



LuftBlick Report 2015010

OMI validation support

Pandora validation data

	Name	Company	Date
prepared by	Martin Tiefengraber	LuftBlick	28 Dec 2015
	Moritz Müller	LuftBlick	28 Dec 2015
checked by	Alexander Cede	LuftBlick	28 Dec 2015
approved by			

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Document Change Record

Issue	Date	Section	Observations
0.1	23 Dec 2015	All	First draft version
1.0	28 Dec 2015	3, 4	Actualization of figures and tables

Acronyms and Abbreviations

NO ₂	Nitrogen Dioxide
O ₃	Ozone
AMF	Air Mass Factor
AOD	Aerosol Optical Depth
CLD	Cloud
DQ	Data Quality
DU	Dobson Unit
dWVL	Wavelength Shift
OMI	Ozone Monitoring Instrument
SCAT	Enhanced Data Scatter
sERR	Strong Data Processing Error
TEFF	Effective Measurement Temperature
th _{AMF}	Air Mass Factor Threshold
th _{PAR}	Defined Parameter Threshold
th _{SCAT}	Enhanced Data Scatter Threshold
th _{WVL}	Wavelength Shift Threshold
wERR	Weak Data Processing Error
WRMS	Weighted Root Mean Square

1 Introduction

This report is deliverable TD3370-1.2 of the contract "OMI validation support" [1] within Task 3 of the ESA IDEAS+ project. Section 2 summarizes the quality of the reprocessed Pandora data base. In section 3 we introduce the parameters which serve as basis for the Pandora data quality examination. Section 4 defines the criteria and thresholds used for Pandora data quality flags and gives an overview of their occurrence in the Pandora data base. Appendix A contains a detailed data quality report for each Pandora unit mentioned in *Tiefengraber and Cede* [4].

1.1 Applicable Documents

- [1] OMI Validation Support - Contract Description, Contract Number: 4000111304/14/I-AM, LuftBlick Proposal 201504A, 2015.
- [2] A. Cede. *Manual for Blick Software Suite Version 3*, 2015. URL http://pandonia.net/docs/manuals_reports_notes/BlickSoftwareSuite_Manual_v3.pdf.

1.2 Reference Documents

- [3] A. Cede and M. Tiefengraber. Inter-calibration of ground-based spectrometers and Lidars – Minispectrometer Intercalibration and Satellite Validation, LuftBlick Report 2013003: Mid-term progress Report, 2013.
- [4] M. Tiefengraber and A. Cede. OMI validation support, LuftBlick Report 2015003: List of Pandoras to be considered for OMI validation, 2015.

2 Pandora Data Quality

2.1 Overall Data Quality Flag

We decided to combine all retrieval parameters (see section 3 and 4) into a final overall data quality flag (DQ). DQ is a simple qualification into three groups

- **DQ0: high quality $\Rightarrow$ ready to use**

Data is labeled as DQ0 if all quality parameters are below defined thresholds.

- **DQ1: medium quality $\Rightarrow$ handle with care**

Data is labeled as DQ1 if

- wavelength shift exceeds threshold [condition (5) with wavelength threshold (th_{WVL}) from Table 3].
- direct-sun air mass factor exceeds threshold [condition (3) with AMF threshold (th_{AMF}) from Table 3].
- data show enhanced scatter [condition (6) with enhanced data scatter threshold (th_{SCAT}) from Table 3].

- **DQ2: low quality $\Rightarrow$ do not use**

Data is labeled as DQ2 if

- clouds are present [condition (2) with th_{CLD} from Table 3]
- data contain saturated pixels (that is ERR(1) in Table 2)
- the spectral fitting algorithm terminated because maximum number of iterations has been reached or no convergence could be reached.
- no standard deviation available since only one cycle was measured.

The evaluated overall data quality for Pandora NO₂ and O₃ retrieval is presented in Table 1. The DQ flags are evaluated for each Pandora including all retrievals, no matter where the instrument has been deployed. Note that only a very small fraction of DQ2 is due to saturated pixels. Most situations in DQ2 are due to clouds.

2.2 Data Quality Summary

Table 1: Overall data quality flags (DQ) for Pandora NO₂ and O₃ retrievals. Shown are the relative occurrences of high quality data (DQ0), medium quality data (DQ1) and low quality data (DQ2) in percent (column 2 to 7). The median value covering all Pandora units is given in the last row. The number of retrievals for each Pandora unit for NO₂ (O₃) is shown in column 8 (9) with the overall number of retrievals in the last row.

Pan [ID]	DQ0 [%]		DQ1 [%]		DQ2 [%]		Nmb. of retr.	
	NO ₂	O ₃	NO ₂	O ₃	NO ₂	O ₃	NO ₂	O ₃
2	39	72	3	4	58	23	274477	202252
3	62	60	16	7	22	33	208144	207279
6	52	48	9	0	39	51	577286	575370
7	38	33	9	1	53	67	320360	316383
8	67	37	4	0	28	63	58496	59226
9	48	46	8	1	44	53	290871	282258
16	78	74	13	5	9	22	77992	78408
17	64	54	13	6	23	40	138065	173795
18	43	47	19	5	38	48	381881	349797
19	75	65	16	5	9	30	291506	295800
20	68	65	10	2	21	33	255117	248061
21	45	45	27	6	29	49	248218	249416
23	61	60	13	8	25	32	417648	408301
24	33	32	3	0	64	68	117857	95157
25	73	61	10	4	18	35	140852	130116
26	49	43	9	2	41	55	337814	307130
27	50	44	9	3	40	54	114193	110350
28	36	34	25	3	39	63	84074	82824
29	49	44	9	3	42	54	199271	193670
30	47	44	9	2	44	54	144042	132469
31	61	50	10	3	30	46	210551	212075
32	43	25	5	1	52	74	195341	181424
33	46	40	4	2	49	58	210637	214379
34	39	52	24	4	37	44	270571	322063
35	39	43	19	2	42	55	197159	202581
36	45	39	7	2	48	58	200249	227801
37	62	55	4	1	34	44	64845	65943
38	61	50	7	2	32	48	23545	14250
39	54	32	4	2	42	66	44044	13665
41	75	47	13	2	12	51	357	4972
42	49	32	24	9	27	59	32673	30850
43	51	25	12	0	38	75	9496	10290
46	46	29	6	0	49	71	1661	1813
47	68	31	13	8	19	61	14366	41008
101	63	74	24	5	13	20	344238	309192
102	51	37	6	1	43	62	8988	9226
106	41	43	37	2	22	55	104966	102294
107	72	63	14	1	14	36	4648	4804
median $\sum$	51	44	10	2	37	53	6616499	6466692

All Pandora units are build up by comparable electronic and optical components and the basic design is the same for all instruments (spectrometer, sun tracking unit, telescope, temperature controller, neutral density and band pass filters, etc.). As a consequence, differences in the Pandora overall data quality are not so much caused by the instruments themselves, but by the conditions at the locations, where the instruments are deployed. DQ2 is dominated by two filters: the cloud filter and the air mass factor filter. The former filters approximately have the same number of retrievals for O_3 and NO_2 , while the latter filters include more O_3 retrievals than NO_2 retrievals. Therefore $DQ2(O_3)$ is larger than $DQ2(NO_2)$. $DQ2(NO_2)$ gives basically the percentage cloud cover at a location. DQ1 is dominated by the enhanced scatter effect (see section 3.3. of *Cede and Tiefengraber* [3]). Since this effect influences the NO_2 retrievals much more than the O_3 retrievals, $DQ1(NO_2)$ is larger than $DQ1(O_3)$. This effect is also strongly dependent on the location.

3 Pandora Data Quality Parameters

The Pandora processing software is designed to collect a wide range of instrumental parameters. This gives rise to group selected parameters according to specific quality features. We define these features and their associated parameters as follows:

- **Retrieval quality:**

- **Uncertainty of the vertical column gas amount (uVC)**

The vertical column uncertainty accrued from the spectral fitting procedure. The uncertainty is based on the measurement noise only (i.e. not including the root mean square error of the residuals). For details see *Cede* [2].

- **Normalized root mean square of the weighted spectral fitting residuals (WRMS)**

$$\text{wrms} := \sqrt{\frac{\sum_{j=1}^{n_p} \left(\frac{\zeta_j}{\sigma_j} \right)^2}{\sum_{j=1}^{n_p} \left(\frac{1}{\sigma_j} \right)^2}} \cdot \frac{n_p}{n_p - n_{\text{fit}}}, \quad (1)$$

with ζ_j denoting the spectral residuals, σ_j the measurement uncertainty, n_p the number of pixels in the fitting window and n_{fit} the number of fitted parameters. Details in *Cede* [2].

The quality features listed below are also captured by uVC and WRMS to some extent.

- **Transportation stress:**

- **Zero order wavelength misalignment or wavelength shift (dWVL)**

Amongst others, transportation requires to disconnect and reconnect the head sensor and the spectrometer unit. This could lead to discrete dWVLs if the alignment at the fiber connector is slightly changed.

- **Environmental stress:**

- **Effective measurement temperature (TEFF)**

Each Pandora unit is stabilized to a given set temperature. The range of measured effective temperatures around this set temperature reveals how strongly Pandora units are influenced by ambient air temperature.

- **Processing quality:**

- **Data processing errors (ERR)**

A number of specific information and errors are collected in the course of the data processing and are listed in Table 2. More details in *Cede* [2].

Table 2: Errors collected in the course of a Pandora retrieval process.

Error index	Error details
0	no temp. given or effective temp. more than 2°C off instruments set temperature
1	saturated data
2	dark count too high
3	absolute value of estimated average residual stray light level above 10 %
4	although attempted, no wavelength change could be retrieved
5	retrieved wavelength shift larger than 0.02 nm
6	retrieved wavelength shift differs more than 0.02 nm from predicted shift

An overview of the quality of the NO₂ and O₃ retrievals is presented in Figure 1 and 2. The figure illustrates a pseudo time series (horizontal data spacing not correlated with time) of the parameters WRMS, uVC and dWVL for each Pandora unit mentioned in RD03 up to the date 2015-10-31. The parameters are depicted as absolute values and only cloud and error screened data points are included.

To further be able to see whether a change in a parameter is correlated with a change in the validity period a colored horizontal bar at the bottom indicates the relevant validity period: brown, yellow, magenta bars signify the first, second, third validity period, respectively.

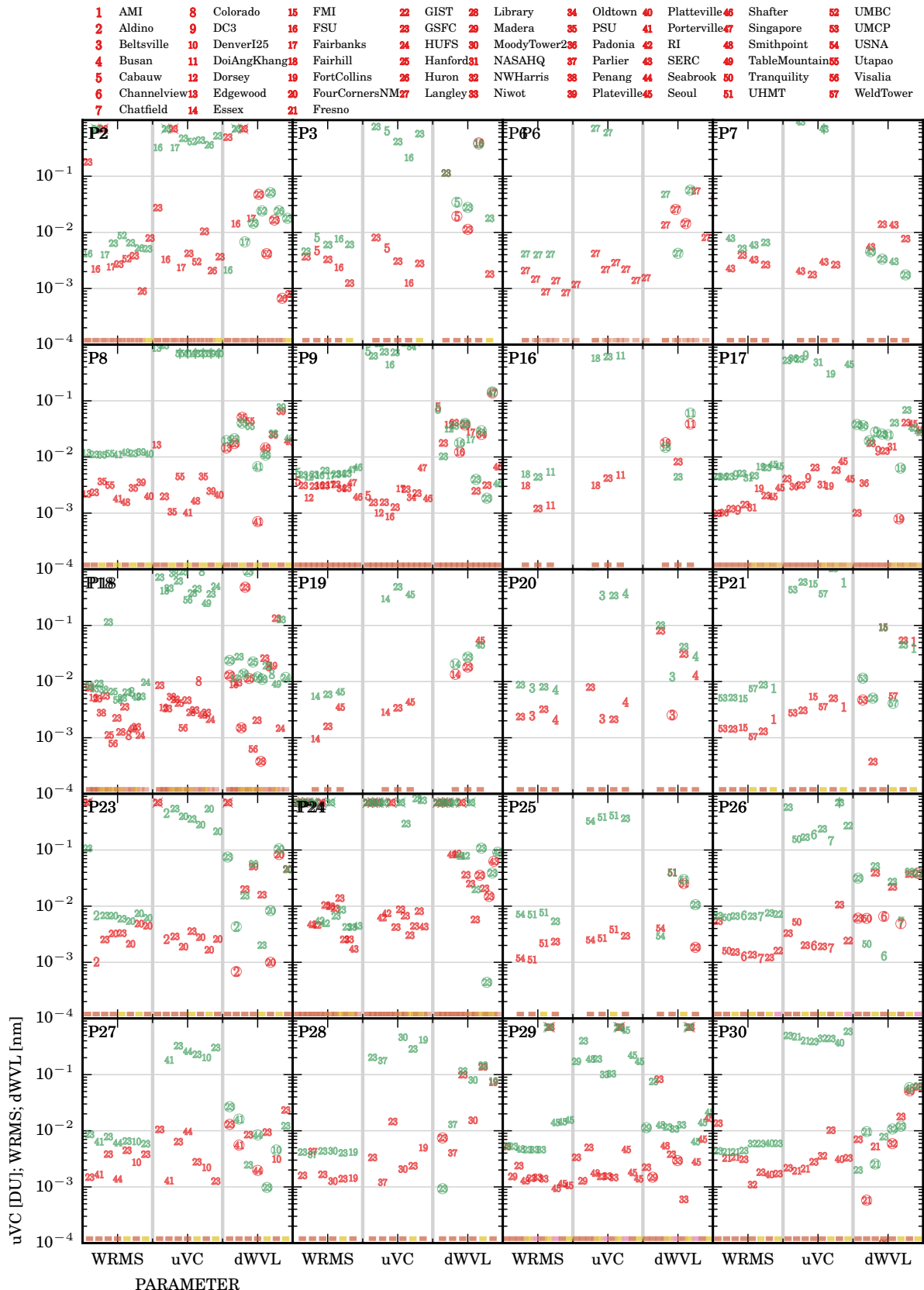


Figure 1: Data quality overview for NO₂ (red) and O₃ (green) Pandora retrievals for Pandora 2 to Pandora 30. Shown are pseudo time series (spacing not correlated with time) of median values of WRMS, uVC and dWVL for Pandora locations providing more than 7 days of measurements. Data points are marked as numbers representing a location. The data set is cloud and error screened. If the screening omits all data of a location the data point is crossed out. Values exceeding the viewing range are indicated by an up arrow and negative values (for dWVL only) are encircled.

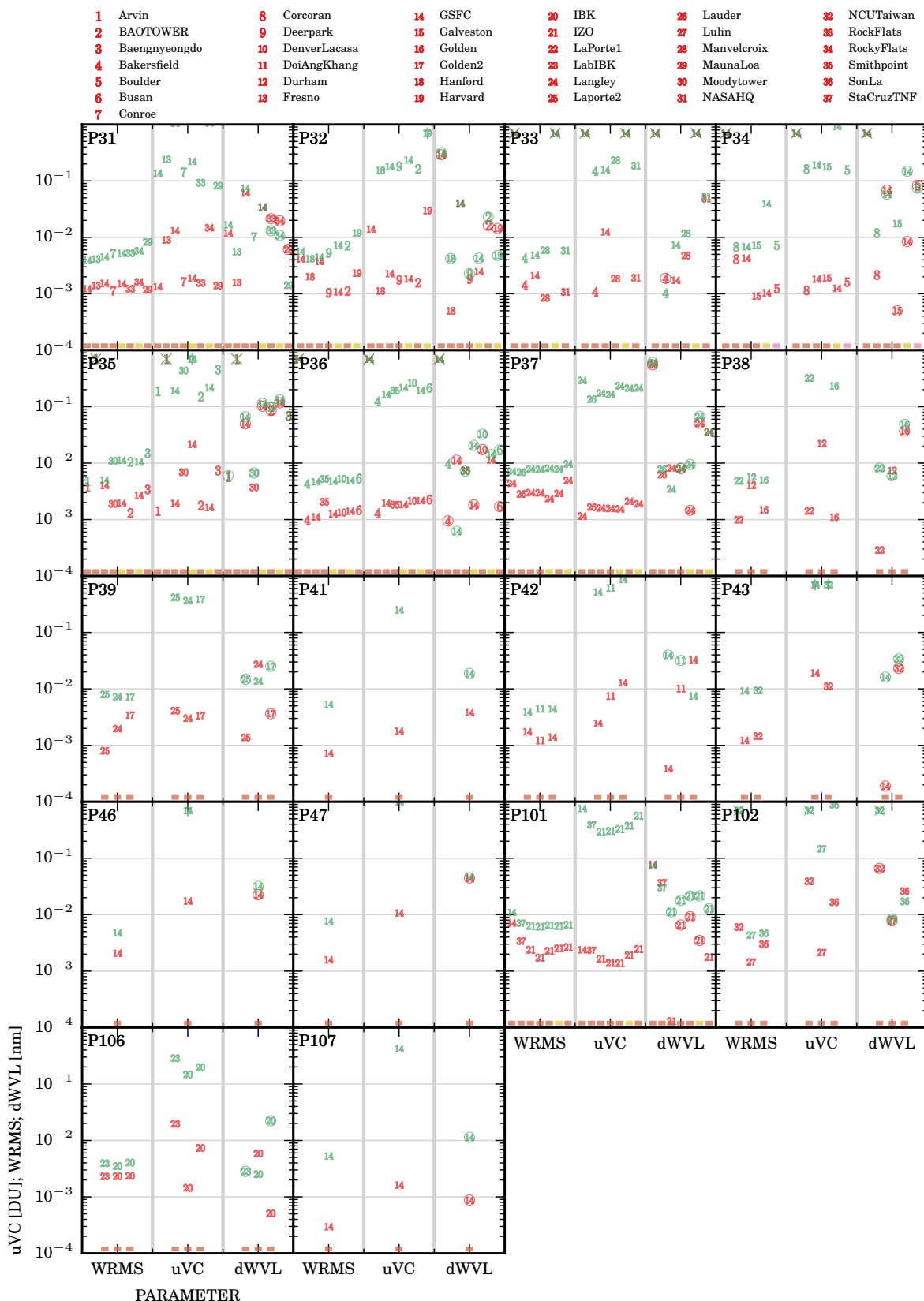


Figure 2: Data quality overview for NO₂ (red) and O₃ (green) Pandora retrievals for Pandora 30 to Pandora 107. Shown are pseudo time series (spacing not correlated with time) of median values of WRMS, uVC and dWVL for Pandora locations providing more than 7 days of measurements. Data points are marked as numbers representing a location. The data set is cloud and error screened. If the screening omits all data of a location the data point is crossed out. Values exceeding the viewing range are indicated by an up arrow and negative values (for dWVL only) are encircled.

4 Pandora Data Quality Flags

The basis for the data quality flags are the parameters defined in section 3. Flags are calculated for each measurement time t and allocated by “1” (flag applicable) if a defined parameter threshold th_{PAR} is reached or exceeded. Section 4.1 describes conditions for each data quality flag. The corresponding th_{PAR} are described in section 4.2.

4.1 Flag conditions

- **CLD** → flag for cloud filtering.

The CLD flag conditions are

$$CLD_t = \begin{cases} 1, & \text{for } uVC(GAS)_t > th_{CLD} \\ 0, & \text{otherwise,} \end{cases} \quad (2)$$

with uVC as vertical column uncertainty.

- **AMF** → flag for direct-sun air mass factor (amf). This flag is necessary to exclude data affected by internal stray light (see *Cede and Tiefengraber* [3], section 3.3). amf is given by

$$amf := \sec \left\{ \arcsin \left[\left(\frac{r}{r + h_{eff}} \right) \cdot \sin(\theta^*) \right] \right\},$$

with θ^* as apparent solar zenith angle (corrected for refraction), r as distance from the measurement location to the earth center and h_{eff} as assumed effective height of the absorbing gas layer.

The AMF flag conditions are

$$AMF_t = \begin{cases} 1, & \text{for } amf_t > th_{AMF} \\ 0, & \text{otherwise.} \end{cases} \quad (3)$$

- **WRMS** → flag for normalized root mean square of the weighted spectral fitting residuals [$wrms$, see equation (1)].

The WRMS flag conditions are

$$WRMS_t = \begin{cases} 1, & \text{for } wrms_t > th_{WRMS} \\ & \text{and } \neg CLD_t \\ & \text{and } \neg AMF_t \\ 0, & \text{otherwise.} \end{cases} \quad (4)$$

That is a data point is only flagged by WRMS if it is not captured by the CLD or AMF flag.

- **WVL** → flag for zero order wavelength misalignment (wavelength shift).

The WVL flag conditions are

$$WVL_t = \begin{cases} 1, & \text{for } |dWVL_t| > th_{WVL} \\ & \text{and } \neg CLD_t \\ & \text{and } \neg AMF_t \\ 0, & \text{otherwise.} \end{cases} \quad (5)$$

Again a data point is only flagged by WVL if it is not captured by the CLD or AMF flag.

- **SCAT** → flag for enhanced data scatter if the data scattering is not correlated with actual variations in the VC over the time (see *Cede and Tiefengraber* [3], section 3.3). The scattering is mirrored by fluctuations in the WRMS.

The flag conditions are [with $T = \{-2, -1, 1, 2\}$]

$$\text{SCAT}_t = \begin{cases} 1, & \text{for any } (|\text{wrms}_{t+i \in T} - \text{wrms}_t|) > \text{th}_{\text{SCAT}} \\ & \text{and any } (\neg \text{CLD}_{t+i \in T}) \\ & \text{and any } (\neg \text{AMF}_{t+i \in T}) \\ & \text{and any } (\neg \text{WVL}_{t+i \in T}) \\ 0, & \text{otherwise .} \end{cases} \quad (6)$$

A data point is only flagged by SCAT if the surrounding data points $t \in T$ are not captured by CLD, AMF or WVL flags.

- **wERR** and **sERR** → flag for “weak” (wERR) and “strong” (sERR) data processing errors (according to Table 2). An error is defined to be weak if the error does not cause change in the magnitude of the retrieved value. In contrast, errors defined to be strong could have the capability to change the magnitude of the retrieved value.

The wERR and sERR flag conditions are

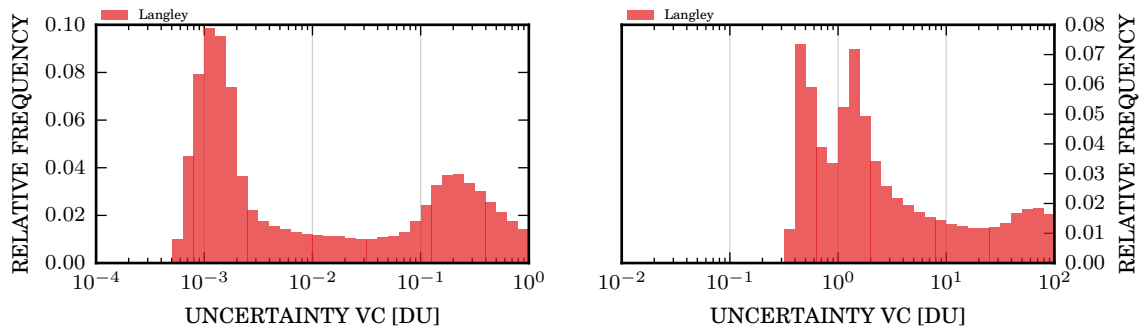
$$\begin{aligned} \text{wERR}_t &= \begin{cases} 1, & \text{for error in } \text{ERR}_t(0, 5, 6) \\ 0, & \text{otherwise ,} \end{cases} \\ \text{sERR}_t &= \begin{cases} 1, & \text{for error in } \text{ERR}_t(1, 2, 3, 4) \\ 0, & \text{otherwise .} \end{cases} \end{aligned}$$

4.2 Flag thresholds

- **CLD**

In direct sun data we expect a bimodal distribution of uVC. One peak (low uVC) represents sun-free situations and one peak (high uVC) sun-covered situations. In between the peaks the threshold for CLD should be located. The data with intermediate uVC are in transition from high aerosol loading to thin clouds. In contrast to AOD cloud screening the exact value for CLD threshold for gas retrievals is not that sensitive.

All Pandora units show comparable magnitudes of uVC (see Figure 1). Thus we choose the Pandora unit with the longest continuous (i.e. excluding travel-uncertainties) time series to define th_{CLD} (Figure 3). Evaluating Figure 3a (3b) for NO_2 (O_3) retrieval declares an uVC value of $5.00\text{e-}02$ ($5.00\text{e+}00$) DU to be a proper CLD threshold.



(a) NO₂ uncertainty distribution, Langley (Pandora 6). (b) O₃ uncertainty distribution, Langley (Pandora 6).

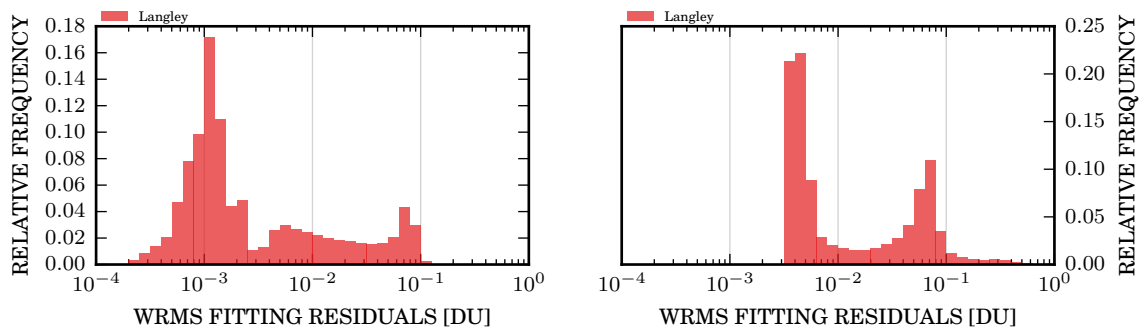
Figure 3: Example uncertainty distribution for NO₂ (a) and O₃ (b) retrievals. The bimodal behavior indicates sun-free (low uncertainty) and sun-covered (high uncertainty) situations.

- **AMF**

The threshold for the AMF flag is defined to be 7 (5) for NO₂ (O₃) retrievals. This restriction is a consequence of internal stray light and has been introduced in *Cede and Tiefengraber* [3].

- **WRMS**

We can expect a close correlation of WRMS and uVC and hence also a bimodal distribution of WRMS in the direct sun data. The bimodal behavior is exemplary shown for Langley, Pandora 6 (longest continuous time series, Figure 4). However the clear separation of sun-free and sun-covered situations obvious for uVC is less pronounced for wrms. Especially for NO₂ retrievals (see Figure 4a). The reason for that is still a point under investigation. The consequence is that cloud screened data still can exhibit enhanced WRMS. Based on Figure 4a (4b) we define the WRMS threshold for NO₂ (O₃) retrievals to be 0.005 (0.02).



(a) NO₂ wrms distribution, Langley (Pandora 6). (b) O₃ wrms distribution, Langley (Pandora 6).

Figure 4: Example distribution of the normalized root mean square of the weighted fitting residual for NO₂ (a) and O₃ (b) retrievals. The almost bimodal behavior indicates sun-free (low wrms) and sun-covered (high wrms) situations.

- **WVL**

Pandora instruments are very robust against changes in the wavelength registration. In addition, misalignments are rectified with great effort by the Pandora processing software. As a result the choice of WVL threshold is not critical. We choose the WVL threshold based on the experience what usually can be

expected when a Pandora unit changes the deployment location (compare also Figure 1). These location changes hardly induce wavelength shifts > 0.1 (0.2) nm for NO_2 (O_3) column retrieval. Consequently we state the WVL threshold allowed for DQ0 data to be ≤ 0.1 (0.2) nm.

• SCAT

As already reported in *Cede and Tiefengraber* [3] the reason for the enhanced data scatter is still unknown. As a consequence we define the threshold for SCAT empirically by investigating specific days where the enhanced data scatter is obvious (Figure 5). An vicarious example is given by the NO_2 columns for Pandora 101 in Izana for the 7th Oct. 2011 (Figure 5a). The enhanced data scatter is properly identified by a threshold of 0.0004 (horizontal lines in the bottom figure). In contrast to NO_2 , O_3 wrms scatter is not correlated with VC scatter. Although periods with enhanced wrms scatter can be identified (Figure 5b bottom) the effect on the data is not distinguishable from the overall variation (Figure 5b top). Hence we define SCAT for O_3 retrievals to be 0.01, but knowing the impact on the data is actually negligible.

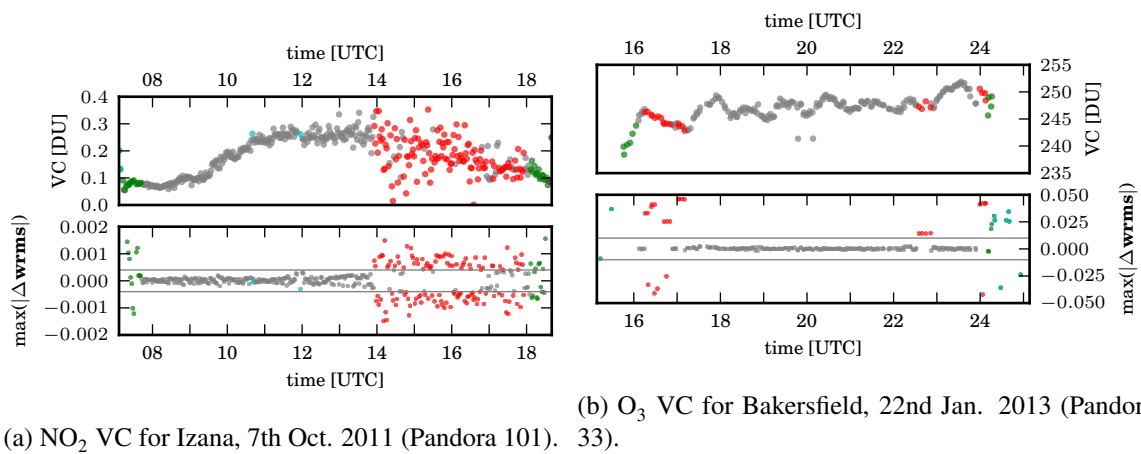


Figure 5: **top**: diurnal variation for NO_2 (a) and O_3 (b). **bottom**: diurnal variation in the maximum deviation of the adjacent wrms values to the reference value [compare equation (6)]. Red data points indicate SCAT, green AMF and cyan CLD flagged data points. Horizontal bars embrace the SCAT threshold.

Table 3 sums up all thresholds th_{PAR} for the defined data quality flags.

Table 3: Thresholds for selected data quality parameters.

th_{PAR}	NO_2	O_3
th_{CLD} [DU]	5.00e-02	5.00e+00
th_{AMF}	7.00e+00	5.00e+00
th_{WRMS}	5.00e-03	2.00e-02
th_{WVL} [nm]	1.00e-01	2.00e-01
th_{SCAT}	4.00e-04	1.00e-02

An overview about the quality flags obtained from the NO_2 and O_3 retrievals is depicted in Figure 6 and 7 for CLD, WVL and SCAT. Data points are calculated and illustrated in the same manner as for Figure 1, but denoting the median values of the relative occurrence of each flag.

A compact view of the quality flags is given in Table 4. Here we averaged all median occurrences from all locations. The averaging does not consider the duration of the measurement period. Therefore long time series do not dominate the mean value.

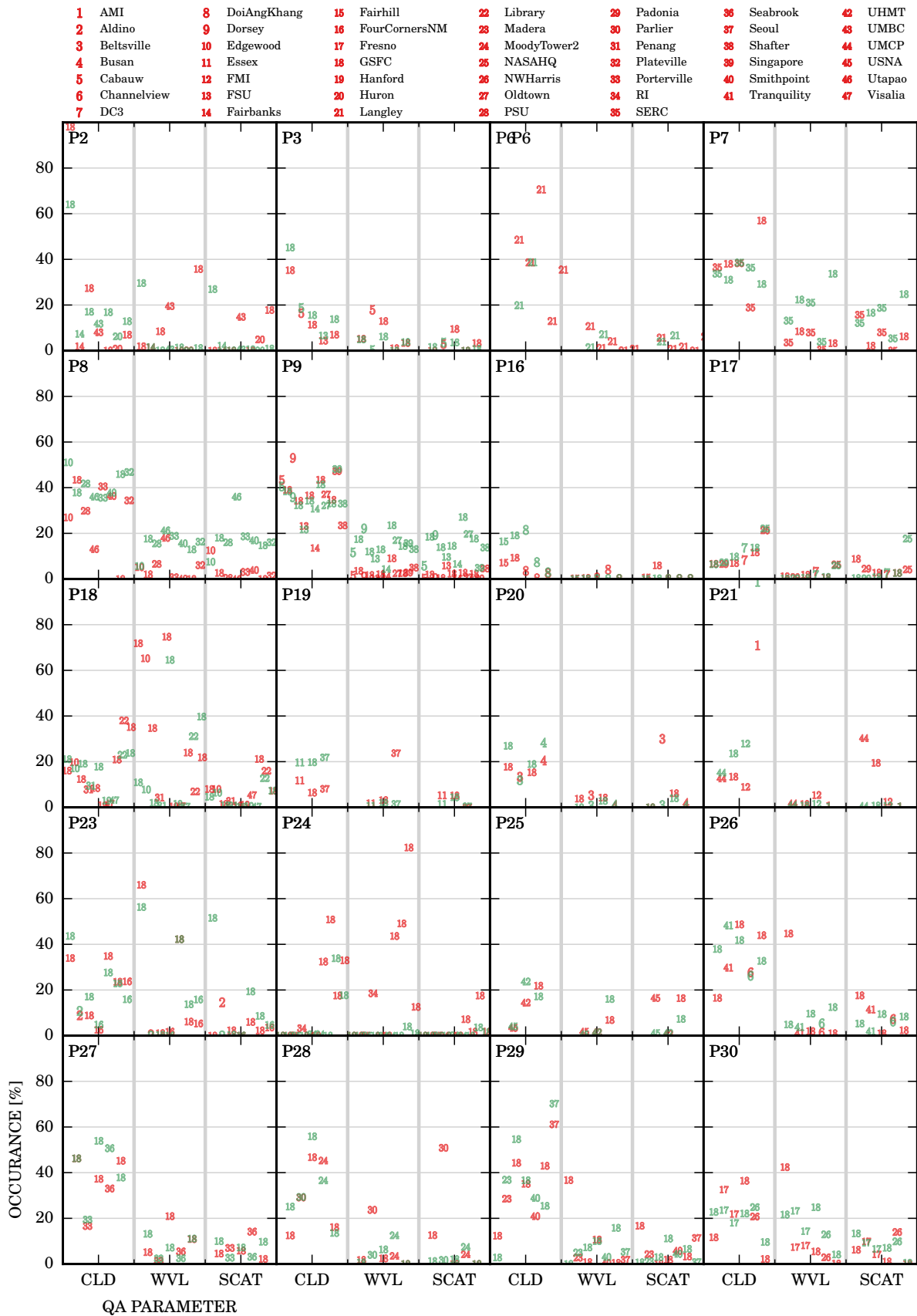


Figure 6: Pandora quality flag overview for NO₂ and O₃ retrieval from Pandora 2 to Pandora 30. Shown are the relative occurrence of CLD, WVL and SCAT flags. Figure explanation see Figure 1. Note that WVL is calculated with a more stringent threshold $th_{WVL} = 0.01$ (0.1) for NO₂ (O₃).

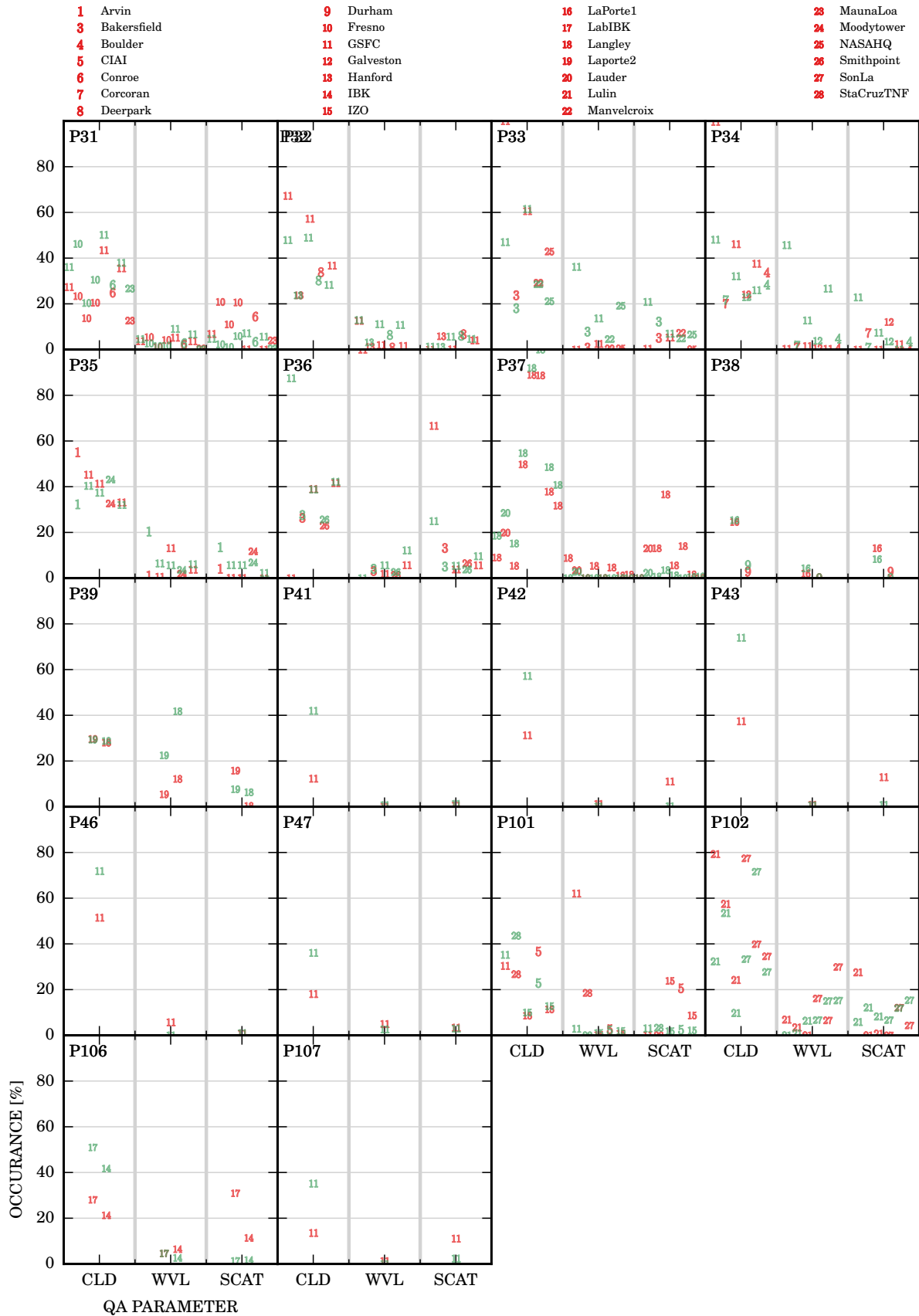


Figure 7: Pandora quality flag overview for NO₂ and O₃ retrieval from Pandora 31 to Pandora 107. Shown are the relative occurrence of CLD, WV and SCAT flags. Figure explanation see Figure 1. Note that WV is calculated with a more stringent threshold $th_{WV} = 0.01$ (0.1) for NO₂ (O₃).

Table 4: Summary of all Pandora quality flags. Each value is calculated by averaging (without weighting) all median flag occurrences of all locations. Note that WVL is calculated with a more stringent threshold $th_{WVL} = 0.01$ (0.1) for NO_2 (O_3).

Pan [ID]	CLD [%]		AMF [%]		WRMS [%]		WVL [%]		SCAT [%]		wERR [%]		sERR [%]	
	NO_2	O_3	NO_2	O_3	NO_2	O_3	NO_2	O_3	NO_2	O_3	NO_2	O_3	NO_2	O_3
2	21	19	13	19	10	5	51	6	5	5	56	74	24	18
3	15	20	12	15	8	3	76	36	3	2	91	96	36	37
6	41	29	10	14	3	4	71	7	3	5	94	87	8	35
7	38	34	13	16	5	19	42	12	6	16	82	89	3	9
8	28	42	8	13	5	16	55	16	3	18	67	83	14	16
9	36	35	13	15	3	14	63	18	2	14	85	83	13	4
16	5	13	8	12	1	0	87	3	1	0	71	69	0	1
17	10	12	12	14	2	2	45	1	4	4	26	83	2	6
18	16	15	14	17	30	18	55	31	7	4	49	67	2	2
19	9	20	13	18	10	1	81	3	4	2	47	78	0	5
20	17	22	14	16	4	1	58	11	10	1	72	76	0	6
21	27	41	15	20	2	1	35	5	13	1	58	64	1	8
23	20	20	9	13	18	18	54	11	4	12	46	58	15	7
24	14	6	4	5	21	1	75	11	3	1	65	78	15	12
25	13	15	10	14	3	6	42	4	11	3	46	51	20	25
26	33	37	13	18	10	7	42	7	8	6	42	59	1	6
27	36	42	14	20	9	7	40	9	7	7	37	54	20	54
28	30	32	13	19	6	5	40	25	14	3	53	72	1	4
29	35	37	12	16	8	7	32	20	6	4	54	72	1	5
30	21	20	13	12	11	17	65	15	6	8	48	57	18	3
31	25	35	14	19	3	4	26	6	10	4	31	47	11	46
32	44	31	13	16	4	7	35	20	3	3	49	55	10	19
33	51	35	15	21	1	16	32	17	4	10	36	52	21	25
34	44	30	11	16	1	16	51	36	4	6	48	75	18	21
35	42	37	12	17	4	8	73	30	3	7	73	81	9	18
36	26	44	10	34	22	5	39	17	19	10	41	57	32	60
37	41	50	10	13	3	0	57	25	10	1	45	71	14	54
38	14	16	4	5	1	2	52	2	8	4	52	62	1	3
39	29	29	7	8	9	32	40	33	8	7	52	41	4	20
41	12	42	15	19	0	1	18	9	1	1	22	67	0	8
42	31	57	11	12	1	0	40	15	11	0	39	82	7	62
43	37	74	11	12	1	1	19	4	13	1	17	53	8	52
46	52	72	11	14	6	0	96	11	1	1	77	89	2	39
47	18	36	14	19	5	3	90	4	3	3	89	89	9	53
101	23	25	8	11	17	2	44	2	11	3	52	64	0	58
102	52	38	30	39	10	7	57	7	7	10	60	63	29	64
106	25	46	14	19	6	4	30	20	21	2	29	41	5	13
107	14	35	10	13	1	0	7	2	11	2	5	22	2	20
median(All)	26	34	12	16	5	5	48	11	6	4	51	68	8	18

5 Pandora Data Quality Reports

Appendix A contains a detailed data quality report for each Pandora unit mentioned in RD03. Each individual report comprises each location a Pandora unit has been deployed up to 2015-10-31. The structure of the reports is as follows:

- **Meta information**
 - **Validity:** start date, end date and version of the validity periods assigned to the data. The periods are horizontally separated by vertical bars.
 - **Instrument:** spectrometer characteristics and spectrometer controller set temperature. Again, validity period specific information are separated by vertical bars.
 - **Spectral fitting parameters:** parameters characterizing the spectral fitting setup for NO₂ and O₃.
- **Pandora site days**
 - Summarizes the periods of Pandora units in each location and gives the number of available retrievals. Also indicating the validity (start) period(s).
- **Data quality**
 - The data quality parameters and flags explained in section 3 and 4 are listed here in detail. The frequency of each parameter within a given interval is depicted (histograms). Additionally, for some parameters (uVC, WRMS, dWVL, TEFF) the minimum and maximum values as well as the 10, 25, 50, 70 and 90 percentiles are listed as box-whisker plots (located above the frequency plots). The box-whisker representation is shown in Figure 8.

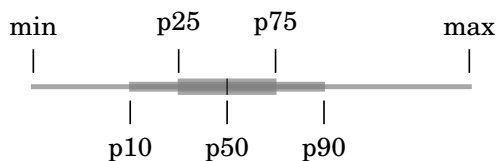


Figure 8: Box plots whisker allocation.

If the minimum (maximum) of the distribution is outside the x-axes range of the figure it is explicitly written on top of the box-whisker plot. If even the median is outside the x-axis range of the figure, then its value is listed underscored on top of the box-whisker plot.

The data quality flags are evaluated based on the thresholds given in Table 3. However, for WVL a more stringent threshold is employed to indicate also minor influences on the wavelength misalignment. In the following th_{WVL} is chosen to be 0.01 (0.1) nm for NO₂ (O₃) retrievals.

Comments on histogram distribution: As already mentioned, some parameters can show bi-or multi-modal distribution of the data. Bimodal distribution in a uVC histogram essentially dissociates a sun-free (low uVC peak) and sun-covered (high uVC peak) region. A Comparable behavior can also be seen for WRMS histograms. Multi-modal distribution emerges primarily for WVL histograms, although more than one mode should ideally not happen. It is typically related to a new instrument situation, e.g. a wavelength shift resulting from a move to a new location, or from bringing it into the laboratory. These wavelength shift can be "reset" with a new calibration, but if we decide to continue with the existing calibration another mode will be seen in the distribution around the new dispersion.

5.1 PANDORA 2 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20090522 20111013
validity period end	20111012 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	1001056U1 1001056U1
number of pixels	2048 2048
A/D converter	16 16 bits
effective saturation limit	57.984 57.984 %
temperature controller set temp.	20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

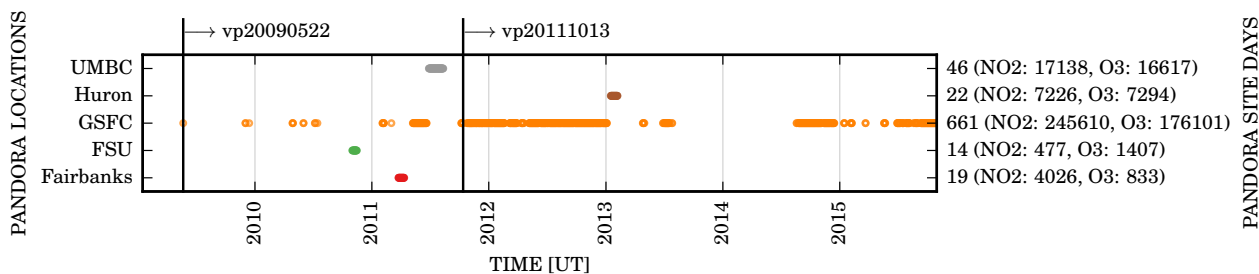
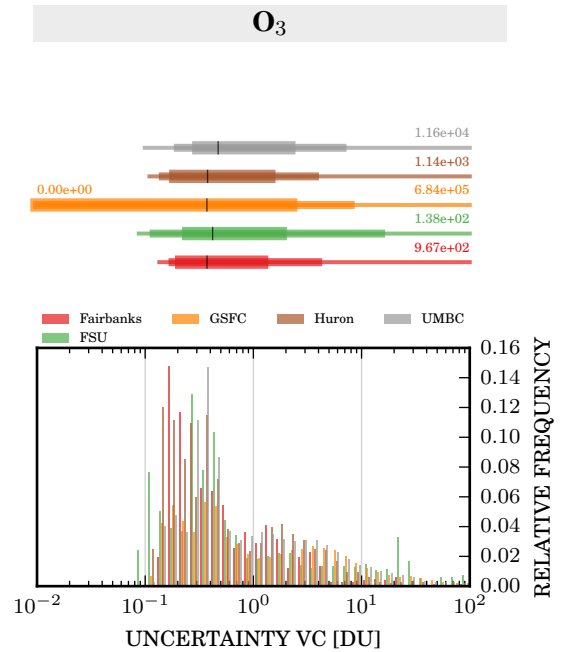
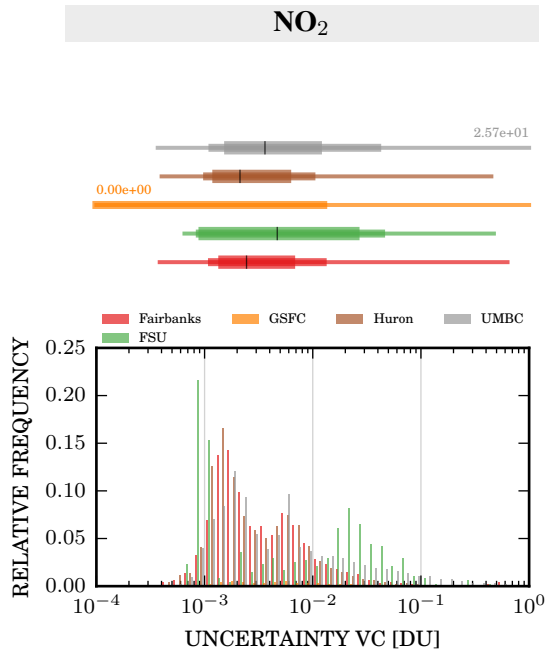


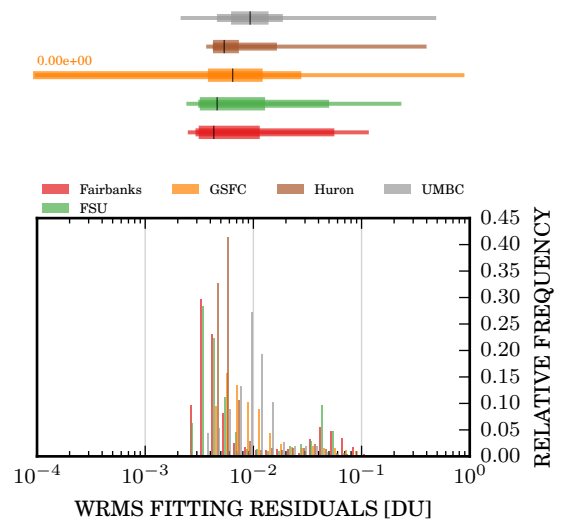
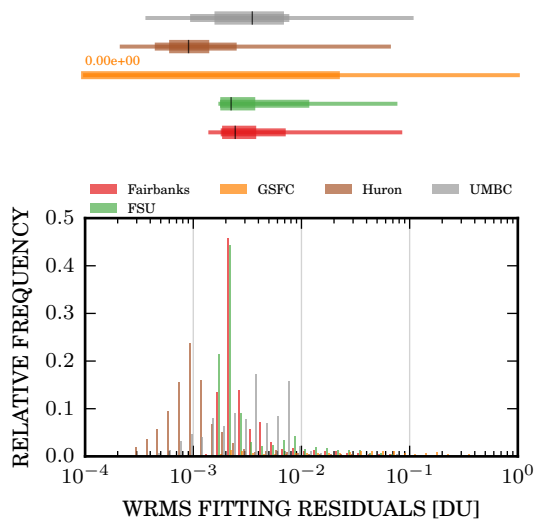
Figure 9: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

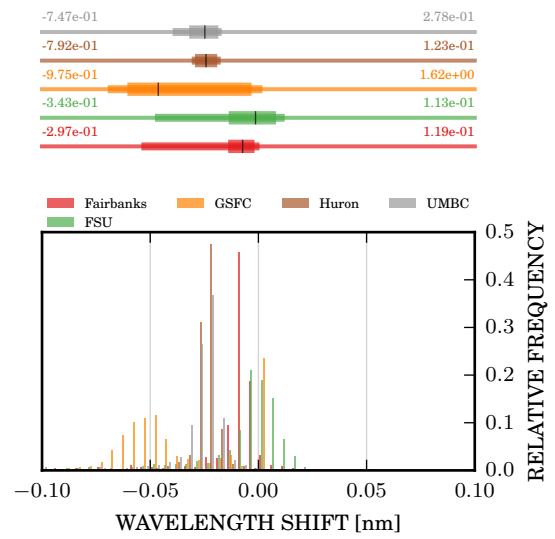
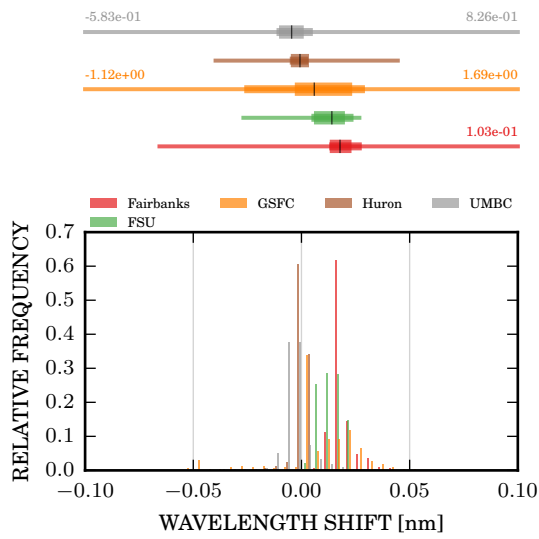
1. UNCERTAINTY VC



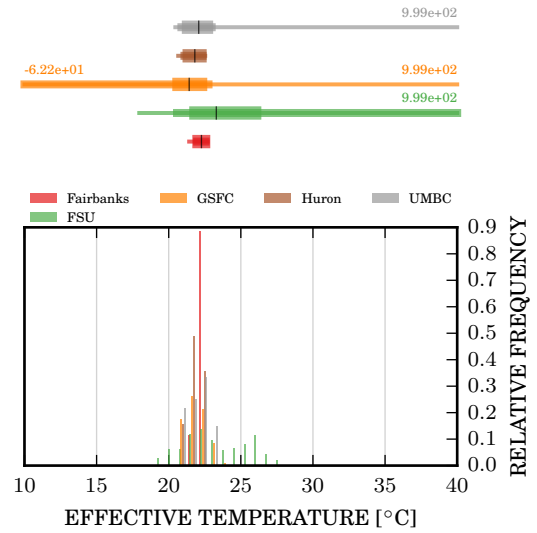
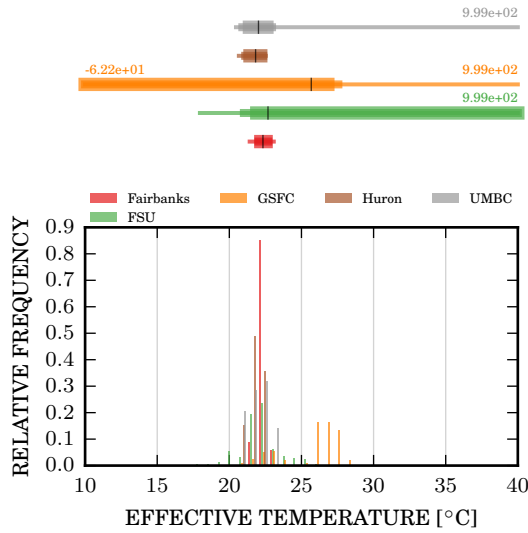
2. WRMS SPEC. FIT. RES.



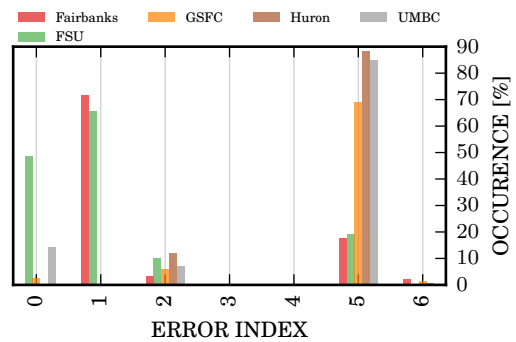
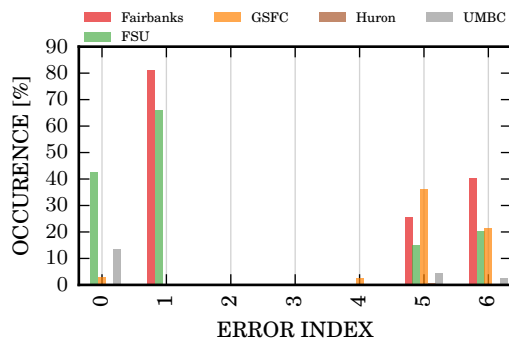
3. WAVELENGTH SHIFT



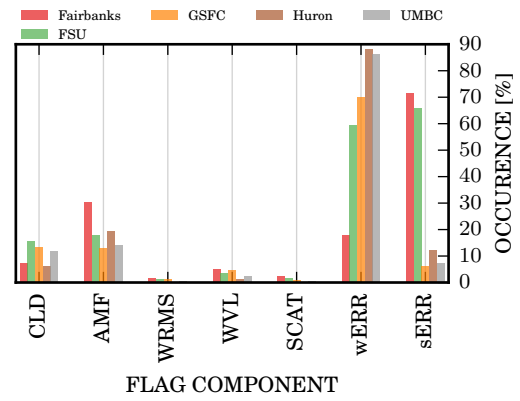
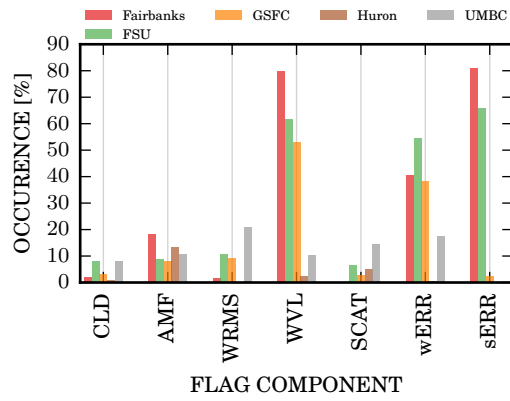
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.2 PANDORA 3 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20090520 20100826 20110220
validity period end	20100803 20110219 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	0801090U1 1001053U1 1001053U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	74.769 76.295 76.295 %
temperature controller set temp.	10.0 10.0 10.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

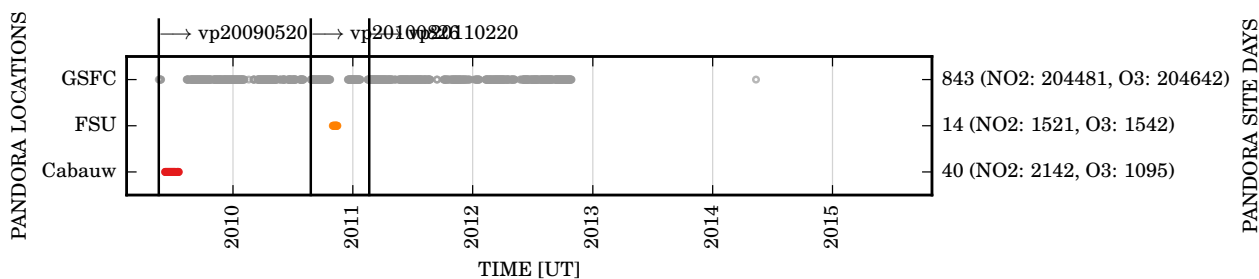
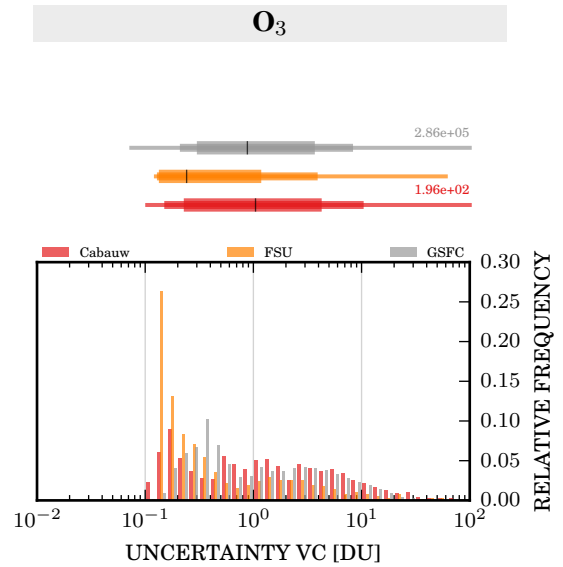
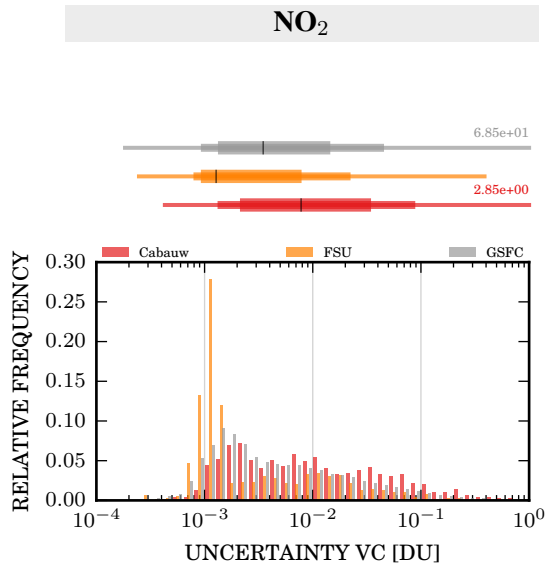


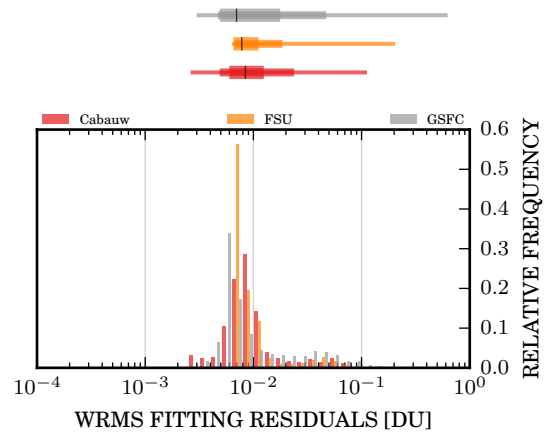
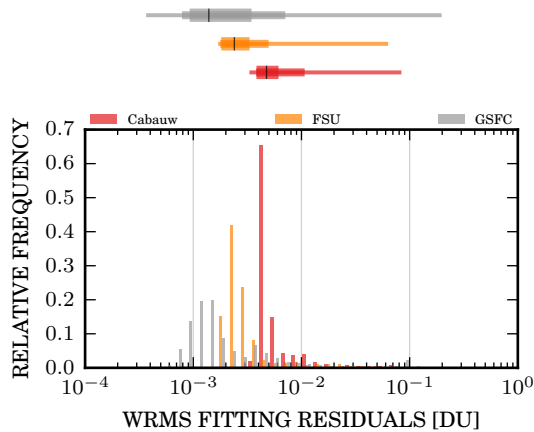
Figure 10: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

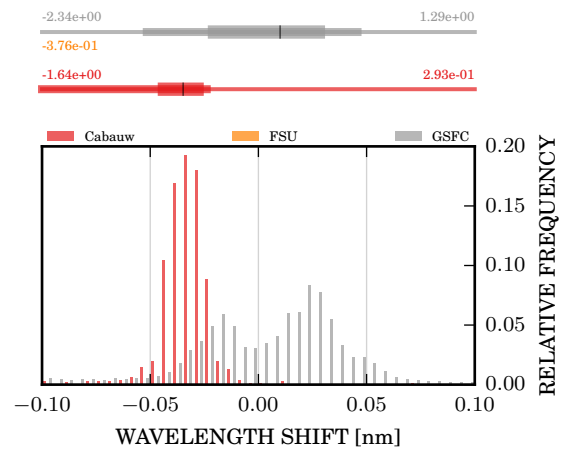
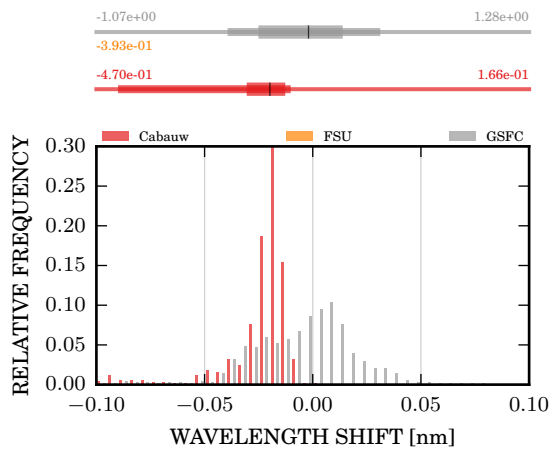
1. UNCERTAINTY VC



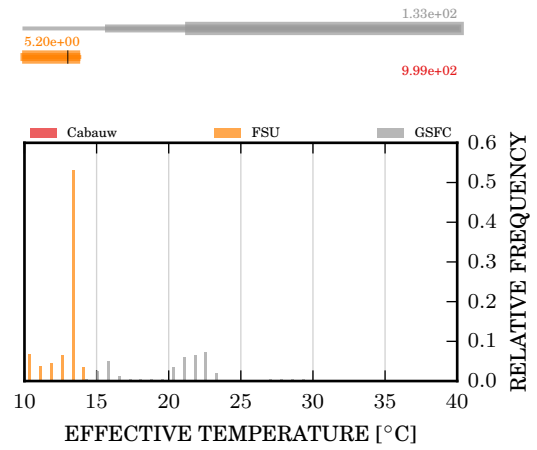
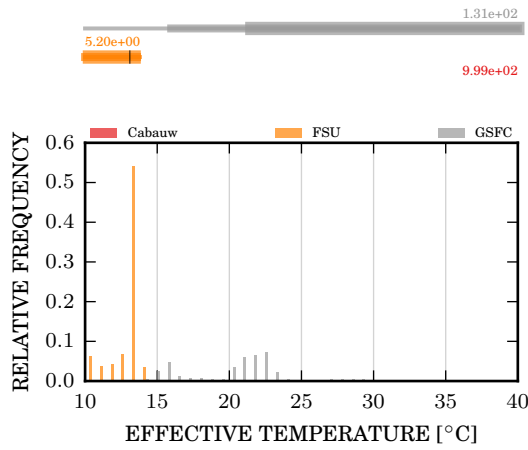
2. WRMS SPEC. FIT. RES.



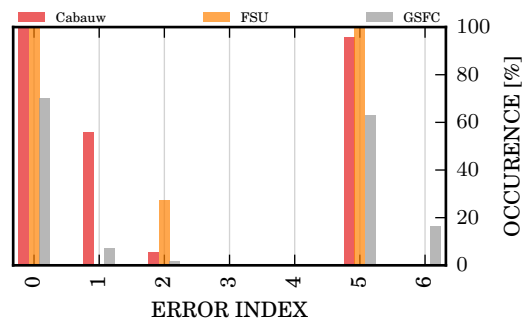
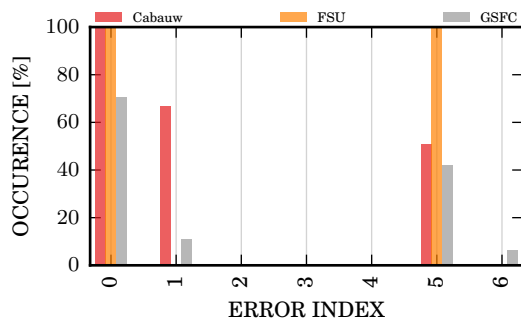
3. WAVELENGTH SHIFT



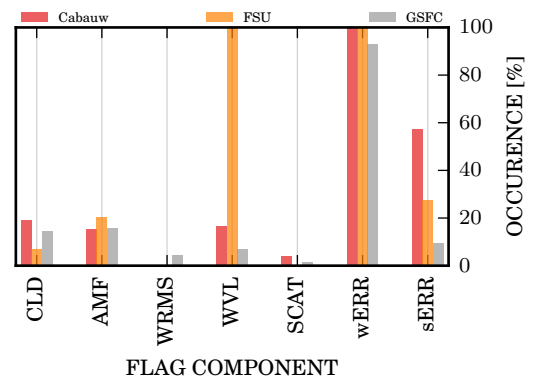
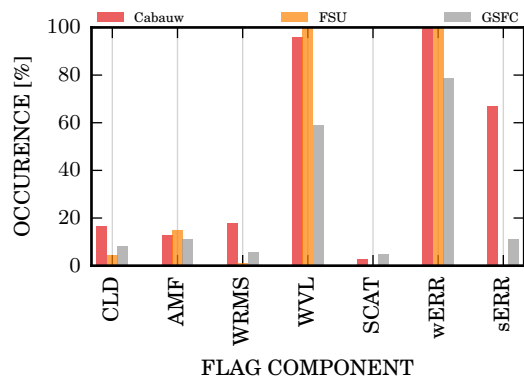
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.3 PANDORA 6 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20090702
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	0805140U1
number of pixels	1024
A/D converter	14 bits
effective saturation limit	97.662 %
temperature controller set temp.	14.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

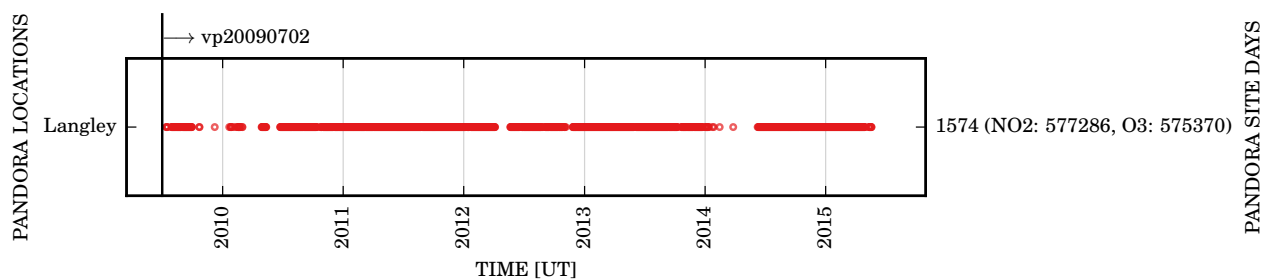
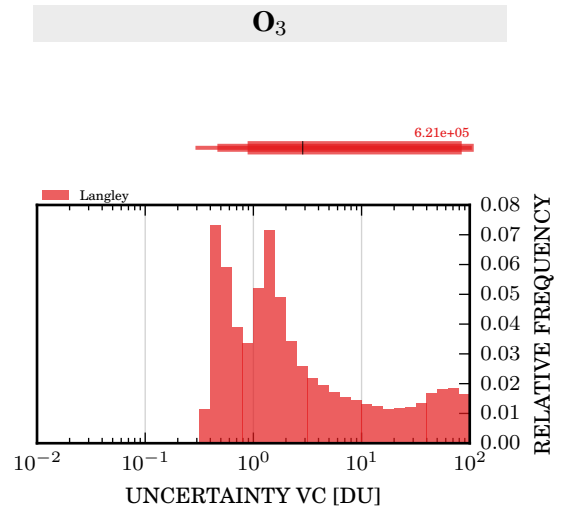
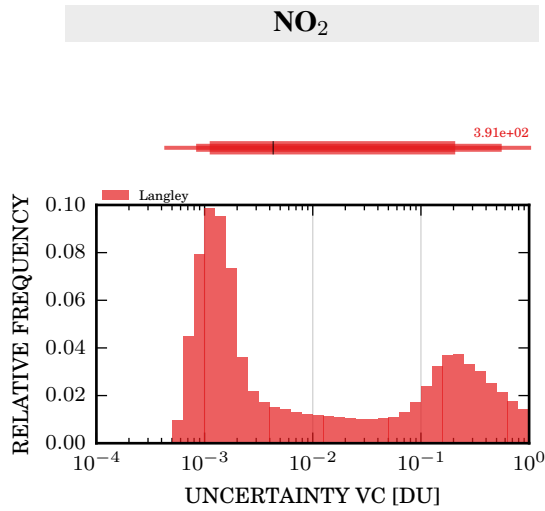


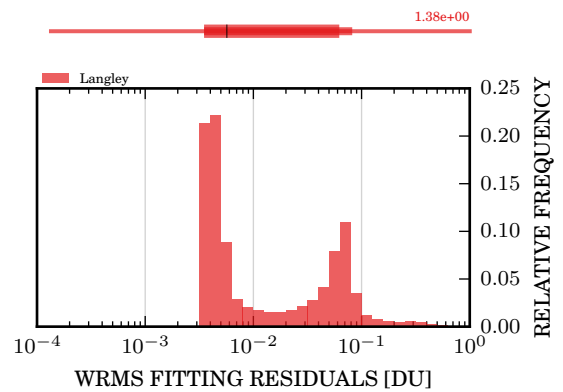
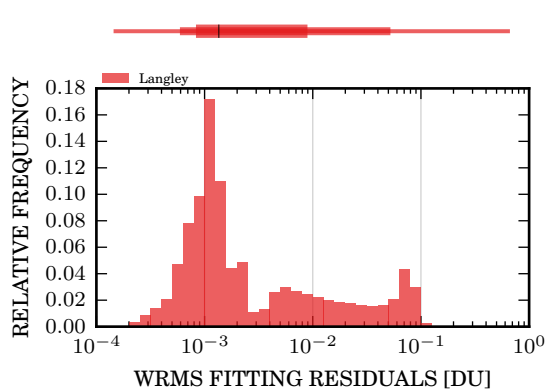
Figure 11: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

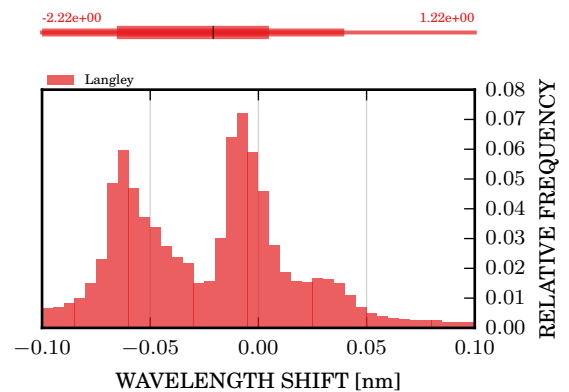
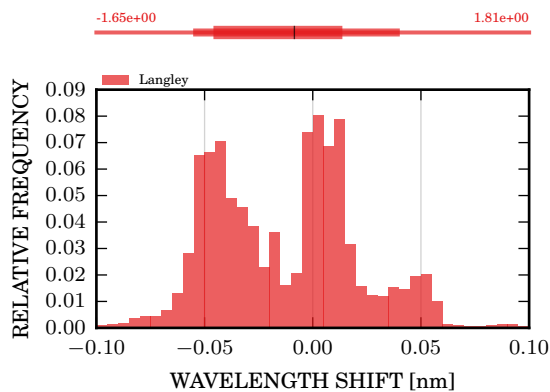
1. UNCERTAINTY VC



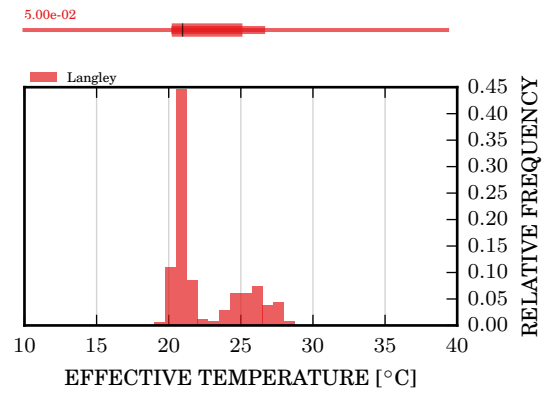
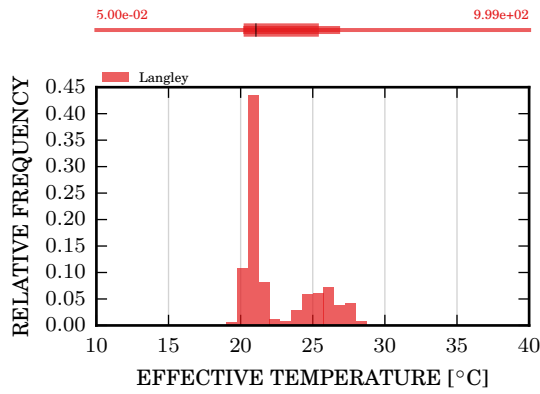
2. WRMS SPEC. FIT. RES.



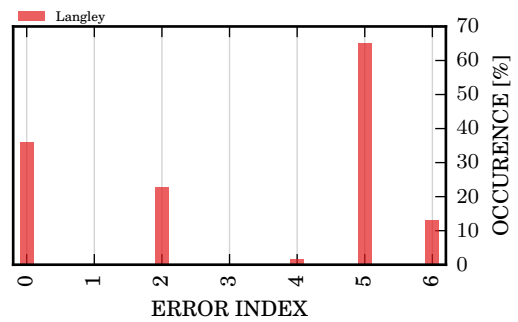
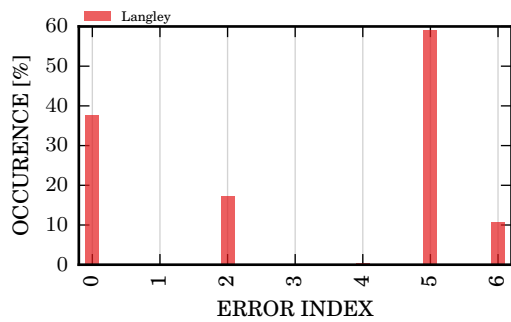
3. WAVELENGTH SHIFT



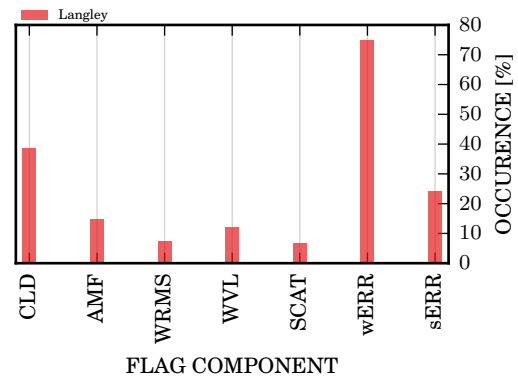
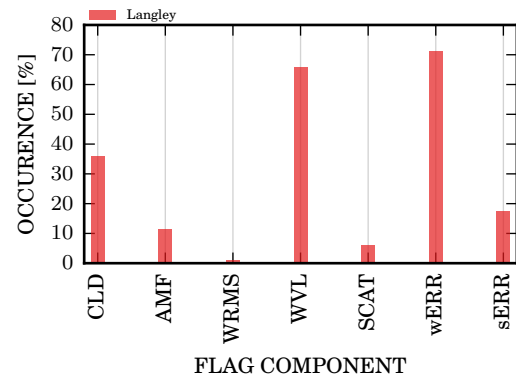
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.4 PANDORA 7 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20090513
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	0805008U1
number of pixels	1024
A/D converter	14 bits
effective saturation limit	97.662 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO ₂	O ₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

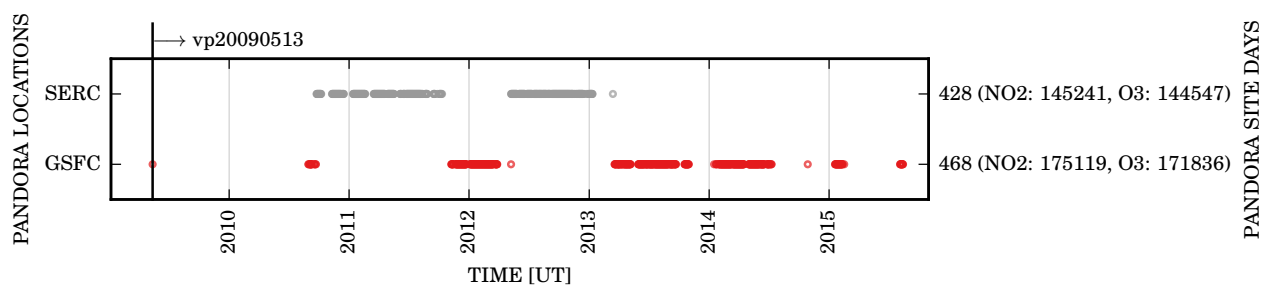
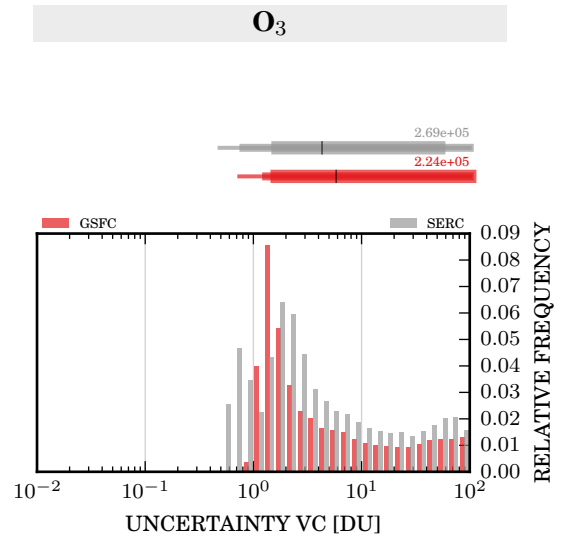
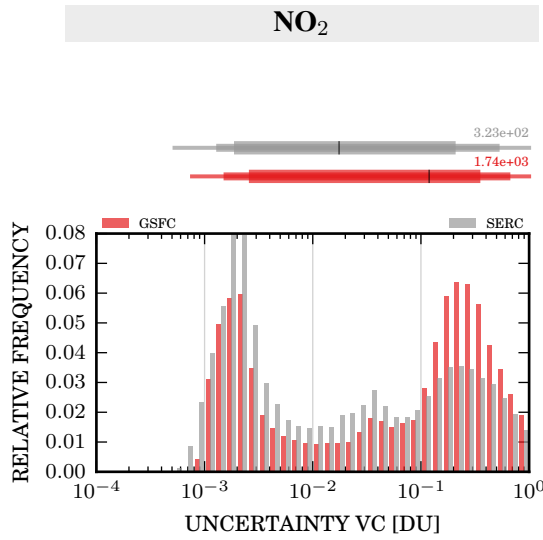


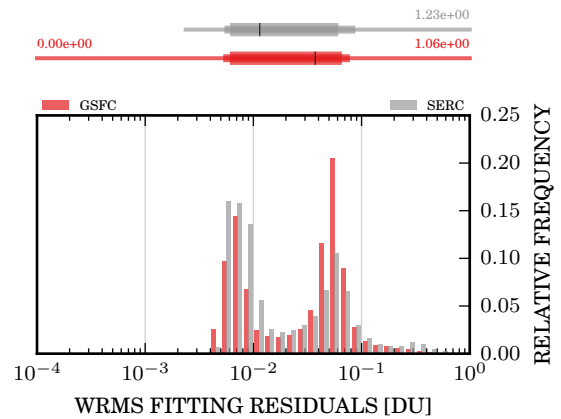
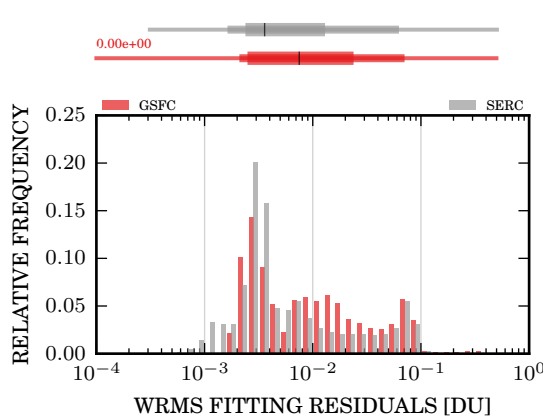
Figure 12: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

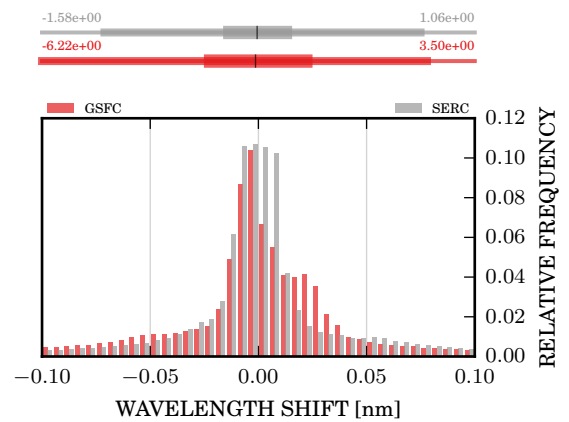
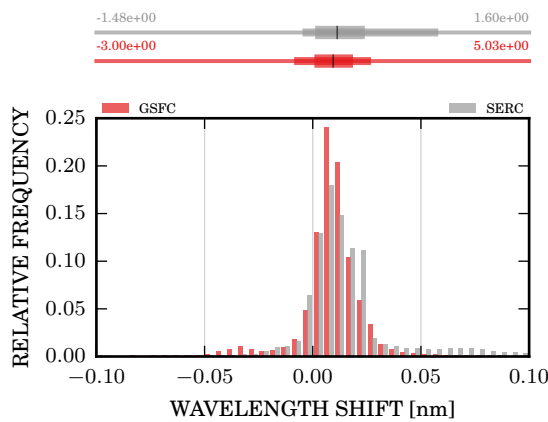
1. UNCERTAINTY VC



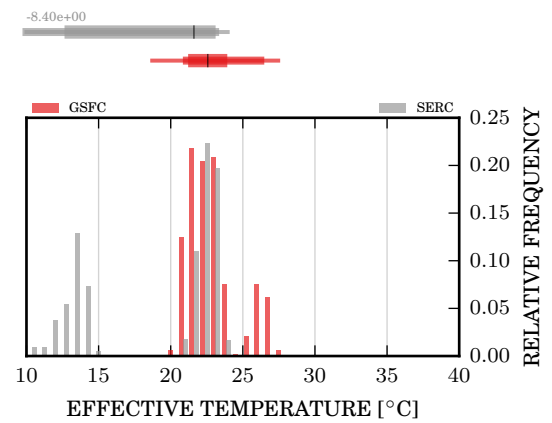
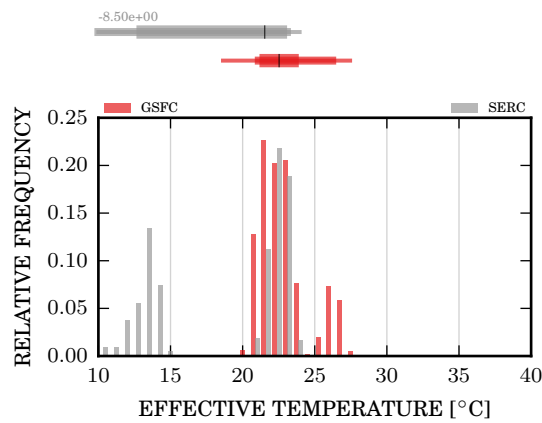
2. WRMS SPEC. FIT. RES.



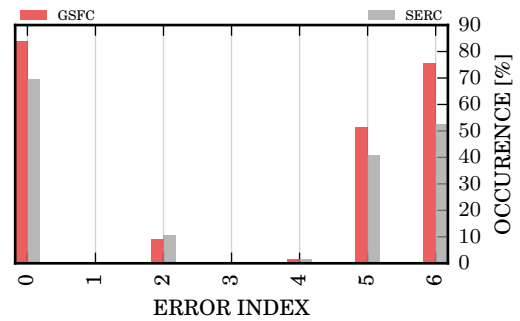
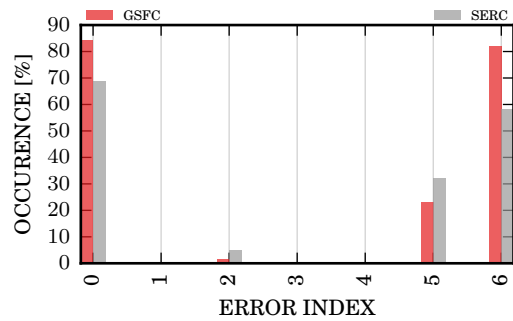
3. WAVELENGTH SHIFT



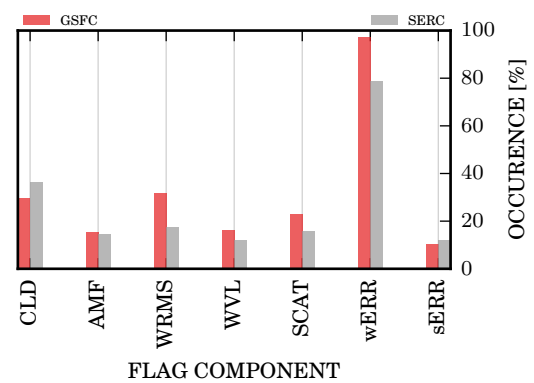
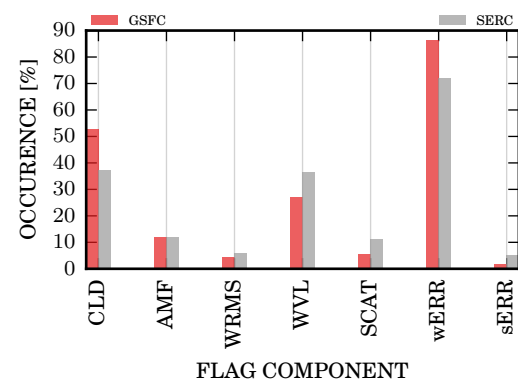
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.5 PANDORA 8 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110706 20120328 20130909
validity period end	20120327 20130908 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	0805007U1 0805007U1 0805007U1
number of pixels	1024 1024 1024
A/D converter	14 14 14 bits
effective saturation limit	97.662 97.662 97.662 %
temperature controller set temp.	15.0 15.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO ₂	O ₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

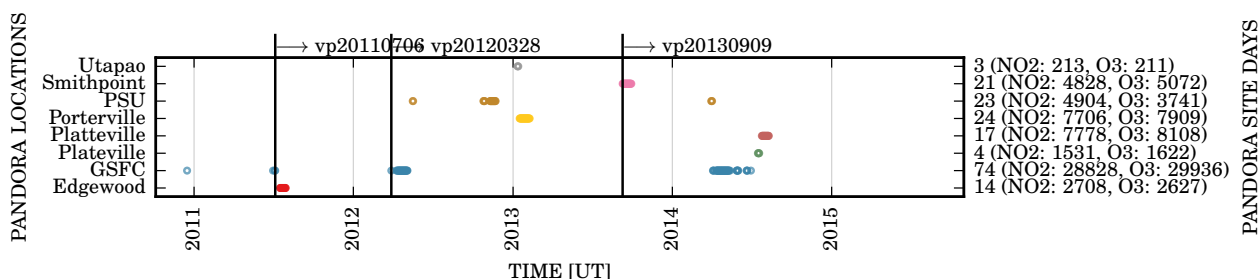
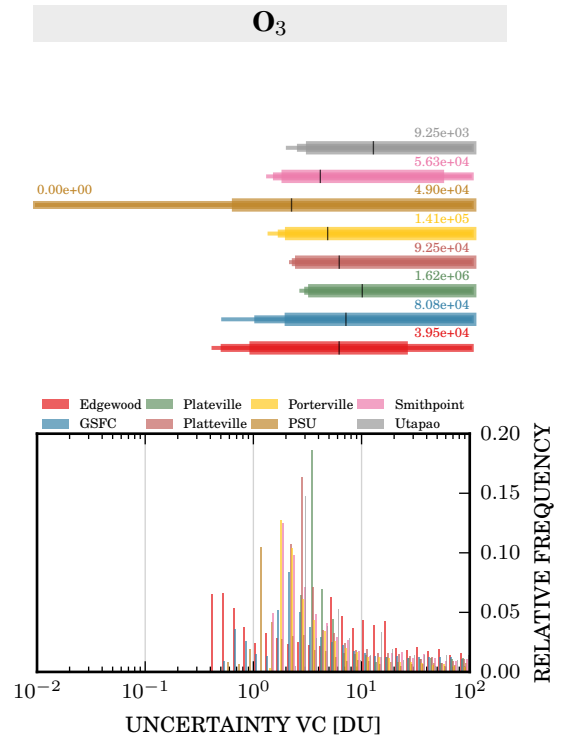
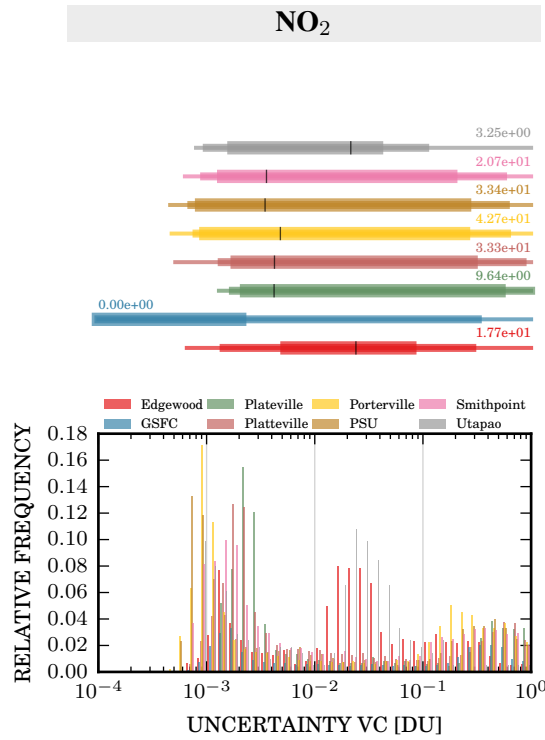


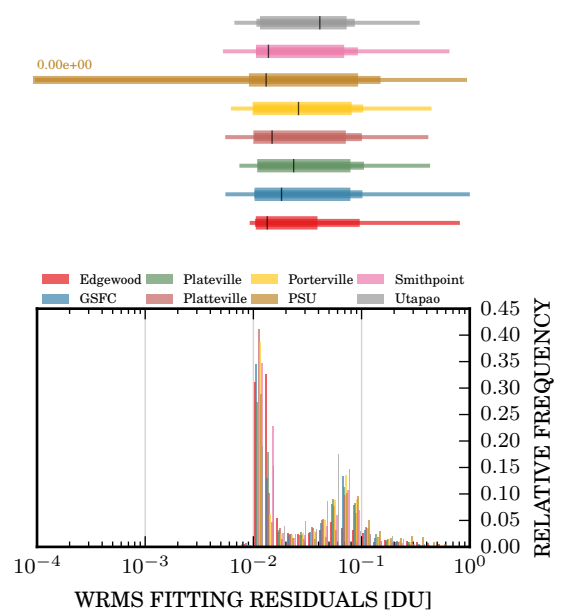
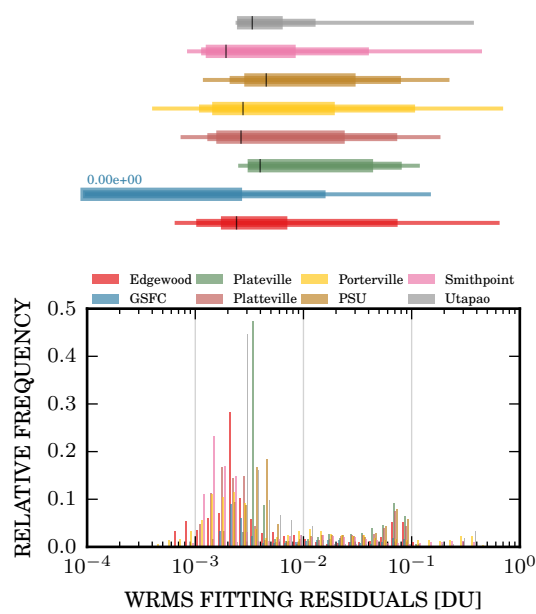
Figure 13: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

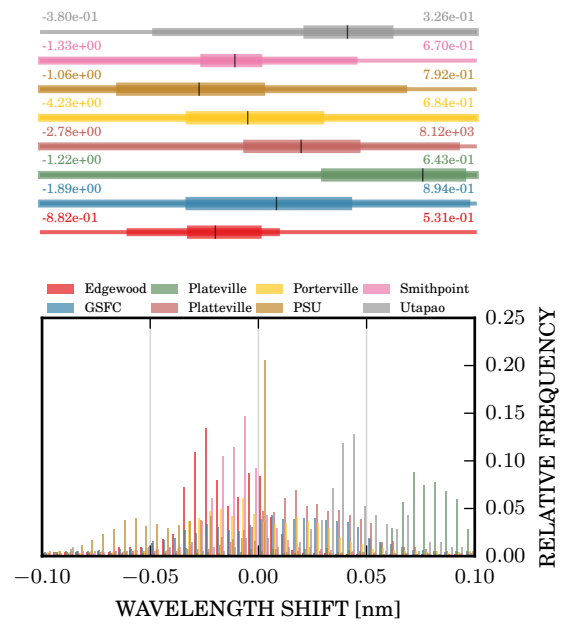
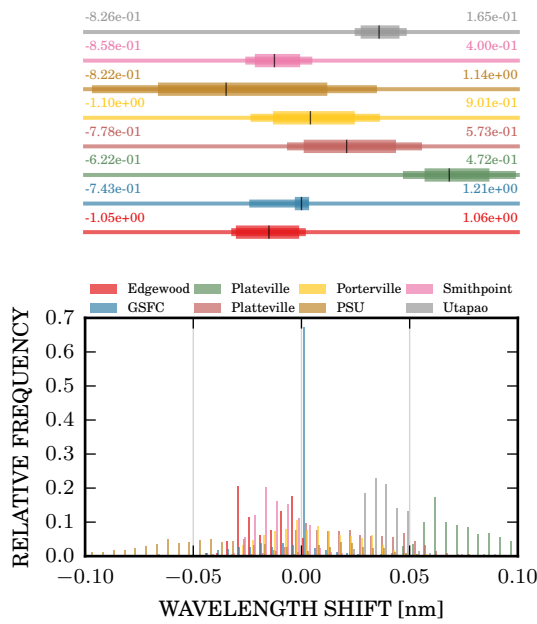
1. UNCERTAINTY VC



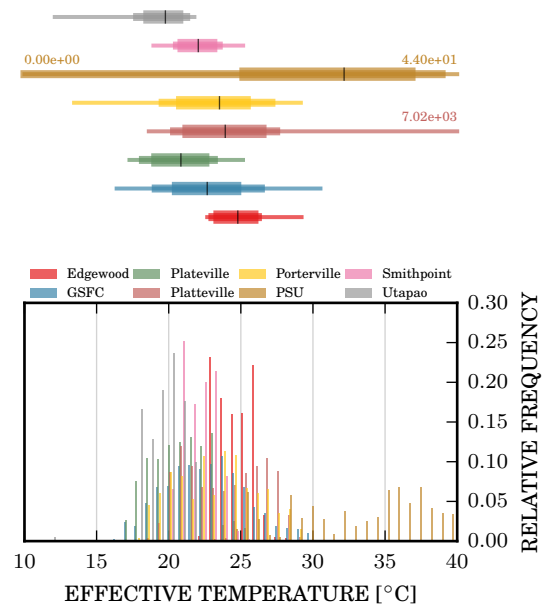
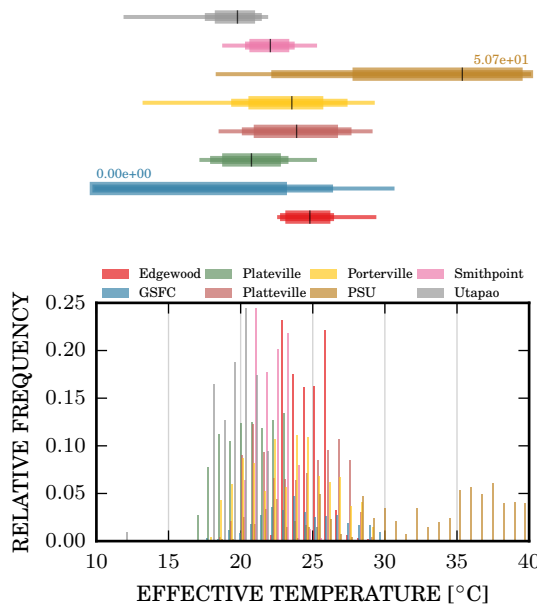
2. WRMS SPEC. FIT. RES.



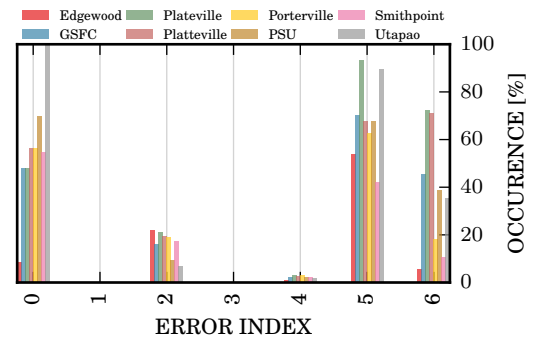
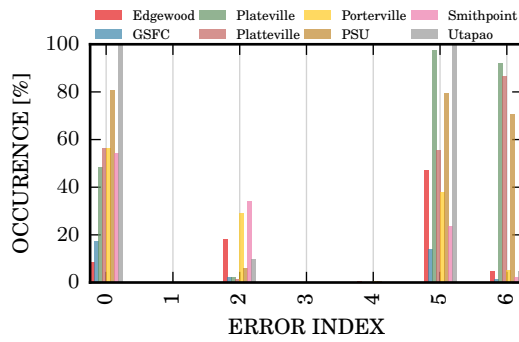
3. WAVELENGTH SHIFT



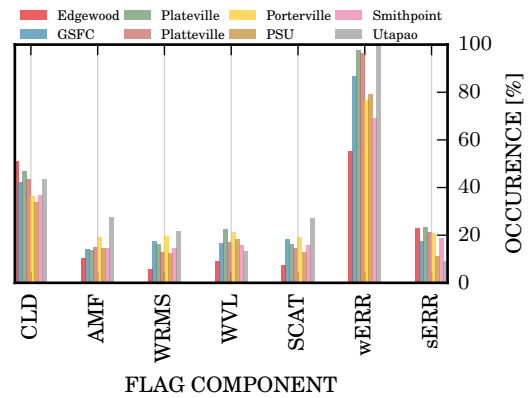
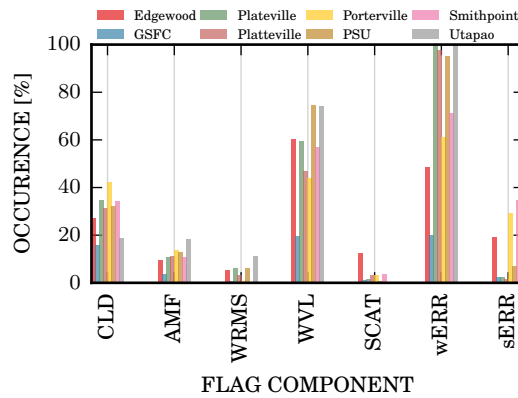
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.6 PANDORA 9 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20090609 20130115
validity period end	20130114 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	0805142U1 0805142U1
number of pixels	1024 1024
A/D converter	14 14 bits
effective saturation limit	97.662 97.662 %
temperature controller set temp.	10.0 10.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

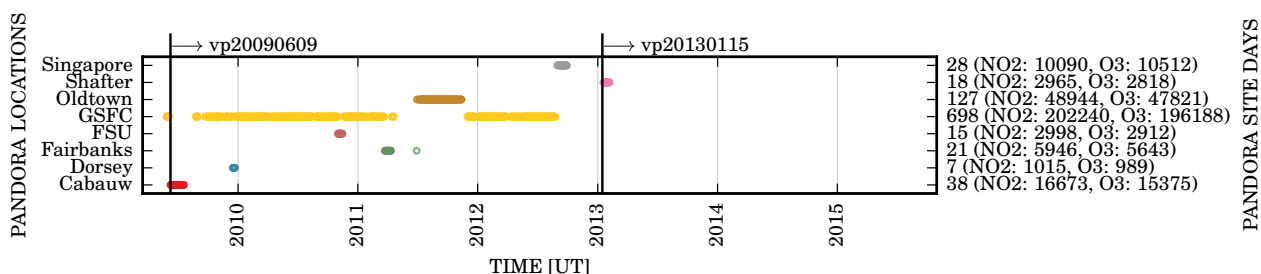
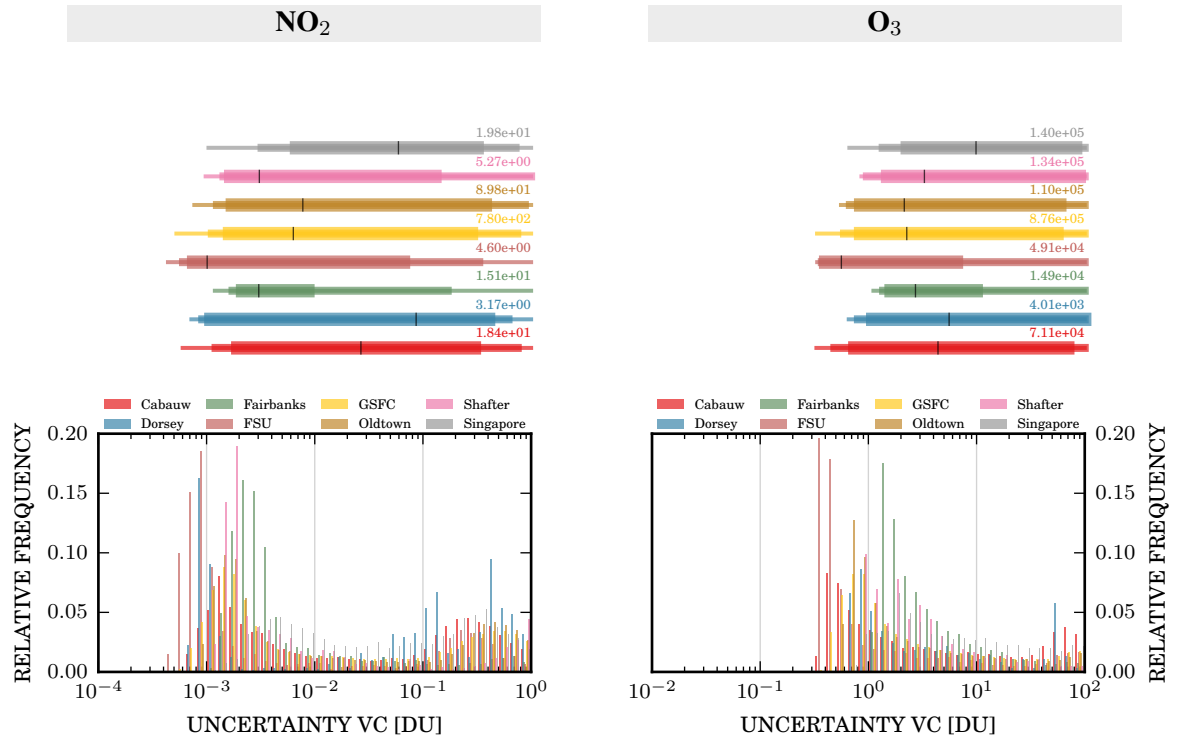


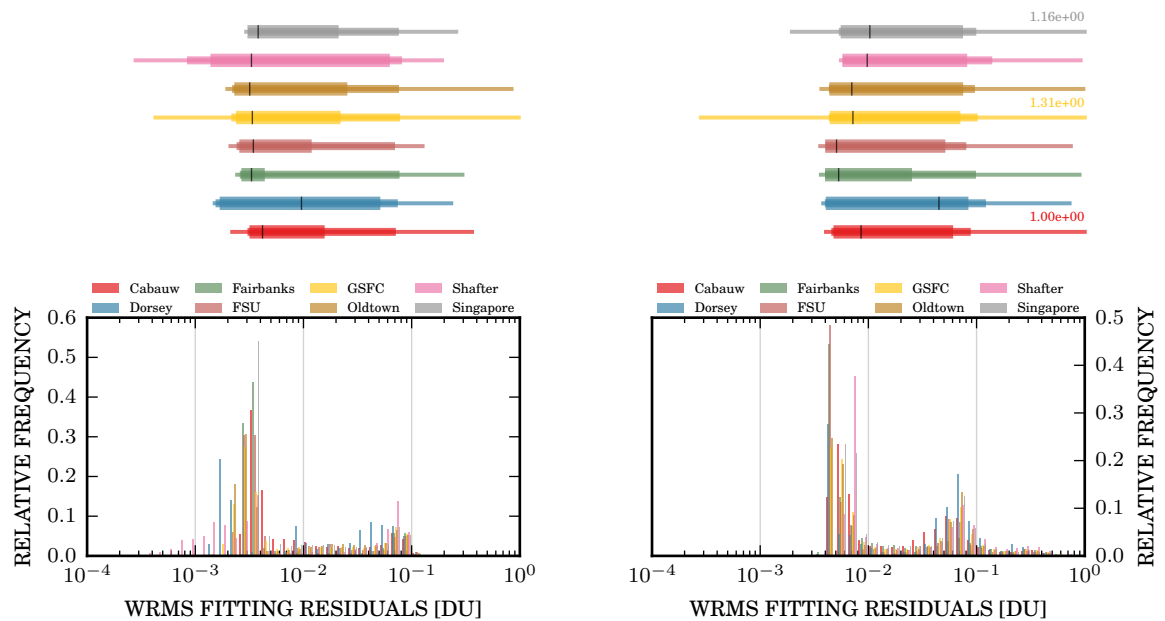
Figure 14: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

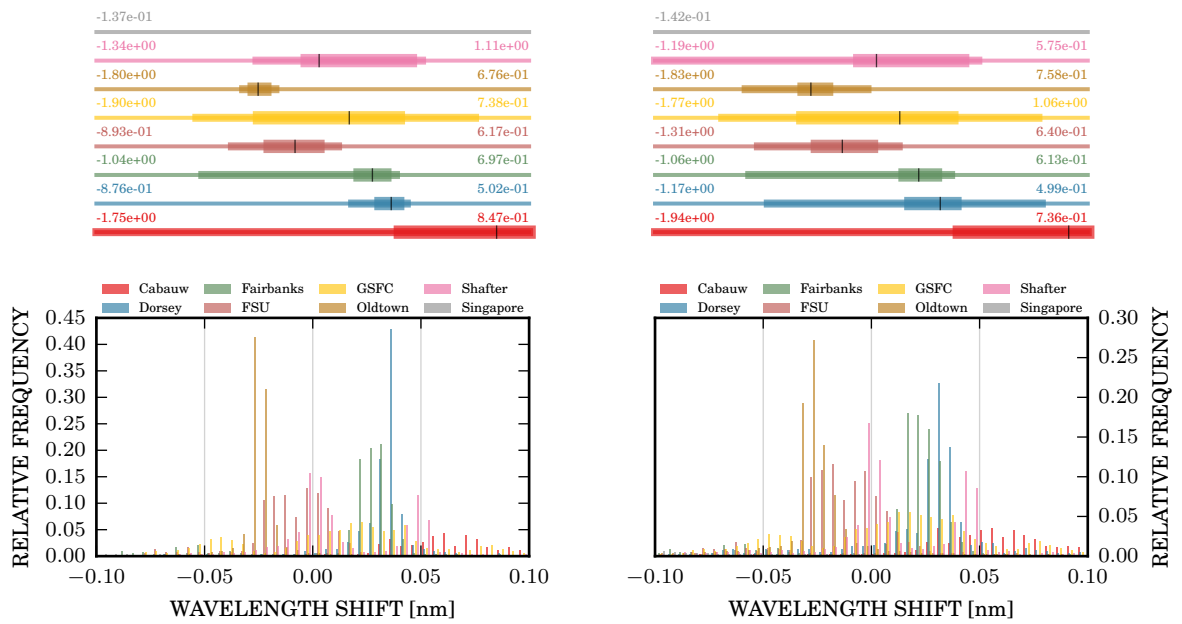
1. UNCERTAINTY VC



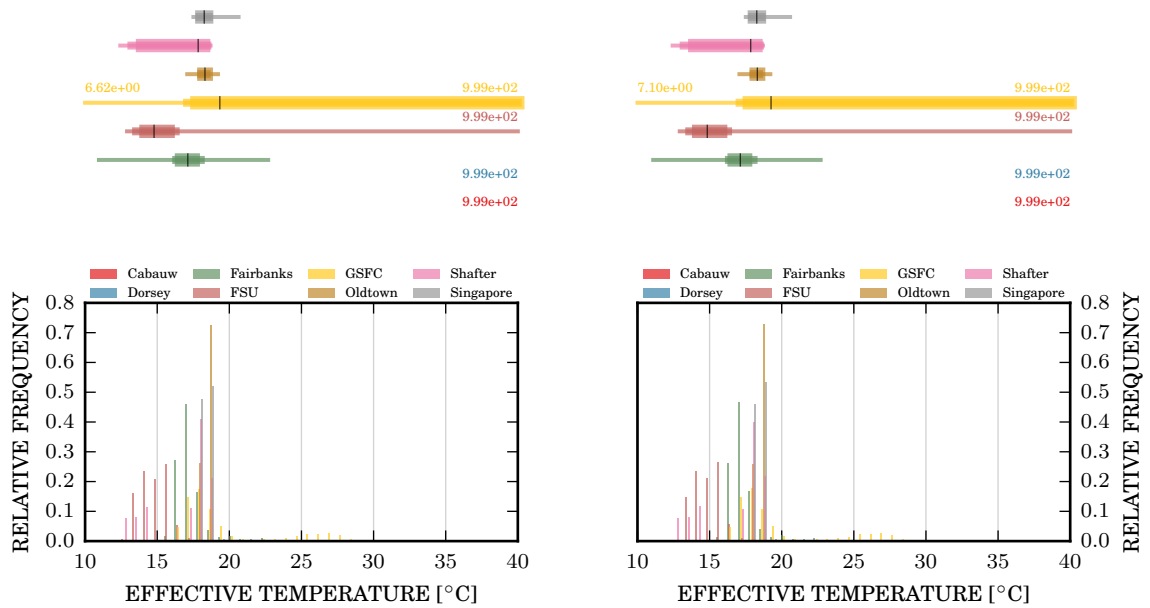
2. WRMS SPEC. FIT. RES.



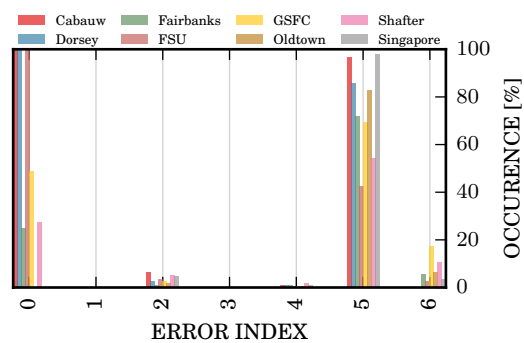
3. WAVELENGTH SHIFT



4. EFF. MEAS. TEMP.

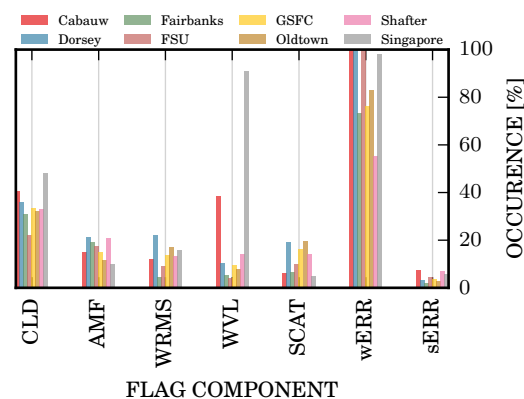


Error Index	Cabauw	Dorsey	Fairbanks	FSU	GSFC	Oldtown	Shafer	Singapore
0	100	100	23	27	48	10	26	23
1	0	0	0	0	0	0	0	0
2	0	0	0	56	10	0	3	3
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	95	95	28	46	70	88	95	95
6	0	0	5	0	15	100	0	100



Bar chart showing the occurrence percentage of FLAG components for eight different datasets. The components are CLD, AMF, WRMS, WVW, SCAT, wERR, and sERR. The datasets are Cabauw, Fairbanks, GSFC, Shafter, Dorsey, FSU, Oldtown, and Singapore. WVW and wERR show the highest occurrence percentages across most datasets, while WRMS and SCAT show the lowest.

FLAG COMPONENT	Cabauw	Fairbanks	GSFC	Shafter	Dorsey	FSU	Oldtown	Singapore
CLD	50	20	35	48	52	10	15	48
AMF	15	15	10	18	15	10	10	10
WRMS	2	2	2	5	2	5	5	5
WVW	55	80	60	45	42	40	95	98
SCAT	5	5	5	5	5	5	5	5
wERR	100	100	78	48	100	100	90	100
sERR	22	5	10	55	5	5	10	10



5.7 PANDORA 16 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110520 20120113 20121017
validity period end	20120111 20121016 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1010035U1 1010035U1 1010035U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	67.140 67.140 67.140 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

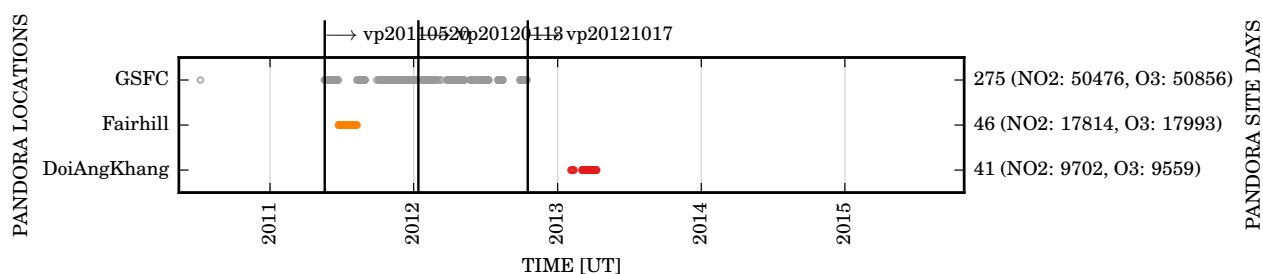
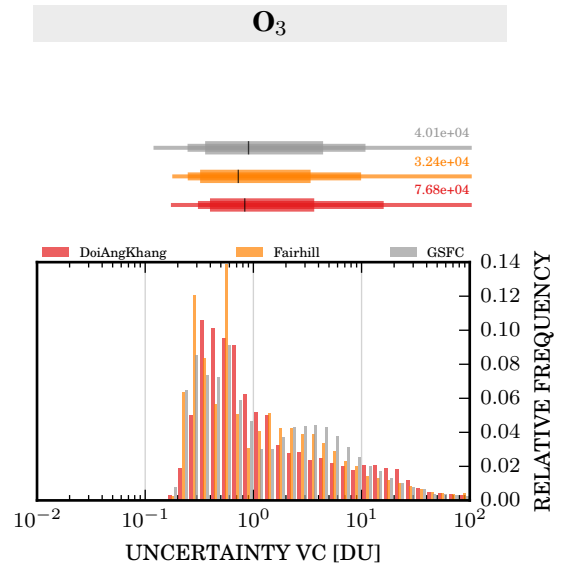
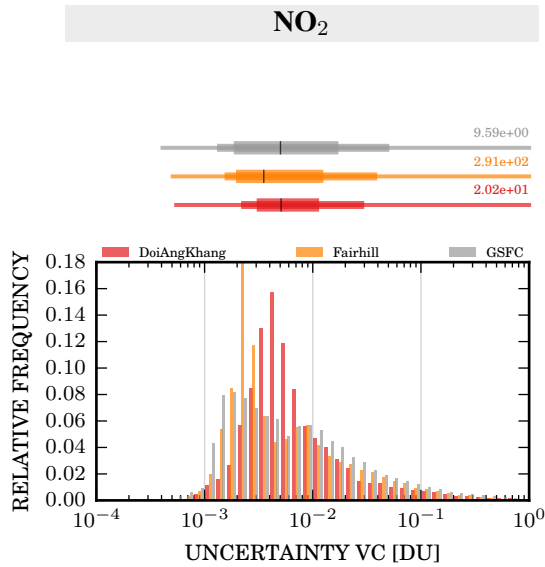


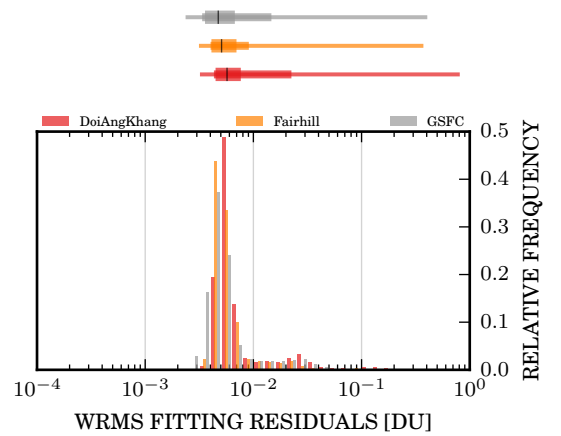
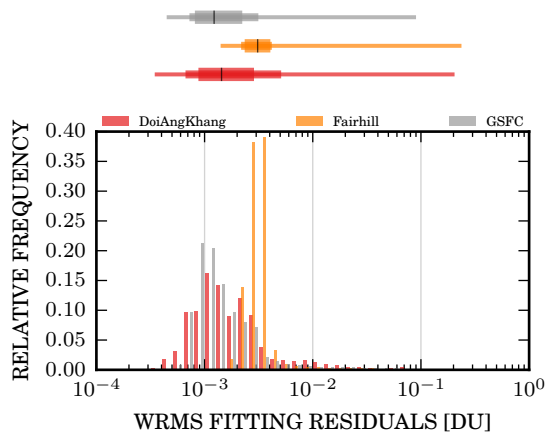
Figure 15: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

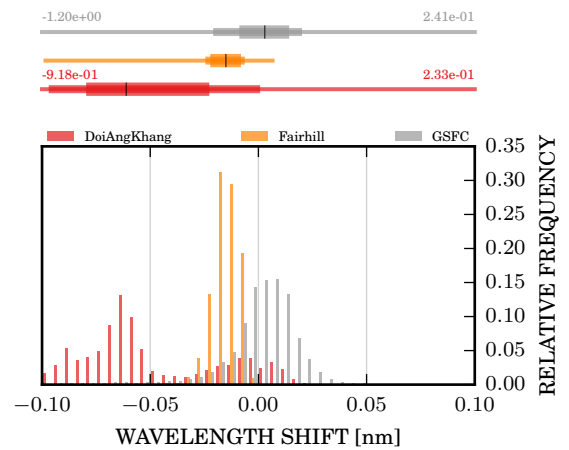
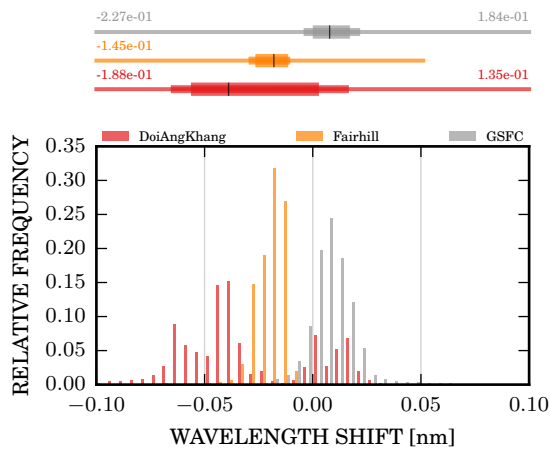
1. UNCERTAINTY VC



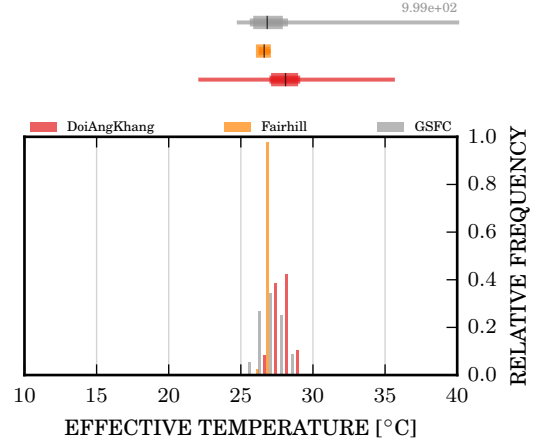
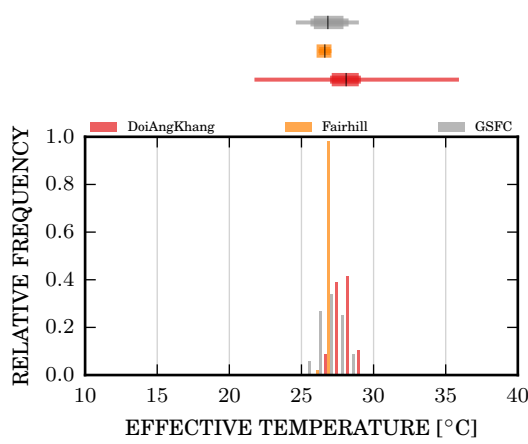
2. WRMS SPEC. FIT. RES.



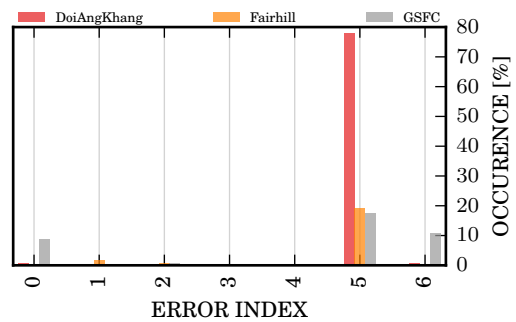
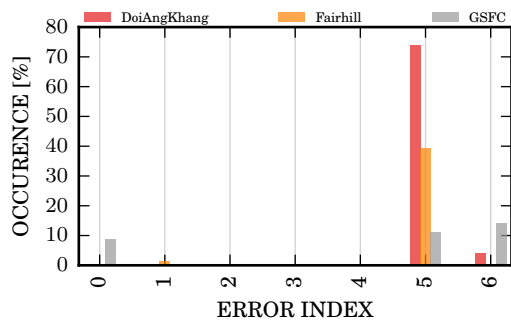
3. WAVELENGTH SHIFT



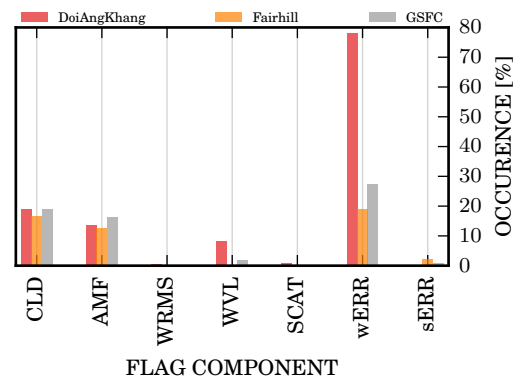
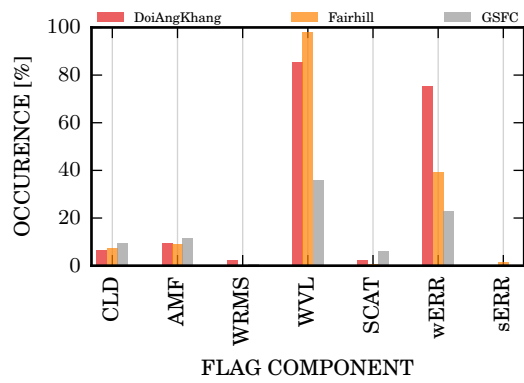
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.8 PANDORA 17 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110523 20140403 20141202
validity period end	20140402 20141201 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1001051U1 1001051U1 1001051U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	67.140 99.184 68.666 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

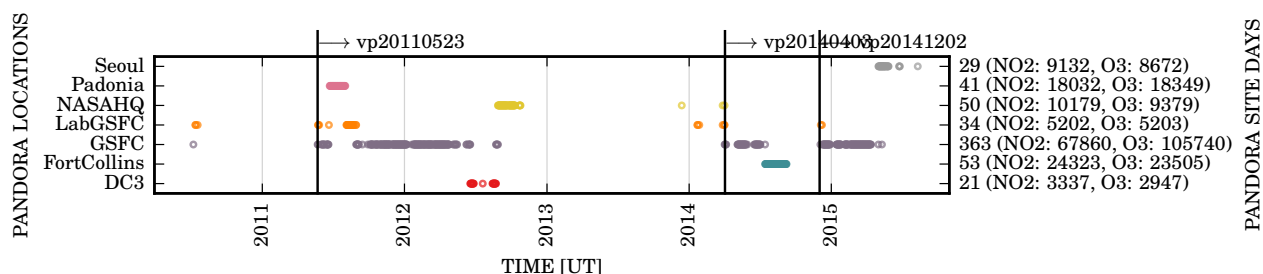
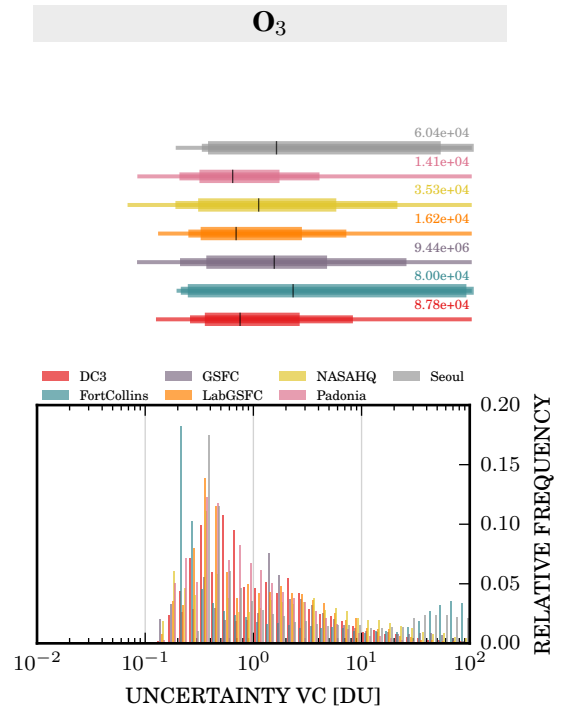
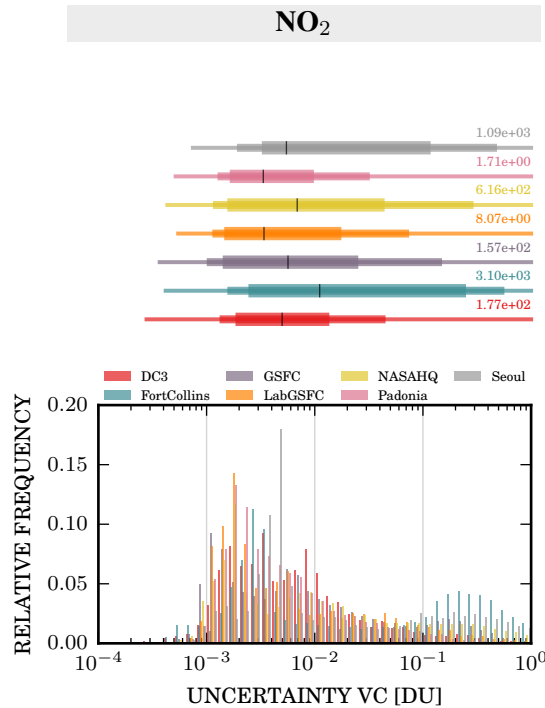


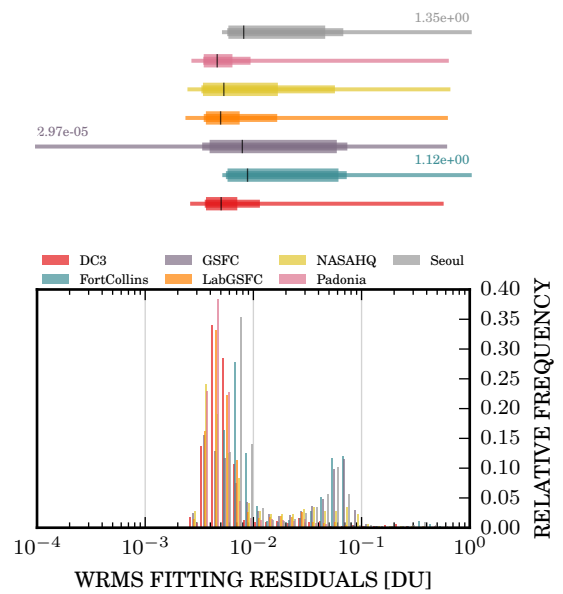
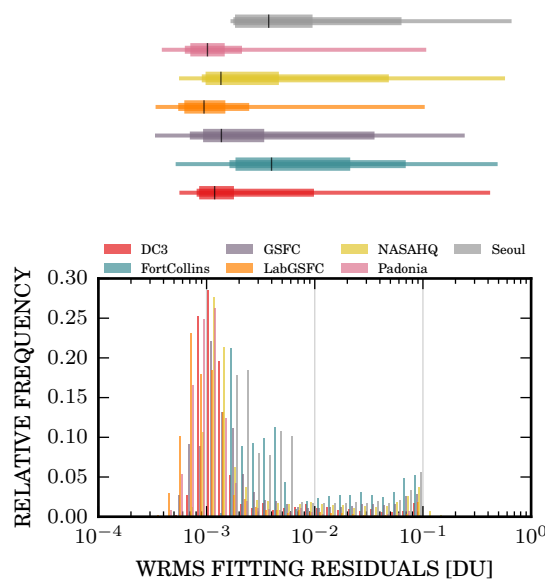
Figure 16: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

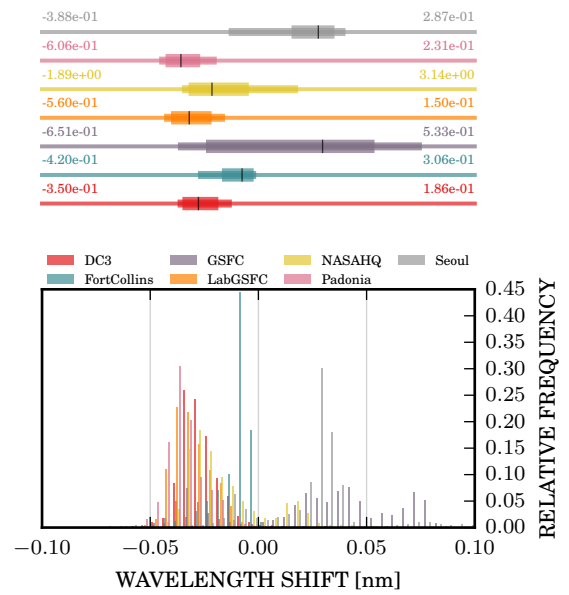
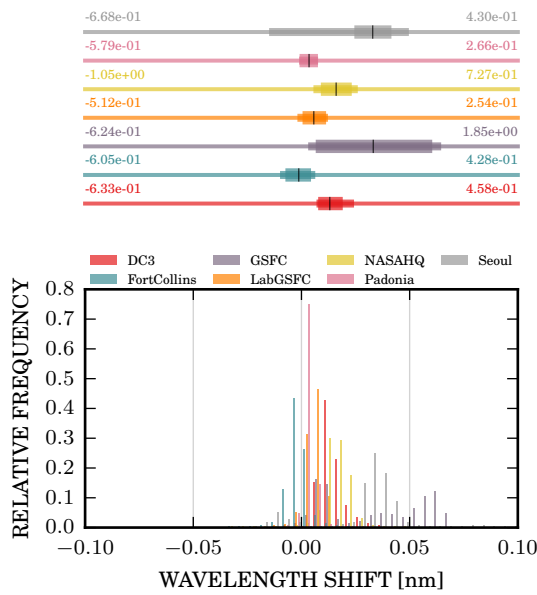
1. UNCERTAINTY VC



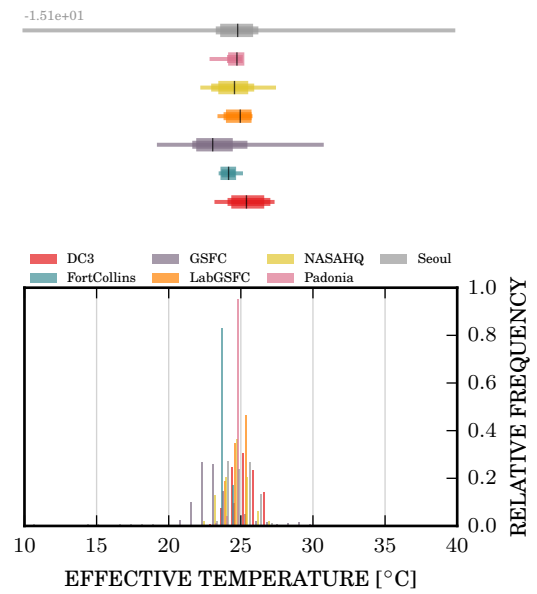
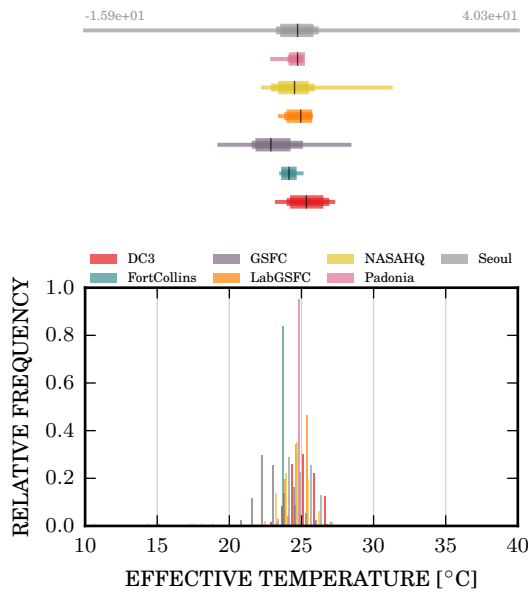
2. WRMS SPEC. FIT. RES.



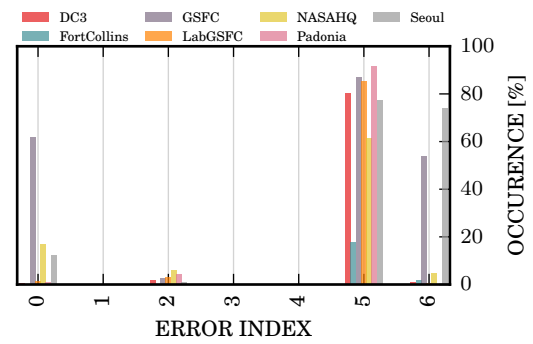
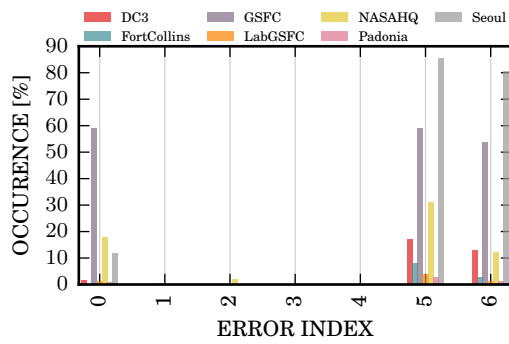
3. WAVELENGTH SHIFT



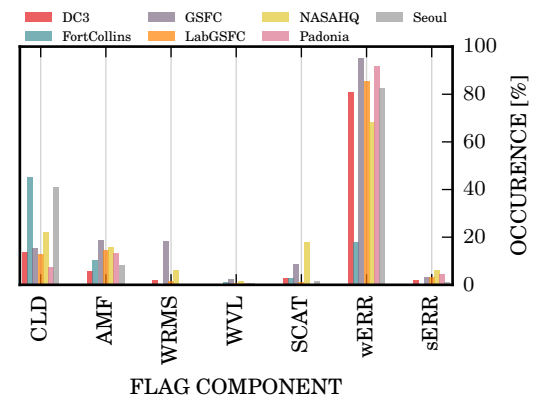
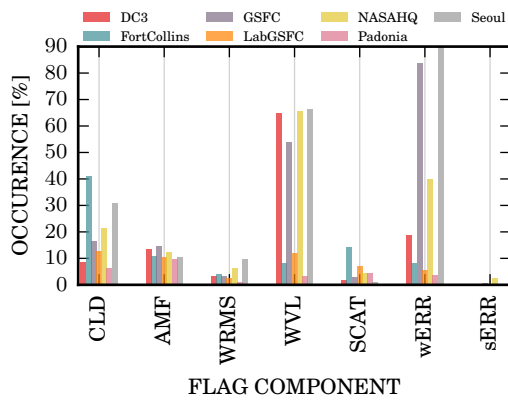
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.9 PANDORA 18 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110531 20120202 20121202 20130819 20140604
validity period end	20120201 20121129 20130818 20140603 20151031, at least
validity period version	1 1 1 1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1 Ava1 Ava1
spectrometer unit ID	1010036U1 1010036U1 1010036U1 1010029U1 1010029U1
number of pixels	2048 2048 2048 2048 2048
A/D converter	16 16 16 16 16 bits
effective saturation limit	67.140 67.140 71.717 71.717 71.717 %
temperature controller set temp.	20.0 20.0 20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

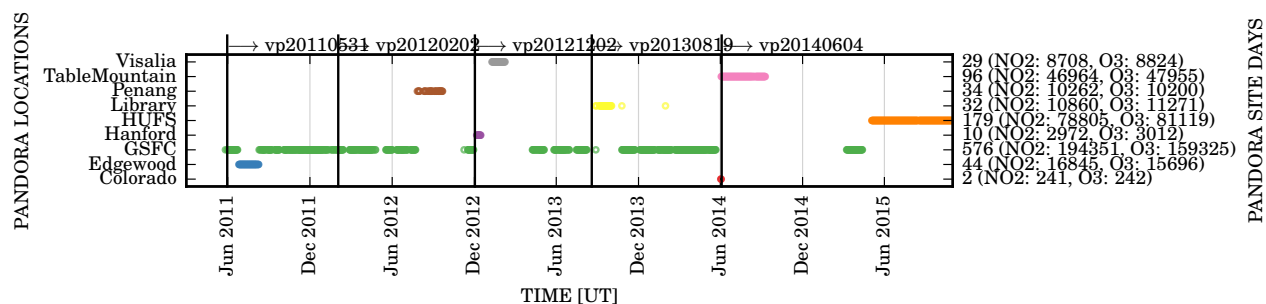
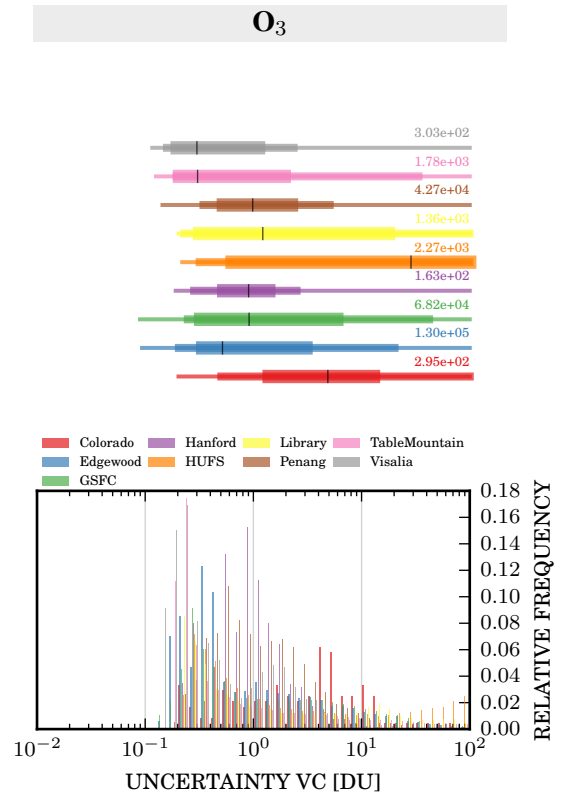
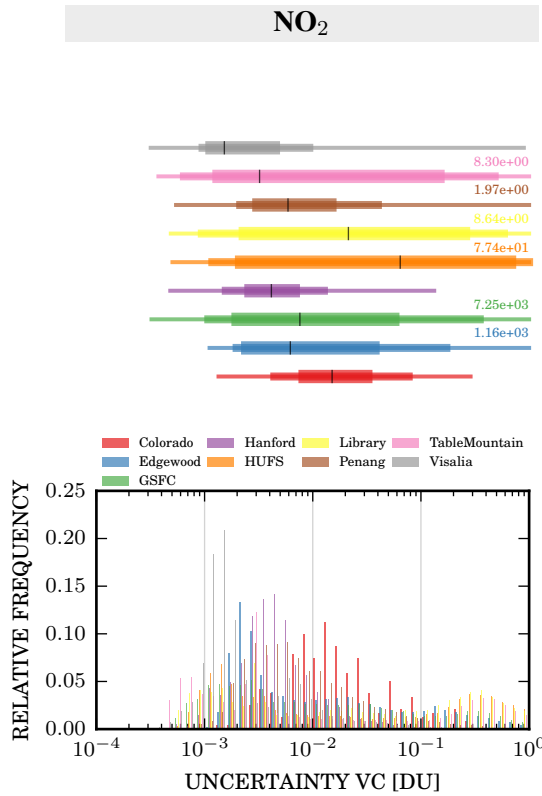


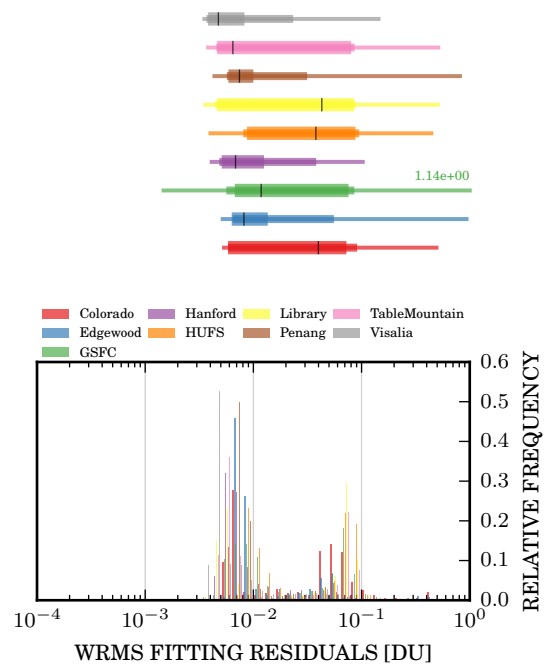
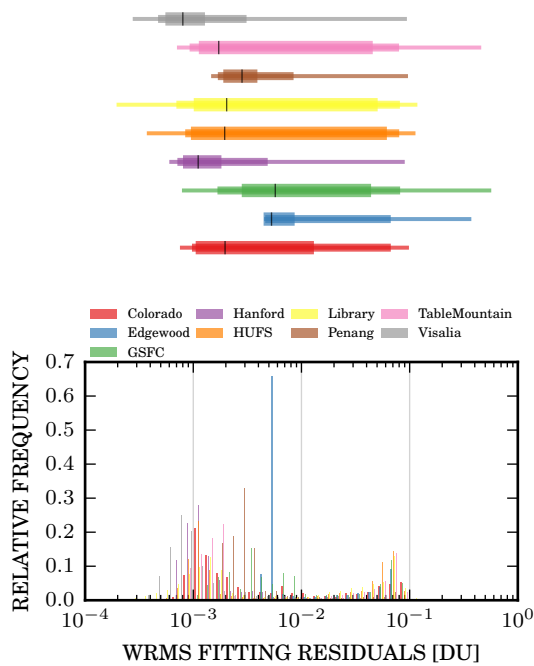
Figure 17: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

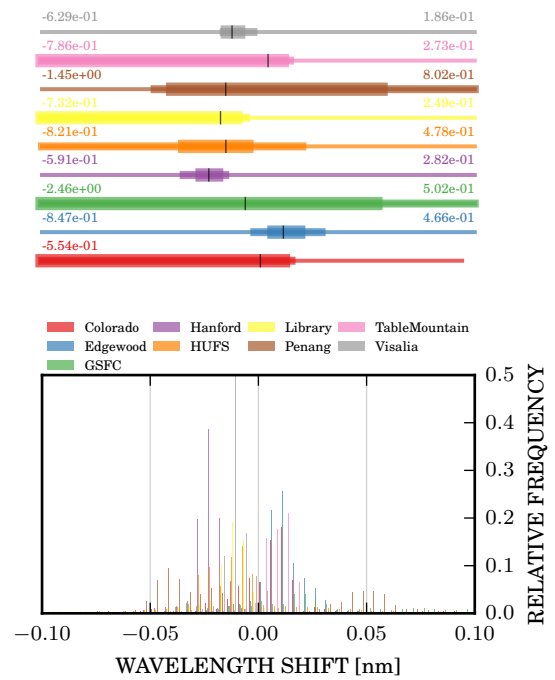
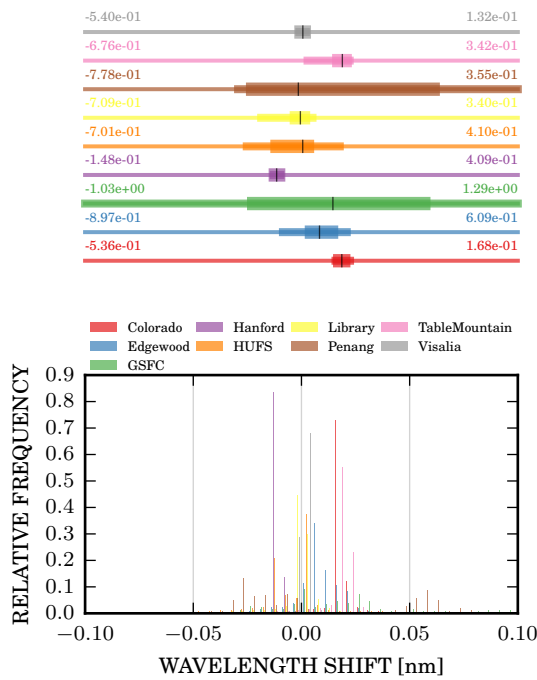
1. UNCERTAINTY VC



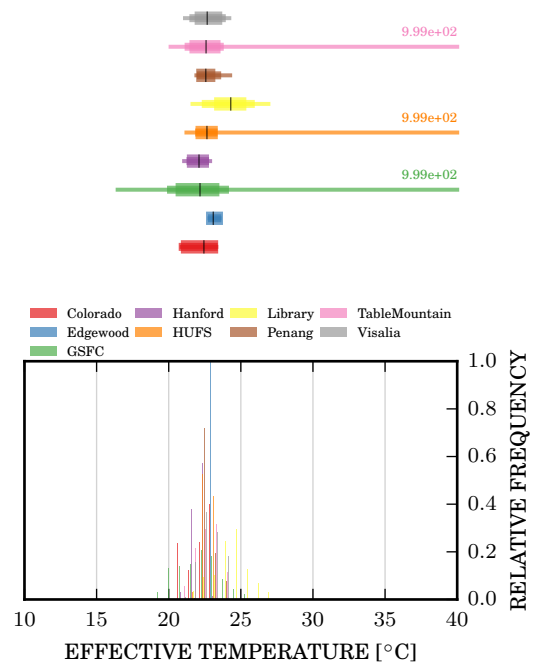
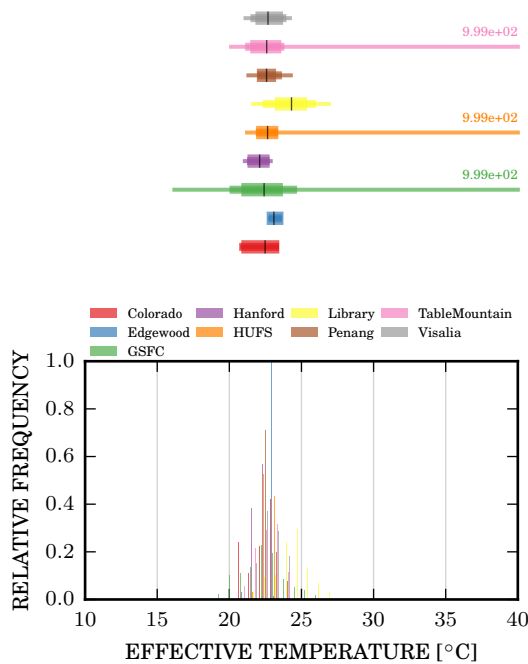
2. WRMS SPEC. FIT. RES.



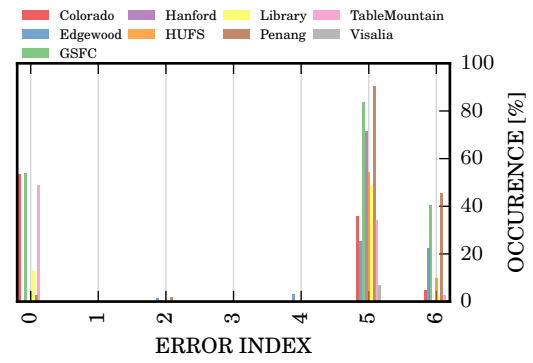
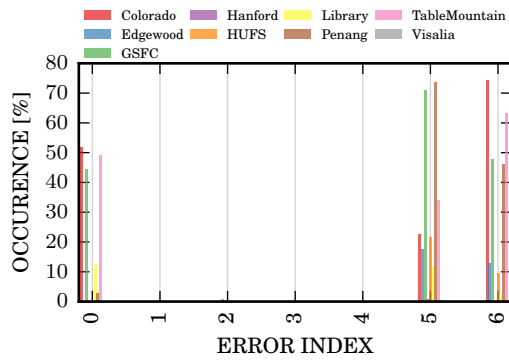
3. WAVELENGTH SHIFT



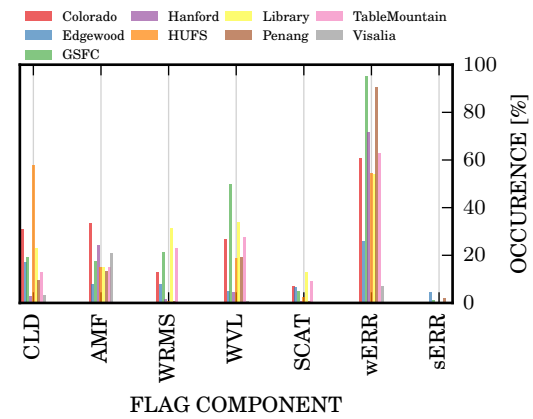
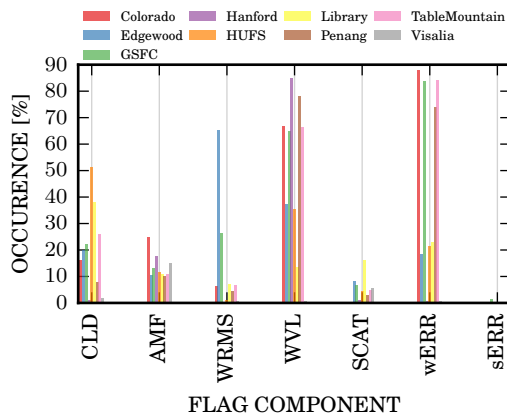
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.10 PANDORA 19 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110606
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1010038U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	77.821 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

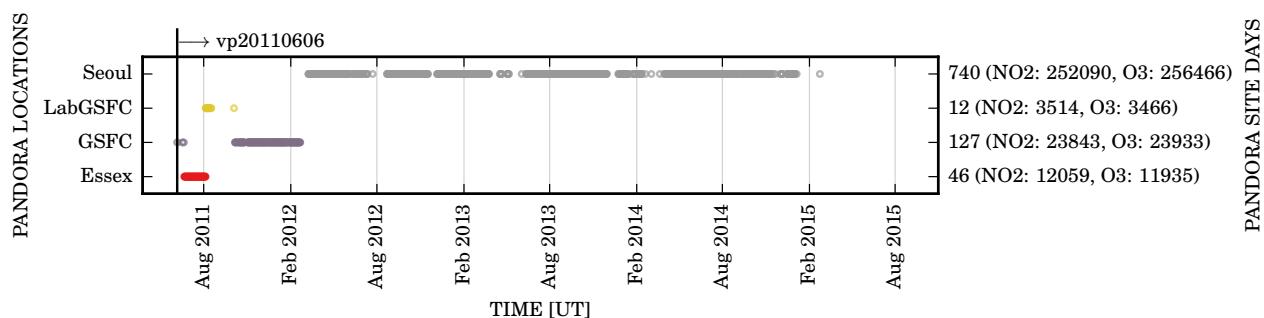
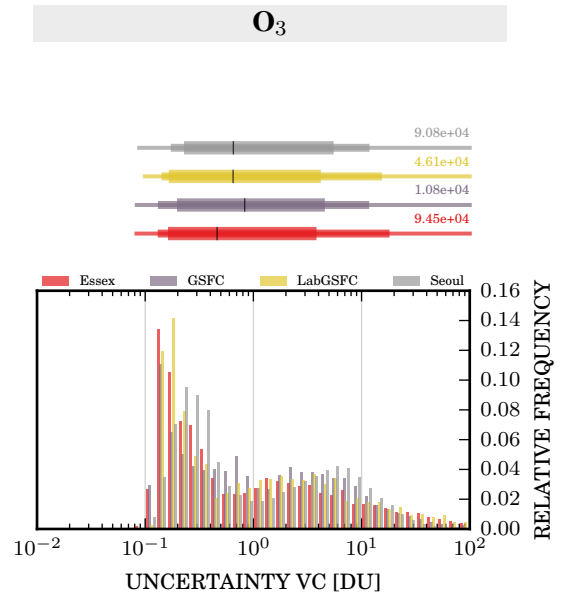
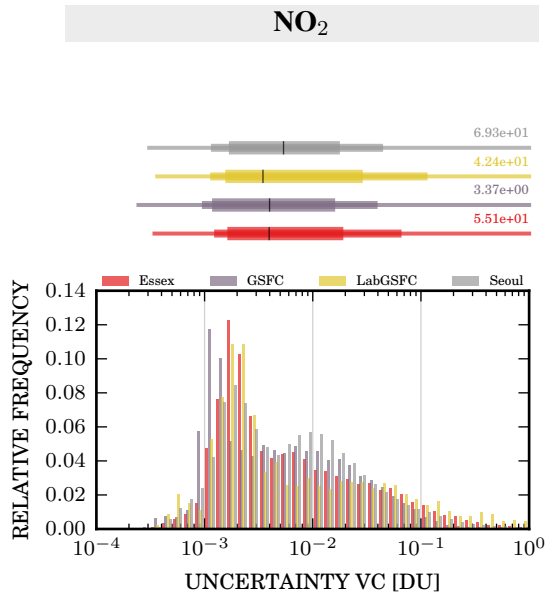


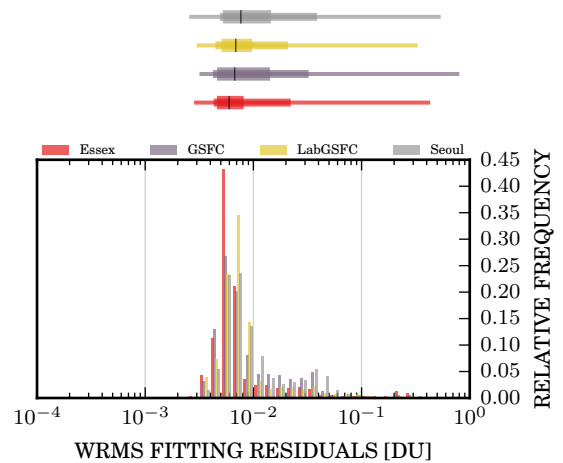
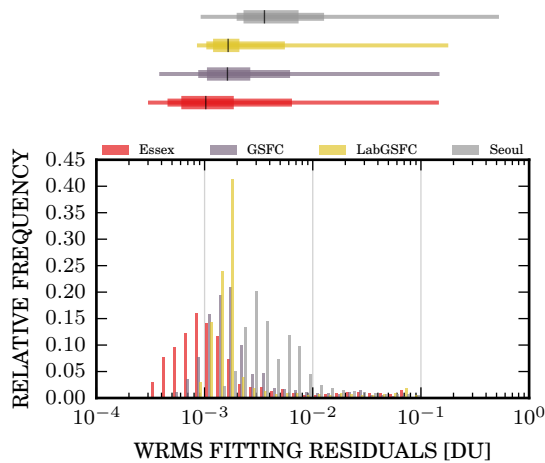
Figure 18: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

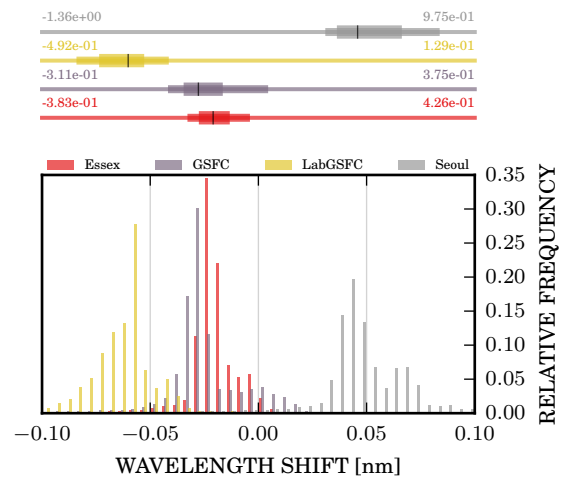
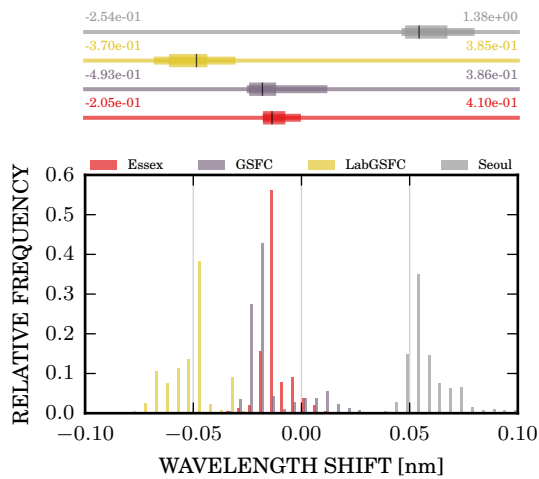
1. UNCERTAINTY VC



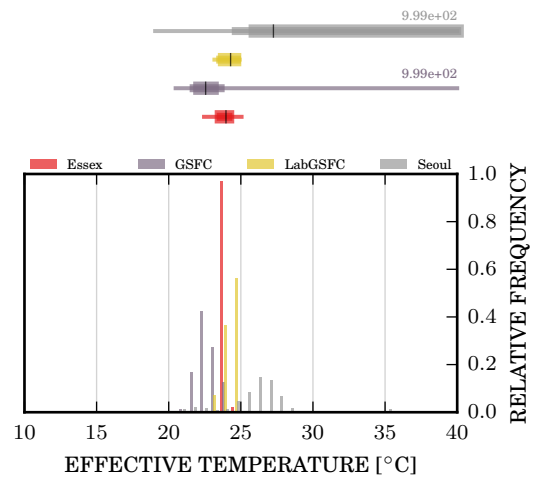
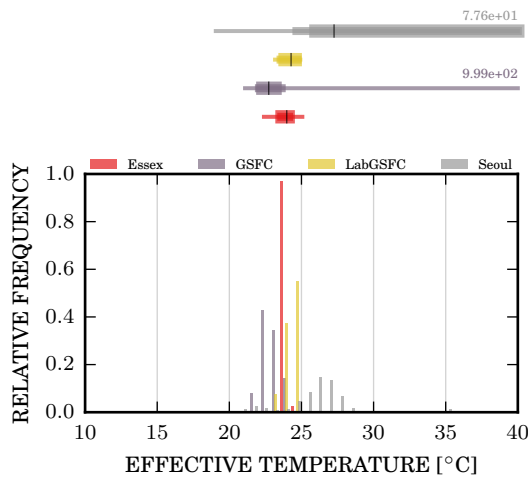
2. WRMS SPEC. FIT. RES.



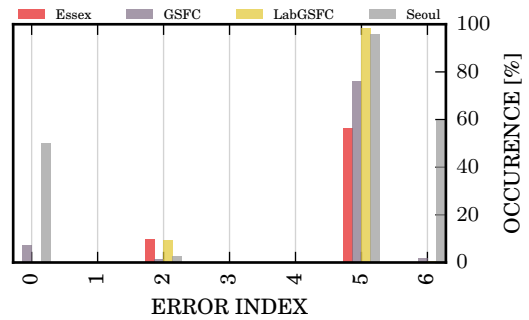
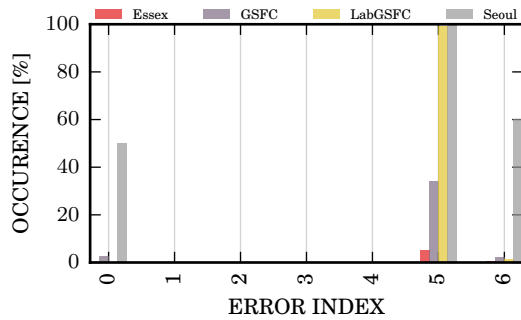
3. WAVELENGTH SHIFT



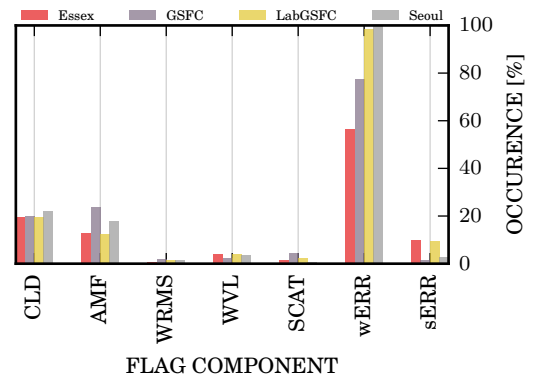
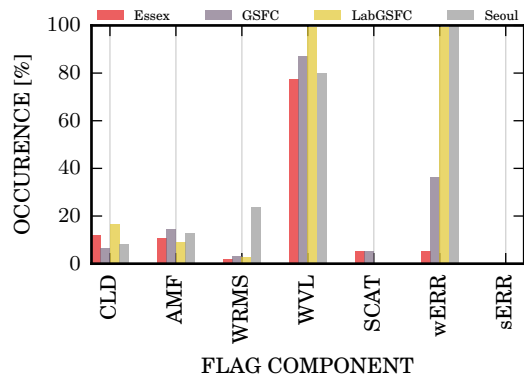
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.11 PANDORA 20 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110609 20120215
validity period end	20120214 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	1010039U1 1010039U1
number of pixels	2048 2048
A/D converter	16 16 bits
effective saturation limit	71.717 71.717 %
temperature controller set temp.	20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

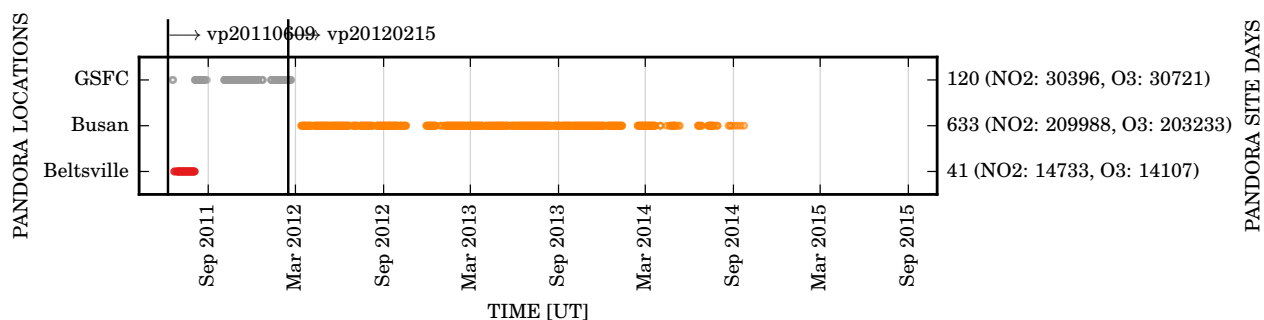
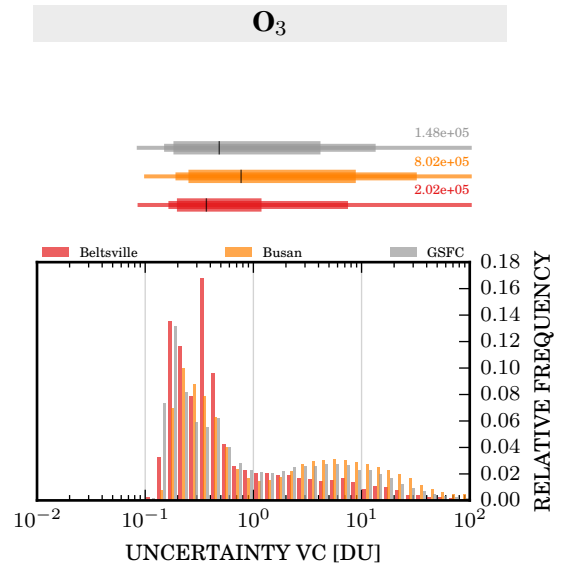
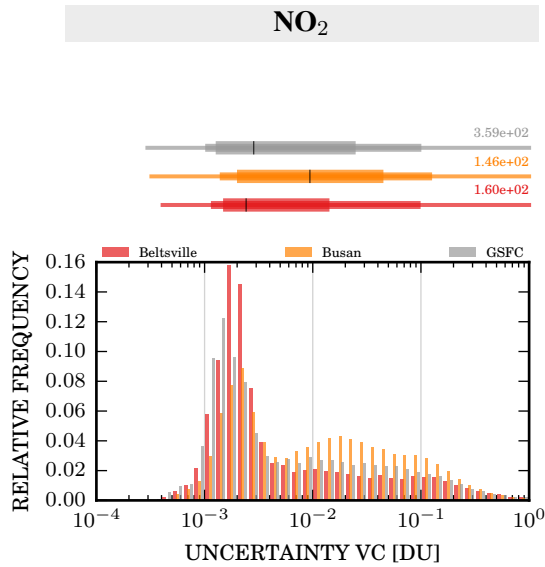


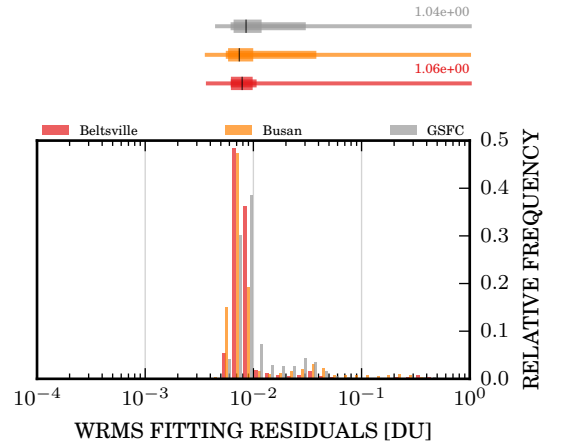
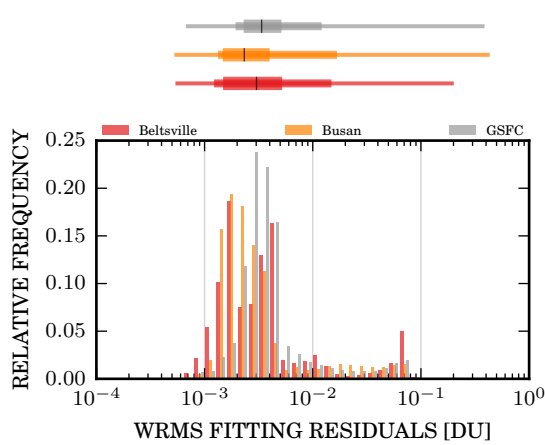
Figure 19: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

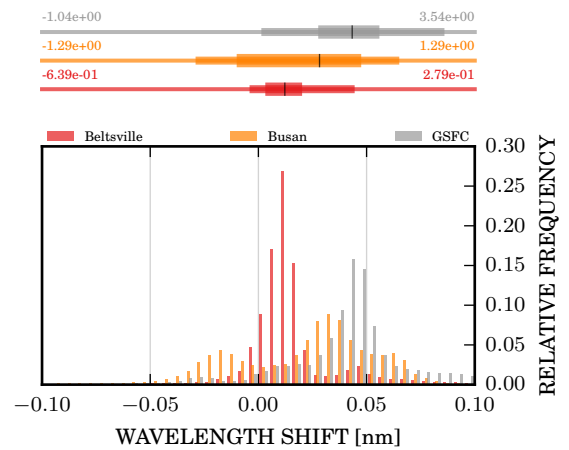
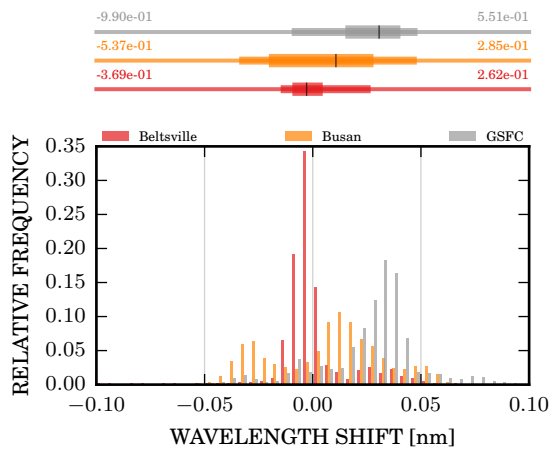
1. UNCERTAINTY VC



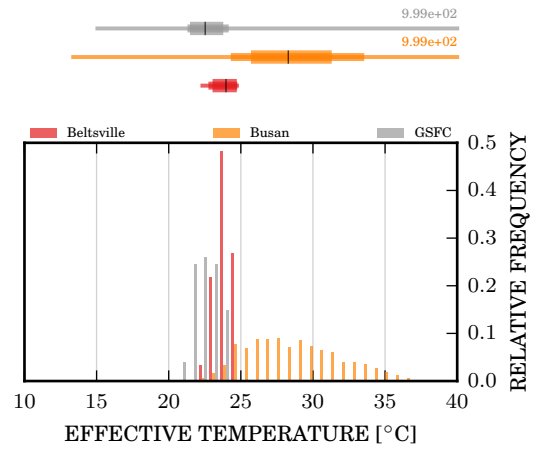
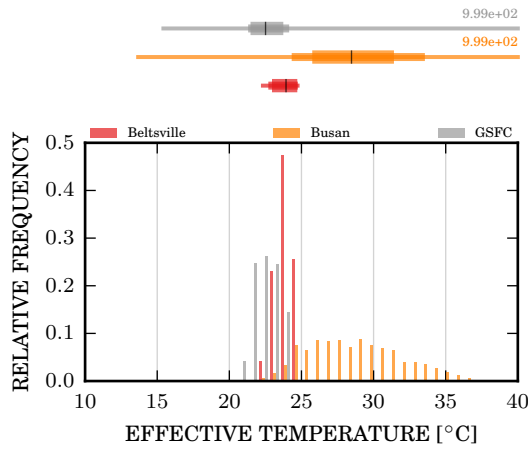
2. WRMS SPEC. FIT. RES.



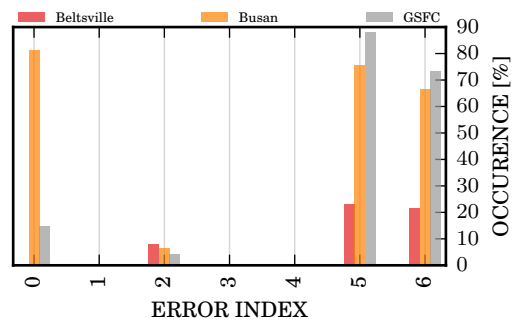
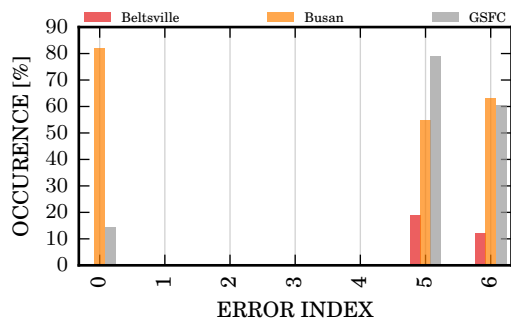
3. WAVELENGTH SHIFT



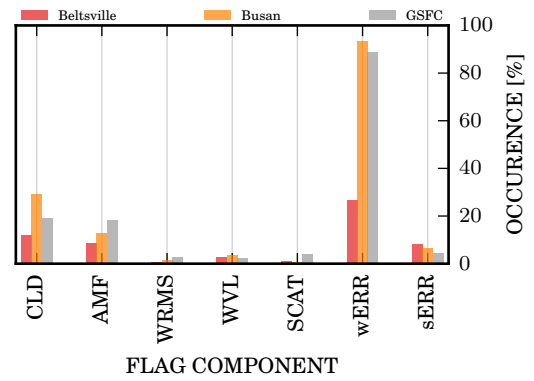
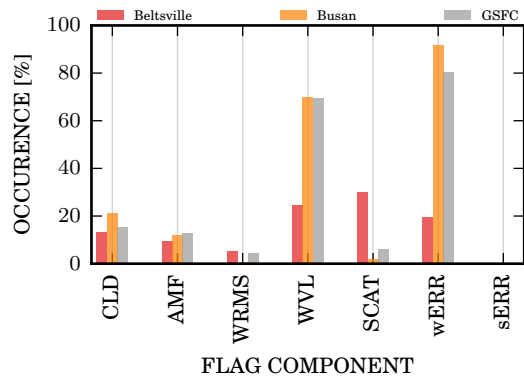
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.12 PANDORA 21 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110627 20110825 20141208
validity period end	20110824 20141205 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1010032U1 1010032U1 1010032U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	73.243 73.243 73.243 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

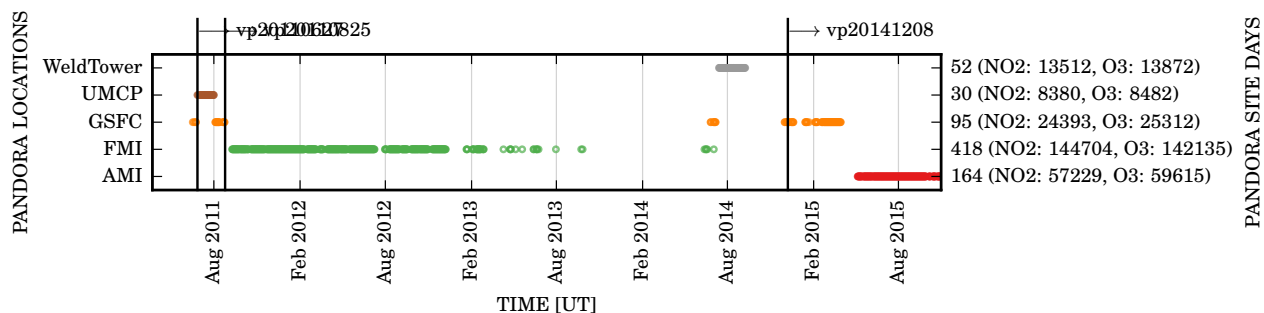
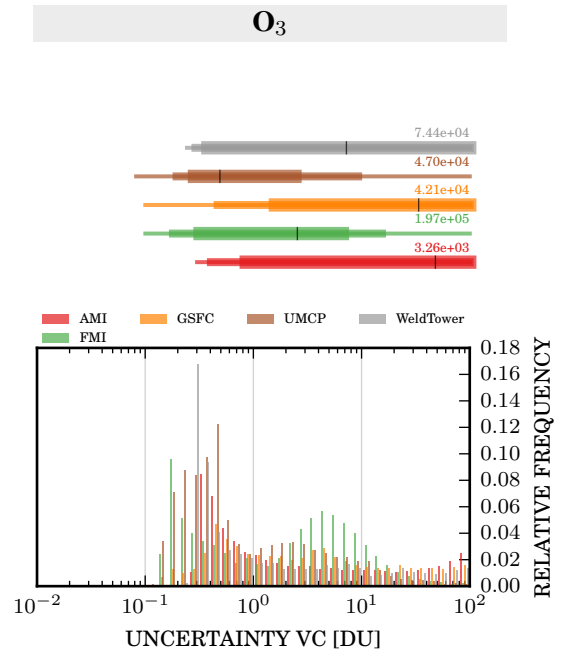
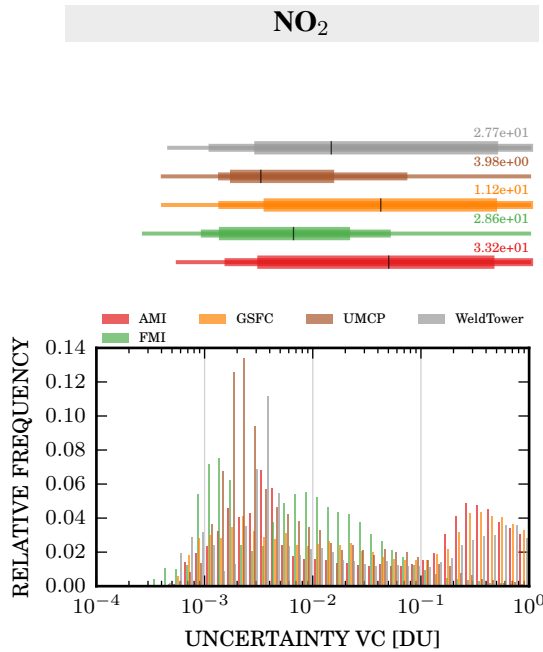


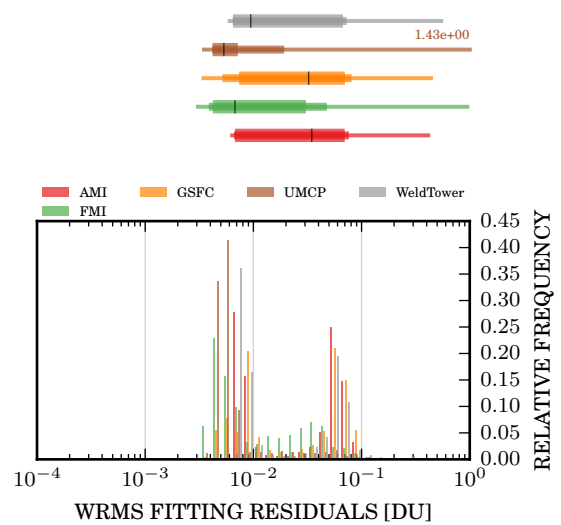
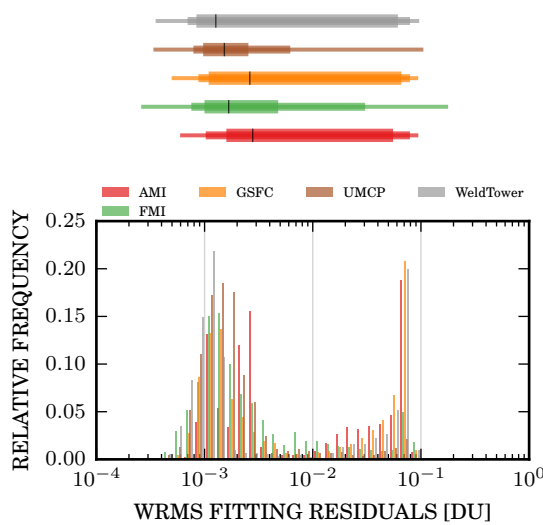
Figure 20: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

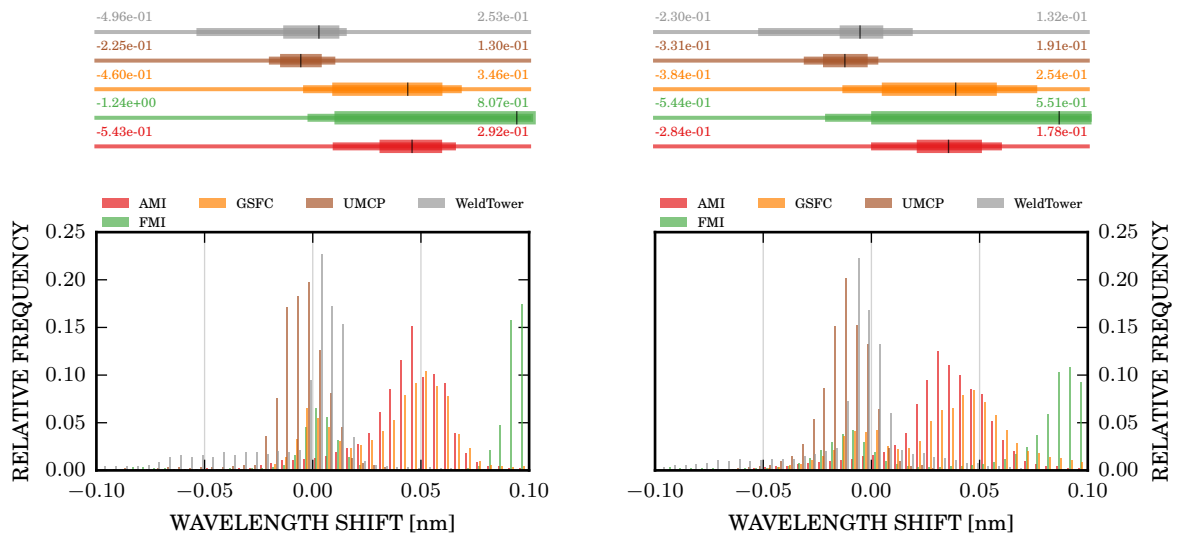
1. UNCERTAINTY VC



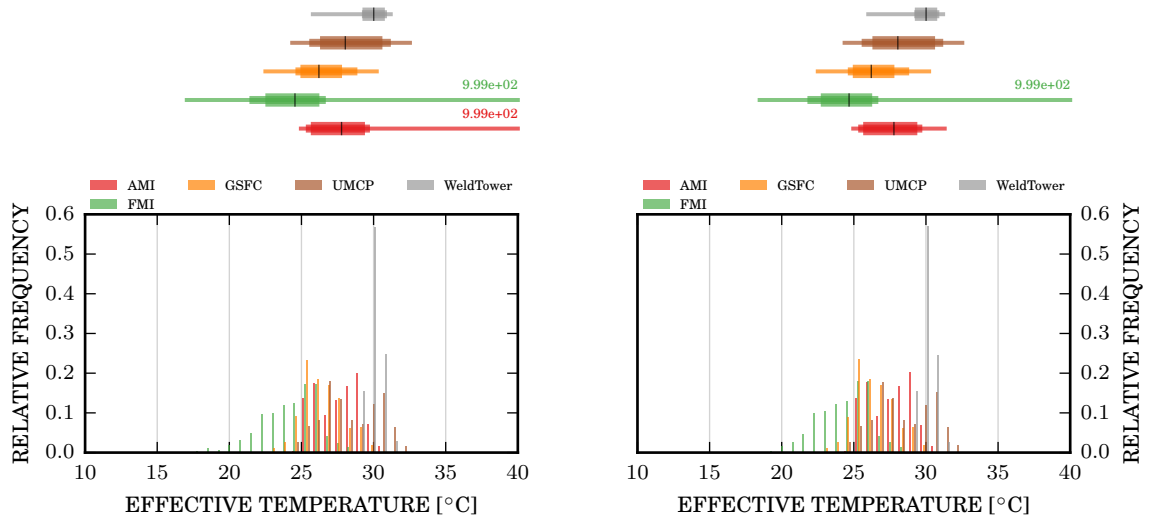
2. WRMS SPEC. FIT. RES.



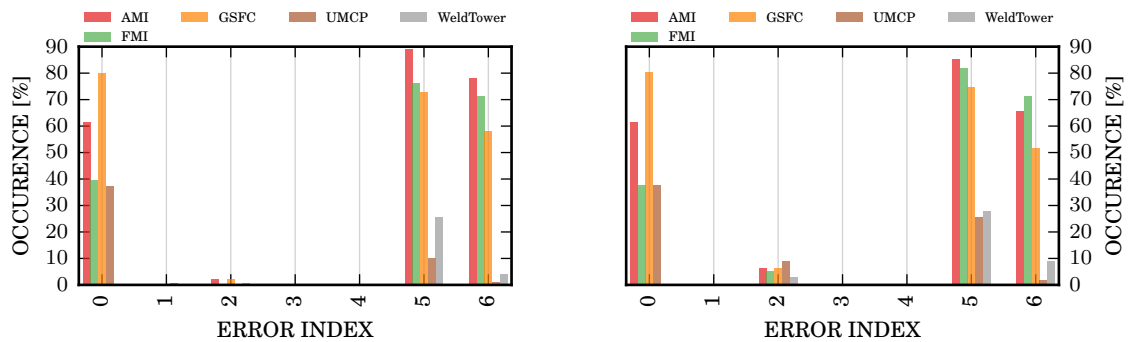
3. WAVELENGTH SHIFT



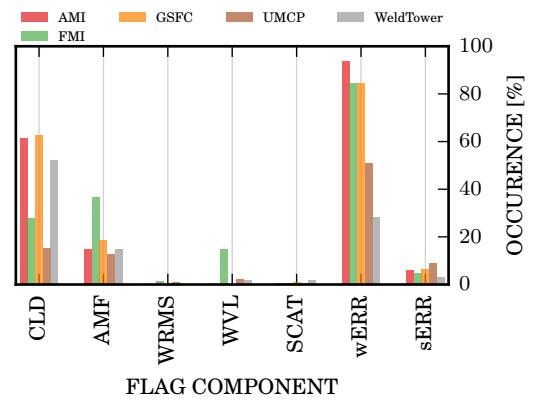
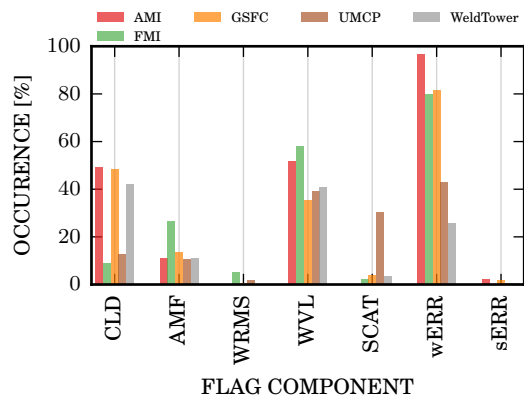
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.13 PANDORA 23 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110622 20130429 20150708
validity period end	20130428 20150707 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1012233U1 1012233U1 1012233U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	67.140 67.140 67.140 %
temperature controller set temp.	20.0 15.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

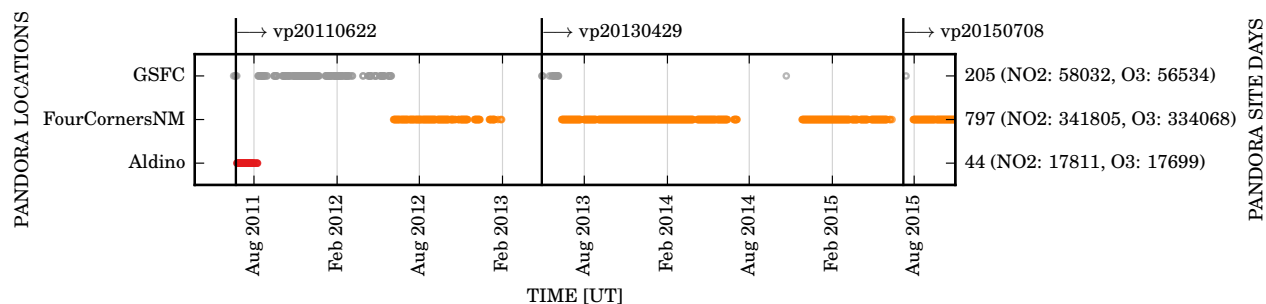
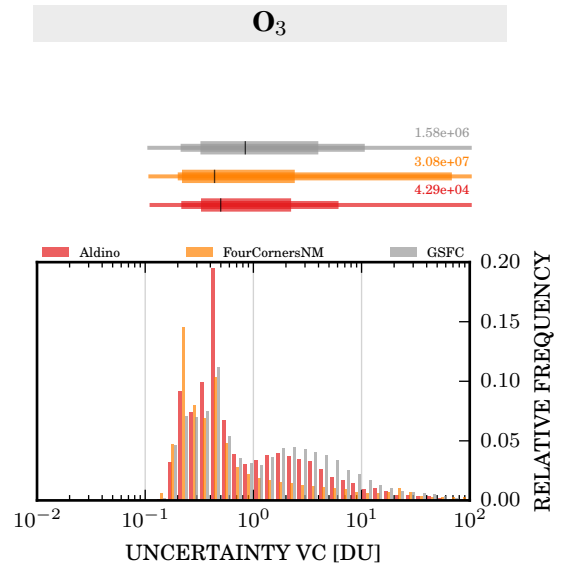
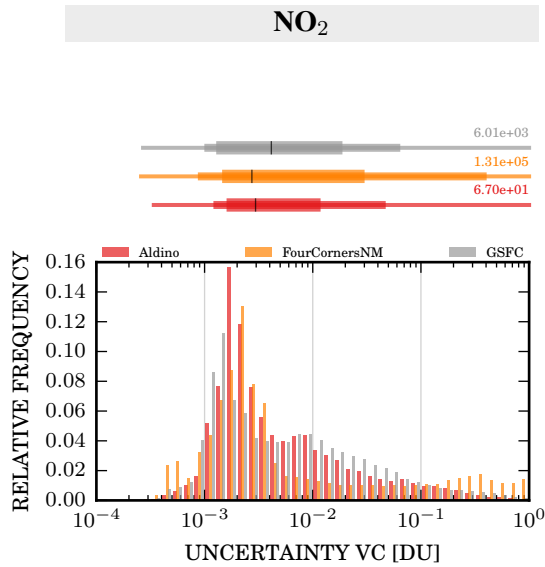


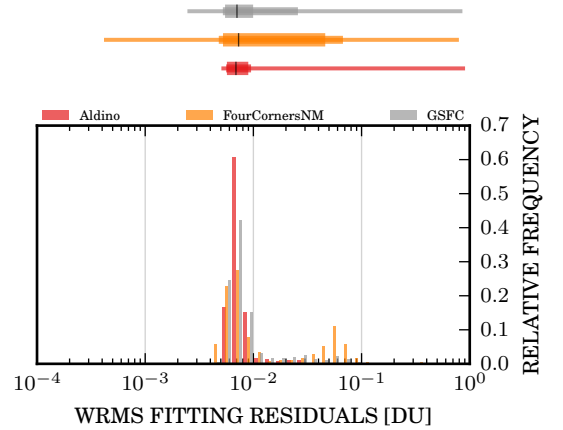
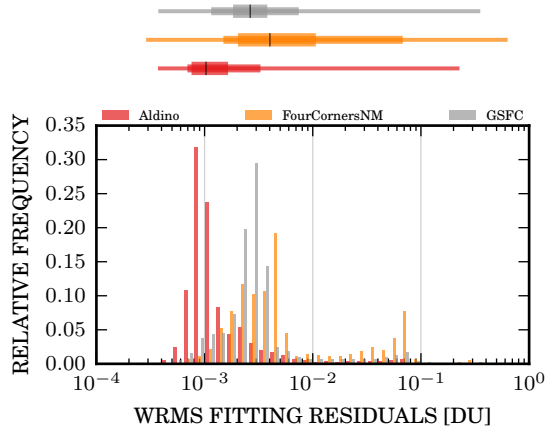
Figure 21: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

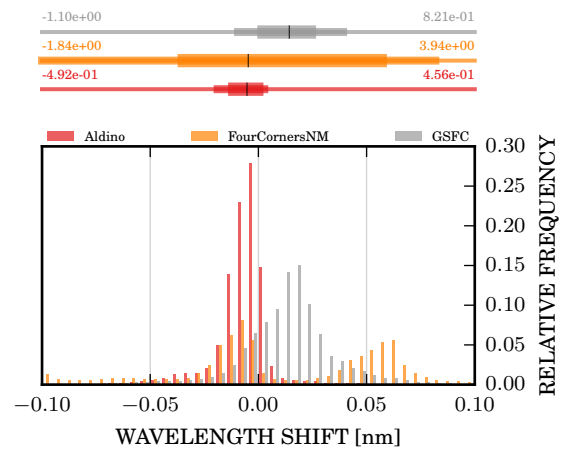
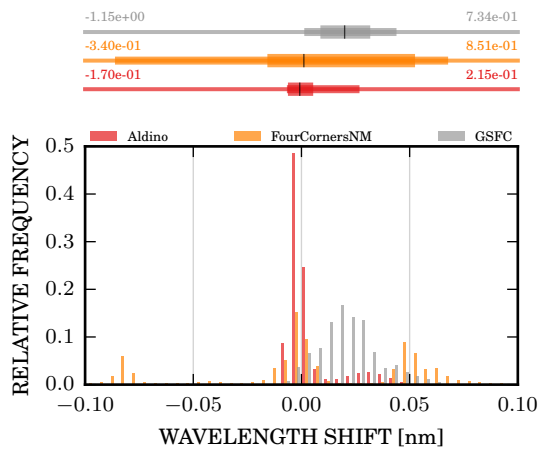
1. UNCERTAINTY VC



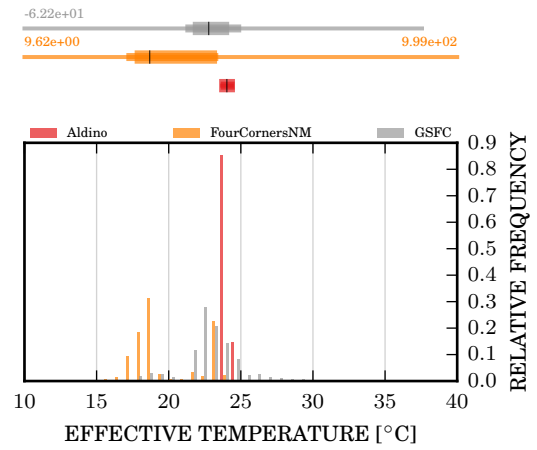
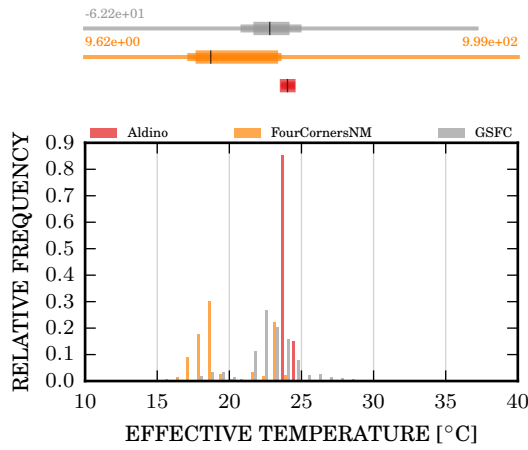
2. WRMS SPEC. FIT. RES.



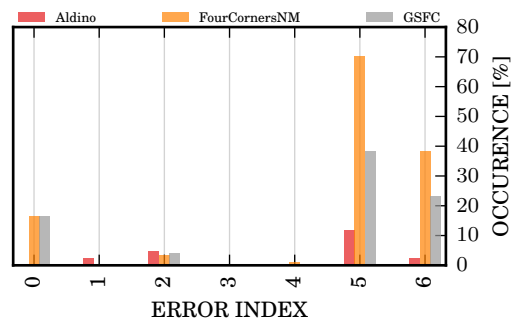
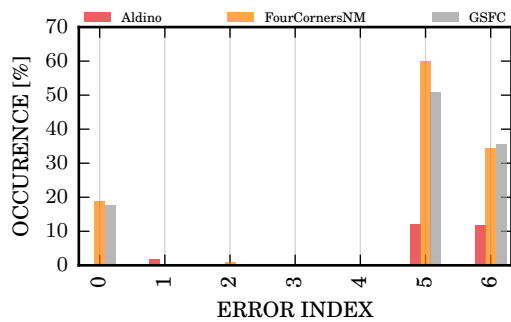
3. WAVELENGTH SHIFT



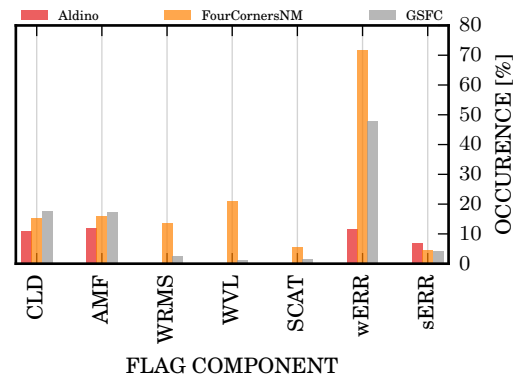
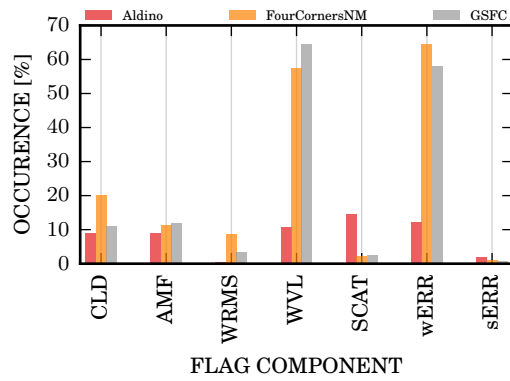
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.14 PANDORA 24 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110708 20130822 20150805
validity period end	20130820 20150804 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1001055U1 1001055U1 1001055U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	48.829 48.829 48.829 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO ₂	O ₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

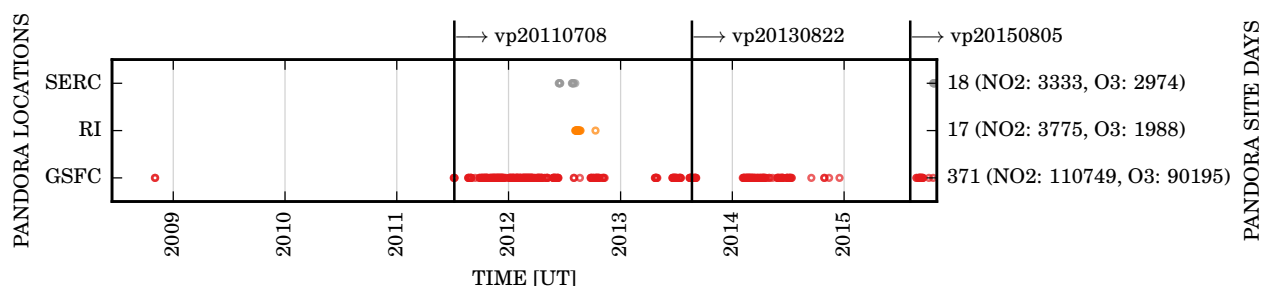
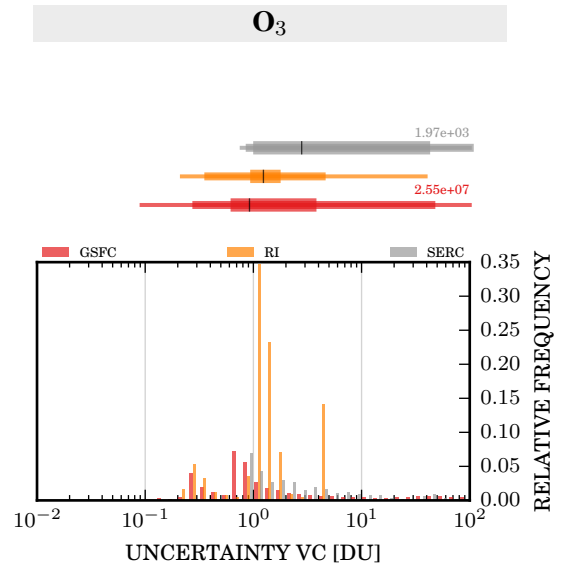
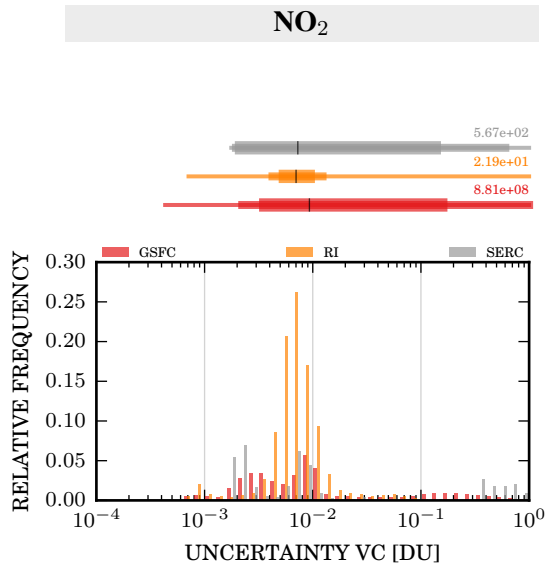


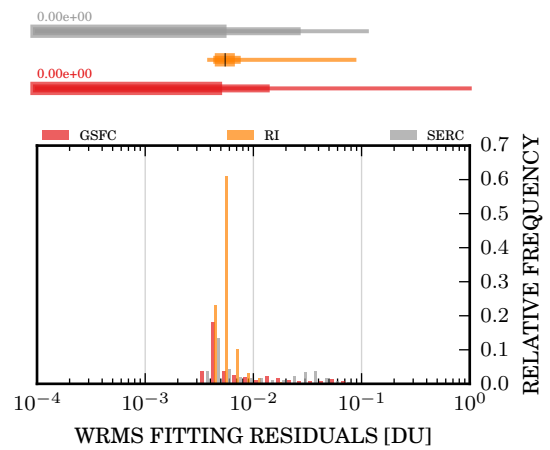
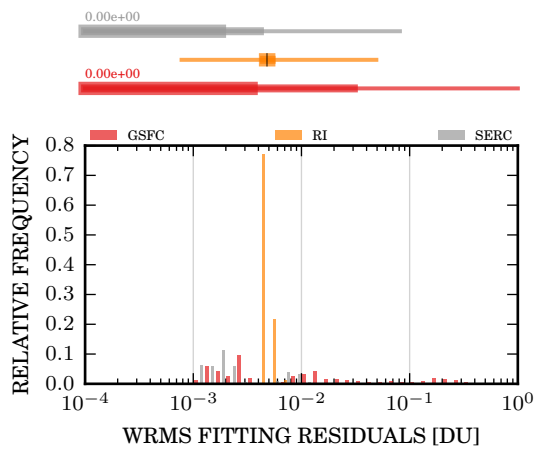
Figure 22: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

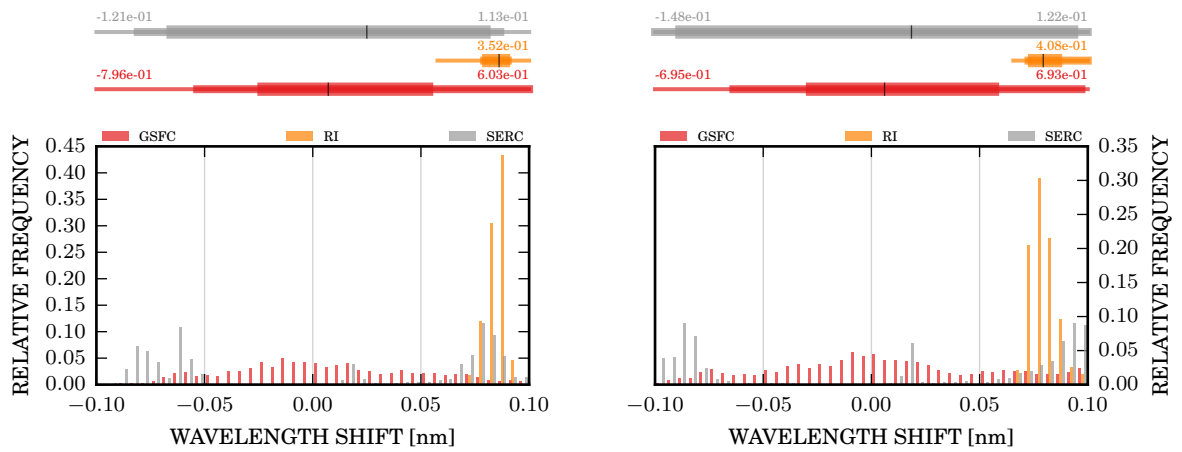
1. UNCERTAINTY VC



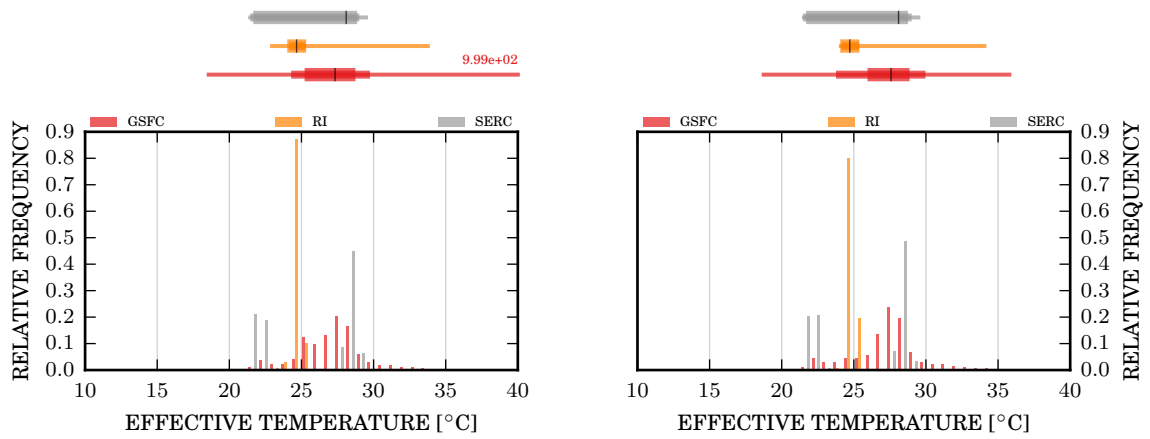
2. WRMS SPEC. FIT. RES.



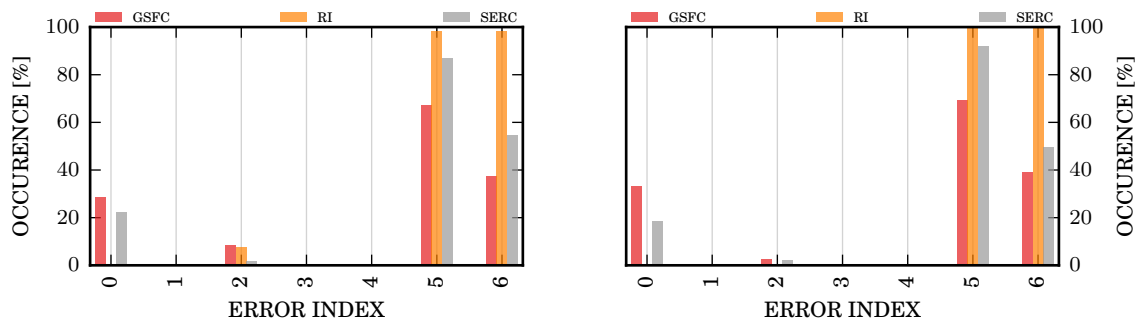
3. WAVELENGTH SHIFT



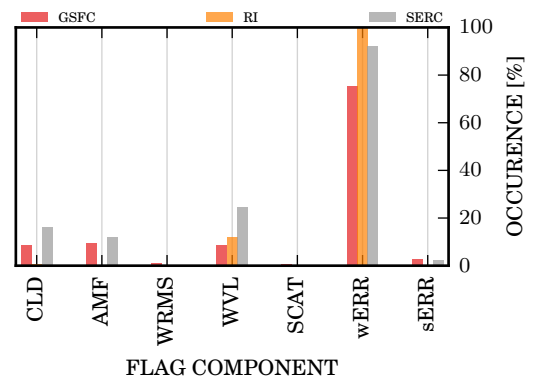
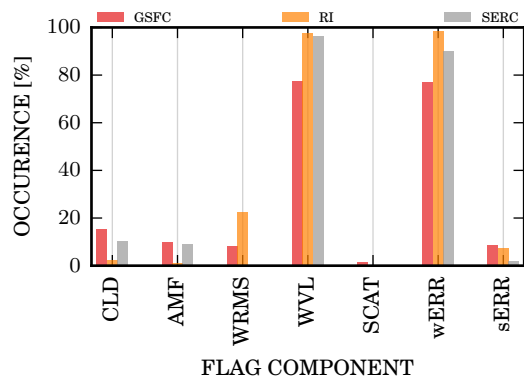
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.15 PANDORA 25 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110715 20120309 20140320
validity period end	20120308 20140319 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1010033U1 1010033U1 1010033U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	65.614 65.614 65.614 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

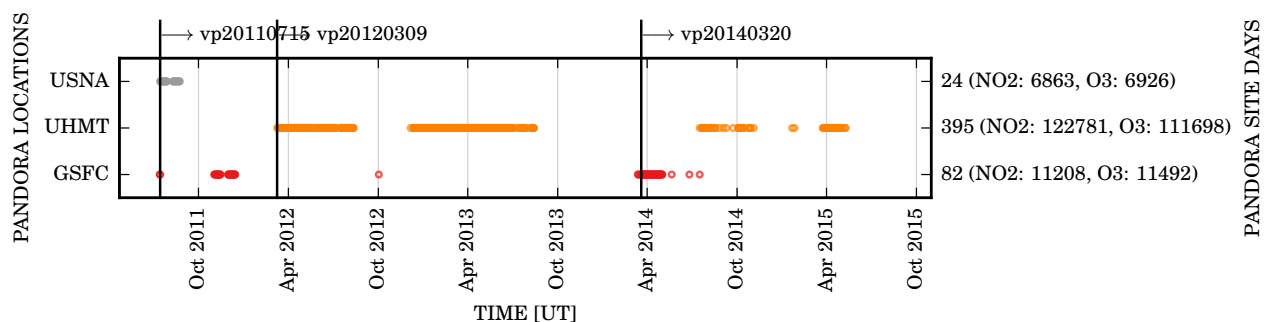
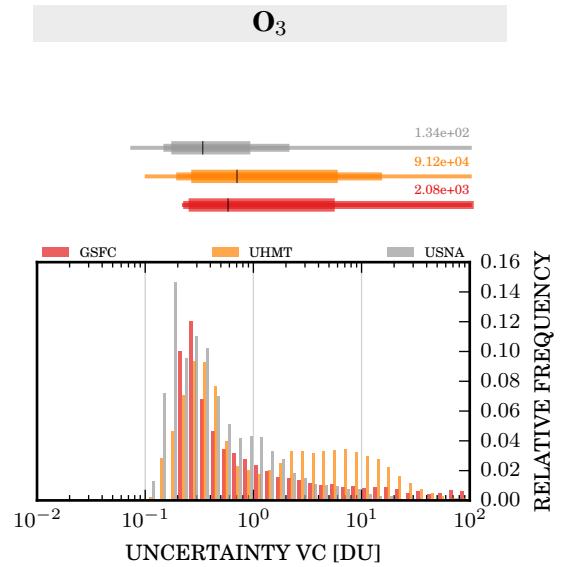
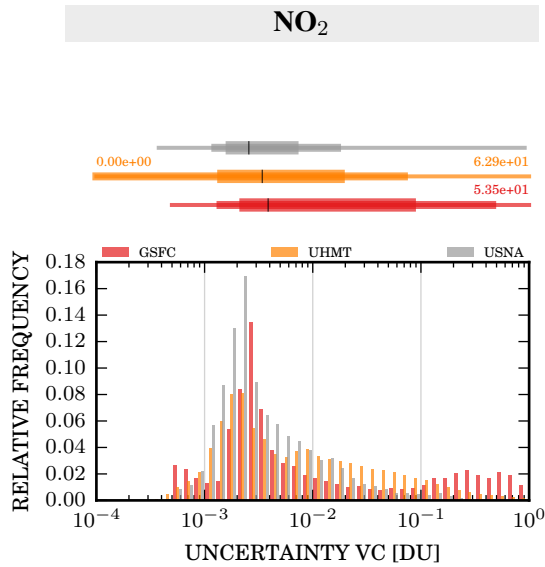


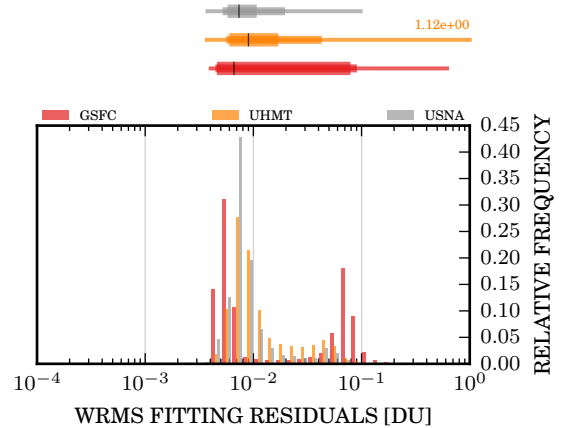
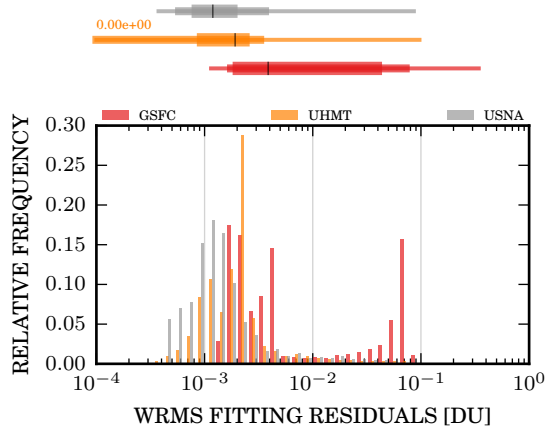
Figure 23: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

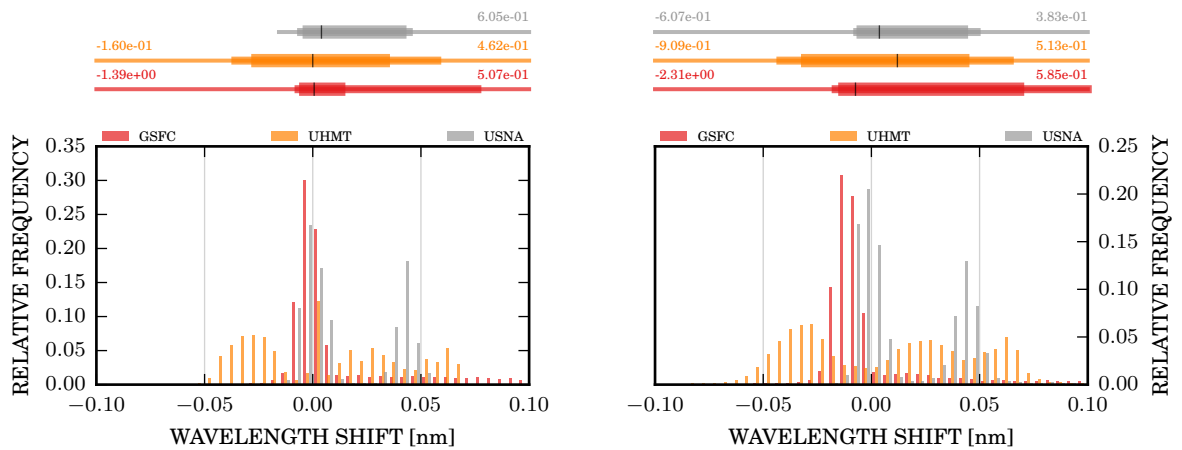
1. UNCERTAINTY VC



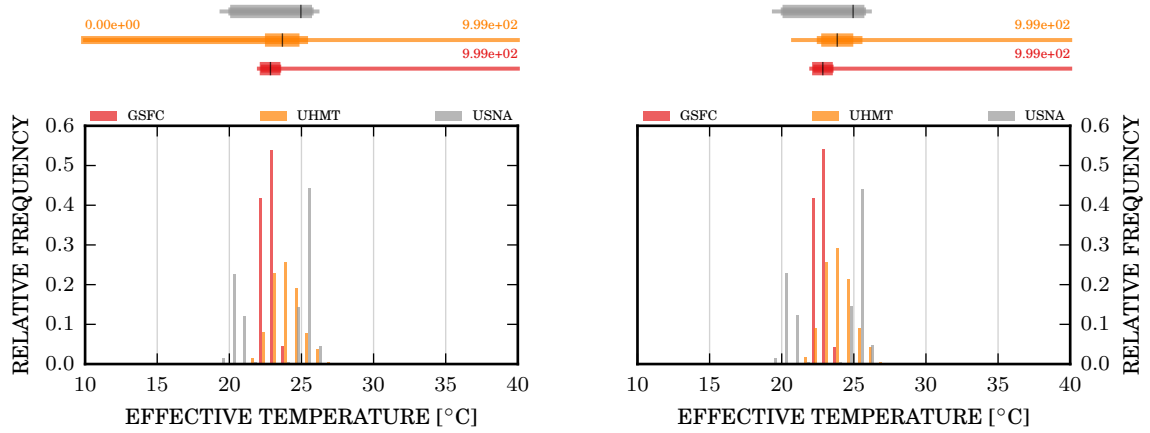
2. WRMS SPEC. FIT. RES.



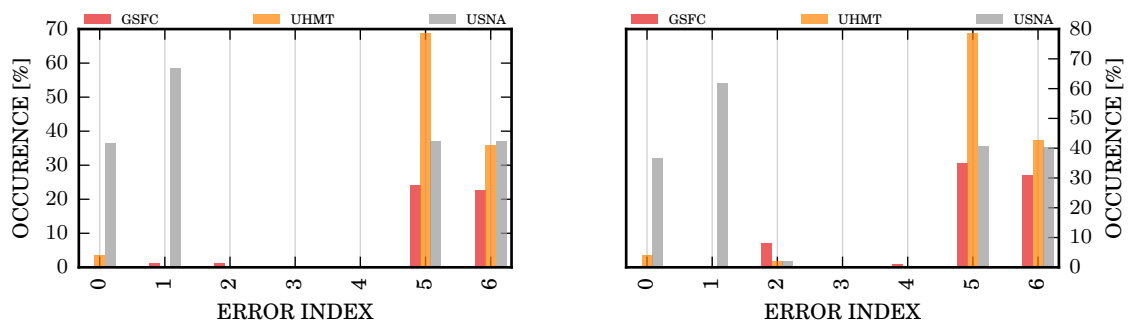
3. WAVELENGTH SHIFT



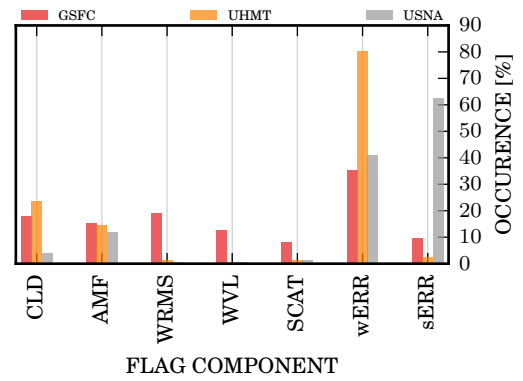
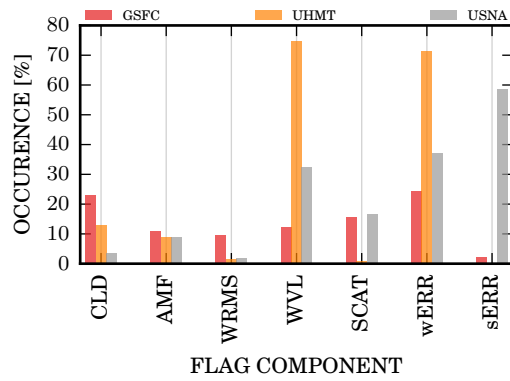
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.16 PANDORA 26 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20120228 20121031 20130614
validity period end	20121030 20130612 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1110083U1 1110083U1 1110083U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	94.606 94.606 97.658 %
temperature controller set temp.	20.0 20.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

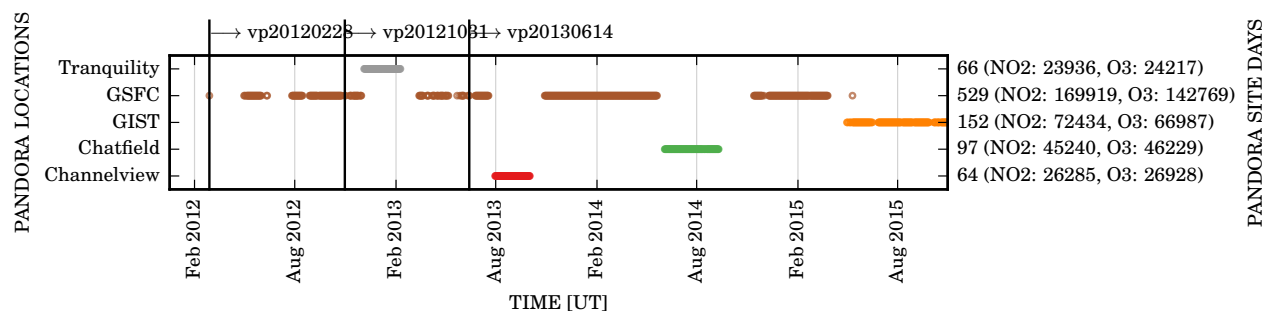
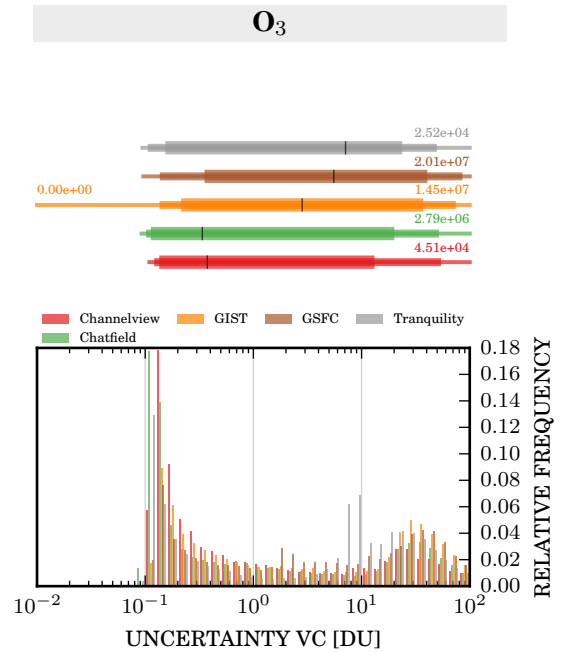
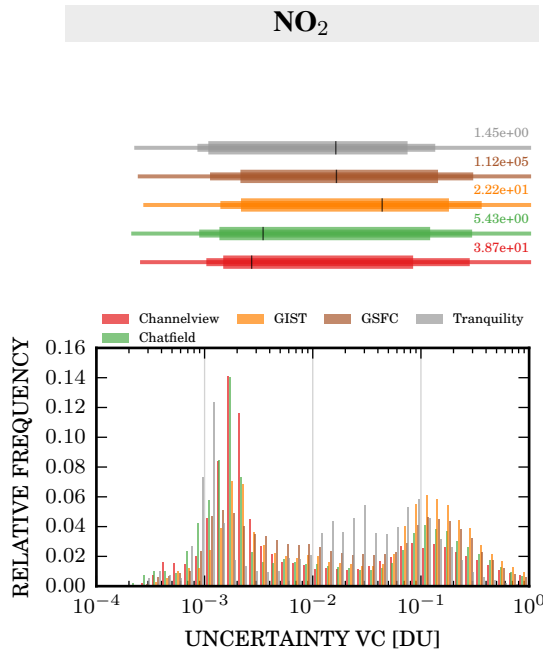


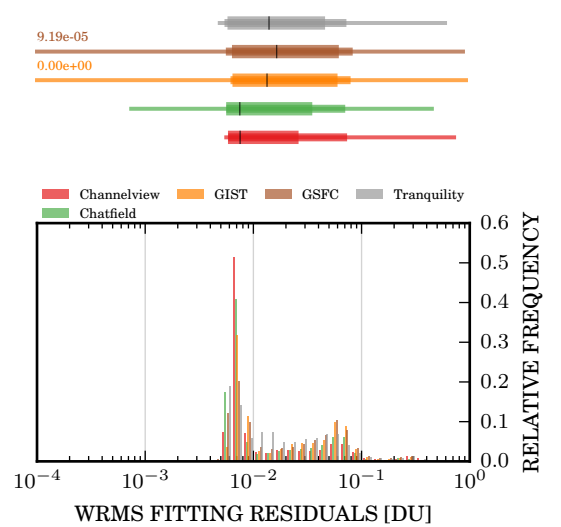
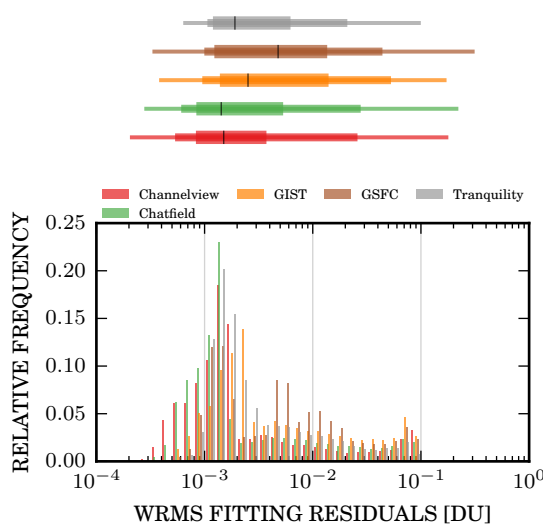
Figure 24: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

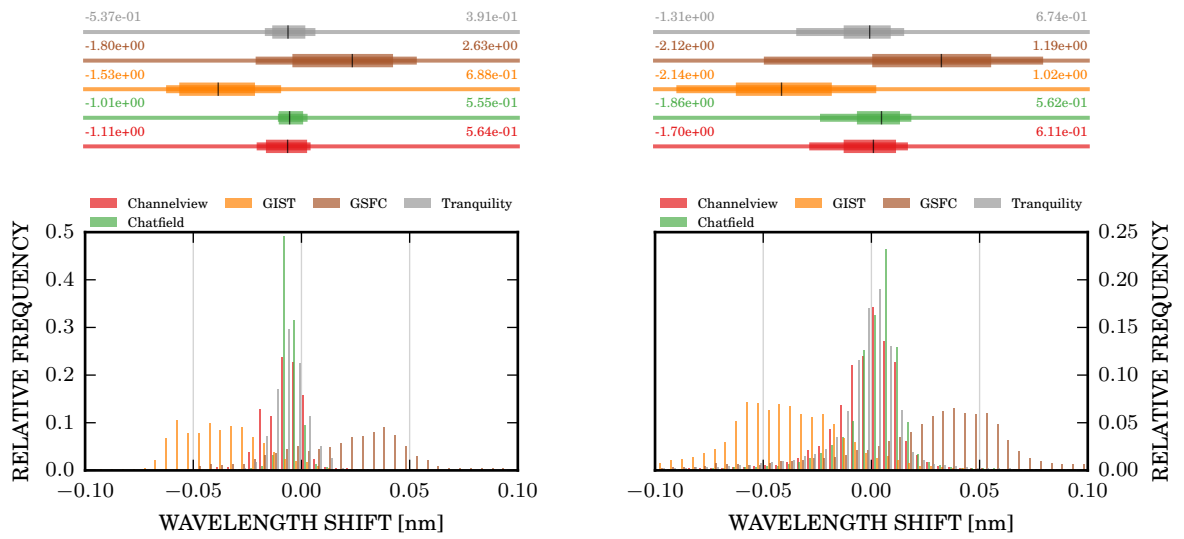
1. UNCERTAINTY VC



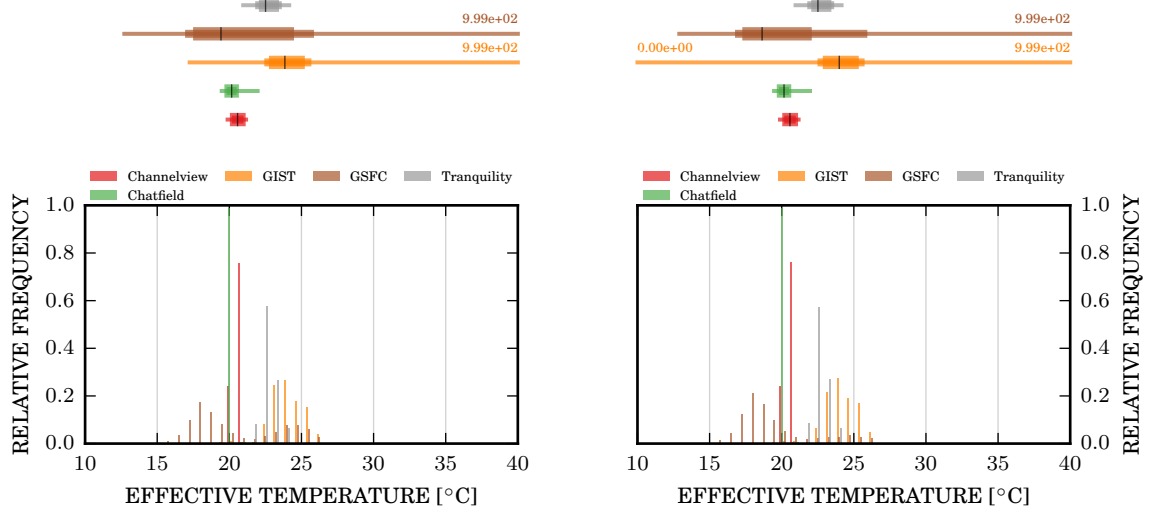
2. WRMS SPEC. FIT. RES.



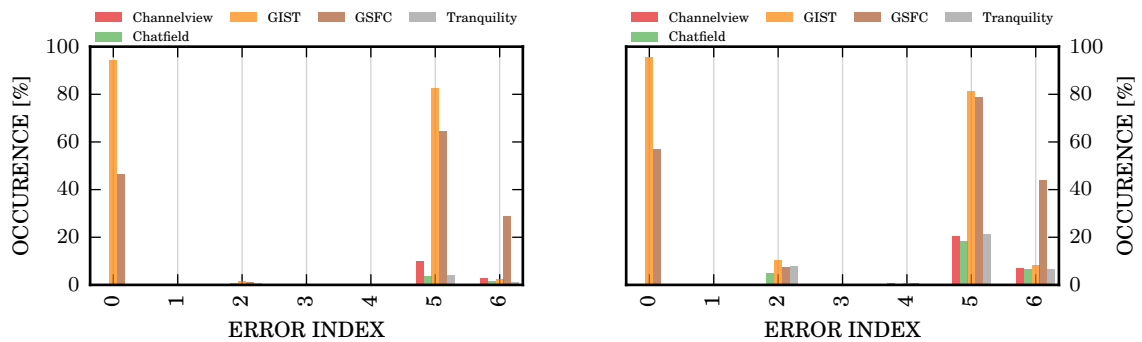
3. WAVELENGTH SHIFT



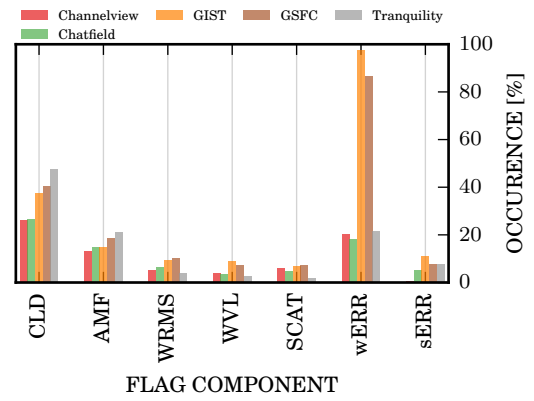
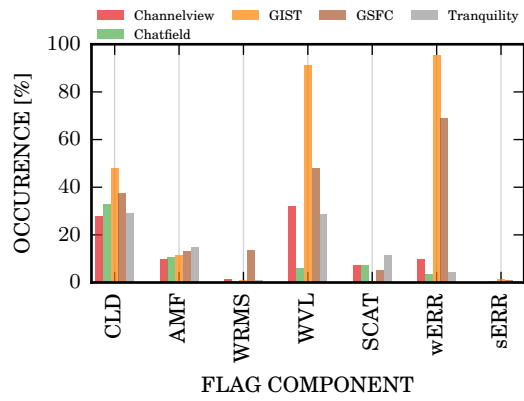
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.17 PANDORA 27 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121120 20130712 20150811
validity period end	20130711 20150810 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1110084U1 1110084U1 1110084U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	91.554 97.658 97.658 %
temperature controller set temp.	20.0 15.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

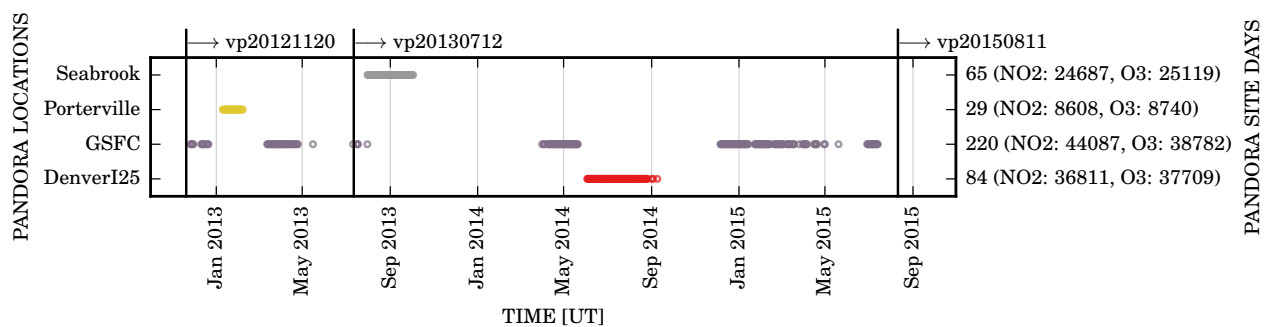
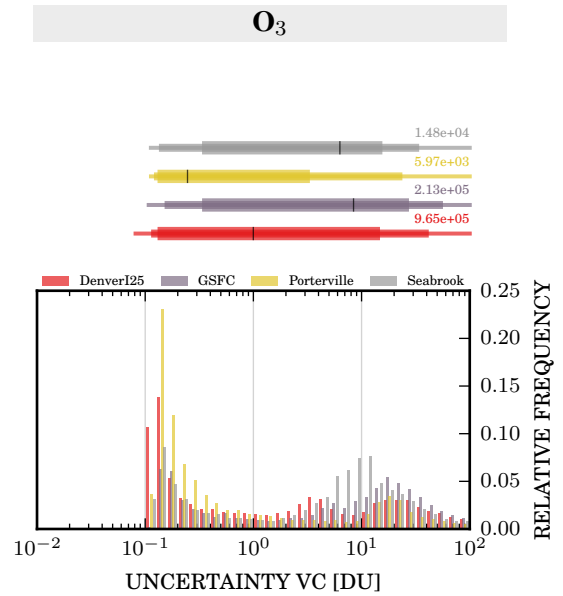
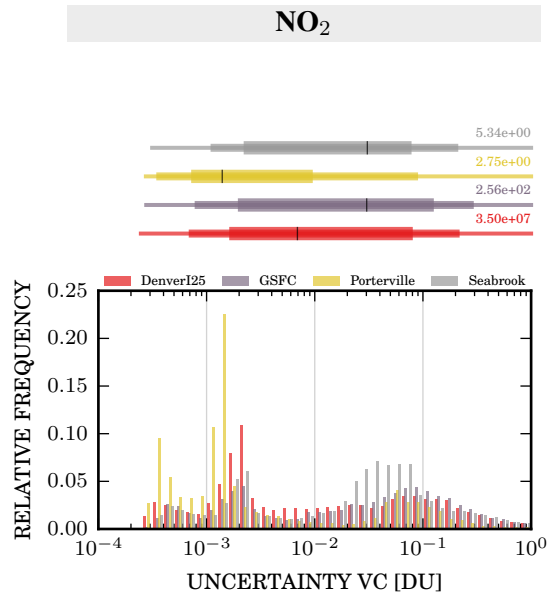


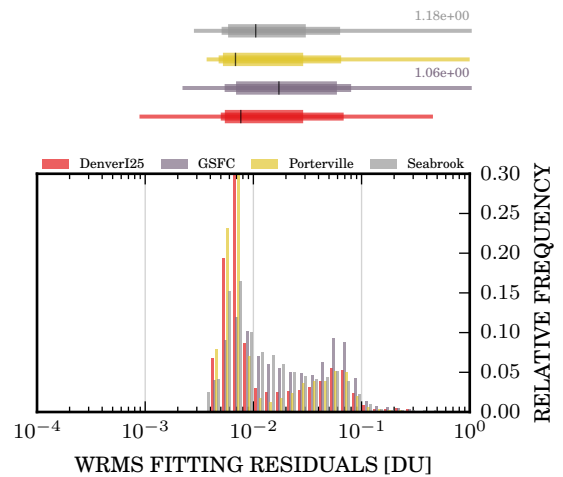
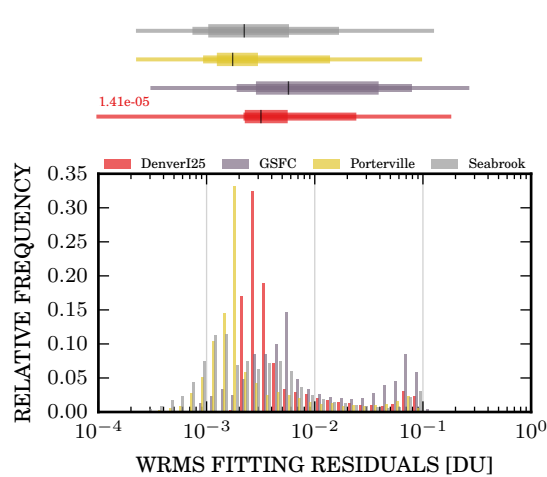
Figure 25: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

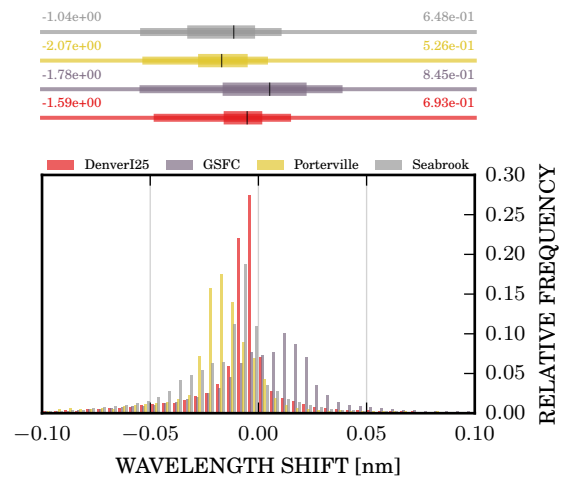
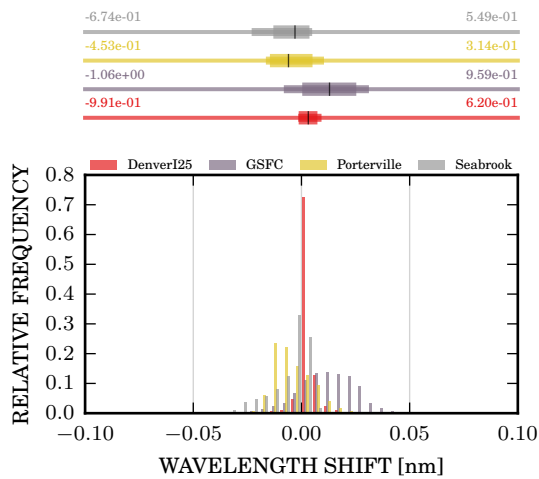
1. UNCERTAINTY VC



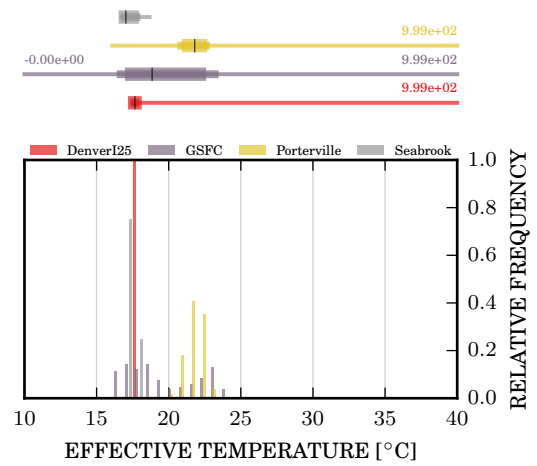
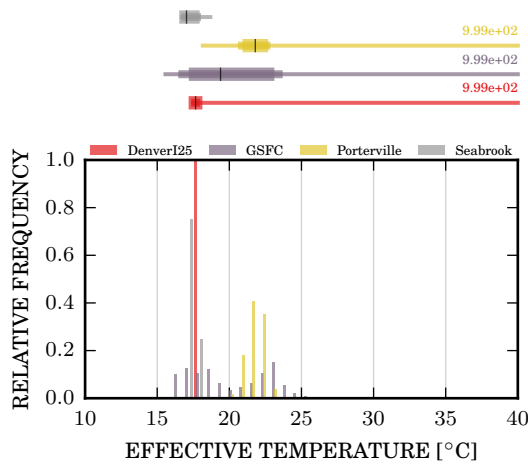
2. WRMS SPEC. FIT. RES.



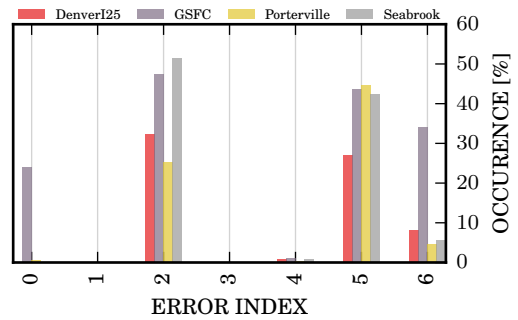
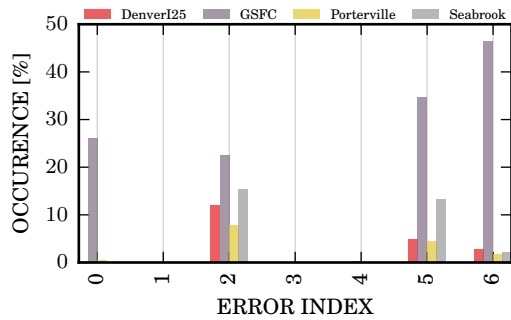
3. WAVELENGTH SHIFT



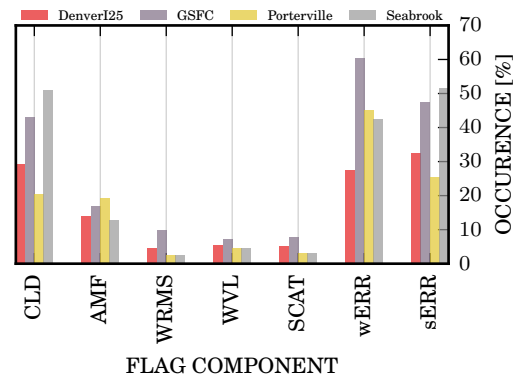
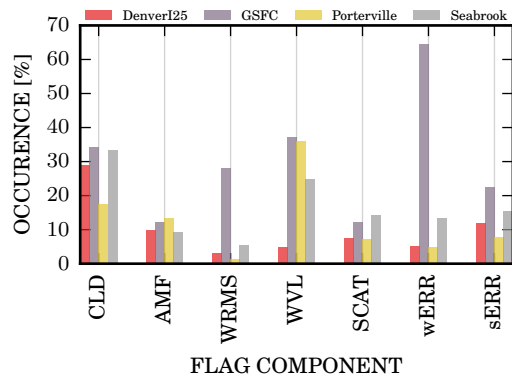
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.18 PANDORA 28 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121011 20130819 20140718
validity period end	20130818 20140717 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1208025U1 1208025U1 1208025U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	91.554 97.658 97.658 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

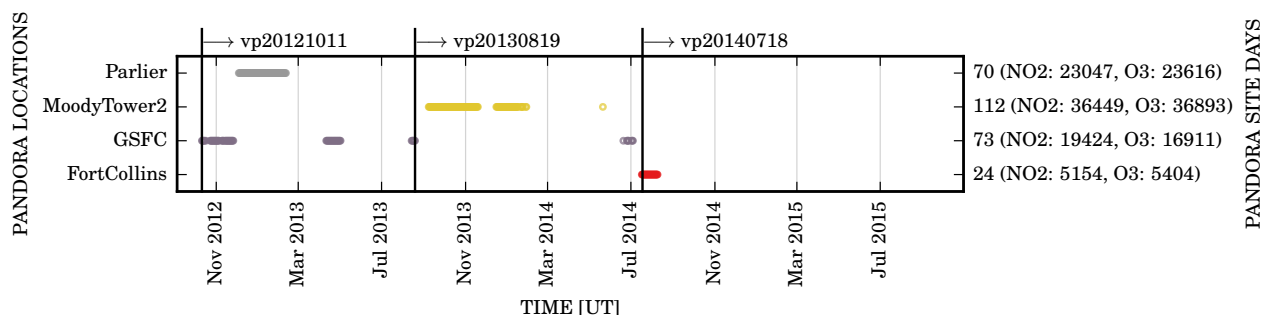
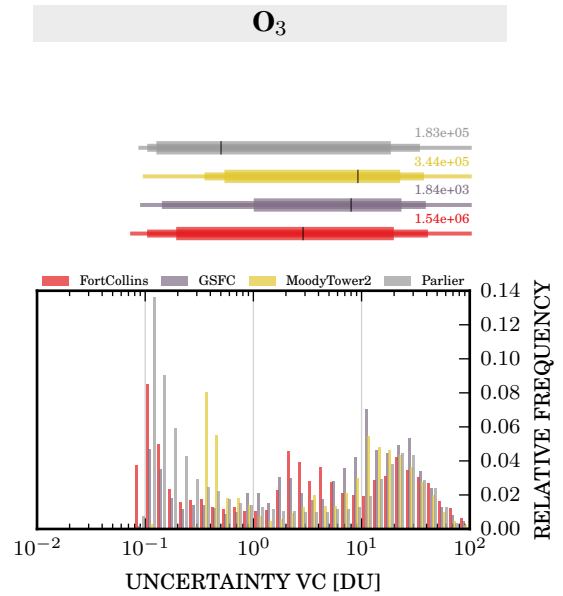
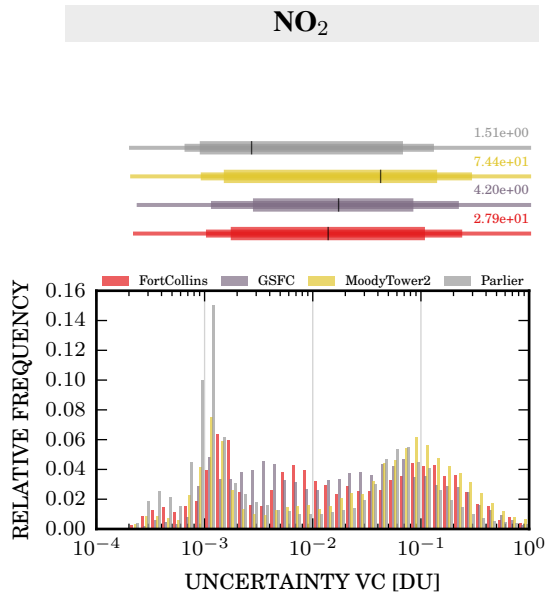


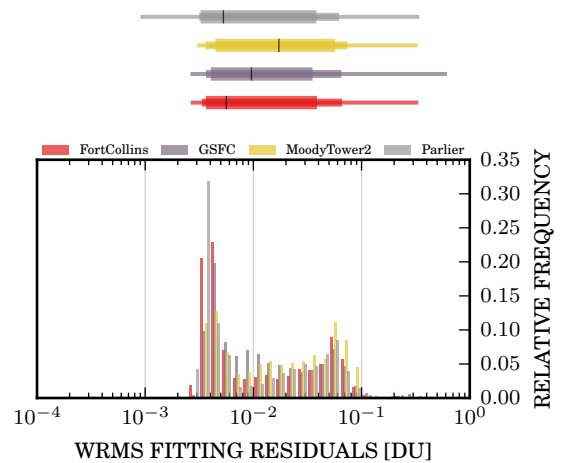
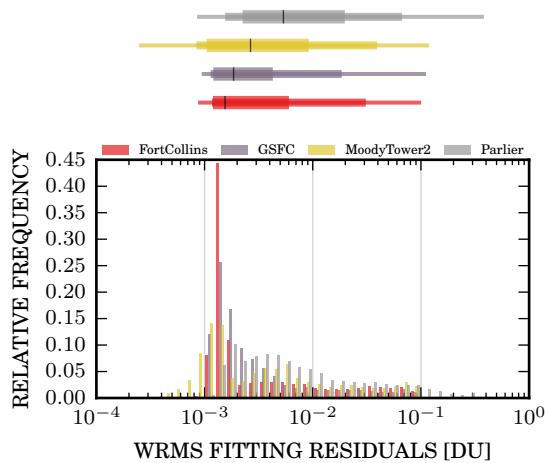
Figure 26: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

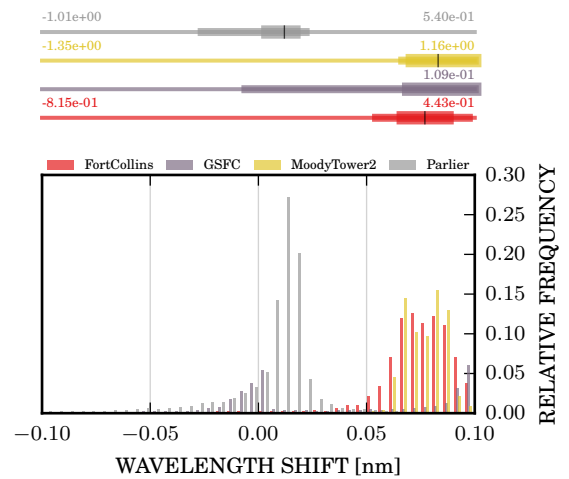
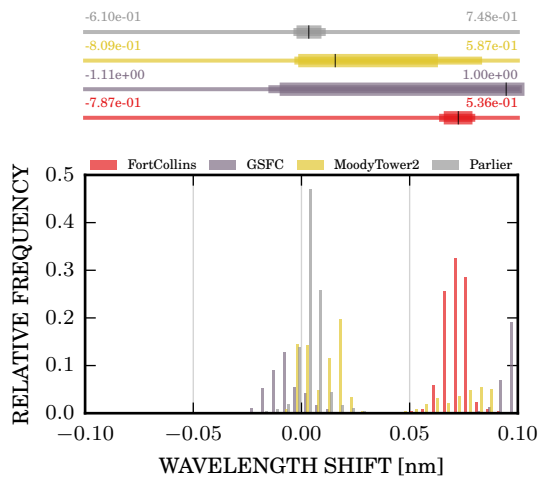
1. UNCERTAINTY VC



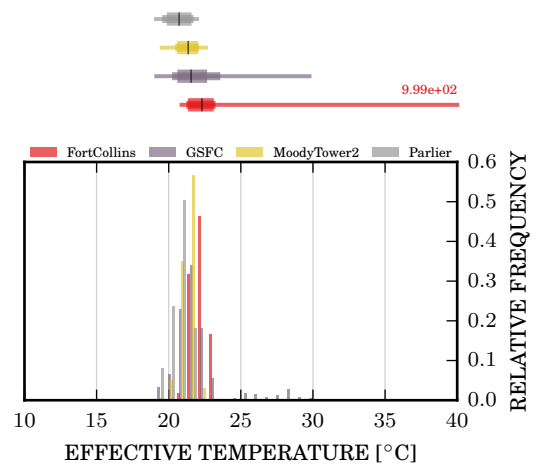
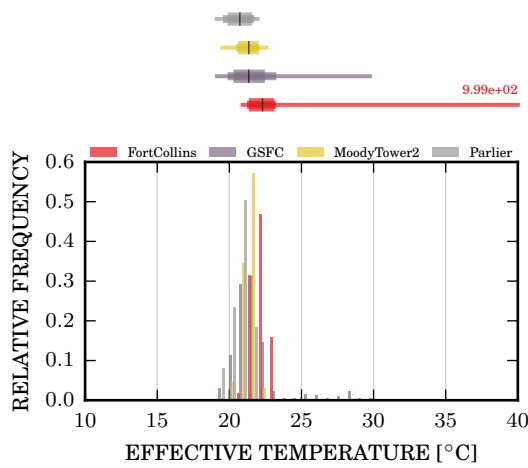
2. WRMS SPEC. FIT. RES.



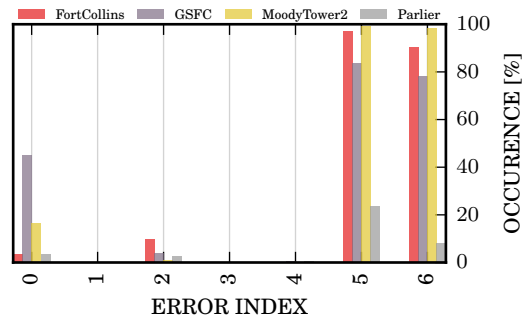
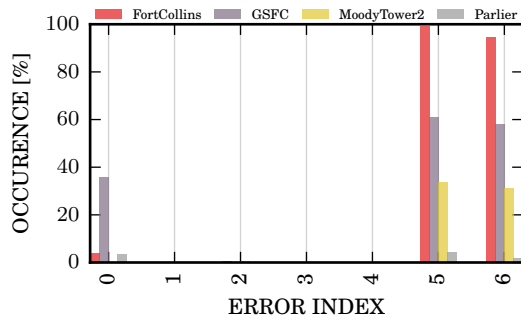
3. WAVELENGTH SHIFT



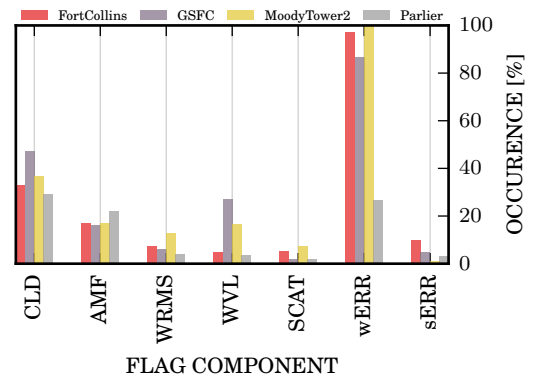
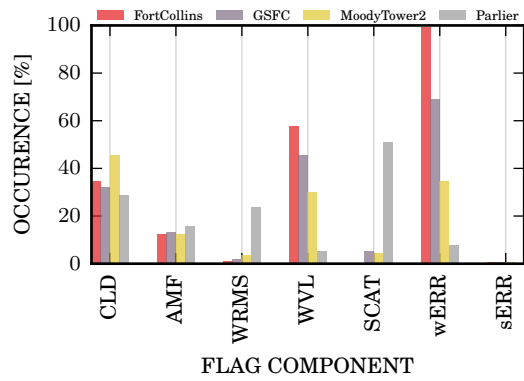
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.19 PANDORA 29 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121016 20130813 20130813 20140602
validity period end	20130812 20140601 20140601 20150608
validity period version	1 1 2 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1 Ava1
spectrometer unit ID	1208023U1 1208077U1 1208077U1 1208077U1
number of pixels	2048 2048 2048 2048
A/D converter	16 16 16 16 bits
effective saturation limit	96.895 96.895 96.895 96.895 %
temperature controller set temp.	20.0 15.0 15.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

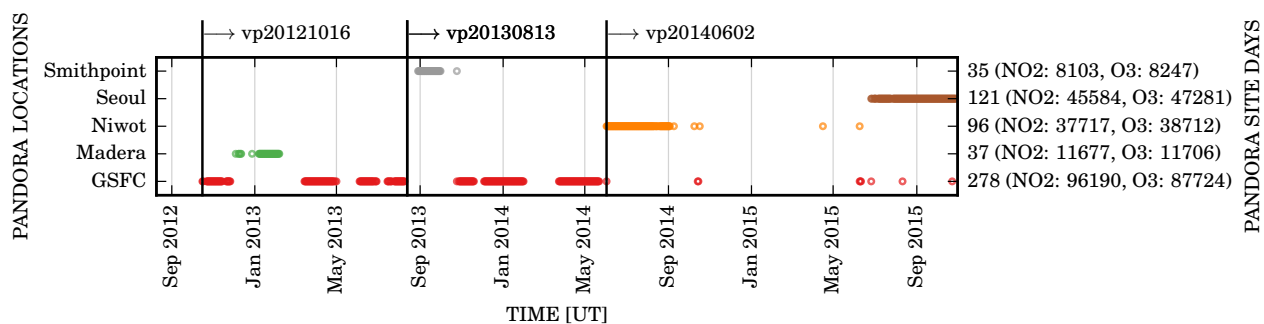
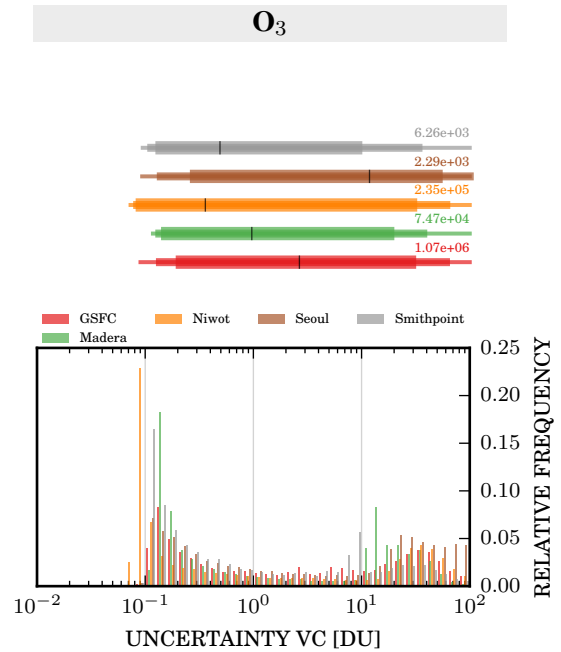
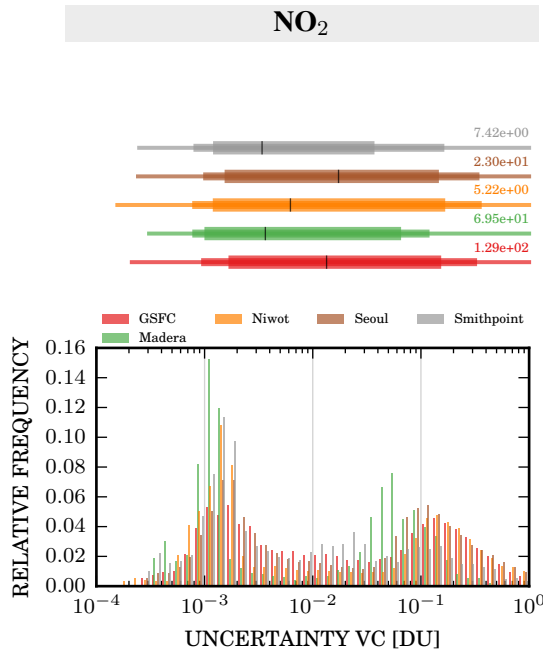


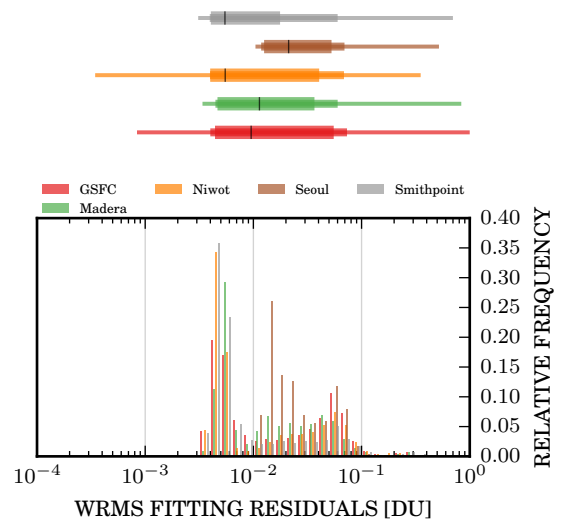
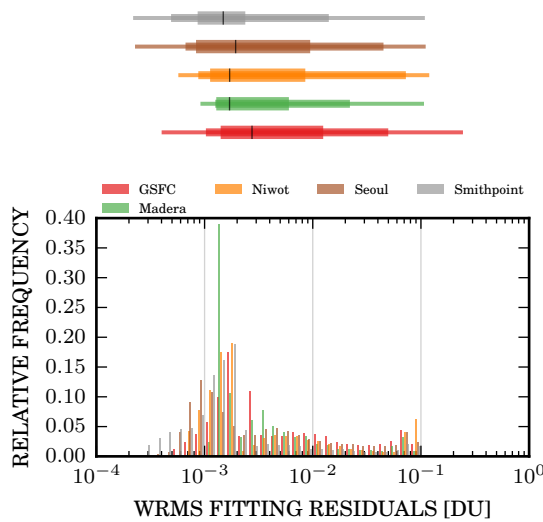
Figure 27: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

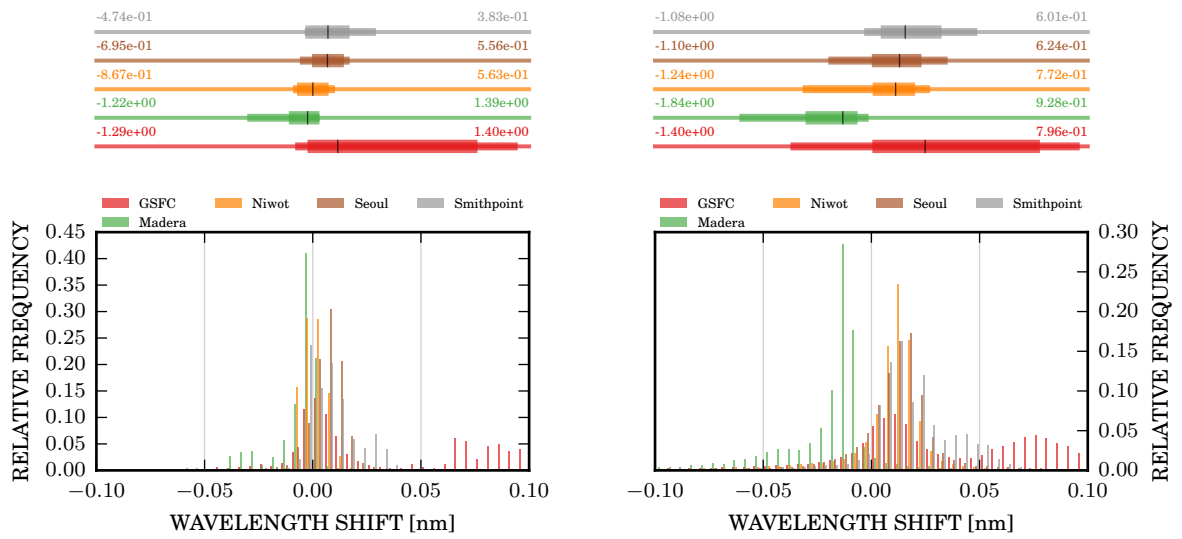
1. UNCERTAINTY VC



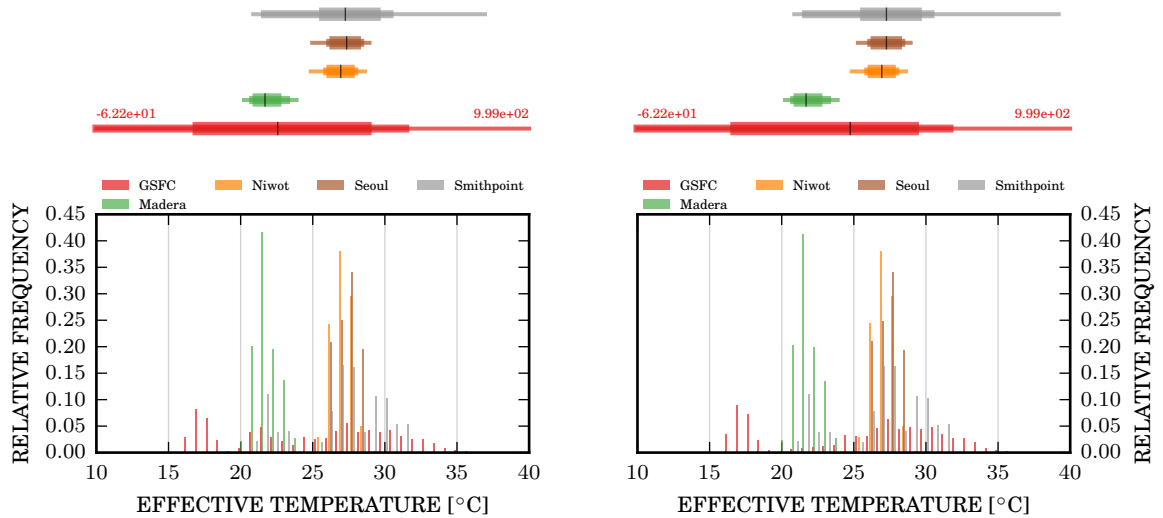
2. WRMS SPEC. FIT. RES.



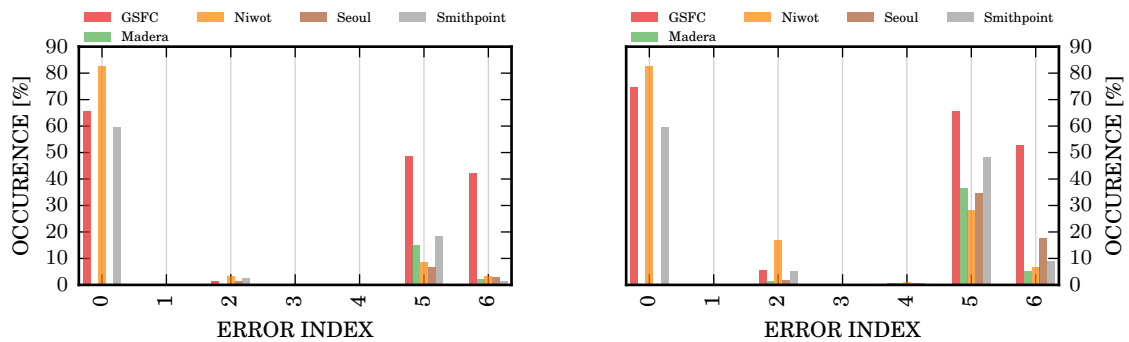
3. WAVELENGTH SHIFT



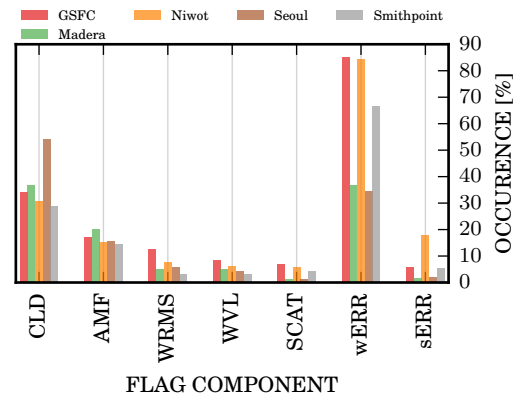
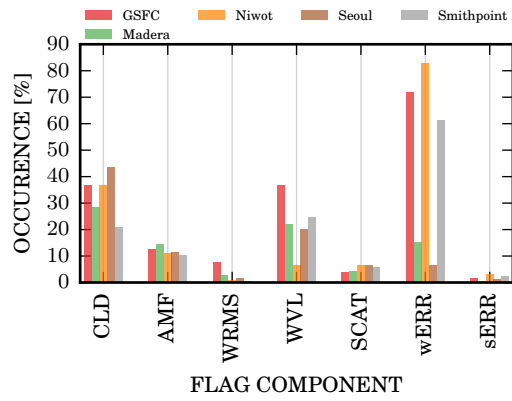
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.20 PANDORA 30 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121025 20130718
validity period end	20130717 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	1001054U1 1001054U1
number of pixels	2048 2048
A/D converter	16 16 bits
effective saturation limit	50.355 48.829 %
temperature controller set temp.	20.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

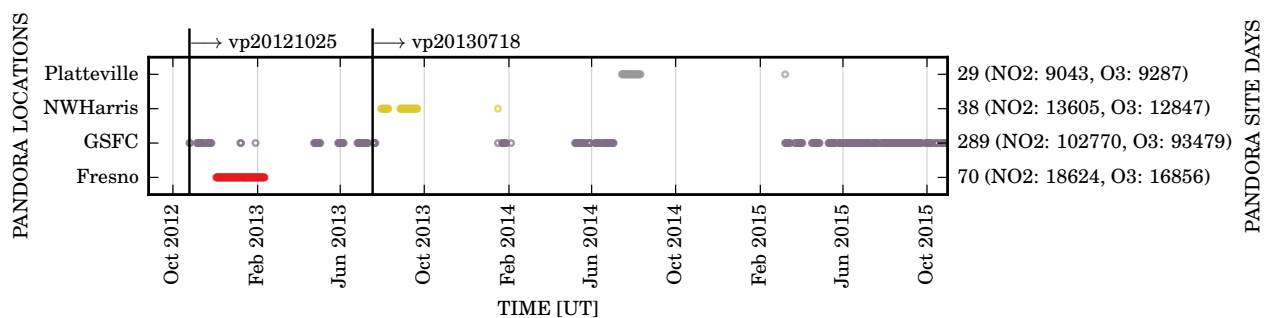
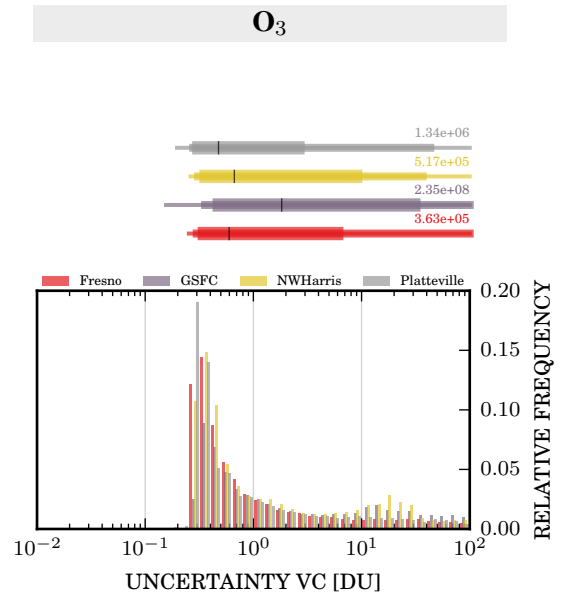
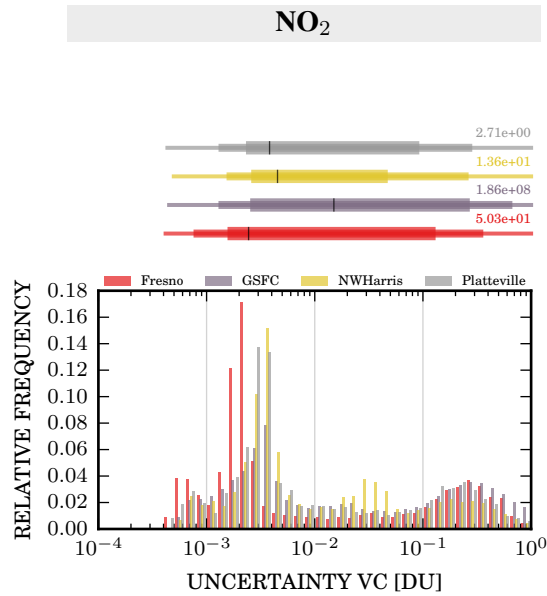


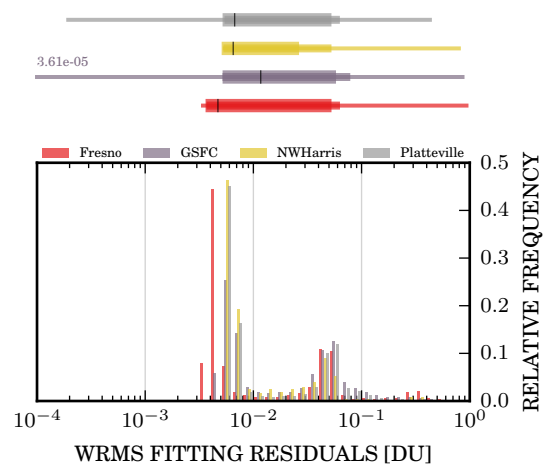
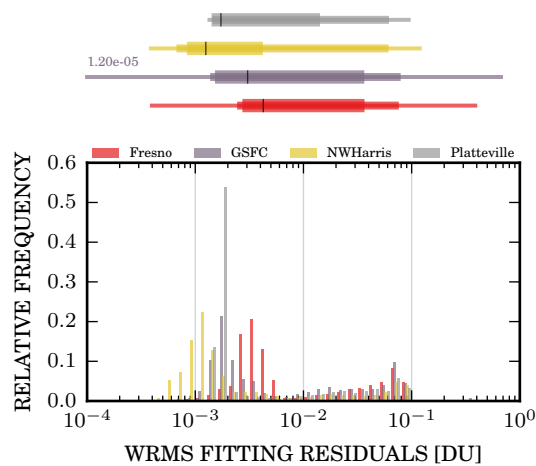
Figure 28: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

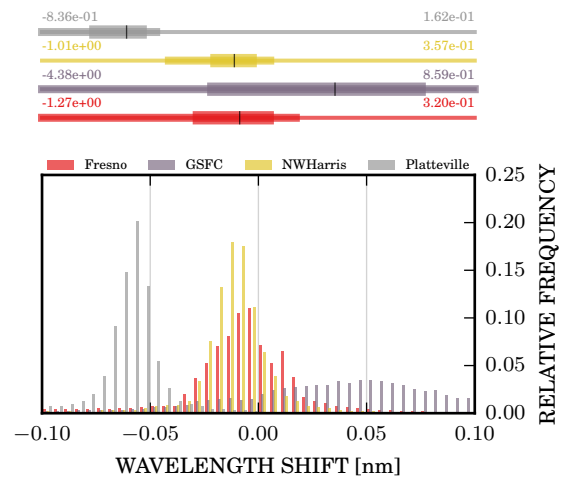
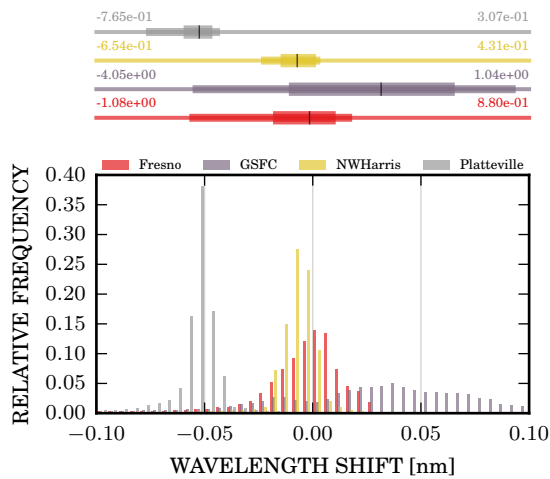
1. UNCERTAINTY VC



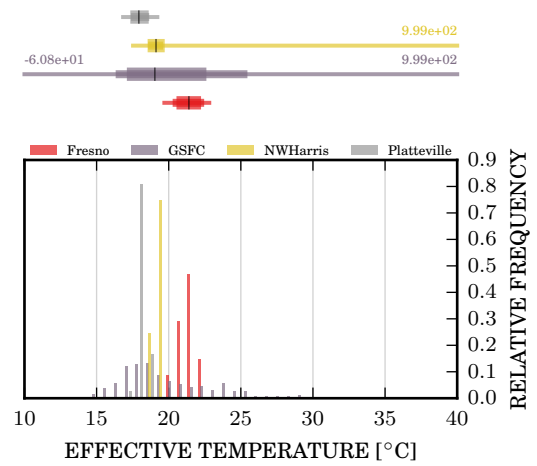
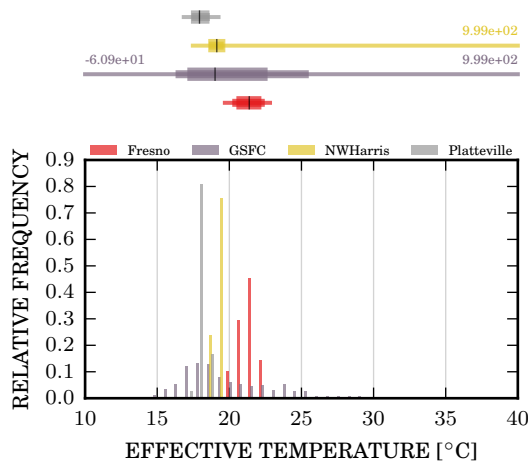
2. WRMS SPEC. FIT. RES.



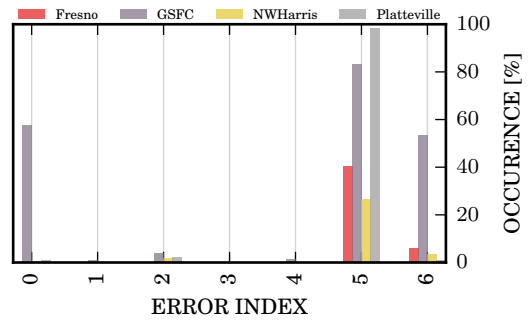
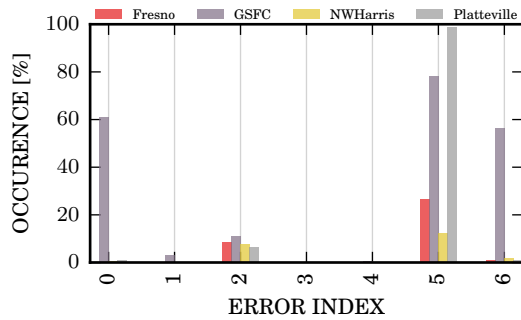
3. WAVELENGTH SHIFT



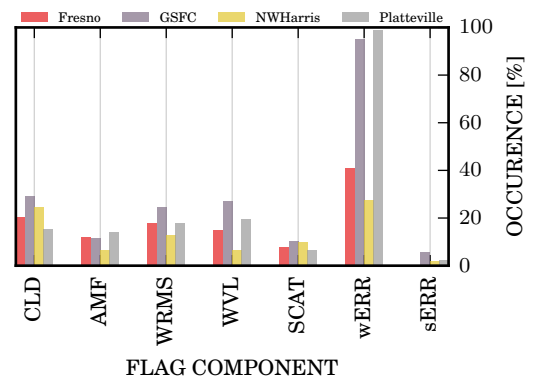
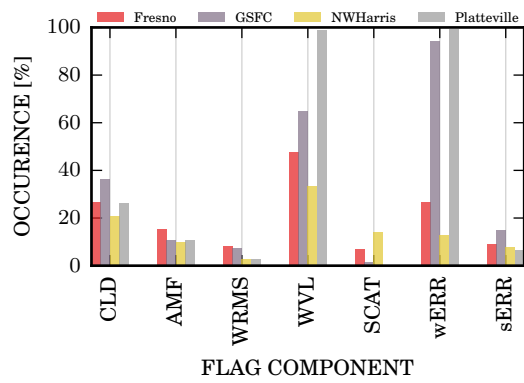
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.21 PANDORA 31 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121113 20130702 20141104
validity period end	20130701 20141103 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1110082U1 1110082U1 1110082U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	91.554 91.554 97.658 %
temperature controller set temp.	20.0 15.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

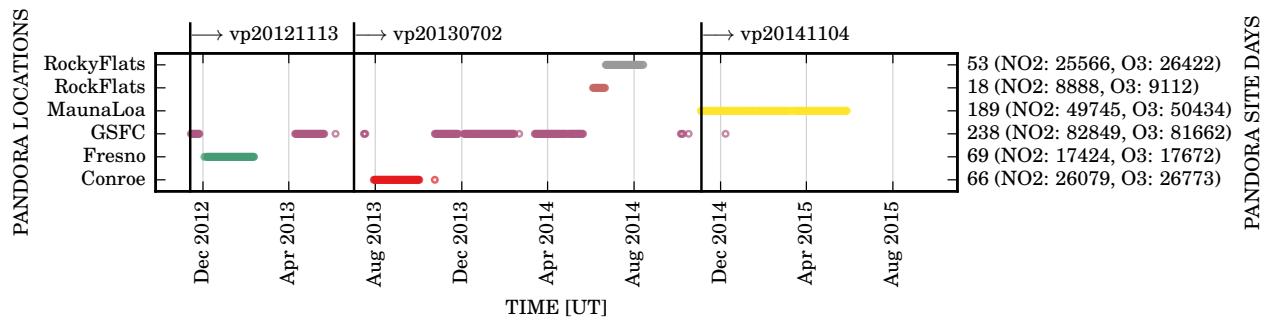
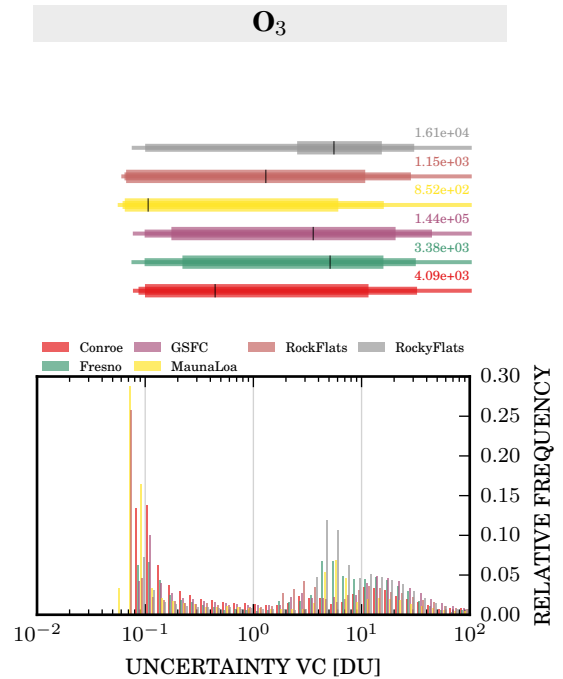
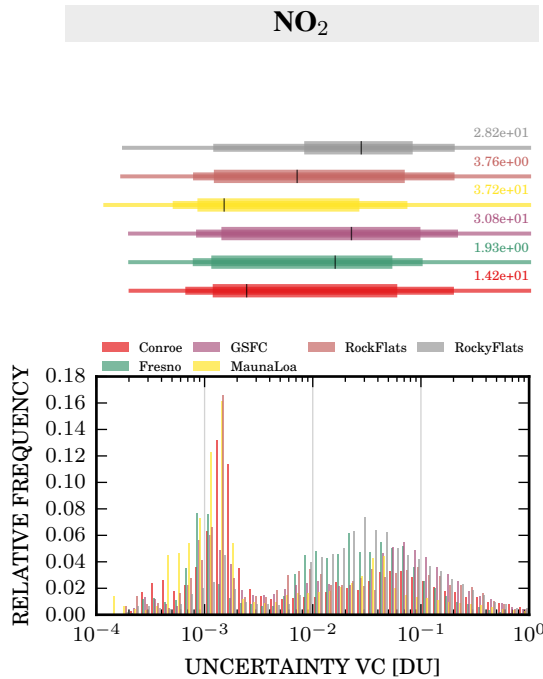


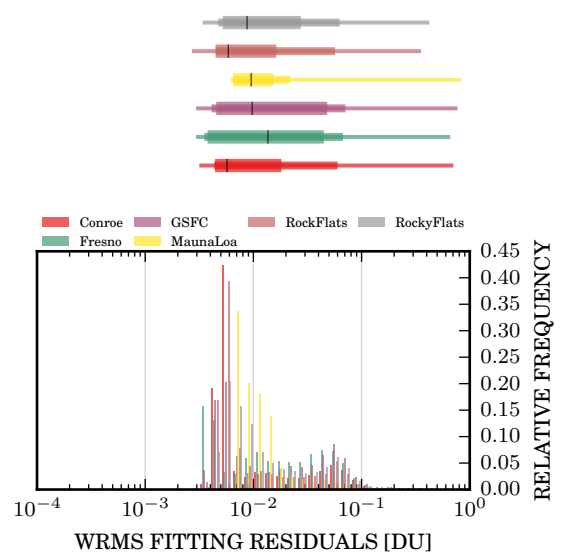
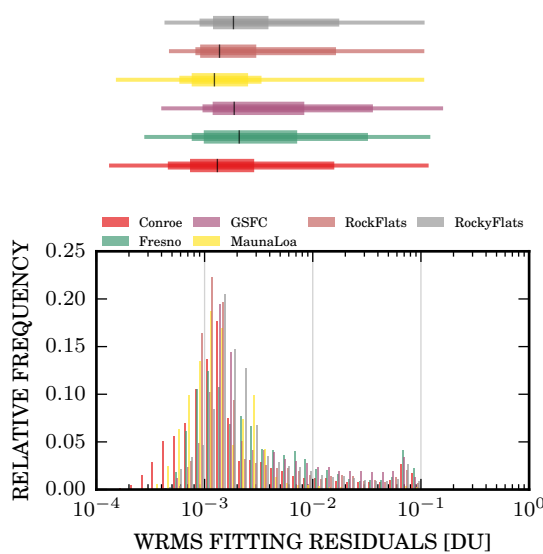
Figure 29: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

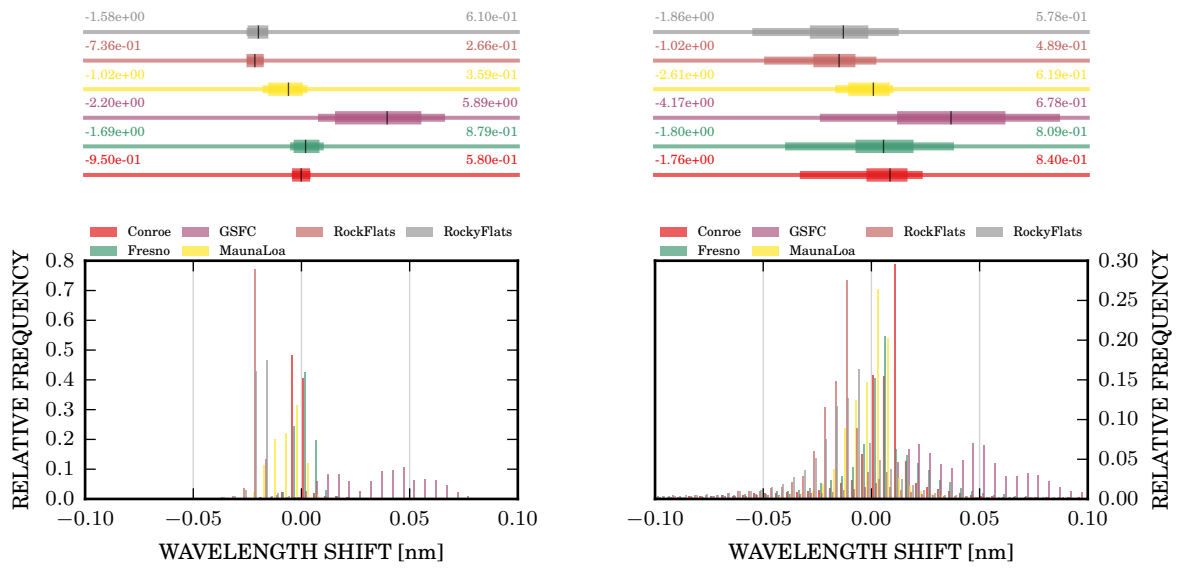
1. UNCERTAINTY VC



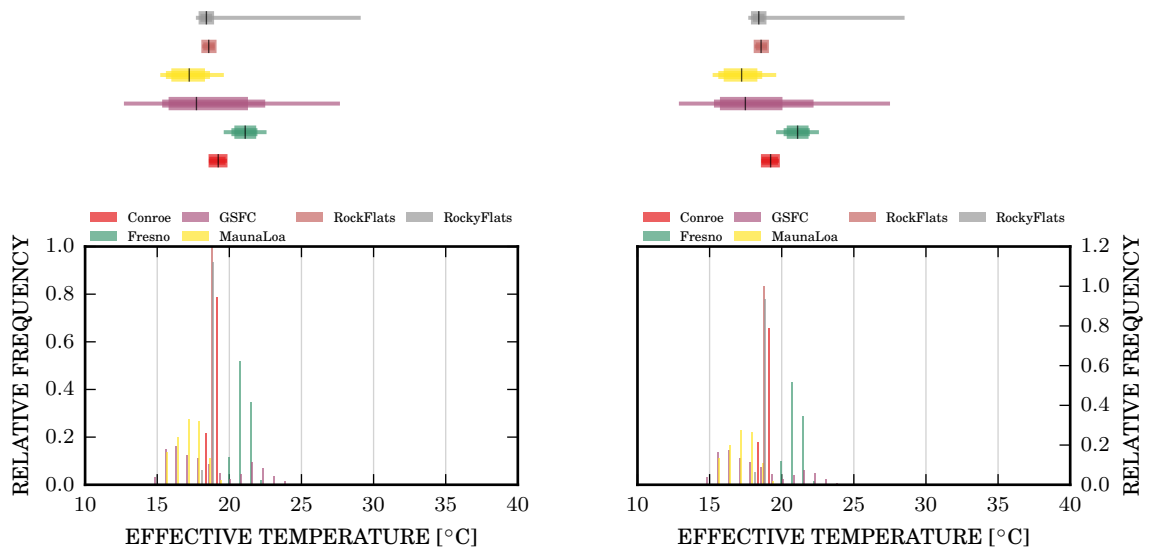
2. WRMS SPEC. FIT. RES.



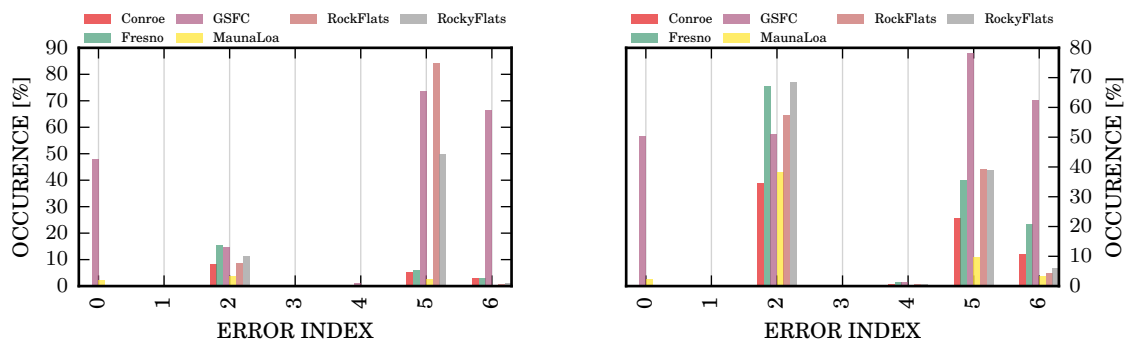
3. WAVELENGTH SHIFT



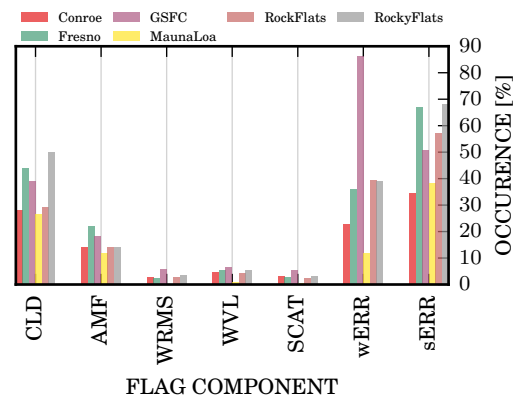
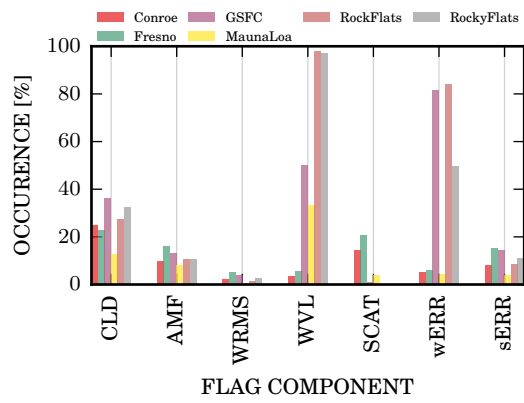
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



META INFORMATION

VALIDITY

validity period start	20121218 20130725 20140314
validity period end	20130724 20140313 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1208027U1 1208027U1 1208027U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	91.554 97.658 97.658 %
temperature controller set temp.	20.0 15.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

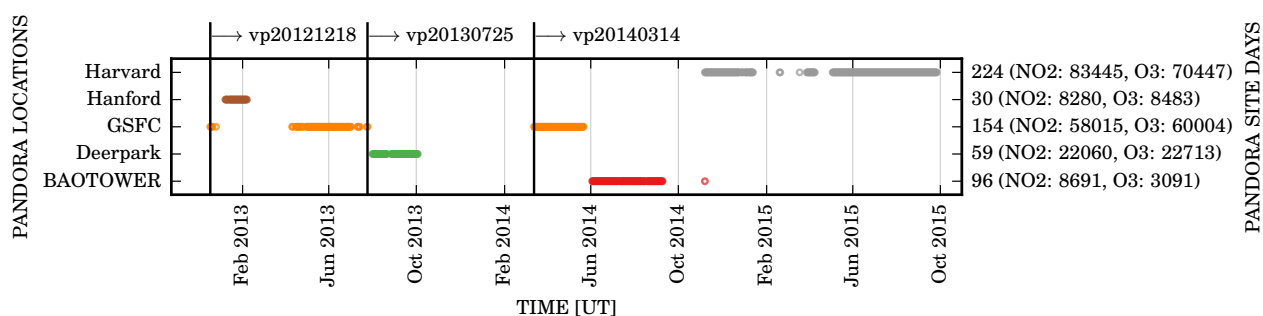
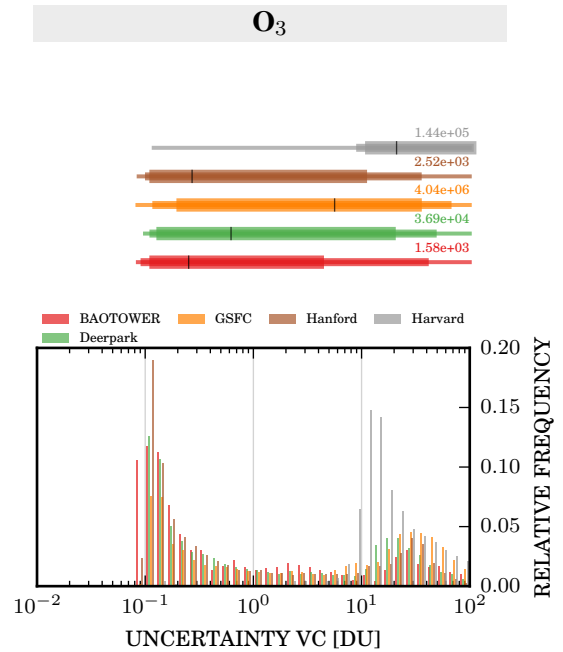
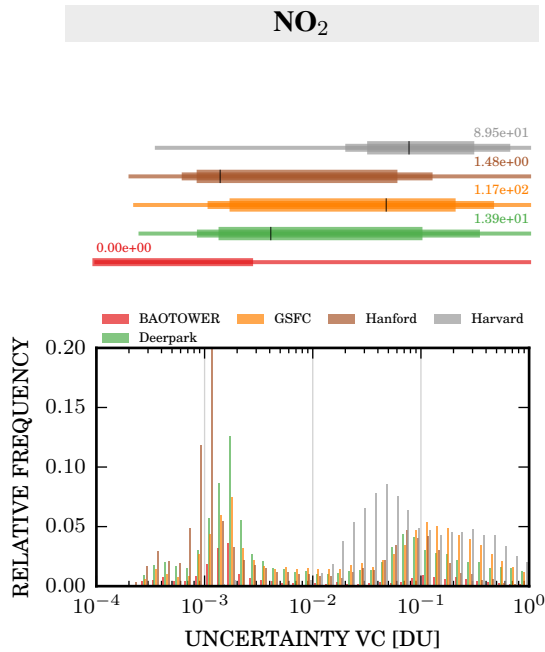


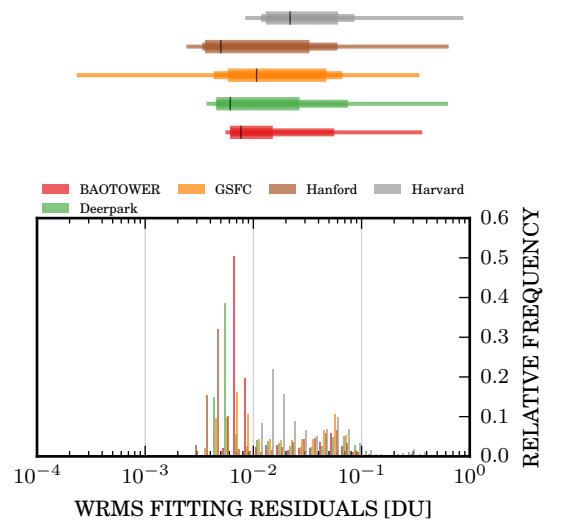
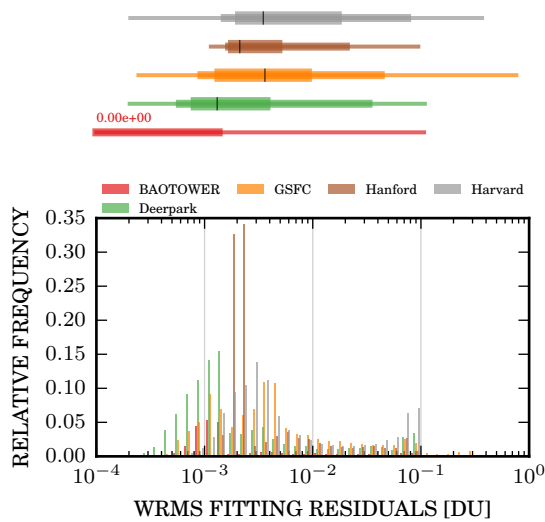
Figure 30: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

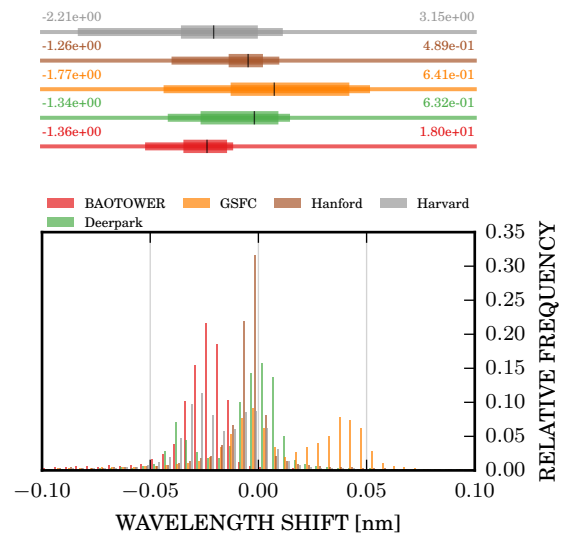
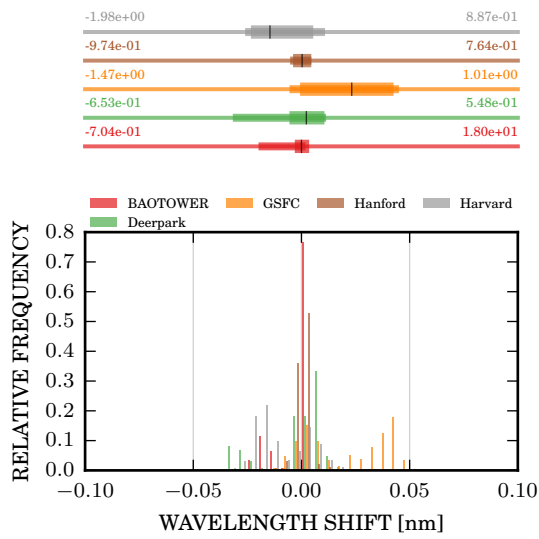
1. UNCERTAINTY VC



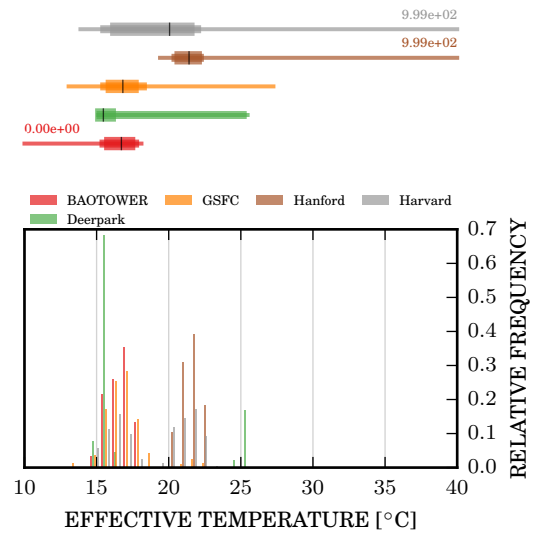
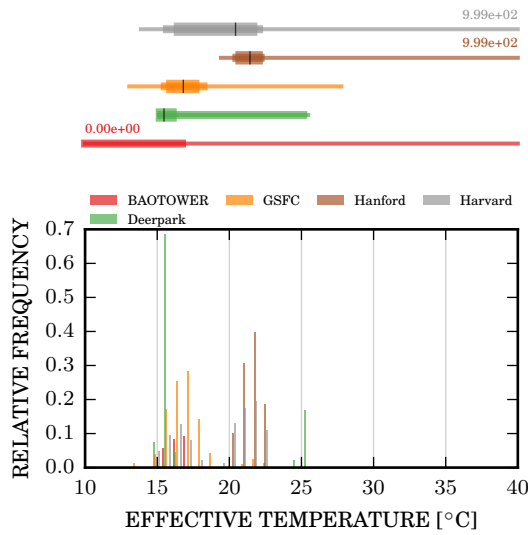
2. WRMS SPEC. FIT. RES.



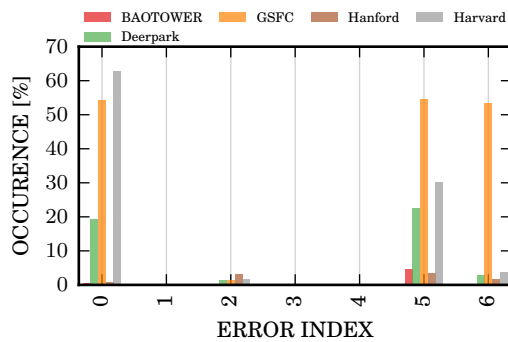
3. WAVELENGTH SHIFT



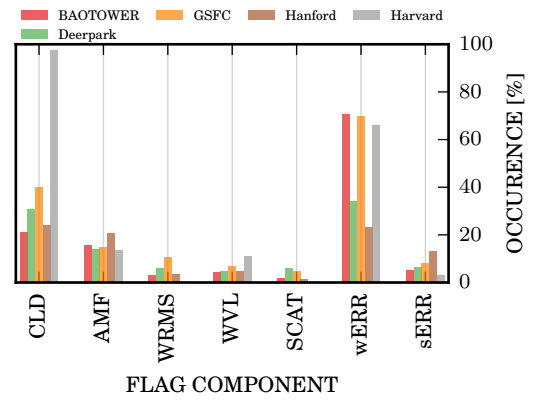
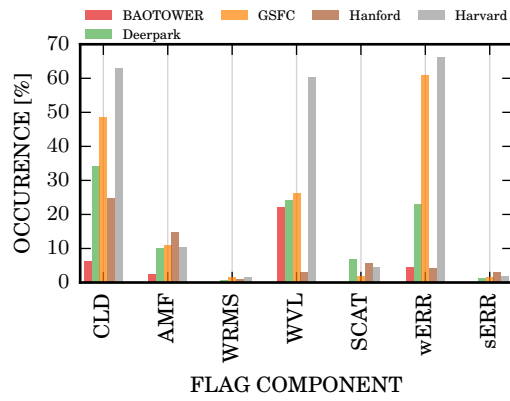
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.22 PANDORA 33 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121231 20130611
validity period end	20130610 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	1208026U1 1208026U1
number of pixels	2048 2048
A/D converter	16 16 bits
effective saturation limit	96.895 97.658 %
temperature controller set temp.	20.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

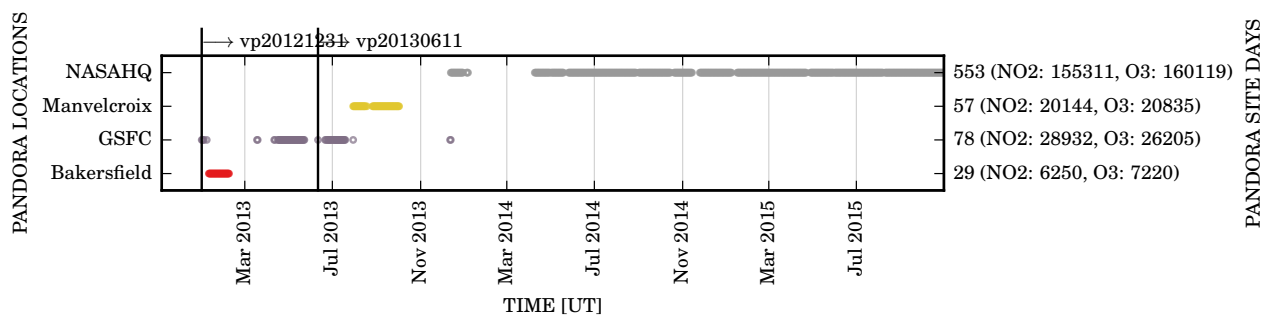
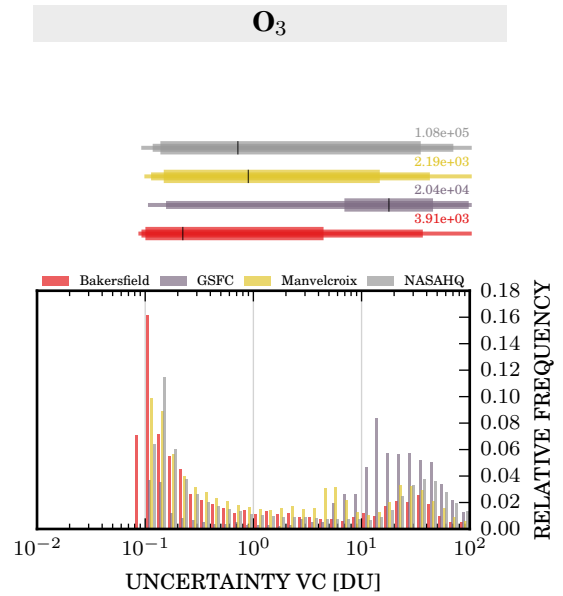
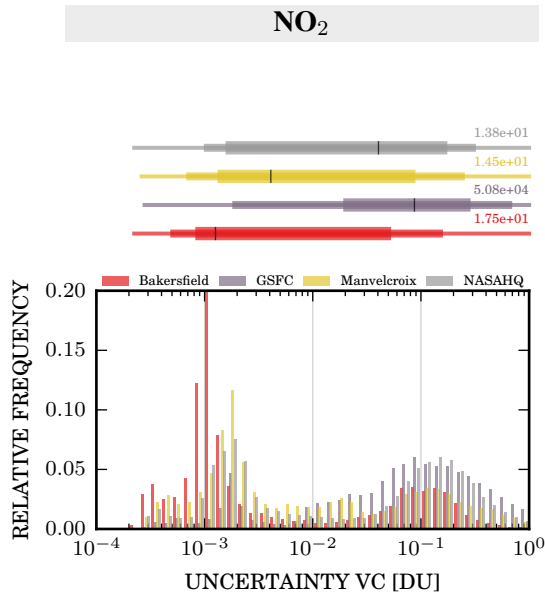


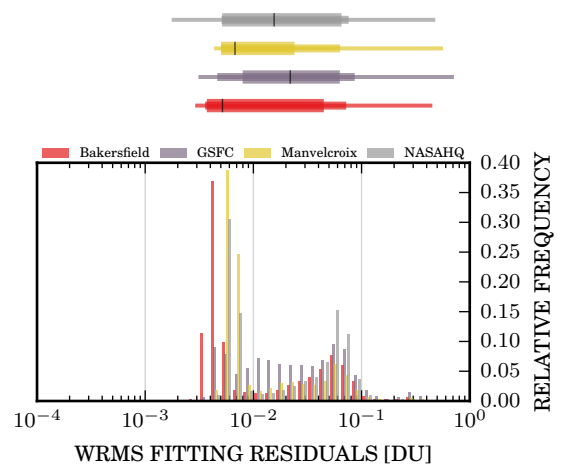
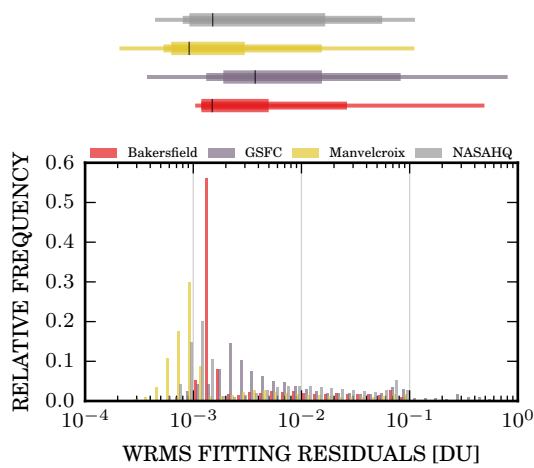
Figure 31: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

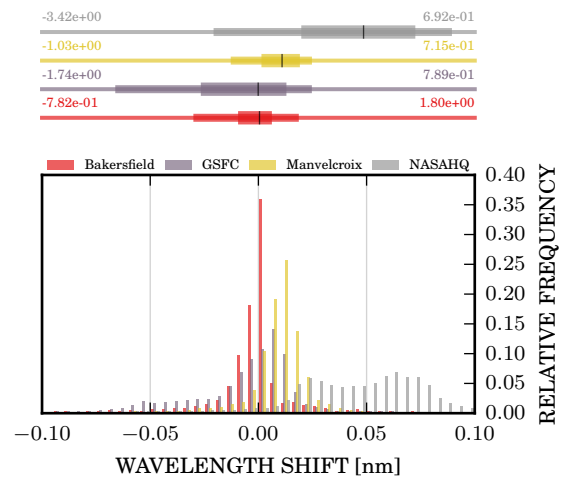
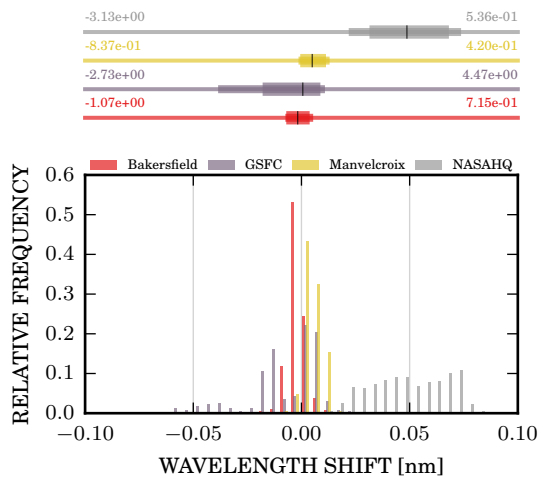
1. UNCERTAINTY VC



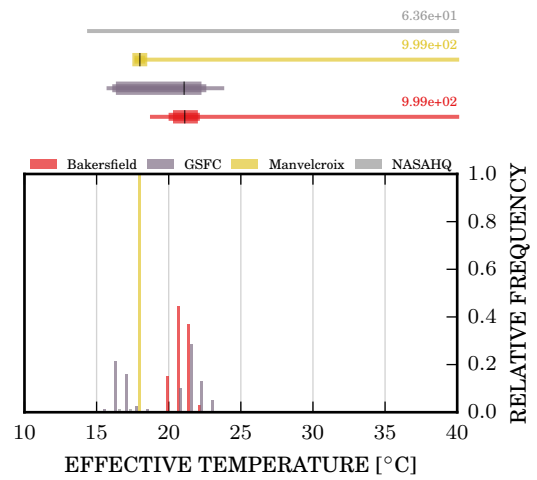
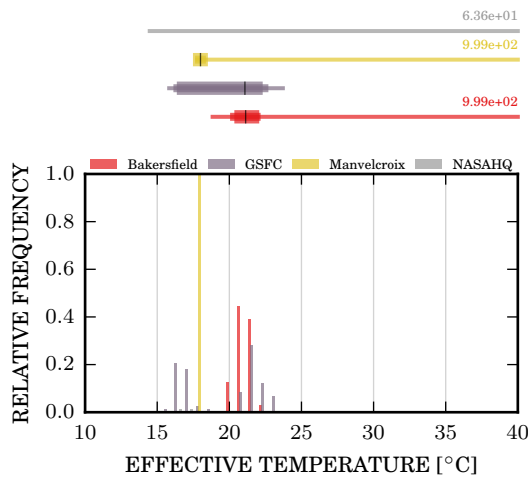
2. WRMS SPEC. FIT. RES.



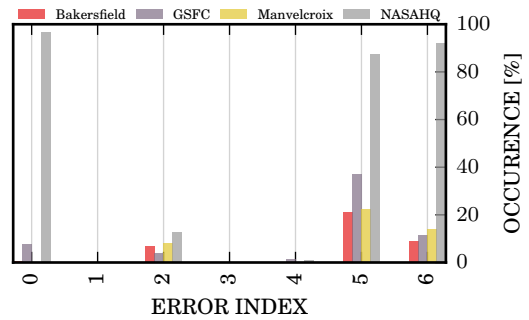
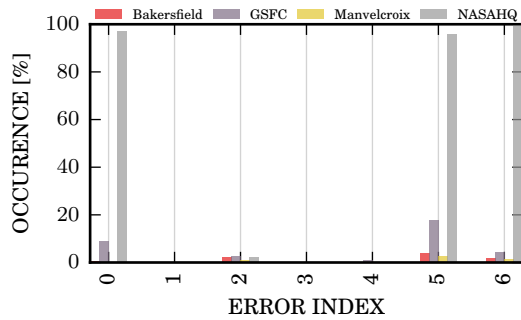
3. WAVELENGTH SHIFT



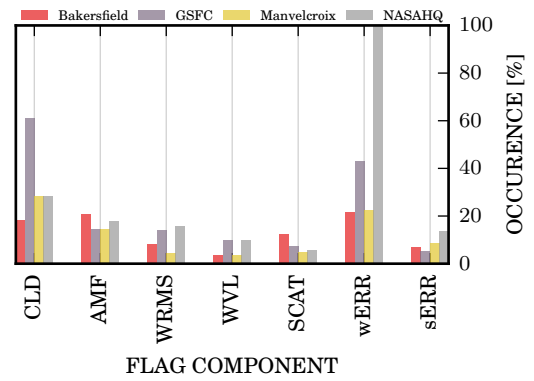
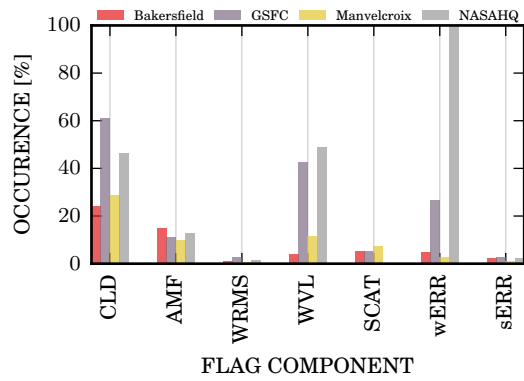
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.23 PANDORA 34 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130102 20130717 20130717
validity period end	20130716 20151031, at least 20151031, at least
validity period version	1 1 2

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1110085U1 1110085U1 1110085U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	96.895 97.658 97.658 %
temperature controller set temp.	20.0 15.0 15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

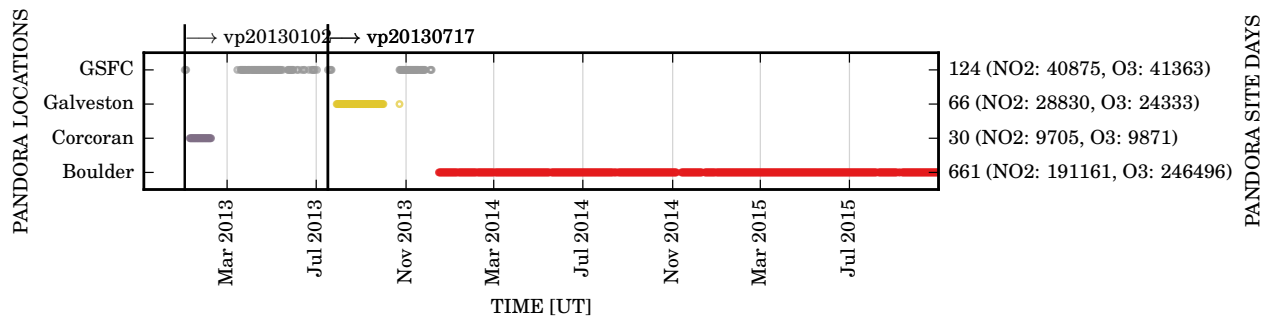
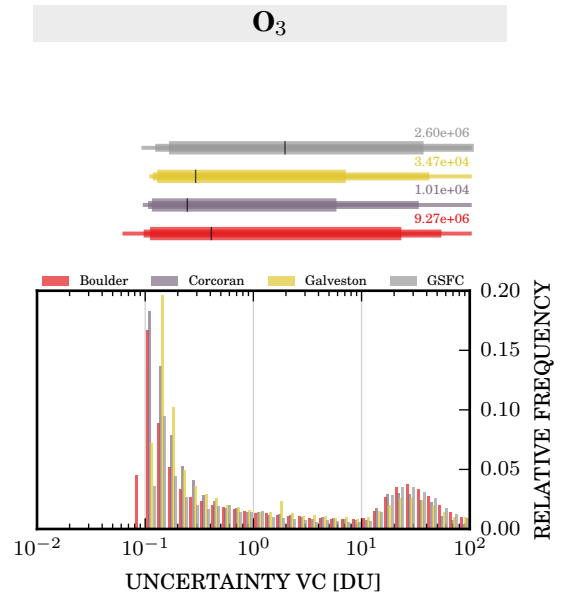
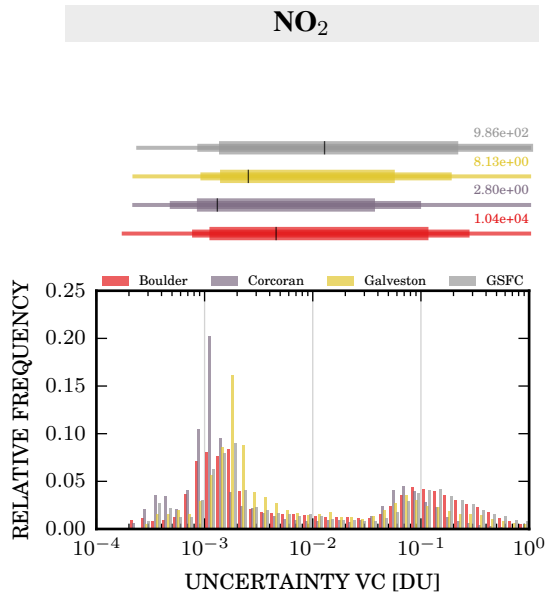


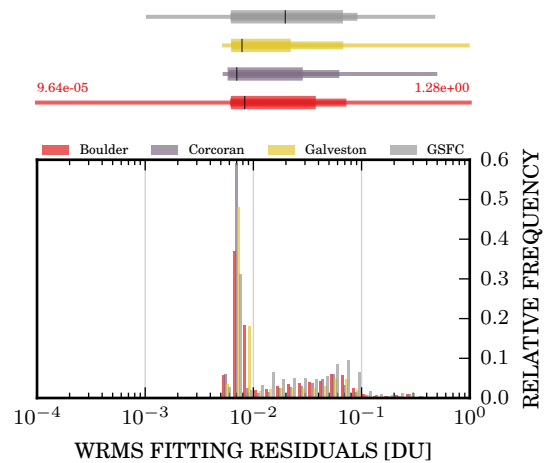
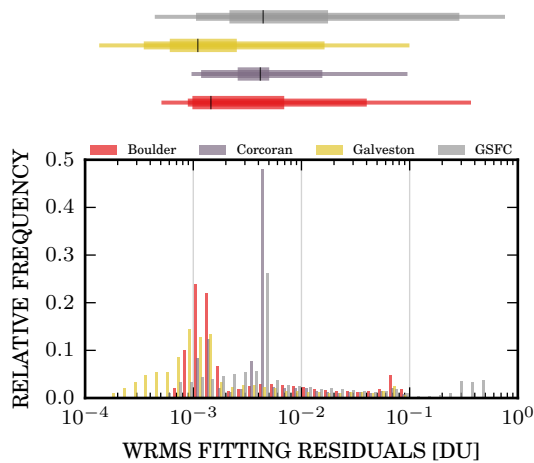
Figure 32: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

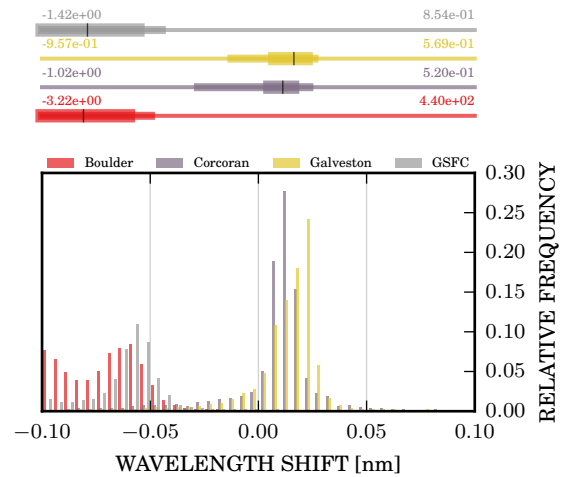
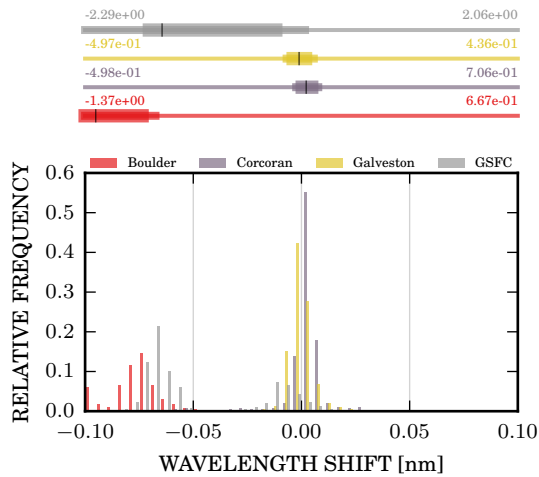
1. UNCERTAINTY VC



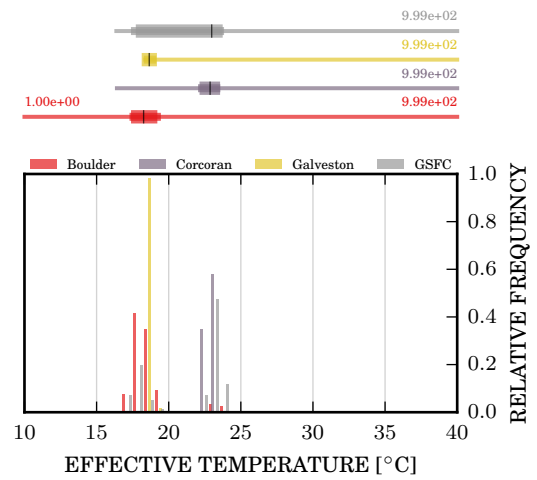
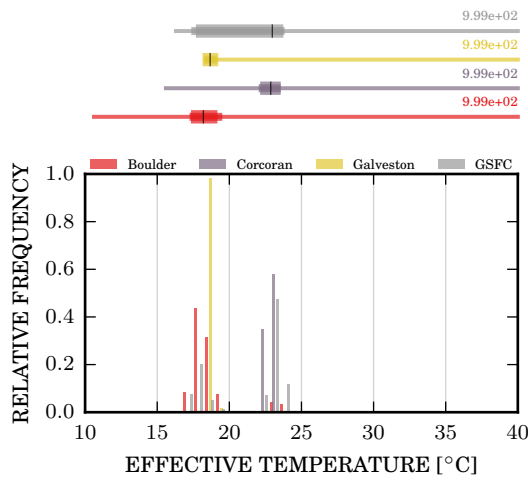
2. WRMS SPEC. FIT. RES.



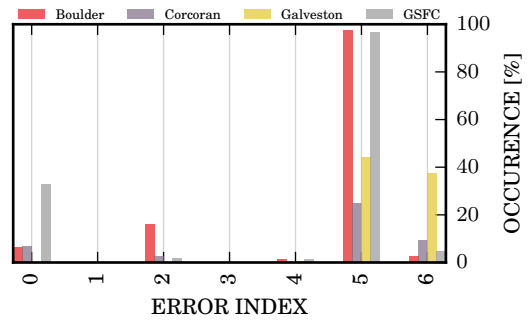
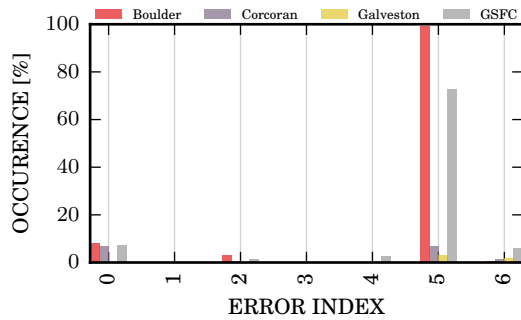
3. WAVELENGTH SHIFT



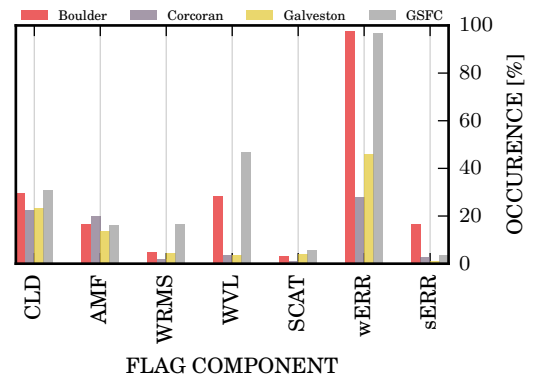
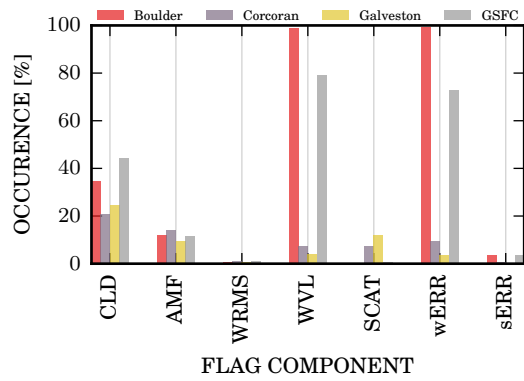
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.24 PANDORA 35 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130103 20130725 20141119
validity period end	20130724 20141118 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1110081U1 1110081U1 1110081U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	96.895 97.658 97.658 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

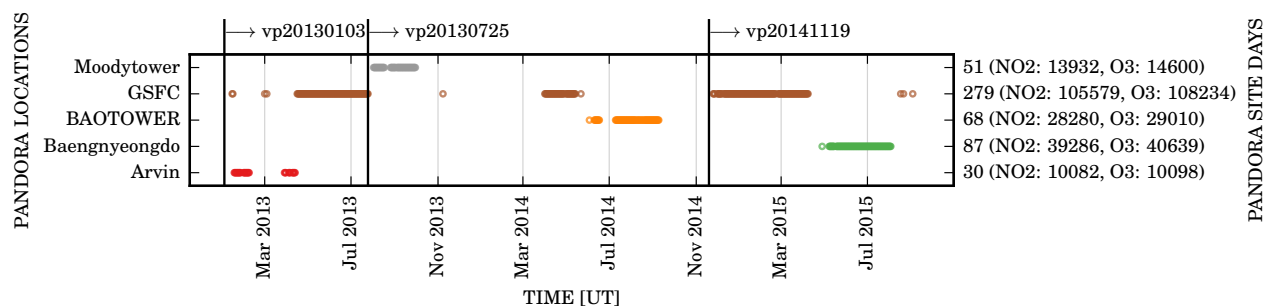
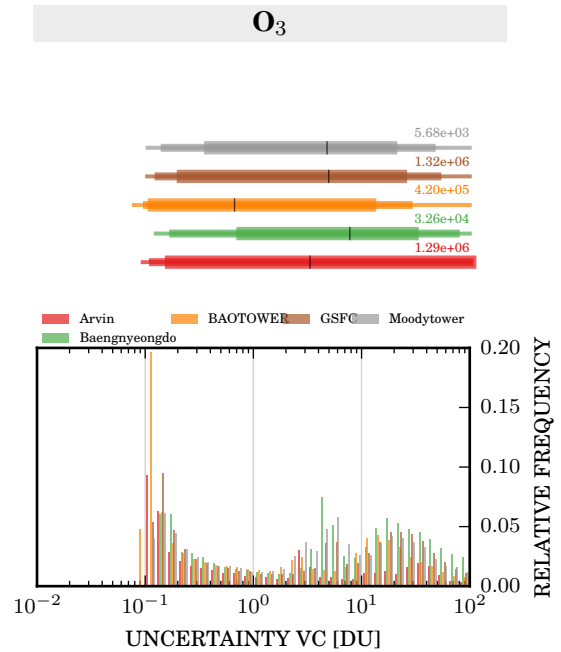
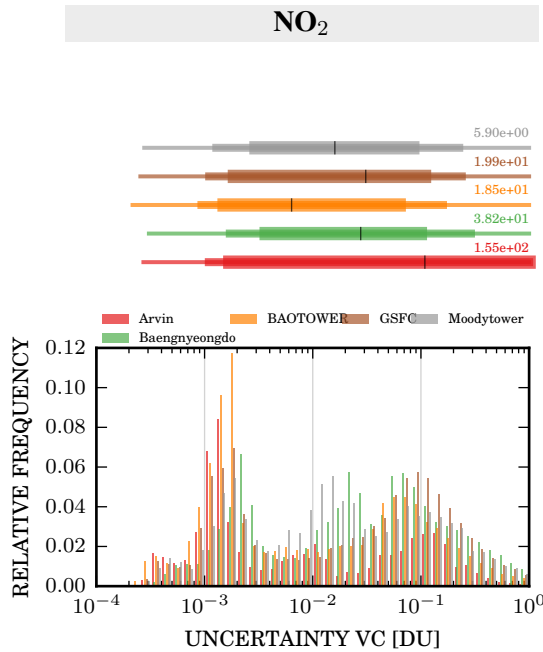


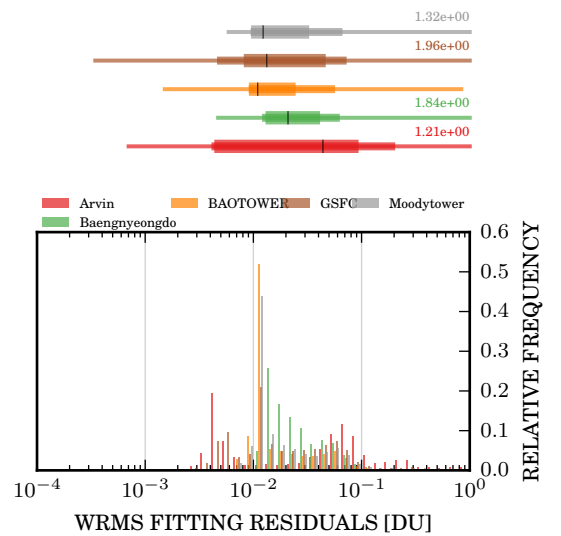
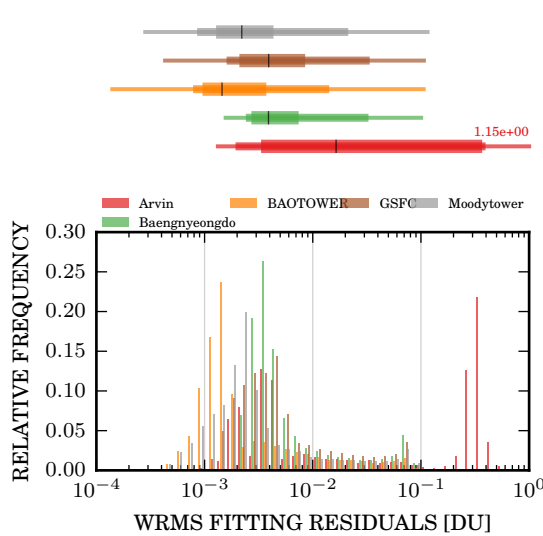
Figure 33: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

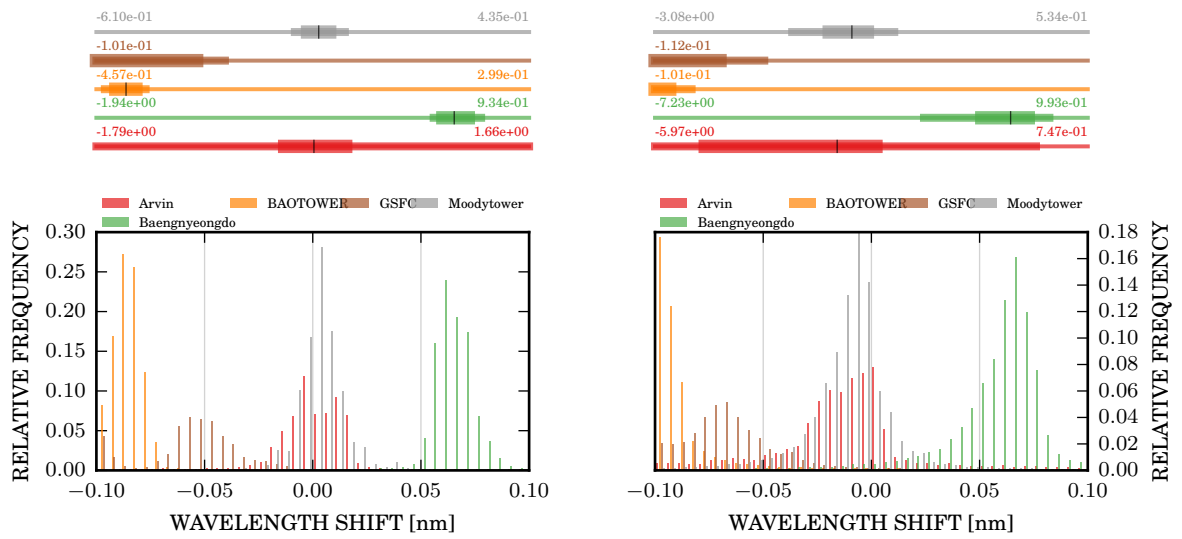
1. UNCERTAINTY VC



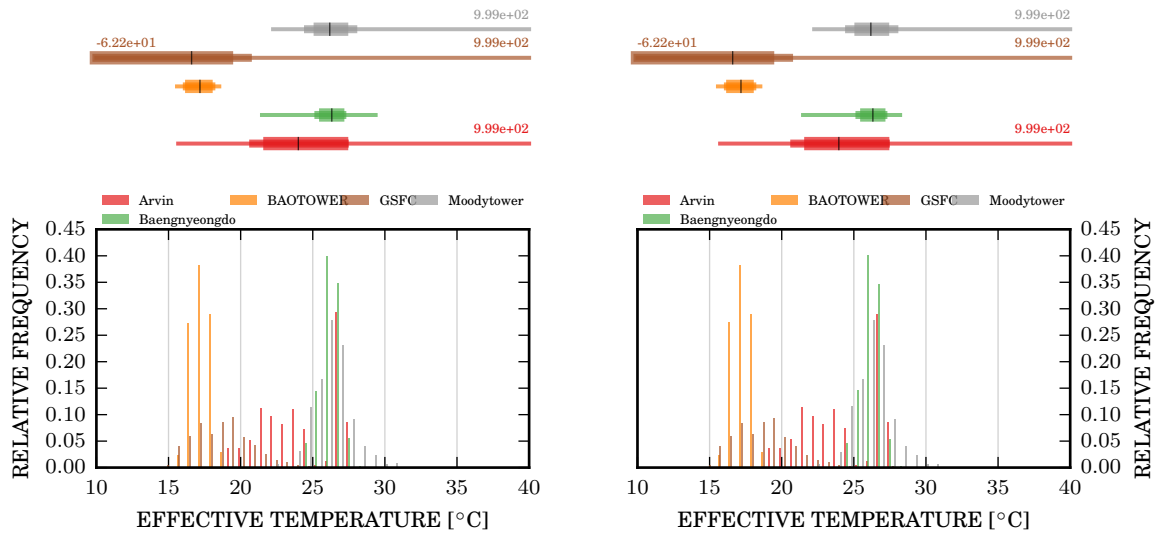
2. WRMS SPEC. FIT. RES.



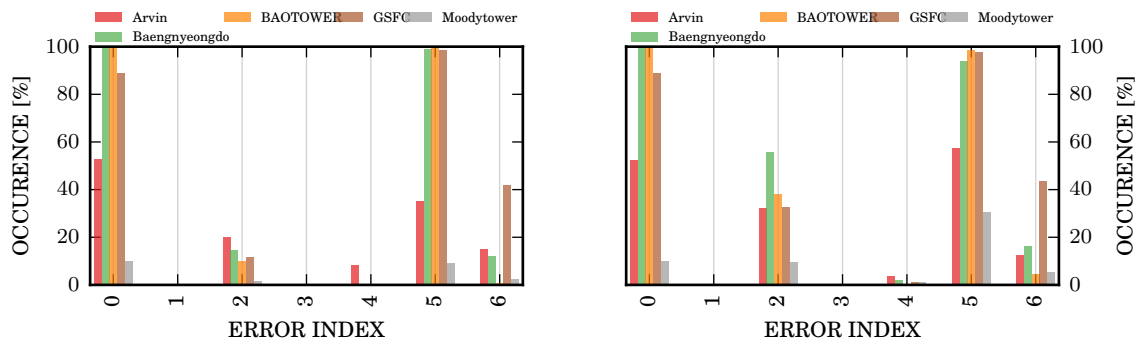
3. WAVELENGTH SHIFT



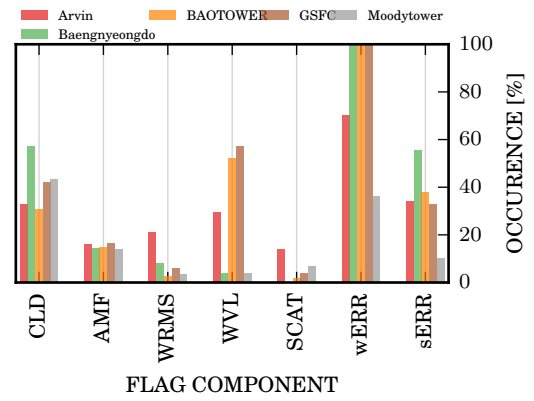
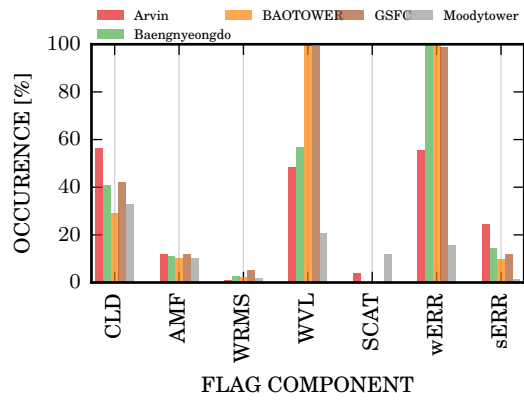
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.25 PANDORA 36 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121231 20130816 20140603
validity period end	20130815 20140602 20151031, at least
validity period version	1 1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1 Ava1
spectrometer unit ID	1204180U1 1204180U1 1204180U1
number of pixels	2048 2048 2048
A/D converter	16 16 16 bits
effective saturation limit	96.132 96.895 96.895 %
temperature controller set temp.	20.0 20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

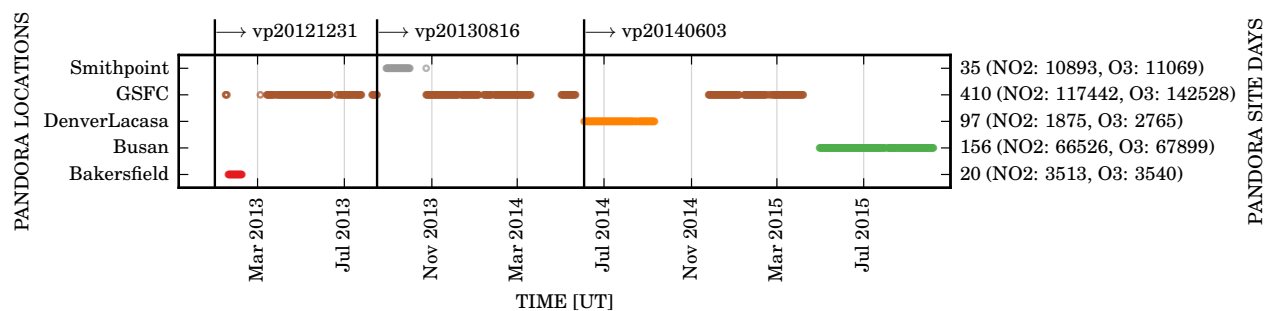
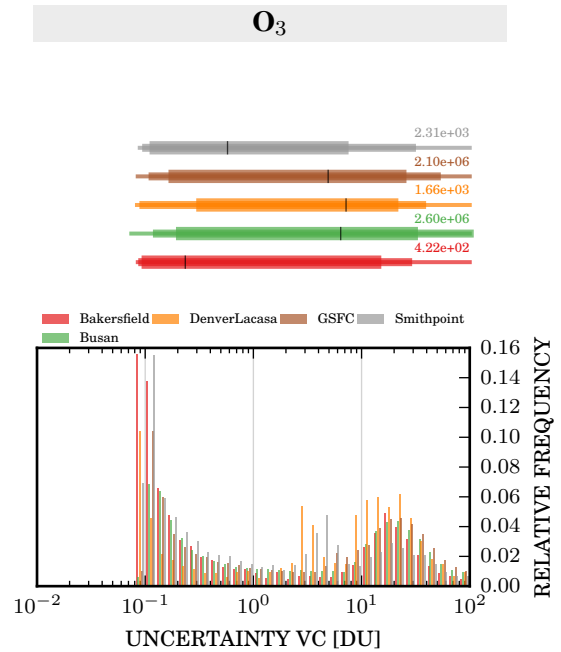
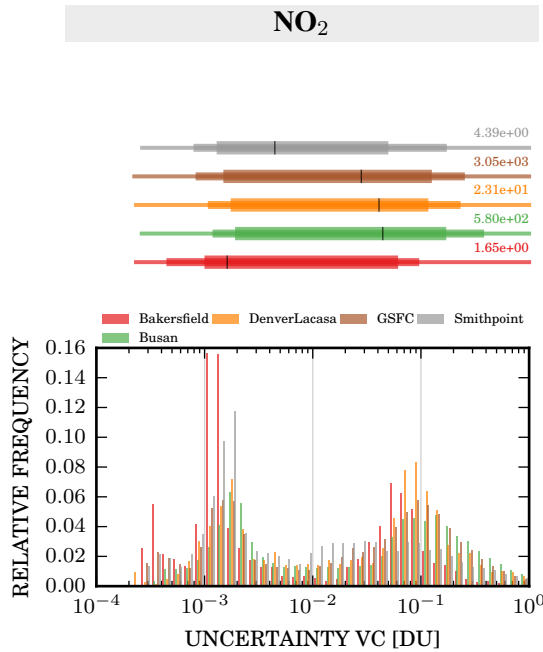


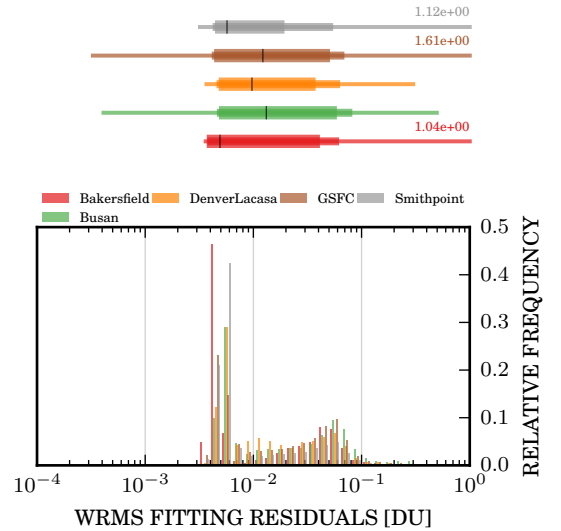
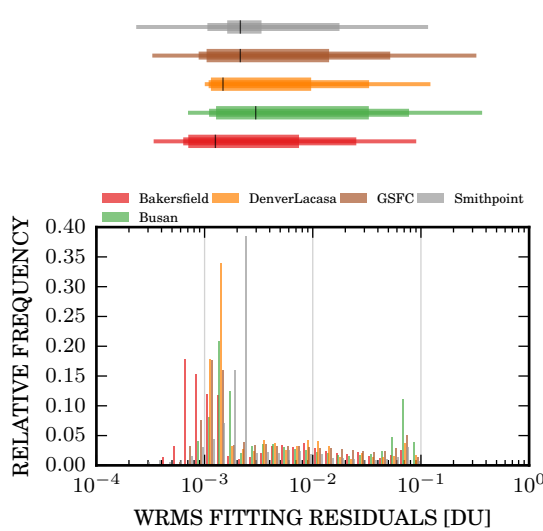
Figure 34: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

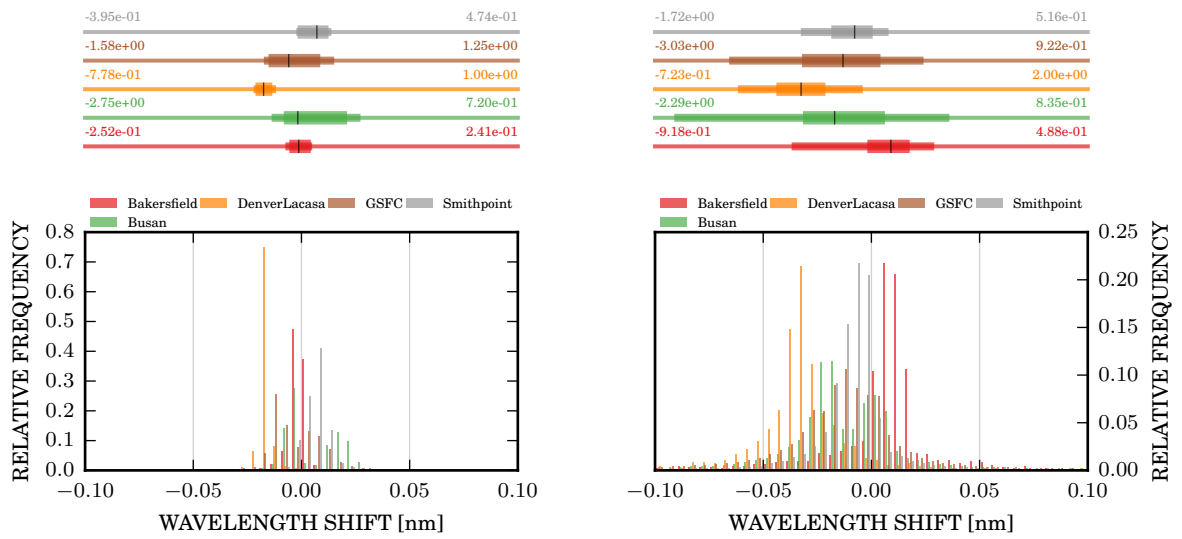
1. UNCERTAINTY VC



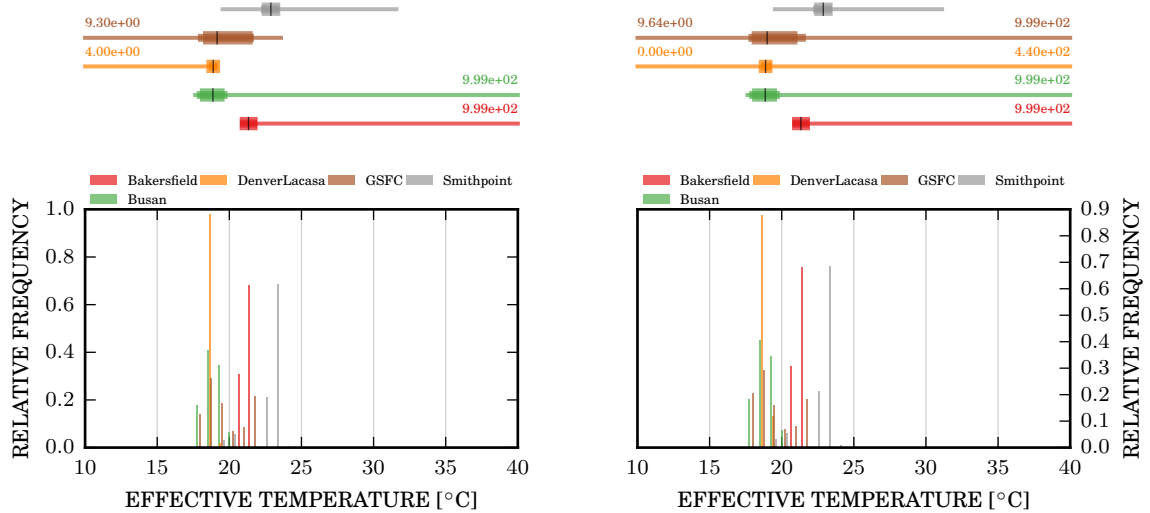
2. WRMS SPEC. FIT. RES.



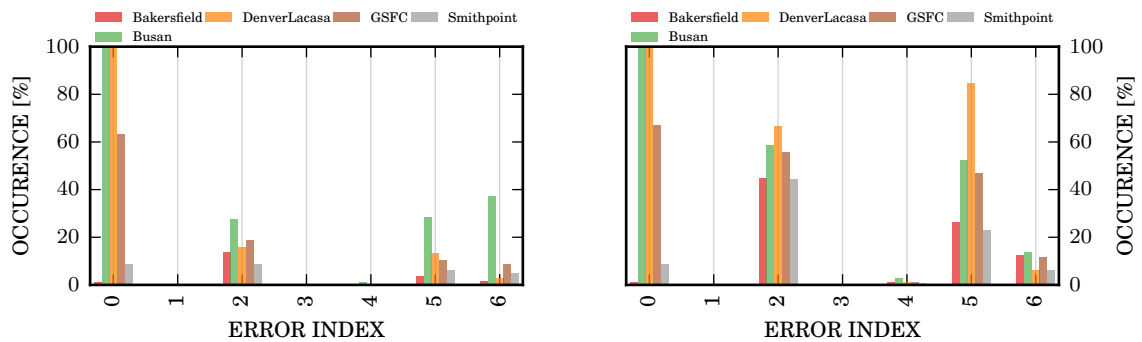
3. WAVELENGTH SHIFT



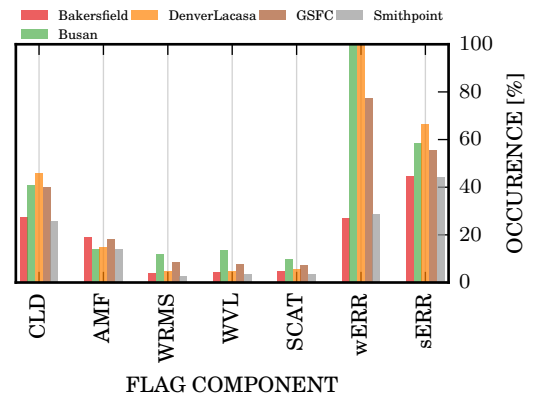
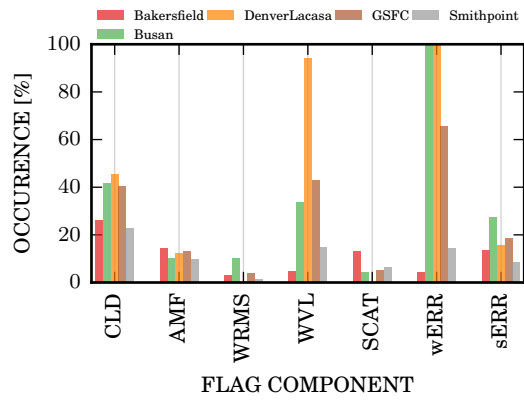
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.26 PANDORA 37 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130131 20130404
validity period end	20130403 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	1204181U1 1204181U1
number of pixels	2048 2048
A/D converter	16 16 bits
effective saturation limit	91.554 91.554 %
temperature controller set temp.	20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

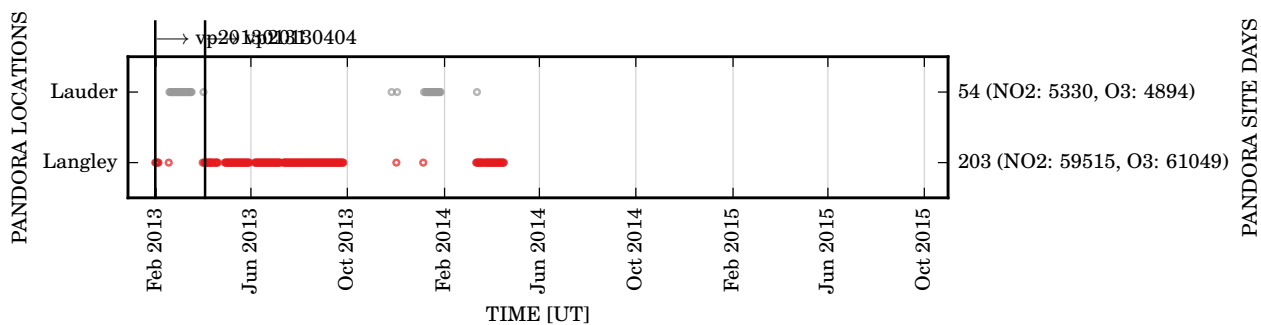
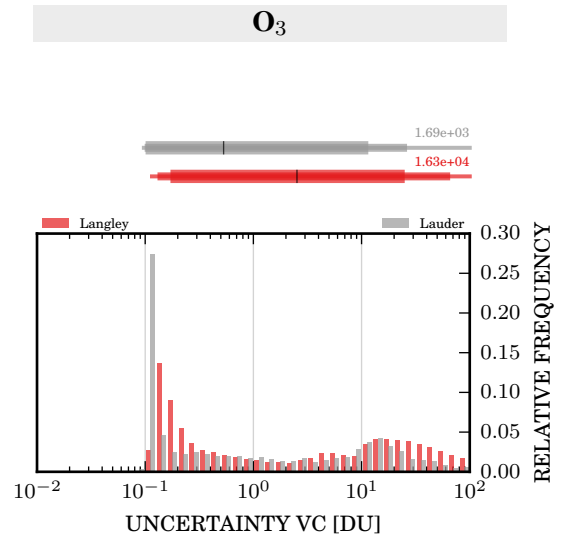
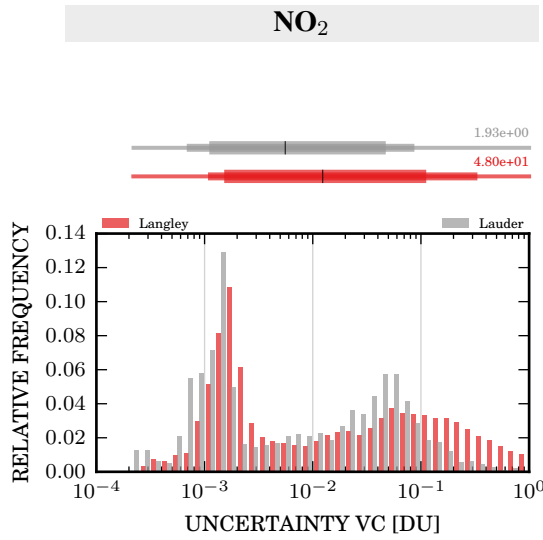


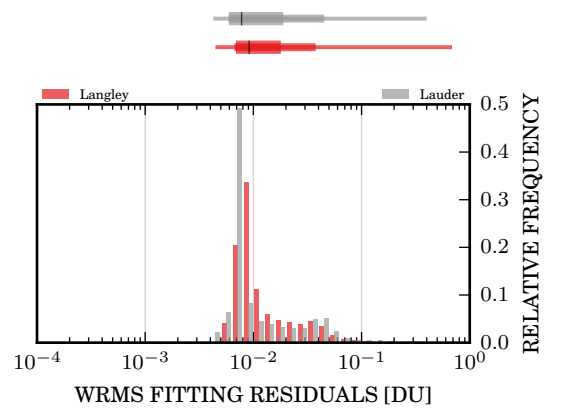
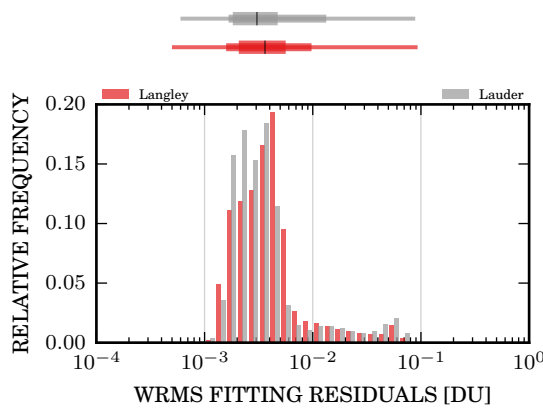
Figure 35: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

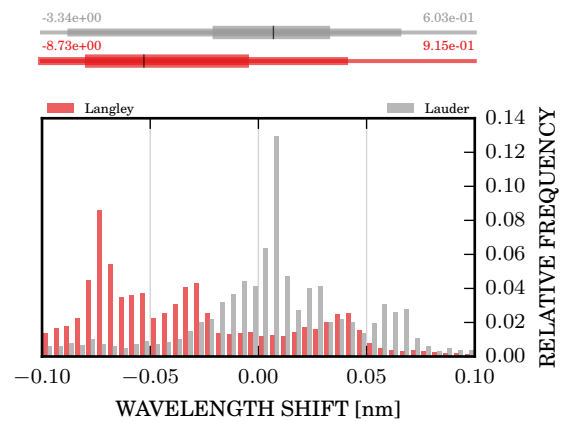
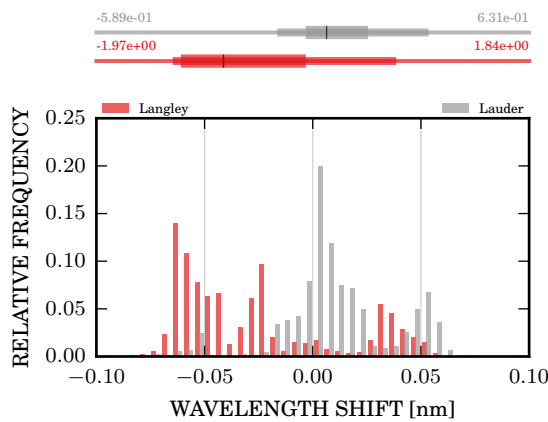
1. UNCERTAINTY VC



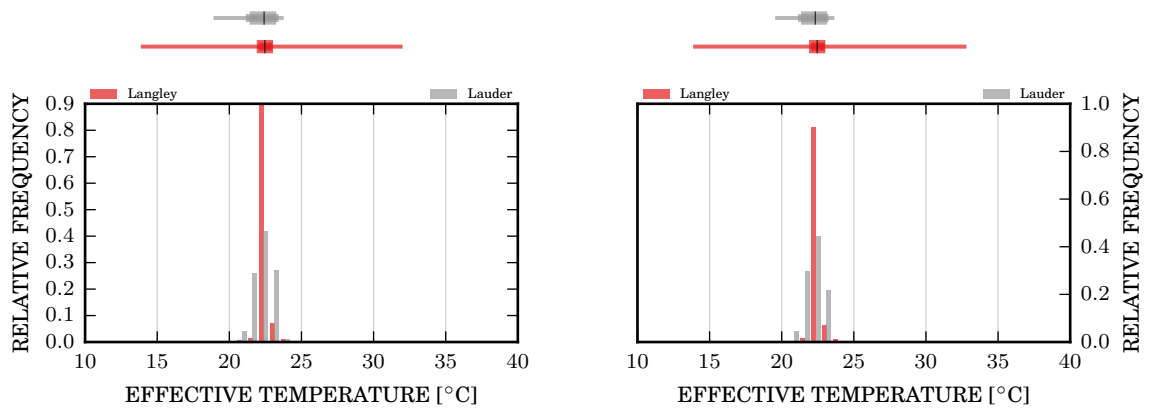
2. WRMS SPEC. FIT. RES.



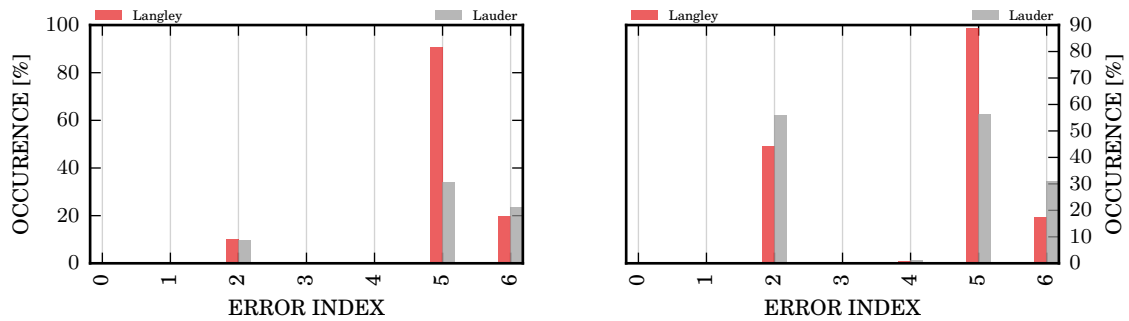
3. WAVELENGTH SHIFT



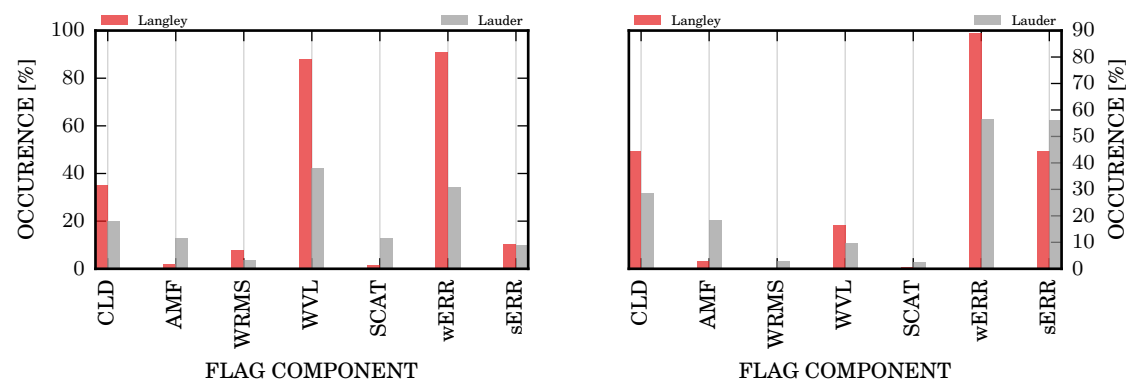
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.27 PANDORA 38 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130820
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1110067U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	96.895 %
temperature controller set temp.	15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

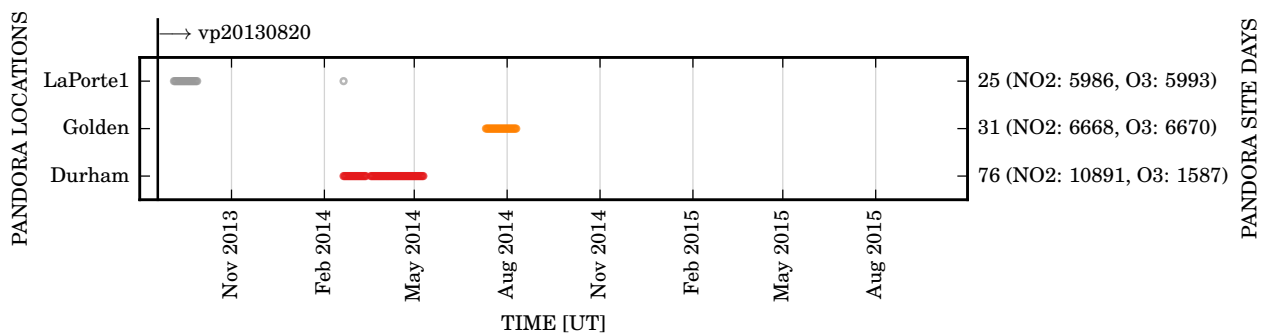
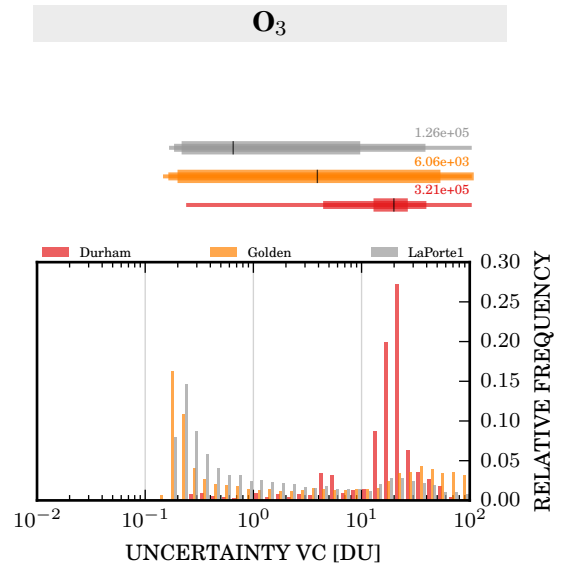
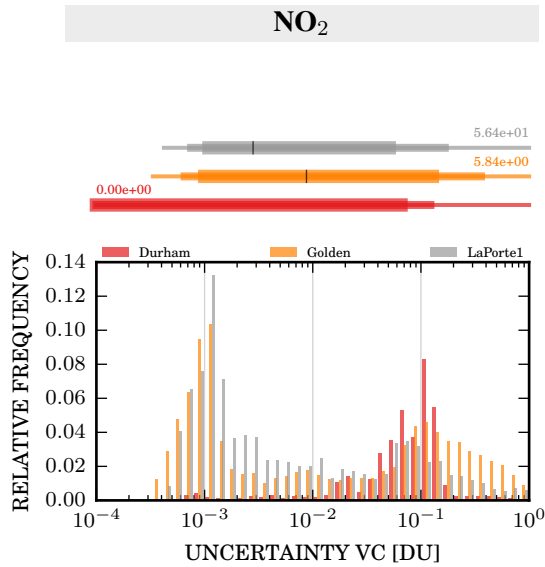


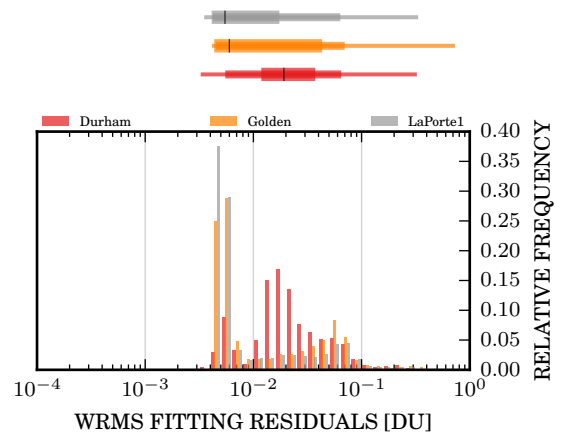
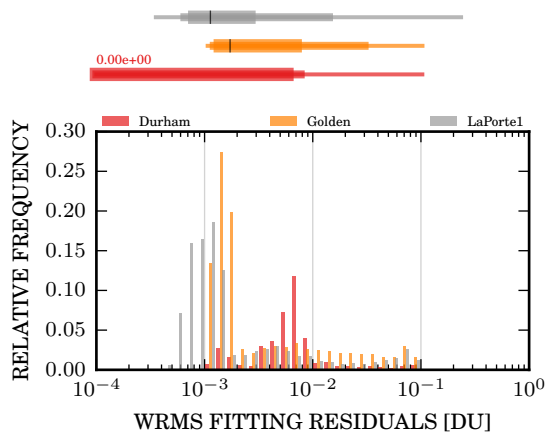
Figure 36: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

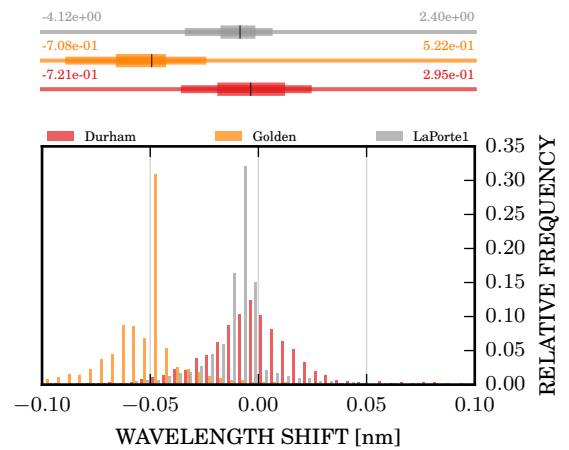
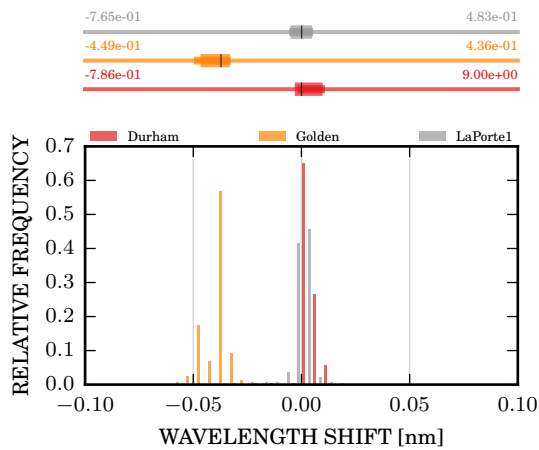
1. UNCERTAINTY VC



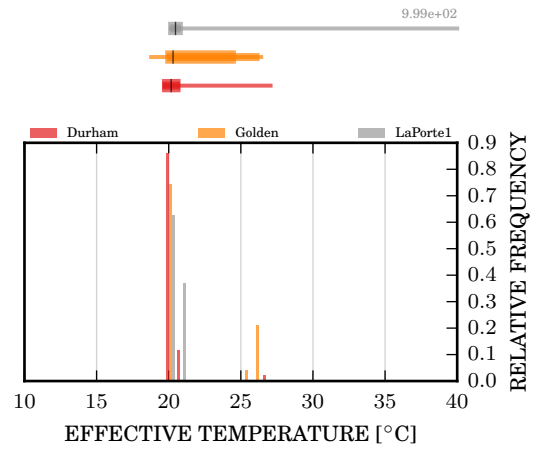
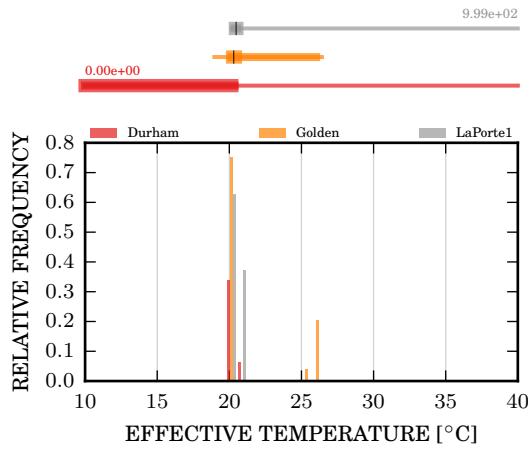
2. WRMS SPEC. FIT. RES.



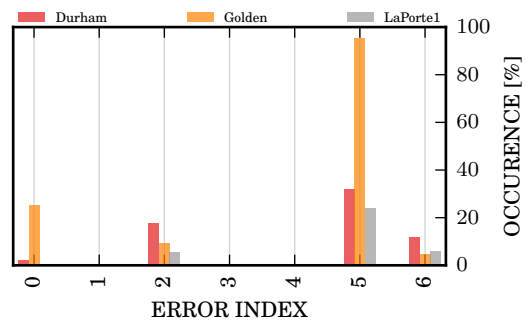
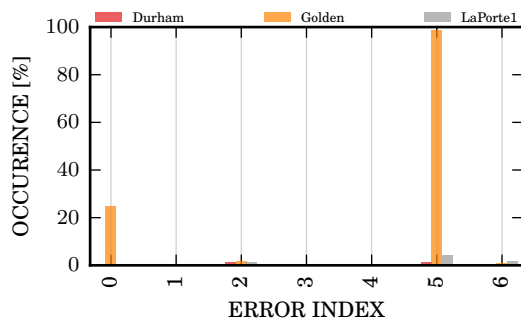
3. WAVELENGTH SHIFT



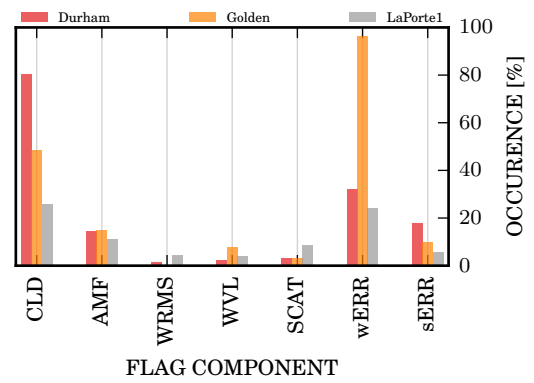
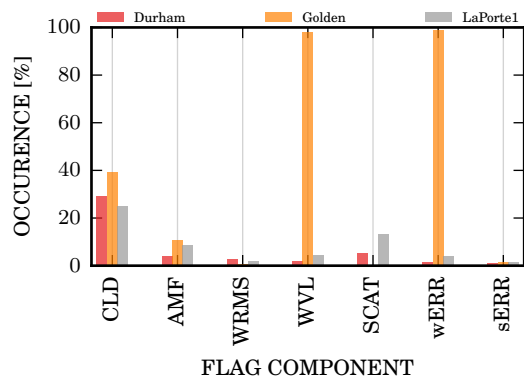
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.28 PANDORA 39 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130824
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1010028U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	83.925 %
temperature controller set temp.	15.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

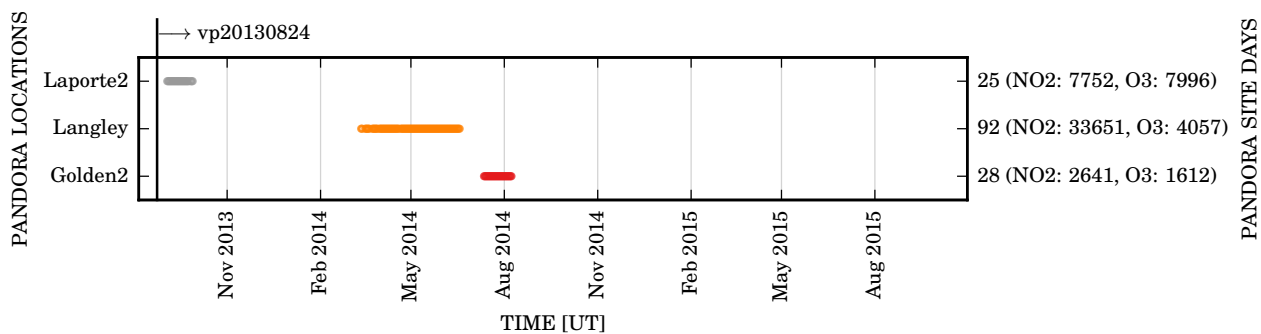
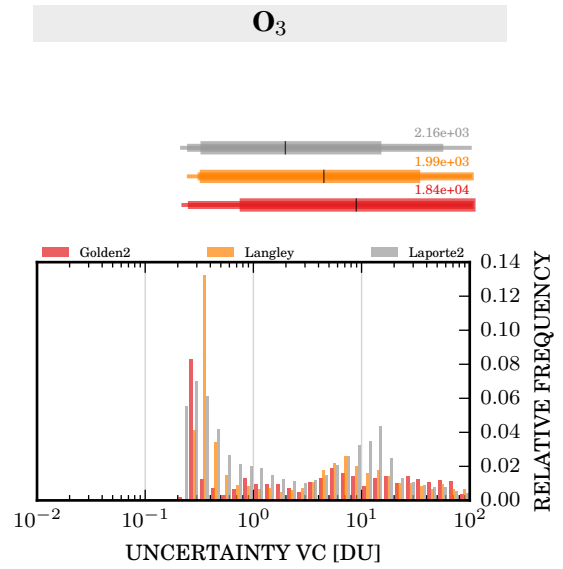
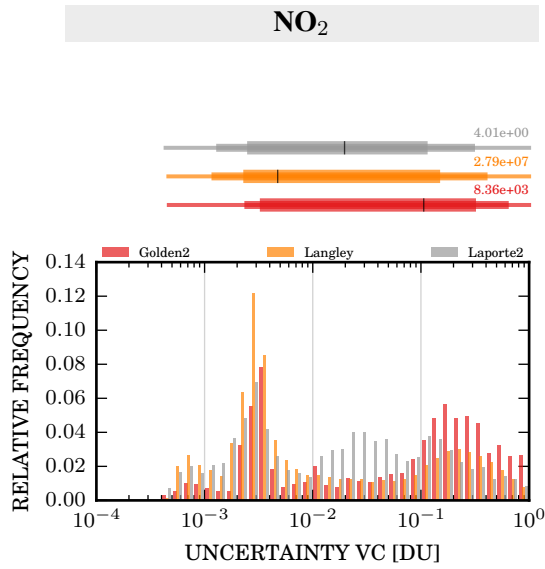


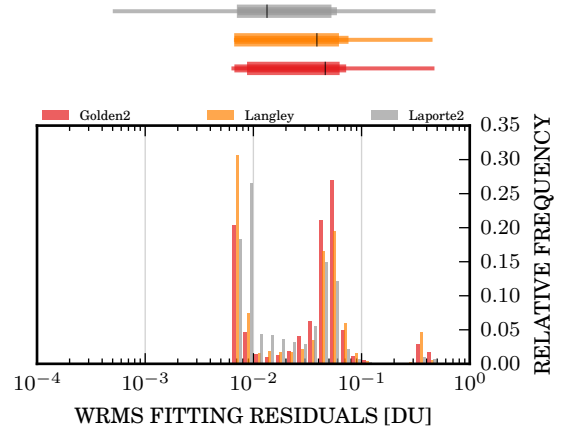
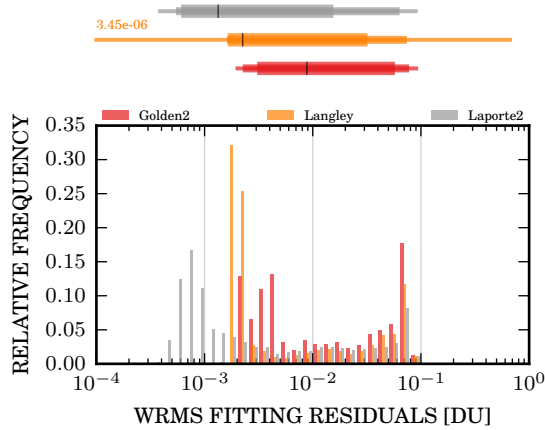
Figure 37: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

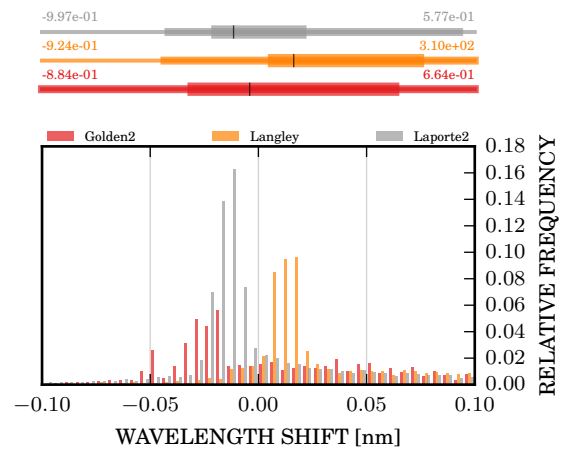
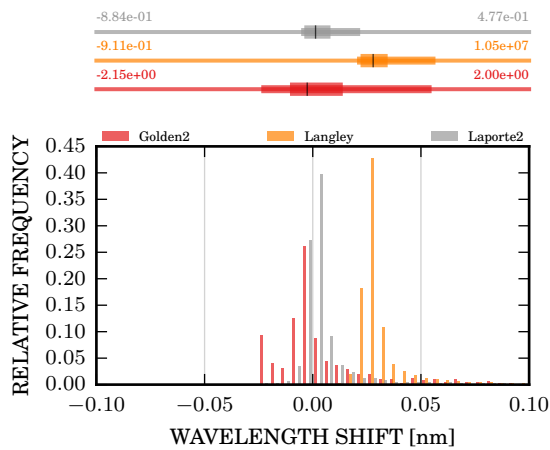
1. UNCERTAINTY VC



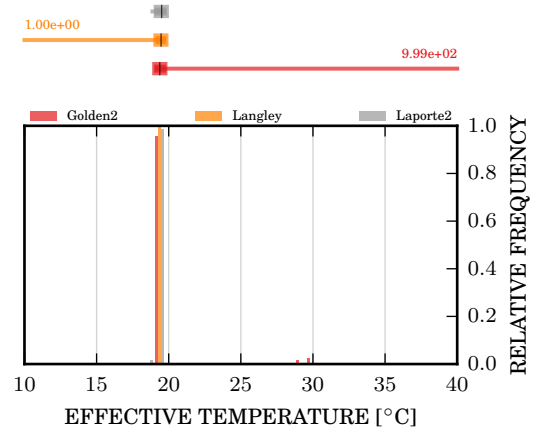
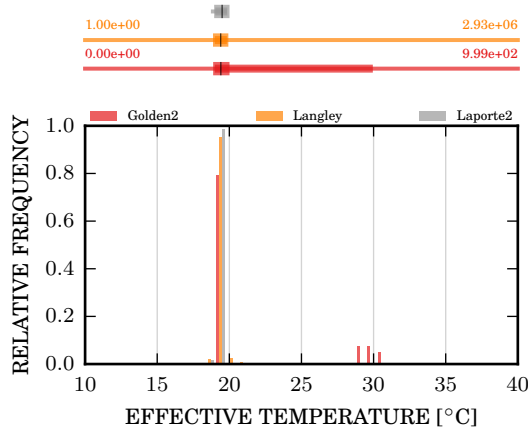
2. WRMS SPEC. FIT. RES.



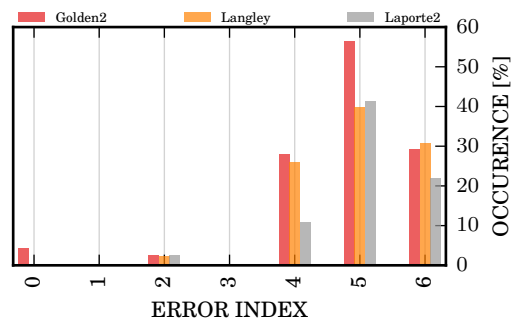
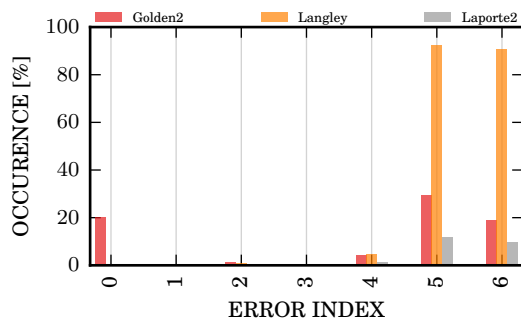
3. WAVELENGTH SHIFT



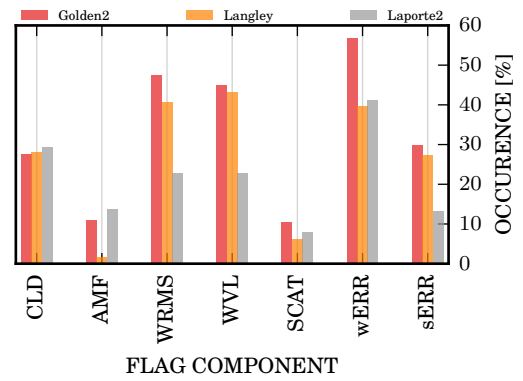
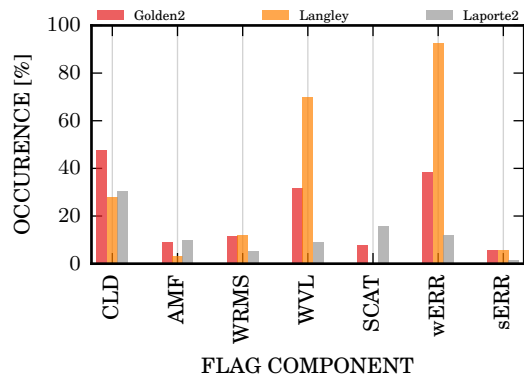
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.29 PANDORA 41 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20131022
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1309137U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	97.200 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

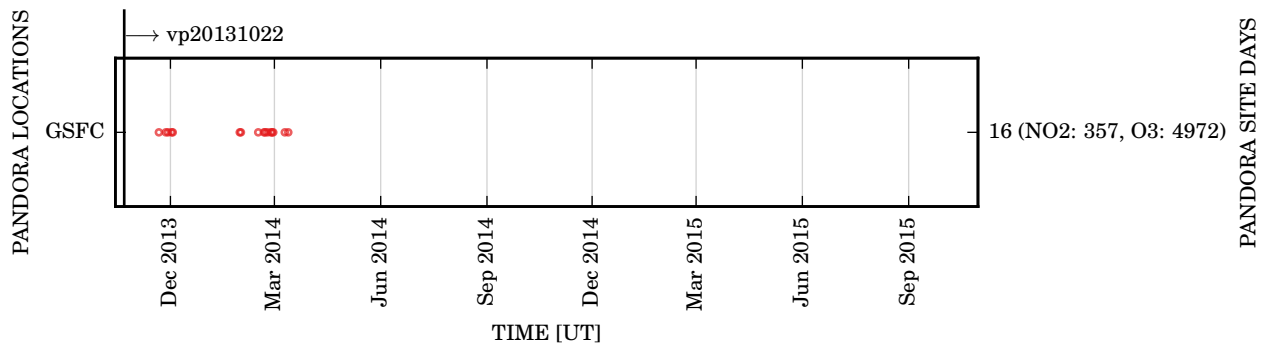
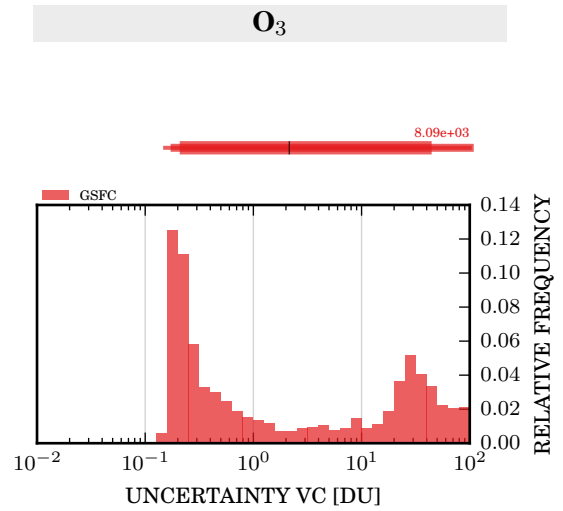
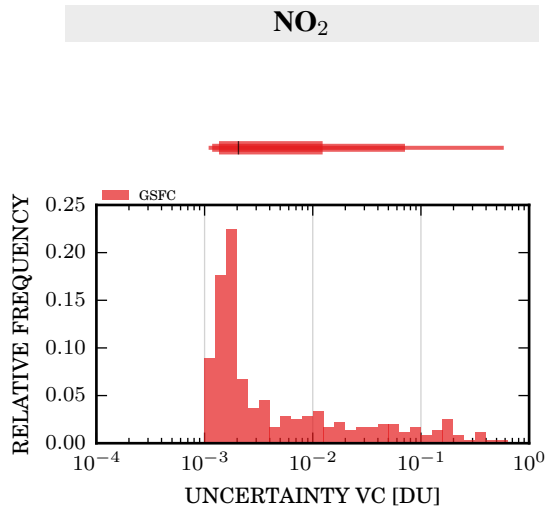


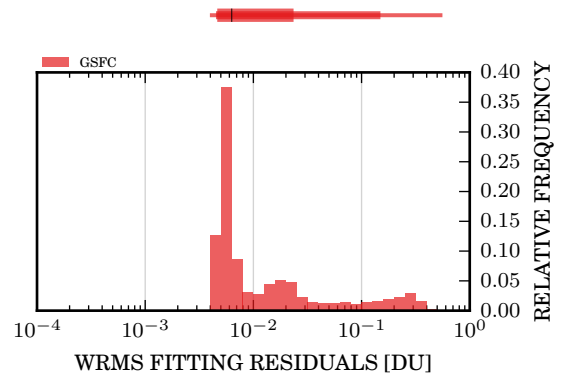
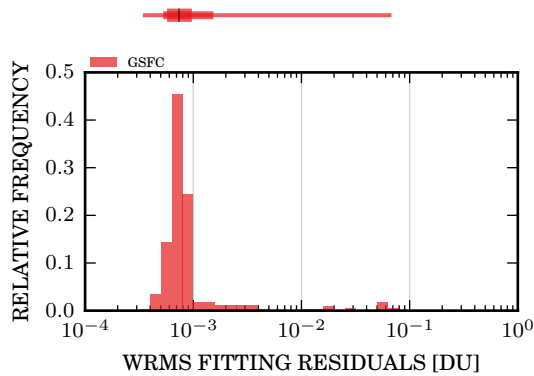
Figure 38: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

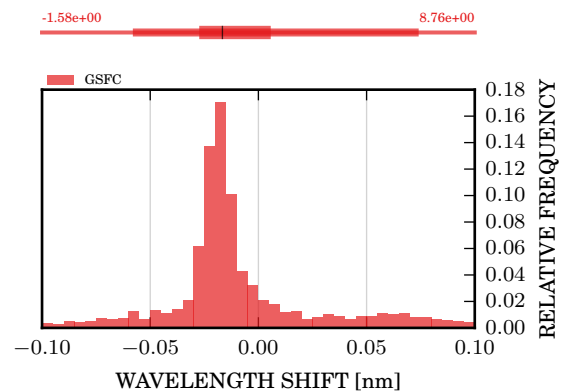
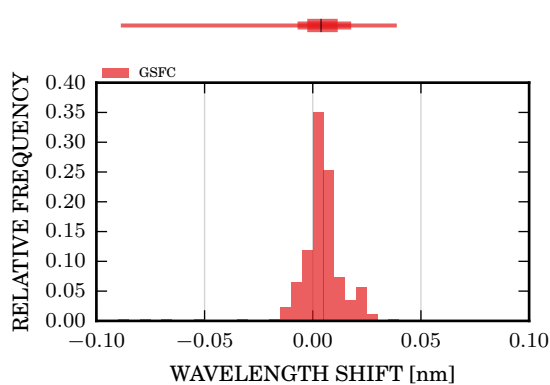
1. UNCERTAINTY VC



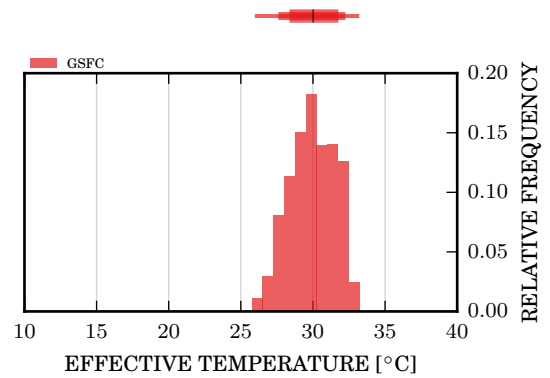
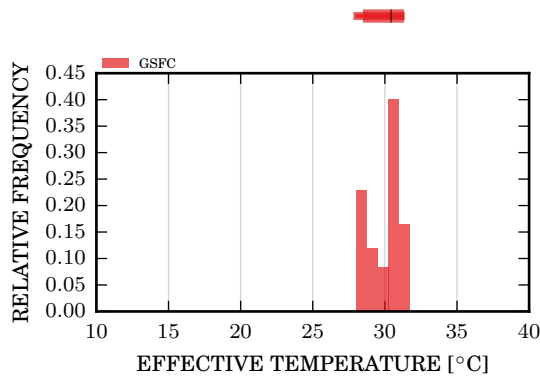
2. WRMS SPEC. FIT. RES.



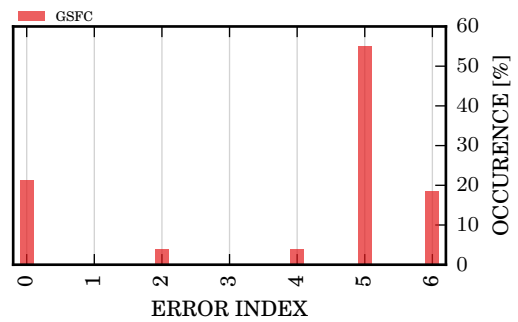
3. WAVELENGTH SHIFT



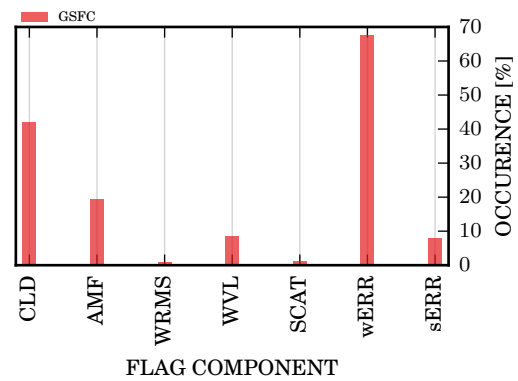
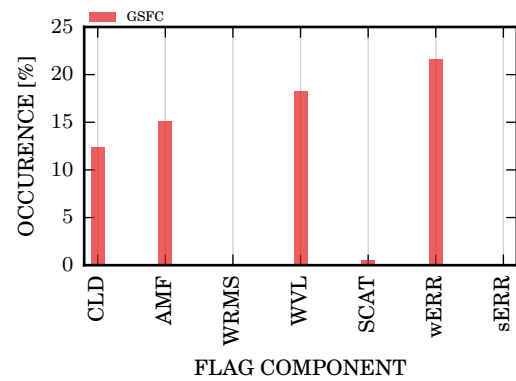
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.30 PANDORA 42 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130814
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1402028U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	91.554 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

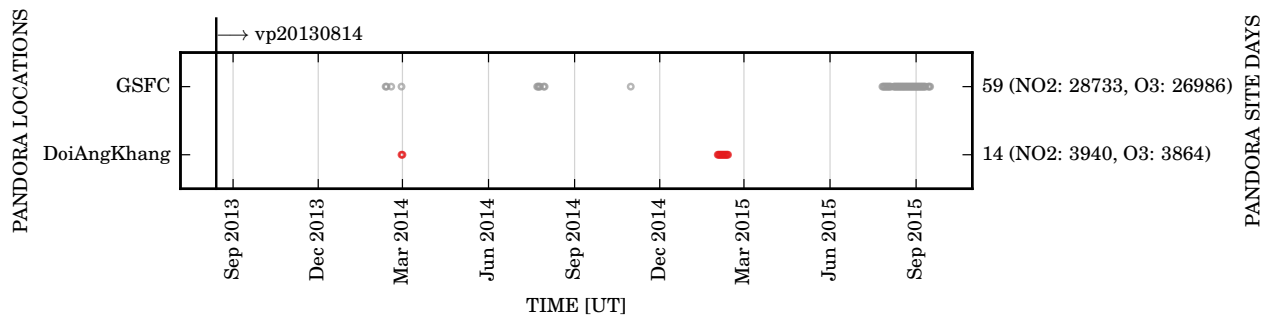
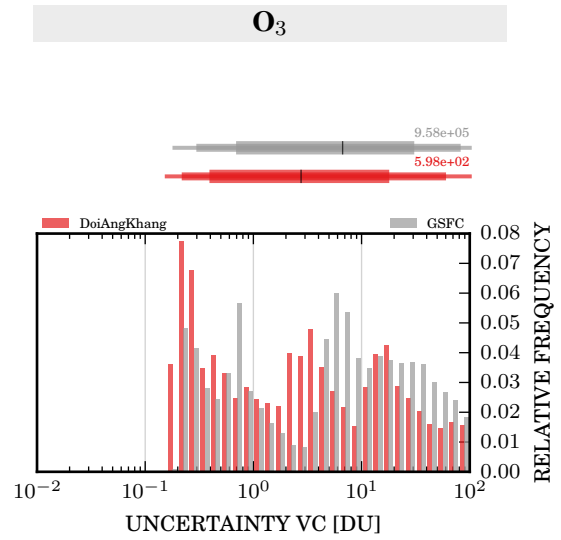
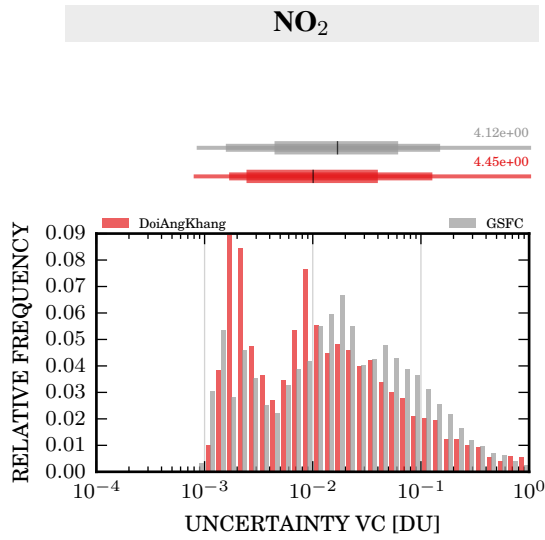


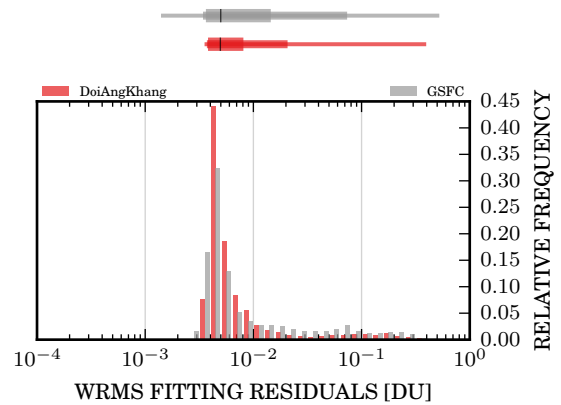
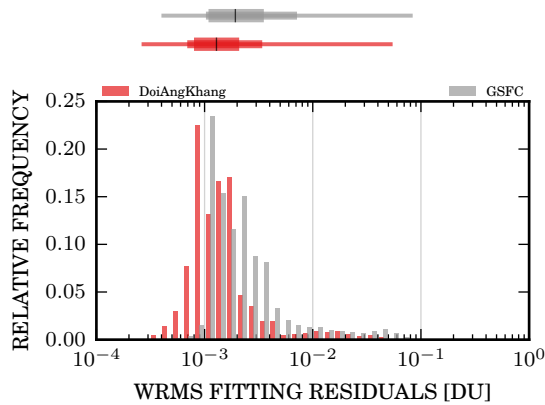
Figure 39: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

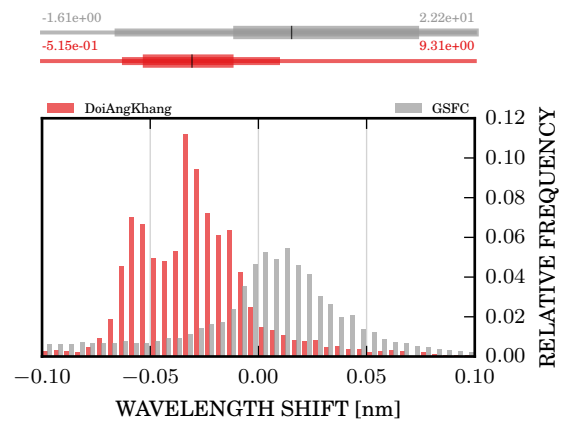
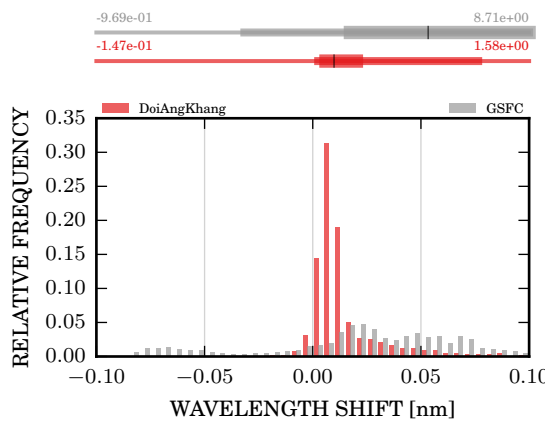
1. UNCERTAINTY VC



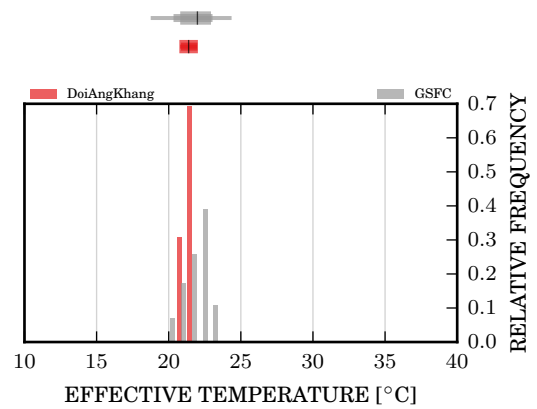
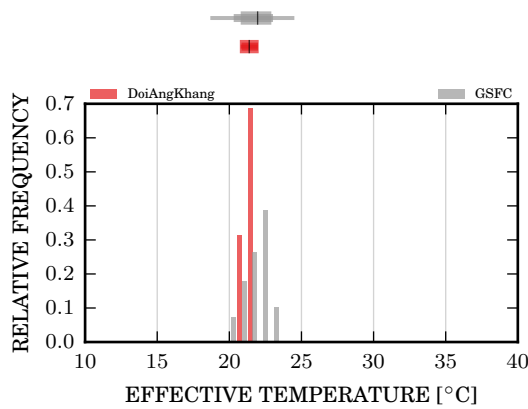
2. WRMS SPEC. FIT. RES.



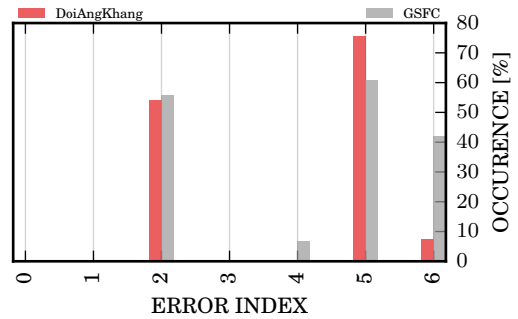
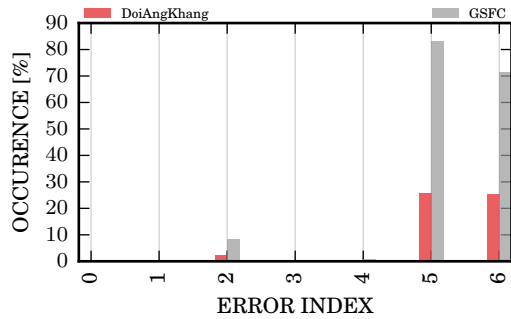
3. WAVELENGTH SHIFT



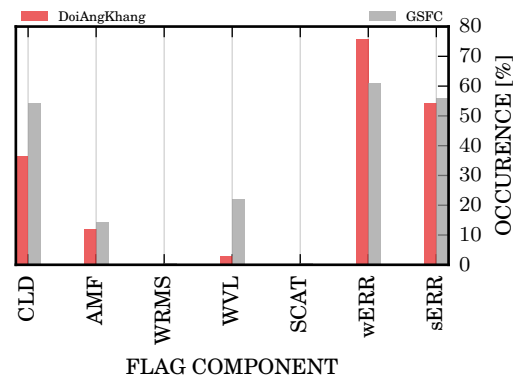
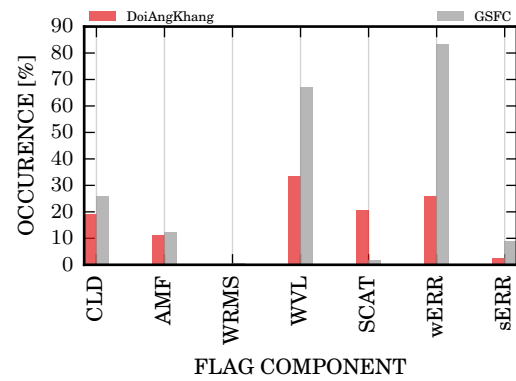
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.31 PANDORA 43 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130808
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1402026U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	91.554 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

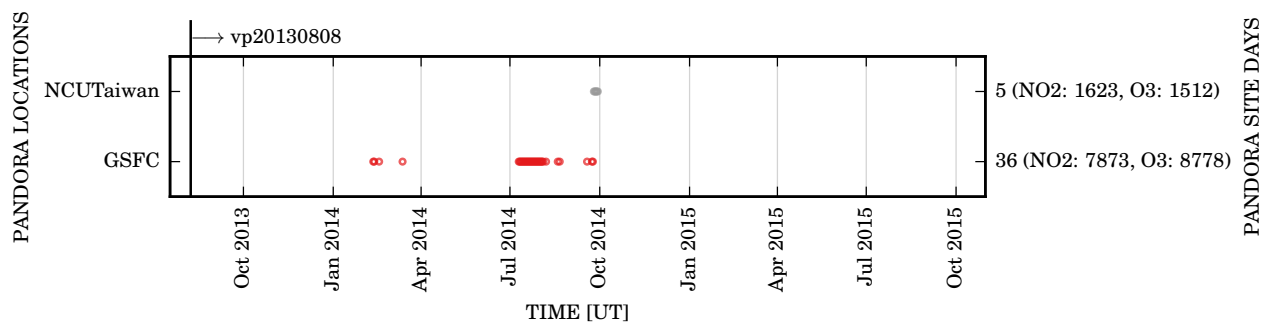
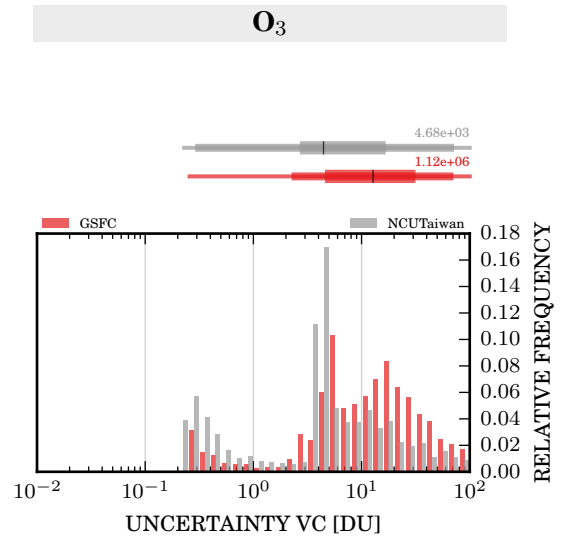
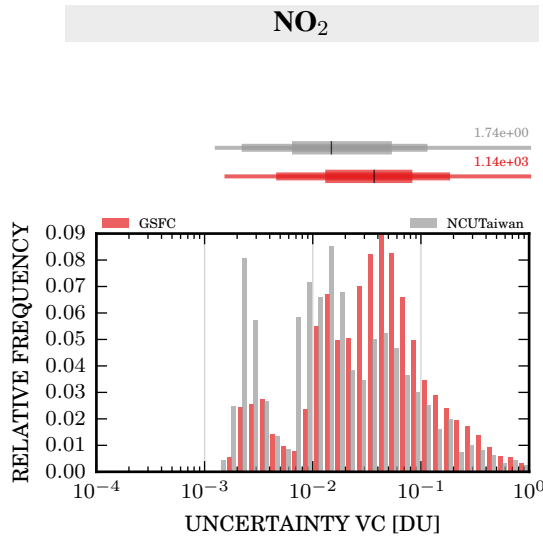


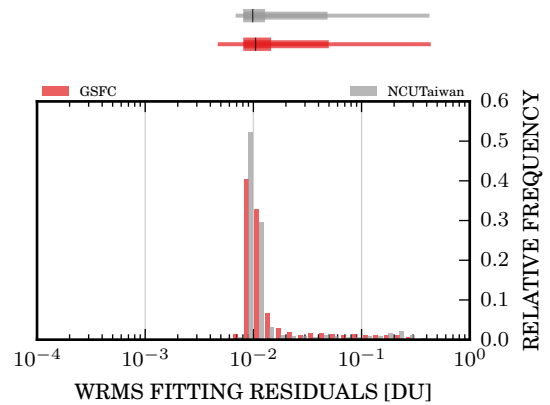
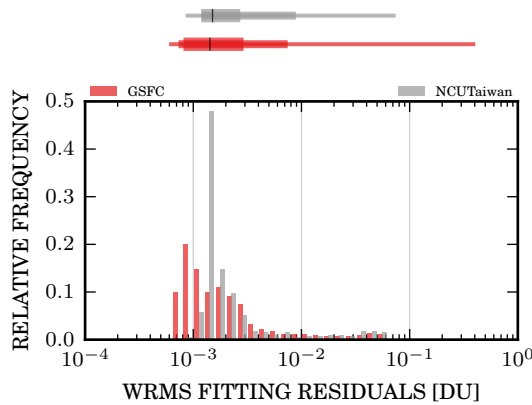
Figure 40: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

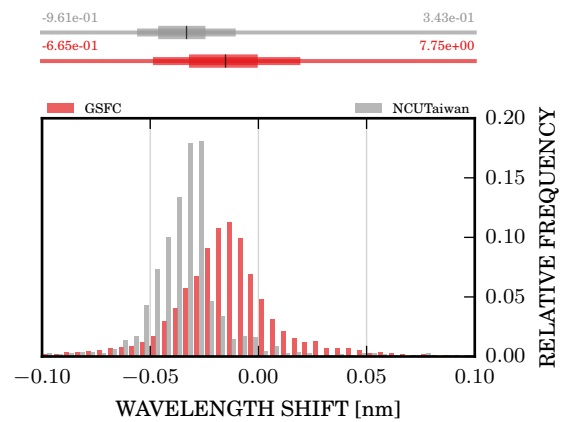
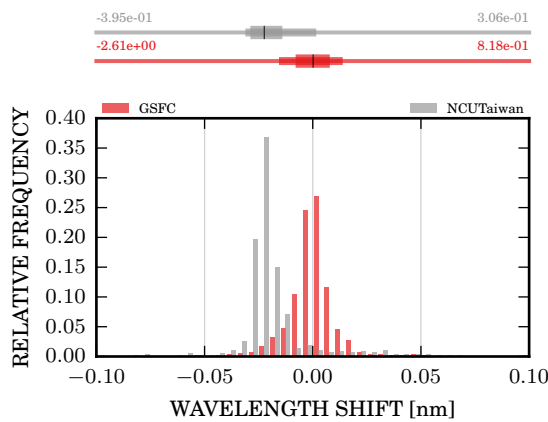
1. UNCERTAINTY VC



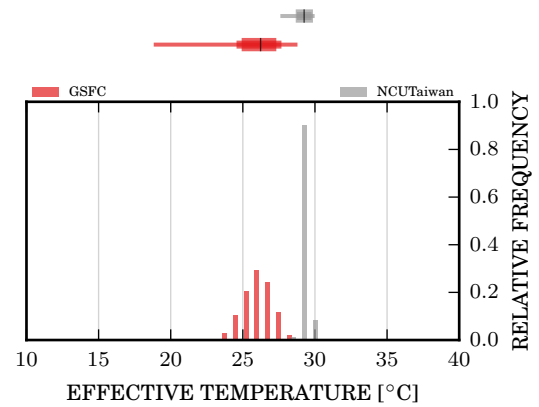
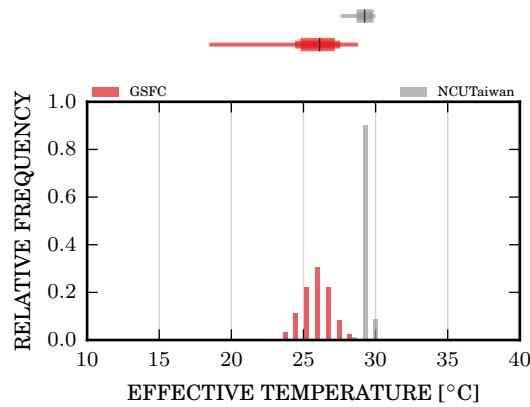
2. WRMS SPEC. FIT. RES.



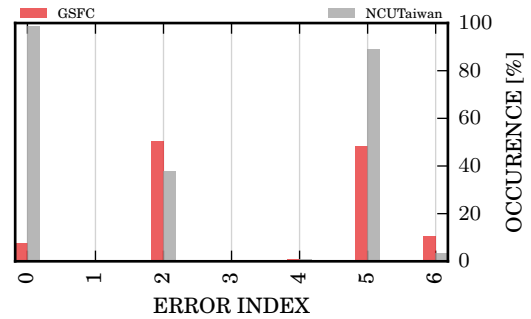
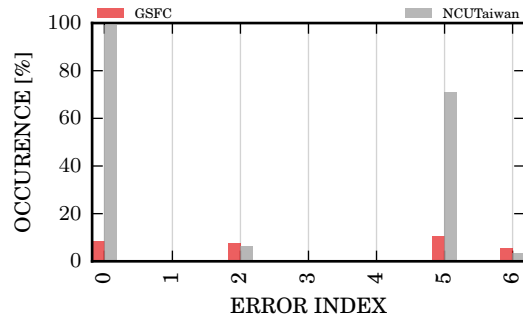
3. WAVELENGTH SHIFT



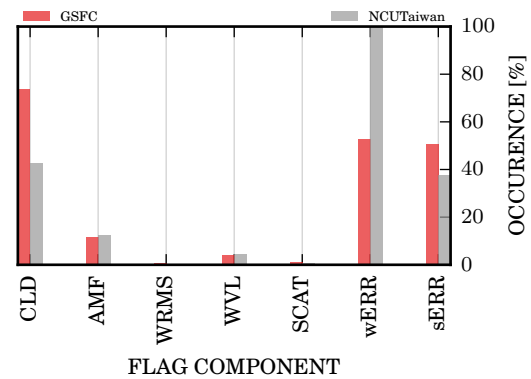
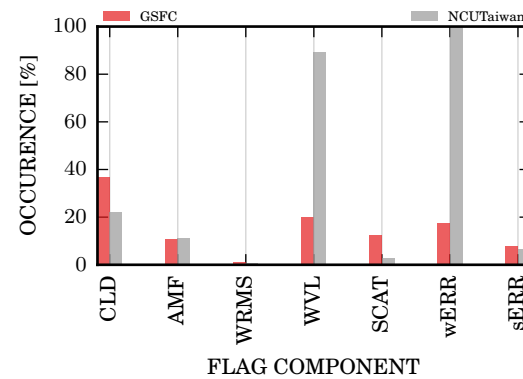
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.32 PANDORA 46 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20140221
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1303163U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	97.200 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

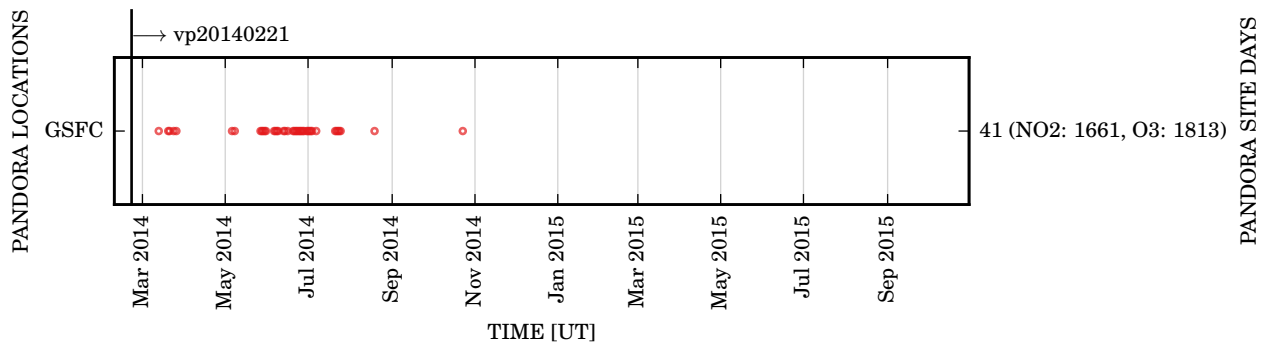
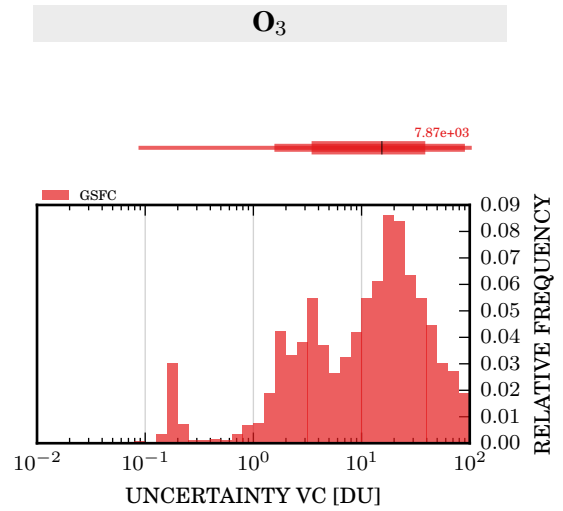
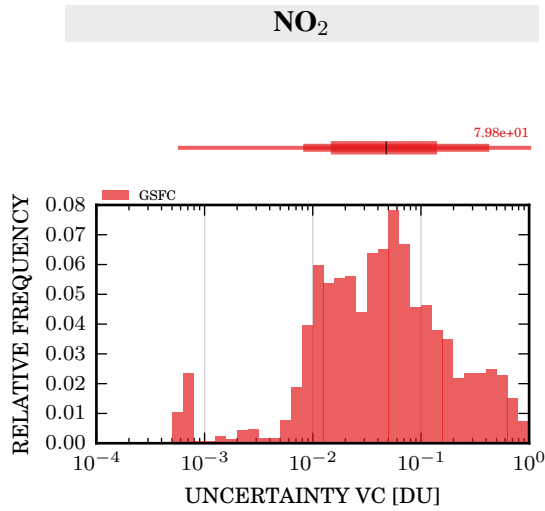


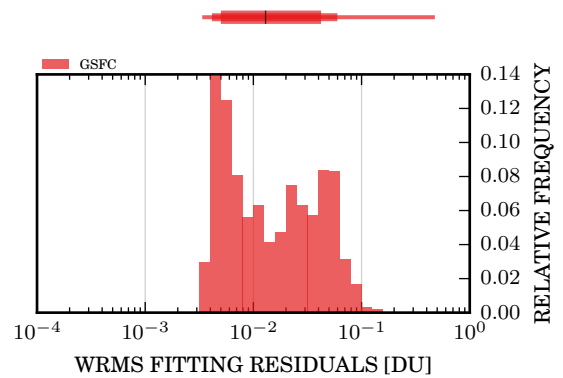
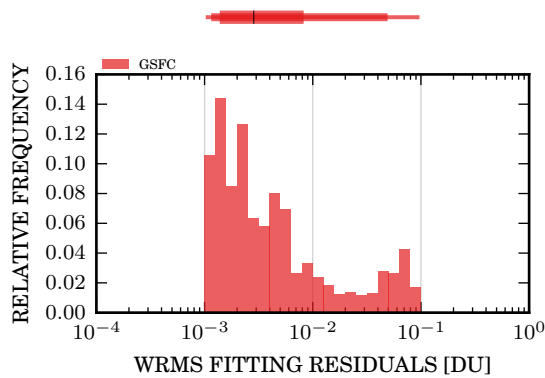
Figure 41: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

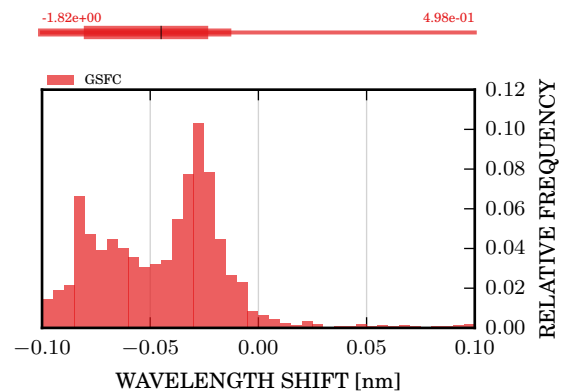
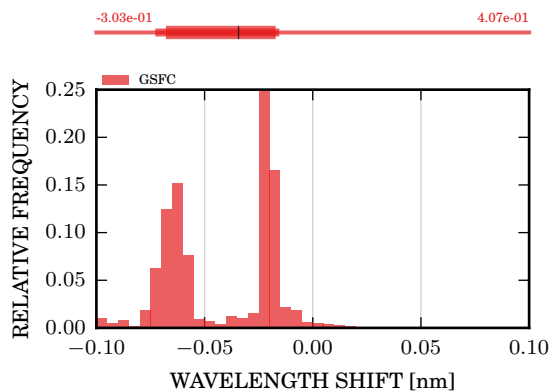
1. UNCERTAINTY VC



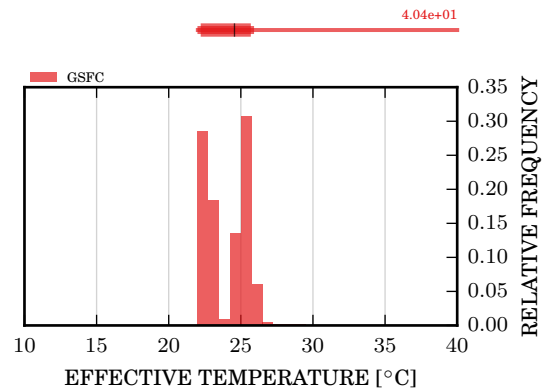
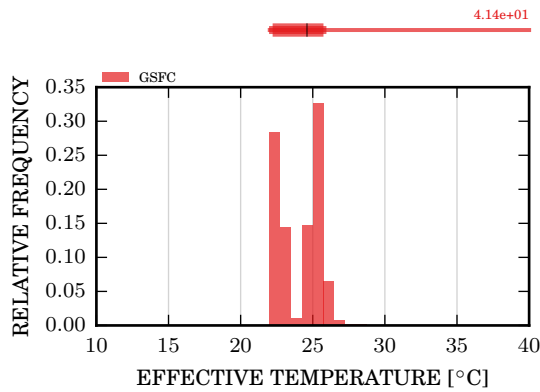
2. WRMS SPEC. FIT. RES.



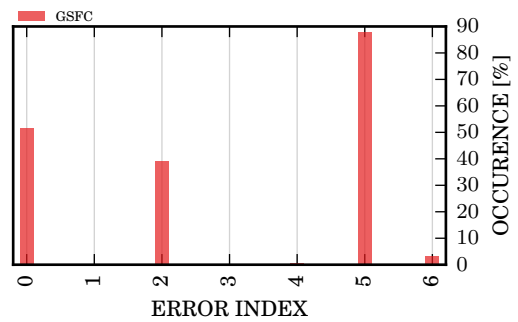
3. WAVELENGTH SHIFT



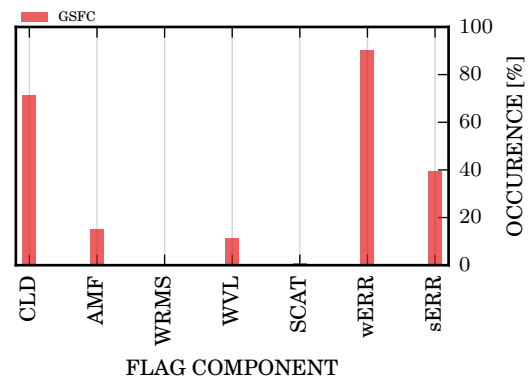
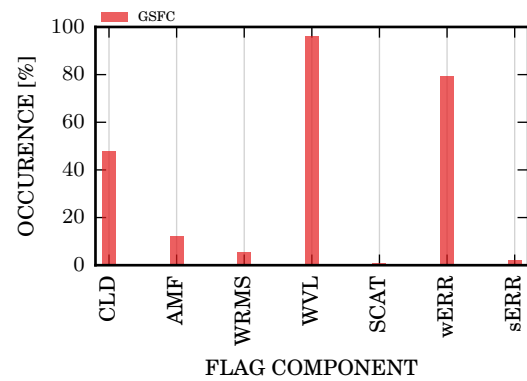
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.33 PANDORA 47 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20141211
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1304083U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	97.658 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

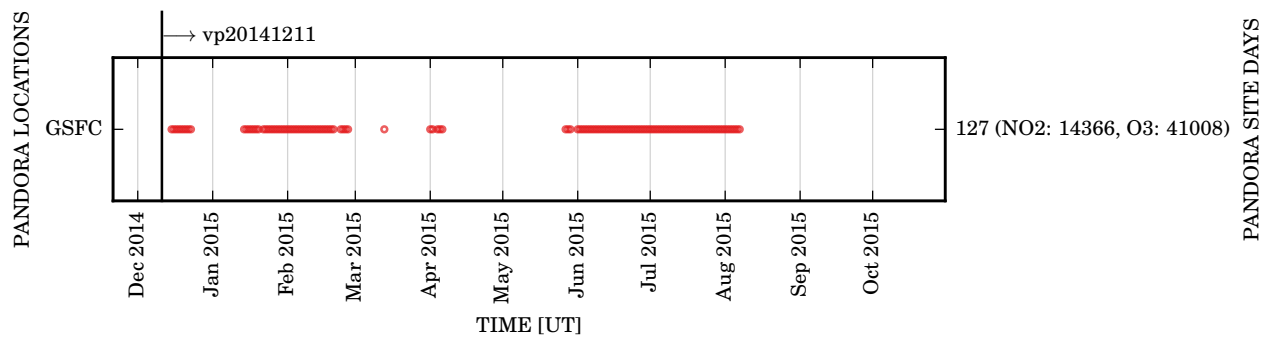
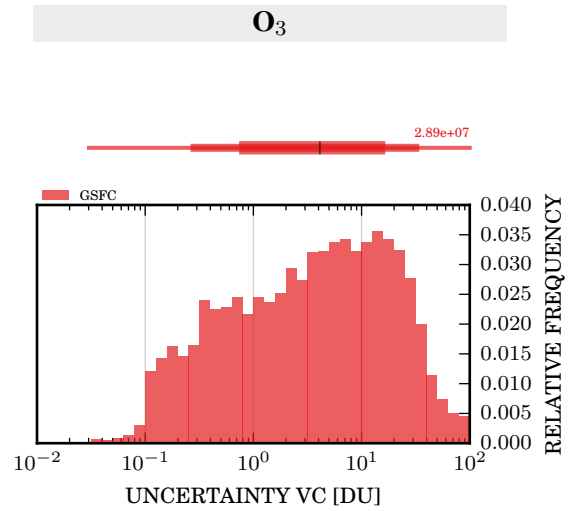
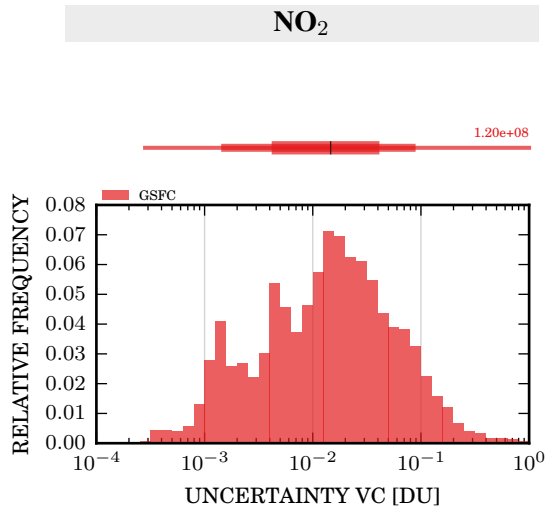


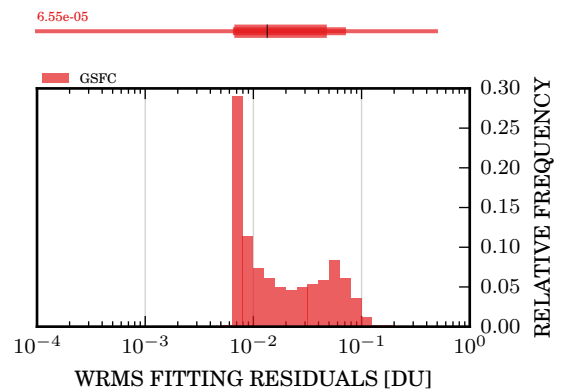
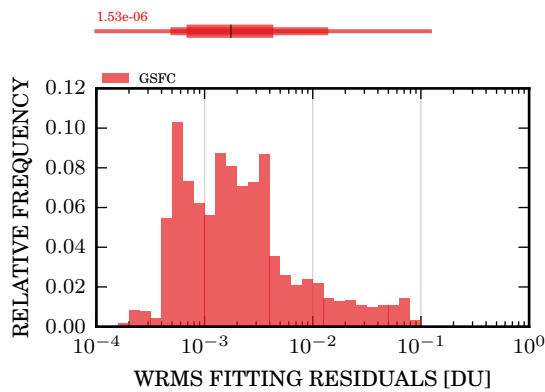
Figure 42: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

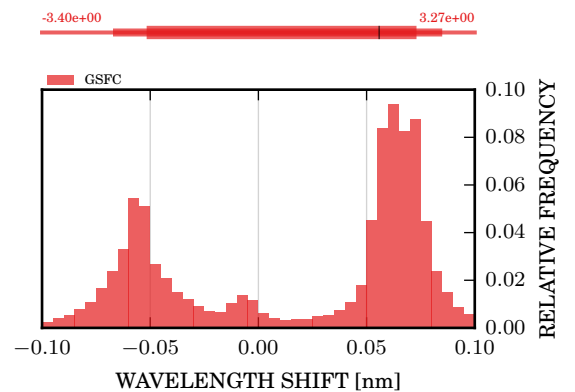
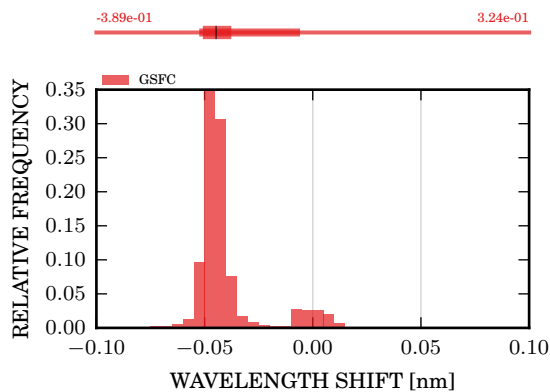
1. UNCERTAINTY VC



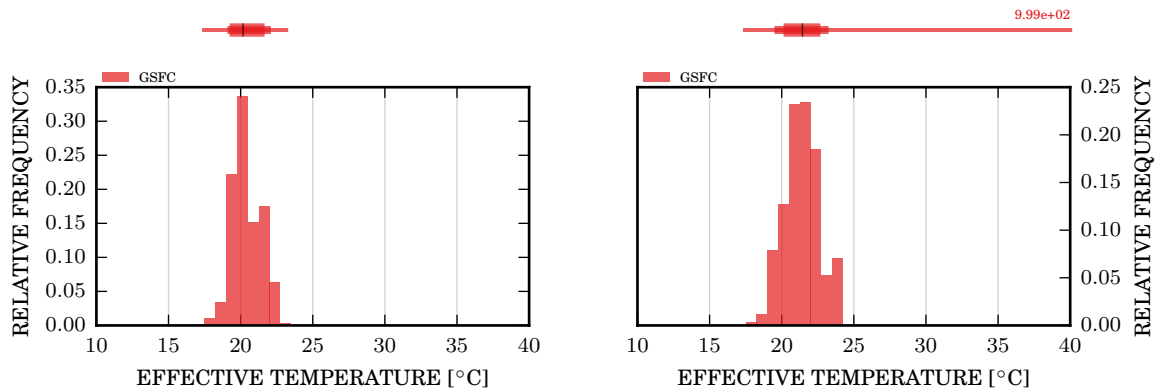
2. WRMS SPEC. FIT. RES.



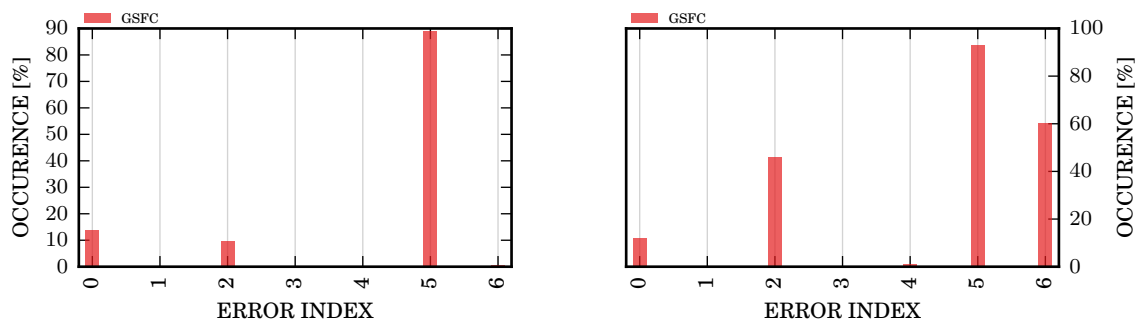
3. WAVELENGTH SHIFT



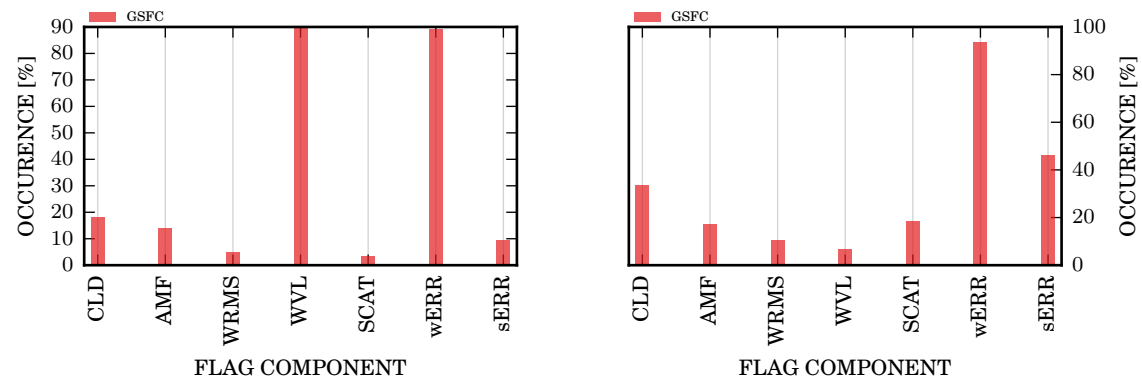
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.34 PANDORA 101 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20110317 20120105
validity period end	20120104 20151031, at least
validity period version	1 1

INSTRUMENT

spectrometer read out type	Ava1 Ava1
spectrometer unit ID	1102185U1 1102185U1
number of pixels	1024 1024
A/D converter	14 16 bits
effective saturation limit	94.610 94.610 %
temperature controller set temp.	20.0 20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

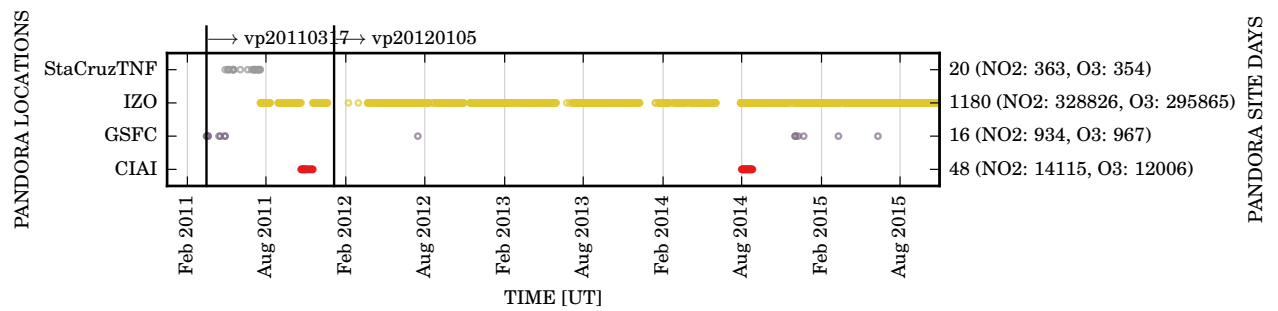
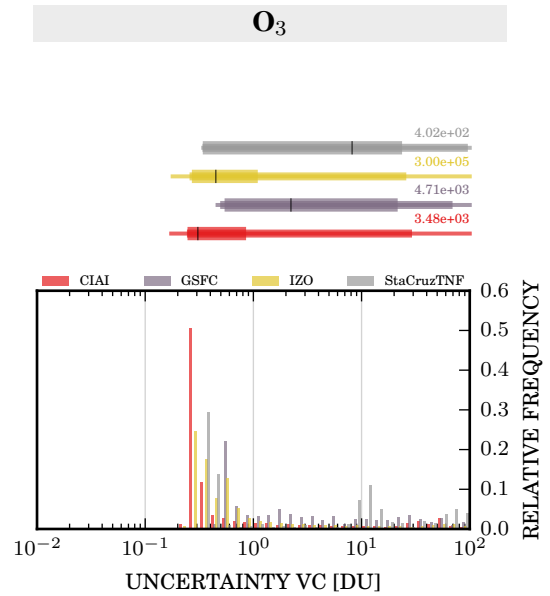
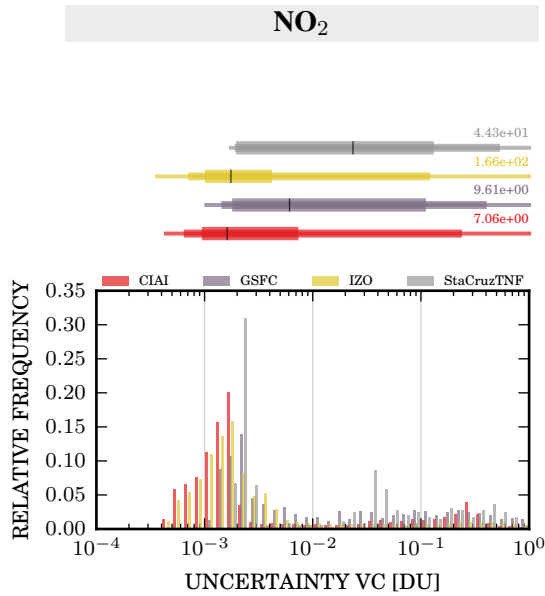


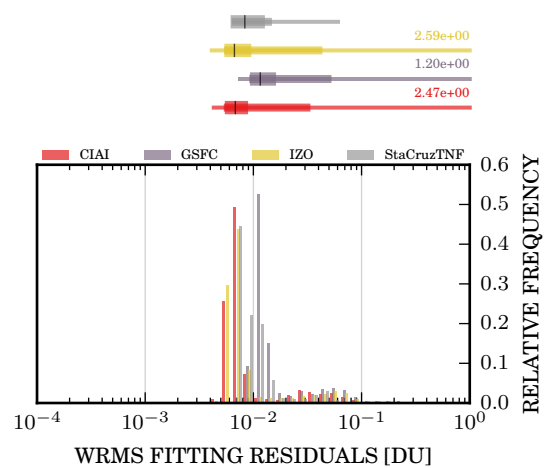
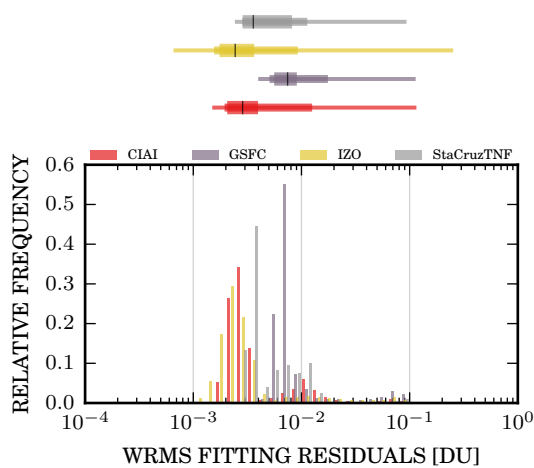
Figure 43: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

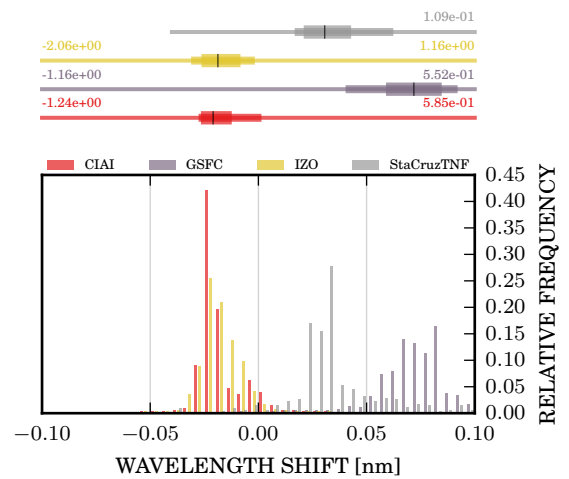
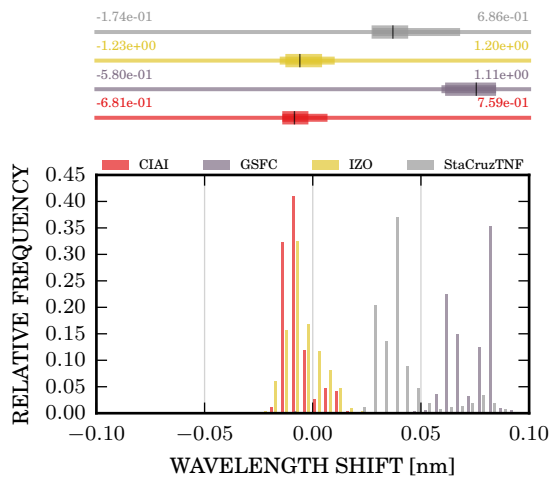
1. UNCERTAINTY VC



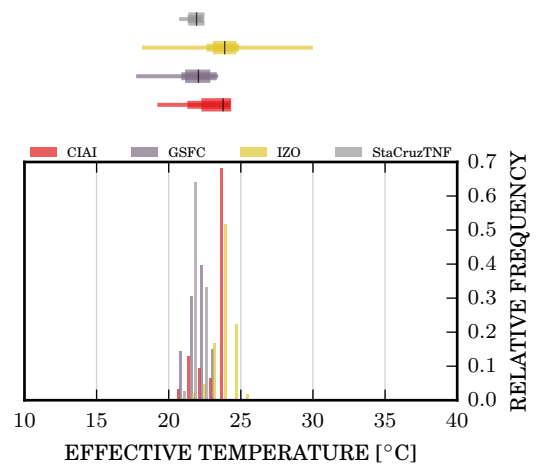
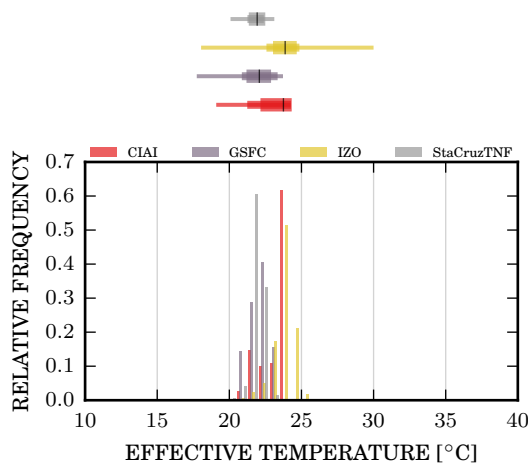
2. WRMS SPEC. FIT. RES.



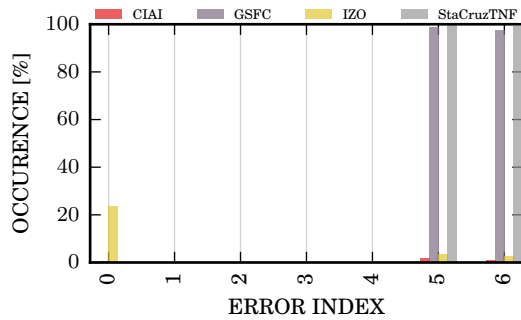
3. WAVELENGTH SHIFT



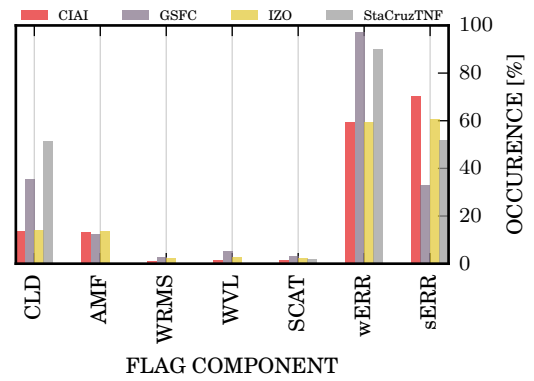
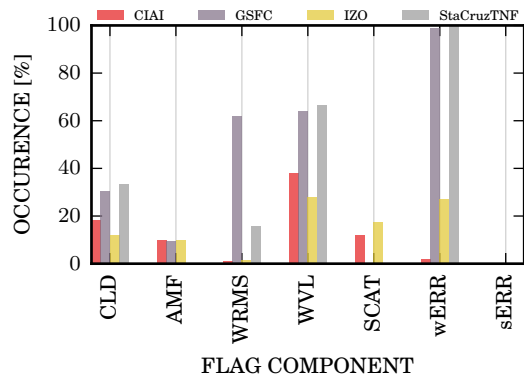
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.35 PANDORA 102 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20121212
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1210028U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	91.554 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

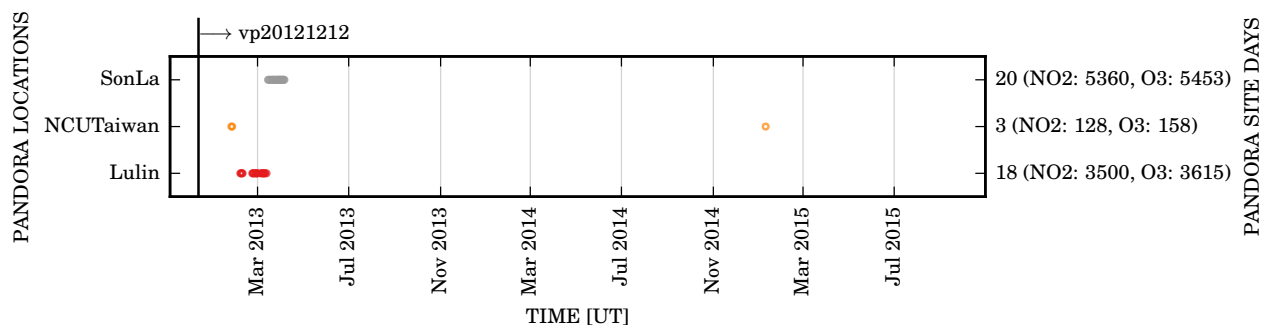
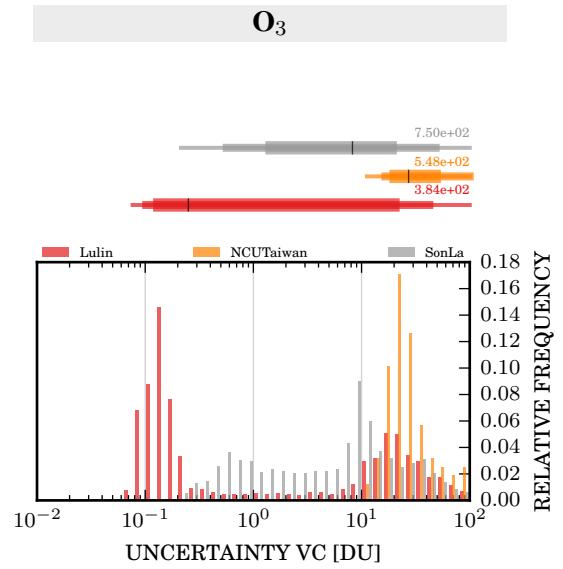
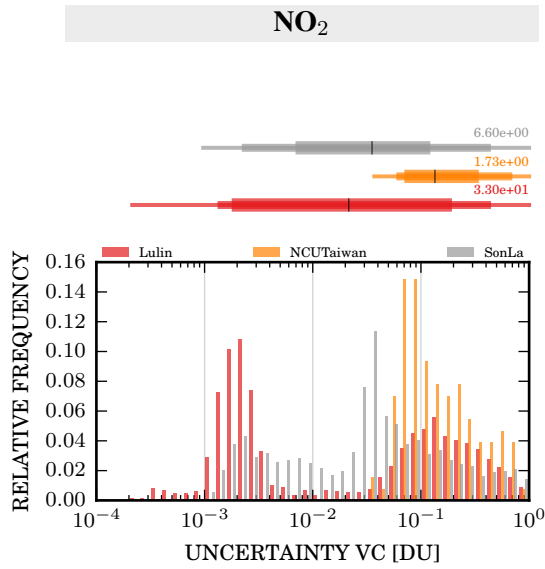


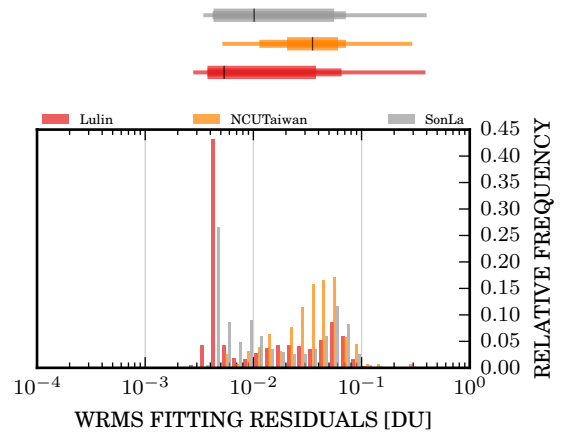
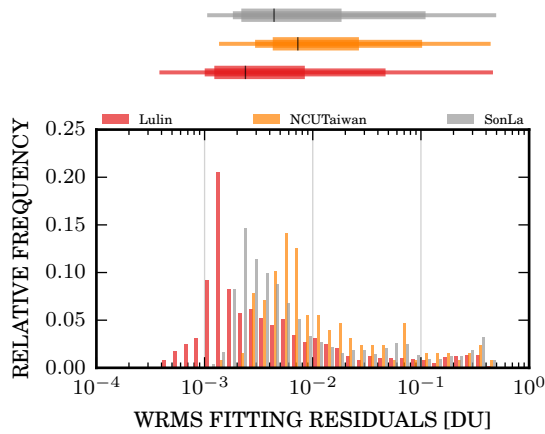
Figure 44: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

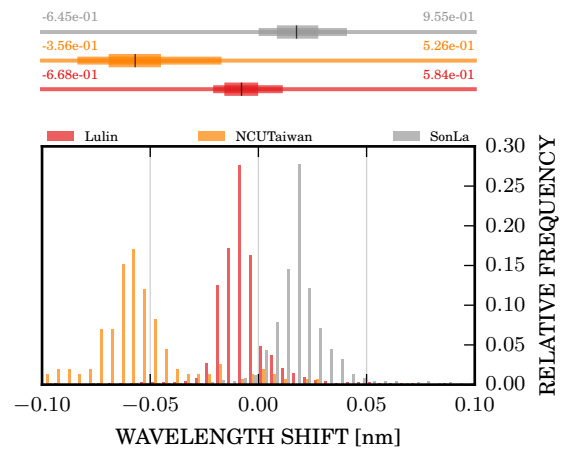
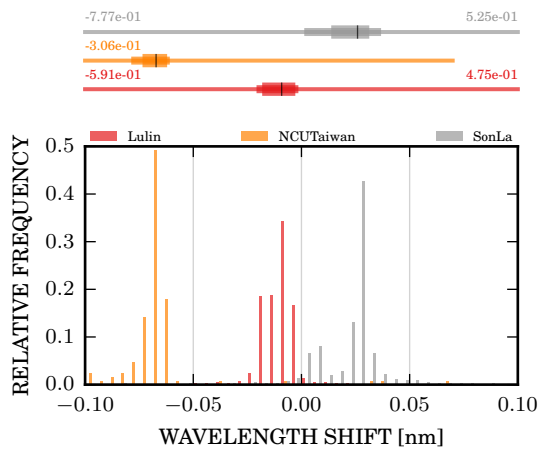
1. UNCERTAINTY VC



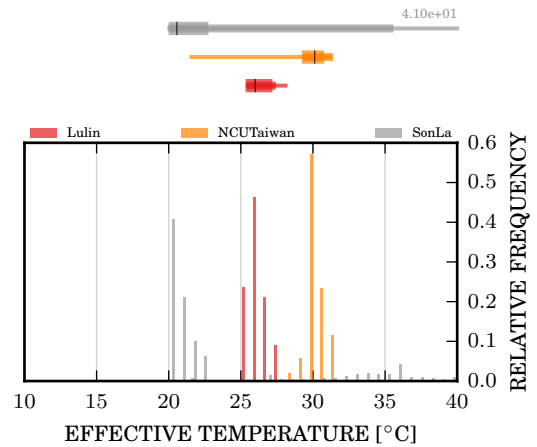
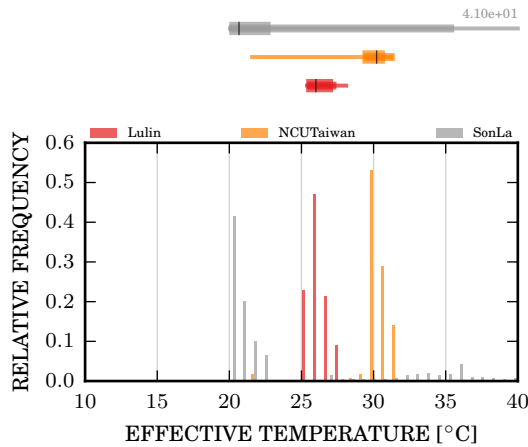
2. WRMS SPEC. FIT. RES.



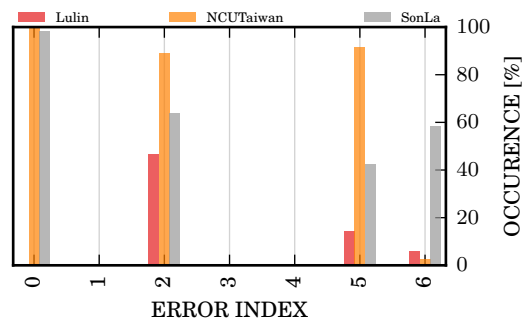
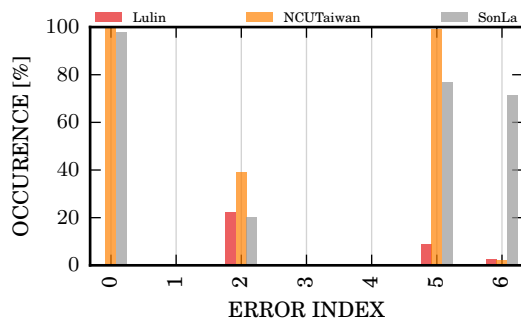
3. WAVELENGTH SHIFT



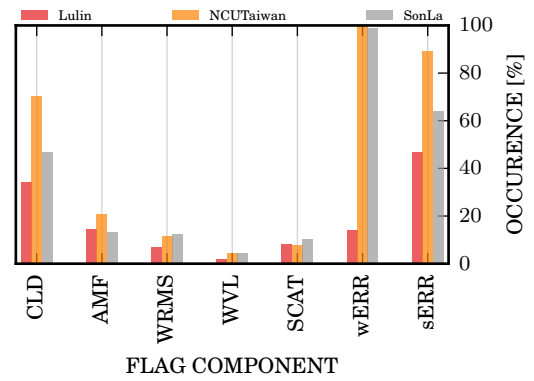
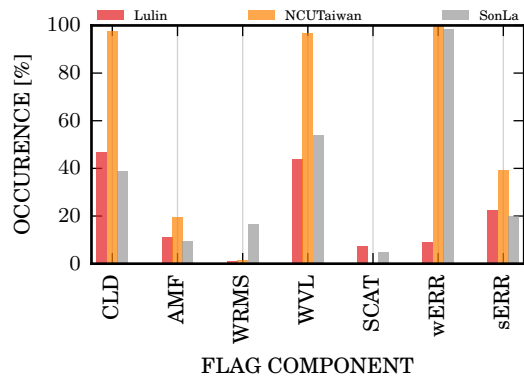
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.36 PANDORA 106 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20130726
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1402206U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	97.658 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

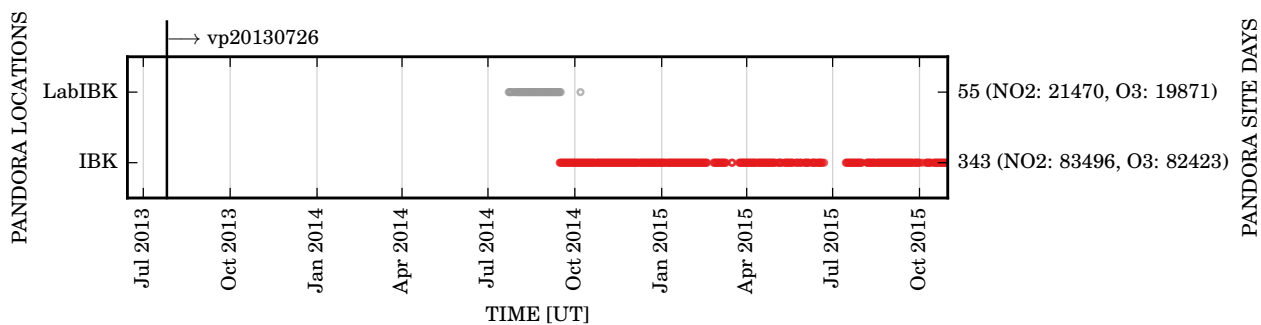
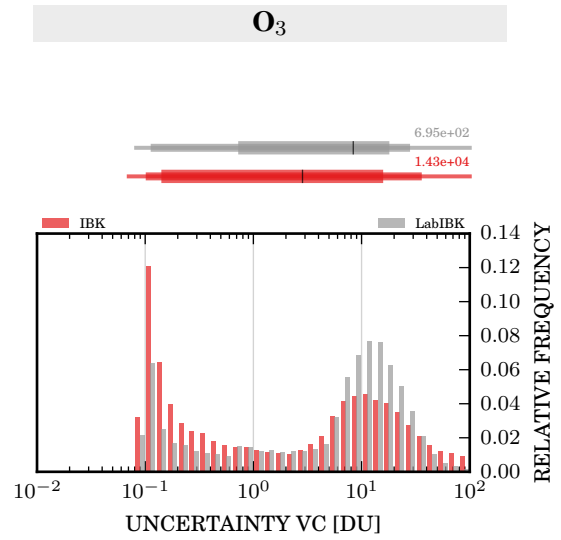
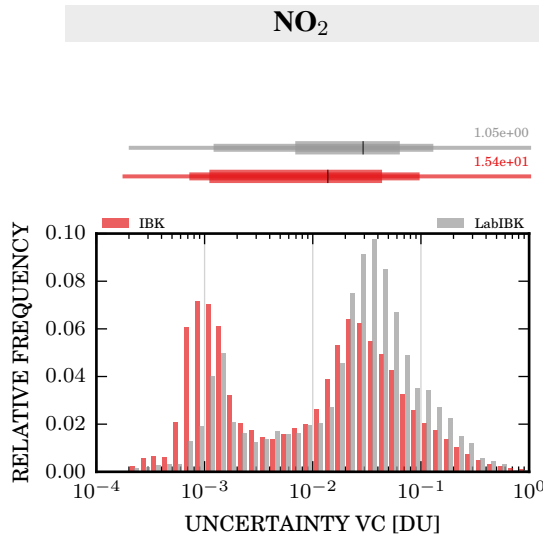


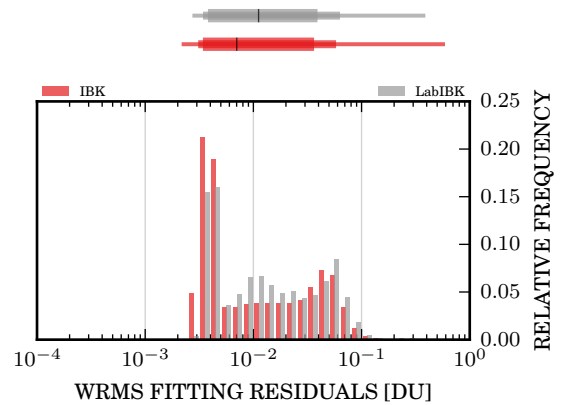
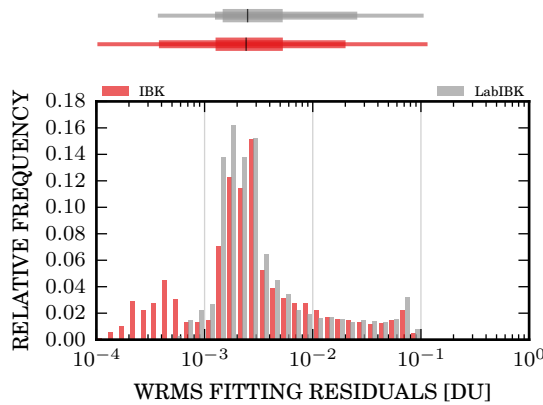
Figure 45: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

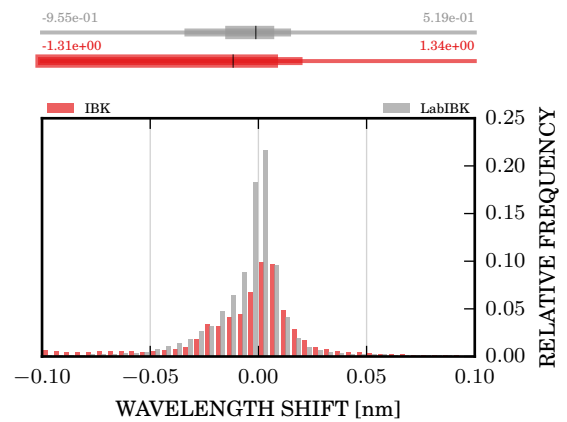
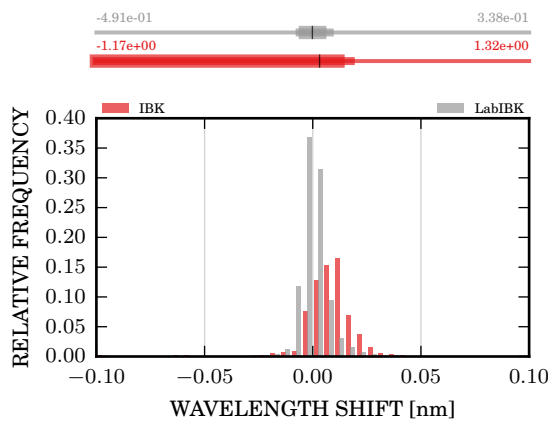
1. UNCERTAINTY VC



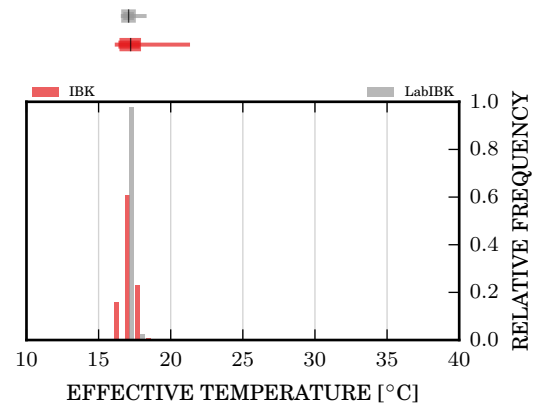
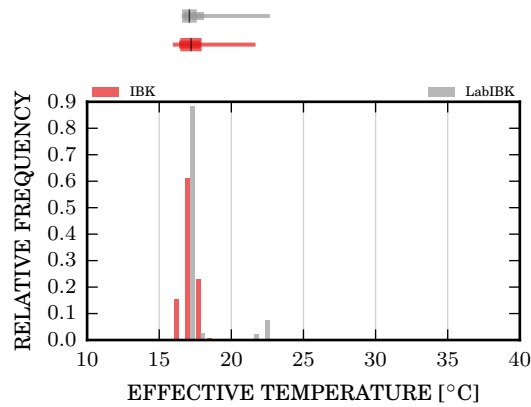
2. WRMS SPEC. FIT. RES.



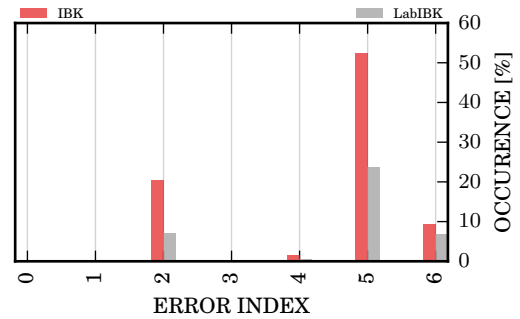
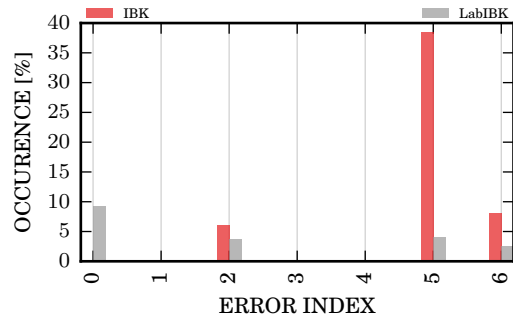
3. WAVELENGTH SHIFT



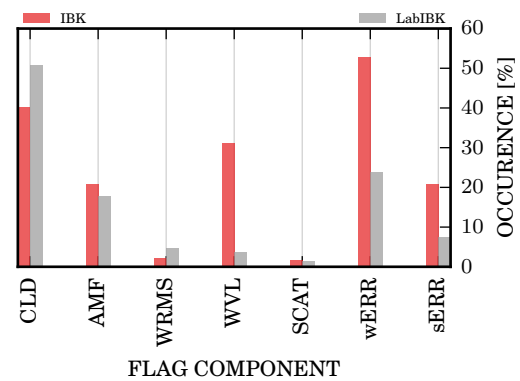
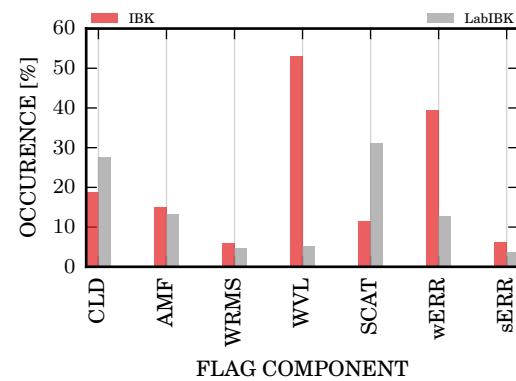
4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS



5.37 PANDORA 107 - DATA QUALITY REPORT

META INFORMATION

VALIDITY

validity period start	20150807
validity period end	20151031, at least
validity period version	1

INSTRUMENT

spectrometer read out type	Ava1
spectrometer unit ID	1402206U1
number of pixels	2048
A/D converter	16 bits
effective saturation limit	91.554 %
temperature controller set temp.	20.0 °C

SPECTRAL FITTING PARAMETERS

	NO₂	O₃
fitting window	400 - 440 nm	310 - 330 nm
fitted gases	NO ₂ , O ₃	O ₃ , NO ₂ , SO ₂ , HCHO
background polynomial	4th order	4th order
offset polynomial	0th order	0th order
wavelength corr. polynomial	1th order	1th order
wavelength corr. λ_{REF}	400 nm	400 nm
reference spectrum	synthetic	theoretic
functional filter	none	U340

PANDORA SITE DAYS

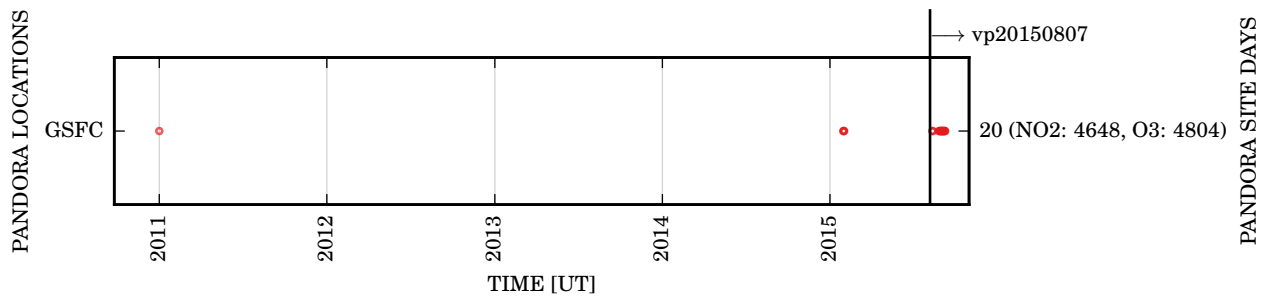
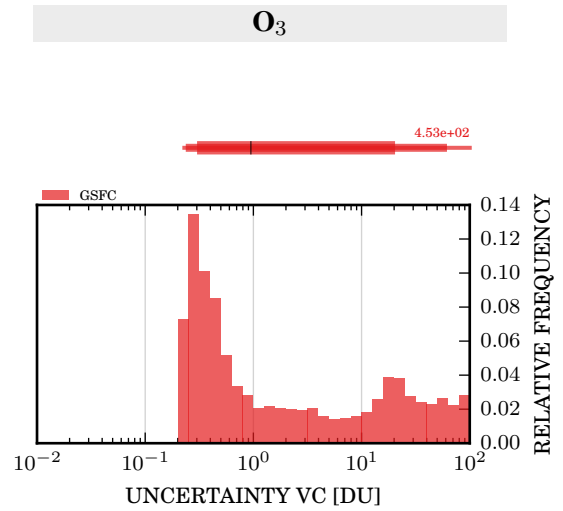
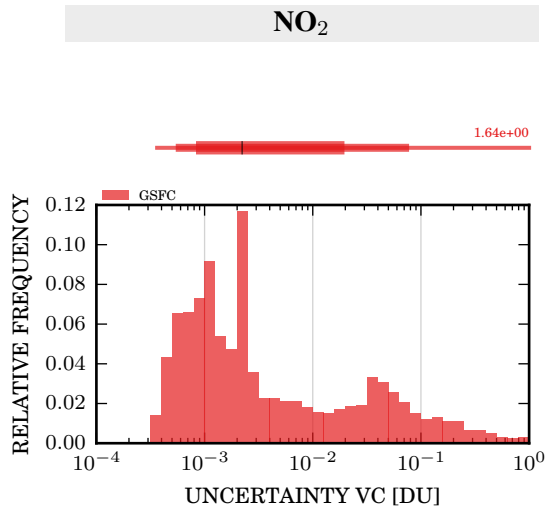


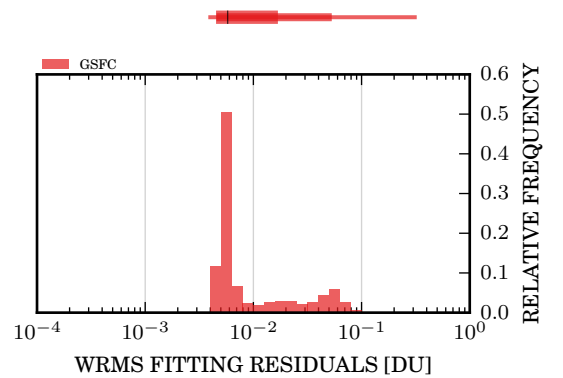
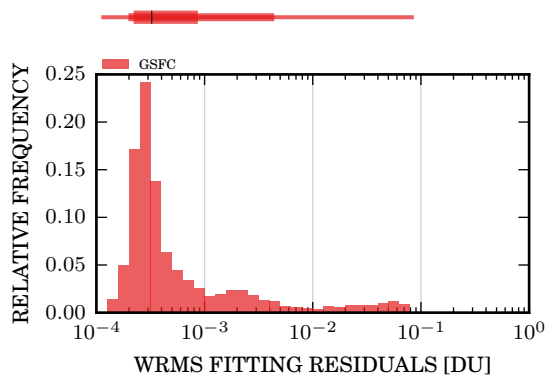
Figure 46: Time series of Pandora measurement locations (left figure axis). The horizontal lines indicate the beginning of a validity period [vp{start date}]. The right figure axis summarizes the number of measurement days at each location (and in brackets the actual number of measurements).

DATA QUALITY

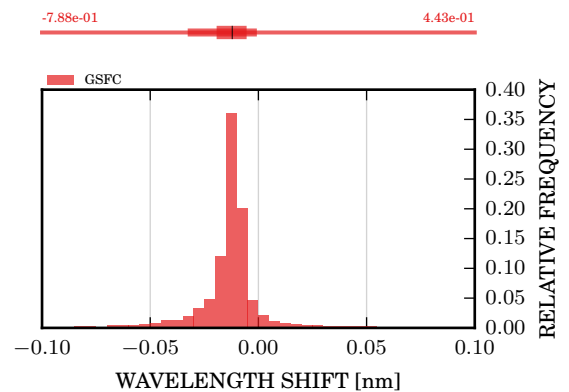
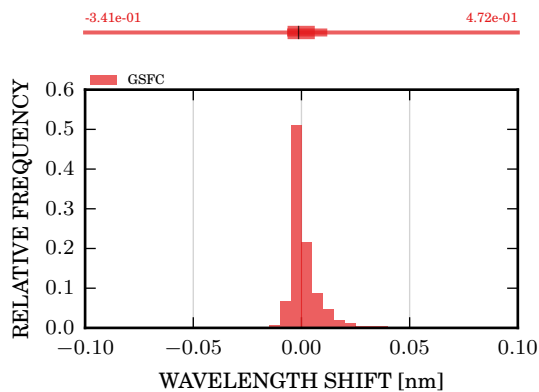
1. UNCERTAINTY VC



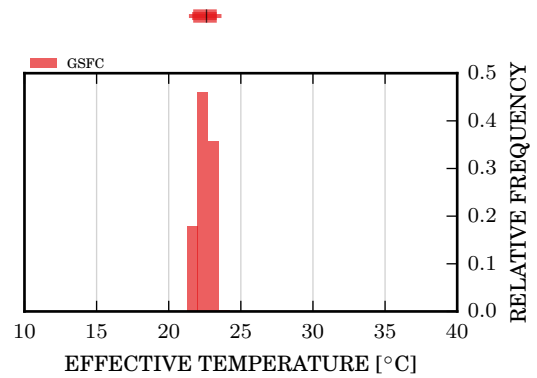
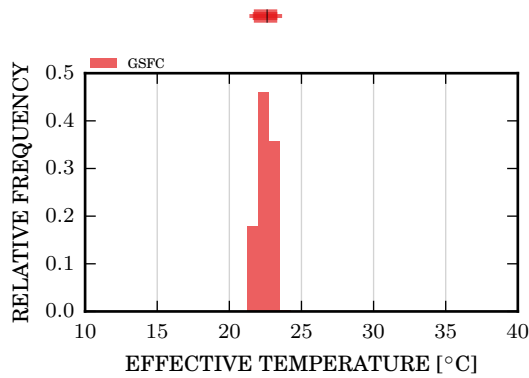
2. WRMS SPEC. FIT. RES.



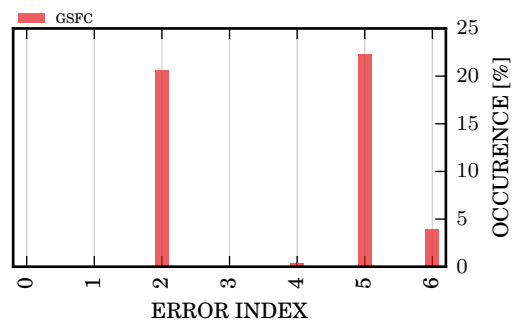
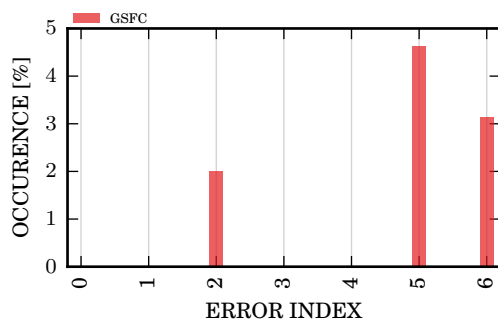
3. WAVELENGTH SHIFT



4. EFF. MEAS. TEMP.



5. DATA ERRORS



6. DATA QUALITY FLAGS

