Second Written Paper for the Course
ABE6254
Simulation of Agricultural Watershed Systems

Opus: An Integrated Simulation Model for Transport of Nonpoint-Source Pollutants at the Field Scale

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INTRODUCTION

The study of this second written paper was focussed on the test of the simulation by Opus, where the first written paper depicted the structure of Opus. Therefore, this paper depicted mostly the problems and substitutive solutions during simulation, the calibration and sensitivity of parameters, the simulation results.

The characteristics of Opus is its finely calculation ability, especially in subsurface water. Other characteristics are the ability of Crop modelling, and the consideration of management practice inside the model. However, since Opus was developed for crop agriculture in most area of US, the special situation of high ground water table and sandy soil in Florida was not taken into account. Therefore, its finely calculation ability became a difficulty needed to be overcome. In addition, the lack of information any crop model would be another problem. This paper would discuss this problem and the substitutive methods during getting a suitable simulation.

PROBLEMS and SUBSTITUTIVE METHODS

The Problem of the Proper Soil Parameters

The finely calculation ability of OPUS is constructed by the delicate mathematical and numeric calculation. It also requires the sufficient soil information to achieve the correct simulation. The input data layers can be as many as six layers. The input soil data was based on the Immokalee Sand (see Appendix 1). There were nine soil layers in the Immokalee Sand. Therefore, combination of this nine soil layers information to six data layers were done and listed in table 1.

TABLE 1. The original soil data and the combined input soil data

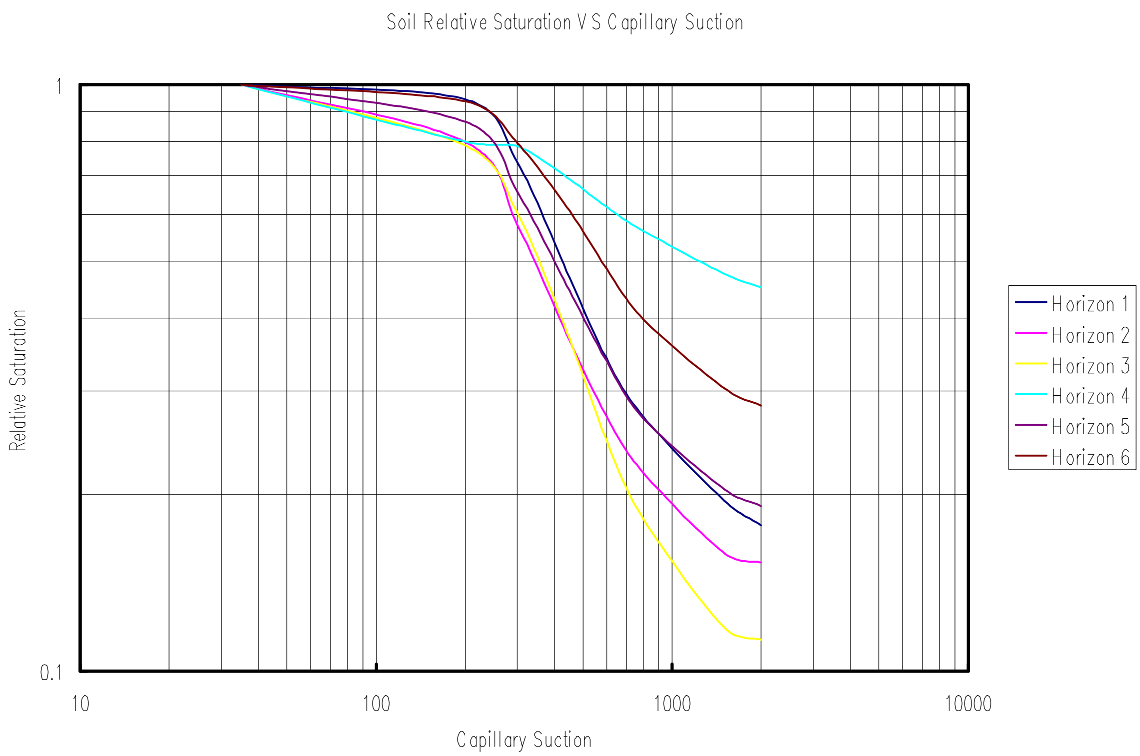
The Original Soil Data

Soil Layer #	Depth(mm)	Phos (ppm)	Sat Cond.	Hydr.	15 Bar	Sand %	Clay %
1	20	30	30.3	1.4	96.7	1.7	
2	13	7	41.4	1.7	97.6	0.8	
3	51	7	25.7	0.6	98.1	0.9	
4	7	60	26.3	2.3	88.4	4.5	
5	13	60	21.7	2.5	89.5	5	
6	15	40	11	2.7	92	4.5	
7	41	45	28	0.9	95.9	1.9	
8	23	40	9.2	1.1	95.6	1.5	
9	20	45	8	0.9	92	5.5	

The Combined Input Data

	Dept	Phos (ppm)	Sat Cond.	Hydr.	15 Bar	Sand %	Clay %
1	20	30	30.3	1.4	96.7	1.7	
2	30	7.00	32.50	1.08	97.88	0.86	
3	34	7	25.7	0.6	98.1	0.9	
4	35	51.43	18.03	2.55	90.35	4.69	
5	41	45	28	0.9	95.9	1.9	
6	46	42.33	8.64	1.01	93.93	3.36	

In addition to the above data, Opus also required the input relation between soil relative saturation and capillary suction. The required input parameters for this relation is the interception and slope of the regression line on the plot of relative saturation and capillary suction on log scales. Therefore, some work has been done to get these input parameters. The plots of relative saturation and capillary on log scales for each layer were displayed in figure 1. The input data points and



the calculation of input parameters were listed in Table 2.

Figure 1. The plots of soil relative saturation and capillary suction on log scales.

Table 2. The soil relative saturation and the capillary suction on each soil layer

Capillary Suction	35	200	300	450	600	800	1500	2000	ALAM	PBUB
Horizon 1	1	0.94	0.73	0.469	0.341	0.271	0.19	0.177	-	125.4
Horizon 2	1	0.80	0.57	0.366	0.272	0.218	0.15	0.153	-	76.0
Horizon 3	1	0.79	0.60	0.368	0.247	0.182	0.11	0.113	-	118.9
Horizon 4	1	0.80	0.78	0.690	0.618	0.563	0.47	0.451	-	115.2
Horizon 5	1	0.86	0.65	0.445	0.338	0.270	0.20	0.191	-	98.3
Horizon 6	1	0.94	0.79	0.609	0.486	0.398	0.30	0.284	-	157.4

The Problem of Matching the Correct Parameters of Highest Permanent Water Table and the Depth of Root Zone

Opus requires the input of highest permanent water table (DWTB in Group B) and the maximum depth of root zone (RDP in Group D). However, Opus manual didn't depict what were the proper ranges for these two parameters, and the relation between them. In the simulation process, some errors happened owing to the improper matching of these two parameters, but Opus just showed some other kind of error messages, such as the errors of internal file I/O. During a huge efforts of trial and errors, finally the problem of improper matching the DWTB and RDP was found out. In fact, it may also need to match the depth to bottom of last soil horizon (GZH in Group C). However, the correct matching among these three parameters could not be determined even though more trials have been done. So far, the only relation could be found out was the relation between DWTB and RDP.

The DWTB need to be deeper than RDP. In some trials, Opus showed the error message that RDP can't not within 200 mm of DWTB. However, in the real success trials, it showed that the difference between DWTB and RDP might be larger than 18 in. In some trials, if the RDP was less than 6 in, Opus also showed some other kind of error messages. Simular trials were also tested for DWTB. Therefore, the safe ranges for these two parameters were guessed as that the RDP > 6 in, DWTB > 2 ft, and (DWTB-RDP) > 18 in. However, if the minimum values or some values near this minimum were used, the number of the iterations in each time step would reach the maximum. In other words, the simulation in each time step was forced to be terminated and uncompleted if the values of these parameter were too small.

The Problem of Setting Runnable Crop Coefficients

Opus has the function of crop modelling, but the crop model component is not allowed to be skipped and no default values are available. However, any crop coefficients information are not available in the study area. Therefore, it is necessary to make up some runnable crop coefficients in order to complete the simulation.

Opus manual provided some example of crop coefficients for some certain crops in some areas (Appendix 3). During several trials, it was found that Improper setting of crop coefficients would cause the stress and the crop show dead rapidly. After a lot of trials, finally, a set of runnable data was gotten. This set of runable crop coefficients was based the cotton in Arizona in Opus examples, but was fixed with PLAI as 3.5, PDRYM as 29000, and DEACT as 0.3.

The Problem of Using the Immokalee Sand Data

Although the use of immokalee sand data was proper for the soil of the study area, yet, the simulation results showed none of runoff. In other words, all of the rainfall was attributed to the ground water due to the high infiltration rate of sandy soil. Even though several trials with minimum DWTB (highest permanent water table) and the setup of a clay layer in the second soil horizon to stop the high infiltration rate, the results just showed the same. Therefore, the Immokalee sand data was forced to be given up, and instead, several runs were made by different soil textures of different percentage of clay, silt, and sand (the other parameters were set by OPUS default based on soil structure) to understand the behaviour of the program of soil water in OPUS.

Three different sets of soil structure was input for calculation. The percentages of sand, silt, and clay for each set were listed in table 3.

Table 3. The percentage of input soil structure data.

	Sand (%)	Silt (%)	Clay (%)
Soil Structure 1	70	20	10
Soil Structure 2	50	35	15
Soil Structure 3	30	50	20

Opus limits the input sand percentage within 5% to 70% and clay percentage within 5% to 50%, if the some default soil values were used. Therefore, the soil structure cannot be set as more sand and less clay.

Additionally, in order to get some runoff results, the soil data from the second horizon were set as 5% sand and 50% clay.

The simulation results were plotted in figure 2.

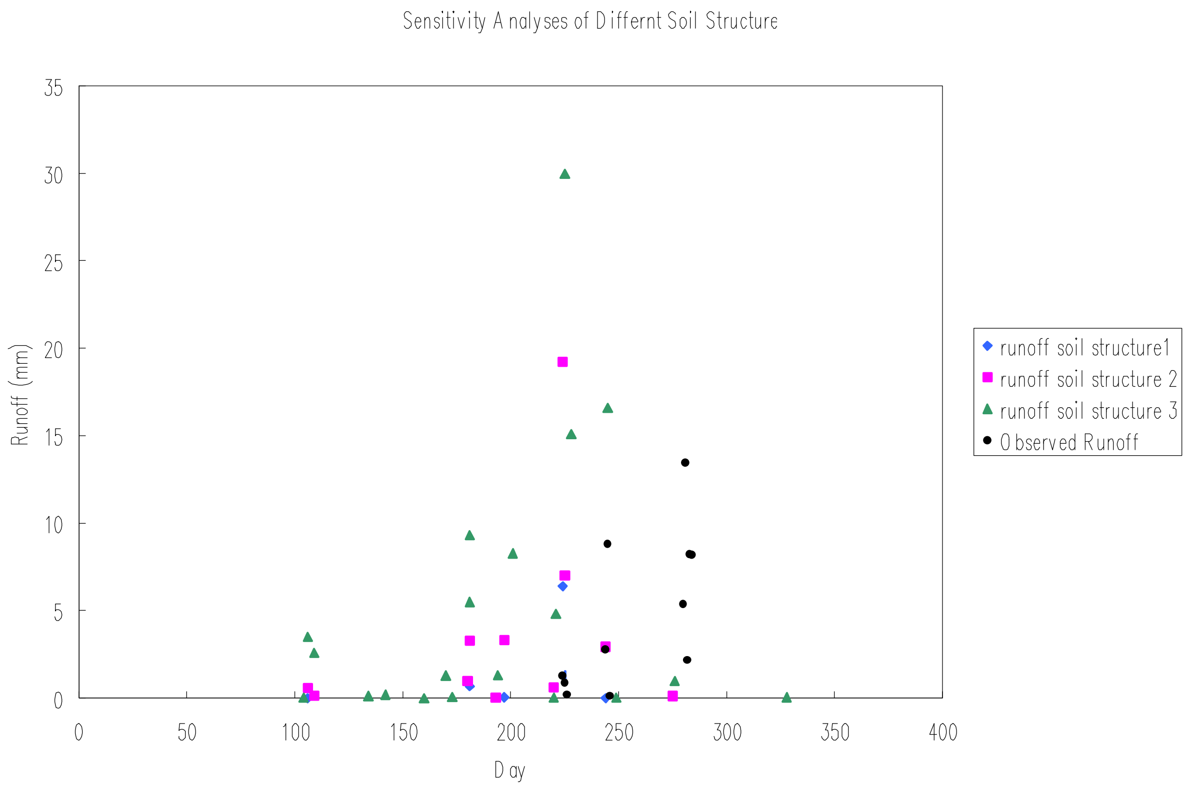


Figure 2. The sensitivity analyses of different soil structure.

The total amount of runoff for the observed data was 51.5 mm, where those for the estimated data of soil structure 1, 2, and 3 were 8.5 mm, 38.2 mm, and 99.7 mm, respectively. The results showed the great influence of adjusting the soil structure. It meant that the correct soil data was the core of simulation in OPUS. Opus underestimated some values and overestimated some values seriously. After comparing with the observed ground water table (figure 3) , it was obvious that Opus overestimated the runoff when the water table was low and underestimated when the water table was high. In other words, the incapability of depicting the variable water table caused the great errors in both the runoff and infiltration.

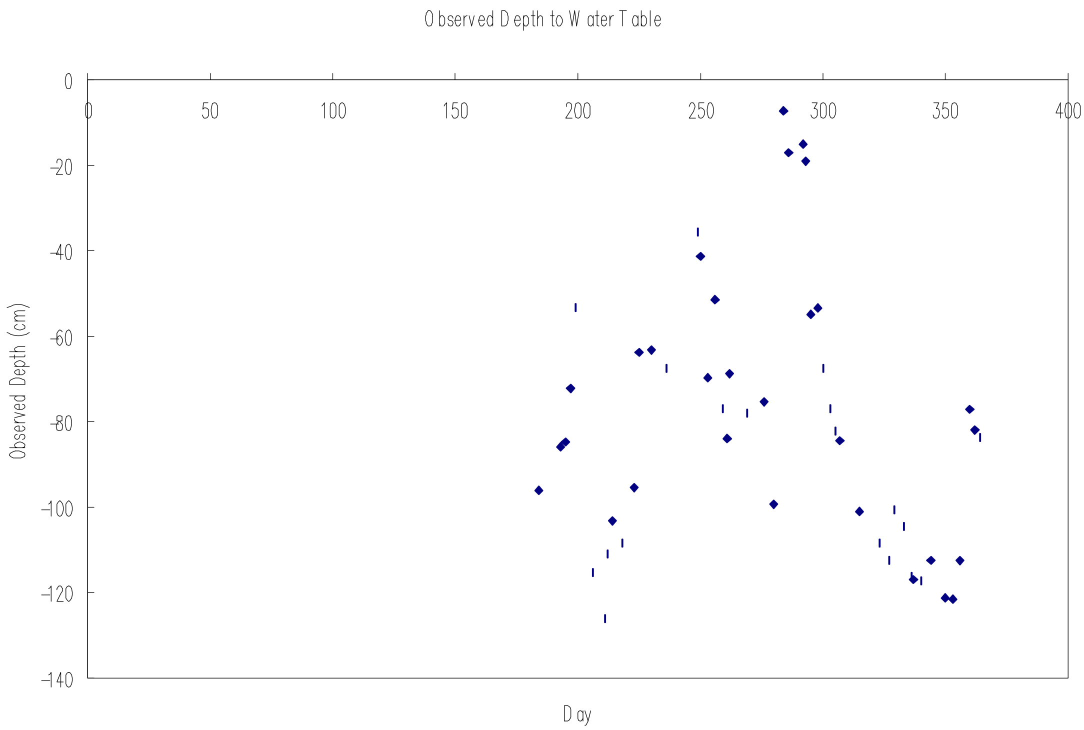


Figure 3. The observed depth of ground water table.