Using a library of downscaled climate projections to teach climate change analysis

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- Overview of Dataset
- Climate change activity

Applications

- Courses
  - General education (hands on!)
  - Climatology
  - Climate Change
  - Statistics
- Research

CMIP3 Dataset

- Coupled model intercomparison project – third one
- Used to support the IPCC Fourth Assessment Report (2007)
- 25 Atmosphere-Ocean Global Climate Models
- Multiple time output (3hr, daily, monthly)
- Multiple variables (standard variables, extremes)
- Multiple simulations (scenarios, 2xCO2, 4xCO2 etc.)

Data Availability Summary (as of 27 February 2008)

shaded area indicates that at least some but not necessarily all fields are available for data type indicated

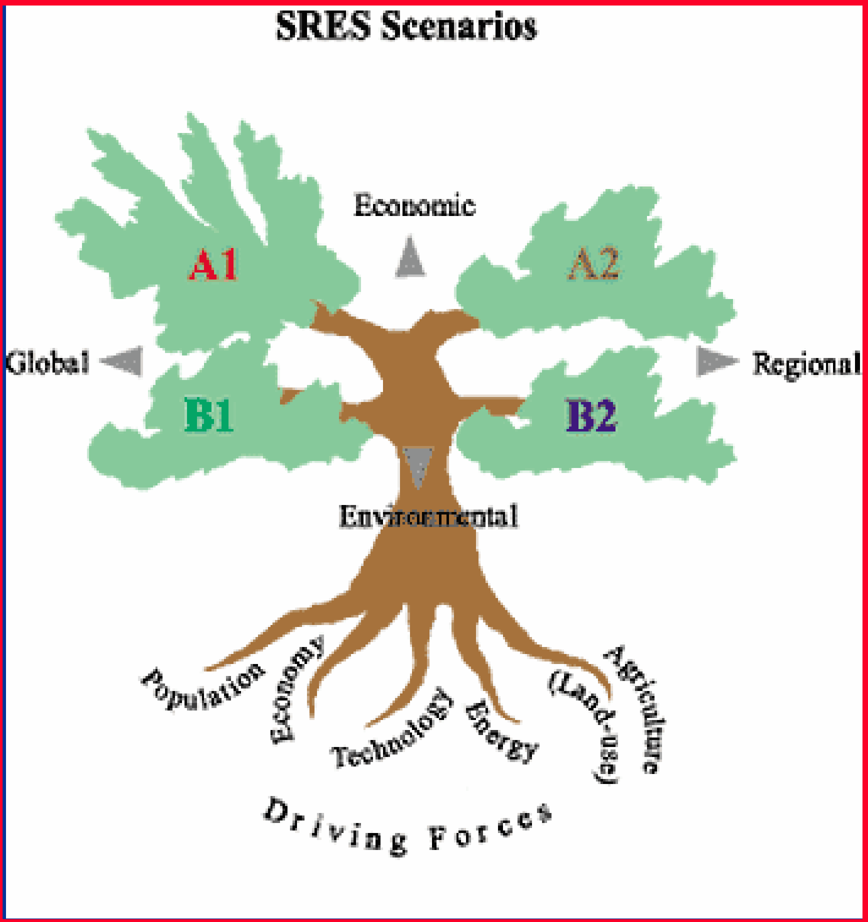
- time-independent land surface
- >1 | 1 monthly-mean atmosphere
- daily-mean atmosphere
- 3-hourly atmosphere
- time-independent ocean
- >1 | 1 monthly-mean ocean
- >1 | 1 Extreme Indices
- Forcing
- ISCCP Simulator

	Picntrl	PDcntrl	20C3M	Commit	SRESA2	SRESA1B	SRESB1	1%to2x	1%to4x	Slab cntl	2xCO2	AMIP
BCC-CM1, China												
BCCR-BCM2.0, Norway												
CCSM3, USA												
CGCM3.1(T47), Canada												
CGCM3.1(T63), Canada												
CNRM-CM3, France												
CSIRO-Mk3.0, Australia												
CSIRO-Mk3.5, Australia												
ECHAM5/MPI-OM, Germany												
ECHO-G, Germany/Korea												
FGOALS-g1.0, China												
GFDL-CM2.0, USA												
GFDL-CM2.1, USA												
GISS-AOM, USA												
GISS-EH, USA												
GISS-ER, USA												
INGV-SXG, Italy												
INM-CM3.0, Russia												
IPSL-CM4, France												
MIROC3.2(hires), Japan												
MIROC3.2(medres), Japan												
MRI-CGCM2.3.2, Japan												
PCM, USA												
UKMO-HadCM3, UK												
UKMO-HadGEM1, UK												

All Variables

Variable	Long Name	Standard Name
cdd	Maximum Number of Consecutive Dry Days	N/A
cl	Cloud Fraction	cloud_area_fraction_in_atmosphere_layer
clisccp	Cloud Fraction as Calculated by the ISCCP Simulator	isccp_cloud_area_fraction
clivi	Column Integrated Cloud Ice Content	atmosphere_cloud_ice_content
clt	Total Cloud Fraction	cloud_area_fraction
clwvi	Column Integrated Cloud Water Content	atmosphere_cloud_condensed_water_content
etr	Intra-Annual Extreme Temperature Range	N/A
evspsblveg	Evaporation from Vegetation Canopy	water_evaporation_flux_from_canopy
fd	Total Number of Frost Days in Year	N/A
gsl	Growing Season Length	N/A
hfcorr	Heat FLux Correction	heat_flux_correction_where_ocean
hfls	Surface Latent Heat Flux	surface_upward_latent_heat_flux
hfogo	Northward Ocean Heat Transport	northward_ocean_heat_transport
hfsib	Upward Heat Flux at Base of Sea Ice	upward_sea_ice_basal_heat_flux
hfss	Surface Sensible Heat Flux	surface_upward_sensible_heat_flux
htovdiff	Northward Diffusive Heat Transport by Ocean	northward_ocean_heat_transport_due_to_diffusion
htovgyre	Northward Gyre Heat Transport by Ocean	northward_ocean_heat_transport_due_to_gyre
htovovrt	Northward Ocean Heat Transport by Overturning	northward_ocean_heat_transport_due_to_overturning
hur	Relative Humidity	relative_humidity
hus	Specific Humidity	specific_humidity
huss	Surface Specific Humidity	specific_humidity
hwdi	Heat Wave Duration Index	N/A
mrfso	Soil Frozen Water Content	soil_frozen_water_content
mrro	Surface and Subsurface Runoff	runoff_flux
mrros	Surface Runoff	surface_runoff_flux

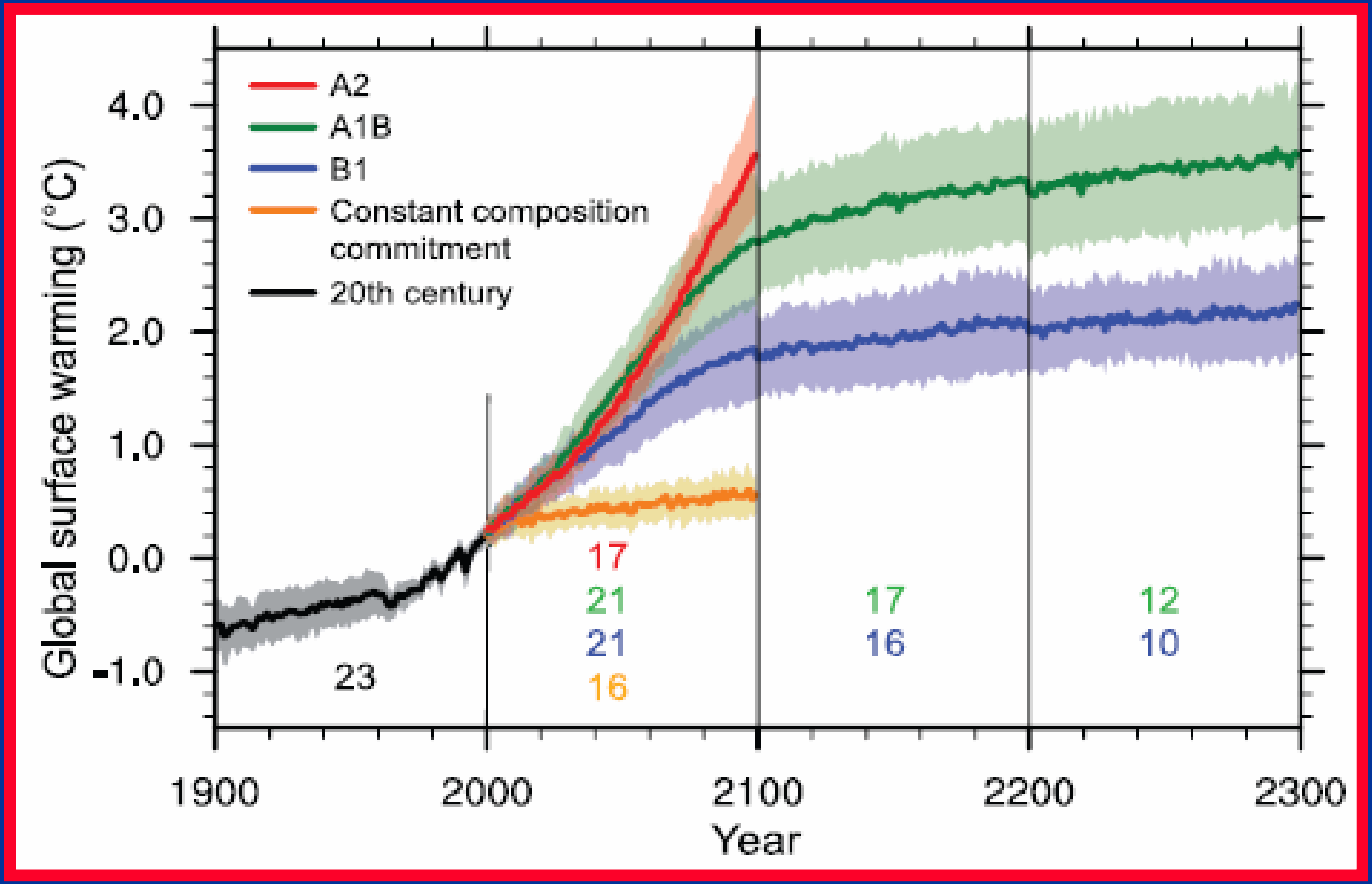
The IPCC Special Report on Emissions Scenarios (SRES)



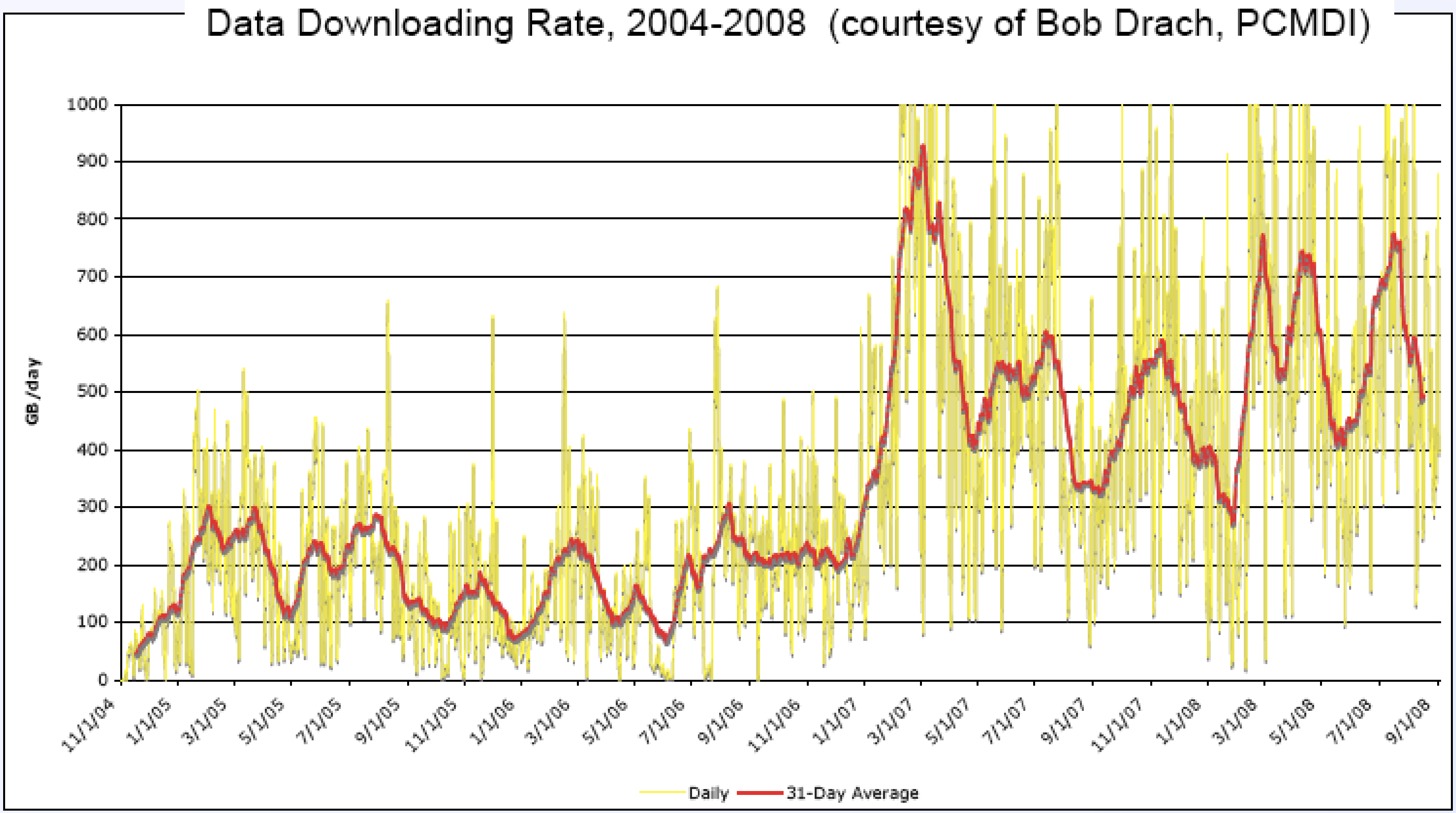
Climate models require “boundary conditions,” prescribed levels of future greenhouse and other trace gases and aerosols. But this requires knowledge about how human societies might evolve in the future.

To address this need, a number of *possible* pathways for societal development, and their implications for the composition of the atmosphere, have been explored in the IPCC SRES.

IPCC AR4: Some findings



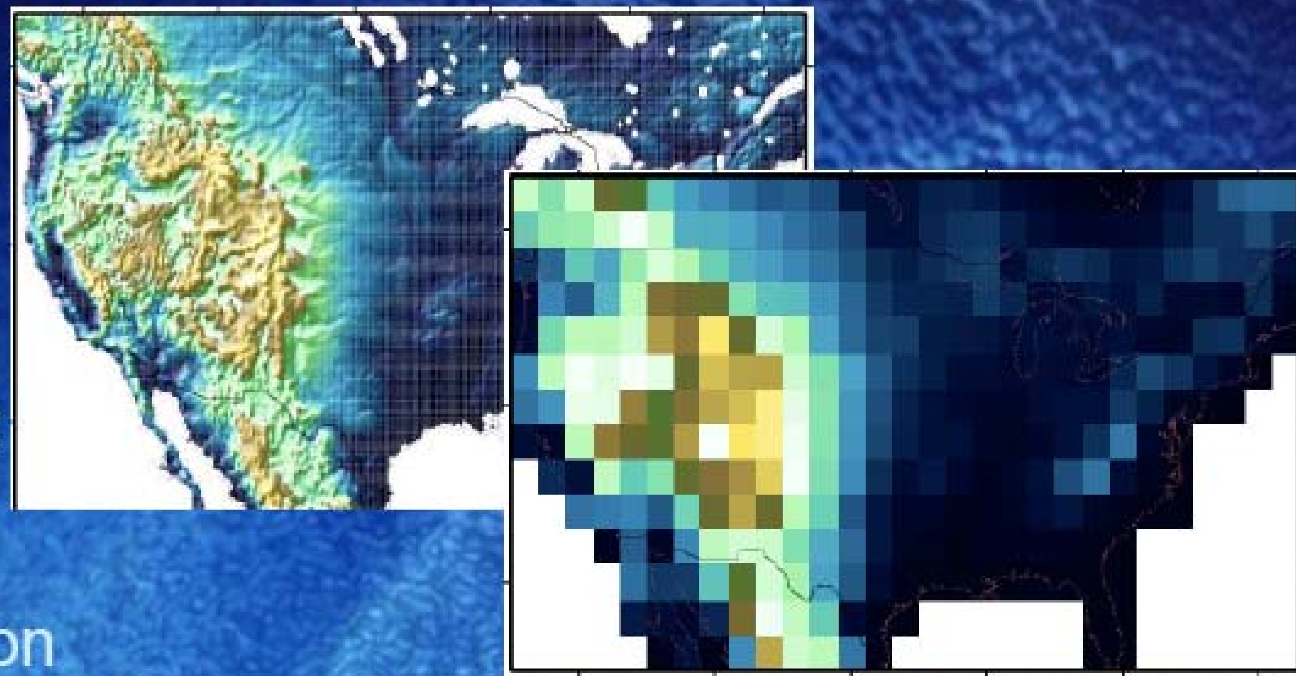
Global mean surface temperature projections, based on various *scenarios.*



CMIP3 Dataset: 35 TB: Downloaded over 300 TB

Statistical Downscaling

- GCM problems:
  - Scale incompatibility between GCM and impacts
  - Regional Processes not well represented



- Resolved by:
  - Bias Correction
  - Spatial Downscaling

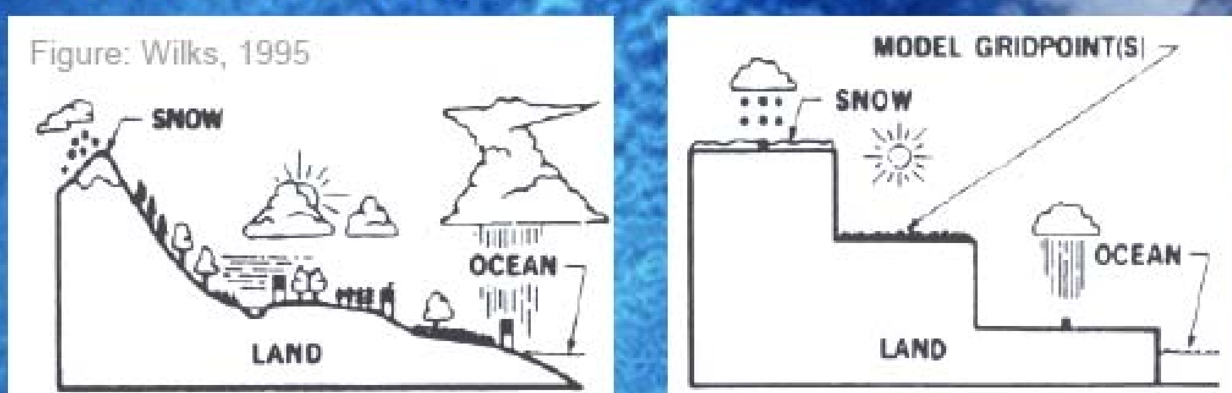


Figure: Wilks, 1995

Statistically Downscaled CMIP3 Climate Projections

- 112 Simulations (20th century, A1B, B1, A2 and ensemble members)
- Monthly averaged data (1950-2100)
- Downscaled to the Continental USA
- 1/8 degree resolutions (~ 12 km)
- Temperature and precipitation
- Web-based interface

Library

http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/

Google: Ed Maurer data

Credit: Prof. Ed Maurer, Santa Clara University
http://www.engr.scu.edu/~emaurer/

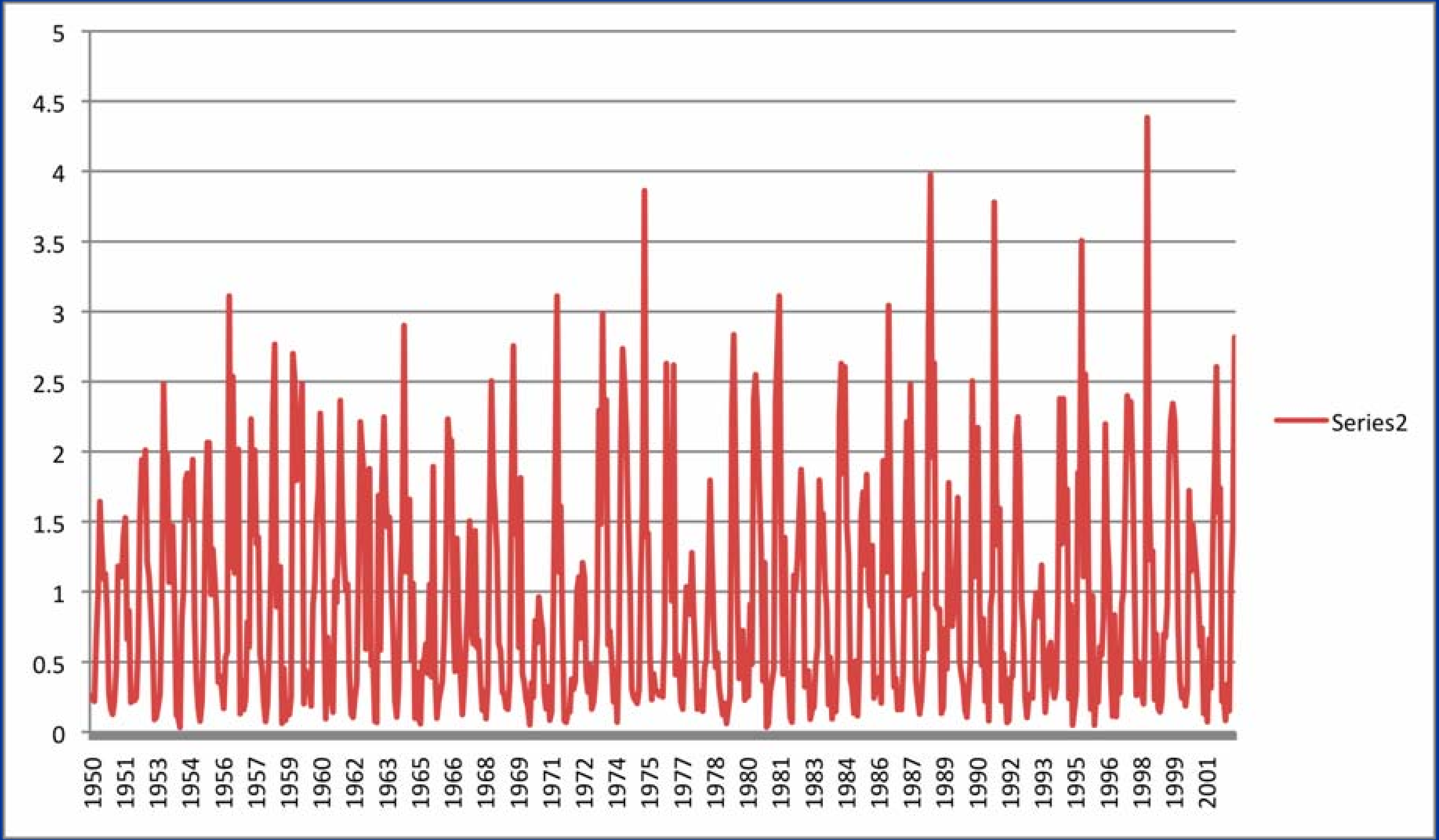
Classroom Activities

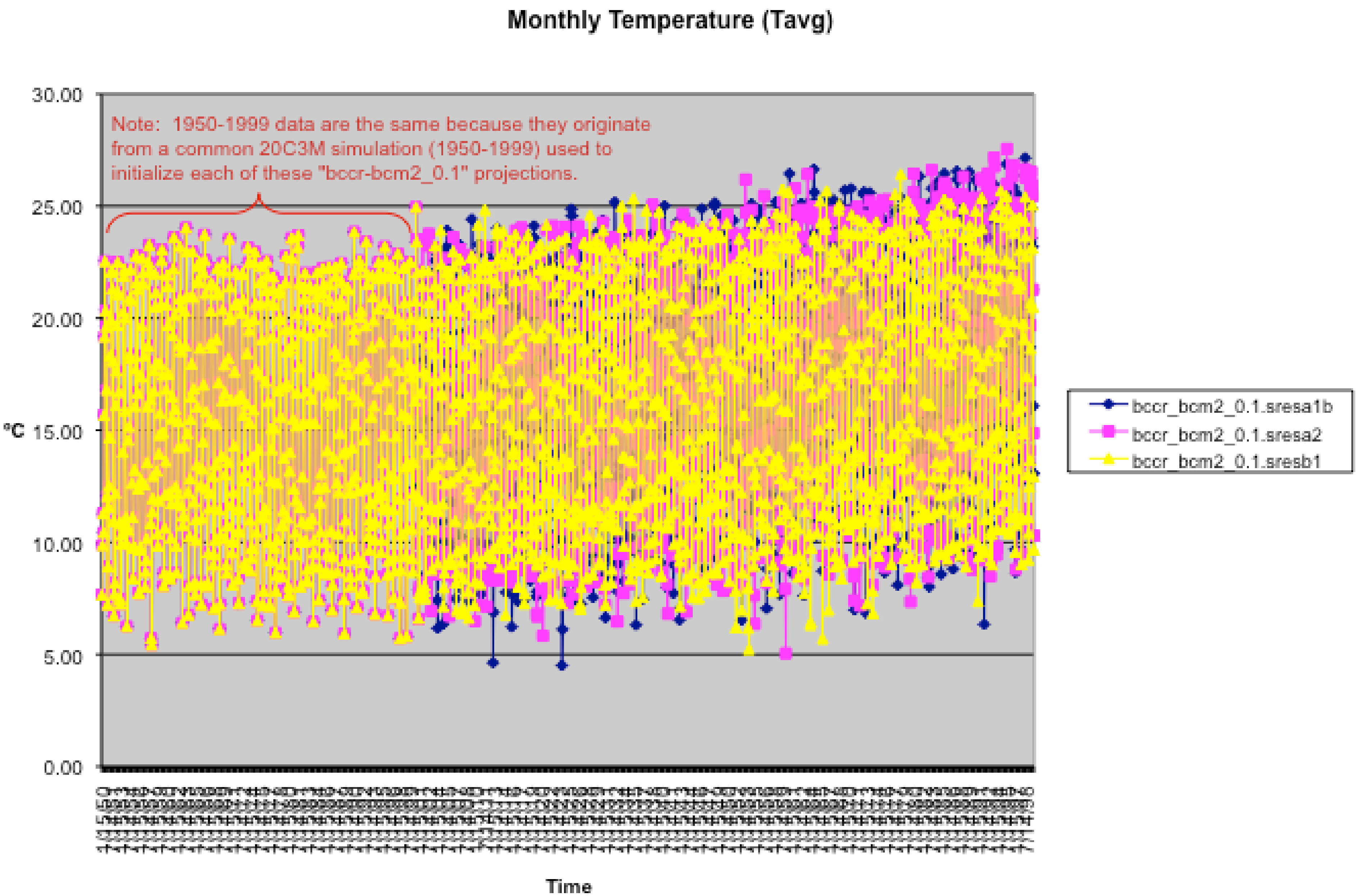
- Library is simple to use – easy to access data!
- Useful for various levels of courses
- Three examples
  1. General education course (Excel)
  2. Statistics course using Matlab/IDL/IDV
  3. Climate Course (Excel/Matlab/IDL)

Example 1

- **Course: General education (non science)**
  - Plot out the local temperatures for your hometown from one model using three scenarios for the years 1950-2100
  - Plot out the average July temperatures in the 1950s compared to the 2050s
  - Simple plots (e.g. Excel)

Precipitation




Monthly Temperature (Tavg)
Note: 1950-1999 data are the same because they originate from a common 20C3M simulation (1950-1999) used to initialize each of these "bccr-bcm2_0.1" projections.
30.00
25.00
20.00
°C 15.00
10.00
5.00
0.00
Time
bccr_bcm2_0.1.sresa1b
bccr_bcm2_0.1.sresa2
bccr_bcm2_0.1.sresb1

Example 2

- **Course: Statistical climatology**
- Download a single model of temperatures for the state of your choice
  - Compute and plot MAM mean temperatures for 1950-2000 and 2050-2099
  - Determine if those means are statistically different
  - Compute and plot state average temperature
  - Compute trend and trend uncertainty

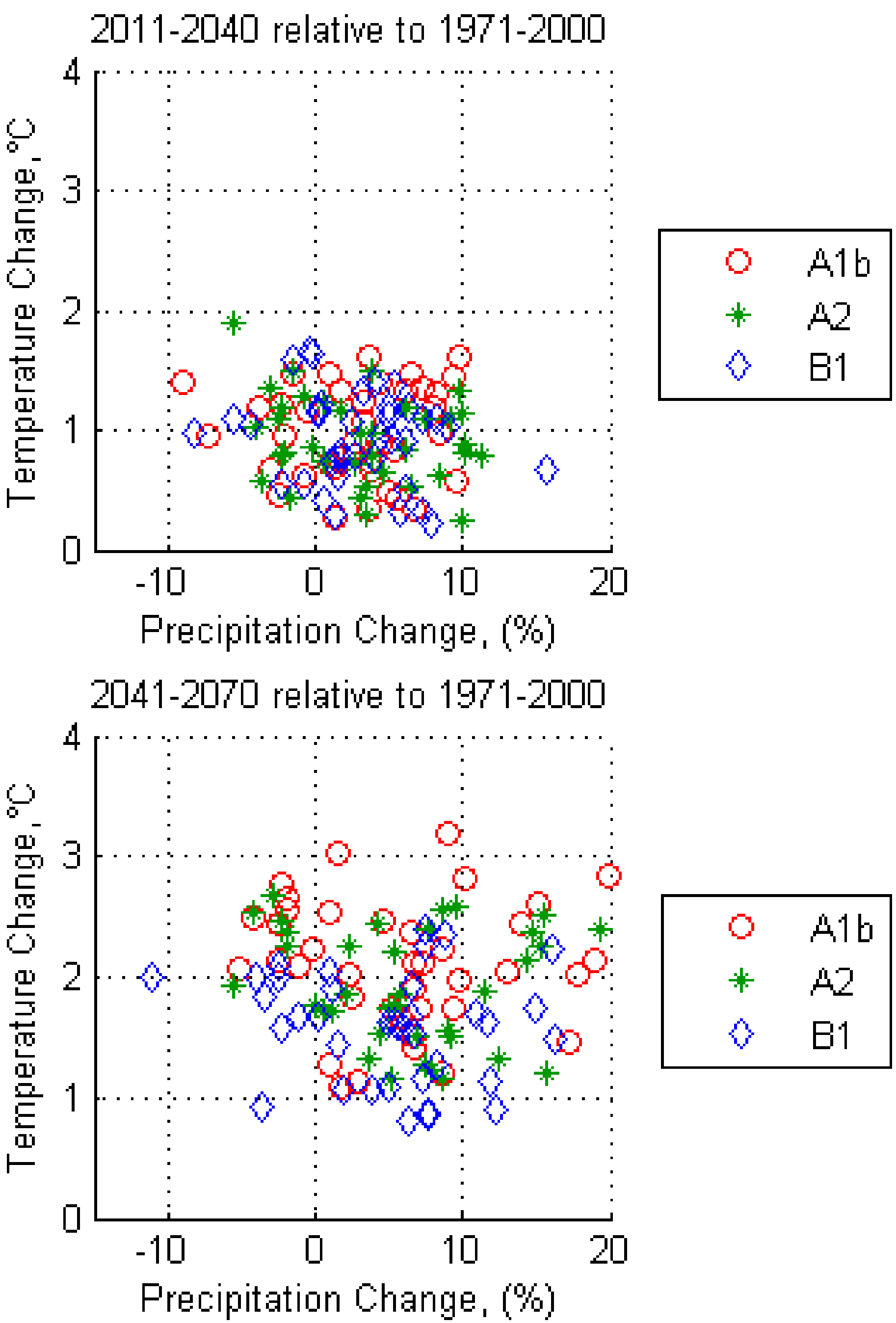
Example 3

- **Course: Climate change course**

Project

- Use CMIP3 library to study how temperature and precipitation may change in the 21st century
  - Compute trends and trend uncertainties in temperature
  - Compare extremes in temp and precip.
  - Explore relationship between temperature change and precip change

Precipitation and Temperature



Array experience

- For single point
  - CSV files – ideal for Excel, easy and fast
- For areas
  - NetCDF files – Arrays
    - Temp1(1800,33,49): 1800 months, 33 lats, 49 lons
    - Temp2(3,1800,33,49) - now with three scenarios
  - Exercise: convert Temp2 to Temp3
    - Temp3(3,12,150,33,49) or (scenario,month,yr,lat,lon)

Data experience

- Library will calculate area and time averages
- Students can do these calculations themselves
- Missing data (-999.0) for areas in ocean
- For example
  - Calculate California average annual temperatures for the 21st century
    - Remove missing data
    - Compute annual mean

Other Useful Datasets

- Global Dataset (downscaled)

  Monthly Temp and Precip

http://www.engr.scu.edu/~emaurer/global_data/

- USA Observations (1950-1999)

  Daily and Monthly Data (Temp and Precip)

http://www.engr.scu.edu/~emaurer/data.shtml

Today's activity

Using the climate model library, answer the following questions.

For your favorite town or state

1. Plot out your data 1950-2100
2. Estimate by how much January temperatures will change between the 1990s compared to the 2090s for the A1B scenario.
3. In the 2090s, estimate the difference in July temperatures between the high emission scenario and the low emission scenario.