

Reviewer 1:

This paper uses the MADCOW model to calculate dust fluxes to the Atlantic Ocean, and compares the results to a dust flux model from Mahowald. The key issue in this comment is that the residence times used to calculate dust fluxes are obtained from Han et al 2008. Those residence times are calculated using the DEAD dust flux model and the BEC ocean circulation and biogeochemistry model for the dissolved Al distribution.

Indeed, our choice of Han et al., 2008 for the residence times was not arbitrary. We could have used our own estimated residence times. However, we would have fallen into a circular approach since we would have calculated atmospheric fluxes from calculated residence times using as input Mahowald deposition fluxes and later on compare our calculated fluxes against Mahowald fluxes. This would have been inappropriate.

The MADCOW model formulation is this:

$$G = ([Al] * MLD) / (T * S * D)$$

Where:

G = dust flux (grams per square meter per year)

[Al] = the dissolved Al concentration in the mixed layer (moles per cubic meter, NOT moles per liter!!)

➔ *This was a mistake and has been corrected*

MLD = mixed layer depth (meters)

T = residence time (years) (from Han et al., 2008)

S = fractional solubility

D = Al concentration in dust (moles/gram)

T is the [Al] inventory from the BEC model divided by the sum of the inputs of dissolved Al from dust and from mixing. The dissolved Al flux from dust was derived from the DEAD dust model using a solubility of 5% and 8% Al in dust (0.002965 moles/gram) and the mixing terms were obtained from the BEC model.

So, T can be written as:

$$T = ([Al] * MLD)_{BEC \text{ model}} / (G * S * D + \text{mixing})_{DEAD \text{ and } BEC \text{ model}}$$

$$T = ([Al] * MLD)_{BEC \text{ model}} / (G * 0.05 * 0.002965 + \text{mixing})_{DEAD \text{ and } BEC \text{ model}}$$

Substituting T into the MADCOW equation yields:

$$G_{Atlantic} = ([Al] * MLD_{Atlantic} * (G * 0.05 * 0.002965 + \text{mixing})_{DEAD \text{ and } BEC \text{ model}}) / ([Al] * MLD)_{BEC \text{ model}} * (S * D)_{Atlantic}$$

When the mixing terms for the dissolved Al input (from the DEAD+BEC model) are small, we can further resolve this equation. I assume they both used 8% Al in dust (D=0.002965 moles/gram) so the D terms cancel. $G_{Atlantic} / G_{DEAD} = ([Al] * MLD_{Atlantic}) / ([Al] * MLD)_{BEC \text{ model}} * ((0.05)_{DEAD} / (S)_{Atlantic})$ This equation can therefore be used to calculate the ratio of the dust fluxes in this paper to those used by Han et al. (2008) from the DEAD model. You can see that

the dust flux ratio is affected by the ratio of the dissolved Al inventory (from the Atlantic data in this paper) to the inventories for the same locations from the BEC model in Han et al. (2008) and, equally as important, by the ratio of the Al solubilities, where the DEAD model used a fixed value of 5% and this paper uses a variety of solubilities obtained from actual aerosol measurements across the Atlantic.

If they used a different Al concentration in dust in this paper (it is not specified!) then the D terms would not cancel, further affecting the dust flux ratios. If the dissolved Al inventories from this paper are the same as those obtained by Han et al. (2008) using the BEC model and if the same fractional solubility is used, then the dust fluxes would be the same and the dust flux ratio would be 1.0. This paper (Table S3) uses Al solubilities always greater than or equal to 5% (often 2-3 times higher), so if the dissolved Al inventories in this paper and from the BEC model are similar, then the predicted dust flux would always be less than or equal to what the DEAD model shows (and probably also less than or equal to what the Mahowald dust model shows). This is a simple mathematical outcome; it does not really say anything substantially new about the MADCOW model and its ability to compare with dust flux models. It would also be very instructive to compare the new dissolved Al inventories in this paper to the inventories for the same locations from the BEC model; if the BEC model inventories are very different from those shown in this paper, then the dust fluxes would not agree with the DEAD model fluxes even if they used the same fractional solubility!

We did use the same value for D as in the original manuscript (8.1% Al in dust). We did calculate our dAl inventories by trapezoidal integration in order to calculate our own residence times. However, as we were using as input the Mahowald dust fluxes and we wanted to compare our calculated atmospheric fluxes against Mahowald fluxes we cancelled our residence times and used published values. We presume that our inventories will be different to the ones presented in Han et al. 2008 since the depth of the mixed layer differs between our study and Han et al. modelling manuscript. We do not have access to the inventories of the BEC model since we are not able to contact Qin Han as she left academia after her PhD.

At the very least, using fractional Al solubilities from the Atlantic data in this paper to calculate dust fluxes that are then compared to the Mahowald dust model fluxes is not the correct comparison to make. The dust fluxes should be compared to the DEAD model dust fluxes, since those fluxes were used to estimate the residence times. And the degree of disagreement can then be attributed to differences in the dissolved Al inventories (measured vs. modeled) and/or differences in the Al fractional solubility. This makes the paper less “descriptive” and more “quantitative”

We have added DEAD model dust fluxes. As Han has left science, the data appears challenging to track down, but other leads are followed.

Minor typos and comments Page: Line: Comment:

3: 17: use particle collection

Done

3: 27: The MADCOW model uses more than one parameter; the residence time is a derived or assumed value, and it is probably the least well known term in the equation.

We have removed that sentence to avoid confusion

4: 17: Please express the acidification of the samples with the molar concentration of acid added. For example, if you add 4 mL of 6M HCl per liter, you added 0.024M HCl.

That would have a pH around 1.7-1.8.

Done

4: 31: The dissolved Al must be in moles per cubic meter units.

Done

14: 9: enhanced

Done

14: 11: likely results in

Done

14: 26: and was somewhat lower

Done

15: 10: constraints

Done

15: 12: sites

Done

15: 15: I would delete “which implies a major strength of the approach used in this study” because this study does not reveal anything substantially new about the use of dissolved Al in the MADCOW model.

Modified to: “ which implies a major strength of the MADCOW model”

15: 18: such as

Done

15: 30: Special thanks

Done

Figure 6: panel (b) needs coordinate values on the axes.

Done

Table 1: Should compare to DEAD dust fluxes, not Mahowald.

DEAD fluxes added. We will also keep the comparison against Mahowald fluxes since this provides us with additional insights into the differences between the various dust deposition approaches.

Table S4: Add two columns to show the residence time and aerosol Al solubility used for the dust flux calculation for each station number.

Done

Figure S5: This is the most useful figure and should be moved into the main body of the paper, where you could discuss why the calculated dust fluxes disagree or agree with the DEAD model fluxes. Is the disagreement due to differences between the observed

and BEC-modeled dissolved Al inventories or because you used a higher fractional aerosol Al solubility?

We have moved the figure to the main body. Now Figure 7. We have renumbered all other figures accordingly to the change.

We are not able to compare inventories, but the chances they are equal are minimal. Both factors are different and presumably disagreements at any certain station are a consequence of variability within the latter factors.