Author's response to Anonymous Referee #1

We appreciate the constructive review of Anonymous Referee #1.We agree with the general comments and we introduced changes in the manuscript in order to address the reviewer's concerns. Also we clarified and corrected the manuscript considering specific comments. We think that these changes (and English and Technical corrections) benefited the manuscript, especially improving the discussion/conclusion section and providing a stronger context for the study. Here, we provide a briefpoint by point response to the general comments (enumerated) of the Referee #1:

1) **The authors must contextualize their findings with more studies about glacial hydrology, discussing more thoroughly the current status of Universidad glacier (area decrease of the last decades?) and its possible future point of peak water considering current shrinkage rates as well as local and downstream impacts of changing river runoff (in the region).**

Author's response

We re-wrote the Discussion section considering this comment and have added some further context to the Introduction. It is difficult to relate the results obtained from one ablation season to a long term perspective, however, considering previous research and our results we have discussed the future runoff and the relatedimpacts on water availability in the region. To address this point we added more literature discussion regarding future runoff trend in the region.

2) **It is not clear, if the results should be seen as a first short snapshot (only 5-6 months measurements) at the beginning of an anomalous period of drought (2010-2015) or if they can be brought into a wider context (ideally with longer in-situ data)**

Author's response

We have clarified this point (also made by two specific comments of this reviewer). We focused on one ablation season due to the availability of data (after March 2010 no more data/observations were obtained from the glacier). Hence, we prefer touse the results as representative of certain synoptic/weather conditions. The analyzed period coincided with the beginning of the "mega-drought" that affected central Chile in the last 7 years so we assume that the results are representative of a dry period.

3) **While relative glacier melt fraction to river runoff might be high particularly in dry periods and the upper Tinguiririca catchment, relative contribution is expected to decrease with increasing distance from headwaters, i. e. for the**

low-lying coastal cities and water users. The mention of (the insignificance of) groundwater flows, probably difficult to estimate without direct measurements / tracing methods, should be revised as many different hydrological models have not been capable to adequately represent groundwater flows. Some studies of the last years suggest that they represent an important driver (e. g. Baraer et al., 2014 for the outer tropical Andes of Peru).

Author's response

We agree with this comment, therefore we changed the text adding, discussing related literature as suggested.

4) **The manuscript contains multiple tables and figures, most of them helpful for further comprehension, others less substantial. In order to reduce total paper volume, I would skip e.g. Table 1 and Figure 4. However, all anomalies / data gaps in the plots should be briefly indicated and explained in the text or subtitles.**

Author's response

We remove Table 1 as the referee#1 suggested, however we keptFig. 4 since Referee #2 recommended to improved and not skipped.This implies hourly wind rose to see if katabatic flow is interrupted during the evening. We explain data gap and anomalies in the data, as specified in Reviewer's specific comments.

Response to specific comments:

All the specific comments and technical correction were addressed in the revised manuscript.

1 / 10-11: is that true that glacier melt represents more than the half of total streamflow contribution in lowlands during dry years in Chile? I would rather expect a reduction of relative contribution with increasing distance from the glacier and headwaters converting glacier streamflow to an important but not the main contributor in the lowlands.

We agree that the manuscript was not clear on this point. Considering that the comparison of glacier melt with observed runoff in this research, as withmany previous studies,was made with data from stations located in the upper part of the mainvalleys, it is difficult to make an assessment of glacier contribution to runoffin the central valley of Chile or on the coast. We clarify this point, in the Abstract and in the Discussion section 4.2.

2 / 38 – 3 / 1: what about glacier area and (estimated) volume changes and current retreat rates of Universidad glacier and/or in the region?

We didn't estimate the area/volume changes for Universidad glacier. We used available literature (Le Quesne et al., 2009; Wilson et al., 2016) regarding these changes in the last years. However we added more literature to contextualize the glacier reduction in the region.

3 / 7-8: you identify the year 2009/2010 as (just) the beginning of a longer dry season (2010-2015) but it is unclear why you did not incorporate a longer period of measurements into you study and**3 / 18-19: again, you do not explain why your study only covers six months of data measurements**

We clarify this point. See General comment 2).

3 / 33-34: how did you discriminate snow from ice with the NDSI? Thresholds and techniques should be mentioned 4 / 3: clarify which images were selected with a cloud cover threshold: Landsat 5 TM?

We have stated more clearly that only MODIS products were used for snowline elevation identification and snow/ice discrimination. The mention of Landsat relates to earlier work not done by us to improve retrieval of sub-pixel snow cover information, and possibly this has been a source of confusion. We have usedthe MOD10A1 product since provides a better differentiation of the ice surface of Universidad glacier (which is dirty due the presence of ogives, debris and impurities), from and the fresh snow areas. However, MOD10A1 product gives the fractional snow cover for each pixel in the range 0 to 100, and to assure a correct snowline altitude we assumed the presence of snow in the pixel with a fractional value of 100. Despite this we expect some uncertainties in the snowline altitude as Fig.5 shows for the end of the ablation where high variability exists.

4 / 14-15: the explanation of how to convert hourly to daily format is very basic and can be neglected

OK. Deleted

10 / 29-31: again, be careful that you distinguish upstream from downstream (lowland) glacier streamflow contribution, the latter possibly less significant; what about flow contribution in australwinter? Although you have only worked in the ablation period, it would be good that the reader gets a general idea of glacier streamflow contribution changes during a whole hydrological year.

We added more literature regarding streamflow contribution during a complete hydrological year.

11 / 3-6: the point of (future) peak water is not sufficiently investigated in many mountainous regions worldwide but an increasingly important research question, particularly for future water management, can you examine this question about the possible peak water of Central-Andean glaciers in Chile a bit more? More literature?

We added more literature discussing this point. (See General comment 1).

11 / 13-14: is it true that melt rates are generally reduced further north (until where?) of Universidad glacier? Sublimation process are strongest with a pronounced water vapor gradient which is true for the dry season of e. g. the outer tropics (Peru/Bolivia) but not for glaciers in the inner tropics.

We were referring to high altitude glaciers in the north of Chile and in the outer tropics from Peru and Bolivia. We clarified this point in the new version of the manuscript.

11 / 37 – 12 / 1: is Universidad glacier really such a particular glacier with highest melt rates in Chile? cite comparing literature

We compared our results with other studies in section 4.3. However, as referee 2 suggests we provided more data from previous studies to establish a meaningful comparison.

12 / 2-3: this affirmation is obsolete as it represents a typical mechanism of glacier energy budget and mass balance

OK. Deleted

12 / 15: does groundwater flow really becomedepleted? any studies (e. g. tracers: Rodriguez et al., 2014)? in other parts ofthe Andes (where reduced ablation also takes place during the winter season) groundwaterhas been identified to be a strong contributor and generally underestimated inmany studies

We reviewed this point and changed the sentence considering that groundwater could be a major contributor. (See also General Comment 3).

12 / 24: the last argument should be more developed. The region isimportant for multiple water users. As an example, just some kilometers downstream,the hydropower plants La Higuera / La Confluencia are situated and possibly stronglyaffected by annual/seasonal changes in river runoff

We added this information about the water used by hydropower as well as for agriculture activities in this particular basin.

16 / Table 1: this table does not contribute substantially to the study comprehension, therefore I would take it out

OK. Deleted

18 / Table 3: indicate period in the title "(2009-2010)"

Added

20 / Figure 1: upper left: the three gauges are not clearly identifiable; the map text "CECs HydroChile" confuses; also, the abbreviations "CECs" and "DGA" in the legend are not proper; text of the figure: add "(orange outline)" after "Universidad glacier"

OK. Changed and added accordingly.

21 / Figures 2-13: indicate altitude (m asl) for ALL station data

OK. Added

23 / Figure 4: in order to reduce paper volume, I would skip this graph as it does not substantially contribute for a further process comprehension

We have preferred to kept this Figure with some changes suggested by referee 2.

25/ Figure 6: eliminate "[dd-mmm-yyyy]" at x-axis legend; you also do not use this definition in Figure 7

OK. Deleted

26 / Figure 7: indicate gaps which are present between November 21-22

OK. We have added and explained each data gap

Figure 12: no runoff measurements from March on? explain this data gap

We explained that period of observations (AWS, PS) is until end of March. See General Comment 2).

Technical corrections

1 / 1-3: with 28 words, the title is too long and complicated. Amore concise title would be: "Glacier melt contribution to river runoff at Universidadglacier, central Andes of Chile"

We changed the title as suggested

1 / 11: eliminate “the” before “glacier melt”

Done

1 / 13: insert“within the” before “central Andes of Chile” 1 / 19: replace “altitude part” by “ablationarea”

Done

1 / 28: insert “a” before “crucial resource”

Done

2 / 21: change order “Mediterraneanclimate type”

Done

2 / 26: use directly the previously introduced abbreviation “AWS”

Done

2 / 32:correct “altitudinal range”

Done

2 / 33: improve “which converge at an altitude”

Done

2 / 35-37:change order considering a clockwise aspect of glaciers (north to the west)

Done

3 / 2-3:“fastest period” does not exist, improve

Changed

3 / 9-10: three times the word “measurements”,Replace

Replaced: “Data collected include meteorological observations at two AWS, surface lowering monitoring from ablation stakes and a sonic ranger (Fig. 1), satellite-derived snow cover distribution and discharge measurements in the proglacial stream”

3 / 14-15: not a full phrase, a verb is missing!

We have added the verb

3 / 16: correct “net all-waveradiation”

Done

3 / 32: insert “spatial” before “resolution” (there are also other types of resolutions)

Done

3 / 33: better specify “Landsat 5 TM (30 m spatial resolution)”

Done

4 / 1-2: eliminatethe long parenthesis “(Advanced Spaceborne. . . Version 2)”

Eliminated

4 / 30-31: improve phrase:it is not “melt overestimation” which is dominated by melt from the ablation zone; insteadof “however” you could use “as it”

Done

5 / 5: “and the afternoon maximum” could bethe beginning of a new phrase and needs a verb

Changed

5 / 14: include “shortwave” before “radiation”

Done

5 / 21: insert “to be” before “a constant”

Done

5 / 22: add “a” before “function”

Done

8 / 2:eliminate “(100% relative humidity” – very basic

Done

8 / 4: correct “was covered”

Done

8 / 21-22:improve phrase, you could separate it into two phrases from “fluxes calculated by” oinserting a new verb

We rather prefer to kept this phrase adding “turbulent” after the first comma.

10 / 3: eliminate “a” before “suitable”

Done

10 / 4: use also the word“correlation” instead of only “agreement”

Done

10 / 8: improve, e. g. “an hourly calibratedlapse rate at the glacier”

Done

10 / 19: maintain the same terms, here “Universidad glacier”

Done

10 / 37: replace “that” by “than”

Done

11 / 14: add “cover” after “cloud”

Done

11 / 20: eliminate“the” before “each”

Done

11 / 24: add “the” before “central Andes”

Done

11 / 25: correct “dependson”; insert “as” before “2013”

Done

11 / 26: correct phrase “while in dry years”

Done

11 / 28: betterwrite “climatic conditions” instead of “meteorology”

Done

11 / 29: insert “model” after “melt”

Done

11 / 34: a final point is missing before “The ablation”

Added

11 / 37: improve phrase avoidingthe semicolon with e.g. “and are thus greater”

Changed

12 / 2: “latitudinal” instead of “latitude”

Changed

12 / 3: “persistent” instead of “persistence”

Changed

12 / 11: add “km” after “1.7”

Added

12 / 12: aspace is missing before “The total”

Added

12 / 13: improve phrase: “Universidad glacier onlyrepresents 36%”

Changed

12 / 14: add the year “2010” after “March”

Added

12 / 20: insert “the” before“zero-degree”

Added