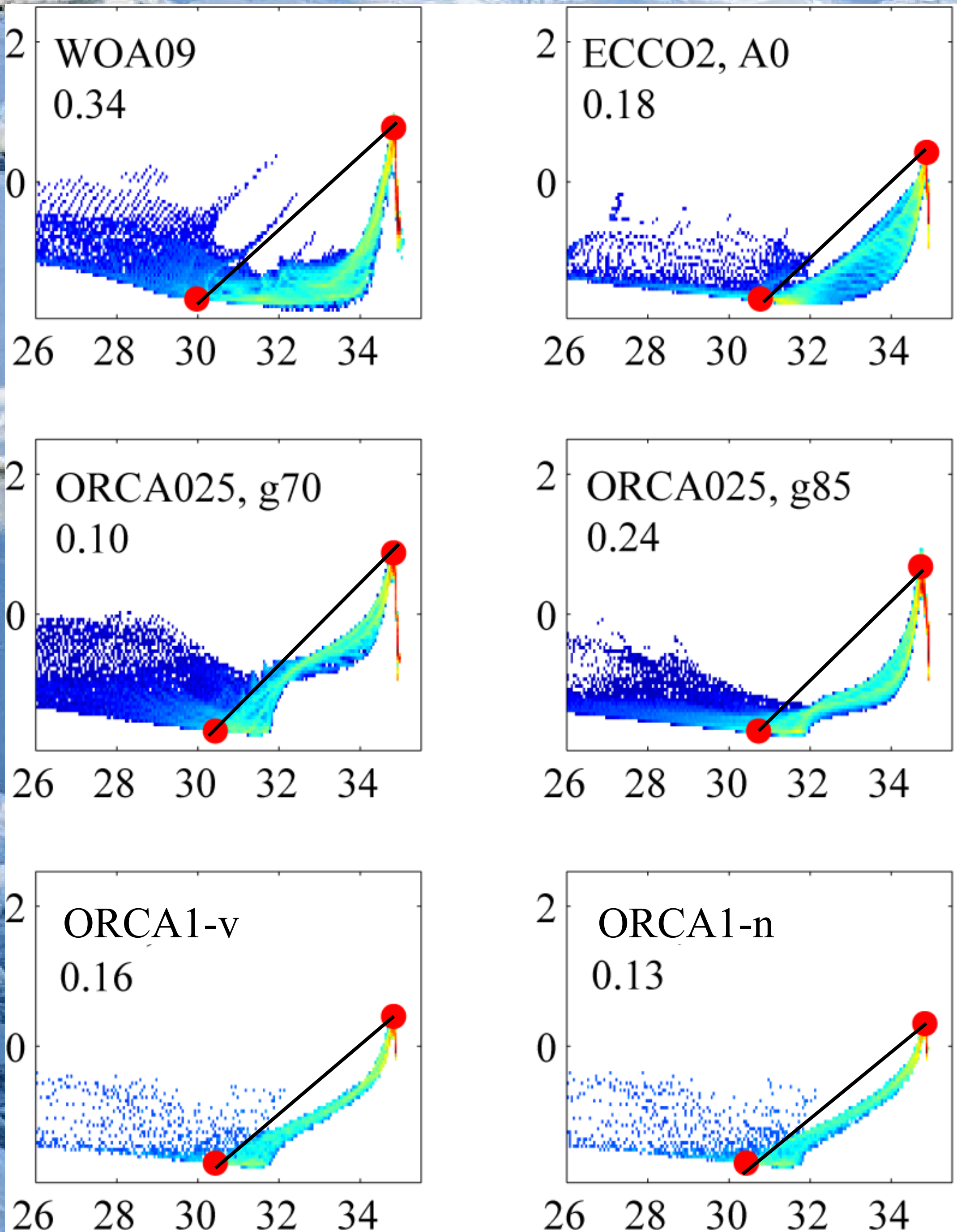









WOA09
0.24
ECCO2, A0
0.13
ECCO2, A1
0.23
ORCA025, g70
0.09
ORCA025, g85
0.16
ORCA025, G
0.15
ORCA1-v
0.11
ORCA1-n
0.15
1.5
0
26
28
30
32
34
Halocline:
Canada Basin

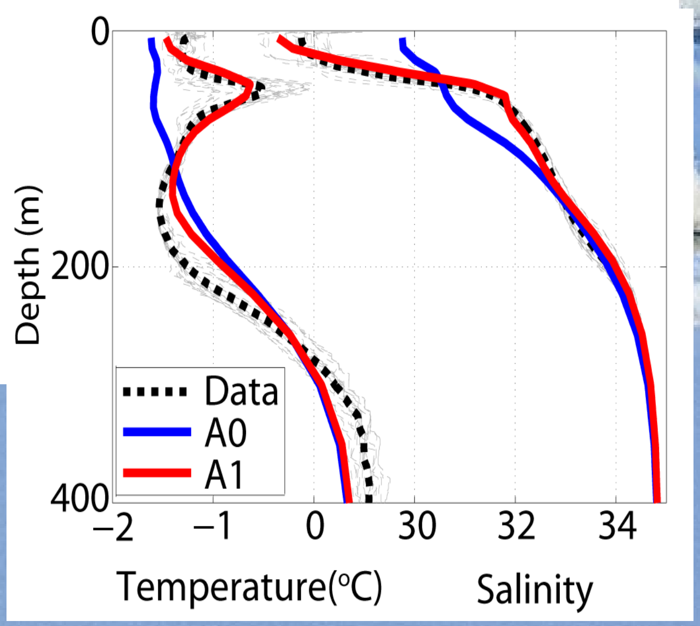


Halocline: Makarov Basin

Discussion

- How to define the mixing line?
  - "works" for Canada and Makarov Basins
- How to use the scores?
    - Identify model biases
    - Resolutions or Missing physics?
      - shelf-water production
      - shelf-basin exchange
      - sub-grid parameterization?

        e.g., brine-rejection scheme



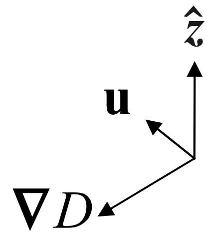

Empty

Background

[Holloway et al, 2007]:

- Circulation direction of Atlantic Water
- A <u>simple</u> measure of currents: “Topostrophy”

$$\tau = \frac{(\mathbf{u} \times \boldsymbol{\nabla} D) \cdot \hat{\mathbf{z}}}{|\mathbf{u}|^2 |\boldsymbol{\nabla} D|^2}$$



- Topostrophy is highly positive when flow is cyclonic with shallow topography to the right
- Advantage: reduce 2-D/3-D vector fields to a scalar