FOCUS Presentation
(10-15 minutes)
January 29, 2001

Topic: Modular Modeling System (MMS), George Leavesley, USGS
(http://www.geog.ucsb.edu/~kclarke/ucime/Leavesley/ucsb.pdf)

Background:
- A product of the Precipitation-Runoff Modeling Project, where chief scientist was/is George Leavesley.
- Hard coupled modeling environment (for the moment).
- Now has a 6-member team giving support to the modeling effort.
- Results are simulated streamflow, which is being used directly by river basin managers for prediction and simulation of alternative operating scenarios.
- Hardware/Software needed: UNIX or Lynyx on a PC, (NT within a few months) and Arc/Info.
- Implemented for the Gunison and Yakima River basins, Rio Grande and Truckee River basins coming soon.

Description:
- Object-oriented modeling environment for watershed and ecosystem models.
- It is a model building framework to simulate a wide range of interdisciplinary environmental and physical water resource processes.
- Developed collaboratively by CADSWES (Center for Advanced Decision Support for Water and Environmental Systems, University of Colorado) and USGS, now supported exclusively by the USGS.
- Models/data inputs included:
  - PRMS (Precipitation-Runoff Modeling System, Leavesley),
  - NWSRFS (National Weather Service River Forecast System, 27 variables, Anderson),
  - ESP (National Weather Service Streamflow Prediciton Program),
  - SSARR (Streamflow Syntheis and Reservoir Regulation, USArmy),
  - Statsgo (soils data), Natural Resources Conservation Service (formerly Soil Conservation Service) in compliance with the U.S. Government "Content Standards for Digital Geospatial Metadata".
  - TOPMODEL (Beven and Kirkby), represents the dynamics of surface and subsurface contributing areas by using a topographic index.
  - Channel Transport of solutes and sediments,
  - MODFLOW (soon), and
  - They would like to add modules on Resource Management and Risk Assessment.
- Does better runoff is influenced by snow-melt-runoff.
- Basin size isn't an issue, only the available data.
- Minimum data requirements: precipitation data, runoff (gauging station) and elevation (DEM)
- Optimization (**Opt**) and sensitivity (**Sens**) tools are provided to analyze model parameters and evaluate the extent to which uncertainty in model parameters affects uncertainty in simulation results.
- A modified version of the National Weather Service's Extended Streamflow Prediction Program (**ESP**) provides forecasting capabilities using historic or synthesized meteorological data.
- A major feature of the model component is the module library that contains a variety of modules for simulating water, energy, chemical, and biological processes.
- Has incorporated a tool for searching out data on the web, Data Chimp.
- MMS does not do a good job with the Biogeochemistry and they are working on improving that side of the suit of models in the model library.

Components (3):
- Three components include graphical user interfaces (**GUIs**) and data-management interfaces (**DMIs**).
  1. **Pre-Processors** to access and prepare data. The pre-process component includes tools used to input and analyze spatial and time-series data for use in model applications.
  2. A library of **models** and modules to simulate hydrologic and ecosystem processes. The model-component includes tools to develop and apply models.

3. **Post-processors** to display and analyze model results (overhead of model framework). Post-process component provides tools to display and analyze model results, and to pass results to management models or other types of software such as the HDB.

- **Input files** to run MMS: Data file (variables), Parameter file, Control File (can use this file to run the model in batch mode, and enabling Monte Carlo runs (involving the use of a random sampling techniques and often the use of computer simulation to obtain approximate solutions to mathematical or physical problems esp. in terms of a range of values each of which has a calculated probability of being the solution). Works with hydrologic response units (HRUs).

Procedure:

1. Login and get your machine and workspace configured correctly.
2. Open **XMBUILD** to build your model (Model Location Pane, Available Models and Current Models) with boxes for models/modules/data and connecting arrows. The user, through an interactive model builder interface, selects and links modules to create a specific model.
   - Model Location Pane: enables user to link data anywhere on your hard-drive or across the Internet.
   - Available Models at that module location.
   - Current Models: what you are creating
3. You can use a canned model (ex. PRMS) that come with the software or other users have put up as freeware.
4. Compile/Build the model (ex **xprms**).
5. With compiled model in **MMS**, select data inputs and the parameter file (ex number of hydrologic response units, nhrus), can review and manipulate data inputs on the fly with a spreadsheet editor, run the model and then look at hydrographies (from gauges, predicted, baseflow, etc.).
6. Use the GIS interface called **the GIS Weasel**. The Weasel facilitates model development and can be used as a watershed analysis tool (ex Watershed Delineation). Here you will need Arc/Info with the Grid module as well as a DEM of your study area.
   - Watershed Delineation: Can create sub-basins (or modeling response units, MRUs) where xprms can be run. *Briefly look at the delineation exercise: can set a limit on the analysis window, can fill pits/holes, make flow direction map, flow accumulation surface, and by locating "pour-points". The delineation will create Area-Of-Interest polygons with slope, aspect and elevation layers, can play with drainage extent by changing the cell count.

Future:

- MMS Version 2 or Object Modeling System (**OMS**): Going towards a loosely coupled modeling environment where all models (now modules) will be wrapped with Java and XML coding. Advantage is that can be run/integrated over the Internet. This part of the work is being done by Olaf David at the University of Frederich Schiller (E. Germany). Will use **Java WebStart** (Sun) to put read/write authorization on your system for Internet users.
- **ESSW** (Earth System Science Workbench) investigating interaction with the new tools his team is developing for "MMS v2:" the Object Modeling System (OMS) using Java and XML.
- OMS building flexibility to be used as a model comparison tool.

How this fits into the context of Land Use Change Modeling:

- Framework is ideal for coupling and integrating models of all sizes and configurations.
- Network based approach is particularly attractive.
- Can work in the three axes of assessing Land-Use Change Models: Time, Space and Human Decision-Making (the later being the most challenging, from low to high complexity).

Examples:

- **WARSMP** (Watershed, and River System Management Program, USGS). Could retool framework to be very useful for Landuse Change Modeling as it incorporates space, time and human decision making. Designed to do: 1.) short-term operations and scheduling, 2.) mid-term operations and planning, 3.) and long-term policy and planning. Encompasses water laws, contracts, treaties and court decrees to assess water limitations, supply and demand. It has decision support systems to create an interagency, integrated decision support system to achieve an equitable balance among stakeholders (municipalities, fish and wildlife, agriculture, recreation, hydropower, and water quality).