Raster Analysis

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Today's programme:

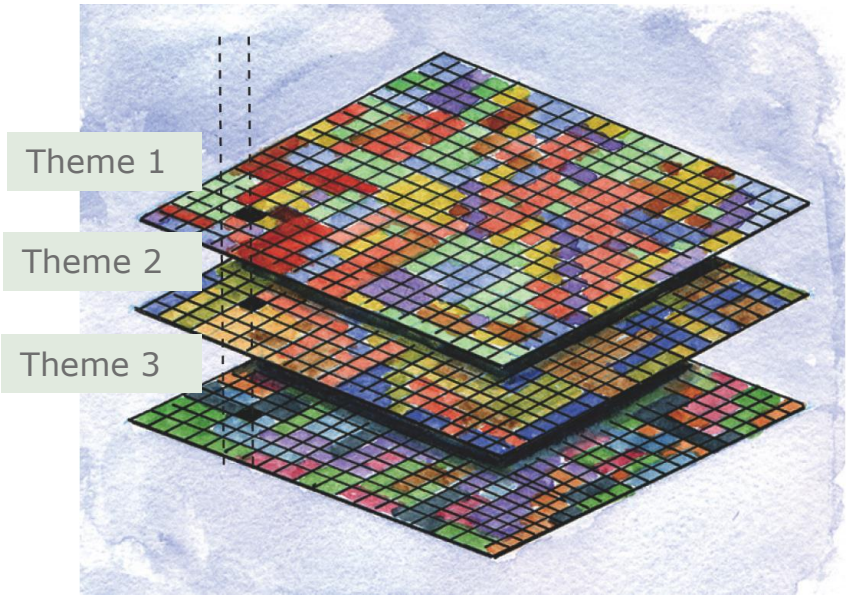
9.00-9.45 AM: Lecture on Raster Analysis, part 1
9.55-10.20 AM: Lecture on Raster Analysis, part 2
10.25-11.00 AM: Lecture on Cost Distance analysis
11.00-12.00 AM: Exercise

12.00 AM – 1.00 PM: Lunch break

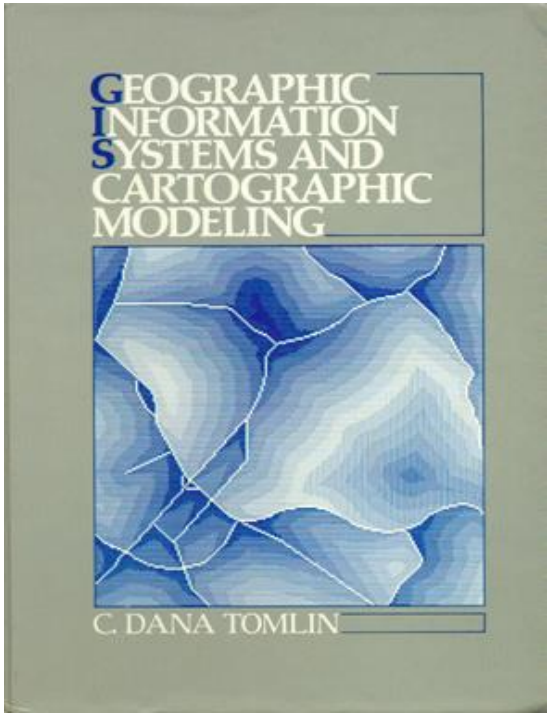
1.00-2.00 PM: Exercise continued
2.00-2.35 PM: Lecture on datasets involved in the exercise
2.35-3.45 PM: Exercise continued
3.45-4.00 PM: Wrap up

Agenda

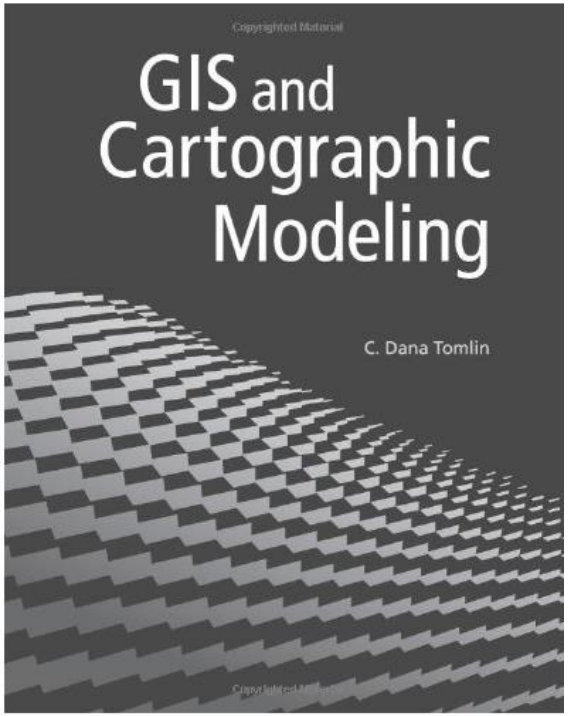
- Introduction to the raster based GIS-datamodel
- When to use it?
- How to use it?
- Map Algebra and cartographic modelling
- Analysis examples



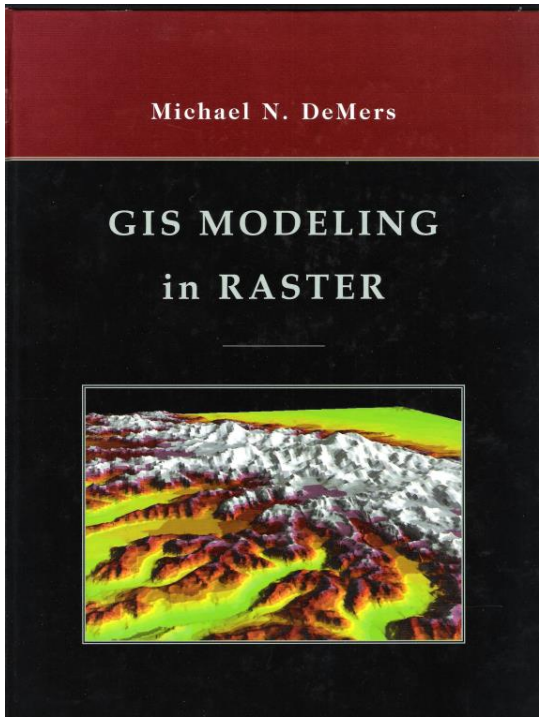
Literature



1990

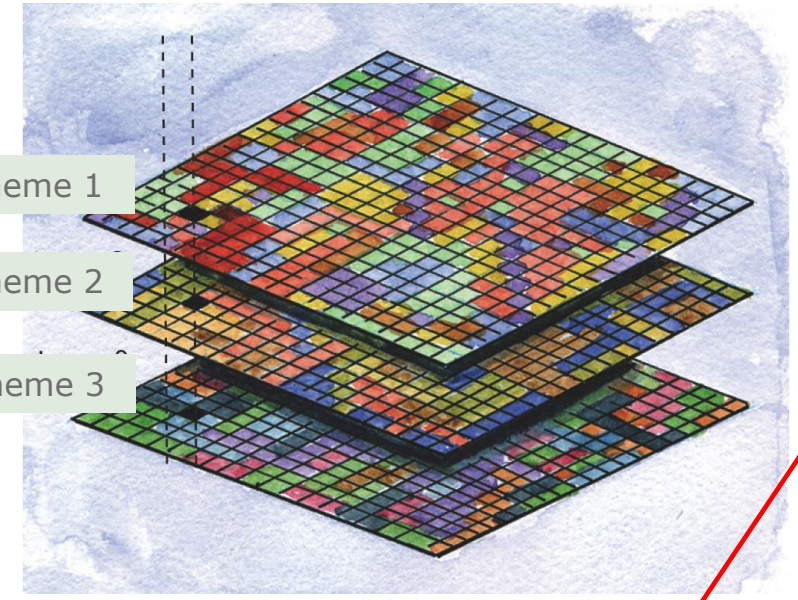


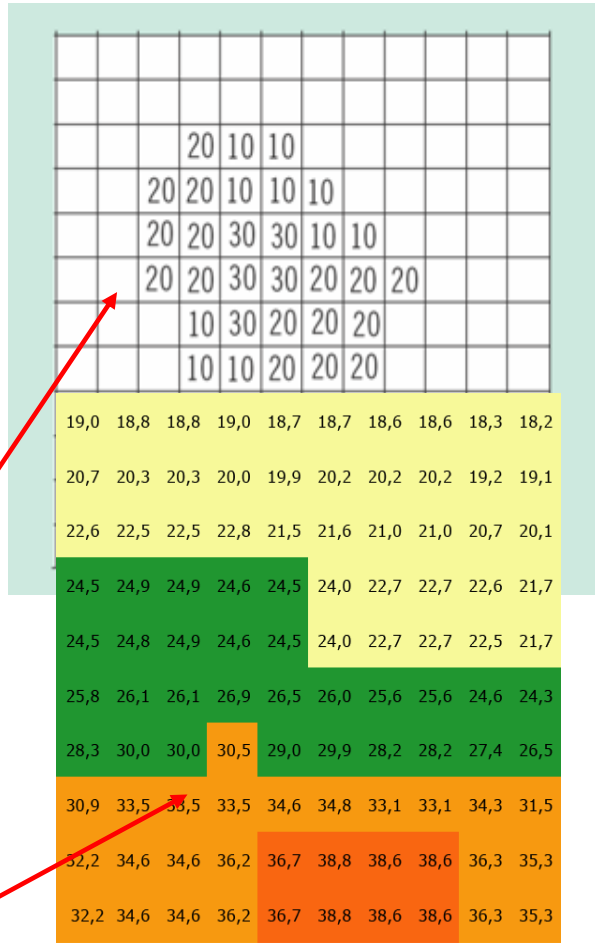
2013



2002

Raster data – qualitative vs. quantitative data sets





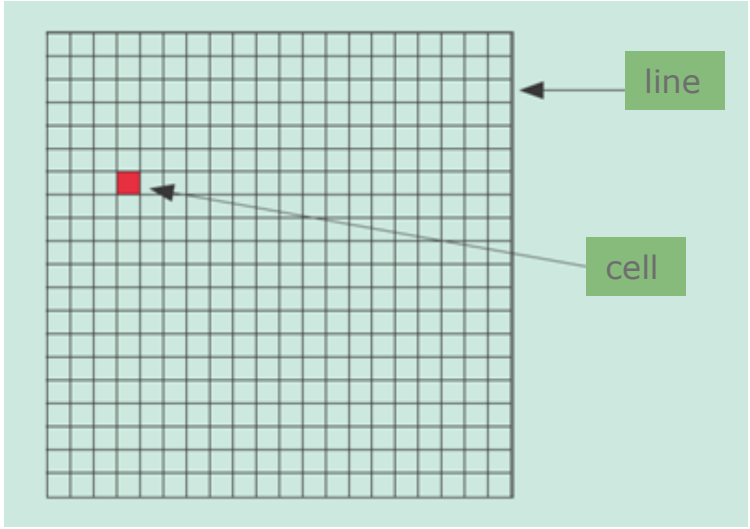
10 = agriculture
20 = forest
30 = urban

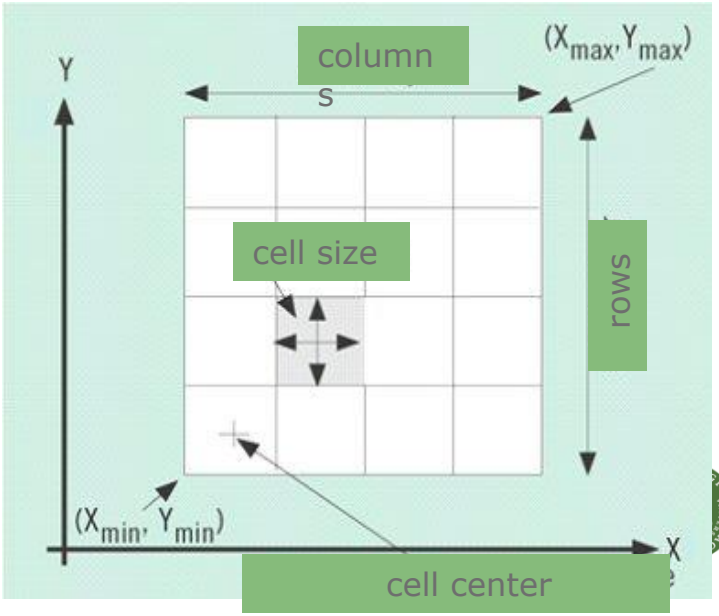
Qualitative (discontinuous) data set: integers to represent a class relationship – like land use

Quantitative (continuous) data set: values according to a linear, calibrated scale – like terrain elevations relative to a vertical datum

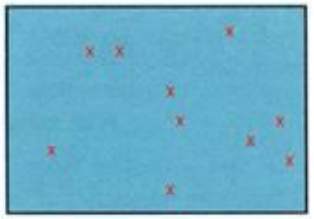
Raster - definitions

- A cell is referenced by a row/column-position
- All cells in a raster have the same geometric shape and size (spatial resolution)
- If the number of rows and columns, the size of one cell and its orientation are known, the world coordinates to all other cells can be derived
- The topology is implicit – the neighbours are easily identified

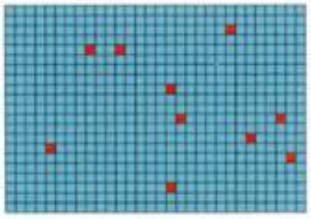




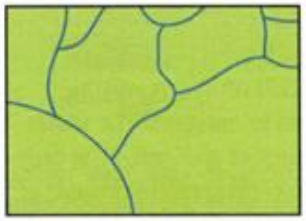
Vector vs. raster?



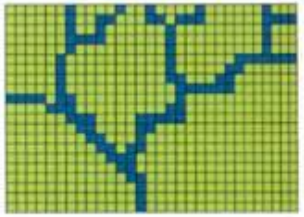
Point features



Raster point features



Polyline features



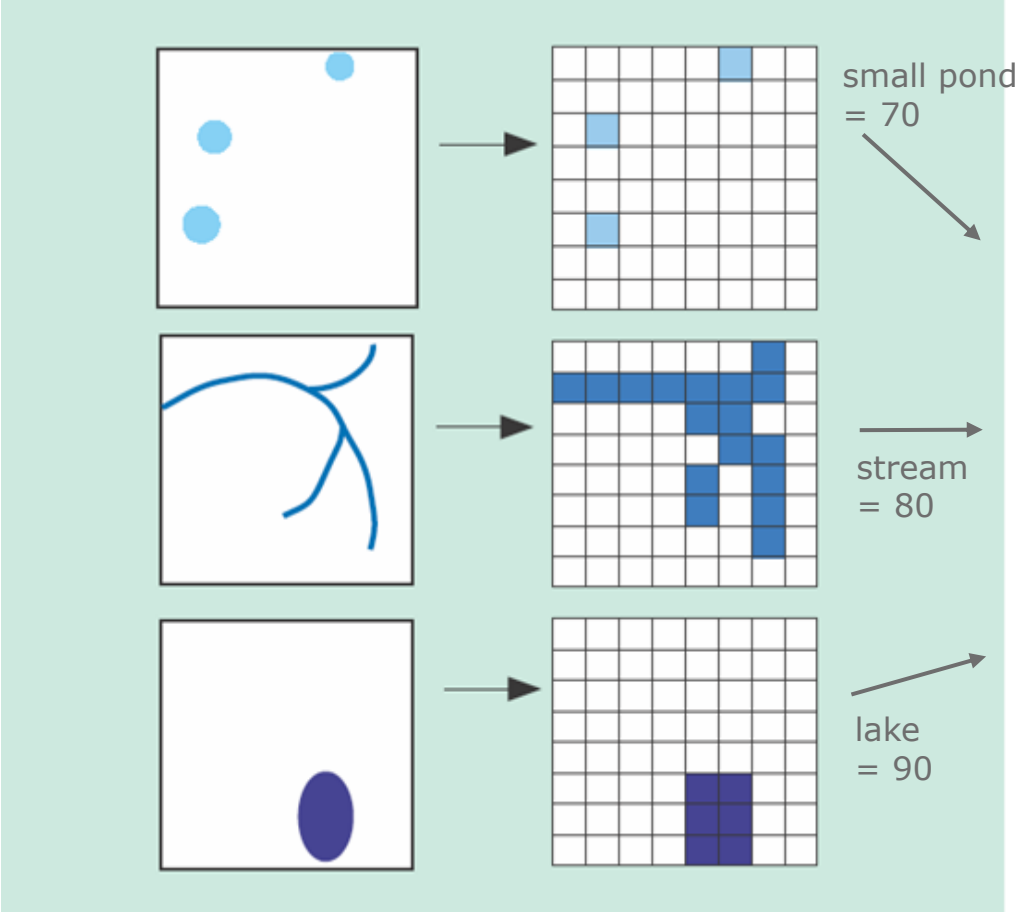
Raster line features

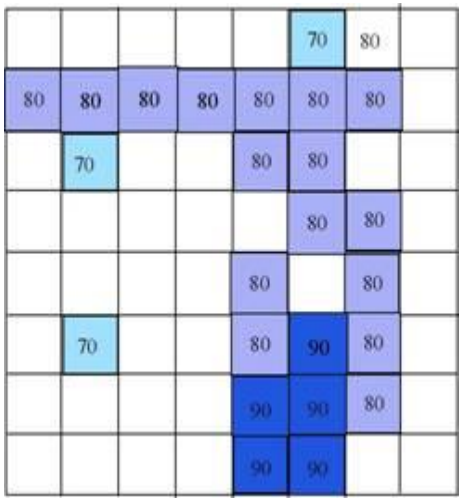
Polygon features

Raster polygon features

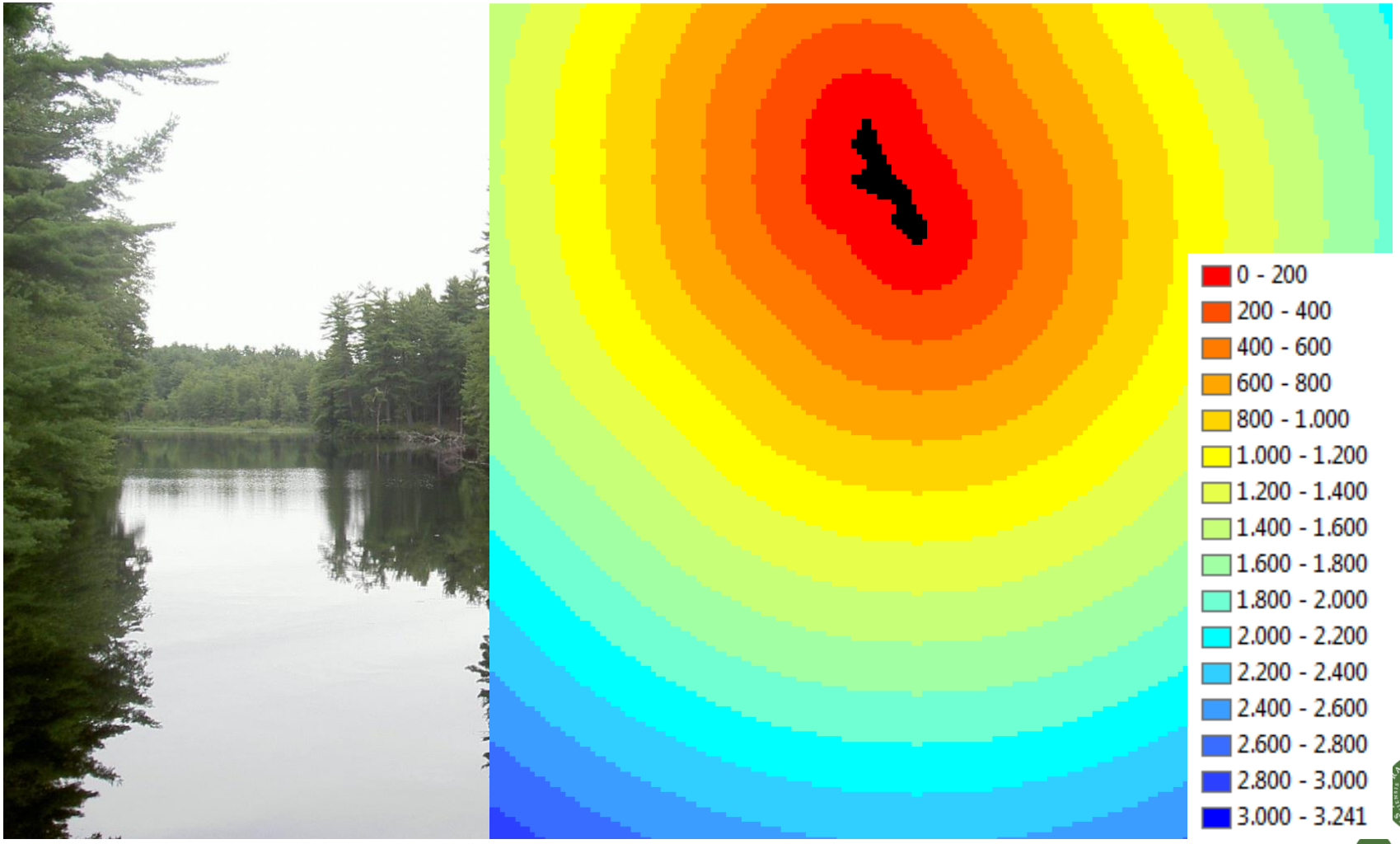
- Efficient storage
- Easy programming
- Fast computations

Simple combinations of rasters (cover)

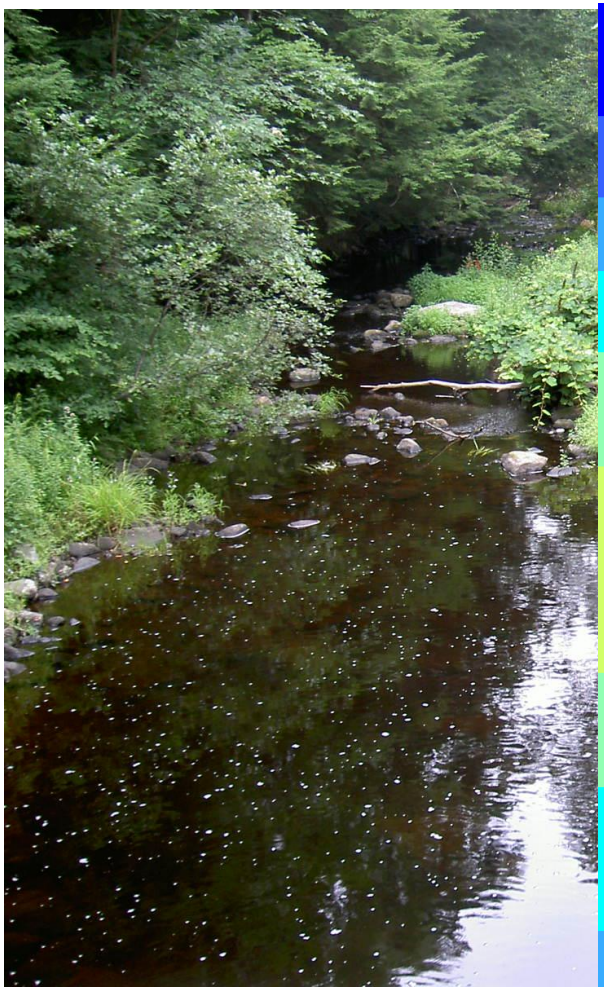


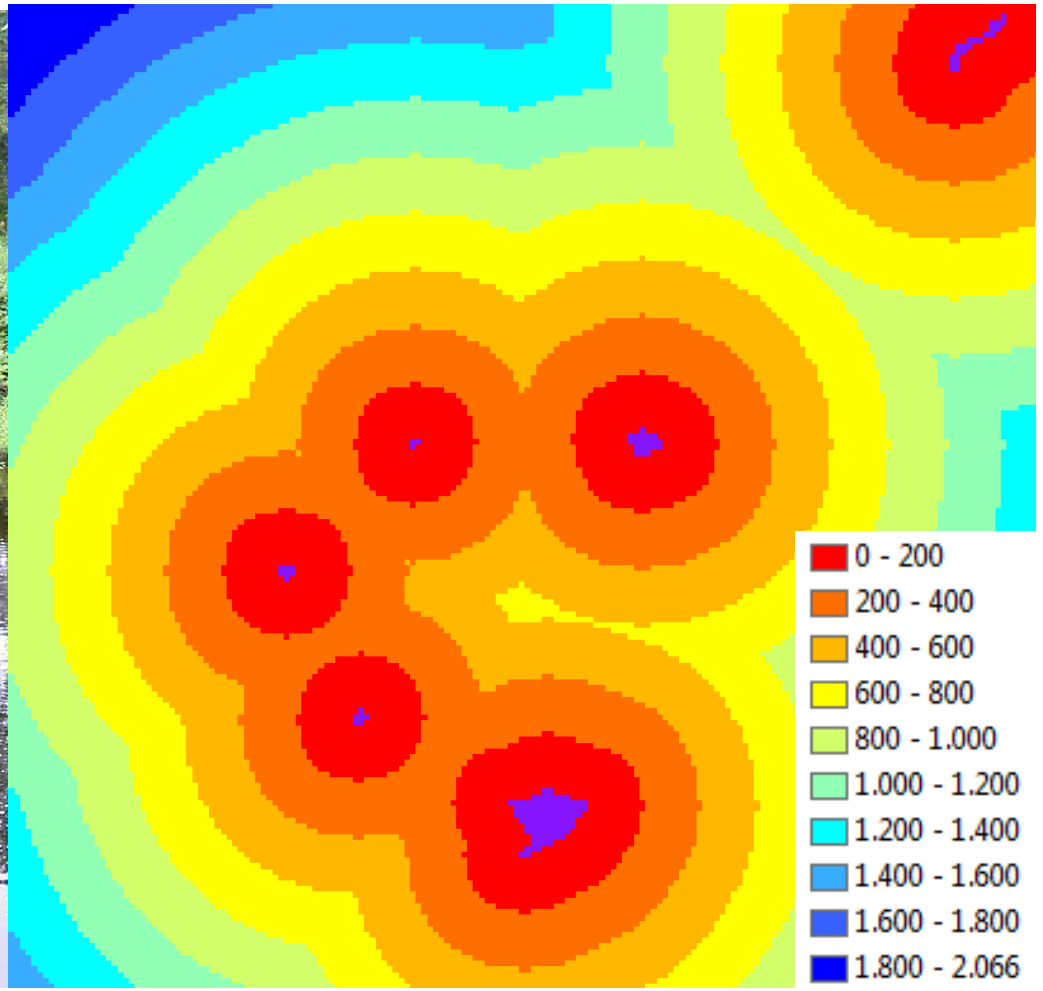


Browns Pond, Petersham, Massachusetts

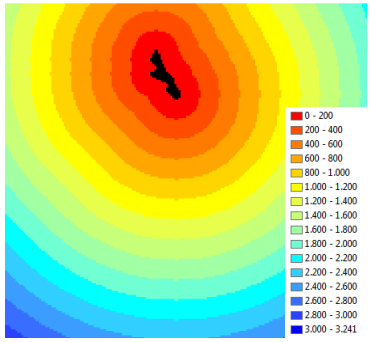


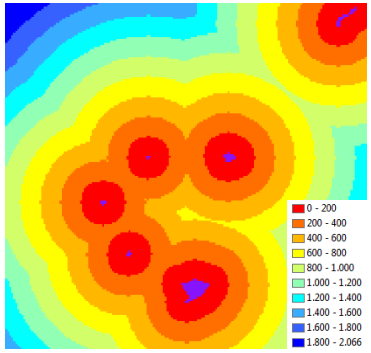
Other ponds nearby

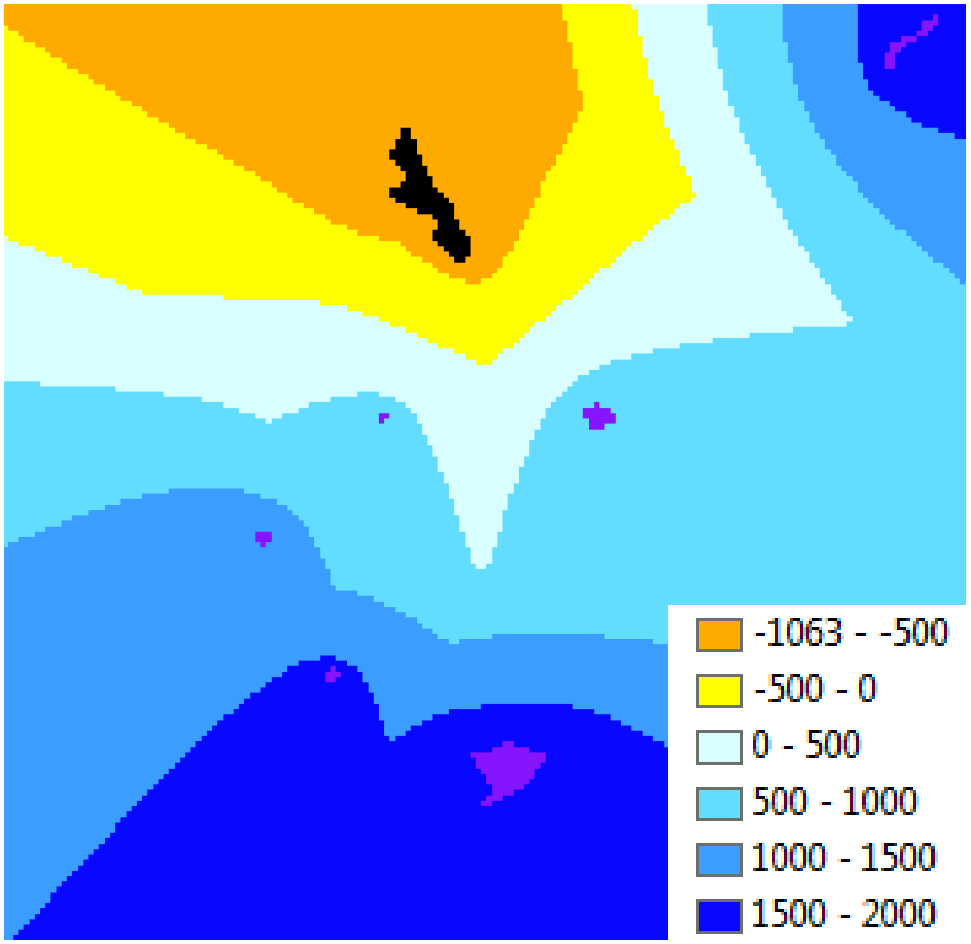




This figure's cells are found by subtracting the values in the OtherPonds raster from the values in the BrownPond raster. So, what do the values represent?



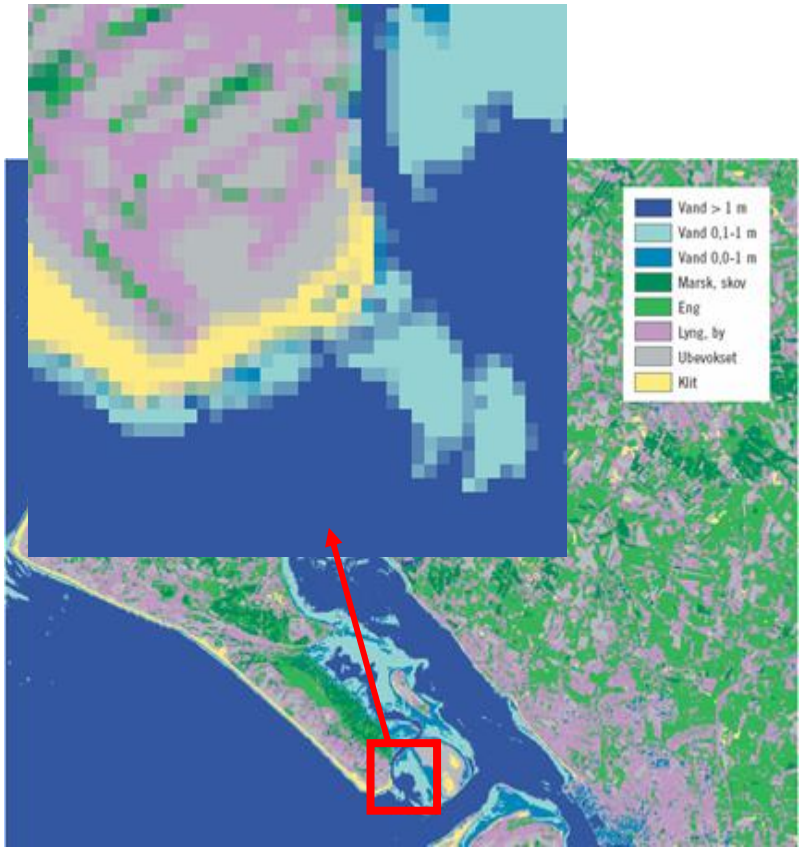




Facts about the raster based GIS data model

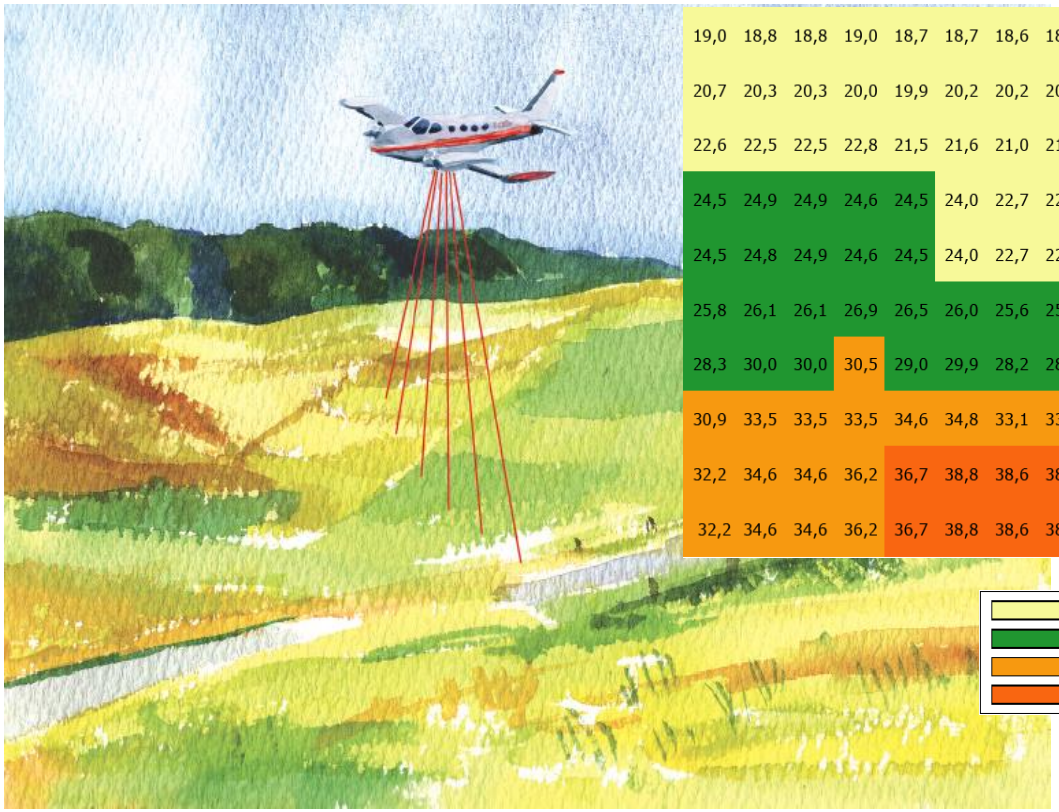
- Introduced during the 1970's due to an increasing demand for analysis of digital satellite data.
- Image processing systems → development of tools for spatial analysis.
- Separate development of vector and raster based GIS data models since the 1990's.
- Today well integrated

From pixel based classifications …

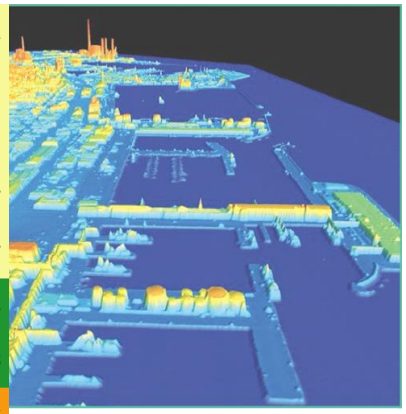


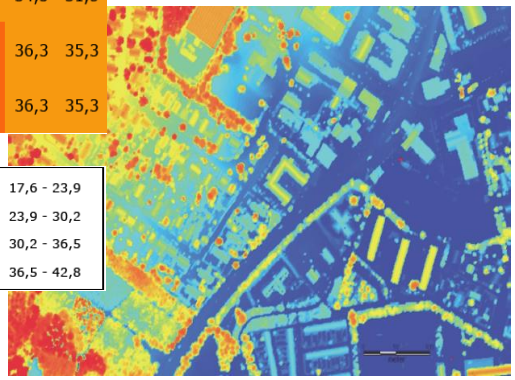
.. to object oriented feature extractions

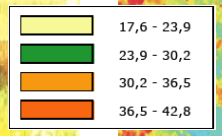
Analysis of laser scanned elevation models (LIDAR)



19,0	18,8	18,8	19,0	18,7	18,7	18,6	18,6	18,3	18,2
20,7	20,3	20,3	20,0	19,9	20,2	20,2	20,2	19,2	19,1
22,6	22,5	22,5	22,8	21,5	21,6	21,0	21,0	20,7	20,1
24,5	24,9	24,9	24,6	24,5	24,0	22,7	22,7	22,6	21,7
24,5	24,8	24,9	24,6	24,5	24,0	22,7	22,7	22,5	21,7
25,8	26,1	26,1	26,9	26,5	26,0	25,6	25,6	24,6	24,3
28,3	30,0	30,0	30,5	29,0	29,9	28,2	28,2	27,4	26,5
30,9	33,5	33,5	33,5	34,6	34,8	33,1	33,1	34,3	31,5
32,2	34,6	34,6	36,2	36,7	38,8	38,6	38,6	36,3	35,3
32,2	34,6	34,6	36,2	36,7	38,8	38,6	38,6	36,3	35,3







Map Algebra functions overview

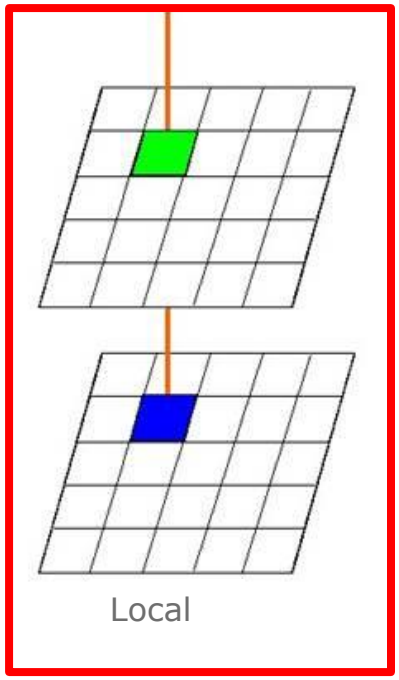
Functions:

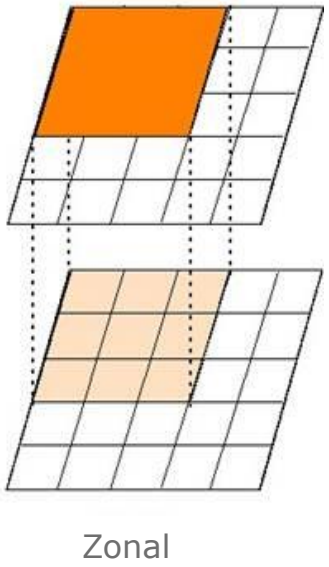
Local

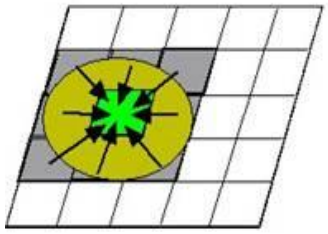
Focal

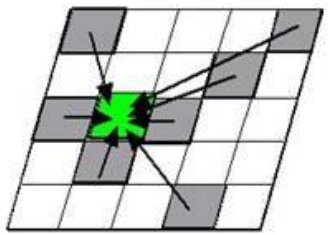
Zonal

Global









Map algebra and cartographic modelling

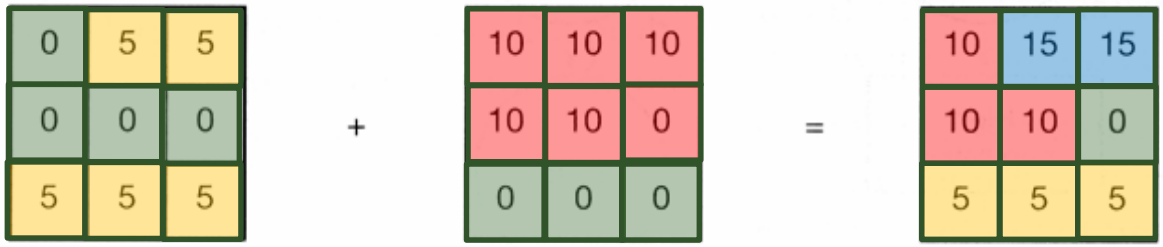
Map Algebra is a modelling language defined by C.D. Tomlin designed to manipulate raster based data.

The basic elements are **objects** and **actions**

Objects are input and output rasters

Actions are operators and functions

Exampel 1: **Local addition** of values cell by cell for two days' precipitation by simple addition of two rasters with calibrated, quantitative data values



Example 2: **Local addition** of two rasters with qualitative data values

0 = open land 0 = private 0 = open land, private, 5 = forest, private

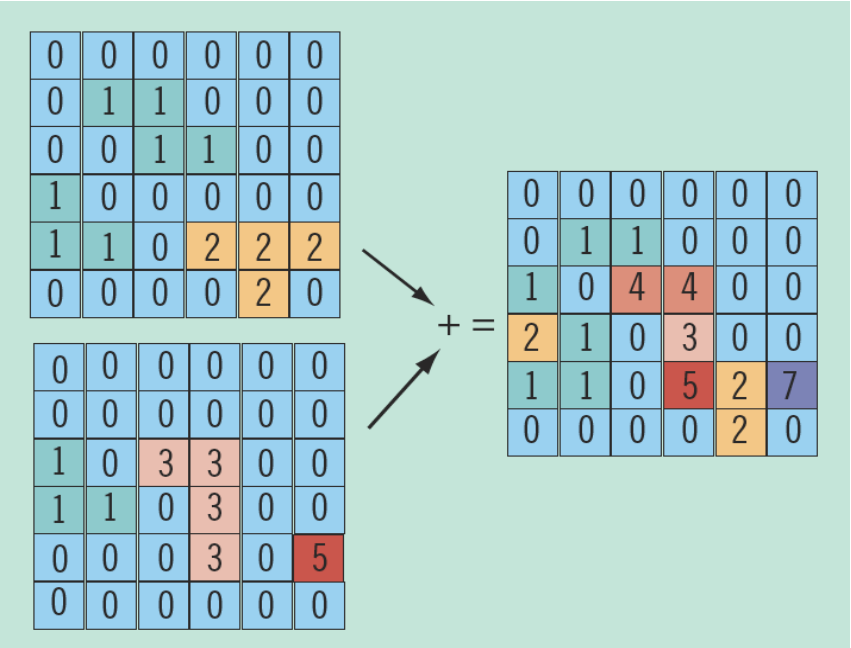
5 = forest 10 = state 10 = open land, state, 15 = forest, state

Local functions

Per-cell functions that calculate a new value for each individual cell based on a mathematical function on one raster or a stack of rasters

Example:
TwoDaysPrecipitation = LocalSum of PrecipitationDay1 and PrecipitationDay1

Other local functions:
Trigonometric (sin, cos, tan ...), logarithmic, truncate, reclassify



Local functions: Renumbering using the Reclassify tool

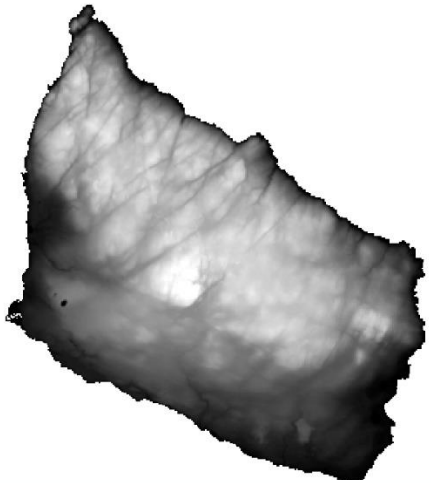
16	16	16	19
16	16	19	19
12	12	19	19
12	12	12	19

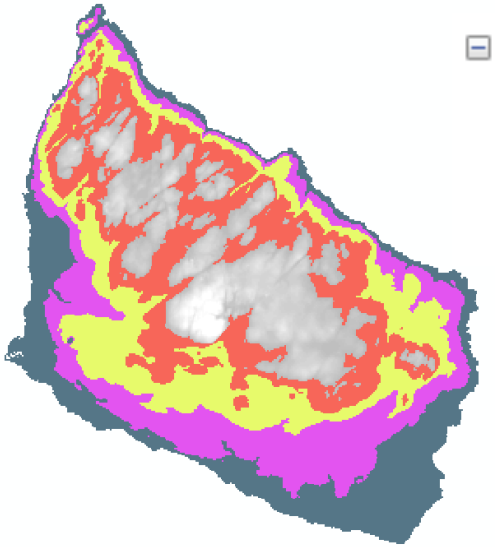
2	2	2	1
2	2	1	1
3	3	1	1
3	3	3	1

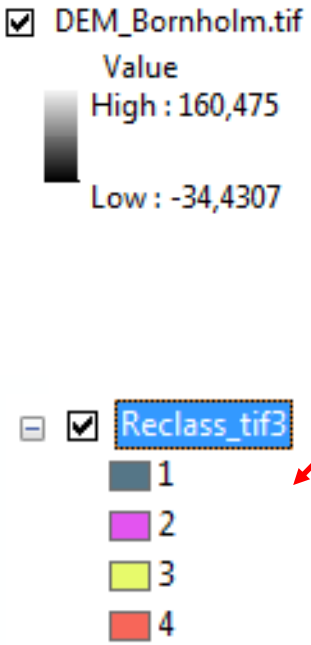
Reclassification schema

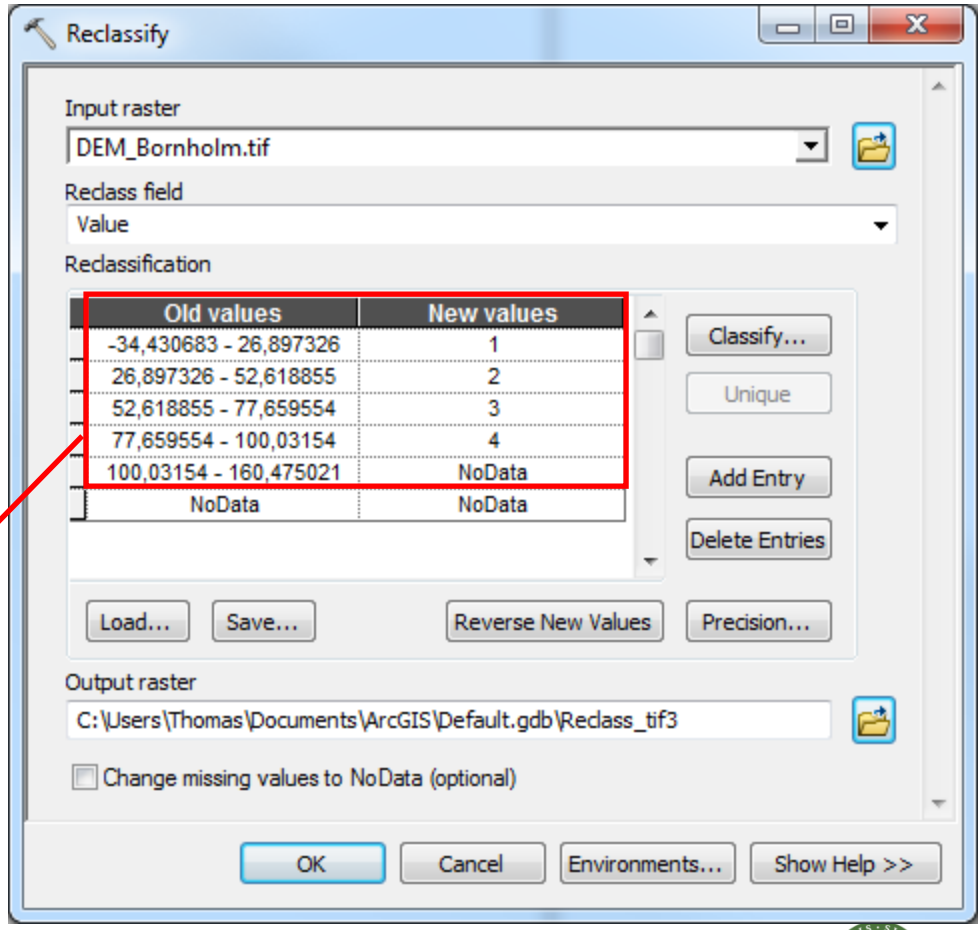
19 → 1
16 → 2
12 → 3

Local functions: Renumbering using the Reclassify tool



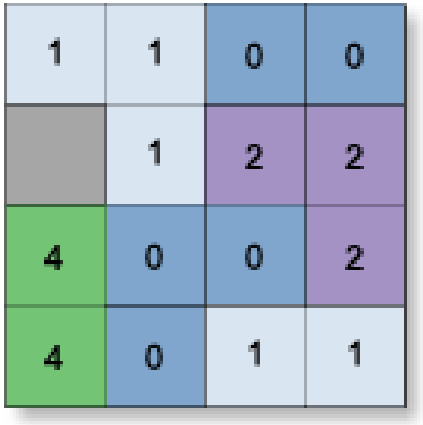






Local functions: Reclassify using the CON tool

Inraster

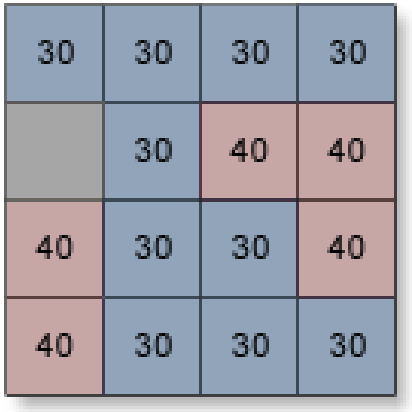


If expression = True

If expression = False

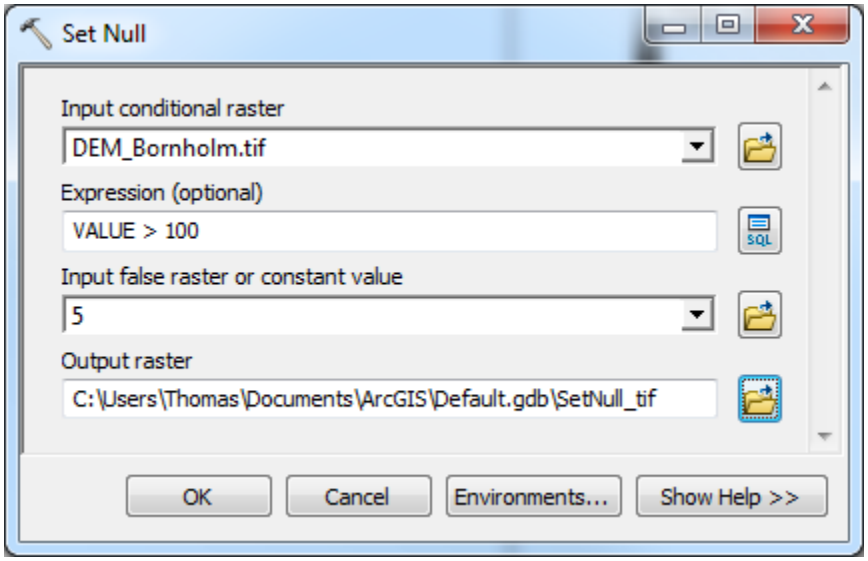
Outraster = Con(Inraster, 40, 30, "Value >=2")

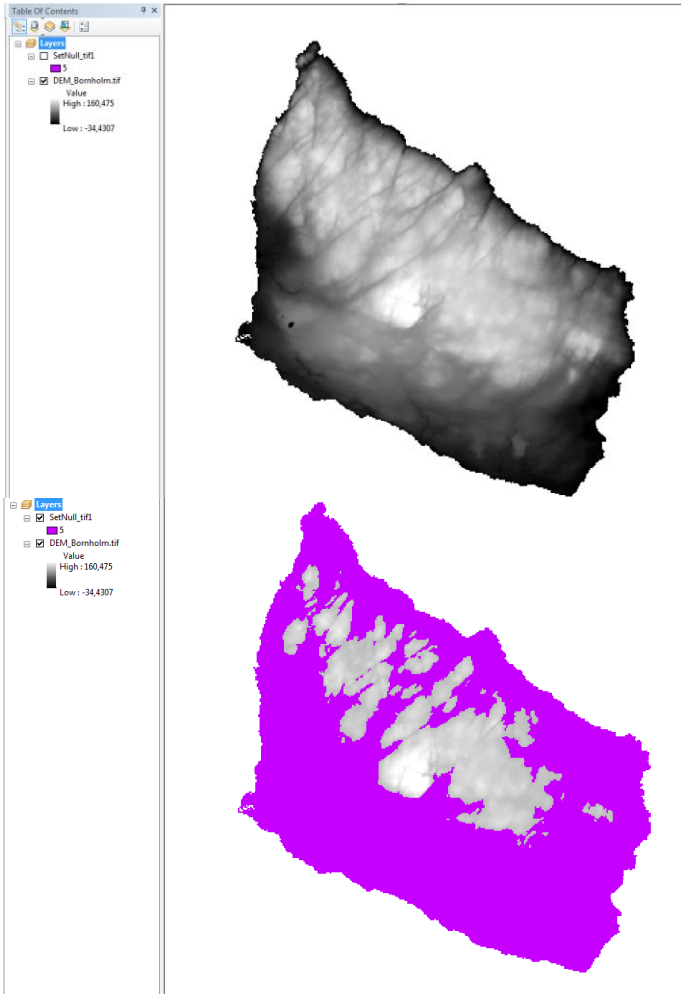
Outraster



Local functions: Reclassify using the SetNull tool

Assigns NODATA value to specific cells





Functions - overview

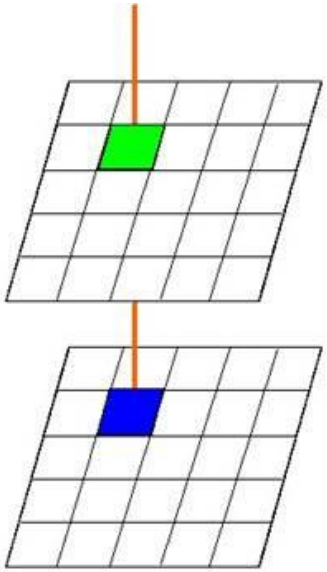
Functions:

Local

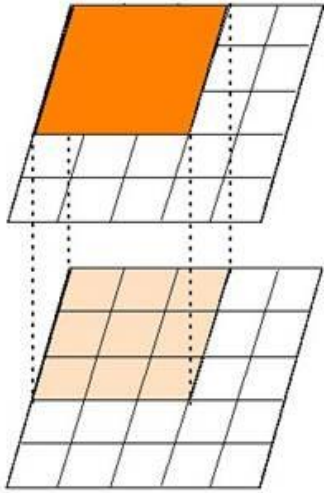
Focal

Zonal

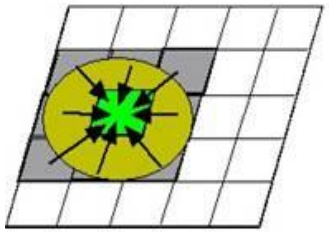
Global



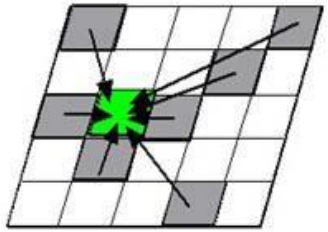
Local



Zonal



Focal



Global

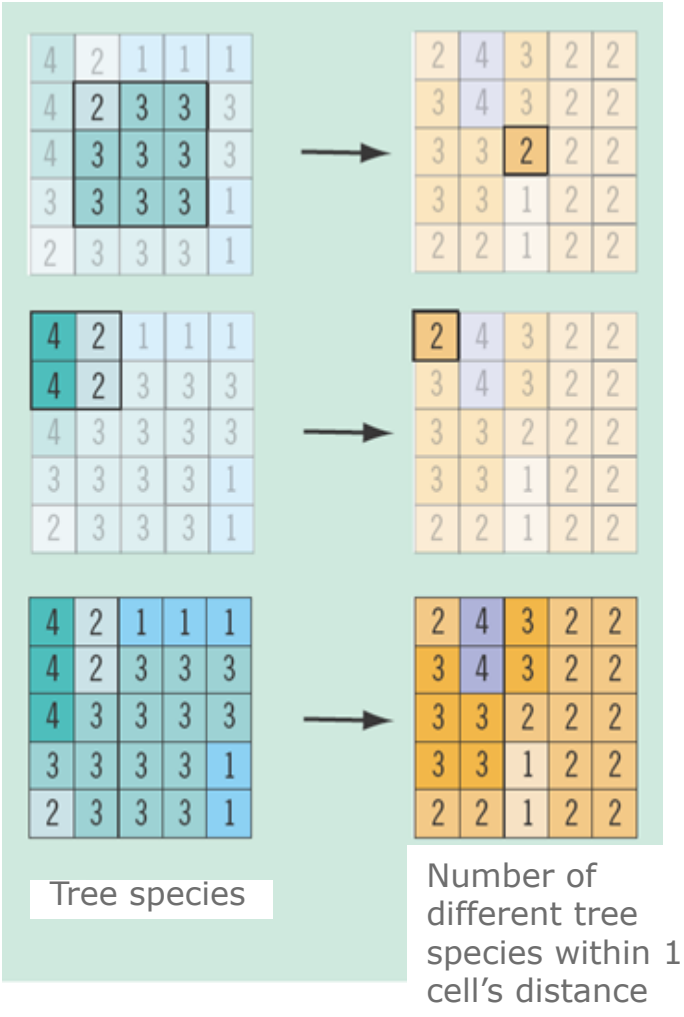
Focal functions

Per-neighbour functions that calculate a new value for each individual cell based on a search within a specific neighborhood.

Example:
NumberOfTreeSpecies =
FocalVariation of Trees within 1

Other focal functions:
Sum, min, max, majority, range

Variable 'neighborhoods'
(donuts, wedges ...)



Focal functions: Slope

Slope calculation, Vagar, The Faroe Islands (4x4 km)

Focal functions: Slope

The maximum slope in percent may be determined from identifying the biggest difference in elevation values for a center cell and its 8 neighbours, and dividing this number by the horizontal distance.

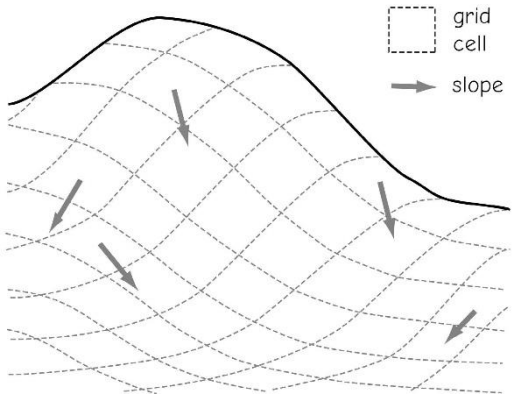
191	214	218
180	196	203
172	184	195

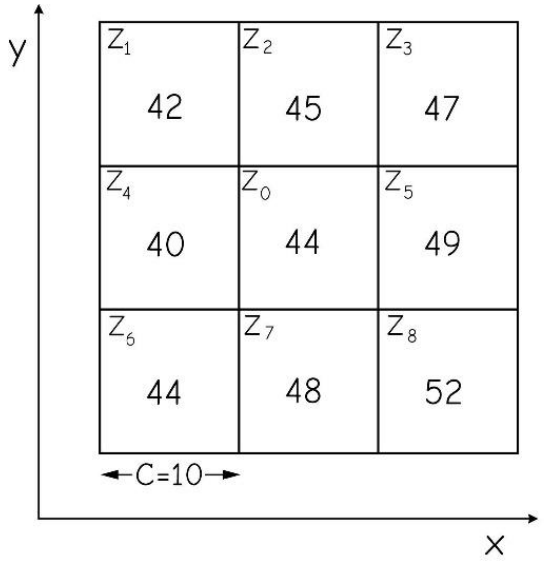
In which direction is the steepest slope (cell size is 100 meters)?

Focal functions: Slope (former Esri method)

The maximum slope in percent may be determined from identifying the biggest difference in elevation values for a center cell and its 8 neighbours, and dividing this number by the horizontal distance.

Focal function: Slope (alternative method, Bolstad)





for Z_o:

$dZ/dx = (49 - 40)/20 = 0.45$

$dZ/dy = (45 - 48)/20 = -0.15$

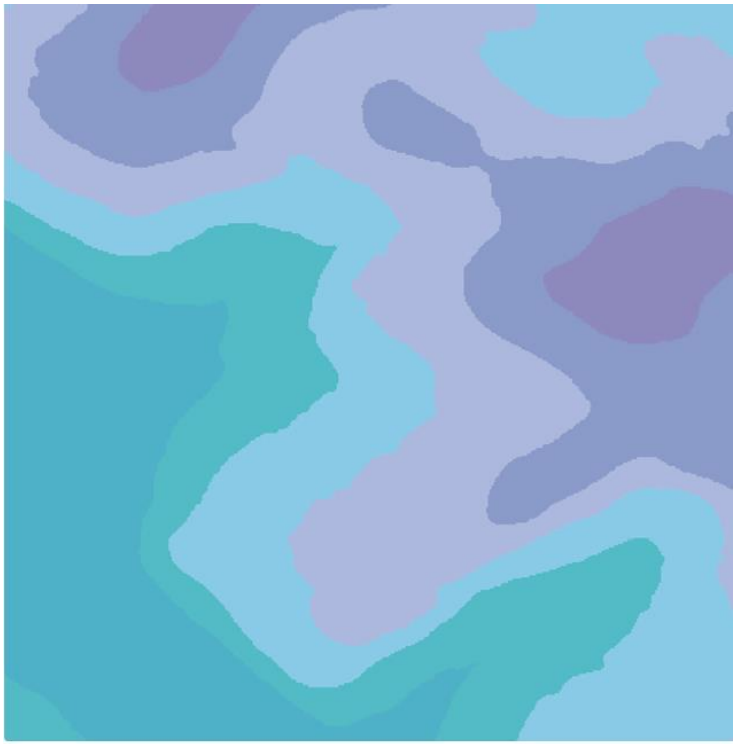
$slope = atan\ [(0.45)^2 + (-0.15)^2]^{0.5}$

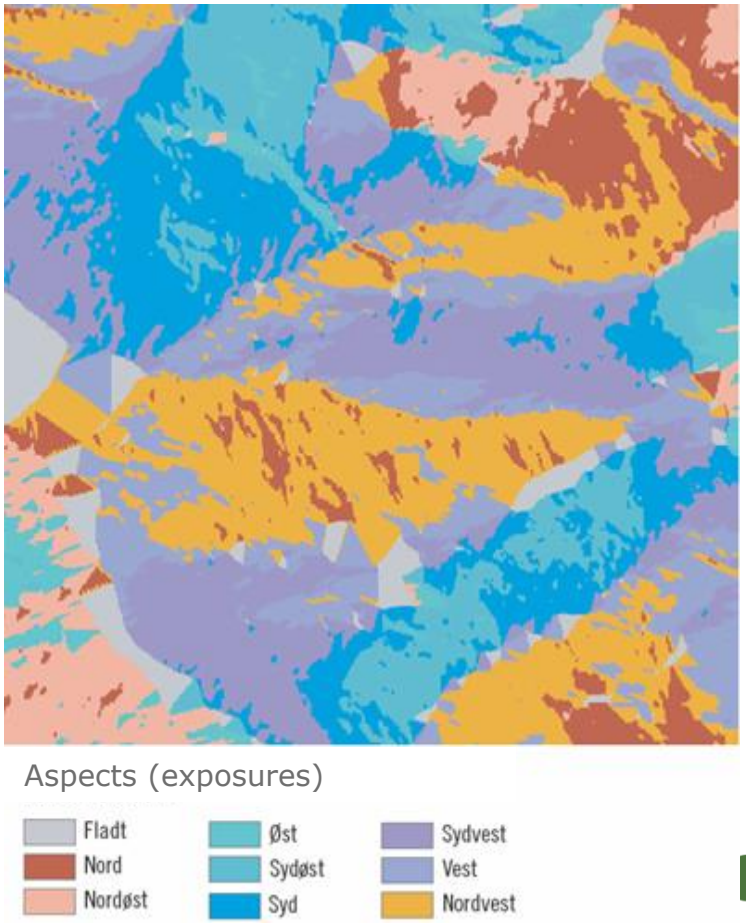
$= 25.3^o$

Slope% = $(0.45^2+(-0.15)^2)^{0,5} * 100 = 47.3\%$

Focal functions: Aspect

Aspect calculation, Vagar, The Faroe Islands (4x4 km)

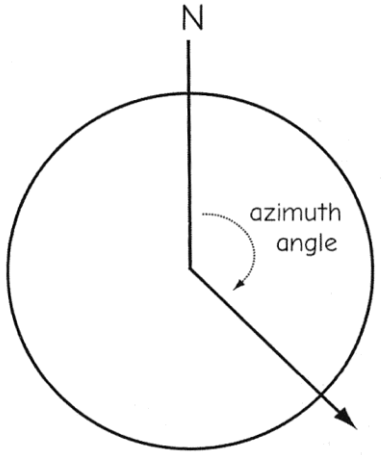




Fokal function: Aspect

Aspect is defined as the direction of the steepest slope

$$\alpha = 180 - \operatorname{atan}\left(\frac{\left(\frac{dZ}{dy}\right)}{\left(\frac{dZ}{dx}\right)}\right) + 90\left(\frac{\left(\frac{dZ}{dx}\right)}{\left|\frac{dZ}{dx}\right|}\right)$$



When using values from Bolstad's calculation of slope:

a = 180 – atan(-0.15/0.45) + 90(0.45/0.45)

α = 180 + 18 + 90 = 288°

Functions - overview

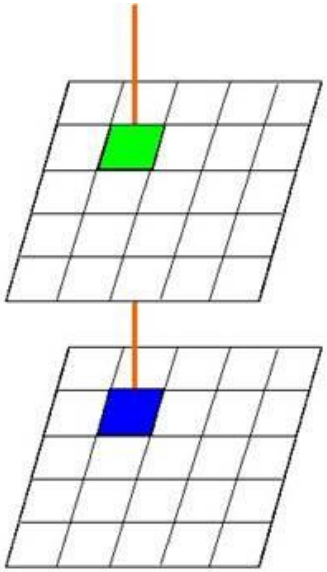
Functions:

Local

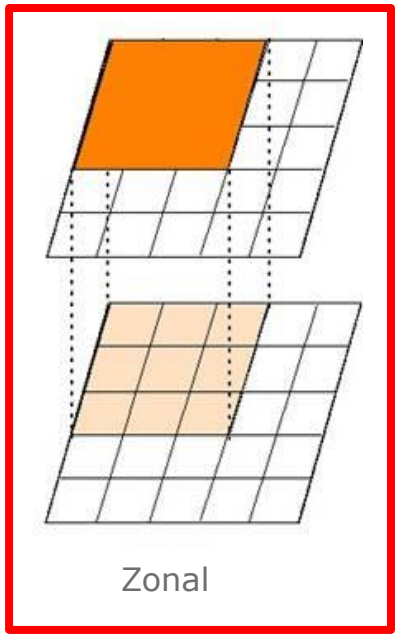
Focal

Zonal

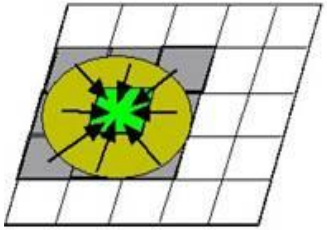
Global



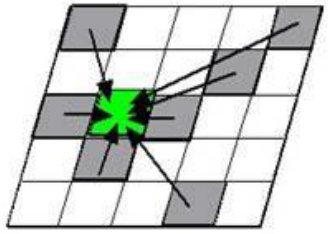
Local



Zonal



Focal



Global

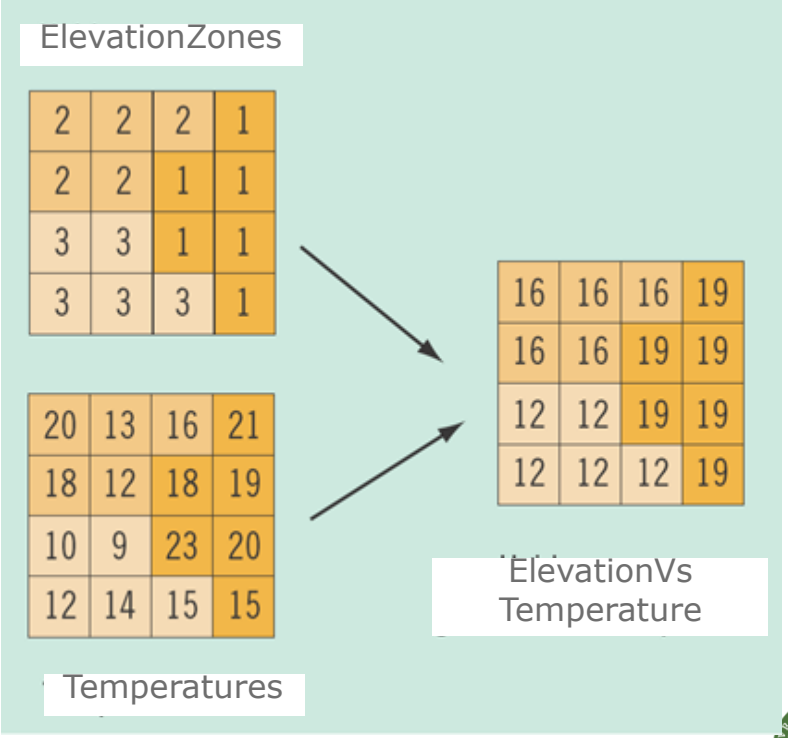
Zonal functions

Calculates a value for each cell in one raster determined by zonal masks in a second raster

Example:

ElevationVsTemperature = ZonalMean of Temperatures in ElevationZones

Other zonal functions:
Sum, minimum, maximum



Functions - overview

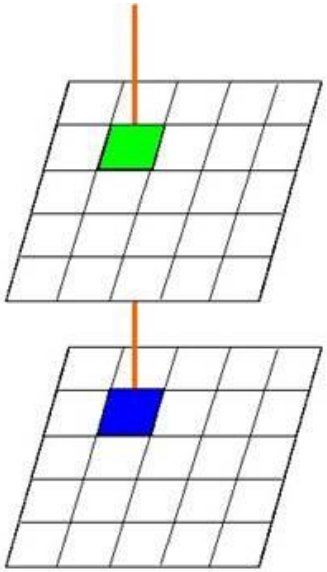
Functions:

Local

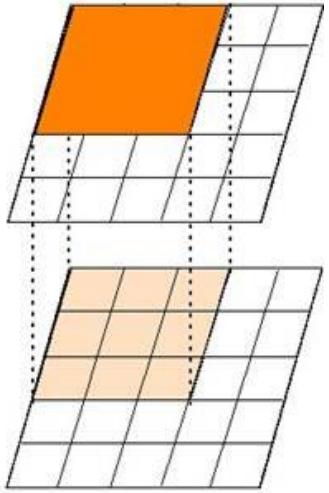
Focal

Zonal

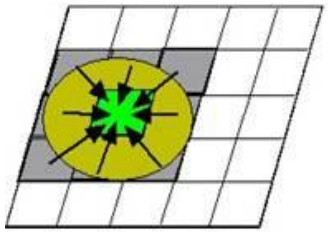
Global



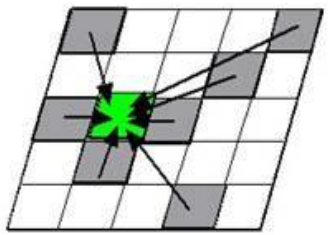
Local



Zonal



Focal



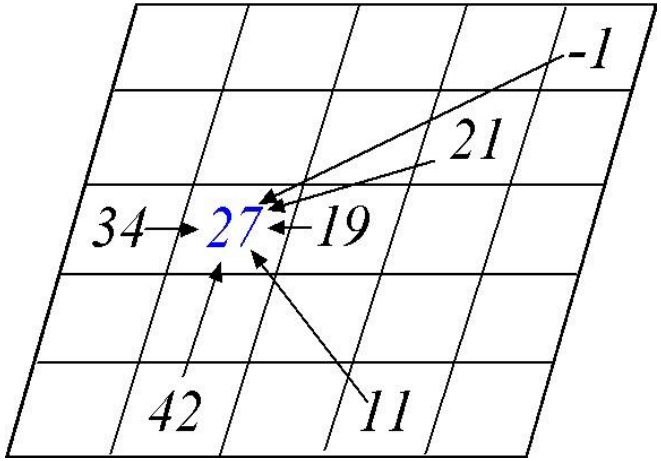
Global

Global functions: Interpolation

Calculate missing values based on existing ones.

Example:
Inverse distance weighthing interpolation.

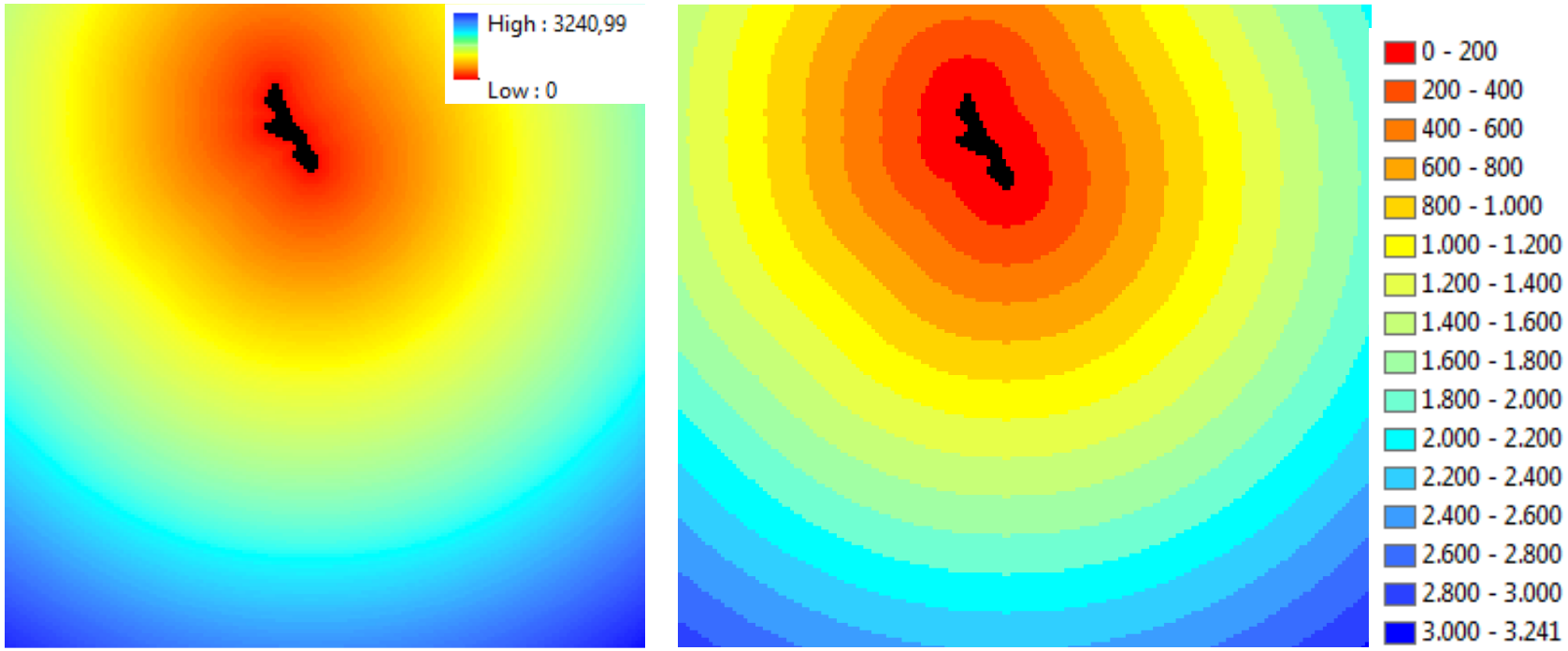
InterpolatedTemperature = GlobalInterpolation of Temperature



Global functions: Euclidean distances / Distance Accumulation

Every cell gets a value telling the distance to the nearest source cell.

Next, the Reclassify tool may be used to slice the data into, say, 16 classes.

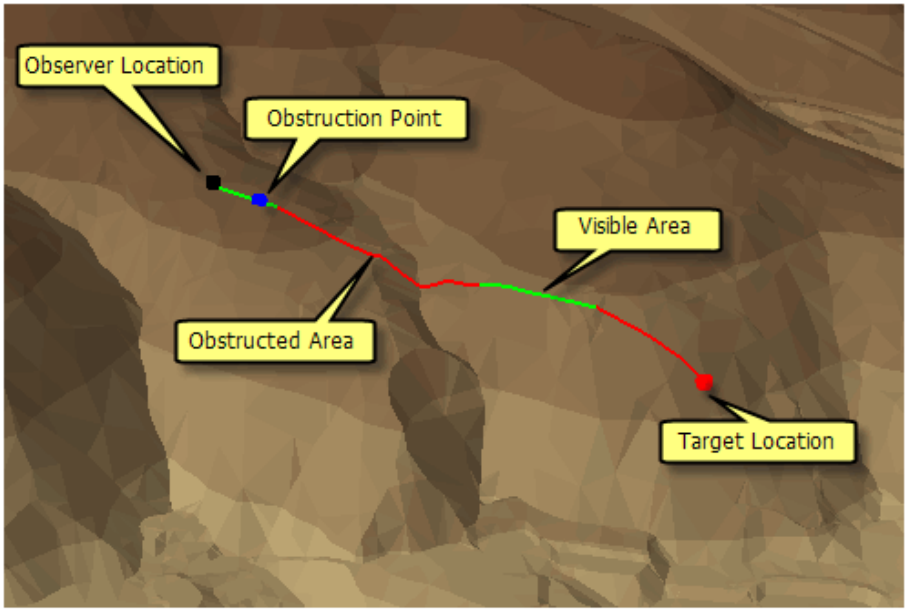


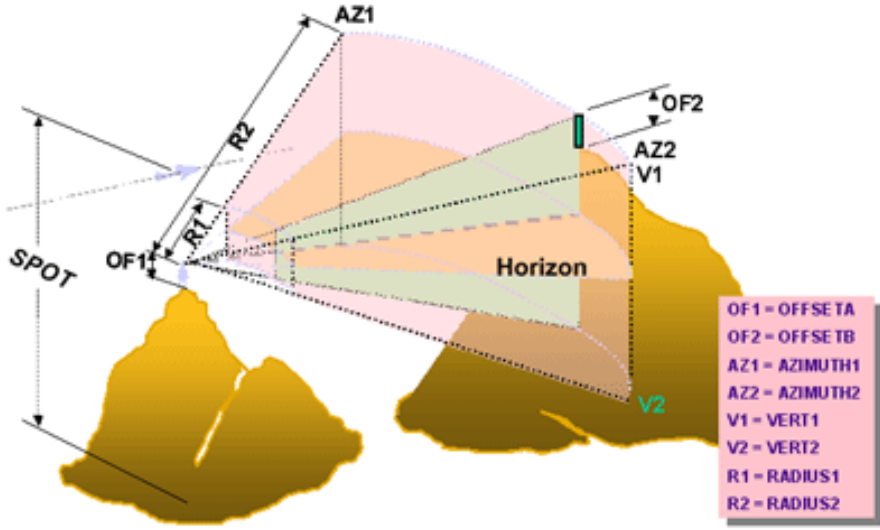
Global functions: Nearest neighbour allocation

Every cell gets a value telling which source cell is nearest.

Method =
Creation of Thiessen polygons

Global functions: Visibility analysis

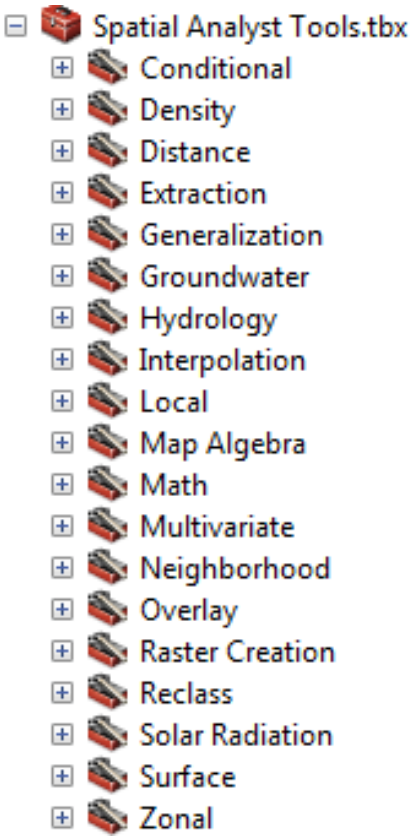




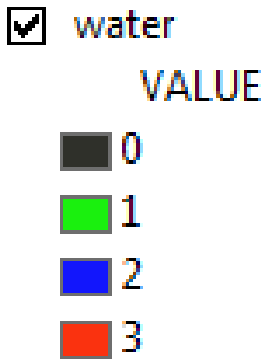
Parameters for controlling the viewshed analysis

Working on rasters in ArcGIS

- Enable the Spatial Analyst extension → Locate the right tools



Working on rasters in ArcGIS



Table

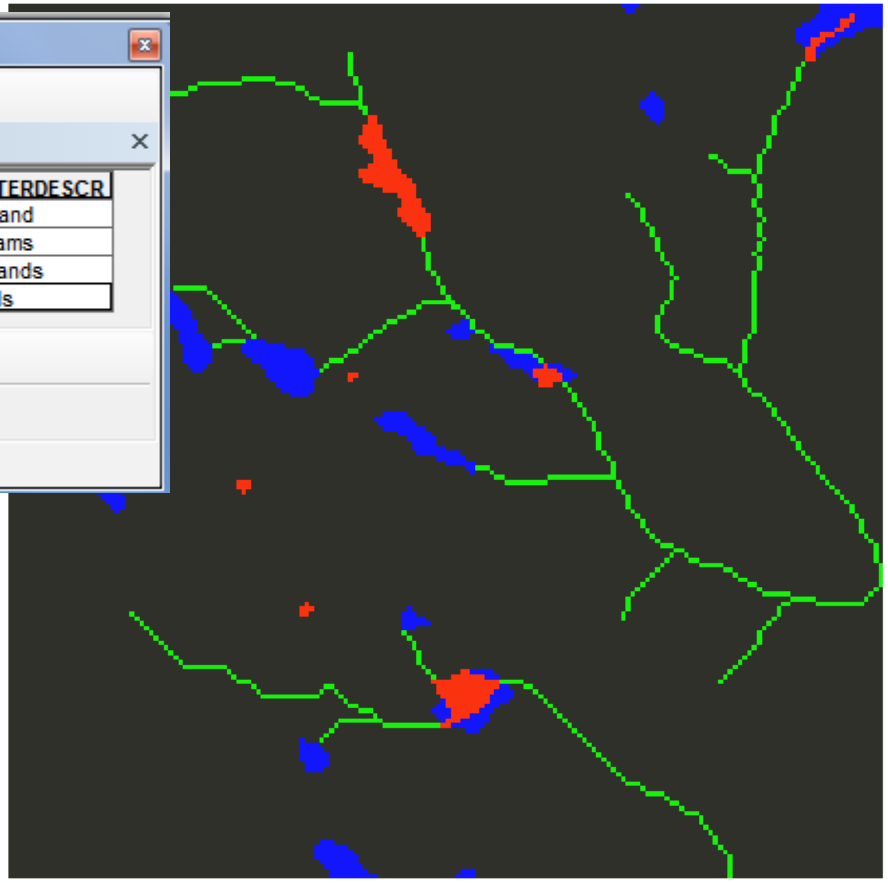
water

Rowid	VALUE	COUNT	WATERDESCR
0	0	30815	Dry land
1	1	595	Streams
2	2	707	Wetlands
3	3	283	Ponds

4

(0 out of 4 Selected)

water



Only integer rasters with < 65536 unique values have attribute tables. Use Build Raster attribute Table to build them

Working on rasters in ArcGIS – layer files