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Interactive comment on "An analytical verification test for numerically simulated convective flow above a thermally heterogeneous surface" *by* A. Shapiro et al.

Anonymous Referee #1

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The authors derive an analytical solution of the two-dimensional steady Boussinesq equations in the limit of zero Reynolds number. To obtain this solution they transform the equations into a sixth-order equation for the streamfunction. Then they seek a solution in the form of a single-harmonic, A(z)cos(kx). Then the general solution is found as an infinite summation of single-harmonic solutions. The procedure is rigorous and well-described. In the second part of the paper the authors proceed to use this analytical solutions to test different boundary conditions for the pressure Poisson equation in a particular numerical implementation. They consider two cases in which they compare numerical results for homogeneous and inhomogeneous types boundary conditions for the pressure Poisson equation to the analytical solution. Only the inhomogeneous

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boundary condition passes both tests. In summary, this is an interesting paper that deserves publication. I have several minor comments:

1. Section 2.1: Please explain the physical meaning of equation (3), i.e. that the equation for b is based on the transport equation for the temperature.

2. Please specify which condition has been substituted in which equation in order to obtain Eqs. (24-25).

3. Section 2.3: "The derivation of the u field requires considerable effort and is not pursued." I do not understand this. As far as I understand, the analytical solution of u is simply the analytical partial derivative of Eq. (39) with respect to x, which can be explicitly written as an infinite sum. Do I miss anything?

4. Section 3: "The surface condition on pressure is the inhomogeneous Neumann condition that arises from projecting the vertical equation of motion into the vertical, and imposing the impermeability condition (Vreman, 2014; also see our Appendix)." The sentence can be maintained, but a sentence should be added that, in addition, it is important that the discretized Poisson equation somehow incorporates the condition that delta = div u=0 on the wall or in the direct vicinity of the wall. This was also stressed by Vreman (and others) and is briefly mentioned in the appendix. It is good to include this requirement also in the main text. In the method of the authors the condition delta =0 near the wall is probably implicitly enforced via the alternative Poisson equation, specified in the Appendix, Eq. (A3b). After Eq. (A3b) the authors cite the pressure Poisson equation parodox using a sentence of Gresho and Sani. Please mention there that Vreman has revisited this paradox and has shown that, at least for the standard staggered method, the discretized version of (A3b) (with appropriate Neumann condition) is equivalent to the discretized version of (A3a) supplemented with the condition that div(Laplacian(u))=0 in the direct vicinity of the wall. Equipped with the latter the condition, the diffusion equation d delta/dt = nu * Laplacian(delta) leads to delta=0 for all time.

5. Section 3: The numerical solutions are obtained on an un-staggered grid. Please explain what was done to prevent odd-even decoupling of the pressure. Was the Rhie-Chow interpolation method used, for example?

6. Section 3: Please explain the meaning of the abbreviations HNC and INC (I guess homogeneous Neumann condition and inhomogeneous Neumann condition).

Interactive comment on Geosci. Model Dev. Discuss., 8, 2847, 2015.