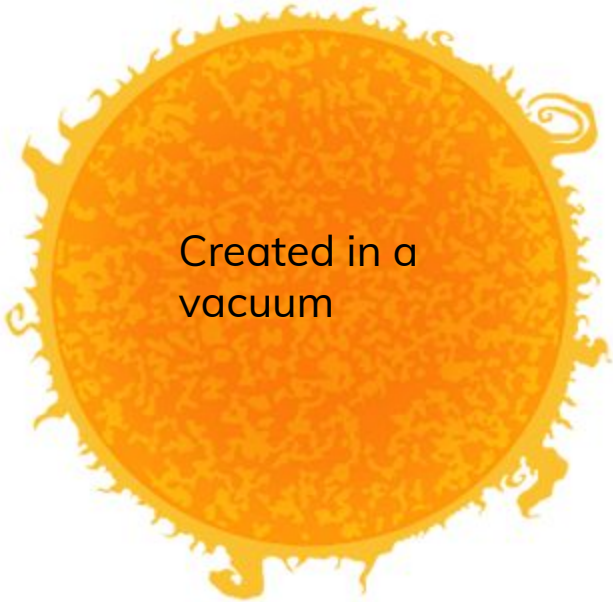
EDS 223: Geospatial Analysis & Remote Sensing
Week 7

USGS via Unsplash

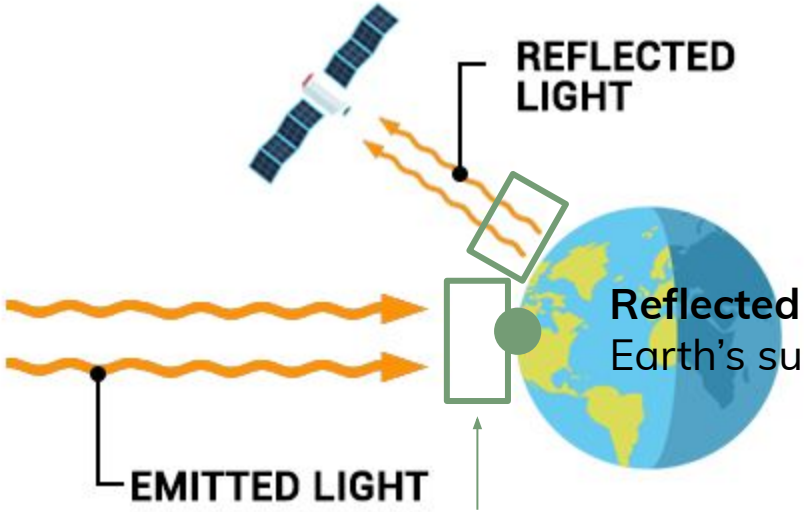
Welcome!

- **Catch up week**
  - Radiation basics
    - Scattering
    - Refraction
  - Raster operations
    - Map algebra

Radiation budget



Created in a vacuum



Reflected off of the Earth's surface

In the atmosphere, can be **absorbed** and/or **scattered**

By passing through media of different densities, can be **refracted**

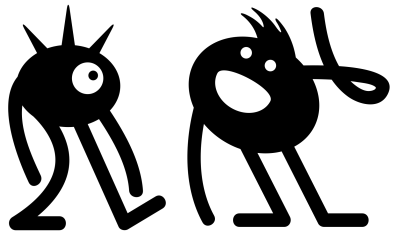
Source: GIS Geography

Absorption

- The process by which radiant energy is absorbed and converted into other forms of energy

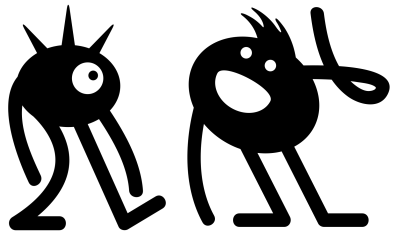
Absorption

- The process by which radiant energy is absorbed and converted into other forms of energy
- Name the top 3 atmospheric constituents which absorb radiation:

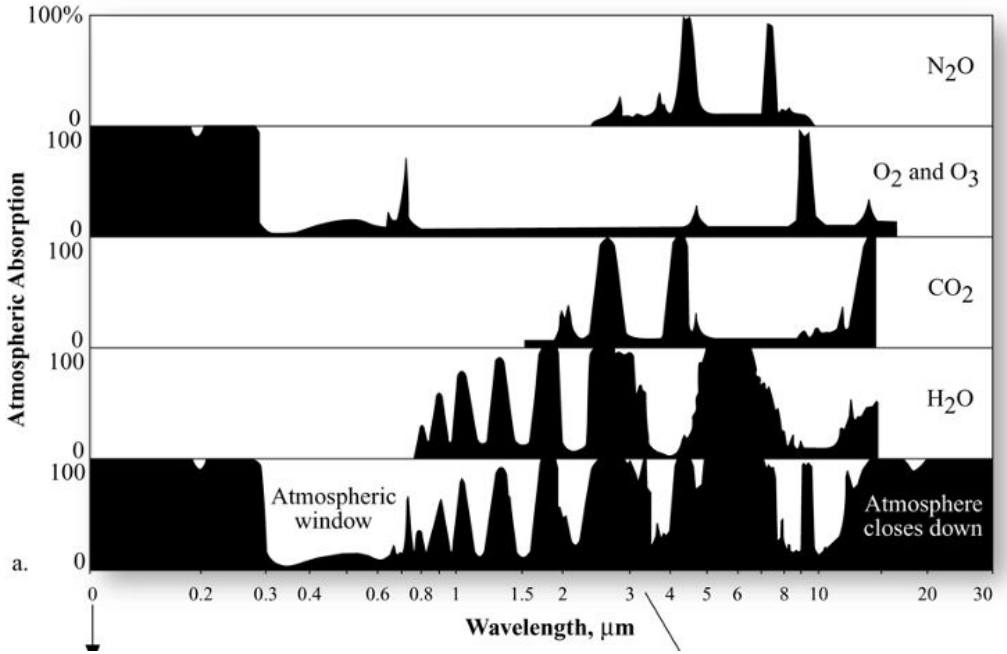


Absorption

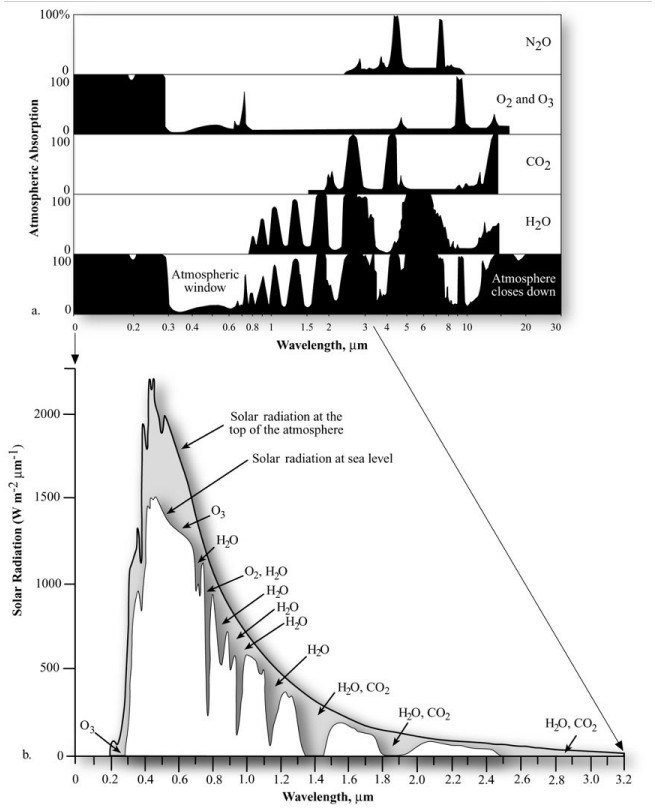
- **The process by which radiant energy is absorbed and converted into other forms of energy**
- **Name the top 3 atmospheric constituents which absorb radiation:**
  - Ozone
  - Carbon dioxide
  - Water vapor



Absorption


100%
0
N_2O
100
0
O_2 and O_3
100
0
CO_2
100
0
H_2O
100
0
Atmospheric Absorption
Atmospheric window
Atmosphere closes down
a.
0
0.2
0.3
0.4
0.6
0.8
1
1.5
2
3
4
5
6
8
10
20
30
Wavelength, μm

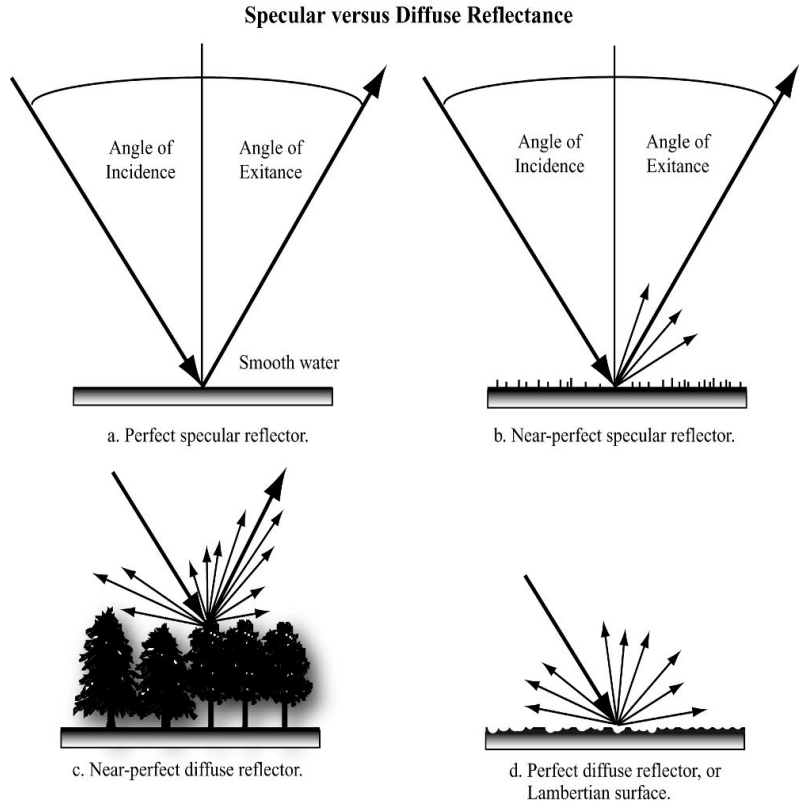
Absorption


100%
0
100
0
100
0
100
0
100
0
Atmospheric Absorption
N_2O
O_2 and O_3
CO_2
H_2O
Atmospheric window
Atmosphere closes down
a.
0 0.2 0.3 0.4 0.6 0.8 1 1.5 2 3 4 5 6 8 10 20 30
Wavelength, μm
Solar Radiation (W m^{-2} μm^{-1})
2000
1500
1000
500
0
Solar radiation at the top of the atmosphere
Solar radiation at sea level
O_3
H_2O
O_2, H_2O
H_2O
H_2O
H_2O
H_2O
H_2O, CO_2
H_2O, CO_2
H_2O, CO_2
O_3
b.
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2
Wavelength, μm

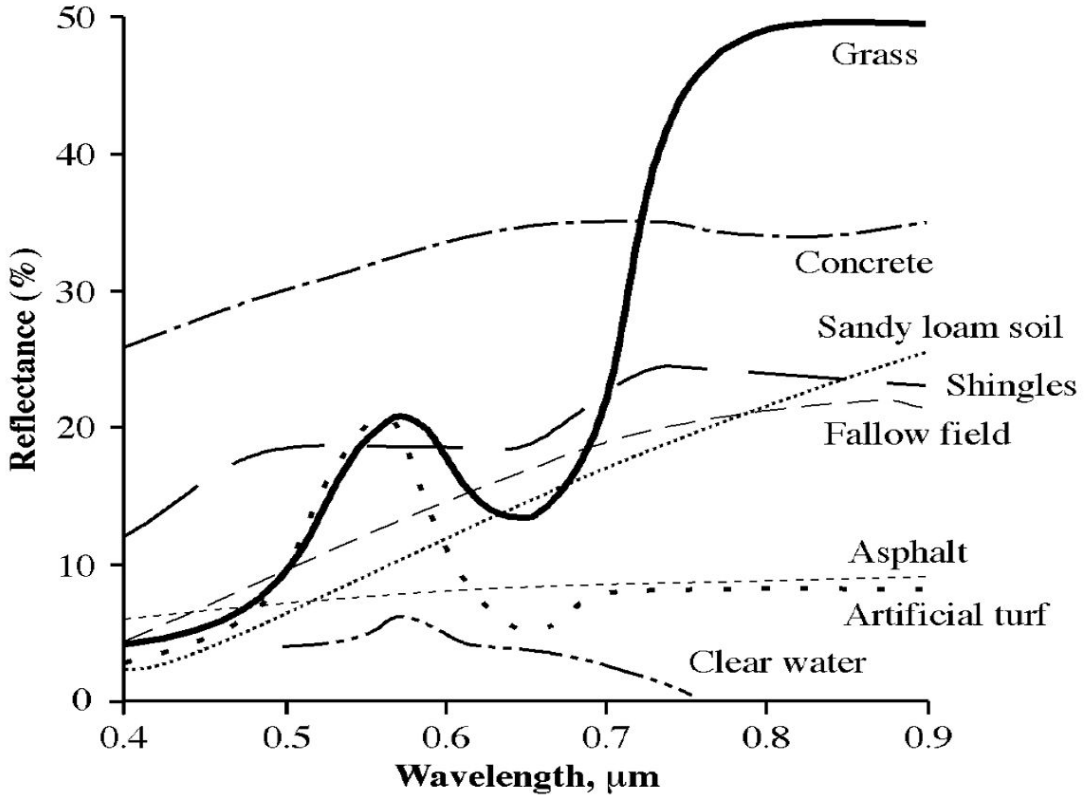
Reflectance

- The process whereby radiation “bounces off” an object and experiences no change in wavelength or frequency

Reflectance



Reflectance



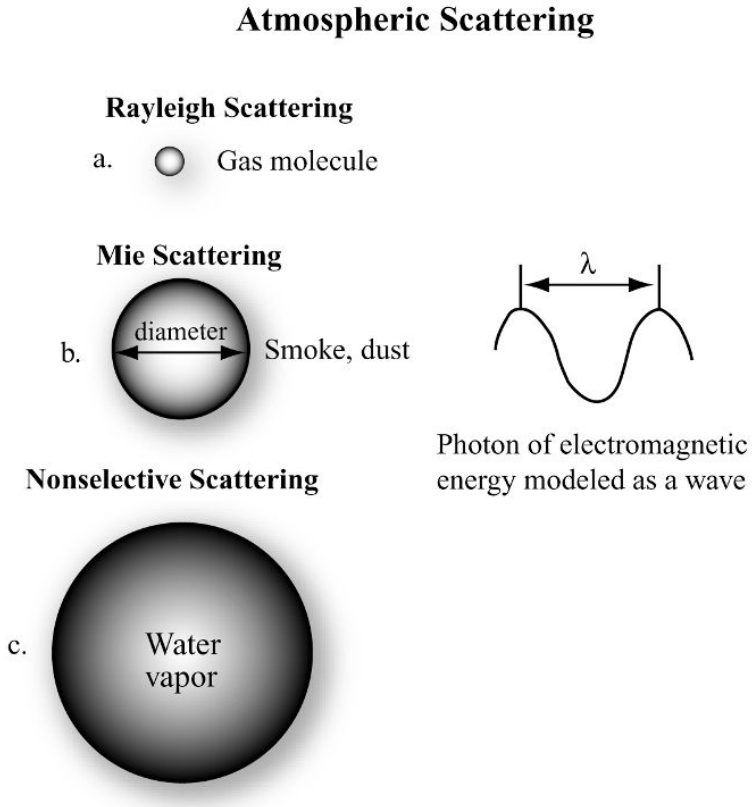
Scattering

- **Reflectance in an *unpredictable* manner**
- **Amount of scattering depends on:**
  - Amount and size of particles or gases radiation is interacting with
  - Wavelength of radiation
  - Distance that radiant energy travels through atmosphere

Scattering

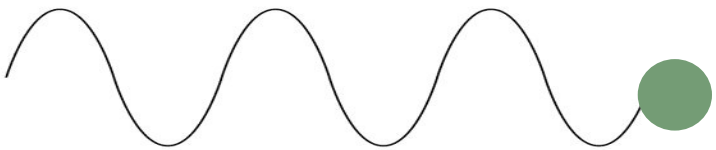
Three types of scattering:

- **Rayleigh scattering**
  - Particle size <<< λ_{light}
  - Highly dependent on wavelength
- **Mie scattering**
  - Particle size ~ λ_{light}
  - Not strongly dependent on wavelength
- **Non-selective scattering**
  - Particle size >>> λ_{light}



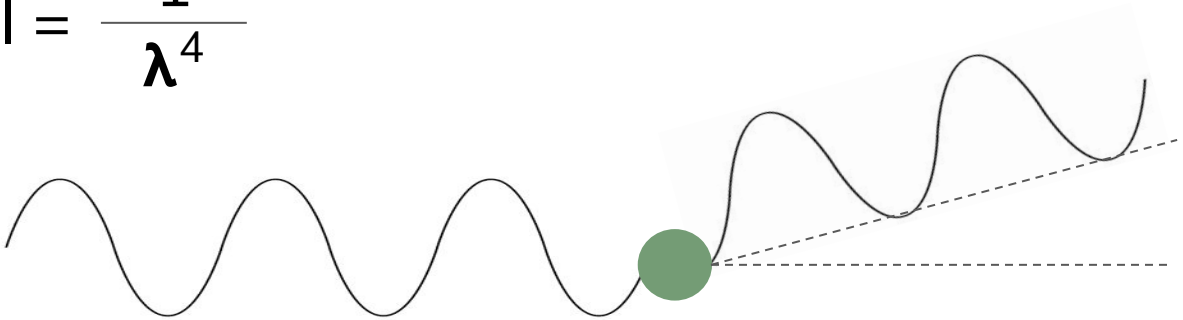
Rayleigh scattering

$$I = \frac{1}{\lambda^4}$$



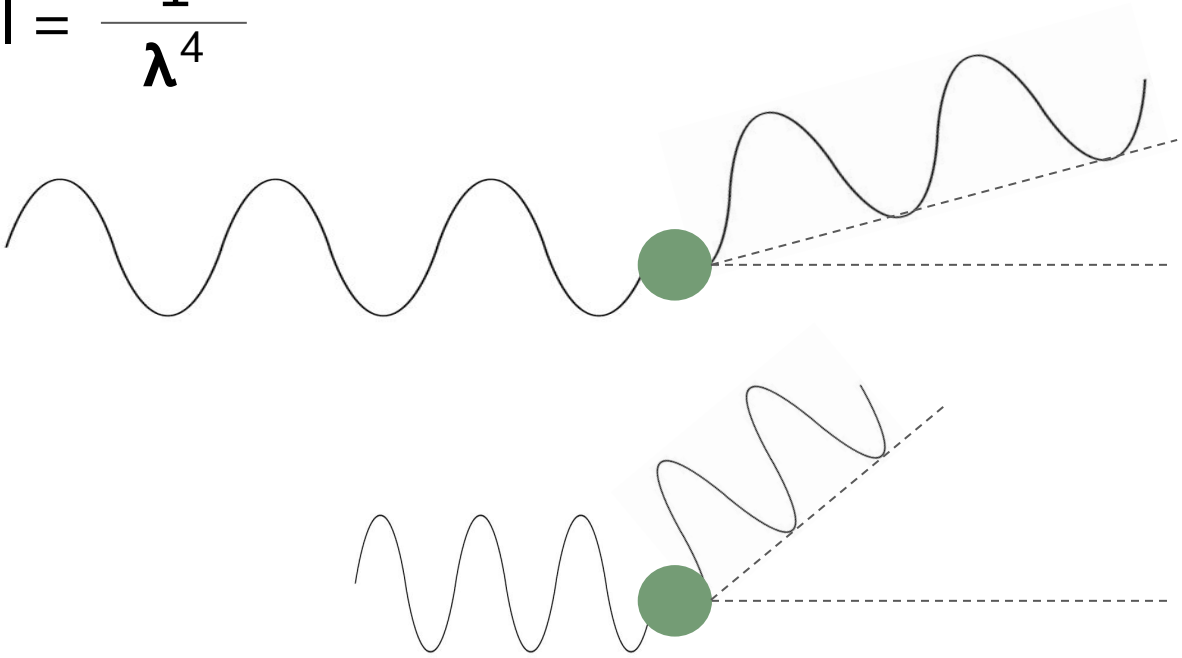
Rayleigh scattering

$$I = \frac{1}{\lambda^4}$$



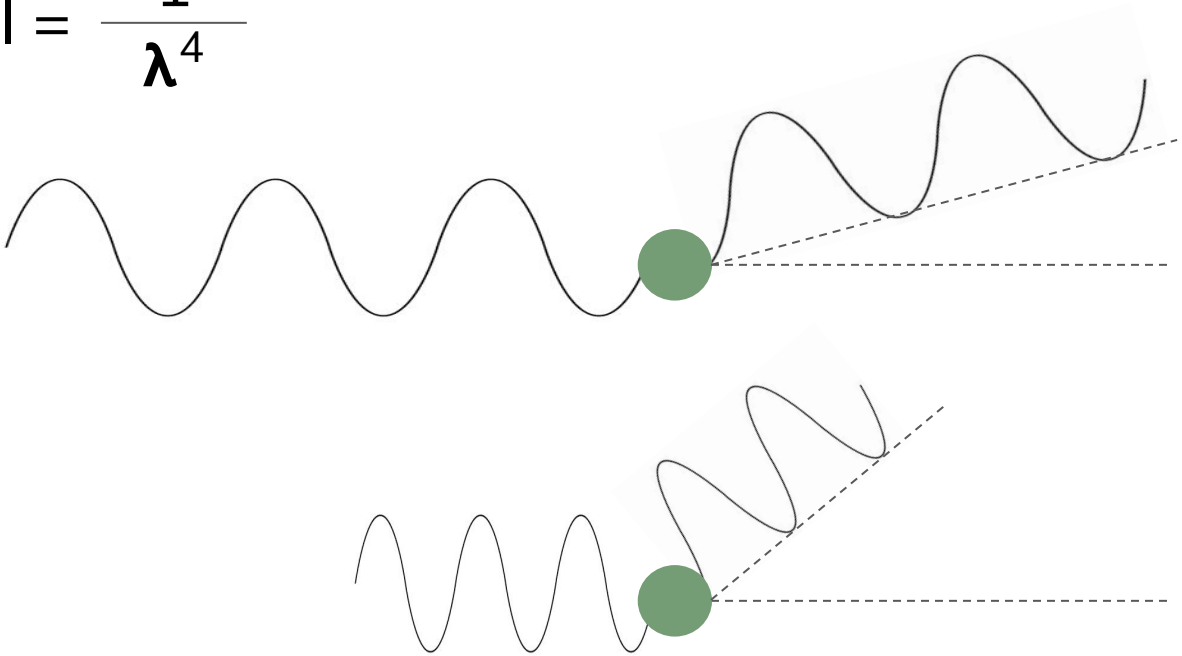
Rayleigh scattering

$$I = \frac{1}{\lambda^4}$$



Rayleigh scattering

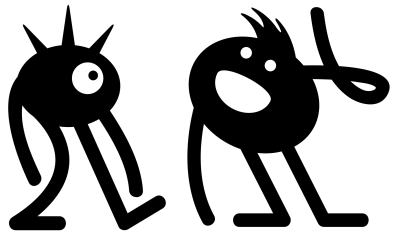
$$I = \frac{1}{\lambda^4}$$



As wavelength increases, intensity of scattering decreases

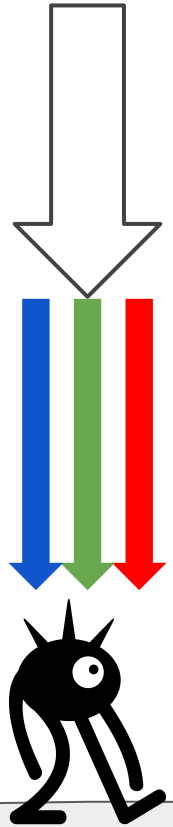
Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



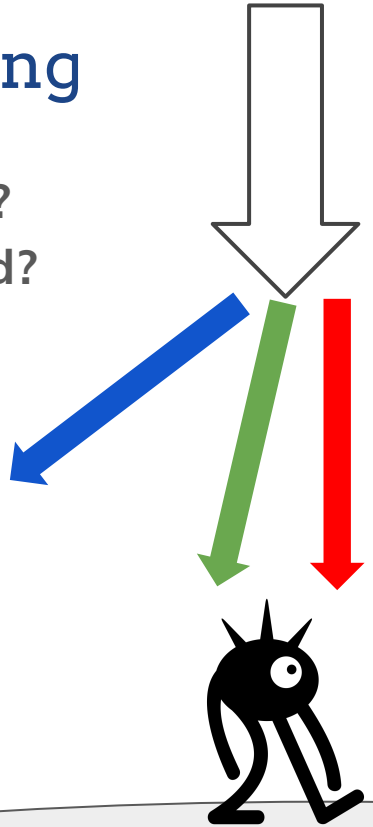
Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



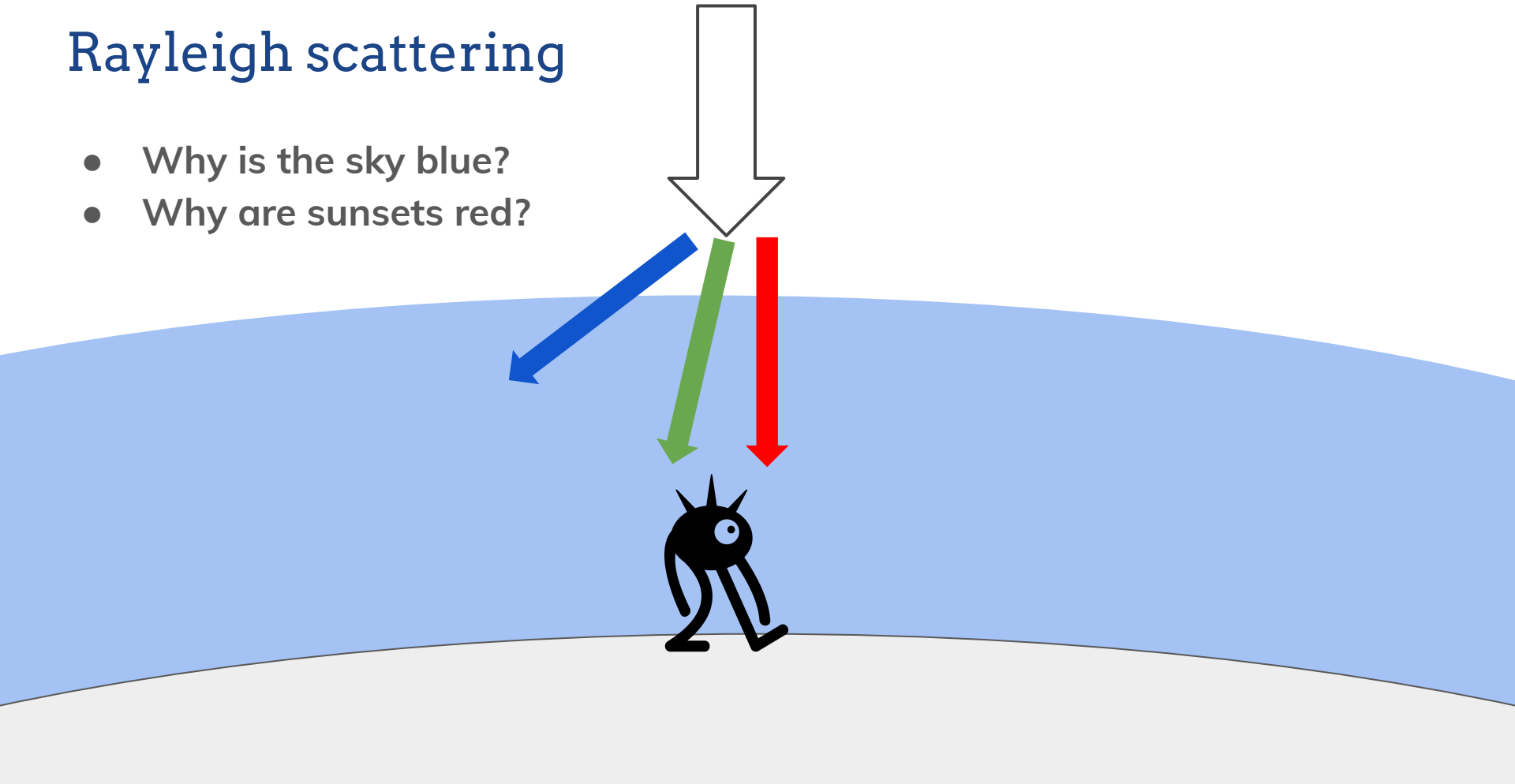
Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



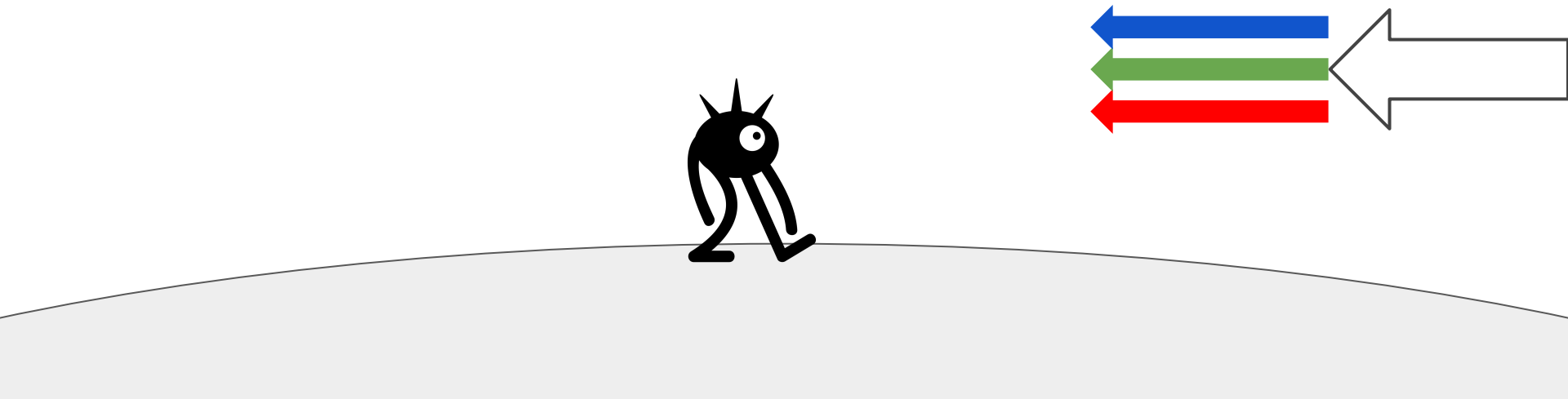
Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



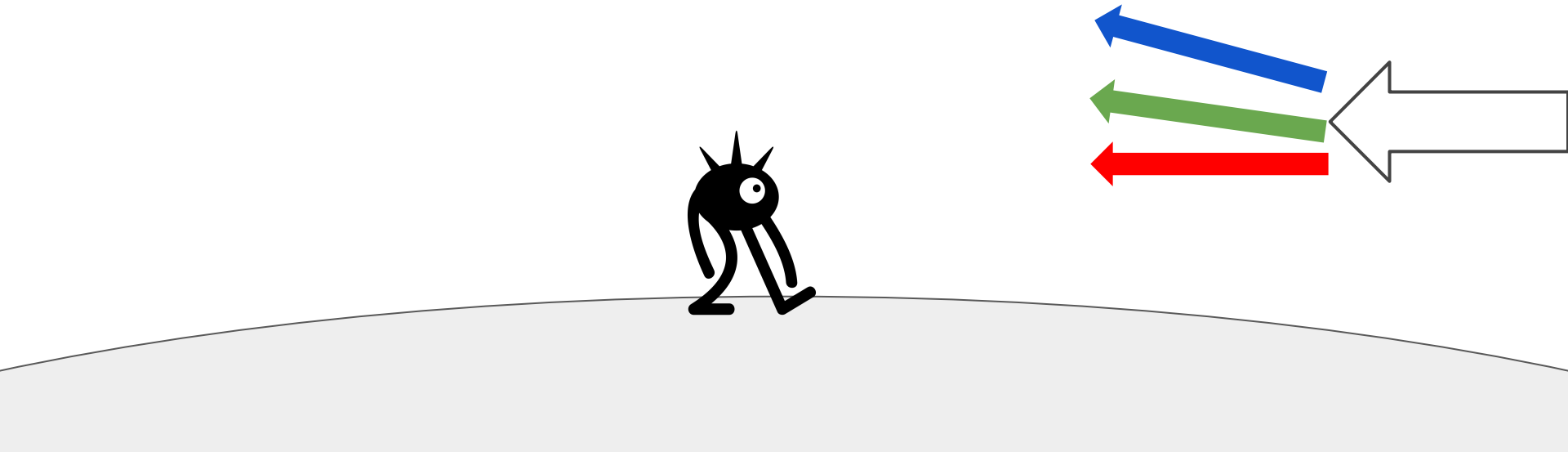
Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



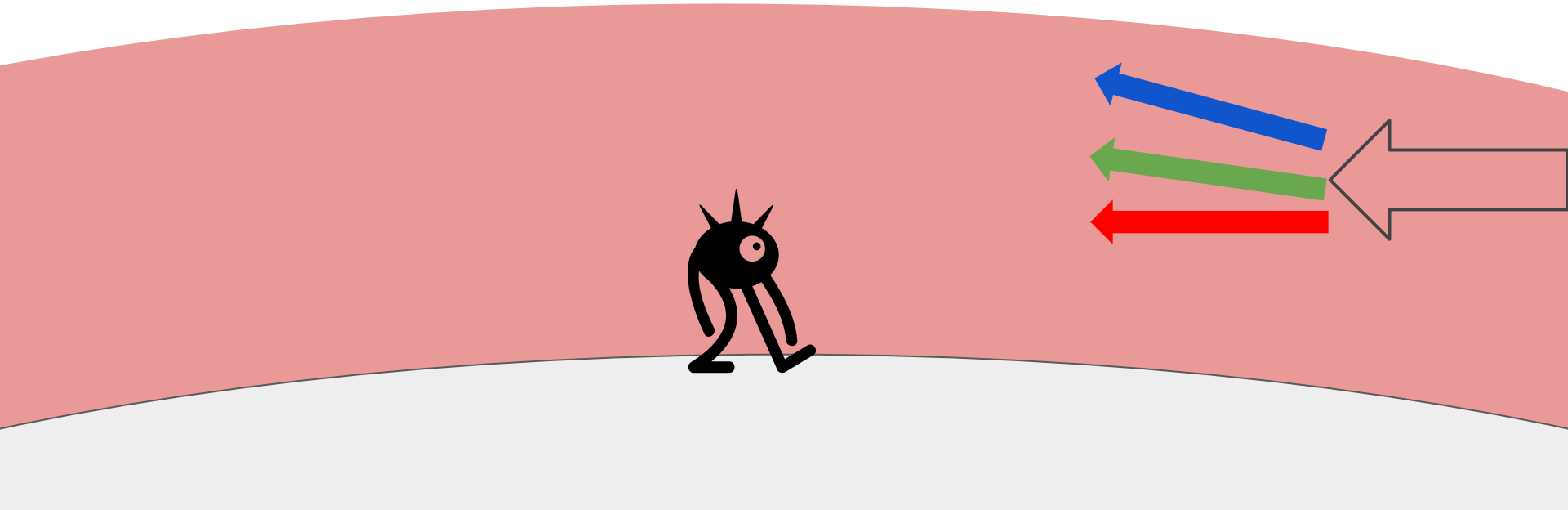
Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



Rayleigh scattering

- Why is the sky blue?
- Why are sunsets red?



Mie and non-selective scattering

- **Mie scattering**
  - Amplifies wavelengths of similar size to particle
  - Pollution and aerosols scatter blue and green light away, contributing to red sunsets
- **Non-selective scattering**
  - Particles in the atmosphere several times the diameter of the wavelength
  - All wavelengths are scattered
  - Water droplets scatter all wavelengths of visible light equally well
    - Why clouds are white!

Refraction

- Refraction is ‘bending’ of light when it passes from one medium to another of different density.
  - The speed of EMR changes
  - In a vacuum $c \approx 3x10^8$ m/s
- *Frequency of a light wave in a medium is determined by its source and is unaffected by the medium!*

Energy-matter interactions with terrain

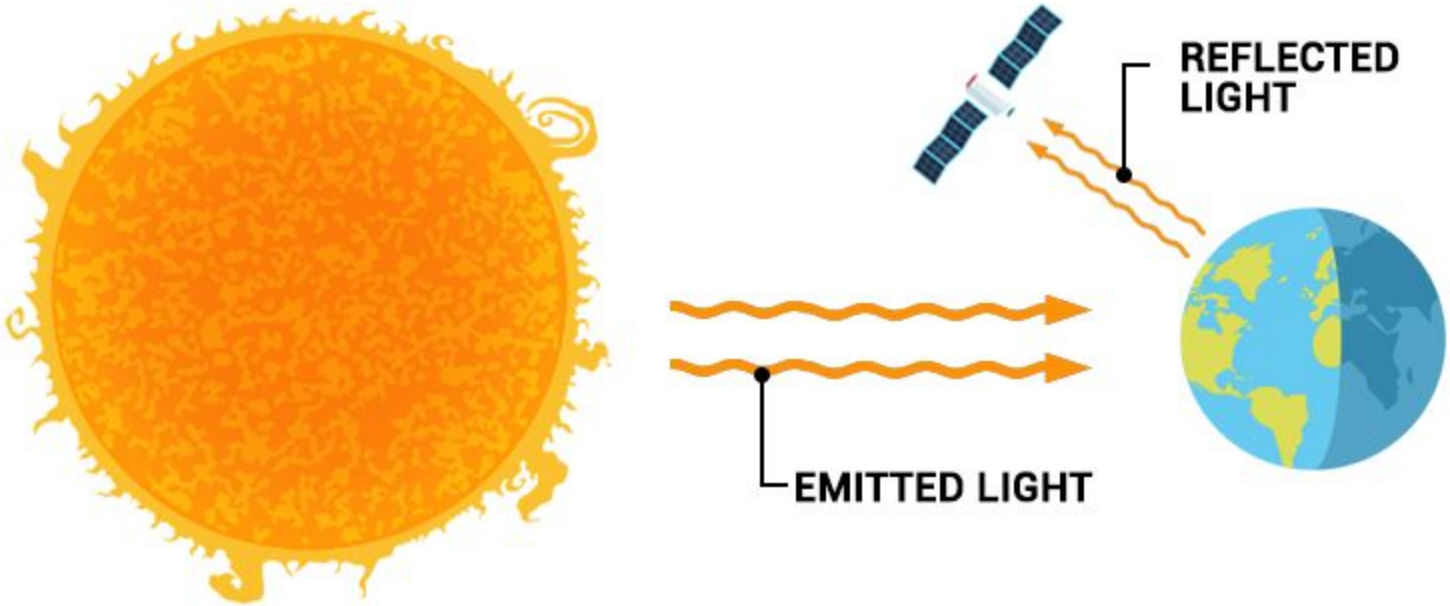
Absorption: process by which radiation is absorbed and converted to other forms of energy.

Reflectance: process whereby radiation “bounces off” an object.

Scattering: reflectance in an unpredictable manner.

Refraction: bending of light through mediums of different density.

Transmittance: process by which radiation passes through a material.



Source: GIS Geography

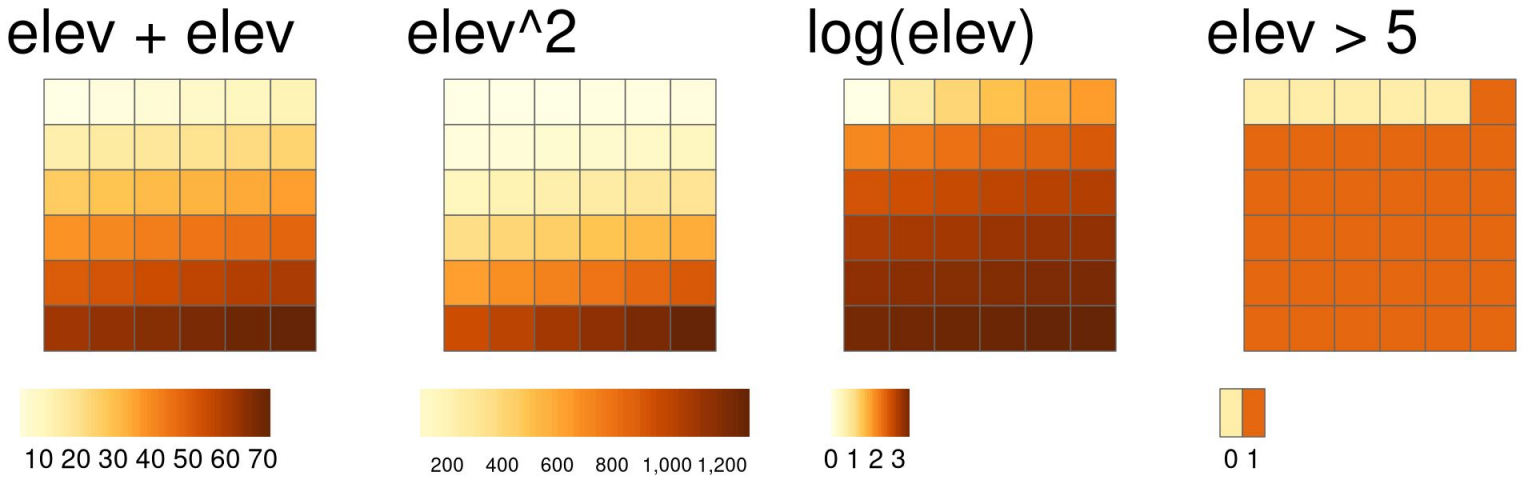
Map algebra

- Local
- Focal
- Zonal
- Global

Scale or number of cells

Map algebra

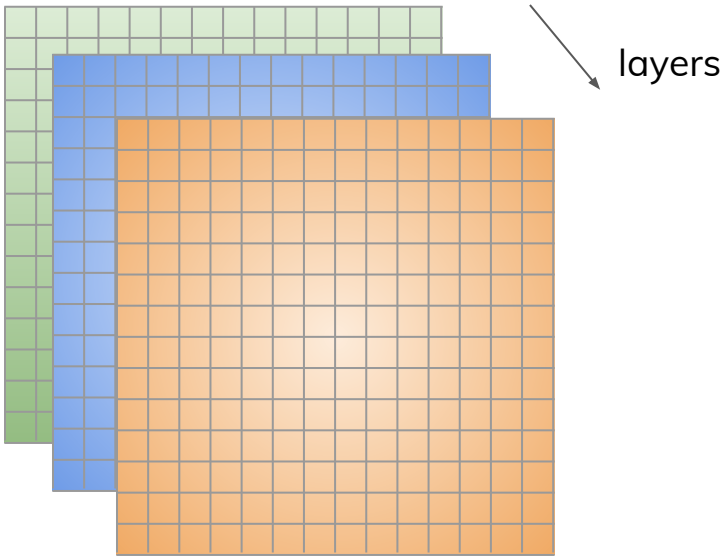
- **Local**
  - Cell-by-cell operations in one or several layers



Source: Geocomputation with R, chapter 4

Map algebra

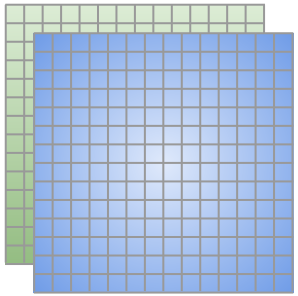
- **Local**
  - Cell-by-cell operations in one or several layers



Source: Geocomputation with R, chapter 4

Map algebra

- **Local**
  - Cell-by-cell operations in one or several layers



$$\text{Normalized Difference Vegetation Index} = \frac{\text{NIR - Red}}{\text{NIR + Red}}$$

Source: Geocomputation with R, chapter 4

Map algebra

- Local
- Focal
- Zonal
- Global

Scale or number of cells

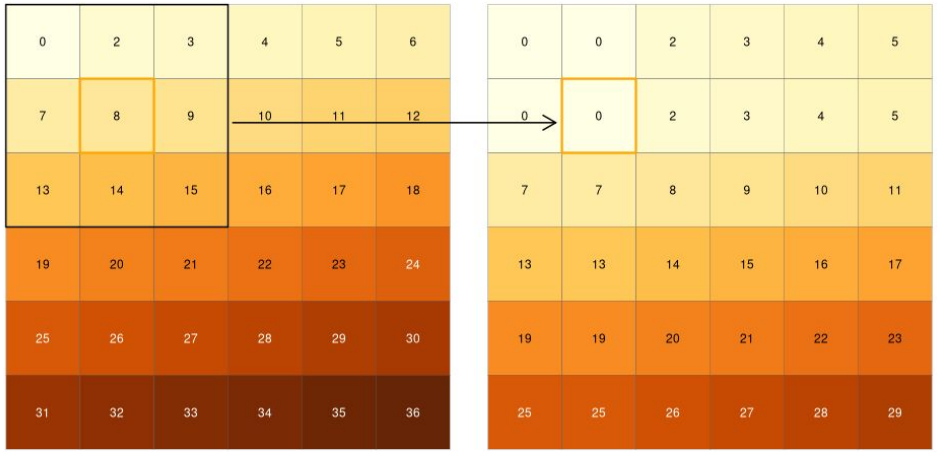
Map algebra

- **Focal**
  - Applies an aggregation function to all cells within a specified neighborhood, uses the corresponding output as the new value for the central cell, and moves on to the next central cell

Source: Geocomputation with R, chapter 4

Map algebra

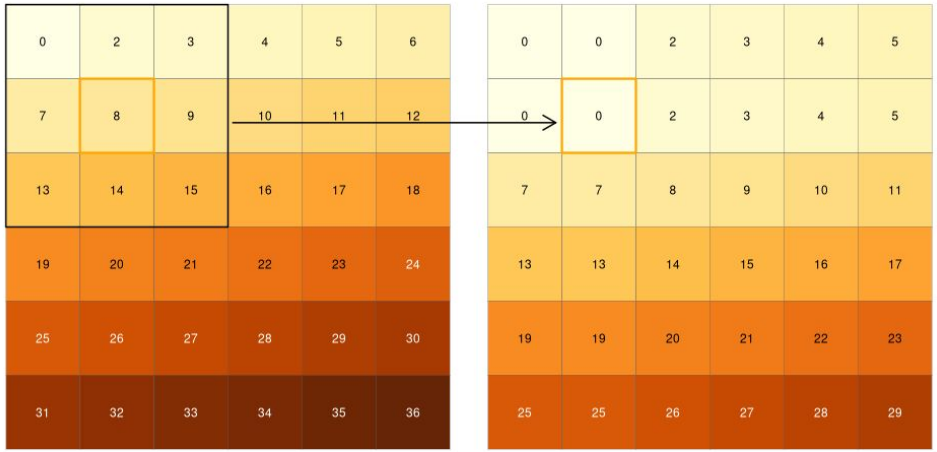
- **Focal**
  - Applies an aggregation function to all cells within a specified neighborhood, uses the corresponding output as the new value for the central cell, and moves on to the next central cell



Source: Geocomputation with R, chapter 4

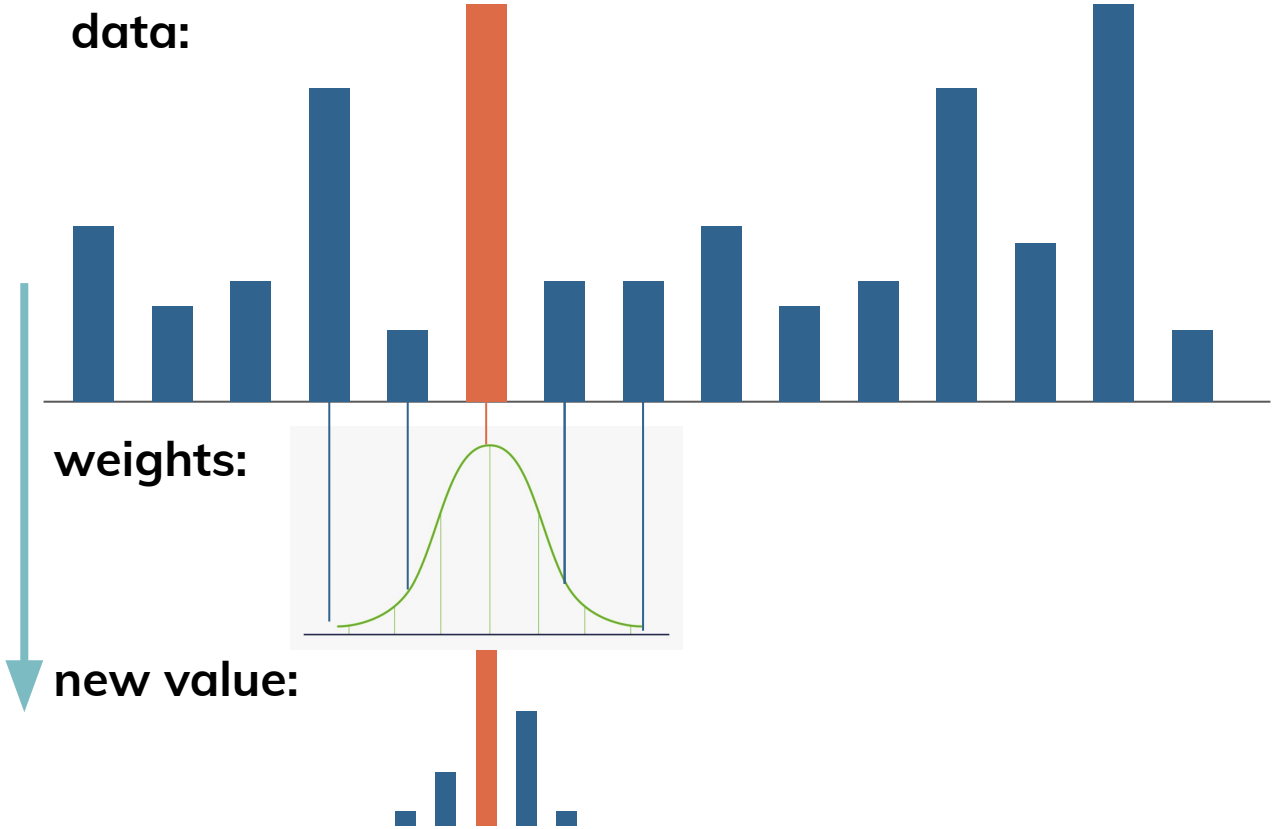
Map algebra

- **Focal**
  - Applies an aggregation function to all cells within a specified neighborhood, uses the corresponding output as the new value for the central cell, and moves on to the next central cell



Source: Geocomputation with R, chapter 4

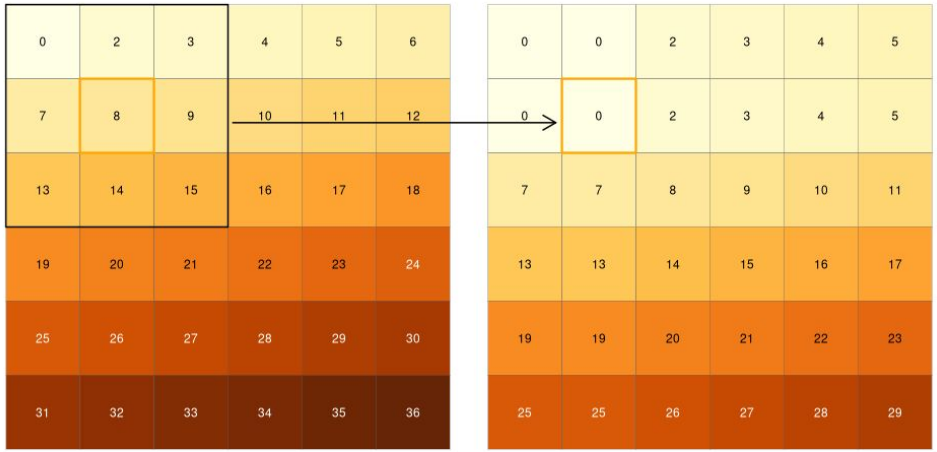
Smoothing: Gaussian kernel



Map algebra

- **Focal**
  - Applies an aggregation function to all cells within a specified neighborhood, uses the corresponding output as the new value for the central cell, and moves on to the next central cell

kernel,
filter,
moving window



Source: Geocomputation with R, chapter 4

Map algebra

- Local
- Focal
- Zonal
- Global

Scale or number of cells

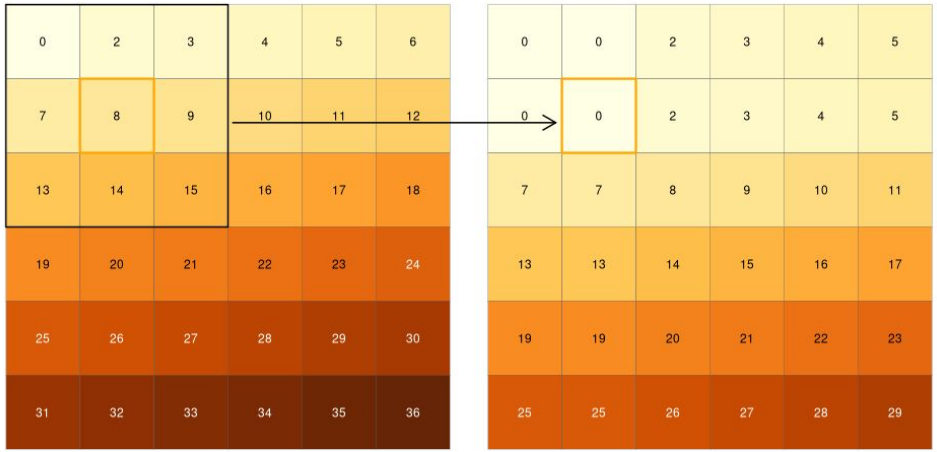
Map algebra

- **Zonal**
  - Applies an aggregation function to multiple cells based on a grouping variable

Source: Geocomputation with R, chapter 4

Map algebra

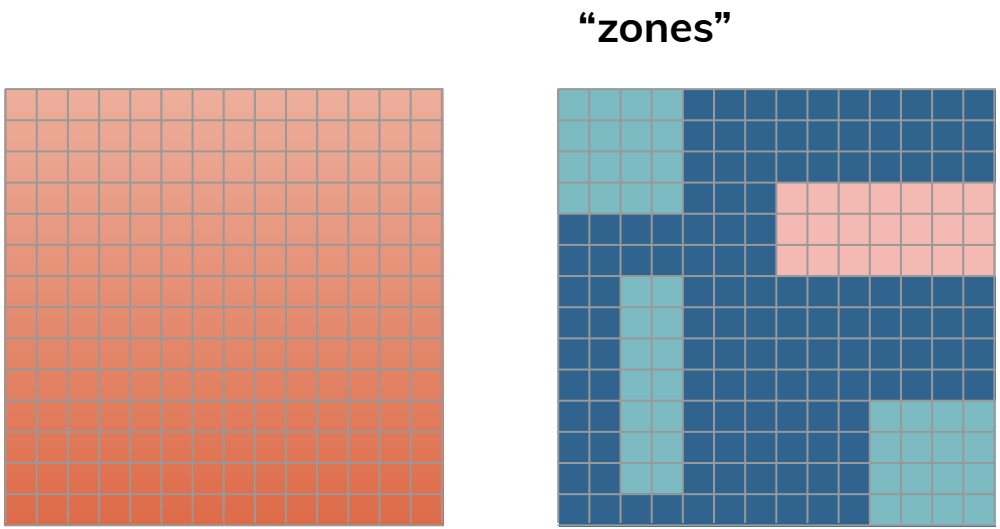
- **Zonal**
  - Applies an aggregation function to multiple cells based on a grouping variable



Source: Geocomputation with R, chapter 4

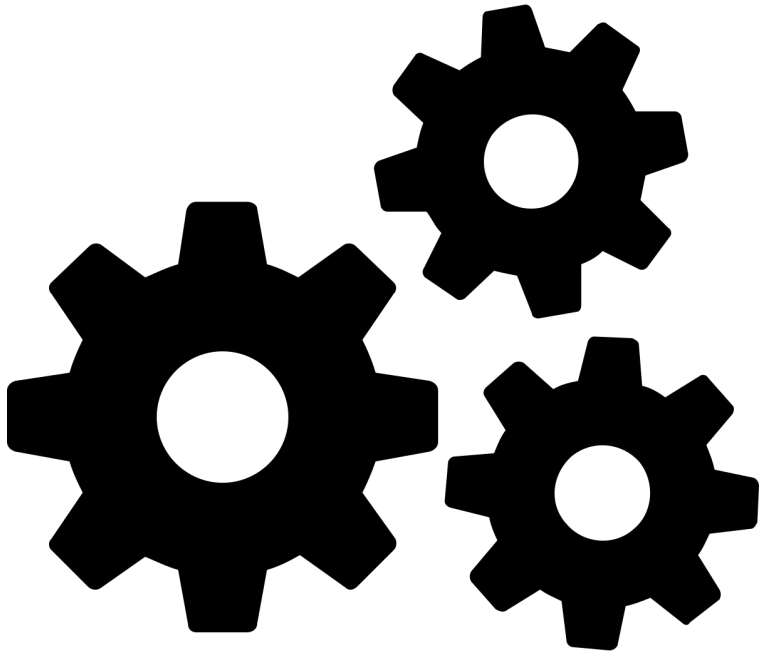
Map algebra

- **Zonal**
  - Applies an aggregation function to multiple cells based on a grouping variable



Source: Geocomputation with R, chapter 4

Switching gears...

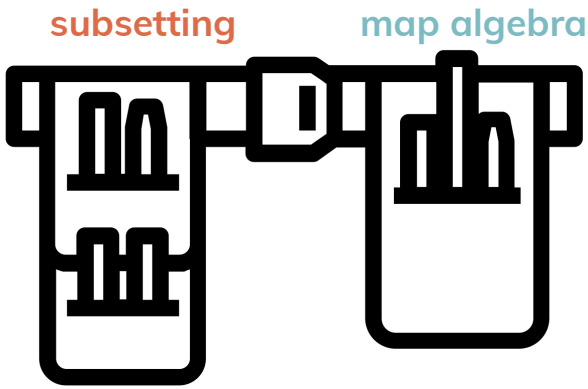


Map algebra

- Local
- Focal
- Zonal
- Global

Scale or number of cells

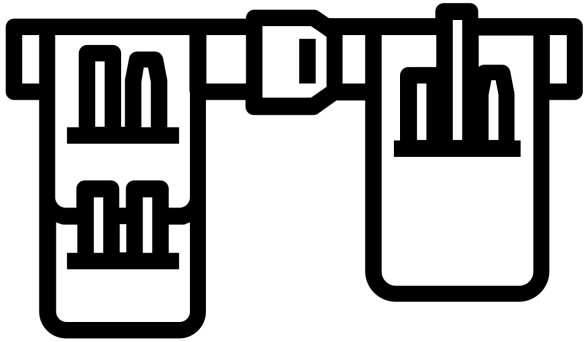
Toolbelt for solving spatial problems



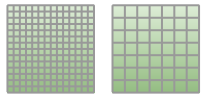
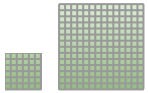
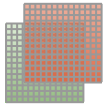
Toolbelt for solving spatial problems

map algebra:
summarizing
filtering
mutating

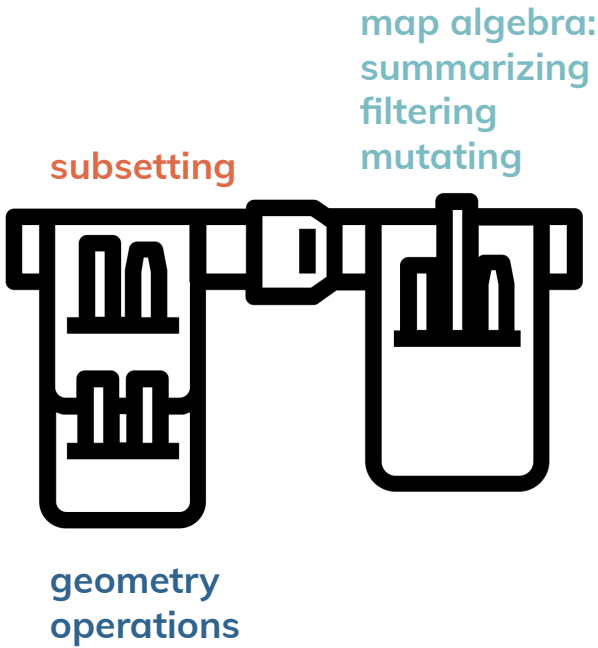
subsetting



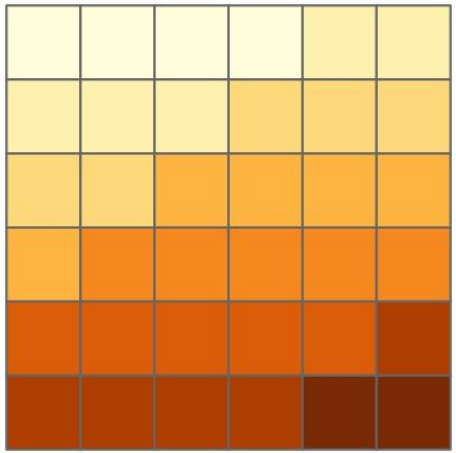
Raster data model

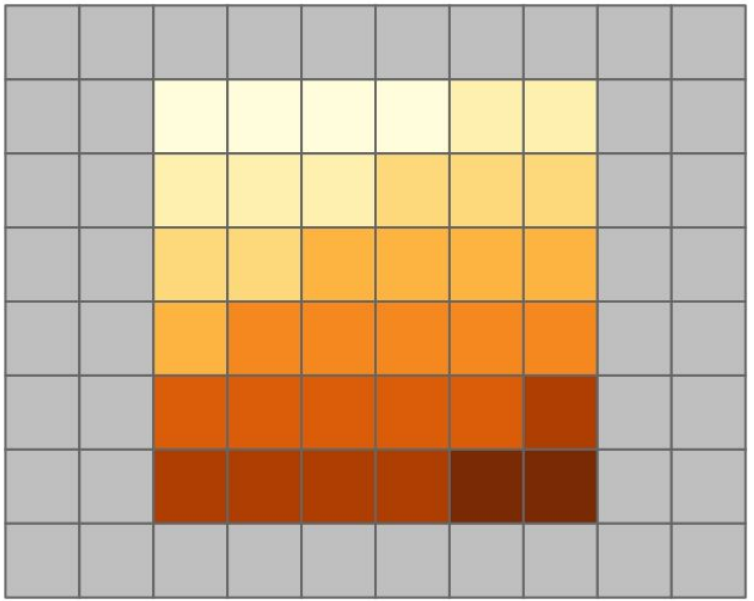
- Resolution 
- Extent 
- Position 

Toolbelt for solving spatial problems



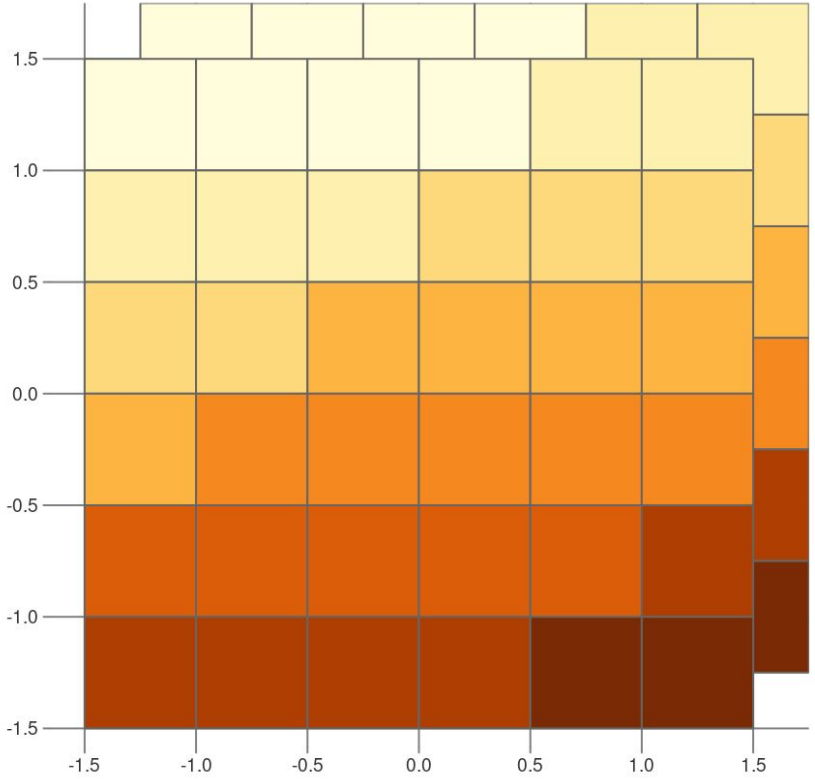
Changing extent and origin





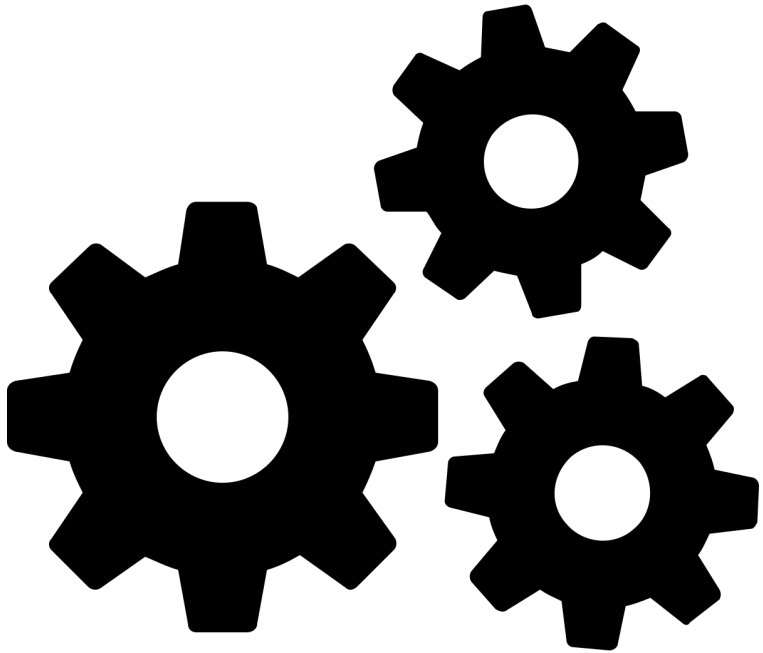
Source: Geocomputation with R, chapter 4

Changing extent and origin

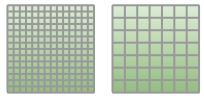
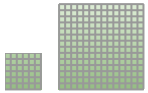
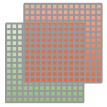


Source: Geocomputation with R, chapter 4

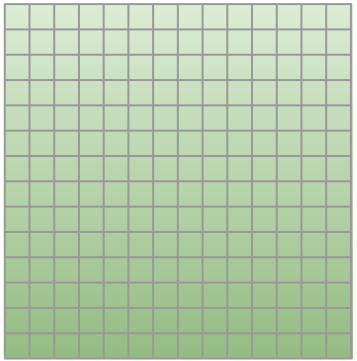
Switching gears...

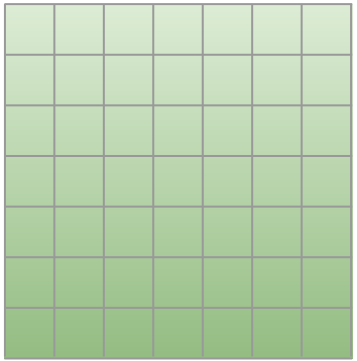


Raster data model

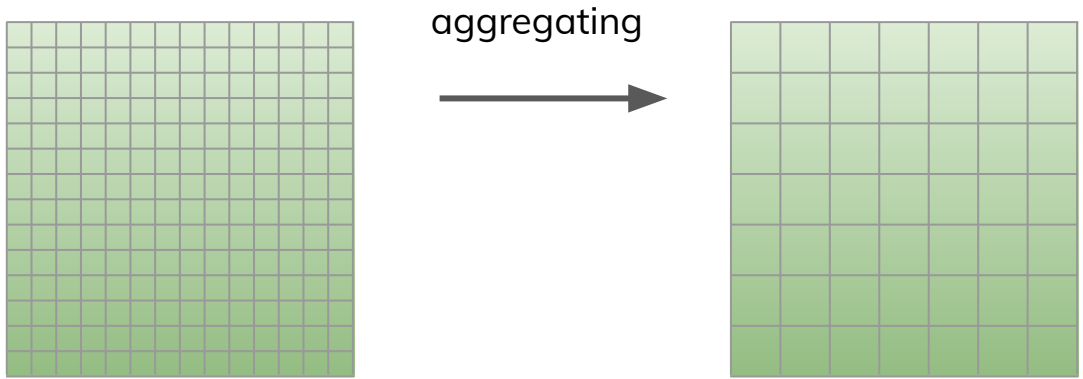
- Resolution 
- Extent 
- Position 

Changing resolution

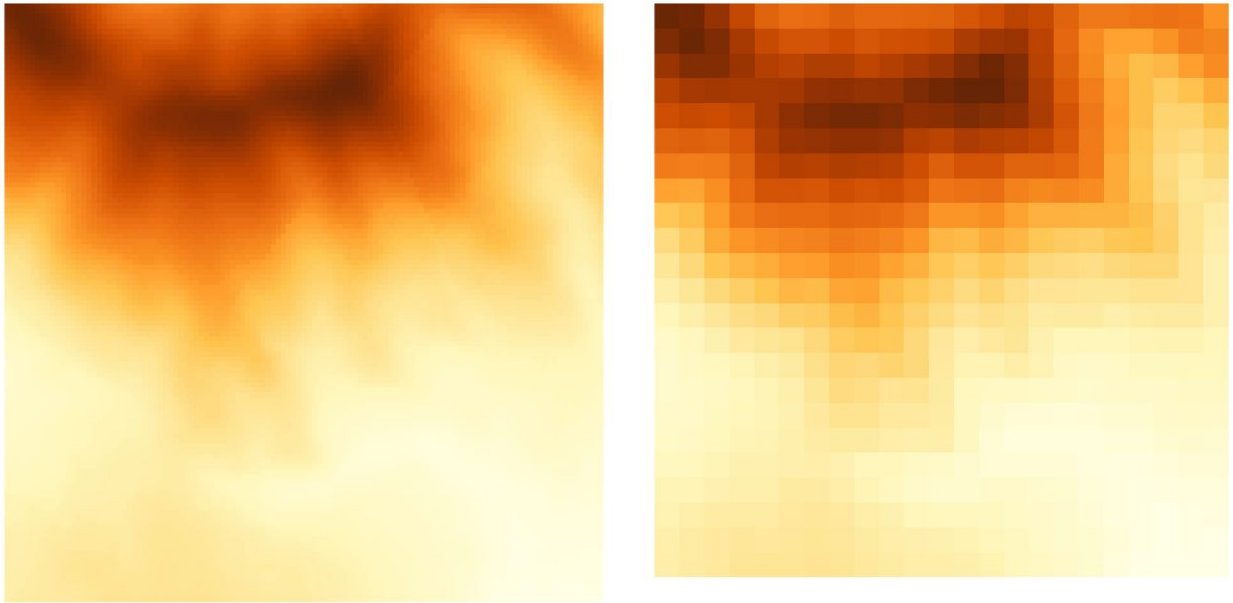




Changing resolution

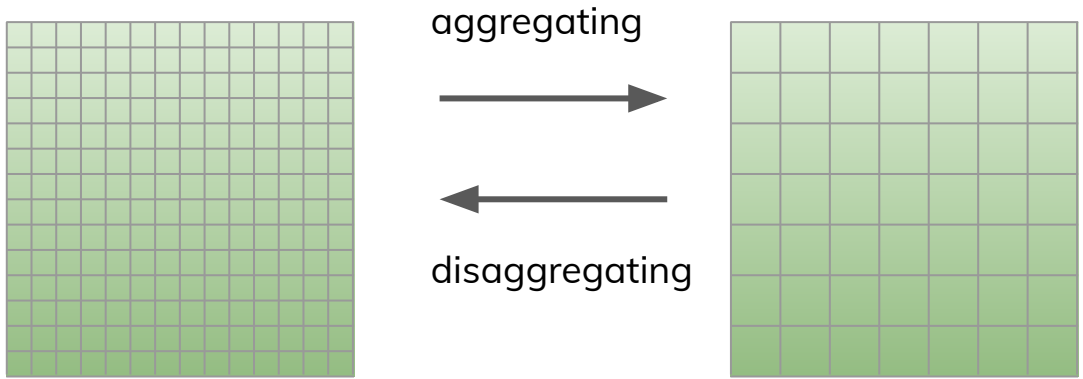


Changing resolution



Source: Geocomputation with R, chapter 5

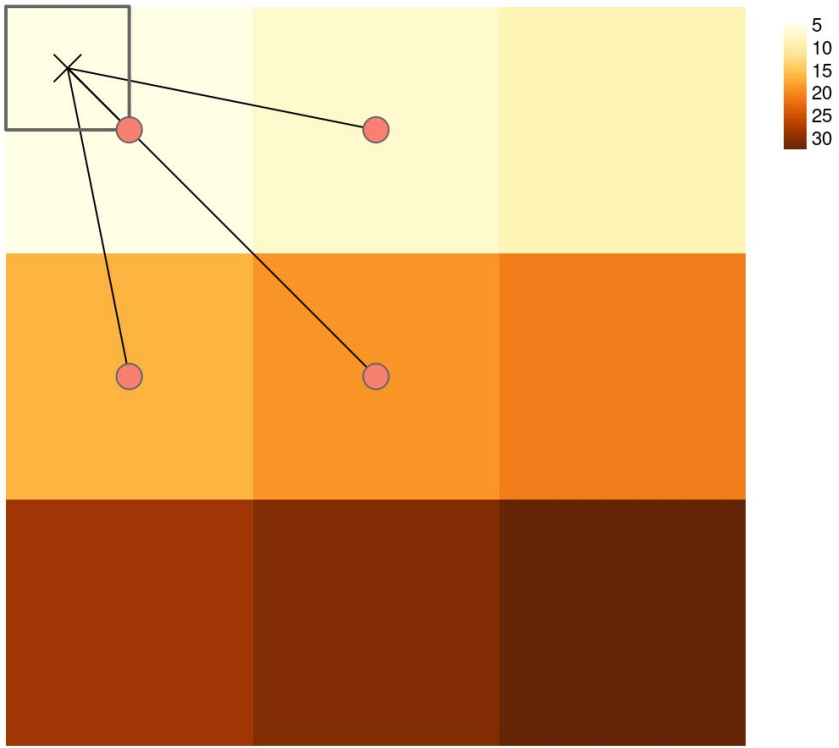
Changing resolution



Changing resolution

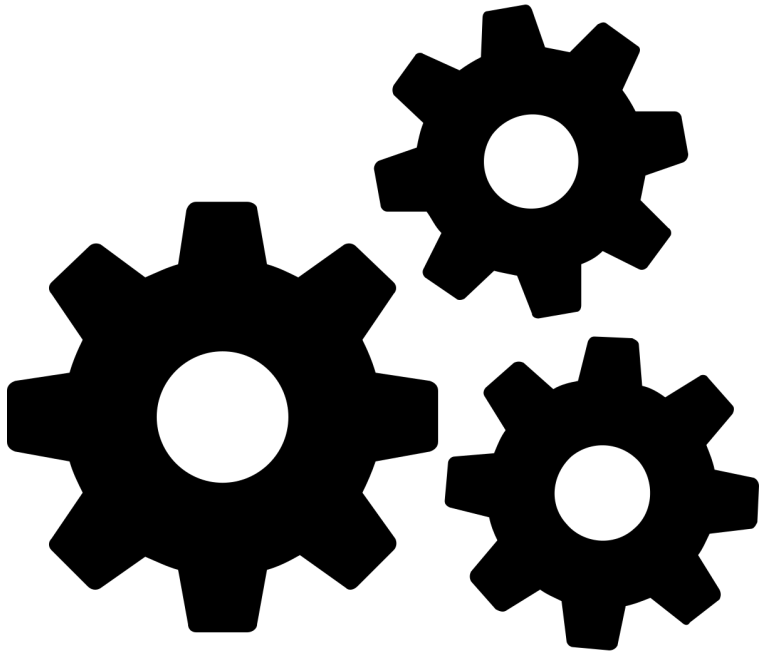
Nearest neighbor

Bilinear interpolation



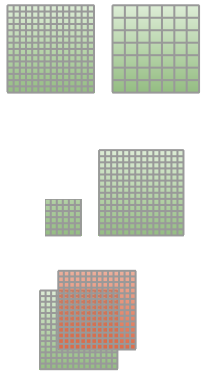
Source: Geocomputation with R, chapter 5

Switching gears...



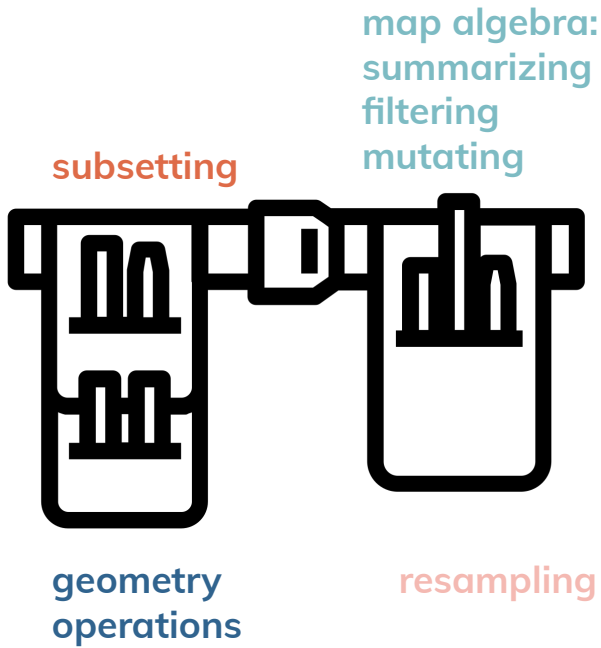
Raster data model

- Resolution
- Extent
- Position

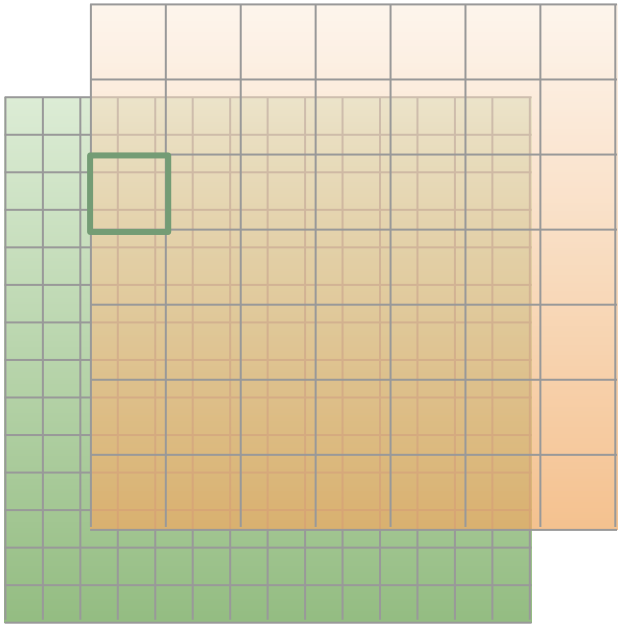


mismatch!

Toolbelt for solving spatial problems



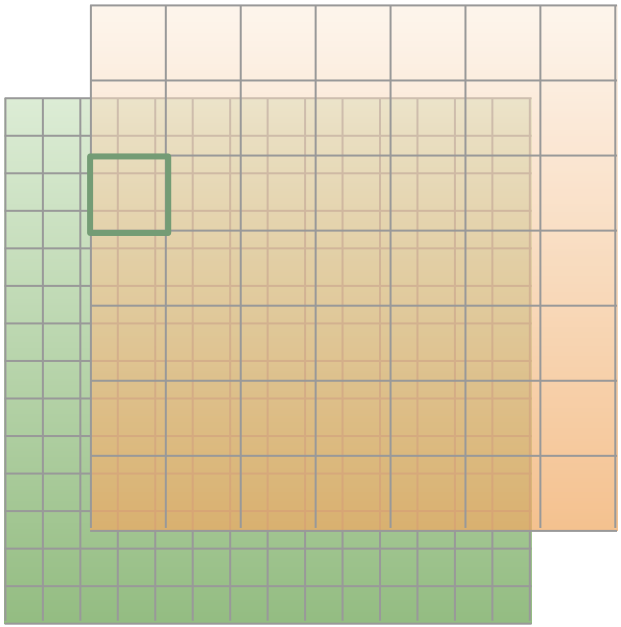
Resampling



Resampling

Nearest neighbor

Bilinear interpolation



Switching gears...