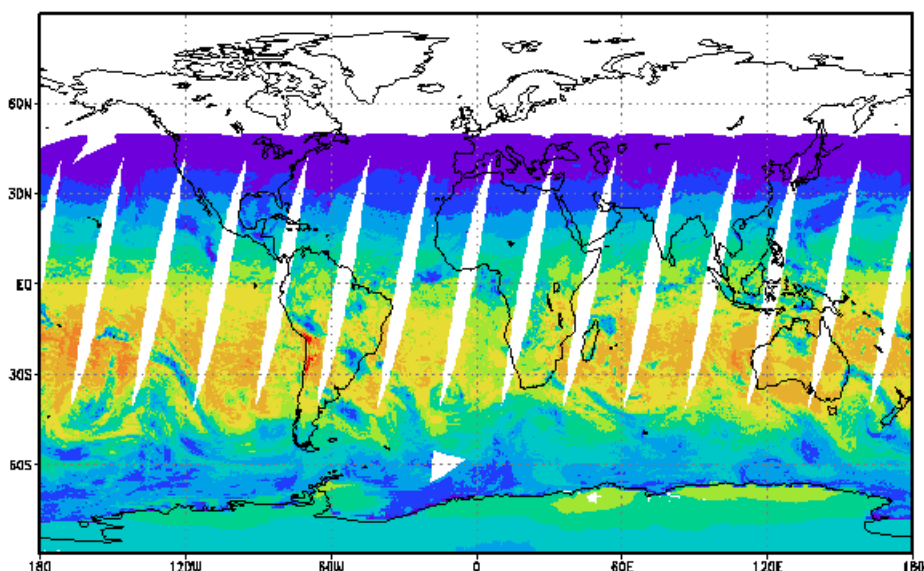


# O3M SAF VALIDATION REPORT

## Validated products:

Identifier	Name	Acronym
O3M-17 ... O3M-22	Offline UV daily doses	OUV/DD_*
O3M-23 ... O3M-28	Offline UV daily maximum dose rates	OUV/DSR_*
O3M-29	Offline UV Index	OUV/UVI



## Author:

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**Reporting period:** June 2007 – May 2008

**Input data versions:** NTO/O3 version GDP 4.1, since 1 June 2007  
 NTO/O3 version GDP 4.2, since 13 June 2007  
 MetOp-A AVHRR L1b LAC version 1.0, since 1 June 2007  
 N-18 AVHRR L1b GAC version 0.0, since 1 June 2007 \*  
 N-18 AVHRR L1b GAC version 1.0, since 20 September 2007

**Data processor versions:** OUV processor version 1.00, since 1 June 2007  
 OUV processor version 1.06, since 21 April 2008

\* Converted from NOAA CLASS archive

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## DOCUMENT STATUS SHEET

<b>Issue</b>	<b>Date</b>	<b>Modified Items / Reason for Change</b>
1/2008	11.4.2008	Initial version
2/2008	29.9.2008	More stations + OMI comparison added. Conclusions added as per ORR-A RIDs
1/2009	13.2.2009	Editorial changes + albedo clarification added as per ORR-B RIDs

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## 1. Introduction

### 1.1 Purpose and scope

The purpose of this document is to present the validation of OUV product (version 1.12) against ground based ultraviolet measurements and surface UV product based on OMI satellite measurements. Validation was performed for the time period starting from June 1<sup>st</sup> 2007 and ending May 31<sup>st</sup> 2008.

### 1.2 Acronyms

CIE	Commission Internationale de L'Éclairage, International Commission on Illumination.
FMI	Finnish Meteorological Institute
GOME-2	Global Ozone Monitoring Experiment, version 2
HDF	Hierarchical Data Format
NSF	National Science Foundation
OUV	Offline UV product
O3M SAF	Satellite Application Facility for Ozone and Atmospheric Monitoring



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### 1.3 References

#### **Applicable Documents**

[AD1] O3M SAF Offline UV Product User Manual, Issue 1.2, 4 April 2008.

#### **Reference Documents**

[RD1] OUV Algorithm Theoretical Basis Document, SAF/O3M/FMI/ATBD/001, Issue 1.1, 2.4.2008.

[RD2] McKinlay A.F and Diffey B.L., */CIE Research Note/*, 6(1), 1987

[RD3] Setlow R.B., */Proc. Nat. Acad. Sci. USA/*, 71, 3363-3366, 1974.

[RD4] Caldwell, M.M. "Solar UV Irradiation and the Growth and Development of Higher Plants", pages 131-177 in Giese A.G (ed.) */Photophysiology/*, vol 6. Academic Press

[RD5] Gruijl F.R. and Van der Leun J.C., */Health Phys/*, 67(4), 319-325, 1994

[RD6] Arctic Research Centre of the Finnish Meteorological Institute home page, <http://fmiarc.fmi.fi/>.

[RD7] National Science Foundation Polar Programs UV Monitorin Network home page, <http://www.biospherical.com/nsf/>.

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## 2. Data sources

### 2.1 Offline UV-product

The O3M SAF Offline surface UV product is derived from measurements of the operational polar orbiting Metop and NOAA satellites. The product contains the most important quantities of the Sun's radiation that can be harmful to life and materials on the surface of the Earth. These quantities include daily doses and maximum dose rates of integrated UV-B and UV-A radiation together with values obtained by different biological weighting functions, solar noon UV index and quality control flags. The product is calculated in a 0.5 degree regular grid and stored in a HDF5 file. An example of the daily erythemal dose product is shown in figure 1 below.

The biological weighting functions (also known as action spectra) model responses of different biological entities to UV radiation. The currently applied functions are plotted in figure 2 and a short description of their meaning is given in Table 1. For more information on OUV product, please refer to OUV Product User Manual. [AD1]

OUV data used in validation were processed using version 1.12 of processing algorithm. Algorithm or processing versions of input data varied during the validation period and can be seen on table 2.

Weighting function	Ref.	Description
CIE	[RD2]	Most often used weighting function. It is also known as the erythemal weighting function, because it measures the reddening of the skin due to sunburn.
DNA	[RD3]	Measures the ability of UV irradiance to cause damage to unprotected DNA. Normalization to 1.0 at 300 nm is used (normalization to 265 nm is divided by 0.0326)
Plant	[RD4]	Measures the generalized response of plants to UV irradiance. Normalization to 1.0 at 300 nm is used (normalization to 280 nm is divided by 0.2176)
SCUP-h	[RD5]	Skin Cancer Utrecht-Philadelphia action spectrum, adjusted for human skin. Measures the incidence of skin cancer (squamous cell carcinoma in human skin, SCC).

Table 1. Description of the biological weighting functions used in the OUV product.

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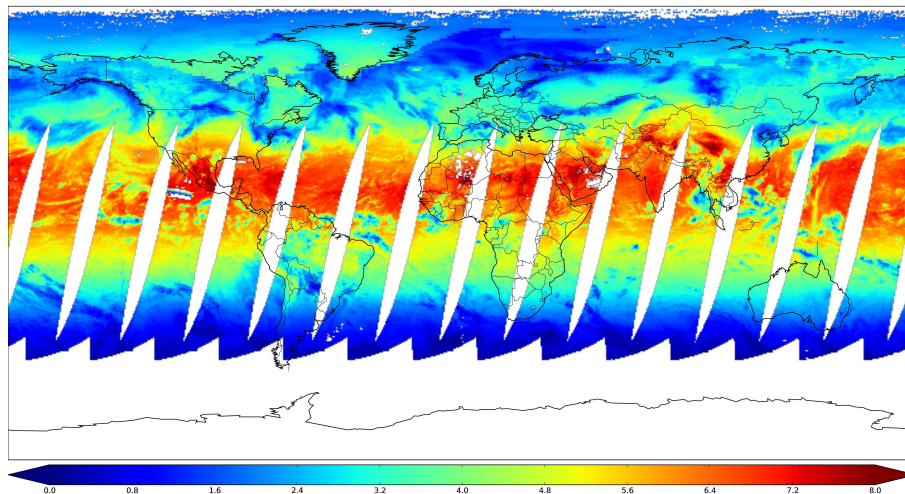


Figure 1. An example product field. Erythemal (CIE) daily dose [ $\text{kJ/m}^2$ ] on 12 May 2008. The global coverage is limited by the swath of GOME-2 instrument, leaving stripes at low latitudes. The polar night and large solar zenith angles limit the coverage at the winter pole.

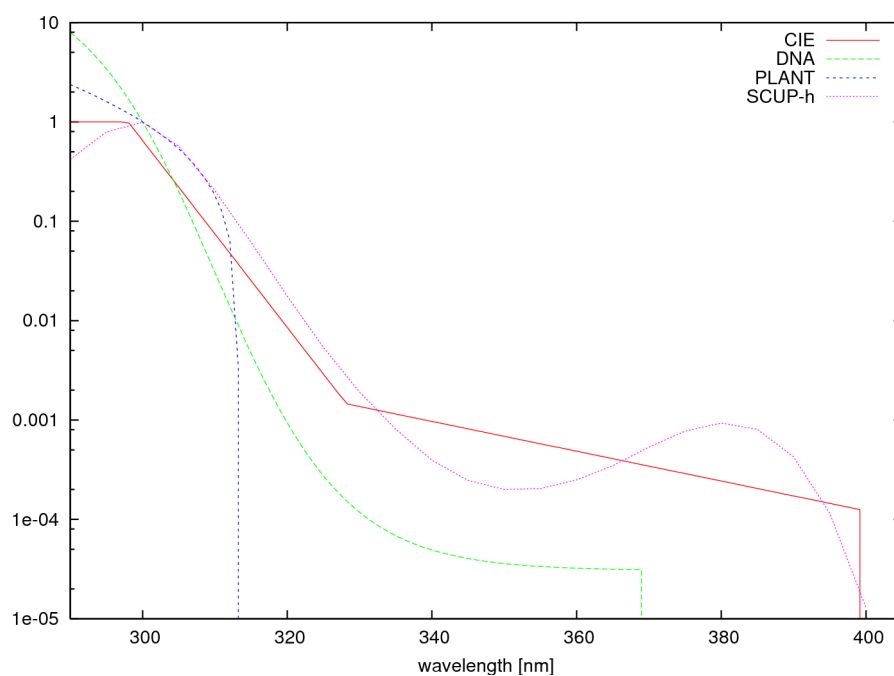


Figure 2. The biological weighting functions (table 1) used in the OUV product: CIE (red), Setlow DNA (green), Caldwell Plant (blue) and SCUP-h (purple).

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Date	NTO/OTO	Metop AVHRR level 1b LAC	NOAA AVHRR level 1b GAC
01.06.2007	GDP-4.1 / upas 1.1.8	1.0	0.0*
13.06.2007	GDP-4.2 / upas 1.1.9		
20.09.2007			1.0**
15.10.2007	GDP-4.2 / upas 1.2.0		
07.12.2007	GDP-4.2 / upas 1.2.1		
29.02.2008	GDP-4.2 / upas 1.2.2		
26.05.2008	GDP-4.2 / upas 1.2.3		
26.05.2008	GDP-4.2 / upas 1.2.4		
31.05.2008	GDP-4.2 / upas 1.2.4	1.9	1.0

Table 2. OUV v1.12 base algorithm/processor versions for the validation period 1.6.2007 – 31.5.2008. \* 0.0 is converted from NOAA CLASS archive, \*\* 1.0 is received from EUMETCAST, which become operational on 14.12.2007

## 2.2 Comparison data sources

Daily doses and daily maximum dose rates from OUV product were compared to ground based measurements. Availability of ground based data for validation was limited. Data from Finnish Meteorological Institute's (FMI) meteorological observatories in Jokioinen and Sodankylä were available for the validation period, although data for 2008 were preliminary at this stage. Preliminary data are not expected to be significantly different from final data, which will be available later this year. FMI station in Jokioinen operates double monochromator Brewer Mk-III spectrophotometer and Sodankylä operates single monochromator Brewer Mk-II.

Data from National Science Foundation (NSF) Polar programs UV Monitoring Network were also available. NSF stations are mainly located in polar regions. Stations used in validation were Barrow (Alaska), McMurdo (Antarctica), Palmer (Antarctica), San Diego (California), Summit (Greenland) and Ushuaia (Argentina). Only preliminary data were available. Again, preliminary data are not expected to differ significantly from final data. Stations are very different from each other and some of them proved to be challenging for the OUV processing. The sites are equipped with SUV-100 spectroradiometers, except Summit, which uses SUV-150B spectroradiometer.

Also used were the data from six stations operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew). Stations are located in continental United States in Bondville (Illinois), Boulder (Colorado), Fort Peck (Montana), Houston (Texas), Niwot Ridge (Colorado) and Raleigh (North Carolina). Stations have been operating since 2006 and use Brewer Mk-IV spectrophotometers. Only daily doses were available from NEUBrew network, so these stations are not used in dose rate comparisons.

In addition, data from Aristotle University of Thessaloniki, Greece were used. Measurements in Thessaloniki were recorded with a Brewer Mk-III spectrophotometer.

Comparisons were also performed between OUV product and OMUVB v003 product processed by Finnish Meteorological Institute. OMUVB is derived from measurements of OMI instrument aboard EOS-Aura satellite. OMI offers measurements similar to those of GOME-2 with wider spatial coverage, which makes it useful for validation purposes.

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### 3. OUV validation

OUV daily doses and daily maximum dose rates were compared to ground based measurements and OMUVB satellite-based measurements. Scatter plots and histograms were used as a visual aid in order to estimate possible bias. Statistics used in validation are explained in Appendix B.

Results discussed here were mostly obtained using CIE weighting function, as these values were available from all of the stations. Other weighting functions, where data for comparisons were available, show very similar behaviour. Only CIE weighing function and total statistics with some examples are discussed here. Plots and statistics for other weighting functions and individual stations can be found in Appendix A.

#### 3.1 Comparison with ground-based measurements

As the example time series in figure 3 shows the OUV daily doses are, in general, in good agreement with the ground based measurements. OUV does, however, slightly overestimate the ground based measurements. Example scatter plots in figure 4 also show this small positive bias. Daily maximum dose rates show slightly smaller bias, but the variance of the results is also higher.

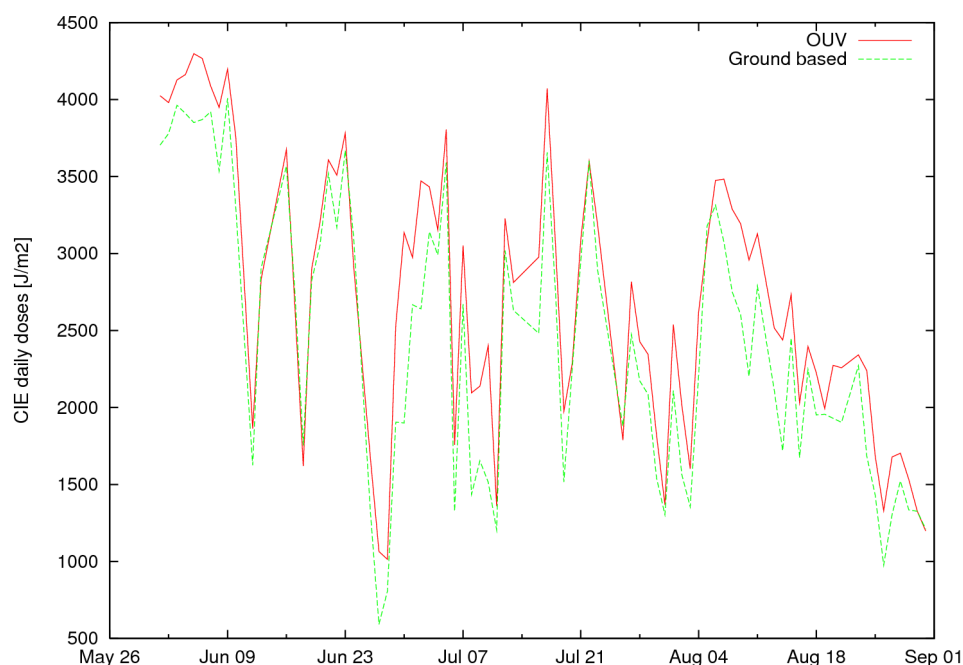


Figure 3. An example time series. OUV and ground based CIE daily doses for Jokioinen from 1 March to 30 May 2008.

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Situation is similar in most of the stations. OUV overestimates the ground based daily doses, generally by 10-20 %. Daily maximum dose rates generally show smaller positive biases.

In McMurdo and Palmer OUV severely underestimates ground based CIE daily dose measurements (figure 5.), by 63 % in McMurdo and by 27 % in Palmer. Maximum dose rates show similar biases (figure 5). Because McMurdo and Palmer show such a big difference from the other stations, their results are not included in total statistics (Tables 3. and 4. and figures 7. and 8.). Errors in McMurdo and Palmer probably due to problems with surface albedo. Grid pixels in both McMurdo and Palmer contain very inhomogeneous terrain, which causes problems for the algorithm. In future versions of data processor pixels with highly variable surface albedos or ground elevations will be flagged with inhomogeneous terrain flag.

Monthly means and standard deviations of daily doses and daily maximum dose rates for OUV and ground-based measurements are presented as bar graphs (figure 6.)

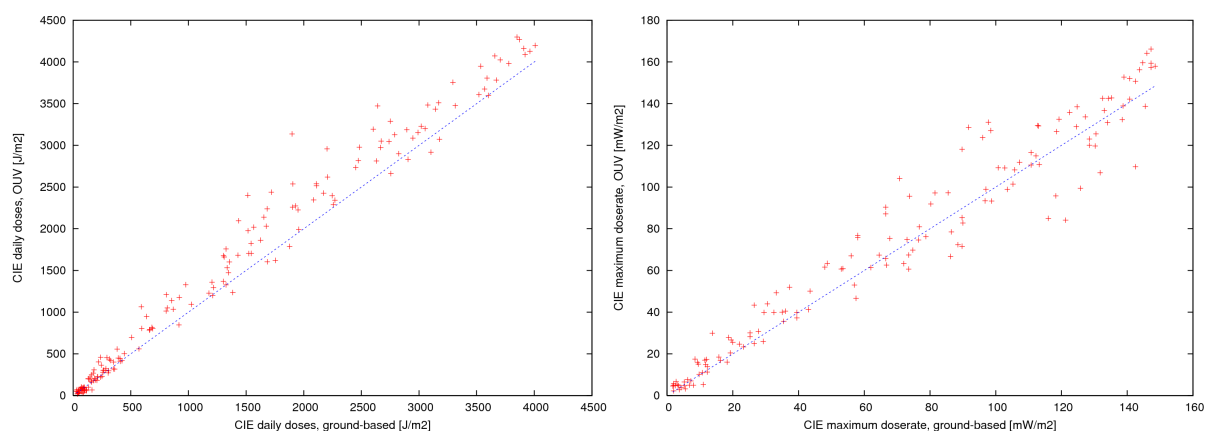


Figure 4. Examples of scatter plots. CIE daily dose (left) and CIE daily maximum dose rate (right) scatter plots for Jokioinen, OUV vs. ground based measurements. Both plots show good agreement between OUV and ground based measurements, although OUV slightly over-estimates daily doses.

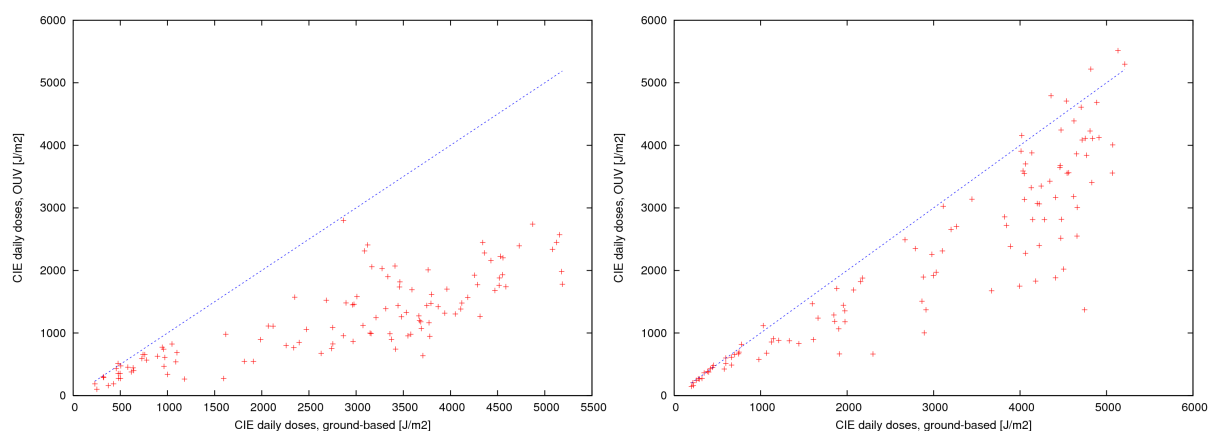


Figure 5. Examples of scatter plots. CIE daily dose scatter plots for McMurdo (left) and Palmer (right). OUV severely underestimates the daily doses.

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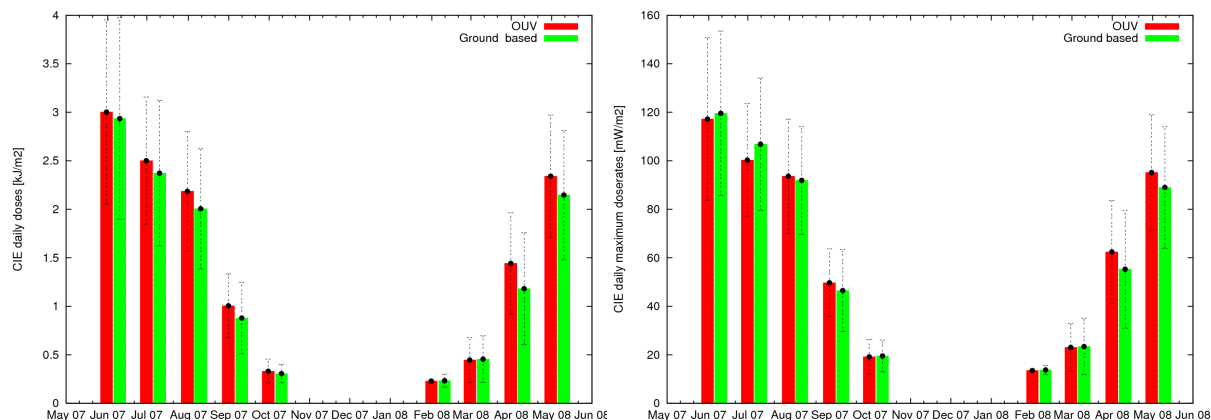


Figure 6. Examples of monthly means. Monthly means of OUV and ground-based measurements with standard deviations for Jokioinen. CIE daily doses (left) and CIE daily maximum dose rates (right).

Mean difference (bias) of the OUV daily dose and ground based daily dose was 339 J/m<sup>2</sup> and mean relative difference 16.5 % for remaining stations. RMS error was 641 J/m<sup>2</sup> and RMS relative error was 46.8 % (figure 7. and table 3.). Mean relative difference for maximum dose rate was 9.6 percent and RMS relative error was 41.5 % (figure 8. and table 4.).

Biases for individual stations can be seen in the histograms showing the distribution of the relative error for daily doses (figure 9.) and daily maximum dose rates (fig. 10.). Most histograms show relatively compact distribution with positive bias of roughly 20 % for daily doses. Exceptions are McMurdo and Palmer, which show large negative biases, and stations like Niwot Ridge and Ushuaia, where distributions are more spread out.

For maximum daily dose rates, distributions are generally similar, although bias is often smaller.

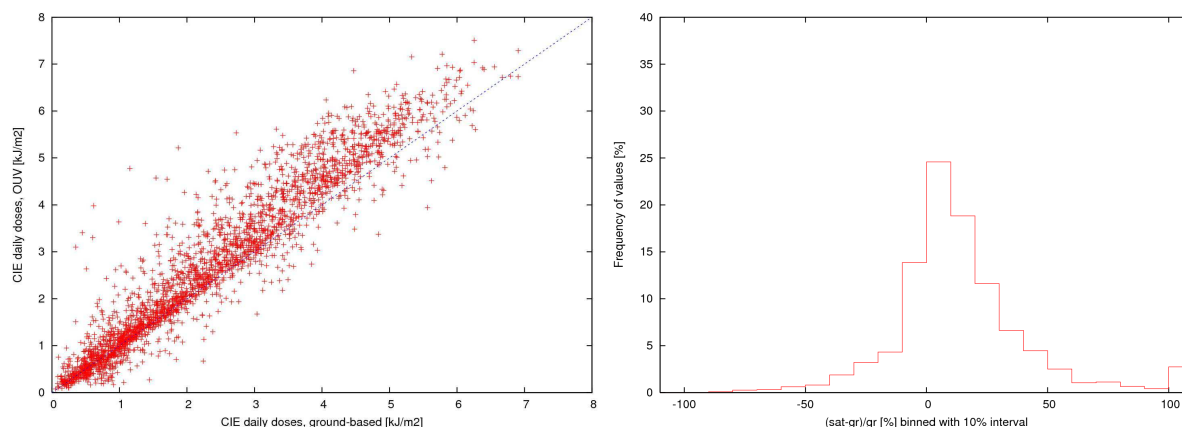


Figure 7. CIE daily doses scatter plot of for all stations, OUV vs ground-based measurements. Histogram for percentual relative difference distribution ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10 % interval for all stations. McMurdo and Palmer were left out of both plots.

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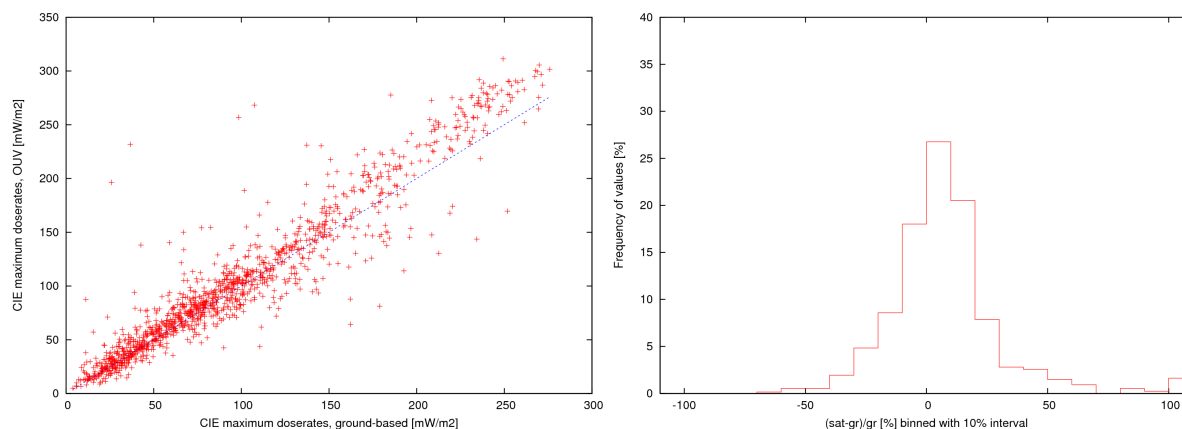


Figure 8. CIE daily maximum dose rates scatter plot of for all stations, OUV vs ground-based measurements. Histogram for percentual relative difference distribution ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily maximum dose rates binned with 10 % interval for all stations. McMurdo and Palmer were left out of both plots.

	CIE
Number of days	2591
OUV maximum, J/m <sup>2</sup>	7506
OUV minimum, J/m <sup>2</sup>	78
Ground maximum, J/m <sup>2</sup>	6908
Ground minimum, J/m <sup>2</sup>	53
Mean difference, J/m <sup>2</sup>	339
Mean relative difference, %	16,5
RMS error, J/m <sup>2</sup>	641
RMS relative, %	46,8

Table 3. Statistics for CIE daily dose comparison for all stations. McMurdo and Palmer were left out.

	CIE
Number of days	1282
OUV maximum, mW/m <sup>2</sup>	311
OUV minimum, mW/m <sup>2</sup>	0
Ground maximum, mW/m <sup>2</sup>	276
Ground minimum, mW/m <sup>2</sup>	4
Mean difference, mW/m <sup>2</sup>	6
Mean relative difference, %	9,6
RMS error, mW/m <sup>2</sup>	22
RMS relative, %	41,0

Table 4. Statistics for CIE daily maximum dose rate comparison in Barrow, Jokioinen, San Diego, Sodankylä, Summit, Thessaloniki and Ushuaia. McMurdo and Palmer were left out.

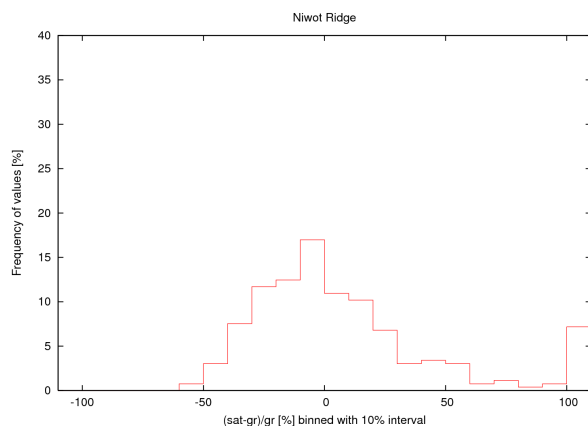
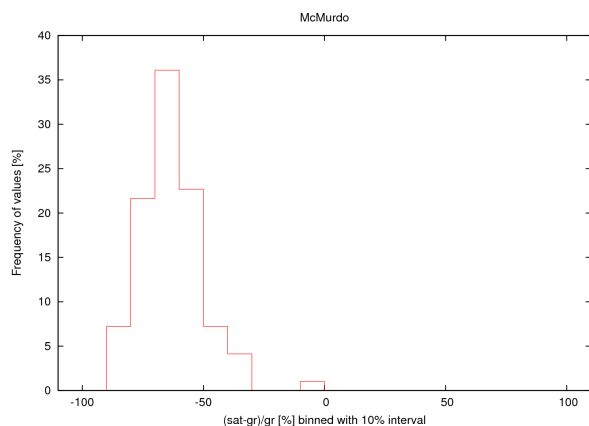
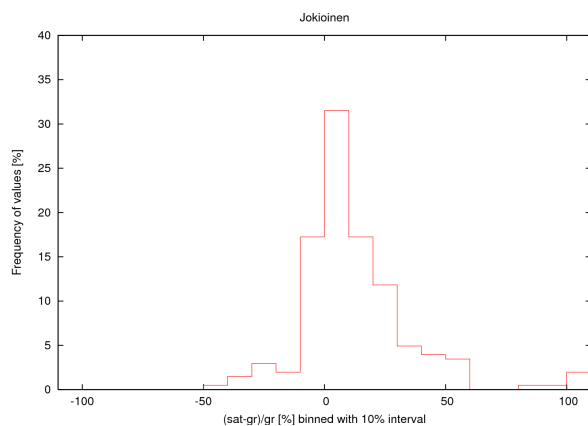
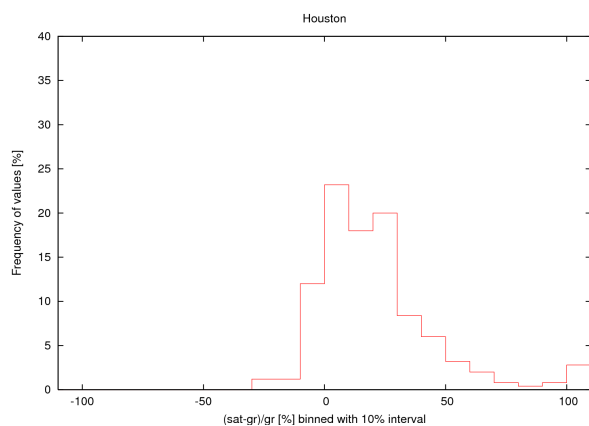
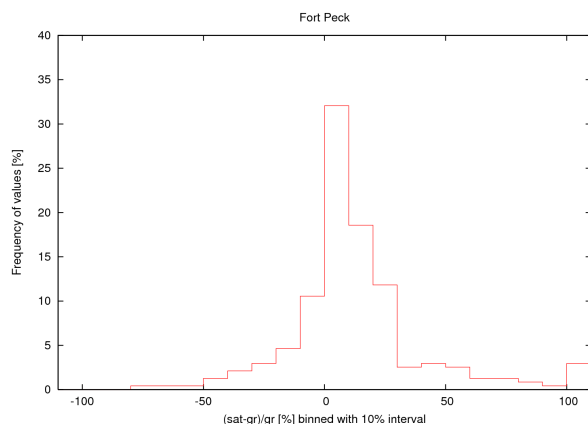
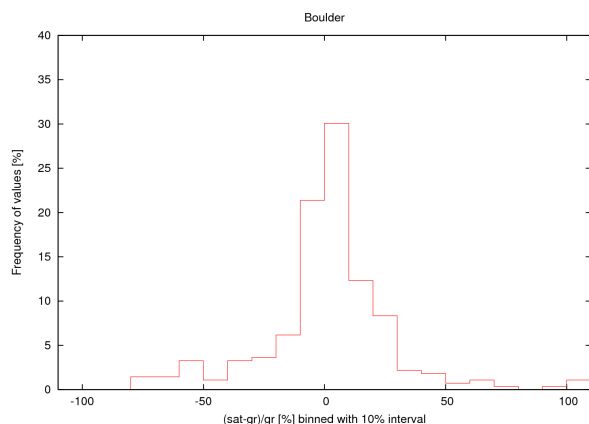
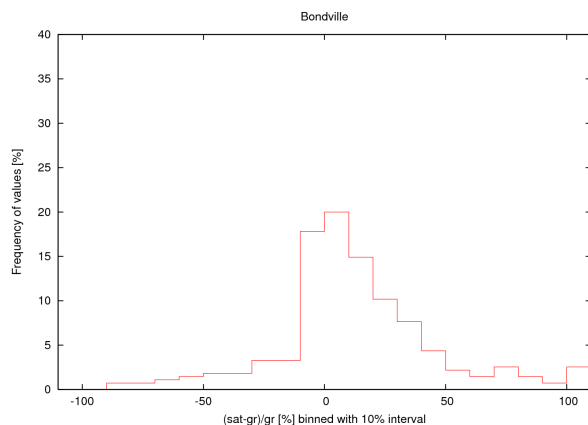
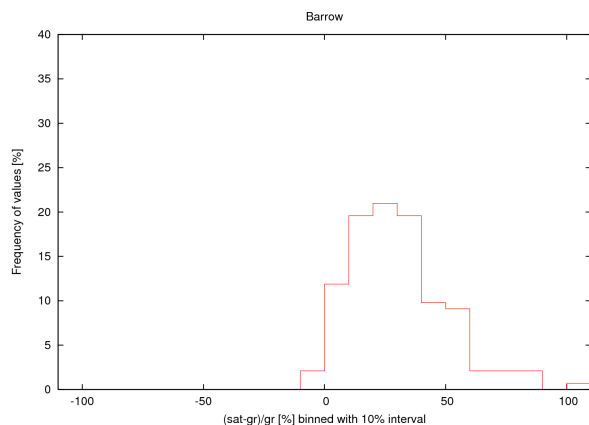


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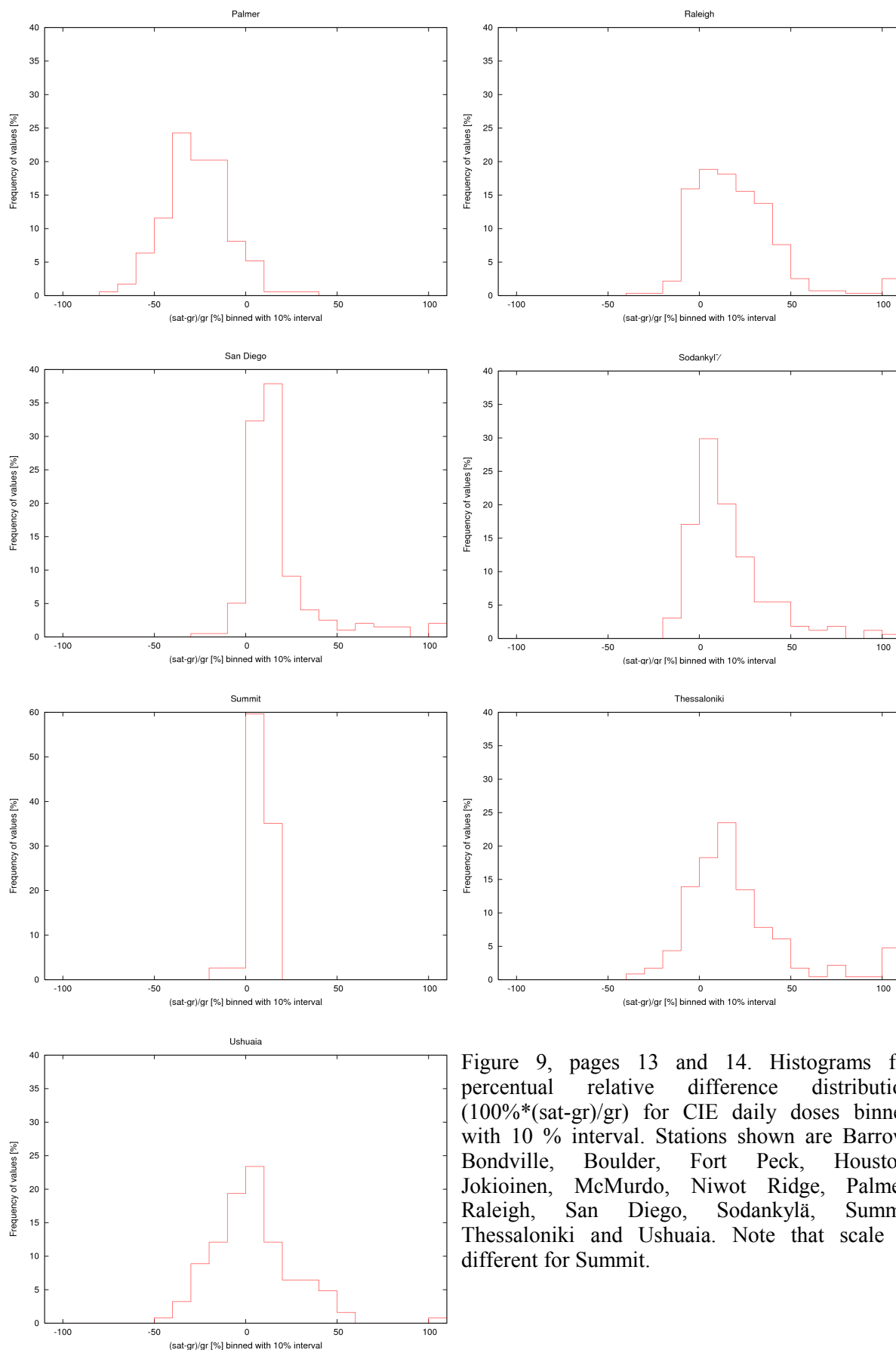
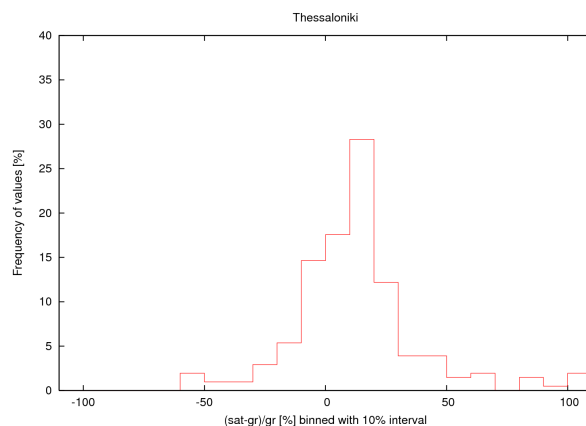
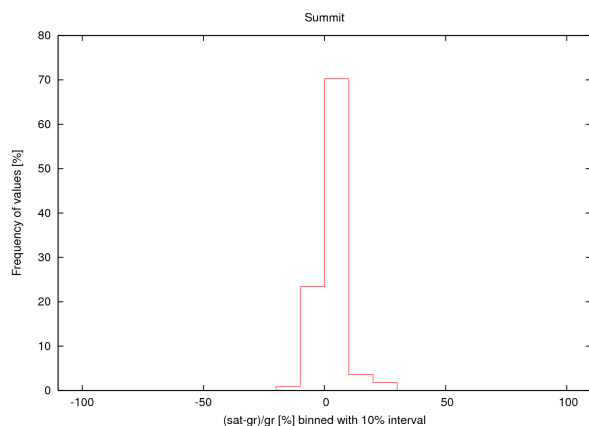
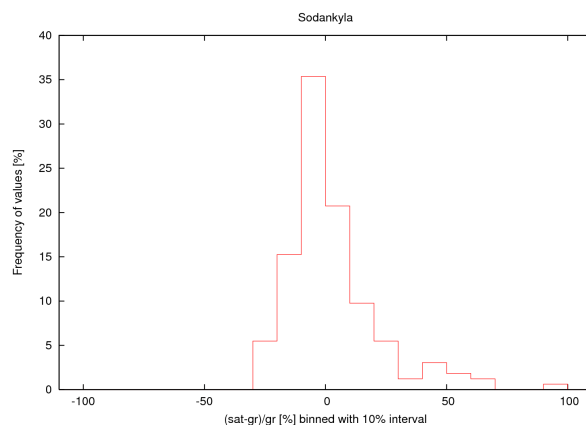
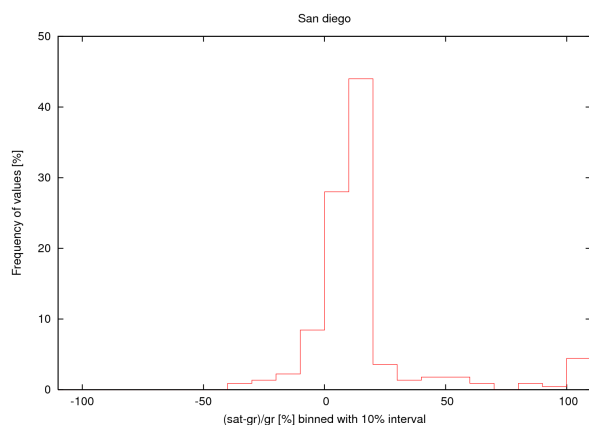
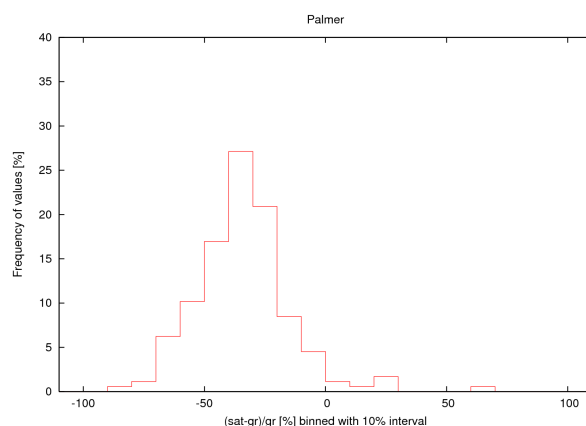
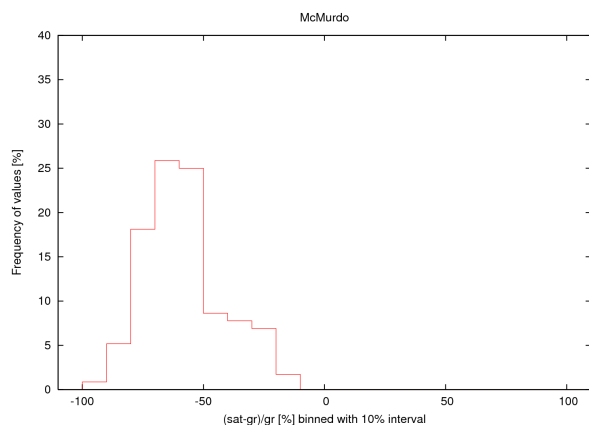
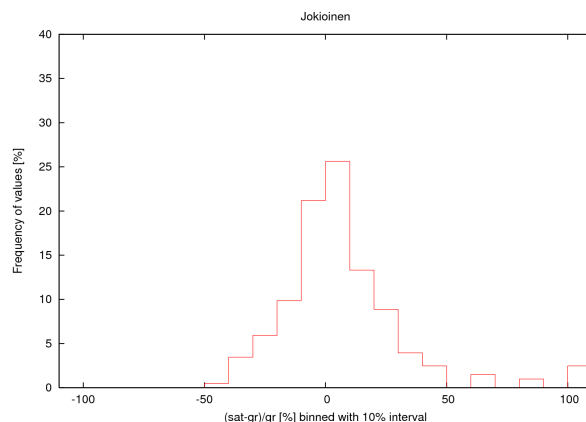
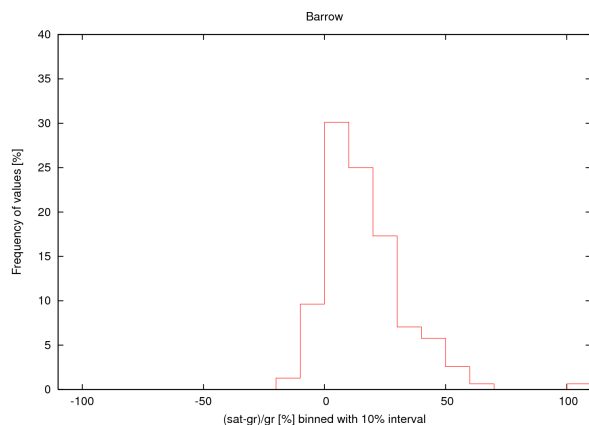


Figure 9, pages 13 and 14. Histograms for percentual relative difference distribution  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily doses binned with 10 % interval. Stations shown are Barrow, Bondville, Boulder, Fort Peck, Houston, Jokioinen, McMurdo, Niwot Ridge, Palmer, Raleigh, San Diego, Sodankylä, Summit, Thessaloniki and Ushuaia. Note that scale is different for Summit.



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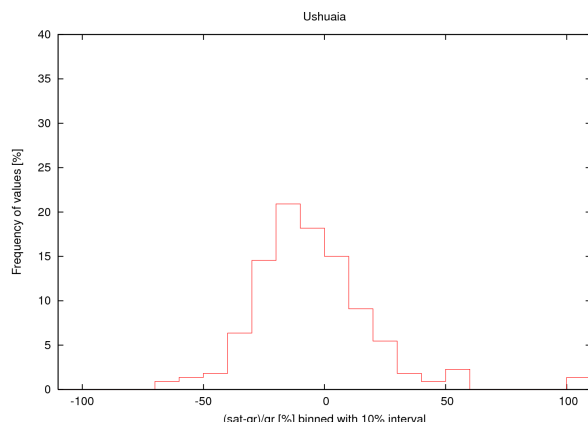


Figure 10, pages 15 and 16. Histograms for percentual relative difference distribution ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily maximum dose rates binned with 10 % interval. Stations shown are Barrow, Jokioinen, McMurdo, Palmer, San Diego, Sodankylä, Summit, Thessaloniki and Ushuaia. Note that the scale is different in the cases of San Diego and Summit.

## 3.2 Comparison with OMUVB

Because of good spatial coverage of both GOME-2 and OMI, comparisons between OUV and OMUVB are best visualized as a map showing differences between these two products. Relative difference between OUV and OMUVB daily dose product fields for 12 May 2008 is shown in figure 11. The map shows that the agreement between two products is generally good although areas of fairly large biases, both positive and negative, can also be seen. Many of these areas probably result from the difference in cloud correction used in the algorithms.

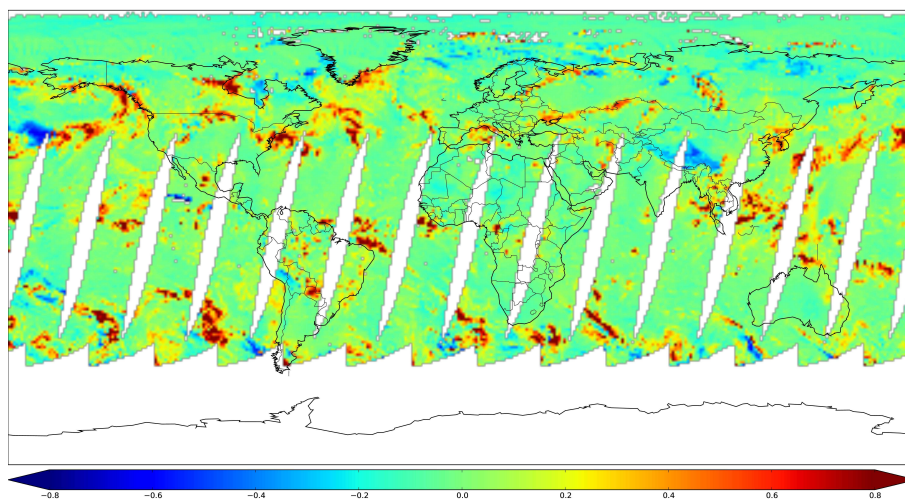


Figure 11. Example map of relative difference between OUV and OMUVB CIE daily doses (  $(\text{OUV} - \text{OMUVB})/\text{OMUVB}$  ) for 12 May 2008.

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Figure 12 shows a comparison between OUV and OMUVB erythemal daily doses co-located at the fifteen ground stations used in the validation. The agreement is generally good with OMUVB slightly larger than OUV. However, several stations, such as Boulder, McMurdo and Niwot Ridge, show much larger biases. Scatter plots for individual stations can be found in appendix A. Statistics of this comparison are shown in table 5. Mean difference between OUV and OMUVB daily doses is -283 J/m<sup>2</sup>, or -7.4 %. RMS error is 707 J/m<sup>2</sup> and RMS relative error is 33.3 %.

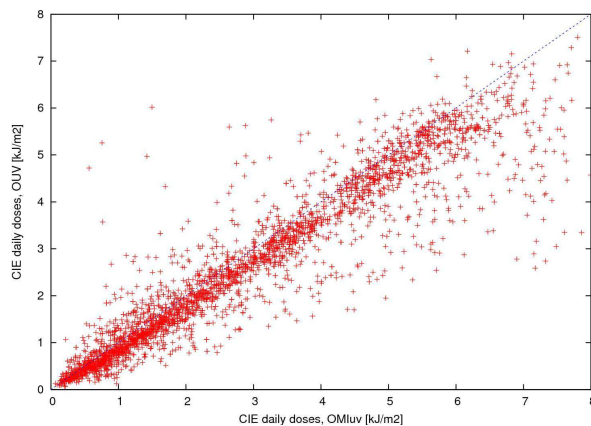


Figure 12. Scatter plot of CIE daily doses for 15 stations used in validation, OUV vs OMUVB.

All stations/OMI	CIE
Number of days	3220
OUV maximum, J/m <sup>2</sup>	70.6
OUV minimum, J/m <sup>2</sup>	69
Ground maximum, J/m <sup>2</sup>	7996
Ground minimum, J/m <sup>2</sup>	68
Mean difference, J/m <sup>2</sup>	-283
Mean relative difference, %	-7.4
RMS error, J/m <sup>2</sup>	707
RMS relative, %	33.3

Table 5. Statistics for CIE daily dose comparison between OUV and OMUVB products for all stations.

<p><b><i>O3M SAF CDOP</i></b></p>	<p><b>O3M SAF OUV Validation</b></p>	<p>REF : SAF/O3M/FMI/VR/OUV/091  ISSUE : 1/2009    DATE : 13.02.2009  PAGE : 18 of 58</p>
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#### 4. Conclusions

Comparisons generally show good agreement between OUV product and ground-based data as well as between OUV and OMUVB. With the exception of McMurdo and Palmer, OUV product generally overestimates the surface measurements. OMUVB product, on the other hand, is generally larger than OUV product. Mean relative error is 16.5 % for CIE daily doses and 9.6 % for CIE daily maximum dose rates. Both achieve the target accuracy of 20 %.

Some stations remain problematic, however. Surface albedo is the most likely problem in McMurdo and Palmer. These two sites are located in the areas marked with inhomogeneous terrain flag in the product. Larger biases at sites like Houston and Thessaloniki could be related to aerosols.

Comparison with ground-based data will be repeated as final ground-based data become available to replace the preliminary data used here.

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## 5. Appendix A: Ground stations and plots

### 5.1 Barrow, USA (71°19' N, 156°41' W)

Intrumentation: SUV-100

The Barrow installation is located on the north slope of Alaska at the edge of the Arctic Ocean near the city of Barrow. The instrument is deployed in the UIC-NARL (Ukpeagvik Inupiat Corporation/ [formerly] Naval Arctic Research Laboratory) facility.

The Barrow system is the most autonomously operating SUV-100 in the network. Normal calibrations and instrument maintenance are conducted by personnel from the nearby NOAA/CMDL facility. Data download is performed via the Internet. [RD7]

Barrow	CIE	DNA	Plant
Number of days	143	143	143
OUV maximum, J/m <sup>2</sup>	3599	1324	3641
OUV minimum, J/m <sup>2</sup>	492	69	134
Ground maximum, J/m <sup>2</sup>	3072	1072	3177
Ground minimum, J/m <sup>2</sup>	303	49	129
Mean difference, J/m <sup>2</sup>	461	206	458
Mean relative difference, %	30,8	50,7	35,5
RMS error, J/m <sup>2</sup>	556	242	560
RMS relative, %	37,1	56,8	42,9

Table A1. Statistics for daily dose measurements in Barrow. Statistics were available for CIE erythemal, Setlow DNA damage and Caldwell Plant response action spectra.

Barrow	CIE	DNA	Plant
Number of days	156	156	156
OUV maximum, mW/m <sup>2</sup>	118	51	140
OUV minimum, mW/m <sup>2</sup>	21	3	7
Ground maximum, mW/m <sup>2</sup>	114	48	131
Ground minimum, mW/m <sup>2</sup>	20	3	7
Mean difference, mW/m <sup>2</sup>	9	4	11
Mean relative difference, %	16,5	23,9	20,0
RMS error, mW/m <sup>2</sup>	13	6	16
RMS relative, %	23,2	31,8	27,5

Table A2. Statistics for daily maximum dose rate measurements in Barrow. Statistics were available for CIE erythemal, Setlow DNA damage and Caldwell Plant response action spectra.

<b>O3M SAF CDOP</b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 20 of 58
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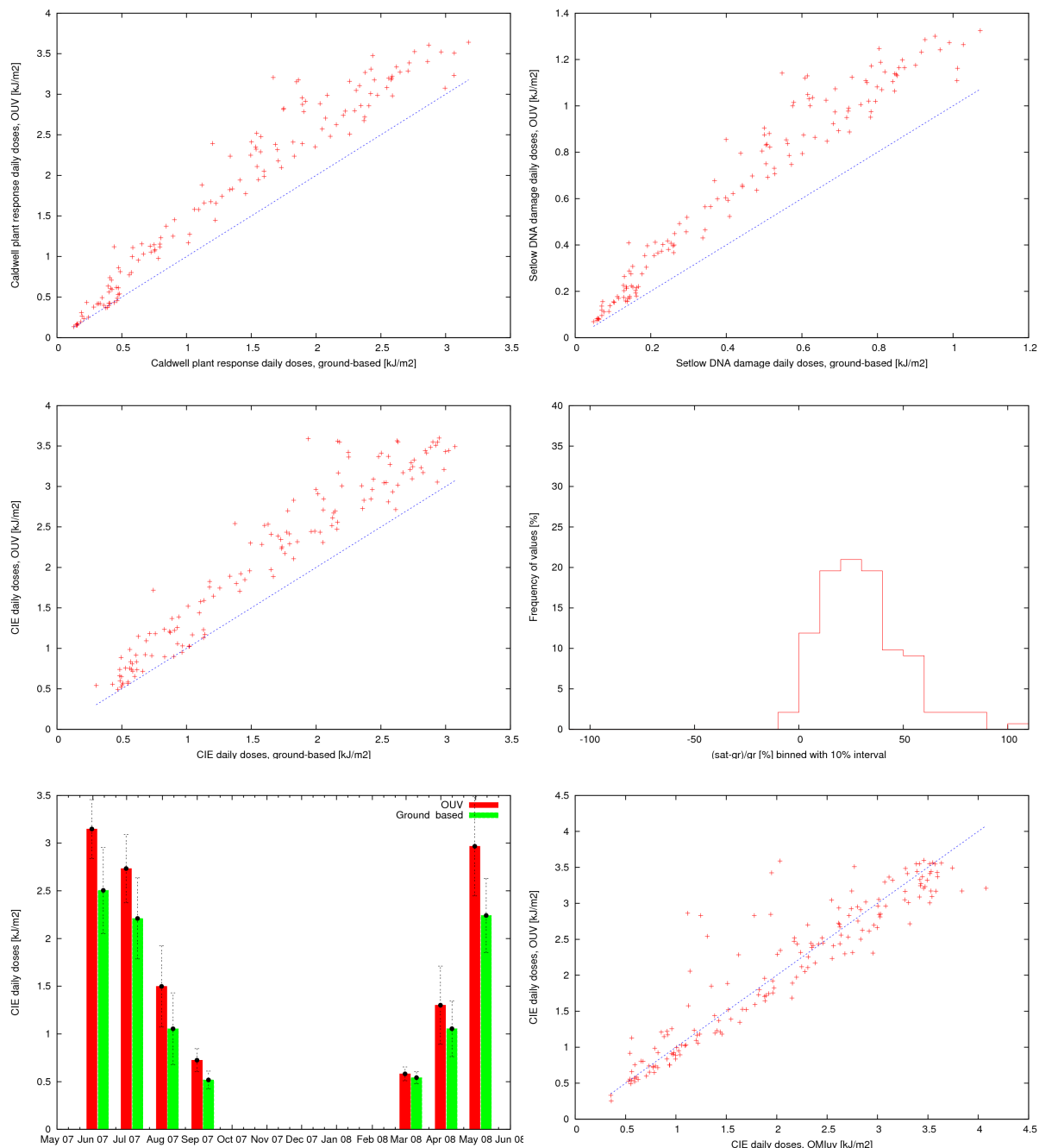


Figure A1. Barrow daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythral, Setlow DNA action and Caldwell Plant response. Histogram at center right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. scatter-plot at the bottom right shows OUV vs OMIuv comparison for Barrow.



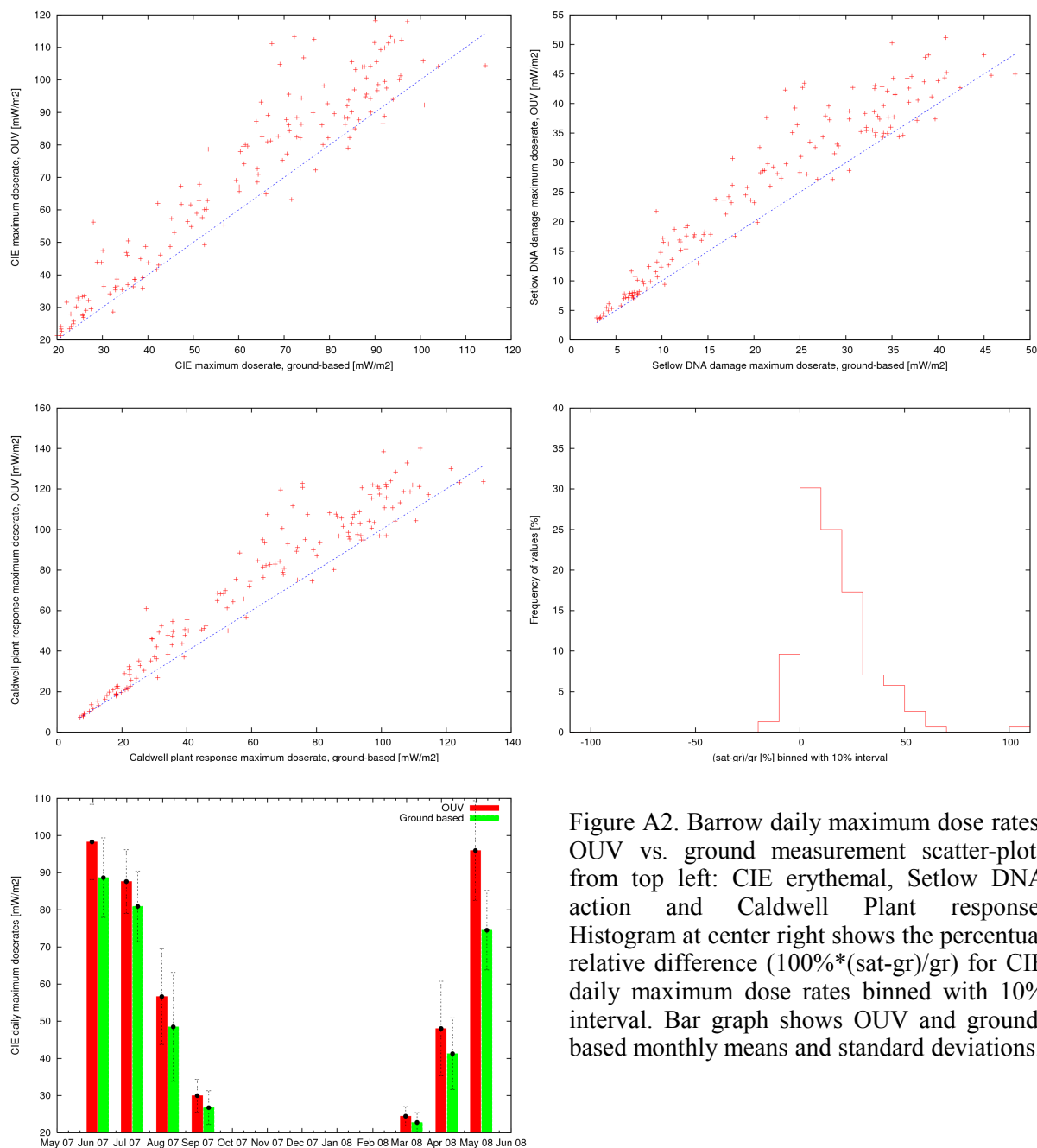


Figure A2. Barrow daily maximum dose rates. OUV vs. ground measurement scatter-plots from top left: CIE erythema, Setlow DNA action and Caldwell Plant response. Histogram at center right shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily maximum dose rates binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations.

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## 5.2 BEARS-Site Bondville, USA (40°03' N, 88°22' W)

Instrumentation: Brewer MkIV

Station is located in Bondsville, Illinois and operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew)

Bondville	CIE
Number of days	275
OUV maximum, J/m <sup>2</sup>	6188
OUV minimum, J/m <sup>2</sup>	106
Ground maximum, J/m <sup>2</sup>	5501
Ground minimum, J/m <sup>2</sup>	84
Mean difference, J/m <sup>2</sup>	313
Mean relative difference, %	13,5
RMS error, J/m <sup>2</sup>	649
RMS relative, %	38,2

Table A3. Statistics for CIE erythral daily dose measurements in Bondville.

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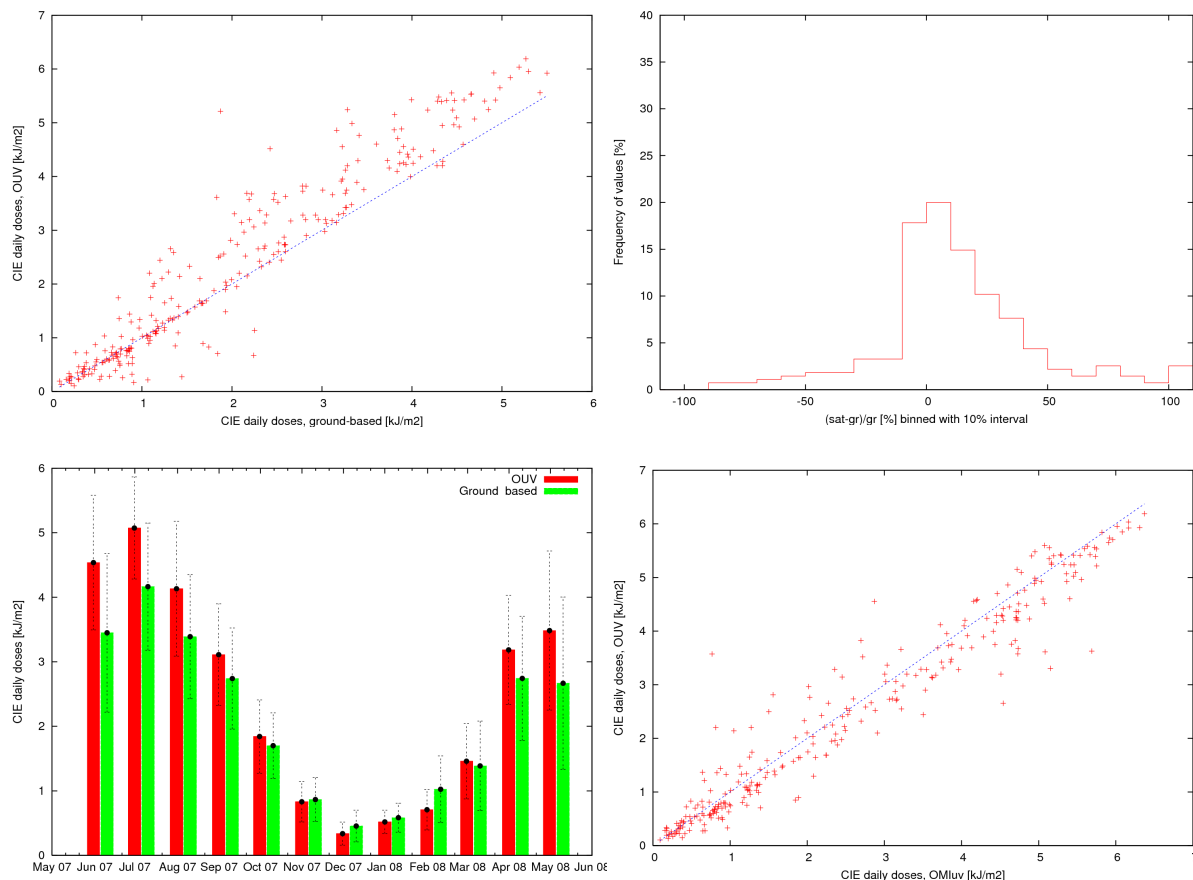


Figure A3. Bondville CIE Erythemat daily doses. At top left OUV vs. ground measurement scatter-plot. Histogram at top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Bondville.

<b><i>O3M SAF CDOP</i></b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 24 of 58
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### 5.3 Table Mountain Test Facility, USA (40°08' N, 105°14' W)

Instrumentation: Brewer MkIV

Station is located in Boulder, Colorado and operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew)

Boulder	CIE
Number of days	276
OUV maximum, J/m <sup>2</sup>	7212
OUV minimum, J/m <sup>2</sup>	125
Ground maximum, J/m <sup>2</sup>	6380
Ground minimum, J/m <sup>2</sup>	220
Mean difference, J/m <sup>2</sup>	209
Mean relative difference, %	4,3
RMS error, J/m <sup>2</sup>	594
RMS relative, %	49,9

Table A4. Statistics for CIE erythral daily dose measurements in Boulder.

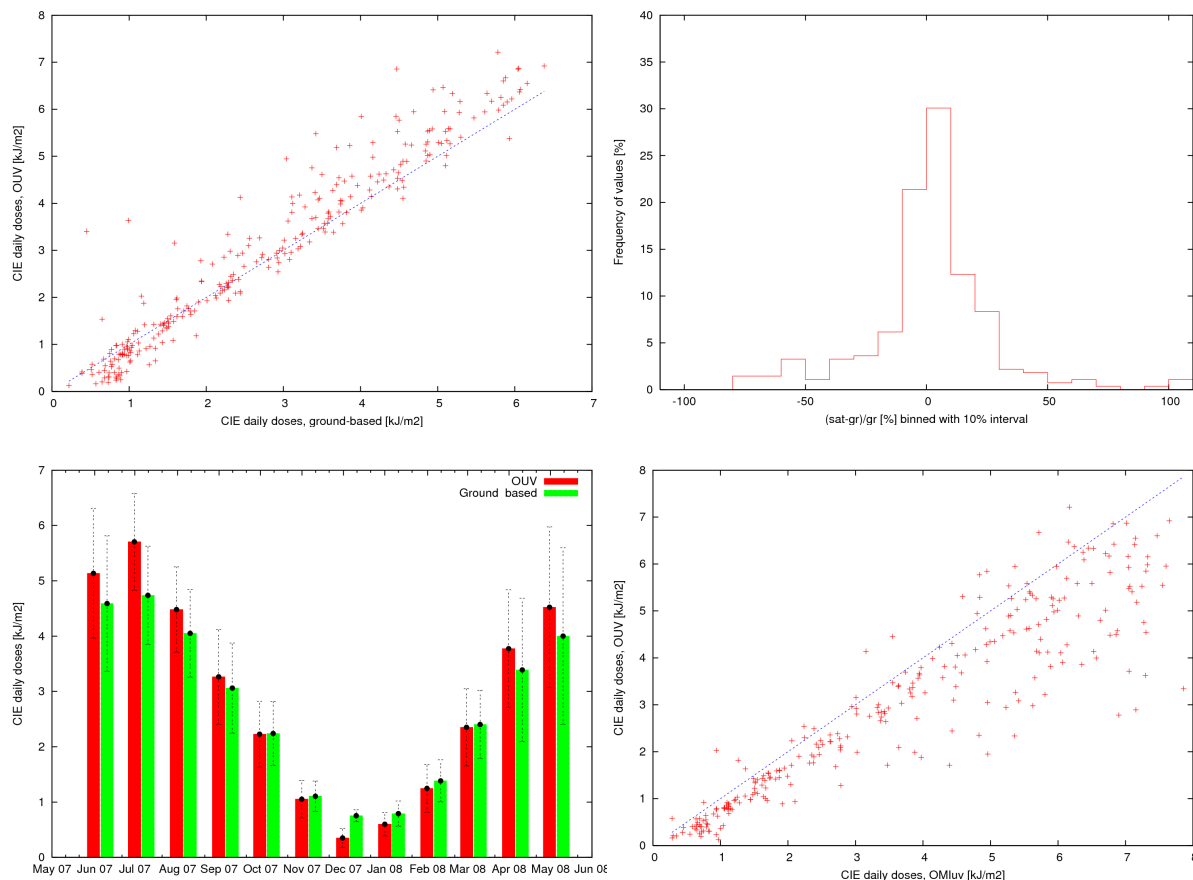


Figure A4. Boulder CIE Erythral daily doses. At top left OUV vs. ground measurement scatter-plot. Histogram at top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Boulder.

<b><i>O3M SAF CDOP</i></b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 26 of 58
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#### 5.4 Fort Peck, USA (48°18' N, 105°06' W)

Instrumentation: Brewer MkIV

Station is located in Fort Peck, USA and operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew)

Fort Peck	CIE
Number of days	237
OUV maximum, J/m <sup>2</sup>	6246
OUV minimum, J/m <sup>2</sup>	100
Ground maximum, J/m <sup>2</sup>	5744
Ground minimum, J/m <sup>2</sup>	144
Mean difference, J/m <sup>2</sup>	340
Mean relative difference, %	14,8
RMS error, J/m <sup>2</sup>	639
RMS relative, %	40,5

Table A5. Statistics for CIE erythral daily dose measurements in Fort Peck.

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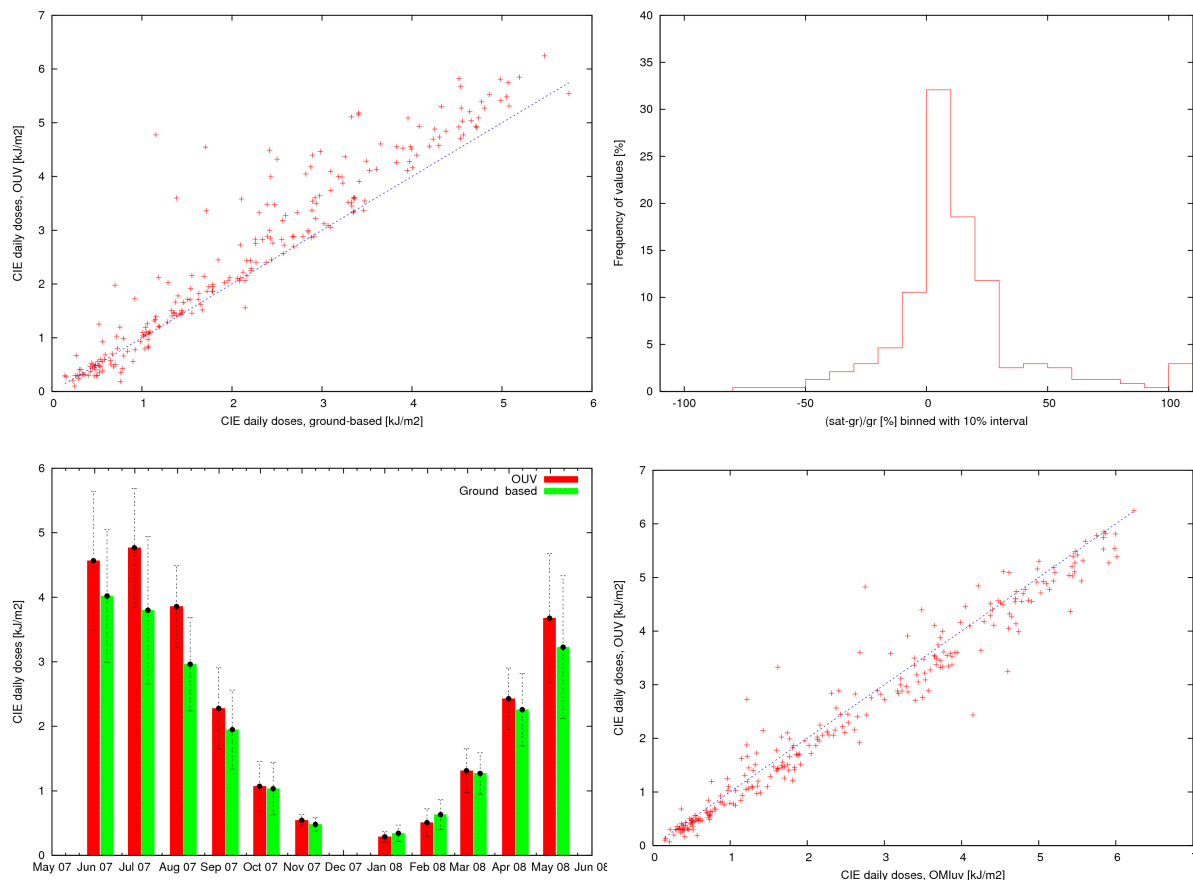


Figure A5. Fort Peck CIE Erythral daily doses. At top left OUV vs. ground measurement scatter-plot. Histogram at top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Fort Peck.

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### 5.5 University of Houston, USA (29°43' N, 95°20' W)

Instrumentation: Brewer MkIV

Station is located in Houston, Texas and operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew)

Houston	CIE
Number of days	250
OUV maximum, J/m <sup>2</sup>	6567
OUV minimum, J/m <sup>2</sup>	604
Ground maximum, J/m <sup>2</sup>	5840
Ground minimum, J/m <sup>2</sup>	539
Mean difference, J/m <sup>2</sup>	565
Mean relative difference, %	22,1
RMS error, J/m <sup>2</sup>	797
RMS relative, %	35,5

Table A6. Statistics for CIE erythral daily dose measurements in Houston.



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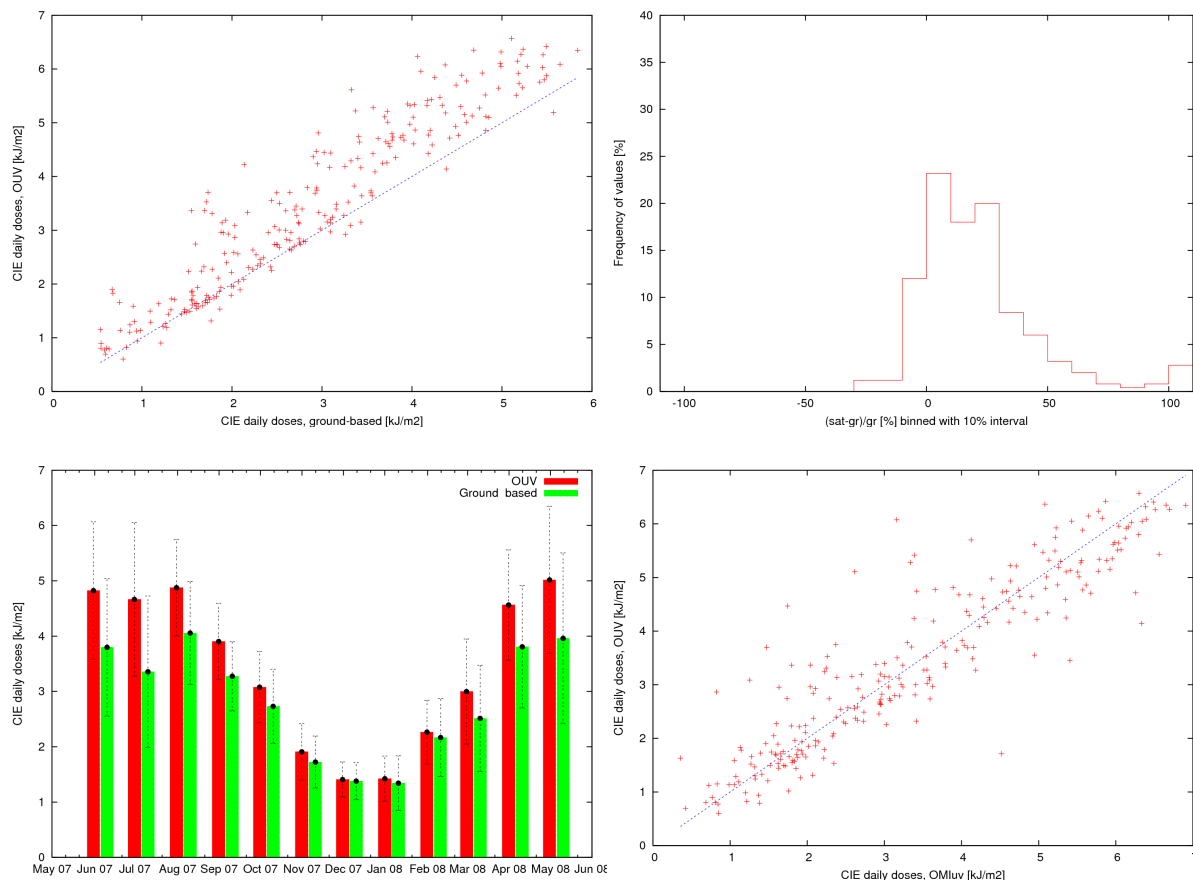


Figure A6. Houston CIE Erythral daily doses. At top left OUV vs. ground measurement scatter-plot. Histogram at top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Houston.

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## 5.6 Jokioinen, Finland (60°49' N, 23°30' E)

Instrumentation: Brewer Mk-III

FMI observatory in Jokioinen is located in rural area in Southern Finland. The immediate surroundings of the station are rural agricultural area dotted with small areas of forest. Further away, area is mostly forest, with some urban areas. [RD6]

Jokioinen	CIE	DNA	Plant	Scup-h	UV-b	UV-a
Number of days	203	203	203	203	203	203
OUV maximum, J/m <sup>2</sup>	4002	1970	0.08	892.	30374	148732.
OUV minimum, J/m <sup>2</sup>	92	22	6.	181	6.6	08170
Ground maximum, J/m <sup>2</sup>	4008	1949	4694	88.3	30847	161040.
Ground minimum, J/m <sup>2</sup>	147	27	62	273	814	96474
Mean difference, J/m <sup>2</sup>	132	89	212	288	861	26933
Mean relative difference, %	13,8	21,1	19,7	14,0	13,4	8,6
RMS error, J/m <sup>2</sup>	240	127	314	020	1703	104481
RMS relative, %	31,6	38,0	38,2	32,1	32,0	27,0

Table A7. Statistics for daily dose measurements in Jokioinen. Statistics were available for CIE erythema, Setlow DNA damage, Caldwell Plant response and SCUP-h action spectra as well as UV-A and UV-B.

Jokioinen	CIE
Number of days	203
OUV maximum, mW/m <sup>2</sup>	157
OUV minimum, mW/m <sup>2</sup>	7
Ground maximum, mW/m <sup>2</sup>	149
Ground minimum, mW/m <sup>2</sup>	7
Mean difference, mW/m <sup>2</sup>	1
Mean relative difference, %	8,2
RMS error, mW/m <sup>2</sup>	12
RMS relative, %	32,8

Table A8. Statistics for daily dose measurements in Jokioinen. Statistics were only available for CIE erythema action spectrum.

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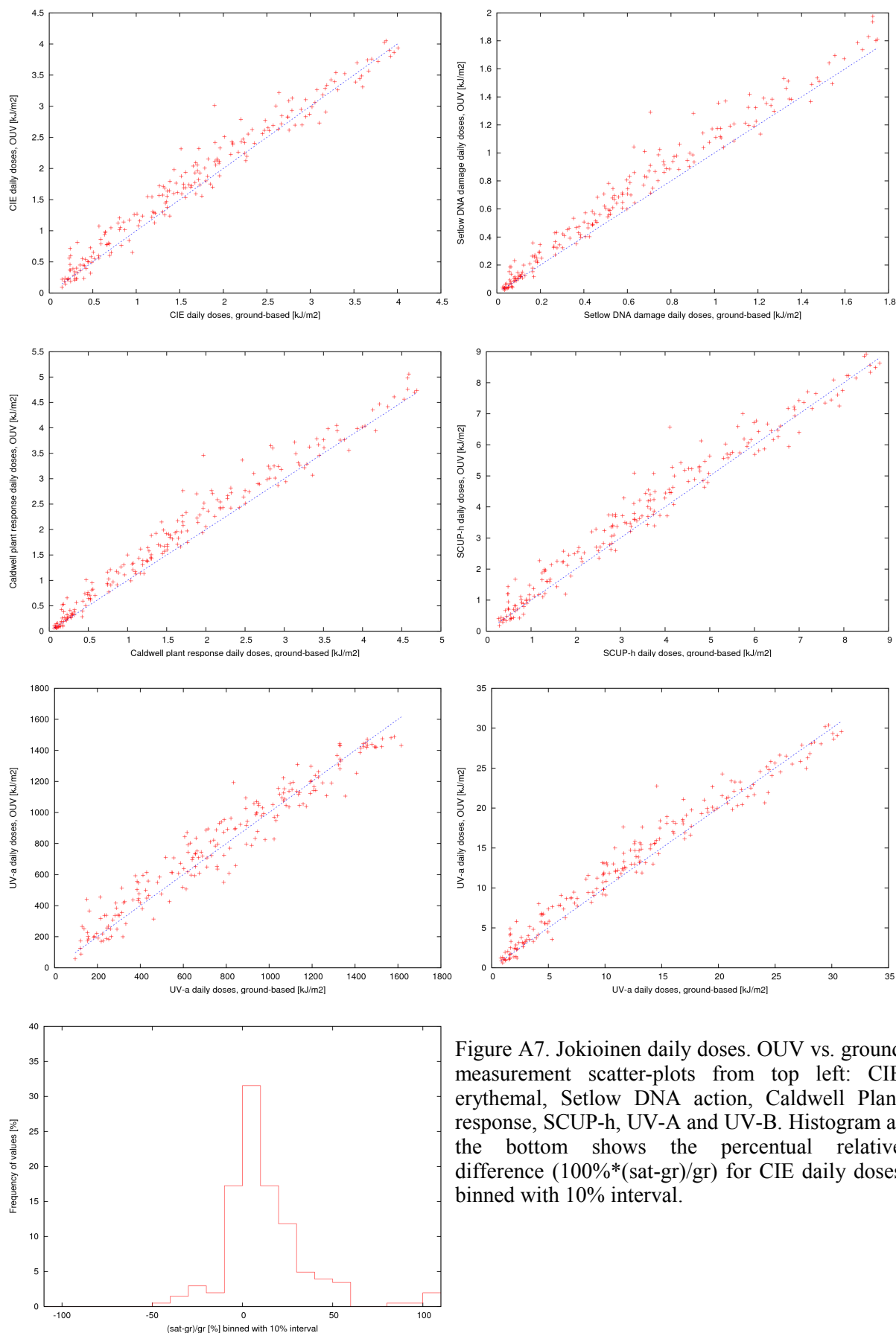


Figure A7. Jokioinen daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythemat, Setlow DNA action, Caldwell Plant response, SCUP-h, UV-A and UV-B. Histogram at the bottom shows the percentual relative difference (100%\*(sat-gr)/gr) for CIE daily doses binned with 10% interval.

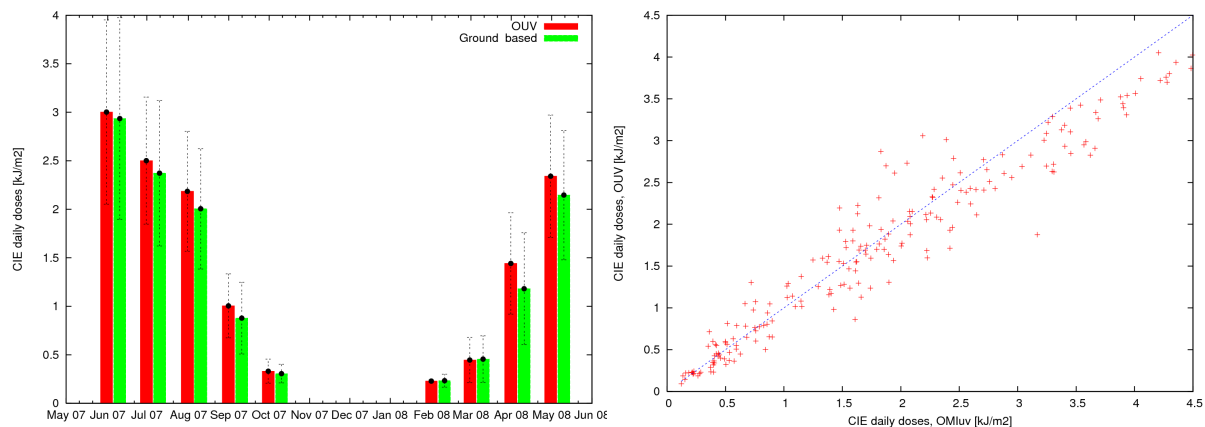


Figure A7 continued: Jokioinen CIE daily doses. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Jokioinen.

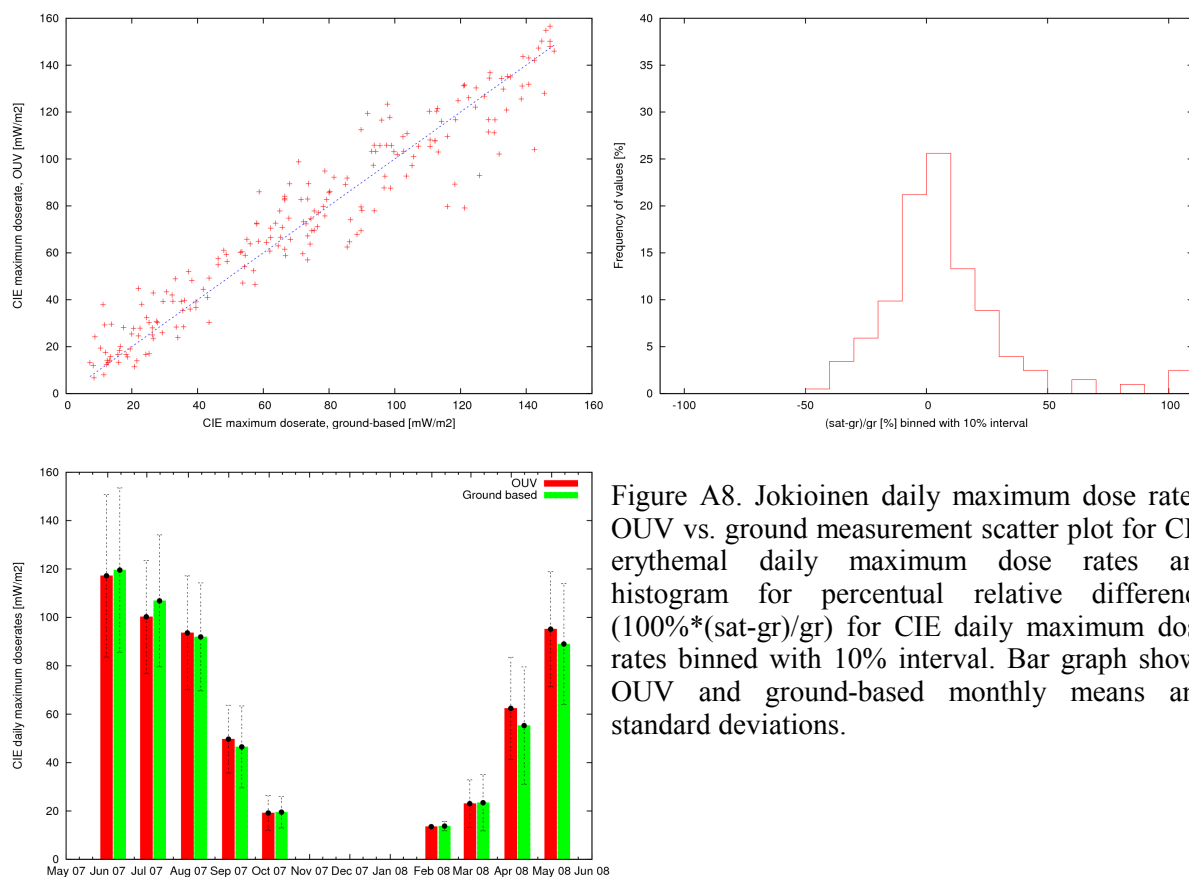


Figure A8. Jokioinen daily maximum dose rates. OUV vs. ground measurement scatter plot for CIE erythemat daily maximum dose rates and histogram for percentual relative difference  $100\% \cdot (\text{sat-gr})/\text{gr}$  for CIE daily maximum dose rates binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations.

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## 5.7 McMurdo, Antarctica (77°50' S, 166°40' E)

Instrumentation: SUV-100

McMurdo Station is located on the southern tip of Ross Island and has had a long history in Antarctic exploration. The research station is operated year-round, but is normally accessible only between October and February with the exception of a short series of flights in early September or late August ("WinFly").

The spectroradiometer system at McMurdo Station is located in the roof of the facility at Arrival Heights, in the hills above the main base. The instrument is inspected by research associates from Raytheon Polar Services every one to three days, weather permitting. Data are transferred automatically via the Internet. [RD7]

McMurdo	CIE	DNA
Number of days	97	97
OUV maximum, J/m <sup>2</sup>	24.9	1271
OUV minimum, J/m <sup>2</sup>	138	33
Ground maximum, J/m <sup>2</sup>	4911	2166
Ground minimum, J/m <sup>2</sup>	691	1.9
Mean difference, J/m <sup>2</sup>	-1896	-575
Mean relative difference, %	-63.0	-58.4
RMS error, J/m <sup>2</sup>	2.24	644
RMS relative, %	64.3	60.5

Table A9. Statistics for daily dose measurements in McMurdo. Statistics were available for CIE erythema and Setlow DNA damage action spectra.

McMurdo	CIE	DNA	Plant
Number of days	116	116	116
OUV maximum, mW/m <sup>2</sup>	98	59	140
OUV minimum, mW/m <sup>2</sup>	4	1	3
Ground maximum, mW/m <sup>2</sup>	144	81	195
Ground minimum, mW/m <sup>2</sup>	30	7	20
Mean difference, mW/m <sup>2</sup>	-49	-20	-54
Mean relative difference, %	-57.6	-56.2	-56.9
RMS error, mW/m <sup>2</sup>	53	23	62
RMS relative, %	59.8	58.9	59.4

Table A10 Statistics for daily maximum dose rate measurements in McMurdo. Statistics were available for CIE erythema, Setlow DNA damage and Caldwell Plant response action spectra.

<b>O3M SAF CDOP</b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 34 of 58
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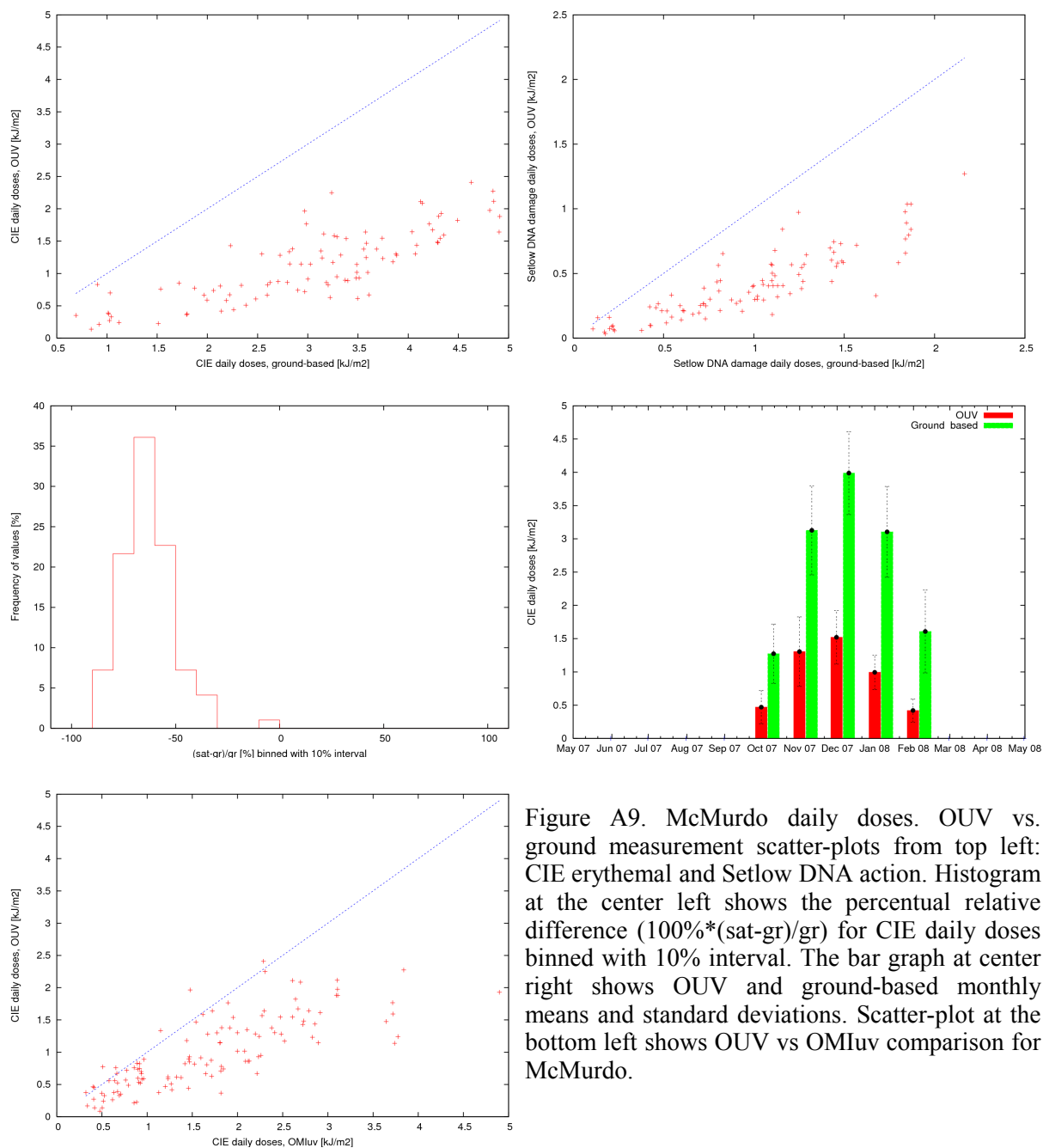


Figure A9. McMurdo daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythemal and Setlow DNA action. Histogram at the center left shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily doses binned with 10% interval. The bar graph at center right shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom left shows OUV vs OMIuv comparison for McMurdo.

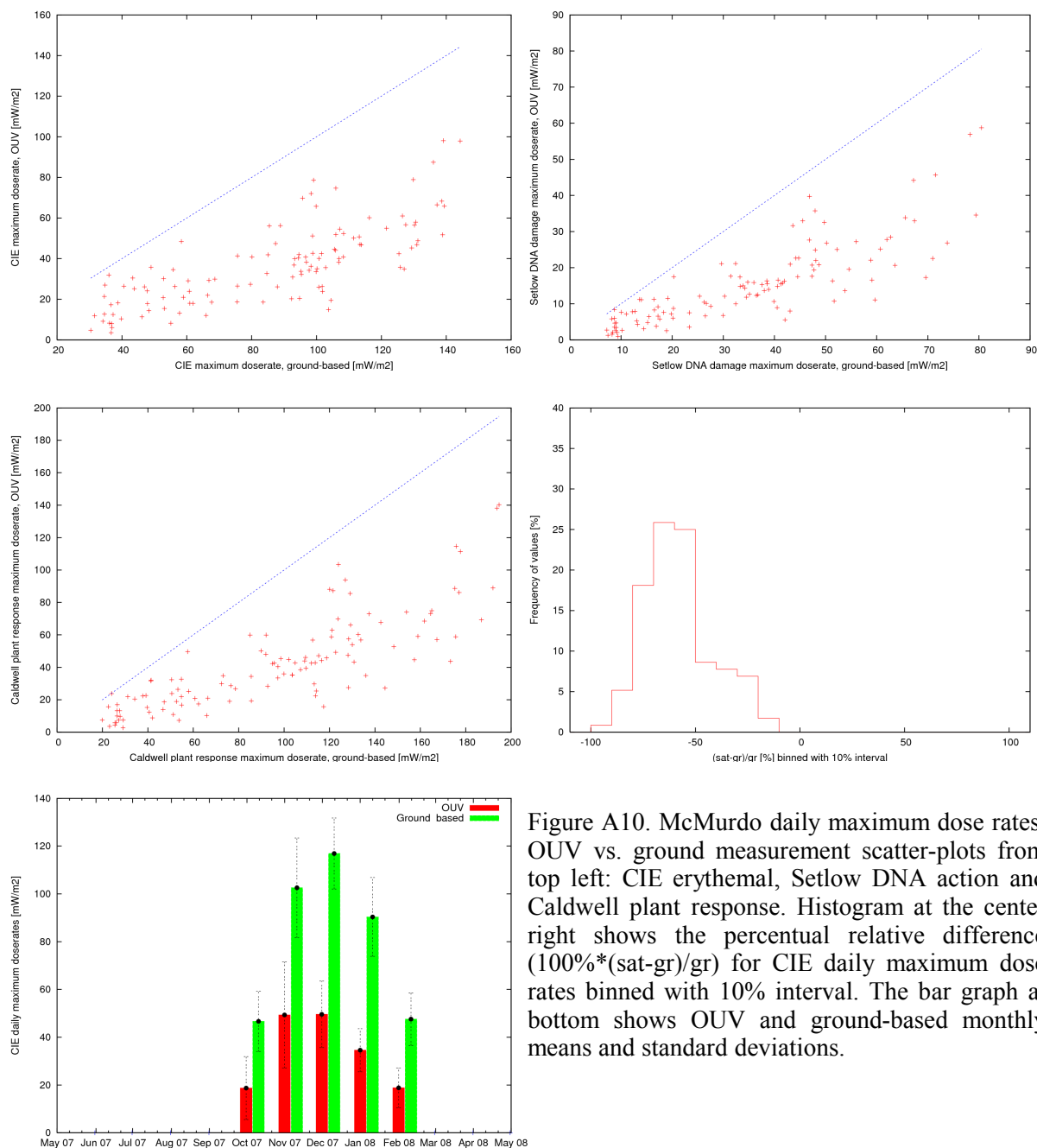


Figure A10. McMurdo daily maximum dose rates. OUV vs. ground measurement scatter-plots from top left: CIE erythemal, Setlow DNA action and Caldwell plant response. Histogram at the center right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily maximum dose rates binned with 10% interval. The bar graph at bottom shows OUV and ground-based monthly means and standard deviations.

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### 5.8 Mountain Research Station, USA (40°02' N, 105°32' W)

Instrumentation: Brewer MkIV

Station is located in Niwot Ridge, Colorado and operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew)

Niwot Ridge	CIE
Number of days	265
OUV maximum, J/m <sup>2</sup>	7506
OUV minimum, J/m <sup>2</sup>	289
Ground maximum, J/m <sup>2</sup>	6908
Ground minimum, J/m <sup>2</sup>	96
Mean difference, J/m <sup>2</sup>	164
Mean relative difference, %	19,4
RMS error, J/m <sup>2</sup>	814
RMS relative, %	91,5

Table A11. Statistics for CIE erythemat daily dose measurements in Niwot Ridge.



<b>O3M SAF CDOP</b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 37 of 58
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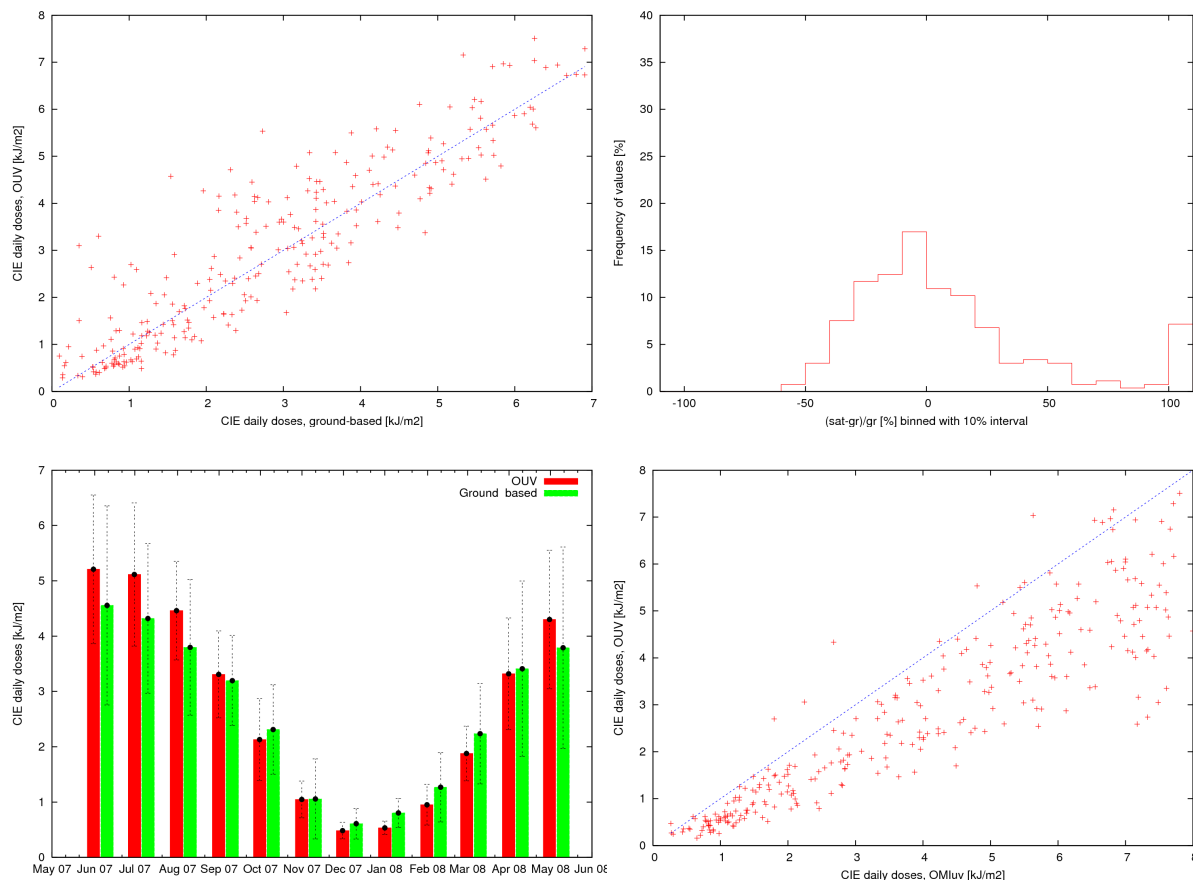


Figure A11 Niwot Ridge CIE Erythral daily doses. At top left OUV vs. ground measurement scatter-plot. Histogram at top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Niwot Ridge.

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## 5.9 Palmer, Antarctica (64°46' S, 64°03' W)

Instrumentation: SUV-100

Palmer Station, established by the United States in 1965, is located on Anvers Island, slightly outside the Antarctic Circle. The station is manned year-round and has diverse flora and fauna. Various experiments, primarily related to biological sciences, take advantage of the laboratory and field facilities. The station is normally only accessible by ice-strengthened boat at intervals of approximately one month.

The SUV spectroradiometer system at Palmer Station was originally installed in the roof of the vestibule of the Clean Air Building in May 1988, but was relocated to Building T-5 in March 1993. In May 2006, it was relocated to the new TerraLab building, which replaces T-5. The instrument is operated by research associates from Raytheon Polar Services under contract to NSF. Data are transferred automatically via the Internet. [RD7]

Palmer	CIE	DNA
Number of days	177	177
OUV maximum, J/m <sup>2</sup>	3.77	19.2
OUV minimum, J/m <sup>2</sup>	12.0	30
Ground maximum, J/m <sup>2</sup>	0.264	31.2
Ground minimum, J/m <sup>2</sup>	1.48	29
Mean difference, J/m <sup>2</sup>	-0.00	-177
Mean relative difference, %	-26.0	-19.3
RMS error, J/m <sup>2</sup>	702	279
RMS relative, %	31.7	28.0

Table A12. Statistics for daily dose measurements in Palmer. Statistics were available for CIE erythral and Setlow DNA damage action spectra.

Palmer	CIE	DNA	Plant
Number of days	177	177	177
OUV maximum, mW/m <sup>2</sup>	135	104	210
OUV minimum, mW/m <sup>2</sup>	6	2	6
Ground maximum, mW/m <sup>2</sup>	227	153	343
Ground minimum, mW/m <sup>2</sup>	7	2	5
Mean difference, mW/m <sup>2</sup>	-33	-12	-40
Mean relative difference, %	-33.9	-26.4	-31.5
RMS error, mW/m <sup>2</sup>	41	18	52
RMS relative, %	39.2	36.7	39.1

Table A13. Statistics for daily maximum dose rate measurements in Palmer. Statistics were available for CIE erythral, Setlow DNA damage and Caldwell Plant response action spectra.

<b>O3M SAF CDOP</b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 39 of 58
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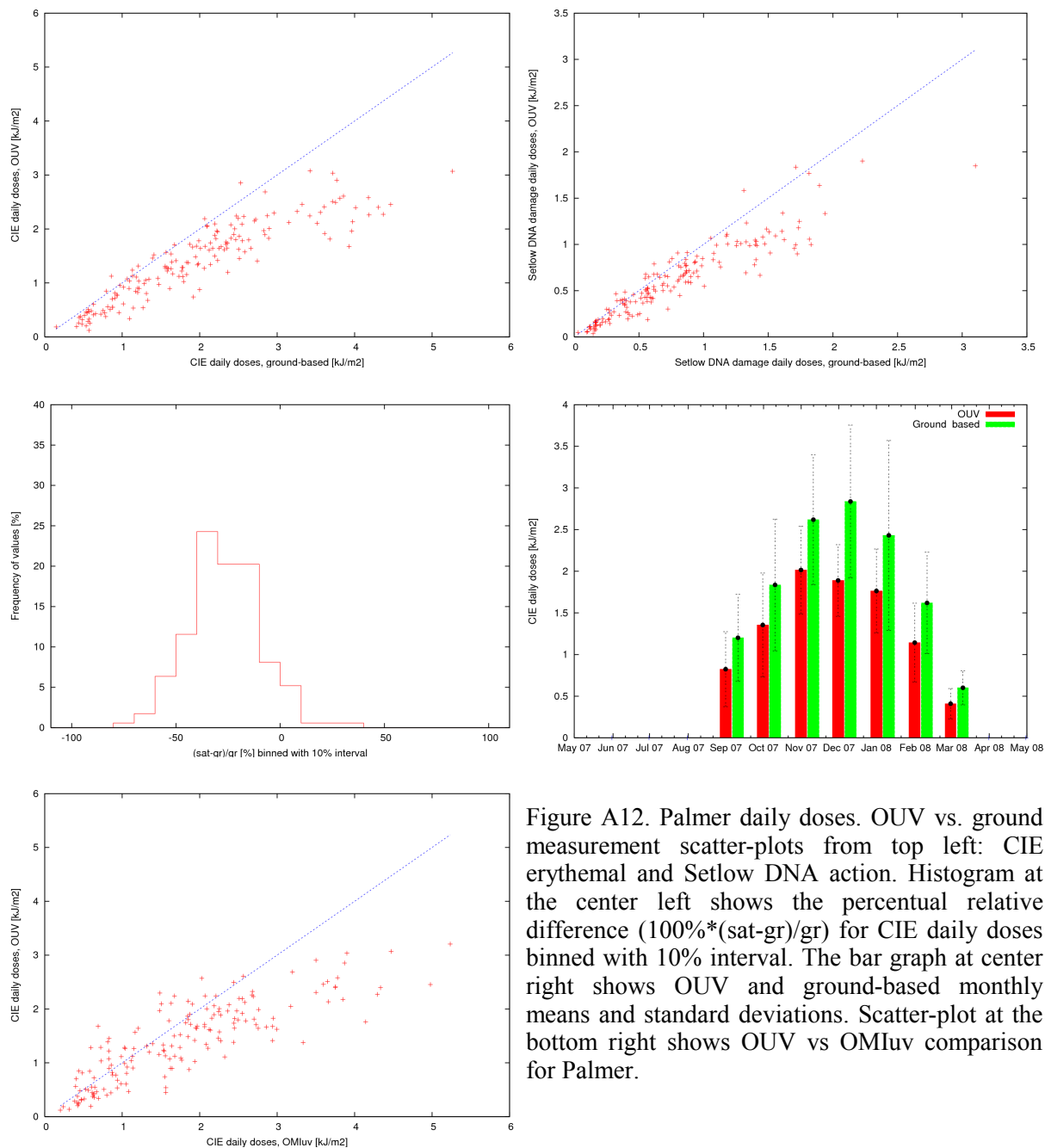


Figure A12. Palmer daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythemal and Setlow DNA action. Histogram at the center left shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily doses binned with 10% interval. The bar graph at center right shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Palmer.

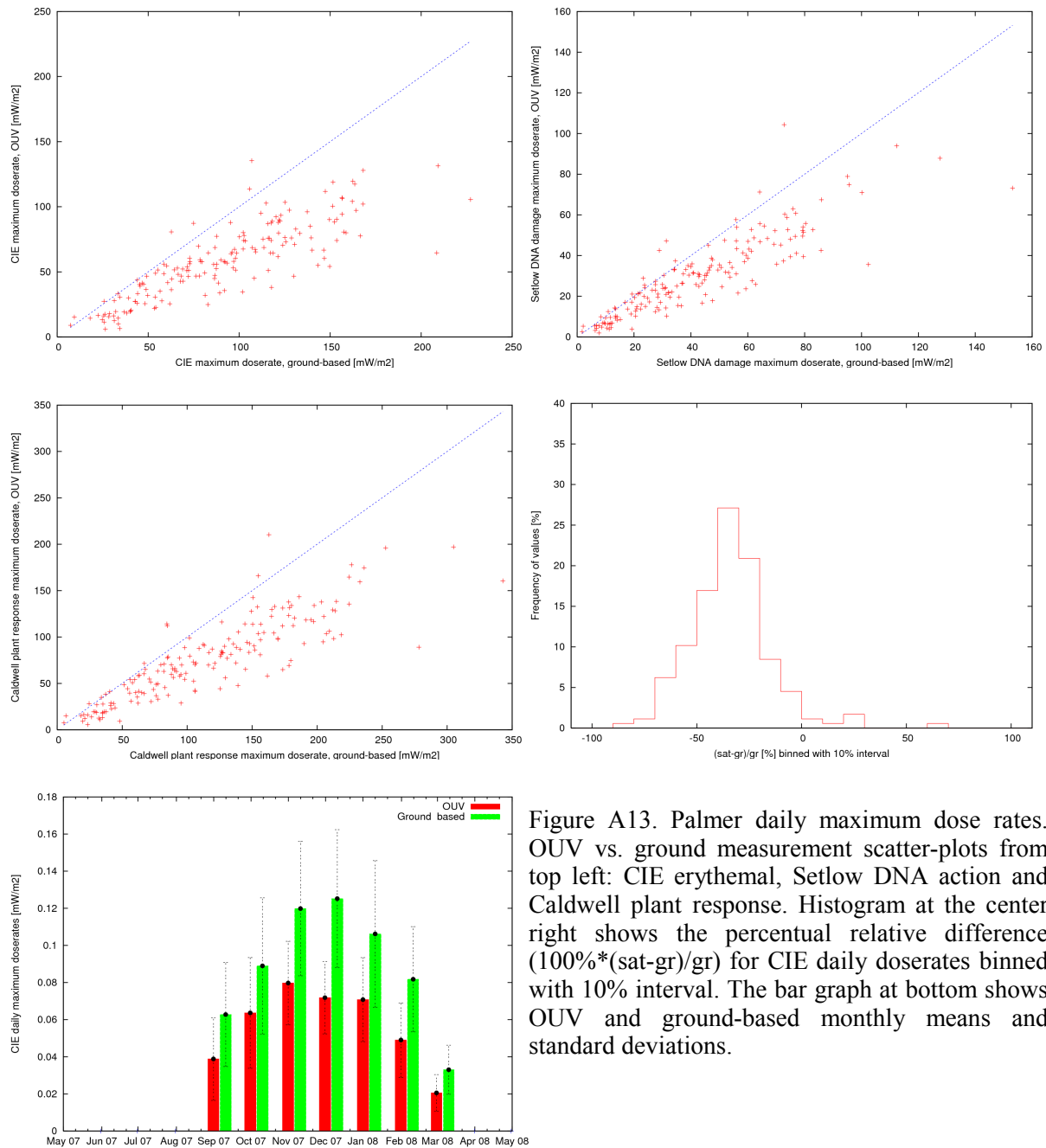


Figure A13. Palmer daily maximum dose rates. OUV vs. ground measurement scatter-plots from top left: CIE erythemal, Setlow DNA action and Caldwell plant response. Histogram at the center right shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily doserates binned with 10% interval. The bar graph at bottom shows OUV and ground-based monthly means and standard deviations.

<b><i>O3M SAF CDOP</i></b>	<b>O3M SAF OUV Validation</b>	REF : SAF/O3M/FMI/VR/OUV/091 ISSUE : 1/2009  DATE : 13.02.2009 PAGE : 41 of 58
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#### **5.10 Raleigh, USA (35°44' N, 78°41' W)**

Instrumentation: Brewer MkIV

Station is located in Raleigh, Nort Carolina and operated by NOAA-EPA Brewer Spectrophotometer UV and Ozone Network (NEUBrew)

Raleigh	CIE
Number of days	276
OUV maximum, J/m <sup>2</sup>	6176
OUV minimum, J/m <sup>2</sup>	288
Ground maximum, J/m <sup>2</sup>	5241
Ground minimum, J/m <sup>2</sup>	131
Mean difference, J/m <sup>2</sup>	554
Mean relative difference, %	20,5
RMS error, J/m <sup>2</sup>	784
RMS relative, %	32,3

Table A14. Statistics for CIE erythemat daily dose measurements in Raleigh.

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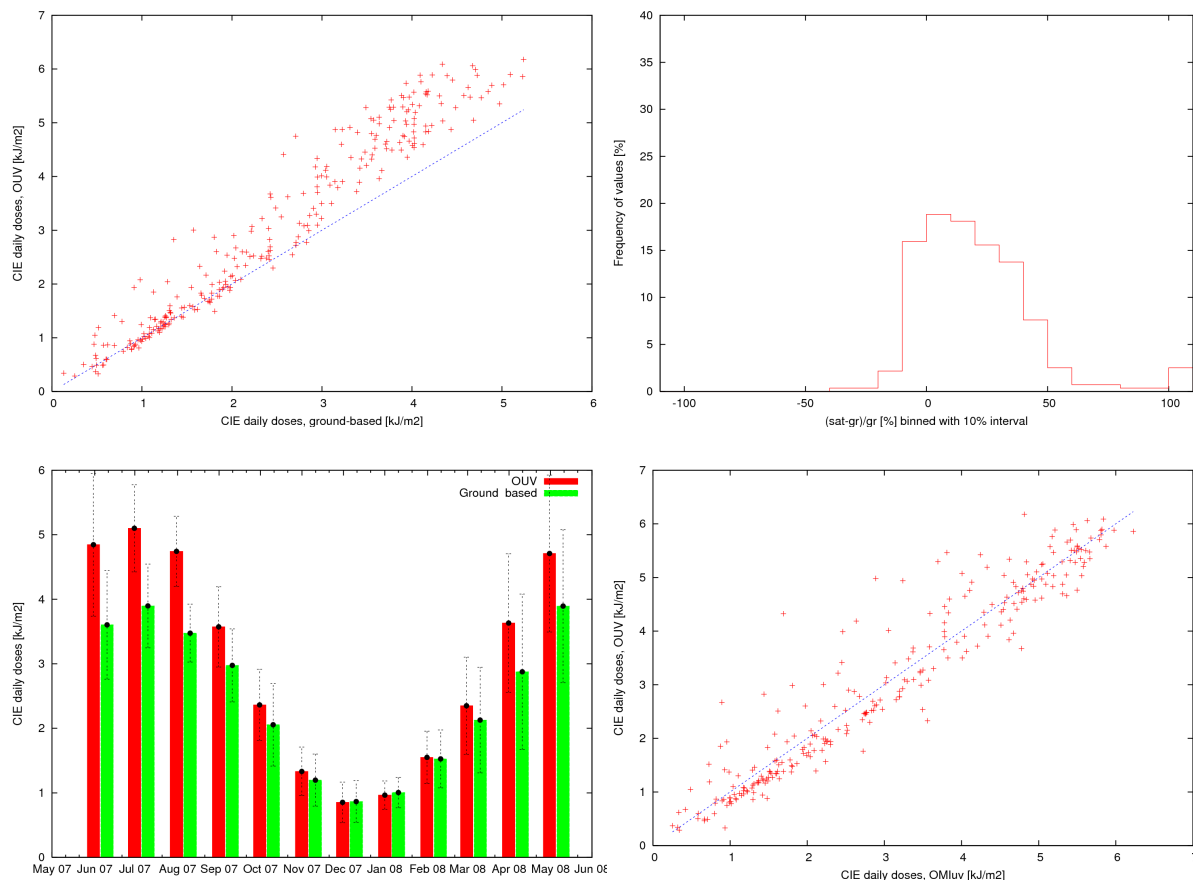


Figure A14. Raleigh CIE Erythral daily doses. At top left OUV vs. ground measurement scatter-plot. Histogram at top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. Bar graph shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Raleigh.

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### 5.11 San Diego, USA (32°46' N, 117°12' W)

Instrumentation: SUV-100

The spectroradiometer system at San Diego is located in the roof of the Biospherical Instruments Inc. building, approximately five kilometers from the Pacific Ocean. The system was installed in October 1992.

The Pacific Ocean tempers prevailing winds and weather, creating an environment different from other locations along this latitude. Mornings are often overcast or foggy, but skies are typically clear at noon and in the afternoon. Monthly average temperatures range from 14 to 23°C.

Besides collecting data for the NSF UV Network, this SUV is also used for testing software and hardware, long-term engineering evaluation, and training of site operators. This means that system operation is more frequently interrupted than at other network sites. [RD7]

San Diego	CIE	DNA
Number of days	198	198
OUV maximum, J/m <sup>2</sup>	6715	4169
OUV minimum, J/m <sup>2</sup>	415	141
Ground maximum, J/m <sup>2</sup>	6036	3431
Ground minimum, J/m <sup>2</sup>	238	78
Mean difference, J/m <sup>2</sup>	445	390
Mean relative difference, %	18,0	30,6
RMS error, J/m <sup>2</sup>	605	500
RMS relative, %	28,3	40,6

Table A15. Statistics for daily dose measurements in San Diego. Statistics were available for CIE erythema and Setlow DNA damage action spectra.

San Diego	CIE	DNA	Plant
Number of days	225	225	225
OUV maximum, mW/m <sup>2</sup>	311	223	476
OUV minimum, mW/m <sup>2</sup>	32	11	30
Ground maximum, mW/m <sup>2</sup>	276	181	416
Ground minimum, mW/m <sup>2</sup>	11	2	6
Mean difference, mW/m <sup>2</sup>	22	23	37
Mean relative difference, %	25,2	54,7	40,4
RMS error, mW/m <sup>2</sup>	37	32	59
RMS relative, %	81,9	202,6	170,3

Table A16. Statistics for daily maximum dose rate measurements in San Diego. Statistics were available for CIE erythema, Setlow DNA damage and Caldwell Plant response action spectra.

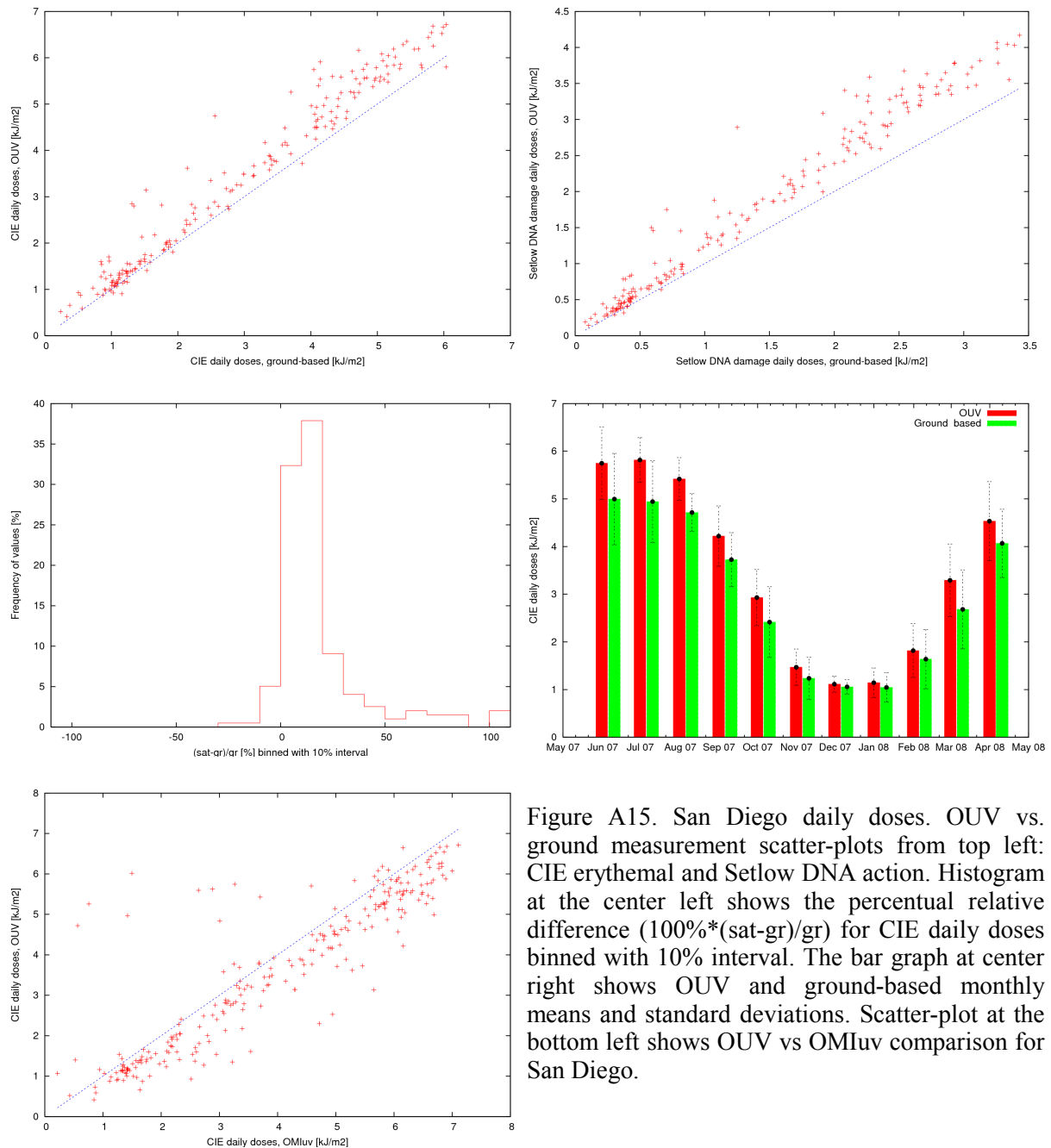


Figure A15. San Diego daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythral and Setlow DNA action. Histogram at the center left shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. The bar graph at center right shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom left shows OUV vs OMIuv comparison for San Diego.



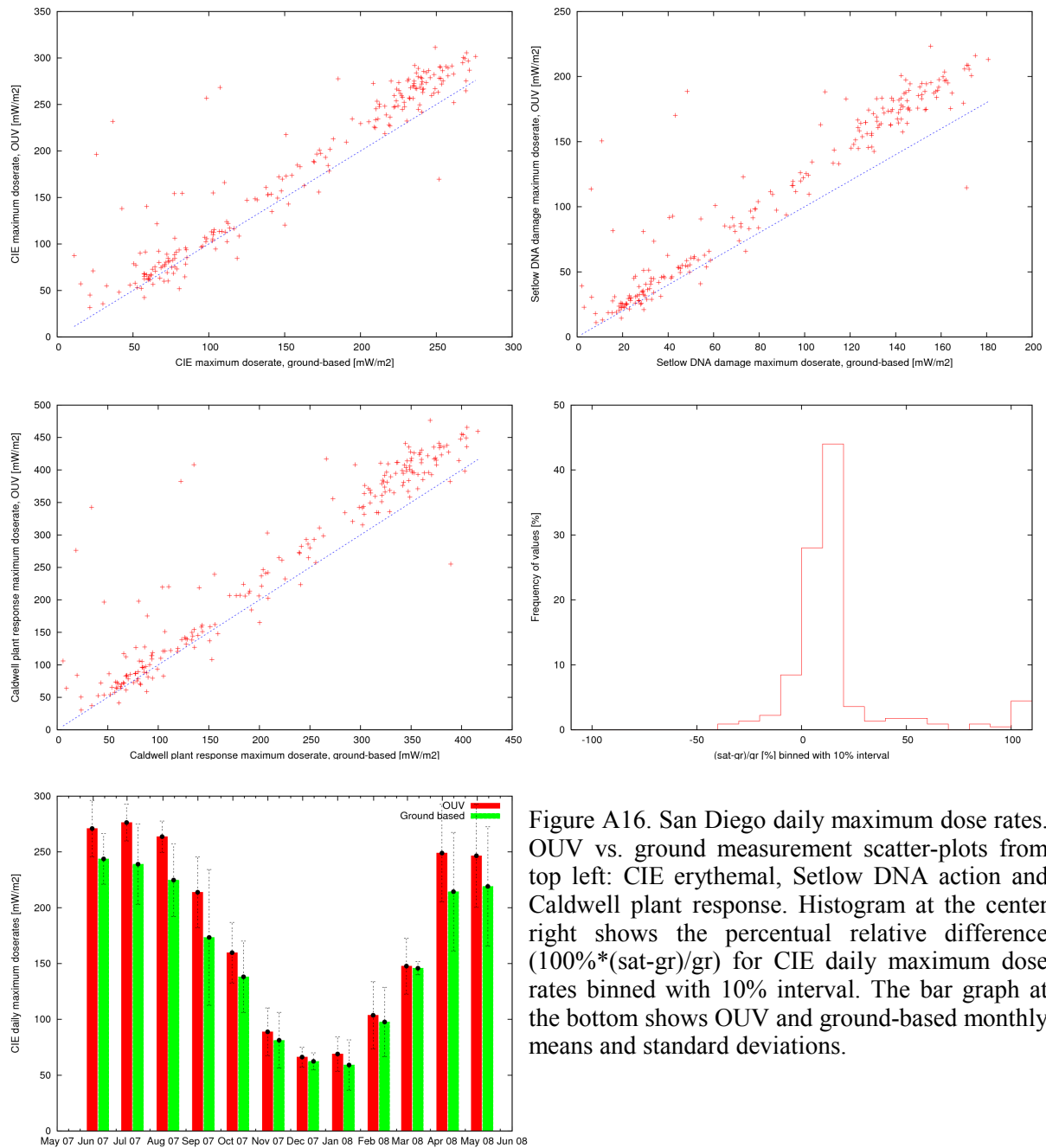


Figure A16. San Diego daily maximum dose rates. OUV vs. ground measurement scatter-plots from top left: CIE erythemal, Setlow DNA action and Caldwell plant response. Histogram at the center right shows the percentual relative difference  $(100\% \cdot (\text{sat} - \text{gr}) / \text{gr})$  for CIE daily maximum dose rates binned with 10% interval. The bar graph at the bottom shows OUV and ground-based monthly means and standard deviations.

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## 5.12 Sodankylä, Finland (67.37 °N, 26.63 °E)

Instrumentation: Brewer Mk-II

The research centre is located at Sodankylä in Finnish Lapland, about 100 km north of the Arctic Circle. Due to the warming effect of the Gulf Stream the area is included in the boreal region. However, with regard to stratospheric meteorology, Sodankylä can be classified as an Arctic site, often lying beneath the middle or the edge of the stratospheric polar vortex and in the zone of polar stratospheric ozone depletion. Its strategic location, coupled with ready accessibility from all parts of the world, makes the FMI-ARC an excellent base for studying various themes of global change in a northern context. [RD6]

Sodankylä	CIE	DNA	Plant	UV-b	UV-a
Number of days	164	164	164	164	164
OUV maximum, J/m <sup>2</sup>	3524	1547	4106	26490	1444092
OUV minimum, J/m <sup>2</sup>	131	32	71	874	82751
Ground maximum, J/m <sup>2</sup>	3449	1433	3829	26455	1433000
Ground minimum, J/m <sup>2</sup>	81	20	51	542	53853
Mean difference, J/m <sup>2</sup>	161	7	169	1018	79657
Mean relative difference, %	16,1	0,1	17,7	14,2	14,8
RMS error, J/m <sup>2</sup>	246	114	267	1765	120005
RMS relative, %	27,3	33,0	31,9	27,2	24,2

Table A17. Statistics for daily dose measurements in Sodankylä. Statistics were available for CIE erythema, Setlow DNA damage and Caldwell Plant response action spectra as well as UV-A and UV-B.

Sodankylä	CIE
Number of days	164
OUV maximum, mW/m <sup>2</sup>	120
OUV minimum, mW/m <sup>2</sup>	7
Ground maximum, mW/m <sup>2</sup>	123
Ground minimum, mW/m <sup>2</sup>	6
Mean difference, mW/m <sup>2</sup>	-1
Mean relative difference, %	2,7
RMS error, mW/m <sup>2</sup>	9
RMS relative, %	19,6

Table A18. Statistics for daily dose measurements in Sodankylä. Statistics were only available for CIE erythema action spectrum.

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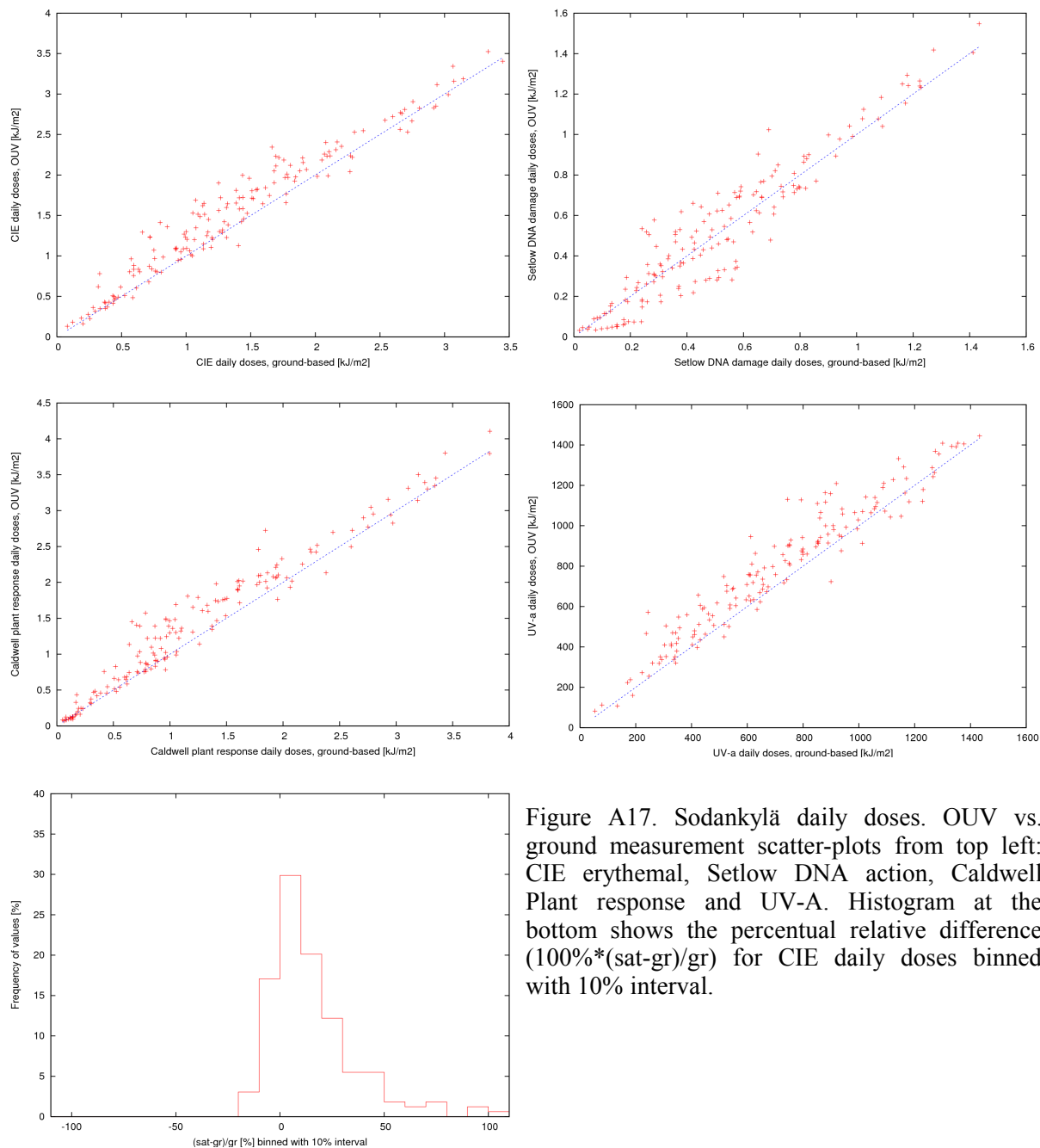


Figure A17. Sodankylä daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythemal, Setlow DNA action, Caldwell Plant response and UV-A. Histogram at the bottom shows the percentual relative difference  $(100\% \cdot (\text{sat} - \text{gr}) / \text{gr})$  for CIE daily doses binned with 10% interval.

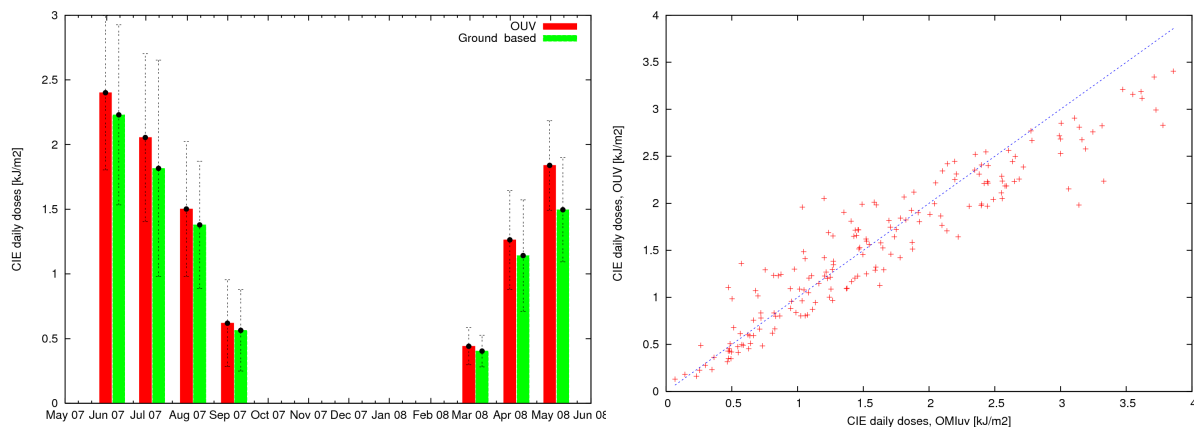


Figure A17 continued. Sodankylä daily doses. The bar graph at center right shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Sodankylä.

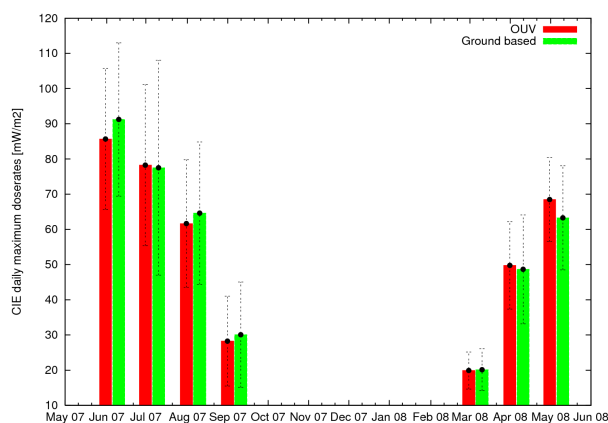
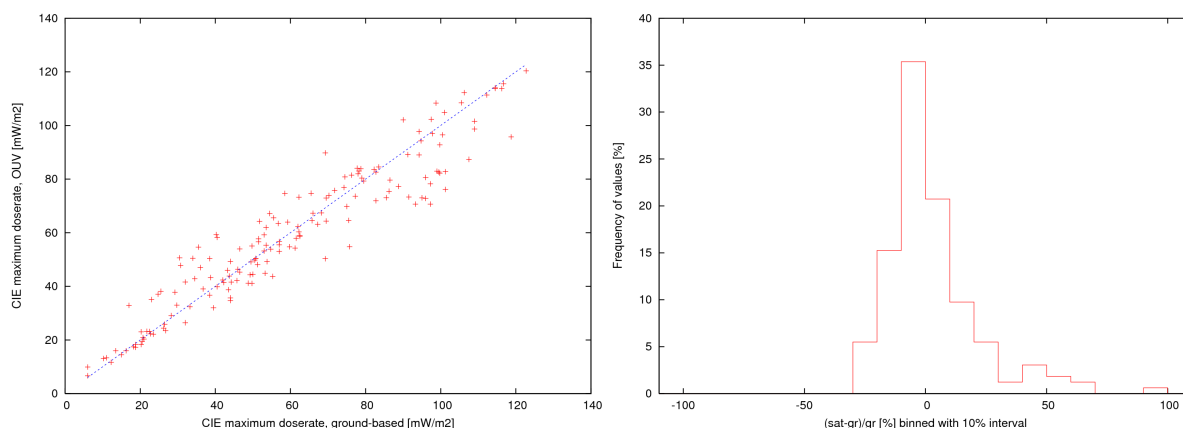


Figure A18. Sodankylä daily maximum dose rates. OUV vs. ground measurement scatter plot for CIE erythemat daily maximum dose rates and histogram for percentual relative difference  $100\% \cdot (\text{sat-gr})/\text{gr}$  for CIE daily maximum dose rates binned with 10% interval. The bar graph at bottom shows OUV and ground-based monthly means and standard deviations.

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### 5.13 Summit, Greenland (72°35' N, 38°27' W)

Instrumentation: SUV-150B

The installation at Summit is located at the peak of the Greenland ice cap and is nearly 400 km away from the nearest point of land. The instrument is located in a heated and highly-insulated structure known as the "Greenhouse", which is part of the research station Summit Camp. This is the first station where a SUV-150B spectroradiometer has been operationally deployed. Instrument operation and data download are performed via the Internet. Station staff assists in operation and calibration. [RD7]

Summit	CIE	DNA
Number of days	114	114
OUV maximum, J/m <sup>2</sup>	5903	2394
OUV minimum, J/m <sup>2</sup>	708	127
Ground maximum, J/m <sup>2</sup>	5211	1853
Ground minimum, J/m <sup>2</sup>	751	123
Mean difference, J/m <sup>2</sup>	311	219
Mean relative difference, %	8,0	19,7
RMS error, J/m <sup>2</sup>	384	260
RMS relative, %	9,7	20,9

Table A19. Statistics for daily dose measurements in Summit. Statistics were available for CIE erythema and Setlow DNA damage action spectra.

Summit	CIE	DNA	Plant
Number of days	111	111	111
OUV maximum, mW/m <sup>2</sup>	162	78	207
OUV minimum, mW/m <sup>2</sup>	29	6	10
Ground maximum, mW/m <sup>2</sup>	160	67	192
Ground minimum, mW/m <sup>2</sup>	29	0	16
Mean difference, mW/m <sup>2</sup>	4	0	7
Mean relative difference, %	3,8	10,8	7,4
RMS error, mW/m <sup>2</sup>	0	16	8
RMS relative, %	7,1	17,8	11,1

Table A20. Statistics for daily maximum dose rate measurements in Summit. Statistics were available for CIE erythema, Setlow DNA damage and Caldwell Plant response action spectra.

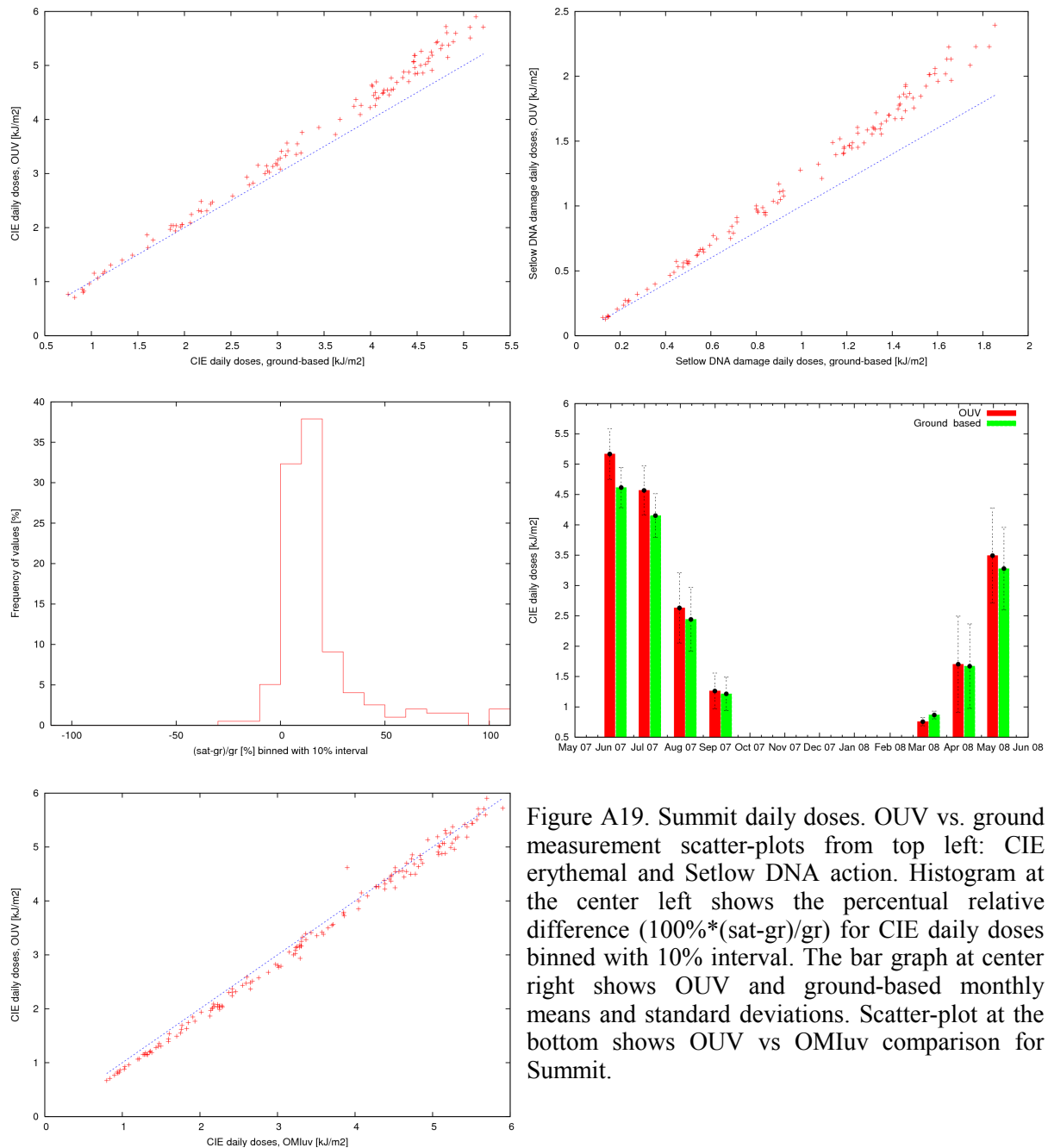


Figure A19. Summit daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythemal and Setlow DNA action. Histogram at the center left shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily doses binned with 10% interval. The bar graph at center right shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom shows OUV vs OMIuv comparison for Summit.

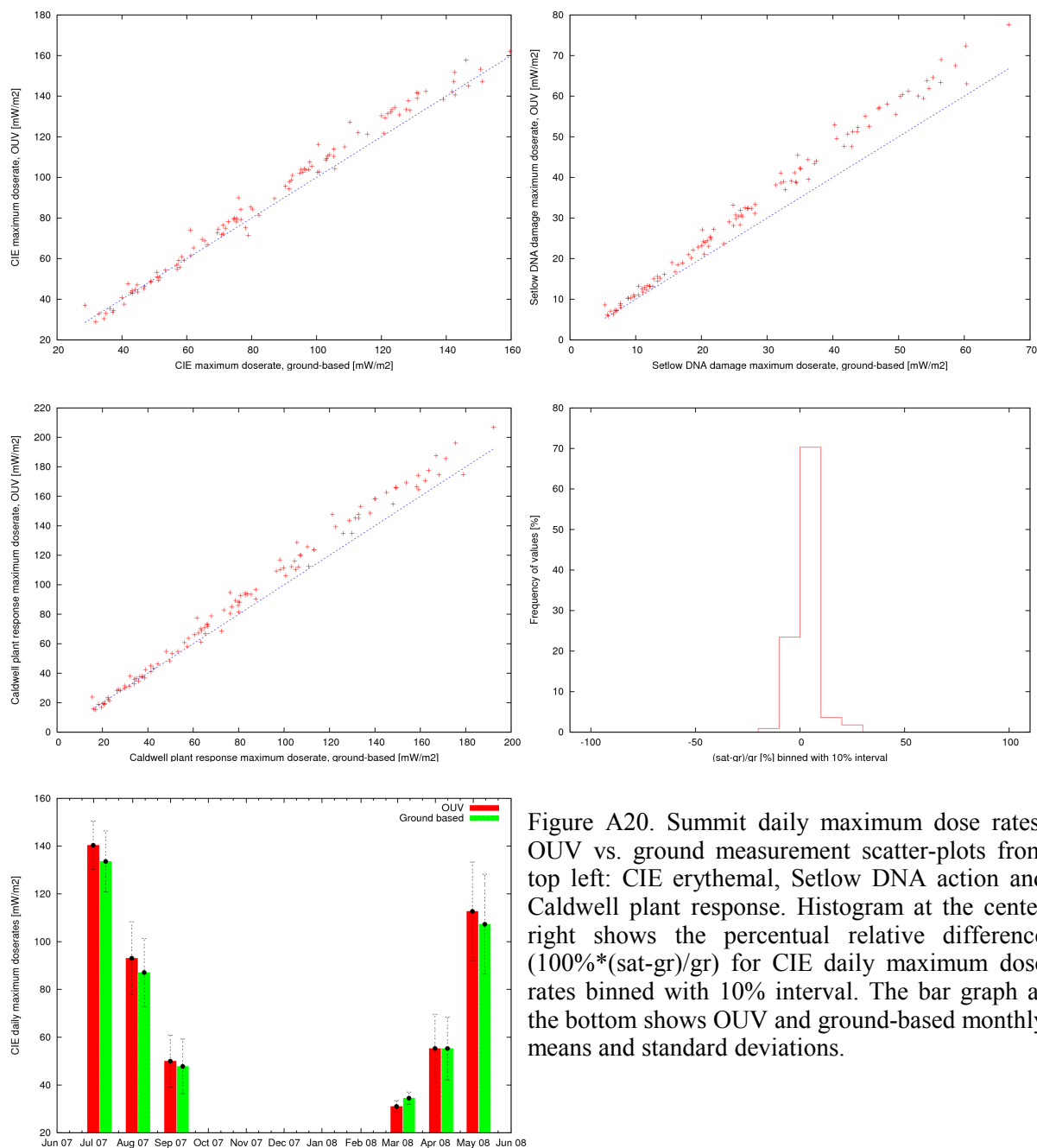


Figure A20. Summit daily maximum dose rates. OUV vs. ground measurement scatter-plots from top left: CIE erythemal, Setlow DNA action and Caldwell plant response. Histogram at the center right shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily maximum dose rates binned with 10% interval. The bar graph at the bottom shows OUV and ground-based monthly means and standard deviations.

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#### 5.14 Thessaloniki, Greece (40°38' N, 22°58' E)

Instrumentation: Brewer MkIII

Station is operated by Aristotle University of Thessaloniki.

Thessaloniki	CIE
Number of days	230
OUV maximum, J/m <sup>2</sup>	6094
OUV minimum, J/m <sup>2</sup>	78
Ground maximum, J/m <sup>2</sup>	5500
Ground minimum, J/m <sup>2</sup>	53
Mean difference, J/m <sup>2</sup>	381
Mean relative difference, %	24,3
RMS error, J/m <sup>2</sup>	592
RMS relative, %	55,8

Table A21. Statistics for daily dose measurements in Thessaloniki. Statistics were only available for CIE erythema action spectra.

Thessaloniki	CIE
Number of days	205
OUV maximum, mW/m <sup>2</sup>	255
OUV minimum, mW/m <sup>2</sup>	5
Ground maximum, mW/m <sup>2</sup>	236
Ground minimum, mW/m <sup>2</sup>	4
Mean difference, mW/m <sup>2</sup>	14
Mean relative difference, %	13,4
RMS error, mW/m <sup>2</sup>	25
RMS relative, %	31,0

Table A22. Statistics for daily maximum dose rate measurements in Thessaloniki. Statistics were only available for CIE erythema action spectra.



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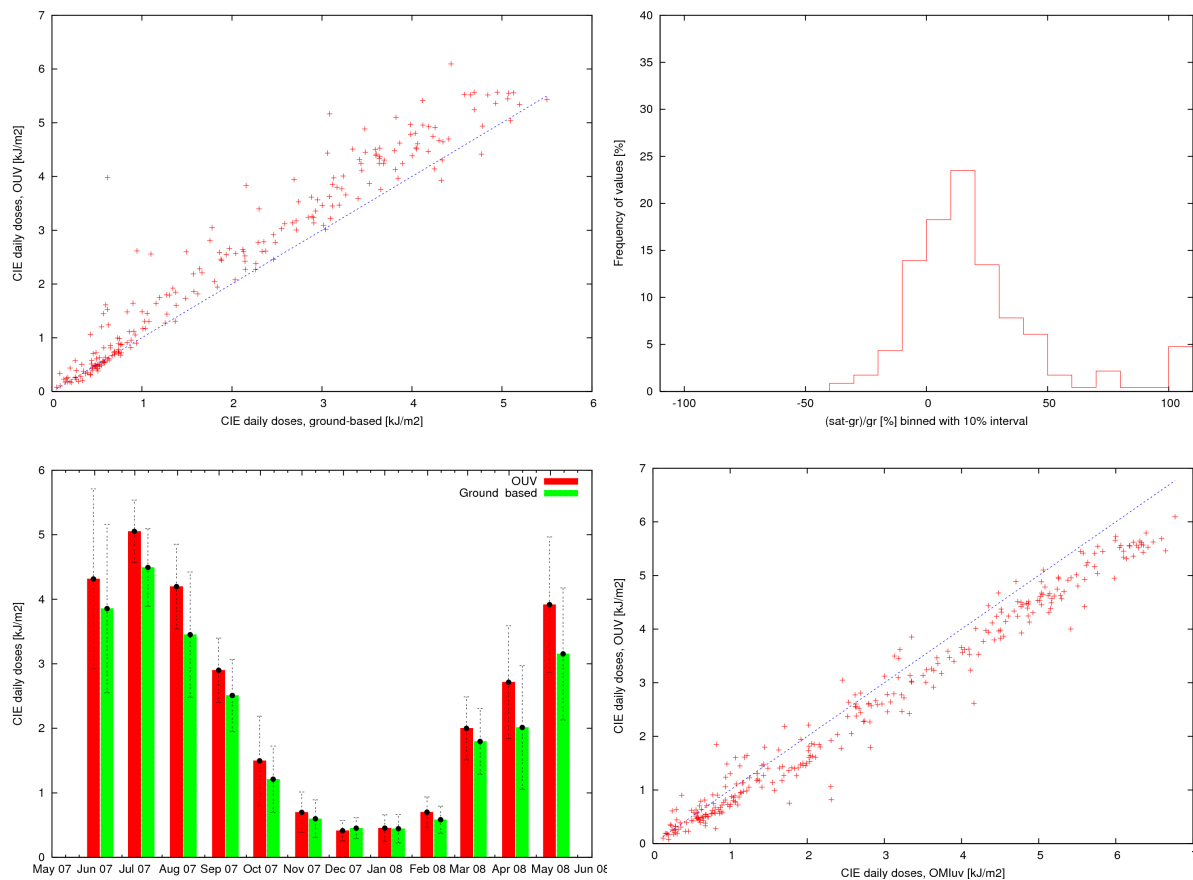


Figure A21. Thessaloniki daily doses. At top left OUV vs. ground measurement scatter-plots for CIE erythema action spectrum. Histogram at the top right shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily doses binned with 10% interval. The bar graph at bottom left shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom right shows OUV vs OMIuv comparison for Thessaloniki.

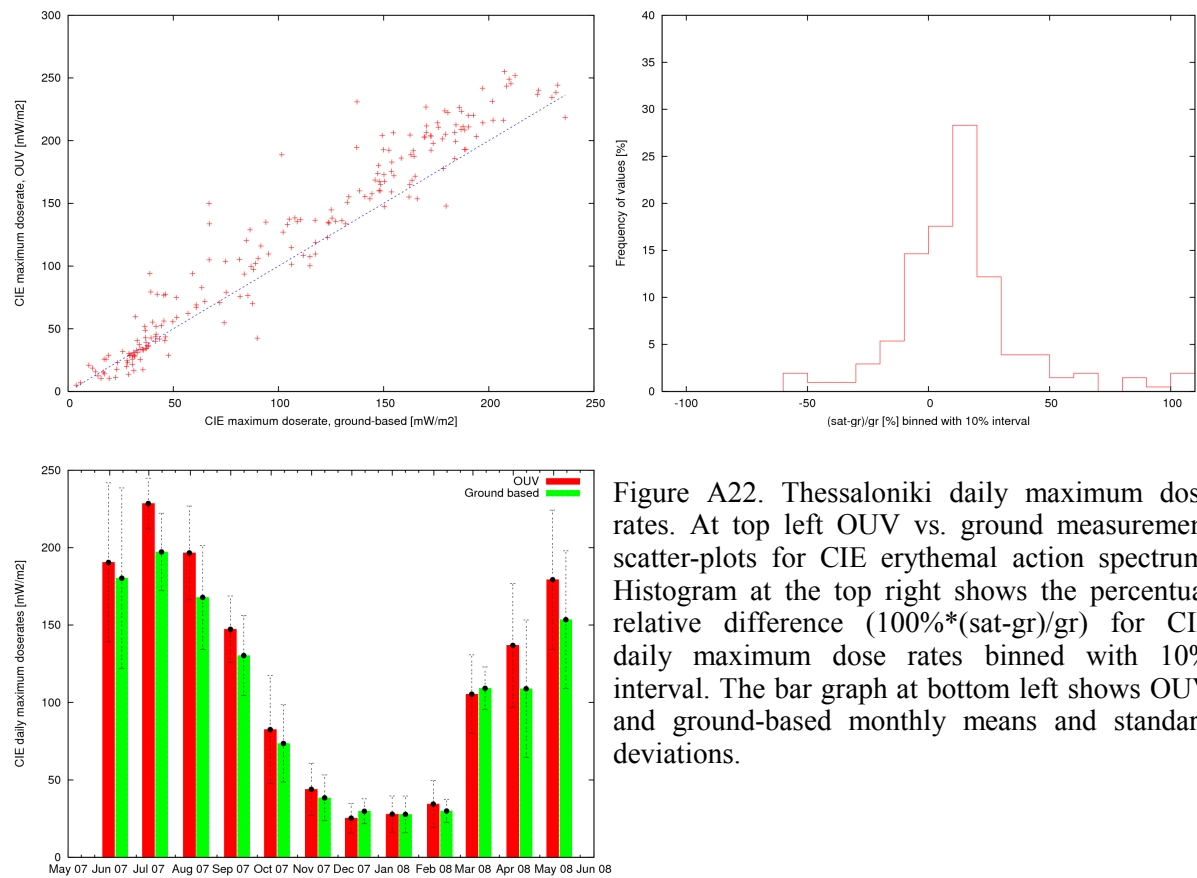


Figure A22. Thessaloniki daily maximum dose rates. At top left OUV vs. ground measurement scatter-plots for CIE erythemal action spectrum. Histogram at the top right shows the percentual relative difference ( $100\% \cdot (\text{sat-gr})/\text{gr}$ ) for CIE daily maximum dose rates binned with 10% interval. The bar graph at bottom left shows OUV and ground-based monthly means and standard deviations.

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### 5.15 Ushuaia, Argentina (54°49' S, 68°19' W)

Instrumentation: SUV-100

The Ushuaia installation, the fourth system added to the network, is located near the southern port city of Ushuaia, Argentina, at the Centro Austral de Investigaciones Cientificas (CADIC) facility. CADIC is a regional research center of the National Research Council of Argentina (CONICET). The installation is located in the foothills of the Andes, an area subject to frequent clouds.

The instrument is installed in the roof of the main CADIC building and is surrounded by mountains ranging in elevation from 2.5° (at bearings of 120° - 206°) to 17° (at bearings of 298° - 302°). Data are sent to Biospherical Instruments via e-mail attachment.[RD7]

Ushuaia	CIE	DNA
Number of days	124	124
OUV maximum, J/m <sup>2</sup>	5246	3254
OUV minimum, J/m <sup>2</sup>	155	35
Ground maximum, J/m <sup>2</sup>	5564	2725
Ground minimum, J/m <sup>2</sup>	174	32
Mean difference, J/m <sup>2</sup>	92	117
Mean relative difference, %	5,1	18,2
RMS error, J/m <sup>2</sup>	442	263
RMS relative, %	27,5	46,8

Table A23. Statistics for daily dose measurements in Ushuaia. Statistics were available for CIE erythema and Setlow DNA damage action spectra.

Ushuaia	CIE	DNA	Plant
Number of days	218	218	218
OUV maximum, mW/m <sup>2</sup>	231	163	351
OUV minimum, mW/m <sup>2</sup>	9	2	6
Ground maximum, mW/m <sup>2</sup>	234	142	337
Ground minimum, mW/m <sup>2</sup>	10	2	6
Mean difference, mW/m <sup>2</sup>	-8	1	-8
Mean relative difference, %	-5,8	5,7	-2,6
RMS error, mW/m <sup>2</sup>	26	15	37
RMS relative, %	25,0	41,9	34,3

Table A24. Statistics for daily maximum dose rate measurements in Ushuaia. Statistics were available for CIE erythema, Setlow DNA damage and Caldwell Plant response action spectra.

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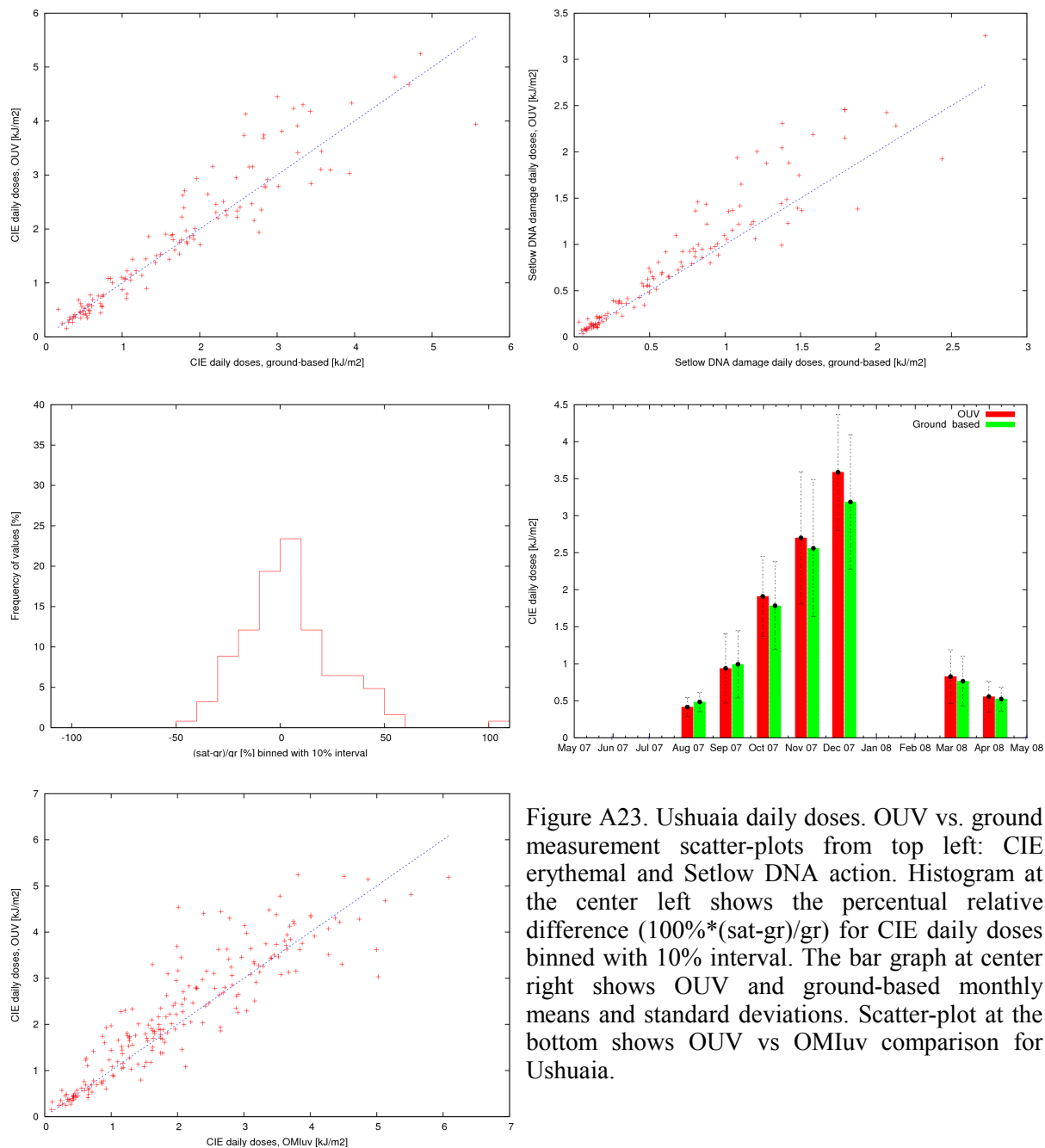


Figure A23. Ushuaia daily doses. OUV vs. ground measurement scatter-plots from top left: CIE erythemal and Setlow DNA action. Histogram at the center left shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily doses binned with 10% interval. The bar graph at center right shows OUV and ground-based monthly means and standard deviations. Scatter-plot at the bottom shows OUV vs OMIuv comparison for Ushuaia.

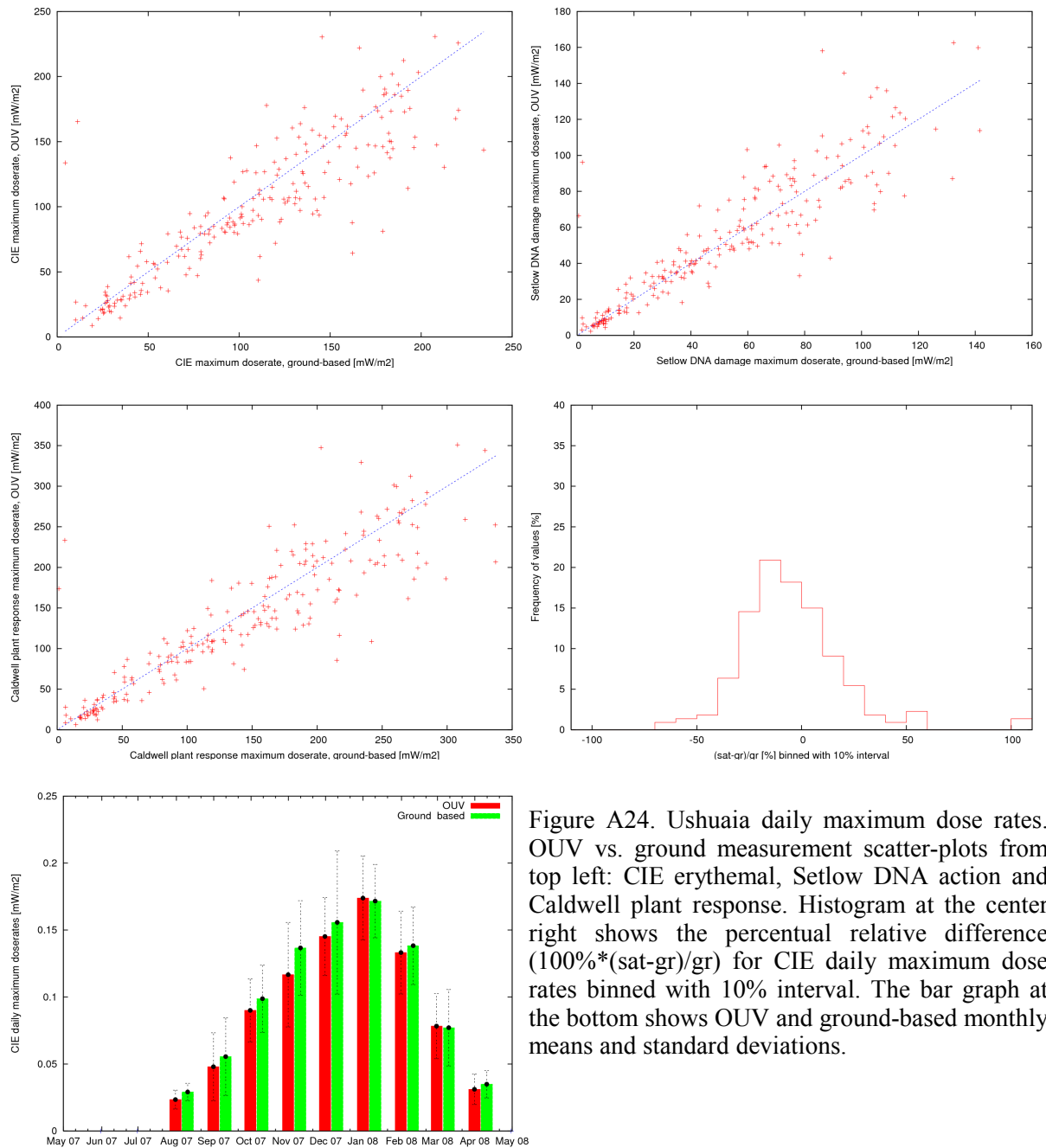


Figure A24. Ushuaia daily maximum dose rates. OUV vs. ground measurement scatter-plots from top left: CIE erythemal, Setlow DNA action and Caldwell plant response. Histogram at the center right shows the percentual relative difference  $(100\% \cdot (\text{sat-gr})/\text{gr})$  for CIE daily maximum dose rates binned with 10% interval. The bar graph at the bottom shows OUV and ground-based monthly means and standard deviations.

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## 6. Appendix B: Statistics used

<b>Number of days</b>	The number of days where both OUV and ground based data were available
<b>OUV maximum</b>	Maximum value of OUV
<b>OUV minimum</b>	Minimum value of OUV
<b>Ground maximum</b>	Maximum value of ground based measurements
<b>Ground minimum</b>	Minimum value of ground based measurements
<b>Mean difference</b>	Mean of the absolute differences between OUV and ground based measurements
<b>Mean relative difference</b>	Mean of the relative differences between OUV and ground based measurements [(OUV-ground)/ground].
<b>RMS error</b>	Root-mean-squared error of absolute differences between OUV and ground based measurements
<b>RMS relative error</b>	Root-mean-squared error of relative differences between OUV and ground based measurements

Table B1. Explanations of the statistics used in validation.