Dear Editor:

We thank you for this opportunity to revise and improve our manuscript. We have considered all comments when revising the manuscript. We have modified the manuscript with real thought as to make it more interesting and relevant to the readers of Earth System Science data. The revised version includes significant progress in addressing the issues raised by the Referees.

Please find below a detailed description of our responses to the comments made by the Referees. We gratefully acknowledge the helpful comments that have contributed to the improvement of our paper.

Sincerely,

The authors.

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, implementation phase, dam height and expected hydroelectric power.

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, the refence to lines with the suffix 'RM' refer to the revised manuscript and the refence to lines with the suffix 'TCM' refer to the revised manuscript with the track changes option activated.

Line 284OM / 360RM / 446TCM:

'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, implementation phase, dam height and expected hydroelectric power.

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 / 17TCM:

'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 / 77TCM:

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

Line 223OM / 238RM / 300TCM:

'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:

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

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 / 387TCM:

'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.'

Line 264OM / 329RM / 414TCM:

'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:

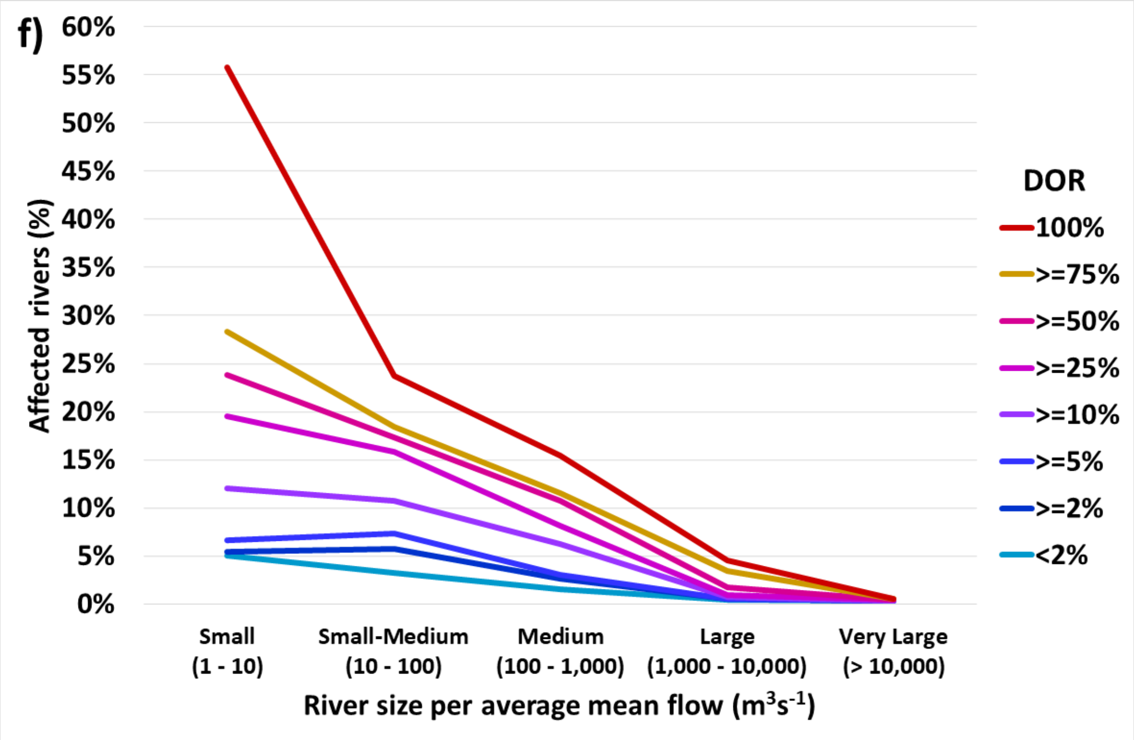

Figure f) *Cumulative affected rivers per river size and per different DOR range*

Figure 5:

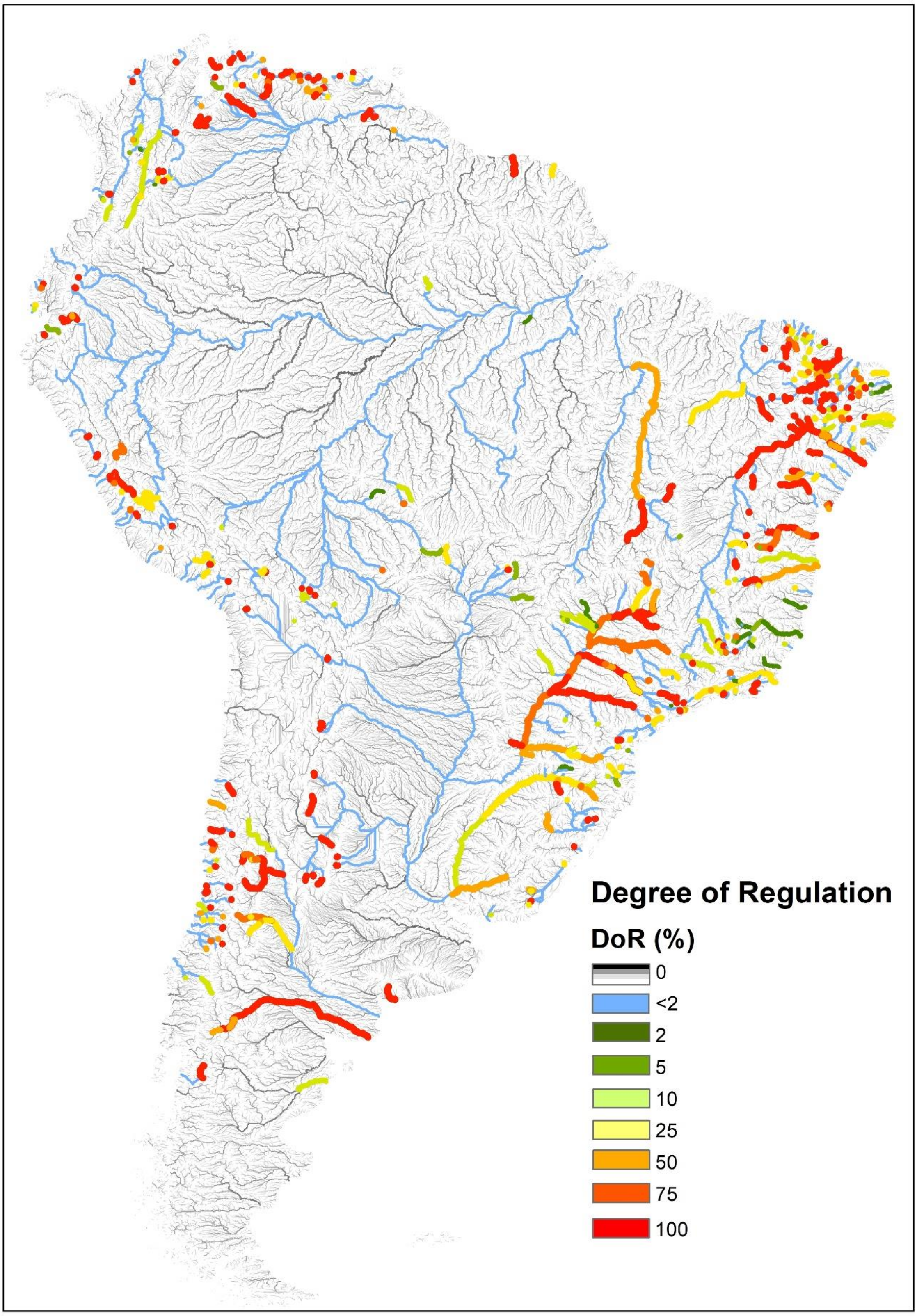

Figure 5 *Degree of Regulation (DoR) of reservoirs of the DDSA database in downstream rivers of South America.*

Figure 6:

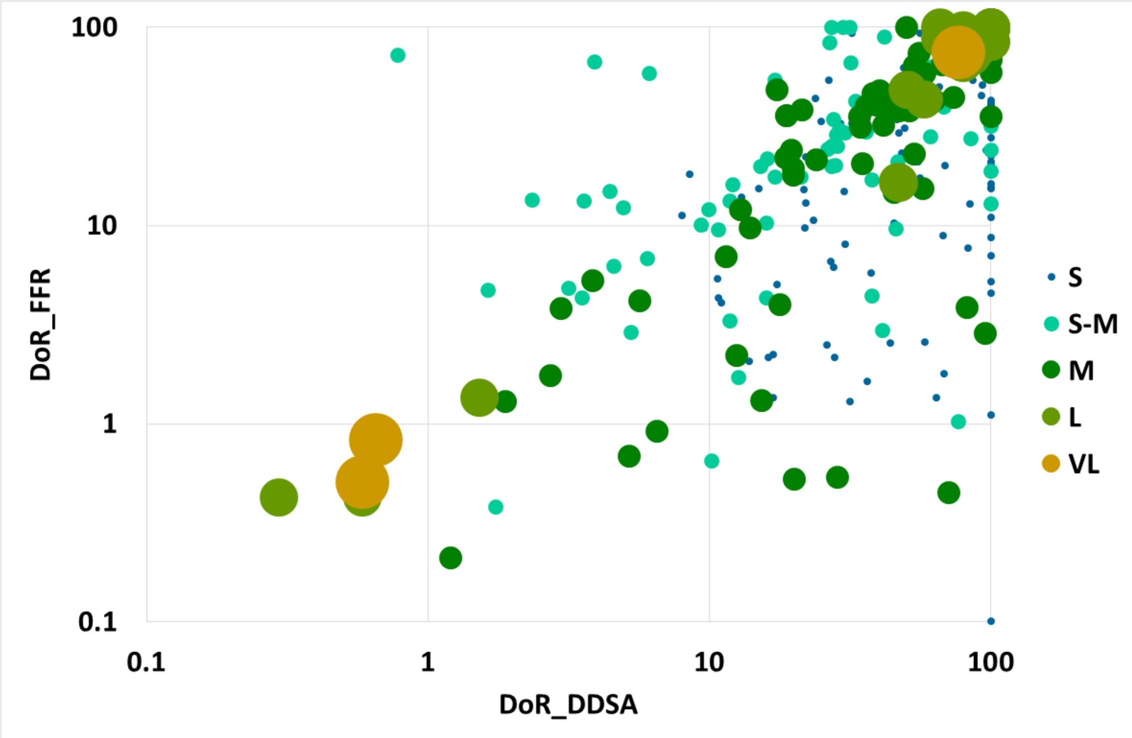

Figure 6 *DOR sensitivity analysis. Degree of regulation values from DDSA database (DoR_DDSA) were compared with matching values from (Grill et al., 2019) degree of regulation values (DoR_FFR). River were classified by their average mean flow; smaller dots represent small rivers and bigger dots represent 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 / 17TCM:

‘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 / 77TCM:

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

Line 223OM / 218RM / 280TCM:

‘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 / 318TCM:

'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 south-east 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 / 412TCM:

'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)

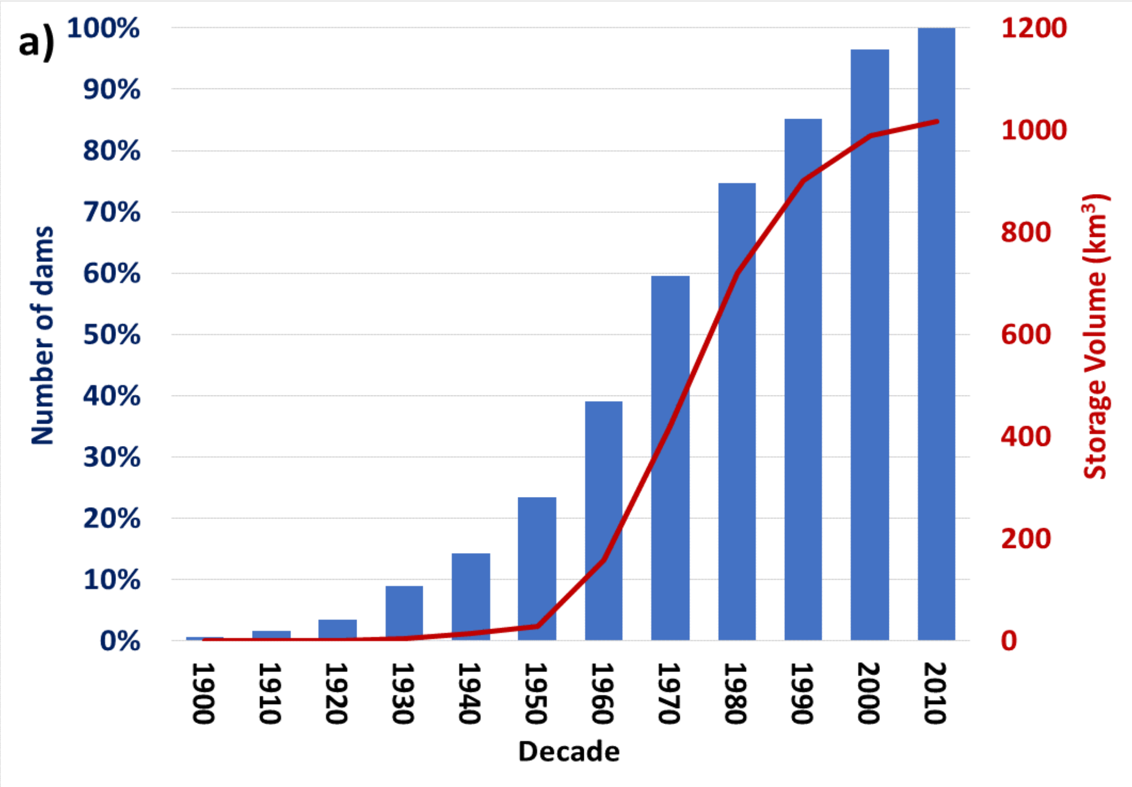

Figure 2a) Cumulative number of dams per decade and per storage volume

Figure 2b:

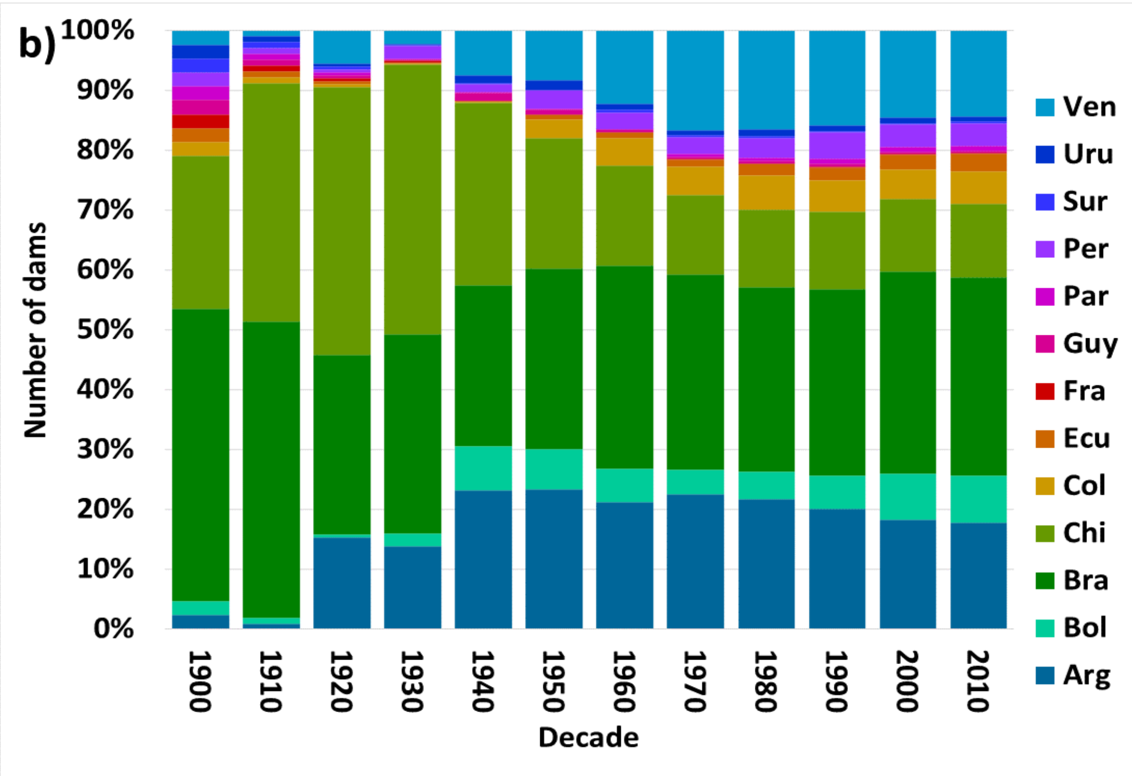

Figure 2b) Cumulative number of dams per decade per country

Figure 2c:

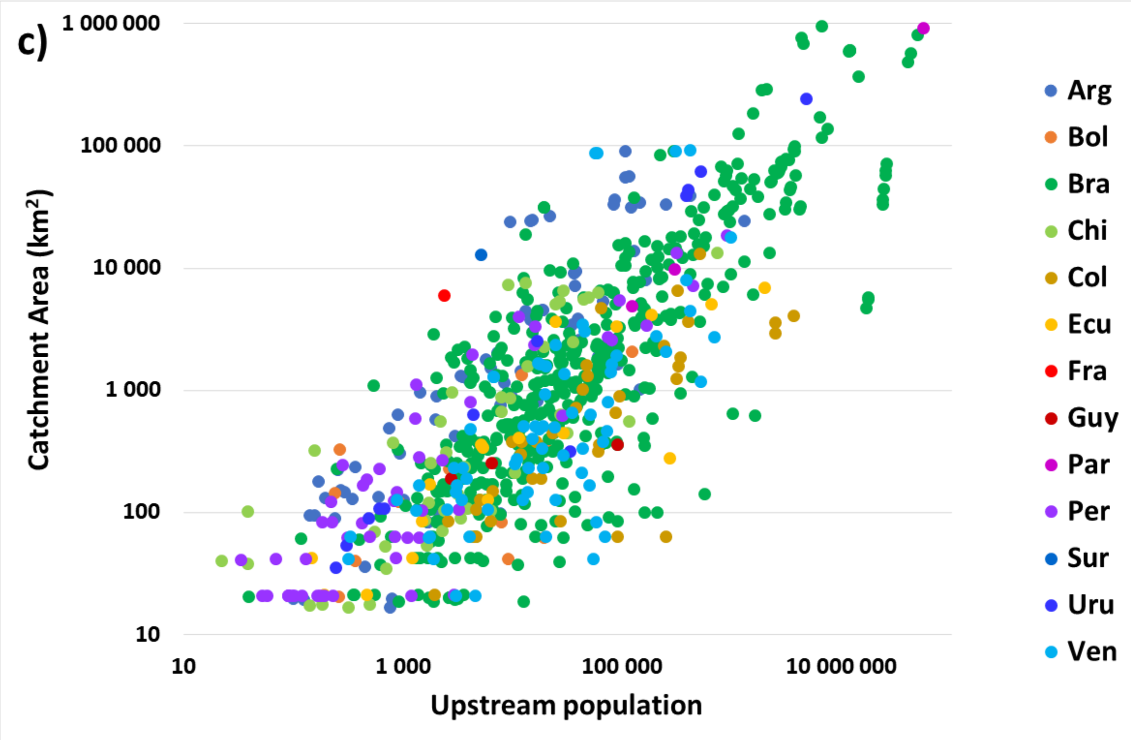

Figure 2c) Upstream population per catchment area and per country

Figure 2d:

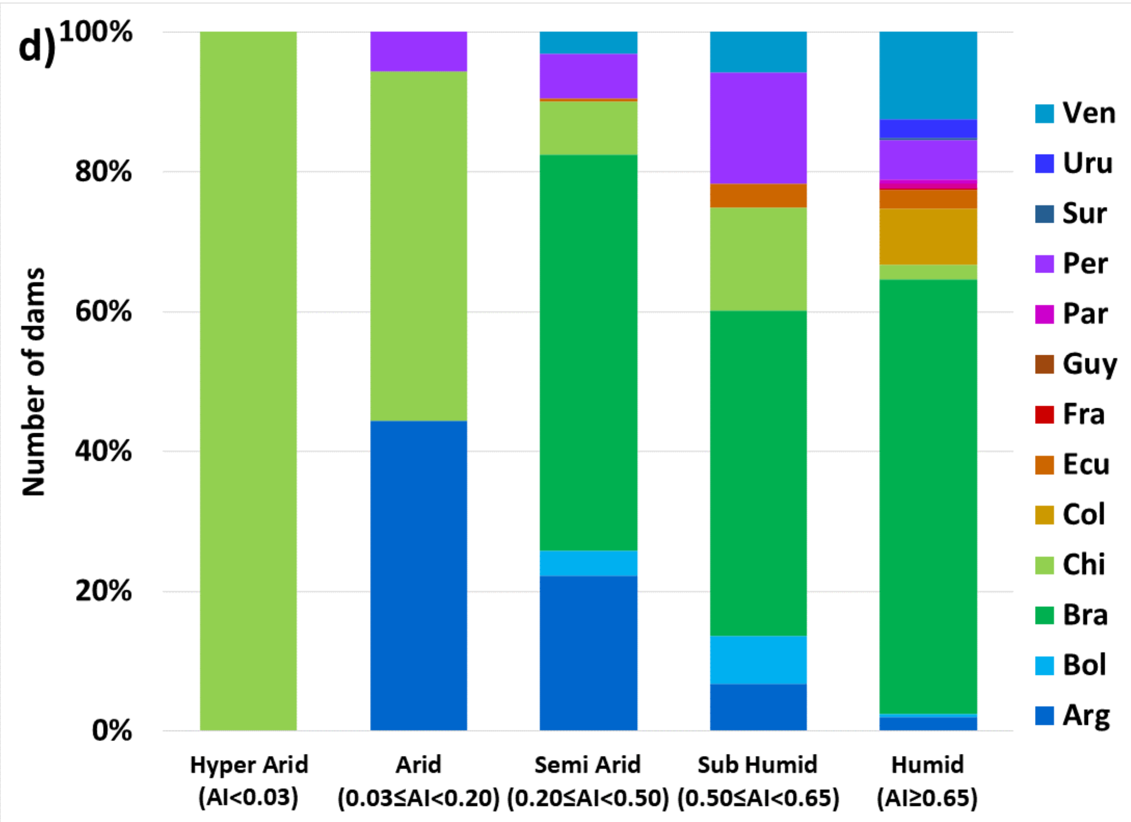

Figure 2d) Number of dams per aridity index type and per country

Figure 2e:

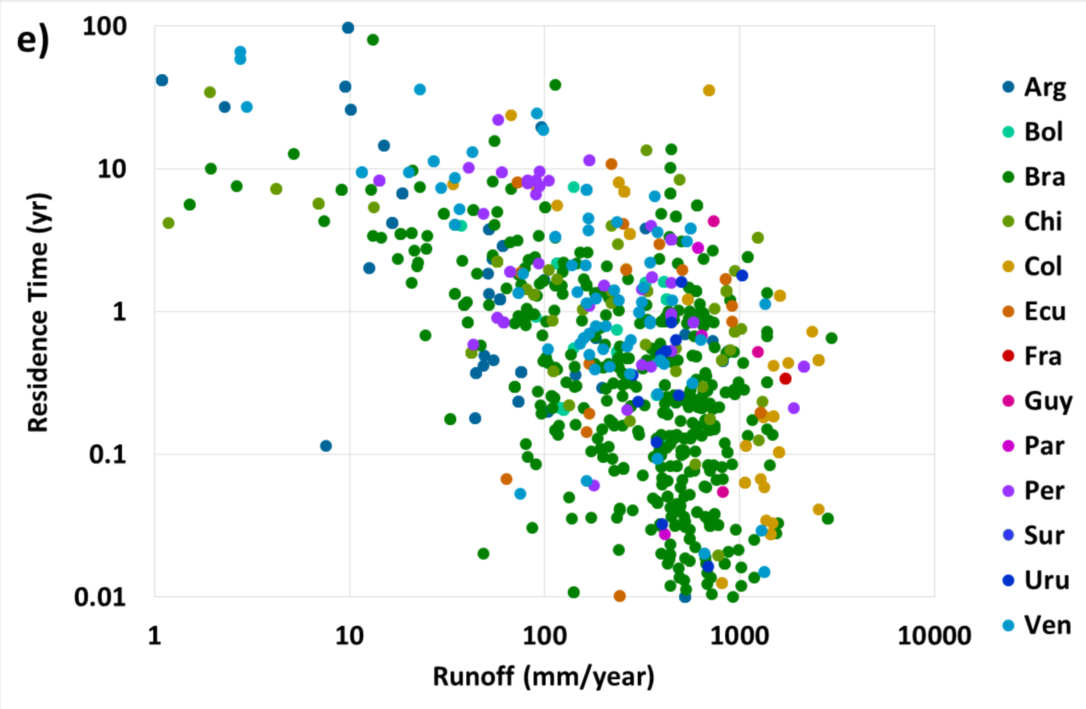

Figure 2e) Annual catchment runoff per residence time and per country

Figure 4:

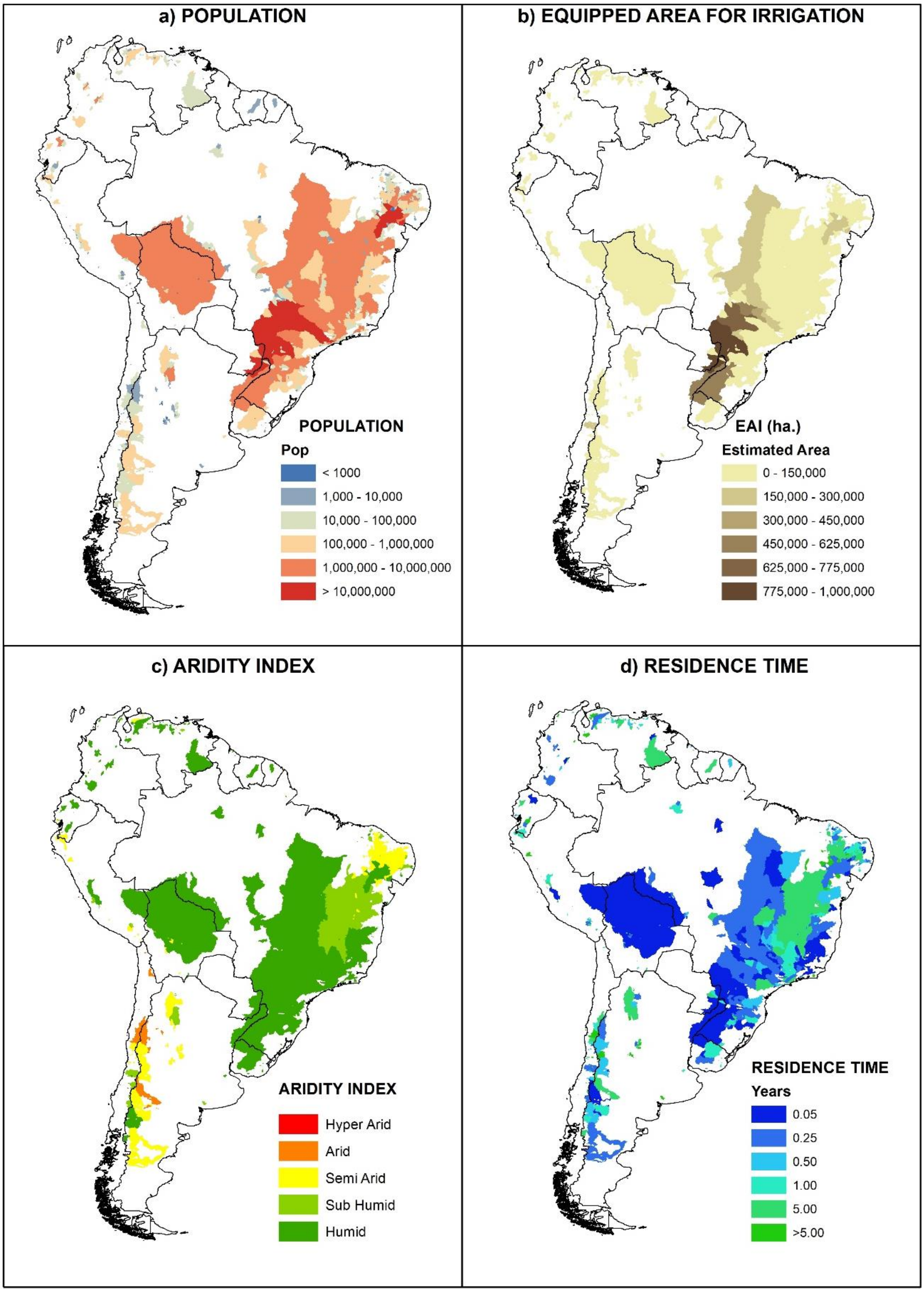

***Figure 4. a)** Population, **b)** Equipped Area for Irrigation, **c)** Aridity Index, **d)** Residence Time per dam catchment.*

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 / 120TCM:</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 / 685TCM:

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 / 241TCM:

'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 / 254TCM:

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

Line 139OM / 205RM / 267TCM:

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

Line 145OM / 216RM / 279TCM:

'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 / 9TCM:

'...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 / 18TCM:

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

__Line 239OM / 281RM / 341TCM:__

'...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 / 23TCM:__

'... 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 / 44TCM:__

'... 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 / 61TCM:__

'...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 /64TCM:__

'... 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 / 66TCM:__

'...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 / 86TCM:__

'...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 / 88TCM:__

'... Paraná ...'

Line 74OM / 83RM / 94TCM:

'...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 / 95TCM:

'...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 / 98TCM:

'...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 / 99TCM:

'... 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 / 102TCM:

'...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 / 104TCM:

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

Line 98RM / 107TCM:

'...the "El Niño" ...'

Line 99RM / 112TCM:

'...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 / 106TCM:

'Climate diversity in South America is also due to the occurrence of several interannual and inter-decadal 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 / 126TCM:

' 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 / 218TCM:

'…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 / 231TCM:

' 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 / 246TCM:

'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 / 260TCM:

'… 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 / 259TCM:

'…the dams' catchments…'

29. L.141 'catchment were extracted'

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

Line 141OM / 208RM / 270TCM:

'… 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 / 265TCM:

'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 / 265TCM:

'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 / 320TCM:

'...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 / 320TCM:

'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 / 67TCM:

'...GRaND...'

Line 97OM / 113RM / 127TCM:

'...GRaND...'

Line 158OM / 125RM / 187TCM:

'...GRaND...'

Line 164OM / 130RM / 192TCM:

'...GRaND...'

Line 228OM / 261RM / 324TCM:

'...GRaND...'

Line 263OM / 267RM / 327TCM:

'...GRaND...'

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

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

Line 240OM / 280RM / 342TCM:

'...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 / 343TCM:

'… km^2. 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 / 343TCM:

'…to the "Jirau" dam in Brazil with an estimated area of 962,732 km^2. 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.

Line 248OM / 280RM / 343TCM:

'…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 south-east of Brazil.'

Line 259OM / 316RM / 401TCM:

'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.

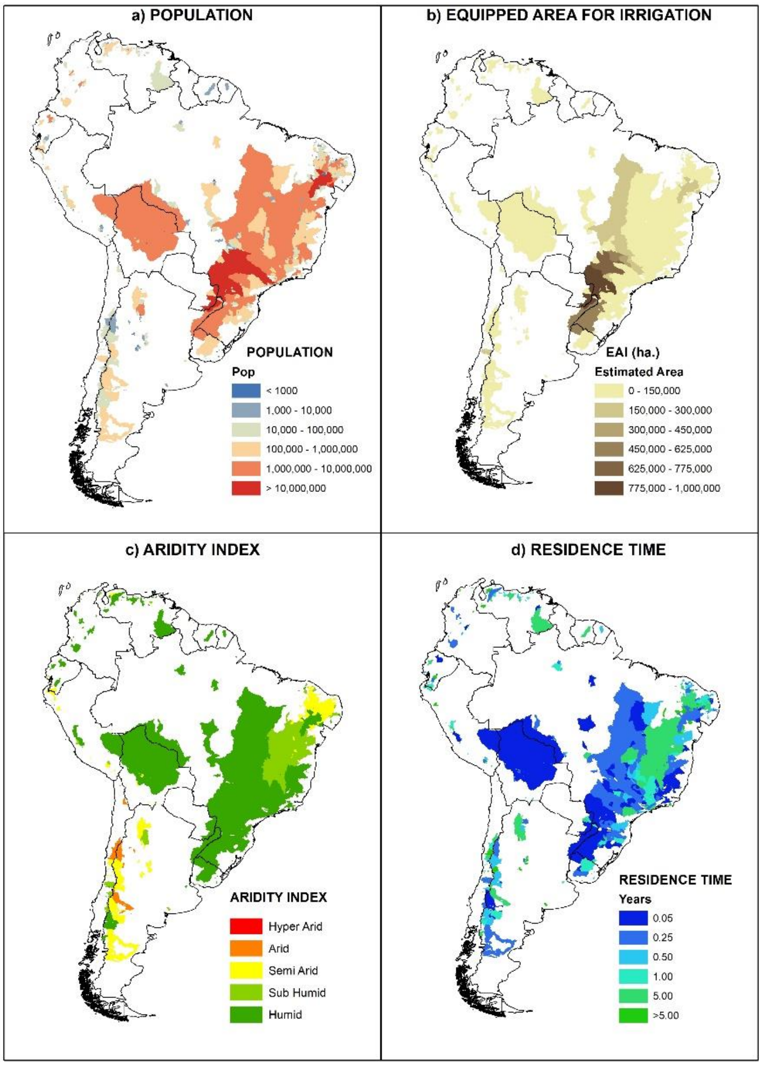

Figure 4. a) *Population,* ***b)*** *Equipped Area for Irrigation,* ***c)*** *Aridity Index,* ***d)*** *Residence Time per dam catchment.*

Response to Anonymous Referee #2

1. This manuscript entitled "Dataset of Georeferenced Dams in South America (DDSA)" clearly explains the importance of a database of georeferenced dams in South America, along with other variables that describe each local dam scenario. Thus, the purpose of the proposed work is clear and important in order to establish a base line of information for other studies related to dams and reservoirs. I think the idea and work are in concordance with the journal's and I encourage the authors to modify the text and also include guidelines for future database modifications (i.e. updates). I recommend this article for publication upon the following 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. The relevance of the proposed database for future studies will be directly linked with latest update. Thus, a mechanism for complementing the information should be provided. What should other researchers do in order to update the data on a given region?

Response: Thank you for this suggestion. We have improved section 5 in order to encourage interested researchers to make whatever contributions they deem necessary to keep our database up to date. Likewise, we have described how to access the database through the free access repository ZENODO and also, we have included in the repository access link, the contact information of the authors, in order to receive the contributions from the research community.

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 265OM / 339RM / 426TCM:

'5 Data availability

The Database of Georeferenced Dams of South America (DDSA) is a joint effort of researchers from the Department of Civil Engineering: Hydraulics, Energy and Environment of the Universidad Politécnica de Madrid and the Civil Engineering Career of the Universidad Técnica de Ambato. The DDSA database is available for both researchers and the general public through the ZENODO open access repository https://doi.org/10.5281/zenodo.3885280 (Paredes-Beltran et al., 2020), where we have detailed the contact information of the authors, in order to receive any valuable contribution which could allow us to improve our database.'

3. The Data description section is divided in three subsections: 2.1. Study Area. 2.2. Data Sources, and 2.3. Data Processing. Subsections 2.2 and 2.3 repeat a significant portion of the information. I would suggest to the authors to fusion these two into a single subsection "Data sources and assessments methods" maintaining the 7 groups originally indicated in subsection 2.2 and including within each of them the methods used for the respective data assessment.

Response: Thank you for this suggestion. We have reviewed your suggestion and found it appropriate. We have combined 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 / 120TCM:</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).'

4. Line 25. Mentions that dams are, in many cases, controversial due to "some associated negative impacts…" and the following sentence indicates that "these structures cause major impacts and changes wherever these are implemented"- this is ambiguous. Please refer to the impacts complementing line 40 in which a list of them is considered and complement it with other topics such as, morphology, water quality and habitat. Please classify them as acute and chronic impacts (time related impacts) since it will add value to the continuous monitoring efforts.

Response: Thank you for this suggestion. We have improved the two paragraphs mentioned in order to avoid ambiguity. Also, we have supplemented these sections with information on the impacts caused by dams and reservoirs.

Line 25OM / 25RM / 26TCM:

'1 Introduction

Dams and their reservoirs provide continuous water supply for different anthropogenic necessities such as electricity generation, water supply, irrigation, flood control, livestock feed or recreation. This becomes crucial in areas where water resources are scarce either by seasonality or due to the increasing effects of climate change. However, in many cases dams and their reservoirs are controversial because they can cause acute and chronic impacts in the environment and also in the nearby human settlements. These impacts are generally well known and include the modification of aquatic and terrestrial ecosystems, reduction of biodiversity, changes in the morphology of river systems, degradation of water quality and characteristics, alterations in sediments and nutrients discharge, changes in seasonal hydrological regimes, the migration of human settlements or changes in land-use patterns (Barbarossa et al., 2020; Bednarek, 2001; Nilsson et al., 2005; Pekel et al., 2016; Stoate et al., 2009).

Due to the obvious importance of dams and their reservoirs, continuous monitoring and resources needs to be dedicated on these structures. The importance of dams and reservoirs also makes them relevant for research. For example, there are studies that assess or propose improvements on construction methods for dams (Ladd, 1992; Noorzaei et al., 2006; Xu et al., 2012), examine improvements on monitoring the structural health or safety of the dam (Gabriel-Martin et al., 2017; Li et al., 2004; Sjödahl et al., 2008) or evaluate their behaviour during seismic or failure events (Alonso et al., 2005; Zabala and Alonso, 2011). Reservoirs associated with dams are also relevant, for instance, by examining the effects, impacts and management alternatives of sediments fluxes (Dai and

Liu, 2013; Kondolf et al., 2014). Usually, these studies require knowing a minimum set of characteristics of the dam, including their location and in most of the cases, need to be included into hydrological models.'

5. Line 65. Please explain which "fields" the authors are referring to.

Response: Thank you for this suggestion. We have improved this section in order to better describe the research fields where we think our database could be used.

Line 65OM / 68RM / 79TCM:

'This database has been developed to provide researchers additional information on dams, reservoirs and dams' catchments in South America, with the expectation to further promote research on dams, hydrology, water resources, ecology environmental science, geography or sociology either on a local, regional or global scale.'

6. Line 70 and 75 mention the Amazon, Parana-Rio de la Plata, and the Orinoco rivers as the largest systems in the region. Please revise to consider mentioning these fluvial systems only once when describing the study area.

Response: Thank you for this suggestion. We have improved these paragraphs in order to avoid repeated sentences.

Line 70OM / 74RM / 83TCM:

'2.1 Study Area

The study area is the continent of South America and includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, French Guiana, Paraguay, Peru, Suriname, Uruguay and Venezuela. A total of 1,010 catchments were considered which drain an area of approximately 5,283,000 km2 and discharge their waters to both the Pacific Ocean and the Atlantic Ocean. Within each of this catchments, necessary observations were made to accurately locate dams with their respective reservoirs.

The study area is diverse and full of contrasts due to its unique geography; for example, the Andes mountains are a continuously seismic region that covers the entire west coast of the continent, the Amazon rainforest in the central part of the continent, large semiarid plains in the southeast and also the Atacama desert, which is a region of extreme aridity in the southwest. In the Andes we have the presence of large glaciers that mostly drain east to form several rivers, including some of the largest in the world such as the Amazon, the Paraná - Rio de la Plata and the Orinoco river. On the east coast of the continent, there exist humid mountain formations that extend from Venezuela to northern Brazil.'

7. Line 85 refers to "El Niño" however there is no mention to "La Niña" that also brings changes to the precipitation patterns and it should be considered.

Response: Thank you for this suggestion. We have improved these paragraphs in order to improve the description of climate events in South America. We have included a description of the ENSO, as well as we have made mention of other relevant climatological events in the region.

Line 85OM / 93RM / 106TCM:

'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.'

8. Line 100 cites Table 1 regarding the government's available information. Please include the respective links to the information. This is important in order to replicate efforts in the future.

Response: Thank you for this suggestion. We have improved the description of Table 1 in order to include an additional column with the reference's information at the end of the table. We have also included the link to each source in the references section. This was due to the fact that we considered that several of the links were too long, so we preferred to mention the links in the references section to improve the visualization of the table.

Table 2: Available public data records of dams per country

COUNTRY	AVAILABLE PUBLIC INFORMATION	NUMBER OF ENTRIES	GEOREFERENCED INFORMATION	REFERENCE*
ARGENTINA	Inventario de Presas y Centrales Hidroeléctricas de la República Argentina	31	No	(Subsecretaría de Recursos Hídricos, 2010)
BOLIVIA	Inventario Nacional de Presas Bolivia	287	Yes	(Programa de Desarrollo Agropecuario Sustentable (PROAGRO), 2010)
BRAZIL	Mapa Interativo das Barragens Cadastradas	18,880	Yes	(Agencia Nacional de Aguas, 2019)
CHILE	Directorio de Presas	107	No	(Comite Nacional Chileno de Grandes Presas, 2019)
COLOMBIA	ISAGEN	-	No	(ISAGEN, 2020)
ECUADOR	Various web pages	-	No	(ElecAustro, 2020; Hidroabanico, 2019; Instituto Nacional de Pesca, 2020)
FRENCH GUIANA	Not available	-	-	
GUYANA	Not available	-	-	
PARAGUAY	Not available	-	-	
PERÚ	Inventario de Presas en el Perú	743	Yes	(Autoridad Nacional del Agua, 2016)
SURINAME	Not available	-	-	
URUGUAY	Not available	-	-	
VENEZUELA	Other	-	No	(Instituto Nacional de Estadistica, 2020)

* The data records of each country website links are detailed in the reference section

Line 257OM / 398RM / 488TCM:

Agencia Nacional de Aguas (2019) Mapa Interativo das Barragens Cadastradas no Sistema, Sistema Nacional de Informações sobre Segurança de Barragens SNISB. Available at: http://www.snisb.gov.br/portal/snisb/mapas-tematicos-e-relatorios/mapa-interativo-das-barragens-cadastradas (Accessed: 11 November 2020).

Line 302OM / 407RM / 496TCM:

Autoridad Nacional del Agua (2016) Inventario de Presas en el Peru. Lima. Available at: https://www.ana.gob.pe/etiquetas/inventario-de-presas.

Line 328OM / 442RM / 531TCM:

Comite Nacional Chileno de Grandes Presas (2019) Icold Chile - Directorio de Presas. Available at: http://www.icoldchile.cl/directorio/ (Accessed: 21 November 2019).

Line 334OM / 453RM / 542TCM:

ElecAustro (2020) Represa El Labrado. Available at: https://www.elecaustro.gob.ec/ (Accessed: 9 February 2020).

Line 361OM / 486RM / 575TCM:

Hidroabanico (2019) Hidroabanico. Available at: http://www.hidroabanico.com.ec/portal/web/hidroabanico/descripcion (Accessed: 9 February 2020).

Line 367OM / 492RM / 581TCM:

Instituto Nacional de Estadistica (2020) Principales Indicadores Ambientales. Available at: http://www.ine.gov.ve/index.php?option=com_content&view=category&id=68:princ-indicadores# (Accessed: 9 February 2020).

Line 370OM / 493RM / 584TCM:

Instituto Nacional de Pesca (2020) Embalse Chongón. Available at: http://www.institutopesca.gob.ec/embalse-chongon/ (Accessed: 9 February 2020).

Line 372OM / 497RM / 586TCM:

ISAGEN (2020) Generacion de Energia. Available at: https://www.isagen.com.co/es/nuestro-negocio/generamos-energia (Accessed: 9 February 2020).

Line 409OM / 546RM / 635TCM:

Programa de Desarrollo Agropecuario Sustentable (PROAGRO) (2010) Inventario Nacional de Presas. Edited by Viceministerio de Recursos Hídricos y Riego (VRHR). Cochabamba. Available at: https://www.bivica.org/file/view/id/2334 (Accessed: 11 November 2020).

Line 420OM / 561RM / 650TCM:

Subsecretaría de Recursos Hídricos (2010) Inventario de Presas y Centrales Hidroeléctricas de la República Argentina. Edited by Ministerio de Planificación Federal Inversión Pública y Servicios. Buenos Aires. Available at: http://datos.minem.gob.ar/dataset/inventario-de-presas (Accessed: 11 November 2020).

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Dataset of Georeferenced Dams in South America (DDSA)

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Abstract. Dams and their reservoirs generate major impacts on society and the environment. 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. These factors, and the additional effects that climate change could cause in these infrastructures and their surrounding environment, highlight the importance of dams and the necessity for their continuous monitoring and study. There are several studies examining dams both at regional and global scale, however, those that include the South America region focus mainly on the most renowned basins (primarily the Amazon basin), most likely due to the lack of records on the rest of the basins of the region. For this reason, a consistent database of georeferenced dams located in South America is presented: Dataset of georeferenced dams in South America DDSA. It contains 1,010 entries of dams with a combined reservoir volume of 1,017 cubic kilometres and it is presented in form of a list describing a total of 24 attributes that include the dams name, characteristics, purposes and georeferenced location. Also, hydrological ~~and additional~~ information on the ~~dam's~~dams' catchments is also included: catchment area, mean precipitation, mean near-surface temperature, mean potential evapotranspiration, mean runoff, catchment population ~~and~~, catchment equipped area for irrigation ~~area~~, aridity index, residence time and degree of regulation. Information was obtained from public records, governments records, existing international databases and from extensive internet research. Each register was validated individually and geolocated using public access online map browsers and then, hydrological and additional information was derived from a hydrological model computed using the ~~Hydrosheds~~HydroSHEDS dataset. With this database, we expect to contribute to the development of new research in this region. ~~The database is publicly available in https://doi.org/10.5281/zenodo.3885280.~~The database is publicly available in https://doi.org/10.5281/zenodo.3885280 (Paredes-Beltran et al., 2020).

1 Introduction

~~Dams and their reservoirs provide continuous water supply for different anthropogenic necessities such as electric generation, water supply, irrigation, livestock or flood control. This becomes crucial in areas where there is a shortage of water resources either by seasonality or due to the increasing effects of climate change. However, in many cases these projects are controversial~~

due to some associated negative impacts like the modification of stream systems, variation of ecological flows, alteration of biodiversity or due to the human resettlements these projects could generate.

In general,Dams and their reservoirs provide continuous water supply for different anthropogenic necessities such as electricity generation, water supply, irrigation, flood control, livestock feed or recreation. This becomes crucial in areas where water resources are scarce either by seasonality or due to the increasing effects of climate change. However, in many cases dams and their reservoirs are controversial because they can cause acute and chronic impacts in the environment and also in the nearby human settlements. These impacts are generally well known and include the modification of aquatic and terrestrial ecosystems, reduction of biodiversity, changes in the morphology of river systems, degradation of water quality and characteristics, alterations in sediments and nutrients discharge, changes in seasonal hydrological regimes, the migration of human settlements or changes in land-use patterns (Barbarossa et al., 2020; Bednarek, 2001; Nilsson et al., 2005; Pekel et al., 2016; Stoate et al., 2009).

Due to the obvious importance of dams and their reservoirs, continuous monitoring and resources needs to be dedicated on these structures cause major impacts and changes wherever these are implemented, which in return. The importance of dams and reservoirs also makes them relevant for research. Usually, dams are studied for various reasons and using different approaches, forFor example, there are studies that assesassess or propose improvements on construction methods for dams (Ladd, 1992; Noorzaei et al., 2006; Xu et al., 2012), examine improvements on monitoring the structural health or safety of the dam (Gabriel-Martin et al., 2017; Li et al., 2004; Sjödahl et al., 2008) or evaluate their behaviour during seismic or failure events (Alonso et al., 2005; Zabala and Alonso, 2011). Reservoirs associated with dams are also relevant, for instance, by examining the effects, impacts and management alternatives of sediments fluxes (Dai and Liu, 2013; Kondolf et al., 2014). Usually, these studies require knowing a minimum set of characteristics of the dam, including their location and in most of the cases, need to be included into hydrological models.

The influence and effects of dams on their surrounding environments is also relevant for research. For instance, the impacts caused by dams and reservoirs on water supply (Biemans et al., 2011; Bouwer, 2000; Khalkheili and Zamani, 2009), the potential effects of climate change on altered river networks (Döll et al., 2009; Nilsson et al., 2005), the prospective scenarios that climate change could cause on irrigation water (Chavez-Jimenez et al., 2015; Elliott et al., 2014; Garrote et al., 2015), the repercussions of dams on water resources and biodiversity (Bejarano et al., 2017; Liermann et al., 2012; Vörösmarty et al., 2010) or the hydrological alterations caused by dams and reservoirs (Batalla and Go, 2004; Ibàñez and Prat, 1996).

In South America, relevant studies about dams at a full regional scale are rather scarce and usually focus on aquatic biodiversity conservation (Barletta et al., 2010; Reis et al., 2016) or river segmentation (Castello et al., 2013; Fearnside, 2001; Latrubesse et al., 2017; Roberto et al., 2009) and in most of the cases their conclusions highlight that potential negative effects of dams are low to moderate. However, these studies generally present two important limitations when trying to reach a full region scale: first, these focus only on the most relevant or renowned basins such as the Amazon, Parana - ElParaná - La Plata or Orinoco, and second, these only consider a limited amount of dam records.

There are several published dam databases that include information from South America. The largest and most recognized database is the World Register of Dams published by the International Commission on Large Dams (ICOLD, 2020) ~~and~~which reports 1,922 dams entries for South America; nonetheless, this database is not georeferenced which limits its use. AQUASTAT database was presented by (FAO, 2015) but it has not been updated since 2015 and for South America it only reports 344 entries of georeferenced dams. Finally, another relevant database is the ~~GRanD~~GRaND database (Lehner et al., 2011) which has been updated for the year 2019 and accounts for 343 geolocated dam entries for South America.

Here, we present an extensive and revised database with 1,010 registers of dams in South America, including information on their identification, the dam main characteristics, the dam purposes and their spatial location. Also, it includes hydrological ~~and additional~~ information derived from the ~~HYDROSHEDS~~HydroSHEDS dataset ~~(Lehner et al., 2008a): catchment area, mean near~~ (Lehner et al., 2008): catchment area, mean near-surface temperature, mean precipitation and mean potential evapotranspiration from the Climatic Research Unit (CRU) time-series dataset (Harris et al., 2020), mean runoff from the University of New Hampshire Global Runoff Data Centre (GRDC) composite runoff field (Fekete et al., 2002), catchment population data from the Global Rural-urban Mapping Project (GRUMP) (Center for International Earth Science Information Network CIESIN et al., 2011)~~ and~~, catchment equipped area for irrigation from the Global Map of Irrigated Area dataset (Siebert et al., 2005)~~.~~, aridity index, residence time and degree of regulation. This database has been developed to provide researchers additional information on dams, reservoirs and dams' catchments in ~~this region~~South America, with the expectation to further promote research on dams, hydrology, water resources, ecology environmental science, geography or sociology either on a local, regional or global scale~~ in any of the fields described.~~.

This database is publicly available free for use in https://doi.org/10.5281/zenodo.3885280 (Paredes-Beltran et al., 2020).

2 Data description

2.1 Study Area

The study area is the continent of South America and includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, French ~~Guyana~~Guiana, Paraguay, Peru, Suriname, Uruguay and Venezuela. A total of 1,010 catchments were considered which drain an area of approximately ~~5'283~~5,283,000 ~~square kilometres~~km^2 and discharge their waters to both the Pacific Ocean and the Atlantic Ocean~~; also, many of these catchments belong to some of the most emblematic rivers of the region such as the Amazon, the Parana - Rio de la Plata or the Orinoco River which drain water from several countries~~. Within each of this catchments, necessary observations were made to accurately locate dams with their respective reservoirs.

The study area is diverse and full of contrasts due to its unique geography; for example, the Andes mountains are a continuously seismic region that covers the entire west coast of the continent, the Amazon rainforest in the central part of the continent, large semiarid plains in the southeast and also the Atacama desert, which is a region of extreme aridity in the southwest. ~~To the north of~~In the Andes we have the presence of large glaciers that mostly drain east to form several rivers, including some of the largest in the world such as the Amazon~~ and~~, the Paraná - Rio de la Plata ~~in the south~~ and the Orinoco river~~ in the north.~~. On the east coast of the continent, there exist humid mountain formations that extend from Venezuela to northern Brazil. The climate on the continent is ~~varied~~diverse mainly due to its size and topography, but also due to its wind patterns and ocean currents. Around the equator, climate can be considered mainly as tropical and humid with large amounts of rain, which decreases while moving further north and south of the equator, where different weather patterns are ~~find~~found. In the southern part of the continent, the humid winds of the Pacific Ocean provide rain to several areas in the coast of Chile, ~~this winds~~which are blocked due to the Andes mountains~~, which~~ and causes low precipitation around the year in the Patagonia region in the southeast. The climate within the Andes mountains ~~are~~is characterized as dry and cold~~, which~~ and covers the highest mountains with snow all year round. The driest region in the continent is the Atacama Desert due to its almost zero humidity, and ~~its~~it is located in the north of Chile and the south of Peru. ~~There are also important climate phenomena in South America, for example "El Niño", which greatly increases precipitation at the northwest area of the continent and have been occurred between periods of two to seven years.~~

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.

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 the GRaND database (http://globaldamwatch.org/grand/, last access: 23 May 2020) database and the AQUASTAT database (http://www.fao.org/aquastat/es/databases/dams/, last access: 23 May 2020) database. It should be noted that although the WORLD REGISTER OF DAMS published by ICOLD is often considered to be the most comprehensive database on dams and reservoirs, is not open access nor has georeferenced entries, which ultimately led to discard it from this study.). In the second case, it was notedwe 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.

2.2.2 Geolocation of entries

To geolocate each dam record we used public access online map browsers such as: 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 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. 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) 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.

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

Mean monthly temperature, precipitation and potential evapotranspiration data was derived from the Climatic Research Unit (CRU TS 4.03) time-series dataset which is hosted by the UK's National Center for Atmospheric Science (NCAS) and produced by the University of East Anglia's Climatic Research Unit (CRU). The data in this dataset is provided in a resolution of 0.5 degrees by 0.5 degrees grid and completely covers the South America continent from 1901 to 2018. This product is derived from periodic interpolation of data from a network of meteorological stations. For this database we used the current 4.03 version, 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~~

~~Runoff data was obtained from the University of New Hampshire Global Runoff Data Center (GRDC) composite runoff field, which is a product developed by the Water Systems Analysis Group (WSAG) at CSRC at the University of New Hampshire (UNH). The GRDC is a dataset that 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 data in this dataset is provided in a resolution of 0.5 degrees by 0.5 degrees in ASCII formats and 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)~~

~~The estimated population data for each of the dams catchment was derived from the Global Rural-Urban Mapping Project (GRUMP) provided by the Socioeconomic Data and Applications Center (SEDAC), which offers different georeferenced population datasets at continental, regional and national scales. The data was obtained from the products 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.~~

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

~~The equipped areas for irrigation for each dam catchment was extracted from the Global Map of Irrigated Areas dataset provided by the Food and Agriculture Organization of the United Nations and it was developed by combining sub-national irrigation statistics with geospatial information. This dataset is presented in a resolution of 0.5 degrees and it is presented in ASCII grid formats. The files were obtained from the products public site (http://www.fao.org/aquastat/en/geospatial-information/global-maps-irrigated-areas/, last access: 23 May 2020).~~

~~2.3 Data processing~~

~~2.3.1 Dams and reservoirs characteristics~~

After an extensive review~~ of available information about dams and reservoirs in South America~~, we determined that georeferenced information about dams in this continent is limited. ~~It~~This is one of the main reasons why we aimed to develop a new database that includes all the current consistent information available. ~~This database is the result of the compilation and treatment of information available from existing public documents from national governments, existing open databases and other web sources. For this, we~~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~~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 ~~collects~~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~~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, ~~emphasizing~~focusing on dams with ~~a~~ reservoir capacity greater than one cubic hectometre, although some records with smaller ~~volume of~~ reservoir volume were included as these ~~were able to~~could be verified in a reliable manner.

Finally, a supplementary search ~~in~~ on the internet was performed in order 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).

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:

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

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≤AI<0.20), semi-arid (0.20≤AI<0.50), subhumid, (0.50≤AI<0.65) and humid (AI≥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:

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

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.

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:

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

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.

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~~, this~~ (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~~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 ~~for~~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~~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~~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 ~~dam’s~~dams’ catchments is approximately ~~14’855~~14,855,192 ~~square kilometres~~km^2 with an average catchment of 18,385 ~~square kilometres, the~~ km^2. The largest catchment belongs to the “Jirau” dam in Brazil with an estimated area of 962,732 ~~square kilometres.~~km^2. Table 4 describes the variables processed for the hydrological information ~~and~~ included in this database. ~~Our results highlight the great influence and importance of the Amazon rainforest in the continent since most of the highest records are observed in this region. In the case of temperature, the highest annual record is located in the catchment of the “Malhada Vermelha” dam in Brazil with a temperature of 27.89 degrees Celsius. In the case of precipitation, the highest annual record is in the catchment of the “Petit Sout” dam in French Guiana with a total of 3,035.74 millimetres per year. The highest potential evapotranspiration record is documented for the catchment of the “Pilões” dam in Brazil with 1,713.32 millimetres per year. Finally, in the case of runoff, the highest annual recorded value is located in the catchment of the "Billings" dam, located in Brazil with 2,961.70 millimetres per year. On the other hand, the lowest records are observed mostly in the southern part of the continent in the Andes mountains, with the lowest temperature being recorded in July in the catchment of the “El Yeso” dam in Chile with -3.36 degrees Celsius, the lowest annual precipitation occurs in the catchment of the "Austral" dam in Chile with 5.21 millimetres per year, and the lowest potential evapotranspiration is recorded in the catchment of the "Huelchueico" dam in Chile with 0.72 millimetres per day in June. Figure 2 details the annual average values for each of the hydrological variables included in this database.~~

~~3.3 Additional Information~~

~~Table 4 describes the variables processed for the additional information provided in this database. Both, in the case of population and equipped areas for irrigation, the highest values belong to “Yacyreta” catchment dam with more than 55 million people in the case of population and more than 930,000 square kilometres of equipped areas for irrigation. Figure 3 depicts the values for population an equipped area for irrigation for all catchments in the 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.

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.

5 Data limitations

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.

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.

6 Data availability

The Database of Georeferenced Dams of South America (DDSA) is available in https://doi.org/10.5281/zenodo.3885280

5 Data availability

The Database of Georeferenced Dams of South America (DDSA) is a joint effort of researchers from the Department of Civil Engineering: Hydraulics, Energy and Environment of the Universidad Politécnica de Madrid and the Civil Engineering Career of the Universidad Técnica de Ambato. The DDSA database is available for both researchers and the general public through the ZENODO open access repository https://doi.org/10.5281/zenodo.3885280 (Paredes-Beltran et al., 2020), where we have detailed the contact information of the authors, in order to receive any valuable contribution which could allow us to improve our database.

~~7~~6 Summary

The database of georeferenced dams in South America (DDSA) has been developed to contribute to the improvement of water resources management in the region. The provision of reliable, high-resolution and available data on dams and reservoirs will contribute in the assessment of freshwater ecosystems and communities both for present and future scenarios in this region, which to this date, have been restricted to a limited number of catchments due to the absence of available information, and thus, contributing to generate more informed decision-making processes in order to safeguard the future sustainability of the communities in this region.

The 1,010 entries of dams present a total of 24 attributes. Each record has been included in the list after an individual review and its position has been determined considering public digital terrain models. In addition, the database also provides mean monthly hydrological information. With this increased spatial coverage and attributes information, this database could be used as a baseline for further studies that address relevant issues regarding dams, hydrology, ecology and people in the region. Also, with the inclusion of data for all the countries in the continent we also expect to contribute to an in-depth comprehension on the hydrological and environmental dynamics for the entire continent, and encouraging the generation of knowledge in areas that have not been considered in past studies.

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 ~~databased~~database is largely based on open-access information available to date, therefore, ~~it is necessary to expect for further contributions and monitoring in order to provide new data inputs and updates that may keep this database relevant to the public.~~ 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.

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Author contributions~~.~~

BEPB: Conceptualization, Investigation, Data curation, Validation, Software, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. ASW: Conceptualization, Formal analysis, Funding acquisition, Methodology, Validation, Writing - review & editing, Supervision, Resources. LG: Formal analysis, Software, Funding acquisition, Validation, Writing - review & editing, Supervision, Resources, Project administration.

Competing interests

The authors declare that they have no conflict of interest.

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Table 1: Available public data records of dams per country

COUNTRY	AVAILABLE PUBLIC INFORMATION	NUMBER OF ENTRIES	GEOREFERENCED INFORMATION
ARGENTINA	Inventario de Presas y Centrales Hidroeléctricas de la República Argentina (Subsecretaría de Recursos Hídricos, 2010)	31	No
BOLIVIA	Inventario Nacional de Presas Bolivia (Programa de Desarrollo Agropecuario Sustentable (PROAGRO), 2010)	287	Yes
BRAZIL	Mapa Interativo das Barragens Cadastradas (Agencia Nacional de Aguas, 2019)	18,880	Yes
CHILE	Directorio de Presas (Comite Nacional Chileno de Grandes Presas, 2019)	107	No
COLOMBIA	Other *(Internet pages)* (ISAGEN, 2020)	-	No
ECUADOR	Other *(Internet pages)* (ElecAustro, 2020; Hidroabanico, 2019; Instituto Nacional de Pesca, 2020)	-	No
FRENCH GUYANA	Not available	-	-
GUYANA	Not available	-	-
PARAGUAY	Not available	-	-
PERÚ	Inventario de Presas en el Perú (Autoridad Nacional del Agua, 2016)	743	Yes
SURINAME	Not available	-	-
URUGUAY	Not available	-	-
VENEZUELA	Other *(Internet pages)* (Instituto Nacional de Estadistica, 2020)	-	No

Table 1: Available public data records of dams per country

COUNTRY	AVAILABLE PUBLIC INFORMATION	NUMBER OF ENTRIES	GEOREFERENCED INFORMATION	REFERENCE*
ARGENTINA	Inventario de Presas y Centrales Hidroeléctricas de la República Argentina	31	No	(Subsecretaría de Recursos Hídricos, 2010)
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BRAZIL	Mapa Interativo das Barragens Cadastradas	18,880	Yes	(Agencia Nacional de Aguas, 2019)
CHILE	Directorio de Presas	107	No	(Comite Nacional Chileno de Grandes Presas, 2019)
COLOMBIA	ISAGEN	-	No	(ISAGEN, 2020)
ECUADOR	Various web pages	-	No	(ElecAustro, 2020; Hidroabanico, 2019; Instituto Nacional de Pesca, 2020)
FRENCH GUIANA	Not available	-	-	
GUYANA	Not available	-	-	
PARAGUAY	Not available	-	-	
PERÚ	Inventario de Presas en el Perú	743	Yes	(Autoridad Nacional del Agua, 2016)
SURINAME	Not available	-	-	
URUGUAY	Not available	-	-	
VENEZUELA	Other	-	No	(Instituto Nacional de Estadistica, 2020)

* The data records of each country website links are detailed in the reference section

Table 2: Number of new dam entries per country

COUNTRY	DDSA	OTHER DATABASES			NEW ENTRIES PER COUNTRY
		GRAND	AQUASTAT	SIMILAR ENTRIES TO DDSA*	
ARGENTINA	107	35	0	35	72
BOLIVIA	66	3	56	57	9
BRAZIL	507	182	0	182	325
CHILE	73	10	0	10	63
COLOMBIA	58	24	16	33	25
ECUADOR	21	6	2	6	15
FRENCH ~~GUYANA~~GUIANA	2	1	1	1	1
GUYANA	3	0	0	0	3
PARAGUAY	4	2	0	2	2
PERÚ	73	13	0	13	60
SURIMANE	1	1	0	1	0
URUGUAY	13	4	0	4	9
VENEZUELA	82	32	0	32	50
TOTAL	**~~1010~~1,010**	**313**	**75**	**376**	**634**

* In some cases, AQUASTAT and ~~GRanD~~GRaND entries were duplicated, so they were considered as a single entry

Table 3: List of variables processed for dams and reservoirs

VARIABLE	UNIT	DESCRIPTION
ID		Unique Id number for each dam
NAME OF THE DAM		Name of the dam
OTHER NAME		Alternative names given to the dam (aliases, former names)
DECIMAL DEGREE LATITUDE	Decimal Degrees	Latitude coordinate of point location of the dam.
DECIMAL DEGREE LONGITUDE	Decimal Degrees	Longitude coordinate of point location of the dam
HEIGHT	m	Height of the dam above foundation expressed in meters
LENGTH	m	Length of the dam measured at the crest expressed in meters
RESERVOIR CAPACITY	MCM	Capacity of the reservoir expressed in million cubic meters
RESERVOIR AREA	~~sq. km.~~ km^2	Area of the reservoir expressed in square kilometres
RESERVOIR NAME		Name of the reservoir or water body, if different from the dam name
RIVER		Name of the river in which the dam is located
INTERNATIONAL		Indicates if the dams or reservoirs lie within more than one country
YEAR OF COMPLETION		Reported year of completion of the dam
FLOOD CONTROL		Use of the dam for Flood Control
IRRIGATION		Use of the dam for Irrigation
HYDROELECTRICITY		Use of the dam for Hydroelectricity
NAVIGATION		Use of the dam for Navigation
RECREATION		Use of the dam for Recreation
WATER SUPPLY		Use of the dam for Water Supply
OTHER USE		Use of the dam for other purposes
COUNTRY		Name of country
NEAREST TOWN		Name of the nearest town or city to the dam location
STATE / PROVINCE		Additional information about the location of the dam
NOTE		Specific comments of importance

Table 4: List of hydrological and additional information processed in this study

VARIABLE	UNIT	DESCRIPTION
CATCHMENT AREA	sq. km.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	Peoplepeople	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.
ARIDITY INDEX	n/a	Calculated aridity index per dam catchment. The aridity index is unitless.
RESIDENCE TIME	years	Calculated residence time index per each dam reservoir. The residence time is expressed in years.
DEGREE OF REGULATION	%	Calculated degree of regulation index per dam stream reach. Degree of regulation is expressed in percentage.

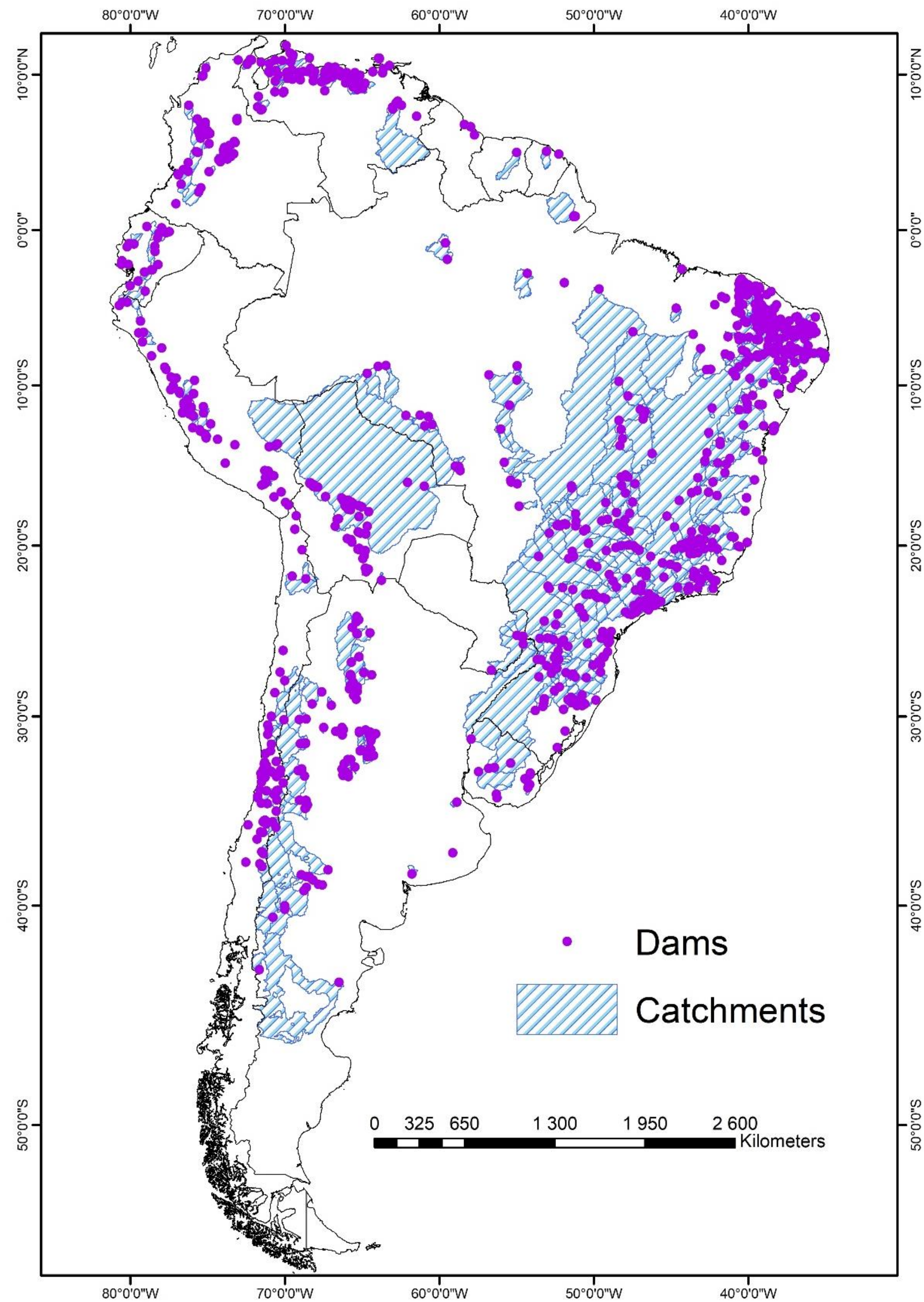


Figure 1. Dataset of Georeferenced Dams in South America (DDSA)

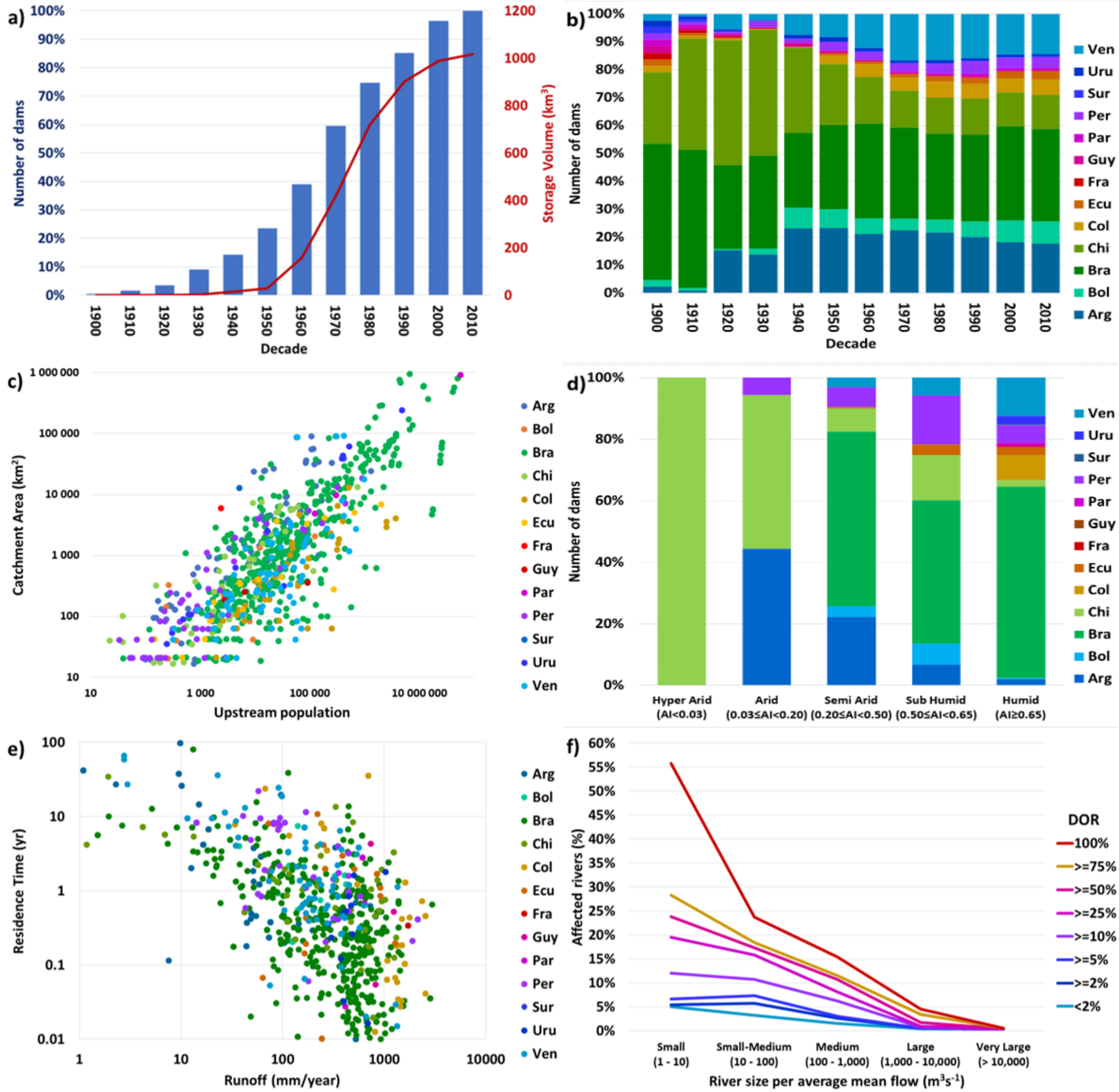


Figure 2 **a)** Cumulative number of dams per decade and per storage volume **b)** Cumulative number of dams per decade per country **c)** Upstream population per catchment area and per country **d)** Number of dams per aridity index type and per country **e)** Annual catchment runoff per residence time and per country **f)** Cumulative affected rivers per river size and per different DOR range.

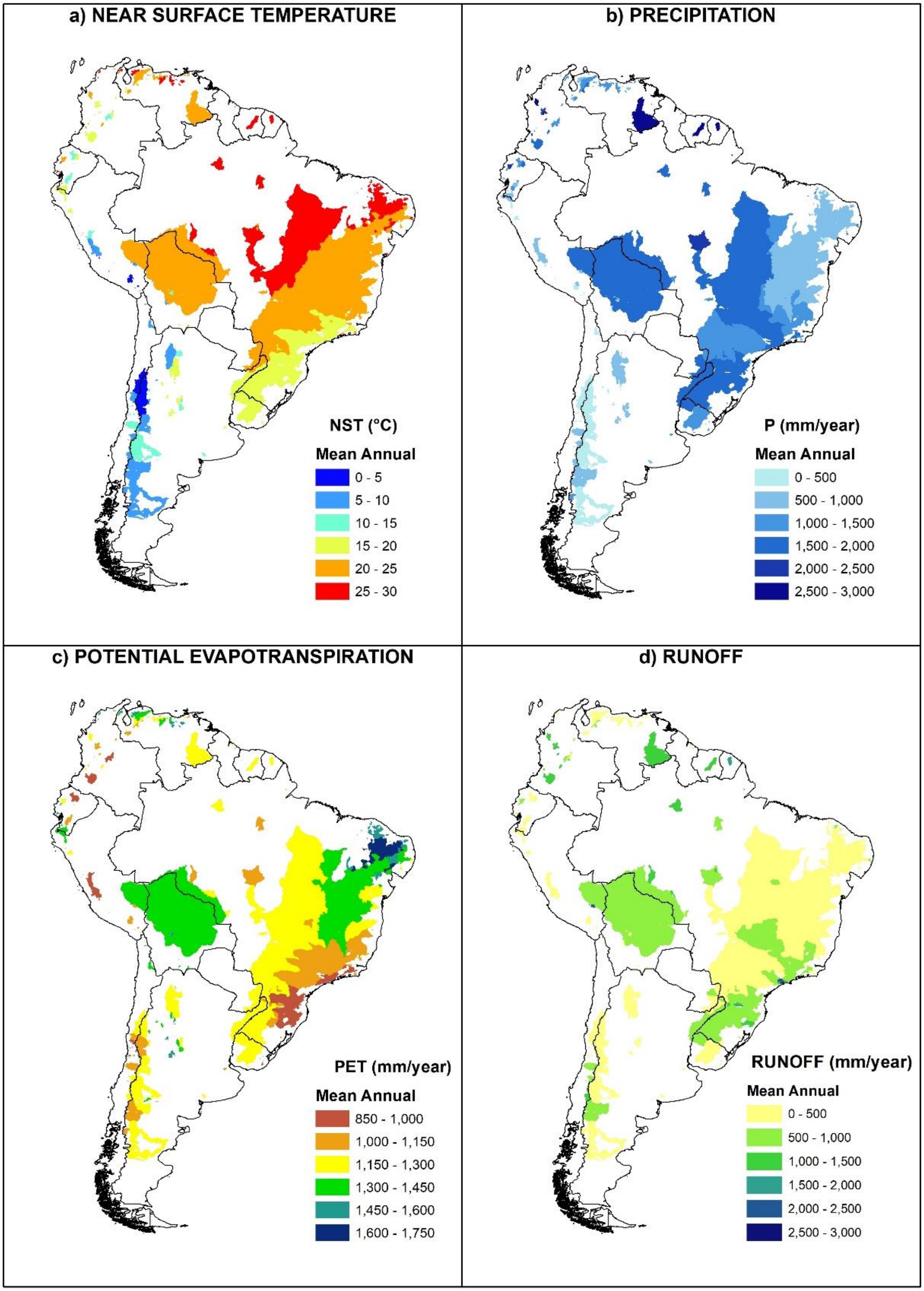


Figure 3. a) Near Surface Temperature**, b)** Precipitation**, c)** Potential Evapotranspiration**, d)** Runoff maps per dam catchment

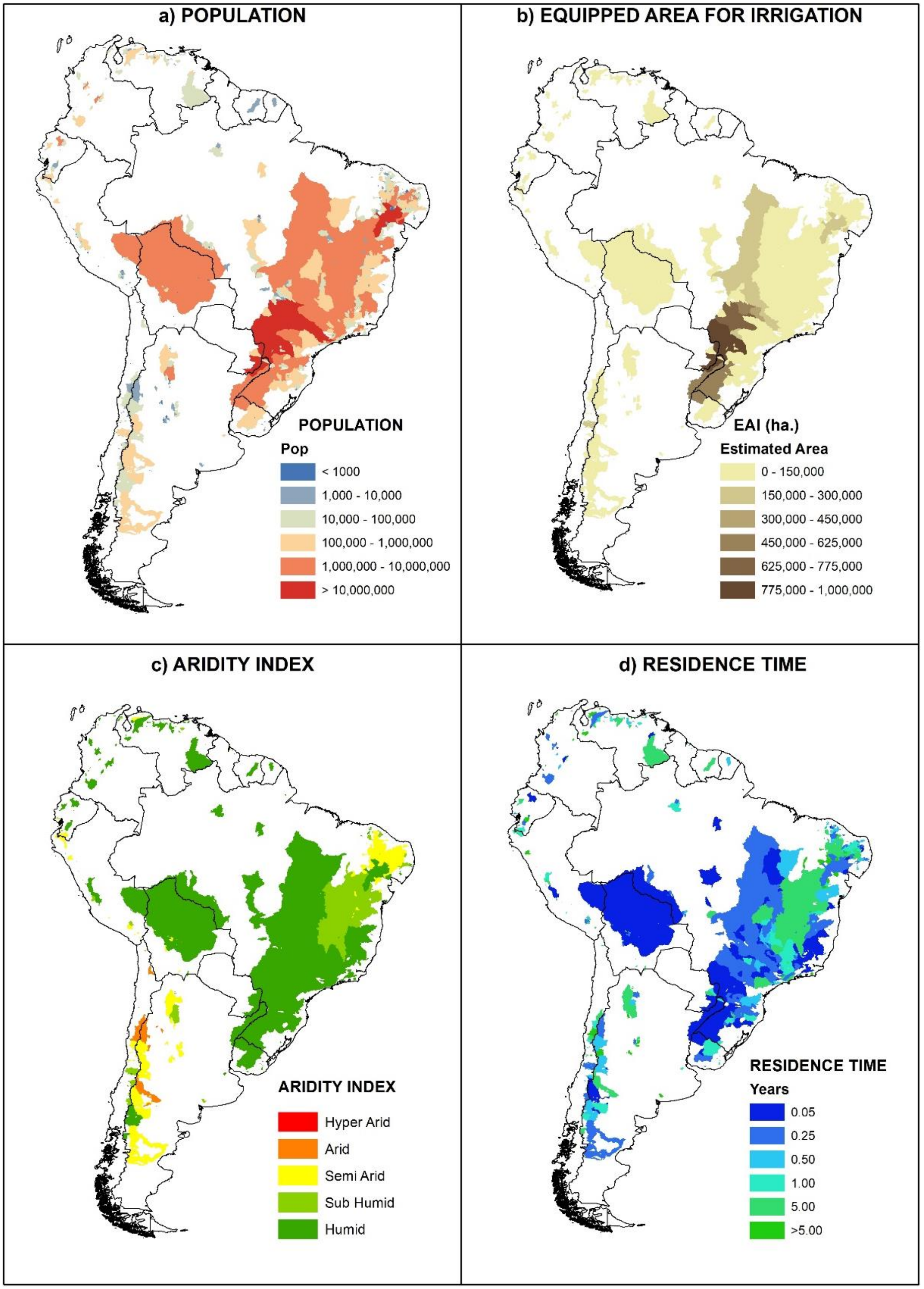


Figure 4. a) Population**, b)** Equipped Area for Irrigation, **c)** Aridity Index, **d)** Residence Time per dam catchment.

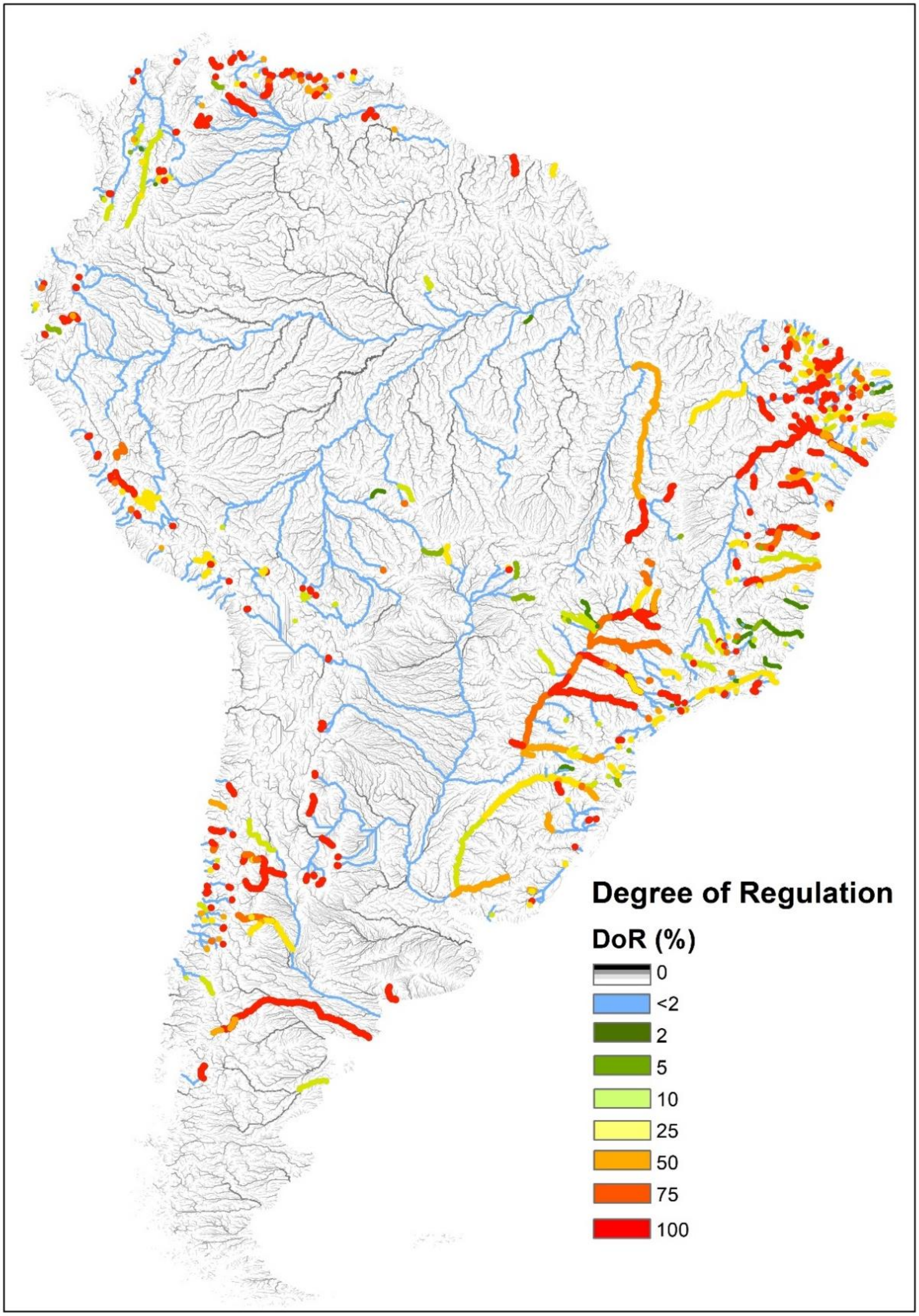
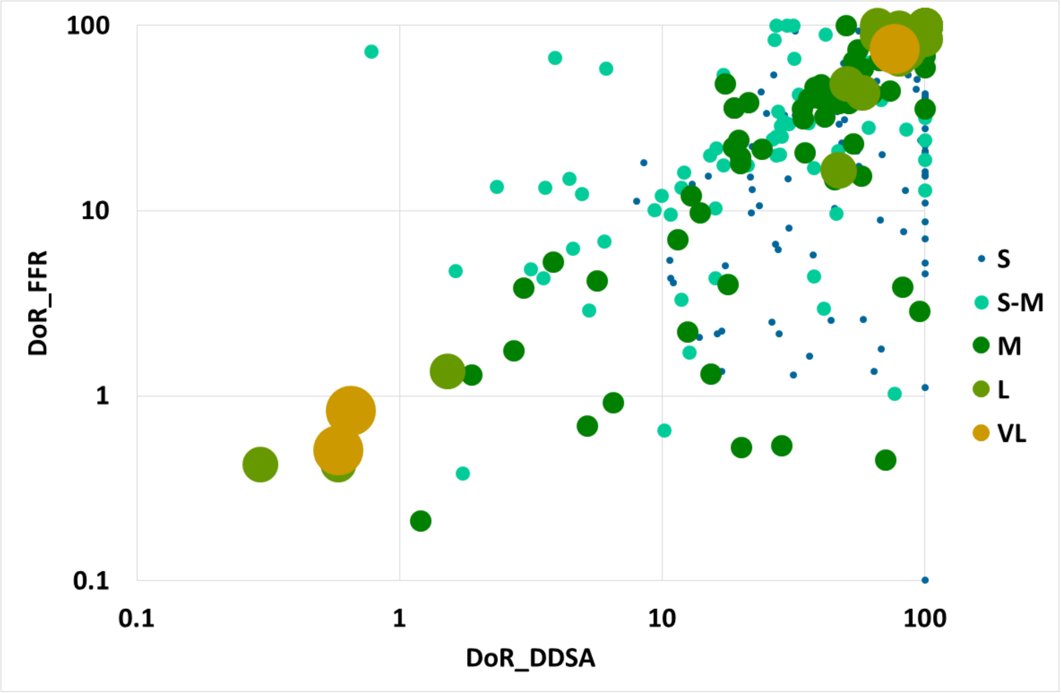


Figure 5 Degree of Regulation (DoR) of reservoirs of the DDSA database in downstream rivers of South America.



705 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.