Agricultural Decision System for the Chesapeake Bay Forecasting System

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Chesapeake Bay Forecast System (CBFS) Overview

- A prototype earth system prediction system at U. of Maryland College Park

- Modules: atmosphere (WRF), land (SWAT), and estuary (ROMS)/biogeochemical models

- WRF $\Rightarrow$ SWAT: precip, temp., etc.

- SWAT $\Rightarrow$ ROMS: flow, sediment and nutrient loadings
Swat Model

Physically Based

- Process directly modeled

Required Inputs

- Weather
- Soil properties
- Topography
- Land use

Water balance drives the underlying modeling structure

Partitioning of surface flow, lateral flow, groundwater flows, evapotranspiration & precipitation
Agricultural Management Selection Tool (AMST)

- Based on climatology, geology & local agronomic practices
- Calculates timing of management practices
- AMST selection drivers:
  - climate factors
  - plant phenological events
  - Historical practices
- Climate scenarios can be modeled and/or predicted
- A Geographic Information System (GIS) interface under development
- Provides a quick method for generating SWAT input files
Land Management Accuracy Needs

- plant growth and cropping practices vary due to:
  - orographic weather phenomena
  - latitudinal and atmospheric impacts on incident radiation
  - geologic differences (altitude, slope, soil)

1800 GDD Zea Mays  
2200 GDD Zea Mays  
2800 GDD Zea Mays
Land Management Accuracy Needs

- Evapotranspiration is up to 68% of precipitation
  - Forested land 50% land cover
  - Agricultural land 26% land cover

- Daily nutrient discharge estimation and prediction
  - 40% of excess nutrients in CB from agricultural lands

Goetz, Prince (2004)
Purpose and Problems

- Automation of input generation
  - Potomac $1.8 \times 10^6$ land management instructions

- Scheduling using heat units
  - Timing based on weather/climate not calendar

- Generation of future land management scenarios
  - What/If scenarios
  - Long term adaptation

- Allow daily discharge, sediment and nutrient watershed modeling
Model Overview

Agricultural Rotation Observations

Climate Profile

Assigned Vegetation Type

Nutrients

Crop Rotation
Nutrient Amendments
Crop Variety (GDD, Days)
SCS Curve Number
Tillage
Sowing Date
Harvest Type

Soil Data

Slope

Dry Atmos. Dep.
Watershed Growing Zone Diversity

5 Distinct Climate Zones

21 year Chesapeake Bay Program climate data sets
Climatic Data

- Chesapeake Bay Program (CBP) climate data

- 21 year observation record

- Interpolated over a 5km grid area by fitting multiple regression equations on the x, y, z axis

- Integrated over a small modeling unit (land river segment)

(Hay et al. 1991; Hay et al. 2000a; Hay et al. 2000b; Hay et al. 2006)
Growing Season Calculations

- Calculated growing season length
  - \( F_{sp} - F_{fl} = GS \)
  - \( F_{sp} \rightarrow 21 \text{ year average last spring hard frost } (-2.5^\circ \text{ C}) \)
  - \( F_{fl} \rightarrow 21 \text{ year average first fall hard frost } (-2.5^\circ \text{ C}) \)

- Calculate potential heat units
  - \( \text{PHU} = \sum T_{av} \)

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Soil, Slope, Curve Number

- Pulls data from SWAT database

SCS Runoff Curve Number
- Empirical parameter determined by slope, soil, vegetation

\[
Q = \frac{(P - I_a)^2}{P - I_a + S} \quad S = \frac{1000}{CN} - 10
\]

- \( Q \) = Runoff Volume (v)
- \( P \) = Precip (v)
- \( I_a \) = Initial Abstraction (v)
- \( S \) = Pot. Max. soil retention
- \( CN \) = Curve Number -> calculated by AMST
Nutrients-Row Crops, Developed, Forests, Open Water

- Nutrient inputs
  - State agronomic guidelines
  - Personal communication with state extension services at the college and county level
  - Farm level data

- Dry Atmospheric Deposition
  - Community Multiscale Air Quality airshed model
    - From CBP
  - Input daily as custom fertilizer types
  - Loadings calculated for every landuse
Nutrients-Pastured

- Pastured Animals
  - Determine area animal weight/area
    \[ AU(\text{adults}) = [(\text{Inventory} + \text{Sold} - \text{Calves}) \cdot \alpha] \cdot \text{Aufactor} + \text{calve\_replace} \]
    \[
    \begin{bmatrix}
    m1 \\
    \vdots \\
    m10
    \end{bmatrix}
    \cdot \alpha
    + \begin{bmatrix}
    m3 \\
    \vdots \\
    m12
    \end{bmatrix}
    \cdot (\text{Aufactor})
    \]
  - \( \alpha = \text{replacement\ factor} \)
  - \( mx = \text{monthly\ growth\ factor} \)

- Calculate Deposition Amount
- Calculate Biomass Removal
- Calculate Biomass Destruction
Calibration and Validation

How?
- Limited ‘Observation’
- Limited Ground Truth Reference

Dry Mass Yields
- Agricultural Census data
  - Convert Reported Harvest to Dry Mass
  - ‘Hay’ in CDL is not reported as ‘Hay’ in Census
  - Pasture, Forest

Evapotranspiration
- Observed Water Supply Paper 2375 Hanson, R. L.
Results

• Yields
  • Rappahannock
  • Patapsco

• Evapotranspiration
  • Rappahannock 64%
  • Patapsco 64%
  • Potomac 59%

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Thank You