Reviewer comments for

"Modelling turbulent vertical mixing using a 1-D version of NEMO"

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General comments

A comparison of two types of turbulent closure is presented using a 1D configuration of the NEMO ocean model: the one-equation TKE model of Gaspar et al. (1990) and the two equation models encompassed by the GLS framework of Umlauf and Burchard (2003) are considered.

A brief explanation of the model primitive equations in a 1D context and then a summary of the main differences between the two types of turbulent closure are given. The performance and numerical behaviour of these closures are assessed in an idealized Kato-Phillips (1969) test case and a realistic test case based on observations from OS PAPA. The numerical behaviour is explored through the use of two vertical grid discretizations (31 and 75 levels), three time step sizes (360s, 1200s and 3600s) and an 'ideal' spatiotemporal discretization (1000 levels and a 36s time step).

The results present a very useful insight into the comparative performance and numerical behaviour of two similar types of statistical turbulent closure, for a range of spatial and temporal discretizations. Furthermore, the results are easily and directly reproducible by virtue of the configuration being immediately available from the NEMO repository. The derivation of NEMO1D from the full 3D domain also allows the performance of the discussed turbulent closures to be applicable to users of the full 3D NEMO model.

I am generally happy with the content of the manuscript but have a few minor revisions that I think should be addressed before publication.

Specific comments

1. I think that the description of the turbulent closures in section 2.2 needs to more clearly contrast the differences between the two types of closure:

   2.2- I think it would be better to introduce the two types of closure presented in the paper at the end of this section, so that in each subsection the treatment by both closures of the solution for *k*, *l*, C_μ and C'_μ can be compared

   2.2.2- The principal difference between the two types of closure presented is that the length scale of the former is an algebraic formulation, while the latter uses a prognostic differential equation to calculate a length scale-related quantity. Often these types of closure are referred to as one and two-equation models (see for example Burchard et al., 2008). I think the clarity of this section would benefit from a concise summary of this key difference at some point.

2.2.3- I think this section should more specifically be about the determination of C_μ and C'_μ, contrasted with their constant values in the TKE model (for the TKE scheme I don't think they are defined elsewhere in the manuscript other than in table 1)

2.2.4- C_μ^0 is missing a defined value here, and I think the reasons for the difference in its value between the models should be briefly described. I'm not sure Pr belongs in this section either- it is not a constant and might be better placed in 2.2.3 since it appears in the TKE model definition of C_μ'

2. I think some caution is needed when describing "realistic" values of H_p (P5262, line 17) in section 2.2.5 for the TKE model without explaining why the 0.5m to 30m profile is realistic. I think this must either be physically justified or else not described as "realistic"

3. At the end of section 2.3 the purpose of the paper is described as providing "feedback on different turbulent closures available in NEMO". However the KPP and simpler models are not considered; rather the "Algebraic Stress Models" of NEMO are put forward. This is acknowledged in section 6, but I feel that a brief explanation of this choice of turbulent closures from those available in NEMO would be useful.

4. An interesting result from section 4.3 is that there is a sensitivity to the time step to varying degrees for *all* closures (figures 3a-c), but this is not really acknowledged. It would be interesting to hear some thoughts on why this might be the case.

5. It would be useful for the paper to deliver a recommendation on which of the presented turbulence closures should be used, particularly as the OS PAPA test case is presented as a readily available configuration: what is the turbulence closure used by PAPA1D and why? This could be presented as a brief discussion item in section 6.

6. Figure 10 is too small to clearly interpret

Technical corrections/suggestions

- P5250, line 5- Rewrite as "Generic Length Scale"
- P5252, line 13- Rewrite as "Section 2 describes the turbulent closures discussed in this paper"
- P5252, line 14- Rewrite as "are listed in section 3"
- P5253, line 13- "the components of the Coriolis term, I the downward"- insert a comma
- P5253, line 22- Rewrite as "an ideal tool"
- P5256, line 10- Rewrite as "The three models most used"
- P5256, line 12- Rewrite as "According to Umlauf and Burchard (2003), the turbulent quantities *kl*, ε and ω"

- P5257, line 1- Rewrite as “Thus, each turbulence model defined within the GLS framework (henceforth the GLS closures)”
- P5257, line 2- I think the “main turbulence requirements” would be better described as standard turbulent flow test cases
- P5257, line 7- Rewrite as “The results obtained with these GLS closures (k-kl, k-ε, k-ω and the generic model)”
- P5258, line 10- “see Umlauf et al. (2013)”. Also include the GOTM manual in the references list.
- P5258, line 14- Rewrite as “The value of 0.25 was determined by”
- P5259, equation 15- I think μ_t should be υ_t
- P5259, line 10- Rewrite as “To ensure a minimum level of mixing”
- P5259, line 11- Is there a reason these parameters are distinct from υ_{t0} and K_{t0} in section 2.2? Briefly explain why if so.
- P5260, equation 17- “TKE model”
- P5260, line 8- Rewrite as “Both of these values are close to”
- P5260, line 18- Rewrite as “as a function of the wave age W_{age}”
- P5260, equation 20- what is $Frac_{HS}$?
- P5261, line 9- “This value is slightly higher than the value of $C_\mu^0 = 0.5268$ established inside the logarithmic boundary layer”- this needs a reference/source. Since C_μ^0 is earlier defined as a model constant, but $C_\mu^0 = 0.5268$ does not correspond to any value in table 1, the source of this value needs to be clarified
- P5261, line 17- Rewrite as “considered, as described by relation (16c)”
- P5261, line 19- Rewrite as “must be slightly smaller than the Von Karmann”
- P5261, line 20- This sentence is slightly confusing, do you mean that k-ε was found to calculate α too high and L too low?
- P5262, line 4- Rewrite as “For the TKE model, relation (19)”. Also do you mean relation (16)? It is much closer to equations 24a and 24b than relation (19)
- P5263, line 1- Rewrite as “The problem then simply involves comparing a closure using an algebraic parameterization of the mixing length to one with using a differential equation”, in line with specific comments
- P5263, line 14- Rewrite as “used in the standard ORCA2 configuration”
- P5263, line 15- Rewrite as “specifically designed for climate applications”
- P5263, line 16- Rewrite as “This is the first grid selected”
- P5263, line 19- Rewrite as “represents the second class of vertical grids”
- P5265, line 4- Rewrite as “The model MLDs”
- P5265, line 8- Eq. (26), not (27)
- P5265, line 20- Rewrite as “a water column of one hundred meters”
- P5265, line 24- Rewrite as “relation (26)”

- P5265, line 25- I think the term "reference solution" throughout might be better written as "analytical solution" for consistency with the previous section. I found I was confusing it with the reference simulation discussed in this section, but it may just be me.
- P5266, line 4- Rewrite as "the numerical framework presented in section 4.2"
- P5267, line 5- Rewrite as "corresponding to the tests done"
- P5267, line 11- Rewrite as "The green points corresponding to test"
- P5267, line 19- Reference should be "Gaspar et al. ,1990"
- P5268, line 2- Rewrite as "followed by a homogenization"
- P5268, line 19- Which "global bathymetry file"? Reference needed, particularly when a specific ocean depth is cited for this grid point
- P5269, line 15- Initialization date should be "15 June 2010"
- P5269, line 25- Rewrite as "section 2.1"
- P5270, line 23- Rewrite as "advective effects, which the model cannot reproduce. Above the MLD formed by the stratification"
- P5271, line 1- Rewrite as "Thus, over a month we observed"
- P5273, line 5- Rewrite as "section 4"
- P5273, line 7- Rewrite as "the k-ω and *k-kl* closures"
- P5273, line 9- Rewrite as "section 4.3"
- P5273, line 14- Rewrite as "For a particular grid"
- P5274, line 7- Rewrite as "the 1-D model version available in NEMO (NEMO1D)"
- P5274, line 10- Rewrite as "the behaviour of two types of turbulence closure available"
- P5274, line 17- Rewrite as "observations performed in a laboratory experiment"
- P5274, line 26- The TKE closure does seem to show *some* sensitivity! From figure 3 at least
- P5275, line 6- Rewrite as "major impact of a particular aspect of the boundary conditions on the TKE closure"
- P5275, line 10- What this problem is needs clarifying- I interpreted this as meaning that it is difficult to tune H_p in a global sense given that it is a very sensitive parameter
- P5275, line 12- What is a "correct" result?
- P5275, line 14- Rewrite as "the TKE closure does not show"
- P5275, line 21- "correctly"
- P5275, line 25- Rewrite as "and in-situ measurements"
- P5276, line 5- Rewrite as "What is a more optimal value of some parameters"
- P5276, line 15- The Kpar formulation needs a reference
- P5277, line 15- "generic length-scale equation"
- P5289, figure 7- "15 June 2010"- there is a rogue "_"
- P5291, figure 9- The black lines are incorrectly labelled as "Kato-Phillips"

References

Burchard, H., Craig, P. D., Gemmrich, J. R., van Haren, H., Mathieu, P. P., Meier, H. E., ... & Wijesekera, H. W. (2008). Observational and numerical modeling methods for quantifying coastal ocean turbulence and mixing. Progress in Oceanography, 76(4), 399-442.