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Interactive comment on "Increasing vertical mixing to reduce Southern Ocean deep convection in NEMO" *by* C. Heuzé et al.

Anonymous Referee #2

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Summary
This paper considers the effect of varying the strength of vertical mixing on the spurious generation of polynyas in the Antarctic by the NEMO ocean model run at 1/4° horizontal resolution. With default settings for vertical mixing, the model unrealistically generates a polynya in austral winter 1986 in the Riiser-Larsen Sea, east of the Weddell Sea, and a more serious polynya there in 1987 with deep convection reaching 3000 m.

The authors find, counterintuitively, that increasing the strength of upper ocean mixing reduces the tendency to spuriously form these polynyas, but that decreasing this vertical mixing causes the model to form a larger polynya that is advected westward into the Weddell Gyre as an extended, persistent (multiyear), deeply convecting, polynya.

The process by which the polynya develops in the default run is studied in terms of the

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evolution of the temperature profile and is ascribed to a sequence of events starting with anomalously high ice cover early in the austral winter of 1986.

Major Comments

The conclusion that increasing vertical mixing helps to suppress the spurious development of polynyas is interesting but I am not convinced by the explanation. Warmer surface waters are not of themselves sufficient to permit the development of deep convection—in the absence of deep convection winter cooling will simply eventually cool these waters to freezing point. Somehow the near-surface waters need to salinify (or the waters below must be freshened and/or warmed) in order to reduce the stratification.

The mechanisms section 3.1 needs to be considerably strengthened, with proper discussion of the evolution of the salinity and density (referenced to the appropriate depth) as well as the temperature. The Hovmöller diagrams in Fig 2c and 2d need to take account of the movement of the fluid column: the fields in 1985 and 1986 should be plotted further northward e.g. (presumably) at the site of the 86 polynya in Sept 1986. More generally, there needs also to be proper discussion of the advective effects: e.g. is there a rotation of the velocity vector with depth that is causing the stratification to evolve?

Detailed Comments

p2950, l 3-4 triggering mechanisms leading to $\Rightarrow$ mechanisms triggering

p2950, l 14 are $\Rightarrow$ give

p2953, Eq. (1). What is V_s? More generally, how does the W impact on the TKE in Axell's parameterization?

p2954, Eq. (2). Is this correct? As written it seems that an amount of energy e_{inertial} is added each time step. This would mean that the shorter the time step, the more rapidly energy is added, which makes no sense.

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p2957, l5-6. ‘When ice-free in summer, the warm waters are incorporated in the mixed layer’. Presumably the summer ML is shallower than the winter ML, so how does this happen? Upwelling?
p2957, l8. ‘The warm surface waters impede sea ice formation, resulting in the development of an open ocean polynya over August to October 1986’. I can’t see any warm anomaly in T in Fig. 2c until Feb 87.
p2957, l22 ‘similar to observations’. I’m confused. Are you saying a polynya in 1986 is realistic? If so more discussion of the observations would be useful. However, on p2950, l 23 you state that full depth open ocean deep convection only occurred in the 70’s.

p2971, Fig 4. Yellow lines are hard to see
p2972, Fig. 5a. I can only see 4 lines; Fig. 5b. Again yellow line is hard to see.

Interactive comment on Geosci. Model Dev. Discuss., 8, 2949, 2015.