Climate Signals from $\delta^{18}O$ of Tree-Ring Cellulose, Northwest AZ

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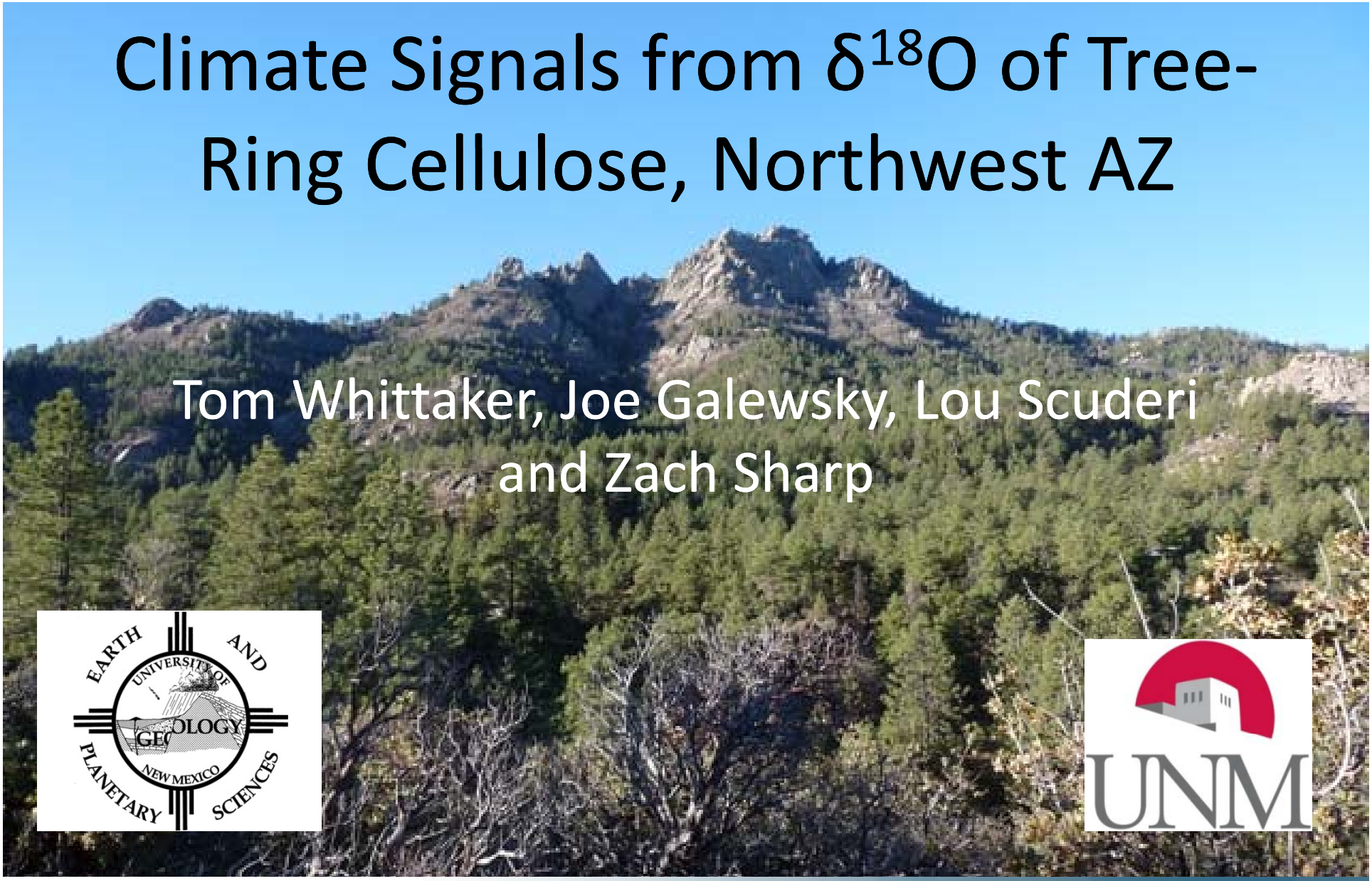


New Mexico EPSCoR

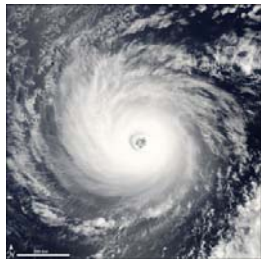
Climate Change Impacts on New Mexico's Mountain Sources of Water

EPSCoR TriState Meeting April 6th-8th 2011

Tamaya Resort, Santa Ana Pueblo, NM

Background

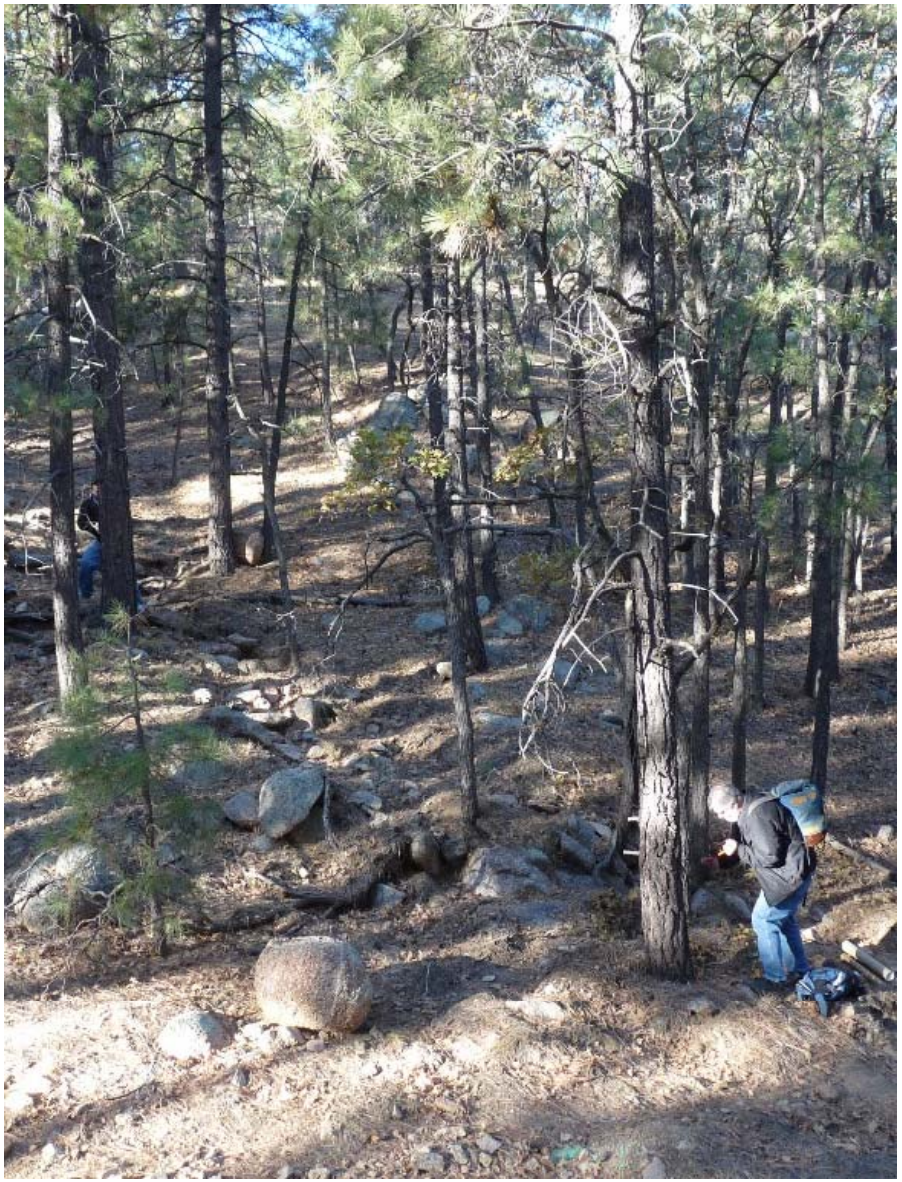
- Tree rings store climate information
  - Ring-width; also isotopic composition
- Tree-ring $\delta^{18}O$ profiles allow identification of sub-annual climate variability
  - Our focus was on looking for tropical cyclone signatures (Hurricane Nora) in tree rings from Arizona

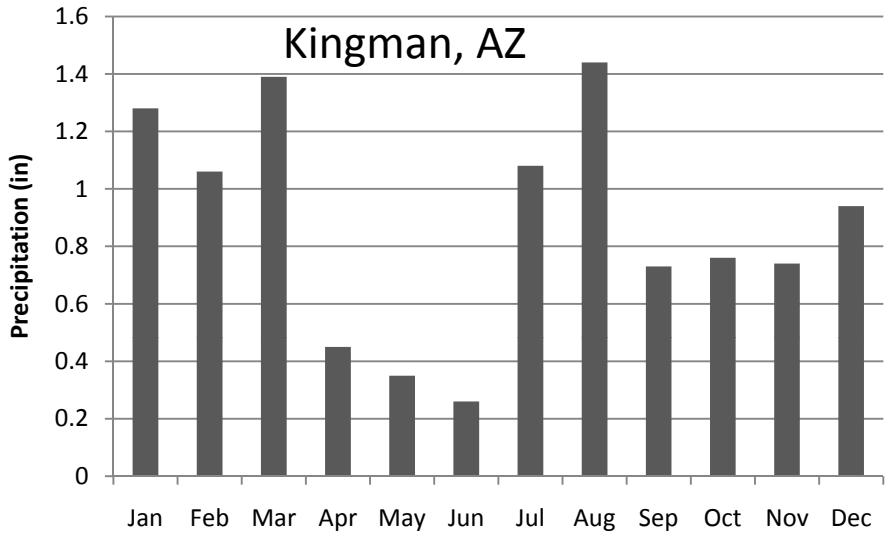


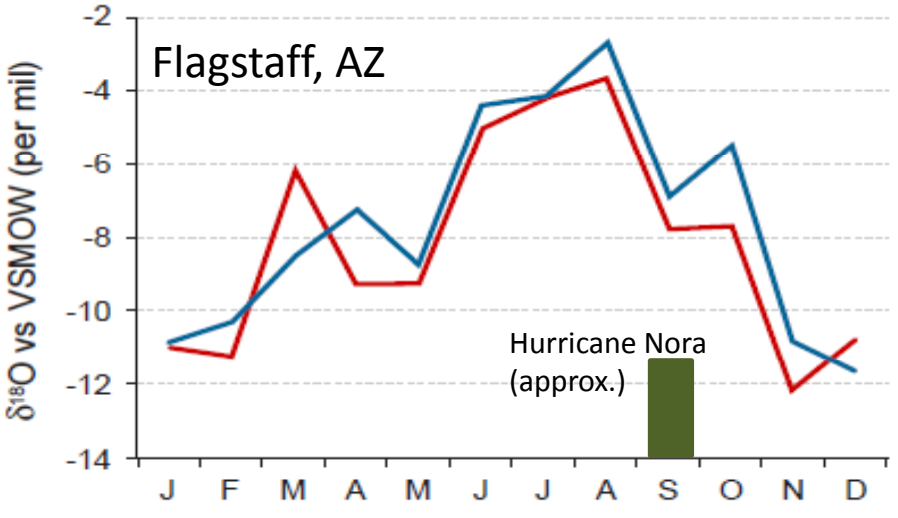
- Very few within-ring $\delta^{18}O$ studies to date
  - Almost none if considering semi-arid sites

Sample Collection Sites

Hualapai Mountain Site

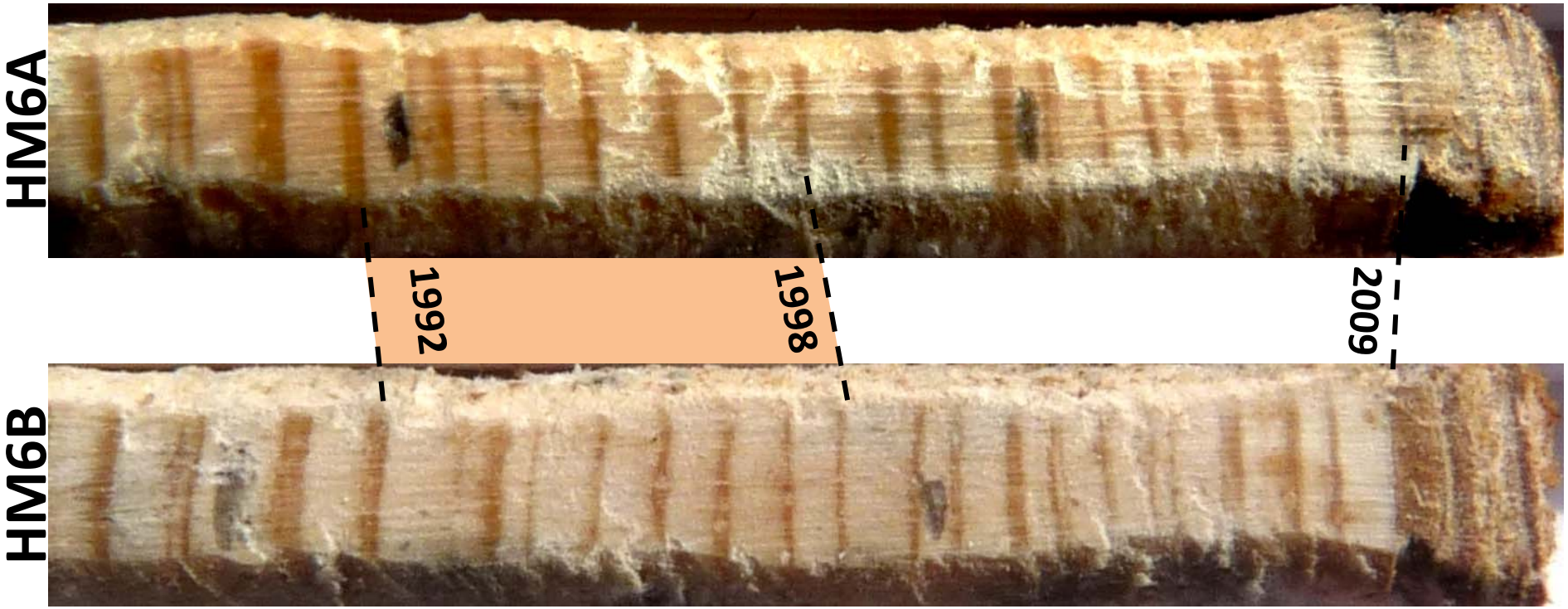






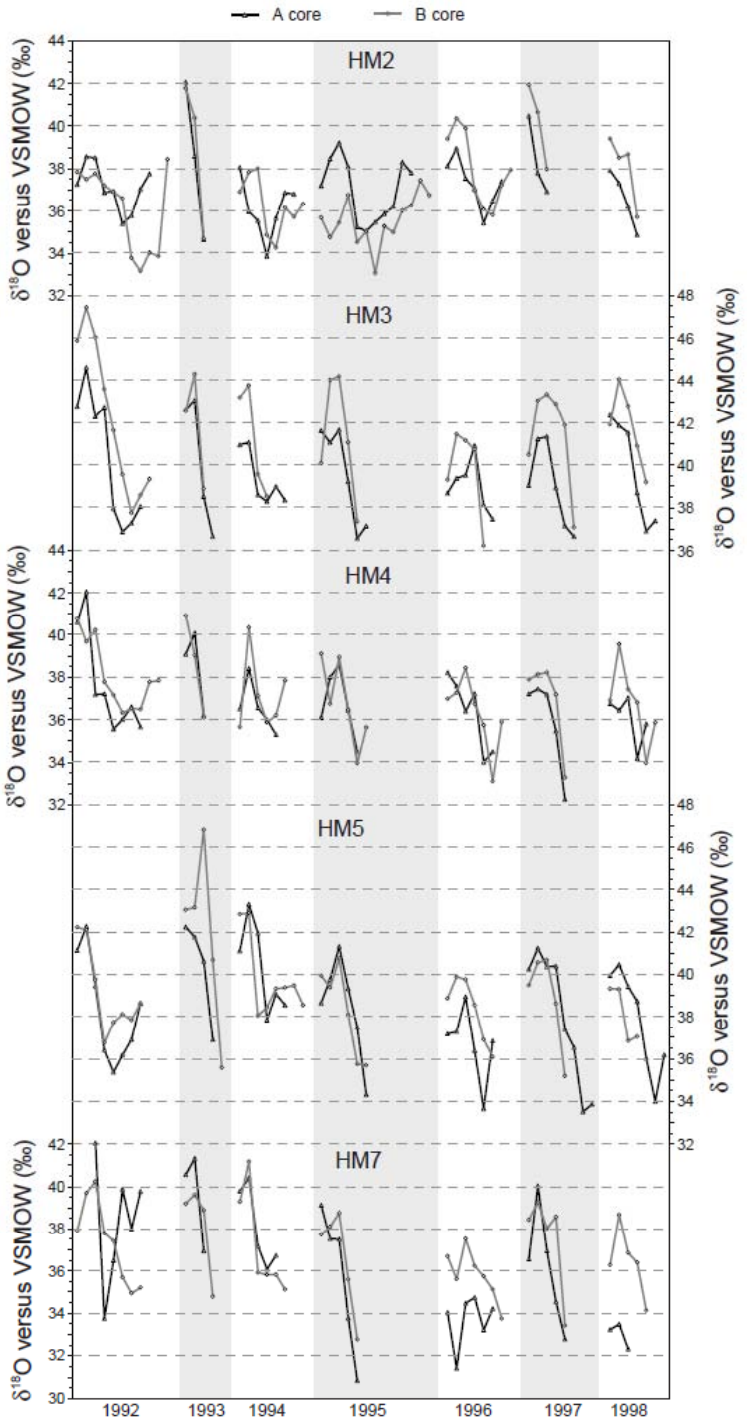
Sample Selection & Analysis

- Two cores (A & B) from 15 trees at Hualapai Mtn
- Cross dated all 30 cores
- 1992-1998 in 5 trees sampled for $\delta^{18}O$ analysis
  - Brendel Method of alpha-cellulose reduction (Brendel et al., 2001)

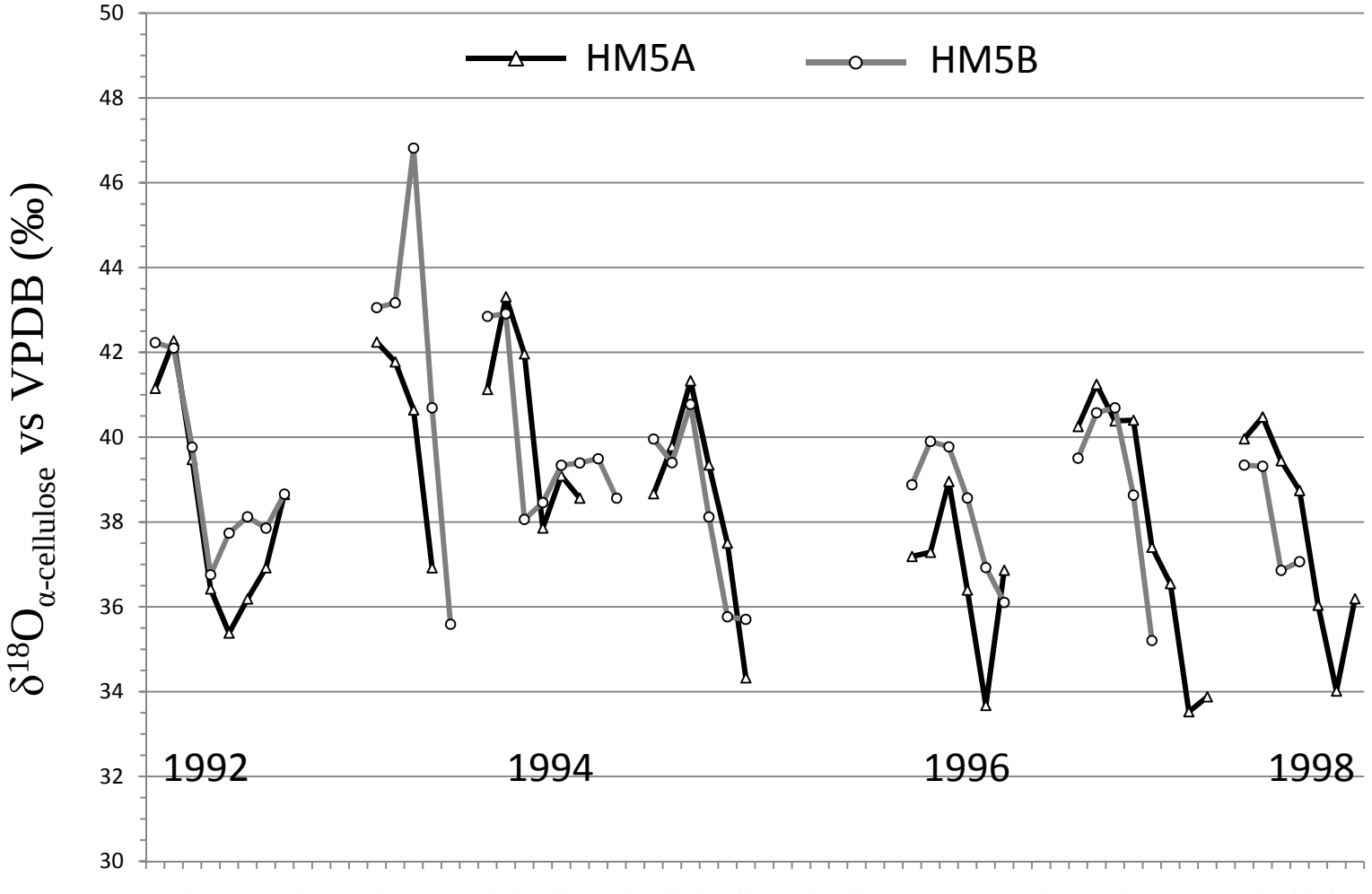


$\delta^{18}O$ Data Summary

- 413 samples analyzed
- Range: 31.4 to 47.4‰
- Reasonable A-B core coherence
- Reasonable inter-tree coherence (some notable exceptions)
- Well-defined annual profile
- No obvious Nora signal



Example: Tree HM5



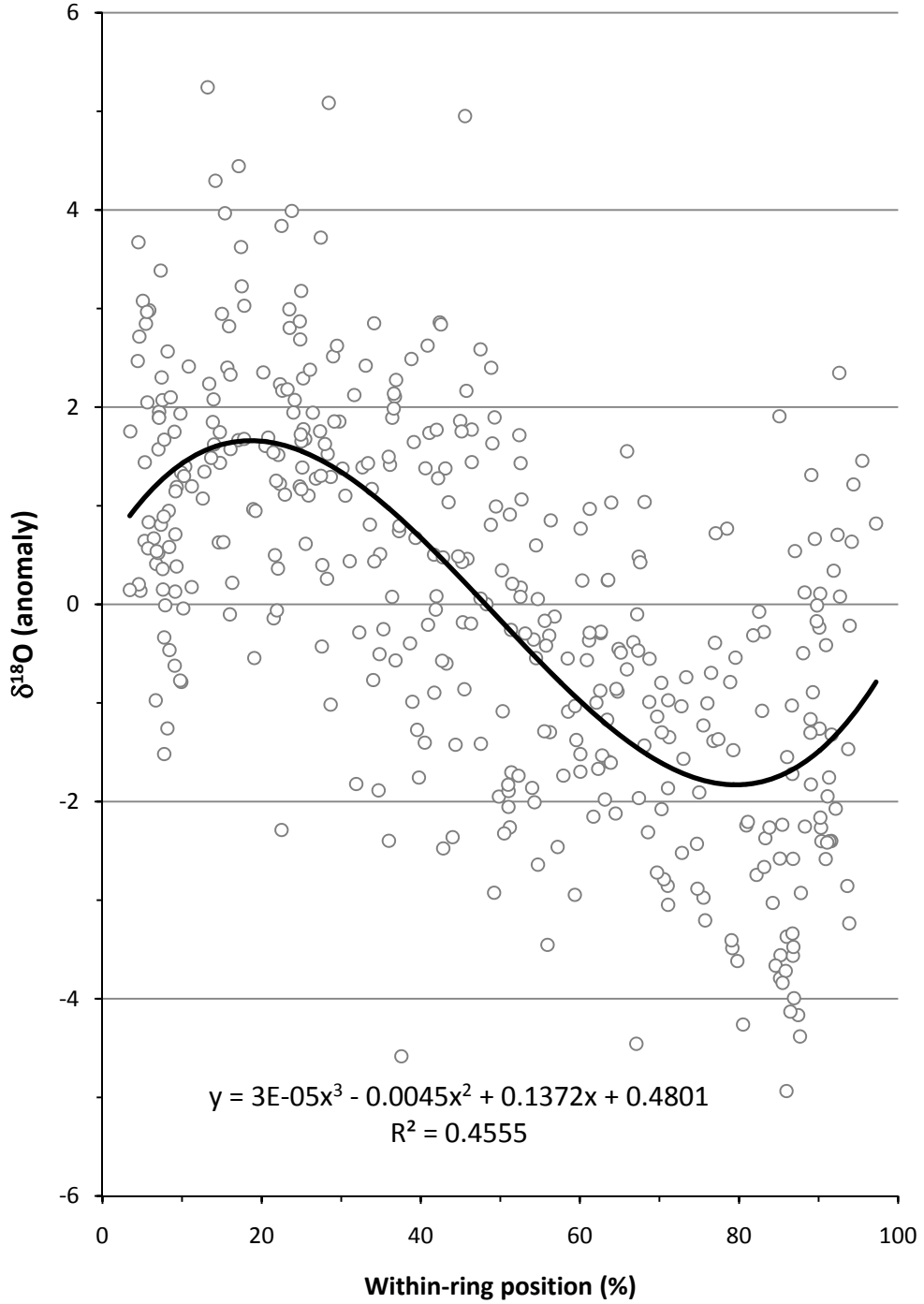
Annual Profile

All acquired data normalized against annual means (n=413)

Large range

Assumption:

– All rings record the same length of time



Cause of the annual Pattern?

- Two major drivers of tree-ring $\delta^{18}O$ profiles recognized in the literature:
  1. Precipitation $\delta^{18}O$ (=Temperature)
  2. Relative Humidity

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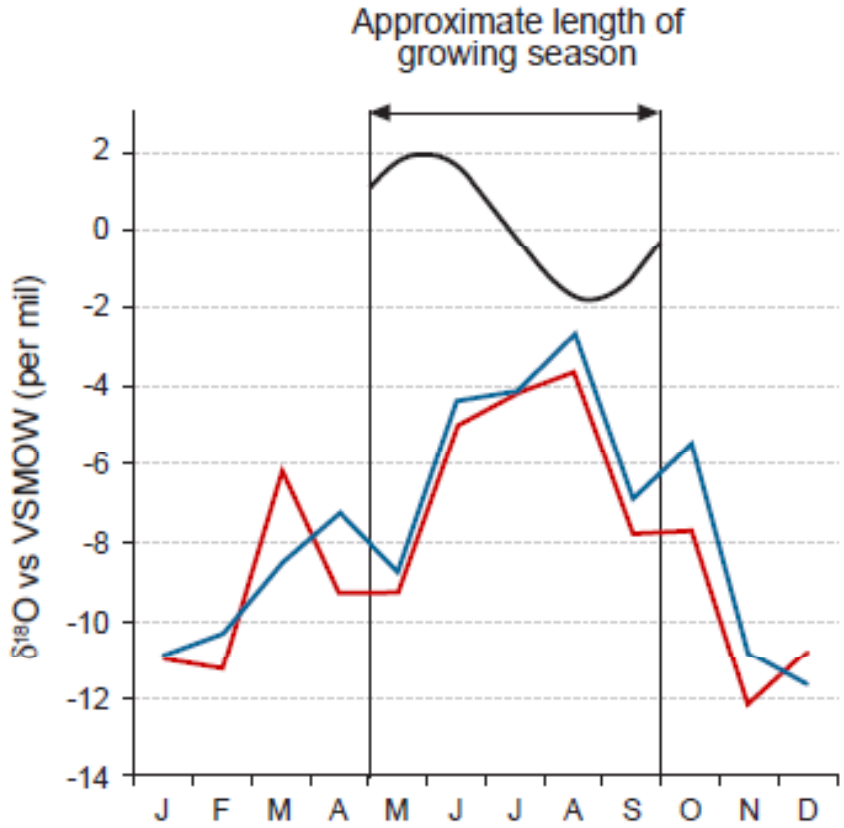
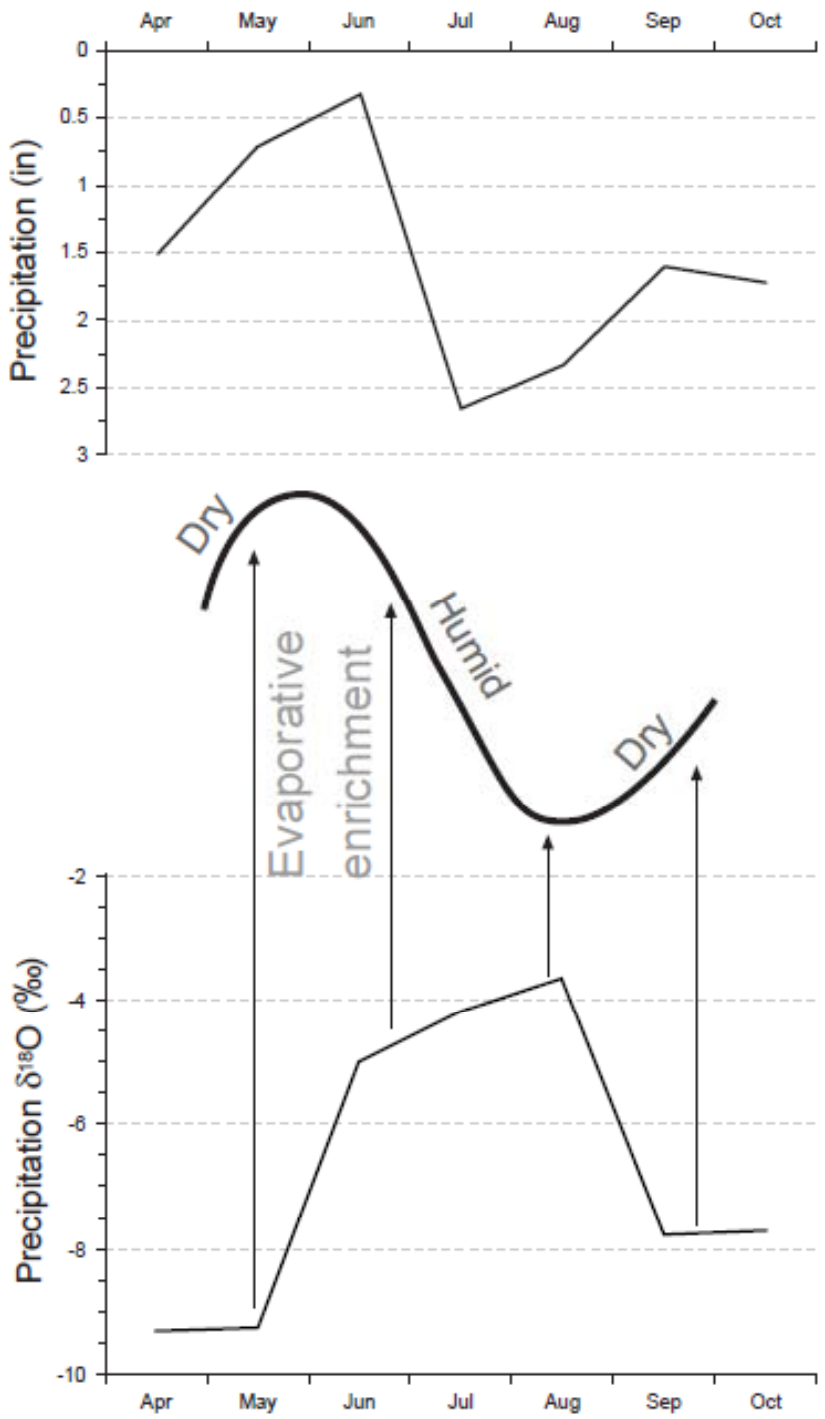
- Unlike most existing studies, precipitation $\delta^{18}O$ alone cannot explain our dataset:



$\delta^{18}O$ of precipitation at Flagstaff, AZ (IAEA, 2006)

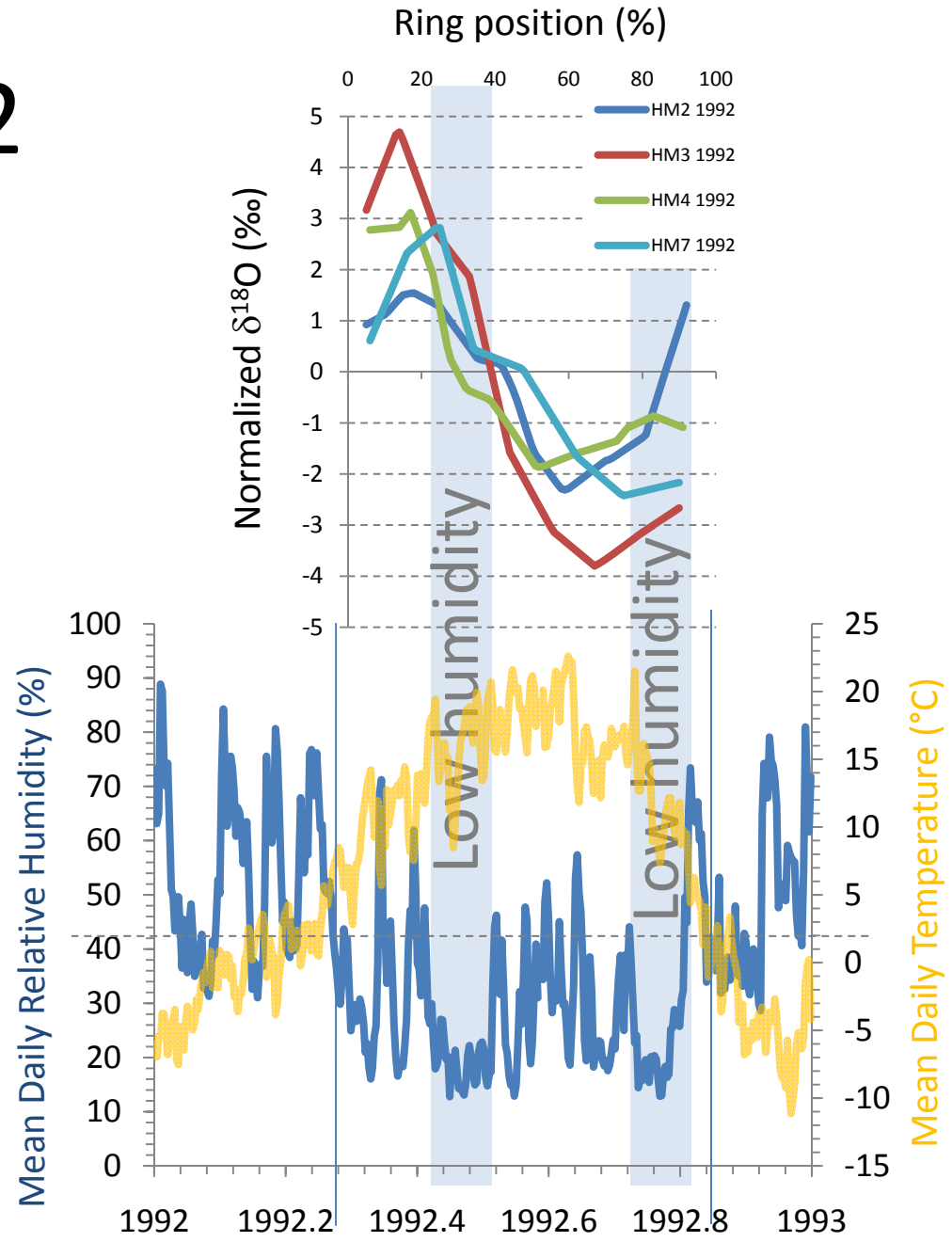
Humidity Conceptual Model

- Humidity controls evaporation which affects $\delta^{18}O$
- Switching between dry and humid (monsoon) alters evaporative potential in leaf (and soil) waters.



Scenario - 1992

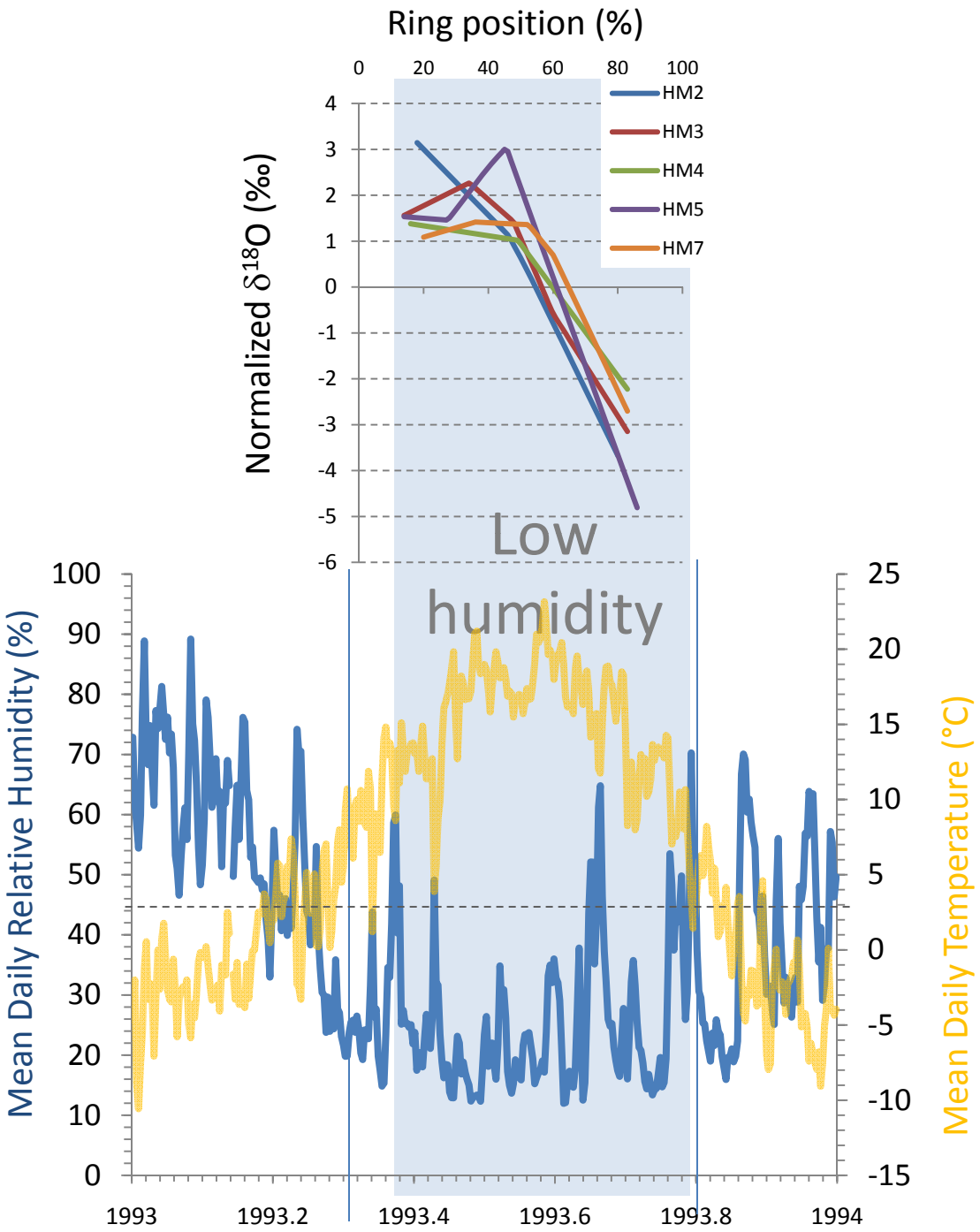
- Low humidity appears to lead to increased isotopic ratios
- However, some inconsistencies



Meteorological data from Kingman AWS. Temperatures estimated for Hualapai Mountain.

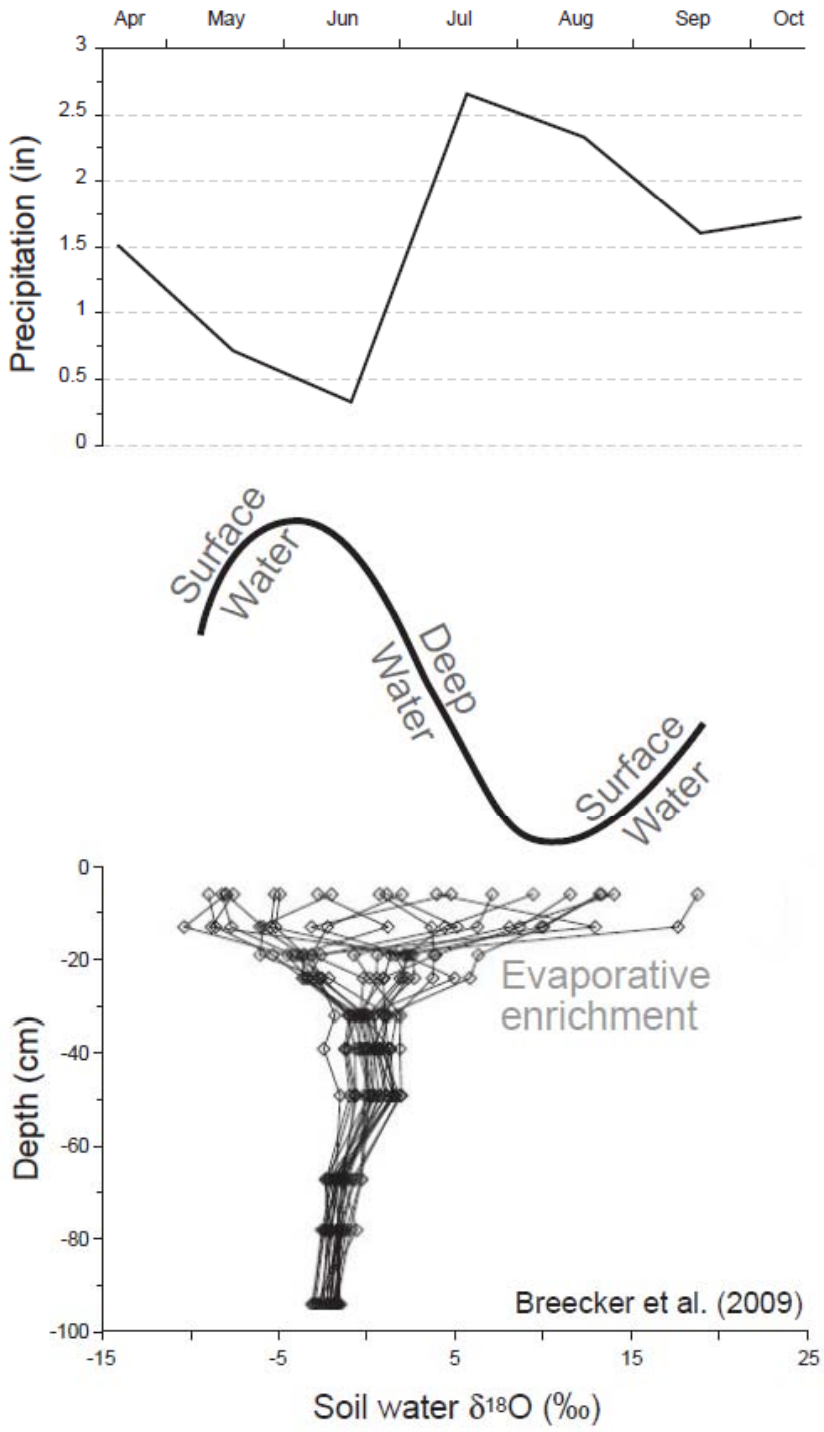
Scenario 1993

- Humidity exposed as coincidence
- 1993 produced narrow rings – suggests lack of water
  - Likely shorter growing season than depicted

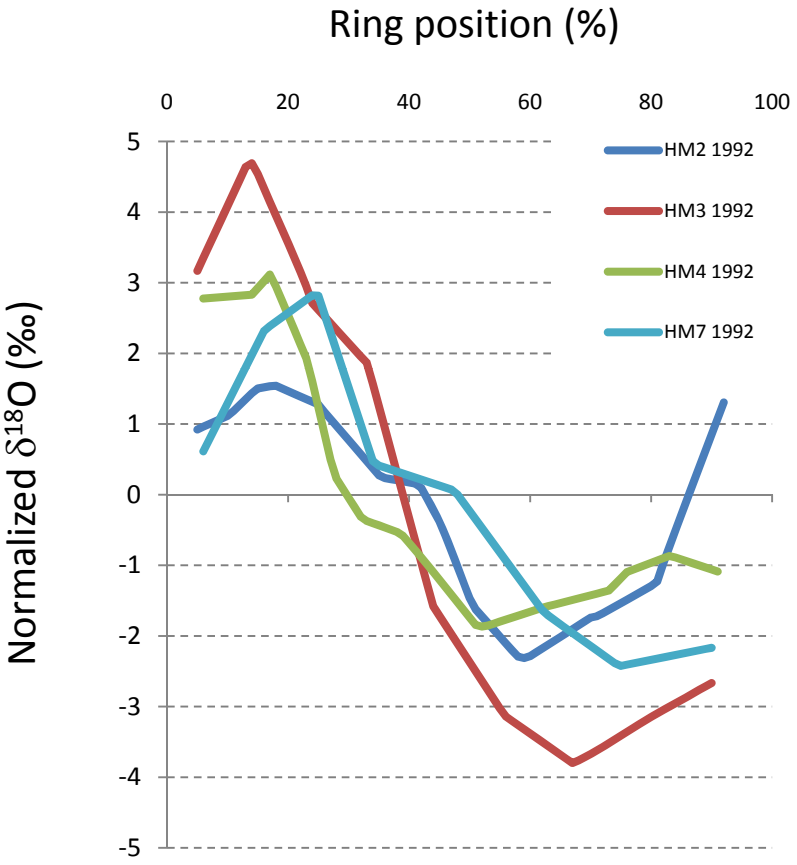


Moisture Source(s) Conceptual Model

- Ponderosas have a demonstrated ‘plasticity’ in their ability to draw moisture from different soil depths (Eggemeyer et al., 2009)



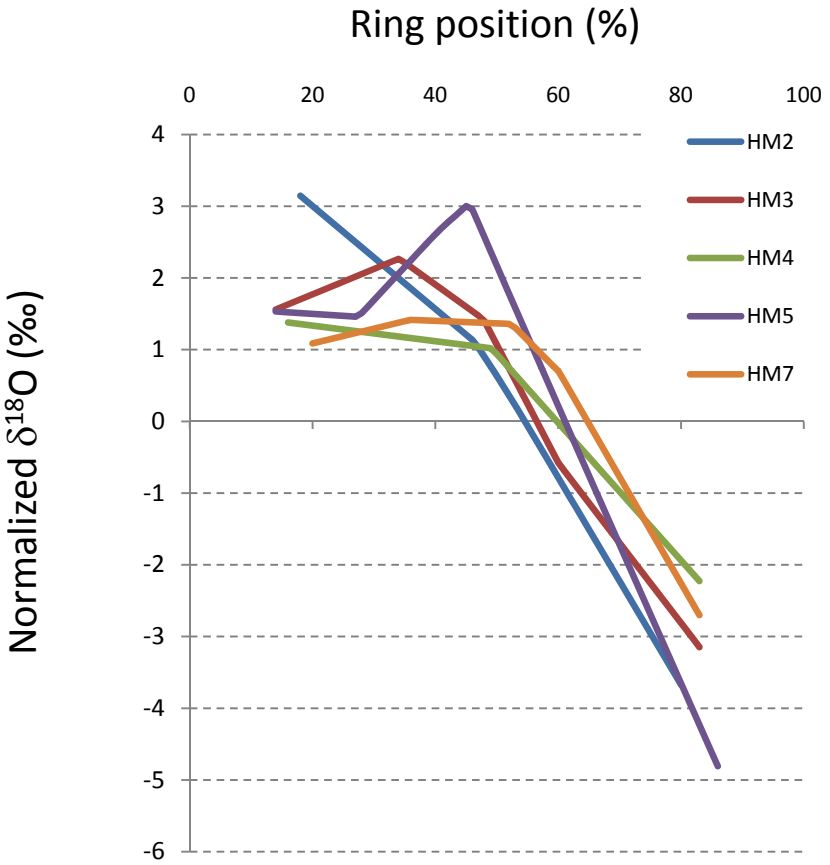
Preliminary Profile Interpretations



Late-Season Upturn

= Long growing season

= Strong/Early Monsoon



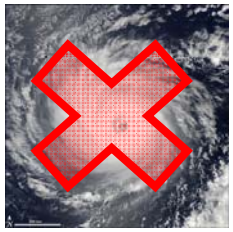
NO Late-Season Upturn

= Short growing season

= Weak/Late Monsoon

Conclusions

- Robust intra-tree and reasonable inter-tree correlations
- 'New' mean tree-ring isotope profile at Hualapai Mountain
  - Early season max., late season min.
  - Large intra-annual range
- Existing hypotheses on drivers of ring cellulose $\delta^{18}O$ cannot adequately describe Hualapai Mountain profile
  - Soil moisture depth model a better fit
- Suggest future studies quantify ring profiles to better determine controls on tree-ring $\delta^{18}O$
- No obvious Hurricane Nora signal



Questions?

Ongoing Work

- Testing the relative strength of the two scenarios in controlling the intra-annual ring-isotope pattern
- Site on UNM campus
  - Sprinkler fed
  - Water has same isotopic value all year (except when it actually rains)

Results – Inter-Annual Trends