DIAGNOSING THE OBSERVED SEASONAL CYCLE OF ATLANTIC SUBTROPICAL MODE WATER USING POTENTIAL VORTICITY AND ITS ATTENDANT THEOREMS

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EDW Formation Map according to the Walin’s framework

Maze et al, JPO, 2009

Capture only the air-sea heat flux forcing
Does not distinguish low vs high EDW stratification
3 years timeserie of PV on the EDW isopycnal surface

EDW seasonal PV loss:
true mode water
being formed

OCCA ocean state estimate
1x1 degree
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Flux form of the PV conservation equation

- PV is conserved between EDW isopycnals (impermeability theorem)
- PV can only be reduced at the surface (boundary intersection)

What processes drive PV reduction in EDW formation at the surface?

Air-sea buoyancy loss

Down front winds

Diabatic forcing

Mechanical forcing

What are their relative contributions? but first ...
Vertical PV flux (3D):

\[ J_z = \omega_z \frac{\partial \sigma}{\partial t} + \mathbf{k} \cdot \left( \frac{\partial \mathbf{u}}{\partial t} + \nabla \pi \right) \times \nabla \sigma \]

**no Q\textsubscript{net}, no Wind-Stress!**
Vertical PV flux mapped over the EDW outcropping region only:

\[
J_z(X_i, h) = \int_{X_j} J_z(t, x, y, z = h) \mathcal{H}_{\text{mld}}^h(t, x, y) \, dX_j
\]

\[
\mathcal{H}_{\text{mld}}^h(t, x, y) = \begin{cases} 
1 & \text{if } \sigma \text{EDW} - \frac{\delta \sigma}{2} < \sigma(z = h) \\
& \sigma(z = h) \leq \sigma \text{EDW} + \frac{\delta \sigma}{2} \\
0 & \text{mld} \leq h
\end{cases}
\]

**OCCA ocean state estimate**

1x1 degree

**Schematic view of EDW formation and circulation**

EDW is formed, then circulate and ventilate the EDW pool

Small contribution from the mechanical forcing (13%),
but this is a 1x1 degree ocean state
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DRAKKAR Eddy resolving simulation (1/12)
Maze et al, DSRII, sub.2012

![Snapshot (2003/03/16)](image)

**Jz Diabatic**

**Jz Mechanic**

**PV gain**

**PV loss**

**Local mean**

**EDW mean**
Key points

- Low PV EDW is mostly formed by diabatic forcing
- Mechanical contribution seems to be about 10-15% the total (at 1x1, 1/12 and more ...)

**BUT**

the EDW *mechanically* formed does not take the same pathway to the EDW core: more (and different) diagnostics are required to quantify formation at meso (and submeso) scales.
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PV on the EDW isopycnal surface:

EDW seasonal PV loss: true mode water being formed