

Interactive comment on “Boundary layer physics over snow and ice” by P. S. Anderson and W. D. Neff

Anonymous Referee #2

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The paper by Anderson and Neff provides a timely review of boundary layer physics, focusing on boundary layer structure and turbulence, for snow/ice covered polar regions. This paper is generally well written, well organized, and thorough in general content, and should be published after some consideration of my hopefully constructive criticisms. While the paper is thorough in terms of discussion of boundary layer physics in stable atmospheres, some of the discussion is very generally about that, and not specific enough, with appropriate examples, about stable boundary layers in polar atmospheres. Indeed, much of the paper is written in the style of a textbook on the subject of stable boundary layers, rather than a review of such environments in the context of exciting observations in the two polar environments. In general, the paper could use much more references to the recent literature, particularly with respect to

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the Arctic. The lack of references and examples makes the paper more dull than it could be. Indeed, the bulk of the references to real examples come from Antarctica. As an example, section 4.4 starts with “Much of the interior of Antarctica is characterized by small terrain slopes. . .”. True, but much of the coastal Arctic region, e.g. Alaska’s north slope, and Greenland, could be characterized this way, to the benefit of readers. While there are indeed great examples from Antarctica, there is also a rich history of observations across the Arctic, and this literature is largely absent in this review. Indeed, as written it might be better if the title read “. . . over snow and ice in Antarctica”. Such a review would be fine, and probably most of the treatment is indeed quite general. But a little attention to the Arctic literature might make this paper even more useful. In the most extreme case, the Antarctic focus could lead to a bias in the historical view, as presented. As a specific important example, the presentation of NO emissions from South Pole snow (pages 3 and 4) would lead the reviewer to believe that photochemically-induced emission of NO_x from snow was discovered at South Pole. While indeed the South Pole observations are very intriguing, and understanding of the coupling between chemistry and boundary layer dynamics is clearly important there, making this an important citation, in fact this phenomenon was discovered at Summit, Greenland, by Honrath and coworkers. There is a rich data set from Summit and other sites in Greenland, re boundary layer dynamics (cf. Cullen et al., 2007). In a historic sense, the bulleted section on the Arctic on page 4 of the manuscript should come first. There are a number of papers related to the AGASP program and the “Polar Sunrise Experiments” that may be useful for this review. Attention to some of these issues will improve the paper. Specific comments, some of a simple editorial nature, are listed below.

1. Bottom page 4 – should say atmosphere-ice chemical interactions, for consistency.
2. Page 7 below equation I – where it reads: “ $O(10^5)$ or more”, this is confusing/unclear.

I note that that entire section could be condensed to one summary sentence, i.e. Turbulent exchange dominates mass transfer.

3. Page 9 near bottom, should be “tracers” (plural).
4. Page 9, bottom, ref. to Prandtl should have a citation.
5. Page 10, end of top paragraph, the last sentence should have a citation.
6. Page 10 – should you show one of the T-profiles from Tarasick and Bottenheim?
7. Page 12, top – in the discussion about mixing between air masses, can you present an example from the literature? A good example may come in the case of bromoform and ozone data from Bottenheim et al., JGR, 1990.
8. Page 13, line before Equation 2 should read “. . . concentration (without chemical production/loss terms) is given by. . .”
9. Page 14, second bullet under Equation 3: might it be better stated that for a given gradient, increasing eddy diffusivity increases the flux?
10. Beginning of section 3.2.3 – fix the sentence as follows: “. . .in that air which makes fleeting intimate contact with the ground then mingles with overlying air.” Note that “surface contact” is misleading, given the porosity of the “surface”.
Below the two bullets – “surface area”. In the sentence that follows add the word area after “surface”. Wind pumping and ventilation may well be “still open to study”, but so is boundary layer physics. You need more references in this paragraph, e.g. to Waddington et al., Albert et al., and others.
11. If section 3.2.4 has no examples with references, it can be deleted.
12. There are several places, e.g. pages 17 and 23, where the bullet lists are just consuming space. You could easily just incorporate those words into the preceding sentence.
13. Page 17 – “introductory paper”? Isn’t it a review?
14. Page 18 – “The turbulent intensity generally decreases. . .”

Would it be useful to show a plot?

15. Page 19 – “Halley” is jargon. Please be specific.

16. Page 19, bottom – do you mean a component of flow nearest the surface that moves toward lowest pressure?

Bottom sentence – which equations?

17. Mid page 21 – firm not firm.

18. Page 22, top – ref. to CHABLIS needs a citation.

19. First sentence of section 4.1.4 – specify location.

20. Lower part of page 22 – the lifetime of NO does not depend specifically on the depth of the boundary layer, but on other things influenced by the boundary layer, specifically, concentrations of O₃, OH, and HO₂.

Page 23 – “longer lived” is vague. The NO (well, NO_x really) lifetime is probably just 1-2 days.

21. Page 24 – this section is very general, and not referring specifically to snow/ice covered regions.

22. Page 25 – the section that starts with $g=9.81$ is not a sentence.

23. Page 31 – re “unique location” – wouldn’t Greenland in winter be similarly “unique”?

24. To me, Section 5 is useful, and I am happy it is there.

25. Sentence starting with “The “J-Spectrometer. . .”” should be deleted.

26. Page 35 – a sonic anemometer doesn’t really measure fluctuations. It just measures the wind velocity and temperature at high sampling frequency.

Is anything near 40Hz really necessary?

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It is not true that “there is no fast response NO_x sensor”. EC NO_x fluxes have been made – see Horii et al., 2006.

27. Bottom page 36 – delete the words “Be aware that”, and start the sentence with “There”.

28. Middle of top paragraph on page 38 – if the “one for the air chemistry sampling” is a sampler, and doesn’t transmit, then it isn’t a “sonde”. Note that ANTCI is not the only field program that has shown the merits of balloon-based profiling. The last paragraph in this section would benefit from some references.

29. The last sentence in Section 5.8 makes this section seem like an advertisement. Either provide citations for work done with UAVs, or delete this section.

30. There is little point in having a Summary.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 7625, 2007.

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