# New parameterizations of gravity currents and turbulence in MICOM

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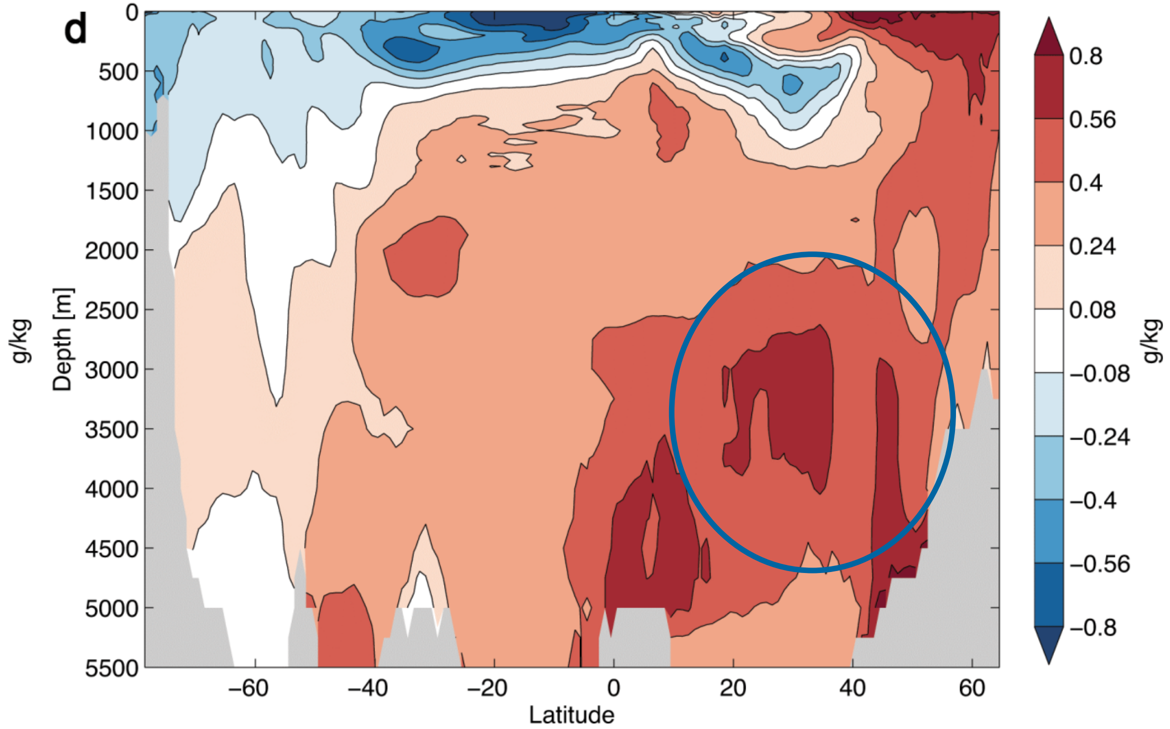
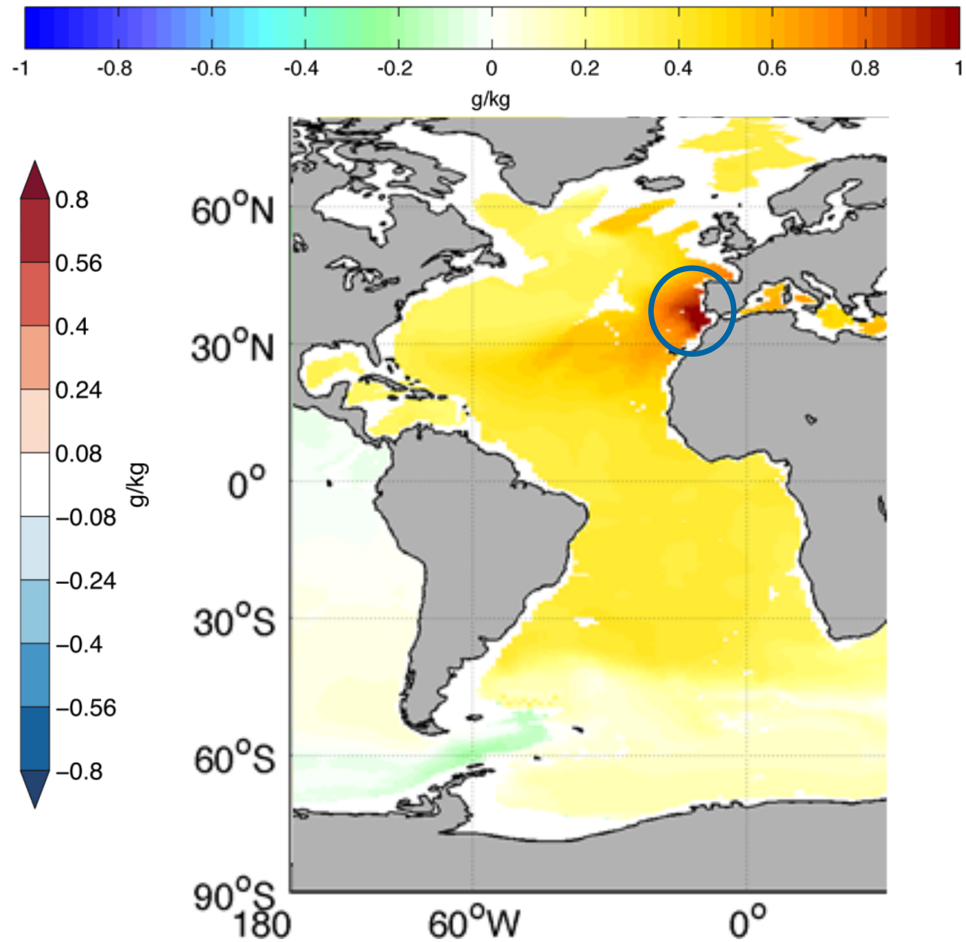
# Outline

- Motivation
- Partial cell approach for narrow channels
- Generic Length Scale (GLS) turbulence model
- Idealized experiments
- Climate simulations (preliminary results)

# Salinity bias in the Atlantic Ocean

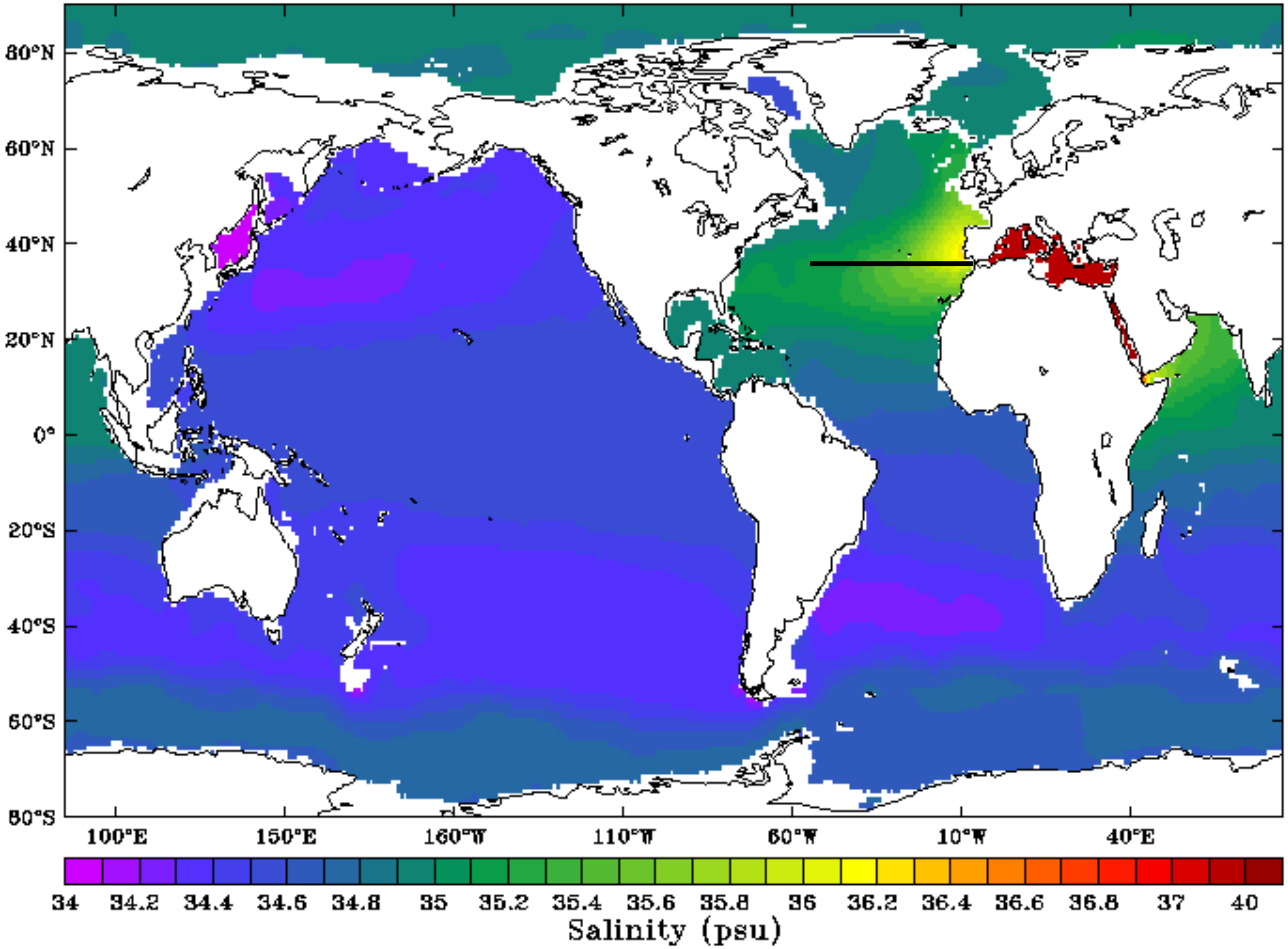



Salinity difference at the Atlantic Ocean.
(Bentsen et al. (submitted))

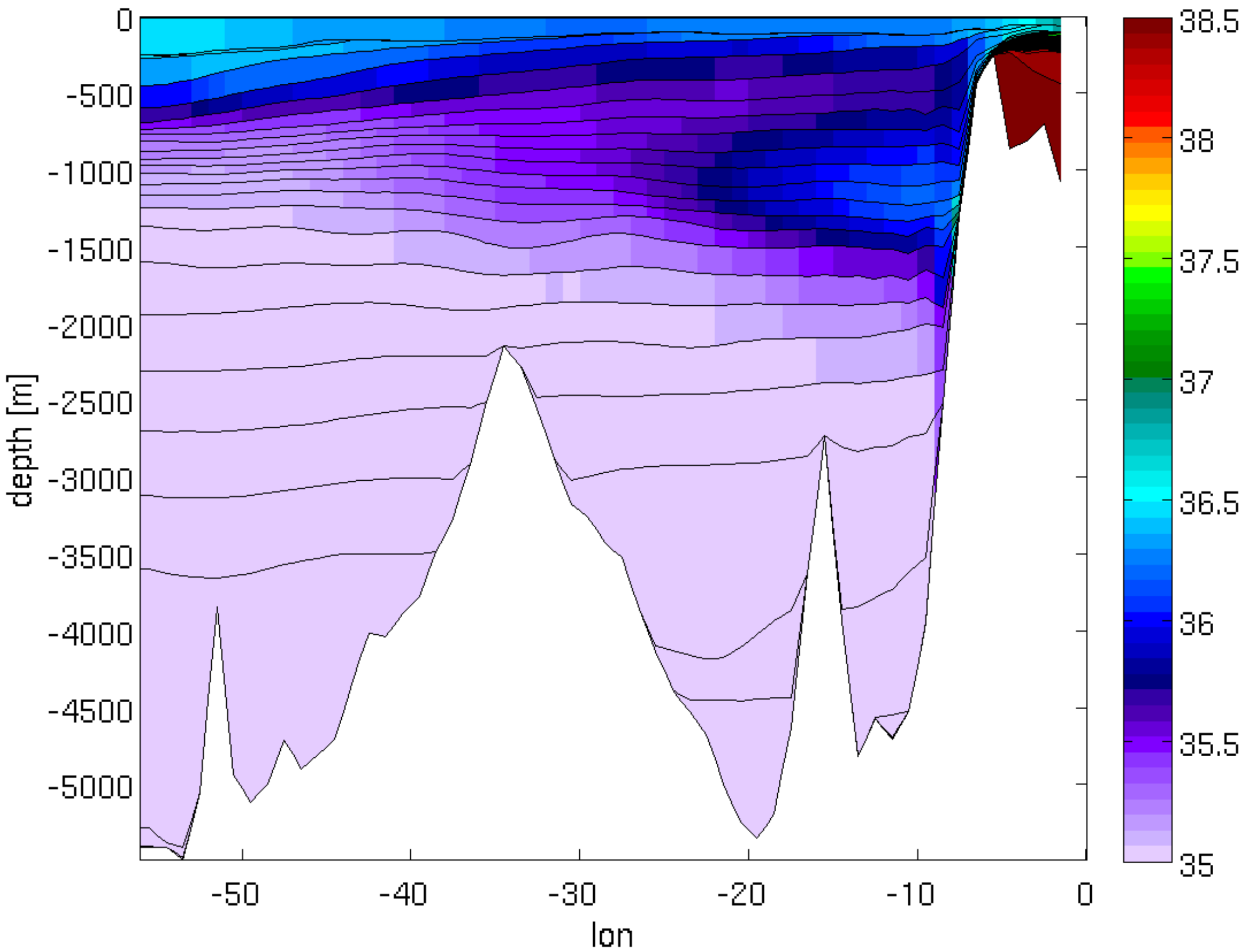



Salinity difference at z=2500m
after 1150 years.

# Climatology Salinity at 1100 m Depth

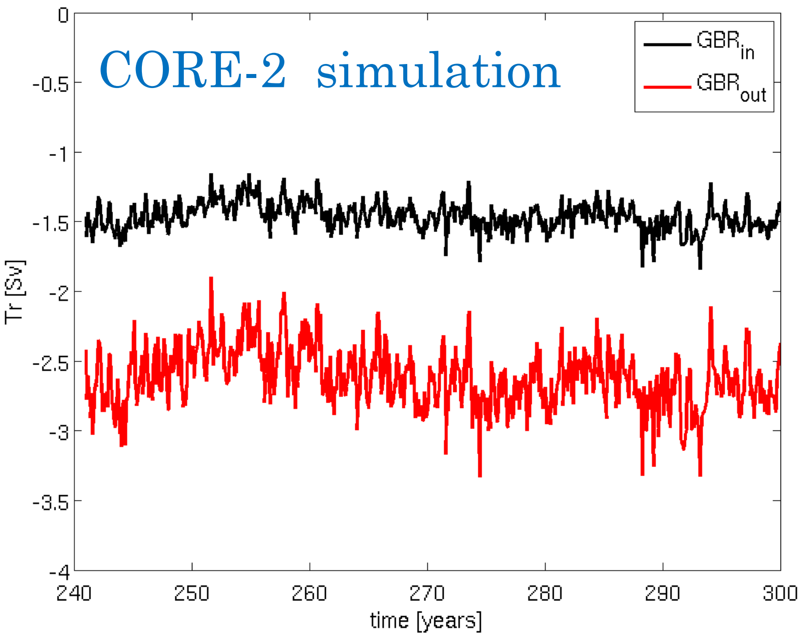


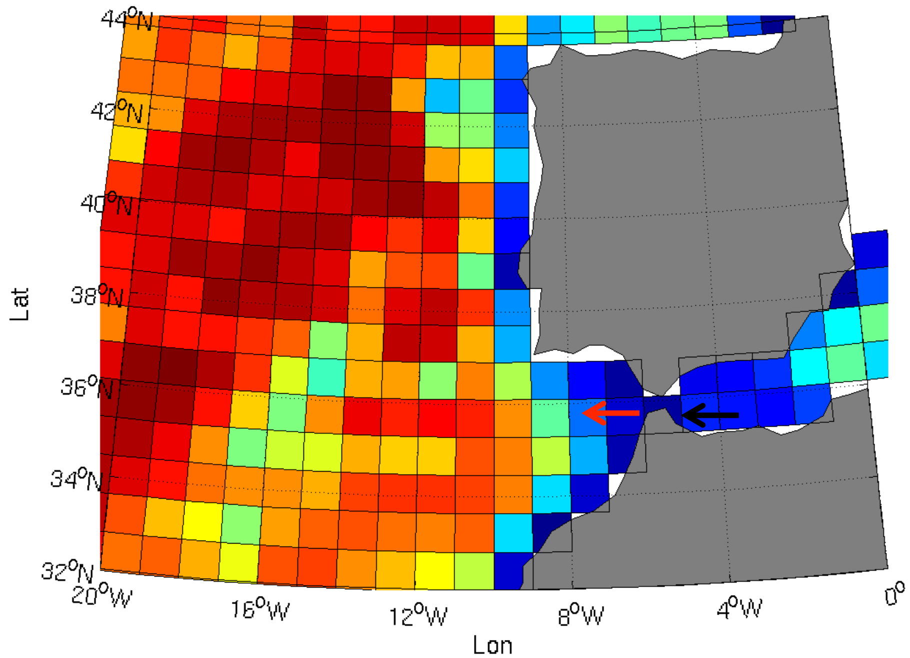
# Salinity in the Med Section movie




Core 2 simulation

# Transport at Gibraltar



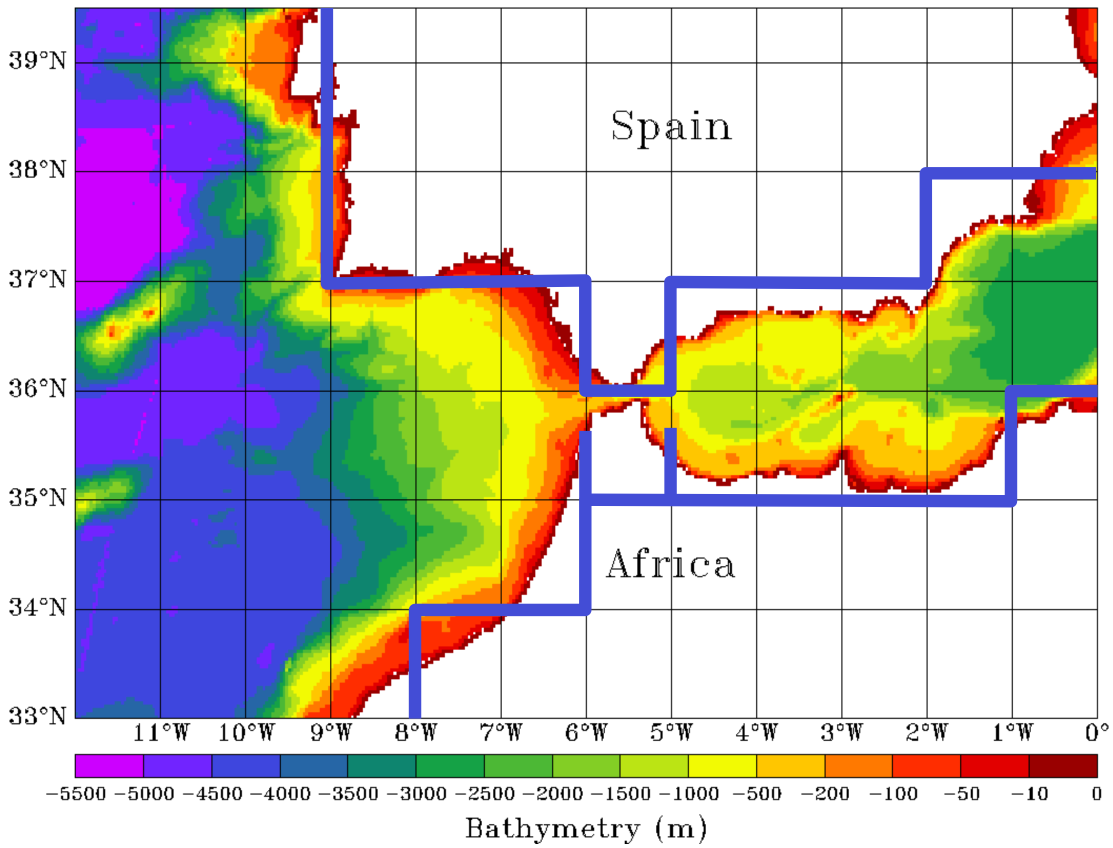




Bathymetry

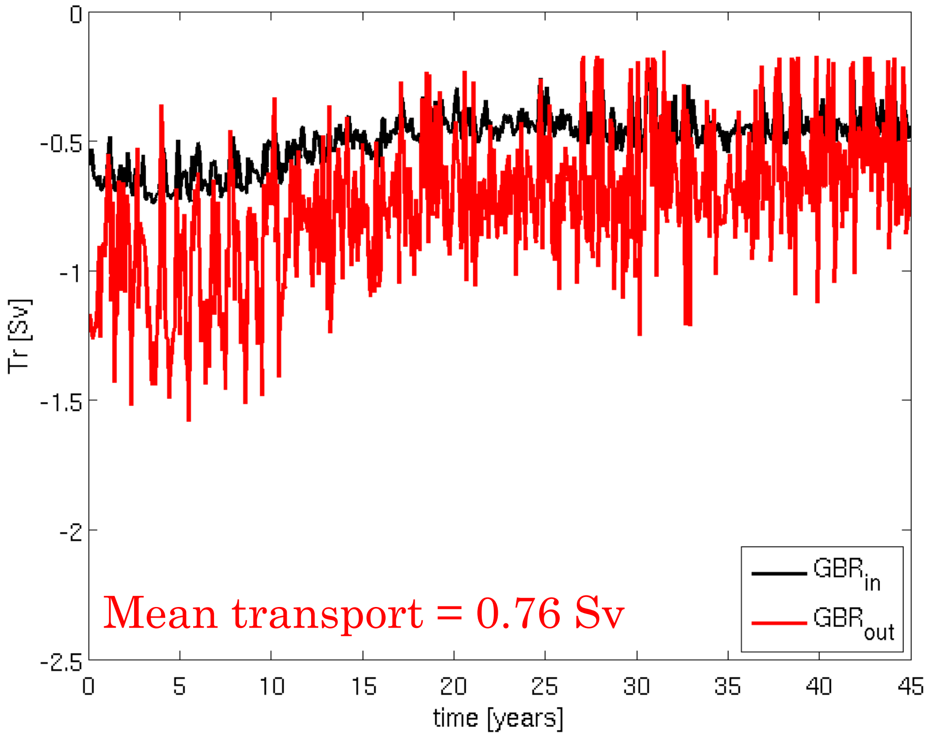
- Gibraltar channel is only 14 km wide.
- 1 degree Ocean Models have larger overflow transport than the observations (≈ 0.7 Sv).

# Transport at Gibraltar

- We employ the GFDL isopycnic model's "partial cell" approach.
- The side walls at the Gibraltar channel are reduced to 14 km.
- KE scheme in the momentum equation and continuity equation have to be slightly modified in MICOM to be energetically consistent.



# Transport at Gibraltar with partial cells




CORE-2 simulation

$$\kappa_\rho = \kappa_0 \left(1 - \left(\frac{Ri}{Ri_{cr}}\right)^2\right)^3$$

where $\kappa_0 = 5x10^{-3} \frac{m^2}{s}$ ; $Ri_{cr} = 0.7$

Bottom 300 m; $\kappa_0 = 2.5x10^{-1} \frac{m^2}{s}$

It does not obey the Buckingham π theorem

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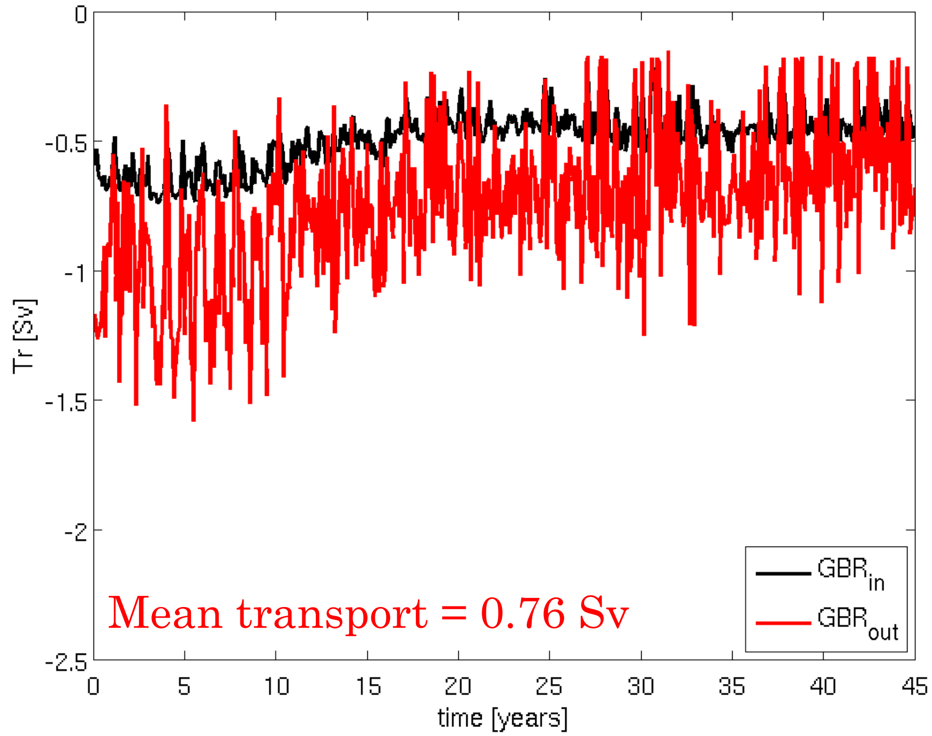


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# GLS two equation turbulence models

<u>Full k- ε turbulence model</u>

$$\frac{Dk}{Dt} = \mathrm{P} + \mathrm{B} - \varepsilon + \frac{\partial}{\partial z}\left(\kappa_t \frac{\partial k}{\partial z}\right)$$

$$\frac{D\varepsilon}{Dt} = \frac{\varepsilon}{k}(c_1\mathrm{P} + c_3\mathrm{B} - c_2\varepsilon) + \frac{\partial}{\partial z}\left(\kappa_t \frac{\partial \varepsilon}{\partial z}\right)$$

$$P = \nu_t\, S^2\, ; B = -\kappa_t\, N^2$$

$$\nu_t = c_\mu \sqrt{k} l S_M\ ;\ \kappa_t = c_\mu \sqrt{k} l S_H$$

$$l = {c_\mu}^3 k^{3/2} \varepsilon^{-1}$$

Umlauf and Burchard (2005)

<u>Algebraic tke turbulence model</u>

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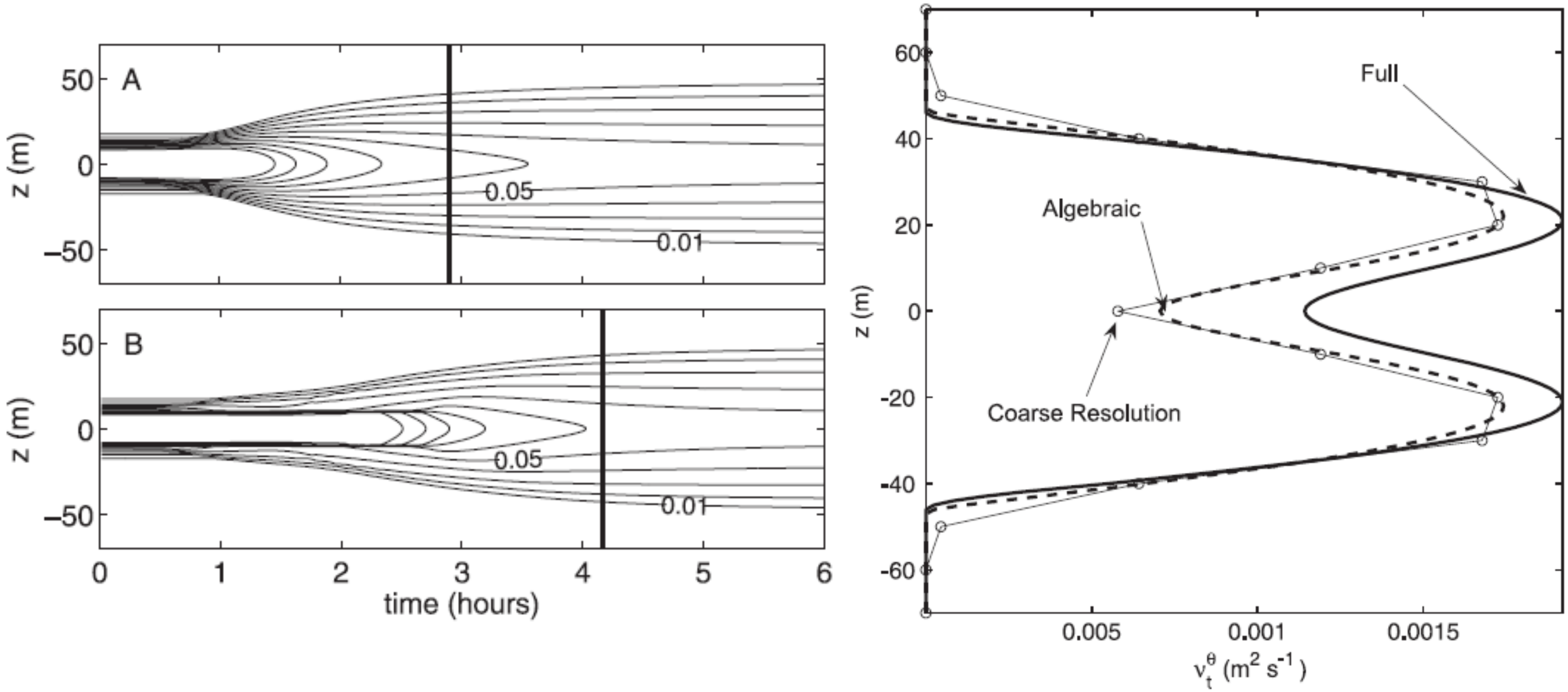
# Test case I: Jet




Umlauf (2009)

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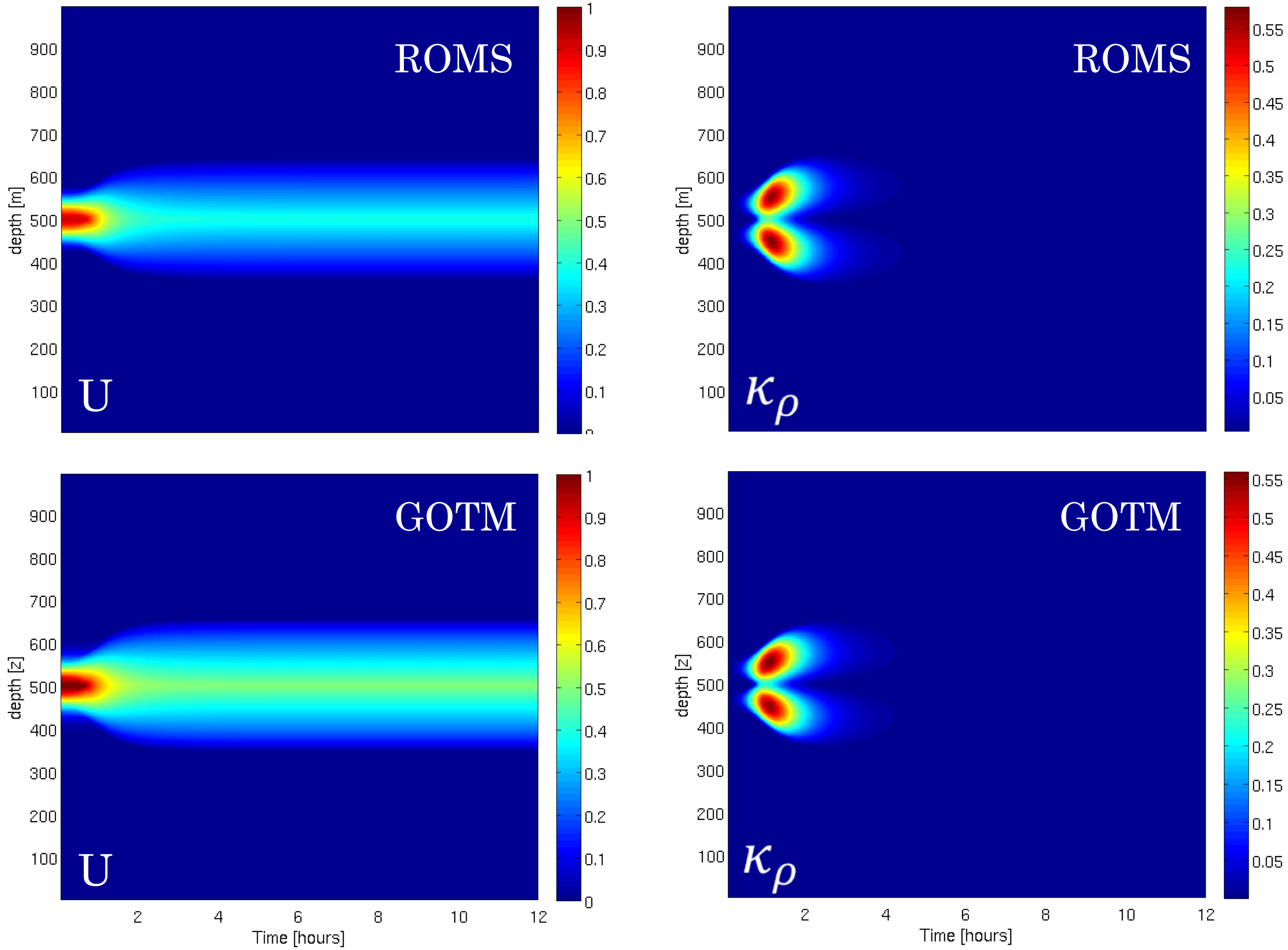
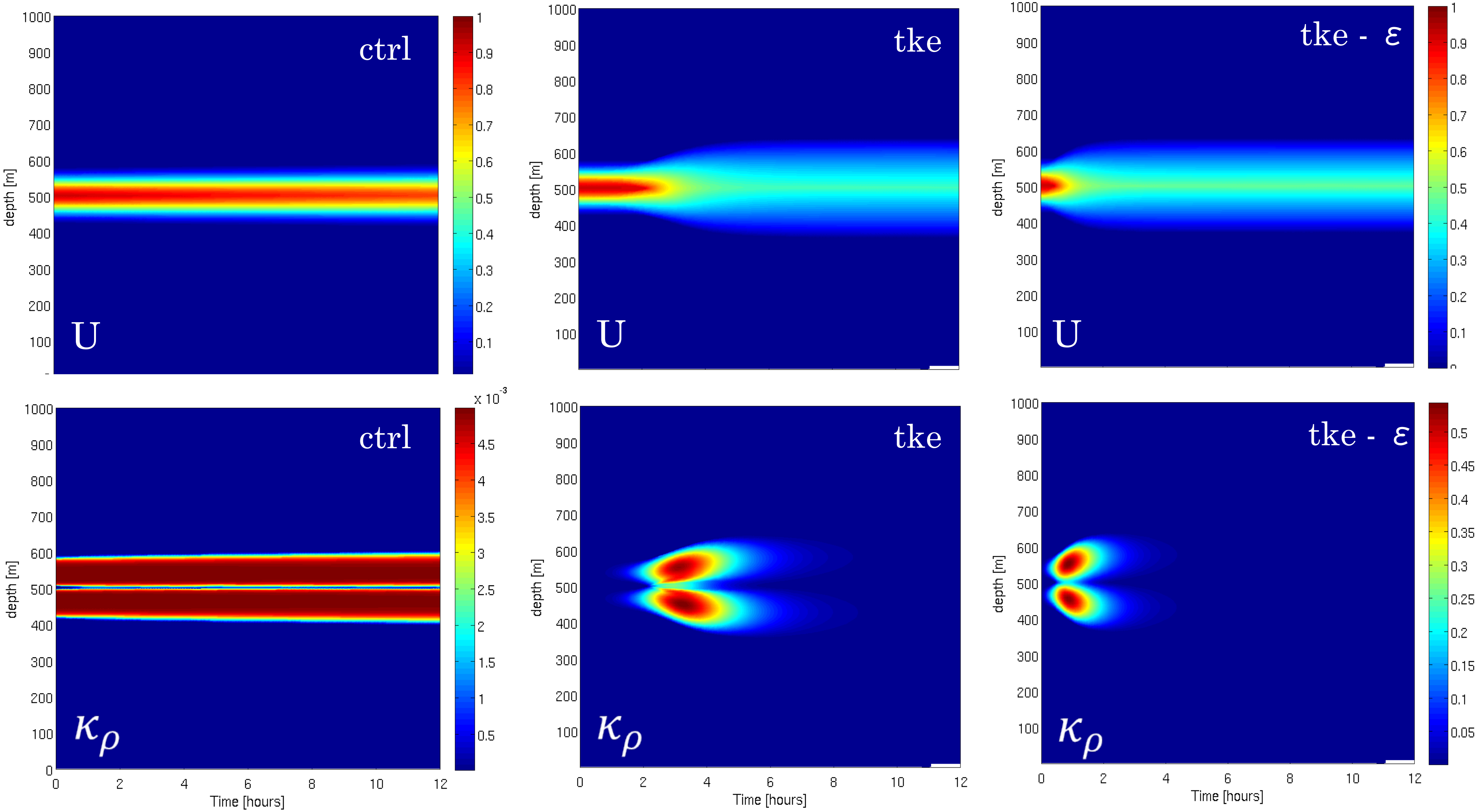
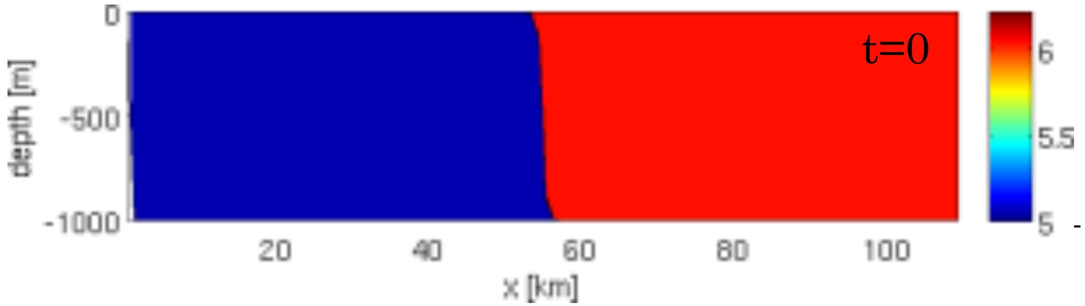
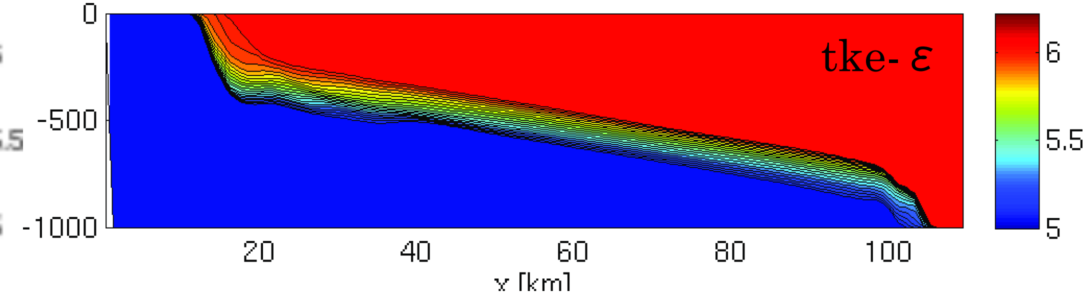


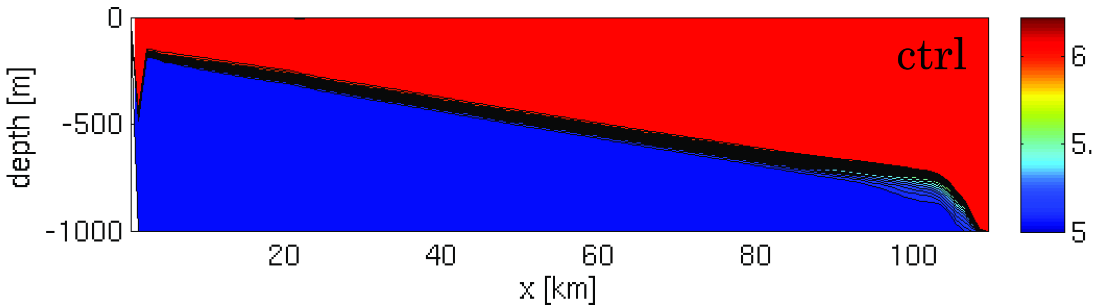
# Test Case I: Jet (MICOM)

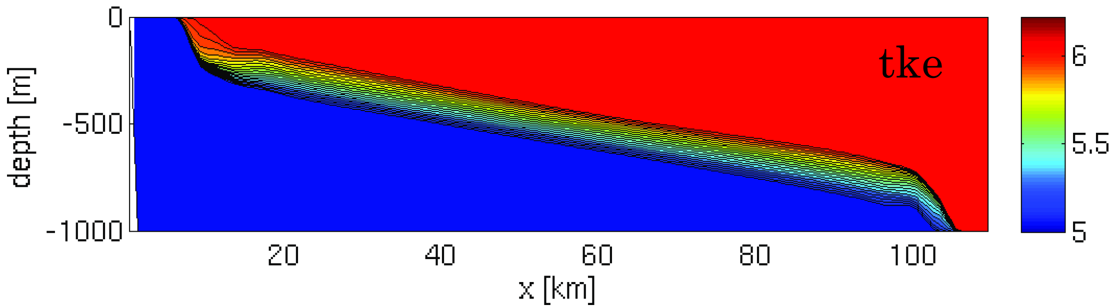


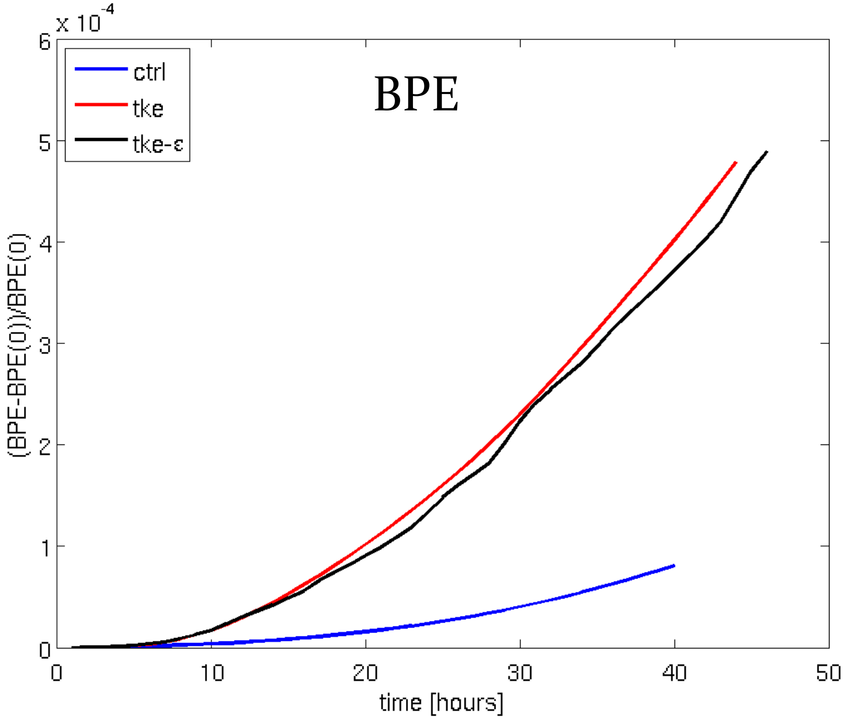
# Test Case II: Lock-exchange



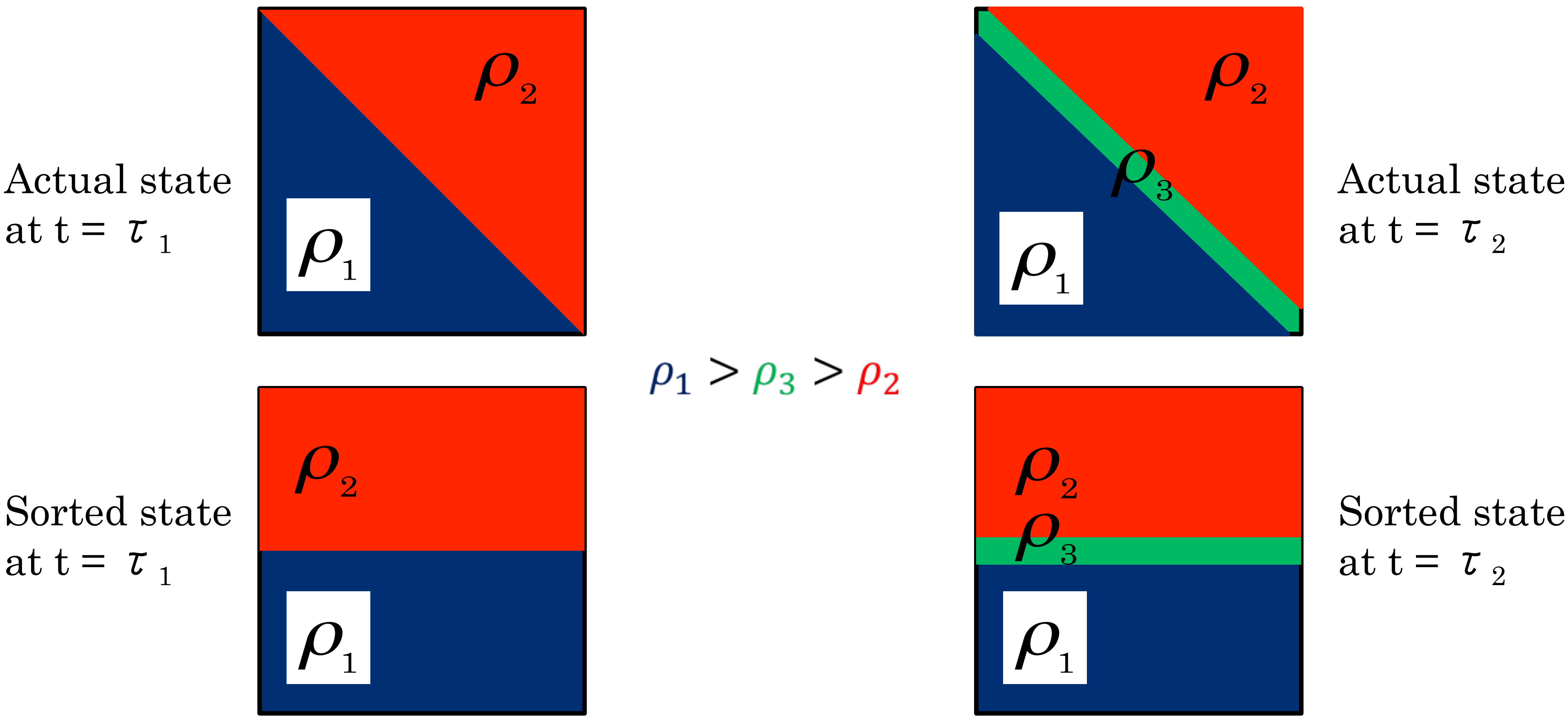



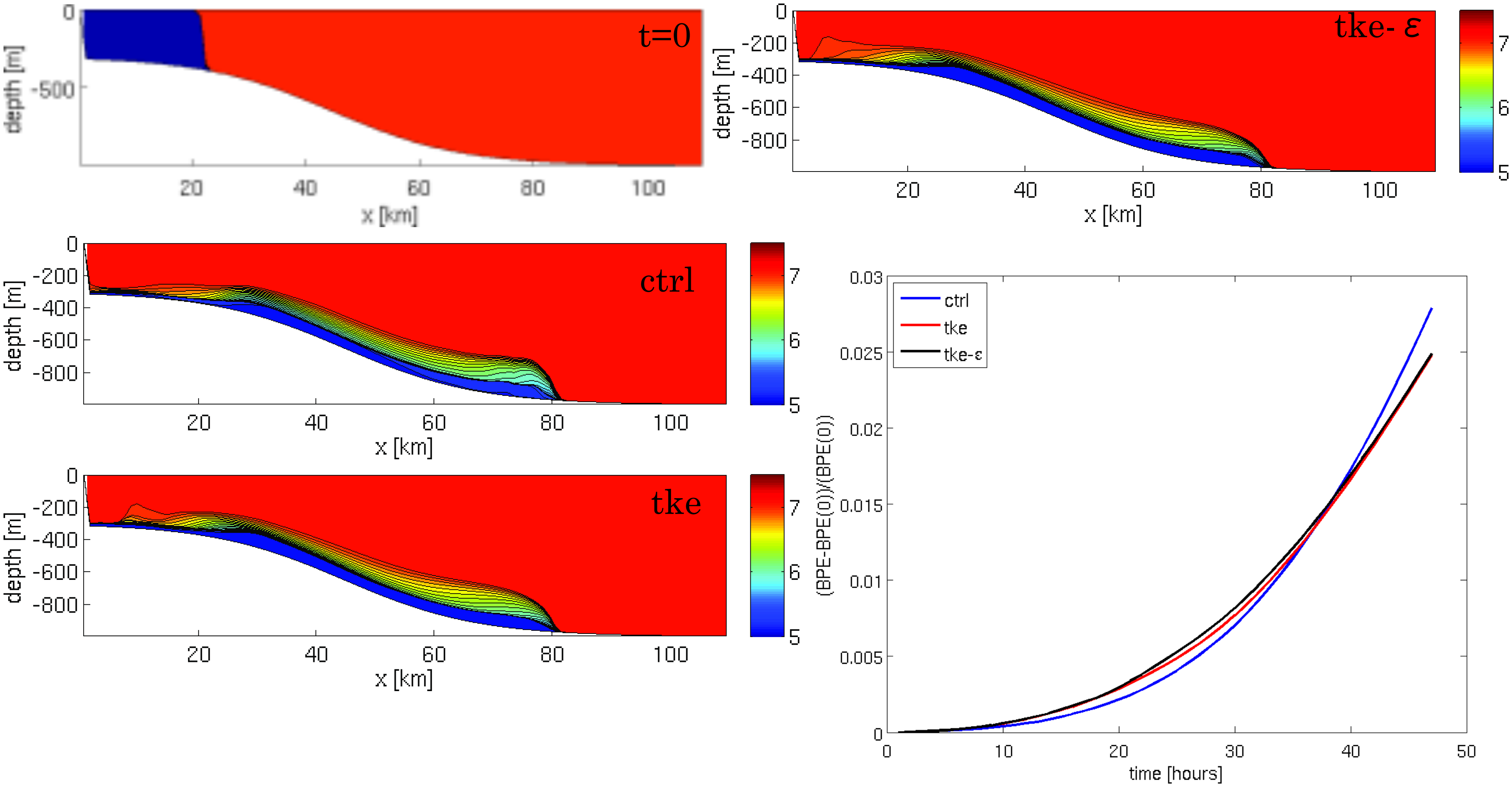



# How to diagnose mixing?

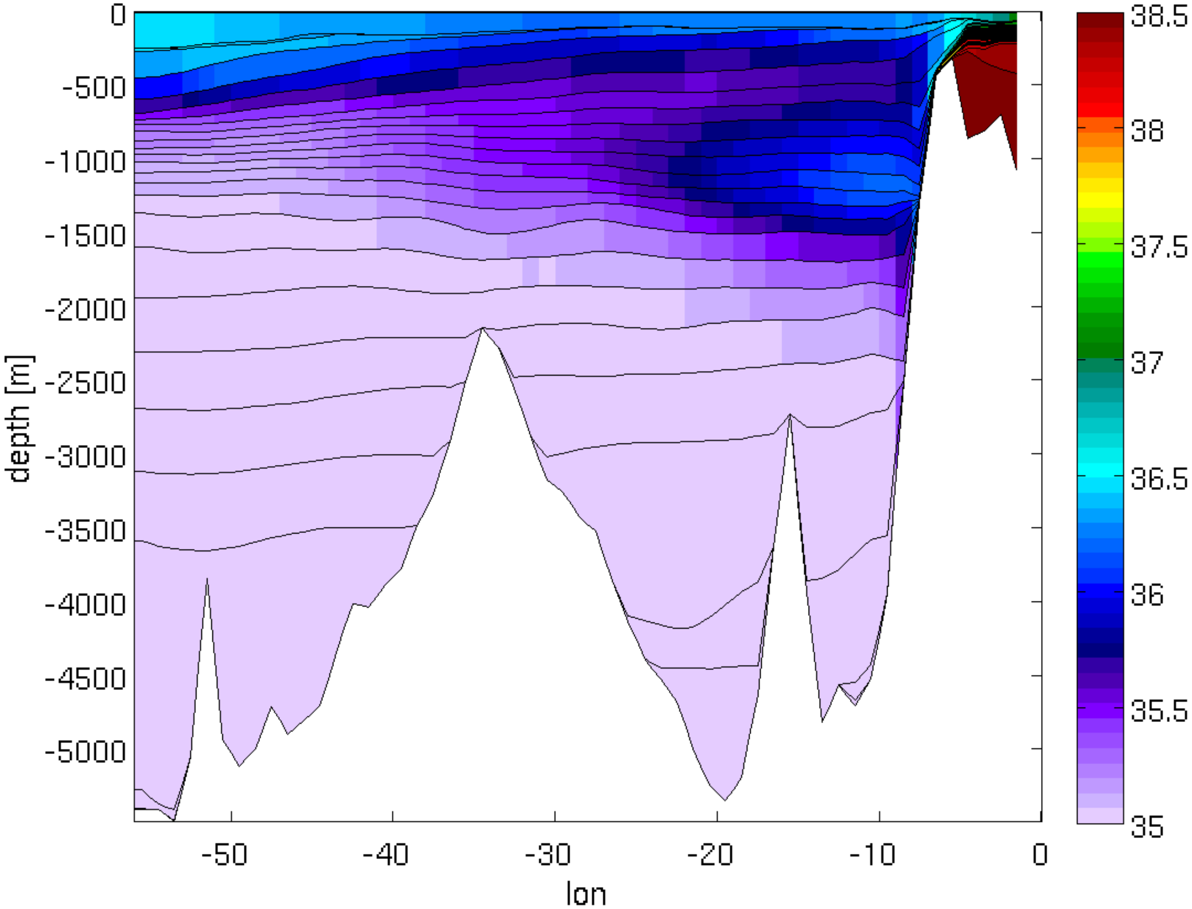



- Background potential energy (BPE) always increases as a result of diapycnal mixing. Winters et al (1995)

# Test Case III: Overflow on a slope



# Core2 simulation with k- ε




- There is less mixing in the Gulf of Cadiz area.
- The Shear production term in tke eq. is relatively small compared to Buoyancy sink term.

# Conclusion

- Partial cell approached is implemented into MICOM. This method might allow us to open other channels such as Bosphorus, Dardanelle, Red Sea, Faroe Bank channel.

- Mediterranean overflow transport in NorESM becomes similar to observational values.

- GLS turbulence closure gives reasonable results for the idealized test cases.

- Climate applications of GLS have to be investigated more thoroughly .