Review on "A Possible Pathway for Rapid Growth of Sulfate during Haze Days in China" by Li et al.

General Comments

This manuscript presents a heterogeneous formation mechanism of sulfate in which gaseous SO_2 is proposed to be oxidized by O_2 on the aerosol water surface with Fe^{3+} serving as the catalyst. The parameterized mechanism is implemented in WRF-Chem and is evaluated through two heavy haze episodes in the China urban environments. Model simulations show that the proposed mechanism can reproduce the observed sulfate concentrations and improve the PM2.5 simulations. This study provides valuable information on improving our understanding of the SO_2 oxidation and sulfate formation in the atmosphere. It is well written and is suitable for publication with minor revisions.

Specific comments

1. There are two possible pathways for the heterogeneous SO_2 oxidation catalyzed by Fe^{3+} involving aerosol water—aqueous reactions in cloud water or fog, and heterogeneous reactions on aerosol surfaces (e.g., lines 47-48 and lines 164-165). Does the proposed mechanism in this study consider both and only the latter? If it considers the latter only, would there still be some overlaps in the parameterization presented? And would the sulfate concentrations be possibly overestimated if both pathways are included? Are there any connections or relations between these two pathways?
2. L208, How is the aerosol water surface area calculated? Since the SO_2 oxidation is highly sensitive to RH, it is critical to treat the aerosol hygroscopic growth, which is closely relevant to the aerosol chemical composition, in the model. How is the aerosol hygroscopic growth treated in the model?
3. Lines 104-106, The two haze events need to be elaborated.
4. Lines 140-155, It would be helpful to provide quantitative contributions of the gas-phase oxidations by OH (and sCI if possible) to the sulfate formation.
5. Section 3.2, Given the evidence of the importance of RH in the SO_2 oxidation, it would be helpful to add the evaluation of the RH simulations and discussions of the effects of possible simulated RH biases.
6. Section 3.2, The authors attribute all modeled biases of sulfate concentrations to long range transport and/or meteorological factors. There may be other factors that also contribute to the biases (such as other oxidation mechanisms). Among the meteorology, RH could be a factor too.
7. Lines 244-350, It would be helpful to include percentage contributions of the HRSO2 mechanism for the two episodes.

Technical comments

1. Line 21, Should switch the order of develop and evaluate.
2. Line 66, “model oxides”?
3. Line 186, “showing considerable background contributions”, of what, irons? PM2.5?