

Step by Step Geo-Processing and Set-up of the Required Watershed Data for MWSWAT (MapWindow SWAT)

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Version 2
October 2011

Contents:

1 Source Data.....	2
1.1 DEM Source Data.....	2
1.1.1 SRTM Processed 90m Digital Elevation Data Version 3:	2
1.1.2 Basic Supporting Geographic Data:.....	4
1.2 Landuse Source DATA:.....	6
1.3 Soil Source DATA:.....	7
1.4 Loading GeoTiffs.....	8
1.5 Note on Projection Warnings.....	8
1.6 Selecting a UTM zone.....	10
2 Setup for Mexico: San Juan River Watershed.....	10
2.1 Elevation maps (DEMs).....	10
2.1.1 Pre-Process of DEM Data.....	10
2.1.2 Re-project DEM to UTM.....	17
2.2 Landuse Data.....	19
2.2.1 Pre-Process of Landuse Data.....	19
2.2.2 Re-project Landuse to UTM.....	22
2.3 Soil Data.....	23
2.3.1 Pre-Process of Soil Data.....	23
2.3.2 Re-project Soil to UTM.....	26
3 Setup for Malawi: Linthipe Watershed.....	28
3.1 Elevation Data (DEMs).....	28
3.1.1 Pre-Process of DEM Data.....	28
3.1.2 Re-project DEM to UTM.....	30
3.2 Landuse Data.....	31
3.2.1 Pre-Process of Landuse Data.....	31
3.2.2 Re-project Landuse to UTM.....	34
3.3 Soil Data.....	35
3.3.1 Pre-Process of Soil Data.....	35
3.3.2 Re-project Soil to UTM.....	38

1 Source Data

1.1 DEM Source Data

1.1.1 SRTM Processed 90m Digital Elevation Data Version 3:

Format: GeoTiff Grid Files in 5° x 5° tiles (Lat/Long, decimal degrees)

Source: <http://srtm.csi.cgiar.org/>

Metadata included in header:

Geotiff_Information:

Version: 1

Key_Revision: 1.0

Tagged_Information:

ModelTiepointTag (2,3):

0 0 0

-105.000416 25.0004171 0

ModelPixelScaleTag (1,3):

0.000833333333 0.000833333333 0

End_Of_Tags.

Keyed_Information:

GTModelTypeGeoKey (Short,1): ModelTypeGeographic

GTRasterTypeGeoKey (Short,1): RasterPixelIsArea

GeographicTypeGeoKey (Short,1): GCS_WGS_84

GeogCitationGeoKey (Ascii,7): "WGS 84"

GeogAngularUnitsGeoKey (Short,1): Angular_Degree

End_Of_Keys.

End_Of_Geotiff.

GCS: 4326/WGS 84

Datum: 6326/World Geodetic System 1984

Ellipsoid: 7030/WGS 84 (6378137.00,6356752.31)

Prime Meridian: 8901/Greenwich (0.000000/ 0d 0' 0.00"E)

PROJ.4 Definition: +proj=latlong +ellps=WGS84 +to_meter=1.0000000000

Contents of the Readme file:

PROCESSED SRTM DATA VERSION 4.1

The data distributed here are in ARC GRID, ARC ASCII and Geotiff format, in decimal degrees and datum WGS84. They are derived from the USGS/NASA SRTM data. CIAT have processed this data to provide seamless continuous topography surfaces. Areas with regions of no data in the original SRTM data have been filled using interpolation methods described by Reuter et al. (2007).

Version 4.1 has the following enhancements over V4.0:

- Improved ocean mask used, which includes some small islands previously being lost in the cut data.

- Single no-data line of pixels along meridians fixed.
- All GeoTiffs with 6000 x 6000 pixels.
- For ASCII format files the projection definition is included in .prj files.
- For GeoTiff format files the projection definition is in the .tfw (ESRI TIFF World) and a .hdr file that reports PROJ.4 equivalent projection definitions.

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ACKNOWLEDGMENT AND CITATION

We kindly ask any users to cite this data in any published material produced using this data, and if possible link web pages to the CIAT-CSI SRTM website (<http://srtm.csi.cgiar.org>).

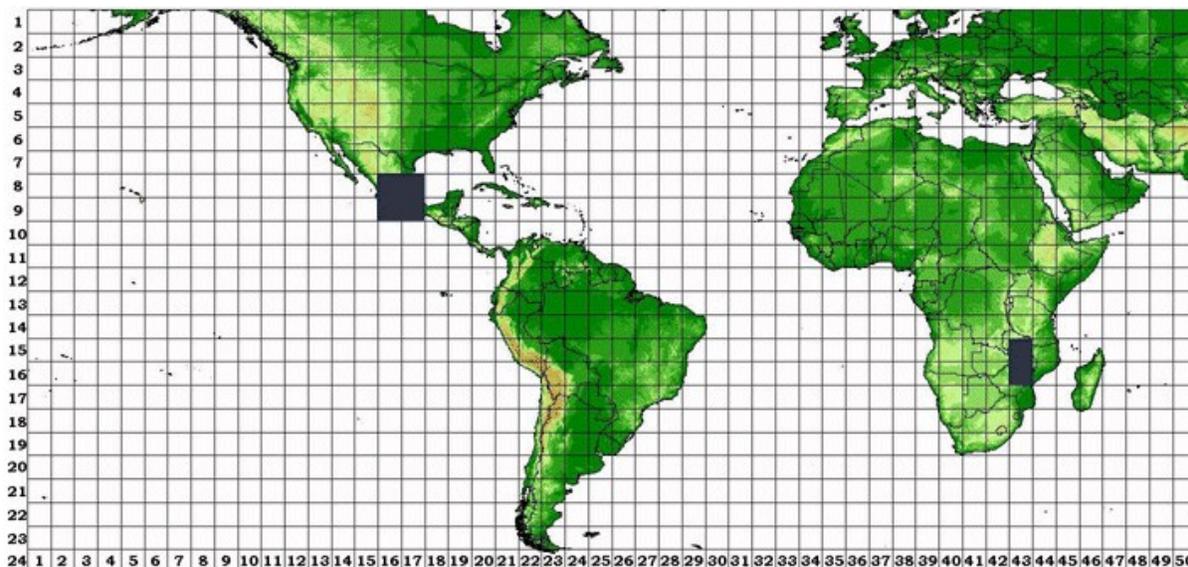
Citations should be made as follows:

Jarvis A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available from <http://srtm.csi.cgiar.org>.

REFERENCES

Reuter H.I, A. Nelson, A. Jarvis, 2007, An evaluation of void filling interpolation methods for SRTM data, International Journal of Geographic Information Science, 21:9, 983-1008.

Downloaded Data



Tiles for Mexico:

srtm_16_08
srtm_16_09
srtm_17_08
srtm_17_09

Tiles for Malawi:

srtm_43_15
srtm_43_16

From the header info on each of these tiles, a simple shape file was created to quickly identify the required tiles when the user zooms in the area of interest (see World_Data_Grids folder and ZIP file).

This guide assumes that the zipped DEM files, such as **srtm_16_08.zip** are available. These can be downloaded from <http://srtm.csi.cgiar.org/>. We use the GeoTiff format. The suggested location to prepare the clipped versions to use in MWSWAT is a temporary folder (e.g. C:\temporary\dems). Once the DEM is merged and/or clipped for the area of interest it is strongly suggested to move the resulting output grid (*filename.tif*) to the MW_project location.

1.1.2 Basic Supporting Geographic Data:

HYDRO1k Elevation Derivative Database:

http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30/hydro

Format: ArcView Shapefile Format (Lambert Azimuthal Equal Area projection)

Documentation:

http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/gtopo30/README

Drainage Basins:

Africa - http://edcftp.cr.usgs.gov/pub/data/gtopo30hydro/af_bas.tar.gz

- Origin (Longitude = 20° E ; Latitude = 5° N)

Asia - http://edcftp.cr.usgs.gov/pub/data/gtopo30hydro/as_bas.tar.gz

- Origin (Longitude = 100° E ; Latitude = 45° N)

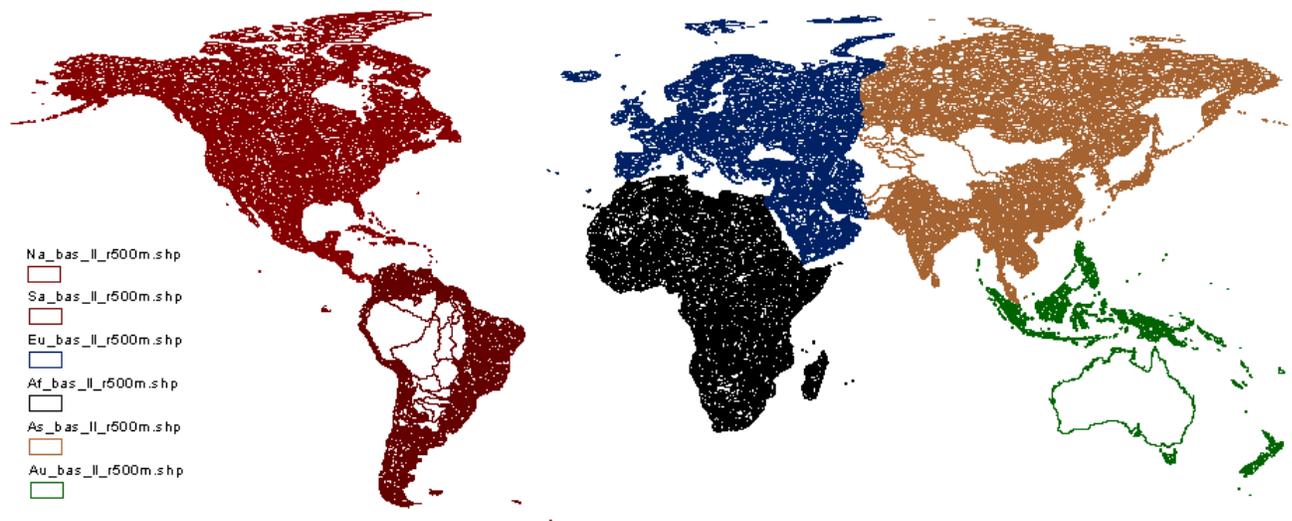
- Australasia - http://edcftp.cr.usgs.gov/pub/data/gtopo30hydro/au_bas.tar.gz
 - o Origin (Longitude = 135° E ; Latitude = 15° S)
- Europe - http://edcftp.cr.usgs.gov/pub/data/gtopo30hydro/eu_bas.tar.gz
 - o Origin (Longitude = 20° E ; Latitude = 55° N)
- North America - http://edcftp.cr.usgs.gov/pub/data/gtopo30hydro/na_bas.tar.gz
 - o Origin (Longitude = 100° W ; Latitude = 45° N)
- South America - http://edcftp.cr.usgs.gov/pub/data/gtopo30hydro/sa_bas.tar.gz
 - o Origin (Longitude = 60° W ; Latitude = 15° S)

The above files are already projected in latitude-longitude and available from the WaterBase web site http://www.waterbase.org/download_data.html as **Global River Basins**. The vertices were also smoothed with 500m threshold.

Format: ArcView Shapefile Format (lat/long)

Projected Basins:

- Africa – af_bas_ll_r500m.zip
- Asia – as_bas_ll_r500m.zip
- Australasia – au_bas_ll_r500m.zip
- Europe – eu_bas_ll_r500m.zip
- North America – na_bas_ll_r500m.zip
- South America – sa_bas_ll_r500m.zip



It is suggested to unzip the contents of the files to a folder in the user's hard drive (e.g. C:\unu_waterbase\Global_Basins_latlong). The above figure, with the basins in different color for each continent, was created with ArcView but a similar image can be generated with MapWindow.

1.2 Landuse Source DATA:

The landuse data was provided by Dr Karim Abbaspour of Eawag (http://www.eawag.ch/index_EN):

Landuse data was constructed from the USGS Global Land Cover Characterization (GLCC) database (<http://edcns17.cr.usgs.gov/glcc/glcc.html>). This map has a spatial resolution of 1 kilometre and 24 classes of landuse representation. The parameterization of the landuse classes (e.g. leaf area index, maximum stomatal conductance, maximum root depth, optimal and minimum temperature for plant growth) is based on the available SWAT landuse classes and literature research.

Pre-processing note:

Due to the huge size of the uncompressed files, after importing the file with ArcView the grids were divided into tiles for each continent. The resulting files were still rather slow to load and manipulate in MapWindow, and were therefore resampled at half the original resolution. Both the original and resampled (*newres*) tiles are available from the WaterBase web site http://www.waterbase.org/download_data.html. We think that there will typically be little difference in the results from SWAT between the two resolutions. When you are starting to use MapWindow and MWSWAT we suggest you use the resampled tiles. It is possible to get much better speed with the original tiles if you hide their display before clipping, but this is likely to be confusing to new users. We give an explanation of this in the sections on generating landuse maps.

Files exported as GeoTiff raster:

- North America – na_landuse.zip, na_landuse_newres.zip (na_land_1, na_land_2, na_land_3)
- South America – sa_landuse.zip, sa_landuse_newres.zip (sa_land_1, sa_land_2)
- Europe & Asia – ea_landuse.zip, ea_landuse_newres.zip (ea_land_1, ea_land_2, ea_land_3, ea_land_4)
- Africa – af_landuse.zip, af_landuse_newres.zip (af_land_1, af_land_2)
- Australia & Pacific – ap_landuse.zip, ap_landuse_newres.zip (ap_land_1)

1.3 Soil Source DATA:

The soil data was provided by Dr Karim Abbaspour of Eawag (http://www.eawag.ch/index_EN):

Soil map was produced by the Food and Agriculture Organization of the United Nations (FAO, 1995). Almost 5000 soil types at a spatial resolution of 10 kilometres are differentiated and some soil properties for two layers (0-30 cm and 30-100 cm depth) are provided. Further soil properties (e.g. particle-size distribution, bulk density, organic carbon content, available water capacity, and saturated hydraulic conductivity) were obtained from Reynolds et al. (1999) or by using pedotransfer functions implemented in the model Rosetta (<http://www.ars.usda.gov/Services/docs.htm?docid=8953>).

Reynolds, C.A., Jackson, T.J., Rawls W.J., 1999. Estimating available water content by linking the FAO soil map of the world with global soil profile database and pedo-transfer functions. Proceedings of the AGU 1999 spring conference. Boston, MA.

The soil data is available from the WaterBase web site
http://www.waterbase.org/download_data.html

Files exported as GeoTiff raster:

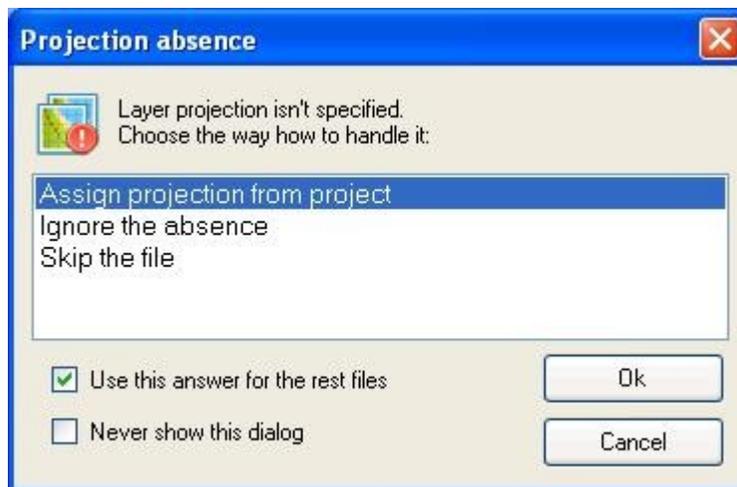
- North America – na_soil.zip (na_soil_1, na_soil_2, na_soil_3)
- South America – sa_soil.zip (sa_soil_1, sa_soil_2)
- Europe & Asia – ea_soil.zip (ea_soil_1, ea_soil_2, ea_soil_3, ea_soil_4)
- Africa – af_soil.zip (af_soil_1, af_soil_2)
- Australia & Pacific – ap_soil.zip (ap_soil_1)

1.4 Loading GeoTiffs

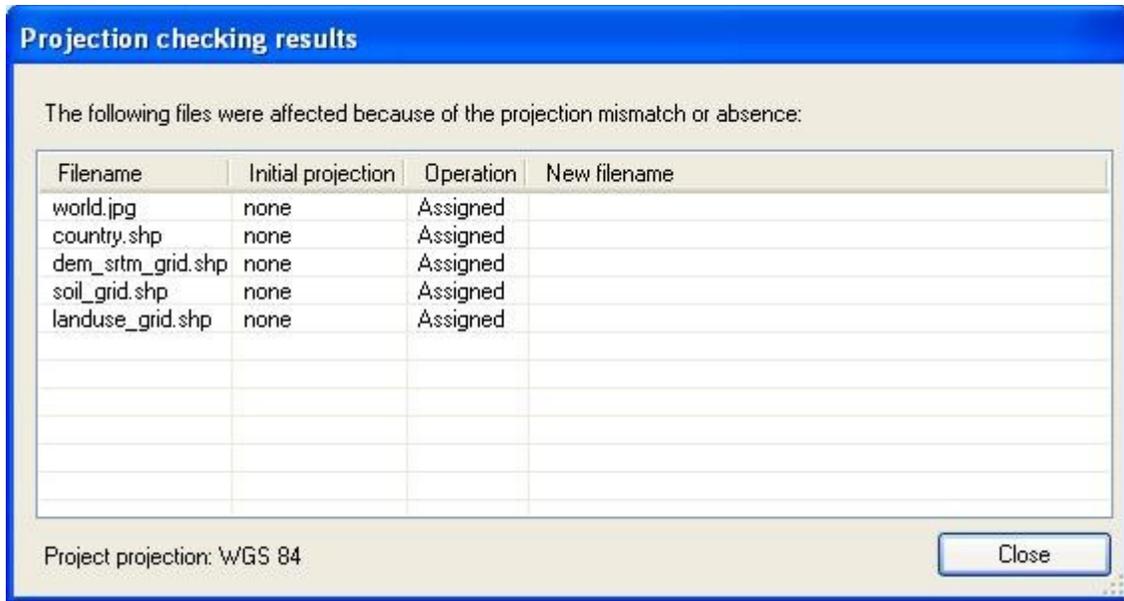
MapWindow can load GeoTiff grids as grids or as images. Before you start, check that you are set up to load them as grids, so that they can be processed. Use *Project -> Settings -> Application Settings* and if necessary change *TIFF/IMG/DEM Loading Behavior* to **LoadAsGrid**. If you changed the setting, exit and restart MapWindow so that your preference is saved.

1.5 Note on Projection Warnings

Sometimes when adding a layer to MapWindow you may see a warning like the following:



This is because one of the maps already added has projection information, which has set the current project projection, and the new map does not. To be safe you can select *Skip the file*, and use *Project\Settings* to look at the *Project Projection*. For a lat/long projection this should say (for the maps we are using) Lat/Long for the Map Data Units and WGS 1984 for the ProjectProjection. For a UTM projection it should say (again for the maps we are using) Meters for the Map Data Units and UTM Zone plus either 14, Northern Hemisphere (for San Juan) or 36, Southern Hemisphere (for Linthipe). Provided the new layer is intended to be lat/long or UTM respectively you can select the default action of *Assign projection from project*. This does not change the layer data, it merely stores an extra .prj file for the layer being added (and prevents any similar warnings for this map in future). If you take this default action, a second window shows the maps for which projections have been assigned, which you can *Close*:



If you are adding a new layer that has a different projection from the current project projection, for example as the result of reprojection, then you get a similar warning titled *Projection mismatch*. In this case the best thing to do usually is *Skip file*, then clear all layers (which removes the current project projection) before adding the differently projected layer.

1.6 Selecting a UTM zone

To select a UTM zone for anywhere in the world, you can use the map at <http://www.dmap.co.uk/utmworld.htm> . Alternatively, if you have a longitude of x° in the center of your watershed, taking E as positive and W as negative, then the zone is $(x + 180)/6$ rounded up to the next integer, plus N if the location is north of the equator, S if it is south. For example, San Juan is about 99°W so we take x as -99 , $(-99+180)/6 = 13.5$, which rounds up to 14, and our UTM zone for San Juan is 14N. Linthipe is around 34°E , and $(34+180)/6 \approx 35.7$, giving UTM zone 36S.

2 Setup for Mexico: San Juan River Watershed

2.1 Elevation maps (DEMs)

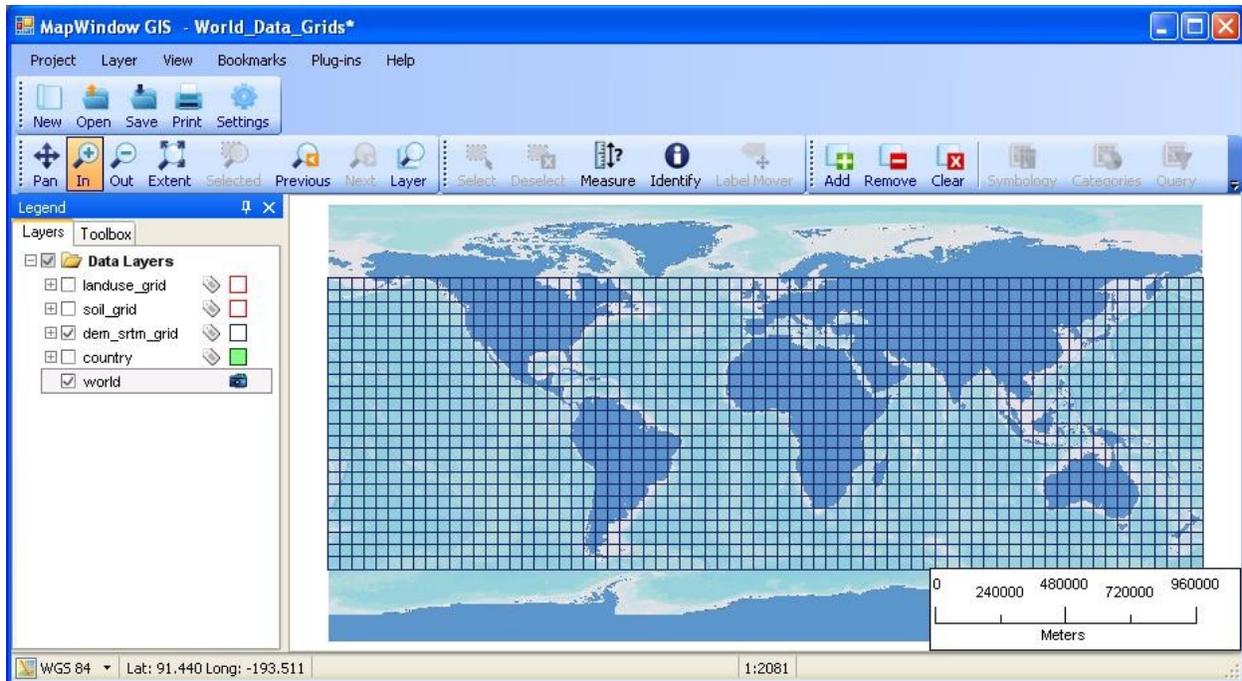
2.1.1 Pre-Process of DEM Data

Objective: Merge and clip the SRTM files for the area of interest.

As an alternative to the derivative basins files, the users may have available their own map data for the region. In this example, there are additional datasets for watersheds, surface water (i.e. lakes and dams) and rivers for the San Juan River watershed. (additional shape files: **sj_washd_ll**, **sj_water_ll** & **sj_rivers_ll**; all in lat/long).

Clip DEM for Area of Interest:

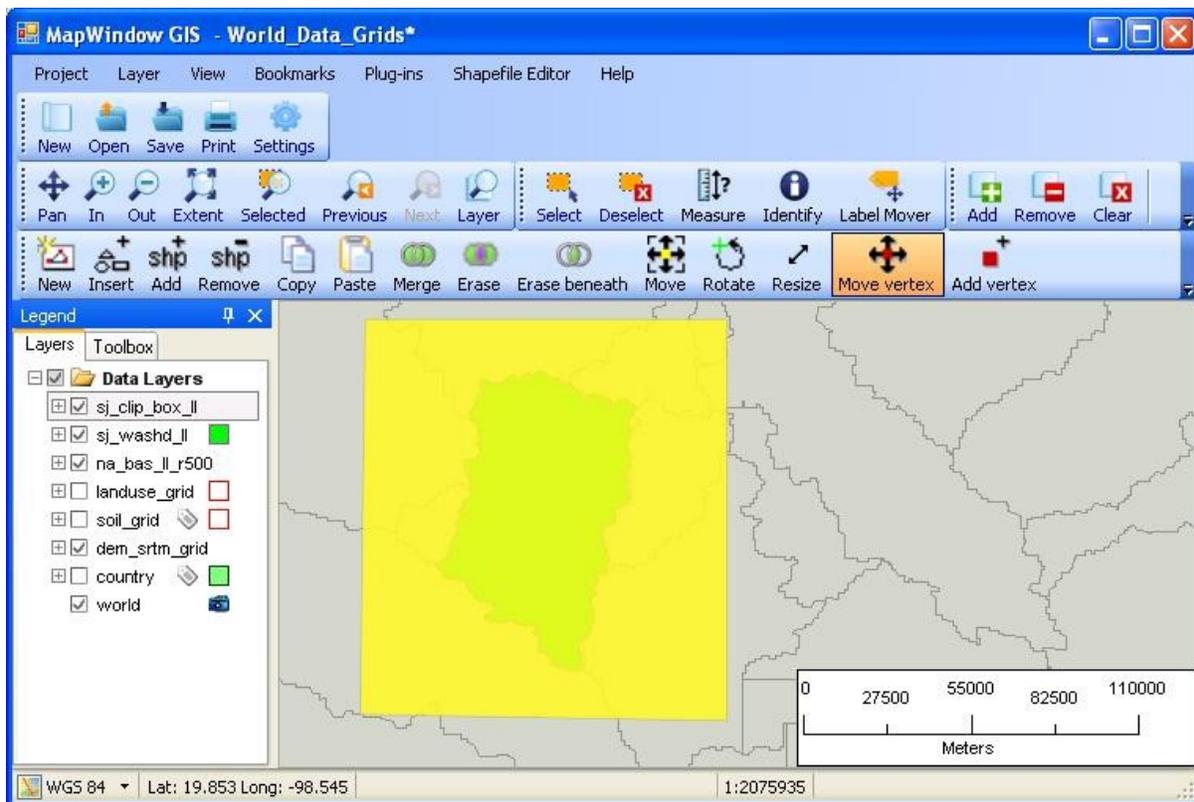
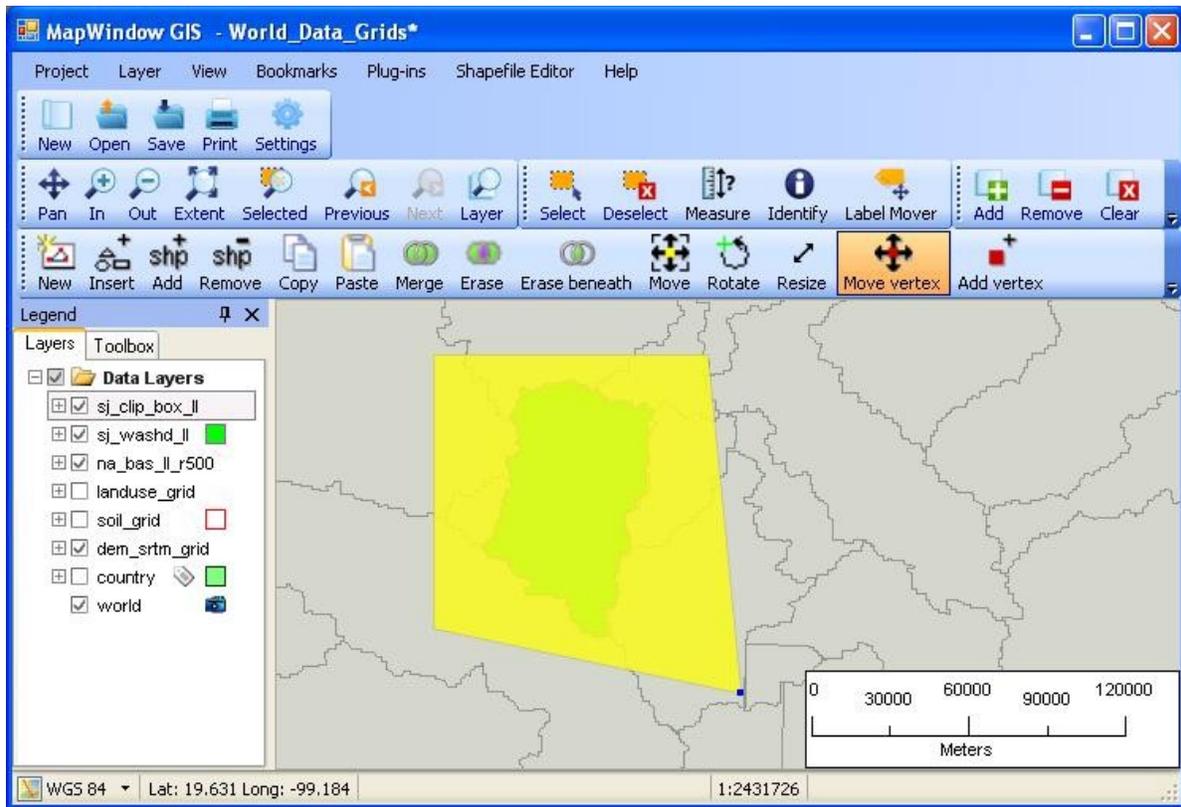
- Unzip **World_Data_Grids.zip** (available from the WaterBase web site http://www.waterbase.org/download_data.html) and use MapWindow to open the project file **World_Data_Grids.mwprj**.



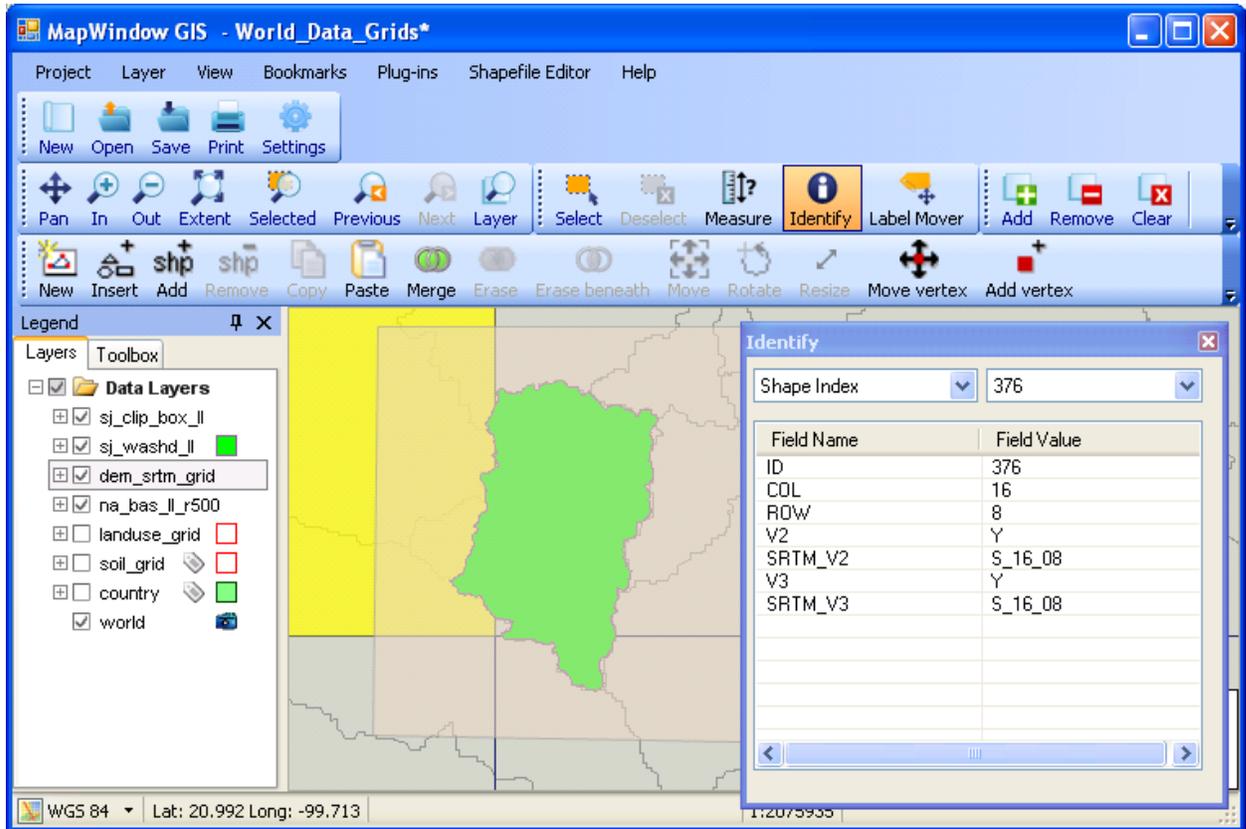
- Add the following layers : **Global_Basins_latlong\na_bas_ll_r500m.shp** (lat/long basins) and **SJ_Maps\sj_washd_ll.shp** (user watershed file, just for reference purposes).
- Zoom in to the required level and create a shape file with a rectangle around the area of interest (namely the shape file **SJ_Maps\sj_clip_box_ll.shp**). To make such a rectangle, first select the *Shapefile Editor* from the *Plug-ins* menu. Then:

1. Use  to open a new shapefile.
2. Set its name to **SJ_Maps\sj_clip_box_ll.shp** and its type to *Polygon* and click *OK*. If you get a warning about no projection, click *OK* to take the default action of setting the new shapefile's projection to the project projection.
3. Click *OK* on the warning about the extents of the new shapefile.
4. Use  to add a regular shape, select **Rectangle**, set the width and height to 1 (which means 1 degree, since the project is in lat/long), click somewhere near the center of the watershed to place the initial rectangle, and click *Done* to stop adding shapes.
5. Before adjusting the rectangle to cover the watershed, set the *Transparency* for the shapefile to some intermediate figure, say 150. To do this, use the right mouse button on the legend entry for **sj_clip_box_ll**, select *Properties*, and then the *Appearance* tab. Change the *Transparency* value and click *Apply* and *OK*.

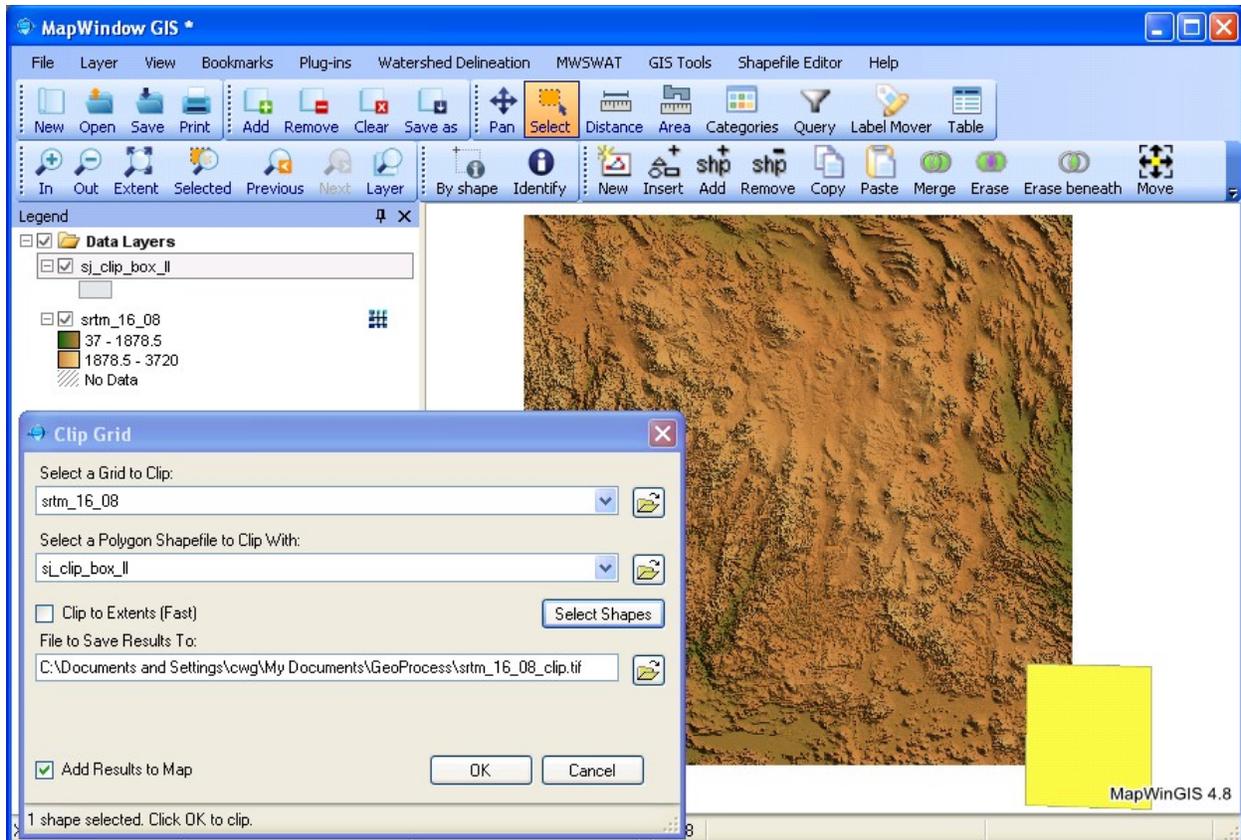
This allows the watershed shape to be seen through the rectangle. Click on  to go into selection mode, click on the rectangle, and then Click on  to move the vertices of the initial rectangle one by one so that it easily includes the watershed. The next two pictures show (a) the situation after moving the first vertex and (b) the situation after moving all four vertices.



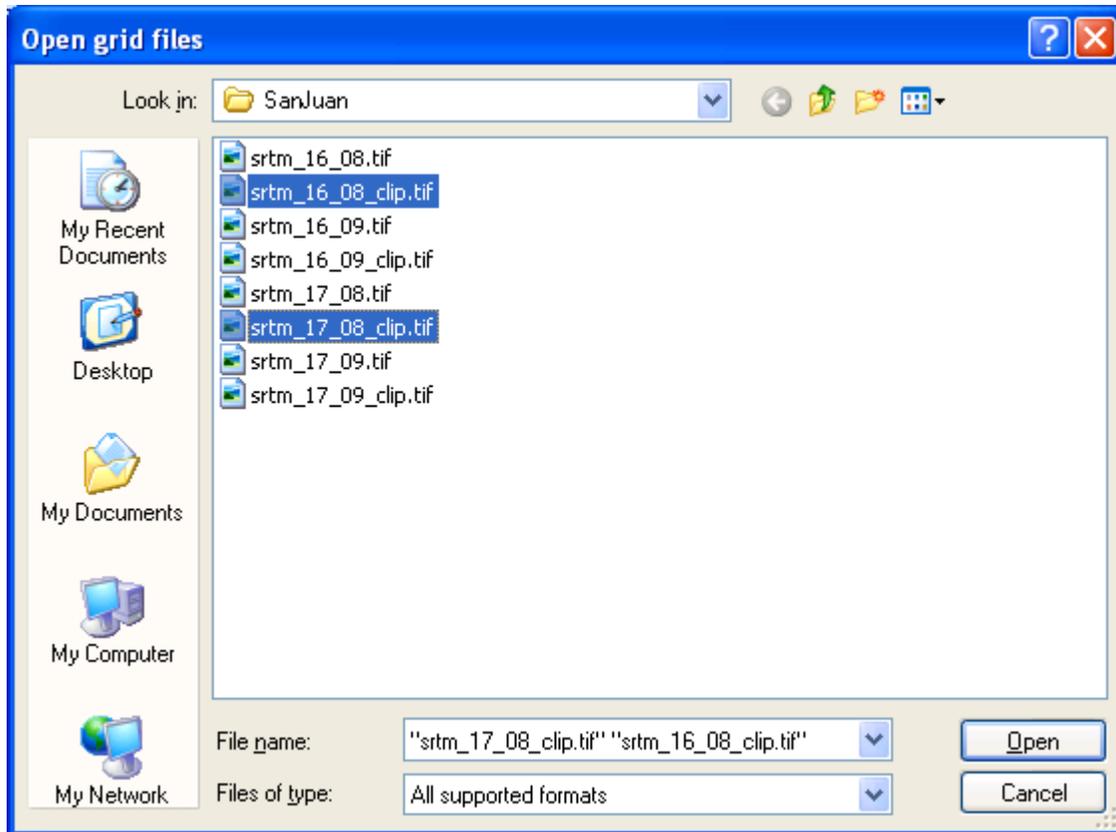
- With the **dem_srtm_grid** active, identify  the four DEM files that needed to be clipped and merged (S_16_08, S_16_09, S_17_08 & S_17_09).



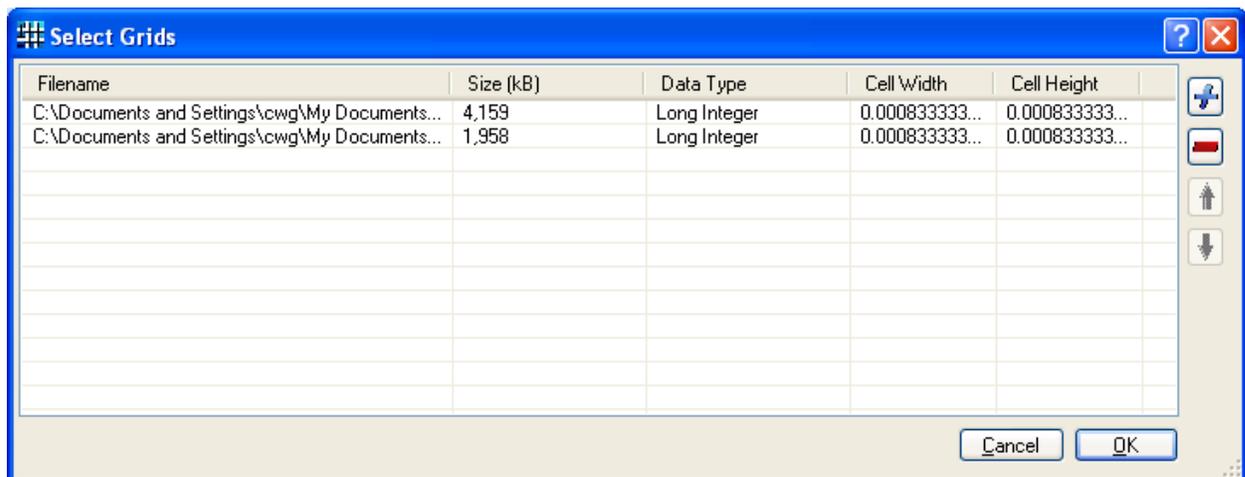
- Exit from MapWindow: do NOT save the changes to the project.
- Unzip **srtm_16_08.tif** from **srtm_16_08.zip**, store it in **temporary\dems** and add it as a layer. Also add the shapefile **SJ_Maps\sj_clip_box_ll.shp**.
- Use *Toolbox\Raster\Clip Grid With Polygon*. Select the dem grid to clip and the box shapefile to clip with.
- Check the *Clip to Extents (Fast)* and *Add Results to Map* options, click *Select Shapes* and select the shape (clip box). Click *Done* when the box is highlighted (yellow). Note that the output file name is created for you (keep this default name and location: **temporary\dems\srtm_16_08_clip.tif**). Click *OK* to clip.



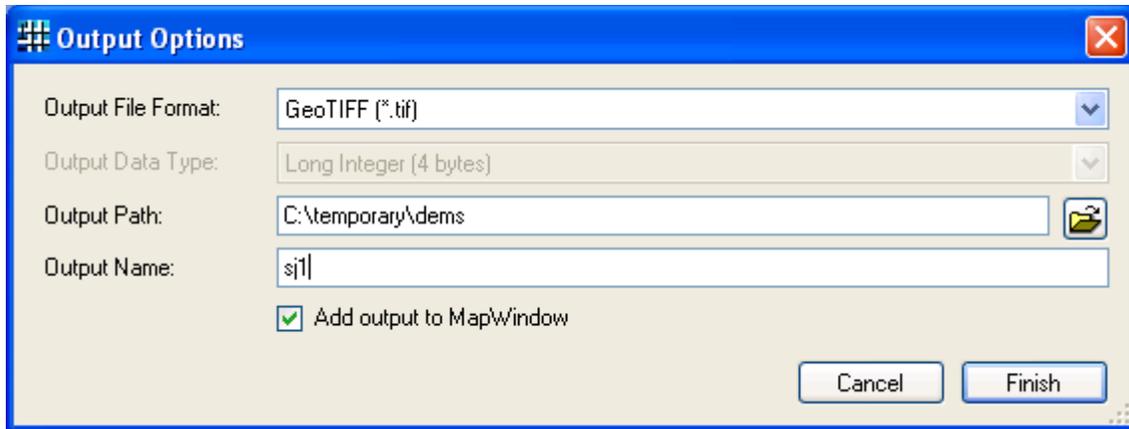
- When the clipping is done, remove the large dem layer (**srmt_16_08.tif**) and repeat the process for the other three tiles (**srmt_16_09.tif**, **srmt_17_08.tif** & **srmt_17_09.tif**). Don't forget to remove them from the view after clipping, leaving only the clipped files.
- Merge the four clipped grids with *Toolbox\Raster\Merge Grids*. It is possible to merge all four in one step, but this often leaves strips of NoData cells at the joins. It is safer to merge two at a time. We start by merging **srmt_16_08_clip.tif** and **srmt_17_08_clip.tif**. Select these two clipped grids (press Ctrl while selecting) and click Open.



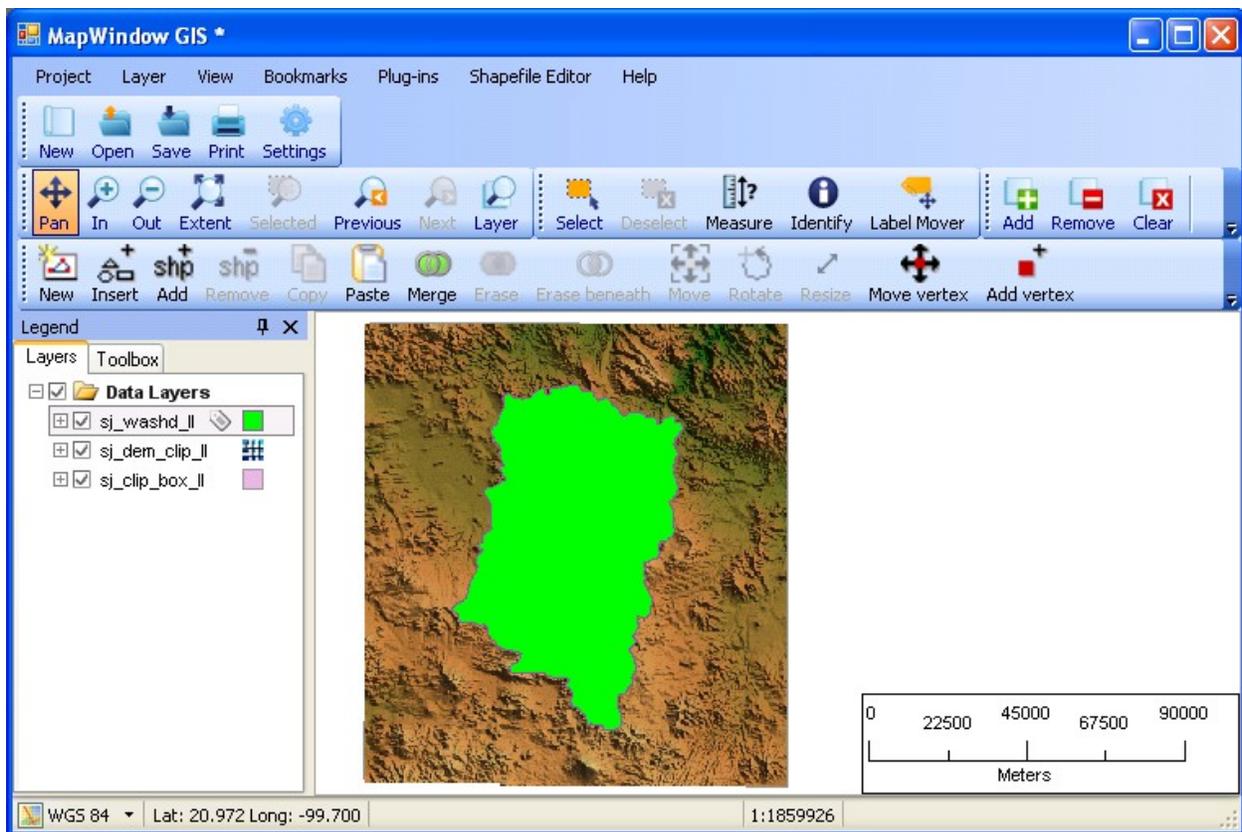
- When done, the Select Grids window will display the information for each of the files.



- Click OK to start merging. Name the result sj1.



- Click *Finish* and remove the clipped layers from the view. In the same way merge **srtm_17_9_clip.tif** and **srtm_16_9_clip.tif** to make **sj2.tif**, and finally merge **sj1.tif** and **sj2.tif** to make **sj_dem_clip_ll.tif**. Reload the watershed layer (**SJ_Maps\sj_washd_ll.shp**) to verify the extents. This **sj_dem_clip_ll.tif** is the final DEM product that, when projected to UTM (see below) will be used in MWSWAT.



2.1.2 Re-project DEM to UTM

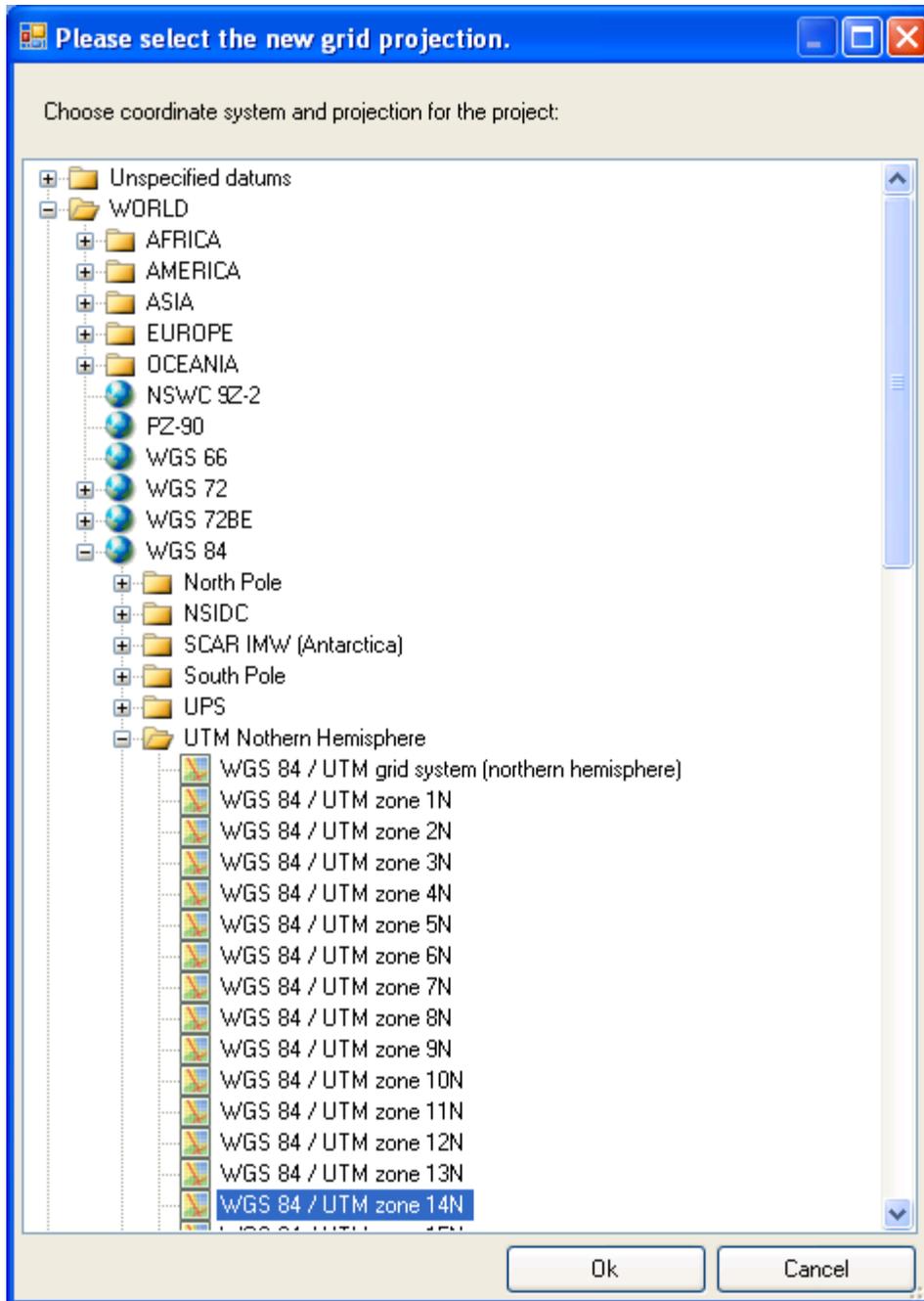
Objective: Re-project the clipped DEM files to UTM and re-clip for the area of interest.

Due to the fact that MWSWAT needs meter units and an equal area projection to perform slope and area calculations, the clipped DEM needs to be re-projected to UTM coordinates¹. In this example, there is an additional dataset for the San Juan River watershed already projected in UTM. (additional shape file: **sj_washd_utm**: Zone 14N).

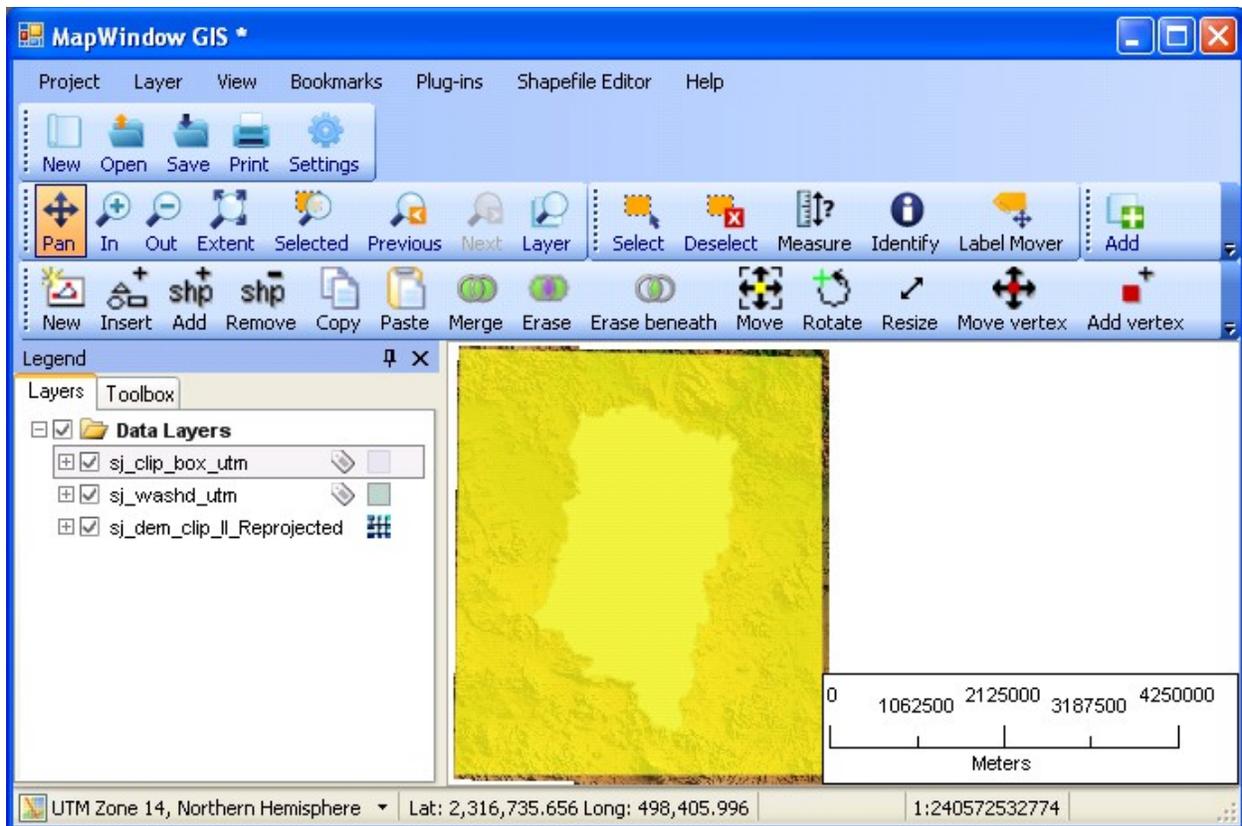
Re-project DEM and re-clip for Area of Interest:

- Select *Toolbox\Raster\Reproject Grids*.
- Select the clipped DEM in lat/long (**temporary\dems\sj_dem_clip_ll.tif**), and when loaded click OK to re-project.
- Choose projection details: WORLD, WGS 84, UTM Northern Hemisphere, and Zone 14N and the current projection values if MapWindow couldn't determine them (Geographical, WGS 1984).

¹ UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds



- A new file will be created (**SJ_Maps\sj_dem_clip_ll_Reprojected.tif**). Do *not* add this layer when asked, as its projection is different from the current one. Clear all layers and then add the layer **SJ_Maps\sj_dem_clip_ll_Reprojected.tif**. As a check, also add the watershed in UTM (**SJ_Maps\sj_washd_utm.shp**).
- Create a new clipping box in this UTM view (this will clean up the grid when re-projected).



- Clip the re-projected dem with the UTM clip box. Select *Toolbox\Raster\Clip Grid With Polygon* and rename the output file as **sj_dem_clip_utm.tif**. OK to clip. When done, exit from MapWindow (do not save project changes) and copy the file **sj_dem_clip_utm.tif** to the project folder as this is going to be the DEM to be used with MWSWAT.

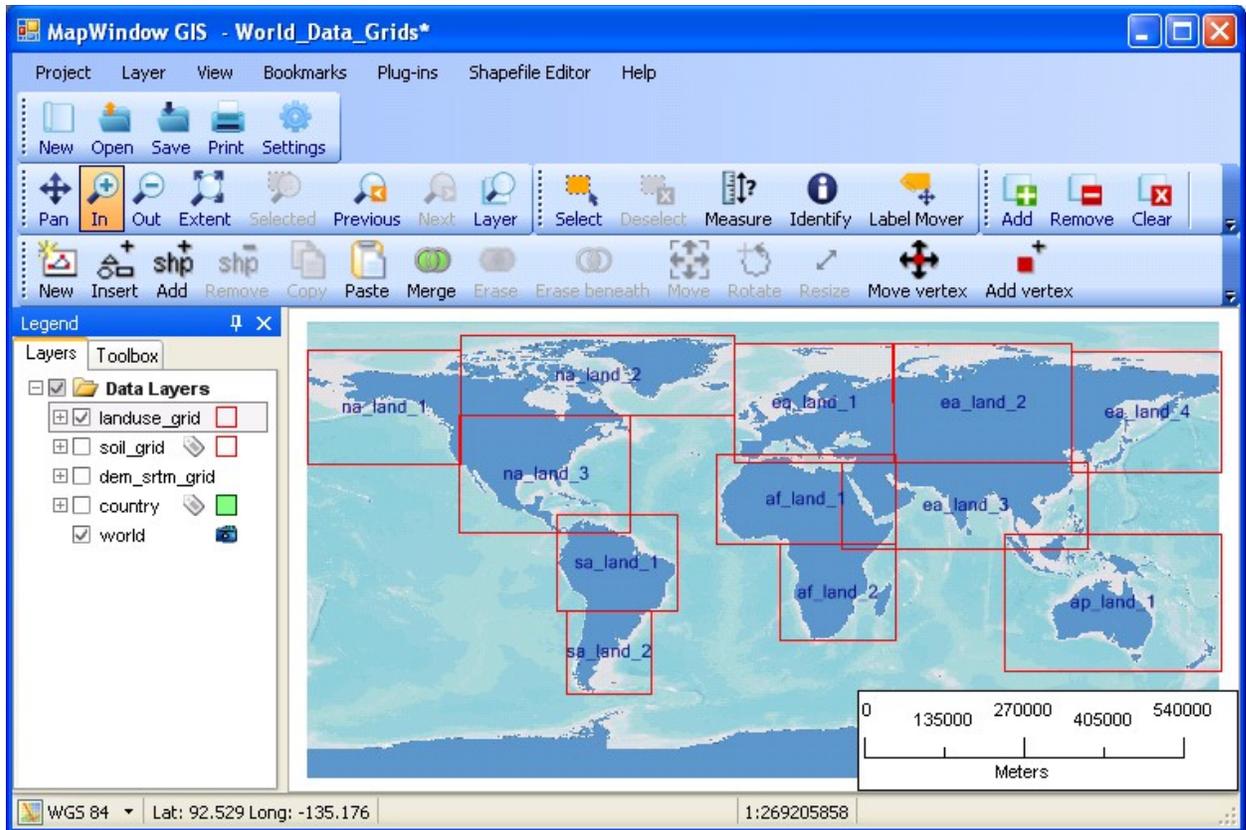
2.2 Landuse Data

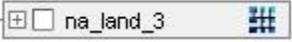
2.2.1 Pre-Process of Landuse Data

Objective: Clip the Landuse file for the area of interest.

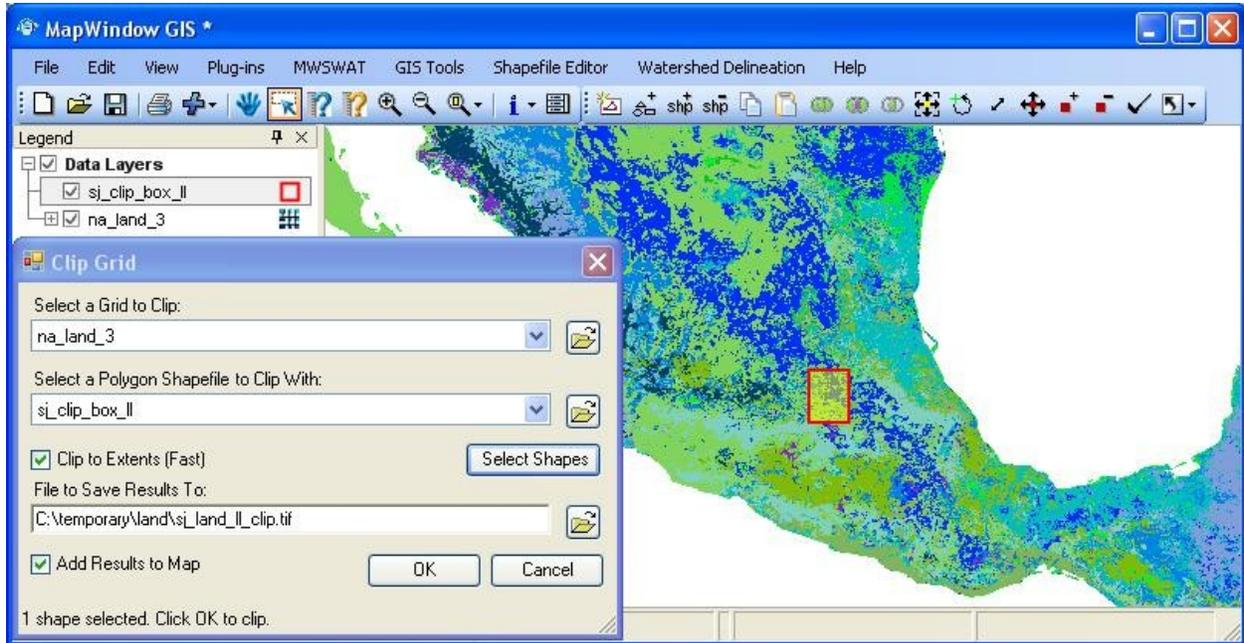
Clip Landuse for Area of Interest:

- Open the project **World_Data_Grids.mwprj** again. This shows that the tile we need for our area of interest is **na_land_3**.

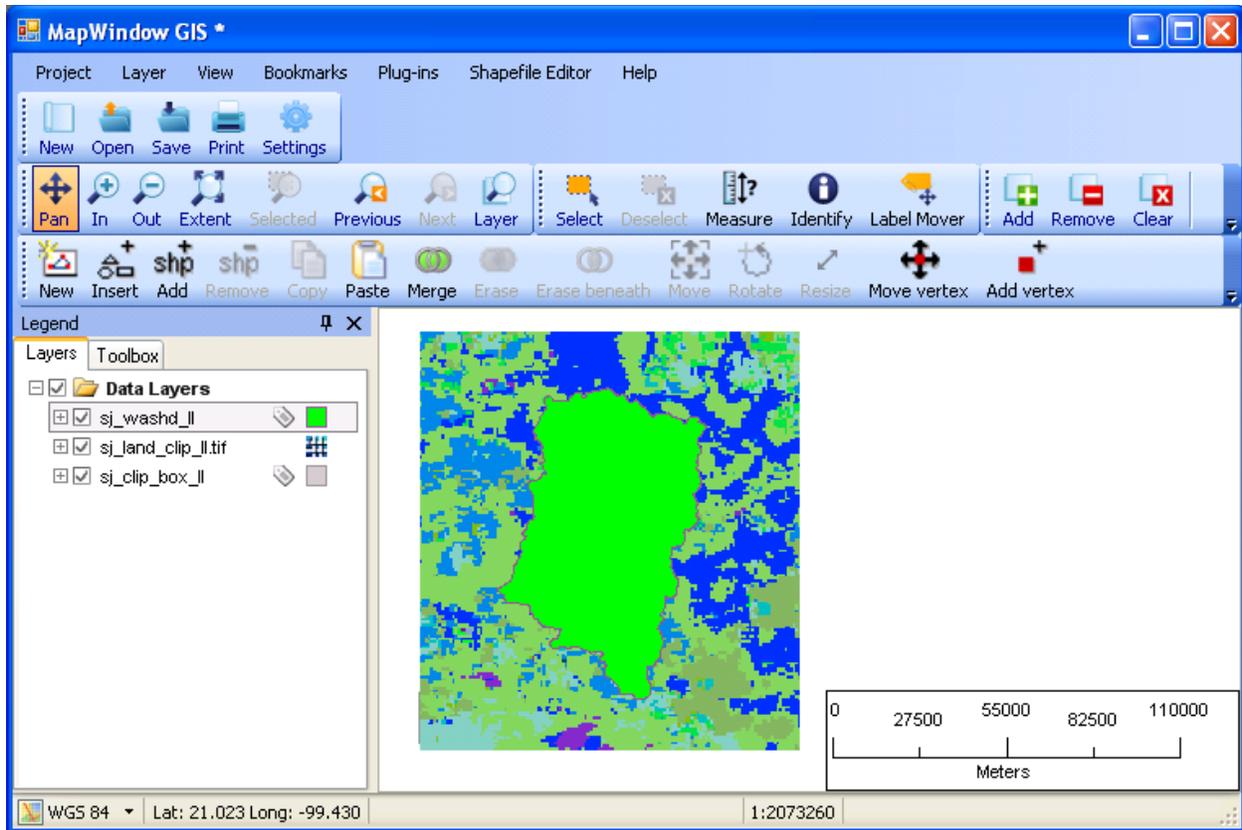


- Extract **na_land_3.tif** together with the corresponding .bmp, .bpw and .mwleg files from **na_landuse_newres.zip** (from the WaterBase web site http://www.waterbase.org/download_data.html). Store them in, say, **temporary\land**.
- Exit from MapWindow. Do NOT save the project data.
- Open mapWindow again, add layer: **temporary\land\na_land_3.tif**.
- *Hint: you can choose instead of **na_landuse_newres.zip** to use the tile from **na_landuse.zip**, the original landuse files. These tiles are large are large and take some time to display, and are also slow to react to any changes in the display. So as soon as such a tile is loaded, remove the tick from its legend, i.e. change  to  This removes the display of the map. You can still proceed with the following steps of loading a clip box and clipping, but you can't see so clearly what is happening.*
- Add the layer for the clip box (**SJ_Maps\sj_clip_box_ll.shp**).
- Select *Toolbox\Raster\Clip Grid With Polygon*. Select the landuse layer and the box to clip with from the ones just loaded into the view.

- Check the Clip to Extents (Fast) option and select the shape (clip box), press Done when the box is highlighted. Note that the output file name is created for you. Rename this to: **temporary\land\sj_land_clip_ll.tif**. Click OK to clip.



- Remove the layer **na_land_3**.
- Zoom to the layer of **sj_clip_box_ll**, and use add layer to reload the watershed layer (**SJ_Maps\sj_washd_ll.shp**) to verify the extents. This **sj_land_clip_ll.tif** is the final landuse product that, when projected to UTM (see below) will be used in MWSWAT.



2.2.2 Re-project Landuse to UTM

Objective: Re-project the clipped landuse file to UTM and re-clip for the area of interest.

Due to the fact that MWSWAT needs meter units and an equal area projection to perform area calculations, the clipped landuse file needs to be re-projected to UTM coordinates². In this example, there is an additional dataset for the San Juan River watershed already projected to UTM. (additional shape file: **sj_washd_utm**: Zone 14N).

Re-project Land and re-clip for Area of Interest:

- Clear all the layers and select *Toolbox\Raster\Reproject Grids*.
- Open the clipped landuse file in lat/long (**temporary\land\sj_land_clip_ll.tif**), when loaded click OK to re-project.

² UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds

- Choose projection details: WORLD, WGS 84, UTM Northern Hemisphere, and Zone 14N and the current projection values if MapWindow couldn't determine them (Geographical, WGS 1984).
- A new file will be created (**temporary\land\sj_land_clip_ll_Reprojected.tif**). Do not add the layer when asked, as it has a different projection, but clear all layers and then add it. Also add the watershed in UTM (**SJ_Maps\sj_washd_utm.shp**).
- Load the clipping box in UTM view (**SJ_Maps\sj_clip_box_utm.shp**) to re-clip and remove all the missing values generated with the rotation of the grid when re-projected.
- Clip the re-projected landuse with the UTM clip box. Select *Toolbox\Raster\Clip Grid With Polygon* and rename the output file as **sj_land_clip_utm.tif**. OK to clip. When done, exit from MapWindow (do not save project changes) and copy the file **sj_land_clip_utm.tif** to the project folder as this is going to be the landuse file to be used with MWSWAT.

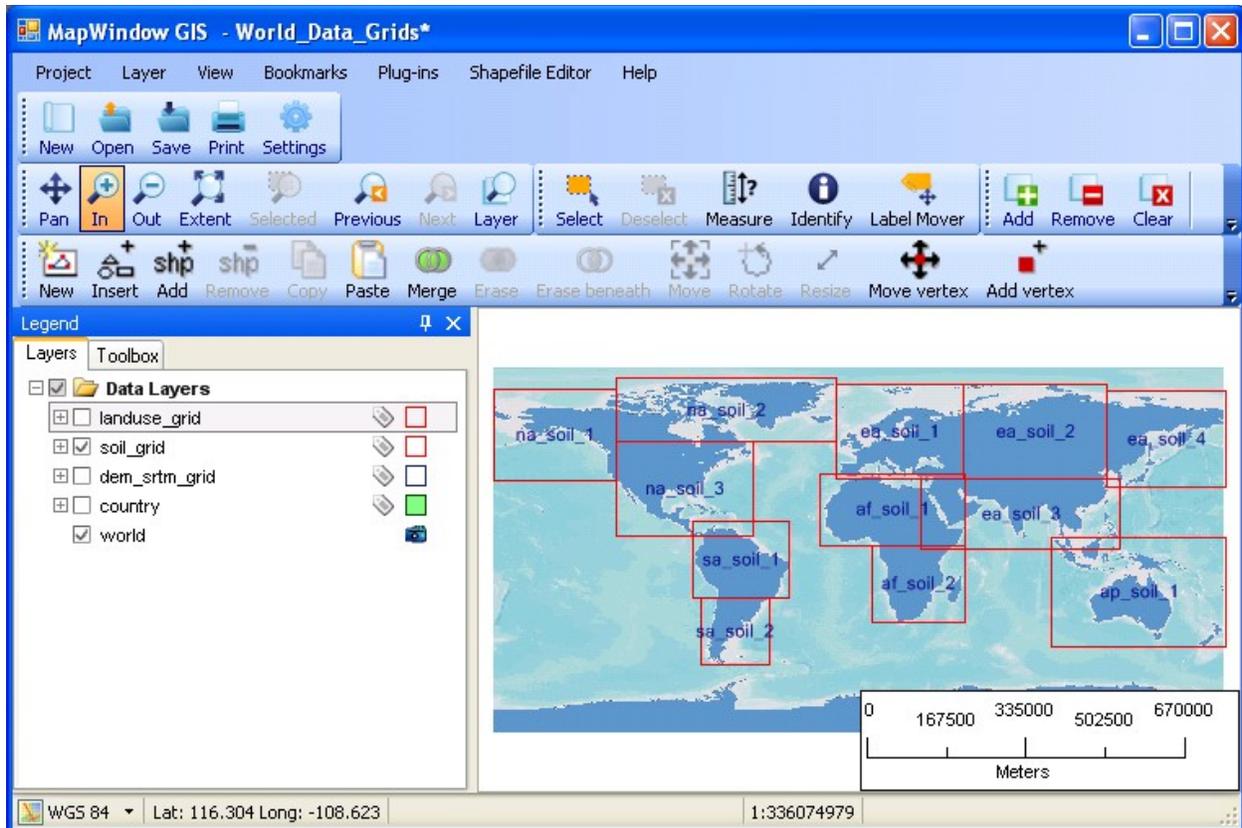
2.3 Soil Data

2.3.1 Pre-Process of Soil Data

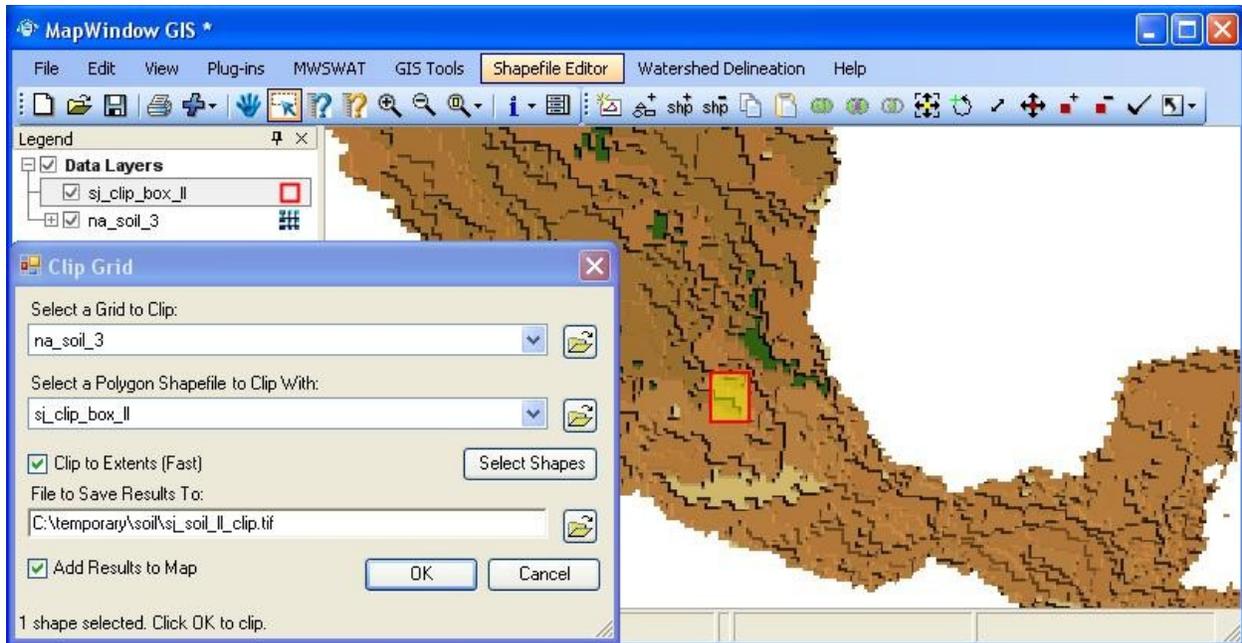
Objective: Clip the Soil file for the area of interest.

Clip Soil for Area of Interest:

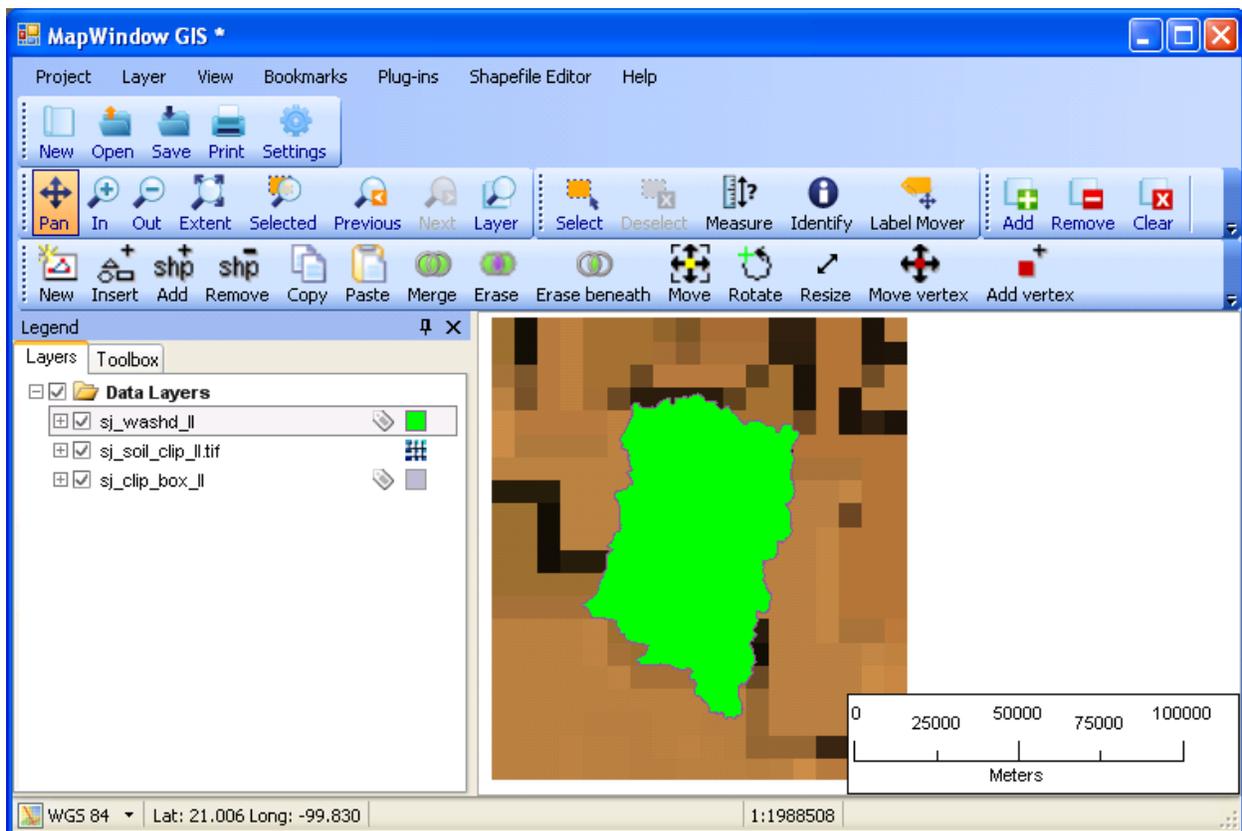
- Open the project **World_Data_Grids.mwprj** again. This shows that the soil tile we need is **na_soil_3**.



- Extract **na_soil_3.tif** together with the corresponding .bmp, .bpw and .mwleg files from **na_soil.zip** (from the WaterBase web site http://www.waterbase.org/download_data.html). Store them in, say, **temporary\soil**.
- Exit from MapWindow. Do NOT save project data.
- Add layer **temporary\soil\na_soil_3.tif**. Also add the layer for the clip box (**SJ_Maps\sj_clip_box_ll.shp**).
- Select *Toolbox\Raster\Clip Grid With Polygon*. Select the soil layer and the box to clip with from the ones just loaded into the view.
- Check the Clip to Extents (Fast) option and select the shape (clip box), press Done when the box is highlighted. Note that the output file name is created for you. Rename this default name to **temporary\soil\sj_soil_clip_ll.tif**. Click OK to clip.



- Remove the layer **na_soil_3**. Use add layer to reload the watershed layer (**SJ_Maps\sj_washd_ll.shp**) to verify the extents. This **sj_soil_ll_clip.tif** is the final soil product that, when projected to UTM (see below) will be used in MWSWAT.



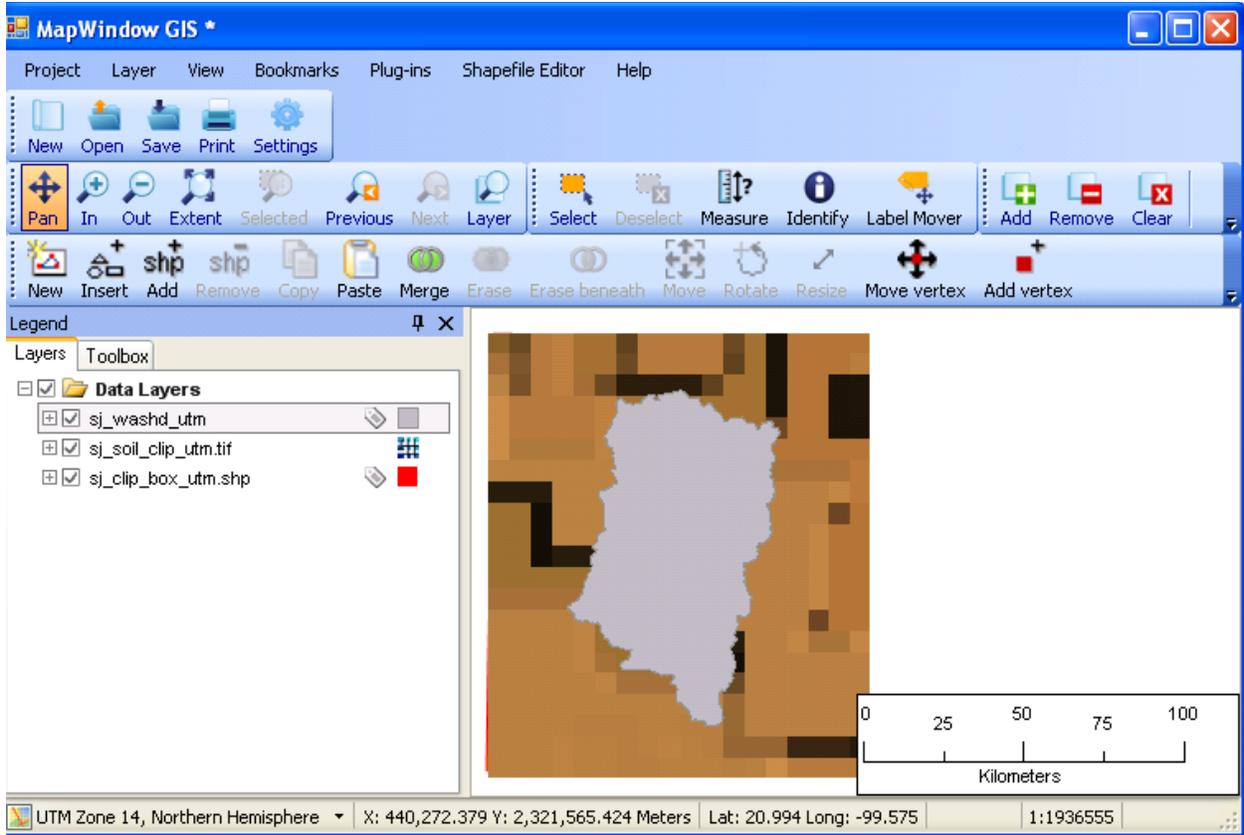
2.3.2 Re-project Soil to UTM

Objective: Re-project the clipped soil file to UTM and re-clip for the area of interest.

Due to the fact that MWSWAT needs meter units and an equal area projection to perform area calculations, the clipped soil file need to be re-projected to UTM coordinates. In this example, there is an additional dataset for the San Juan River watershed already projected in UTM. (additional shapefile: **sj_washd_utm**: Zone 14N).

Re-Project Soil and re-clip for Area of Interest:

- Remove all the layers and select *Toolbox\Raster\Reproject Grids*.
- Open the clipped soil file in lat/long (**temporary\soil\sj_soil_clip_ll.tif**), when loaded click OK to re-project.
- Choose projection details: WORLD, WGS 84, UTM Northern Hemisphere, and Zone 14N and the current projection values if MapWindow couldn't determine them (Geographical, WGS 1984).
- A new file will be created (**temporary\soil\sj_soil_clip_ll_Reprojected.tif**). Do not add the layer when asked, as it has a different projection, but clear all layers and then add it. Also add the watershed in UTM (**SJ_Maps\sj_washd_utm.shp**).
- Load the clipping box in UTM view (**SJ_Maps\sj_clip_box_utm.shp**) to re-clip and remove all the missing values generated with the rotation of the grid when re-projected.
- Clip the re-projected soil with the UTM clip box. Select *Toolbox\Raster\Clip Grid With Polygon* and rename the output file as **sj_soil_clip_utm.tif**. OK to clip. When done, exit from MapWindow (do not save project changes) and copy the file **sj_soil_clip_utm.tif** to the project folder as this is going to be the soil file to be used with MWSWAT.



3 Setup for Malawi: Linthipe Watershed

3.1 Elevation Data (DEMs)

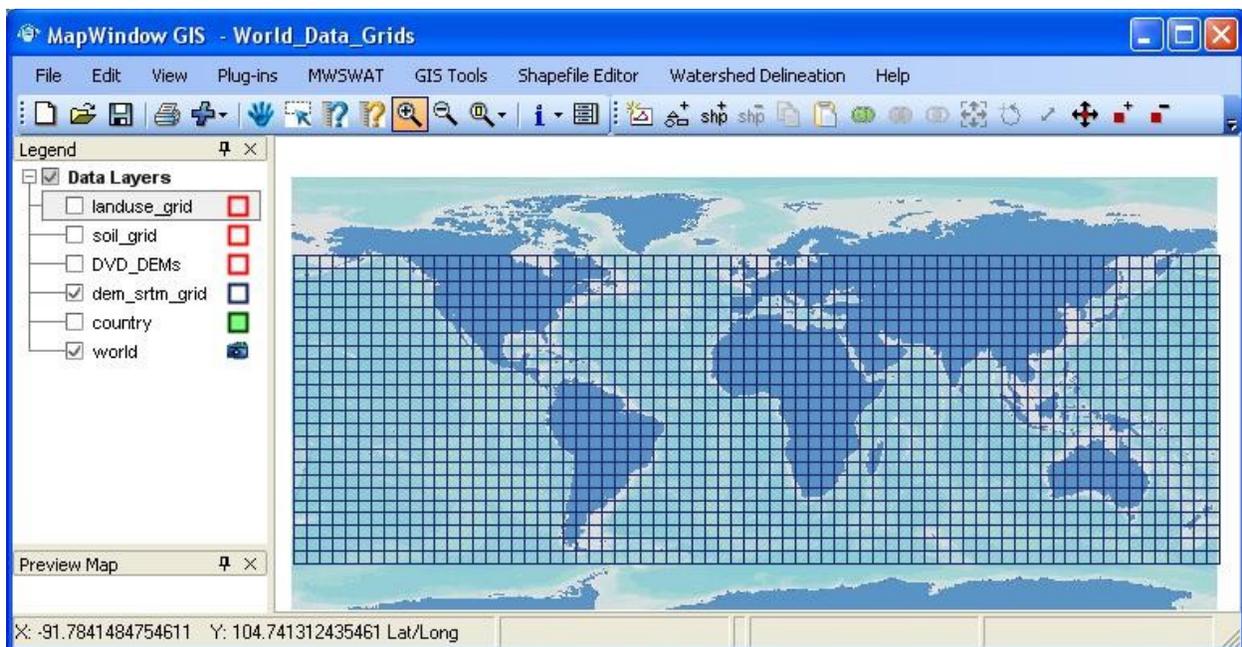
3.1.1 Pre-Process of DEM Data

Objective: Clip the SRTM file for the area of interest.

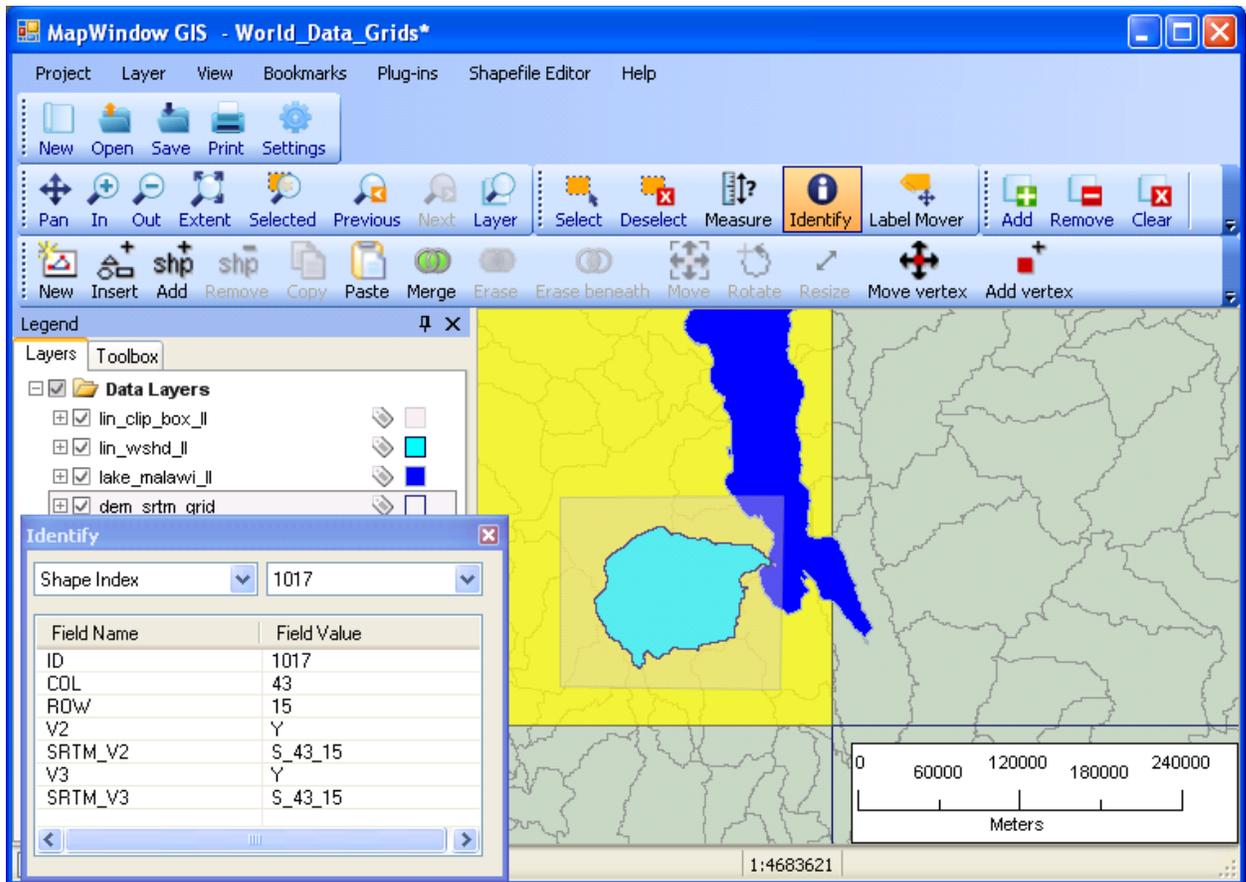
As an alternative to the derivative basins files, the users may have available their own map data for the region. In this example, there are additional datasets for: Malawi rivers, Lake Malawi and for the Linthipe watershed. (additional shapefiles: **malawi_rivers_II**, **lake_malawi_II** & **lin_wshd_II**; all in lat/long).

Clip DEM for Area of Interest:

- Unzip **World_Data_Grids.zip** (from the WaterBase web site http://www.waterbase.org/download_data.html) and use MapWindow to open the project file **World_Data_Grids.mwprj**.



- Add the following layers: **Global_Basins_latlong\af_bas_II_r500m.shp** (lat/long basins), **Lin_Maps\lin_wshd_II.shp** and **Lin_Maps\lake_malawi_II.shp** (user watershed file and Lake Malawi, just for reference purpose).
- Zoom in to the required level and create a shape file with a rectangle around the area of interest (namely the shape file **Lin_Maps\lin_clip_box_II.shp**).



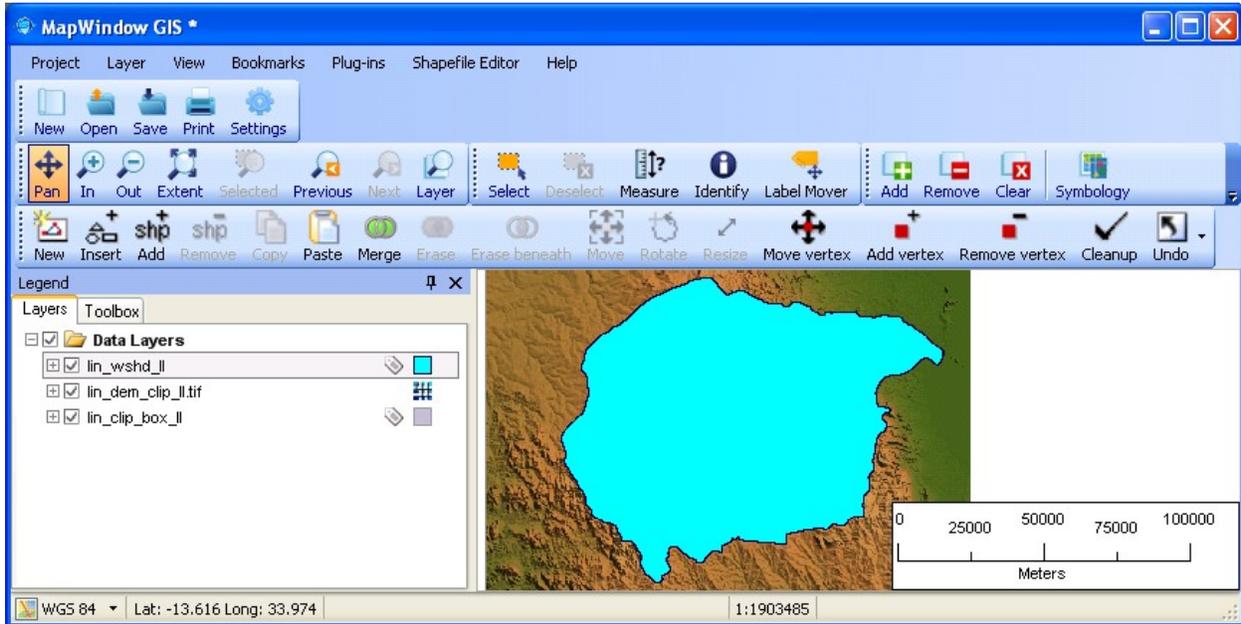
- For this watershed only one dem tile is required (**S_43_15**), easily identified , so the only process left to do is clipping for the area of interest.
- Exit from MapWindow: do NOT save the changes to the project.

- Unzip **srtm_43_15.zip** to extract **srtm_43_15.tif**, storing it in **temporary\dems** and add it as a layer (being patient – it takes a few minutes). Also add the shapefile **Lin_Maps\lin_clip_box_ll.shp**.

Select *Toolbox\Raster\Clip Grid With Polygon*. Select the dem grid to clip and the shapefile to clip with..

- Check the **Clip to Extents (Fast)** option and select the shape (clip box), press Done when the box is highlighted. Note that the output file name is created for you (rename this file: **temporary\dems\lin_dem_clip_ll.tif**). Click OK to clip.

- This **lin_dem_clip_ll.tif** is the final DEM product that, when projected to UTM (see the projection section) will be used in MWSWAT. When the clipping is done, remove the large DEM layer (**srtm_43_15.tif**).
- Reload the watershed (**Lin_Maps\lin_wshd_ll.shp**) to verify the extents.



3.1.2 Re-project DEM to UTM

Objective: Re-project the clipped DEM files to UTM and re-clip for the area of interest.

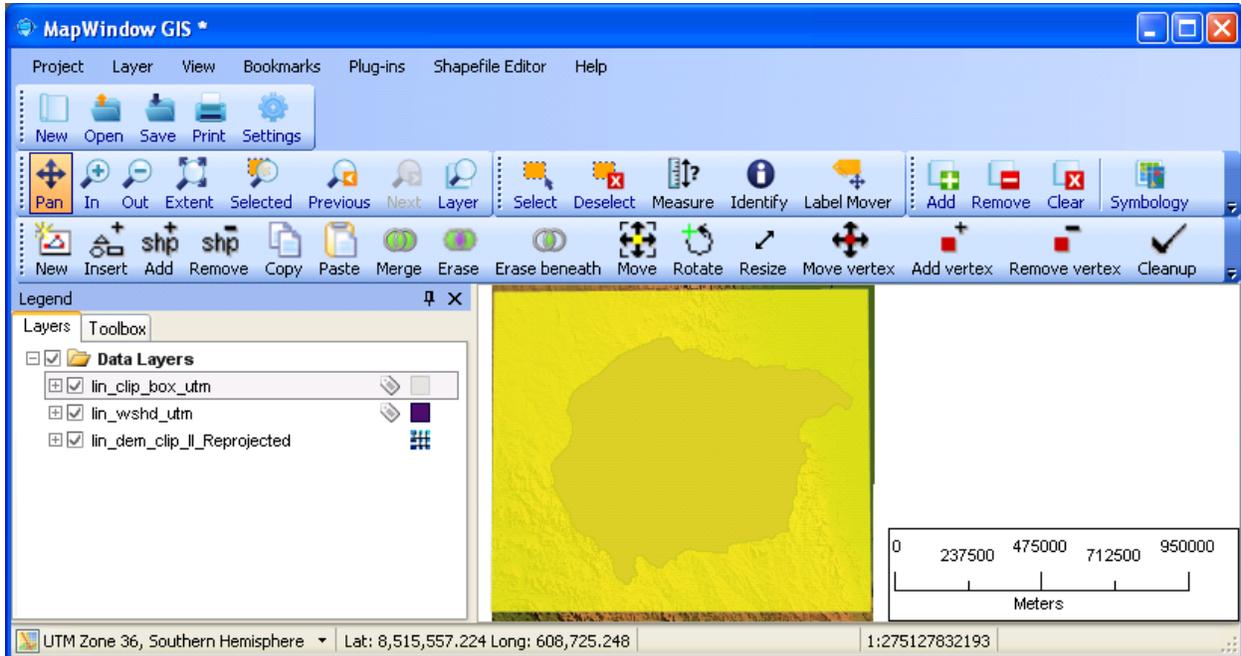
Due to the fact that MWSWAT needs meter units and an equal area projection to perform slope and area calculations, the clipped DEM needs to be re-projected to UTM coordinates³. In this example, there is an additional dataset for the Linthipe watershed already projected in UTM. (additional shapefile: **lin_wshd_utm**: Zone 36S).

Re-Project DEM and re-clip for Area of Interest:

- Select *Toolbox\Raster\Reproject Grids*.
- Open the clipped DEM in lat/long (**temporary\dems\lin_dem_clip_ll.tif**), when loaded click OK to re-project.
- Choose projection details: WORLD, WGS 84, UTM Southern Hemisphere, and Zone 36S and the current projection values if MapWindow couldn't determine them (Geographical, WGS 1984).

³ UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds

- A new file will be created (**temporary\dems\lin_dem_clip_ll_Reprojected.tif**). Do not add this layer when asked, as it has a different projection. Clear all layers, then add the reprojected DEM and the watershed in UTM (**Lin_Maps\Geo_processed\lin_wshd_utm.shp**).
- Create a new clipping box in this UTM view (this will remove all the missing values generated with the rotation of the grid when re-projected).



- Clip the re-projected DEM with the UTM clip box. Select *Toolbox\Raster\Clip Grid With Polygon* and rename the output file as **lin_dem_clip_utm.tif**. OK to clip. When done, exit from MapWindow (do not save project changes) and copy this final file to the project folder as this is going to be the DEM to be used with MWSWAT.

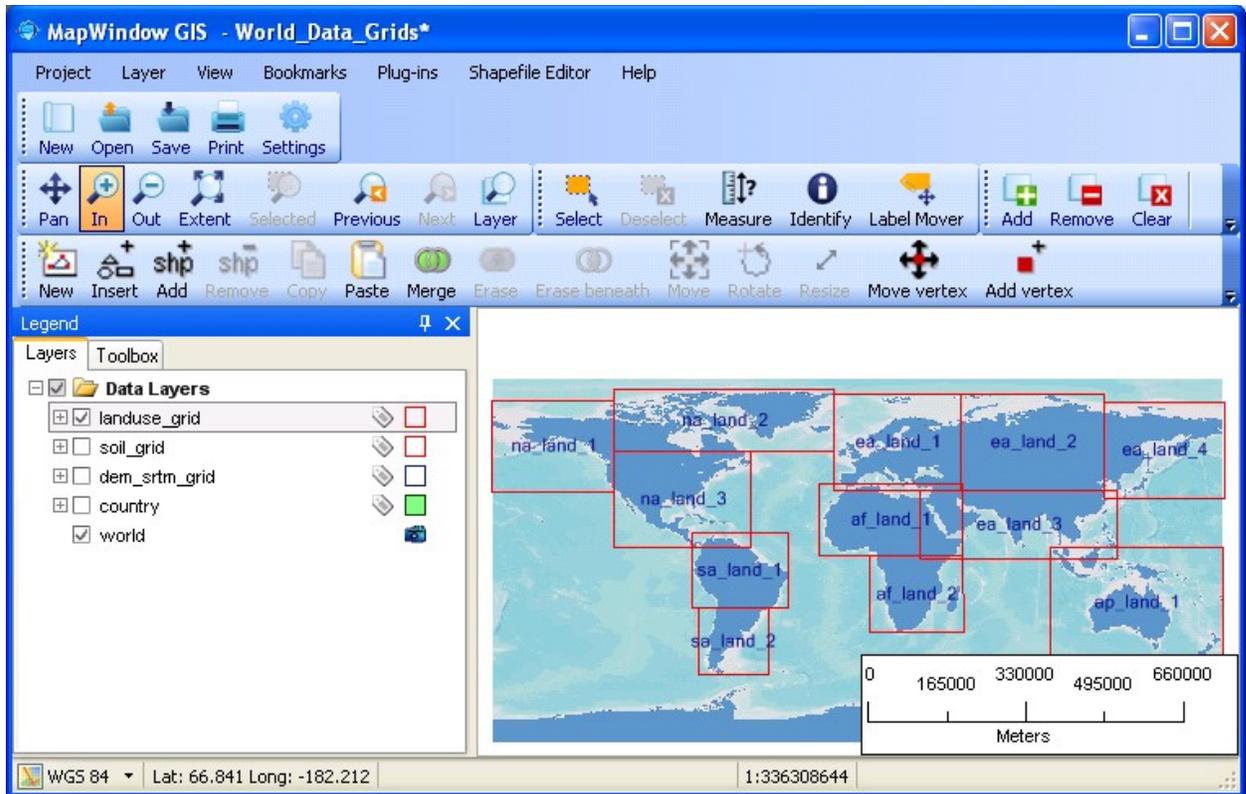
3.2 Landuse Data

3.2.1 Pre-Process of Landuse Data

Objective: Merge and clip the Landuse files for the area of interest.

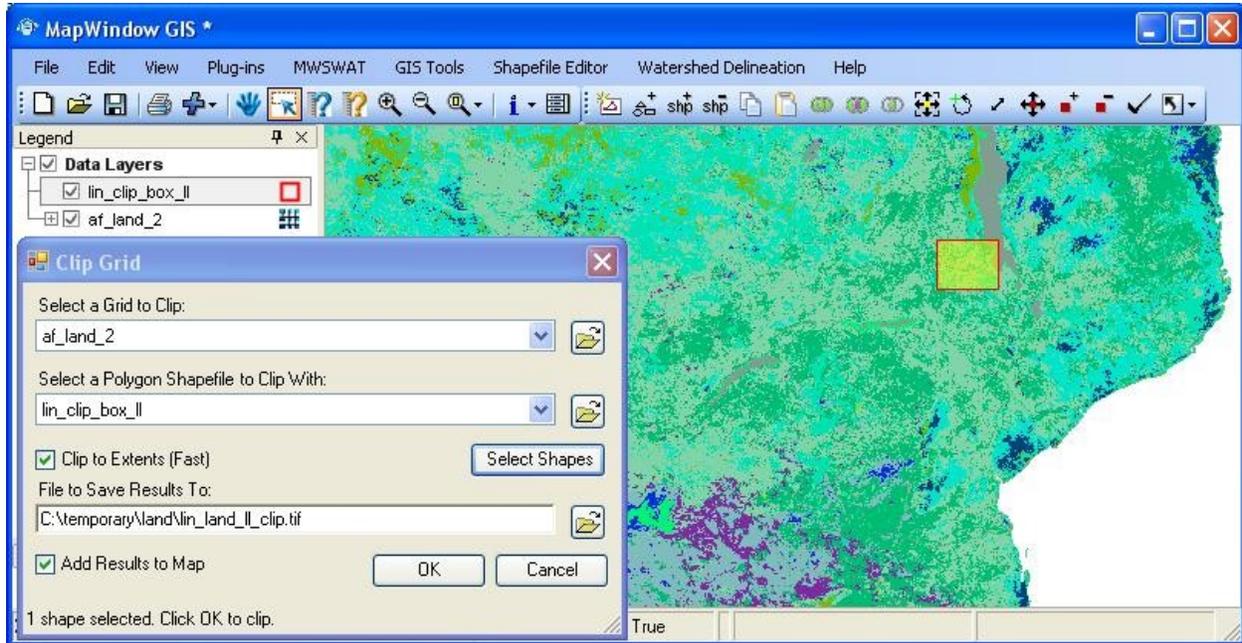
Clip Landuse for Area of Interest:

- Exit from MapWindow, and open the project **World_Data_Grids.mwprj** again. This shows that the tile we need for our area of interest is **af_land_2**.

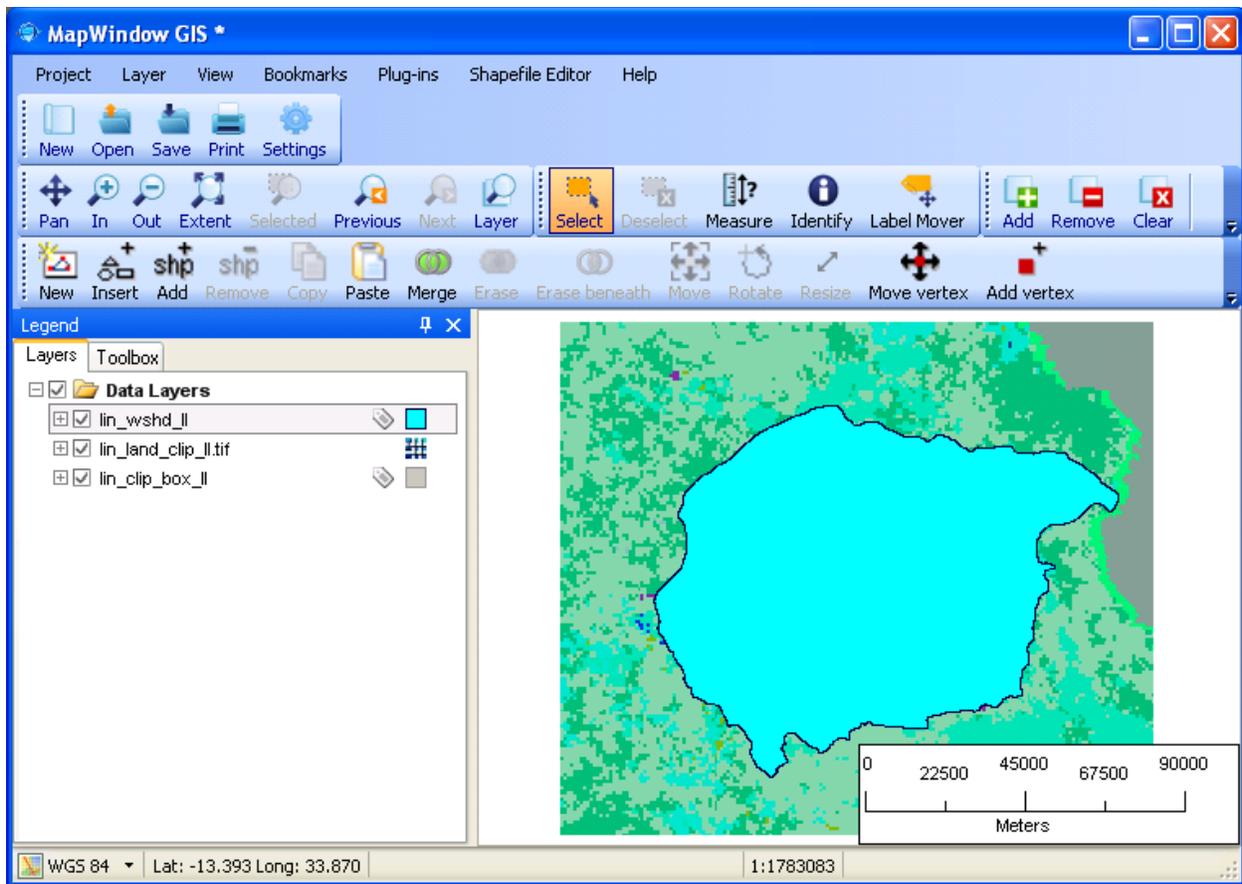


- Extract **af_land_2.tif** together with the corresponding .bmp, .bpw, and .mwleg files from **af_landuse_newres.zip** (from the WaterBase web site http://www.waterbase.org/download_data.html). Store them in, say, **temporary\land**.
- Exit from MapWindow. Do NOT save the project data.
- Add layer **temporary\land\af_land_2.tif** (note: be patient! MapWindow takes a few minutes to load the file).
- *Hint: you can choose instead of **af_landuse_newres.zip** to use the tile from **af_landuse.zip**, the original landuse files. These tiles are large are large and take some time to display, and are also slow to react to any changes in the display. So as soon as such a tile is loaded, remove the tick from its legend, i.e. change*
 af_land_2  *to* **af_land_2**  *This removes the display of the map. You can still proceed with the following steps of loading a clip box and clipping, but you can't see so clearly what is happening.*
- Add the layer for the clip box (**Lin_Maps\lin_clip_box_ll.shp**).
- Select **Toolbox\Raster\Clip Grid With Polygon**. Select the landuse layer and the box to clip with from the ones just loaded into the view.

- Check the Clip to Extents (Fast) option and select the shape (clip box), press Done when the box is highlighted. Note that the output file name is created for you. Rename this default name: **temporary\land\lin_land_II_clip.tif**. Click OK to clip.



- Remove the layer **af_land_2**.
- Zoom to the layer of **lin_clip_box_II** and with add layer reload the watershed layer (**Lin_Maps\lin_wshd_II.shp**) to verify the extents. This **lin_land_II_clip.tif** is the final landuse product that, when projected to UTM (see below) will be used in MWSWAT.



3.2.2 Re-project Landuse to UTM

Objective: Re-project the clipped landuse file to UTM and re-clip for the area of interest.

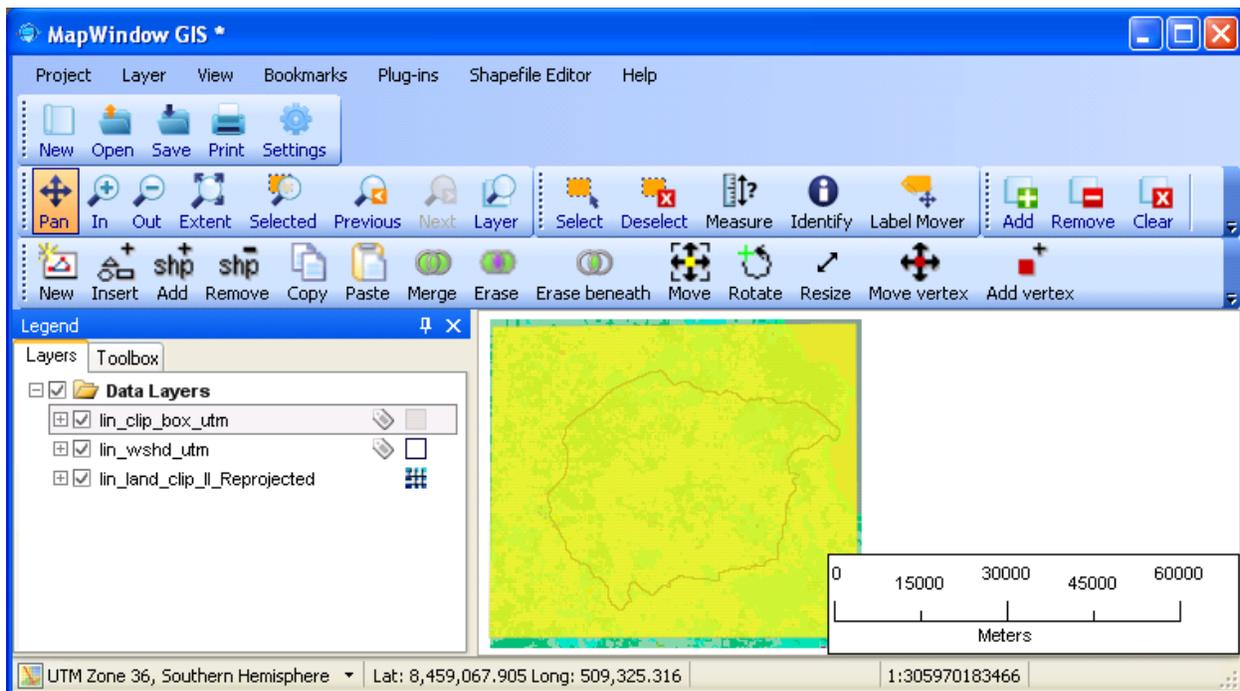
Due to the fact that MWSWAT needs meter units and an equal area projection to perform area calculations, the clipped landuse file need to be re-projected to UTM coordinates⁴. In this example, there is an additional dataset for the Linthipe watershed already projected to UTM. (additional shape file: **lin_wshd_utm**: Zone 36S).

Re-Project Landuse and re-clip for Area of Interest:

- Clear all the layers and select *Toolbox\Raster\Reproject Grids*.
- Open the clipped landuse file in lat/long (**temporary\land\lin_land_clip_ll.tif**), when loaded click OK to re-project.

⁴ UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds

- Choose projection details: WORLD, WGS 84, UTM Southern Hemisphere, and Zone 36S and the current projection values if MapWindow couldn't determine them (Geographical, WGS 1984).
- A new file will be created (**temporary\land\Lin_land_clip_II_Reprojected.tif**). Do not add the layer when asked, as it has a different projection, but clear all layers and then add it. Also add the watershed in UTM (**Lin_Maps\Geo_processed\lin_wshd_utm.shp**).
- Load the clipping box in UTM view (**Lin_Maps\sj_clip_box_utm.shp**) to re-clip and remove all the missing values generated with the rotation of the grid when re-projected.



- Clip the re-projected landuse with the UTM clip box. Select *Toolbox\Raster\Clip Grid With Polygon* and rename the output file as **lin_land_clip_utm.tif**. OK to clip. When done, exit from MapWindow (do not save project changes) and copy the file **lin_land_clip_utm.tif** to the project folder as this is going to be the landuse file to be used with MWSWAT.

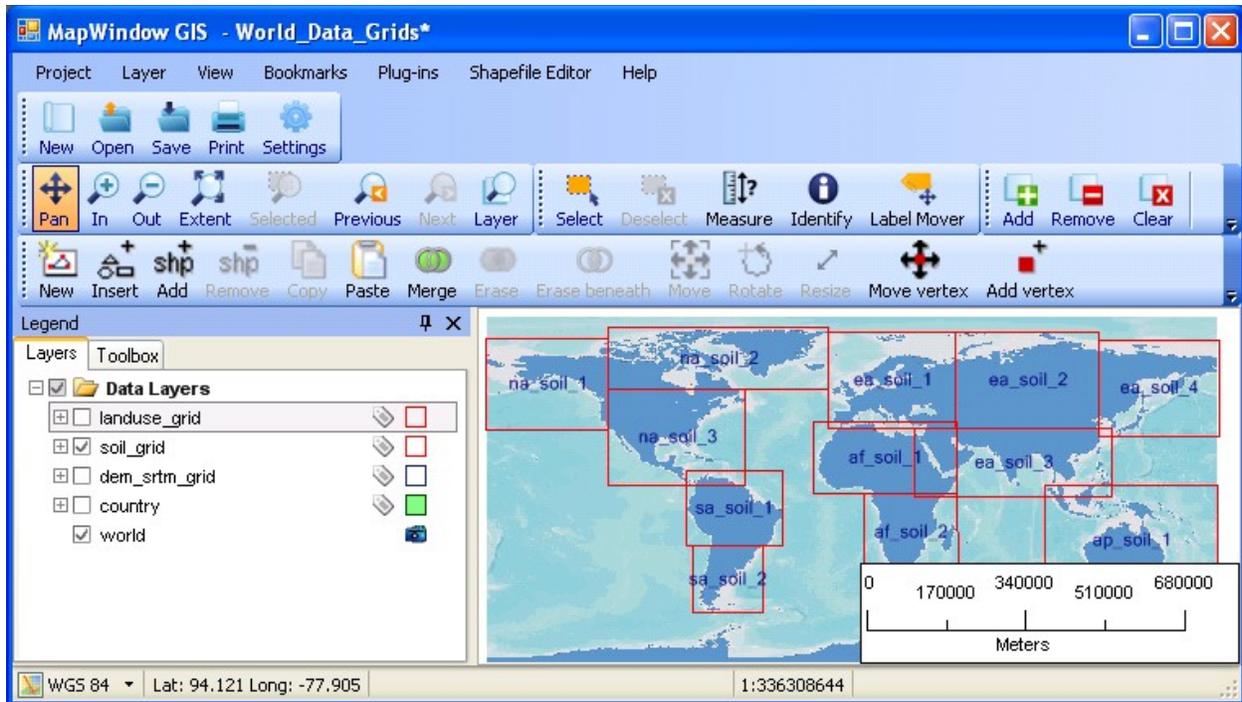
3.3 Soil Data

3.3.1 Pre-Process of Soil Data

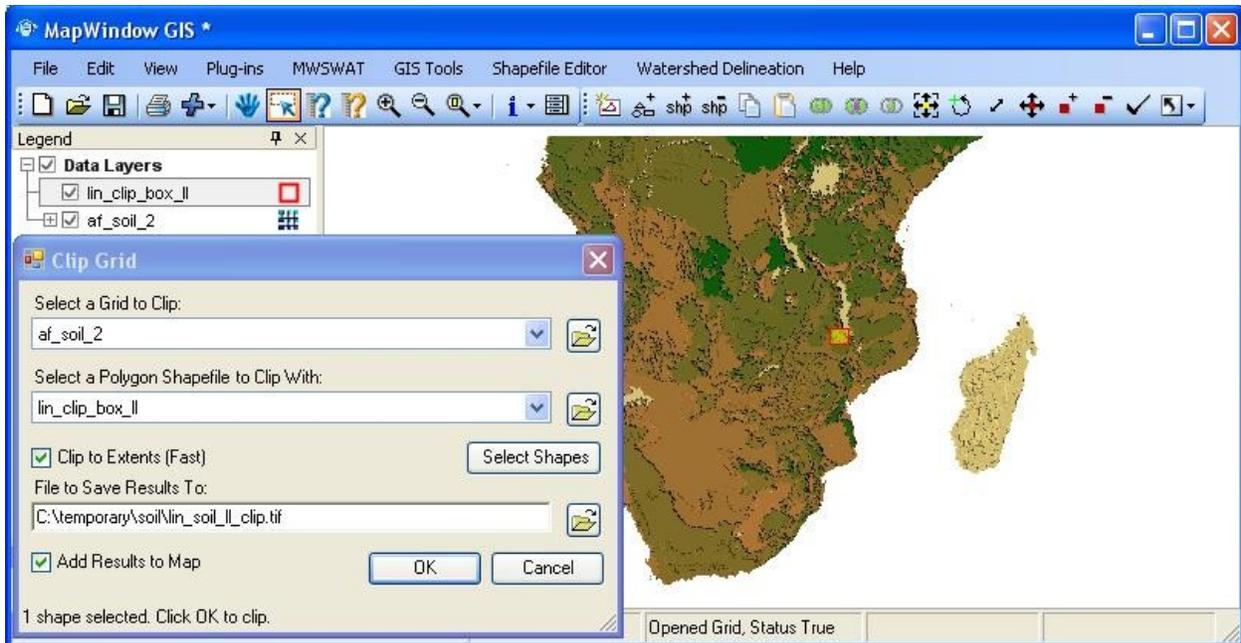
Objective: Clip the soil file for the area of interest.

Clip Soil for Area of Interest:

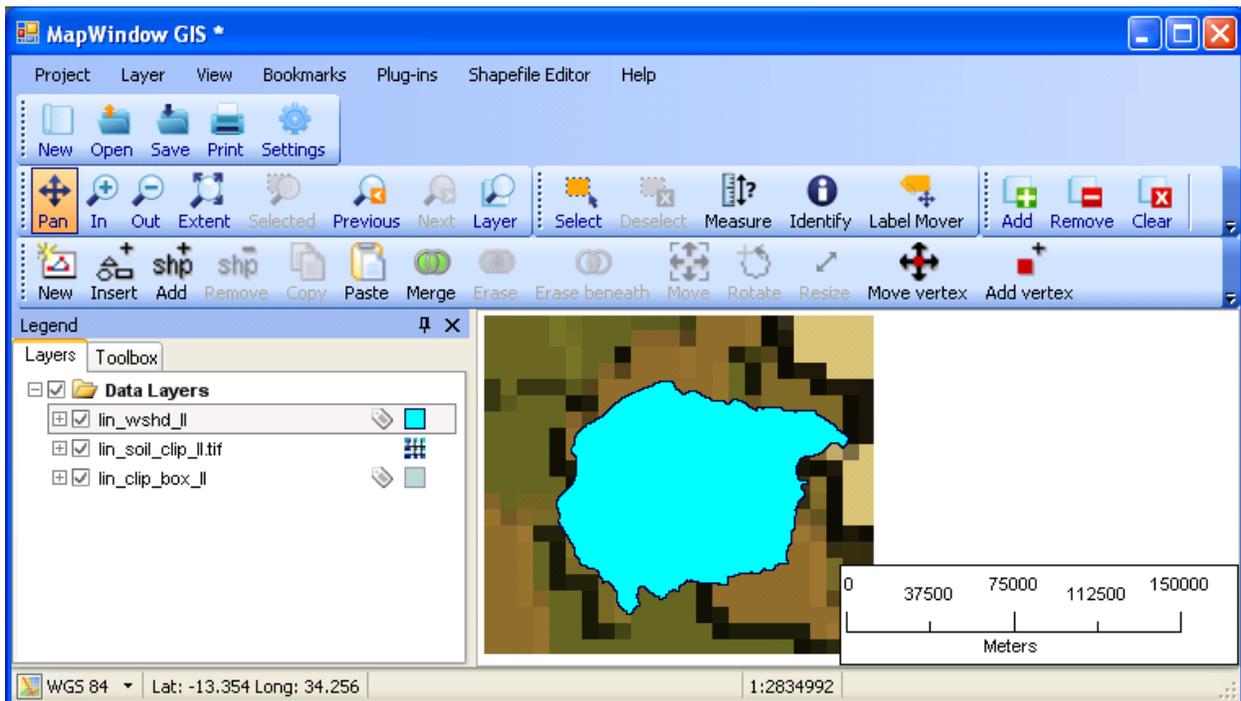
- Open the project **World_Data_Grids.mwprj** again. This shows that the soil tile we need is **af_soil_2**.



- Extract **af_soil_2.tif** together with the corresponding .bmp, .bpw and .mwleg files from **af_soil.zip** (from the WaterBase web site http://www.waterbase.org/download_data.html). Store them in, say, **temporary\soil**.
- Exit from MapWindow. Do NOT save project data.
- Add layer **temporary\soil\af_soil_2.tif**. Also add the layer for the clip box (**Lin_Maps\lin_clip_box_ll.shp**).
- Select *Toolbox\Raster\Clip Grid With Polygon*. Select the soil layer and the box to clip with from the ones just loaded into the view.
- Check the Clip to Extents (Fast) option and select the shape (clip box), press Done when the box is highlighted. Note that the output file name is created for you. Rename this default name: **temporary\soil\lin_soil_clip_ll.tif**. Click OK to clip.



- Remove the layer **af_soil_2**.
- Zoom out and with add layer reload the watershed layer (**Lin_Maps\lin_wshd_ll.shp**) to verify the extents. This **lin_land_ll_clip.tif** is the final landuse product that, when projected to UTM (see below) will be used in MWSWAT.



3.3.2 Re-project Soil to UTM

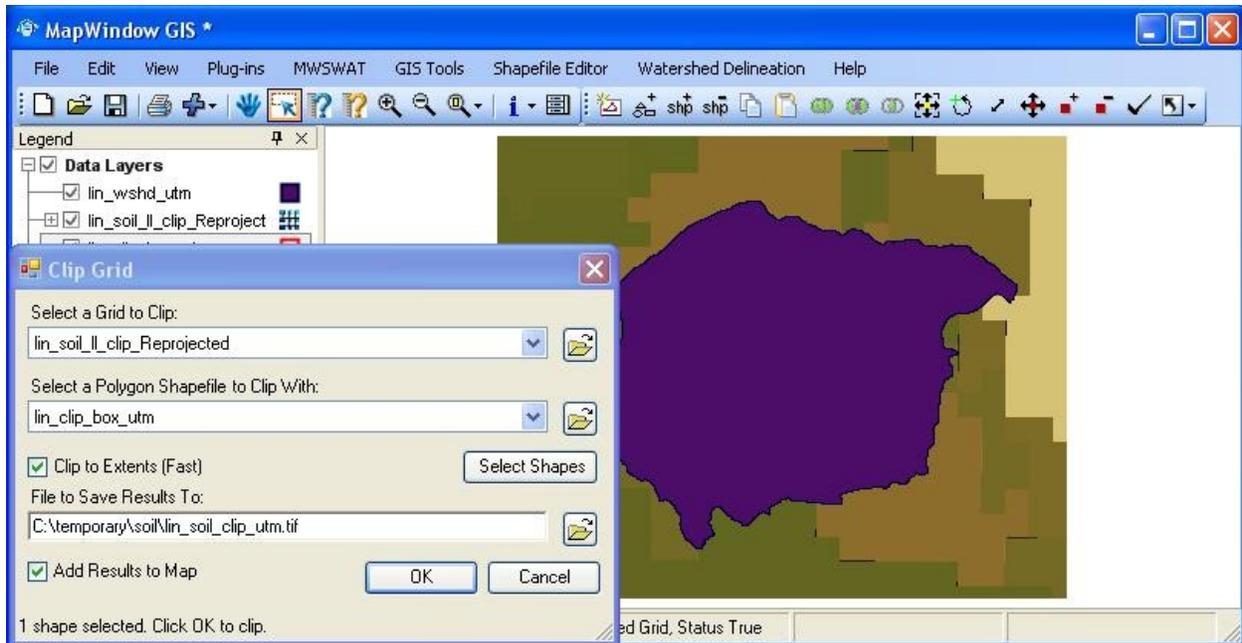
Objective: Re-project the clipped soil file to UTM and re-clip for the area of interest.

Due to the fact that MWSWAT needs meter units and an equal area projection to perform area calculations, the clipped soil file need to be re-projected to UTM coordinates⁵. In this example, there is an additional dataset for the Linthipe watershed already projected in UTM. (additional shapefile: **lin_wshd_utm**: Zone 36S).

Re-Project Soil and re-clip for Area of Interest:

- Remove all the layers and select *Toolbox\Raster\Reproject Grids*.
- Open the clipped soil file in lat/long (**temporary\soil\lin_soil_clip_ll.tif**), when loaded click OK to re-project.
- Choose projection details: WORLD, WGS 84, UTM Southern Hemisphere, and Zone 36S and the current projection values if MapWindow couldn't determine them (Geographical, WGS 1984).
- A new file will be created (**temporary\soil\lin_soil_clip_ll_Reprojected.tif**). Do not add the layer when asked, as it has a different projection, but clear all layers and then add it. Also add the watershed in UTM (**Lin_Maps\Geo_processed\lin_wshd_utm.shp**).
- Load the clipping box in UTM view (**Lin_Maps\sj_clip_box_utm.shp**) to re-clip and remove all the missing values generated with the rotation of the grid when re-projected.

⁵ UTM is not an equal area projection, but is close to being so, and sufficiently close for SWAT to use on most watersheds



- Clip the re-projected soil with the UTM clip box. Select *Toolbox\Raster\Clip Grid With Polygon* and rename the output file as **lin_soil_clip_utm.tif**. OK to clip. When done, exit from MapWindow (do not save project changes) and copy the file (**lin_soil_clip_utm.tif**) in the project folder as this is going to be the soil file to be used with MWSWAT.