

# Symbolization; the basics

By NTUA

# Symbolization

The symbolization process consists of three separate stages:

1. The selection of appropriate **measurement levels** of the attribute values of spatial data/entities
2. The definition of **spatial entities dimensions**
3. The selection of **visual variables** for displaying spatial entities.



- The **nominal scale**: categorization of data based on their qualitative characteristics.
- The **ordinal scale**: categorization of data in some hierarchical structure, not based on numerical values.
- The **interval scale** is used to classify data based on successive value intervals, after first defining an arbitrary starting point that takes the value zero and a standard unit of measurement that can also be arbitrary.
- The **ratio scale** is a variation of the interval scale, where the starting point, i.e., the zero point, is not arbitrary, but has a physical meaning.

## Measurement Levels

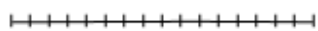
# Nominal Scale

qualitative differences

categorical data, unranked and non-numerical



Metro station



railway



river



Arable land



lake

# Ordinal Scale

Ordered or ranked data with no assigned numerical values.  
It is used to distinguish data based on a hierarchy (rank, order)



Large settlement



Motorway



Medium  
settlement



Arterial road



Small settlement



Collector road

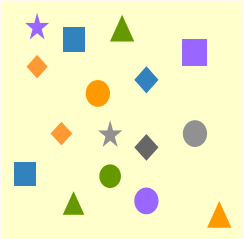
# Interval Scale

- Numerical data
  - Examples of interval level data: temperature and year.
- The zero point is arbitrary on interval scales (e.g., zero degrees Fahrenheit and zero degrees Celsius): neither indicates the absence of temperature.

# Ratio Scale

- Numerical data
  - Examples of ratio level data: distance, area, population.
- On ratio level of measurement, the zero point indicates the absence of the phenomenon; this means that a quantity of 20 measured at the ratio scale is twice the value of 10, a relation that does not hold true for quantities measured at the interval level (20 degrees is not twice as warm as 10 degrees).

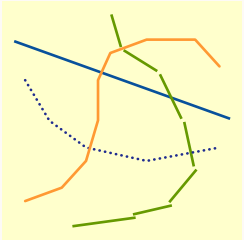
# Dimensions of Spatial Entities



**Point (0-D)**



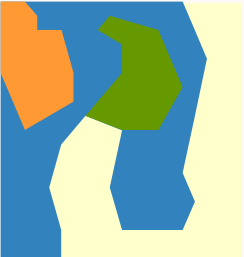
An old telephone booth in Finland



**Linear (1-D)**



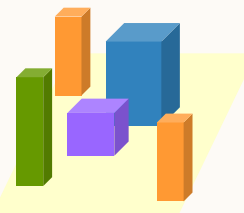
A highway in Honduras



**Areal (2-D)**



A field of sunflowers in Spain, by Diego Delso, CC BY-SA 3.0



**Volumetric (3-D)**

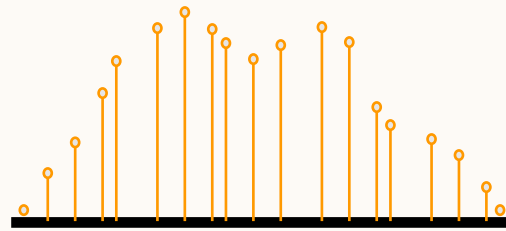
Mount Olympus, GR



Lake Como, IT

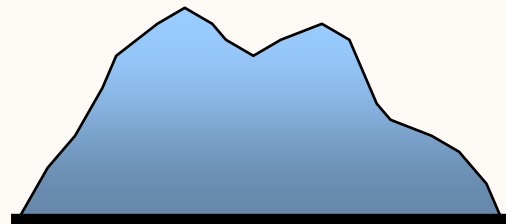


# Discrete vs. Continuous Spatial Entities



Discrete

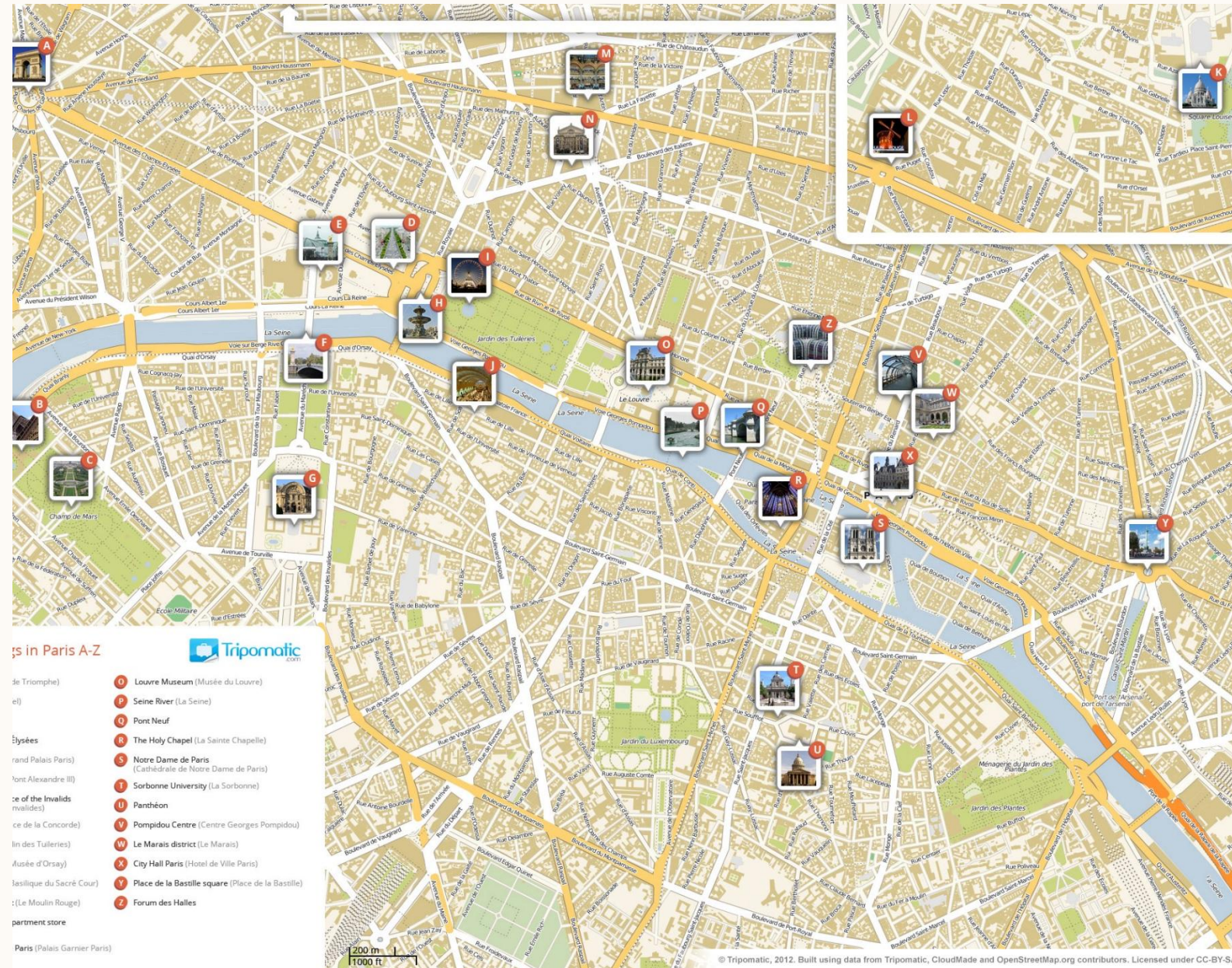
Individual entities in specific locations  
- intermediate surfaces are empty of this element or have a zero value, e.g., individual houses or industrial facilities.



Continuous

No location is empty from the phenomenon being considered, for example, categories of land cover, temperature.

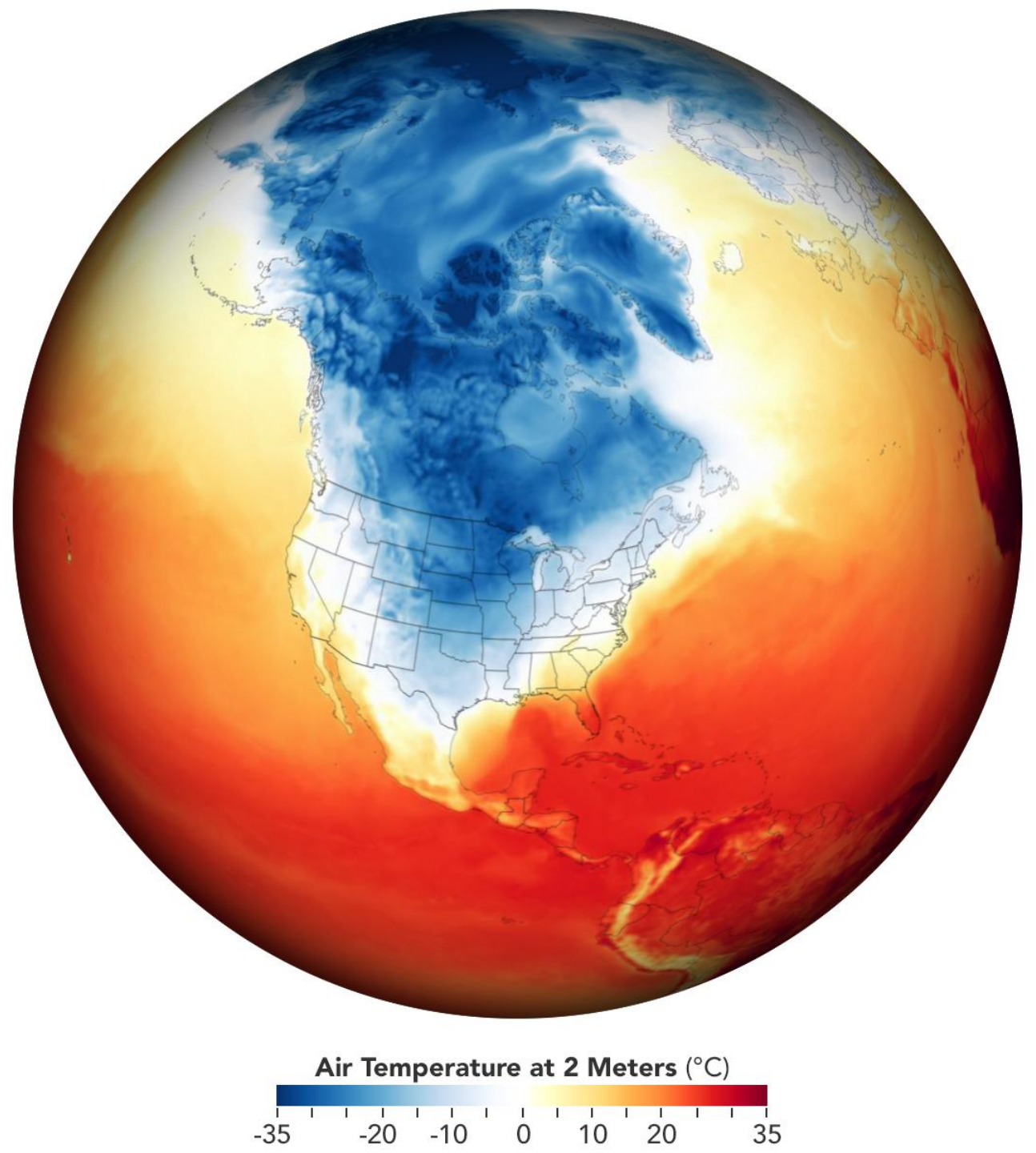
# A Map of Discrete Spatial Entities; Tourist Attractions



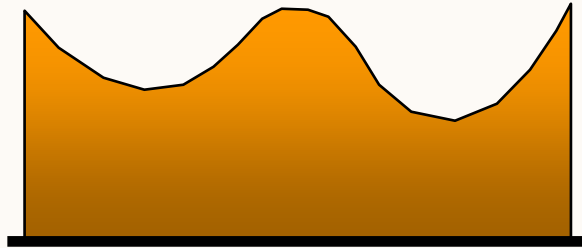


# A Map of a Continuous Spatial Entity; Temperature

North America air temperature at two meters above the ground on Feb 15, 2021.  
By Joshua Stevens/NASA Earth Observatory - Public Domain.

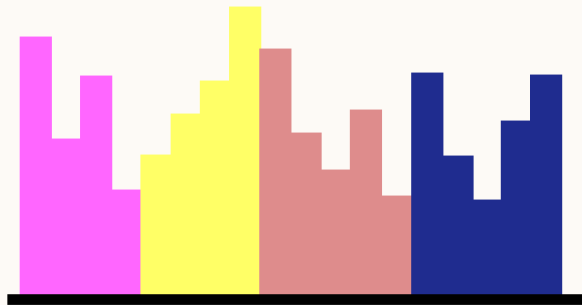


# Smooth vs. Abrupt Spatial Entities



Smooth

The phenomenon changes smoothly and not sharply from place to place, e.g.,  
atmospheric pressure

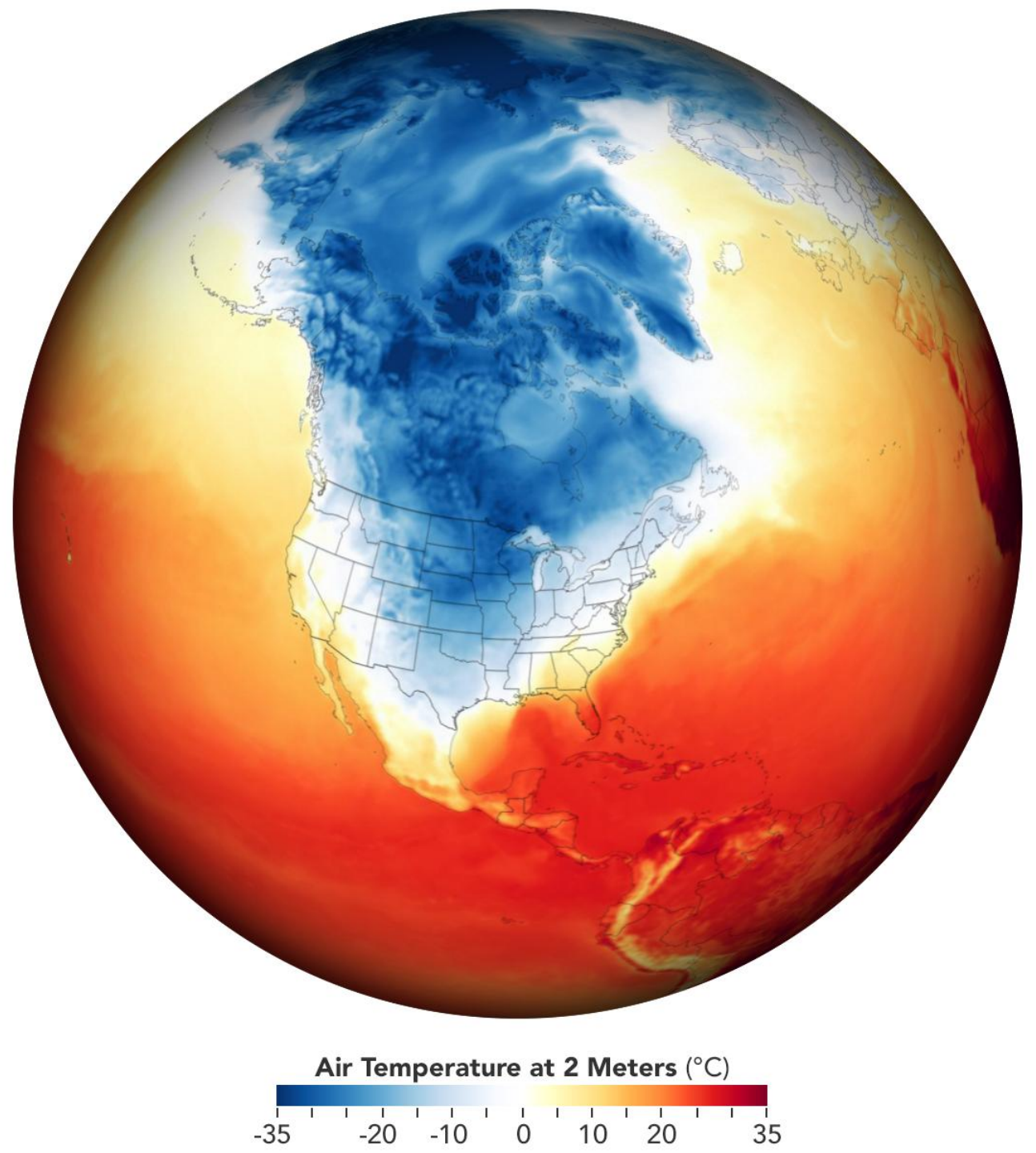


Abrupt

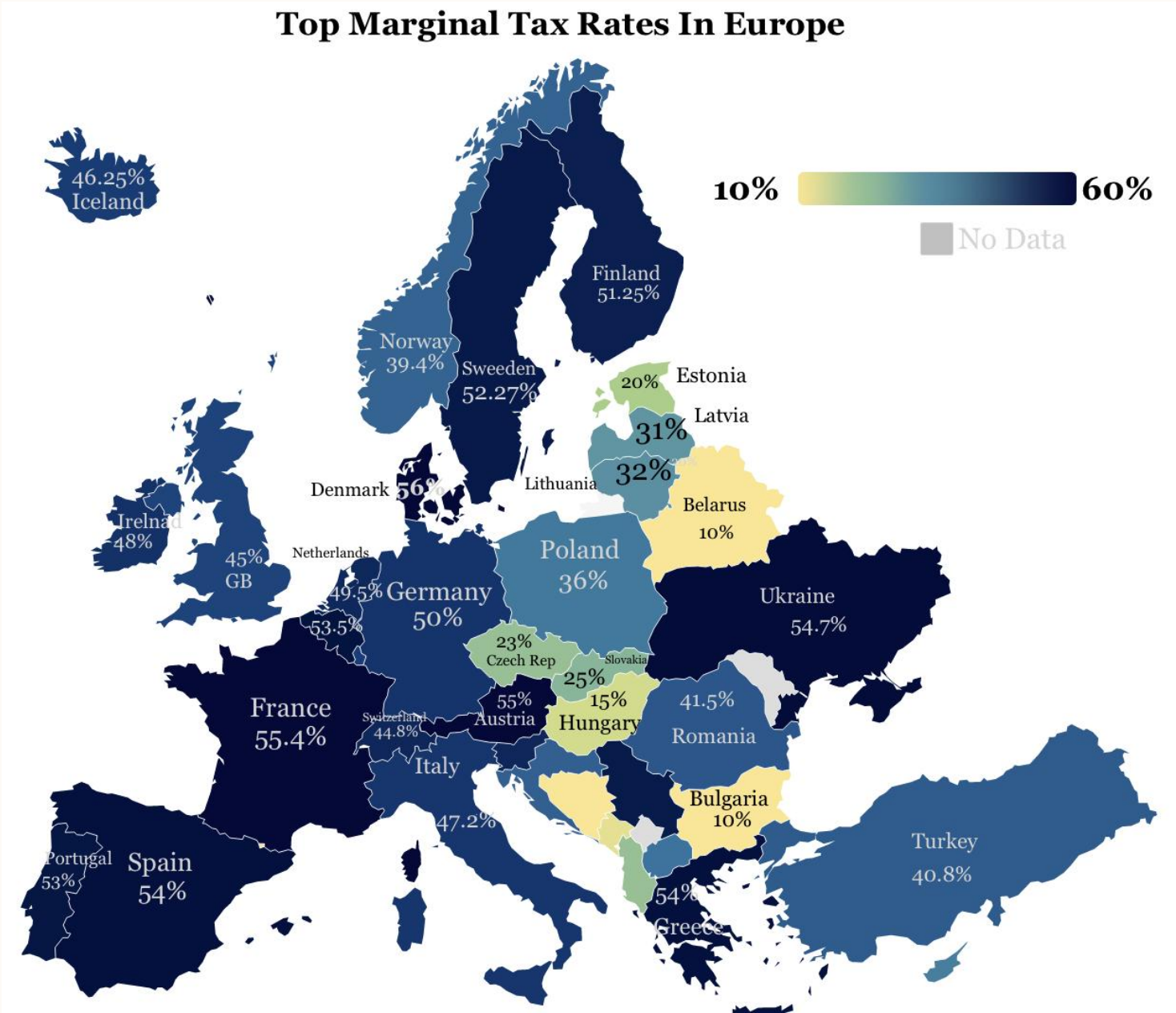
The phenomenon changes abruptly at the border, creating a gradual surface, e.g., VAT  
rates

# A Map of a Smooth Spatial Entity; Temperature

North America air temperature at two meters above the ground on Feb 15, 2021.  
By Joshua Stevens/NASA Earth Observatory - Public Domain.



# A Map of an Abrupt Spatial Entity; Tax Rate (per country)



Top marginal tax rates in Europe. By Wikideas1 - Own work  
<https://taxfoundation.org/top-personal-income-tax-rates-europe-2022/>, CC0



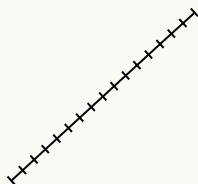
# Symbolization: Categories Of Symbols

**Point:** represent point entities or the value of an attribute on a location of attributes

**Linear:** represent linear entities (e.g., rivers, roads, borders) or contour lines

**Areal:** represent areas with common attributes (e.g., vegetation, water bodies, land use)

**Volumetric:** represent the vertical dimension or the intensity of a spatial phenomenon in space



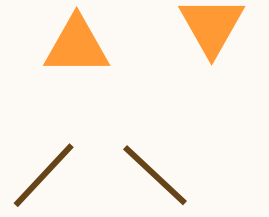
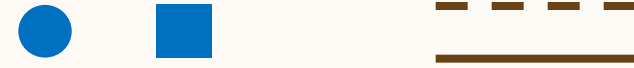
# Symbolization: Visual Variables

- Types of variations that the human eye may perceive, and which can be used to indicate **similarity**, **classification** and **analogy**.
- They are distinguished in:
  - Primary visual variables
  - Secondary visual variables



# Primary Visual Variables

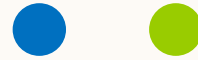
- **Shape:** variations in the appearance or form of a symbol.
- **Size:** variations in the length, area, or volume of a symbol.
- **Orientation:** the direction or angle of rotation of a symbol.



# Primary Visual Variables

## Color Dimensions

- Color hue
- Color value
- Color saturation



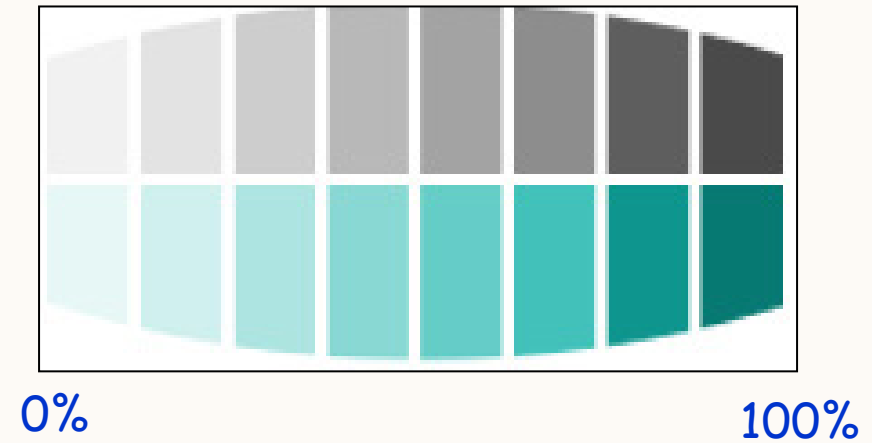
# Color Hue

- The term we use to describe the different colors: red, yellow, green, orange, etc.
- Each hue has its own wavelength in the visible light spectrum
- The color circle is used to sort color hues sequentially according to the wavelength in the visible light spectrum



# Color Value (Lightness)

- Corresponds to the lightness or darkness of a single hue (how light or dark a single hue appears)
- 0% value corresponds to a light color (e.g., light gray or light red), while 100% value corresponds to a dark color (e.g., black or dark red respectively)



# Color Saturation

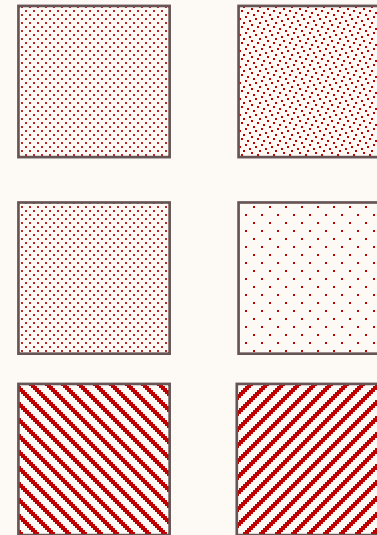
- Corresponds to the intensity of a single hue.
- Corresponds to the vitality of a color (how vivid or dull a color is)
- Color saturation may be understood by comparing a color with a neutral gray: by adding more color dye it appears less and less gray until full saturation is achieved
- For a given hue, saturation varies from 0% (neutral gray) to 100% (full saturated color does not include any gray)



# Secondary Visual Variables

**Pattern:** repetition of graphic elements  
- is produced by different combinations of the main visual variables

- **Arrangement:** The distribution of individual marks that make up a symbol.
- **Texture:** size and intervals between the pattern components
- **Orientation:** direction of parallel linear symbols



# Symbolization: Visual Variables

- Size, color value, and saturation reflect differentiations between the values of the data displayed. By adding numbers in the legend, data in interval and ratio levels of measurement may also be represented.
- Instead, pattern, color hue, orientation, and shape are the visual variables used to differentiate the qualitative characteristics of the data
- Finally, x and y coordinates of the plane are the only visual variables that bring together all the aforementioned properties: they are sortable, they highlight proportions, they are associative, and they are highly selective. This fact proves the importance of the location variable.