

Interactive comment on “Atmospheric processing of iron carried by mineral dust” by S. Nickovic et al.

Anonymous Referee #4

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The paper entitled “Atmospheric processing of iron carried by mineral dust” by Nickovic et al., deals the numerical simulation of the path of iron on its atmospheric route from desert mineral dust sources to its deposition on the North Atlantic ocean. For doing that the authors developed a regional atmospheric dust-iron model that included parameterization of the transformation of iron to a soluble form driven by dust mineralogy, cloud processes and solar radiation. They validated the simulations with aerosol iron collected during some ship campaigns in North Atlantic Ocean, concluding that the model was capable of reproducing the major observed patterns.

This is a groundbreaking paper since the authors used for the first time high resolution mineralogy to calculate the emitted iron fraction in dust. On the other hand, they introduced a transport equation for the free iron as one of the governing equations to

C2187

parameterize the soluble iron chemical reaction as a function of the mineralogy at dust sources. Although the results have associated very high uncertainties, this modeling effort is really an important step forward in the atmospheric chemical processing of iron. For these reasons the paper, undoubtedly, merits to be published in Atmospheric Chemistry and Physics. However, there are some comments and questions the authors should address.

General comments:

1. I would suggest reorganizing and simplifying the text of sections 2.2, 2.3 and 2.4. Some concepts are repeated in these sections (mainly regarding cloud chemical processing). Although the idea of dividing Section 2 in subsections is good, the result is rather confusing, moving forward and backward in the arguments.
2. The term “weathering”, broadly used in the paper, should be explained in more detail.
3. Concerning the iron processing by clouds and solar radiation (described in section 2.3), the authors should assess these general considerations in terms of the specific atmospheric conditions of the study region: the Sahara, the Sahel and the subtropical North Atlantic Ocean. For example, what is the role played by the fast cloud processing over the Sahara taking into account that during Saharan outbreaks over the ocean the cloudiness is almost inexistent? In this case, which would be the role played by the slower solar radiation process?
4. Probably the paper is too ambitious in model validation, when the soluble iron concentration is validated against observed value. As addressed by the authors, the solubility processes are still based on insufficient information about the iron chemical transformations. On the other hand the approach used to validate iron model outputs, probably the only available at the moment, is quite risky since it is based on comparison with observed data taken from a ship moving on the southern edge of a dust cloud over the ocean where high temporal and spatial variability of dust concentration is ex-

C2188

pected, as shown in Figure 3. The authors recognize that even the “simple” validation of predicted surface dust concentration (in $\mu\text{g}/\text{m}^3$) shows large errors, of one order of magnitude or more (e.g. the case of November 6, 2002, page 2707, Line 21). In these conditions, we cannot expect reasonable good results when validating the much more complex simulation of soluble iron concentration (of the order of pg/m^3). The authors should put in context more clearly these limitations in the results assessment.

Specific questions:

1. Page 2701: The solar radiation effect is in terms of temperature tendencies. Why? It makes sense the dependence of radiation with the temperature tendency for short wavelengths (solar range)?
2. Page 2702 (Line 5): correct dustproductive
3. Page 2702: Please, check the following sentences (line 25): “The free-total iron ratios in the samples ranged from 0.13 (Libya) to 0.6 (Niger). The Sahel soils (Niger sites and Mali) which were mostly weathered had the highest Spot values”. These sentences seem to be contradictory with the previous sentence: “There was considerable spatial variability among the samples in the free-to-total iron ratio, with generally higher ratios in less weathered soils”. These sentences are not in concordance with results shown in Figures 1b and 1c.
4. Page 2705: Page 17. Could you, please, specify what means “dominated by the Saharan dust”? Could you quantify this assessment?
5. Page 2705: Line 20. Could you, please, describe more in detail the group of Observations G2?
6. Figure 3a; Since total iron doesn't play an important role in the iron solubilization process, why not to use dust concentration to describe better the dust intrusion over the ocean?
7. Figure 6 is quite interesting showing that Iron solubility is higher than about 8% only
C2189

when dust concentration is lower than $1 \mu\text{g}/\text{m}^3$. This scenario does not correspond really with typical dust concentration associated to dust intrusions in which we might record concentrations two orders of magnitude higher. This low value might be result of dust gravitational settling taken place far away from the sources, or long after the intrusion near sources. Does it mean that the major iron solubility would take place preferable far away from dust sources?, in this case, near the Americas? Does it mean that iron solubility would keep always low near the African coast during and after a dust intrusion?, and only might be significantly higher long time after dust intrusions? Please, assess scientifically the results of Figure 6.

8. Concerning the model validation with in-situ observations, it should be taken into account the fact that a strong acid digestion procedure is normally used to determine total Fe using an ammonium acetate leach at pH 4.7 (see Baker et al., (2006); Marine Chemistry 98, 43–58), what does not seem to fit seawater pH (around 8). Could you, please, assess this potential limitation in observations for model validation?

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 2695, 2013.