How Modern Variability in Fluvial $\delta^{13}C_{DIC}$ May Impact Fundamental Assumptions in Carbon Isotope Stratigraphy and Neoproterozoic Carbon Cycling Interpretations

Olivia Wren and Jon Husson
School of Earth and Ocean Sciences, University of Victoria, British Columbia, Canada
University of Victoria

Background:

- The Neoproterozoic carbon isotope record is characterized by large variations in $\delta^{13}C$ values measured from carbonate rocks ($\delta^{13}C_{carb}$), ranging from +10‰ to -15‰.[1] The origin of this variability cannot be easily explained by the traditional steady state carbon cycle model (Figure 1), which is often used to interpret such records.
- Neoproterozoic carbonates are shallow-water carbonates (i.e., deposited on continental crust).
    - Such carbonates often form in marginal marine and mixed carbonate-siliciclastic systems, where water column DIC values may be more sensitive to local river input.[2]

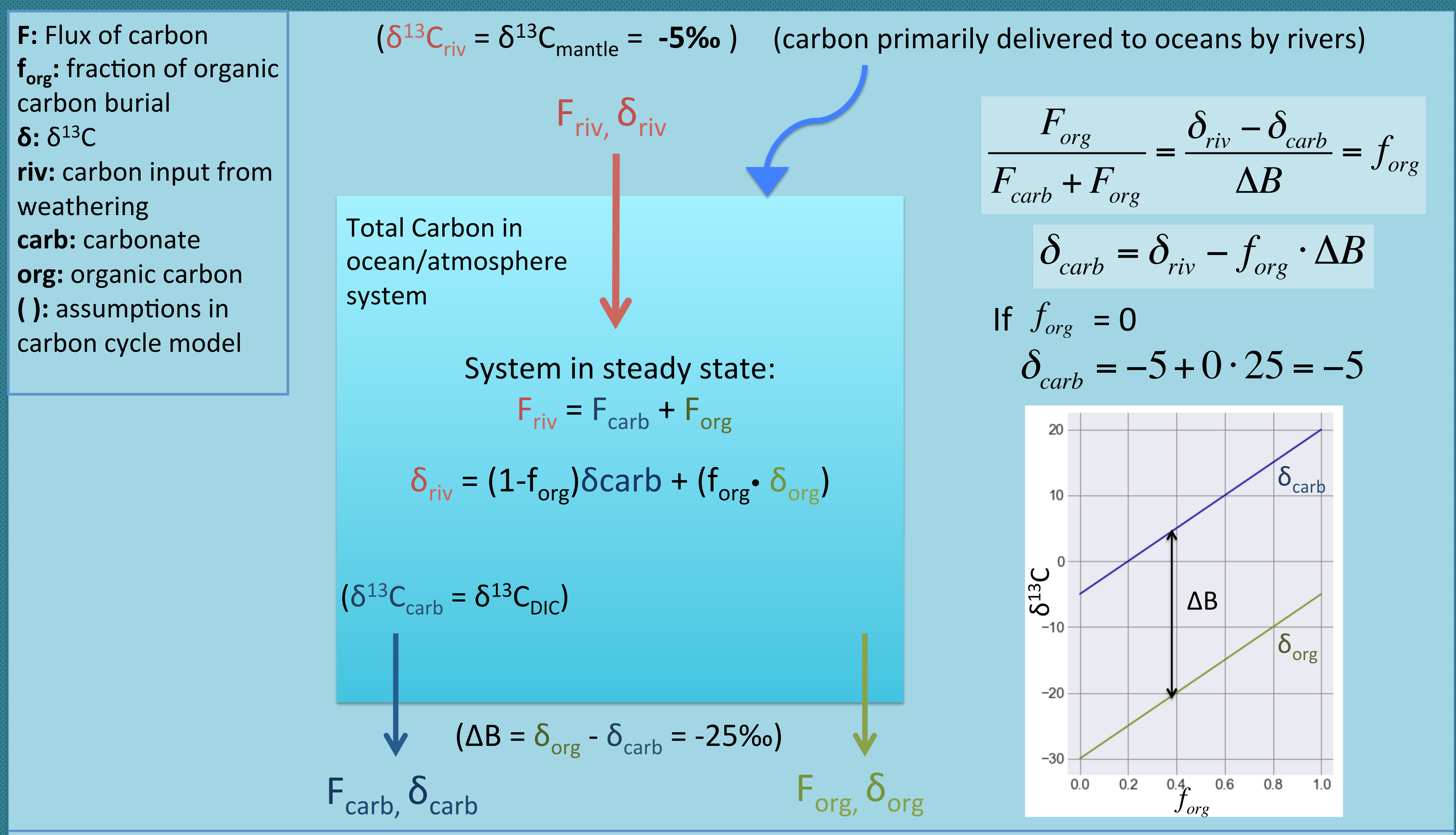

Figure 1: Traditional carbon mass balance model, with its assumptions and equations (ref. 3)

Objectives/Hypotheses:

- Objectives:
    - Quantify the variability of modern $\delta^{13}C_{DIC}$ values in rivers and describe the dominant controls on the observed variability
- Hypotheses:
    - Where river basin lithology is carbonate dominated and or where Ca concentrations in river waters are high, associated $\delta^{13}C_{DIC}$ measurements will be heavier than $\delta^{13}C_{atmospheric\ CO2}$[4]
    - Where river basin lithology is siliciclastic dominated, associated $\delta^{13}C_{DIC}$ measurements will be lighter than $\delta^{13}C_{atmospheric\ CO2}$[4]

Methods:

- Data mining for papers useful to this study using GeoDeepDive (https://geodeepdive.org/)
- Data compilation of $\delta^{13}C_{DIC}$ and other relevant river chemical data including DIC, alkalinity, Ca concentrations, and river discharge rates from 135 papers
- Data analysis using Python
- Bedrock geology maps made using QGIS and Macrostrat[5]
- Full bibliographic metadata for 135 papers is available via GDD

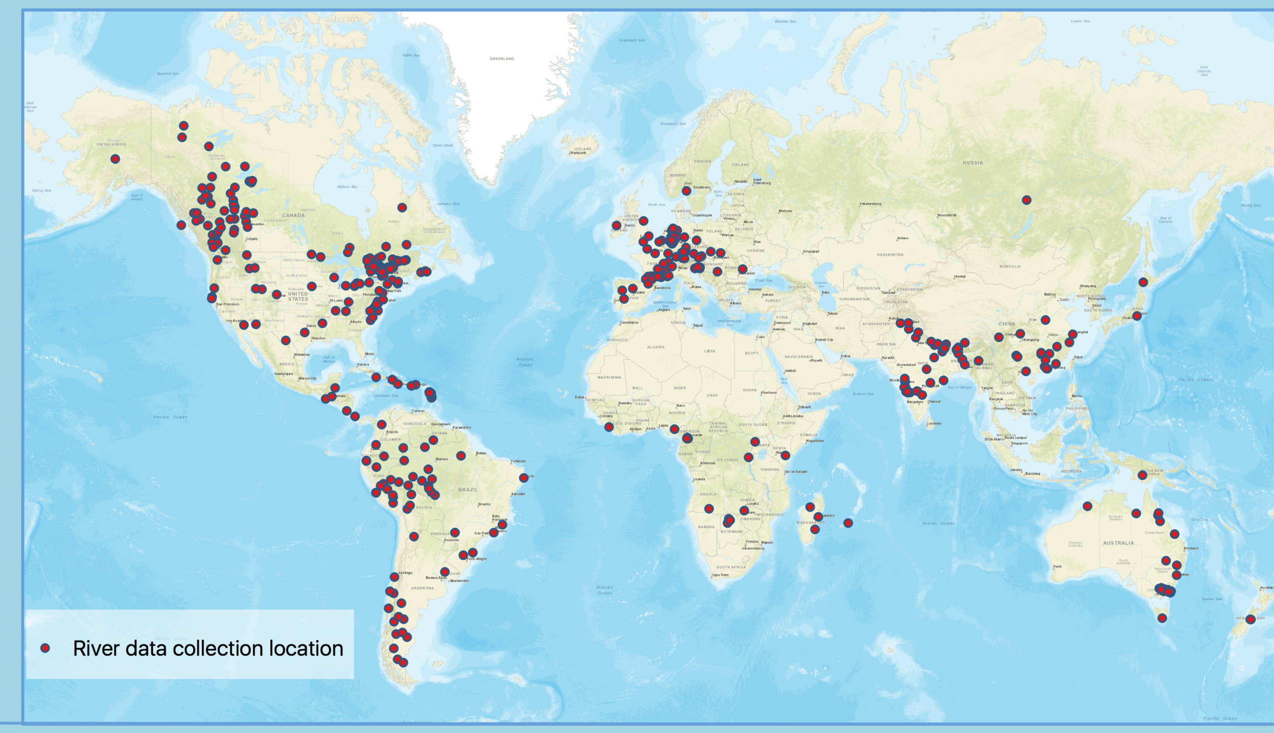

Figure 2: World map showing river data collection locations used in this study

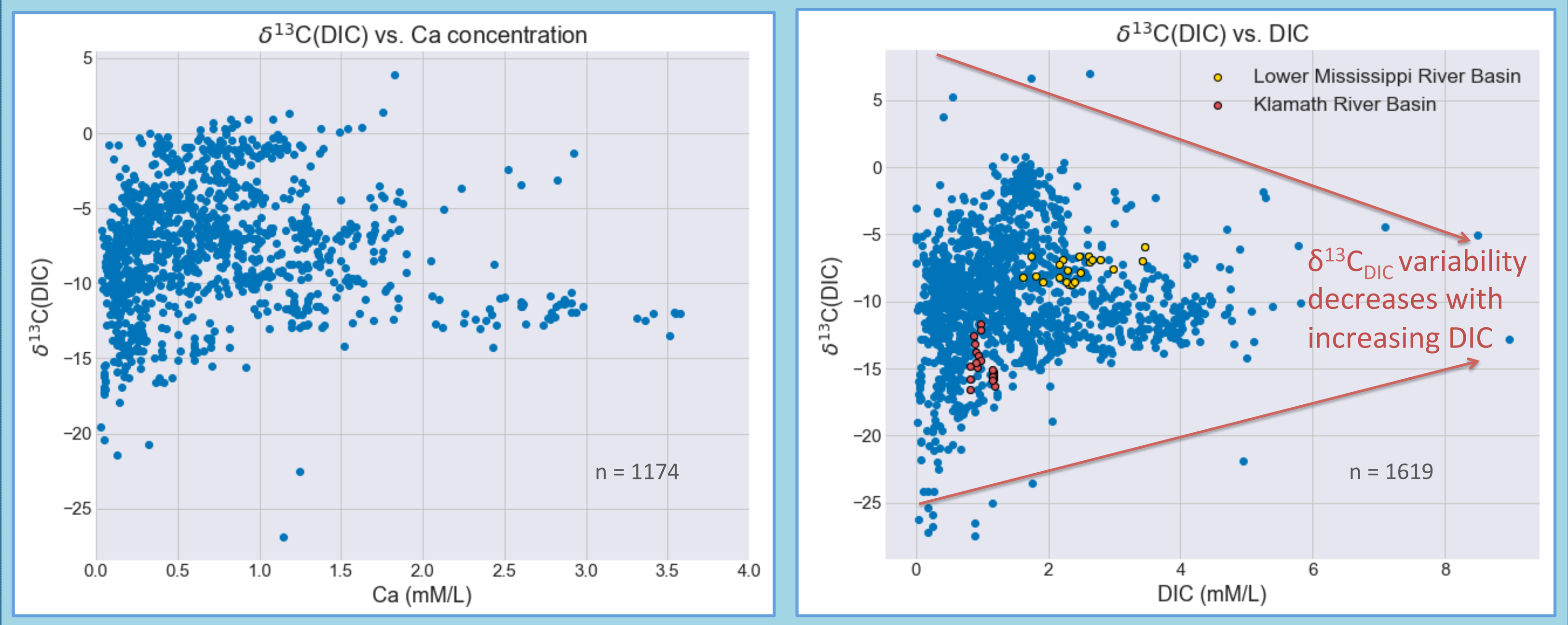

Figure 3: $\delta^{13}C_{DIC}$ plotted against associated calcium concentrations and DIC concentrations

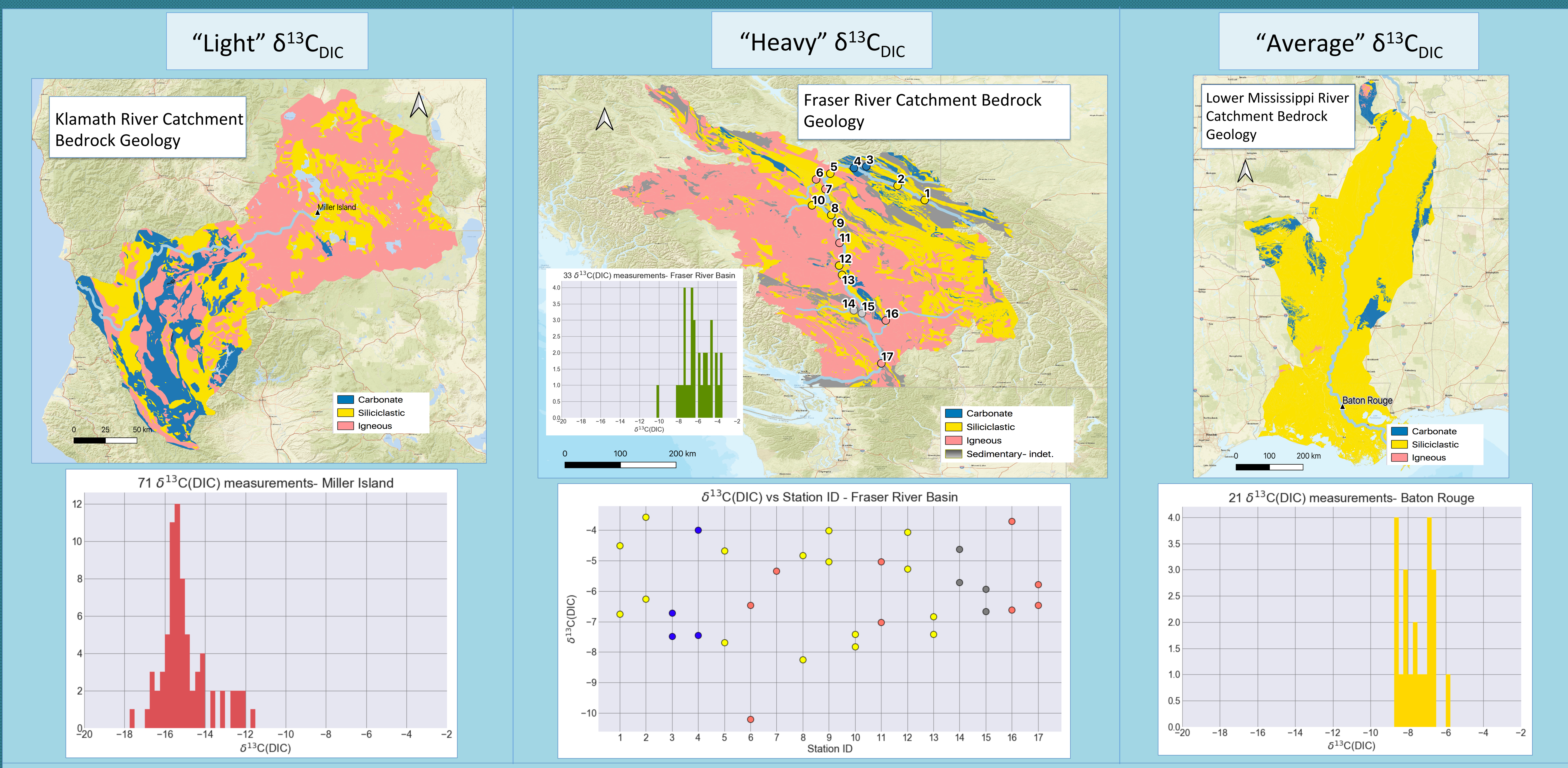

Figure 4: Examples of three different river catchments with isotopically heavy[6,7], light[8,9], and average[10,7] $\delta^{13}C_{DIC}$ values (compared to total distribution) and their bedrock geology

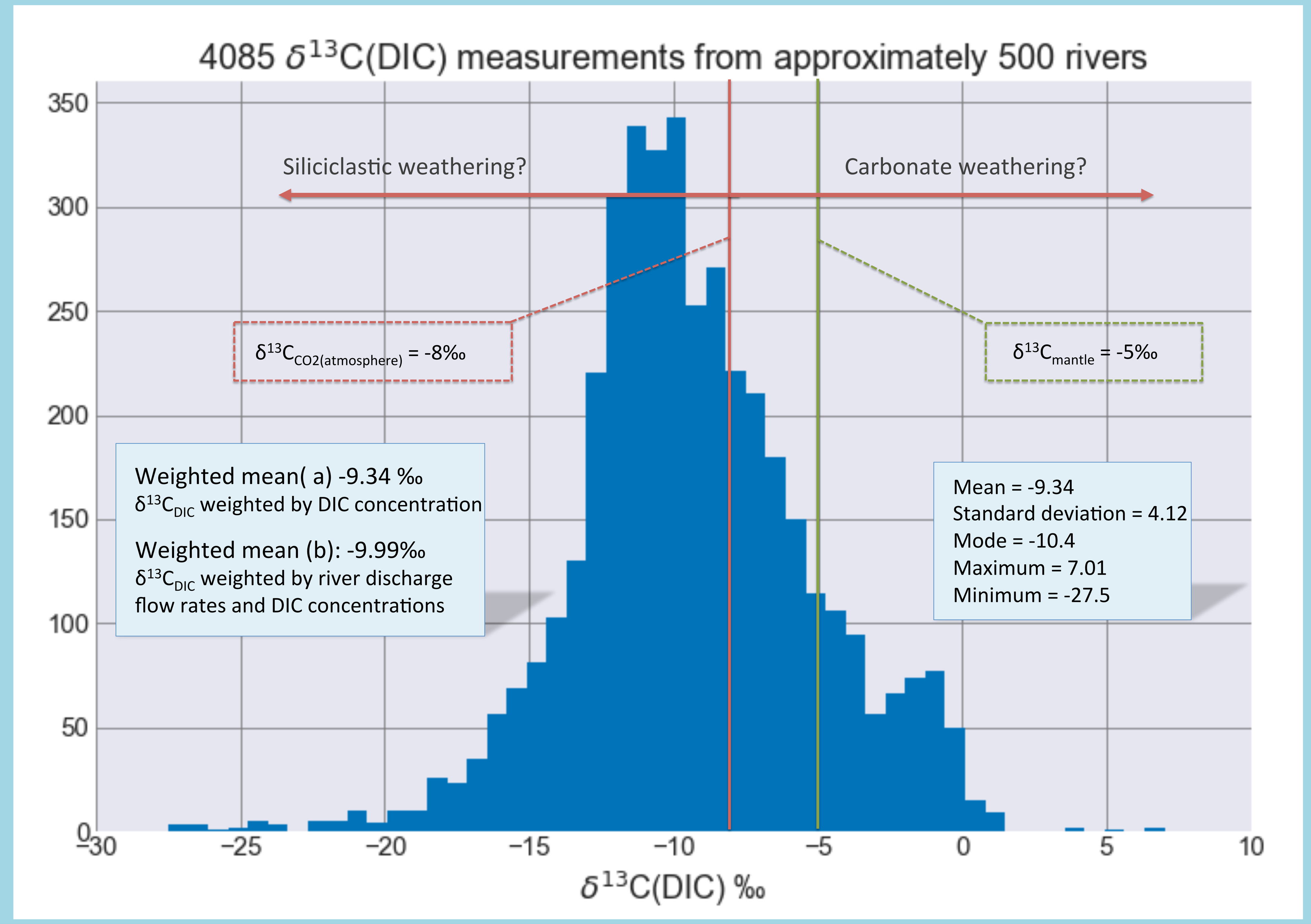

Figure 5: $\delta^{13}C_{DIC}$ histogram with statistics, calculations, and annotations to visualize hypotheses in this study

Conclusions:

- The weighted mean from this study is lighter than the assumed riverine $\delta^{13}C$ input in the classic carbon cycle model by 4‰
- Variability in $\delta^{13}C_{DIC}$ tends to decrease with increasing DIC concentrations
- Ca concentrations do not appear to have any significant affect on $\delta^{13}C_{DIC}$ values
- "Light" $\delta^{13}C_{DIC}$ values recorded from the Klamath river may be linked to siliciclastic/igneous dominated bedrock lithology upstream of the sampling site
- Bedrock lithology does not appear to be the dominant variable controlling $\delta^{13}C_{DIC}$ in the Fraser and Lower Mississippi rivers
- Variables affecting $\delta^{13}C_{DIC}$ in river water is too complex to test using only these methods

Future Directions:

- Constrain lithology map to a smaller area upstream of the sampling site(s)
- Break down lithology further (shale vs. sandstone)
- Describe river catchment bedrock lithology quantitatively (% Carbonate, % Igneous…)

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