Outline

Intro

Season of pedogenic carbonate precipitation affects their carbon and oxygen isotope values and thus what climate information they encode for paleoclimate reconstruction. Both annual and seasonal climate information can be reflected in pedogenic carbonate isotope values associated with different surface processes. Annual precipitation can be stored in soils and plant fractionation is affected by yearly precipitation, while respiration and evaporation rates are specific to the season of pedogenic carbonate formation. We assume pedogenic carbonate formation takes place over a 3-month season (DJF, MAM, JJA, SON), hereby referred to as the pedogenic carbonate quarter (PCQ). We create a mechanistic model connecting carbon and oxygen isotope values of pedogenic carbonate to both seasonal and annual climatic drivers. This model is highly variable in its accuracy of predicting modern soil carbonate carbon and oxygen isotope values, based on modern global climate grids. We explore the effectiveness of the model with different model assumptions and its implications for the timing and mechanisms of pedogenic carbonate formation.

Discussion

Warm vs. Dry Quarter as the PCQ

We ran the mechanistic model assuming the PCQ is the driest and warmest quarter of the year, based on global climate grid data. Comparing the predicted vs. measured carbonate carbon isotope values for the warm quarter as the PCQ reveals that using this quarter as the PCQ systematically underestimates carbon isotope values, which infers that the model is overestimating respiration rates if this is the “real” PCQ. Using the dry quarter as the PCQ yields carbon isotope values that are more normally distributed around the 1:1 line, with lower temperatures yielding lower respiration rates in the model. Predicted oxygen isotope values of pedogenic carbonate in the warm quarter reveal roughly normally distributed data around the 1:1 line, while using the dry quarter of precipitation reveals systematically lower values for predicted oxygen isotope values compared to the measured values. This arises from the lower formation temperature of pedogenic carbonate, driving fractionation more and getting more negative values. Selecting only the arid to sub-humid sites that would normally precipitate carbonate to create the modeled respiration rate regression reveals that lower MAP sites have a higher respiration sensitivity to precipitation than higher MAP sites.

Evaporative and Seasonal Effects on Oxygen Isotope Values

When the model considers evaporative effects and seasonal bias in precipitation as free variables, the lowest variance in residuals of the predicted values is when these effects are non-existent. This could suggest that evaporative and seasonal bias in precipitation is less important and does not affect most pedogenic carbonate oxygen isotope values. Thus, we propose that annual precipitation oxygen isotope value estimates without accounting for evaporative effects is the best way to estimate oxygen isotope values of pedogenic carbonate in most cases.

CO2 degassing as a mechanism of pedogenic carbonate formation

Both the previous section, noting the lack of evaporative effects on oxygen isotope values of pedogenic carbonates, and the observation that respiration rates seem to be consistently low during pedogenic carbonate formation, lead us to believe that CO2 degassing could be the dominant mechanism of pedogenic carbonate precipitation.