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Всемирная метеорологическая организация
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Form for
Regular Reporting of CIMO Testbeds and Lead Centres

(expand the cells as required to properly reflect your activities)

Terms of Reference for CIMO Testbeds and Lead Centres are available under:
ttp://www.wmo.int/pages/prog/www/IMOP/Testbeds-and-LC.html

Name of Testbed / Lead Centre	**WMO-CIMO Testbed for Aerosols and Water Vapour Remote Sensing Instruments (Izaña, Spain)**
Location of Testbed / Lead Centre	**Izaña Atmospheric Observatory, Tenerife, The Canary Islands, Spain**

Contact Person for the Testbed/Lead Centre

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Has contact person changed in last 2 years?	No
If yes, who was the previous contact person?	

Report on Activities

Main activities that TB/LC carried out in the last 2 years for which results are already available:

- **1. Research on water vapor isotopologues with Fourier Transform Infrared Technique**

Development of methodologies envisaged to obtain vertical profiling of HDO/H216O, and corresponding validation and comparison with ground-based remote sensing observations at Izaña.

Main results achieved during the reporting period: González et al. (2016), Barthlott et al. 2017, and

Schneider et al. (2017).

- **2. The Izaña Tesbed site has contributed to field campaigns for instruments evaluation**

The Izaña Testbed site has contributed with references and data to several field campaigns of remote sensing instruments evaluation.

China Aerosol Remote Sensing Network (CARSNET) and the Institute of Remote Sensing and Digital Earth (CAS) reference instruments are recalibrated at Izaña on a regular basis meeting the need of high quality calibrated photometers to transfer calibration to all instruments operated in their own networks. Last calibration at Izaña was performed in June 2017.

TENUM Company regularly calibrates at Izaña small hand-held and low cost photometers (Calitoo) designed for teaching within the GLOBE (Global Leadership & Organizational Behavior Effectiveness) educational Project (http://globeproject.com). Last calibration at Izaña was performed in June-July 2017.

The following main studies were published during the reporting period:

Bassani et al., 2016: Effect of the Aerosol Type Selection for the Retrieval of Shortwave Ground Net Radiation: Case Study Using Landsat 8 Data

García et al., 2017a: Compatibility of different measurement techniques of global solar radiation and application for long-term observations at Izaña Observatory.

Kazadzis et al., 2017: Results from the 4th WMO Filter Radiometer Comparison for aerosol optical depth measurements.

- **3. The Izaña Tesbed site has contributed to model evaluation exercises.**

Accurate measurements of total column atmospheric aerosols during nighttime requires the use of a reference model for Moon's irradiance. The United States Geological Survey (USGS) Robotic Lunar Observatory (ROLO) model is considered the most reliable lunar radiometric reference available until now, with an estimated accuracy of 1% in Moon's reflectance and an expected accuracy in Moon's irradiance ranging from 5% to 10%. Determination and assessment of the absolute uncertainty of USGS/ROLO model has been one of the main activities of the Izaña Testbed in the period 2016-2017. Evaluation and correction of zenith and phase angle dependencies found in the literature for USGS/ROLO has been one of the outstanding results published by Barreto et al., 2017. This has been the first attempt to correct the USGS/ROLO model.

Other activities related with model evaluation and carried out during the reporting period have been the following:

Torres et al., 2017: Advanced characterization of aerosol properties from measurements of spectral optical depth using the GRASP algorithm.

García et al., 2018: Comparison of observed and modelled longwave downward radiation (2010–2016) at the high mountain BSRN Izaña station.

- **4. Comprehensive assessment of GAW-PFR and AERONET-Cimel intercomparability and traceability**

The main objective of this study is to provide consistent and accurate information on the degree of agreement between AERONET-Cimel and GAW-PFR observations. For this, a long-term intercomparison of Cimel/AERONET –GAW/PFR instruments at Izaña in the period January 2005 – November 2014 (10 years) has been performed in collaboration with PMOD-WRC using 1-minute simultaneous Cimel-PFR AOD data at 500 and 870 nm channels. A total of 15 Cimel sunphotometers and three PFR were used during this period. Preliminary results indicate that more than 93% of 1-minute AOD differences at 500 and 870 nm (more than 81,000 data in each channel) fell within the AOD 95% uncertainty limits defined by WMO. Statistics of the traceability and possible explanations to non-traceable data have been investigated. This study has been published as an AEMET Technical note (Romero-Campos et al., 2017).

- **5. Design, development and testing of a new low-cost and robust zenith-looking multi narrow-band radiometer (ZEN) for AOD retrieval.**

A look-up table (LUT) methodology for AOD retrieval from zenith sky radiance has been developed and applied to AERONET Cimel sunphotometers from Santa Cruz de Tenerife, Izaña and Tamanrasset

(Algeria) validating the results against AERONET AOD. The LUT was optimized for mineral dust aerosols. The methodology has been applied to a new low-cost and robust zenith-looking multi narrow-band radiometer developed in collaboration with SIELTEC S.L. company (http://www.sieltec.com.es/). Estimated AOD with the new prototypes demonstrated good results when validated against reference AOD from AERONET (Almansa et al., 2017).

Main activities that TB/LC carried out in the last 2 years for which results will soon be available:

- A lunar photometric campaign was held at Izaña Observatory between June 1th and 17th, including a side workshop on nocturnal aerosols measurements on June 7th and 8th. These events were organized by the Izaña Atmospheric Research Center (IARC), and the Atmospheric Optics Group of Valladolid University (GOA-UVa) in the framework of the WMO-CIMO Testbed. The objective of this campaign was to intercompare the instruments and procedures currently being used to determine the aerosol optical thickness at night, which mainly uses the moon as a reference. Details of the campaign can be obtained at http://testbed.aemet.es/index.php/lunar-photometry-campaign-and-workshop-at-izana-2017/

- As part of the lunar photometric campaign a new "ROLO Implementation for Moon-photometry Observation" (RIMO) model has been developed. ROLO and RIMO have been intercompared each other within the first multi-instrument nocturnal intercomparison campaign. A paper about the main results of both models assessment is being prepared and published within 2018.
- Development of synergy photometer/lidar/ceilometer methodologies for retrieving vertical aerosol extinction. A preliminary two-layer approach to obtain vertical atmospheric extinction (α) at Santa Cruz de Tenerife station (Canary Islands, Spain) using Micropulse lidar (MPL-3 Lidar) and CL-51 Vaisala ceilometer has been developed. Uncertainties commonly associated with the estimation of Lidar Ratio (LR) are notably reduced by using a two-layer inversion model, in which AOD is extracted from two different sun-photometers located at two different layers: one at SCO (sea level) and another one at IZO (2400 m asl) representative of both free troposphere and Saharan Air Layer conditions.
- Validation of AOD in UV range using double Brewer spectrophotometers. A new AOD product in the UV range has been developed and assessed using the Izaña Testbed facilities and ancillary data. This new algorithm is being implemented in EUBREWNET to produce AOD on an operational basis. It will allow real-time aerosols monitoring at more than 20 Brewer stations, from Algeria to Finland. Main results of the new algorithm and corresponding validations are described in López-Solano et al., 2017.
- A new development to obtain AOD and Angstrom parameter (AE) retrievals from spectral direct irradiance measurements obtained with an EKO MS-711 spectroradiometer has been performed as part of the Izaña testbed activities. This instrument performs spectral direct irradiance measurements from 300 to 1100 nm, with a full width at half maximum of 3.35 nm, and was calibrated using the Langley technique. Once calibrated, total spectral optical depth of the atmosphere was obtained from absolute direct solar irradiance measurements. Quality assessment has been performed by comparing the EKO AOD with coincident Cimel/AERONET AOD data at 340, 380, 440, 500, 675, 870 and 1020 nm during the dust episode in a large AOD range (from 0.01 to about 0.65 in 500 nm). The straightforward comparison between both measurements for all wavelength shows an excellent agreement with Pearson determination coefficient, R > 0.99. Regarding AE, the results show quite fairly good R of 0.85. Results were presented by García et al., 2017b.

Which guidance documents/standard procedures were developed during the last 2 years (please include full reference and web-link if available)?

Which IOM reports / peer-reviewed publications were published in the last 2 years (please include full reference and web-link if available)? (Since march 2016)

- Almansa, A. F., Cuevas, E., Torres, B., Barreto, Á., García, R. D., Cachorro, V. E., de Frutos, Á. M., López, C., and Ramos, R.: A new zenith-looking narrow-band radiometer-based system (ZEN)

for dust aerosol optical depth monitoring, Atmos. Meas. Tech., 10, 565-579, doi:10.5194/amt-10-565-2017, 2017. https://www.atmos-meas-tech.net/10/565/2017/amt-10-565-2017.pdf.

- Barreto, Á., Román, R., Cuevas, E., Berjón, A. J., Almansa, A. F., Toledano, C., González, R., Hernández, Y., Blarel, L., Goloub, P., Guirado, C., and Yela, M.: Assessment of nocturnal aerosol optical depth from lunar photometry at the Izaña high mountain observatory, Atmos. Meas. Tech., 10, 3007-3019, https://doi.org/10.5194/amt-10-3007-2017, 2017. https://www.atmos-meas-tech.net/10/3007/2017/amt-10-3007-2017.pdf
- Barthlott, S., Schneider, M., Hase, F., Blumenstock, T., Kiel, M., Dubravica, D., García, O. E., Sepúlveda, E., Mengistu Tsidu, G., Takele Kenea, S., Grutter, M., Plaza-Medina, E. F., Stremme, W., Strong, K., Weaver, D., Palm, M., Warneke, T., Notholt, J., Mahieu, E., Servais, C., Jones, N., Griffith, D. W. T., Smale, D., and Robinson, J.: Tropospheric water vapour isotopologue data (H216O, H218O, and HD16O) as obtained from NDACC/FTIR solar absorption spectra, Earth Syst. Sci. Data, 9, 15-29, doi:10.5194/essd-9-15-2017, 2017. https://www.earth-syst-sci-data.net/9/15/2017/.
- Bassani, C.; Manzo, C.; Zakey, A.; Cuevas-Agulló, E.: Effect of the Aerosol Type Selection for the Retrieval of Shortwave Ground Net Radiation: Case Study Using Landsat 8 Data, Atmosphere 2016, 7, 111. http://www.mdpi.com/2073-4433/7/9/111.
- García, R. D., Cuevas, E., García, O. E., Ramón, R., Romero-Campos, P. M., de Ory, F., Cachorro, V. E., and de Frutos, A.: Compatibility of different measurement techniques of global solar radiation and application for long-term observations at Izaña Observatory, Atmos. Meas. Tech., 10, 731-743, doi:10.5194/amt-10-731-2017, 2017a. https://www.atmos-meas-tech.net/10/731/2017/amt-10-731-2017.html.
- García,R.D., E. Cuevas, A. Barreto, V. Cachorro, R. Ramos, C. Guirado, C. Toledano and K. Hoogendijk,: Preliminary results of Aerosol Optical Depth and Angstrom Exponent at the Izaña Atmospheric Observatory from spectral direct irradiance measured with an EKO MS-711 spectrorradiometer, 44th Annual European Meeting on Atmospheric Studies by Optical Methods, 4-8 September, Barcelona, Spain, 2017b.
- García, R. D., Barreto, A., Cuevas, E., Gröbner, J., García, O. E., Gómez-Peláez, A., Romero-Campos, P. M., Redondas, A., Cachorro, V. E., and Ramos, R.: Comparison of observed and modelled longwave downward radiation (2010–2016) at the high mountain BSRN Izaña station, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2017-303, in review, 2018. https://www.geosci-model-dev-discuss.net/gmd-2017-303/.
- González, Y., Schneider, M., Dyroff, C., Rodríguez, S., Christner, E., García, O. E., Cuevas, E., Bustos, J. J., Ramos, R., Guirado-Fuentes, C., Barthlott, S., Wiegele, A., and Sepúlveda, E.: Detecting moisture transport pathways to the subtropical North Atlantic free troposphere using paired H2O-δD in situ measurements, Atmos. Chem. Phys., 16, 4251-4269, https://doi.org/10.5194/acp-16-4251-2016, 2016. https://www.atmos-chem-phys.net/16/4251/2016/.
- Kazadzis, S., Kouremeti, N., Diémoz, H., Gröbner, J., Forgan, B. W., Campanelli, M., Estellés, V., Lantz, K., Michalsky, J., Carlund, T., Cuevas, E., Toledano, C., Becker, R., Nyeki, S., Kosmopoulos, P. G., Tatsiankou, V., Vuilleumier, L., Denn, F. M., Ohkawara, N., Ijima, O., Goloub, P., Raptis, P. I., Milner, M., Behrens, K., Barreto, A., Martucci, G., Hall, E., Wendell, J., Fabbri, B. E., and Wehrli, C.: Results from the 4th WMO Filter Radiometer Comparison for aerosol optical depth measurements, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-1105, in review, 2017. https://www.atmos-chem-phys-discuss.net/acp-2017-1105/acp-2017-1105.pdf
- López-Solano, J., Redondas, A., Carlund, T., Rodriguez-Franco, J. J., Diémoz, H., León-Luis, S. F., Hernández-Cruz, B., Guirado-Fuentes, C., Kouremeti, N., Gröbner, J., Kazadzis, S., Carreño, V., Berjón, A., Santana-Díaz, D., Rodríguez-Valido, M., De Bock, V., Moreta, J. R., Rimmer, J., Smedley, A.R.D, Boulkelia, L., Jepsen, N., Eriksen, P., Bais, A. F., Shirotov, V., Vilaplana, J. M., Wilson, K. M., and Karppinen, T.: Aerosol optical depth in the European Brewer Network, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-1003, in review, 2017. https://www.atmos-chem-phys-discuss.net/acp-2017-1003/acp-2017-1003.pdf
- Romero-Campos, P.M., Cuevas-Agulló, E., Kazadzis, S., Kouremeti, N., García-Cabrera, R. D., Guirado-Fuentes, C., Análisis de la trazabilidad en los valores del AOD obtenidos a partir de las medidas de las redes AERONET-CIMEL y GAW-PFR durante el período 2005-2015 en el Observatorio Atmosférico de Izaña, Agencia Estatal de Meteorología (AEMET), Notas técnicas de

AEMET, 23, 2017. http://hdl.handle.net/20.500.11765/7572

- Schneider, M., Borger, C., Wiegele, A., Hase, F., García, O. E., Sepúlveda, E., and Werner, M.: MUSICA MetOp/IASI {H2O,δD} pair retrieval simulations for validating tropospheric moisture pathways in atmospheric models, Atmos. Meas. Tech., 10, 507-525, doi:10.5194/amt-10-507-2017, 2017. https://www.atmos-meas-tech.net/10/507/2017/amt-10-507-2017.html
- Torres, B., Dubovik, O., Fuertes, D., Schuster, G., Cachorro, V. E., Lapionok, T., Goloub, P., Blarel, L., Barreto, A., Mallet, M., Toledano, C., and Tanré, D.: Advanced characterization of aerosol properties from measurements of spectral optical depth using the GRASP algorithm, Atmos. Meas. Tech., 10, 3743-3781. https://www.atmos-meas-tech.net/10/3743/2017/, 2017. https://www.atmos-meas-tech.net/10/3743/2017/amt-10-3743-2017.pdf

Title(s) of IOM report(s) presently being developed by your Testbed/Lead Centre: (please specify level of development: draft, ready for review, …)

Has your Testbed/Lead Centre collaborated with one or more CIMO Expert Teams in developing guidance material? Yes

If yes, with which CIMO Expert Team(s)?

CIMO Expert team on New remote Sensing Technologies (ET-NRST):

1. Monitor and review outputs of assigned CIMO Testbeds and Lead Centres
2. Assess needs to, and develops if required, update for relevant parts of CIMO Guide.

Capacity Building and Training Activities

Which capacity building/training activities have been carried out by the Testbed in the last 2 years?

- Mr Lahouari Zeudmi (Office National de la Météorologie-Tamanrasset station, Algeria), and Mr. Ilyes Zarrouk (Institut National de la Météorologie de Tunisie -Tunis_Carthage station, Tunisia) attended to a 20-hour training course on Cimel sun-photometer operation in January and April 2017, respectively.

Has your testbed developed a twinning activity / special relationship with a companion station/site from a developing country? Yes

If yes, with which station/site?

Tamanrasset GAW Station (Algeria) from the « Office National de la Météorologie » (ONM)

Is your Testbed/Lead Centre making an oral/poster presentation at this year's TECO? Yes
(If yes, please specify Title(s) and Author(s) of the presentation(s))

Aerosols and water vapor remote sensing instruments activities carried out at Izaña CIMO Testbed

E. Cuevas, A. Barreto, F. Almansa, R.D. García, P.M. Romero-Campos, C. Guirado

Recent Changes in Circumstance

Have there been any recent changes in your Test Bed/Lead Centre's capabilities? If so, please specify:

- A new integrating sphere was installed at Izaña at the end of 2017 for solar and lunar photometer absolute radiance calibrations as well as optical tests required for QC/QA of reference instruments. The

new integrating sphere has a 20 inches diameter, an 8 inches aperture, and 400 W power, with a total cost of **27,820 €**.

- Three new Triple photometers (Cimel CE318T) for aerosols and water vapor measurements using sun, sky and lunar observations were purchased with a cost of **136,000 €**. One of them will be permanently in operation at Izaña site being calibrated with the World Radiation Center (WRC) PFR Triad (an instrument of the world reference PFR is permanently calibrated at Izaña with sun Langleys). The three new CE318T photometers will be part of the Cimel reference, being set up at Izaña in collaboration with the World Radiation Center PMOD.

  The integrating sphere and the three CE318-T photometers were purchased in the framework of a competitive scientific infrastructure call of the National Plan for Research, Development and Innovation of Spain (Ministry of Economy and Competitiveness, MINECO)

Have there been any recent changes in your Test Bed/Lead Centre's infrastructure? If so, please specify:

- Since mid-October 2017, Izaña Testbed facility enlarged the photometers calibration platform. The capability to simultaneously calibrate master/field instruments has been extended from 8 to 20 units. The new installation has required two new heavy, stable and labelled aluminum tables, five new stainless shelter cases, and rewiring works. The costs of around 3,700 € have been covered by AEMET own funds.

Have there been any recent changes in your staffing? If so, please specify, and advise whether replacement staff have the required competencies:

- None.

Future Plans

What are your plans for the next two years?

- Implementation of inversion products with the Generalized Retrieval of Atmosphere and Surface Properties (GRASP) algorithm on Cimel photometers and ZEN radiometers. GRASP has been developed at the Laboratoire d'Optique Atmosphérique (LOA) (CNR-Université de Lille; France), and infers a large number of aerosol and surface parameters including particle size distribution, the spectral index of refraction, the degree of sphericity and absorption. The algorithm is designed to retrieve aerosol properties from spectral, multiangular polarimetric remote sensing observations.
- Deliver free available on-line data processing software to compute AOD, AE and PWV from MS-700 DNI spectrometers under the Izaña testbed website.
- Deliver free available on-line data processing software to compute AOD, AE from ZEN radiometers under the Izaña testbed website.
- AOD determination and validation during night period with a micropulse lidar (MPL) assuming a constant lidar ratio in a two-layer scheme.
- Establishment of permanent traceability with PMDO/WRC world reference for AERONET sunphotometer references at IZO.
- Development and evaluation of new algorithms for aerosol retrieval with the new PANDORA-2S spectrometer in collaboration with Luftblick company (Austria). This instrument will form the new PANDONIA global network.
- Characterization of the new lidar prototype namely CE376, from Cimel Electronique, which works at two wavelengths (532 & 808nm) with 2 depolarization channels.
- Comprehensive assessment of the potential use of the very low-cost Calitoo-TENUM hand-held sunphotometer for operational dust model and satellite observations evaluation activities within the WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS).

● Participate in the next national R+D infrastructures competitive call to purchase a humidity and temperature profiler microwave radiometer (MWR)	
Is your Testbed/Lead Centre able to continue in the role of a Test Bed/Lead Centre during the coming two years?	Yes

Other relevant information (other activities of special interest to CIMO, etc.)

- Strong links and synergies with GAW and SDS-WAS.
- GOA-UVa will develop specific campaigns in the next two years using the CIMO Testbed facilities in order to give answer to the ESA Invitation To Tender (ITT) “Lunar spectral irradiance measurements and modelling for absolute calibration of EO optical sensors”.

February 15th, 2018 — **Date**

Emilio Cuevas — **Name of Person Filling the Form**