Revealing the climate story hidden in mangroves in NSW coastal wetlands

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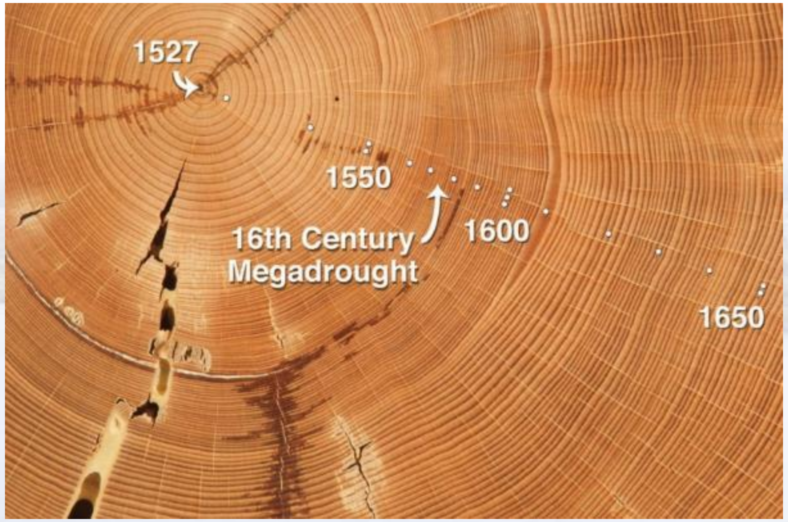
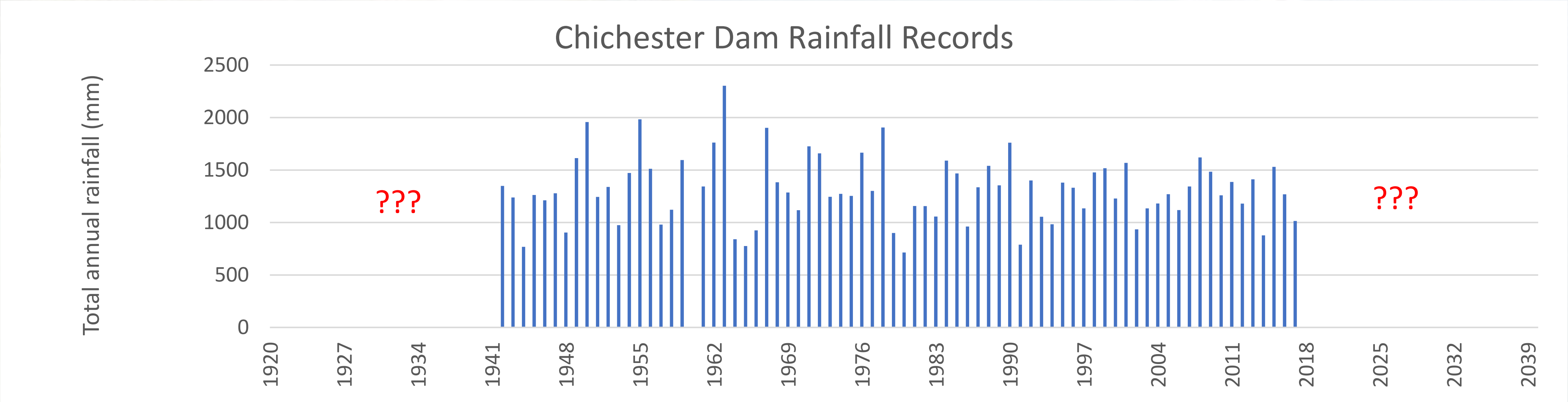
Image credit: (Ashley, 2017)

Framing the problem…

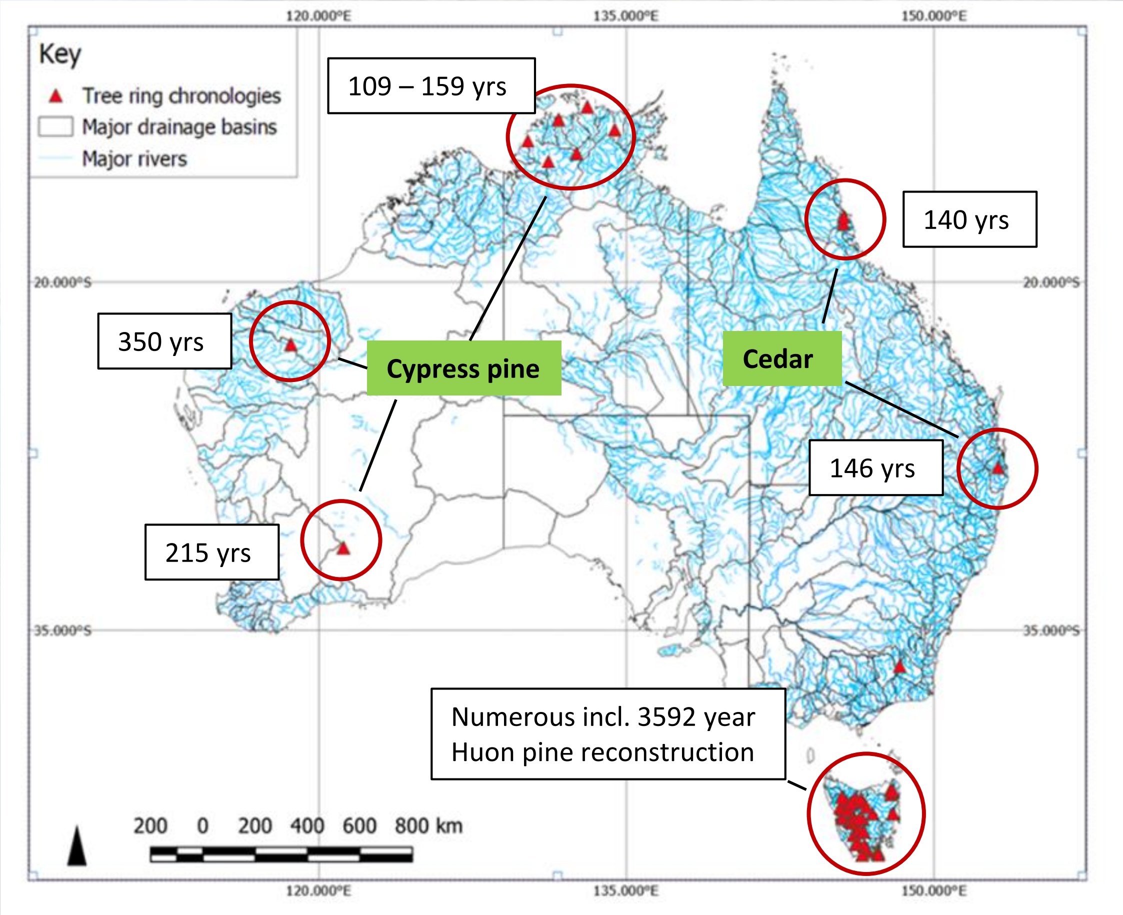
- Australian climate is highly variable
- Instrumental climate records are very short (<150 years)
- However, can be supplemented with data interpreted from palaeoclimate archives…
    - Cave deposits, lake sediments, ice cores, coral luminescence, **<u>tree rings</u>**





Australian tree ring climate reconstructions

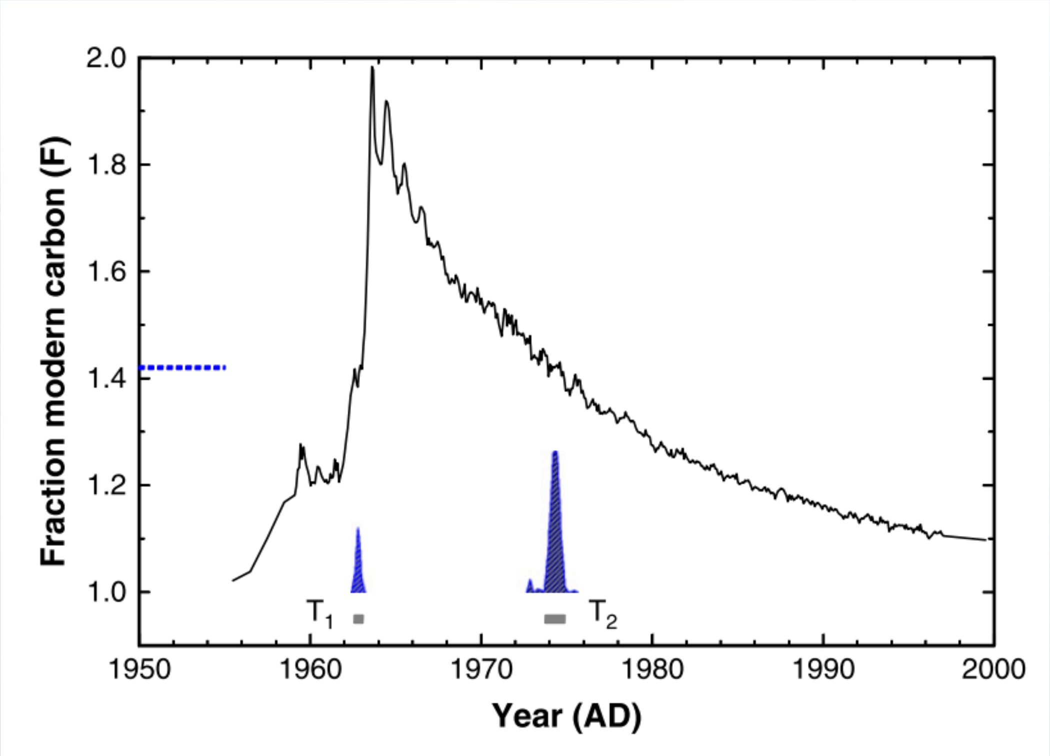
- Most feature Tasmanian species
- Very few mainland climate reconstructions
    - Scarcity of annual ring forming species
    - Limited life span



Australian mainland tree ring palaeoclimate reconstructions

Beyond ring width – emerging approaches

- Alternate wood properties that may vary in response to climate
  - Chemical composition (stable isotopes C, H, O),
  - Anatomic features (xylem vessel size and abundance)
- Measured in sequence from pith to bark
- Temporal control – when did the growth occur?
  - Bomb pulse radiocarbon dating



Bomb pulse radiocarbon dating example (adapted from Hua, 2009)

Why consider Grey Mangroves for dendroclimatology?

- Long lived (>1000 years)
- Very common in Australia
- Demonstrated environmental sensitivity
- Santini et. al (2013) – wood density of West Australian mangroves correlates significantly with the Pacific Decadal Oscillation
- Success in other mangrove species, but untested in grey mangroves

Grey mangrove “growth rings”

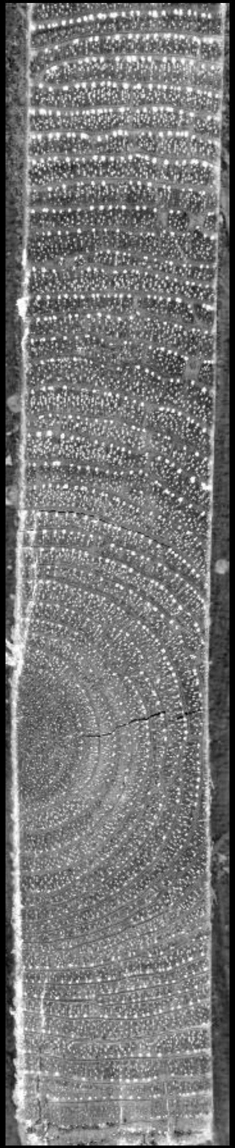
<u>Study Aim: to establish whether radiocarbon dated timeseries of C and O isotopes and wood anatomy correlate with a range of climate variables</u>

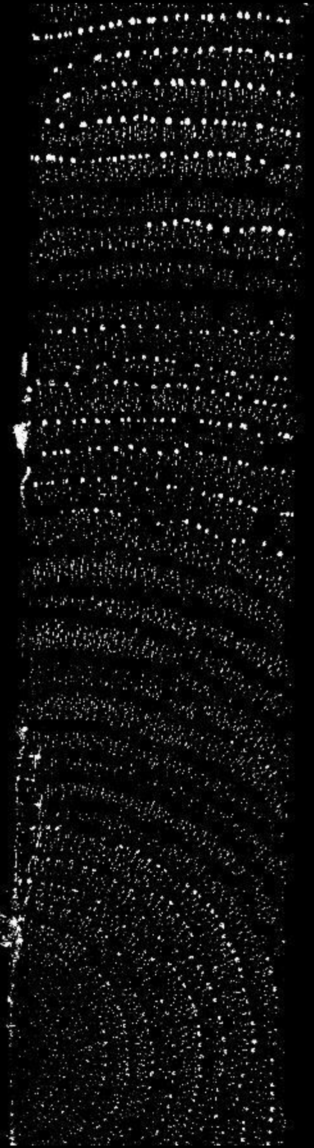
Sample sites

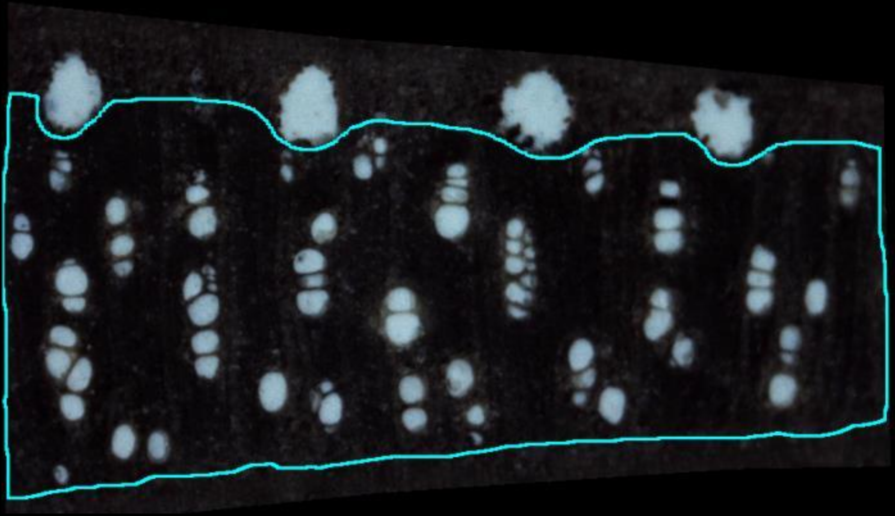
Basemap: OSM street map

Samples collected with permission from NSW DPI (*Fisheries Management Act* section 94 permit) and NPWS (scientific collection licence).

Methods: quantitative wood anatomy







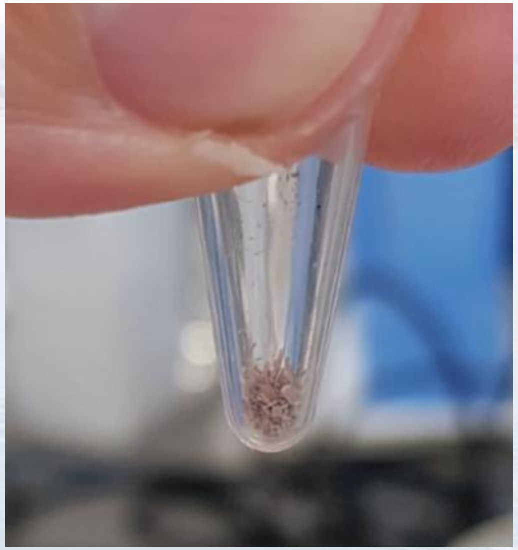
Within each growth layer:

1. Mean vessel area

2. Vessel density

$$= \frac{n\ vessels}{target\ area}$$

Stable isotope analysis and bomb pulse radiocarbon dating



- Separate individual layers
- Grind into powder
- Alpha cellulose extraction
- $D^{13}C$ & $D^{18}O$ measured using EA-IRMS @ James Cook University

  (Elemental Analyser-Isotope ratio mass spectrometer)
- Radiocarbon content analysed at ANSTO STAR accelerator, converted to modelled age in calendar years

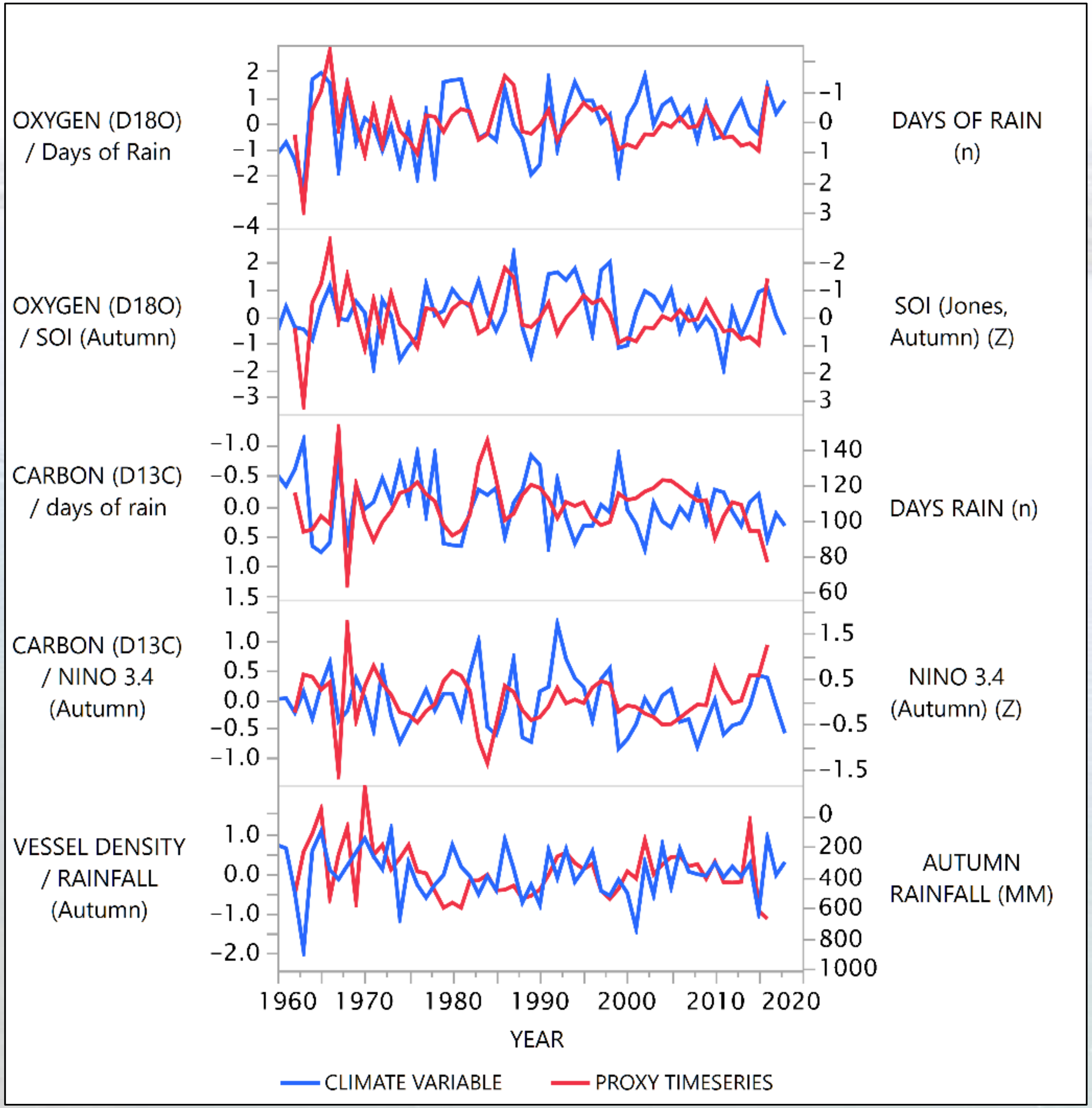
Results: timeseries comparison

- Most significant correlations for each parameter:

- Oxygen isotopes ($\delta^{18}O$)
  - Days of rain
  - SOI (Autumn)

- Carbon isotopes ($\delta^{13}C$)
  - Days of Rain
  - Nino 3.4 (Autumn)

- Vessel density
  - Autumn rainfall

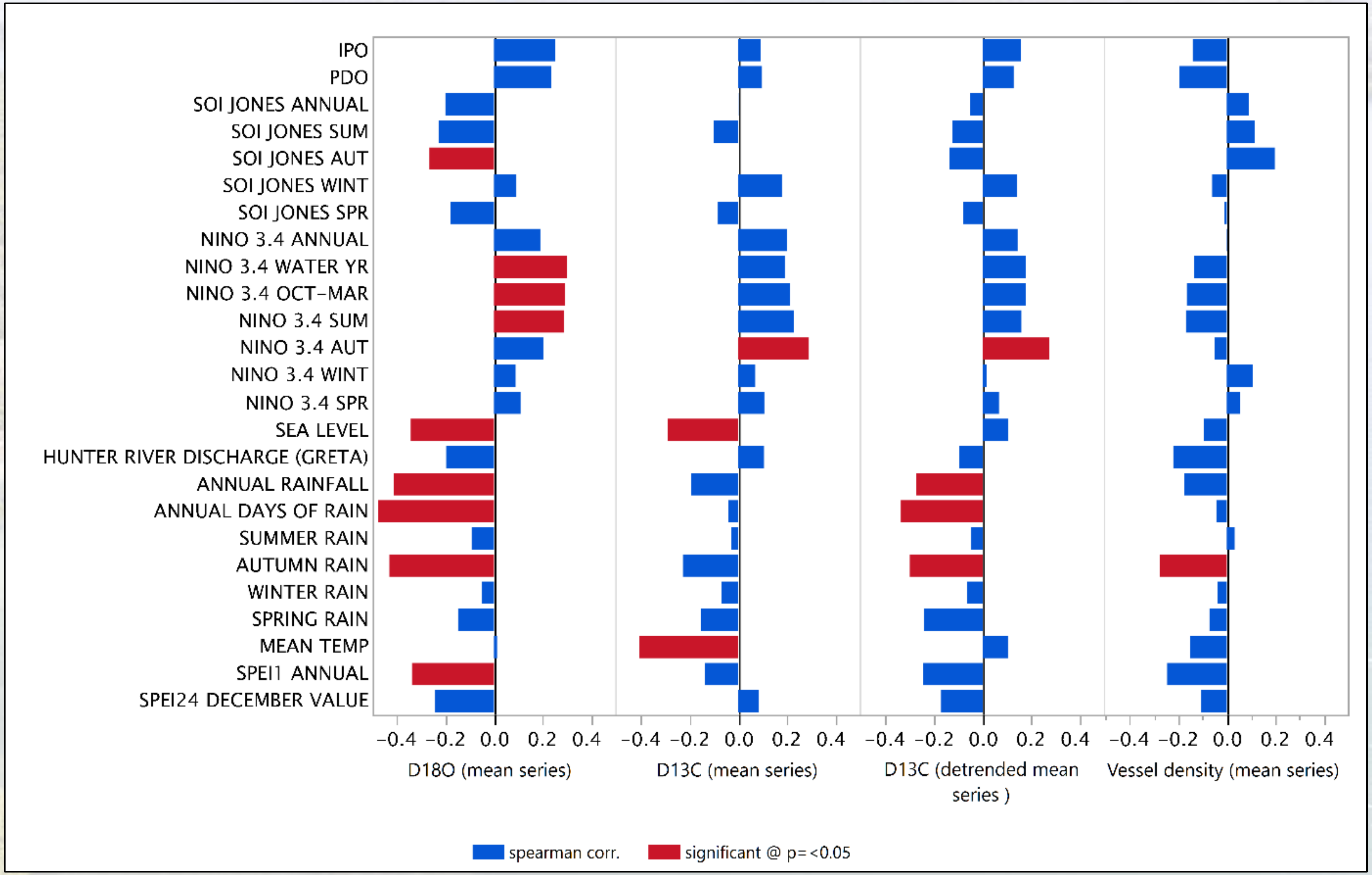


Results - Spearman correlation

Consistent significant correlations with multiple ENSO indices, sea level and rainfall…

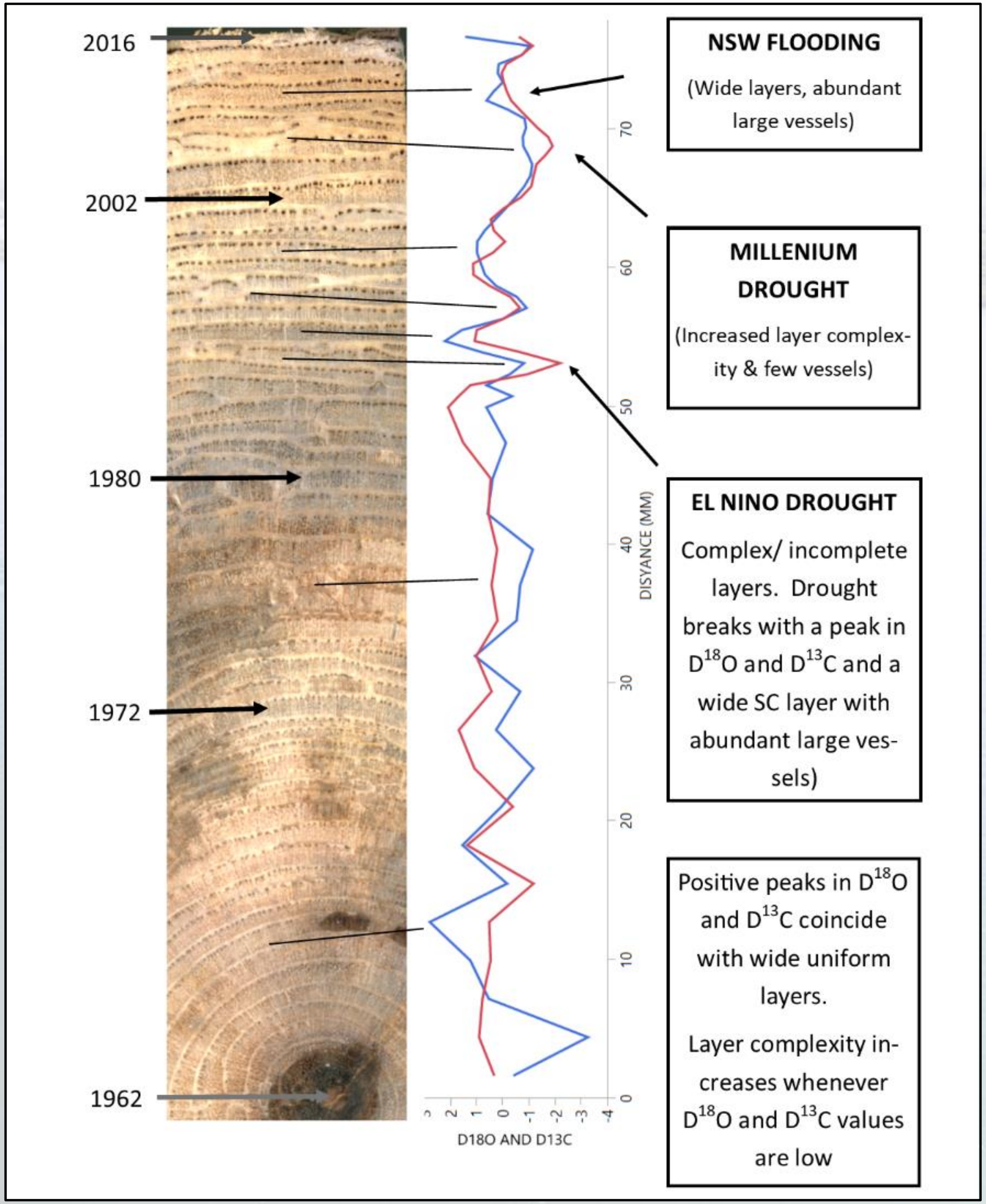
IPO & PDO – low frequency variability in pacific

SOI & NINO 3.4 – measures of ENSO (separated by season)



Qualitative interpretation

- During periods of drought:
  - Growth layers become more complex and interconnected
  - Oxygen isotopes indicate that mangroves are relying primarily on sea water for their water needs
  - Carbon isotopes indicate that photosynthetic productivity is reduced and water use efficiency is increased



Significance

- Grey mangroves hold significant potential for climate reconstruction
  - Potentially contribute to addressing the lack of palaeoclimate data on the Australian East Coast
- Assessments of mangrove health no longer limited to direct observations at singular points in time
  - Entire life history can be interpreted
- Can detect changes to estuarine habitats, and impacts on mangroves
  - Saline / fresh water balance
  - Favourability of environmental conditions to mangrove growth

…a powerful tool with many potential applications in climate, coastal and estuarine research

Thanks!

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