Applied Climate Research and Tool Implementation

PNWS – AWWA
"Climate Variability and Water Resource Planning
From the Science to Adaptation and Decision Making"

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Presentation Outline

- A historic opportunity to integrate applied climate change research with short and long-term planning
- Recent climate change research and direction
- Climate model projections
- Integrating climate model results with a planning tools
- Climate variability in the West

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- Water resource planning
  - Water and waste treatment
- Greenhouse Gas Inventory
  - Carbon footprint
- Transportation engineering
  - Design, build
- Energy
  - Traditional, wind, solar
- Environmental
  - Green technology

Climate Change Impacts

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We Are At Critical Climate Juncture…

- Critical Alignment
  - Resources, technology, knowledge
  - Ability to assess, mitigate, or adapt to climate change-driven impacts
  - Local, regional, national, or global scales
- If not us, who?
- If not now, when?
- Small steps all count!

U.S. Climate Change Science Program

- U.S. Climate Change Science Program http://www.climatescience.gov/
  - Impacts on Water Resources, Agriculture, Land Resources and Biodiversity in the U.S.
  - Weather and Climate Extremes in a Changing Climate
  - Sea Level Rise – Focus on Mid-Atlantic Region
  - Climate Literacy – The Essential Principles of Climate Sciences

U.S. Climate Change Science Program

- Research Elements and Cross-cutting Activities for 2009 and beyond - http://www.usgcrp.gov/usgcrp/ProgramElements/default.htm
  - Atmospheric Composition
  - Ecosystems
  - Global Carbon Cycle
  - Land Use / Land Cover Change
  - Decision-support Resources Development & Related Research on Human Contributions & Responses
  - Climate Variability and Change
  - Global Water Cycle
  - Observing and Monitoring the Climate System
  - Communications – Public understanding of climate change research
  - International Research and Cooperation

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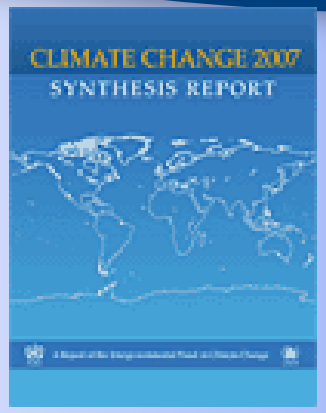
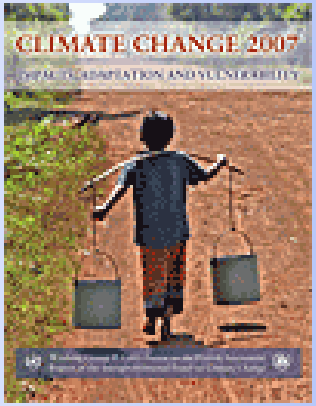
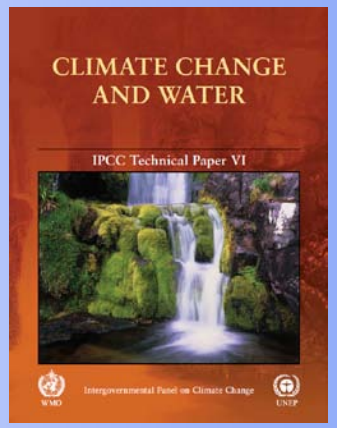
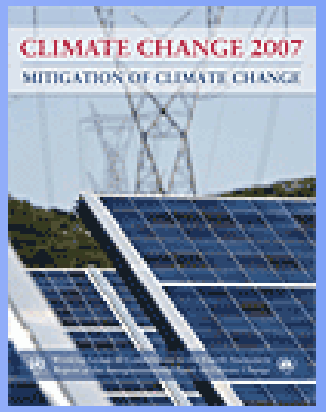
Intergovernmental Panel on Climate Change

- Intergovernmental Panel on Climate Change http://www.ipcc.ch/
  - Synthesis Assessment Report 4 - Policy
  - The Physical Science Basis – WG I
  - Impacts, Adaptation and Vulnerability – WG II
  - Mitigation of Climate Change – WG III
  - Climate Change and Water – TP VI









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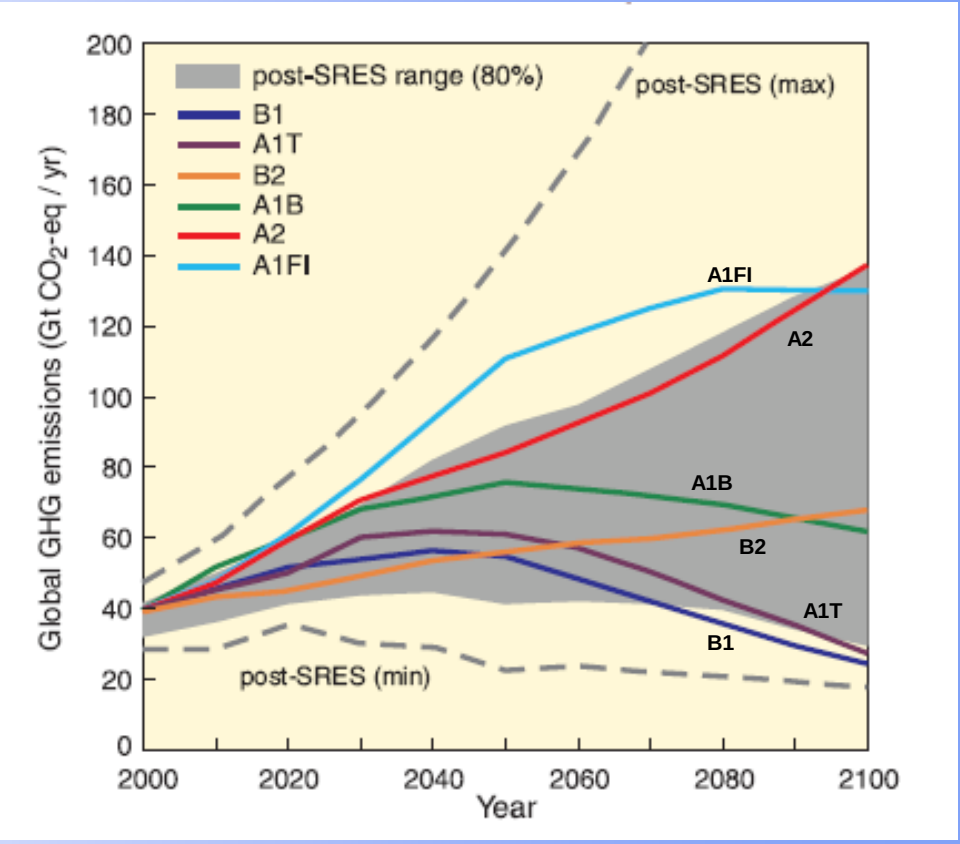
Intergovernmental Panel on Climate Change

- Assessment Report 5 - Scheduled Release in 2013 http://www.ipcc.ch/ipccreports/assessments-reports.htm
  - Regional focus on sustainable development and climate change
  - New emission scenarios to span a wide range of socio-economic and emissions outcomes and have the underpinning socio-economic drivers – WG III
  - Biomass, food production and carbon credits
  - Sea-level rise, Greenland and West Antarctic Ice Sheets
  - Abrupt changes in the climate system
  - Climate engineering
  - Assessment of the performance of Market Mechanisms for climate change mitigation

IPCC Emission Scenarios - 2000

"Scenario Family"	Description
A1 – Rapid Growth A1FI - Fossil Intensive A1T - Non-fossil A1B – Balanced	Second Highest Greenhouse Emissions
A2 – Heterogeneous High Population Growth Slow Economic and Technology Change	Highest Greenhouse Emissions
B1 – Convergent World Same Population as A1, more service and information technology.	Lowest Greenhouse Emissions
B2 – Intermediate Population growth, local solutions.	Second Lowest Greenhouse Emission

SRES (Special Report on Emission Scenarios, IPCC 2000)



Scenarios for GHG emissions from 2000 to 2100 in the absence of additional climate policies.

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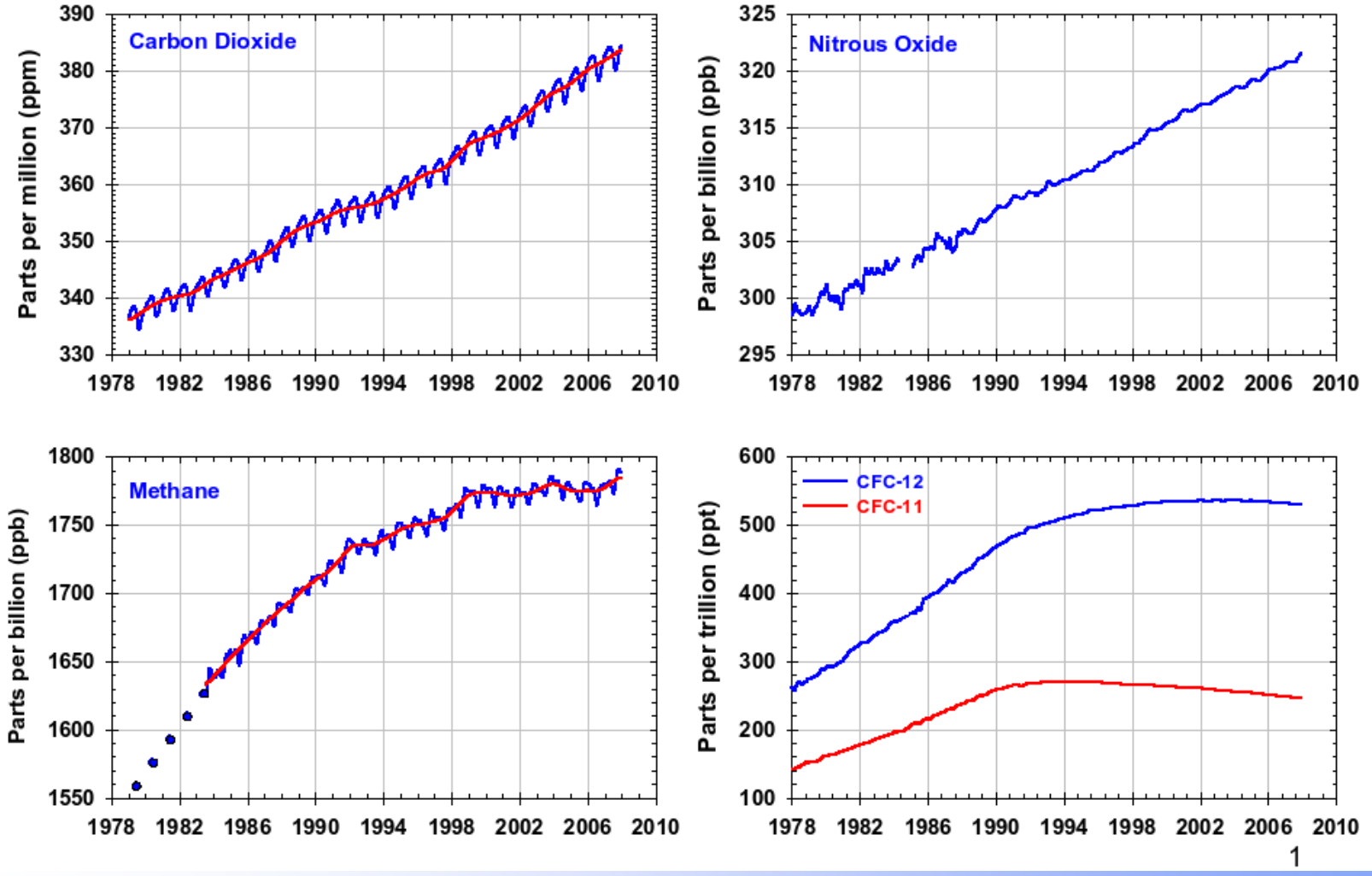
GHG Concentrations – (NOAA-ESRL)



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http://www.esrl.noaa.gov/gmd/aggi/

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GHG Concentrations – 11/25/2008 - WMO

- Carbon dioxide (1), methane (21), nitrous oxide (310), – (global warming potential/GHG multiplier)
- 2007 Values and change from 2006
  - CO2 = 383.1 **ppm** +0.50% from 2006
  - CH4 = 1,789 **ppb** +0.34% "
  - N2O = 320.9 **ppb** +0.25% "
  - World Meteorological Organization
  - http://www.wmo.int/pages/mediacentre/press_releases/pr_833_en.html

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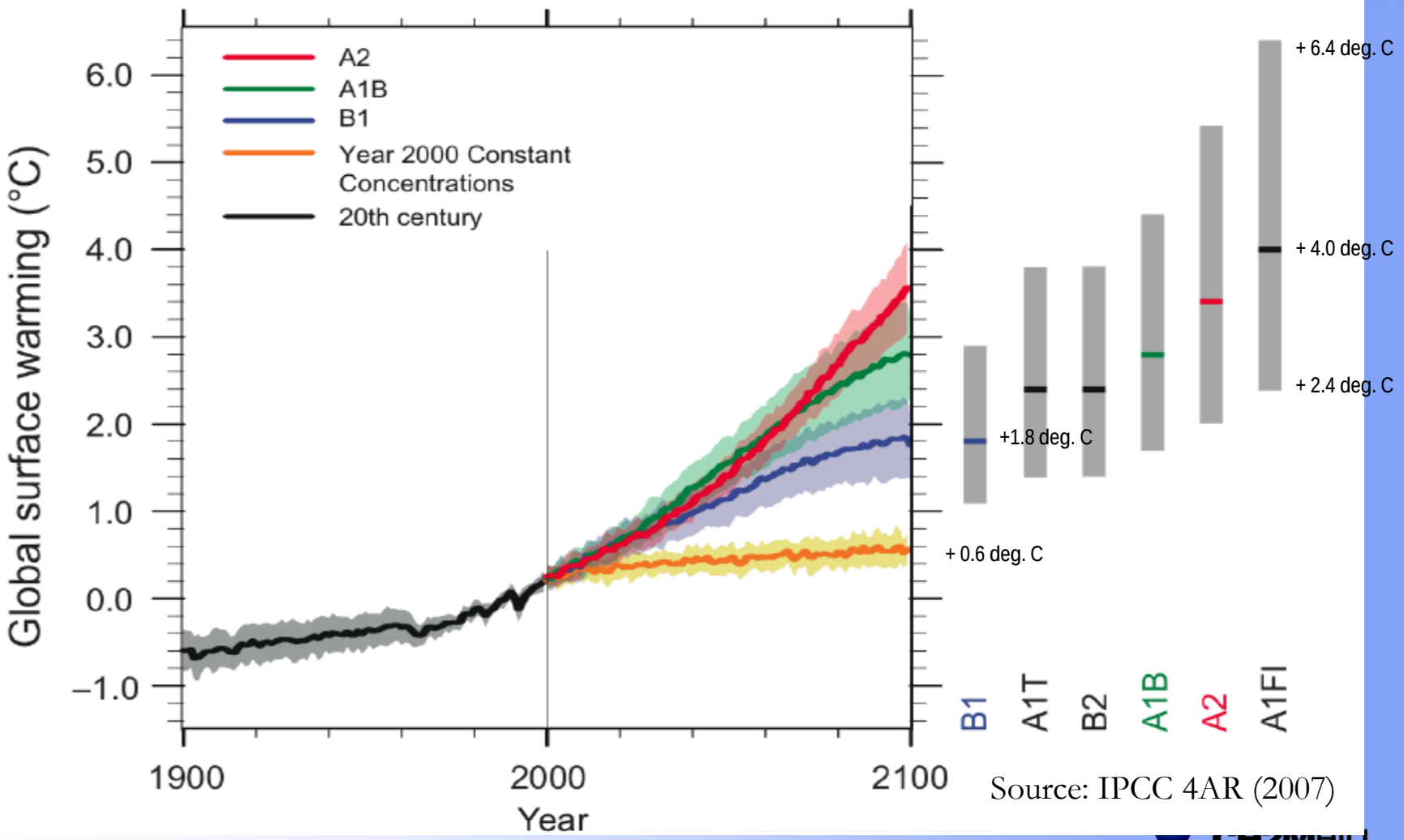
Multi-Model Projected Temperature Increases



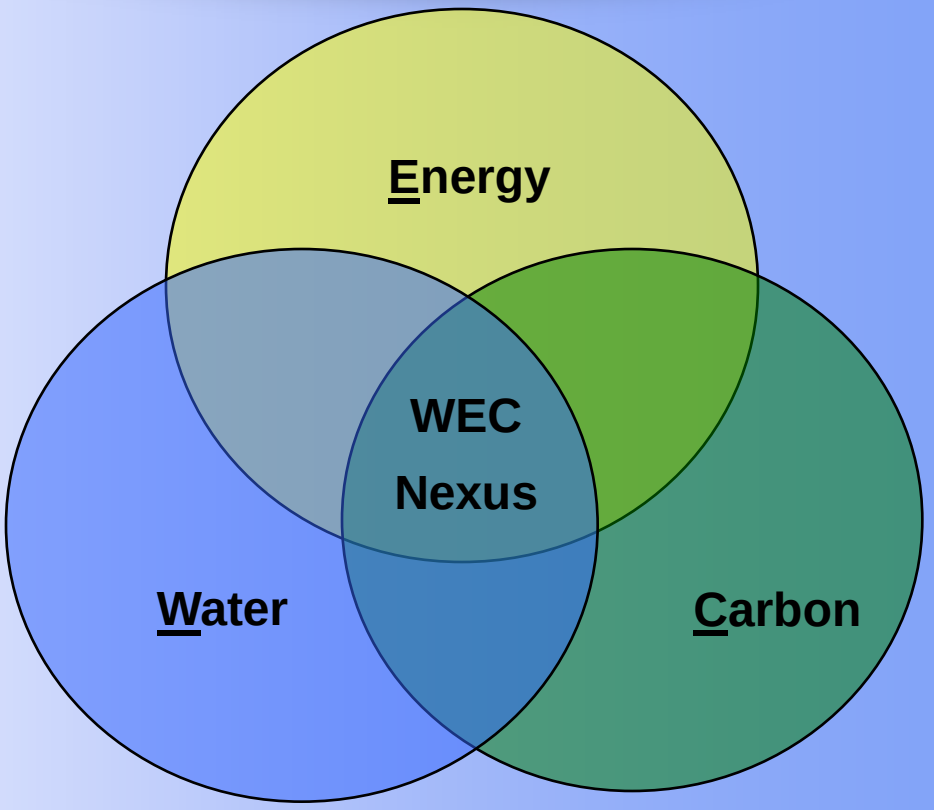
Source: IPCC 4AR (2007)

Climate Change – Projected Impacts (IPCC)

- **Sea ice and snow cover losses will continue**, and **declining snowpack** will affect snow-dependent water supplies and streamflow levels around the world;
- The **risk of drought** and the **frequency, intensity, and duration of heat waves** are expected to **increase**;
- **More extreme precipitation** is likely, increasing the risk of flooding and will impact drainage designs;
- **Sea level is projected to rise 7 to 23 inches** during the 21st century due to melting snow and ice on land and thermal expansion of ocean waters. (IPCC 2007)

Stakeholders Require Sustainable Solutions

- **Solutions that fully integrate climate information to better manage**
  - Water
  - Energy
  - Carbon
- **There is a critical need to understand and manage this linkage**
  - The Water-Energy-Carbon (WEC) Nexus



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WEC Framework Linking Stakeholders and Global Change Technology

Utilities and Stakeholders – Water, Energy, Carbon, +…

Project Objectives – Improve service, Min risk, Max profit

Decision Method – MCA, Optimization, Uncertainty

Modeling Environment – Voyage, WEAP, GoldSim

Science Models – VIC, MIKE, HSPF, SWAT, SWMM

Data Management – netCDF, ACIS, RDMS

Data – Observed Climate, PRISM, Climate Change

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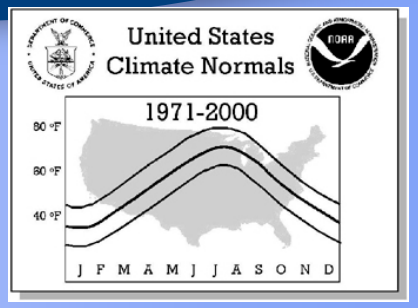
Water Portfolio Management Elements

- Element 1: Define Goals and Objectives, Leadership and Commitment
- Element 2: Impact Assessment and Stakeholder Participation
- Element 3: Data Collection and Analysis
- Element 4: Develop & Select Models for Analysis
- Element 5: Assessment and Alternative Evaluation and Selection
- Element 6: Institutional Framework
- Element 7: Adaptive Management/Legacy

Water Portfolio Management Elements

- **Element 3: Data Collection and Analysis**
  - Define existing data availability and outline data needs in the context of project framework
  - Obtain additional data for study
  - Collect and organize data



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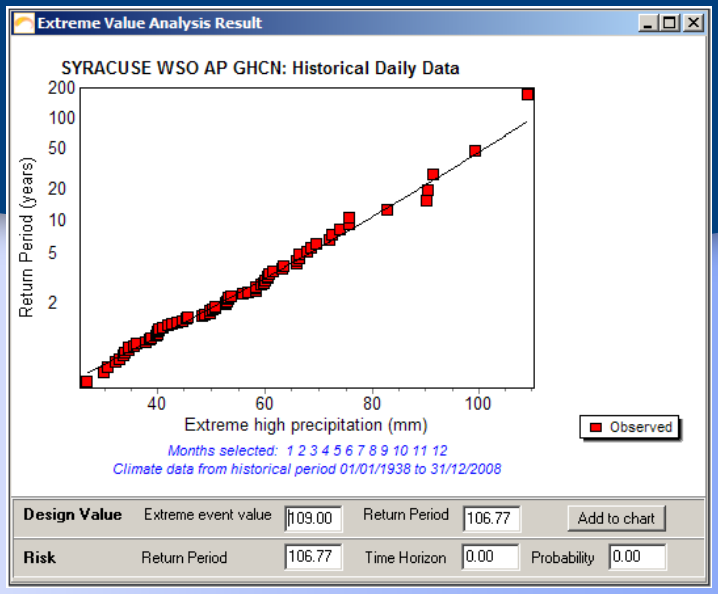
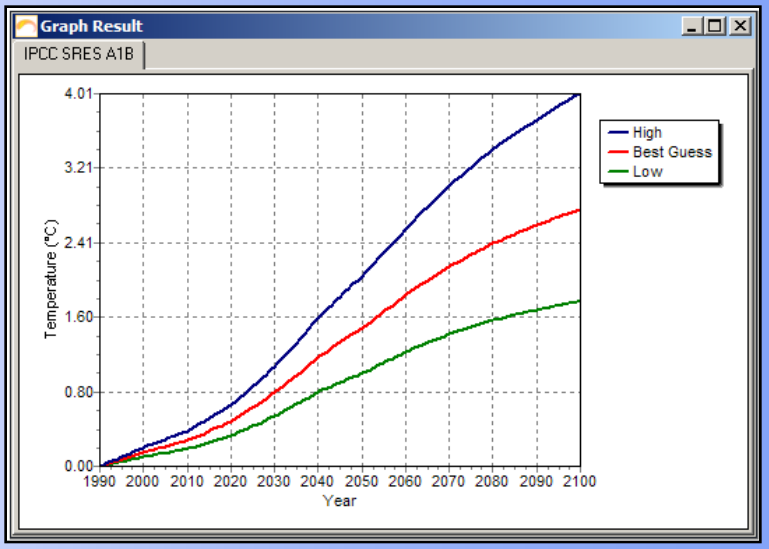
What Climate Data and Tools are Needed?

- **Element 3 – Data Collection and Analysis**
- Observed data
  - Hourly, daily, monthly, and annual precipitation, temperature, evaporation, wind speed/direction, and tide data
- Climate change projections
  - Standard Greenhouse Gas (GHG) emission scenarios
  - Global Change Model (GCM) results
- Analysis tools
  - Turn data into information to assess risk and vulnerability using historical data and GCM projections

WPM Elements

- Element 4: Select & develop models for analysis to feed into decision tools
  - Select models to meet objectives
  - Develop and calibrate models
  - Feed results into decision tools to evaluate alternatives





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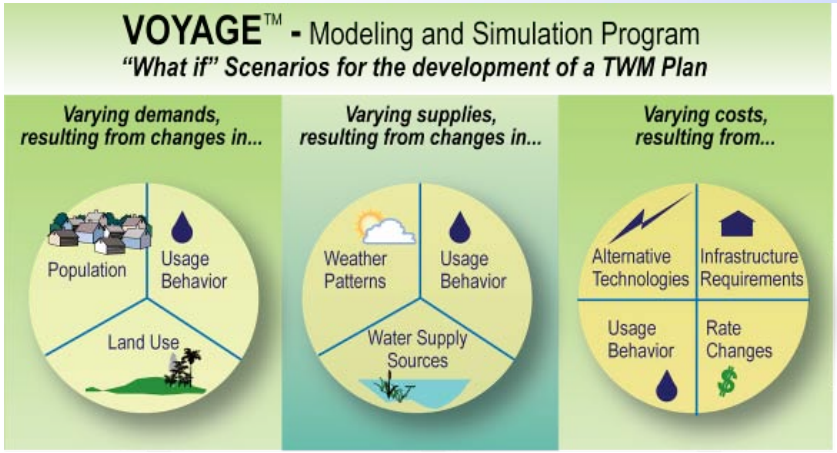
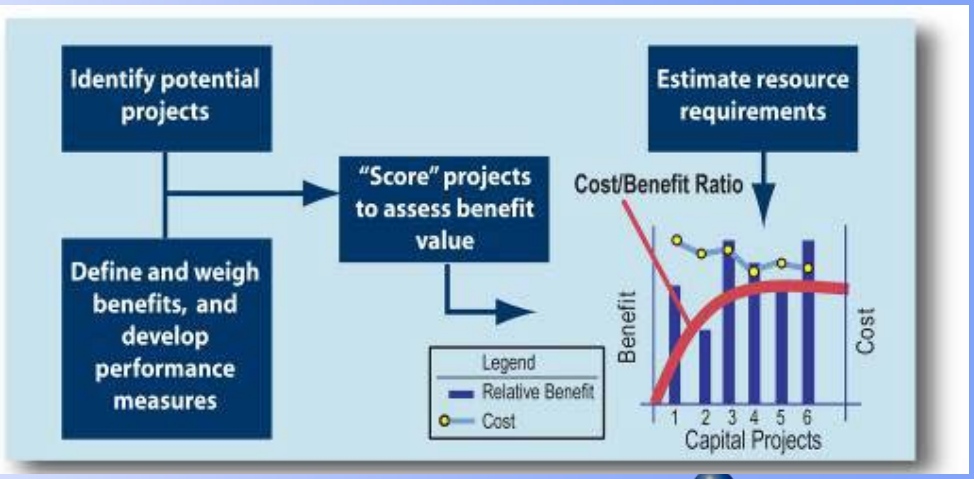
Water Portfolio Management Elements

- Element 5: Assessment & Alternative Evaluation and Selection
  - Scenario Planning
  - Alternatives Identification
  - Screening and Ranking Alternatives
  - Selection of Prioritization Method





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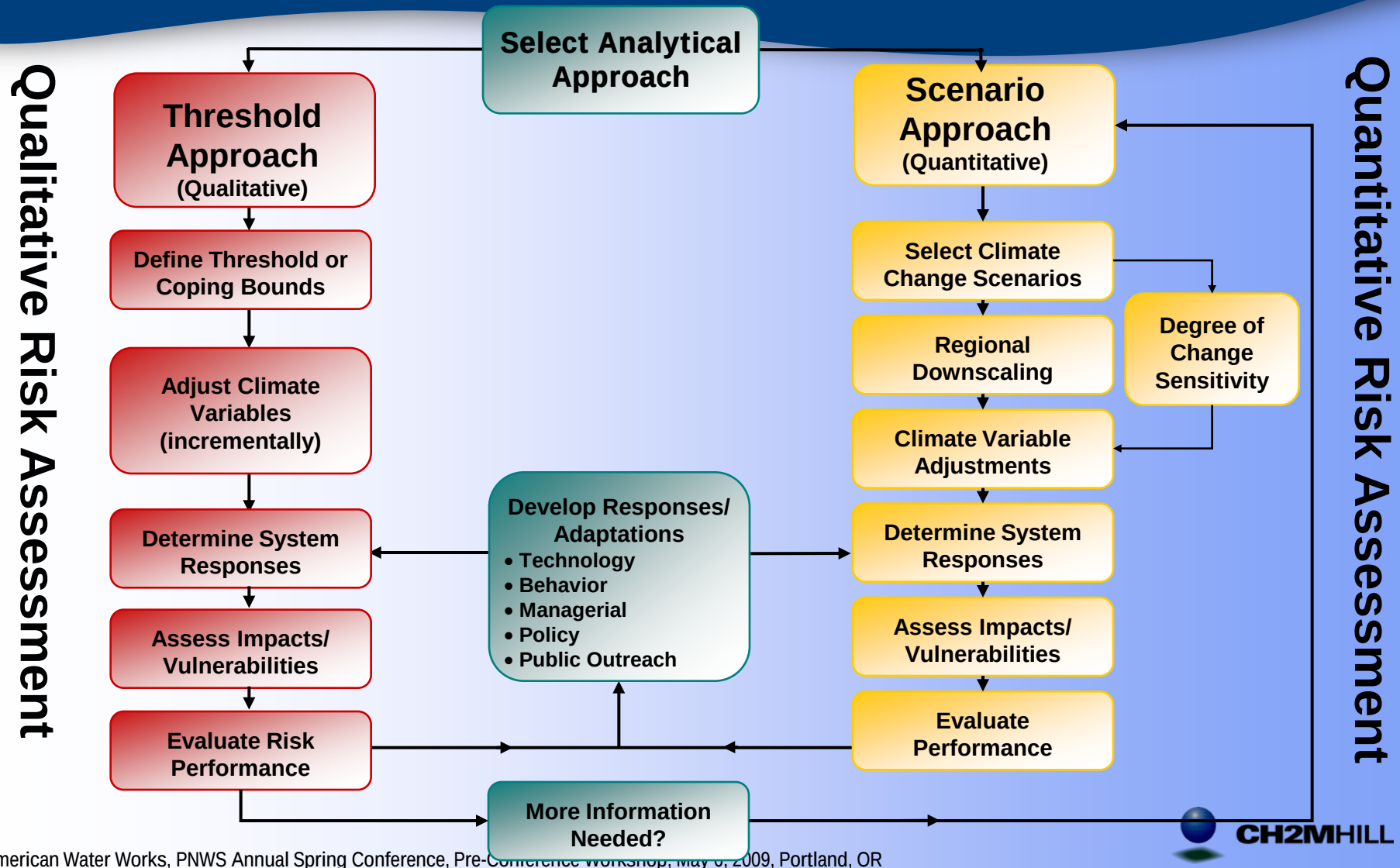
Threshold / Scenario Risk Assessment Model



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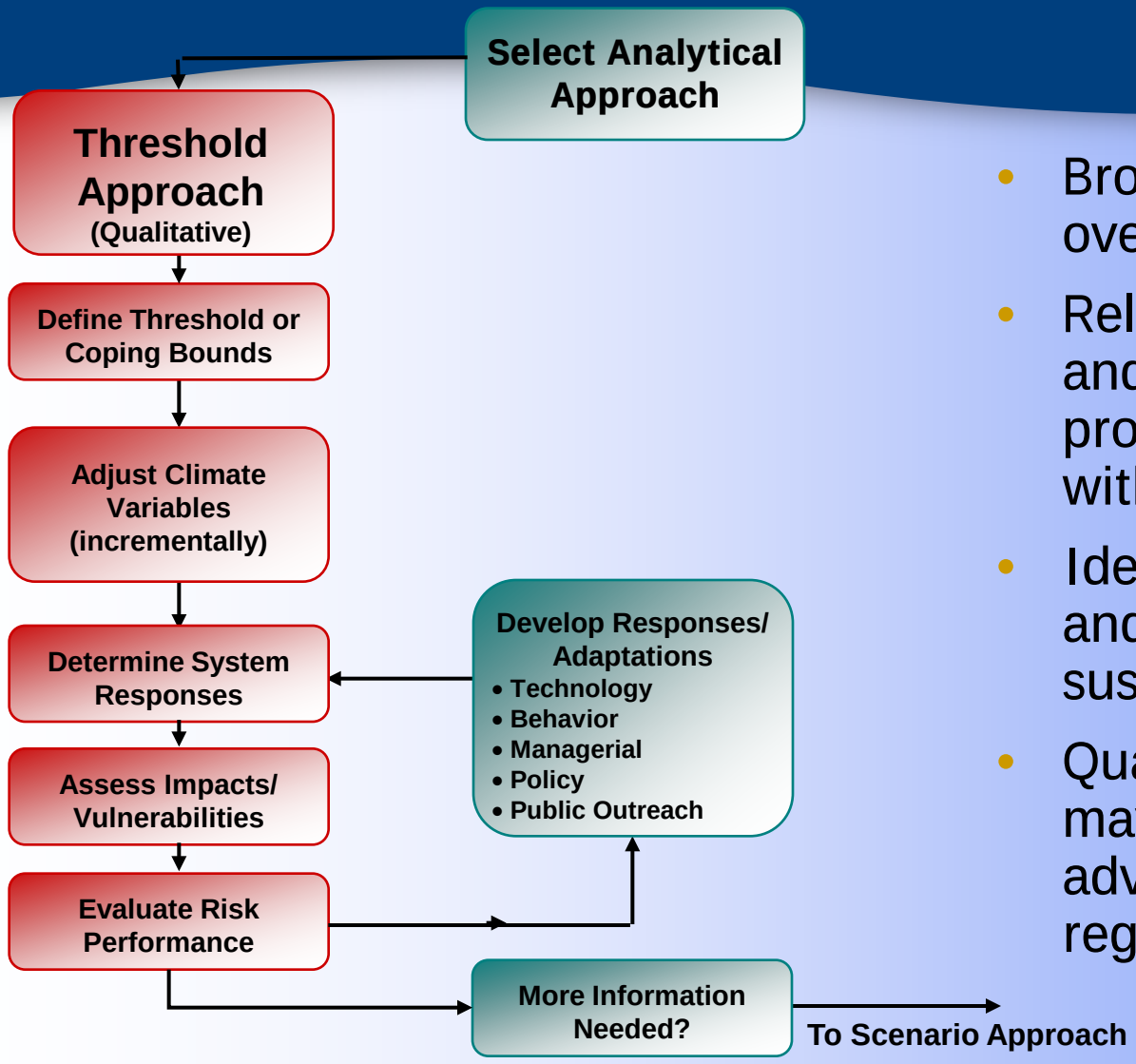
Threshold (Qualitative) Risk Approach



- Broad, less intensive overview approach
- Relies on experience and judgment of professionals familiar with system
- Identifies components and functions most susceptible to GCC
- Qualitative approach may be sufficient to advise decision making regarding adaptations

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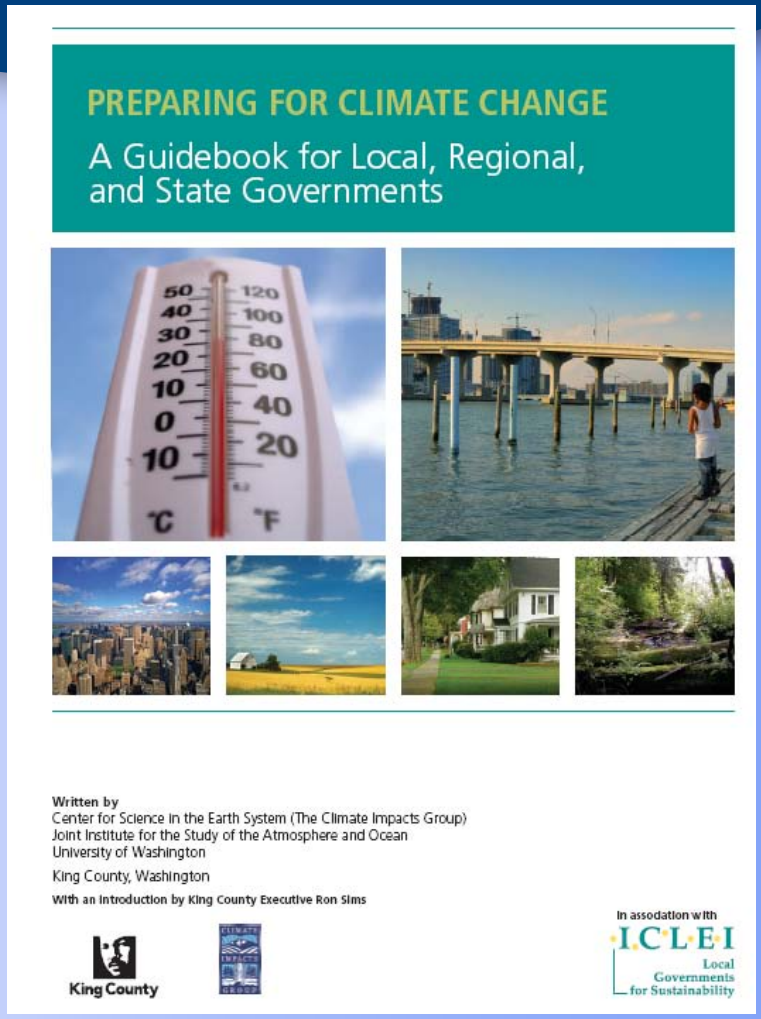
Qualitative Risk Approach

- "Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments"
- Establishing *"Climate Resilient Communities"*
- Focuses on the process to assess climate impacts and risk
- Designing a response
- Workbook-style with checklists and milestones



http://cses.washington.edu/cig/fpt/guidebook.shtml

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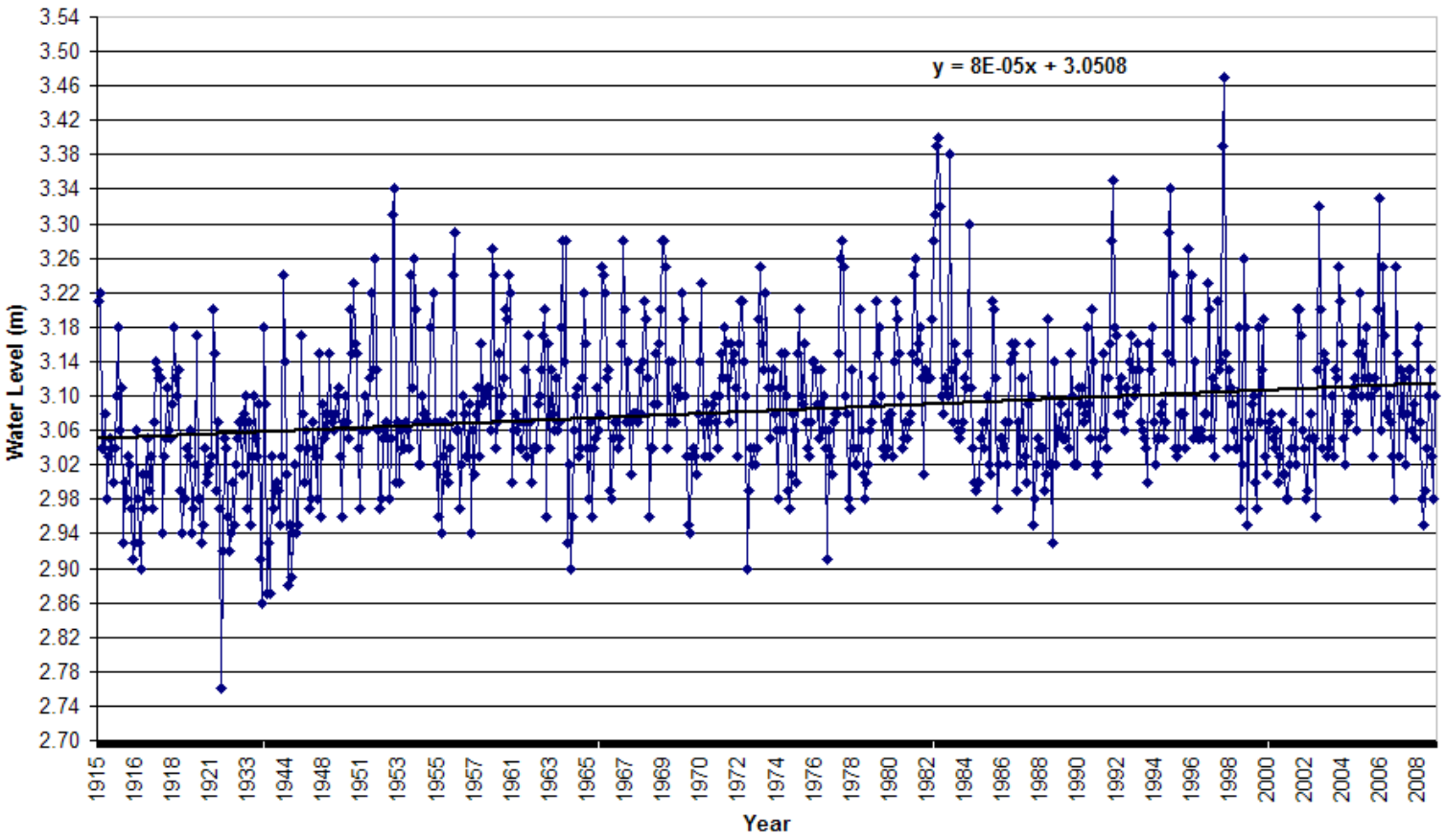
Qualitative Analysis of Sea Level Rise



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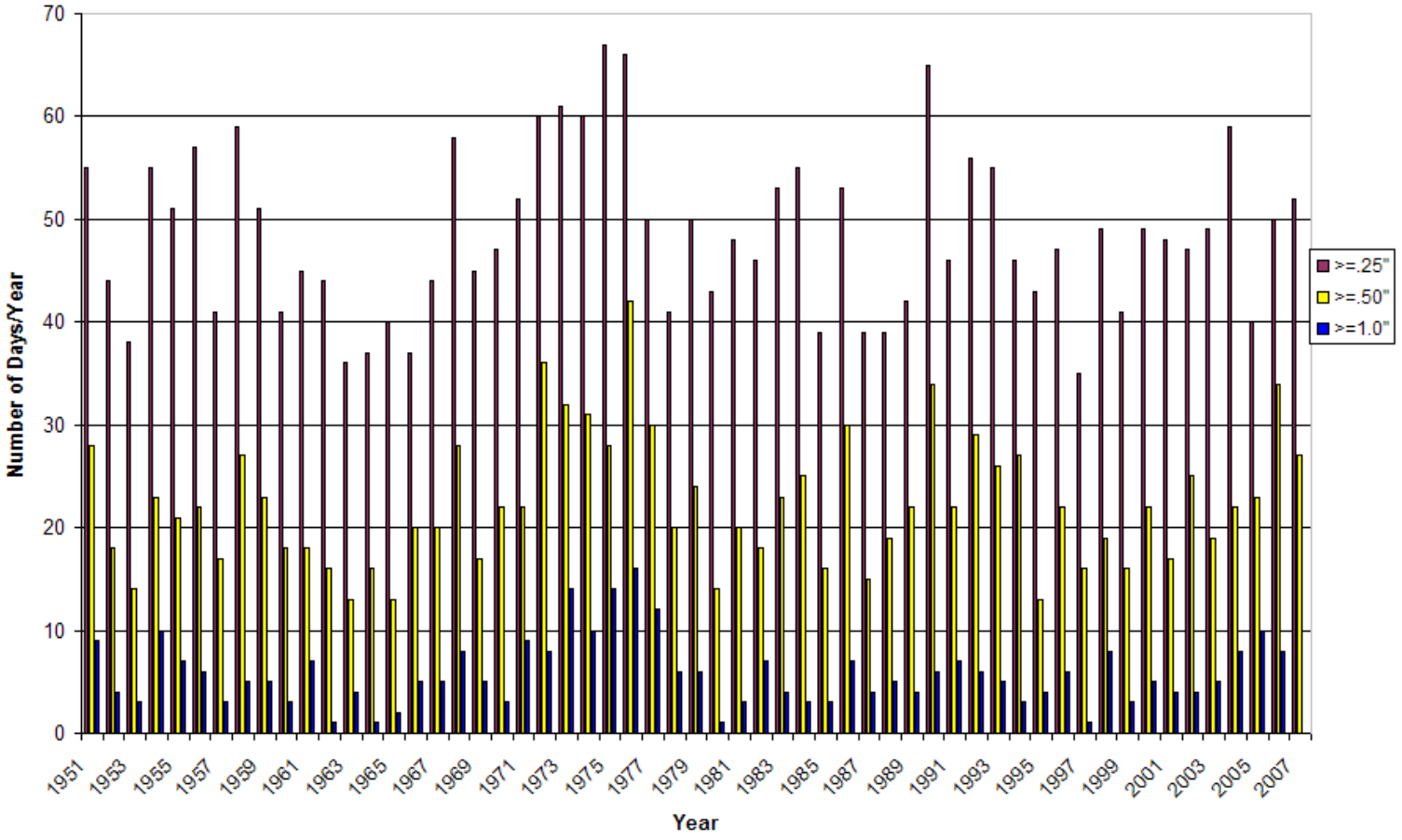
Qualitative Analysis of Precipitation Totals



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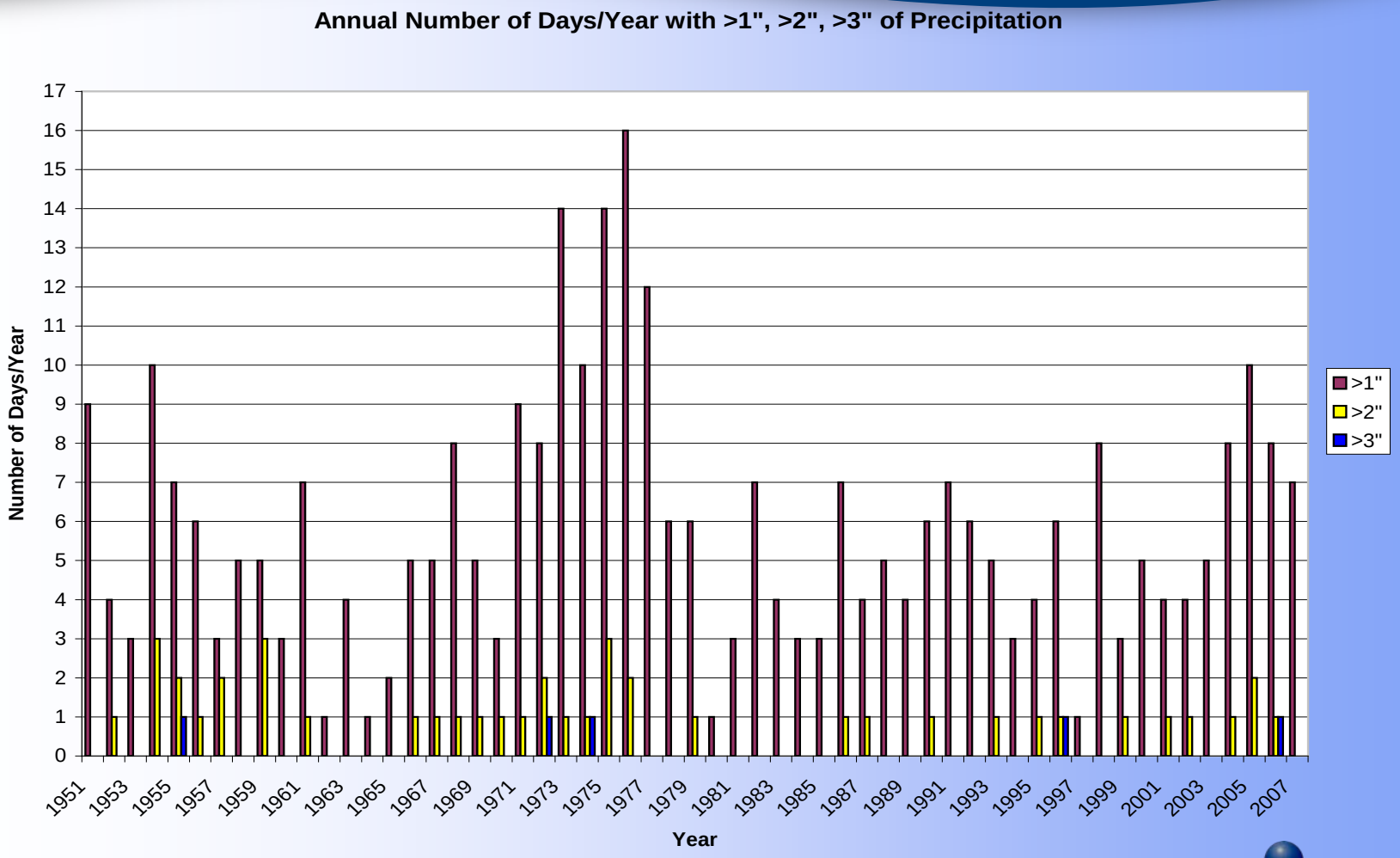
Qualitative Analysis of Precipitation Totals



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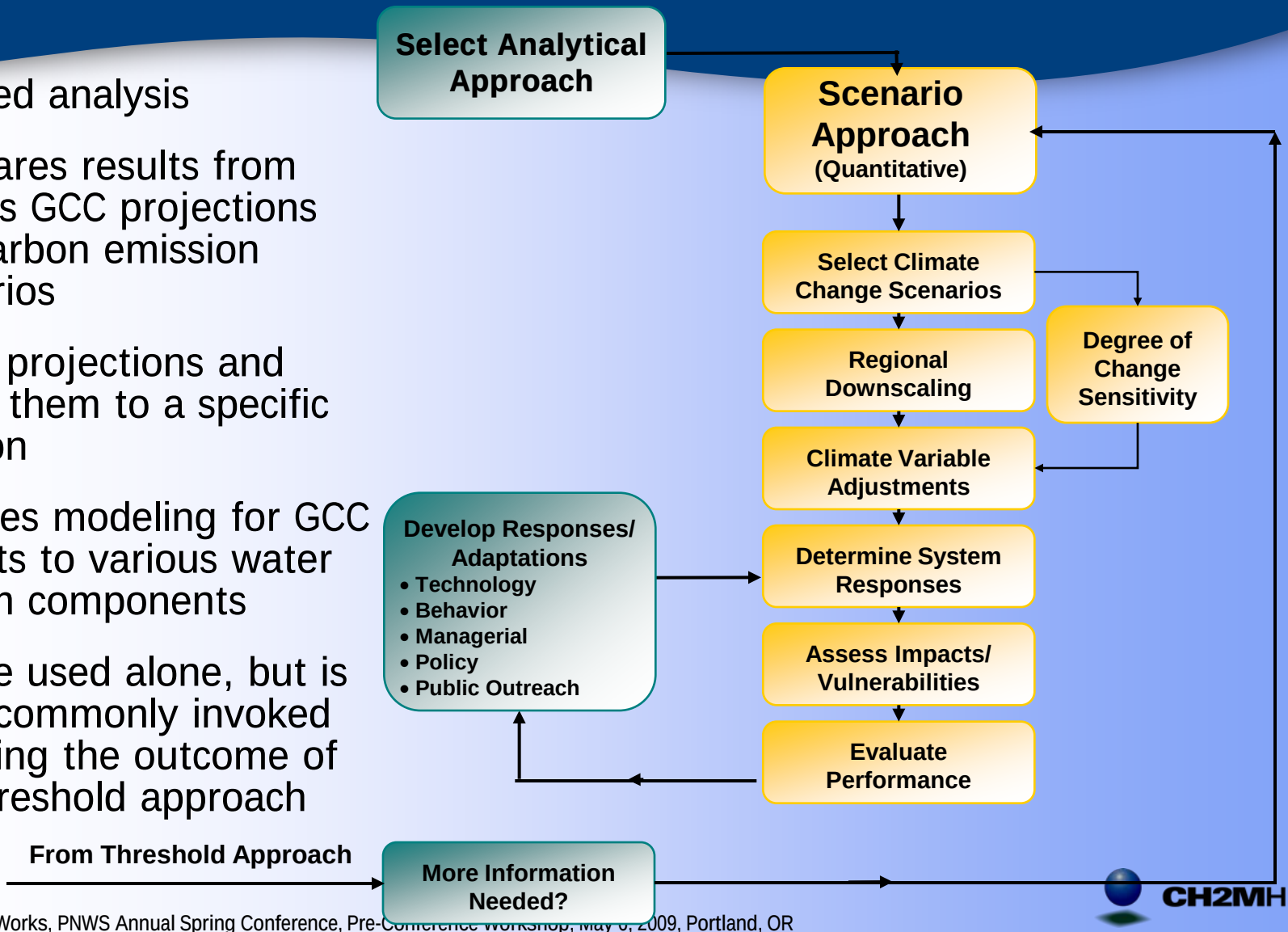
Scenario (Quantitative) Approach

- Detailed analysis
- Compares results from various GCC projections and carbon emission scenarios
- Takes projections and scales them to a specific location
- Includes modeling for GCC impacts to various water system components
- Can be used alone, but is more commonly invoked following the outcome of the threshold approach



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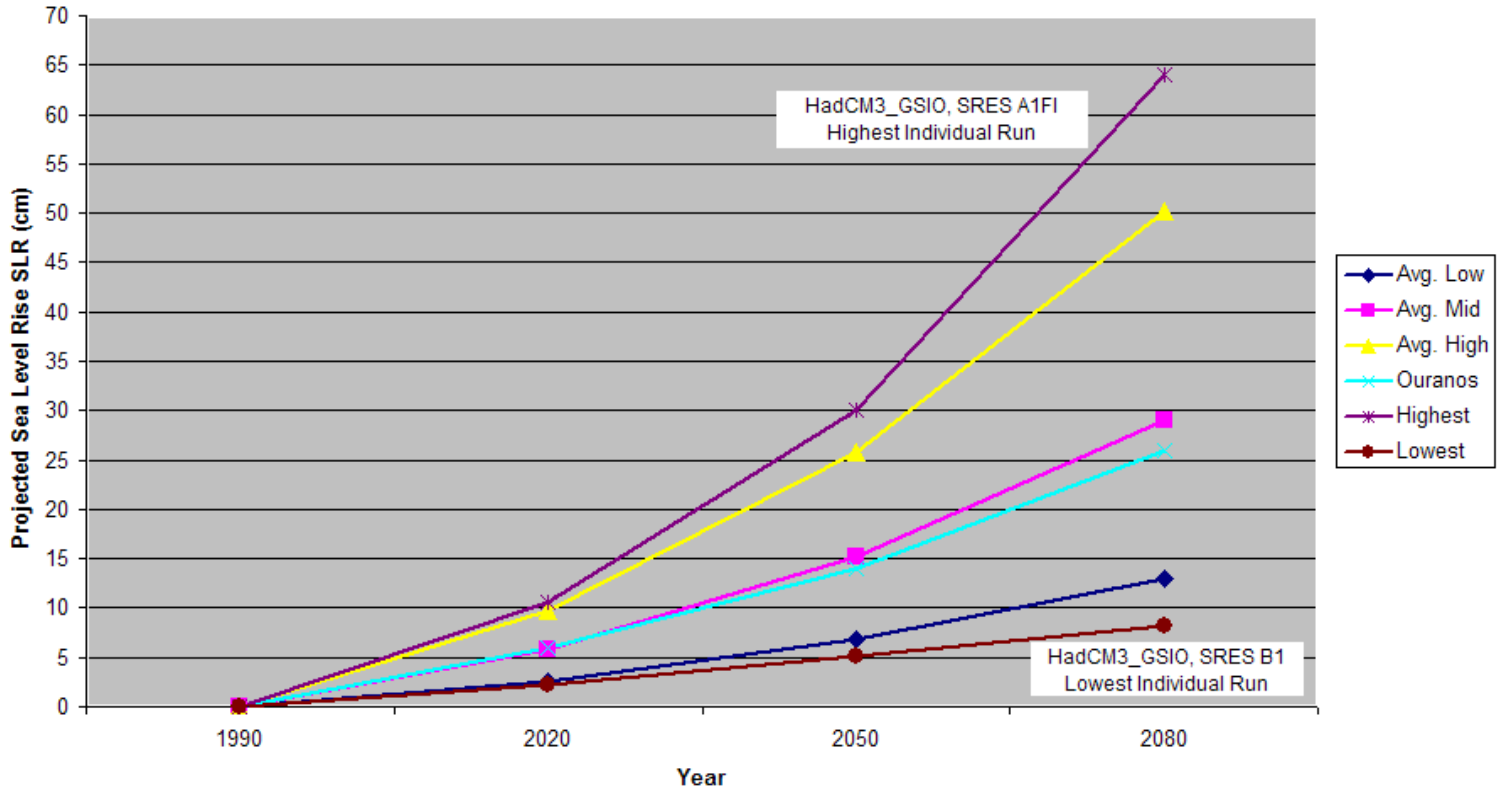
Quantitative Analysis of Sea Level Rise



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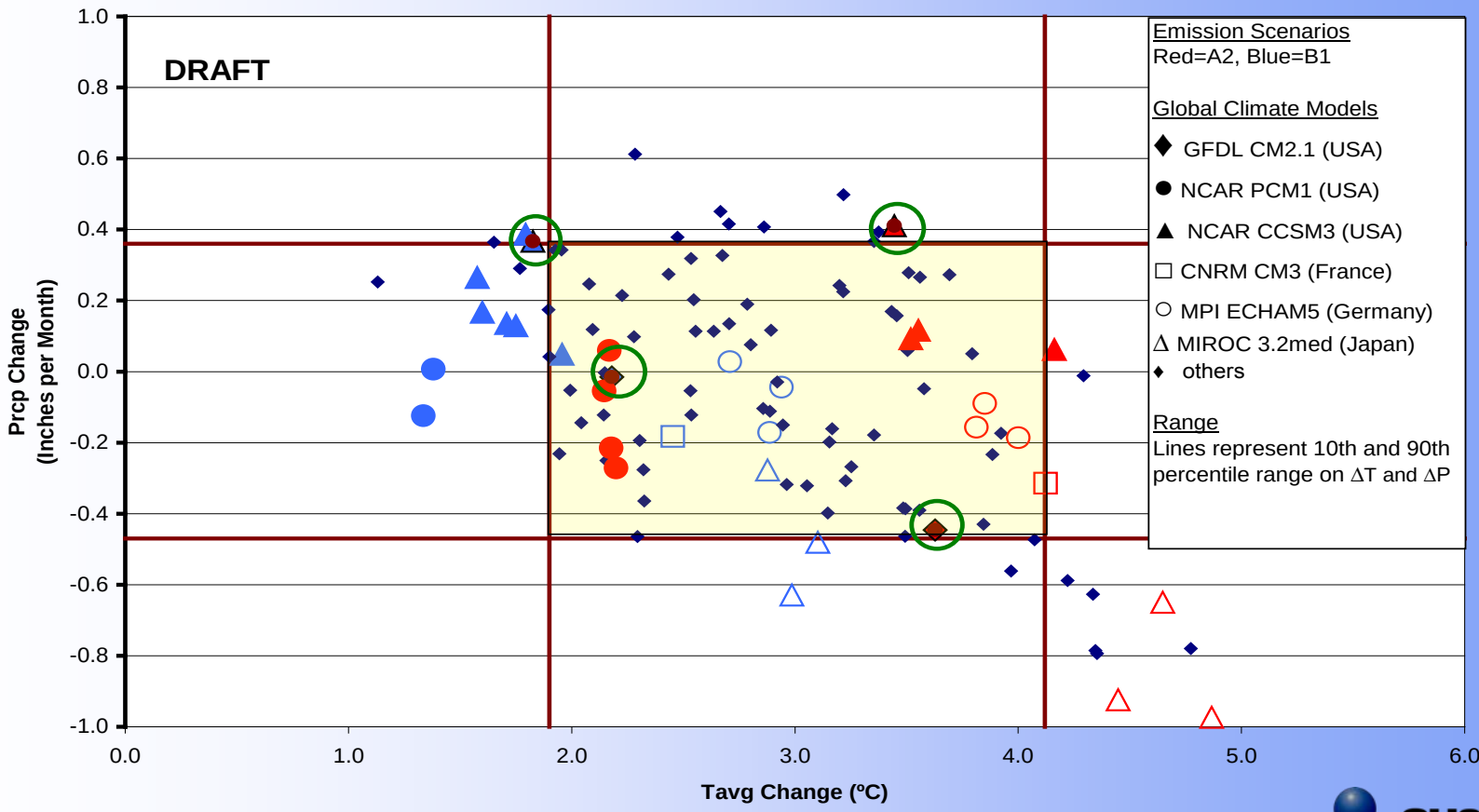
Boundaries of GCM Temp/Precip Results

Relationship between Changes in Period-Mean Annual Precipitation and Temperature: Austin
(112 projections, evaluated at 2080 [2066-95] relative to 1970-99)



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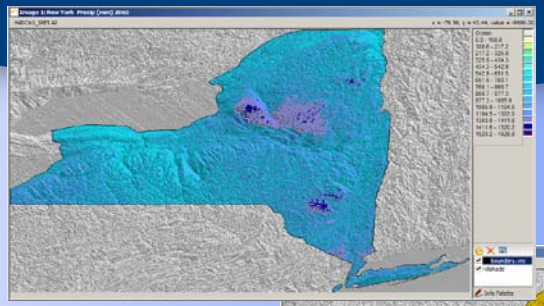
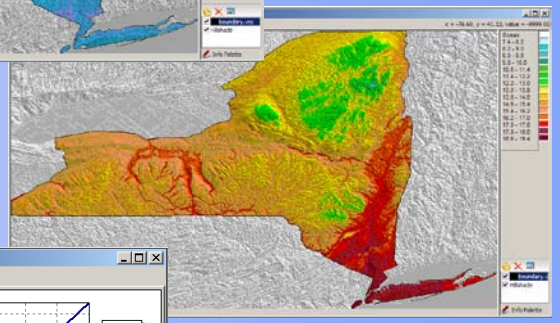
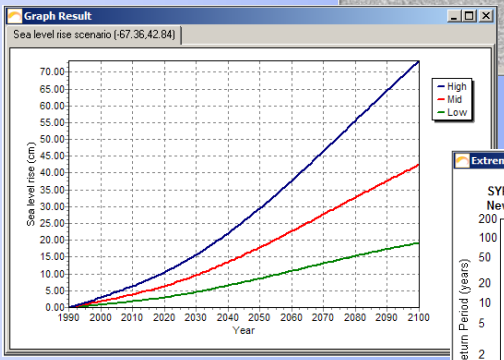
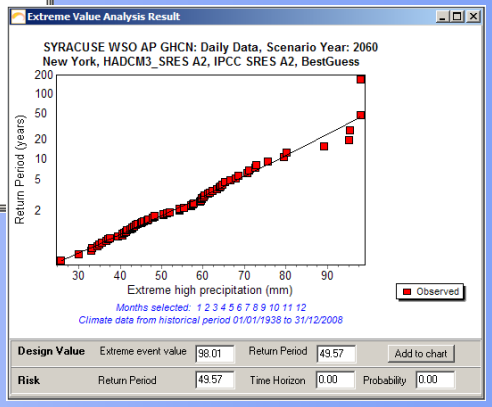
Quantitative Scenario Approach – NYC DEP

- In New York City Department of Environmental Protection
- Scenario Approach to quantify climate change impacts on drainage and wastewater infrastructure
- Sea level rise/Storm surge
- Temperature increase
- Potential increased frequency and intensity of extreme precipitation events









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Who Benefits When Climate Change Needs Are Met?

- Stakeholders that deal with agriculture, water, energy, carbon inventories, and all involved with sustainability issues
- City, state, and regional governments
- Federal and international governments / countries
- The private sector who has the flexibility and resources to work with each stakeholder

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Western U.S. Climate Observations

- Climate Variability

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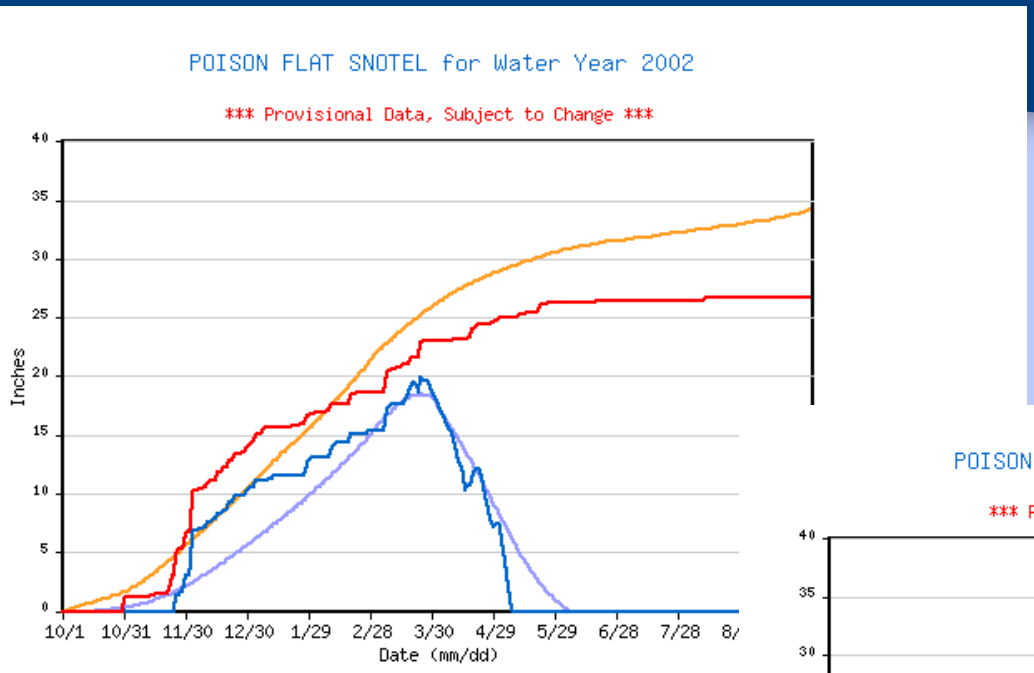
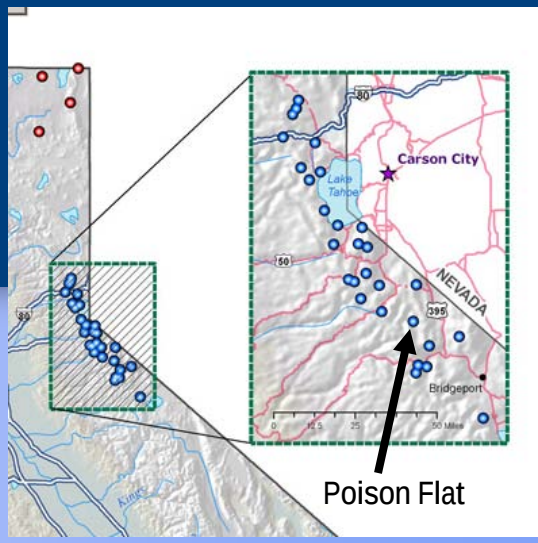
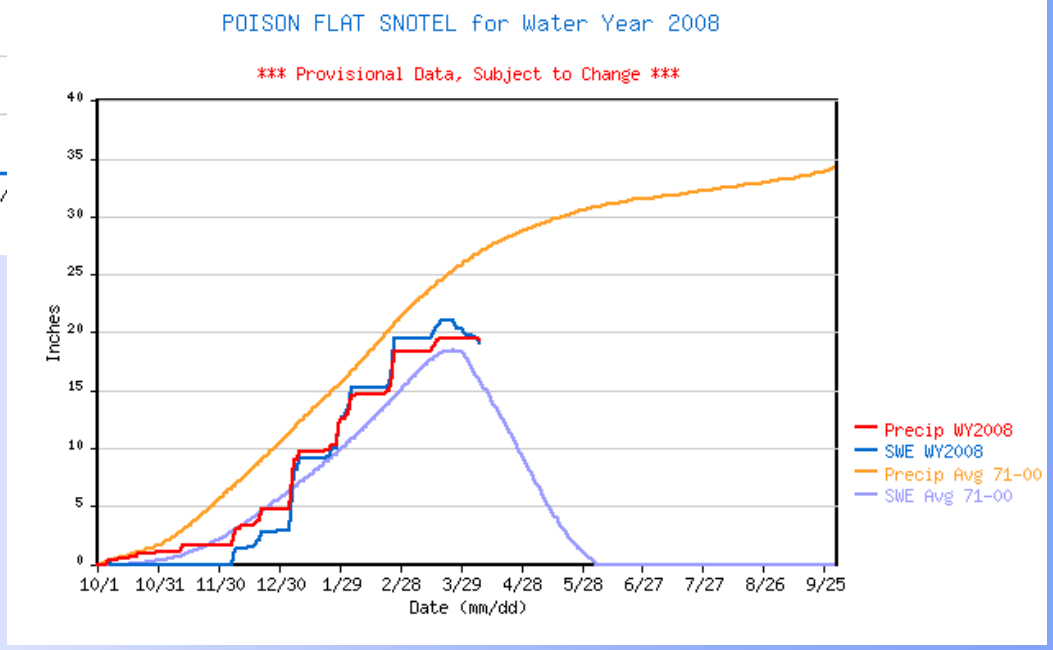
Is Western Snowpack Changing?







What happened to the "smooth" snowpack accumulation?

NRCS-NWCC - www.wcc.nrcs.usda.gov

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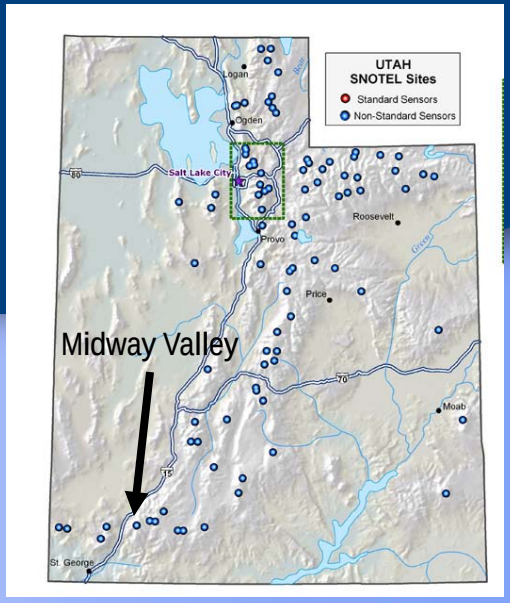
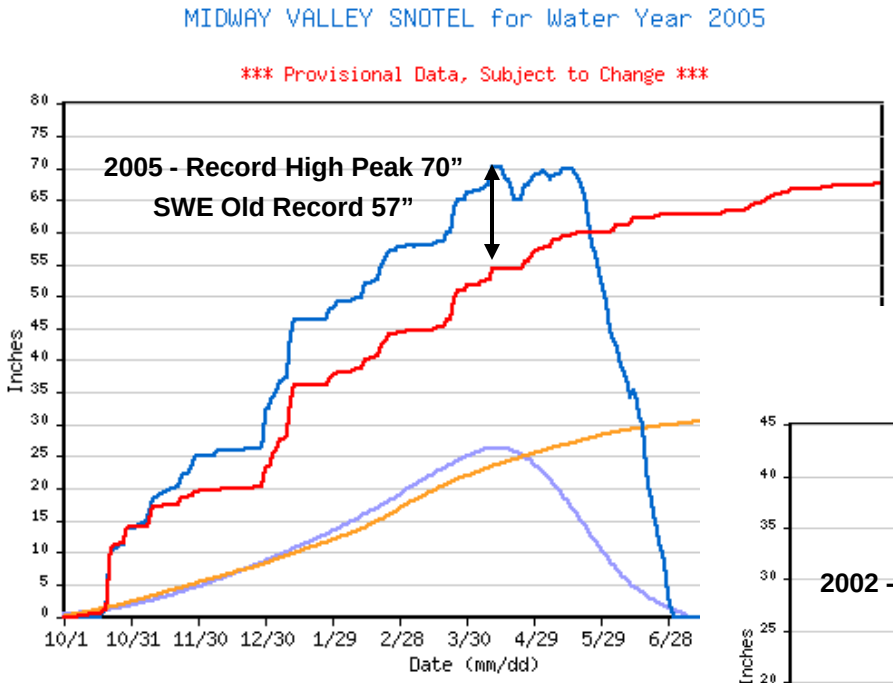
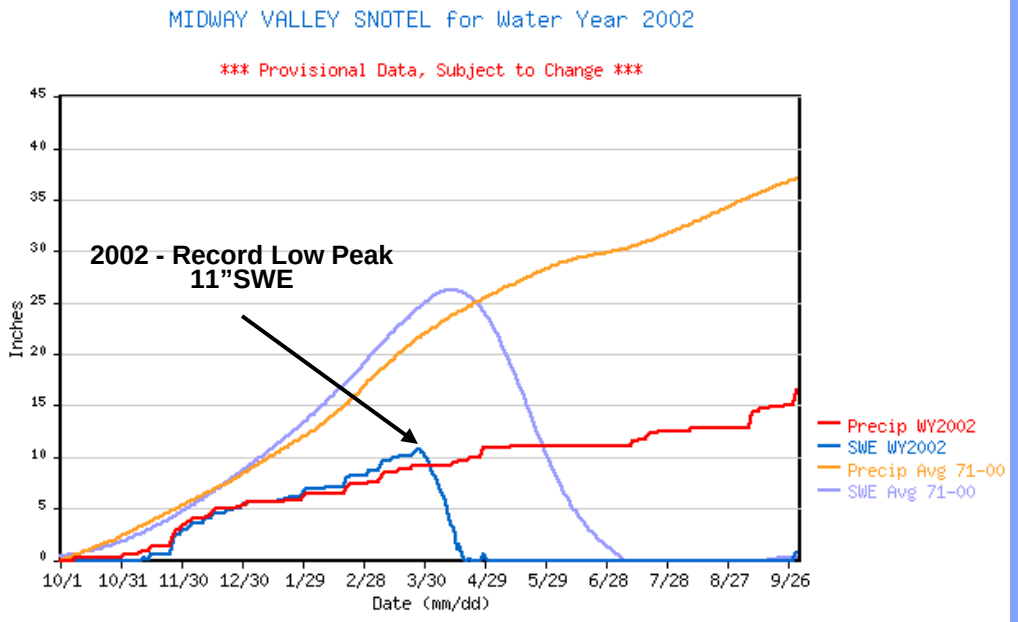
Is Western Snowpack Changing?







Wide variations in peak snowpacks

NRCS-NWCC - www.wcc.nrcs.usda.gov

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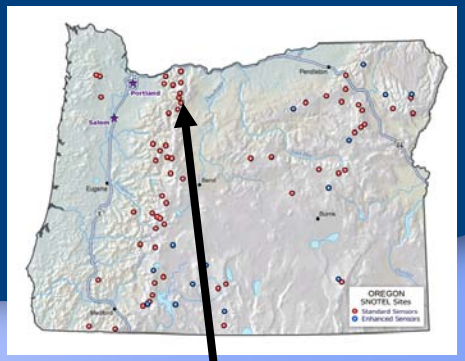
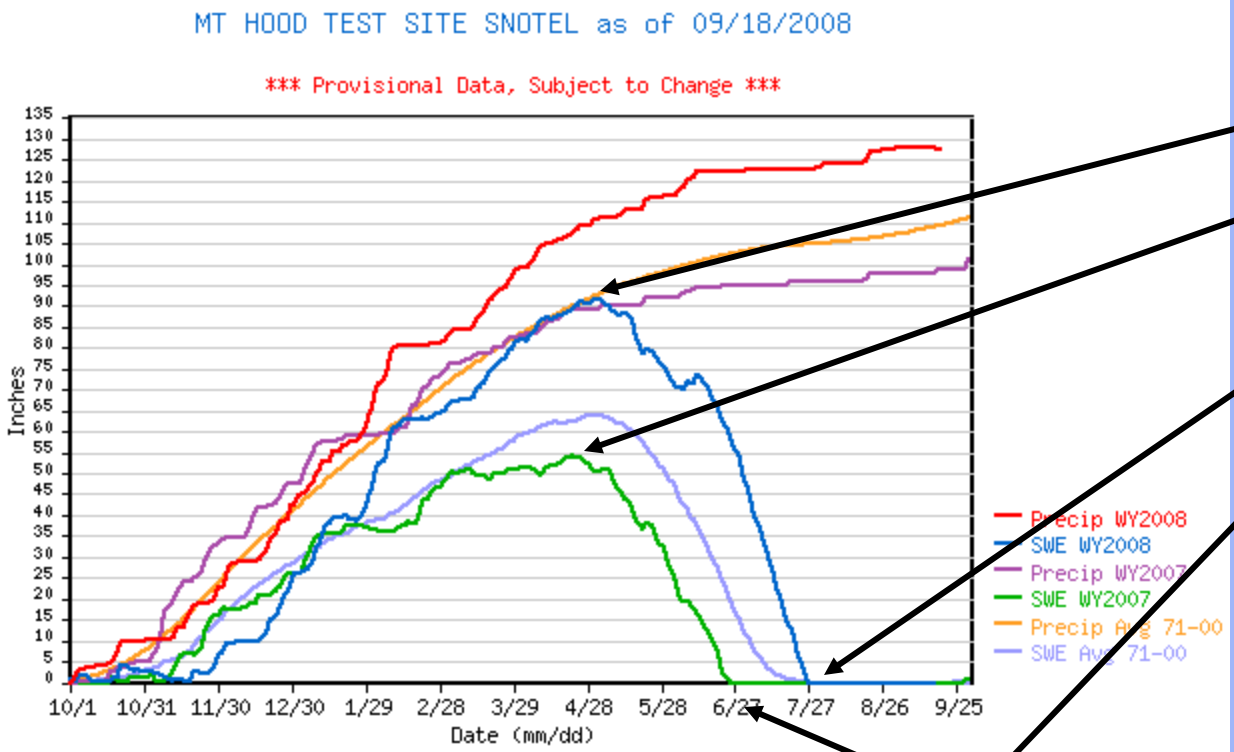
Is Western Snowpack Changing?



Delayed snowmelt in 2008



Mt. Hood

SWE Peak

92” in 2008

55” in 2007

Meltout

July 27, 2008

June 25, 2007

Impacts

Delayed agriculture flows – water rights

Recreation areas snowed-in

NRCS-NWCC - www.wcc.nrcs.usda.gov

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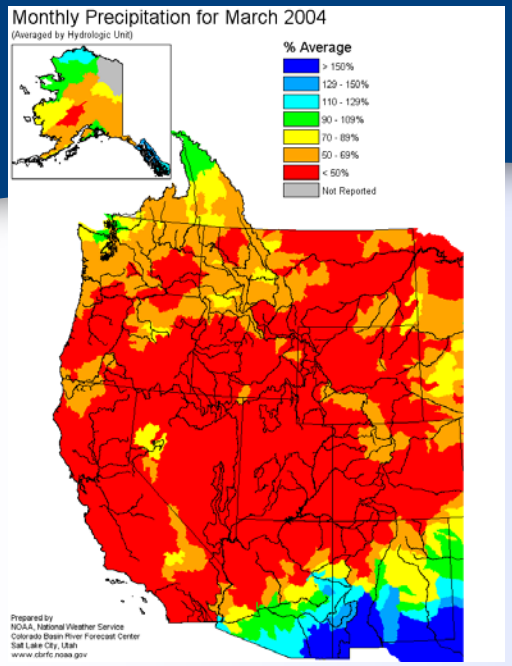
Complex Intra-Annual Changes? – March 2004



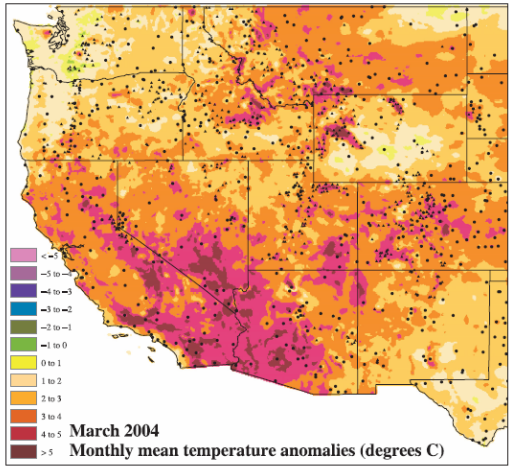


Fig. 1. March 2004 observed monthly mean temperature anomalies in degrees Celsius. NRCS SNOTEL sites are shown as triangles, and NWS sites are shown as circles. Contours are derived using the PRISM system (http://www.ocs.orst.edu/prism/).

Lack of precipitation

+

Warm temperatures

=

"Perfect storm" for snowpack reduction

Table 1. Summary of Mountain Snowpack (Snow Water Equivalent) Changes Between 1 March and 1 April 2004.

State/Area	*Statewide % of Average, 1 March 2004*	*Statewide % of Average, 1 April 2004*	*Statewide % of Average, Change*
Arizona	74	22	-51
Sierra/Tahoe	113	70	-35
Colorado	90	64	-26
Idaho	105	81	-25
Montana	93	78	-16
Nevada	118	64	-54
New Mexico	80	37	-43
Oregon	126	96	-30
Utah	109	70	-39
Washington	93	86	-7
Wyoming	91	71	-19

(Pagano, Pasteris, Dettinger, Redmond EOS 2004)

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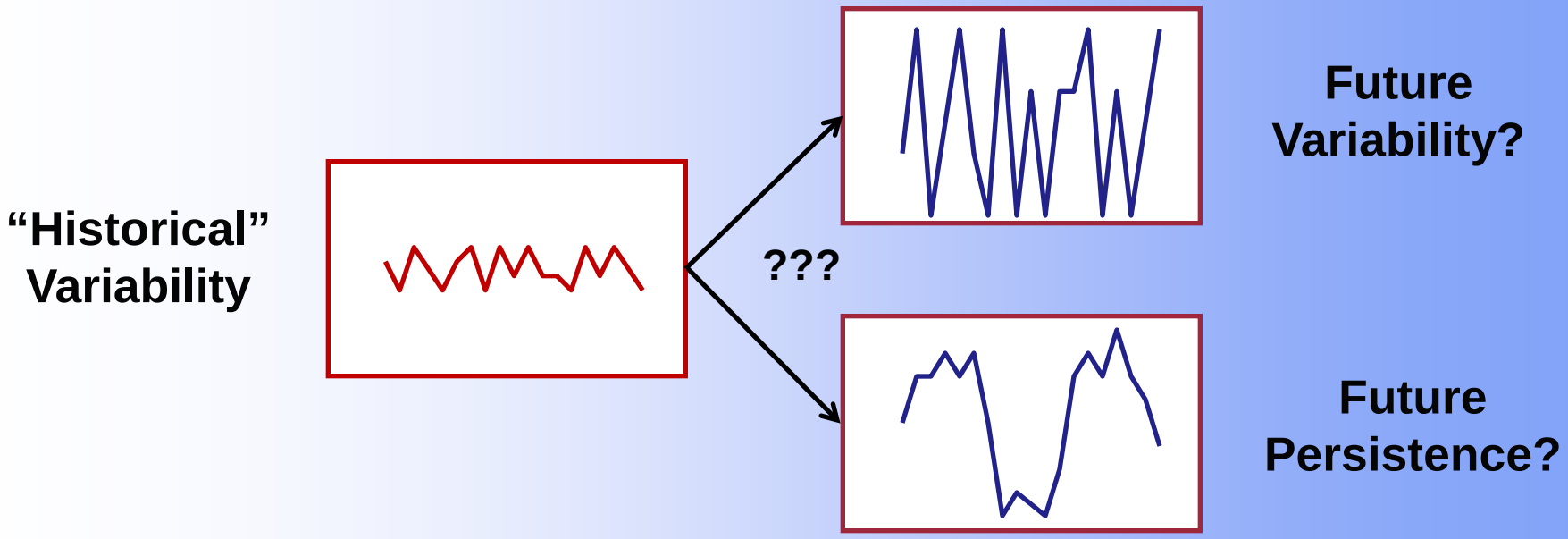
Patterns of Variability

Will the climate get "stuck" or swing between extremes?



Are there thresholds, tipping points, surprises?

(Pagano, Garen 2005)

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Yogi Berra On Climate

Climate Stationarity

"The future ain't what it used to be."

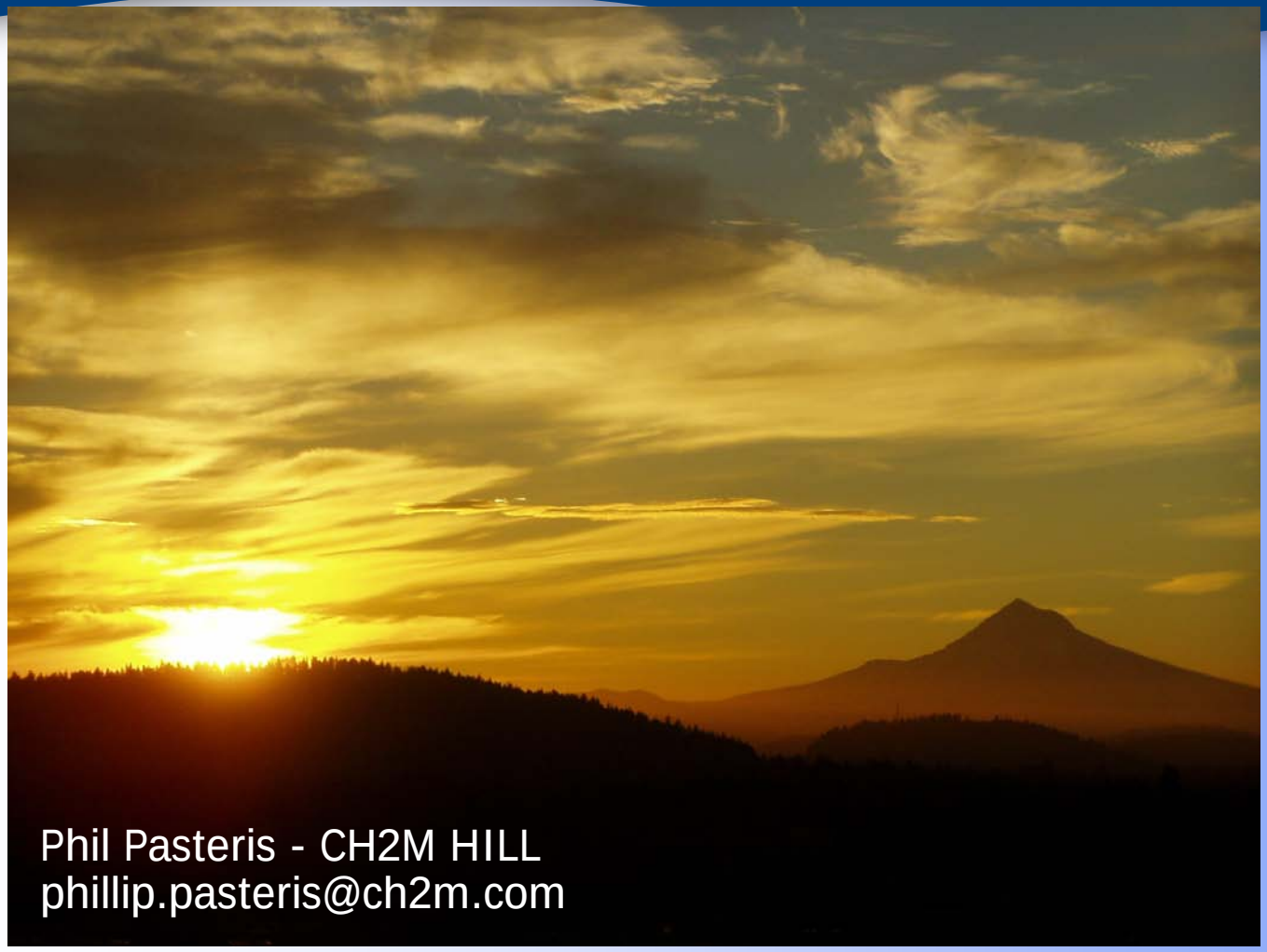
Future Climate

"I wish I had an answer to that because I'm tired of answering that question."

Yogi Berra

Thank You!

Questions?



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