**Summarize topics that are relevant and should be tracked during SPICE tests, to allow the robustness of sensors tested: e.g. failures, intermittence, etc.**

Yves-Alain Roulet, with inputs from site managers

**Version history**

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| Version | Date | Notes |
| 1 | May 16, 2014 | Initial draft prepared by Yves-Alain Roulet based on input from site managers |

1. **Challenges/Issues with the experiment (covering all aspects and instruments)**

Challenges and issues listed below are compiled from several site reports submitted by the site managers.

1. **Site issue**

* Rikubetsu: Vertical wind affects particles fall velocity. This effect will reduce the accuracy of the measurement of disdrometer. Comparison between the disdrometer data and the 3D ultra-sonic anemometer will be done.
* Rikubetsu: A weighing gauge with higher resolution in precipitation rate is necessary because weaker snowfall rates than the ability of the present instruments are frequently occurred in cold regions.
* Formigal: Average snow depth on site is less than 2m. The top of the gauges were placed at 2.5m above level ground. This winter was characterized by strong snowfalls. As a result the gauges were buried on the snow under almost 3m snowpack in mid-February. No damages on electronic of gauges.
  + Solution 1: We removed 1 meter snowpack thanks to Formigal snowplow
  + Solution 2: We will purchase an additional one meter mast for 2014/2015 winter season
* Guthega Dam: The location of the measurement site on an exposed outcrop will likely pose some challenges for analysis as the relative exposures of the gauges may change with wind speed and direction. The potential for stratifying the dataset based on such factors remains to be seen.

1. **Data collection**

* Weissfluhjoch: Double or missing line in the daily data files occurs regularly for all instruments. Algorithm has been implemented to check and homogenize all data files before sending them to NCAR database.
* Bratt’s Lake: Computer shut-down due to failure of the UPS resulted in the logger memory filling and over-writing. Approximately 1 week of data is missing and unrecoverable.
* Haukeliseter: Some ancillary data are missing since March 2014 due to data transfer problem. Data are available but not been transferred, will be resend.
* Haukeliseter: Not all data at NCAR yet
* Col de Porte: Data transfer to NCAR was also delayed due to the need to coordinate and concentrate a large number of data providers (handling of different formats, data transfer protocols etc.). We hope to be able to complete this task by summer 2014.
* Col de Porte: A data acquisition gap due to a programming error occurred between 18 February 2014 and 5 March 2014 for the ventilated temperature sensor located together with the snow height sensors, and was fixed as soon as it was noticed.

1. **Geonor**

* Weissfluhjoch: One transducer has been changed.
* Weissfluhjoch: Erroneous data coming from one defective transducer during the period 2013/09/23 to 2013/10/28. Replacement of the defective transducer with a new one on October 28, 2013.
* Caribou Creek: In the clearing exhibited a high degree of high frequency noise that must be related to transient interference but could not be resolved during the winter period.
* Caribou Creek: Heaters, especially those in the clearing, could not maintain a rim temperature of +2C during colder periods (-5 to -10 C).
* Bratt’s Lake: Persistent temperature related drop out of one of the vibrating wire sensors on the heated R2, same as previous year but DIFFERENT sensor. Possibly caused by the Geonor transient protection circuit supplied with the gauge.
* Bratt’s Lake: Heaters could not keep at air temperatures below -5 to -10 deg C and require more power and/or re-wiring. It will be interesting to see how others resolved this issue.
* Rikubetsu: Two kinds of noise patterns are seen in Geonor data. One is high frequency noise, which may be caused by vibration of the instrument due to wind. Low pass filtering, e.g. running mean, will be needed to derive the stable value from the measured data. The other is a drift to the lighter-ward during daytime, which seems to be related to temperature but we have not grasped the cause of that as of yet.
* Rikubetsu: Among the three sensors for weight measurement, two sensors outputted nearly absolute values of weight but the rest of sensors outputted very different absolute value. The check of the data and the instrument will be done before the next season.
* Guthega Dam: The intermittent nature of the R3 noise made diagnosis relatively difficult. Although the site is not strictly remote, it is located some distance from the office, and the need for repeated visits to investigate various aspects meant that the entire process took some time. Once a number of potential causes had been ruled out and some promising leads obtained, the final stage of the investigation was completed in the workshop using spare components. A solution was then installed and tested at the measurement site.
* Guthega Dam: Although there appeared to be some precipitation events in winter 2013 that were not affected by the R3 gauge noise issue, the noise occurred relatively frequently and was intermittent, so it is recommended that the analysis uses a site dataset beginning in April 2014.
* Guthega Dam: The noise in the gauge signals has been linked to the (previously unobserved) influence of the data logger on the power supply during logger scans. In a test configuration, it was observed that about 10 ms of high frequency noise was introduced each logger scan (15 s), interrupting the output of the Geonor signal adaptors for 100-200 ms and resulting in an under-measurement of the sensor frequency. It is believed that this power supply noise varies between loggers and under different environmental conditions. The use of ferrite cores and a capacitor on the power supply line ensures the continuous operation of the signal adaptors and has removed this type of noise from the signals.
* Haukeliseter: Heating problems with unshielded reference gauge (not solved) and with DFIR gauge (working again), causing snow capping.
* Col de Porte: using the manufacturer heater without rim temperature monitoring and feedback to heating system leads to over heat, which was discussed at one SPICE telecon.

1. **OTT Pluvio**2

* Weissfluhjoch: Evaporation in non-negligible quantities, even with oil layer in the bucket
* Weissfluhjoch: Phantom accumulation observed on data (“Accumulated” parameters).
* Weissfluhjoch: The unshielded gauge (part of the R3 reference) is not heated (not a heated version). It will be replaced with a heated version in Summer 2014.
* Col de Porte: Use of the POWERCOOL antifreeze mixture, recommended by OTT for the Pluvios, was found very unsatisfying (events when freezing occurred, etc.).
* Col de Porte: The Tretyakov shield purchased to OTT and installed along with the OTT Pluvio2 seemed inappropriate to conditions encountered at col de Porte (frequent capping).

1. **Belfort gauge :**

* Weissfluhjoch: Calibration issues due to provided documentation not in agreement with the firmware version of the gauge. Interaction with the provider to have the right calibration procedure. This led to data gap (erroneous data) from 2013/09/23 to 2013/10/28 due to bad calibration on September 23, 2013. A second bad calibration on October 28, 2013 led to bad data too until a good calibration (following manufacturer’s recommendations) occurs on February 3, 2014. Between the two first (bad) calibrations, data are erroneous and can’t be recovered. Data between the second (bad) calibration and the last (good) calibration were erroneous but we had the possibility to get them back by applying a correction factor, following a procedure recommended by the manufacturer. Data following the good calibration are reliable. Bad calibrations occurred because of a documentation provided that didn’t fit with our firmware version.
* Weissfluhjoch: Frozen part of bucket content observed. A more adapted anti-freeze quantity/quality will be investigated.
* Weissfluhjoch: One transducer has been changed.

1. **Meteoservis ZAMG gauge**

* Weissfluhjoch: Gauge was too far from the data logger, implying too weak signal and signal hidden into noise. This led to data gap from 2013/10/30 until 2013/12/13. After having installed an amplifier at the level of the logger, data came out but the signal was hidden into the noise. A filter has been applied, but the gauge signal was too low and couldn’t be retrieved. The solution found has been to put the amplifier module and the filter at the level of the gauge. The signal has then been recorded properly.

1. **Lufft sensor**

* Weissfluhjoch: Accumulation observed on the dome at top of the device (where precipitation measurement is done via radar principle).
* Weissfluhjoch: Poor data quality due to data acquisition issue. The problem comes from the connexion choice between the logger and the instrument which is a 2 wires connexion. The difference in switch speed between the logger and the instrument lead the instrument to not be ready to receive the new request while it is sending data from the last minute. The consequence is missing values in data sample recorded by the logger. An attempt of slowing down the speed of the logger will take place at the next field visit to have the data logger and the instrument synchronized.

1. **FROS-D GPS sensor**

* Weissfluhjoch: No data at all. The prototype is correctly installed, but connexion issues to the satellite apparently due to close mountains topography avoid reliable and usable measurements. A new revised antenna will be installed next summer for next winter season with an improved and adapted connexion device.

1. **Thies LPM disdrometers**

* Weissfluhjoch: Numerous short (2-3 days) and long (more or less 1 week) data gaps between December 23, 2013 and April 11, 2014 for the two instruments. Data gaps come from a problem in data acquisition. The procedure was to let the data acquisition software send the request to the instrument each minute. Because of a small shift in data sending, requests of the software were finally sent during the time range where the data are processed (4 seconds before and after minute changes) leading to a no response from the instrument. The data were recorded again as soon as the shift in time reached the time range where the instrument could respond the request. The problem has been fixed by requesting the instrument to send itself each minute the telegram with the corresponding data we need from it. In this way, no shift in data sending and instrument sends always when it is able to (not during processing phases).

1. **Parsivel disdrometer**

* Caribou Creek: stopped recording data mid-winter and was not fixed.

1. **SR50**

* Caribou Creek:One of the host provided SR50 snow depth sensors failed early winter and could not be replaced until late winter.

1. **Thies precip detector**

* Bratt’s Lake: failed mid- to late- winter, reason unknown.

1. **MRW500 gauge**

* Bratt’s Lake: One MRW500 gauge appeared to freeze up (pump or drain tube) resulting in false increases in bucket weight over a 1 to 2 week period.

1. **Yankee hotplate**

* Bratt’s Lake: not installed as it arrived from the manufacturer in mid-winter.
* Haukeliseter: Hotplate installation not completed due to severe weather and low resources.

1. **Webcam**

* Bratt’s Lake: A severe wind storm in January changed the orientation of the web camera and caused a period of disruption in the photo series.

1. **Wind**

* Bratt’s Lake: 10m anemometer wind speed failed mid winter due to bearing wear.

1. **APG sonic snow depth sensor**

* Formigal:Wrong installation
  + Solution: Installation in January of Campbell SR-50. Good performance of this sensor

1. **THIES tipping bucket**

* Formigal:from 2014/02/10 to present
  + Cause: Broken when buried on snow

1. **Relevant topics**

According to issues reported in Chap. 1, and additional experiences from site managers, the following aspects and topics should be very carefully investigated and addressed in order to guarantee the robustness of sensors under various climates and conditions:

1. **Siting**

* Remote location should be avoided. If not possible, robust webcam should be placed in order to monitor the site in real time.
* Distance between instrument and data logger can be problematic for some type of instruments.
* Climatology of the site must be known, in order to mount the instruments at appropriate height above ground, avoiding them to be buried in snow.

1. **Instruments configuration**

* Follow strictly user’s guide.
* Get feedback and approval from the manufacturers.

1. **Heating configuration (see also 5.3(2))**

* Very difficult to define one configuration for all climates, as too low heating may result in snow capping and high heating in evaporation loss.
* Shape of the gauge is relevant (e.g. accumulation on non-heated parts as OTT Pluvio2 shoulders)

1. **Shielding**

* Shield is recommended to improve catch efficiency, but…
  + It can cause vibration on gauge when mounted on the gauge’s pole.
  + Effect of shield with moving part (e.g. Single Alter) is doubtful by very high wind conditions
* Level of shield must fit exactly in order to avoid negative influence on catch efficiency

1. **Anti-freeze and oil (see also 5.3(3))**

* Use of anti-freeze mixture is recommended to prevent freezing and evaporation of solid precipitation within the gauge bucket, but…
  + Unsaturated mixture can result in non-realistic accumulation due to hygroscopic effect
  + Viscosity and density of the mixture is important to ensure a good mixing with solid precipitation (and thus prevent from freezing in the bucket)
  + Oil layer on top is recommended to prevent anti-freeze (and water) evaporation
  + Oil type is relevant (freezing point, layer thickness)

1. **Mechanical mounting**

* Robust structure is mandatory, especially in harsh environment
* Avoid vibrating parts

1. **Electrical installation**

* Cables must be protected (buried) between gauge and data logger (animal, wind, temperature changes, etc.)
* Data logger must be in a suitable cabinet (heated and/or placed inside), or must contain suitable electronic components (robust to high and low temperature, in order to avoid breakdown or artefacts due to reaction by temperature changes)
* The entire installation, from sensor up to the cabinet must be protected with grounding loops

1. **Weighting gauges**

* Calibration procedure must be given great attention (following user’s guide)
* Calibration on site can be problematic
* The gauge orifice must be perfectly horizontal (stable mounting)

1. **Tipping bucket**

* Calibration procedure must be given great attention (following user’s guide)
* Heating must be configured very carefully as it can cause significant evaporation in the funnel

1. **Acoustic snow depth sensors**

* Target must be leveled and flat, 1x1 m artificial ground (not changing over the seasons), must not retain melted water, and must have identical albedo to the environment
* Sensor must be heated, in order to avoid blowing snow capping it (temperature compensation!)
* Rigid mounting to avoid vibration

1. **Optical snow depth sensors**

* Rigid mounting to avoid vibration
* Target must be leveled and flat