



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

Acronyms and Abbreviations

ESA	European Space Agency
ESRIN	European Space Research Institute
GSFC	Goddard Space Flight Center
INOE	National RD Institute for Optoelectronics, Romania
NASA	National Aeronautics and Space Administration
Pandonia	ESA Ground-Based Air-Quality Spectrometer Validation Network
R&D	Research and Development
SciGlob	SciGlob Instruments and Services, LLC, USA
Serco	Serco S.p.A., Italy

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 current network status and section 3 future plans. Both sections often refer to table 1 and figure 2 in the appendix, which show all the locations worldwide, where Pandora systems have been distributed. Throughout the document, Pandora locations will be referred to by the given short name (column 'Short name' in table 1).

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.

2 Pandonia - current status

The following bullets summarize the current status of the Pandonia network:

- At present there are two "official" instruments in the network, Pandora 101 at IZO and Pandora 106 at IBK (green color in figure 1).
- A first version of the web server is operational. Data can be uploaded on the server, processed, displayed and downloaded (<http://pandonia.net/data/>).
- In addition to the two official Pandonia measuring stations, data from Pandora Minispectrometers outside the scope of this project have been included to test the capacity of the server etc.. There are currently no official agreements that these additional stations will be part of Pandonia.
- The first Pandora-2S unit (Pandora 110) is currently undergoing calibration trials in the Innsbruck laboratory, and will be measuring at IBK shortly.

3 Pandonia - outlook

The Pandonia webpage is currently operational, with additional planned enhancements to be completed over the course of the project. These additions will not be discussed in this report as they are addressed within deliverables D17 and D18 of the project. Here we focus on the hardware evolution of the network. At present there exist 46 Pandora systems, which could in theory all be part of Pandonia (see table 1 and figure 2). In addition, there are a few more Pandora systems, which are used for other purposes and have a different wavelength range and resolution than the regular systems and are therefore not considered here. We differentiate three groups among the Pandoras and will refer to these groups in the following sections.

- Group "Pans-ESA": Instruments sponsored (not owned) by ESA
- Group "Pans-NASA": Instruments owned by NASA
- Group "Pans-Other": Instrument owned by other institutions (universities, other national agencies)

3.1 Instruments and locations

Here we describe existing and planned instruments/locations for Pandonia, of which we are aware of at this time.

Pans-ESA

Six instruments are sponsored by ESA as part of the Pandonia project [1], purchased by LuftBlick. The regular Pandora 106 is operating at IBK and Pandora 110 (the Pandora-2S prototype) is undergoing extensive laboratory work at IBK. This unit will then be installed in IBK until approximately October and then transferred to IZO as a reference instrument. Two more Pandora-2S systems are currently being built and will arrive at IBK in November 2015. One of them will stay at IBK as a monitoring instrument, while Pandora 106 will become a research instrument. Finally two more Pandora-2S systems will be produced in 2016. There are no final destinations determined for three of the units yet. We suggest at least one of the units becoming a mobile reference instrument.

Three more Pandora-2S systems are sponsored by ESA as part of the IDEAS+ project during 2015. Two of them are purchased by LuftBlick, one by Serco. The instruments will be ready for deployment at a final

destination by the end of 2015. The instrument purchased by Serco will be stationed at ESRIN, Italy (called ITA in figure 1). The locations for the other two units are still to be determined.

One ESA-sponsored Pandora-2S (number 111) will arrive in Bukarest August 2015, where it will stay as a monitoring unit. This unit is purchased by INOE (called BUK in figure 1).

Pans-NASA

All instruments with numbers below 100 (see table 1) are owned by NASA. Many of these units are deployed during measurement campaigns only, from 2011 to 2014 for the DISCOVER-AQ project (see <http://discover-aq.larc.nasa.gov/>) and now for the KorUS project (see <https://espo.nasa.gov/home/korus-aq/content/KORUS-AQ>). Ten of the NASA-owned instruments are stationary:

- Boulder, USA, Pandora 34 (BOUL in figure 1)
- Busan, South Korea, Pandora 20 (2xKOR)
- FourCornersNM, USA, Pandora 23 (NM4C)
- Harvard, USA, Pandora 46 (4xNASA)
- Langley, USA, Pandora 6 (4xNASA)
- MaunaLoa, USA, Pandora 31 (MLO)
- NASAHQ, USA, Pandora 17 (4xNASA)
- Seoul, South Korea, Pandora 19 (2xKOR)
- SERC, USA, Pandora 7 (4xNASA)
- UHMT, USA, Pandora 25 (TEX)

Pans-other

Most existing Pandoras owned by other institutions are in monitoring operation. Not all are listed in table 1, since not all of them upload their data to Pandonia.

- Pandora 101, IZO, Spain (TEN in figure 1)
- Pandora 102, Lulin, Taiwan
- Pandoras 103, 104, 107, 108, Environment Canada (4xCAN)
- Pandora 105, FMI, Finland (FMI)
- Pandora 109, in Australia (2xAUS, just deployed)

In addition, the following instruments have been ordered:

- 2 Pandoras for Argentina (2xARG in figure 1)
- 1 more Pandora for Australia (2xAUS)
- 1 Pandora for Greece (GRE)

3.2 Ownership/Agreements

Here we discuss legal questions related to Pandonia.

Pans-ESA

To our knowledge all instruments sponsored by ESA-projects (not just the ones within the Pandonia project) will be inventory of the purchasing entity until the end of the respective project. It will then be decided, whether the Pandora system stays with the contractor or the ownership is transferred to ESA. All instruments purchased by LuftBlick will be incorporated into Pandonia. LuftBlick will make agreements with stations receiving a

unit regarding the terms of operation. Thus far, to our knowledge there has been no official decision as to the ownership of the instruments at the conclusion of the project in 2016. We are unaware of the plans of the cooperating contractors (Serco and INOE). As of this juncture, we assume that all of these instruments will be part of Pandonia and the respective agreements will be made.

Pans-NASA

All instruments are owned by NASA. Currently, we are allowed to use these data without formal agreement for the Pandonia webpage. We are in discussions with NASA to include all of their units permanently within Pandonia as NASA has expressed interest in becoming an active member of Pandonia: Including man-power for R&D and operation, and facilitating the use of the laboratory at GSFC. No final decision regarding Pandora-related research at a NASA site has been made yet, but is to be expected in 2016.

Pans-other

Other institutions owning Pandoras have expressed interest in participating in Pandonia and it is LuftBlick's goal to facilitate this outcome. However, there are no plans to begin incorporating them prior to the resolution of relevant legal and operational aspects.

3.3 Calibration/Repair

Pans-ESA

All instruments initially undergo laboratory calibration in IBK. Recalibrations or small repairs are to be performed by LuftBlick personnel. Currently, no decisions regarding instrument maintenance beyond the conclusion of the Pandonia project have been made.

Pans-NASA

All instruments initially undergo laboratory calibration at GSFC. Recalibrations or small repairs are to be performed by NASA personnel. There exists the possibility of maintenance collaboration in the future.

Pans-other

All instruments initially undergo laboratory calibration at either IBK or Ellicott City (SciGlob). Thus far, recalibrations or small repairs are the owner's responsibility. LuftBlick is currently offering support to other institutions in this. E.g. Pandora 105 from FMI was repaired (broken fiber) and recalibrated by LuftBlick in IBK during July 2015.

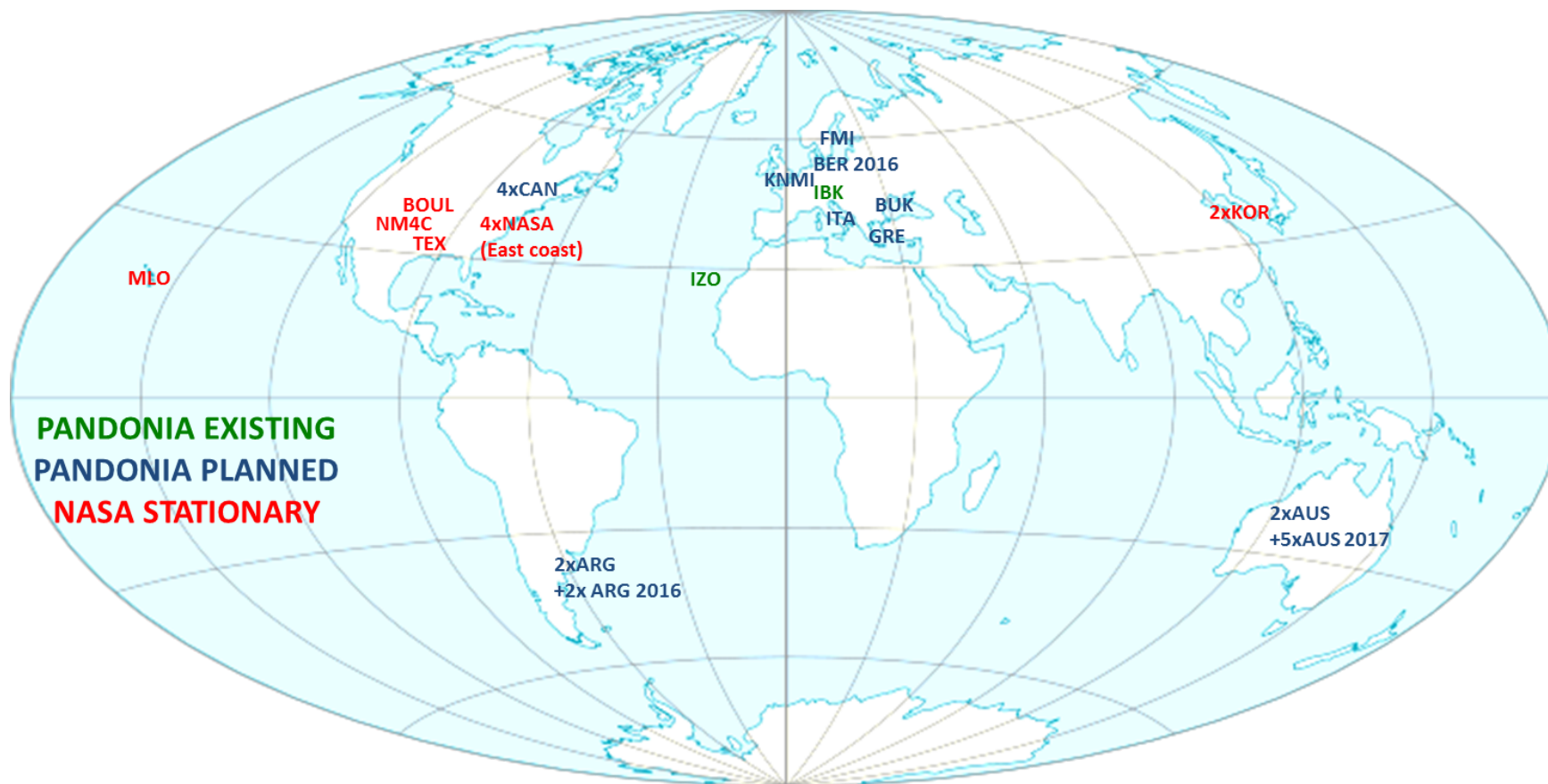


Figure 1: Overview of existing and planned Pandonia network locations.

4 Appendix

Table 1: List lists the locations worldwide, where Pandora systems have been distributed. The Pandora instruments which have been deployed at each site are listed in the very right column.

Short name	Long name	Country	Latitude [-90°, 90°]	Longitude [-180°, 180°]	Altitude [m.a.s.l.]	Pandora ID(s)
AMI	Anmyeon	KOREA	36.538	126.33	41.9	21
Aldino	Aldino (Maryland)	USA	39.563333	-76.203889	128	23, 101
Arvin	Arvin (California)	USA	35.291	-118.7887	158	35
BAOTOWER	BAO TOWER (Colorado)	USA	40.043	-105.006	1579	32, 35
Baengnyeongdo	Baengnyeongdo (Korea)	KOREA	37.965	124.631	114	35
Bakersfield	Bakersfield APT (California)	USA	35.3246	-118.9976	115	33, 36
Beltsville	Howard University Beltsville Laboratory	USA	39.055277	-76.878333	73	20
Boulder	Boulder (Colorado)	USA	39.99093	-105.26067	1600	34
Busan	Busan/South Korea	SOUTH KOREA	35.2353	129.0825	228	20, 36
CIAI	CIAI Izana	SPAIN	28.309	-16.4994	2360	101
Cabauw	Cabauw	NETHERLANDS	51.9704	4.92625	0	3, 6, 9
Channelview	Channelview (Texas)	USA	29.8025	-95.1255	6	26
Chatfield	Chatfield State Park (Colorado)	USA	39.53	-105.07	1675	26
ChesapeakeBay	Chesapeake Bay NOAA/Boat	USA	38.98401	-76.467265	12	24
Conroe	Conroe (Texas)	USA	30.350	-95.425	67	31
Corcoran	Corcoran (California)	USA	36.1022	-119.5656	60	34
DC3	Salina	USA	38.4746	-97.3855	388	17
Deerpark	Deer Park (Texas)	USA	29.6700	-95.1283	6	32
DenverI25	Denver I25 (Colorado)	USA	39.732	-105.015	1590	27
DenverLacasa	Denver Lacasa (Colorado)	USA	39.778	-105.006	1599	36
DoiAngKhang	Doi Ang Khang Site	THAILAND	19.9332	99.04526	1546	16, 42
Dorsey	Dorsey Rock Farm	USA	39.2663	-77.0258	200	6, 9
Downsview	Envcanad (Downsview)	CANADA	43.781	-79.468	187	103
Durham	EPA_RTP	USA	35.8893	-78.8747	100	38
Edgewood	Aberdeen Proving Ground	USA	39.41008	-76.29698	8	8, 18
Essex	Essex (Maryland)	USA	39.310833	-76.474444	12	19
FMI	FMI/Helsinki	FINLAND	60.2037	24.9612	97	21

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Short name	Long name	Country	Latitude [-90°, 90°]	Longitude [-180°, 180°]	Altitude [m.a.s.l.]	Pandora ID(s)
FSU	Frostburg State University	USA	39.6511	-78.9329	567	2, 3, 8, 9
Fairbanks	Fairbanks	USA	64.86	-147.85	510	1, 2, 9, 24
Fairhill	Fairhill (Maryland)	USA	39.701111	-75.868	118	16, 24
FortCollins	Fort Collins West (Colorado)	USA	40.596	-105.129	1577	17, 28
FourCornersNM	Los Alamos D.O.E	USA	36.797	-108.480	1639	23, 29
Fresno	Fresno Garland (California)	USA	36.7854	-119.7731	95	30, 31
GIST	Gwangju	SOUTH KOREA	35.226	126.843	33	26
GSFC	Goddard Space Flight Center	USA	38.9926	-76.8396	90	1, ..., 9, 16, ..., 47, 101, 104, 106
Galveston	Galveston (TEXAS)	USA	29.2544	-94.8612	0	34
Golden	Golden (Colorado)	USA	39.7437	-105.1779	1846	38
Golden2	Golden 2 (Colorado)	USA	39.7437	-105.1779	1846	39
HUFS	Yongin (Korea)	KOREA	37.338	127.265	122	18
Hanford	Hanford (California)	USA	36.3193	-119.6433	80	18, 32
Harvard	Harvard Science Center (Cambridge MA)	USA	42.376211	-71.116155	41	32, 46
Huron	Huron (California)	USA	36.206	-120.105	60	2
IBK	Medical University Innsbruck	AUSTRIA	47.2643	11.3852	616	106
IZO	Izana Atmospheric Research Center	SPAIN	28.309	-16.4994	2360	101
LaPorte1	La Porte 1	USA	29.672	-95.0647	15	38
LaPorte2	La Porte 2 (Texas)	USA	29.672	-95.0647	15	39
Langley	Langley	USA	37.1036	-76.3868	4	3, 6, 37, 39
Lauder	Lauder	NEW ZEALAND	-45.038	169.684	370	37
Library	West Houston Library	USA	29.8334	-95.657	33	18
Lulin	National Central University (Lulin)	TAIWAN	23.46861	120.87361	2868.0	102
Madera	Madera City (California)	USA	36.9533	-120.0342	77	29
Manvelcroix	Manvel Croix (Texas)	USA	29.520	-95.392	18	33
MaunaLoa	Mauna Loa	USA	19.4795	-155.6027	4169	31
MoodyTower2	Moody Tower (Houston)	USA	29.7175	-95.3413	18	28
Moodytower	Moody Tower (Texas)	USA	29.7175	-95.3413	18	35
NASAHQ	National Aeronautics and Space Administra- tion	USA	38.9926	-76.8396	90	17, 33

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Short name	Long name	Country	Latitude [-90°, 90°]	Longitude [-180°, 180°]	Altitude [m.a.s.l.]	Pandora ID(s)
NCUTaiwan	National Central University (Taiwan)	TAIWAN	24.967533	121.185483	150	43
NWHarris	NWHarris Co (Texas)	USA	30.0394	-95.6738	55	30
Niwot	Niwot (Colorado)	USA	40.0318	-105.5334	2888.8	29
Oldtown	Baltimore (Maryland)	USA	39.291492	-76.596456	120	9, 101
PSU	Pennsylvania State University	USA	40.793171	-77.86677	391	8
Padonia	Padonia Elementary School	USA	39.460833	-76.631111	120	17
Parlier	Parlier (California)	USA	36.5974	-119.5037	108	28
Penang	USM_Penang	MALAYSIA	5.358	100.302	181	18
Platteville	Platteville (Colorado)	USA	40.181	-104.726	1521	8, 30
Porterville	Porterville (California)	USA	36.03179	-119.055	141	8, 27
Potchefstroom	Welgedund	SOUTHAFRICA	-26.056986	26.93926	1505	8
RI	ECOMon/NOAA-boat	USA	41.53	-71.3	90	24
RockyFlats	Rocky Flats (Colorado)	USA	39.92	-105.19	1801	31
SERC	Smithsonian Environmental Research Center	USA	38.88	-76.55	90	7, 24
Seabrook	Seabrook park (Texas)	USA	29.9010	-95.3261	18	27
Seoul	Yonsei University/Seoul	SOUTH KOREA	37.5644	126.934	181	17, 19, 29
Shafter	Shafter (California)	USA	35.5035	-119.27264	106	9
Singapore	Singapore	SINGAPORE	1.28	101.77	22	9
Smithpoint	Smith Point(Texas)	USA	29.5462	-94.7869	0	8, 29, 36
SonLa	Son La Vietnam	VIETNAM	21.33	103.91	679.0	102
StaCruzTNF	CIAI Santa Cruz de Tenerife	SPAIN	28.4725	-16.2474	52	101
TableMountain	Table Mountain (Colorado)	USA	40.1249	-105.237	1699	18
Tranquility	Tranquility (California)	USA	36.6341	-120.3824	50	26
UHMT	University of Houston Moody Tower	USA	29.718	-95.341	64	25
UMBC	University Of Maryland Baltimore County	USA	39.2547	-76.709157	73	2
UMCP	University Of Maryland College Park	USA	38.990906	-76.942519	73	21
USNA	Naval Academy (Annapolis Maryland)	USA	38.983673	-76.479558	160	25, 101
Visalia	Visalia (California)	USA	36.3141	-119.3930	90	18
WeldTower	Weld Co Tower (Colorado)	USA	40.39	-104.73	1489	21



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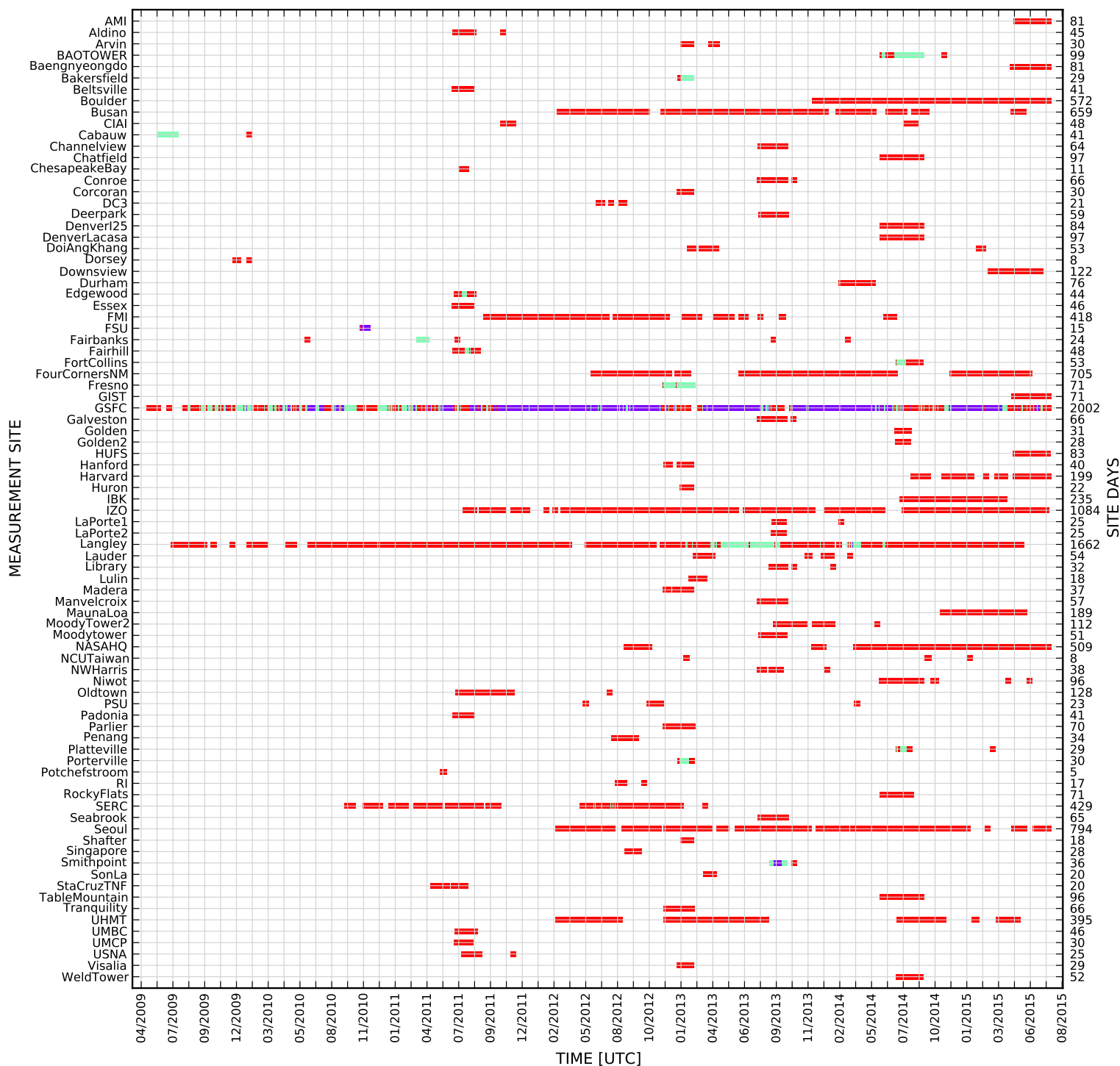


Figure 2: Time periods covered by each measurement site listed in Table 1. Red symbols indicate that one Pandora instrument was operating, green symbols indicate that two Pandora instruments were operating and violet symbols mean that more than two instruments were operating simultaneously at one site.