

Lecture 8
Raster Analysis

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Raster Analysis

Raster cells store data (nominal, ordinal, interval/ratio)

Complex constructs built from raster data

- Connected cells can be formed into networks

- Related cells can be grouped into neighborhoods or regions

Examples:

- Predict fate of pollutants in the atmosphere

- The spread of disease

- Animal migrations

- Crop yields

- EPA - hazard analysis of urban superfund sites

- Local to global scale forest growth analysis

Map algebra

Cell by Cell combination of raster data layers

Each number represents a value at a raster cell location

Simple operations can be applied to each number

Raster layers may be combined through operations

Addition, subtraction and multiplication

Entails operations applied to one or more raster data layers.

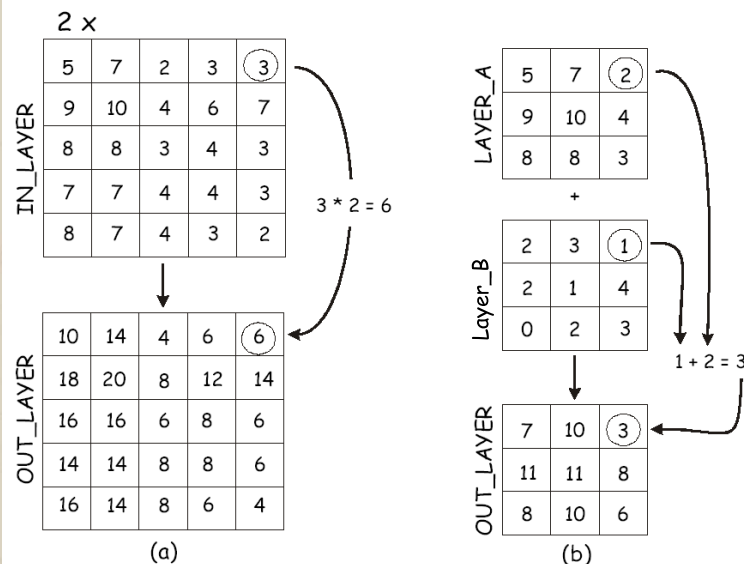
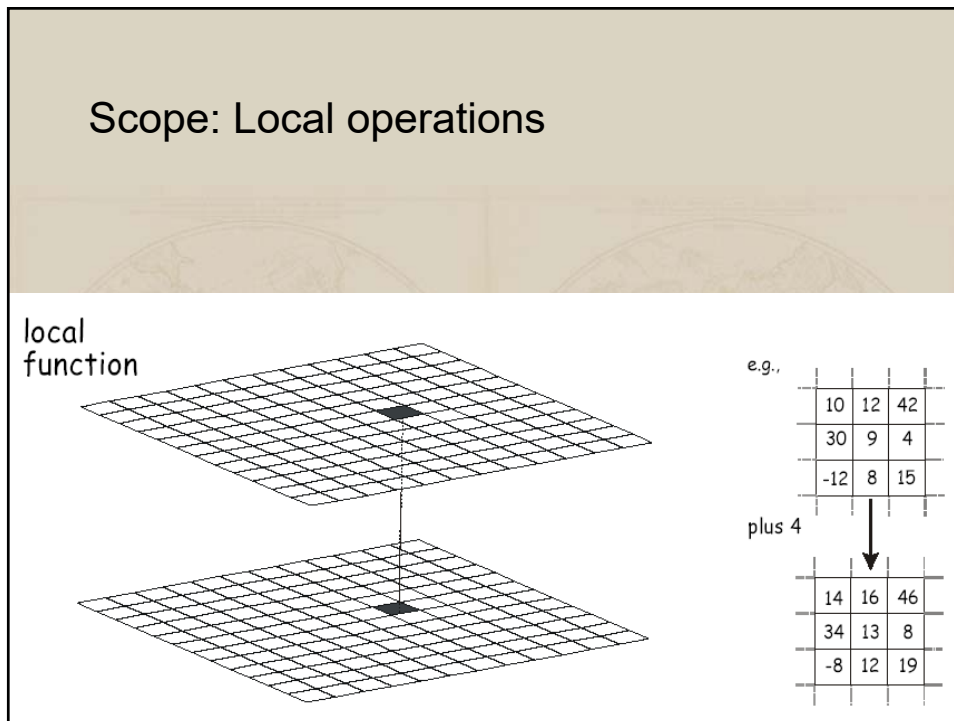
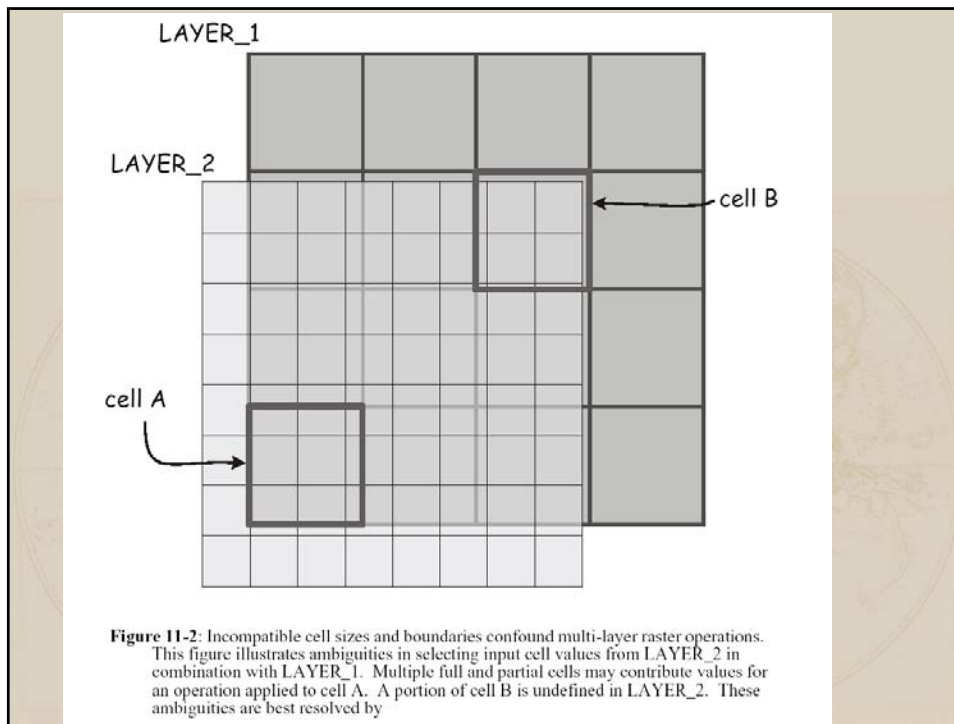
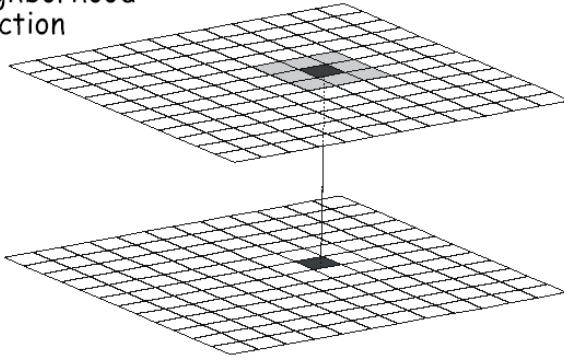


Figure 11-1: An example of raster operations. On the left side (a) each input cell is multiplied by the value 2, and the result written stored in the corresponding output location. The right side (b) of the figure illustrates layer addition.



Scope: Neighborhood operations

neighborhood
function



e.g.,

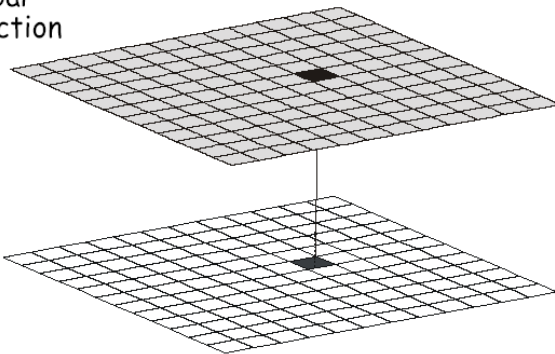
10	12	42
30	9	4
-12	8	15

neighborhood
maximum

33	42	42
30	42	42
30	30	17

Scope: Global operation

global
function



e.g.,

10	12	42
30	9	4
-12	8	15

global
maximum

42	42	42
42	42	42
42	42	42

Local Functions

Function	Description
Add, subtract, multiply, and divide	cell-by-cell combination with the arithmetic operation
ABS	Absolute value of each cell
EXP, EXP10, LN, LN10	Applies base e and base 10 exponentiation and logarithms
SIN, COS, TAN, ASIN, ACOS, ATAN	Apply trigonometric functions on a cell-by-cell basis
INT, TRUNC	Truncate cell values, output integer portion
MODULUS	Assigns the decimal portion of each cell
ROUND	Rounds a cell value up or down to nearest integer value
SQRT, ROOT	Calculates the square root or specifies other root of each cell value
POWER	Raises each cell to a defined power

Logical Operations AND

Non-zero values are "true", zero values are "false"
N = null values

Input					Output								
1	3	1	1	AND	0	1	0	9	=	0	1	0	1
0	N	2	-1		0	5	2	5		0	N	1	1
1	2	5	0		0	2	N	2		0	1	N	0
0	1	N	N		0	-3	4	8		0	1	N	N

Logical Operations OR

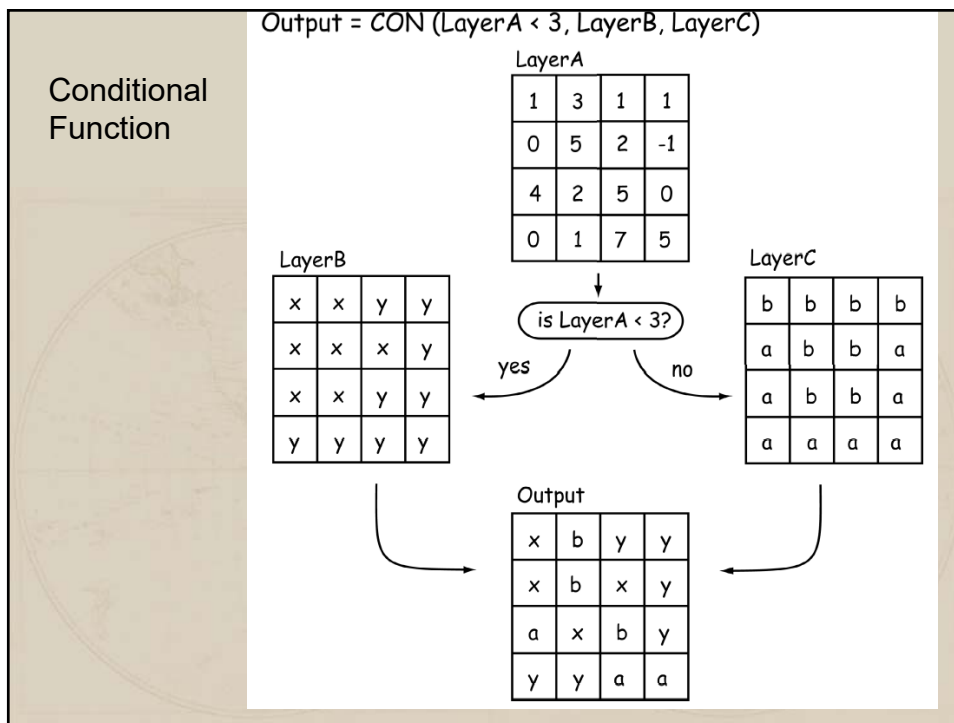
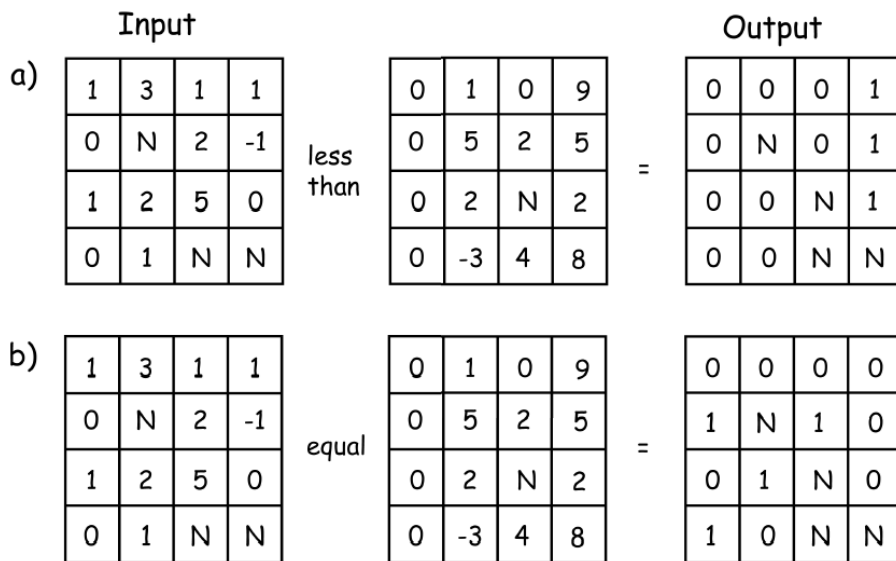
Non-zero values are "true", zero values are "false"
N = null values

1	3	1	1		0	1	0	9		1	1	1	1
0	N	2	-1		0	5	2	5		0	N	1	1
1	2	5	0	OR	0	2	N	2	=	1	1	N	1
0	1	N	N		0	-3	4	8		0	1	N	N

Logical Operations NOT

	1	3	1	1		0	0	0	0
	0	N	2	-1		1	N	0	0
NOT	1	2	5	0	=	0	0	0	1
	0	1	N	N		1	0	N	N

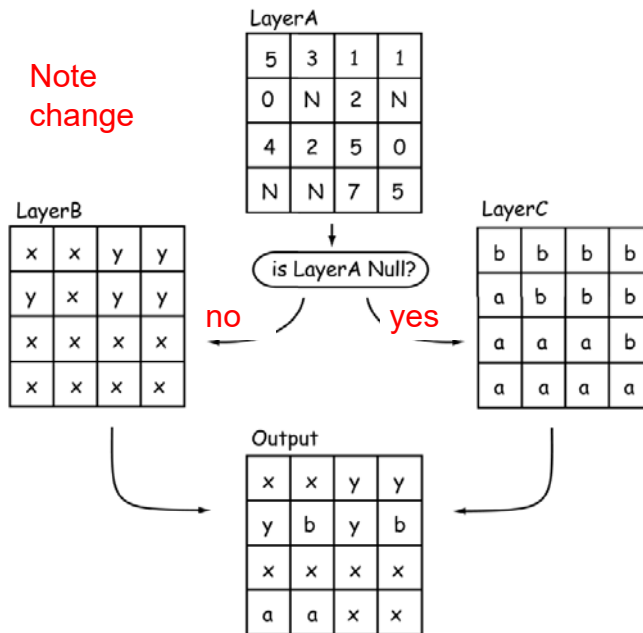
More Local Functions – logical comparisons



Nested Functions

Output = CON(ISNULL(LayerA), LayerC, Layer B)

Note
change



Overlay in Raster

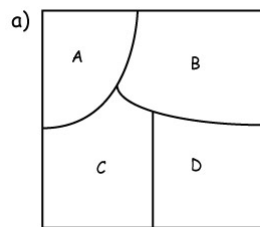
Union and Clip

Cell by Cell Addition or Multiplication

Attribute combinations corresponding to
unique cell combinations

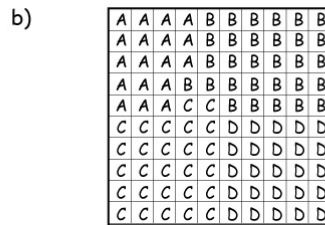
A Problem with Raster Analysis

- Too many cells
- Typically, one-to-one relationship between spatial object and attribute table
- Rasters have multiple cells per feature
- Attribute tables grow to be unwieldy



one to one

ID	type	area
1	A	16.8
2	B	22.2
3	C	18.4
4	D	20.7



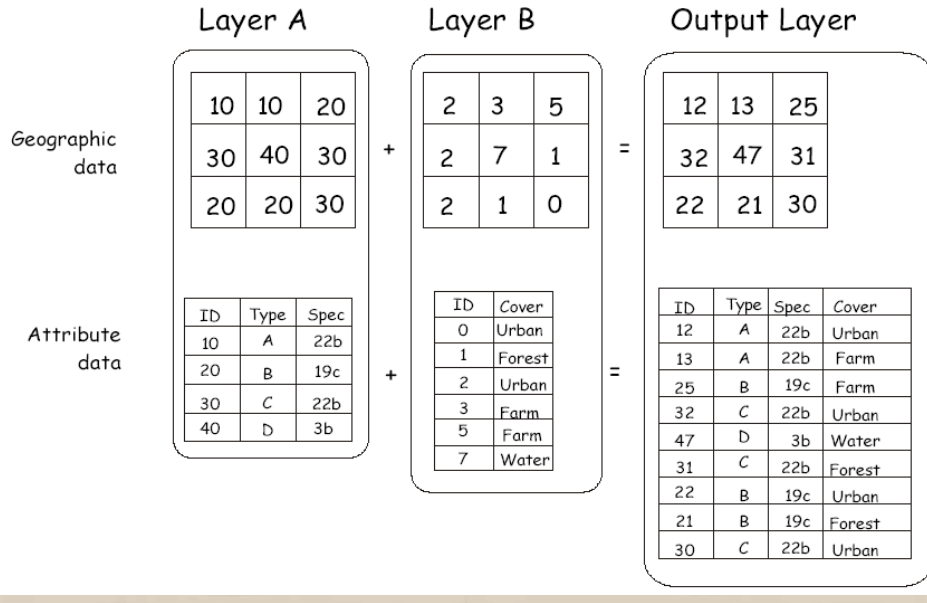
one to one

ID	type	area
1	A	0.8
2	A	0.8
3	A	0.8
4	A	0.8
5	B	0.8
6	B	0.8
7	B	0.8
8		
9		
10		
100	b	0.8

one to many

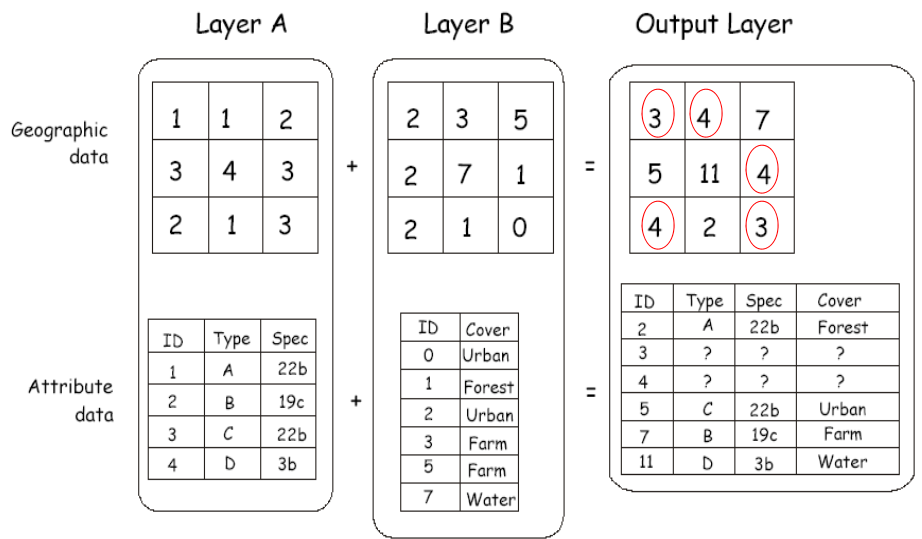
ID	type	area
1	A	16.8
2	B	22.2
3	C	18.4
4	D	20.7

Raster overlay as addition

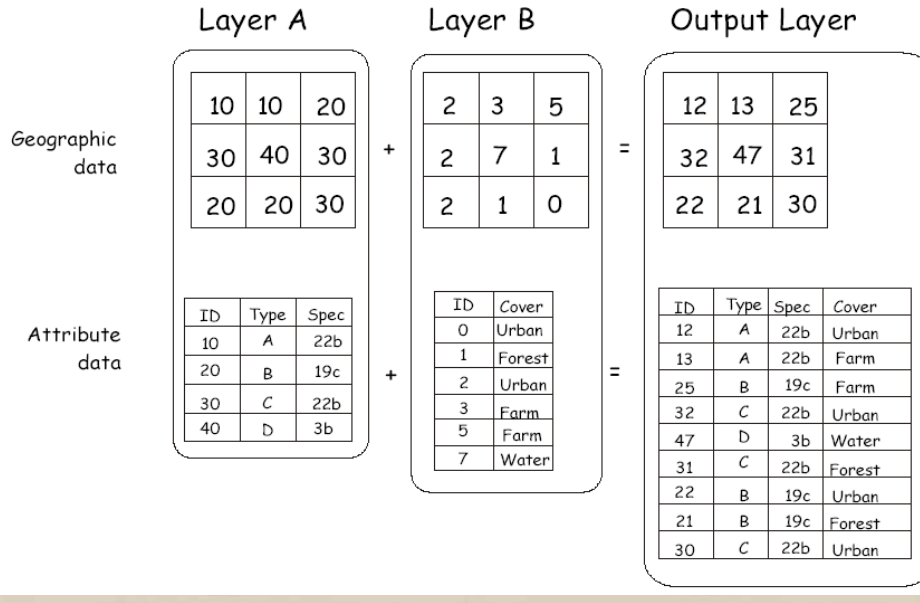


Raster Overlay

Output layer **DOES NOT** have unique records



What to do? First multiply Layer A by 10



Neighborhood Operations

Moving Windows
(Windows can be any size; often odd to provide a center)

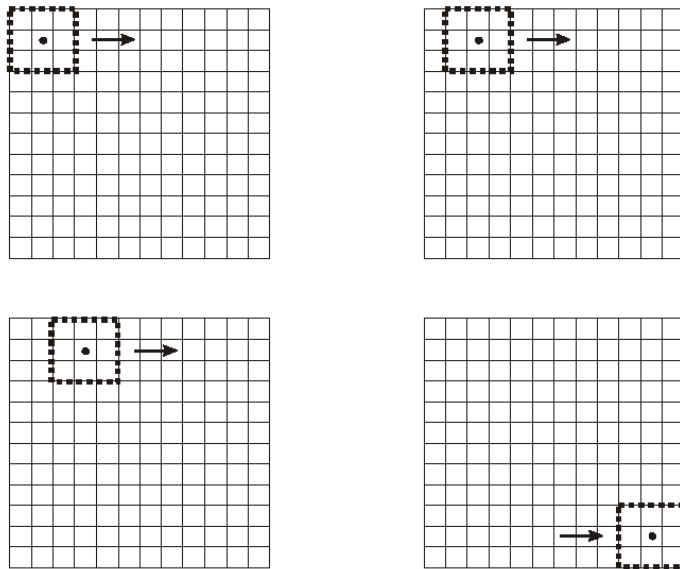
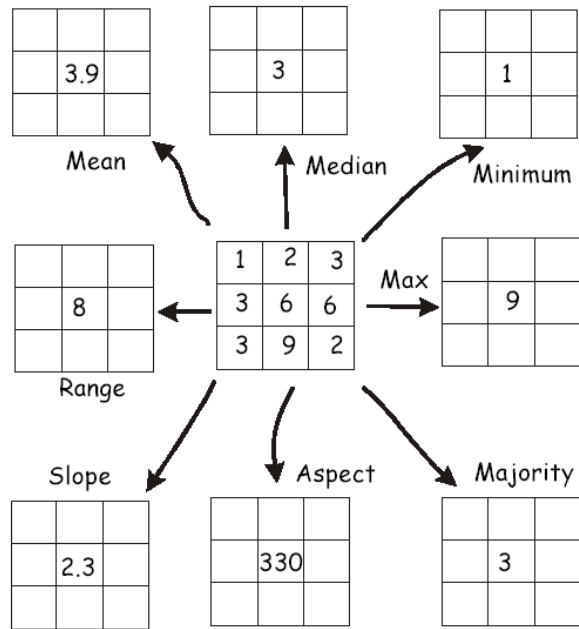
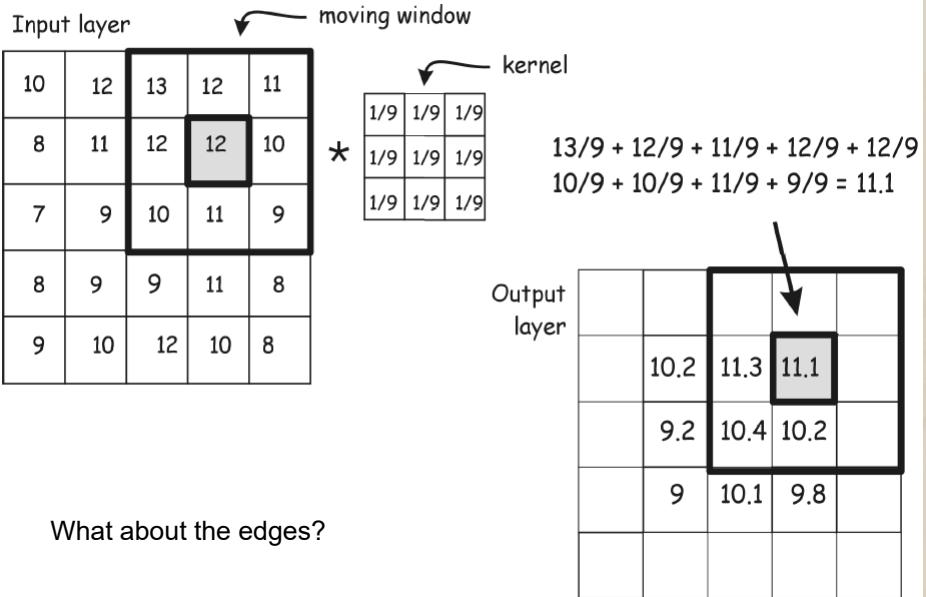


Figure 11-4: The concept of a moving window in raster neighborhood operations. Here a 3 by 3 window is swept from left to right and from top to bottom across a raster layer. The window at each location defines the input cells used in the raster operation.

Neighborhood Operations



Neighborhood Operations: Mean Function



Neighborhood Operations: Separate edge kernels can be used

Mean function kernels

corner

$\frac{1}{4}$	$\frac{1}{4}$
$\frac{1}{4}$	$\frac{1}{4}$

margin

1/6	1/6	1/6
1/6	1/6	1/6

corner

$\frac{1}{4}$	$\frac{1}{4}$
$\frac{1}{4}$	$\frac{1}{4}$

example application,
lower right corner

10	12	13	12	11
8	11	12	12	10
7	9	10	11	9
8	9	9	11	8
9	10	12	10	8

margin

1/6	1/6
1/6	1/6
1/6	1/6

main

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

margin

1/6	1/6
1/6	1/6
1/6	1/6

corner

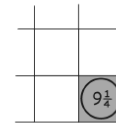
$\frac{1}{4}$	$\frac{1}{4}$
$\frac{1}{4}$	$\frac{1}{4}$

margin

1/6	1/6	1/6
1/6	1/6	1/6

corner

$\frac{1}{4}$	$\frac{1}{4}$
$\frac{1}{4}$	$\frac{1}{4}$



$$\frac{1}{4} \cdot 11 + \frac{1}{4} \cdot 8 + \frac{1}{4} \cdot 10 + \frac{1}{4} \cdot 8 = 9\frac{1}{4}$$

Example: Identifying
spatial differences in
a raster layer

Input
layer

980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940
980	980	980	980	980	940	940	940	940	940

Kernels

0	0	0
1	0	-1
0	0	0

horizontal
difference

0	1	0
0	0	0
0	-1	0

vertical
difference

Output A

0	0	0	0	40	40	0	0	0	0
0	0	0	0	40	40	0	0	0	0
0	0	0	0	40	40	0	0	0	0
0	0	0	0	40	40	0	0	0	0
0	0	0	0	40	40	0	0	0	0
0	0	0	0	40	40	0	0	0	0
0	0	0	0	80	80	0	0	0	0
0	0	0	0	80	80	0	0	0	0
0	0	0	0	80	80	0	0	0	0
0	0	0	0	80	80	0	0	0	0

Output B

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	40	40	40	40	40
0	0	0	0	0	40	40	40	40	40
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

Raster Analysis

Moving windows and kernels can be used with a mean kernel to reduce the difference between a cell and surrounding cells. *(done by average across a group of cells)*

Raster data may also contain “noise”; values that are large or small relative to their spatial context.
(Noise often requiring correction or smooth(ing))

Known as “high-pass” filters

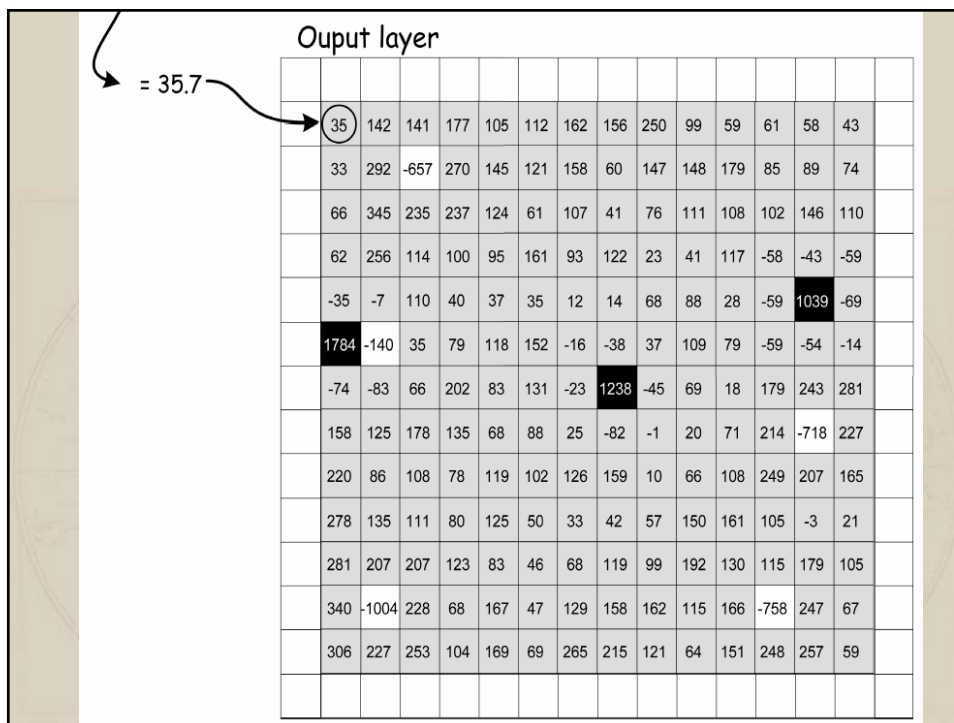
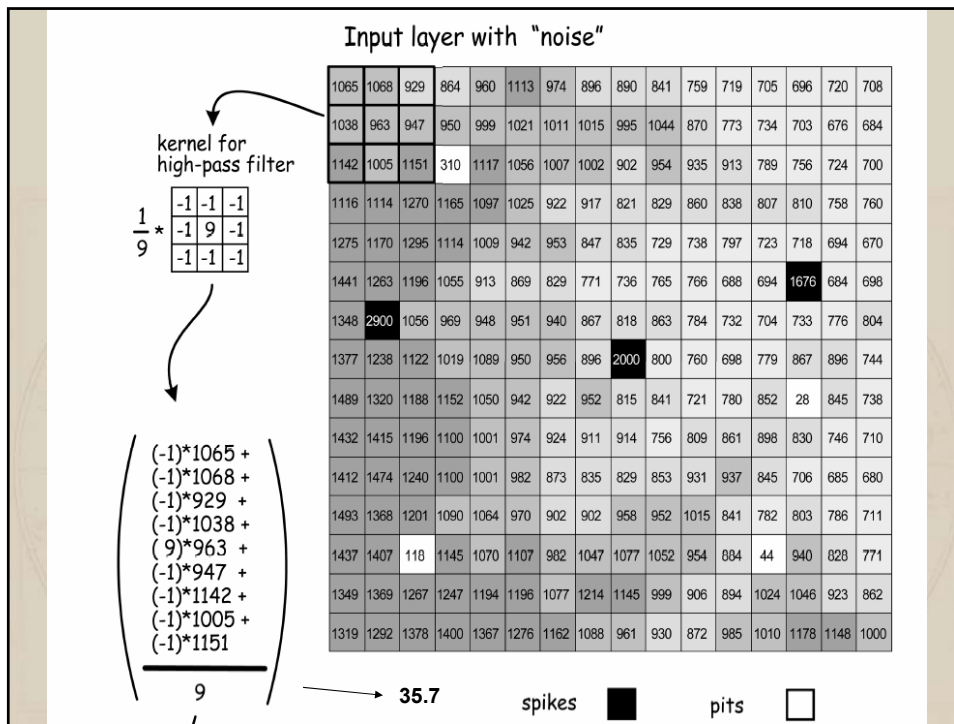
The identified spikes or pits can then be corrected or removed by editing

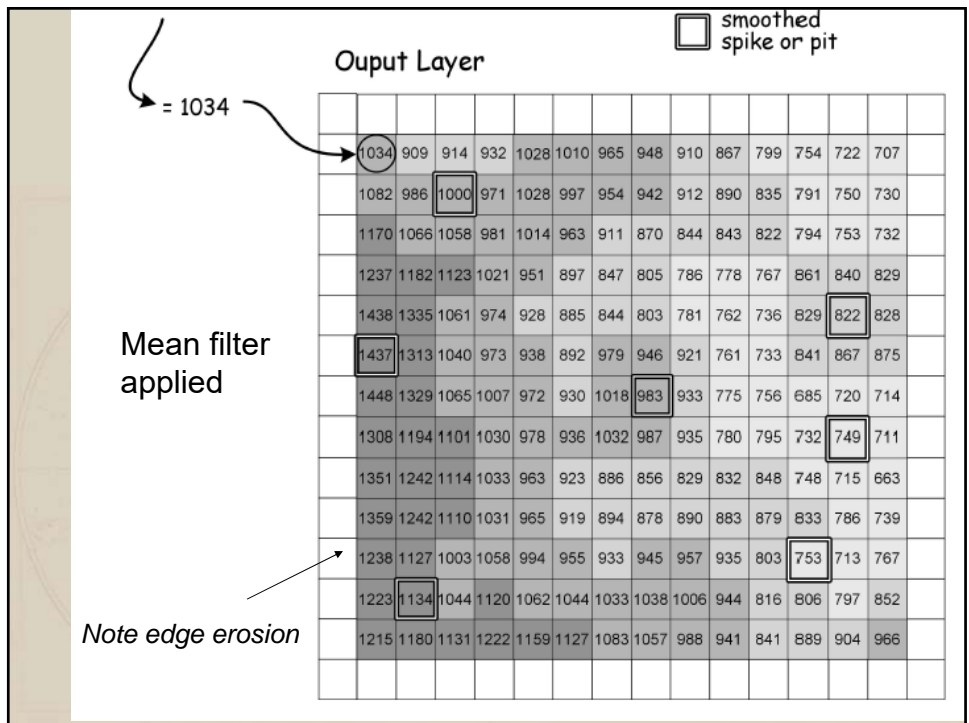
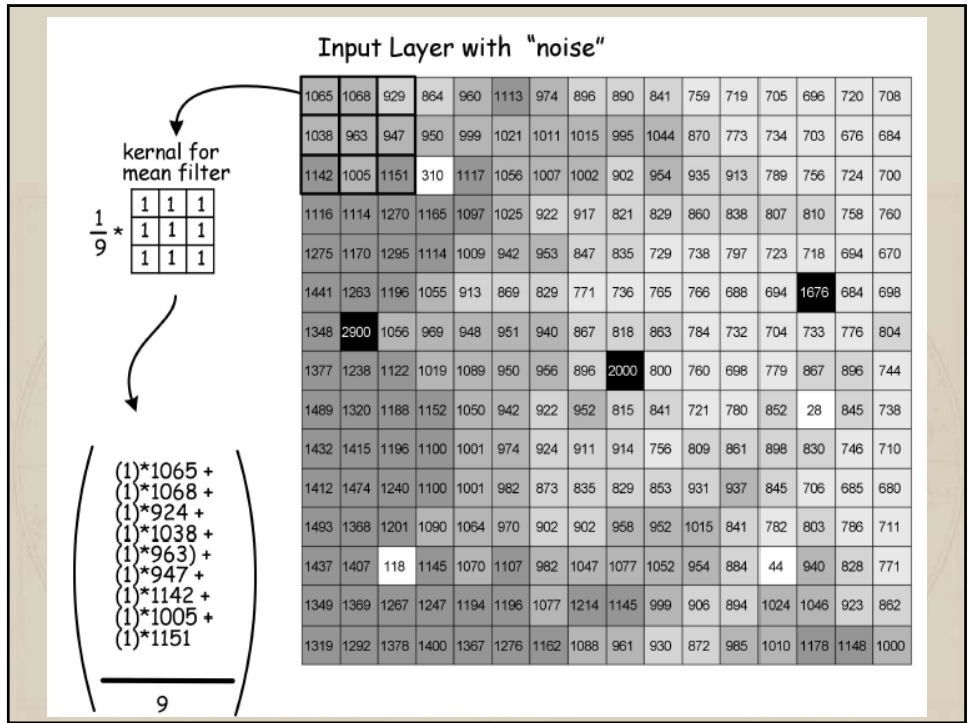
Raster Analysis

High pass filters

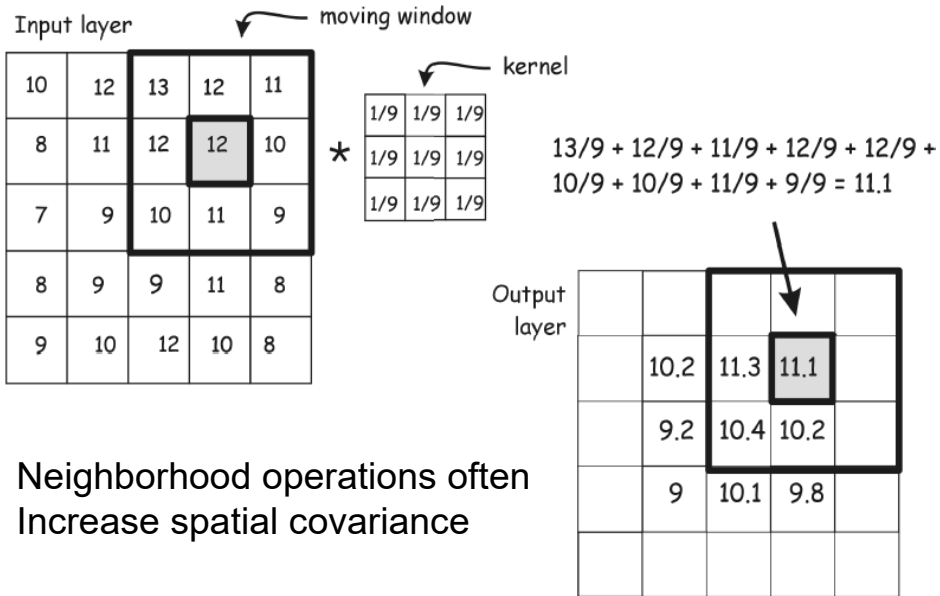
Return:

- Small values when smoothly changing values.
- Large positive values when centered on a spike
- Large negative values when centered on a pit





Moving windows: Consider the overlap in cell calculations



Cost Surface

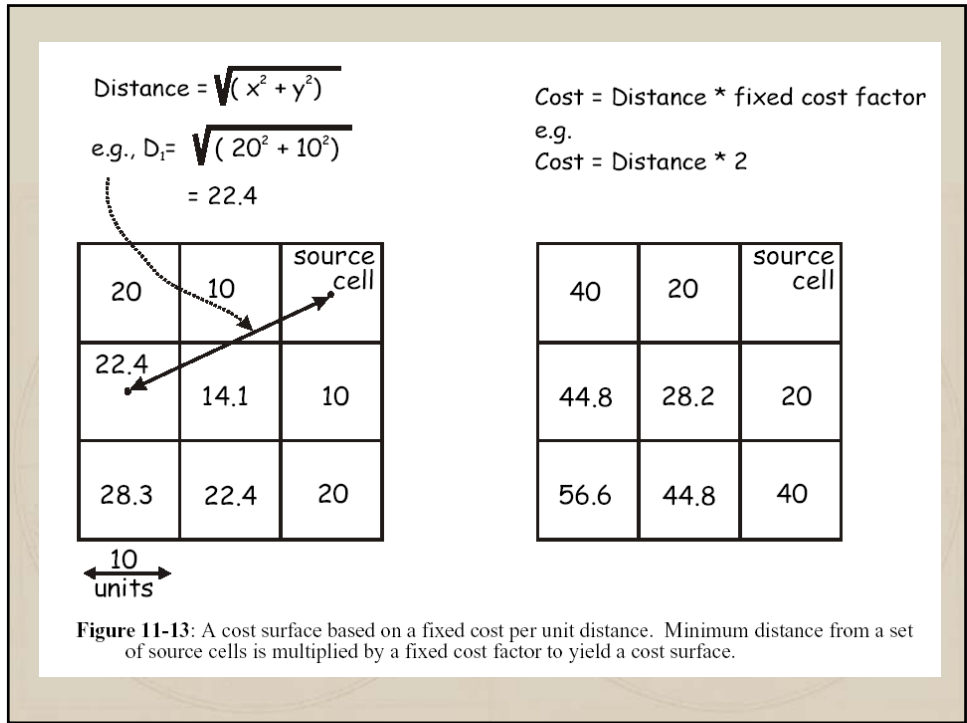
The minimum cost of reaching cells in a layer **from** one or more sources cells

“travel costs”

Time to school; hospital;

Chance of noxious foreign weed spreading out from an introduction point

- Units can be money, time, etc.
- Distance measure is combined with a fixed cost per unit distance to calculate travel cost
- If multiple source cells, the lowest cost is typically placed in the output cell



Friction Surface *(version of a Cost Surface)*

The cell values of a friction surface represent the cost per unit travel distance for crossing each cell – varies from cell to cell

Used to represent areas with variable travel cost.

Notes:

- Barriers can be added.
- Multiple paths are often not allowed
- Cost surfaces are always related to a source cell(s); “from something”
- The center of a cell is always used the distance calculations

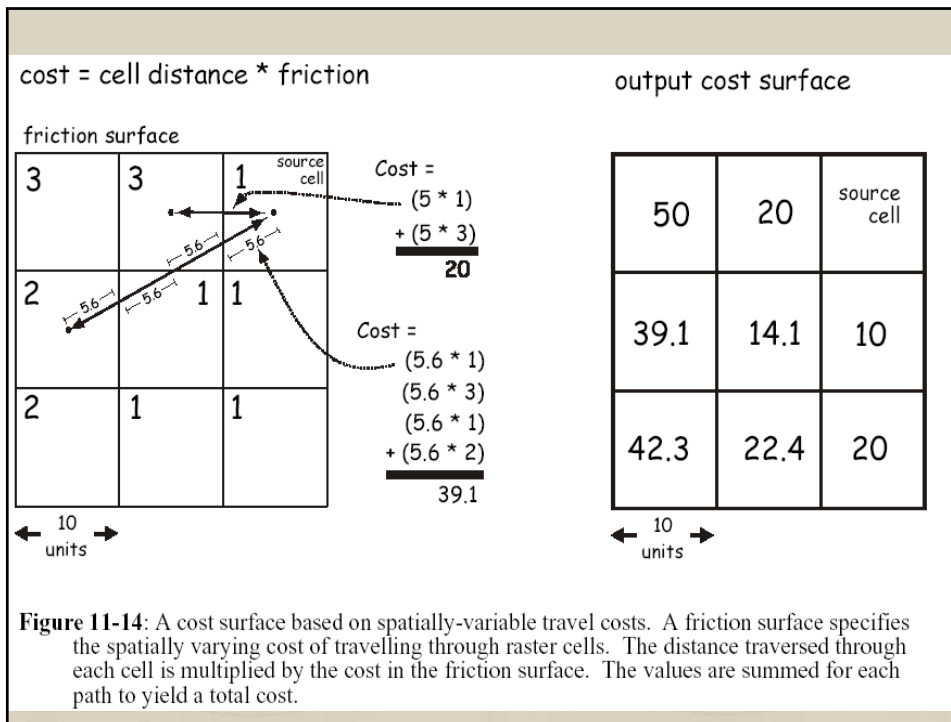


Figure 11-14: A cost surface based on spatially-variable travel costs. A friction surface specifies the spatially varying cost of travelling through raster cells. The distance traversed through each cell is multiplied by the cost in the friction surface. The values are summed for each path to yield a total cost.