

Availability and Use of Weather, Climate, and Climate Change Data



Cory Morin

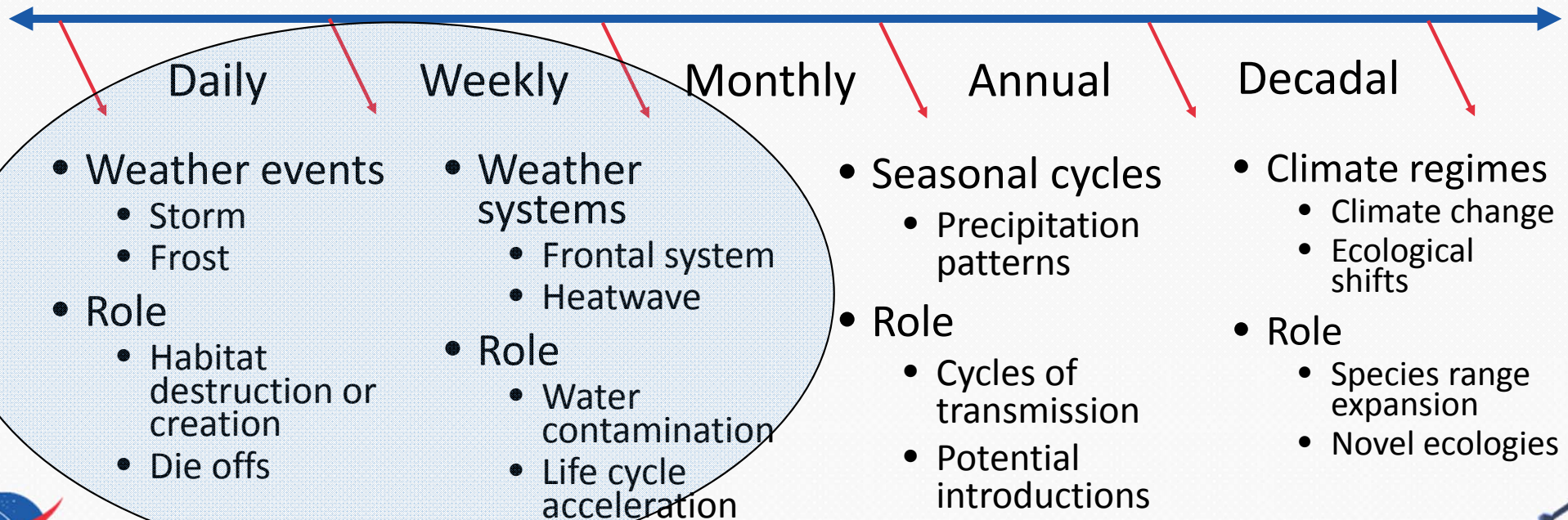
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(Special thanks to Dr. Kacey Ernst, Dr. Dale Quattrochi and Dr. Jeff Luvall)

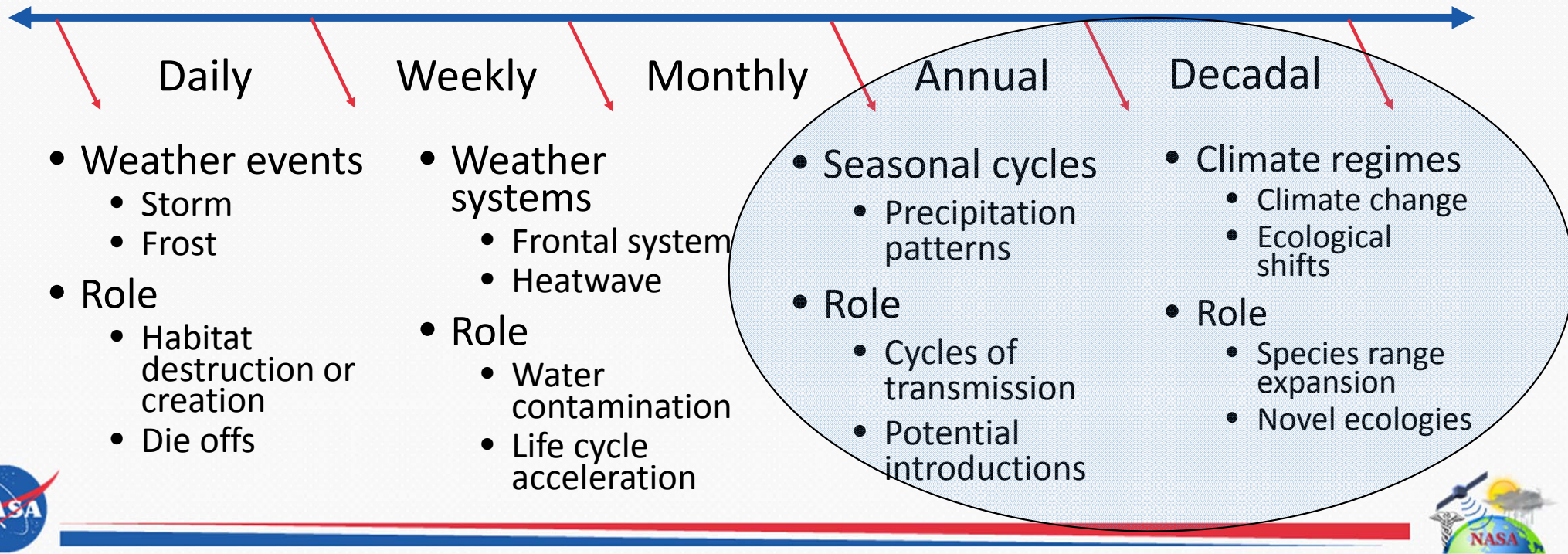
Weather

- Weather: The conditions of the atmosphere at a particular location and time period (i.e. its raining in Cape Town and the temperature is 20°C)



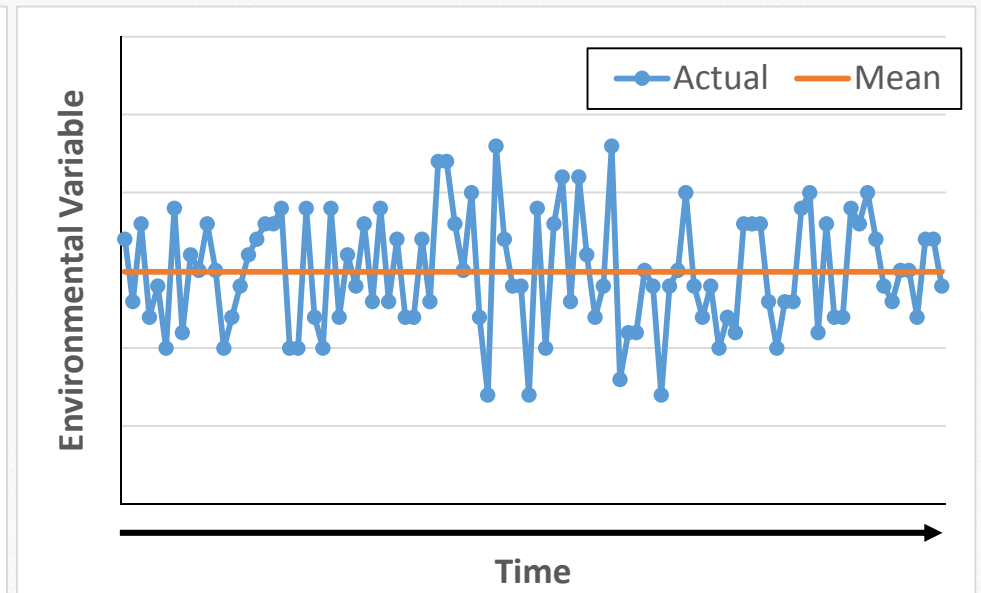
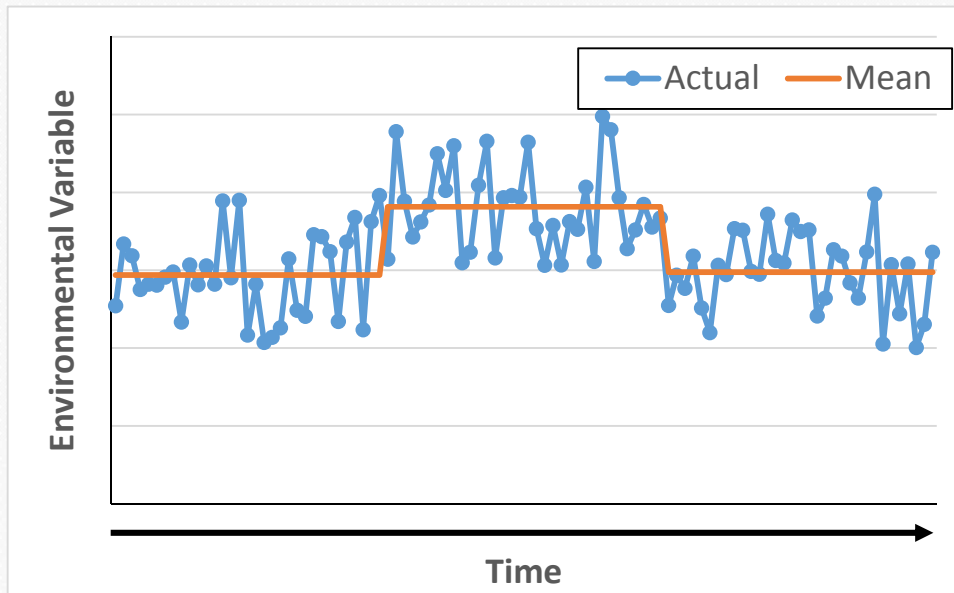
Climate

- Climate: The long-term average conditions of the atmosphere over a region (i.e. Tucson, Arizona has an arid climate with seasonal precipitation)



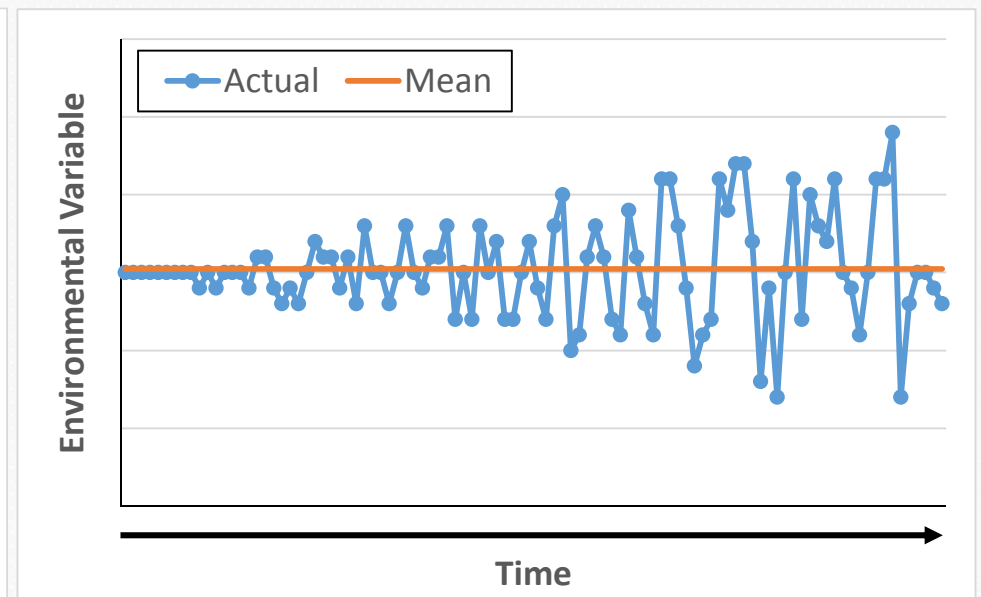
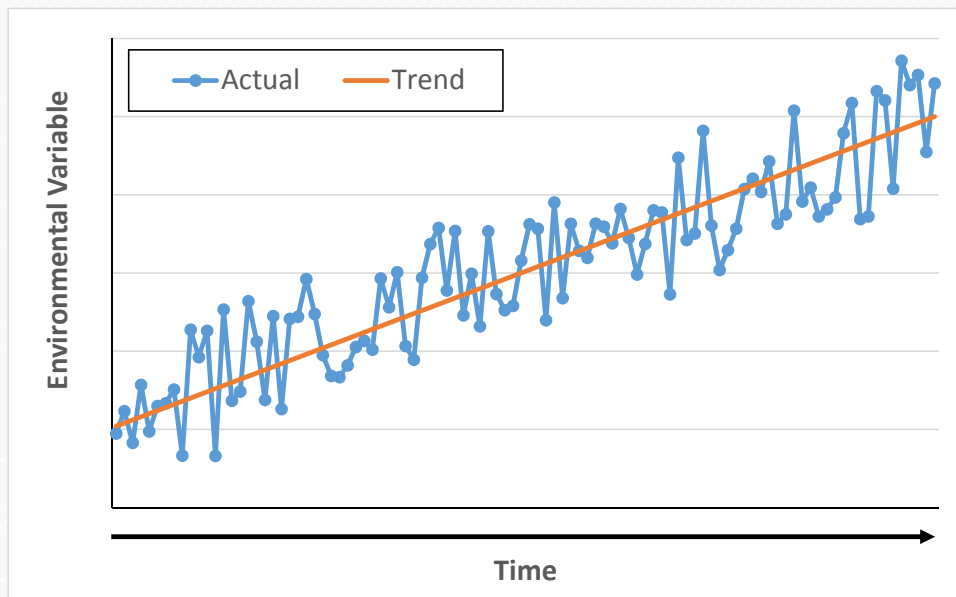
Climate Variability

- Climate variability: The fluctuation in climate around its mean value
 - Can include phases and oscillations



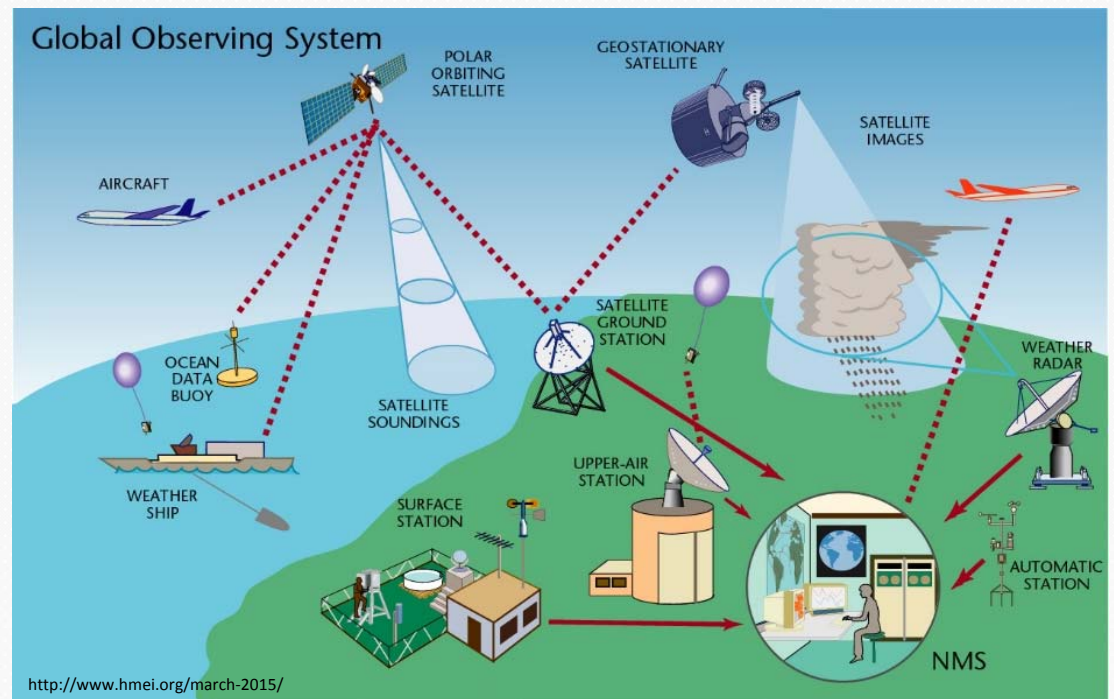
Climate Change

- Climate change: A long-term alteration in climate mean or variation
 - Associated with trends



Sources of Data

- Weather/Climate Data
 - Paleoclimate data
 - Stations and other recorders
 - Satellite and remotely sensed data
 - Reanalysis datasets
 - Forecasting
- Climate Change
 - Global climate models (GCMs)
 - Scenario building
 - Downscaling



Paleoclimate Data

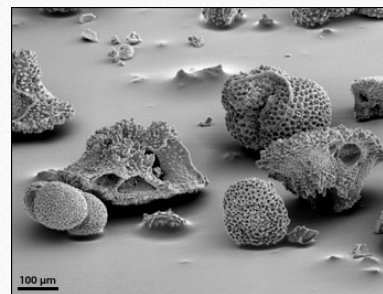
- Past climate data obtained through proxy records
- Many methods of obtainment
 - Ice cores
 - Tree rings (dendrochronology)
 - Sediments
 - Various organisms
- Rarely used in climate and disease research



<http://sites.dartmouth.edu/jstroup/photo-gallery/>



<http://www.thenakedscientists.com/HTML/interviews/interview/643/>



Earthobservatory.nasa.gov



<http://www.visualisingdata.com/2015/02/dendrochronology-visualisation-literacy/>

Weather Stations

- Can record a suite of variables depending on the instrumentation
 - Temperature, precipitation, humidity, wind speed, wind direction, incoming solar radiation
 - Records are usually daily
- Found at many airports, universities, and research centers
- Data is often available through local or national weather services



http://mea.com.au/upload/AWS_with_Labels.jpg

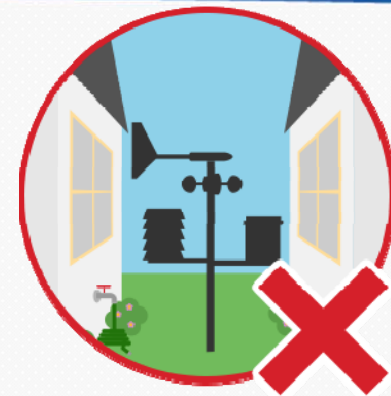
Weather Stations

- Strengths

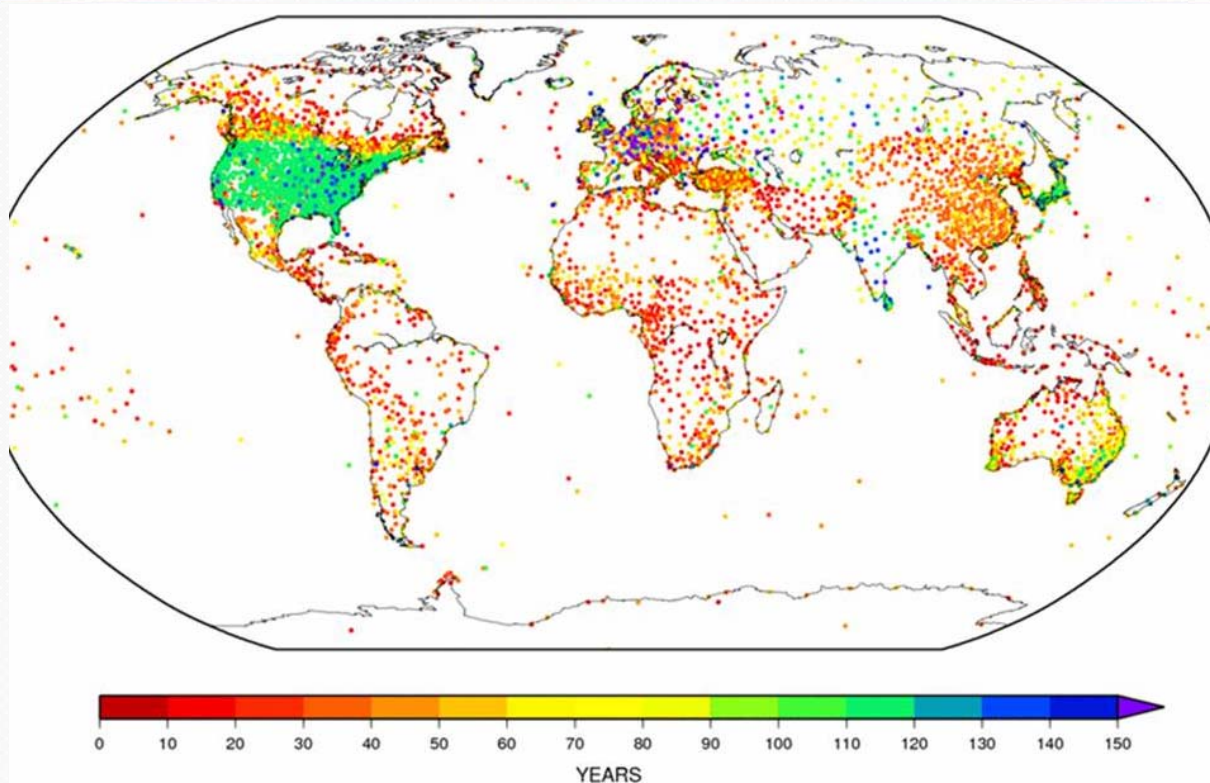
- Often record many variables
- Daily resolution (sometimes hourly)
- Most populated areas contain at least one
- Long record history

- Weaknesses

- Not uniformly distributed
- Potential breaks in recording or location
- Can be heavily influenced by local environment
- Not representative of a large area
- Data is sometimes unavailable or expensive



Global Historical Climatology Network



<https://catalog.data.gov/dataset/global-historical-climatology-network-monthly-ghcn-m-version-3>



Mini Weather Data Loggers

- Devices for collecting weather data
 - Generally record temperature and/or humidity
 - Data downloaded via connection to laptop or wifi
- Advantages
 - Small and inexpensive
 - Can record at various time intervals
 - Good for sampling microclimates
- Disadvantages
 - Usually self employed
 - Limited variables
 - Representative of very small areas



<http://thermometer.co.uk/71-humidity-and-temperature-data-loggers>

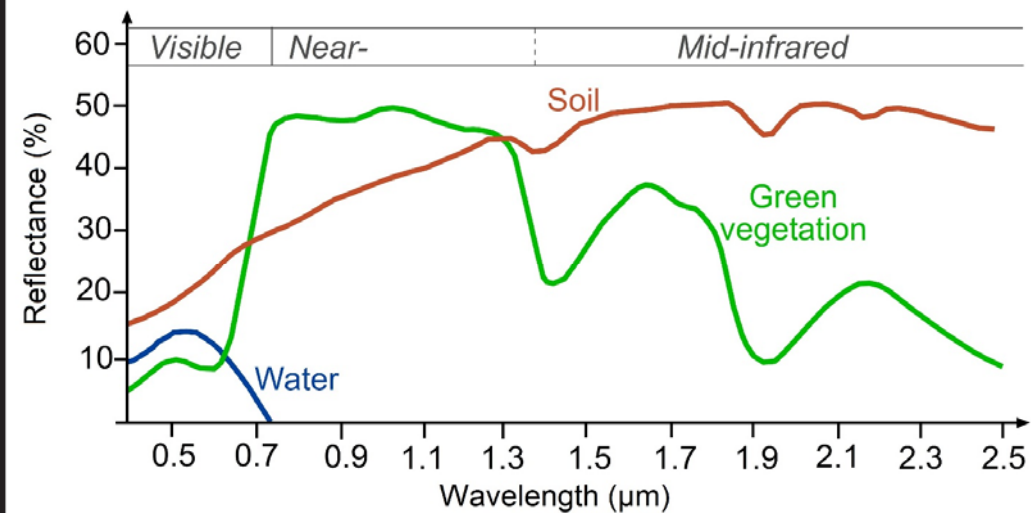
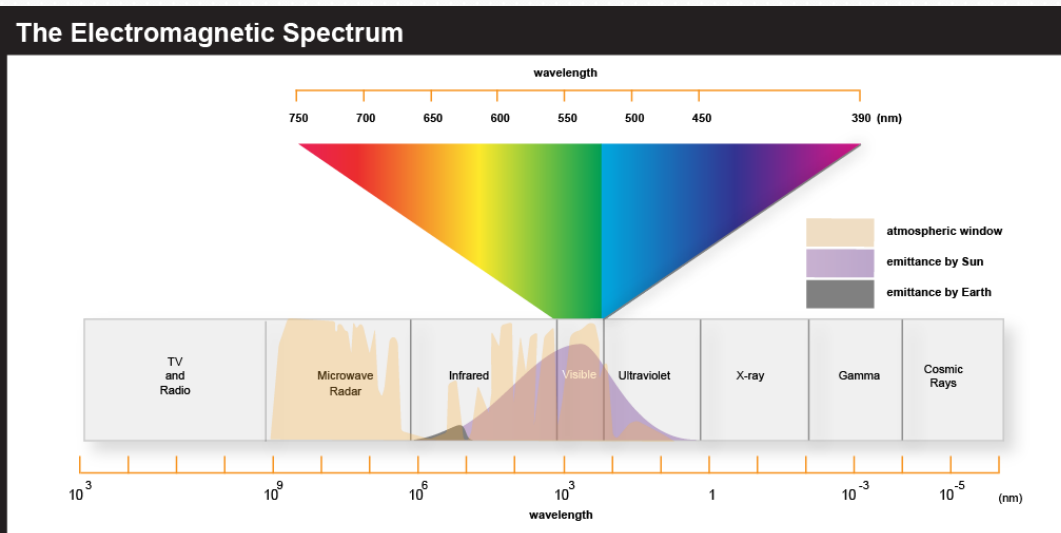


Remote Sensing: How it Works

- Technique that collects information through signals (i.e., electromagnetic radiation) using sensors with filters specific to certain wavelengths
 - Found on satellites, planes, towers, ect.
 - Features on Earth identified through their specific radiative frequencies

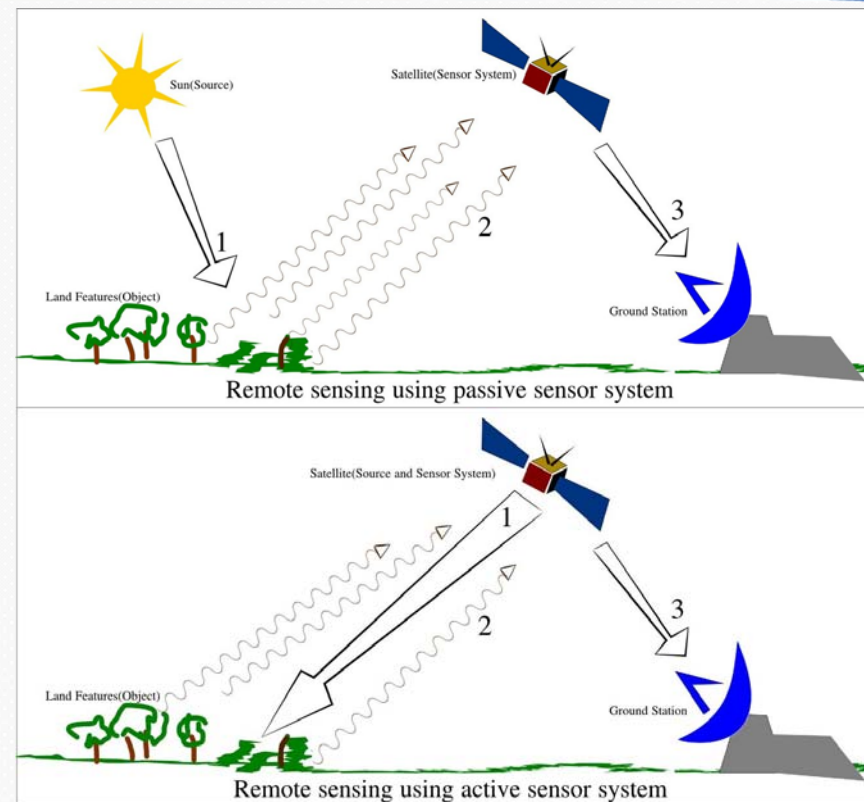
<https://www.e-education.psu.edu/geog160/node/1958>

<http://www.seos-project.eu/modules/classification/classification-c00-p05.html>



Remote Sensing Techniques

- Passive vs Active remote sensing
 - Passive only collects signal
 - Active emits a signal and then collects a return signal
- Levels of data
 - 0: Raw data
 - 1: Data calibrated, georeferenced, time-referenced, ect.
 - 2: Derived geophysical variables
 - 3: Data mapped on uniform grid
 - 4: Modeled variables from the lower level data (NDVI)



https://en.wikipedia.org/wiki/Remote_sensing



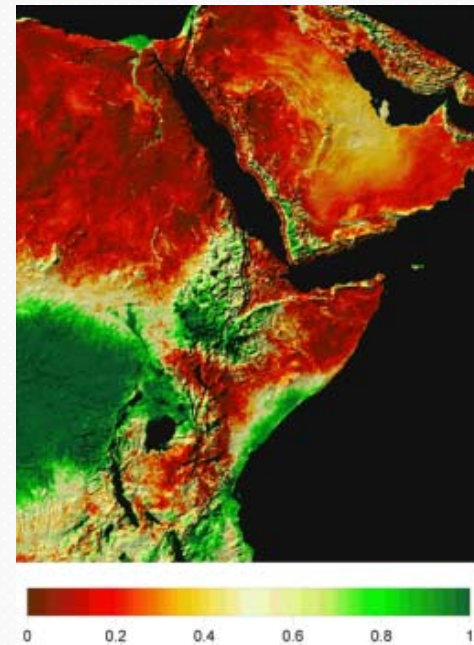
What Can Remote Sensing Measure?

- Temperature- ECOSTRESS (2017), HypsIRI (2020+), ASTER (1999), Landsat (5,7,8), MODIS
- Precipitation- GPM (2014)
- Soil Moisture- SMAP(2015)
- Hyperspectral- Hyperion (2000), HypsIRI (2020+)
- Structure - IceSat2 (2016)
- Flooding/water levels lakes streams, groundwater storage – GRACE (2002) SWOT (late 2020)
- Land Cover/Use- Landsat, MODIS, ASTER, Sentinel-2(2015)



Remote Sensing Strengths

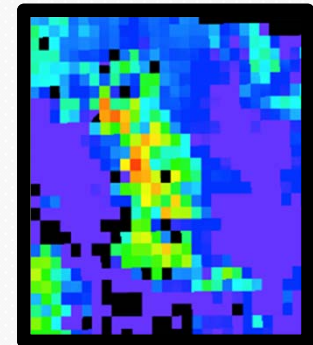
- Measures environmental state functions important to pathogen life cycles
 - Precipitation, soil moisture, temperature, vapor pressure deficits, wet/dry edges, solar radiation....
- But also the interfaces as process functions:
 - Land use/cover mapping; Ecological functions/structure, canopy cover, species, phenology, aquatic plant coverage.....
- And provides a Spatial Context
 - Spatial coverage & topography – local, regional & global...
- Lastly, but perhaps the greatest strength:
 - Provides a time series of measurements



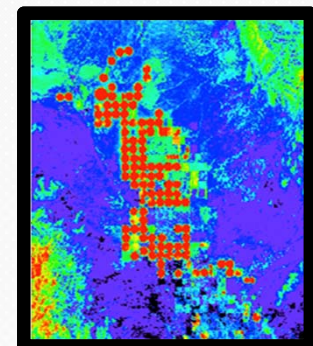
Remote Sensing Weaknesses

- Tradeoff between spatial and temporal resolution
 - Satellites may pass over multiple times per day or once every few weeks
 - Spatial resolution can by sub-meter to kilometers
- Atmospheric interference
 - Clouds can obscure views
 - Detrimental if the data has poor temporal resolution
- Accuracy and interpretation
 - Algorithms often required and will not be perfect
- Availability
 - Although NASA provides data free, other space agencies and private companies charge exorbitant prices for data

MODIS – 1 km

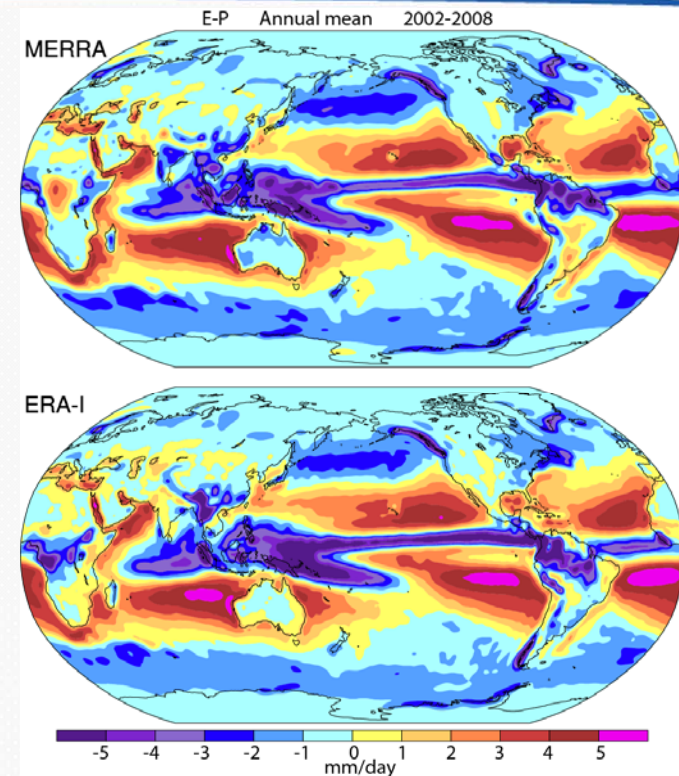


Landsat 7 – 60 m



Reanalysis Data

- Uses multiple sources of recorded climate data combined with data assimilation and modeling techniques to create a gridded environmental datasets
 - Observational data from weather stations, satellites, radiosondes, ect.
- Multiple sources
 - NASA Global Land Data Assimilation System
 - NCEP Reanalysis



<https://climatedataguide.ucar.edu/climate-data/atmospheric-reanalysis-overview-comparison-tables>



Reanalysis Data

- **Advantages**

- Includes huge amount of variables
- Global gridded data with consistent spatial and temporal resolution
- Incorporates millions of observations
- Free and relatively easy to use

- **Disadvantages**

- Reliability depends on location, time period, and variable
- The type and number of observations changes over time
- Use of modeled data

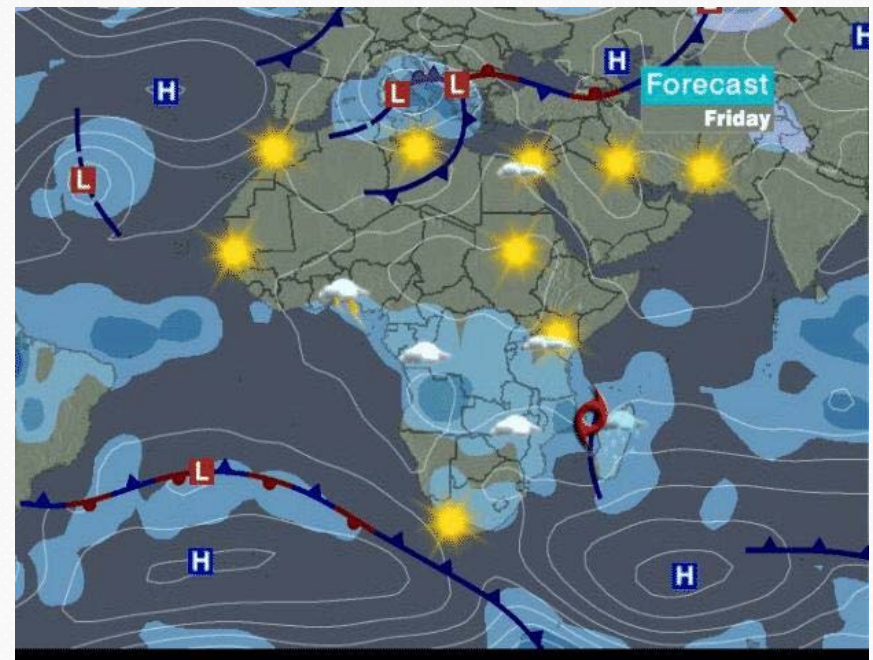


<http://cpo.noaa.gov/ClimatePrograms/ModelingAnalysisPredictionsandProjections/MAPPNewsEvents/TabId/506/ArtMID/1256/ArticleID/197/MAPP-kicks-off-Climate-Reanalysis-Task-Force-activities.aspx>



Weather Forecasts

- Short-term predictions out to 2 weeks into the future
- Meteorologists use multiple methods to produce forecasts
 - Current observational data
 - Tracking weather systems and air masses
 - Weather forecasting models
 - Weather research and forecasting model WRF
 - Experience

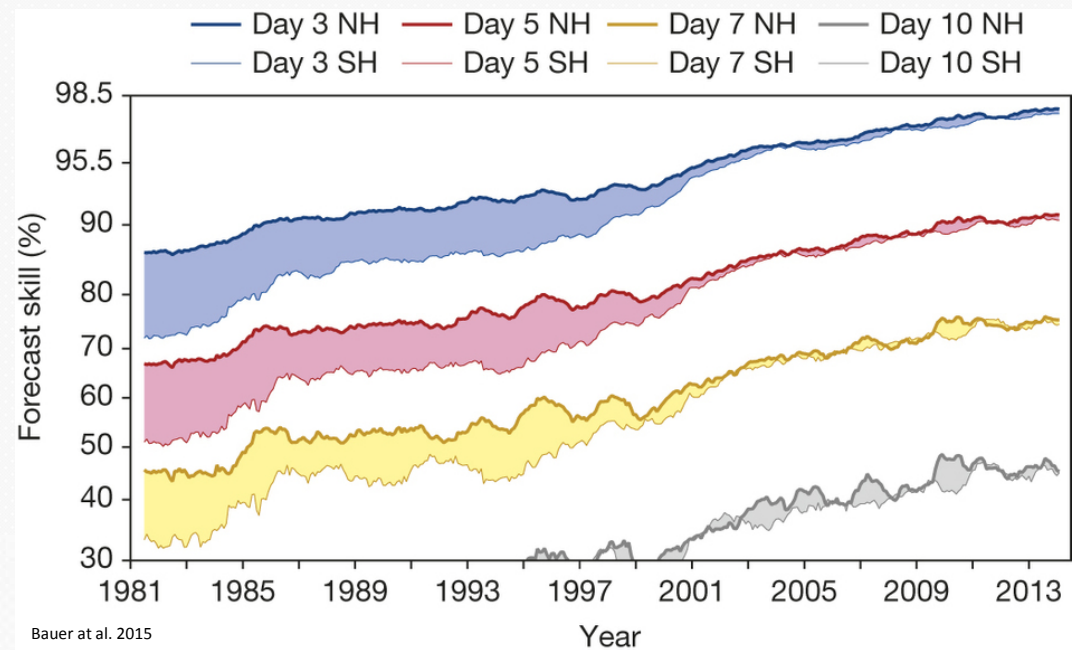


<http://www.cnn.com/WEATHER/Africa/frct.html>



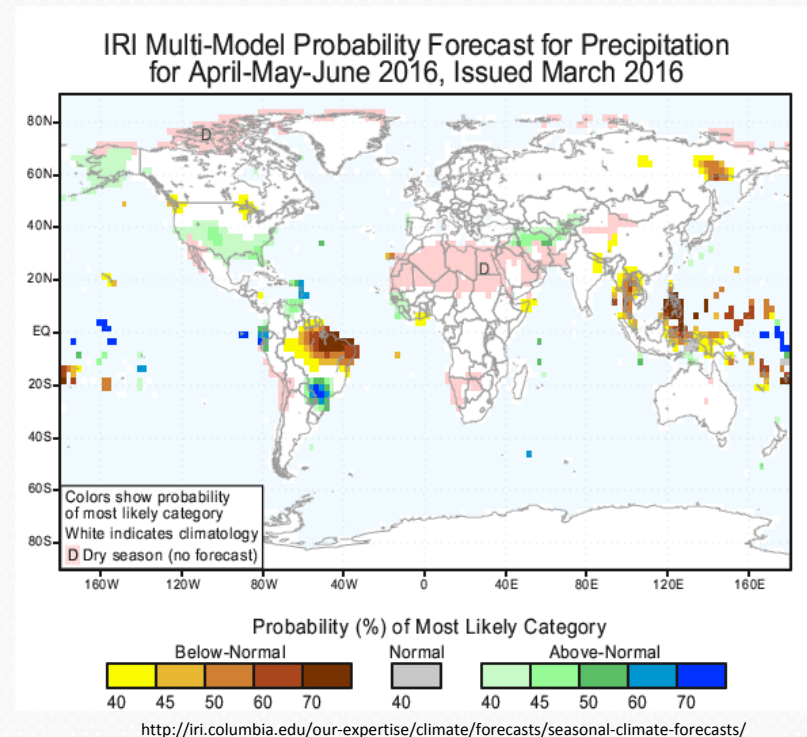
Weather Forecasts

- Multiple sources
 - Local or national weather service
 - Private companies: TV or Websites
 - weatherunderground.com
- Considerations when using weather forecast data
 - Uncertainty
 - Forecasts degrade in quality as they extend out
 - Evaluation of forecasts are important



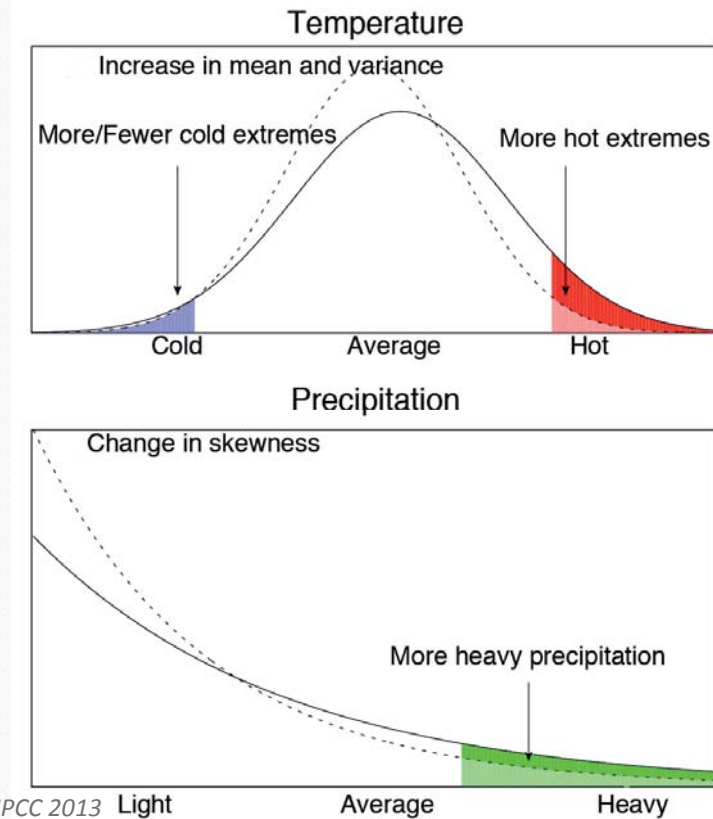
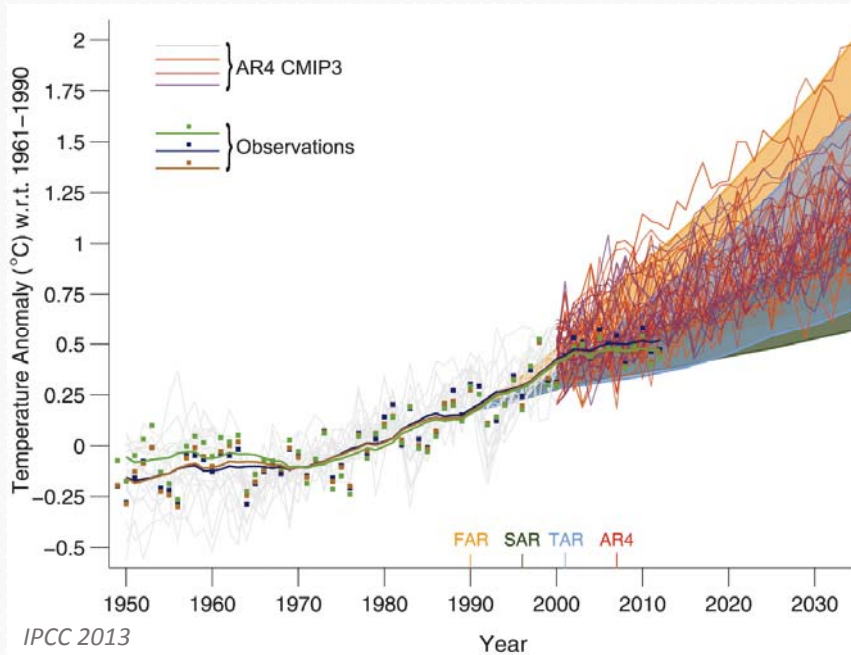
Seasonal Forecasts

- 1-6 Month Forecasts
 - Based on long-term climate trends, sea surface temperatures, oscillations
 - From numerical weather prediction models and/or statistical models
- Example: North American Multi-Model Ensemble
 - Made up of multiple models
 - Gridded, monthly
 - Daily downscaled version available but are not specific daily predictions



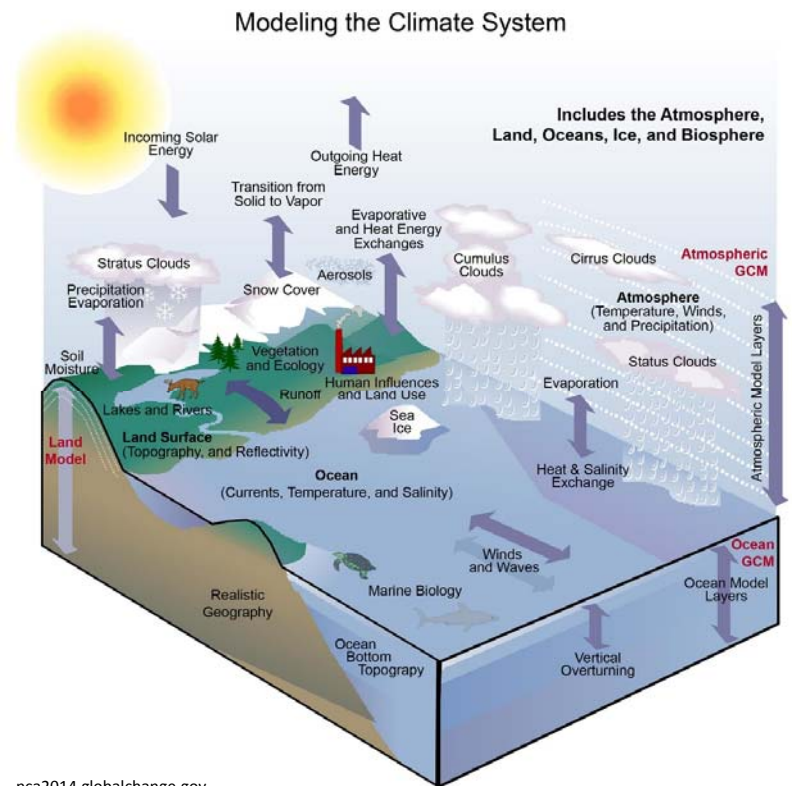
Climate Variability and Change

- Shift in mean and variance
- Increase in frequency of extreme conditions



Global Climate Models

- Global climate models
 - Attempt to simulate the climate system through mathematically modeling the physical, chemical, and biological processes that occur within and between the atmosphere, hydrosphere, lithosphere, and biosphere
 - Many different models with different resolutions, assumptions, and regional accuracy

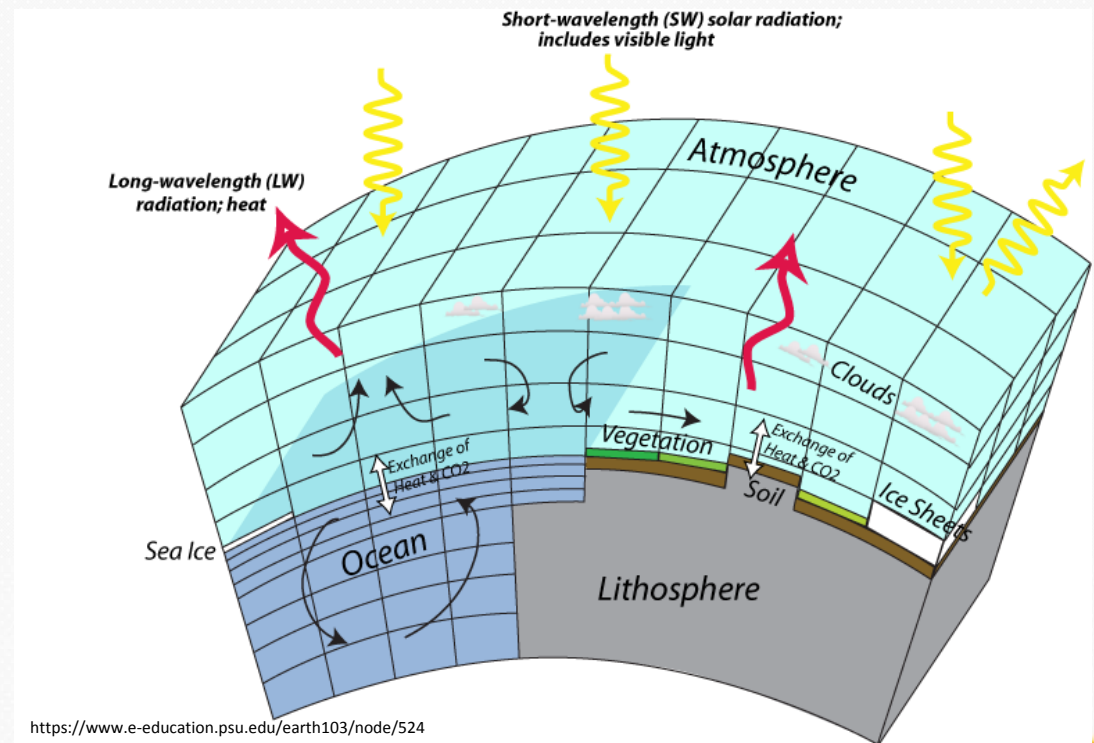


nca2014.globalchange.gov



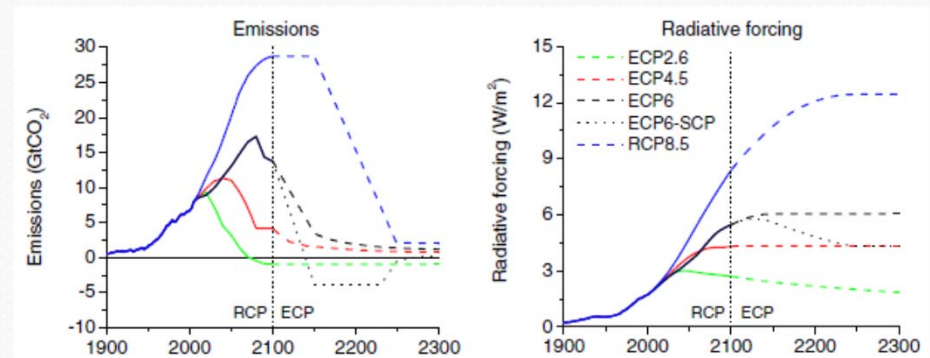
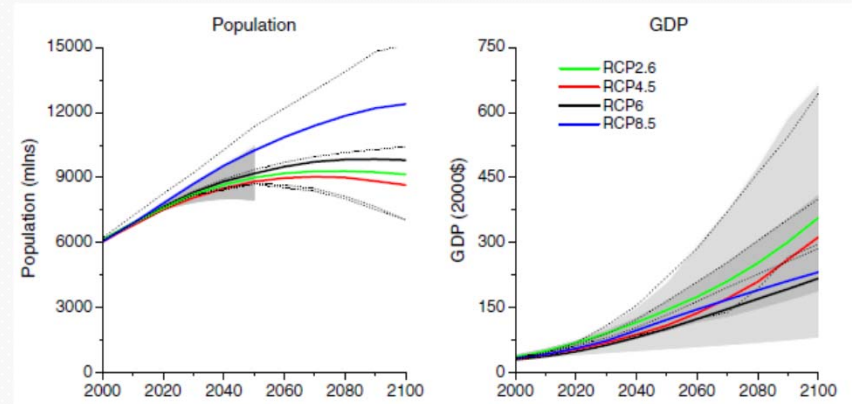
Climate Change Models

- Earth and atmosphere divided into a 3-d grid which interact
- Higher resolution is more accurate but requires increased computing power
- Can simulate the climate system under various conditions



Climate Change Data

- GCM inputs
 - Greenhouse gas, aerosol, and pollutant concentrations
 - Land use/cover
- Representative concentration pathways
 - Scenarios created based on projected socioeconomic conditions
- Designed to deal with uncertainty

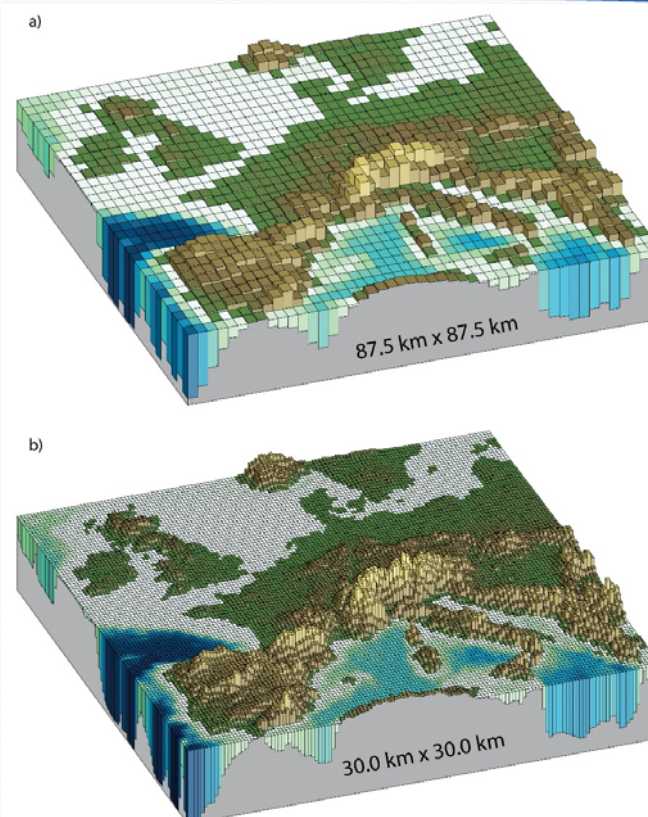


Van Vuuren et al. 2011



Downscaling Climate Change Data

- A method of estimating local scale climate/weather features from larger scale models
 - Important for local impact assessments
- Downscaling can refer to both spatial and/or temporal downscaling
- Two major methods of downscaling GCM climate data
 - Dynamic downscaling
 - Statistical downscaling

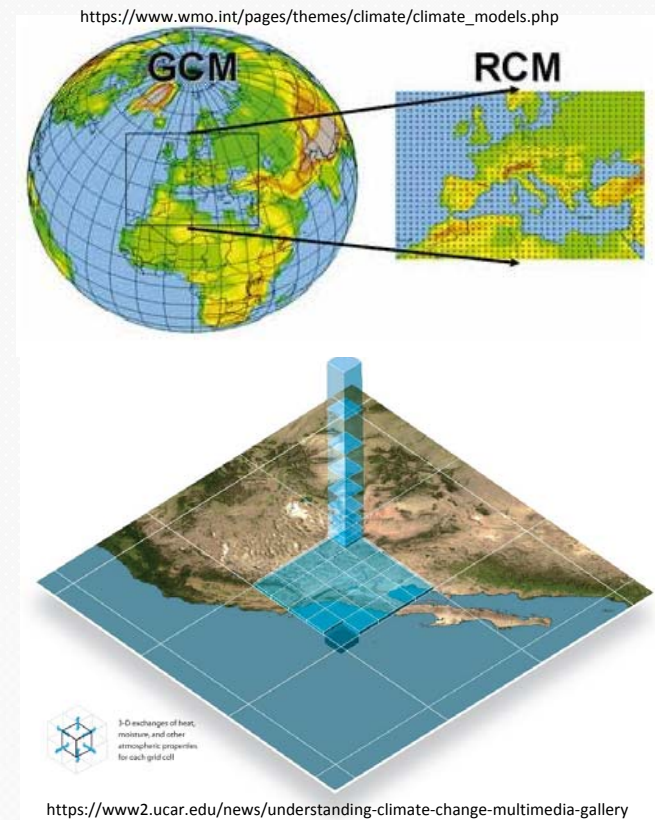


<http://www.climatechange2013.org/report/reports-graphic/ch1-graphics/>



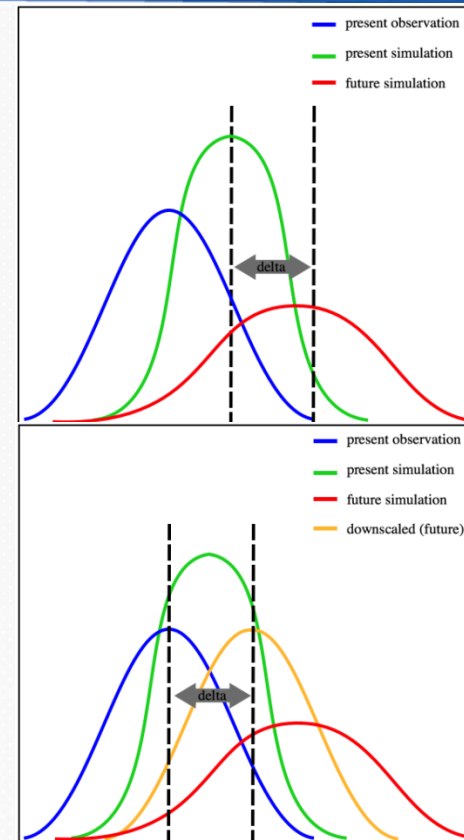
Dynamic Downscaling

- Regional GCMS
 - GCM boundary conditions used to drive a finer scale numerical weather/climate model
- Advantages
 - Based on known atmospheric mechanics
 - Atmospheric processes resolved
 - Does not rely on historical records
- Disadvantages
 - High complexity and computing power
 - Small scale processes still difficult to simulate
 - Relies on accuracy of GCMs



Statistical Downscaling

- Based on relationships between large-scale and local atmospheric conditions
 - Methods: linear regression, weather classification, weather generators
- Advantages
 - Simple with little required computer power
 - Can downscale to very fine resolution
 - Methods are flexible
- Disadvantages
 - Assumes stationary relationships over time
 - Accuracy and resolution are method dependent
 - Relies on accuracy of GCMs and historic data

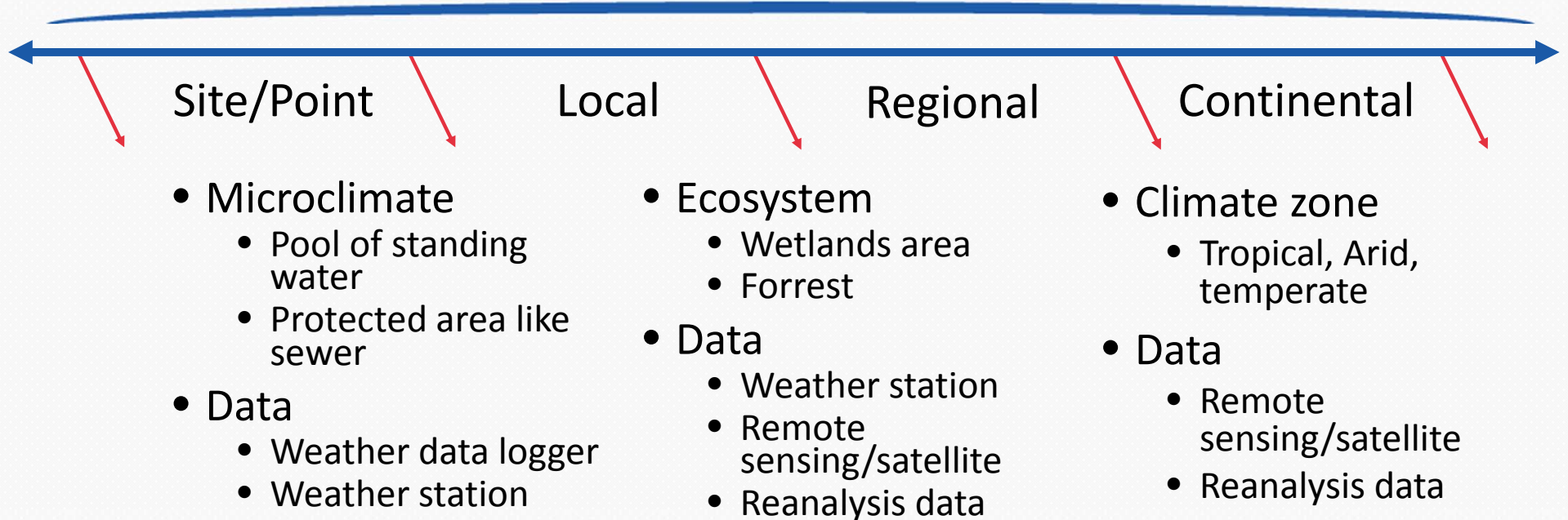


Data Considerations in Climate and Health Research

- What is the required resolution?
 - Spatial
 - Temporal
- What is the period of study?
 - Historic
 - Future
- How to deal with uncertainty?
 - Sources
 - Solutions



What is the required resolution?



*Remember that temporal resolution may also be an issue but only when trying to obtain a finer resolution



What is the Period of Study?

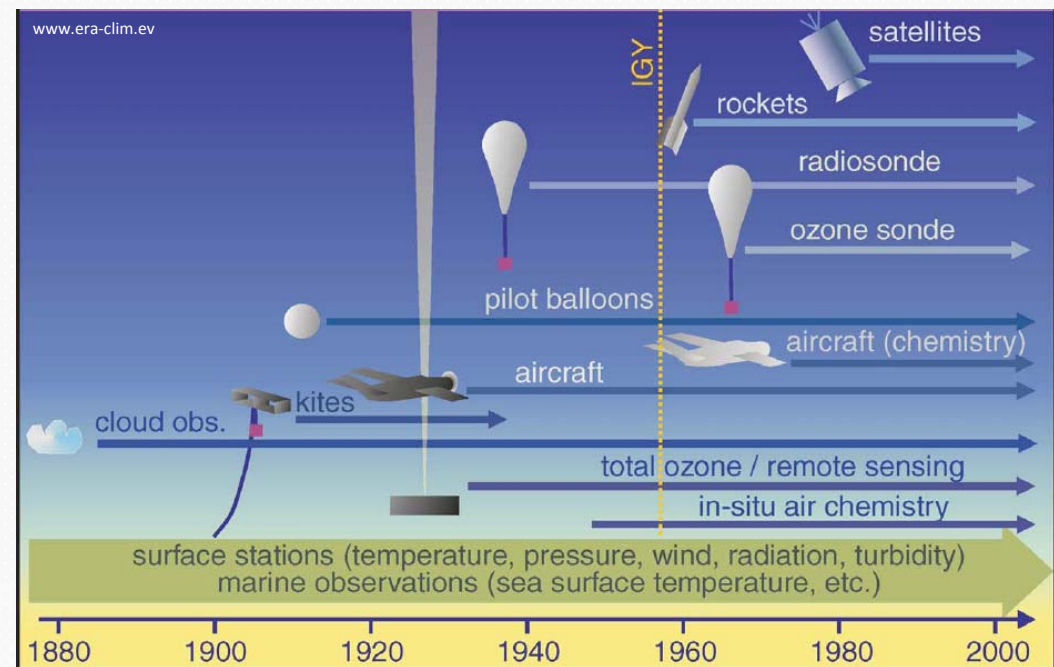
- **Historic**

- Methods of collecting weather/climate data change over time
 - Certain variables are only available more recently
- The number of collections also changes over time

- **Future**

- Short-term: weather forecast
- Mid-term: seasonal forecast
- Long-term: climate change

} Uncertainty increases as forecast increases while specificity decreases



How to Deal with Uncertainty?

- Uncertainty comes from multiple sources
 - Model parameterization
 - Model accuracy
 - Data accuracy
- Solutions
 - Select appropriate models and data
 - Use multiple models / parameters / datasets
 - Evaluate predictions when possible
 - Report ranges

