**WORLD METEOROLOGICAL ORGANIZATION**

CIMO/MG-11/INF. 4
(28.II.2014)

**COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION**

**CIMO MANAGEMENT GROUP**
**Eleventh Session**

Payerne, Switzerland
10 – 14 March 2014

ITEM: 2.2

Original: ENGLISH

# OPAG STANDARDIZATION AND INTERCOMPARISON

## Solid Precipitation Intercomparison Experiment WMO SPICE

## Progress Report Jan 27, 2014

(Submitted by Rodica Nitu, SPICE Project Leader)

**Summary and purpose of document**

This document provides a status report of the WMO SPICE intercomparison, including challenges and risks.
It is also seeking support from CIMO Management Group on : Extending the intercomparison to include an additional winter season of experiments, 2014/15, and identifying and allocating resources to support the data analysis, interpretation of results, and report writing.

**ACTION PROPOSED**

The MG is invited to note this information in the context of the report of the relevant OPAG Co-Chair, to consider the request made by the SPICE project leader and provide appropriate feedback.

# Solid Precipitation Intercomparison Experiment
# WMO SPICE

*Progress Report Jan 27, 2014*

*2010-2014 Work Plan of the Expert team on Instrument Intercomparison, OPAG Standardisation and Intercomparisons*

*Prepared by: Rodica Nitu, Chair, IOC SPICE*

## Report Objective

1. Provide a status report of the WMO SPICE intercomparison, including challenges and risks.

2. Seeking support from CIMO Management Group on :
   - Extending the intercomparison to include an additional winter season of experiments, 2014/15.
   - Identifying and allocating resources to support the data analysis, interpretation of results, and report writing.

## Overview

The IOC of the WMO SPICE commenced its work in May 2011, and the formal experiments started in December 2012. The intercomparison has been designed as a two winter seasons experiment on multiple sites, and expected to result in a data set sufficiently large for a comprehensive assessment of instruments and methods of measurement and reporting of solid precipitation and snow on the ground.

As a testimony of the importance of the goals of SPICE, internationally, and of the broad interest in working towards improvements in measuring solid precipitation, as of December 2013, SPICE experiments are being conducted on twenty sites, in fifteen countries. Over 30 different instrument models in multiple configurations are being tested, covering all major measurement principles for measuring solid precipitation and snow on the ground (current and emerging). These have been provided by the host organizations, reflecting their national interest, and by eighteen manufacturers. The instruments provided by manufacturers are being tested on ten of the participating sites.

The project has been managed through four face to face meetings (Oct 5-7, 2011, in Geneva; June 11-15, 2012, in Boulder, CO, USA; Oct 15, 2012, in Brussels, and June 17-21, in Davos, Switzerland), and monthly or more frequent teleconferences facilitated by WMO. The use of WebEx contributed significantly to increasing the effectiveness of the teleconferences.

## SPICE Contribution to other WMO Programs and Initiatives

The results of the SPICE project have been identified as key inputs for other initiatives that rely on accurate solid precipitation and snow on ground measurements and data.

SPICE has been identified as a Demonstration Projects by the Global Cryosphere Watch (GCW) of EC-PORS, and the contribution to meeting the GCW objectives wll include the development of instruments and measurement guidelines, and best measurement practices. The network of SPICE sites around the globe, in the Northern and Southern Hemispheres, and in a wide range of climate regimes, provide the capacity for establishing long term reference sites, operating a sustained standardized program for observing as many cryospheric variable as possible . SPICE sites and results will provide the knowledge base to improving the observing networks around the world, thus contributing to meeting the objectives of the WMO Integrated Global Observing System (WIGOS).

The results of SPICE on the ability to accurately measure and report solid precipitation at various time scales, on the use of automatic instruments, and the improvements possible, are expected with interest by the Commissions for Climatology of WMO and the World Weather Research Program of WMO. Representatives of the Joint Working Group on Forecast Verification Research (JWGFVR) and the Nowcasting Research Working Group are actively engaged in SPICE, contributing to the derivation of results relevant to their respective communities.

The global distribution of the SPICE sites, also makes them prime candidates for the ground validation of current and planned precipitation satellite missions. Currently, the SPICE sites at CARE (Canada) and Sodankylä (Finland) are considered for the Ground Validation supporting the NASA's Global Precipitation Mission, to be launched in 2014.

Given the impact of the results of SPICE towards facilitating achieving the objectives of other programs (e.g. establishing networks in sparse areas, as is the Arctic), the delivery of a SPICE Final Report on time and including results relative to the established objectives are critical to the project's success.

Presentation on the SPICE configuration and progress have been made at various conferences and meetings; for example: Snow Watch Workshop of GCW (Jan 2013), 4$^{th}$ International Workshop on Space-based Snowfall Measurement (May, 2013), Meteorological Technology International (Oct, 2013), GEO Cold Regions, as part of GEO X Plenary and Ministerial Summit. An article on the launching of SPICE and its overall organization was published in Aug 2013 by the Meteorological Technology International magazine.

## Status of Experiments

[1]Of the fifteen sites accepted for participation in SPICE in 2012, the experiments have been running on eleven sites, at least partially, since December 2012. In June 2013, at the Davos meeting, five additional sites have been accepted for participation.

The participation of sites in SPICE consists in:

- Running IOC recommended references, as a function of local conditions;
- Testing instruments belonging to the host organization and its partners;
- Testing instruments submitted by manufacturers, if the case;
- Provision of ancillary measurements;
- Archiving of site SPICE data, including the transmission to the SPICE archive.
- Contributing to the data analysis, including analysis of own results (if desired).

Taking into account the goals of the project, the SPICE experiments have three components:

- SPICE Working field references: Definition, configuration and the derivation of the reference data (see Annex A);
- Assessment of instruments and configurations under test measuring precipitation accumulation;
- SPICE experiments for the measurement of snow on ground.

Experiments commenced in 2012 (at least in a partial configuration):

- Northern Hemisphere:
  - Bratt's Lake (Canada);
  - CARE(Canada);
  - Caribou Creek (Canada);
  - Sodankylä (Finland);
  - Haukeliseter (Norway);
  - Valdai (Russian Federation): only manual measurements;
  - Weissfluhjoch (Switzerland);
  - Marshall (USA);
  - Hala Gasienicowa (Poland): significant overhaul of site configuration completed in 2013; experiments in 2012/13 not representative for the intent.
- Southern Hemisphere:
  - Guthega Dam (Australia);
  - Tapado (Chile);

[1] *For the purpose of this document, season one of SPICE, also referenced as 2012/2013, includes the experiments conducted during the winter of 2012/13 in the Northern Hemisphere and in 2013, in the Southern Hemisphere. The same approach will apply for the subsequent seasons.*

- Mueller Hut (New Zealand);

Experiments commenced in 2013 (all situated in the Northern Hemisphere):

- Joetsu and Rikubetsu (Japan)
- Voljskaya (Russian Federation)
- Col de Porte (France)
- ARAMON – Formigal (AEMET – Spain)
- Gochang Observatory (Republic of Korea)
- *Forni Glacier/Upper Valtellina/Italy,* EVK2CNR – UNIMI, University of Milan
- *Pyramid International Laboratory Observatory/ Lobuche /Solu Khumbu/Nepal,* EVK2CNR – UNIMI, University of Milan

### Data archive

The SPICE Data Archive is being hosted by the National Centre for Atmospheric Research (NCAR), USA; this is a significant contribution, which facilitates the archival and quality control of SPICE data in a consistent manner, making it available for analysis.

The SPICE Archive from NCAR is being mirrored by Environment Canada.

### Data Analysis Team

The complexity of the SPICE experiments requires a dedicated focus regarding the organization and delivery of the data analysis towards meeting the project objectives. For that reason a dedicated Data Analysis Team was assembled bringing together experts from the participating countries. As of June 2013, Dr Mareile Wolff (Norway) has assumed the leadership of the Data Analysis Team, with Dr J Kochendorfer (USA) as the co-lead. The Data Analysis Team includes representatives from the participating site teams.

The mission of the Data Analysis Team is to prepare, interpret and report on the SPICE results in accordance with project objectives. Chief among these objectives are the preparation of a reference dataset for inclusion in the WMO-SPICE Final Report and the analysis of the intercomparison data.

## SPICE Final Report: Work Plan and Risk Assessment

The SPICE IOC has identified two major risks that could impact the timely delivery of the expected SPICE results:

- Risk of not delivering the planned results as a result of not acquiring a comprehensive and representative data set, if the project is limited to two winter seasons.
- The risk of delaying the publishing of the SPICE Final Report for one or more years, as a result of very limited capacity currently dedicated to analysis of the results and writing the report.

***Noting that:***

The first formal year of SPICE, 2012/13, resulted in a partial experiment: At the end of the first formal season of experiments, 2012/13 the dataset available is limited to just over 50% of what was anticipated and expected, as a result of technical, scheduling, and resource availability challenges. Only twelve participating sites ran SPICE experiments in 2012/13, and most of these experiments were partial.

Dedicated resources for data analysis are not available at the level needed for a timely Final Report: The efforts required for the analysis of data and interpretation of results significantly exceeds the resources available within the current project team. It is estimated that about 400 instruments are included in the experiment, when fully running, resulting on an estimated 50,000 daily data files for each year of the experiment. The effective analysis and synthesis of results requires an intense and sustained focus, which is not entirely available today. The participating teams have limited capacity for analyzing data with a sustained level of depth and complexity, as required to derive relevant results. While the project team includes a number of renown experts, their availability is limited, however they could support with guidance a dedicated team of young scientists.

A two seasons intercomparison, will only partially assess the performance of the instruments under test. During the first season of SPICE the instruments provided by manufacturers were installed and tested only in a proportion of about 60%, due to delays in obtaining the instruments, difficulties in installation, and an early onset of the winter weather on some of the sites (Oct 2012). This is further exacerbated by the variability of winter conditions on the participating sites.

A reliable field working reference system for SPICE required additional adjustments in 2013: As a result of the assessment of the results of the 2012/13 season of experiments, in 2013, all sites had to make changes on the configuration of field references (heating of gauges and precipitation detectors) to improve the sensitivity of the event selection. These changes will result on reference data for the experiment that are different from the reference data from the first season, and the linking of results will be more difficult.

***Considering that:***

Sufficient data from all participating instruments are required to derive statistically meaningful results. A relevant season for SPICE is limited to 4 - 5 months per year, on any of the participating sites. Furthermore, the number, extent and representativeness of solid precipitation events are limited, owing to local climatology and the variability from one season to another.. It is estimated that a minimum of 2-year data for the instruments under test is required.

The year one of SPICE, 2012/13 focused primarily on characterizing a reliable, and defendable SPICE working field reference system. At the start of SPICE, there was no recognized field reference for the measurement of solid precipitation using automatic instruments. A well characterized and understood field reference is the foundation of stronger and defendable results published in the Final Report of SPICE.

The characterization of the working field reference system will be published in the SPICE report planned for 2014. To prepare the ground for reliable SPICE results, the configuration and characterization of the SPICE working field references will be documented in a SPICE report, for publication in 2014. This report will communicate the configuration of the proposed reference, the methodology for the derivation of the reference data, and the linking with results of previous experiments. It is anticipated that the report will generate an active conversation with the stakeholder community, enabling increased clarity and acceptance of the results reported in the Final Report.

***Recommends that:***

In order to address the risks on completing of the experiment, the SPICE IOC is seeking support from CIMO Management Group on:

- **Extending** the duration of the intercomparison **from two to three winter seasons**, covering the winter seasons of 2012/13, 2013/14, 2014/15, in both Northern and Southern Hemispheres, with the Final Report issued one year after the completion of the experiment (2016).

- Securing **financial resources** to support the data analysis; specifically, acquire the services of a data analyst, working under the guidance of the SPICE Data Analysis Team. The role of the data analyst will be to performing defined data analyses, generate data plots and other data products as directed by the DAT, draft report. It is estimated that a total of **two person-year** is required to complement the existing project team resources, **for the completion of the data analysis and report writing** . The SPICE IOC recommends that funding is made available to hire a young scientist or a graduate student to conduct this work.

If the funding for the additional required resources is not available, it would impact the ability to deliver on the SPICE results on time and within the defined scope, resulting in a final report that would take additional years for completion and including results on fewer objectives, than defined.

Given the broad interest from the scientific community in timely and comprehensive SPICE results, as identified above, neither the delay in issuing the Final Report, nor the reducing scope of the report are satisfactory, nor desirable.

## SPICE Work plan:

Assuming that the request for an additional year of experiments is granted, and that additional resources for data analysis are acquired, the following is the work plan for the SPICE project, leading tp its completion:

- 2013/14: run the second year of experiments with a consistent and stable configuration, across all 20 participating sites.

- 2014/15 run the 3rd year of experiments in the configuration of 2013/14.
- 2014: publish the report on SPICE Field Working Reference System, outlining the principles and implementation of the working field reference system for the experiment, the methodology for the derivation of the field reference data, and the links between the different levels of reference on the participating sites.
- 2014: Initiate the development of analysis methods relative to project objectives.
- 2015 develop methods of analysis relative to each project objective, and conduct analysis.
- 2015: return instruments to manufacturers;
- 2016: issue SPICE Final Report.
- 2014-2016: Explore engagements with other initiatives, programs and projects (WMO, GEO, etc) focusing on solid precipitation, snowfall, and snow on ground data and their applications, that could build on the SPICE datasets, infrastructure and expertize developed at local and regional level, that could lead to further refining the results reported by SPICE in its final report.

SPICE results will report on the quality and uncertainty of snowfall measurements at different time scales, using current technology, and will recommend adjustments derived based on the data collected over the 2-3 years of experiments. Owing to the complexity and variability of solid precipitation events, including from one year to another, the changing in precipitation patterns, and the complexity of measuring solid precipitation and snowfall, the SPICE results will require additional validation, at local or regional level, using datasets other than those used for the derivation of the results. SPICE results confirmed through validation will critically influence the quality of products generated as part of GCW, from WIGOS networks, the projects of WWRP and WCRP of WMO.

To date, the SPICE contribution to the international community consists in the development of a network of 20 sites with a consistent configuration of instrumentation that could support a wide range of coordinated projects, beyond SPICE. These sites, and in particular those with a R2 reference, DFAR, (Double Fence Automatic Reference) could support other initiatives, like verification of models and radar calibration, ground validation of satellite data.

As part of the evolution of the SPICE experiments on each site, the participants will be encouraged to enter in agreements to continue at local or regional level the experiments, with a focus on the and recommendations made at the end of the formal SPICE experiments.

Additionally, efforts need to be made to explore options for SPICE-like activities that could continue under the umbrella and/or be linked in the future to other initiatives of WMO or other organizations.

## ANNEX A:

## Field Reference for the Measurement of Precipitation Amount

In the context of the multi-site participation in SPICE, the IOC recognized the need to develop a flexible approach for the configuration of the field references. This would allow linking the results of SPICE with those from the previous experiments and ensure the transferability of the results from the participating sites, while recognizing the physical limitations on some of them.

Three levels of working field reference systems have been defined for SPICE and noted as R1, R2, R3.

At the end of the first WMO Solid Precipitation Intercomparison (1989-1993), the IOC recommended that "*The Double Fence International Reference (DFIR) should be accepted as a secondary reference for the (manual) measurement of solid precipitation*." This is configured as

> *"The octagonal vertical double-fence inscribed into circles 12 m and 4 m in diameter, with the outer fence 3.5 m high and the inner fence 3.0 m high surrounding a Tretyakov precipitation gauge mounted at a height of 3.0 m. In the outer fence there is a gap of 2.0 m and in the inner fence of 1.5 m between the ground and the bottom of the fences." (*WMO/TD-872/1998, section 2.2.2)

For SPICE, the IOC decided that working field reference with a higher temporal resolution, using an automatic gauge is needed, and should be configured similarly to the secondary field reference, above. This has been defined as:

> *The octagonal vertical double-fence inscribed into circles 12 m and 4 m in diameter, with the outer fence preferably 3.5 m high, and the inner fence 3.0 m high, (DFIR-fence) surrounding an automatic weighing precipitation gauge mounted at a height of, preferably, 3.0 m and installed with an Alter shield". This ensemble has been called Double Fence Automatic Reference, aka DFAR.*

As a result:

***Working Field Reference System type R1*** *is represented by the secondary field reference as defined* at the end of the WMO Intercomparison of Solid Precipitation 1989-1993 (WMO/TD-872 (1998)], together with a precipitation detector. A site hosting a R1 reference is designated as a S1 type site.

***Working Field Reference System type R2 is represented by a***n automatic weighing gauge equipped with a single Alter windshield within a DFIR-fence, aka DFAR, together with a precipitation detector. A site hosting a R2 reference is designated as a S2 type intercomparison site.

***Working Field Reference System type R3***
The Working Field Reference System type R3 consists of a pair of identical automatic weighing gauges heated in the same manner, one being unshielded and the second installed with a single Alter shield, together with a precipitation detector. A site operating only a R3 reference is designated as a S3 site.

Sites type S3 are those that are unable to configure a R1 or R2 reference, however they represent significant contributions to SPICE, due to location, climatology, representation, capacity building.

Additionally, a **Working Field Reference R0**, is identified as the "Bush Gauge", one or more gauges (manual or automatic) which are surrounded by bushes trimmed at the level of the gauges. Based on the literature, this has been recognized as the highest level of field reference for the measurement of solid precipitation. Currently, Valdai (Russ Federation) has the only R0 reference, with a long record (decades).

The SPICE reference configuration, by site, is summarised in the table below.

| | **Site** | | **R0** | **R1** | **R2** | **R3** | **Site Type** |
|---|---|---|---|---|---|---|---|
| | **Northern Hemisphere** | | | | | | |
| **1** | Bratt's Lake | Canada | NA | NA | x | x | S2 |
| **2** | Caribou Creek | Canada | X (automatic) | NA | x | x | S0/S2 |
| **3** | CARE | Canada | NA | x | x | x | S1 |
| **4** | Haukeliseter | Norway | NA | NA | x | x | S2 |
| **5** | Marshall | USA | NA | x | x | x | S1 |
| **6** | Sodankylä | Finland | NA | NA | x | x | S2 |
| **7** | Valdai | Russian Fed | X (manual) | x | NA | NA | S0 |
| **8** | Volga | Russian Fed | NA | NA | x | TBD | S2 |
| **9** | Weissfluhjoch | Switzerland | NA | NA | x | x | S2 |
| **10** | Joetsu | Japan | NA | NA | x | x | S2 |
| **11** | Rikubetsu | Japan | NA | NA | x | x | S2 |
| **12** | Col de Porte | France | NA | NA | NA | x | S3 |
| **13** | Formigal | Spain | NA | NA | NA | x | S3 |
| **14** | Gochang | Rep of Korea | NA | NA | x | x | S2 |
| **15** | Forni Glacier | Italy | SoG manual measurements | NA | NA | NA | SoG |
| **16** | Pyramid Observatory | Nepal (Italy) | SoG manual measurements | NA | NA | NA | SoG |
| **17** | Hala Gasienikowa | Poland | SoG manual measurements | NA | NA | NA | SoG |
| | **Southern Hemisphere** | | | | | | |
| **13** | Guthega Dam | Australia | NA | NA | NA | x | S3 |
| **14** | Mueller Hut | New Zealand | NA | NA | NA | x | S3 |
| **15** | Tapado | Chile | NA | NA | NA | x | S3 |