



LuftBlick Report 2015001

ESA Ground-Based Air-Quality Spectrometer Validation Network and Uncertainties Study

Network Evolution Document

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Document Change Record

Issue	Date	Page	Observations
1	31 Jul 2015	All	First draft version
2	15 Jan 2017	All	Total redesign for all sections

Acronyms and Abbreviations

ESA	European Space Administration
LuftBlick	LuftBlick OG, Austria
NASA	National Aeronautics and Space Administration
Pandonia	ESA Ground-Based Air-Quality Spectrometer Validation Network
SciGlob	Sciglob Instrument & Services LLC, USA
SERCO	SERCO SpA, Italy
Spectral Earth	Spectral Earth GmbH, Germany
USB	Universal Serial Bus

1 Introduction

This report is deliverable D11 of the ESA Ground-Based Air-Quality Spectrometer Validation Network (Pandonia) project [2, 1]. Section 2 describes the currently existing instruments and locations in Pandonia. Section 3 summarizes instrument repair activities. Section 4 presents our view on how to proceed with Pandonia.

1.1 Applicable Documents

- [1] Ground-Based Air-Quality Spectrometer Validation Network and Uncertainties Study [Proposal], LuftBlick Proposal 201309A, Issue 2, 2013.
- [2] ESA Ground-Based Air-Quality Spectrometer Validation Network and Uncertainties Study [Statement of Work], ENVI-SPPA-EOPG-SW-13-0003, Issue 1, Revision 3, 2013.

1.2 Reference Documents

- [3] A. Cede and N. Abuhassen. OMI validation support, LuftBlick Report 2016006: Tracker Design Document, 2016.
- [4] A. Cede and N. Abuhassen. OMI validation support, LuftBlick Report 2016012: Tracker prototype report, 2016.
- [5] A. Cede and M. Tiefengraber. ESA Ground-Based Air-Quality Spectrometer Validation Network and Uncertainties Study, LuftBlick Report 2014004: Pandora-2S Design and Evolution Document, 2014.
- [6] A. Cede and M. Tiefengraber. ESA Ground-Based Air-Quality Spectrometer Validation Network and Uncertainties Study, LuftBlick Report 2017001: Network Calibration and Data Quality Report, 2017.

2 Instruments and locations

Table 1 and figure 1, both located at the end of this document, show existing and potential Pandonia locations. Note that there exist more Pandora instruments than the ones listed, but they are usually not installed on a permanent location or we do not know enough about them and therefore they are not listed in the table.

All locations with an entry in column 4 ('Start Date') in table 1 are measuring nearly continuously since that date. Those without an entry are still in preparatory phase or even not installed at the site, in which case column 1 says TBD. The currently operating instrument(s) are listed in column 5 ('P#').

A 'Prev' in the last column means that the during earlier times, other instruments were monitoring on this site. E.g. the data base at GSFC (first row) started in 2010, but not with the current monitoring instrument Pandora 2.

'Repair' and 'Recal' in the last column means that the current operating instrument has been repaired or re-calibrated respectively at some time since the start date. If the repair/recalibration date is known, then it is listed in format YYYYMM. E.g. Pandora 110 at Innsbruck was re-calibrated in October 2015.

Column 6 ('Type, Owner') gives the 'Instrument type' and the ownership of the instrument. The instrument type can be:

1 - Actual Pandonia station

At the moment we define an "Actual Pandonia station" as a station, which is regularly checked by the network operator. This implies that the instrument is calibrated and uploads data to the server.

2 - Decided Pandonia station

These stations will be part of Pandonia as soon as they are ready to operate continuously.

3 - NASA station

These stations are usually operational and could join Pandonia as soon as the planned ESA-NASA agreement is established.

4 - Interested Pandonia station

These stations have expressed interest to join Pandonia and could be added to the network as soon as a legal and administrative framework is given (see section ??).

The options for 'Owner' are:

LuBl: Instrument was sponsored by ESA and is currently in the property of LuftBlick.

SpEa: Instrument was sponsored by ESA and is currently in the property of Spectral Earth.

SERC: Instrument was sponsored by ESA and is currently in the property of SERCO.

NASA: Instrument is in property of NASA.

self: Instrument is in property of the local institution.

3 Repair

As shown in table 1, Pandonia instruments needed to be repaired occasionally. Smaller repairs can be made by LuftBlick, while for larger repairs the instrument has to be sent to the manufacturer SciGlob. It must be pointed out that all the cost for repairs including the shipping have been paid by LuftBlick or SciGlob so far, even when the age of the instrument was already outside the guarantee-period.

The two-spectrometer system Pandora-2S was developed as part of this project [5]. It required a re-design for most Pandora-parts. The next sections describe some of the consequences of the Pandora-2S design and list the most common reasons for repair.

3.1 Consequences from Pandora-2S development

- Operating a Pandora requires stable and fast communication through serial and USB ports. With Pandora-2S the already high communication data rate nearly doubled.
- A second optical path had to be placed in the head sensor. This reduced the space for the parts inside the head sensor (optical paths, electronics board) and required a total re-design of it.
- With more optical parts in the head sensor its weight increased. This was a problem, since the currently used Pandora tracker is already at the limit of what it can move. Despite reducing the weight as much as possible (e.g. by thinning the head sensor enclosure box), the weight of the Pandora-2S head sensor has still increased compared to what it was before.
- A different temperature controller was adapted, since the area to be temperature-stabilized doubled.
- The layout of the Pandora box had to be changed to accommodate more and larger parts in it.

3.2 Tracker

Currently Pandora uses a commercially available tracker, which is modified to suite our needs. We have noticed the quality of the product to degrade more and more over the last years, since the manufacturer changed to cheaper hardware parts. In combination with the increased weight of the Pandora-2S head sensor (section 3.1), this made the tracking the most 'unreliable' part of the system. In most case, when a tracker problem happened, we had to replace the entire tracker or the tracker driver. We hope that this will change with the new tracker [3, 4].

3.3 Operating computer

Originally, standard commercial laptops were used in the Pandora spectrometer system. With the much higher data rate for Pandora-2S (section 3.1), we have noticed more and more connection interruptions, which required frequent actions from the local or network operator to solve it. Therefore, the laptops have been replaced with rugged single board computers for all Pandoras produced after August 2016. Since those computers have more reliable interface ports, this has significantly reduced the connection issues. The plan is to also replace the operating computers also for instruments produced before August 2016.

3.4 Filterwheels

The re-design of the head sensor (section 3.1) brought several advantages such as improved alignment, better access to the inner parts, better sealing etc. However in the first Pandora-2S types, the newly designed filterwheels were too close together, which caused some friction between them, producing dust that could potentially deposit on the mirror of the opto-encoder. As a consequence the mirror's reflectivity decreased and the filterwheel did not always stop at the correct position anymore. The problem required a repair, that was usually done in Innsbruck.

3.5 Fiber

When Pandora looks to angles close to the horizon, the fiber optics cable(s) usually make a rather sharp bend directly after the stiff part at the front side coming out of the head sensor. This is a critical place, especially when the rest of the fiber is inhibited to move freely for some reason (e.g. being tangled around something or snowed in). We think that this has caused fibers to break. Therefore we want to add the newly developed 'Fiber guide' [6] as soon as possible to many units.

4 Suggested next steps for Pandonia

These are our suggested steps to make the Pandonia network operational:

- Solve the legal questions about Pandonia. This includes a protocol about what it means for a measurement location to be part of the network, and also a well-structured organization among the institutions running and sponsoring the network.
- Add a first instrument 'officially' to the network. That means the protocol must be signed and the station 'approved', the instrument is calibrated, the calibration history is fully documented, and the instrument is operating and send data to the server.
- Add new official instruments one by one to the network using the same criteria.
- Improve the network communication by having emails distributed to all registered operators or data users.
- Optimize current data products and add new data products.

Table 1: List of locations designated to have long-term measurements with Pandora. 'P#' stands for the Pandora number. In the last column 'Prev' stands for previously installed Pandoras at that location, 'Repair' and 'Recal' means that at this date (or no date, if it is unknown) the instrument has been repaired or recalibrated respectively.

Location	Country	Lat/Long/Alt [°/°/m]	Start date	P#	Type, Owner	Remark
Goddard SFC	USA	39/-77/90	20100602	2	3,NASA	Prev 3, 9,19,25,26,29,36
			20121218	32	3,NASA	
Langley RC	USA	37/-76/4	20100624	6	3,NASA	Repair, Recal
			20130131	37	3,NASA	
			20140313	39	3,NASA	
Izaña, Tenerife	Spain	28/-16/2360	20110221	101	1,self	
			20160420	121	1,LuBl	
Houston Univ.	USA	30/-95/64	20120312	25	4,self	
Maryland Univ.	USA	39/-77/73	20120312	25	3,NASA	Prev 21
Busan	South Korea	35/129/228	20120313	20	3,NASA	Prev 17,24,36, Repair
Los Alamos	USA	37/-108/1639	20120605	23	3,NASA	Repair
Toronto	Canada	44/-79/176	20130907	104	4,self	Prev 103
NASA HQ	USA	39/-77/90	20131213	33	3,NASA	Prev 17
Boulder	USA	40/-105/1600	20131216	34	3,NASA	
Innsbruck	Austria	47/11/616	20140208	110	1,LuBl	Prev 106, Recal 201510
Mauna Loa	USA	19/-156/4169	20141103	31	3,NASA	
Harvard Univ.	USA	42/-71/40	20141107	31	4,self	
Downsview	Canada	44/-79/187	20150303	103	4,self	Prev 104
Seoul	South Korea	38/127/181	20150502	17	3,NASA	Prev 19,29
Bucharest	Romania	44/26/93	20160129	111	1,self	Recal 201510, Repair 201611
WRC Davos	Switzerland	47/10/1590	20160404	120	1,SERC	Repair 201606
Athens	Greece	38/24/130	20160406	119	1,self	Repair 201611
Rome Univ.	Italy	42/13/75	20160411	117	1,SERC	
ESRIN, Frascati	Italy	42/13/190	20160501	115	1,SERC	Repair 201607, 201701
Fort McKay	Canada	57/-112/367	20160503	108	4,self	
Helsinki	Finland	60/25/97	20160627	105	1,self	Prev 21, Repair 201507
Barbados	Barbados	13/-59/0	20160806	126	1,SpEa	Repair 201612
Utrecht	Netherlands	52/5/20	20160818	118	1,self	Repair 201701
Richmond	USA	37/-77/6	20160819	35	3,NASA	
Hafelekar	Austria	47/11/2275	20160928	106	1,LuBl	Recal 201507
Broadmeadows	Australia	-38/145/110		112	4,self	
Palau	Palau	7/134/23		127	1,SpEa	
Buenos Aires	Argentina	-34/-59/20		113	4,self	
Comodoro Riv.	Argentina	-46/-67/46		114	4,self	
TBD	Argentina			124	4,self	
TBD	Argentina			125	4,self	
Hamburg	Germany	54/10/0		126	2,SpEa	
Potsdam	Germany	52/13/90		127	2,SpEa	
TBD	Australia			128	2,LuBl	
TBD	Australia			129	2,LuBl	

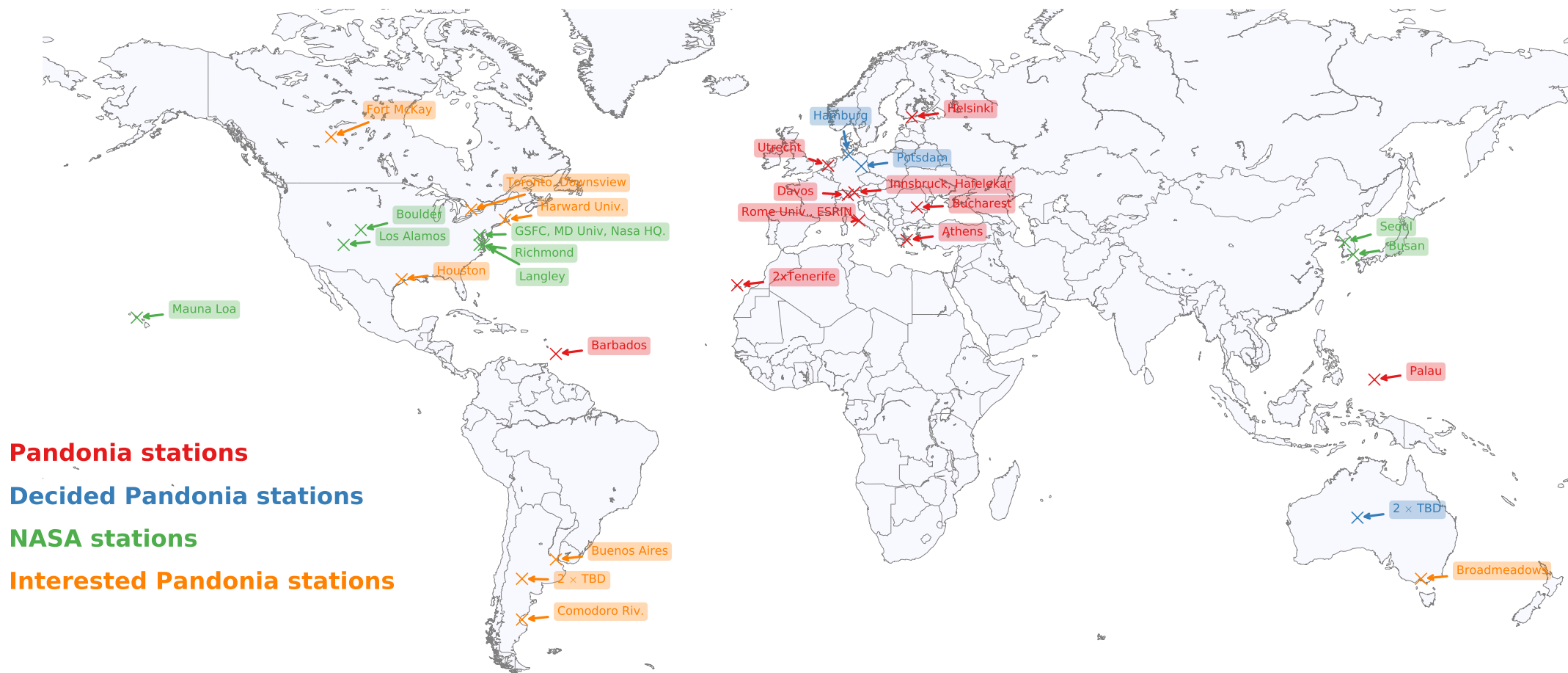


Figure 1: Overview of existing and planned Pandonia network locations.