Annex 3
to Doc.WGCEM/1/00

COST

COST Action 726

Long term changes and climatology of UV radiation over Europe

PROGRESS REPORT

Period: from March 2004 to August 2006
(Start date of the Action) (last update)

This Report is prepared by the Management Committee of the Action and presented to the relevant Technical Committee or directly to the Committee of Senior Officials.
The report is a "cumulative" report, i.e. it is updated annually and covers the period beginning from the start date of the Action.

CONTENTS

1. OVERVIEW: ACTION IDENTIFICATION DATA

(Fill and update the attached table "Action identification data" attached at the end)

2. OBJECTIVES

The aim of the action is to determine a UV radiation climatology and asses UV changes over Europe in the past, also for time and regions where UV measurements are not available. This will be done by UV reconstruction models that use available proxy atmospheric and ancillary data as input parameters. The results will be analysed with respect to different biological UV effects. To use only high quality measurements, a quality control for UV radiometers is planned.

3. TECHNICAL DESCRIPTION AND IMPLEMENTATION

To meet the Action's scientific and technical programme, four working groups were established, corresponding to the eight research areas identified.

WG1 – Data collection (Leader: Dr. Hugo de Backer)

- Inventory and collection of measured ancillary data.
- Inventory of available high quality UV-measurements.

WG2 – UV modelling (Leader: Dr. Peter Köpke)

- Identify models suited for building an European climatological dataset of UV radiation.
- Generate a prototype subset for a European UV climatology for evaluation purposes, using different models and ancillary data.
- Quality check of UV climatologies modelled by different algorithms, both against each other and against measured data.
- Modelling long time UV series with high spatial and temporal resolution for selected biological processes.
- Calculation of UV trend patterns and their temporal variability.
- Establishing the sources of UV trend variability over Europe.
- Visualisation with respect to beneficiaries needs.
- European UV climatology assessment.

WG3 – Requirements for biological UV effects (Leader: Dr. Alois Schmalwieser)

- Collection of action spectra for photobiological effects induced by UV radiation and selection of representative action spectra.
- Derivation of requirements for ancillary data collection, reconstruction, climatology and trend analysis.
- Recommendation of biological action spectra, time resolution and other requirements for UV modelling.

- Dissemination of information on the biological importance of effective UV radiation and gained results to a broader audience.

WG4 – Quality Control (Leader: Dr. Julian Gröbner)

- Drafting and implementation of common Q/A and Q/C procedures.
- Characterisation and intercomparison of selected broadband radiometers.

The Action has been operating in the Annual Grant system since June 2005. The Annual Grant Agreement has been signed by the COST Office and the Institute of Meteorology and Water Management, (IMWM) Poland. Therefore, the Grant Holder Secretariat has been established. All documents, such as reports and Minutes, are prepared by Grant Holder Scientific Officer, Mrs Bozena Lapeta, while the financial matters are carried out by Grant Holder Administrative Officer Mrs. Magdalena Malinska.
At the MCM4 in Warsaw, the STSM bureau has been established. The STSM bureau consists of the Chairwoman - Zenobia Litynska and the Vice-chairman - Peter Koepke. The STSM applications are discussed with the WGs chairmen before approving them. Since the first Annual Grant Agreement, the Grant Holder is responsible for STSM management.

4. PARTICIPATION AND COORDINATION

4.1 Management Committee

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Mr. Philipp WEIHS, Dept. of Wasser-Atmosphäre-Umvelt Universitaet für Bodenkultur

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Mr. Hugo De BACKER, Royal Meteorological Institute RMI Observations Department

Mrs. Anne CHEYMOL, Royal Meteorological Institute RMI Observations Department

CYPRUS

Mr. Stelios PASHIARDIS, Meteorological Services Ministry of Agriculture, Natural Resources and Environment

Ms. Sophia LOUCA Meteorological Services Ministry of Agriculture, Natural Resources and Environment

CZECH REPUBLIC

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Mr. Karel ETTLER Dept of Dermatology Faculty Hospital Charles University

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Mr. Paul ERIKSEN, Danish Meteorological Institute Research and Development Dept.

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Mr. Anders LINDFORS, Finnish Meteorological Institute Meteorological Research Division Ozone and UV-radiation Research Group

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Mr. Uwe FEISTER, DWD Meteorologisches Observatorium Lindenberg

Mr. Gunther SECKMEYER (MC substitute), Institut fur Meteorologie und klimatologie

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Mr. Kostar ELEFTHERATOS, Lab. Atmospheric Environment Faculty of Geology and Geo environment University of Athens

HUNGARY

Mr. Zoltán TÓTH, Hungarian Meteorological Service, Measurement Techniques and Methodology

Mr. Zoltán NAGY, Hungarian Meteorological Service, Measurement Techniques and Methodology

ITALY

Ms. Anna Maria SIANI, University of Rome" La Sapienza" Physics Dept

Mr. Gaetano ZIPOLI, CNR-IBIMET

NETHERLANDS

Mr. Michiel van WEELE, Royal Netherlands Meteorological Institute (KNMI)

Mr. Harry SLAPER, Laboratory of Radiation Research National Institute of Public Health and the Environment (RIVM)

NORWAY

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POLAND

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ROMANIA

Mrs Laura MANEA, National Institute Meteorology Hydrology and Water Administration

Mr. Constantin RADA, National Institute Meteorology Hydrology and Water Administration

SLOVAKIA

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Mr. Weine JOSEFSSON, SMHI Atmospheric Research Unit

Mr. Ulf WESTER, SSI Swedish Radiation Protection Authority

SWITZERLAND

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Mr. Julian GRÖBNER, Physikalisch-Meteorologisches Observatorium Davos World Radiation Center (PMOD\WRC)

UNITED KINGDOM

Ms. Ann R WEBB, School of Earth Atmospheric and Environmental Sciences University of Manchester

EC, Joint Research Centre (JRC)

Mr. Jean VERDEBOOT, Joint Research Centre

WMO, World Radiation Data Centre (WRDC)
Mr. Anatoly TSVETKOV, Voeikov Main Geophysical Observatory

4.2 **Participating Institutions**

Institute of Medical Physics and Biostatistics University of Veterinary, Austria
Dept. of Wasser-Atmosphäre-Umvelt Universitaet für Bodenkultur, Austria
Royal Meteorological Institute RMI, Belgium
Meteorological Services Ministry of Agriculture, Cyprus
Solar and Ozone Observatory Czech Hydrometeorological Institute, Czech Republic
Dept of Dermatology Faculty Hospital Charles University, Czech Republic
Danish Meteorological Institute Research and Development Dept., Denmark
Tartu Observatory Ministry of Education and Science, Estonia
Finnish Meteorological Institute Meteorological, Finland
Université des Sciences et Technologies de Lille, France
Univesité J. Fourier CNRM/GMME, France
Meteorological Institute University of Munich, Germany
DWD Meteorologisches Observatorium Lindenberg, Germany
Institut fur Meteorologie und klimatologie, Germany
Aristotle Univ. of Thessaloniki, Greece
University of Athens, Greece
Hungarian Meteorological Service, Hungary
University of Rome " La Sapienza", Italy
CNR-IBIMET, Italy
Royal Netherlands Meteorological Institute (KNMI), Netherlands
National Institute of Public Health and the Environment (RIVM), Netherlands
Norwegian University of Science and Technology Department of Physics, Norway
Norwegian Radiation Protection Authority, Norway
Institute of Meteorology and Water Management, Poland
Institute of Geophysics Polish Academy of Sciences, Poland
Instituto de Meteorologia de Portugal, Portugal
National Institute Meteorology Hydrology and Water Administration, Romania
Slovak Hydrometeorological Institute, Slovakia
Geophysical Institute Slovak Academy of Science, Slovakia
Instituto Nacional de Técnica Aeroespacial, Spain.
Instituto Nacional de Meteorologica, Spain
Swedish Meteorological and Hydrological Institute, Sweden
SSI Swedish Radiation Protection Authority, Sweden
Meteo Swiss, Switzerland
Physikalisch-Meteorologisches Observatorium Davos World Radiation Center (PMOD\WRC), Switzerland
University of Manchester , UK
Joint Research Centre (JRC), EC
World Radiation Data Centre (WRDC), WMO

4.3 **Meetings of the Management Committee**

MCM1, 29 March 2004, Brussels, Belgium

MCM2, 8-9 June 2004, Kos, Greece

MCM3, 21-22 October 2004, Warsaw, Poland

MCM4, 18-19 April 2005, Špindreluv-Mlýn, Czech Republic

MCM5 and Internal Workshop, 5-7 September 2005, Garmisch-Partenkirchen, Germany, (joined with ICB 2005)

MCM6 6-7 April 2006, Larnaca, Cyprus

4.4 **Meetings of the Working Groups**

WG4 Meeting, 21-22 October 2005, Davos, Switzerland

WG1 & WG2 meeting, 6-7 April 2006, Larnaca, Cyprus

WG3 meeting, 6-7 April 2006, Larnaca, Cyprus

WG4 meeting, 6-7 April 2006, Larnaca, Cyprus

WG3 Meeting, 8-9 June 2006, Warsaw, Poland

4.5 **Short-term scientific missions**

11-17 September 2004, Julian Gröbner, European Reference Centre for Ultraviolet Radiation Measurements (ECUV), Institute for Health and Consumer Protection, Joint Research Centre (JRC), Polish, "Calibration of the IMWM reference broadband UV-Biometer SL501, serial number 0935";

13-17 December 2004, Julian Gröbner, European Reference Centre for Ultraviolet Radiation Measurements (ECUV), Institute for Health and Consumer Protection, Joint Research Centre (JRC), Spanish, "Calibration of broadband UV radiometers, and comparison of the agreement between the calibration facilities in JRC and INTA";

16 May – 03 June 2005, Bjørn Johnsen Norwegian Radiation Protection Authority, Oslo, Norway; Greek, "Participation in the NRPA Intercomparison of Multiband Filter Radiometers";

16 May – 03 June 2005, Bjørn Johnsen Norwegian Radiation Protection Authority, Oslo, Norway; Polish, "Participation in the NRPA Intercomparison of Multiband Filter Radiometers";

22 May 2006 – 2 June 2006, Peter Köpke, Meteorological Institute University of Munich, Germany; Slovak, "Compilation of results of the modelling exercise WG1 and WG2";

31 May 2006 – 9 June 2006, Peter Köpke, Meteorological Institute University of Munich, Germany; Polish, "Evaluation of the performance of the UV reconstruction models examined in the modeling exercise WG1 and WG2 using Taylor Diagram tools";

06-19 August 2006, Julian Gröbner, PMOD/WRC, Davos, Switzerland, Austrian, "Spectral UV measurements during the broadband intercomparison at PMOD";

31 July -11 August 2006, Julian Gröbner, PMOD/WRC, Davos, Switzerland, Spanish, "Technical assistance in the PMOD/WRC broadband calibration campaign";

5. RESULTS

The up-to-date status of the Action is consistent with the time-table and objectives. The following stages have been completed:

- The available data for UV reconstruction have been recognised;
- Action's data base have been implemented and it is operated by Finish Meteorological Institute;
- The BSCW package (provided by DWD) was used for data and results access and exchange;
- The data Protocol has been agreed and has to be signed by all data-base and BSCW users;
- The data from selected six stations were made available to UV reconstruction models;
- The Data Protocol has been approved and sent out to all Action members;
- Update of the list of potential available data sets.
- The BSCW tool is now operational.
- Quality check of different algorithms and of input data for the UV reconstruction was completed.
- Models suited for building an European climatological dataset of UV radiation were identified.
- The Action's web page project was accepted by MC and the web page is now available at the site: http://i115srv.vu-wien.ac.at/uv/COST726/ Cost726.htm
- The modelling exercise has been performed, using well defined input data prepared by WG1. Thirteen WG2 members with sixteen models and algorithms took part in the exercises and the results were presented at MCM6. The modelling exercise was very successful. Models that are suitable to perform the COST action have been identified. Moreover, a large body of data is available which can be used for many scientific questions, like practical aspects of cloud, aerosol or albedo effects on UV and model improvement. As an outcome, the paper describing the modelling exercises was prepared and submitted for SPIE 2006 Conference (see **Annex 1**);
- The first draft of the report from the modelling exercise was prepared by WG2.
- The calibration/comparison campaign of the broadband UV radiometers was held at PMOD/WRC Davos from 1 to 26 August 2006. It consisted of 2 weeks of laboratory characterizations of all participating radiometers and two weeks of outdoor measurements for the absolute calibration based on the QASUME spectroradiometer.
- Following the decision of MC made during MCM6, the Standard Operating Procedures for broadband instrument was prepared separately by COST-726

WG4 in the cooperation with the contributors to UV SAG of WMO. The draft has been sent out to the national delegates for consideration and acceptance.

6. DISSEMINATION OF RESULTS

6.1 Publications and Reports

P. Koepke, et. al, “UV exposure in Europe during the past”, in Proceedings of the 17th International Congress of Biometeorology, ICB 2005 Annale der Meteorologie, 41, 2, 659-662;
Eerme K., “Variation of total solar radiation and estimated erythemal UV doses in Estonia during 1953-2004”, in Proceedings of the 17th International Congress of Biometeorology, ICB 2005 Annale der Meteorologie, 41, 2, 663-666;

6.2 Conferences and Workshops

17th International Congress of Biometeorology 2005, 5-9 September 2005, Garmisch-Partenkirchen, Germany.

Mr. Peter Koepke, the leader of WG2, was one of the UV session convenors. The session consisted of 9 oral presentations and 13 posters, among which 5 oral and 9 poster presentations were submitted by members of the Action COST-726 (see **Annex 2**).
Mr Alois Schmalwieser, the leader of WG3, gave the presentation titled “UV and vitamin D” presented in the frame of the Plenary II session.
Mr Kalju Eerme gave the presentation titled “Variation of total solar radiation and estimated erythemal UV doses in Estonia during 1953-2004”

A COST-726 Internal Workshop, joined with ICB Symposium, took place on 6-7 September 2005. The workshop consisted of 19 posters presenting the first results on the UV reconstruction as well as the Action progress in other fields (see **Annex 3**).

6.3 Web site

The Action’s web site has been accepted by MC and is run by University of Veterinary Medicine, Vienna, Austria. The web page is available at the following site: http://i115srv.vu-wien.ac.at/uv/COST726/Cost726.htm
The web page is divided into three parts: Challenge, Meeting the challenge, Outcomes “The Challenge” contains the information concerning the UV radiation, its climatology and the goals of COST-726 Action. In the chapter “Meeting the Challenge” information about the Action, its structure, members and activities is presented. “Outcome” chapter contains the Minutes from the meetings, the Progress Reports as well as the Public Information that includes any form of dissemination of COST-726 results on different forum.
The we page includes the password-protected zone that contained all the documents and information that should be available only for Action’s

members. The decision concerning the content of this zone is made by the MC or by the individual authors. The last applies to the presentations.
The web-site construction and maintenance was subsided with 1500 €.

6.4 Scientific and Technical Cooperation

The Action cooperates with EU project SCOUT. Members of the Action's MC are involved in the project activities and the information as well as the results are being exchanged;

At the MCM3 meeting in Warsaw, the Vice-chairwoman of COST Action 719, Izabela Dyras presented the applications of GIS method to meteorology and climatology.

The Head of the WMO, World Radiation Data Centre (WRDC) in Petersburg, Russia, dr Anatoly Tsvetkov had a presentation on: The WMO World Radiation Data Centre - 30 years of its activity. He was asked to join the Action.

·One member of COST Action 726, Bozena Lapeta was hosted by COST Action 719 at their meeting in Budapest and she participated in the Conference on the Spatial Interpolation Techniques in the Climatology and Meteorology, 25-28 October 2004, Budapest, Hungary.

The experts from the outside of UV community, dealing with influence of UV on environment, were invited to cooperate. Their remarks and suggestion are taken into account while preparing the COST-726 outcome.

The cooperation and contacts were established with the UV SAG WMO group in order to prepare the 'Standard Operating Procedure' guide.

Permanent observers to Action COST-726 are: Mr. Georgios Amanatidis – EC DG Research, Ms. Liisa Jalkanen – WMO, and Mr. Peter Havranek - TC on meteorology (ESSEM).

6.5 Transfer of results

7. ECONOMIC DIMENSION

(List estimate of total manpower expressed in person-year dedicated to the activities of the action for each year and the total duration of the action)

2004:	1 650 000 €
2005:	2 200 000 €
01-08/2006	1 467 000 €
Total for the period:	5 317 000 €

For the whole duration of the Action: 11 000 000 €.

The costs in 2004 – June 2005

Secretariat:	?? €
Publications:	?? €
Workshops and Seminars:	?? €
MC and WGS Meetings:	101 743.00 €
STSM	5 005.00 €
Others	?? €
Total for the period:	**106 748.00 € (???)**

Following the MC decision made at MCM4, the Annual Grant Agreement has been signed by the COST Office and the Institute of Meteorology and Water Management, (IMWM) Poland.

1st July 2005 to 30th June 2006

Secretariat:	11 749.85 €
Publications:	0.00
Workshops and Seminars:	0.00
MC and WGS Meetings:	62 808,36 €
STSM	3 852.00 €
Others	1 500.00 €
Total for the period:	**79 910.21 €**

Expenditure for the Action's duration: 186 658.21 €

8. **SELF EVALUATION** (only in the last annual progress report)

Action Identification Data

COST Action ***726*** ***Long term changes and climatology of UV radiation over Europe***

TC Recommendation: *(day/month/year)*
CSO Approval: *(03/10/204)*
Start date: *(08/01/2004)* [(1)]
Duration: *60*
Extension:
End date: *(28/03/2009)*

First MC meeting: *(29/03/2004)*
Last MC meeting: *(day/month/year)*
Final Report: *(day/month/year)* [(2)]
Evaluation Report: *(day/month/year)* [(2)]
TC Evaluation: *(day/month/year)*

Number of signatories: *22*
Signatories and date of signature: *(day/month/year)*

Austria 02/02/2004
Belgium 08/01/2004
Bulgaria
Croatia
Cyprus 08/01/2004
Czech Rep. 20/04/2004
Denmark 18/10/2004
Estonia 08/01/2004
Finland 08/01/2004
France 07/05/2004
Germany 29/01/2004
Greece 04/06/2004
Hungary 12/01/2004
Iceland
Ireland
Italy 22/06/2004
Latvia
Lithuania
Luxembourg
Malta
Netherlands 14/01/2004
Norway 02/03/2004
Poland 08/01/2004
Portugal 27/06/2004
Romania 16/03/2004
Slovakia 11/06/2004
Slovenia
Spain 25/02/2004
Sweden 08/01/2004
Switzerland 18/03/2004
Turkey
United Kingdom 22/04/2005

Institutes of non-COST countries:
World Radiation Data Center (WRDC), St. Petersburg (RU)
Area: ESSEM
Action Web site: http://i115srv.vu-wien.ac.at/uv/COST726/Cost726.htm
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TC Rapporteur: *Mr. Peter HAVRANEK Czech Hydrometeorological Institute*
External Evaluator: *Title, name, affiliation, country*
External Evaluator: *Title, name, affiliation, country*

(1) When 5 Signatures have been collected
(2) When the report is received by TC Secretariat

Annex 1

Modelling solar UV radiation in the past: Comparison of algorithms and input data

P. Koepke [(1)], H. De Backer [(2)], A. Bais [(3)], A. Curylo [(4)], K. Eerme [(5)], U. Feister [(6)], B. Johnsen [(7)], J. Junk [(8)], A. Kazantzidis [(3)], J. Krzyscin [(9)], A. Lindfors [(10)], J. A. Olseth [(11)], P. den Outer [(12)], A. Pribullova [(13)], A. W. Schmalwieser [(14)], H. Slaper [(12)], H. Staiger [(15)], J. Verdebout [(16)], L. Vuilleumier [(17)], P. Weihs [(18)]

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ABSTRACT

The objectives of the COST action 726 are to establish long-term changes of UV-radiation in the past, which can only be derived by modelling with good and available proxy data. To find the best available models and input data, 16 models have been tested by modelling daily doses for two years of data measured at four stations distributed over Europe. The modelled data have been compared with the measured data, using different statistical methods. Models that use Cloud Modification Factors for the UV spectral range, derived from co-located measured global irradiance, give the best results.

Keywords: UV-radiation; UV-modelling; UV-climatology; UV data base; UV proxy data

1. INTRODUCTION

The variation of UV-irradiance during the last decades is of interest for skin cancer development and other long-term studies of UV effects. Thus, to determine the geographical distribution of the UV-daily dose for whole Europe during the last 50 years, the COST action 726 "Long term changes and climatology of UV radiation over Europe" has been established [(1)]. UV-radiation in the past can only be obtained by using adequate models running with the correct input data, i.e. values of the parameters that affect the solar UV radiation at the surface. Consequently, available numerical models and algorithms have been recorded, and the availability has been tested, both of the meteorological data, which are needed to run these models for different places in Europe, and of measured UV data that can be used to check the model results.

2. METHOD

To test the model quality, erythemal weighted daily dose have been calculated by each model and compared with measured values.
The reason for erythemal weighting was its relevancy for human health damage and it is the quantity that has been measured most frequently. The daily dose has been chosen as a compromise between the temporal resolution that is available for the input data and what is needed to investigate biological UV-processes. To check the widest range of meteorological conditions, two complete years have been chosen as time interval, 1999 and 2002, and four stations distributed over Europe:
Bergen (Norway, 60,4° N, 5.3° E, 45 m a.s.l.),
Davos (Switzerland, 46.8° N, 9.8° E, 1590 m a.s.l.)
Potsdam (Germany, 52.4° N, 13.1° E, 107 m a.s.l.)
Thessaloniki (Greece, 40.6°N, 23.0°E, 60 m a.s.l.)

The modelled daily doses have been compared with the measured data with absolute differences for each day. To get a final estimation of the model quality, a combination of model-measurement correlation together with equality of root mean square values of the modelled and the measured data has been used, as proposed by Taylor [2].

3. OBSERVATIONAL DATA

For the four stations and two years that should be modelled, observational data have been made available by working group 1 of the COST-action [1], which should be used by all modellers. An overview of the measured data is listed in the Table 1. The way how to use these data and to derive the needed input data, e.g. surface albedo from snow information or cloud impact on UV from solar radiation or cloud cover, was decided by the modellers as part of their algorithm.

	Bergen	Potsdam	Davos	Thessaloniki
Cloud cover	X	X	X	X
(relative) sunshine duration	X	X	X	X
Diffuse solar radiation	X	X	X	
Global solar radiation	X	X	X	X
Visibility	X	X	X	X
Snow height	X	X	X	
Snow age			X	
Ozone	TOMS	Dobson or Brewer	Dobson (Arosa)	Brewer

Tab. 1. List of meteorological, radiation and ozone data made available for the modelling exercise. Meteorological and radiation data are from meteorological or synoptic observations.

The UV-index data, which have been used to get the UV-daily doses used for the comparisons, are from measurements with broadband Instruments or derived from spectral measurements as specified for the stations in the following.
The UV-measurements for Bergen are based on a GUV multiband filter radiometer from Biospherical Instruments Inc with 5 detector channels in the UV. A linear combination of the output from different detector channels forms the basis for deriving CIE-effective doses. The absolute calibration is traceable to the Nordic Ozone Group international intercomparison of global sky instruments in Tyløsand, Sweden, 2000.
Erythemally weighted UV irradiance at Potsdam was integrated from UV spectra measured by a Bentham DM150 double monochromator. Calibration has been based on standard lamps of the FEL1000W type calibrated by the Physikalisch-Technische Bundesanstalt (PTB) in Germany. Due to a wrong data file for 1999, only UV-measurement for 2002 have been used for the comparison.
The daily UV data for Davos are integrated from 2-minute broadband instrument (Solar light 501) observations. The instrument is operational since 1995.
The UV data for Thessaloniki were produced by an erythemal detector of type YES UVB-1 with temporal resolution of 1 min. The detector is regularly calibrated against two Brewer spectroradiometers, and hence its stability in time is sufficiently controlled to within about ±7%.

4. MODELS

Sixteen models and algorithms took part in the modelling exercise. The way, how to use the available information from the observational meteorological data, is decided individually by each modeller.
All models firstly calculate the UV irradiance for cloud free conditions with one of the high quality radiation transfer models in the UV. These models from the mathematical point of view all give good results [(3)]. The uncertainties mainly come from the uncertainty of the used input parameters to describe the atmosphere. Using the UV-irradiance for cloud free conditions, the cloud effects are taken into account in a second step, which results in additional and variable uncertainty.
The albedo values used for UV-modelling are taken individually by the modellers. They are fixed to low values for summer conditions and to values depending on snow age and snow height for snow conditions.
Measured aerosol information was only visibility and very few dates with measured optical depth. It is known that visibility is only weakly correlated to the aerosol optical depth in the UV and, moreover, besides optical depth also the absorption properties of the aerosol have to be taken into account. Thus many of the modellers used climatolgical vales of optical depth and single scattering albedo, typical for the site, or even fixed values for all stations.

To consider the influence of clouds, generally so called Cloud Modification Factors (CMF) have been used, but with different methods to get their values. CMFs are defined as the ratio between the irradiance under cloudy conditions against that resulting from the atmosphere with the same conditions, but with no clouds.
The CMFs are connected with the cloud conditions either by cloud amount (4, 5), or by cloud amount in different cloud layers (6, 7) or by the correlation of a CMF_{sol} , valid for the complete solar spectral range, to the needed CMF_{UV} , valid for the erythemally weighted UV (8). The latter takes the global solar irradiance as input information, which more often is available as measured quantity than UV irradiance, with the advantage that the actual conditions of the sky really are taken into account. This includes the position of a cloud against the sun, resulting in shadow or even enhancement of irradiance, considers the optical thickness of the clouds in all layers, resulting in change of transmittance, and even includes aerosol effects on the irradiance to a certain amount. To get proper CMF_{UV} the differences of the cloud effects in solar and in UV-spectral range, depending on solar elevation, have to be taken into account (8).
If only the cloud amount is taken to get a CMF_{UV}, the detailed actual information mentioned above is lost and the description of the cloud effects by the CMF is more general, valid only in average (7). On the other hand this description of the CMF_{UV} has the advantage that information on cloud amount more often is available than solar irradiance, especially in the past.
A third method to describe the reduction of UV-daily dose due to clouds is the use of sunshine duration. It is based on the assumption that direct sun is the most important factor for UV daily dose. Consequently, for conditions with the sun not obscured, the irradiance has been modelled as a sky with no clouds at all. For the opposite condition, when the sun is blocked by clouds, overcast conditions have been modelled. These two results have been weighted by sun shine duration. Here again no detailed information on sky properties and their effects have been considered.
With help of a neural network also additional information on the atmospheric conditions besides solar global radiation, like sun shine duration and diffuse irradiance, can be used to describe cloud effects in the UV.

The UV doses can be modelled on hourly values and added to the daily dose, if the measured input data are available, or directly be modelled as daily values. The latter often results in reduced quality, due to daily variations in cloudiness. The way how to interpolate the measured data, which are available with different temporal resolution and at different time, belongs to the modellers.
Since the modelling exercise is going on, and not all reasons for discrepancies have been analysed, the models are described with alphabetic characters and only their basic properties are given (Tab.2). Detailed description of all models and of the final results of modelling-measuring comparison will be presented in a COST booklet (9).

Model	Cloud effects	Temp res.	Aerosol	Albedo
A	CMF_{UV} via CMF_{sol}	hourly	fix SSA, local fix AOD	snow effects
B	CMF_{UV} via CMF_{sol}	daily	climat SSA, climat AOD	snow effects

C	CMF_{UV} via CMF_{sol}	hourly	climat SSA, climat AOD	snow effects
D	broad avail. info	hourly	in cloud effects	in cloud effects
E	CMF_{UV} via CMF_{sol}			
F	CMF_{UV} via CMF_{sol}	hourly	AOD from visibility	snow effects
G	broad avail. info	hourly	fix SSA, fix AOD	snow effects
H	CMF_{UV} via CMF_{sol}	hourly	climat alpha,climat AOD	snow effects
I	CMF_{UV} via CMF_{sol}	hourly	in cloud effects	clim value visible
J	CMF_{UV} using GR_{sol}	hourly	AOD from visibility	snow effects
K	CMF_{UV} via CMF_{sol}	daily	fix SSA, fix AOD	snow effects
L	CMF_{UV} using GR_{sol}	hourly	AOD from direct meas	snow effects
M	sun shine duration	daily	local fix AOD	fix no snow, snow
N	cloud amount	hourly	AOD from visibility	snow effects
O	sun shine duration	hourly	AOD from visibility	snow effects
P	sun shine duration	daily	no aerosol	

Tab. 2. General properties of models

The different methods to get CMF_{UV} can be applied by using data that are individually adapted for each of the sites to be modelled. These “local” models have the advantage to take into account the climatological conditions of the site, but have the disadvantage that they cannot be applied directly for the whole of Europe as they have to be trained first with data from very many positions, which often are not available or even do not exist. The “general” models that use one parameterization for all sites easily can be used to produce UV-maps. The sunshine duration models, of course, are general.

5. RESULTS

The agreement between measured and modelled data is shown as differences, modelled minus measured daily dose, as function of the day in the year. Presented are two examples, namely Bergen 2000 (Fig.1) and Thessaloniki 2000 (Fig.2), two stations with very different latitude to show effects of different climate and solar elevation. Absolute differences are shown for the comparison, since the absolute doses are relevant for human health.

Measured daily UV-doses do not exist for all days, and also not all modellers calculated UV-doses for all days, especially if one of the meteorological quantities used as input parameter was not available. To perform the comparison of the modelled results on the basis of equal days, only those days have been used, which were available from all modellers.

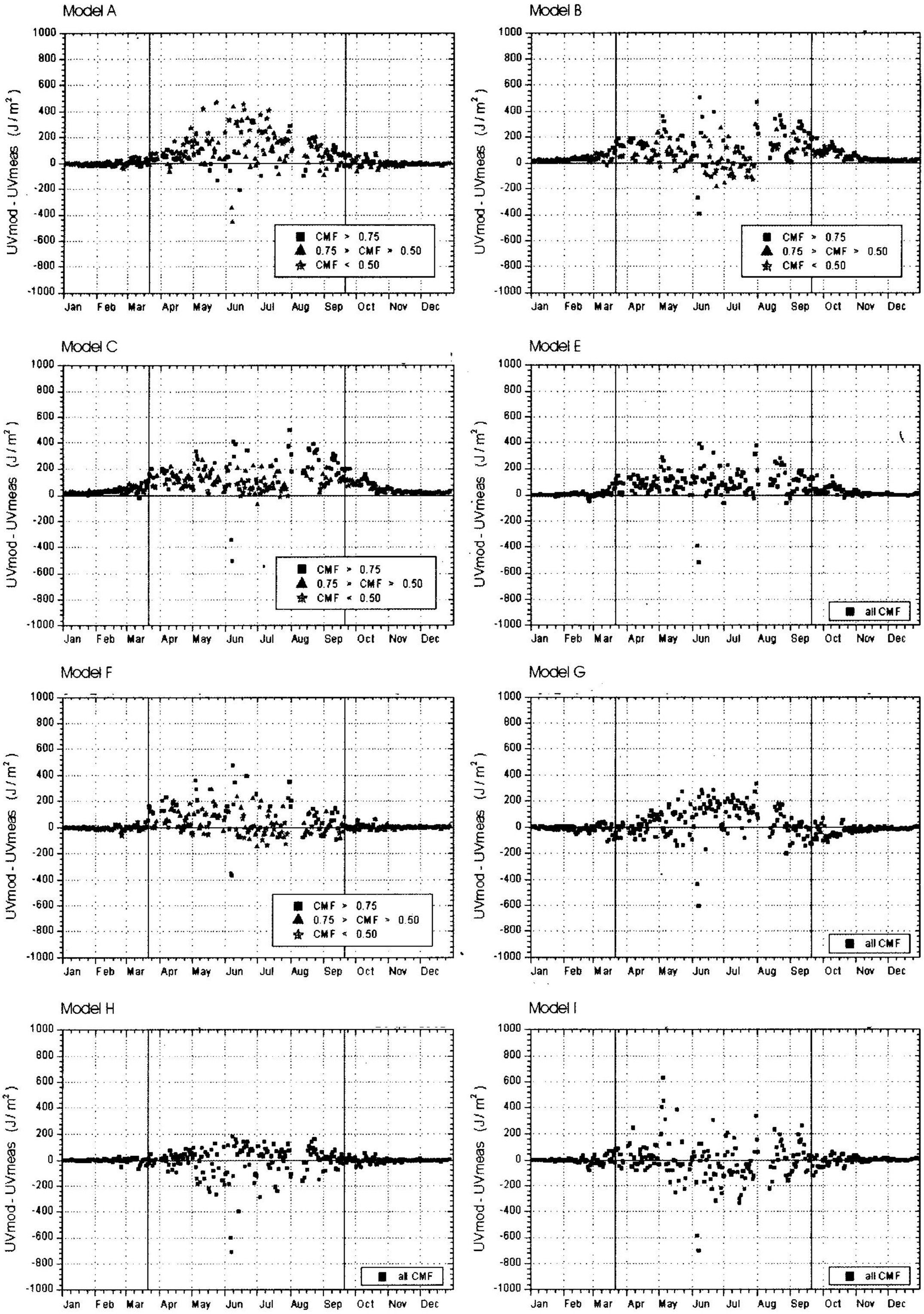

Fig. 1a Differences between modelled and measured daily UV dose for Bergen 2002
Models as shown on the separated figures with the letter given in Tab.2.

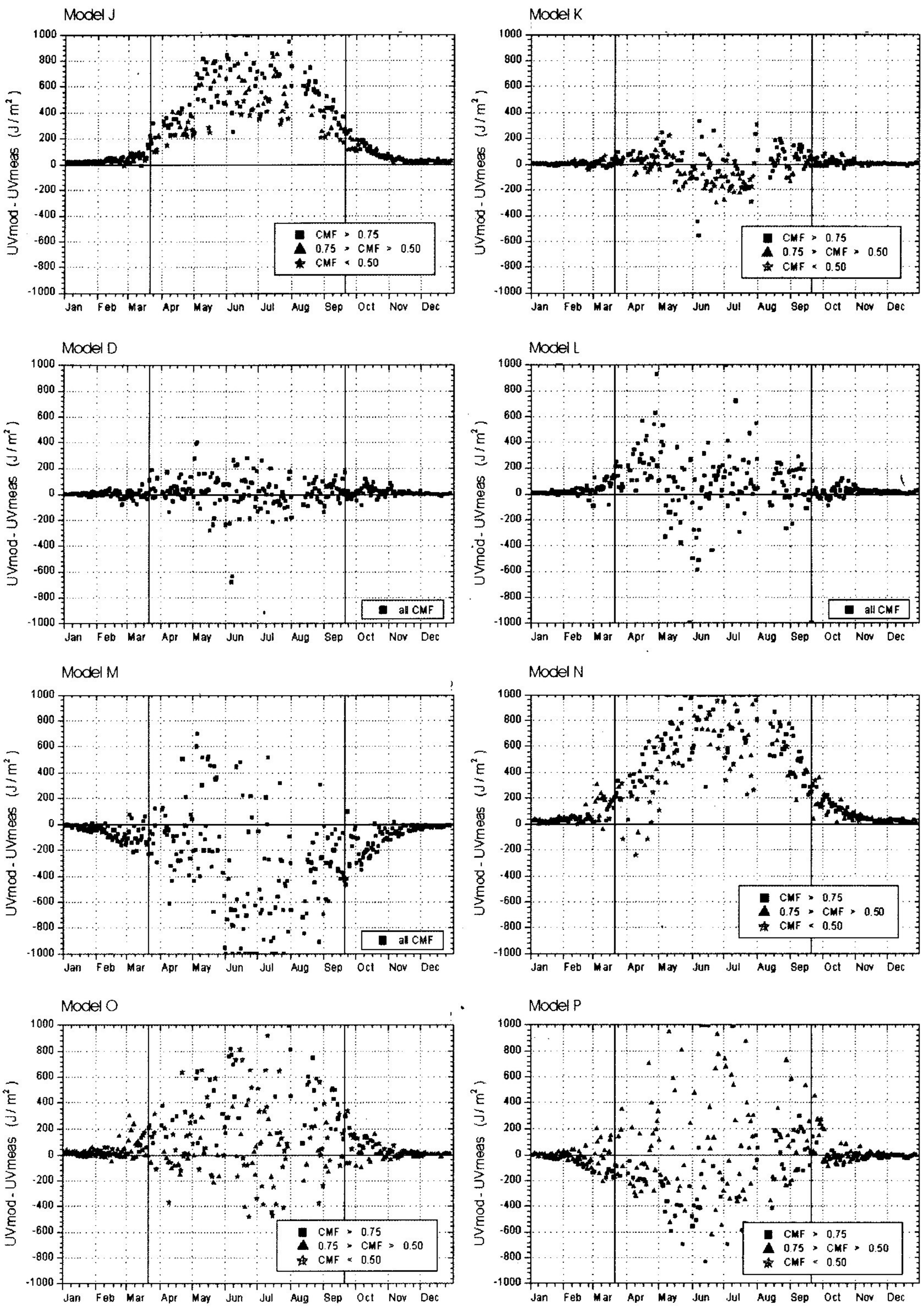

Fig. 1b Differences between modelled and measured daily UV dose for Bergen 2002
Models as shown on the separated figures with the letter given in Tab. 2

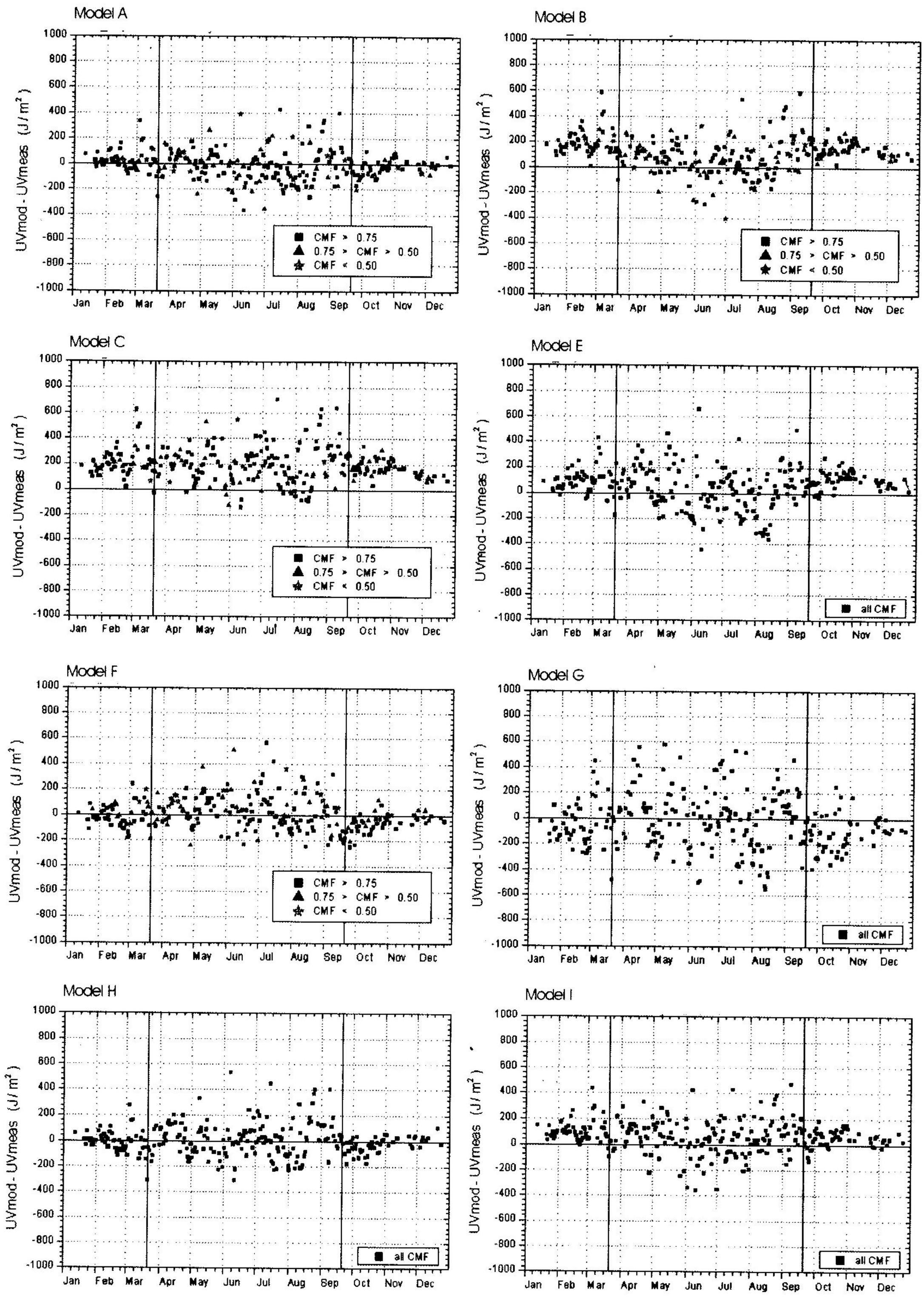

Fig. 2a Differences between modelled and measured daily UV dose for Thessaloniki 2002
Models as shown on the separated figures with the letter given in Tab. 2

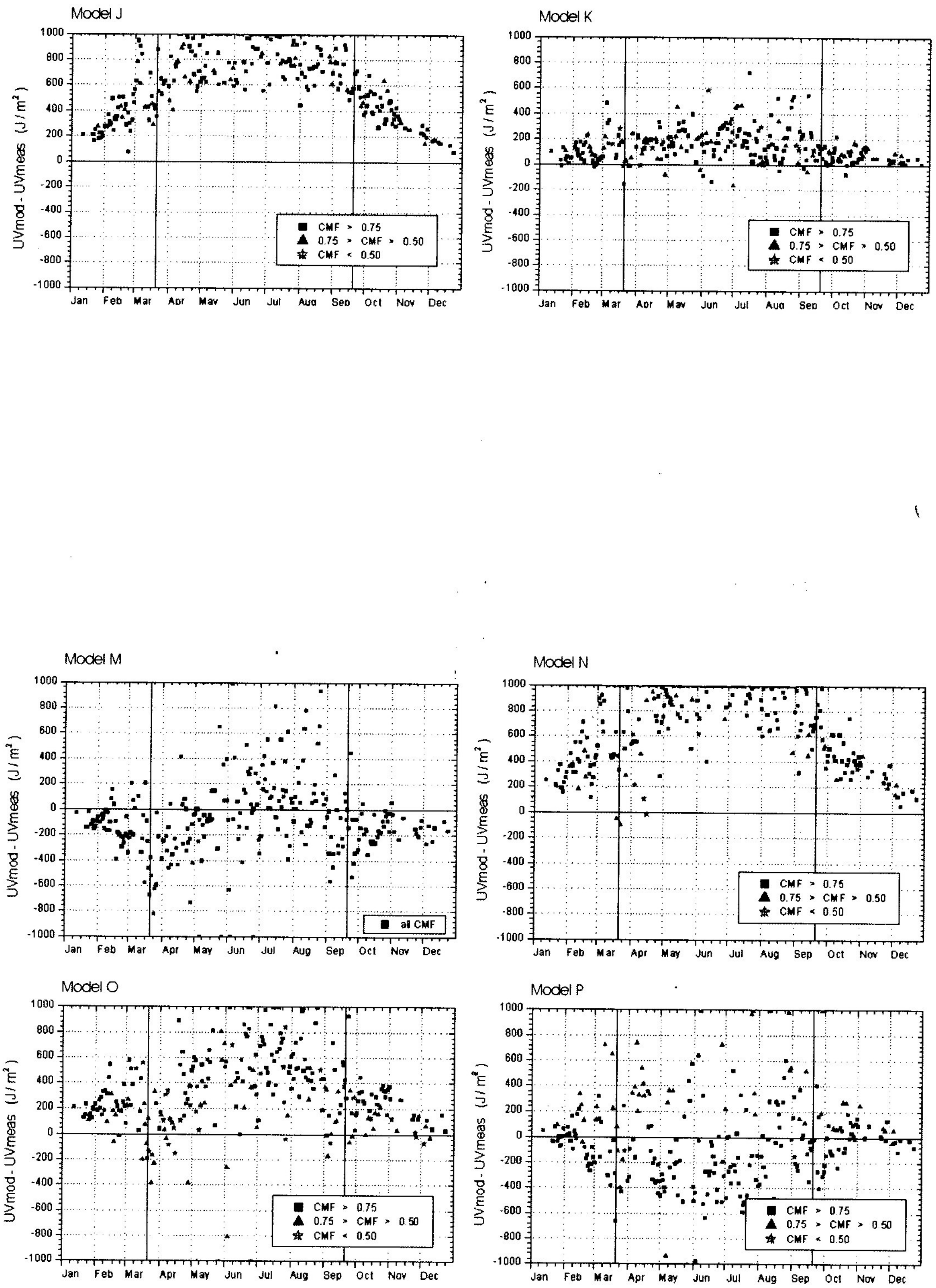

Fig. 2b Differences between modelled and measured daily UV dose for Thessaloniki 2002
Models as shown on the separated figures with the letter given in Tab. 2.

Within Figs. 1 and 2 each graph shows the result for one model, denoted with the character from Tab. 2. Model D is not between C and E, but on the second page due to technical reasons. For Thessaloniki, data from models D and L are not available. If the value of the CMF is known, the data are separated by symbol for conditions with low (CMF > 0.75), medium (0.75 >= CMF > 0.50) and large attenuation due to clouds (CMF<0.50). Values exeeding 1000 J/m² are clipped to the 1 kJ/m² line and negative values accordingly, to have the same range in all figures. The days 21 March and 21 September are shown with vertical lines, to separate the summer time.

The possibility for large absolute differences increases with increasing daily doses. Thus the differences for the winter time generally are lower, especially for Bergen, independent of the model. For Thessaloniki even in winter larger deviations occur due to rather high daily doses due to high sun and low cloudiness.
The agreement for the models A to K, which use the information from solar global irradiance, is clearly better, then that for the models M to P which do not. From the rather bad agreement of models J and L it can be seen that solar irradiance should be used as a basis to convert a CMF_{sol} into a CMF_{UV} and not be used directly. The clear overestimation of the UV dose by models J and N results from the fact that they have been trained with local data, but have been used as general models.

To identify a group of models with the best agreement a method proposed by Taylor [(2)] has been used, which combines in one figure the information on model-measurement correlation and on the equality of root mean square (RMS) values calculated from the modelled and observed data. The results for the absolute deviations are shown in Fig. 3 for 2002 as example for all four stations with the symbol of the model at a point on a polar plot.
The position of this point is given by the correlation coefficient between modelled and measured data (line with increasing slope) and by the ratio of the standard deviation of the model values to that of the observed data (distance from the origin). Using these characteristics to describe the model quality, an ideal model (being in a full agreement with measurements) is marked by the point with coordinates $\varphi=0$ and radius=1. It means the correlation coefficient is equal to 1 and modelled and measured variations have the same amplitude. In case different models have been compared, the quality of the model decreases with increasing distance between its point on the Taylor diagram and the ideal model point (0, 1). Points with the same distance to the point (0,1) are marked as circles.
The analyzed time series of UV daily doses have a strong annual course with the maximum in late spring/early summer and minimum in winter. Thus, any model simulating such behaviour will yield a high correlations coefficient and close RMS value to the observed one. So, to better distinguish between models' performances, the annual pattern has been removed from the analyzed time series. To do this, an annual course is extracted for each year and station for the measured data using the locally weighted scatter (LOWES) smoothing technique and the deviations from the smoothed curves are calculated both for measured and each of the modelled time series.

For the four stations shown in Fig. 3 , the resulting Taylor-points are given in each case for all models, marked by their symbol. The distributions are different for the different stations, but similar patterns can be seen. A group of points, models A, B, C, D, E, F, H, and K, gathers closely to the ideal model point (0,1) and some points appear away from this point. Clearly the models M, N, O, and P, that do not use global radiation as a proxy for the cloud attenuation effects, stay more away than other model points. Models G, J, I, and L, are in between. These are the models that either use the global solar irradiance directly or use a mixture of information to get the $CMF_{UV.}$
To get final insight into the model performance, combination of the results of all four stations and both years have been used. These results confirm the previous finding obtained from individual station and year data. They will be shown in the final report [(9)], but are not yet given, because firstly detailed discussions between the modellers are necessary.

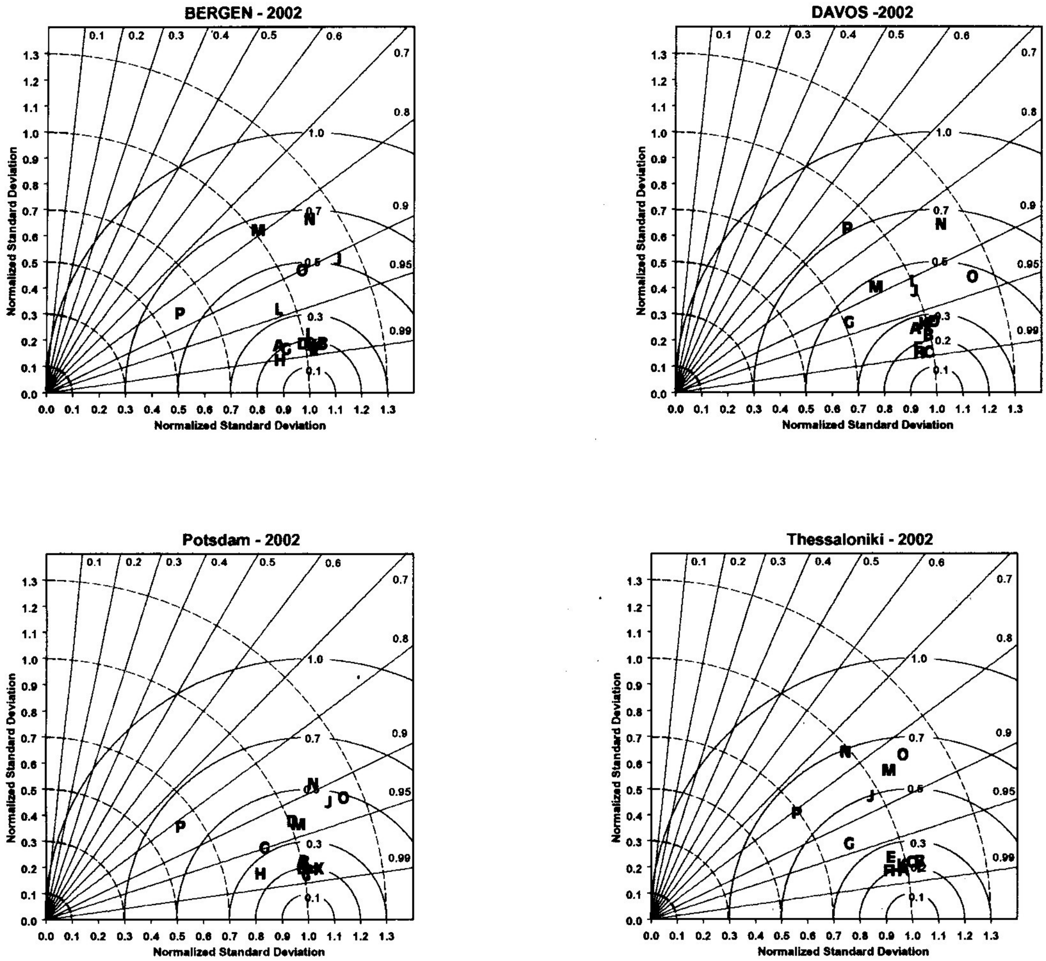

Fig. 3 Taylor diagrams (See text) for absolute deviations between modelled and measured UV doses. The letters stand for the models, as described in Tab.2

6. CONCLUSION

The models with best performance to model erythemal weighted UV daily dose in the past are those that take a CMF_{UV} derived from a measured CMF_{sol} to describe the cloud effects. The reason is that the global solar radiation is affected by the clouds similarly as the UV-radiation. Thus solar irradiance is the most important input parameter to model UV in the past Strong effects of course result from variable ozone, which however is less variable in space and therefore can be taken more easily from old measurements. To determine the quality of the aerosol modelling cloud-free data have to be check independently. As a first result it seems to be better to use climatological aerosol properties with low variability than strong variations inferred from visibility data. In addition, the snow effects should be analysed again, and perhaps can be improved, since the correlation between snow height and age on the one hand, and regional albedo on the other hand, clearly depends on station altitude, longitude and skyline.

The modelling exercise was very successful. Models that are suitable to perform the COST action have been identified. Moreover, a large body of data is available which can be used for many scientific questions, like practical aspects of cloud, aerosol or albedo effects on UV and model improvement.

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Annex 2

17th International Congress of Biometeorology2005, 5-9 September 2005,

Garmisch-Partenkirchen, Germany.

Presentations given by COST-726 members.

Orals:

M. van Weele, et. al, **GSE PROMOTE: Surface UV Radiation**

H. Staiger, et. al, **Global, WHO-Conform Forecast of UV Index for Sites by GSE PROMTE**;

P. Koepke and COST 726 Data and Model Consortium, **UV Exposure in Europe During the Past**;

K.Eerme, **Variations of Total Solar Radiation and Estimated Erythemal UV Doses in Estonia Durin 1953-2004**;

A. Schmalwieser, G. Schauberger, **A First Approach of Forecasting the Vitamin D Effective UV Radiation**;

Posters:

Biszczuk J., Z.Litynska, M.Markowska, **The UV measurements on the Henryk Arctowski Polish Antarctic Stations.** (ICB 2005 P4.01);

Casale G. R., N.Bono, A.M.Siani, M.G.Kimlin, **Response of polysulphone dosimeters exposed under different environmental conditions**, (ICB 2005 P4.08);

Curylo A.., Z.Litynska, **New approach to the UV reconstruction modeling**, (ICB 2005 P4.02);

Litynska Z., A.Curylo, B.Kois, B.Lapeta G.Zablocki, **The UV Index forecasting and nowcasting in Poland**, (ICB 2005 P4.03);

Schmalwieser A., and G.Schauberger, **Modelling the spatial distribution of the biologically effective radiation from measurements at certain sites**, (ICB 2005 P4.06);

Schmalwieser A., et al., **Comparison of spatial resolution, temporal resolution and measuring uncertainties of total ozone content as an input to calculate the erythemally effective UV radiation**, (ICB 2005 P4.07);

Simic S., P.Weihs, H.Kromp-Kolb, A.Vacek, and W.Laube, **Influence of ground albedo and cloudiness on ground UV at Sonnblick observatory (3106m, Austria): model – measurements comparison**, (ICB 2005 P4.09);

Van Weele M., et al., **GSE PROMOTE: surface UV radiation**, (ICB 2005 P4.11);

Verdebout J., and Diana Rembges, **A satellite-derived UV climatology over Europe: dataset and application to human exposure and marine biology**, (ICB 2005 P4.12);

Annex 3

COST-726 Internal Workshop

6-7 September 2005Garmisch-Partenkirchen, Germany

List of the posters

Biszczuk J., Z.Litynska, M.Markowska, **The UV measurements on the Henryk Arctowski Polish Antarctic Stations.** (ICB 2005 P4.01);

Casale G. R., N.Bono, A.M.Siani, M.G.Kimlin, **Response of polysulphone dosimeters exposed under different environmental conditions**, (ICB 2005 P4.08);

Cheymol A., H. De Backer, A. Mangold, R. Lemoine and A. Delcloo, **Impact of the Aerosol Optical Depth at Uccle (Belgium) on the UV index**;

Curylo A.., Z.Litynska, **New approach to the UV reconstruction modeling**, (ICB 2005 P4.02);

Grifoni D., G. Carreras, F. Sabatini and G. Zipoli, **Ultraviolet radiation and eyes damage: incident radiation on tilted surfaces under different environmental conditions**;

Jaroslawski J. and J. Krzyscin, **Importance of aerosol variations for the surface UV-B radiation level**;

Kalju E., **Variation of total solar radiation and estimated erythemal UV doses *in Estonia during 1953-2004***

Kazantzidis A., A. F. Bais, ***Estimation of daily erythemal UV dose at five European stations from measurements of solar irradiance, total ozone and snow observations: first results;***

Kazantzidis A., A. F. Bais, D. S. Balis, E. Kosmidis C. S. Zerefos, **Variations of modeled solar UV irradiance using measured and standard vertical profiles of ozone and temperature**;

Krzyscin J., **Reconstruction of the surface UV doses available for any European site and action spectrum since 1950**;

Lapeta B., and Z.Ustrnul, **Application of the mean monthly visibility maps for Poland to UV modeling**;

Lindfors A., and J.Kaurola, **UV reconstruction method developed at FMI: description and first results;**

Litynska Z., A.Curylo, B.Kois, B.Lapeta G.Zablocki, **The UV Index forecasting and nowcasting in Poland**, (ICB 2005 P4.03);

Pribullowa, A., **Reconstruction of UV-B radiation time series at Skalnaté Pleso (Slovakia) in period 1961-2004**;

Schmalwieser A., and G.Schauberger, **Modelling the spatial distribution of the biologically effective radiation from measurements at certain sites**, (ICB 2005 P4.06);

Schmalwieser A., et al., **Comparison of spatial resolution, temporal resolution and measuring uncertainties of total ozone content as an input to calculate the erythemally effective UV radiation**, (ICB 2005 P4.07);

Simic S., P.Weihs, H.Kromp-Kolb, A.Vacek, and W.Laube, **Influence of ground albedo and cloudiness on ground UV at Sonnblick observatory (3106m, Austria): model – measurements comparison**, (ICB 2005 P4.09);

Sivertsen T. H., **Discussing the scientific method and a documentation system of meteorological parameters. An interpretation of the hypotetico deductive principle**;

Van Weele M., et al., **GSE PROMOTE: surface UV radiation**, (ICB 2005 P4.11);

Verdebout J., and Diana Rembges, **A satellite-derived UV climatology over Europe: dataset and application to human exposure and marine biology**, (ICB 2005 P4.12);

Wester U., **Polysulfon and spore-film UV-dosimeters compared to a UVI-monitoring instrument and two radiation transfer model systems for a UV-dosimetry study 2004 of preschool children**;