

## ***Interactive comment on “The SP19 chronology for the South Pole Ice Core - Part 2: gas chronology, $\Delta$ age, and smoothing of atmospheric records” by Jenna A. Epifanio et al.***

### **Anonymous Referee #1**

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Epifanio et al. present the gas age chronology for the new South Pole ice core that dates back to 54 ka. The timescale is constructed by synchronization of the methane record with that of the WAIS Divide ice core following established methods. Sources of uncertainty are accounted for thoroughly. The paper is well-written and clear, and accompanied by a high-quality dataset. It will be important publication for the South Pole group and others to refer to.

I have no major issues with this straightforward study and so have listed minor comments and suggestions below. My only disappointment is that the paper touches on two interesting areas that aren't followed up: using the independent chronologies to

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assess firn densification model performance and the confirmation of centennial-scale methane signals throughout the record. I look forward to subsequent manuscripts on these topics.

Abstract: Can the ‘relatively minor’ smoothing be quantified here? Pg 1, Line 32: Are ice core timescales really “very accurate”? Absolute age constraints are rare. Pg 2, L8: “trace impurities” – can you be more specific?

Pg 4, L1: How is the PSU blank correction “estimated”? What is the standard deviation on the 35 ppb blank? Information not in supplement. Pg 4, L15: The pooled standard deviation calculation considers samples from both labs? After the correction for the inter-lab offset? Pg 4, L18: Would be useful to know if this comparison uses WD continuous or discrete data, or combination of the two?

Pg 5, L17: What criteria were used to identify the non-DO/Heinrich tie points? Particularly through the Holocene... Pg 5,L28: Not sure I understand what “low frequency measurement offsets could cause problems for the synchronization? How was the choice of filter made? Is the filtered record displayed anywhere in figures? Doesn’t using such a filter risk the introduction of signal artifacts that may bias the optimization algorithm? Pg 5, L30: 189 years is a big change – is the algorithm definitely picking out the same event in both records? Pg 5, L32: Are r-values the best method of assessing synchronization? When there are a lot of wiggles involved, as in through the Holocene, it is easy to get a high r-value while lining up the wrong events, i.e., one cycle out.

Pg 6, L10: The authors know this, but to be very clear, the WD gas age uncertainty is dependent on different things at different points in the record (i.e., Holocene vs. Glacial), depending on WD2014 construction. Pg 6, L 26: Suggest re-phrasing to “difficulty in simulating past firn densification has led to uncertainties in the relative phasing ...”

Pg 7, first paragraph. Could you provide some more information on the firn densification model results? Is the red line of Figure 4 delta-age output of one of the 3 model

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results shown on Figure 13 of Winski? Why do you suggest delta-age is driven by accumulation rate changes? Pg 7, L23: “were” should be “was” Pg 8, L2: Wouldn't the WD2014 gas age dating paper be a more suitable reference here? Or just admit that WD is not atmospheric history but it's the best we've got.

Pg 8, L5: Is the “gradual bubble trapping” in model as described by Mitchell et al. 2015? Please cite if so. Pg 8, L6: Please explain how model was calibrated to EDC? Could adjustments to this tuning impact your results? Pg 8, L17: Couldn't this (gradual bubble trapping causing broadening) be demonstrated by turning off the gradual bubble trapping and comparing gas age distributions?

Pg 8, L25: Is there more discussion to have here? 3% of delta-age is less smoothing than we might have expected, at least based on the old rule of thumb of 10% delta-age. Why is the smoothing at these low accumulation rate sites less than might be expected? Pg 8, L28: Be more quantitative than “significant short term variability” Pg 8, L33: Are the centennial-scale features not present in South Pole > 16.1 ka? Or has smoothing or sampling meant they are not resolved?

Figure 1, legend. Are the labels mixed up? Figure 5, left panel. Which “events” do the black markers refer to? Surely the amplitude difference should be a percentage change to make different events comparable?

Figure 5, right panel. Please include markers for the SP data points, to show that amplitude difference is not simply a result of under-sampling. Figure 6: Maybe I missed it in the main text, why does the width of the age distribution “correspond to the median age of distribution”?

Figure 7: Could the three records be offset slightly in the y-direction to help reader see the common variations? Maybe also add a couple of sub-panels to focus in on regions of excellent match in the Holocene.

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