

Interactive comment on “Local artifacts in ice core methane records caused by layered bubble trapping and in-situ production: a multi-site investigation” by R. H. Rhodes et al.

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Received and published: 29 February 2016

This manuscript describes an effect that controls some of the more subtle yet potentially important aspects of air enclosure in polar ice. This effect, through the layered physical properties of the firn layer, has the potential to affect the atmospheric records produced from ice sheets, which are the main way that we know about pre-observational atmospheric composition. The effect has been observed for some time now but as far as I know this is the most comprehensive measurement and analysis of it to date. The authors use the latest continuous measurement technologies, complemented by discrete but highly resolved measurements, to reveal these high frequency spatial information along several ice cores. The influence of melt layers on CH₄ levels

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is also revealed. Tying the CH₄ variations to the ice age (eg. Page 18) is done methodically and further reveals the layering mechanism. I may have missed this, but is it possible that some CH₄ artefact could have been produced by production during the melt extraction process for the ice core gases? Would this have a variability related to, and in phase with, the ice properties? Predicting the CH₄ artefact from incursion of “laboratory” air into ice from near lock-in is from my experience very difficult to do due to the highly variable CH₄ concentrations that core samples are exposed to during their post drilling life. It is likely that some of this air is retained in the pores and post drilling bubble formation. Would this help explain the variability measured in this region of the cores? A question that arose from the proposed layering mechanism several years ago is how the processes of bubble closure and firn diffusion might interact. Early bubble closure, as demonstrated here for “advanced” closure layers might also impede diffusion of air to lower layers, which would offset the CH₄ variability imparted by closure alone. How could this effect be observed or quantified with the current analysis? Furthermore, if the layering influence on closure also affects diffusivity of the firn, it might have an impact on the air age distribution width of ice core air. Sealing layers are mentioned on Page 23, and have been observed in sites such as Law Dome, but not in sites in the present study. How would such layers, if they existed, show up in the observations presented here? Is it possible, although I understand it’s probably beyond the scope of this work, that vertical movement through cracks or channels (Page 23 Line 30) could induce non-diffusive mixing, with implications for isotopic fractionation as well as age spread? A little more discussion on the evidence and impacts of these potential processes could make the results of this work very relevant to the interpretation of ice sheet reconstructions of atmospheric composition. The writing is clear and the data are presented nicely and analysed logically. After addressing the general comments above and the more minor ones which follow, I would expect that the work would be in very good shape for publication.

Minor comments Abstract The first sentence is rather long and awkward and could be rephrased. “Trapping noise” seems an unsuitable name for a reproducible and pre-

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dictable signal on a regular scale. Consistency of units such as yr⁻¹ in some figures and text needs addressing. The abstract could also be improved with some idea of the size of the trapping signals and their implications for reconstructions of atmospheric CH₄ and potentially other gases. Page 4 Line 17. An estimate of “small scale” would help. Page 6 Line 28 Explain t90 Page 7, lines 21-26. Were these measurements made on horizontally-adjacent ice to avoid possible differences over small depth increments? Page 8 Line 22. The differences may also be due to the other chemical-physical processes presented in this work? Line 28. Please specify what statistic is used for the age distribution width. Page 9. Line 8. Did the forest fire cause high CO in the laboratory air? Wouldn't this help to detect ingress of ambient air? Line 24. How does microbial activity enhance CH₄ in the vicinity of melt? Page 10. Line 10. Isn't the dissolved CH₄ released during re freezing of the layer? Line 30. Might need to explain what wind crusts are. Page 12. Line 13. This has been stated several times already and could be left out or précised here. Page 16. Line 12. ...the different. ... Page 20. Line 30. ...ice chemistry...

Interactive comment on Clim. Past Discuss., doi:10.5194/cp-2015-183, 2016.

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