pmod wrc

Annual Report 2008

Physikalisch-Meteorologisches Observatorium Davos und Weltstrahlungszentrum

Mission

Das PMOD/WRC

- *dient als internationales Kalibrierzentrum für meteorologische Strahlungsmessinstrumente*
- *entwickelt Strahlungsmessinstrumente für den Einsatz am Boden und im Weltraum*
- *erforscht den Einfluss der Sonnenstrahlung auf das Erdklima*

Auftragerteilung

Das Physikalisch-Meteorologische Observatorium Davos (PMOD) beschäftigt sich seit seiner Gründung im Jahr 1907 mit Fragen des Einflusses der Sonnenstrahlung auf das Erdklima. Das Observatorium schloss sich 1926 dem Schweizerischen Forschungsinstitut für Hochgebirgsklima und Medizin Davos an und ist seither eine Abteilung dieser Stiftung. Auf Ersuchen der Weltmeteorologischen Organisation (WMO) beschloss der Bundesrat im Jahr 1970 die Finanzierung eines Kalibrierzentrums für Strahlungsmessung als Beitrag der Schweiz zum Weltwetterwacht-Programm der WMO. Nach diesem Beschluss wurde das PMOD beauftragt, das Weltstrahlungszentrum (World Radiation Center, WRC) zu errichten und zu betreiben.

Kerntätigkeiten

Das Weltstrahlungszentrum unterhält das Primärnormal für solare Bestrahlungsstärke bestehend aus einer Gruppe von hochpräzisen Absolut-Radiometern. Auf weitere Anfragen der WMO wurden 2004 das Kalibrierzentrum für Messinstrumente der atmosphärischen Langwellenstrahlung eingerichtet und 2008 das Kalibrierzentrum für spektrale Strahlungsmessungen zur Bestimmung der atmosphärischen Trübung. Seit 2007 wird auch das Europäische UV Kalibrierzentrum durch das Weltstrahlungszentrum betrieben. Das Weltstrahlungszentrum besteht heute aus vier Sektionen:

- Solare Radiometrie
- Infrarot Radiometrie
- Atmosphärische Trübungsmessungen (WORCC)
- Europäisches UV Kalibrierzentrum

Die Kalibriertätigkeit ist in ein international anerkanntes Qualitätssystem eingebettet (ISO 17025) um eine zuverlässige und nachvollziehbare Einhaltung des Qualitätsstandards zu gewährleisten.

Das PMOD/WRC entwickelt und baut Radiometer, die zu den weltweit genauesten ihrer Art gehören und sowohl am Boden wie auch im Weltraum eingesetzt werden. Diese Instrumente werden auch zum Kauf angeboten und kommen seit langem bei meteorologischen Diensten weltweit zum Einsatz. Ein globales Netzwerk von Stationen zur Überwachung der atmosphärischen Trübung ist mit vom Institut entwickelten Präzisionsfilterradiometern ausgerüstet.

Im Weltraum und mittels Bodenmessungen gewonnene Daten werden in Forschungsprojekten zum Klimawandel und der Sonnenphysik analysiert. Diese Forschungstätigkeit ist in nationale, insbesondere mit der ETH Zürich, und internationale Zusammenarbeit eingebunden.

Das PMOD/WRC ist eine Abteilung der
Stiftung Schweizerisches Forschungsinstitut
für Hochgebirgsklima und Medizin in Davos

Physikalisch-Meteorologisches Observatorium Davos
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pmod wrc

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Jahresbericht 2008

Werner Schmutz

Konstruktion und Herstellung von Weltraumexperimenten im Haus waren seit jeher das Aushängeschild der Forschung am Institut. Das Experiment VIRGO auf SOHO wurde im Jahr 1995 gestartet und war das letzte Experiment, das in Betrieb genommen wurde bis letztes Jahr wieder ein Start erfolgte: Am 7. Februar 2008 wurde das Experiment SOVIM durch die Weltraumfähre Atlantis zur Internationalen Raumstation gebracht. Im Vertrag mit der ESA zum Bau des Experiments datiert vom März 1998 war ursprünglich geplant, dass das fertig gebaute Experiment im Jahr 2001 abgeliefert werden sollte. Durch zahlreiche Änderungen am Projekt und dem bekannten Ausfall der Weltraumfähren verzögerte sich der Start des Experimentes um viele Jahre. Schlussendlich hat SOVIM aber eine Besonderheit gegenüber anderen Projekten: Dank seinem Platz auf der Weltraumstation existieren Fotos des Experimentes im Weltraum. Die wunderschönen Aufnahmen der Space Station werden noch beeindruckender, wenn man weiss, dass dort eines unserer Experimente installiert ist.

Es ist eine Tradition der Schweizerischen Botschaft in Berlin, dass für die Feier am Nationalfeiertag ein Kanton als Gastgeber auftritt. Letztes Jahr war der Gastgeberkanton Graubünden und das PMOD/WRC hatte die Gelegenheit dort Graubündens High Technologie zu repräsentieren. Wir bekamen ein Zelt mit ungefähr 35 m^2 Grundfläche zur Verfügung gestellt und haben an den Zeltwänden Poster befestigt, die ein Bild der Raumstation zeigten, die Tätigkeiten des PMOD/WRC zusammenfassten sowie unsere vergangenen und zukünftigen Weltraumexperimente beschrieben. Zudem zeigten wir Resultate von Klimarechnungen für das zukünftige Klima der Welt, mit Hervorhebung der Wintertemperaturen in Davos. Weiters stellten wir die Entwicklungsmodelle einiger Weltraumexperimente die am Observatorium gebaut wurden, aus. Das zentrale Ausstellungsobjekt war ein Computeraufbau mit dem wir eine direkte Verbindung zu unserem Experiment SOVIM in Echtzeit aufbauen konnten und auf dem wir den Status der Instrumente und die laufenden Messwerte darstellten. Stephanie Ebert, Daniel Pfiffner und Werner Schmutz standen während der Feier für die Gäste als Ansprechpartner zur Verfügung und haben mit schätzungsweise 20 % der rund 1200 Gäste, die unser Zelt besuchten angeregt und interessiert über unsere Experimente und allgemeine Klimafragen diskutiert.

Weltstrahlungszentrum Dienstleistungsbetrieb

Der Dienstleistungsbetrieb ist der Haupt-Daseinsgrund des Weltstrahlungszentrums. Es ist daher sehr erfreulich, dass man, wie praktisch in jedem der vergangenen Jahre, berichten kann, dass die Anzahl der Kalibrierungen zugenommen hat. Diese Zunahme ergibt sich nicht nur weil es nun mehr WRC Sektionen gibt, und daher auch Kalibrierungen in zusätzlichen Wellenlängenbereichen angeboten werden, sondern daraus, dass jede einzelne Sektion einen Zuwachs aufweist. Mit anderen Worten: Die Welt braucht das WRC in Zeiten zunehmender öffentlicher Wahrnehmung der Klimaänderung.

Die Sektion für Infrarot Radiometrie hat einen Prototyp zur genauen Messung der Himmels-Infrarotstrahlung Anfangs 2008 fertig gestellt und im Verlauf des Jahres intensiv getestet. Das neue Instrument bewährt sich hervorragend und eine erste Abschätzung der Fehler ergibt, dass es möglich sein sollte, die Infrarotstrahlung genauer als auf 2 Wm^{-2} mit einer einzigen Absolutmessung zu bestimmen. Das ist eine ähnliche Genauigkeit wie von einem früher entwickelten Gerät, aber durch den Einsatz einer so genannten Ulbricht-Kugel kann die Gesamtstrahlung sehr schnell im 10-Sekundentakt mit nur einer Messung ermittelt werden. Damit kann das Gerät auch bei nicht stabiler Wetterlage mit Bewölkung eingesetzt werden.

Im letztjährigen Jahresbericht wurde vom bevorstehenden Wechsel des WORCC, der Abteilung zur Messungen der optischen Trübung der Atmosphäre, zu einer vollen Sektion des WRC ab dem Jahr 2008 berichtet. Zuvor war das WORCC durch den Schweizerischen Beitrag zum Global Atmosphere Watch Programm der WMO finanziert. Eine finanzielle Unterstützung durch GAW-CH besteht nun für eine andere Tätigkeit des WRC: Ein neuer Vertrag unterstützt das Europäische Ultraviolett Kalibrierzentrum (EUVC) bis Ende 2011.

Entwicklung und Bau von Experimenten

Die Entwicklung einer neuen Radiometer-Generation macht erfreulichen Fortschritt. Das Projekt zur Phasen-Sensitiven Datenauswertung der Radiometer Messungen, mit der die systematischen Fehler verkleinert werden sollten, kam einen wichtigen Schritt voran. Wir entwickelten einen Prototyp, mit dem die theoretischen Erwartungen verifiziert werden können. Zudem tritt unser Gemeinschaftsprojekt mit dem NPL und dem METAS zum Bau eines kryogenen Radiometers in die Phase, in der ein Prototyp gebaut wird. Der Entwurf des Instrumentes ist somit praktisch abgeschlossen.

Das Experiment PREMOS ist im Juli 2008 zur Integration in die Französische Mission PICARD abgeliefert worden. Zusammen mit dem Instrument LYRA für den Satelliten PROBA2, das im Jahr 2007 abgeliefert wurde, warten nun zwei PMOD/WRC Weltraumexperimente auf ihren Einsatz im Weltall. PROBA2 wird voraussichtlich Mitte 2009 gestartet und PICARD entweder Ende 2009 oder Anfang 2010.

Unser Weltraumexperiment SOVIM hatte zwei Hauptziele: Einerseits die Fortsetzung der kontinuierlichen Überwachung der variablen Sonneneinstrahlung auf die Erde und andererseits den Vergleich mit den Messungen des langjährigen Experiments VIRGO/SOHO. Das zweite Ziel ist besonders interessant, da VIRGO nun schon seit 13 Jahren in Betrieb ist. Das sehr positive Ergebnis: VIRGO und SOVIM stimmen sehr gut überein.

Klimaforschung

Unsere Studien im Rahmen der zweiten Phase des Polyprojekts zielen darauf ab, den Einfluss der variablen Sonne auf das Erdklima der Vergangenheit zu erfassen und zu verstehen. Entsprechende Klimamodellrechnungen für das 20. Jahrhundert haben gezeigt, dass an besonders empfindlichen Orten auf der Erde, z.B. Sibirien, Skandinavien und Zentral-USA, die Änderung der Sonne der Grund für bis zu 50 % des Temperaturanstiegs des lokalen Klimas ausmacht. Das Polyprojekt endet im Jahr 2009.

Die Klimaforschungsgruppe am PMOD/WRC bereitet sich darauf vor, mit den zu erwartenden Beobachtungsdaten unserer Weltraummissionen LYRA/PROBA2 und PREMOS/PICARD die chemische Zusammensetzung in der mittleren Atmosphäre in Fast-Echtzeit zu berechen und via Internet zu publizieren. Diese Aktivität wird u. a. durch unsere Teilnahme an einem Drei-Jahres Projekt des 7. Europäischen Rahmenprogramms finanziert. Wir sind Partner im Projekt Solar-Terrestrial Investigations and Archives (SOTERIA). Im Rahmen der langjährigen Vorbereitungen wurde eine Version unseres Chemistry Climate Models SOCOL entwickelt, das auch die Ionosphäre mit einschliesst. Die neueste Verbesserung der Modellrechnungen besteht darin, dass wir neben der variablen Sonnenstrahlung auch Solar Proton Events mit berücksichtigen.

Personelles

An der Sitzung der Aufsichtskommission des PMOD/WRC am 19. März 2008 wurden Jules Wyss und Hansjörg Roth von Gerhard Müller, Präsident der Aufsichtskommission des WRC sowie von Walter Ammann, Präsident der Stiftung SFI, feierlich gewürdigt und verabschiedet.

Am 1. März 1964 begann Jules Urs Wyss als Feinmechaniker am Observatorium Davos zu arbeiten, das damals noch in der Villa Dora beheimatet war. Er wurde im Verlauf seiner Tätigkeit zum Konstruktionsspezialisten und entwarf und baute insgesamt sieben Weltraumexperimente. Am 30. April 2008 haben wir uns mit einem „Werkstatt-Fest“ verabschiedet: „Danke Jules – für 44 Jahre Obs!“

Hansjörg Roth liess sich per Ende Mai 2008 nach 35 Dienstjahren frühzeitig pensionieren. Hansjörg Roth nahm am 1. Dezember 1972 seine Arbeit als Elektro-Ingenieur am Observatorium Davos auf und prägte den Erfolg unseres Institutes als Leiter der Elektronik-Abteilung und als Stellvertretender Direktor massgebend mit. Auch er war intensiv in den Bau aller Weltraumexperimente involviert und war für die Entwicklung unserer eigenen Radiometer zuständig. Hansjörg war ein von allen geschätzter Arbeitskollege, Vorgesetzter und Lehrmeister. Er hat während seiner Tätigkeit bei uns 16 Lehrlinge ausgebildet.

Ende Januar verliess uns Dr. Margit Haberreiter um ihre Karriere in Boulder USA ihre Karriere fortzusetzen. Im Juli konnte unsere Sonnenphysikgruppe mit der Anstellung von Dr. Rosaria Simoniello wieder verstärkt werden. Die nächste Erweiterung der Sonnengruppe erfolgte im Oktober mit der Anstellung von Dr. Alexander Shapiro. Mit der Anstellung von Anna Shapiro in der Klimagruppe konnte das Team der Doktoranden auf fünf erweitert werden.

Als Nachfolger für Hansjörg Roth ernannten wir Silvio Koller zum Leiter der technischen Abteilung. Silvio Koller ist bereits seit 2003 an unserem Institut beschäftigt und durch seine berufliche Laufbahn bestens für diese Aufgabe qualifiziert. Als sein Stellvertreter fungiert Dany Pfiffner, der zudem als Projektleiter für unsere Weltraumexperimente verantwortlich ist.

Die Technik-Abteilung wurde mit Ricco Soder als Versuchsingenieur verstärkt. Er absolviert zudem berufsbegleitend ein Studium der angewandten Elektrotechnik an der HTW Chur.

Im August hat Chasper Buchli seine Ausbildung als Elektroniker erfolgreich abgeschlossen und mit sehr guten Noten die Berufsmittelschule und Lehrabschlussprüfung bestanden. Neuer Lehrling in der Elektronik-Abteilung ist Matthias Müller. Auch in der Administration gibt es wieder eine Lernende: Nadia Casanova hat gleichzeitig mit Matthias Müller Anfang August ihre Ausbildung begonnen.

Infrastruktur

Die geplante Erneuerung des Innenausbaus des Observatoriums beanspruchte zahllose Stunden für Besprechungen und dem Ausfüllen von Formularen zu Planungszwecken. Nach heutigem Informationsstand wird der eigentliche Ausbau erst nach den 11. Internationalen Pyrheliometer Vergleichen im Herbst 2010 beginnen. Im Jahr 2009 wird als Sofortmassnahme hinter dem Gebäude eine Nottreppe erstellt und darin ein neuer grösserer Lift integriert.

Dank

Einen speziellen Dank haben die beiden Mitarbeiter Jules Wyss und Hansjörg Roth für ihren langjährigen Einsatz für das Observatorium verdient. Wir alle danken ihnen für ihren grossen Einfallsreichtum und ihre kompetente Arbeit bei so vielen grossen und kleinen Projekten an unserem Institut.

Die kommende Erneuerung des Innenausbaus des Alten Schulhauses wäre nicht möglich, wenn der Bund sich nicht bereit erklärt hätte, die Kosten dafür zu übernehmen. Dass dies möglich wurde, ist der sehr positiven Beurteilung des Weltstrahlungszentrums durch die Behörden zu verdanken. Der Präsident der Aufsichtskommission des WRC, Gerhard Müller, hatte einen wesentlichen Anteil an diesem Ergebnis. Ihm und allen weiteren bekannten und unbekannten involvierten Personen möchte ich im Namen des Instituts für die Ermöglichung des Umbaus herzlich danken.

Dem Präsidenten und den Mitgliedern des Ausschusses des SFI sowie dem Präsidenten und den Mitgliedern der Aufsichtskommission WRC danke ich für ihre stets positive und unterstützende Begleitung der Institutsaufgaben. Die Grundfinanzierung des WRC ist dem Bund, dem Kanton Graubünden und der Gemeinde Davos zu verdanken.

Die Leistung des Institutes ist die Summe aller Beiträge meiner Mitarbeiter. Den PMOD Mitarbeitern gebührt daher der Verdienst für die oben erwähnte positive Beurteilung. Ich möchte allen Mitarbeitern meinen herzlichen Dank für ihren Beitrag zum Observatorium aussprechen.

Introduction

Werner Schmutz

In-house design and the manufacture of hardware for space experiments has always been the forte of the institute's research activities. VIRGO on SOHO was launched in 1995 and was the last experiment put into space until finally, another launch of an observatory-built experiment occurred: On February 7, 2008, the space experiment SOVIM, Solar Variability and Irradiance Monitor, was transported to the International Space Station (ISS) by the space shuttle Atlantis. The contract with ESA for implementation of SOVIM dates back to March 1998 and originally, it was intended that SOVIM would be delivered in 2001. However, many changes to the project and the temporary non-availability of shuttle transport to the ISS delayed installation of the Solar payload on the ISS by many years. Finally, when the experiment was in place and operational, dramatic pictures of SOVIM were relayed back to Earth from the departing Atlantis shuttle. The breathtaking images of the huge ISS structure are even more impressive when one realizes that an instrument built in Davos is aboard (see inside back cover).

There is a tradition that the Swiss embassy in Berlin invites a canton to organize the celebration party on August 1 which is Swiss National Day. Last year the host canton was Grisons and the PMOD/WRC had the opportunity to represent Grisons' high technology industry. At our disposition was a tent of about 35 m^2. Six posters were dedicated to describing our involvement in the ISS, our institute, past and future space experiments, and climate modeling efforts in predicting future temperatures on Earth with emphasis on winter temperatures in Davos. In addition, engineering models of space instrumentation built by PMOD/WRC were displayed in a showcase. The central piece of the exhibition was a computer setup that had a direct real-time link to SOVIM on the ISS displaying the instrument status and measurement readings. Three members of the PMOD/WRC staff represented the institute, Stephanie Ebert, Daniel Pfiffner, and Werner Schmutz. We had a very interesting and busy evening with about 20 % of the 1200 guests visiting our tent and a large fraction of them discussing our experiments and climate issues in general.

In the 2007 annual report we reported that WORCC, the World Optical Depth Research and Calibration Center, became a full section member of the World Radiation Center. Previously, WORCC was supported by a Swiss contribution to WMO's Global Atmosphere Watch program (GAW-CH). Financial support by GAW-CH has now shifted to another section of the institute: A new contract until the end of 2011 now finances the European Ultraviolet Calibration Center.

Two research projects on researching the Solar-Terrestrial relationship have come to an end. Fortunately, it was possible to obtain a new contract in the frame of the European Seventh Framework Programme. We are part of the project SOTERIA, SOlar-TERrestrial Investigations and Archives, which started in November 2008 and will ensure a continuation of this research activity for the next three years.

The forthcoming renovation of the observatory's interior structure required many hours of consultation and paperwork preparation with PMOD/WRC staff and the Architects. This preparation was needed for planning criteria. At present, the main construction work is scheduled to begin after the 11th International Pyrheliometer Comparisons in October 2010. In 2009, only a fire-escape stair and a new larger elevator will be constructed at the rear of the building.

Operational services is the main livelihood of the WRC. It is therefore very pleasing that we can report growing demand for our services every year, not only because there now exist more WRC sections but also because every section reports an increase in activity. This indicates that in these times of growing public awareness of climate change issues the services offered by the World Radiation Center will continue to be in high demand.

Figure 1. *Impressions of the "research tent" on August 1, 2008 at the Swiss embassy in Berlin to celebrate Swiss National Day. Left: The exhibition tent; middle left: the showcase; right: discussions with guests.*

Operational Services

Quality Management System

Silvio Koller

PMOD/WRC QMS

Since 2006 the PMOD/WRC maintains an approved quality management system based on the general requirements for the competence of testing and calibration laboratories (EN ISO/IEC 17025).

To date, the WRC Solar Radiometry Section is covered by the QMS and it calibrates customer instruments in accordance to the EN/ISO standard.

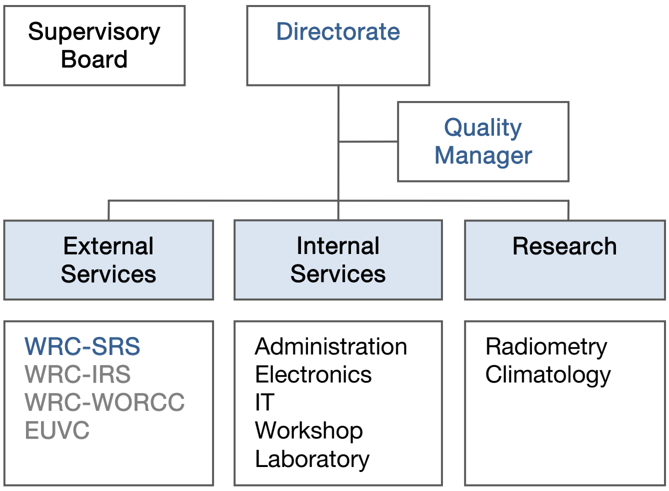

Figure 1. *Organizational chart of the PMOD/WRC quality management system. The WRC Solar Radiometry Section performs its calibrations according to the EN ISO/IEC standard 17025.*

PMOD/WRC is a designated institute of the Swiss National Metrology Institute, METAS, which is a signatory of the CIPM-MRA (Comité international des poids et mesures - Mutual Recognition Arrangement).

Quality Management System Activities

Two calibration and measurement capabilities were approved in 2008 and are listed in the database of the „Bureau International des poids et mesures“ (BIPM): Responsivity, direct and global solar irradiation.

Based on the approval the WRC Solar Radiometry Section may now use the official logo on its issued certificates.

As in previous years, PMOD/WRC attended the international inter-laboratory comparison at NREL in September 2008.

Calibrations

Silvio Koller

Solar Radiometry Section (WRC-SRS)

The number of instrument calibrations significantly increased in 2008. Compared to 2007 when 38 instruments were calibrated, the number increased to 88 instruments in 2008. The WRC section „Solar Radiometry“ calibrated 75 pyranometers, 2 pyrheliometers and 11 actinometers during 78 days of measurement.

Infrared Radiometry Section (WRC-IRS)

The infrared radiometry section of the World Radiation Center calibrated 24 pyrgeometers in 2008. Each instrument was first characterized with a black-body source; the final calibration was obtained by direct outdoor comparison of downwelling longwave irradiance against the World Infrared Standard Group (WISG) of pyrgeometers.

Atmospheric Turbidity Section (WRC-WORCC)

The World Optical depth Research and Calibration Center calibrated 16 PFR instruments by comparison to the WORCC standard Triad. Three of these PFR belong to the GAW network, and 13 to international institutes. Five additional PFR of the GAW network were calibrated by the Langley method at their operational sites.

European Ultraviolet Calibration Center (EUVC)

The Ultraviolet Calibration Center of the PMOD/WRC calibrated 2 spectroradiometers at their respective field sites using the traveling reference spectroradiometer QASUME. Eight UVB and one UVA broadband radiometers and one Bentham Se-Te Diode were calibrated. In July 2008, 7 Brewer spectrophotometers were calibrated relative to the QASUME spectroradiometer during the 3rd RBCC-E campaign at Arosa, Switzerland.

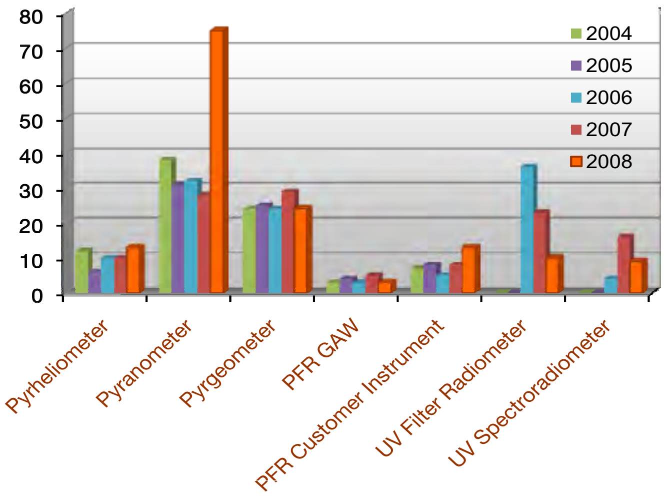

Figure 2. *Statistics of instrument calibrations at PMOD/WRC.*

Instrument Sales

Silvio Koller

In 2008, five Precision Filter Radiometers (2 Japan, 1 Sweden, 1 WORCC, 1 EUSAAR) and two Absolute Radiometers (1 Luxembourg, 1 Germany) were sold. In addition, 10 instruments of each type were manufactured in order to more quickly respond to customer orders.

Solar Radiometry Section (WRC-SRS)

Wolfgang Finsterle

The record number of calibration items, participation in the U.S. National Pyrheliometer Comparisons at the National Rewnewable Enregy Laboratory (NREL) in Golden, Colorado, and the manufacturing of a new series of ten PMO6-cc absolute radiometers were the highlights of 2008.

As discussed in the Operational Services section of this report the technical staff of the Solar Radiometry Section (SRS) was busy with calibrating a record number of instruments during the 2008 calibration season. At times the calibration facilities were reaching their capacity limits as was the data acquisition system. To avoid future overload the already planned modernization and extension of the calibration platform for pyranometers was expedited. A new concrete foundation was built on the old measuring field to accommodate the new platform after the calibration season had ended in October. The new platform itself will be installed in spring 2009.

Figure 1. *At the US National Pyrheliometer Comparisons the WRR-calibrated transfer instruments AHF-32455 (right, top) and PMO6-0401 (right, bottom) share a solar tracker with two other PMO6s.*

New Data Acquisition System

With the new calibration platform the bottleneck will shift to the current 72-channel data acquisition system. Because this system is already more than 20 years old it was decided to replace rather than upgrade it. Two competitive tenders from different suppliers were evaluated. We eventually decided to buy an integrated system based on the PXI (PCI eXtension for Instrumentation) standard. For testing and validation purposes it is planned to operate the new 384-channel system in parallel with the old system during 2009. Once the respective quality management documents will be adapted accordingly the new PXI system will be dedicated to the calibration duties within the SRS.

Pyrheliometer Comparisons

The SRS participated with two transfer instruments in the National Pyrheliometer Comparisons at NREL in Golden, Colorado, USA (Fig. 1) from September 22 to October 3. The WRR-calibrated transfer instruments PMO6-0401 and AHF-32455 confirmed the agreement of the US national standard group with the World Radiometric Reference (WRR). Regular intercomparisons with national and regional standards also provide confidence in the stability of the WRR.

A new series of PMO6-cc absolute radiometers was built during 2008. Twenty detector heads but only ten control units were initially built. The reduced number of control units was thought as a measure to save cost but high customer demand actually warrants construction of control units for all 20 detector heads. The new series ‘08’ features a modernized look and improved control electronics components (Fig. 2).

Figure 2. *While technically identical to its tried predecessors the PMO6-cc body of the new ‘08’ series has an appealing new exterior.*

Infrared Radiometry Section (WRC-IRS)

Julian Gröbner

The Infrared Radiometry Section of the WRC maintains and operates the World Infrared Standard Group of Pyrgeometers (WISG) which represents the world-wide reference for atmospheric longwave irradiance measurements.

Performance of the WISG

The WISG operated continuously during the whole of 2007, showing an excellent relative stability between individual instruments of ±1 Wm^{-2}. For the third consecutive year each WISG instrument was calibrated in the PMOD reference blackbody, showing no significant changes in the respective responsivity over this time span. This yearly calibration procedure is used as an independent check of the WISG long-term stability.

Measurement Platform Enhancement

A third INTRA tracker was installed on the PMOD roof platform in late November, increasing the number of shaded pyrgeometer calibration sites from originally 3 to 8 (see Fig. 1). Even though pyrgeometer calibrations will still only be performed during night time to be independent from solar radiation interferences, this addition will also finally allow routine investigations of their performance during daytime conditions.

The Infrared Integrating Sphere Radiometer IRIS

The development of a reference instrument for atmospheric longwave radiation reached a new milestone with the completion of the IRIS radiometer in early 2008. Its key characteristic is the custom-made integrating sphere with incorporated shutters which allows measurements of longwave irradiance at high temporal resolutions of up to 1 Hz. Extensive characterisation tests were carried out to investigate its performance since one fundamental requirement of this radiometer is its ability to measure irradiance. As can be seen in Figure 2 the angular response measurement carried out in the PMOD laboratory closely follows the desired cosine response, demonstrating the excellent performance of this unique integrating sphere design. The radiometer was further calibrated with respect to the new PMOD blackbody on repeated occasions during 2008, showing a reproducibility of its responsivity to better than ±1% between successive calibrations. A preliminary uncertainty estimate indicates that the radiometer should be able to measure atmospheric longwave irradiance to within ±2 Wm^{-2} or better. Routine outdoor measurements were initiated in November whenever the atmospheric conditions allowed the deployment of the instrument. One particular noteworthy feature of IRIS is its ability to measure longwave irradiance also under changing atmospheric conditions. Figure 3 shows measurements obtained during the night of November 5 to 6, 2008. The very good agreement with the WISG is particularly satisfying.

Outlook

The IRIS radiometer will be deployed alongside the WISG whenever atmospheric conditions are favourable to initiate a long-term record of comparisons. The construction of a second slightly modified IRIS radiometer is planned for 2009 in view of eventually replacing the interim WISG reference with a set of independent absolute longwave radiometers traceable to the international system of units.

Figure 1. *The roof platform of WRC-IRS with the three INTRA trackers allowing state-of-the-art pyrgeometer calibrations using shading disks.*

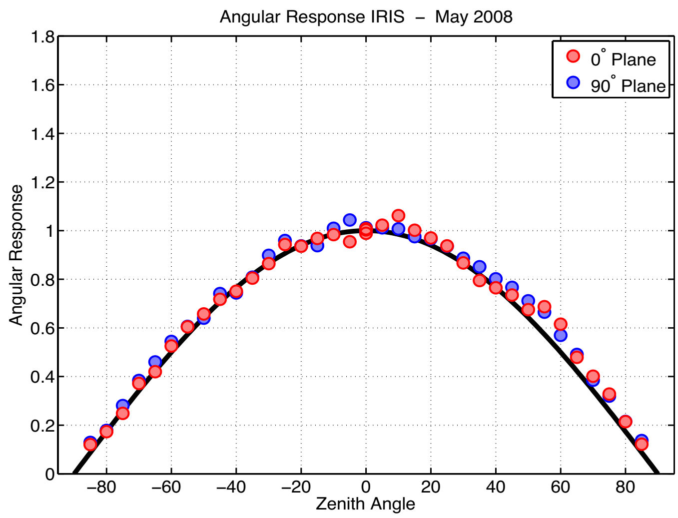

Figure 2. *Angular response of the IRIS radiometer in two planes. The nominal cosine response is shown as the thick black line.*

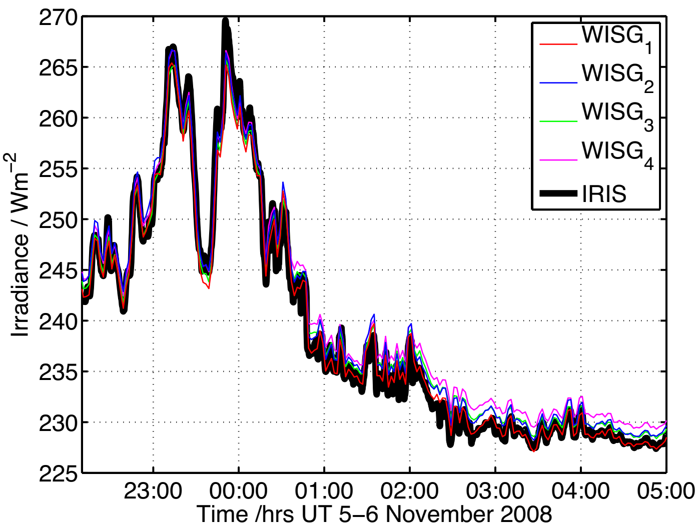

Figure 3. *Downwelling longwave irradiance measurements from November 5 to 6, 2008. The IRIS radiometer is shown by the thick black line while the WISG pyrgeometers are shown by the thin colored lines.*

Atmospheric Turbidity Section (WRC-WORCC)

Christoph Wehrli and Stephan Nyeki

Routine operations of the GAW-PFR network continued smoothly in 2008 and quality assured data up to 2007 were submitted to the WDCA. Instrument calibrations were updated at 9 GAW stations and audits were conducted at two EUSAAR sites. Seven stations were upgraded for near-real-time data acquisition with regard to a WIGOS pilot project.

Calibration of station PFRs was conducted by exchange of instruments at Hohenpeissenberg (Germany), Mace Head (Ireland), Ny Ålesund (Norway), and Ryori (Japan). Instruments at Mauna Loa (USA), Jungfraujoch (Switzerland), Izaña (Spain), Bratt's Lake (Canada), and Alice Springs (Australia) were calibrated in-situ by the Langley method. Excellent instrument stability over several years was again confirmed.

Quality controlled AOD from 9 stations for 2006 and 2007 was submitted as hourly mean data to the World Data Centre for Aerosols (WDCA). A total of 696 station-months of AOD data collected by the GAW-PFR network are now available at WDCA. Several national meteorological institutes running PFR instruments are also contributing their AOD results to WDCA. With the association of a PFR operated by the Koninklijk Nederlands Meteorologisch Instituut at their BSRN site in Cabauw (Netherlands), the GAW-PFR network has grown to 14 stations.

Several issues are being tackled at 2 new stations. For instance, the new PFR station at Cape Point (South Africa) suffers from rapid window contamination by wind-blown dust and maritime spray. Despite daily and even hourly cleaning by South African Weather Service station personnel, quality assurance of AOD results seems almost impossible. A passive wind-screen was thus designed by WORCC and will be tested at CPT in 2009. In addition, first results from the newly established PFR station at Mt. Waliguan (China, 3800 m) in Figure 1 show monthly mean AOD several times higher than at Mauna Loa or Jungfraujoch. Whether AOD at Mt. Waliguan is predominantly due to natural or anthropogenic aerosols remains to be determined.

Seven GAW stations were upgraded for near-real-time acquisition of PFR measurements via the internet. At 3 other stations, it has not been possible to implement this solution due to technical and administrative limitations at the host organization. Negotiations with the remaining 4 stations are still open. Preliminary AOD is processed on a daily basis at WORCC and available on our website at: http://www.pmodwrc.ch/worcc.

These new near-real-time capabilities support the promotion of the WMO Information System which is part of the WIGOS program (WMO Integrated Global Observing Systems). WORCC has become a partner in the pilot project "Improvement of Dissemination of Ozone and AOD through WMO Information System" launched by GAW in June 2008.

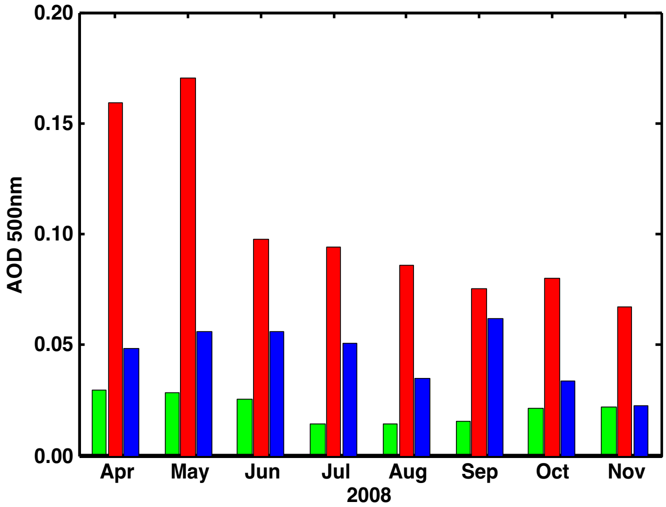

Figure 1. *Monthly mean AOD at high altitude stations: Mauna Loa (3400 m, green), Mt. Waliguan (3810 m, red) and Jungfraujoch (3580 m, blue). Despite similar station altitudes, AOD appears to be signifycantly larger at Mt. Waliguan.*

In addition to these activities, WORCC is participating in the EUSAAR (European Super-sites for Atmospheric Aerosol Research) project whereby station audits and AOD inter-comparison campaigns are conducted. A travelling standard (PFR and EKO mobile sun-tracker), was therefore constructed and used in campaigns at Cabauw, and the Joint Research Centre, Ispra (Italy). AOD derived from CIMEL radiometers at these sites (federated to the AERONET AOD network), agreed with PFR AOD to within 0.010 ±0.005 optical depths, as recommended by GAW. Another aspect of WORCC EUSAAR activities is to conduct station audits of AOD measurements. A first audit was conducted at Mace Head in 2008. Further audits and AOD campaigns will be conducted at other EUSAAR sites up to January 2011.

Other instruments measuring AOD at WORCC include CIMEL and MFRSR-7 shadow-band radiometers. The CIMEL radiometer worked well until October 2008 when it was sent to AERONET for recalibration, while the MFRSR-7 had to be returned to the manufacturer for repair in January 2009.

Maintenance of the PFR Calibration Triad at WORCC

Christoph Wehrli, Stephan Nyeki, and Julian Gröbner

Precision Filter Radiometers (PFR) operating in the GAWPFR network or sold to international customers are routinely calibrated by comparison with a set of three master PFRs at Davos. The long-term stability of this master Triad is periodically assessed by its internal consistency and external verification.

The current GAW recommendation (WMO, 2005) for AOD observations calls for a 95 % uncertainty defined by U95 < 0.005 + 0.01/*m* (optical depth units). The first term accounts for instrumental and algorithmic uncertainties, and the second term represents the uncertainty δEAV in the exoatmospheric calibration value EAV. This latter contribution to U95 varies inversely with the optical air-mass *m* of the observation and corresponds to a requirement of a relative uncertainty in calibration of <1%.

Traditionally, the primary EAV calibration of a filter radiometer is determined by Langley extrapolation of measurements taken at a high altitude station. Two members of the WORCC Triad were calibrated at Mauna Loa in 2000 and 2005, and the third instrument obtained its calibration from a stratospheric balloon flight in 1998 at 40 km height. Based on the results of the second international Filter Radiometer Comparisons (FRC-II) 2005 in Davos, the calibration of 2 channels in the balloon PFR and 1 channel in the PFR calibrated at Mauna Loa Observatory in 2000 were adjusted by 1%.

Three years after FRC-II, the internal consistency of the Triad was verified by pair-wise cross-calibration between its members and boot-strap calibration by the General Method (Forgan, 1994) of the 4 individual channels in each instrument. In relation to each other, all but 1 channel changed by less than 0.5 % in 3 years.

Table 1: *Internal consistency of PFR master Triad expressed as results of cross-calibrations related to calibration in use. Column headers indicate wavelength in nm.*

	862	500	412	368
N01/N27	1.003	0.997	1.000	1.000
N26/N27	1.003	1.004	0.999	1.007
N01/N26	1.001	0.993	0.995	0.995

This excellent result was also confirmed by an intercomparison campaign in autumn 2007 where several CIMEL radiometers traceable to AERONET showed an agreement with the Triad to within ±0.01 optical depth.

It is thus concluded that the GAW requirements for a calibration uncertainty of better than 1% is still maintained by the Triad of master PFRs.

While Langley extrapolation on manually selected days at Davos readily confirm the EAV calibrations with high precision, the statistics of a large number of objective extrapolations show standard deviations exceeding the 1% level. Average atmospheric conditions at Davos are unsuitable for reliably obtaining accurate primary calibrations.

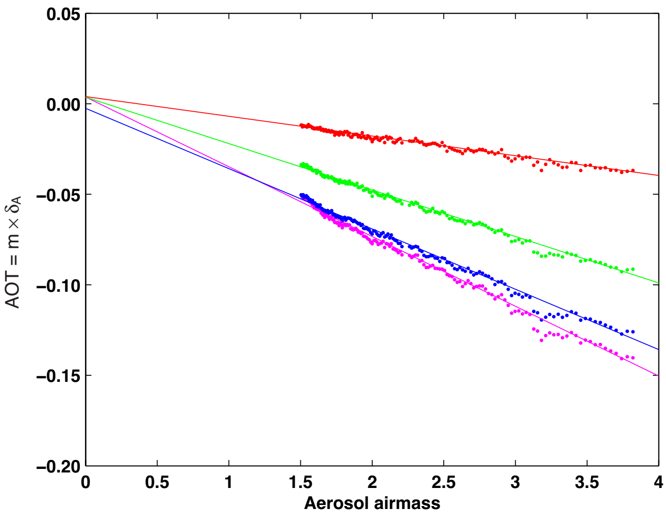

Figure 1. *Selected Langley extrapolation for N26 on 16.07.2008. Regression lines match exoatmospheric optical depth within 0.004 or EAV within 0.4 %.*

Starting in 2009, at least one PFR of the Triad will be substituted annually by an instrument with a recent primary calibration at Mauna Loa, Izaña, or Jungfraujoch. The aim of this quality control program is to assure the long-term stability of the WORCC AOD reference to below the ±1% level.

References: WMO: 2005, WMO/GAW Experts workshop on a global surface-based network for long term observations of column aerosol optical properties, Davos 2004. (U. Baltensperger, L. Barrie, C. Wehrli, Editors) GAW No. 162, WMO/TD-No. 1287.

Forgan B.W.: 1994, General method for calibrating Sun photometers, Applied Optics 33, 4841 – 4850.

Aerosol Optical Depth Inter-Comparison Campaigns at European "Super-Sites" within the EU 6th Framework EUSAAR Program

Stephan Nyeki, Christoph Wehrli, and Julian Gröbner

This work summarizes WORCC activities within the EU FP6 EUSAAR (European Super-Sites for Atmospheric Aerosol Research) program.

The EUSAAR program aims to integrate and harmonize measurements of aerosol optical properties at European observation sites, amongst other goals. WORCC is participating in EUSAAR by conducting audits and aerosol optical depth (AOD) inter-comparison campaigns at sites with existing, extensive aerosol measurement programs, so-called super-sites.

An audit at Mace Head (Ireland) and two AOD inter-comparisons at Ispra (Italy) and Cabauw (Netherlands) have so far been conducted. These sites have CIMEL sun-photometers federated to the AERONET AOD network which measured alongside a WORCC PFR (precision filter radiometer) travelling standard. The travelling standard is regularly calibrated against the WORCC reference standard consisting of 3 PFRs. PFR and CIMEL AOD multi-wavelength measurements which occurred to within ± 30 seconds were used for analysis. A comparison of individual channels was constrained by wavelength differences smaller than ±1% of the mean wavelength which limits the comparison to λ = 500 and 865 nm at Ispra and λ = 865 nm at Cabauw.

The quality of AOD data from the inter-comparison can be gauged by comparison with WMO criteria (WMO, 2005). These state that inter-comparisons should be over a sufficient period of time to ensure that: a) ≥ 1000 coincident AOD data points are collected, b) a minimum of 5 clear sunny days occur, and c) AOD at 500 nm should be in the range 0.04 - 0.20. If these conditions are met, then for traceability to exist 95 % of CIMEL-PFR points should lie within limits defined by Equation 1 where m = airmass:

$$U_{95} < \pm (0.005 + 0.010/m) \qquad \text{Eq. 1}$$

Figure 1a-b illustrates the CIMEL-PFR AOD difference versus airmass at Ispra and Cabauw, respectively. Although the criterion for the number of coincident measurements was not met at both sites despite 8-week campaigns, WMO limits of ~ 95 % at Ispra, and ~ 90 % at Cabauw were close to the recommended value of 95 %.

These measurements suggest that the WMO goal of achieving an AOD uncertainty < 0.02 is achieved in routine operations at the EUSAAR Cabauw and Ispra super-sites. Further on-site audits and AOD inter-comparisons will be conducted at other EUSAAR sites up to January 2011.

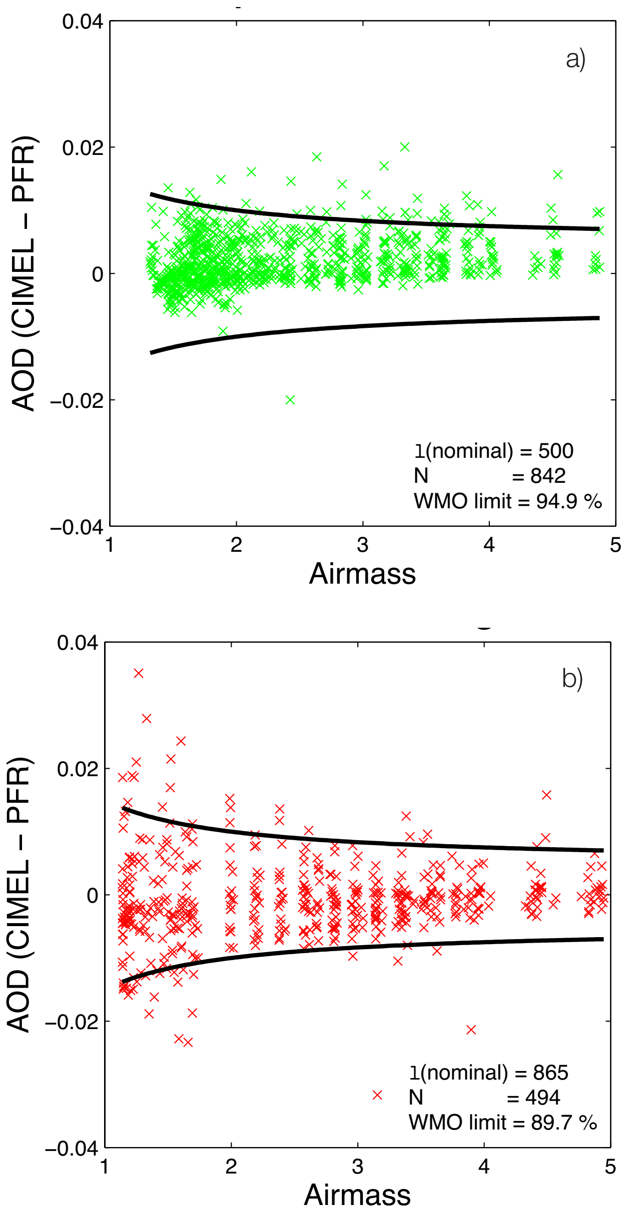

Figure 1. *CIMEL-PFR AOD difference versus airmass, illustrating the WMO criteria for traceability (solid line) at: a) Ispra Sept. 8-26, 2008 (λ = 500 nm), and b) Cabauw June 11-12, 2008 (λ = 865 nm).*

References: WMO: 2005, WMO/GAW Experts workshop on a global surface-based network for long term observations of column aerosol optical properties, Davos 2004. (U. Baltensperger, L. Barrie, C. Wehrli, Editors) GAW No. 162, WMO/TD-No. 1287.

European Ultraviolet Calibration Center (EUVC)

Julian Gröbner and Gregor Hülsen

The UV radiometers located at PMOD/WRC and the Weissfluhjoch measurement field worked reliably for all of 2008, providing continuous UV measurements without significant interruptions. All radiometers were collected and re-calibrated during a two-week period in August at PMOD/WRC. The stability of the UV Radiometers was satisfactory, even though changes in some instruments were observed. This underlines the necessity of recalibrating UV broadband Radiometers on a yearly basis.

In 2008 the EUVC served as calibration center for an increasing number of customer UV radiometers. Furthermore, quality assurance audits were performed at three sites in Italy and Switzerland with the QASUME spectroradiometer. Results of these site audits can be found at the EUVC web-site:
www.pmodwrc.ch/euvc/euvc.php?topic=qasume_audit.

The 3rd Regional Brewer Calibration Center-Europe (RBCC-E) campaign was hosted in 2008 by the Lichtklimatisches Observatorium at Arosa, Switzerland. The reference spectroradiometer QASUME acted as the UV reference for the 7 participating Brewer spectrophotometers whereas the Brewer #163 was calibrated against the RBCC-E total column ozone reference.

A tutorial was held from July 7-11 at the EUVC on UV Radiometer operations. It provided on-site training and expert advice to station personnel to help them maintain and improve the required data quality of their measurement sites. One operator from Spain and two from Chile participated in this tutorial.

Figure 1. On-Site Quality Assurance audits during the 3rd RBCC-E campaign held at the LKO at Arosa, Switzerland between the QASUME reference spectroradiometer and seven Brewer spectrophotometers. From front to back: Brewer#40, Brewer#72, Brewer#156, Brewer#17, Brewer#163, QASUME, Brewer#185, Brewer#64.

Instrument Development

Space Radiometers and Phase-Sensitive Radiometers

Wolfgang Finsterle and Uwe Schlifkowitz

The year 2008 was characterized by significant steps forward in the development and improvement of new and existing absolute radiometers.

The laboratory characterization of PREMOS space radiometers took place in early 2008. For the first time a PMO6-type radiometer was characterized for its reaction to thermal variability of the heat sink. The importance of such a characterization manifested itself when the first data from the SOVIM experiment aboard the International Space Station (ISS) became available shortly after. In the unstable thermal environment of the ISS the corrections according to the findings from the PREMOS characterization have proven vital to accurately estimate the total solar irradiance.

In April, PREMOS radiometers were vacuum-calibrated against the SI primary standard for spectral responsivity at the National Physical Laboratory (NPL) in Teddington, UK. The non-equivalence (air-vacuum difference) was also determined at NPL and found to be significantly different from previous values obtained at PMOD. Careful investigation of the reason for the discrepancies led to the discovery of problems with stray light in the vacuum tank that was used to determine non-equivalence on the solar tracker at PMOD. Whether the other PMO6 radiometers in space (i.e. VIRGO and SOVIM) are also affected by this problem remains to be determined.

Phase-Sensitive Radiometer

The development of the radiometer for phase-sensitive signal detection leapt forward by finally reaching the prototype stage, featuring a digital heater control unit. Thermal simulations revealed great potential for suppressing the non-equivalence of radiant and electrical heating when the shutter period is set to 30 seconds instead of the usual 180 seconds (Fig. 1). Unlike the old analog control loop the new digital electronics can easily handle such short shutter periods.

Progress in construction of the Cryogenic Solar Absolute Radiometer (CSAR) project is further described in a dedicated Section.

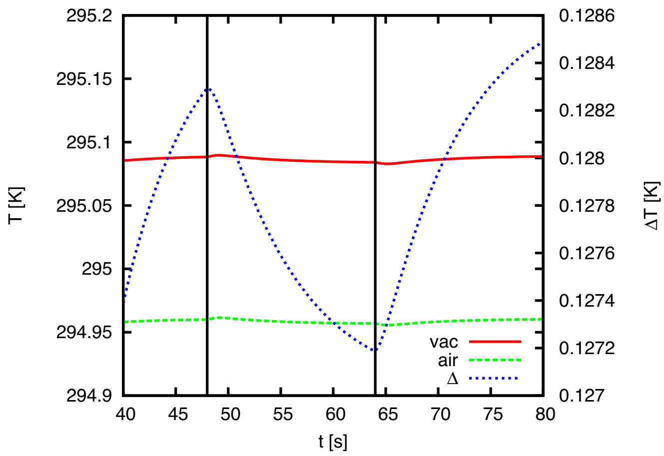

Figure 1. *Thermal simulations of the temperature at the cavity base. The air-vacuum difference (dotted line) is representative of the non-equivalence of radiant and electrical heating. When the shutter period is ~30 seconds the spurious error signal due to non-equivalence is phase-shifted by 90° with respect to the shutter cycle and hence maximally suppressed by the phase-sensitive signal analysis (shutter switches are indicated by the vertical lines).*

Monitor to Determine the Integrated Transmittance of Windows (MITRA) and the Cryogenic Solar Absolute Radiometer (CSAR)

André Fehlmann, Wolfgang Finsterle, and Werner Schmutz in collaboration with Ulrich Straumann, University of Zürich, Peter Blattner, METAS, Rainer Winkler, Eric Usadi, David Gibbs, and Nigel Fox, NPL, England

We report on the nearly finished CSAR design phase and the prototype status of MITRA.

The PMOD/WRC, METAS and NPL project (Fehlmann, 2008) to build a cryogenic solar absolute radiometer is progressing well. During the last year the CSAR design was further refined. Hardware components such as the cryogenic cooler have been selected and ordered. Currently, detailed drawings of the instrument are being finalized at NPL in London. In April 2009 METAS (Bern, Switzerland) will then start to produce the CSAR parts which we then plan to assemble in July 2009. Figure 1 shows a drawing of the CSAR instrument.

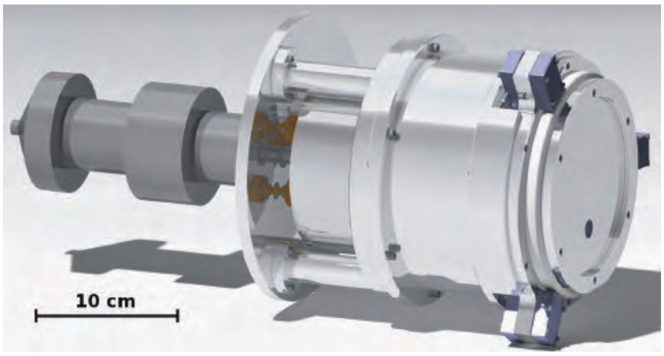

Figure 1. The CSAR instrument without vacuum tank. The dark gray part on the left is the cryogenic cooler which allows the instrument to be cooled to 20 Kelvin.

Development of MITRA

The monitor to determine the integrated transmittance of windows has already reached prototype status (Figure 2). MITRA has two identical cavities which are mounted on a common heat sink via two thermal resistors. Thermopiles form these resistances and simultaneously measure the temperature differences between the cavities and the heatsink. Since these temperature differences are proportional to the solar irradiance and both cavities see the same sun, we end up with a constant ratio of the two signals produced by the thermopiles.

Characterization of MITRA

Experiments with MITRA in the laboratory revealed a non-constant ratio of the thermopile signals with changing irradiance. This is due to thermal relaxation time constants that are not equal for both cavities. We managed to fine-tune the thermal resistances and thermal capacities of the instrument to obtain a constant signal at all times.

Once MITRA has proven itself in ground-based solar measurements we will start to measure the transmittance of our Sapphire and Quartz windows. These windows have been characterized at METAS in the 300-1000 nm wavelength range and will be characterized at PMOD/WRC in the 250-500 nm and 1000-5000 nm ranges.

As soon as the final CSAR design is fixed, we will start to develop the definitive MITRA instrument. In doing so, special attention will be payed so that both instruments have the same optical setup, i.e. baffles, apertures and geometries. Thus, the problem of stray light, which is to be characterized, will be similar for both instruments and will not unintentionally introduce a systematic effect.

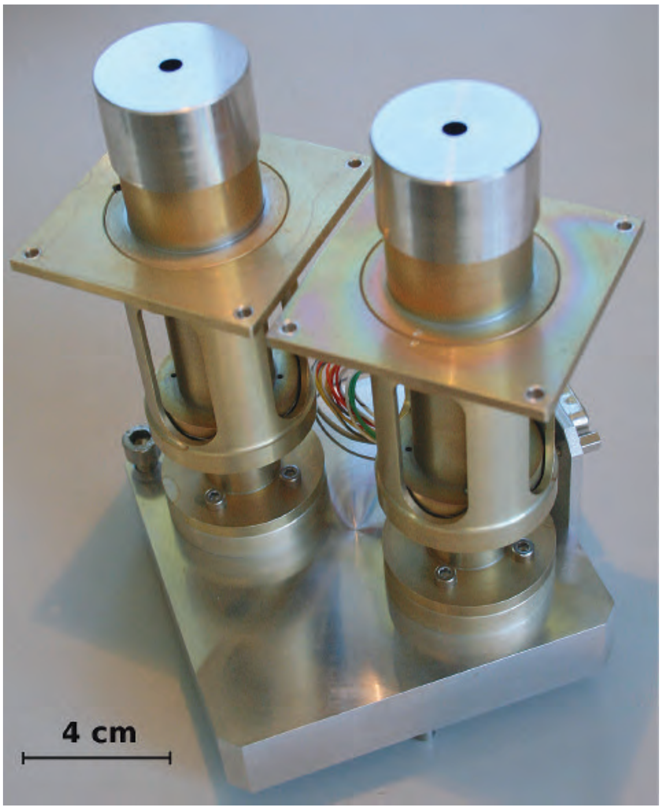

Figure 2. The dual cavity monitor MITRA prototype. Not shown is the instrument housing which acts as a wind-shield and thus makes it insensitive to ambient temperature.

References: Fehlmann A., Finsterle W., Schmutz W., Straumann U., Blattner P., Winkler R., Gibbs D., Fox N., 2008, Cryogenic Solar Absolute Radiometer (CSAR), PMOD/WRC Annual Report 2007.

Space Experiments

Silvio Koller and Dany Pfiffner

PREMOS

The PREMOS experiment, a payload unit aboard the French micro satellite PICARD, reached its final development phases in 2008. PREMOS contains two PMO-6 type absolute radiometers and three filter radiometers, measuring three visible- and three UV wavelength ranges. The launch of PICARD is planned for the end of 2009.

The Proto Flight Model was assembled during the spring months. The experiment contains five instruments, cover mechanisms for each of them and auxiliary electronics, such as: power converters, instrument control electronics, data acquisition and data interfaces.

Following internal functional tests at hard- and software level, the required environmental tests were carried out. Electro-magnetic compatibility tests were performed at the "EMC Testlab", Zürich, Switzerland. Electromagnetic susceptibility was investigated, as well as emission levels determined. The thermal vacuum test took place at PMOD/WRC. It consisted of a burn-in test under vacuum at elevated temperature and four times cycling between the minimum and maximum qualification temperature (-40°C to +60°C). Afterwards the experiment underwent vibration tests at the University of Berne, Switzerland. During these tests resonance frequencies of the experiment are measured and vibrations with a random spectrum as input simulate conditions during the satellite launch. The measured accelerations are then compared with previously calculated values in order to verify the structural model.

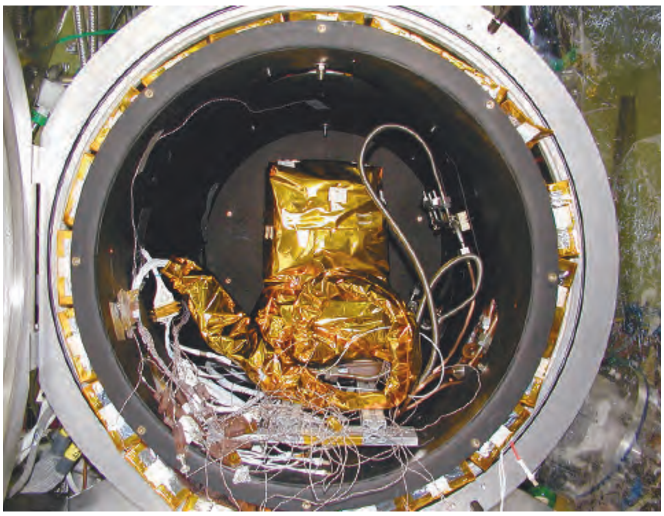

Figure 1. *PREMOS Thermal Balance Test. The experiment is placed in a vacuum chamber and wrapped with MLI (Multi-Layer Insulation). Several temperature sensors are placed on different locations of the instrument to provide measurement points for verification of the thermal model.*

PREMOS was delivered to CNES (Centre Nationale d'Éspace Spatiale), the French Space Agency, in July. Several incoming inspection tests were carried out at CNES. Its cleanliness was screened, power consumption and functionality were verified and magnetic moment measurements were conducted.

PREMOS was shipped to IAS, Paris for the Thermal Balance Test where the instrument was set-up in a vacuum chamber under different thermal environment cases. Measured absolute temperatures, temperature distributions and time constants then allowed cross-correlation with the PREMOS thermal model.

Requested documentation was prepared in parallel. A "Point Clé"-Meeting was organized by CNES in order to compare requirements, performed tests and verification status during the official delivery of PREMOS. In the last months of 2008 PREMOS was integrated on PICARD.

Figure 2. *Launch of ATLANTIS STS-122 occurred on schedule on February 7, which turned out to be a really nice day with clear skys. It brought the experiment SOVIM to the ISS.*

SOVIM

A reflight Instrument was built around original components from the SOVA/EURECA instrument. The start of the project was in 1998, launch occurred 10 years later on February 7, 2008. SOVIM contains 4 absolute Radiometers two Sunphotometers and a Two-Axis-Sun-sensor.

The launch, originally planned for December 7, 2007, was unfortunately cancelled and shifted to February 7, 2008. Hansjörg Roth, Project Manager of SOVIM, and Dany Pfiffner, Project Engineer, travelled to Kennedy Space Center to witness the launch.

After a few days in orbit (Figure 3), SOLAR was attached to the International Space Station (ISS) (Figure 4). First switch-on of SOVIM occurred on the night of February 15 to 16, 2008. The initialization commands were sent from the Belgian User Operation Center (BUSOC) at Brussels. After solving a few troubles upon switch-on, SOVIM functioned and operations were nominal on the next day.

We received the first data from SOVIM on February 15, 2008. The Coarse Pointing Device (CPD) was not working properly from the beginning. No measurements were possible during the first sun-window, however, during the second sun-window the first useful data with a calculated pointing were obtained. The sun sensor and its software were not yet functioning. During the third sun-window we then obtained the first real pointing, which unfortunately was off by more than 1°, and so the data could not been used. A Criss-Cross was performed to find out the offsets and to provide the necessary information for an appropriate correction of the sun sensor. Finally, a few hours of reasonable data out of the available 250 hours of that window were collected. The end of that window was on early May 11, 2008, nearly 3 months after switch-on. During the 4th sun window, only about 70 % of observation time was available, mainly due to some resets and other accidents with the CPD. The next sun window was completely lost because of a communication problem between COLUMBUS and SOLAR, which turned out to be due a failure in COLUMBUS.

The next sun window began at the end of July and only slightly more than 60 % of the available observation time could be used – still due to recurring failures of the CPD. Similar coverage occurred for the next two solar windows, namely between 55 and 65 % of the available observation time.

In preparation of the next observation window on October 25, 2008, SOVIM was suddenly switched-off and could not be re-activated. This was the unfortunate end of SOVIM's observation phase. After a comprehensive investigation by PMOD, ESA and NASA, the understanding surfaced that it is no longer possible to switch on SOVIM instrument. The switch-on circuitry of the old EURECA power converter had apparently failed. The main reason for the re-use of this circuitry was the program schedule – if the delay of nearly 10 years could have been foreseen then this circuit would have been replaced with a new design to prevent a single-point-failure. Although we only had about half the available observations we obtained excellent data and the corresponding results are reported in the science section.

Figure 3. *SOLAR in orbit within the STS.*

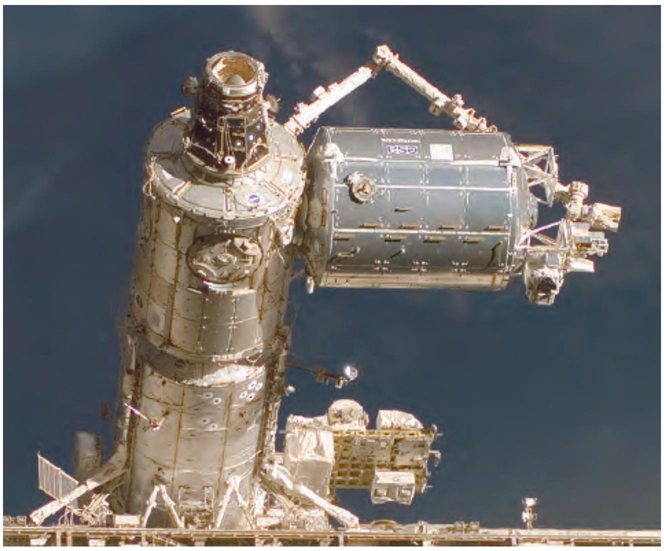

Figure 4. *Mounting of SOLAR outside of COLUMBUS.*

LYRA

The Lyman-Alpha Radiometer is a payload experiment of ESA's technology mission PROBA-2. LYRA contains three UV filter radiometers, each with four channels. Some of them are equipped with BOLD detectors (Blind to the Optical Light Detectors). The project began in 2002 and the flight unit was delivered to Verhaert Space, Belgium in 2007. The launch date for PROBA-2 has been postponed again and is now foreseen in July to September 2009.

No activities were performed by PMOD concerning the hardware in 2008. A consortium for future data treatment was established by PMOD/WRC in order to provide online space weather forecast data on the internet. The Fachhochschule Baden, Switzerland will develop four-dimensional visualization software displaying spectral data of UV components over time. The same method will be applied to the PMOD/WRC space experiment PREMOS aboard the French satellite PICARD.

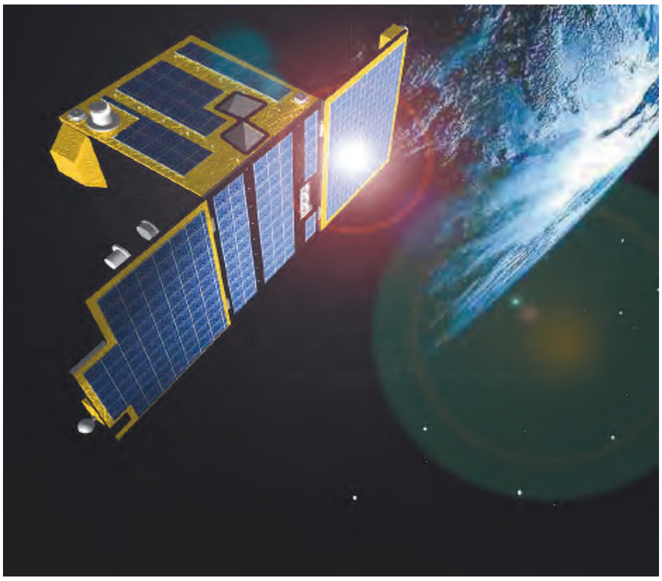

***Figure 5**. Animation Drawing by Verhaert Space of the ESA technology mission PROBA-2. The solar instrumentation of PROBA-2 comprises two instruments: SWAP and LYRA. SWAP is a EUV imaging telescope with a field of view of 54 arcmin, imaging the sun in a wavelength band cantered at 17.5 nm. LYRA is a 4-channel filter radiometer measuring the spectral solar irradiance in two Extreme-UV and two Near-UV passbands, which are relevant to Solar Physics, Space Weather and Aeronomy with a cadence of up to 50 Hz. The hardware of LYRA was built at PMOD/WRC.*

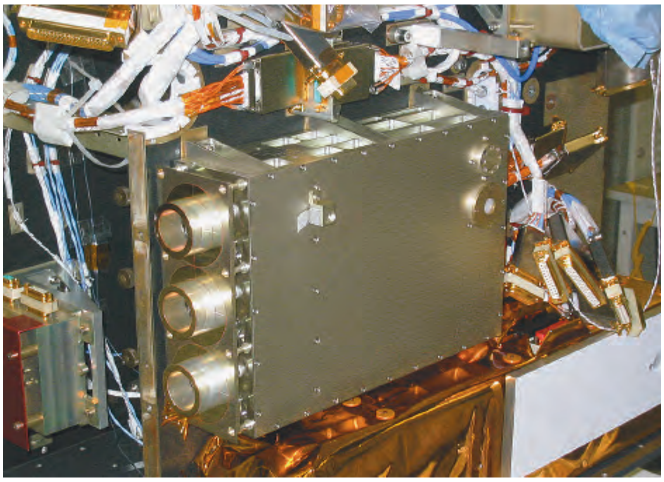

***Figure 6.** LYRA Integrated on PROBA-2.*

Scientific Research Activities

Overview

Werner Schmutz

Space climate, the long term influence of solar variability on the terrestrial climate, and *space weather,* the short term influence of outer space on the terrestrial space environment are the main topics of research activities at the institute. In most projects there is emphasis on the effects of solar radiation. We address questions concerning the radiation energy budget of the terrestrial atmosphere as well as questions in the solar physics field to understand the origin of the solar irradiance variability. The hardware projects at the institute are part of the European space weather activities providing measurements of the spectral and total solar irradiance.

Beside of the relevance to the main research themes, there is another important aspect that governs the choice of projects to be carried out at the institute: Synergy between the know-how obtained from the operational services of the World Radiation Center and the research activities. Basically, the same instruments are built for space-based experiments as are utilized for ground-based measurements.

The research activities are grouped into three themes:

- climate modelling;
- terrestrial radiation balance;
- solar physics.

Almost all of the research projects are financed through third party funding. Presently, we are supported by the Swiss National Science Foundation (5 projects), MeteoSwiss (1 project), European Framework Program FP6 (1 project), and by the State Secretariat for Education and Research (1 COST project). The hardware development of space experiments is paid by the ESA PRODEX program (3 projects).

The most recent funding obtained by the institute, starting on November 1, 2008, is the SOTERIA project. The acronym stands for SOlar-TERrestrial Investigations and Archives and is a collaborative project within the first space science research call of the seventh framework program for research and technological development of the European Commission. The partners are 15 European institutes and one institute from Russia.

The PMOD/WRC contribution to the SOTERIA project is on the one hand spectral and total irradiance measurements of its future space experiments, LYRA and PREMOS. The observational data will be available on-line in near-real time to the space weather community. On the other hand, after the launch of PROBA2, presently scheduled to be launched in the second half of 2009, we intend to publish an operational nowcasting of the chemical composition of the middle atmosphere on the internet. Photochemical reactions under the influence of the variable UV irradiance as observed by the space experiments will be calculated. The modeling tool is a 3-D coupled Chemistry-Ionosphere-Climate model, SOCOLi[i], which has been developed at PMOD/WRC.

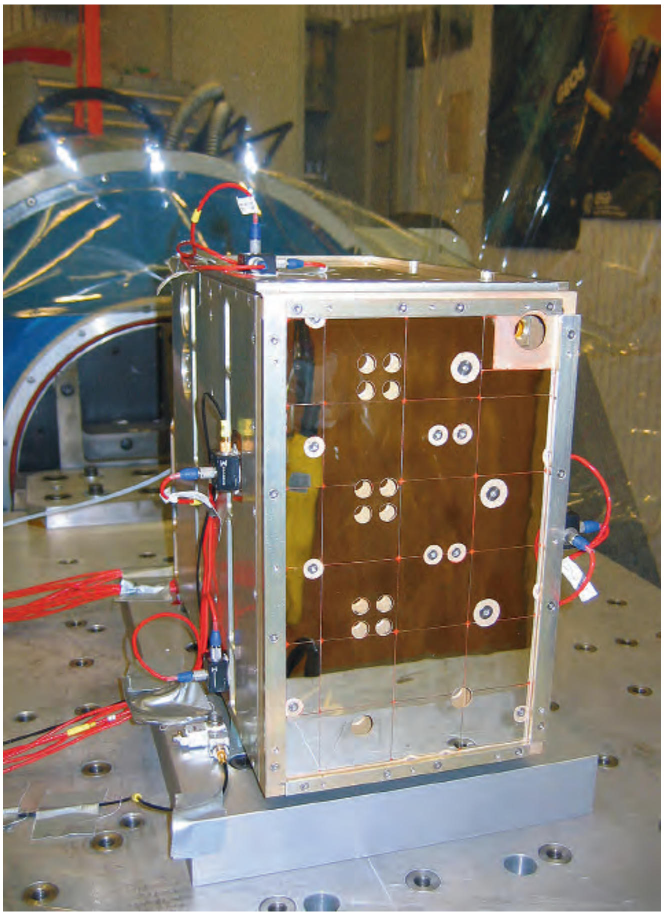

Figure 1. *Hardware built at PMOD/WRC is tested for space qualification. The PREMOS instrument is mounted on the vibration test adapter at the University of Berne. The red cables connect the various 3-dimensional accelerometers to acquire the response of the PREMOS structure during vibration.*

Influence of Galactic Cosmic Rays on Atmospheric Composition and Temperature

Eugene Rozanov and Tatiana Egorova in collaboration with Marco Calisto and Thomas Peter IAC ETH, Zurich

We investigated the influence of Galactic Cosmic Rays on atmospheric chemistry and temperature using a Chemistry-Climate model and the most recent parameterization of ionization rates. The implementation of Galactic Cosmic Rays in the model causes a ~40 % increase of reactive nitrogen in the entire troposphere and a ~9 % tropospheric ozone increase over high latitudes, however, the temperature response is not statistically significant.

Galactic Cosmic Rays provide an additional source of reactive nitrogen and hydrogen in the atmosphere due to ionisation of neutral species. The effects of Galactic Cosmic Rays on the atmosphere have only been estimated with simple models and their implications for past trends in atmospheric ozone and temperature have not been properly established. Galactic Cosmic Rays forcing was not taken into account in simulations of the past atmosphere in the framework of the Chemistry-Climate Model validation (CCMval) campaign. Therefore, it is important to estimate the influence of Galactic Cosmic Rays on atmospheric composition and climate and formulate a recommendation about their significance in the future.

To answer this question we performed two 13-year (1976-1988) long transient simulations with the CCM SOCOL v2.0 model with and without a Galactic Cosmic Rays source. The ionization rate due to Galactic Cosmic Rays was adopted from the recent paper by Usoskin and Kovaltsov (2006). The source of reactive nitrogen and hydrogen was parameterized according to Porter et al. (1976) and Solomon et al. (1981). The atmospheric response to Galactic Cosmic Rays was calculated as the difference between the results of the run with Galactic Cosmic Rays and the reference run without Galactic Cosmic Rays, which gives the upper limit of their effects and also allows the statistical significance of the obtained atmospheric response to be estimated.

The results show, that Galactic Cosmic Rays produce a substantial amount of NO_x. The simulated NO_x increase shown in Figure 1 exceeds 30 % in the southern polar troposphere, whereas over low and middle latitudes the NO_x increase only reaches 10-20 % and is confined to the upper troposphere/lower stratosphere. The significant increase of ozone (see Figure 2) up to 10 % is mostly confined to the troposphere over the southern hemisphere, where ozone production via smog reactions is most sensitive to additional NO_x due to low background NO_x mixing ratios. The annual mean temperature response (not shown) is not statistically significant. From these results we can conclude that Galactic Cosmic Rays may generally be important in the troposphere over southern high latitudes.

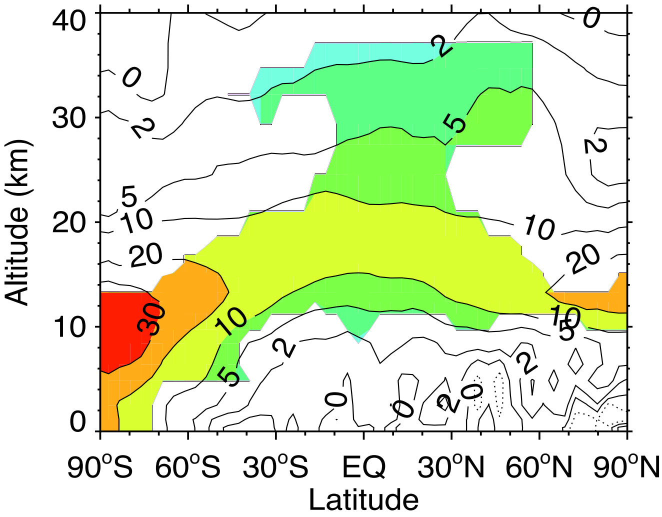

Figure 1. *Annual mean percentage changes of zonal mean NOx due to GCR implementation. The areas where changes are significant to better than the 95 % confidence level are shaded.*

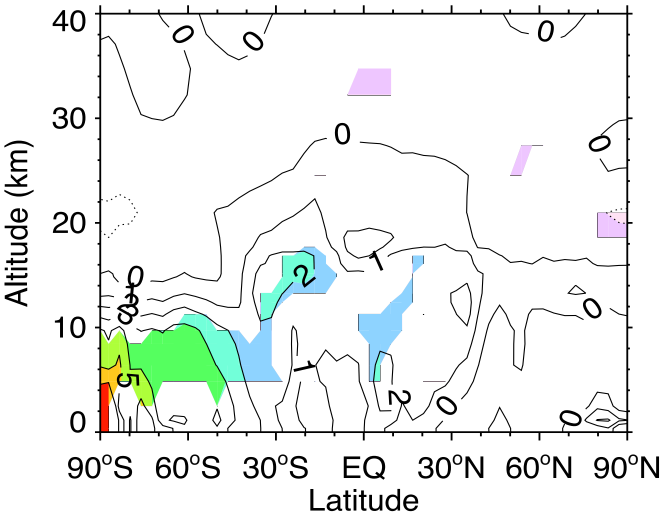

Figure 2. *Annual mean percentage changes of zonal mean ozone due to GCR implementation. The areas where changes are significant to better than the 95 % confidence level are shaded.*

References: Porter H.S., Jackman C.H., Green A.E.S., Efficiencies for production of atomic nitrogen and oxygen by relativistic proton impact in air, J. Chem. Phys., 65, No.1, 1976.

Solomon S., et al., The effect of particle precipitation events on the neutral and ion chemistry of the middle atmosphere: II. Odd Hydrogen, Planet. Space Sci., 29, No. 8, 885 – 892, 1981.

Usoskin I.G., Kovaltsov A., Cosmic ray induced ionization in the atmosphere: Full modeling and practical applications, J. Geophys. Res., 111, D21206, doi: 10.1029/2006JD007150, 2006.

Simulations of the Climate, Chemistry, and Ozone Changes during 1960-2006

Eugene Rozanov and Tatiana Egorova

With CCM SOCOL v2.0 we simulated the evolution of the climate, chemistry and ozone during 1960-2006. The results of the experiments have been submitted for the second phase of the Chemistry-Climate Models Validation campaign (CCMval-2).

The CCMval-2 campaign was organized to provide necessary data for the next WMO Ozone depletion report. One of the CCMval-2 requests was to simulate climate, chemistry and ozone trends in the recent past (1960-2006) using provided sets of the monthly mean natural and anthropogenic forcings: sea surface temperature, sea ice concentration, greenhouse gases, ozone destroying substances, sources of carbon monoxide and reactive nitrogen oxides, solar spectral irradiance, stratospheric sulfate aerosol, and stratospheric quasi-biennial oscillation.

We have carried out this experiment with CCM SOCOL v2.0 (Schraner et al., 2008) in ensemble mode (3 ensemble members) and many requested atmospheric quantities were uploaded to the CCMval-2 ftp-server.

To illustrate the model performance we have plotted the zonal mean total inorganic chlorine (Cl_y) mixing ratio in October over 80°S averaged over the pressure range 30-50 hPa. This quantity was chosen because the previous version of CCM SOCOL failed to simulate its magnitude (Eyring et al., 2006) causing some problems in the simulation of the total ozone tendencies over the southern high-latitudes. The results from the CCM SOCOL v2.0 run are shown in Figure 1. The simulated Cl_y reveals a steady increase from 1960 to 1995 and some stabilization due to limitations in ODS production afterwards. The peak value is around 2.7 ppbv, which is much closer to the 3.0 ppbv estimated on the basis of different satellite observations (Eyring et al., 2006). The relatively small dependence on the ensemble member should be noted.

Figure 2 illustrates the time evolution of the zonal mean total ozone from 1960 to 2006 over 80°S in October. In general, the behavior of total ozone follows the time evolution of Cl_y, however, some deviations after the eruption of Pinatubo (1991-1993) are noticeable. A leveling off of ozone depletion is reached in the late 1990s, while towards the end of the record a slight increase in total ozone can be observed, albeit small and probably not statistically significant. Full analyses of the results obtained will be conducted by the scientific community next year.

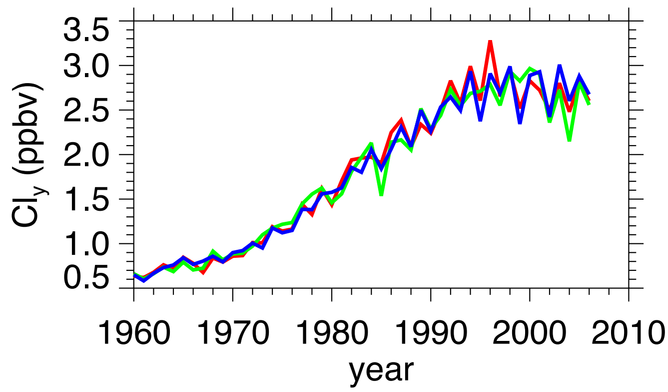

***Figure 1.** Time evolution of the zonal mean October Cly mixing ratio in the 30-50 hPa layer over 80° S. The results of three ensemble members are shown in different colors.*

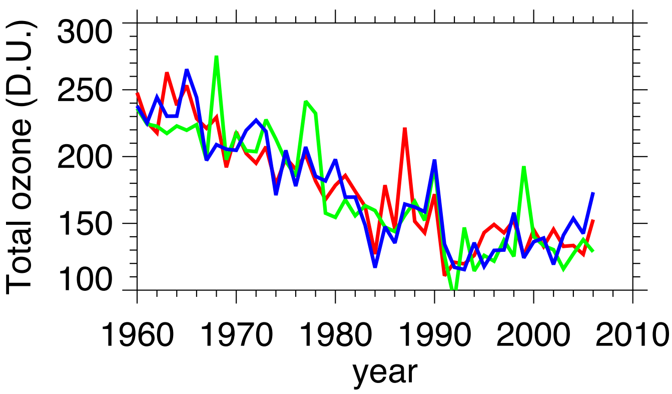

***Figure 2.** Time evolution of the zonal mean October Total Column Ozone over 80° S. The results of three ensemble members are shown in different colors.*

References: Eyring V., Butchart N., Waugh D.W., Akiyoshi H., Austin J., Bekki S., Bodeker G.E., Boville B.A., Brühl C., Chipperfield M.P., Cordero E., Dameris M., Deushi M., Fioletov V.E., Frith S.M., Garcia R.R., Gettelman A., Giorgetta M.A., Grewe V., Jourdain L., Kinnison D.E., Mancini E., Manzini E., Marchand M., Marsh D.R., Nagashima T., Newman P.A., Nielsen J.E., Pawson S., Pitari G., Plummer D.A., Rozanov E., Schraner M., Shepherd T.G., Shibata K., Stolarski R.S., Struthers H., Tian W., Yoshiki M., Assessment of temperature, trace species, and ozone in chemistry-climate model simulations of the recent past, J. Geophys. Res., 111, D22308, doi: 10.1029/2006JD007327, 2006.

Schraner M., Rozanov E., Schnadt Poberaj C., Kenzelmann P., Fischer A.M., Zubov V., Luo B.P., Hoyle C.R., Egorova T., Fueglistaler S., Brönnimann S., Schmutz W., Peter T., Technical Note: Chemistry-climate model SOCOL: version2.0 with improved transport and chemistry/micro-physics schemes, Atmos. Chem. Phys., 8, 5957-5974, 2008.

The Response of the Land Surface Temperature to the Solar Irradiance Variability

Eugene Rozanov, Tatiana Egorova, and Werner Schmutz
in collaboration with Andreas Fischer and Stefan Brönnimann IAC ETH, Zurich

With CCM SOCOL v2.0 we have simulated the evolution of the climate, chemistry and ozone during 20th century. The analysis of the land surface temperature changes revealed that the contribution of solar variability to climate warming can reach ~50 % in some regions (e.g., Siberia, Scandinavia, Central USA and Southern Canada).

We have carried out a 9-member 100-year long transient ensemble simulation with CCM SOCOL spanning the entire 20th century driven by the prescribed time evolution of the sea surface temperature, sea ice distribution, volcanic aerosols, solar spectral irradiance, greenhouse gases, ozone depleting substances, sources of CO and NO_x, land use, and quasi-biannual oscillation. The model set-up and some results from this experiment were presented by Fischer et al. (2008). To elucidate the role of changes in solar activity we have also performed one run without solar irradiance variability.

Figure 1 illustrates the annual mean land surface temperature changes calculated as the difference between mean values over the time periods 1985-1999 and 1901-1915. The increase of the sea surface temperature is prescribed from observations, so it is consistent with observations. The model also simulates the observed warming over land, which maximizes over high-latitudes and Saudi Arabia.

To estimate the contribution of the solar irradiance variability we compared temperature changes during 20th century shown in Figure 1 with the same temperature changes obtained from the model run carried out with fixed solar spectral irradiance. The contribution of solar irradiance variability is shown in Figure 2. The solar spectral irradiance contribution is rather small over the ocean, because the ocean temperature was prescribed in both experiments. Over land the contribution of solar irradiance variability is noticeable over some geographical locations. Its magnitude can reach 0.6 K over Siberia, Scandinavia, Central USA and Canada. Cooling due to solar irradiance variability is observed over Northern Canada, China and Northern Africa.

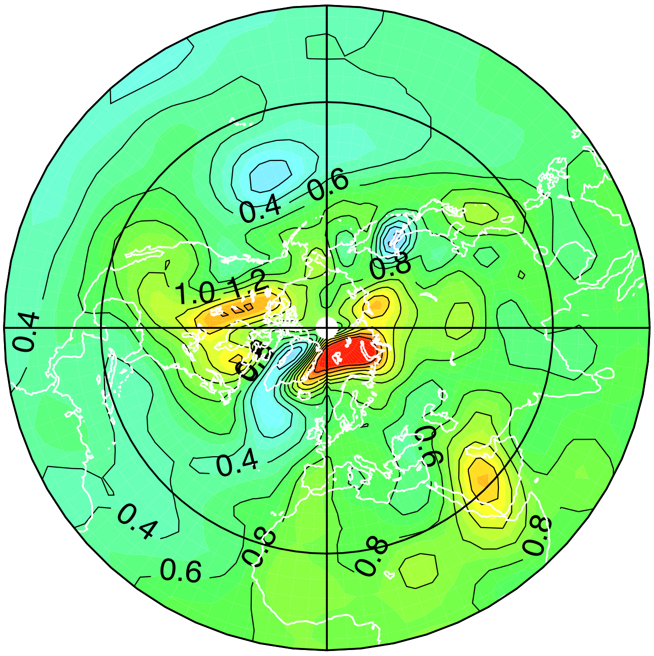

Figure 1. *Changes of the annual mean surface air temperature between two time periods: 1985-1999 and 1901-1915.*

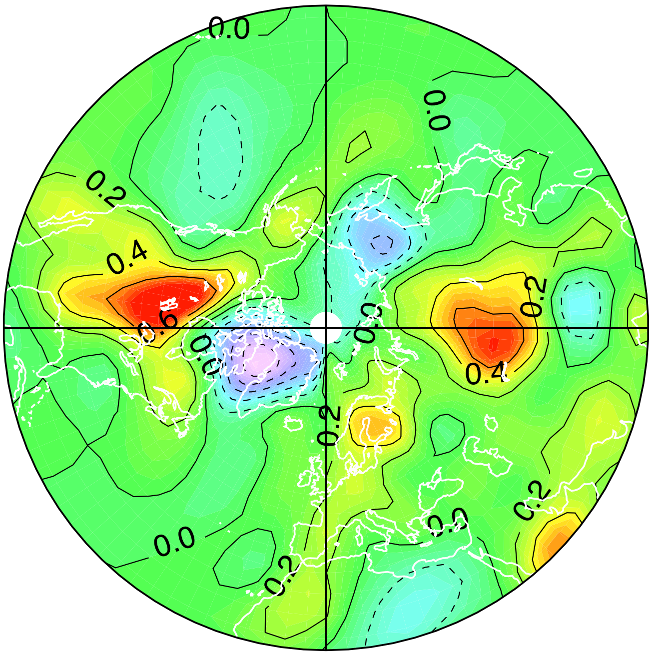

Figure 2. *Contribution of solar irradiance variability to changes in the annual mean surface air temperature between two time periods: 1985-1999 and 1901-1915.*

References: Fischer A., Schraner M., Rozanov E., Kenzelmann P., Schnadt Poberaj C., Brunner D., Lustenberger A., Luo B.P., Bodeker G.E., Egorova T., Schmutz W., Peter T., Brönnimann S., Interannual-to-decadal variability of the stratosphere during the 20th century: ensemble simulations with a chemistry-climate model, Atmos. Chem. Phys., 8, 7755-7777, 2008.

The Response of the Middle Atmosphere to Short-Term Solar Irradiance Variability: Comparison of Different Solar Irradiance Data

Anna Shapiro, Eugene Rozanov, and Tatiana Egorova

Using 1-D radiative-convective model with interactive photochemistry we compare the atmospheric response to the short-term variability of solar irradiance obtained from observations (SUSIM instrument onboard the UARS satellite) and compiled by Lean (2005). The ozone response in the model driven by this data is found to be underestimated in the stratosphere.

The solar rotational cycle in irradiance reflects the heterogeneity of the sunspot distribution across the Sun's surface. The variability of solar irradiance during the solar rotational cycle influences the abundance of ozone in the stratosphere and mesosphere.

Figure 1 illustrates power spectra of the solar irradiance from data compiled by Lean and observed by SUSIM during 2003. The figure shows that the solar rotational cycle dominates both spectra.

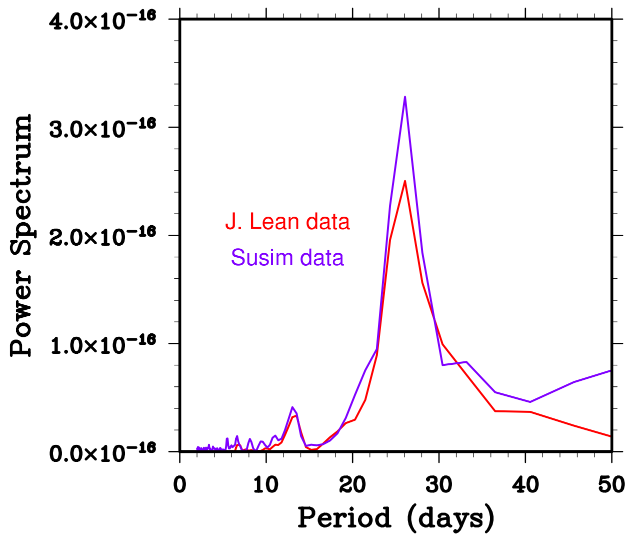

Figure 1. *Power spectrum of the solar irradiance variability during 2003.*

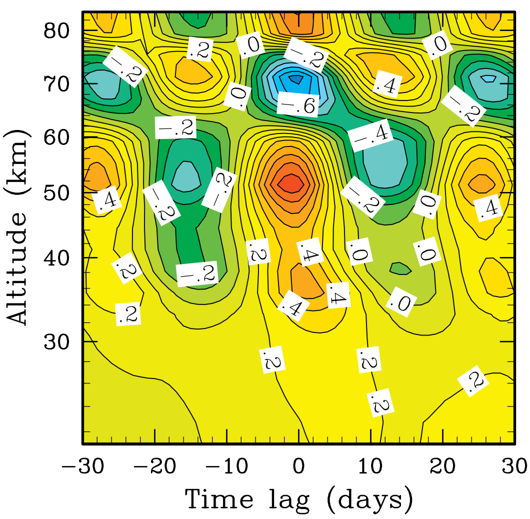

Figure 2. *Cross-correlation function of ozone concentration versus the solar irradiance at 205 nm for 2003.*

We have calculated the response of the middle atmosphere to the solar irradiance variability with a 1-D radiative-convective model with interactive photochemistry. Cross-correlation function of simulated ozone concentration versus the solar irradiance at 205 nm for Lean data is illustrated in Figure 2. A good correlation with a near zero time lag in the middle atmosphere is seen.

Figure 3 illustrates the simulated correlation between ozone concentration and the solar irradiance at 205 nm for the time lag with maximum correlation. Correlation coefficients simulated with Lean's data are underestimated in the stratosphere in comparison with SUSIM data. Tentatively, it can be explained by a high correlation between solar irradiance at different wavelengths in Lean's data, which is not supported by observations.

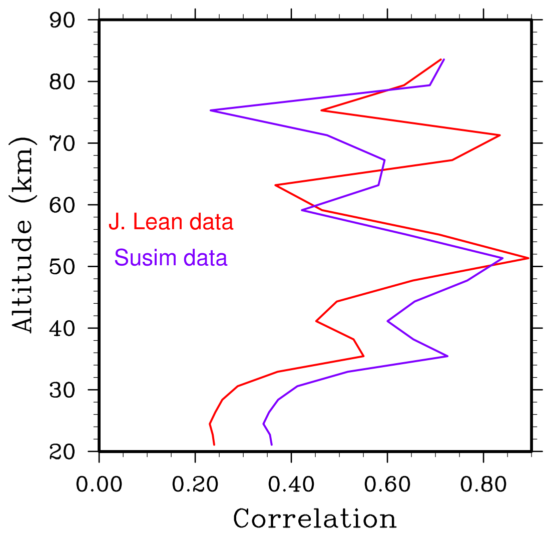

Figure 3. *Correlation between ozone concentration and the solar irradiance at 205 nm (the time lag at each altitude corresponds to the correlation maximum).*

References: Rozanov E., Egorova T., Schmutz W., Peter T., Simulation of the stratospheric ozone and temperature response to the solar irradiance variability during sun rotation cycle, Journal of Atmospheric and Solar-Terrestrial Physics, 68, 2203-2213, 2006.

Lean J., Rottman G., Harder J., Kopp G., Sorce contributions to new understanding of global change and solar variability, Solar Physics, 230, 27-53, 2005.

Modeling Changes in Global Ozone and Atmospheric Dynamics in the 21st Century with the Chemistry-Climate Model SOCOL

Eugene Rozanov, Tatiana Egorova, and Werner Schmutz
in collaboration with Vladimir Zubov and Igor Karol (MGO, Russia)

Our previous simulations of the future total ozone evolution showed that total ozone in the second half of the 21st century tends to exceed the pre-ozone hole values. To elucidate the causes of this super-recovery we have carried out a series of time-slice runs and showed that the additional increase in total ozone results from the acceleration of the meridional circulation due to enhanced tropospheric wave forcing.

The PMOD/WRC and the Main Geophysical Observatory (Russia) have been partners in the SCOPES Joint Research Project titled "Modeling of the global ozone and climate evolution in the first half of the XXI century" from 2005 to 2008. To elucidate the causes of the so-called total ozone super recovery we have performed three time-slice numerical experiments with the chemistry-climate model SOCOL for the years 2000, 2050 and 2100. Sea surface temperature, sea ice, concentrations of greenhouse gases and ozone depleting substances (ODS) were taken from the IPCC scenario *A1B* and WMO scenario *Ab* and used as the boundary conditions for these experiments consisted of the 10-year spin-up runs and the two-year five members ensemble runs with the slightly different initial conditions. This ensemble approach was necessary to estimate the statistical significance of the changes in the total ozone and other considered quantities. Analysis of the results of the model experiments revealed cooling the model stratosphere by about 5 K from 2000 to 2050 and by about 10 K from 2000 to 2100 years. The simulated temperature of the lower atmosphere increases by about 2.5 K in 2100. Tropospheric heating causes the growth of the planetary wave activity at the tropopause level leading to the increase of the Eliassen-Palm flux divergence in the middle and upper model stratosphere. As a result the westerlies become weaker (see Figure 1) and the Brewer-Dobson circulation becomes stronger especially in winter-spring seasons over the both hemispheres. These dynamical changes in the model dynamics accelerate the ozone recovery process initialized by decreasing the stratospheric chlorines and bromines due to reduction of the ODS emission. Figure 2 illustrates that in 2100 the model results show the "super recovery" of the total ozone in the middle latitudes of both hemispheres and filling up of the spring time ozone hole over Antarctica. The detailed analysis of the results will be presented by Zubov et al. (2009).

References: Zubov V., Rozanov E., Rozanova I., Egorova T., Karol I., Schmutz W., Total ozone recovery and dynamical changes in the second half of the 21th century simulated with the CCM SOCOL, Transactions of Russian Academy of Science, Physics of Atmosphere and Ocean, 2009 (in preparation).

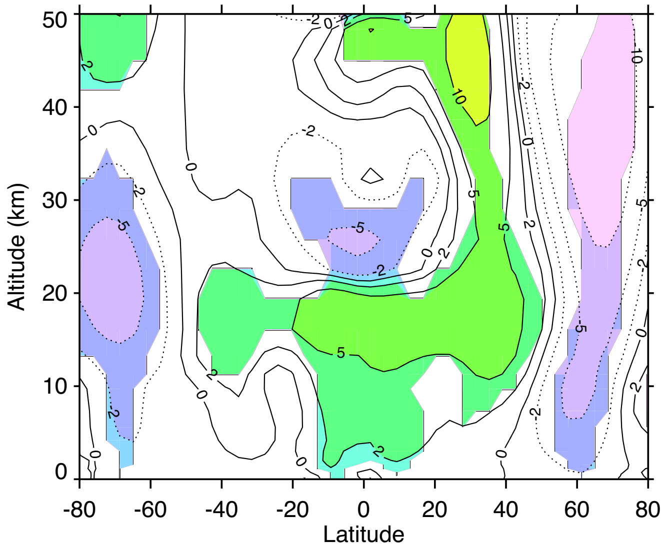

Figure 1. *January height-latitude cross-section of zonal mean wind velocity (m/s) changes of the year 2100 with respect to 2000. The areas where the changes are significant to greater than the 95 % confidence level are shaded.*

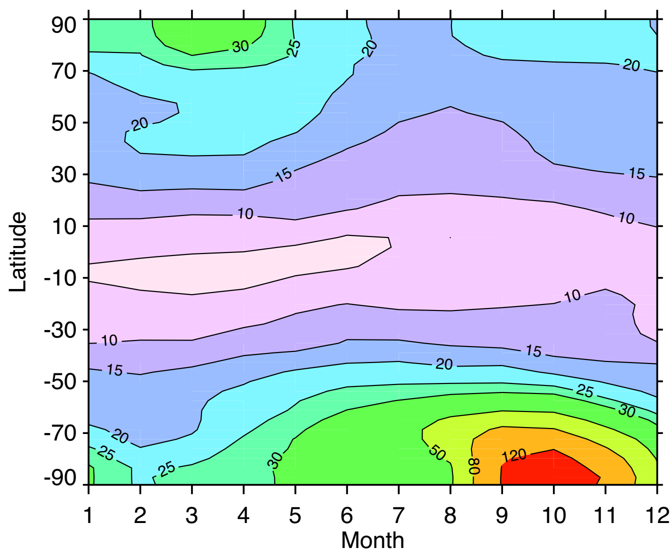

Figure 2. *Time-latitude cross-section of total ozone changes (%) of the year 2100 with respect to 2000. Changes are significant to greater than the 99 % confidence level.*

The Atmospheric Effects of 2003 SPE Simulation with Chemistry-Ionosphere-Climate Model SOCOL[i]

Tatiana Egorova, Eugene Rozanov, and Werner Schmutz in collaboration with Y. Ozolin (MGO, St.-Petersburg, Russia)

This work is a continuation of the solar proton events study on atmospheric composition. In this study we evaluate whether it is important to use a simple parameterization instead of real ion chemistry for production of odd nitrogen (NO_y) and odd hydrogen (HO_x). The study was performed with the 3-D chemistry-ionosphere-climate model SOCOL[i] (described in PMOD/WRC Report 2007) that has been improved by introducing the missing set of ion-ion recombination chemical reactions as the most probable source for HNO_3 production in the middle atmosphere.

For this investigation we have carried out two sets of 2-month long ensemble runs (ten members in each run) for the October 2003 solar proton event using SOCOL[i]. The first experiment was performed with daily ionization rates due to the solar proton events. In the second experiment we applied a simple parameterization of NO_y and HO_x production instead of full ion chemistry for the solar proton events. For the production of NO_y constituents by the protons and their associated secondary electrons it was assumed that 45 % of the N atoms produced per ion pair result in the production of $N(^4S)$ (~0.55 per ion pair) and that 55 % of the N atoms produced per ion pair result in the production of NO (~0.7 per ion pair) (Jackman et al. 2005). For HO_x production we follow the methodology of Solomon et al. (1981), where each ion pair results in the production of around two HO_x constituents in the upper middle atmosphere. The results, represented as the relative difference between the experiment with full ion chemistry and the parameterized NO_y and HO_x production, show that using the parameterization we underestimate the effect of the solar proton events on NO_x, HO_x and ClO_x species, which results in underestimation of the solar proton events effect on ozone by 10-15 %, though statistically insignificant. Some of the results are shown in Figure 1. Parameterization of NO_y production during the solar proton events leads to a NO underestimation by 30 % (not shown), OH by > 70 %, and HOCl by > 60 % (Figure 1). Because the obtained effect for O_3 is statistically insignificant we can conclude that ozone response is not too sensitive to the representation of the ion chemistry after the solar proton events. Therefore, it is satisfactory to use a simple parameterization for NO_y and HO_x production for ozone research. More results and analysis on the effect of the solar proton event in October 2003 on atmospheric composition can be found in Egorova et al. (2009 in preparation).

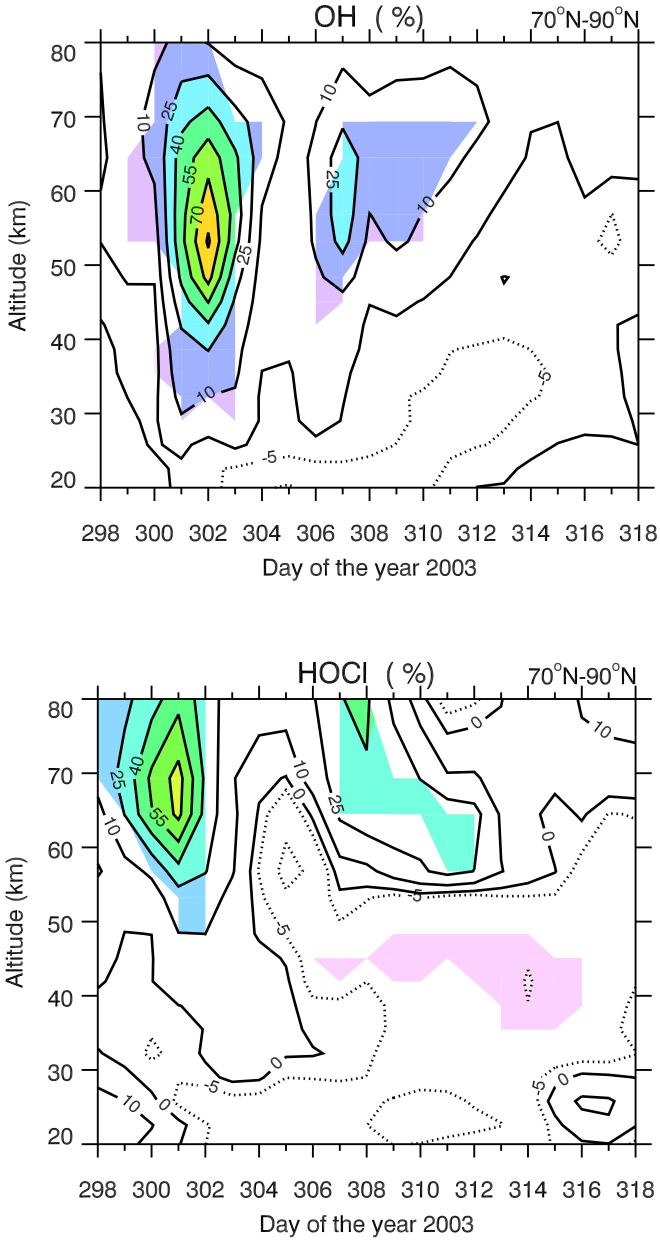

Figure 1. *Time-altitude distribution of OH and HOCl difference in percent between the experiment with parameterization and full chemistry for the solar proton events. Shaded areas show where the signal is statistically significant at a 95 % confidence level.*

References: Egorova T., Rozanov E., Ozolin Y., Schmutz W.,
The atmospheric effects of 2003 SPE simulated with chemistry-ionosphere-climate model SOCOL[i], in preparation for JGR, 2009.

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Neutral atmospheric influences of the polar proton events in October-November 2003, J. Geoph. Res, v.110, A09S27, doi: 10.1029/2004JA010888, 2005.

Solomon S., Rusch D.W., Gerard J.-C., Reid G.C., Crutzen P.J., The effect of particle precipitation events on the neutral and ion chemistry of the middle atmosphere, 2, Odd hydrogen, Planet. Space Sci., 29, 885-892, 1981.

Measurement of Vitamin D3 Weighted Irradiances Using UV Broadband Ultraviolet Radiometers.

Gregor Hülsen and Julian Gröbner

We describe how to convert the raw data from UV broadband radiometers to UV irradiances weighted with various UV response functions.

Measurements of solar ultraviolet (UV) irradiance are currently conducted by many regional networks around the world which usually consist of broadband filter radiometers only sensitive to the ultraviolet wavelength region.

Even though these instruments are constructed so that their spectral response function should be equal to the desired spectral response, small deviations between the detector specific response and the desired spectral response need to be taken into account. For example, the erythemal weighted solar irradiance is obtained from broadband filter radiometers by calculating correction functions based on the solar zenith angle and total column ozone to convert from the actual detector weighted irradiance to the desired erythemal weighted irradiance.

This procedure can be adapted so that the same instruments can be used to retrieve solar weighted irradiances for other action spectra, such as the CIE Vitamin D action spectrum using a suitable conversion function similar to the one used to calculate erythemal weighted irradiances.

The calculated weighted UV irradiances were compared to spectral measurements from the European Reference spectroradiometer QASUME, weighted with the corresponding action spectra during a three-week calibration campaign in June/July 2008.

The expanded uncertainty of the processed broadband measurements relative to the reference measurements lies between 6.5 % and 7.5 % for three different weighting functions (CIE Erythemal, CIE Vitamin D, and broadband UVB) and for the three major types of instruments (Solar Light 501, Yankee UVB-1, Kipp&Zonen UV-S-E-T).

Thus, a single broadband filter radiometer can be used for various investigations of the effects of UV radiation on biological organisms, if a suitable characterization and calibration – taking into account specific characteristics of the detector – is performed.

References: Hülsen G., Gröbner J., 2007, Characterization and calibration of ultraviolet broadband radiometers measuring erythemally weighted irradiance, Appl. Optics 46, 5877-5886.

Figure 1. *A Solar Light 501 UV broadband Radiometer is designed to measure erythemally weighted UV irradiance. The calibration procedure for such instruments was adapted, to convert the output signal to UV irradiance weighted with different UV response functions.*

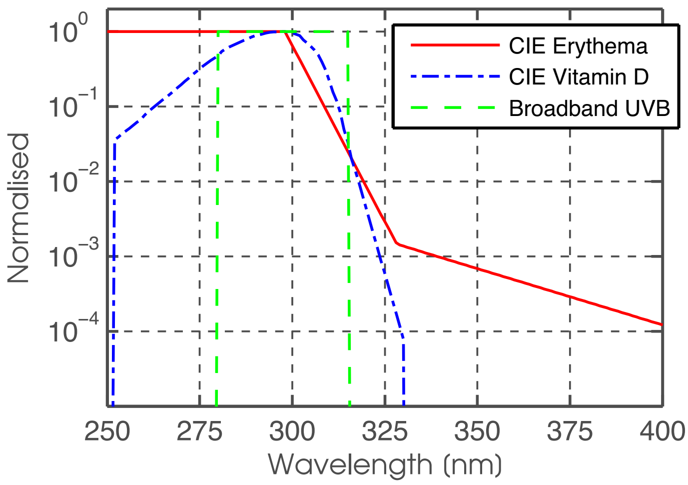

Figure 2. *Different UV weighting functions which can be used to convert UV broadband radiometer signals to the desired weighted UV irradiance.*

Down-Welling Longwave Radiation Comparison Between Models and Measurements for Clear-Sky and Stratus Conditions

Stefan Wacker and Julian Gröbner

We performed two comprehensive radiative transfer studies considering clear-sky and stratus conditions for the Payerne BSRN site.

In the first study, we compared modeled down-welling longwave radiation to measured down-welling longwave-fluxes for nocturnal clear-sky conditions at Payerne by applying the Radiative Transfer Models MODTRAN and libRadtran. Absorption coefficients for libRadtran were generated using the line-by-line (i.e. highest possible resolution) ARTS model and the LOWTRAN band parameter model characterised by a much lower resolution of 20 cm^{-1}. The resolution of the MODTRAN band model is 2 cm^{-1}. We computed down-welling longwave radiation for the broadband wavelength range (2 to 300 μm) and for the wavelength range of the atmospheric window from 8 to 14 μm for 40 carefully selected nocturnal clear-sky cases at Payerne. Vertical profiles of pressure, temperature and humidity obtained from radiosondes launched at Payerne around 23 UTC were incorporated into the models. The calculations were compared to the corresponding measurements, i.e. to a standard pyrgeometer and a modified CGR3-pyrgeometer which is only sensitive in the atmospheric window. Results revealed good agreement within the measurement uncertainty of ±2 Wm^{-2} between model and observations for both wavelength ranges using ARTS and MODTRAN (see Fig. 1). The calculations with LOWTRAN were outside the measurement uncertainty. The excellent results from this analysis can be also regarded as an independent validation of CGR3 measurements. Finally, the investigation revealed that pyrgeometers, sensitive only in the atmospheric window, are an attractive addition to support explicit validation of Radiative Transfer Models in the regime where water vapor spectra in the atmospheric window are not saturated.

In the second study, we presented down-welling longwave-fluxes and surface cloud radiative forcing results for single-layered stratus cases at Payerne by using down-welling longwave radiation surface measurements and MODTRAN. Thirty cases with single-layered completely overcast stratus conditions were selected in fall and winter months between October and February in the period from 2000 to 2005. Cloud base and cloud extent were determined for each case using synoptic observations, ceilometer data and humidity profiles obtained from radiosondes. These data were incorporated in MODTRAN together with pressure, temperature and humidity profiles of the radiosonde launched at 11 UTC at Payerne. The mean difference between model and measurements was 0.7 Wm^{-2} ±1.4 Wm^{-2} for the 30 cases (see Fig. 2). We used these model results to deduce the surface longwave cloud radiative forcing which is a quantitative measure of the effect of clouds on the radiation budget relative to the clear-sky radiation budget. Cloud radiative forcing can be derived by subtracting the model results for clear-sky conditions from the corresponding cloudy computations. The obtained value of 81 Wm^{-2} for such single-layered, fully overcast stratus clouds can be regarded as corresponding to extreme conditions and will be less for all-sky cases which also include stratus situations that are not totally overcast as for example the value of 54 Wm^{-2} proposed by Dong et al. (2006).

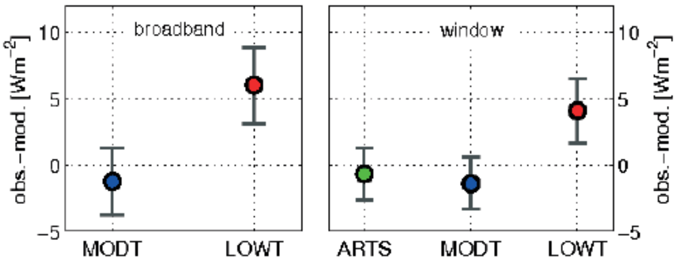

Figure 1. *Errorbars indicating mean and standard deviation of observed minus modeled DLR of 40 clear-sky night situations at Payerne using various band parameter models. ARTS and MODTRAN calculations are within the measurement uncertainty of ±2 Wm^{-2}, whereas LOWTRAN is outside.*

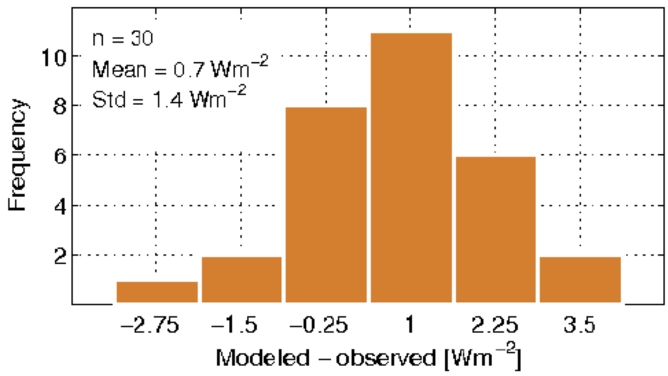

Figure 2. *Distribution of the differences between modeled and observed DLR for the 30 single-layered stratus cases at Payerne.*

References: Dong X., Xi B., Minnis P., 2006, A climatology of midlatitude continental clouds from the ARM SGP central facility. Part II: Cloud fraction and surface radiative forcing, J. Climate, 19, 1765-1783.

Retrieving the Effective Boundary Layer Temperature from Pyrgeometer Measurements

Julian Gröbner and Stefan Wacker

We describe a method to determine the effective boundary layer temperature from concurrent measurements of two pyrgeometer. Measurements from four sites in Switzerland (Davos, Payerne, Locarno-Monti and Jungfraujoch) were analyzed. The measurements at Davos, Payerne and Locarno-Monti show a stable inversion layer during the night and the transition to a convective state during daylight. These sites also show distinct diurnal and seasonal patterns of the atmospheric boundary layer temperature with respect to surface temperature. At Payerne, the measurements were additionally validated with temperature measurements from a meteorological tower.

We derive the atmospheric boundary layer (ABL) temperature from concurrent measurements of two pyrgeometers measuring over two wavelength ranges: One standard pyrgeometer sensitive to the 3 µm to 50 µm wavelength range and one modified pyrgeometer sensitive only in the atmospheric window, i.e. from 8 µm to 14 µm. By combining the two measurements we retrieve the effective temperature of the saturated atmospheric water vapor from the radiation emitted by the atmosphere in the wavelength range 3 µm to 8 µm and 14 µm to 50 µm at four sites in Switzerland: Davos, Payerne, Locarno-Monti and Jungfraujoch. The radiation in this wavelength range is emitted from the layers of the atmosphere closest to the Earth's surface which form the atmospheric boundary layer. The temperature derived from these measurements can be considered as an effective temperature of the saturated atmospheric water vapor, which depends directly on the profiles of humidity and temperature.

The atmospheric boundary layer temperature measurements obtained from the pyrgeometers were compared to air temperature measurements obtained from a meteorological tower at 10 m and 30 m at the Payerne BSRN site. The measurements clearly show the stable inversion layer during the night with atmospheric temperatures larger than at the surface, followed by the transition to a convective boundary layer during daylight due to solar heating (see Fig. 1). Measurements from Davos and Locarno-Monti confirm the observations obtained at Payerne. The measurements also reveal the seasonal variability of the atmospheric boundary layer: during night, the temperature difference between the ground and the atmospheric boundary layer is more pronounced in winter than in summer due to the enhanced cooling of the snow-covered surface (see Fig. 2). Indeed, the short and reduced solar heating in winter is not capable of breaking up the strong inversion during daytime.

Our observations of the atmospheric boundary layer temperature using infrared radiation emission of saturated water vapor are a crucial parameter for the parametrization of atmospheric longwave radiation models and can be used to improve cloud cover algorithms using longwave radiation measurements from standard pyrgeometers.

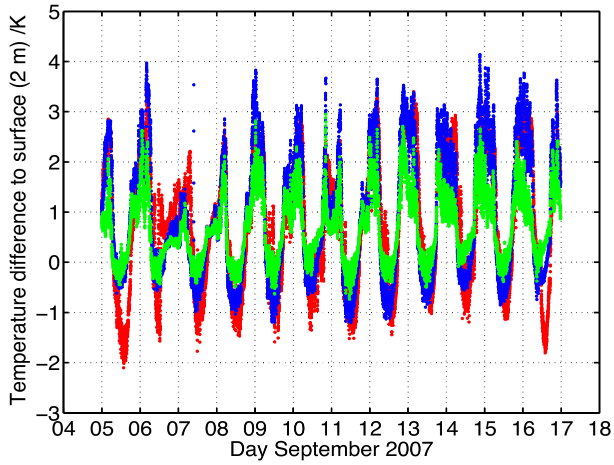

Figure 1. *Air temperature from pyrgeometer measurements (red curve), 30 m (blue) and 10 m (green) temperature from the tower relative to synoptic temperature at Payerne.*

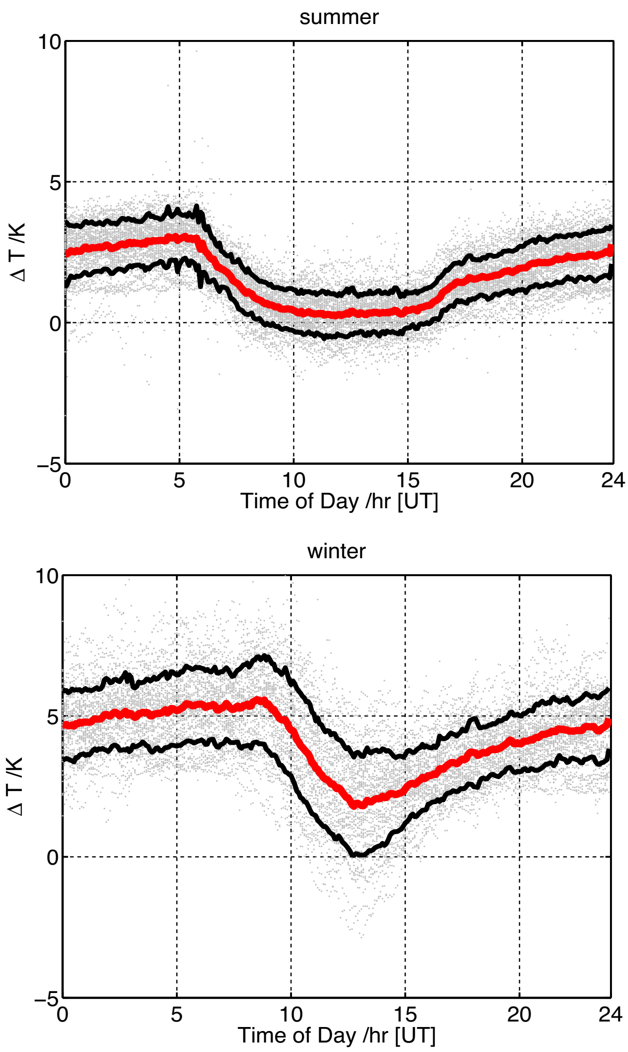

Figure 2. *Diurnal course of ABL temperature derived from pyrgeometer measurements for summer (top) and winter (bottom) at Davos. Mean and standard deviation are highlighted in red and black, respectively.*

Calculations of the Spectral Solar Irradiance with Molecular Lines

Alexander Shapiro and Micha Schöll

We introduce the calculation of molecular lines to the radiative transfer code COSI (Code for Solar Irradiance). The molecular lines significantly contribute to the total opacity in the solar atmosphere and therefore play an important role in the understanding of spectral solar irradiance.

Robust knowledge of the opacity in the solar atmosphere is crucial for spectral irradiance calculations. The COSI code explicitly calculates only a small number of selected transitions (about 100) in non local thermodynamic equilibrium, while all other line transitions are taken into account via the iteratively calculated opacity distribution function (Haberreiter et al., 2008).

Molecular lines play an important role in forming the solar spectrum and dominate in specific spectral regions. We introduce the calculation of the chemical equilibrium and the formation of the most prominent molecular systems (i.e. G band, CN violet system, Herzberg band) to the COSI code which enables us to include the contribution from molecules to the total opacity distribution function.

As a significant fraction of atoms can be associated with molecules the chemical equilibrium calculation also affects the atomic lines. In Fig. 1 we present the deviations in carbon and oxygen concentrations due to the association with molecules together with CN and CO concentrations for three atmospheric models by Fontenla et al. (1999). Both molecular concentrations and deviations in atomic concentration show strong temperature sensitivity which can be important for the solar variability study.

In Fig. 2 we illustrate the comparison between synthetic COSI spectra calculated with and without molecular lines in the CH G-band region and compare it to SORCE observations. Both spectra were calculated with the same atmospheric structure (ASUN) and slightly modified to give better continuum level agreement abundances (K91) by Kurucz (2005). The inclusion of the CH G-band is necessary to reproduce the spectral irradiance in the 410–450 nm region, however, because of the non local thermodynamic equilibrium effect, it can also affect UV irradiance, which is important for the terrestrial climate.

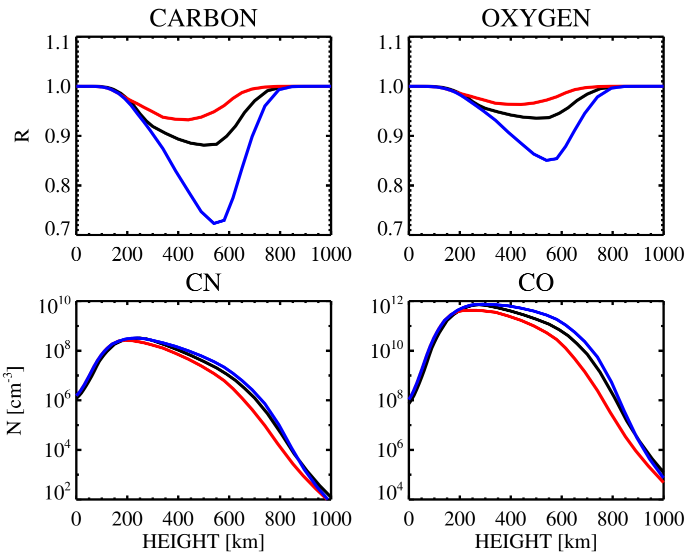

Figure 1. *The ratio R of unattached carbon and oxygen molecules to their total amount (upper panels) and the CN and CO concentrations (lower panels) for three solar atmospheric models: the relatively cold supergranular cell center model FALA (blue curves), the averaged "quiet" Sun model FALC (black curves) and the relatively worm bright network model FALP (red curves).*

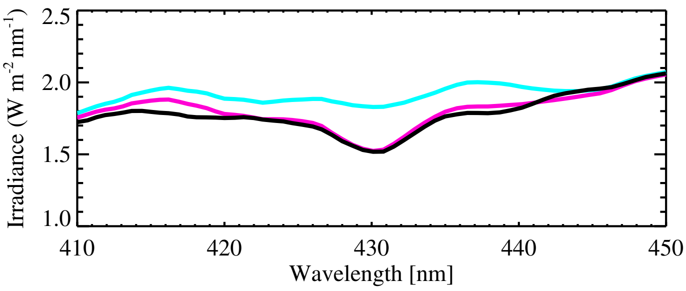

Figure 2. *Two synthetic spectra calculated with and without molecular lines (magenta and cyan curves accordingly) in comparison to SORCE observations (black curve).*

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Reconstructing the Long Term Spectral Solar Irradiance

Micha Schöll and Werner Schmutz

We present a spectral reconstruction of solar irradiance back to 1610 utilizing sunspots for short-term variations and the open magnetic flux for long-term trend.

Solar irradiance variation is an important forcing component in climate models as it is known that climate reacts to changing solar irradiance. As Rozanov et al. (2002) have shown, the Lyman-α line is of particular importance to chemical reactions in the upper atmosphere.

To reconstruct past climate, spectra as a function of time are required. Following the approach of Krivova et al. (2005) the spectral reconstruction is based on a four component model with filling factors for the area of quiet sun, sunspots, faculae and network regions. Wenzler extracts the filling factors using MDI magnetogram data and images of the visible sun.

Utilizing the open magnetic flux to reconstruct the long-term network evolution we obtain spectral irradiance back to 1610 where the Maunder minimum is below the current minimum.

The sunspot area and faculae are reconstructed using the sunspot number. The long-term network is split into active and passive networks. The active network corresponds to the active areas on the sun and is hence reconstructed using the sunspot number. The quiet network is assumed to correspond to the open magnetic flux with the assumptions that no open magnetic flux translates to a quiet sun and that the current quiet network is 14 % in accordance with Foukal et al. (1991). Using this approach, together with the active area expansion (see Schöll and Schmutz 2007) and a modeled spectrum using the COSI code, we obtain the reconstructed spectrum, with the Lyman-α line (121.5 nm) shown in Figure 1 and 2. Figure 1 is an enlargement of Figure 2 for the 1992 to 2001 period.

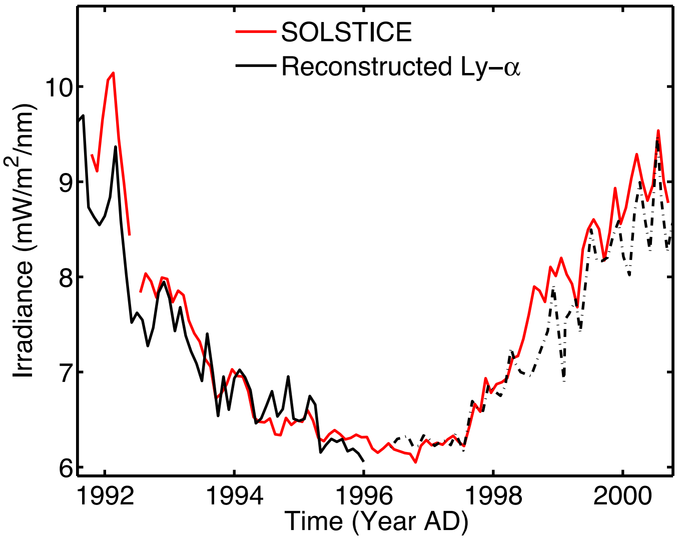

Figure 1. Reconstructed Lyman-α compared to SOLSTICE. The solid black line uses the reconstructed filling factors for all regions, while the dashed line displays the reconstruction using Wenzler's MDI data and reconstructed network regions.

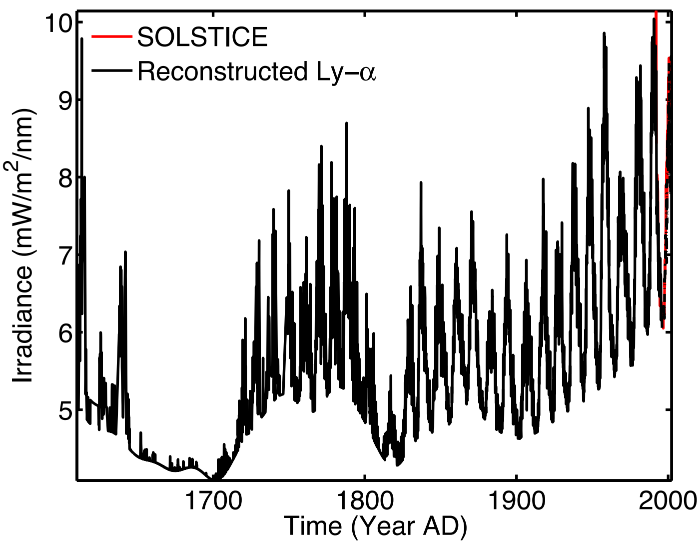

Figure 2. Reconstructed Lyman-α from 1610 to the present using the open magnetic flux for the long-term trend network.

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To Estimate the Effect of Leaking p-Modes on Solar UV Intensity: A Physical Explanation for UV Variability

Rosaria Simoniello and Wolfgang Finsterle

We analyzed full disk integrated sunlight measurements to investigate amplitude variation of acoustic waves in the frequency range 2.5-4.5mHz over solar cycle 23.

Periodic motions in the solar atmosphere have been known for more than half a century. This phenomenon has been interpreted as a resonant response of a large bubble of gas to a shock excitation. They are acoustic waves and it is predicted that only waves above the acoustic cut-off frequency of 5.3 mHz could travel freely in the solar atmosphere, whereas waves with lower frequencies are trapped inside the acoustic cavity of the Sun. Recent observations and analysis of upward traveling waves in the solar atmosphere, have detected traveling waves with frequencies below the cut-off. It is claimed that they are magneto-acoustic waves, propagating, where the inclined magnetic field lowers the cut-off. These waves are, therefore, tunneled into the chromosphere along the magnetic fields lines and becoming progressively steeper they eventually shock and dissipate their energy. This result could provide the major contribution to wave heating of the solar chromosphere compared to high frequency acoustic waves (5-40mHz). These high frequency waves were suggested early on to play an important role in chromospheric heating, but even if produced in abundance in the convection zone, they are thought to be inadequate In balancing the radiative losses by a factor of five. It has therefore been proposed that magnetic waves could account for the missing energy. Recent simulations have shown that photospheric oscillations can produce chromospheric shocks through upward propagation, but the role played in chromospheric heating is still under debate. Hence the importance of the role played by low and high frequency acoustic/magneto acoustic waves in the chromospheric heating and in UV variability is still debatable. We plan to investigate the amplitude variation for the standing and traveling regime over solar cycle 23 by investigating the role of the magnetic field. This parameter, in fact, measures the energy carried by the waves which is eventually dissipated in the higher layers of the solar atmosphere. In this preliminary analysis, we focus our attention on the standing wave regime below 4.5mHz.

To this aim, we analyze integrated sunlight measurements (Sun-as-a-star observations) provided by the Birmingham Solar Oscillation Network (BiSON), which is fully operational since 1976. Figure 1 shows how the p-mode surface amplitude is affected by the magnetic fields: the response depends on the wave frequency range. We found p-mode power suppression in the low frequency band as the solar cycle approaches its maximum, but the strength of the suppression depends on the frequency band: -15 % for 2.5-3.5mHz (line) and -4 % for 3.5-4.5mHz (dots). This suggests that the increasing level of magnetic activity affects the amount of energy pumped into the modes over the solar cycle. There are two possible mechanisms driving this phenomenon:

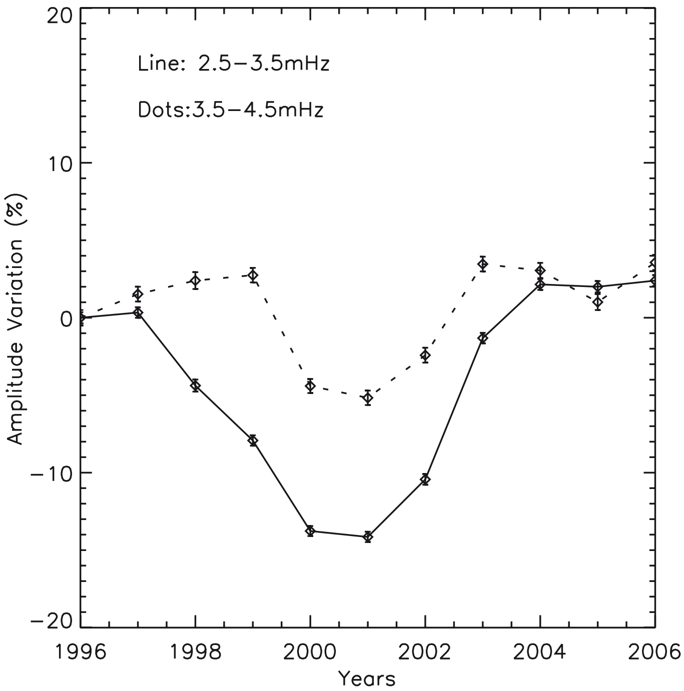

Figure 1: *P-mode power variation as seen in integrated sunlight measurements from BiSON observations in two frequency bands: 2.5-3.5 (line) and 3.5-4.5 (dots).*

– magnetic fields inhibit convection, therefore less energy is pumped into the modes as the solar cycle approaches its maximum;

– intense magnetic fields allow acoustic waves to be tunneled along the field lines and they therefore escape into the higher layers of the solar atmosphere.

We aim to investigate which one of these two mechanisms are behind the power suppression observed in the standing wave regime. Furthermore we aim to extend this research to above 5.5mHz, in the traveling wave regime. T of the role played by the waves in the chromosperic heating. This will give us the chance to gain a fuller picture of the role played by waves in chromospheric heating.

Results from the SOVIM Experiment on the International Space Station: Comparison of the Radiometers with those of VIRGO

Claus Fröhlich, Wolfgang Finsterle, and the SOVIM Team

SOVIM is an experiment within the ESA mission SOLAR on the International Space Station which was realized by PMOD and IRMB (see Section 'Space Experiments') and launched in February 2008. We present here the first results from April to October 2008 of the five radiometers and compare them with those of VIRGO. The agreement demonstrates not only the high level of reproducibility of building radiometers, but also the validity of the corrections applied to the VIRGO radiometers for degradation and other long-term changes in space.

As described in the instrumental part SOVIM is part of SOLAR on ISS and is operated through BUSOC and the COLUMBUS module. The experiment was developed by PMOD and IRMB under the leadership of PMOD. It was finally launched early February 2008 and observed the Sun until early October. In contrast to VIRGO/SOHO it can only observe the sun during periods of about 10-14 days with interruptions of similar length. On top of these restrictions the Coarse Pointing Device (CPD) of SOLAR did not properly function so that only 31% of the possible observations could be used. At the beginning the CPD was offset by more than a degree. Later, there were malfunctions: From time to time the CPD was reset instead of pointing.

Nevertheless, some good measurements were obtained during about 600 orbits which are shown in Fig. 1. The most striking result is the close agreement in the absolute value between VIRGO and SOVIM. This confirms on one hand that the correction applied for the changes of the VIRGO radiometers during the last 12 years are reliable, and on the other hand that the PMOD and IRMB radiometry is very reproducible. This latter result is probably more important than the former as it shows that radiometers build according to a well defined recipe are able to trace measurements of solar irradiance over a decade with an uncertainty which is substantially less than the stated absolute accuracy. The improvements made in the recent past for the determination of the area of the precision apertures is well documented by the very close agreement (difference of 90 ppm) of DIARAD-L and R, which have both apertures measured by NIST with the same apparatus. The PMO6 radiometers show also smaller differences than their stated uncertainties and it is interesting to see the close agreement between PMO6-1 and PMO6-R which has flown on EURECA. The difference between PMO6-1 and 2 is somewhat larger, but still within the uncertainty and most probably due to the uncertainty of the aperture measurements which is with a diameter of 5 mm larger than the uncertainty for DIARAD which has 10 mm apertures. This conclusion has to be confirmed from the ground comparisons.

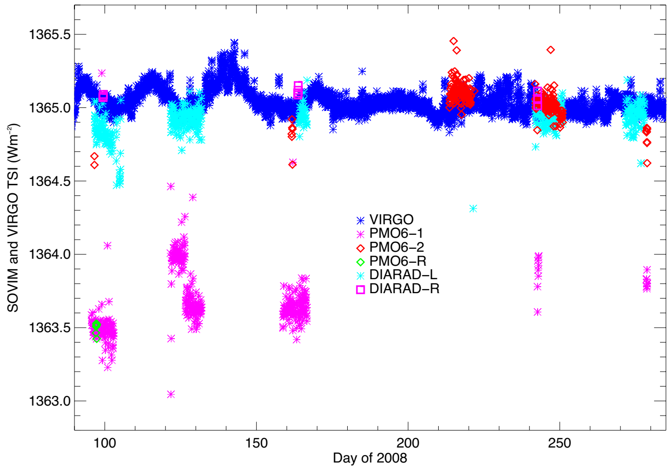

Figure 1. *Comparison of the measurements from SOVIM and VIRGO. The sampling of SOLAR is not very good and one may not catch variability reliably.*

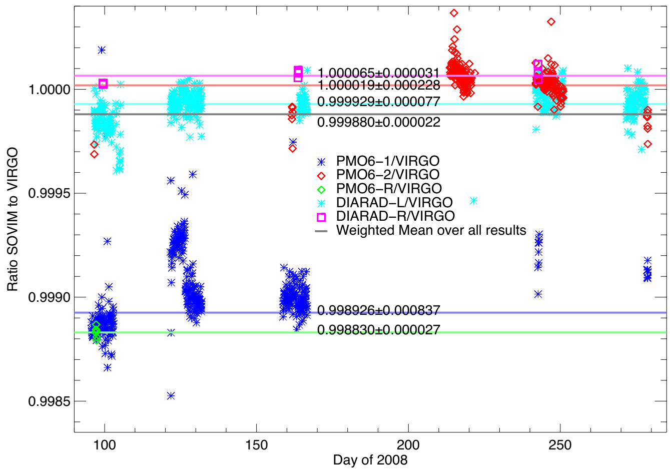

Figure 2. *Ratio of the irradiance measured by SOVIM and determined from VIRGO. The overall weighted mean ratio is with 0.99988 ± 0.00002, and the results from the SOVIM radiometers are only 120 ppm below the one of VIRGO.*

The agreement of SOVIM/ISS and VIRGO/SOHO measurements holds only if DIARAD on VIRGO is corrected for a non-exposure dependent change. The present result shows, that this correction is indeed needed and the estimates for the magnitude of the correction are correct. Without the correction for these non-exposure-dependent changes, the published results of DIARAD on VIRGO have increased since 1996 by almost 0.5 Wm^{-2}.

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Personnel Department

Sonja Degli Esposti

After fantastic 100th Anniversary celebrations at the PMOD in 2008, the year was also highlighted by two retirements.

Jules Urs Wyss went into retirement on 30th April 2008 having worked for 44 years at PMOD/WRC. He began work at the “Observatorium Davos” on March 1, 1964, which at the time was housed in the Villa Dora. Soon enough, the young engineer was assigned with challenging construction projects, and he developed with time into a true specialist. Over the decades, he would use engineering drawing to design complex instruments which were then precisely manufactured in his workshop. However, he exchanged drawing ink and paper for computer techniques in the last 10 years, when he learnt 3-D CAD design.

Jules could rightly be proud of his achievements! He used 3D-CAD techniques to design and construct the mechanical components of the last two space projects out of the seven in which he participated. He was a helpful and competent member of staff, and was involved in the development of other mechanical components and instruments. His mechanical expertise and innovative ideas were always fascinating, and if a special farewell present or medal for a school competition was required then Jules made them in his workshop.

We all thank him for his ingenuity and competent help in the many small and large projects at the PMOD/WRC. A surprise farewell party was organised on 30th April where we said our farewells.

The next farewell followed just a month later: Hansjörg Roth went into early retirement at the end of May 2008 after 35 years at the PMOD/WRC. Hansjörg began work at the Davos Observatorium on December 1, 1972, as an electrical engineer, only planning to stay several years. However, things turned out different, and during his time he decisively shaped and contributed towards the success of the Institute. He was head of the Electronics Department and was closely involved in all space projects, was responsible for the design and development of PMOD/WRC radiometers, and was deputy director of the PMOD/WRC. Last but not least, he was a well-respected colleague, supervisor and teacher. As such, he taught 16 apprentices who went on to become competent electronic technicians. After 35 years in Davos, Hansjörg is spending his retirement in Basel and nearby France where he is looking forward to a new and exciting life. We all wish Hansjörg much happiness and success in all of his “renovation” projects.

Jules Wyss and Hansjörg Roth were paid tribute and bid farewell by Gerhard Müller (President Supervising Committee) and Walter Amman (President of the SFI Foundation) during the PMOD/WRC Supervising Committee meeting on 19th March. Claus Fröhlich, former PMOD/WRC director and colleague of both, also paid tribute by recounting several anecdotes from their long and interesting careers. Werner Schmutz thanked both for their commitment towards the institute and presented them with a farewell gift.

Margit Haberreiter left at the end of January to continue her career as a Postdoc at LASP in Boulder, USA. Margit began her doctoral thesis at the PMOD/WRC on December 1, 2001 and was thereafter appointed as a Postdoc for 2 years. During her years at the PMOD/WRC Margit was greatly involved in our research successes. We thank her for her dedication and her enduring commitment towards our institute.

Our „Solar-Physics-Group“ was joined by Rosario Simoniello in July. Rosaria is working as a Postdoc specialising in helio-seismology in the long-term National Foundation Project „Variability of Solar Irradiance, Oscillations, and Seismology of the Sun“.

A further addition to this group occurred in October: Alexander Shapiro, previously a doctoral student at the ETZ Zürich, was appointed as a Postdoc. Alexander will be working on the “SOTERIA” EU FP7 research project. Several weeks later, Anna Shapiro joined the team and increased the number of doctoral students at PMOD/WRC to five.

Silvio Koller was appointed as successor to Hansjörg Roth and is in charge of the Technical Department. Silvio has been at PMOD/WRC since 2003 and is well-qualified for this task as a result of his career experience. Dany Pfiffner takes on the role of deputy, as well as being Project Leader for space projects.

The electronics department gained a new member of staff: Ricco Soder was employed as an engineer and will mainly be involved with the design and construction of prototype instruments. Alongside his job, Ricco is studying electrical engeneering at the HTW Chur.

Christian Gubser who was previously an apprentice at PMOD/WRC, also supported us for a short 2-month assignment.

Another electronics apprentice successfully finished his training at our institute in August: Chasper Buchli successfully attended Training College and passed his apprentice exams with good marks. The whole team is proud of his achievements! He was employed as an electronic technician at PMOD/WRC until his enlistment as a military conscript, after which he hopes to continue his studies in Higher Education.

Matthias Müller joined the apprentice team in the electronics department and began his training at the beginning of August.

The administration department also gained a new apprentice. Nadia Casanova, as well as Matthias Müller, began her training in August and we look forward to working with her.

After the birth of her son, Denise Dicht, who is the PMOD housekeeper and cleaner, reduced her working hours. Savina Stark joined the team on 1st April and will help out for one year. In addition, Jutta Jäger has started a part-time cleaning job at PMOD.

As in every year, PMOD/WRC also engaged numerous civil conscripts in 2008 who supported our work with enthusiasm and energy. We also thank their engagement.

Scientific Personnel

Prof. Dr. Werner Schmutz	Director, physicist, sun-earth connection, astrophysics, CoI ETH-Polyproject, PI PREMOS, CoI LYRA, SOVIM
Dr. Julian Gröbner	Head WRC-sections IR radiometry, WORCC and EUVC, physicist, CoI PREMOS
Dr. Wolfgang Finsterle	Head WRC-section solar radiometry, physicist, absolute radiometry, solar physics, CoI VIRGO, SOVIM, PREMOS, LYRA
Dr. Christoph Wehrli	Scientist, WORCC section, physicist, CoI VIRGO, SOVIM, PREMOS, LYRA
Dr. Eugene Rozanov	Physicist, project manager ETH-Polyproject, sun-earth connection, CCM calculations, CoI LYRA, CoI PREMOS
Dr. Gregor Hülsen	Scientist, EUVC, physicist
Dr. Tatiana Egorova	Postdoc, meteorologist, sun-earth connection, CCM calculations, COST-724, SNSF project
Dr. Margit Haberreiter	Postdoc, physicist, solar physics, CoI PREMOS, SNSF project (until 31.1.2008)
Dr. Stephan Nyeki	Scientist, WORCC section
Dr. Rosaria Simoniello	Postdoc, physicist, solar physics, SNSF project, (since 1.7.2008)
Dr. Alexander Shapiro	Postdoc, physicist, FP-7 project SOTERIA (since 1.10.2008)
Anna Shapiro	PhD student, ETHZ, SNSF project (since 17.11.2008)
Uwe Schlifkowitz	PhD student, ETHZ
Micha Schöll	PhD student, ETHZ, ETH-Polyproject
André Fehlmann	PhD student, UZH, SNSF project
Stefan Wacker	PhD student, UNIBE, LIRAS project

Expert Advisor

Dr. Claus Fröhlich	Physicist, solar variability, helioseismology, radiation budget, PI VIRGO, PI SOVIM, CoI GOLF, MDI

Technical Personnel

Hansjörg Roth	Deputy director, department head technical support, electronic engineer, experiment manager VIRGO, SOVIM, PREMOS (until 31.5.2008)
Silvio Koller	Head technical department (since 1.6.2008) Electronic engineer, LYRA experiment manager, PREMOS, quality system manager
Daniel Pfiffner	Project manager space experiments, deputy head technical department and quality system (since 1.6.2008), electronic engineer SOVIM, PREMOS
Marcel Spescha	Technician
Christian Thomann	Technician
Daniel Bühlmann	Technician
Diego Wasser	Electronic technician
Ricco Soder	Research engineer (since1.11.2008)
Christian Gubser	Electronic technician (May-June)
Jules U. Wyss	Mechanic, general mechanics, 3D design and manufacturing of mechanical parts (until 30.4.2008)
Chasper Buchli	Electronics apprentice 4th year (until 8.8.2008), electronic technician 11.8. –17.10.2008
Samuel Prochazka	Electronics apprentice, 2nd/3rd year
Matthias Müller	Electronics apprentice, since 1.8.2008

Administration

Sonja Degli Esposti	Head administration/Human Resources
Stephanie Ebert	Secretary
Nadia Casanova	Administration apprentice, since 1.8.2008

Caretaker

Denise Dicht	General caretaker, cleaning
Regula Dicht	Cleaning, part time
Savina Stark	Cleaning, part time, since 1.4.2008
Jutta Jäger	Cleaning, part time, since 15.12.2008

Civilian Service Conscripts

Gabriel Schneider	01.10.2007 – 04.01.2008
Andrin Doll	01.10.2007 – 01.03.2008
Roger Oechslin	07.01. – 01.07.2008
Urs Gähwiler	03.03. – 21.04.2008
David Moser	07.07. – 16.08.2008
Marc Labudde	21.04. – 25.07.2008
Peter Leiser	04.08. – 30.09.2008
Stefan Osterwalder	15.09. – 26.12.2008
Robert Cerny	since 27.10.2008

Public Seminars

15.02.2008 Prof. Dr. Stefan Brönnimann, IACETH CLIVAR's "Climate of the 20th century project": SOCOL in a GCM intercomparison

12.03.2008 Volkmar Holzwarth, Max-Planck-Institut für Sonnensystemforschung "The magnetic activity of cool stars – from the convection zone to the astrosphere"

20.03.2008 Alexander Shapiro, IACETH "Solar Spectrum Modeling"

09.04.2008 Dr. Rosaria Simoniello, IAC Tenerife, Spain "Probing the solar atmosphere with acoustic waves"

29.04.2008 Dr. Junying Sun from Chinese Acad. Met. Sciences "Brief Introduction of China GAW Stations"

18.08.2008 Isla Simpson, Imperial College London, UK "Downward propagation of the solar signal in a simplified GCM"

Guided Tours

11.01.2008: 8 persons
13.01.2008: 5 persons
28.02.2008: 3 persons
17.04.2008: 40 persons
20.05.2008: 8 persons
31.05.2008: 23 persons
03.06.2008: 8 persons
07.06.2008: 27 persons

10.06.2008. 3 persons
27.06.2008: 16 persons
21.08.2008: 19 persons
27.08.2008: 20 persons
27.09.2008: 90 persons
30.09.2008: 15 persons
28.11.2008: 12 persons

Course of Lectures, Participation in Commissions

Werner Schmutz	Course of lecture Astronomie, HS 2008, ETH-ZH Examination expert in astronomy, BSc ETH-ZH International Radiation Commission (IRS, IAMAS) Comité consultatif de photométrie et radiométrie (CCPR, BIPM) Federal Space Affairs Commission (SER) Prodex Program Committee (CFAS, SER) Expert Team on Meteorological Radiation and Atmospheric Composition Measurements (CIMO, WMO) International Living With a Star Working Group (ESA) Committee on Space Research, commission of SCNAT Executive board of the Swiss Society for Astrophysics and Astronomy (SCNAT) GAW-CH working group (MeteoSwiss) Swiss management committee delegate to the COST action 724 (ESF)
Wolfgang Finsterle	Expert Team on Meteorological Radiation and Atmospheric Composition Measurements (CIMO, WMO)
Claus Fröhlich	Visiting lecture Atmosphärische Strahlungsprozesse und Klima, WS 2008/2009, Universität Innsbruck Comitee des Programmes Scienitifiques du CNES, Paris Science Commitee of ISSI, Bern (since Oct 2008)
Julian Gröbner	Course of Lecture Solar Ultraviolet Radiation WS 2008, ETH-ZH GAW-CH working group (Meteoswiss) Swiss management committee delegate to the COST action 726 (ESF) Working group leader of COST action 726 NEWRAD scientific committee member Working group of Baseline Surface Radiation Network (WMO/WCRP)
Christoph Wehrli	Aerosol Optical Depth course at GAWTEC GAW-CH working group (MeteoSwiss) Scientific Advisory Group Aerosol (WMO/GAW) SAG sub group AOD, chairman (WMO/GAW) Working group Baseline Surface Radiation Network (WMO/WCRP)

Donations

The PMOD/WRC is fortunate to have a very loyal sponsor: Mr. Daniel Karbacher from Küsnacht, ZH. Every year since 2002, he has made extra investments possible in addition to those covered by the regular budget. Last year the WRC infrared radiometry section obtained a BRUSAG sun tracker which is used for additional calibration capacity of pyrgeometer instruments, i.e. instruments measuring infrared radiation.

Figure 1. *The new BRUSAG sun tracker in operation on the roof of the PMOD/WRC building.*

Balance Sheet 2008

Aktiven	31.12.2008 CHF	31.12.2007 CHF
Flüssige Mittel	876'972.33	633'338.18
Debitoren	113'436.45	44'385.30
Kontokorrent Stiftung	32'398.18	24'206.90
Mehrwertsteuer	20'462.45	30'389.45
Verrechnungssteuer	2'189.50	2'152.50
Kontokorrent Drittmittel	251'562.46	489'784.41
Transitorische Aktiven	4'280.60	33'964.00
	1'301'301.97	1'258'220.74

Passiven		
Kreditoren	107'935.02	161'940.09
Transitorische Passiven	319'258.80	434'557.35
Rückstellungen	701'365.20	512'540.85
Eigenkapital	172'742.95	149'182.45
	1'301'301.97	1'258'220.74

Annual Accounts 2008

Ertrag	CHF
Beitrag Bund Betrieb WRC, IRC, WORCC	1'287'868.00
Beitrag Kanton Graubünden	213'959.00
Beitrag Davos	555'470.00
Beitrag Davos, Mieterlass	145'675.00
Beitrag GAW/CH für EUVC	160'000.00
Forschungsbeitrag EUSAAR	27'480.00
Beitrag SOTERIA	12'357.80
Einnahmen Drittmittel	687'067.46
Instrumentenverkauf	184'103.00
Übriger Ertrag/Eichungen	188'957.76
Spenden	28'225.65
Finanzertrag	14'260.47
	3'505'424.14

Aufwand	CHF
Personalaufwand	1'850'479.67
Ausgaben Drittmittel	687'067.46
Investitionen	218'346.14
Unterhalt	32'527.45
Verbrauchsmaterial	37'915.85
Verbrauch Commercial	163'888.05
Reisen, Kongresse, Kurse	78'049.11
Bibliothek und Literatur	25'115.00
Raumaufwand	226'389.05
Verwaltungsaufwand	43'372.53
Finanzaufwand	61'121.18
Übriger Betriebsaufwand	57'592.15
	3'481'863.64
Ergebnis 2008	23'560.50
	3'505'424.14

Abbreviations

AERONET	Aerosol Robotic Network, GSFC
AOD	Aerosol Optical Depth
ASRB	Alpine Surface Radiation Budget
BIPM	Bureau International des Poids et Mesures, Paris, F
BISON	Birmingham Solar Oscillation Network
BOLD	Blind to Optical Light Detector
BSRN	Baseline Surface Radiation Network of the WCRP
BUSOC	Belgian User Support and Operation Centre of ESA
CCM	Chemistry-Climate Model
CAS	Commission for Atmospheric Sciences, Commission of WMO
CCPR	Comité Consultatif de Photométrie et Radiométrie, BIPM
CIE	Commission Internationale de l'Eclairage
CIPM	Comité International des Poids et Mesures
CIMO	Commission for Instruments and Methods of Observation of WMO, Geneva
CMC	Calibration and Measurement Capabilities
CNES	Centre National d'Etudes Spatiales, Paris, F
CNRS	Centre National de la Recherche Scientifique, Service d`Aéronomie Paris
CoI	Co-Investigator of an Experiment/Instrument/Project
COSI	Code for Solar Irradiance – solar atmosphere radiation transport code developed at PMOD/WRC
COSPAR	Commission of Space Application and Research of ICSU,
COST	Co-operation in the Field of Scientific and Technical Research, an Intergovernmental Framework Program of the ESF
CPD	Coarse Pointing Device
CSAR	Cyrogenic Solar Absolute Radiometer
CTM	Chemical Transport Model
CUCF	Central UV Calibration Facility, NOAA, Boulder, USA
DIARAD	Dual Irradiance Absolute Radiometer of IRMB
DLR	Deutsche Luft und Raumfahrt
ESA	European Space Agency, Paris, F
ESF	European Science Foundation
ESPNET	European Sun-Photometer NETwork
ESTEC	European Space Research and Technology Center, Noordwijk
ETH	Eidgenössische Technische Hochschule (Zürich, Lausanne)
EURECA	European Retrievable Carrier on SOVA
EUSAAR	FP6 project: European Supersites for Atmospheric Aerosol Research
EUV	Extreme Ultraviolet Radiation
EUVC	European Ultraviolet Calibration Center at PMOD/WRC
FP6/FP7	European Framework Program of the European Commission
FRC	Filter Radiometer Comparison
GAW	Global Atmosphere Watch, an Observational Program of WMO
GAWTEX	GAW Training & Education Center
GCM	General Circulation Model
GHG	Greenhouse Gases
GOLF	Global Oscillations at Low Frequencies, Experiment on SOHO
GONG	Global Oscillations Network Group
GSFC	Goddard Space Flight Center, Greenbelt, MD, USA
HF	Hickey-Frieden Radiometer Manufactured by Eppley, Newport, RI, USA
IACETH	Institute for Climate Research of the ETHZ
IAMAS	International Association of Meteorology and Atmospheric Sciences of IUGG
IAU	International Astronomical Union of ICSU, Paris, F
ICSU	International Council of Scientific Unions, Paris, F
IPC	International Pyrheliometer Comparisons
IPHIR	Inter Planetary Helioseismology by Irradiance Measurements
IR	Infrared
IRC	International Radiation Commission, Commission of IAMAS
IRIS	Infrared Integrating Sphere Radiometer
IRMB	Institut Royal Météorologique de Belgique, Brussel, B
IRS	International Radiation Symposium of the Radiation Commission of IAMAS
ISO/IEC	International Oranisation for Standardization/International Electrotechnical Commission
ISS	International Space Station
ISSI	International Space Science Institute, Bern
IUGG	International Union of Geodesy and Geophysics of ISCU
JRC	Joint Research Center of the European Commission in Ispra, I
KIS	Kiepenheuer-Institut für Sonnenphysik, Freiburg i.Br., D
LYRA	Lyman-alpha Radiometer, Experiment on PROBA 2
METAS	Swiss Federal Office of Metrology and Accreditation
MFRSR	Multi Filter Rotating Shadowband Radiometer
MGO	Main Geophysical Observatory, St. Petersburg, RUS
MITRA	Monitor to Determine the Integrated Transmittance
NASA	National Aeronautics and Space Administration, Washington DC, USA
NEWRAD	New Developments and Applications in Optical Radiometry
NIP	Normal Incidence Pyrheliometer
NIST	National Institute of Standards and Technology, Gaithersburg
NOAA	National Oceanographic and Atmospheric Administration, Washington DC, USA
NPL	National Physical Laboratory, Teddington, UK
NRL	Naval Research Laboratory, Washington DC, USA
NREL	National Renewable Energy Lab, Golden, CO, USA
ODS	Ozone Destroying Substances
PFR	Precision Filter Radiometer
PHOBOS	Russian Space Mission to the Martian Satellite Phobos
PI	Principle Investigator, Leader of an Experiment/Instrument/Project
PICARD	French Space Experiment to Measure the Solar Diameter
PMOD	Physikalisch Meteorologisches Observatorium Davos
PMO6	PMO6 Type Radiometer
PREMOS	Precision Monitoring of Solar Variability, PMOD/WRC experiment on PICARD
PROBA 2	ESA Technology Demonstration Space Mission
PRODEX	Program for the Development of Experiments, ESA
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig & Berlin, D
QASUME	Quality Assurance of Spectral Ultraviolet Measurements in Europe
QMS	Quality Management System
RA	Regional Association of WMO
SCNAT	Swiss Academy of Sciences
SCOPES	Scientific Collaboration between Eastern Europe and Switzerland, grant of the SNSF
SER	State Secretariat for Education and Research, Bern
SLF	Schnee und Lawinenforschungsinstitut, Davos
SFI	Schweiz. Forschungsinstitut für Hochgebirgsklima und Medizin, Davos
SI	International System of Units
SIAF	Schweiz. Institut für Allergie- und Asthma-Forschung, Davos
SNSF	Swiss National Science Foundation
SOCOL	Combined GCM and CTM Computer Model, developed at PMOD/WRC
SOHO	Solar and Heliospheric Observatory, Space Mission of ESA/NASA
SOLAR	Experiment Platform on the ISS
SORCE	Space Mission of NASA
SOTERIA	Solar-Terrestrial Investigations and Archives
SOVA	Solar Variability Experiment on EURECA
SOVIM	Solar Variability and Irradiance Monito¬ring, PMOD/WRC Experiment on the International Space Station Alpha, 2008
STEP	Solar Terrestrial Energy Program of SCOSTEP/ICSU
SUSIM	Solar Ultraviolet Spectral Irradiance Monitor on Board UARS
TSI	Total Solar Irradiance
UARS	Upper Atmosphere Research Satellite of NASA
UTC	Universal Time Coordinated
UV	Ultraviolet Radiation
UVA	UV Radiation in the Range of 315-400 nm
UVB	UV Radiation in the Range of 280-315 nm
VIRGO	Variability of Solar Irradiance and Gravity Oscillations, PMOD/WRC experiment on SOHO
WCRP	World Climate Research Program
WDCA	World Data Center for Aerosols, Ispra, I
WIGOS	WMO Integrated Global Observing System
WISG	World Infrared Standard Group of Pyrgeometer, at WRC
WMO	World Meteorological Organization, Geneva
WORCC	World Optical Depth Research and Calibration Center
WRC	World Radiation Center, Davos
WRC-SRS	Solar Radiometry Section of WRC
WRDC	World Radiation Data Center, St. Petersburg, RUS
WRR	World Radiometric Reference
WSG	World Standard Group, realizing the WRR, at WRC
WWW	World Weather Watch, an Observational Program of WMO

View of the International Space Station (ISS) showing the ESA Columbus science module and SOVIM (see arrow in lowest inset picture). ISS dimensions are about 73 m in width by 93 m in length with a current weight of 227 metric tonnes. The ISS orbits the Earth in about 91 minutes at an altitude of 349-358 km. The SOLAR payload (first inset) was launched to the ISS aboard the Atlantis Shuttle on February 7, 2008 (second and third insets). SOVIM is part of the "SOLAR" platform (fourth inset), externally mounted to the ESA Columbus module, and is comprised of four absolute radiometers, two sun-photometers and a two-axis sun-sensor.

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