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# *Interactive comment on* "Interaction of katabatic wind and local surface mass balance at Scharffenbergbotnen Blue Ice Area, Antarctica" *by* T. Zwinger et al.

**Anonymous Referee #2**

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Dear Editor,

Here is my review of the manuscript entitled "Interaction of katabatic wind and local surface mass balance at Scharffenbergbotnen Blue Ice Area, Antarctica."

General remarks: The manuscript uses finite element code Elmer to model the winds that cause the formation of blue ice area (BIA) in Scharffenbergbotnen valley, Antarctica. The authors use incompressible Navier-Stokes equation, and with boundary conditions (as I understand it) to resemble katabatic flow. This is a high resolution model with 50 m horizontal resolution inside the valley where the BIAs are located. Three variations of vertical wind velocity profile of the katabatic wind front are used here.



Katabatic winds follow the ice surface topography and therefore the experiment setup is to understand the affect of topography on the formation of BIA. Of the three types of terrains used, the authors find that the present day topography constructed from a DEM derived from airborne survey is capable of producing the high wind speeds at the locations of BIAs. A smoother topography as well as a prescribed ice surface elevation for the LGM fails to produce the high winds that would be required if the observed BIA was to exist leading to the conclusion that the BIA in this valley is younger than the LGM. In the end, the authors describe an actual katabatic storm that develops in the region of the BIA when the atmosphere is calm and stable elsewhere. The authors note a 30% increase in BIA during this time. On the other hand, a synoptic storm that produces high wind speeds in the surrounding region on some other day does not affect the BIA region at all leading the authors to believe that the BIA in the Scharffenbergbotnen valley is maintained by individual katabatic storms not by strong synoptic events.

This work is significant because it involves a high resolution model to simulate katabatic winds that lead to the formation of blue ice areas in Antarctica and has the potential of extending it to other places in Antarctica where katabatic winds routinely scour the ice surface. The manuscript is generally well written and the work is very interesting. My main problem with it is that I got stuck while trying to understand how an incompressible Navier-Stokes equation could be used to simulate katabatic winds that inherently require a variable density. The results, however, are very convincing and that intrigued me. I think I found the answer in the boundary conditions they use, but the authors need to make this clear earlier in the manuscript. I support publication after the comments are addressed.

The abstract needs a little reordering of the sentences. The figures need some tweaking to bring out the details.

My specific comments are below:

P 2232 L4: show highly spatially variable . . . sounds weird. suggestion: High spatial variability in wind . . . P 2232 L6: I think this line should appear later in the abstract at L 16.

P22323 L13: Is located further interior in the valley. . .?

P 2232 L20-21: The second part of the sentence has some redundancy. Ice surface clear of snow is the same as snow –free earlier in the sentence. You can write glacier ice is exposed and therefore reflects a bluish color.

P 2232 L25: compared to 'snow covered surfaces'

P 2233: L6: 'must' play a role. I am trying to tighten words so it is easier to read.

P 2233 L19: I need arrows for wind direction.

L2235 L1-10: I need more explanation here for those of us who do not deal with Navier-Stokes equation on a day-to-day basis. As you are using the condition of incompressibility, density is constant right? I do not understand which terms then satisfy the characteristics of katabatic winds that form in buoyant atmosphere where the density has to change, even if small? What makes this equation simulate a katabatic wind? I probably missed something, and that is why you need to make it clear. I agree that the results are very convincing, so it is important to understand. What exactly does the gravitational body force do in this equation?

It may be appropriate to include details in supplementary information section for interested readers.

P 2237 L18: I like the high horizontal resolution of 50 m in the interior.

P2239 L6: I see the boundary conditions and see that you force the flow only along the surface and do not allow any vertical component. So essentially terrain following like a katabatic wind?

P2240: L20: This is cool!



P2240 L22: I understand one profile will always do better than the others, but I would like to understand why the other profiles do not do as well at 5m above the ground?

P 2240 L23: In addition, what happens to these runs at 1250 s? That is when Fig 6 is most striking. Is there a reason you use 1000 s and not 1250s for the rest of the figures?

P2241, L10: Oh I think I found the answer why you use 1000 s instead of 1250 s in the other figures here.

Comments on the Figures:

Please provide directions in the figures. At least show which is East, so I do not have to go back and forth between figures. An arrow for prevailing wind direction will be helpful.

Fig2: Arrows to show ice flow will be helpful here. I know they are in Zwinger et al. 2014, but the figures have to be self sufficient.

Figure 5: The equilibrium yellow and white dotted line is hard to see. Please label some of the elevation contours here and elsewhere.

Fig 6: Again all the solid and dashed lines are very hard to see.

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Interactive comment on The Cryosphere Discuss., 9, 2231, 2015.