COINS - an integrative modelling tool for greenhouse accounting and natural resource management

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1. Introduction

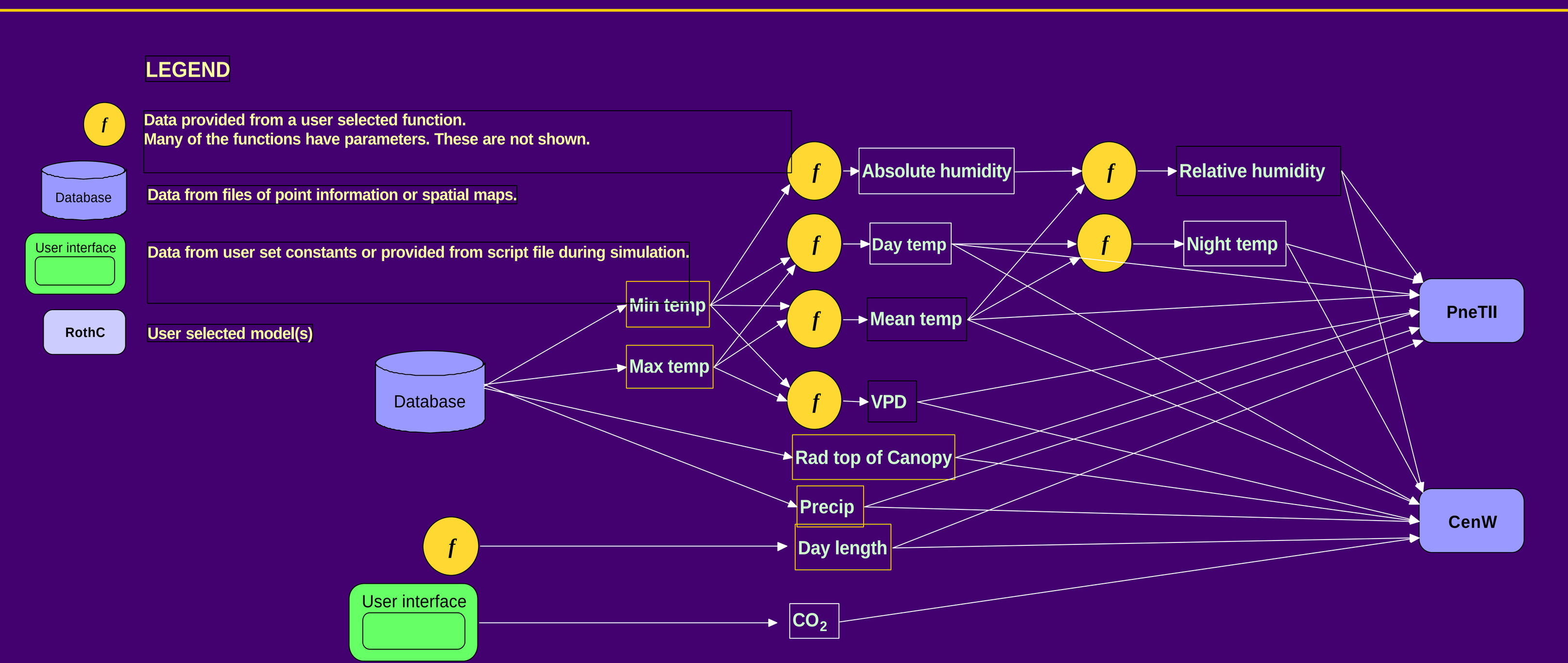
Many natural resource management problems require the integration of a wide range of data and analyses within the same analysis framework. Often, interactions between biological, physical and anthropogenic aspects also need to be incorporated, most typically on a temporally and spatially-explicit basis. Such requirements can provide major challenges for assembling and conducting analyses which are flexible enough to successfully capture the range of dynamics required.

The ability to develop, combine and compare different models within the same software environment provides one way of conducting integrative analyses of environmental problems, and provides a consistent framework for data and model comparison. This poster describes the COINS (COmparison and INtegration Shell) software shell. Although COINS was developed specifically for the analysis of terrestrial carbon dynamics, its potential utility is much broader; particularly within the general area of natural resource management.

2. Software philosophy & design

The philosophy underlying the COINS shell is to take the common features that exist among a range of models, and embed them centrally within the main computer code of the shell. These common features may comprise shared process descriptions, shared data input and output routines, or algorithms for the presentation of results. Co-locating many models within the same software environment brings with it many advantages:

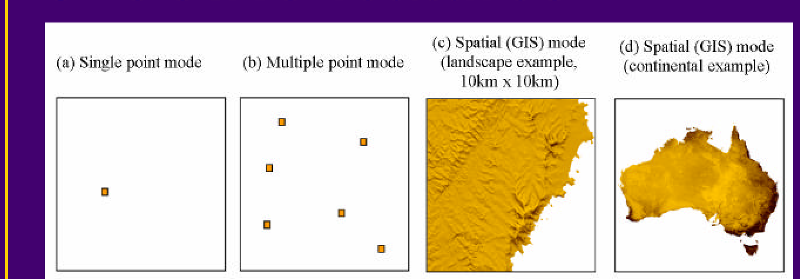
- The separation of shared model code and ancillary functions from the 'core' model specification facilitates the rapid development of new models, and the efficient modification of existing models. It also aids in making transparent key underlying model assumptions.
- Housing similar models within the same environment facilitates model intercomparison activities through ensuring consistency in both input data, and in the presentation of model outputs.
- Housing similar models and model components within the same environment provides opportunities for 'mixing and matching' algorithms, and allowing the construction of new analysis options.



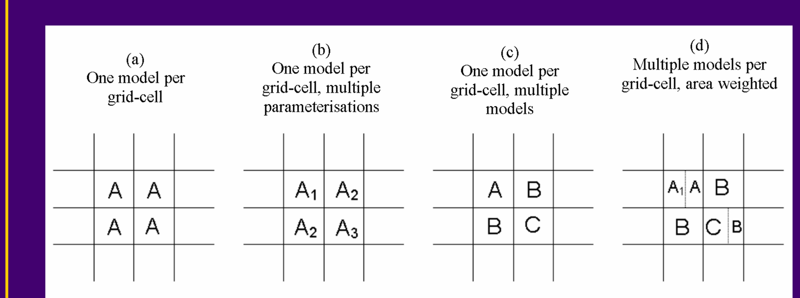
The figure above shows a schematic of a COINS simulation. The example comprises two models (PneTII & CenW), each of which access a common database of climate driver data. The driver data can either be used directly from the database (e.g. 'Precip' above), or can be processed using a library of default or user-defined modifier functions (e.g. 'VPD' above).

The COINS software is written with Borland Delphi© 7 and designed with ModelMaker 6, a Unified Modelling Language (UML) design tool.

3. COINS features

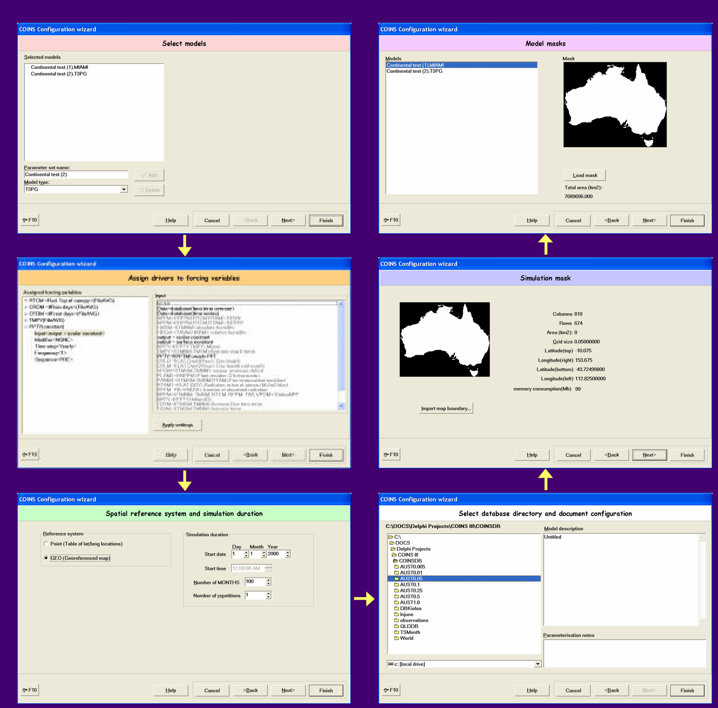


1. Spatial scaling: COINS models can be implemented at (a) a single 'point'; (b) a collection of points; through to (c), (d) full spatial mode where the model(s) run across multiple cells within a GIS-type framework.



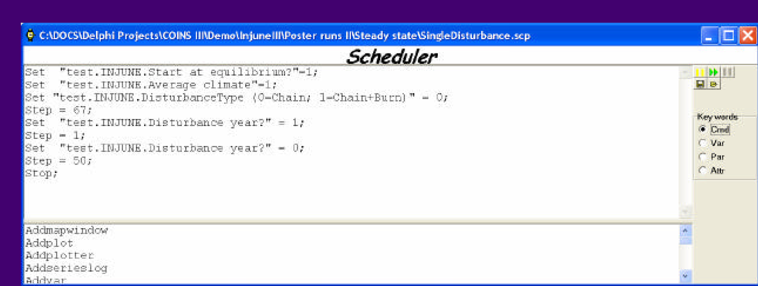
2. Multi-model simulations. Different models, and different parameterisations of the same model, can be combined within a COINS simulation in a number of different ways.

3. Temporal scaling. There are three temporal scales at which models can be combined; daily, monthly and yearly. The temporal resolution is implemented via three nested loops, and models are called only when required.

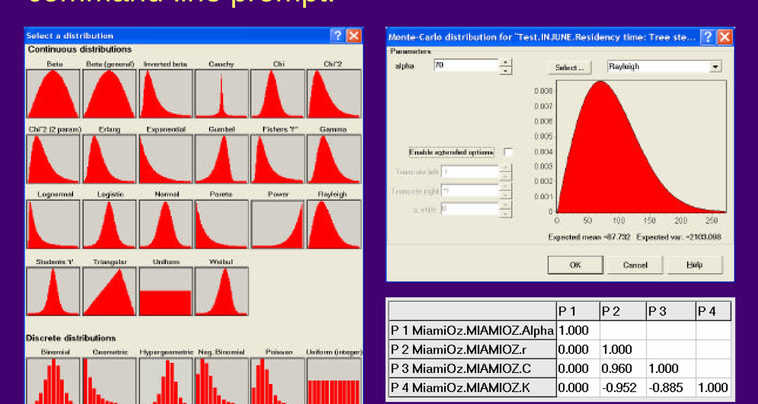


4. A model initialisation wizard guides the user through the process of setting up a simulation, including the selection of the models, the specifications of the necessary driver data, and the spatial and temporal reference details.

5. Tables of observations can be imported into COINS, and as a simulation progresses these observations can be graphically compared against the model outputs, allowing 'visual' run-time validation of models to be assessed.

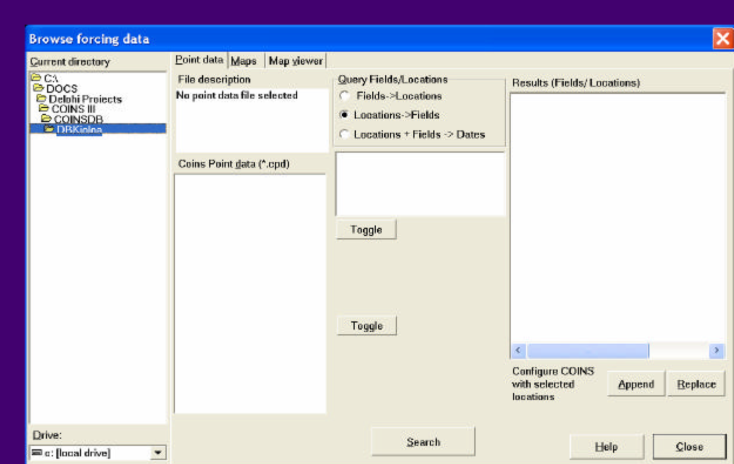


6. An event scheduler allows complex simulations to be built, through specifying events such as disturbance, fertilizer addition etc. The scheduler has its own command syntax. Scheduler commands can also be entered one-line-at-a-time through a command-line prompt.



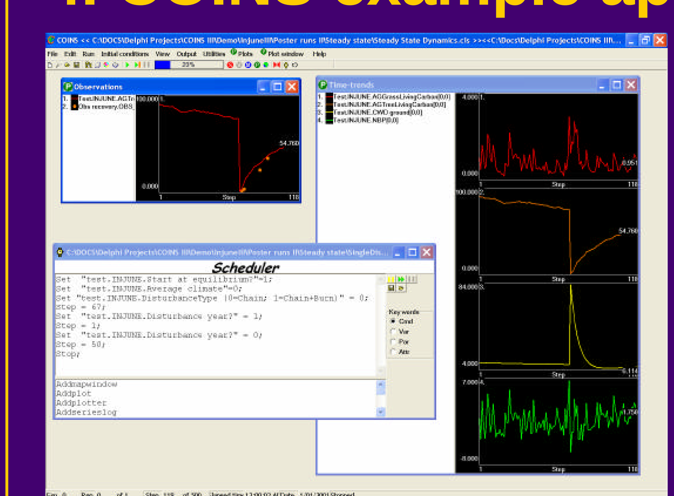
7. Uncertainty analyses can be conducted in COINS via Monte-Carlo simulation. An interactive dialog box allows the user to select parameter values from any one of 22 continuous or 6 discrete probability distribution functions, with user-defined correlation structures.

8. Any combination of output variables can be viewed as a simulation progresses, depending upon the type of simulation selected (point vs. spatial), and the parameters and variables defined in the model. These outputs include scalar quantities, vectors, matrices (e.g. maps) and XY-scatter plots (including plots of output variables vs. time). A GIS-type map viewer allows the visualisation and interrogation of spatial input data and model outputs.

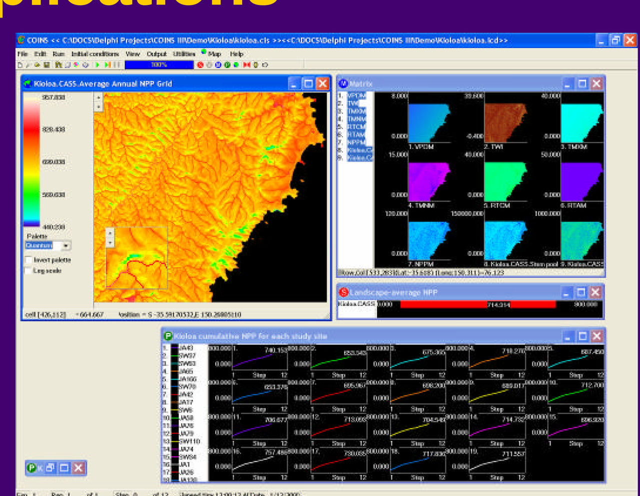


9. A utility for browsing driver data allows database-like queries to me made, such as searching for all available data for a particular model and simulation period. Results from queries can be applied to the current simulation, allowing changes in driver data to be readily applied.

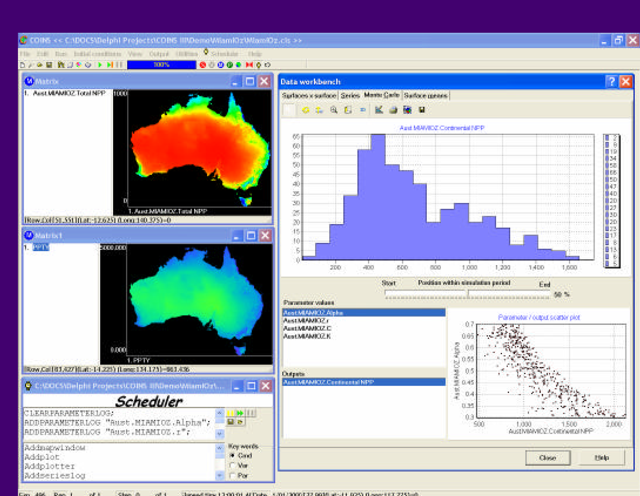
4. COINS example applications



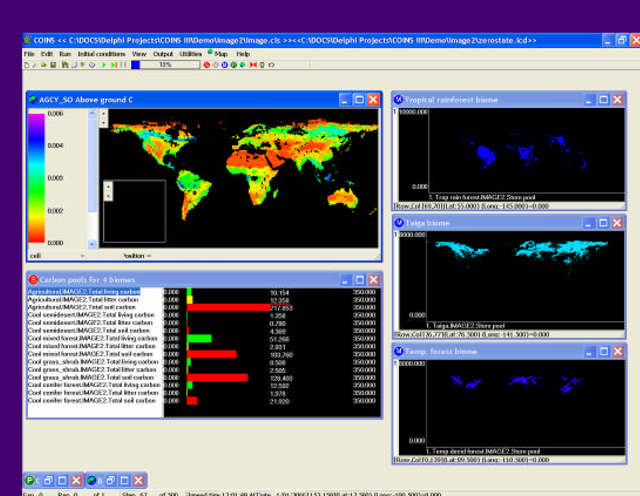
1. Point model: Assessing the impact of land-clearing on the carbon dynamics within a grazed woodland. The schedular is used to specify the timing of a disturbance event.



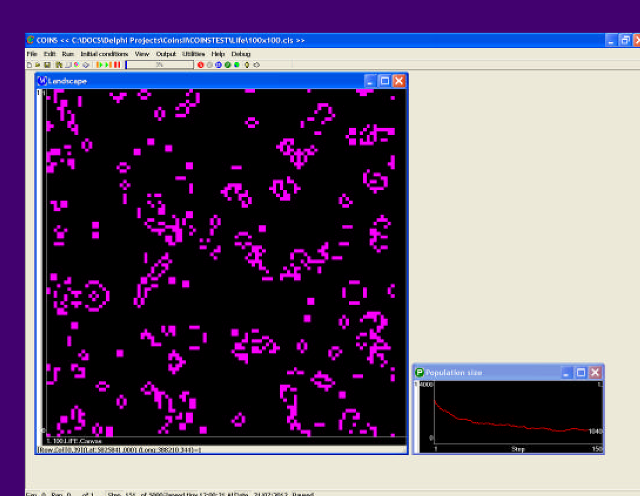
2. Landscape-scale model: Assessing forest growth and carbon sequestration potential across a forested landscape.



3. Continental-scale model: Monte-Carlo analysis of continental net primary productivity. The histogram summarises the model outputs for 500 randomly selected sets of parameters.



4. Global-scale model: Biome-specific carbon stocks from a simple carbon budget model. Each biome is a separate instance of the underlying model. The world map combines the output from all biomes.



5. Cellular automata model: Although not computationally optimised for modelling between-cell communication, spatially contagious processes can never-the-less be easily incorporated within COINS.

SUMMARY: Exploring and solving environmental problems is typically a complex, expensive process involving data collection, observation and experimentation. Simulation modelling provides one tool for integrating and summarising this information within a single framework. Modelling shells, such as the COINS environment presented here, provide a further tool for model analysis and scenario development, and provides significant potential for bringing together, with minimal effort, novel analysis options and approaches that would otherwise not be possible.

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