Background

- Relative humidity (RH): the percentage of water vapor in the air relative to the saturation state at the same temperature (T).
- The accurate reconstruction of past RH is needed to model the natural greenhouse effect and the global water cycle. However, Global Climate Models struggle to accurately reconstruct past continental RH.

Stable Oxygen Isotope Compositions of Plant Water and Phytoliths

- The degree of evaporation of plant water is inversely correlated to the RH.
- Oxygen isotope fractionation of plant water during transpiration:

  No isotopic fractionation during water uptake in non-transpiring tissues (like stems). Transpiring tissues (like leaves) have stomata that allow water to evaporate, and the untranspired water becomes increasingly enriched in heavy isotopes to the tips of leaves [1-3].

- Phytoliths: amorphous silica microparticle formed during the life cycle of a plant, which can be well preserved for thousands of years after deposition.

Results and Discussion

Late Growing Season RH Recorded in the $^{17}$O-excess of Leaf Phytoliths

- $^{17}$O-excess of leaf phytoliths has a stronger relationship with the late growing season RH compared to the whole growing season RH, which is consistent with the theory that most phytoliths precipitate when the plant reaches maturity [3].
- The stronger relationship with the RH calculated by $\Delta^{17}$Oleaf-stem phytolith suggests that the daily average RH data collected might not precisely represent the humidity conditions surrounding the grass leaves involved in transpiration.
- The growth chambers calibration line [5, 8] lies in the middle of the relationships between daily minimum and daily average RH with $^{17}$O-excess of leaf phytoliths, which is consistent with the theory that $^{17}$O-excess of leaf phytoliths tends to represent daytime RH instead of whole day RH [9].

17$^O$-excess of Stem Phytoliths across North America

- The $^{17}$O-excess of stem phytoliths does not show any trend with RH, and the standard deviation of all $^{17}$O-excess_stem phytolith is $\pm 17$ per meg (close to the measurement precision of $\pm 15$ per meg).

- The relationships of RH vs. $^{17}$O-excess_leaf phytolith is similar to RH vs. $^{17}$O-excess_leaf phytolith.
- The soil water evaporation and the variation of precipitation composition are negligible compared to the extent of leaf water evaporation in North America.

Monthly $^{17}$O-excess of Stem Phytoliths, Soil Water, and Precipitation

- The closeness of monthly $^{17}$O-excess of weighted average soil water and precipitation shows soil water evaporation is negligible in temperate climate over the growing season.

- $^{17}$O-excess of green stem phytoliths recorded monthly precipitation variation /weighted average soil water variation without evaporation.

Conclusions

- In natural climates in North America, the $^{17}$O-excess of leaf phytoliths is a good proxy for regional late-growing season RH.
- Soil water evaporation is negligible, and variation of precipitation composition does not affect the relationship of $^{17}$O-excess of leaf phytoliths and RH in North America.