遥感数字图像处理

Remote Sensing Digital Image Processing

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第七章 遥感数字图像分析方法

7.1 一般分析方法

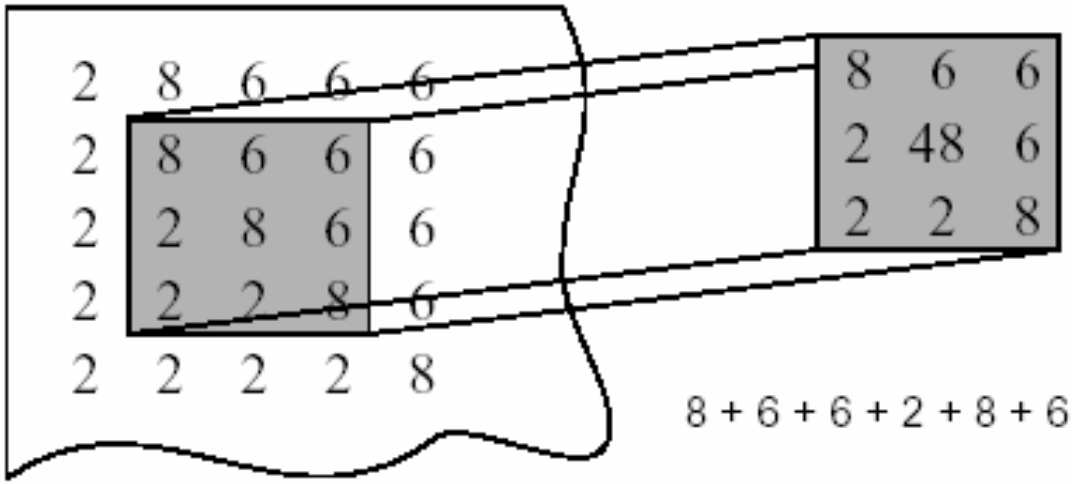
- 是遥感数字图像计算机解译的重要组成部分。
- 对图像进行各种空间分析，进行像元之间或专题分类之间的空间关系处理，使处理后的图像能够更好地表达主要的专题信息。

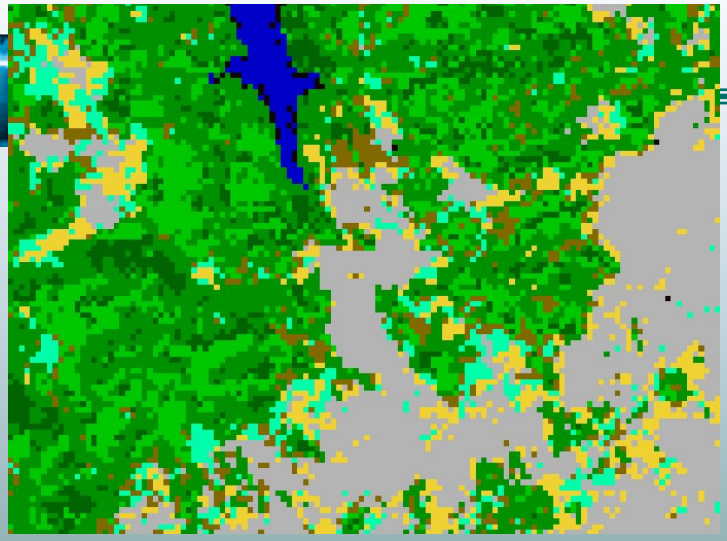
7.1.1 邻域分析（neighborhood analysis）

针对分类专题图像，采用类似于卷积滤波的方法对图像分类值（class values）进行多种分析，每个像元的值都参与用户定义的邻域范围和分析函数所进行的分析，而邻域中心像元的值将被分析结果所取代。系统所提供的邻域范围大小有3×3，5×5、7×7三种，而邻域的形状可以在矩形的基础上任意修改。

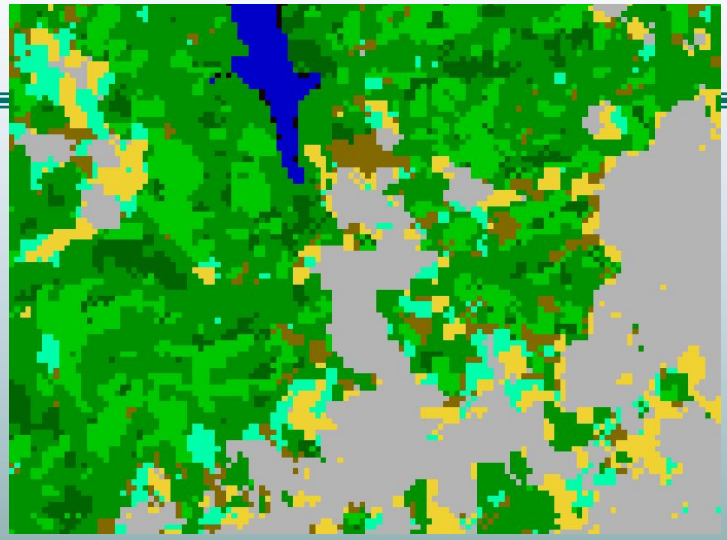
系统所提供的分析函数有：

- Density—outputs the number of pixels that have the same class value as the center (analyzed) pixel. This is also a measure of homogeneity (sameness), based upon the analyzed pixel. This is often useful in assessing vegetation crown closure.
- Diversity—outputs the number of class values that are present within the window. Diversity is also a measure of heterogeneity (difference).
- Majority—outputs the class value that represents the majority of the class values in the window. The value is defined by you. This option operates like a low-frequency filter to clean up a salt and pepper layer.
- Maximum—outputs the greatest class value within the window. This can be used to emphasize classes with the higher class values or to eliminate linear features or boundaries.
- Mean—averages the class values. If class values represent quantitative data, then this option can work like a convolution filter. This is mostly used on ordinal or interval data.
- Median—outputs the statistical median of the class values in the window. This option may be useful if class values represent quantitative data.
- Minimum—outputs the least or smallest class value within the window. The value is defined by you. This can be used to emphasize classes with the low class values.
- Minority—outputs the least common of the class values that are within the window. This option can be used to identify the least common classes. It can also be used to highlight disconnected linear features.
- Rank—outputs the number of pixels in the scan window whose value is less than the center pixel.
- Standard deviation—outputs the standard deviation of class values in the window.
- Sum—totals the class values. In a file where class values are ranked, totaling enables you to further rank pixels based on their proximity to high-ranking pixels.

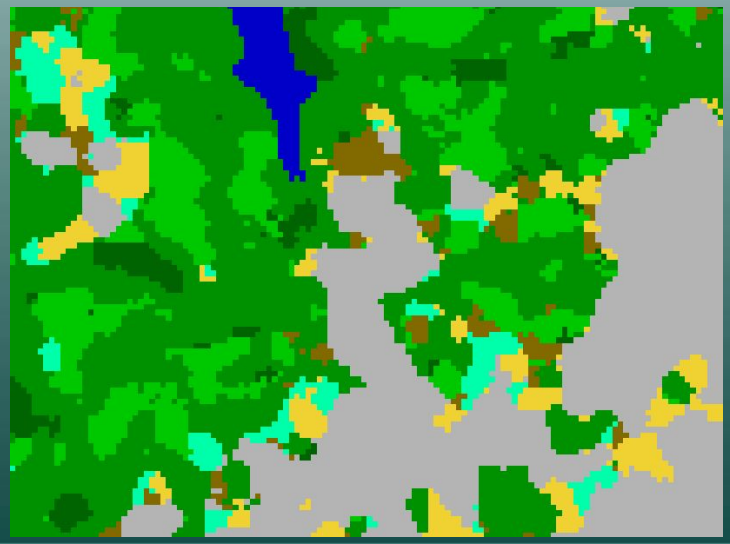

2 8 6 6 6
2 8 6 6 6
2 2 8 6 6
2 2 2 8 6
2 2 2 2 8
8 6 6
2 48 6
2 2 8
Output of one iteration of the sum operation
8 + 6 + 6 + 2 + 8 + 6 + 2 + 2 + 8 = 48



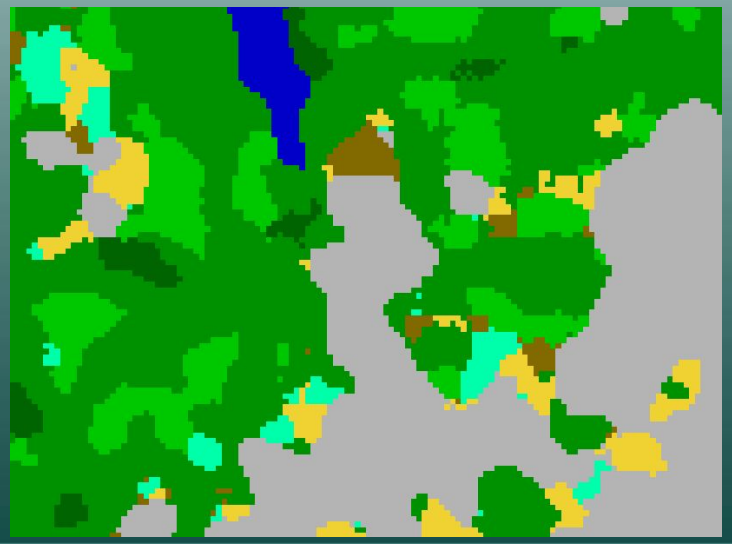
原图像



3×3邻域分析



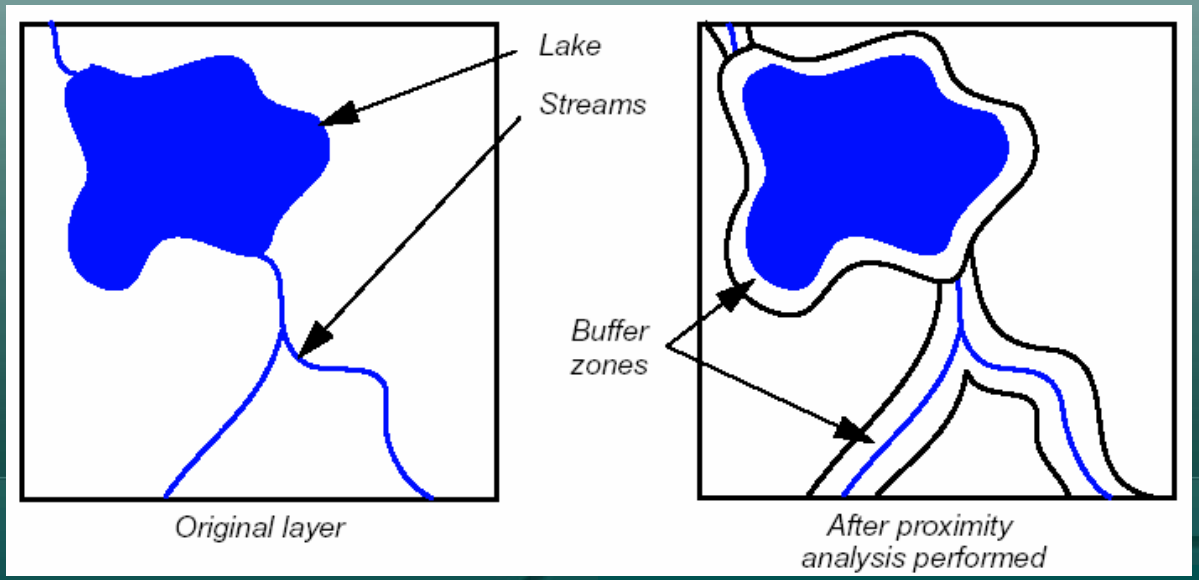
5×5邻域分析



7×7邻域分析

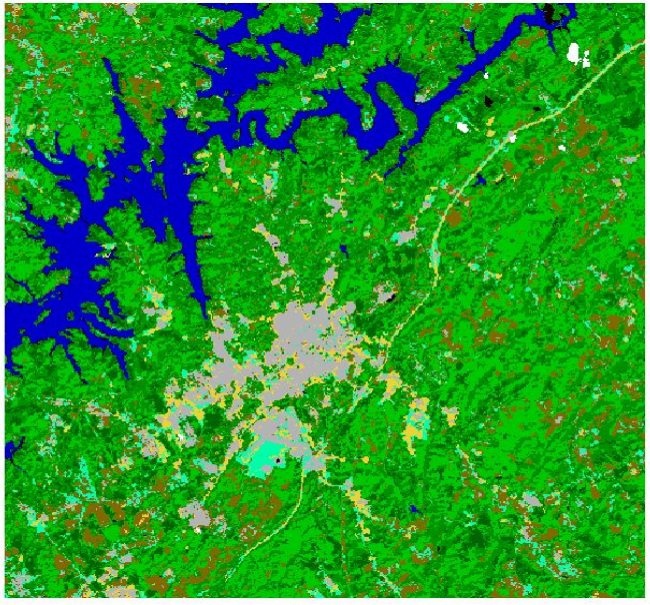
7.1.2 查找分析（search analysis）

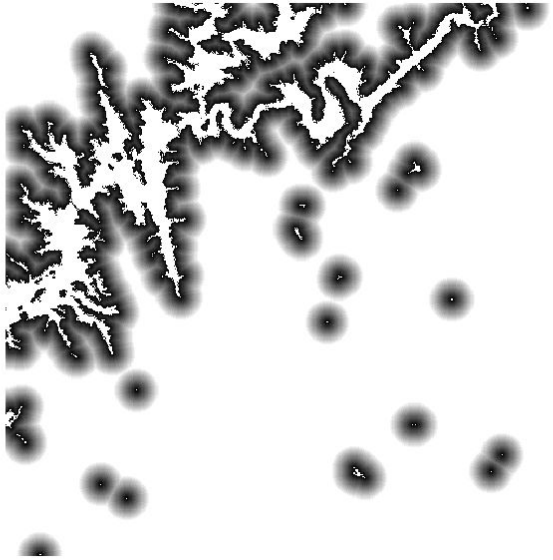
Proximity analysis determines which pixels of a layer are located at specified distances from pixels in a certain class or classes. A new thematic layer (image file) is created, which is categorized by the distance of each pixel from specified classes of the input layer. This new file then becomes a new layer of the database and provides a buffer zone around the specified class(es). In further analysis, it may be beneficial to weight other factors, based on whether they fall inside or outside the buffer zone.



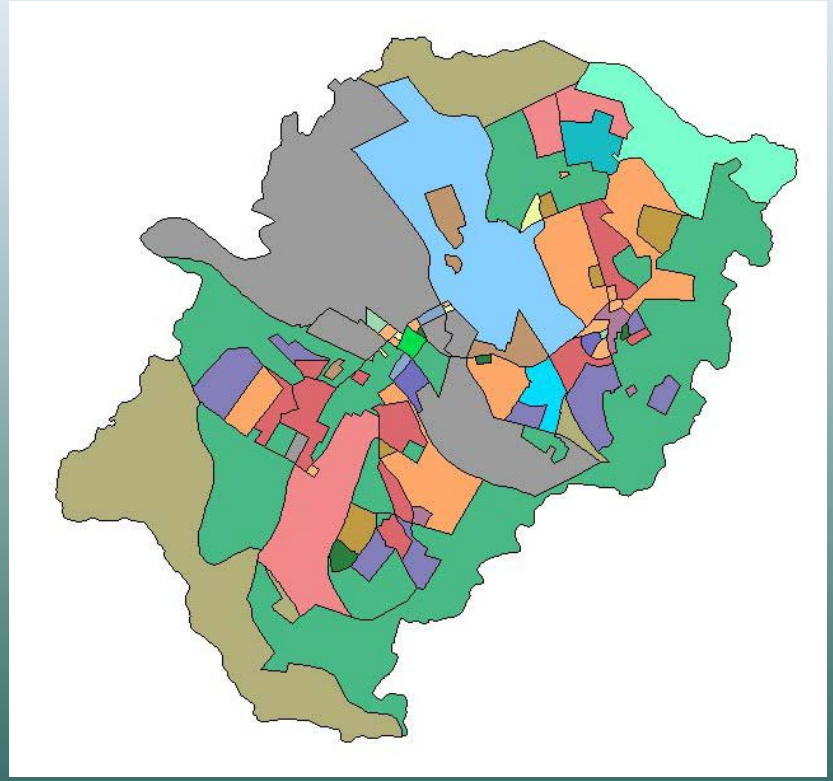
1. 输入分类专题图像的查找分析

对输入的分类专题图像进行临近（proximity）分析，产生一个新的栅格文件、输出像元的属性值取决于其位置与用户选择专题类型像元的接近程度和用户定义的接近距离，输出文件中用户所选择专题类型的属性值重新编码为0，其它相邻区域属性值取决于它们与所选择专题类型像元的欧氏距离。

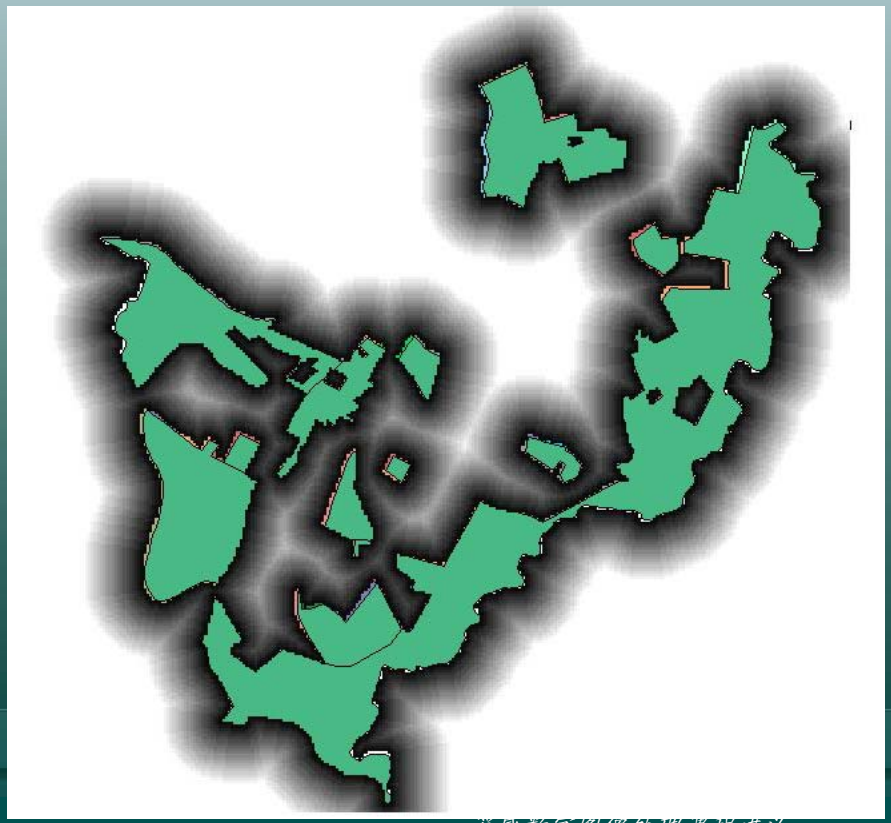




2. 输入矢量图形的查找分析

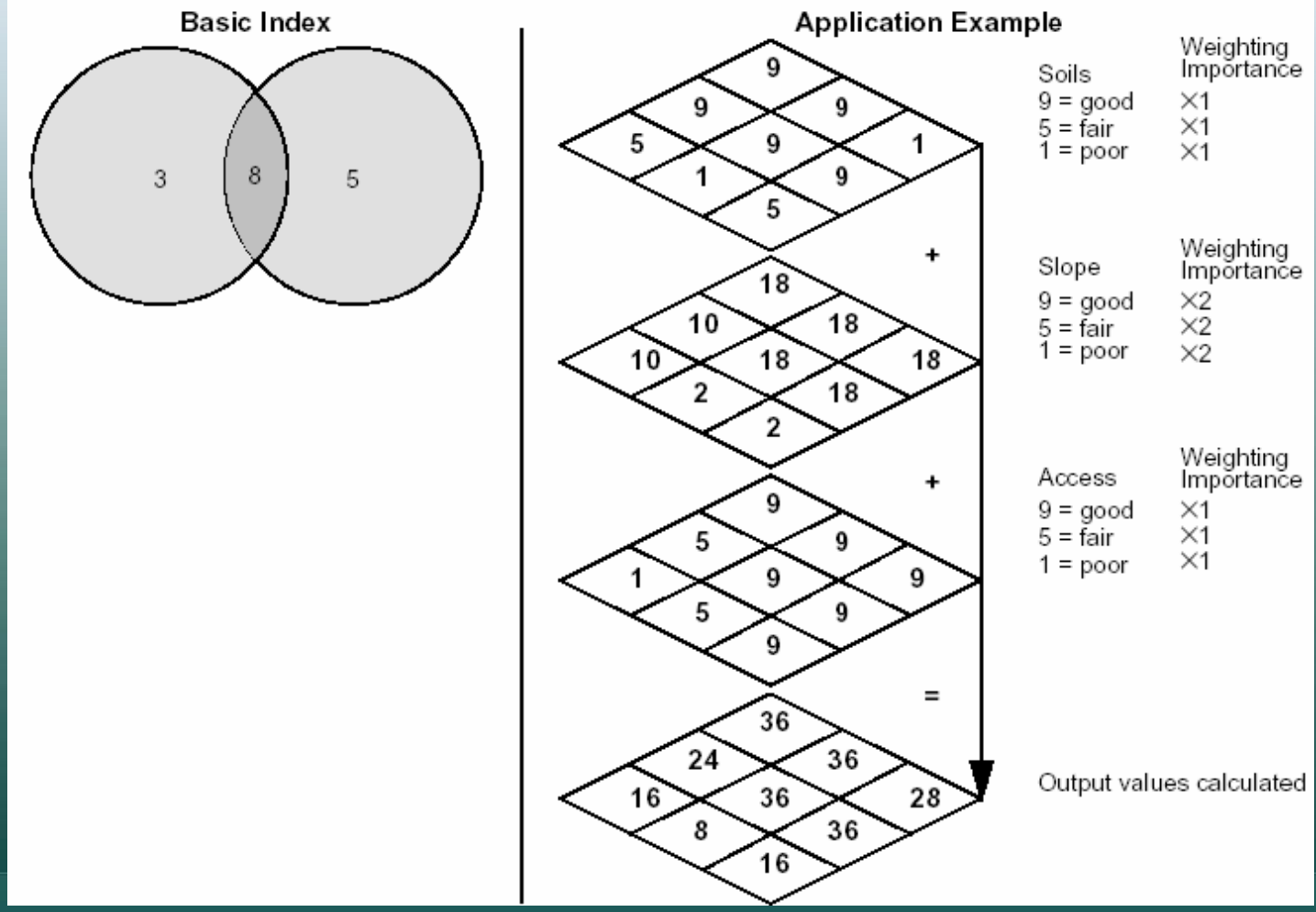


例：矢量多变性**zone88**（**arcinfo coverage**），以属性**zoning**为操作属性，输出像元大小为**100**米的图像。



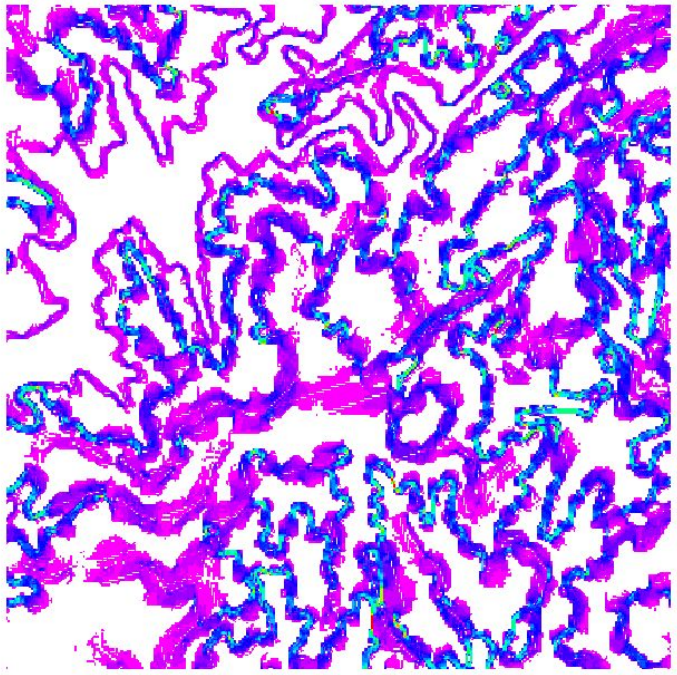
并查找生成距属性为**4**，距离为**20**个像元的图像。

7.1.3 指标分析（index analysis）

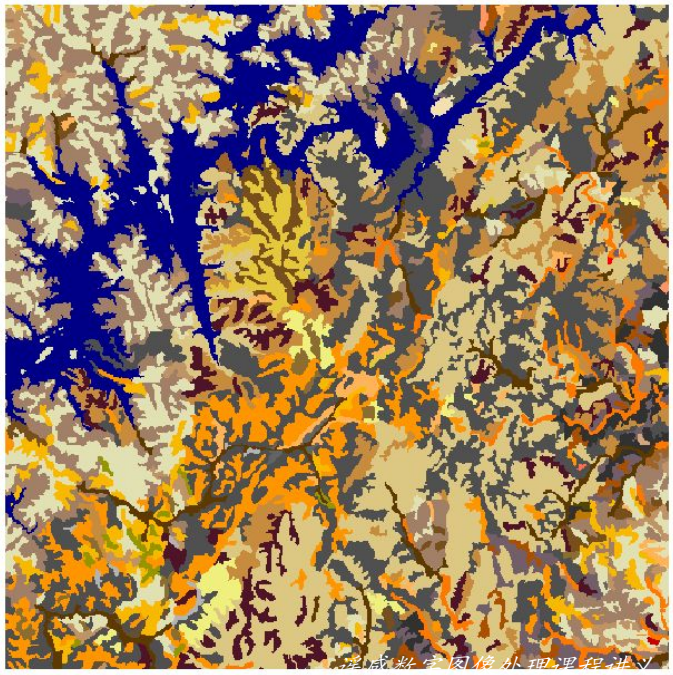


将两个输入分类专题图像或矢量地图数据，按照用户定义的权重因子（**weighting factor**）进行相加，产生一个新的综合图像文件。

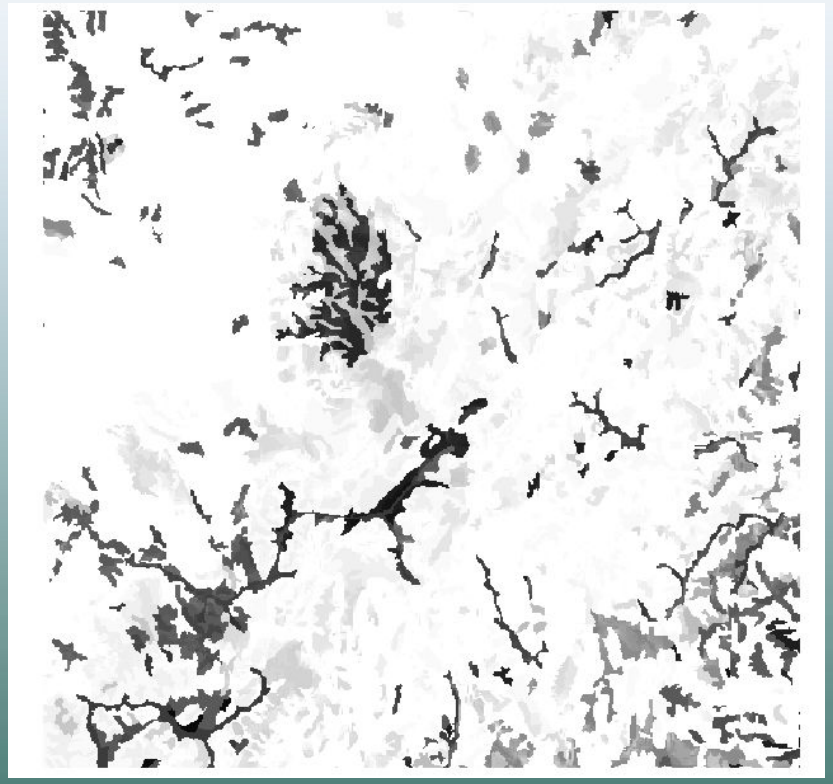
例：坡度分类专题图**inslope.img**与土壤分类专题图像**insoils.img**，分别按照权重因子**5**和**10**进行相加。



坡度图

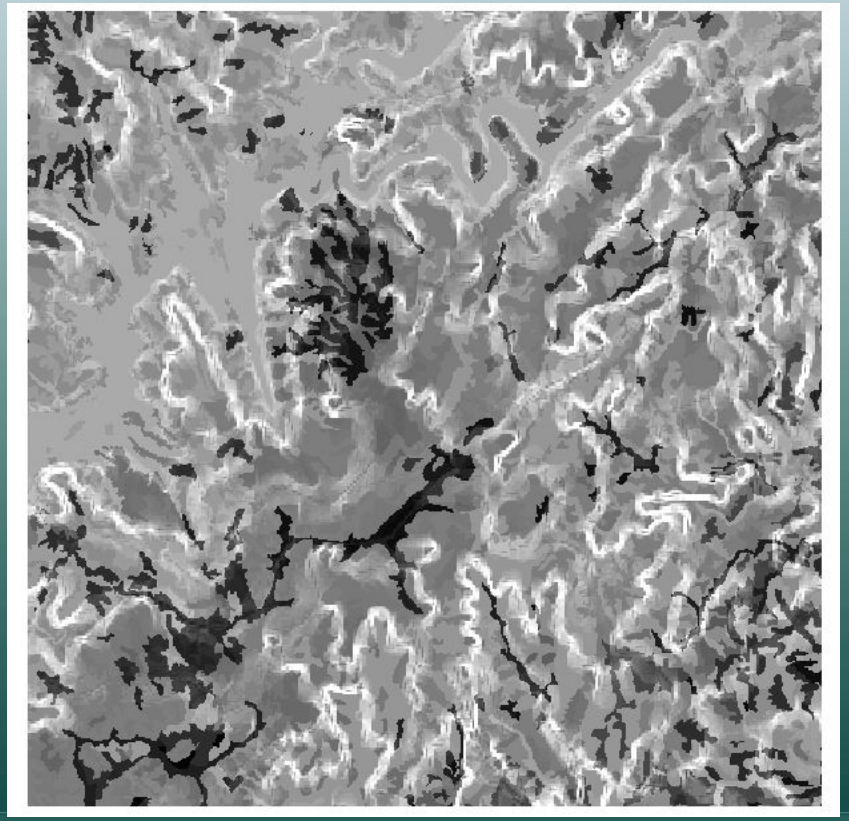


土壤图

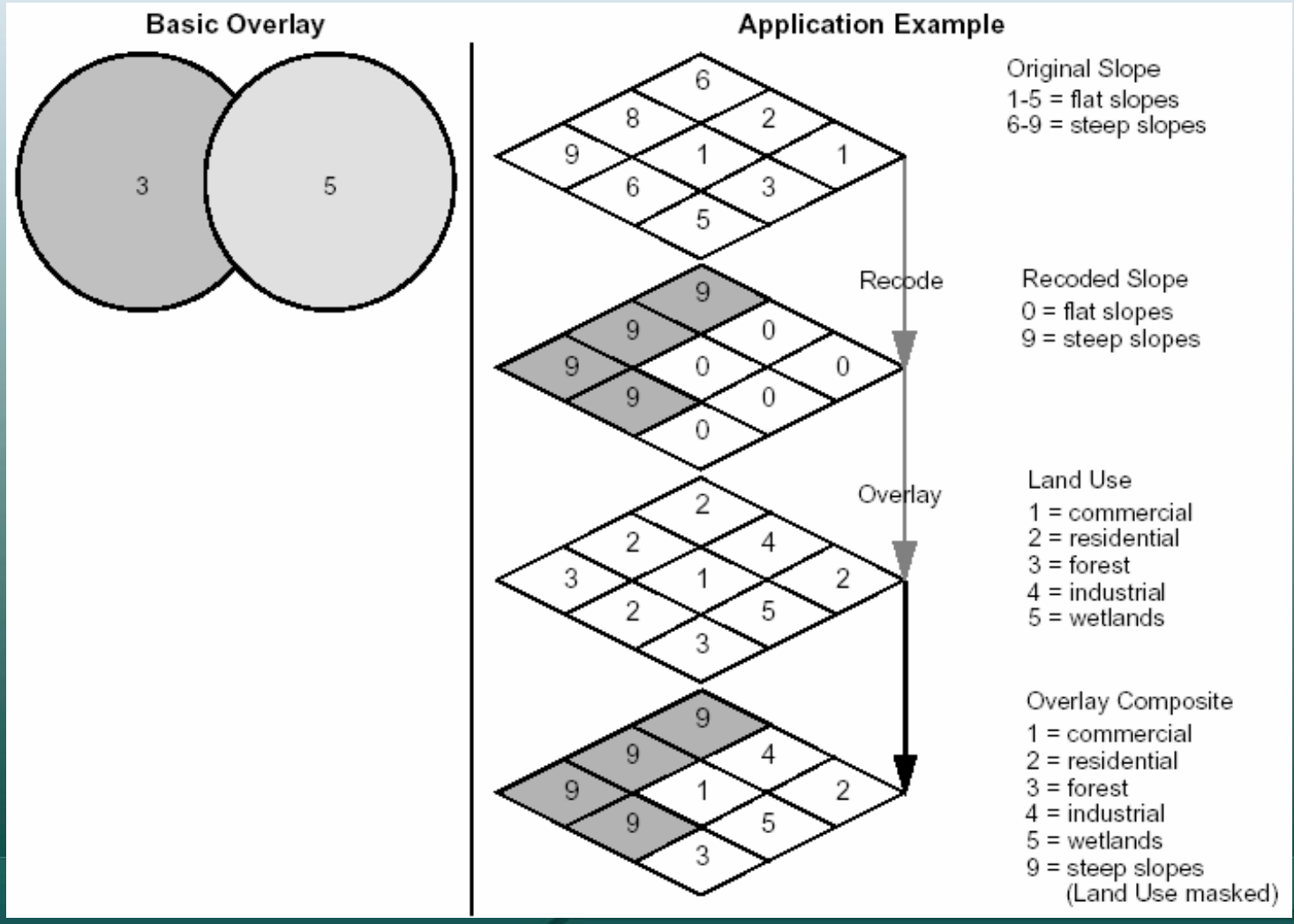


坡度-土壤图

土壤-坡度图

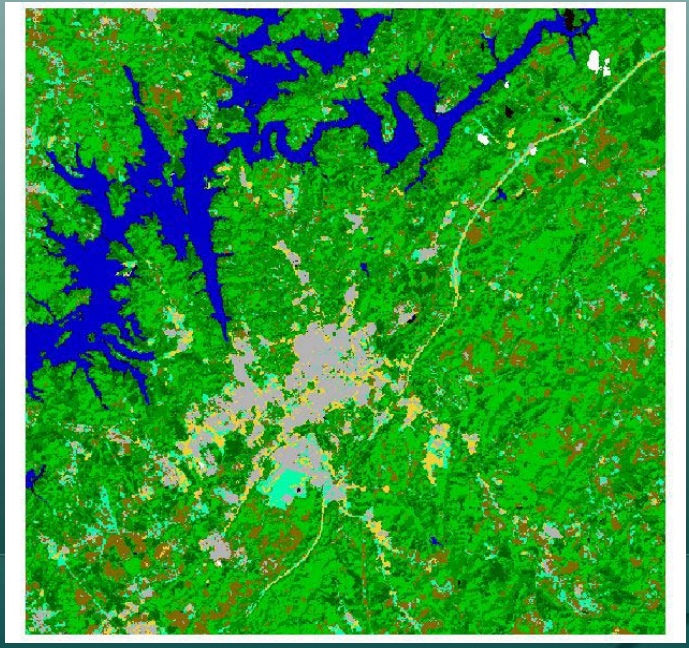


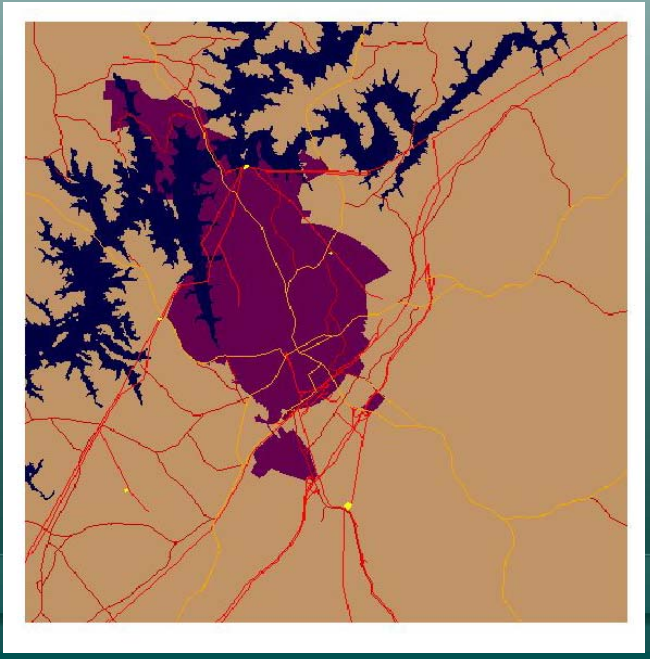
7.1.4 叠加分析（overlay analysis）

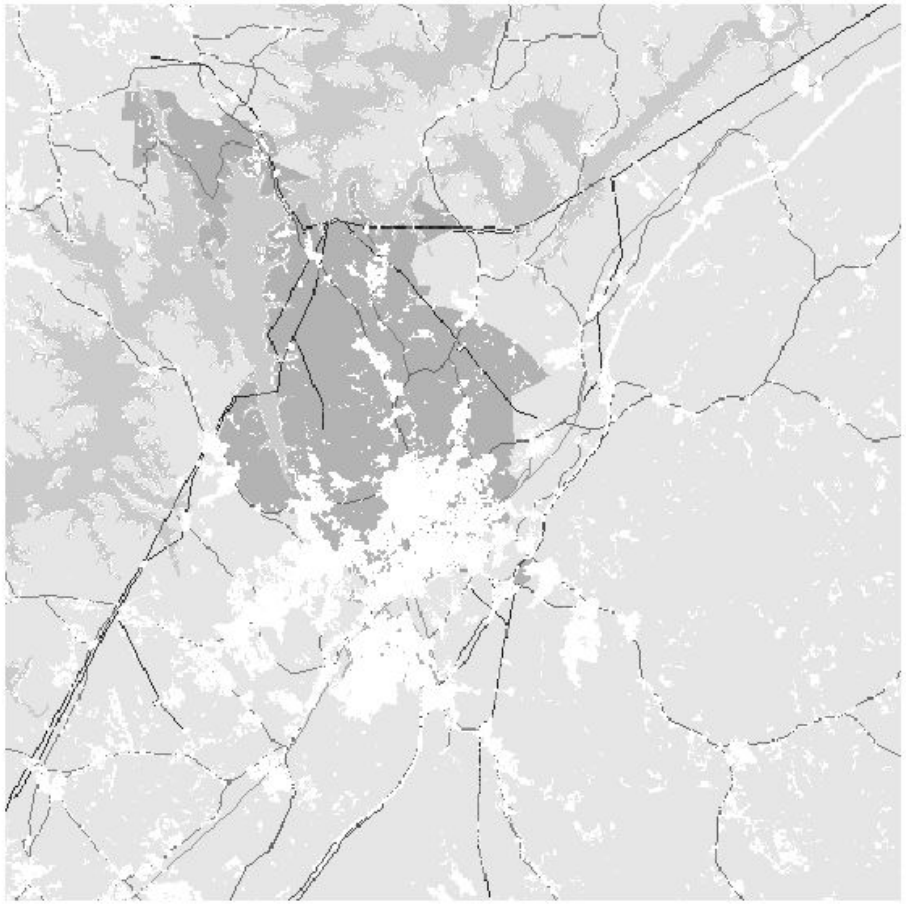


根据两个输入分类专题图像文件或矢量图形文件数据的最小值或最大值，产生一个新的综合图像文件，系统所提供的叠加选择项允许用户提前对数据进行处理，可以根据需要掩膜剔除一定的数值。

例：土地利用分类图和道路交通分类图叠加分析，根据两幅图像的最大值产生新的综合分类专题图。





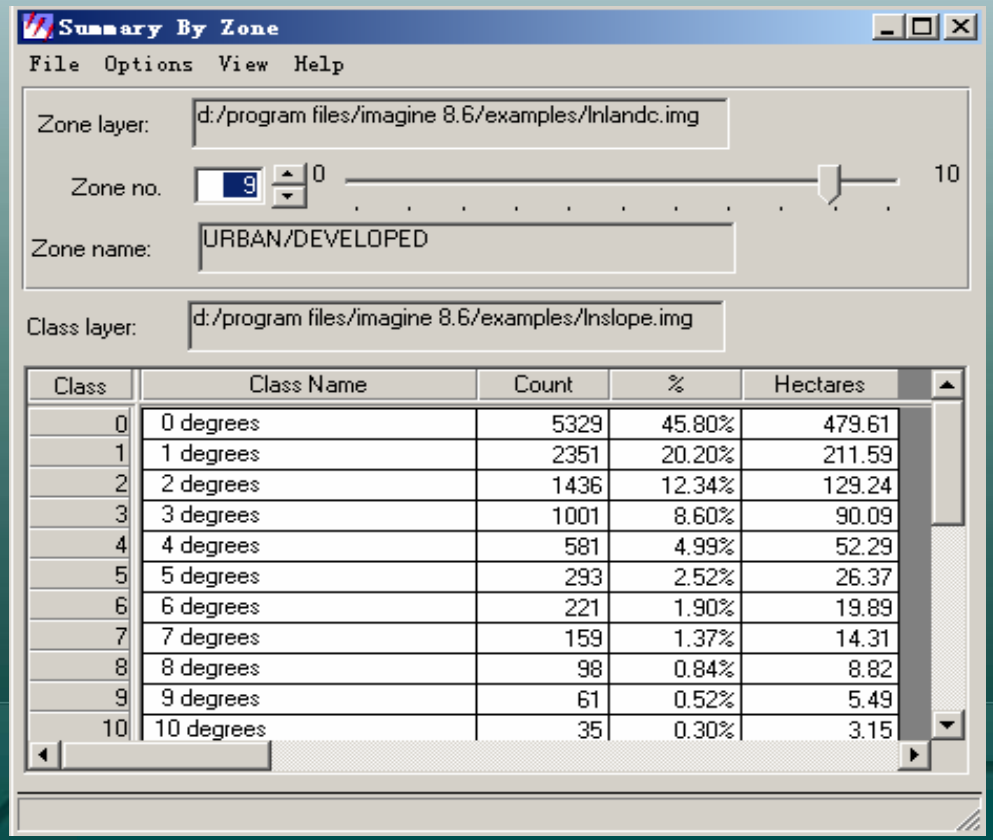


7.1.5 归纳分析（summary analysis）

根据两个输入分类专题产生一个双向统计表格（cross-tabulation输出报告），内容包括每个zone类型区域内所有class类型的像元数量及其面积、百分比等统计值，可用于一定区域内多种专题数据相互关系的栅格叠加统计分析。

例：土地利用分类图和坡度分类图归纳分析，表现每种土地类型的坡度分布情况。

也可选择交互式的统计表格（interactive CellArray)作为输出结果。



Class	Class Name	Count	%	Hectares
0	0 degrees	5329	45.80%	479.61
1	1 degrees	2351	20.20%	211.59
2	2 degrees	1436	12.34%	129.24
3	3 degrees	1001	8.60%	90.09
4	4 degrees	581	4.99%	52.29
5	5 degrees	293	2.52%	26.37
6	6 degrees	221	1.90%	19.89
7	7 degrees	159	1.37%	14.31
8	8 degrees	98	0.84%	8.82
9	9 degrees	61	0.52%	5.49
10	10 degrees	35	0.30%	3.15

将两个输入分类专题图或矢量地图数据，按照其专题属性在空间上的重叠性产生一个新的图像文件，新文件包含两个输入文件中重叠的专题属性，用矩阵描述最形象：

		input layer 2 data values (columns)					
		0	1	2	3	4	5
input layer 1 data values (rows)	0	0	0	0	0	0	0
	1	0	1	2	3	4	5
	2	0	6	7	8	9	10
	3	0	11	12	13	14	15

Unlike overlaying or indexing, the resulting class values of a matrix operation are unique for each coincidence of two input class values. In this example, the output class value at column 1, row 3 is 11, and the output class at column 3, row 1 is 3. If these files were indexed (summed) instead of matrixed, both combinations would be coded to class 4.

7.2 地形分析方法（terrain analysis）

遥感影像承载着丰富的地形、地物等方面的信息，是地学分析应用领域不可或缺的信息源。

Topographic data are essential for studies of trafficability, route design, nonpoint source pollution, intervisibility, siting of recreation areas, etc. Especially useful are products derived from topographic data. These include:

• slope images—illustrates changes in elevation over distance. Slope images are usuallycolor-coded according to the steepness of the terrain at each pixel.

• aspect images—illustrates the prevailing direction that the slope faces at each pixel.

• shaded relief images—illustrates variations in terrain by differentiating areas that would be illuminated or shadowed by a light source simulating the sun.

地形分析就是指在点、线、面高程基础上，对各种地形因素进行分析，并对图像进行地形校正。各种操作都是以DEM为基础的。

地形分析的用途

Topographic data and its derivative products have many applications, including:

• calculating the shortest and most navigable path over a mountain range for constructing a road or routing a transmission line

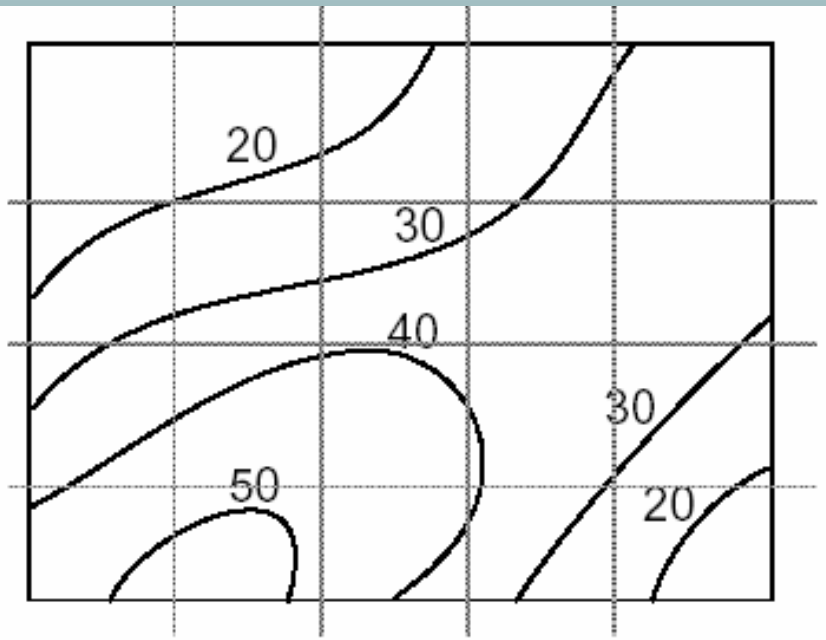
• determining rates of snow melt based on variations in sun shadow, which is influenced by slope, aspect, and elevation

Terrain data are often used as a component in complex GIS modeling or classification routines.

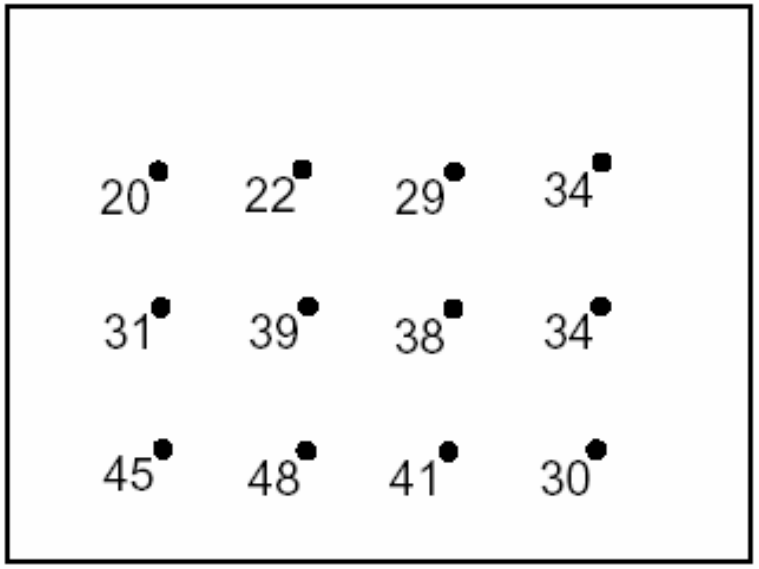
They can, for example, be a key to identifying wildlife habitats that are associated with specific elevations. Slope and aspect images are often an important factor in assessing the suitability of a site for a proposed use. Terrain data can also be used for vegetation classification based on
species that are terrain-sensitive (e.g., Alpine vegetation).

7.2.1 高程图像数据生成

将ASCII码点文件、ArcInfo的coverage点文件和线文件等插值生成表面文件（surface）。ERDAS采用TIN插值，包括线性（一次多项式）插值和非线性（五次多项式）插值。



Topographic image with grid overlay



DEM or regularly spaced terrain data points (Z values)

7.2.2 坡度分析（slope ）

Pixel X,Y has elevation e

a	b	c
d	e	f
g	h	i

a,b,c,d,f,g,h, and i are the elevations of the pixels around it in a 3 X 3 window.

10 m	20 m	25 m
22 m	30 m	25 m
20 m	24 m	18 m

$$\Delta x_1 = c - a \qquad \Delta y_1 = a - g$$
$$\Delta x_2 = f - d \qquad \Delta y_2 = b - h$$
$$\Delta x_3 = i - g \qquad \Delta y_3 = c - i$$

$$\Delta x = (\Delta x_1 + \Delta x_2 + \Delta x_3)/3 \times x_s$$
$$\Delta y = (\Delta y_1 + \Delta y_2 + \Delta y_3)/3 \times y_s$$

$a...i$	=	elevation values of pixels in a 3×3 window, as shown above
x_s	=	x pixel size = 30 meters
y_s	=	y pixel size = 30 meters

$$s = \frac{\sqrt{(\Delta x)^2 + (\Delta y)^2}}{2}$$

$$slope\ in\ degrees = \tan^{-1}(s) \times \frac{180}{\pi}$$

举例

10 m	20 m	25 m
22 m		25 m
20 m	24 m	18 m

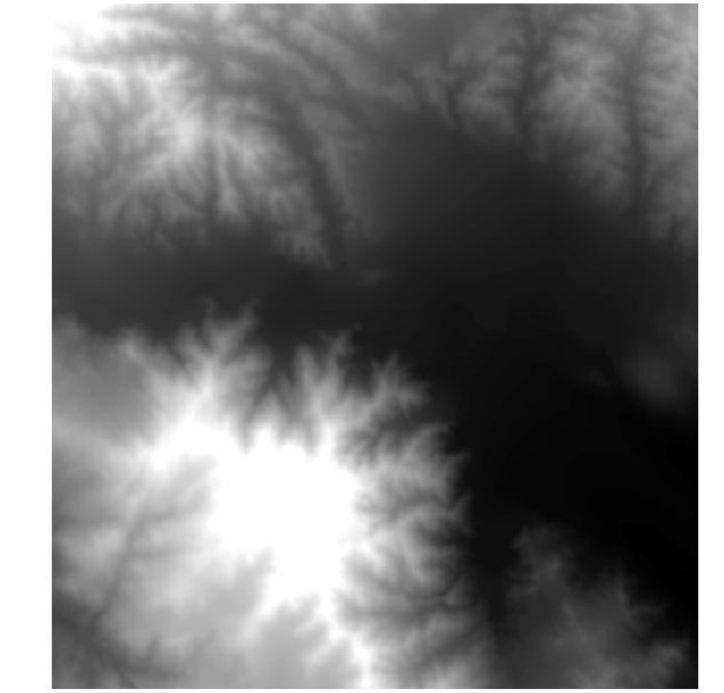
$$\Delta x_1 = 25 - 10 = 15$$
$$\Delta x_2 = 25 - 22 = 3$$
$$\Delta x_3 = 18 - 20 = -2$$

$$\Delta y_1 = 10 - 20 = -10$$
$$\Delta y_2 = 20 - 24 = -4$$
$$\Delta y_3 = 25 - 18 = 7$$

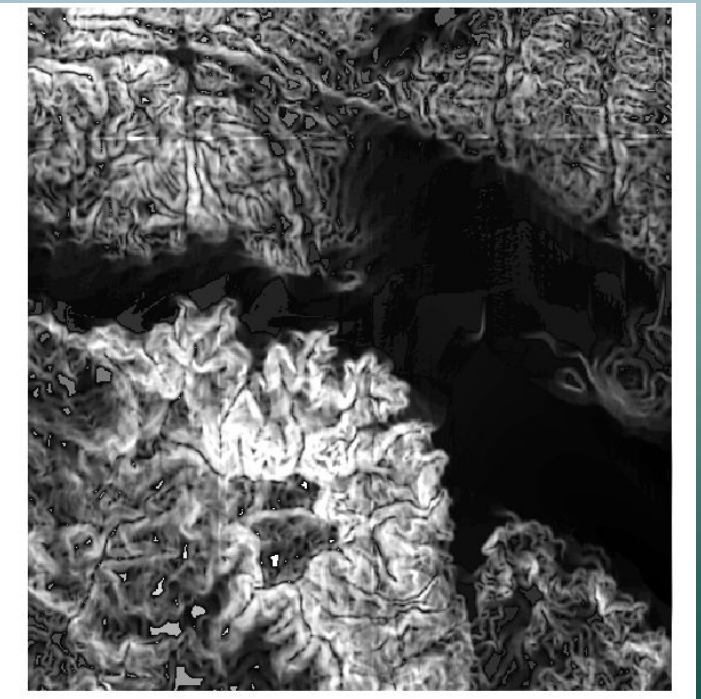
$$\Delta x = \frac{15 + 3 - 2}{30 \times 3} = 0.177 \qquad \Delta y = \frac{-10 - 4 + 7}{30 \times 3} = -0.078$$

$$slope\ in\ degrees = \tan^{-1}(s) \times \frac{180}{\pi} = \tan^{-1}(0.0967) \times 57.30 = 5.54$$

前提：DEM图像必须是具有投影地理坐标，而且其中高程数据及其单位是已知的。如果DEM图像中平面坐标为经纬度（角度）、而高程坐标为距离单位，坡度分析将无法进行。



DEM



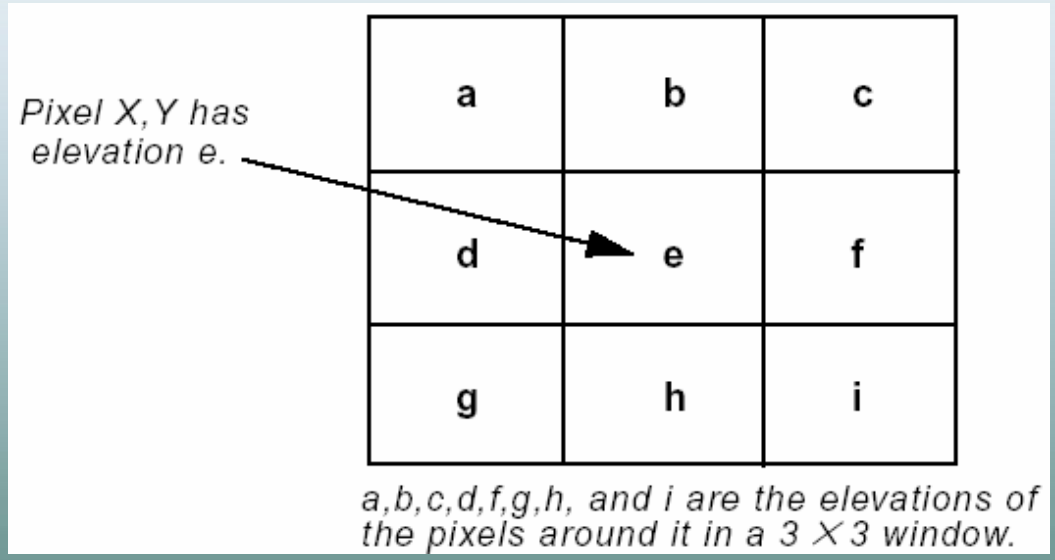
SLOPE

7.2.3 坡向分析（aspect ）

An aspect image is an image file that is gray scale coded according to the prevailing direction of the slope at each pixel. Aspect is expressed in degrees from north, clockwise, from 0 to 360.

Due north is 0 degrees. A value of 90 degrees is due east, 180 degrees is due south, and 270 degrees is due west. A value of 361 degrees is used to identify flat surfaces such as water bodies.

Aspect files are used in many of the same applications as slope files. In transportation planning, for example, north facing slopes are often avoided. Especially in northern climates, these would be exposed to the most severe weather and would hold snow and ice t longest. It would be possible to recode all pixels with north facing aspects as undesirable for road building.



$$\Delta x_1 = c - a \qquad \Delta y_1 = a - g$$
$$\Delta x_2 = f - d \qquad \Delta y_2 = b - h$$
$$\Delta x_3 = i - g \qquad \Delta y_3 = c - i$$

$$\Delta y = (\Delta y_1 + \Delta y_2 + \Delta y_3)/3$$

$$\Delta x = (\Delta x_1 + \Delta x_2 + \Delta x_3)/3$$

If $\Delta x = 0$ and $\Delta y = 0$, then the aspect is flat (coded to 361 degrees). Otherwise, θ is calculated as:

$$\theta = \tan^{-1}\left(\frac{\Delta x}{\Delta y}\right)$$

Note that θ is calculated in radians.

Then, aspect is 180 + θ (in degrees).

举例

10 m	20 m	25 m
22 m		25 m
20 m	24 m	18 m

$$\Delta x_1 = 25 - 10 = 15$$
$$\Delta x_2 = 25 - 22 = 3$$
$$\Delta x_3 = 18 - 20 = -2$$

$$\Delta y_1 = 10 - 20 = -10$$
$$\Delta y_2 = 20 - 24 = -4$$
$$\Delta y_3 = 25 - 18 = 7$$

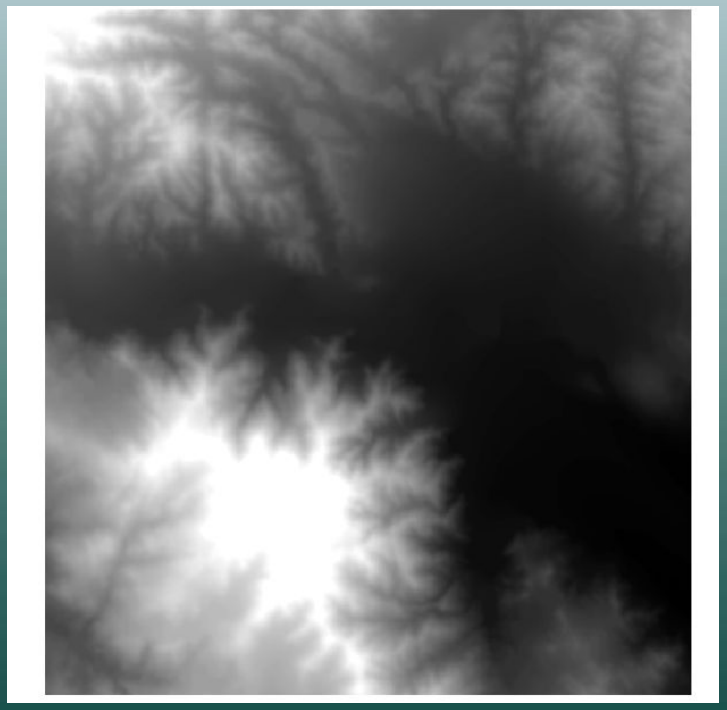
$$\Delta x = \frac{15 + 3 - 2}{3} = 5.33 \qquad \Delta y = \frac{-10 - 4 + 7}{3} = -2.33$$

$$\theta = \tan^{-1}\left(\frac{5.33}{-2.33}\right) = 1.98$$

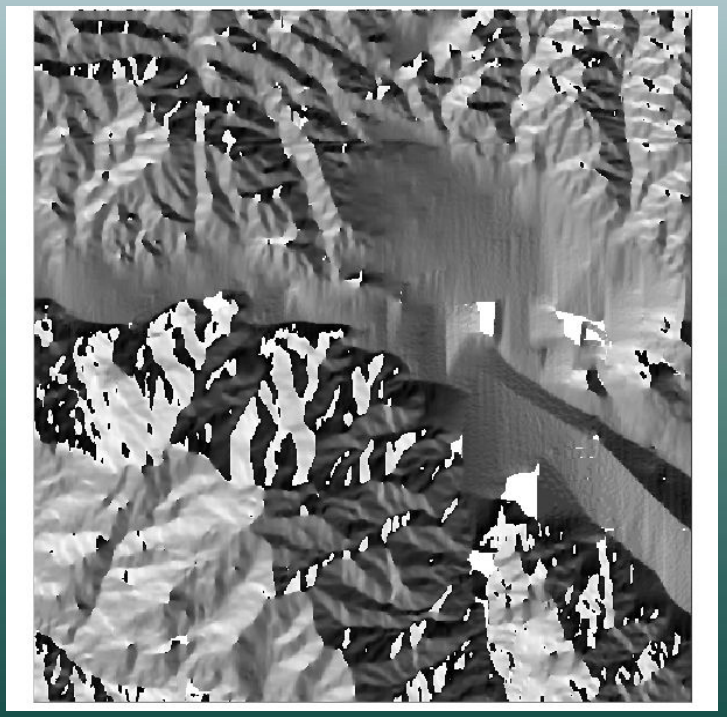
1.98 radians = 113.6 degrees

aspect = 180 + 113.6 = 293.6 degrees

以DEM数据为基础进行地形坡向分析时，输出图像有两种类：连续色调（continuous）和专题地图（thematic）。



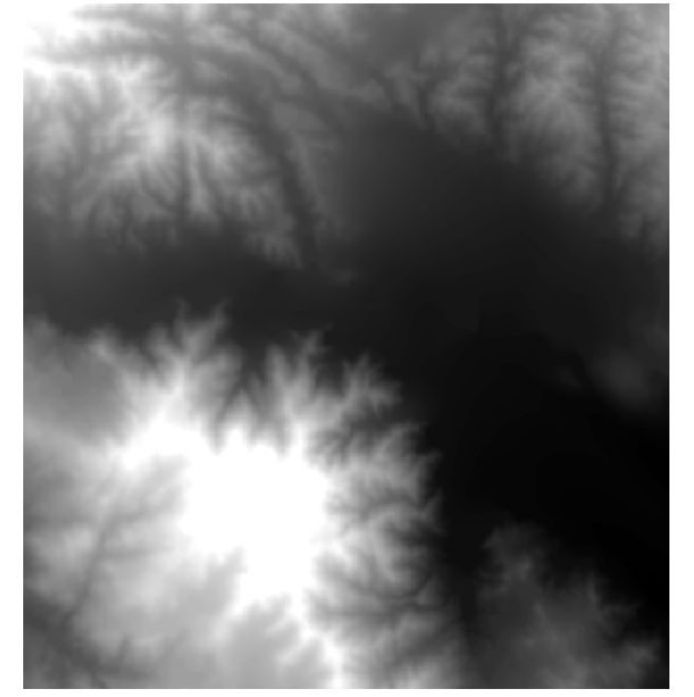
DEM



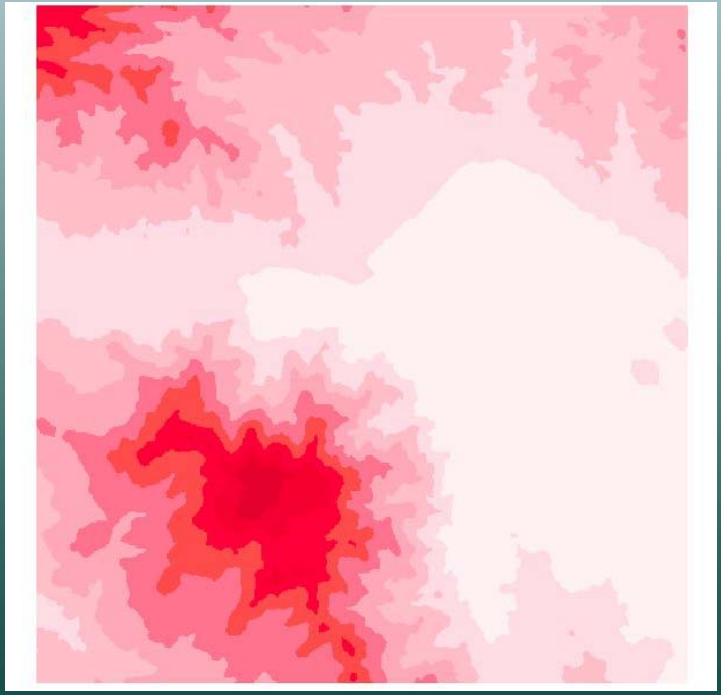
ASPECT

7.2.4 高程分带（level slice）

按照用户定义的分级表对DEM数据或其它图像数据进行分带（分类或分级），每个分带中的数据间隔相等。对于DEM数据，这种处理就是高程分带，而对于其它遥感图像，这种处理相当于进行专题分类（或分级）。



DEM



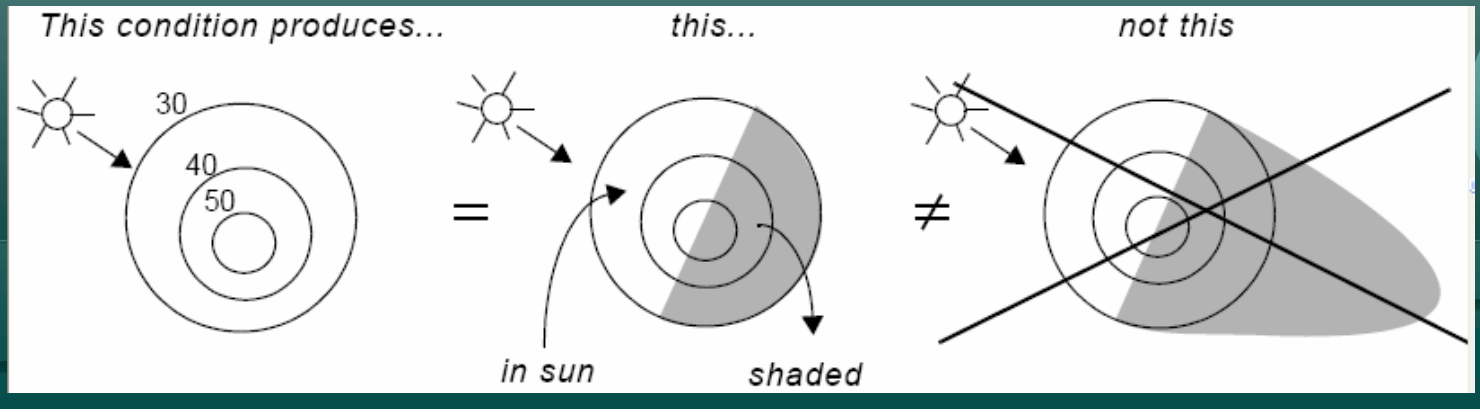
LEVEL

7.2.5 地形阴影（shaded relief）

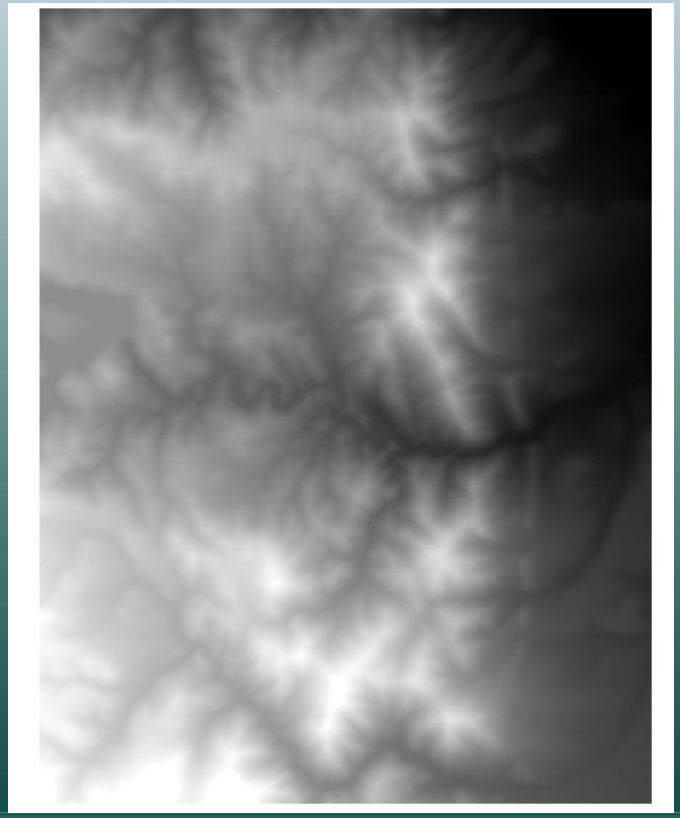
A shaded relief image provides an illustration of variations in elevation. Based on a user specified position of the sun, areas that would be in sunlight are highlighted and areas that would be in shadow are shaded. Shaded relief images are generated from an elevation surface, alone or in combination with an image file draped over the terrain.

It is important to note that the relief program identifies shadowed areas—i.e., those that are not in direct sun. It does not calculate the shadow that is cast by topographic features onto the surrounding surface.

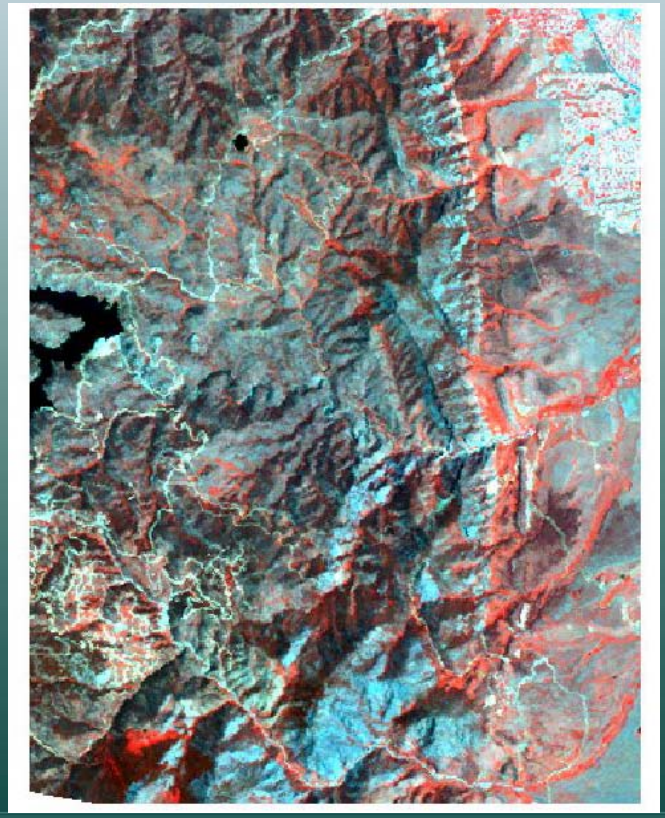
For example, a high mountain with sunlight coming from the northwest would be symbolized as follows in shaded relief. Only the portions of the mountain that would be in shadow from a northwest light would be shaded. The software would not simulate a shadow that the mountain would cast on the southeast side.



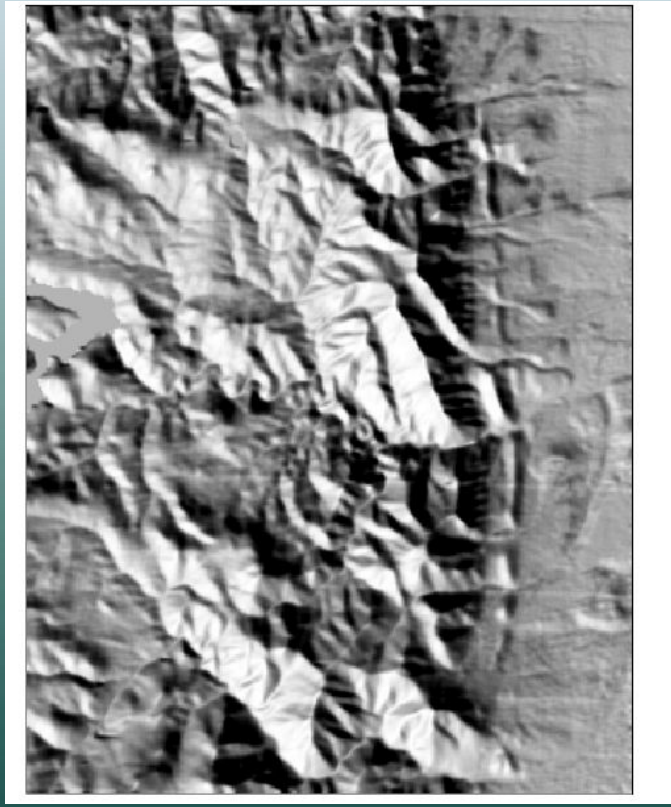
以DEM栅格数据为基础，在一定的光照条件下生成地形阴影图像（地势图）。如果需要在地形阴影图上叠加其它图像数据层，可以确定叠加图像，产生具有地形阴影的影像图。



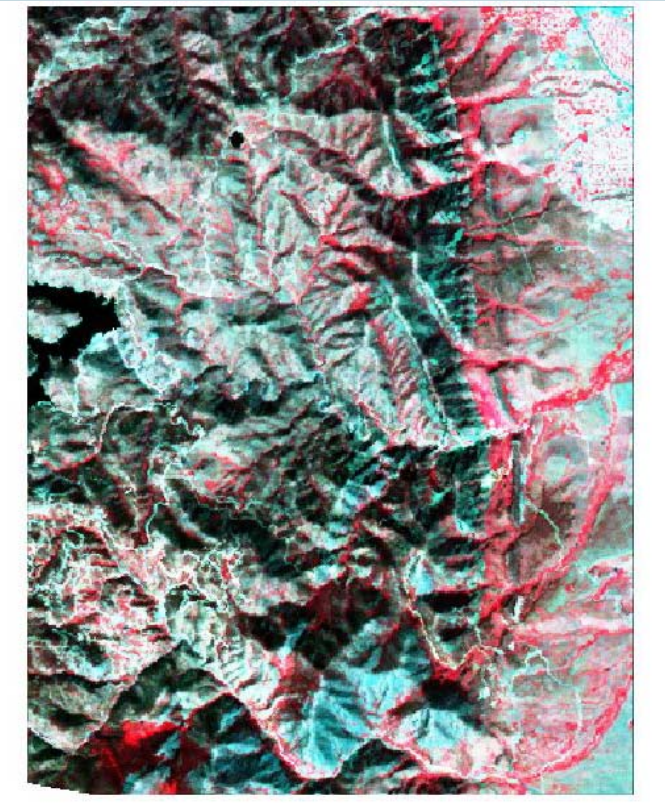
DEM



叠加图像



SHADE



SHADED后的叠加图像

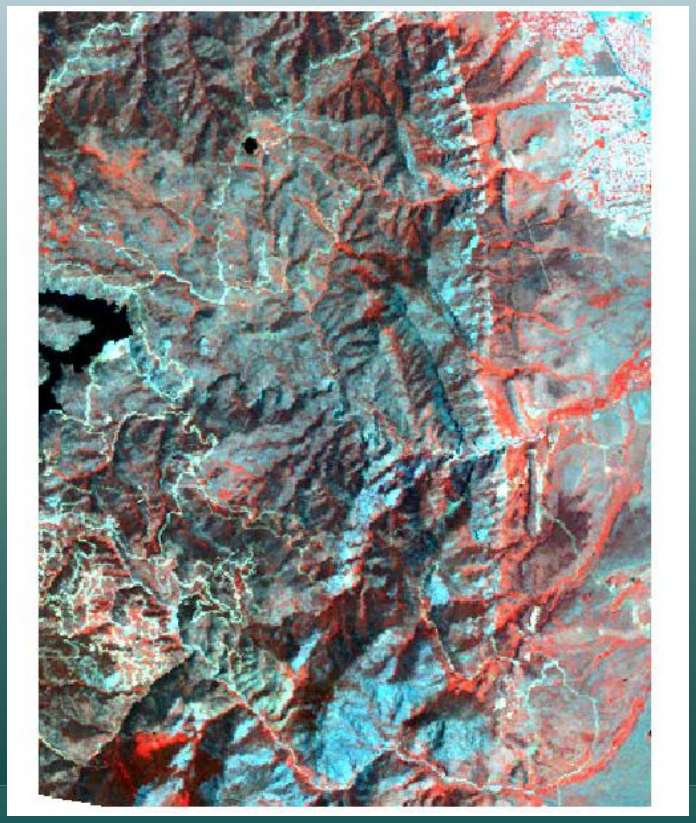
7.2.6 地形校正处理（topographic normalize）

Digital imagery from mountainous regions often contains a radiometric distortion known as topographic effect. Topographic effect results from the differences in illumination due to the angle of the sun and the angle of the terrain. This causes a variation in the image brightness values. Topographic effect is a combination of:

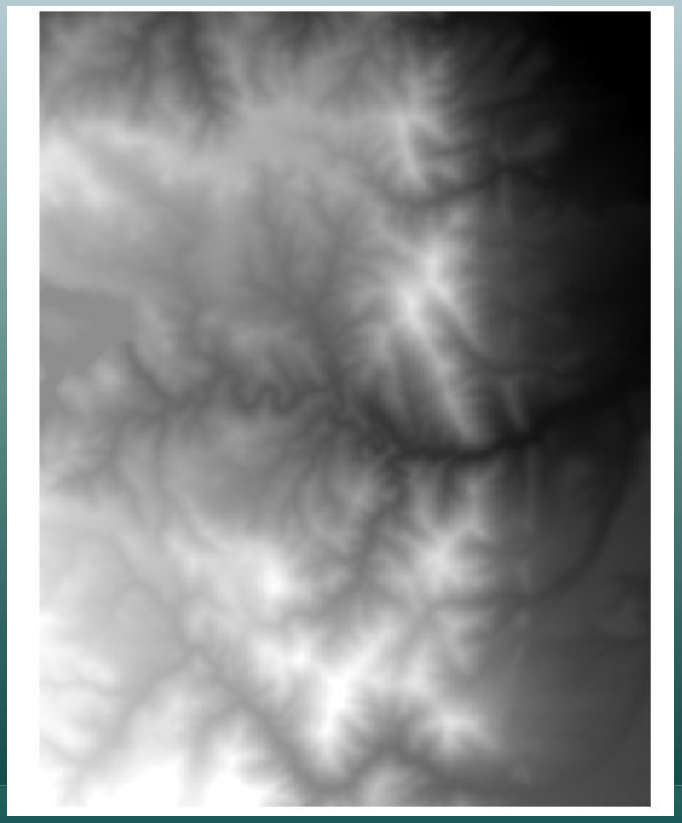
- incident illumination —the orientation of the surface with respect to the rays of the sun
- exitance angle— the amount of reflected energy as a function of the slope angle
- surface cover characteristics— rugged terrain with high mountains or steep slopes

One way to reduce topographic effect in digital imagery is by applying transformations based on the Lambertian or Non-Lambertian reflectance models. These models normalize the imagery, which makes it appear as if it were a flat surface.

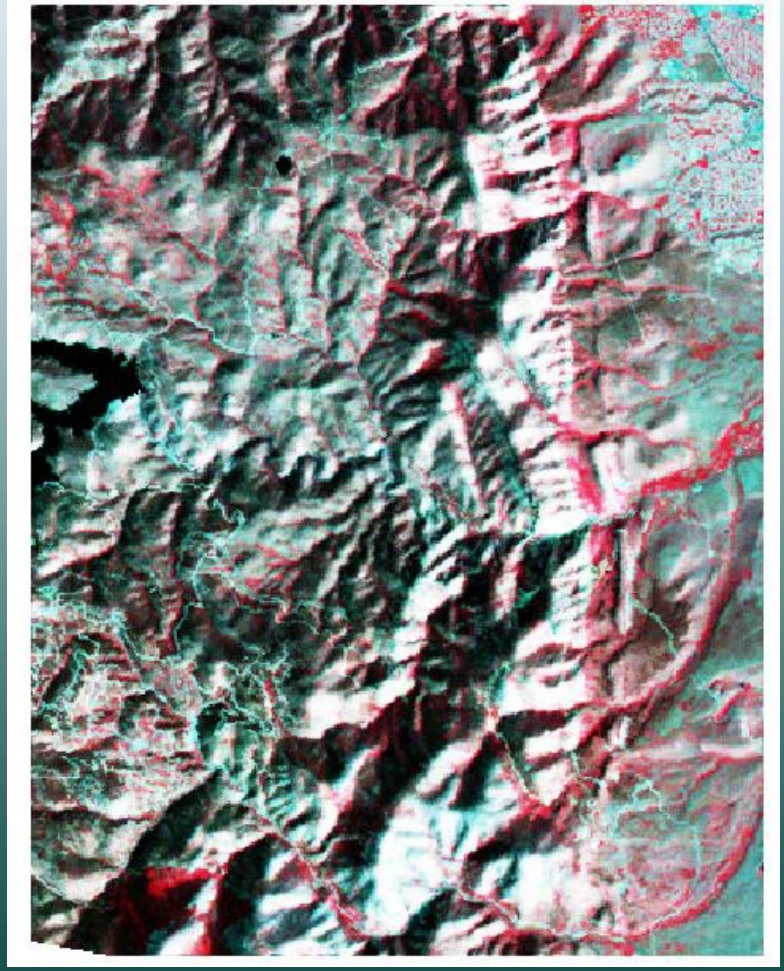
应用朗伯体或非朗伯体反射模型来消除地形对遥感图像的影响。太阳高度角和方位角参数信息通常包含在图像的头文件（**header**）中，可以在图像分发商那里获得。



原图像



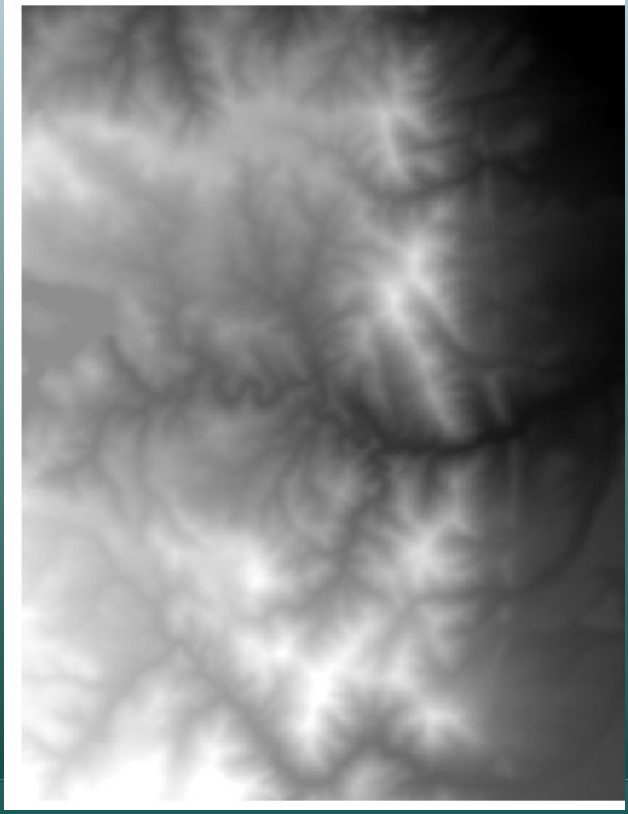
DEM



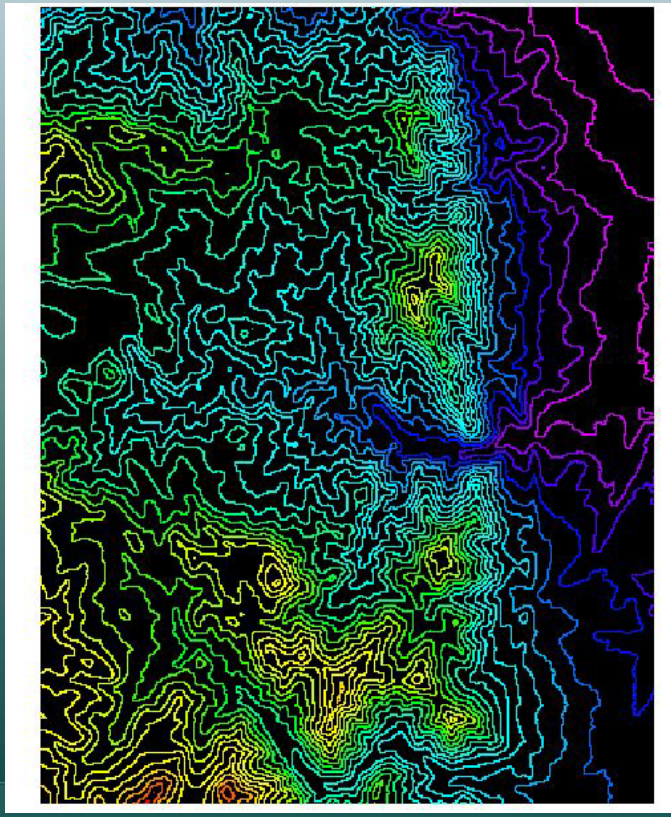
地形校正后的图像

7.2.7 栅格等高线（raster contour）

以DEM栅格数据为基础产生栅格等高线图。推而广之，如果输入图像是温度模型可以产生等温线，如果是数字环境模型，可以产生环境等值线等等。



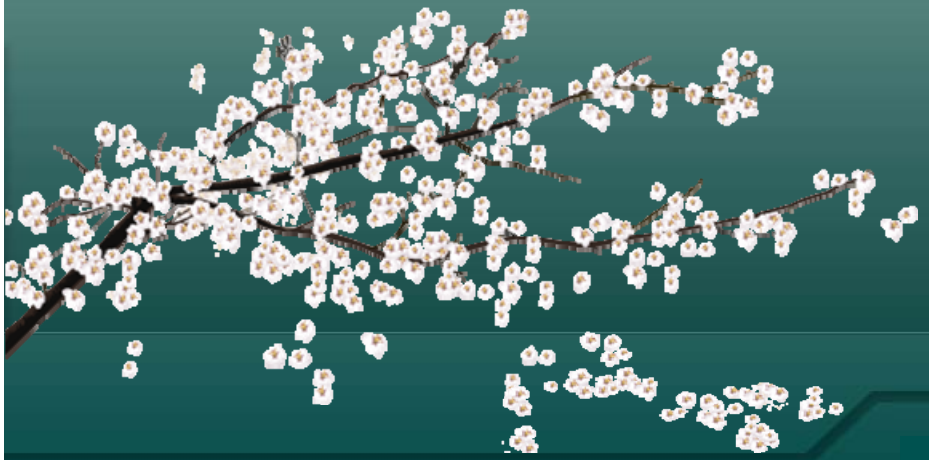
DEM



CONTOUR

谢　　谢！

Thank you very much



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