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Interactive comment on "Iron oxides in the cryoconite on the glaciers over Tibetan Plateau: abundance, speciation and implications" *by* Zhiyuan Cong et al.

Anonymous Referee #1

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This paper concerns iron geochemistry in cryoconite samples from the Tibetan plateau region. Its main focus is on the optical impacts related to iron oxides on the properties of cryoconite and of its potential role in the reduction of glacial albedo, also considering other impurities that could play a role in this context: organic and inorganic carbon and dust. The topic is definitely appropriate for The Cryosphere. Unfortunately, I have some concerns about the methodological side of this work. This is a paper where the experimental side is dominant, since many measurements were carried out, using different instruments and techniques. For this reason I would have expected that the discussion about accuracy, precision, reproducibility was expanded and largely detailed. On the contrary it is poor and the reader cannot understand and evaluate the significance and

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the robustness of the data.

One of the most critical points concerns sample preparation for ICP-MS. The authors declare that the samples were prepared for ICP-MS analyses using 1% HNO3. This is impossible. Dealing with mineral samples it is necessary to completely dissolve them using high concentration inorganic acids. Nitric acid alone is not sufficient and surely if used at the concentration of 1%. For example, there are a lot of mineral phases that can be dissolved only using a mixture of HClO4, HF and HNO3. If the authors applied the protocol they described, results cannot be considered reliable and I also cannot believe that their recovery factor for Fe was 95 %. Using 1% HNO3 is almost the same of using pure water. The authors should explain in detail this point. In addition to this, it should be taken into account that the authors applied a stronger acid attack to the samples for carbon analysis, I am asking myself why they didn't apply the same protocol for ICP-MS measurements.

Still on the methodologies. I have some concerns about their method to estimate the mineral composition of Fe oxides. At first it should be mentioned that if the datum about total iron content (i.e. the one gathered through ICP-MS) is wrong, all the successive analysis about "free iron-total iron-oxide iron" is in turn inaccurate. Secondarily the equation presented at page 4, line 26, is given without any explanation or reference and it is the equation that allowed the authors distinguishing goethite from hematite. What is strange is that the authors used only hematite to test and validate their method, but they are working on both the oxides. Given the fact that one of the main result of this work is that Fe oxide contained in cryoconite is almost completely composed by goethite (more than 80%), it is strange that they prepared their calibration using only hematite, which accounts only for less than 20 % of their samples.

Given these critical issues I cannot support the publication of this paper in The Cryosphere. The authors should completely revise their methodological approach before going on with the analysis and the interpretation of the data.

Despite my final comment, I started to comment more punctually the paper. For this reason, I include a partial revision of the paper.

PAGE 1

Line 18: change to “influence the radiative properties of mineral dust and thus its radiative impact. In particular, the different optical features of. . .”

Line 20: the term speciation is not appropriate here, you are talking about minerals, not elements. You could refer to “geochemical behavior” or something like that; change to “from five glaciers located in different regions of the Tibetan. . .”

Line 21: “abundance”

Line 22: change to “. . . by mass, in accordance to typical natural background level”

Line 23-25: the passage is not clear, why finding such ratios should be indicative about considering free or immobile iron fractions? Probably something is missing here.

Line 25-27: I guess that here you are referring to the only immobile fraction of Fe, aren’t you? So probably it would be better to change to “Considering the immobile mineral Fe fraction, goethite is definitely dominant, accounting for more than 80 % of total iron”.

Line 31: change to “anthropogenic/natural impacts on glaciers.”; remove “and then taking the proper mitigation measures.”

Line 33: they can do that, not could

Line 34: you talk about glacier and snowpack, what about ice?; change to “more solar energy, with effects on glacier mass balance (Warren and Wiscombe, 1985)

Line 35: improve references, there are plenty of good works about this point, not only one; remove “along with the rising air temperatures (IPCC, 2014)”

Line 37: what is soil dust? On the surface of glaciers it is more common to find rock fragments or dust produced from the weathering of the surrounding rocky outcrops. In

addition to this you should also considered long-range transport from arid areas. See Cook et al., 2016 to review this point (“The dark biological secret of the cryosphere”).

PAGE 2

Line 1-4: I don’t understand why the compositional complexity of TP cryoconite should be major than the one of cryoconite from other areas. Be careful because Baccolo et al., 2017 talks about Alpine cryoconite, not about the TP.

Line 5: change to: “Considering this region, tremendous attention has been paid to. . .”

Line 6: change “partly” with “mainly”

Line 7: remove “and is receiving strong influences from those anthropogenic Emissions”

Line 8: change “Nevertheless” with “On the contrary”; change to “despite dust is apparently the predominant. . .”

Line 12: change to “the snow albedo reduction and the subsequent radiative forcing caused by dust overwhelm the impact related to black carbon.

Line 14: “models”

Line 15: change to: “only dust concentration is taken into account, not its composition”

Line 16-22: consider also Formenti et al., 2014 (“Dominance of goethite over hematite in iron oxides of mineral dust from Western Africa: Quantitative partitioning by XâĂŘray absorption spectroscopy”) and references therein. You are saying that these two oxides are the most common ones “in nature”, but this true only if you talk about atmospheric mineral dust, not if you consider the entire Earth (see for example Torrent et al., 1983 “Quantitative relationships betwe en soil color an hematite content”). Rewrite this passage.

Line 23-24: Why you say “are not well understood”? You could say that they are not

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investigated, not that they are not understood. Do you know a recent paper from Hawkings et al., 2018 ? (“Biolabile ferrous iron bearing nanoparticles in glacial sediments”), I guess you could find useful information in this sense.

Line 25: “remains”; change to “The aim of the present work is to estimate the radiative forcing of cryoconite in the TP region, trying to address several key issues.”

Line 34: change “examine” with “consider”; “regions”; remove “and surroundings”

Line 35: change to “were chosen to sample the cryoconite”; change to “A detailed description of the collection sites is given in Table 1”

Line 36: change to “The Urumqi No.1 glacier (UG, 43°06âĂšN, 86°49âĂšE), presents two branches covering 1.6 km2, it is located in eastern Tien Shan. The air circulation of this region is dominated by westerly winds in summer and by the influence of the Siberian High baric field during winter (Wang et al, 2014).”

PAGE 3

Line 2: change to “(LHG, XX°XX’X, XX°XX’X)

Line 3: change to “where a typical continental climate is found (Dong et al., 2014)”

Line 5: follow the sam scheme of above “(XDK, XX°XX’X, XX°XX’X)”

Line 6: “at the center of TP”

Line 7: “Tanggula Mountains represent the northern boundary of the area influenced by the South Asian monsoon.”

Line 8: “(PL, XX°XX’X, XX°XX’X)”

Line 10: “and it is characterized”

Line 11: “(BS, XX°XX’X, XX°XX’X)”; “with a length of 2.26 km and an area of 1.32 km2”

Line 12: “in the Yulong Mountains, at the southeastern edge of TP”

Line13: “low altitude”

Line 14: “kept frozen”

Line 17: “freeze-dried” what dou you mean, explain; “and reduced to powder”; how did you powdered your samples? Explain also this point

Line 18: “Therefore in this work concentrations and fractions are referred to dry cryoconite mass.”

Line 21: change to “under a laboratory bench”

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