

## ***Interactive comment on “A scheme for calculating soil moisture content by using routine weather data” by K. Z. Shang et al.***

**K. Z. Shang et al.**

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Author final response

1 response to Interactive comment of Referee 2

Question :(1) This special issue is for the CUACE/Dust system. What is the dust event operational forecasting system (DOFS) of the National Meteorological Center in China? It would be nice to show the application of this scheme in the CUACE/Dust system.

Answer:

From 8 to 11/04/2006, a strong dust storm event occurred in North China and Mongolia. We have simulated this dust storm event by CUACE/Dust system. Fig.1 shows the actual dust storm distribution and simulated dust concentration distribution with two kind soil moisture contents as input condition at 10/04/2006, 06:00 (UTC). It can be

seen that the sand dust occurred in two area. The maximum strong sand dust occurred in the South of Mongolia and North China (including inner Mongolia, west of Gansu and North of NingXia). For this area, the dust concentration simulated in Fig.1 (c) is close to the actual sand dust distribution than those simulated in Fig.1 (b). The second strong sand dust occurred in the taklimakan. In this area, the two kind simulated results are all close to the actual sand dust distribution. Besides above, the two kind simulated results all show a high dust concentration in Qinghai-Xizang plateau, This situation is more severe in Fig.1 (c). But there was no sand dust occurred in this area. This error may be caused by incorrect soil moisture estimating and interpolation. We are revising the calculating method for this area. The recalculated results and validation will be given in revised version. The above results show that the forecasting accuracy of the CUACE/Dust system for the East China can be improved by using our scheme. Because the accuracy of sand dust forecasting in the east China is more important than those in the West China, so our scheme can be used in CUACE/Dust system.

(a) the actual dust storm distribution. 1,2,3 represent actual floating dust, blowing sand and dust storm respectively

(b) the simulated result with original soil moisture contents as input condition

(c) the simulated result with soil moisture contents calculated according to our scheme as input condition

Fig.1 The actual dust storm distribution and simulated dust concentration distribution with two kind soil moisture contents as input condition at 10/04/2006, 06:00 (UTC)

Question :(2) Figure 3 showed the soil moisture calculated from the proposed scheme. Please mark the unit of soil moisture in the figure. The scale of the soil moisture used in the figure needs to be changed. A scale between 0.1 and 5 was not appropriate. Moisture in the range of 0.1 to 5

Question (3) Soil moisture observations from the agro-meteorological stations have

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some bias compared to the natural soil moisture in the desert areas due to the irrigation practice. This may reflect the problem in Figure 3. Comparison with other data, such remote sensing data, would help to validate the scheme for using the dust storm forecasts. It is suggested that results from this scheme be compared with other type of soil moisture data.

Answer for question 2 and question 3

As reviewer point out, some meteorological stations in Xinjiang and Gansu influenced by irrigation, so the soil moisture content is obviously higher in these stations than it should be. Expelling these incredible data, Eq. (23), (25), (27) and (29) will be revised as follows:

$$A=1.21-0.758x_4+0.018x_5+1.81x_6 \quad R=0.6742$$

$$B=6.56-0.040x_2 \quad R=0.5332 \quad (23)$$

$$A=1.50-0.732x_4+0.018x_5+1.77x_6 \quad R=0.6786$$

$$B=4.45-0.029x_2 \quad R=0.6762 \quad (25)$$

$$A=1.02-0.736x_4+0.018x_5+1.84x_6 \quad R=0.6768$$

$$B=9.81-0.061x_2 \quad R=0.5902 \quad (27)$$

$$A=0.87-0.738x_4+0.018x_5+1.96x_6 \quad R=0.6876$$

$$B=3.68-0.023x_2 \quad R=0.6189 \quad (29)$$

According to Eq. (22) ( $S= A+BX$ ), the value of A in Eq. (23), (25), (27) and (29) should be the lowest soil moisture content. But, it's not the case. The value of A is roughly equal 2.5 times the lowest soil moisture content for the 79 agro-meteorological stations. Therefore, in order to fit the situation that it no rain for long time, Eq. (22) needs to be corrected as follows:

$$S=0.4A+2.5BX \quad X<0.4A/B$$

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$$S=A+BX \quad X \geq 0.4A/B \quad (30)$$

Fig. 2 shows the distribution of the lowest soil moisture content in China calculated by using Eq. (23) and (30). It can be seen that the lowest soil moisture content is less than 5

Fig. 2 The distribution of the lowest soil moisture content in China

Fig.3 shows a comparison between calculated soil moisture time series and those of observations for 3 agro-meteorological stations in China from 1980 to 2002. It can be seen that the calculated soil moisture accords well with observational soil moisture

(a) TaiLai

(b) GuYuan

(c) HuaiLai Fig. 3 Time series of observational and calculated soil moisture of 3 stations in China from 1980 to 2002

Question (4) Fig. 4 showed the comparison of dust storm forecasted from two soil moisture inputs. Improvements are seen from the figure. However, large differences between these two forecasts over the Pacific and part of India were shown up. This seems rather strange. An explanation is needed.

Answer:

There are some mistakes in Fig. 3 (in original MS) , so Fig. 3 and Fig. 4 (in original MS) will be replaced by Fig. 1 (in author final response)

2 Response to Interactive comment of Referee 1 that have not been answered in author comment 1

Question 2: The soil moisture scheme is established based upon 79 stations. But the validation is only conducted at 7 stations which seems not very convincing. On the other hand, from the operational point, for sand-storm forecast, I assume spring/early

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summer soil moisture is very important. Thus, a comparison between calculated soil moisture time series to those of observations are highly desirable.

Having been partly answered in author comment 1, the added Answers are as follows.

The variations of calculated soil moisture content from 2003 to 20005, for 7 agro-meteorological stations in the east of Gansu Province in China, accords well with the variations of observational soil moisture content at 6 agro-meteorological stations except Maqu station (in northeast of Qinghai-Xizang plateau). Fig. 4 shows calculated and observed soil moisture content time series of Xifeng and DingXi from 2003 to 20005.

(a) Xifeng

(b) DingXi

Fig. 4 The comparison between observational soil moisture content and calculated one in the east of Gansu from 2003 to 20005 (a Xifeng b DingXi)

Question 4: Almost all current numeric models have soil hydrology scheme that will calculate spatial-temporal-varying soil moisture. In addition, there are many land surface schemes too. Then, it would be very interesting to see, compared to some of them (e.g., reanalysis soil moisture or offline model simulated soil moisture), how much improvements this method can produce in estimating soil moisture and forecasting sand-storm in the retrospective sense. A reason for this is that such products (e.g., reanalysis soil moisture) is routinely updated through the assimilation system

Answers:

In NOAA climate prediction center (CPC), global soil moisture is estimated by a one-layer (1.6m depth) hydrological model. The unit for soil moisture is millimeter (mm). Global monthly soil moisture can be downloaded from the internet address:

[ftp://ftp.cpc.ncep.noaa.gov/wd51yf/global\\_monthly](ftp://ftp.cpc.ncep.noaa.gov/wd51yf/global_monthly). Dividing this monthly soil moisture by 1600, we get soil moisture percenta

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(c) (d)

(e) (f)

Fig. 5 The comparison of the soil moisture calculated by our scheme with those from NOAA CPC in China during Feb. 2006 to May 2006 (a, c, e, calculated by our scheme; b, d, f, from NOAA CPC; a, b, Mar 2006; c, d, Apr. 2006; e, f, May. 2006)

Question 6: The authors should check the reference in the paper and review the introduction more carefully. E.g, P3, "In most numerical models, soil moisture content in China is treated as a constant ...". This shouldn't be the case. Almost all GCMs, though differing in the treatment of land surface hydrology, treat soil moisture as a time-dependent variable. This can be easily seen by looking at the recent IPCC AR4 models. Also P3, "Entin et al., 1999" is not about calculation soil moisture content. Also P3, "But this type needs real-time soil moisture content data of multiple layers as initial values and thus can not be used widely". This is definitely not true. Although true soil moisture initial conditions are hard to obtain, there are many spin-up methods available to reduce if not complete remove the effects of unrealistic initial conditions. P4 Line 2 "This type is good for drought monitoring and the climatic evaluation of soil moisture, but not so good for daily soil moisture content retrieval". The authors should explain why as not all readers have the necessary background.

Answer:

"In most numerical models, soil moisture content in China is treated as a constant ..." is revised as "in most sand-dust numerical models developed by Chinese, soil moisture content in China is treated as a constant,  $\bar{E}$ ".

delete "Entin et al., 1999" from references.

"But this type needs real-time soil moisture content data of multiple layers as initial values and thus can not be used widely". Revised as "Because the real-time soil moisture content data are hard to get, so the initial value of soil moisture content need be

reduced by other method, such as remote sensing. ”

There are many methods on soil moisture monitoring by remote sensing. They can be divided into two kinds: optical remote sensing and microwave remote sensing. The application, are mainly optical remote sensing, including improved thermal inertia, crop water shortage index (CWSI) and vegetation index. The thermal inertia method fits with the bare soil or low vegetation covered surface, and suffering the interference of cloudy weather. So, in practice, usually the data from 10 days remote sensing are synthesized to monitor soil moisture. CWSI and vegetation index are fit with high vegetation covered surface. But they mainly represent the soil moisture in 20 cm depth, because of the roots of most plants in this depth. The daily variation of soil moisture in 20 cm is weaken than that in surface. So, at present, soil moisture monitoring by remote sensing is manly used in drought monitoring and the climatic evaluation of soil moisture.

Question 8: With respect to conclusions part, Conclusion 1 seems ungrounded or at least is not the results of this paper. This has to be done by. e.g., looking at auto-correlation between sm and P. Additional contents are needed to support (3) and (4) [refer 1-5,7].

Answer:

The simply calculated the delay cross correlation coefficient between precipitation and soil moisture declines with the lag time. Fig. 6 shows the average delaying cross correlation coefficients between precipitation and soil moisture for 79 agro-meteorological stations in China. It can be seen that when delaying over 7 days, the delaying cross correlation coefficients between precipitation and soil moisture become lower and can't pass the significance test at the level of 945;  $\alpha=0.1$  (sample=448, so,  $r_c=0.078$ ). But it don't mean the influence of precipitation on soil moisture is merely in 7 days. When we use the compound factor X (see original MS Eq. (19) and (20)) to consider the influence of precipitation on soil moisture, we find the cumulated influence can reach 16 days (see original MS Fig 1 b).

Fig. 6 Average delaying cross correlation coefficients between precipitation and soil moisture for 79 agro-meteorological stations in China

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