Summary of changes to manuscript CP-2018-53:

Spatial pattern of accumulation at Taylor Dome during the last glacial inception: Stratigraphic constraints from Taylor Glacier

Given substantial changes to the manuscript following comments from reviewers, we summarized the main changes here so that the editor can more easily keep track. The major revisions generally fall into the numbered categories below. Please see the other posted documents for detailed responses to the referees' specific comments.

1. Adjust tie points

Four referees questioned our choice of tie points, mainly because they found certain tie points ambiguous. We will add text to the revised manuscript to justify our tie point selections more clearly. We increased the size and resolution of Figures 3 and 4 (see below) in the revised manuscript so that it is more apparent to readers why we chose to match the variability the way we did. We will also increase the size and resolution of Figure 2 for the same purpose. We are plotting smoothed particle count data (instead of raw data as in the original manuscript) so readers can see the dust events during MIS4 more easily and can tell the difference between true events versus noise. We also plotted the tie points on Figure 3 and Figure 4 so the features we matched are clear to readers. We refined/ adjusted the tie points as described below, based on feedback from reviewers and what we deduced was the reason for the perceived ambiguities. The final tie point selections are listed in Tables 1-4 below, and the revised versions of Figure 3 and Figure 4 are also included below so the quality of the matches to the reference ice core records can be assessed.

- a. Taylor Glacier gas tie points remain the same as in the original manuscript except for the two oldest tie points.
    - i. Reviewers had few specific comments about the Taylor Glacier gas tie point choices, except one referee questioned the validity of the gas chronology in the top 4 m where we cannot rule out contamination of the gases by shallow cracks in the glacier surface. We decided to keep the tie points the same in the revised manuscript as in the original, including the top 4 m, but we will emphasize in the text that we do not use or interpret the chronology in the top 4 m rigorously. Our interpretations of the high delta age values do not depend on these data because the highest delta age values occur at ~ 5.5 m with delta age increasing steadily and significantly between 5.5-10 m depth. We also clearly mark the top 4 m in the gas data in gray in Figure 3 so that readers can see which portion of the record is shallower than 4 m.
    - ii. One reviewer suggested picking tie points using the CO_2 data. We originally chose not to do this because CO_2 offsets between ice cores are a known and unresolved issue, hence we hesitate to value-match the CO_2 data. We prefer not to pick tie points using the CO_2 data in the revised manuscript for the same

reason. We would like to point out that even if we did choose tie points using CO_2, it would not change the gas age scale enough to alter our interpretations about the high delta age values. This point is discussed in more detail in response to the reviewer's specific comment.

    iii. We changed the two oldest tie points slightly. Based on a reviewer's comment we changed the oldest $\delta^{18}O_{atm}$ tie point to match the low inflection point in the NGRIP $\delta^{18}O_{atm}$ data at 73.74 ka (instead of 74.65 ka in the original manuscript) before the transition. We also changed the second oldest $\delta^{18}O_{atm}$ tie point to match the mid point in the NGRIP $\delta^{18}O_{atm}$ transition at 72.7 ka.

b. Taylor Glacier ice tie points changed somewhat from the original manuscript, following the comments from reviewers:

    i. For the majority of the Taylor Glacier ice tie points (6 out of 9 dust tie points) we decided to match Taylor Glacier $nssCa^{2+}$ variability to EDC $nssCa^{2+}$ instead of matching Taylor Glacier insoluble particle count to EDC laser dust. The reasons are: (1) the $nssCa^{2+}$ measurements are more quantitative than the insoluble particle count measurements, (2) our $nssCa^{2+}$ record is less noisy than the insoluble particle count record, and (3) comparing Taylor Glacier $nssCa^{2+}$ directly to EDC $nssCa^{2+}$ is a "like-to-like" comparison, whereas the methods for measuring laser dust and insoluble particle counts are less similar. As a consequence of picking $nssCa^{2+}$ variability instead of insoluble particle counts, many of the final tie points are shifted in depth and age slightly (< 10 cm and < 0.1 ka) relative to the tie points presented in the original manuscript in order to align features exactly.

    ii. We added two additional $\delta^{18}O_{ice}$ tie points (at 7.75 m and 12.20 m) for a total of three $\delta^{18}O_{ice}$ tie points. This is so readers can see more clearly how we interpret the isotope variability at AIM 19 and AIM 20 to match EDC (Table 2, Figure 3). This avoids an issue that two referees commented on: matching $nssCa^{2+}$ in the deeper part of the core where the $nssCa^{2+}$ variability is comparatively small and alignment of individual peaks is possibly more ambiguous. By picking tie points directly from $\delta^{18}O_{ice}$ we avoid this ambiguity – readers see immediately how the variations in the $\delta^{18}O_{ice}$ correspond to those at AIM19 and AIM20 in EDC.

    iii. We added one additional $nssCa^{2+}$ tie point (4.94 m) to match a low value in the EDC $nssCa^{2+}$ during early MIS4.

    iv. We changed the 4.19 m tie point to 4.47 m because there is an offset at this depth between the peak in Taylor Glacier insoluble particle count measured in the field versus the peak in Taylor Glacier nssCa^{2+} measured in the laboratory, and we prefer to match the nssCa^{2+} instead of insoluble particle counts.

   v. We eliminated the 6.3 m particle count tie point that matched the low dust concentration before the MIS4 dust onset. This inflection point in dust is possibly ambiguous, and we prefer the $\delta^{18}O_{ice}$ maximum at AIM19 (7.75 m) to provide age constraints in this section of the core.
   vi. We still chose to match the variability in the Taylor Glacier insoluble particle count to the EDC laser dust for three tie points where nssCa^{2+} variability was small but where particle count variability was larger and showed similar features to laser dust (Table 2).

c. Taylor Dome gas age tie points changed somewhat from the original manuscript, following comments from reviewers and following the publication of (Baggenstos et al., 2018):
   i. We adopted three published tie points from (Baggenstos et al., 2018) that tie the Taylor Dome CO_2 (Indermuhle et al., 2000) to the WAIS Divide CO_2 record (currently unpublished). Note that the CO_2 data are not value-matched by (Baggenstos et al., 2018), rather the tie points represent the mid points of transitions at A3 and A4.
   ii. Otherwise the tie points matching Taylor Dome CH_4 variability to EDML CH_4 (Schilt et al., 2010) are the same as in the original manuscript.
d. Taylor Dome ice age tie points changed somewhat from the original manuscript, following comments from reviewers and following the publication of (Baggenstos et al., 2018):
   i. We adopted four published tie points from Baggenstos et al. 2018 that tie Taylor Dome nssCa^{2+} (Mayewski et al., 1996) to WAIS nssCa^{2+} (Table 4).
   ii. We eliminated the 456.3 m tie point and the 466.8 m tie point from the original manuscript because the tie points from (Baggenstos et al., 2018) provide age constraints around these depths.
   iii. We added tie points to more precisely match Taylor Dome Ca^{2+} variations to EDC laser dust and EDC nssCa^{2+} (Table 4, Figure 4).
   iv. We added 4 $\delta^{18}O_{ice}$ tie points to clearly demonstrate the variability we see at AIM 19 and AIM 20.

Table 1 – Tie points relating Taylor Glacier depth to gas age on the AICC 2012 timescale. Gray shading indicates tie points < 4 m depth where abundant cracks in shallow ice may cause contamination of the gas records. “DO” refers to Dansgaard-Oeschger event.

Depth (m)	Gas Age (ka)	Parameter, Data Source	Feature Description	Tie Point Source
1.74	58.21	CH_4/ this study	Peak during DO16/17, synch. to EDML CH_4	This study
3.15	59.10	CH_4/ this study	Peak during DO16/17, synch. to EDML CH_4	This study
4.19	59.66	CH_4/ this study	Midpoint transition DO16/17, synch. to EDML CH_4	This study
5.40	59.94	CH_4/ this study	Low before DO16/17, synch. to EDML CH_4	This study
7.79	64.90	CH_4/ this study	Peak during DO18, synch. to EDML CH_4	This study
11.24	69.92	CH_4/ this study	Small peak between DO19 and DO18, synch. to EDML CH_4	This study
12.43	70.62	CH_4/ this study	Low after DO19, synch. to EDML CH_4	This study
13.25	71.21	CH_4/ this study	High before transition late DO19, synch. to EDML CH_4	This study
16.20	72.27	CH_4/ this study	Midpoint transition DO19, synch. to EDML CH_4	This study
16.94	72.70	$\delta^{18}O_{atm}$/ this study	Midpoint transition, synch. to NGRIP $\delta^{18}O_{atm}$	This study
19.27	73.74	$\delta^{18}O_{atm}$/ this study	Low before transition, synch. to NGRIP $\delta^{18}O_{atm}$	This study

Table 2 - Tie points relating Taylor Glacier depth to ice age on the AICC 2012 timescale. Ice phase parameters (dust and $\delta^{18}O_{ice}$) are unaffected by surface cracks below the top 40 cm (Baggenstos et al. 2018). Gray shading indicates tie points < 0.4 m depth where abundant cracks in shallow ice may cause contamination of the ice records due to local dust deposition. “AIM” refers to Antarctic Isotope Maximum event. “MIS” refers to Marine Isotope Stage.

Depth (m)	Ice Age (ka)	Parameter/ Data Source	Feature Description	Tie Point Source
0.34	61.47	Insoluble particles/ this study	Peak near end of MIS4, synch. to EDC laser dust	This study
1.25	63.93	$nssCa^{2+}$/ this study	Peak late MIS4, synch. to EDC $nssCa^{2+}$	This study
1.80	64.91	Insoluble particles/ this study	Peak late MIS4, synch. to EDC laser dust	This study
2.45	65.65	Insoluble particles/ this study	Peak mid MIS4, synch. to EDC laser dust	This study
3.10	66.73	$nssCa^{2+}$/ this study	Peak mid MIS4, synch. to EDC $nssCa^{2+}$	This study
4.47	68.63	$nssCa^{2+}$/ this study	Peak mid MIS4, synch. to EDC $nssCa^{2+}$	This study
4.94	69.72	$nssCa^{2+}$/ this study	Low early MIS4, synch to EDC $nssCa^{2+}$	This study
5.60	70.20	$nssCa^{2+}$/ this study	Peak early MIS4, synch. to EDC $nssCa^{2+}$	This study

7.75	71.95	$\delta^{18}O_{ice}$/ this study	Peak AIM19, synch. to EDC $\delta^{18}O_{ice}$	This study
12.20	73.62	$\delta^{18}O_{ice}$/ this study	Low between AIM19 and AIM20, synch. to EDC $\delta^{18}O_{ice}$	This study
16.62	75.75	$\delta^{18}O_{ice}$/ this study	Peak AIM20, synch. to EDC $\delta^{18}O_{ice}$	This study
19.76	76.50	nssCa^{2+}/ this study	End of record, loosely constrained, synch. to EDC nssCa^{2+}	This study

Table 3 – Tie points relating Taylor Dome depth to gas age on the AICC 2012 timescale.

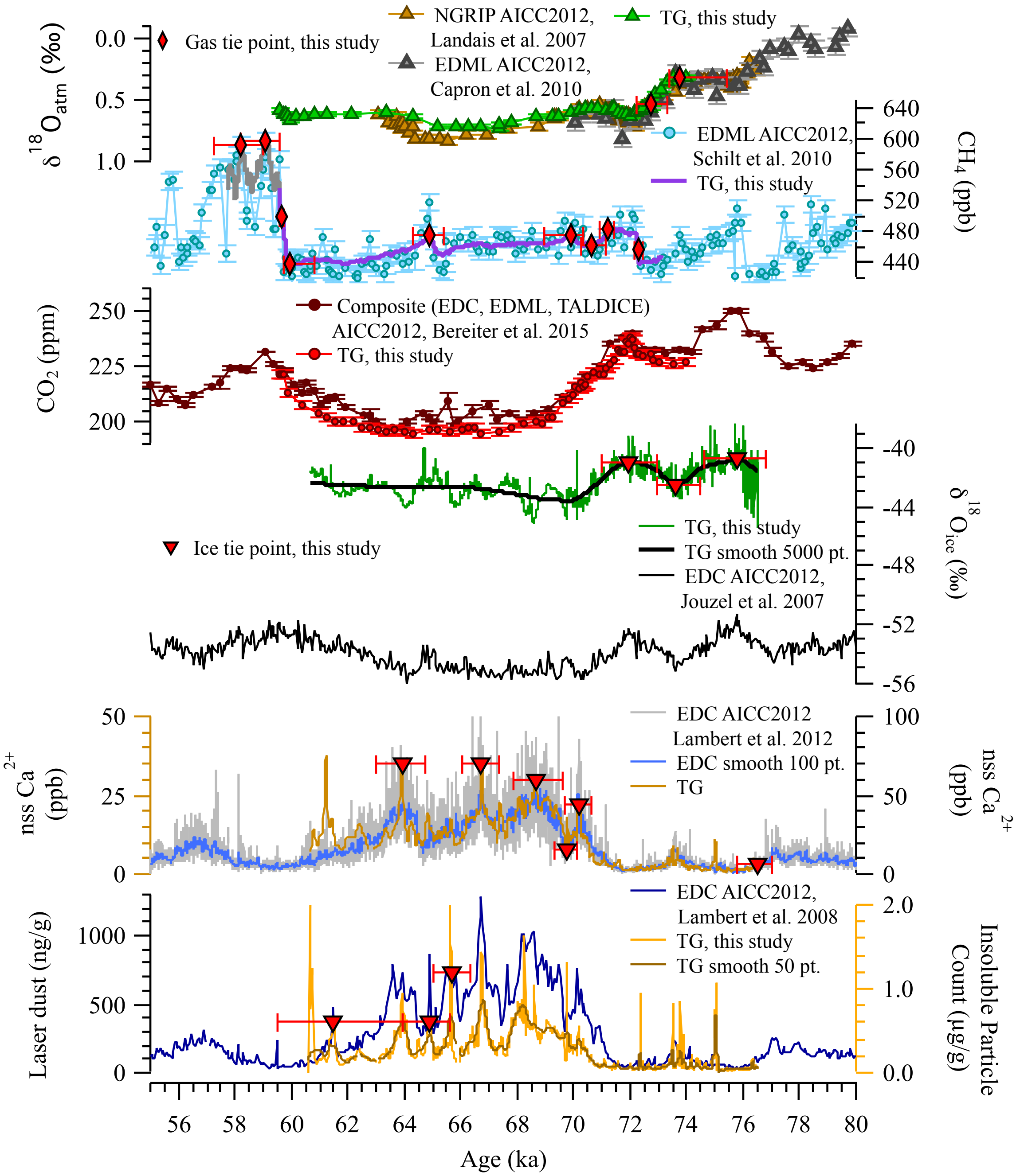
Depth (m)	Gas Age (ka)	Parameter/ Data Source	Feature Description	Tie Point Source
455.95	54.667	CO_2/ Indermühle et al. 2000	Midpoint transition A3, synch. to WAIS CO_2	Baggenstos et al. 2018
460.90	57.913	CO_2/ Indermühle et al. 2000	Midpoint transition A4, synch. to WAIS CO_2	Baggenstos et al. 2018
464.62	59.99	CH_4/ Brook et al. 2000	Low before DO16/17, synch. to EDML CH_4	This study
467.10	62.303	CO_2/ Indermühle et al. 2000	Midpoint transition A4, synch. to WAIS CO_2	Baggenstos et al. 2018
474.95	65.50	CH_4/ this study	Low before DO18, synch. to EDML CH_4	This study
487.83	73.10	CH_4 /this study	Low after DO19, synch. to EDML CH_4	This study
493.50	76.05	CH_4/ this study	Midpoint transition DO19, synch. to EDML CH_4	This study

Table 4 - Tie points relating Taylor Dome depth to ice age on the AICC 2012 timescale.

Depth (m)	Ice Age (ka)	Parameter/ Data Source	Feature Description	Tie Point Source
455.10	55.80	Ca^{2+}/ Mayewski et al. 1996	nssCa^{2+} synch. to WAIS	Baggenstos et al. 2018
457.60	58.85	Ca^{2+}/ Mayewski et al. 1996	nssCa^{2+} synch. to WAIS	Baggenstos et al. 2018
463.30	61.47	Ca^{2+}/ Mayewski et al. 1996	Peak late MIS4, synch. to EDC laser dust	This study
466.40	63.50	Ca^{2+}/ Mayewski et al. 1996	nssCa^{2+} synch. to WAIS	Baggenstos et al. 2018
467.80	64.30	Ca^{2+}/ Mayewski et al. 1996	nssCa^{2+} synch. to WAIS	Baggenstos et al. 2018
468.10	64.66	Ca^{2+}/ Mayewski et al. 1996	Low late MIS4, synch. to EDC laser dust	This study
471.37	65.57	Ca^{2+}/ Mayewski et al. 1996	Peak mid MIS4, synch. to EDC laser dust	This study
472.70	66.71	Ca^{2+}/ Mayewski et al. 1996	Peak mid MIS4, synch. to EDC nssCa^{2+}	This study
475.12	67.47	Ca^{2+}/ Mayewski et al. 1996	Low mid MIS4, synch. to EDC nssCa^{2+}	This study
476.90	68.63	Ca^{2+}/ Mayewski et al. 1996	Peak early MIS4, synch. to EDC nssCa^{2+}	This study
478.70	69.70	Ca^{2+}/ Mayewski et al. 1996	Low early MIS4, synch. to EDC nssCa^{2+}	This study
479.90	70.15	Ca^{2+}/ Mayewski et al. 1996	Peak early MIS4, synch. to EDC nssCa^{2+}	This study

484.30	71.95	$\delta^{18}O_{ice}$/ Steig et al. 1998	Peak AIM19, synch. to EDC $\delta^{18}O_{ice}$	This study
487.40	73.62	$\delta^{18}O_{ice}$/ Steig et al. 1998	Low between AIM19 and AIM20, synch. to EDC $\delta^{18}O_{ice}$	This study
490.80	75.75	$\delta^{18}O_{ice}$/ Steig et al. 1998	Peak AIM20, synch. to EDC nssCa^{2+}	This study
493.40	77.08	$\delta^{18}O_{ice}$/ Steig et al. 1998	Low before AIM20, synch. to EDC nssCa^{2+}	This study

Revised Figure 3:



Revised Figure 4:

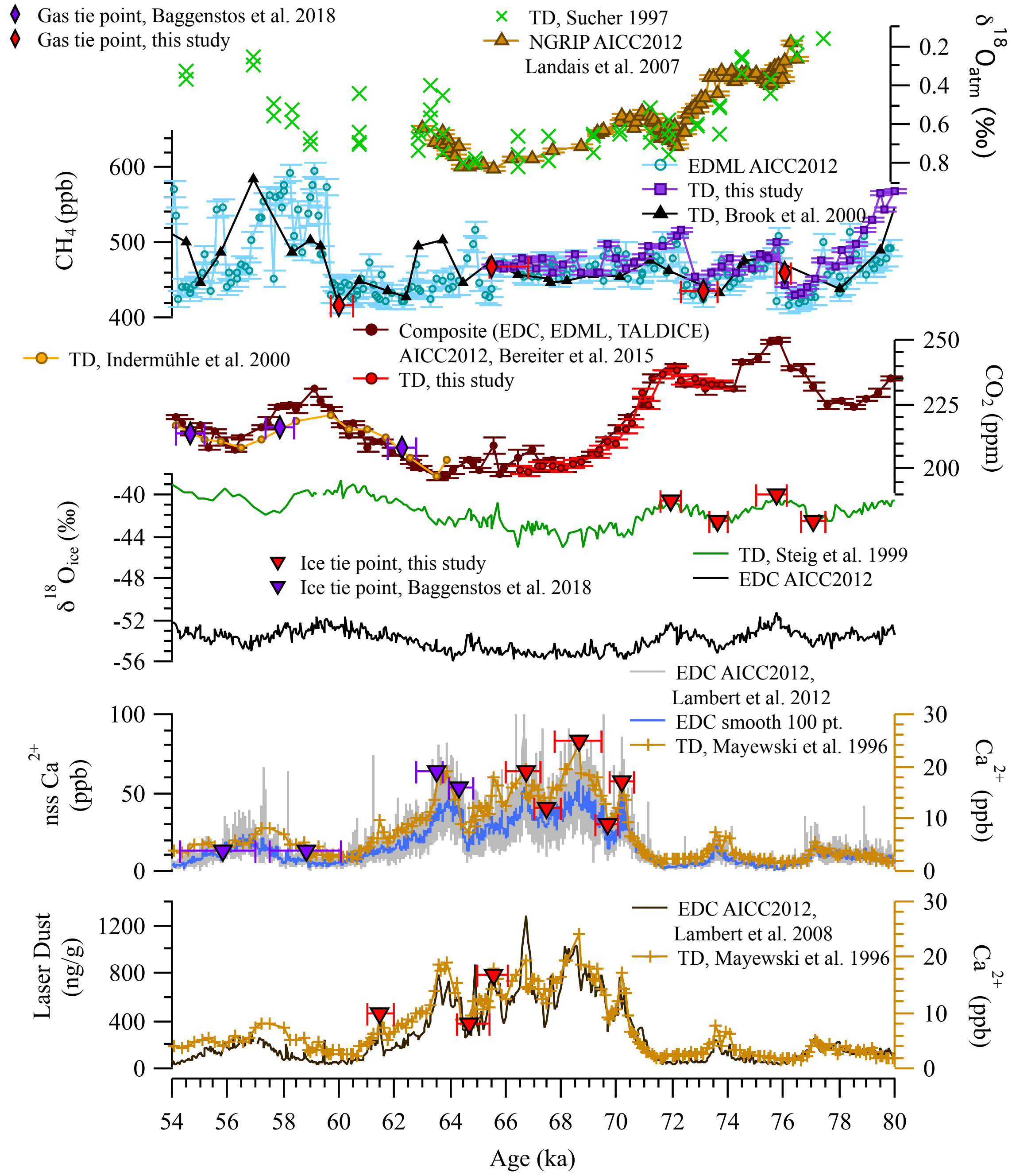
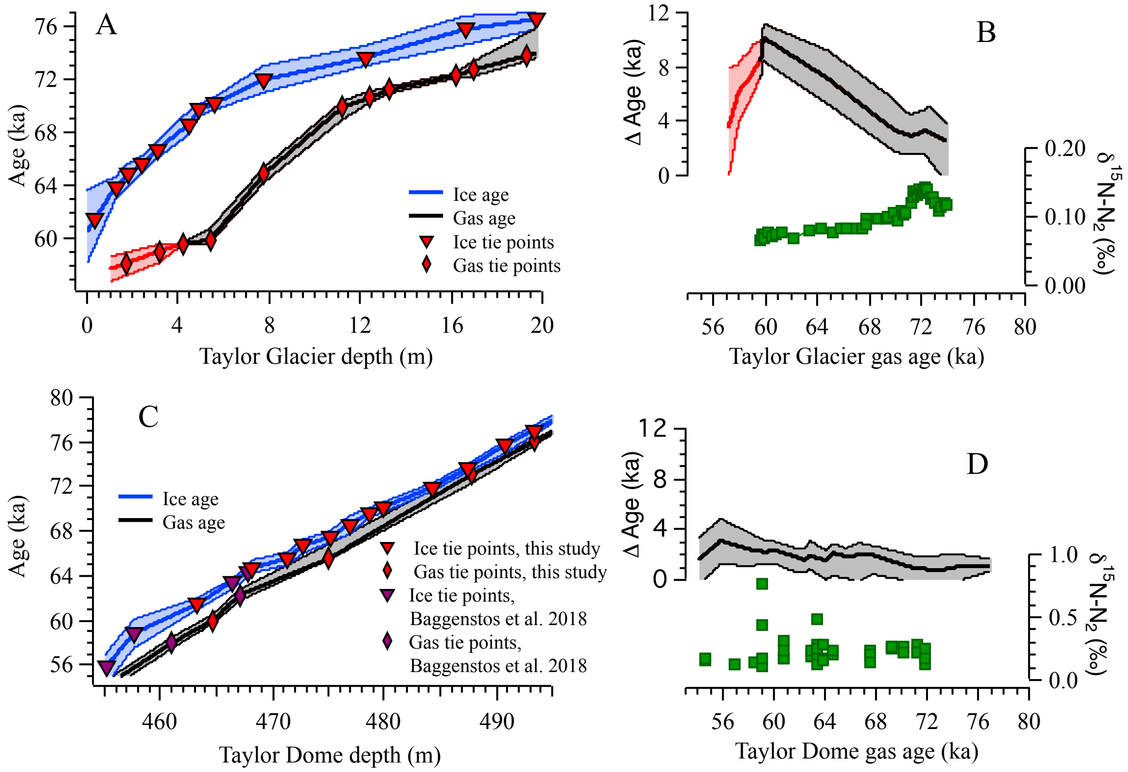


Figure 5 – Age models for new Taylor Glacier 5/4 BID cores (A), Taylor Glacier delta age and $\delta^{15}N\text{-}N_2$ (B), and Taylor Dome revised age models (C), and Taylor Dome delta age and $\delta^{15}N\text{-}N_2$ (D). Red shading on Taylor Glacier gas age chronology and delta age indicates ice shallower than 4 m where surface cracks may affect the CH_4 age matching.



2. Estimate error

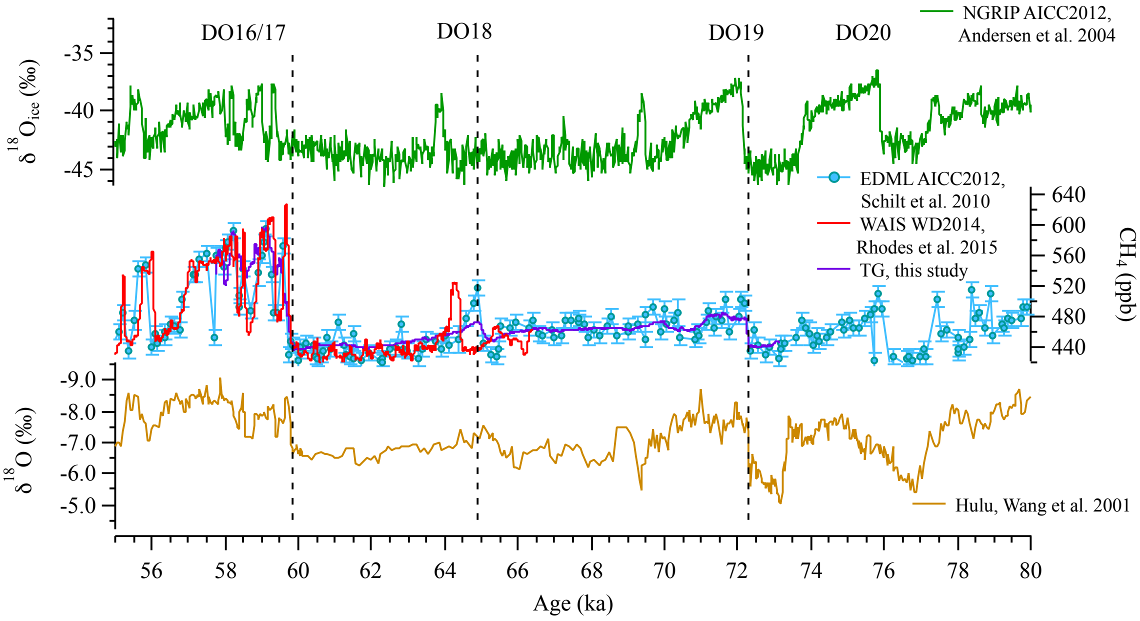
A number of reviewers commented on how we assessed the uncertainty in our chronologies - specifically reviewers said the uncertainty was not clearly presented, and one reviewer thought there might be a more realistic way to assess the uncertainty. Since our tie points are chosen by hand, there is not a probability distribution associated with the matches from which we can give a true 1-sigma uncertainty. In the original manuscript we assigned maximum/ minimum ages to each tie point that estimated the range of possible ages. Our choice of age range for each tie point was based on consideration of (1) the resolution of the data for a given feature that we matched, (2) the analytical uncertainty of the data that we matched to, and (3) how robust (or possibly ambiguous) the matched feature was (i.e. could we be matching the wrong feature?). If any of the three criteria were poor or ambiguous then we enlarged the age uncertainty range to reflect a worse quality match. We then propagated the uncertainties by interpolating through the maximum and minimum age at each tie point, which resulted in an oldest and youngest possible chronology (and therefore also a maximum and minimum delta age). We considered calculating a fit index for each tie point and a probability distribution for each match, but this method is more suited for value-matching data whereas we are matching features where multiple parameters are changing at the same time (i.e. peaks and troughs in $d^{18}O_{atm}$ and CH_4, or in $nssCa^{2+}$ and particle count). We think a computer algorithm will not necessarily do this better than we can do by eye, or at least the difference will be negligible for the delta age story we are telling in this manuscript.

We think the uncertainties estimated by the methods described above are justified because (1) even with assigning very generous uncertainty to each tie point, the uncertainty does not affect our interpretations about delta age (i.e., the delta age that we calculate after propagating the uncertainties to our chronologies is still large during MIS 4 and supports the notion of the development of a steep accumulation gradient between the Taylor Dome coring site and the Taylor Glacier accumulation zone), (2) the uncertainty we estimate for delta age is realistic and is similar magnitude to the uncertainty in delta age from other Antarctic ice cores, including the delta age uncertainties for Taylor Glacier and Taylor Dome published in (Baggenstos et al., 2018), and (3) the CH_4 record on our new gas age scale matches Hulu speleothem $\delta^{18}O$ very closely at the onset of DO 16/17 and DO 19 (Figure 6). The last point supports our choice of tie points for synchronizing to the AICC2012 gas age scale because the Hulu data are independently dated.

In the revised manuscript we would prefer to estimate our uncertainty ranges the way we did originally, but we propose to (1) more clearly show the uncertainty on the age model by plotting the max/min chronologies on Figure 5 (above), not just the max/min delta ages that were shown in the original manuscript, and (2) enlarge the uncertainty ranges in response to reviewers' scrutiny, particularly where tie points were possibly more ambiguous. The revised uncertainties are shown in Figure 3 and Figure 4 as horizontal error bars on tie points, and the propagated max/min chronologies are displayed in Figure 5 as shading. We will also justify how we assessed the uncertainty more clearly in the text. We will also show the comparison to Hulu because it independently supports our gas age scale (Figure 6, below).

Two reviewers pointed out that we made a mistake when citing the absolute uncertainty in the AICC2012 chronology. We will correct the absolute uncertainty that we cite to $1\ \sigma = 1500$ years for the EDML gas age scale and $1\ \sigma = 2500$ years for the EDC ice age scale. Though we naturally acquire these uncertainties when using AICC2012 as our reference age scale, we think that the absolute age uncertainty in our gas age scale is probably less than this given the close match to Hulu. We also note that the relative errors in our ice cores will be less than the total propagated EDC and EDML 1 σ uncertainties because the uncertainties in gas age and ice age are correlated with depth.

Figure 6 – Comparison of the timing of abrupt CH_4 changes in the new Taylor Glacier ice core with abrupt events in the Hulu speleothem record.



3. Calculate accumulation rates/ firn modeling

Two referees suggested that we estimate quantitatively the accumulation rate that you would expect for Δage = 10,000 years. In the original manuscript we stated that we preferred not to do this because it requires extrapolating the firn model beyond its empirical calibration range. The mechanics of bubble trapping in very slowly accumulating firn are poorly known, which is why we hesitate to push the firn model to such extremes. Nevertheless, we will report a cautious estimate in the revised manuscript. Using the Herron-Langway densification model and the barometric equation, we computed the expected Δage and

$\delta^{15}N$ for a range of accumulation rates and temperatures. For Δage = 10,000 years and $\delta^{15}N$ = 0.08 ‰, we estimate the accumulation rate to be between ~ 0.05-2 cm/yr ice equivalent, conservatively. We note that this estimate depends strongly on the height of the convective zone, which is unknown. A deep convective zone would drive $\delta^{15}N$ to lower values, consistent with the low $\delta^{15}N$ that we measured in the -380 m MT core as well as the new 5/4 BID cores.

4. Reorganize text

All reviewers recommended reorganizing the main text, and we intend to follow their suggestions. We will reorganize the text into this outline, consistent with referee 1's comments.

1. Introduction
2. Field site and analytical methods
    a. presentation of field site
    b. description of measurements and methods (including new table with metadata to present more clearly which measurements were performed on which cores)
        i. Taylor Glacier
        ii. Taylor Dome
    c. analytical uncertainties
3. Age models
    a. Taylor Glacier
        i. justification of tie point choices
        ii. age model uncertainties
    b. Taylor Dome
        i. justification of tie point choices
        ii. age model uncertainties
4. Results
    a. Δage
5. Discussion
    a. implications of high Δage and how it relates to the previous work on Taylor Dome that suggested steep accumulation gradients

5. -380 m core chronology

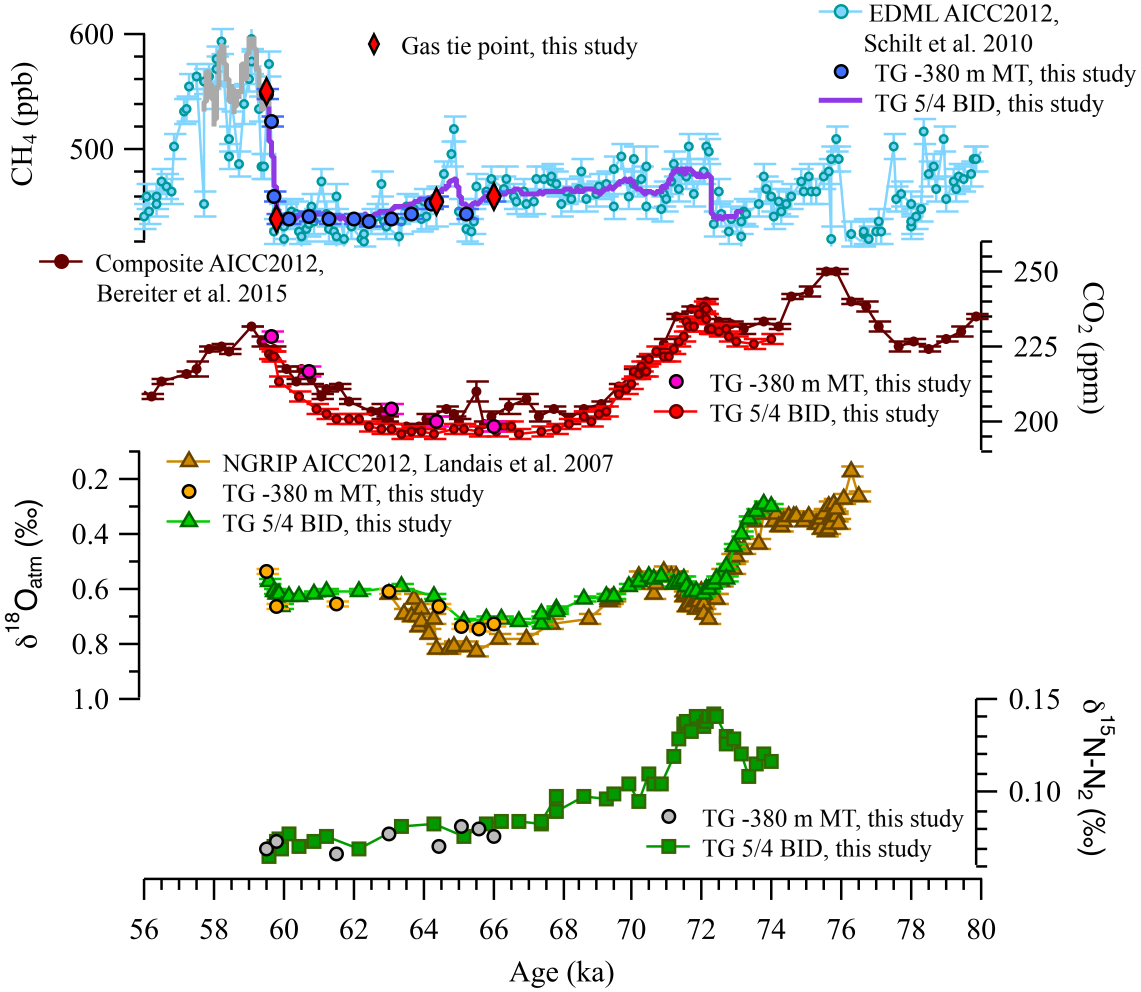
Referee 1 and 3 commented on how we dated the -380 m core. We agree that the chronology of the -380 m core is more uncertain than the BID cores because there are fewer data points to match features in the gas records. The core also appears to cover the period 59-68 ka where the variability in the gases is relatively small (besides the large rise in CH_4 and CO_2 at the onset of DO16/17). In the original manuscript we value-matched CH_4 to create the gas age timescale for the -380 m core, but we did not list the tie points explicitly like we did for the Taylor Glacier 5/4 BID cores and the Taylor Dome core. We also did not describe the dating sufficiently. In the revised manuscript, we will explicitly list the tie points in a new table (Table 5). We will also plot the -380 m core data in a separate figure that shows how it compares to data from the TG 5/4 BID cores and the reference records on AICC2012 (Figure 7 below); we think it will simplify Figure 3 to not include the -380 m data and keep it less cluttered.

We will also describe and justify the tie point choices for the -380 m core more clearly in the main text. The discussion of the -380 m core, including justification of the tie points, will be moved to its own sub-heading in the main text. We will clearly state why we date and interpret the -380 m core: it is evidence of stratigraphic continuity between the new 5/4 BID cores and the Main Transect in the Taylor Glacier blue ice area. We intend to revise the text so that the exact chronology of the -380 m core is deemphasized; we present it as a plausible interpretation. The important part of the -380 m core is that it is *generally* of late MIS4 and MIS 4/3 transition age, which is robust because the $\delta^{18}O_{atm}$, CO_2, and CH_4 all change at the same time, consistent with the variations that occurred during the MIS 4/3 transition in other ice cores. Because the $\delta^{15}N$ is similarly low as in the 5/4 BID cores at this time, it suggests that the ice from both sites came from the same accumulation region and that there are not different deposition zones sourcing Taylor Glacier ice at different times.

Table 5 – Tie points relating -380 m Main Transect core depth to gas age on the AICC 2012 timescale.

Depth (m)	Gas Age (ka)	Parameter/ Data Source	Feature Description	Tie Point Source
3.751	59.53	CH_4/ this study	High value at start of DO16/17, synch. to EDML CH_4	This study
5.301	59.83	CH_4/ this study	Low before DO16/17, synch. to EDML CH_4	This study
9.929	64.40	CH_4 /this study	Low after DO18, synch. to EDML CH_4	This study
14.849	66.00	CH_4/ this study	Low before DO18, synch. to EDML CH_4	This study

Figure 5: -380 m core from the Main Transect.



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