Reply to:

Interactive comment on "Rosalia: an experimental research site to study hydrological processes in a forest catchment" by Josef Fürst et al.

Anonymous Referee #1
Received and published: 22 December 2020

Josef Fürst (on behalf of the co-authors) April 26, 2021
Replies are formatted in blue, while the original referee's text is in black. Line numbers in blue refer to the revised manuscript.

Dear anonymous reviewer,
thank you for your thorough review and your efforts to improve our article. We have gratefully adopted the suggestions and made extensive changes to the article. The changes are documented below:

This data publication aims to describe the Rosalia experimental watershed, and introduce the data that is collected between 2015 and 2019. The authors give a very detailed description of all sensors and data storage application used, which I feel came at the expense of more information about the actual watershed and data. The geological background is summarized in one sentence only, and no geologic, vegetation or soil maps are shown, which are key if other researchers are to work with the data.
R: The geological background is indeed very uniform and is described in a few sentences in section 2 (L 99 to 127), which was comprehensively re-written. A soil map with the main soil categories, watershed divides and gauges has been added.

No information is given about the process of data cleaning, or the analysis of the isotopic samples in the lab. Since one of the main aims of a data publication is that other people can work with the data after, I suggest that the article is adapted so that such crucial (!) information is described, and other researchers can also work with the data.
R: Information about data cleaning is introduced in section 4, L 251 – 254, and described specifically in the context of the data-specific paragraphs. Stable isotopes (L 244 to 247): $\delta^{18}O$ and $\delta^{2}H$ are analysed using laser spectroscopy (Picarro L 2140-i, Picarro Inc., Santa Clara, CA, USA) in the isotope laboratory at BOKU. A calibration with laboratory reference material calibrated against the Vienna Standard Mean Ocean Water and Standard Light Antarctic Precipitation scale was used. All values are given in delta notation, and the precision of the instrument (1σ) was better than 0.1‰ and 0.5‰ for $\delta^{18}O$ and $\delta^{2}H$.

Some timeseries of the actual data are shown (i.e., of discharge, soil moisture, rainfall, electrical conductivity and the stable isotopic composition of discharge and rainfall), but the presentation of these is very minimal. Furthermore, for or one of the figures the axes were not correctly chosen (i.e., cutting off part of the data), and the figure captions cover only the bare minimum of information.
R: The data repository contains comprehensive documentation and visualization of the time series data in an easily accessible and interactive HTML format. Therefore, we selected only 2 years for the figures in the paper to improve readability. We extended the captions. The characterization of the time series was extended in the text and by new tables including basic statistics. The wrong axis scaling of Fig. 5 (now Fig. 6) was corrected.

When reading this article, I stumbled over numerous grammar mistakes, wrong interpunction, colloquial language, use of the imperial system, and sentences that were clearly not formulated in correct English. I felt like I was doing the final reading before submitting, rather than a review.
R: We removed mistakes and improved the text. It was proof-read by a native speaker in a professional proof-reading service.
Regarding use of the imperial system: this is used only in the naming of the H flume devices where it is, in our opinion, appropriate. H flumes are standardized, off-the-shelf devices which are characterized by their depth in ft. Even European vendors and German textbooks on hydrometry (E.g. (Morgenschweis, 2010)) list H flumes by their depth in ft (and not m). The rating curves for H flumes have been developed by the US SCS for a range of different sizes and therefore it would not help any reader to write about a 0.305 m or 0.61 m H Flume.

I was surprised that this was the case because from
the abstract it sounded like the Rosalia catchment is the flagship of BOKU, and its
documentation thus would deserve adequate attention. In addition to the language of
this article, the structure also clearly needs more time and attention. Some definitions
and topics are introduced but not fully discussed, and come back multiple times in the
manuscript. This does not help the future reader of this article to find the information
needed.
I apologize for my lack of in-depth comments to this article, but this article needs more
time and attention before an in-depth review can be helpful. I suggest that the authors
take this task serious and resubmit after careful re-structuring and rewriting. Documentation
for a long-term research site (1875!) should be more comprehensive than
this, and should for instance also include a background of the most important findings
and the mechanistic understanding of how this watershed functions, in addition to the
missing information with regard to data processing as mentioned above.
R: Mentioning that BOKU is using the Rosalia forest since 1875 was not meant to implicitly indicate that data are available for the entire time period. To avoid any misunderstanding, we removed or reformulated those parts to clearly focus on the monitoring network established and the data recorded since 2015.

Detailed comments:
L21: remove additionally
R: removed. New L 20-21: In addition, since 2018, nitrate, TOC and turbidity have been monitored at one gauging station. In 2019, a programme to collect isotopic data in precipitation and discharge was initiated.

L24: one site of how many sites? The discharge gauging stations?
R: at one new discharge gauging station (Q4). See new L20-21.

L24: nitrate is capitalized where it should not be
R: corrected

L28: remove 'their'
R: corrected

L32: Global change impacts, such as climate warming? I don't see how climate itself
is a global change impact.
R re-phrased L 29-31: Given these long-term datasets, changes in the hydrological cycle, such as those resulting from climate warming, can be investigated in these watersheds (Bogena et al., 2018).

L33-35: Although I somewhat agree, who realized this? reference needed
R:Re-phrased and reference added (L 32-34): In recent decades, there has been growing recognition that hydrology (and its related disciplines) cannot be treated in isolation. Rather, hydrological processes driven by meteorological conditions are also strongly controlled by complex feedback mechanisms with biotic and abiotic systems (Porporato and Rodriguez-Iturbe, 2002).

L35: experimental catchments? remove sites
R: corrected: L34-35: Therefore, hydrological experimental watersheds have gradually transitioned into multi-disciplinary experimental watersheds.

L45: unclear which framework is referred to
R: re-phrased (L 40-45): Examples of such networks are the German 'TERrestrial ENvironmental Observatory network' (TERENO) (Zacharias et al., 2011), the 'International Network for Alpine Research Catchment Hydrology' (Bernhardt et al., 2015), the 'US National Science Foundation's National Ecological Observatory Network' (NEON) (Kampe et al., 2010), and the 'Euro-Mediterranean Network of Experimental and Representative Basins'(ERB) as part of UNESCO FRIEND (Flow Regimes from International Experimental and Network Data) (Holzmann, 2018).

L57-65: why is the LTER not introduced together with the other networks?
R: LTER is now introduced together with the other networks (L46-54)

L74: if the object "was and still is" the word "is" is sufficient to indicate that
R: re-phrased (L75): "The overall objective is to implement …"

L76: if this is "a research emphasis" what are other important points?
L79: what are 'point related measurements'?point measurements?
L76-80: please rephrase this sentence to provide more clarity.
R: re-phrased L75-78: The overall objective is to implement a multi-scale, multi-disciplinary observatory that facilitates the study of water, energy, and solute transport processes in the soil-plant-atmosphere continuum. Research emphasis is put on deriving effective parameters for scales on which models simulate flow and transport processes (e.g. hillslope, catchment) by upscaling point measurements.

L83: how does the set-up allow for these experiments, in comparison to other sites?
R: BOKU has management options in the forest that are generally not available in private forests where often just the implementation of monitoring stations is possible.
We added the following information into the revised manuscript (L80-86): Because BOKU has the right of access for educational and research purposes, large-scale controlled experiments can be undertaken. For example, rain-out shelters were used in parts of the forest by Netherer et al. (2015) to investigate drought impacts on bark beetle attacks on Norway spruce, while Schwen et al. (2015) and Leitner et al. (2017) used rain-out shelters to investigate soil water repellency and short-term organic N-fluxes under a changing climate. Besides such local experiments, the monitoring network established since 2015 enables researchers to investigate the impacts on the large-scale forest ecosystem and its services by providing the necessary baseline data. Investigating the transition of the forest ecosystem from its actual state into a pristine, unmanaged natural forest is among future research plans.

L89: "are and will be investigated by a team of researchers" this sounds as if the team is already chosen, and cannot be adapted anymore. This is contrary to what I would expect is the aim of publishing this article, which is to promote other researchers to also use the data that is being published in this publication.
R: With publishing the dataset we are certainly inviting other researchers to use the data too. We rephrased L 80-86 (see above).

L89: same comment as with "was and still is" in L77
R: re-phrased, see above.

L95-98: since this is such a standard article lay-out, I would suggest that the others consider removing this description.
R: removed

L100-101: this sentence is gramatically incorrect.
L102: 'is' steeper than
R: corrected (L 91-93): Terrain heights range from 320 to 725 m a.s.l., and the watershed is characterised by steep slopes (96% of the area is steeper than 10%, and 55% steeper than 30%).

L111-112: gramatically incorrect sentence
R: comprehensively re-written paragraph.

The description of the watershed was extended to provide more information on geology, soils, vegetation and forest management(L 99-127), and a soil map was added (Fig. 3)

L129: the names of the watersheds, and their respective sizes, have not been introduced yet.
R: we improved this part and redesigned Fig. 1 and Table 1 to provide this information.

L30: monitored "with" a spectrometer probe
R: corrected (L 142)

Line 131-135: every sentence starts on a new line.
R: corrected

L312(132?): which altitudes?
R: altitudes were added to table 1. Also, Fig. 1 displays terrain height.

L136-137: this sentence is redundant because this is mentioned in the figure and table captions.
R: removed

L148: please specify what the "DMBS addVANTAGE Pro' is directly when first mentioning it.
R: short description of addVANTAGE Pro was added (L 160 – 166).

L154: can the authors be more specific about the treatment samples after being collected by the totalisers or as grab samples? How are these samples stored in the samplers to ensure that the chemistry and isotope samples can both be analyzed adequately?
R: we described the sampling in L 167-169: Stable water isotope data are not automatically uploaded to the DBMS but samples are collected on-site and picked up manually by university staff for analysis in the laboratory. Precipitation samples are collected bi-weekly with totalisators with plans to refine the sampling interval to daily, while streamflow samples are collected as daily grab samples using an autosampler.

Handling of the samples and laboratory analysis is comprehensively described in section 3, L222-247.

157: The field courses are organized by students? Or should this be "by students during field courses
R: moved to section 5 Applications (L 355-358): The site is regularly used for advanced field courses in the water management and environmental engineering curriculum. During these courses, students not only learn about the setup and operation of a hydrological monitoring network, but they also contribute to the improvement of knowledge about the watershed by collecting and analysing soil samples or performing validation measurements of the instruments.

L158: which other (LiDAR-based) DEMS are available? and, LiDAR is commonly spelled with a lower-case 'i'
R: reference to DEMs moved to section 4.6 Spatial data (L 348-352). We kept the spelling LIDAR, which is as common as LiDAR.

L161: what is a "hydrological" site? A site at which hydrological measurements are being performed? in this case, the word 'hydrological' is redundant, given the sentence that follows.
R: re-phrased (L172): The sites for discharge measurements were selected to collect data for nested sub-catchments of different sizes.

L163: new line started where not needed.
R: corrected

L169: grammatically incorrect sentence. L170: grammatically incorrect sentence
R: checked and corrected

L168: please use the metric system.
R: Foot is appropriate in this context, see note above

L178: Reference missing for the "Thompson" weir.
R: reference added (L185)

L181: is their SDI-12 interface really important to mention in this article? And if so, be specific as to why the SDI-12 interface is preferred.
R: it is not directly relevant for the dataset, but readers might be interested in the sensors that we use. SDI-12 sensors are generally known for their very low power requirements and their standard interface to most data-loggers.

L181-184: Colloquial language. Please rewrite.
L183-184: please rewrite to make the sentence clearer.
R: re-phrased L191-196: They work electronically reliably, but the measured conductivities are sensitive to biofilms on the sensor, and the internal firmware requires more than an hour to achieve a stable reading after power-on or after cleaning. Furthermore, the measured conductivity tends to show an offset compared to manual measurements conducted approximately bi-weekly. Nevertheless, the recorded curves show plausible dynamics, e.g., during storm events. Currently, alternative sensors are tested to replace the C4E devices. At site Q4, a different type of sensor (s::can condu::lyser ™) is used, which, after more than a year of operation, recorded reliable and stable data.

L189: should be "are' possible.
R: corrected (L199)

L190: atmospheric deposition of what? Salts, leaves? please be specific.

R: re-phrased L199-201: They require more maintenance than weighing rain gauges because the funnel is easily blocked by deposition of leaves, pollen, dust or insects, and they are inoperable during frost.

L193: please rewrite to clarify the meaning of the sentence. Also, please quantify and be specific about how the rain measurements are affected, and why they are reliable in this data publication.
R: re-phrased L 202- 205: Also, in the forest, it was not possible to follow all the rules for the proper placement of a rain gauge. Particularly, the recommendation that the height of nearby objects, such as trees, should not exceed the distance from the gauge to the objects (WMO, 2008), had to be disregarded for Q1 and Q2. In particular, the rain gauge at Q1 is directly affected by the interception of the trees above.

Added discussion in section 4.2 (L 304-311): In this densely forested watershed, it is not possible to place all rain gauges at sites without interception or rain-shading. However, a comparison of rainfall depths at all seven rain gauges for several events revealed good agreement. Gauge Q1 is affected by interception, which amounts to typically less than 2 mm per event (compared to weighing rain gauges K1 and K2), but monthly precipitation at Q1 is on average only 75% of the mean of K1 and K2. At Q2, monthly precipitation is on average 87% of the mean of K1 and K2. (K1 is close to the highest elevation of the watershed, K2 at the lowest – see Figure 1 and Table 1). Therefore, the data from all rain gauges are useful for analysing storm events, as interception reduces rainfall depths by only a small percentage. For water balance investigations of periods longer than a week, however, only the gauges not affected by interception should be used

L212: d18O and d2H are already defined earlier in the manuscript. Please use the short-hand notation to make the text more concise, or refrain from defining the shorthand notations.
R: corrected (L223)

L230: 'using' addVantage Pro?' or does the program also assess the data? If so, please be specific about which protocols are used.
R: changed to "using" (L249).

L234: can the authors be more specific about this data cleaning process?
R: variable-specific statements on data cleaning have been added
Discharge data (L 265-272): Raw discharge data at the H flume gauges Q1, Q2, and Q4 needed careful inspection and editing. First, spikes in the hydrographs (one or two consecutive values significantly exceeding the value before and after the spike) were attributed to random events such as a leave under the ultrasonic depth sensor and were automatically replaced by linear interpolation. Next, visually detected implausible discharges were replaced by linear interpolation where reliably possible, or deleted otherwise. As an example, occasionally during very low flow, single leaves can temporarily (a few hours) get stuck at the narrow outlet of the flume and cause the water level to rise a few millimetres. Such events are clearly visible as plateau-shaped parts of the hydrograph and can be safely replaced by linear interpolation. At these gauges, the measurements have never disturbed by freezing.
At the weir Q3, two issues required editing: 1) during very low flow, leaves and grass can occasionally get stuck at the weir crest, causing the water level to rise. These events can be detected in the images transmitted daily by a surveillance camera and visually in the hydrograph. Such artefacts are replaced by linear interpolation; 2) during longer frost periods, the stilling basin may be covered by ice and therefore the discharge is no longer described by the weir formula. These situations can be detected by visual inspection of the hydrograph and comparison with the temperature. These parts of the records have been deleted.
Precipitation (L293-299): For quality control, rainfall data recorded by tipping bucket devices (Q1 to Q4) are compared to records of the weighing rain gauges and to corresponding hydrographs. They are deleted if the funnel appears to have been (partially) blocked. Also, records for the winter season from November to February are excluded due to tipping bucket issues with freezing. Anomalies observed during field maintenance visits (one to two per month) are also considered. The three weighing rain gauges have provided gap-free records since the time of installation up to now, with a resolution of 0.1 mm. For most rainfall events between March and October, consistent and plausible data were acquired by up to seven rain gauges in total, providing a high-resolution rainfall pattern for a small area of 222 ha, and being spread over different altitudes from 320 to 700 m a.s.l (Table 4, Figure 8).
Electrical conductivity (L 328-333): Besides frost, conductivity records at sites Q1 and Q2 are additionally negatively influenced by the sensor problems described in section 3.2. Regular conductivity measurements with a portable device showed that the conductivity of base flow is stable at sites Q1 and Q2 (typically approx. 120 µS/cm), so that the recorded conductivity series are still informative for the separation of base flow and direct runoff events, despite conductivity offsets in the records.

L247: redundant to describe what Figure 5 illustrates, because this is mentioned in the caption. Please refer to the figure in the text itself.
R: corrected

L247: hydrographs 'for' July and August 2018
R: corrected (L286).

L273: could it not also be due to natural preferential flow paths? and if not, why not? and since in L274 the natural pref. flowpaths are mentioned, please be more specific about the limits to the period at which the disturbance affected the measurements.
R:extended the explanation (L316-322): It is important to mention that the installation of the sensors requires digging a trench, which causes considerable local disturbance of the soil. Despite careful refilling, local infiltration paths could be influenced, and data do not necessarily reflect natural conditions for some time after installation. During the first few months after installation, for example, deeper probes reacted faster to rainfall than those close to the surface (Figure 10). This can be attributed to artificial flow paths along the walls of the trench and the cables, or to effects arising from interrupted and destroyed natural macropores like wormholes. However, direct effects due to installation practically disappeared after the first season.

L288: I would expect to find this sentence in an introduction, not in a 'results' section
R: removed

L298: reference?
R: added reference (L 340): Feng et al. (2009): "Seasonality of isotopes in precipitation: A global perspective"

L300: which stable isotope? oxygen18 I assume?
R: $\delta^{18}O$ added in L 341

L305: I think the spatial data can be introduced where the DEMS are introduced first, and don't need a separate section dedicated to them.
R: It is more than just DEM, also watershed divides, surveyed creeks and location of sites. We add a more detailed description here (L 348-352): Data interpretation is complemented by a comprehensive amount of spatial data characterising the site. DEMs at various resolutions are available, including a 10 × 10 m DEM provided by the government of Austria, and a LIDAR based DEM at 0.5 × 0.5 m (Immitzer, 2009), accessible at https://zenodo.org/record/4601057. From these DEMs, watershed divides and the drainage network were derived in GIS. Additionally, a ground survey was performed for the main creeks in 2018. These data are included in the repository in shapefile format.

L311: please avoid one-sentence paragraphs at all times.
R: Section 5 is entirely re-written (L 354-374)

L314: what are the assumptions to this two end-member mixing model, and are these assumptions valid in the Rosalia catchment? What is the influence of soil water during rainfall events, and what is the EC signature of soil water vs. groundwater?
Section 5.1: please be more specific and actually quantify the results of your baseflow separation (don't forget to include uncertainties).
L320: please provide a reference for end-member splitting analysis.
L343: please give a measure of how well they match, NSE for instance.
R: we completely re-wrote section 5. Both examples are probably too complex to be described in this context and we provide overview presentations in section 5 only. In the meantime, an additional study using the dataset (on the effect of forest access roads on the generation of floods) became available and is included here. (compare recommendations by Reviewer #2).

L348: please be more specific about the data cleaning process. This is a very important part of the data collection and publication process, and is not mentioned at all in the manuscript.
R: we paid attention to the data cleaning process, which is described in section 4 and its sub-sections.

Table 1: what does 0.2 mm 'events' or 0.1 mm 'events' mean? usually, 0.2 mm is the resolution of individual tips.
R: "0.1 or 0.2 mm events" is the terminology used in the documentation of our tipping bucket rain gauges as well as in the data acquisition system. It refers to rainfall events with a total depth of 0.1 or 0.2 mm. Our tipping bucket devices

have a resolution of 0.2 mm, our weighing rain gauges provide an output that simulates a tipping bucket rain gauge with 0.1 mm per tip. We record a time series of the tipping times so that the highest possible temporal resolution of precipitation intensity is obtained. These data are not included in the data repository and the reference has been removed from Table 1.

Table 1: Does the "tipping bucket device" have any other specification?
R: Yes. It is listed as 1l (1 liter per tip), but apparently this is difficult to read. It is used as a complementary device at Q1 to measure discharge when it is smaller than the lower limit of a 1-ft H Flume (0.02 l/s). This never happened since 2015. In table 1 it reads “1 liter per tip” now.

Table 1: please also mention the size (i.e., area in ha) of the different sites.
R: We added the sizes of the watersheds and height of sites.

Figure 1: The cities on the inset map of Figure 1 are unreadable, and even the font size of the different sites in the main figure are a bit small. The legend nor caption describes what the green shading or crosshatching indicates. What is a "relais" in this context?
R: we completely redesigned Fig. 1 and removed the relais (the relais just serves for broadcasting data from the RTUs to the base station and is not relevant for using the data)

Figure 3: Please use the metric system.
R: would be misleading. See notes above.

Figure 5: y-axis is too low (Q2 peak cut off).
R: corrected (now Fig 6). Fig. 6 displays Q in log scale now to improve readability

Figure 10: "stream water" or ”river water” isotopes rather than river isotopes.
R: changed in new Fig. 11

Figure 11: in its current form, Figure 11 does not add much to the article. The precipitation and discharge timeseries have already been shown in previous figures, and the results of the end-member mixing analyses are not shown.
R: the Figure became obsolete in the re-written section 5, as mentioned above.

Figure 12: is this specific discharge or absolute discharge?
R: the Figure became obsolete in the re-written section 5, as mentioned above.

Morgenschweis, G. (2010) *Hydrometrie - Theorie und Praxis der Durchflussmessung in offenen Gerinnen*, 582 pp., Springer-Verlag, Berlin Heidelberg.

Reply to:

Interactive comment on "Rosalia: an experimental research site to study hydrological processes in a forest catchment" by Josef Fürst et al.

Anonymous Referee #2
Received and published: 4 January 2021

Josef Fürst (on behalf of the co-authors) April 26, 2021
Replies are formatted in blue, while the original referee's text is in black. Line numbers in blue refer to the revised manuscript.

Dear anonymous reviewer,
thank you for your thorough review and your efforts to improve our article. We have gratefully adopted the suggestions and made extensive changes to the article. The changes are documented below:

1. General comments
This data description paper depicts the Rosalia experimental research site in Austria.
It introduces the forested watershed and its characteristics, the monitoring stations and
hydrological equipment, the recorded data since 2015, and finally two example studies.
The manuscript describes the sensors and data storage applications in detail, but it
should be presented in a more consistent and structured way. In addition, full documentation
of the sites and accuracies would be desirable for the understanding of
readers and potential users.
R: we improved the text to be more consistent. We added more details to the documentation of the sites and on the accuracies of the data (new Table 2).

The two examples give an insight into two aspects of the studies. However, because
they are not the main focus of the paper, the explanations and discussions can only be
very brief here.
R: We have completely revised chapter 5. It now contains a list and very brief description of the previous applications.

The datasets are available in the specified data repository. Data collected at the described
sites since 2015 are provided. It comprises a documentation of the dataset,
GIS and time series data.
2. Specific comments
Right in the third line of the abstract, the operation of the study area since 1875 is mentioned.
The reader looks forward to a long-term data series and analysis. However,
he/she is then disillusioned relatively quickly that it is only about the data analysis since
2015. Many graphs even show only two years 2018-2019. I therefore recommend defusing
the initially high expectations by moving the long-term aspect from the abstract
to the introduction chapter.
R: We re-wrote the abstract to avoid any confusion about the time period of the dataset (L12-23).

In order to understand the multiplicity
of sites, sensors and measurement data, a comprehensive
listing and description is necessary. This is only done partially because the
reader has to compile the information himself.
R: we improved the description of the sites, sensors and data by improved Fig. 1 and Tab. 1. Table 2 was added to provide characteristics of the sensors. We modified the text as described in the detailed replies below.

The following appears to be in need of improvement:
a) Fig. 1 shows sites of 2018, but Tab. 1 shows the status of March 2020. Is the 2018
status up-to-date and does it correspond to the 2020 status?
b) Where is Q2S0 in Fig. 1?
c) The function of R1 Relais (Fig. 1) is not mentioned in the text - is it relevant for
understanding?

R: (a-c): we completely redesigned Fig. 1 to resolve your concerns and improved the text according to the suggestions. The relais is required for broadcasting between the RTUs, but not required to understand the dataset (removed from Fig. 1).

d) In Tab. 1 there are the sites Q1-4, K1-3, Q2S1 and Q2S2, but Q1S0 and Q2S0 are missing.
R: the missing sites were added to Table 1 and clearly labeled in Fig 1

e) Chapter 3 - L127-137 – is difficult to understand and to match with Tab. 1 and Fig. 1. It would be helpful to insert the site numbers/names here. Otherwise, one has to pick up everything from these lines and the table and the next chapters.
f) It would also be helpful to add the watershed sizes to Tab. 1. The same applies also to the depths of the four soil profiles, as these are assigned very unspecifically in L134-135 and L202-203. A column with the measurement interval and start date of the sensors used to measure each parameter could also be added to Table 1. To estimate data quality and sources of uncertainties and errors, further details about the sensors, such as sensor accuracy and operating range, should be provided with the data. Data gaps to show the proportion of no-data values could also be visualised in a graph.
R: We improved Fig. 1 and added the requested information to Tab. 1. In an additional table 2, we provide details of the sensors, including sensor accuracy and operating range. Tables are added in the sections of the data description to illustrate the time of records, and proportion of no-data values for each site. Also mean and range of the data values are included.

g) L127 what is measured: river discharge or water level?
R: The direct sensor output is voltage that is converted to water level. Since both, the H Flume devices and the Thomson weir at Q3, have a standard geometry with fixed rating curves (not specifically calibrated at site), it is, in our opinion, appropriate to write about discharge measurement.

h) Chapter 2: It would also be helpful to list the characteristics of the four sub-basins in more detail: Is there heterogeneity in geology, soils and slopes? Is further information on soil important for understanding? What are the elevation ranges within the sub-basins, are there differences between the sub-basins? A map could help for visualisation.
R: we added the following information: a description of the very uniform geological background, a soil map (Fig. 3) and an extended description of the vegetation (per watershed). Fig. 1 displays the terrain heights. Elevation of the gauges was added to table 1.

See section 2, L89-127

How is the forest managed (maintenance measures, use practices, fertilisation, sustainability, roads and infrastructures)?
R: We added the following information into the revised manuscript (L 119-127): Forest management is performed by the Austrian Federal Forests (Österreichische Bundesforste, OeBf) owned by the Republic of Austria. BOKU has the right of access for educational and research purposes. OeBf manages the forest sustainably, balancing the protection of the environment, the needs of society, and economic success. The management of the forest is characterised by long production cycles of 100 to 140 years. The main species of the forest are the broadleaved beech (fagus sylvatica) and the coniferous Norway spruce (picea abies). The forest is at different development stages ranging from clear cut areas to mature forest stands. Natural regeneration is preferred to planting, and fertilisation is almost never done. Timber harvesting is usually done with harvesters and forwarders, and cable cranes are used at steep slopes. Management and timber transport are supported by a dense network of forest roads (50 m per hectare), suitable for heavy timber trucks. Main threats to the forest are snow break, wind throw and bark beetles, the latter affecting mainly coniferous tree species.

Chapter 4.1: Is the specific discharge (L245-246) related to site Q3? What about the other sites?
R: rephrased L280-282: Specific discharge does not vary significantly between the four watersheds and typically ranges from 1 to 2 l s^{-1} km^{-2} during low to medium flow and up to 30 l s^{-1} km^{-2} during peak flows (calculated from daily means).

As this is a data description paper - add mean and range for all four gauges. The same for chapter 4.4.

R: We added Tables 3 and 4 to provide the requested information.

Chapter 4.5: Which method was used for the isotope analyses in the lab?
R: We used a laser spectroscope (Picarro L2140-i, cavity ring-down spectroscopy). This information was added in section 3.2, sub-section water quality (L244-247). The description of collecting and pre-treating the samples was also extended (L 222-243).

Chapter 5.2: This is an interesting topic, but too complex for this kind of data description paper. Therefore, some assumptions and relationships are unproven, not supported by numbers or graphs (_L325-336). Exact model performance remains unclear, statistical indicators are missing. Reference to other studies and a discussion are also not provided. Therefore, a separation between an overview presentation in this data description paper and a scientifically sound analysis in an original research article would certainly make more sense.
R: Section 5 is entirely re-written (L 354-374).

3. Technical corrections
Fig. 1: German-language city names (Wien, München. . .) appear in Fig. 1; the English names would be appropriate for this map in an English-language paper.
R: Fig. 1 was redesigned to fulfill this and other requirements.

Fig. 7: Same scale length or axis layout as in Fig. 5 enables a better comparison.
R: we harmonized the axis style and also corrected the y-axis scale in Fig. 5 (now Fig 6).

L314: Add 'electrical' for electrical conductivity.
R: added in L228

4. References
Chapter 4.6: What is the source of the DEMs? Add references.
R. references added (L348-352): DEMs at various resolutions are available, including a 10 × 10 m DEM provided by the government of Austria, and a LIDAR based DEM at 0.5 × 0.5 m (Immitzer, 2009), accessible at https://zenodo.org/record/4601057. (Publication of this DEM on Zenodo was triggered by this dataset publication!)

Reference list: L418-419 Roadmap & Strategy Report on Research Infrastructures – cite as in the text as European Strategy Forum on Research Infrastructures, 2020 or ESFRI, 2020.
R: all references have been carefully checked and corrected.

Missing references in reference list which can be found in the text: Cosby and Emmett, 2020; Gröning et al. 2012; Hydrologic Engineering Center, 2010; Hipp et al., 2019 Klaus and McDonnell, 2013; Müller et al., 2018; McGuire and McDonnell, 2006; Stevens, 2015.
R: added. Klaus and McDonnell, 2013; and McGuire and McDonnell, 2006 became obsolete.

5. Data repository
Regarding the file 'Isotope_ESSD.xlsx' in Table 'Q4DailyIso' in the data repository: Strange or missing values are marked and explained in the column 'Comment'. But gaps of several days are only marked by a line but not by an explanation, e.g. from 25.06.2019 to 03.07.2019, from 16.08.2019 to 28.08.2019, from 20.09.2019 to 04.10.2019, etc.
R: data gaps were clarified and comments included. Some gaps resulted from not being able to visit the field site regularly and collecting samples for isotope analysis. An updated file was uploaded to the repository.