Review of the manuscript
Modelling turbulent vertical mixing sensitivity using a 1D version of NEMO
by G. Reffray, R. Bourdallé-Badie and C. Calone

General Comments:

This paper investigates the responses of the four most popular two-equation turbulence closure models (k-kl, k-ε, k-ω, GLS) and the TKE mixing scheme. The schemes were used to simulate the Kato-Phillips idealized experiment case (1969) and the PAPA real case (15 June 2010 - 15 June 2011) in the Pacific ocean. Both these configurations are well adapted for a 1D approach. They were carried out with the one dimensional version (NEMO1D) of the 3D NEMO model. Thanks to its low computational cost, NEMO1D is a suited tool for testing the 5 turbulence schemes according to 4 global configurations in terms of vertical grid and time step of NEMO (L75, Δt=360s ; L75, Δt=1200s ; L31, Δt=3600s ; L75, Δt=3600s). As consequence, the results explore a wide time and space resolution and should be of great interest for modellers. Having said this, I have several major concerns that the authors need to address before the article can be accepted for publication.

Major Comments:

The text could be more concise and the conclusions clearer. Indeed, the authors test 5 parameterizations of vertical mixing without any modification or improvement. As consequence, the presentation of the GLS and TKE parameterizations should focus on the basics equations (k and ψ) and on main differences.

In particular the constraints used for determining the 6 model constants should be clearly exposed in order to understand the "philosophy" of the GLS approach. The GLS closure assigns m=1, n=-0.67 and p=2 (Table 1). The question is how these parameters are defined ? Umlauf and Burchard (2003) speak of the polymorphism nature (exponents m and n considered as variables) of the GLS model for calibration. To understand the basic idea, please develop these aspects, not as completely as in Umlauf and Burchard (2003), and reject the expanded expressions of the stability functions and the details of the surface boundary conditions in annexe.

As the paper focuses on turbulence models, I suggest to present the models first, then the NEMO1D framework. A section describing the numerical implementation (description of the explicit and implicit terms) of the turbulence parameterizations in NEMO would be interesting for readers of GMD and for understanding the possible causes of sensitivity of the results to the time-step obtained in the idealized and real cases. Finally the results presented on Figures 7-10 are not sufficient to identify the fundamental differences between the turbulence schemes. These differences could be highlighted by showing the vertical profiles of heat ($w'T'$), salt ($w'S'$) and momemtum ($w'u'; w'v'$) fluxes computed by the different turbulent schemes. I do not ask but further validation would be to compare these models with LES simulations.

To streamline and clarify the paper, I suggest to reorganize the paper as follows:

2) vertical turbulence models
  2.1) TKE model
  2.2) GLS models
    2.2.1) Determination of model constants
3) The NEMO1D framework
  3.1) Equations system
  3.2) Space and time discretization
  3.3) Numerical implementation of the turbulence parameterizations
4) Experimental Design
  4.1) Idealized case
  4.2) PAPA station
    4.2.1) Second-order moment distribution
    …

Minor Comments:

1) All the Figures are really too small and it is very difficult to read the colored lines and captions. Please enlarge them.
2) Equation 8 is not the original mixing length described in Gaspar et al. (1990). Include the computation l=sqrt(lup*ldown) in the paper.
3) Put the stability functions in annexe
4) Surface boundary conditions should be streamlined
5) Change "Relation (21)" into "relation (21)"
6) Unit of equation (24b) ? l in m and u* in m/s
7) Page 5264: "NEMO 1D has no restriction on the time step" Although there is no CFL condition, there is still a restriction on the time step associated with the vertical diffusion which is $K\Delta t / \Delta z^2 < 1$. Check if the sensitivity of the results to the time-step for a given vertical resolution is not associated with this constraint.
8) Page 5265: Change "Eq. (27)" into "Eq. (26)"
9) Page 5266: Change "focussed" into "focused"
10) Page 5266: Remove "in passing"
11) Page 5269: Change "15 June 2011" into "15 June 2010 "

12) Page 5270 : Change «108000» Pa into «100800 Pa»

13) Page 5270 : Figure 7 and 8 are presented at the beginning of Section 5.3 and suddenly the discussion skips on Figure 9 (In order to focus on two major steps …). Please be linear in the discussion. As Figure 9 is used to evaluate the capacity of the turbulence schemes to capture the MLD deepening, replace the profiles of temperature by the density.

14) Page 5273: For a given vertical grid, the k-kl and k-ω schemes display a significant sensitivity to the time-step in the idealized and real cases. It is quite disturbing because it shows a lack of robustness of the schemes. Isn't it induced by the numerical method used ? That is why a section on the Numerical implementation of the turbulence parameterizations would be fruitful.

15) Figure 11: The best result obtained with L31 versus L75 for Δt=360s is attributed to numerical dilution associated with L31. I am not convinced. With no advection the temperature below the thermocline should not change compared to the initial profile. As consequence, I assume that the observed temperature below the thermocline in August is close to the temperature in June, that is confirmed in Figure 7 (top left). Hence, I do not understand why the simulated profiles L31 and L75 do not fit the observed profile below 20 m depth (Figure 11).

15) Conclusions:

It is in the perspectives but why did you not test K-profile models, for instance the formulation of Large et al. (1994) in this study ?

After reading, my conclusion is that the most robust parameterizations are k-ε and TKE_10m. Nevertheless the authors make no recommendation on the use of either parameterization in NEMO, yet expected by the NEMO user. Numerous prospects are proposed. Only one or two main aspects should be proposed.