Reference measurements for WMO/CIMO SPICE and on-going projects at the Formigal-Sarrios field site

Samuel T. Buisán[1], Javier Alastrué[1], José Luís Collado[1], Ismael San Ambrosio Beirán[1], Rafael Requena Briones[1], María López Bartolomé[2], Manuel Gil Gómez[2] and Juan Ramón Moreta González[2]

[1] AEMET Aragón Regional Office, Zaragoza, Spain

[2] AEMET Headquarters, Madrid, Spain

Corresponding author: sbuisans@aemet.es

Abstract

A WMO-SPICE (Solid Precipitation Intercomparison Experiment) site has been set up by AEMET (Spanish State Meteorological Agency) at Formigal-Sarrios in the Pyrenees range in 2013. The field site is located at 1800 m asl in a flat area in a subalpine environment with no vegetation, except for small amounts of grass. A DFIR (Double Fence Intercomparison Reference) was installed in 2014. Thanks to this infrastructure, unique in Spain and in the Pyrenees range, AEMET can participate in international solid precipitation intercomparisons. This experimental site represents the efforts of AEMET to contribute to improve the accuracy of the measurement of solid precipitation and to analyze the performance of observation devices in extreme conditions such as mountainous environments. The site will be also used as a long-term reference to monitor the changes in precipitation and to test and to compare new instruments in close collaboration with national and international partners. The site is at present equipped with numerous automatic devices measuring snow depth, snow water equivalent, total precipitation, air temperature, wind, air pressure, visibility, type of precipitation and radiation. This work gives an overview of the on-going projects and some preliminary results of interest for WMO-SPICE as well as for national interests such as hydrology, climatology and nowcasting.

Keywords: SPICE, AEMET, Formigal, Precipitation, Snowfall, DFIR

1. The site

A WMO-SPICE (Solid Precipitation Intercomparison Experiment) site has been set up by AEMET (Spanish State Meteorological Agency) at Formigal-Sarrios in the Pyrenees range in 2013.The Formigal-Sarrios test site is located on a small plateau at 1800 m asl in the Pyrenees mountain range. This is a sub-alpine environment consisting of a mixture of bare ground and only very low grasses. The prevailing winds are from the northwest all year round. Snowfalls are frequent with maximum measured snow depths of almost 300 cm during the 2013-2014 and 2014-2015 winter seasons. Southerly and southwesterly snowfall events are associated with light winds and mild temperatures (near 0 °C) whereas northerly and northwesterly snowfalls are associated with strong winds and colder temperatures (<-2 °C). Snow cover usually begins at the end of November and disappears in mid-May. The site is equipped with power supply, easy access by road and good internet communications. All these conditions were perfect to create a field site to test instruments in harsh environment and to participate in national and international projects.

Figure 1. Formigal-Sarrios experimental site and DFIR

The site is equipped with 18 automatic devices (August 2016) measuring snow on the ground, precipitation, air temperature, wind, air pressure, visibility, type of precipitation and radiation (Figure 2). A DFIR (Double Fence Intercomparison Reference) has also been built, according to WMO-SPICE requirements. The reference gauge inside the DFIR is a 200 cm^2 OTT Pluvio2 200 cm and is defined as DFAR (Double Fence Automatic Reference) according to SPICE project. More information at:

http://www.wmo.int/pages/prog/www/IMOP/intercomparisons/SPICE/SPICE.html

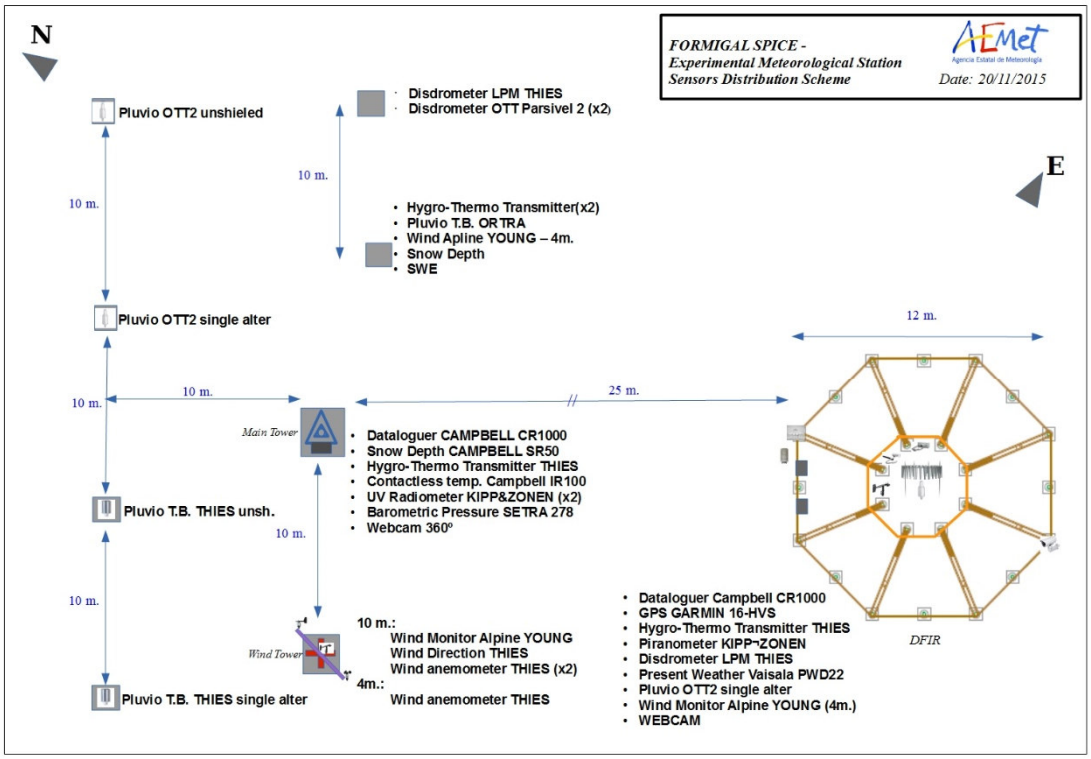
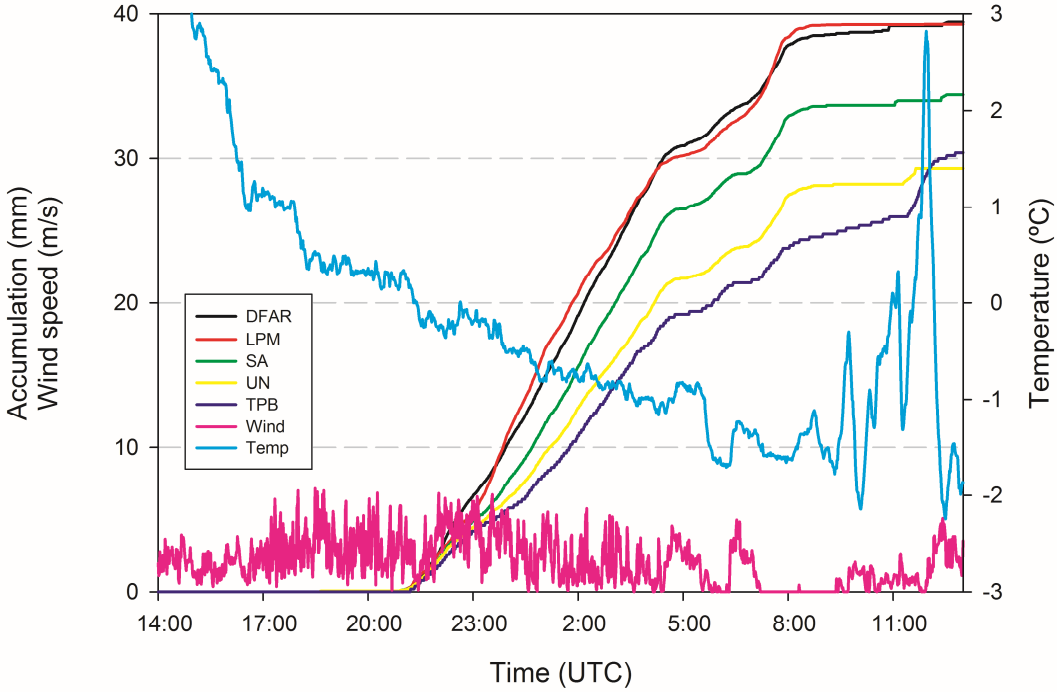


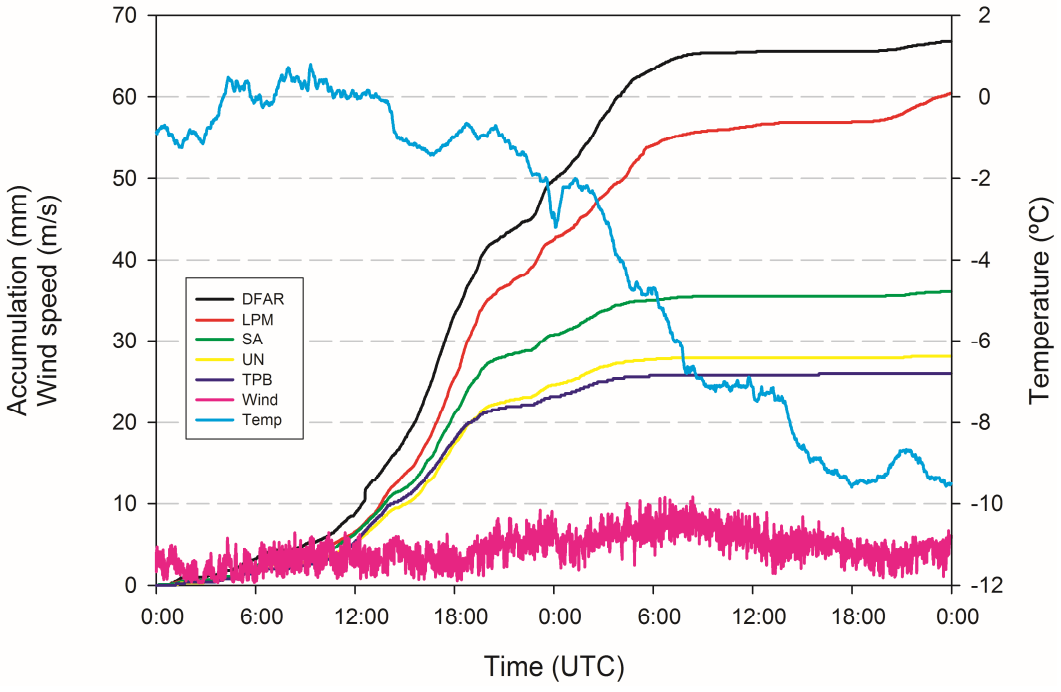
Figure 2 Layout of Formigal-Sarrios experimental site

2. Some preliminary SPICE results

Figure 3 shows time series of accumulated precipitation measured at the Formigal-Sarrios test field site for two different types of weather conditions. Figure 3 a) shows a typical snowfall occurring within a southerly flow characterized by mild temperatures and light winds. In this situation, the differences in snowfall accumulation between the instruments located inside the DFIR (OTT-Pluvio2-DFAR and Thies LPM disdrometer) and the unshielded heated Pluvio2 (UN) and the heated Thies Tipping Bucket (TPB) were less than 20%, while the difference with the Pluvio2 with single alter wind shield (SA) was approximately 10%. Figure 3 b) shows that under colder temperatures and stronger winds (up to 10 m/s the differences in accumulation with the reference were significantly higher, with the TPB (65%), UN (60%) and SA (45%). In both situations, there is good agreement between both instruments DFAR and LPM which agree to within 90 - 100%. In both situations in Figure 3, the instruments performed as expected with a relatively good agreement in the timing of the accumulations. The deviations in accumulations are most likely related to the wind-induced undercatch related to each of the instrument configurations.



a)



b)

Figure 3 Episodes of snowfall accumulation a) 16-17 January 2015 b) 26 – 28 December 2014

Another preliminary results is shown in Figure 4 which shows time series of accumulated precipitation measured between 20th of November and 20th of March for the reference (DFAR), a heated Thies tipping bucket with a single alter wind shield (TB1) and a heated Thies tipping bucket without shield (TB2) which is the same configuration of the operational network of AEMET. The positive impact of the wind shield in the total accumulation (TB1) is evident when compared with the TPB2 with caught 20% less of precipitation. However, still the underestimation of the TPB1 and TPB2 were remarkable when compared with DFAR.

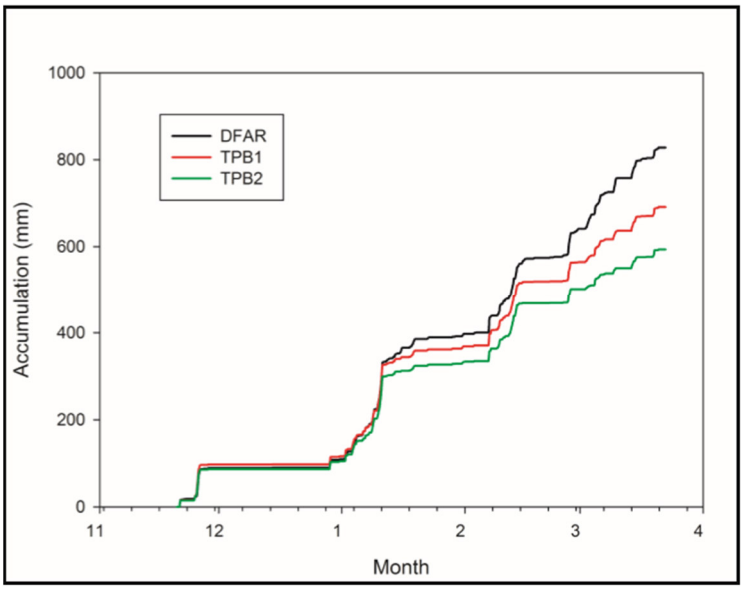


Figure 4. Accumulated precipitation between November and March of tipping buckets and DFAR

Formigal site is also a perfect place to test technologies measuring snow and based on non-catchment instruments such as disdrometers. Figure 5 shows time series of accumulated precipitation during a snowfall episode in November 2015. The Thies LPM outside DFIR (LPM2) overestimated more than 40% the precipitation when compared with DFAR and the Thies LPM within the DFIR. This behavior has been observed in numerous episodes along the 2015-2016 winter season and suggests that the internal algorithm of these disdrometers doesn't resolve properly the precipitation intensity of snowfall under windy conditions.

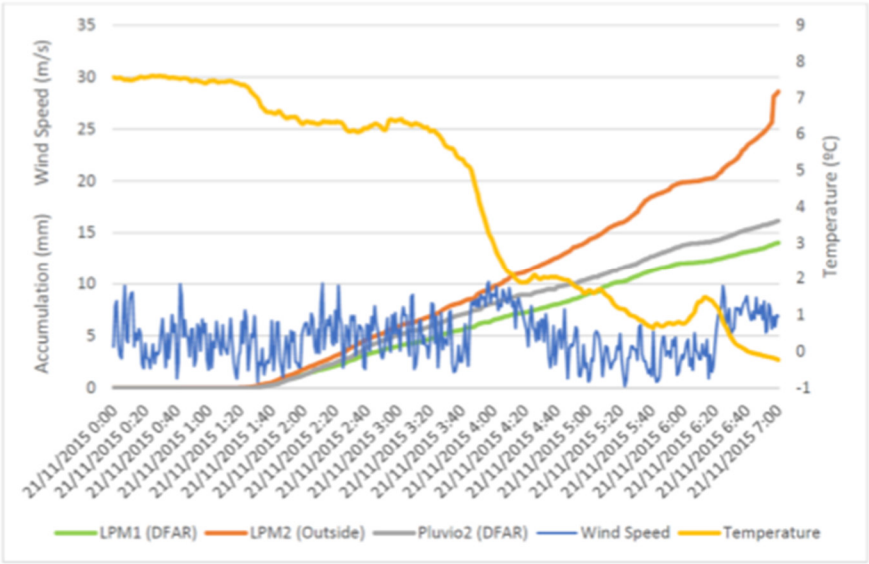


Figure 5 Snowfall episode and accumulated precipitation of Thies disdrometers and the DFAR

3. On- going projects

In close collaboration with scientific centers, hydrological services and, national and international weather services, several projects have been set up in Formigal-Sarrios. The projects that are currently underway are listed below:

- Impact of snow on UV Radiation (AEMET Radiation Department)
- Impact of the undercatch of snowfall on water resources and intercomparison of operational instruments (AEMET-Ebro Basin Hydrological Service)
- Measurement of snowfall operationally using disdrometers (AEMET-MeteoSwiss)
- Impact of wind speed and wind direction in the measurement of snowfall using disdrometers (AEMET-Spanish Research Council)
- Contributing station for the WMO-Global Cryosphere Watch

4. Publications, congress and reports

In only 3 years a large amount of data have been produced and some works have been already prepared and published:

1. ***WMO-SPICE report.*** Manuscript in preparation by SPICE team with the collaboration of AEMET experts and the learnings, experience and data from Formigal-Sarrios.

2. S. T. Buisan, J. L. Collado, J. Alastrue: 2016: **The impact of a windshield in a tipping bucket rain gauge on the reduction of losses in precipitation measurements during snowfall events**, Geophysical Research Abstracts, Vol. 18, EGU2016-7055.

3. Samuel T. Buisan, Michael E. Earle, José Luís Collado, John Kochendorfer, Javier Alastrué, Mareile Wolff, Craig D. Smith, and Juan I. López-Moreno. **Assessment of the underestimation of snowfall accumulation by tipping bucket gauges used operationally by the Spanish national weather service** . Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-197, 2016 . (Manuscript under review for AMT)

4. R. Nitu, J. Alastrue, J. L. Collado, S. Buisan, 2015: **WMO – SPICE Un experimento internacional para mejorar las observaciones de la nieve**, "Tiempo y Clima", No. 50, Bulletin of Spanish Meteorological Society (http://pkp.ame-web.org/index.php/TyC)

5. Marta Angulo-Martínez, Roberto Serrano Notivoli, José Luis Collado, Javier Alastrué, Samuel Buisán, Santiago Beguería**. Monitorización de la intensidad de precipitación en montaña mediante disdrómetro óptico.** X International Congress of the Spanish Climatological Society, November 2016

6. Samuel Buisán, Roberto Serrano Notivoli, José Luís Collado, Ignacio López-Moreno, Javier Alastrue, Andrés Chazarra, Ismael Sanambrosio. **¿Se mide bien la precipitación en forma de nieve en españa? Ejemplo: temporada invernal 2015-2016.** X International Congress of the Spanish Climatological Society, November 2016

7. José Luis Collado, Samuel Buisán, Javier Alastrue, Ismael Sanambrosio, Rafael Requena. ***Campo de pruebas de AEMET en Formigal-Sarrios y participación de AEMET en el WMO-SPICE***. XXXIV Congress of the Spanish Meteorological Society. February 2016

5. Conclusions

This experimental site represents the efforts of AEMET to contribute to improve the accuracy of the measurement of solid precipitation and to analyze the performance of observation devices in extreme conditions such as mountainous environments. Due to the AEMET commitment to the WMO-SPICE project all these activities are planned within the AEMET strategy, and the infrastructure installed in Formigal-Sarrios will be used as a long-term reference to monitor the changes in precipitation and test new instruments in close collaboration with national and international partners.

6. Acknowledgments

Thanks to all SPICE team for their continuous advice and contributions on this challenging project. Special thanks to the Formigal Ski Resort for its support in the installation of the ste and in-situ help and maintenance. Thanks to all colleagues of AEMET, especially to whom which helped us from the beginning in this project both in Aragon Regional Office and in Headquarters