The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2019-207-RC1, 2019

The Cryosphere
Discussions

Interactive comment on "Refractory Black carbon (rBC) variability in a 47-year West Antarctic Snow and Firn core" *by* Luciano Marquetto et al.

Anonymous Referee #1

Received and published: 19 December 2019

This manuscript by Marquetto et al presents a 47 yr black carbon record from a 20-m firn core recovered from the Pine Island Glacier in West Antarctica. The authors measured rBC using the SP2 method, and dated the core primarily using the seasonal cycle of rBC. Potential southern hemisphere rBC source regions to this site were explored by correlating the seasonal cycle of rBC to Australian and South American fire spot data and GFED biomass burning emissions estimates as well as by comparing the power spectrum of rBC to large-scale atmospheric patterns (ENSO, AAO, and ASL) and fire spot data.

While Antarctic rBC records are important for understanding changes in southern hemisphere biomass burning as well as radiative forcing, and undoubtedly an immense amount of work went into developing this highly-resolved dataset, the interpretation

and discussion are not thorough or novel enough to add significantly to the understanding of rBC deposition in West Antarctica. The discussion focused on three analyses: SNICAR snow albedo modeling, identifying continental emissions sources, and linking rBC to atmospheric circulation using spectral analysis. The SNICAR modeling showed that rBC deposition at this site has little to no effect on snow albedo, which is not unexpected given the extremely low rBC concentrations and (as noted by the authors) has already been shown for clean Antarctic snow (Casey et al., 2017). The identification of source regions by comparing seasonal cycles in observed rBC and GFED fire emissions is purely correlativeâĂŤI do not think is a strong enough approach, especially with my concerns about dating, to draw conclusions about source regions without a more robust approach that would consider atmospheric transport and magnitude of biomass burning emissions. Finally, the spectral analysis was similar to that conducted by Bisiaux et al. (2012) for the WAIS Divide and Law Dome rBC records and does not provide any concrete new links between atmospheric circulation and Antarctic rBC. Furthermore, I have concerns about the factor of 2-3 lower rBC concentrations compared to other West Antarctic ice cores (see comments below).

Overall, since the conclusions do not add substantial new insight or understanding to rBC deposition and mainly confirm what is already known, I do not think this manuscript is suitable for the scope of The Cryosphere.

I have two major concerns about the methods: 1.) rBC measurements, and 2.) dating.
1. rBC measurements: The rBC concentrations presented in this study are a factor of 2-3 lower than rBC concentrations in other West Antarctic cores, including the WAIS Divide ice core as well as other measurements from Pine Island Glacier (Pasteris et al., 2014). Note that rBC measurements from early 1900s to 2006 from Pine Island Glacier (as well as Thwaites Glacier and the divide between Pine Island and Thwaites Glaciers) were previously published in Pasteris et al. (2014) and are also 2-3x higher than the concentrations presented in this manuscript- it would be worth including this citation and even comparing to this published dataset to see how the magnitude and temporal

variability of the records compare. The authors need to provide more information to determine if this offset is real or a result of the SP2 calibration/analytical system. Since the referenced Marquetto et al. (2019) manuscript does not appear to be published at the time of this review, please include details on the SP2 internal/external calibration in this manuscript. How were the ice samples melted (room temperature?), and how soon before SP2 analysis were they melted (lines 96-97)? Wendl et al. (2014) show how rBC is lost after melting during sample storage in polypropylene vials over just a few days (with proportionally greater losses for low-concentration samples). How often was 5% HNO3 used to clean the system (line 118), and how did you determine when the acid was flushed from the system? Wendl et al. (2014) also discuss how acidification can result in significant loss of rBC. What kind of tubing was used to transport the aerosol from the Marin 5 nebulizer to the SP2?

2. The description of the dating, namely the role of the datasets from the Schwanck et al. (2017) study, is vague. Since much of the analysis, including the seasonal cycle correlations and spectral analysis, require precise dating, more explanation of the dating must be given. The annual picks in Fig. 1 are consistently on the austral summer (January) decrease of rBC concentration, but appear to be inconsistently placed across the S, Sr, and Na records. Is the S, Sr, and Na data shown in Fig. 1 all from the Schwanck et al. core from $\sim$1 km away? I would expect cores 1 km apart to have a depth offset, so I would not be confident in correlating the picks from TT07 to the Schwanck et al. core without a common dataset to both cores to linking the cores in depth. Without showing that the chemical species from the TT07 core and Schwanck core are not offset in depth, it is not advisable to guide the dating of the TT07 core with data from the Schwanck et al. core, and likewise not justified to apply annual picks based on rBC in TT07 core to the Schwanck core Na record (I can't tell if the Na spectral analysis was conducted on the TT07 age scale or the original Schwanck et al. age scale). How does the Schwanck et al. data compare to the 5.6 m of S, Sr, and Na data for the core taken immediately adjacent to the rBC core (mentioned on lines 154-155)? There should be a few years of overlapping data to compare and that would

at least be a start to justify comparing the two cores in depth.

Furthermore, there appears to be circular logic between the dating and seasonal comparison to GFED. If indeed the drop in rBC concentration at the end of the austral summer was used as the primary annual pick, and this pick was justified by GFED/fire spot seasonality as stated in lines 161-163, how can you then draw meaningful conclusions about the timing of rBC vs. GFED (in Fig. 6a) to identify source regions? The rBC and GFED are already inherently linked based on how you defined the dating of the core. Based on GFED seasonality in Fig. 6a, BC emissions drop in November for Asia/Africa/S. America, two months before the January drop for Australia/NZ. Even a month or two difference on where the rBC drop is assigned could have significant implications for the correlations used in section 4.6 (based on n=12 months) which are used to underpin the conclusion on lines 286-289. It would be much more appropriate to date the TT07 core using an independent chemical species, and then use the independent dating to examine the rBC seasonality.

Other comments- Lines 14-15: Please specify what you mean by wet and dry season? I assume southern hemisphere wet/dry season, not at the ice core site (also on lines 145-146).

Lines 87 and 82: Is Marquetto et al. (2019) published and available?

Lines 83 and 90: Same heading title for sections 3.2 and 3.3.

Line 116: Did you average the rBC data for the full 5 minutes that it was run? Can you quantify the stability of the measurement with a standard deviation over the time period averaged?

Lines 135-143: The Brazilian hotspot data is defined here, but never mentioned in the results and discussion section. Can it be omitted? Or did it result in a null finding?

Line 140: How do the timeseries of the fire hotspot data compare to the rBC data? You only compare the power spectrums in this study. Do years with more hotspots correspond to years with more rBC deposition?

Lines 147-148: Please define Na, Sr, and S before using abbreviations

Lines 167-173: Please plot the average of the two density profiles in Fig. 3 that the quadratic equation was fit to.

Line 180: Please explicitly state which months went into the summer/fall and winter/spring averages.

Line 193 and 296: Is the Na record you use for spectral analysis from the TT07 core, or is it from Schwanck et al.? If it is from Schwanck et al., have you changed the dating?

Lines 211-212: Per comments above, please clarify what dating is used for which chemical species.

Lines 244-246: Please include comparison to rBC data from Pasteris et al. (2014) from Pine Island Glacier.

Line 338: Abstract says record extends from 1968-2015.

Figure 1: Please check location of B40 ice core site.

Figure 2: Please define which records are from the TT07 core and which are from Schwank et al.

Figures 4, 5: It would be helpful to include the standard deviation (or standard error) of the measurements that went into the annual averages and wet/dry season plots as an error bar.

Figures 6, 8: Again, it would be helpful to have an estimate of uncertainty on the seasonal cycles.

Figure 7: Did you use rBC flux or concentration for the spectral analysis?

Figure 8: Could the broad Na peak over 4 months be a result of mixing/matching Na data and depth picks between the TT07 and Schwanck et al. cores?

Table 4: Please include Pasteris et al. (2014) rBC data.

References: Pasteris, D. R., J. R. McConnell, S. B. Das, A. S. Criscitiello, M. J. Evans, O. J. Maselli, M. Sigl, and L. Layman (2014), Seasonally resolved ice core records from West Antarctica indicate a sea ice source of sea-salt aerosol and a biomass burning source of ammonium, J. Geophys. Res.Atmos.,119, 9168–9182, doi:10.1002/2013JD020720

Wendl, I. A., Menking, J. A., Färber, R., Gysel, M., Kaspari, S. D., Laborde, M. J. G., and Schwikowski, M.: Optimized method for black carbon analysis in ice and snow using the Single Particle Soot Photometer, Atmos. Meas. Tech., 7, 2667–2681, https://doi.org/10.5194/amt-7-2667-2014, 2014.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-207, 2019.