DIGITAL ELEVATION MODELS

PRINCIPLES, SOURCES AND ANALYSIS
INTRODUCTION

Relief is an important component of any project dealing with the territory (hydrology, land resources,...). It is therefore necessary to find ways to introduce the elevation information in GIS projects. One mean is the digital elevation model. It considers the altitude as continuous variable over the space.

TERMINOLOGY I

Digital Elevation Model (DEM): generic term for altitude grid
Digital Terrain Model (DTM): ground elevation model
Digital Surface Model (DSM): ground + cover elevation model
Digital Height Model (DHM): cover elevation model
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TERMINOLOGY II

DEM

DTM DSM DHM
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REGULAR GRID

The digital elevation model corresponds to a regular grid of elevation. Each node of the grid shows an altitude value.

The resolution of the grid corresponds to the distance between to neighbor nodes.
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**DEM SOURCES 1**

Several DEM sources are available, showing various acquisition modes and resolution

<table>
<thead>
<tr>
<th>SCALE</th>
<th>NAME</th>
<th>RESOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL</td>
<td>GTOPO30</td>
<td>~900 m</td>
</tr>
<tr>
<td></td>
<td>SRTM30</td>
<td>~900 m</td>
</tr>
<tr>
<td>REGIONAL</td>
<td>SRTM 3 arc&quot;</td>
<td>~90 m</td>
</tr>
<tr>
<td></td>
<td>SRTM 1 arc&quot;</td>
<td>~30 m</td>
</tr>
<tr>
<td></td>
<td>ASTER DEM</td>
<td>~30 m</td>
</tr>
<tr>
<td>LOCAL</td>
<td>PHOTOGRAM.</td>
<td>~1 m</td>
</tr>
<tr>
<td></td>
<td>LASER DEM</td>
<td>~1 m</td>
</tr>
</tbody>
</table>
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DEM SOURCES 2 – GTOPO30 & SRTM30

The GTOPO30 DEM was created based on heterogeneous topographical maps. The quality of the elevation data varies consequently over space.

The SRTM30 DEM was acquired through space shuttle radar interferometry. This new source of elevation data overcome the major quality problems of the GTOPO30.

They both present a resolution of 30 arc seconds (∼900 m) and are freely available for the Earth surface.
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DEM SOURCES 3 – SRTM 90 m & SRTM 30 m

The SRTM 90 & 30 m DEM were acquired through space shuttle radar interferometry.

They present a resolution of 3 arc seconds (~90 m) respectively 1 arc seconds (~30 m) and are available for the Earth surface.

The SRTM 90 m is freely available

The SRTM 30 m costs being of 0.5 $ per square kilometer.
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DEM SOURCES 3 – LASER DEM

This new acquisition technology allows the capture of very high resolution DEM (~1 m).

Both terrain (ground) and surface (objects) are captured in the same time. Such detailed digital elevation model offers good potential for local relief analysis in applications such as hydrology, hazard mapping, ...

The cost of acquisition are relatively high (150-300$ per square kilometer)
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DEM SOURCES 3 – LASER DEM
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DEM ANALYSIS

Several analysis are available on digital elevation models

- global indicators
- local indicators
- transforms
- map algebra & treatment model
DEM ANALYSIS: Global indicators

The global indicators corresponds to statistical variables calculated over the whole DEM extent.

The main variables are:
- the altitude distribution
- the mean elevation
- the median elevation
- the min and max values
- the altitude range
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DEM ANALYSIS: Local Indicators

Various local indicator can be calculated using GIS tools.

They are based on the local context analysis for each pixel, considering a moving window as neighborhood.

Window can vary in

- size
- form
- content
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DEM ANALYSIS: Local Indicators

Window shifting follows the illustrated principles

Side effects are created in DEM limits according to the given example
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DEM ANALYSIS: Slope and Orientation Indicators

Slope and orientation calculation corresponds to the first order derivative of the surface.

SLOPE = SQRT( SQR( (-Z4+Z6) / 2R) + SQR( (Z2-Z8) / 2R))
ORIENTATION = ARCTAN( (-Z2+Z8) / (Z4-Z6))
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DEM ANALYSIS: Curvature Indicators

Profile and Plan Curvature calculation corresponds to the second order derivative of the surface.
DEM ANALYSIS: Scale Management

Scale can be managed using different methods, though some of them are not recommended.
DEM ANALYSIS: Visibility analysis

The visibility analysis, or Viewshed analysis, considers one central point of view and determines the extent of the visible area over the DEM.
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DEM ANALYSIS: Hillshade

The hillshade corresponds to a shaded representation of the elevation.

It allows a better interpretation of the relief morphology.

The “common” practice for shading is place the light source at 315°
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DEM ANALYSIS: Radiation

The radiation corresponds to a representation of the cumulated energy received over the DEM.
DEM ANALYSIS: Contours extraction

Isoline of elevation, contours, can be created based on a DEM. The elevation interval to be chosen is determined by the DEM resolution and its vertical accuracy.
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DEM ANALYSIS: Profile extraction

Profile can be created based on a polyline and a DEM.
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DEM ANALYSIS: Hydrology features extraction

Watershed and riverbed can be created based on a DEM analysis.

Streams detection

Watershed delineation

Upstream area detection
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DEM VISUALIZATION: 3D Representation of Relief