Response to Anonymous Referee #1

1. The manuscript 'Dataset of Georeferenced Dams in South America (DDSA)' presents a very important compilation of georeferenced dams in South America (SA). Since most global databases do not include many important dams in SA, it is indeed paramount that regional initiatives as the one presented here be developed to foster water management in the continent. I thus support the publication of this manuscript in ESSD, after some revisions as highlighted below, and for this I suggest major revisions

Response: The authors take the opportunity to acknowledge the valuable comments provided by the anonymous referee, as well as the time that has been committed to provide this valuable feedback. All suggestions made have been considered and addressed in a reasoned manner. Revisions have been made to the manuscript and are described below.

2. Firstly, a section with perspectives for future developments of large-scale datasets of dams in SA could be included. For example, this dataset provides mainly information on the location of the dams. However, other data are also fundamental to foster water management across the continent, e.g., availability of dam outflows (i.e. discharge time series). For instance, Brazil's ONS (Operador Nacional do Sistema) provides daily discharge data and reservoir storage for most reservoirs in the national interconnected system (https://www.ana.gov.br/sar/sin). These data were used for example for a national scale assessment by Passaia et al 2020 (Impact of large reservoirs on simulated discharges of Brazilian rivers; Brazilian Journal of Water Resources). Another information relates to time series of energy generation, and some SA countries also make it available online (e.g., Brazil, Colombia). I think a paragraph could be included to discuss which kind of information would be interesting for improving water management related to reservoirs in SA (and which datasets already exist and are not included in DDSA). This could push the international hydrology community somehow to develop new initiatives of data sharing.

Future dams (i.e. proposed dams or dams under construction) are also neither included nor discussed in the text. I think it should be included somehow (at least a paragraph about it). For instance, ANEEL (Brazilian energy agency) has an available shapefile of the status of dams in the country (in operation, proposed, at inventory phase, etc). The FHReD dataset also provides proposed dams worldwide, which includes many in SA (http://globaldamwatch.org/fhred/).

Response: Thank you for these relevant suggestions. We have improved section 6 'Summary' in order to include information regarding future perspectives for extending our database. First, we discuss information about future dams in South America. Additionally, we have included a Supplementary Table (Supplementary Table 1), which contains information about 245 future projects in South America, 61 under construction as of 2020 and 184 projects planned to be developed in the future. Supplementary Table 1 details future dams in South America identified by country, name and implementation phase.

Also, we present a discussion about additional attributes which could be included in future versions of our database, e.g. outflows of dams (discharge time series) or energy generation data from hydroelectric dams (energy generation time series):

References to lines with the suffix 'OM' refer to the original manuscript and the refence to lines with the suffix 'RM' refer to the revised manuscript.

Line 284OM / 360RM:

'One of the main goals of this endeavour is to foster the research of water resources in South America. To achieve this objective, we consider that we must make the necessary efforts to keep our database relevant to the international hydrology community.

For this, we believe it will be necessary to keep our database updated, and also, include additional information regarding hydrology and water resources management in future versions of our database. Future dams are one of the topics we need to observe to maintain our database updated. In recent years, several South American countries have made public their intention to develop new dam projects, mainly for hydroelectric generation (Anderson et al., 2018; Moran et al., 2018; Zhang et al., 2018). We have identified 245 future projects in South America, 61 under construction for 2020 and 184 projects planned to be developed in the future. Supplementary Table 1 details future dams in South America identified by country, name and implementation phase.

Monitoring the development of future dams in South America is necessary due to the relevance of these projects on the local and regional scales. It is not likely that all projects listed in Supplementary Table 1 will be carried out due to different economic, social or political factors (Anderson et al., 2018). However, the likely ecological or social impacts that these projects may cause (Doria et al., 2018; Lees et al., 2016; Winemiller et al., 2016) highlight the necessity for the international hydrological community to be conscious of the status of these projects.

Similarly, we consider that future versions of our database may be extended with additional attributes. For example, information such as outflows of dams (discharge time series) or energy generation data from hydroelectric dams (energy generation time series), could also be included in the future. However, to date, including this type of information on a continental scale represents a significantly great effort due to the lack of readily available information on water resources in most countries of the region. There are countries, like Brazil, which make public their relevant information about water resources and energy generation through their official agencies, e.g. the National Agency of Water ANA (https://www.ana.gov.br/sar/sin, last access: 9 Nov 2020), and the National Electric Energy Agency ANEEL (https://www.aneel.gov.br/siga, last access: 9 Nov 2020). Then again, other countries of the region keep this information restricted or outdated, which makes it difficult to complete these attributes for the entire database.

Finally, the data presented in this database is largely based on open-access information available to date, therefore, the valuable support of both public institutions and the international hydrology community will be necessary for extending future versions of our database. This will allow us to keep our database relevant, which in turn will support the development of future research initiatives on water resources in the region.'

3. The authors could consider presenting an updated map of the degree of regulation index (DoR; basically the total storage of upstream reservoirs divided by the average discharge at a given river reach) which is a simple one yet powerful to understand reservoir regulation at large drainage networks. This is easy to do, since the authors already have the Hydrosheds ID for each dam location. This would be a kind of updating for SA of the free-flowing rivers map published recently (Grill et al 2019 Nature).

Response: Thank you for this valuable suggestion. We have determined the degree of regulation for the dams in our database and included the results in our manuscript in sections: 'Abstract', '1 Introduction', '2.2.10 Degree of regulation', section '3.2 hydrological information', section '4 Data limitations' and also in figure 2f, figure 5 and figure 6.

Line 17OM / 17RM:

'Also, hydrological information on the dams' catchments is also included: catchment area, mean precipitation, mean near-surface temperature, mean potential evapotranspiration, mean runoff, catchment population, catchment equipped area for irrigation, aridity index, residence time and degree of regulation.'

Line 64OM / 68RM:

'…Map of Irrigated Area dataset (Siebert et al., 2005), aridity index, residence time and degree of regulation.'

Line 223OM / 238RM:

'2.2.10 Degree of Regulation

The degree of regulation (DOR) provides a first approach to assess the potential impact of reservoirs on their downstream network. This index measures the degree of flow regulation that a dam or a cluster of dams can cause on a river network. This regulation alters the connectivity of the streams and can cause disruptions on seasonal flow events or can reduce the transport of sediments or species though the river network (Grill et al., 2019; Lehner et al., 2011).

In order to determine the DOR index, we followed the methodology described by (Grill et al., 2019) and computed the DOR index for each dam location based on the relationship between the accumulated reservoir volume and the total annual flow river at each dam's location. This index is determined in percentage and is represented by:

$$DOR_i = \frac{\sum_{j=1}^{n} reservoir\ volume_j}{discharge\ volume} \quad [3]$$

Where DOR_i is the degree of regulation index for each stream reach i, reservoir $volume_j$ is the reservoir volume of the dams j located upstream or the stream reach i, n is the total number of upstream dams, and discharge volume is the average discharge volume per year at the stream reach i. For this study we used a minimum threshold of 2% to distinguish between free-flowing rivers (Dynesius and Nilsson, 1994) and also, we restricted the DOR value to 100% to limit multi-year reservoirs to the same maximum DOR (Lehner et al., 2011).

We extracted the river network from the HydroSHEDS dataset and defined the rivers as the streams that exceeded an upstream catchment area of 10 km^2. For the annual discharge volume, we used the information from the GRDC composite runoff field dataset and the area of each dam catchment which was derived from the HydroSHEDS dataset. Reservoir volume is expressed in cubic kilometres and the discharge volume is expressed in cubic kilometres per year. The degree of regulation is expressed in percentage values.'

Line 258OM / 308RM:

'Finally, figure 2f provides information on the DOR index in the rivers of South America classified by river flow category and level of regulation. The river flow category refers to different values of average mean flow. Our results indicate that the regulation effects of reservoirs are more evident in the rivers with smaller average flows. Over 50% of the total "affected rivers" in the region, these are the rivers with a DOR>=2%, correspond to small flow rivers. The DOR affectation decreases as the mean river flow increases, which is observed in very large average flows, whose level of DOR affectation is less than 1%. Rivers with multi annual reservoirs, this is streams with a DOR=100%, are more frequent in small flow rivers, with more than 27% of the total observations. Figure 5 shows

the degree of river regulation of the reservoirs of the DDSA database for the "affected" rivers of South America.'

<u>Line 264OM / 329RM:</u>

'Also, in the case of the DOR index, there are many important inputs in our assessment that may have not been considered due to the absence of information. For example, we are not considering information about local water use, specific stream characteristics or relevant and updated urban information. Also, our DOR assessment does not consider unidentified small reservoirs, which could alter the final results. Furthermore, the impacts of river regulation also depend on a wide range of factors, e.g. local or international policies, which have not been considered either. Altogether, we consider that despite the aforementioned uncertainty factors, our results give a consistent first approximation of these indices at a regional scale.

Finally, in order to assess the robustness of our DOR assessment, we conducted a sensitivity analysis by comparing our findings with the results determined by (Grill et al., 2019) in their manuscript 'Mapping the world's free-flowing rivers' (DoR_FFR). Figure 6 compares 409 stream matches from both studies and determines a strong correlation (r=0.702) between our results and the DoR_FFR manuscript. The correlation results are more evident on large and very large rivers'

Figure 2f:

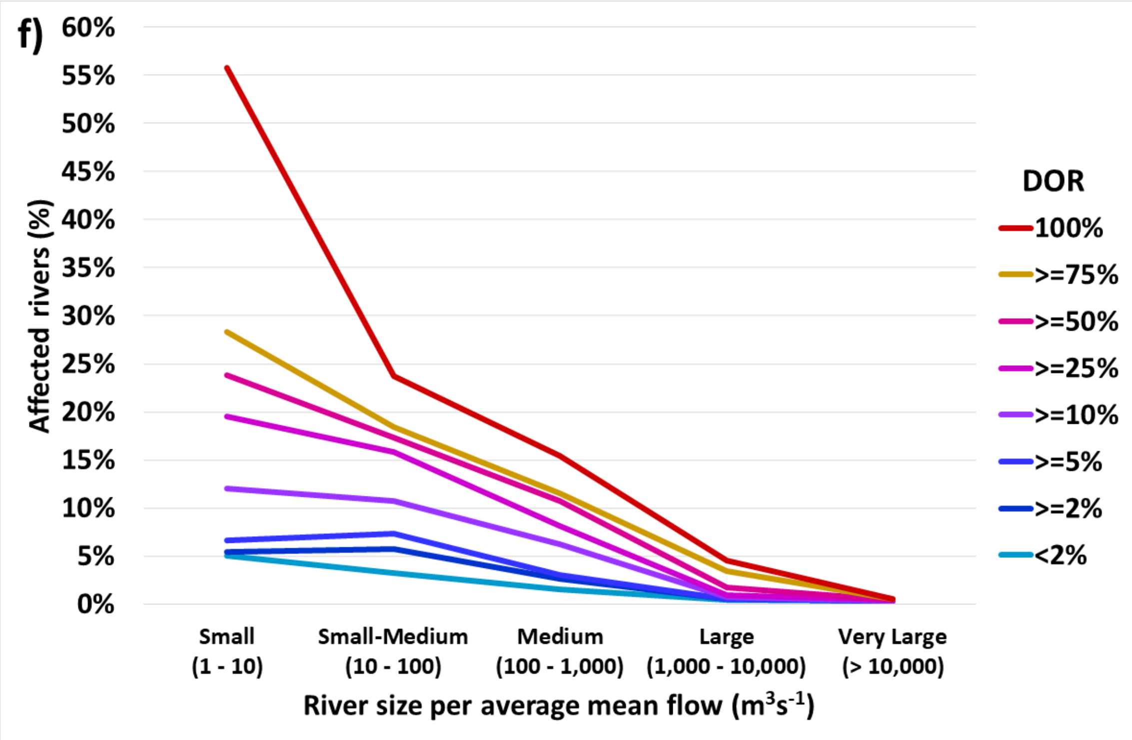

Figure f) Cumulative affected rivers per river size and per different DOR range

Figure 5:

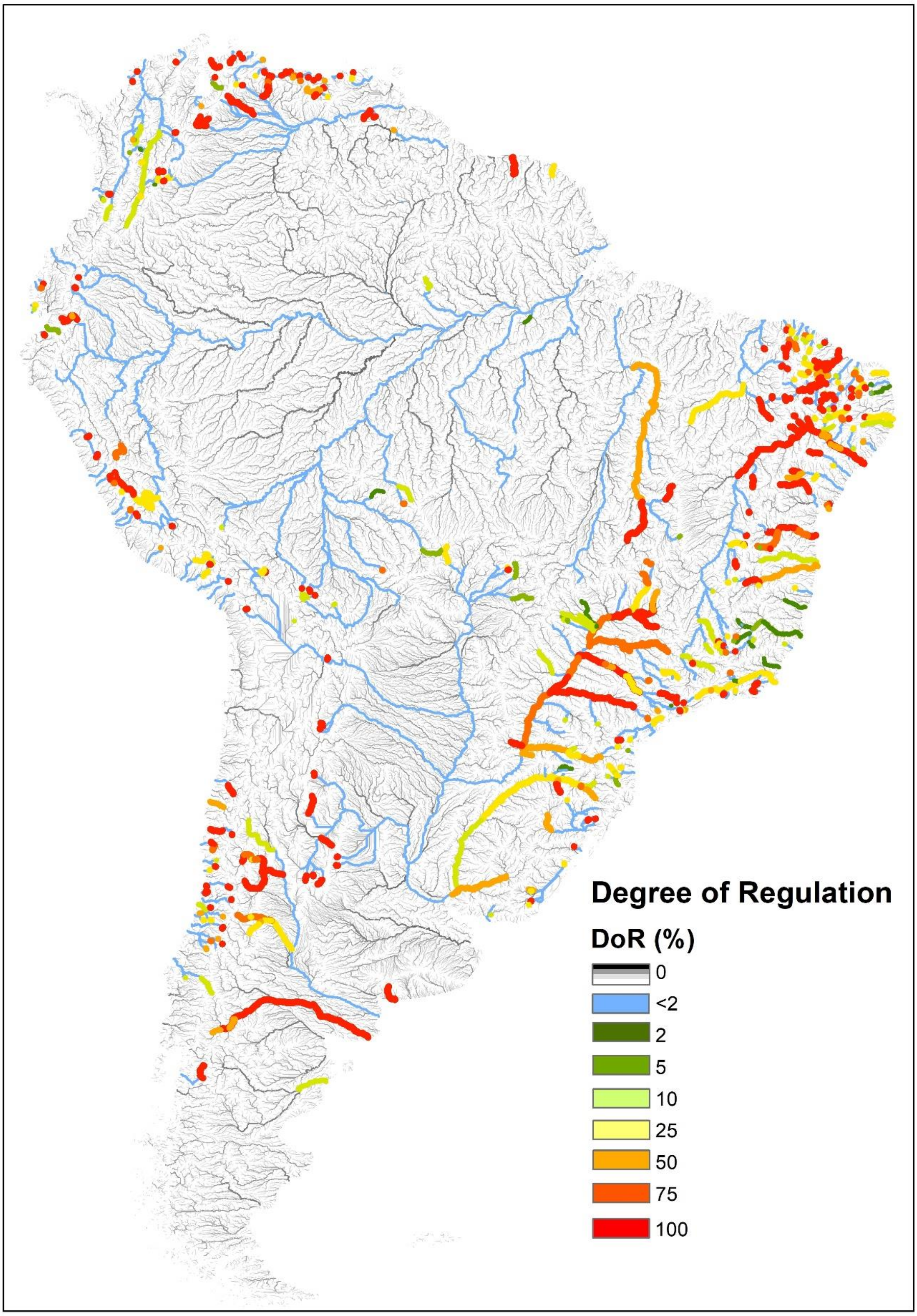

Figure 5 Degree of Regulation (DoR) of reservoirs of the DDSA database in downstream rivers of South America.

Figure 6:

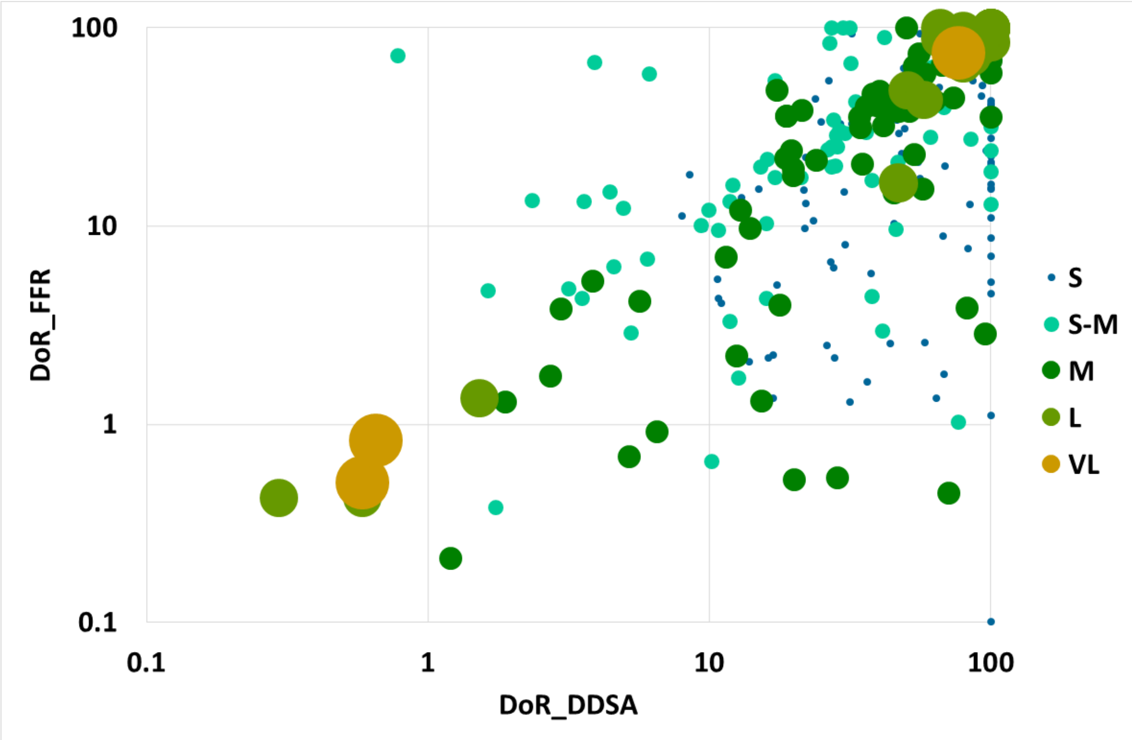

Figure 6 DOR sensitivity analysis. Degree of regulation values from DDSA database (DoR_DDSA) were compared with matching values from (Grill et al., 2019) degree of regulation values (DoR_FFR). River were classified by their average mean flow; smaller dots represent small rivers and bigger dots represent large to very large rivers.

4. The interpretation of the hydrological data and the outcomes of the dataset in the Results section is too simplistic. For example, in the section 3.1 Dams and Reservoirs there is only a comparison with GRanD and AQUASTAST databases. However, given the large amount of data available, more interesting figures as histograms with number of dams implemented per year and per country should be included. Regional analyses could also be performed, e.g., higher dams are mainly located in which countries, in which type of environment? Although I recognize that this is mainly a paper describing the dataset itself, some additional analyses could be included and would certainly improve the overall quality of the manuscript. In section 3.2 Hydrological Information, the authors focus on describing extreme values of PET, Precipitation, temperature and other variables at individual sites (e.g., 'The highest potential evapotranspiration record is documented for the catchment of the "Pilões" dam in Brazil with 1,713.32 millimetres per year'). However, for a continental scale dataset as this one, I think that regional analyses would be much more interesting, e.g., how many dams are located in regions with high aridity index (PET/P)? Similarly, in section '3.3 Additional Information', there is only a simple phrase on how Yaciretá dam is associated to the highest upstream population and equipped areas of irrigation. A more thorough analysis describing the distribution of dams at different levels of population pressure across the continent could be included.

The authors could consider analyzing upstream population divided by the dam drainage area, this would put some weight on the large upstream population for dams located in downstream reaches as Yaciretá dam in the Paraná river.

Response: Thank you for this suggestion we have made several improvements in our analysis. Besides the 'Degree of Regulation Index' explained in the previous section, we have included 2 additional indicators for our assessment: 'Aridity Index' and 'Residence Time'. We mention these indicators in sections: 'Abstract', '1 Introduction', '2.2.8 Aridity Index' and '2.2.9 Residence Time', '3.2 Hydrological Information', and '4 Data limitations and uncertainties'. We also have improved the entire section '3 Results'. We believe these indicators and further assessment will allow us to clarify our results and improve the overall outcome of our manuscript.

We have also included several additional figures: 2a, 2b which depict an analysis about dam information (number, storage volume, country, year). Figure 2c assesses population and catchment data per each dam and country. Figure 2d evaluates dams per aridity index and per country and figure 2e assesses upstream runoff and residence time. In addition, figure 4 was updated to include the aridity index and the residence time per dam catchment.

Line 17OM / 17 RM:

'Also, hydrological information on the dams' catchments is also included: catchment area, mean precipitation, mean near-surface temperature, mean potential evapotranspiration, mean runoff, catchment population, catchment equipped area for irrigation, aridity index, residence time and degree of regulation.'

Line 64OM / 68RM:

'…Map of Irrigated Area dataset (Siebert et al., 2005), aridity index, residence time and degree of regulation.'

Line 223OM / 218RM:

'2.2.8 Aridity Index

The aridity index (AI) is a useful indicator to evaluate long-term climatic water deficiencies on a region. For this study, we determine the AI for each dam catchment using the methodology proposed by UNESCO (UNEP et al., 1992) which is represented by:

$$AI_i = \frac{P}{PET} \qquad [1]$$

Where AI_i is the aridity index for each dam catchment, P is the mean annual value of precipitation for each dam catchment (mm/year) and PET is the mean annual potential evapotranspiration for each dam catchment (mm/year). The aridity index is unitless. Both the mean annual precipitation and potential evapotranspiration values are derived from the CRU dataset. The units for both P and PET values are expressed in millimetres per year.

In general, higher values of AI represent humid climates, while lower values represent dry or arid climates. Aridity indexes are commonly classified based on the following subtypes: hyper-arid ($AI<0.03$), arid ($0.03 \leq AI<0.20$), semi-arid ($0.20 \leq AI<0.50$), subhumid, ($0.50 \leq AI<0.65$) and humid ($AI \geq 0.65$) (Pour et al., 2020).

2.2.9 Residence Time

The residence time (RT) or the 'age' of water, is a common indicator used to determine useful information about the storage, sediment transport, water quality or flow pathways of a catchment (Mcguire et al., 2005; Vörösmarty et al., 2003). This indicator usually refers to local conditions in a single reservoir and is usually represented by:

$$RT_i = \frac{reservoir\ volume_i}{discharge\ volume} \qquad [2]$$

Where RT_i is the residence time for each reservoir, reservoir $volume_i$ is the volume of the reservoir i, and discharge volume is the average discharge volume per year at each dam i. If reservoir volume *is expressed in cubic kilometres and discharge volume is expressed in cubic kilometres per year, residence time is expressed in years.*

For the annual discharge volume, we used the information from the GRDC composite runoff field dataset and the area of each dam catchment which was derived from the HydroSHEDS dataset.'

Line 223OM / 257RM:

'3 Results

3.1 Dams and Reservoirs

Once the review, refinement and processing of the data was concluded, a total of 1,010 dam entries were accepted for our database (Figure 1). This represents a noticeable progress in the identification and geolocation of dams in the region and thus, enables the opportunity for new research that allows a more precise understanding of the water resources systems in the region. After a comparison with other databases, 376 entries were similar to the AQUASTAT and GRaND databases; however, they were included in our database since the 1,010 entries were inspected and verified following the same procedure described in previous sections. Additionally, this database increases dam entries not only as a total regional number but also increases the number of entries per country, which means that with this database we also expect to contribute to new research in study areas that have not been considered to date due to the absence of reliable information. Table 2 details the entries in our database for each country considered in this study, including a comparison with the AQUASTAT and GRaND databases. Table 3 describes the 24 variables processed and accepted for this database. The estimated total reservoir volume of this database is 1,017 cubic kilometres and the largest reservoir belongs to the "El Guri" dam in Venezuela with an estimated volume of 135 cubic kilometres.

We also present an analysis on the implementation of dams in South America. This analysis is shown in Figures 2a and 2b. Our results show that the largest number of dams were built since the 1960s, a period in which more than 70% of the dams on the continent have been built. Similarly, the greatest increase in storage capacity occurred between the 1970s and the 1990s, which suggests that the largest projects were implemented in this period, including the "El Guri" dam. In the case of dams implemented by countries, we can observe the relevance of Brazil, the country with the highest number of dams in our database with more than 50% of records. This predominance is also seen in the total storage volume, since Brazil has more than 60% of the total volume of storage reported in our database, probably due to the vast amount of water resources in this country.

3.2 Hydrological Information

The model derived from the HydroSHEDS dataset allowed us to determine the catchment areas of this database, which were necessary to carry out the subsequent hydrological calculations. The accumulated area of the dams' catchments is approximately 14,855,192 km2 with an average catchment of 18,385 km2. The largest catchment belongs to the "Jirau" dam in Brazil with an estimated area of 962,732 km2. Table 4 describes the variables processed for the hydrological information included in this database.

Figure 3 presents the annual values for NST, P, PET and runoff estimated for each dam catchment. Both in the case of NST and P, higher values would seem to be mostly located near the equator, while PET higher values are more noticeable in the northeast of Brazil. In the case of runoff, values are scattered and there is no evident predominance, except for higher values localized in the southeast of Brazil.

Figures 2c and 4a represent the values of catchment population per each dam catchment. We observe a clear connection between these attributes, with larger catchment areas corresponding to larger populations. Although this trend by itself is expected, figure 4a suggests a strong population pressure on downstream catchments, which is mainly inflicted by upstream population catchments. For example, the "Yayreta" dam has the largest population with more than 55 million people. However, this value comes mainly due to the accumulated population of upstream catchments, including the "Itaipu" dam catchment population of almost 49 million people, which in turn also receives most of its large catchment population from upstream catchments. Figure 4b presents the equipped area for irrigation for each dam catchment. The dam with the largest equipped area for irrigation corresponds to "Yacyreta" dam catchment dam with more than 930,000 hectares of equipped areas for irrigation.

Figure 2d and 4c describe the number of dams per aridity index type and per country. In this case, we observe that dams located in arid areas are mostly located in the southwest of the continent, especially in Argentina, Chile and Peru. Most significantly, we observe that two dams: 'Austral' and 'Candelaria' have their catchments located in hyper-arid areas. In the case of catchments located in humid areas, we observe that most of these dams are located near the equator, largely due to the high precipitation values in this region.

Figure 2e describes the relationship of runoff and residence time per dam. We observe a clear relation between these two attributes, with reservoirs with larger specific capacity corresponding to catchments with lower runoff values. This indicates an 'expected' performance from most of the dams in our database, from large reservoirs located in regions with low available water resources areas like the 'Cocorobó' dam in Brazil or the 'Las Maderas' dam in Argentina. In the opposite side, we observe small reservoirs in large water resources areas like the 'Chisaca' dam in Colombia or the 'Suytococha' dam in Peru. Figure 4d describes the residence time for each dam. Again, if we visually compare this figure with figure 3d, we observe a clear relation between the residence time and runoff, with high residence time values located in areas with low runoff areas.'

Line 264OM / 327RM:

'Our results regarding aridity index, residence time and degree of regulation also need to be interpreted with caution. First, our results are intended to assess the dams' catchments and therefore, should be used carefully if intended for other type of assessment. Also, in the case of the DOR index, there are many important inputs in our assessment that may have not been considered due to the absence of information. For example, we are not considering information about local water use, specific stream characteristics or relevant and updated urban information.'

Figure 2a (Figure 2 is a composition of figures 2a, 2b, 2c, 2d, 2e and 2f)

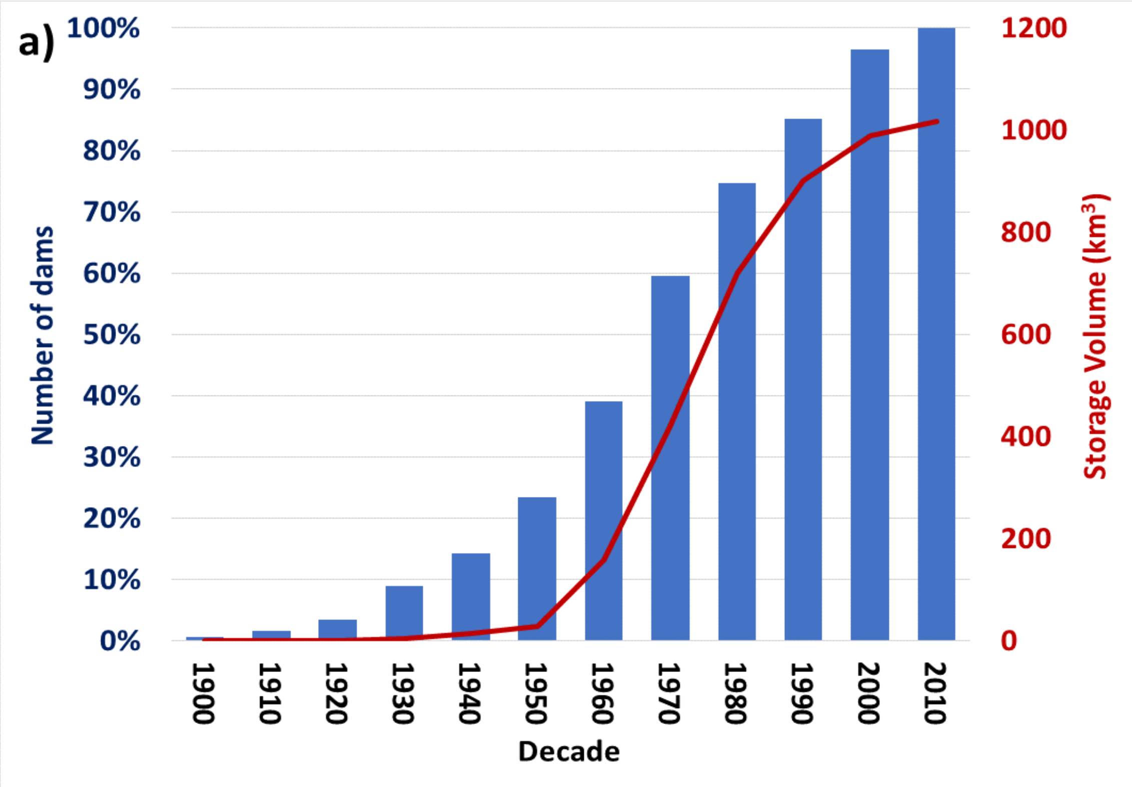

Figure a) Cumulative number of dams per decade and per storage volume

Figure 2b:

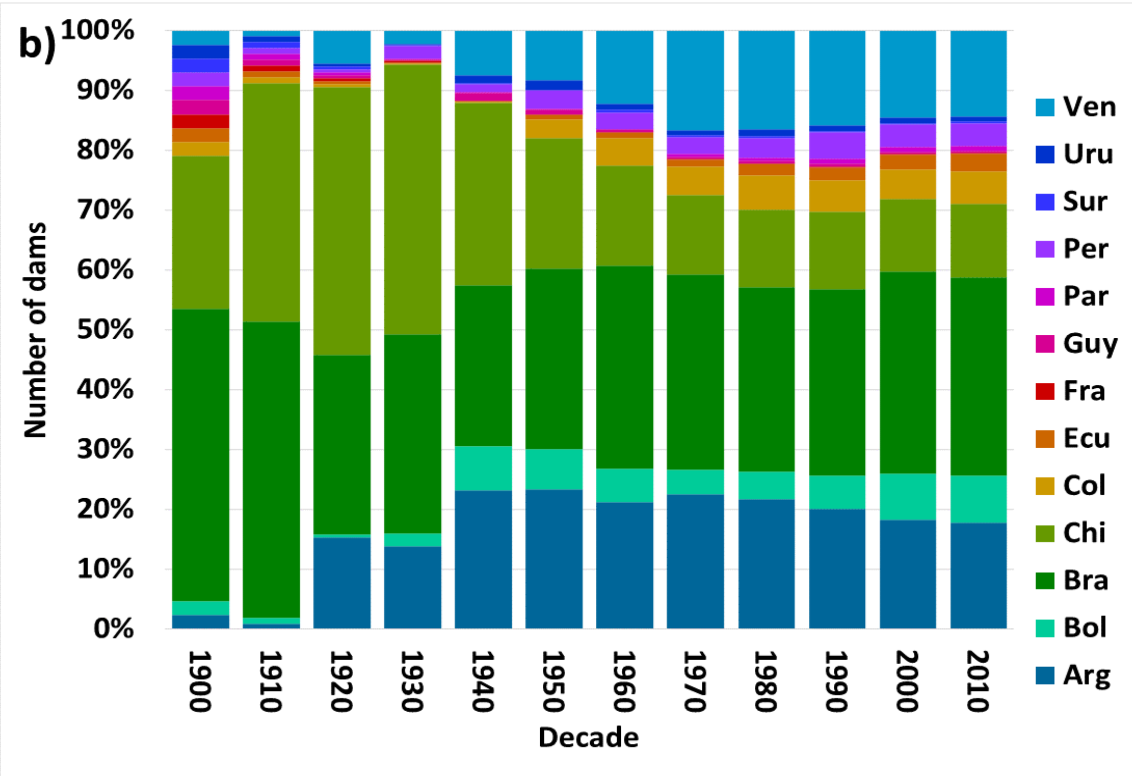

Figure b) Cumulative number of dams per decade per country

Figure 2c:

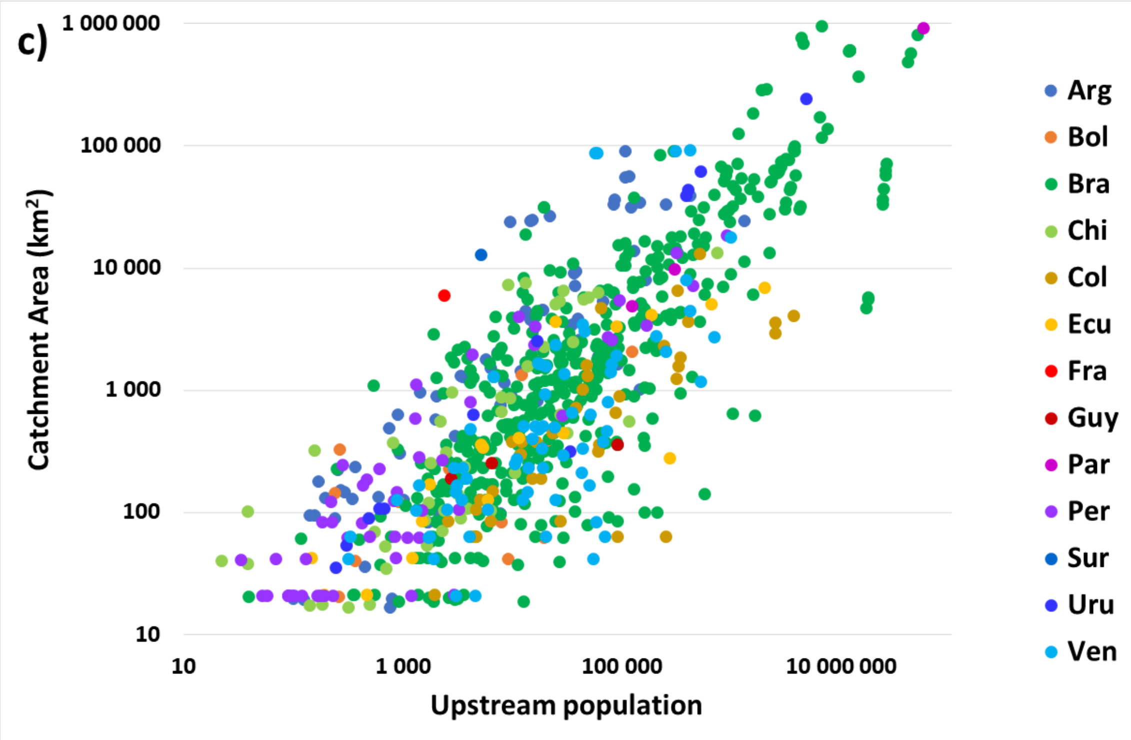

Figure c) Upstream population per catchment area and per country

Figure 2d:

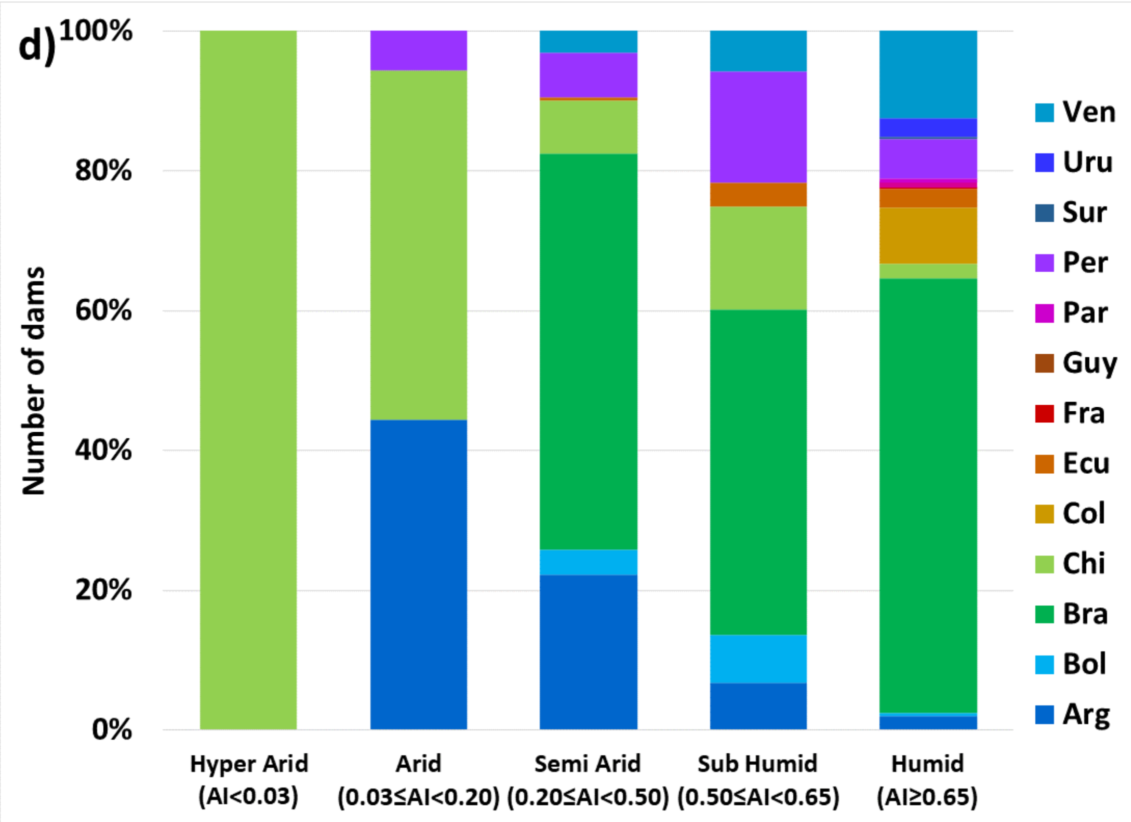

Figure d) Number of dams per aridity index type and per country

Figure 2e:

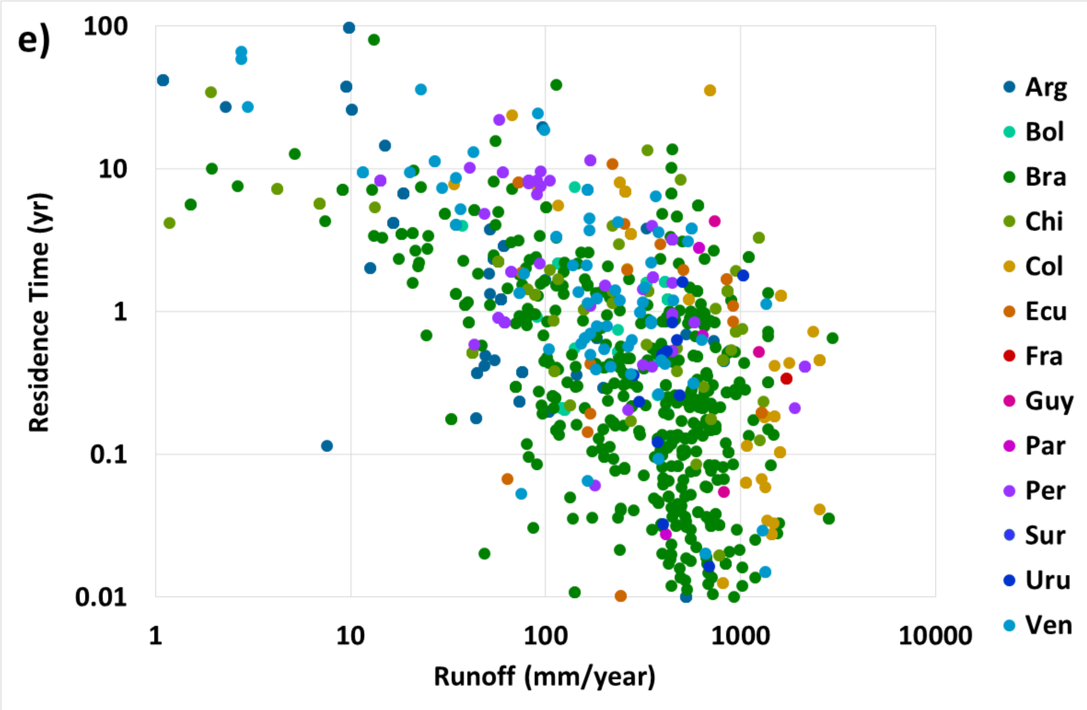

Figure e) Annual catchment runoff per residence time and per country

Figure 4:

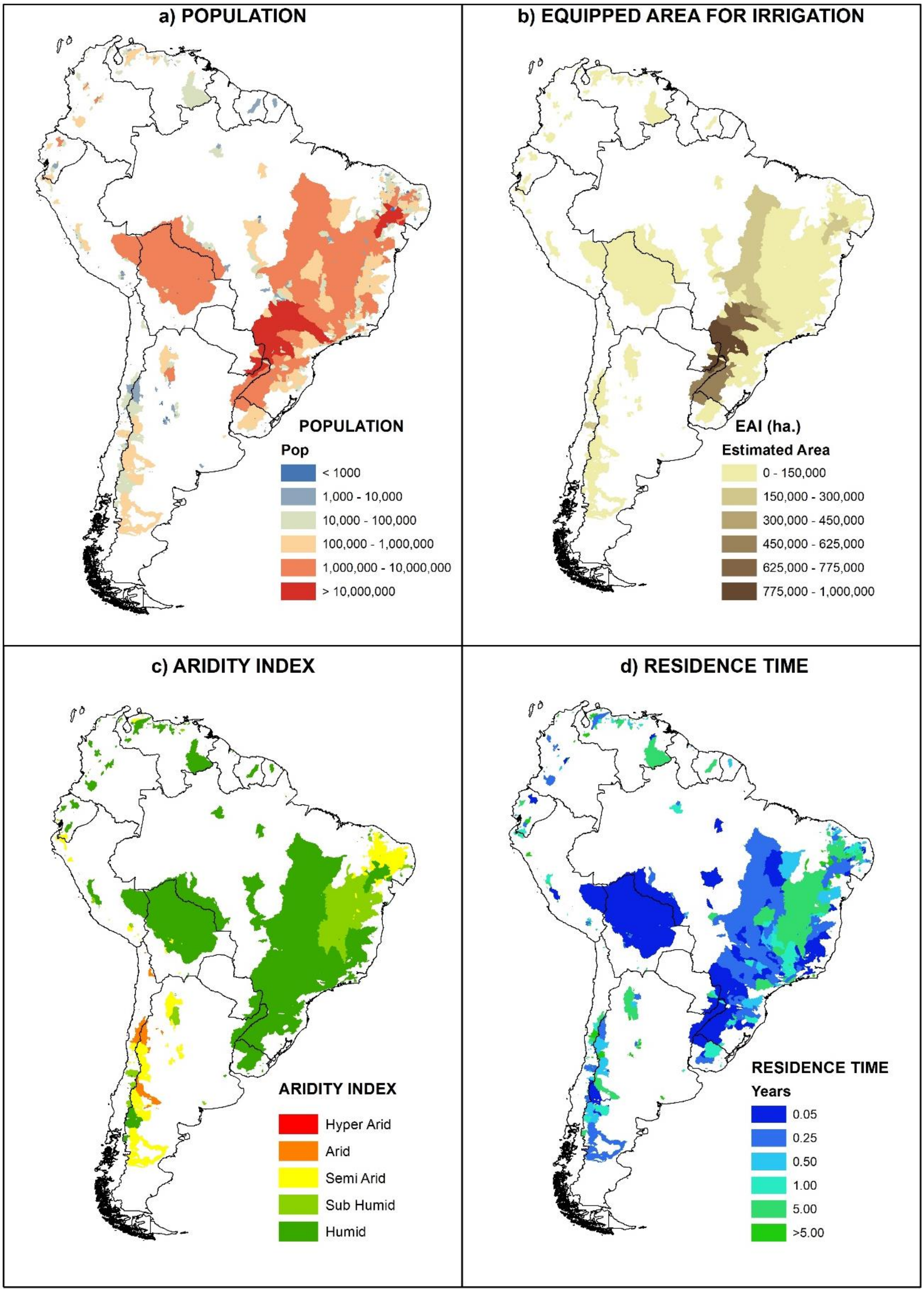

Figure 4. a) Population, b) Equipped Area for Irrigation, c) Aridity Index, d) Residence Time per dam catchment.

5. Why is 'equipped areas of irrigation' considered an 'additional information'? For me it is a hydrological information.

Response: Thank you for this suggestion. We have considered your suggestion appropriate and made an improvement on this entire section. We have removed the 'Additional information' in section 2 by combining the section '2.2 Data Sources' and the section '2.3 Data processing', into a new section '2.2 Data sources and assessment methods'. The relevant information in section 2.3 has been included in each of the groups in section 2.2. Finally, we have revised each of the groups in the new section 2.2 to include only the appropriate content.

<u>Line 91OM / 107RM:</u>

'2.2 Data sources and assessments methods

2.2.1 Compilation of preliminary information

A preliminary compilation of data regarding dams and reservoirs in the continent was first carried out to serve as a basis prior to the creation of this database. For this, two types of bibliographic sources were used: first, dams and reservoirs information from currently published databases, and second, records available about dams, reservoirs and water resources, from governments and other official sources. In the first case, we used two well-known open access databases of dams and reservoirs: the GRaND database (http://globaldamwatch.org/grand/, last access: 23 May 2020) and the AQUASTAT database (http://www.fao.org/aquastat/es/databases/dams/, last access: 23 May 2020). In the second case, we found that many governments keep up-to-date and comprehensive records of their water resources including dams and reservoirs. However, there were cases in which official information is not available. Table 1 details the public sources from which most of the information was obtained for each of the countries.

After an extensive review, we determined that georeferenced information about dams in this continent is limited. This is one of the main reasons why we aimed to develop a new database that includes all the current consistent information available. We proceeded in three stages: first, we collected all the available published information on dams and reservoirs; second, we compared and validated this data with the existing information available from local and national governments; and finally, we determined the geolocation of each point. This information has been processed and we carried out an extensive data validation and error checking, elimination of duplicate or inaccurate entries and completion of information where possible.

First, we researched for the most relevant databases of dams and reservoirs available and found three consistent results: The World Register of Dams from ICOLD, the GRaND database and the AQUASTAT database of dams. After the initial inspection, we discarded the ICOLD database because even though it is widely considered as the largest database on dams with over 57,985 entries worldwide and 1,922 dam entries in South America, it is not georeferenced nor it is an open-access database, which limits later validation of our results. Then, we inspected the AQUASTAT database (which has not been updated since 2015) and collected detailed information of more than 14,000 dams; nonetheless, in the case of South America the list consists of 1,964 dams of which only 344 entries are georeferenced. Finally, we examined the GRaND database which presents 7,320 entries, however, only 343 of those entries correspond to South America.

Once initial information was collected from open-access databases to assemble our preliminary list, we examined public records available from local and national governments in each country. We compiled them in order to compare this data with our preliminary list, data collected from governments and other public sources is available in different formats and in most cases required different types of approximation and treatment to obtain results. Each dam record was compared individually and in the case of correspondence it was accepted, in the case of countries where we did not find *available public reports, we compared and verified our preliminary records with information available on the internet, focusing on dams with reservoir capacity greater than one cubic hectometre, although some records with smaller reservoir volume were included as these could be verified in a reliable manner.*

Finally, a supplementary search on the internet was performed to exclude gaps, mismatches or errors.

2.2.2 Geolocation of entries

Once we compiled and verified our preliminary list of dams and reservoirs, we proceeded with the geolocation of each individual record. First, we verified and corrected the data of the preliminary list and then we carried out a second geolocation assessment for our final database using public access online map browsers like Google Earth (https://earth.google.com/web/, last access: 23 May 2020), Bing Maps (https://www.bing.com/maps, last access: 23 May 2020) and Open Street Maps (https://www.openstreetmap.org/#map, last access: 23 May 2020).

Although these map browsers do not provide us with the analytical capabilities of Geographic Information Systems (GIS) files and programs, these products are operative when visually searching for geographic locations and landmarks, as well as providing data that is often up to date.

In most cases, it was necessary to carry out extensive examinations for each dam since there were cases in which the names of the dams were not sufficient reference to locate them, thus, it was necessary to use additional references such as the nearby cities or villages, the reservoirs names, rivers names, or secondary or alternative names of the dams.

The coordinates in this database are described in decimal degrees using the WGS84 reference coordinate system.

2.2.3 HydroSHEDS

To perform the analysis of the dam catchments, the HydroSHEDS (Hydrological data and maps based on SHuttle Elevation Derivatives at multiple Scales) (Lehner et al., 2008) dataset was used. This product allows users access to consistent hydrographic information on a regional scale at a resolution of 15 arc seconds and was derived primarily from the Shuttle Radar Topography Mission (SRTM). The dataset information was obtained from the public site (https://www.hydrosheds.org/downloads, last access: 23 May 2020) in raster format and for this project we utilized 3 layers: void-free elevation, drainage direction and flow accumulation.

Once each dam location was verified and accepted, each location point was aligned according to the HydroSHEDS raster dataset (Lehner et al., 2008) in order to determine the dams' catchments. First, flow direction of each of the model raster cells was computed by applying the 'D8' algorithm. Second, the ridge cells between catchments were identified to delineate them. Finally, the catchment areas were calculated by counting the contributing above cells to each dam.

2.2.4 Climatic Research Unit (CRU TS 4.03) time-series dataset

Surface climate variables are commonly used inputs in studies like agriculture, ecology and biodiversity. For this reason, near-surface temperature (NST), precipitation (P) and potential evapotranspiration (PET) mean monthly values from 1901 to 2018 are included for each dam catchment in this database. This data was derived from the Climatic Research Unit (CRU) time-series dataset (Harris et al., 2020), which is hosted by the UK's National Center for Atmospheric Science (NCAS) and it is produced by the University of East Anglia's Climatic Research Unit (CRU). This dataset is *a commonly used high-resolution gridded dataset and has been compared favourably with other climatic datasets (Beck et al., 2017; Jacob et al., 2007).*

First, the datasets for each variable were downloaded in netCDF formats for monthly periods from 1901 to 2018. Then, these files were converted, resampled and aligned into raster formats in order to match the dams' catchments model. Finally, we computed the long-term mean monthly values for precipitation, near-surface temperature and potential evapotranspiration for the complete time period (1901 to 2018) and for each of the dams' catchments.

This dataset is provided in a resolution of 0.5 degrees by 0.5 degrees grid, it covers the South America continent from 1901 to 2018 and is derived from a periodic interpolation of data from a network of meteorological stations. The NST units are expressed in degrees Celsius (◦C), the PRE units are in expressed in millimetres per month (mm/month) and the PET units are expressed in millimetres per month (mm/month).

For this database we used the version 4.03, which is provided by the Center for Environmental Data Analysis (CEDA) website (https://crudata.uea.ac.uk/cru/data/hrg/#current, last access: 23 May 2020), in a NetCDF format.

2.2.5 University of New Hampshire Global Runoff Data Centre (GRDC) composite runoff field

A basic requirement in the assessment of water resource systems is monthly runoff data. For this, the mean monthly runoff data for each dam was also included in this database. We used the University of New Hampshire and Global Runoff Data Centre (UNH/GRDC) Composite Runoff field v1.0 (Fekete et al., 2002), which is often regarded as the best available runoff dataset for large scale models (Gonzàlez-Zeas et al., 2012; Lv et al., 2018). The GRDC dataset combines observed river discharge information with climate-driven water balance models in order to develop consistent composite runoff fields. The method applied in this product uses selected gauging stations data archives to a simulated topological network and compares them with outputs from water balance model (WBM) simulation performed by the authors.

The runoff dataset for South America was downloaded from the data product site in ASCII-grid formats in a resolution of 0.5 degrees by 0.5 degrees. Then, the file was converted, resampled and aligned in order to match the dams' catchments model. Finally, the mean monthly runoff data for each dam catchment was derived. The units of runoff are expressed in millimetres per month (mm/month).

The dataset was obtained from the product public site (http://www.compositerunoff.sr.unh.edu/, last access: 23 May 2020).

2.2.6 Population data from the Global Rural-urban Mapping Project (GRUMP)

Demographic data is usually a necessary input for studies that include urban or rural information on water resources assessments. Population for each of the dams' catchments is included on this database and was derived from the Global Rural-urban Mapping Project (GRUMP) (Center for International Earth Science Information Network CIESIN et al., 2011). The GRUMP dataset is provided by the Socioeconomic Data and Applications Center (SEDAC) and offers different georeferenced population datasets at continental, regional and national scale. This dataset is often used as baseline for studies that require large-scale maps of urban or rural areas (Florczyk et al., 2020; Mcdonald et al., 2011) and is based on polygons defined by the extent of the night-time light imagery and approximated urban extents from ground-based settlement points.

The dataset was downloaded from the data product public site (https://sedac.ciesin.columbia.edu/data/collection/grump-v1, last access: 23 May 2020) in ASCII format in a 30 arc second resolution. The files were converted, resampled and aligned in order to match the dam's catchment model, and then the population was computed for each dam catchment. The units of population per dam catchment are expressed in number of people.

2.2.7 Equipped Area for Irrigation from the Global Map of Irrigated Area dataset

The equipped area for irrigation (EIA) for each of the dams' catchments were extracted from the Global Map of Irrigated Areas dataset provided by the Food and Agriculture Organization of the United Nations (Siebert et al., 2005) which is often used to provide valuable information about irrigation in hydrological models (Wisser et al., 2008). This dataset is a global scale dataset of irrigated areas based on cartographic information and FAO statistics and it was developed by combining sub-national irrigation statistics with geospatial information.

The EIA data was downloaded from the data product public site (http://www.fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas/, last access: 23 May 2020) in ASCII-grid formats, then, the file was converted, resampled and aligned in order to match the dams catchment model, and then the equipped area for irrigation for each dam catchment was computed. This dataset is presented in a resolution of 0.5 degrees and it is presented in ASCII-grid formats. The units of EIA are expressed in hectares (ha).'

6. More information on the data used (section 2.2) should be provided. For example, some information is missing, as the unit of catchment irrigation area (this is only presented in figure 3, and it not presented in the main manuscript or in the provided data in Zenodo).

Response: Thank you for this suggestion. Table 4 describes the list of variables processed for dams and reservoirs in our database, this table includes information about units and other relevant information. Also, file 4. Dataset Attribute Description in the Zenodo repository, includes detailed description for all attributes in the database. Nevertheless, we have made improvements in section 2.2 to include unit's information to each subsection.

Line 441OM / 595RM:

Table 1: List of hydrological and additional information processed in this study

VARIABLE	UNIT	DESCRIPTION
CATCHMENT AREA	km^2	Calculated catchment area per dam expressed in square kilometres
NEAR SURFACE TEMPERATURE	◦C	Calculated monthly average near surface temperature value derived from the Climatic Research Unit (CRU TS 4.03) time-series dataset per each dam catchment expressed in degrees Celsius
PRECIPITATION	mm/month	Calculated monthly average precipitation value derived from the Climatic Research Unit (CRU TS 4.03) time-series dataset per each dam catchment expressed in millimetres per month
POTENTIAL EVAPOTRANSPIRATION	mm/day	Calculated monthly average potential evapotranspiration value calculated using the Pen-Monteith method derived from the Climatic Research Unit (CRU TS 4.03) time-series dataset per each dam catchment expressed in millimetres per day
GRDC	mm/month	Calculated monthly average monthly runoff derived from the University of New Hampshire Global Runoff Data Centre (GRDC) composite runoff field per each dam catchment expressed in millimetres per month
POPULATION	people	Calculated population data from the Global Rural-urban Mapping Project (GRUMP) per dam catchment
IRRIGATION	ha	Calculated irrigation area from the Global Map of Irrigated Area dataset per dam catchment expressed in hectares.

Line 125OM / 177RM:

'The NST units are expressed in degrees Celsius (◦C), the PRE units are in expressed in millimetres per month (mm/month) and the PET units are expressed in millimetres per month (mm/month).'

Line 133OM / 192RM:

'The units of runoff are expressed in millimetres per month (mm/month).'

Line 139OM / 205RM:

'The units of population per dam catchment are expressed in number of people.'

Line 145OM / 216RM:

'The units of EIA are expressed in square hectares (ha).'

7. The authors use the catchments of each dam to estimate some properties (upstream population, etc). The catchment polygons are presented in Figures 2 and 3. I think a shapefile with the polygons should also be provided in the Zenodo dataset, what is very useful for users to extract other interesting information, and it would be in the context of other initiatives of hydrological datasets as CAMELS-Chile (Alvarez-Garreton et al 2018 HESS) and CAMELS-Brazil (Chagas et al 2020 ESSD).

Response: Thank you for this suggestion. In order to assist potential users of our database we uploaded a new version of the DDSA database, including the new attributes that have been processed: aridity index, accumulated upstream reservoir capacity, average discharge volume per year, and degree of regulation. Also, we included a shapefile with the catchment polygons of each dam.

Finally, some text clarifications are still required in some parts. Some paragraphs are also too long and must be reduced or splitted. I provide some minor suggestions below.

Minor suggestions:

8. Line 9 Split into two sentences: 'In general, its relevance relies on facilitating the management of water resources for anthropogenic purposes. However, dams could also generate many potential adverse impacts related to safety, ecology orbiodiversity.'

Response: Thank you for this suggestion. We have split the initial sentence into two sentences.

Line 9OM / 9RM:

'...In general, its relevance relies on facilitating the management of water resources for anthropogenic purposes. However, dams could also generate many potential adverse impacts related to safety, ecology or biodiversity. ...'

9. L.18 'dams' catchments'

Response: Thank you for this suggestion. We have corrected the writing in this phrase.

Line 18OM / 18RM:

'...dams' catchments ...:'

Line 69RM:

'...dams' catchments...,'

Line 162RM:

'...the dams' catchments.'

Line 173RM:

'...the dams' catchments...'

Line 175RM:

'...the dams' catchments.'

Line 195OM / 191RM:

'...the dams' catchments...'

Line 203OM / 197RM:

'...the dams' catchments...'

Line 215OM / 208RM:

'...the dams' catchments...'

10. L.23 'contribute to the development...'

Response: Thank you for this suggestion. We have corrected the writing of this phrase.

Line 23OM / 23RM:

'... to contribute to the development...'

11. L.33 'assess'

Response: Thank you for this suggestion. We have corrected the writing of this word.

Line 33OM / 37RM:

'... that assess or...'

12. L.49 'La Plata' instead of 'El Plata'

Response: Thank you for this suggestion. We have corrected the writing of this word.

Line 49OM / 53RM:

'...La Plata...'

13. L.52 'which reports' instead of 'and reports'

Response: Thank you for this suggestion. We have corrected the writing of this phrase.

Line 52OM / 56RM:

'... which reports...'

14. L.54'...America it only reports...'

Response: Thank you for this suggestion. We have corrected the writing of this phrase.

Line 54OM / 58RM:

'...America it only reports...'

15. L.72 check:'5,283,000'

Response: Thank you for this suggestion. We have corrected the writing of numbers.

Line 72OM / 77RM:

'...5,283,000 ...'

16. L.74 'Paraná' with acute accent

Response: Thank you for this suggestion. We have corrected the writhing of this word.

Line 49OM / 53RM:

'... Paraná ...'

Line 74OM / 83RM:

'...Paraná ...'

17. L.81'...the continent, there exist humid...'

Response: Thank you for this suggestion. We have corrected the writing of this phrase.

Line 81OM / 83RM:

'...the continent, there exist humid...'

18. L.84'found' instead of 'find'

Response: Thank you for this suggestion. We have corrected the writing of this word.

Line 84OM / 87RM:

'...are found ...'

19. L.85'...Chile, which are blocked due to the Andes mountains, which causes low precipitation...'

Response: Thank you for this suggestion. We have corrected the writing of this phrase.

Line 85OM / 88RM:

'... Chile, which are blocked due to the Andes mountains, which causes low precipitation...'

20. L.88'and it is located'

Response: Thank you for this suggestion. We have corrected the writing this phrase.

Line 88OM / 91RM:

'...and it is located in ...'

21. L.89'for example the "El Niño",...'

Response: Thank you for this suggestion. We have corrected the writing of this phase.

Line 89OM / 94RM:

'..., the "El Niño Southern Oscillation" (ENSO)...'

Line 98RM:

'...the "El Niño" ...'

Line 99RM:

'...the "El Niño" ...'

22. L.89-90 this whole phrase is confusing, please rephrase. Besides, it is too simplistic to state that ENSO 'increases precipitation at the northwest area' since it affects in very different ways different regions of South America. Please improve this description here.

Response: Thank you for this suggestion. We have improved these paragraphs in order to improve the description of climate events in South America.

Line 89OM / 93RM:

'Climate diversity in South America is also due to the occurrence of several interannual and interdecadal large-scale climate events. For example, the "El Niño Southern Oscillation" (ENSO) which is a Pacific Ocean sea-surface temperature (SST) event that fluctuates from warm ("El Niño") and cold ("La Niña") phases, and occurs in periods of between two to seven years. The ENSO causes disruptions of precipitation and temperature in the continent and is often considered as the major source of interannual climate variability in most of South America.

In general, the "El Niño" causes low precipitation over tropical South America, high precipitation over the south east of the region and high temperatures over tropical and subtropical areas. Also, the "El Niño" is often associated to regionally diverse events like droughts in the Amazon rainforest and the north-east of South America, but also to flooding events in the tropical west coast and the south-east of the continent (Cai et al., 2020; Hao et al., 2020). On the other hand, "La Niña" generally causes the opposite precipitation and temperature events for the same areas (Garreaud et al., 2009).

Other regional climate events in South America like the sea-surface temperature (SST) anomalies in the tropical Atlantic (Garreaud et al., 2009; Jiménez-Muñoz et al., 2016), the Pacific Decadal Oscillation (PDO) (Nathan and Steven, 2002), or the Antarctic Oscillation (AAO) and the North Atlantic Oscillation (NAO) (Garreaud et al., 2009) also play an important role in the variability of South America climate.'

23. L.96 'The GRanD' - 'The' should be in lowercase.

Response: Thank you for this suggestion. We have corrected the writing of this word.

Line 96OM / 113RM:

' the GRaND database...'

24. L.112 a reference for HydroSHEDS should be included (Lehner et al), not only the dataset website

Response: Thank you for this suggestion. We have included the corresponding reference to the HydroSHEDS dataset.

Line 112OM / 155RM:

'…the HydroSHEDS (Hydrological data and maps based on SHuttle Elevation Derivatives at multiple Scales) (Lehner et al., 2008) dataset …'

25. L.119 a reference for CRU should be included (New et al)

Response: Thank you for this suggestion. We have included the corresponding reference to the CRU dataset. We should point out that we used the reference (Harris et al., 2020) because this is the reference that that authors mention in the dataset website for their latest versions. (https://crudata.uea.ac.uk/cru/data/hrg/#current).

Line 119OM / 169RM:

' This data was derived from the Climatic Research Unit (CRU) time-series dataset (Harris et al., 2020),'

26. L.127 a reference for GRDC should be included

Response: Thank you for this suggestion. We have included the corresponding reference to the GRDC dataset.

Line 127OM / 185RM:

'We used the University of New Hampshire and Global Runoff Data Centre (UNH/GRDC) Composite Runoff field v1.0 (Fekete et al., 2002),…'

27. L.135 a reference for GRUMP should be included

Response: Thank you for this suggestion. We have included the corresponding reference to the GRUMP dataset.

Line 135OM / 198RM:

'… the Global Rural-urban Mapping Project (GRUMP) (Center for International Earth Science Information Network CIESIN et al., 2011).'

28. L.135 'for each of dams' catchments...'

Response: Thank you for this suggestion. We have corrected this phrase.

Line 135OM / 197RM:

'…the dams' catchments…'

29. L.141 'catchment were extracted'

Response: Thank you for this suggestion. We have corrected this phrase.

Line 141OM / 208RM:

'… for each of the dams' catchments were extracted …'

30. L.180 ’reservoirs’ catchments’ instead of ’reservoir’s catchments’: please check this throughout the whole text. The ’catchments’ refer to all ’reservoirs’, and not just to one reservoir and stated in the current form ’reservoir’s catchments’

Response: Thank you for this suggestion. We have checked throughout the manuscript to improve the writing of this phrase. On the other hand, as mentioned above section title ‘2.3.2 Hydrological information of the reservoir’s catchments’ in line 180 has been removed due to an improvement on this section.

31. L.195 ’performed’ instead of ’calculated’

Response: Thank you for this suggestion. We have improved the writing in this phrase.

Line 195OM / 173RM:

‘Finally, we computed the long-term mean monthly values for…’

32. L.195 which statistical analysis was performed? or was it just a long-term average for each month?

Response: Thank you for this suggestion. We have improved the writing in this phrase.

Line 195OM / 173RM:

‘Finally, we computed the long-term mean monthly values for…’

33. L.225’...of the data was concluded, ...’

Response: Thank you for this suggestion. We have improved the writing in this phrase.

Line 225OM / 258RM:

‘…of the data was concluded …’

34. L.225-226 phrase too long, please reduce it or split into two phrases.

Response: Thank you for this suggestion. We have improved this phrase and divided it into two phrases.

Line 225OM / 258RM:

‘Once the review, refinement and processing of the data was concluded, a total of 1,010 dam entries were accepted for our database (Figure 1). This represents a noticeable progress in the identification and geolocation of dams in the region and thus, enables the opportunity for new research that allows a more precise understanding of the water resources systems in the region.’

35. L.228 ’GRanD’ instead of ’GrAND’ - please check throughout the text

Response: Thank you for this suggestion. We have checked throughout the manuscript to improve the writing of this term.

Line 55OM / 59RM:

‘…GRaND…’

Line 97OM / 113RM:

‘…GRaND…’

Line 158OM / 125RM:

'...GRaND...'

Line 164OM / 130RM:

'...GRaND...'

Line 228OM / 261RM:

'...GRaND...'

Line 263OM / 267RM:

'...GRaND...'

36. L.240'14,855,192'

Response: Thank you for this suggestion. We have corrected the writing of numbers.

Line 240OM / 280RM:

'...14,855,192...'

37. L.240 please split phrase in two:'...kilometres. The largest catchments...'

Response: Thank you for this suggestion. We have improved this phrase and divided it into two phrases.

Line 240OM / 280RM:

'... square kilometres. The largest catchment ...'

38. L.242 'Our results highlight the great influence and importance of the Amazon rainforest in the continent since most of the highest records': I do not understand the relevance of this phrase for the context of a database of dams.

Response: Thank you for this suggestion. We have removed this phrase and improved the understanding in this section.

Line 242OM / 280RM:

'...to the "Jirau" dam in Brazil with an estimated area of 962,732 km2. Table 4 describes the variables processed for the hydrological information included in this database.

Figure 3 presents the annual values for NST, P, PET and runoff estimated for each dam catchment. Both in the case of NST and P, higher values would seem to be mostly located near the equator, while PET higher values are more noticeable in the northeast of Brazil. In the case of runoff, values are scattered and there is no evident predominance, except for higher values localized in the southeast of Brazil.'

39. L.248 this runoff value of 2961 mm/year for Billings catchment is certainly a model error, since it does not rain that much in this catchment to have this runoff. The high precipitation rates occur more in the mountains close to São Paulo. You can check it in the Brazilian precipitation maps by the Brazilian Geological Survey (CPRM): <http://www.cprm.gov.br/publique/Hidrologia/Mapas-e-Publicacoes/Atlas-Pluviometrico-do-Brasil-1351.html>. The runoff model uncertainty should be discussed here. I honestly

Response: Thank you for this valuable suggestion. We have taken note of your observation and have verified our runoff model. Our model derives the runoff value from the cells of the UNH/GRDC dataset that are within the catchment area of each dam.

In the case of the Billings catchment, two particular situations are observed: The first is that the catchment area of this dam is smaller than the individual cell area of the UNH/GRDC dataset (0.5x0.5 decimal degrees), which prevents our model to sample enough cells to estimate a more accurate result than those which could be derived from a local study. The second is that the Billings dam catchment area is located between two cells of the UNH/GRDC dataset: the first cell is in the area of São Paulo, where the dam is located, and the other cell is located in the mountainous area near São Paulo, which is an area with high precipitation values. This second cell is where a significant part of the catchment area is located and thus, the source from the majority of the runoff value for this catchment.

After reassessing our model, we consider that the uncertainty in the runoff value computed for the Billings dam has a low probability of occurrence for other dams in our database.

However, having evidenced this situation, we have considered it necessary to include an improvement to section '3.2 Hydrological information' and section '4 Data limitation and uncertainties', mentioning the potential limitations of our hydrological inputs.

<u>Line 248OM / 280RM:</u>

'…to the "Jirau" dam in Brazil with an estimated area of 962,732 km2. Table 4 describes the variables processed for the hydrological information included in this database.

Figure 3 presents the annual values for NST, P, PET and runoff estimated for each dam catchment. Both in the case of NST and P, higher values would seem to be mostly located near the equator, while PET higher values are more noticeable in the northeast of Brazil. In the case of runoff, values are scattered and there is no evident predominance, except for higher values localized in the southeast of Brazil.'

<u>Line 259OM / 316RM:</u>

'4 Data limitations and uncertainties

The information provided in this database cannot be considered error free since it has been prepared using the information available at the time of its elaboration. It should also be noted that although our database was created independently, through an individual investigation and based primarily on reports and documents available from each of the countries in the region, the database may include attributes of dams that are also reported by other existing dam databases such as ICOLD, AQUASTAT and GRaND.

Hydrological inputs provided in this database also need careful interpretation to avoid misleading interpretations. First, the resolution of the hydrological datasets used in the DDSA database could affect the accuracy of results for small catchments. Although all the datasets considered in this database have been largely validated for large-scale or regional assessments models (Gonzàlez-Zeas et al., 2012; Lv et al., 2018), we suggest caution if the intention is to use these results in catchments with an area smaller than the cell size of each dataset.

Our results regarding aridity index, residence time and degree of regulation also need to be interpreted with caution. First, our results are intended to assess the dams' catchments and therefore, should be used carefully if intended for other type of assessment. Also, in the case of the DOR index, there are many important inputs in our assessment that may have not been considered due to the *absence of information. For example, we are not considering information about local water use, specific stream characteristics or relevant and updated urban information. Also, our DOR assessment does not consider unidentified small reservoirs, which could alter the final results. Furthermore, the impacts of river regulation also depend on a wide range of factors, e.g. local or international policies, which have not been considered either. Altogether, we consider that despite the aforementioned uncertainty factors, our results give a consistent first approximation of these indices at a regional scale.*

Finally, in order to assess the robustness of our DOR assessment, we conducted a sensitivity analysis by comparing our findings with the results determined by (Grill et al., 2019) in their manuscript 'Mapping the world's free-flowing rivers' (DoR_FFR). Figure 6 compares 409 stream matches from both studies and determines a strong correlation (r=0.702) between our results and the DoR_FFR manuscript. The correlation results are more evident on large and very large rivers.'

40. L.450 I do not understand why Figure 3 has figures e) and f), and not a) and b), since it is a figure by itself, and not a continuation of Fig 2.

Response: Thank you for this suggestion. We have updated figure 4 to correct the numbering of the maps on the Figure and also include data from aridity index and residence time.

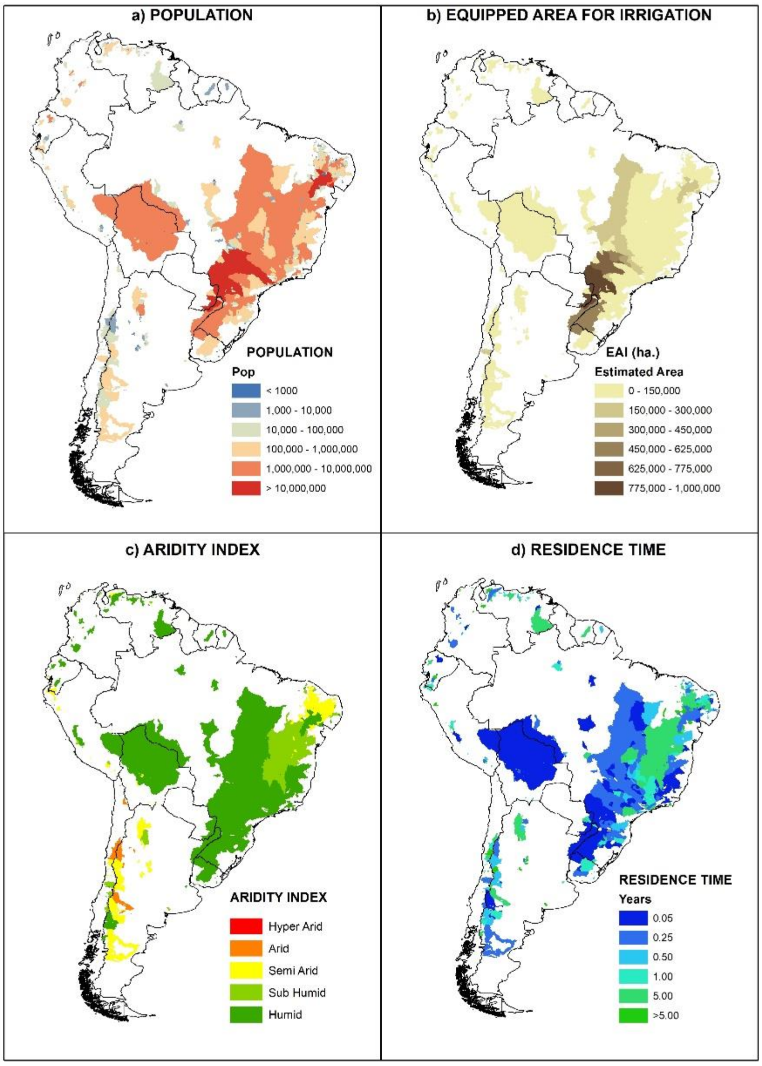

Figure 4. a) Population, b) Equipped Area for Irrigation, c) Aridity Index, d) Residence Time per dam catchment.

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