ARS Model Development using the Object Modeling System

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Outline

• OMS Introduction
• System Development Update
• Application Update
  – Implementing an ARS Unified Water and Wind Erosion Model based on WEPP / WEPPS
  – Create a physical based simulation model supporting the iFarm effort (Integrated Farm Management) at ASRU, Livestock/Rangeland
• Model development under Colab and Version Control
Why OMS Modeling Framework for CEAP?

- Establish standardized method for model development
- Plan for medium-long term maintainability
- Enable model adaptation (regional model variants)
- Implement a model development process that can be managed, tracked, and verified.
- Allow for flexible Data I/O management that is model independent
Modelling System

Generic System Components
- GUI
- Data IO
- Time step component
- Spatial unit component
- Data Parameter Handling
- Sensitivity Analysis
- Optimisation

Model Setup
- time step iteration
- spatial unit iteration

ETP
- Interception
- Snow
- Soil-water
- Ground-water
- Base-flow
- Stream RO
- Surface RO
- Irrigation

Plant growth

Irrigation

Erosion

Surface water use

Ground water use

Process module library
- ETP
- Hydr.
- GW
- WQ
- Irrig.

[Krause 2004]
Benefits

- Supports building of new models and decision support tools from reusable/standardized components from a library.
- Leads to “Customized Modeling” – fitting the model to the problem and customer need.
- Enhances deployment of new tools to action agencies (NRCS) and leverages established databases.
- Eliminating duplication of work by modelers. The library of components will serve as a reference and a coordination mechanism for future improvements.
- Significantly reduce the problem for users of different models giving different results by utilizing a library of evaluated, documented and standardized modules
- The common interface for model usage will result in lower training costs and reduced startup time for future modelers and scientific users.
OMS Features/Workflow

- Component Builder
- Model Builder
- Output Analysis
- Component Library
- Model Runtime
- Data Analysis

Arrows indicate the workflow:
- Component Builder → Component Library
- Component Library → Model Builder
- Model Builder → Output Analysis
- Component Library → Model Application
- Model Application → Component Integration
- Component Integration → Component Library Management
- Component Library Management → Component Development
- Component Development → Model Application
- Model Application → Component Integration
- Component Integration → Data Analysis
- Data Analysis → Output Analysis
- Output Analysis → Component Library
- Component Library → Component Builder
OMS as a Modeling Environment

- Modeling Projects
- Component Editor
- Output Analysis
- Component Library
- Assembled Model
- Parameter Editor
ModelBuilder

- Build a hierarchical model based on dictionary components
- Visual Assembly of components to a model
- Dependency check
  - Access
  - Scale
Model Application

- Model Parameterization
- Automated GUI Element generation
- Parameterization
- Visualization of results
- Visualization GUI is adaptable
Recent System Accomplishments in Development

- Release OMS 2.0
  - Comprehensive Fortran 95 support
  - Netbeans 5.0 platform porting
  - Extended the OMS tools set
  - Updated Manual / Training material

- Adopt a CMM level 2 for OMS development
  - shared ARS NRCS project management in Colab

- Model Building extended for the development of spatial models
Work in Progress

- Uncertainty and Sensitivity Analysis and Parameter Estimation
- Analysis tool set
- Spatial/Temporal pattern
  - Network traversal
  - Gridded processing
(1) Common Wind and Water Erosion Model

- The Natural Resources Conservation Service (NRCS) re-evaluated its need for erosion prediction technology from ARS.
- A high priority long-term need of NRCS was development of a common wind and water erosion process model, to work with a single interface and database and give consistent results for plant growth, water balance, crop yield, etc.
ARS Erosion Prediction Tools

• Erosion Prediction Tools developed by ARS:
  – Universal Soil Loss Equation (USLE)
  – Revised USLE (RUSLE)
  – Water Erosion Prediction Project (WEPP)
  – WEPP-SPUR (Simulation, Production & Utilization of Rangeland)
  – Wind Erosion eQuation (WEQ)
  – Revised WEQ (RWEQ)
  – Wind Erosion Prediction System (WEPS)

• Model Interface & Database Systems:
  – Individual RUSLE, WEPP, RWEQ, WEPS interfaces
  – Trend of moving from standalone Windows applications to Web-based interfaces (at least for WEPP & WEPP-SPUR-RHEM)
Hillslope Erosion Module for WWEM

• Initially
  – Convert hillslope erosion component from WEPP into a standalone Fortran program.
  – Test and verify standalone program against original WEPP v2004.7 model
  – Incorporate standalone program into OMS, test and verify.

• Continuing
  – Add more components – surface hydrology, daily water balance, plant growth, wind detachment, etc.
  – Contribute to development of CEAP regional water and air quality models (CEAP objective 5).
Erosion Model – named “erroder” here

Conditional – Daily Time step – goes through loop for number of days read in from climate file.

Conditional – to do infiltration, runoff and erosion calculations, only if there is rainfall on the day

Conditional – to do Erosion Calculations only if there is outflow or inflow to plane.
Water Balance Routines for WWEM

• Provide basic water balance functionality to support erosion code development
  – Use existing code if possible – don’t reinvent the wheel
• Easily switched out for newer / robust routines to be developed by ARS, therefore clean interface
• Developed and executed in OMS
Model Structure

- Soil profile initialization
- Daily meteorology
- Potential evapotranspiration
- Time adjustment
- Green-Ampt Infiltration
- Breakpoint rainfall
- Darcy water redistribution

Needed
- Wind Erosion
(2) Range Livestock Model

**Animal**
- demand
- maintenance intake
- weight
- count
- sex

**Calf**
- weaned?
- demand milk intake
- maintenance

**Heifer**

**Cow**
- lactating?
- pregnant?
- milk production
- maintenance body condition

**Bull**
- service rate

**Steer**

**Cow-Calf Herd**
- birth
- pregnancy
- mortality
- weaning
- culling/sale

**Supplement**
- ration
- TDN amount

**Phenology**
- cumulative GDD
- green-up
- senescence
- maturity
- $t_{\text{max}}, t_{\text{min}}, t_{\text{opt}}$

**Shoot**
- height
- stress
- growth
- forage TDN biomass

**Feeds**
- allocate forage
- allocate supplement
- diet digestibility

**Range Community**
- WSG
- CSG
- Legumes
- Shrubs
- Forbs

**Plant**
- partitioning
- NPP

**Root**
- distribution
- biomass
- mortality

**WaterBalance**

**Soil**

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Spatial / Temporal Interaction in this model
Progress in Component Extraction/Module Creation

- Water Balance – Runoff, Infiltration, ET, Deep Seepage (GPFARM)
- Soil Parameter Estimation (RZWQM)
- Management Practices (RZWQM)
- Green-Ampt Infiltration (RZWQM)
- Snowmelt (PRMS)
- Overflow Flow Routing (Kineros)
- Soil Erosion (WEPP)
- Object-Oriented Nutrient Model – NOURISH (RZWQM)
- “Simple” Crop Model (WEPS)
- “Complex” Crop Model (DSSAT 4.0 CSM – Cropping System Model)
- Range Forage Growth Component (GPFARM)
OMS & Colab

- Supporting the co-located development of simulation models using an Software project management infrastructure - **USDA Colaborative Development Laboratory (Colab)**
- Host **Object Modeling System (OMS)** modeling projects and related modeling efforts in Colab.
- Host major ARS modeling projects for CEAP and other activities in Colab
USDA Colab Overview

- **Acronym**
  - Collaborative Software Development Laboratory
- **Purpose**
  - Facilitate collaborative software/model development in a location independent environment.
- **History**
  - Identified in 2004 .. Prototype in 2004/2005 .. Production in April 2005
  - Founding members USDA, EPA, CSU, USGS
Benefits for Model Development

- Manage issues ranging from requirements to bugs
- Workflow (Approval), Peer Review
- Real time visibility on tasks, bugs, resources and projects
- “Live” Document Management (WIKI)
- Seamless SCM integration for Subversion
- Source Code Comprehension & Coding violations, QA and Audits with trends
- Build Automation using schedulers for builds, releases and tests
- Development Interaction: Discussion Forums, Chats
- CMM Level-2 and Level-3 software measurement reports
Colab Status

- ~220 Projects, ~520 registered Users, ~60-70 active User/Day
- Code repository ~20 GB, Documents ~4GB
- Users from ~15 different institutions.
- Example Modeling Projects
  - AGNPS (NRCS), FRAMES/3MRA (EPA), OMS Unified Wind and Water Erosion (ARS), PRMS (USGS), SWAT (ARS; 2005), RZWQM (ARS), DSSAT Components (OMS), Range/Lifestock (ASRU), J2000 (FSU Jena), COSU (MOU on MIMS), and many others ...
- Training classes on (i) Version Control Workflow using Subversion (ii) Codebeamer Project Management and (iii) OMS
Structured Model Development Process

1. Integrate Source into Colab
2. Adopt the use of a (i) version control system and (ii) software project management as provided in Colab
3. Modeling Source; Refactoring using peer review
4. Modularize and use a modeling framework (OMS), eliminate redundancies
5. Implement automated model tests against selected data sets within Colab
6. Use Colab progress tracking methods on model development (software project management)
7. Involve external collaborator and scientific community for contribution and enhancements.

- Progress Levels for different models
  - SWAT: 1..2
  - WWEM: 4
  - Plant Growth: 5
  - AGNPS: 2
  - OMS ASRU Components: 5
USDA Modeling and Collaboration Infrastructure

Model Development
- Construct
- Run
- Analyze
- Test
- Verify

Model Project Management
- Tracker
- Forums
- Documents
- CMM Reports
- Access Control

Model Resources Change Management
- Version Control
- Change Management
- Repository
- Concurrent Access

OMS
Codebeamer
CoLab
Subversion