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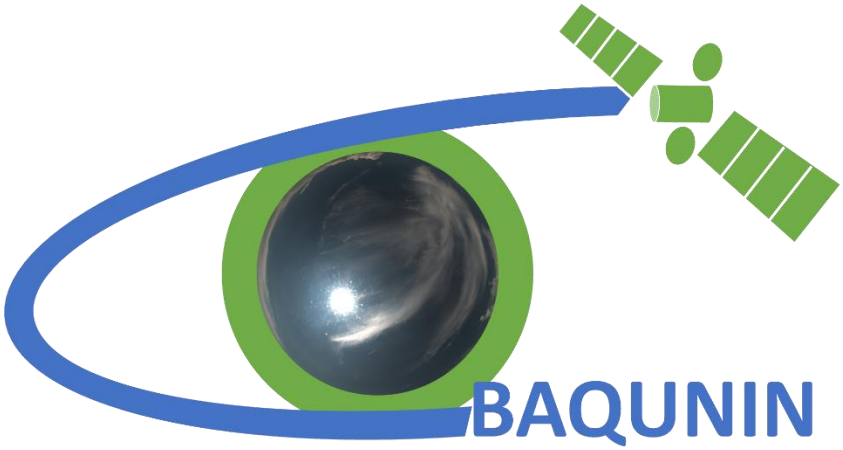

BAQUNIN contributions to satellite Cal/Val

Abstract : This document describes the BAQUNIN contribution to Satellite Cal/Val activities and includes a discussion about the data property rights for Cal/Val data providers.

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Change History

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

ISSUE	DATE	REASON
1.0	27 Nov 2019	First version

APPLICABLE DOCUMENTS

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

[RD.1] BAQ-MGT-TEN-SER-017

[RD.2] BAQ-MGT-TEN-SER-015

ACRONYMS

Acronym	Definition
AERONET	Aerosol Robotic Network
APL	Atmospheric Physics Laboratory (at Sapienza)
BAQUNIN	Boundary-layer Air Quality-analysis Using Network of INstruments
TPM	Third Party Mission

1. INTRODUCTION

1.1 Background

In the framework of ESA SPPA section, many activities are of “Research and Development” nature. The R&D projects are, by definition, non-operational and, as such, not subject to Service level Agreements (SLA) and Key Performance Indicators (KPI) are not defined.

The BAQUNIN project is structured into two phases.
During **Phase 1** (first 12 months) the BAQUNIN project is in the pilot and a demonstrator stage.
Envisaged achievements of this stage are:

- Set-up of the BAQUNIN service organization
- Set-up of the BAQUNIN instrumentation infrastructure and Laboratory
- Integration in applicable ground-based instrumentation network
- Data provisioning activities set-up and operations, for existing products
- Preparation for the support to Mission calibration activities
- Set-up of the required infrastructure and laboratory
- Creation and deployment of the service portal

During **Phase 2** (subsequent 24 months), main achievements will be:

- All what already part of Phase 1, plus
- Improvement of algorithms involved in data provisioning
- Calibration/Validation Support activities for agreed missions

After 9 months of BAQUNIN lifetime, the Phase 1 achievements have been successfully realised.

1.2 Objective of this document

This document is designed to help BAQUNIN stakeholders to identify practical indicators helping to appreciate the usefulness of the BAQUNIN concept.
This may also be considered as a general Lesson Learned helping to define some guidelines to ascertain the contribution of R&D projects in general.
The metrics for a correct evaluation of the “usefulness” of a R&D project, and in particular for BAQUNIN, could be summarised as:

a) Prompt delivery documentation on instrument calibration, maintenance and operation
b) Efficient and documented QA/QC for the data produced within the project
c) Relevance of technical notes, reports, presentations and publications to ESA

d) Relevance of the distributed products and of activities directly performed by the project team for scientific and Cal/Val applications

Points a), b) and c) are controlled through standard delivery control mechanisms embedded in the contract, and so they will not be addressed here.

In this document we provide full evidence of the use of the BAQUNIN data provision service to the satellite Cal/Val community, including TPMs.

This aim is achieved by reporting on the following topics:

1) Assessment of evidence of data usage from the “provider” point of view
2) Description of the BAQUNIN data provision “service”
3) BAQUNIN data usefulness in the context of EDAP TPM validation activities
4) BAQUNIN infrastructure for calibration and inter-comparison campaigns
5) BAQUNIN efforts in educational activities

2. ASSESSMENT OF EVIDENCE OF DATA USE

Provision of satellite Cal/Val reference data is usually considered a simple task from those who little or no experience in operating a scientific instrument. In their view, the activity reduces to install and run a device as it was a coffee machine: the instrument runs and the data flow smoothly in the hands of users. This opinion is probably generated by the relative simple file format and content of the reference datasets, when compared, for example, to the complexity of those generated from satellite measurements.

Of course, reality is much more complicated than this: experimentalists tackle any sort of hardware and software technical and theoretical problems is their everyday life, and the data provision is only the last in problems' ranking. In fact, there would be no data to be delivered if instruments could not run as they should.

All the efforts spent in operating any instrumental suite, whatever its complexity, are not visible to the user community and, usually, data providers are not even acknowledged for their work. This is particularly true when data are made available to the community via web services.

2.1 Networks

In the last 20 years, it has become a common practice to freely distribute ground based reference data via open internet services. AERONET is one of the most popular example of this, but other networks, such as PGN, do provide data in a similar fashion.

What are the advantages for a scientist operating an instrument, in joining a national or international networks?

In few words:

1) The instrument PI is "forced" to adopt state-of-art operation and maintenance procedures
2) Data underpass automatic quality checks using community agreed procedures
3) Processing chains are (usually) centralised and state-of-art retrieval schemes are adopted
4) Instruments are checked remotely to assess possible issues (e.g. calibration)
5) The instrument calibration can be under the responsibility of the networks
6) Data are stored and freely distributed under the responsibility of the network

All this allows the community to access high quality and standardised products, which can be used as reference for many applications, included satellite Cal/Val. Also, such a service allows the saving of time and resources on PI side, that can be dedicated to research.

The free data distribution is, in particular, a service of exceptional value for the progress of science, and PIs joining a network formally and knowingly agree on this point.

However, an important drawback has been recently put in evidence by the scientific community: when a dataset becomes part of a network, **any link to the data provider is virtually lost**.

In fact, when downloading a dataset, from e.g. AERONET, the data fetcher is asked to *agree that he/she will contact the instrument PI to offer co-authorship (if the dataset is particularly relevant for the study) or that the PI will be fully acknowledged in the publication*.

Then, by clicking the "*I agree*" button, the data are made freely available without any further notification. Thus, it is up to the user who grabbed the data to contact the instrument PI, and there is no mechanisms in place to check if this really happens.

An explatory example of what stated above, is shown in Figures 1, 2 and 3, in which the AERONET data download service pages are reproduced.

In Figure 1, the data selection tool allows the user to select the most appropriate products needed for his/her studies. Please note that, in the lower left section of the web page, the "Download all sites" button allows the user to fetch data from the entire AERONET network!

Figure 1 AERONET data download page for "Rome_La_Sapienza" (BAQUNIN-APL)

After product selection, by clicking on the “Download” button, a “Notice to users” page appears, as shown in Figure 2. In this page, the user is invited to contact the PI(s) to agree on data usage and possibly offer co-authorship.

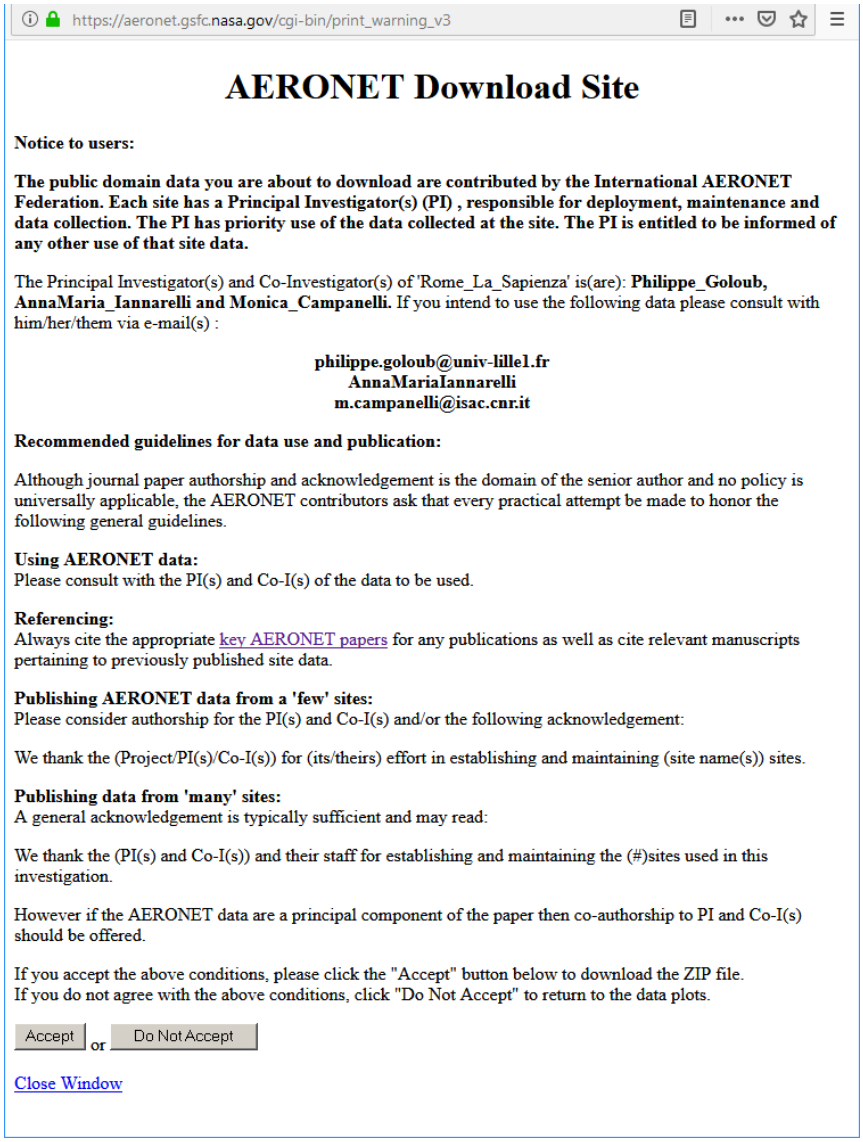

Figure 2 AERONET “Note to users”

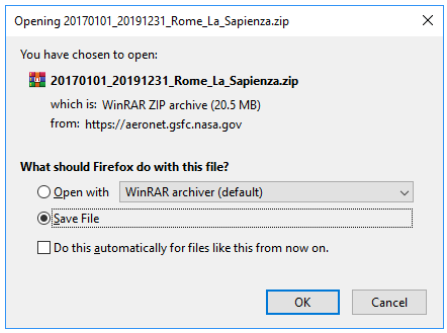

Figure 3 AERONET data download after clicking the "Accept" button in Figure 2

By simply accepting this "invitation" (clicking the "Accept" button), the user can freely download the selected dataset, as shown in Figure 3.

As a matter of fact, there is no mechanism to verify that the user has followed the AERONET "Recommended Guidelines".

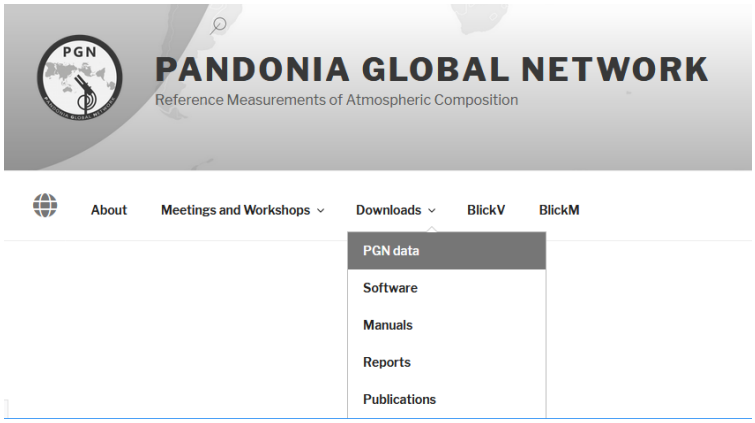

Figure 4 PGN data download page

In the case of PGN data, there is no "Note to users" to be accepted before downloading the data. As shown in Figure 4, by clicking on "Downloads – PGN data", the user has full access to the entire PGN network data.

2.2 Digital Object Identifier

In the recent years, it was proposed to adopt the Digital Object Identifier (DOI) as the possible solution to this problem.

The beneficial effects the adoption of the DOI will have on the recognition of the "PI data property rights" will be subject, in my opinion, to the following:

1) The DOI should be associated to each product type (e.g. NO2 total column) and the PI
2) The DOI should not be associated to networks
3) Networks should notify PIs on any download activity related to their products

4) The review process of scientific publication should include, by default, a service that checks whether a dataset used in the work was properly identified and associated PI has been properly acknowledged. The article should be rejected in case this check is not successfully passed.

If all above is not put in place, it is my opinion that the DOI will have very little effects: as soon as the direct link between PI and his/her data is cut, there will be no way to properly trace back the data usage.

In particular, the scientific community should protect its members not only from “text plagiarism” but, even more efficiently, from “lack of recognition”. This can only be efficiently done at Journal Editor and Reviewer levels.

2.3 Literature

In principle, one could be able to check if his/her own dataset has been used to perform scientific or validation activities, if he/her is not directly involved. It would be sufficient to access all publications related to the PI field of research, read all articles with great attention and verify if the authors have been so kind to make the dataset recognizable.

Of course, this is not feasible, as the PI would spend all his/her time in this activity. And, most important, the results would be unsatisfactory in any case, as in the majority of cases it will be impossible to “detect” the owned dataset.

Alternatively, one can search for articles dealing with the networks of reference to his/her instruments, and assume that his/her data have been used.

Of course, this is not fully correct, as no one can prove that this is not true (with the exception of the authors of the article), but the PI cannot prove that his/her data were actually used.

The situation becomes much more complicated if the publication is in form of oral or poster presentation, and even worse if validation results are described in technical notes (e.g. project documentation) not accessible to the public. In these cases, it is virtually impossible to verify who is using what.

2.3.1 BAQUNIN for NIDFORVAL

As an example of the contribution of BAQUNIN to satellite validation, we report here the list of presentations (oral and poster) and of technical reports produced by the S5PVT AO project NIDFORVAL (ID 28607), and for which the BAQUNIN data have been used.

As can be depicted from these lists, the BAQUNIN project has contributed to the validation of TROPOMI, GOME-2 and OMI mission by providing data through PGN, without being formally informed by the NIDFORVAL project. In fact, the lists have been kindly provided by G. Pinardi (BIRA-IASB) through personal communication after S. Casadio enquiry on 30 Nov 2019.

As a matter of fact, it would have been impossible to get this information by simple web search.

2.3.1.1 Oral presentations

- Gaia Pinardi, Steven Compernolle, Michel Van Roozendael, François Hendrick, Henk Eskes, Alexander Cede, Martin Tiefengraber, Andreas Richter, Ankie Piters, Thomas Wagner, Sebastian Donner, Julia Remmers, Alkis Bais, Hitoshi Irie, Yugo Kanaya, Michel Grutter, Claudia Rivera, Sander Niemeijer, Sentinel-5p Tropospheric NO2 Data Assessment using MAXDOAS and Direct-Sun Measurements, S5PVT meeting, Frascati, 11-14 november 2019.
- Gaia Pinardi & the NIDFORVAL team , Oral presentations (NO2 and HCHO) at the S5P first products release workshop, 25-26 June 2018, ESA-Esrin, Frascati, Italy (https://nikal.eventsair.com/QuickEventWebsitePortal/sentinel-5p-first-product-release-workshop/sentinel-5p/ExtraContent/ContentPage?page=5)

2.3.1.2 Poster presentations

- G. Pinardi, S. Compernolle, F. Hendrick, M. Van Roozendael, N. Theys, J.C. Lambert, P. Valks, F. Boersma, H. Eskes, Validation of tropospheric NO2 columns measurements from GOME-2, OMI and TROPOMI using MAXDOAS and DirectSun network observations with focus on dilution effects, 2019, Living Planet symposium, 10-13 May, Milano, Italy.
- Pinardi, Gaia; Vigouroux, Corinne; Langerock, Bavo; De Mazière, Martine; Granville, José; Compernolle, Steven; Lambert, Jean-Christopher; Hendrick, François; Van Roozendael, Michel; De Smedt, Isabelle; Eskes, Henk, Validation of TROPOMI NO2 and HCHO vertical columns with UV-Vis DOAS and FTIR instruments, ATMOS 2018, Nov 2018, http://atmos2018.esa.int/
- Gaia Pinardi, Vigouroux, Corinne, Langerock, Bavo, De Mazière, Martine, Granville, José, Lambert, Jean-Christopher, Hendrick, François, Van Roozendael, Michel, Sentinel-5 Precursor NO2 and HCHO validation using NDACC and complementary UV-Vis DOAS systems, Poster in AS3.15 – First Results of the Copernicus Sentinel-5 Precursor Mission, Abstract identification number EGU2018-15991, EGU conference, 8–13 April 2018, Vienna, Austria.

2.3.1.3 Technical reports

- G. Pinardi, H. Yu, J.-C. Lambert, J. Granville, Jeroen van Gent, M. van Roozendael, and P. Valks, Validation report of GOME-2 GDP 4.9 NO2 column data for MetOp-C Operational Readiness Review , SAF/AC/IASB/VR/NO2/ValidationReport_NO2_ORR_MetopC, draft 25/11/2019
- Quarterly Validation Report of the CopernicusSentinel-5 PrecursorOperational Data Products–#04:April2018–August 2019.Lambert, J.-C., A. Keppens, D. Hubert, B. Langerock, K.-U. Eichmann, Q. Kleipool, M. Sneep, T. Verhoelst, T. Wagner, M. Weber, C. Ahn, A. Argyrouli, D. Balis, K.L. Chan, S. Compernolle, I. De Smedt,H. Eskes, A.M. Fjæraa, K. Garane, J.F.Gleason, F. Goutail, J. Granville, P. Hedelt, K.-P. Heue,G. Jaross, ML. Koukouli, J. Landgraf, R. Lutz, S. Niemejer,A. Pazmiño, G.Pinardi, J.-P. Pommereau, A. Richter, N. Rozemeijer, M.K. Sha, D. SteinZweers, N. Theys, G. Tilstra, O. Torres, P. Valks, C. Vigouroux, and P. Wang.S5P MPC Routine Operations Consolidated Validation Reportseries, Issue #04, Version 04.0.0, 129pp., September 2019.

http://mpc-vdaf.tropomi.eu/ProjectDir/reports/pdf/S5P-MPC-IASB-ROCVR-04.0.0-20190923_FINAL.pdf

- Quarterly Validation Report of the CopernicusSentinel-5 PrecursorOperational Data Products–#03:July2018–May2019.Lambert, J.-C., A. Keppens, D. Hubert, B. Langerock, K.-U. Eichmann, Q. Kleipool, M. Sneep, T. Verhoelst, T. Wagner, M. Weber, C. Ahn, A. Argyrouli, D. Balis, K.L. Chan, S. Compernolle, I. De Smedt,H. Eskes, A.M. Fjæraa, K. Garane, J.F.Gleason, F. Goutail, J. Granville, P. Hedelt, K.-P. Heue,G. Jaross, ML. Koukouli, J. Landgraf, R. Lutz, S. Niemejer,A. Pazmiño, G. Pinardi, J.-P. Pommereau, A. Richter, N. Rozemeijer, M.K. Sha, D. SteinZweers, N. Theys, G. Tilstra, O. Torres, P. Valks, C. Vigouroux, and P. Wang.S5P MPC Routine Operations Consolidated Validation Reportseries, Issue #03, Version 03.0.1, 125pp., June2019. http://mpc-vdaf.tropomi.eu/ProjectDir/reports/pdf/S5P-MPC-IASB-ROCVR-03.0.1_FINAL_190621-1827.pdf
- Quarterly Validation Report of the CopernicusSentinel-5 PrecursorOperational Data Products–#02:July2018–February2019.Lambert, J.-C., A. Keppens, D. Hubert, B. Langerock, K.-U. Eichmann, Q. Kleipool, M. Sneep, T. Verhoelst, T. Wagner, M. Weber, C. Ahn, A. Argyrouli, D. Balis, K.L. Chan, S. Compernolle, I. De Smedt,H. Eskes, A.M. Fjæraa, K. Garane, J.F.Gleason, F. Goutail, J. Granville, P. Hedelt, K.-P. Heue,G. Jaross, ML. Koukouli, J. Landgraf, R. Lutz, S. Niemejer,A. Pazmiño, G. Pinardi, J.-P. Pommereau, A. Richter, N. Rozemeijer, M.K. Sha, D. SteinZweers, N. Theys, G. Tilstra, O. Torres, P. Valks, C. Vigouroux, and P. Wang.S5P MPC Routine Operations Consolidated Validation Reportseries, Issue #02, Version 02.0.2, 109pp., April2019. http://mpc-vdaf.tropomi.eu/ProjectDir/reports//pdf/S5P-MPC-IASB-ROCVR-02.0.2-20190411.pdf
- StevenCompernolle,TijlVerhoelst,GaiaPinardi,JoséGranville,Jean-ChristopherLambert(BIRA-IASB)Kai-UweEichmann, S5P MPC VDAF Validation Web Article: Nitrogen Dioxide Column Data, April 2019, http://mpc-vdaf.tropomi.eu/ProjectDir/reports//pdf/S5P-MPC-IASB-ROCVR-02.0.2-20190411.pdf
- Steven Compernolle, Tijl Verhoelst, Gaia Pinardi, José Granville, Jean-Christopher Lambert, Kai-Uwe Eichmann, S5P MPC VDAF Validation Web Article: Nitrogen Dioxide Column Data, 10/9/2018, http://mpc-vdaf.tropomi.eu/ProjectDir/reports//pdf/5bace818a80cc.pdf

2.3.2 Time between data provision and publication of results

Finally, a brief discussion on the time lag between the downloading of a dataset from a provider (e.g. BAQUNIN) and the publication of the related scientific paper or technical document, is reported. We refer here to the BAQUNIN data that are made available through EVDC and the BAQUNIN web services, i.e. to those not routinely distributed via established networks (see Section 3.0 for more details).

The data download, screening, collocation (time/space) and analysis require a few weeks to months, depending on the complexity and nature of the satellite and ground based products.
The scripting of a scientific article requires a few weeks to months, depending on the workload of the authors and on the complexity of the topic.
The scientific article review process might take a few weeks (very rarely) to months (or years, in some cases), depending on the quality of the work or on the complexity of the topic.
Thus, we can optimistically expect to find the first BAQUNIN data related publications in a year from data release to public, i.e. by end 2020.
Of course, the BAQUNIN team is also involved in the Cal/Val activities and in scientific research based on BAQUNIN data. This will result in the production of dedicated Technical Notes and, if findings are of general interest, in scientific publications.
The production time for a Technical Note is much faster than for a scientific paper, however the relevance for the community of the latter is much higher.

3. BAQUNIN DATA PROVISION

In the BAQUNIN project, a large number of ground based active and passive instruments operate in synergy, providing an enormous quantity of atmospheric products of different level of complexity. These products are made freely available to the community.

Three data distribution flows are (or will be) in place:

1. International and National Networks:
   i. EUBREWNET (Brewer)
   ii. EUROSKYRAD (POM-Prede)
   iii. AERONET (CIMEL)
   iv. PGN (Pandora)
   v. Climate-Network (meteorological station)
   vi. Aeroqual (air quality in situ)
2. BAQUNIN web site (http://www.baqunin.eu/)
3. EVDC

The AERONET, PGN, EUROSKYRAD, EUBREWNET and Climate-Network data flow is up and running since quite some years, and the BAQUNIN data have been made available to the scientific community without significant interruptions. The Aeroqual data flow will be active starting on early 2020.

The BAQUNIN web site has been activated on November 29, 2019, all data will be progressively accessible via FTP. This means that the users will be progressively accessing the delivery service and that, at the moment, it is not possible to provide any statistics on number of accesses and downloaded data volumes.

EVDC will be open to public access by early December 2019. It should be noted that, even for this ESA service, no mechanisms for checking “who is downloading what” is in place.

Thus, from start of the BAQUNIN project since now, the data flow was only performed through National and International Networks.

As thoroughly discussed in Chapter 2, this implies that there is no mechanism to verify if and how the BAQUNIN data have been used by the satellite Cal/Val community or by generic users.

What we can provide, however, is the evidence that the BAQUNIN instruments have been used for specific experiments and campaigns during the last 4 years, i.e. since the launch of the BAQUNIN WP in IDEAS+ support contract (2015).

3.1 BAQUNIN data related Peer Reviewed Publications

In what follows, the lists of (known to us) scientific articles published between 2016 and 2019 is reported for EUBREWNET and EUROSKYRAD networks. These article make use of the BAQUNIN

instrumentation and testify the usefulness of the project for scientific and Cal/Val activities, including TPMs.

EUBRWENET (COST1207) aims at establishing a coherent network of European Brewer Spectrophotometer monitoring stations. Currently, 49 brewer instruments are part of EUBREWNET, including the one operating at APL under BAQUNIN responsibility (PI, Anna Maria Siani, University Sapienza - APL).

The EUROSKYRAD (or ESR) network was established in 2010 as a free collaborative platform among scientists involved with studies of aerosol remote sensing by means of sun-sky radiometers. Representatives of ESR are Dr. Monica Campanelli (PI of BAQUNIN instruments) from CNR-ISAC, Italy, and Dr. Victor Estelles from the University of Valencia, Spain.

1) Siani, A.M., Frasca, F., Scarlatti, F., Religi, A., Diémoz, H., Casale, G.R., Pedone, M., Savastiouk, V., "*Examination on total ozone column retrievals by Brewer spectrophotometry using different processing software*" (**2018**), Atmospheric Measurement Techniques, 11 (9), 5105-5123

2) Zerefos, C.S., Eleftheratos, K., Kapsomenakis, J., Solomos, S., Inness, A., Balis, D., Redondas, A., Eskes, H., Allaart, M., Amiridis, V., Dahlback, A., De Bock, V., Diémoz, H., Engelmann, R., Eriksen, P., Fioletov, V., Gröbner, J., Heikkilä, A., Petropavlovskikh, I., Jarosławski, J., Josefsson, W., Karppinen, T., Karppinen, U., Meleti, C., Repapis, C., Rimmer, J., Savinykh, V., Shirotov, V., Siani, A.M., Smedley, A.R.D., Stanek, M., Stubi, R., "*Detecting volcanic sulfur dioxide plumes in the Northern Hemisphere using the Brewer spectrophotometers, other networks, and satellite observations*", **(2017**) Atmospheric Chemistry and Physics, 17 (1), 551-574

3) Marchetti, F., Esteve, A.R., Siani, A.M., Martínez-Lozano, J.A., Utrillas, M.P., "*Validation of UV solar radiation data from the ozone monitoring instrument (OMI) with ground based measurements on the Mediterranean coast*", (**2016**) Revista de Teledeteccion, 47, 13-22

4) Campanelli, M., Siani, A. M., di Sarra, A., Iannarelli, A. M., Sanò, P., Diémoz, H., Casasanta, G., Cacciani, M., Tofful, L., and Dietrich, S.: "Aerosol optical characteristics in the urban area of Rome, Italy, and their impact on the UV index", (**2019**), Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-300 , in review

5) Campanelli M., Mascitelli A., Sanò P., Diémoz H., Estellés V., Federico S., Iannarelli A.M., Fratarcangeli F., Mazzoni A., Realini E., Crespi M., Bock O., Martínez-Lozano J-A, and Dietrich S.; "Precipitable water vapour content from ESR/SKYNET sun–sky radiometers: validation against GNSS/GPS and AERONET over three different sites in Europe", (**2018)**. Atmos. Meas. Tech., 11, 81-94, https://doi.org/10.5194/amt-11-81-2018

6) Campanelli M., A.M. Iannarelli , S. Kazadzis, N. Kouremeti, S. Vergari, V.Estelles, H. Diemoz, A. di Sarra, A. Cede, (**2018**), "The QUATRAM Campaign: QUAlity and TRaceabiliy of

Atmospheric aerosol Measurements". Instruments and Observing Methods; Report No. 132; The 2018 WMO/CIMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (CIMO TECO-2018) "Towards fit-for-purpose environmental measurements" 8 - 11 October 2018, Amsterdam, the Netherlands

For what concerns AERONET and PGN networks, it was not possible to find scientific articles in which the BAQUNIN instrumentation is mentioned. However, as discussed in previous sections, this does not imply that the BAQUNIN AERONET and PGN data have not been used.

As can be seen, these scientific publications, for which some of the BAQUNIN data have been used, deal with:

- TPM validation (OMI UV)
- New products (SO2)
- New retrieval schemes (O3)
- Characterisation of urban atmosphere (aerosols)
- Validation of network performances (water vapour column)
- Sun-photometers inter-comparison campaign

These activities fit very well in the mandate of BAQUNIN project, and have been successfully carried out by the BAQUNIN team.

4. BAQUNIN FOR TPM

4.1 General support

BAQUNIN and EDAP contracts have started to cooperate strictly taking advantage on the BAQUNIN capability in support to EDAP Characterization and Maturity assessment.

As such, it has been settled a cooperation protocol in which a BAQUNIN study is triggered and performed (at no additional cost for ESA) for any EDAP supported Atmospheric mission.

4.2 GOSAT

As recently reported in two BAQUNIN Technical Notes [RD.1, RD.2], a validation activity has been carried out to assess the quality of IWV (vertically integrated water vapour) and AOD (aerosol optical depth evaluated at 500 nm) TPM products.

This activity has been carried out in the context of the ESA's Earthnet Data Assessment Pilot EDAP project (https://earth.esa.int/web/sppa/activities/edap).

The IWV product from GOSAT TANSO-FTS measurements have been compared to the correlative data retrieved from BAQUNIN-AERONET station at APL (Rome downtown). The validation results, discussed in detail in RD.1, are extremely good, thanks to the favourable position of APL in the TANSO_FTS ground pixels. In fact, the so-called collocation-error is de facto negligible, allowing for the evaluation of the IWV uncertainties included in the TANSO-FTS products.

4.3 GCOM-C

The GCOM-C SGLI AOD (500 nm, unpolarised measurements) was compared to BAQUNIN AERONET and EUROSKYRAD counterparts, and to the CNR-ISAC AERONET AOD products (PI G. Gobbi). The exercise focused on one complete year of satellite products.

Validation results, reported in RD.2, showed that the SGLI aerosol products are significantly affected by errors in handling the Earth surface reflectance for urbanised scenes.

These two exercises were performed as demonstrators of the possibilities offered by the BAQUNIN instrumental suite.

5. BAQUNIN FOR CAMPAIGNS

Last but not least, BAQUNIN is actively contributing to inter-comparison, inter-calibration and scientific campaigns, by hosting several instruments at APL for periods ranging from a few weeks to several months (e.g. QUATRAM and QUATRAM-2 for sun photometers in the period 2017-2019, http://www.euroskyrad.net/quatram.html).

Measurement traceability and data quality are essential requirements by the WMO for monitoring atmospheric aerosol optical properties by International radiometer networks. SKYNET network is a WMO-GAW contributing network and a program of traceability to CIMO defined standard instruments and methods has been established, together with inter-comparison and calibration of ESR/SKYNET master instruments activity.

These campaigns have a direct impact on the quality of the data provided by the involved networks that, in turn, are used for the validation of satellite products.

Hence, the factual contribution of BAQUNIN to ANY satellite mission validation is implicitly provided through this mechanism.

6. BAQUNIN FOR EDUCATION

The “SOlar Radiation Based Established Techniques for aTmospheric Observations” (SORBETTO) International Summer School was successfully organized by ISAC-CNR (www.isac.cnr.it), with the support of Sapienza University of Rome (http://www.phys.uniroma1.it/fisica/) and SERCO (www.serco.eu), and financially supported by ESA-ESRIN SPPA Section (https://earth.esa.int/web/sppa/home).

The school was help during the first summer week of July 2018 and aimed at forming young scientists providing them with an overview of the current status of solar radiation based techniques, a solid theoretical base, and hands-on experimental activities.

Students (33) from 16 Nations (Italy, Greece, UK, Spain, Ghana, Senegal, China, Iran, Belgium, Turkey, USA, Algeria, Serbia, Germany, Israel, Hong Kong) attended the courses divided in theoretic lessons, exercises and laboratory activities. Students had also the possibility, during the laboratories, to see the “interior” of state-of-art instrumentations and to learn the principles of their design and operations.

The theory of sun photometry was discussed in morning lessons, held at CNR Head Quarters (https://www.cnr.it/en/headquarters), the afternoon practical lessons were given at Physics Department premises.

International teachers (18) from leading Universities and Research Centres in Europe and Asia were invited to share their experiences with newer generations of scientists, and several sponsors (CIMEL www.cimel.fr, Kipp&Zonen www.kippzonen.com, Delta-T, https://www.delta-t.co.uk/, eurelettronica, http://www.eurelettronicaicas.com/, Lombard e Marozzini, https://www.lombardemarozzini.com/it) showed new equipment. More details on the school programme, teachers and lessons can be found here: http://sorbetto2018.artov.isac.cnr.it/.

In the framework of SORBETTO, the BAQUNIN team was deeply involved in both practical and lessons, and the BAQUNIN-APL site was visited by students and teachers, being considered an excellent example of remote sensing observation structure.

During year 2020, a new edition of the SORBETTO school will take place. Final dates will be agreed by January 2020, the programme is in preparation. Theoretical lessons will be held at CNR HQ while practical will be performed at BAQUNIN-APL (Sapienza).

7. CONCLUSIONS

The aim of this document was to provide evidence of the usefulness of the BAQUNIN project in the context of satellite Cal/Val activities, including TPMs.

As a matter of fact, BAQUNIN data provision for some specific products started on 2015, when the IDEAS+ WP was activated and a Pandora (PGN) and a CIMEL (AERONET) were installed at ESRIN, on the roof of building 11.

During the last five years, the BAQUNIN team as ensured instrument operation and data provision, and continued to increase to number of instruments included in the BAQUNIN suite.

As discussed in this TN, it is virtually impossible to assess the usage of the BAQUNIN data.

However, we demonstrated that the BAQUNIN project has been already been “useful” to:

a) TROPOMI, OMI, GOME-2, GOSAT and GCOM-C product validation
b) EUROSKYRAD Network instrument calibration and data quality assessment
c) Development of new products from sun photometers
d) Development of new retrieval schemes
e) Education

8. NETWORK WEB SITES

Network	URL
AERONET	https://aeronet.gsfc.nasa.gov/
AEROQUAL	https://www.aeroqual.com/outdoor-air-quality/urban%20-air-monitoring
BAQUNIN	http://www.baqunin.eu/
CLIMATE-NETWORK	https://fondazioneomd.it/climate-network
EUBREWNET	http://www.eubrewnet.org/eubrewnet
EUROSKYRAD	http://www.euroskyrad.net/
EVDC	https://evdc.esa.int/
PGN	https://www.pandonia-global-network.org/
SKYNET	https://www.skynet-isdc.org/index.php

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