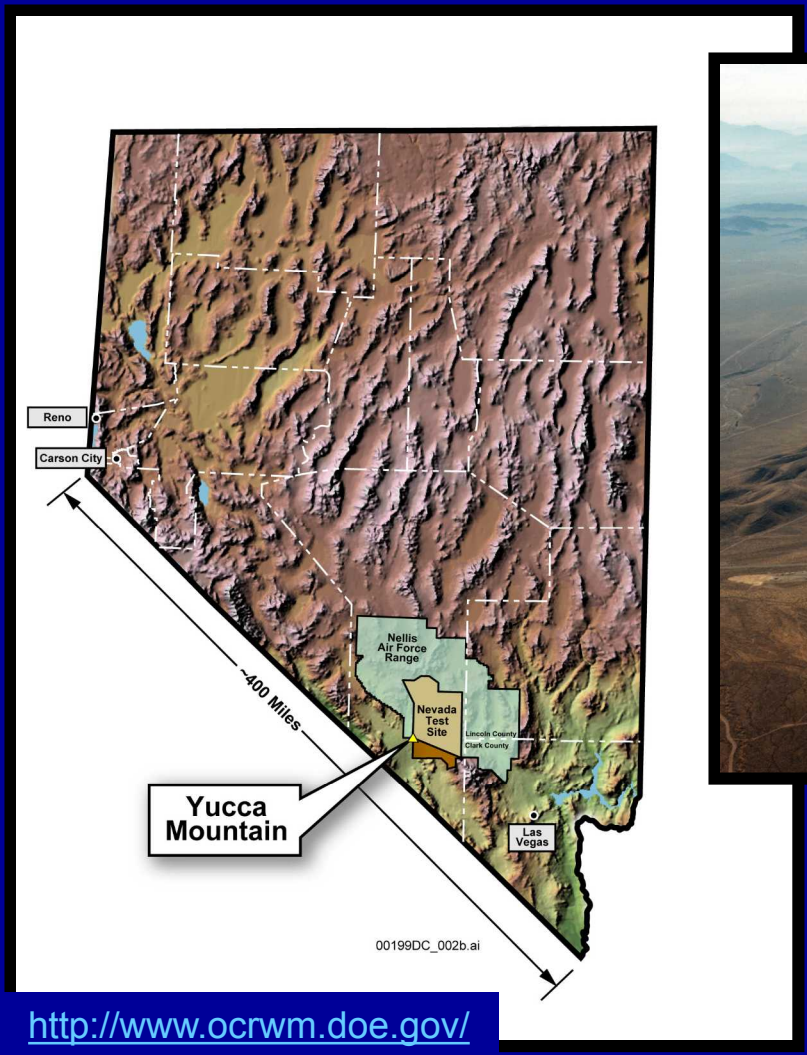
SAND2008-0886P

Yucca Mountain Climate: Past, Present, and Future



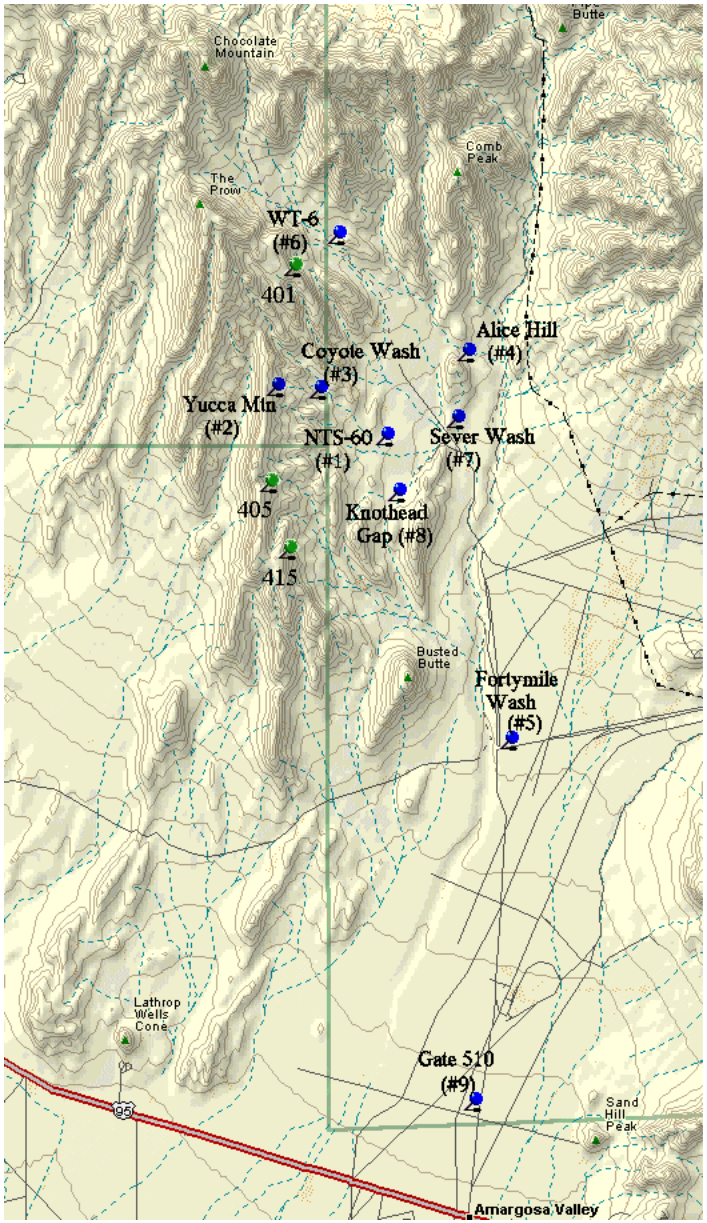
Saxon Sharpe
Desert Research Institute
Reno, Nevada

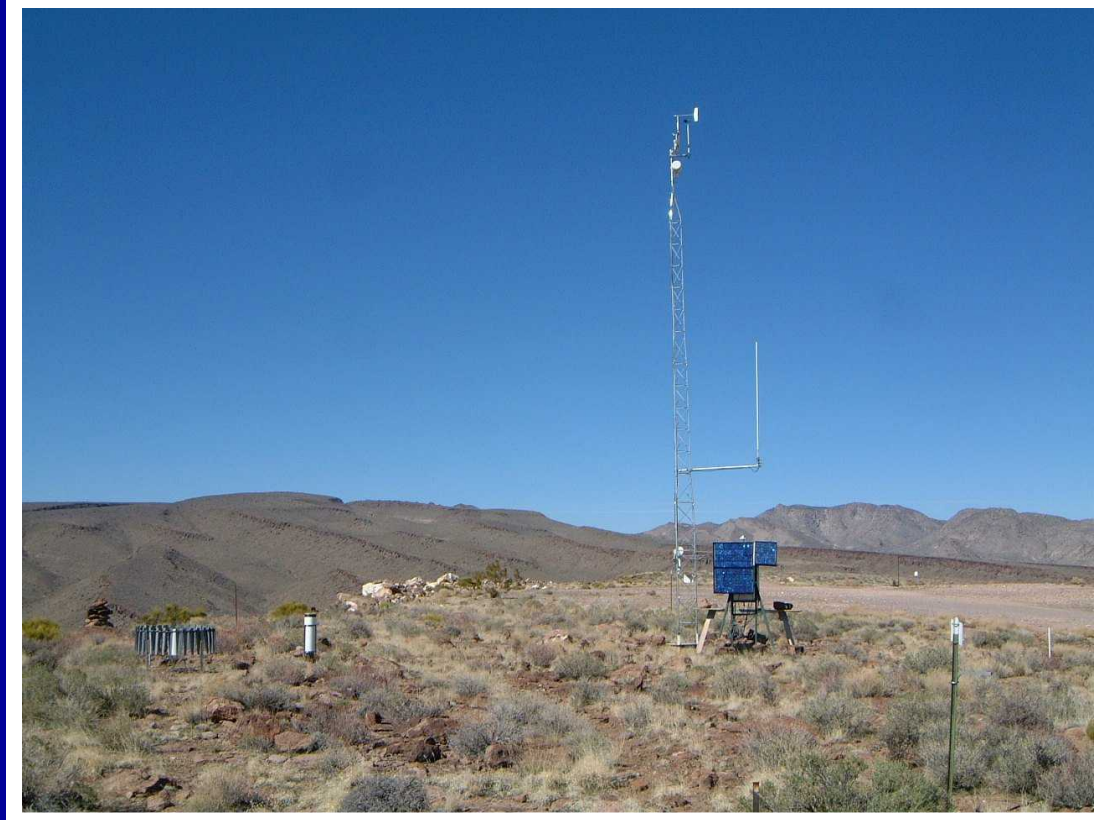
http://www.ocrwm.doe.gov/

Why

1. Evaluation of **modern climate** is necessary to relate climatic events to near-surface processes such as infiltration, runoff, and evapotranspiration.
2. **Modern climate** information also aids in environmental analyses of repository design facilities and atmospheric dispersion models.
3. Evaluation of **past climate** regimes, particularly temperature and precipitation, is needed to assess the relation of past climate to past hydrologic conditions.
4. Estimates of **potential future climate** and hydrology are needed to evaluate long-term repository performance.

Yucca Mountain Met Stations





Data from regional stations in southern Nevada are also used

Waste must be isolated for at least 10,000 years, therefore climate change during this time period must be considered

Sharpe, S.E. (2007) Using modern through mid-Pleistocene climate proxy data to bound future variations in infiltration at Yucca Mountain, Nevada

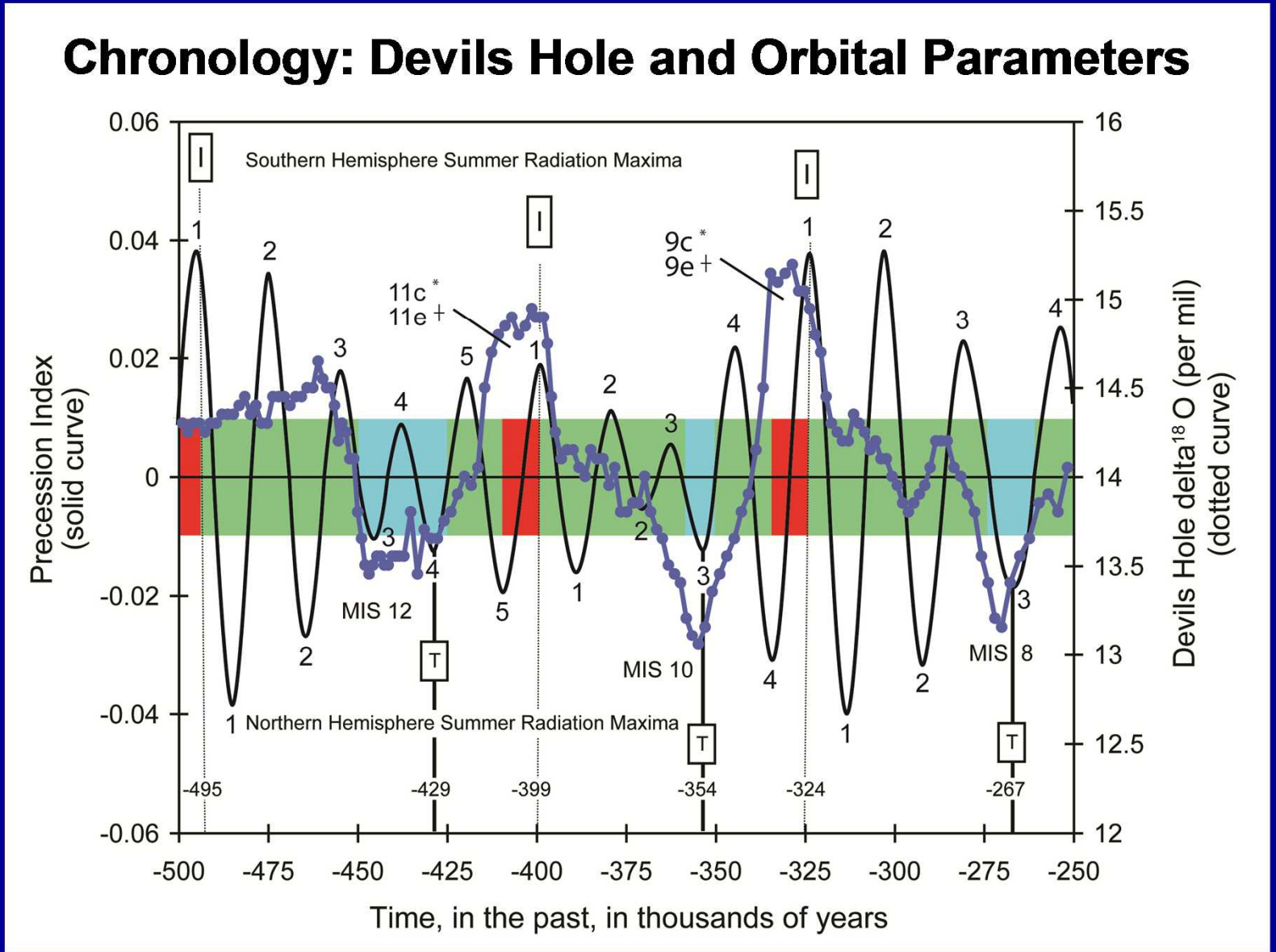
in Levich, R.A., and Stuckless, J.S., eds., **The Geology and Climatology of Yucca Mountain and Vicinity, Southern Nevada and California**: Geological Society of America Memoir 199, p. 155-205, doi: 10.1130/2007.1199 (05).

Approach

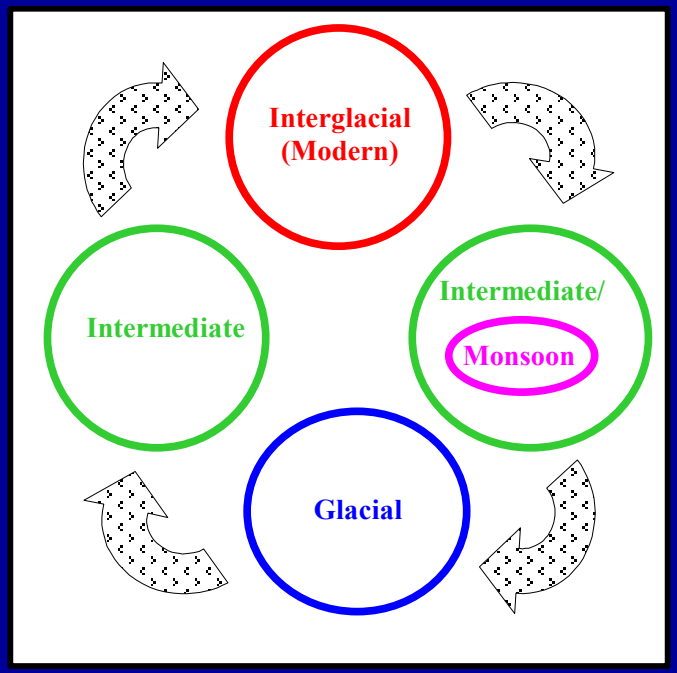
1. Close match between Devils Hole climate proxy record and calculated orbital parameters provides the rationale for past climate being the key to future climate.
2. Future climate is based both on the nature of past climate and the assumption of repeated climate cycles.
3. The nature of future climate is based on the sequencing and characteristics of past climate.
4. Past and future climate may be represented using 4 major climates states.

4 Primary Assumptions

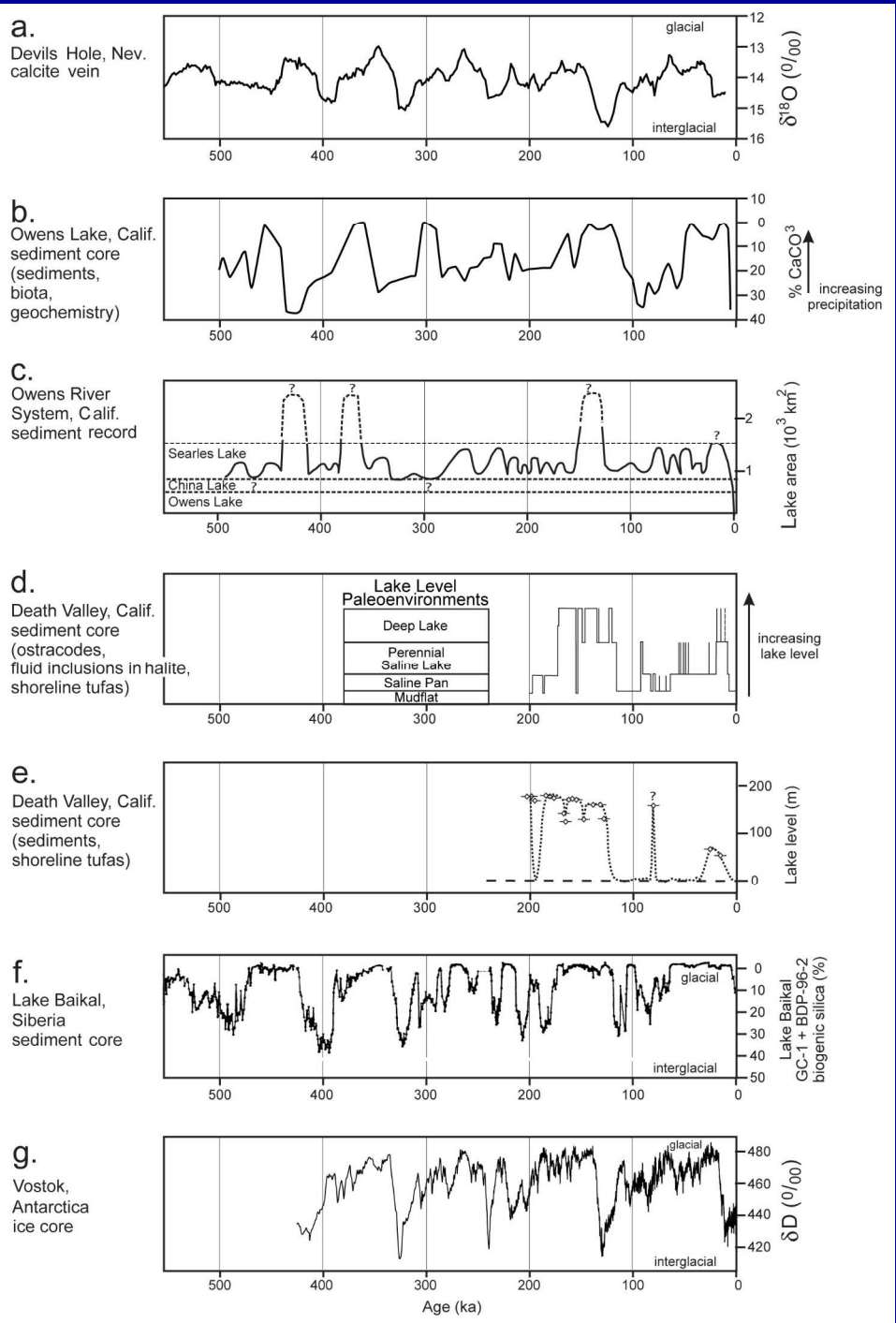
#1 Relation exists between the timing of long-term climate change and orbital parameters



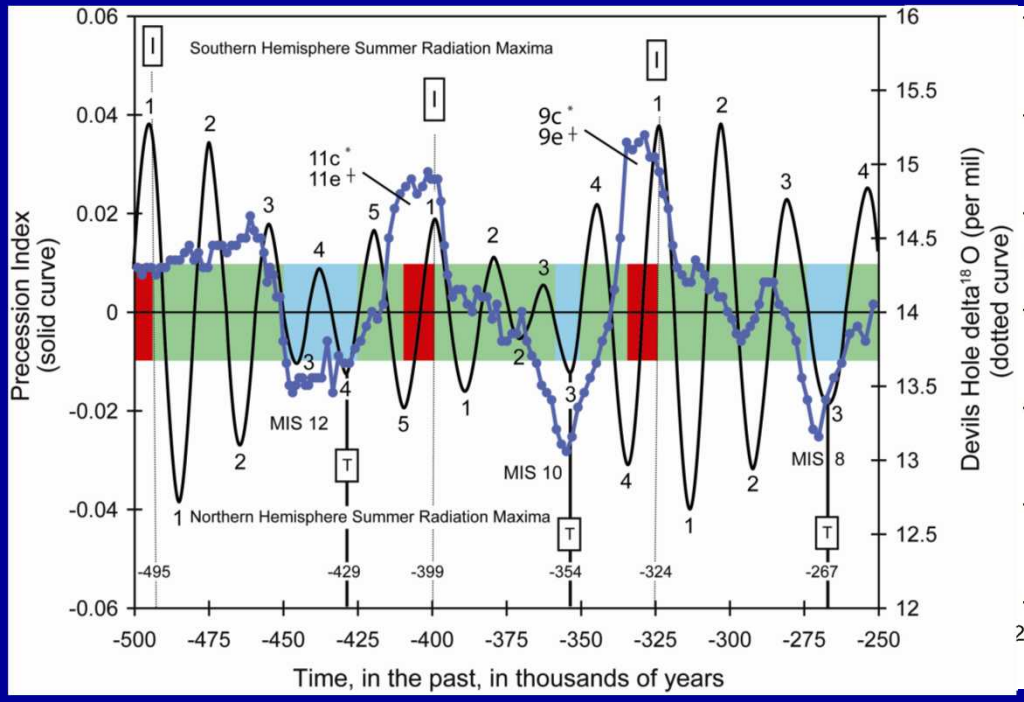
#2 Climate is sequential, the past is the key to the future

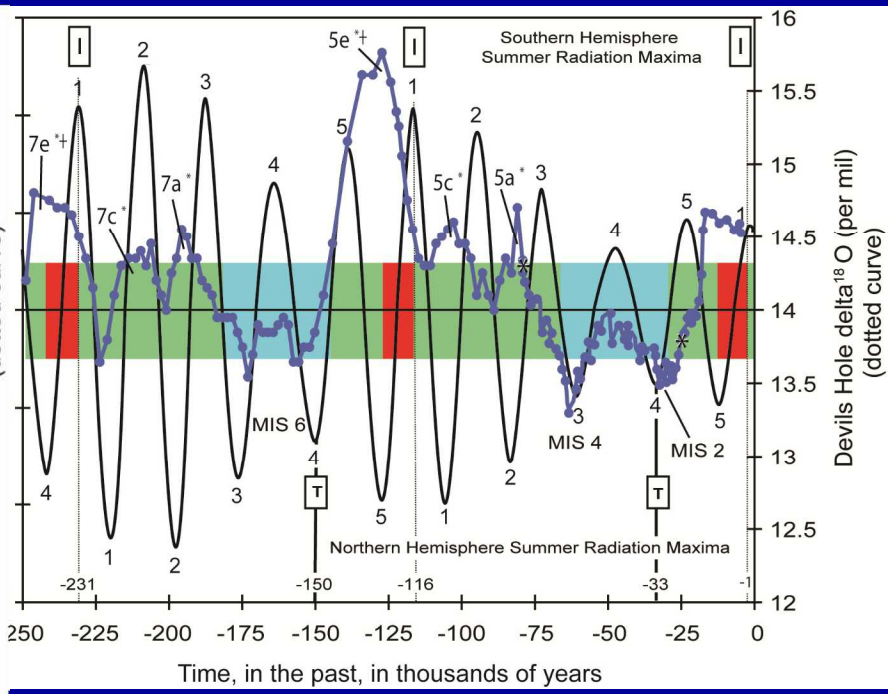


a) Landwehr et al. 1997
b) Smith et al. 1997
c) Jannik et al. 1991
d) Lowenstein et al. 1999
e) Ku et al. 1998
f) Prokopenko et al. 2001
g) Petit et al. 1999

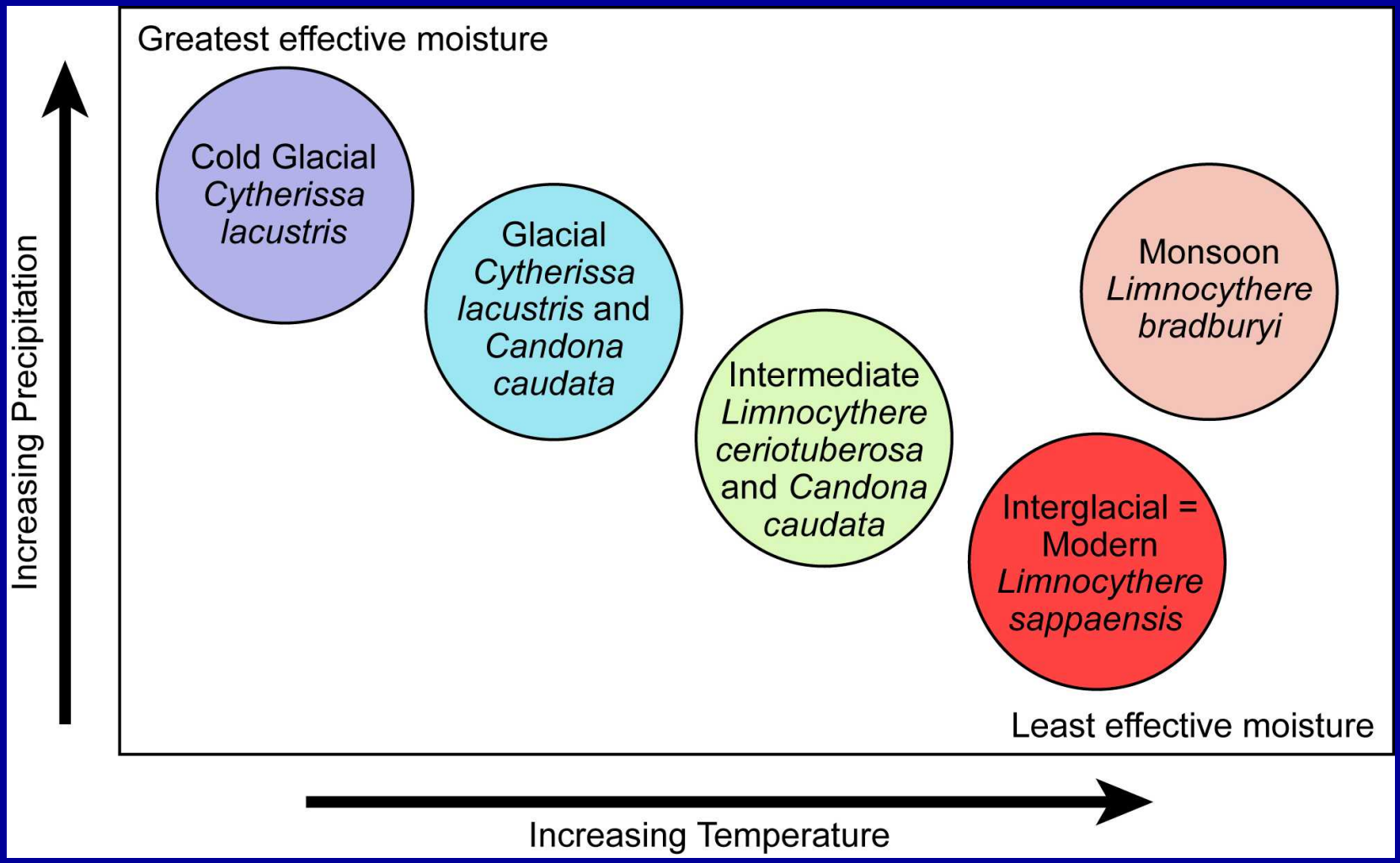


3 Characteristics of late Quaternary glacial and interglacial climates differ from each other in a systematic way





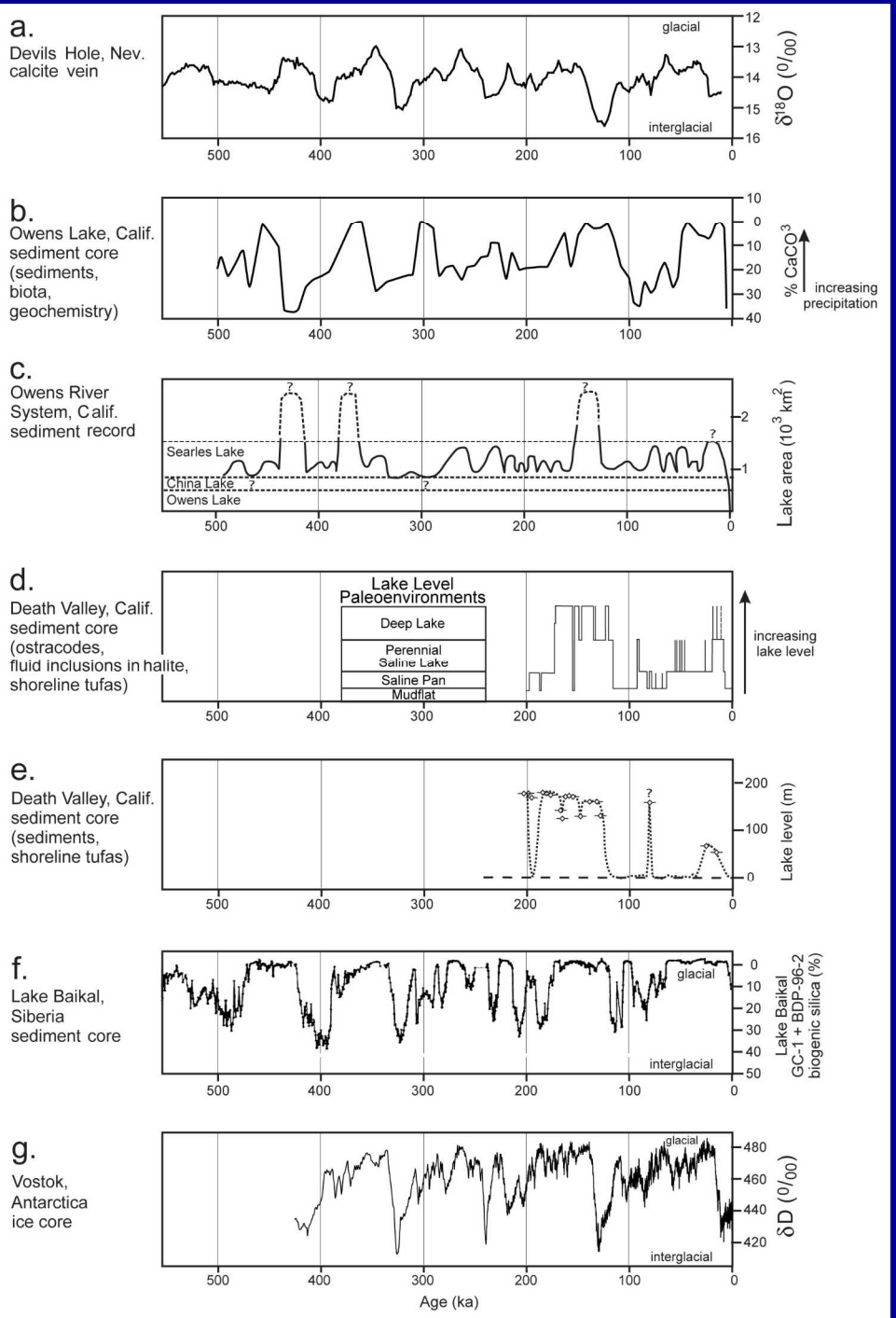
4 Past and future climate may be represented using 4 major climates states



Forecasting the next 500,000 years

1. Compare the relation of the Devils Hole record to calculated orbital parameters to identify past climate pattern.
2. Project this pattern into the future to establish the timing of future climate regimes.
3. Identify the magnitude and nature of past climate states – Interglacial (modern), Intermediate, Monsoon, Glacial.
4. Select present-day meteorological stations to represent those past climate states.

Devils Hole, Nevada



Comparison of Proxy Records for Glacial and Interglacial Climate

a)Landwehr et al. 1997
b)Smith et al. 1997
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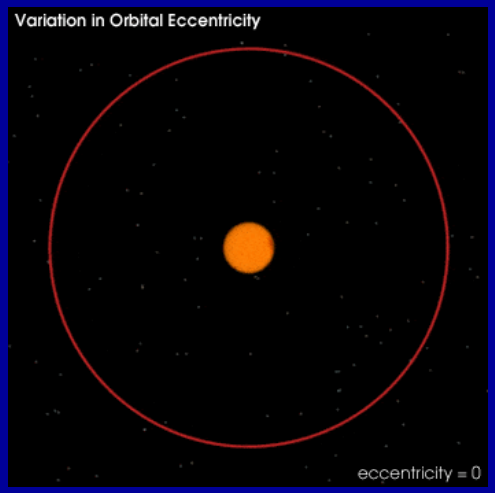
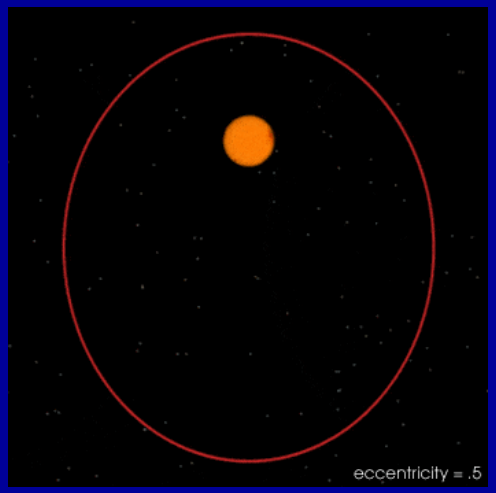
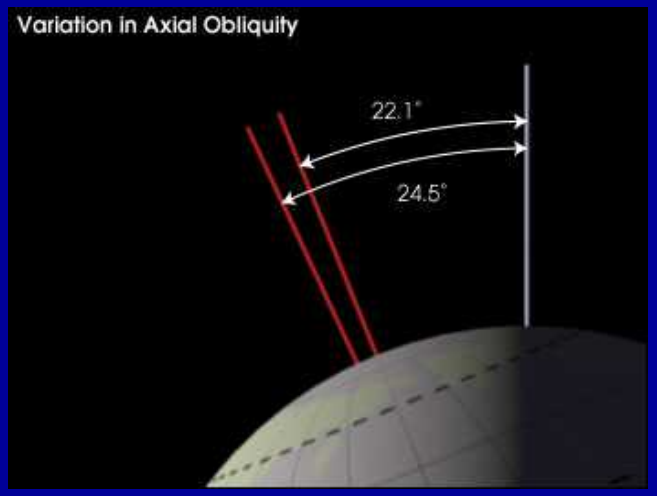
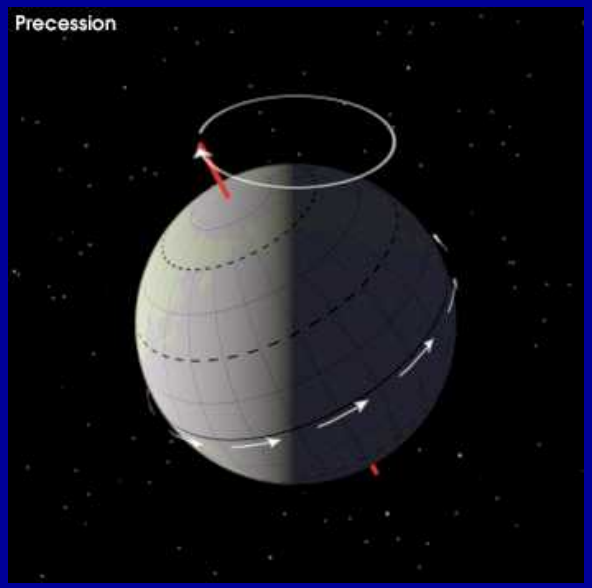






Eccentricity: changes the annual total radiation received at the top of the earth's atmosphere. ~100,000 yr cycle

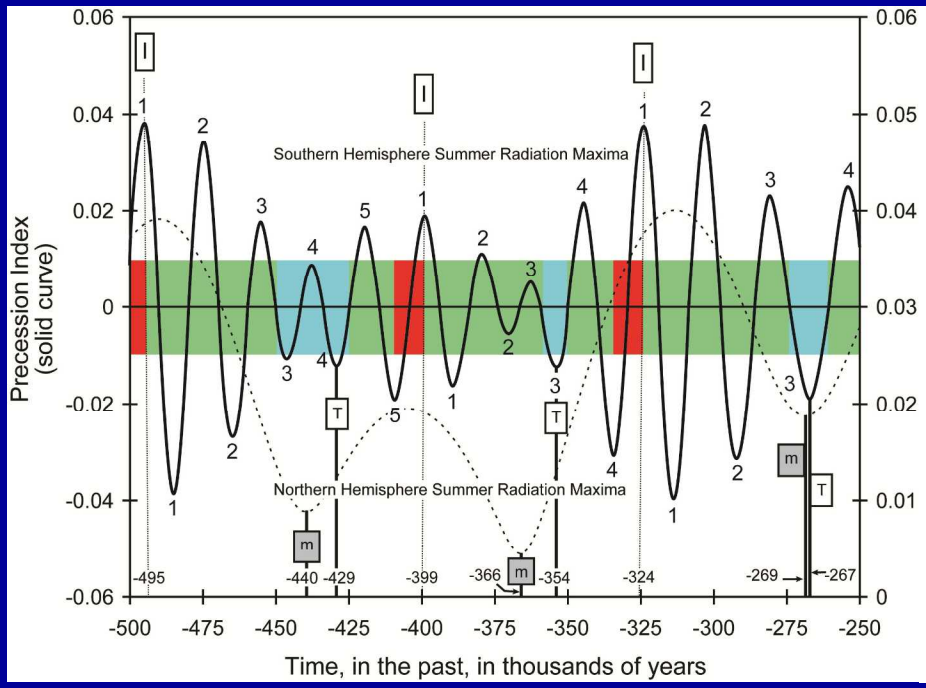
Obliquity: changes the seasonal and latitudinal distribution of insolation at the top of the earth's atmosphere. ~40,000 yr cycle

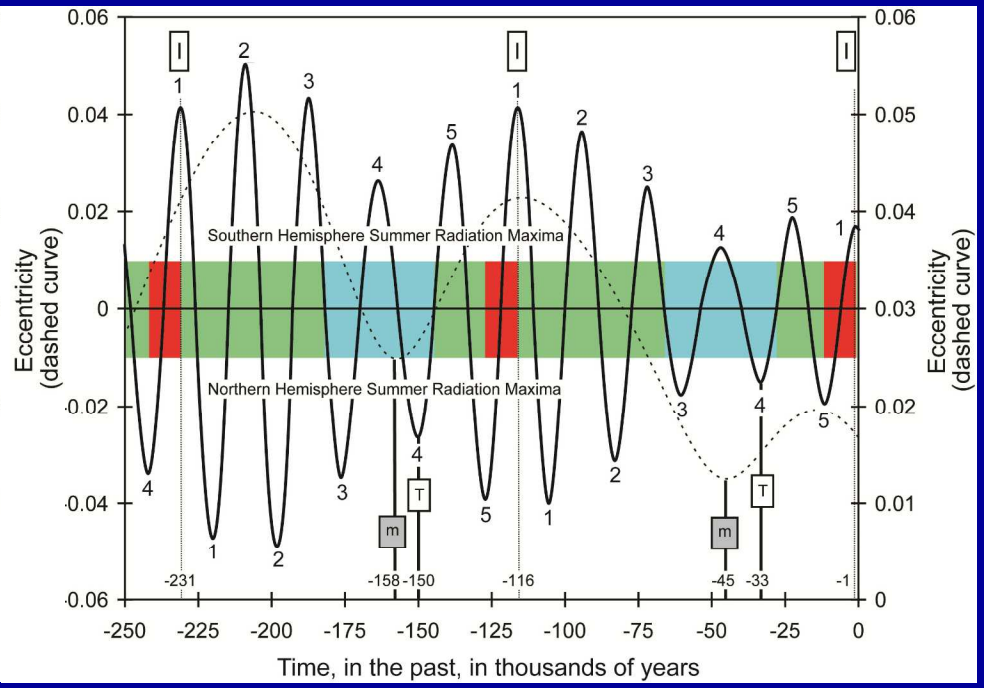


Precession: change the seasonal and latitudinal distribution of insolation at the top of the earth's atmosphere, but not the total insolation. ~ 22,000 yr cycle

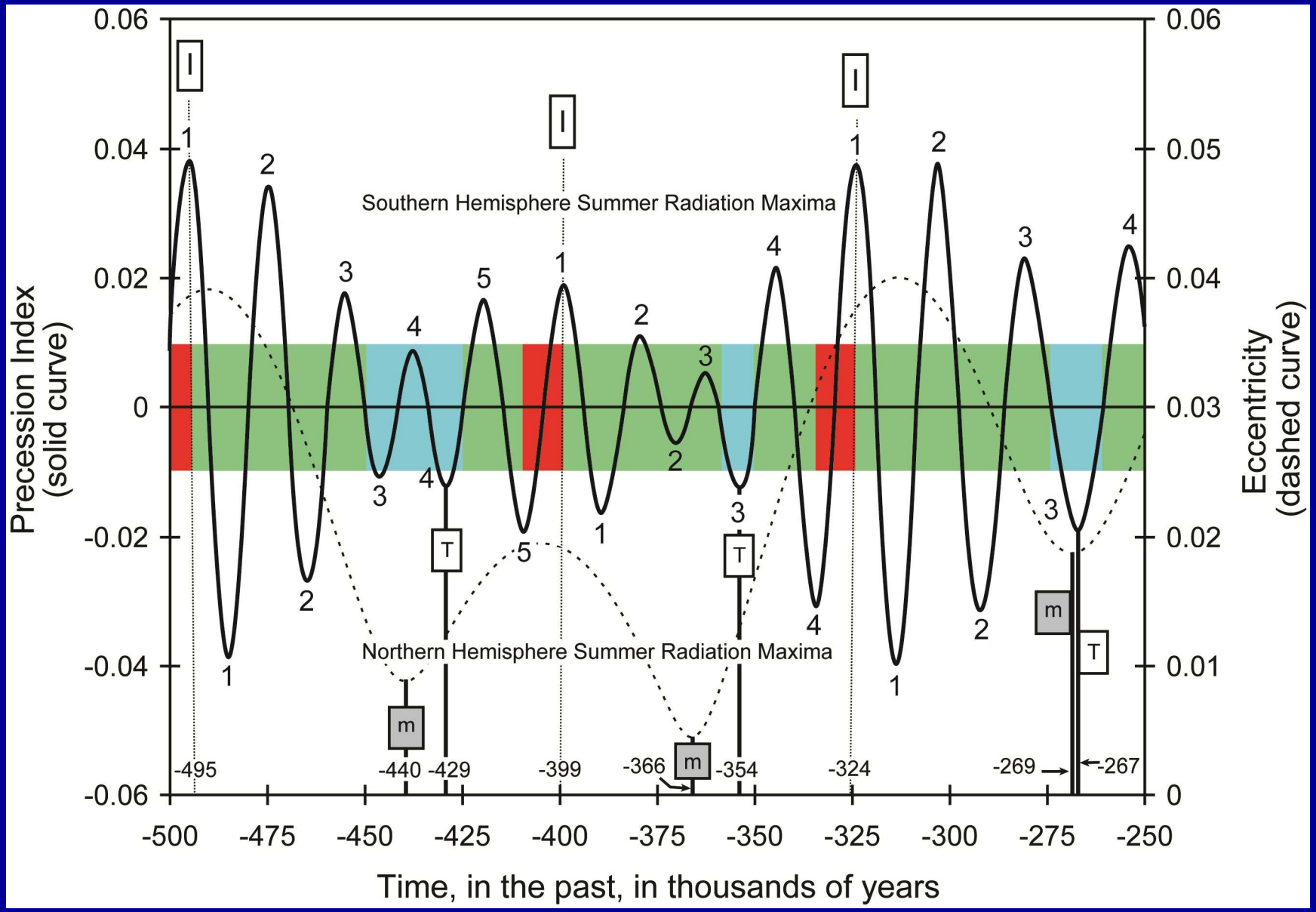
http://earthobservatory.nasa.gov/Library/Giants/Milankovitch/milankovitch_2.html

Precession and eccentricity for the last 500,000 years

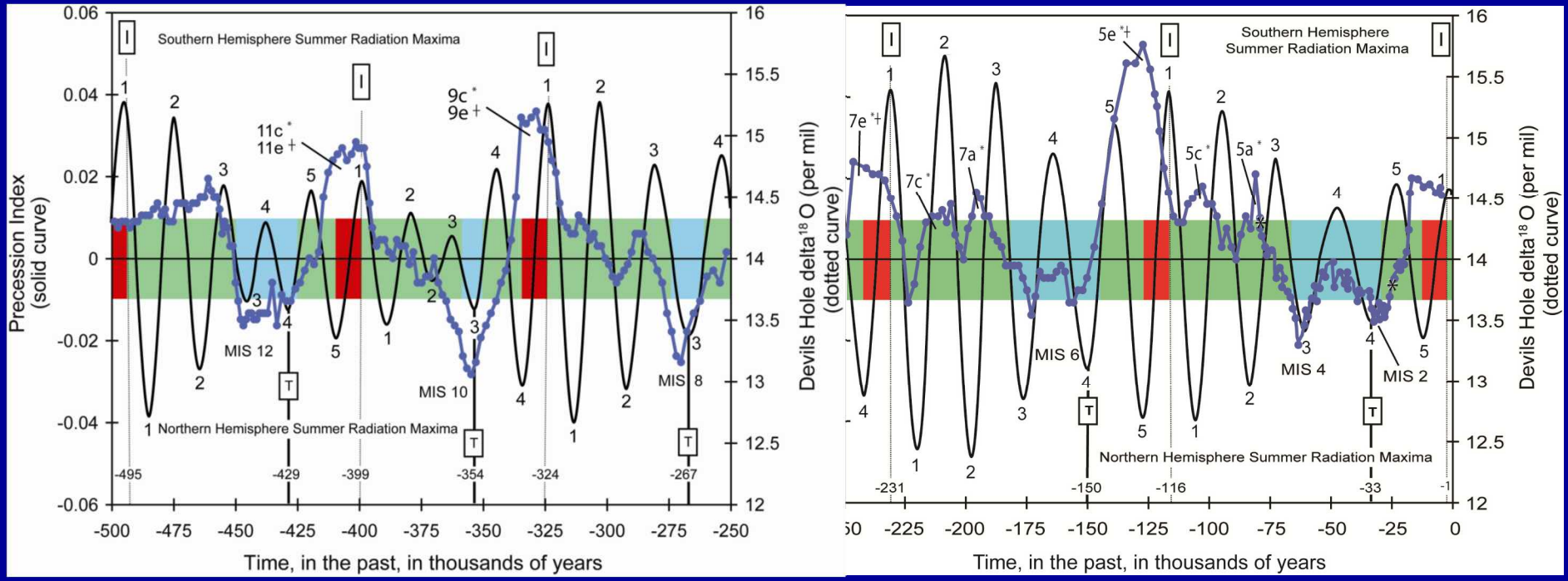




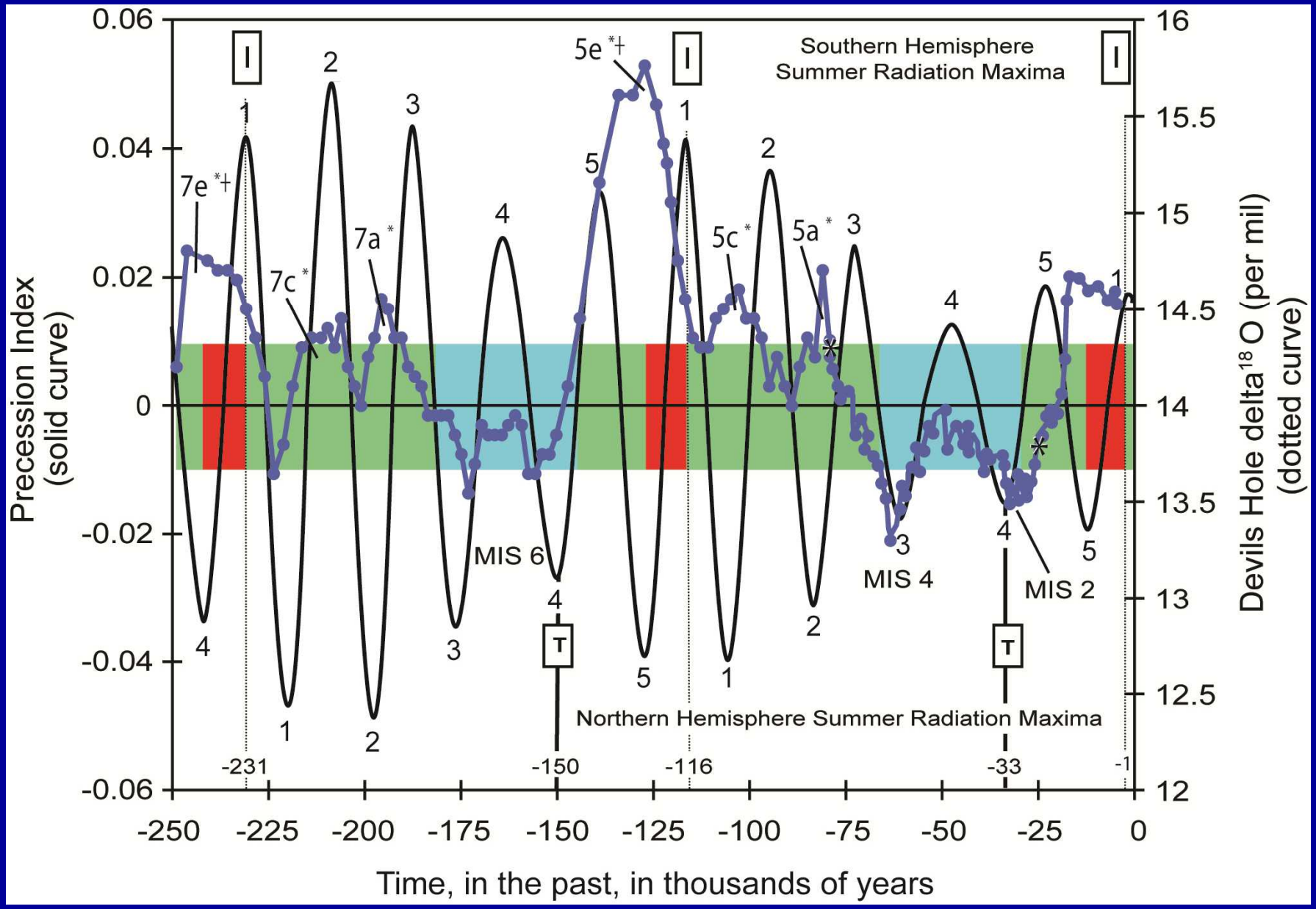
Precession and eccentricity



The relation of Devils Hole to orbital parameters



Devils Hole record and orbital parameters



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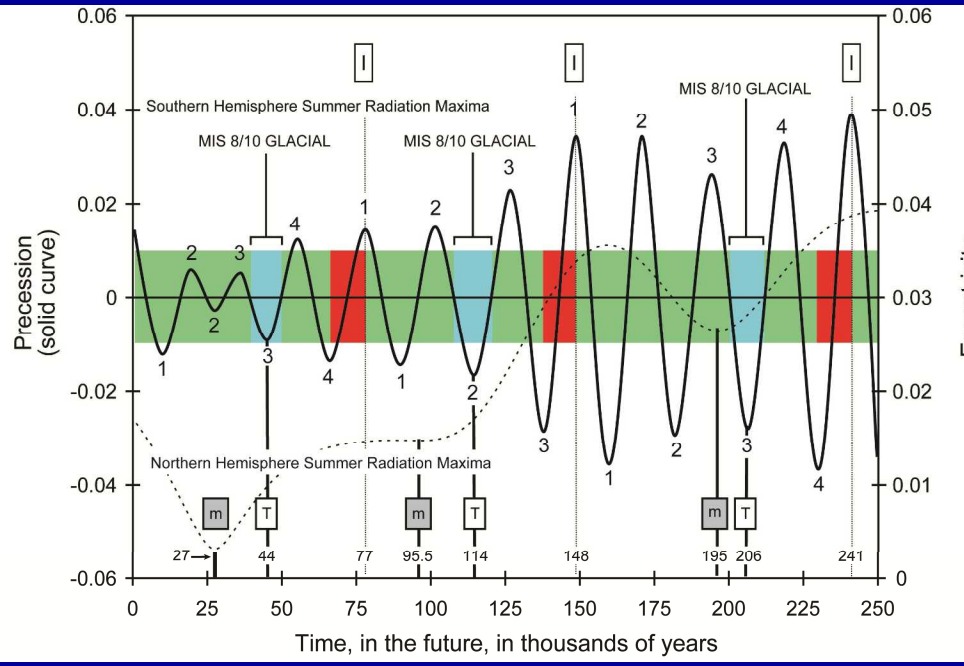
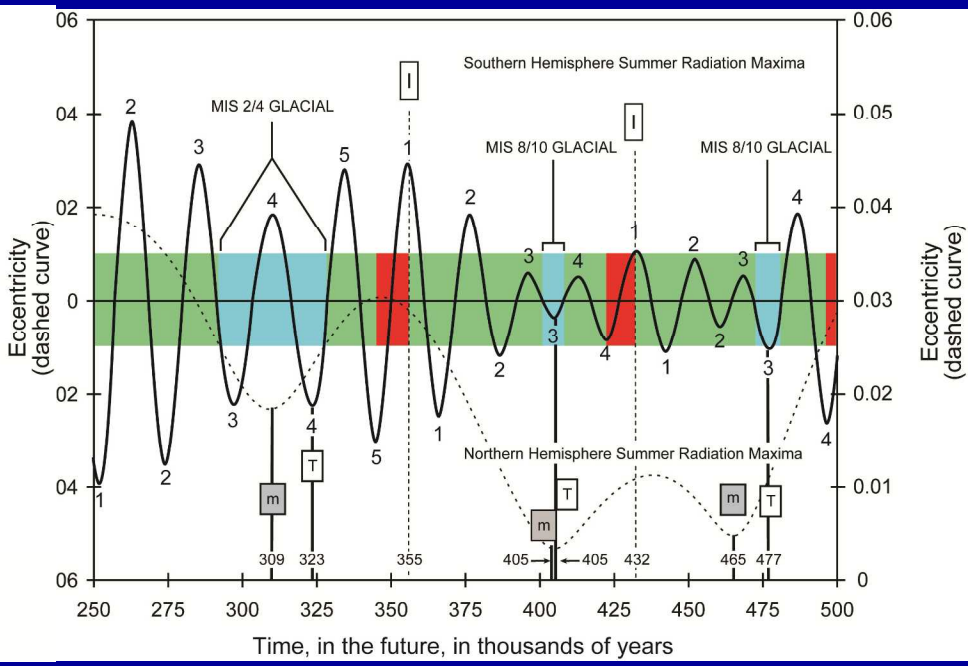
Future climate and orbital parameters





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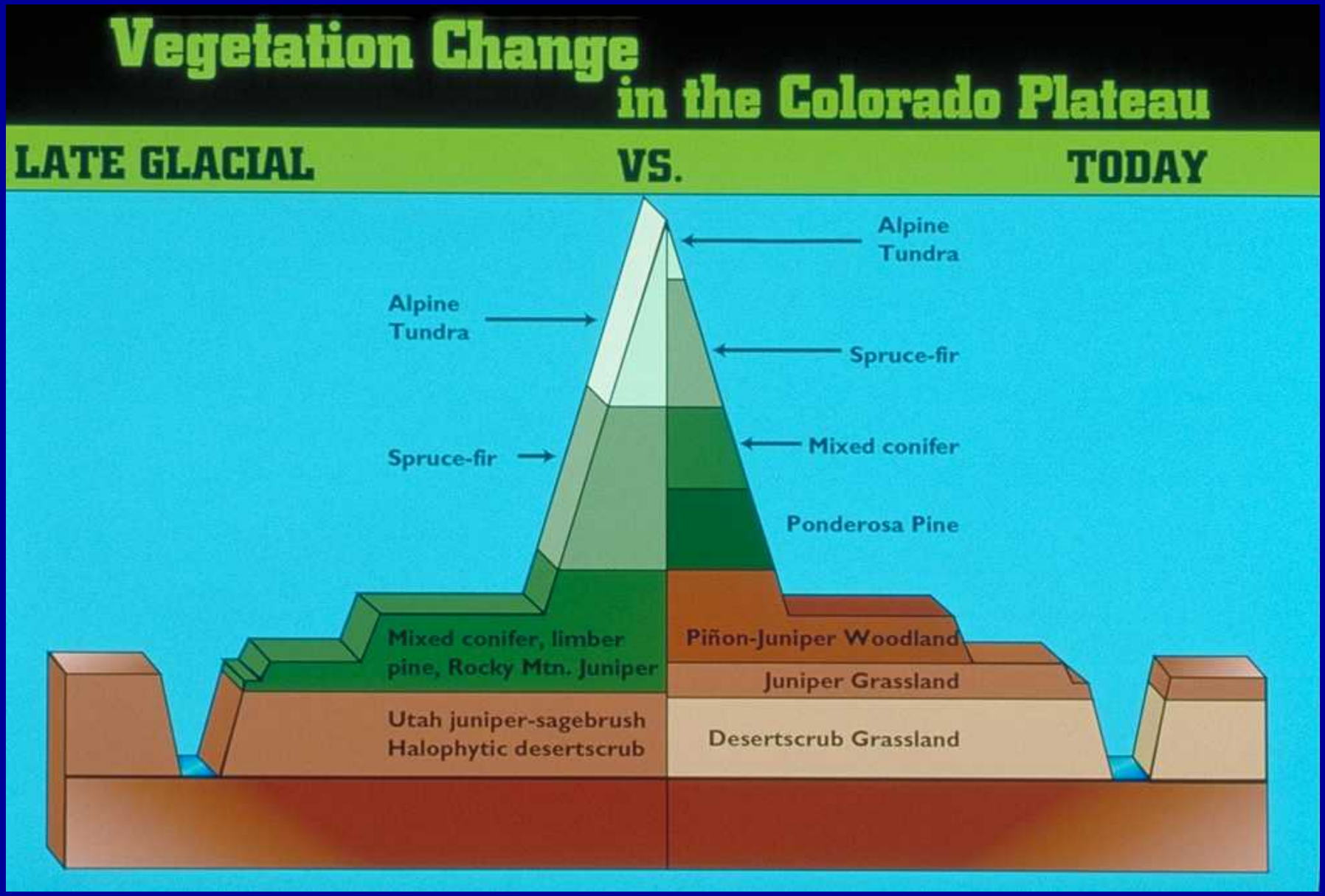
Local records

Springs and wetlands

Packrat Middens

"Messiah" violin made by Antonio Stradivari. Norway spruce.



J. Betancourt

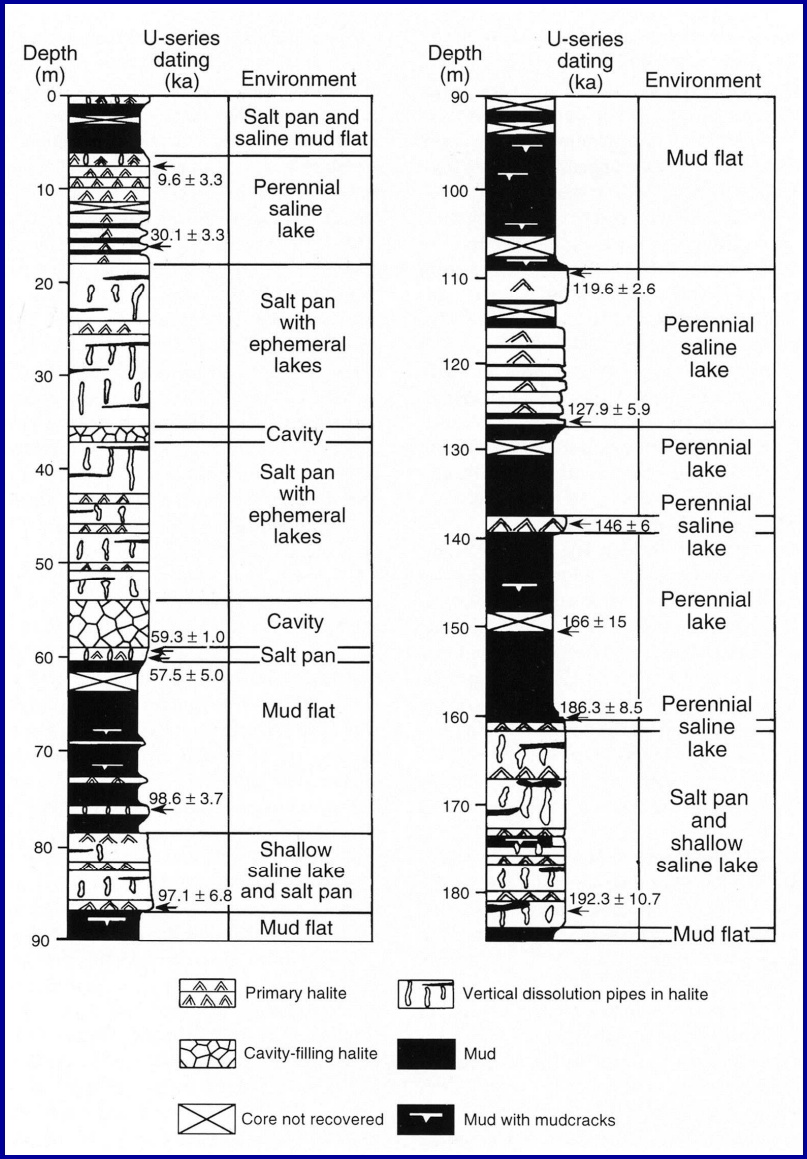
Vegetation change in the Grand Canyon

Cole & Myer 1982, Cole 1998

Regional Record
Death Valley, California

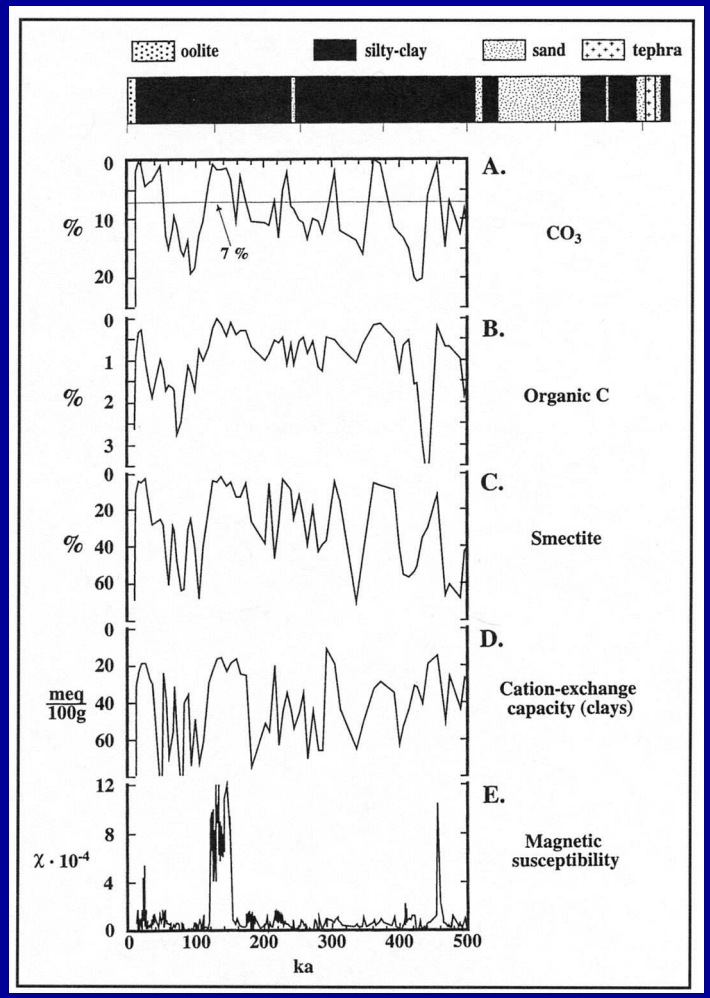
Regional Record
Owens Lake, California

Death Valley core 93-1



Lowenstein 2002 GBASH

Owens Lake sediments



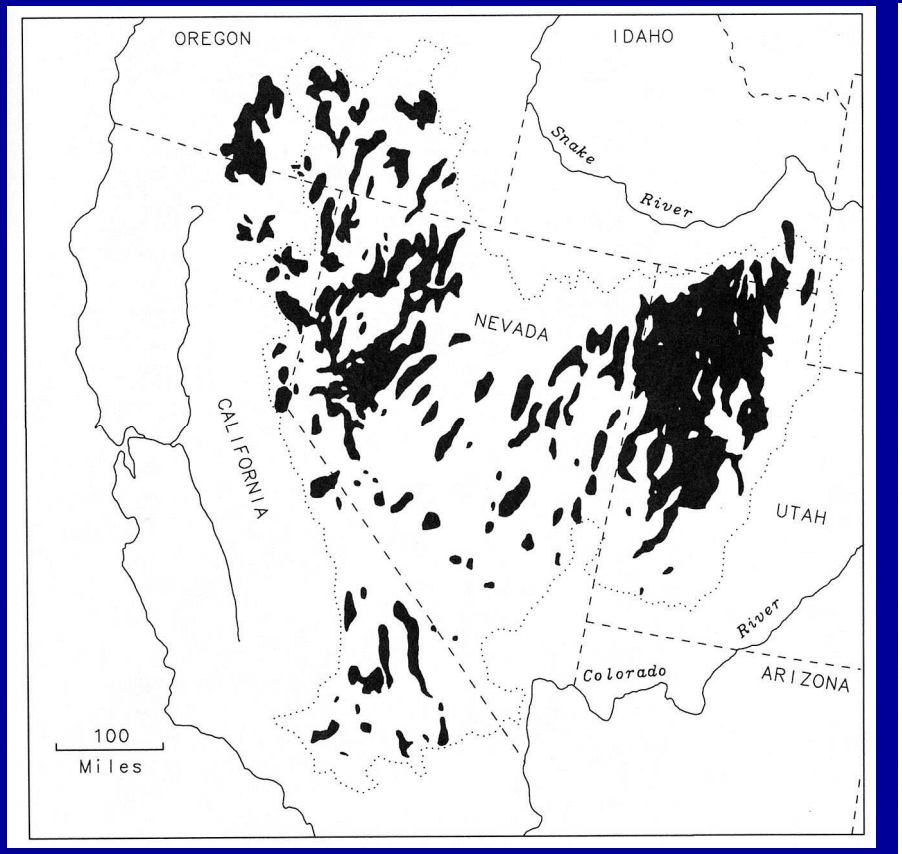
Smith et al. 1997

Glacial periods

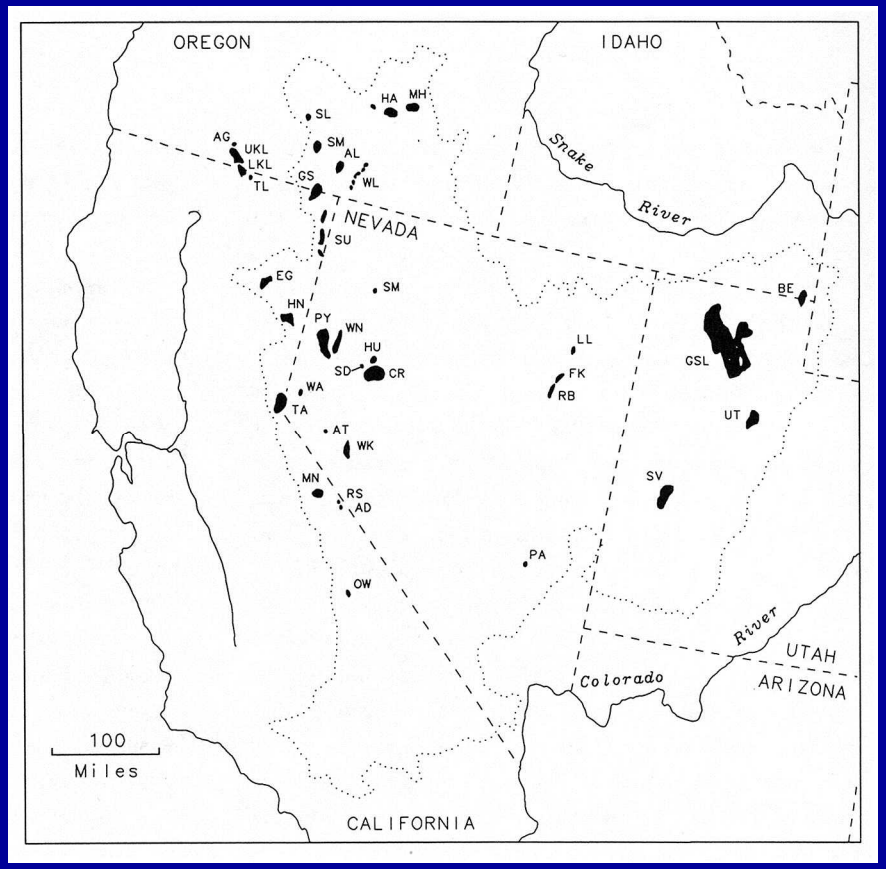
- have greater effective moisture (precipitation minus evaporation) compared to other climate states
- have the greatest potential for infiltration above the repository

Great Basin lakes

Late Pleistocene Lakes

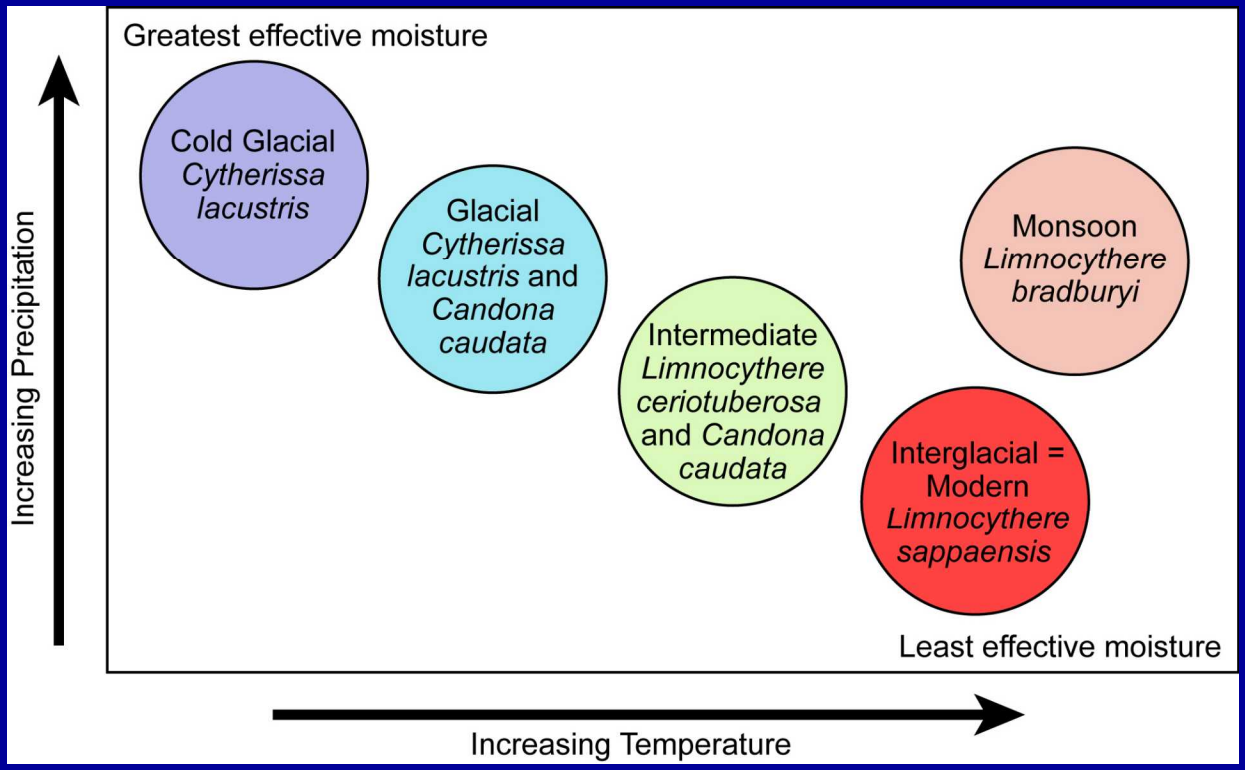


Holocene (today's) Lakes



Grayson 1993

Climate states identified & magnitude of climate states



Paleoenvironmental data from Owens Lake, packrat middens, Death Valley, and Las Vegas Valley marsh deposits are used to calibrate magnitude

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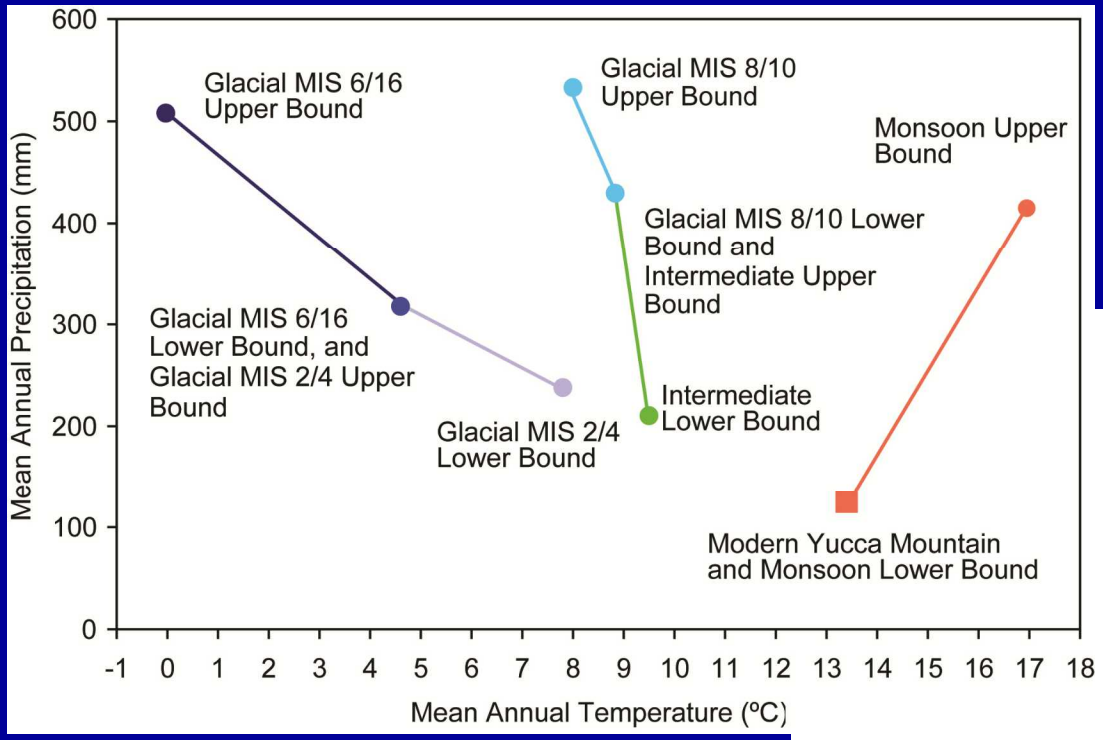
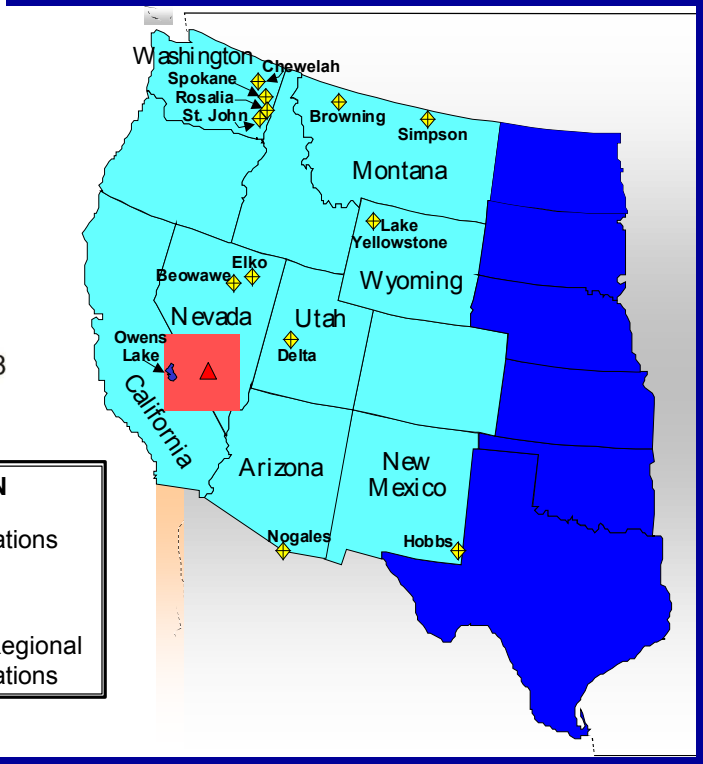
Modern meteorological station temperature and precipitation





Paleoenvironmental data from Owens Lake, packrat middens, Death Valley, and Las Vegas Valley marsh deposits are used to calibrate magnitude

Long-term climate: the last 500,000 years

- Encompassed higher, sometimes much higher, effective moisture relative to today. Greater effective moisture can mean increased precipitation or decreased temperature or both.
- Precipitation was often higher and/or temperature lower in the past because tropical moisture-laden air was coupled with colder air masses over the YM area.
- Infiltration was commonly higher relative to today because water is stored more readily during periods of greater effective moisture.

Long-term climate: the last 500,000 years

- During past glacial periods, mean annual temperature may have been as much as 10° to 15 °C cooler than present temperatures, with mean annual precipitation as much as 1.4–3 times present precipitation.
- Precipitation was often higher and/or temperature lower in the past because tropical moisture-laden air was coupled with colder air masses over the YM area.
- Modern climate has less effective moisture and is of shorter duration than the glacial and intermediate climate states.

Estimated future timing based on this approach

- Modern climate state estimated to last ~ 600 more years
- Monsoon climate state estimated to occur ~ 600-2,000 yr A.P.
- Intermediate climate state estimated to occur ~ 2,000-30,000 yr A.P.
- Glacial climate state estimated to occur after ~ 30,000 yr A.P.

Estimated future precipitation and temperature based on past climate proxy data

- Modern climate state: ~125 mm/yr; 13.4 ºC.
- Monsoon climate state: ~410 mm/yr; 17 ºC.
- Intermediate climate state: ~200-450 mm/yr; 9 ºC.