Author responses to referee C285 comments on Manuscript: ESSD-2013-24, entitled "Soil, snow, weather, and sub-surface storage data from a mountain catchment in the rain–snow transition zone" – Earth System Science Data (Discussions)

- **Reviewer comments are in bold font and author responses are in normal font.**
- **Page and line number references are to the original manuscript unless otherwise noted.**
- **Quotes from the text are italicized and proposed revisions are noted by underline.**

RESPONSE TO REVIEWER C285 COMMENTS TO AUTHOR:

General Comments

1. **The authors mention several limitations in the data collection, namely the discharge data and the snow depth data. The equipment malfunctions, according to the paper, may account to 1.5 month of missing discharge measurements and to 4 months of missing snow depth measurements from ultrasonic sensors. Additionally, the soil moisture data collected at the southwest-facing slope display gaps (Fig. 4d) that are not discussed in the text (Part 5.4).**

   We appreciate the referee's comments here as it demonstrates a lack of clarity in data preparation methods as presented in the Introduction section of this paper. This paper focuses on presenting a serially complete set of weather data, which may be thought of as model forcing data. We then present hydrologic response data, which can be thought of as model validation data, "as-measured". To clarify this point, we propose to include the following statements in the "Abstract" on page 812, line 11: "<u>*This data is often viewed as "forcing data", and is therefore gap filled and serially complete*</u>." Then on line 16 on the same page, we propose to include "<u>*Snow and hydrologic response data are meant to provide data on the catchment hydrologic response to the weather data. This data is mostly presented "as measured" although snow depths from one sensor and streamflow at the catchment outlet have been gap filled and are serially complete.*</u>" We will also modify the "Introduction" on page 814, lines 16-18 as follows: "*Model developers can use distributed soil and topographic data to obtain state variables, <u>serially complete and gap filled</u> weather data to drive, and snow, soil moisture, and streamflow data to evaluate model performance*."

   We respond to missing discharge measurements, snow depth measurements, and soil moisture measurements separately below.

- **missing discharge measurements**

The stream in the Treeline experimental catchment is ephemeral as is stated on line 13 page 815, and as the referee points out in specific comments. Streamflow data is measured from December 16, 2010 and continues to the cessation of flow. Missing streamflow data between initiation and December 16, 2010 is estimated because of equipment malfunction, as is stated on lines 13-18 on page 819. This is also stated in the README_DATA.txt file under the section that describes the STREAM_DISCHARGE.txt file. Ideally this data would have been measured. We had installed 2 measurement systems prior to the onset of streamflow in the early winter of 2010. Both of these systems failed. Replacement sensors were installed and functional on December 16th. This highlights the challenges associated with collecting long-term and serially complete field data sets. These types of issues are common with long-term data collection efforts and we feel that missing early streamflow measurements, and the estimation of the missing data, are clearly defined in the "*Stream discharge*" section of the manuscript and in the README_DATA.txt file associated with the data.

- **missing snow depth measurements from ultrasonic sensors**

  Continuous and serially complete snow depths are available from the mid slope north ultrasonic snow depth sensor. This data is available in the WEATHER_DATA.txt file. Ultrasonic snow depth data from the additional 5 sensors begin on January 19th and are available in the SNOW_DEPTH_USD.txt file. Although the referee's "4 month" estimate is on the lengthy side, we agree that those gaps are less than ideal. Again, we state that this data set is meant to provide a serially complete set of weather data, with hydrologic response, or validation data, presented "as measured".

- **soil moisture data collected at the southwest-facing slope display gaps (Fig. 4d) that are not discussed in the text (Part 5.4).**

  We thank the referee for bringing this to our attention. We propose to add text to the manuscript after "*Data from Pit_3 and Pit_4 are hourly and serially complete.*" on line 2 page 820. "*<u>Due to instrument malfunctions, gaps exist in soil moisture data from SD_5, SU_5, SU_10, SU_20, and SU_30, as is typified in figure 4d.</u>*"

Specific Comments

1. **The authors mention (p. 814, line 14 - 25) hydrological modeling and annual water balance calculations as possible applications for the provided dataset. This statement seems to be rather optimistic for two main reasons: the size of the catchment under consideration and the duration of the observation. The catchment area of 1.5 ha (it would be more appropriate to provide the area in sq. km) allows for its qualification rather as a hydrotope than an elementary basin. This assumption can be supported by the ephemerity of the local stream. Further investigation is probably required to assess the minimum size of the catchment to form permanent stream under given conditions. One-year duration of the observations seems to be also unsuitable for**

water balance calculations. No direct measurement of the evaporation is mentioned, which would be most appropriate for water balance studies. I suggest the authors to moderate the aforementioned statement (p. 814) on possible application of the dataset.

We thank the referee for pointing out several items that need clarification and several ways to improve the manuscript. We respond to comments about the scale of the basin and the duration of the observations separately below.

- **The size of the catchment**

We agree with the referee in that the Treeline experimental catchment is relatively small (0.015 km^2). We will include the area units of square kilometers. The use of word hydrotope implies that areas within the catchment would respond uniformly in terms of hydrologic processes (surface runoff, soil erosion, infiltration). The presentation of soil depth, vegetation cover, soil moisture response, and snow cover differences between dominant hillslopes demonstrates the important heterogeneity within this catchment. These differences are further explained by McNamara et al., 2005, and Williams, et al., 2009 (already cited in the manuscript). We feel that the significance of streamflow classification (ephemeral, intermittent, or perennial) to an elementary basin scale is somewhat subjective. The appropriateness of the scale of elementary basins and hydrotopes is dependent on the specific problem being addressed. We also note that there are many larger basins in this semi-arid environment that are ephemeral. See the following citation for examples from Reynolds Creek Experimental Watershed.

Pierson, Frederick B., Charles W. Slaughter, and Zane K. Cram. "Long-Term Stream Discharge and Suspended-Sediment Database, Reynolds Creek Experimental Watershed, Idaho, United States." Water Resources Research 37.11 (2001): 2857-2861.

- **The duration of the observation**

We agree with the referee in that many hydrologic modeling tasks require multiple years of data. However, we feel that the sufficiency of the duration of the presented data is dependent on the specific problem being addressed. Here we refer to the modeling of hydrologic processes, and not larger scale stream flow modeling. We therefore propose to leave in statements about the usefulness of this dataset to modeling. We also note that there is a much longer duration dataset for this and other locations within the Dry Creek Experimental Watershed available at earth.boisestate.edu/drycreek/data/, and through the CUAHSI Hydrologic Information System. We note that the data presented in this article for the 2011 water year differs from that data by having weather and streamflow data gap filled to the best of our ability. We also include all available soil texture, snow survey data, and snow depth data from the 5 additional ultrasonic depth sensors.

We agree that the lack of direct evaporation (and/or transpiration) measurement and the short duration of the time series are not sufficient to describe the water balance of the catchment in any general long term or statistical sense. The data set does provide detailed information to describe components of the water balance. The sentence and reference, "*Traditional watershed hydrology methods, such as annual water balances, can be used to make generalizations on geographic regions and watershed classifications (Wagener et al., 2007).*" from lines 23-25 on page 814 will be removed from the manuscript.

2. **More detailed soil layer description apart from references to other studies would be more useful for a reader.**

While the referee is correct that we do not provide a soil layer description, we feel that the wealth of texture and soil depth data presented is sufficiently useful to the reader. We did not present soil layer description data because we do not have that data. The alternative is to look up and repeat soil layer data in larger "already published" data sets, such as SSURGO or STATSGO. The soil data that we do provide is critical in understanding the soil temperature and moisture data.

3. **A more detailed description of the underlying bedrock and its hydrogeological properties would be more appropriate. The importance of such ephemeral streams as the one under consideration is mentioned in the paper, yet no further description is given concerning the interaction between the surface and the groundwater storage.**

We thank the referee for pointing out this short coming and propose inserting the following text on line 12 of page 815. "*Streamflow in upland ephemeral streams is disconnected from deep, regional groundwater (Miller et al., 2008), perhaps due to high bedrock hydraulic conductivity, which has been estimated at 10.93 m/s (Hoffman, 2008).*" We did not present additional information on the interaction between the surface and groundwater storage, because we do not have that information. This information is rarely available and expensive to obtain, but extremely valuable. Perhaps this dataset provides the information needed to quantify and describe that interaction through a series of modeling exercises. The collection of subsurface hydrologic properties was beyond the scope of this project.

Hoffman, B. A.: Scale and heterogeneity in hydraulic properties of the fractured granitic Boise front, Boise, Idaho, M. Sc. Thesis, 51 pp., Dep. Of Geosci., Boise State University, available at: http://icewater.boisestate.edu/boisefront-products/other/Publications/Hoffman_2008Thesis.pdf, 2008.

4. **Part 5.3: I also recommend providing the description of the stream ice conditions. Weather time series show air temperatures as low as -18^{o}C, yet no cease in streamflow is observed due to freezing. This aspect should be either outlined in the paper, or illustrated by any observations available.**

We thank the referee for their suggestion to outline stream ice conditions in our manuscript. Stream ice conditions are rarely observed at this site during times when the stream is flowing.

The streamflow usually initiates after a snowpack has developed then flows under the snowpack. The snowpack then insulates the streamflow from extreme and brief low temperatures. In general, subsurface soil temperatures remain above freezing. This particular gauge is visited very frequently (*ie*. October 1st, 4th, 8th, 10th, 11th, 15th, 25th, 26th, November 5th, 8th, 12th, 17th, 19th, December 1st, 7th, 13th, 14th, 15th, 17th, 27th of 2010 and January 17th, 21st, 28th, 31st , February 4th, 11th, 18th, 25th, 28th, March 3rd, 4th, 8th, 21st, April 4th, 5th, 8th, 15th, 22nd, and 30th, in 2011) Ice was not observed during these site visits. We propose to include the following statement on page 819, line 13: "*Stream ice is rarely an hindrance to streamflow measurement as it is commonly insulated from brief extreme low temperatures by the snowpack.*" We also propose to include a list of the site visit dates in the README_DATA.txt file and include the following sentence in the description of the STREAM_DISCHARGE.txt file: "*Stream ice conditions were not noted in field notes associated with site visits from the above list*."

Technical Corrections

1. **The rain-on-snow first mention on p. 812 line 5 requires an abbreviation.**

   We didn't think it was appropriate to use abbreviations in the abstract. We will include it in the revised manuscript at the editor's request.

2. **SOIL_TEXTURE_PROFILES.TXT: in the header the column names 'easting' and 'northing' are swapped.**

   We thank the referee for catching this mistake. It will be fixed in the data file in the PANGEA database.

3. **SOIL_SURFACE_TEXTURE.txt: in the header the column name 'pct_course' should be named 'pct_coarse'.**

   We thank the referee for catching this mistake. It will be fixed in the data file in the PANGEA database.