A new permanent multi-parameter monitoring network in Central Asian high mountains – From Measurements to Data Bases

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Reply & Comments for: Anonymous Referee #3
The Reviewer's comments are in bold & italic.

We would like to thank also the 3rd reviewer for her/his detailed and useful comments!

1. Synopsis
The manuscript describes the development and adaptation of a hydro-meteorological sensor network for remote, high altitude environments in Central Asia. Central Asia's arid lowlands heavily rely on water resources originating from the high mountain ranges of this region. Thus, shared open-access hydro-meteorological data are of high societal relevance in this region – in particular, as collecting observations of environmental parameters has been declining since the former Soviet Republics became independent. The introduced sensor data-base is designed for open access to hydro-meteorological observation data with the option (and declared goal) of integrating future environmental sensor networks. However, to achieve the latter task further information is needed in terms of (i) system integration specifications and (ii) a full description of the underlying (meta)data model. Obviously, this can't be documented in a scientific paper – however supplementary material or a technical report covering these issues would be highly appreciated (I fully agree with the other referees).

2. General Statement
The structure of the paper is clear, the language is concise. The figures and tables are supportive, but some figures could be joined or should be reworked (details see below). A rather weak point of the paper is the discussion. Discussion and conclusion should be separated. Right now, it's a conclusion with very little discussion. In the discussion, the design of the installed sensor network should be compared and discussed with similar wireless sensor networks (WSN) operated in alpine environments (Scientific WSN: e.g. Beutel et al. 2009, Simoni et al. 2011, Zhang et al. 2012; Governmental WSN: e.g. Egli et al. 2008; Commercial WSN: e.g. Campbell, Decagon, Ott, Seba etc.). The topic of the paper - multi-parameter (wireless) sensor networks - is not a novelty itself. However, the significance of this paper lies in the task specific adaptation of an ex-pandable WSN at a multi-national scale in a region where environmental observations are heavily needed by society and science. Finally, making data freely available is a great approach, which should be better acknowledged by the science community.

We will extend the discussion section in the revised manuscript.

3. Detailed Suggestions
3.1 Title
Monitoring is not limited to sensors – it implies both, sensing and sampling of the environment. However, the manuscript focuses on sensor networks. As sampling is in the scope of this paper, I suggest to replace the term "monitoring" by "sensing".

We see your point. However, in our understanding, "monitoring" means Earth Observation which includes the sensing, sampling, analyzing, and phenomena modeling.

3.2 Text

p302/l2 please define "flow formation zone" or give a reference

In Central Asia, it is quite common to differentiate between the “flow formation zone” in the mountain areas where the majority of river runoff is generated, and the “flow distribution zone” in the (semi-)desert lowlands where water is allocated to water users. Apparently, this term is very specific and we will substitute it by “headwater catchments”.

p302/l16-20 are (or will be) these rehabilitated stations be included into your WSN?

In the current phase of our activities, the integration of other 3rd party stations is not planned. However, this is indeed an open question which we have in mind for future activities. The integration of those stations is a technical challenge, requires long-term funding and political. It might be more efficient, if World Data Centers (WDC) become involved into this type of activities.

p302/l24-27 The chosen WSN design should be discussed and be put in context with WSN’s operated in Alpine/High Mountain regions (see references in general statement)

See our earlier comment on the extension of the discussion section.

p302/l28 Why are real-time data transmissions to data users are needed? Please illustrate that (example, application, reference). This part could/should be discussed (-> new section discussion), as this has a significant impact on power consumption (and thus of the design) of your WSN!

The stations of our network are designed to be used as part of the existing national hydrometeorological monitoring networks. This implies regular transmissions of meteorological data as required by the WMO. For purely scientific purposes, real-time data transmission may not be required, but it provides fast information about any operational problems (e.g. communication failure, sensor malfunction) and thus helps in planning maintenance expeditions. Also an increasing number of applications require real-time streaming of GPS (Global Navigation Satellite System (GNSS)) data. With now already three stations having a broadband seismometer, another application requires real-time streaming.

p304/l1-2 The data management structure and the underling data model should be discussed (-> new section discussion), described or referenced at least. The hardware is nicely described in section 2.1, the sensors in section 2.2, but neither section 2.3 nor 3 does explain the data model -> this could be illustrated in an addition figure (e.g. simplified data model).

Our internal data model is based on the SWE Observation and Measurement specification (O&M, 2010) in combination with the SOS standard data model (SOS, 2007). The experienced user thus may take advantage of the standard SOS requests *GetCapabilities*, *GetObservation* and *DescribeSensor*. The link to the user demonstration interface is given in the paper (http://cawa.gfz-potsdam.de:8080/SOS) with a snapshot of the user demonstration interface in Fig. 5.

p306/l3ff You nicely describe the sensors in detail. Is would be interesting to know more about your sensor selection criteria (e.g. power consumption vs accuracy/precision vs robustness), which have to be balanced/optimized. - > This could be done either in the text or possibly in Tab. 1

This information will be added to the revised version as suggested.

p306/l17 Typo: headwater?

Typo corrected

p311/l15ff Beyond a description of the central IT-platform, it would be very useful to have an illustration of the applied data model, e.g. a Figure XY (more see under Figures). This would help external users interested in make use of your open data base, as it would clarify the query options (and might be more illustrative than Tab.3).

In this case, the search for information in SOPAF (Fig. 6) can be organized hierarchically. The level to determine is "Offering", followed by "Procedure" or Station, which made the measurement, and then define "Composite Phenomenon". Since the "Composite Phenomena" is composed of several "Phenomenon", you can choose only the necessary "Phenomenon".

A (snapshot) overview is given in the table below.

SOS object name	Object description	Corresponding names in SOPAF
FeatureOfInterest	Geo-referencing of the sensor, assignment to the location of the Observation	Abramov Station
		Baitik Station
		Taragai Station
		Kokomeren Station
		Merzbacher1 Station
		Dupuli Station
		Ayvadzh Station
		Aksai Station
Procedure	Creates the type of observation (Phenomenon) by a sensor, simulation product or processing results (in SOPAF FeatureOfInterest is identically used to Procedure).	Abramov Station
		Baitik Station
		Taragai Station
		Kokomeren Station
		Merzbacher1 Station
		Dupuli Station
		Ayvadzh Station
		Aksai Station
Observation	Measured value created by a sensor related to a distinct time or period	More than 83.000.000 observations to date 09/25/2012
Phenomenon	Type of an Observation (e.g. air temperature, wind speed, rain), related to the FeatureOfInterest	more than 90 pieces, some of them, see Table 4.
Composite Phenomenon	Grouping of several physically related phenomena (Phenomenon) (e.g., CompositePhenomenon “Surface wind” is composed of phenomena (Phenomenon) wind speed, gust and wind direction).	Temperature, Pressure, Humidity
		Station Operation
		U10 wind
		Radiation
		Soil Parameters
		All Phenomena ??
		Precipitation: Rain, Snow
		River Discharge
		Snow Cover Parameters
Offering	Group of Observation(s) offered by a service (e.g. web site) to the user	Meteorology
		Hydrology
		Station Operation
		All Phenomena

		GPS measurements

p314/l5ff Section 4.1 Could you please specify, which hydro-meteorological parameters are observed? (same for section 4.2).

The basic observations are defined in section 2.2:

Meteorology: wind sensor, combined air temperature and relative humidity probe, air pressure sensor, a tipping bucket for rain monitoring and a 4-component net radiation sensor to measure the ratio between the incoming short-wave and long-wave infrared radiation versus surface-reflected short-wave and outgoing long-wave radiation.

Soil: soil temperature, volumetric water content - both in various depths

River discharge: water level, river flow surface velocity, discharge calculated

Snow: see reply to comment to p315/l13

We have uploaded the Format Specification for our hydromet sensor system (see reply to Reviewer #2). This (internal) document contains all observed quantities.

p314/l10 What is "the standard hydro-meteorological equipment"? Which parameters, sensors types & specs? Alternatively, reference to Tab.2 and/or 5.

The standard hydrometeorological equipment includes all meteorological sensors and the soil sensors. In the revised version, we will reference this more clearly.

p315/l13 ":… snow and its properties". Please specify these snow properties: snow-water-equivalent, snow temperature gradient, …? Or cross-reference to the according table.

Detailed information is given in the reference (Sommer, 2009). The SPA delivers information about the snow depth, the average snow density, a profile of snow density, the snow water equivalent, the average liquid water content of the snow pack, and a profile of liquid water content

3.3 Figures

Fig.1 Could Fig.1 be merged with Fig.8? A legend illustrating elevation would be helpful (or contour lines at 1000m, 2000m, 3000m, 4000m). Locations and labeling of large glaciers (Fedschenko etc.) and large reservoirs could be supportive. Possibly better use 'Tien Shan' (Russian name) instead of 'Tian Shan' (Chinese name).

For the revised version, we will merge both figures and add additional information on the station locations. We may also provide kmz-files in a supplement.

Fig.2 Is this picture really needed? The sensors are hard to see, the picture is taken form an non-illustrative position (back side) - I assume you have better pictures - otherwise I suggest to skip this picture.

We understand your concerns and will check our photo collection for other pictures. The main value of this picture is to illustrate a typical setup and the spatial extent of our stations. This is of particular interest if you compare our stations to other (purely scientifically motivated) high-elevation stations which typically use very compact meteo stations not necessarily complying with WMO standards (e.g. figure 6 in Aizen et al., 2009).

Fig.8 This figures has to be reworked. Scale, N-arrow and/or coordinates are missing. Major rivers (Amu Darya, Syr Darya) and 3000m, 4000m, 5000m contour lines would help to understand the site selection of your stations.

See our earlier comment on merging figures 1 and 8.

–> Why are there no stations planned in the Central and Eastern Pamir regions? Kyrgzstan is much better covered than Tajikistan (or N-Afganistan, Wakhan Valley).

The station locations are proposed mainly by the NHMS who will finally take over the operation of the stations. Hence, the selection of station locations is based on economical as well as scientific considerations. With regard to Afghanistan, we are planning two pilot stations only. At a later stage further station locations may be considered.

The rather dense coverage in Kyrgyzstan is due to the inclusion of GFZ’s Global Change Observatory station network (GCO-CA). GCO-CA has a very open data policy, which allows us to re-distribute data.

What about the Fedchenko-Glacier station (Aizen et al., 1997)? Will this station be included into your data base? Fig.XY ->

Do you mean Aizen et al. (2009)? We have no information whether the AWS in the accumulation area of Fedchenko glacier is still working. The Fedchenko meteorological station at 4169 m asl is working, though some of the sensors do not transmit the data, in particular the snow sensors (personal communication by Hydromet specialists). Please see our earlier comments on the integration of existing stations into the network. SOPAF is able to import different data types and station information. Currently we have no intention to include data from other sources unless the data originators are actively requesting such inclusion. We rather prefer SOPAF acting as a virtual station distributing data through standard operation procedures to the NHMS.

Additional Fig.: Simplified (meta)data model, illustration the query options of the data base.

see our comment to: ***p304/l1-2***

3.4 Tables
Tab.1 Please add columns describing precision & accuracy of the instrument/sensor.

Will be added in the revised version.

Tab.4 Please add a column sensor/instrument.

We consider your suggestion for the revised version.

Tab.6 Please add columns altitude and coordinates of station. –> I assume that snow sensors and stream sensors are spatially separated - what’s the difference in altitude and horizontal distance?

Tables 5 and 6 will be updated in the revised version of the manuscript to include the two stations in Tajikistan.

We would prefer not to add additional data to table 6, because the precise locations of the planned stations are not defined yet and may be subject to changes. Instead, we may include the rough station location in the map (merged figures 1 and 8).

4. References

Aizen et al. 1997. Climatic and Hydrologic Changes in Tien Shan, Central Asia. Jour-nal of Climate, VOL.10, pp. 1393-1404.
Beutel et al. 2009. Operating a Sensor Network at 3500 m Above Sea Level. Proc. 8th ACM/IEEE Intl Conf. on Information Processing in Sensor Networks (IPSN/SPOTS 2009), pp. 405-406.
Egli, L. 2008. Spatial variability of new snow amounts derived from a dense network of alpine automatic stations. Annals of Glaciology, VOL.49(1), pp. 51-55(5).
Simoni et al. 2011, Hydrologic response of an alpine watershed: Application of a meteorological wireless sensor network to understand streamflow generation. WATER RESOURCES RESEARCH, VOL.47, W10524, 16 PP., doi:10.1029/2011WR010730
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Additional references:

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WMO, 2008: Guide to Meteorological Instruments and Methods of Observation. WMO-No. 8, available at: http://www.wmo.int/pages/prog/gcos/documents/gruanmanuals/CIMO/CIMO_Guide-7th_Edition-2008.pdf (last access: 29-09-2012)