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Organisation météorologique mondiale

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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:
<http://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: <ul style="list-style-type: none">• 1. Development and testing of several lunar-photometer prototypes and the new Triple (Sun-Lunar-Sky) CE318-T photometer Development and testing of several lunar-photometer prototypes (i.e. modified CE318-N and CE318-U)

capable of measuring aerosols and column water vapour during the night period, has been performed at IZO in collaboration with Cimel Electronique (<http://www.cimel.fr>). The final version, the CE318-T, is able to perform daytime and nighttime photometric measurements using the sun and the moon as light source. This new device permits a complete cycle of diurnal aerosol and water vapour measurements valuable to enhance atmospheric monitoring. Two new methodologies to transfer the calibration from a reference instrument using only daytime measurements (Sun Ratio and Sun-Moon gain factor techniques) have been developed and evaluated. These methods allow the reduction of the previous complexities inherent to nocturnal calibration. A quantitative estimation of CE318-T aerosol optical depth (AOD) uncertainty by means of error propagation theory during daytime and night period has been assessed. A subsequent performance evaluation including CE318-T and collocated measurements from independent reference instruments has served to assess the CE318-T performance, day and night, as well as to confirm its estimated uncertainty. The CE318-T has been recently adopted by NASA AEROSOL ROBOTIC NETWORK (AERONET) as the new standard instrument of the network. See Barreto et al. (2016).

- **2. The reconstruction of a 73-year time series of AOD at 500 nm by using artificial neural networks**

The reconstruction of a 73-year time series of AOD at 500 nm at IZO has been achieved by using artificial neural networks (ANNs) from 1941 to 2001 and AOD measurements directly obtained with a Precision Filter Radiometer (PFR) between 2003 and 2013. The ANN AOD time series has been comprehensively validated against coincident AOD measurements performed with a solar spectrometer Mark-I (1984–2009) and AERONET CIMEL photometers (2004–2009) at IZO, obtaining a rather good agreement on a daily basis (Pearson $r=0.97$ between AERONET and ANN AOD, and 0.93 between Mark-I and ANN AOD estimates). The ANN method has proved to be a very useful tool for the reconstruction of daily AOD values at 500 nm from meteorological input data, such as the horizontal visibility, fraction of clear sky, and relative humidity, recorded at IZO. This methodology might be extrapolated to other sites, especially those affected by high dust loads. See García et al. (2016).

- **3. 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 in-situ airborne and ground-based observations during the MUSICA remote sensing validation campaign were performed during 2014 and 2015. The project MUSICA (MULTI-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water, <http://www.imk-asf.kit.edu/music>), supported by the European Research Council within the Seventh Framework Programme (FP7/2007-2013/ERC Grant Agreement, n° 256961), has as main goal the generation of a high-quality database in a global scale of tropospheric water vapour isotopologues (H₂16O y HD16O) from ground-based remote measurements (Fourier Transform InfraRed spectrometers, FTIR) and space-based platforms (Infrared Atmospheric Sounding Interferometer, IASI, on board the satellites EUMETSAT/MetOp-A and MetOp-B). The Izaña Tesbed has played a very active role in MUSICA being the main station supporting different experiments. The results of this project will contribute to a better understanding of the different processes affecting the cycle of atmospheric water and its link to the energy balance at a global scale.

Main results achieved up to now have been published by Scheepmaker et al. (2014), Wiegeler et al. (2014), Dyrhoff et al. (2015), González et al. (2015), and Schneider et al. (2015; 2016).

- **4. The Izaña Tesbed site supporting different field campaigns of radiation/aerosols prototypes**

The Izaña Tesbed site has been used for different field campaigns of radiation/aerosols prototypes, such as the new Precision Solar Spectroradiometer (PSR), developed at PMOD/World Radiation Centre (WRC, Davos Switzerland), which will replace current filter sunphotometers for long AOD and absolute solar irradiance measurements. This instrument has been absolutely calibrated at Izaña and compared with other reference photometers. Preliminary stellar measurements have also been performed.

The Izaña tesbed has been the facility of an intensive 2-month campaign for the determination of the NIR irradiance spectra will be used to retrieve the top-of-atmosphere (TOA) solar spectral irradiance through wavelength ranges free of O₂, O₃, CO₂ and H₂O absorption the Bouguer-Langley technique. The results obtained within this campaign are expected to solve some discrepancies observed in published TOA solar spectra in the infrared range. An accurate knowledge of the NIR TOA solar irradiance is important due to its role in Earth radiative budget, namely atmospheric and upper layer of the ocean absorption processes. NIR TOA is also needed to validate semi empiric models of solar atmosphere. Results have been reported by Bolsée et al. (2014).

Two campaigns of TENUM Calitoo hand-held photometers (<http://www.calitoo.fr/index.php?page=calibration>) in 2014 and 2015.

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

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

A look-up table methodology for aerosol optical depth (AOD) retrieval from zenithal 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 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 provide good results when validated against reference AOD from AERONET. At the moment we are working on the revision of a paper where the new instrument and the methodology are described in detail, and where evaluation results are assessed and discussed. This paper will be submitted to Atmospheric Measurement Techniques (AMT) journal.

- **2. Long-term comparability between GAW/PFR and AERONET/Cimel techniques and methodologies**

A comprehensive intercomparison of aerosol optical depth (AOD) and Angstrom exponent (AE) retrievals over Izana Tesbed from multiple ground-based radiometers, such as a PFR (Precision Filter Radiometer) from the GAW-PFR (Global Atmospheric Watch-Precision Filter Radiometer) Network (acting as the reference instrument), several AERONET CIMEL sun-photometers, a MFRSR (Multifilter Rotating Shadowband Radiometer), and a PMOD/Rocket (Physikalisch-Meteorologisches Observatorium Davos), as well as space-borne sensors including MODIS (on Terra and Aqua satellites), MISR, OMI, and SeaWiFS was conducted for 2001-2015. Results of the intercomparison between PFR and the ground-based and space-borne radiometers are shown in a paper (under preparation) will be submitted to Atmospheric Measurement Techniques (AMT) journal.

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

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

- Bolsée, D., N. Pereira, W. Decuyper, D. Gillotay, H. Yu, P. Sperfeld, S. Pape, E. Cuevas, A. Redondas, Y. Hernández, M. Weber, Accurate Determination of the TOA Solar Spectral NIR Irradiance Using a Primary Standard Source and the Bouguer-Langley Technique Solar Physics, DOI: 10.1007/s11207-014-0474-1, 2014 (<http://link.springer.com/article/10.1007/s11207-014-0474-1>)
- Barreto, A., Cuevas, E., Pallé, P., Romero, P. M., Guirado, C., Wehrli, C. J., and Almansa, F.: Recovering long-term aerosol optical depth series (1976–2012) from an astronomical potassium-based resonance scattering spectrometer, Atmos. Meas. Tech., 7, 4103-4116, doi:10.5194/amt-7-4103-2014, 2014. (<http://www.atmos-meas-tech.net/7/4103/2014/amt-7-4103-2014.html>)
- Diémoz, H., Siani, A. M., Redondas, A., Savastouk, V., McElroy, C. T., Navarro-Comas, M., and Hase, F.: Improved retrieval of nitrogen dioxide (NO₂) column densities by means of MKIV Brewer spectrophotometers, Atmos. Meas. Tech., 7, 4009-4022, doi:10.5194/amt-7-4009-2014, 2014. (<http://www.atmos-meas-tech.net/7/4009/2014/amt-7-4009-2014.html>)
- García, R. D., Cuevas, E., García, O. E., Cachorro, V. E., Pallé, P., Bustos, J. J., Romero-Campos, P. M., and de Frutos, A. M.: Reconstruction of global solar radiation time series from 1933 to 2013 at the Izaña Atmospheric Observatory, Atmos. Meas. Tech., 7, 3139-3150, doi:10.5194/amt-7-3139-2014, 2014. (<http://www.atmos-meas-tech.net/7/3139/2014/amt-7-3139-2014.pdf>)
- García, R.D., O.E, García, E. Cuevas, V.E. Cachorro, P.M. Romero-Campos, R. Ramos and A.M. de Frutos, Solar radiation measurements compared to simulations at the BSRN Izaña station. Mineral dust radiative forcing and efficiency study, JGR-Atmospheres, Vol 119, 1-16, DOI: 10.1002/2013JD020301, 2014. (<http://www.atmos-chem-phys.net/14/3865/2014/acp-14-3865-2014.pdf>)
- García, O.E., Schneider, M., Hase, F., Blumenstock, T., Sepúlveda, E., and González, Y.: Quality assessment of ozone total column amounts as monitored by ground-based solar absorption spectrometry in the near infrared (> 3000 cm⁻¹), Atmos. Meas. Tech., 7, 3071-3084, doi:10.5194/amt-7-3071-2014,

2014. (<http://www.atmos-meas-tech.net/7/3071/2014/amt-7-3071-2014.html>)

- Guirado, C., Cuevas, E., Cachorro, V. E., Toledano, C., Alonso-Pérez, S., Bustos, J. J., Basart, S., Romero, P. M., Camino, C., Mimouni, M., Zeudmi, L., Goloub, P., Baldasano, J. M., and de Frutos, A. M.: Aerosol characterization at the Saharan AERONET site Tamanrasset, *Atmos. Chem. Phys.*, 14, 11753-11773, doi:10.5194/acp-14-11753-2014, 2014. (<http://www.atmos-chem-phys.net/14/11753/2014/acp-14-11753-2014.pdf>)
- Karppinen, T, A. Redondas, R.D. García, K. Lakkala, C.T. McElroy & E. Kyrö, Compensating for the Effects of Stray Light in Single-Monochromator Brewer Spectrophotometer Ozone Retrieval, *Atmosphere-Ocean*, DOI: 10.1080/07055900.2013.871499, 2014. (<http://www.tandfonline.com/doi/abs/10.1080/07055900.2013.871499>)
- Scheepmaker, R. A., Frankenberg, C., Deutscher, N. M., Schneider, M., Barthlott, S., Blumenstock, T., Garcia, O. E., Hase, F., Jones, N., Mahieu, E., Notholt, J., Velasco, V., Landgraf, J., and Aben, I.: Validation of SCIAMACHY HDO/H₂O measurements using the TCCON and NDACC-MUSICA networks, *Atmos. Meas. Tech. Discuss.*, 7, 11799-11851, doi:10.5194/amtd-7-11799-2014, 2014. (<http://www.atmos-meas-tech.net/8/1799/2015/amt-8-1799-2015-discussion.html>)
- Torres, B., Dubovik, O., Toledano, C., Berjon, A., Cachorro, V. E., Lapyonok, T., Litvinov, P., and Goloub, P.: Sensitivity of aerosol retrieval to geometrical configuration of ground-based sun/sky radiometer observations, *Atmos. Chem. Phys.*, 14, 847-875, doi:10.5194/acp-14-847-2014, 2014. (<http://www.atmos-chem-phys.net/14/847/2014/acp-14-847-2014.html>)
- Wiegele, A., Schneider, M., Hase, F., Barthlott, S., García, O. E., Sepúlveda, E., González, Y., Blumenstock, T., Raffalski, U., Gisi, M., and Kohlhepp, R.: The MUSICA MetOp/IASI H₂O and δD products: characterisation and long-term comparison to NDACC/FTIR data, *Atmos. Meas. Tech.*, 7, 2719-2732, doi:10.5194/amt-7-2719-2014, 2014. (<http://www.atmos-meas-tech.net/7/2719/2014/amt-7-2719-2014.html>)
- Camino, C., E. Cuevas, S. Basart, S. Alonso-Pérez, J.M. Baldasano, E. Terradellas, B. Marticorena, S. Rodríguez, A. Berjón: An empirical equation to estimate mineral dust concentrations from visibility observations in Northern Africa, *Aeolian Research*, Vol. 16, Pages 55–68, March 2015. (<http://www.sciencedirect.com/science/article/pii/S1875963714000998>)
- Dyroff, C., Sanati, S., Christner, E., Zahn, A., Balzer, M., Bouquet, H., McManus, J. B., González, Y., and Schneider, M., Airborne in situ vertical profiling of HDO/H₂O in the subtropical troposphere during the MUSICA remote sensing validation campaign, *Atmos. Meas. Tech.*, 8, 2037-2049, 2015, doi:10.5194/amt-8-2037-2015. (<http://www.atmos-meas-tech.net/8/2037/2015/>)
- Fountoulakis, I., Redondas, A. M., Bais, A. F., Rodriguez-Franco, J. J., Fragkos, K., and Cede, A.: Dead time effect on the Brewer measurements: correction and estimated uncertainties, *Atmos. Meas. Tech. Discuss.*, 8, 12589-12632, doi:10.5194/amtd-8-12589-2015, 2015. (<http://www.atmos-meas-tech-discuss.net/amt-2015-319/>)
- García, R.D., Cachorro, V.E., Cuevas, E., Toledano, C., Redondas, A., Blumthaler, M., and Benounna, Y.: Comparison of measured and modelled spectral UV irradiance at Izaña high mountain station. Estimation of the underlying effective albedo, *International Journal Climatology*, DOI: 10.1002/joc.4355, 2015. (<http://onlinelibrary.wiley.com/doi/10.1002/joc.4355/pdf>)
- García, R.D., García, O.E., Cuevas, E., Cachorro, V.E., Barreto, A., Guirado-Fuentes, C., Kouremeti, N., Bustos, J.J., Romero-Campos, P. M., and de Frutos, A.M. : Aerosol Optical Depth retrievals at the Izaña Atmospheric Observatory from 1941 to 2013 using artificial neural networks, *Atmos. Meas. Tech. Discuss.*, 8, 9075-9103, doi:10.5194/amtd-8-9075-2015, 2015. (<http://www.atmos-meas-tech.net/9/53/2016/amt-9-53-2016-discussion.html>)
- García, O. E., Sepúlveda, E., Schneider, M., Hase, F., August, T., Blumenstock, T., Köhl, S., Munro, R., Gómez-Peláez, A., Hultberg, T., Redondas, A., Barthlott, S., Wiegele, A., González, Y., and Sanromá, E. Consistency and quality assessment of the Metop-A/IASI and Metop-B/IASI operational trace gas products (O₃, CO, N₂O, CH₄ and CO₂) in the Subtropical North Atlantic, *Atmos. Meas. Tech. Discuss.*, 8, 13729-13778, doi:10.5194/amtd-8-13729-2015. (<http://www.atmos-meas-tech-discuss.net/amt-2015-345/>)
- 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. Discuss.*, 15, 27219–27251, 2015. (<http://www.atmos-chem-phys-discuss.net/acp-2015-627/>)

- Román R., M. Antón, V.E. Cachorro, D. Loyola, J.P. Ortiz de Galisteo, A. de Frutos, P.M. Romero-Campos, : Comparison of total water vapor column from GOME-2 on MetOp-A against ground-based GPS measurements at the Iberian Peninsula, Science of The Total Environment, Volume 533, 15 November 2015, Pages 317-328, ISSN 0048-9697, <http://dx.doi.org/10.1016/j.scitotenv.2015.06.124>. (<http://www.sciencedirect.com/science/article/pii/S0048969715303260>)
- Schneider, M., González, Y., Dyroff, C., Christner, E., Wiegele, A., Barthlott, S., García, O. E., Sepúlveda, E., Hase, F., Andrey, J., Blumenstock, T., Guirado, C., Ramos, R., and Rodríguez, S.: Empirical validation and proof of added value of MUSICA's tropospheric δD remote sensing products, Atmos. Meas. Tech., 8, 483-503, doi:10.5194/amt-8-483-2015, 2015. (<http://www.atmos-meas-tech.net/8/483/2015/amt-8-483-2015.html>)
- Barreto, A., Cuevas, E., Granados-Muñoz, M. J., Alados-Arboledas, L., Romero, P. M., Gröbner, J., Kouremeti, N., Almansa, A. F., Stone, T., Sorokin, M., Holben, B., Canini, M., and Yela, M.: The new sun-sky-lunar Cimel CE318-T multiband photometer – a comprehensive performance evaluation , Atmos. Meas. Tech., 9, 631-654, 2016 doi:10.5194/amt-9-631-2016. (<http://www.atmos-meas-tech.net/9/631/2016/>)
- García, R. D., García, O. E., Cuevas, E., Cachorro, V. E., Barreto, A., Guirado-Fuentes, C., Kouremeti, N., Bustos, J. J., Romero-Campos, P. M., and de Frutos, A. M.: Aerosol optical depth retrievals at the Izaña Atmospheric Observatory from 1941 to 2013 by using artificial neural networks, Atmos. Meas. Tech., 9, 53-62, doi:10.5194/amt-9-53-2016, 2016. (<http://www.atmos-meas-tech.net/9/53/2016/>)
- Schneider, M., Wiegele, A., Barthlott, S., González, Y., Christner, E., Dyroff, C., García, O. E., Hase, F., Blumenstock, T., Sepúlveda, E., Mengistu Tsidu, G., Takele Kenea, S., Rodríguez, S., and Andrey, J.: A framework for accurate, long-term, global and high resolution observations of tropospheric H₂O- δD pairs – a MUSICA review, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2015-330, in review, 2016. (<http://www.atmos-meas-tech-discuss.net/amt-2015-330/amt-2015-330.pdf>)

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

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Has your Testbed/Lead Centre collaborated with one or more CIMO Expert Teams in developing guidance material? No

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

Capacity Building and Training Activities

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

- Training courses about sunphotometry for operators and technicians of the AERONET stations at Ouarzazate (Morocco), Tamanrasset (Algeria), Cairo (Egypt) and Tunis (Tunisia) in 2014 and 2015.
- Two calibration and evaluation of hand-held sunphotometers involved in the Global Learning and Observations to Benefit the Environment (GLOBE) Programme, have been carried out in 2014 and 2015.

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-Algeria Global Atmosphere Watch (GAW) station of global importance, for testing the zenith-looking Cimel AOD estimation methodology, the new low-cost and robust zenith-looking multi narrow-band radiometer for AOD retrieval, and the very low-cost Calitoo (Tenum) hand held photometer.

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))

Activities of the WMO-CIMO Testbed for Aerosols and Water Vapour Remote Sensing Instruments (Izaña, Spain); Cuevas, E., Barreto, A., Guirado, C., Almansa, F., García, R., García, O., Schneider, M., Redondas, A., and Berjón, A.

Recent Changes in Circumstance
<p>Have there been any recent changes in your Test Bed/Lead Centre's capabilities? If so, please specify: Yes</p> <p>A new MS-700 DNI spectrometer, that covers a spectral range from 350nm to 1050nm with a 5-degree angle collimating tube, has been purchased as part of the project "Equipment for greenhouse gases and aerosols monitoring and research at the Izaña Global Atmospheric Watch observatory", financed by the Ministry of Economy and Competitiveness (MINECO) of Spain (specific competitive call for research infrastructures). This new instrument will mean a strong reinforcement of capabilities envisaged to the development of new methodologies to determine aerosols and water vapor, as well as in the evaluation of new instruments/prototypes.</p>
<p>Have there been any recent changes in your Test Bed/Lead Centre's infrastructure? If so, please specify:</p> <p>Yes.</p> <p>A larger platform for photometer observations has been set up at the main observation tower of the Izaña Testbed.</p>
<p>Have there been any recent changes in your staffing? If so, please specify, and advise whether replacement staff have the required competencies:</p> <p>No</p>

Future Plans	
<p>What are your plans for the next two years?</p> <ul style="list-style-type: none"> • Establishment of permanent traceability with PMDO/WRC world reference for AERONET sunphotometer references at IZO. • Development of synergy photometer/lidar/ceilometer methodologies for retrieving vertical aerosol extinction. • Accurate and comprehensive evaluation of the new algorithm to retrieve operational AOD in the UV range from Brewer spectrophotometers within EUBREWNET Cost Action 1207. • Development and evaluation of new algorithms for aerosol retrieval with the new PANDORA-2 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). 	
<p>Is your Testbed/Lead Centre able to continue in the role of a Test Bed/Lead Centre during the coming two years?</p>	<p>Yes</p>

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

<p>March 13, 2016</p> <p style="text-align: center;">Date</p>	<p>Dr. Emilio Cuevas</p> <p style="text-align: center;">Name of Person Filling the Form</p>
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