Reconstructing Past Droughts in Texas

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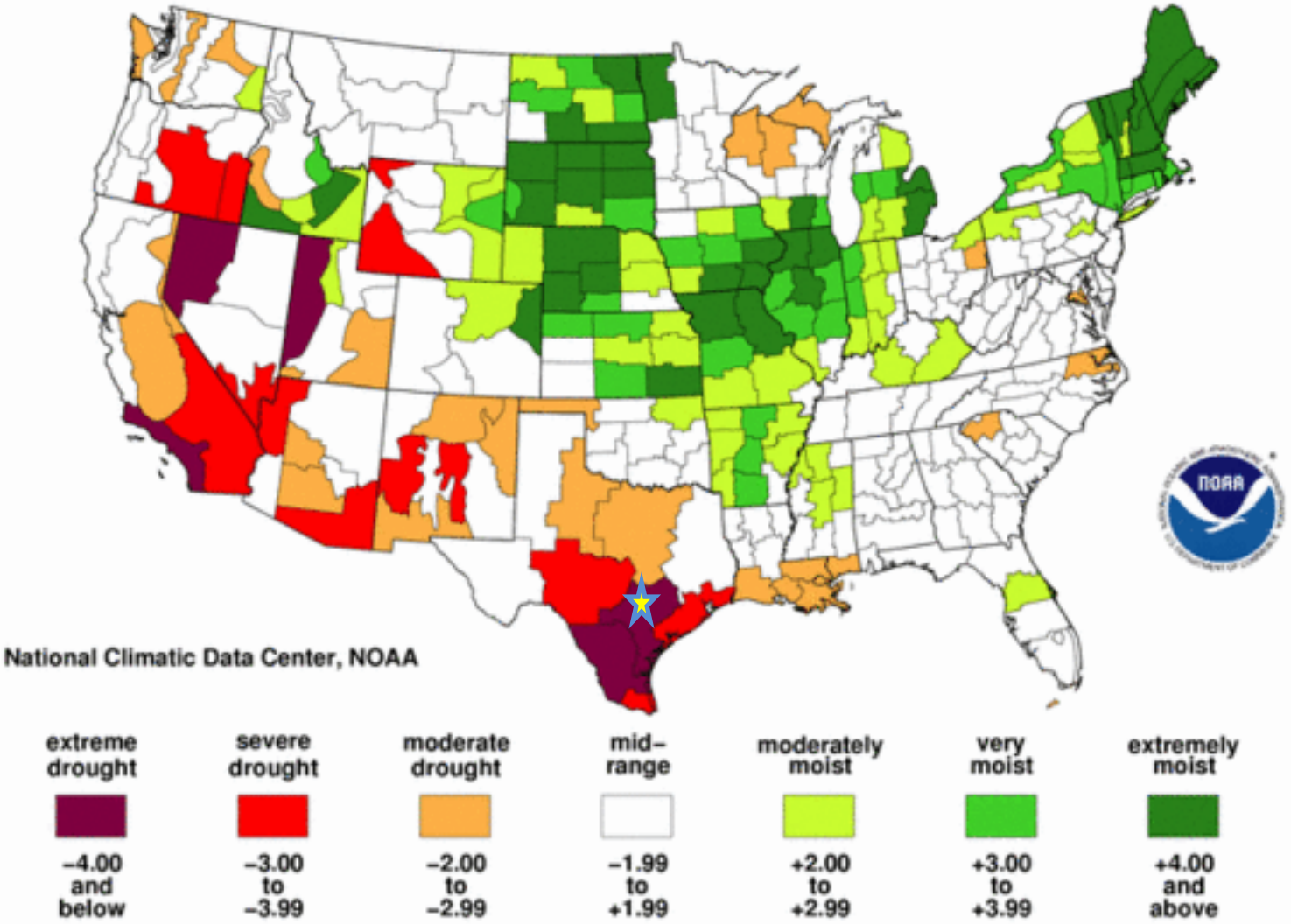
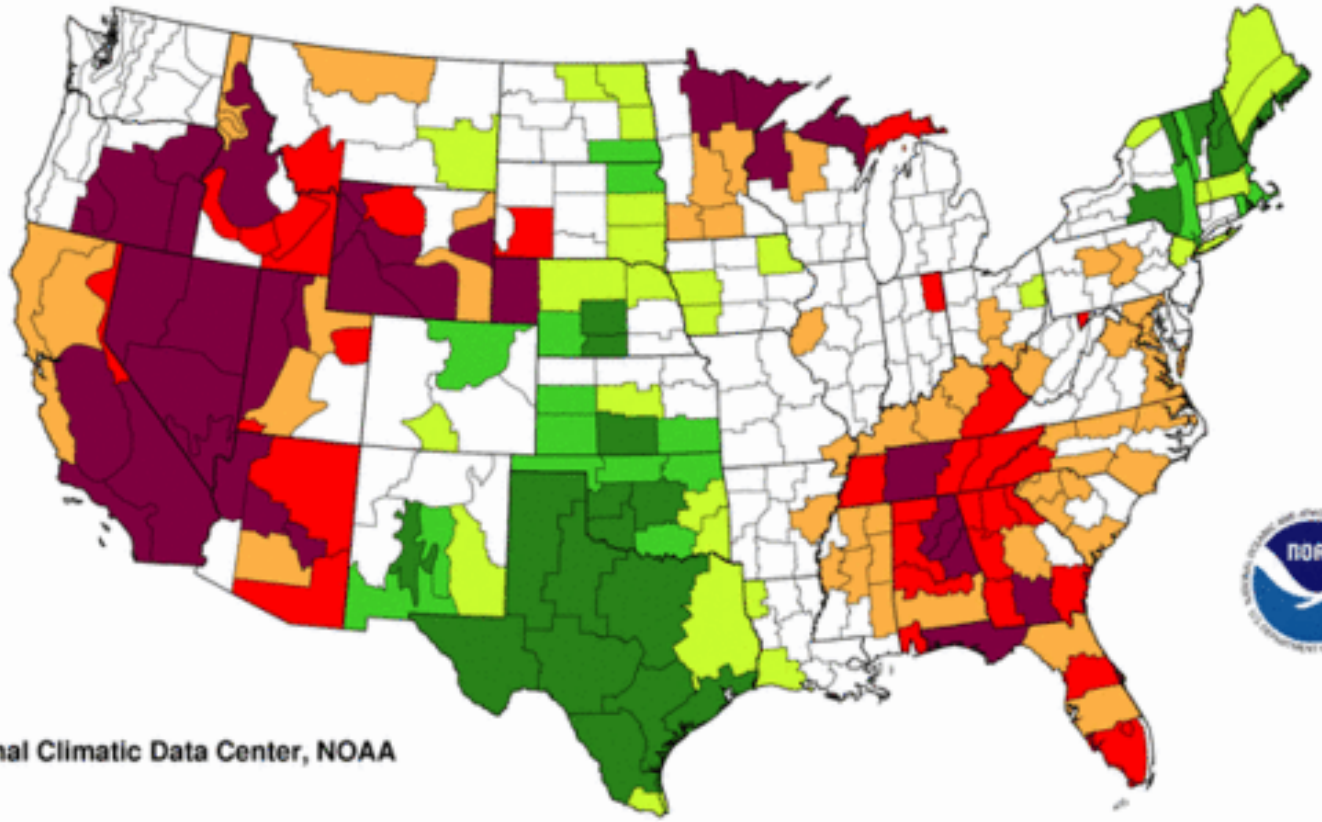
Outline

- Texas climate
  - Present and past droughts
- Drought reconstructions:
  - Tree rings
- Hot vs. dry droughts
- Temperature reconstructions:
  - Stalagmites

1. Temperature 2. Rainfall 3. Soil moisture



Palmer Drought Severity Index
July, 2007



National Climatic Data Center, NOAA

extreme drought	severe drought	moderate drought	mid–range	moderately moist	very moist	extremely moist
–4.00 and below	–3.00 to –3.99	–2.00 to –2.99	–1.99 to +1.99	+2.00 to +2.99	+3.00 to +3.99	+4.00 and above

Tree rings

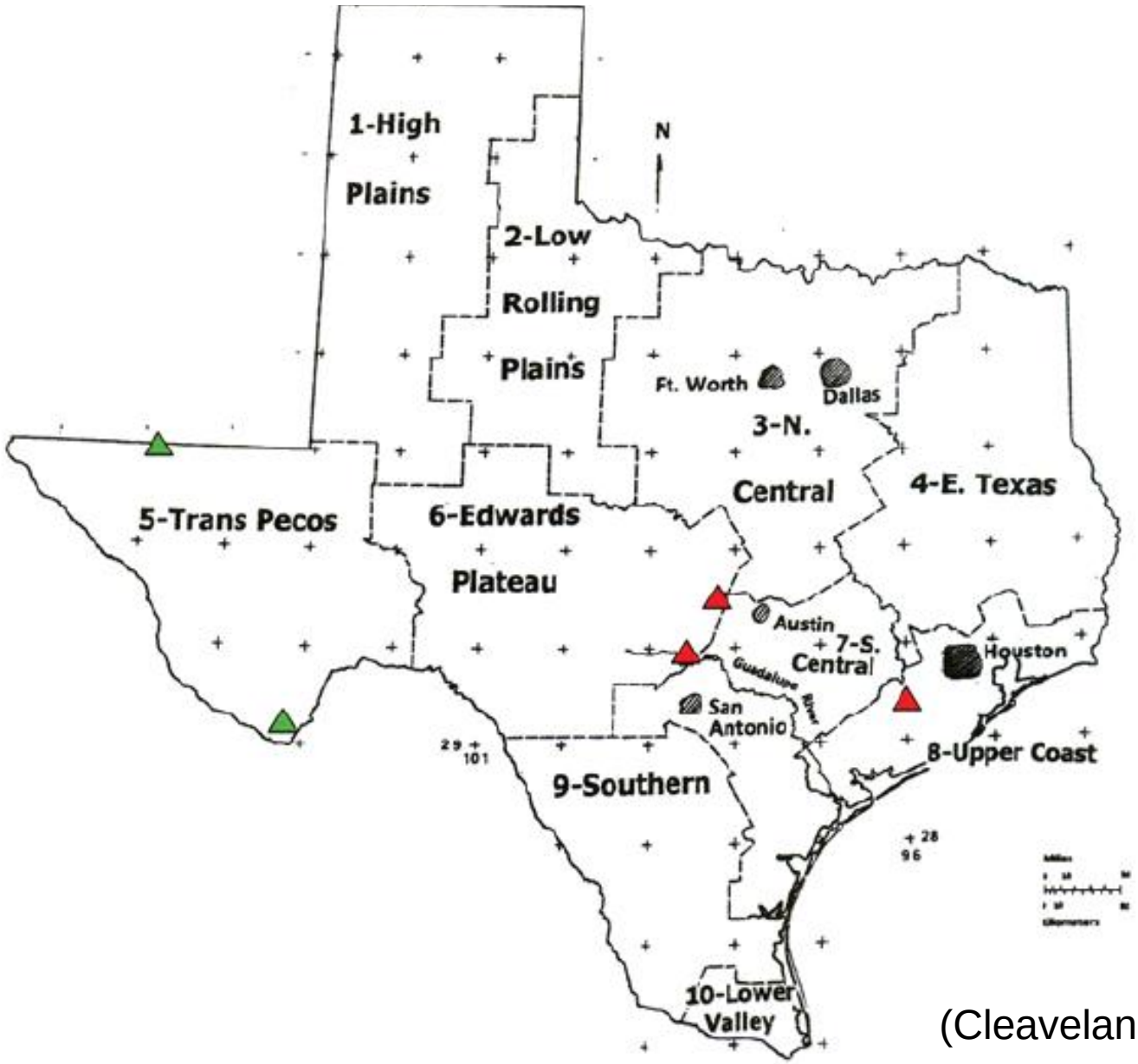
High resolution: Annual PDSI reconstruction

PDSI reconstruction of the last 500 years

How severe and protracted were past droughts?

http://www.futurity.org/earth-environment/fragile-forests-hard-hit-by-warming/

Climate regions of Texas



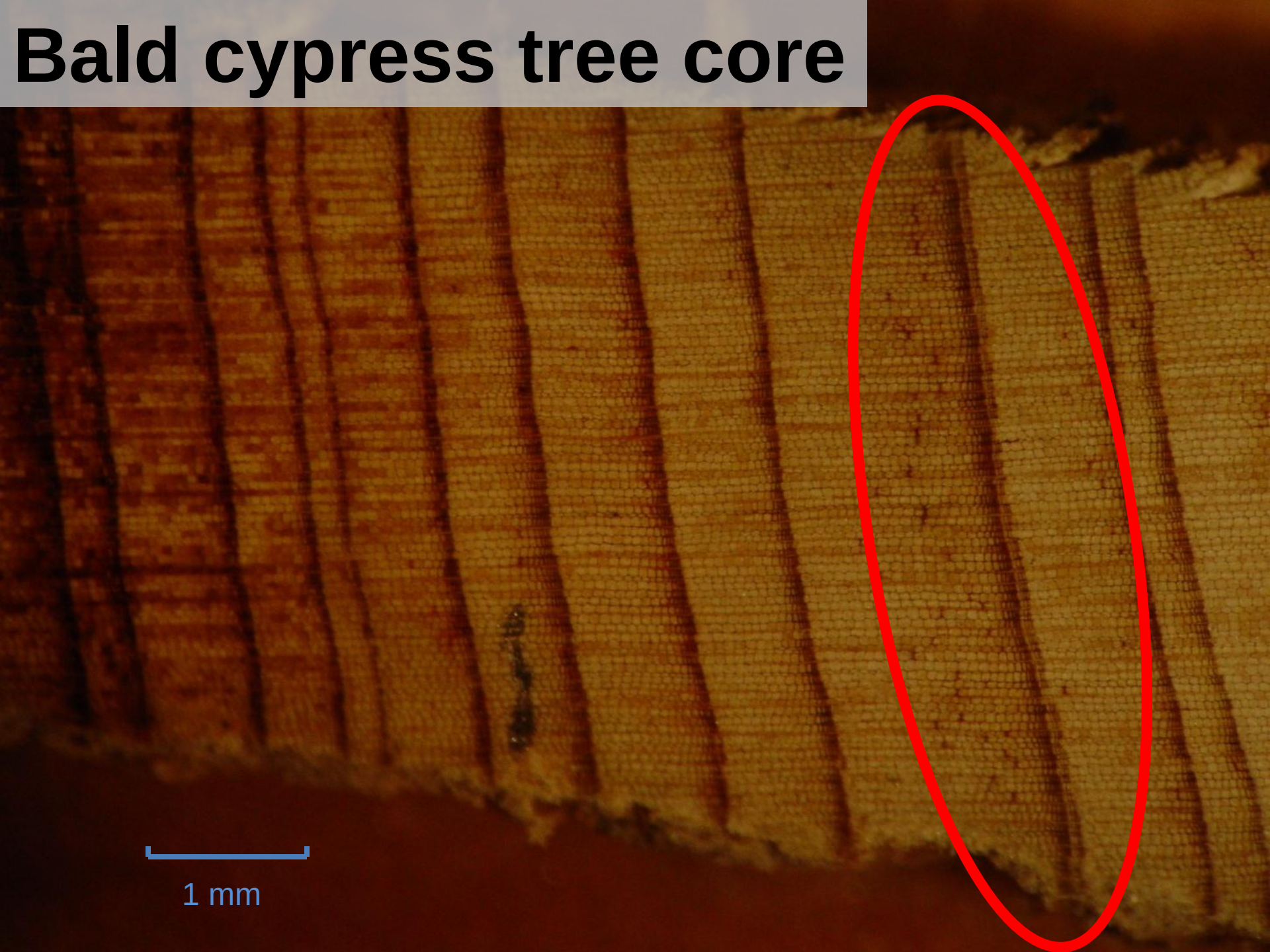
(Cleaveland et al., 2011)

Bald Cypress

Biggest tree in Texas

Tree core extraction

Bald cypress tree core



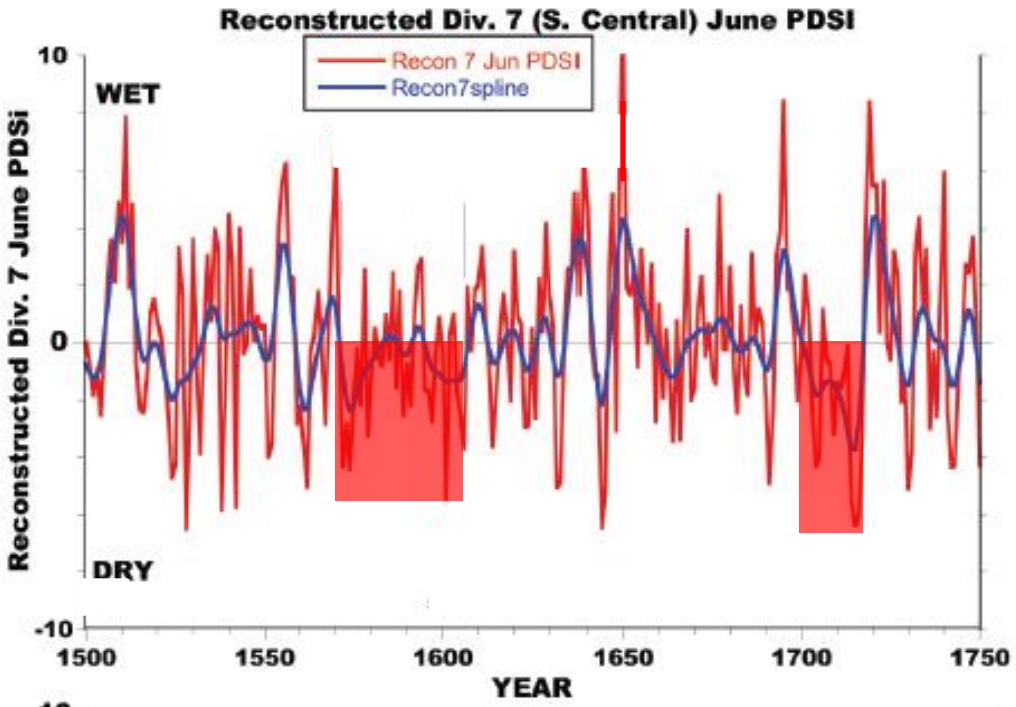
Central Texas drought history

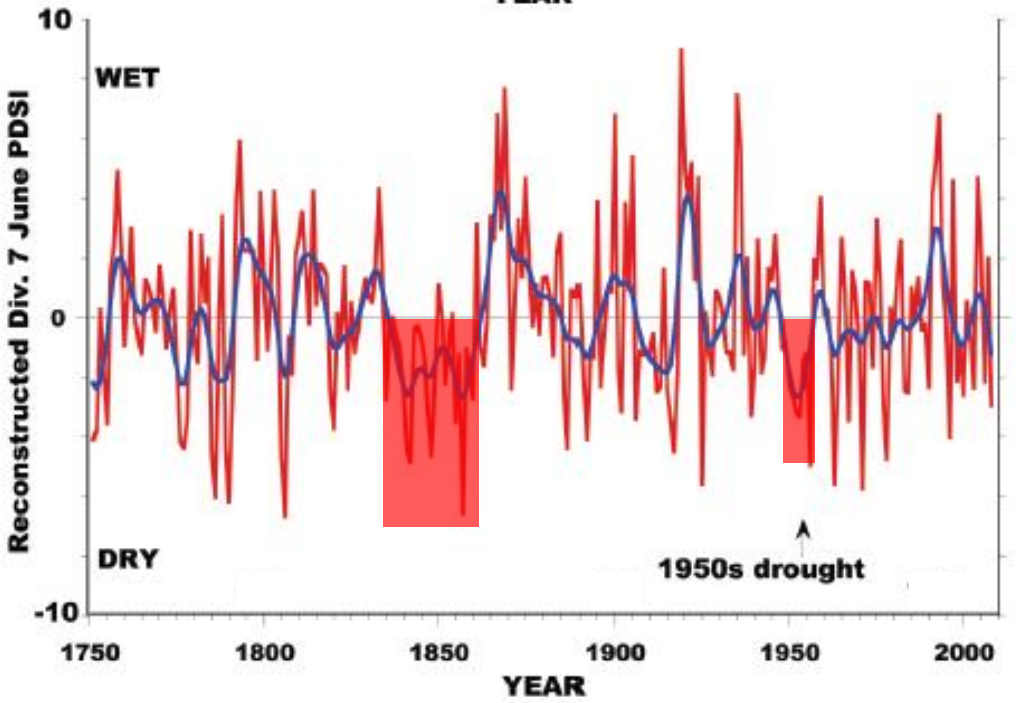
Calibrate tree rings to instrumental PDSI record

Measure tree rings to reconstruct PDSI

<u>Severe drought</u>
At least once a century since 1500s

(Cleaveland et al., 2011)





Triggers and sustaining mechanisms of drought in SW US

Two types in the SW US:

1. Dry droughts
   Triggered/sustained by lack of rainfall

2. Hot droughts
   Triggered/sustained by high temperatures

(Weiss et al., 2009)

Hot vs. dry drought

	DRY DROUGHT	HOT DROUGHT
EXAMPLE	1950s	2000s
RAINFALL	LOWER (74%)	HIGHER (86%)
TEMPERATURES	COOLER	WARMER (+1^{o} C)
PDSI	LESS NEGATIVE LESS DRY THAN 2000s	MORE NEGATIVE DRIER THAN 1950s

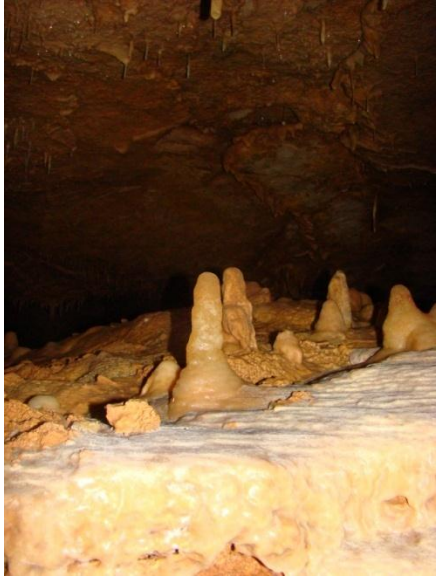
Tree rings as drought proxies

- Reconstruct PDSI
  - Temperature
  - Rainfall
  - Soil moisture

- One component temperature
- Two components moisture

- How to separate hot vs. dry droughts?

Stalagmites

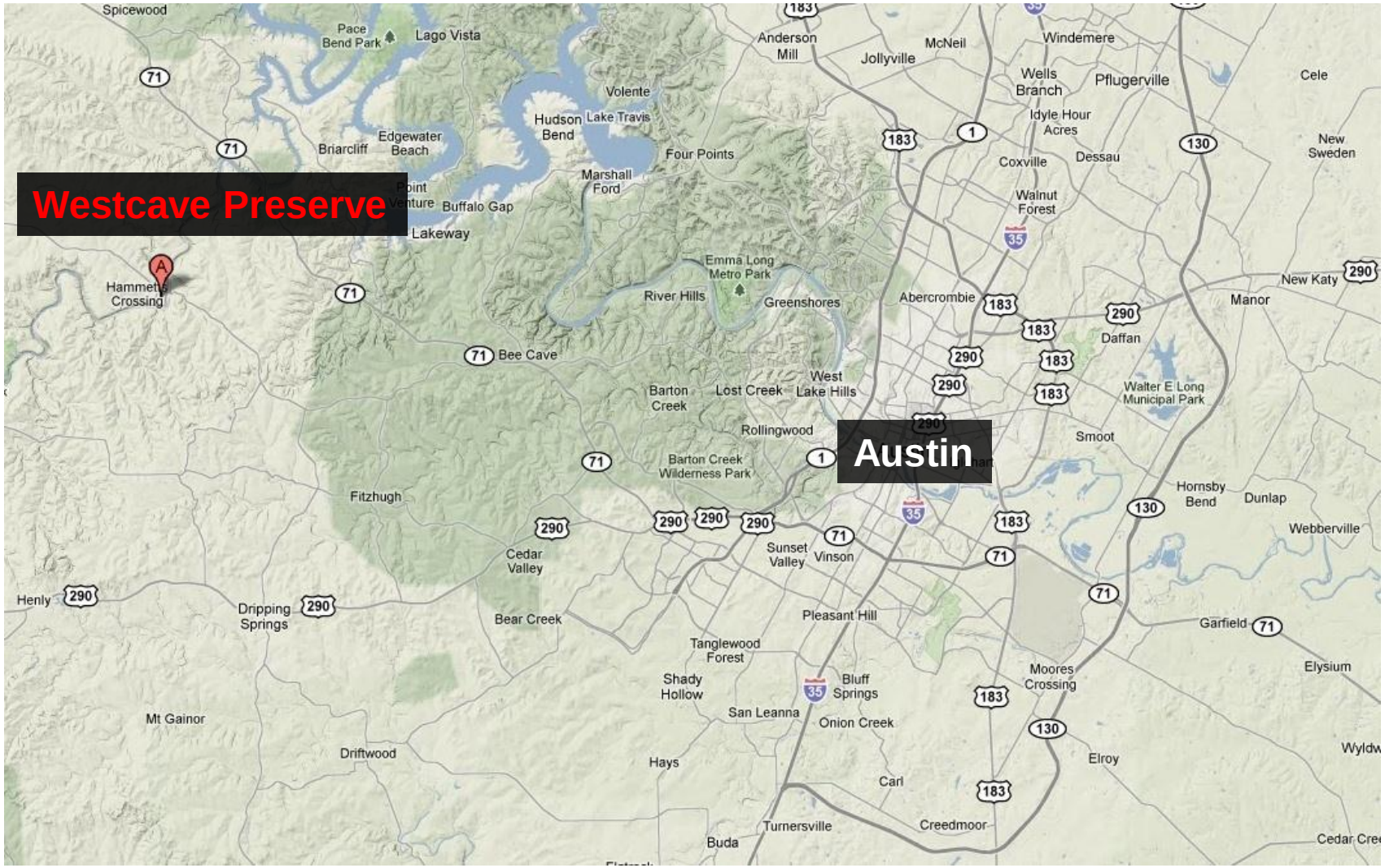


Oxygen isotopes ($\delta^{18}O$) as a temperature proxy

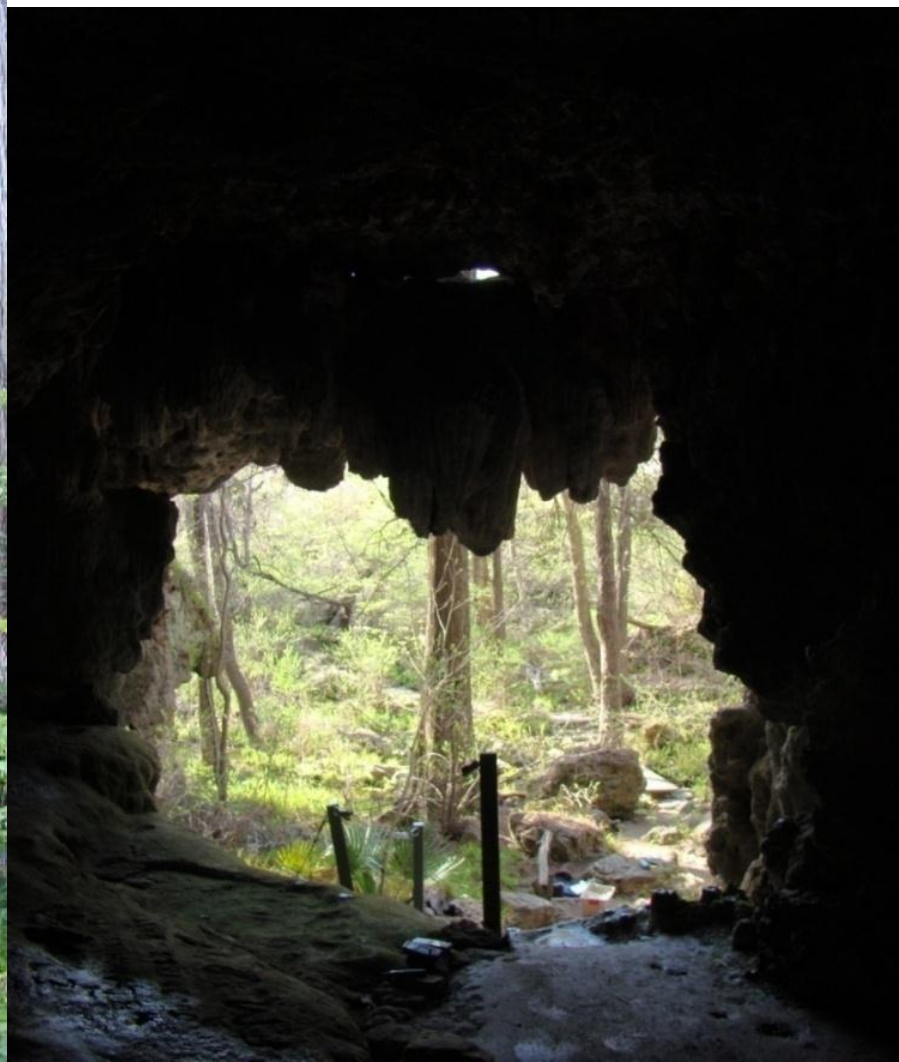
http://www.encyclopedia.com/topic/stalactite_and_stalagmite.aspx

http://www.stonemania.co.uk/glossary/244-stalagmites

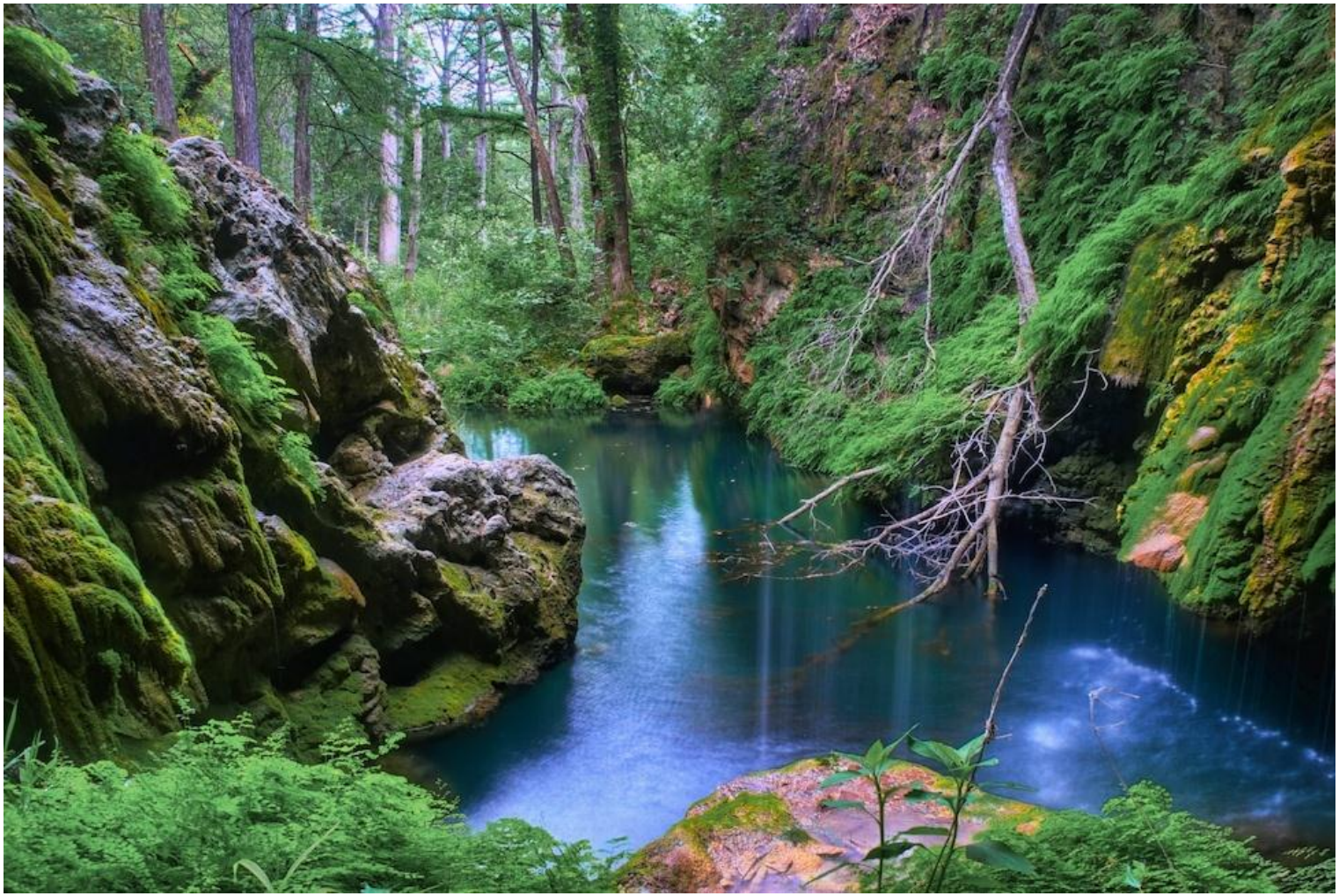
Westcave Preserve



Westcave Preserve



Westcave: Outside



http://www.nomadicpursuits.com/blog/2010/6/2/westcave-preserve.html

Westcave: Inside

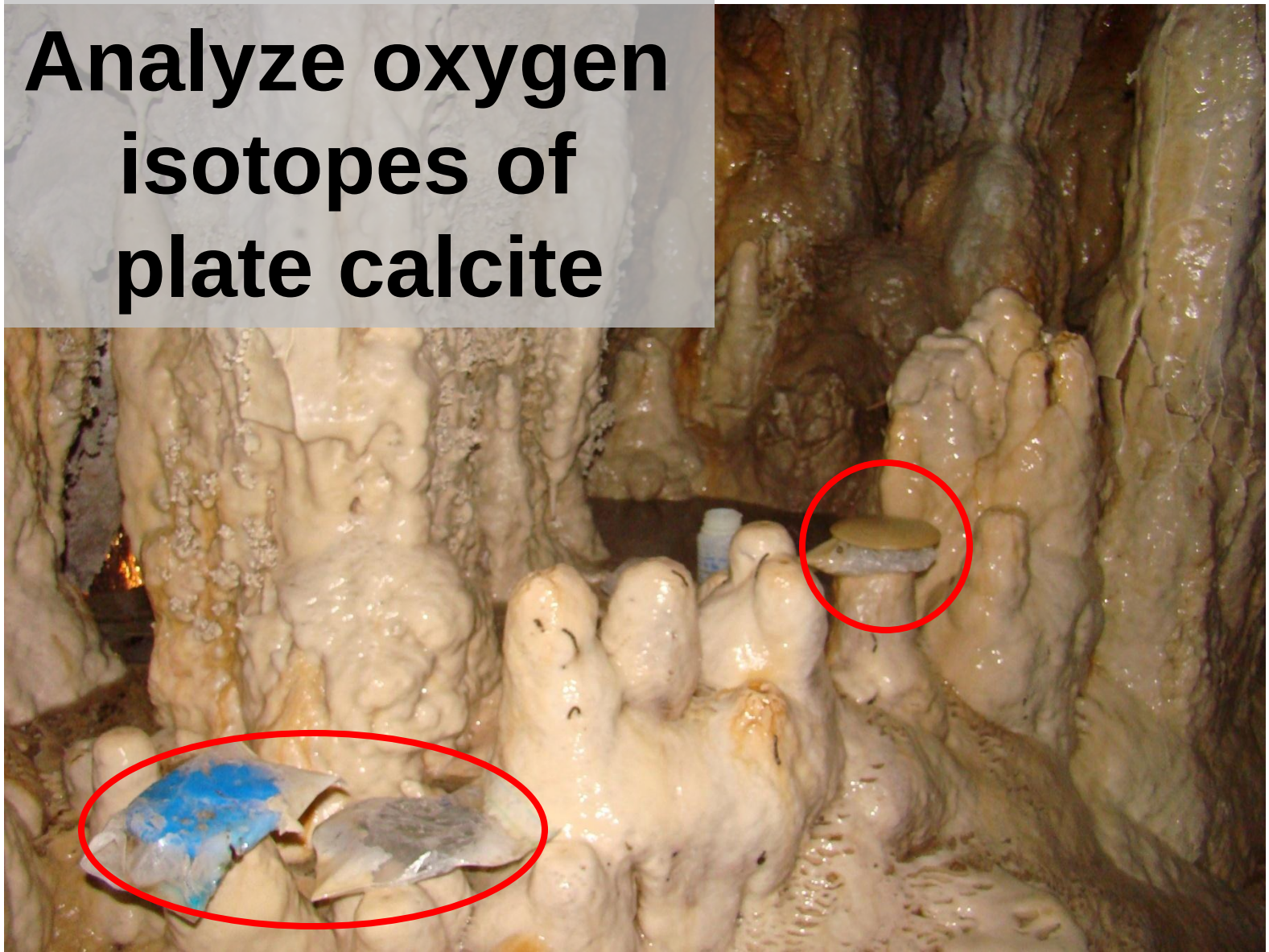
Cave drip waters

Surface water infiltrates into cave

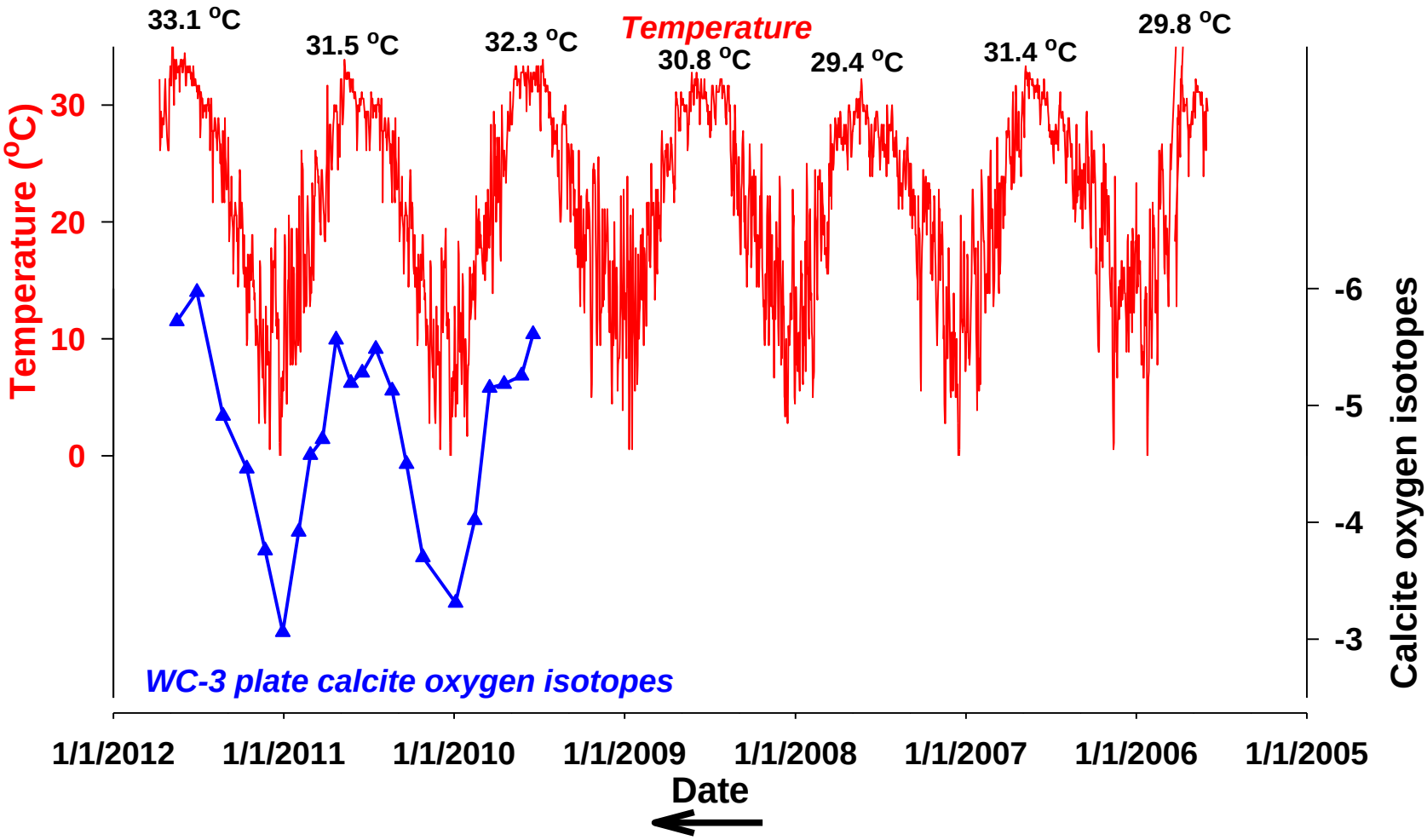
Drip waters precipitate calcite and make stalagmites

Place glass plates for drip waters to precipitate calcite on

Calcite collection plates



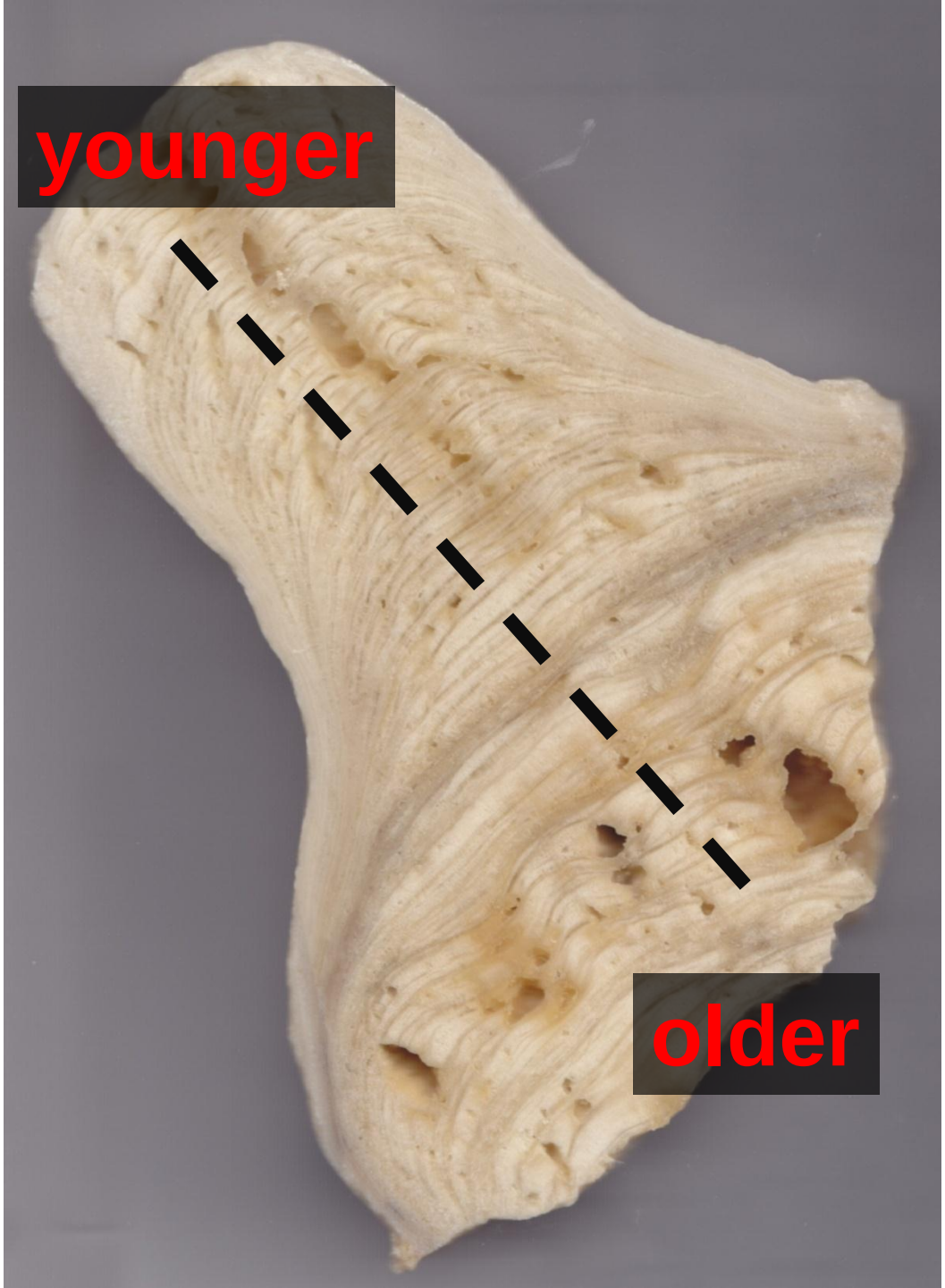
Temperature vs. plate calcite oxygen isotopes



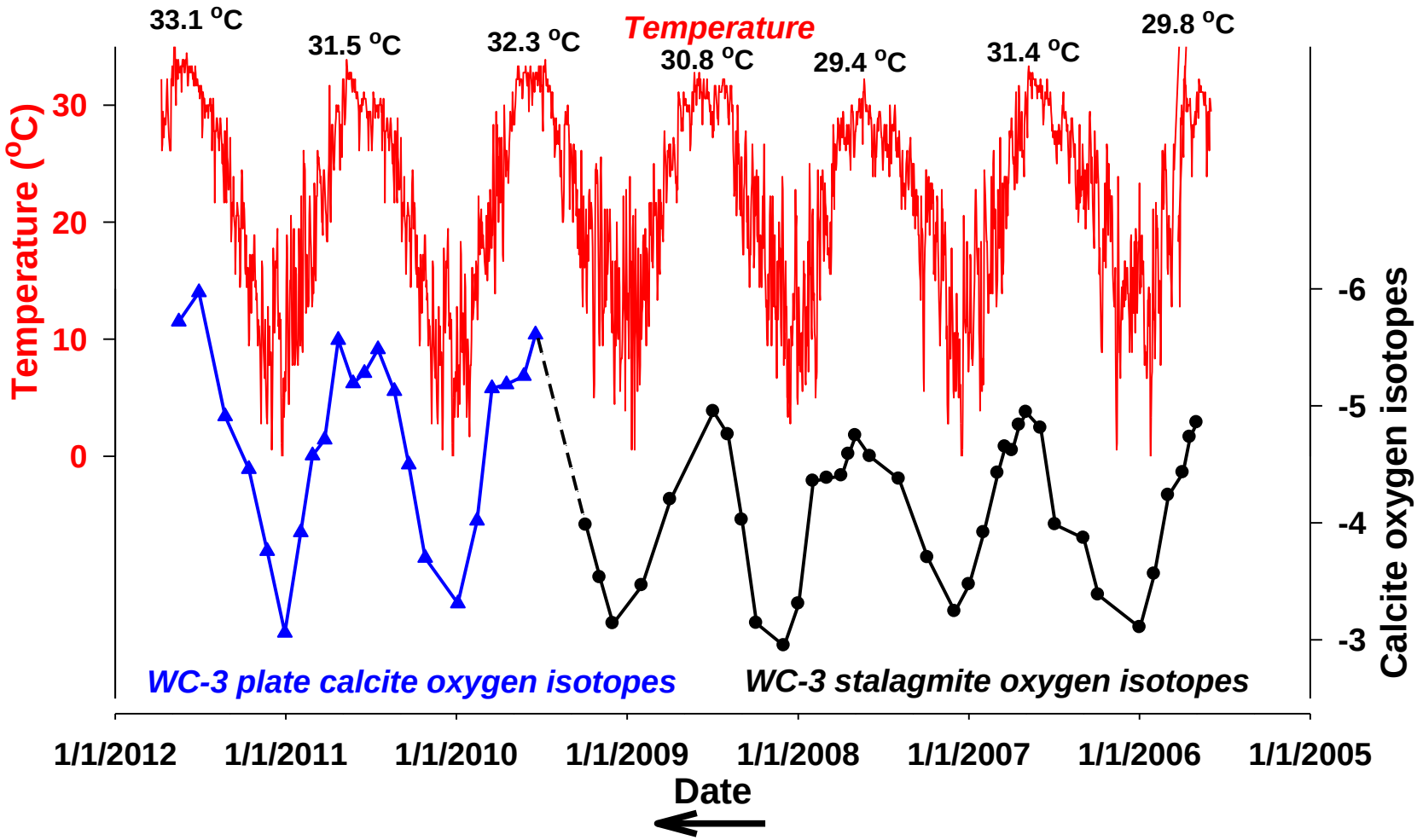
Stalagmite WC-3

Oxygen isotopes of the stalagmite

Reconstruct temperature



Temperature vs. stalagmite oxygen isotopes



Climate proxies

- PDSI (tree rings)
  - ~~Temperature~~
  - Soil moisture
  - Rainfall

- Oxygen isotopes (stalagmites)
  - Temperature

Dry droughts vs. hot droughts

Conclusions

- Droughts in the past were at least as severe and/or more protracted than the drought of record
- Increased temperatures can trigger/sustain droughts
- Possibility of teasing apart temperature from PDSI
  - Occurrence of dry droughts or hot droughts
- Potential of stalagmites as temperature proxies

Acknowledgements

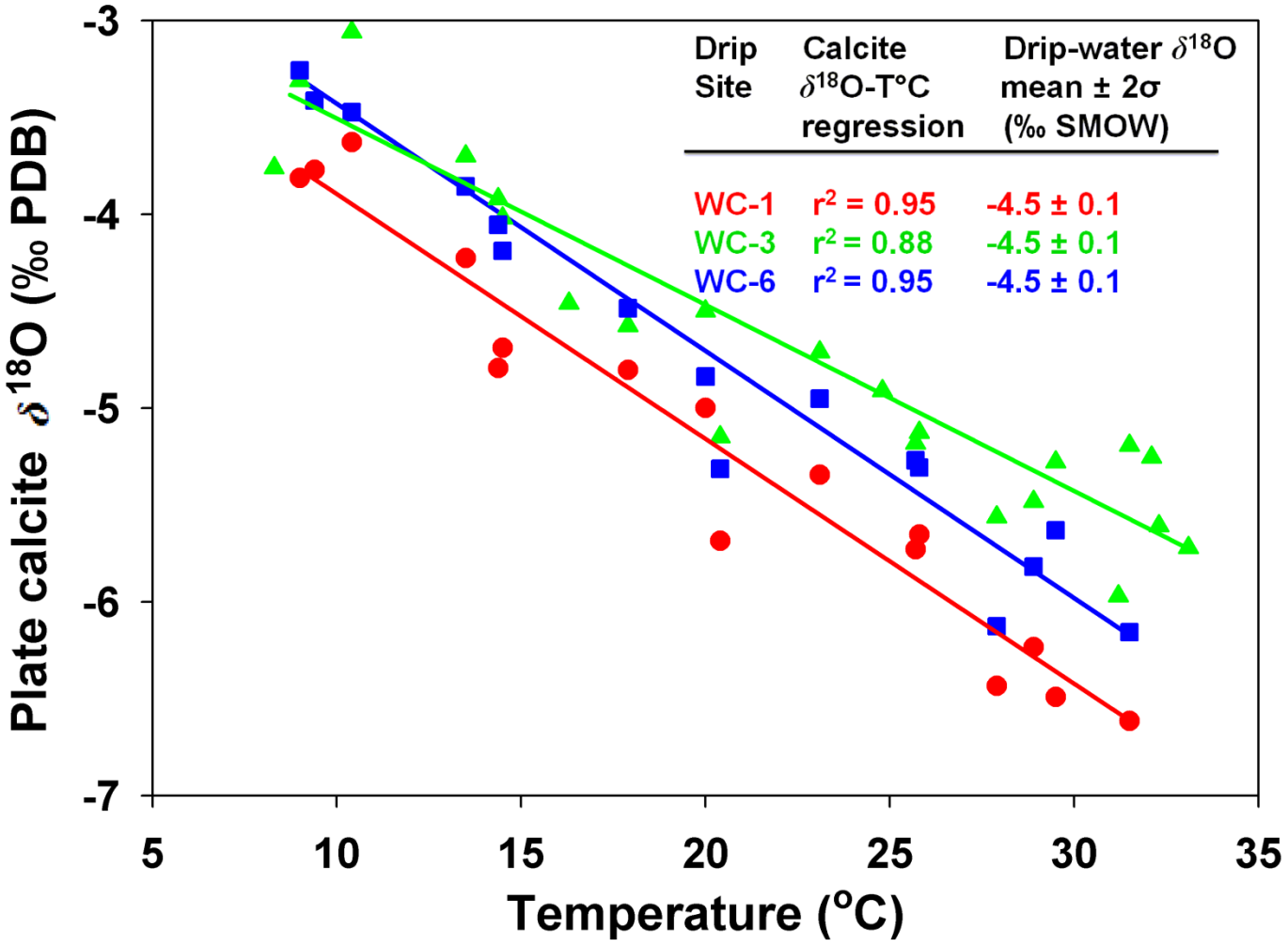
- Malcolm Cleaveland, University of Arkansas
- Guadalupe-Blanco River Authority and Todd Votteler
- Jackson School of Geosciences
- Environmental Science Institute


QUESTIONS?

Conclusions

- Higher temperatures predicted

- Tease apart hot vs. dry droughts using:
  - Reconstructed PDSI (tree rings)
  - Reconstructed temperature (oxygen isotopes)


Drip Site
Calcite δ18O-T°C regression
Drip-water δ18O mean ± 2σ (‰ SMOW)
WC-1 r2 = 0.95 -4.5 ± 0.1
WC-3 r2 = 0.88 -4.5 ± 0.1
WC-6 r2 = 0.95 -4.5 ± 0.1
Plate calcite δ18O (‰ PDB)
-3
-4
-5
-6
-7
5
10
15
20
25
30
35
Temperature (°C)

Variables that can effect stalagmite geochemistry

- Rainfall
- Temperature
- How to tell the difference?

What are the droughts triggers

We only have 2 data points, the 1950s and 2000s.

So.....

“Past is the key to the future”

- Speleothem sample

younger

- U-series dating for age constraints

- Geochemically analyze samples taken along the growth axis

- Reconstruct climate

Future climate projection:

Increased temperature

Rainfall distribution uncertain

24,000 years ago

Low latitude ice sheets (~39° N)

Cooler and wetter

-Faunal evidence

-Pollen data