Evaluation on the Agricultural Policy Environmental Extender (APEX) Water Flux Simulation for the Chesapeake Bay Watershed

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Abstract

The Agricultural Policy/Environmental Extender (APEX) is a complex mechanistic simulation model designed to evaluate agricultural management strategies and effects on yields, water and soil quality, and resource use. The model is a useful tool for investigating water related natural farm land mechanisms, but it may perform differently depending on the study area or data availability. For use in the Chesapeake Bay Watershed, the model parameters have been generally calibrated using data from several test sites where appropriate information is available. The objective of this study is to evaluate APEX model performance using current parameters with observations from the OPE-3 site (Optimizing Production Inputs for Economic and Environmental Enhancement) which located at the US Department of Agriculture, Agricultural Research Center, Beltsville, Maryland, USA. Data from the OPE-3 site consists of water content at various layers and locations, runoff, corn yields, and ET covering the period from 1998 to 2014. The APEX model was run using OPE-3 characteristics for soil texture and field operation schedules from 1998 to 2014. The initial results for total water in the soil profile (to 100 cm) showed that simulated water amounts were about 4.4 cm higher than observed but the trends were very similar. Measured yields were higher and were more variable than simulated yields, likely due to high spatial variability in the measured yields.

Study Area

The Chesapeake Bay is an estuary lying inland from the Atlantic Ocean, and surrounded by the North American mainland to the West, and the Delmarva Peninsula to the East. It is the largest such body in U.S. the northern bay is within Maryland, the southern portion is within Virginia, and is a very important feature for the ecology of those two states. More than 150 major rivers and streams flow into the bay's 166,534 Km^2 drainage basin.

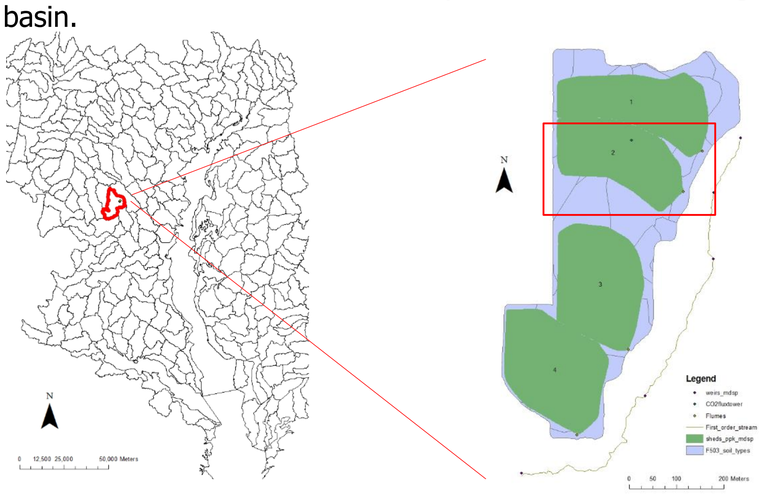

Figure 1. Chesapeake Bay and OPE-3 site.

Methodology

(a) Agricultural Policy/Environmental Extender (APEX)

- Developed for use in whole farm/small watershed management
- Constructed to evaluate various land management strategies
- Taken from the Environmental Policy Integrated Climate (EPIC) model for the individual field simulation component
- Three APEX user interface: WinAPEX, ArcAPEX and IAPEX

(b) Interactive APEX (IAPEX)

- A user friendly interface for the physical process and environmental model
- A single Microsoft ACCESS database to manage both the input and output (Figure 2)

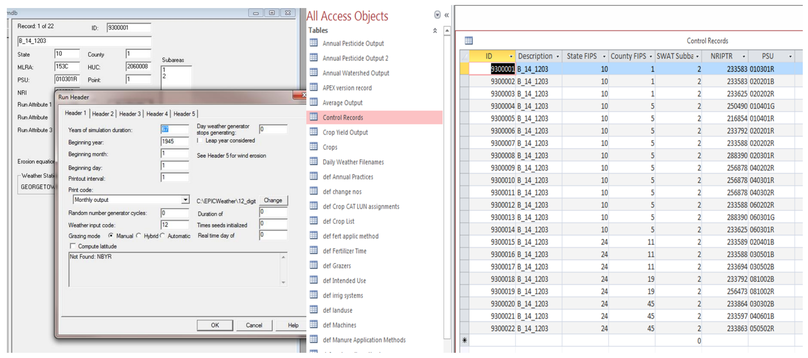

Figure 2. Microsoft ACCESS database to integrate IAPEX graphic user interface.

(c) Investigate SCS Curve Number Method for water flux

- Surface runoff is predicted for daily rainfall by using SCS CN equation (U.S. Department of Agriculture, Soil Conservation Service 1972)

- $Q=(RFV-0.2*s)^2/(RFV+0.8*s)$; $RFV>0.2*s$ (1)
- $Q=0.0$; $RFV<0.2*s$

  where Q is the daily runoff, RFV is the daily rainfall, and s is retention parameter.
- The retention parameter, s, varies (a) among watersheds because soils, land use, and slope all vary and (b) with time because of changes in soil water content.
- The parameter s is related to CN by SCS equation.
- $s=254*(100/CN-1)$ (2)
- The constant, 254, in Eq. 2 gives s in mm.
- The CREAMS (Knisel, 1980) model related s directly to soil water content using the linear equation
- $s=s_1*(1.0-FFC)$ (3)

  where s1 is the value of s associated with CN1 (moisture condition 1: dry) and FFC is the fraction of field capacity.
- $FFC=(ST-WP)/(FC-WP)$ (4)

  ST is the soil water content in root zone, WP is the wilting point water content and FC is field capacity water content.

(d) Five different methods of linking CN and soil water options

1. Variable daily CN nonlinear CN/SW with depth soil water weighting
2. Variable daily CN nonlinear CN/SW no depth weighting

Methodology

(d) Five different methods of linking CN and soil water options

3. Variable daily CN linear CN/SW with no depth soil water weighting
4. Non-varying CN2 (moisture condition 2: normal) used for all storms
5. Variable Daily CN simulation based on soil moisture index

Results

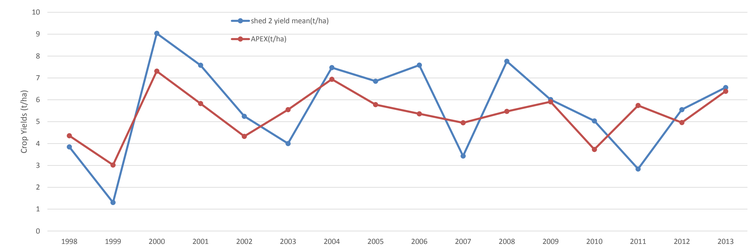

Figure 3. APEX crop yield simulation comparison with OPE-3 data.

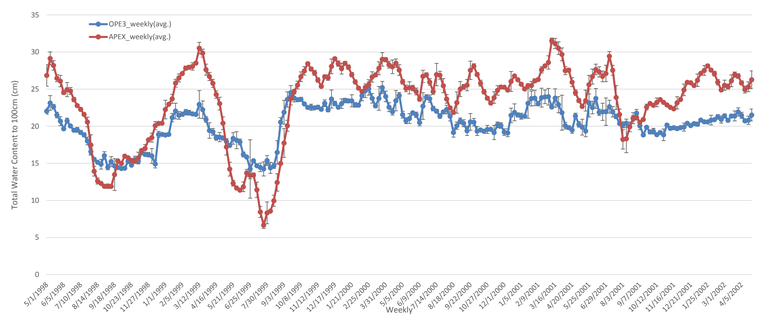

Figure 4. APEX soil water content simulation comparison with OPE-3 data.

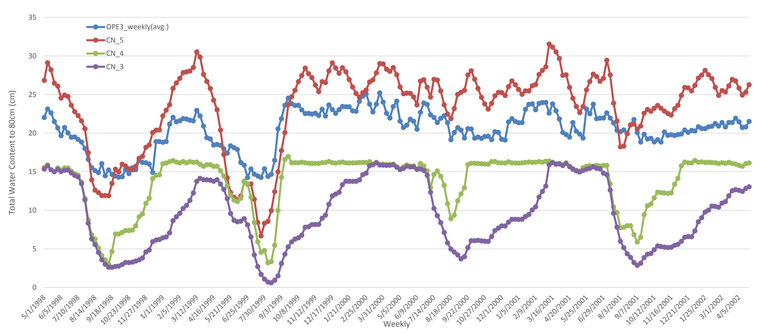

Figure 5. APEX soil water content simulations with different CN and soil water options.

Conclusions

- Measured yields were 4.6 t/ha for 16 years higher than simulated but the trends were also very similar.
- The initial results for total soil water content in the soil profile (to 100 cm) showed that simulated water amounts were about 4.4 cm higher than observed but trend were very similar.
- Water balance showed that 0.7 for stream/precipitation, 0.29 for evapotranspiration/prec., and 0.74 for surface runoff/total runoff.
- Surface runoff ratio is less than normal (<0.8), thus ground water ration may be high.
- Use of variable daily CN simulation (#5 of CN and soil water option) is the most robust and reliable because it can be updated with less errors based on Soil Moisture Index.