On the reasons for the formation and the variability of the Azores Current

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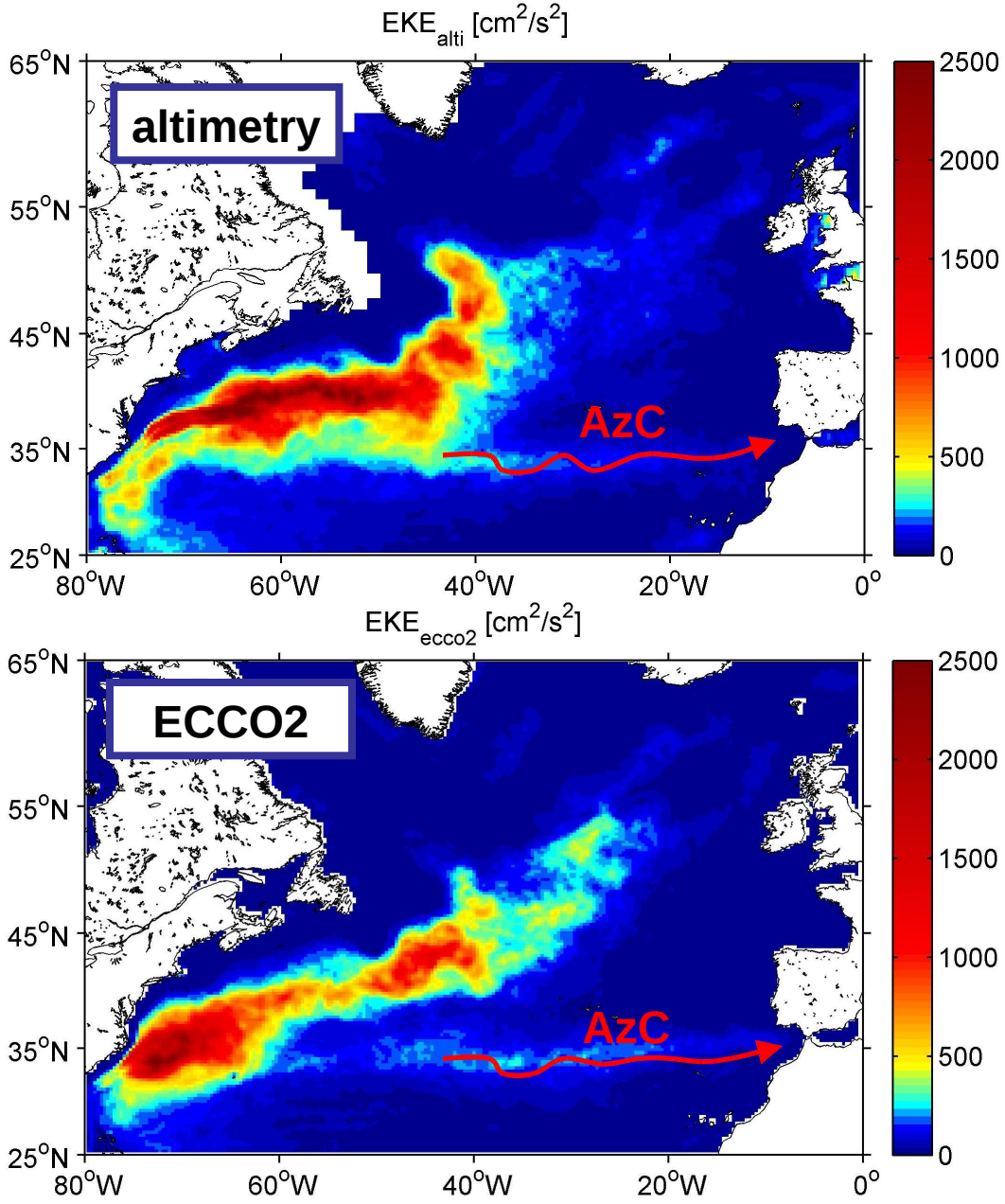


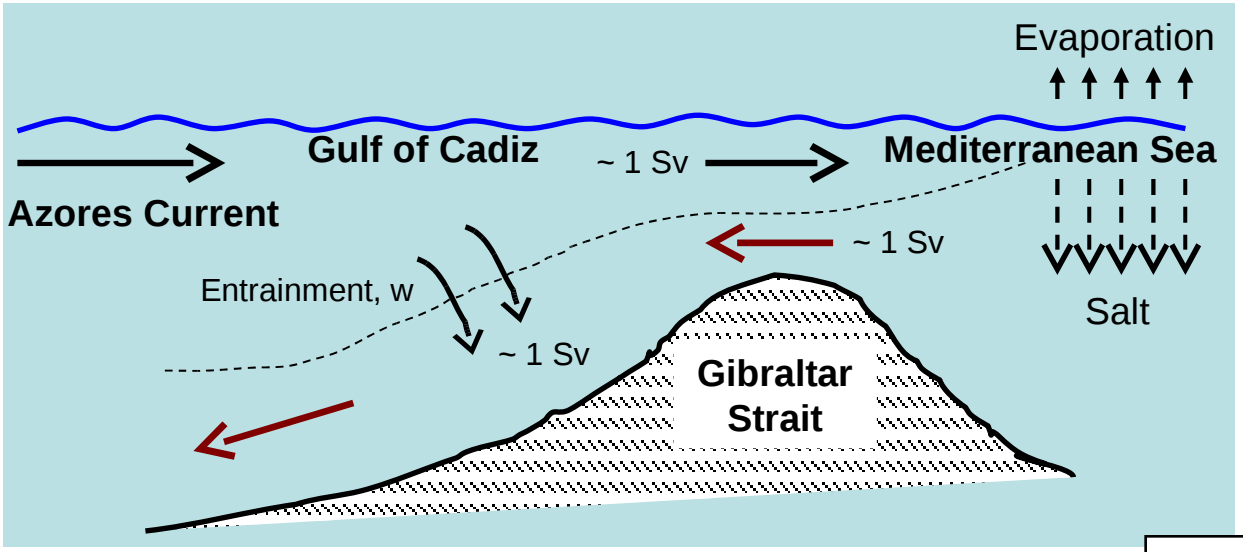
10-year mean eddy kinetic energy, [cm²/s²]

Azores Current:

- Part of the North Atlantic Subtropical Gyre
- Quasi-zonal current (between 32ºN-36ºN)
- Eastward transport ~10-12 Sv (mostly concentrated in the upper 1000 m)
- Velocities > 10 cm/s
- Complex mesoscale variability (meandering, eddies, Rossby waves)

Why is it there?

- Sverdrup dynamics fails to explain zonal orientation of the AzC [Townsend et al., 2000]
- Large variations in wind stress curl do not explain relatively stable position of the AzC axis [Le Traon and de Mey, 1994].
- The exchange through the Strait of Gibraltar and associated water mass transformation in the Gulf of Cadiz may be the key factor. **Hypothesis: the AzC is formed by the virtue of β-plume mechanism** [Jia, 2000; Özgökmen et al., 2001; Kida, 2006].



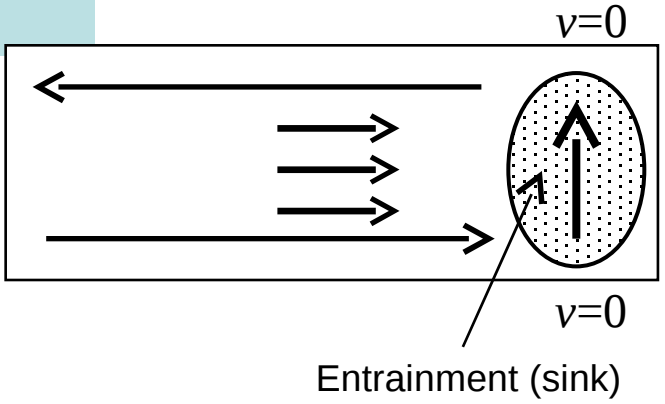
β-plume concept:

[Stommel, 1982; Spall, 2000]

$$v = \frac{f}{\beta H} w_d$$

w_d – diapicnal velocity

H – thickness of the active layer



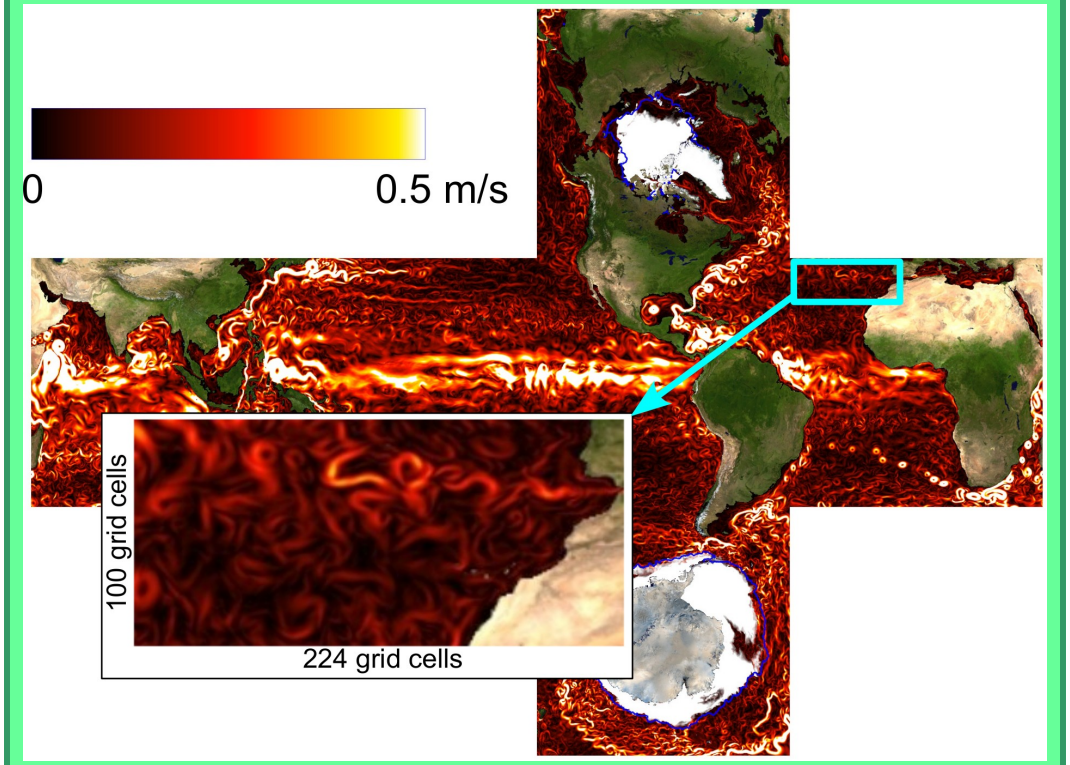
Uncertainties:

1. Linear theory greatly exagerates transport
2. Hypothesis is based on simplified [Jia, 2000; Özgökmen et al., 2001] and idealized [Kida, 2006] models

Questions:

1. Would the AzC exist in the absence of the Mediterranean overflow (no Gibraltar Strait)?
2. How the variability of wind forcing influences the variability of the AzC?
3. Would there be the AzC if the wind forcing was absent?
4. How the strength of the water mass exchange through the Gibraltar Strait influences the AzC?
5. How the variability of the water mass exchange through the Gibraltar Strait influences the AzC?

Methods:



Numerical experiments

- Baseline experiment (Exp0) – global optimized ECCO2 solution
- 10 sensitivity experiments on the AzC domain with boundary conditions from Exp0
- Forcing – ERA40
- Period of model run – Jan 1992 to Jan 2001

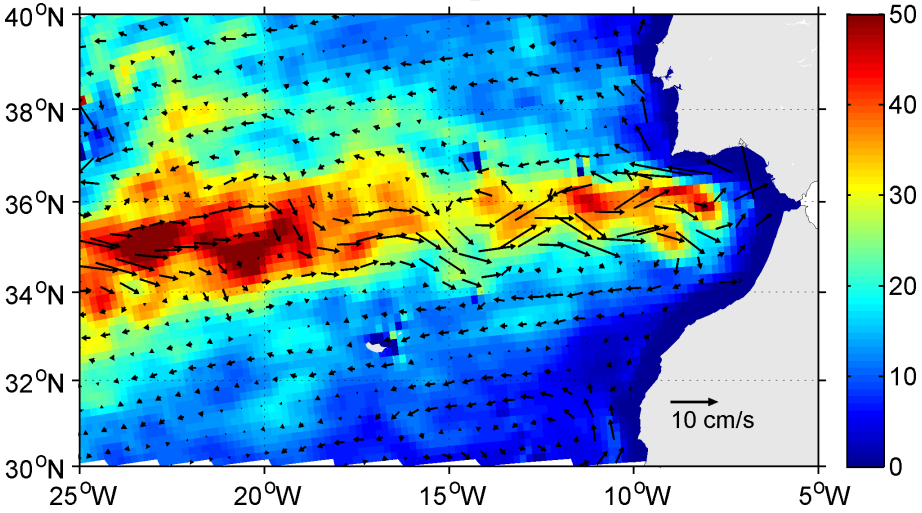
Question 1

Would the AzC exist in the absence of the Mediterranean overflow?

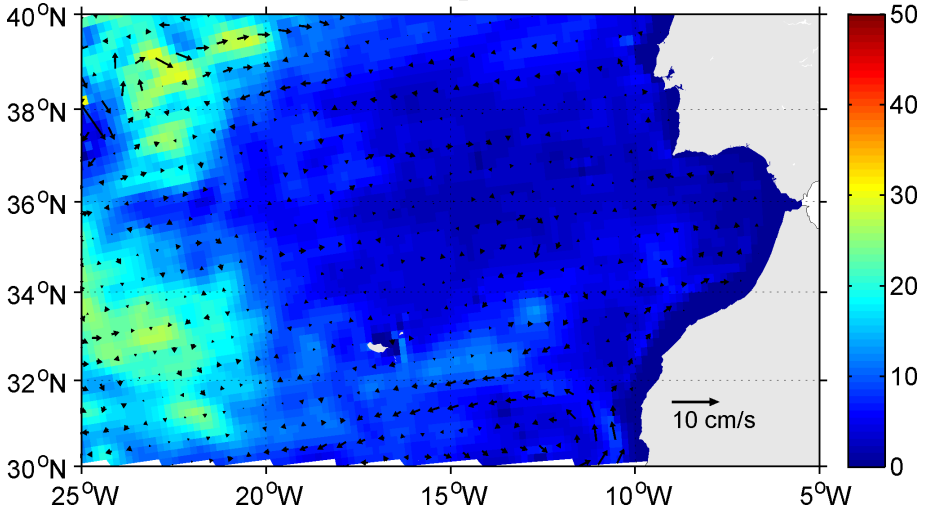
NO!
Confirms β-plume hypothesis

Experiment	*Gibraltar St*	*Wind forcing*	*AzC transport*	*Entrainment*
Exp0 (optimized global)	realistic ~1 Sv in and out	realistic	8.3	0.8
Exp1	closed	realistic	0.9	-

Exp0



Exp1



Eddy kinetic energy (cm^2/s^2) and velocity (cm/s) averaged from 100 to 800 m depth

Questions 2 and 3

How the variability of wind forcing influences the AzC?

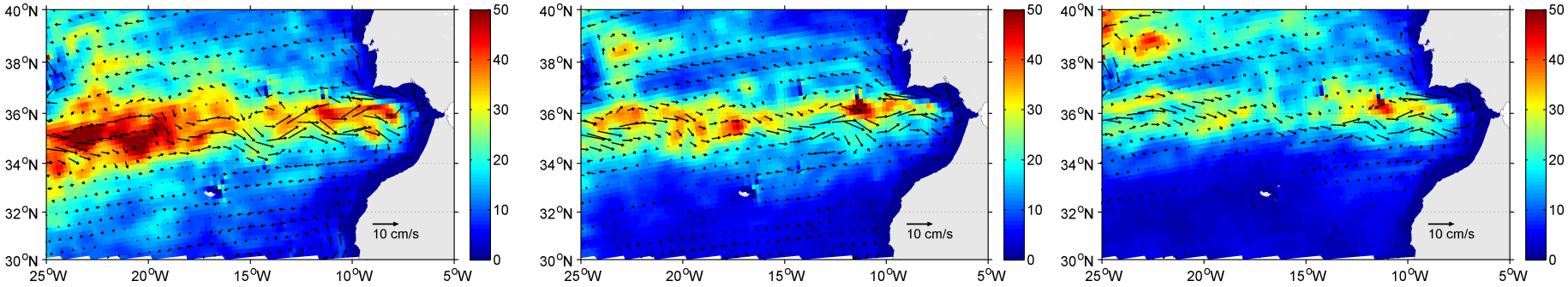
→ **Modifies variability with almost no effect on transport**

Would there be the AzC if the wind forcing was absent?

→ **Yes, with smaller transport**

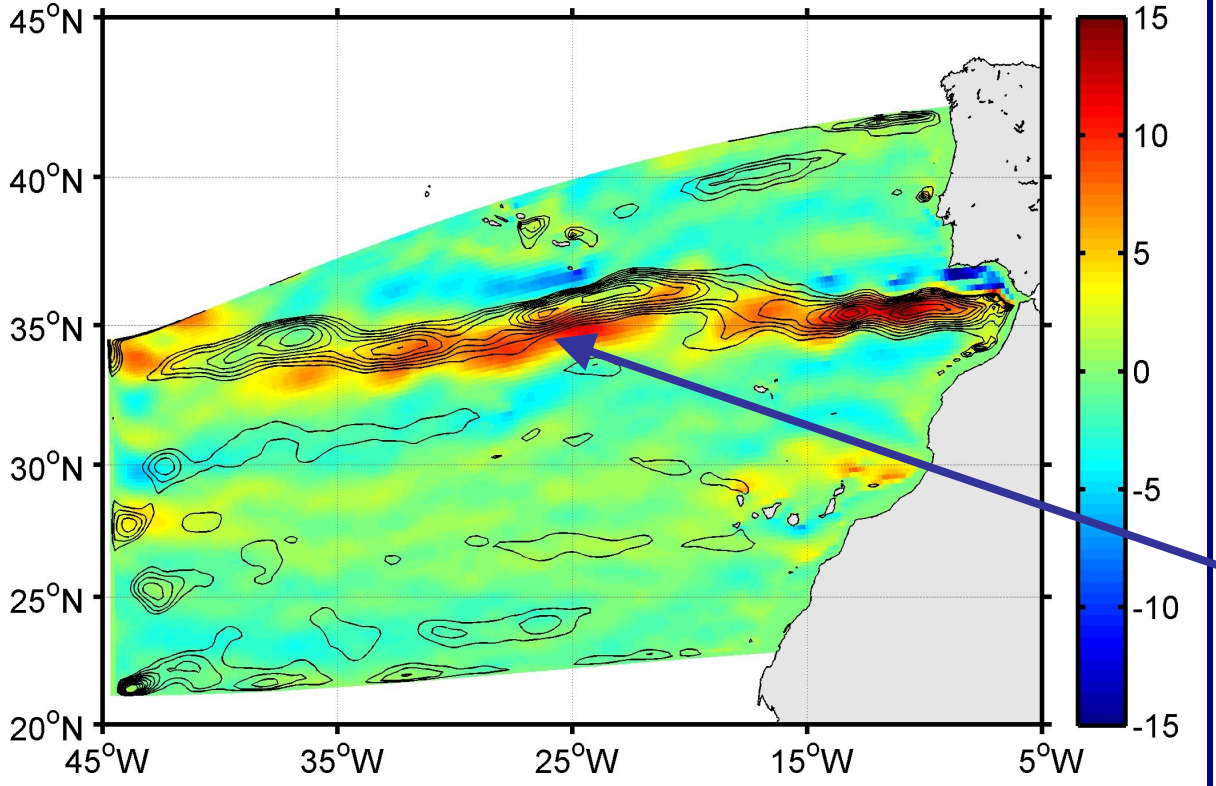
Experiment	*Gibraltar St*	*Wind forcing*	*AzC transport*	*Entrainment*
Exp0 (optimized global)	realistic ~1 Sv in and out	realistic	8.3	0.8
Exp2	realistic	constant (time mean for 1992)	7.6	0.8
Exp3	realistic	no wind	6.2	0.64

Exp0 **Exp2** **Exp3**



Eddy kinetic energy (cm²/s²) and velocity (cm/s) averaged from 100 to 800 m depth

Wind and the latitude of the AzC



The eastward velocities (cm/s), averaged from 100 to 860 m.

Exp0 – color, realistic wind

Exp3 – contour, no wind

Shift of ~ 1 deg

Sverdrup dynamics possibly modifies the latitude of the AzC (?)

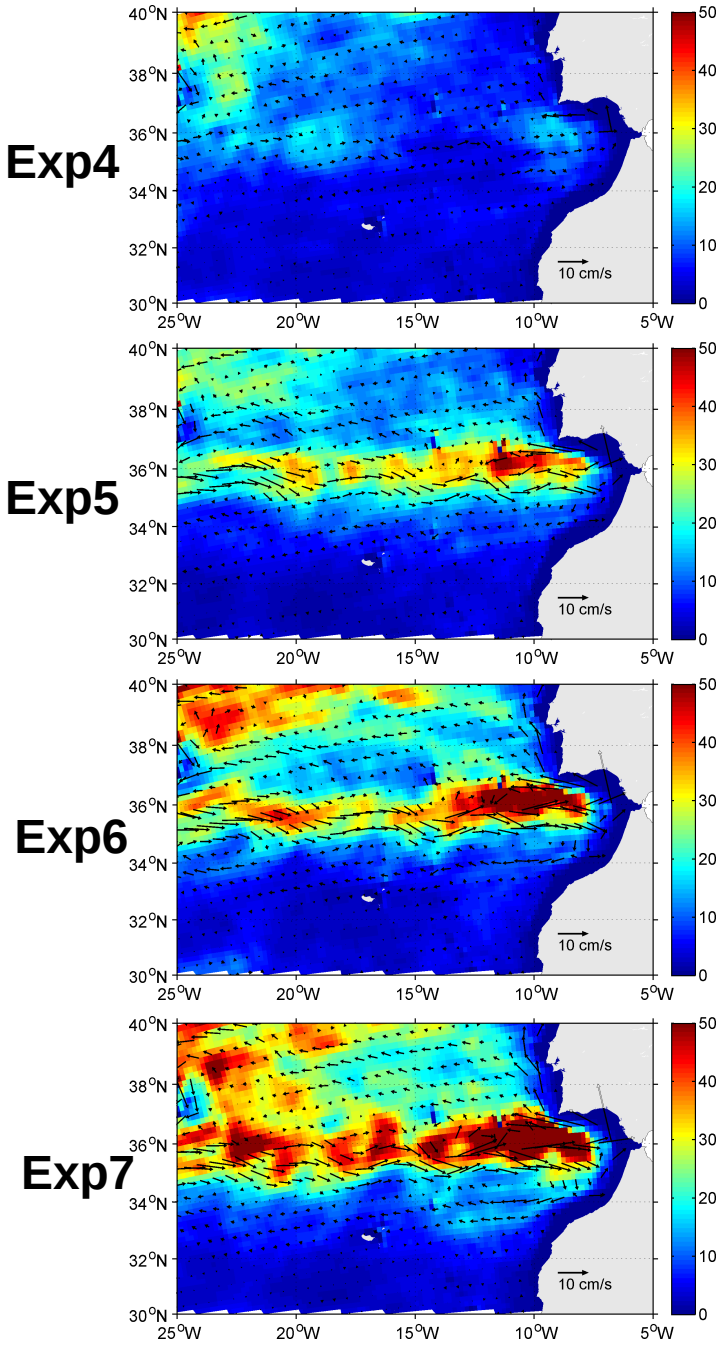
Question 4

How the strength of the water mass exchange through the Gibraltar Strait influences the AzC?

The stronger the exchange through the strait – the larger the transport and the variability of the AzC

Experi-ment	*Gibraltar Strait*	*Wind forcing*	*AzC transport*	*Entrain-ment*
Exp4	constant =0.5 Sv in and out	no wind	3.0	0.47
Exp5	constant =1 Sv in and out	no wind	7.0	0.66
Exp6	constant =1.5 Sv in and out	no wind	10.4	0.82
Exp7	constant =2 Sv in and out	no wind	12.5	0.89

Eddy kinetic energy (cm^2/s^2) and velocity (cm/s) averaged from 100 to 800 m depth

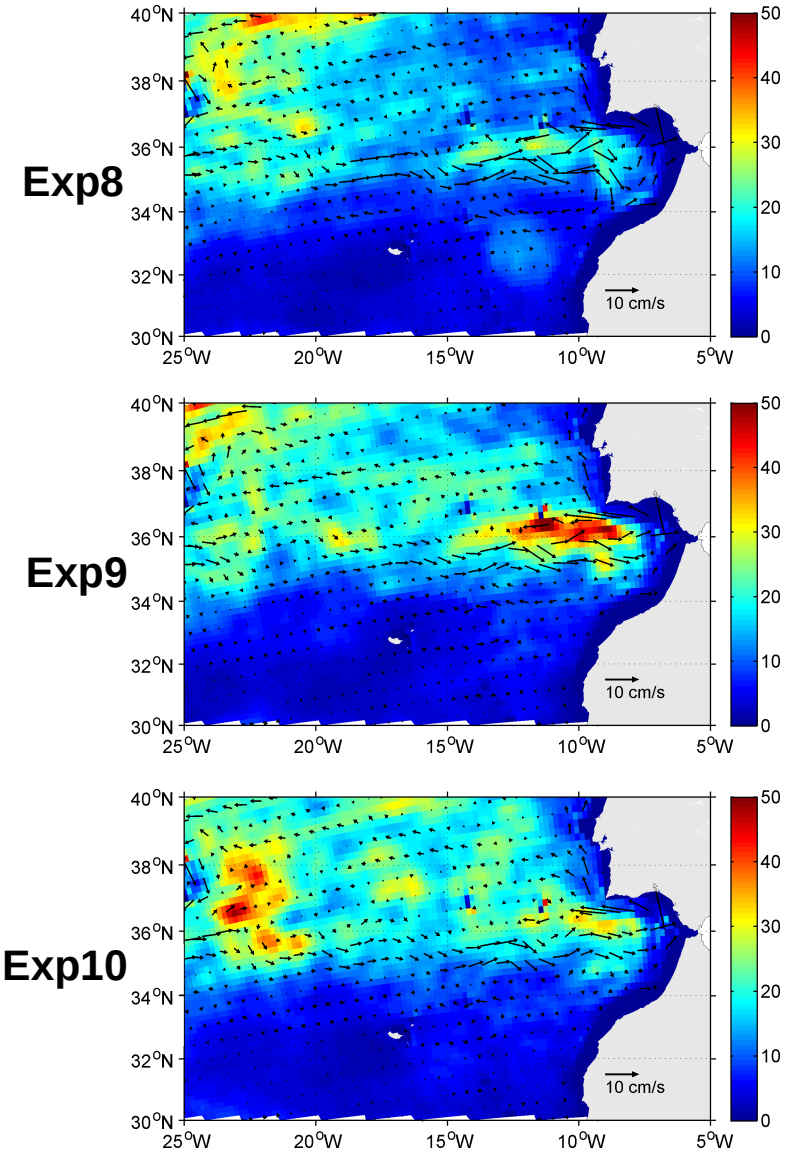


Question 5

How the variability (seasonal) of the water mass exchange through the Gibraltar Strait influences the AzC?

Experi -ment	*Gibraltar Strait*	*Wind forcing*	*AzC transport*	*Entrain -ment*
Exp8	variable [Q]=1 Sv, A(Q)=0.1 Sv	no wind	6.1	0.68
Exp9	variable [Q]=1 Sv, A(Q)=0.3 Sv	no wind	5.2	0.7
Exp10	variable [Q]=1 Sv, A(Q)=0.5 Sv	no wind	5.7	0.68

No significant impact on the strength and the variability of the AzC



Eddy kinetic energy (cm^2/s^2) and velocity (cm/s) averaged from 100 to 800 m depth

Summary:

1. The exchange through the Strait of Gibraltar and associated diapicnal sinking in the Gulf of Cadiz play a key role in the formation of the Azores Current (confirms the β – plume hypothesis).

2. The effect of wind forcing:
   - Wind is not responsible for the formation of the AzC
   - The variability of wind forcing increases the variability of the AzC
   - Wind shifts the latitude of the AzC axis southward by ~1^{o}

3. The effect of the water mass exchange through the Strait of Gibraltar:
   - The stronger the exchange the stronger the transport and the variability of the AzC
   - The seasonal variability of the exchange has no great effect on the strength and the variability of the AzC