LTRR-SRP II

THE CURRENT DROUGHT IN CONTEXT:

A TREE-RING BASED EVALUATION OF WATER SUPPLY VARIABILITY FOR THE SALT-VERDE RIVER BASIN

Dave Meko & Katie Hirschboeck
University of Arizona - Laboratory of Tree-Ring Research

Summary presentation,
February 26, 2008
Salt River Project, Phoenix,AZ

MAIN OBJECTIVE

To update the tree-ring reconstructions of annual streamflow of the Salt-Verde-Tonto Basin through the period of the most recent drought and place it into a long-term, historical context linked to climatic variability

MAIN PROJECT ACTIVITIES

1. **UPDATING TREE-RING CHRONOLOGIES** – Field collections and laboratory analysis to develop chronologies in the Salt-Verde basin with data through growth year 2005

2. **NEW STREAMFLOW RECONSTRUCTION** – Analysis of the new tree-ring chronologies to place the most recent drought in a long-term context

3. **EW-LW EVALUATION** – Exploration of the seasonal precipitation signal in separate measurement of earlywood and latewood width measurements

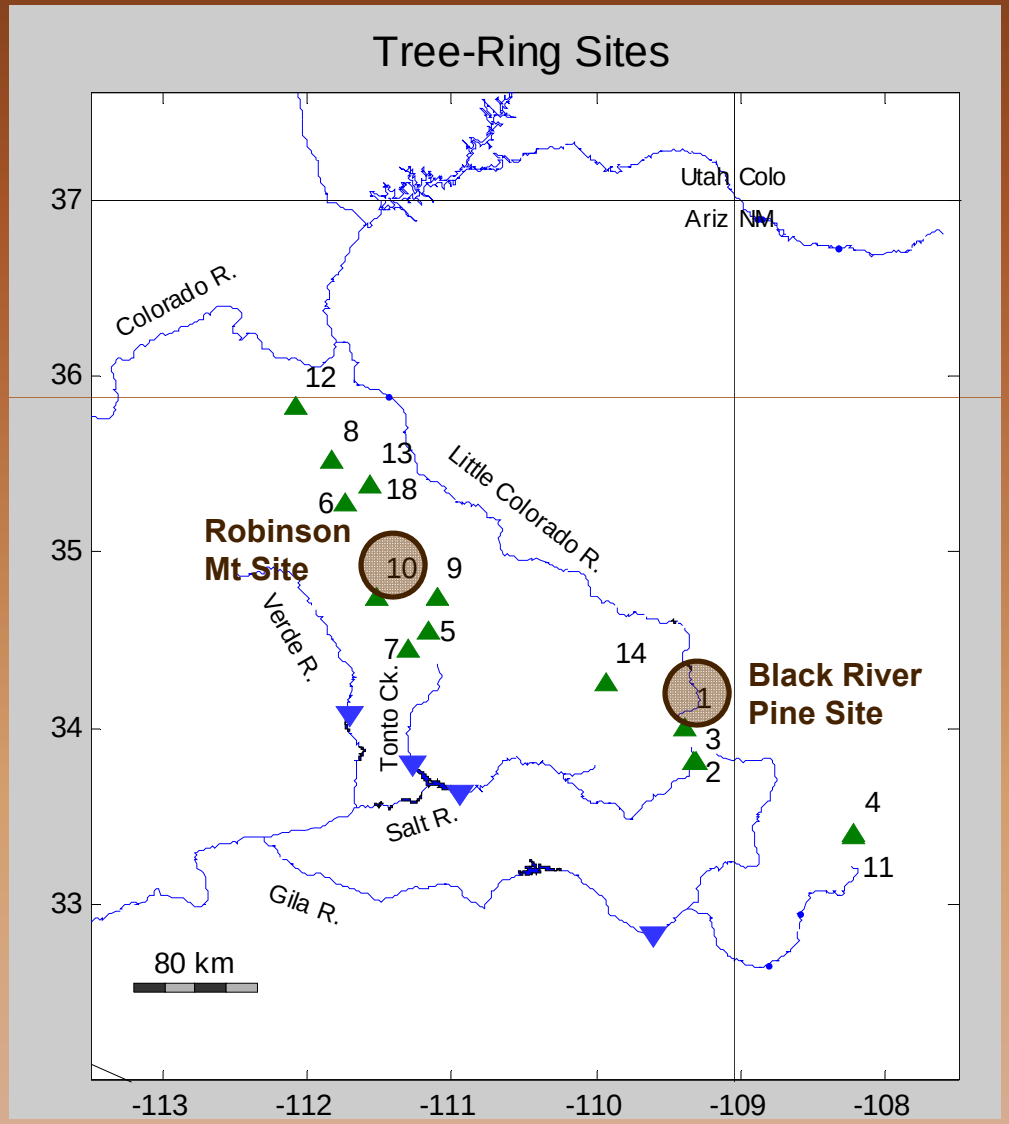
4. **ONGOING CLIMATIC ANALYSES** – Synoptic dendro-climatology studies of observed record to better interpret the reconstructed record

TREE-RING CHRONOLOGY UPDATING

Tree-Ring Collections

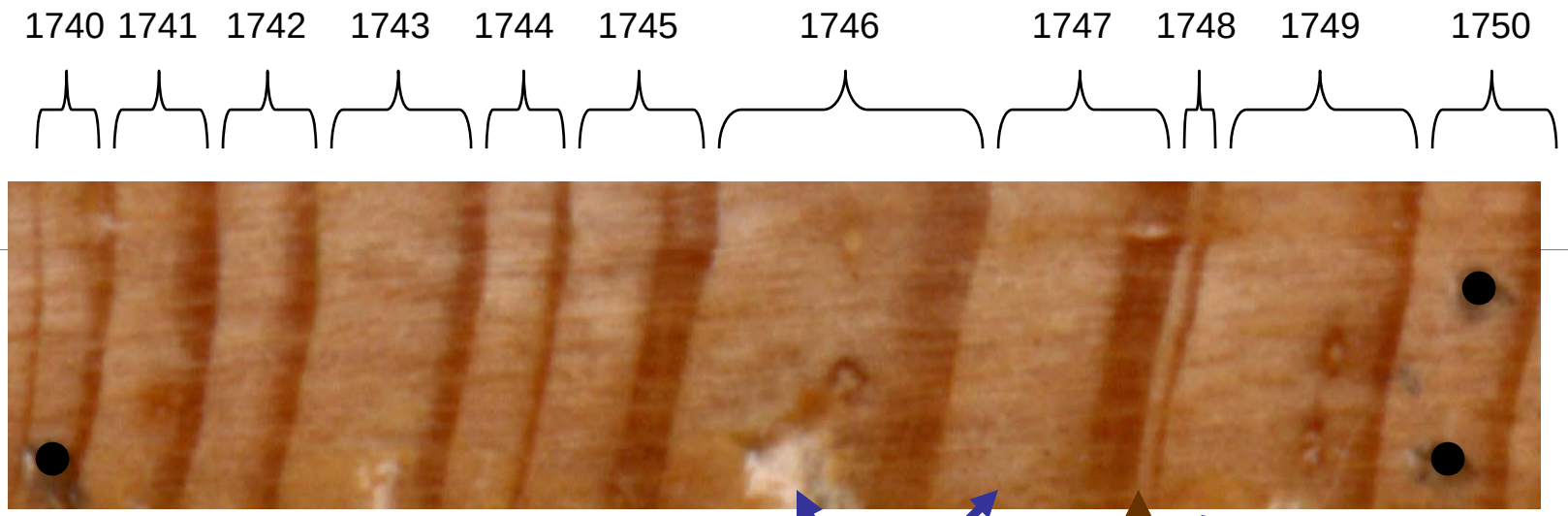
Douglas-fir at Wahl Knoll site, White Mountains , AZ

Tree-Ring Collections



- **Collections at 14 Sites in Fall 2005**
- **Species:**
  - **Douglas-fir**
  - **ponderosa pine**
  - **pinyon pine**
- **Some re-collections, some new collections**
- **Cores only**

Tree Ring Widths – the Basic Data



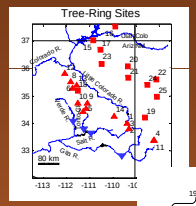
Site 1 - Black River Pine Core 13B

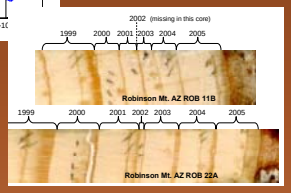
Link to previous LTRR-SRP I study on joint drought (LL HH) in Salt-Verde and Upper Colorado Basins

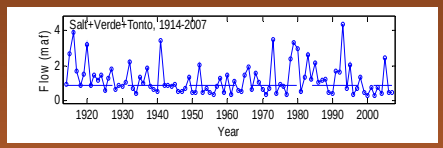
Narrow rings in dry years, wide rings in wet years

STREAMFLOW RECONSTRUCTION PROCESS

Overview of the Reconstruction Process



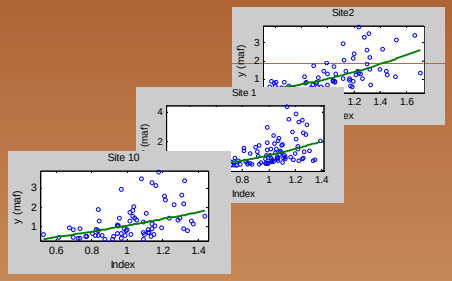




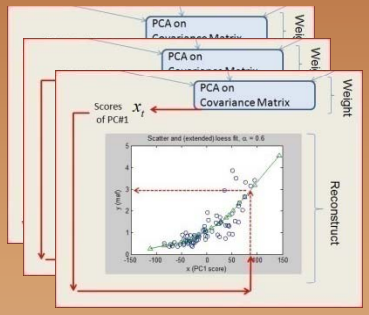
Tree Ring Network

Observed Streamflow

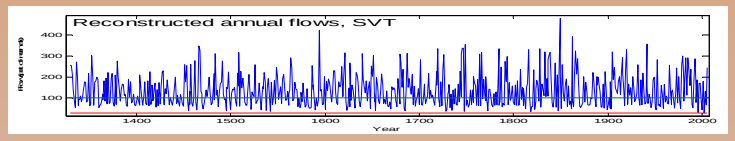
Statistical Calibration: regression



Reconstruction Models

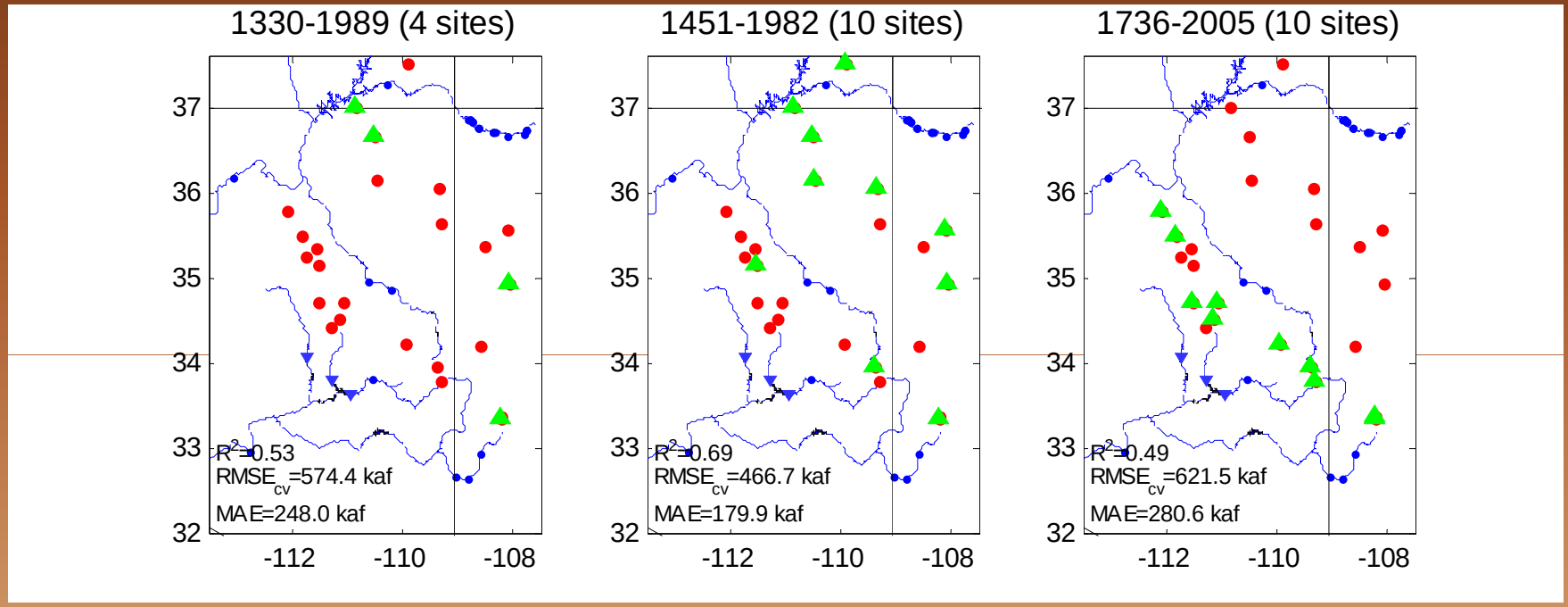


Time Series of Reconstructed Streamflow



Three Different Models Used

(based on different sub-periods)



* Tree-ring sites not in model

▲ Tree-ring sites in model

- **Tree-ring sites have variable time coverage**
- **Uniform time coverage required for a model**

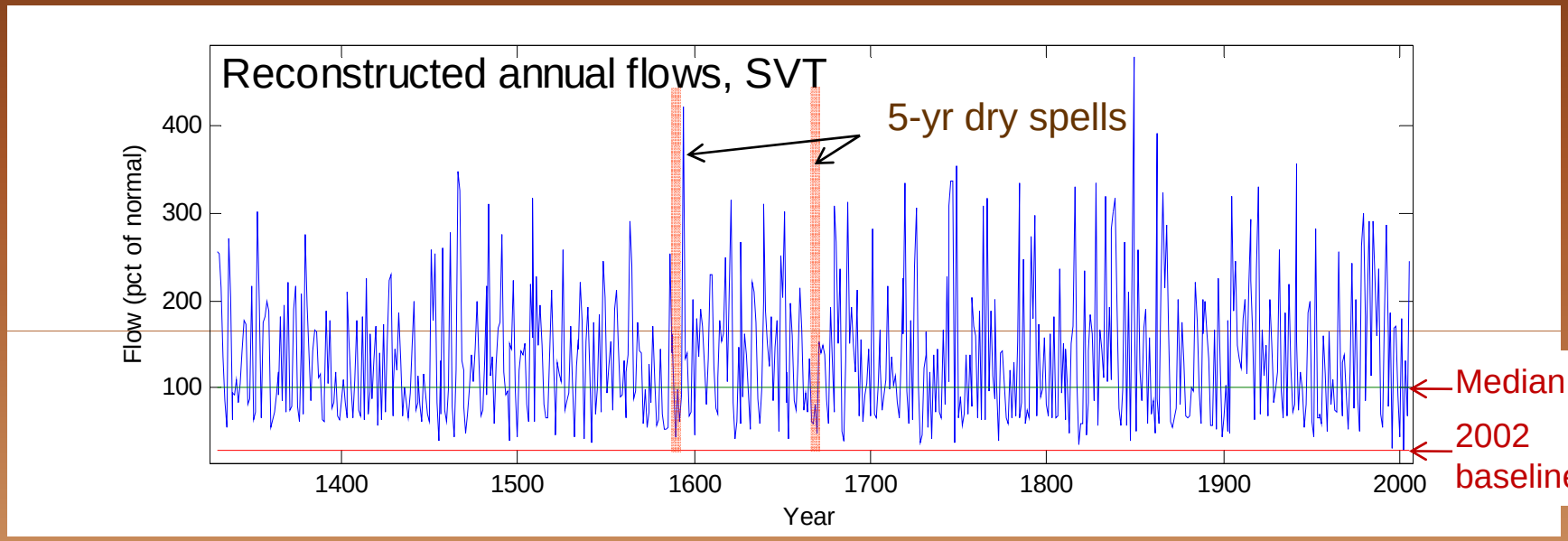
Sub-period reconstructions ultimately blended into final time series of reconstructed streamflow

RESULTS OF THE NEW RECONSTRUCTION

Annual Reconstructed Flows, 1330-2005

Plotted as % of normal*

*normal = defined as 1914-2006 median of observed flows



2002 and 1996 have the lowest reconstructed annual flows in the entire record (28% and 30% of normal* respectively)

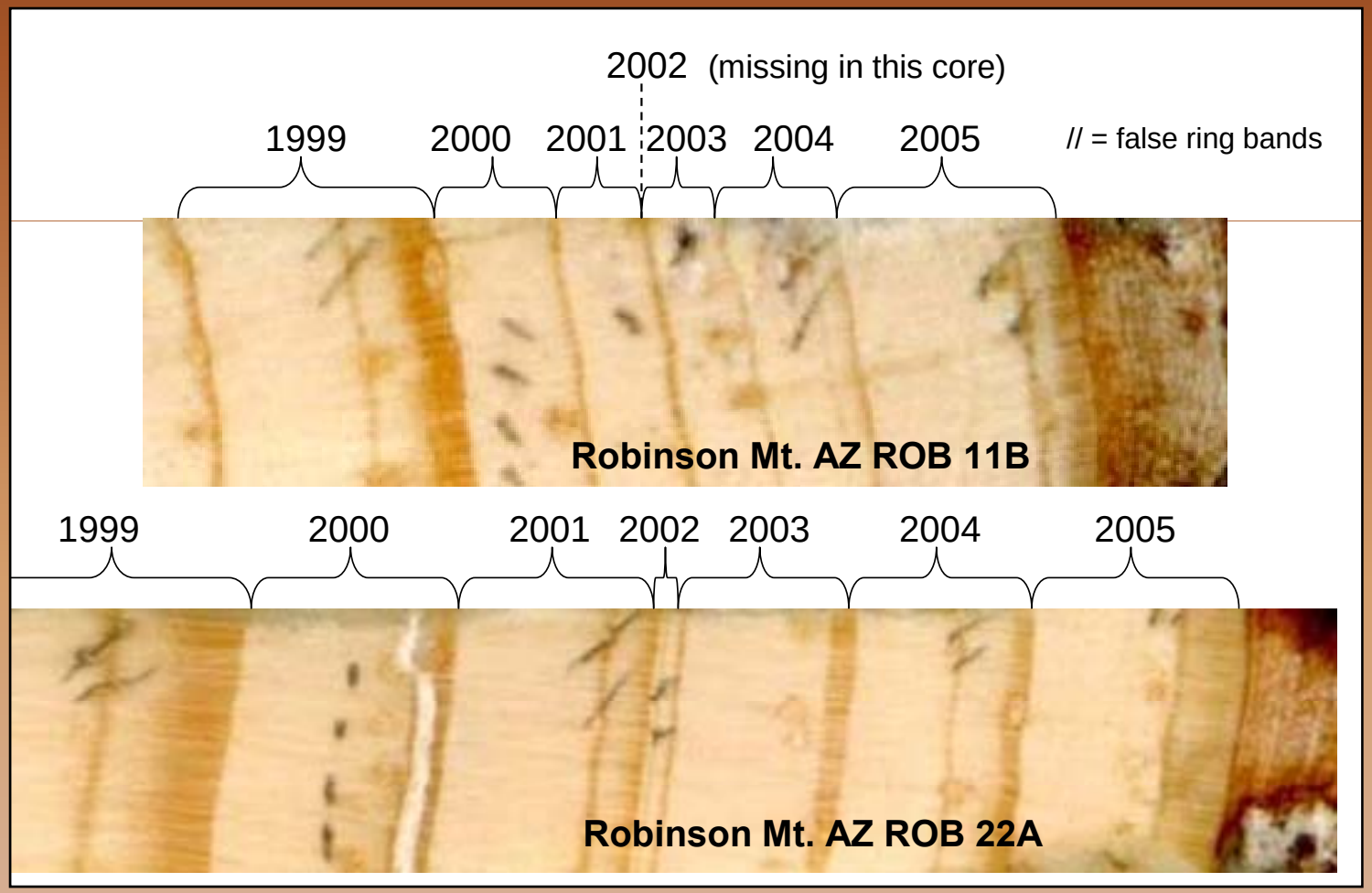
- **Maximum number of consecutive years below normal = 5 (in 1590s and 1660s)**
- **Longest stretch of consecutive years below normal in recent interval of 1914-2005 is 4 years (in 1950s)**

“Missing” Rings (locally absent on tree where cored)

Close up of cores from two different trees
at Site 10, located near Flagstaff:

This core is missing the year 2002

(27 of the 30 trees at this site had no 2002 ring)

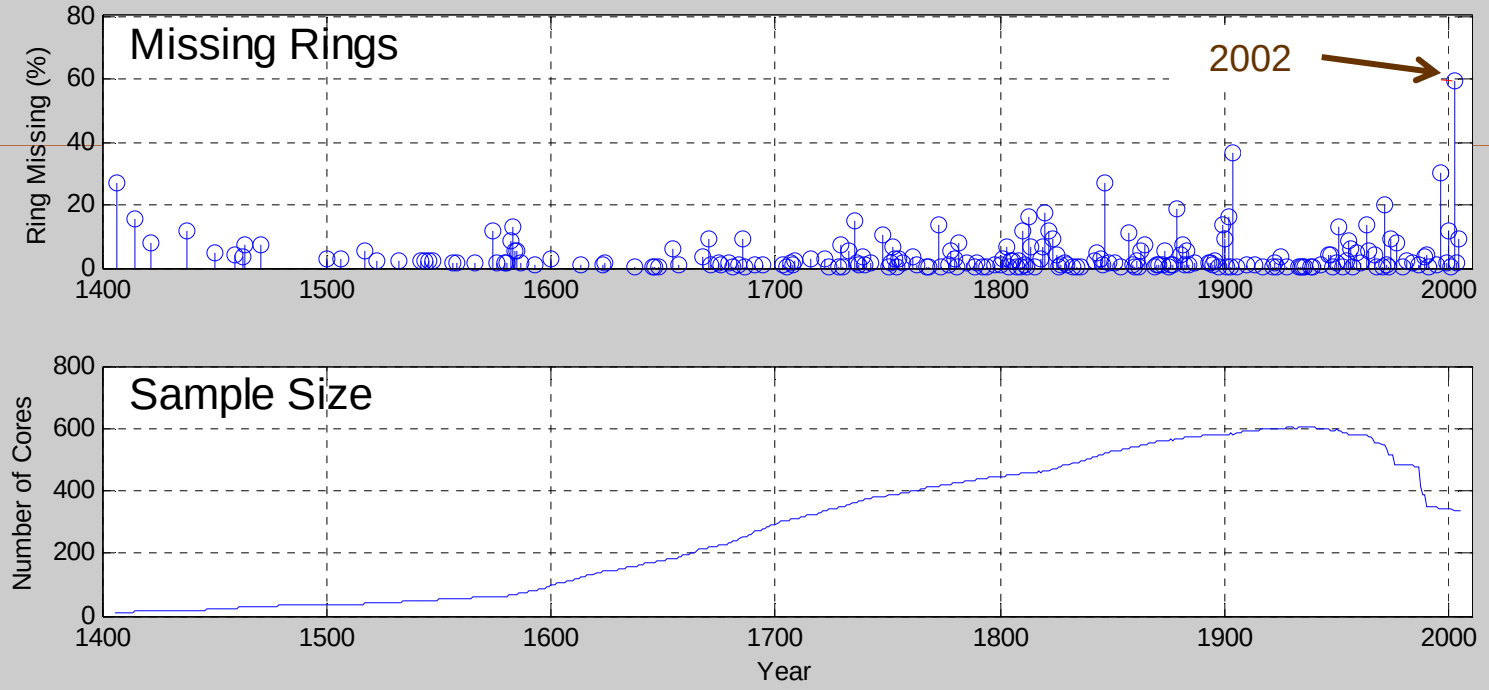


This core has a very narrow 2002 “micro-ring”

(only 3 trees at this site had a 2002 ring)

Missing-Ring Percentage Through Time

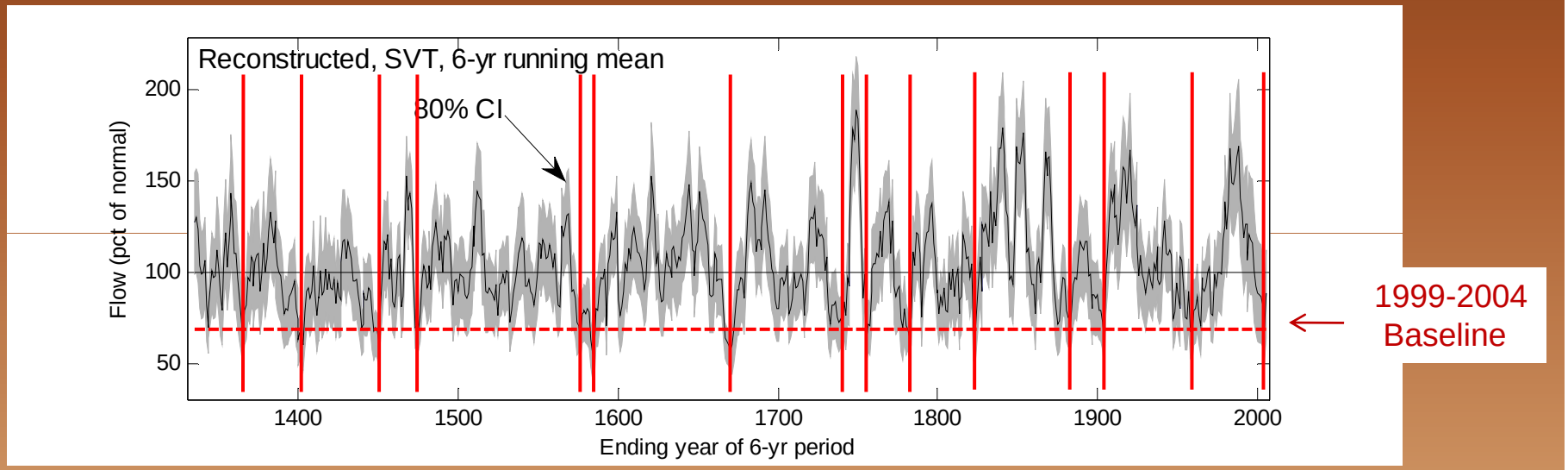
How unusual is such a high % of missing rings?



2002 was unprecedented for frequency of missing rings

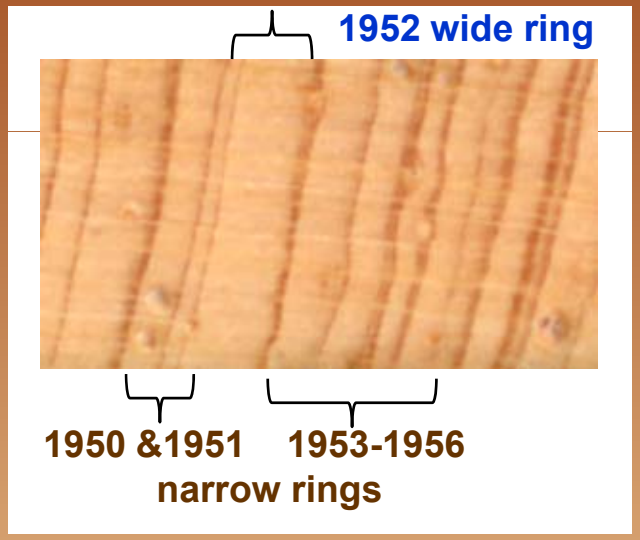
Variations in Time-Averaged Flows

Plotted as % of normal*
*normal =median of all 6-year running means

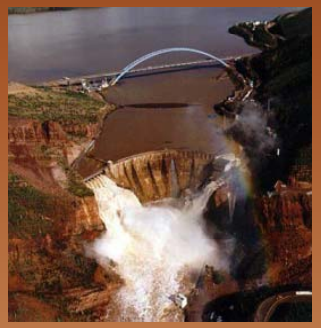


- **14 distinct prior occurrences of flow as low as 1999-2004 average**
- **1- 3 occurrences in each century**
- **Most severe conditions at ~1590 and ~1670**

Variations in Length of Intervals Between High Flow / Wet Years



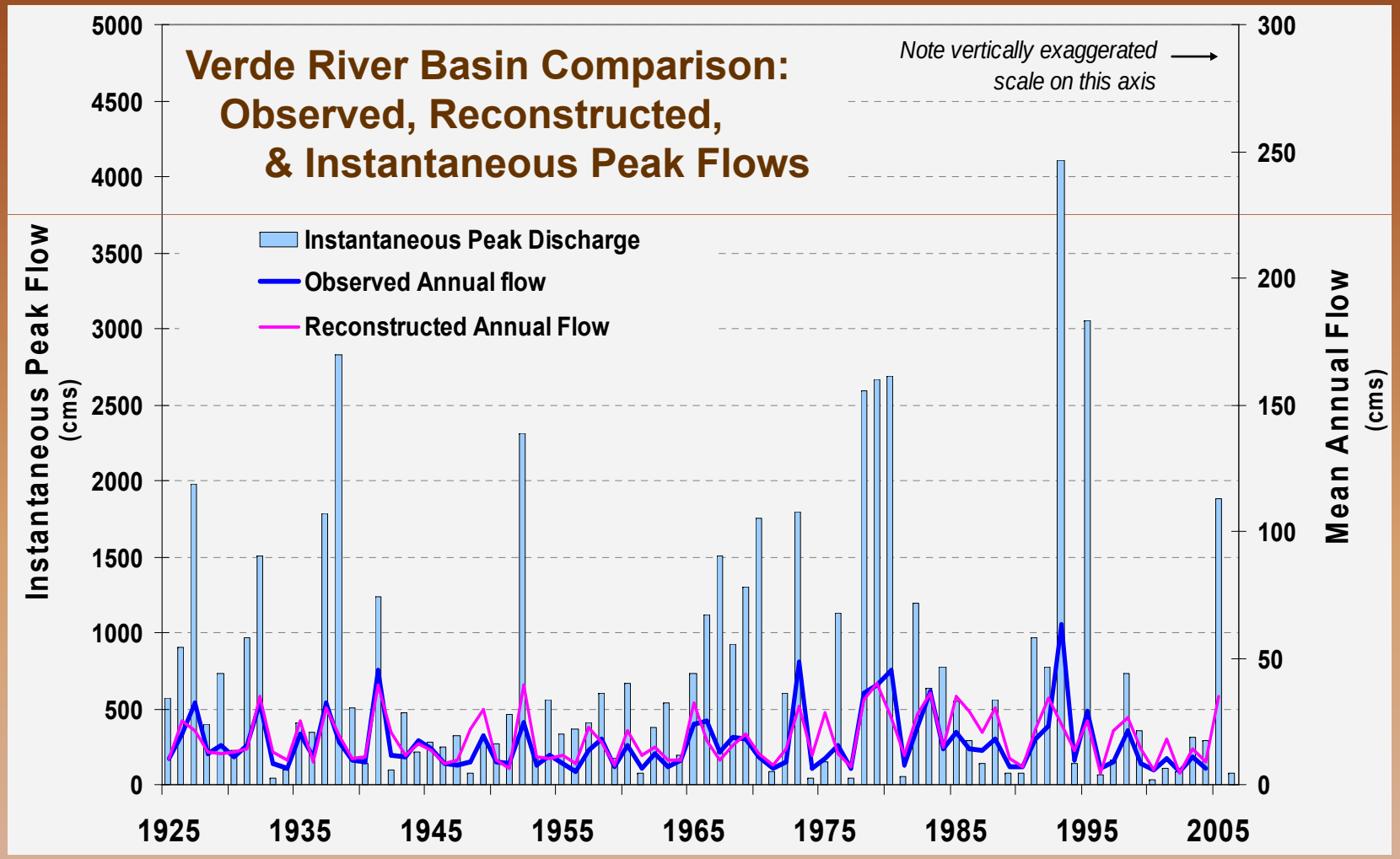
Wide rings can occur in otherwise narrow-ring sequences



High flows and large floods can occur during periods of drought and low flows

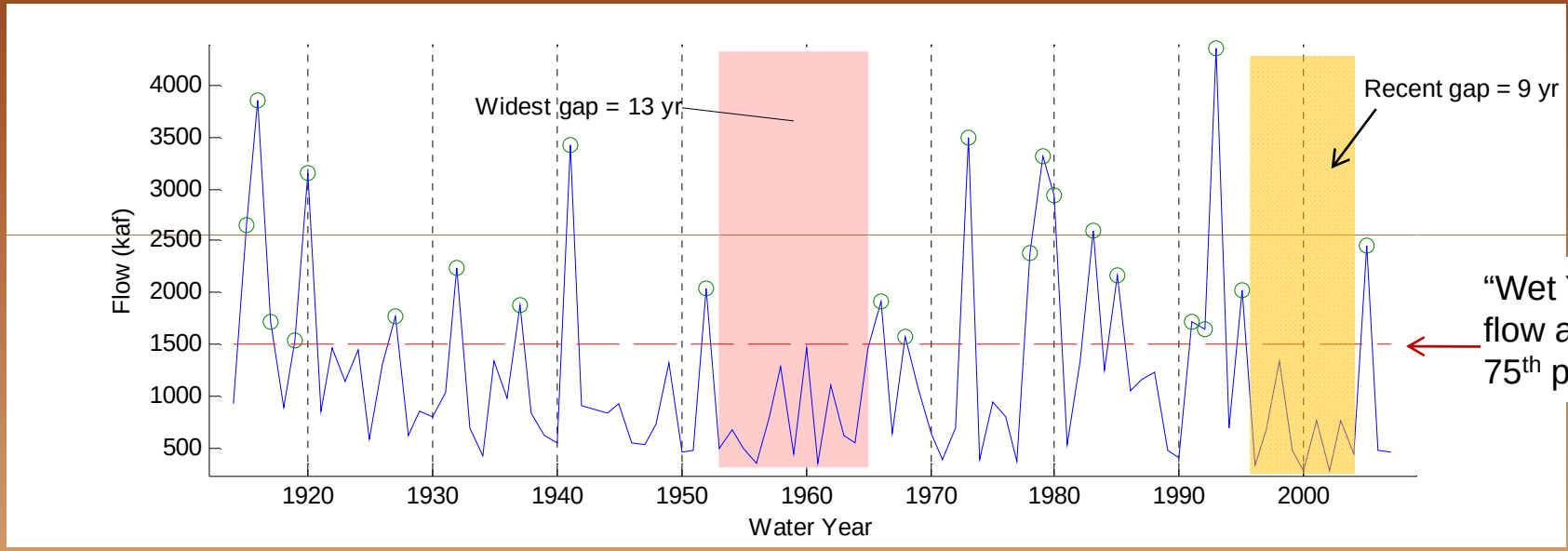
Floods / High Flows & Reconstructed Flows

High flow / flood "wet years" are tracked reasonably well by Verde River tree-ring reconstruction



Length of Intervals Between Wet Years

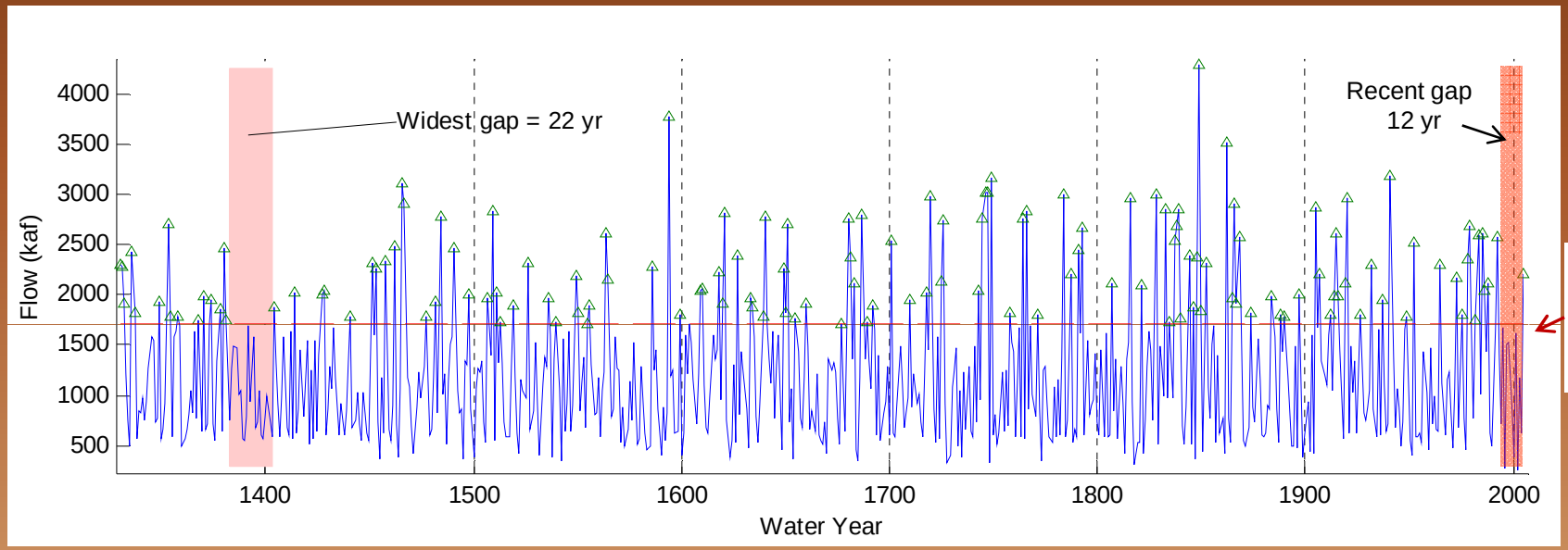
Based on Observed Flows, 1914-2007



- **Interval longer in 1950s than during recent drought period**
- **If not for mildly wet 1952, the earlier interval would have been 25 years**
- **Median interval is 2 years in the observed record**

Length of Intervals Between Wet Years

Based on Reconstructed Flows, 1330-2005



"Wet Year" = flow above 75th percentile

Longest interval = 22 years (1382-1403)

Recent interval = 12 years (1993-2004)

1950s interval = 12 years (1953-1964)

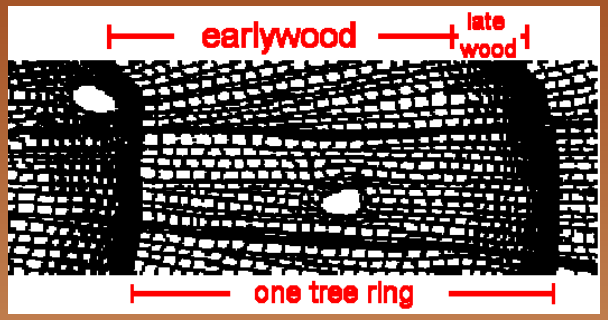
10 intervals ≥ 12 years

Median interval is 3 years

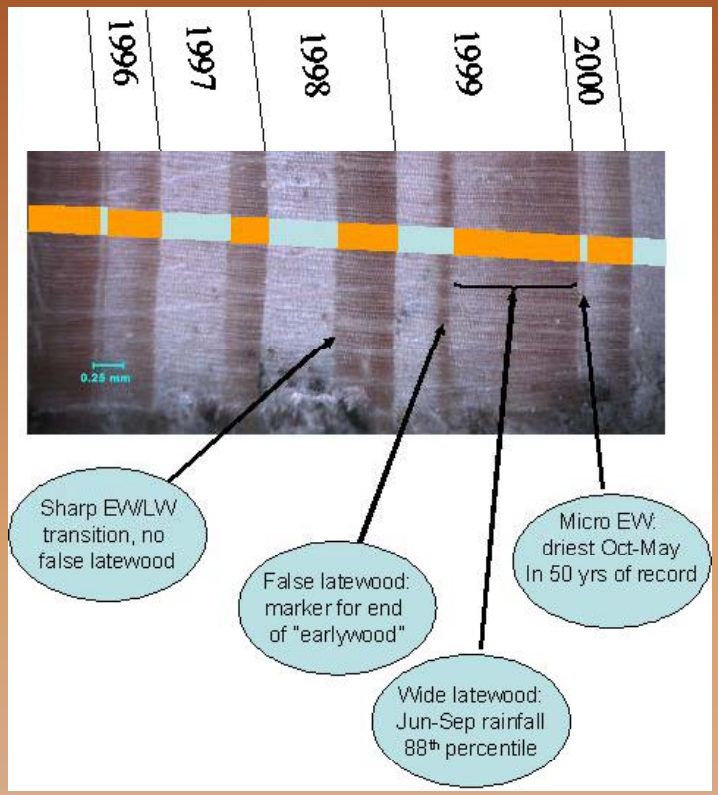
EARLYWOOD-LATEWOOD EVALUATION

Earlywood / Latewood Evaluation

Ring width can be partitioned into parts formed early and late in the growth year



Studies have shown some success at inferring summer rainfall variations from latewood width



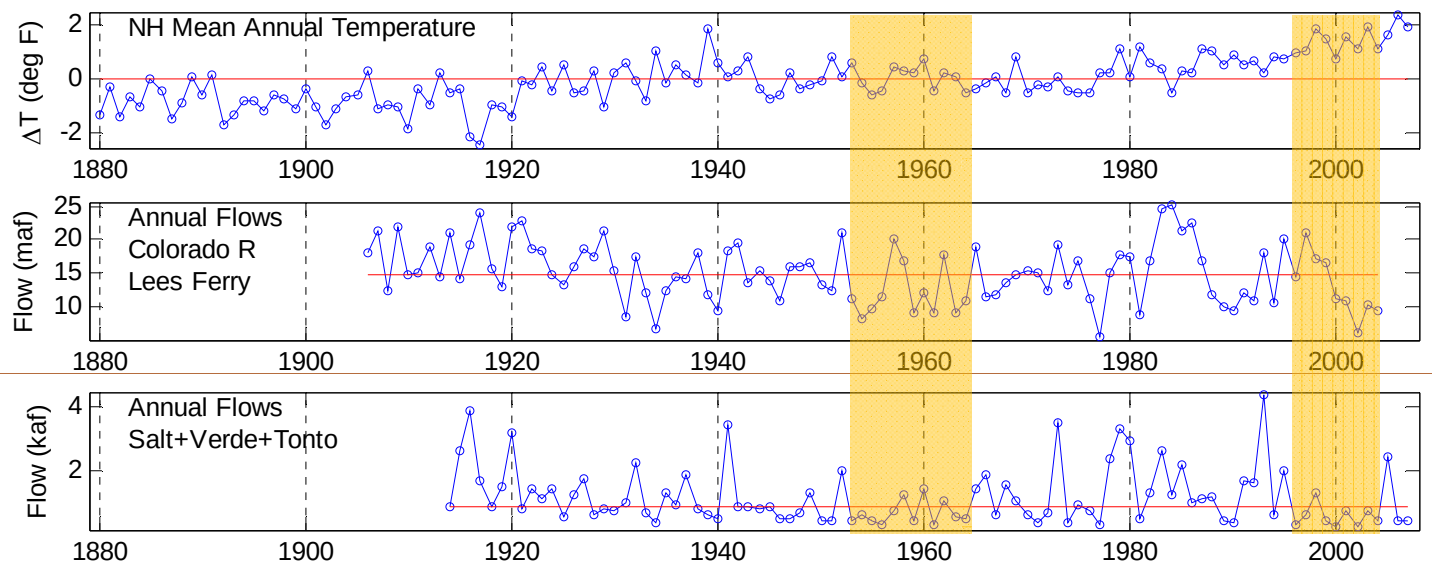
Testing for Latewood Signal of Summer Rainfall

- **Total width had signal for annual precipitation, but no signal for summer precipitation**
- **Latewood width had a weak but significant signal for summer precipitation**

SUMMARY: Results encouraging, but summer precipitation signal in partial ring widths is too weak to expect useful reconstruction of summer monsoon variability from this limited site coverage

THE CLIMATIC CONTEXT OF RECENT DROUGHTS

The “Big Picture” Global Climate Context



NH Temperature Data from NASA/GISS; data are departures from 1951-80 mean based on GHCN met stations

Upper Colorado Flows natural flows for Lees Ferry from USBR

Salt-Verde-Tonto Flows from USGS

Horizontal lines for flows are at medians

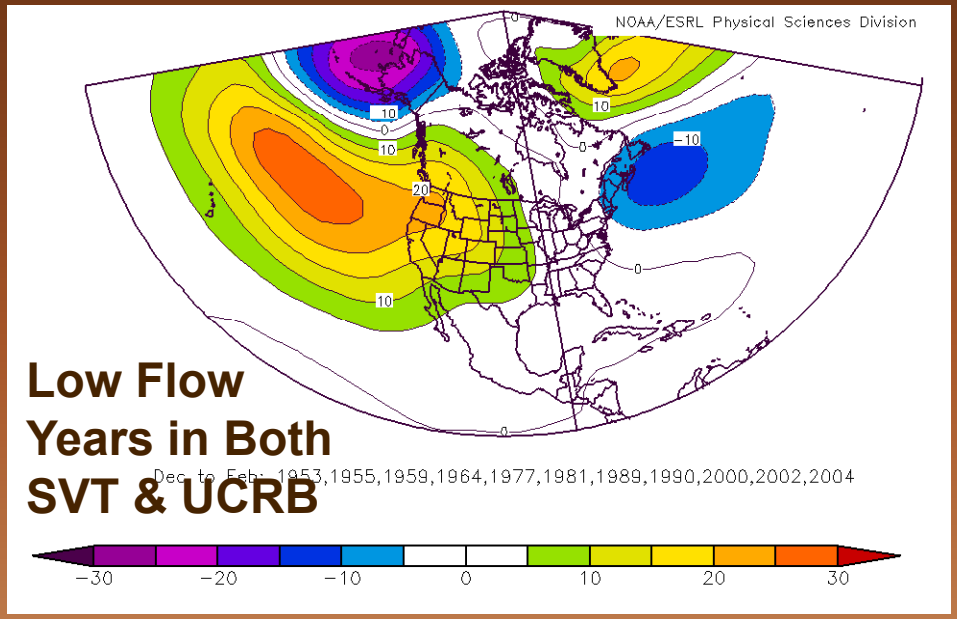
- **Recent drought: mean NH temperatures near record highs**
- **1950s drought: mean NH temperatures near middle of long-term warming trend**
- **Wet late 1970s to early 1980s: mean NH temperatures higher**
- **Wet period 1915-20: mean NH temperatures low**

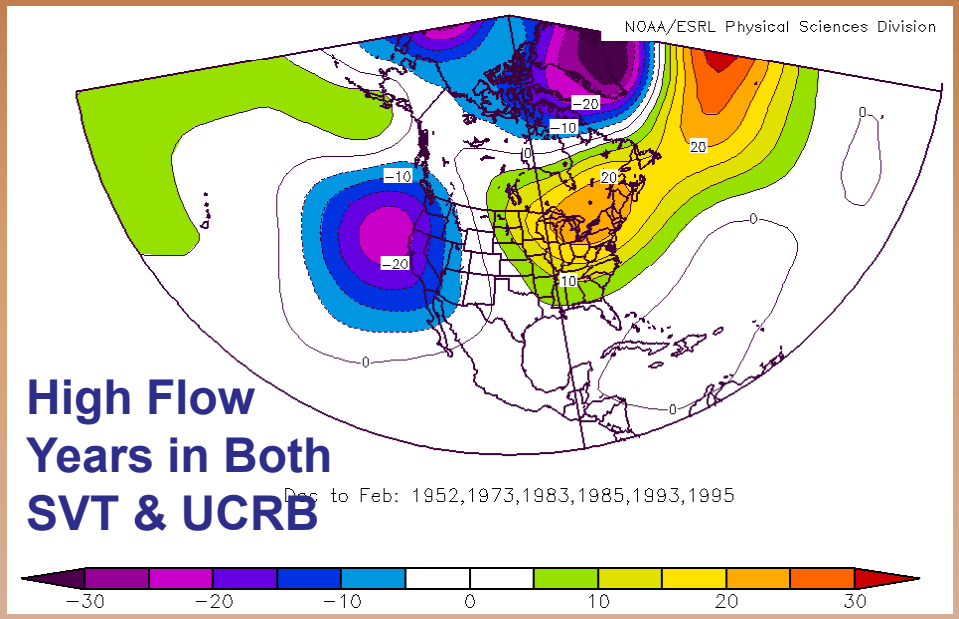
(not shown here) severe tree-ring drought of 1899-1904: mean NH temperatures very low

Link to LTRR-SRP- I Project

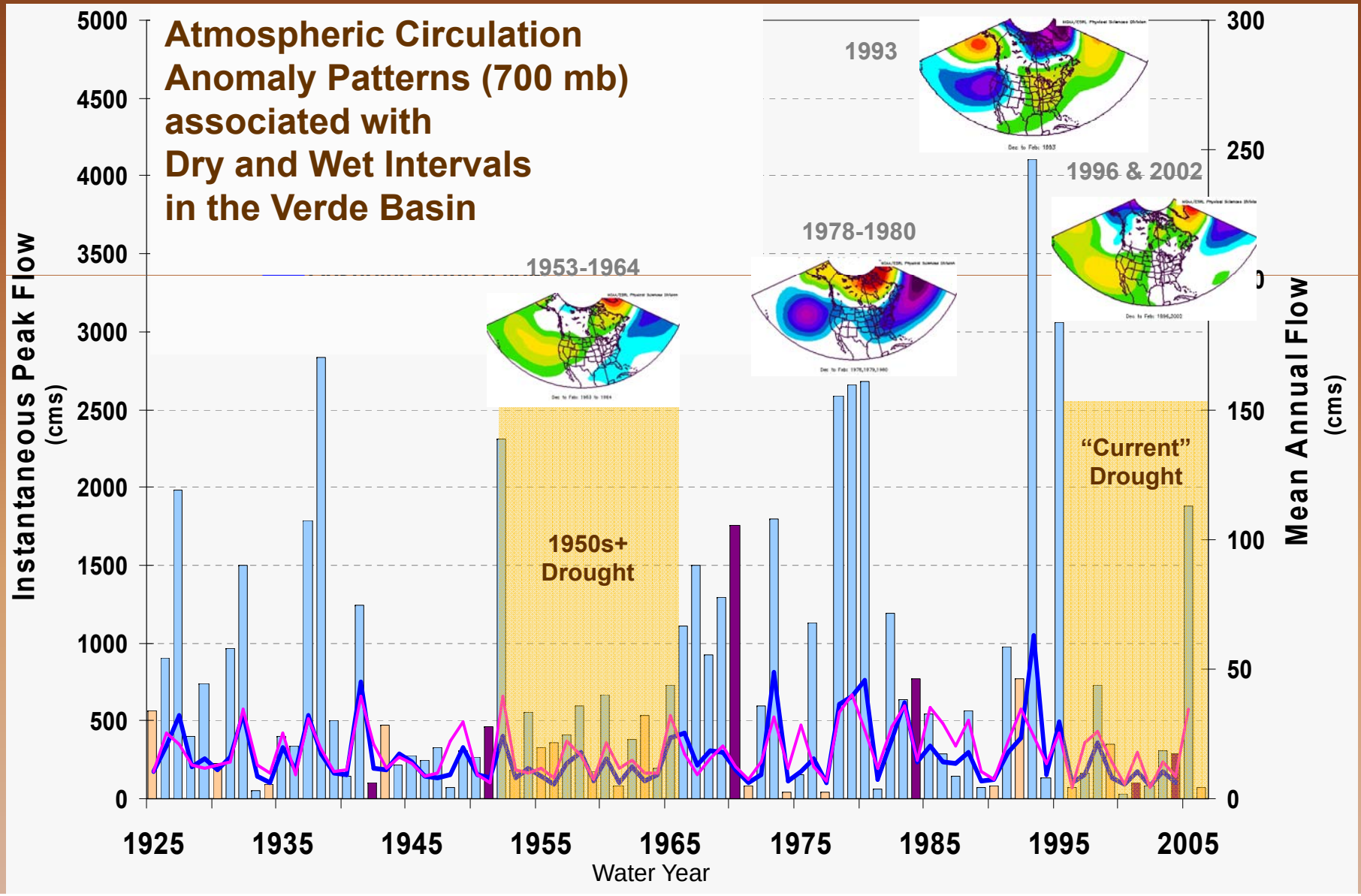
Updated LL and HH years exhibit anomaly patterns similar to those of the earlier study

700 mb composites of new LL and HH years for Dec-Feb



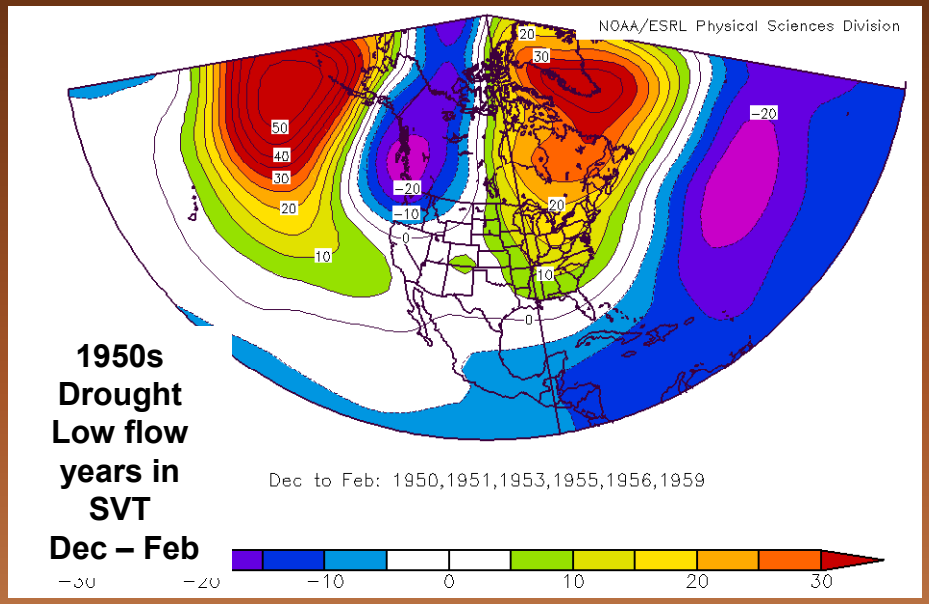


Synoptic Atmospheric Circulation Patterns Linked to Dry and Wet Intervals

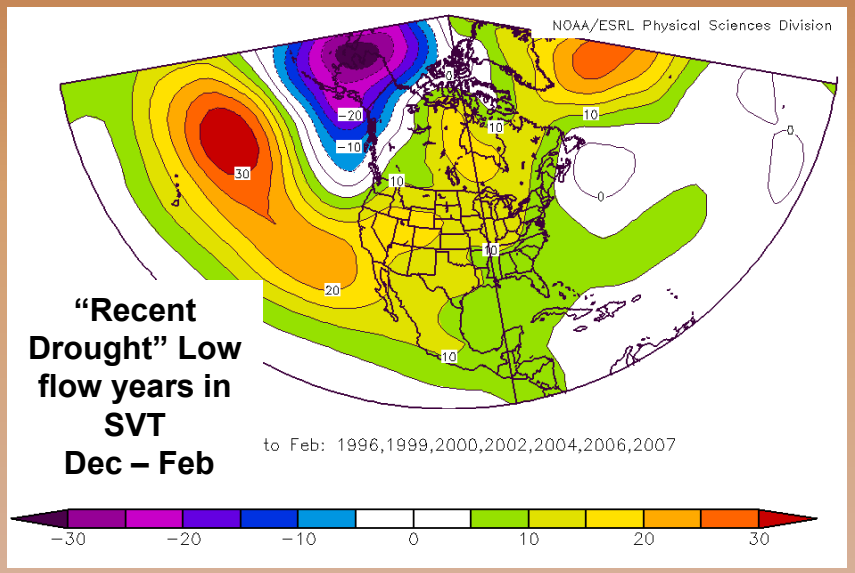


Synoptic Circulation Patterns for SVT

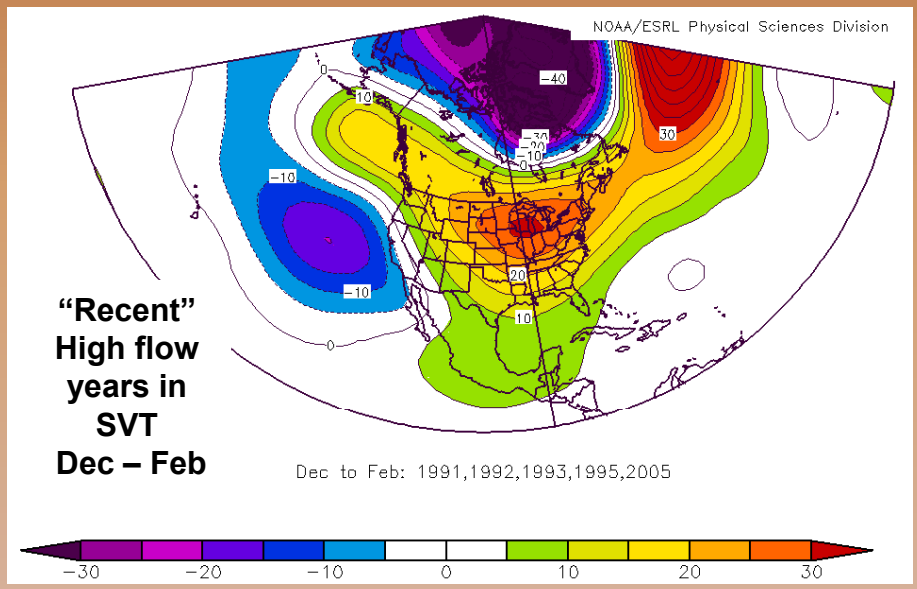
Verde Basin study: tree-ring record is a good indicator of winter storm track activity



1950s pattern vs. "Recent Drought" pattern



Recent High Flow Year pattern



SUMMARY & CONCLUSIONS

Reconstruction Model Summary

- Ring widths of the new collections have a strong annual runoff signal
- Subset models blended together yield a streamflow reconstruction covering 1330-2005
- The reconstruction explains 49- 69% of the variance of the annual flows

Extreme Single-Year Summary

- The reconstructed 1996 value was the 2nd lowest reconstructed flow since 1330
- The reconstructed 2002 value was the LOWEST reconstructed flow since 1330
- From tree's perspective 2002 was a year like no other: 60% of 300+ cores were missing the 2002 ring!

CONCLUSIONS

1) Single-year intensity: drought in recent years unsurpassed in long-term tree-ring record (i.e., 1996, 2002)

2) Multi-year intensity: 14 distinct prior occurrences of flow as low as 1999-2004 average

CONCLUSIONS

3) Several intervals between "drought relieving" wet years were longer than any observed in the instrumental record

4) Winter storm track position key factor in drought signature (1950s vs. recent drought)