TOPEX User Guide

Version 1.0

An extension to compute relief TOPographical EXposure with ArcView 3.2

Third version: **Pierre Racine**, 2006
Second version: **Vincent Laflèche**, 2001
First version: **Michel Dornier**, 2001

The TOPEX script was originally created at The Windthrow Research Group
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http://faculty.forestry.ubc.ca/mitchell/windthrow.htm

This version of TOPEX was first modified by **Michel Dormier**
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INTRODUCTION

TOPEX stands for **TOP**ographical **EX**posure. This is a topographical index describing wind exposure. TOPEX is a program developed to run with the geographical information system ArcView 3.2 from the company ESRI. It is written in the language Avenue. Typically, you will want to compute the TOPEX value for every point of a raster dataset representing elevation. The result will be a new raster dataset containing a TOPEX index for every point. If your topographical data are not in a raster-based (i.e. they are in the form of a digital elevation model (DEM), contour lines or TIN – Triangulated Irregular Network), you will first have to convert them to the ESRI GRID raster format.

Topographical exposure (or wind exposure) is a very important factor to consider when evaluating vegetation sensibility to windthrow. This recurrent phenomenon is very important in forestry. In the absence of major disturbances, it often determines the time when forest populations start to decline. It also influences the speed at which the canopy deteriorates. Windthrow risk has an impact on silviculture, in that it can restrict the management or harvesting options to foresters. In this context, it is important to understand the links between windthrow risk, natural population evolution and silviculture.

How TOPEX is computed

The TOPEX index is the sum of the slope angles for eight compass directions around a target point. This index is computed for every point on a GRID raster containing elevation data. As you can see in Figure 1 and 2, the angles involved in computing the sum can be either positive or negative depending on whether the target point is lower or higher than the extremity (the reference point) used to compute the angle. As a result, the sum can also take positive or negative values.

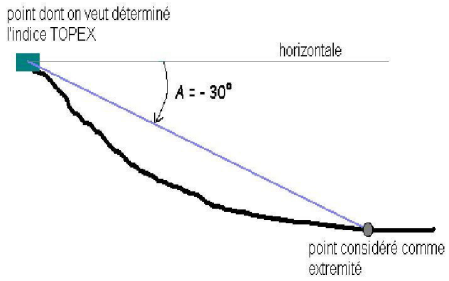

Figure 1: Angle calculation when the target point is on a hill top

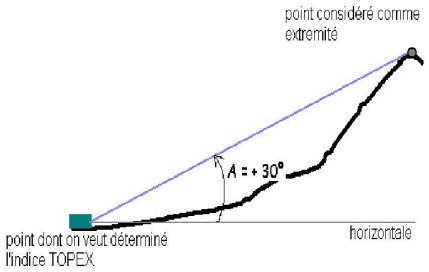

Figure 2: Angle calculation when the target point is at the bottom of the slope

Based on a test site, the following TOPEX classes were defined:

[-150 , -60] severely exposed
[-60 , -20]
[-20 , 20] little exposed
[20 , 60]
[60 ,150] very sheltered
[No data] values outside this range

"No data" values sometimes correspond to errors incurred when digitizing the map.

These classes are used in ArcView to map exposure hazards as shown in Figure 3.

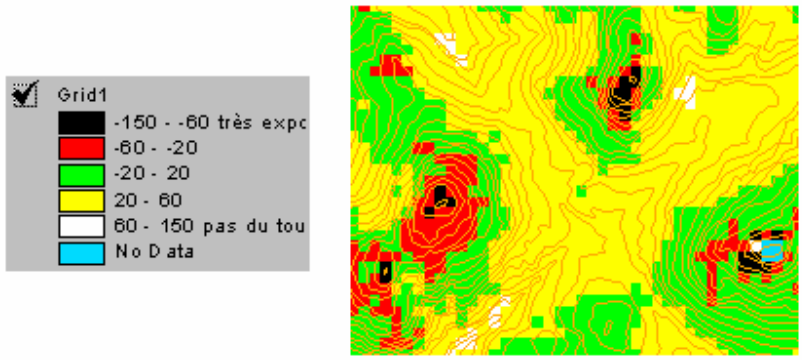

Figure 3: Example of ArcView exposure mapping based on the proposed classes

USING THE SCRIPT

Prerequisites

Software

You will need ArcView 3.2 with the Spatial Analyst and 3D Analyst extensions installed. Most conversion procedures can be done with ArcView 3.2 but re recommend doing them with ArcGIS 9.1 and above if you have access to a copy of this software.

Data

You need to have elevation data about the target area for which you want to compute the TOPEX. Ideally these data should be in ESRI GRID raster format. The appendix will show you how to obtain and convert different formats like DEM, contour lines and TIN to the ESRI GRID raster format (or ArcGRID). In order to avoid incorrect measurements, the GRID raster should be projected in the UTM coordinate system. The correct UTM coordinate system zone is determined following the geographical area covered by the data. Typically, UTM zones for North America range from 9 to 21 proceeding from west to east. See the end of the appendix for a map of UTM zones.

- **The appendix will show you how to obtain and convert elevation data**

Procedure

Here is the procedure to compute TOPEX values for an ESRI GRID raster dataset.

1. **Double-click on the TOPEX.APR project. It should open in ArcView.**

   If APR files are not associated with ArcView on your computer, start ArcView first and then check “Open an existing project”. Browse to the folder containing TOPEX.APR and select this file. Make sure the project file is not in a folder containing a space.

   If you do not see the window asking to load a project, select “File ->Open Project…” from the menu. Browse to the folder containing TOPEX.APR and select it.

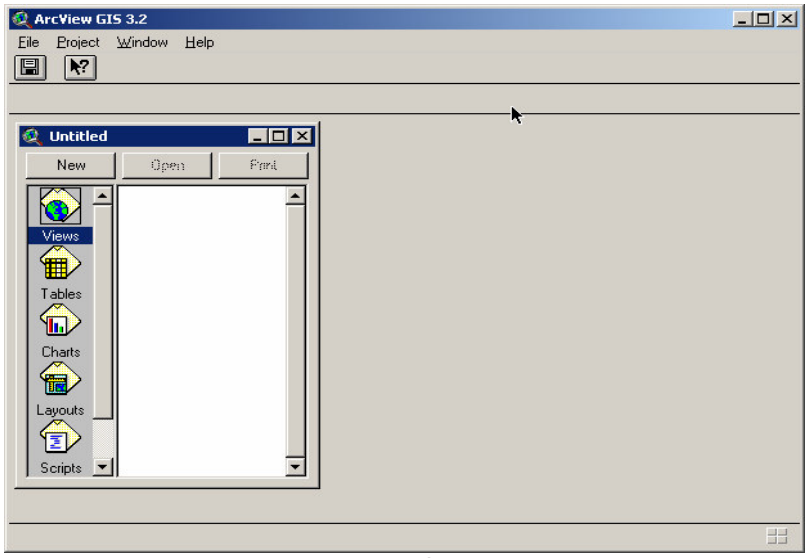

Figure 4: ArcView with TOPEX.APR loaded

You should now have an empty ArcView window like the one in Figure 4.

2. Create a new view and open the GRID raster containing elevation data

a. Select “Views” in the project window

b. Click on the “New” button

c. Select “View -> Add Theme” from the ArcView menu (or CTRL-T)

d. Select “Grid data source” as Data Source Types

e. Browse and select your GRID raster file and click “OK”

f. Make sure the theme is displayed by checking the box next to the theme's name in the view

You should now have a view similar to the one in Figure 5.

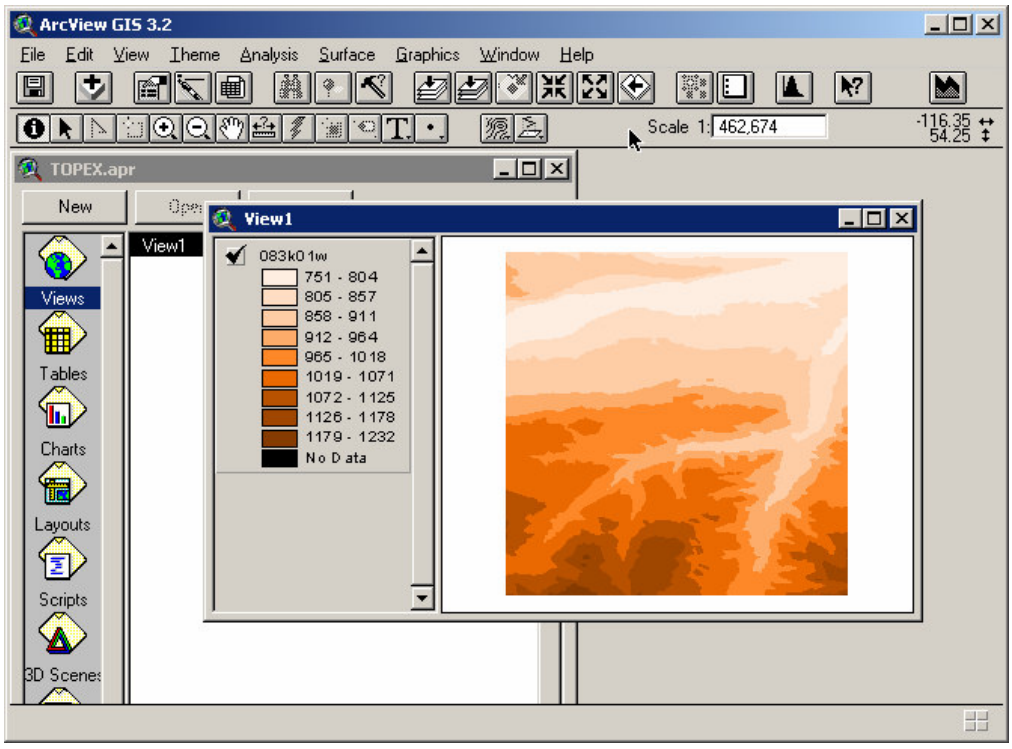

Figure 5: ArcView with TOPEX ready and a GRID raster loaded

3. Select the target area

The script can compute the TOPEX for a complete GRID raster or only for a part of the raster. TOPEX computation is generally very long. Be sure to restrict yourself to the minimal area corresponding to your needs.

a. You might want to zoom to the target area using the “Zoom” tool before selecting the zone for which you want to compute the TOPEX. Select the rectangle tool as shown in Figure 6.

b. Select the computation area by drawing a rectangle over the raster. You must select an area smaller than the grid so that a buffer zone at least equal to the limit distance set for TOPEX calculation (in the TOPEX dialogue box, see below Topex Distance) remains. If you are about to select a distance of 1000 m, make sure there is at least 1000 m available around each side of the selected rectangle. Otherwise, you could receive the error message “Can’t convert string to number: Number.”

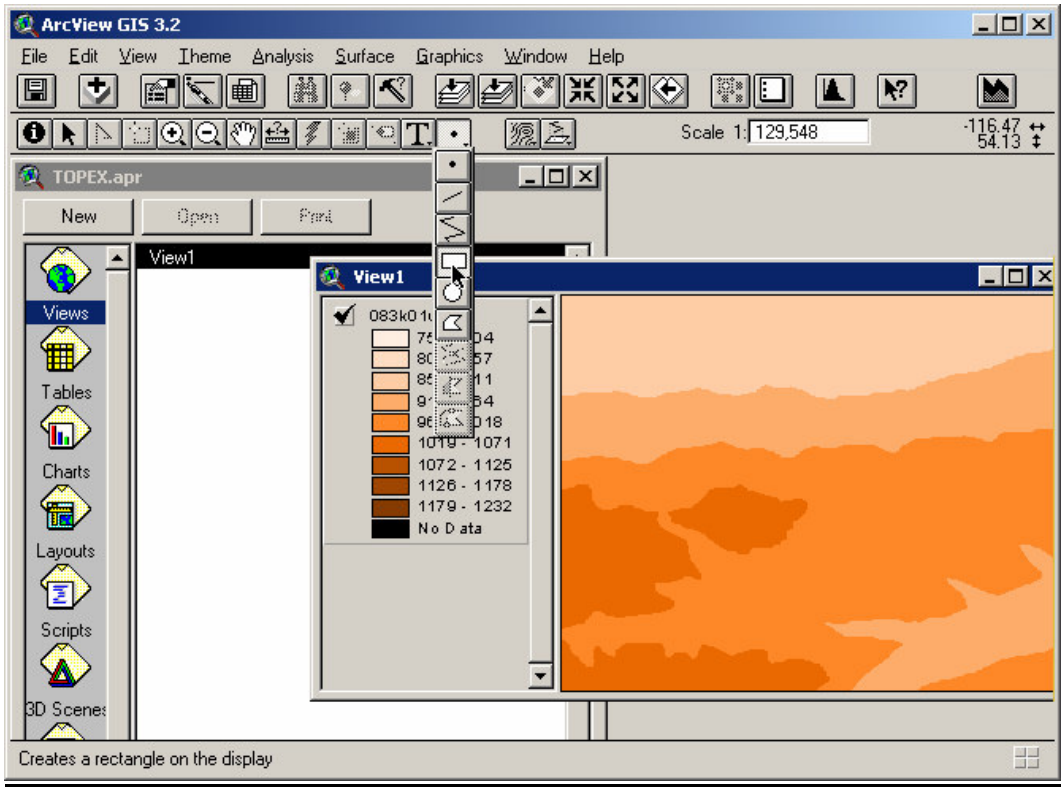

Figure 6: Selecting the rectangle tool

4. Execute the TOPEX script

a. Click on the TOPEX icon 

b. A dialogue box like the one in Figure 7 should open

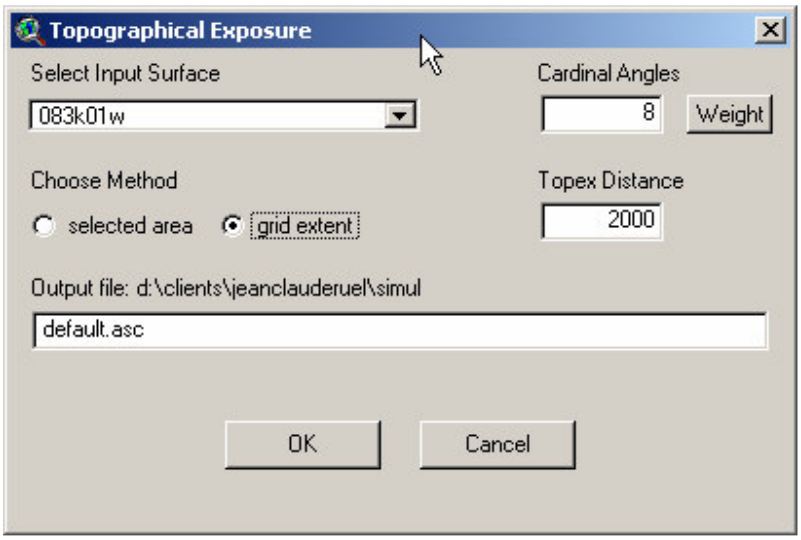

Figure 7: The TOPEX dialogue box

c. Set the following options:

Select Input Surface: Normally, the loaded GRID raster should be automatically selected. If you have more than one raster opened, select the one for which you want to compute the TOPEX.

Choose Method: If you have selected an area using the rectangle tool, click the "selected area" option button. If you want to compute for the whole raster, click "grid extent". Remember that computing TOPEX for the whole raster can take many hours.

Output file: When computing TOPEX for a large area, if for some reason the process crashes, the state of the process will be saved in the file you have specified. If this happens, you can restart and resume the process in another TOPEX session by selecting the file you had specified before the process crashed.

Cardinal Angles: This is the number of cardinal direction for which you can compute the TOPEX. 360 divided by this number should give an integer. Although 8 is the standard value, 2, 3, 4, 6 or any divisor of 360 are valid. The "Weight" button is inactive for now.

Topex Distance: This is the maximal distance from the point being analyzed from which the script will try to compute the slope. The greater the distance; the longer the computation, as TOPEX has to check every intervening point to find the highest or lowest point to use when computing the slope. Use the ArcView measure tool  to make sure you set a reasonable value. The correct distance depends on the scale of the file and the topography of the area. Try to choose a value that encompasses the main topographical features surrounding the computing area. The distance is in the same units as the cell size of the GRID raster. To determine the cell size, select "Theme->Properties" from the ArcView menu. If the cell size is

1 and you select a distance of 100, then a hundred points will be checked to determine the correct slope; this process will be repeated for every cardinal directions. Typically, your file will be projected to UTM and the cell size will be expressed in meters. You can double-check this by measuring the edge of a pixel in the raster. For 30-meters DEM, the edge should measure 30 meters.

d. Click “OK”. The computation should begin…

e. If the computation takes too long and you want to cancel the process, click on the “Stop” button appearing at the bottom right corner of the ArcView window. You might have to click more than once for this to work…

5. Symbolise the resulting raster

a. Make sure the resulting raster theme is displayed by checking the box next to the theme's name in the view

b. Double-click on the legend box. The Legend Editor should appear

c. Click the load button and browse to open the TOPEX_Legend.avl file. The Legend Editor should display standard categories, as in Figure 8.

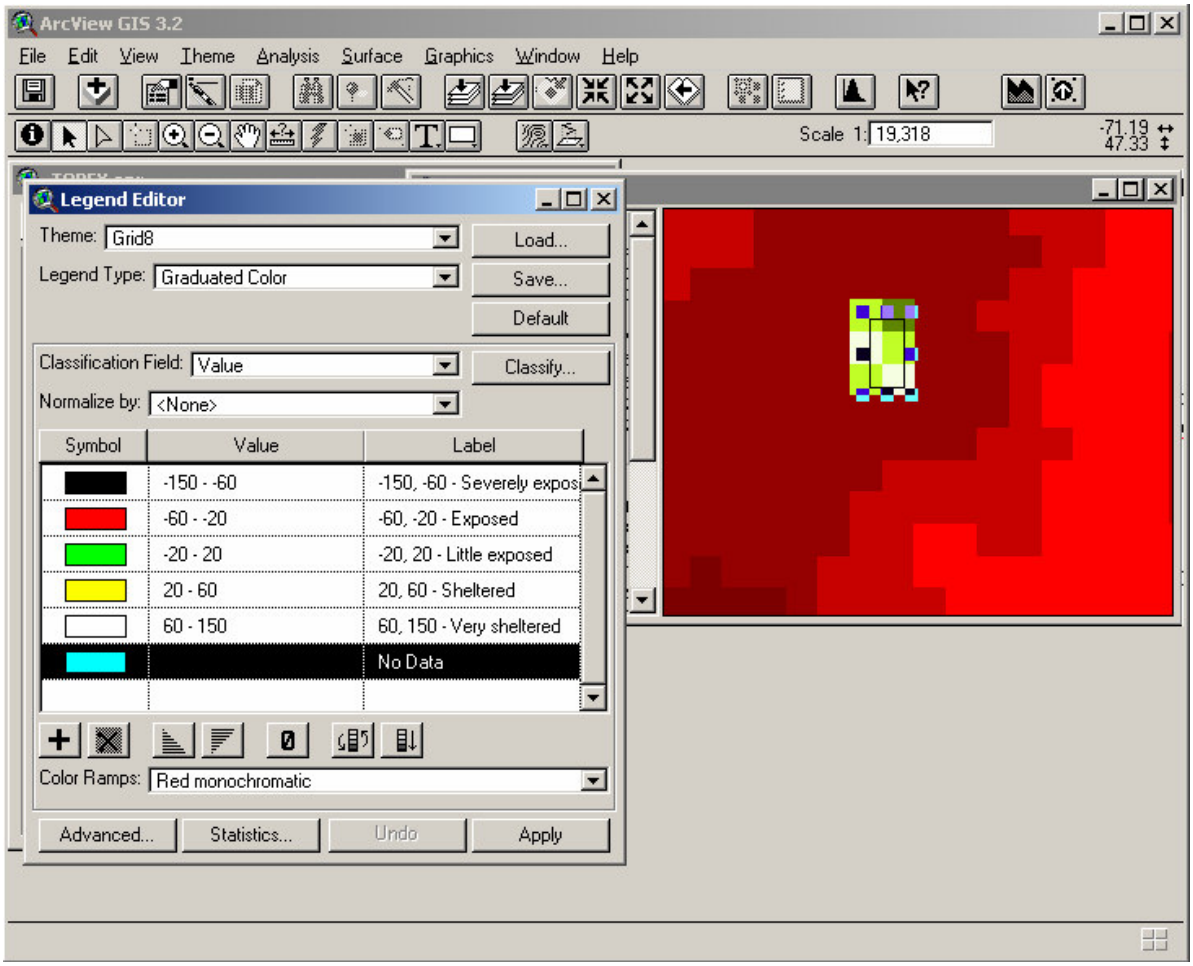

Figure 8: The Legend Editor dialogue box with the TOPEX legend loaded

d. Click on “Apply” and close the dialogue

6. Save the generated raster

a. From the “Theme” menu, select “Save Data Set…”

b. Browse and give a name to the raster

REFERENCES

1. Ruel, J.-C., Mitchell, S.J. and Dornier, M. (2002) *A GIS Approach to Map Wind Exposure for Windthrow Hazard Rating.* Northern Journal of Applied Forestry 19 (4) : 183-187

2. Quine, C.P. and Wright, M.S. (1998) *The potential of distance-limited topex in the prediction of site windiness.* Forestry 71 (4): 325-332

3. Ruel, J.-C., Pin, D., Spacey, L., Cooper, K. and Benoît, R. (1997) *The estimation of wind exposure for windthrow hazard rating: comparison between Strongblow, MCs, Topex and a wind tunnel study.* Forestry 70: 253-265

4. Wilson, J.D. (1984) *Determining a Topex score.* Scottish Forestry 38(4): 251-256

APPENDIX

How to obtain elevation data and convert them to GRID raster

ArcView 3.2 already is old software. Unfortunately, the more recent versions of this GIS (ArcGIS 8 and above) do not support Avenue, the language which was used to develop TOPEX. ArcGIS is much more efficient when converting data from one format to another. We will first explain how to convert elevation data to GRID raster using ArcGIS 9.1, and then using ArcView 3.2. If you have access to a copy of ArcGIS, we recommend using this software to do the conversions even if TOPEX calculations will be performed in ArcView.

Obtaining DEM data

Digital Elevation Data (DEM) is one of the most current formats used to exchange elevation data.

Canada

DEM for Canada are called Canadian Digital Elevation Data (CDED). They can be found at:

- GeoBase (http://www.geobase.ca/geobase/fr/data/cded1.html)
- DMTI (http://www.dmtispatial.com/digi_elev_model.htm)

GeoBase data are free. DMTI data cost a fee, but are of better quality. Your university map library might have an agreement with DMTI, thereby giving you free access to these files. It is worth checking.

CDED files have a DEM extension. They must be converted to GRID and projected to the UTM coordinate system in order to be used with TOPEX.

United States

- **CDED DEM = Canada**
- **SDTD DEM = USA**

Information about DEM for the United States can be found on the USGS (United States Geological Survey) site at:

- Digital Elevation Models (DEMs) (http://eros.usgs.gov/products/elevation.html)
- USGS Geographic Data Download (http://eros.usgs.gov/geodata/). Select *"1:24,000 Scale Digital Elevation Models (DEM) SDTS format only"*

These DEM can be downloaded for free from many sites:

- GeoCommunity (http://data.geocomm.com/dem/demdownload.html)
- MapMart (http://www.mapmart.com/DEM/DEM.htm)
- ADTI (http://www.atdi-us.com/SDTS_DL_b.htm)

These DEM are generally in the Spatial Data Transfer Standard (SDTS) format, which consists of a set of files with the DDF extension. They must be converted to GRID before using them with TOPEX. They are already projected to UTM.

USGS have replaced DEM with a new enhanced product called NED (National Elevation Data). They can be downloaded at:

- USGS NED (http://ned.usgs.gov/)

NED data are already in the ESRI GRID format so they do not need to be converted. However, they still have to be projected to UTM to be used with TOPEX.

Converting CDED DEM to GRID using ArcGIS 9.1

1. Convert CDED DEM to raster using the "DEM to Raster" AcrToolBox tool

a. In ArcToolBox, double-click on the "Conversion Tools", on the "To Raster" section and then on the "DEM To Raster" tool

b. Select your DEM file as "Input USGS DEM file" or drag it from the ArcCatalog tree

c. Modify the proposed "Output raster" file name, if desired

d. Keep the "Output Data Type" to FLOAT and click "OK"

2. Convert from decimal second to decimal degree using the "Project Raster" ArcToolBox tool

CDED files are in a geographic coordinate system with angular units in decimal seconds. In order to display them correctly in ArcGIS, you must use the Project Raster tool to convert them to decimal degrees.

You can skip this step and go directly to "Projecting GRID to UTM using ArcGIS 9.1" if you have to project the raster to the UTM coordinate system anyway.

a. In ArcToolBox, double-click on the "Conversion Tools", on the "Projection and Transformations" section and then on the "Project Raster" tool

b. Select your raster file as "Input raster" or drag it from the ArcCatalog tree

c. Modify the proposed "Output raster" file name, if desired

d. Click on the "Coordinate System Button" and then on the "Select" button

e. Navigate and select the "Geographic coordinate Systems -> North America -> North American Datum 1983.prj" coordinate system and click "Add" and then "OK"

f. Click "OK" in the Project Raster tool window

The resulting raster will have the angular unit set to Decimal Degrees.

See also:

- http://library.usask.ca:9003/data/geography/nrcan/CDED-tutorial.pdf
- http://www.mcgill.ca/files/gic/CDED9.pdf

Converting SDTS DEM to GRID using ArcGIS 9.1

1. **Make sure the Arcview 8.x "Conversion Tools" toolbar is active**

   a. From the "View" menu, select "Toolbars" and then "Arcview 8.x Tools"

2. **Convert the file using the "SDTS Raster To GRID" tool from the "Conversion Tools" toolbar**

   a. From the "Conversion Tools" toolbar, select "SDTS Raster To GRID…"

   b. To fill the "Input prefix:" field, browse to the folder containing the SDTS DEM file

   c. Select the prefix corresponding to your set of DDF files

   d. Make sure the "Record no.:" field correspond to the field containing elevation data

   e. Set the name of the output GRID and click "OK"

Converting Contour lines to GRID using ArcGIS 9.1

It is possible to construct an elevation GRID from topographical contour lines. However, we do not recommend this as you might might produce erroneous data. Instead, you should try to get the DEM files from the above sources and convert them to GRID. These files have already passed through a correction process and should be of much better quality than what you would get by converting contour lines files. Use contour lines files ONLY if you have no other options.

First technique using ArcGIS 3D Analyst

1. **Create a TIN using the "Create TIN from Features…" tool of the "3D Analyst" toolbar**

   a. Start ArcMap and make sure the "3D Analyst" toolbar is displayed. You can do this by first selecting "Tools" and then "Extensions" from the menu, and then check the "3D Analyst" check box. You then have to display the toolbar by right-clicking in the space to the right of the menu and selecting "3D Analyst"

   b. From the "3D Analyst" toolbar menu, choose "Create/Modify TIN" and then "Create TIN from Features"

c. Open the layer (shapefile) containing the contour lines from which you want to create the TIN

d. Beside the "Height source" text, select the field containing the elevation values and select "soft line" as the triangulation method

e. Click "OK"

2. Convert the TIN to a GRID using the "TIN to Raster…" tool of the "3D Analyst" toolbar

a. From the "3D Analyst" toolbar menu, choose "Convert" and then "TIN to Raster…"

b. Select the TIN you just created as "Input TIN"

c. Set the Attribute to "Elevation"

d. Leave the Z factor set to 1

e. Set the cell size in order to get a raster with the number of rows and columns you want. The value should be between 0 and 1.

f. Set a name for the output GRID raster and click "OK"

See also:

- http://web.austin.utexas.edu/architecture/courses/parmenter/gis/arcgis_tips/create-tin.html

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Projecting GRID to UTM using ArcGIS 9.1

You DO NOT have to project GRID produced from SDTS DEM files as they already are in the UTM coordinate system. However, you DO HAVE to project GRID produced from other sources in order to use them with TOPEX.

a. In ArcToolBox, double-click on the "Data Management Tools", on the "Projections and Transformations", on the "Raster" section and then on the "Project Raster" tool

b. Select your raster file as the "Input raster" or drag it from the ArcCatalog tree

c. Modify the proposed "Output raster" file name, if desired

d. Click on the "Coordinate System Button" and then on the "Select" button

e. Navigate to "Projected Coordinate Systems -> UTM -> Nad 1983" and then select the projection file corresponding to the zone of your dataset. Click "Add" and then "OK"

f. Click "OK" in the "Project Raster" tool window

Converting CDED DEM to GRID using ArcView 3.2

1. Install the DEMShift Avenue script

a. Download this Avenue script from the ESRI site:

http://arcscripts.esri.com/details.asp?dbid=10711

b. Open ArcView, click on the “Script” button in the Project window and then click on “New”

c. Copy the content of the downloaded file into the empty window as in Figure A1

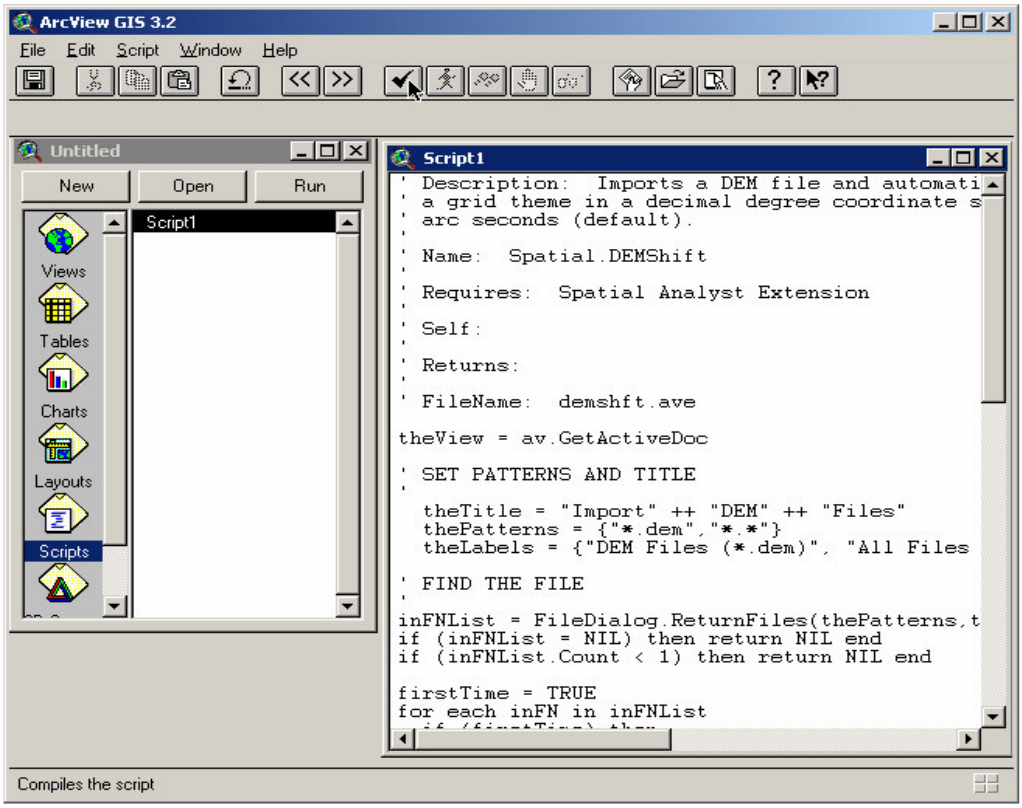

Figure A1: ArcView 3.2 with the DEMShift script loaded and ready to compile. Notice the mouse pointing on the Compile button

d. Click on the “Compile” button 

2. Execute the DEMShift Avenue script

a. Click on the “Run” button

b. You should get a dialogue like the one in Figure A2

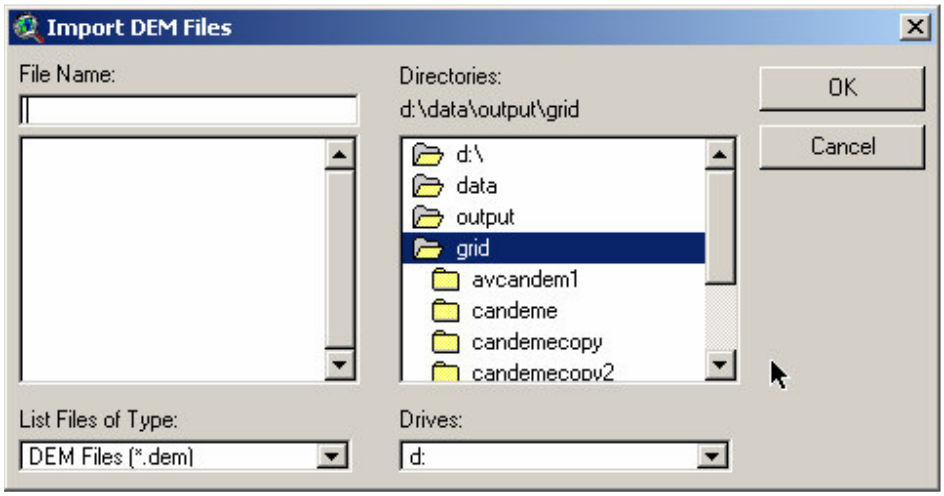

Figure A2: The DEMShift script dialogue box

c. Browse to select your CDED DEM file

d. Set an Output file name and click “OK”. If the script ends with an error, just click “OK”.

3. Create a new view and open the created raster

See also:

- http://www.brocku.ca/maplibrary/procedures/CDEDinAV.htm

Converting SDTS DEM to GRID using ArcView 3.2

The following procedure will explain how to convert SDTD DEM to GRID using ArcView 3.2:

http://support.esri.com/index.cfm?fa=knowledgebase.techarticles.articleShow&d=16605

See also:

- http://www.esri.com/news/arcuser/0100/webdata8.html
- http://www.esri.com/news/arcuser/0400/webdata9.html
- http://web.austin.utexas.edu/architecture/courses/parmenter/gis/tips/DEM-import.html

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Converting Contour lines to GRID using ArcView 3.2

First technique using ArcView 3D Analyst

1. Create a TIN using “Create TIN from Features…” from the “Surface” menu

a. Create a new view and open the contour line shape file

b. Make sure the “Surface” menu is available. If not, select “Extensions…” from the “File” menu and then check the “3D Analyst” check box

c. In the “Surface” menu, select “Create TIN from Features…”

d. If there are many themes loaded, make sure the right contour line feature theme is selected at the left of the view window

e. Select the field containing the elevation values as “Height source” and “soft line” for the “Input as…” field

f. Click “OK” and select an output file name for the TIN

g. ArcView should add the created TIN to the view

2. Convert the TIN to a GRID using “Convert to Grid…” from the “Theme” menu

a. Make sure the TIN theme is highlighted in the view window

b. From the “Theme” menu, select “Convert to Grid…”

c. Select the location for the output grid

d. A dialogue like the one in Figure A3 should appear

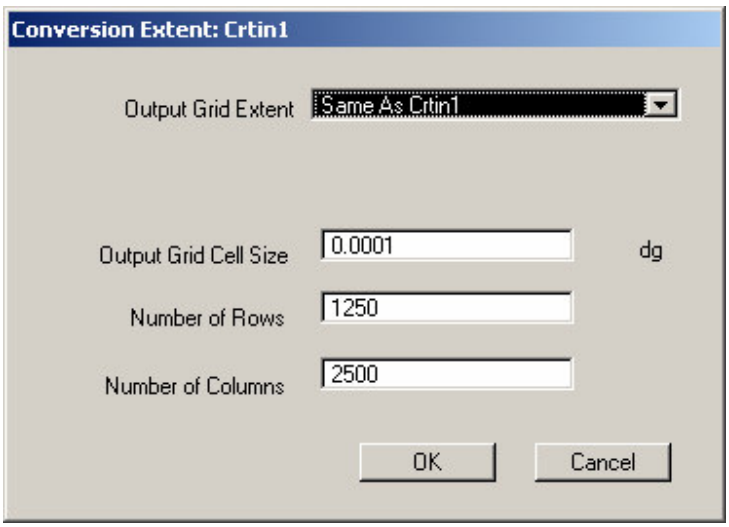

Figure A3: The Convert Theme to Grid ArcView 3.2 dialogue box

e. Make sure the “Output Grid Extent” is the one of the TIN

f. Set the “Output Grid Cell Size”, “Number of Rows” and “Number of Columns” to values reflecting the size of the raster you want and click “OK”

See also:

- http://www.ce.utexas.edu/prof/maidment/grad/azagra/Research/tin.htm

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Projecting GRID to UTM using ArcView 3.2

a. From the ArcView “File” menu select “Extensions…” and then check the “Grid Projector” check box. A button like this  should appear

b. Create a new view, open the GRID raster to be converted and make it the theme active

c. Make sure the Map Units are “decimal degrees” and the Distance Units are “unknown” in the “View ->Properties” dialogue

d. Click on the Grid Projector button and select "meters" as the output units

e. From the “Projection Properties” dialogue box, select “UTM -1983” from the Category dropdown list and the zone corresponding to your dataset from the “Type” dropdown list. Click “OK”. You can refer to Figure A4 to determine the right UTM zone

f. Select the view in which you want the new raster to appear and click “OK”

g. To save a permanent copy of the GRID, select “Theme -> Save”, navigate to the directory to save the data, give the file an appropriate name and click “OK”

See also:

- http://www.brocku.ca/maplibrary/procedures/dd2utm.htm

UTM Zones

Figure A4 shows a map with the different UTM zones for North America

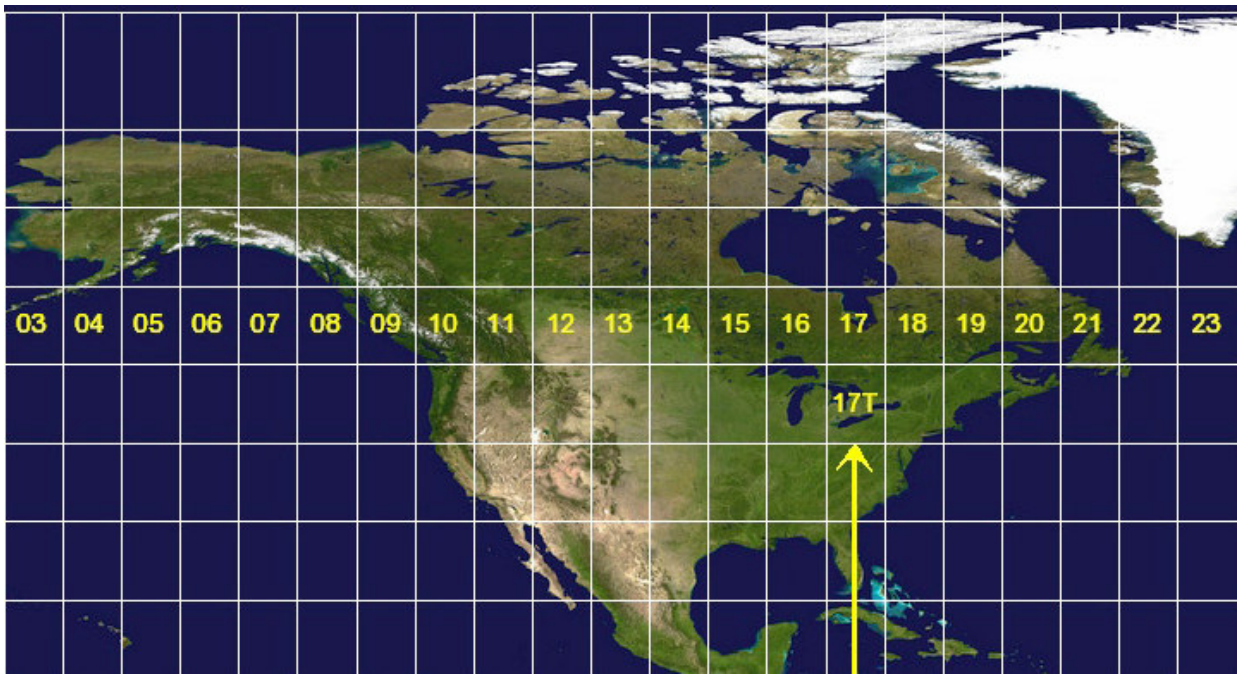

Figure A4: UTM zones