

Application of Modular Modeling System To Predict Evaporation,
Infiltration, Air Temperature, and Soil Moisture

By

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ABSTRACT

Models are used for numerous application including hydrology. The Modular Modeling System (MMS) is one of the few that can simulate a hydrology process. MMS was tested and used to compare infiltration, soil moisture, daily temperature, and potential and actual evaporation for the Elinsboro sandy loam soil and the Mattapex silty loam soil in the Microwave Radiometer Experiment of Soil Moisture Sensing at Beltsville Agriculture Research Test Site in Maryland. An input file for each location was created to run the model. Graphs were plotted, and it was observed that the model gave a good representation for evaporation for both plots. In comparing the two plots, it was noted that infiltration and soil moisture tend to peak around the same time, temperature peaks in July and August, and the peak evaporation was observed on September 15 and July 4 for the Elinsboro Mattapex plot, respectively. MMS can be used successfully to predict hydrological processes as long as the proper input parameters are available.

INTRODUCTION

Mathematical modeling is an accepted scientific process providing a mechanism for comprehensively integrating basic processes (physical, biological, and chemical) and describing a system beyond what can be accomplished using subjective human judgments. As our understanding of the basic principles of basic processes deepens, it is possible to construct a model that better represents the natural system, and to use the models in an objective manner to guide both our future research efforts and the current measurement techniques. The soil properties and other hydrological processes are an example of a natural system that has been modeled with different levels of resolution, and to which a modeling effort has been applied. Recently the Modular Modeling System (MMS) has been used to model the hydrology and related processes.

MMS is a complex system of computer software, written in FORTRAN or C language, to create models for various applications. MMS was developed in September 1989 with the establishment of a three-year agreement between the U. S. Geological Survey and the University of Colorado's Center for Advanced Decision Support for Water and Environmental Systems. MMS provides the framework needed to enhance development testing, and evaluation of physical-process algorithms and it facilitates the integration of user selected algorithms into operational physical-process models (MMS, User's Manual 1989).

Few hydrology models are currently available that simulate a hydrology process. The purpose of this project is to test MMS and simulate a hydrology process and to compare infiltration, soil moisture, daily temperature, and potential and actual evaporation for two bare plots at different locations consisting of Elinsboro sandy loam soil and Mattapex silty loam soil.

MATERIALS AND METHODS

The data used to run the MMS came from the Microwave Radiometer Experiment of Soil Moisture Sensing at Beltsville Agricultural Research Center Test Site from Maryland. Data for this project was collected everyday from June 19, 1981 to October 2, 1981 at approximately 9:30 a.m. MMS is designed to run on a Silicon Graphics computer using a UNIX system. To run and input data into the model, a basic knowledge of the commands are required. First, an input file must be created for each bare plots. The input file requires header information with a list of variable names each followed by a number which represents the number of values for that variable in each row of the input file. Next, there should be a separator line which includes at least four pound symbols (####). After the separator line, the data lines are divided into fields, where each field is separated by a space. There are ten fields in the data line. The first six fields are assigned for time to include year, month, day, hour, minute, and second. The seventh, eighth, ninth, and tenth fields are assigned for the input parameters rainfall (in.), minimum temperature (°C), maximum temperature (°C), and evaporation (in.).

After both input files are created, the model can be executed using one input file at a time. Once the proper procedure is followed to execute the model and input parameters are given to the model, the output data and plots will be generated. To make comparisons within and among plots the following four parameters were used 1) infiltration, 2) soil moisture, 3) average minimum, and maximum temperature, and 4) evaporation.

RESULTS AND DISCUSSION

By observing the graphs for the Elinboro Sandy loam soil (see Figures 1-4), several things can be noted. Infiltration has its highest peak on September 15, probably due to lack of runoff, nature of soil type and high rainfall. There is a steady decline in soil moisture from June until September where there is a sharp inclination that corresponds with the highest peak of infiltration. Temperature peaks in July and August, then it starts to decline. The highest peak of actual evaporation occurs on September 15. Although the potential evaporation that the model predicts is slightly overestimated, it is a good estimation of the actual evaporation. Overall as infiltration increases, soil moisture increases, but evaporation decreases. The decrease in evaporation could be attributed to a decrease in air temperature or due to a relatively high humidity.

Figure 1. Temporal representation of Infiltration for June 19, 1981 to October 2, 1981 for Elinboro Sandy Loam Soil

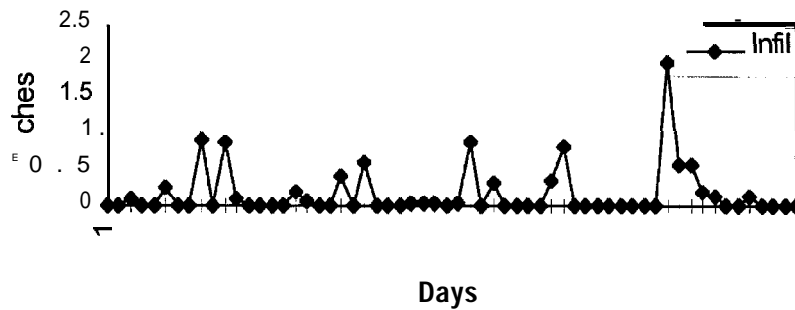


Figure 2. Temporal representation of soil moisture for June 19, 1981 to October 2, 1981 Elinboro sandy Loam Soil

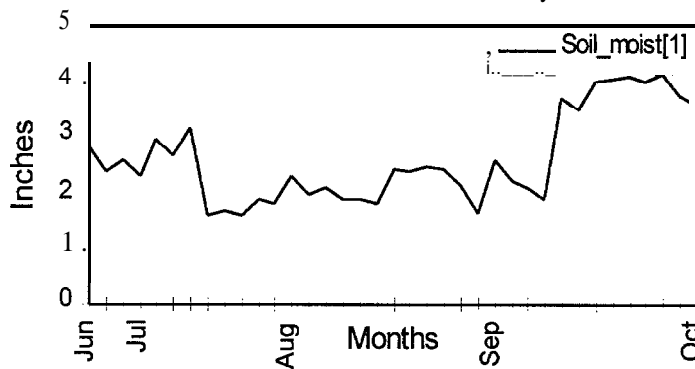


Figure 3. Temporal representation of Temperature (°C) for June 19, 1981 for Elinboro Sandy Loam Soil

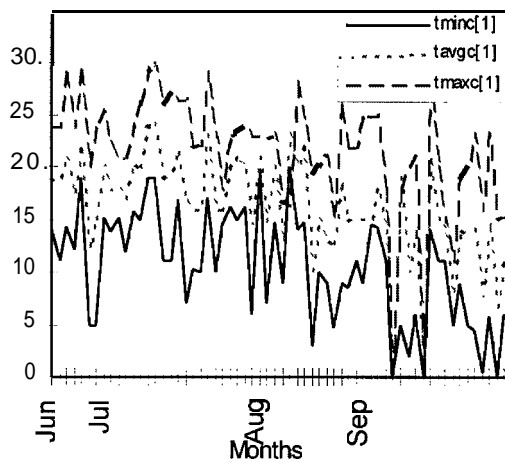
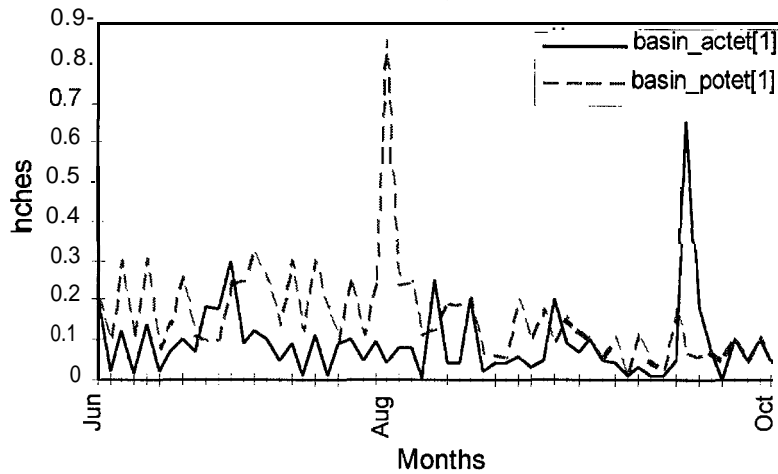


Figure 4. Actual and Potential Evaporation from June 19, 1981 to October 2, 1981 for Eingoro Sandy Loam Soil



By studying the graphs for the Mattapex silty loam soil (see Figures 5-8), it can be shown that the highest infiltration peak values occur on July 3 and September 15, which could be attributed to lack of runoff and high rainfall. Soil moisture is also highest around the same time due to the preceding rainfall activity and less evaporation (data not shown). After July 3 there is a sharp decline in soil moisture until September 15, which is due to lack of rainfall. Temperature declines over time and has its highest peak on August 15, but its main peak time is during July and August. Actual evaporation peaks most around July 4. The model gives a good representation of evaporation.

Figure 5. Temporal representation of Infiltration for June 19, 1981 to October 2, 1981 for Mattapex Sandy Loam Soil

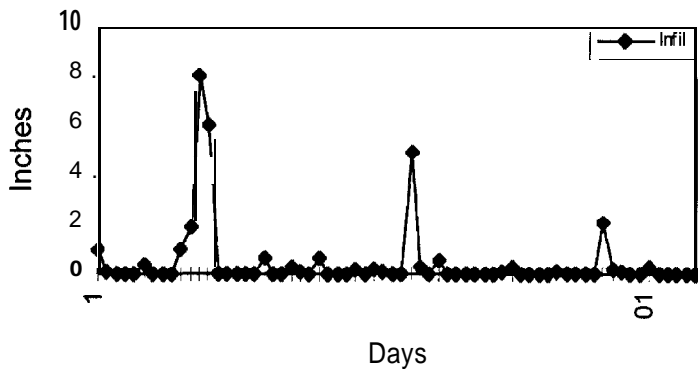


Figure 6. Temporal representation of Soil Moisture for June 19, 1981 to October 2, 1981 for Mattapex Silty Loam Soil

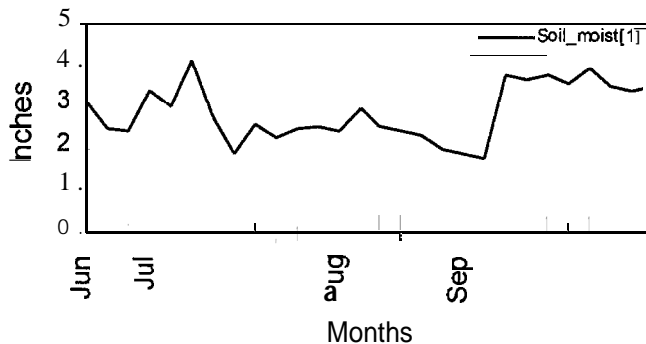


Figure 7. Temporal representation of Temperature (°C) for June 19, 1981 to October 2, 1981 for Mattapex Silty Loam Soil

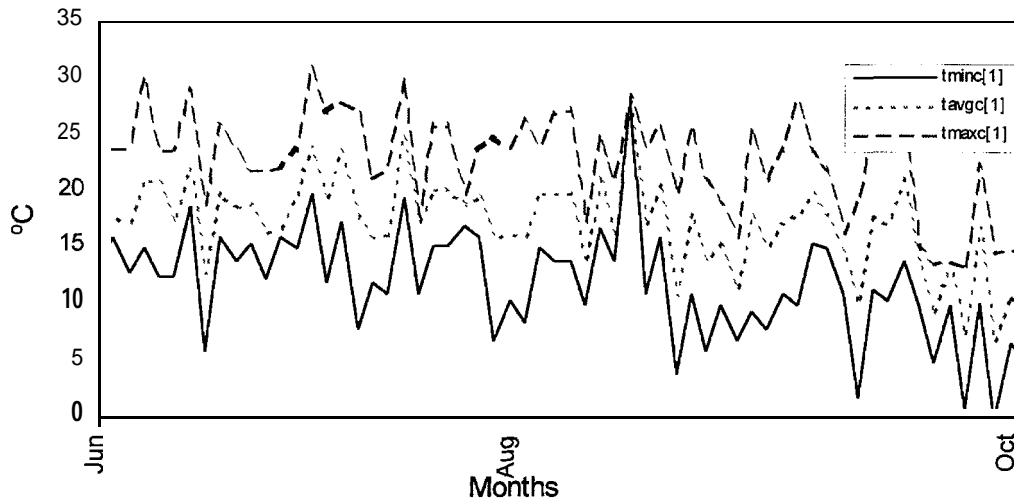
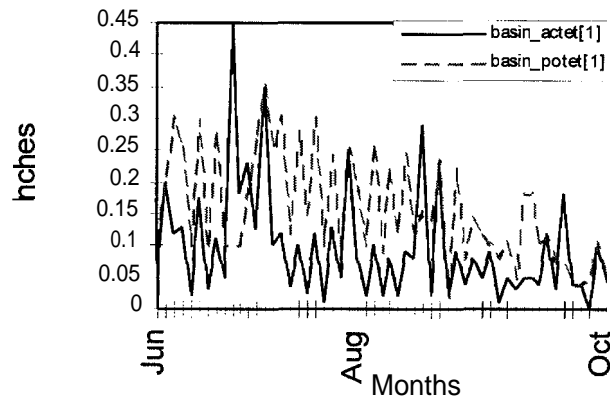


Figure 8. Actual and Potential Evaporation from June 19, 1981 to October 2, 1981 for Mattapex Silty Loam Soil



Comparing the infiltration, soil moisture, temperature, and evaporation of both experiment plots, many similarities exist among the plots, although the two plots are not in the same location. According to the graphs infiltration, soil moisture and temperature generally peak at the same time, but evaporation peaks at different times. This could happen because of the change in local variability of evaporation.

CONCLUSION

The MMS is currently running and an hydrology related process can be simulated. Comparing the output parameter of each plot, both plots behave similarly with very few dissimilarities. The highest peak of infiltration and soil moisture content for both plots was observed on September 15 as a result of the preceding rainfall activity on both locations. Temperature for both plots was at its highest peak in July and August, however, the peak evaporation for the two plots occurred at two different occasions i.e. for the Elinsboro plot it occurs on September 15, and for the Mattapex plot is occurs on July 4. Such models can be successfully used to predict soil surface evaporation and/or soil hydrology processes if the proper input data set is available.

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REFERENCES

Modular Modeling System User's Manual: Volume One. University of Colorado at Boulder Center for Advanced Decision Support for Water and Environmental Systems 1989.

Wnag, J., T. Jackson, E. Engman, W. Gould, J. Fuchs, W. Glazer, P. O'Neil, T. Schmugge, and J. McMurtrey, 1984. Microwave Radiometer Experiment of Soil Moisture Sensing at BACR Test Site.