# EGU – May 24 2022

# Chaotic variability of the North Atlantic Subtropical Mode Water

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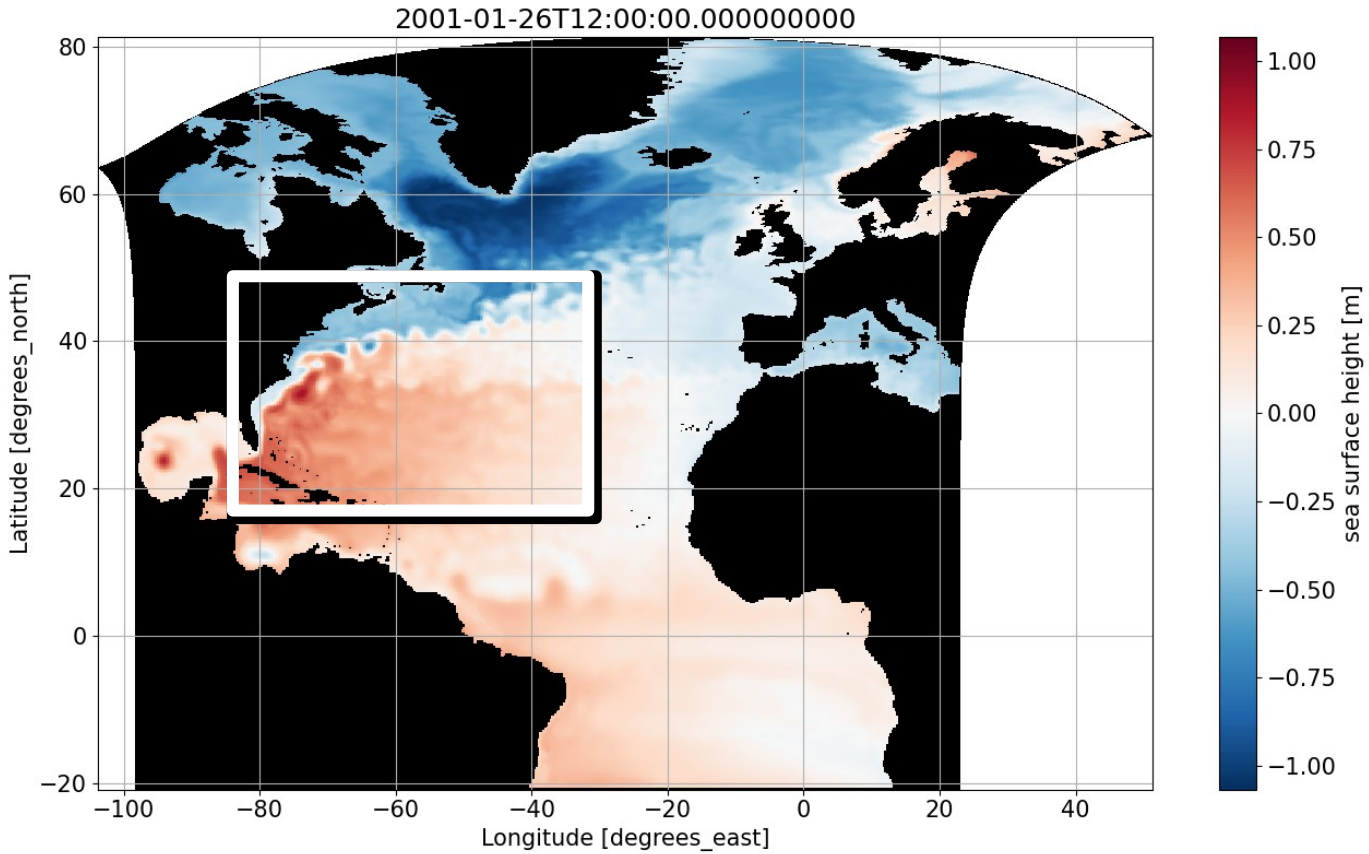
# Importance of chaotic/intrinsic variability

CMIP6: 1/4° ocean now possible, turbulence hence visible (“eddy-resolving” e.g. in sea surface height below)
Model: NEMO, 1/4° - region: North Atlantic
Area of focus: Eighteen Degree Water (North Atlantic Subtropical Mode Water) in the Sargasso sea

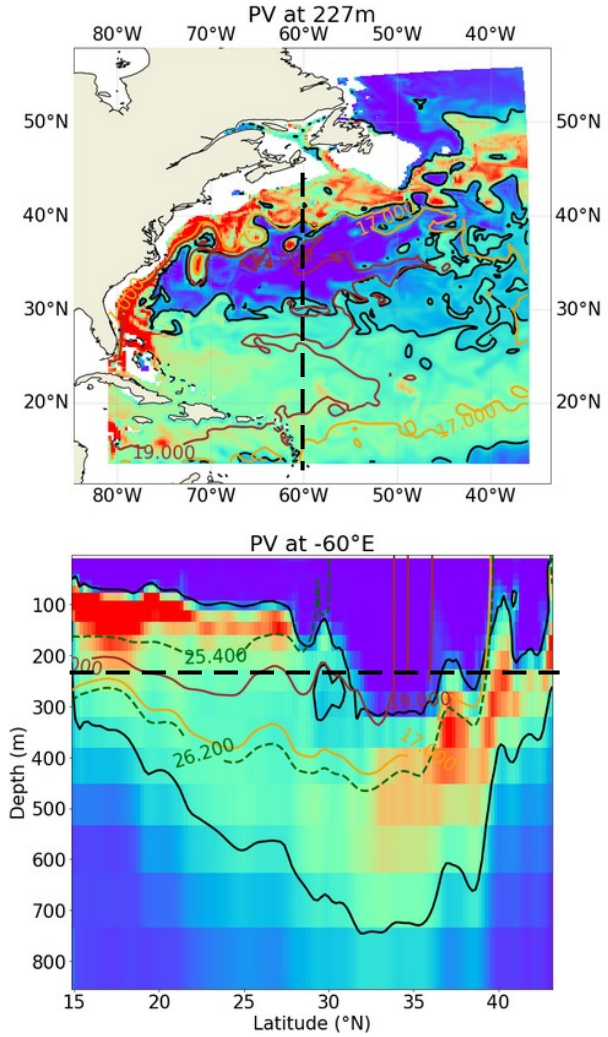



**How much chaotic variability do eddies introduce?**

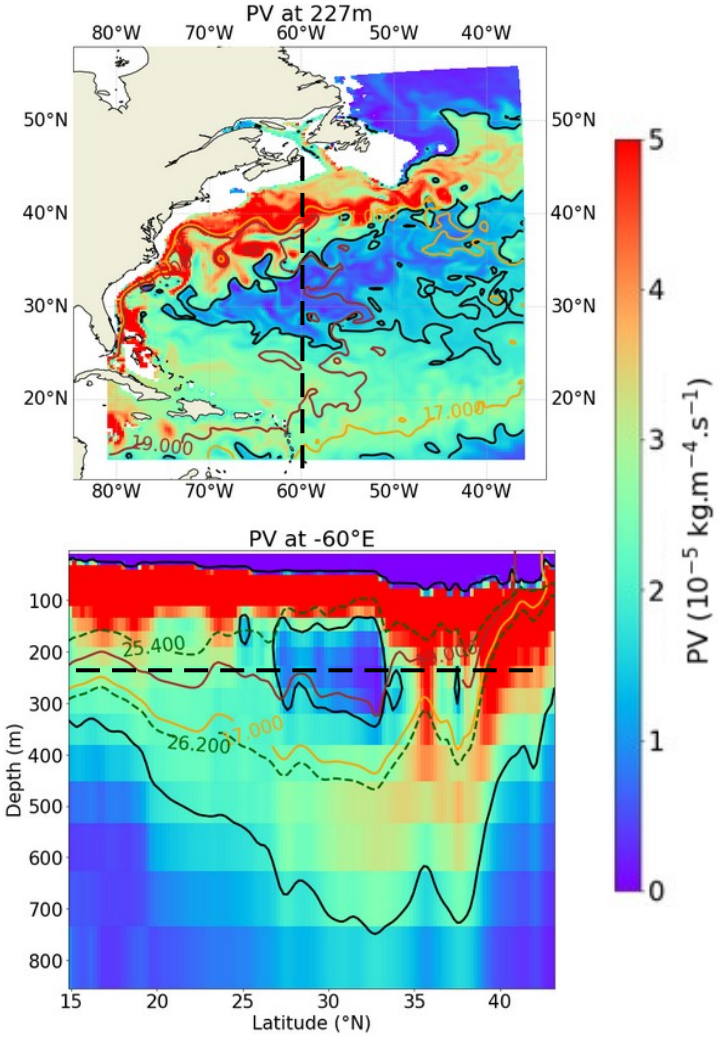
# EDW in the model

Colormap: PV
orange/brown: 17°C/20°C isotherms
Green dashed: density
**Black**: PV=1.7 (max value threshold for EDW definition)

## March 20, 2009




## November 9, 2009




**EDW**:
Region: 13°N-55°N and 36°W-82°W

Neutral density range: 25,4 to 26,2 kg.m$^{-3}$

$Q_{Ertel} < 1{,}7\ 10^{-5}$ kg.m$^{-4}$.s$^{-1}$

$$Q = \frac{1}{\rho_0} \cdot (\zeta + f) \cdot \frac{\partial \rho}{\partial z}$$

**Model EDW matches observations**

**EDW formation and variability are generally thought to be largely atmosphere-driven: formed in winter mixed layer**

# Ensemble approach

**Ensemble approach:**

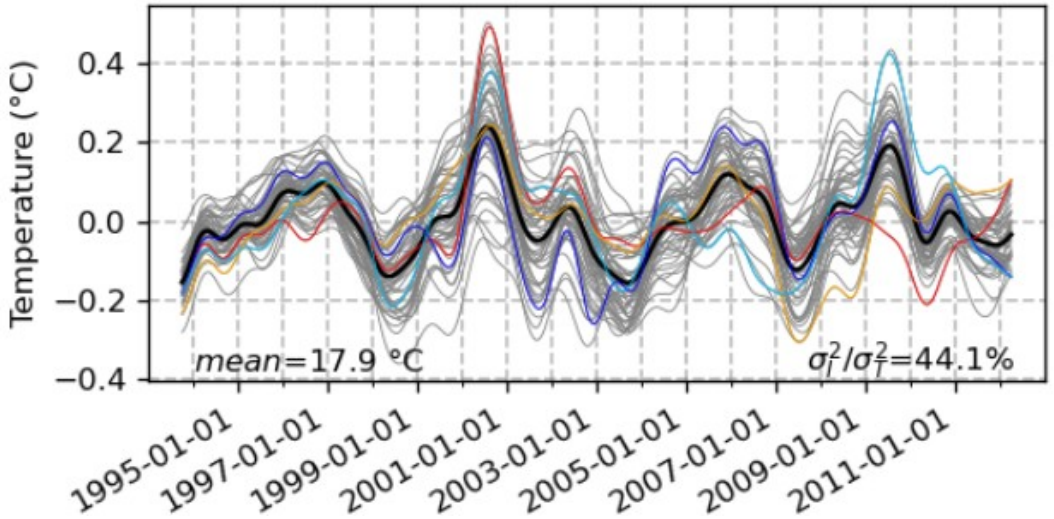
- 50 members with the same equation of state
- stochastic perturbations in the ocean for one year
- same DFS5.2 atmospheric forcing (reanalysis)
- same surface fluxes

$$\sigma_I^2 = \overline{var_m(X(t))}^t$$ **Intrinsic variability**

$$\sigma_F^2 = var_t(\langle X(t)\rangle_m)$$ **Forced variability**

$$\sigma_T^2 = \langle var_t(X(t))\rangle_m$$ **Total variability**

**Interannual temperature anomalies in the EDW (18-month cutoff)**




*Thin lines are individual members, thick black line is ensemble average*

Contribution of chaotic/intrinsic processes to EDW interannual variance

| | Volume (Sv.y) | Temperature (°C) | PV ($10^{-7}$ $kg.m^{-4}.s^{-1}$) | Salinity (psu) | Depth (m) | Neutral density ($kg.m^{-3}$) |
|---|---|---|---|---|---|---|
| $\sigma_I^2/\sigma_T^2$ | 13.2 % | 44.1 % | 10.6 % | 24.8 % | 13.0 % | 38.4 % |

**Oceanic chaos accounts for a substantial part (10-44 %) of the interannual variability of EDW. These results are obtained at 1/4° resolution and are likely underestimated**