G L E A M S

V E R S I O N 2.10

Part II. Model Validation

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MODEL VALIDATION

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ABSTRACT

The nutrient component of the **GLEAMS** model was validated with readily-available published data over a range of soils, climate, and management. Se-lected locations include Watkinsville and Tifton, Georgia, Traer, Iowa, and East Lansing, Michigan. The Watkinsville data include poultry litter application on coastal bermudagrass and inorganic fertilizer on continuous corn. At Tifton, inorganic fertilizer was applied in a 10-year cropping system that included peanuts and soybeans. Subsurface flow from a tile drain was measured and sampled for nitrate determination. Corn-soybean rotations, typical of the Cornbelt and Lake States regions, were observed at the Iowa and Michigan locations.

Results of the validation simulations generally indicate the model represents the physical system within the range of variability of field data except late-season NO_3-N concentrations. Nitrate-nitrogen appears to be depleted too rapidly in the fall and winter, either by uptake or denitrification. However, simulated leaching below the root zone with poultry litter application agreed very well with observed values. The results indicate the **GLEAMS** nutrient component can be used effectively to compare alternate management practices.

Comparisons of simulated evapotranspiration using the Priestly-Taylor (Priestly and Taylor, 1972) and Penman-Monteith (Monteith, 1965) methods were made for several climatic regions. Although readily available lysimeter data are limited, the results of comparison of the two methods are included.

INTRODUCTION

Readily available published data are used in the validation study to avoid the need to describe the analytical procedures for determining the various nutrient elements and species. The reader is referred to the respective publications for the methods of analyses.

Each validation study is described by location, and the results are given in the respective sections. This structure is less confusing than to discuss, say nitrate-nitrogen or labile phosphorus, across all locations. Overall findings are summarized at the end of this paper.

WATKINSVILLE, GEORGIA

Two validation studies was conducted at the Watkinsville location. The nutrient portion of a joint ARS-EPA project on a cropped watershed is used in one study. A second independent project considered poultry litter application on coastal bermudagrass plots. The two studies are described separately.

Cropped Watershed P-2

A cooperative ARS-EPA project was conducted at the Southern Piedmont Conservation Research Center from 1973 to 1975 (Smith et al., 1978). Four small agricultural watersheds were selected and instrumented for runoff, sediment, plant nutrient, and pesticide measurements. The four study sites involved different management practices typical of the Piedmont physiographic area. Watershed P-2, a 1.3 ha (3.2 acres) area, was selected for validation of the GLEAMS nutrient component. Data from watershed P-2 were used in the validation of the CREAMS model, also (Knisel, 1980).

The soil on watershed P-2 is dominantly Cecil sandy loam (Typic Hapludult) although other soils of lesser importance occur on the watershed. Corn (Zea maize) was grown on the watershed for the 3-year study period, 1973-75. Conventional tillage, i. e. moldboard/disk harrow as primary tillage, was practiced on the site to represent customary practices.

Data collection began on May 19, 1973, but complete sampling schedules for plant nutrients were not initiated on that date. For example, soil samples were taken for NO_3-N and TKN determinations but samples of sediment-laden runoff water were not taken until 1974. Soil samples were not analyzed for phosphorus content. The summary data are not complete, but they represent one of the few locations where model validation can be made.

NO_3-N concentrations were determined by soil depth at 11 sampling locations, or watershed segments, in the field on selected dates. Sampling dates began prior to fertilization for spring planting and continued through the growing season until after corn harvest in the fall. Samples were taken to a depth of 150 cm with the first two intervals 7.5 cm and the others 15-cm.

The GLEAMS model was applied with an effective rooting depth (RD) of 61 cm (24 in) as determined from the soil profile description of the Cecil sandy loam soil on the site. This depth was considered the "best" representation for evapotranspiration and runoff simulations by the model. The soil horizon representation in the model input was designated to make an approximation of the sampling depths, thus having a minimum of external calculations for direct comparisons of simulated and observed data.

Comparisons of simulated and observed runoff volumes, sediment yield, and associated solution and adsorbed nitrogen and phosphorus are shown in Table 1. Observed N and P data are not available for 1973, but the other comparisons are shown. Runoff comparisons are good for 1973 and 1974, but in 1975, runoff was grossly over-estimated which resulted in gross over-estimation of the sediment yield. Sediment yield was also over-estimated in 1974. The comparisons for nitrogen in runoff and sediment are relatively good while adsorbed phosphorus was under-estimated. These comparisons are results of the combined components which may include cumulative effects of the several components.

Table 1. Simulated and observed runoff, sediment, and nutrient losses, watershed P-2, Watkinsville, Georgia, 1973-75.

Year	Runoff		Sediment		Nitrogen				Phosphorus			
					Runoff		Sediment		Runoff		Sediment	
	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.
	cm	cm	t/ha	t/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
1973	15.90	14.48	11.35	10.05	NA	6.93	NA	6.09	NA	0.24	NA	3.57
1974	11.98	13.13	1.88	4.27	8.24	10.44	6.51	2.55	0.79	0.16	1.67	1.55
1975	7.32	25.20	0.07	3.20	3.39	2.98	4.97	2.72	0.17	0.26	4.09	2.04
Total	35.20	52.81	13.30	17.52	-	20.35	-	11.36	-	0.66	-	7.16

Comparisons of simulated and observed NO_3-N concentrations in the 61-cm effective rooting depth are shown in figures 1-12 for the 3-year study period. Maximum and minimum observed values for the 11 sample sites are shown in the figures, also. Figure 1 shows the simulated concentrations are within the range of observed values for all depths during the growing season. Figure 2 shows the comparison is not as good after the growing season. Observed NO_3-N concentrations in the top 7.5 cm were considerably higher than that simulated, and the reverse occurred for the 7.5-15 cm layer. The comparison was good for the third layer, but the model under-estimated concentrations in the bottom sampling layers in the rooting depth. The pre-fertilization samples on April 19, 1974 (Fig. 3) were consistently higher than simulated, but the model represented the shape of the concentration depth curve. The same 1974 after-fertilization simulated trend with depth occurred as in 1973 (Fig. 4), an over-simulation in the 7.5-15 cm layer. This over-estimate for layer 2 continues to be exhibited in Fig. 5. A top-dress nitrogen fertilizer application in June resulted in relatively good comparisons a month later (Fig. 6) except that the simulated value in the top layer was greater than the largest observed value. The depth trend at the end of the 1974 growing season (Fig. 7) was represented although the model under-estimated the observed concentrations. The model generally under-estimated concentrations in 1975 (Figs. 8-12) with an over-estimate in the surface layer on July 21 (Fig. 11).

Nitrate-nitrogen and TKN mass remaining in the effective root zone were reported on selected dates in 1974 and 1975 (Smith et al., 1978), and comparisons with simulated values are shown in Table 2. TKN from sampling was reported for 1974 only. TKN is a measure of most all species of nitrogen except nitrate, i. e. ammonia, mineralizable and stable soil N, and organic N in plant residue (incorporated residue and roots) and animal waste. The observed TKN showed considerably more variability from sampling-to-sampling than would be expected without animal waste application. The nearly 3 t/ha measured in April 1974 declined to 1.7 t/ha by mid growing season and then increased to 4 t/ha at harvest (Table 2) without incorporation of crop residue (corn stover) by tillage and without animal waste application. Under estimation of TKN in the model throughout 1974 and 1975 probably is due to under estimating the various pools when simulation began in 1973. However, the consistency of 1.6 to 1.7 t/ha is what would be expected for TKN since it is not a highly dynamic variable.

Table 2. Observed and simulated nitrate-nitrogen and total kjeldahl nitrogen in the soil, watershed P-2, Watkinsville, GA.

Date	NO_3-N		TKN	
	Observed	Simulated	Observed	Simulated
	kg/ha	kg/ha	kg/ha	kg/ha
1974				
Apr. 19	36.85	16.56	2,913.27	1,650.89
May 8	40.88	59.83	NA	1,694.44
May 14	56.99	63.19	NA	1,679.34
May 20	64.31	65.31	2,213.38	1,684.70
June 5	62.13	67.95	NA	1,669.97
June 6	NA	68.01	1,699.28	1,669.97
July 8	98.33	130.01	3,116.76	1,660.71
Oct. 30	53.44	13.31	4,007.26	1,691.50
1975				
Apr. 22	16.92	10.09	NA	1,670.18
June 10	55.92	13.36	NA	1,681.93
June 23	48.53	10.66	NA	1,681.93
July 21	98.30	72.76	NA	1,705.26
Oct. 30	43.49	4.49	NA	1,713.98