How Do I?

How Do I...

- Determine Average Gradient (Slope)
- Determine Maximum Gradient (Slope)
- Converting From Percent Slope to Degrees

Operations

- Interpolate
- Krige
- Grade
- ARCTAN ()

What Do I Need?

To successfully use the **Grade** operation you need a map layer with continuous data. If you have sparse or incomplete data you must use the **Interpolate** or **Krige** operation first to create a map layer of continuous data.

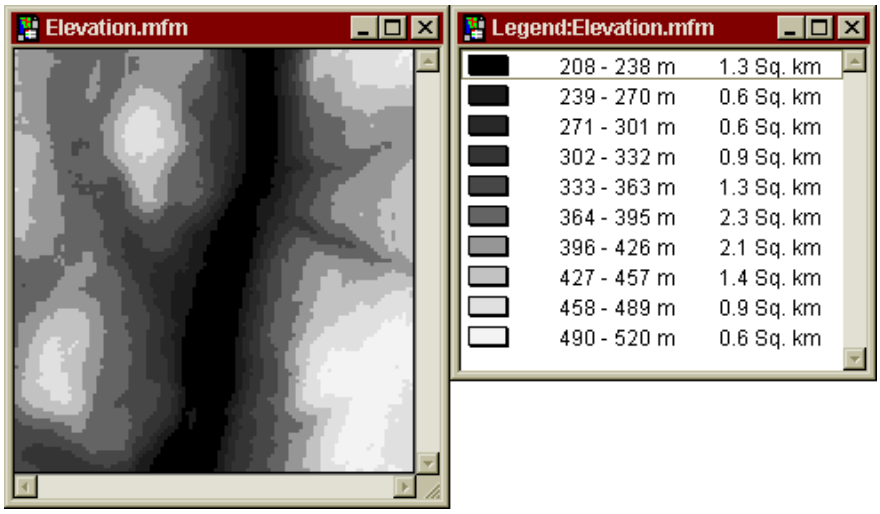
Example

Determine Average Gradient (Slope)

DEMs (Digital Elevation Models) give a visual impression of the relief of a surface. Normally they are coloured so that lower elevations are darker than higher elevations. This colour scheme creates the impression of depth in an image. Darker colours recede from the eye while brighter colours move towards the eye. However, more information can be derived from a DEM by determining the variations in gradient (slope) across the mapped surface. Gradient information allows you to locate very steep areas, flat areas, and so on. This in turn has applications for engineers, landscape architects, hydrologists, urban planners, railway designers, avalanche planners, ski resort developers, and so on.

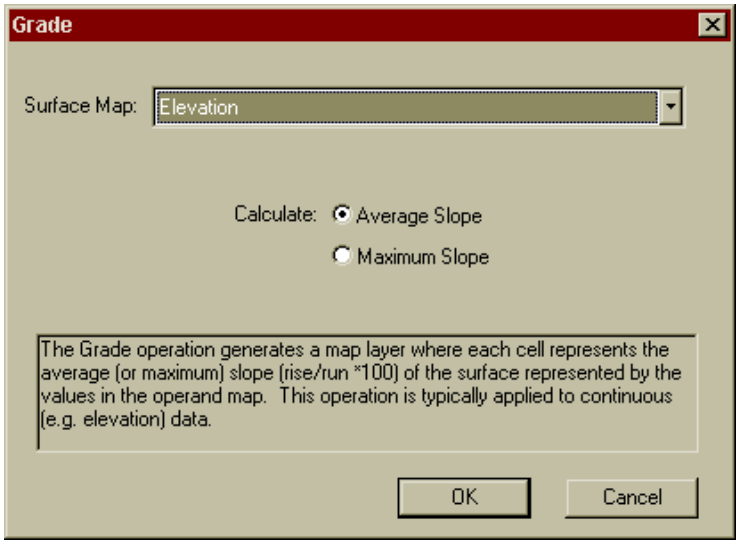
The following map layer, a DEM, depicts a valley in Vermont. The brightest areas represent the highest elevations. To simplify the figure, the zones have

been grouped in the Legend window. Grouping has no effect on the underlying data values:



An Ecotourism company is proposing to develop this valley for camping and hiking. One of the criteria for determining locations for camp sites and hiking trails is steepness of the terrain. The DEM yields a rough idea of where the steep and flat areas are, however, it does not give the actual steepness of the surfaces. Camp sites require a slight grade for drainage. Hiking trails should not exceed a certain steepnesses if they are to be accessible to the majority of hikers.

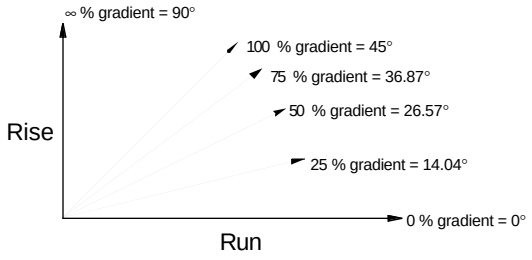
The **Grade** operation, which generates a map layer of surface gradients of the DEM map layer, will be used as a first step in identifying those areas that are most suitable for development:



If you were performing this operation from the Script window the statement would be:

```
GradeMap = Grade Elevation;
```

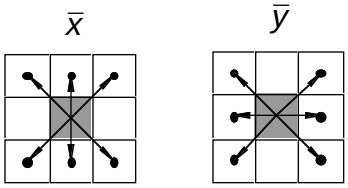
The **Grade (Average)** operation assigns a value to each cell based on its average slope. Gradient is calculated as the average slope (rise over run) multiplied by 100. Flat areas are 0%, a 45˚ slope is 100% and a 90˚ slope (straight up) is +∞% (positive infinity percent):



Gradient is determined by:

- Calculating the slopes of the lines that run from north to south and diagonally through the centre cell.
- Averaging the slopes.
- Calculating the slopes of the lines that run from east to west cells and diagonally through the centre cell.
- Averaging the slopes.
- The two averages are then squared and added together.
- The square root of this result is multiplied by 100.

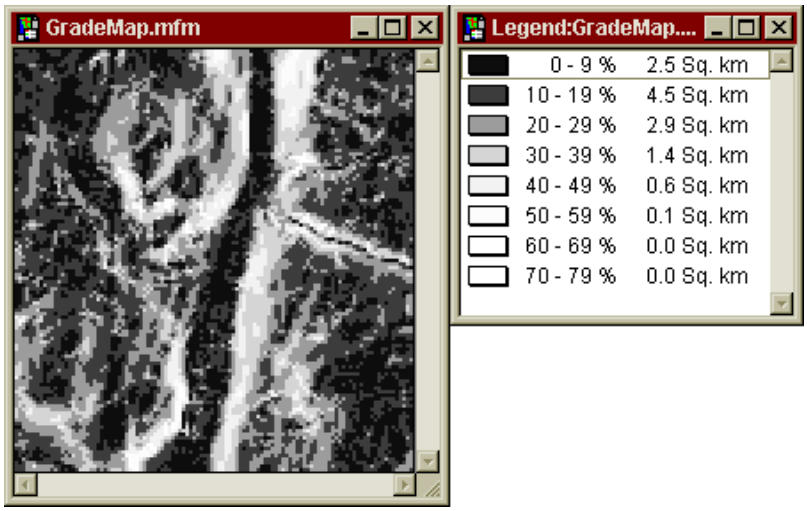
This yields the average grade (intersection of the north-south plane with the east-west plane) of the cell:



$$Grade = \sqrt{\bar{x}^2 + \bar{y}^2} * 100$$

The **Grade** operation does not yield surface orientation information. The **Grade** operation works well when used in conjunction with the **Orient** operation which does yields surface aspect (*i.e.*, the direction each cell is facing).

The bright areas in the map layer named **GradeMap** have the steepest gradients and dark areas have the lowest gradients:



The numeric magnifying glass is used to examine the values at a point where the valley floor meets the valley walls. The table on the left depicts the average elevation in metres for each 30m x 30m cell. The table on the

right depicts the average gradient of each 30m x 30m cell at the same location. Flat areas have a 0% gradient, 45° slopes have a 100% gradient:

Elevation

263	251	220	220	220
260	250	220	220	220
258	247	220	220	220
260	248	236	225	224
256	245	232	224	226

Gradient

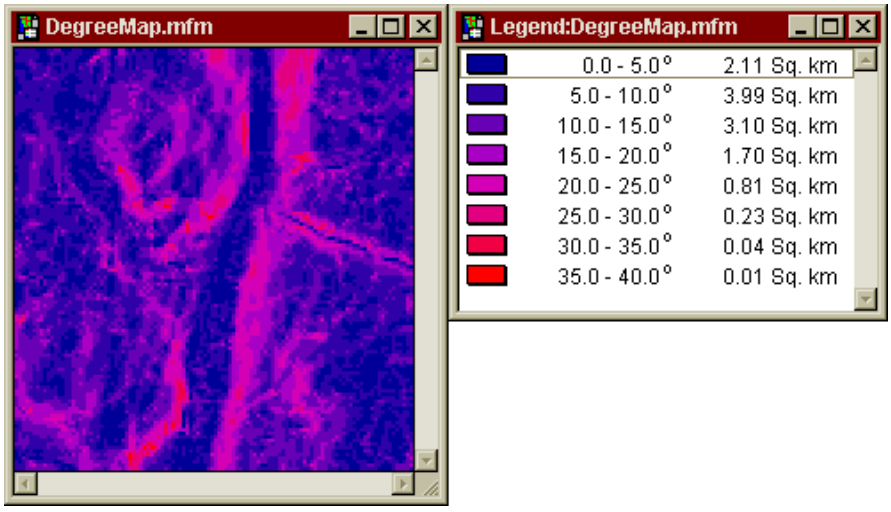
34	58	42	0	0
32	54	39	0	1
31	47	49	12	8
32	38	32	14	6
35	34	29	10	4

Converting from Percent Slope to Degrees

Sometimes you will want to express the results of the **Grade** operation as degrees of slope rather than percent slope. It is simple to convert the results of a **Grade** operation to degrees slope: just enter and execute the following script in the Script window:

```
DegreeMap = ARCTAN(GradeMap/100.0)*180/3.1415;
```

Here is the result of executing this Algebraic statement:



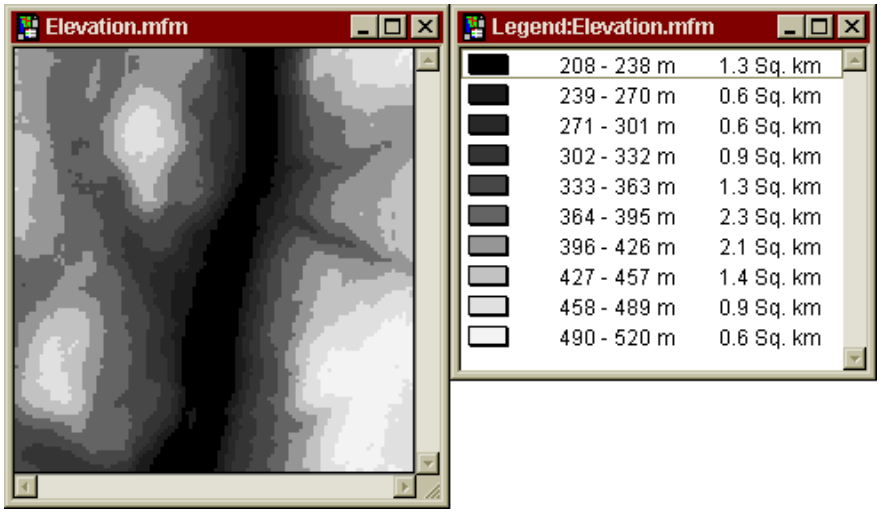
Example

Determine Maximum Gradient (Slope)

DEMs (Digital Elevation Models) give a visual impression of the relief of a surface. Normally they are coloured so that lower elevations are darker than higher elevations. This colour scheme creates the impression of depth in an image. Darker colours recede from the eye while brighter colours move

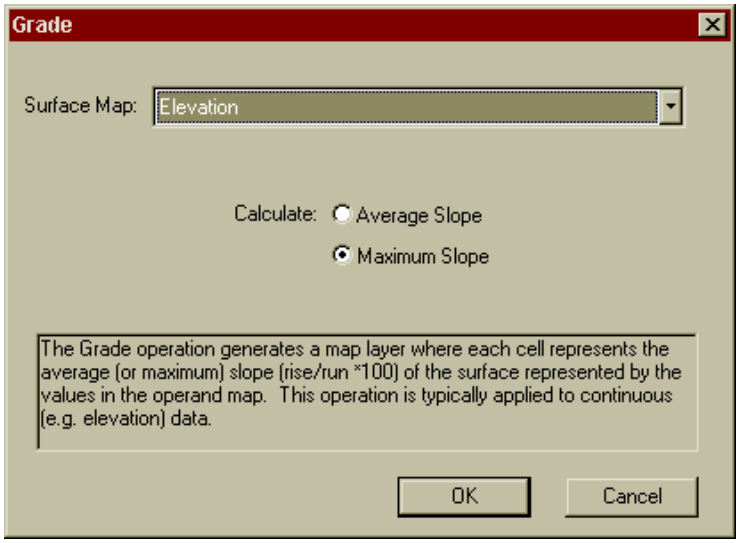
towards the eye. However, more information can be derived from a DEM by determining the variations in slope across the mapped surface. Slope, or gradient, information allows you to locate very steep areas, flat areas, and so on. This in turn has applications for engineers, landscape designers, hydrologists, urban planners, railway designers, avalanche planners, ski resort developers, and so on.

The following map layer, a DEM, depicts a valley in Vermont. The brightest areas represent the highest elevations. To simplify the figure, the zones have been grouped in the Legend window. Grouping has no effect on the underlying data values:



An Ecotourism company is proposing to develop this valley for camping and hiking. One of the criteria for determining locations for camp sites and hiking trails is steepness of terrain. The DEM yields a rough idea of where the steep and flat areas are, however, it does not give the actual steepness of the surfaces. The steepest slopes are susceptible to erosion if they are

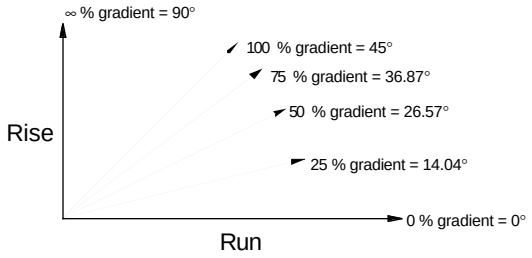
disturbed. To identify where in the valley the steepest slopes are, the **Grade** operation with the **Maximum slope** option specified is used:



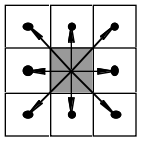
If you were performing this operation from the Script window the statement would be:

```
GradeMaxMap = Grade Elevation Maximally;
```

The **Grade (Average)** operation assigns a value to each cell based on its average slope. Gradient is calculated as the average slope (rise over run) multiplied by 100. Flat areas are 0%, a 45˚ slope is 100% and a 90˚ slope (straight up) is +∞% (positive infinity percent):



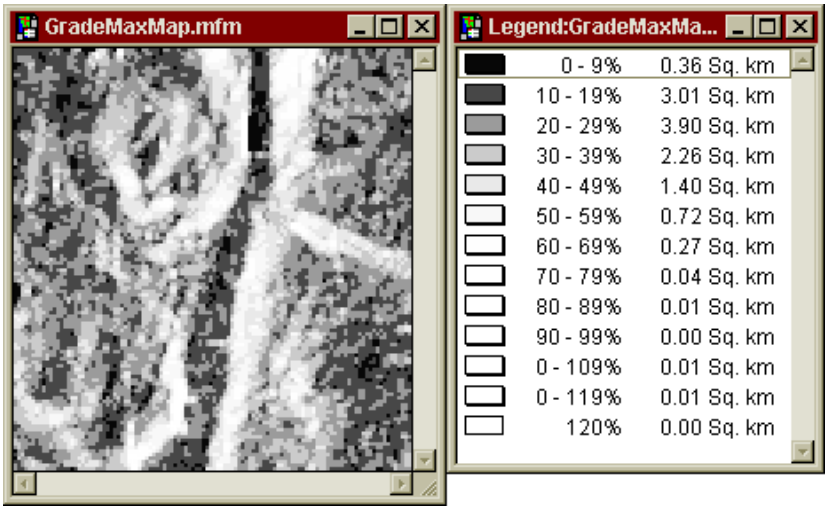
If the **Maximally** modifier is specified in a script or the **Maximum slope** option in the **Grade** dialog box, the resulting value is based on the maximum of the eight slopes surrounding each cell:



All 8 cells

The **Grade** operation does not give any surface orientation information. The **Grade** operation works well when used in conjunction with the **Orient** operation which yields surface aspect (*i.e.*, the direction the cell is facing).

The bright areas in the map layer named **GradeMaxMap** have the steepest maximum gradients and dark areas have the lowest maximum gradients:



Converting from Percent Slope to Degrees

Sometimes you will want to express the results of the **Grade** operation as degrees of slope rather than percent slope. It is simple to convert the results of a **Grade** operation to degrees slope. In the Script window, enter and execute the following script:

```
DegMaxMap = ARCTAN(GradeMaxMap/100.0)*180/3.1415;
```

Here is the result of executing this Algebraic statement: