Sediment Runoff Modeling, Integration of RZWQM and GLEAMS

Minghua Zhang, UC Davis, September 27, 2014

Background & Goals
The Surface Water Protection Program at the California Department of Pesticide Regulation (DPR) aims to protect human health and the environment by preventing pesticides from adverse effects on surface water quality. The program evaluates potential pesticide risks during the registration process and regulates pesticides with high potential risk to surface water. A cost-efficient and accurate risk evaluation procedure relies on advanced scientific tools such as simulation models. The Surface Water Protection Program is developing modeling procedures to provide quantitative basis for decision making and, therefore, enhance DPR’s scientific capacity in pesticide risk assessment. After a preliminary search of existing models, the Root Zone Water Quality Model (RZWQM) has been identified as one of the best candidates capable of simulating pesticide runoff under California’s agricultural conditions. The primary goal of this contract is to customize and improve the current RZWQM model performance under California conditions, collaborating with USDA ARS group in Colorado.

RZWQM is a mechanistic model, initially developed by the USDA ARS, designed to simulate plant growth and movement of water, nutrients and pesticides in an agricultural system. The model has been widely used in the world to simulate water and agrochemical movement as impacted by different management practices. It has been recently enhanced by improving the pesticide sub-model, which includes detailed algorithms for simulating pesticide transport and fate in four (4) compartments: crop foliage, crop residues, soil surface and soil sub-surface or root zone. A Windows based user interface has made data input and output user-friendly for RZWQM. However, we expect the contract can overcome the model’s current drawback, the lack of the ability to simulate sediment erosion. Since sediment erosion and transport is essential for hydrophobic pesticides, such as pyrethroids, simulating sediment erosion and transport is indispensable. Therefore, the Surface Water Protection Program propose this contract to modify the RZWQM by adding the soil erosion simulation and a few other features so that the model can be used to assist pesticide risk assessment at DPR.

Completed tasks: outline
- RZWQM codebased cleaned to compile on Intel Fortran.
- GLEAMS fully integrated into RZWQM and producing output in line with measured values.
- WEPP fully integrated into RZWQM and modified to produce a reasonable output.
- RZWQM models built and calibrated for output flow for ARDEC experiments, DPR alfalfa experiments, and Phil Heilman's basin dataset.
- Sensitivity analysis completed for RZWQM surface water flow, GLEAMS and WEPP sedimentation parameters.
• Paper drafted describing the sensitivity analysis process and results.

Completed tasks: detail

• Updated RZWQM codebase to compile under Microsoft Visual Studio using Intel Fortran. Many small errors in variable declarations and formatting needed to be fixed for successful compilation under the more strict Intel Fortran compiler. A version was also ported to GNU's Fortran compiler, which required a more extensive level of code modification, including the use of the automated code rewriting tool plusFORT.

• Integrated GLEAMS daily sediment runoff model into RZWQM. If a GLEAMS specific input file is present, it is read and the GLEAMS erosion module is called at each daily time step in which RZWQM determined that runoff had occurred. New code was added to RZWQM to read the input files into global variables and initialize other variables (e.g., soil texture and field size) using RZWQM's internal state. New output code was also written to produce a condensed, easy-to-parse output file which lists the following for all days with surface runoff: surface runoff amount, bulk sediment loss, and concentrations of sediments of various size classes in the tail water.

• Integrated the WEPP-Standalone sediment runoff model into RZWQM. Jim Ascough and ARS supplied a cleaned, modularized version of the WEPP sediment model which was then inserted into RZWQM along side the GLEAMS model. Initial debugging revealed several minor corrections necessary for the WEPP codebase to support repeated calling without modifying the input variables. Testing revealed that the supplied model was producing results orders of magnitude out of range so work was done in collaboration with Jim Ascough to fix the WEPP code. As with the GLEAMS integration, additional input and output code was written in order to read the parameters from an input text file and output the results in an easily parsable plain text format.

• Created sample input files to model Phil Heilman's basin level dataset, Jim Ascough's ARDEC experiment and DPR's alfalfa field experiments; all calibrated to match measured outputs. Each dataset was used to test certain aspects of the model and as bases for the automated parameter study. Phil Heilman's dataset is a large scale watershed model that covers many hectares and spans several decades. GLEAMS and WEPP were designed for this type of large scale spatial and temporal averaging. Only natural rangeland is modeled, so RZWQM's crop management subroutines are not used here. DPR's alfalfa models cover a single field for just over two growing seasons and employ RZWQM's irrigation, fertilization, crop growth, and pesticide subroutines. The ARDEC dataset covers a very small, unvegetated plot of land for only 1-3 storm events. It is ideal model for testing just the added sediment components and RZWQM's surface runoff calculations.

• Ran a sensitivity analysis on RZWQM and the GLEAMS component, studying parameter sensitivity to both surface runoff and sediment load. Similar analyses of WEPP are underway. Each sensitivity analysis experiment required 10,000s of model runs over the entire parameter space. In addition to indicating which parameters need to be most carefully considered, these mass model runs also tested the stability of the model and subcomponents, and revealed errors which were fixed. DATKOTA, from Sandia National Labs, was used for the batch model runs. Input parameter selection and output analysis was accomplished using custom Python codes that utilized Sobol sampling and statistical analysis.

• Drafted a paper discussing the sensitivity analysis of RZWQM, GLEAMS, and WEPP with respect to surface flow and sediment loading. Sensitivity analysis for both a vegetated model (based on DPR's alfalfa experiment) and a bare soil model (based off the ARDEC experiment) were completed for all variables in RZWQM related to infiltration and runoff and all sediment specific variables in GLEAMS and WEPP. Both Morris one-at-a-time and Sobol variation analysis methods were used to quantify the influence of all variables on surface flow and sediment run off. The paper is currently being prepared for submission for publication.

• Began drafting a user manual for the new sediment subsystems. Documentation is underway to help users of the final, unified model understand the input parameters, file structure, and outputs. Each input parameter will be described with units, typical maximum and minimum values, and the sensitivity of the output flow and sediment loads to it.