

Comments by referees are in blue.

Our replies are in black.

Changes to the manuscript are highlighted in red both here and in the revised manuscript.

### **Reply to referee #3**

This manuscript presents an important and timely topic regarding the role of anthropogenic combustion sources, particularly residential burning, in supplying soluble iron (Fe) to the ocean. The study combines direct laboratory measurements of Fe solubility across a wide range of anthropogenic fuels with the MIMI model. It provides a thorough investigation into the relatively contributions from anthropogenic activities for the present-day and pre-industrial era. The manuscript is generally well written, well referenced, and of interest to the atmospheric chemistry, ocean biogeochemistry, and Earth system modeling communities. Therefore, I would recommend it to be accepted with minor revisions, if the following comments can be properly addressed.

**Reply:** We would like to thank ref #3 for reviewing our manuscript and recommending it for publication after minor revision. We have carefully addressed all the comments, as detailed below.

Major comments:

1. A major innovative contribution of this study is quantifying the contributions of Fe from multiple main sources with newly measured emission factors and modeling simulations. The authors mention ranges of solubility and provide multiple simulations. While there are several processes that may retain large uncertainties with the modeling effort (e.g., Fe-to-BC ratio variability, emission inventory biases, solubility parameter assumptions), the propagation of uncertainties is not fully quantified. A sensitivity analysis is recommended to improve the reliability of the conclusions. For example, how much do uncertainties in residential coal solubility affect global estimates? A sensitivity analysis may help provide more robust policy-relevant implications for the conclusions.

**Reply:** This is an important point that was also raised by ref #1. Accordingly, we have reworded much of methods section 2.2.2 to better describe inventory development and have additionally created/tested an additional Fe emissions inventory that follows different assumptions to separate residential from industrial sources of Fe aerosol. Using the new inventory (now labeled as a high-residential [the original] and low-residential emissions inventory), we conducted 3-additional model simulations in the present day to compare and assess the resultant uncertainties stemming from residential burning.

We report these findings in a sensitivity analysis as suggested and interpretation has been updated in Section 3.3. Ultimately, the uncertainty revealed that residential updates increase anthropogenic fluxes to the ocean by between 25% and 100% depending on Fe content assumptions. Ref #3 is kindly referred to our revised manuscript and supplement for more details on our revision, and below we summarize major changes we have made:

1) The data used to make the new emissions inventory is now described in Table S8 (page 17 in the revised supplement), and the final emissions by sector are reported in Table S9 (page 18 in the revised supplement).

2) Development and implementation of the new emissions inventory, is now detailed in section 2.2.2 (page 11-14 in the revised manuscript).

3) The uncertainty resulting from the emissions inventory and its assumptions are now shown in Figure 3 (page 34 in the revised manuscript), Figure 4 (page 36-37 in the revised manuscript) and Figure 5 (page 40 in the revised manuscript).

#### Minor comments

1. In the abstract it would be better to briefly describe the relative importance of residential burning compared to other anthropogenic sources (e.g., percentage contribution to total soluble Fe flux).

**Reply:** As suggested, we have revised the abstract accordingly (page 3 in the revised manuscript): “Anthropogenic combustion is estimated to contribute up to 20% of the global soluble Fe flux to the ocean in the present day. Furthermore, we identified residential coal burning as a previously neglected but potentially important source with regional flux contributions ranging from <1% to 21%. Our work underscores the need to further refine understanding of aerosol Fe properties from a wide variety of anthropogenic sources by increasing observations in more novel aerosol regimes, with a focus on residential coal burning. This understanding will in turn aid in characterizing the influences of anthropogenic activity on past, present, and future atmospheric nutrient inputs to marine ecosystems.”

2. line#83: “A study ... is needed” or “studies ... are needed”.

**Reply:** The referee is right. In the revised manuscript (page 5) we have revised this sentence to “...studies examining socioeconomic, technology, and policy driven changes to anthropogenic fuel-burning, are needed to...”

3. line#473 “was found to range” should be “ranged”.

**Reply:** As suggested, in the revised manuscript (page 27) we have changed it to “Fe solubility in acetate buffer (pH: 4.3) ranged from 0.002% to 0.17%...”