UV Quality Assurance within COST 726

Activities of working group 4

Julian Gröbner and WG4 participants

pmod wrc

UV measurements within COST 726

1)Validation of modeling activities (Climatology)

2)Determination of relationship CMF_UV to CMF_GLO

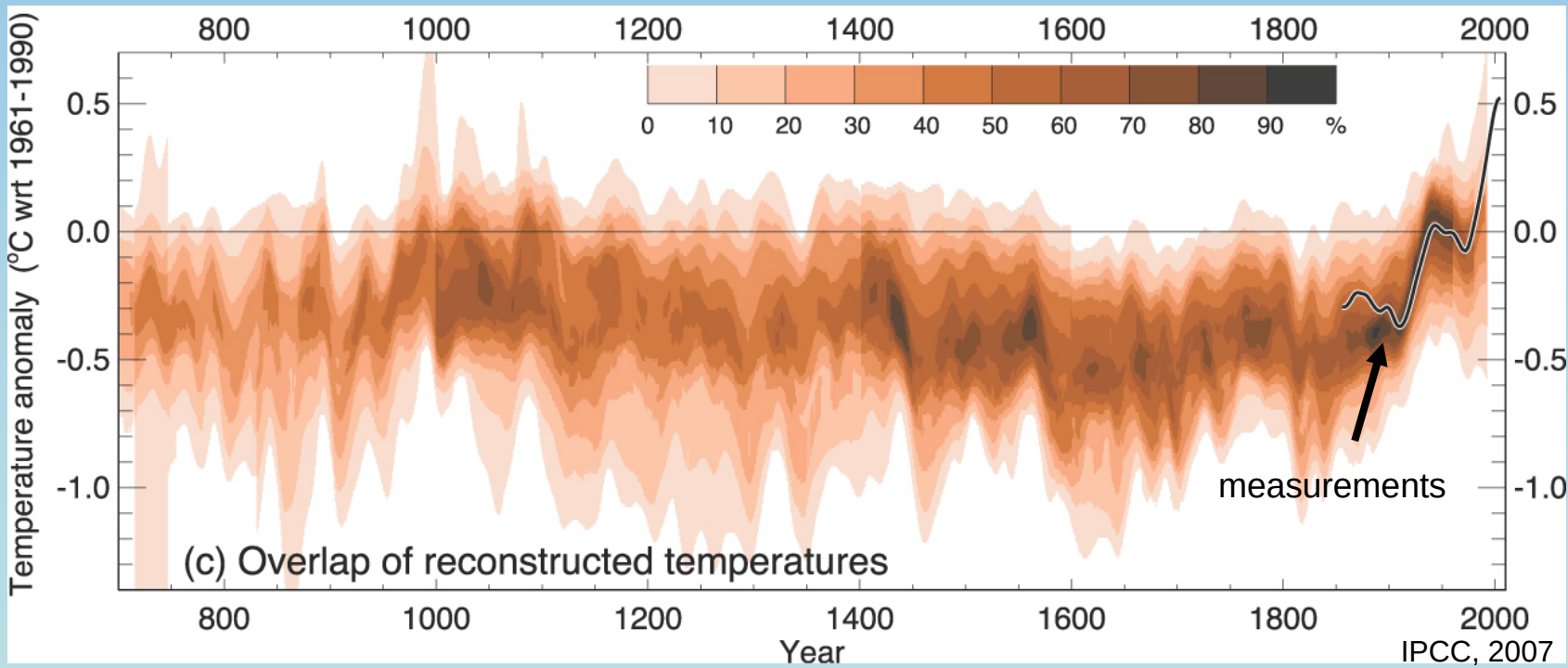
3) Future:

Improve measurement quality in view of future UV Climatologies.

An Analogy: Temperature reconstruction

Historical temperature reconstruction from proxy data:

Tree rings, ice cores, etc…



IPCC, 2007

pmod wrc

History of broadband filter radiometer calibration campaigns

- 1995 WMO/STUK intercomparison
  - 20 radiometers
- 1999 LAP/COST/WMO intercomparison
  - 29 radiometers
- 2006 PMOD_WRC/COST intercomparison
  - 36 radiometers

Intercomparison results WMO/STUK

Manufacturer calibration

Deviations up to 30%

Table 2. Examples of the improved comparability of EW measurements after the common cali
parison

Radiometer manufacturer	Model	Serial number	Deviation from the daily dose* (%)			
			Manufacturer calibration		Calibration from WMO/STUK intercomparison	
			Clear day†	Cloudy day‡	Clear day†	Cloudy day‡
Vital Technologies Corporation	Vital BW-20	9533	−10	−6	1	6
Vital Technologies Corporation	Vital BW-100		−85	−246	1	3
Yankee Environmental Systems Inc.	YES UVB-1	920706	−21	−32	0	−12
Solar Light Co., Inc.	SL 501 V.1	635	3	5	1	3
	SL 501 V.3	922	−8	−8	−1	0
		1081	−21	−22	−1	2
		1450	−14	−15	0	−2
		1466	−10	−11	−1	−1
	SL 501A V.3	1492	−13	−14	−1	−1
		1896	−8	−7	0	0

*Based on the cosine–corrected calibrated data.
†Total daily dose 21.0 MED. Total ozone 315 DU.
‡Total daily dose 5.5 MED. Total ozone 300 DU.

Leszczynski et al., Photochem.Photobiol. 1998

pmod wrc

Intercomparison results LAP/COST/WMO

Manufacturer/Owner calibration

Deviations up to 30%

Table 2: CIE-based Calibration factors of the instruments that took LAP/COST/WMO intercomparison or erythemal radiomete

Instrument Type	Serial Number	Calibration factors				
		Certificate	LAP 1999 (327 DU)	LAP 1999 (270 DU)	Change (%)	
SL 501	0629	1.089	0.999	1.021	-6.3	
	0635	0.98[S]	0.882	0.889	-9.3	
	0922	1.08[S]	0.965	0.990	-8.3	
	0935	1.000	0.952	0.979	-2.1	I
	1081	1.26[S]	1.011	1.024	-18.7	R1
	1098	1.000	0.919	0.933	-6.7	NL1
	1120	1.20[S]	1.227	1.238	3.2	PL2
	1240	1.000	1.159	1.178	17.8	AT4
	1451	1.000	1.018	1.024	2.4	DE2
	1466	1.11[S]	1.065	1.074	-3.3	FI1
	1483	1.000	1.016	1.028	2.8	AT2
	1485	1.000	0.962	0.972	-2.8	AT1
	1875	1.000	0.973	0.982	-1.8	CZ1
	2706	1.000	1.258	1.278	27.8	AT3
	2733	1.114	1.066	1.064	-4.5	CZ2
	3749	1.000	0.828	0.840	-16.0	PT1
SL 501A	1493	0.214	0.220	0.225	5.1	CH1
	4388	0.230	0.209	0.212	-8.0	SE2

Bais et al., Gaw report 141, 1999

pmod wrc

Intercomparison results PMOD_WRC/COST

Manufacturer/Owner calibration

Deviations > 60%

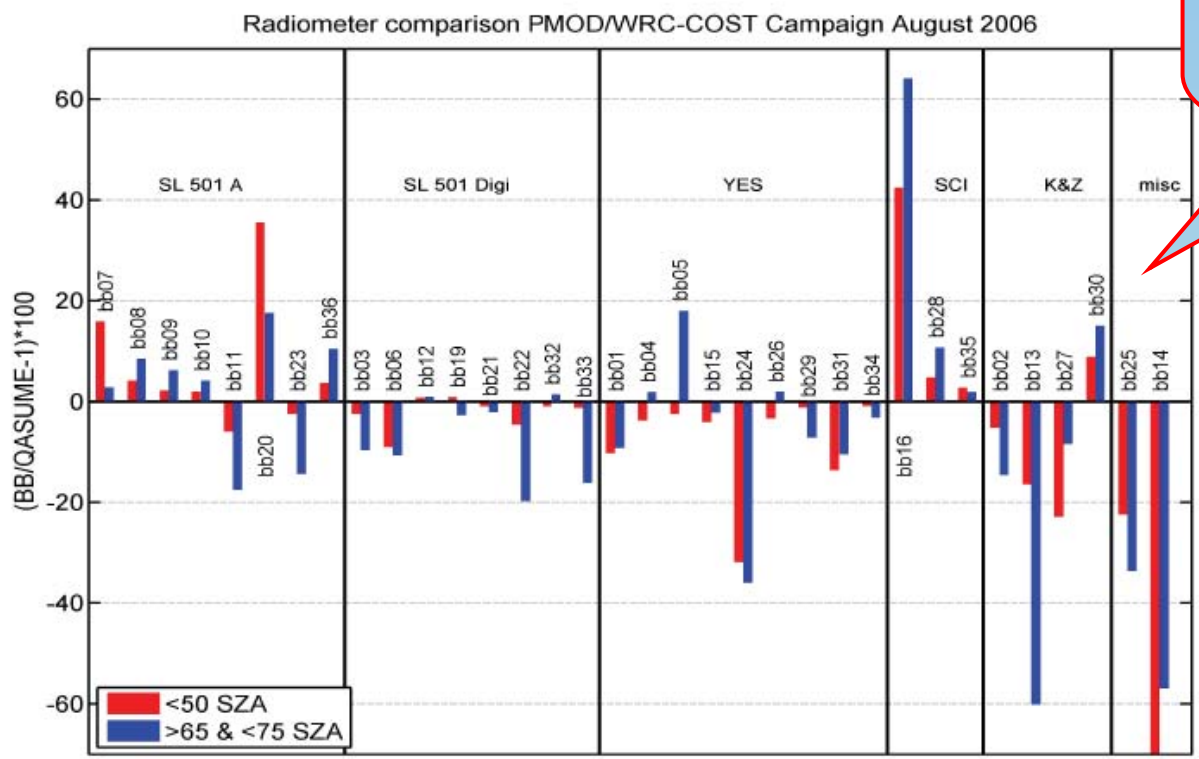


Figure 10 Average relative differences between the radiometers and the QASUME reference spectroradiometer for the two solar zenith angle ranges 1) smaller than 50° and 2) higher than 65° and lower than 75°.

pmod wrc

Summary from these intercomparisons

Average difference (median) and standard deviation between original calibration and campaign reference (all radiometers):

1995	STUK	-11 ± 24%
1999	LAP	-3 ± 11%
2006	PMOD	-1 ± 14%

Radiometers present at several intercomparisons:

Inst ID	STUK(1995)		LAP(1999)		PMOD(2006)
635 (SL)	0.98	-11%	0.88	+11%	0.98
922 (SL)	1.08	-10%	0.97	+7%	1.04
935 (SL)			0.95	+15%	1.10
1493 (SL)			0.220	+0%	0.220
970839 (YES)			0.121	-3%	0.118

pmod wrc

Conclusions from these intercomparisons

1) Small but definite improvements. Individual radiometers still show very large discrepancies.

2) Broadband radiometers are unstable ?

unlikely for deviations >20%

3) Manufacturer calibration is not correct ?

There are known cases.

4) Operators do not apply the correct radiometer equation ?

WG4 in COST 726

Goal: Harmonize UV measurements in Europe

- Broadband radiometers
- Narrowband filter Radiometers
- Spectral measurements

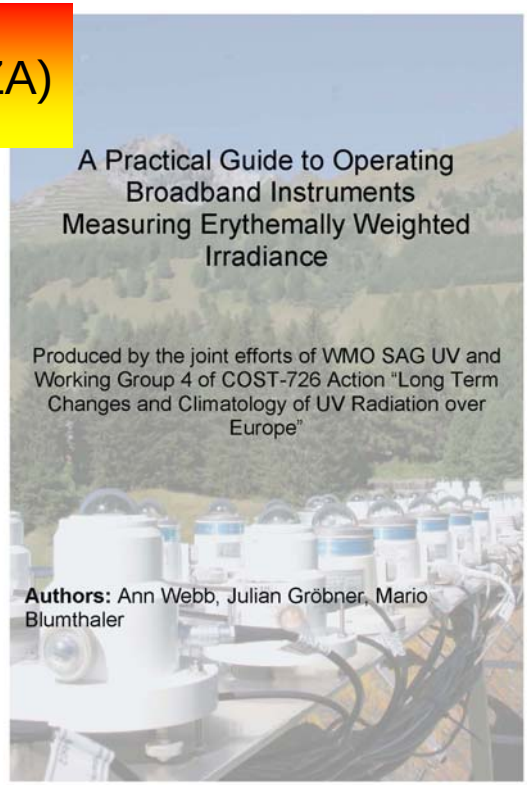
pmod wrc

I – Broadband radiometer equation

$$E_{CIE} = (U - U_{offset}) \cdot C \cdot f_n\,(SZA, T_{O3}) \cdot \varepsilon(T) \cdot Coscor(SZA)$$

The calibration will result in values for:

1) Calibration factor **C** [$Wm^{-2}V^{-1}$]
2) Detector to erythemal weighted response conversion matrix **f_n (SZA, T_{O3})** normalised to SZA 40° and 300 DU total column ozone
3) Cosine correction function **Coscor(SZA)**
4) **ε(T)** temperature correction function (optional)



pmod wrc

Broadband radiometer uncertainties

Calibration uncertainty ~7-16%

Table 1. Uncertainty Budget for the Calibration of Broadband Radiometers (SZA < 75 deg)

Contribution	Relative Standard Uncertainty (%)
Uncertainty of C	
Variability	1.8
Reference spectroradiometer	2.5
Combined calibration uncertainty	3.1
Uncertainty of the erythemal weighted irradiance	
Conversion function f_n–SRF uncertainty	0.7
Conversion function f_n–model uncertainty	0.9
Conversion function f_n–TO_3 uncertainty (±10 DU)	1.2
Cosine correction	0.9–7.2
Combined total uncertainty	3.6–8.0
Total expanded uncertainty (k = 2)	7.2–16.0

Instrument dependent

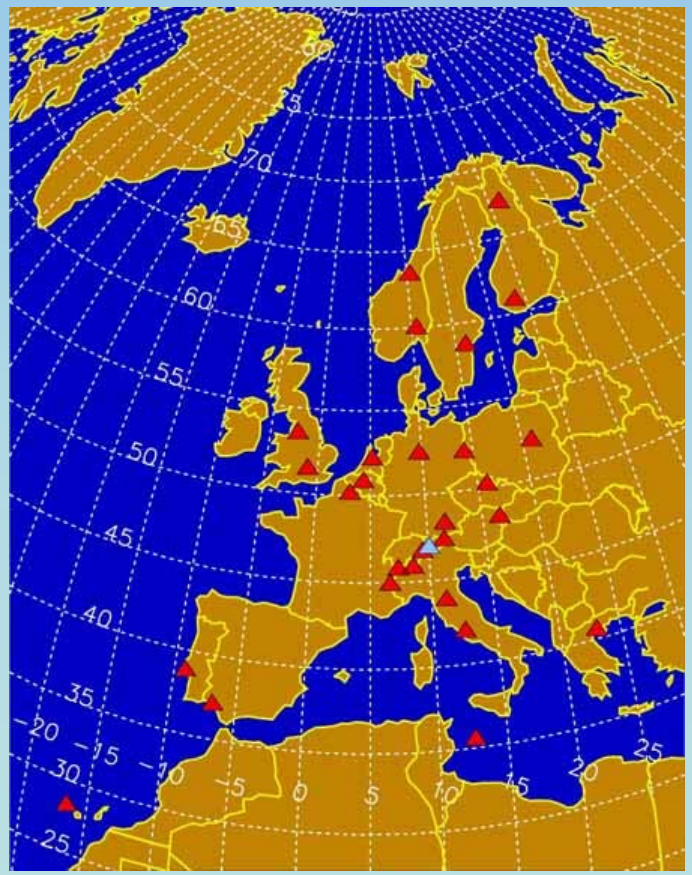
Hülsen and Gröbner, Appl. Opt., 2007.

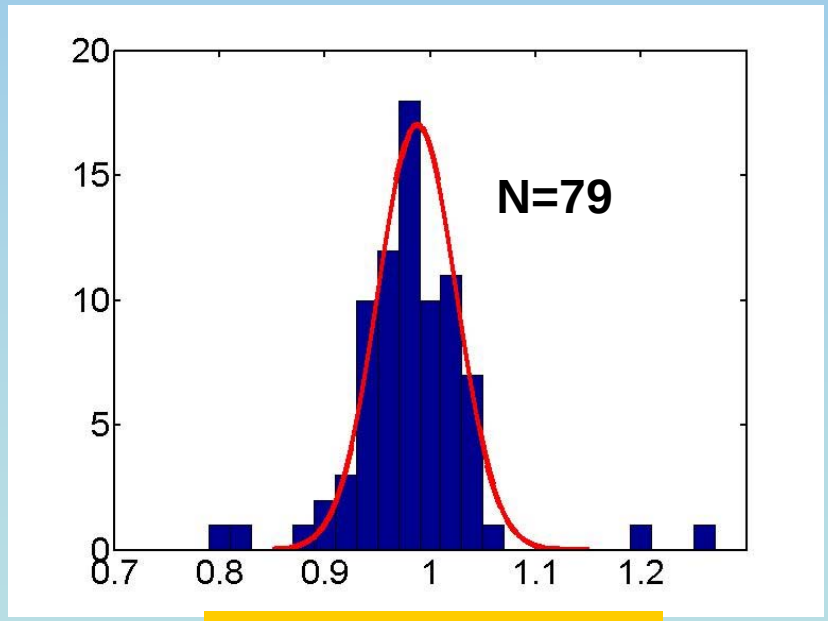
pmod wrc

European UV Quality Assurance Program

On site comparison with the QASUME reference spectroradiometer

40 site visits between 2002 and 2008





R=0.99±0.08
(95% confidence interval)

http://www.pmodwrc.ch/euvc/euvc.php?topic=qasume_audit

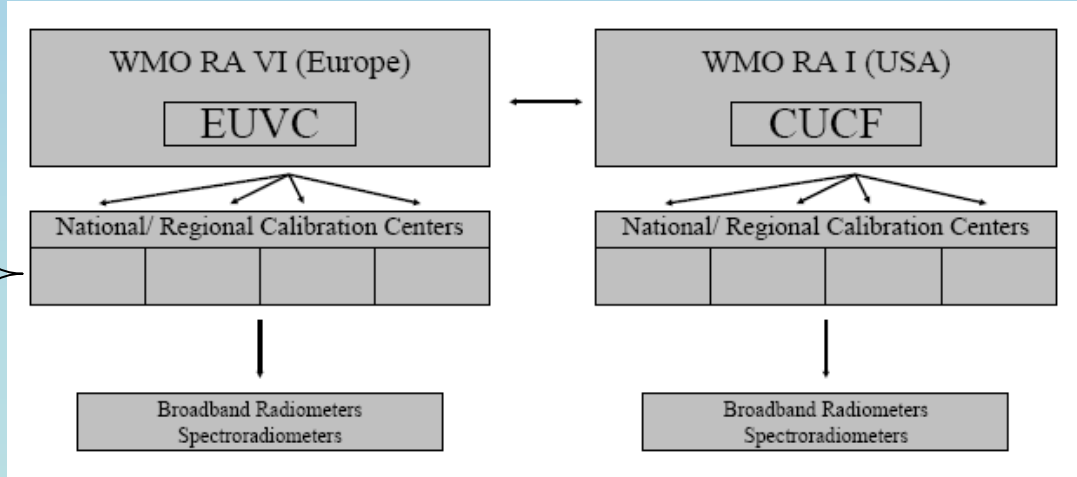
pmod wrc

European UV Quality Assurance Program

As of January 1st 2008

The European UV Calibration Center (EUVC) at PMOD/WRC is formally recognised by the WMO as **GAW regional UV calibration center for Europe**.

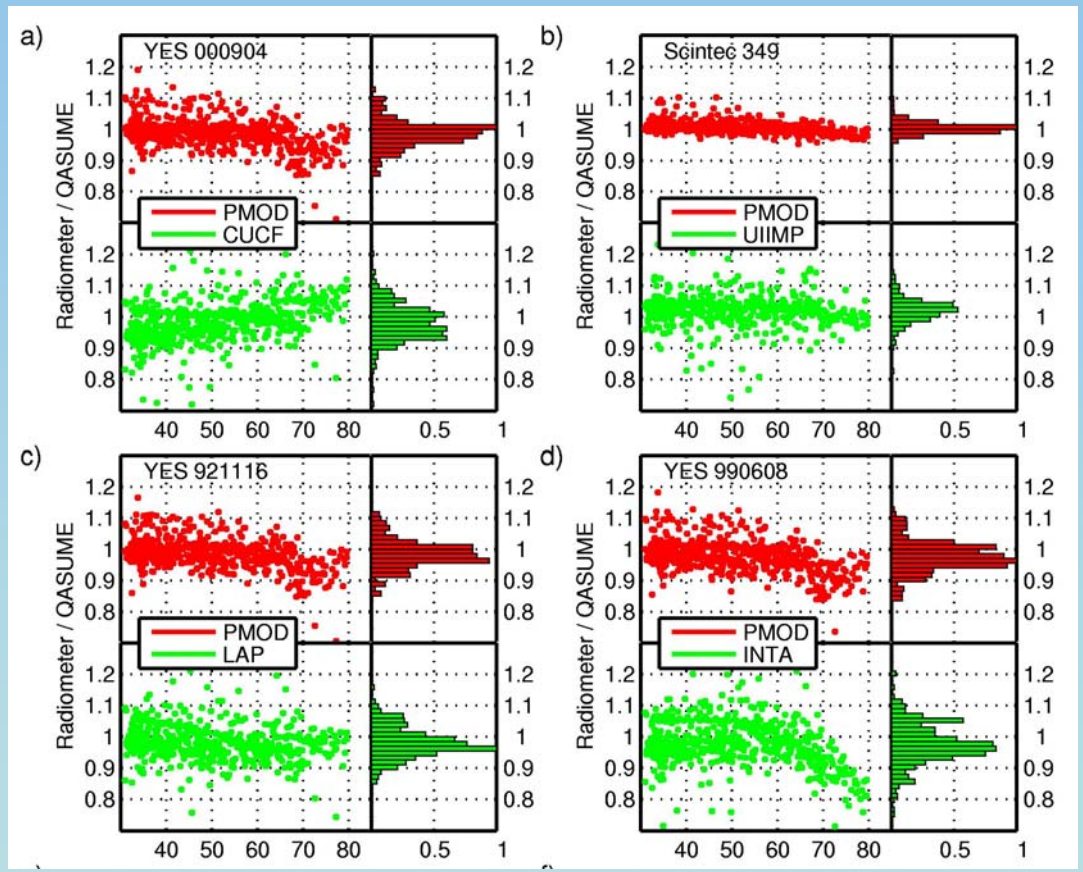
- INTA, Spain
- LAP, Greece
- NRPA, Norway
- STUK, Finland
- UIIMP, Austria

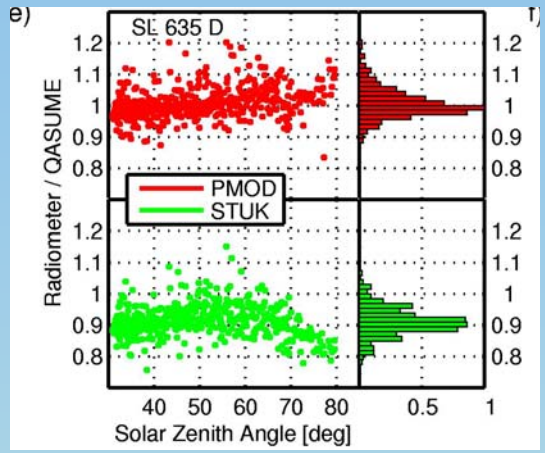


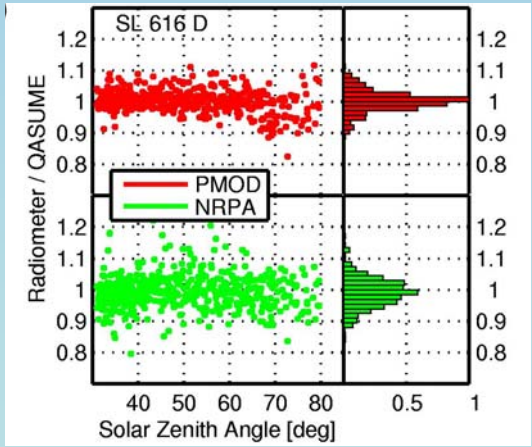
Hülsen et al., ACP, 2008

pmod wrc

Intercomparison of seven UV calibration facilities in Europe and the U.S.A.







pmod wrc

Intercomparison of seven UV calibration facilities in Europe and the U.S.A.

Conclusions:

Measurements of erythemal weighted irradiance agree to within ±2% for six out seven institutes. One Institute is lower by 9% relative to PMOD/WRC.

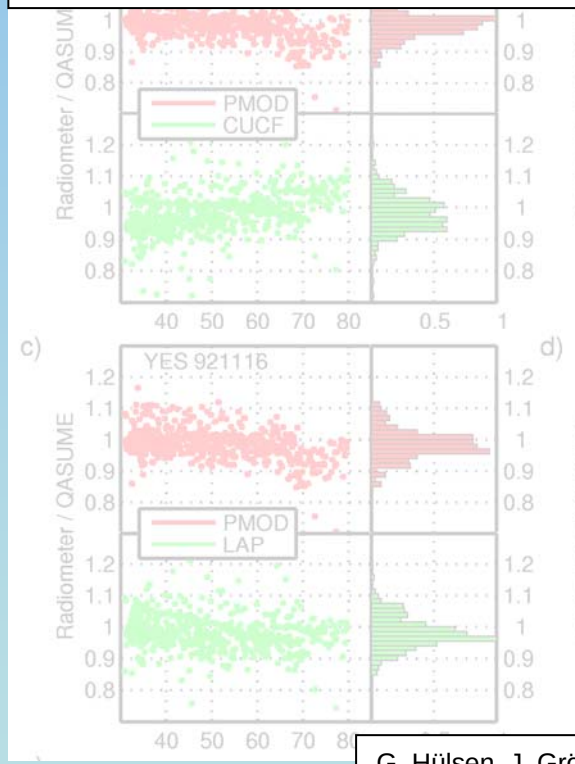


Table 5. Summary results of the outdoor measurement campaign (see also Fig. 4). The second and third columns list the mean and standard deviation of the erythemally weighted irradiances ratios between the radiometer and the QASUME reference spectroradiometer, calibrated by PMOD/WRC and the owners respectively.

Instrument	PMOD/WRC	Owner
YES 000904	0.985 ± 0.049	0.982 ± 0.063
Scintec 349	1.004 ± 0.019	1.020 ± 0.054
YES 921116	0.983 ± 0.050	0.981 ± 0.061
YES 990608	0.975 ± 0.052	0.977 ± 0.074
SL 635 D	1.006 ± 0.049	0.912 ± 0.051
SL 616 D	1.000 ± 0.035	0.990 ± 0.071

G. Hülsen, J. Gröbner, A. Bais, M. Blumthaler, P. Disterhoft, B. Johnsen, K. O. Lantz, C. Meleti, J. Schreder, J. M. Vilaplana Guerrero, and L. Ylianttila, Intercomparison of erythemal broadband radiometers calibrated by seven UV calibration facilities in Europe and the USA, **Atmos. Chem. Phys., 8**, 4865-4875, 2008

pmod wrc

FARIN Intercomparison of multiband filter radiometers

Organised by NRPA, Norway in Oslo in Summer 2005.

33 participating Instruments

Multiband filter radiometers: GUV, NILU-UV, UV-MFRSR

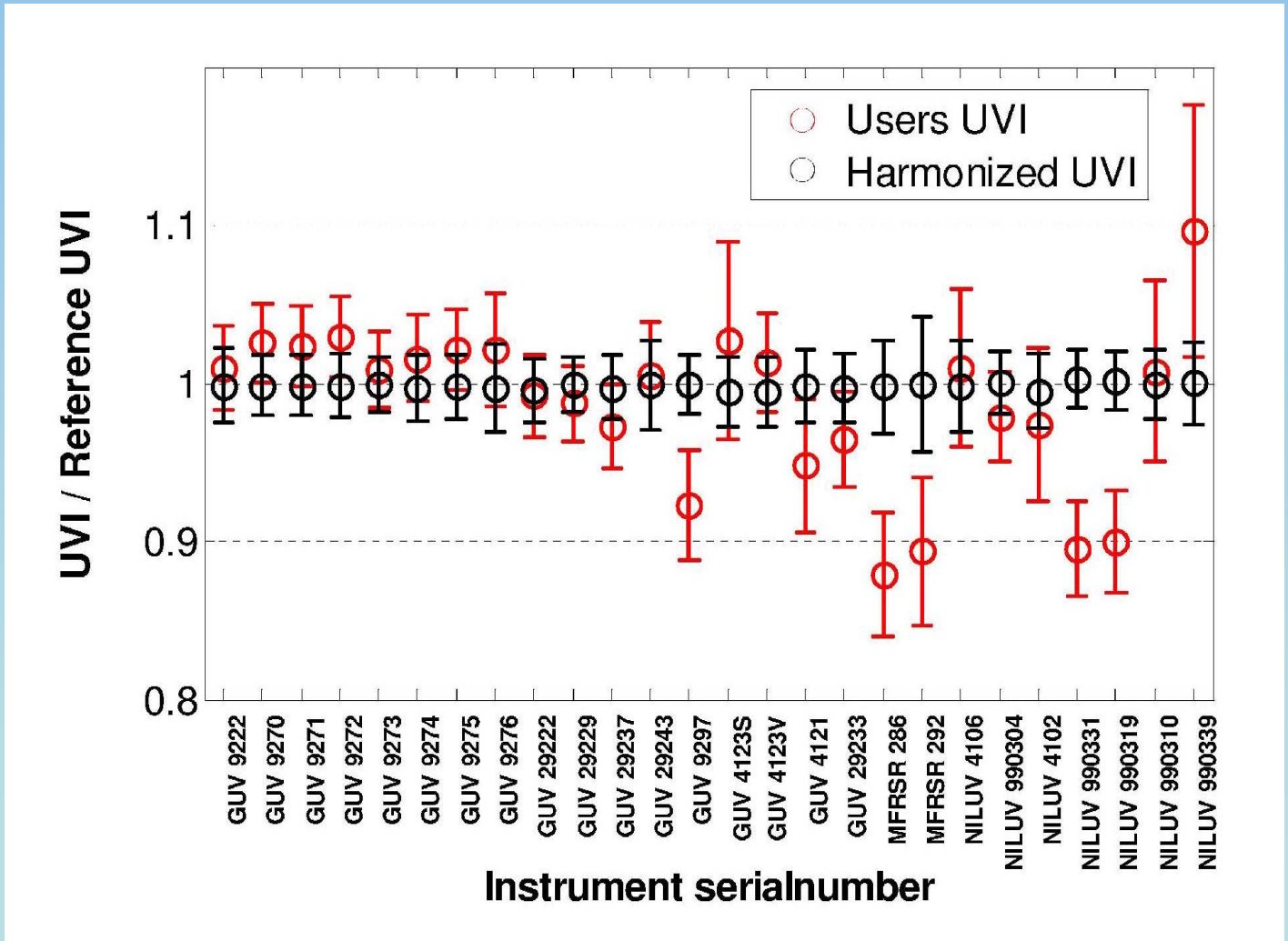
Instrument	Number of channels	Nominal wavelengths, nm	FWHM, nm	Manufacturer
NILU-UV I	6	305, 312, 320, 340, 380, PAR (400-700)	10	NILU Products AS
NILU-UV II	6	305, 312, 320, 340, 380, PAR (400-700)	10	NILU Products AS
GUV-511	5	305, 320, 340, 380, PAR (400-700)	10	Biospherical Instruments, Inc
GUV-541	5	305, 312, 320, 340, 380	10	Biospherical Instruments, Inc
GUV-2511	7 (8)	305, (305), 313, 320, 340, 380, 395, PAR (400-700)	10	Biospherical Instruments, Inc
MFRSR	7	300, 305, 311, 317, 325, 332, 368	2	Yankee Environmental System, Inc

courtesy B. Johnsen, NRPA

Statens strålevern
Norwegian Radiation Protection Authority

pmod wrc

FARIN Intercomparison Results:



B. Johnsen et al., JGR, 2007.

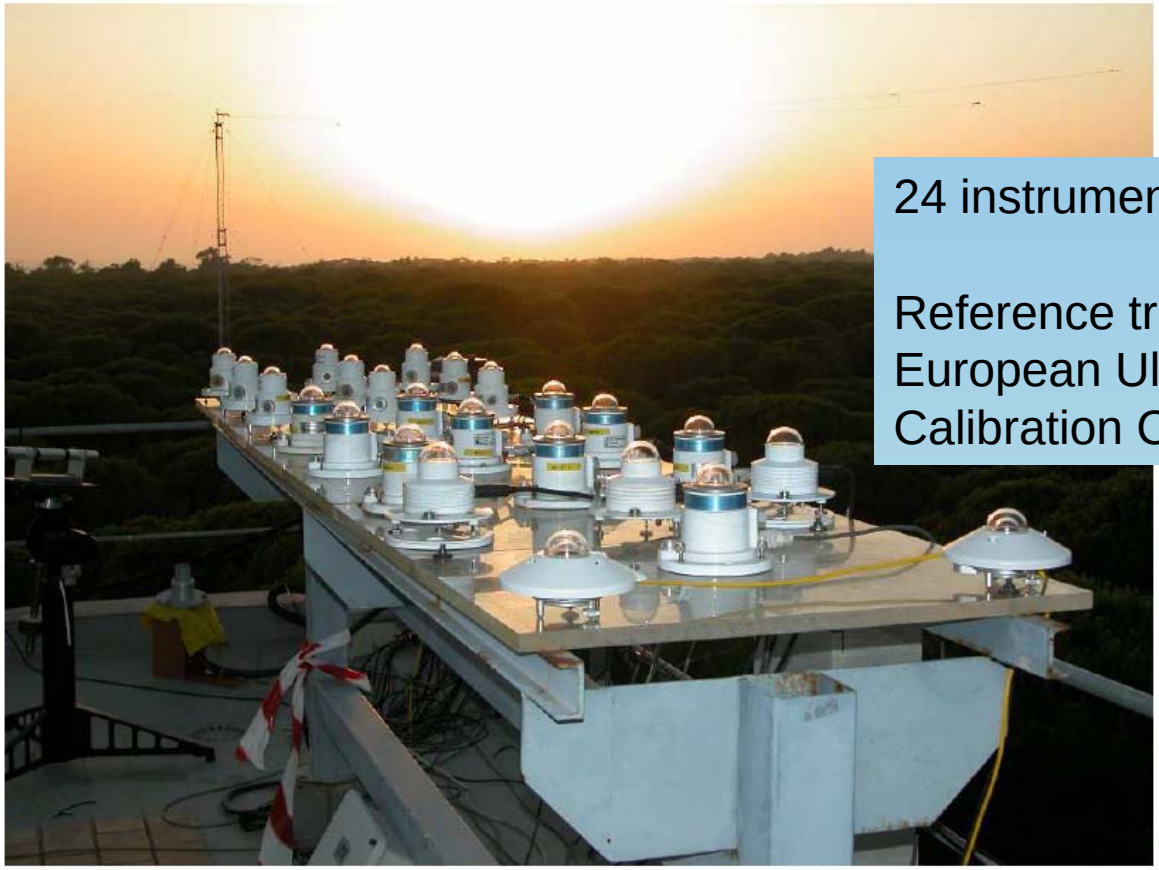
pmod wrc

National Spanish Intercomparison of broadband radiometers in September 2007

Figure 1: ”El Arenosillo” Station, in Huelva, south-western Spain

pmod wrc

National Spanish Intercomparison of broadband radiometers in September 2007



24 instruments

Reference traceable to the European Ultraviolet Calibration Center (EUVC)

Figure 10: Broadband radiometers installed on the terrace of El Arenosillo Station.

pmod wrc

Summary COST 726 WG4 activities

1) **European UV Calibration Center** has been created under the auspices of the GAW Program of the WMO to harmonize UV measurements in Europe.
2) UV Quality Assurance program implemented.
3) Uniform broadband filter radiometer equation formulated.
4) 3 filter radiometer campaigns were held between 2005 and 2007.
5) 4 COST reports published (partly in collaboration with the WMO).
6) 3 refereed publications.

pmod wrc