# Holocene climate variability in south-eastern Australia

## Inferred from oxygen isotopes in sedimentary cellulose at Lake Surprise, Victoria

Photo: Asika Dharmarathna

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# Research aims

- **Question: What is the long term context for recent hydroclimate variability?**

- Develop a well-dated, high resolution Holocene climate record using stable isotopes in lake sediments

- Validate sediment proxy data with recent climate data to test the paleoclimate interpretations

- Develop isotope hydrological models to understand the modern lake hydrology

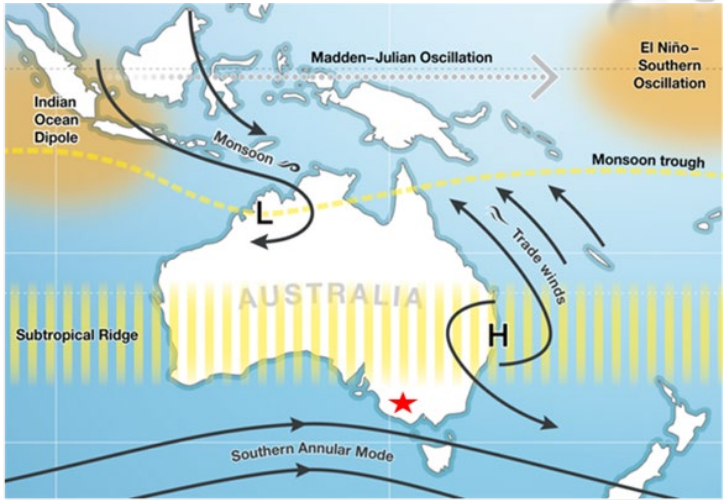



Fig 1: Map showing the climate drivers surrounding Australia and the location of study site (Source: *Bureau of Meteorology)*

- Current data sets:
  - radionuclide and radiocarbon dating
  - **stable isotopes in cellulose**
  - stable isotopes in organic matter (C, N)
  - XRF and ITRAX elemental data
  - stable isotopes in water samples

# Study area – Lake Surprise

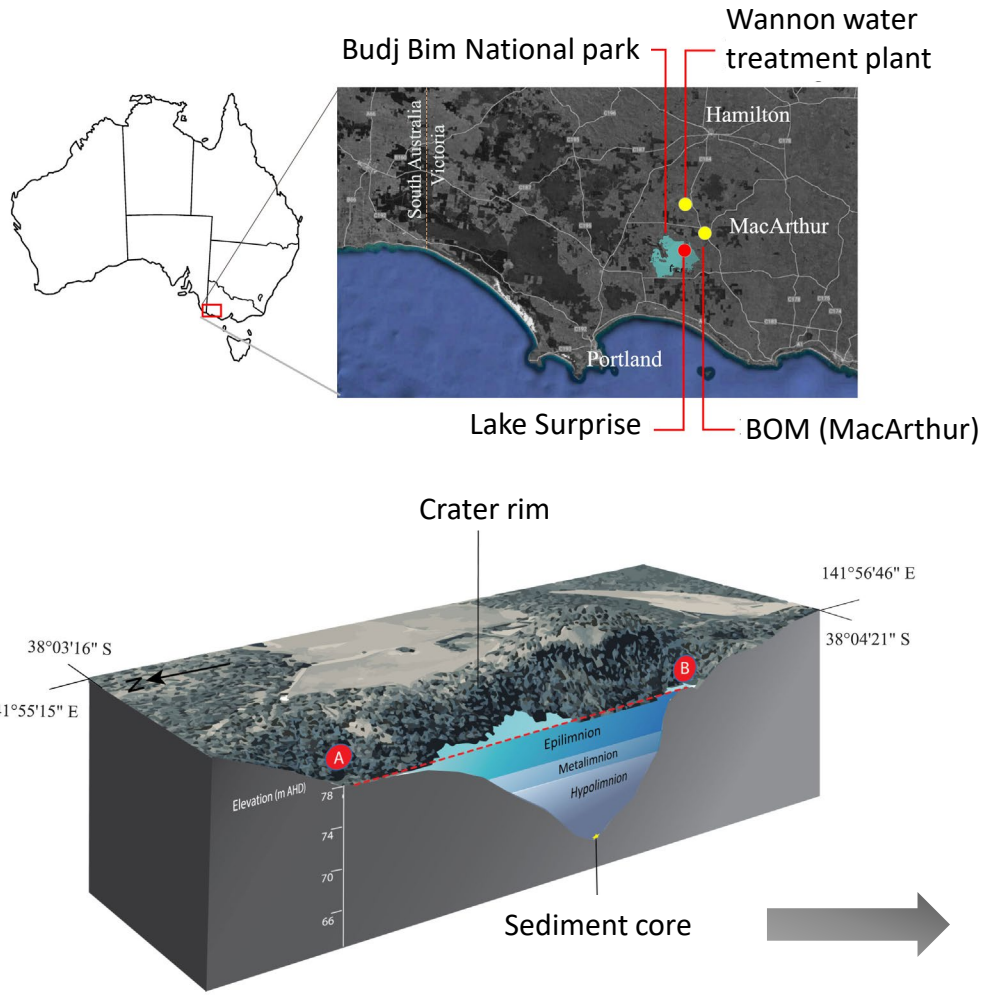



Fig 2: Location of Lake Surprise along with proximal rain gauge stations (top) and cross-section of the lake (bottom)

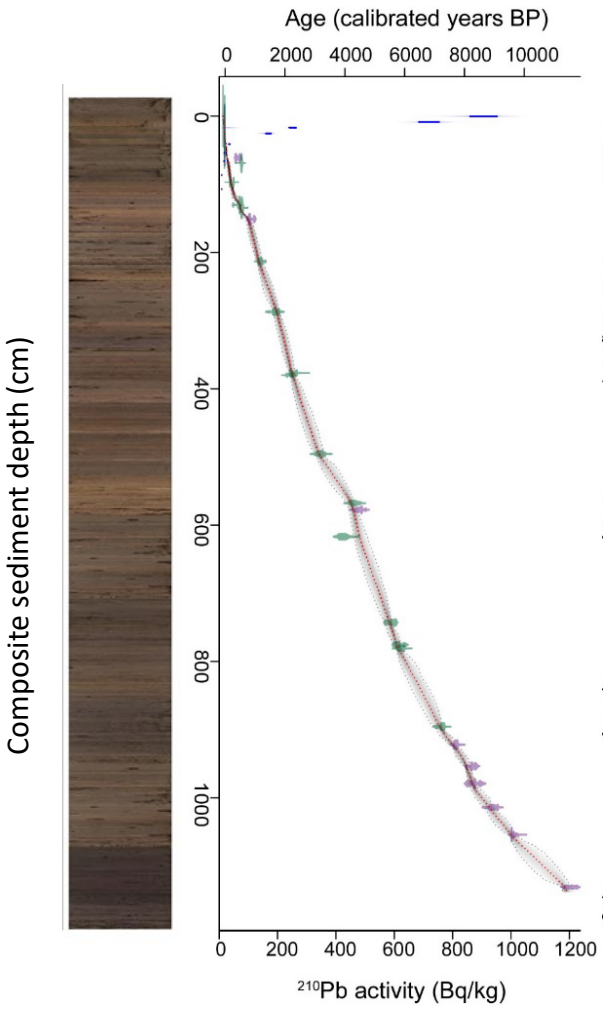



Fig 3: Sediment core and age-model developed using $^{210}$Pb, Pu and $^{14}$C dates

# Modern lake hydrology

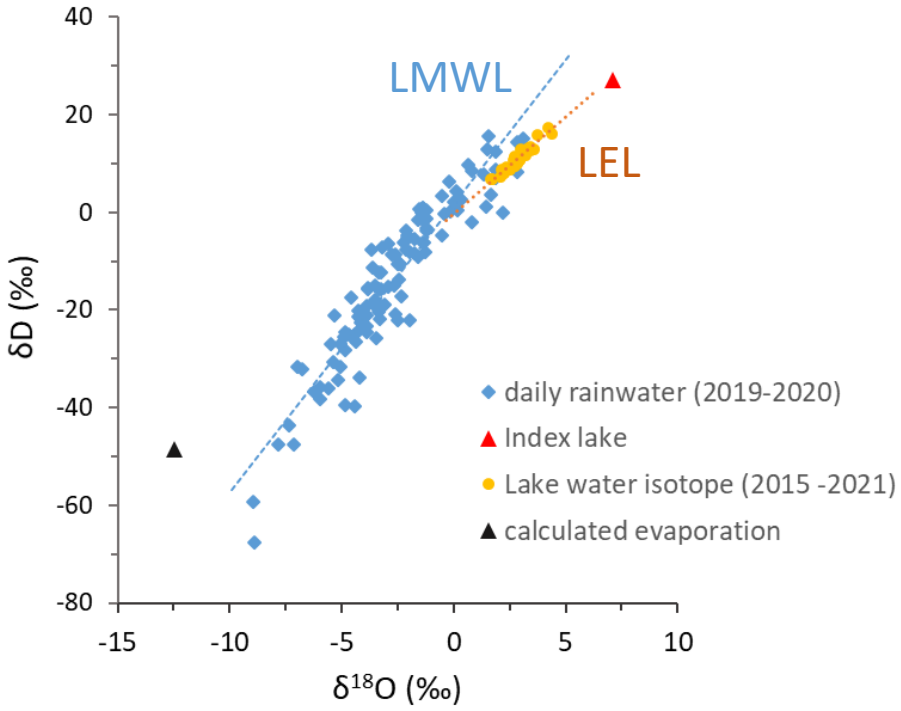



Fig. 4: Index-lake model approach for Lake Surprise (Lacey and Jones, 2018)

- Monitoring of rainwater and lake water variability at quarterly intervals
- Increase in $\delta^{18}O_{LW}$ values represent greater E/P ratio
- More positive $\delta^{18}O_{LW}$ = Dry periods
- More negative $\delta^{18}O_{LW}$ = Wet periods
- A possible ground water recharge into the lake
- Lake modelling–in progress

# Validating proxy data against recent climate data

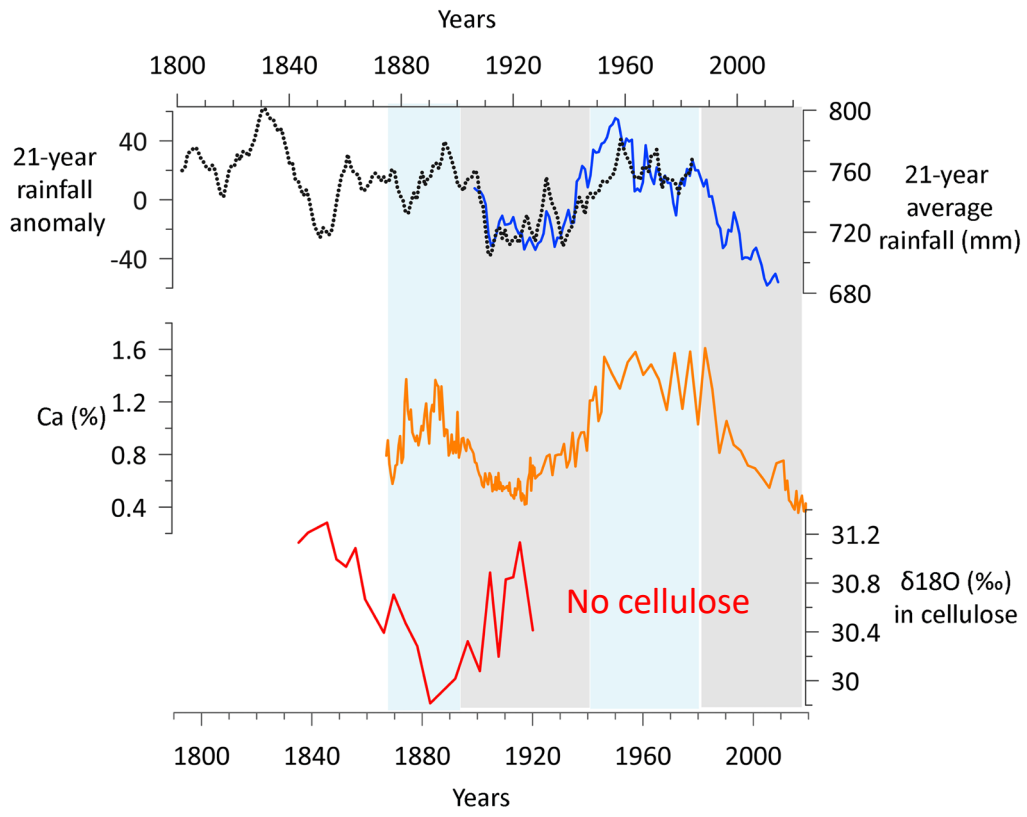



Fig. 5: Correlation of sediment proxy data against instrumental rainfall data from BOM (MacArthur) and reconstructed rainfall anomaly (Gergis et al. 2011)

- More depleted cellulose oxygen isotopes correlate with wetter periods
- Wet periods coincide with increased Ca%
- We hypothesize that wet climates lead to increased nutrient mobilisation and higher carbonate production

# Cellulose as a climate proxy

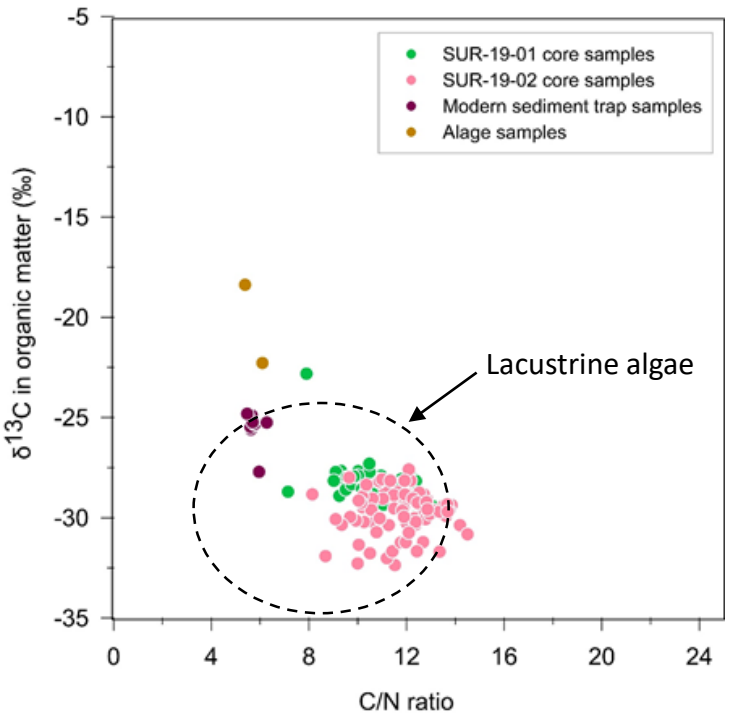



Fig. 5: Bi-plot of carbon isotopes and C/N ratio in lake sediments

- Used $\delta^{18}O_{cellulose}$ in sediments as a tracer of lake water isotope composition
- $\delta^{18}O_{LW} = 0.963\ \delta^{18}O_{Cell} - 27.2$ *(Rozanski et al. 2010)*
- 2 key assumptions -
  - Fine grained cellulose in lake sediments are dominantly aquatic in origin
  - Cellulose-water fractionation is constant and independent of temperature

# Cellulose inferred lake water isotope record ~ 11-0 ka

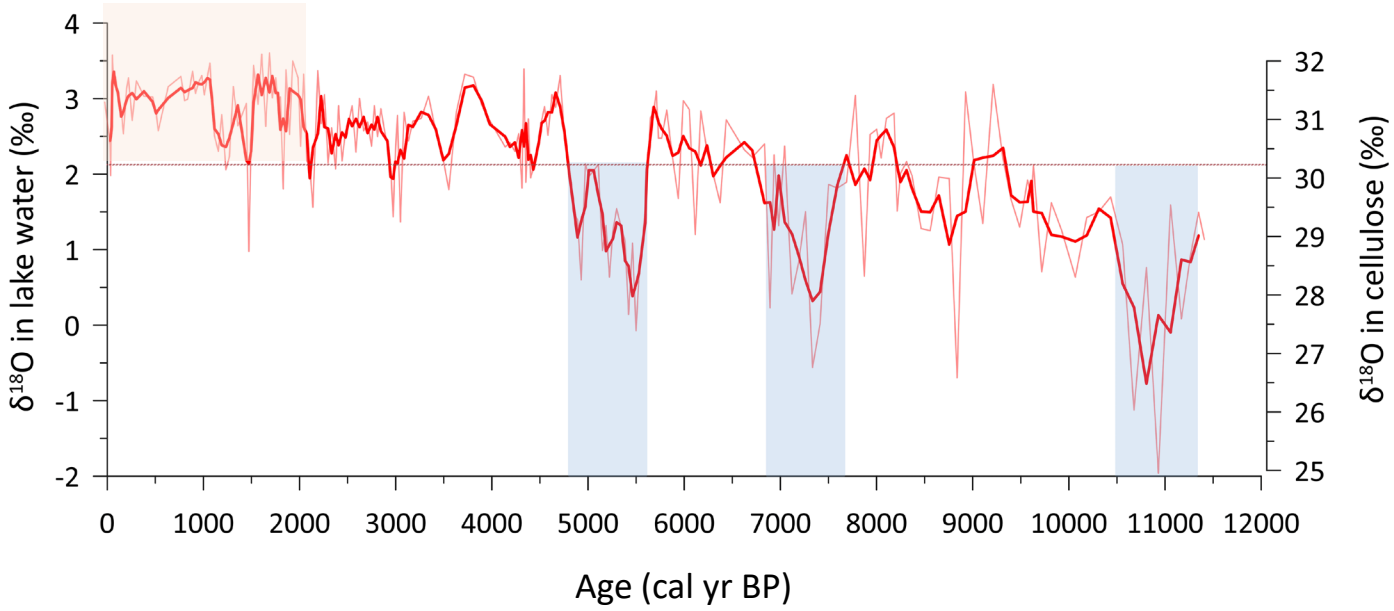



Fig. 6: Lake water oxygen isotope record developed for Lake Surprise through Holocene

- Early Holocene – 3 extreme wet phases,
  - ~11400 – 10600 cal yr BP
  - ~7800-7000 cal yr BP
  - ~5700 – 4900 cal yr BP

- Last two millennia marks the onset of extensive dryness in the Holocene

# Inorganic carbonate deposition through Holocene?

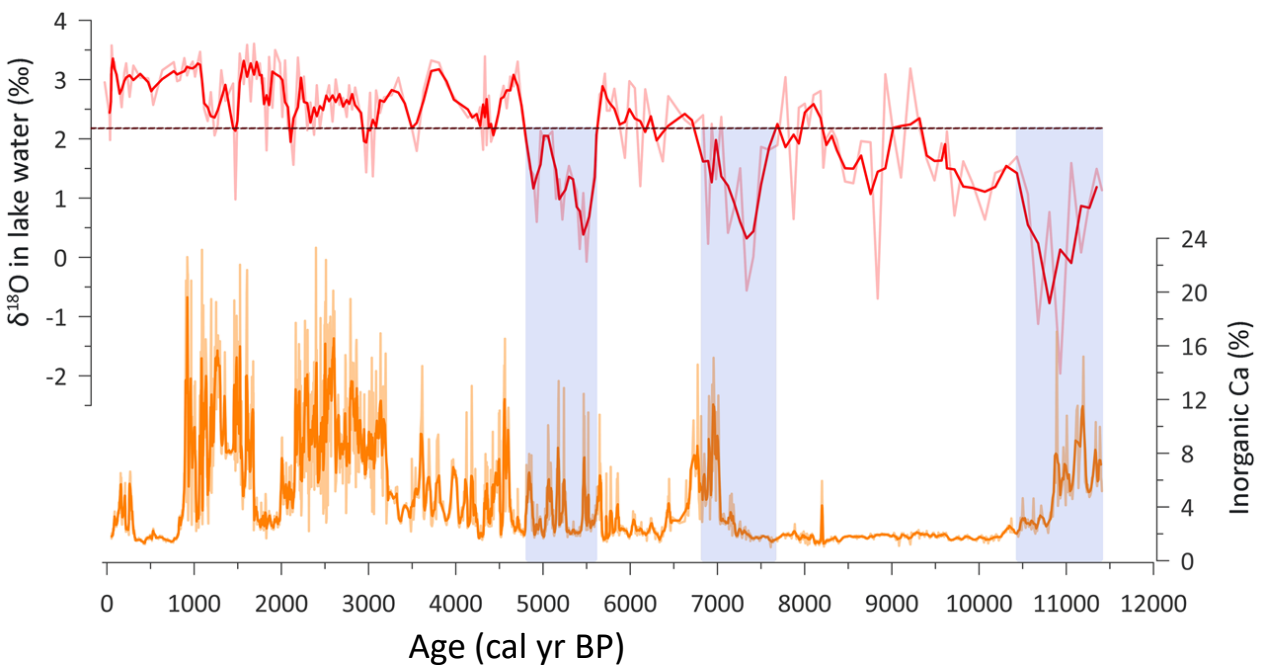
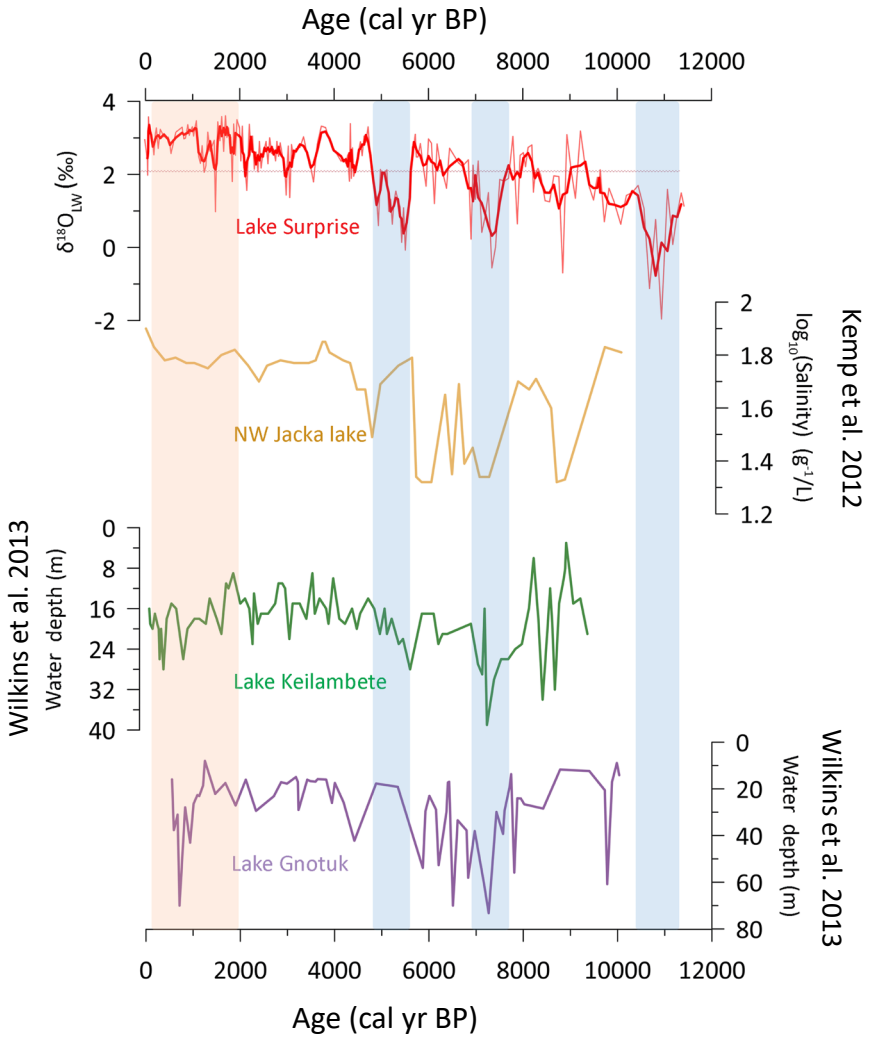



Fig. 7: Reconstructed lake water oxygen isotope record against inorganic Ca distribution through the Holocene

- Wet periods coincide with increased Ca%
- However, carbonate accumulation increases with lake level decline
- Assumption – increase in ground water input leads long-term Ca accumulation?

# Correlation with previous records



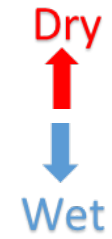




Fig 8: Correlation of Lake Surprise data with other Holocene records from Western Victoria

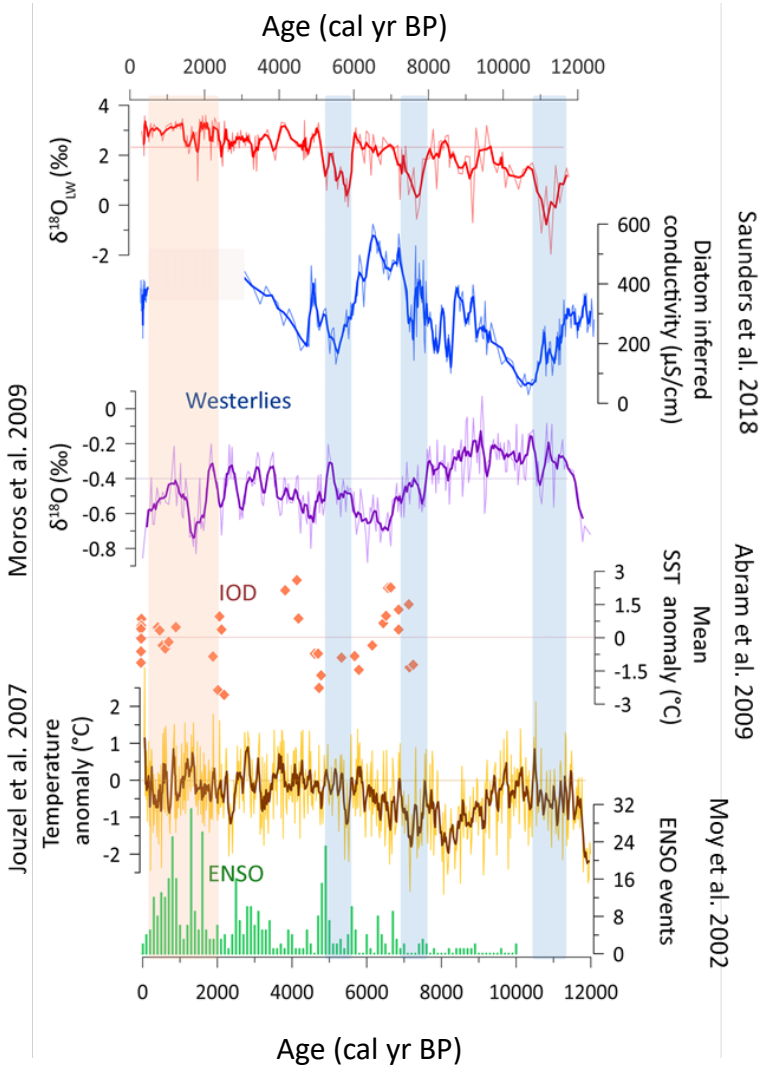



Fig 9: Correlation of Lake Surprise record with climate anomaly reconstructions

# Conclusions

- Lake Surprise record supports previous observations of a trend from wetter to drier climate in western Victoria during the Holocene
- Three distinct wetter periods existed in early-Holocene were not recognized in detail elsewhere in the region.
- Warming in Antarctica, weakening in westerlies and increase in the frequency of El-Nino events effect on long-term trajectory of drying in western Victoria
- Increasing carbonate deposition through the Holocene is consistent with a decrease in lake level and an increase in groundwater input. However, short term peaks in carbonate are correspond with relatively wet periods

# THANK YOU!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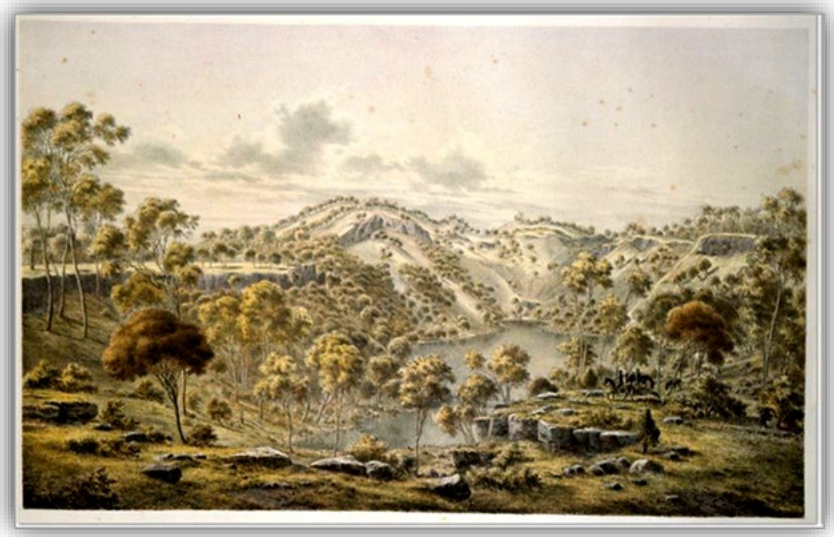

Fig. 10: Historical painting of **Crater of Mt Eccles with Lake Surprise** by the artist Von Guerard, Eugene 1811-1901 (Source: State Library of Victoria)