Analysis, Buffers and Map Algebra [2020]

GEOG 176B: Technical Issues in GIS / Spatial Data

Krzysztof Janowicz

What You Will Learn in This Lecture

- Understand **buffers** over raster data an different vector primitives.
- Understand design decisions when selecting buffers, e.g., when to **nest buffers** or **dissolve their boundaries**.
- Learn about examples of **proximity analysis**.
- Review terms such as the **scope of operations** or moving windows.
- Understand the basics of **map algebra** and how to apply it to several use cases.

Some Common Types of Overlays (Recap)

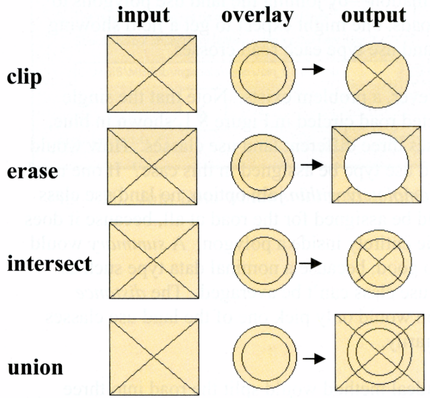
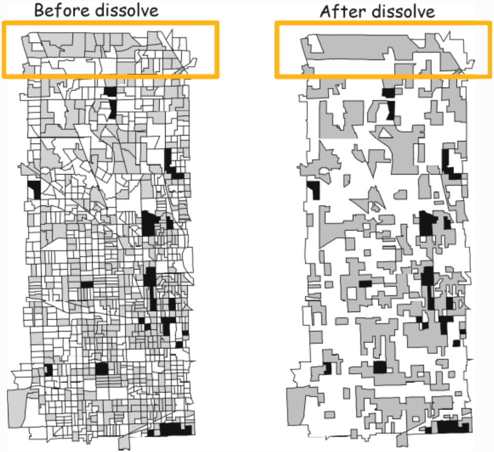


Fig. 8.4. Polygon overlay operations and results. Union and intersect join the attributes of the two input layers. Clip and erase do not.

Dissolve Operation (Recap)

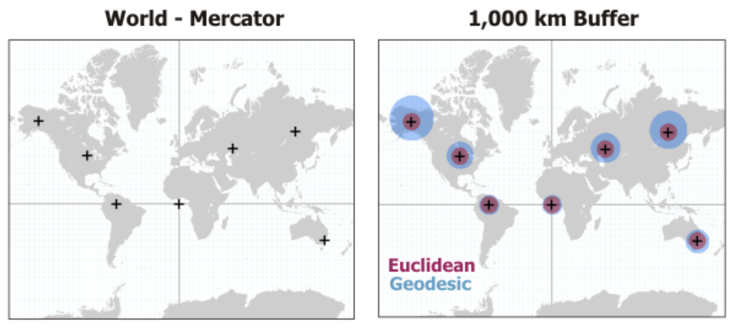


- Creation of **aggregated polygons** based on **merging adjacent** polygons that **share a common attribute value**
- In this neighborhood example, adjacent polygons are merged when they belong to the **same class**.

Buffers in GIS

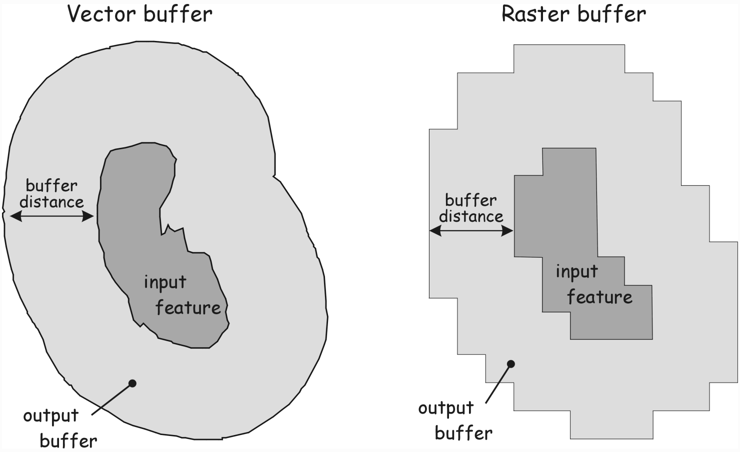
- A **buffer is a feature or zone** surrounding a input feature (or zone) that is generated using some **distance** (and distance measure).
- This distance can also be measured in **time** (or other costs).
- Buffers around **vector** geometries, e.g., points and polygons, are very common, but buffers can also be computed for **raster** datasets.
- **Buffers are areas**.
- Buffers can be **combined** when their borders are adjacent or when the buffers overlap.
- Buffers can be **nested** based on different distance bins.
- A common example for the usage of buffers is excluding zones, e.g., around a nature preserve.

Buffers Distance Methods

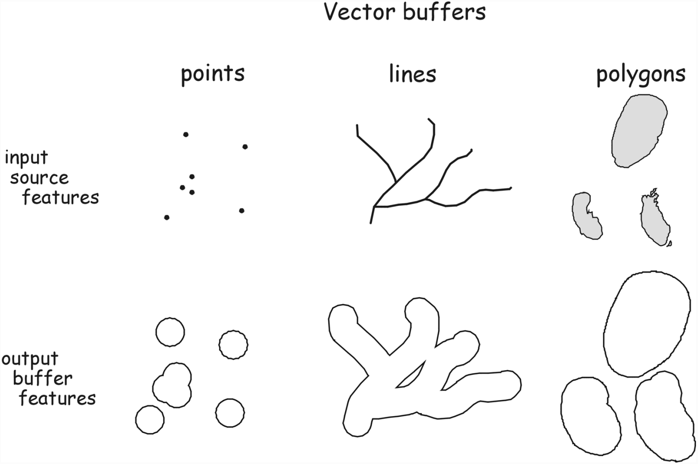


The **Geodesic buffers** (using a geographic coordinate system) the **Euclidean buffers** (using a projected coordinate system) are computed around the same cities; notice how they differ.

Vector and Raster Buffers

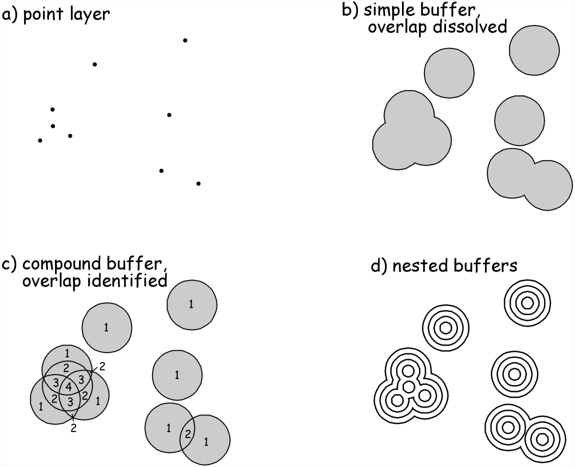


Vector Buffers



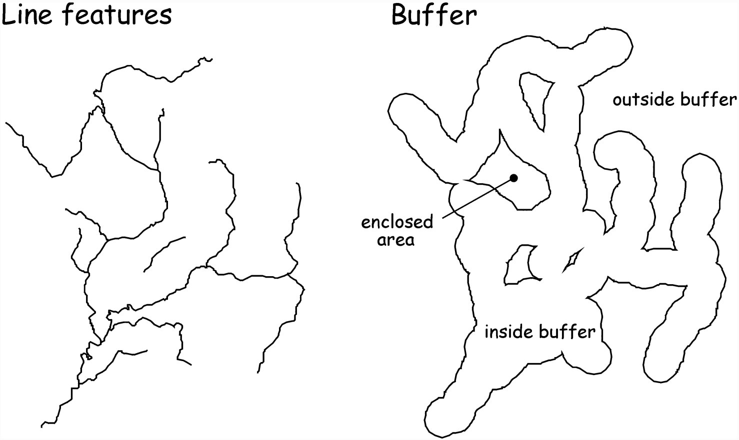
Note how all vector buffers are **polygons**.

Point Buffers

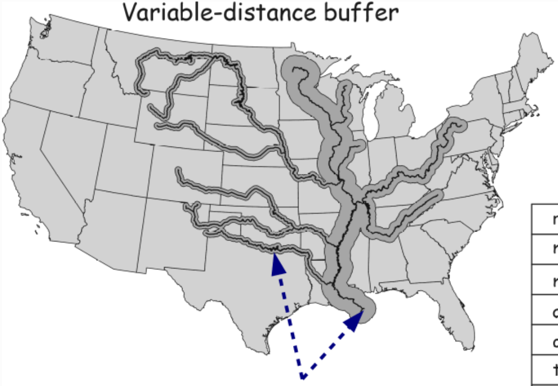


Note how c) translates to densities.

Line Buffers



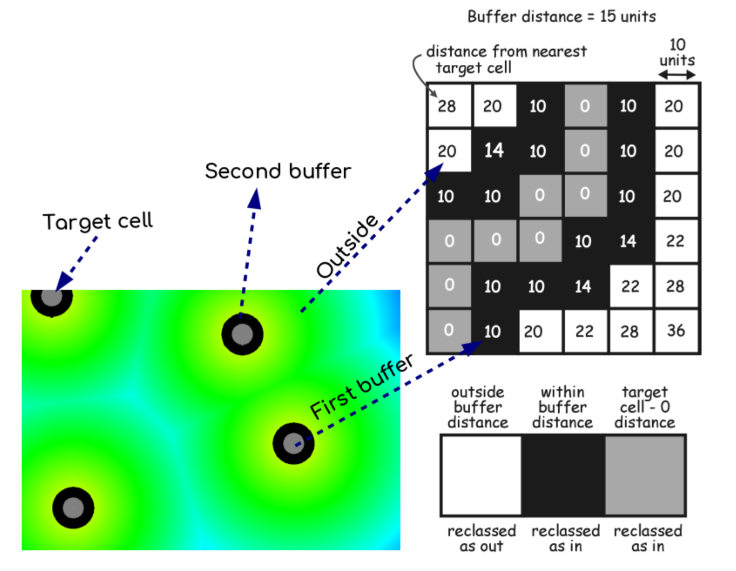
Variable-Distance Buffers



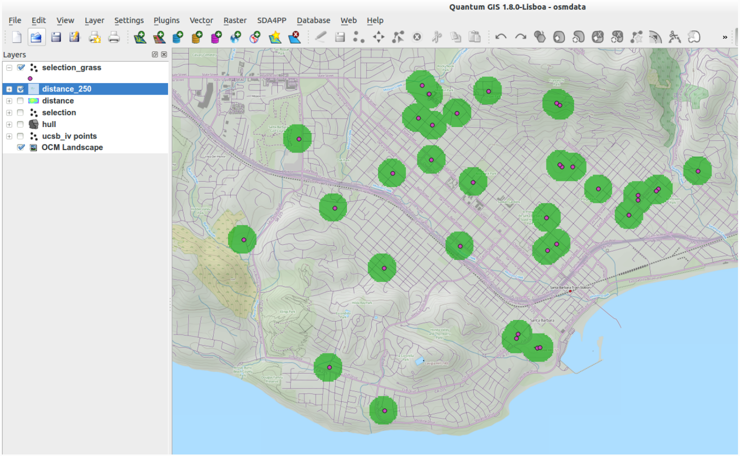
Variable buffer size based on river size

river_identifier	buffdist
mississippi	100
missouri	50
arkansas	50
ohio	75
tennessee	75
st. croix	75
illinois	75
wisconsin	75

Raster Buffers

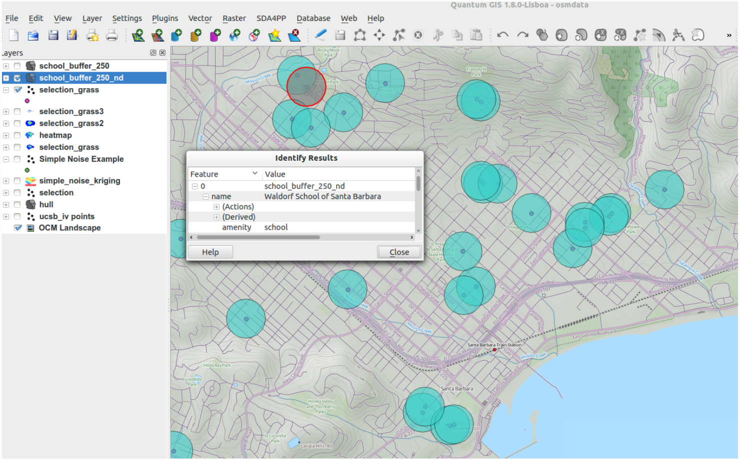


Raster Buffer Example



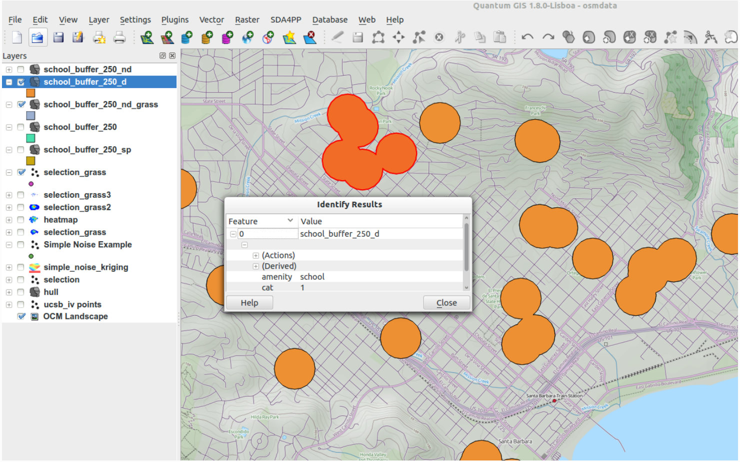
What can be asked of such raster buffer layer; when to use them?

Point-Based Vector Buffer Example



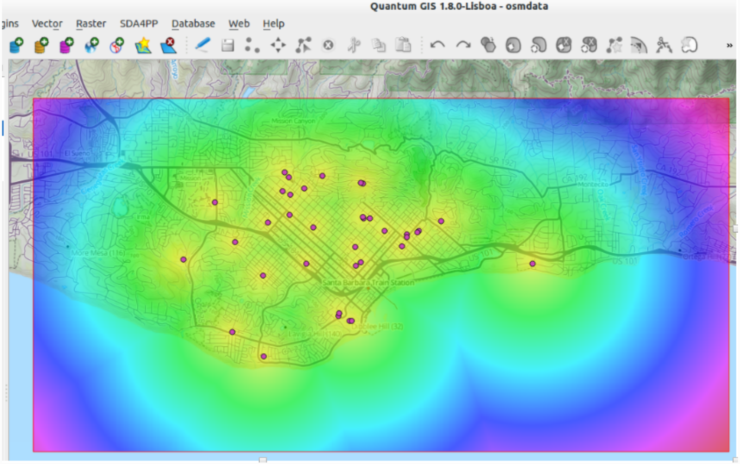
Note how this buffer is about one specific school.

Point-Based Vector Buffer Example



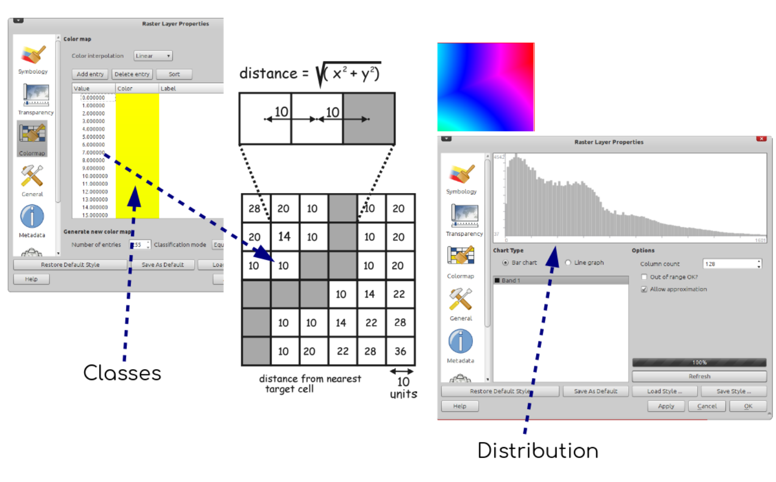
These buffers are **dissolved** using **common** feature **type**.

Proximity Map



What do the **colors** mean; what are the **values** of these cells?

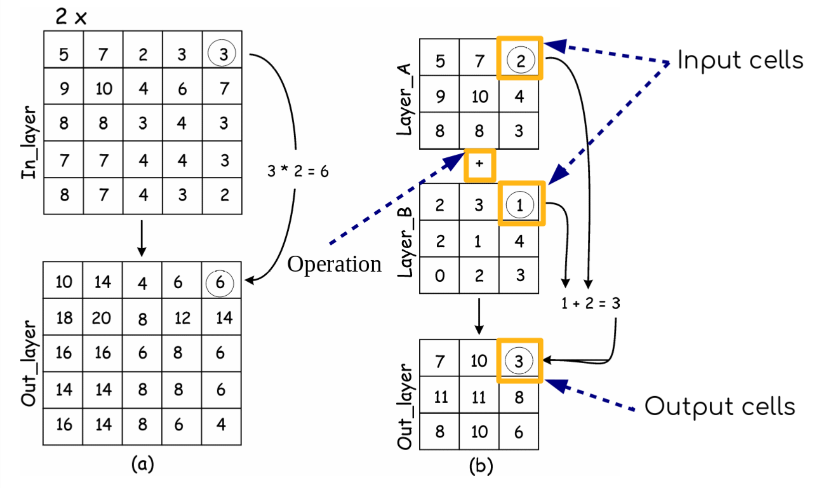
Proximity Map



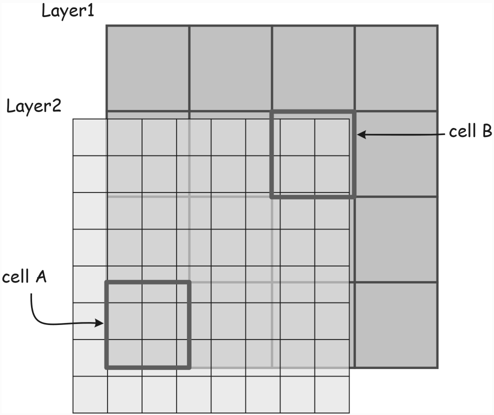
Map Algebra

- **Map algebra** is a set-based algebra introduced by Tomlin in the 1980s. It describes how to perform (and combine) primitive operations over **1..*** geographic (raster) data **layers**
- These operations often include:
  - **Arithmetic operations** such as addition or multiplication
  - **Statistical operations** such as means, maxima or minima
  - **Relational operations** such as greater than or (not) equal
  - ...
- can be used to combine expressions or perform different operations based on some conditional statement (**IF...THEN...**)
- Use cases range from everything starting from data cleaning to visualization.

Map Algebra – Combining Cell Values



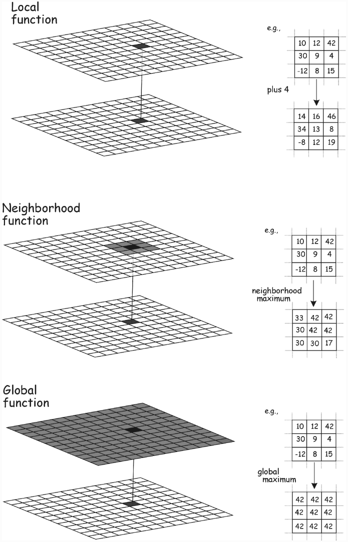
Map Algebra – Requirements



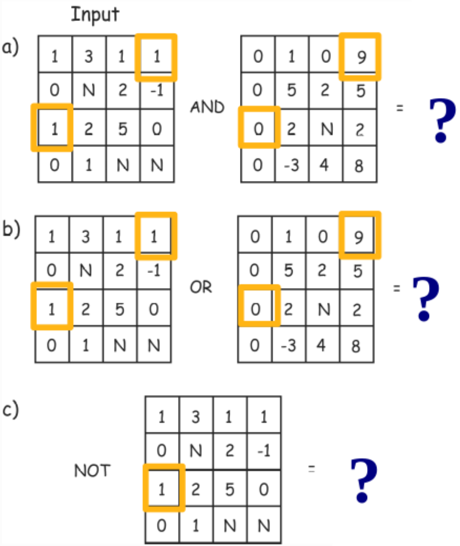
- Before combining cell values, both layers must be **geo-registered** and of the same spatial **resolution**.
- You may have to **resample** the layer.

Scopes of Raster Operations

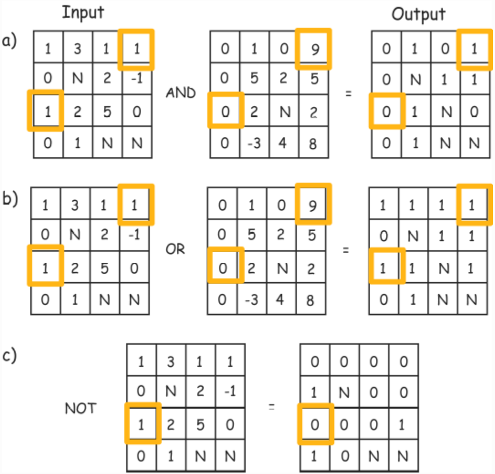
- Similarly, to **vector** operations **raster** operations have a local, neighborhood, or global **scope**.
- **Local** and **neighborhood** scopes are most often used in raster analysis.



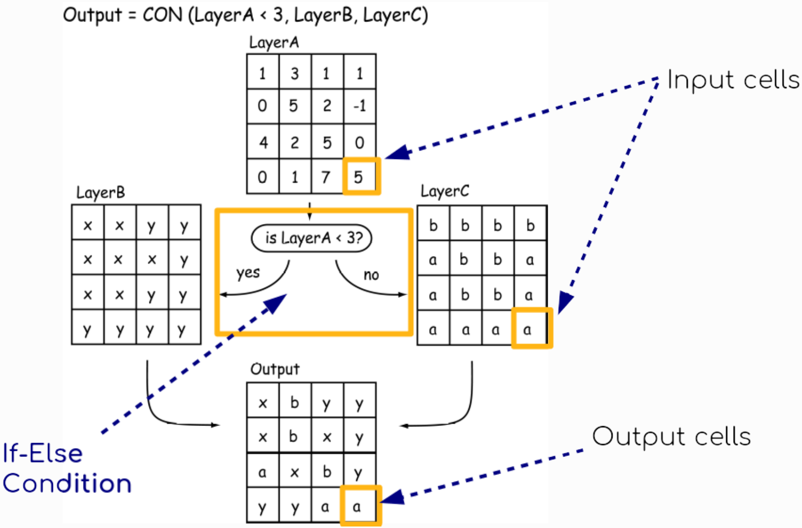
Local Functions – Boolean Operators



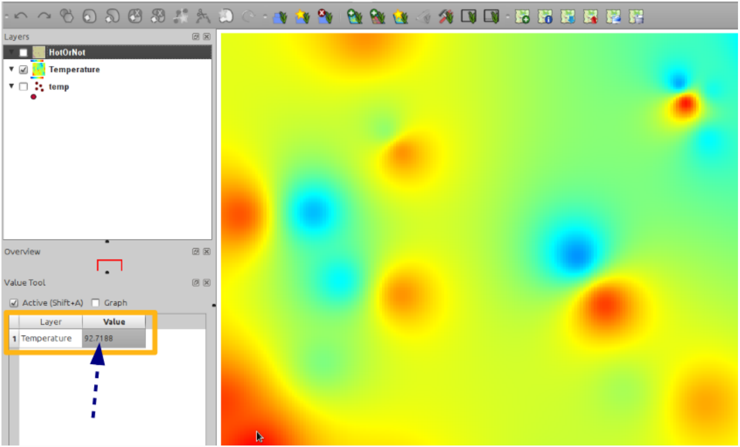
Local Functions – Boolean Operators



Introducing Conditions/ Control Statements

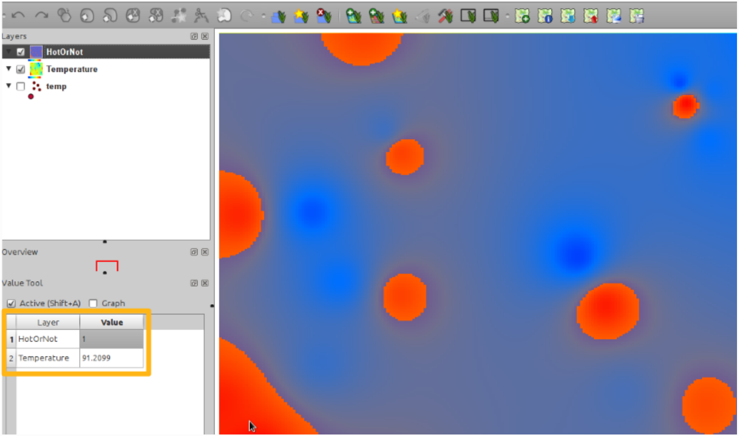


Classify Temperature Example



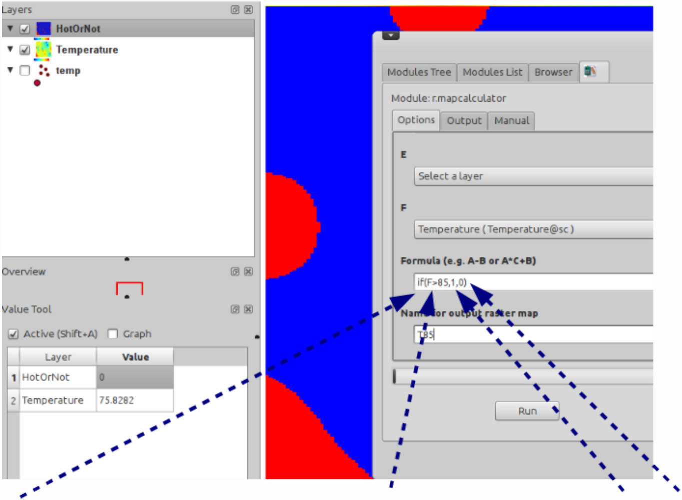
Based on your personal ranking, is this a very warm/hot temperature spot?

Classify Temperature Example



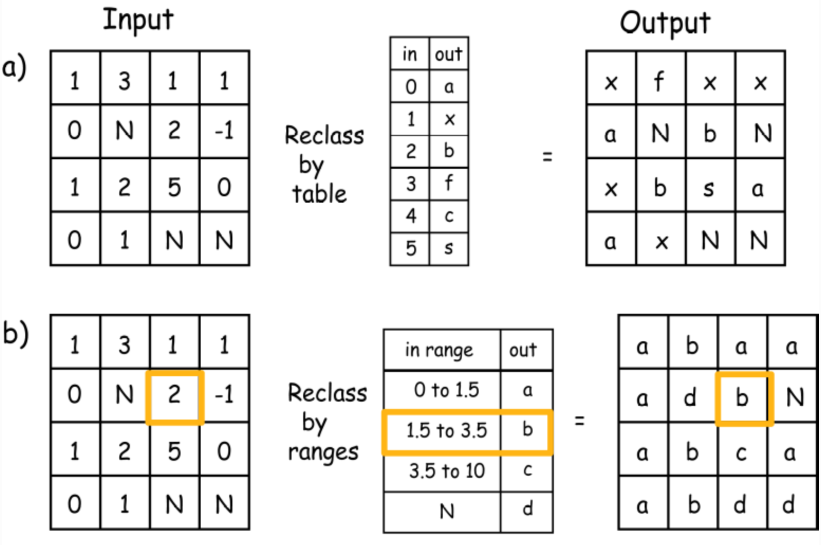
How to create a raster map showing hot areas based on your ranking?

Classify Temperature Example

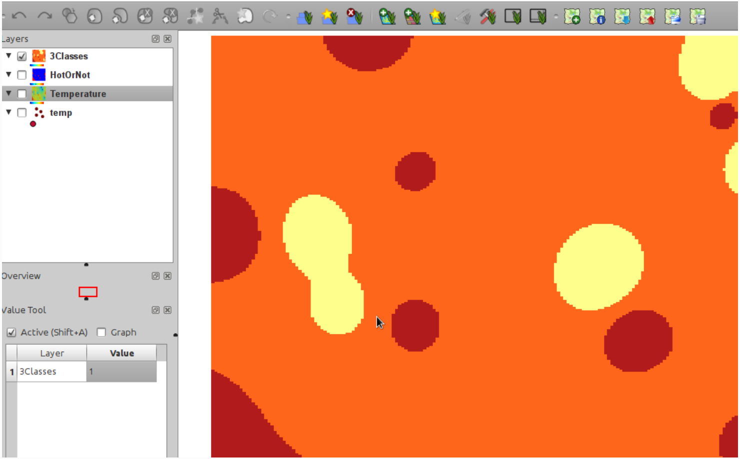


If a cell temperature value is greater than 85, set the cell value to 1, else 0.

Reclassification Operations

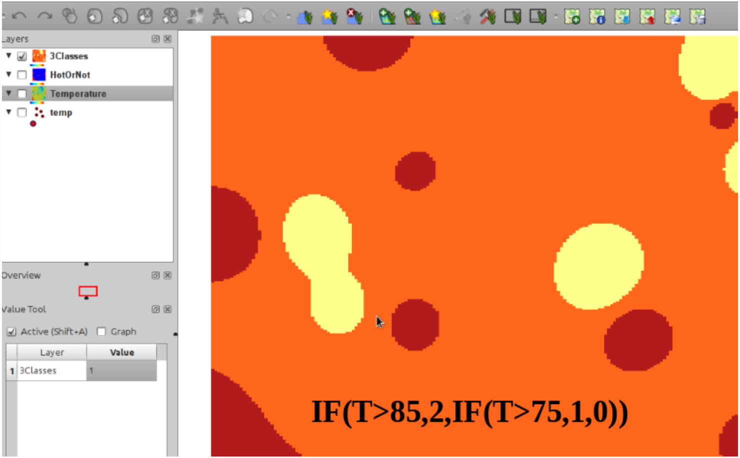


Classify Temperature Example with 3 Classes



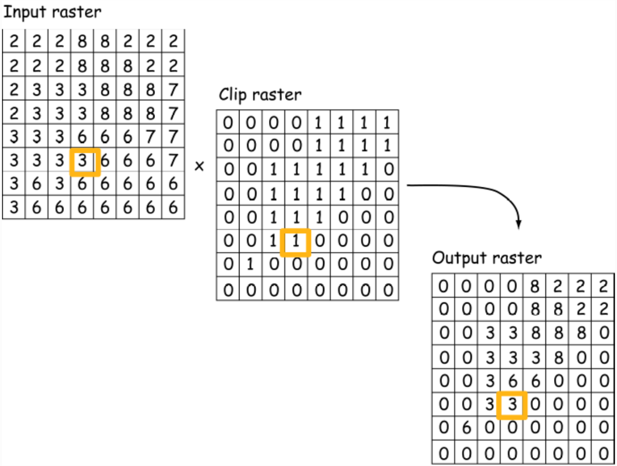
How to create a raster map showing **hot, warm, and cold** areas ?

Classify Temperature Example with 3 Classes



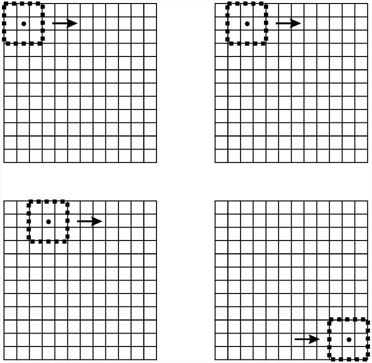
How to create a raster map showing **hot, warm, and cold** areas ?

The Map Algebra Realization of a Clip Overlay



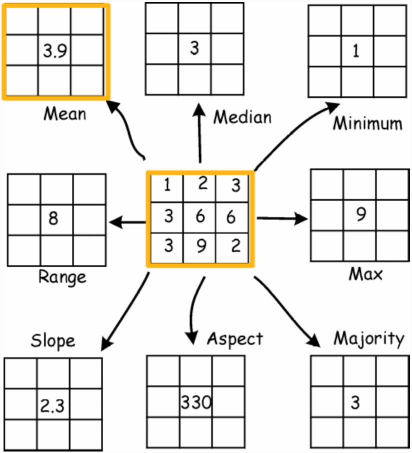
How to use just one operator to realize an **erase overlay**?

Neighborhood Functions – Moving Window



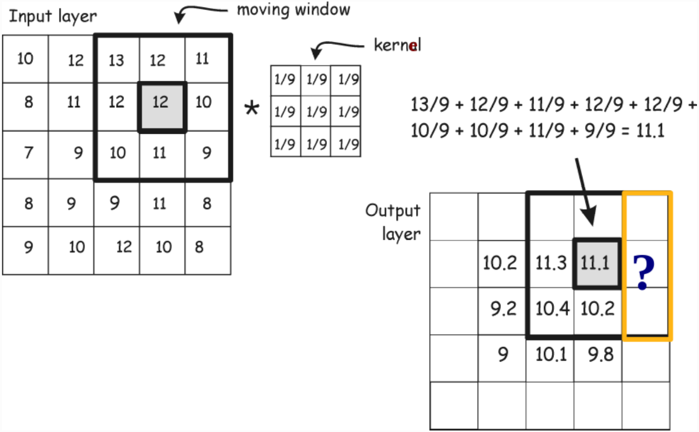
- The **value** for the cell in the **center** of each window is **computed** by all the 3x3 **neighbor cells**.
- The **window moves** cell by cell for each row and column
- **Why 3x3** or 5x5 cells but not 4x4 cells?

Moving Windows and Neighborhood Functions



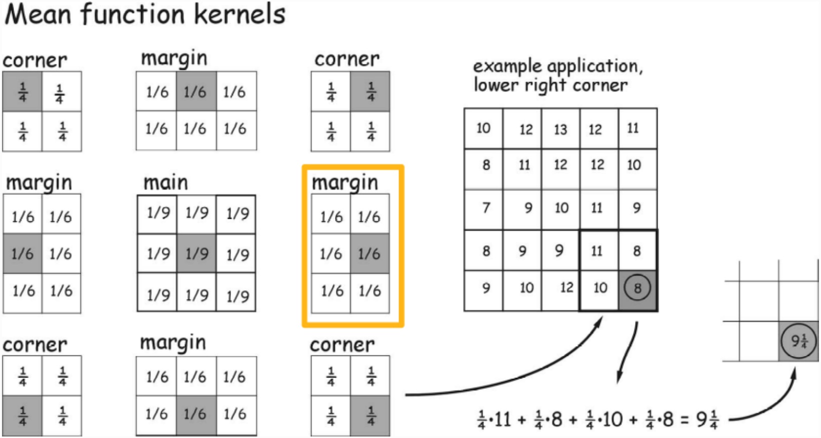
How would you realize the **mean** using map algebra?

Kernels



A **kernel** is the set of **constants** for the cell values in a given **window**.

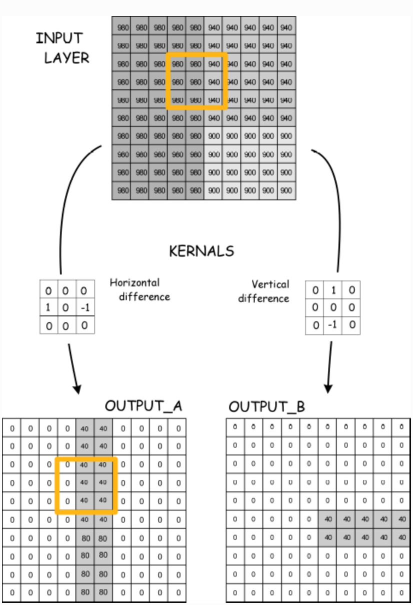
Different Kernels for Corners and Margins



Select a different kernel window for corners or margins or a **larger study area**.

Kernel-Based Edge Detection

- Detect **abrupt changes** in cell values using a kernel.
- **Example**:
  (980*1) + (940*-1)
  = 980-940
  = 40



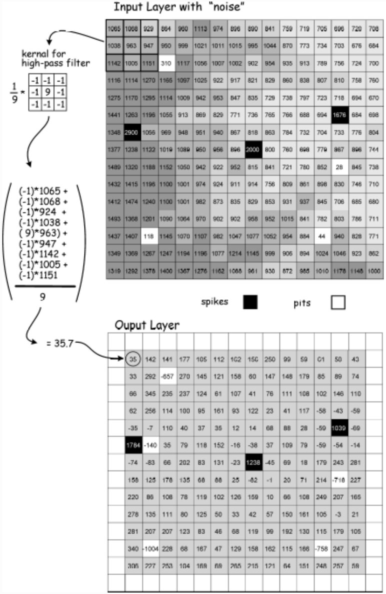
Kernel-based High-Pass Filter

100	100	100
100	100	100
100	100	100

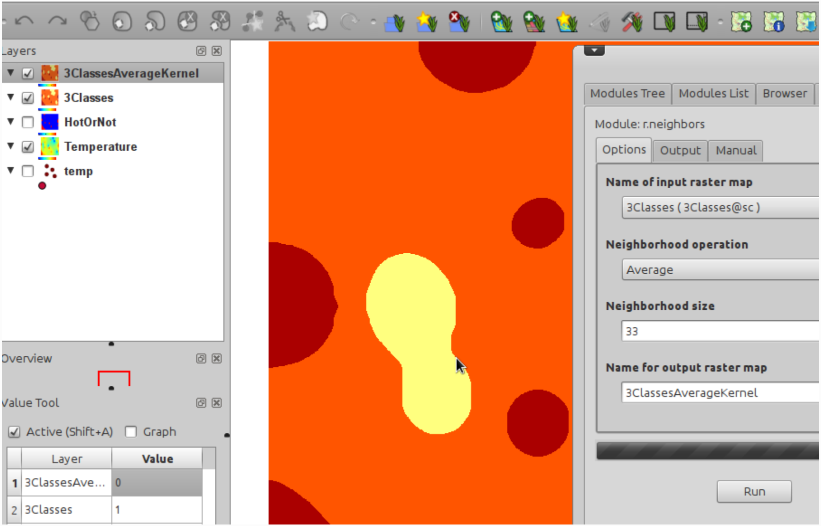
(-800+900) / 9 = 11

100	100	100
100	1000	100
100	100	100

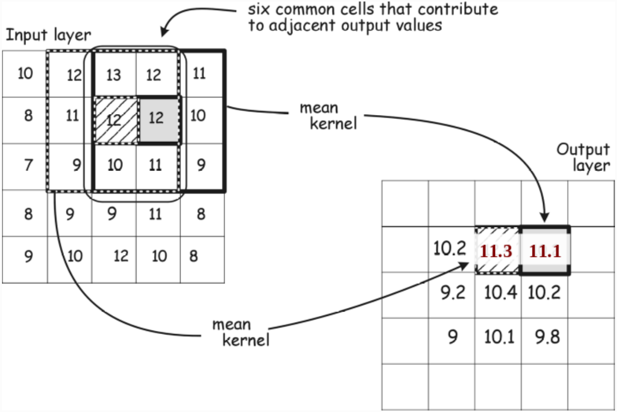
(-800+9000) / 9 = 911



Using an Averaging Kernel for Smoothing

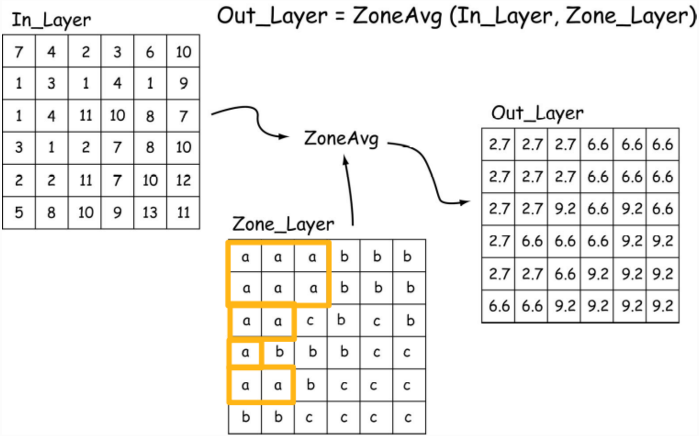


Kernel Functions and Spatial Covariance



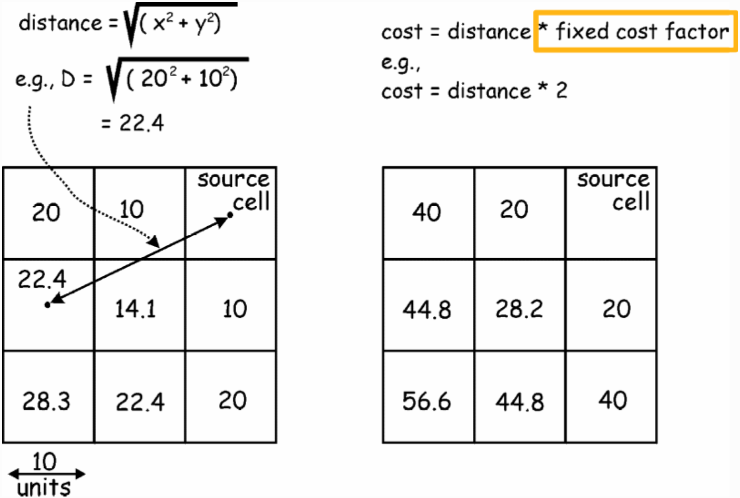
Keep in mind that kernel functions will **increase** the **spatial covariance** of cell values. For adjacent cells, **6 out of 9 cells** used to compute the new value will be the same.

Zonal Functions

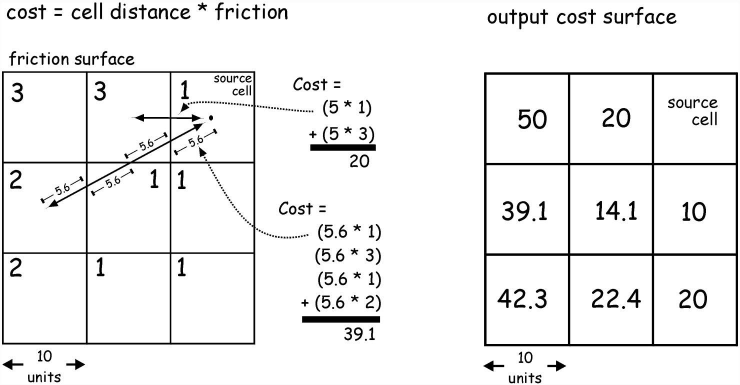


The term **neighborhood** may also be **generalized** for **regions** or zones.

Cost Surfaces As Analogy to Network Analysis

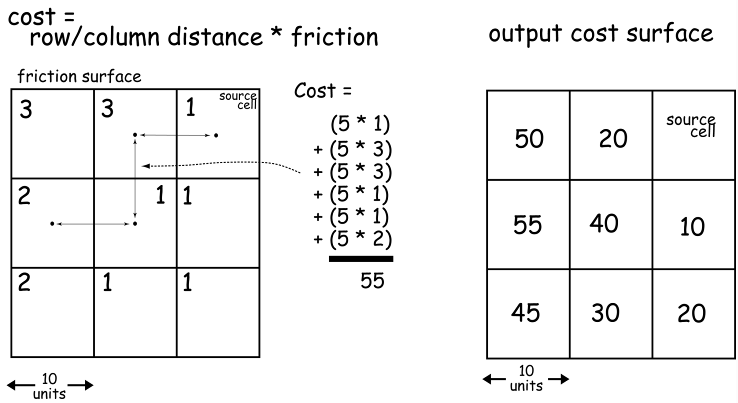


Cost Surfaces As Analogy to Network Analysis



Instead of a cost constant, **costs** can be modeled as **cell values**.

Row-Column Distance



All edges have the same length – either **5 or 10** units.