

1) I noticed that Benjamin Chazeau has been added to the author list. For the sake of transparency, could you please briefly state why he was added? Also, adjust the author contribution section accordingly.

We have included Benjamin Chazeau as a co-author as his contribution was essential during the initial phase of the source apportionment, where he provided critical technical expertise and training on the SoFi Pro software. His guidance in setting up the model and ensuring the proper implementation of the methodology directly impacted the quality and reliability of the data presented here.

2) Abstract: " aldehydes may serve as precursors of sulfur(IV) species in aerosols" – Given that this sentence is so prominent in the abstract, I suggest more clarifying it. As is, it reads as if aldehydes form S(IV). However, I assume you mean "aldehydes may form sulfur(IV) adducts in aerosols"

Fixed.

3) l. 39: Here it is not obvious why ammonia play a role in HMS formation. Though you explain that is due pH in l. 590ff, it may be good to make it clearer in the abstract as well.

Fixed.

4) l. 139/140: "The average relative uncertainty regarding the concentration derived from the propagation of the relative uncertainties on the transmission and the k is estimated to be within $\pm 30\%$."

I agree with the referee that some more information could be provided on this.

We have added this text starting at line 147, with new text underlined: "The average relative uncertainty regarding the concentration derived from the propagation of the relative uncertainties on the transmission and the k is estimated to be within $\pm 30\%$. This value aggregates the systematic uncertainty of the reaction rate constants, typically 25-30% (Ellis and Mayhew, 2014; Zhao and Zhang, 2004), and the experimental ion transmission curve (15%). The combined root sum-square calculation yields an estimated uncertainty of approximately 30% for uncalibrated VOCs. While this uncertainty can be in the range of 20-50% for specific compounds (Sekimoto et al., 2017), 30% represents a reasonable overall estimate across the range of species considered in this study."

5) l. 287/88: Please convert this into a proper reference: "U.S. Environmental Protection Agency, 2017" and add it to the reference list. Since it does not have a doi, please also add the last access date.

Fixed.

6) I. 298: replace 'x' by 'times'

Fixed.

7) I. 307: Is there a verb missing? (..it IS/WAS slightly lower...)

Fixed.

8) I. 587: "This is important for ammonium, which could have a significant portion in the gas-phase"

Ammonium is the ion NH_4^+ which is not in the gas phase. For accuracy, you should clarify that you look at the total of ammonia (NH_3) and ammonium here.

Fixed.

9) I. 646: what do you mean by 'particulate S(IV) formation'. Are you saying that S(IV) is indeed formed in the particle phase? Or do you rather mean the 'formation of S(IV) adducts in the particle phase'?

Fixed.

10) Conclusions: Please extend the conclusions such that they adhere to our author guidelines

https://www.atmospheric-chemistry-and-physics.net/policies/guidelines_for_authors.html

We have expanded the conclusion in the last three paragraphs (new text is underlined):

“We further compare these source profiles with other complementary measurements, including total ammonium and S(IV). Total ammonium, which allows for the moderate aerosol pH that S(IV) formation requires in wintertime Fairbanks, is best correlated with the gasoline factor. S(IV) (largely made up of HMS) is best correlated with the diesel factor, which is the largest primary source of formaldehyde (an HMS precursor), and S(IV) has a similar diurnal cycle to both gasoline and diesel vehicles. These results suggest that formation of S(IV) adducts in the particle phase may be linked to vehicle emissions through ammonia and aldehydes, highlighting the importance of VOCs on secondary aerosol formation in extremely dark and cold environments like Fairbanks.

Several aspects can be further improved in future work. Measurements of short-chain alkanes and alkenes would provide a more comprehensive characterization of VOCs in wintertime Fairbanks. In addition, the lack of ammonia measurements during the ALPACA campaign precludes definitive conclusions about secondary S(IV) formation. Future

measurements that simultaneously characterize VOCs, ammonia, ammonium, and S(IV), combined with aerosol pH modeling, would enable a more comprehensive understanding of the mechanisms controlling S(IV) formation.

Our work highlights the important role of VOCs, particularly aldehydes, in secondary aerosol sulfur formation in winter urban environments. We show that vehicle emissions can influence aerosol sulfur chemistry directly through S(IV) precursors and indirectly through ammonia that modulates aerosol acidity. These findings demonstrate the coupled roles of organic and inorganic emissions in wintertime secondary aerosol formation and may help develop more effective air quality control strategies in cold urban environments beyond Fairbanks.”