

# Data Visualization & Design

**Week 10**

1. Visualizing **Scalars, Vectors, & Tensors**
2. Studio: Building **Wind Vector Maps** in R

1. Visualizing **Scalars, Vectors, & Tensors**
2. Studio: Building **Wind Vector Maps** in R

Scalars, vectors, and tensors refer to different types  
of **data objects in space**.

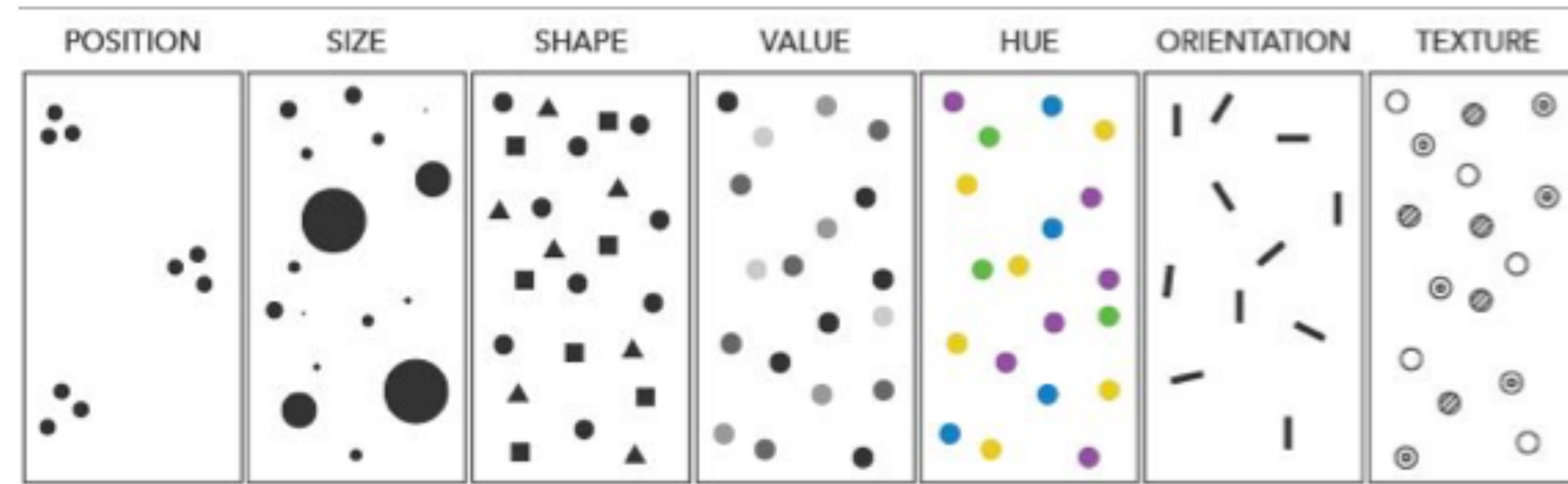
They contain data dimensions **in addition to position.**

# Terminology

- **Data Dimensions:** The dimensions of information that the data represents. They are variables or features that a dataset contains -- think columns in a table.
- **n-D Space:** The visual space that data is projected onto. For visualization, information must be projected onto 1-D, 2-D, or 3-D space.

# Terminology, cont'd

- **Visual Variables:** A concept that was developed by Jacques Bertin, Visual Variables are the channels that information can be mapped into a visual appearance. Bertin defined seven main categories of visual variables:



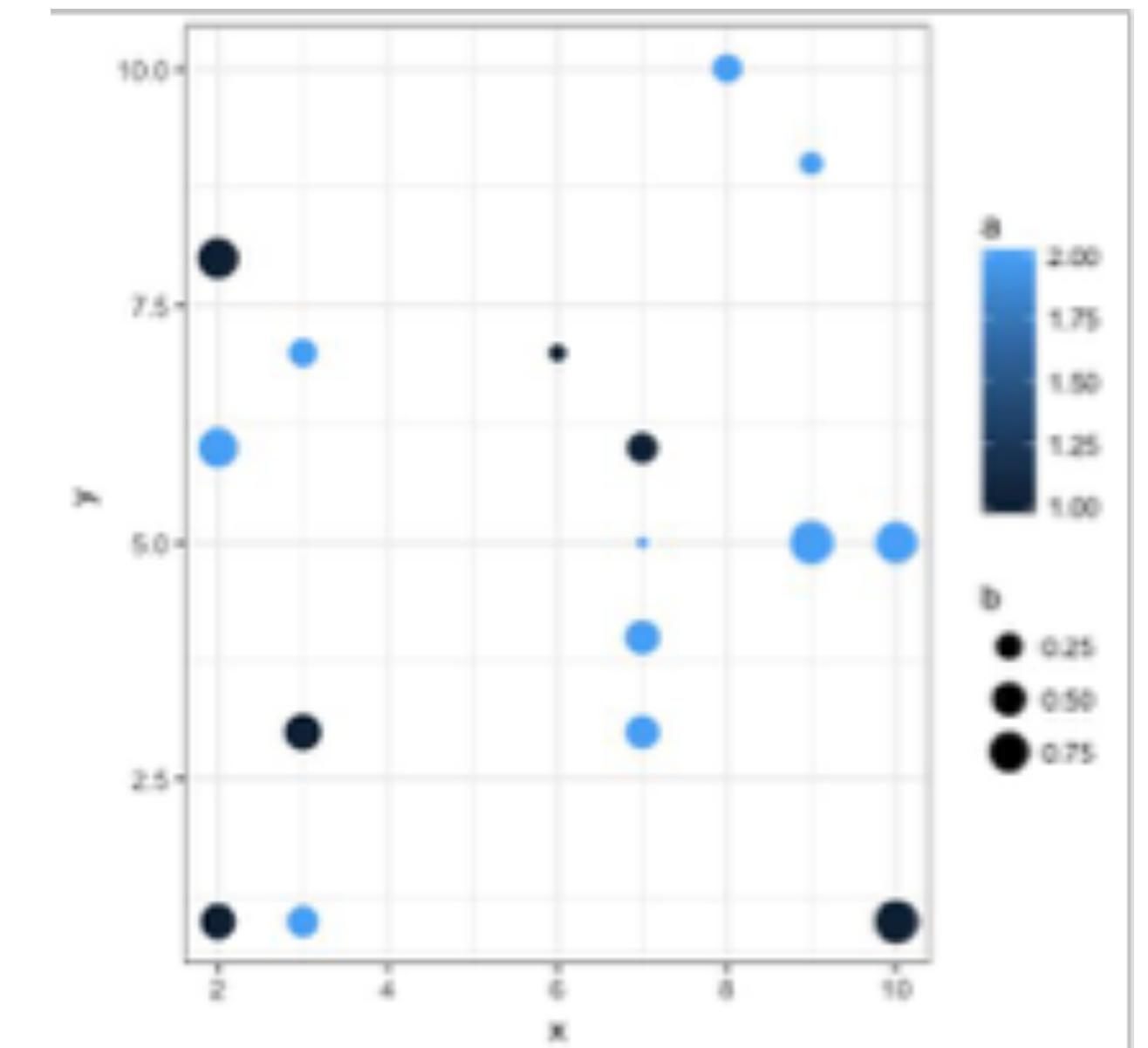
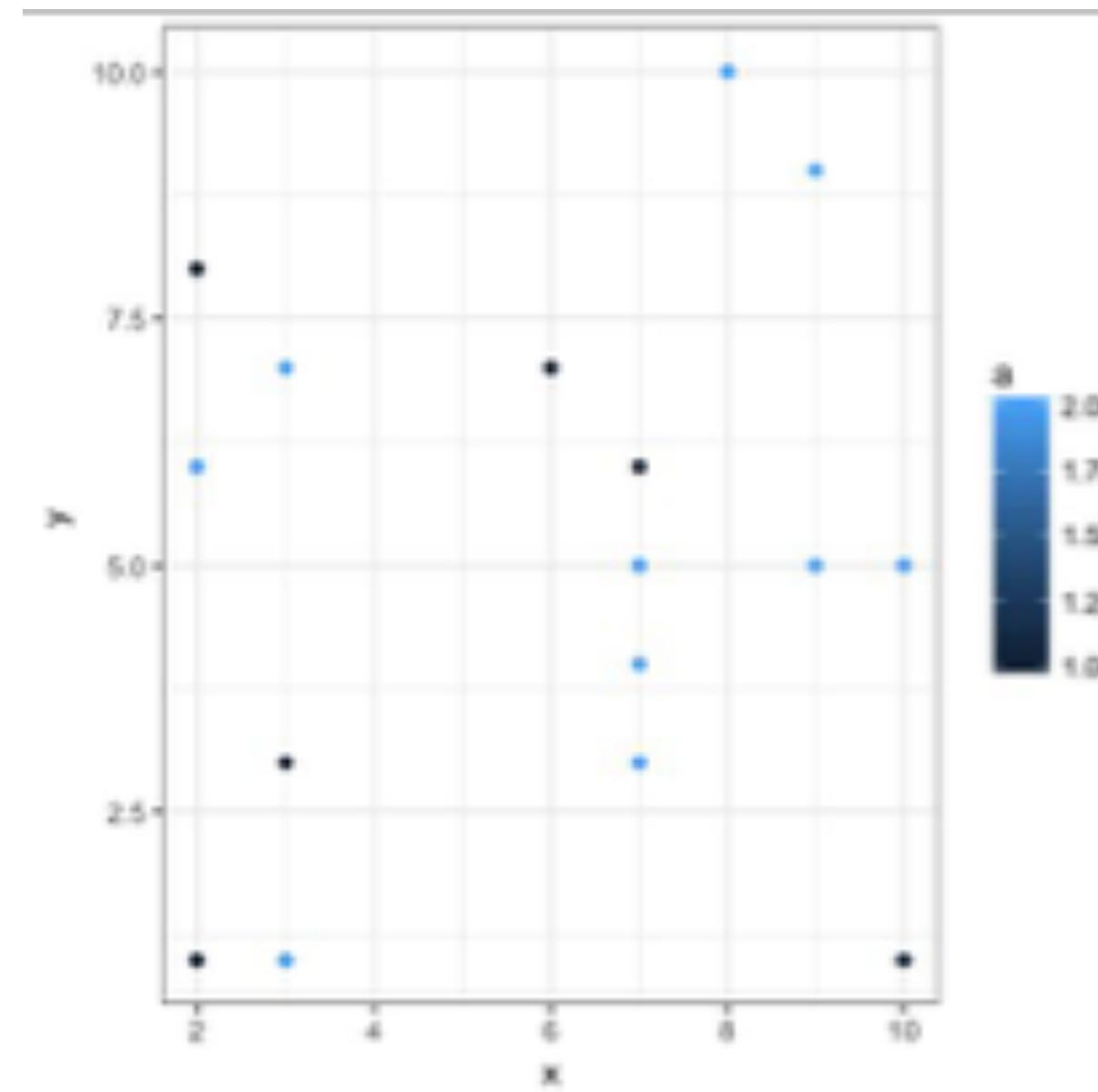
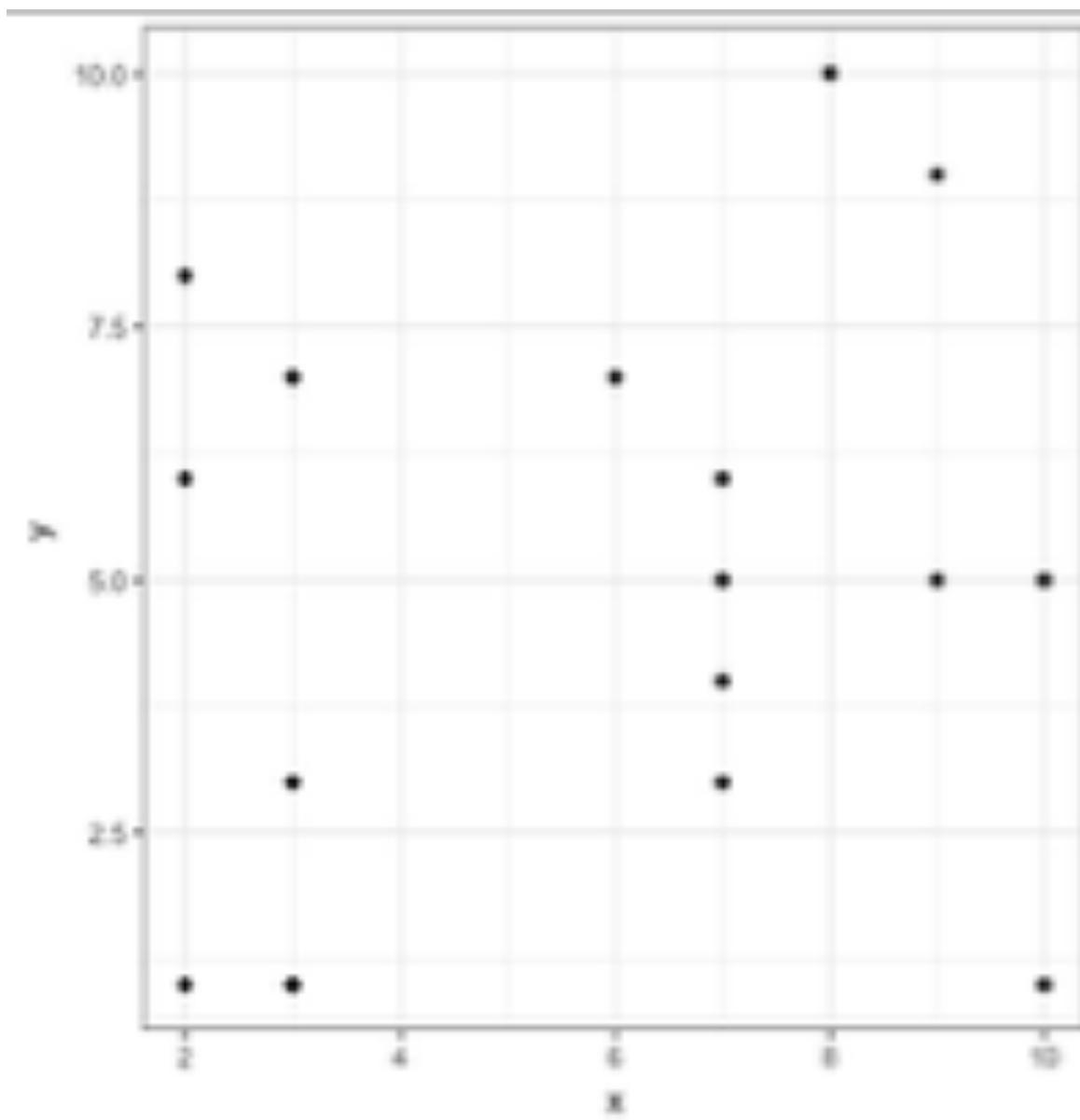
Data Objects can contain **n-dimensions** of information.

Each data entry is represented as a **point in space**. That position carries anywhere between 2 and 3 data dimensions, depending on the space it's projected onto (2-D or 3-D space)

Each point may contain **extra dimensions of information**, in addition to its position.

# Data Objects in 2-D Space

- **2** total data dimensions
  - **2-D** position
- **3** total data dimensions
  - **2-D** position
  - ‘a’ data dimension
- **4** total data dimensions
  - **2-D** position
  - ‘a’ + ‘b’ data dimensions



A closer look: **Scalars**

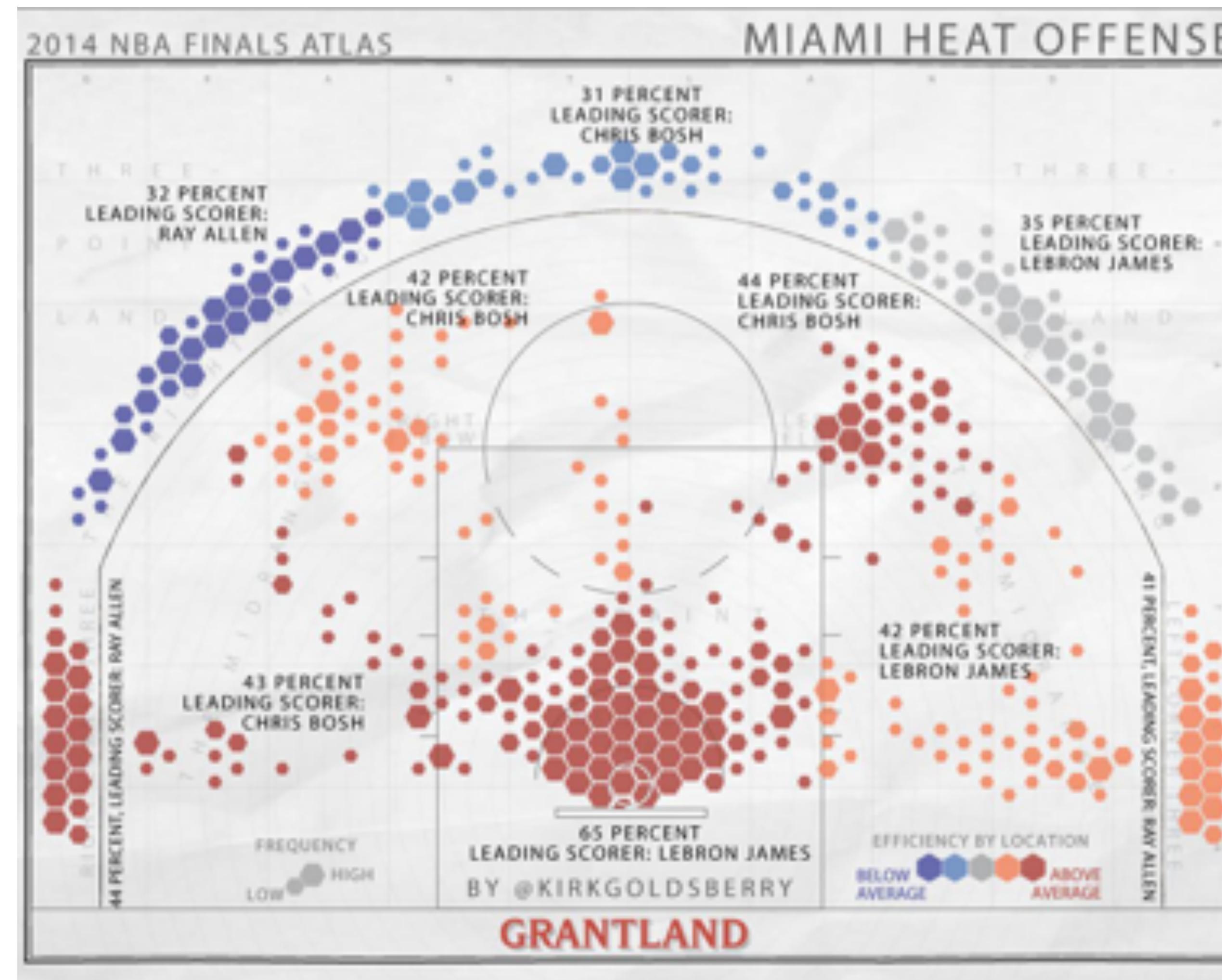
# Scalars

- Data types that contain information about **only magnitude** (not direction)
- Have a one-dimensional visual representation at each point in space
- Typically continuous variables
- Examples of **scalar data variables**:
  - Temperature
  - Area
  - Speed
  - Density

# Scalars: Visual Examples



# Scalars: Visual Examples

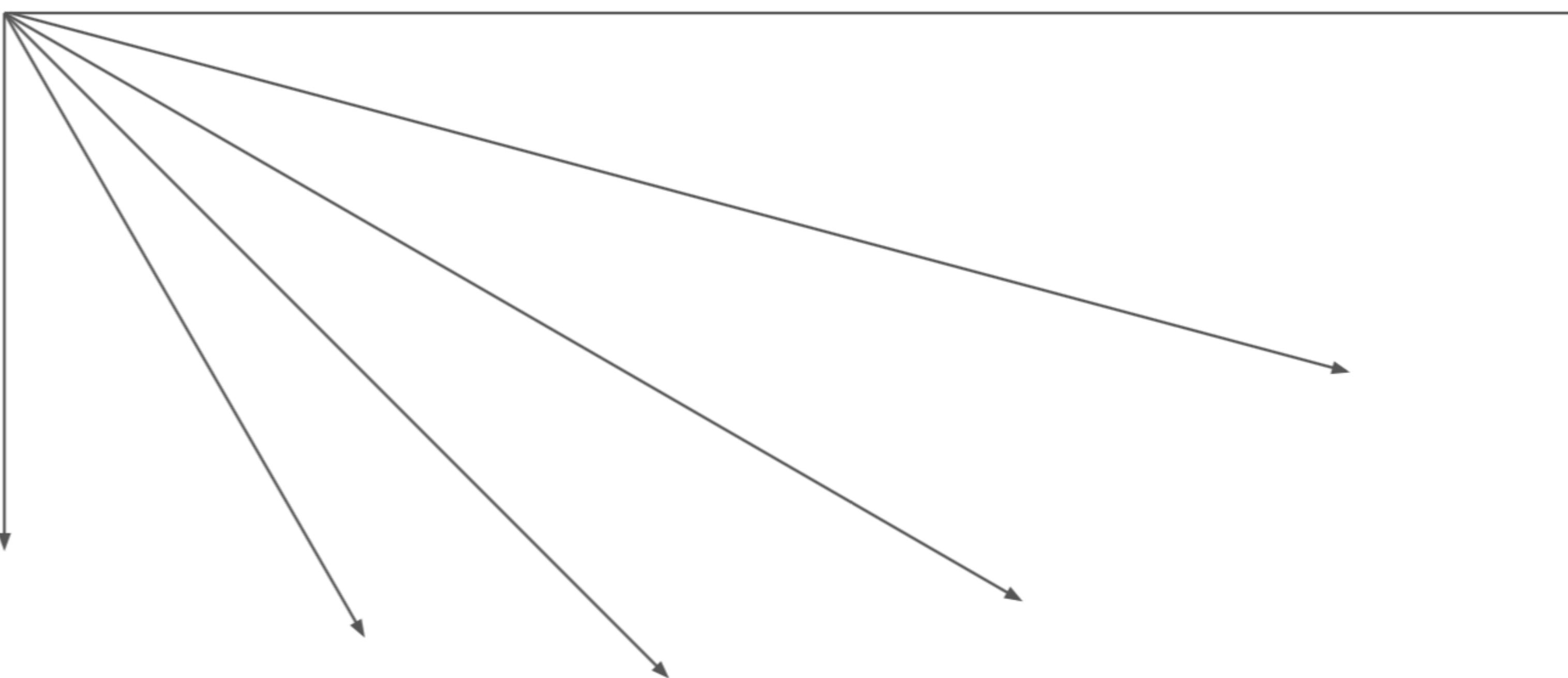


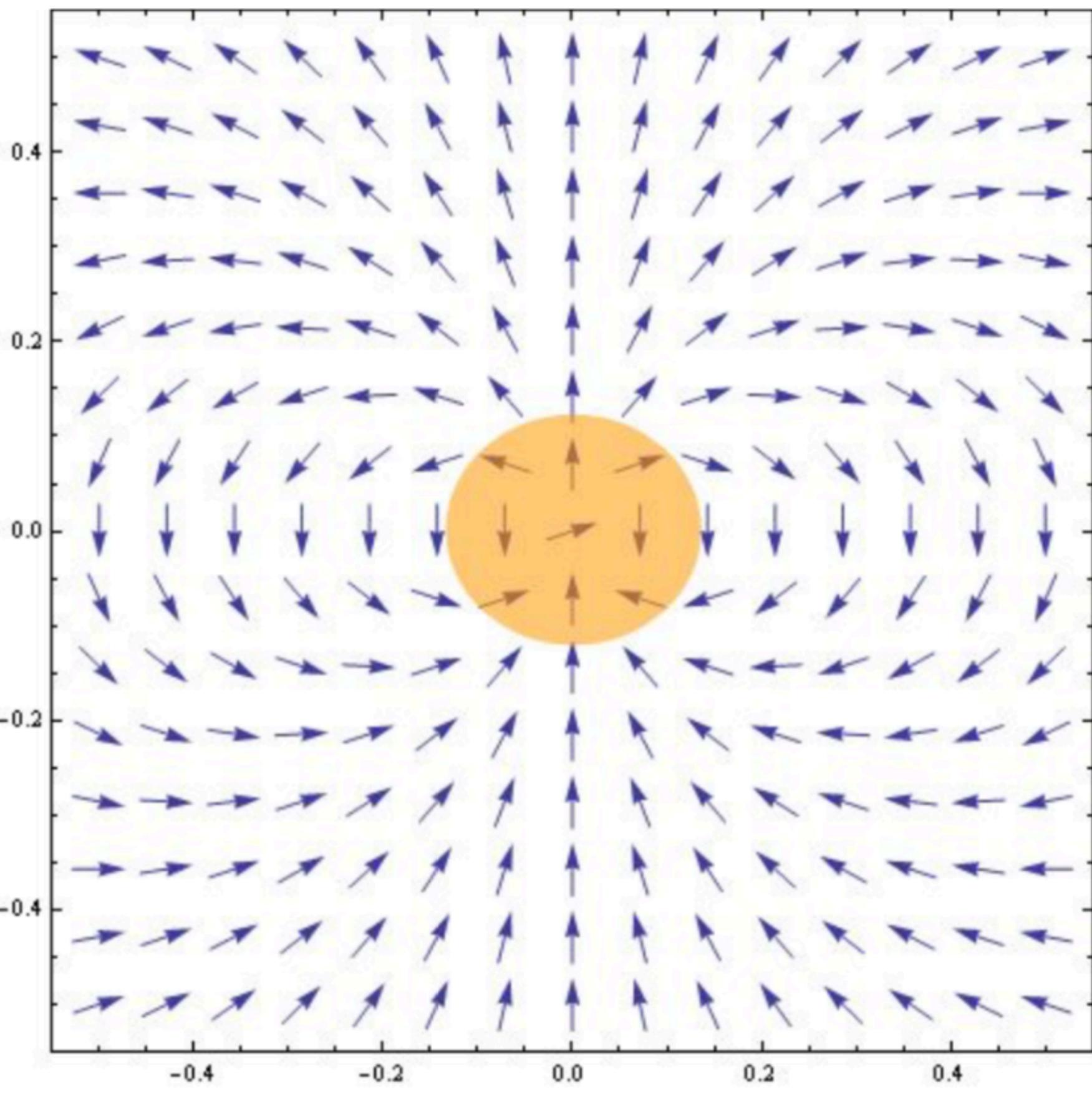
# Scalars: **Visual Variables**

- Color
- Size
- Area
- Length

A closer look: **Vectors**

# Vectors





(fluid flow)

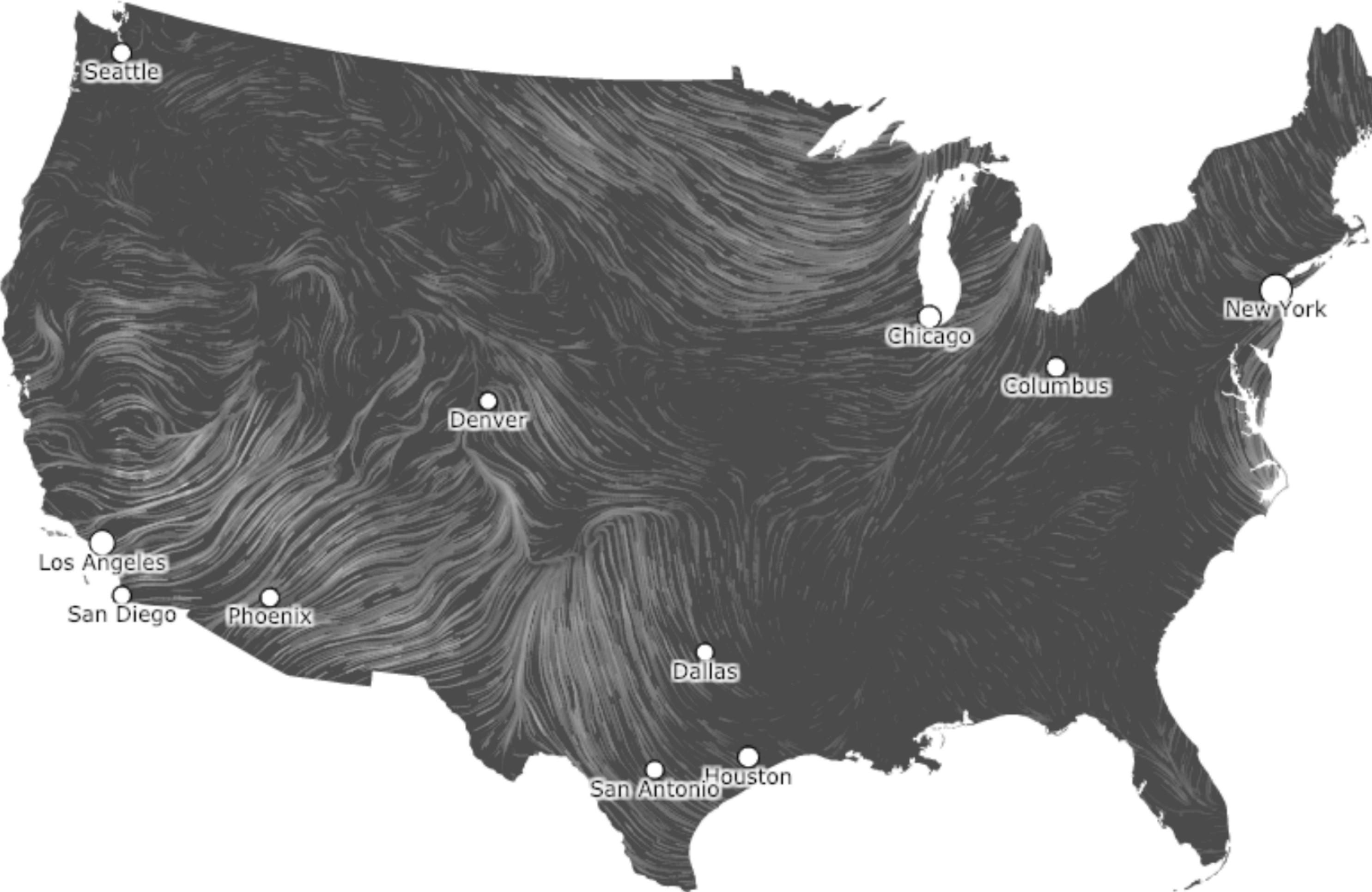
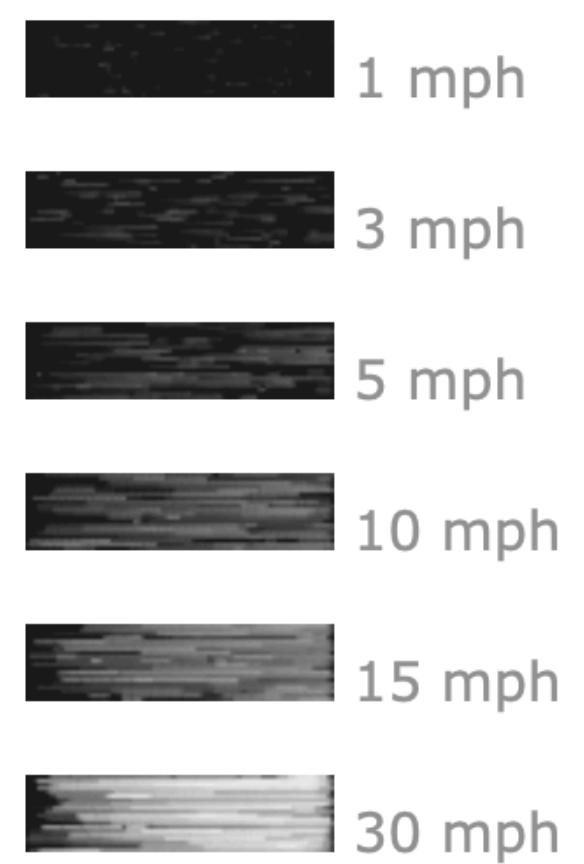
# wind map

April 2, 2019

7:24 pm EST

(time of forecast download)

top speed: **59.9 mph**  
average: **9.2 mph**



PROJECT

# Ukko

3.00

SETTINGS / INFO

LEGEND

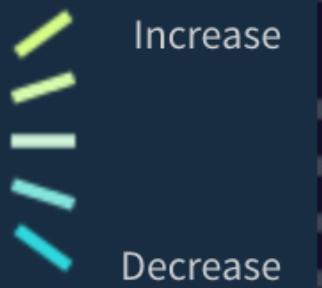
SKILL



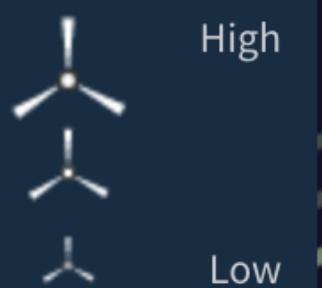
PREDICTED WIND SPEED



PREDICTED CHANGE



INSTALLED WIND POWER



Mapbox

# Vectors: **Visual Variables**

- Lines
- Glyphs
- Streams

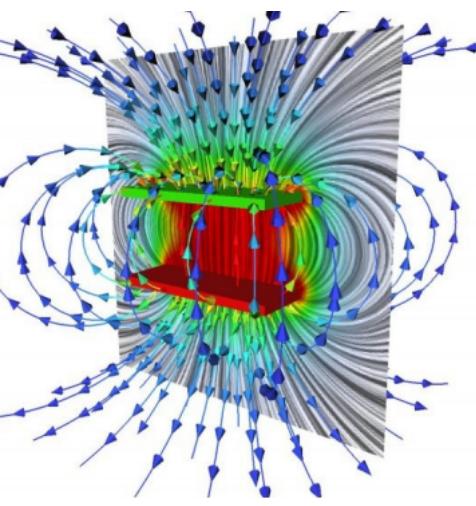
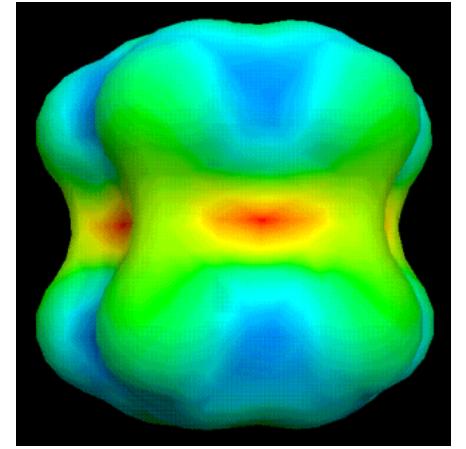
A closer look: **Tensors**

Scalars and vectors are both considered **tensors**.

# What is a tensor?

- A tensor is a data of rank  $k$  defined in  $n$ -dimensional space
  - **Rank 0:** Scalar
  - **Rank 1:** Vector
  - **Rank 2:** Matrix
  - **Rank 3:** 3-D Array
- A tensor of rank  $k$  requires  $3^k$  numbers

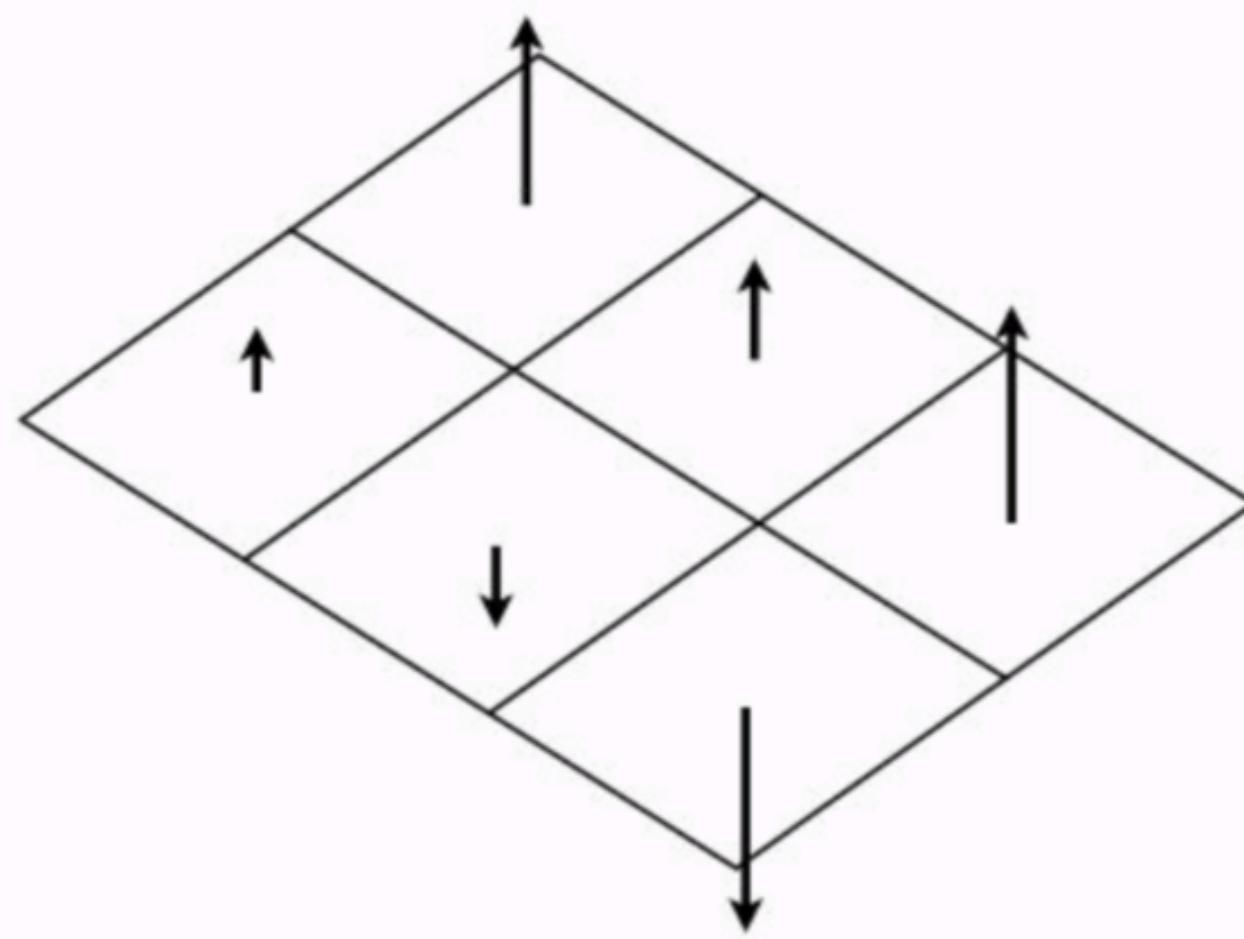
# Visual variables per data type



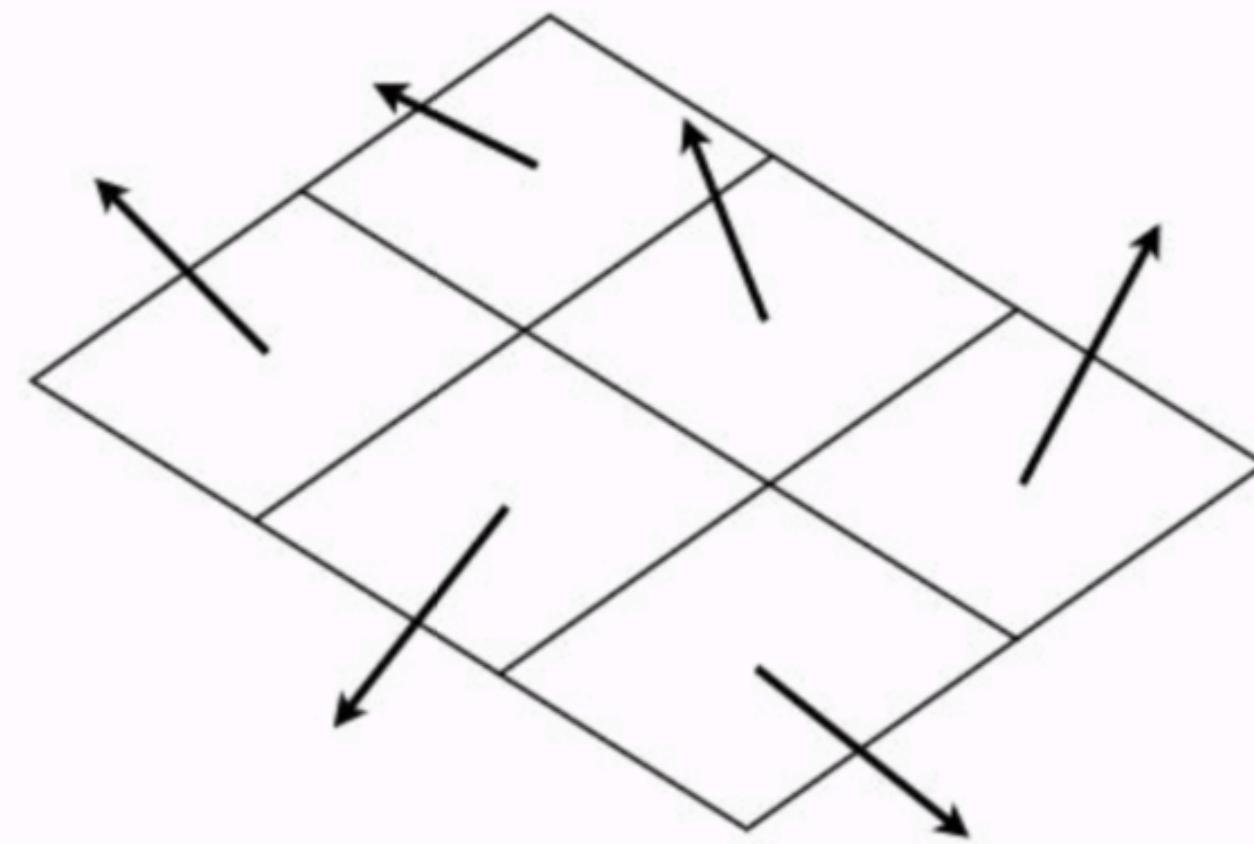
- **Scalar:**
  - Color mapping
  - Contouring
- **Vector:**
  - Lines, glyphs, streams
- **Tensor:**
  - Complex problem; active area of research

Typically in tensor visualization (non scalar/vector), a tensor quantity represents at least **three dimensions** at **every point in space**.

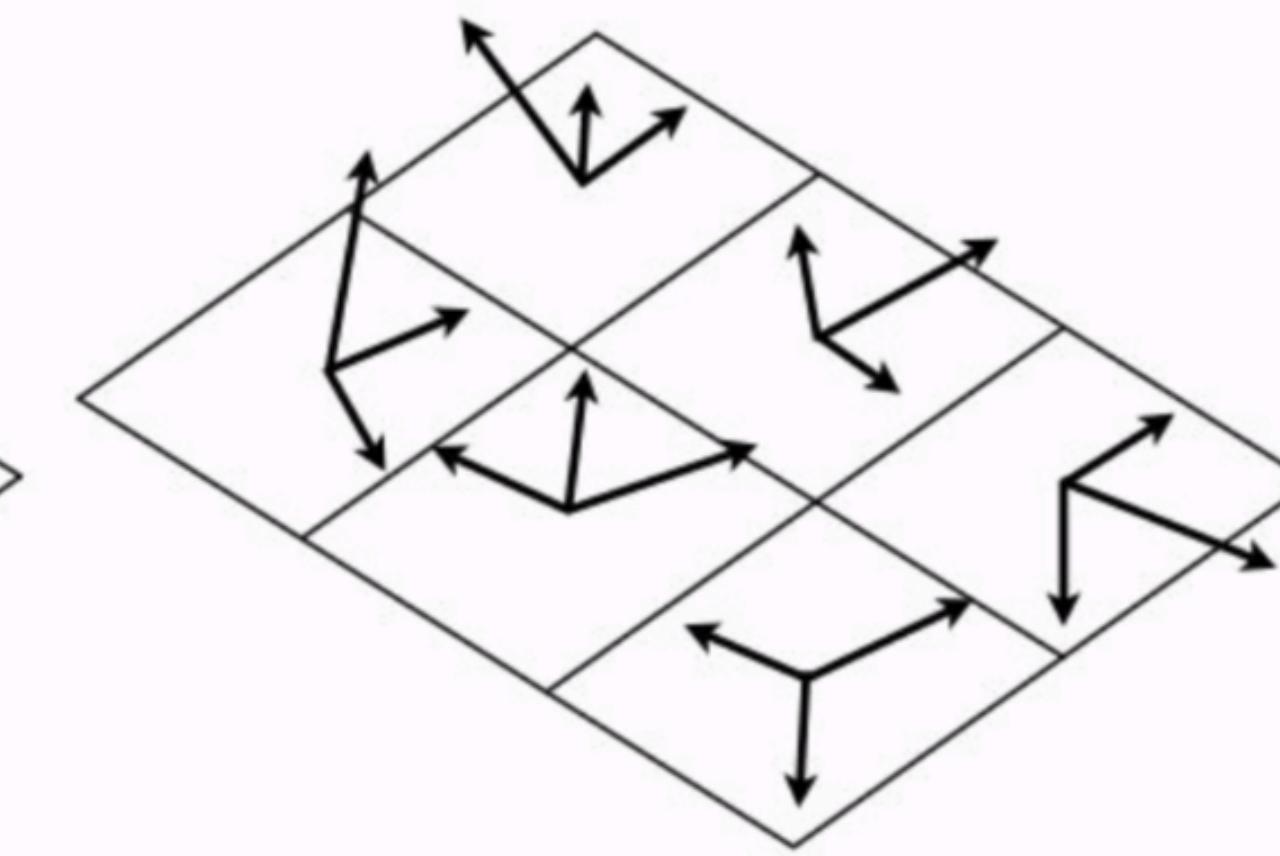
**Scalar field**



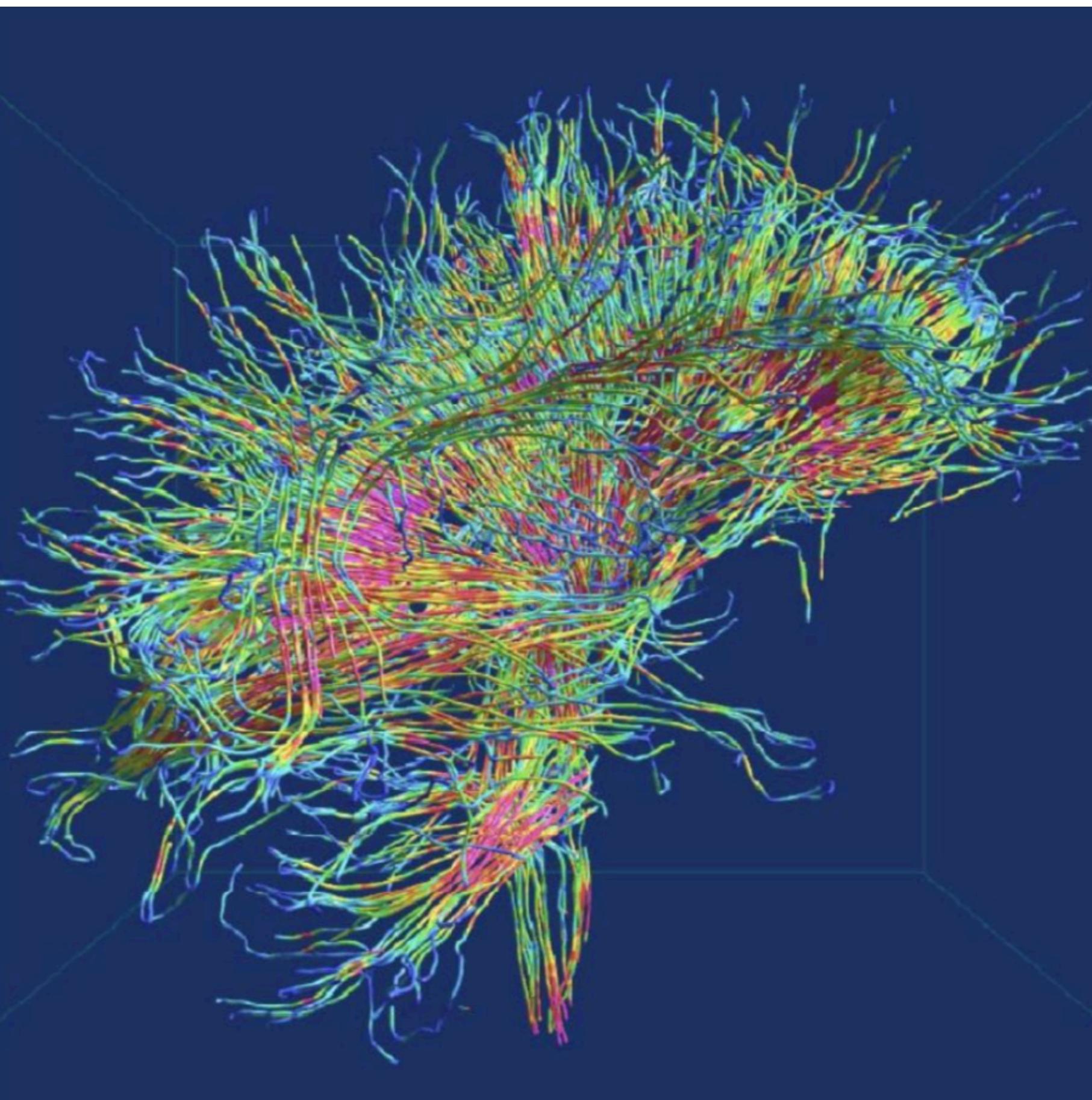
**Vector field**



**Tensor field (Rank 2)**



# Tensors: **Visual Examples**



# Tensors: **Visual Examples**

[https://www.youtube.com/watch?  
v=wvsE8jm1GzE&feature=youtu.be&t=18s](https://www.youtube.com/watch?v=wvsE8jm1GzE&feature=youtu.be&t=18s)

1. Visualizing **Scalars, Vectors, & Tensors**
2. Studio: Building **Wind Vector Maps** in R

[https://github.com/emilyfuhrman/  
datavis\\_design/blob/master/2019\\_Spring/  
Studios/07\\_Building\\_Wind\\_Vector\\_Maps\\_in\\_R.md](https://github.com/emilyfuhrman/datavis_design/blob/master/2019_Spring/Studios/07_Building_Wind_Vector_Maps_in_R.md)

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