W O R L D   M E T E O R O L O G I C A L   O R G A N I Z A T I O N

COMMISSION FOR INSTRUMENTS
AND METHODS OF OBSERVATION

INTERNATIONAL ORGANIZING COMMITTEE FOR THE WMO SOLID PRECIPITATION INTERCOMPARISON EXPERIMENT

Fourth Session

Davos, Switzerland
17 – 21 June 2013

FINAL REPORT

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EXECUTIVE SUMMARY

This report provides a summary of the Fourth session of the International Organizing Committee (IOC) of the WMO Solid Precipitation Intercomparison Experiment (SPICE) that was held in Davos, Switzerland from 17 to 21 June 2013.

The IOC reviewed the outcomes of the first winter season focusing in particular on issues which were experienced on the different sites and which could affect data quality and data availability towards deciding on necessary modifications and clarifications on the overall set-up of the experiment and procedures to be followed within SPICE.

The IOC reviewed the procedures in place within SPICE and modified some of them based on the outcomes of the first winter season.

The IOC reviewed the work done by the Data Analysis Team, and agreed on the way forward for the linkages of the different reference types available within SPICE.

The IOC reviewed the status of commissioning of all sites and agreed on a binding schedule to complete the commissioning of all sites, on the procedures to follow and on the responsibilities for meeting this objective.

The IOC reviewed the submissions for potential participation in SPICE received in reply to the third call for participation in SPICE issued in early 2013 and agreed on a number of new participating sites, instruments (as well as on the allocation of these instruments to the sites) and on other proposals for participation in SPICE.

The IOC agreed on the draft structure for the SPICE Report on the Field Reference for the Experiment and assigned tasks towards its completion.

AGENDA

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   - 1.2 Adoption of the Agenda
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GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the Session

1.1.1 The fourth session of the International Organizing Committee (IOC) for the WMO Solid Precipitation Intercomparison Experiment (SPICE) was opened on Monday, 17 June 2013 at 8:30, by Ms Rodica Nitu, the IOC Chairperson and SPICE Project Leader. The list of participants is given in Annex I.

1.1.2 Prof. Bertrand Calpini, president of CIMO, welcomed the participants on behalf of MeteoSwiss. He recalled that CIMO's mission is to support high quality observations and their world-wide compatibility and mentioned a number of other CIMO activities that are contributing to achieving this goal, among others instruments intercomparisons, regular updating of the CIMO, and capacity building.

1.1.3 He noted that WMO in general had large expectations from SPICE and that the results of the experiment should be in line with CIMO's goals, helping to improve observations, providing advice to Members on how to carry them out, as well as to manufacturers on how to further improve instruments. He stressed the importance of drafting the report in a neutral and objective manner with respect to the manufacturers. He also stressed the importance of the commissioning protocols for all sites to provide confidence that they would be able to provide reliable and high quality data. He also stressed the importance to strive at publishing the final report of the comparison shortly after the completion of the measurement phase.

1.2 Adoption of the Agenda

The meeting adopted the Agenda as reproduced at the beginning of this report.

1.3 Working Arrangements for the Session

The working hours and tentative timetable for the meeting were agreed upon.

2. REPORT OF THE CHAIRPERSON

2.1 Ms Rodica Nitu, the SPICE Project Leader and Chairperson of the IOC, presented a status report of the project. It provided a summary of the status of commissioning of the SPICE sites, on the reference systems implemented on all sites, and on the availability of the data from the 2012/13 winter. It also included a list of the instruments from Instrument Providers which could not be operated as had been expected during the 2012/13 winter, and a list of presentations made on SPICE since the previous SPICE-IOC meeting held in Brussels, Belgium, on 15 Oct. 2012. Finally, it also summarized the proposal received in reply to the 3rd call for potential participation in SPICE that was issued in February 2013. An extract from this report is provided in Annex II.

3. REVIEW OF THE FIRST WINTER SEASON

3.1 Each of the SPICE sites was invited to provide a site report on the status and configuration of the site focussing on the outcomes of the first winter season, addressing in particular issues which could affect data quality and data availability, including the performance of the heating of the reference gauges in the various climatic conditions. A summary of these reports focussing on the lessons learned during this first winter of measurements is provided in Annex III. The full site reports are available on the meeting website (http://www.wmo.int/pages/prog/www/IMOP/meetings/SI/IOC-SPICE-4/SPICE-IOC-4.html).

3.2 The site of Caribou Creek is the only site which has a representation of the primary reference for the measurement of solid precipitation (known as R0) operating at the Valday site (Russian Federation), the bush gauge ,equipped with an automated gauge (known as R0a). In view of the novelty of this site and in the interest of linking the Caribou Creek results with those obtained at Valday , the meeting recommended that the configuration of the bushes, as well as the procedure used for maintaining the bush gauge at these two sites be clearly described and requested the respective site managers to develop and implement consistent configuration procedures prior to the 2013/14 winter. Once available, these procedures will become part of the site documentation.

3.3 The gauges tested within SPICE are not necessarily always those used operationally within the national networks. The meeting recommended that all sites consider running gauges and configurations used operationally in their country, including the same gauge with different or older firmware versions. These should not be part of the working reference system. The meeting noted the value of reporting on these gauges in view of their relevance for climate monitoring purposes.

3.4 The meeting noted that SPICE will be providing a data set that could be used for further studies. As all operational networks carry their measurements all year round (not only during the period presenting most solid precipitation), the meeting recommended that the SPICE sites endeavour to operate all instruments all year around and ensure the same data quality. This would allow for further data mining supporting applications that would contribute to improving the quality of precipitation datasets, in general. The meeting requested all site managers to notify the IOC of their plans in this respect.

3.5 Most sites experienced some problems with the setup of the gauges and had to perform a number of tests to improve their configuration and set-up (noise, grounding, vibrations, heater power, capping, etc.). All these experiences are very valuable for others setting up similar gauges and also particularly when transitioning from manual to automatic observations. The meeting therefore recommended that all site managers document the type of tests they performed to improve the performance of the gauges and that these experiences be collated and published, or possibly through a blog (SPICEBOOK), which will be made available to the project team members before the winter of 2013/14.

3.6 Several issues were identified during the course of the winter on the Marshall SPICE site One of the more critical issues was the noise noted in the GEONOR wires in the R2 reference. These vibrations were primarily due to winds shaking the tower the GEONOR was mounted to, even though multiple guy-wires were used to secure the tower. The issue was eventually resolved with the installation of rubber spacers placed between the shield poles and tower, as well as rubber spacers placed between the GEONOR and mounting plate. The meeting acknowledged the approach and recommended to the other site mangers to consider this approach.

3.7 For the site of Hala Gasienicowa, the meeting noted that the ground below the sensors under test was not flat, and this impacted the data quality. It recognized that this may be typical of remote locations, where an ideal siting for the instruments may be difficult or impossible. The meeting recommended that the site manager reviews the sensor installation, considering the levelling of the ground below the sensors and use of hard surface target that would improve the data quality and enable the derivation of meaningful data. The meeting also requested that the site manager finalizes the siting of this instrument in close collaboration with the Instrument Provider and the SPICE IOC, following the procedures established for the Snow on Ground experiment, to ensure consistency across all sites organizing similar tests.

3.8 Some site managers experienced issues with the quality of the data from instruments contributed. The meeting urged them to address such issues with extreme care and to be in close contact with the relevant Instrument Providers to solve the problem before the start of the next winter.

Configuration of heating of gauges in the SPICE reference (R2, R3): review of 2012/13 results and experience

3.9 The review of the 2012/13 data from the working field reference systems R2 and R3 on the participating sites indicates that in several cases the heating applied was not sufficient to prevent the snow capping. This was the case in particular at Haukeliseter, where the WMO-SPICE heater algorithm, as adopted at the IOC SPICE-2, does not reach positive temperatures for strong winds. Additionally, in Sodankylä, when using the same heating algorithm, the gauges remained capped for extensive periods, in low winds, high amounts of snow, and in the absence of sun (arctic winter period). Additionally, it was noted that when heaters are on, the signals from transducers appear with increased noise (CARE, Haukeliseter).

3.10 The IOC noted that the capping of gauges has a significant impact on quality/availability of data (accuracy and timeliness) due to accumulation of snow on the gauge. This can be prevented by heating the gauge (just above freezing). Once formed the snowcap can be removed, although this impacts the accumulation, or be allowed to melt naturally, which could result in significant data loss.

3.11 , The effectiveness of the heating of the top of the gauges is influenced by the environment (wind speed, temperature regimes, presence of direct solar radiation, sun azimuth), heater circuits (location of heaters, power applied), gauge shape, and the use of wind shields.

3.12 The meeting agreed on a number of modifications to the setup of the gauge heating, and procedure for removing gauge capping, which are summarized below:

Addressing the capping of Gauges in the reference system

- If the reference gauges become capped, the capping will be removed from the reference gauges as soon as possible. All metadata related to the capping event needs to be captured for future use for the data QC and data analysis (these should include timing of event, pictures, webcam pictures, descriptions, assessment of amount of capping, etc.)
- Data from the reference gauges that is used for analysis should not include data with evidence of capping of the reference gauges.

Addressing the capping of Gauges which are systems under test

- The gauges under test (non reference) will be allowed to cap during storm events. At minimum 24 hour after the end of the event the gauges are cleaned, if they operate at sites where intervention is possible/available.
- If intervention is not possible after 24 hours, cleaning of the cap will take place as early as resources are available
- Any capping event noted is recorded and documented. This will be used as input to the data analysis, together with all ancillary data set available (narratives of the event and web cam and pictures included)
- All data during a capping event should be flagged and analysed separately, and the results considered for inclusion in the Final Report. The IOC recommended that a procedure for flagging the data in the database be developed by NCAR with input from Data Analysis Team
- The IOC recommends that procedures for cleaning the capping is required to ensure consistency of approach. The step increase in the accumulation resulting from the cleaning of the cap, should be ignored (pictures, webcam pictures, etc are very important to be included in the metadata, to describe the conditions). These procedures will be made available to all site managers prior to the winter 2013/14.

Changes in the heating configuration of the gauges in SPICE, included in the reference

- As a result of the review of the experience of 2012/13 season, the functional requirement for the temperature range of the heaters have been updated to maintaining the rim temperature at +2°C to +3° C, for ambient temperatures of +2° C and below, during precipitation periods for both Pluvio2 and Geonor used in the reference.

- The Geonor inlet is heated over its entire length uniformly, while the Pluvio gauges will use the manufacturer provided heater and heating algorithm.

3.13 A number of stations in the Alps are successfully operating heated gauges with batteries. The meeting recalled that an outcome of SPICE is to make recommendations on the configurations of gauges powered from sources other than the power grid, on the required heating power to prevent capping.

4. DATA ANALYSIS

4.1 The methodology to be used for the data analysis was discussed in a breakout session and refined with all the meeting participants. It included the methodologies for filtering, corrections and integrating the reference gauge data over various time intervals, the preparation and filtering of event based level 3 data for the derivation of transfer functions. Supplementary information on the outcomes of these discussions is provided in Annex IV.

4.2 The meeting agreed that the DAT will develop the event selection algorithm (see flow chart in Annex IV). The final code will be realized and implemented at the SPICE web archive at NCAR for processing data of all sites to secure the production of comparable event files. The thresholds and the list of event parameters might be adapted if necessary. The resulting event file is the site-dataset which is the basis for further analysis and the retrieval of transfer functions.

4.3 As the proposed event selection scheme strongly depends on data from the precipitation detector the use of appropriate precipitation detectors was extensively discussed leading to changed requirements for the type of the precipitation detector used as part of the field working reference system. The IOC decided that the precipitation detectors included in the working field reference system of the experiment shall be of optical type. This is an update of the decision made at the IOC SPICE-2, when capacitive detectors had been recommended.. The IOC also recommends placing the precipitation detector inside the DFIR-fence (see details in Annex IV).

4.4 The results of the preliminary analysis of the 2012/13 data indicate that the reliability of the final results will depend on the ability of identifying the precipitation type. Based on these findings, and at the recommendation of the DAT, the IOC decided that all sites are strongly encouraged to use a laser-disdrometer-type instrument (e.g. Thies LPM or OTT Parsivel) for identifying the precipitation type. This is a requirement primarily for the sites operating a R2 reference. At a site where a disdrometer type instrument is used, this could have the role of the precipitation detector, as well, and a separate precipitation detector, while desirable, is not mandatory.

4.5 The location of the precipitation detector and of the disdrometer is expected to be consistent across all sites and will follow the guidance provided by the IOC, as outlined in Annex IV. All sites are expected to complete these changes prior to the 2013/14 winter season.

4.6 First results of the data analysis demonstrated a strong need for a detailed and precise determination of the precipitation type. The IOC highly recommends the use of an optical precipitation type sensor (e.g. a laser disdrometer) as part of the reference instrumentation which should preferably also be placed inside the DFIR-fence and can double as an optical precipitation detector. At sites without a DFIR-fence the precipitation detector should be mounted at a wind-protected place or be shielded by a suitable shield.

4.7 For deriving unique transfer functions the DAT agreed on a list of filter parameters (thresholds) to extract homogeneous data and to classify the measured accumulations by its influencing parameters (see also Annex IV). The DAT will perform a sensitivity study of these and further parameter thresholds based on data sets from several sites.

4.8 Mr Boris Sevruk presented the results of an analysis addressing the correction of measured precipitation in the Alps using the water equivalent of snow, which was performed using measurements carried out at the Weissfluhjoch site. He also presented the results from another analysis carried out at a number of sites in the Swiss Alps, investigating the relationship between the depth of fresh snowfall and its water equivalent. The meeting was invited to consider the relevance and use of these approaches for the SPICE data analysis. He encouraged the meeting to consider using the SWE to check the results obtained within SPICE.

4.9 Mr Vladislav Nespor presented the results of simulations of wind induced errors on two types of precipitation gauges.

4.10 Mr Matteo Colli also presented the preliminary results from simulation experiments aimed at assessing the wind induced under catch and also wind pumping effect in a single alter shield and in the DFIR-fence. The new proposed approach takes advantage of a Large Eddies Simulation modeling (LES) which allows a time dependent solution of the airflow passing through the bodies. A Lagrangian particle trajectories numerical evaluation is then developed and the collection efficiency of various crystal type precipitation will be addressed using infield observation of the particle terminal velocity and size distribution. The outcome of the work will be compared with the empirical comparative evaluation of the different shields collection efficiency.

4.11 The DAT discussed several methods and information sources to assess the uncertainty of the reference gauges, such as results of the field calibrations, use of the dynamic field calibrator (see also para 7.17) like that proposed by the Lead Center on Precipitation Intensity (Italy), comparison of measurements at very low wind speed and during rain events. The meeting recognized that on several sites there are pairs of gauges in similar configurations and encouraged DAT to use their data to assess their variance. The DAT decided to evaluate these and further methods as part of its work plan for the coming season.

4.12 On the linkage between R0 to R1, during the teleconference of 21 March 2013, Daqing Yang presented an analysis of the relationship between R0 and R1 data based on the results over multiple seasons collected at the Valdai site. These results were also provided as a document to this meeting. The IOC recommended that the DAT review the proposed methodology prior to the next meeting and provide feedback to the authors. The IOC recommended that this work be complemented by a broader literature research, and considered for inclusions in the Final Report.

4.13 On the linkage between R1 and R2, the IOC recommended that an analysis of the data set available from the CARE site from the 2011/12 and 2012/13 seasons, be conducted during the coming season . CARE is the only SPICE site which had a functional R1 and R2 in the 2012/2013 winter season. The IOC recommended that this work be complemented by a literature research. A summary of the findings will be used by DAT to refine the approach for assessing the reference data for SPICE.

4.14 On the linkage between R2 and R3, the DAT presented a framework for relating the R3 (proposed as a ratio of an unshielded gauge and an Alter shielded gauge) to the R2 reference, as provided in Annex V. In order to test the validity of the concept that was developed based on data from the Marshall site, the DAT will analyze data from other sites to finalize the algorithm. The IOC recommended that this work be complemented by a literature research.

4.15 The meeting encouraged DAT to work with each site manager for testing the procedures provided in Annex V on the data of their sites, for velocities up to 5 m/s. A comparative summary of the results will be prepared under leadership from DAT.

5. SNOW ON THE GROUND

5.1 The meeting recognised that a structured and consistent approach is required for the design of the experiments addressing the SPICE objectives relative to the measurement of snow on ground. During the season 2012/13 only two sites have focused their experiments on the measurement of snow on ground; these are Sodankylä (Finland) and Hala Gasienicowa (Poland).

5.2 A break-out session was organized to address the methodology to be followed for the snow on the ground component of SPICE building upon the experience gained on the sites that carried out such measurements during the 2012/2013 winter period.

5.3 The Sodankylä (Finland) site normally experiences heavy snowfall with low wind speeds allowing for a consistent snow accumulation with little variability in depth. This makes the site an excellent candidate for intercomparison of snow depth instruments. Unfortunately, the absence of wind also creates issues with snow building up on the sensors and sensor mounts, which influences the sensor measurements.

5.4 The Hala Gasienicowa (Poland) site is a suitable candidate for examining the functionality of snow depth instrumentation in a relatively severe environment while still taking advantage of manual observations. The IOC expressed some concerns over the setup at Hala Gasienicowa as the measurements of snow depth are being taken on a sloping and uneven surface. The target surface of the sensors, from photos, appears to be inconsistent. These are likely to impact the variability in accumulation below and around the two sensors. The natural vegetation, although having advantages in naturally trapping snow at the beginning of the season and producing natural melt in the spring, makes it difficult for the sensors to acquire an accurate snow depth measurement at the beginning and end of the accumulation period. To ensure accurate results, the IOC strongly recommended Changes to the configuration at this site (see also para 3.6).

5.5 The matter of the heating of the infrastructure/sensor mount was addressed to prevent snow building on them and the meeting decided that the infrastructure should not be heated, but that cleaning protocols needed to be established and incorporated into the experiment plan, similar to those adopted for snow accumulation.

Experiment Plan

5.6 The discussions of the breakout group were shared with the larger group which sparked further discussions and further refinements of the experiment plan for the 2013/2014 period. This was guided by the requirement to have tangible results by the end of the 2013/2014 season

5.7 Discussions in the breakout session identified the “purpose of measurement” as a key factor of the configuration of measurement and the reporting procedures applied; for example, capturing an accurate measurement, or a depth estimate, or a “yes/no” on the occurrence of snowfall events at the beginning of the accumulation season (f.ex. for road weather applications). It is recognized that depending on the purpose of the measurements, the expectations may exceed the capabilities of current sensor technologies (including those under test) and should be captured in the objectives and the experiment. The experiment plan was refined to reflect this perspective.

5.8 The proposed experiment plan is provided in Annex VI The meeting recognized that the plan needs to be further refined, taken particularly into account the experience and contribution of the new sites participating in SPICE; in particular Col de Porte (France) and Forni Glacier (Italy).

Action Items

5.9 The meeting recognized that the snow on the ground experiment plan would have to be further refined and decided to distribute it to the relevant site managers and experts for feedback. The site managers of the sites running snow on ground experiments are required to determine how their sites can apply the requirements of the experiment plan and suggest revisions for the IOC to consider. This document will be distributed shortly after the IOC-4 meeting with feedback expected prior to August 1, 2013. Upon receiving feedback, the IOC will finalize the experiment plan prior to September 1st for implementation prior to the start of the 2013/2014 accumulation period. It is at this time that the IOC will determine if the intercomparison site can and will comply with the requirements and recommendations set out in the experiment plan.

5.10 The meeting welcomed the interest of the representatives from Col de Port, Forni Glacier and Pyramid Observatory to take an active role in the snow on the ground component of SPICE. Interaction with the newly selected sites, will be required, including feedback on the experiment plan, to solidify and document their participation in SPICE including SOG experiments.

6. REVIEW, SELECTION AND APPROVAL OF THE SITES AND INSTRUMENTS

6.1 Review and approval of all site commissioning protocols

6.1.1 In view of the large number of SPICE testsites and their distribution around the world, it is not feasible to organize a visit of the sites to check their readiness prior to the beginning of the experiment. Therefore, the IOC had decided that each site would have to provide to the IOC a comprehensive commissioning report, reflecting the configuration of the site at the start of the experiment and demonstrating its readiness to produce high quality data. The purpose of these commissioning reports is to demonstrate the quality of the experiment.

6.1.2 The commissioning reports of only 5 sites were provided to the IOC prior to the meeting. A member of the IOC reviewed themand noted that some information was missing in each of them. He further noted that the level of details of the information provided in these commissioning protocols differed strongly from one to the other and recommended that a similar approach be followed for all and should provide sufficient details on the site configuration, so that it could be exploited as needed during the data analysis. The meeting decided that one complete report providing the expected level of information would be shared with all site managers by August 01 2013 as guidance to help them in finalizing their own protocols. Some of the site managers who completed their commissioning reports felt that the flow of information in the document could be improved.

6.1.3 The meeting agreed that the commissioning of a site provides information on the status of the site at the start of the experiment. To ensure an accurate representation of the running of the experiment, a methodology is required to document the operation of the site over the course of the experiment, covering configuration changes, site problems and maintenance (preventive and corrective) performed on the equipment.

6.1.4 Taking into consideration the above, the meeting decided that:

- All key aspects of the site configuration and operation at the time of commissioning are reflected in the current version of the Commissioning Report. Sites which have already prepared these reports may maintain the original format (Version A – 8 Oct. 2012). In order to facilitate the preparation of these reports, the format will be revised for sites which have not yet prepared them (Version B). As these reports reflect the status of the sites at the time of commissioning (the start of the experiment), they represent the baseline for the experiment and they will not be modified over the course of the experiment. Any changes in the site configuration after the start of the experiment will be tracked separately. The meeting tasked Francesco Sabatini, Mareile Wolff, Craig Smith, Anton Timofeev and Mike Earle to develop the Version B template and set the deadline of 15 July 2013 for completing the development of the template and for providing examples of completed commissioning report that could be shared with all site managers and posted on the SPICE website.
- To facilitate the tracking of performance and changes over the course of the experiment, instrument metadata reports will be prepared for each instrument individually, using the metadata reports in the commissioning report (Version B) as basis for a template. The meeting decided that a proposal for the format of these reports needed to be developed and accepted by the group. It tasked Jordy Hendrikx to lead this development, with the support of Mareile Wolff, Francesco Sabatini and Craig Smith and set the deadline of 31 August 2013 for completion of this work.

6.1.5 The meeting requested all site managers to provide their complete commissioning reports to the IOC by **1 September 2013**, to enable the IOC to **review and approve them by 1 October 2013.** The same deadline applies to the newly selected sites as they will be expected to be ready for operation before the onset of winter.

6.1.6 The Meeting welcomed the offer of Mr Sabatini, with the help of Shane Bilish, to carry out the review of all sites' commissioning reports to ensure they are assessed in a uniform manner and requested him to provide early feedback (missing information, need for clarifications, etc.) to each of the site managers on the modifications they should perform to their commissioning reports so that they could be approved by the IOC.

6.1.7 The meeting confirmed that the site commissioning protocols will be made available through the SPICE website once they will have been approved by the IOC.

6.2 Selection of new participants in SPICE

6.2.1 A third call for potential participation in SPICE was issued on 8 February 2013 and sent to all WMO Members and HMEI members. Submissions for sites, instruments, as well as for collaboration were received. A summary of the proposals is provided in Annex VII. The IOC reviewed these proposals by correspondence and the decisions listed below were finalized during the meeting. The meeting requested the Secretariat to inform all the newly accepted site proponents, instrument providers and the other interested parties on the decisions made regarding their proposed participation in SPICE and to update the list of site managers available on the SPICE website.

Sites

6.2.2 The SPICE IOC assessed the site submissions received in 2013 and decided that the following sites are approved for participation in SPICE, starting immediately:

- France: Col de Porte;
- Italy: Forni Glacier;
- Nepal: Pyramid International Laboratory Observatory,
- Republic of Korea: Gochang Observatory,
- Spain: ARAMON-Formigal.

The first three sites will focus primarily to the assessment of snow on the ground, while the latter two will contribute to both snow on the ground and precipitation amount.

6.2.3 The submission of sites from Kazakhstan has not been evaluated, as the proponent has not provided the required details on the proposed sites.

6.2.4 The site managers of these newly approved sites were invited to present their sites to the meeting.

6.2.5 Mr Jaegwang Won presented the site of Gochang (Republic of Korea) which is preparing for 2013-2014 experiment with one R2 (DFIR-fence with Pluvio^2 200). It is planned that another DFIR-fence additionally with Geonor 200B would be established by Oct. 2013 by KMA, and a few remote sensing instruments, such as 2D disdrometer, POSS and VertiX would be included in the experiment with the support from Kyungbook National University. Gochang is also equipped with several snow depth sensors of which data would be analysed in accordance with SPICE recommendation or protocol.

6.2.6 Mr Daniele Bocchiola presented the two sites proposed by EVK2CNR (Italy) on Forni Glacier (Northern Italian Alps, Valtellina) and Pyramid International Laboratory Observatory (Nepal) as well as the on-going activities taking place on both sites, and how the EVK2CNR Committee intends to contribute to SPICE hereon. The proposal is that both sites will be performing the Snow on the Ground measurements (in particular accumulated snow on the ground, and snow water equivalent). Given that SPICE is a demonstration project of the Global Cryosphere Watch (GCW), both sites (as well as similar sites participating in SPICE) could effectively contribute to GCW objectives, and therefore their inclusion within the experiment was highly welcomed. Both sites will contribute in the assessment of the Snow on the Ground primarily, and should be considered as SPICE S4 sites. Apart from the measurement of the snow depth performed by ultrasonic sensors already installed in each of them, Dr Bocchiola and the EVK2CNR committee have been invited to evaluate the feasibility and affordability of the following additional measurements and to provide the results of their evaluation by the next telephone conference of SPICE:

- Laboratory-Observatory Pyramid:
  - frequent as possible measurement of depth of freshly fallen snow and snow water equivalent preferably using snow board nearby the snow depth sensor already installed;
  - frequent as possible manual measurement of snow depth by rulers in a number of points (optimal 4) on a grid around the snow depth sensor or alternatively "visual"

snow depth measurement by the installation of permanent graduated stakes (1 to 4) on a grid around the snow depth sensor and by the installation of a webcam (remotely visual assessment of snow depth);
    - frequent as possible assessment of snow density and water equivalent on the ground using e.g. snow corer nearby the snow depth sensor already installed;

- Forni Glacier:
    - measurements of freshly fallen snow, snow depth, snow water equivalent and snow density above-listed for the Pyramid site at a frequency depending on site accessibility of this site;
    - detection of precipitation event by precipitation detector (preferably optical);
    - continuous measurements of snow water equivalent by the installation of snow pillow, nearby the snow depth sensor;
    - measurements of precipitation amount by a R3 (heated) SPICE reference (in this case the site will be configured as S3 site instead of S4).

6.2.7 Mr Samuel Buisan presented the site of Formigal – AEMET (Spain). The site is located in the Pyrenees at 1850 m asl and 150 km away from Atlantic Ocean, in a flat place with no forested area on the surroundings. The climate of the site is alpine with a clear Atlantic influence. It can snow from October to April, however it is from December to March when solid precipitation is likely expected. On average a maximum snow depth of around 150 cm is usual.

6.2.8 The main objective is to install a R3 SPICE recommended field reference in order to meet the SPICE objectives, mainly that regarding the precipitation amount, over various periods of time. It is planned to install between September and October 2013 the following instruments and datalogger:

- Geonor TB2003 (or pluvio2 OTT) with alter shield – R3 SPICE reference
- Geonor TB2003 (or pluvio2 OTT) – R3 SPICE reference
- THIES (tipping bucket) with single alter shield - Heated
- THIES (tipping bucket) - Heated
- Hellman rain gauge
- Snow depth sonic sensor APG
- Wind monitor Young Alpine
- Temperature and humidity THIES sensor
- Datalogger Campbell CR1000
- Snow stake

6.2.9 There will be 220 V AC power supply on site and infrastructure and electrical maintenance 24h per day on winter season. Data communications will be provided thanks to 3g communication technology and all these data will be reported to SPICE central archive when required. The data from SPICE R3 reference will also be used to contrast with the data from THIES gauges and Hellman gauge. Since75% of AEMET automatic weather stations use the THIES gauge and all manned stations used the Hellman gauge, this comparison will be very useful for AEMET in order to evaluate the losses in solid precipitation measurement.

6.2.10 Mr Samuel Morel Presented the site of Col de Porte (France). For precipitation amount, a GEONOR-based R3 reference gauge will be installed during the summer 2013, including a 2D sonic anemometer at the immediate vicinity of the gauge orifices (similar height). In addition to instruments that have been operated for a long time at Col de Porte (i.e., 1 GEONOR T-200B1, 2 PG 2000 cm^2 instruments operating at hourly time resolution), the following instruments provided by the site will be set-up: 2 OTT Pluvio2 (to test different shielding strategies), 1 PWS100 disdrometer, 1 Biral disdrometer. The acquisition frequency of these newly installed instruments will be 1 minute.

6.2.11 For snow depth, the Col de Porte site operates hourly measurements of snow depth using US gauges (SR50A) and laser (Dimetix sensor), and weekly manual measurements at the snowpit subsite (within the site). For the season 2013-2014, two SR50A sensors provided by Campbell Scientific will be operated and compared to manual observations carried out as often as possible with a ruler. New webcam(s) will be deployed to monitor the SPICE instruments. For the season 2013-2014, the site will not carry out the snow depth measurements tests including snow removal after each event (in order to assess instrument/methods performances for shallow snowpack conditions). This will require additional thinking and coordination with SPICE partners and the site wishes to concentrate first on setting up the precipitation gauges, which was the initial motivation of Col de Porte partners (not only Météo-France).

Instruments

6.2.12 The assessment of the instrument submissions made in 2013 was conducted during the meeting, recalling that the primary focus of the 3rd call for potential participation in SPICE was in soliciting interest in participating with emerging technologies for solid precipitation and snow on the ground, priority being given to measuring technologies not represented in the experiment yet.

6.2.13 The IOC approved all proposals of instruments for participation in SPICE listed in Annex VII, provided they could be accommodated at sites having appropriate climatic conditions to test them. It decided to allocate the instruments as follows:

- PWD 53/PWD33 (Vaisala): Sodankyla (1) and Weissfluhjoch (1)
- PWD 52 (Vaisala): Sodankyla (1) and Weissfluhjoch (1)
- FS11P Sodankyla (1)
- TPS3100 hotplate (Yankee) Bratt's Lake (1), Sodankyla (1) and Haukeliseter (1) (TBC)
- SMH30 (Jenoptik) Col de Porte (2)
- SR50AH (Campbel Scientific Canada) Col de Porte (2)
- FROS-D (Univ. Colorado): Weissfluhoch (1)
- ANS410/H (Eigenbrodt GmbH): Marshall (1)

6.2.14 The FROS-D GPS sensor normally requires a generally unobstructed field of view of 30 m radius. However, the provider of this instrument has indicated that it could report on measurements over smaller areas, thus minimising the overlapping with other structures. The IOC accepted the proposal of the Weissfluhjoch site manager to assign this system at the Swiss site. In order to ensure that the site of the Weissfluhjoch would be suitable for testing this instrument, the meeting requested the site manager to check with the instrument provider the suitability of the proposed siting of the instrument, taking into account the other instruments present on the site. Should this site not be suitable for operating the FROS-D, an alternative site will be considered for testing it.

6.2.15 In view of the limited operational temperature range of the ANS410/H, only few sites can be considered for its installation and one unit was allocated to Marshall. Based on the capacity available at the participating sites, the IOC may consider the possibility of a second site that could accommodate the second proposed unit prior to the onset of the 2013/14 winter.

Other collaboration

6.2.16 The SPICE IOC has accepted the participation of WMO Joint Working Group for Forecast Verification (JWGFVR) in an advisory role regarding the methodologies for data analysis with the focus on providing advice on the statistical analysis procedures and methods to be developed for the SPICE data analysis and interpretation.

6.2.17 The meeting decided to invite a representative from JWGFVR to take part in the data analysis teleconferences

7. PLANNING, SCHEDULING AND COORDINATION OF SPICE

Overall Configuration of the Experiment

7.1 The variability and complexity of the configurations of the sites participating in SPICE requires a review of how they contribute to meeting the overall project objectives. A summary of the SPICE site definitions agreed upon in previous meeting is provided in the Annex VIII. Specifically, consideration needs to be given to those sites where a fully functioning R3 reference may not be feasible, however, the contribution to meeting overall project objectives, warrants the inclusion of such sites in the project, e.g. specific conditions.

7.2 A proposal was made for amending the site types, including a fourth category, S4, for sites with peculiar weather regimes - Arctic, Mountain, Ocean, etc, where a reference (R1, R2, or R3) is not possible. This meeting reviewed and approved this proposal (as provided in Annex VIII).

7.3 To meet the revised requirements for the use of the precipitation detector in support of the field working reference system of the experiment, as per paragraph 4.3 of this document and Annex IV, the IOC will communicate with the Site Managers by August 15, 2013, on the required configuration changes. The meeting recommended that the location of the precipitation detector shall be based on a consideration of the interaction between the precipitation detector and the flow of air around the gauge, also minimizing the potential for the field of view of the precipitation detector to be affected by water droplets from the Alter shield or other parts of the fence structure.

7.4 The meeting requested the Site Managers to engage the Instrument Providers in validating the installation and the operation of their instruments on the respective SPICE sites, as early as possible in the experiment, to minimize the risk of collecting data which could be seen as not representative for the operation of the provided instruments. The Site Managers are encouraged to invite the Instrument Providers to visit the sites where their instruments are installed.

Report on the Reference

7.5 Responding to the CIMO Management request to provide yearly reports on the progress of SPICE experiments, the IOC has decided that a report on the field working reference system for SPICE will be prepared and be made available in 2014. This report will allow the IOC to establish a defendable reference system for the experiment,

7.6 The “Report on the SPICE Reference” will focus on the levels of reference systems configured on all participating sites for the running of the experiment, with a focus on precipitation accumulation,. The report will cover the reference system configurations, how they relate to each other, and how the reference data set will be derived. These data will later be used for reporting on the performance of measurement of the instruments under test, and for deriving the SPCIE results, addressing the project objectives. This report will be included as part of the final report of SPICE.

7.7 The meeting was provided with and reviewed a proposed skeleton for the Report on the Reference. It agreed on the proposed structure and assigned responsibilities for drafting the various sections of this reports to members of the team, as provided in Annex IX. The meeting recognized that this report might have to be updated and modified based on the experience that will be gained in the course of the evaluation of the SPICE data, and the feedback received from the broader community.

7.8 The meeting recommended that the description of the reference configuration available at all sites be presented using a similar format and recommended to derive it as far as possible from the site commissioning protocols.

Coordination of SPICE

7.9 In the past year intense collaboration took place between the SPICE team members. This took place mainly by correspondence and through teleconferences (webex) of the whole team and of the DAT team. Short protocols of the teleconferences were made and distributed to the whole team, as well as posted on the SPICE website, together with other documents of relevance for SPICE.

7.10 The meeting considered how the overall interaction could be improved to meet the expectations of all. It was recognized that the general approach had been quite satisfactory. However, the participants recognized the need for more informal interactions, which could occur by telephone, webex, meeting of opportunities, etc… The meeting further noted that the webex teleconference application could be obtained free of charge for meetings up to 3 participants.

7.11 The meeting recognized that a lot of progress could be achieved by correspondence and teleconferences for well-defined topics. However, it noted that regular face to face meeting of the whole group were essential to make the project progress at a good pace.

7.12 The IOC recommended that additional interactions should take place through task-driven small teams (2-3 persons), reporting back to the IOC. Specific members of the IOC would be appointed to monitor and review the outcome of the work of these teams, as appropriate.

7.13 The meeting recommended to include on the SPICE website an overview of the project, including possibly pictures of all sites and site managers. It also recommended developing mailing lists for the main group of interest (IOC, DAT, SPICE-Team, etc.).

Data archives

7.14 Acknowledging the commitment made during the SPICE-IOC-3 meeting (Brussels, Belgium, 15 Oct. 2012) to share responsibilities with NCAR for hosting the SPICE data archive, Environment Canada mirrored the NCAR archive. Guidance will be given to the team members on how to access the SPICE data through this archive as well.

Duration of the Experiment

7.15 The meeting noted that a number of sites had not been able to complete the installation and commissioning of their sites before the onset of the 2012/13 winter season and that the amount of data available for the analysis of the instrument under test would be limited. In order for the site managers to be able to properly plan activities on their sites, an early information will be required about the possibility to extend the duration of the experiment. The meeting requested the SPICE Project Leader to prepare and document a request for prolongation to be submitted to the CIMO Management Group by 1st of September 2013. That request should include the availability of commissioning reports available at that time.

Workplan

7.16 The meeting decided to develop a list of actions to follow-up on the decisions taken during this meeting and the outstanding actions from the teleconference to ease their monitoring and ensure all tasks are followed-up and completed in due time. The meeting requested the Project Leader to develop this list of actions in collaboration with the Secretariat.

Field Calibrator

7.17 The WMO Lead Centre on Precipitation Intensity in Italy briefly introduced the portable field calibrator (Field Calibrator) that is used to perform calibration tests of all catching type precipitation gauge in the field conditions. The main purpose of this device is to verify the operational status of precipitation gauges to detect malfunctions, output anomalies and calibration drifts throughout the field intercomparison. The IOC recognized the possible suitability of the field calibrator to verify that the instruments' performances are maintained in time throughout the intercomparison and for providing additional information on dynamic behavior of gauges. The meeting invited the Lead Centre to consider further developing and testing the field calibrator for lower intensities similar to snow fall intensities and to assess the timeframe by which such instruments could be made available to Site Managers.

8. OTHER BUSINESS

8.1 A visit of the Weissfluhjoch site took place on Tuesday 18 June 2013. The meeting welcomed this opportunity to visit a SPICE testsite and was impressed by the facilities available on the site, as well as by the DFIR-fence that was built on the site. The meeting recognized the value of the capacity developed on the SPICE sites in the context of the project and strongly encouraged the proponent to consider the continuation of the operations of such facilities, in particular those operating DFIR-fences and bush gauges beyond the official duration of SPICE.

8.2 The Finnish representatives invited to host the next meeting of the SPICE-IOC in Sodankyla (Finland), possibly in January 2014, or at another date convenient for the SPICE project. The IOC welcomed this offer and decided to agree on the date and goals for the next meeting at a later stage.

8.3 The IOC recommended that the focus of the next physical meeting of the SPICE IOC should focus on snow on the ground, as it was given much less attention than snow accumulation to date, and/or on the finalization of the report on the reference.

8.4 The IOC reiterated its desire to have close collaboration between the site managers and the instrument providers, including encouraging them to visit the sites where their instruments are operated.

9. DRAFT REPORT OF THE SESSION

The meeting review the draft report of the session and decided to finalize it and approve it by correspondence.

10. CLOSURE OF THE SESSION

The session closed on Friday, 21 June 2013 at 17:00 hours.

ANNEX I

LIST OF PARTICIPANTS

Rodica NITU ***Chair, IOC-SPICE*** ***SPICE Project Leader*** ***Site manager of CARE (Canada)***	Environment Canada 4905 Dufferin St. TORONTO, ON, M3H 5T4 **Canada** Tel.: +1 416 739 4133 Fax: +1 416 739 5721 rodica.nitu@ec.gc.ca
Jordy HENDRIKX ***Member, IOC-SPICE***	Snow and Avalanche Laboratory Department of Earth Sciences Montana State University P.O. Box 173480 Bozeman, Montana, 59717-3480 **United States** tel: +1 406 994 6918 fax: +1 406 994 6923 jordy.hendrikx@montana.edu
Eckhard LANZINGER ***Member, IOC-SPICE***	Deutscher Wetterdienst Frahmredder 95 22393 Hamburg **Germany** Tel.: +49 40 6690 2455 Fax: +49 40 6690 2499 eckhard.lanzinger@dwd.de
Haihe LIANG ***Member, IOC-SPICE***	Meteorological Observation Centre China Meteorological Administration No. 46 Zhongguacun, Nandajie BEIJING 100081 **China** Tel.: +86 10 6840 6999 Fax: +86 10 6840 0936 Lhhaoc@cma.gov.cn
Yves-Alain ROULET ***Member, IOC-SPICE*** ***Site Manager of Weissfluhjoch (Switzerland)***	Météo Suisse Station Aérologique Case postale 316 CH-1530 PAYERNE **Switzerland** Tel.: +41 26 662 6258 Fax: +41 26 662 6212 yves-alain.roulet@meteoswiss.ch

Francesco SABATINI ***Member, IOC-SPICE***	CNR-IBIMET Institute of Biometeorology Via Giovanni Caproni, 8 50145 Florence **Italy** tel.: +(39) 055 303 3711 tel.: +(39) 055 522 6029 fax: +(39) 055 308 910 f.sabatini@ibimet.cnr.it
Valery VUGLINSKI **Member, IOC-SPICE**	State Hydrological institute 2nd Line 23 St. Petersburg 199053 **Russian Federation** tel.: +7 812 3233458 fax: +7 812 3231028 vvuglins@vv4218.spb.edu
Roy RASMUSSEN ***SPICE Project Co-Leader*** ***Site Manager of Marshall (USA)***	National Center for Atmospheric Research 3450 Mitchell Lane Boulder, CO 80301 **United States** Tel.: (1 303) 497-8430 Fax: (1 303) 497-8401 rasmus@ucar.edu
Osmo AULAMO ***Site Manager of Sodankyla (Finland)***	Finnish Meteorological Institute Tähteläntie 62 99600 Sodankylä **Finland** osmo.aulamo@fmi.fi
Shane BILISH ***Site Representative of Guthega Dam (Australia)***	Snowy Hydro Limited PO Box 332 Cooma NSW 2630 **Australia** Tel.: +61 2 6453 2658 Fax: +61 2 6453 2052 Shane.Bilish@snowyhydro.com.au
Daniele BOCCHIOLA ***Site Manager of Pyramid International Laboratory Observatory (Nepal)***	Ec-K2-CNR Committee S. Bernardina 145 24100 Bergamo **Italy** tel: +(39)022 399 6223 fax: +(39)022 399 6207 daniele.bocchiola@polimi.it
Matteo COLLI ***Invited Expert***	DIAM - Department of Environmental Engineering University of Genoa Via Montallegro, 1 16145 Genova **Italy** Matteo.colli@unige.it

Brian DAY ***HMEI Representative***	Campbell Scientific 11546 149 Street NW Edmonton AB T5M 1W7 **Canada** Tel.: +1 780 454 2505 Fax: +1 780 454 2655 brian.day@campbellsci.ca
Michael EARLE ***Invited Expert***	Environment Canada 45 Aldeney Dr. Queens Square Dartmouth, NS B2Y 2N6 **Canada** tel.: +1 902 426 4477 Michael.earle@ec.gc.ca
Charles FIERS	WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 7260 Davos Dorf **Switzerland** tel: + 41 81 4170 165 fax: + 41 81 4170 110 fierz@slf.ch
Barry GOODISON ***Representing EC-PORS, GCW and GCOS***	4 Vezina Place Kanata, Ontario K2K 3G9 **Canada** barrygo@rogers.com
Maciej KARZYNSKI ***Site Manager of Hala Gasienicowa (Poland)***	Institute of Meteorology and Water Management National Research Institute Cracow's Branch 14 Piotra Borowego Str. 30-215 Cracow **Poland** Tel.: +48 12 6398132 Fax: +48 12 6398201 maciej.karzynski@imgw.pl
Timo LAINE ***Site Representative of Sodankyla (Finland)***	Finnish Meteorological Institute **Finland** timo.laine@fmi.fi
Luca LANZA ***Site Representative of Italy***	DIAM - Department of Environmental Engineering University of Genoa Via Montallegro, 1 16145 Genova **Italy** Tel: +39 010 353 2123 Fax: +39 010 353 2481 luca.lanza@unige.it

Yves LEJEUNE ***Site Representative of Col de Porte (France)***	Météo-France Centre National de Recherches Météorologiques Centre d'Etudes de la Neige CNRM-GAME/CEN 1441, rue de la piscine 38400 St Martin d'Hères **France** tel: +(33)4 76 63 79 24 fax: +(33)4 76 51 53 46 yves.lejeune@meteo.fr
Christoph MARTY	WSL Institute for Snow and Avalanche Research SLF Flüelastrasse 11 7260 Davos Dorf **Switzerland** tel: + 41 81 4170 168 fax: + 41 81 4170 110 marty@slf.ch
Samuel MORIN ***Site Manager of Col de Porte (France)***	Météo-France Centre National de Recherches Météorologiques Centre d'Etudes de la Neige CNRM-GAME/CEN 1441, rue de la piscine 38400 St Martin d'Hères **France** tel: +(33)4 76 63 79 03 fax: +(33)4 76 51 53 46 samuel.morin@meteo.fr
Kurt NEMETH ***HMEI Representative***	Business Development Manager Meteorology OTT Hydromet GmbH P.O.Box: 2140 / 87411 Kempten **Germany** Tel: +49 831 5617 – 270 Fax : +49 831 5617 – 209 k.nemeth@ott.com
Vladislav NESPOR ***Invited Expert***	ETHZ **Switzerland** nespor@id.ethz.ch
Audrey REVERDIN	Météo Suisse Station Aérologique Case postale 316 CH-1530 PAYERNE **Switzerland**
Boris SEVRUK ***Invited Expert***	Imbisbühlstrasse 133 8049 Zürich **Switzerland** boris.sevruk@env.ethz.ch

Craig SMITH ***Site Manager of Bratt's Lake (Canada)***	Environment Canada 11 Innovation Boulevard Saskatoon, SK S7N 3H5, **Canada** Craig.Smith@ec.gc.ca
Anton TIMOFEEV ***Site Representative of Valdai (Russian Federation)***	State Hydrological Institute Metrology Department 23, Second Line, V.O. St. Petersburg **Russian Federation** Tel/Fax: +7 (812) 323 11 67 ggi@hotmail.ru
Emanuele VUERICH ***Chair, CIMO ET-II*** ***Invited Expert***	Italian Met Service – Air Force Centre of Meteorological Experimentations Via Braccianese Claudia, km 20,100 00062 Vigna di Valle (Rome) **Italy** tel.: +39 06 99 88 7702 fax: +39 06 99 87 297 vuerich@meteoam.it
Mareile WOLFF ***Site Manager of Haukeliseter (Norway)***	Norwegian Meteorological Institute P.O. Box 43 Blindern Henrik Mohns plass 1 0313 Oslo **Norway** Tel.: +47 2296 3185 Fax: +47 2296 3050 Mareile.wolff@met.no
Jaegwang WON ***Site Representative of Gochang Observatory (Republic of Korea)***	Observation Infrastructure Bureau Korea Meteorological Administration 45 Gisangcheong-gil Dongjak-gu SEOUL 156-720 Republic of Korea tel.: +82 2 2181 0694 fax: +82 2 2181 0709 wonjg@kma.go.kr, ecotus37@korea.kr
REMOTE PARTICIPATION	
Bruce BAKER ***Vice-President of CIMO*** ***Member, IOC-SPICE***	NOAA / ATDD 456 South Illinois Avenue OAK RIDGE, TN 37830 **United States** Tel.: +1 865 576 1248 Fax: +1 865 576 1327 bruce.bakernoaa.gov

Samuel BUISAN ***Site Representative of ARAMON - Formigal (Spain)***	AEMET Aragon Regional office Paseo del Canal 17 50007 Zaragoza **Spain** Tel.: +34976569700 (ext 26) Fax: +34976374144 sbuisans@aemet.es
Paul JOE ***Invited Expert***	Environment Canada 4905 Dufferin Street Toronto Ontario M3H 5T4 **Canada** Tel.: +1 416 739 4884 Fax: +1 416 739 4211 paul.joe@ec.gc.ca
Yoshihiko TAHARA	Observations Department Japan Meteorological Agency 1-3-4 Otemachi Chiyodaku Tokyo 100-8122 **Japan** Tel: +81-3-3211-6019 Fax: +81-3-3213-1742 y-tahara@met.kishou.go.jp
William WRIGHT ***Representative of the Commission for Climatology***	Climate and Water Division Bureau of Meteorology 700 Collins Street MELBOURNE 3008 **Australia** Tel.: +61 3 9669 4457 W.Wright@bom.gov.au
Daqing YANG ***Site Manager of Caribou Creek (Canada)***	National Hydrology Research Centre (NHRC) Environment Canada 11 Innovation Boulevard Saskatoon, SK S7N 3H5, **Canada** tel: +(1 306) 975 6483 fax: +(1 306) 975 5143 daqing.yang@ec.gc.ca
WMO SECRETARIAT 7 bis, avenue de la Paix Case postale 2300 CH 1211 Geneva 2 Switzerland	**IMOP website** http://www.wmo.int/pages/prog/www/IMOP/IMOP-home.html
Isabelle RÜEDI Head, Instruments and Methods of Observation Unit WMO Observing Systems Division	Tel.: +41 22 730 8278 Fax: +41 22 730 8021 E-mail: iruedi@wmo.int

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ANNEX II

REPORT OF THE CHAIR

Season 2012/13 Experiment Configuration and Site Commissioning

The winter of 2012/13 in the Northern Hemisphere was the first formal season of the SPICE experiment.

The meeting of IOC SPICE-2 agreed that (5.2.47) each Site Manager is responsible for the configuration of the experiment on their particular site. Prior to the official start of the experiment, it is required that the site configuration is commissioned following a procedure approved by the SPICE IOC. the acceptance of the Commissioning Report by the IOC represents the formal commencement of the experiment. The date of the start of the experiment is that indicated in the Commissioning report and accepted by the IOC.

Of the 12 SPICE sites in the Northern Hemisphere, nine have run at least partial experiments during this season. The two sites in Japan, Joetsu and Rikubetu, have planned the formal start of the experiment for 2013, while the Volga site (Russian Federation) will be configured during the summer of 2013.

In parallel, the three sites in the Southern Hemisphere, Guthega Dam, Mueller Hut, and Tapado have prepared for their first formal season of experiments, estimated to commence in June 2013.

A summary of the status of the SPICE experiments and the commissioning of sites is provided in the table below.

It remains imperative to finalise the commissioning of the sites as soon as possible, as the participation of a site in the experiment of next winter season is conditioned by its commissioning.

Given the inability to visit and review the installation and operation of each site, the Commissioning Report is the most reasonable tool to demonstrate the readiness of the site, as a premise for the quality and comprehensiveness of the SPICE data set.

	Site (Country)	Running since	Commissioning date	Notes
	Northern Hemisphere			
1	Bratt's Lake (Canada)	Dec 14, 2013	Dec 14, 2013(*)	Partial commissioning (**)
2	Caribou Creek (Canada)	Feb 21, 2013	June 17, 2013 (*)	Partial commissioning(**)
3	CARE (Canada)	Dec 01, 2012	Dec 01, 2012 (*)	
4	Haukeliseter (Norway)	Jan 18, 2013	Jan 18, 2013 (*)	
5	Hala Gasienikowa (Poland)	Dec 01, 2012		Focused on Snow on ground; changes to site configuration are required prior to commissioning
6	Marshall (USA)	Dec 01, 2012	Dec 01, 2013 (*)	Partial commissioning(**)
7	Sodankylä (Finland)	Dec 21, 2012	Dec 21, 2012 (*)	Partial commissioning(**)
8	Valdai (Russian Fed)	Nov15, 2012	Nov 15, 2013 (*)	Only manual measurements(**)
9	Volga (Russian Fed)	Not operational 2012/13		
10	Weissfluhjoch (Switzerland)	Feb 07, 2013 (*)	Feb 07, 2013 (*)	Partial commissioning(**)

11	Joetsu (Japan)	Not operational 2012/13		
12	Rikubetu (Japan)	Not operational 2012/13		
	Southern Hemisphere			
13	Guthega Dam (Australia)	June 2013	June 2013	
14	Mueller Hut (New Zealand)	June 2013	June 2013	
15	Tapado (Chile)	June 2013	TBD	

(*): The Commissioning Reports have been prepared; the IOC review is pending.
(**): Partial Commissioning of sites is possible when the field working reference systems are operational and prior to all the instruments under test being operational on the SPICE sites. The commissioning of the additional instruments is conducted, as they are installed. The SPICE results will be derived only from fully commissioned instrument configurations.

Note: the sites Joetsu and Rikubetu are in process of redefining the nature of their participation in SPICE, following the inability to obtain full funding for the configuration of the experiments. In spite of this, the proponents will conduct SPICE related experiments in 2013/14, supported by the Japan Meteorological Administration.

SPICE Reference Configuration

The SPICE field working reference systems were configured on each site, according to Section 5.2, Configuration and Operation of the Working Field reference, of the report of the IOC SPICE-2 meeting, Boulder, June 10-15, 2012. The reference type(s) operating on each SPICE site are summarized in the table below, and reflects the status on June 17th, 2013.
For communication purposes, the IOC agreed on a site type system based on type and configuration of the site references. This is only used to enable the communication between the team members, and has no impact on the quality of data.
The detailed definition of the Field Working Reference Systems and the site type is given in Annex IX of this document.

	Site	R0	R1	R2	R3	Gauge	Sampling interval	output Interval	Site Type
	Northern Hemisphere								
1	Bratt's Lake	NA	NA	X (2)	x	Geonor 600	20 sec	1 min	S2
2	Caribou Creek	X (automatic gauge)	NA	x	x	Geonor 600	20 sec	1 min	S0/S2
3	CARE	NA	x	x	x	Geonor 600	6 s	6 s	S1
4	Haukeliseter	NA	NA	x	x	Geonor 1000	6 s	1 min	S2
5	Hala Gasienicowa	SoG manual measurem	NA	NA	NA				SoG
6	Marshall	NA	x	x	x	Geonor 600	6 s	6 s	S1
7	Sodankylä	NA	NA	x	x	Pluvio2	6 s	6 s	S2

8	Valdai	X (manual)	x	NA	NA	NA	NA	NA	S0
9	Volga	Not operational for 2012/13							
10	Weissfluhjoch		NA	x	x	Pluvio2		10 min, 1 min in preparation	S2
11	Joetsu	Not operational for 2012/13							
12	Rikubetu	Not operational for 2012/13							
	Southern Hemisphere								
13	Guthega Dam	NA	NA	NA	x	Geonor 1000			S3
14	Mueller Hut	NA	NA	NA	x	Geonor 1500			S3
15	Tapado, Chile	NA	NA	NA	x	Geonor 600			S3

Data availability

The meeting of IOC SPICE-2 agreed that (5.2.48) for every field intercomparison, an initial phase is needed to ensure that all instruments and equipment are working correctly. To shorten this phase, it was agreed that the data of each site has to be monitored carefully by experts of the SPICE project team. The local site managers will be supported to identify possible errors or malfunctions of instruments and equipment as early as possible.

All participating sites have own archives for storing the SPICE data. Each site has stored the experiment data since the start of the experiment locally.

A summary of the data availability (references and systems under test) will be made available based on the individual site reports by September 1, 2013 and will support the request for extending the SPICE experiments by one winter season.

Data transmitted to NCAR

NCAR has established the capability of archiving all SPICE data, as provided by the participating sites. The NCAR data archiving requirements have been adopted by IOC SPICE-3 in Brussels, in Oct 2013. The NCAR offers the option of quick plotting of the SPICE data.

Additional guidance on the use of the NCAR SPICE archive will be provided by NCAR in the form of a training video, before the start of the season 2 of the experiment, but no later than Oct 2013.

In parallel, since April 2013, Environment Canada has established a SPICE mirror archive, ensuring redundancy of the SPICE Archive configured at NCAR.

The transfer of test data to the SPICE Archive remains a high priority, as the consistency of format and the availability of data quick view, will significantly enable the carrying out of data analysis. The Site Managers are strongly encouraged to ensure the transfer of their data ongoing before the start of the next test season.

Instruments from Instrument Providers

Most of the instruments from the Instrument Providers have been installed on the sites to which they were allocated, prior or during the 2012/13 winter season. Some exceptions, though, exist:

1. CARE: Meteorological Particle Sensor from Droplet Technologies allocated to CARE was not installed for the winter of 2012/13 due to the unforeseen difficulties related to accommodating the dedicated computer required by the system. In May 2012, in consultation with the Instrument Provider, the system has been relocated to the Marshall SPICE site.
2. Bratt's Lake: MRW500 precipitation gauges from Meteoservis in the Czech Republic were not installed due to the early onset of winter conditions at the site in mid- to late-October. Installation is planned for the 2013/2014 season

3. Caribou Creek: Parsivel 2 from OTT was never provided, therefore not installed. No communication has been made with the Provider.
4. The CS725/GMON was not installed in Sodankylä for the 12/13 season, requiring additional site preparation. Its installation will be completed before October 2013.

Data Analysis Team (DAT)

The IOC SPICE-2 established a dedicated team within the SPICE Project Team focusing on the definition and the carry out of the data analysis of the project, leading to the Final Report
DAT has been led by Eckhard Lanzinger and has met via WebEx frequently. Its work focused on the development of the methodologies for filtering and the derivation of the observation for the reference of the experiment. As of June 2013 the DAT will be led by Dr Mareile Wolff (Norway) and Dr. John Kochendorfer (USA).

SPICE presentations

The SPICE experiment has generated a lot of interest at national and international level. During the period between IOC SPICE-3 and IOC SPICE-4, several presentations were made at international conferences and workshops.

- WMO Technical Conference, TECO, Oct 2012
- American Geophysics Union (AGU), Dec 2012
- Global Cryosphere Watch (GCW), Snow Watch Workshop, Toronto, Jan 2013
- American Meteorological Society (AMS), Atlanta, USA, January, 2013
- Australian Meteorological Society
- New Zealand Meteorological Society
- NASA Precipitation Measurement Mission Workshop, March 2013
- International Workshop on Spaceborne Snowfall Missions (IWSSM), May 2013. The workshop organized under IPWG (International Precipitation Working Group) of CGMS of the Space Program of WMO.
- Canadian Meteorological and Oceanographic Society (CMOS), Saskatoon, Canada, May 2013

2013 Call for interest for participation in SPICE

On Feb 08, 2013 WMO issued a third letter of interest for participation in SPICE to all WMO Members and the HMEI Members.
Positive responses have been received regarding the potential participation with sites and instruments.

ANNEX III

SUMMARY OF SITE REPORTS PRESENTED AT THE MEETING

Bratt's Lake (Canada)

The Bratt's Lake site has been fully operational since December 14th, 2012 including functioning R2G (both heated and unheated) and R3G. R2G has been collecting data from November 1, 2012. The only instrument installed under test was the Geonor T-200B1500. Two MRW500 precipitation gauges were received from Meteoservis but were not installed for the 2012/2013 winter due to the late arrival and complexity of the gauge. Ancillary measurements include wind speed and direction at 2m, temperature and relative humidity at 2m, and surface pressure. The precipitation detector employed was the DRD11A which seems to not recognize all precipitation occurrences with an estimated failure rate greater than 50%. The site received snow starting in late October and experienced snowfall far greater than normal (> 200%) over the accumulation period with increased frequency of blowing snow events late in the season (late February/early March). Site data is being downloaded from the logger daily and reformatted and transferred to NCAR on a weekly basis (since Dec 14, 2012). Currently, the scan rate of the logger is set to 20 seconds with data output minutely. This is a recognized issue (lack of 6 second data) but is due to logger/programming restrictions related to the number of Geonor vibrating wire sensors at the site. The heating methodology seems to be working well after switching to larger and independent power supplies for each precipitation gauge heater. The Geonor gauges on site are using the USCRN heater configuration and the SPICE algorithm as defined at IOC-3. Some noise is noted in the Geonor data (especially the Geonor 1500mm gauge) with some intermittent sensor problems with the R2G gauges. Some analysis has occurred on the heated vs. unheated R2 intercomparison which shows some definite advantages to heating (during a freezing rain event in November) and possibly some disadvantages (due to evaporation/sublimation in the heated collector) but this impact is small compared to other errors. Prior to the 2013/2014 season, the MRW500, Thies disdrometer, and web camera will be installed at the site.

Caribou Creek (Canada)

The infrastructure installation at Caribou Creek was delayed due to an early and severe winter but the site was finally completed (with exceptions) on February 20th, 2013 and caught the end of the 2012/2013 accumulation period. Starting Feb 20, the site has an R0G and R0P (Bush shielded Geonor and Pluvio), R2G and the Geonor T-200B1500mm gauge under test. The R3 Geonors were installed and are functioning but both gauges are unshielded and only one is heated. Ancillary data includes wind speed at 2m and 3m, Wind speed and direction at 6m (30 minute data only), 1.5m Temperature and Humidity and surface pressure. The site is using a DRD11A precipitation detector with recognized detection problems. Data is being collected by a logger (minutely) and being transferred to a PC (daily) onsite. Currently, the data is collected from the site periodically during site visits but satellite internet is planned and will allow daily or sub-daily data collection. Currently, the scan rate of the logger is set to 20 seconds with data output minutely. This is a recognized issue (lack of 6 second data) but is due to logger/programming restrictions related to the number of Geonor vibrating wire sensors at the site. The heating methodology seems to be working well after switching to larger and independent power supplies for each precipitation gauge heater. The Geonor gauges on site are using the USCRN heater configuration and the SPICE algorithm as defined at IOC-3. Some noise is noted in the Geonor data (especially the Geonor 1500mm gauge). Some of the noise associated with the Geonor gauges could be related to the hasty winter installation in less than ideal conditions. Installation of further ancillary instrumentation, including a web camera, is planned prior to the 2013/2014 accumulation period. Analysis priorities at this site include the R0G/P vs R2G intercomparison.

CARE (Canada)

Site fully operational since Dec 01, 2012. The site operates R1, R2, and R3 references.

A total of 150 days of data were collected for each sensor site. All data was QC'd using internal applications, covering Missing records, Missing fields, Correct/Incorrect file sizes reported, Missing time stamp, Fields containing unexpected characters, Duplicate records.

The site team has been able to address all maintenance and site intervention issues efficiently, reducing to a minimum the loss of data. The internal quick plot view tools, QC applications, and the part time field person contributed to it.

The NCAR data transfer was initiated in May 2013, and covers all the past data since Dec 2012.

Guthega Dam (Australia)

The existing precipitation gauges (3x ETI NOAH II) at Guthega Dam are currently operational for the 2013 winter season. Wind speed and direction sensors at heights of 3 m and 10 m are also operational, and a new temperature and humidity sensor has been installed. Two Geonor T-200BM3 (1000 mm capacity) precipitation gauges and a Thies Precipitation Monitor were purchased for the establishment of an R3 reference; installation of these instruments has begun. Final commissioning of the site is expected to take place in July 2013. Testing of the procedure to upload data to NCAR will take place after that.

Hala Gasienicowa (Poland)

The SR50ATH instrument from Campbell was install at the Hala Gasienicowa site. A problem with the calibration of the sensor was experienced which led to the acquisition of erroneous data. The heating worked in accordance with the instructions of the manufacturers. The site is not fully commissioned yet and the ground below the sensor is not flat.
The Site Manager is considering making the following improvements to the setting:

- Increase the number of calibration of the sensor.
- Increase the frequency of measurements up to 30-60 seconds and sending them every 10 minutes.
- Replace the logger by a newer model including GPRS modem. This will allow for the transmission of larger amounts of data.
- Change the location of the sensor and change the mast.
- Level the ground below the sensor.

Haukeliseter (Norway)

After an installation period in early winter 2012/2013 most of the instruments at Haukeliseter were working since January 18th 2013. Today, 25 instruments are operating at the site. Additional to the existing R2 (Geonor w Alter in DFIR) the R3 was realized, containing of Alter shielded and unshielded Geonor gauges. The WMO SPICE test instruments, weighing gauge TRWS405 (MPS System) and the present weather sensor PWS 100 (Campbell) were installed. Data are not yet checked with the instrument providers. Due to the winter installation not all grounding could be finished. The finalizing of the grounding is planned for summer 2013. Two of the Geonor transducers (one of them in the shielded R3 gauge) are experiencing unusual high noise. They were changed several times and grounding was improved, but the problem remains so far. Instrument issues were also noted for the humidity sensor and the disdrometer-type Ott Parsivel. Both were addressed and we are currently evaluating the functionality after the changes. The WMO-SPICE heaters at the reference gauges were not able to reach 0°C for strong wind situations. Significant amounts of snow were recorded for temperatures below the lower threshold for heating (TA=-5°C) and caused situation where total or partial capping could have occurred. Because the webcamera was not in place before mid-march, only evidences of partial snow-clinging could be found.

The commissioning process revealed that all Alter shields are mounted equal to the gauge height. They will be lifted according to the WMO SPICE requirements in Summer 2013. A field test of all weighing gauges was performed on April 16th 2013.

There were difficulties to setup a working datastream from the test site to the long-term site-archive. Automatic data transfer started in the end of May, we are currently in the process of transferring the complete data set of the first winter to our long-time site archive. A working datastream is expected to be finished in July 2013. Outstanding tasks are the commissioning report (to be finished 1 September 2013) and the transfer of data to NCAR (work starts after the datastream to the internal site archive is fully functional).

Marshal (USA)

The Marshall Field site underwent significant upgrades to its power and networking infrastructure last fall in anticipation of adding approximately 30 new gauges to the site for testing. As of this spring, all additional sensors had been installed at the site, including the R1, R2 and R3 References. The R2 reference gauge for the site is a standard GEONOR T-200b 600mm gauge. Two R3 references were installed at the site: one using the GEONOR T-200b 600mm gauges and one using the OTT Pluvio2 gauges.

Several issues were identified during the course of the winter. One of the more critical issues was the noise noted in the GEONOR wires in the R2 reference. These vibrations were primarily due to winds shaking the tower the GEONOR was mounted to, even though multiple guy-wires were used to secure the tower. The issue was eventually resolved with the installation of rubber spacers placed between the shield poles and tower, as well as rubber spacers placed between the GEONOR and mounting plate. The Sutron gauges are also showing problems with noise in the data, but this has not been resolved and Sutron plans to send a technician to the site this summer to evaluate the problem. The C.A.E. gauge had trouble with the heating throughout the winter and attempts to update the firmware have thus far been unsuccessful. C.A.E. also plans to send a technician to evaluate the gauges this summer.

In planning for the additional equipment at the site, it was found that portable concrete pads made installation of the instruments much quickly and easier than having to mount the instruments into the ground. Also, the ability to daisy chain the CR3000 dataloggers together saved significant time and money in having to run additional cabling to each individual datalogger. This was also true for all the gauges that used the SDI-12 interface for transferring data. The SDI-12 also made wiring both the data lines and the power much simpler and required much less time and other sensors to install. One of the biggest challenges was the power conversion from 110v to 220v. Many of the European gauges were designed to run off of 220v, which required a step-up transformer to be installed at the site.

Preparations for next winter are already underway. This includes plans for a full site calibration of all instruments, the addition of webcams with the ability to take photos of each gauge orifice under test once every hour, and dedicated webcams focused on the orifice openings for the R1 and R2 references. An aerial photograph of the Marshall site is also planned for inclusion in the site-commissioning document.

Sodankyla (Finland)

Installation of 11 SPICE instruments under test on the empty field worked very well. Some of the instruments arrived in the winter season with snow cover but the installation could be made in hard conditions. The site field was build and equipped with 36 installation slots having all AC electricity and internet connection. In addition to the SPICE instruments FMI takes part in the future NASA GPM mission ground validation (LUMI-project). Totally 8 instruments for this project are or will be installed on the same field. Some of these instruments are the same used in SPICE as well. For internal purposes FMI also has installed two OTT Pluvio 400 versions and two old Vaisala VRG gauges on the same field. FMI’s operational network has used VRG gauges but in the nearest future these will be replaced by the OTT Pluvio 400.

Snow depths sensors SR50 ATH and USH-8 are delivered with spare by the instrument providers. Also the spares are installed and in both the measurement booms are tilted 45 degrees upwards whereas in the nominal instruments the booms are horizontal. The tilted boom is nominally used in FMI’s operational weather stations.

Ancillary data from Sodankylä SPICE site consists of a separate ancillary weather station that measures following parameters: T, Rh, pp, DD and FMS

The ancillary instruments are: Vaisala PT100 (T) for temperature (2m), VaisalaHumicap (Rh) for relative humidity (2m), Thies acoustic windmeter for DD and FMS (~ 5m) and Vaisala PTB220 for pressure (2m). If other parameters are needed, those are collected from Sodankylä weather station about 200 meters away from the SPICE site.

Sodankylä SPICE field had problems with Pluvio's rim capping. The rim heating algorithm of all Pluvios were changed 18.3.2013 from WMO's heating algorithm to Pluvio's own internal heating algorithm. All Pluvios were cleaned 4.2.2013 due to capping.

Weissfluhjoch (Switzerland)

The Weissfluhjoch test site (S2) has been equipped with the basic infrastructure (cables, concrete pads, DFIR) in Summer and Autumn 2012. Following instruments could be installed early February 2013:

- Ott Pluvio2 in the DFIR as a R2 (currently unshielded),
- Ott Pluvio2 (2x) outside the DFIR as a R3 (currently both unshielded),
- Geonor T-200B provided by the manufacturer, with shield (according to manufacturer's specification),
- Belfort AEPG 600 with double Alter shield, both provided by the manufacturer.

The start of the experiment (partial commissioning) was performed on 8 February 2013. Since then, data from these five gauges have been collected on a 10 min basis. Ancillary data from the SLF test field are also retrieved, as well as webcam images pointing on the five gauges (every 2 hours). Data are stored on the MeteoSwiss database, and have not been transferred to NCAR yet. The 1 min data is currently being implemented, and will be stored in the SPICE data base at NCAR. The system encounters missing values at regular interval, probably caused by problems in the data logger configuration.

Issues encountered on the sensors:

- Geonor: additional electronic module had to be produced as the signal was too weak for the electronic module in the data logger, large unexplained variations (positive/negative)
- Belfort: one transducer was not working at installation, spare set was provided by the manufacturer

The data have not been analyzed yet. Plans for the near future concerning the data include:

- Centralization of all data available from the test site (SLF, MeteoSwiss)
- Data formatting and transfer to NCAR
- Start data analysis

The site will be fully equipped according to SPICE specification and new instrument submission by 1st October 2013. This includes:

- Shield for the Pluvio2 inside the DFIR and for one of both Pluvio2 outside the DFIR
- Precipitation type detector between the DFIR inner fence and the shield of the Pluvio2
- Thies LPDM (instrument under test, provided by the manufacturer)
- TB MR3H-FC ZAMG-version (instrument under test, provided by the manufacturer)
- PWD L52 and L53 (according to SPICE IOC decision during this meeting)
- GPS from Surfasense (according to SPICE IOC decision during this meeting, after clarification of the needed footprint with the manufacturer)

Following aspects have worked particularly well:

- Preparation of the site (concrete base, power lines, DFIR, wiring)
- Collaboration with SLF for on-site support
- Collaboration with Belfort
- Installation of the instruments and data logging
- Data transfer (GPRS)
- Heating: no heating issues (e.g. capping) have been noticed

Following aspects could be improved:

- Install instruments before Winter starts
- Complete the set of ancillary measurements
- Finalize data format and transfer (including QC), and start data analysis.

Valdai (Russian Federation)

Anton Timofeev reported on Valday precipitation polygon condition. Reference chain is still not full (R2 and R3 are not installed because of lack of instruments). R0 and R1 are fully operated and data sent to NCAR server. Mean time next data is available:

- R0, volume method, 1/24 hr measurements;
- R1, volume method, 1/24 hr measurements;
- Pluvio2 200 mm, 1/10 min measurements, preprocessed via OTT instrument firmware and AdCon server*;
- Pluvio^2 400 mm, 1/15 min measurements, same «data level» as for 200 mm*;
- Ancillary data (wind speed, atmospheric pressure, atmospheric temperature, 6 Tretyakov gages measurements).

*data is available for Site team and Site manager

QC performed:

- If wind speed at 2 m is higher than at 3 m – measurement is excluded;
- If there was something wrong with OTT gauges, data is not reported/values marked with NULL(part of OTT+AdCon QC results).

Difference between firstly proposed instrument set:

- Site team decided to exclude most meteostation data: there is 1 km between meteostation and experimental site. Only more or less reliable data from meteostation was added to site dataset (atmospheric pressure, air temperature);
- one DFIR with Tretyakov gauge (№22 on layout) data was not reported as site was waiting for T-200B to be installed there.

Analyses:

The only analyses could be performed now: 24 hr accumulation bias calculations (absolute bias). Analyses started at April 2013, not yet finished.

Plans for the next 2013/2014 winter period were also reported:

- Valday site administration is planning to purchase and install one more OTT Pluvio instrument in order to combine R3 reference;
- Waiting for Environment Canada's Geonor T-200B;

– Set of sensors shall be installed. This set should cover precipitation polygon with reliable ancillary data, like more frequently measured wind speed, temperature etc.

Valday's commissioning report will be updated as soon as new instruments will be installed and measurements will be available.

Voljskaya (Russian Federation)

Valery Vuglinsky presented a short information on the organization of SPICE experiment during 2012/2013 winter season at the Voljskaya Hydrometeorological Observatory (Nizhniy Novgorod, Russian Federation), based on the Site Report, prepared by A. Koldaev. During this season configuration R1, three manual snow depth gauges and laser snow depth sensor «Nast» (Russian production) have been operated at this place. Heating were not used for manual instruments. Internal heating of the laser snow depth sensor allows keeping instrument operating up to -30C and keep clean all optical parts. Capping is not applicable for manual devices. Capping was observed on the laser snow depth sensor, but it didn’t lead to any visible effect on the data quality. Data of observations are available for the period from 1 December 2012 to 1 April 2013.

During winter season 2012/2013, problems were encountered with the regular electric power availability. To solve this problem some options are under consideration: using UPS with big capacity, gasoline electric engine and very careful grounding at all possible sites of electric lines.

Future plan for season 2013/2014: one Geonor, and one OTT gauge will be installed at the experimental plot. Fiber optics Internet and one joint data logger will provide a collection and transfer data in real time.

Joetsu and Rikubetsu (Japan)

The National Research Institute for Earth Science and Disaster Prevention (NIED), the National Institute of Polar Research (NIPR) and the Japan Meteorological Agency (JMA) are preparing for the participation in the SPICE project. In the 2013/14 winter, NIED plans a field observation experiment at Joetsu, Niigata, and NIPR also plans an experiment at Rikubetsu, Hokkaido using resources available under limited funding. The Japan Meteorological Agency (JMA) will support the experiments and be the contact point of Japan.

ANNEX IV

REPORT OF DATA ANALYSIS BREAKOUT GROUP

Preparation of Level 3 data

Background

In order to achieve comparable event-files for all sites which include all detected events with all parameters needed for the analysis, the following workflow for producing level 3 data (analysis ready dataset) has been agreed on.

1. Outlier Filter
2. Jump Filter
3. Noise Filter
4. Event Selection
5. Calculation of event parameters.

The individual steps are described in more details below.

Outlier Filter

Positive and negative spikes in the data will be removed by using a gradient filter. The outlier filter will be realized for all site data sets at the SPICE Web-archive at NCAR .The DAT will define a threshold for definition of an outlier (both 6s and 1min).

Jump Filter

Sudden jumps in the data will be detected and flagged for later manual inspection. The DAT will define a threshold for definition of a jump (in 6s as well as 1min data). The jump detection and flagging will be realized for all site data sets at the SPICE Web-archive at NCAR.

Noise Filter

The DAT evaluated several noise-filtering methods of precipitation data (see paper 4(1) from Mike Earle and the SPICE DAT submitted to the meeting http://www.wmo.int/pages/prog/www/IMOP/meetings/SI/IOC-SPICE-4/SPICE-IOC-4.html). Two filters, a Gaussian filter and a moving average filter, were showing an effective noise reduction. Only slight differences could be seen when applied on artificial data sets (with real noise). The Gaussian filter had a better dynamic response. The DAT agreed on using both filter methods on the SPICE data in order to further evaluate the difference when used on real data.
The DAT decided to use the same filter width for both methods and for both reference gauges (Geonor, Pluvio2). The filter widths are set to 2 min and 8 min to be used on the 6 s data sets and the 1 min data sets respectively. The DAT acknowledges that the chosen filter width is not optimal for the Pluvio2 gauges (because of lower noise frequencies) in favor of equal time response of both gauges.

Both filter methods will be realized for all site data sets at the SPICE Web-archive at NCAR. Pseudo-codes will be made available for the site managers for their own implementation by the DAT.

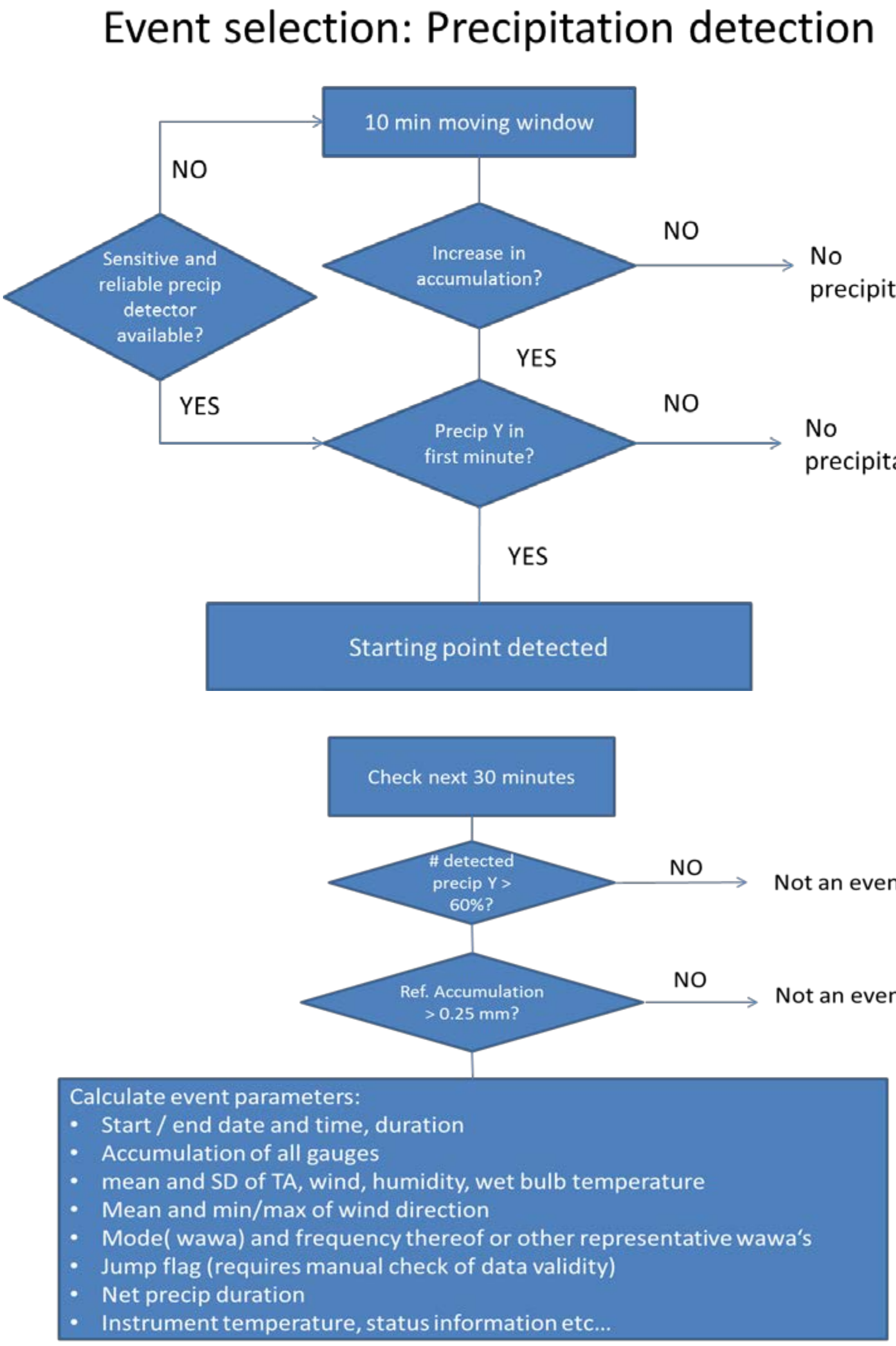
Temperature correction

The DAT decided not to apply a temperature correction because it is shown to be very extensive while not being reliable in all cases. For the retrieval of the transfer function, precipitation events with high temperature variations will be filtered out in order to minimize the temperature effect on gauges.

Event Selection

The DAT recommends an event selection (described in the flow chart below) which is based on analyses from Haukeliseter and Marshall data. The IOC adopted the algorithm with the following thresholds:

- Accumulation higher than 0.25 mm / 30 min
- Net precipitation duration larger than 60%.
- Aiming at achieving a higher degree of accuracy in detecting the precipitation events, the DAT suggested a methodology which would be using the data from precipitation detectors in combination with a check for positive accumulation over a 10 minute gliding window.



From level 3 data to transfer functions

The DAT suggests the following steps to retrieve adjustment functions from the level 3 data:

- Homogenization: Results in a subset of events which have very homogeneous parameters over the course of the event. This will help to reduce the scatter in the catch-efficiency plots and can be used to understand the physics of the processes. It is expected that it will be easier to formulate models for possible adjustment functions on the base of these homogeneous events.
- Classification: In order to understand which parameters influence the catch ratio in which way, the DAT suggests a classification of the homogeneous subset of the event.
- Use these subsets to suggest the shape and behavior of the transfer functions for different conditions and retrieve coefficients.
- Determine the total uncertainty of the transfer function due to the natural variations of the forcing parameters in the unfiltered data set.

Homogenization

The DAT will investigate the following list of possible thresholds:

- Temperature standard deviation < 0.2°C
- Dewpoint / Wetbulb standard deviation
- Wind speed standard deviation / wind speed < 0.2
- Changes in the wind direction of less than 50°
- If necessary: remove from the data set the data corresponding to the wind-shadow range due to the DFIR.
- Dominant precipitation phase close to 100%
- Standard deviation Intensity (RI)?
- …

The DAT will perform sensitivity studies of these and further thresholds based on several site data sets, resulting in a more comprehensive list.

Classification

For the purpose of the analysis, the DAT proposes organizing the data sets based on the ancillary data. The following criteria are under consideration::

- Wind speed bins of 1 m/s
- At least three temperature bins: below -4°C; -4°C to +3°C, and above 3°C; or finer bins
- Wetbulb temperature bins: to be determined
- Accumulation of non-reference gauges of more than 0.25 mm
- Precipitation phase: solid / mixed / liquid

The DAT will perform a sensitivity study of the classification, and refine it accordingly, recognizing that the results will be critically influenced by the ability to reliably determine the precipitation type.
It is assumed that wind speed is influencing the results as well (f.ex.: high wind speeds could be mistaken for high falling velocities).

Recommended change concerning the precipitation detector and the detection of the precipitation type

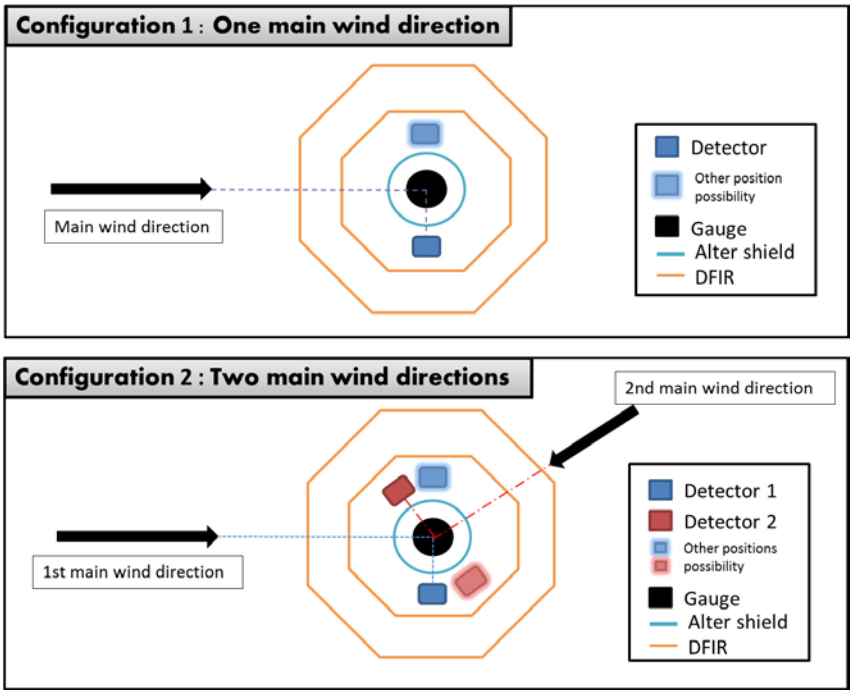
The proposed event selection scheme depends to a large degree on the performance and sensitivity of the precipitation detector used as part of the field working reference system on all sites. The IOC SPICE-2 (Boulder) meeting recommended the use of a capacitive precipitation detector. The additional analysis of several data sets has shown the following caveats in that proposed configuration:

- The required capacitive precipitation detectors (as part of the reference) at several SPICE sites have shown limitations in reliably detecting winter precipitation events.

- Tests at DWD in Germany and NOAA, USA have shown that optical precipitation detectors have a higher sensitivity and a lower false alarm rate than capacitive precipitation detectors.
- Measurements at Haukeliseter suggest that measurement of optical precipitation detectors are highly influenced by azimuthal orientation, most likely due to wind dependency.
- Data from Haukeliseter and other sites have shown that different precipitation type sensors (forward scatter instrument and disdrometer) report different precipitation types in a significant number of cases. That is due to the technical differences of the instruments (measurement technique, design, internal algorithms).

Based on these findings, the DAT made several recommendations regarding the ability to detect the presence of precipitation and to identify the precipitation type. At the recommendation of the DAT, the IOC decided that:

- all sites are strongly encouraged to use a laser-disdrometer-type instrument (e.g. Thies LPM or OTT Parsivel) which also gives data on size/velocity distribution classes which may be used to evaluate the reliability of the reported precipitation phase). This is primarily the case for the sites operating a R2 reference, in which case this sensor should be placed inside the inner fence of the DFIR, outside the Alter shield, at a height below that of the gauge.
- All sites are required to use **an optical precipitation detector** as the required precipitation detector for the field working reference (requires also an update of the commissioning report), replacing the capacitive precipitation detector. The location of the precipitation detector at a site with a DFIR is within the DFIR, between the inner fence and the Altershield.
- At a site where a disdrometer type instrument is used, this could have the role of the precipitation detector, as well, and a separate precipitation detector, while desirable, is not mandatory.
- At a site with a R2 reference, the location of the precipitation detector and or the disdrometer type sensor, inside the DFIR-fence is as follows (also shown on the schematic figure below):
    1. inside the inner fence, in the middle between Alter shield and inner fence
    2. 75 cm below the gauge opening, corresponding to half way down the inner fence
    3. perpendicular to the main wind direction
    4. if possible a second sensor can be mounted in order to accout for different wind directions.
- At sites without a DFIR-fence the precipitation detector should be mounted at a wind-protected place or be shielded by a suitable shield.



Linking of the references

R0-R1

According to the meeting document 4(5) by Daqing Yang (http://www.wmo.int/pages/prog/www/IMOP/meetings/SI/IOC-SPICE-4/SPICE-IOC-4.html) the bush gauge measures on average 105 % - 106 % more snow than the DFIR. During blowing snow events, the bush gauge (at 2 m) caught, on average, 12 % more snow than the DFIR (at 3 m). This difference, however, is partly caused by the height difference of the gauges, as the flux of blowing snow is greater at 2 m than at the DFIR height of 3 m.
The proposed second order adjustment curve is not in agreement with recent findings from Haukeliseter, Marshall and CFD simulations, which suggest an s-shaped curve. The catch efficiency for different wind shields remains close to 1 until a certain wind speed (transition point 1) which is depending on the shield design, and decreases to a second transition point from where turbulence effects dominate leading to a constant catch efficiency. The wind speed range of the Valdai data set (< 9 m/s) does not allow the determination of a non-ambiguous catch efficiency curve.
Furthermore, the manual observations are introducing uncertainties in the classification of the precipitation type. The averaged wind speeds and temperatures may not be representative for the conditions during the storm.

Recommendation:
The derivation of a more robust transfer function between the bush gauge and the DFIR is essential for the whole WMO-SPICE effort and therefore a larger and more comprehensive data set on a finer time scale is needed.
The measurements from Caribou Creek with a co-located bush gauge and DFIR (both equipped with automated gauges) and the continuous observations from Valdai will form a valuable data base for this purpose.
Because of the difficulties in quantifying the effects of blowing snow arising from the different heights of the compared gauges, the DAT suggests equal installation heights for all gauges at one site.

R1-R2

Until today the DAT has not worked on the transfer function from R1 to R2. The DAT recommends an analysis of the data set measured at CARE, being the only SPICE site which had a functional R1 and R2 in the 2012/2013 winter season.

R2-R3

The DAT presented a framework for relating the ratio of the unshielded gauge to the Alter shielded gauge (R3) back to the R2 based on data from the Marshall site. In order to test the validity of the concept and to finalize the algorithm, the DAT will analyze data from other sites.

ANNEX V

PROPOSAL FOR A METHODOLOGY TO USE AN UNSHIELDED AND ALTER SHIELDED SNOWGAUGE AS A REFERENCE (R3) FOR SPICE

Background

In order to provide an approximation to the reference DFIR (as available at R1 and R2 sites) for sites that can only host a single Alter and unshielded gauges, a proposal was made at the Boulder meeting that a configuration including an unshielded snowgauge and an Alter shielded snowgauge (using either the GEONOR or PLUVIO2 as the gauge) may allow such sites to provide a reference estimate that could be used to relate the measurements at this site to other sites that include a DFIR and to potentially calculate a transfer function for gauges under test at these sites.

Assumptions

The key assumption behind the two gauge configuration for reference is that the transfer function of an unshielded gauge is sufficiently different than an Alter shielded gauge. By estimating the difference of the slope of the transfer function from an Alter shielded gauge compared to an unshielded gauge, an estimate of the reference amount can be obtained. This requires that a methodology of determining a transfer function is established that can detect such a difference in slope. A data set from this past winter from January 1 – May 1, 2013 was utilized to determine a reasonable methodology to calculate transfer functions. Based on this analysis, it was determined that a reasonable method for transfer function calculation was possible if the following procedure was followed:

a. To achieve a reliable estimate of accumulation above the noise level, use a 30 minute accumulation or averaging period.

b. A minimum of 0.25 mm/30 minutes in the DFIR is required to have a sufficiently large signal to calculate the ratio of accumulations between the two gauges.

c. Eliminate zero values from the unshielded and shielded gages and ratios. This will significantly bias both the mean and standard deviation.

d. Only use data from snow cases that have a mean temperature less than -4° C over the 30 minute period to reduce contamination from rain and mixed phase cases.

e. Bin the data into 1 m/s bins based on the average wind over the 30 minutes period including the ratio of unshielded to shielded accumulation during each 30 minute period.

f. Calculate a mean and standard deviation of the accumulation ratio per 1 m/s bin.

g. Use the mean accumulation ratio per 1 m/s bin for the transfer function curvefit.

h. Only do the curvefit from 0 to 5 m/s to avoid the region in which the curve flatten out out above 5 m/s.

***Definitions* of terms:**

UN: 30 minute accum from unshielded ref gauge
SA: 30 minute accum from shielded ref gauge
DF: 30 minute accum from DFIR reference gauge
Wsp: Wind speed in m/s at gauge height

***Equations*:**

(UN/DF) = 1 – Cun*wsp

(SA/DF) = 1 – Csa*wsp
(UN/DF)/(SA/DF) = UN/SA = (1 – Cun*wsp)/(1-Csa*wsp) = 1 – A*wsp

Procedure:

a. Calculate “A” from regression fit of (UN/SA) to wsp for a given R3 site using the data defined under assumptions (see Figure 1 for example from Marshall winter data 2013).

b. Calculate Cun or Csa by using the value “A” and the above equations. The exact methodology to do this still needs to be defined as the equation is non-linear.

c. Finally, calculate DF for each data point from the following equation:

   DF = (SA-UN)/(wsp*(Cun-Csa)
   using the value of SA, UN, and wsp from the R3 site.

d. Relationships to the other sites and to the DFIR can now be made.

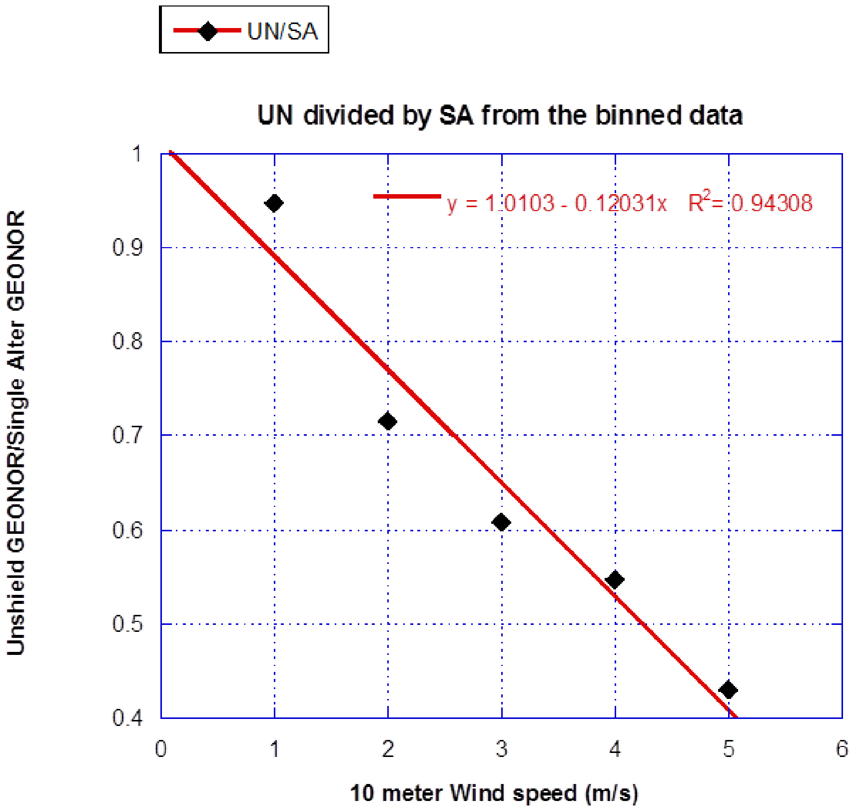


Figure 1: Transfer function for Unshielded GEONOR with respect to Single Alter Shielded GEONOR from Marshall data collected January 1 –May 2 2013. Thirty minute average data organized into 1 m/s bins. Value shown is the average value per bin. Only data points with a mean temperature less than -4 C are included to ensure that snow is the dominant precipitation type. In this case the factor “A” is equal to 0.1203.

ANNEX VI

Experiment Plan for SPICE Snow on the Ground (SoG) Intercomparison

1. Background

The overall WMO-SPICE objectives, as defined at the first SPICE IOC meeting (October 2011), have identified the expectation that the measurement and reporting of snow depth also referred as depth of snow on ground, and its link with the snowfall (depth of freshly fallen snow), are investigated, and results are included in the Final Report. SPICE is expected to:

- Recommend appropriate automated field reference system(s) for the unattended measurement of solid precipitation in a range of cold climates and seasons, and to provide guidance on the performance of modern automated systems for measuring: (…)(ii) **snowfall (height of new fallen snow), and (iii) snow depth.**

- investigate and report on the measurement and reporting (…) over various time periods (minutes, hours, days, season), as a function of precipitation phase (liquid, solid, mixed), [of] **snow on the ground (snow depth); as snow depth measurements are closely tied to snowfall measurements**, the intercomparison will address the linkages between them**.**

- As a key outcome, recommendations will be made to WMO Members, WMO programs, manufacturers and the scientific community, on the ability to accurately measure solid precipitation and snow on ground, on the use of automatic instruments, and the improvements possible. Results of the experiment will inform those Members that wish to automate their manual observations.

After completion of 2012/13 season in the Northern Hemisphere, the component of the SPICE experiments related to the measurement of snow on ground and its link to the snowfall are being further refined, in the context of the experience gained and the opportunity of engagement of the newly accepted sites.

2. SPICE SoG Objectives

The IOC SPICE-4 meeting further refined the objectives of the WMO-SPICE SOG Intercomparison. to focus on:

1) Characterize and recommend automated methods, appropriate for the measurement of total snow depth in a range of cold climate conditions. Different measurement strategies may be recommended for different climatic regimes and for various measurement purposes. The final report is expected to include recommendations regarding measurement thresholds, siting of instruments, availability of ancillary measurements for correcting the measurements of the snow depth sensors (e.g.location and siting of temperature for sonic corrections), instrument sensitivity and accuracy.

2) Investigate and report on the measurement and reporting performance of snow depth sensors measuring total snow depth, over various time periods (minutes, hours, days), linking these measurements to the reference gauge measurements of total precipitation where possible.

While recognizing the limited duration of SPICE, the IOC recommended that, based on the experiment data, SPICE should endeavor to report on the:

3) Assessment of the feasibility to derive reliable spatial representativeness based on using point measurements of snow depth and recommendations for future initiatives focusing on this issue.

4) Assessment of the capability of automated sensors to determine the Snow Water Equivalent (SWE) of accumulated or freshly fallen snow, linking these measurements to reference gauge precipitation measurements and snow depth measurements (where possible).

The IOC recognizes the importance of developing methods for the automated estimation of snowfall for various time intervals to replicate manual and historical snowfall measurements and recommends that further definition of the methodology is developed in a collaboration between Global Cryosphere Watch and CIMO. SPICE will make available data collected during the intercomparison, in support of other initiatives addressing this issue.

3. SPICE: Field Working References for Snow on Ground measurement

a. Total Snow Depth Reference (STR)

STR0: Two ruler based manual measurements at the periphery of the footprint outside the field of view (FOV) of each automatic sensor, conducted at least once per day, at the same time, with minimum disturbances of the snow pack under and around the sensor. Although this is recognized as the Level 0 reference, it is also recognized that this measurement creates site disturbance and this needs to be considered.

STR0a: Manual observation of 4 graduated stakes at the corners of the automated snow depth sensor footprints at least once per day. An observer is required. Graduated stakes should have cm graduations and be observed as close as possible to the level snow pack to the nearest half centimetre. The stakes should be placed 40 cm outside of the sensor FOV to avoid impacting the snow characteristics within the sensor FOV.

STR0b: Where equipped, hourly camera observations of the 4 graduated stakes (described as the STR0a reference). Also, where possible, small LED lights should be installed to enable nocturnal observations..

STR1: Manual snow depth transect of a minimum 10 points (preferably at fixed points or using graduated stakes at fixed intervals of 3-10 metres) conducted at least once per day near the auto snow depth sensor array to assess variability of snow depth over the observing site. An observer is required. The IOC recognizes that the integrity of the snow pack in the observation field needs to be preserved.

The IOC recognizes that the realisation of the STR1 may not be feasible on all sites, and encourages the site managers to assess this or alternative options for obtaining the desired data set.

In addition to the manual measurements other methods for assessing the performance of measurement of the sensors under test at higher temporal resolutions will be explored by the project team.

b. Snow Water Equivalent Reference (SWR)

SWR0: Manual Snow Water Equivalent (SWE) measurement following procedures described in the CIMO Guide conducted biweekly near each auto snow depth sensor just outside the field of view. Samples should not be taken within 30cm of a previous sample and the core can be used to partially refill the sample hole. Known snow sampler biases/errors must be considered. A precise description of equipment and procedures used at each site will be required. An observer is required.

4. Experiment Design

a. Site Configuration

Automated Snow Depth Sensors should be installed according to manufacturer's specifications, at a minimum of 15 metres from a DFIR or other large structures that may impact the distribution of snow on the ground under the sensors. It is recommended that the SOG instrumentation also be a minimum of 10 metres from precipitation gauges, and avoiding overlapping footprints for the ultrasonic sensors.

Four stakes with 1 cm graduations should be installed approximately 40 cm outside of the maximum calculated field of view of the automated sensor to serve as the STR0a reference. The sensor FOV needs to be calculated according to the installation height of the sensor and following the manufacturer's guidance regarding the minimum distance between the sensing element and the maximum height of the snowpack (for example, a Campbell Scientific Canada Snow depth sensor model SR50ATH-316SS has a footprint radius of 54 cm when mounted at 2 metres height).

The target area of the automated sensors needs to be as flat (horizontal) as possible with the sensors (especially for acoustic sensors), installed as prescribed by the instrument manufacturer. The FOV should be clear of any other obstructions, including the mounting infrastructure of the sensor itself.

b. Surface Target

All measurements of snow on the ground using automatic sensors, on all SPICE sites, must be taken against consistent surfaces, to ensure the consistency and comparability of the results. While various surfaces have been used in previous experiments and in national programs, for the purpose of SPICE, the IOC recommended the application of the solution tested by the German Met Service, DWD, and presented at TECO 2010, http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-104_TECO-2010/P3_12_Lanzinger_Germany.doc

The surface target used in DWD is made of glass fibre reinforced plastic (GRP) which is a very cost effective and durable material. Colour and surface roughness of the material need to be selected appropriately. The use of a plate will allow for the definition of a zero level for the signal strength of the sensors under test.

The plate has about 3 cm "feet" so that the target is not in total contact with the ground surface, of square format with the side of minimum 1 meter, large enough to cover the sensor field of view., The target is1 installed flush with the surrounding ground or vegetation. On an un-vegetated surface, the target needs to be dug into the ground such that it is flush with the surface and maintained in this fashion prior to the accumulation period. Where the surface is vegetated, the vegetation should be maintained to be flush with the installed target prior to the accumulation period.

Figure: German snow plate (right) for use with automatic snow depth sensors, ultrasonic type.

A similar product has been identified from a Canadian company: http://www.dockinabox.com/dock-decking.php

c. Data Resolution

A temporal resolution of 1 minute will be used for the data output of all automated snow depth sensors. The temporal resolution of Level 3 data will be determined based on the assessments conducted in preparation of the development of the data analysis methodology.

d. Sensor Maintenance

The maintenance (e.g. clearing of snow from the instruments or the general instrument maintenance) shall follow the same protocols as established for the precipitation gauge intercomparison. Specifically, when a sensor's performance is hampered by an environmental condition such as blockage due to snow or rime, the condition should be documented (through site logs and photographs) and the sensor should be given a 24 hour period (starting at the time when the issue is first discovered) for the situation to correct itself naturally. If intervention is still required after the 24 hour period has expired, the intervention will take place and is to be documented (and photographed when appropriate). Site managers should prevent or remedy snow accumulation on mounting infrastructure after or during precipitation events without impacting the sensor FOV.

e. Auxiliary Measurements

The following auxiliary measurements are either **Required** or **Recommended**:

1. Air Temperature and Humidity at 1.5m (or at the national standard observing height) recorded at a minimum 1 hour resolution but preferably at 1 minimum resolution (**Required**)
2. Global incoming solar radiation recorded at a minimum 1 hour resolution but preferably at 1 minimum resolution (recommend a 4-way net radiometer) (**Recommended**)
3. Wind speed and direction at 2m and 10m recorded at a minimum 1 hour resolution but preferably at 1 minimum resolution (**Required**)
4. Precipitation intensity and amount (preferably from an R2 or R3 reference) (**Required**)
5. Precipitation occurrence and type (minimum capacitance or optical precipitation detector) (**Recommended**)
6. A fixed 5-10 point snow course with multiple Snow Water Equivalent (SWE) and snow depth measurements conducted biweekly following procedures outlined in the CIMO Guide. Known snow sampler biases/errors must be considered. A precise description of equipment and procedures used at each site will be required. An observer is required. (**Recommended**)

7. Snow pack or near snow pack temperatures (using the surface of the target as the point of reference, -3cm, 0cm, 5cm, 20cm, 50cm) recorded at a minimum 1 hour resolution but preferably at 1 minimum resolution (**Recommended**)

5. Participating Sites

Finland (Sodankylä)
The Sodankylä site is hosting the following instruments provided by the Instrument Providers, which have been installed for the season 2012/13: **1)** Campbell Scientific Canada Snow depth sensors model SR50ATH-316SS (2), **2)**ESW Snow Depth Sensor SHM30/012840-642-22 (2), **3)**Felix Technology Snow Depth Sensor, model SL300 (2), **4)**Sommer Snow Depth Sensor, model USH-8 (2).

Poland (Hala Gasienicowa)
Hala Gasienicowa is hosting the following instruments under test as provided by the Instrument Provider, Campbell Scientific Canada Snow depth sensors model SR50ATH-316SS (2). These instruments were installed in Dec 2012, however the assessment of the site configuration conducted by the IOC indicates that changes must be made to ensure the availability of the expected data quality.

France (Col de Porte)
The new SPICE site at Col de Porte will focus primarily on the SPICE objectives related to the snow on ground and snowfall. Instrumetns from two Instrumetn providers have been assigned to this site; these are the Campbell Scientific Canada Snow depth sensors model SR50ATH-316SS (2) and ESW Snow Depth Sensor SHM30/012840-642-22 (2), Additional activities organized on the site will be refined prior to the start of the 2013/14 season.

CARE (Canada)
CARE Canada will add to its SPICE configuration a Snow on Ground Component, using instrumentation owned by Environemtn Canada. The following instruemtns will be included: 1) Campbell Scientific Canada Snow depth sensors model SR50ATH-316SS, 2)ESW Snow Depth Sensor SHM30/012840-642-22, 3)Felix Technology Snow Depth Sensor, model SL300, 4)Sommer Snow Depth Sensor, model USH-8. Three sensors of each type will be collocated on site. Function of availability, other instruments will be collocated on site.

Italy EVK2-CNR: Forni Glacier and Observatory Pyramid (Nepal)
Both sites will contribute in the assessment of the Snow on the Ground primarily, as the measurement of the snow depth performed by ultrasonic sensors is already configured on each of them.

- Laboratory-Observatory Pyramid:
  - frequent as possible measurement of depth of freshly fallen snow and snow water equivalent preferably using snow board nearby the snow depth sensor already installed;
  - frequent as possible manual measurement of snow depth by rulers in a number of points (optimal 4) on a grid around the snow depth sensor or alternatively “visual” snow depth measurement by the installation of permanent graduated stakes (1 to 4) on a grid around the snow depth sensor and by the installation of a webcam (remotely visual assessment of snow depth);
  - frequent as possible assessment of snow density and water equivalent on the ground using e.g. snow corer nearby the snow depth sensor already installed;

- Forni Glacier:
  - measurements of freshly fallen snow, snow depth, snow water equivalent and snow density above-listed for the Pyramid site at a frequency depending on site accessibility of this site;
  - detection of precipitation event by precipitation detector (preferably optical);

- continuous measurements of snow water equivalent by the installation of snow pillow, nearby the snow depth sensor;

6. Expected Results

1. Integrate the results from multiple sites to characterize the instruments under test, measuring snow on ground, and identify their limitations. This should include assessments of thresholds, location and siting of snow depth instruments, and corrections applied (such as temperature for sonic corrections), instrument sensitivity and accuracy.

2. Assess and characterise measurement errors and biases, and their correlation with the operational environment.

3. Assess the ability to estimate the SWE as a result of the correlation between the measurement of snow depth sensors (total or differential over a given period) and the total precipitation amount (R2, where available) Based on this analysis, recommendations can be made for making these linkages in national operation networks to estimate SWE where one set of this instrumentation are not available.

4. Assess the capabilities of automated non-conventional SWE measurement instrumentation to capture the changes in snowpack SWE over both the accumulation and melt periods commenting where possible on the sensor footprint, resolution, and other capabilities and limitations.

5. Report on the performance of various materials used as targets for the measurements based on the SPICE results, if available, and the review of the literature available on this topic.

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ANNEX VII

SUMMARY OF PROPOSALS FOR POTENTIAL PARTICIPATION IN SPICE RECEIVED IN REPLY TO THE 3RD CALL FOR INTERST IN PARTICIPATION

SITE SUBMISSIONS

Six submissions for hosting SPICE experiments have been received.

France

Météo-France, Centre National de Recherches Météorologiques, Centre d'Études de la Neige (CNRM-GAME/CEN) proposed the site Col de Porte (CDP).
The site location is 30 km from Grenoble, France, Latitude: 45.30°N, Longitude: 5.77°N, Elevation: 1325 m. Several snow physics projects use the site for investigating the time evolution of the physical properties of snow in relationship with meteorological conditions.
General information on the site is available at the following url: http://www.cnrm-game.fr/spip.php?rubrique218&lang=en
The site will focus on the measurement of snow on ground and will provide instruments for inclusion in the SPICE intercomparison. The site does not have the possibility of installing a DFIR, but will install a R3 reference for the measurement of total precipitation.

Italy

The EVK2CNR – UNIMI, University of Milan proposed two sites:

1. Forni Glacier/Upper Valtellina/Italy.
This site, at elevation of 2669 m, has been operational since 2005 as the first Italian permanent supraglacial AWS. The Forni Glacier hosts several experiments, in particular devoted to deepen the glaciological issues. The site will provide instruments for inclusion in the SPICE intercomparison.
The site climate is cold, average annual temperature: -1.5°C; maximum yearly value: ca. +16°C; and minimum yearly value: ca. -26°C. The yearly cumulative solid precipitation: 0.7 m w.e. Generally, the winter period is cold and drier with respect to other Italian alpine sites.

2. Pyramid International Laboratory Observatory/ Lobuche /Solu Khumbu/Nepal.
This is an existing site at elevation of 5.050 m asl. The site will provide instruments for inclusion in the SPICE intercomparison and has capacity to accommodate instruments proposed for SPICE. Other projects are currently underway on the proposed intercomparison site. The pyramid site hosts several experiments, and local personnel are operating also with remote support from the head office.
The terrain is rough topography, high mountain vegetation, mosses, lichens and the prevailing climate is dry winters, warm summers, mainly monsoonal precipitation.

Republic of Korea

Korea Meteorological Administration proposed to participate in SPICE with the site Gochang Observatory (supporting the CIMO Chupungnyeong Lead Center for the Evaluation of Precipitation Measurement Accuracy), fully operational since December 1st, 2010
The site situated at 52 m asl will provide instruments for inclusion in the SPICE intercomparison, and has capacity to accommodate instruments proposed for SPICE, by other participants.
Other projects are underway on the proposed intercomparison site, which may share/use data from instruments included in SPICE. During the winter, continental highs from NW cause often heavy snow in this region and a large amount of snowfall is common due to its location (Yellow sea located upwind direction).

Spain

AEMET (Spanish State Meteorological Agency) proposed to participate in SPICE with the site ARAMON – Formigal located at the elevation of 1855 m asl, at the largest Spanish ski resort and it has been part of the AEMET network of manned stations in the Pyrenees for more than10 years.
The site has capacity to accommodate instruments proposed for SPICE, by other participants. The site has an alpine climate with Atlantic influence; the site is located along the hillside in a flat place. No vegetation.

Kazakhstan

RSE "Kazhydromet" proposed to use 3 of their meteorological stations: Astana (Shortandy), Esik (Almaty) and Kaztalovka. At these three stations they perform the following standard visual observations: visibility, estimation of intensity of atmospheric phenomena, amount of precipitation measured by Tretyakov rain gauges and the height of snow cover with "snow-meter".
Also these observing stations are equipped with automatic weather stations made by Vaisala and Microstep for estimation of amount of precipitation, snow height and the weather.
The proponent did not provide detailed information on the sites.

OTHER CONTRIBUTIONS

WMO Joint Working Group on Forecast Verification (JWGFVR)

The JWGFVR was formed in 1999-2000 to oversee and participate in the experimental verification of nowcasts and short-range forecasts for the Sydney Olympics under the umbrella of a WMO Research demonstration project (RDP).
The JWGFVR brings with it a strong collective knowledge of statistical methods applied to the analysis of meteorological data. JWGFVR also brings a global perspective on the use of routine observational data both in verification and in statistical post-processing of forecasts. Given this body of knowledge, JWGFVR proposes to be involved in the data analysis part of CIMO-SPICE, specifically, by working with the Data Analysis Team to build statistical analysis procedures for deriving the expected results.

INSTRUMENT SUBMISSIONS

The following Instrument submissions have been received in response of the 3rd SPICE Letter of Interest:

FROS-D GPS ground reflections snow depth sensor

Proponent: University of Colorado at Boulder
Number of instruments proposed: 1
The FROS-D instrument uses multipath GPS signals to make a height calculation. When the height of the instrument affects the range over which the antenna can collect the signals reflecting off the ground.
Minimum distance between sensor and snow/ground surface 300 cm

Minimum footprint required for a reliable measurement: 30 m radius area, ideally open space environment with few other experiments located within area.
Measurement range: from 0 cm to 200 cm.
Measurement uncertainty*:* 2.4 cm; measurements averaged over 180 minutes, and are synchronized to GPS time.

Enhanced Present Weather Detector / Enhanced Precipitation Identification Sensor model PWD53 / PWD33

Instrument Provider: Vaisala Inc
Number of instruments proposed: 2

Description: PWD53 is an optoelectronic present weather sensor, reporting present weather, intensity and accumulation of precipitation. The measurement comprises of an optical forward scatter measurement, an acoustic hydrometeor impact sensor, a capacitive rain detector and a temperature sensor.
Measurement range for PI: from 0.01 mm/h to 999 mm/h.

Present Weather Detector, PWD52 (2 units)

Instrument Provider: Vaisala Inc
Number of instruments proposed : 2
Vaisala Present Weather Detector PWD52, an optoelectronic present weather sensor, reporting present weather, precipitation intensity and accumulation. The measurement comprises an optical forward scatter measurement, a capacitive rain detector and a temperature sensor.

Present Weather Sensor, FS11P (1 units)

Instrument Provider: Vaisala Inc
Number of instruments proposed : 1
Vaisala Present Weather Sensor FS11P, consisting of FS11 for visibility sensing and PWD32, an optoelectronic present weather sensor, reporting present weather, precipitation intensity and accumulation. The measurement comprises two optical forward scatter measurements, a capacitive rain detector and a temperature sensor.

TPS3100 hotplate snow gauge

Instrument provider: Yankee Environmental Systems
Number of instruments proposed: 3

SMH30 Snow Depth Sensor

Instrument provider: Jenoptik
Number of Instruments proposed: 2
This is a second submission from the same provider of the same snow depth sensor. The first two sensors submitted in 2012 have been operational in Sodankylä since Dec 2012. These additional two sensors are available for allocation to another site which would focus on the assessment of instruments for the measurement of snow depth.

SR50AH

Instrument Provider: Campbell Scientific Canada
Number of Instruments proposed: 2
This is a second submission from the same provider of the same snow depth sensor. The first four sensors submitted in 2012 have been operational in Sodankylä and Hala Gasnienicowa during the 2012-13 winter.

Rain Gauge Type ANS 410/H (Eigenbrodt)

Instrument Provider : Eigenbrodt GmbH & Co. KG, Environmental measurement systems
Number of Instruments proposed : 2
Principle of operation: differential level measurement (pressure gauge)
Operating temperature range: from -25°C to 70°C
The system empties out automatically when a high level is reached, therefore no manual intervention is necessary. A controlled heating prevents the rain gauge from freezing. The lean shape of the rain gauge (champagne glass form) leads into minimized losses related to high wind speeds (compared to Hellmann or similar shapes). It is also possible to detect drizzle rain and snow events.

ANNEX VIII

SPICE SITE DEFINITION

(Extracted from CIMO ET-II & IOC-SPICE - Annex V and expanded with S4 definition)

For the first WMO Intercomparison for solid precipitation, 1989-1993, report WMO/TD-872/1998, the participating sites have been divided in two categories:

a. Evaluation Station - most intensively instrumented for the purpose of analyzing in detail the differences in snowfall catch between all national methods of measuring solid precipitation and the Double Fence Intercomparison Reference (DFIR) and the Working Network Reference.
b. Basic Station - instrumented with the minimum amount of equipment to assess the performance of national methods of measuring solid precipitation relative to the working-Network Reference.

As stated in hte report of that intercomparison, it was deemed desirable for Evaluation Stations to be located at existing synoptic or other observing stations to take advantage of the complete observing program at such stations. Basic Stations should be located at sites where a complete program of national methods of measuring solid precipitation can be conducted.
In carrying out the Intercomparison, the manner of installation of gauges and other observing equipment was required to agree with the instructions and specifications provided.

Configurations of SPICE Field References
In the context of the multi-site organization of SPICE, the IOC recognized the need to develop a flexible approach for the configuration of the field references to ensure the transferability of the results from the participating sites, while recognizing the physical limitations on some of the sites.

- R0: is the Bush gauge, either manual, using a Tretyakov gauge, or automatic using a weighing gauge approved as reference within SPICE (R0a)
- R1: DFIR fence + Tretyakov gauge (manual measurements)+Tretyakov shield, designated in the 1989-1993 intercomparison as secondary field reference WMO/TD-872/1998);
- R2: DFIR fence + automatic weighing gauge (AWG) + shield + preciptiaiton detector; the model and the configuration of the AWG and its shield will be determined at the end of the 11/12 pre-SPICE experiment.
- R3: A combination of twoautomatic weighing gauge of the same model and configuration, one installed with a single Alter shield and the second installed with no shield, and a precipitation detector. The characterization of R3 will be done in relation to the R1 and R2, and could be done as part of SPICE.

Intercomparison Site Nomenclature
Given the SPICE field reference, defined above, the participating sites would have the following configurations:

- S0: Sites with R0, and R1 or R2,
- S1: sites with references type R1, R2 and R3; the presence of R3(s) will allow its characterization against the R1 and R2;
- S2: sites with references type R2 and R3 are available (no manual measurements, being made); the presence of R3(s) will allow its characterization against the R2;
- S3: sites with only field references type R3.
- S4: sites with peculiar weather regimes - Arctic, Mountain, Ocean, etc, where the implementation of a reference (R1, R2, or R3) may not be possible.

The presence of R3 on sites type S1 and S2, will enable the transferability of results between the participating sites, by enabling the characterization of R3 as a function of the R1 and R2.

The site and reference nomenclature has been introduced to allow an easy differentiation between different configurations, and is not intended as a classification mechanism.

All or some of the intercomparison sites may have specific measurement objectives, as agreed between the hosting country and the SPICE IOC, for example:

- Sites with a predominance of precipitation climates – dry, wet, light, heavy, mixed or blowing;
- Sites with peculiar weather regimes – Arctic, Mountain, Ocean, etc.

The intercomparison sites are configured with instruments under test and auxiliary measurements, which will allow meeting the agreed site specific measurement objectives. Some examples of potential site specific objectives are:

- measurement and reporting of snowfall and snow on the ground;
- assessing different shield configurations (e.g. one gauge type in multiple configurations on a site with a wide range of wind regimes);
- assessing heating solutions for gauges;
- assessing emerging technologies (non-catching type).

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ANNEX IX

DRAFT OUTLINE FOR THE REPORT ON THE REFERENCE

Context: SPICE

- SPICE project and objectives (summary)
- discussion on the SPICE outcome on recommending a field reference for future experiments and the need for a reference for the experiment itself. The two may or may not be the same, but the former will build on the latter.
- Introduce the concept of the reference for the experiment, field working reference system (SPICE REF), including the historical perspective
- General discussion on why the SPICE project needs a reference for running the experiment itself
- Relevance for the SPICE results to be reported in the Final Report

Principles for the definition of the SPICE REF

Will cover:

- weather/climatology, confounding factors, snow characteristics (height of snow on ground)
- other....
- Specific scientific, data issues - is the aggregation metric sufficient
- Expected tradeoffs - bias, variance, minimum detectability, thresholds, PDF discussion
- configuration factors (automation, hence different time scales, heating, shields, redundancy

SPICE REF Configuration

- The agreed configuration of the Field Reference for the Experiment (R0, R1, R2, R3)
- Description of the various configurations, shields (DFIR, Single alter), gauges (Geonor 600/1000, pluvio2), heating, and other sensors; cover the sampling strategy.
- Principles for selecting the configuration and gauges selected technology and models (the 2008 survey results), including the historical perspective
- tradeoffs/limitations/risks when using different gauges
- the value of different levels of references for the experiment in the context of a large number of sites in a variety of climates

Implementation of SPICE REF

- Sites Participating in the Reference Experiment (site by site)
- Overview of participating Sites (summary of site reports): locations, representation of various climate regimes
- Reference Configurations by Site and Their Characteristics: each site manager to write about own site reference or input into the document; Rodica/alternate will oversee to ensure consistency (may provide a template).

SPICE REF Data

(this will be the reference data for the analysis)

- Data Levels for SPICE
- Reference Data/Observation (Sampling intervals and impacts (or not), confounding factors, aggregation intervals and methods for each reference level – R0, R1, R2, R3 -
- Principles; Results; Outcomes; Recommendations; Limitations
- processing/filtering and the data analysis; the resulting characteristics (typing, bias, variance, sensitivity) and the metrics (HSS, minimum variance);
- Outliers, jumps, noise filter, event selection, calculation of event parameters (event characterizing data):
- Notes; this will be addressed again under the data analysis
- DATA homogenization and classification

Uncertainty of the reference
(would be prepared in parallel to the other work, as data and cases are available) assessment methodologies, results, tradeoffs, issues

Report on the comparison of data from various levels of references located on the same site

- Problem Statement, Equipment/Method, Analysis Technique, Results;
- R0-R1; R1-R2; R2-R3

Annexes:

- Glossary of terms (will be expanded and included in the final report)
- Glossary of equations used