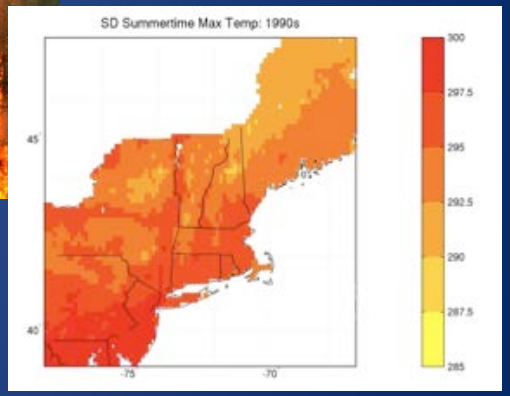
Elements of a Vulnerability Assessment:
Exposure



“Be educated enough to make your own decisions.”

Ann Marie Chischilly
Executive Director, Institute for Tribal Environmental Professionals

Listening for the Rain
from Kunatsm Ja'ay Productions,
http://vimeo.com/87696613

Climate Change Exposure

Measure of how much of a change in climate or other environmental factor a species or system is likely to experience

And, climate is just one of many…

- Energy development
- Urban/suburban growth
- Human use
- Fire
- Invasive species
- Introduced species

But our class (and this presentation) will focus on climate.

Class exercise

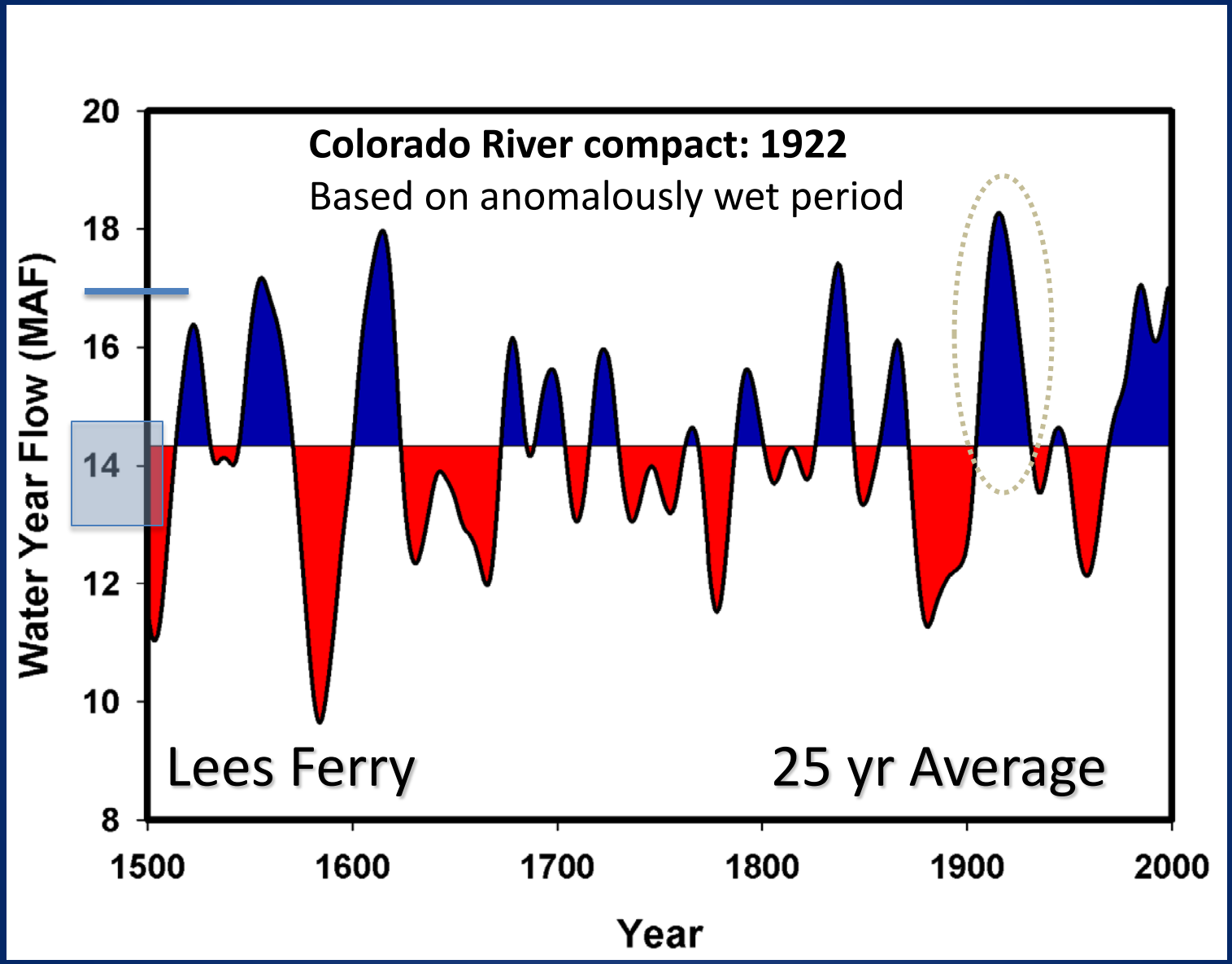
What do you think of when someone says “climate data”?

The future's not what it used to be...

- Historical data
  - Long term (paleo-climate)
  - Observations from weather stations (NOAA's National Climate Data Center)
  - Gridded observations (e.g. PRISM, DayMet)

- Projections for future scenarios
  - Global Climate Models
  - Statistically Downscaled Global Climate Models
  - Regional Climate Models

“Stationarity is Dead” (Milly et al., Science 2008)



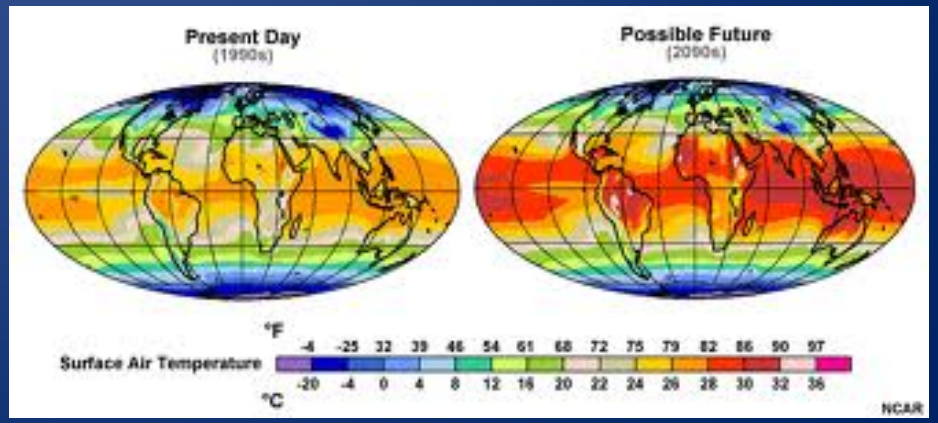
Slide courtesy of Dr. Steve Gray, DOI Alaska Climate Science Center, based on Woodhouse, Gray, and Meko (2006). Water Resources Research 42:W05415

Some important acronyms

- Intergovernmental Panel on Climate Change (IPCC)
- Assessment Reports (AR)
  - TAR (first AR), second (SAR), third (TAR), AR4, AR5,…
- CMIP5 - Coupled Model Intercomparison Project (CMIP5 = most current & goes with Assessment Report 5)
- GCM: Global Climate Models
- RCM: Regional Climate Models
- Representative Concentration Pathways (RCP) (which is the CMIP5 term for emissions scenarios, in CMIP3 they were referred to as SRES, special report on Emissions Scenarios)

Global Climate Models (GCMs) considerations

- **Forcings:** Based on prescribed principles of thermodynamics and fluid dynamics
- **Model physics:** describing complex interaction between atmosphere, cryosphere, oceans, land, and biosphere
- **Output:** mainly output temperature and precipitation (but also winds and other information)
- **Scale:** in time and space, and possible downscaling



Forcings: emissions

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Analysis Area	Time Period	Map Options	Measurement	Resources
(•) United States ( ) Global United States	( ) Past 50 Years ( ) Mid Century (2050s) (•) End Century (2080s)	( ) Map of Average (•) Map of Change Compare & Animate Models	(•) Average Temperature ( ) Precipitation Annual	Suggested Reading Documentation | Developer Data and Map Image Download ClimateWizard Custom Analysis Printer Friendly Version

Future Climate Model

IPCC Fourth Assessment

Emission Scenario

High A2

Model

Future Climate Model

IPCC Fourth Assessment

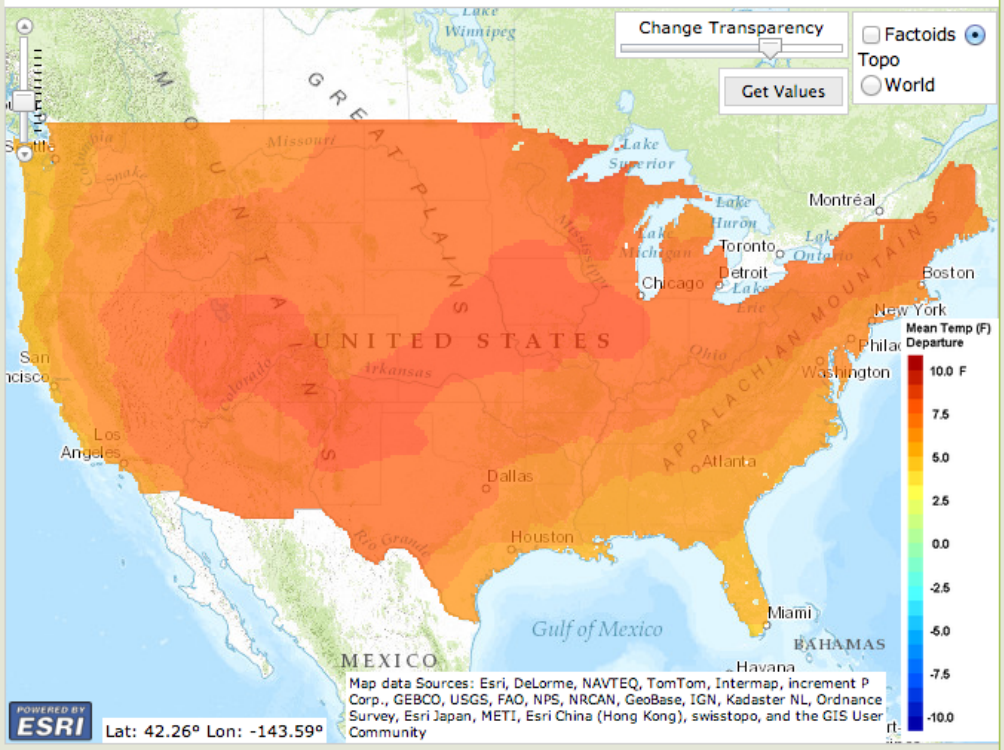
Emission Scenario

High A2

50%: This map shows the temperature change projected by the middle model. That is, **half of the models project a greater amount of change, and half of the models project less change** as compared to the 1961-1990 baseline average.

Change in Annual Temperature by the 2080s

Model: Ensemble Average, SRES emission scenario: A2



Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

Model physics

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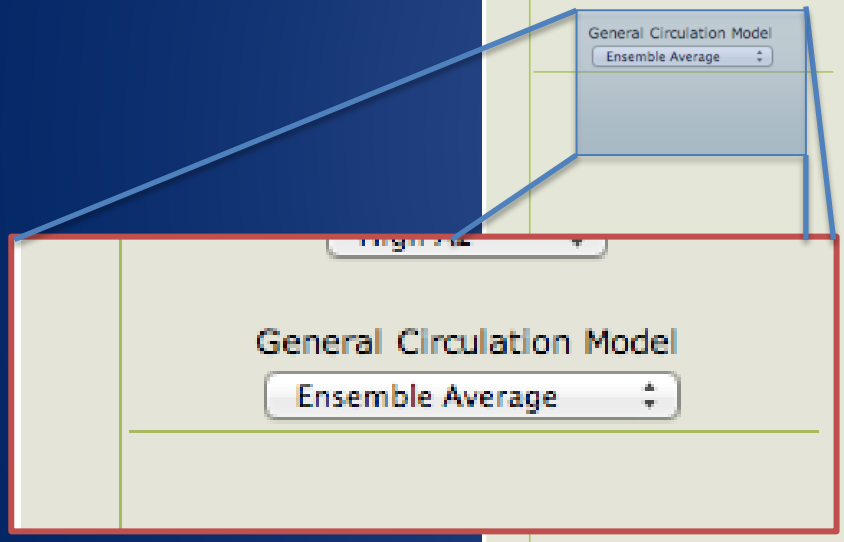
Analysis Area	Time Period	Map Options	Measurement	Resources
◉ United States ○ Global United States	○ Past 50 Years ○ Mid Century (2050s) ◉ End Century (2080s)	○ Map of Average ◉ Map of Change Compare & Animate Models	◉ Average Temperature ○ Precipitation Annual	Suggested Reading Documentation | Developer Data and Map Image Download ClimateWizard Custom Analysis Printer Friendly Version

Future Climate Model

IPCC Fourth Assessment

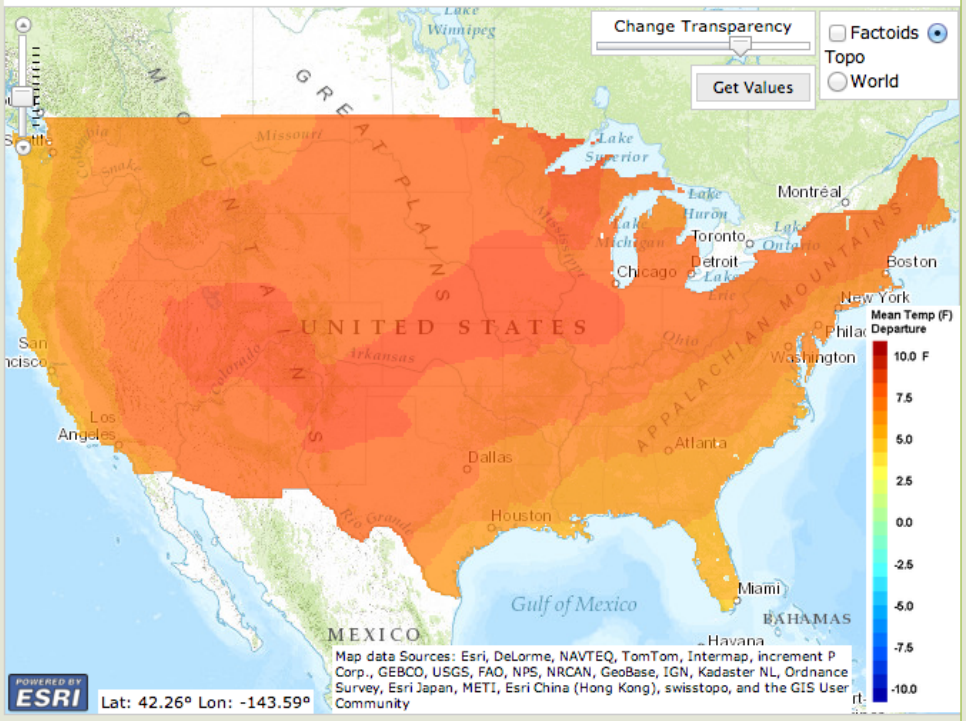
Emission Scenario: High A2

General Circulation Model: Ensemble Average



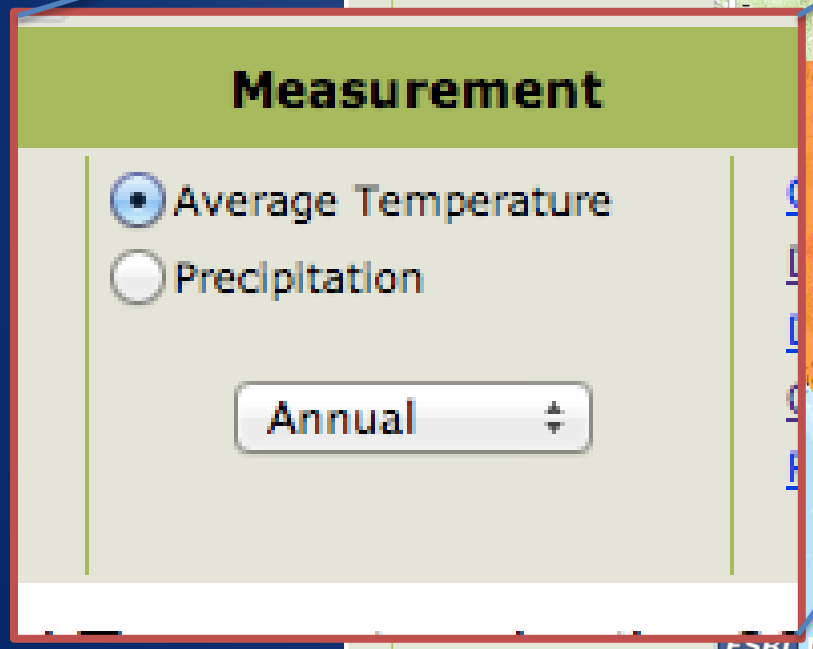
Change in Annual Temperature by the 2080s

Model: Ensemble Average, SRES emission scenario: A2



Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

Output



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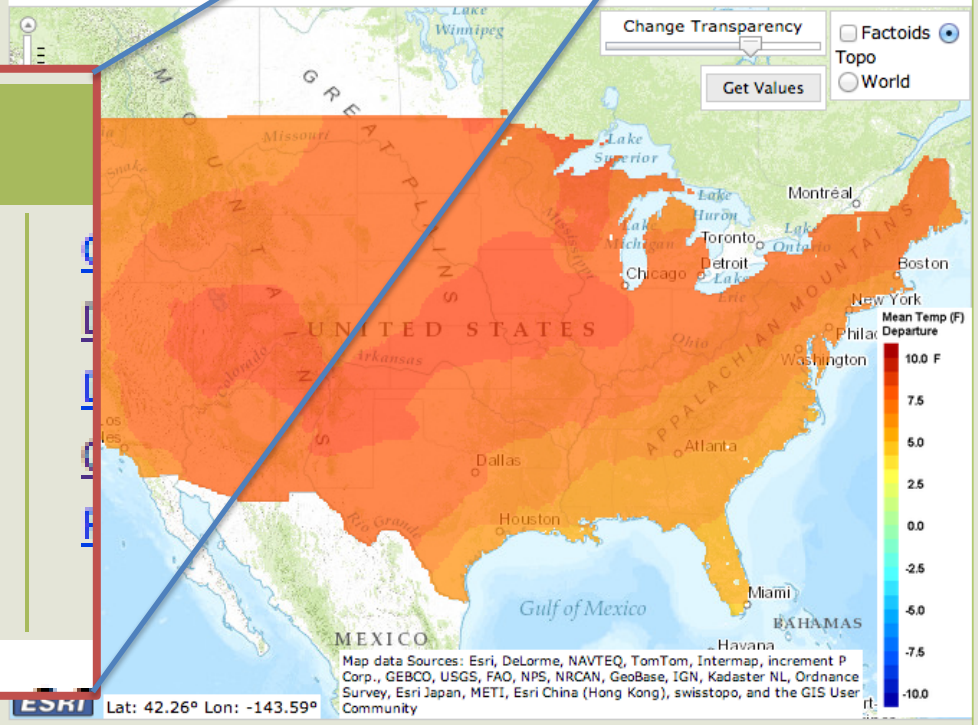
IPCC Fourth Assessment
Emission Scenario
High A2

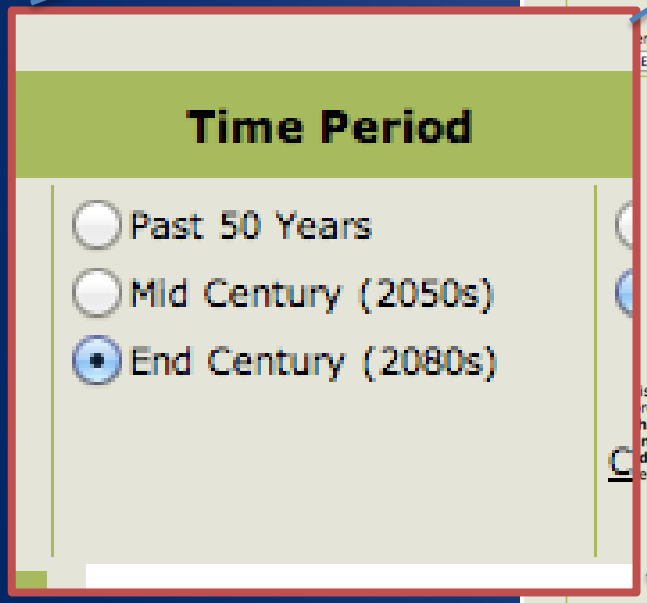
Change in Annual Temperature by the 2080s
Model: Ensemble Average, SRES emission scenario: A2

Change Transparency
Get Values
Factoids
Topo
World



Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

Scale



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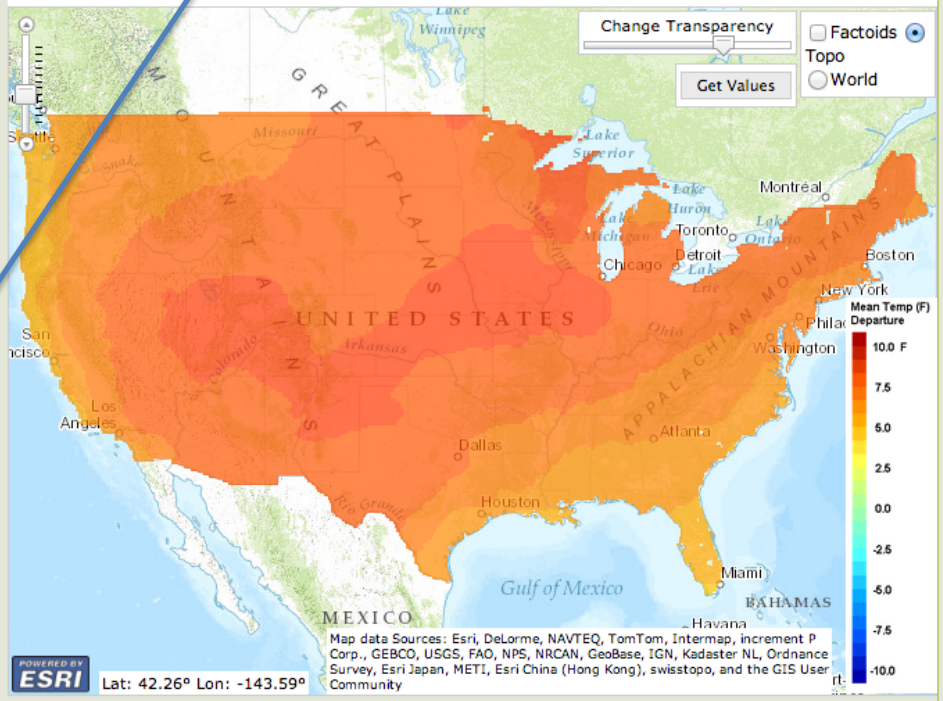
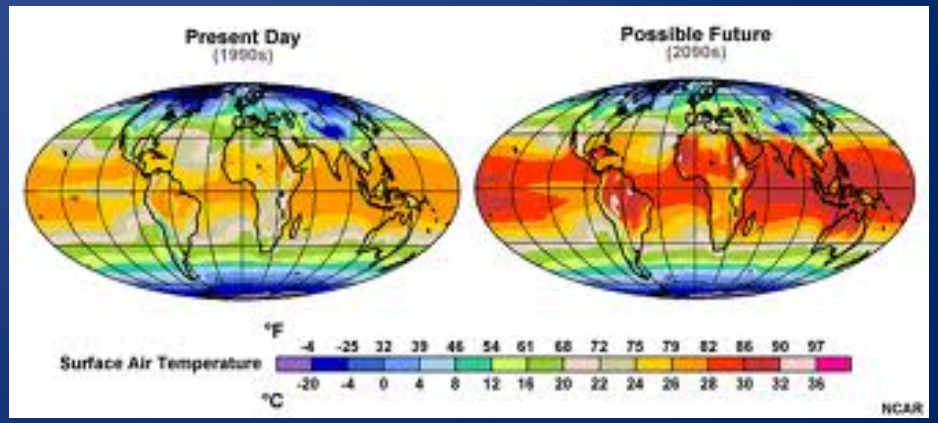


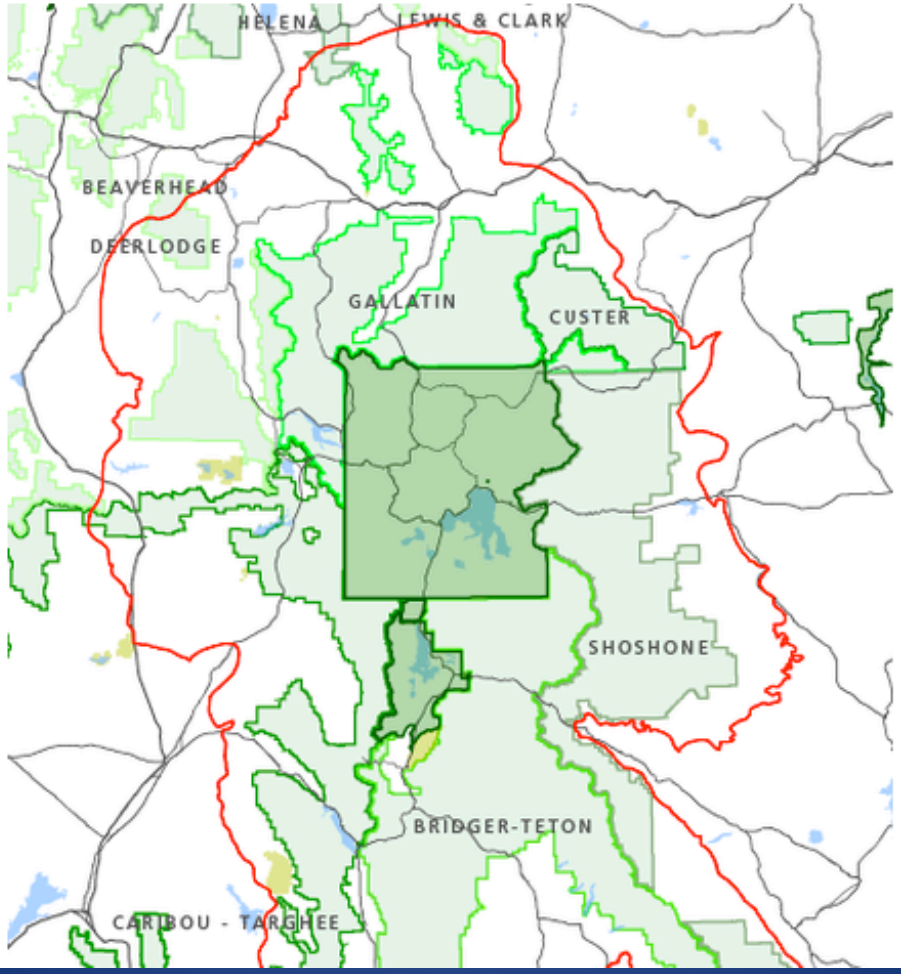
Data Source: Base climate projections downscaled by Maurer, et al. (2007) Santa Clara University. For more information see About Us.

For every climate change vulnerability assessment you want to recognize the choice for:

- Forcings
- Model physics
- Output
- Scale: in time and space



Welcome to the GYA Climate Explorer



- Welcome
- Average Min Temperature
  - Spring
  - Summer
  - Fall
  - Winter
- Average Max Temperature
- Average Temperature
- Average Precipitation
- Combined Flow
- Snow Water Equivalent
- Snowpack Vulnerability
- About
- Glossary

Greater Yellowstone Coordinating Committee
Climate Change Adaptation Subcommittee

http://www.greateryellowstonescience.org/files/Climate_program/indexIE.html

Greater Yellowstone Area Climate Explorer

- Forcings: A1B emissions scenario, which is a *mid-level scenario* for both carbon dioxide emissions and economic growth, with atmospheric concentrations of carbon dioxide rising from 390 ppmv (parts per million by volume) at present to 550 ppvm by the mid-2050s

Greater Yellowstone Area Climate Explorer

- Physics: 10 GCMs, chosen by the Climate Impacts Group because they performed the best in the Northern Rockies/Upper Missouri and Central Rockies/Upper Colorado areas in simulating historic observed temperature and precipitation trends of the 20th century.

Greater Yellowstone Area Climate Explorer

Products: ensemble mean for…

GYA CLIMATE EXPLORER VARIABLES	ADDITIONAL VARIABLES ON ECOSHARE
Minimum Temperature	PET 1
Maximum Temperature	PET 5
Average Temperature	Runoff
Precipitation	Snow Depth
Combined Flow	Relative Humidity
Snow Water Equivalent	Soil Moisture Deficit
Snowpack Vulnerability	Water Balance Deficit
	Base Flow
	Evapotranspiration
	Soil Moisture

Greater Yellowstone Area Climate Explorer

- Scale…
- coarse climate projections were downscaled to a 1/16thdegree latitude/longitude grid (~6 x 6 km) over most of the western U.S. using a modified Delta method.
- Average of historic (1916 - 2006) climate values
- Future projection for the mid-century (Ensemble Mean 2030 - 2059 values).
-

Projecting Global Climate Models

Projections for changes in climatic variables (e.g., average temperatures, precipitation) based on one or more scenarios for emissions of greenhouse gases, particulates, and other factors

- Factors to consider
  - Scenarios are not predictions, but possible futures (depend on policy, economics, population, etc.)
  - Fairly significant variation among output from different modeling centers
  - Confidence (or at least consistency) in results are much higher for temperatures than precipitation

Climate Change in Colorado

A Synthesis to Support Water Resources Management and Adaptation

A REPORT FOR THE COLORADO WATER CONSERVATION BOARD

Colorado
University of Colorado at Boulder

In all parts of Colorado, no consistent long-term trends in annual precipitation have been detected.

Variability is high.

Climate model projections *do not agree* whether annual mean precipitation will increase or decrease in Colorado by 2050.

FIGURE 5-6. Projected Monthly Temperature and Precipitation near Steamboat Springs, CO (2050)

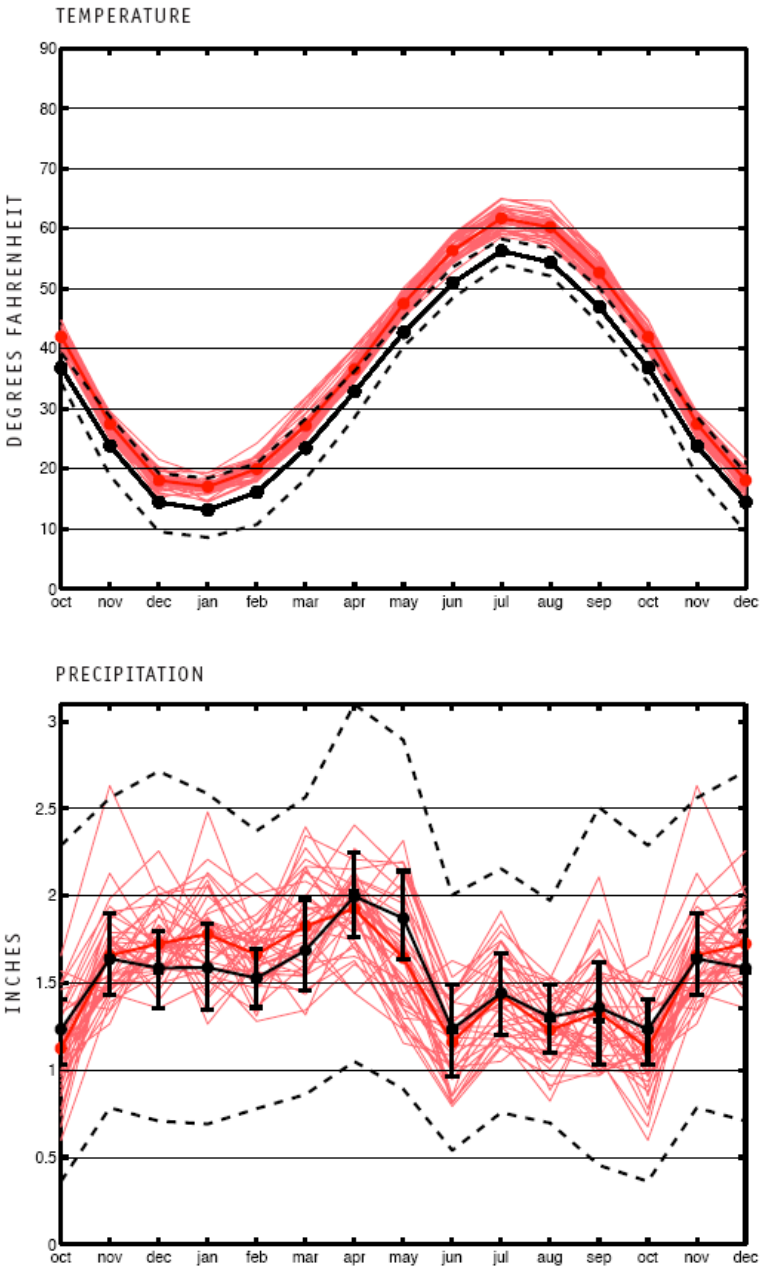
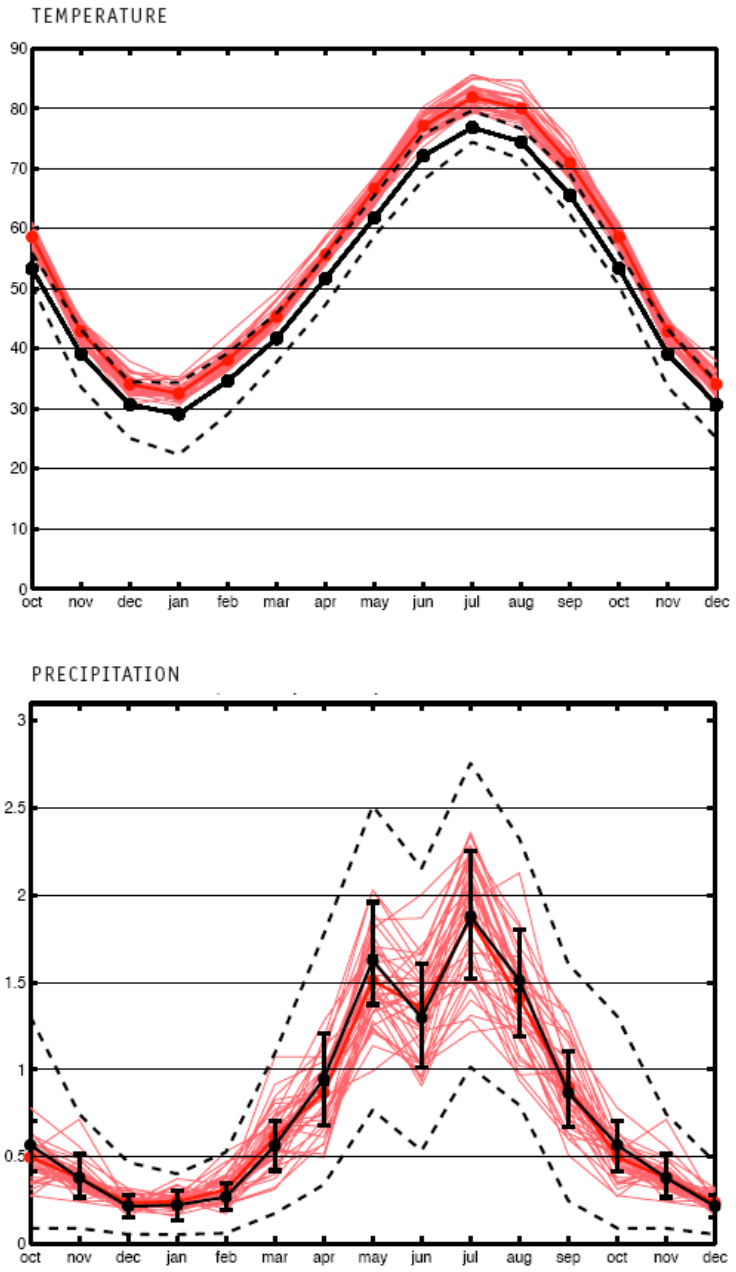


FIGURE 5-7. Projected Monthly Temperature and Precipitation near La Junta, CO (2050)



Recommendation from recent meeting with climate modelers*

1. Don't try to find "the best", but rather work with climate modelers to cull the group of available model output based on intended use.
2. Consider both downscaled GCM and RCM.
3. Use multiple downscaled climate to do multiple impacts models, then ensemble (don't run a climate ensemble then do impact model).

* NCPP Quantitative Evaluation of Downscaling Workshop 12-16 August, 2013 http://earthsystemcog.org/projects/downscaling-2013/ (based on my notes!)

Class exercise:

- Have you ever bought an air conditioner?

Segue to ecological response modeling

- Most species don't care about averages.
- Most ecosystems are defined by the extremes (or harshest) climate conditions.
- Sometime referred to as secondary variables or climate derivatives, indices, or summaries.

Example: BioClim summaries

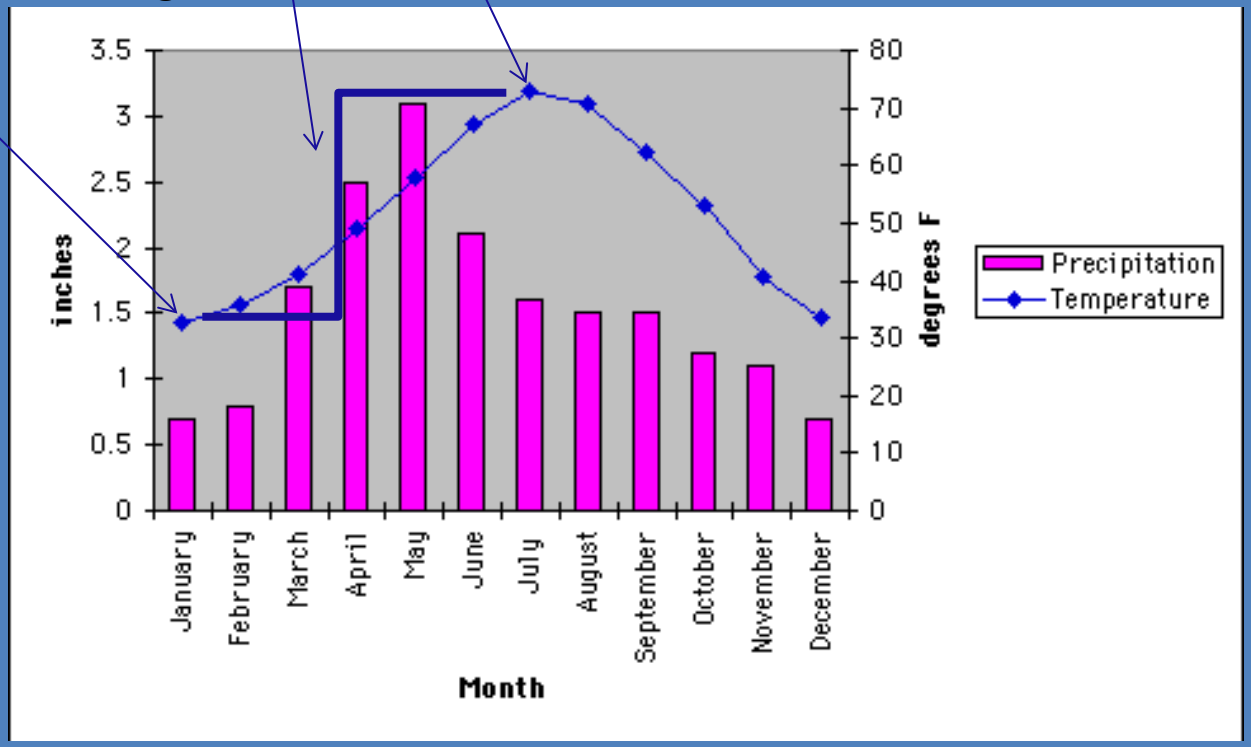
BIO1 = Annual Mean Temperature
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO5 = Max Temperature of Warmest Month
BIO6 = Min Temperature of Coldest Month
BIO7 = Temperature Annual Range (BIO5-BIO6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Month
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter
BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter

Nix, H. 1986. A biogeographic analysis of Australian elapid snakes. Pages 4 - 15 in R. Longmore, editor. Atlas of Elapid snakes of Australia. Australian Government Publishing Service, Canberra.

Bio 5: max temp, warmest month

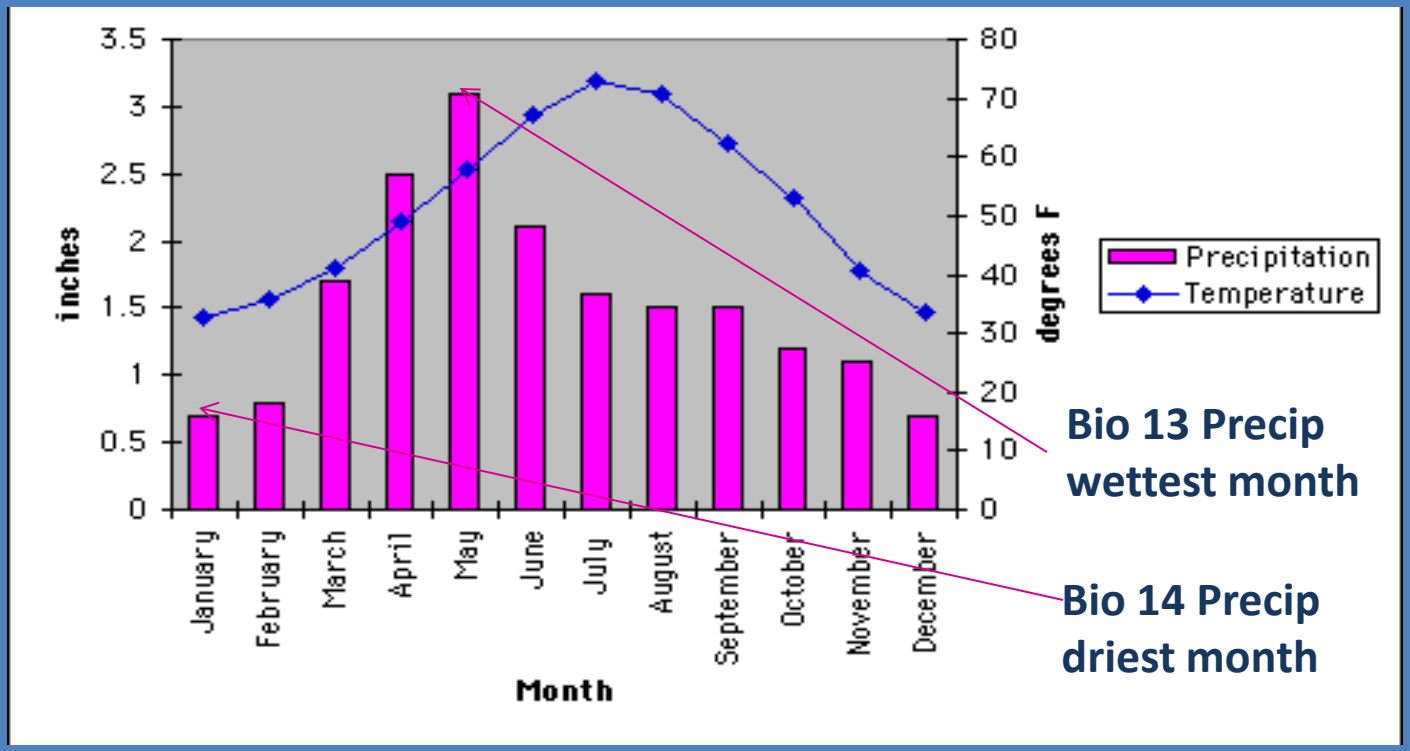
Bio 7: temp. annual range

Bio 6: min temp, coldest month



7 Temperature layers

BIO1 = Annual mean temp.
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)

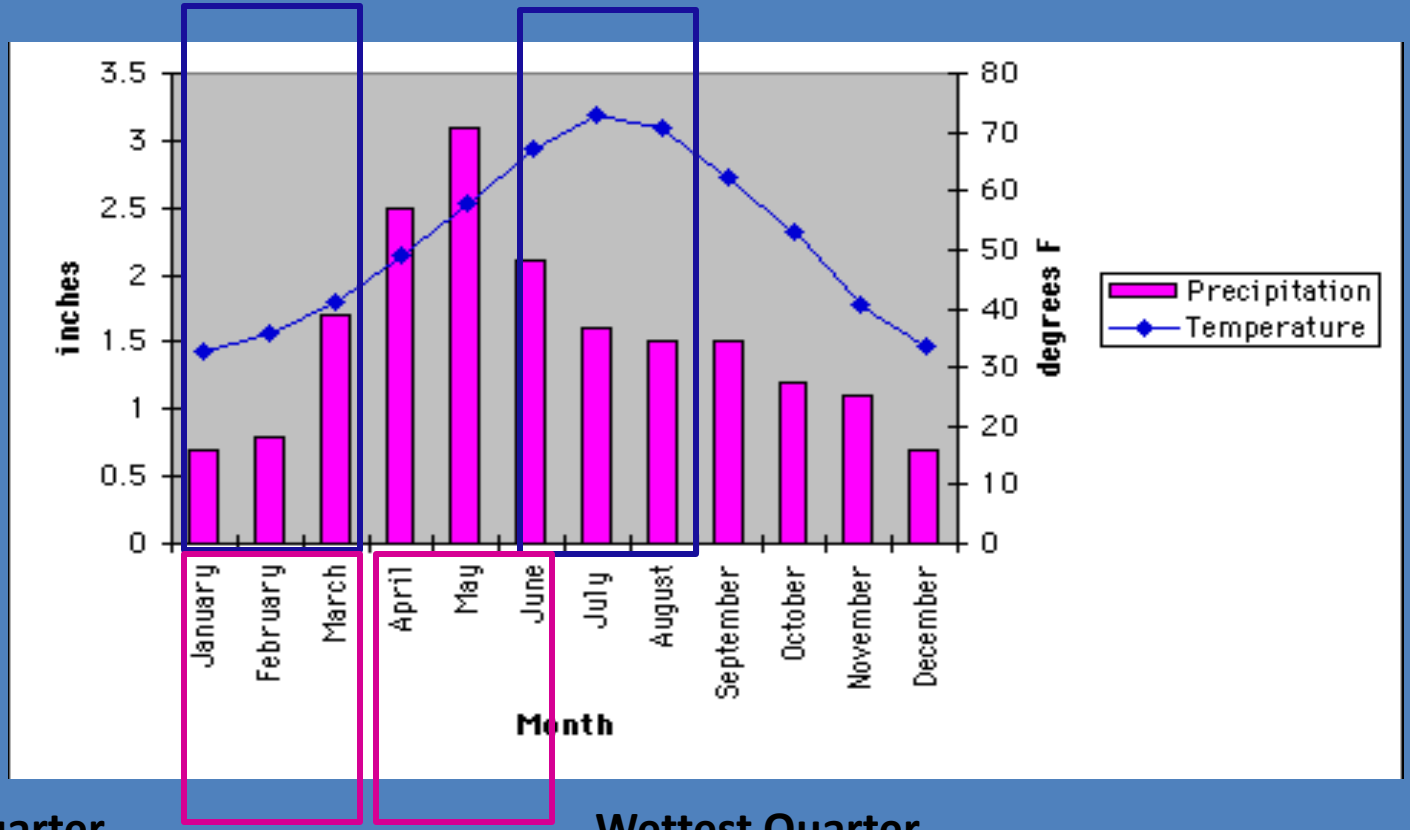


Bio 12: Annual precipitation
Bio 15: Coefficient of Variation for precip

4 Precipitation layers

Coldest Quarter
Bio 11: Mean temp
Bio 19: Precip

Warmest Quarter
Bio 10: Mean temp
Bio 18: Precip



Driest Quarter
Bio 9: Mean temp
Bio 17: Precip

Wettest Quarter
Bio 8: Mean temp
Bio 16 Precip

8 Temperature/Precipitation Interaction layers

… and there are others

- Heat stress index
- Drought stress index
- Growing degree days or other phenology parameters
- First frost
- Stream temperature
- Stream runoff

More information

MetEd

through the University Corporation for Atmospheric Research:

Teaching and Training Resources for the Geoscience Community

https://www.meted.ucar.edu/