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Interactive comment on "A 1-D model study of Arctic sea-ice salinity" *by* P. J. Griewank and D. Notz

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The article "A 1-D model study of Arctic sea-ice salinity" by P. J. Griewank and D. Notz presents a sea ice model which includes their parametrization of gravity drainage (Griewank and Notz, 2013) and presents new parametrizations for processes of surface snow melt, flushing and flooding.

The paper has very substantial problems that prevent verification, validation or even proper assessment of their model. There are no partial differential equations in this paper, and that perhaps highlights the fundamental problem. The physics of the model needs to be separated from the numerical scheme. This is true for the state equations, which are never stated and need to be, and for the new model parametrizations, which are presented as grid-layer dependent quantities rather than continuous variables. For example, writing an expression for "brine leaving each layer" (line 4, p1730) as a linear

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function of the time step and grid spacing may be a useful quantity for their code, but it is not straight forward how a brine volume change translates to a state variable flux (absolute salinity or enthalpy) in their model nor how one might generalize the term for use in a different numerical scheme. Another example, instead of introducing the state variables (paragraph 1 section 2.1) for sea ice, the model is introduced by defining the fundamental variables for a layer. Delta z (L3, P1728), the thickness of a layer is a grid specific quantity, depends on the model resolution and not fundamental to sea ice. Ice thickness (h) is the state variable and expressions should be written in terms of h.

There are also major problems with some of the parametrizations introduced in this model. The complex flushing scheme (section 2.4.2) is based on hydraulic networks of both horizontal and vertical flow, but has some faulty assumptions. The expression for ice permeability as a function of porosity (Frietag, 1999? Ref?) is valid for vertical flow but not horizontal flow (L5, p1739). The pressure force from positive freeboard (I assume only positive freeboards are included in L20. Should be stated) has a direction and it's vertical. The horizontal pressure force will arise from assumptions of incompressibility and will depend on the vertical resistivity. For example, highly porous ice will have almost entirely vertical flow, while an impermeable layer will possibly allow for runoff at the surface (though not in the interior). The "horizontal" terms in this scheme do not capture these features and obscure the impact of the vertical flushing term making it extremely difficult to validate.

The simple flushing scheme (section 2.4.3) is also problematic. It imposes a stability criteria that has no experimental or physical foundation and is, in fact, violated during sea ice growth and gap layer formation or the freeze melt cycle. Density and not volume determines a stable profile. In addition, the description of the scheme needs an equation or two.

For the complex flooding scheme (section 2.4.5), it is not clear why a hydraulic flow is not considered. In line 15 (p 1741) it is stated that "upward brine displacement through the whole ice (would result in) desalination (that) would quickly turn the ice imperme-

TCD
8, C1279–C1281, 2014

able". However upward flushing has been observed through the ice interior. It will desalinate some ice layers while increasing others and produce, in fact, a net increase in ice salinity. The authors need some physics based reason to exclude a process (upward driven hydraulic flow) that they include without justification for flushing (downward driven hydraulic flow). It seems that a model is precisely the place to test this process. Instead, the authors assume the flow is entirely through macroscale features which they do not model or provide any information about (cracks and channels). The parameter, maximum negative freeboard, is set a 5 cm. Why isn't this dependent on ice thickness?

L6, p1728: In appendix, show equations for mass fractions, solid, liquid and gas volume fractions (and reference them)

L11 to L20: Numerics should have a separate section, some details in an appendix.

The simulations and results of this paper do not provide validation for any of the melt processes discussed previously. Before the model can hope to inform about Arctic sea ice, a rigorous comparison of model and lab/field data needs to be performed.

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8, C1279–C1281, 2014