Review of *Erosion and weathering in carbonate regions reveals climatic and tectonic drivers of carbonate landscape evolution* submitted to EGUsphere

I found this paper to be a clearly written and illustrated compilation of chemical weathering and denudation rates in carbonate landscapes. The data compilation and analysis is timely, and the interesting discussion is clearly relevant to understanding landscape evolution under different tectonic and climate boundary conditions. Overall, the manuscript is in a great shape, and I only have a few comments that I suggest to consider before publication.

Calculation of weathering rate

It would help me if you could state explicitly (i.e. with equations) how you convert concentrations into "weathering rates" in mm/yr and how you interpret these rates. I presume that you need a density to get a quantity in mm/yr? Did you use densities of just Mg and Ca, or did you consider some form of calcite/dolomite?

On a minor note: To me, a denudation rate (in L T^{-1}) is an average/effective rate of surface lowering. Does the weathering rate here (in L T^{-1}) have an equivalent interpretation as a surface lowering rate? Typically, dissolution (or weathering) rates on the mineral scale are defined as a change in concentration per time (Mol L^{-3} T^{-1}). On the landscape scale, the term "weathering rate" is inconsistently used in the literature. In general, multiplying concentrations by runoff yields a weathering flux (in the sense of a flow of mass per unit area per unit time). Comparing denudation and weathering fluxes (in M L^{-2} T^{-1}) would be more intuitive for me – but either one works, as long as the calculations are clear.

Comparison of weathering and denudation rates

Not all study areas yield measurements of both bedrock and catchment-averaged denudation rates. I don't think it should be a big issue, but in case there were some biases in climate, lithology or tectonic regimes toward the Mediterranean samples with respect to the other samples, it could affect the distributions of the relative rates. Could you state, how much the relative distributions in Fig 2 would change if only those datasets were considered that have all data constrained?

Discussion of weathering limits

As far as I understand, the authors suggest that silicate weathering is sensitive to physical erosion (L250) in contrast to carbonate weathering that is limited by climate (L209). This seems a bit simplified and perhaps misleading. Increasingly, models and data suggest that silicate weathering fluxes – at least on the scale of mountain catchments – are often not sensitive to denudation and become limited by climate at relatively moderate denudation rates of 10^{-2} – 10^{-1} mm/y (Bufe et al., 2022; Bufe et al., 2021; Gabet and Mudd, 2009; Hilley et al., 2010; West, 2012; West et al., 2005). In turn, where carbonates are a minor component of the rocks and waters remain undersaturated with respect to carbonates, they can be sensitive to denudation, even at very high denudation rates (Bufe et al., 2022; Erlanger et al., 2021). Even where waters are saturated with respect to carbonate, they can be indirectly limited by denudation if denudation increases the acid supply (Bufe et al., 2021; Hilton and West, 2020). I do not think that a detailed discussion of weathering limits is necessarily needed for the paper, but I would like to caution against simplifying the discussion to silicate weathering = denudation sensitive and carbonate weathering = climate sensitive.

Bedrock versus catchment scale

In conclusion 1, the authors suggest that weathering is dominant on the bedrock scale – because bedrock denudation rates mirror weathering rates. Perhaps I missed some information in the manuscript, but I do not follow. As far as I understand, there is data on (1) denudation on bedrock and catchment scales and (2) weathering on the catchment scale. The contrast between denudation rates on bedrock and catchment scales was assigned to different erosion processes on these spatial scales (e.g. mass movements). Is it therefore possible to compare weathering on the catchment scale to denudation on the bedrock scale? Perhaps, weathering on the bedrock scale is also slower than on the catchment scale – or maybe it is even higher. I am not sure if these rates can be directly compared – or perhaps I missed some discussion of this in the manuscript?

Line comments

SI: Not all data table entries have units – and not all missing units are obvious. Would be great if fixed.

L13: “Their” in this sentence refers to “carbonate-dominated landscapes” as far as I understand. What is meant by “their climate sensitivity”. Vegetation, denudation, weathering, or other parameters could all be climate sensitive in the landscape.

L17: Which discrepancy is “This” referring to? Discrepancy between bedrock denudation versus catchment denudation or discrepancy between catchment denudation and catchment weathering?

L19: I do not follow how a lower discrepancy between weathering and denudation makes denudation more spatially uniform? In other words – how does a difference between two rates bear implications for the spatial distribution of these rates?

L32: To me, the word “which” seems to refer to erosion – but it should be denudation?

L65: At the beginning of the methods, it would be great to have an introductory sentence or two on the selected study areas. What range of denudation rates and climate do they span? Were all available ^{36}Cl areas included or were some measurements/study areas discarded? Perhaps most importantly, it would be great to have a sense of the range of lithologies. Are these all pure carbonate landscapes, or are there mixed-siliceous rocks. Are the carbonates all unmetamorphosed massive limestones, or are there marbles or more loosely consolidated detrital carbonate sediments etc. I do not mean to ask for a detailed review of all study areas, but a sentence or two to get a sense for the range of settings that you are looking at would be great.

L106ff: I do not quite understand the idea behind the role of recharge area. Could you explain that a bit more? Maybe it already helps if you spell out the way you calculate weathering rates (see above).

L174: I think it has to be “faster”.

L176: What do you mean by “finding increasing relief”? I do not follow the sentence well.

L194: Minor point – this start to the sentence seems to evoke that it is surprising to find differences in denudation and weathering or at least that there has to be a discussion of possible reasons. Given there is sediment in the rivers, it seems pretty clear to me that explanation (3) definitely has to apply. The question of whether some other biases could apply seems somewhat separate to me.

L224-225: From the figure, it looks like Ireland has the ration of 1.0 – not southern France as the text suggests.

L226: Do you mean to say “*carbonate* weathering rates are largely […]”, or do you mean to apply this to all weathering rates?

L231: What do you mean by “carbonates remain subdued” – do you mean something like relief in carbonate landscapes remains subdued?

L254: I think a citation to e.g. Bufe et al. (2021), Erlanger et al. (2021) or Knapp and Tipper (2022) would be more appropriate here. Inferring a limit to carbonate weathering in Bufe et al. (2022) was done in reference to our previous work. Note also that only Erlanger et al. (2021) look at more carbonate rich rocks. The other studies are global Knapp and Tipper (2022) or focused on siliceous rocks (Bufe et al., 2022; Bufe et al., 2021).

L268 – 270: “[…] studies […] show” needs a citation.

L271: Could add Lague (2014). Also, I got confused when I read “channel steepness – erosion rate relationships” because it doesn’t say which way around this is. Lague (2014) has values < 1, but I presume you mean $E=f(k_{sn})$ and not $k_{sn}=f(E)$. Could be worth specifying.

I hope that these comments are helpful and remain with best wishes to the author and the editor. Sincerely, Aaron Bufe

References

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