

Elements of a Vulnerability Assessment:  
**Exposure**



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**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.

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*"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>

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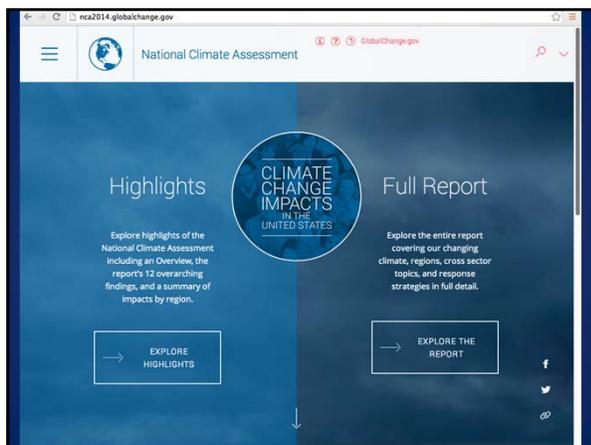
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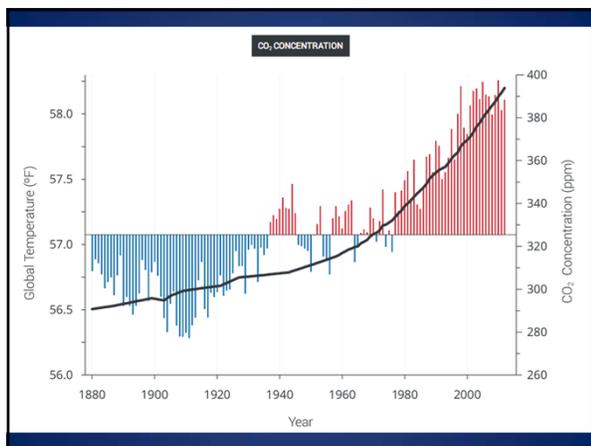
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## The future's not what it used to be...

- Historical data
  - Long term (paleo-climate)
  - Observations from weather stations (NOAA's National Climate Data Center)
  - Gridded observations
- Projections for future scenarios
  - Global Climate Models
  - Statistically Downscaled Global Climate Models
  - Regional Climate Models

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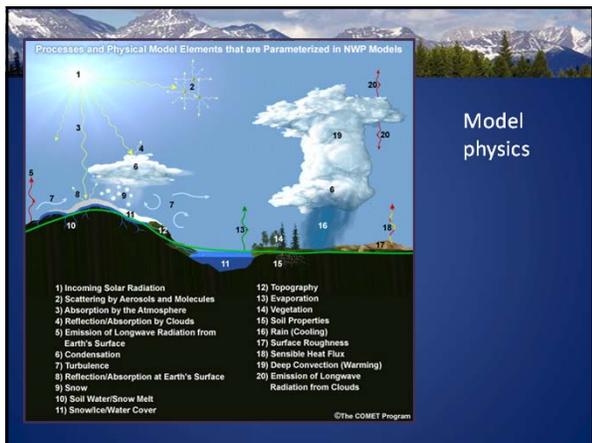
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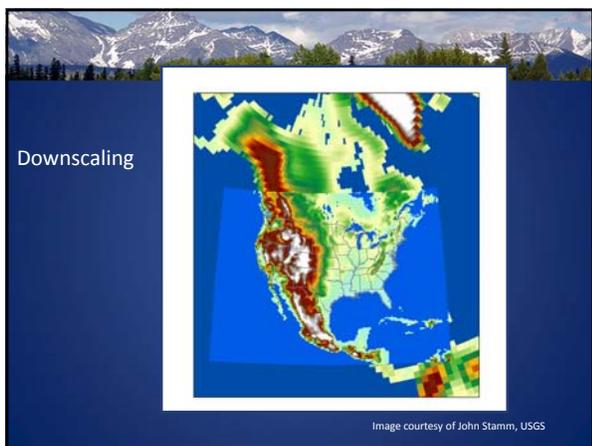
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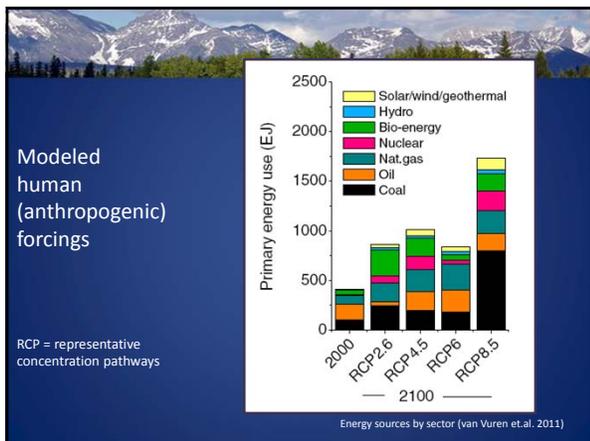
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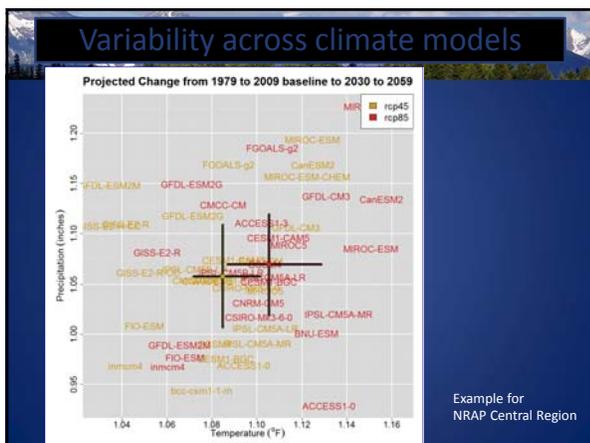
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**Projecting Global Climate Models**

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

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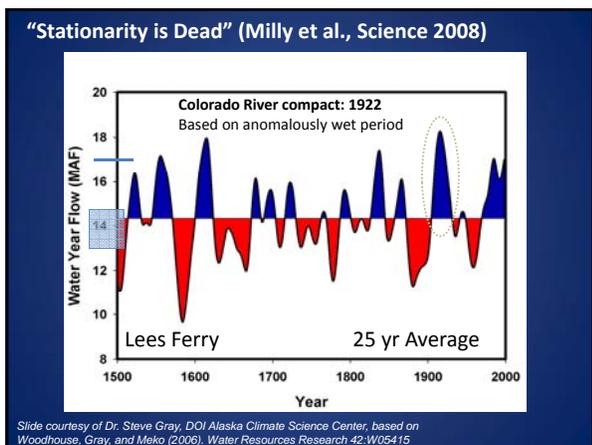
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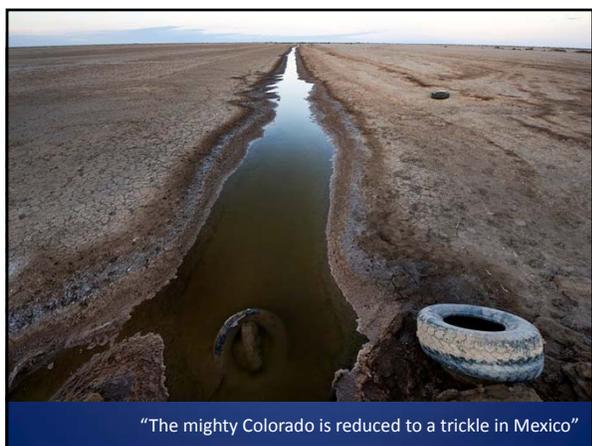
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“The mighty Colorado is reduced to a trickle in Mexico”

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## Some important terms & 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)
- Downscaling: statistical or dynamical

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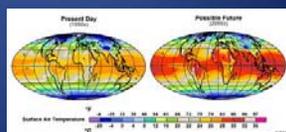
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## <http://nca2014.globalchange.gov/downloads>

- **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




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**Forcings:  
emissions**

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### Model physics

The Nature Conservancy  
Protecting nature. Promoting life.

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Analysis Area: United States | Time Period: Past 50 Years | Measurement: Average Temperature | Resolution: State

Future Climate Model: IPCC Fourth Assessment | Ensemble Average: Ensemble Average

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

Map of the United States showing projected temperature changes by the 2080s. A color scale on the right ranges from 0 to 14 degrees Celsius. The map shows significant warming across the entire country, with the most intense warming (red/orange) in the central and southern regions.

ESRI | Tel: 42.28° Lat: -143.59°

Data Source: Best climate projections downloaded by Miguez-Macho (2007) Santa Clara University. For more information see [Miguez-Macho](#).

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### Output

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### Scale

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Analysis Area: United States | Time Period: End Century (2080s) | Measurement: Average Temperature | Resolution: State

Future Climate Model: IPCC Fourth Assessment | Ensemble Average: Ensemble Average

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

Map of the United States showing projected temperature changes by the 2080s. A color scale on the right ranges from 0 to 14 degrees Celsius. The map shows significant warming across the entire country, with the most intense warming (red/orange) in the central and southern regions.

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### Orange County, CA

- July max temp:
- January min:
- Annual Precip:

Source for county summaries are from  
National Climate Change Viewer (NCCV)  
[http://www.usgs.gov/climate\\_landuse/clu\\_rd/apps/nccv\\_viewer.asp](http://www.usgs.gov/climate_landuse/clu_rd/apps/nccv_viewer.asp)  
historical data from 1950 – 2005

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### Raleigh, NC

- July max temp:
- January min:
- Annual Precip:

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### Bayfield, Wisconsin

- July max temp:
- January min:
- Annual Precip:

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### La Crosse, Wisconsin

- July max temp:
- January min:
- Annual Precip:

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### Segue to ecological response modeling

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

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### 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.

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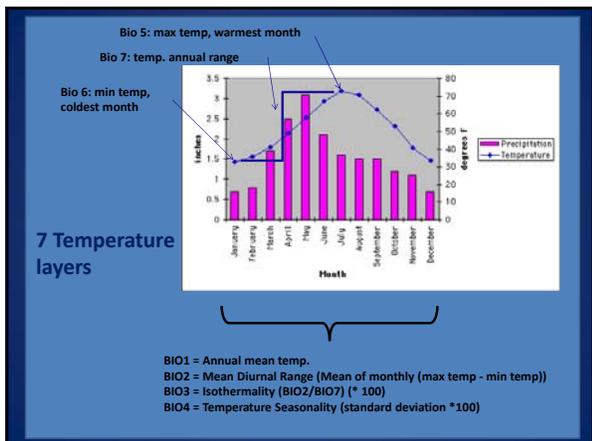
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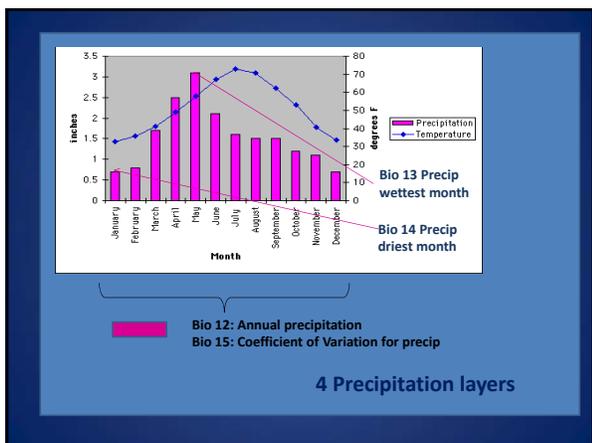
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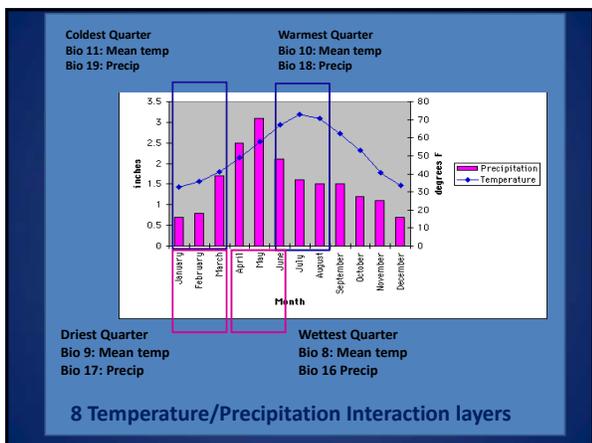
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### ... and there are others

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

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### More information

#### MetEd

through the University Corporation for Atmospheric Research:  
Teaching and Training Resources for the Geoscience Community  
<https://www.meted.ucar.edu/>

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The screenshot shows the ClimateDataGuide website interface. At the top, it says "ClimateDataGuide inform • compare • discover". Below that is a navigation bar with "CLIMATE DATA", "ANALYSIS TOOLS", "MODEL EVALUATION", "EXPERT CONTRIBUTORS", and "ABOUT". The main content area is titled "DAYMET: DAILY SURFACE WEATHER AND CLIMATOLOGICAL SUMMARIES". It features a map of the United States showing precipitation data for 2010. To the right of the map, there is a text box describing the data: "Developed by Dr. Peter E. Thornton to fulfill the need for daily climatological data necessary for plant growth model inputs, Daymet generates daily, gridded surfaces of temperature, precipitation, humidity, and radiation over large regions and takes into account areas of complex terrain." Below this, there is a "KEY STRENGTHS:" section with a bullet point: "• Very high resolution over area covered." On the right side of the page, there is a "RELATED PAGES" section with a link to "PRISM High-Resolution Spatial Climate Data for the United States: Max/min temp, dewpoint."

<https://climatedataguide.ucar.edu/climate-data>

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