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Interactive Comment

Interactive comment on "Data assimilation of dust aerosol observations for CUACE/Dust forecasting system" *by* T. Niu et al.

T. Niu et al.

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Page 8310 line 18: Reference Uno et al. 2006 must be changed to Uno et al. 2004 (JGR, which is not in the reference list). It has been changed in the paper.

Page 8311 line 26: Please include Yumimoto et al. (2007; published in GRL) for the most recent 4d-var dust data assimilation results. It has been changed in the paper.

Page 8311 line 28: Seifeld (2001) must be changed to Seinfeld (2006). It has been changed in the paper.

Page 8312 line 2: What is the meaning of ‘algorithm depending closely on a model’? Can that be clarifyed or rephrased? Because the 4D-Var needs an adjoint which is a inverse model of the forecast model, the algorithm of 4D-Var is closely linked to a model. It has been changed in the paper.

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Page 8313 Section 2.1.1 Based on Hu’s paper, IDDI = Ts - Tbb. The authors must describe what IDDI stands for, what we can get from IDDI, and how reliable it is in a short sentence. The current version of the text is difficult to accept. It has been changed, see Section 2.1.1

Page 8314 Section 2.1.2 I believe that the system is using the surface SYNOP visibility data. In most cases, the surface visibility includes effects of anthropogenic air pollution. How do you discriminate between dust-related and air-pollution-related visibility?

Normally the SYNOP visibility includes the effects of both anthropogenic air pollution and dust aerosol and it is difficult to distinguish them. However, during the dust storm events, dust aerosol is the dominant factor which affects the SYNOP visibility. According to the definition issued by WMO, SYNOP visibility determines the class of dust storm except for the period of frog and have no distinguish between air pollution and dust effects. Consequently, the DAS in CUACE/Dust system behaves better in the SDS periods than in the pollution episodes.

Page 8315 Section 2.1.4 I checked the paper by Hu et al. They showed a scatter plot of IDDI and visibility (having a very big scatter!) and reported that the correlation coefficient depends on the location. I cannot understand why the correlation depends on location so strongly. Is this dependent upon the dust size distribution or the air pollution level? I also have a question. The system estimates the IDDI value based on the surface visibility. Actually, the IDDI might be a function of dust-column loading, but the surface visibility is only a surface value. How do you treat a vertical profile?

We agree with the reviewer. The reason for the scatter is the different local characteristics of both the dust size bin distribution and the air pollution level, which influences the correlation coefficient and causes a big scatter in the plot of IDDI and visibility.

IDDI is different from the surface visibility but they have the same essentials (the dust mass ratio determines all of them during dust storm events). The statistical relationships have been obtained by Hu et al. (2007) from large amount of observation data

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of IDDI and surface visibility in a number of stations and reasonable correlations are achieved. We use them to estimate the IDDI value from visibility and we haven’t treated a vertical profile in this step. We know that this might cause some uncertainty and fortunately we only estimate the IDDI in the cloudy area.

Page 8316 Section 2.2.1 Why does the data assimilation produce a negative concentration? The system assimilates IDDI ($>$0), so I wonder if the setting of background error has some problems.

Below is an example where negative concentrations may occur after data assimilation.

. | | . |a(100) |b(50) .————————————&
. | | . | | . | 。y=2 | . | H(x)=45| . | | . | | . |c(10) |d(20)
.——————————————&#
. | | . | |

In this figure, a, b, c and d are four grid sites of model space with values displayed and the dot is observation site. If yo=2 is observation value, H(x)=45 is the corresponding value from model grid to the observation site through the observation operator H. Therefore, d= yo - H(x) = 2- 45= - 43$<$0. Through minimization a,b,c,d will get negative correction based on background error structure(B) and the value in c-grid maybe turn into negative. This is an example just for explaining the question asked by reviewer. This situation seldom occurs. That’s the reason why “3Dvar gives the negative value”.

LBFGS must be BFGS (L is not necessary) It has been changed.

Page 8316-8317 Section 2.2.2 The authors describe a method to estimate the background error matrix B. They show two equations, eqs. (2) and (3). Nevertheless, it is very difficult to understand how to establish the B matrix based on those two equations. More detailed descriptions must be included here.

More detailed descriptions have been given in Section 2.2.2 with definitions of B matrix (eq. 2), (eq. 5).

Page 8318 Section 2.3 I have very great difficulty understanding this section as it is presented. What is dust matter 40 (DM 40)? How do you convert DM40 to IDDI (IDDI is based on temperature differences from satellite sensors. The definition is completely different from dust concentration.)? Judging from the text here, the control variable (x) of eq. (1) is IDDI. If that is so, please insert the statement at the definition of eq.(1). The authors are also changing the dust size bin information to obtain an optimal solution. I believe that there are many different size bin distributions that give the same DM40 (which means that we can not obtain unique size bin information from IDDI or DM40). How do you treat this problem?

The CUACE/Dust simulates the total dust mass mixing ratio with a diameter less than 40 m (DM40) by 12 size bins. Therefore, DM40 is a simulated quantity. There is no conversion between DM40 and IDDI in the DAS. In order to clearly show the data flow, we have added a new figure (now Figure 1) to illustrate the entire process. In the data assimilation process, IDDI is converted into a normalized dust loading. And model forecasting DM40 in each layer are integrated to obtain the total simulated dust column loading and the loading is then normalized into the same dimensionless scale as the IDDI, which are performed by the observation operator matrix H. The size bins distribution information from the model is used for converting analysis DM40 to dust mass mixing ratio in 12 size bins.

There is a more detail description in the paper (see Section 2.3).

Page 8318-8319. Section 3 Assimilation experiments Figures 3a-3c only show qualitative results. We can obtain more reasonable results if we use additional observation data such as satellite observations and surface observations. What can we get from your discussion? The most important information is why traditional dust modeling methods (which use no data assimilation) are wrong (i.e., desert area estimates and surface condition estimates are wrong) and state what we have to do to improve the

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dust model? I want to advance the same comments to the discussion of Figs. 5, 6 and 7. The present discussion is very poor and seems like an internal model evaluation report.

A detailed discussion about how DAS improved the dust model performs has been added in section 4.1. Specifically, we added a figure (Figure 6) to quantitatively show the impacts of the DAS at various geographical locations from source regions to the downwind areas (Korea and Japan). The DAS corrected model weakness in the transport (such as in the Korean Peninsula) and dust emissions (such as in the central East Inner Mongolia). What the DAS has done was to provide the more realistic initial dust conditions to the model so as to correct the under- or over-estimates due model problems in transport and dust emissions. The entire manuscript has been revise to reflect this corrections by the DAS.

Page 8319 Section 3.2 What are O-B and O-A? How do you define each and what are their units? I cannot understand what the authors want to show.

O stand for observation PM10 value, B is the model forecasting PM10 value without DAS and A is the analysis forecast PM10 value with DAS. O-B stands for the observation PM10 minus forecasting PM10 without DAS while O-A stands for observation PM10 minus analysis forecast PM10 with DAS. The units all of them are g/m3 . We have revised the section (3.2).

Page 8320 Section 4.1 In the analyses related to Fig.5, do you include surface visibility data from Korea and Japan? Yes, we have included the real time data from Korea and Japan.

Page 8321 Section 4.2 How do you define the dust forecast as YES or NO in order to calculate the Threat Score?

This is a daily TS obtained from 24 hr of observations and modeling results. “YES” or “NO” is a dichotomous forecast quantifying

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the performance. Whenever there is a FD, BD, SDS, severe SDS observed in a grid and forecasted by the model, it is a “YES” otherwise it is a “NO”. This is what we included in the manuscript:

“A daily TS is based on a dichotomous forecast of SDS or non-SDS event. A SDS event includes FD, BD, SDS and severe SDS. Whenever there is a SDS event observed in a grid and forecasted by the model, it is a “YES” otherwise it is a “NO”.”

Figure 4(b) What does the horizontal axis show? The horizontal axis is “Stations”. This figure has been revised for an ease read.

Figure 8 Please change the color from blue to red (for triangle line). Changed

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Interactive comment on Atmos. Chem. Phys. Discuss., 7, 8309, 2007.

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