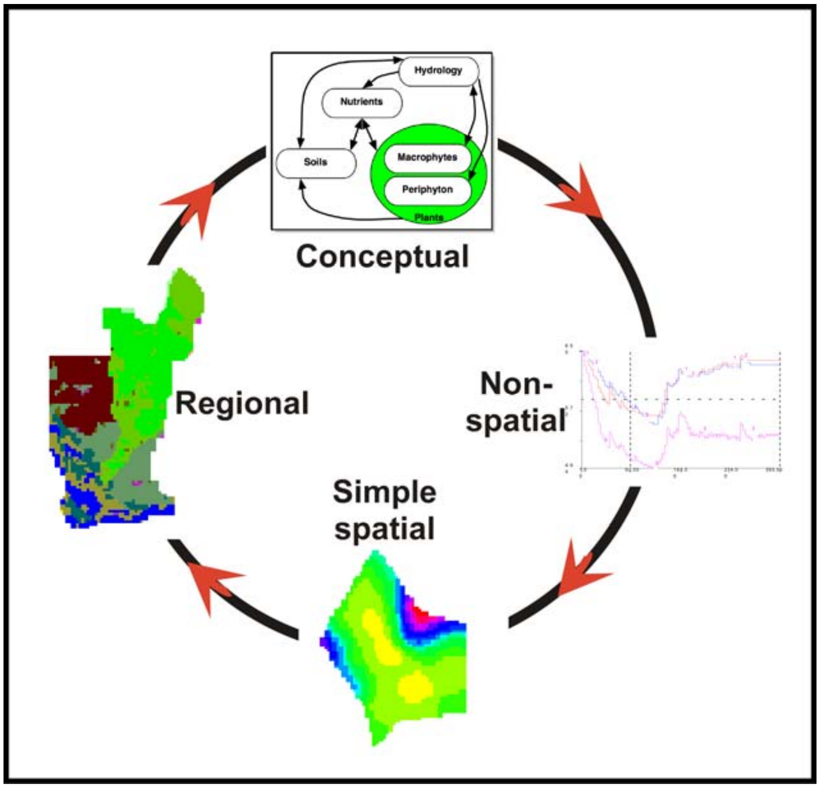
Documentation of the Everglades Landscape Model: ELM v2.5

Chapter 9: Model Refinement



http://my.sfwmd.gov/elm

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Chapter 9: Model Refinement

9.1 Overview

The Everglades Landscape Model (ELM) has been under continuous development and refinement since the inception of the project in the early 1990's. In this Chapter, we provide a high-level summary of the major developments in the timeline of the ELM project. These developments are documented in technical reports and/or peer-reviewed manuscripts, which are available (where possible) on the ELM web site under the Publications section.

All models have uncertainties (see Uncertainty Chapter) and associated limitations. Those limitations, and plans to reduce such limitations if applicable, are outlined in this Chapter. In particular, we hope that our Open Source philosophy will stimulate further collaborations towards continued refinement of this model - for enhanced understanding of the greater Everglades and its restoration.

9.2 Version control

Starting with ELM v1.0, scripts were used to archive major and minor version increments during updates to the model source code and the model input data[1]. One script assembles a compressed unix "tar" file archive of all source code (including scripts), while also forcing the user/developer to create a metadata file containing notes on the nature of the update. Another script performs the same operation for all input data files and databases. These two versioned archives are used to distribute the fully functional ELM project, as described in the User's Guide Chapter. The following are the guidelines that we used in maintaining version numbers in source code and data archives:

- *version numbering (starting with v2.1)*
    a. the version number is based upon the model-release version number for which it was created: x.y.z, where x=primary, y=secondary, z=tertiary version attribute (e.g., version 2.5.1)
    b. version incrementing:
        i. model-release[2] versions are incremented only by the primary and secondary version attributes[3];
        ii. if data or code are developed specifically for updating to a new model-release version, the data/code version is assigned the upcoming primary.secondary version number, appended with a x.y.0 tertiary version attribute;
        iii. based upon the projected model-release version, changed data/code versions are incremented by the tertiary version attribute;

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[1] The ELM code of v2.5.0 was put into the Open Source versioning tool, CVS; an SVN implementation for all code and data is being adopted during summer 2006.

[2] A "model-release" version represents a principal milestone in the model's project development, and includes some level of posting to the ELM's internet web site

[3] Tertiary version attributes are used for developer version control, and omitted from "model-release" version attributes for simplicity. An increment to the secondary version number would be used for any subsequent public release.

iv. if a change in data/code is associated with change(s) in the model-release version, the primary and secondary version attribute of the new data/code becomes that of the new model-release version, appended with a x.y.0 tertiary version attribute;

v. a model-release version may be incremented without simultaneously incrementing the version number(s) of data/code file(s), only if the specific data file(s) remain completely unchanged for the model-release update;

c. an associated date of creation/modification specifies the date of the (creation or) modification of the version of the file, and is only modified when the data/code changes and a new data/code version is assigned (changes to *any* numeric information in data file represents a new version and thus date of creation)

d. modification to metadata content or format is not considered a version increment of the data/code

9.3 Version history

The ELM project was initiated in the early 1990's, with the first published components of the model in 1996 (Fitz et al. 1996). The first application was a subregional implementation of the ELM (v1.0) to Water Conservation Area 2A (Fitz and Sklar 1999), a well studied region that supported much of the model parameterization and assessment of the model performance. In ELM v2.1 (Fitz et al. 2003, Villa et al. 2003), refinements were made to the model based on newer data that improved our understanding of the Everglades. The ELM v2.1 was targeted for application to projects in the greater Everglades region, and reviewed for CERP application by inter-agency volunteers in 2002 (ELM_Team 2002, Fitz et al. 2002). The reports and publications available on the ELM web site provide greater detail on the algorithms and the data that were improved with advances in Everglades research. The following lists some of the major changes:

9.3.1 ELM beta (1995)

- baseline of reference to changes
- had very general performance capabilities for regional system (i.e., calibration was based on professional judgment)

9.3.2 ELM v1.0 (1997)

- hydrology refined for horizontal solutions (water management, raster fluxes)
- introduced detailed budget and error analyses for water and phosphorus
- calibrated ecological variables (hydrology, water quality, soils, macrophytes, succession) along phosphorus gradient in subregional application

9.3.3 ELM v2.1 (2000)

- refined vertical integration of surface-ground water (and constituents)
- added organic soil phosphorus storage
- added dynamic carbon:phosphorus stoichiometry

- added floc module to improve soils and biogeochemical dynamics along gradient
- added scripted post-processing for rapid application turn-around
- calibrated hydrology and phosphorus water quality across greater Everglades region
- (2002) documentation enhanced (to v2.1a) for model release version for inter-agency review (subsequent to this, numerical, vs. alphabetic, tertiary version increments were used)

9.3.4 ELM v2.5 (2006)

- added dynamic stage (including tidal) boundary conditions
- added dispersion algorithm for water quality (phosphorus & chloride) constituents
- added automated sensitivity analysis for users
- implemented other subregional applications (at 100, 200, 500, 1000 meter grids)
- validated hydrology and phosphorus water quality across greater Everglades region
- the code and data released on July 10, 2006 for independent peer review were ELM v2.5.2, and the full release is referred to as simply ELM v2.5

9.4 Current limitations

In the current ELM v2.5, we do not offer regional Performance Measures for ecological variables beyond those involving hydrology and phosphorus “water quality”. (An earlier version, as listed above, demonstrated those capabilities in a subregional implementation; subsequent improvements have enhanced its capabilities). Some of the principal limitations or uncertainties associated with the current model dynamics are:

- **Hydrologic** flows in the canal system are dependent on the extent to which we segment an actual canal (separated by managed water control structures) into multiple interacting canal reaches with “virtual” structures. Using observed gradients and trends of chloride and phosphorus observations, the grain of reach segmentation generally captures the seasonal/annual distributions of canal-canal-marsh exchanges.
- **Phosphorus** is considered in the aggregated, Total Phosphorus variable. A simple relationship between total phosphorus and bio-available phosphorus is assumed to be representative of the long-term dynamics of the integrated biogeochemistry and plant biology.
- **Soils** are a fundamental property of this wetland system, and it is essential to ensure that they are adequately characterized in the simulation. We have not yet made use of the significant body of new data that are available to compare to the model output and to better parameterize vertical fluxes in the soil, floc and water column modules, throughout the regional system. Moreover, we currently assume that a very simple vertical zonation in the sediment/soil profile allows sufficient differentiation of the deep aquifer and the active soil zone near the surface.
- **Macrophytes** and soils are the principal determinates of the habitat type in the model (and in the field). The macrophytic vegetation type is known to be heterogeneous at scales finer than 1 km^2, and thus those fine-scale patterns are not captured in the regional (1 km^2) implementation of ELM. We thus assume that our ability to discriminate habitat types at the regional scale is representative of the major trends in principal habitats such as sawgrass-cattail transitions over long (decadal) time scales.

- **Fire** is known to be a driving influence in habitat succession of the Everglades. Because we do not simulate fire dynamics, the direct effects of drought are only imparted through soil decomposition and changes to macrophyte mortality and growth. Any short term effects of fire on bio-available phosphorus are aggregated in the long-term phosphorus and macrophyte/soil dynamics.

9.5 Planned refinements

- **General**: 1) Acquire and synthesize more of the ecological monitoring and research data that have been collected/published since the mid- to late- 1990's. 2) Extend the sensitivity and uncertainty evaluations of the model applications. 3) Continue development of integrated databases and post-processors.
- **Hydrology**: our long-term plan is to integrate the biogeochemical and biological modules of ELM into the SFWMD's Regional Simulation Model (RSM); in the near-term, we plan to obtain the additional observed data in the southern and southwest mangrove regions for calibrating the ELM flows and stages in that region. Moreover, we plan on incorporating the updates to 1) land surface elevation data in northern WCA-3A and Big Cypress National Preserve and 2) the spatial time series of potential evapotranspiration for 1965-2000.
- **Soils**: further evaluate the (currently good) performance of the dynamics of peat accretion/oxidation, and phosphorus concentration, to determine the need to modify the algorithms regarding 1) vertical stratification of nutrients and 2) inorganic soil gain/loss.
- **Multi-scales**: two options are feasible for considering finer-scale ecological dynamics: 1) given current fast run-time, moderate dynamic memory (RAM) usage, and modular source code structure, it is feasible to incorporate a dynamic fine-grid array of macrophytes operating within the "coarse" 1 km^2 grid of the regional model; 2) employing the new multi-scale dynamic boundary condition code, it is attractive (in the near-term) to make sequential runs of the regional (1km^2) implementation, followed by a finer-scale subregional implementation with the regional-ELM boundary conditions.
- **Fire**: historical fire maps, available from Department of Interior, are planned be used to generate a probabilistic (non-mechanistic) module to capture subregional trends in fire effects on soil losses and the disturbances that broadly affect macrophyte succession over long time scales.

9.6 Literature cited

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