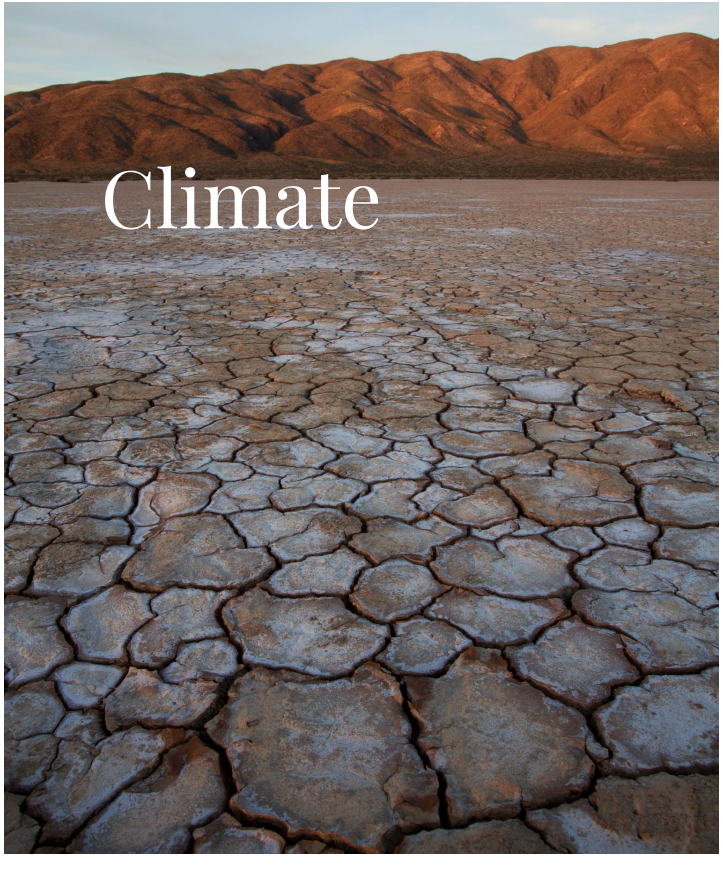
Weather & Wireless Communication

How wireless communication enables needed real time pervasive climate data collection

Weather vs. Climate

vs.



Weather vs. Climate

Weather:

- Short-term atmospheric conditions in a specific place at a specific time.
- Includes daily changes in temperature, humidity, precipitation, wind, and visibility.

Example: Today's forecast predicts rain, yesterday was sunny and warm.

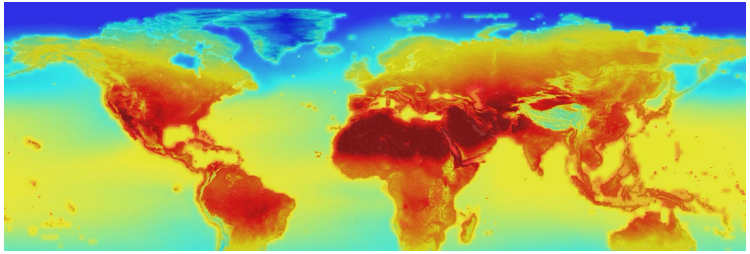
Climate:

- Long-term average of weather patterns over an extended period (usually 30 years or more) in a specific region.
- Describes the typical conditions and variations experienced over seasons and years.

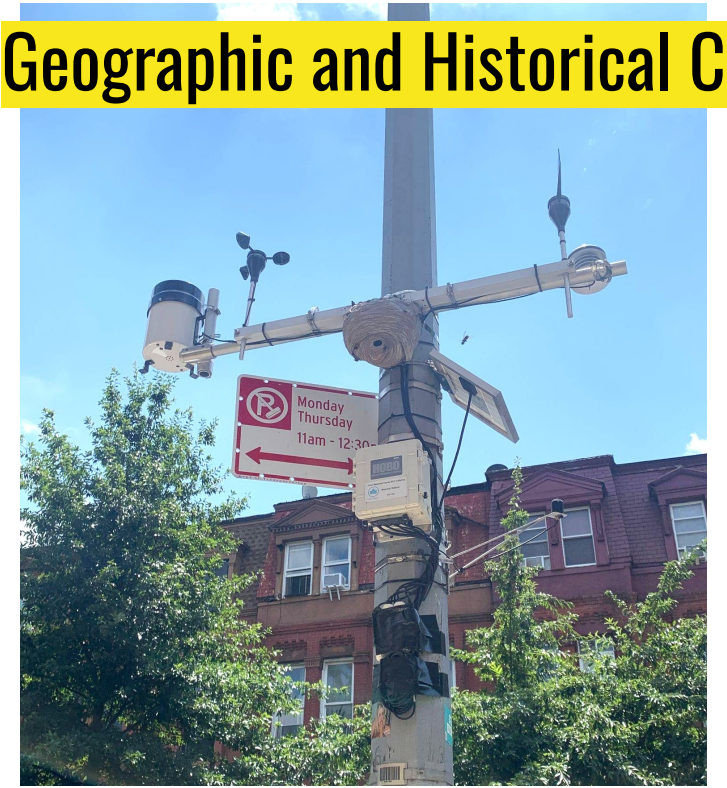
Example: The Mediterranean climate is characterized by hot, dry summers and mild, wet winters.

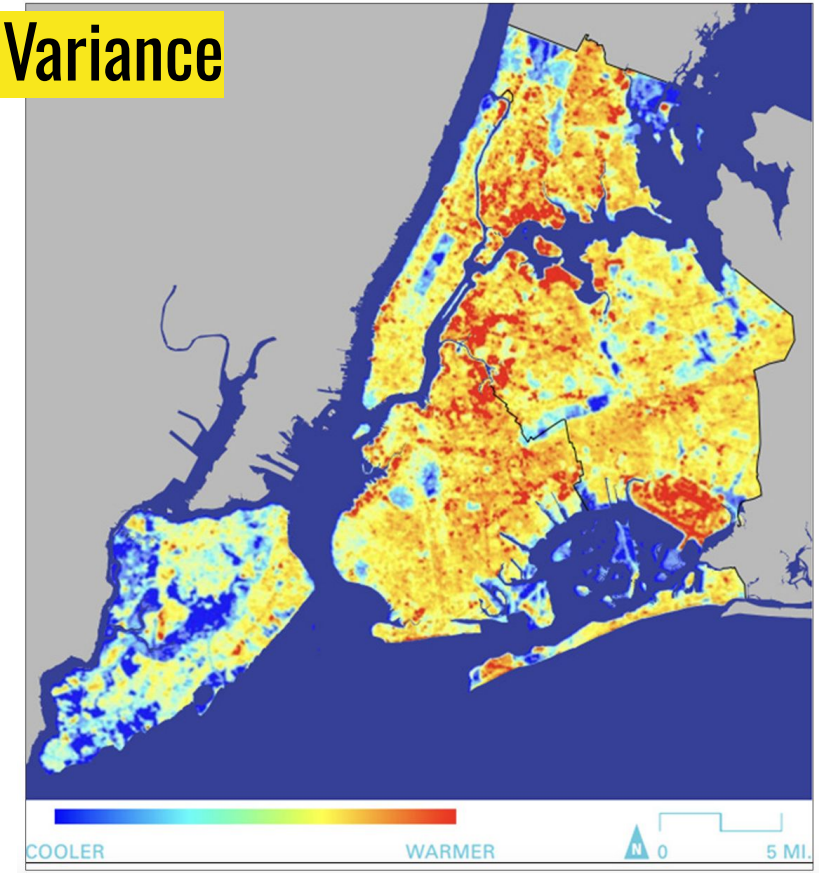
Importance of Weather Data

- Daily Activities
- Safety & Emergency Preparedness
- Economic Impact
- Climate Change Monitoring
- Environmental Protection
- Scientific Research
- Public Health



Geographic and Historical Climate Variance





Cool Neighborhoods NYC Initiative

https://climate.cityofnewyork.us/reports/cool-neighborhoods-nyc/

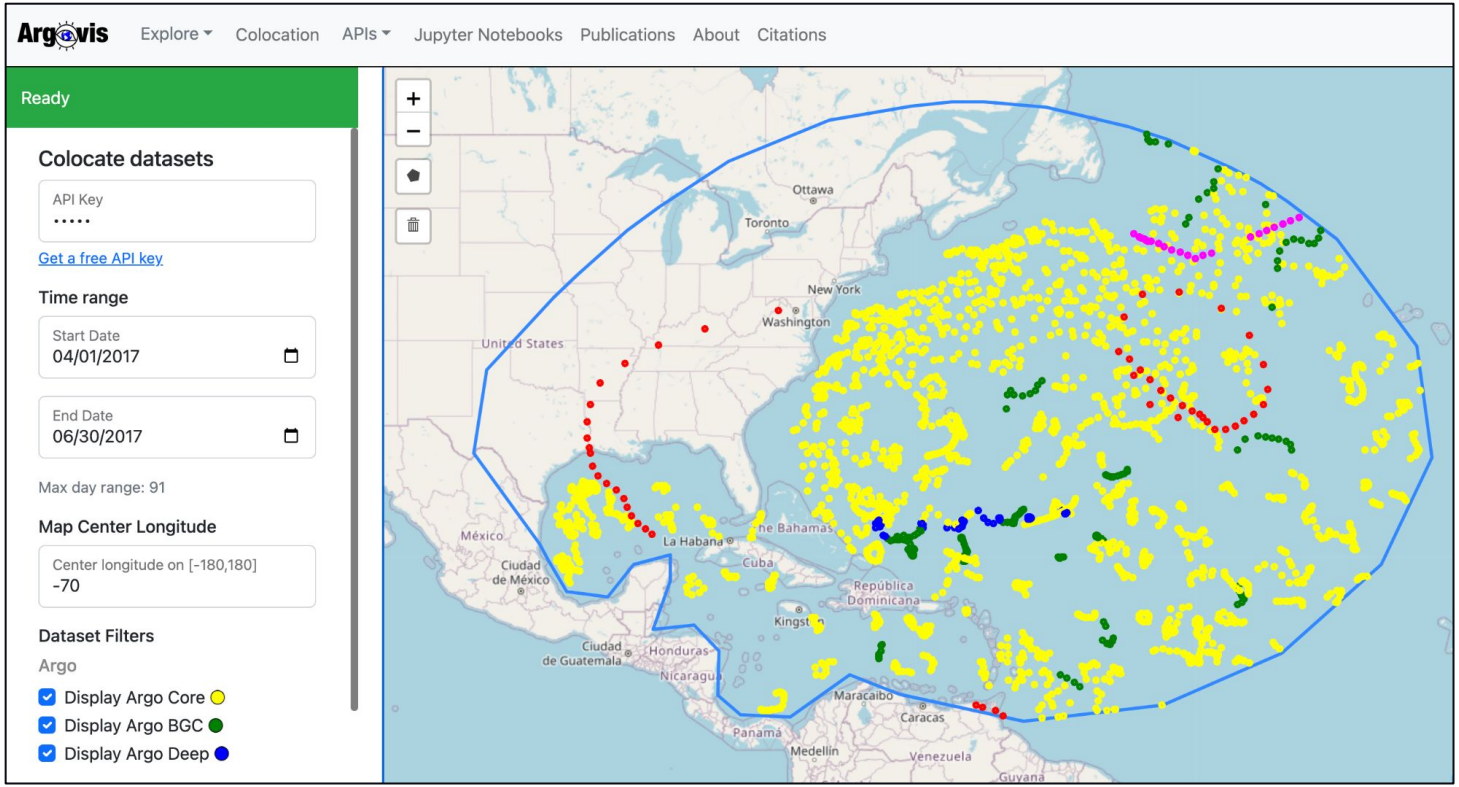
Oceanographic Data

- **hundreds of Spotters deployed globally free-drifting or moored**
- **largest privately-owned network of ocean sensors.**
- **Each day, makes more than 1.5 million real-time observations**
- **Use the Spotter Dashboard and API to access real-time data sent via satellite and cellular and stored in the cloud**
- **buoys make direct observations of wave spectra, wind, sea surface temperature, and atmospheric pressure.**

https://www.sofarocean.com/
https://argo.ucsd.edu/data/
https://sio-argo.ucsd.edu/statusbig.gif

SOFAR

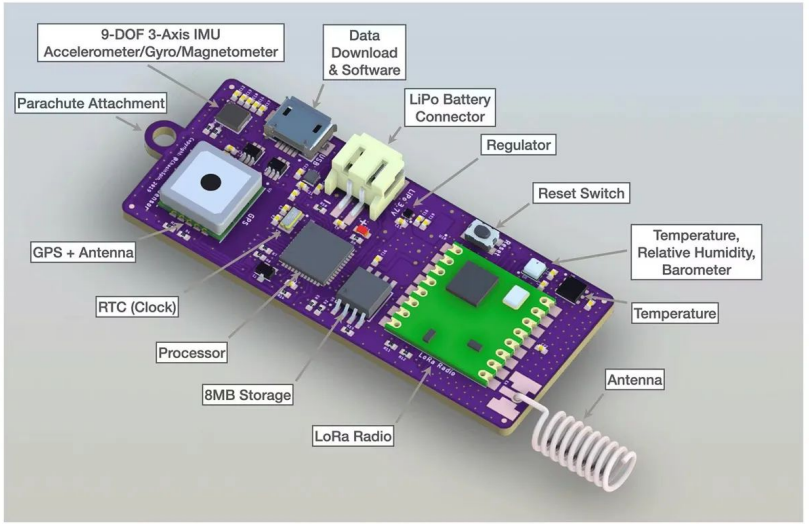
Oceanographic Data



https://argo.ucsd.edu/data/
https://sio-argo.ucsd.edu/statusbig.gif
https://argovis.colorado.edu/

EXTREME WEATHER RESEARCH

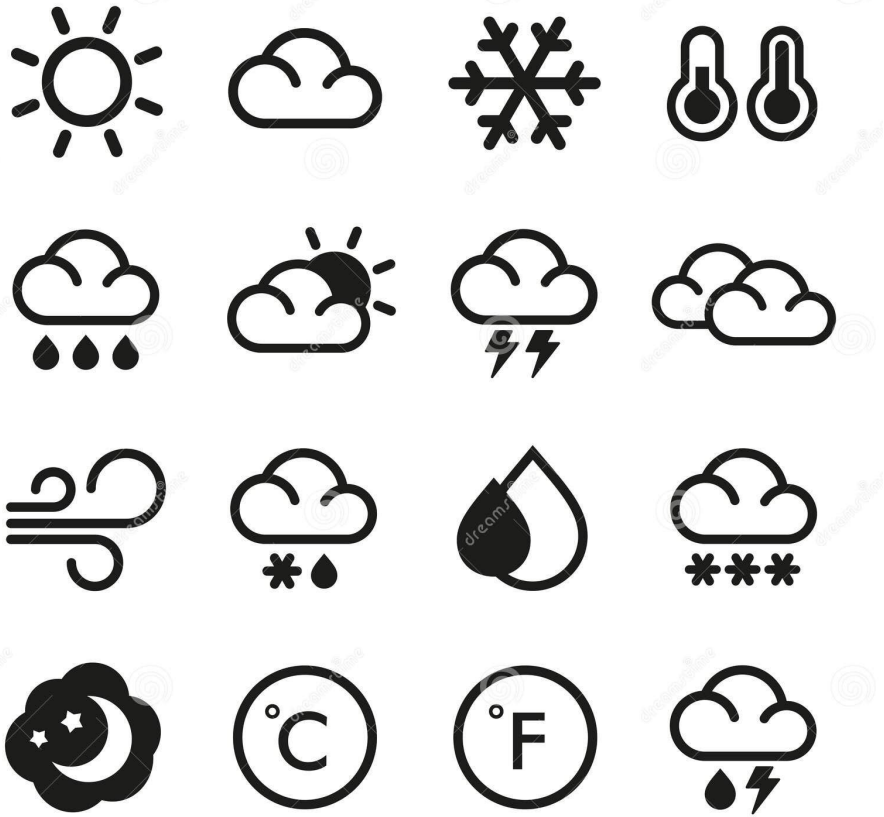
Tornado Science Probe



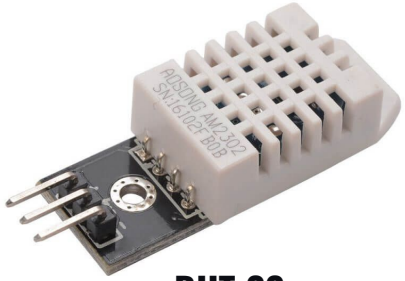
https://makezine.com/article/science/storm-chasers-real-twister-tech/

Types of Weather Data

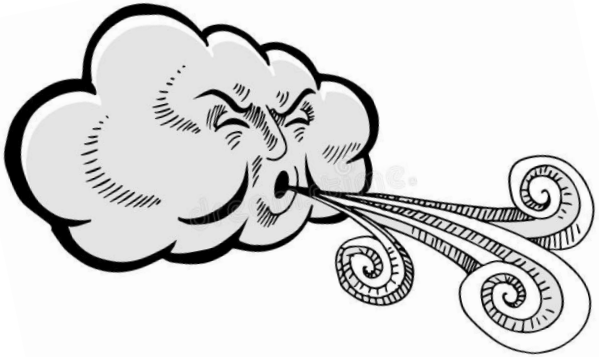
- Temperature
- Humidity
- Precipitation
- Wind Speed and Direction
- Atmospheric Pressure
- Solar Radiation
- Visibility
- Cloud Cover
- Air Quality

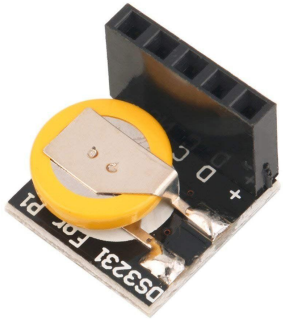


Sensors

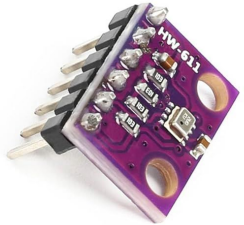


DHT-22
Humidity
Temperature





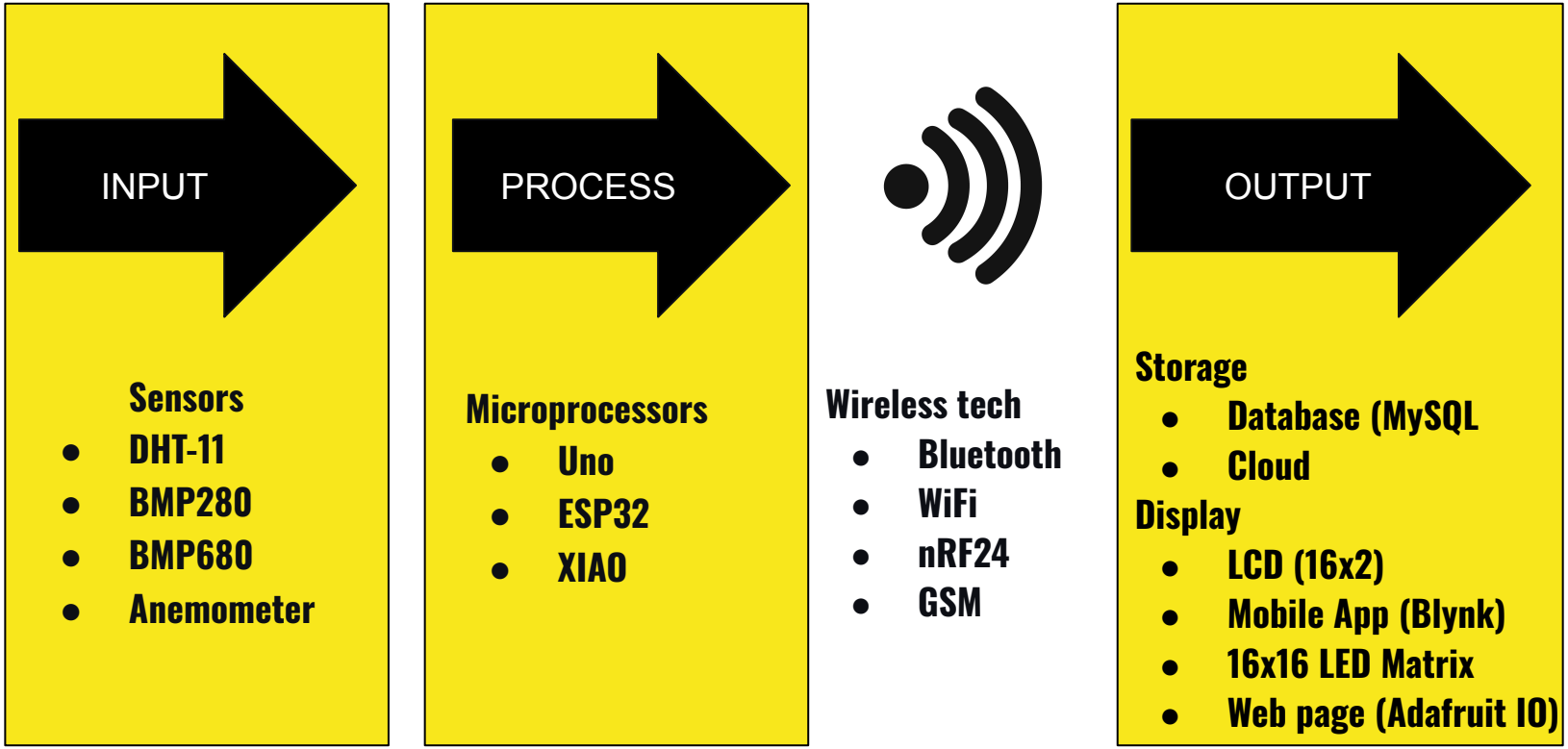
RTC
Time



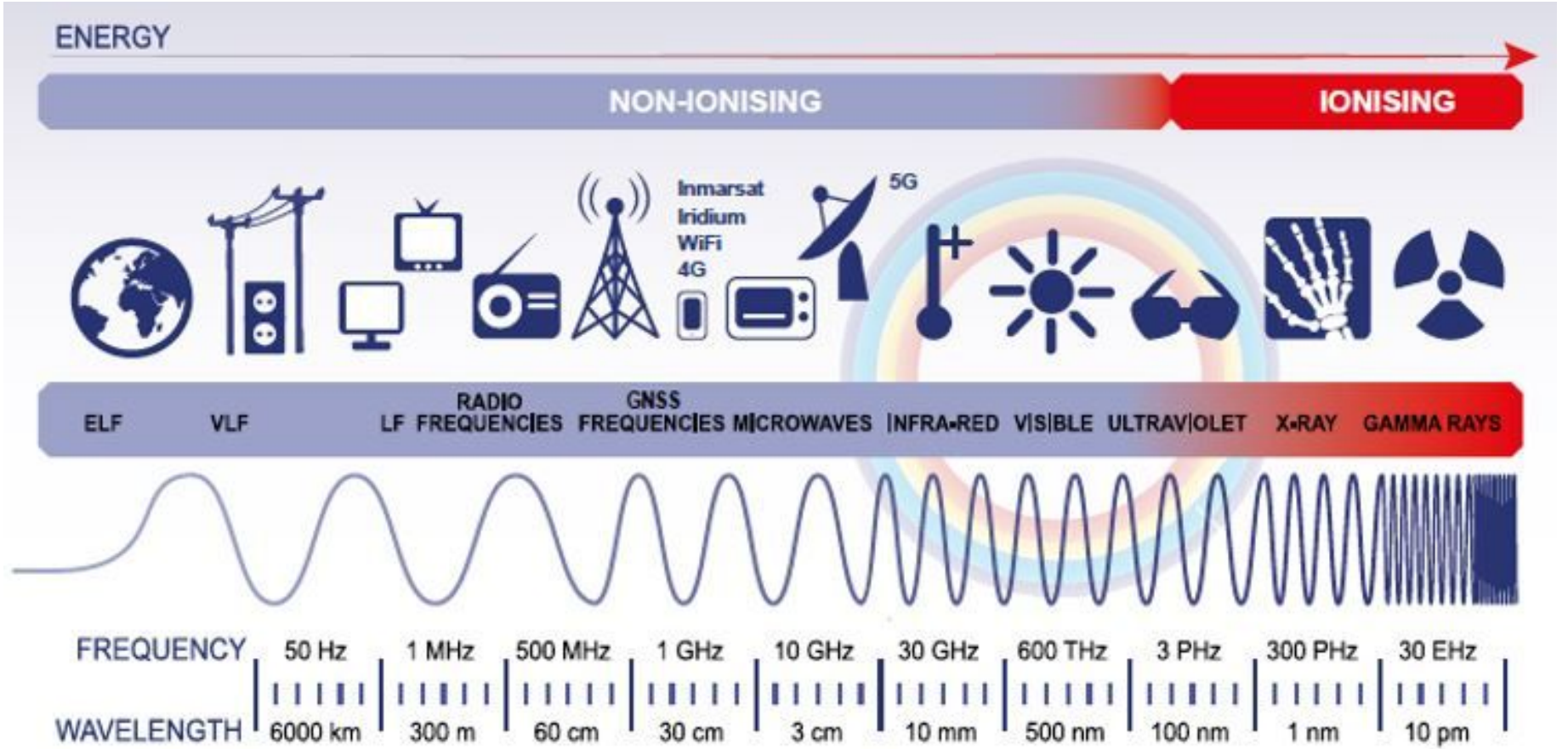
BMP280
Temperature
Pressure
Altitude

Anemometer
Wind Speed

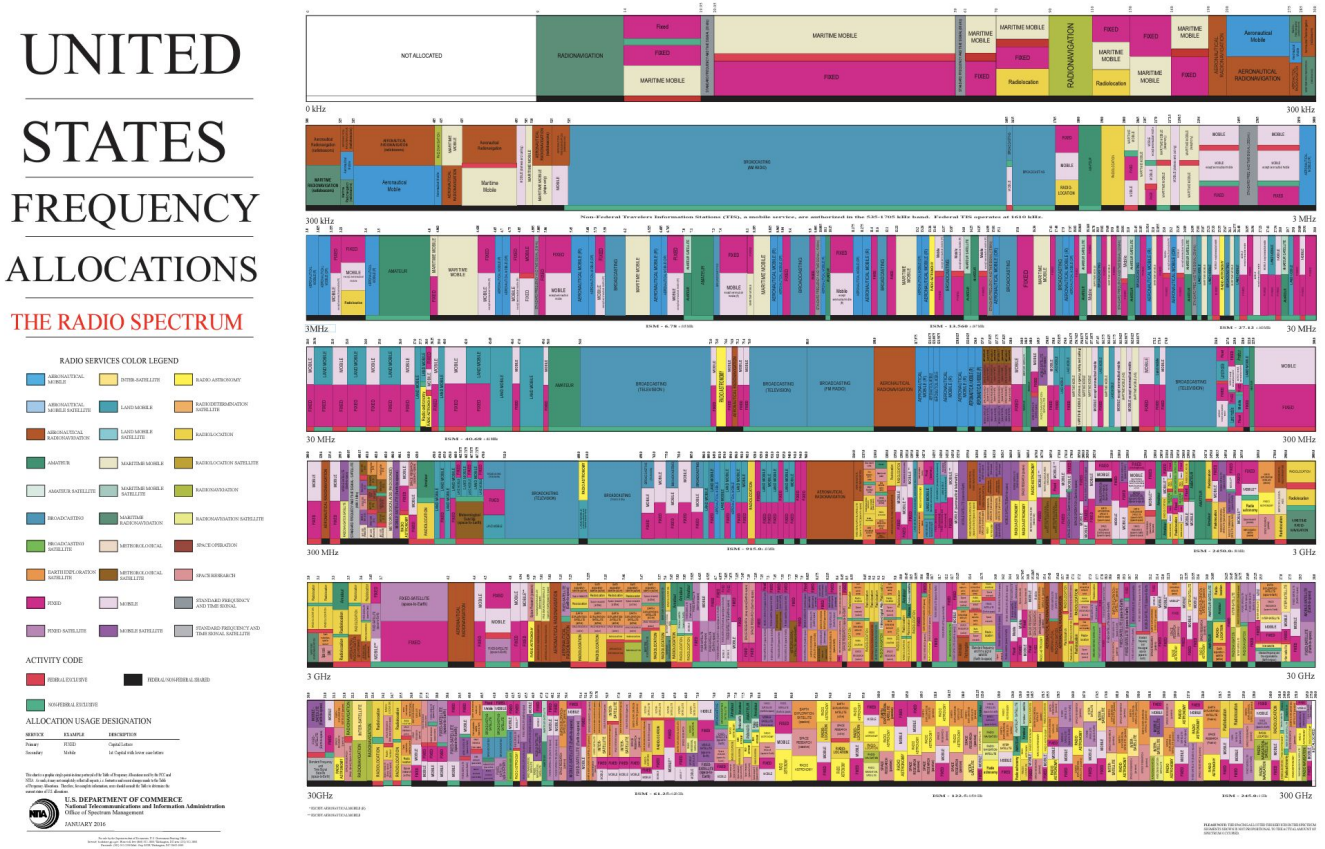
Wireless Data Flow



The Electromagnetic Spectrum



Wireless = Radio



https://www.ntia.gov/sites/default/files/publications/january_2016_spectrum_wall_chart_0.pdf

Frequency Ranges

Why Ranges Exist:

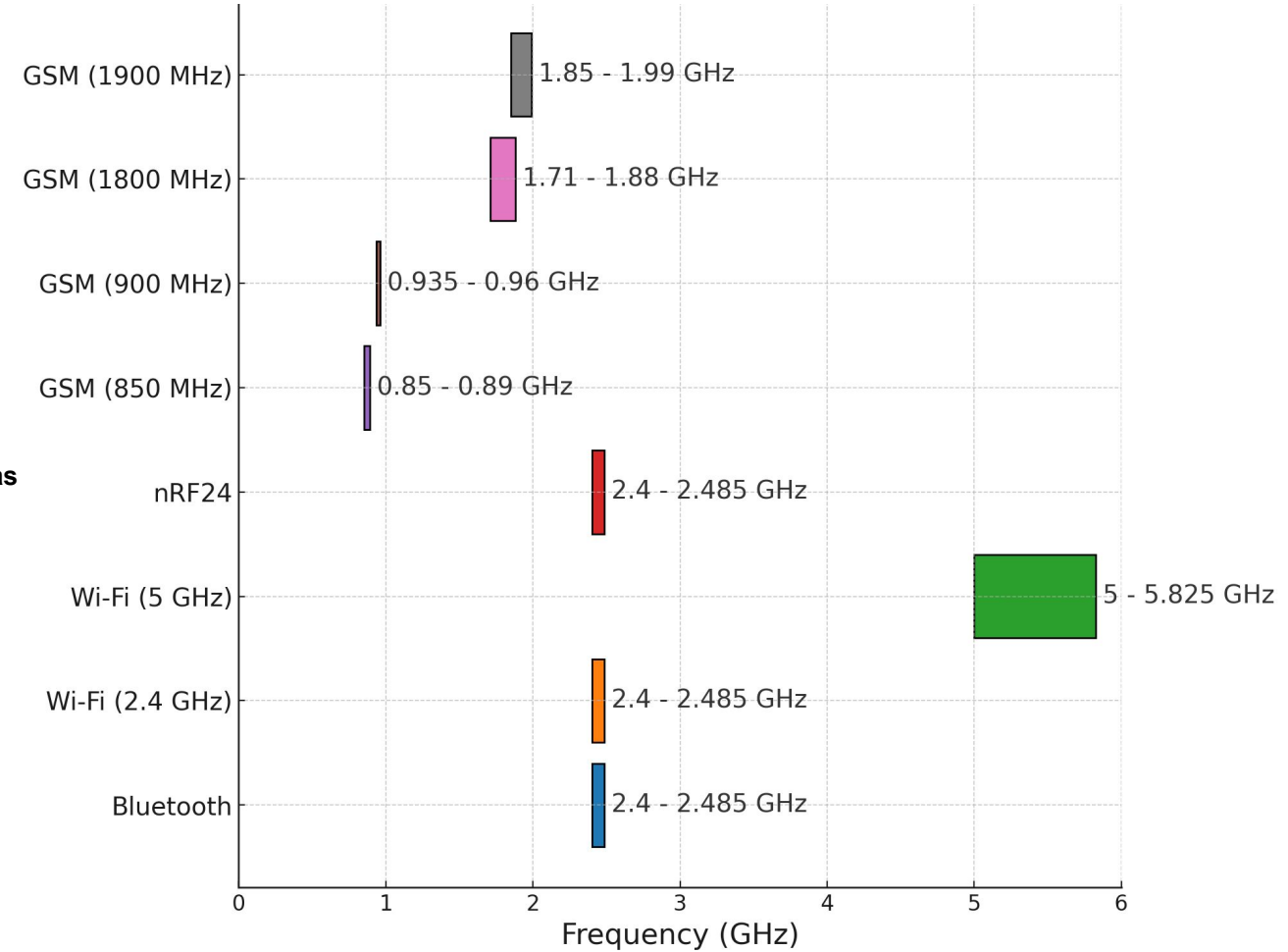
- **Interference Management**
- **Regulatory Compliance**
- **Technology Needs**

Broad Ranges

- **Higher Data Rates**
- **Reduced Interference urban areas**
- **Shorter Range**
  - **(**obstacle penetration**)**

Narrow Ranges

- **Simplicity:**
  - Easier design, lower power use.
- **Cost-Effective devices**
- **Compatibility**



Protocol and Handshakes

A case study of communication between devices

Goal: transmit temperature and humidity data from a DHT sensor connected to an Arduino UNO to an ESP32 using the nRF24 wireless communication module.

What Happened: communication did not work as expected. Despite having the correct wiring and power setup, the devices were not understanding one another, leading to blank serial outputs on the receiver side.

Root Cause: The differences in how the two processors handle data structures, memory alignment, and byte order causing the transmitted data to be misinterpreted by the receiver

Solution: a consistent data protocol by:

- Serializing the data into a byte array before transmission.
- Using memcpy to ensure data integrity.
- Adding detailed serial debugging statements to trace the flow and identify issues.

Designing a Weather Station

- How will you ensure your weather station is weatherproof and stable?
- What is the optimal placement for each sensor, and why?
- How will you power your weather station (e.g., battery, solar power)?
- How will you ensure accurate data transmission from your weather station to your data collection system?
- What methods will you use to calibrate your sensors for accurate readings?
- How will you protect your weather station from potential hazards like wildlife or vandalism?
- What will be your process for regularly maintaining and updating your weather station?

Understand:

- Review materials and their functions.
- Identify sensors, microcontroller, power source, and communication module.

Plan:

- Sketch a layout.
- Decide on sensor placement for accuracy.
- Ensure stability and weatherproofing.

Assemble:

- Connect sensors to the microcontroller.
- Secure components on a stable base.
- Test connections.

Program the Microcontroller:

- Write code for sensor data reading.
- Enable wireless data transmission (if applicable).
- Test and debug the code.

Test and Calibrate:

- Test in a controlled environment.
- Calibrate sensors with known values.
- Adjust for accuracy.

Prompts

What type of radio does this technology use?

What are the power requirements for this technology?

What is the typical communication range of this technology?

How does this technology handle data transmission and reception?

What are the advantages and disadvantages of using this technology in a weather station project?