

WORLD METEOROLOGICAL ORGANIZATION

**COMMISSION FOR INSTRUMENTS
AND METHODS OF OBSERVATION**

**INTERNATIONAL ORGANIZING COMMITTEE
FOR THE WMO
SOLID PRECIPITATION INTERCOMPARISON EXPERIMENT**

Third Session

**Brussels, Belgium
15 October 2012**

FINAL REPORT



CONTENTS

	<u>Pages</u>
Executive Summary	p. ii
Agenda	p.iii
General Summary of the Meeting	p. 1 – p. 7
Annexes:	
Annex I List of Participants	p. 1 – p. 5
Annex II Data Archival, Monitoring and First-level Quality Control Proposal	p. 1 – p. 8
Annex III Site Instruments Layouts	p. 1 – p. 5
Annex IV SPICE Objectives	p. 1 – p. 2

EXECUTIVE SUMMARY

This report provides a summary of the third session of the International Organizing Committee (IOC) of the WMO Solid Precipitation Intercomparison Experiment (SPICE) that was held in Brussels, Belgium on 15 October 2012.

The IOC reviewed the proposal from NCAR to provide the data archive for level 1 and 2a data and approved it. It made a number of recommendations for the finalization and improvement of the proposal relevant for example to the data format, interaction with sites, and provision of maintenance information by the sites.

The IOC reviewed the status of preparation of all northern hemisphere sites.

The IOC addressed a number of aspects related to the planning, scheduling and coordination of SPICE. It reviewed the objectives, recalled decisions made concerning participating instruments provided to the different site, agreed on the participation of Italy as a laboratory testing facility.

A discussion session was organized and all instrument providers were invited to attend it, ask questions and raise any concern they may have on the conduct of SPICE, and interaction with the SPICE IOC and testsite personal.

AGENDA

- 1. ORGANIZATION OF THE SESSION**
 - 1.1 Opening of the Session
 - 1.2 Adoption of the Agenda
 - 1.3 Working Arrangements for the Session

- 2. REPORT OF THE CHAIRPERSON**

- 3. SITE DATA FLOW AND DATA ARCHIVAL**

- 4. REVIEW OF THE SITES INSTRUMENTS LAYOUT**

- 5. PLANNING, SCHEDULING AND COORDINATION OF SPICE**

- 6. DISCUSSION WITH MANUFACTURERS**

- 7. OTHER BUSINESS**

- 8. DRAFT REPORT OF THE SESSION**

- 9. CLOSURE OF THE SESSION**

GENERAL SUMMARY

1. ORGANIZATION OF THE SESSION

1.1 Opening of the Session

1.1.1 The third session of the International Organizing Committee (IOC) for the WMO Solid Precipitation Intercomparison Experiment (SPICE) was opened on Monday, 15 October 2012 at 9:00, by Ms Rodica Nitu, the IOC Chairperson and SPICE Project Leader. This meeting was organized as an opportunity meeting, recognizing that a number of the SPICE IOC members and SPICE Site Managers would be present in Brussels to attend the WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observations (TECO-2012, 16-18 Oct. 2012) that was held in conjunction with the Meteorological Technology World Expo.

1.1.2 The list of participants is given in [Annex I](#).

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 summary of the activities that were carried out since the SPICE IOC-2 meeting (11-15 June 2012, Boulder, USA). Significant progress was achieved through weekly teleconferences, using WebEx, which were generally well attended. Since the SPICE-IOC-2 meeting the project team:

- Finalised the allocation of instruments to Sites,
- Formally invited Site proponents and Instrument Providers to participate;
- Approved the Data Protocol;
- Approved the Commissioning Protocol template which will be used to document the site configuration at the onset of the experiment, as a baseline for the data analysis and assessments during the experiment;
- Defined the configuration of references: consistent and defensible, for all participating sites;
- Obtained clarification regarding the OTT Pluvio² data to be used for the derivation of reference observations;
- Assessed and approved installation and configuration details: calibration of gauges, use of antifreeze, Alter shield configuration.

2.2 The objectives for meeting the SPICE goals regarding the measurement of snow on the ground and snowfall, are being refined and will be finalised by the team prior to the start of the experiment.

2.3 The IOC decided to establish a SPICE Data Archive for hosting all the SPICE data, complementing the archiving capabilities of each site. The SPICE Data Archive will ensure consistent data format and data quality control, and will enable the data analysis. The National Centre for Atmospheric Research (NCAR), USA and Environment Canada, Canada indicated interest in sharing this responsibility.

2.4 Additional submissions of instruments were received after the submission deadline. Most of the technologies proposed are emerging, with real potential. The IOC Chair recommended that

the IOC considers issuing a second call for participation in early 2013, for canvassing interest in participating in SPICE with emerging technologies.

3. SITE DATA FLOW AND DATA ARCHIVAL

3.1 In order to meet the needs of the SPICE Data Analysis Team, a comprehensive SPICE Data Archive will be established that will include a central repository for all the level 1 and 2 data. It is expected that the SPICE Data Archive will provide a first level of data quality control, including monitoring the data for inconsistencies, missing data, upload times, file sizes, etc. Additionally, quick-look data plots will be made available to participating team members for viewing their data graphically and manually checking for any errors or inconsistencies in the data. The NCAR offered to host the central SPICE Data Archive; a summary of its proposal is included in Annex II. The SPICE IOC welcomed the offer, and committed to work with the NCAR team to facilitate the data transfer and data management.

3.2 The meeting recalled that the Commissioning Report for each site will include the instrument metadata, which will be used for the configuration of the SPICE Data Archive. A consistent nomenclature of terms and units must be used to enable the data transfer. NCAR will provide guidance on the expected names, based on the existing archive requirements.

3.3 The meeting decided that all measurements shall be submitted to the SPICE Data Archive with a GMT timestamp.

3.4 The project team agreed that the lowest temporal resolution of the data transmitted to the SPICE Data Archive is that specific for the data collection of each instrument, e.g. 10 Hz; this is a key requirement in particular for the weighing gauges used as part of the reference system. Each site needs to ensure that they could archive and transmit the highest frequency data they collect (preferably 6s data, as stated in SPICE-IOC-2, para 5.2.35). Mr Rasmussen agreed to modify the NCAR SPICE Data Archive to enable this.

3.5 The ancillary data should be provided to the NCAR SPICE Data Archive with a 1-min resolution (level 2a).

3.6 It was agreed that the NCAR SPICE Data Archive would also be used for storing the snow depth measurements. NCAR will advise whether the same or another format will be used for these measurements.

3.7 The discussion suggested that it would be appropriate to redefine level 1 data as 6s-data, and level 2 data as 1-min data. The IOC requested Dr Joe and Dr Rasmussen to finalize the definitions of the data levels, including some examples, for consideration and final approval by the IOC.

3.8 The sampling strategy to produce the data, as well as any method used to produce 1-minute data (e.g. averaging of 6s data) should be clearly documented in the metadata. The meeting agreed that, the site metadata will be made available together with the site data, from the SPICE Data Archive.

3.9 The IOC requested the Data Analysis Team to review the proposed metadata to ensure all the necessary information is included in it.

3.10 The NCAR SPICE Data Archive also includes a MySQL database, which will offer one page per site, which can generate up to 3 day length plots, and which would indicate the missing data.

3.11 The Quality Control procedures implemented in the NCAR SPICE Data Archive are based on the WMO Manual on the Global Data Processing and Forecasting System (WMO-No.485, 1992b App. II-1 Quality Control): Good, inconsistent, doubtful, erroneous, missing, under maintenance (power down, empty gauge). Automatic emails will be sent to the site managers indicating data issues identified during quality control checks.

3.12 It is expected that links from maintenance records to data will be established. NCAR will develop a proposal on how to upload maintenance information and modification of the data format including these quality control flag, for consideration by the IOC.

3.13 Dr Rasmussen committed that together with the Site Mangers, he will develop an approach to make available the data from the SPICE Data Archive back to sites, after being quality controlled. He also recommended that sites start sending their data to the NCAR SPICE Data Archive as soon as possible to enable further testing of the system.

3.14 As described in the Commissioning Protocol, the sites have to submit the data to NCAR within 3 months after commissioning, using the recommended NCAR format for data transmission. The IOC decided that if a site is not providing the data on a regular basis (as identified based on their specific conditions) to the SPICE Data Archive, it would not be considered as part of SPICE anymore.

3.15 The archival of manual observations requires additional attention given its reduced temporal resolution and the difficulty to obtain the observations at predefined times. A key requirement is that the manual observations are correctly time-stamped to enable the correlation with the observations from the automatic instruments. A detailed methodology needs to be developed to outline the format and frequency of the submission of the manual observations.

3.16 The IOC decided that all manual observations needed to be entered into excel files, which would be submitted approximately weekly to the SPICE Archive and which must include both snow volume and mass. Dr Barry Goodison indicated that, historically volumetric measurements were done including a wetting loss factor. Ms Nitu agreed to share the Excel file in use in Canada for manual observations with the other site managers to ensure a single file format is used at all sites.

4. REVIEW OF THE SITES INSTRUMENTS LAYOUT

4.1 The meeting reviewed the status of preparation of each site, by reviewing the proposals made available by the site managers for the siting of instruments (references, gauges under test provided by the host and by Instrument Providers, ancillary instruments). The review was conducted to ensure that instruments are appropriately located to avoid any interference between instruments, and with the surroundings.

Canada

4.2 Ms Nitu presented the status of the sites of Care, Bratt's Lake and Caribou Creek. These site layouts are provided in Annex III.

4.3 The IOC recommended clarifying what was the shielding and heating of the C3 and Z1 gauges of Bratt's Lake.

4.4 Ms Nitu will provide to the other site managers, the instructions for mounting the Alter shield within the DFIR-fence, removed from the post of the gauge. The IOC recommended that the site summaries include the height of the DFIR-fence.

Finland

4.5 Mr Aulamo indicated that the Sodankyla site has been built and was ready for instrument installations, at the time of the meeting. The DFIR-fence was constructed and the installation of the instrument was underway. The proposed instruments layout for the site is provided in Annex III.

Norway

4.6 Mrs Mareille Wolff presented the current configuration of the site. The proposed instruments layout for the site is provided in Annex III. The site is very windy. She indicated concern with the heating limit of -5°C for the weighing gauge of the reference system. At this site, significant precipitation occurs below -5°C and it is feared that capping could occur. The IOC agreed that this should be carefully monitored and possibly reconsidered if the heating is not effective under these conditions.

Poland

4.7 Mr Maciej Karzynski presented the status of the Hala Gasnienicowa site. It is planned to start the measurements on 2nd December 2012. The siting of the instruments is not finalized yet. The IOC noted that great care would be required to avoid interferences with the other instruments of the site and with the manual measurements. It therefore requested Mr Karzynski to prepare a drawing with the proposed instrument layouts and requested that Ms Nitu provides support in finalizing it, to meet the project's objectives.

4.8 Mr Karzynski indicated the plan to set-up an R3 reference system. The IOC welcomed this plan, but noted that as the site will be focussing on snow depth measurements, and R3 reference was secondary. Furthermore, the IOC stressed the need to use one of the instrument models that were considered as suitable for use as part of the field working reference system for the R3 reference: GEONOR T-200B3 gauges with 600 mm or 1000 mm capacities, or the OTT Pluvio² gauge with 200 cm² inlet opening.

4.9 The normal frequency of manual measurements is two observations per day. The IOC recommended more frequent measurements, as far as possible.

Russian Federation

4.10 Mr Arkadiy Koldaev presented briefly the status of the Voljskaya site, which is under development, and in the process of acquiring instruments. The site is planned to be ready by mid-November. The IOC requested that he provides a detailed site layout including instruments and their locations with details of surrounding topography.

4.11 The IOC requested that Mr Koldaev provides details on the site data collection and plans for data transfer to the NCAR archive.

4.12 Mr Koldaev indicated that the local customs policies were not favourable for temporary importation of instruments and that he would prefer to acquire the instruments at a reduced price for use in SPICE. The IOC stressed the need to ensure that such a process would be in-line with the SPICE data policy and requested Mr Koldaev to inform the IOC for further consideration/decision, should this option be pursued.

4.13 The IOC was informed that some delays were experienced with setting-up the Valdai site due to the absence of some of the gauges and delays with the site funding, which meant the site would not be fully operational before 2013. The IOC was concerned with the limited information available to date, including on the plans for the data archive and data transfers. The IOC requested the site proponents to develop the detailed description required for the proper site commissioning.

Switzerland

4.14 Mr Yves-Alain Roulet presented the status of the Weissfluhjoch site. The DFIR-fence was built. The concrete had to be brought in to the site by helicopter. It is planned to mount the gauges as they will be provided by the manufacturers (shields will only be used if provided by manufacturers).

USA

4.15 Dr Rasmussen presented the summary of the Marshall site layout. The site has battery backup which allows the continuity in operation, in case of a power failure. The site will have one R1 reference, two R2 references (one with Geonor T200-B3, one with Pluvio²) and several small DFIRs. Two DFIR-fences for R2 will have standard heights. Details on the site configuration and layout will be provided, as they become available and part of the Commissioning Protocol report of the site.

5. PLANNING, SCHEDULING AND COORDINATION OF SPICE**SPICE Objective**

5.1 The meeting reconsidered the objectives of SPICE in the context of WIGOS, which is one of the priorities of WMO. It recognized that the aim of WIGOS was the integration of various observing systems. In this context, the ability to use the SPICE database for further data mining,

not only related to in-situ observations, but also to address the integration of in-situ with remote-sensing observations are highly relevant. It therefore decided to revert to the original SPICE objectives (see Annex IV of this report), which included the mention of remote-sensing observations.

5.2 The meeting recognized that the overall coordination of SPICE was a real challenge and that site managers could possibly not manage to handle the additional remote-sensing observations at their sites. The meeting consequently recommended that site managers be urged to reach out to other communities operating remote-sensing instruments in the vicinity of their sites, in particular radar operators, to draw their attention to the potential of the SPICE data sets to calibrate their instruments, and encourage them to do solid precipitation reflectivity studies. The reference and results from such joint projects could be included in the final report of SPICE.

5.3 The IOC Chair will communicate with all site managers, encouraging them to inform the remote sensing communities active in their countries, about SPICE.

Update on Instrument Provider Participation

5.4 The meeting was informed that the following 3 instrument providers withdrew their submission in the past months:

- ETG: Heated Rain Gauge, model R102R (CARE, Marshall) and Snow Depth Sensor, model SENULSNIV (Sodankyla)
- KNMI: Electrical Rain Gauge
- Hydrological Service America (Austria): Snow Pack Analyzer.

5.5 MPS Systems in consultation with the IOC updated its submission and provided for inclusion in the intercomparison the Total Rain Weighing sensor, model TRwS 405 which replaces the model TRwS 204. Three sensors model TRwS 405 are included in SPICE, one will be tested in Haukeliseter (Norway) with no shield, and the other two at the Marshall site (USA), one in an unshielded configuration, and the second with a shield provided by the manufacturer.

5.6 At the request of the IOC, Environment Meas. Limited agreed to provide an additional Universal Precipitation Gauge UPG1000 for inclusion in the intercomparison, with the standard manufacturer recommended shield, for a total of three instruments. The additional instrument will be installed at Marshall, in an unshielded configuration. The other two UPG1000 instruments, originally approved by SPICE-IOC-2, will be installed as proposed in the submission of the manufacturer with shield at Marshall and Sodankyla.

5.7 Consultation between Meteoservis and the IOC, lead the IOC to decide that the two pairs of Meteoservis weighing rain gauges MRW500 that will be provided to Bratt's Lake (Canada) and Marshall (USA) will be operated in a shielded and unshielded configuration at both sites instead of keeping instruments as spares.

5.8 The submission from Droplet Measurement Technologies of a Meteorological Particle Sensor (MPS) consisted of only one system with a second only as a spare. As a result, only one such instrument has been provided for the intercomparison at this time and it will be installed the CARE site. The manufacturer will be working with NOAA/NCAR for provision of a second fully operating instrument for the Marshall site, thus meeting the IOC planned experiment at this site.

5.9 The meeting recalled that on 5 September, 2012, WMO received a submission of instruments from Vaisala, which was considered by the IOC during a September teleconference. Based on the lateness of the submission and the need to treat all instrument providers consistently, the IOC decided to reject the proposal at this time. The IOC had been of the opinion that it would not be appropriate to include additional instruments in SPICE at this stage, given the need to focus on finalising the experiment configuration for the winter of 2012/13, and also giving every manufacturer same chances regarding the participation.

5.10 The IOC agreed that any other new submission of instruments would be treated in the same way.

5.11 The IOC further recalled that it had already decided to consider making a new call for participation in early 2013, if additional capacities are available on the SPICE testsites.

Update on Site Participation

5.12 A formal proposal for participating in SPICE was received from Italy. The participation would consist in the contribution from the University of Genoa, as part of the WMO/CIMO Lead Centre on Precipitation Intensity. Italy had already expressed its interest to participate in SPICE since its preparatory phase and had taken part in pre-SPICE. At the time of the second session of the SPICE IOC (Boulder, USA, 11-15 June 2012) the representatives from Italy had reiterated Italy's commitment. The SPICE IOC had agreed to their participation as indicated in the SPICE-IOC-2 report.

5.13 The IOC requested that the representative from Italy prepare a more detailed proposal of its contribution to SPICE for consideration by the IOC, should it be planned to be wider than stated in the SPICE-IOC-2 report. Italy provided clarification before finalizing this report and indicated that its contribution will be extended to cover at least the following studies :

- analysis of the accuracy and precision of the reference instruments under various static and dynamic conditions;
- in collaboration with NCAR, investigation of the capping conditions and the impact of the chimney effect on solid precipitation measurements by using the snow machine;
- development of correction algorithms for the optimization of the information content of the signal provided by the two reference instruments (especially under dynamic input conditions);
- development of de-noising algorithms for the interpretation of the T-200B vibrating wires signal in different conditions (e.g. dynamic input and wind);

5.14 The IOC accepted the proposal from Italy to participate in SPICE as detailed above, as a laboratory testing facility. The work conducted at the University of Genoa or by its representatives in cooperation with the SPICE team will be subject to the SPICE Data Protocol.

6. DISCUSSION WITH MANUFACTURERS

6.1 Representatives of a number of Instrument Providers joined the meeting for a short and informal discussion session. An overview of the SPICE goals and the overall project organization were briefly presented, as well as their expected role and engagement between them and the project team. The Instrument Providers were invited to ask questions and share any concern they would have with the conduct and organization of SPICE.

6.2 In addressing the questions from the manufacturers, the IOC Chair indicated that the instruments under test will be compared with reference configurations which are common across all sites. Also, most gauges are tested at the Marshall site, as well as on most of the other participating sites, function of the number of instruments provided for the intercomparison. The instruments were allocated to those sites which are best suited to test their performances, also taking into the account the existing capacity of the sites.

6.3 In order to develop a personal relationship and a spirit of collaboration between the site managers and the instrument providers, it was recommended that the site representatives do their utmost to meet the instrument providers present at the Meteorological Technology World Expo in Brussels.

7. OTHER BUSINESS

7.1 The IOC Chair recalled that the data protocol needed to be signed by all participants in SPICE, including all IOC members, site managers, instrument providers. She urged those who hadn't signed it yet to do so urgently.

7.2 The IOC noted that the visit of test sites by Instrument Providers was possible and in-line with the spirit of collaboration promoted within SPICE. It recommended that the manufacturer visits are planned with the site manager, who will inform the IOC of the visit, and sufficiently in advance of it taking place, so that they could use this opportunity to relay questions they may have on the operation and performance of the instruments. When such visits lead to specific advice and recommendation from the manufacturer on the operation of their instruments, these should be shared with the IOC and other relevant site managers. Furthermore, the IOC recalled that such visits should take place within the spirit of the SPICE Data Protocol.

8. DRAFT REPORT OF THE SESSION

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

9. CLOSURE OF THE SESSION

The session closed on Monday, 15 October 2012 at 17:00 hours.

LIST OF PARTICIPANTS

<p>Ms Rodica NITU</p> <p><i>Chair, IOC-SPICE SPICE Project Leader Site manager of CARE (Canada)</i></p>	<p>Environment Canada 4905 Dufferin St. TORONTO, ON, M3H 5T4 Canada</p> <p>Tel.: +1 416 739 4133 Fax: +1 416 739 5721 rodica.nitu@ec.gc.ca</p>
<p>Dr Bruce BAKER</p> <p><i>Vice-President of CIMO Member, IOC-SPICE</i></p>	<p>NOAA / ATDD 456 South Illinois Avenue OAK RIDGE, TN 37830 United States</p> <p>Tel.: +1 865 576 1248 Fax: +1 865 576 1327 bruce.bakernoaa.gov</p>
<p>Dr Eckhard LANZINGER (by teleconference)</p> <p><i>Member, IOC-SPICE</i></p>	<p>Deutscher Wetterdienst Frahmredder 95 22393 Hamburg Germany</p> <p>Tel.: +49 40 6690 2455 Fax: +49 40 6690 2499 eckhard.lanzinger@dwd.de</p>
<p>Dr Haihe LIANG</p> <p><i>Member, IOC-SPICE</i></p>	<p>Meteorological Observation Centre China Meteorological Administration No. 46 Zhongguacun, Nandajie BEIJING 100081 China</p> <p>Tel.: +86 10 6840 6999 Fax: +86 10 6840 0936 Lhhaoc@cma.gov.cn</p>
<p>Dr Yves-Alain ROULET</p> <p><i>Member, IOC-SPICE Site Manager of Weissfluhjoch (Switzerland)</i></p>	<p>Météo Suisse Station Aérologique Case postale 316 CH-1530 PAYERNE Switzerland</p> <p>Tel.: +41 26 662 6258 Fax: +41 26 662 6212 yves-alain.roulet@meteoswiss.ch</p>
<p>Dr Roy RASMUSSEN</p> <p><i>SPICE Project Co-Leader Site Manager of Marshall (USA)</i></p>	<p>National Center for Atmospheric Research 3450 Mitchell Lane Boulder, CO 80301 United States</p> <p>Tel.: (1 303) 497-8430 Fax: (1 303) 497-8401 rasmus@ucar.edu</p>

<p>Mr Osmo AULAMO <i>Site Manager of Sodankyla (Finland)</i></p>	<p>Finnish meteorological Institute Tähteläntie 62 99600 Sodankylä Finland</p> <p>osmo.aulamo@fmi.fi</p>
<p>Mr Timo LAINE <i>Site Representative of Sodankyla (Finland)</i></p>	<p>Finnish meteorological Institute Finland</p> <p>timo.laine@fmi.fi</p>
<p>Dr Mareile WOLFF <i>Site Manager of Haukeliseter (Norway)</i></p>	<p>Norwegian Meteorological Institute P.O. Box 43 Blindern Henrik Mohns plass 1 0313 Oslo Norway</p> <p>Tel.: +47 2296 3185 Fax: +47 2296 3050 Mareile.wolff@met.no</p>
<p>Ragnar Braekkan <i>Site Representative of Haukeliseter (Norway)</i></p>	<p>Norwegian Meteorological Institute P.O. Box 43 Blindern Henrik Mohns plass 1 0313 Oslo Norway</p> <p>Tel.: +47 2296 3191 Fax: +47 2296 3050 ragnar.braekken@met.no</p>
<p>Maciej Karzynski <i>Site Manager of Hala Gasnienicowa (Poland)</i></p>	<p>Institute of Meteorology and Water Management National Research Institute Cracow's Branch 14 Piotra Borowego Str. 30-215 Cracow Poland</p> <p>Tel.: +48 12 6398132 Fax: +48 12 6398201 maciej.karzynski@imgw.pl</p>
<p>Arkadiy KOLDAEV <i>Site Representative of Volga River (Russian Federation)</i></p>	<p>Research and Production "TYPHOON" 3, Pervomayskaya Street 141700 DOLGOPRUDNY Moscow Region Russian Federation</p> <p>Tel.: +7 495 579 9455 Fax: +7 495 408 7758 avk425@rambler.ru</p>
<p>Shane BILISH (by teleconference) <i>Site Representative of Gutega Dam (Australia)</i></p>	<p>Snowy Hydro Limited PO Box 332 Cooma NSW 2630 Australia</p> <p>Tel.: +61 2 6453 2658 Fax: +61 2 6453 2052 Shane.Bilish@snowyhydro.com.au</p>

<p>Barry GOODISON (by teleconference) Representing PORS and GCOS</p>	<p>bgoodison@wmo.int barrygo@rogers.com</p>
<p>Jeffrey HOOVER Site Representative of CARE (Canada)</p>	<p>Environment Canada Canada Jeffery.Hoover@ec.gc.ca</p>
<p>Paul JOE Invited Expert</p>	<p>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</p>
<p>Luca LANZA Site Representative of Italy</p>	<p>University of Genoa Italy Tel: +39 010 353 2123 Fax: +39 010 353 2481 luca.lanza@unige.it</p>
<p>Sherlock SUNG Site Representative of CARE (Canada)</p>	<p>Environment Canada 4905 Dufferin Street Toronto Ontario M3H 5T4 Canada Tel.: +1 416 739 4149 Sherlock.sung@ec.gc.ca</p>
INSTRUMENT PROVIDERS	
<p>Mike BRETTL</p>	<p>Campbell Scientific (?) 80 Hathern Road Shepshed LE12 9GX UK Tel.: +44 (0)1509 601141 mike.brettle@campbellsci.co.uk</p>
<p>Mr Brian DAY</p>	<p>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</p>

Mark DUTTON	<p>General Manager/Technical Director Environmental Measurements Limited 7 Jupiter Court Orion Business Park North Shields NE29 7SE UK</p> <p>Tel: 0191 2583757 Fax: 0191 2570209 mark@emltd.net</p>
Steve EAGAN	<p>Belfort Instrument Company</p> <p>Tel: 410 259 6096 seagan@belfortinstrument.com</p>
Giandomenico LORENZO	<p>CAE S.p.A. Via Colunga 20 40068 San Lazzaro di Savena (BO) Italy</p> <p>Lorenzo.Giandomenico@cae.it</p>
Ivar FREDRIKSEN Per PIEN	<p>GEONOR AS Norway</p> <p>Tel: +47 67159280 if@geonor.no</p>
Bernardi GUIDO	<p>CAE S.p.A. Via Colunga 20 40068 San Lazzaro di Savena (BO) Italy</p> <p>Guido.Bernardi@cae.it</p>
Helmut HOHENSTEIN	<p>OTT Hydromet GmbH Marketing Manager Ludwigstr. 16 87437 Kempten Germany</p> <p>Tel: +49 831 5617 230 Fax: +49 831 5617 209 h.hohenstein@ott.com</p>
Kurt NEMETH	<p>Business Development Manager Meteorology OTT Hydromet GmbH P.O.Box: 2140 / 87411 Kempten Germany</p> <p>Tel: +49 831 5617 – 270 Fax : +49 831 5617 – 209 k.nemeth@ott.com</p>

Jessika SCHUGARDT	JENOPTIK Defense & Civil Systems Sensor Systems Business Unit ESW GmbH Prüssingstr. 41 07745 Jena Germany Tel: +49 3328 334-484 Fax :-590 Jessika.Schugardt@jenoptik.com
Juraj SCHWARZ	MPS systém s.r.o.Pri vinohradoch 326831 06 Bratislava Tel/fax: +421 2 4488 9486 schwarz@mps-system.sk
Wolfram SOMMER	Sommer GmbH Tel : +43 5523 55989 sommer@sommer.at
Holger WILLE	JENOPTIK Defense & Civil Systems Sensor Systems Business Unit ESW GmbH Prüssingstr. 41 07745 Jena Germany Tel: +49 3328 334-349 Fax:-590 Holger.wille@jenoptik.com
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
Mr Wenjian ZHANG <i>Director, Observing and Information Systems Department</i>	Tel.: +41 22 730 8567 Fax: +41 22 730 8021 E-mail: WZhang@wmo.int
Mr Miroslav ONDRÁŠ <i>Chief, WMO Observing Systems Division</i>	Tel.: +41 22 730 8409 Fax: +41 22 730 8021 E-mail: MOndras@wmo.int
Mrs Isabelle RÜEDI <i>Head, Instruments and Methods of Observation Unit WMO Observing Systems Division</i>	Tel.: +41 22 730 8278 Fax: +41 22 730 8021 E-mail: IRuedi@wmo.int
Mr Roger ATKINSON <i>Scientific Officer, Instruments and Methods of Observation Unit WMO Observing Systems Division</i>	Tel.: +41 22 730 8011 Fax: +41 22 730 8021 E-mail: ratkinson@wmo.int

SOLID PRECIPITATION INTERCOMPARISON EXPERIMENT (SPICE)**DATA ARCHIVAL, MONITORING AND FIRST-LEVEL QUALITY CONTROL PROPOSAL****Scott Landolt and Andy Gaydos, NCAR****Matteo Colli, U. of Genoa, Italy****October 12, 2012**

In order to meet the needs of the SPICE Data Analysis Team, a comprehensive data archive must be established that includes a central repository for all the level 1 and 2 data with a first level of data quality control including monitoring the data for inconsistencies, missing data, upload times, file sizes, etc. Additionally, quick-look data plots should be made available to participating members to view their data graphically and manually check for any errors or inconsistencies in the data. To accomplish this, the National Center for Atmospheric Research (NCAR) is proposing to host the central data archive and provide the initial data monitoring and quality control as outlined below.

Central Data Archive

The purpose of the central archive is to provide a repository for all participating sites to upload their data. It is assumed that each site will maintain a local archive of all of the data collected locally at their site, which will include the level 1 and 2 data, metadata, site logs, maintenance logs, event logs, and other information relevant to SPICE. It is also assumed that each participating site will be able to transfer data automatically or manually (via flash drive, removable hard drive, DCD, etc.) to a central location that is linked to the Internet so the data can propagate to the central archive.

All data being uploaded to the central archive will be in a common format, as outlined below. NCAR can provide assistance to participants if they don't have the resources to put their data into the archive format.

SPICE Data Format Requirements

Data being prepared for inclusion into the central archive shall be delivered by ftp to a server designated by NCAR. The data shall be delivered in a daily file format (with an expected 1440 lines of data for each file) using the following file naming convention:

<site>YYYYMMDD.<instrument>

where <instrument> is a short, one-word description of the data and can refer to a specific instrument or a datalogger containing multiple instruments, e.g. Marshall20120621.GEONOR or MAR20120621.GEO. If multiple instruments or data loggers of the same type exist at the site, numbering can be used in the filename, e.g. MAR20120621.GEO1, MAR20120621.GEO2, etc.

Files shall contain an ASCII representation of the data. Each line of data shall be delimited by a single 'newline' character having an ASCII code of 0x0A (i.e. a decimal value of ten). The top of each file shall contain five or more header lines describing the location where the measurement(s) were made, a short description of the instrument used for the measurement, and a description of the data field(s). Header lines shall have a pound sign ('#') as the first character, and shall have the following format:

```
# <site ID>
# <site description>
# Latitude: <lat>, Longitude: <long>, Altitude: <alt>
# <dataset description>
```

where:

<site ID> is a short description of the site, using only alphanumeric characters (i.e. [a-z|A-Z|0-9] and the underscore '_' character) to describe the site (i.e. Marshall would be MAR or MARS)

<site description> is a more verbose description of the site, which may contain spaces and punctuation, but should be brief (i.e. Marshall SPICE site data)

<lat> and <long> are decimal position coordinates of the site/sensor (i.e. -108.3754) and <alt> is the altitude of the measurement, in meters above sea level

<dataset description> is a description of the dataset, (i.e. GEONOR gauges in single Alter and DFIR shields.) This may contain spaces and punctuation followed by one or more data field descriptors using the following format:

<column number> <data ID>, <data description>, <data units>

where:

<column number> The column position, starting with column #1. (Does not include date and time stamps)

<data ID> is a short description of the data field, using only alphanumeric characters (i.e. [a-z|A-Z|0-9] and the underscore '_' character) (i.e. GEO_vw1)

<data description> is a more verbose description of the data, which may contain spaces and punctuation except for the comma (,) character (i.e. Single Alter Geonor vibrating wire #1)

<data units> contains the unit of measurement for the data (e.g. mm, m/s, etc.).

All units shall be given in metric.

The header lines shall be followed by lines of data collected at the site on the relevant day, in ascending temporal order, using the following format:

YYYYMMDD, HH:MM:SS, <field1>, <field2>, ...

The time MUST be included for each line of data, and must be recorded in UTC time. All data collected at the site at the given time shall be listed on a single line. Data from multiple instruments at a particular site can be uploaded as separate files, using the naming conventions described above.

Each data field shall be either a numeric or ASCII string value, and shall be delimited using the comma (,) character. Numeric values shall include only a combination of the characters 0-9, a negative (-) sign, and a decimal point (.). ASCII strings are permitted, but must be surrounded by double quotation marks ("). If data for a particular field is not available for the given timestamp, the field shall be populated with the string "NULL" (excluding quotation marks).

The following can be used as an example data file, with the filename '20110121.PWD':

```
# USA_DIA1
# Denver International Airport Site
#1, Deicing Pad, USA # Latitude: 39.8679, Longitude: -104.6795, Altitude: 1615.0
# Data collected from a Vaisala PWD-22
# 1) Status, Status Message,
# 2) Vis_One, Visibility 1 minute avg, m
# 3) Vis_Ten, Visibility 10 minute avg, m
# 4) IPW_NWS, Instant Present Weather NWS Codes,
# 5) Temp, Ambient Temperature, C
```

20110121, 00:00:00, "00", 20000, 20000, "C", -4.37
 20110121, 00:01:03, "00", 20000, 20000, "C", -4.77
 20110121, 00:01:15, "01", 18746, 20000, "-S", NULL
 20110121, 00:02:06, "01", 14746, 19375, "S", NULL
 20110121, 00:03:26, "01", 12342, 17432, "S+", -5.02

Data Archival

Once the data has been formatted, it can be uploaded to the NCAR FTP site. The FTP site will have a login and password for each participating site. The login will be unique to each site and will ensure only the site managers can upload data, site logs, etc. for their particular site.

The data archival system monitors the FTP site for new data and parses the data into a MySQL database. Each site will have its own MySQL database. Data monitoring done at this time is described in the Data Monitoring section later in this proposal. Once the data is in the MySQL database, the raw data files are transferred to a permanent archive that is backed up in five locations both onsite and offsite. The MySQL database is also backed up in three locations onsite and offsite to protect against disk failures. Once the data has been parsed to the MySQL database, it can be accessed through a user-friendly webpage interface. Users and site managers do NOT need to know how to use MySQL as the database is accessed via the webpage described below.

Webpage Interface and Data Quick-View

The webpage interface to the MySQL database serves two purposes. It allows users to access and download their data for any given time period by combining the data into a single ASCII file. Sensors from multiple files can be combined into a single file using the data download capabilities of the website.

Each participating group will have their own login and passwords to access the website. Logins are configurable to restrict users to data collected from just their site or allowed access to other sites. Once a user has logged in, they have the options of plotting their data, adding site logs, maintenance notices, uploading photos or downloading data (Figure 1 below).



Figure 1 – Primary page each user will see when logging into the NCAR page.

The “**Webplots**” link will allow users to access the data plotting capabilities of the website. The webpage can be configured to provide a listing of daily pre-made plots and/or the user can opt to create their own hourly/daily/weekly/monthly/etc. plots (Figure 2).

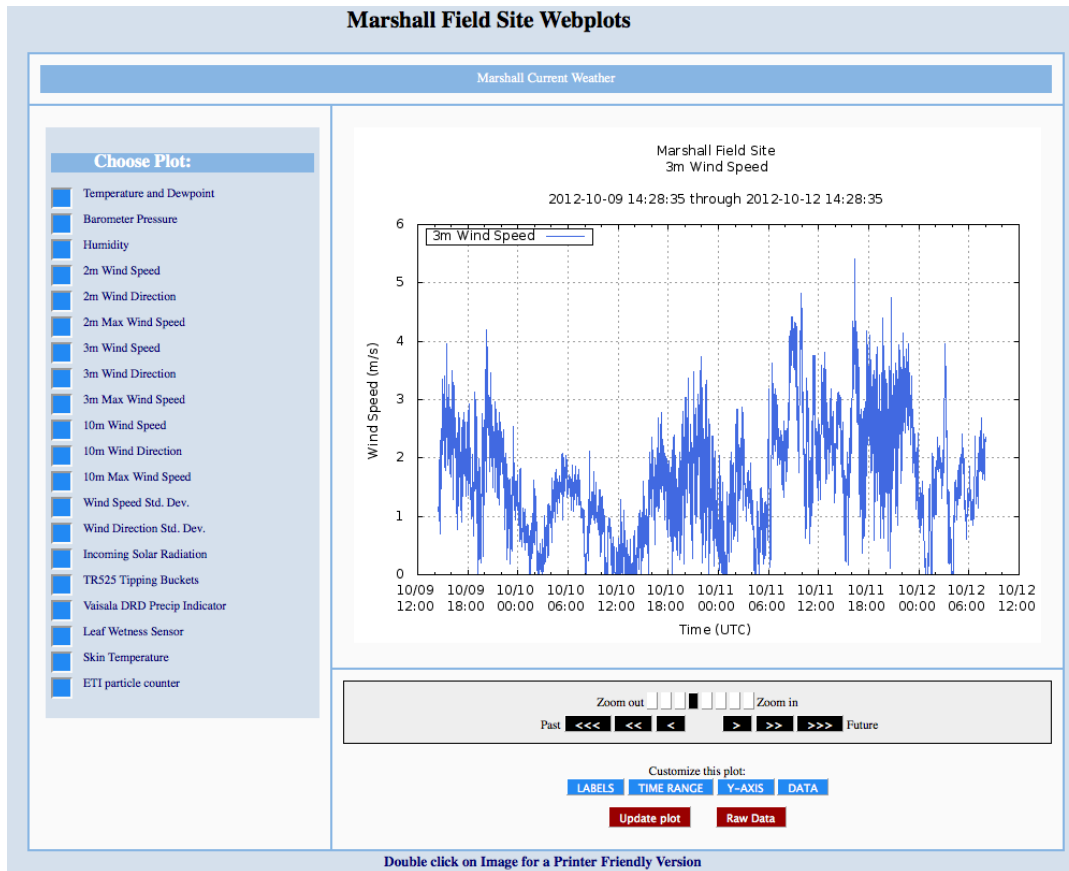


Figure 2 – Webplot example of time series of Marshall data

Access to the raw data in the MySQL database is available under the ‘**Raw Data**’ link on the main page for each participating site. The raw data page allows the user to define the period of time they are interested in, as well as how the data is formatted (comma versus tab delimited), whether to add a data header, which string to use for missing values, and characters that denote comments. Data can also be aligned to the nearest minute or second (Figure 3). The “available data” button will allow a user to easily check and view periods where data is available in the database or periods where data is missing. After selecting the data to be downloaded, the user provides their email address and an email is sent to them with a link to download their data. The data will download as an ASCII file and can be opened in any text editor, Microsoft Excel or any plotting program (Figure 4).

Marshall Field Site Information

- [Webplots](#)
- [Raw data](#)
- [Location map](#)
- [Photo archive](#)
- [Site logs](#)
- [Event logs](#)
- [Contacts](#)

[SPICE Home](#)

Raw Data Request Form

Show data from to UTC
(Use date format YYYY-MM-DD HH:MM:SS)

Format Options:

Output format:

Time format:

Align data to nearest:

Include data header:

Comments use this character:

String to use for NULL data:

Requested datasets (click name to choose desired fields)

Check/Uncheck All Toggle All

Data Point 1

Add a new dataset:

Database: Instrument:

Please provide an email address, and a link to your requested data file will be emailed to you shortly.

Email Address:

Compress data? (recommended) Yes No

Data filename desired:

Figure 3 – Raw data request form on the webpage.

```

!--- Raw Data output
!--- Date range: 2012-10-11 14:45:00 through 2012-10-12 14:45:48 UTC
!---
!--- (c) 2012 NCAR
!-----
!  DATABASE  DATASET          FIELD DESCRIPTION          UNIT
!-----
1)          Year                      YYYYY
2)          Month                     MM
3)          Day                       DD
4)          Dechrs                    HH.HH
15)  marshall  CURR_WEATHER      2m CS500 Temperature      C
16)  marshall  CURR_WEATHER      2m CS500 Relative Humidity %
!-----
!Year, Month, Day, Dechrs, AveTemp, AvgRH
2012, 10, 11, 14.750, -106.860, -73.699
2012, 10, 11, 14.767, -106.840, -73.695
2012, 10, 11, 14.783, -106.830, -73.685
2012, 10, 11, 14.800, -106.830, -73.677
2012, 10, 11, 14.817, -106.820, -73.674
2012, 10, 11, 14.833, -106.830, -73.679
2012, 10, 11, 14.850, -106.840, -73.687
2012, 10, 11, 14.867, -106.820, -73.687
2012, 10, 11, 14.883, -106.810, -73.687
2012, 10, 11, 14.900, -106.820, -73.687
2012, 10, 11, 14.917, -106.790, -73.676
2012, 10, 11, 14.933, -106.800, -73.681
    
```

Figure 4 – Example dataset downloaded from the webpage.

Data Monitoring Capabilities

The NCAR data ingest has the ability to provide some high-level monitoring of the data. Once the data arrives on the ftp site, the data is checked to ensure that 1440 lines of data are there for the 1-minute daily files. File sizes are also checked to ensure they fall within a given expected range of sizes. This was developed to safeguard against the cases where files may contain lines that have only a time stamp and no data to go with them. Each measurement within the files is also checked

to ensure that the data falls within an expected range (i.e. relative humidity values should be between 0 and 100%). If any problems are detected during any of these checks, an email is automatically generated and sent to the appropriate site manager(s) informing them of potential problems with their data. Further information on this is provided in the data quality control section below.

If sites are able to upload their data on a regular basis, the update frequencies can also be monitored and if a dataset fails to make it to the ftp site within an allotted time, another email can automatically be generated and sent to the site manager, informing them of the problem. Typically, emails are sent when the dataset fails to show up alerting someone to a potential problem, and then again after it has been uploaded to the ftp server letting the site manager know the problem has been corrected.

Automatic Quality Control Guidelines

According to the WMO Manual on the Global Data-processing and Forecasting System, WMO-No. 485 (WMO 1992b), Appendix II-1, Table 1 "Minimum standards for quality control of data - both real time and not real time", the proposed quality control protocol will apply to the following tags to the Marshall site data (as described in BUFR table 033020, "Quality control indication of following values"):

- Good #1, (accurate; data with errors less than or equal to a specified value);
- Inconsistent #2, (one or more parameters are inconsistent; the relationship between different elements does not satisfy defined criteria);
- Doubtful #3, (suspect);
- Erroneous #4, (wrong; data with errors exceeding a specific value);
- Missing data #5, (external error or "to be checked" during the event);
- Under maintenance #6, (data missing due to a maintenance action).

The raw data from the snow gauges are processed in real-time to produce 1-minute snowfall data. Raw data from ancillary sensors are also processed in real-time to produce the 1-minute averages of wind speed and wind direction, maximum wind speed, temperature and standard deviation (STD), relative humidity and STD, output of wetness sensors, global irradiance and atmospheric pressure. The automatic quality control (AQC) procedure checks files coming from the sites after they have been ingested into the database, namely the raw data and the 1-minute snowfall data and ancillary data. Based on this protocol the following quality-controlled fields can be processed:

- The QC 1-minute snowfall depth and intensity data file;
- QC information data with FLAGS;
- The QC daily diagnostic report for snow gauges performance monitoring;
- The QC 1-minute ancillary data file.

"Good" 1-minute snowfall data are labeled by FLAG=1 and stored as a separate field in the MySQL database. Similarly, "Missing" data will be flagged with FLAG=5. Other flags are automatically assigned as given below. An email is automatically generated and sent to the site manager, informing them that some of their data was flagged for possible problems. A separate webpage can be developed allowing them to log in to the website and change the flags of the data manually to reflect the appropriate value. Site managers will also be able to log in and override any flags to reflect instruments that may be under maintenance or data they know to be bad/erroneous.

Flags can be incorporated automatically using the following proposed methods:

1) Number of samples QC - MISSING DATA (FLAG=5)

If the number of samples collected in one minute is less than the Minimum Number of Samples of the considered gauge, that minute is tagged as "MISSING" and the flag = 5 is coded. The missing datum can be originated either by a problem occurring in the instrument

or by a bias between the internal clock of the gauge with respect to the clock of the acquisition system.

2) **Native errors- DOUBTFUL/ERRONEOUS DATA (FLAG=3,4)**

In the case of native error messages transmitted by those instruments that could provide diagnostic information the ingest system will be able to assign “DOUBTFUL/ERRONEOUS” data flag = 3/4 depending on the type of message received from the gauge. This would require sites to ensure that all data error-checking codes are transmitted in the 1-minute data files.

3) **Operational limits - DOUBTFUL/ERRONEOUS DATA (FLAG=3,4)**

Also known as “Plausible value check”. This is the range check performed on the 1-minute aggregate values of the gauge outputs. The instrumental operational range is assumed plausible as declared by the manufacturer and where it is not declared or declared unlimited the limits are assumed.

- i.e. 1-minute limits for snowfall depth: 0 - 1.5 mm (snowfall intensity: 0 - 90 mm/h)

If the value of snow depth/intensity collected in 1 minute exceed the given limitation such datum is flagged as “DOUBTFUL”, FLAG=3. If such value is negative the datum is flagged as “ERRONEOUS”, FLAG=4.

4) **Check E-logbook reports - UNDER MAINTENANCE DATA (FLAG=6)**

All maintenance actions performed during the intercomparison period will be recorded in an electronic logbook accessible via the webpage, in order to exclude from data analysis and errors statistics missing or erroneous data due to ordinary maintenance procedures. The electronic version of the logbook will be structured with the following record format:

Start date / Start Time / End date / End time/ Instrument id / Type of action

Information derived from the Logbook summary are used for the automatic assignment of “UNDER MAINTENANCE” label, FLAG=6.

The QC of ancillary data will take into account (a) the working limits of ancillary sensors, (b) the plausible values related to climatic conditions, (c) the “external” consistency conditions about the maximum and minimum time variability of the parameters, and (d) the “internal” consistency.

The QC procedures for ancillary data check:

1) **Operational limits - ERRONEOUS DATA (FLAG=4)**

The environmental values implemented in the QC system are comprised within limitation provided by the manufacturer and climatic limits as follows:

- Air Temperature: -40 °C, +60°C
- Relative Humidity: 0, 100%
- Atmospheric Pressure: 600, 1100 hPa
- Wind Direction: 0, 360 °C
- Wind speed: 0, 100 m/s (1-minute average)
- Wind gust: 0, 100 m/s
- Global solar radiation (irradiance): 0, 1600 W/m²
-
-

If the measured value is outside the acceptable range limit it is flagged as “ERRONEOUS”, FLAG=4.

2) **Time consistency - DOUBTFUL/ERRONEOUS DATA (FLAG=3)**

a) Check of the maximum allowed variability of the 1-minute value.

If the 1 minute value differs from the previous one by more than a specific limit (step), the the current 1-minute values fails the check and it is flagged as doubtful (suspect, FLAG=3). Limits of the maximum variability (the absolute difference between two successive values) are reported in the following table:

	Limit for suspect data	Limit for erroneous data
Air Temperature	5 °C	10 °C
R/H	10%	15%
Wind Speed	10 m/s	20 m/s
Irradiance	800W/m ²	1000W/m ²
....		

b) Check of the minimum required variability of 1-minute values during 1 hour; Once the measurements of a controlled variable has been done for at least 60 minutes, a check of its minimum variability (a threshold value) inside this temporal period will be carried out as follow:

- Air Temperature: observed variation $\geq 0.1^{\circ}\text{C}$ over the past 60 minutes
- Relative Humidity: observed variation $\geq 0.1\%$ over the past 60 minutes
- Wind Speed: observed variation $\geq 0.5\text{ m/s}$ over the past 60 minutes
- Wind direction: observed variation $\geq 10^{\circ}$ over the past 60 minutes
-

If the value fails the time consistency checks it is flagged as “DOUBTFUL”, FLAG=3.

3) **Internal consistency - INCONSISTENT DATA (FLAG=2)**

The following conditions must exist as an example to crosscheck various sensors:

- Wind speed $\neq 0\text{ m/s}$ and wind direction $\neq 0^{\circ}$
- Wind gust (speed) \geq wind speed
- ...

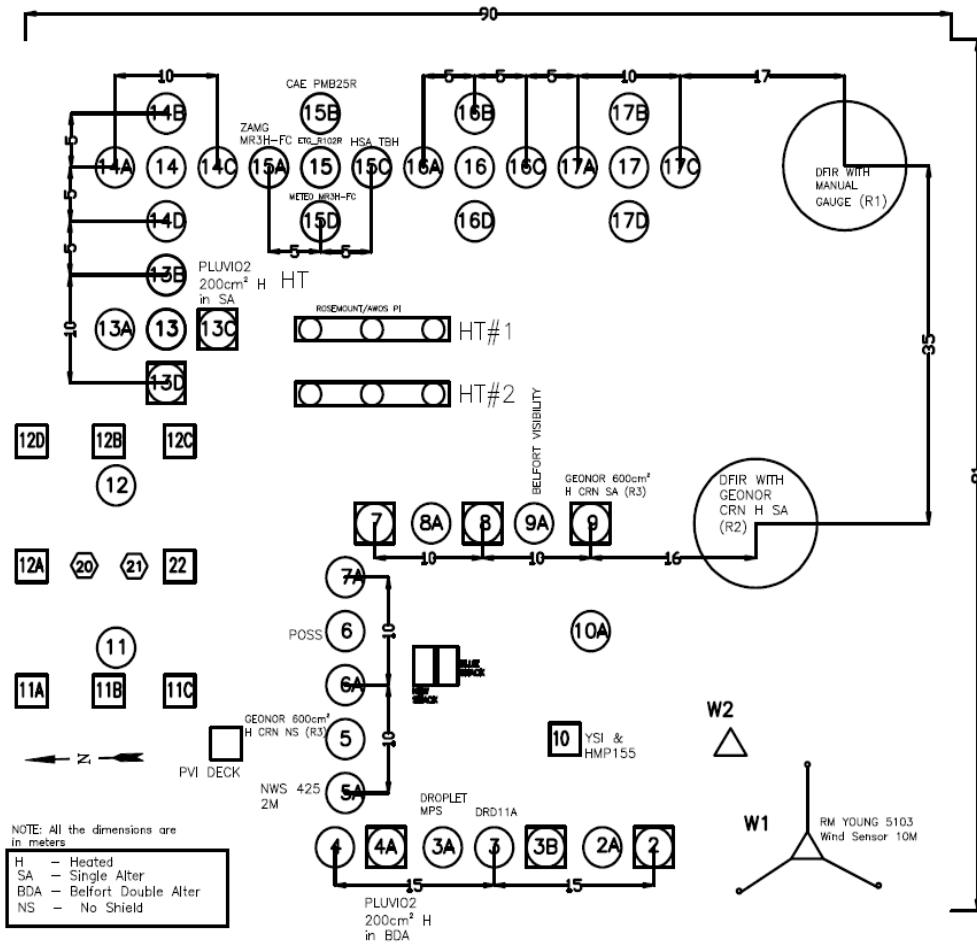
If the value fails the internal consistency checks it is flagged as “INCONSISTENT”, FLAG=2.

REFERENCES

- BUFR Reference Manual of ECMWF, 2006
- Vuerich E., Monesi C., Lanza L.G., Stagi L. and Lanzinger E., 2009. WMO Field Intercomparison of Rainfall Intensity Gauges. World Meteorological Organization – Instruments and Observing Methods Rep. No. 99, WMO/TD No. 1504, pp. 286.
- WMO Final Report of the fifth session of the Expert Team Meet CIME-SBII&CM, Vigna di Valle, Italy, 17-21 September 2007
- WMO Manual on the Global Data-processing and Forecasting System, WMO-No. 485, 1992

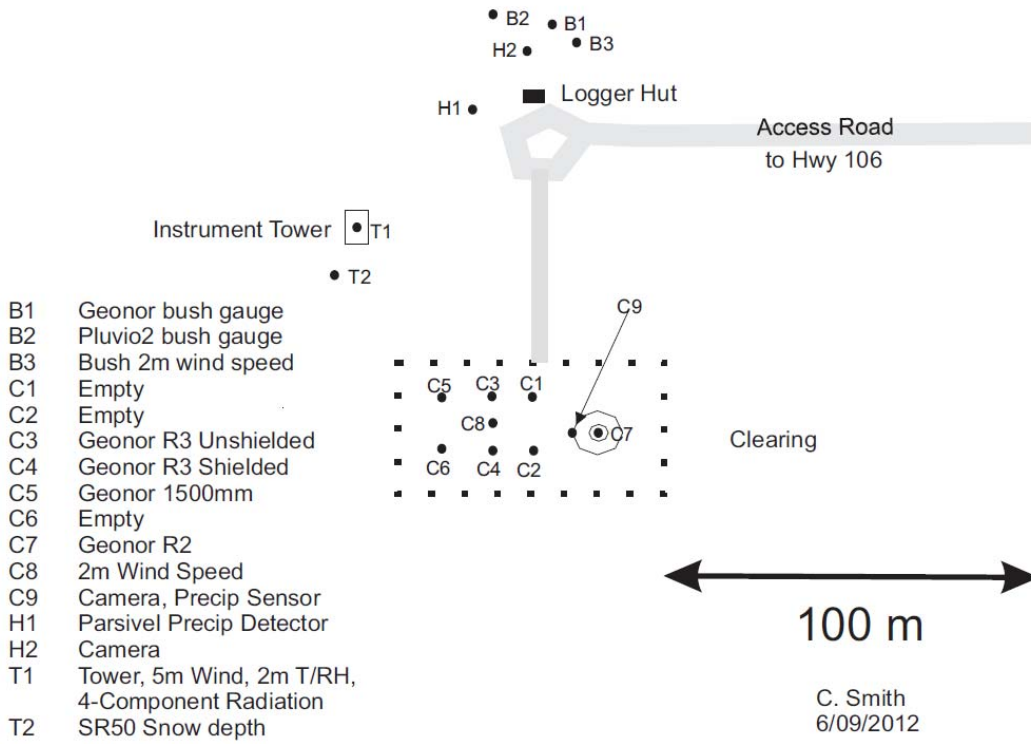
SITE INSTRUMENT LAYOUTS
(Status as of 15 Oct. 2012)

CARE Site (Canada)



Caribou Creek Site (Canada)

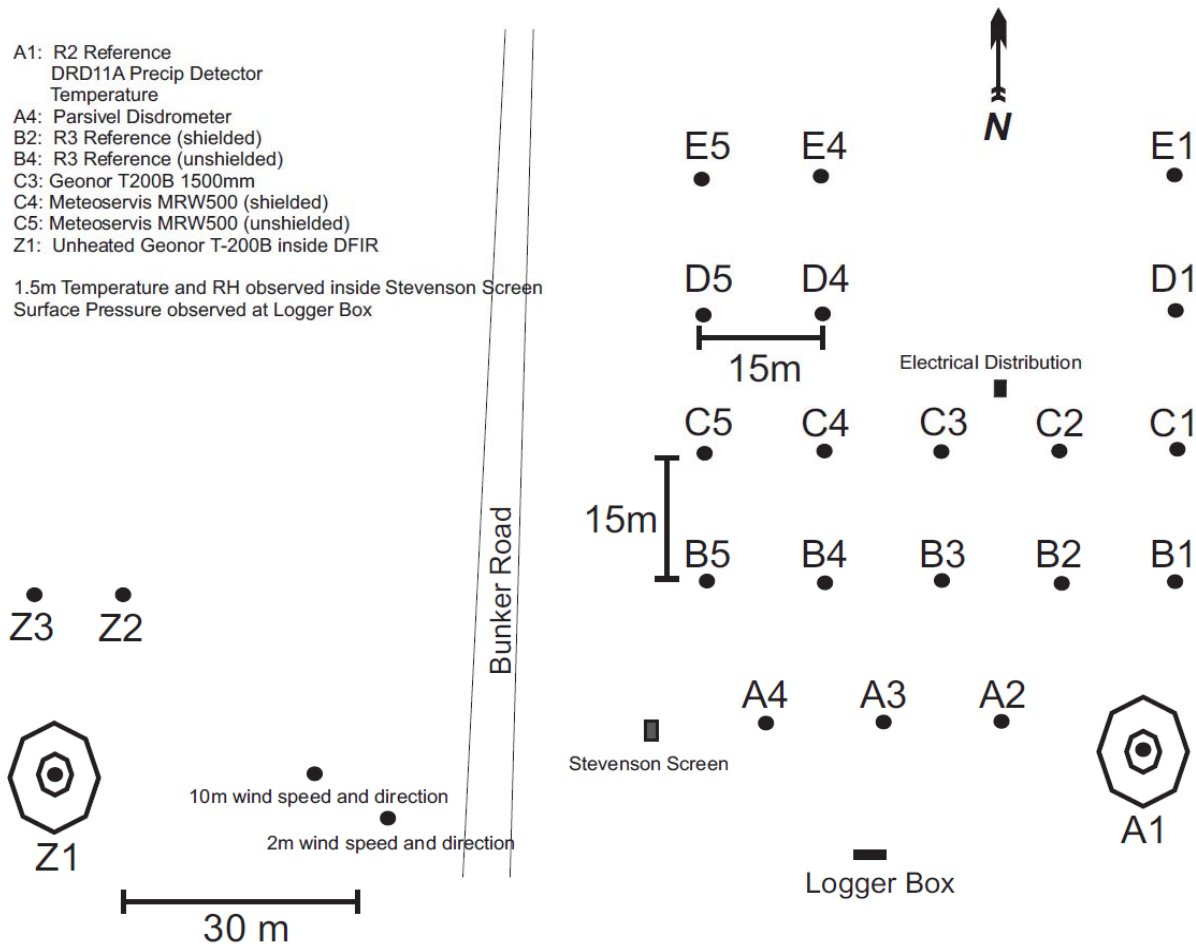
Caribou Creek



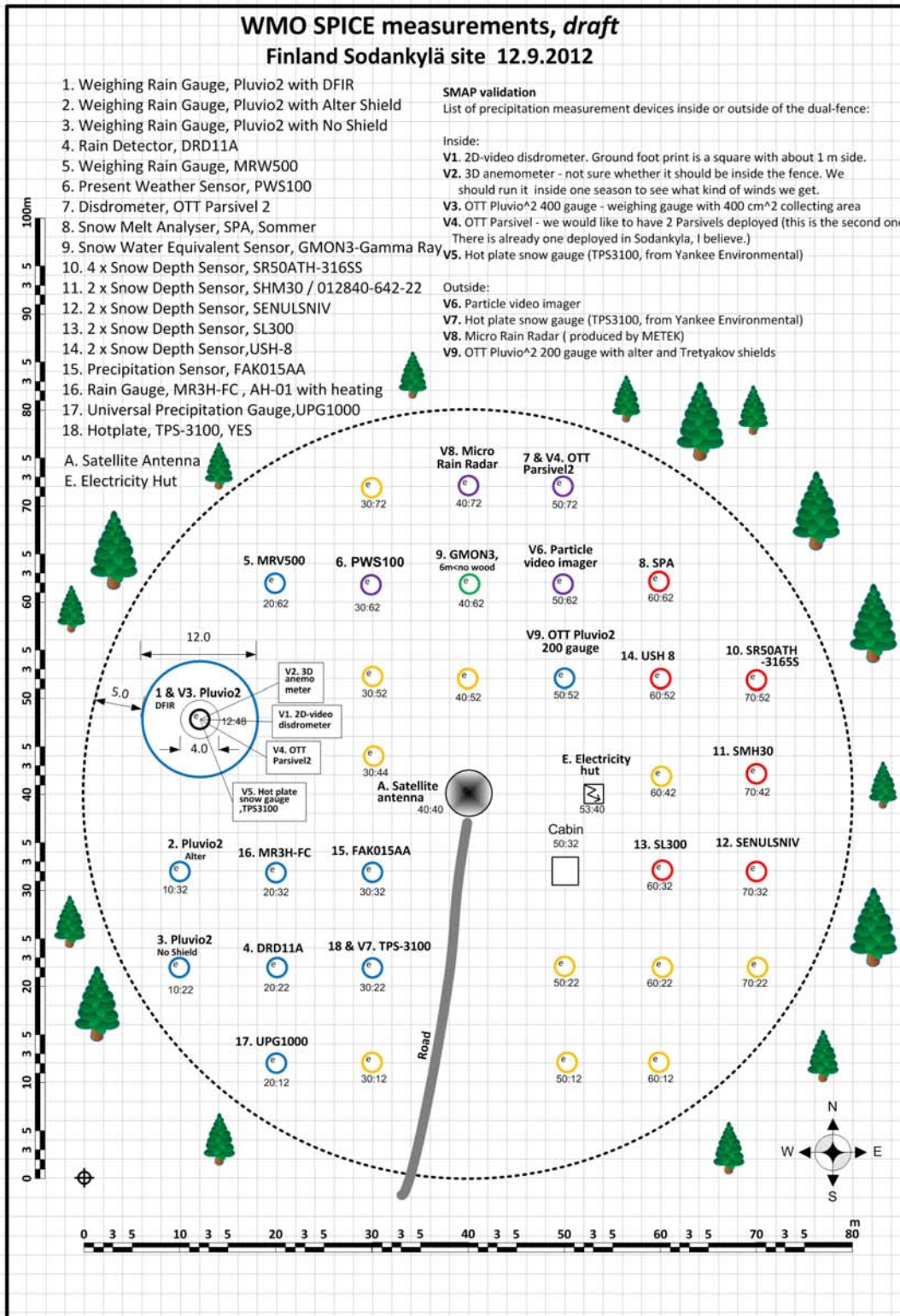
Bratt's Lake Site (Canada)

- A1: R2 Reference
DRD11A Precip Detector
Temperature
- A4: Parsivel Disdrometer
- B2: R3 Reference (shielded)
- B4: R3 Reference (unshielded)
- C3: Geonor T200B 1500mm
- C4: Meteoservis MRW500 (shielded)
- C5: Meteoservis MRW500 (unshielded)
- Z1: Unheated Geonor T-200B inside DFIR

1.5m Temperature and RH observed inside Stevenson Screen
Surface Pressure observed at Logger Box

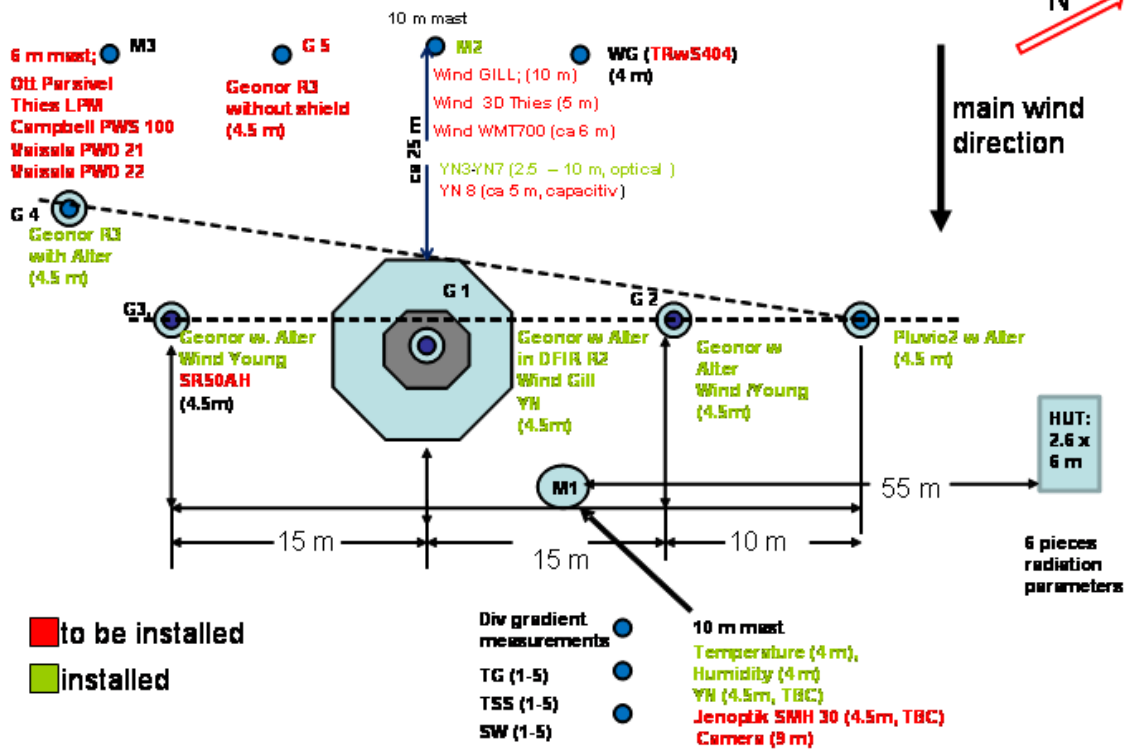


Sodankyla Site (Finland)



Haukeliseter Site (Norway)

Haukeliseter Test site (Status Oktober 2012)



INTERCOMPARISON OBJECTIVES

WMO-SPICE will focus on the following key objectives:

- I. Recommend appropriate automated field reference system(s) for the unattended measurement of solid precipitation. Define and validate one or more field references using automatic instruments for each parameter being investigated, over a range of temporal resolutions (e.g. from daily to minutes).
- II. Assess/characterize automatic systems (both the hardware and the associated processing) used in operational applications for the measurement of Solid Precipitation (i.e. gauges as “black boxes”):
 - a. Assess the ability of operational automatic systems to robustly perform over a range of operating conditions;
 - b. Derive adjustments to be applied to measurements from operational automatic systems, as a function of variables available at an operational site: e.g., wind, temp, RH;
 - c. Make recommendations on the required ancillary data to enable the derivation of adjustments to be applied to data from operational sites on a regular basis, potentially, in real-time or near real-time;
 - d. Assess operational data processing and data quality management techniques;
 - e. Assess the minimum practicable temporal resolution for reporting a valid solid precipitation measurement (amount, snowfall, and snow depth on the ground);
 - f. Evaluate the ability to detect and measure trace to light precipitation.
- III. Provide recommendations on best practices and configurations for measurement systems in operational environments:
 - a. On the exposure and siting specific to various types of instruments;
 - b. On the optimal gauge and shield combination for each type of measurement, for different collection conditions/climates (e.g., arctic, prairie, coastal snows, windy, mixed conditions);
 - c. On instrument specific operational aspects, specific to cold conditions: use of heating, use of antifreeze (evaluation based on its hygroscopic properties and composition to meet operational requirements);
 - d. On instruments and their power management requirements needed to provide valid measurements in harsh environments;
 - e. on the use of visibility to estimate snowfall intensity
 - f. On appropriate target(s) under snow depth measuring sensors;
 - g. Consideration will be given to the needs of remote locations, in particular those with power and/or communications limitations.
- IV. Assess the achievable uncertainty of the measurement systems evaluated during SPICE and their ability to effectively accurately report solid precipitation.
 - a. Assess the sensitivity, uncertainty, bias, repeatability, and response time of operational and emerging automatic systems;
 - b. Assess and report on the sources and magnitude of errors including instrument (sensor), exposure (shielding), environment (temperature, wind, microphysics, snow particle and snow fall density), data collection and associated processing algorithms with respect to sampling, averaging, filtering, and reporting.
- V. Evaluate new and emerging technology for the measurement of solid precipitation (e.g. non-catchment type), and their potential for use in operational applications.
- VI. Configure and collect a comprehensive data set for further data mining or for specific applications (e.g., radar- and/or satellite-based snowfall estimation). Enable additional studies

on the homogenization of automatic/manual observations and the traceability of automated measurements to manual measurements.

5. Deliverables

WMO-SPICE will provide reports on the intermediate and final results of the experiment covering the following aspects;

- a. Recommendations of automatic field references systems, for the unattended measurement of the parameters evaluated;
 - b. Characterization of the performance of existing, new, and emerging technologies measuring solid precipitation, and their configurations, addressing the objectives of the intercomparison.;
 - c. A comprehensive data set for legacy use, for further data mining.
 - d. Update of relevant chapters of the CIMO Guide (WMO No 8) and potential publications of WMO/ISO standards (under the WMO-ISO agreement, 2009).
 - e. Guidance to Members on transition to automation from manual observations of solid precipitation measurements;
 - f. Recommendations made to manufacturers on instrument requirements and improvements.
-