

Review- HYDROCLIMATE EVOLUTION ALONG CHILE OVER THE LAST 20,000 YEARS: INSIGHTS FROM LEAF-WAX HYDROGEN ISOTOPE RECORDS

General Comments:

I really liked reading this paper. The analyses are well thought out and compelling. I think this paper would benefit from a brief overview of the current biogeography/vegetation in the Study Area section. Most of my feedback is regarding the Discussion section and essentially boils down to 'describe the proxy evidence'. Throughout the discussion, the authors keep referencing proxy data, but there is no actual discussion of what that data is. I noted below that they do well with this in lines 556-560 (when they stated that the changes in sedimentology were what suggested the gradual drier conditions), they just need to do it throughout section 5.3. Finally, the paper begins with this idea that large scale climate features have local impacts, and I think the authors should return to that in the conclusion with some brief commentary about how this work is furthering our understanding of local climate, which could have implications on local populations in the future. I also make a few notes about a few minor changes that could be made for the figures.

Specific comments:

0. ABSTRACT

- a. Antarctic cold reversal – consider adding a date to this, just for consistency with the rest of the abstract where you do include dates
- b. The abstract is pretty wordy, you could consider rephrasing to something like “We present a leaf-wax reconstruction which reveals distinct dry and wet phases and imply that the drivers of these phases are periodic migrations of the sww belt. From 17-11.5ka, these migrations appear to be tied to changes in the interhemispheric temperature gradient and subsequent changes in Hadley circulation, while the migrations in the Holocene (11.5ka-present) appear to be predominantly controlled by ENSO and insolation.”

1. INTRODUCTION

- a. Intro sentence sets this up to be 'large scale climate features have local impacts', how does your first example impact local climate
 - i. Consider adding some mention of how shifts in the sww belt impact the westerly storm track, winter rainfall, etc.
- b. Line 49-50: previous sentence says the issue is the lack of high-res reconstructions, so I'd modify this sentence to be “Here we aim... by generating several high-resolution hydroclimate records.”

- c. Line 65: “drier conditions were inferred” → inferred from what kind of record?
- d. Lines 67-69: same thing as above, what kind of evidence or records support those inferences? Paleobotanical? Geochemical?
- e. Overall, I think the intro is good, but it does read as a little bit scattered, the purpose of each paragraph could be more clearly defined
 - i. Paragraph 1: large scale systems impact local climate, here’s examples of large scale features and how they impact local climate in modern, we don’t know about the past
 - ii. paragraph 2: previous studies lack resolution of sww belt to clearly elucidate how large scale impacts small scale in the past, we want to do that using sediment from west coast of south america
 - iii. paragraph 3: here’s why the study region is ideal for this
 - iv. paragraph 4: here’s the tool we’re using for this

2. STUDY AREA

a. GEOLOGICAL SETTING AND SITE SELECTION

- i. Line 113: I would just add the word leaf-wax here. (“use it to calibrate the leaf-wax signal recorded in marine archives.”)
- ii. Also, what do you mean by calibrate? Is there an actual mathematical calibration you’re using or do you mean that you’re using the Gaviria-Lugo record to aid your interpretation of the paleorecord?
- iii. See my note about Figure 1 below
- iv. Is there any potential for aeolian deposition of waxes into the sediment, or do the local wind patterns not facilitate this?

b. CLIMATE FEATURES AND TEMPORAL PATTERNS ALONG THE WEST COAST OF SOUTH AMERICA

- i. I really like this section, I think it is well written and describes regional climate very well, however I do think it could use a description of the overall biogeography of Chile. What biomes are present, what’s the dominant vegetation of each biome, etc.
- ii. A brief discussion of the modern dD isoscape would be useful. Is winter rainfall more deuterium depleted here, like it is in the winter rainfall zone of Southern Africa? It’s shown in Fig 2, but it would be nice to have a sentence or two describing the isoscape in the main text as well. Is the predominant rainfall type stratiform or convective? Also what is the average rainfall amount here? What is the predominant driver of the isotopic signal of modern rainfall? Is it rainfall character (stratiform vs convective), is it rainfall amount, vapor

source, all the above? Also, do those dD values change during ENSO or SASM?

1. →Ok, just read further into section 3.6 and see you do address this. So maybe here just include average rainfall amounts in the source area for each site, whether there's a lot of seasonality, and just mention that the controls on rainfall dD will be evaluated in section 5.2?

3. METHODS

a. SAMPLING STRATEGY

- i. No feedback

b. RADIOCARBON AGE-DEPTH MODELS

- i. Line 226: what do you mean by you 'preferred' the previously published ages?

c. LIPID EXTRACTION AND N-ALKANE ABUNDANCES

- i. Did you calculate Chain-length Preference Index in addition to ACL?

d. HYDROGEN AND CARBON ISOTOPIC ANALYSES

- i. Why did you choose not to apply a vegetation correction to the dD record? I think skipping the correction is the right move here, especially considering the likely presence of CAM plants, but I think that it's also important to maybe have a sentence just saying "we didn't do this because..."

e. STATISTICAL METHODS

- i. No feedback, though I feel like this section could reasonably be moved to the SI if you need extra room for words. Not sure how strict *Climates of the Past* is with word-count (honestly, same with much of your methods, you could reasonably move the more detailed descriptions to the SI and just give a brief overview of each section if you need the space).

f. GIS METHODS

- i. No feedback

4. RESULTS

a. AGE-DEPTH MODELS

- i. No feedback

b. BIOMARKER ANALYSES

i. AVERAGE CHAIN LENGTHS AND ABUNDANCES OF N-ALKANES

1. Can you also list CPI just to verify that the hydrocarbons you are measuring are indeed terrestrial in nature and not petrogenic?

ii. LEAF-WAX N-ALKANE HYDROGEN ISOTOPE RATIOS OF THE MARINE SITES

1. Line 354-356: This sentence doesn't make sense as written, consider rewriting to something like "Although the n-C29 alkane record closely resembles the n-C31 record (see SI fig), we utilize the n-C31 record for further analyses, as it can be directly compared to the n-C31 record of Kaiser et al."

iii. CARBON ISOTOPE RATIOS OF FLUVIAL AND MARINE SEDIMENTS

1. For both carbon and hydrogen, I'd just add a sentence stating that, for modern fluvial and marine samples there is virtually no change in isotopic signal from 42 to ~30 degrees, then the values become progressively enriched as latitude decreases, just to let the reader know that yes, this is something you observed and it will be discussed in the following sections

iv. CATCHMENT-AVERAGED CLIMATE VARIABLES AND dD VALUES OF MODERN PRECIPITATIONS ALONG CHILE

1. No feedback

5. DISCUSSION

a. CARBON VALUES AS RECORDERS OF PAST CHANGES IN PLANT WATER USE EFFICIENCY ALONG CHILE

- i. I feel like an SI figure plotting $\delta^{13}\text{C}$ alongside a few pollen plots from Heusser et al. or Werner et al. could be beneficial to really cement the idea that $\delta^{13}\text{C}$ is capturing water use efficiency and not vegetation change. Really show that, regardless of the vegetation changes observed in the pollen records, water use efficiency is static
- ii. Line 400: this sentence needs a citation for some paper on $\delta^{13}\text{C}$ in C_3 vs C_4

b. LEAF-WAX N-ALKANE HYDROGEN ISOTOPE RATIOS AS A MOISTURE SOURCE PROXY ALONG CHILE

- i. Line 420-421: citation needed
- ii. Line 422-425: I'd also cite Aggarwal et al. 2016, as dD values can also be influenced by the proportion of convective vs stratiform rainfall (ie. dD is influenced by vertical motions and microphysical processes within clouds)
- iii. Line 432-435: I'm not sure what the in-text citation style of *Climates of the Past* dictates (maybe you *have* to cite the SST records this way, if so ignore this comment). The citations and various parentheses in this sentence make it difficult to figure out. I'd consider rewording it to

something like “This secondary role of temperature is confirmed by the opposing responses of the GeoB3304-5 and 22SL dD records to a ~4C increase in temperature observed in the alkenone sst records from nearby sediment cores located at 30S (Fig 5i; Kaiser et al., 2008) and at 36S (Fig 5j; de Bar et al., 2018a).”

- iv. For the section in which you define the four types of dD signals, you mention that north of 27S, annual dD values are governed by SASM precip, is this because of lower rainfall volumes during the rest of the year? Likewise, south of 27S, the annual dD values are dictated by the signal from winter rainfall from the SWW storm track. Again, is this due to extreme seasonality? What is the local phenology like? Do plants in these regions tend to make their waxes at the beginning of the growing season, thus only incorporating the signal from that season? Or do they tend to continuously generate waxes, like grasses do?

v.

c. PAST HYDROLOGICAL REGIME IN CENTRAL CHILE

- i. Line 468: “which we attribute to the larger source area”- see my note about figure 1 below.
- ii. Lines 485-486: “It also agrees with the wax ratios of site GeoB7139...”
– Specify that you mean the 33S and 30S sites more closely agree with one another *after* 17ka. Right now, it reads as though you’re saying the wax record from 33S agrees with the records from both 30S and 36S before 17ka. I’d consider rewording to combine these two sentences into something like: “At 33S, wax values indicate influences of both SWW and SHP over the last 20ka, with lower values prior to 17ka indicating greater influence from SWW core, and higher values after 17ka indicating more of an influence from SWW peripheral. The highest values between 8-5ka suggest influence from the SPH.” Then you could say something like, “this coheres with our interpretation of the record from 30S, which indicates influence from the peripheral prior to 17ka and greater influence from the SPH from 14-5ka. Together these records suggest the SWW was in a more northerly position during the LGM”
- iii. Line 487: I’d replace the word “following” with “subsequent”
- iv. Line 504-521: I don’t feel that this paragraph is absolutely necessary in it’s entirety, given that you discuss the phases in detail in the next few subsections. I’d suggest cutting lines 504-510 (the sentences

where you discuss the phases) and moving right into timing uncertainties. (something like: “The reconstruction of latitudinal displacement of SWW and SPH- precipitation at 33 and 30S, alongside compiled paleoclimatic records from references 1-15, allow us to define five phases of hydroclimatic regimes. We acknowledge that the precise timing of the transitions between these phases is relatively uncertain due to uncertainties in our age-depth models (4.1), as well as the variability in age constraints in references 1-15, which are generally associated with differences in age-model calibrations, low temporal resolution, variable proxy response times.” And then go right into lines 515-521.)

v. PHASE I

1. Line 541-542: What proxy types support these inferences?
2. ^Same for Line 547-548
3. I’d mention somewhere here that the lack of available data south of 50S and north of ~26S makes determining the full widths of the peripheral and core zones impossible during this phase

vi. PHASE II

1. Line 556: I’d add the word “which is” so that this reads “implies a decrease in humidity, which is recognized in...”
2. Line 560-562: Describe the proxy evidence (I’m not going to comment on this anymore, but throughout this 5.3 I think you need to describe how the proxy evidence supports your inferences. It could be as simple as saying “pollen records from site x indicate vegetation changes consistent with a more mesic environment (citation).” You did well with this in lines 556-560 when you stated that the changes in sedimentology were what suggested the gradual drier conditions.)
3. Line 563: replace “low response” with “minimal response” or “minor response”
4. Line 564-665: and/or suggesting a persistent influence
 - a. (the way it’s written right now sounds like the data scatter could be masking both low amplitude changes and the persistent SWW influence)

vii. PHASE III

1. Not super critical, but for line 587, when you say the GeoB3304-5 ‘poorly’ cover the time interval, you could include the number of samples or sampling resolution of this interval.

viii. PHASE IV

1. Line 600: is “extend” supposed to be “extent”?

ix. PHASE V

1. Line 629: “indicating” should be “which indicates”
2. Line 630-631: I’d consider rewording this to “While many records suggest an earlier increase in humid conditions, the more negative trend in the wax records from GeoB7139-2 and GeoB3304-5 suggest the northward migration of SWW-precip occurred around 5.5ka”

d. ATMOSPHERIC PATHWAYS OF THE SOUTH AMERICAN WEST COAST SINCE THE LGM

- i. Lines 669-671: I’d consider rewording this to something like “ENSO events are the primary mode of modern interannual variability on the west coast of South America (citations), however, other phenomena such as the MJO and PDO can interfere with the atmospheric pathways associated with ENSO (cite).”
- ii. Line 676: add the word “pathways” so that this reads “these pathways tend to be reduced”, as written it is unclear what is being reduced.
- iii. Line 691-694: I’d combine these last two sentences into something like “Our approach focuses solely on the influence of the SWW and ITCZ on hydroclimate in Chile, however, as these features are global, we encourage future works which assess and compare our results to climate reconstructions in locations such as Southwestern Africa and Australia, which are influenced by the same features.”

iv. LAST GLACIAL MAXIMUM: PHASE I

1. Line 702-703: I’d add the phrase “not consistent” so that this reads “such conditions also imply a weaker subtropical jet and southward shift of the SWW belt, which is not consistent with our observations.”
2. I’d briefly mention sea ice in this paragraph somewhere. Maybe in line 705 (e.g. “A more northerly position of the SWW belt during the LGM suggests that a mechanism different than those discussed above may have been active during this period. Further in-depth investigation of regional climate during the

LGM is needed, particularly to examine the influence of sea ice-wind interactions on regional hydroclimate.”

v. DEGLACIATION PERIOD: PHASE II AND III

1. This whole section feels a little redundant and wordy, making it hard to read. I'd try to condense.

vi. THE HOLOCENE (PHASE IV A AND B, 11.5-5.5 KA BP AND PHASE V, 5.5 KA BP-PRESENT)

1. You start by saying that the Holocene is characterized by small temperature difference between the hemispheres (among other things), but then in the next sentence you say that summer insolation caused asymmetric warming of the Northern and Southern hemispheres, which contradicts the first sentence. Consider rewriting this paragraph.
2. Line 752-753: I'd reword this to something like “The relationship between reconstructed climate conditions (including our dD records) and insolation, and inferred atmospheric pathway clearly indicates that local conditions during Phase IV A and V resemble those seen during modern-day ENSO events. Specifically conditions which resemble La Nina during....”
3. I'd make it clear in this section that you're not suggesting that your records are resolving individual ENSO events. Also, are you saying that it was just ENSO-like conditions (i.e. sustained presence of warmer waters in the tropical pacific during Phase V indicates an El Padre-type situation) or are you saying that ENSO events were operating to such a degree that it's obfuscating any other climate signals?

6. CONCLUSION

- a. Line 798: “Antarctic Cord Reversal” should be “Antarctic Cold Reversal”
- b. I'd rewrite/restructure this first paragraph a bit so that it's basically “our study provides the high-res hydroclimate regime reconstruction. Our results essentially show that dD, along with several other proxy records, can be used to infer the location of the SWW belt, with more negative dD values suggesting wetter conditions and a more northerly position of the SWW, and more positive dD values indicating drying and a more southerly position of the SWW. [go into explanation of circulation regime changes and how each phase is characterized by different circulations]

- c. One thing I'm missing from this paper is any reason why people outside of the paleoclimatic community should care about this. How would it affect them? I'd basically go the standard route and say that our understanding of past climate can help us predict future climate. 'This paper is particularly relevant because it's showing that large scale circulation changes can have highly localized impacts on regional hydroclimate, as the oceans warm the meridional temp gradient will shift and could produce climate states and mechanisms akin to what we see in our reconstructions of the past, etc.'

7. FIGURES/TABLES:

- a. Fig 1: I know this figure has a lot of information on it, but would it be possible to highlight the Maipo and Aconcagua rivers, the Biobio and Itata Rivers, and Elqui and Limari Rivers? Just to show exactly where the sediments from the gravity cores is sourced from? If it's too messy on this map, maybe highlight the relevant basins in Fig S8 and point the reader to that in the main text?
- b. Fig 2: This is a fantastic figure, can you just label the sites just so the reader isn't flipping between fig 1 and fig 2
- c. Fig 3: This is a fantastic figure
- d. Fig 4: I also really like this figure. The label "Peripheral zone of the SWW belt" could just be "SWW- Peripheral" for consistency. (You'd need to update this in Fig.S11 as well)

I suggest that you also make an SI table for the references you use to construct this figure (maybe you've already done this. I'd include the following headings:

Ref no. /name	Latitude	Date Range	Proxy Type
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- e. In both figures 3 and 4 can you mark the timings of Heinrich stadial 1, like you did with the Younger Dryas and Antarctic Cold Reversal?