

U.S. DEPARTMENT OF ENERGY  
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

**SUBJECT: FUTURE CLIMATE MODELING**

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# **Future Climate Modeling**

## **Objective:**

**Provide estimates of future climate conditions in the Yucca Mountain region for use in estimating the effects of future climate on hydrologic conditions.**

# Future Climate Modeling

## Strategy for Meeting Objectives:

- **Establish that a coupled global/regional climate modeling system can suitably simulate climate**
- **Identify future climate scenarios that could occur in the next 100,000 years that may impact post-closure repository performance by affecting hydrologic conditions**
- **Perform climate simulations and provide results for both Hydrology and Performance Assessment**

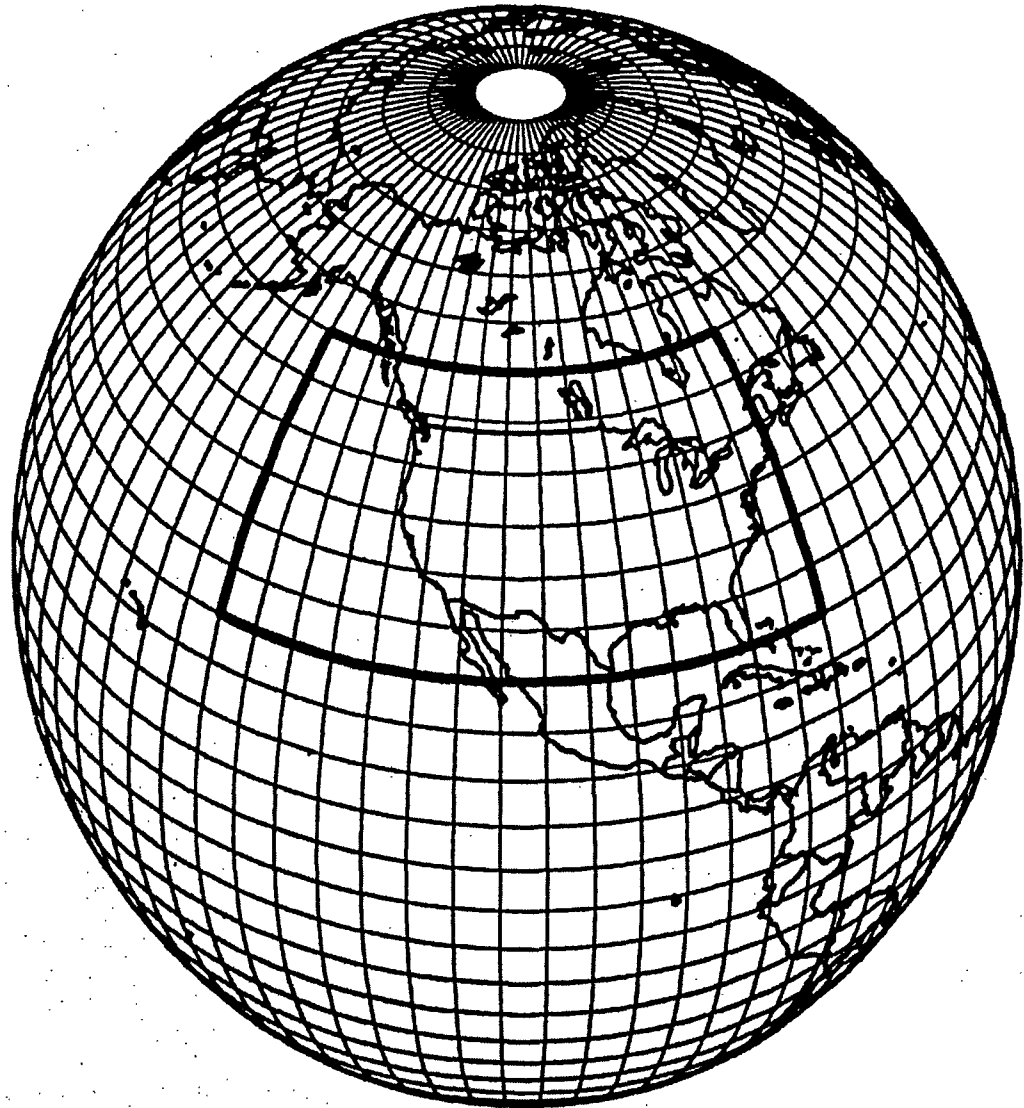
# Modeling Strategy

- **It is not feasible to perform continuous climate simulations for 10K to 100K years**
- **Instead, we perform a finite set of short simulations designed to sample the envelope of probable climate states**
- **This is done by prescribing, rather than simulating, boundary conditions that strongly influence climate (e.g., CO<sub>2</sub>, ice sheets, orbital forcing)**

# Nested Climate Modeling System

- Global climate models are limited to coarse spatial resolution
- We employ a nested, two-stage modeling approach using both global and regional climate models

Example of typical global model grid and nested regional model domain



# **NCAR Climate Models**

**Global Climate Model: GENESIS version 2.0a**

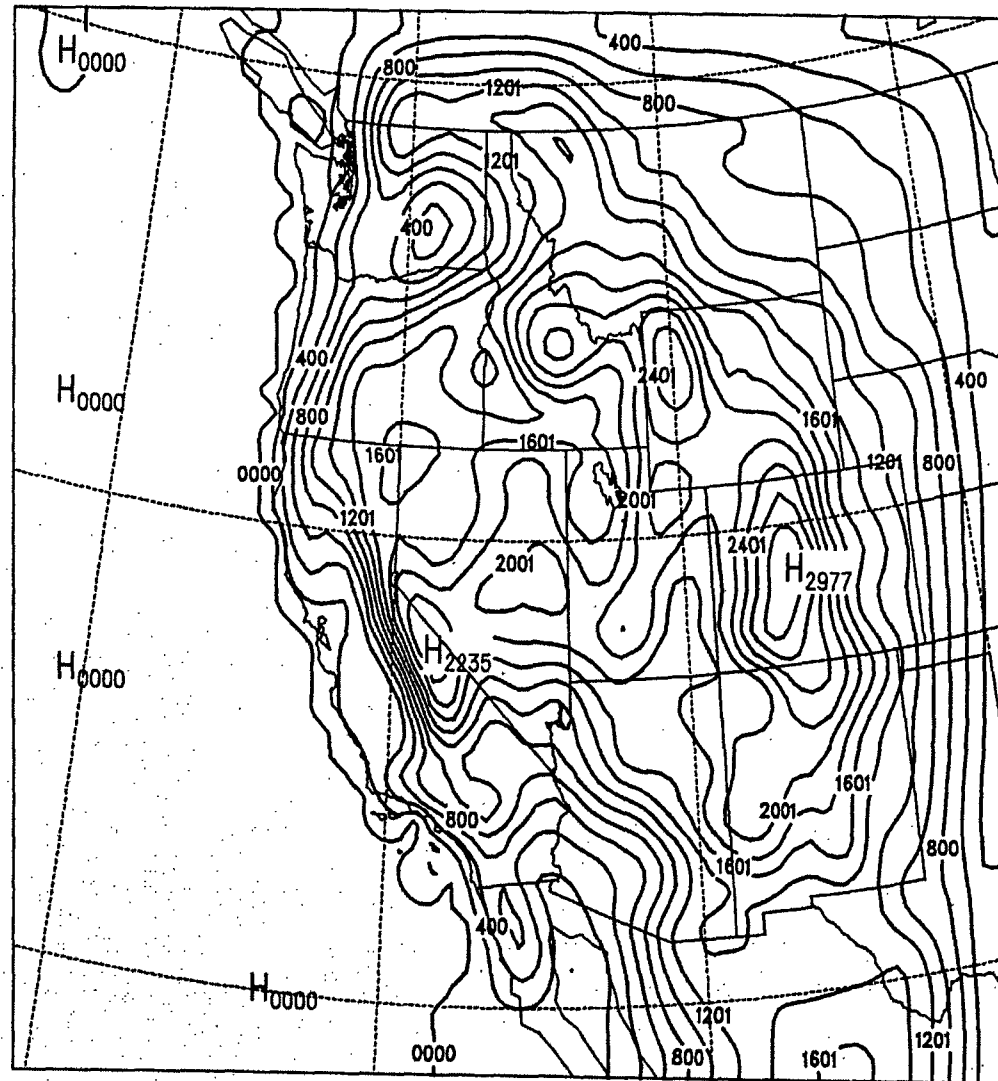
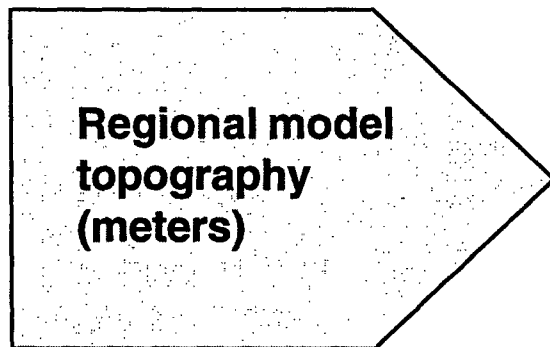
- **400 km grid spacing**
- **Provides boundary conditions to regional model**

**Regional Climate Model: RegCM2**

- **Climate version of NCAR/PSU MM4**
- **50 km grid spacing**

# Regional Model Domain

- Western U.S.
- Domain size and grid spacing are limited by computation requirements



# **The Value of Climate Modeling**

**Modeling has the potential to identify and quantify  
unprecedented, non-analog climate behavior**



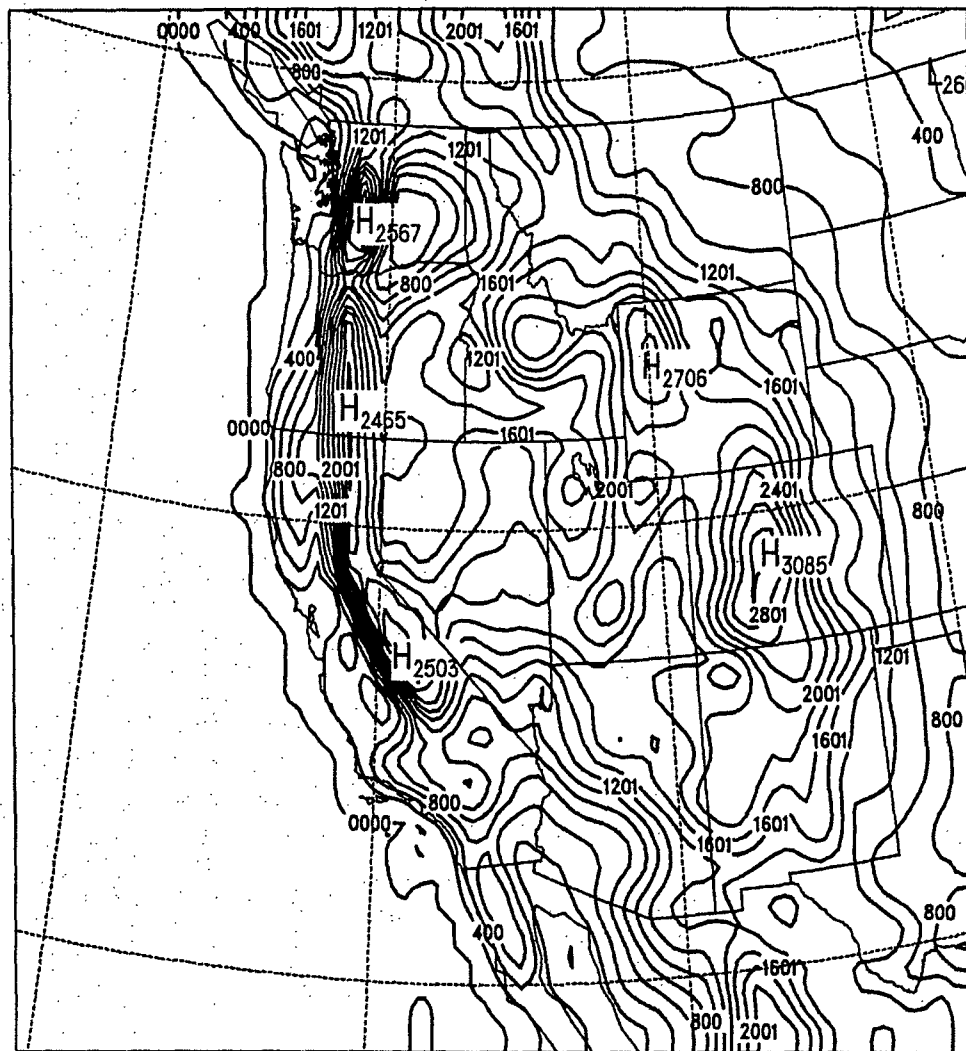
# Limitations of Climate Modeling

- **Imperfect simulations:** Errors arise from approximations in numerical methods and included processes.
- **Important climatic change scenarios may be neglected.**
- **Statistical sampling error:** Intense computational demands require short simulations.

# Model Testing

- **GENESIS** model has been used in numerous non-YMP studies
- **RegCM2** was tested for YMP in stand-alone and coupled mode

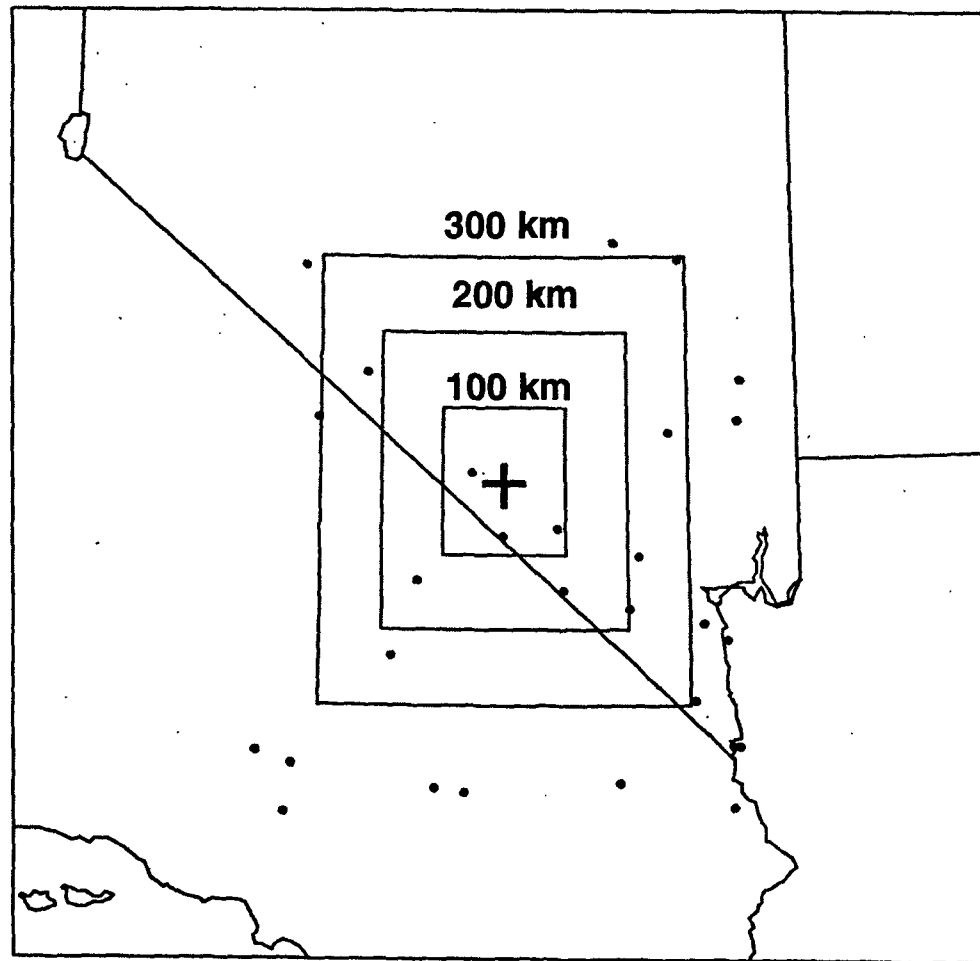
Example of enhanced topography used to test the sensitivity of RegCM2 to mountain height (meters)



# Comparison of RegCM2 to Observations

- Compare regional model grid cell averages to station data averaged over comparable areas

Map showing the location of the Yucca Mountain and selected climate data sites



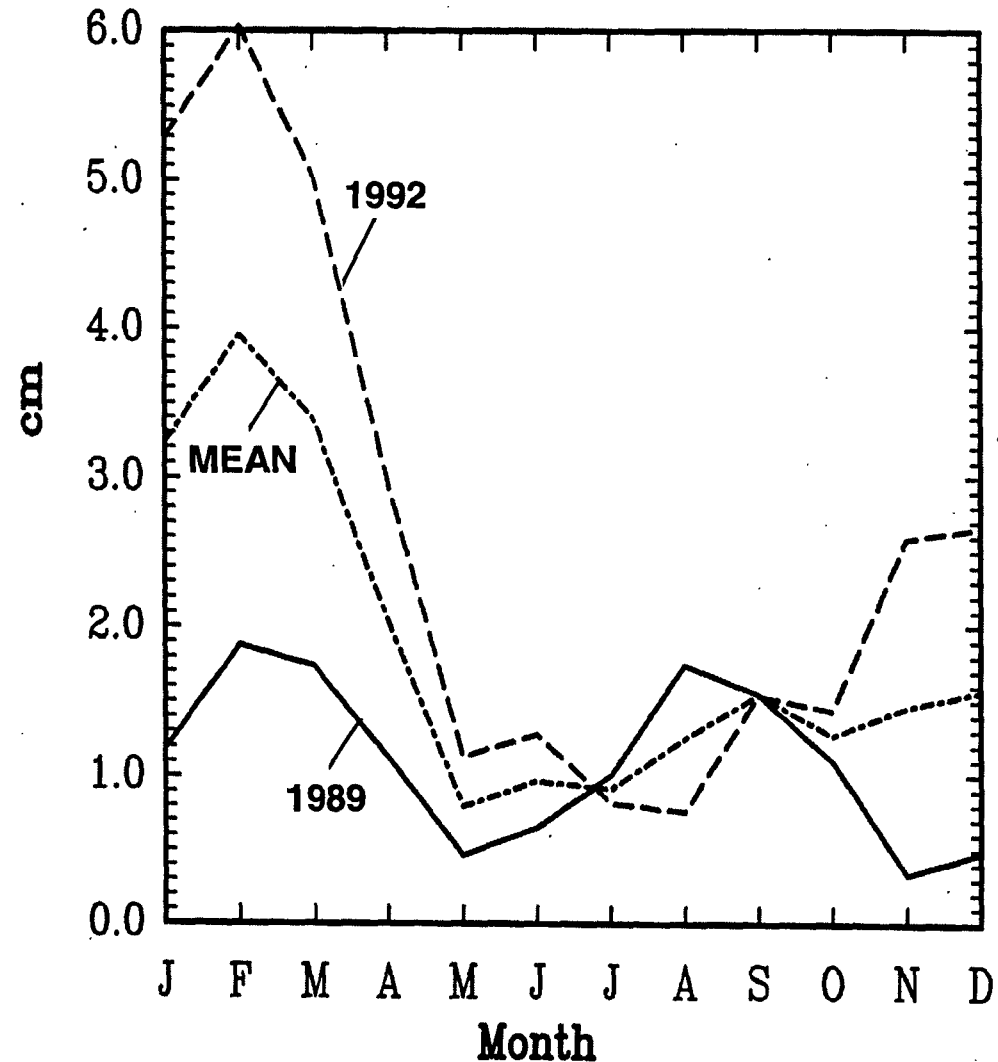
+ Yucca Mountain

• Weather Stations

# Two Years of RegCM2 Precipitation

- 1989 and 1992
- RegCM2 uses observed boundary conditions
- Results spatially averaged within 150 km of the YMP site
- Note large interannual variability

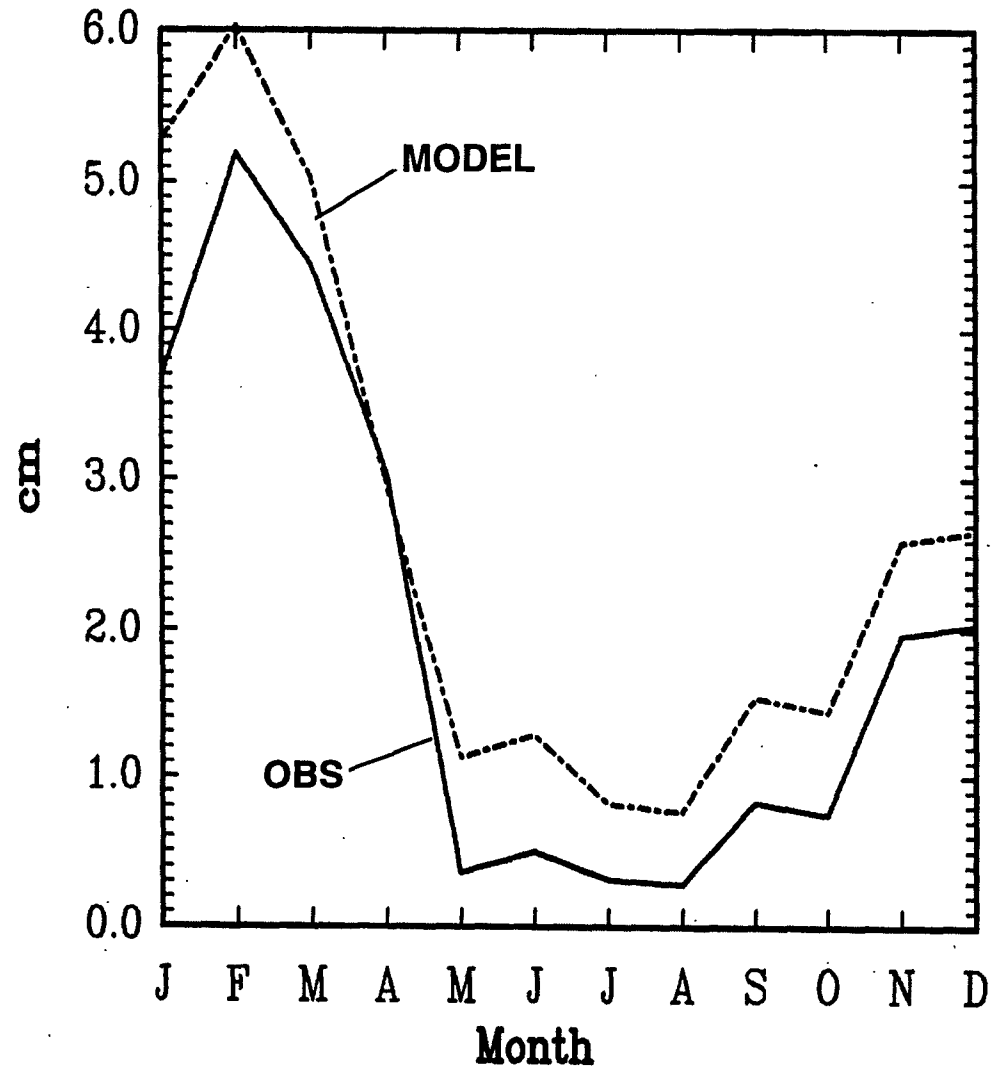
Monthly precipitation smoothed using a 3-month running mean. The two year average is also shown.



# RegCM2 Model vs. Observed Rainfall for 1992

- 1992 was an El Nino year
- Results spatially averaged within 150 km of the YMP site

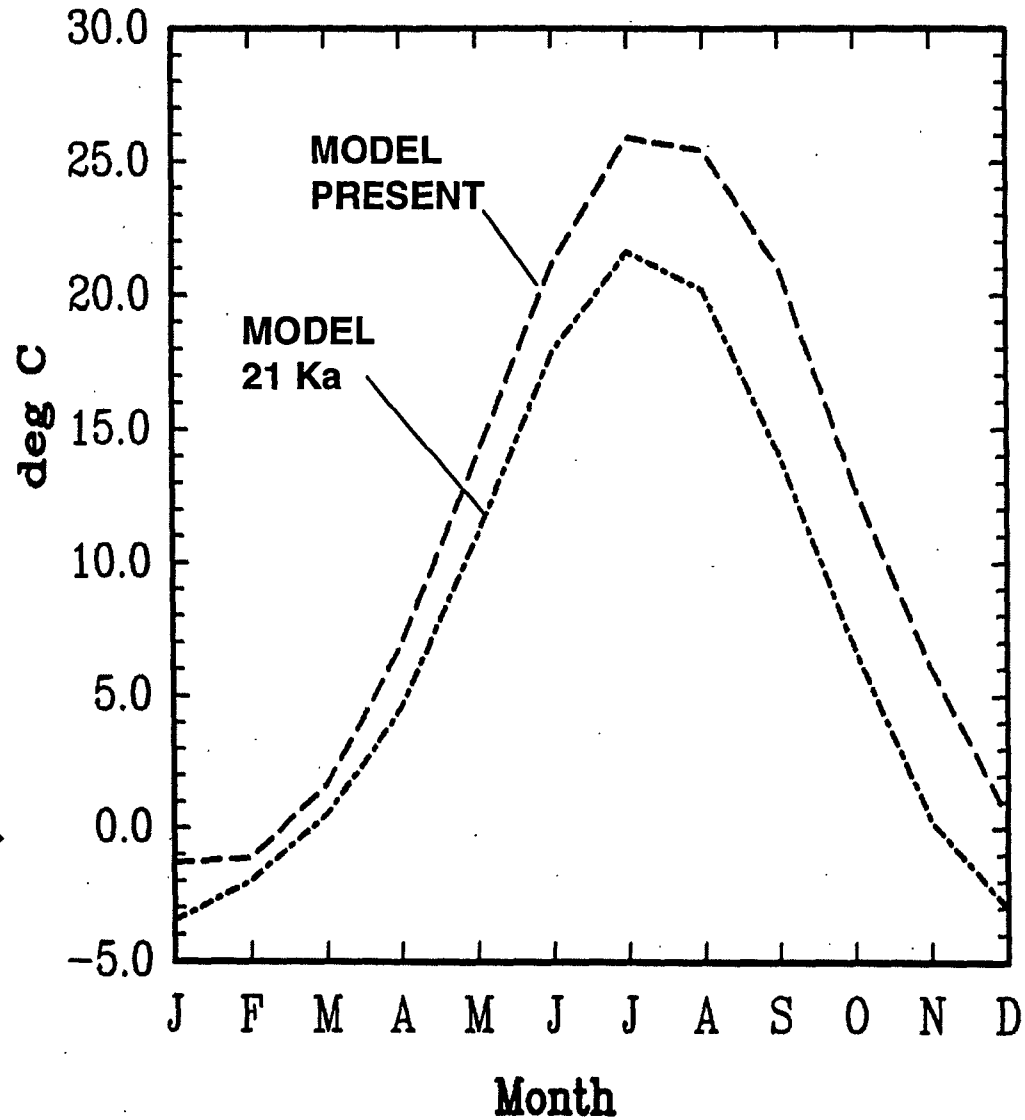
Monthly precipitation smoothed using a 3-month running mean



# Paleoclimate Test of RegCM2

- Simulation for 21,000 years BP, the last glacial maximum (LGM)
- Prescribed ice sheets, CO<sub>2</sub> and insolation
- RegCM2 driven by global model output

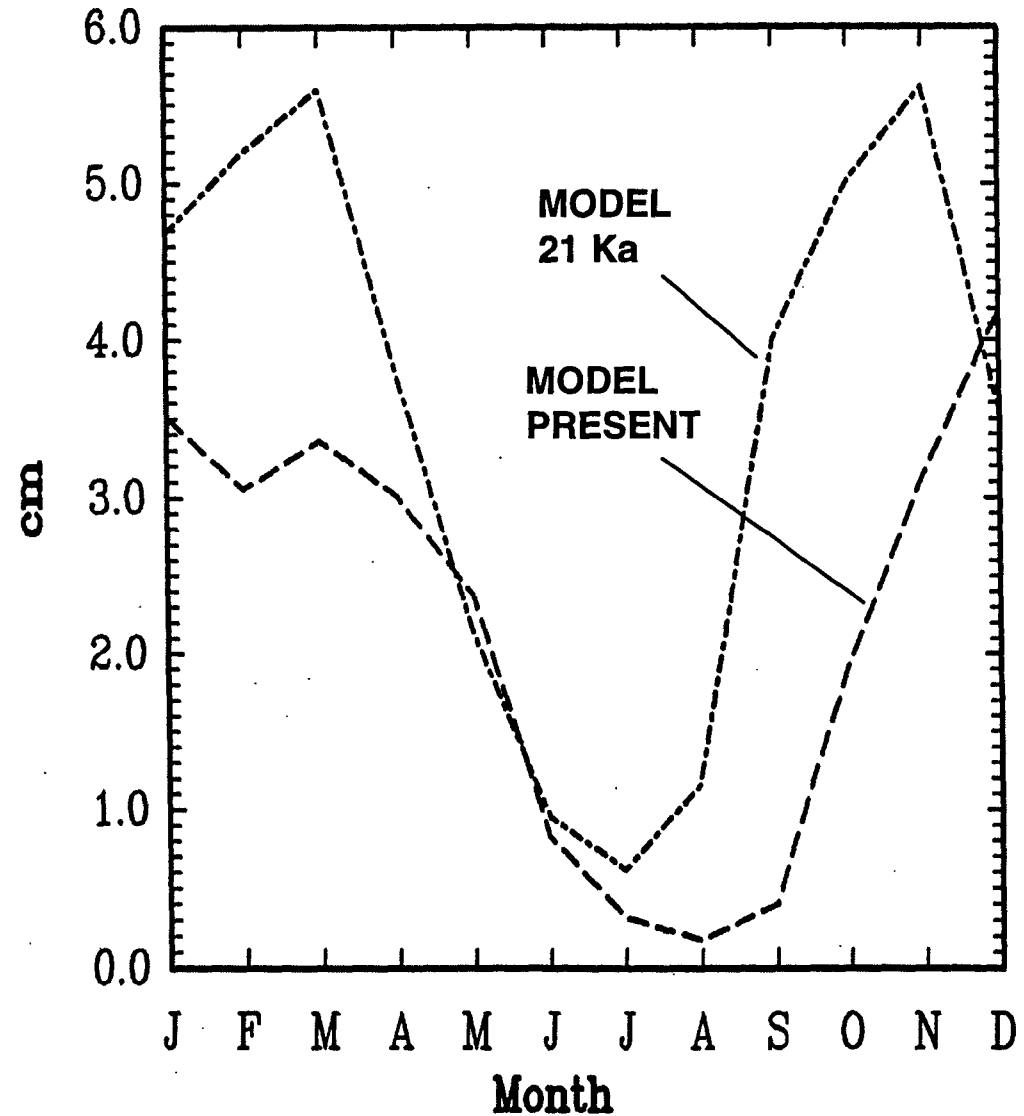
Monthly temperature  
in the YMP site region  
for the control and  
paleoclimate test  
cases



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# **Conclusions From Testing Phase**

## **The Climate Modeling System**

- **Adequately simulates interannual climate variability and “wet” years for YMP site region**
- **Correctly simulates the 21K glacial climate for the YMP site as being colder and wetter**
- **Is ready for use in future climate analyses**



# **Selection of Future Climate Scenarios**

- **Assume future climate can be represented as a finite set of states. Selections from this set are called “future climate scenarios”**
- **Selections are derived from expert judgment based on paleoclimate, present climate, theoretical arguments and projections for anthropogenic effects**
- **Selections try to anticipate conditions yielding greater effective moisture in the Yucca Mountain region**
- **Choice and schedule of scenarios is subject to limitations of available computer resources**

# Future Climate Scenarios

## **FY96:**

- **Control**
- **2xCO<sub>2</sub> (anthropogenic greenhouse)**

## **FY97, choice of two of the following:**

- **6xCO<sub>2</sub> (large anthropogenic greenhouse)**
- **2xCO<sub>2</sub> with large El Nino**
- **21K LGM (paleo comparison)**

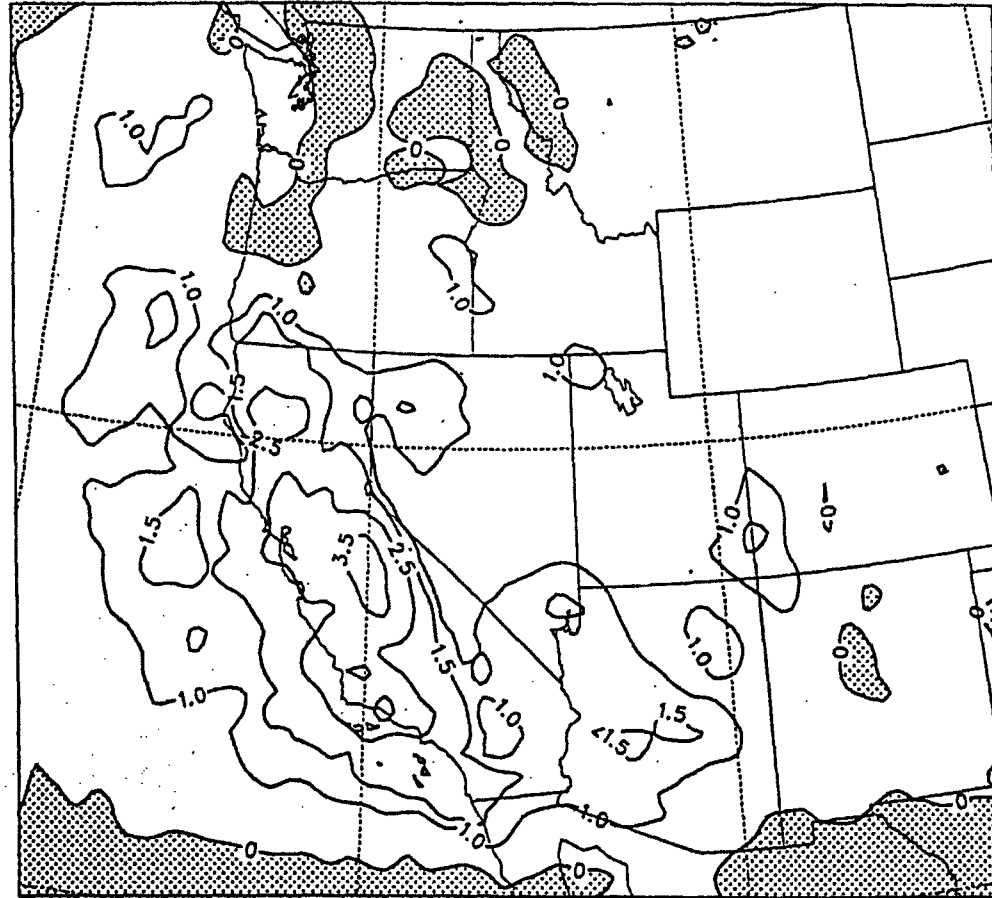
## **Other potential scenarios:**

**Intermediate glacial case; Super glacial case;  
Reduced North Atlantic deep water case**

# 2xCO<sub>2</sub> Future Climate Simulation

- Increased winter precipitation over much of the West and Southwest
- 4-year average

Monthly precipitation change for 2xCO<sub>2</sub> minus the control.  
Contours are mm/day

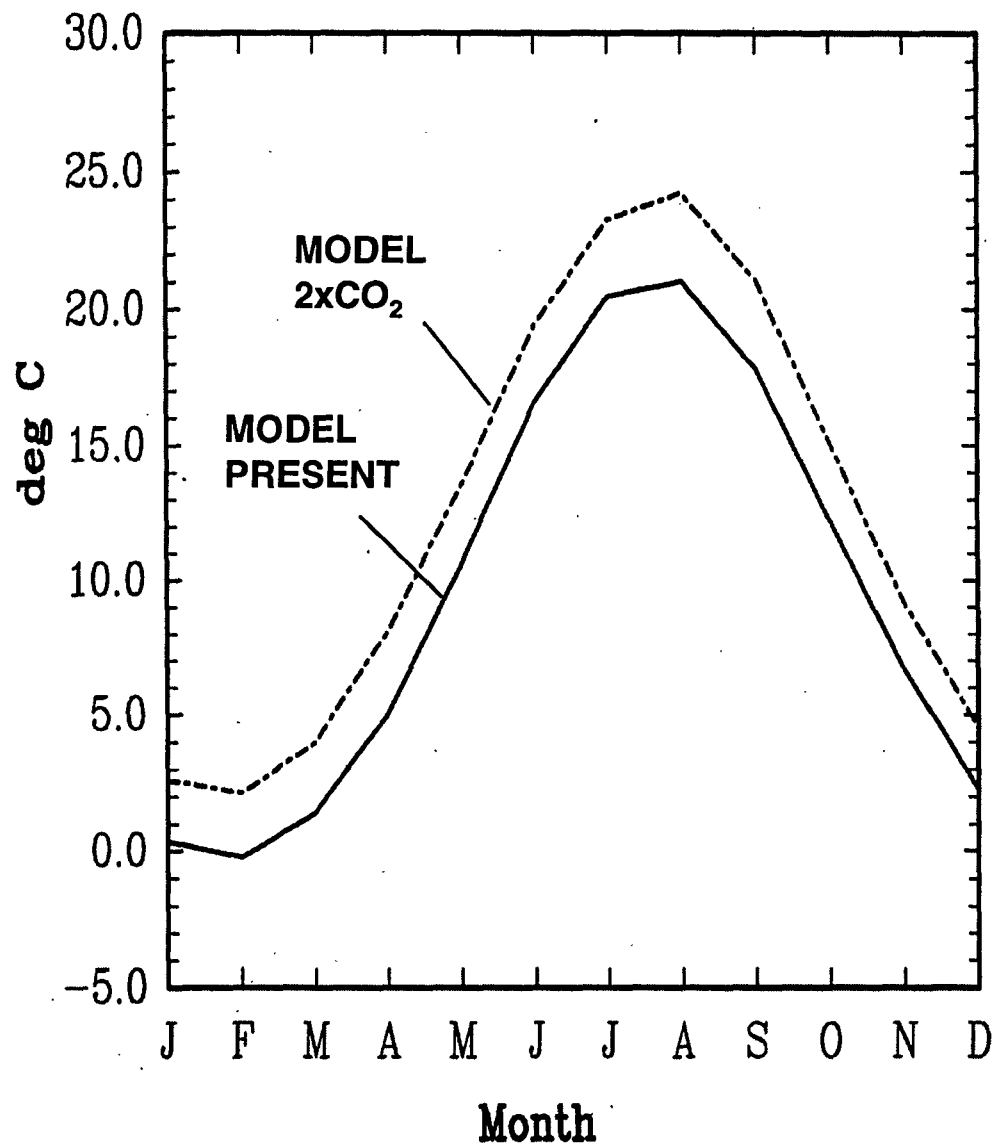


# 2xCO<sub>2</sub> Future Climate Simulation

- Year-round increase of temperature around the YMP site of 2-3 degrees C.
- 4-year average

Monthly temperature for the control and 2xCO<sub>2</sub> cases

Averaged within 150 km of the YMP site

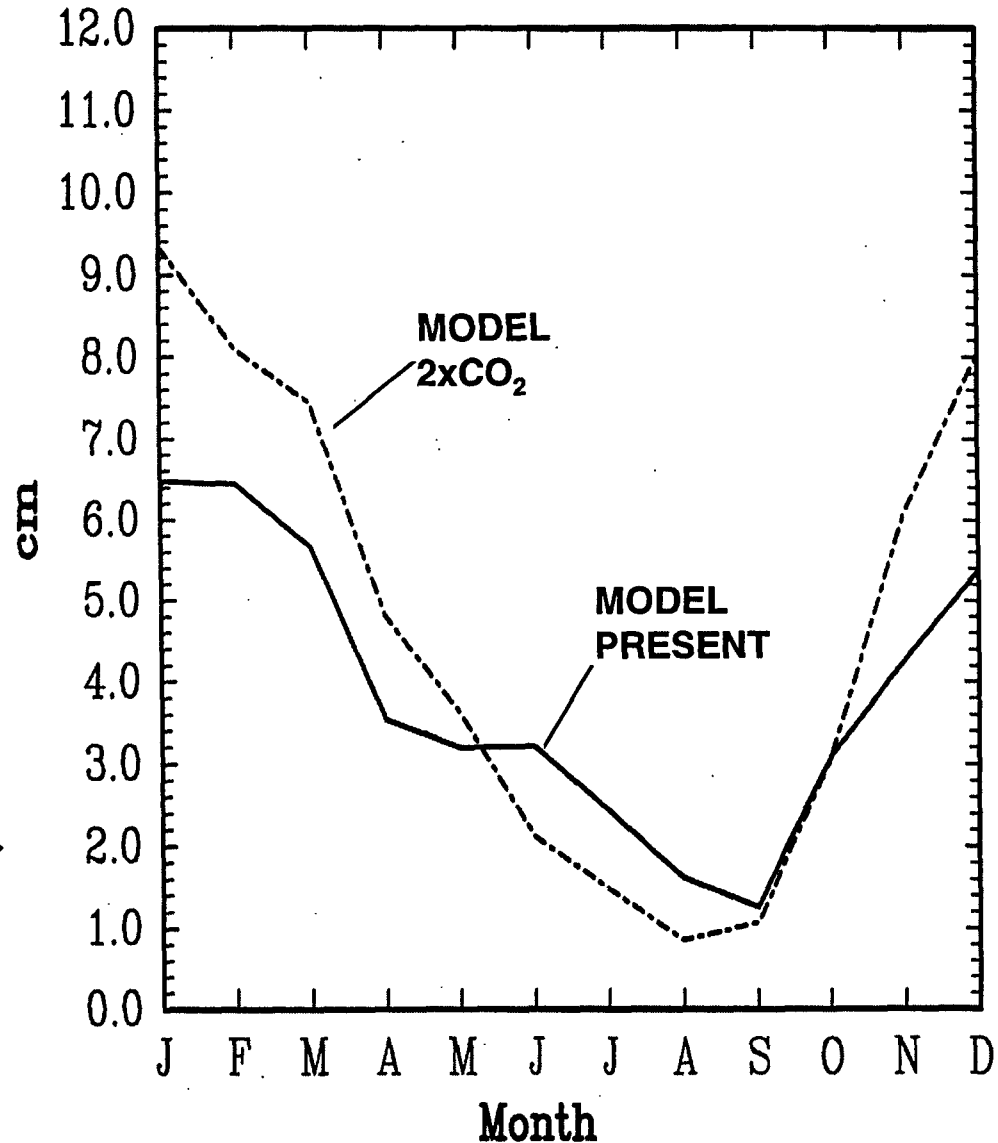


# 2xCO<sub>2</sub> Future Climate Simulation

- Winter increase and summer decrease of precipitation around the YMP site
- 4-year average

Monthly precipitation for the control and 2xCO<sub>2</sub> cases

Averaged within 150 km of the YMP site



# **Output to Other Program Elements**

## **Hydrology:**

**Daily values of temperature, precipitation and cloud cover from each simulation.**

## **Performance Assessment:**

**Monthly averaged and extreme values of precipitation and other variables as required.**