Antarctic sub-shelf melt rates via PICO (Revised)

Major comments:

After having read the paper several times I keep coming back to the question of how many of the simplifing choices were made to ensure that the resulting box model equations could be analytically solved? Reducing a complex system to a form amenable to analytical analysis can be a valuable exercise that can yield insights into a system's behavior. However, in the case of PICO I have a lingering impression that most of its numerous simplications were made to yield an analytically solvable system simply for the sake of having an analytically solvable system. If some of the simplifying assumptions were lifted and the resulting nonlinear system had to be solved iteratively would that really make PICO an ineffective tool? If some of these assumption were lifted and the resulting nonlinear model conserved mass and energy would that not be considered worthwhile? More discussion about why these assumptions were made and their consequences would make the manuscript stronger and allow people to make more informed choices about adopting the PICO model in the future.

Minor comments:

Abstract Line 11. Change “The two-dimensional melt rate fields …” with “We identify a set of parameters that yields two-dimensional melt rate fields that qualitatively reproduce the typical pattern of … “

Line 28. I take issue with the use of the term “resolving” here because to me it implies that the PICO is driven with equations of fluid motion at a resolution fine enough to capture the overturning. PICO parameterizes the ice shelf cavity transports associated with an imposed overturning circulation driven by the ice pump.

Page 5 line 15. Of the many simplifying assumptions made here, why are the gamma T and gamma S parameters set as constant? I don't see why you couldn't pull out an some kind of velocity in the PICO grid cells. Just stating that you are following OH10 does not explain why the choice is made. Would introducing velocity dependence interfere with the analytical solvability?

Page 6 line 5: Neglecting heat fluxes into ice shelves is another odd choice. As ice shelves thin or under warm ice shelves the conductive heat flux into ice can be about 10% of heat flux that melts ice.

Page 6 line 9-14 and E8: Just to be clear, you are solving for the melt rate using far field T and S (A5) and then using that melt rate to solve for the boundary layer T and S (A2 and A3)?

Page 6, line 10: The discussion in Holland and Jenkins 1999 describes the conditions in which simplified forms of the 3-equations model can be expected to yield similar results. Is the PICO

model subjected to that same range of conditions or are there circumstances under which one might expect that your simplified equations might be expected to substantically deviate from the three equation solution?

Page 9, "exemplary shown"?

Page 10, Line 1-2: This section describes a parameter tuning exercise, not a model validation exercise. You are seeking a range of acceptable parameters using four criteria as constraints.

Page 12 Line 14: Provide the parameter values shown in OH10 and Holland and Jenkins 1999 here so the reader doesn't have to go digging.

Page 14, Line 6: Change "Due to this model assumptions" to "Due to these model assumptions"

Page 14, Line 12: How large are the deviations of the Filchner-Ronne and Ross Ice shelves then?

Page 16, Line 24: Change to, "PICO does not resolve ocean dynamics. PICO parameterizes vertical ocean circulation in the ice shelf cavities." Later you say they do not "resolve horizontal ocean circulation" Probably better to say "As PICO is a 2D box model, no horizontal flow variations are represented."

Page 17, Line 2-3. I do not understand the sentence that begins, "A necessary condition for the box model to work..."