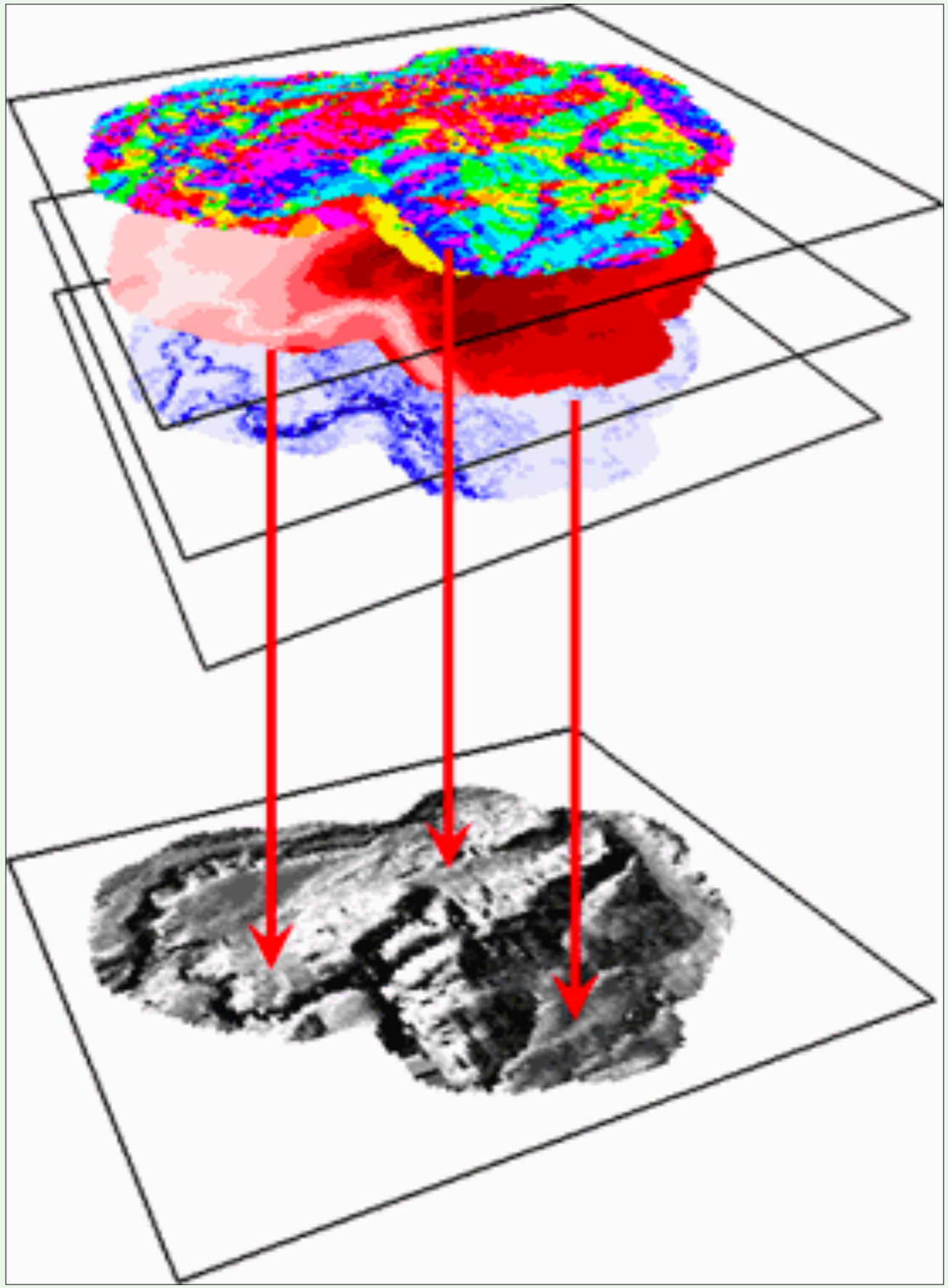
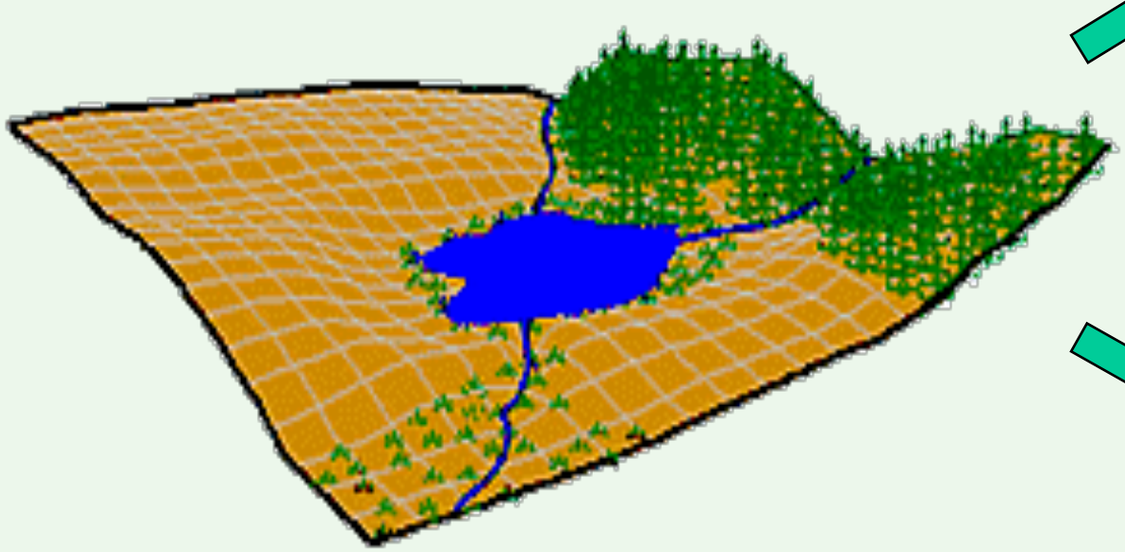
GEOG 358: Introduction to Geographic Information Systems

Raster Analysis

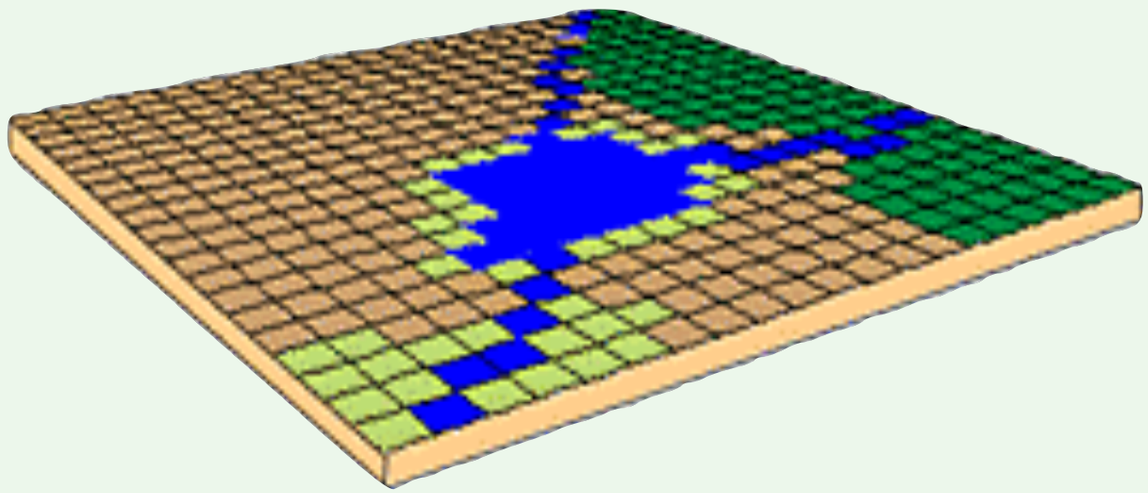


Multiple Representations

vector data model



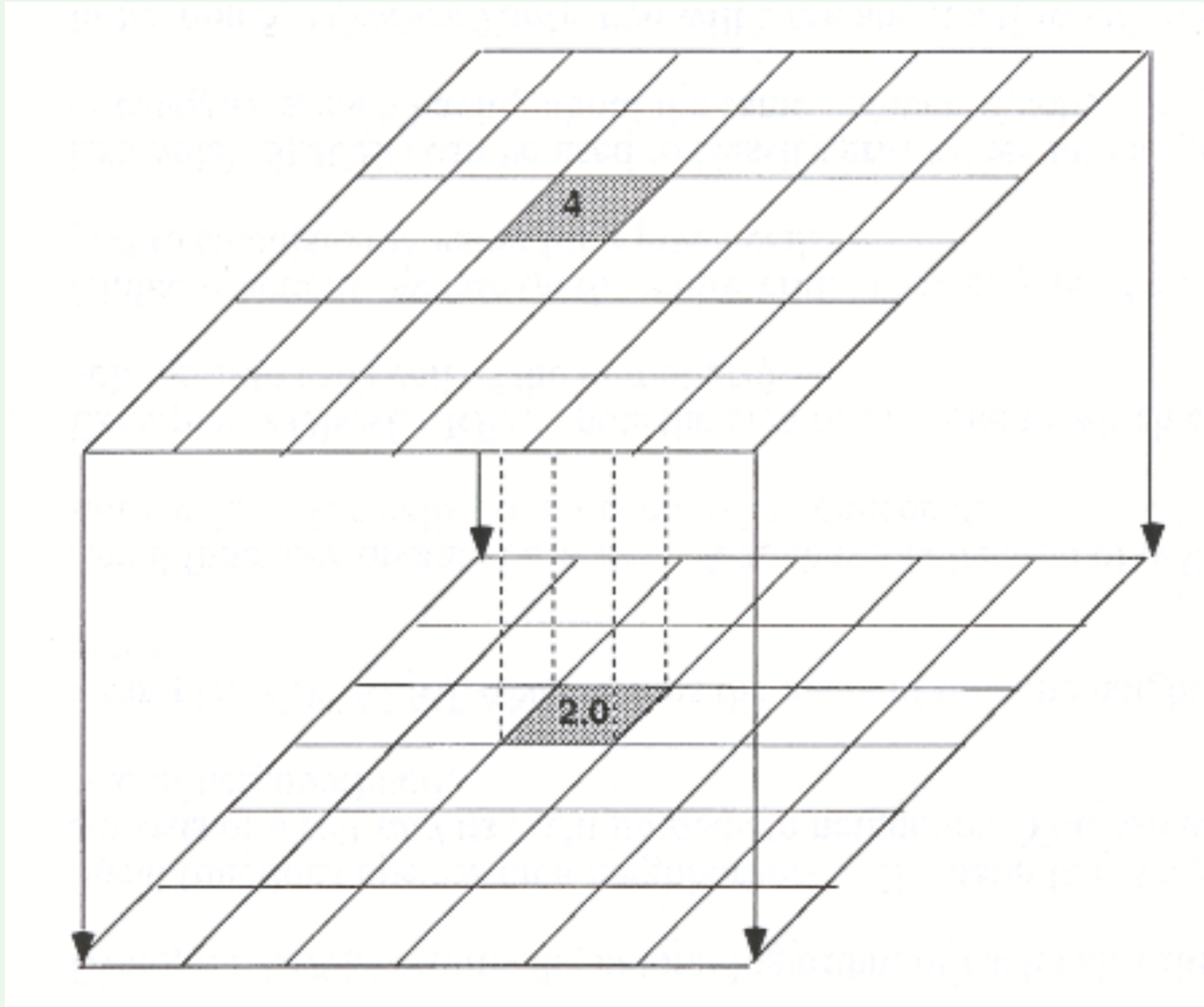
real world



raster data model

Local Operations

- Compute a new value for each cell on the output raster layer as a function of one or more existing cell values ***at the same location/cell*** on the input raster layer(s)
- Example
  - Square root or divide by 2



Geoprocessing

Reclassify

Parameters Environments

Input raster

Elevation

Reclass field

VALUE

Reclassification

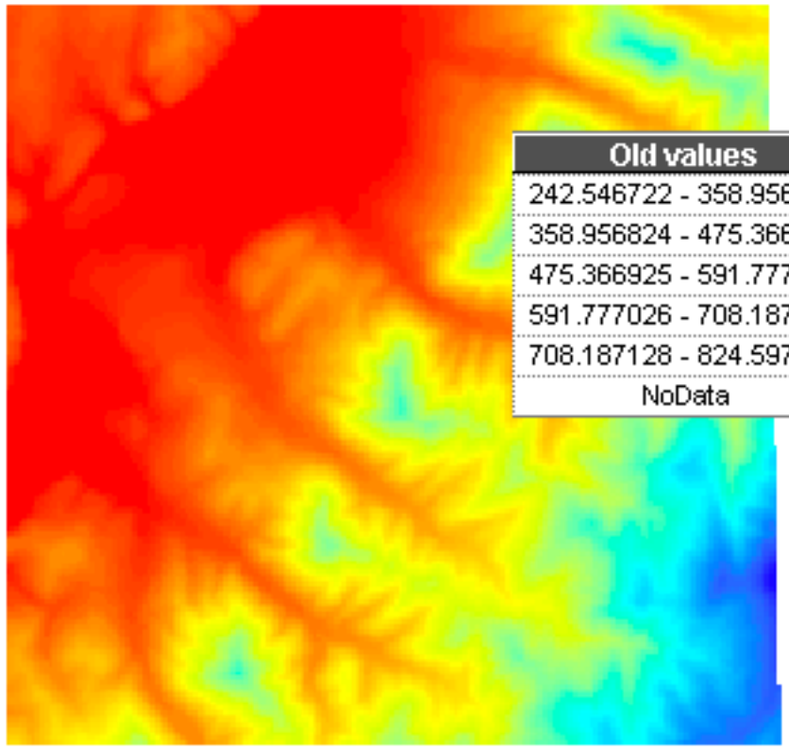
Start	End
124.415001	174.240869
174.240869	212.289713
212.289713	246.714858
246.714858	282.045928
282.045928	355.425842
NODATA	NODATA

Unique Classify

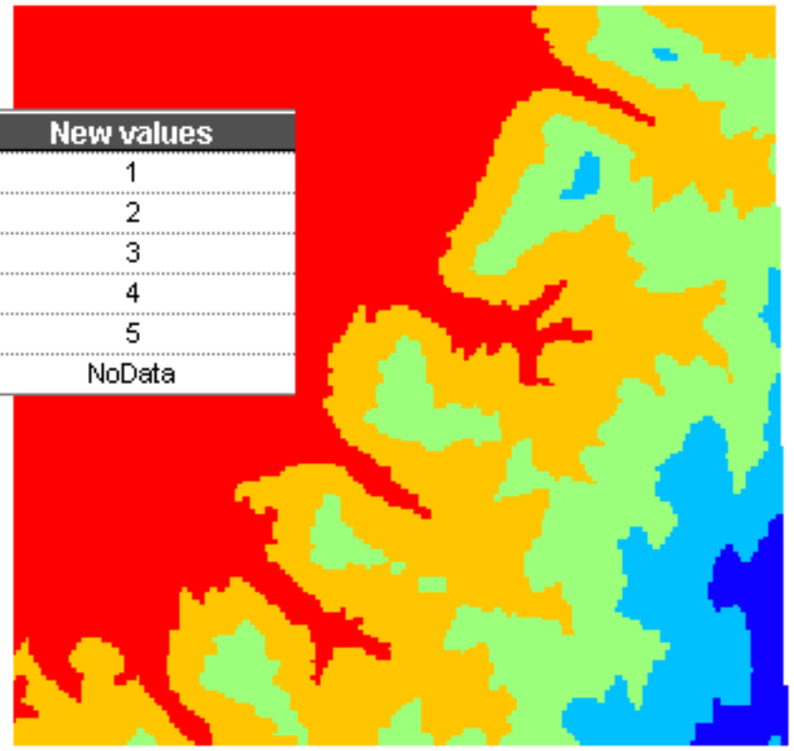
Output raster

Reclass_elev1

Change missing values to NoData

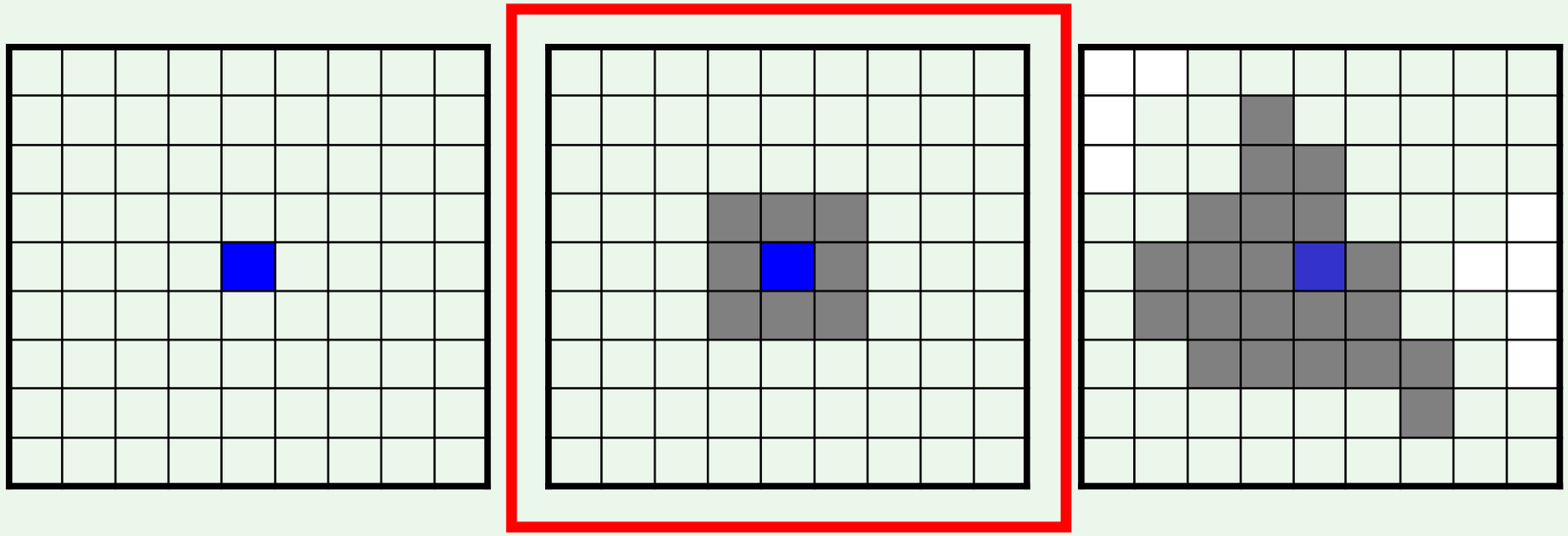


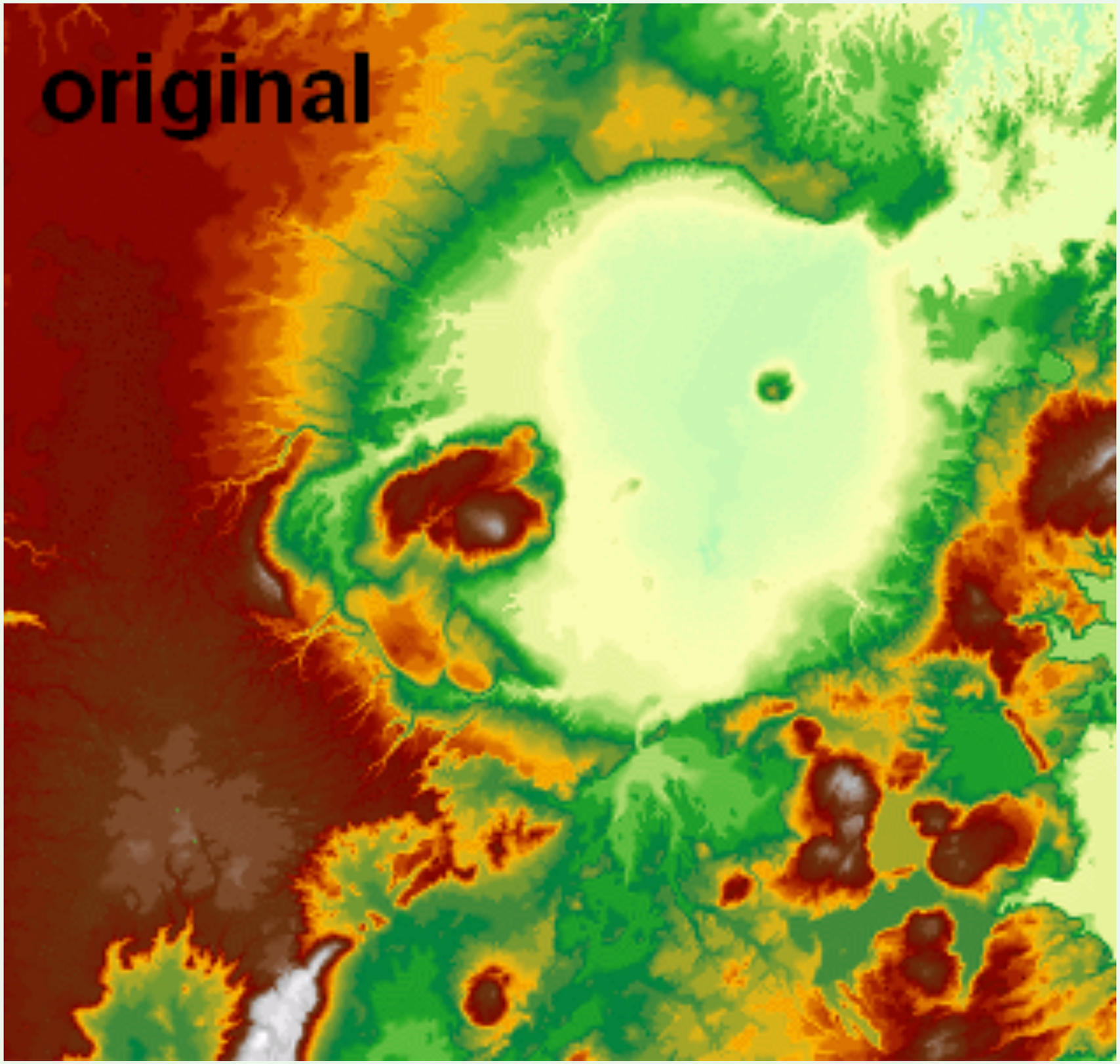
Old values	New values
242.546722 - 358.956824	1
358.956824 - 475.366925	2
475.366925 - 591.777026	3
591.777026 - 708.187128	4
708.187128 - 824.597229	5
NoData	NoData

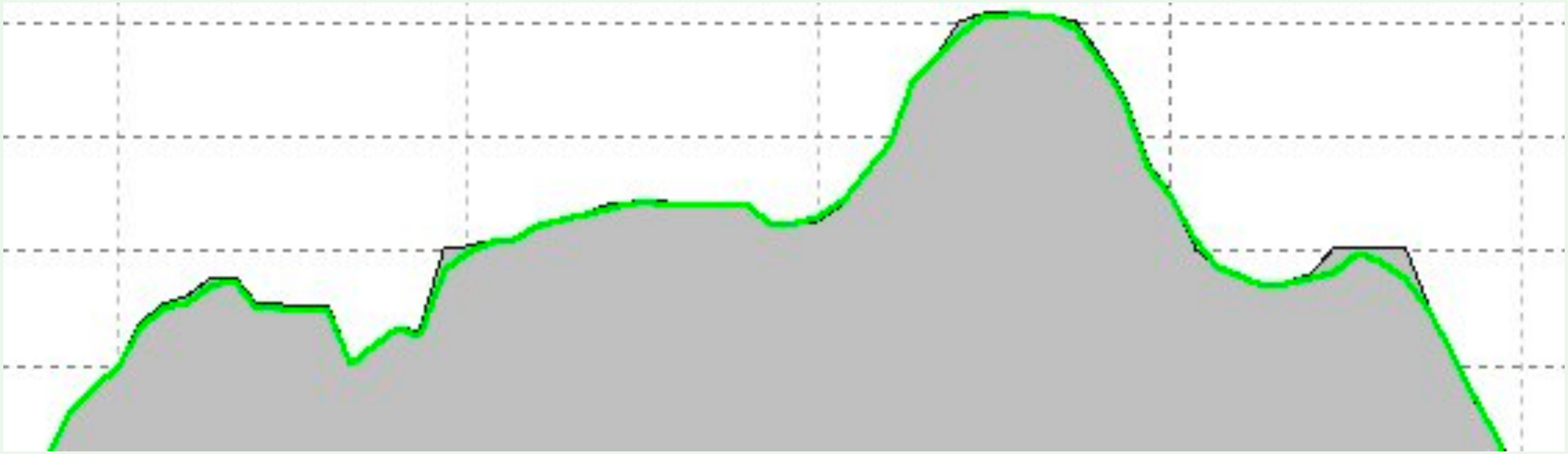


Map Algebra / Cartographic Modeling

- Raster operations are grouped as *local*, ***focal***, and *zonal* according to the *spatial scope* of the operations

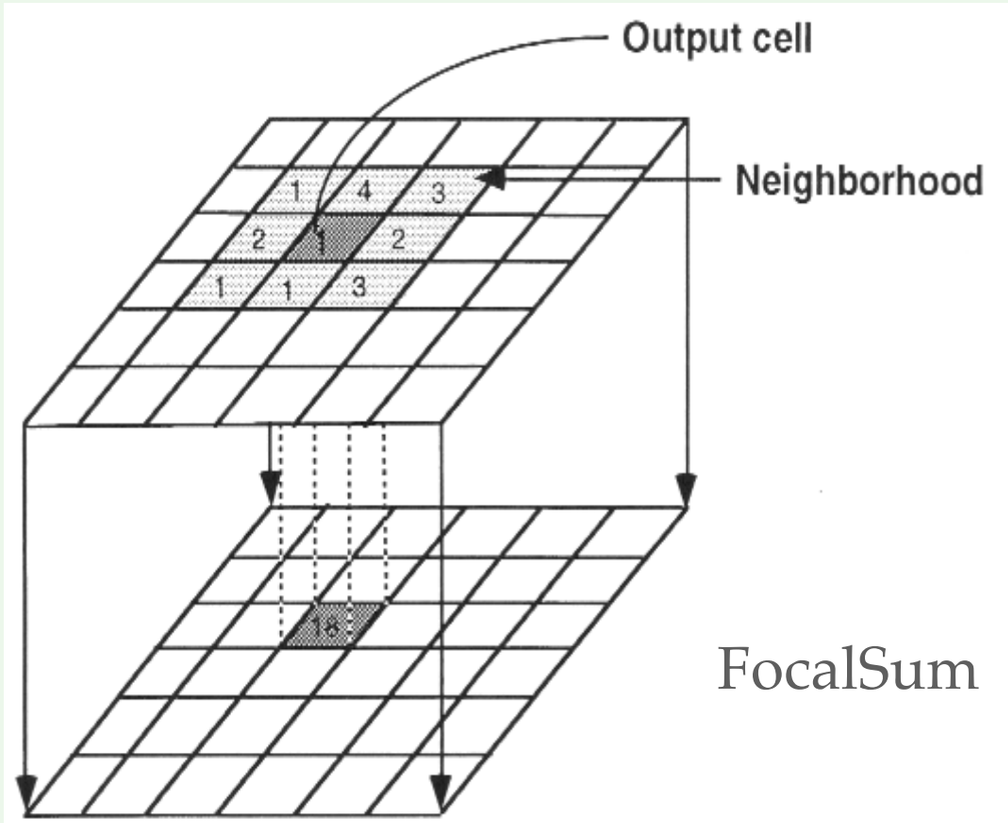



original



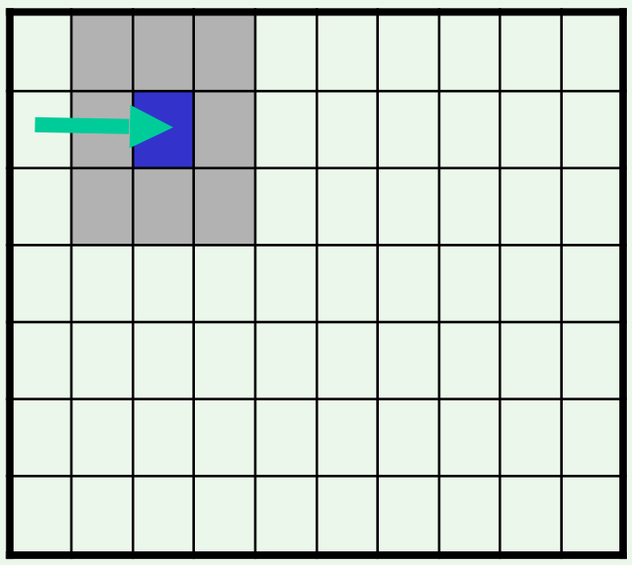
Focal Operations

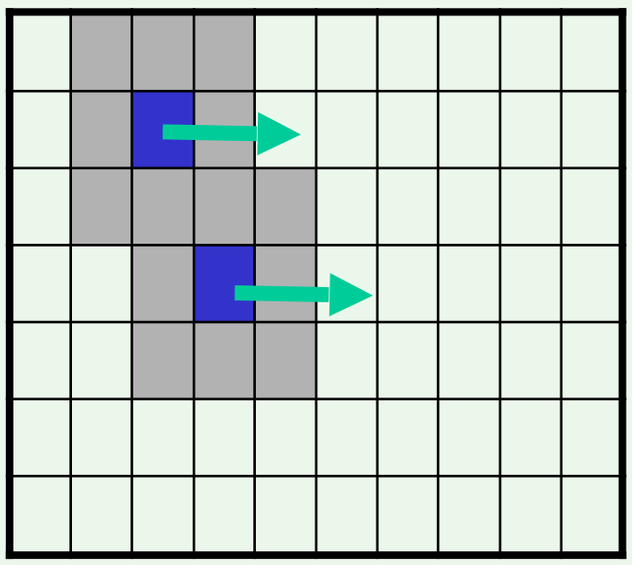
- Compute an output value for each cell as a function of the cells that are within its neighborhood
- Widely used in image processing with different names
  - Convolution, filtering, kernel or moving window
- Focal operations are *spatial* (beyond the cell) in nature



Performing a Focal Operation

- Iterate through each cell (focus cell)
- Values within its neighborhood are extracted and manipulated
- Result is saved at the focus cell on the output raster
- Neighborhoods may overlap with each other
  - Cells may share their neighborhoods
- Boundary cells

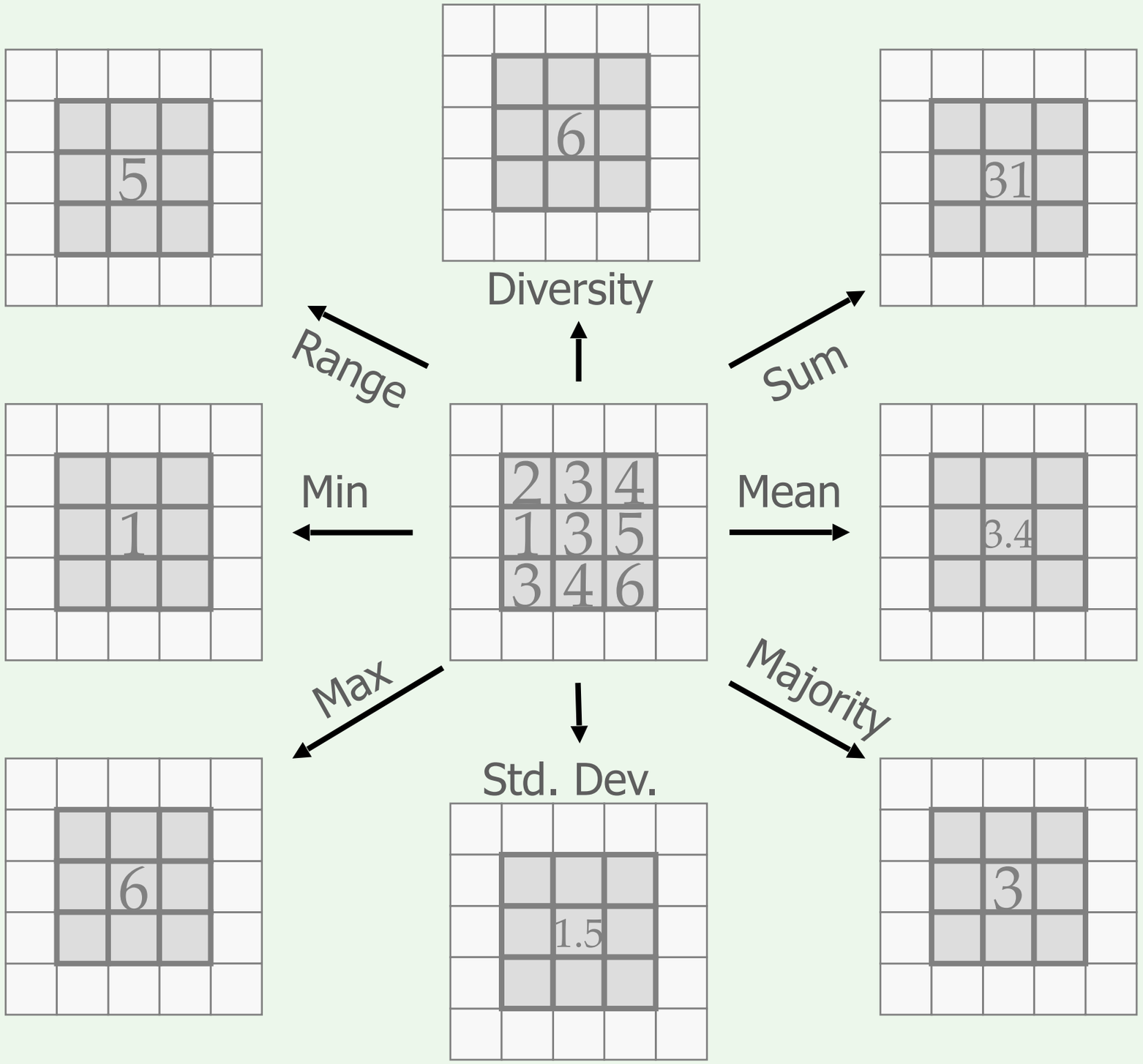




0	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36

NA	NA	NA	NA	NA	NA
NA	0	2	3	4	NA
NA	7	8	9	10	NA
NA	13	14	15	16	NA
NA	19	20	21	22	NA
NA	NA	NA	NA	NA	NA

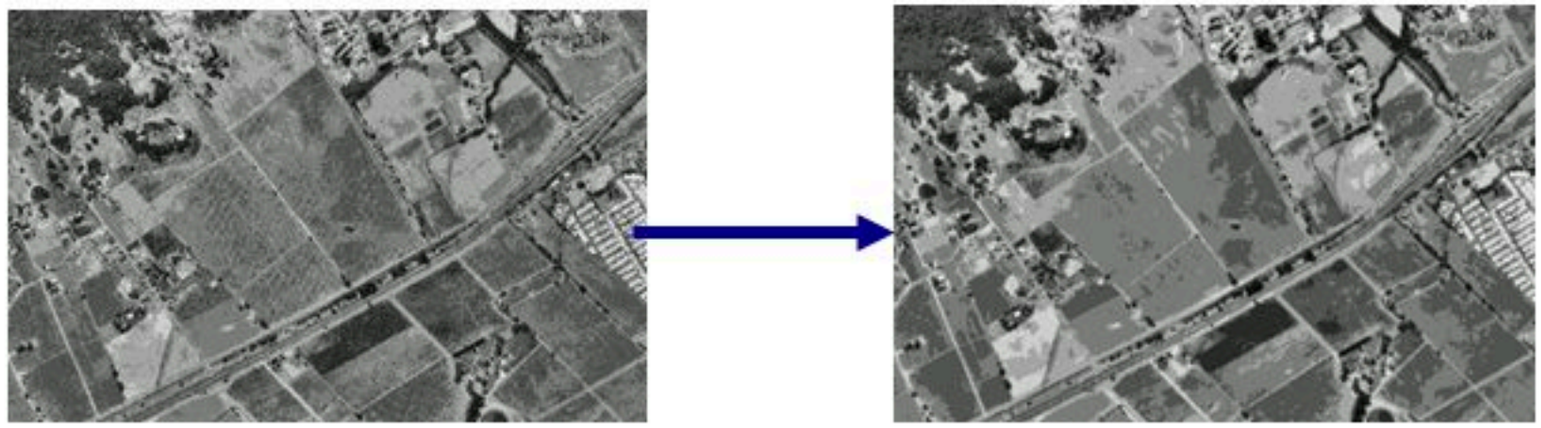
Focal Statistical Operations



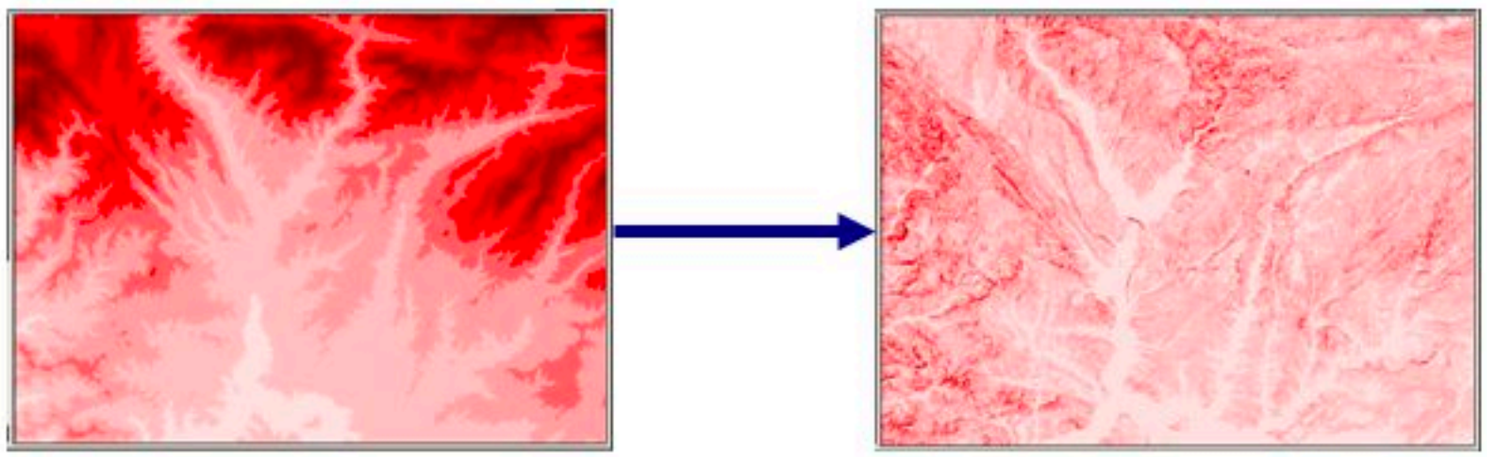
Neighborhood Filters

Filter types

– Low pass filters – remove noise (emphasize trends)



– High pass filters – edge enhancement (emphasize local detail)



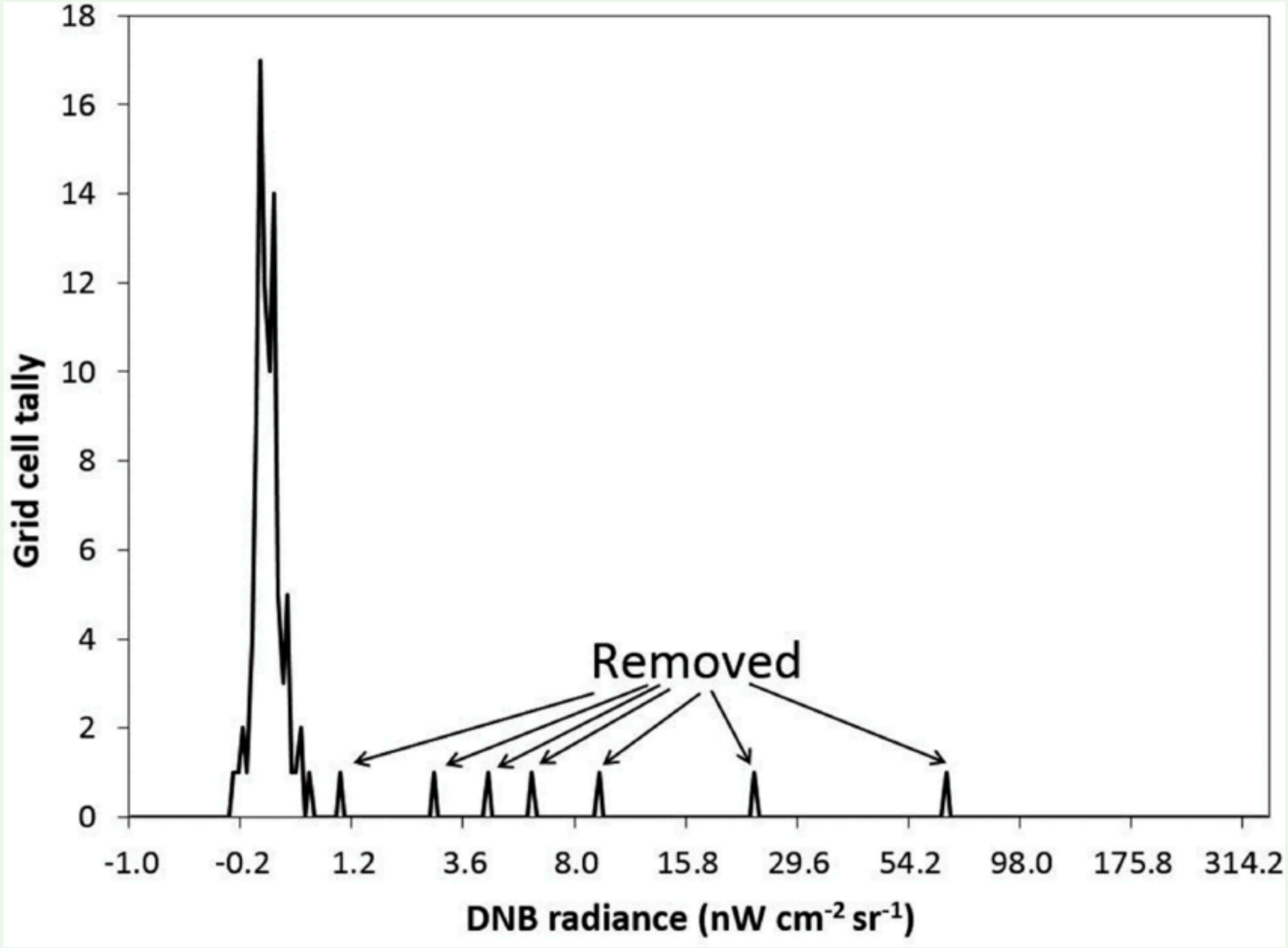
Focal Mean Operation (remove data noise)

1065	1068	929	864	960	1113	974	896	890	841	759	719	705	696	720	708
1038	963	947	950	999	1021	1011	1015	995	1044	870	773	734	703	676	684
1142	1005	1151	310	1117	1056	1007	1002	902	954	935	913	789	756	724	700
1116	1114	1270	1165	1097	1025	922	917	821	829	860	838	807	810	758	760
1275	1170	1295	1114	1009	942	953	847	835	729	738	797	723	718	694	670
1441	1263	1196	1055	913	869	829	771	736	765	766	688	694	1676	684	698
1348	2900	1056	969	948	951	940	867	818	863	784	732	704	733	776	804
1377	1238	1122	1019	1089	950	956	896	2000	800	760	698	779	867	896	744
1489	1320	1188	1152	1050	942	922	952	815	841	721	780	852	28	845	738
1432	1415	1196	1100	1001	974	924	911	914	756	809	861	898	830	746	710
1412	1474	1240	1100	1001	982	873	835	829	853	931	937	845	706	685	680
1493	1368	1201	1090	1064	970	902	902	958	952	1015	841	782	803	786	711
1437	1407	118	1145	1070	1107	982	1047	1077	1052	954	884	44	940	828	771
1349	1369	1267	1247	1194	1196	1077	1214	1145	999	906	894	1024	1046	923	862
1319	1292	1378	1400	1367	1276	1162	1088	961	930	872	985	1010	1178	1148	1000

smoothed
spike or pit

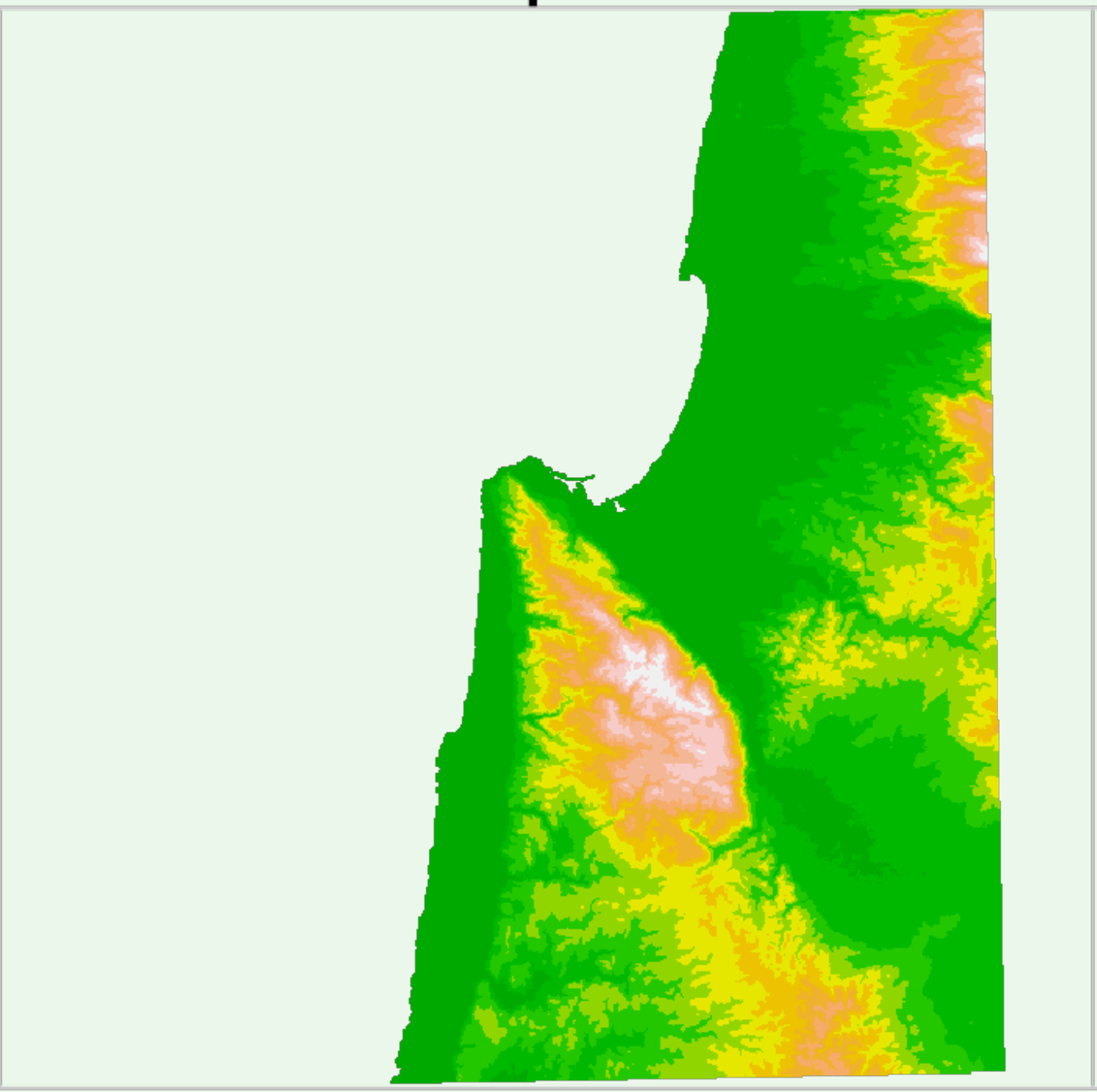
Ouput Layer

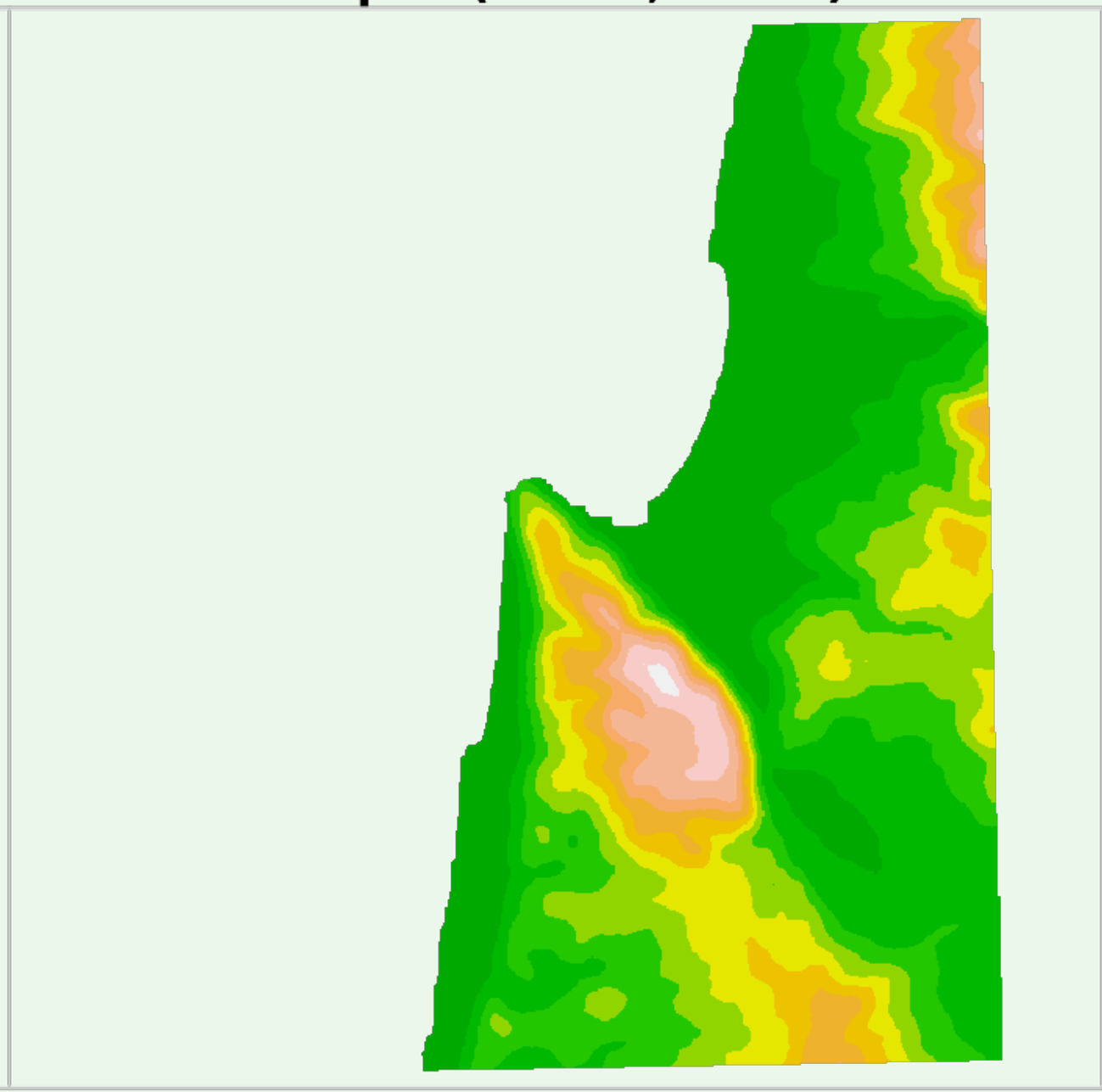
	1034	909	914	932	1028	1010	965	948	910	867	799	754	722	707	
	1082	986	1000	971	1028	997	954	942	912	890	835	791	750	730	
	1170	1066	1058	981	1014	963	911	870	844	843	822	794	753	732	
	1237	1182	1123	1021	951	897	847	805	786	778	767	861	840	829	
	1438	1335	1061	974	928	885	844	803	781	762	736	829	822	828	
	1437	1313	1040	973	938	892	979	946	921	761	733	841	867	875	
	1448	1329	1065	1007	972	930	1018	983	933	775	756	685	720	714	
	1308	1194	1101	1030	978	936	1032	987	935	780	795	732	749	711	
	1351	1242	1114	1033	963	923	886	856	829	832	848	748	715	663	
	1359	1242	1110	1031	965	919	894	878	890	883	879	833	786	739	
	1238	1127	1003	1058	994	955	933	945	957	935	803	753	713	767	
	1223	1134	1044	1120	1062	1044	1033	1038	1006	944	816	806	797	852	
	1215	1180	1131	1222	1159	1127	1083	1057	988	941	841	889	904	966	

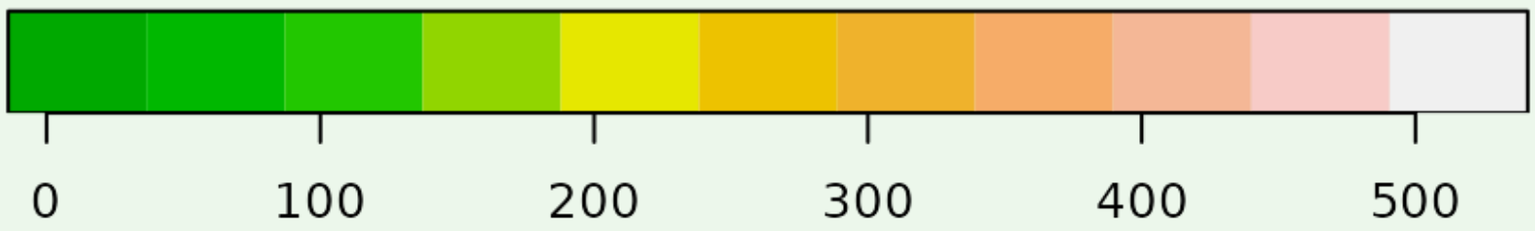

18
16
14
12
10
8
6
4
2
0
Grid cell tally
Removed
-1.0
-0.2
1.2
3.6
8.0
15.8
29.6
54.2
98.0
175.8
314.2
DNB radiance (nW cm-2 sr-1)

input

output (mean, k=15)







Focal Majority Operation
(remove "noise" for nominal data)

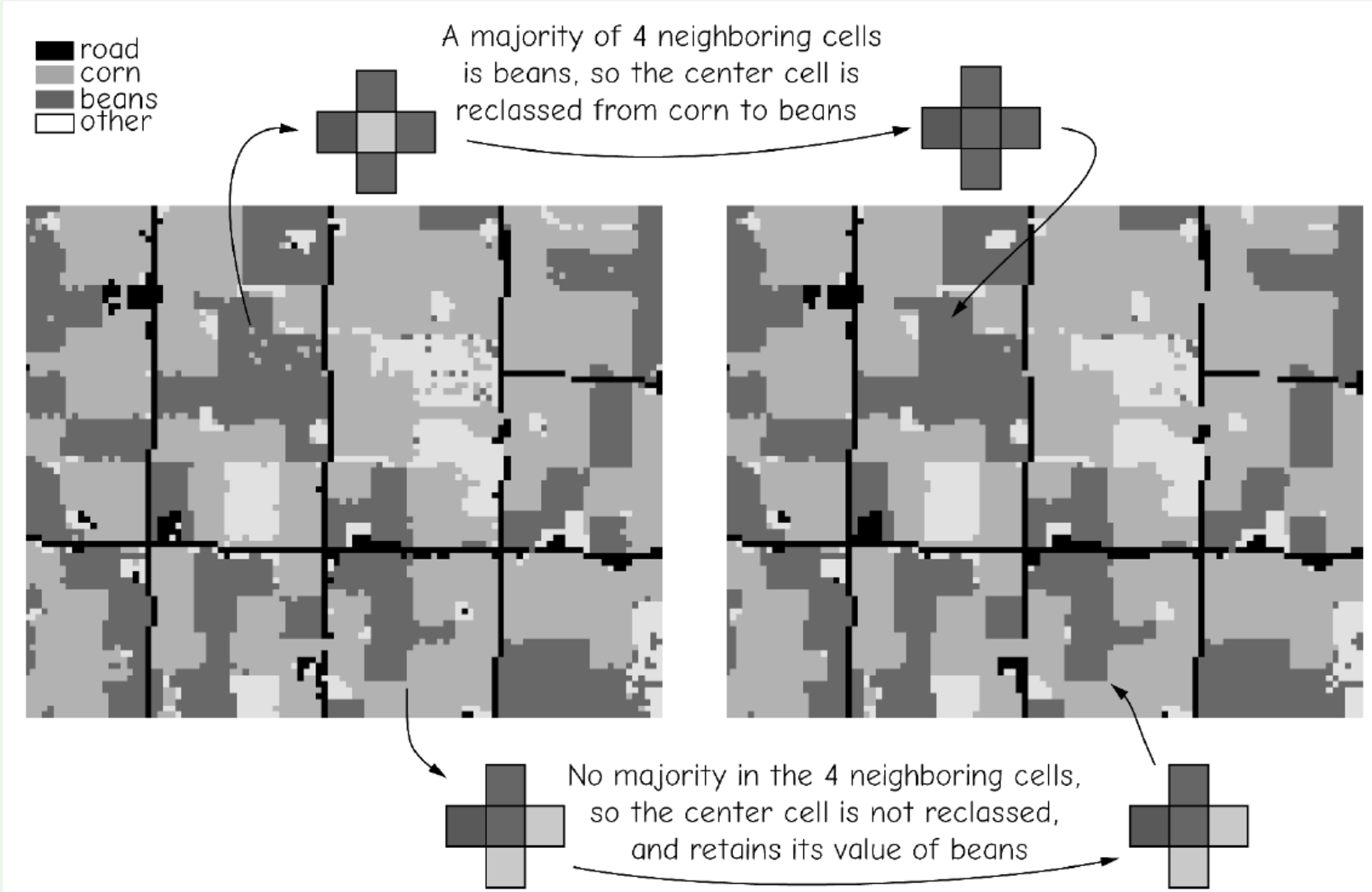
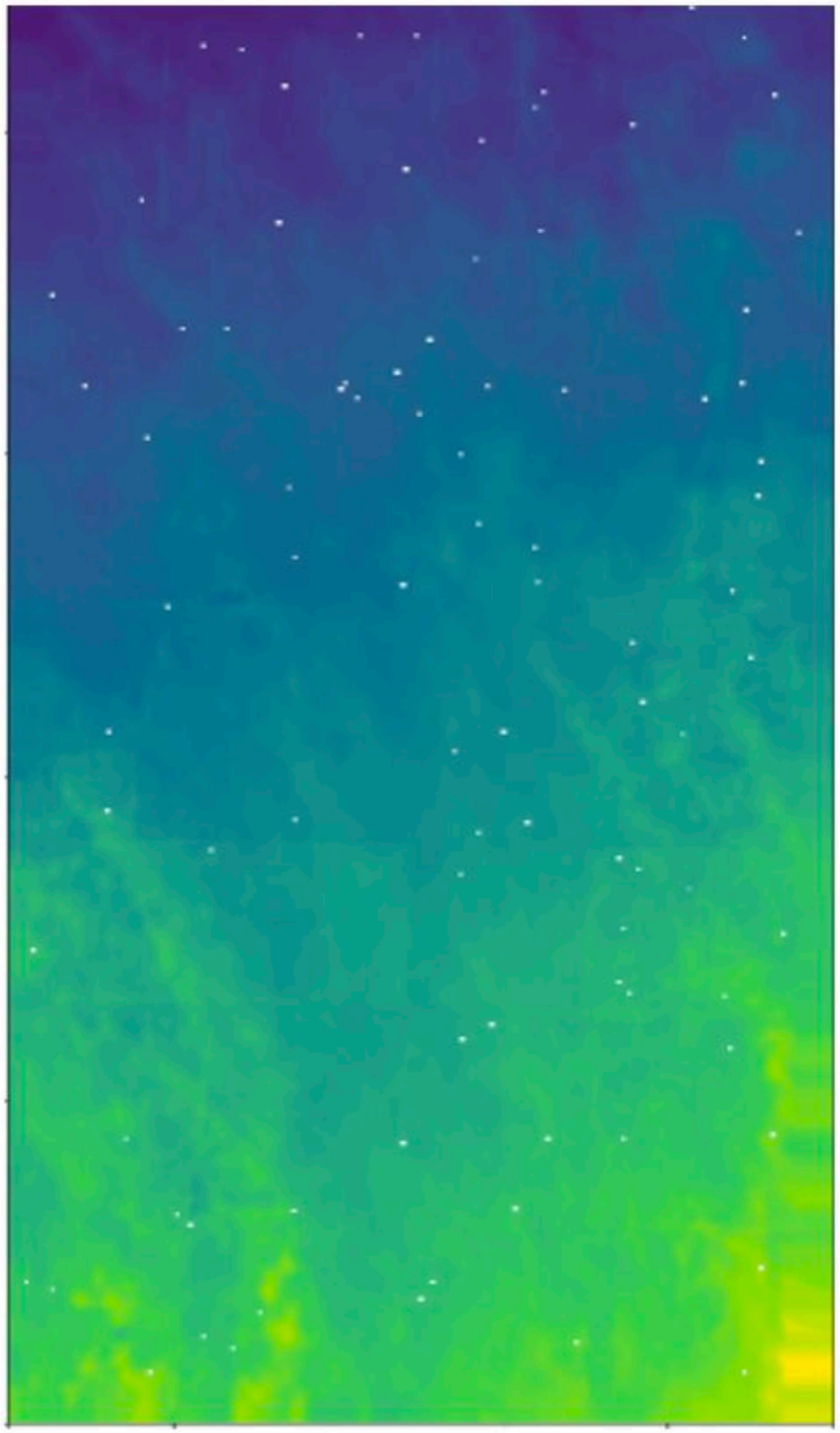
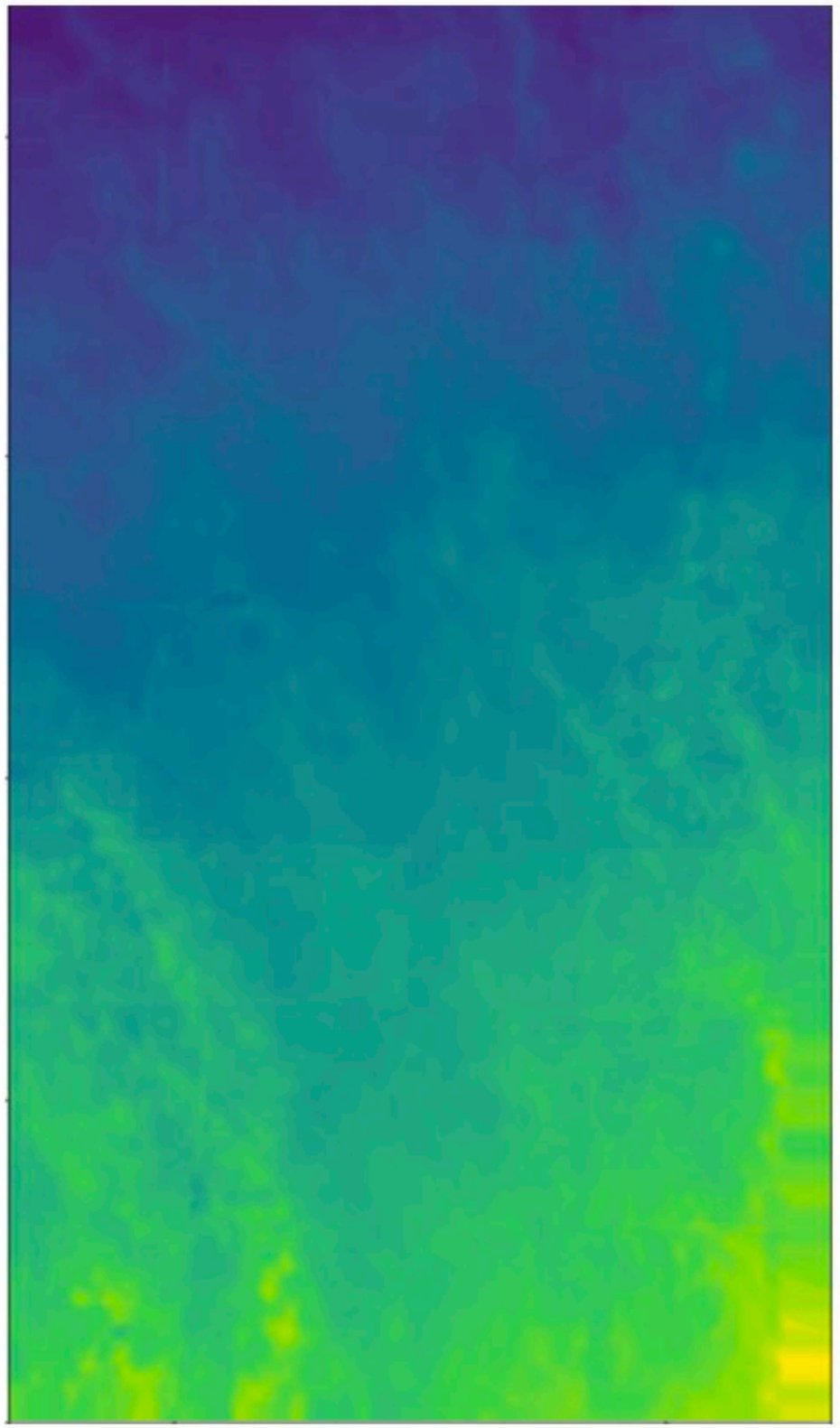


Figure 10-17: An example of a majority filter applied to a raster data layer from a classified satellite image. Many isolated cells are converted to the category of the dominant surrounding class.

Smoothing null values with spatial filtering



BEFORE



AFTER

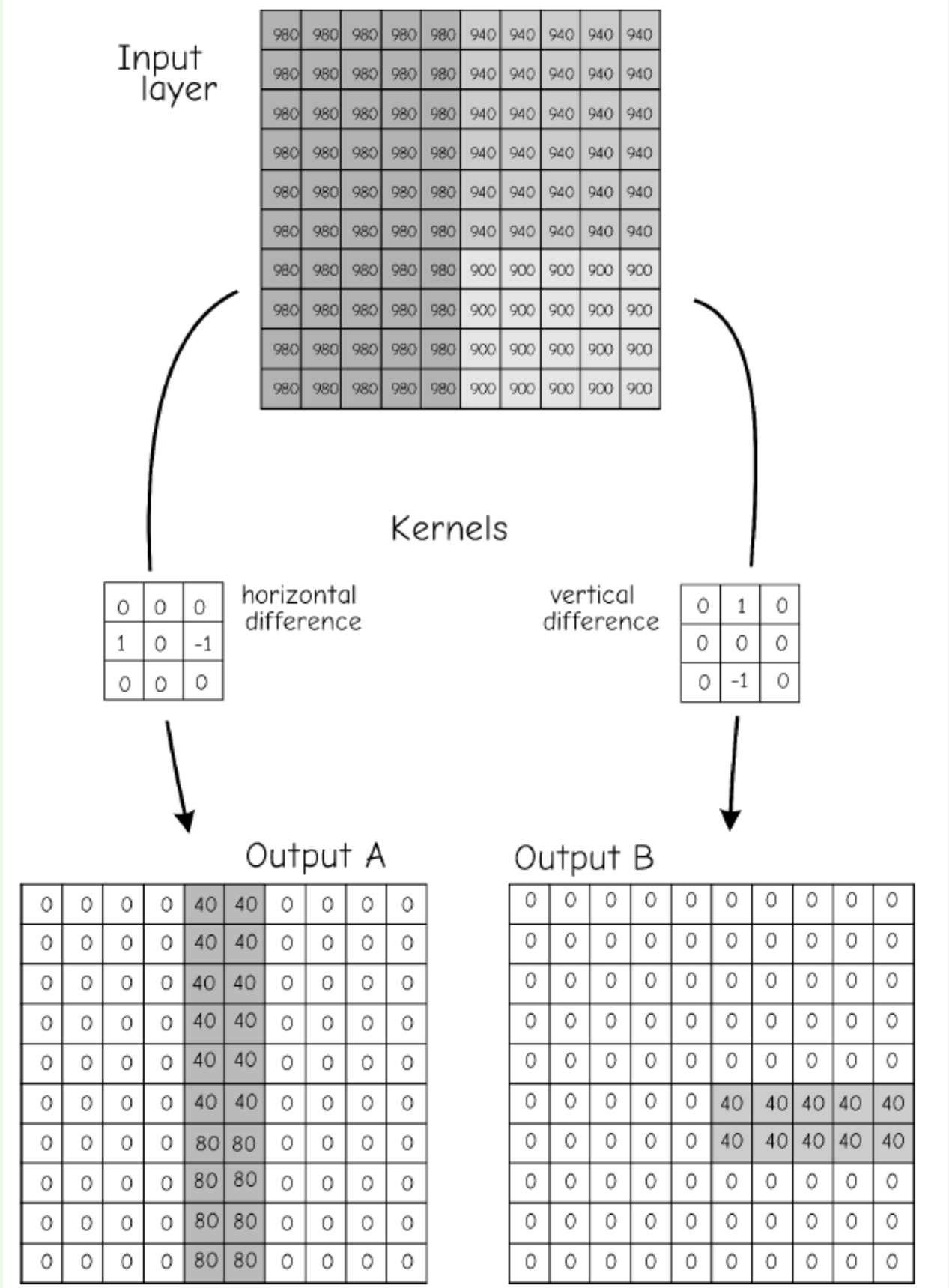


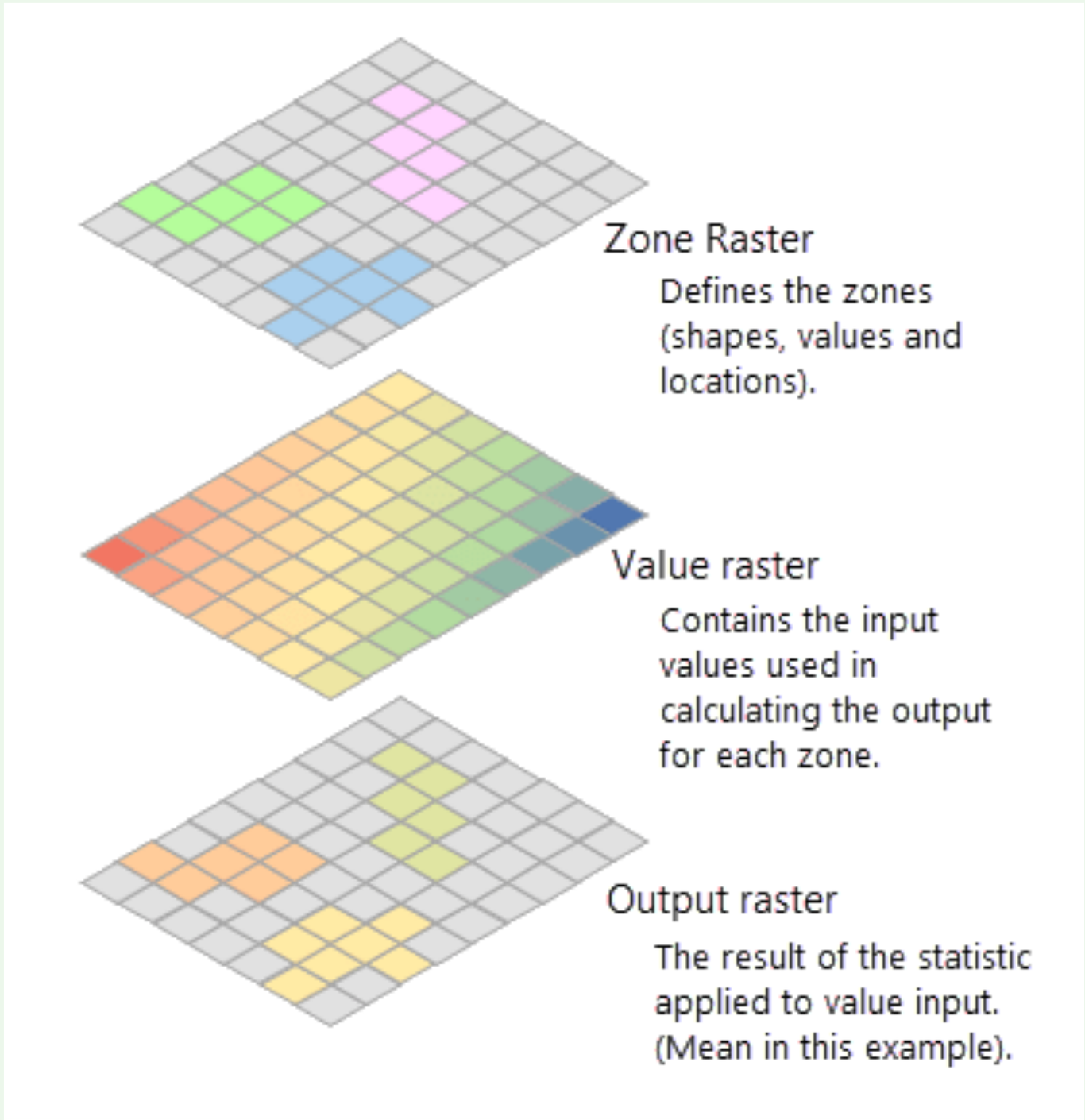
Figure 10-20: There is a large number of kernels used with moving windows. The kernel on the left amplifies differences in the x direction, while the kernel on the right amplifies differences in the y direction. These and other kernels may be used to detect specific features in a data layer.

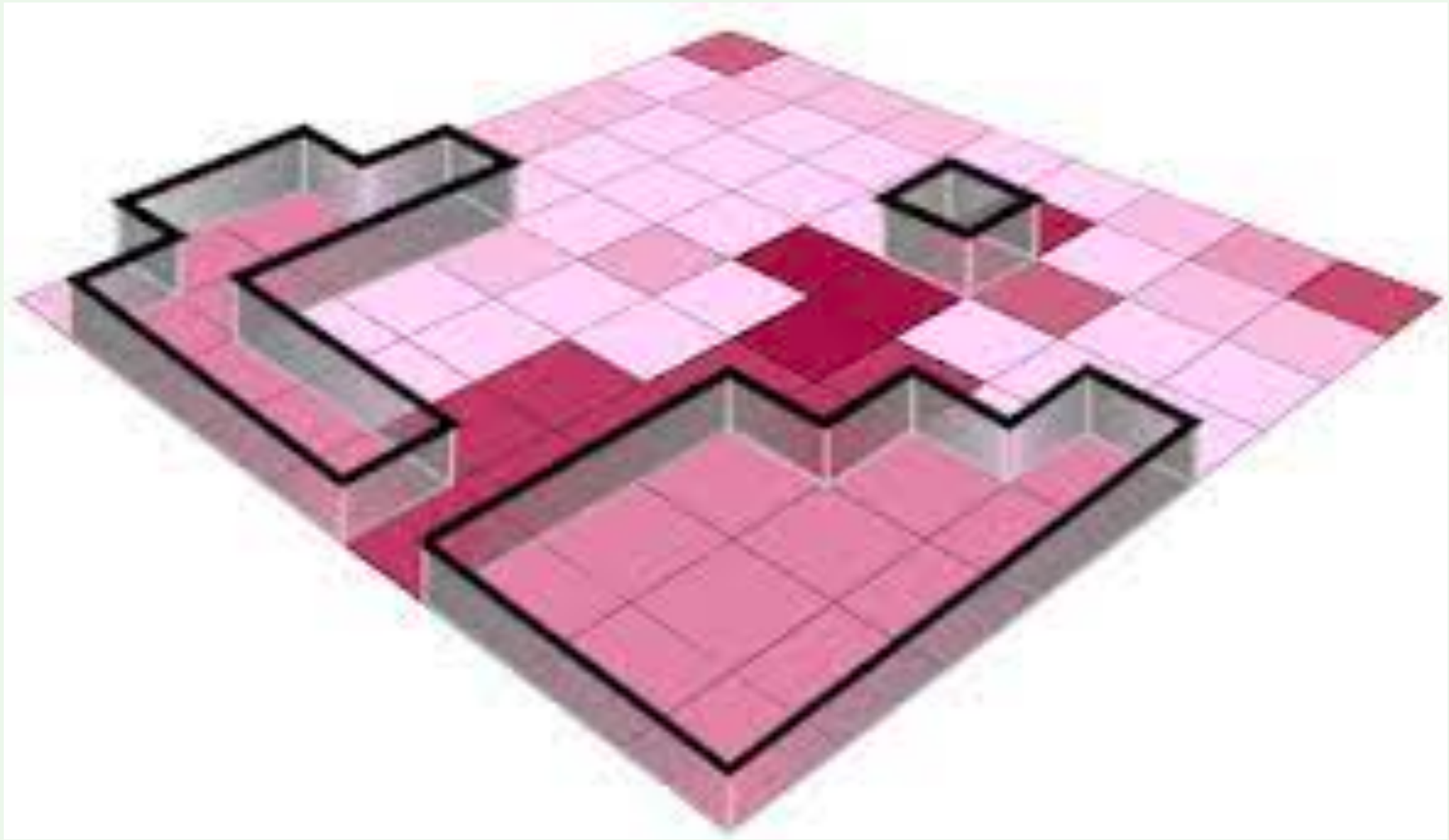
Weighted Neighborhood

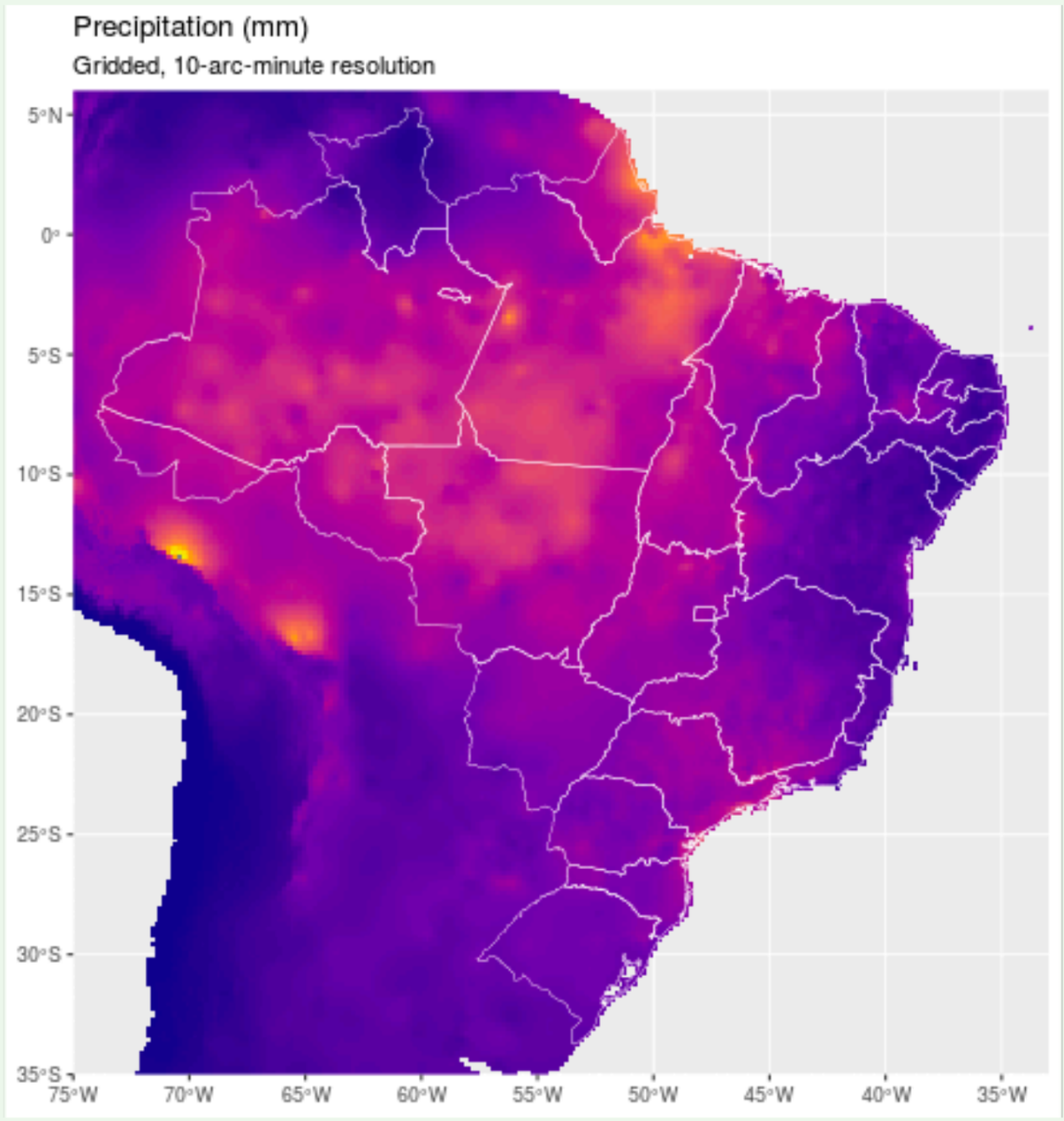
- Operation = weighted summation

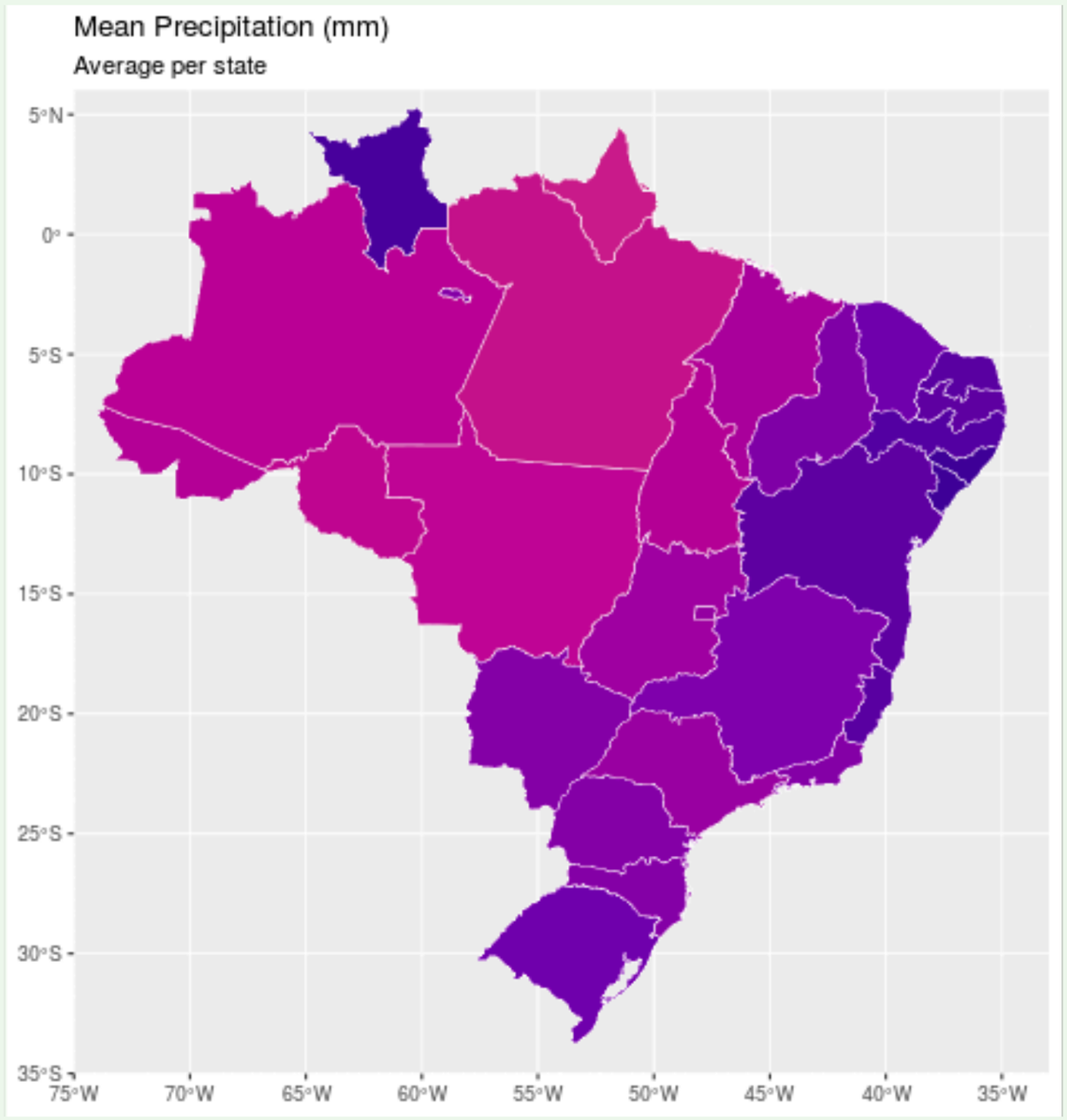
Zonal Operations

- Focal operations with zone as the neighborhood

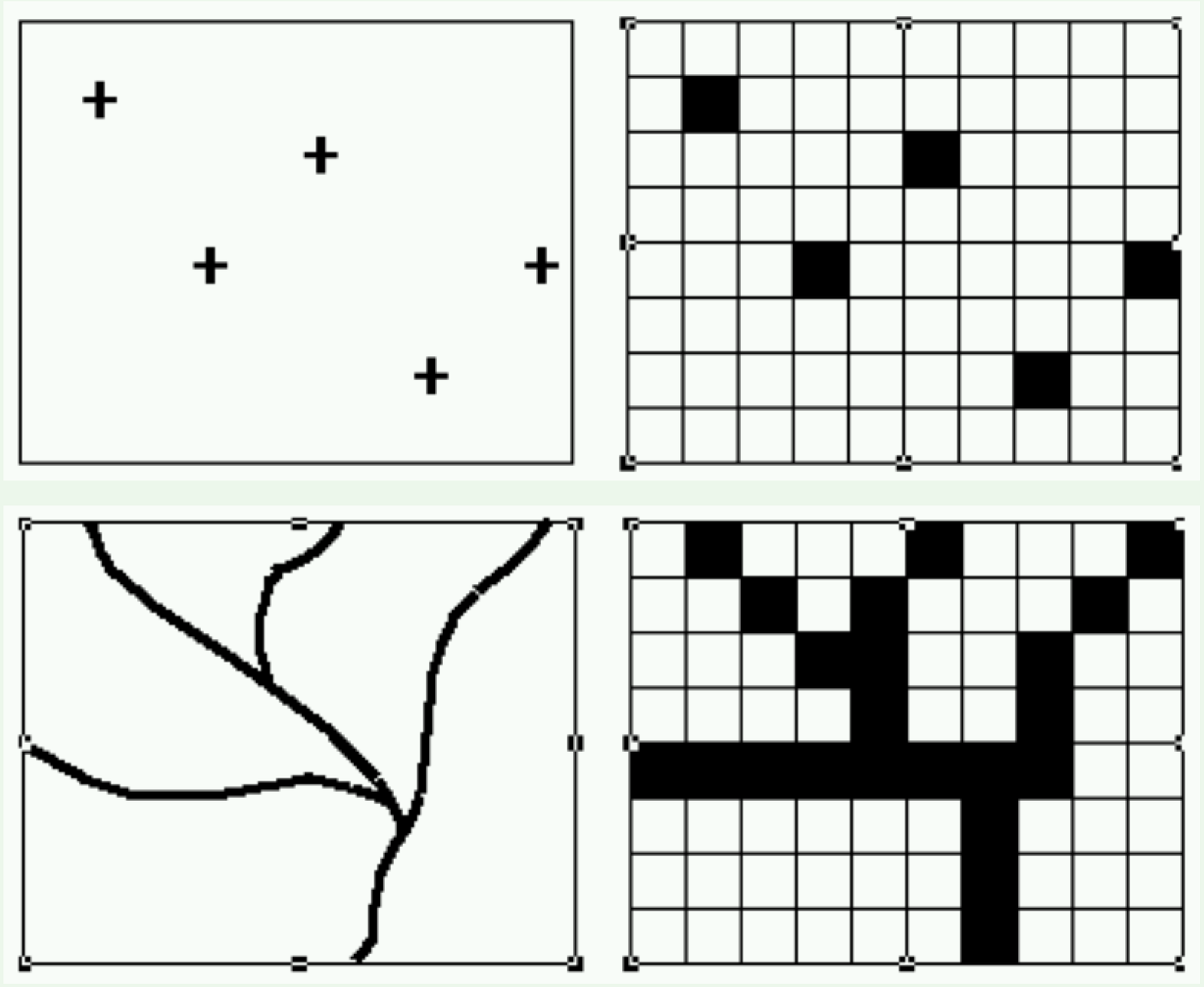





Precipitation (mm)
Gridded, 10-arc-minute resolution
5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S
75°W
70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W


Mean Precipitation (mm)
Average per state
5°N
0°
5°S
10°S
15°S
20°S
25°S
30°S
35°S
75°W
70°W
65°W
60°W
55°W
50°W
45°W
40°W
35°W

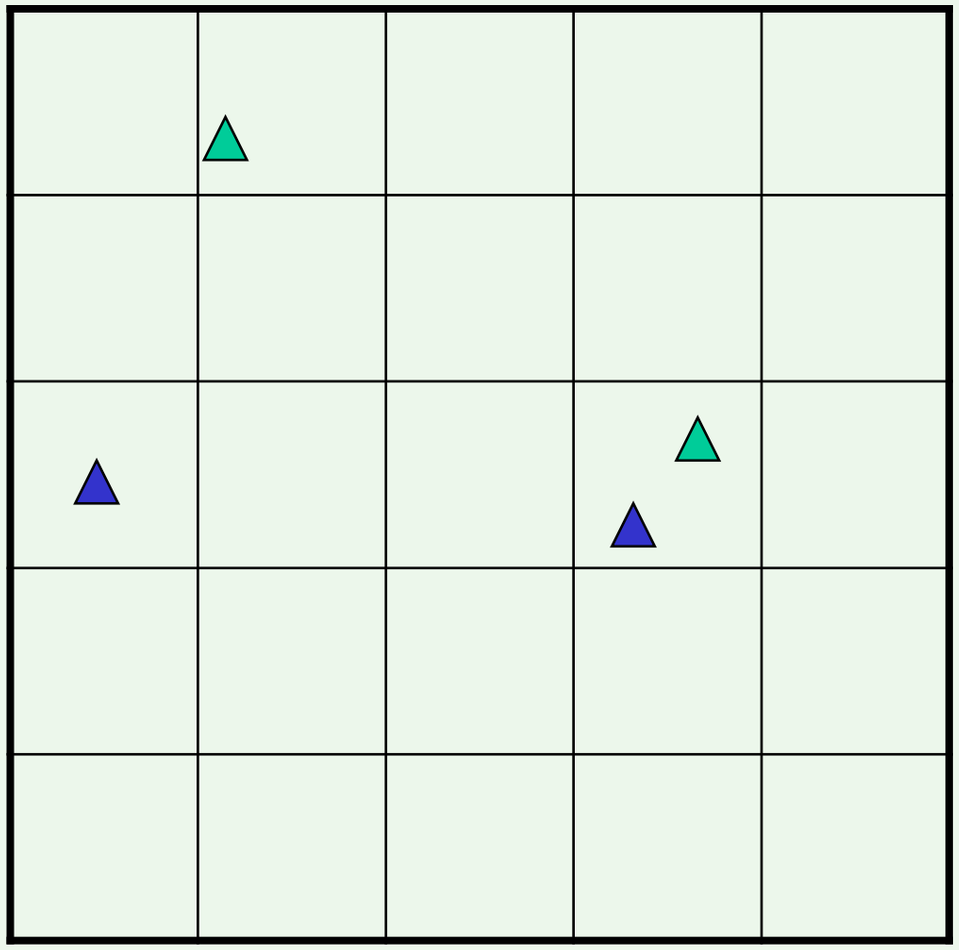
Vector-to-Raster Conversion

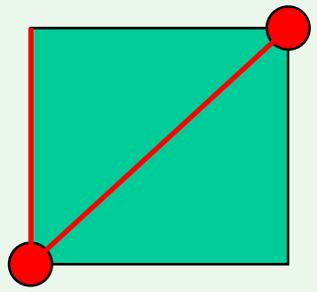


- Vector data can be converted to raster for use with the map algebra operations
- A raster layer usually represents **one** attribute of the features
- The meaning of the raster layer depends on the chosen attribute
- Multiple raster layers can be created from one vector layer

Point-to-Raster Data Conversion

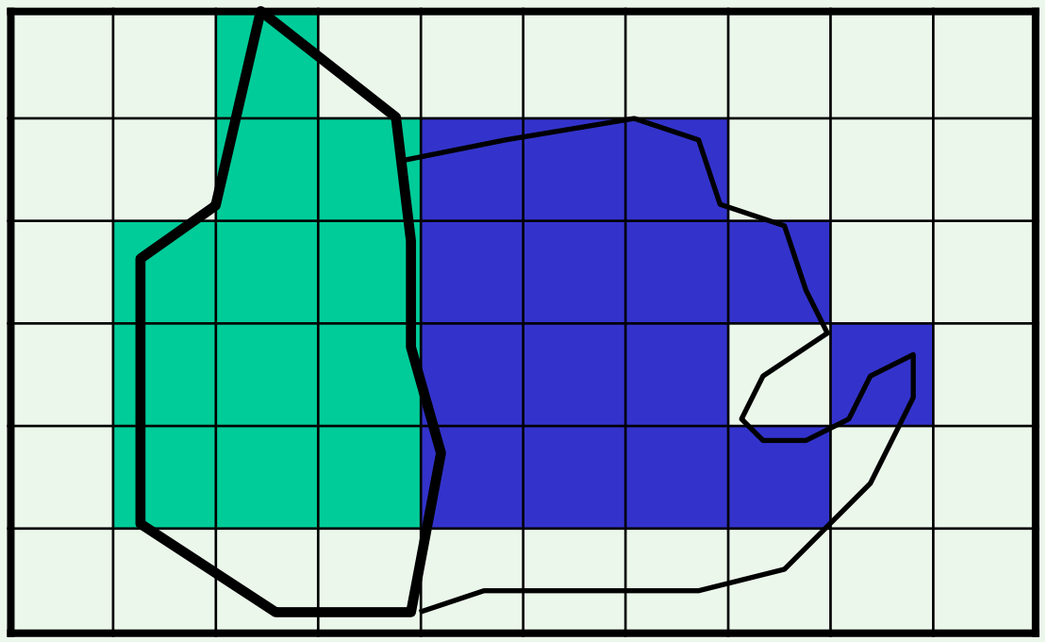
- Assign the value (any attributes) of the point to the cell in which the point falls
- What to do if more than one points fall in a cell?
- Decrease cell size to make sure that each point is represented
- What is the max. cell size that can represent every point?
  - Cell size <= the shortest distance between two points/sqrt(2)



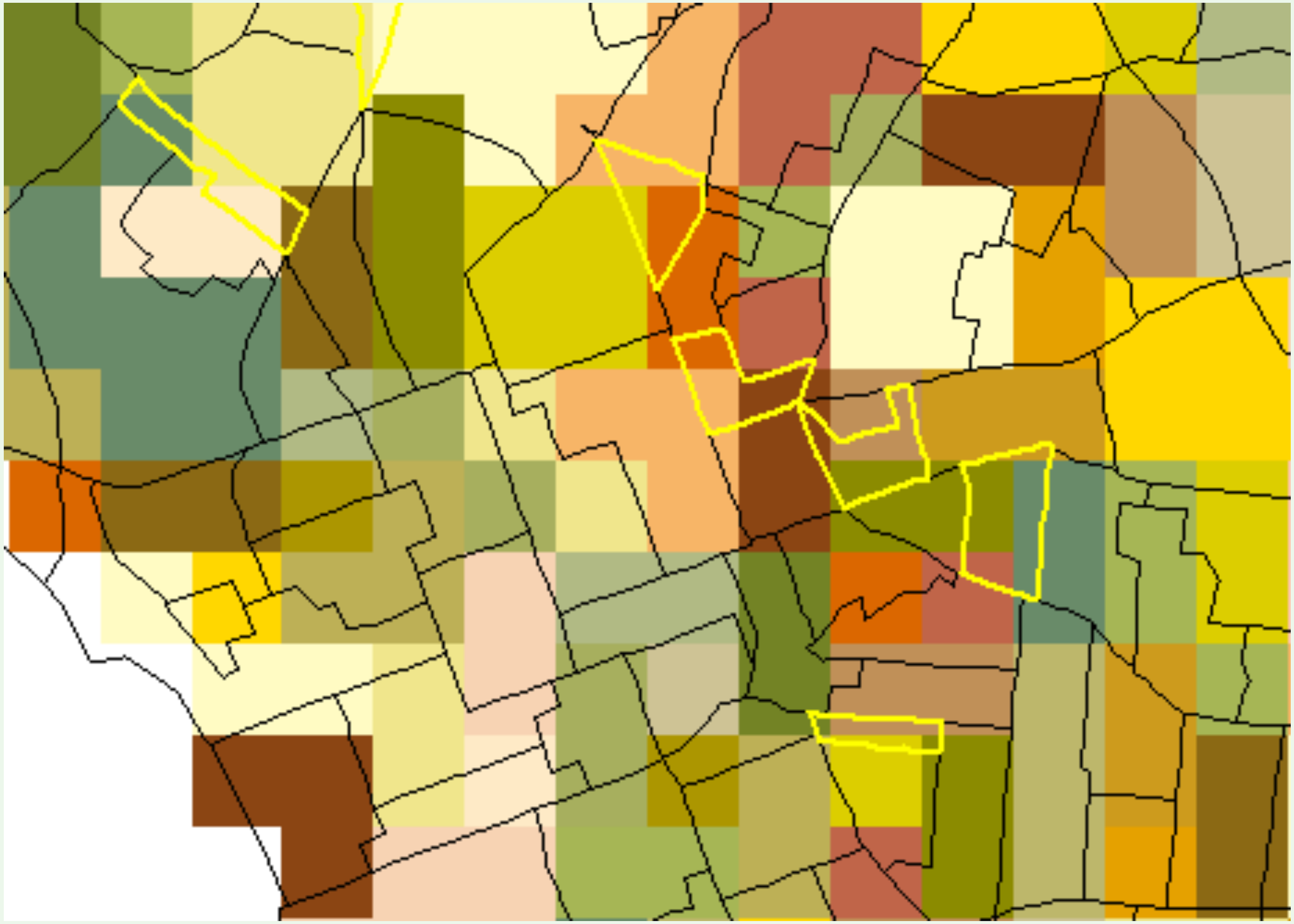


Polygon-to-Raster Conversion

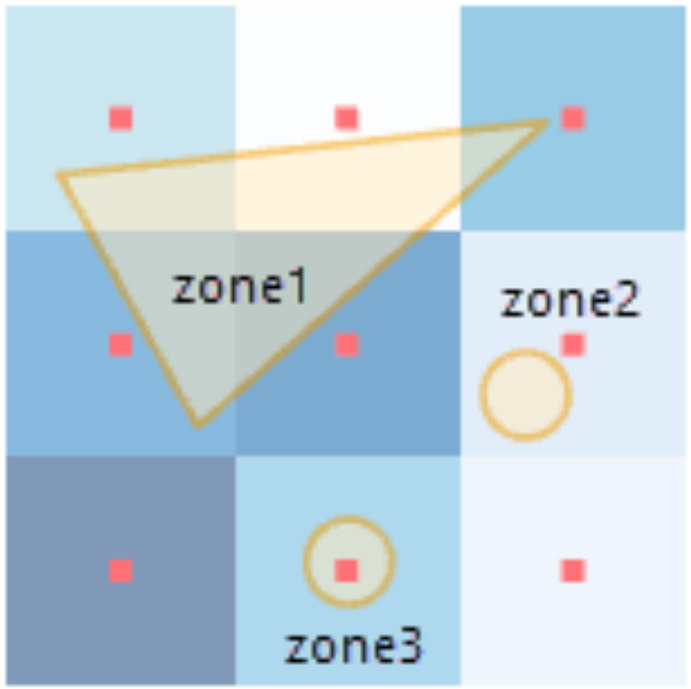
- Assign each cell the value of the polygon in which the cell falls
- Partially inside
  - A cell is inside the polygon if the cell's center is within the polygon (ArcGIS).
  - Other rules:
    - A cell is inside the polygon if the cell's major part is occupied by the polygon.



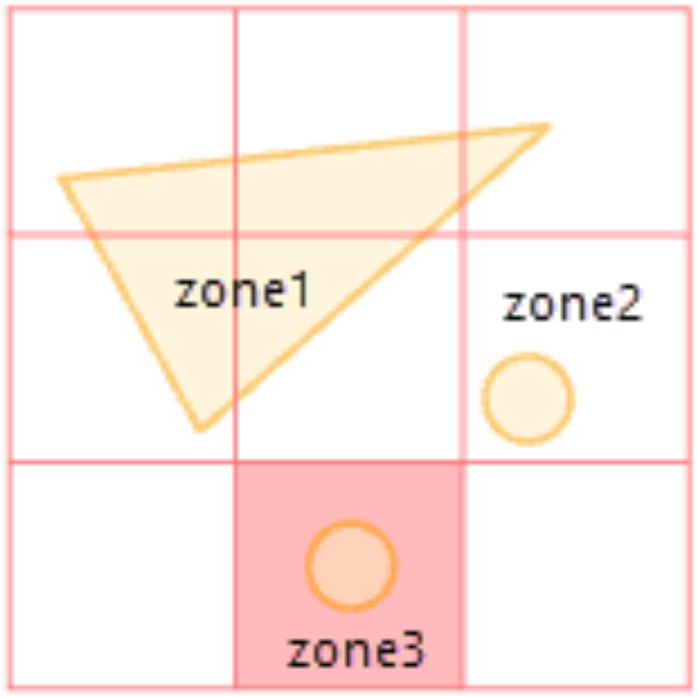
Polygon-to-Raster Conversion



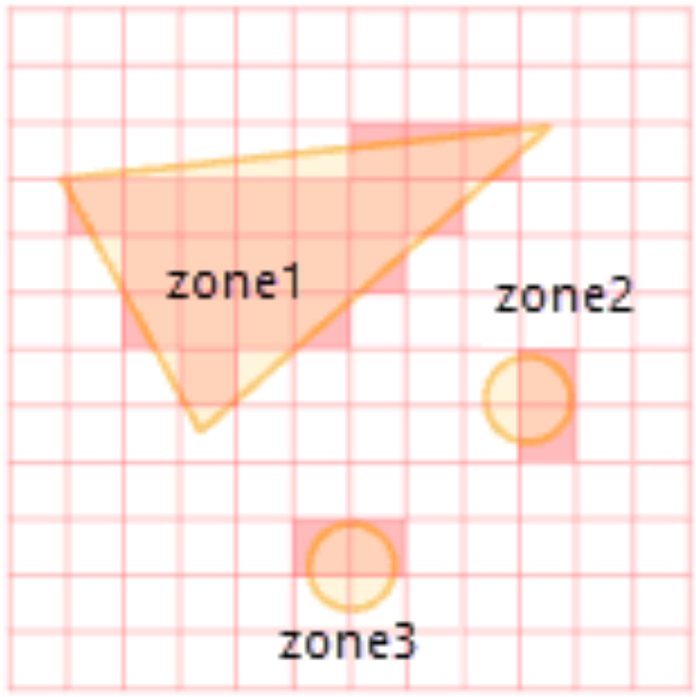
(1)



(2)



(3)



Input feature

Input value raster

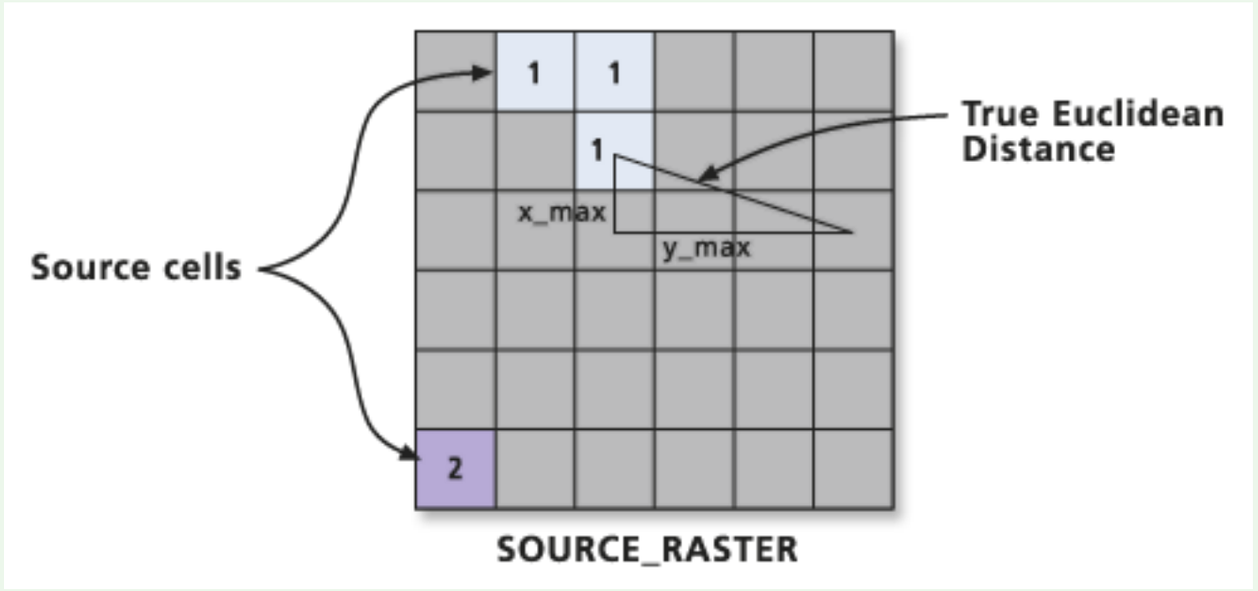
Rasterization grid cell center

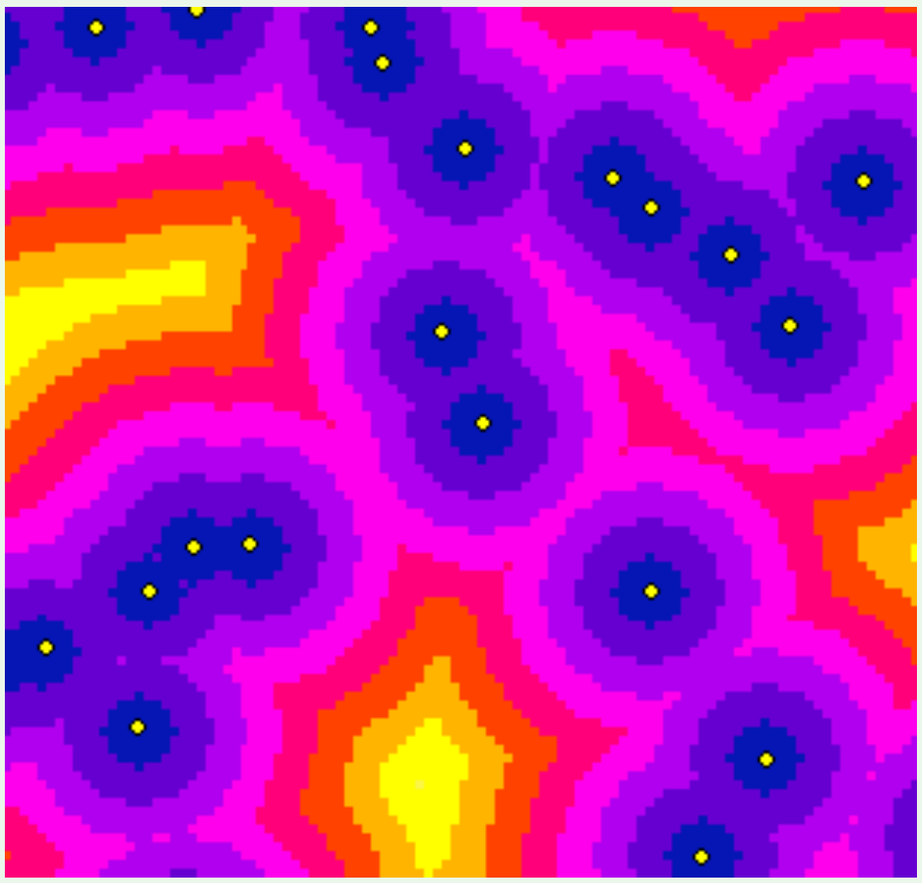
Zone rasterization grid

Rasterized zone

Euclidean Distance Calculation

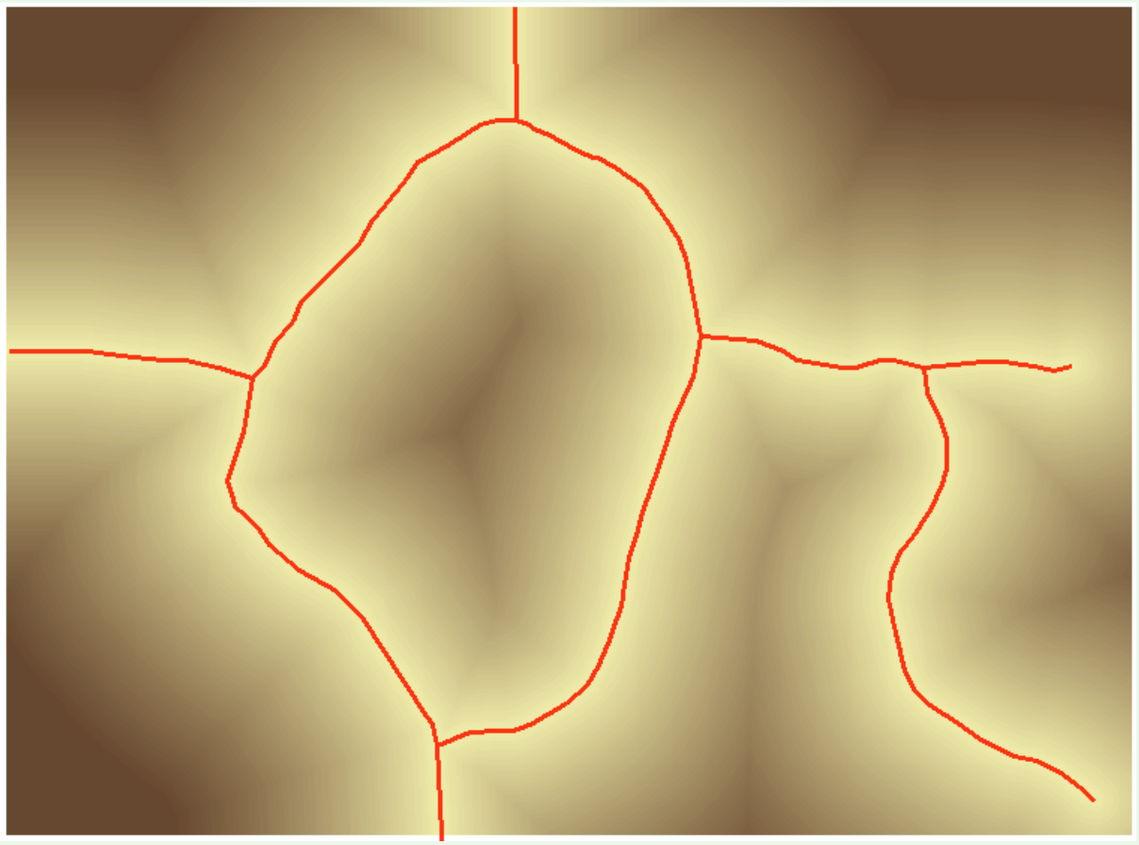
- Features are first converted to raster cells implicitly
  - Also called source cells in ArcGIS
- Distance to the nearest source cell is calculated at each cell
- Distance is calculated using the Pythagorean theorem
- Input & output
  - Raster or vector layer representing features
  - Distance raster layer

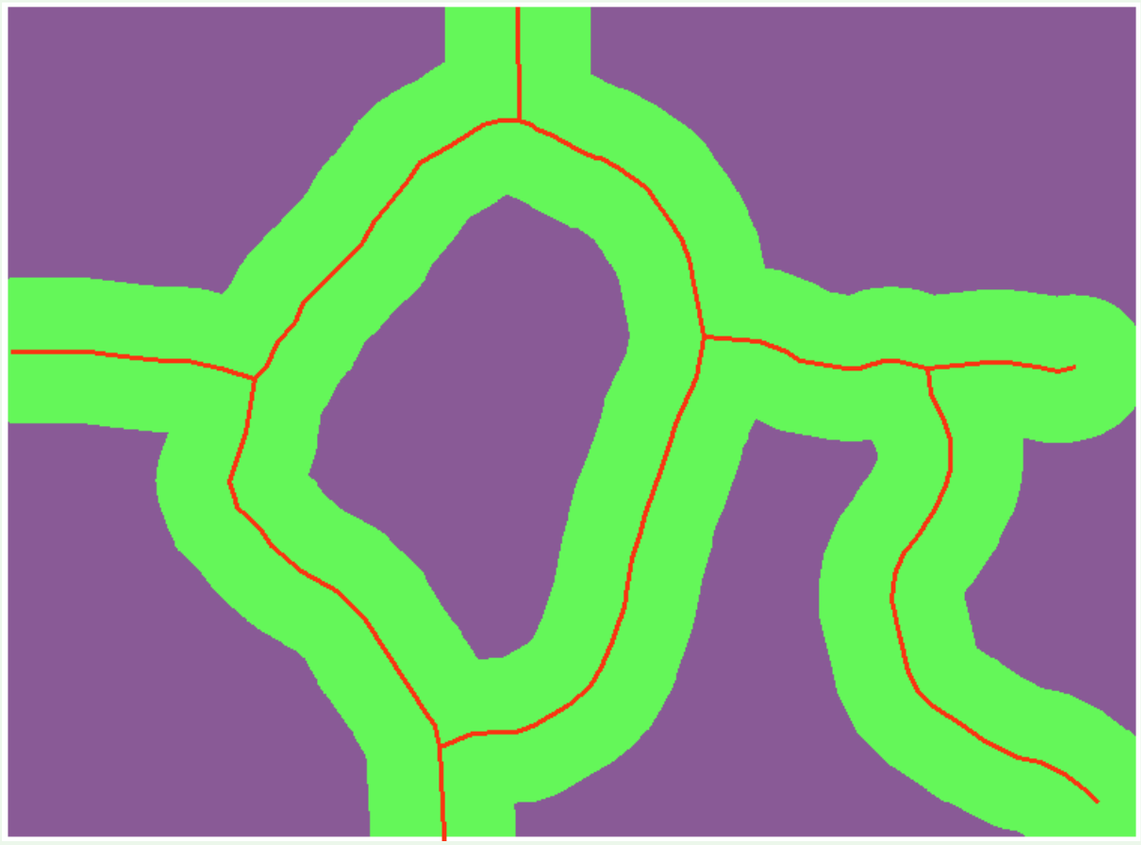




Creating Buffer in the Raster Data Model

- Buffers are generated differently in the vector and raster data model
- Two steps in Raster model
  - Euclidean distance calculation
  - Selection (distance <= buffer distance)

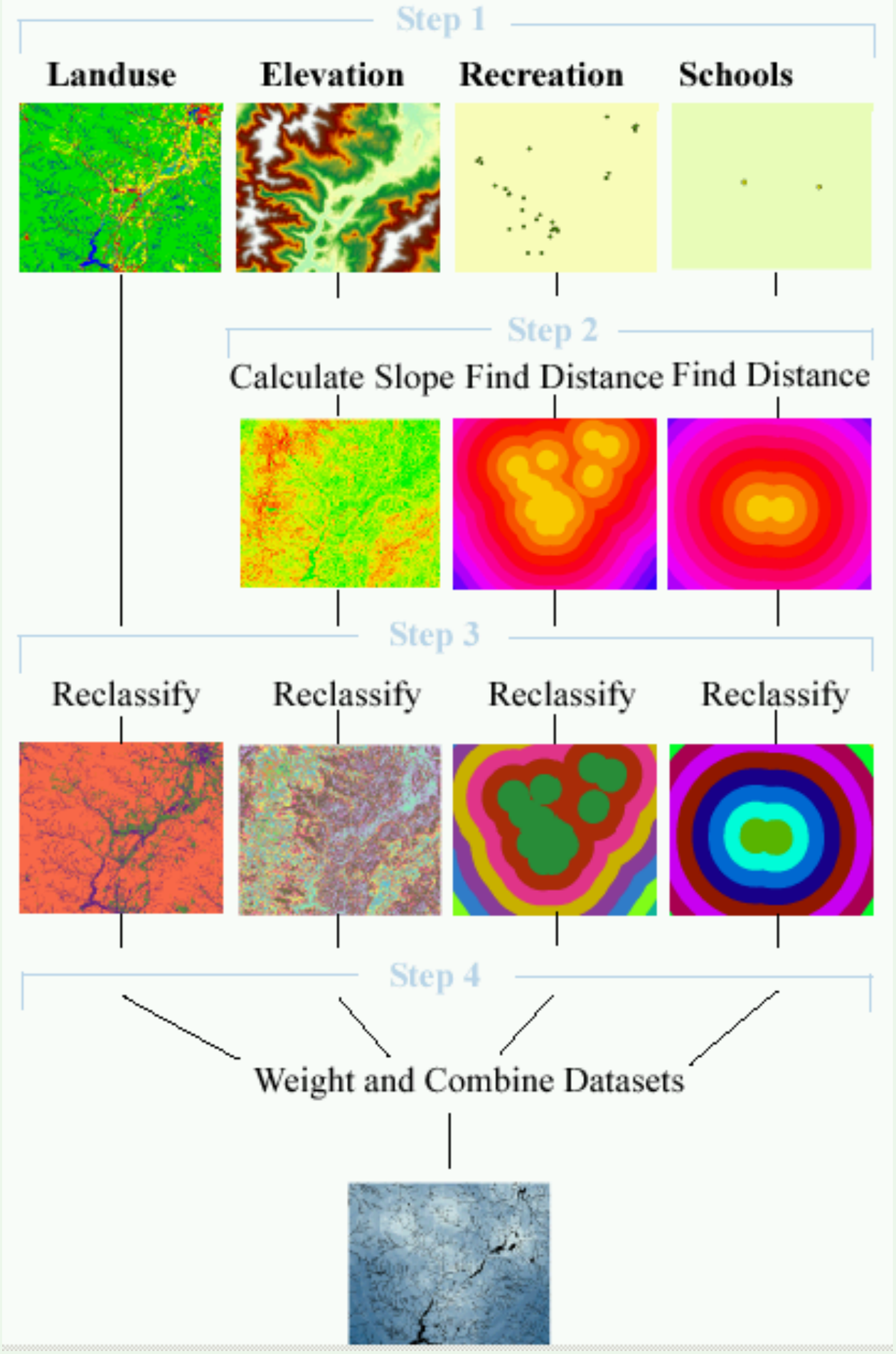




Non-Euclidean Distance (Cost Distance)

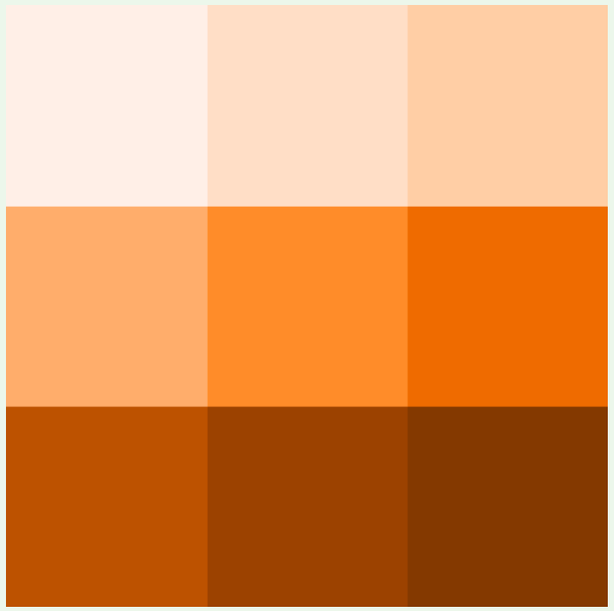
- Distance is one type of cost
- Cost could also be measured as time, energy, or money spent
- Movement in space may have cost
- Cost may vary in space
- Least cost and least-cost-path to source cells
- Cost Distance function

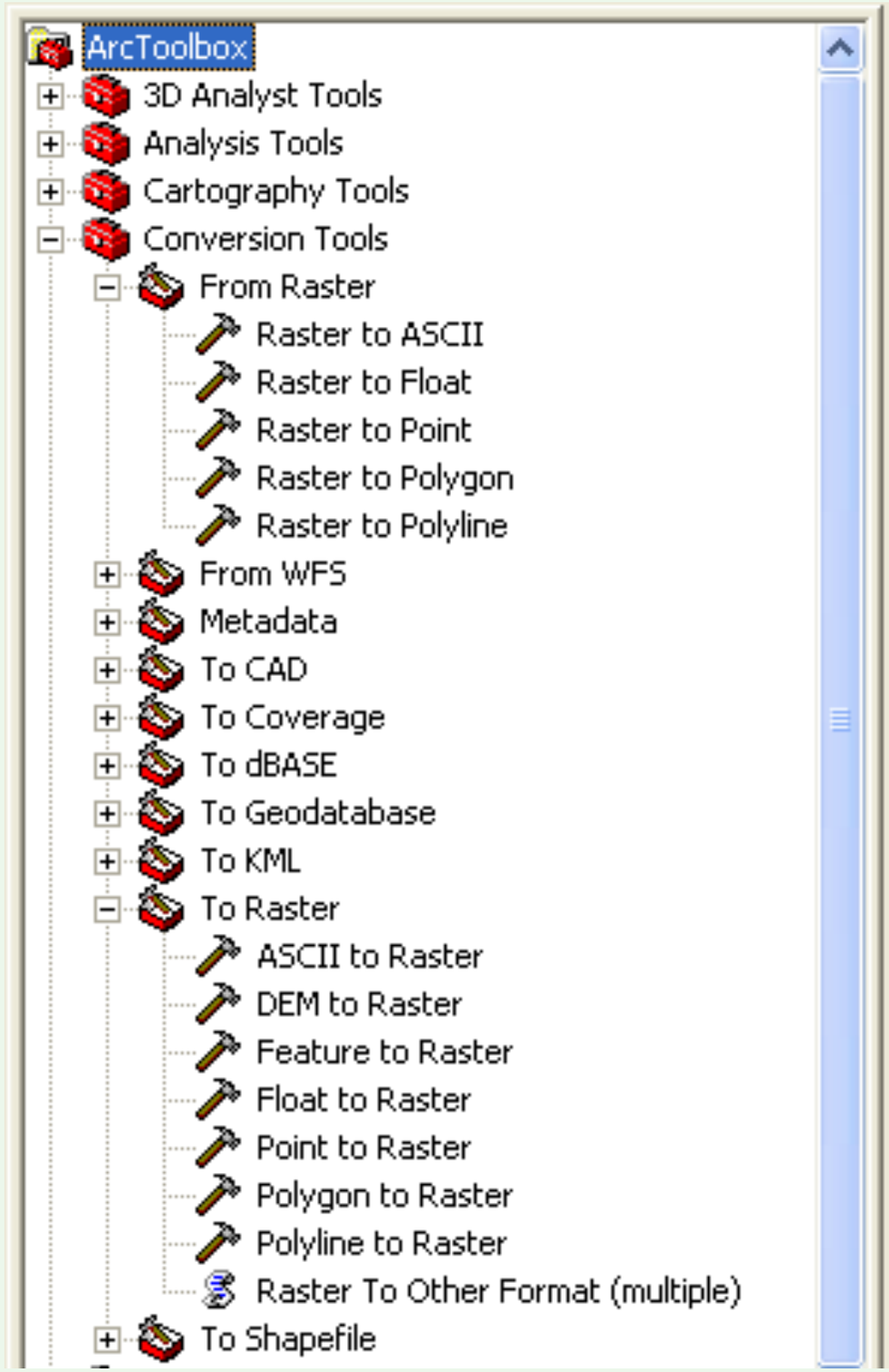
Raster Analysis



Import and Export ESRI GRID (ASCII GRID files)

- mytextgrid.txt
- ncols 3
- nrows 3
- xllcorner 1234.5
- yllcorner 6789.0
- cellsize 30
- NODATA_value -9999
- 1 2 3
- 4 5 6
- 7 8 9





Advantages of Raster Data Model

- A simple data structure
  - Data maps directly to memory array and screens
  - Easy to locate, read and write cells
  - Simple spatial relationships among cells
- Consistent representation
  - Good at representing continuous field surface
  - Could also represent discrete features (points, lines, and polygons)
- Availability of raster data from satellite, aircraft, and scanned document
- Spatial analysis through map algebra (cartographic modeling) operations

Disadvantages of Raster Data Model

- Less accurate location
- Large data volume, even with compressing technologies
- Only cells no features
- Relationships at feature-level are lost
  - Polygon adjacency
  - Line connectivity