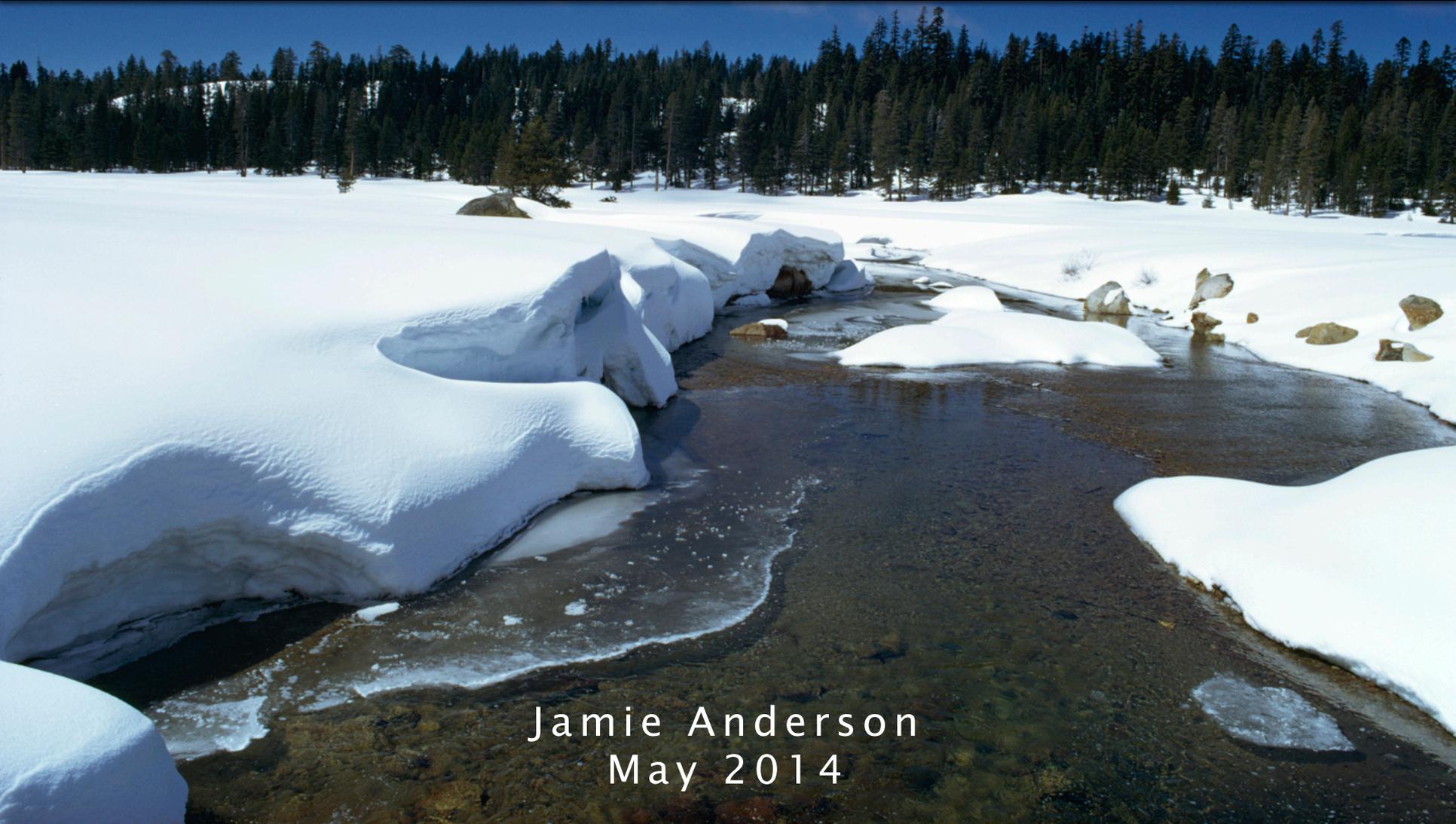




Climate Modeling



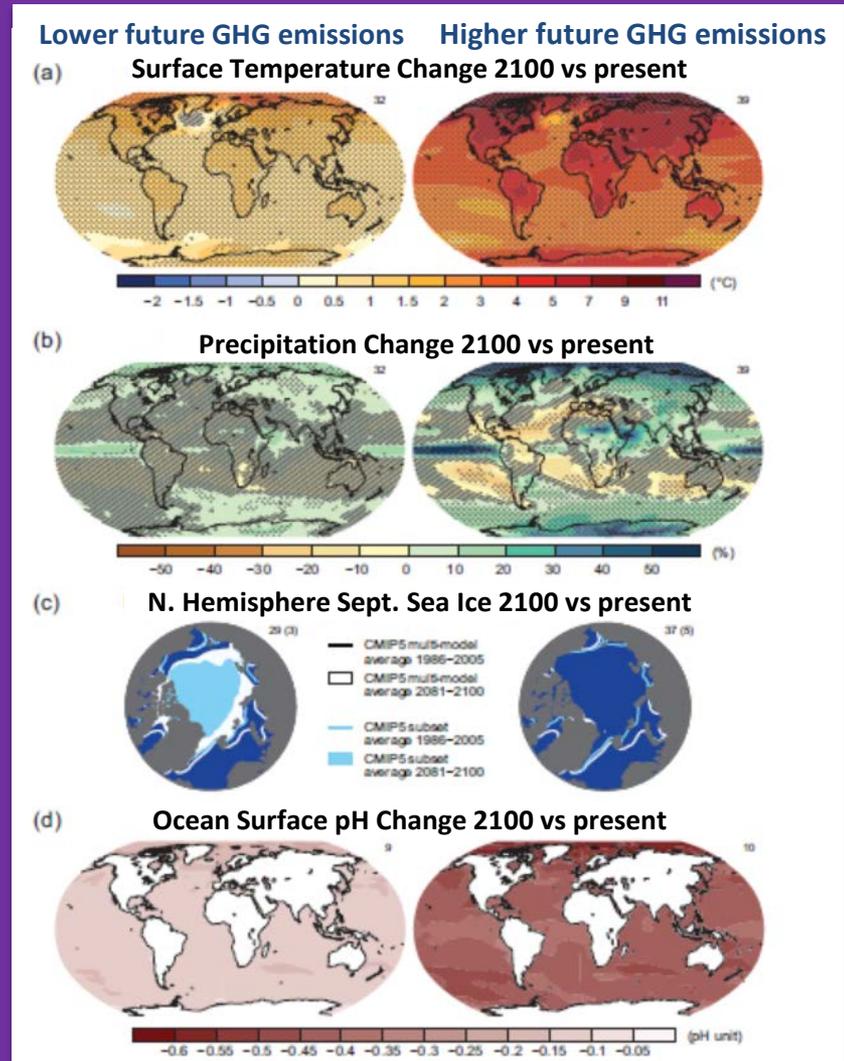
Jamie Anderson
May 2014

Climate Monitoring vs Climate Modeling

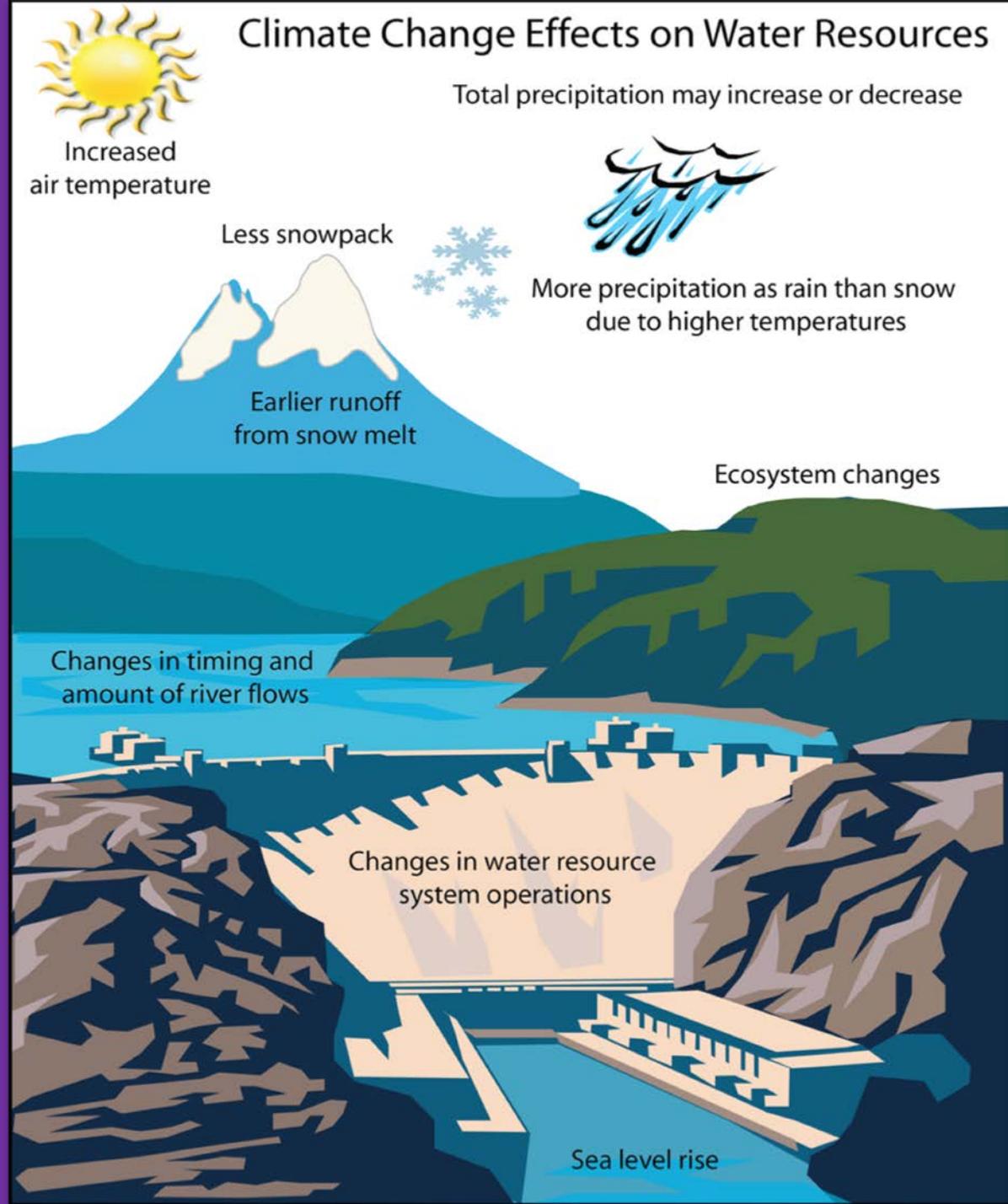
Monitoring tells us how the current climate has/is changing



Modeling tells us how the future climate might change



Why are climate models important for DWR?



What is a model?

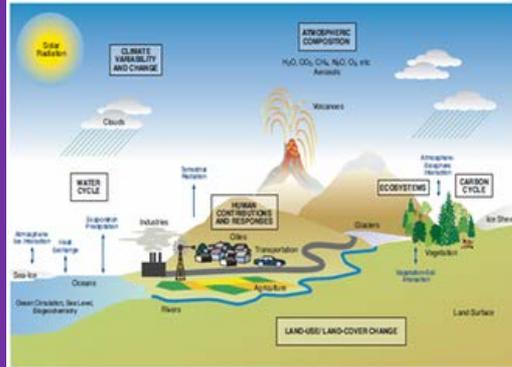
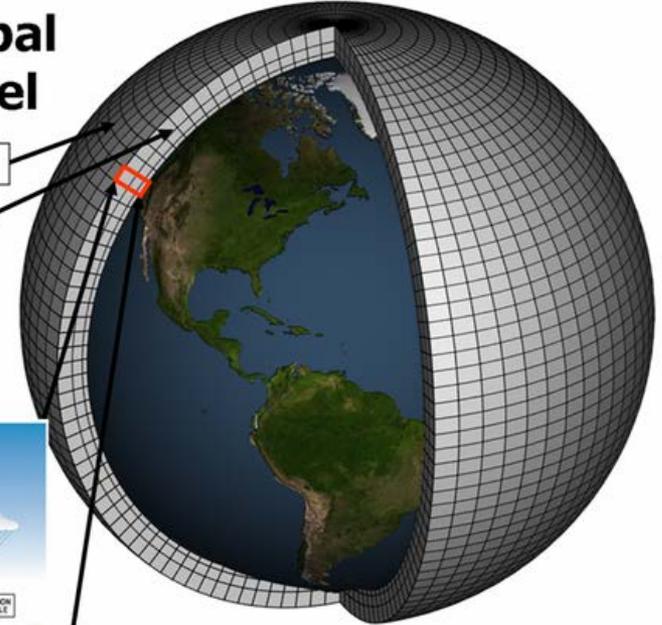
Mathematical representation on a computer



Schematic for Global Atmospheric Model

Horizontal Grid (Latitude-Longitude)

Vertical Grid (Height or Pressure)



Building a Global Climate Model

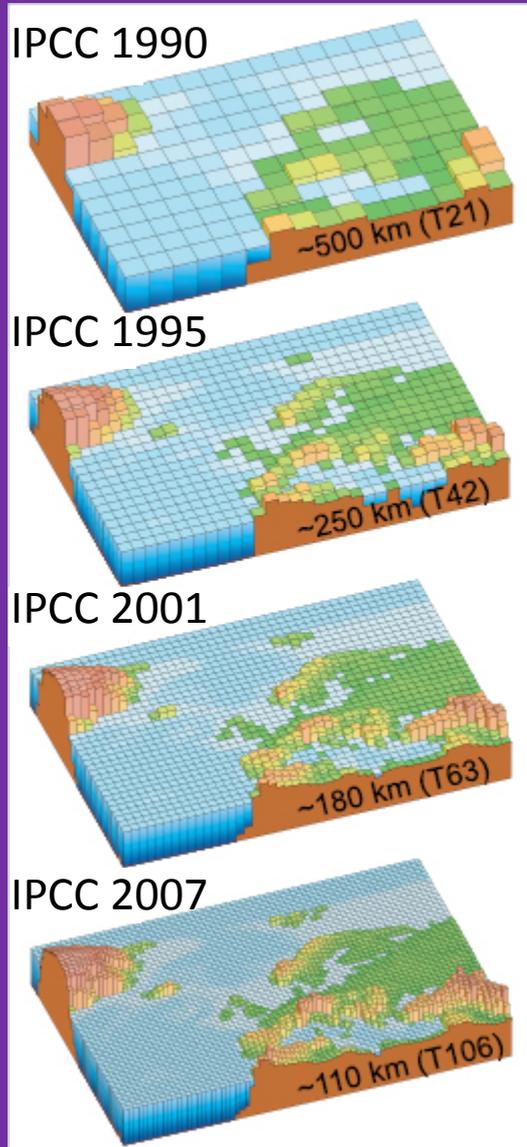
National Earth Science Teachers Association

http://www.windows2universe.org/earth/climate/climate_modeling.html

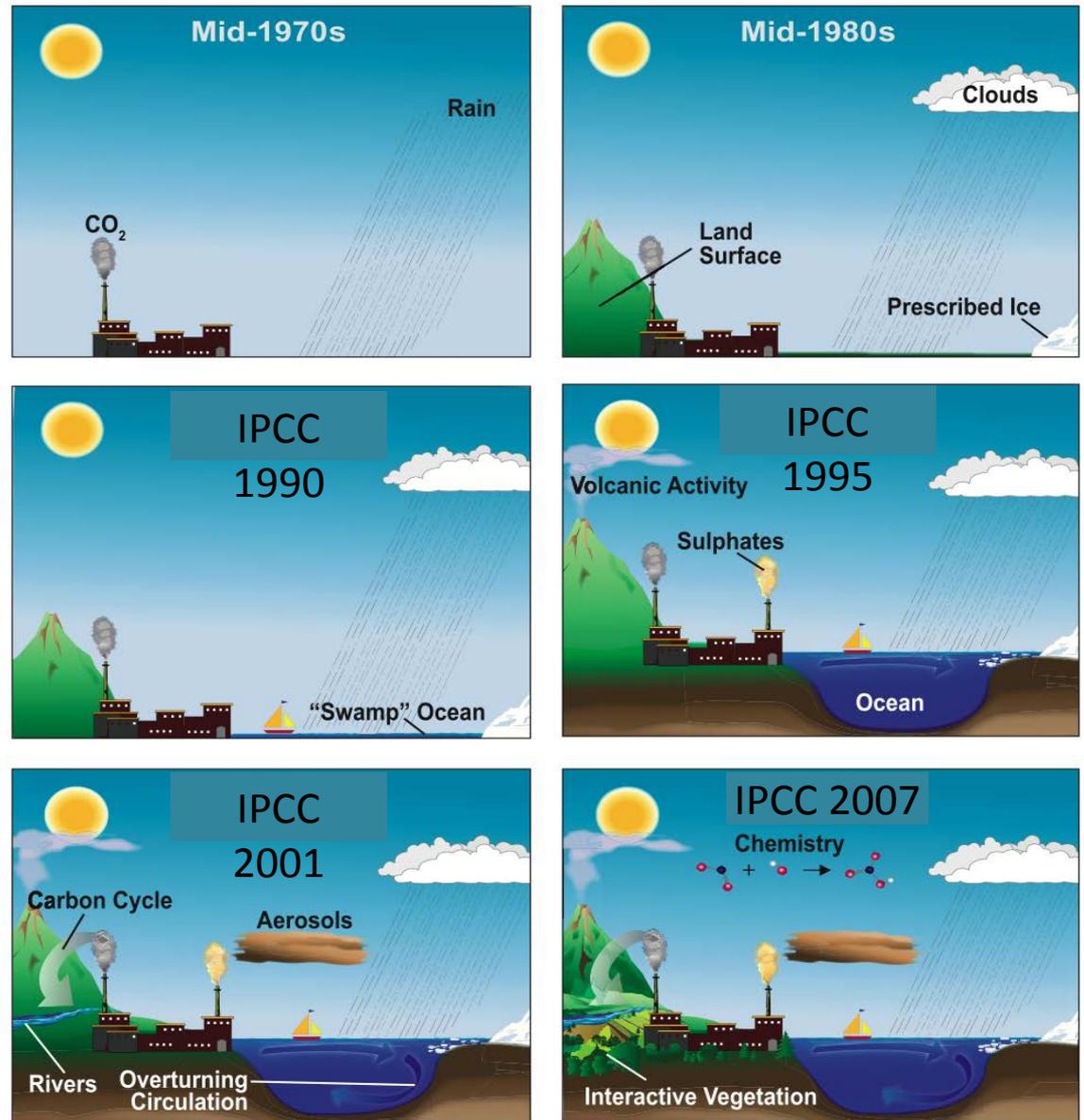


More Spatial Resolution

More Land/Ocean/Atmosphere Processes



The World in Global Climate Models



IPCC = Intergovernmental Panel on Climate Change
Climate Change Assessment reports every 5 years

Processes in Climate Models

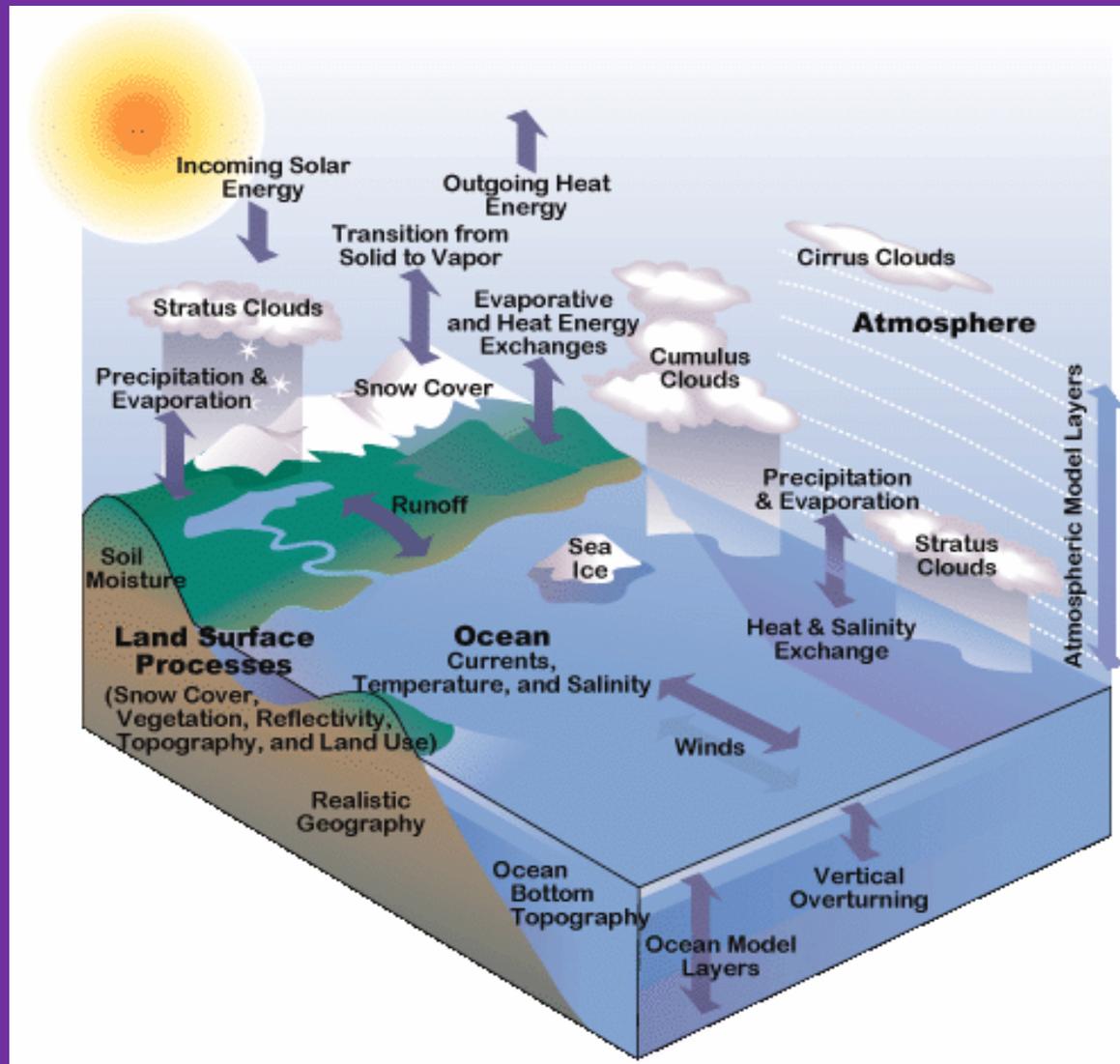
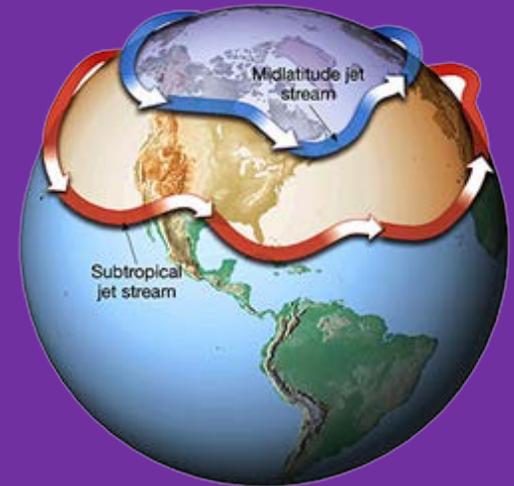


Image from National Center for Atmospheric Research

Why so hard to do?



- ❖ *Future Uncertainty*
- ❖ *Data collection*
- ❖ *Computational resources needed*
- ❖ *Computer model variability*
- ❖ *Feedback mechanisms*
- ❖ *Spatial Resolution*



Trivia Time: How long does it take a modern global climate model to simulate 150 years?



Climate models are used to **explore** possible future changes in climate



Climate models don't **predict** future changes in climate

Weather Modeling vs Climate Modeling

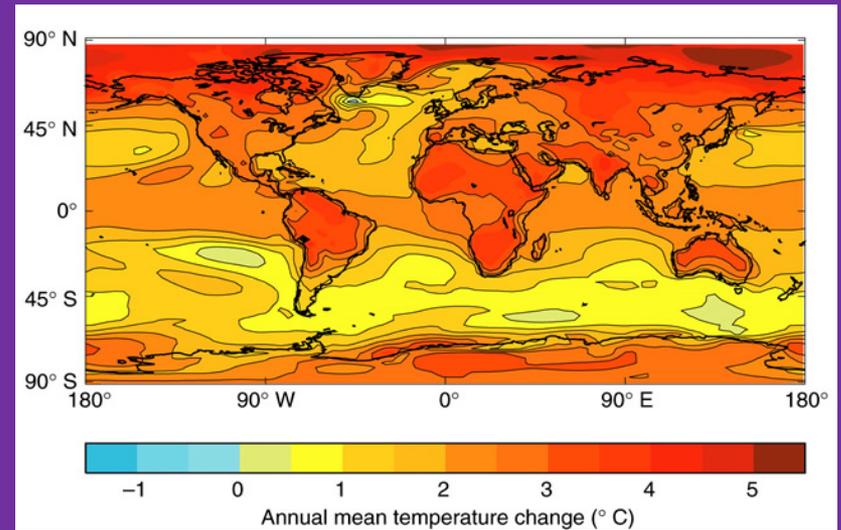
Weather Forecasting

- What will the weather be on a specific day in a specific place
- Short term (7-10 days)



Future Climate Simulations

- What will the climate trends be in a region in the future
- Long term (100 years)





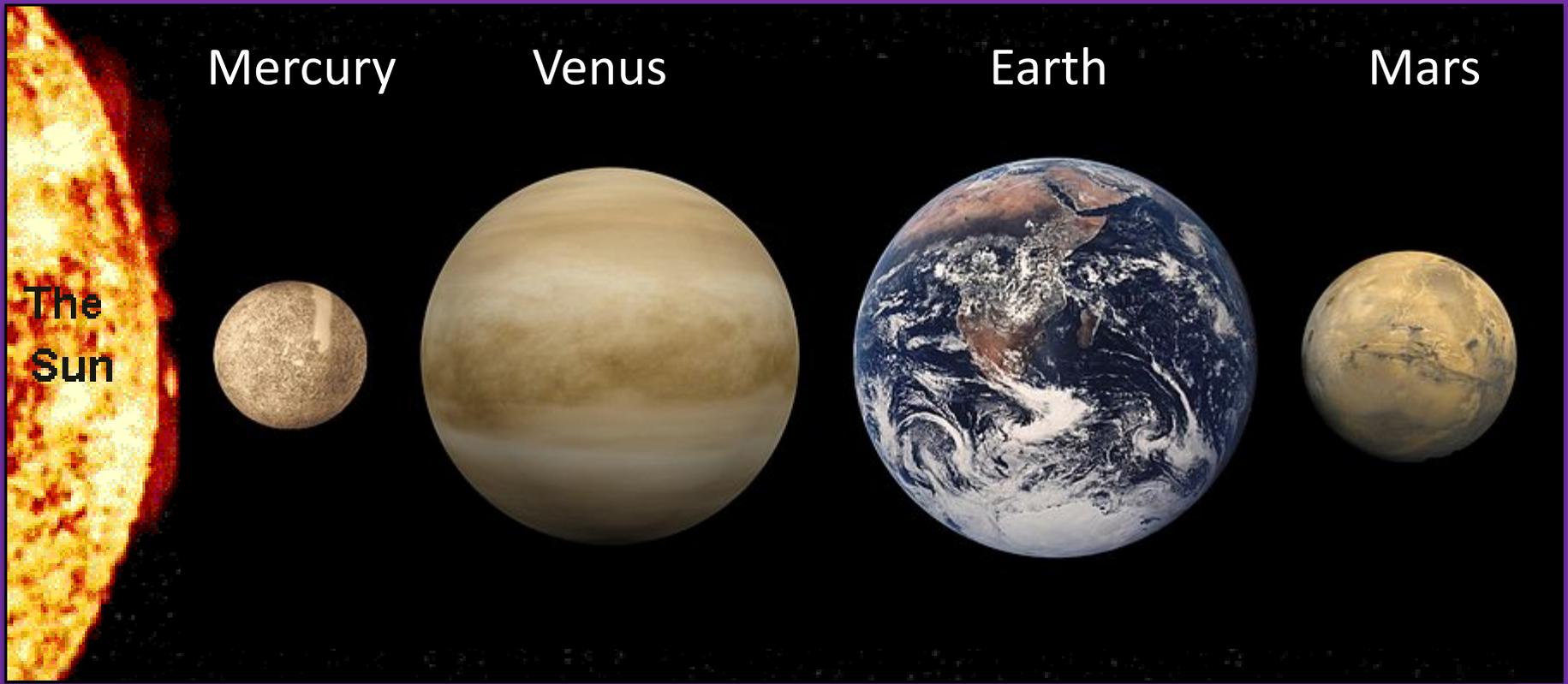
Climate models are used to **explore** possible future changes in climate



Climate models don't **predict** future changes in climate



Scientists & planners use information from **many models** to make decisions



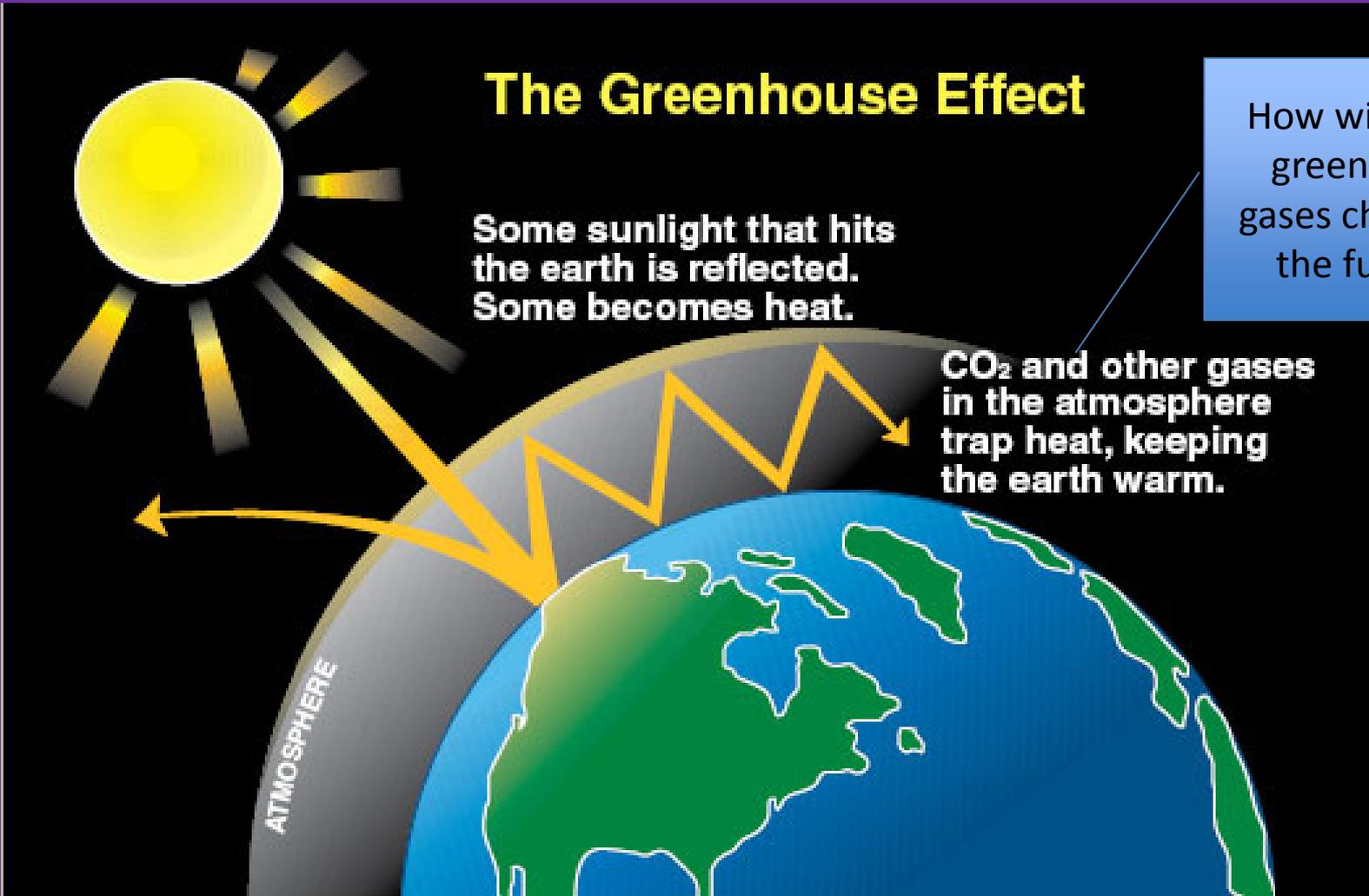
Which planet is the warmest? Why?

The Greenhouse Effect

Some sunlight that hits the earth is reflected. Some becomes heat.

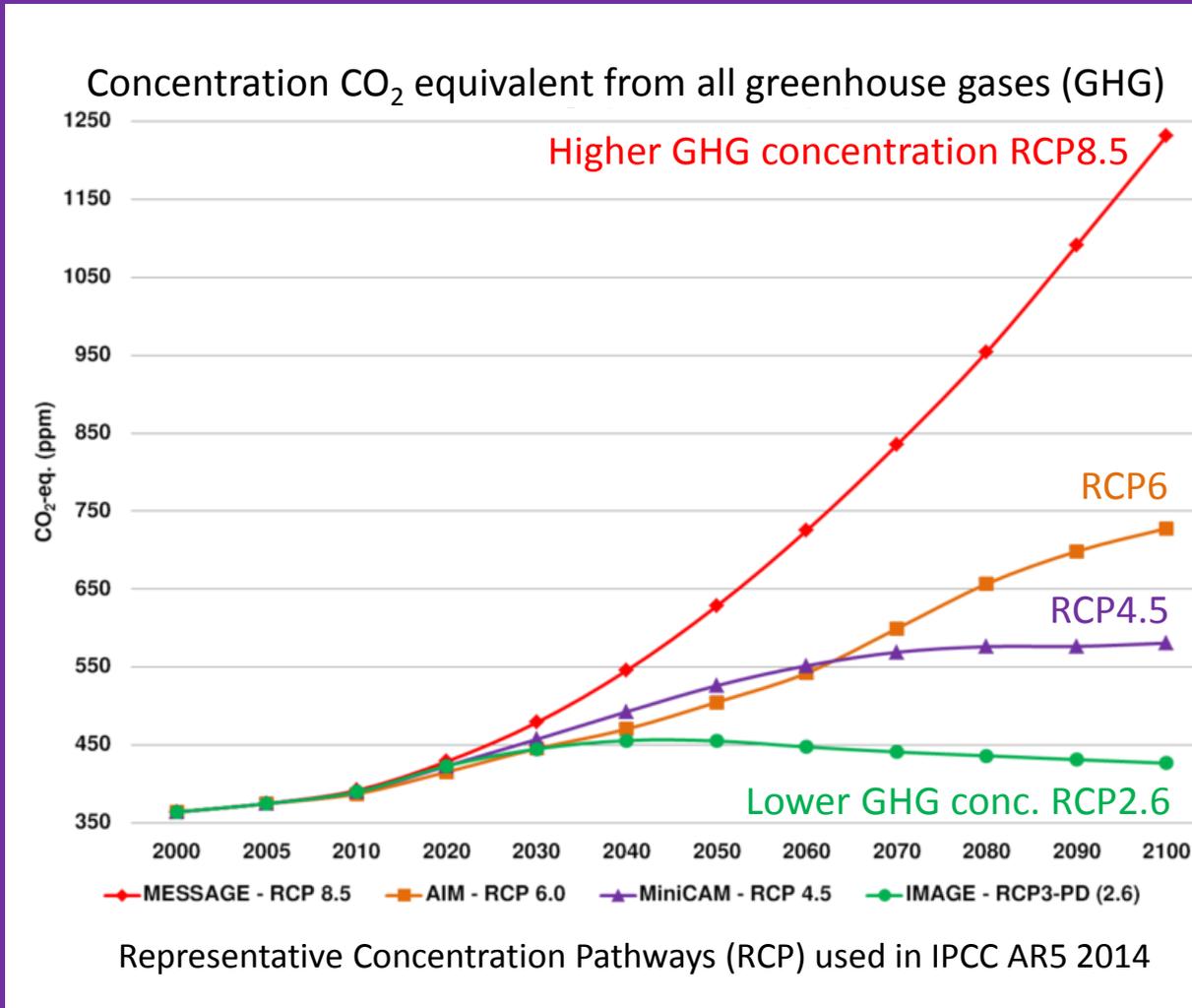
CO₂ and other gases in the atmosphere trap heat, keeping the earth warm.

How will these greenhouse gases change in the future?



Greenhouse Gases in Climate Models

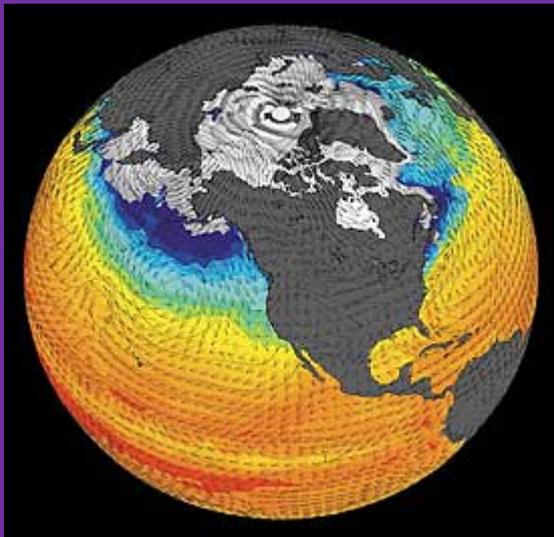
4 scenarios for future Greenhouse Gas Concentrations



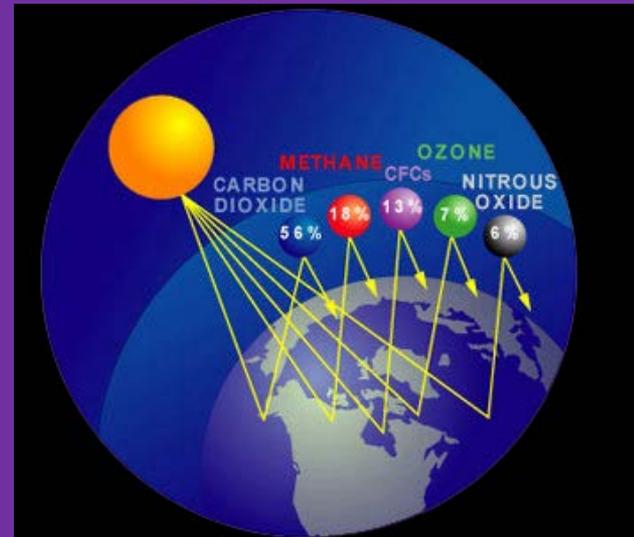
IPCC AR5 = Intergovernmental Panel on Climate Change 5th Assessment Report on Climate Change
RCP = Representative Concentration Pathway for future greenhouse gas concentrations, 2.6, 4.5, 6.0, and 8.5 W/m² in 2100
RCP overview: <http://link.springer.com/article/10.1007/s10584-011-0148-z>



Climate models are used to **explore** possible future changes in climate.



Global Climate Model



Estimate of Future Greenhouse Gases

Climate Change Scenario Activity

4 volunteers needed



Available Climate Change Scenarios

From 2007 IPCC [CMIP3]

- 112 available scenarios (GCM x Greenhouse Gas)
- Subset of 12 scenarios recommended by California's Climate Action Team

From 2014 IPCC [CMIP5]

- More available scenarios (200+)
- More variables available
- Higher spatial and temporal resolution
- Models include improved representations of processes
- Regional impacts in California are similar to CMIP3

Future Climate Projections

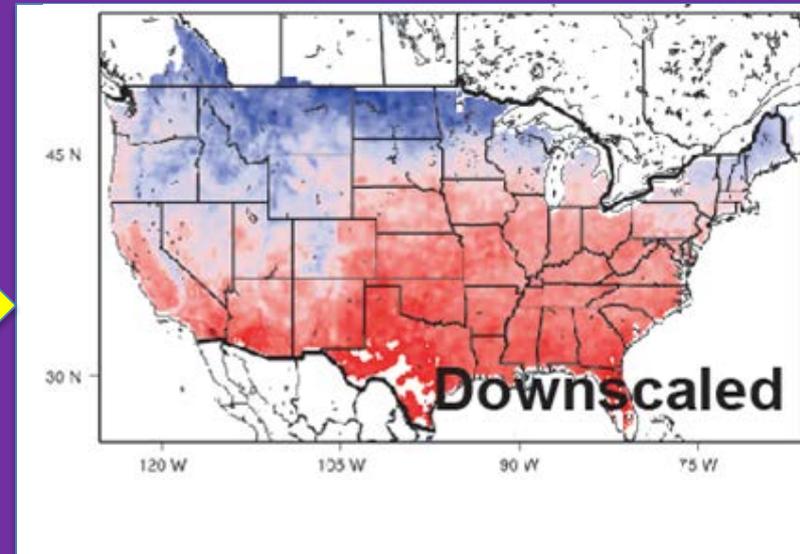
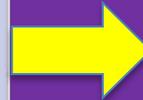
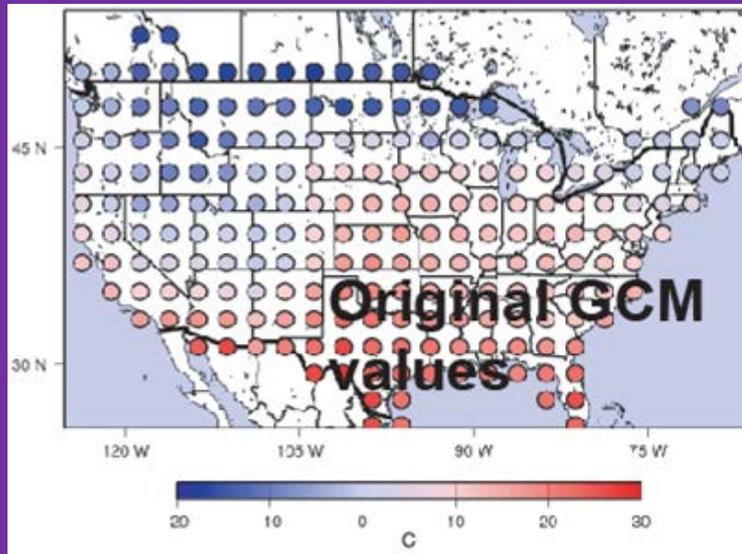
National Center for Atmospheric Research

<http://www.youtube.com/watch?v=U9YAzrmeOGI>



Downscaling

Converting **Global** model output
into **Regional or Local** information



More specific, Higher resolution, More useful

Website for Downscaled Climate Change Scenarios

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

The screenshot shows a web browser window with the URL gdo-dcp.ucllnl.org/downscaled_cmip_projections/. The page features logos for RECLAMATION, Santa Clara University, USGS, CLIMATE CENTRAL, and SCRIPPS INSTITUTION OF OCEANOGRAPHY. The main heading is "Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections". A navigation menu includes "Welcome", "About", "Tutorials", "Projections: Subset Request", "Projections: Complete Archives", "Feedback", and "Links". The main content area has a section for "Downscaled CMIP5 climate projections' documentation and release notes available [here](#)." followed by a "Summary" section. The summary text states: "This archive contains fine spatial resolution translations of climate projections over the contiguous United States (U.S.) developed using two downscaling techniques (monthly BCSD Figure 1, and daily BCCA Figure 2), and hydrologic projections over the western U.S. (roughly the western U.S. Figure 3) corresponding to the monthly BCSD climate projections." It also mentions the data is based on global climate projections from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model dataset and the phase 5 (CMIP5) multi-model dataset. A "Purpose" section follows, stating the archive is meant to provide access to climate and hydrologic projections at spatial and temporal scales relevant to watershed and basin-scale decisions. On the right side, there is a figure titled "Figure 1. Central Tendency Changes in Mean-Annual Precipitation over the contiguous U.S. from 1970-1999 to 2040-2069 for BCSD3, BCSD5, and Difference." Below the figure is a map of the contiguous United States showing precipitation changes in percent. A color scale at the bottom of the map ranges from -20 (red) to 20 (blue), with 0 being white. The map shows a mix of red and blue areas, indicating both decreases and increases in precipitation.

Downscaled CMIP3 and CMIP5
Climate and Hydrology Projections

This site is best viewed with [Chrome](#) (recommended) or [Firefox](#). Some features are unavailable when using Internet Explorer. [Requires JavaScript to be enabled.](#)

Welcome About Tutorials Projections: Subset Request Projections: Complete Archives Feedback Links

Downscaled CMIP5 climate projections' documentation and release notes available [here](#).

Summary

This archive contains fine spatial resolution translations of climate projections over the contiguous United States (U.S.) developed using two downscaling techniques (monthly BCSD Figure 1, and daily BCCA Figure 2), and hydrologic projections over the western U.S. (roughly the western U.S. Figure 3) corresponding to the monthly BCSD climate projections.

Archive content is based on global climate projections from the [World Climate Research Programme's \(WCRP's\) Coupled Model Intercomparison Project phase 3 \(CMIP3\)](#) multi-model dataset referenced in the Intergovernmental Panel on Climate Change Fourth Assessment Report, and the phase 5 ([CMIP5](#)) multi-model dataset that is informing the IPCC Fifth Assessment.

For information about downscaled climate and hydrology projections development, please see the [About](#) page.

Purpose

The archive is meant to provide access to climate and hydrologic projections at spatial and temporal scales relevant to some of the watershed and basin-scale decisions facing water and natural resource managers and planners dealing with climate change. Such access permits several types of analyses, including:

Figure 1. Central Tendency Changes in Mean-Annual Precipitation over the contiguous U.S. from 1970-1999 to 2040-2069 for BCSD3, BCSD5, and Difference.

Mean-Annual Precipitation Change, percent
CMIP3, 1970-1999 to 2040-2069, 50%tile

Climate scientists and modelers explore possible future climate conditions



DWR staff assess potential **impacts and risks** that those climate change conditions could have on California's water resources

<http://www.water.ca.gov/climatechange/articles.cfm>

Climate Change Technical Advisory Group



<http://www.water.ca.gov/climatechange/cctag.cfm>

What Climate Change Scenarios/Models Should We Use?



- Bookends
 - scenarios that represent high/middle/low changes
- Ensemble
 - Use information from a group of models/scenarios
 - One way to address variability and uncertainty
- Other?



UNCERTAINTY

Climate Projections

Population

Converting global data
to local/regional scales

Water cycle changes
Future water demands

Sea level rise

\$\$\$\$

Ecosystem response

Adaptation Strategies

Land use changes

Changes in societal values



Take Home Messages

Global climate models **explore possible future climate conditions**, they don't predict future climate conditions

DWR uses results from global climate models to **evaluate possible impacts** of climate change on CA's water resources

DWR has a **Climate Change Technical Advisory Group** to provide us with guidance

Thank You!



Jamie.Anderson@water.ca.gov