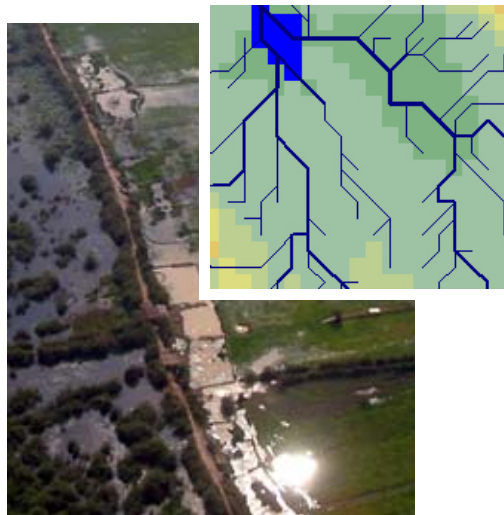




Mekong River Commission

Hydrological, Environmental and Socio-Economic Modelling Tools for the Lower Mekong Basin Impact Assessment



Water Utilisation Programme

WUP-FIN Phase2
Technical Paper No. 7
RLGis Manual

Draft – June 2006



Finnish Environment Institute
in association with
EIA Centre of Finland Ltd.
Helsinki University of Technology

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Technical paper		Status
TP1	EIA 3D model manual	Draft
TP2	VMod Hydrological model manual	Draft
TP3	HBV Hydrological model manual	Draft
TP4	Tonle Sap Lake water balance calculations	Draft
TP5	Sediment dynamics of Tonle Sap Lake	Draft
TP6	Database report	Draft
TP7	RLGis manual	Draft

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The opinions and interpretations expressed within are those of the authors and do not necessarily reflect the views of the Mekong River Commission.

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1 INTRODUCTION

RLGis is a system for performing hydrological computation on river catchments using geographical information (GIS data) such as elevation models, land-use information meteorological timeseries. The system capabilities include GIS and timeseries data import, export and editing, and several computation methods to extract relevant hydrological information from the data.

RLGis is capable of setting up the VMod hydrological model database from GIS-data. VMod can be run directly on this database. The data includes elevations, land use, initial ground water height, soil properties etc.

1.1 INSTALLATION

Run the RLGisSetup.exe or VivSetup.exe, and follow the instructions given by the setup program. Install at least the following options (when available):

- Viv base system
- RLGis

If you have a previous installation of the Viv system you can install the system (or update) in the same directory - uninstallation of the previous version is not needed.

1.2 STARTING RLGis

The installation program creates a Viv folder to the selected menu. RLGis system starts by selecting the RLGis icon in that folder. After start-up the system opens an empty map window.

2 MAIN WINDOW

The RLGis main window contains a program menu, a toolbar, a layer bar on the left side of the window, and a child window area. The child window area may contain different kind of child windows, including map windows, timeseries windows, text edit windows and command window. After start-up an empty map window is shown.

2.1 WORKING WITH MAPS

A RLGis map is a group of one or more map layers shown in a map window. A map layer is group of single type of geographical data objects. A map layer could contain, for examples, a digital elevation grid, watershed boundary lines, or water quality measurement point locations.

RLGis maps are stored into files having a *.gip file type. Saving and opening maps is done using the File menu. Each map is shown in a separate child window displaying the map file name in the window title bar. Several maps can be open at any one time.

Map layers are saved separately from maps, saving a map does not guarantee that the map layers are saved and will found next time the map is used. The user must keep account of the layers and remember to save modified and new map layers.

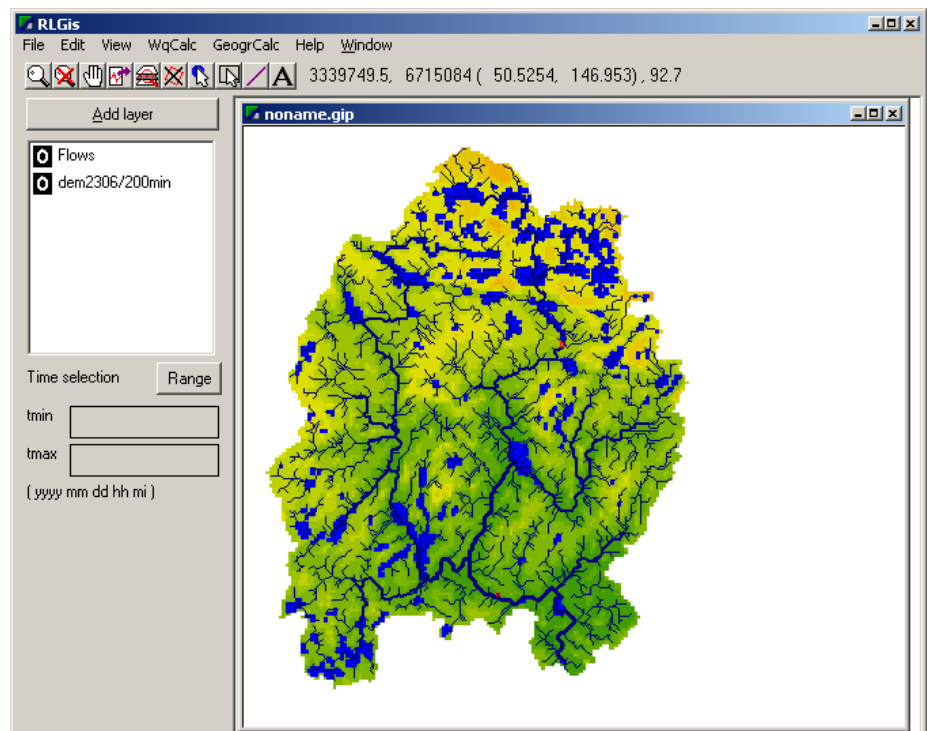












Figure 1. RLGis map window

Map window toolbar icons and corresponding actions are presented below:

	ZoomIn
	ZoomOut
	Move
	Copy view to Clipboard
	Zoom to selected layer boundaries
	Select nothing
	Change grid data
	Select lines or marker data
	Draw new lines
	Write new text

Current mouse coordinates are displayed on the right side of the tool buttons. First are the x-y coordinates of the layer, then optionally geographical lat-lon coordinates in parentheses. Rightmost there is map layer related data, such as grid value in the mouse location (if there is a grid layer in the window).

3 WORKING WITH LAYERS

3.1 ADDING LAYERS TO PROJECT

Map layers are added to map using the "**Add layer**" - button above the layer list. Layers are stored on hard disk or network as files. Adding layers is done by selecting a file containing the required information, after which the RLGis reads the file and display the information on the project window. A list of loaded map layers is shown in the layer bar in the left side of the RLGis window.

RLGis is able to read following file formats:

- IPD – RLGis internal text format for storing layer data (see appendix)
- SHP – ESRI shape file format for storing vector data
- BIL – raw raster format for storing gridded data
- TIFF – image format for storing gridded data
- TXD – rlgis internal text format for storing timeseries data (see appendix)
- DIG – text format for storing vector data (see appendix)
- EXV – text format for storing hydrodynamic data (see appendix)
- VMD – text format for storing distributed hydrological model grid data

Files can be saved in IPD, SHP, BIL, TIFF, TXD and VMD formats.

Pressing "**Add layer**" pops up a menu containing following options

- GIS-data - reads IPD type layers
- Timeseries - reads timeseries files
- Import file - imports SHP, BIL, TIFF, EXV, DIG and VMD type files
- Decorations - adds length- and colour scales

3.1.1 The layer list

The layer list on the layer bar contains names of all layers in the active map window. The check box just left of layer name controls if the layer is visible or not. Double clicking the layer name brings up a layer properties dialog, the contents of which depend on the layer type. Pressing right mouse button on the layer name shows a pop up window containing following options

- Properties** – show layer properties dialog (same as double click)
- Remove** – remove layer
- MoveTop** – move layer to be the topmost layer
- MoveUp** – move layer one step up in the list
- MoveDown** – move layer one step down in the list
- File** – show layer file name and file attributes
- Save** – save layer to a file

In addition to these actions there may be other options that depend on the layer type.

RLGis allows computations to be performed for whole layers. For this the computation target layers need to be selected from the layer list. Selection is done by clicking the layer name in the layer list with mouse, and is shown by gray layer name background. If more than one layer needs to be selected, keep SHIFT key down while selecting.

3.1.2 Saving layers

Layer data can be saved to disk files using right mouse click popup-menu **Save** command. At the lower left corner of the save-dialog is a 'Save file as type:' selection, that can be used to export layer data to different formats. For line layers shapefiles are supported, for grid layers BIL raster format is available.

3.2 LINE LAYERS

Line layers contain line data, or a set of connected points, that can be interpreted as lines or polygons. One layer may contain any number of distinct lines or polygons. A new line layer is created, for example, when a shape-file or a digit-file is imported.

3.2.1 Selecting lines

To select lines from a line layer first activate the line selection tool by clicking the **Select Lines** tool icon in the toolbar. When line selection is active point and click lines on the map to select any single line. To select many lines keep SHIFT key down while selecting. You can also use the mouse to draw a rectangle to select all lines inside the rectangle.

Selection tool is deactivated by clicking the right mouse button while on the map area, or by selecting some other tool from the toolbar. However, the selection done is preserved and can be modified by pressing the **Select Lines** tool again. To deselect all lines while not in selection tool press the **Select nothing** tool in the toolbar.

3.2.2 Joining lines

Selected lines can be joined to form a single line (or polygon) by *GeogrComp/Vector Data/Lines – join lines* menu command. To join lines first select all line segments you wish to join and then choose the above join lines command from the menu. The command will process the lines and create a new single line consisting all selected line segments. After join is complete a dialog with options what to do with the new data is shown

Add as new layer - creates a new line layer and adds the new line to it

Add to selected layer - add the new line to topmost selected line layer

Discard line - discard new line

3.3 GRID LAYERS

A grid layer contains gridded data, that is, a rectangular matrix of rectangular grid cells, associating a single number for land area located inside each grid cell. The associated number may contain any data, for example average land elevation in the grid cell, or a land use or soil type classification for the grid cell area. All the grid cells have same cell size, typically from 10 x 10 meters upwards. The grid matrix itself may have any dimension in the x and y directions.

3.3.1 Grid types

The number values associated with each grid cell may be of different types. RLGis understands four types, 8,16 and 32 bit integer numbers and single precision floating point values. Some grid computation requires specific type of grid to work, but single precision floating point should work in most cases. The integer types save storage space and are faster to process, but values are limited as follows:

Type	Value range
8-bit integer	0 ..255
16-bit integer	0 .. 65535
32-bit integer	- 2147483647 .. 2147483647
single prec.	-1e38 .. +1e38, about 6 numbers precision

Grid type can be changed using the *GeogrCalc/Grid/Grid – change grid type* command.

3.3.2 Extracting part of a grid

Smaller areas from a larger grid can be extracted using following techniques:

1. Given a polygon, the grid data inside the polygon can be extracted
2. Rows and columns can be cut from sides of the grid
3. A second grid can be used to select area to extract

The first method is useful, for example, when extracting a watershed elevation data for a specific watershed using watershed boundary data. To create a new grid for a specific watershed first select a watershed boundary polygon using **Select Lines** tool, then select layer containing the boundary polygon, and the elevation grid from the layer list. Then select *GeogrComp/Grid/Grid – extract data using polygon* command from the menu. The command creates a new grid to the layer list containing the extracted grid data. Note that the area defining polygon must be a single polygon completely enclosing the area to be extracted.

3.3.3 Modifying single grid box values

Single grid data values can be modified easily by using the **Change grid data** tool in the toolbar. To change a grid value first move the grid layer to be the topmost layer in the layer list, then click the change tool, and then click a spot on the grid. A dialog showing the current grid box value appears – you can change the value by typing in a new value.

3.4 FLOW LAYERS

Flow layers are grid layers, where the grid box value defines downhill flow direction. Flow layers are drawn as arrows or lines to showing the flow direction in each grid box. Each box may flow only to a neighbouring box, so there are eight possible flow directions (N,NE,E,SE,S,SW,W,NW). Flow layers are computed from elevation models and can be used, for example, to estimate watershed boundaries and in hydrological modelling.

3.4.1 Creating a flow layer from elevation model

A new flow layer is computed from an elevation data. However, there are some restrictions for the elevation information:

1. The elevation model should be cut to approximate watershed boundary, since the flow layer computation algorithm will force all points having nonzero elevation to flow out from a single point.
2. The elevation grid should of single precision float type
3. The elevation model should have only one lowest point, from which the computation can start from.
4. The point having lowest elevation should be on the boundary of the elevation model.
5. The point having lowest elevation should not be a lake point.

If the above restrictions apply for the DEM a new flow layer can be computed using following steps

1. Select the elevation data layer for which you want to compute the flow data and select *GeogrComp/Flow/Flow - Create empty flow for DEM*. This will create a new flow layer with no flow directions defined so far.
2. If there are lot of lakes it is recommended to set lakes to the flow data before computing the flow directions.
 - a. If you have lakes defined in landuse grid use the command *GeogrComp/Flow/Flow – set lakes from landuse*. You need to know which landuse number corresponds to lakes.
 - b. If you have lakes defined as polylines use the command *GeogrComp/Flow/Flow –set lakes using polygons*.
3. To compute flow select the new flow layer (with lakes defined) and the elevation model from the layer list and then select the *GeogrComp/Flow/Flow – compute from lowest point* command
4. The computation takes some time depending on the flow grid size. Especially large lakes take long time to compute.
5. After the computation is done it is always a good idea to check the resulting flow field. Following checks can be done
 - a. Are all points included? Select the area outflow point by clicking it with a mouse (while flow layer is visible and on top), then select *GeogrComp/Flow/Flow – compute upper area* command from the menu. A new grid layer is created which shows the upper watershed area from the selected point. This should include all grid points of the watershed.
 - b. Use *GeogrComp/Flow/Flow – check flow* command from the menu. This will highlight problem spots with red squares. Some crossing flows are often produced by the computation algorithm, use this option to search and change these.
 - c. Computed flow direction should be compared to real river network. If differences are seen, they can be corrected either by changing the elevation model and recomputing the flow, or by modifying the computed flows.
6. Rivers can be taken into account using following procedure:
 - a. read rivers as polylines to window
 - b. use *Flow – set rivers using lines* command that creates a partial flow direction data from the river line data
 - c. carve river data to DEM by using *Flow – modify DEM using flow*. This command gives you an option to lower defined flow points elevations in the DEM.
 - d. Clear flow directions and recompute from lowest point using the modified DEM

3.4.2 Modifying computed flows

Computed flow directions can be modified using the **Change grid data** tool in the toolbar. To change a single flow direction first move the flow layer to be to topmost layer in the layer list, then click the change tool, and then click a spot on the flow network. A dialog showing the flow direction in that spot appears – you can change the direction by selecting some other flow direction in the dialog.

3.4.3 Computing subcatchements

As the flow layer defines flow directions for all points in the given watershed, the upper watershed for any point can be computed using the flow direction data. To compute upper catchment for any point first move the flow layer to be the topmost layer and then select it from the layer list, after that select the point you wish to get the upper area of by clicking it with a mouse, and then select *GeogrComp/Flow/Flow – compute*

upper area command from the menu. A new grid layer is created which shows the upper watershed area from the selected point.

If a line boundary of the computed upper area is needed this can be obtained using the *GeogrComp/Grid/Grid – boundary to polyline* command. This will create a new line layer containing the boundary of the upper area.

3.4.4 Defining flow data for fld layer

A flow timeseries file can be defined for a flow layer. This flow data is used to compute flow in different points of the flow network based on simple area size relation, e.g. the flow in required data point is computed as follows:

$$\text{FlowA} = \text{A/B} * \text{FlowB},$$

Where FlowA - flow in point of interest
 A - upper catchment area of the point of interest
 FlowB - flow in measurement point
 B - upper catchment area of point B

The measured flow file for the fld layer is defined as follows:

- Activate flow layer in layer list by clicking it once.
- Select a point on a map, from where you have measured flow data. A red square should appear to the clicked spot to mark selection of that point.
- Double click the active flow layer in the layer list, to get the flow properties dialog, and click "change flow file" in the dialog.
- Select a flow file from the file dialog (must be in txd format) and click OK.
- In the confirmation dialog select "map data point" and press "Update" and then "Done".

After the flow data is defined, clicking any point on fld layer twice in the same grid box will bring up a flow data dialog, displaying upper catchment area size and average flows for the selected point.

4 WATER QUALITY RELATED COMPUTATIONS

Water quality computations require at least a flow to be defined. Using computation related additional data, such as land use or average yearly flow data, following water quality related computations can be done:

- Average flow in any flow network point
- Effect of single point load to concentrations downstream
- Characteristic loads
- Land use percent of upper catchment

4.1 AVERAGE FLOW IN ANY FLOW LAYER POINT

Click a flow layer point twice. See "defining flow data for fld layer" above.

4.2 EFFECT OF SINGLE POINT LOAD TO CONCENTRATIONS DOWNSTREAM

This option computes concentration from the given point load location to downstream direction, supposing that the given load is completely mixed in the water flowing downstream. The concentration is computed as follows

$$c = \text{load} / (q * 86.4)$$

where c - concentration (mg/l)

load - point load, kg/d

q – flow in given location (m³/s)

86.4 – unit conversion factor

For this option, select a point on an fld layer, and then select *WqCalc/Point load effects* from menu. The point load dialog has following options:

Xcoordinate & Ycoordinate - location for point load

Get selected – button to set the coordinated to selected fld layer point

Load data location – name to be used in computed results

Load data variable - name to be used in computed results

Load data Load – load amount in kg/d

Flow data – flow data to be used, avgmin, average, or avgmax

Color scale options – min value, max value and number of colors

Draw to map – draw result as a colored line to map

Draw Concentr. – draw result as a line graph relating concentration and distance downstream

4.3 CHARACTERISTIC LOADS

This option computes sediment, nitrogen and phosphorous load at a given point using land use data and fld layer data. Loads are computed by first computing upper catchment area land use (km² for each land use type) from the given point, and then applying characteristic load values (kg/km²/a) and obtained areas to compute yearly load from the area.

For this option to work you need

- land use data grid
- computed fld layer
- characteristic load information (defaults to **rlchload.txd** file in viv-directory)
- a mapping from land use classed to characteristic load data classes

Characteristic load information is located by default in rlchload.txd file, found in viv-directory. This file can be viewed in Characteristic load dialog. A mapping from land use to the characteristic load information is also needed, often the numbers in land use raster are not the same as the numbers in the characteristic load table. This mapping is located to land use grid attribute list, the matrix name is "chload_landuse_map". This matrix should contain two columns, the first column a land use number in the land use grid, and the second the corresponding characteristic load table land use number.

To compute the characteristic loads first select fld layer and land use layer from the layer list, and select a spot on the map. Then select WqCalc/Characteristic loads from the menu, and if the data in the dialog is ok press "Compute". Load values are computed to a table window shown after the computation is finished.

The Characteristic load dialog has following items

Xcoordinate & Ycoordinate - location for point load

Get selected – button to set the coordinates to selected fld layer point

Characteristic load data / Browse – select a characteristic loads file

Characteristic load data / Display – view the characteristic loads file

Grid to Chload mapping / Browse – select mapping data file

Grid to Chload mapping / Display – view mapping data

The Grid to Chload mapping is by default set to land use grid layer attribute "chload_landuse_map" if found. If attribute is not found identity mapping is used. Data in a txd file can also be read in using **Browse** button.

5 TIME SERIES

Time series windows are used to display and analyze time series data. A time series window appears by selecting data using marker layers, or by opening or importing a time series file to a new time series window, shown in Figure 2 below.

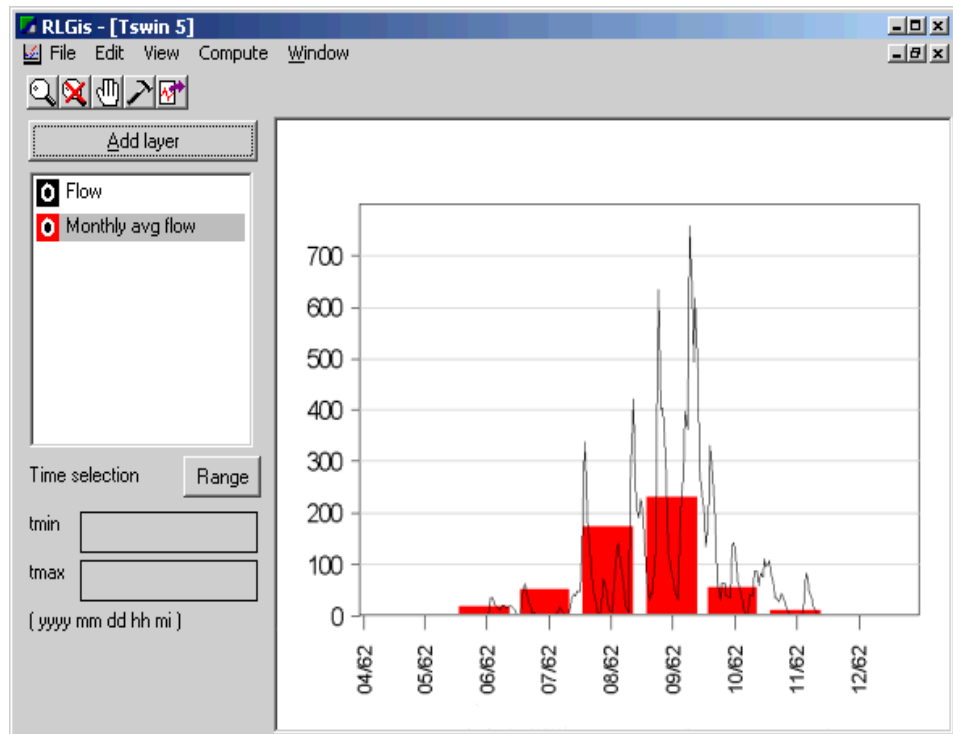


Figure 2. Time series window showing yearly flow and computed monthly average

Time series can be plotted as lines, dots, and bars. Any number of time series can be drawn in the same window. Available data analyses include standard statistics, FFT, autocorrelation, cumulative series, r^2 fit and correlation two series, and grouping to daily, weekly, monthly and yearly values. Available time series manipulations include linear transformations, moving average, self differencing, selection by depth or time, and two times series arithmetics.

Time series data in following file formats can be used:

- TXD – model system specific text file format
- DBF – DBase file format
- XLS – Excel files, file needs be organized in a specific way
- TEXT – Ascii text file, must be organized in a specific way
- SQL databases – SQL database queries can be run through JDBC.
- GRA – Flow and water quality model formats for model results

Data can be written to TXD, DBF and XLS formats.

6 HOW TO...?

Compute upper watershed area of a point in elevation model ?

1. Import DEM for the given area
2. Import main watershed boundaries for the given area
3. Extract the main watershed containing the point of interest from the DEM
4. Compute flow network for the area
5. Select point of interest and compute upper watershed area using *GeogrComp/Flow/Flow – compute upper area* command

Convert grid layer boundaries to shape file ??

1. Select the grid layer of interest
2. Use the *GeogrComp/Grid/Grid – boundary to polyline* command to create a line layer
3. Save the line layer as shape file by clicking pointing the layer in layer list, clicking with right button and selecting Save option from the menu. Set the file type to SHP in the save dialog box before pressing OK.

Modify landuse type in a grid for a specific area ??

1. Draw a polyline round the area to be changed using Draw line tool
2. Save the new polyline to a new layer
3. Select the new polyline using line select tool
4. Select both the new polyline layer and the landuse layer
5. Select *GeogrComp/Grid/Grid – reclassify inside polygon* command
6. In the reclassification matrix choose the landuse number you like to change and set the second column value to the new value, and click "Store" button.
7. if the change does not show use view/redraw all

Optionally:

Store to grid as a BIL or TIFF file and modify it using a different program