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Physikalisch-Meteorologisches Observatorium
Davos
World Radiation Center

Annual Report 2003

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SFI

Schweizerisches Forschungsinstitut für Hochgebirgsklima und Medizin

DAVOS

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Zusammenfassung Jahresbericht 2003

Vorwort

Das Weltstrahlungszentrum gilt seit dem Jahr 2003 als von der WMO anerkanntes Kalibrierzentrum für Messgeräte der atmosphärischen Infrarotstrahlung. Der XIV Kongress der Weltorganisation für Meteorologie (WMO) folgte im Mai 2003 den Empfehlungen der Kommissionen für Instrumente und Beobachtungsmethoden (CIMO) und für Atmosphärenwissenschaften (CAS), und hat sich für die Einrichtung des Zentrums am PMOD/WRC ausgesprochen. Die von der MeteoSchweiz und der Stiftung SFI finanzierte Aufbauphase ist nun abgeschlossen und ab diesem Jahr wird die entsprechend erhöhte reguläre Finanzierung des Weltstrahlungszentrums auch diese zusätzliche Aktivität des PMOD/WRC abdecken. Der Vertrag für die Finanzierung des Weltstrahlungszentrums zwischen Bund, Kanton Graubünden, Landschaft Davos und Stiftung SFI konnte allerdings noch nicht unterzeichnet werden, da der Kanton die dafür nötige gesetzliche Grundlage erst schaffen muss. Alle Beteiligten haben aber klar signalisiert, dass dies nur ein formales Problem sei und dass bei allen die Absicht besteht, den Vertrag im vorgeschlagenen Finanzierungsumfang zu unterzeichnen. Damit kann das PMOD/WRC zwar noch nicht offiziell die gelungene Erweiterung seiner Dienstleistungsaufgaben feiern, aber zumindest darf man sich über die offizielle Anerkennung durch die WMO freuen.

Das PMOD/WRC baut zur Zeit an drei Weltraumprojekten, von denen das älteste, SOVIM, kurz vor der Auslieferung zur Integration steht. SOVIM umfasst sowohl Absolut-Radiometer als auch Filterradiometer, während die beiden neueren Experimente, PREMOS und LYRA, Filterradiometer-Experimente sind, die nur in ausgewählten Spektralbändern die Sonnenstrahlung messen werden. Um die führende Rolle des Observatoriums in der Absolut-Radiometrie zu erhalten, ist es wichtig, dass wir auch Pyrheliometer technisch weiterentwickeln und bei Weltraummissionen einsetzen . Die Möglichkeiten solche Experimente auf Satelliten zu fliegen sind sehr rar und letztes Jahr ist leider eine Gelegenheit im letzten Moment gescheitert. Die Amerikanische Weltraumorganisation (NASA) hat uns einen Platz auf dem Sonnenbeobachtungssatelliten “Solar Dynamic

Observatory" (SDO) angeboten, jedoch unter der Voraussetzung, dass sich auch die Europäische Weltraumorganisation (ESA) an der Mission beteiligt. Leider hatte die ESA kein Interesse und lehnte es ab, einen Beitrag für SDO zu leisten.

Die theoretische Untersuchung des Sonneneinflusses auf das Erdklima verläuft weiterhin erfreulich und liefert interessante Erkenntnisse. Die Unterstützung des Projekts durch die ETH Zürich ist erwartungsgemäss – da zwei Jahre zu kurz wären um die laufenden Dissertationen abzuschliessen – um ein weiteres Jahr auf drei Jahre verlängert worden. Somit erreicht das auf sechs Jahre ausgelegte Projekt im Jahr 2004 Halbzeit und es gilt nun in unserem Fortsetzungsantrag die ETH zu überzeugen, dass die Qualität unserer Forschung eine zweite 3-Jahres-Phase wert ist.

Dienstleistungen, Instrumentenverkauf und Messnetze

Im Jahr 2003 kalibrierte das PMOD/WRC 79 Instrumente an 90 Messtagen, davon 14 Pyrgeometer als Infrarot-Radiometer Kalibrierzentrum. Die Anzahl Kalibrierungen ist etwas geringer als im Vorjahr, liegt aber durchaus im Rahmen der durchschnittlichen Auftragszahlen der letzten Jahre.

Die 2-Jahres Aufbauphase des Infrarot-Radiometer Kalibrierzentrum konnte 2003 abgeschlossen werden und nun bilden zwei Eppley PIR Pyrgeometer und zwei Kipp & Zonen CG4 Pyrgeometer eine Infrarot Standardgruppe, deren Stabilität regelmässig mit unserem Absolute Sky-Scanning Radiometer (ASR) überprüft wird. Die vier Instrumente sind auf dem Dach des Observatoriumsgebäudes installiert. Zu kalibrierende Gastinstrumente werden zuerst mit einer Schwarz-Körper Strahlungsquelle im Labor charakterisiert und erhalten dann relativ zur Standardgruppe die endgültige Feldkalibrierung im simultanen Betrieb unmittelbar neben der Standardgruppe.

Neu bietet das PMOD/WRC Ventilations- und Heizsysteme für Pyrgeometer zum Verkauf an, die zusammen mit zusätzlichen Dom-sensoren die Messgenauigkeit der Instrumente verbessern. Im Berichtsjahr konnten wir zwei solcher Systeme verkaufen. Im vorletzten Jahr gelang es uns vier PMO6-cc Pyrheliometer zu verkaufen, was für Absolut-Radiometer einen ausserordentlich grossen Absatz darstellt. Dafür war nun im Jahr

2003, trotz der Partnerschaft mit Kipp & Zonen, die Nachfrage gering und wir konnten nur eine moderne Elektronik für die Erneuerung eines alten Radiometers verkaufen. Im Gegensatz zum Desinteresse an Absolut-Radiometern gab es einige Anfragen für PMOD/WRC Präzisions-Filterradiometer. Leider hatten wir nur noch drei Filterradiometer an Lager, die nach Finnland verkauft wurden, und wir beabsichtigen daher im laufenden Jahr wieder eine neue Serie von Filterradiometern zu bauen.

Die vollständigen Messreihen bis Ende 2002 von sechs der acht Präzisionsfilterradiometer des GAW Versuchsmessnetzes zur Überwachung der Trübung durch Aerosol Teilchen wurden qualitätskontrolliert und als Stundenmittelwerte an das Aerosol-Weltdatenzentrum in Ispra abgeliefert. Sie stehen nun entsprechend der WMO-Richtlinien allen Interessenten zur freien Verfügung. Die Auswertungen einer Vergleichskampagne von Messinstrumenten zur Bestimmung der Aerosol optischen Dicke im kanadischen Bratt's Lake ergab eine sehr gute Übereinstimmung zwischen Instrumenten, die als genau gelten, und erfreulicherweise gehören auch unsere Präzisions-Filterradiometer zu dieser Gruppe.

Die 10-Stationen des Alpine Surface Radiation Budget (ASRB) Messnetzes des PMOD/WRC laufen seit 1995 und liefern im zwei Minuten Intervall einen Messwert. Diese Messdaten werden alle vier Stunden über eine Telefonleitung ans PMOD/WRC kopiert, wo sie kontrolliert und gespeichert werden.

Entwicklung und Bau von Instrumenten – Weltraumexperimente VIRGO, SOVIM, PICARD und LYRA

Das PMOD/WRC Experiment VIRGO auf dem ESA/NASA-Satelliten SOHO begann seine Mission Ende 1995 mit einer nominal vorgesehenen Betriebsdauer von zwei Jahren. Mittlerweilen misst VIRGO die Sonnenstrahlung schon seit mehr als acht Jahren – und dies ohne wesentliche Probleme. Das Nachfolgeexperiment SOVIM bekam neu „Oktober 2006“ als Space Shuttle Starttermin, um auf der Internationalen Raumstation installiert zu werden. SOVIM ist fertig zusammengebaut und befindet sich zur Zeit in der Test- und Kalibrierphase.

Am Filterradiometer-Experiment PREMOS für die französische Mission PICARD wurde nur sehr wenig weiterentwickelt, da die Mission von der französischen Raumfahrtsagentur (CNES) aus finanziellen Gründen eingefroren worden ist. Die Franzosen werden im Verlauf des Jahres 2004 über eine Reaktivierung des Experiments entscheiden. Dafür kommt die Entwicklung des fast baugleichen Experiments LYRA um so schneller voran. LYRA ist – wie PREMOS – ein Filterradiometer, wird aber unter der Führung des Königlich Belgischen Observatoriums für den ESA Technologie-Satelliten PROBA 2 gebaut. Es existieren bereits Prototypen-Teile der Mechanik und der Elektronik und nächstens werden Flug-Komponenten gebaut werden.

Charakterisierung und Kalibrierung der SOVIM Radiometer

Eines der wissenschaftlichen Ziele des SOVIM Experiments ist die absolute Genauigkeit der Solarkonstantenmessung zu verbessern. Die SOVIM Radiometer wurden daher im Labor sehr aufwendig charakterisiert, d.h. alle uns bekannten Einflüsse auf die Messungen untersucht und quantifiziert. Einer der grössten Unsicherheitsfaktoren ist der Übergang der Messungen in der Luft zum Vakuum im Weltraum. Idealerweise vergleicht man daher die SOVIM Radiometer im Vakuum mit kryogenen Radiometern eines metrologischen Labors. Bis anhin scheiterte dieses Vorgehen an der Leistungslimite der metrologischen Radiometer, die nur Bruchteile der solaren Einstrahlung auf der Erde messen konnten. Das neue Radiometer des National Physical Laboratory (NPL) in England kann nun genügend hohe Leistungen messen und daher sind wir mit unseren Radiometern ans NPL in Teddington (London) gereist. Leider stellte es sich heraus, dass die mechanischen Justiermöglichkeiten der Messeinrichtung im Vakuumtank nicht ausreichten um die geforderte Genauigkeit zu erreichen.

ETH-Polyprojekt „Variabilität der Sonne und Globales Klima“

Das Projekt zur Untersuchung des Einflusses der variablen Sonnenstrahlung auf das Erdklima läuft nun zweieinhalb Jahre und nähert sich dem Ende der ersten 3-Jahres-Phase, die im Wesentlichen der Entwicklung der benötigten Computerprogramme gewidmet war. Sowohl die

Programme als auch das Forschungsthema, d.h. das Erdklima, sind ausserordentlich komplex und deshalb versucht man mit möglichst einfachen Problemstellungen, oder besser, möglichst wenig komplexen Problemstellungen, die Simulationen mit Beobachtungen zu verifizieren. Die Resultate entsprechen unseren Erwartungen und die im Projekt formulierten Teilziele sind erreicht worden. Ebenso wurden in der spektralen Rekonstruktion der einfallenden Sonnenstrahlung Fortschritte erzielt. Der für die Stratosphärenchemie wichtige UV Spektralanteil kann nicht mit der üblichen Näherung des lokalen thermodynamischen Gleichgewichts (LTE) berechnet werden, sondern muss Nicht-LTE-Effekte berücksichtigen. Je kurzwelliger die Strahlung desto grösser wird der Unterschied zwischen LTE und Nicht-LTE Strahlungsfluss, der bis zu einem Faktor von einer Million bei 100 nm anwächst.

Modellierung der Chemie- und Transportprozesse in der Atmosphäre zur Berechnung der Ozonkonzentration

In Zusammenarbeit mit dem IACETH wird versucht die globale zeitliche Entwicklung aller im Zusammenhang mit der Ozonkonzentration relevanten chemisch-atmosphärischen Bestandteile zu berechnen, wobei vor allem die Bestandteile von Interesse sind, die Ozon zerstören. Die Randbedingungen für die Modellrechnungen stammen aus Nachberechnungen der globalen Atmosphäre. Zu Beginn des Projekts stützte man sich auf Zirkulationsdaten, die nur die letzten 10 Jahre überdeckten, was die Aussagekraft der Resultate einschränkte, da gewisse Konzentrationsentwicklungen längere Zeitskalen haben. In einem weiteren Ausbauschritt wurden nun globale Zirkulationsdaten der letzten 40 Jahre den Simulationen zugrunde gelegt und es gelingt nun die beobachtete Ozonkonzentration realistisch zu simulieren.

Infrarot Strahlungsmessungen bestätigen den zunehmenden Treibhauseffekt

Mit dem Alpine Surface Radiation Budget (ASRB) Messnetz, das vom PMOD/WRC seit 1995 betrieben wird, konnte mittlerweile genügend lange gemessen werden, dass die Messreihen erste Trendaussagen der

Strahlungsklimatologie in den Alpen erlauben. Die Infrarotstrahlung steigt bei allen Stationen des Messnetzes monoton an und zwar um das Dreifache des Wertes, den man aufgrund der steigenden CO_2 Konzentration erwarten würde. Die Ursache dieses Unterschieds ist nicht klar und der Unterschied muss auch noch durch eine längere Beobachtungsreihe erhärtet werden. Der Anstieg der atmosphärischen Infrarotstrahlung ist aber auf jeden Fall signifikant und bestätigt, dass die ansteigenden Bodentemperaturen zumindest teilweise auf eine Änderung des Treibhauseffekts zurückzuführen sind.

Automatische Beobachtung des Bedeckungsgrades

Aus Temperatur und Feuchte kann ein guter theoretischer Schätzwert der Infrarot-Einstrahlung berechnet werden. Wenn an einer meteorologischen Station nebst diesen zwei Messgrössen auch die Infrarot Strahlung gemessen wird, kann aus dem Verhältnis des Infrarot-Messwerts zum theoretischen Erwartungswert der Bedeckungsgrad des Himmels bestimmt werden. Das am PMOD/WRC entwickelte Verfahren APCADA (Automatic Partial Cloud Amount Detection Algorithm) erlaubt den Bedeckungsgrad in Echtzeit auszurechnen. In einem Testbetrieb wird für Davos und Payerne die Bewölkung ermittelt und kann auf unserer Webseite www.pmodwrc.ch unter „Projekte“ aufgerufen werden.

Der APCADA Algorithmus wurde mit Daten von fünf BSRN Stationen mit einer Methode verglichen, die den bedeckungsfreien Himmel aus kurzwelligen Beobachtungsdaten detektiert. Es zeigt sich, dass beide Methoden ungefähr gleich mit etwa 90%iger Erfolgsquote freien Himmel erkennen. Die Schwäche beider Algorithmen ist, dass hohe, dünne Bewölkung nicht detektierbar ist. Die Stärke von APCADA ist, dass sie im Gegensatz zur Methode, die auf der kurzwelligen Strahlung basiert, auch nachts angewandt werden kann.

Internationale Zusammenarbeit

Die Kollaboration des PMOD/WRC mit dem Ulugh Beg Astronomischen Institut in Taschkent, Usbekistan im Rahmen des SCOPES Programmes (Scientific Collaboration between Eastern Europe and Switzerland) des

Schweizerischen Nationalfonds wurde mit einem gegenseitigen Besuch fortgesetzt. Im Frühjahr verbrachte der Sonnenphysiker Dr. S. Kholikov zwei Wochen am PMOD/WRC und Ende 2003 besuchte Herr Richard Wachter Taschkent zum zweiten Mal. Das Projekt wurde bis Mitte 2004 verlängert.

Auch im Rahmen des INTAS (International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union) Projektes der EU besuchte ein Wissenschafter, Dr. V. Zubov vom MGO in St. Petersburg, das PMOD/WRC. Er übernahm von uns das Klimamodell SOCOL, das im Rahmen des ETH Polyprojekts entwickelt wurde, um damit die Heizung durch vom Sonnenwind induzierte Ströme in der unteren Stratosphäre zu untersuchen.

Infrastruktur

Das Bundesamt für Bauten und Logistik bezahlte im Jahr 2003 die Renovation des Zeichnungsbüros sowie die Abdichtung und Verkleidung der grossen Bogenfenster in der ehemaligen Turnhalle, in der die mechanische Werkstatt untergebracht ist. Insbesondere die zweite Investition brachte eine wesentliche Verbesserung des Raumklimas in der Werkstatt.

Lehrverpflichtungen

In den Wintersemestern 2002/2003 und 2003/2004 hielt W. Schmutz gemeinsam mit PD Dr. H. M. Schmid die Vorlesung „Astronomie“ an der ETH Zürich und im Sommersemester 2003 die Vorlesung „Sternatmosphären“ gemeinsam mit Prof. Dr. S. Solanki.

R. Philipona las in den Wintersemestern 2002/2003 und 2003/2004 an der ETH Zürich die Vorlesung „Strahlungsmessung in der Klimaforschung“.

Personelles

Der Personalbestand in der Administration wurde durch die Aufnahme eines Kauffrau Lehrlings verdoppelt. Annika Weber wird mit Enthusiasmus und Freude von Frau Degli Esposti betreut und wir erwarten – trotz gestiegener Anforderungen an den Ausbildungsbetrieb – eine Entlastung in unserem Sekretariat. Wir sind stolz darauf, dass wir als kleiner Betrieb der Region nun drei Lehrstellen bieten können.

Mit dem Beginn der Bauphase des Weltraumprojekts LYRA konnten wir Herrn Silvio Koller einstellen, einen erfahrenen Ingenieur, der sich vollzeitlich um das Projekt kümmert und auch für die Entwicklung der Elektronik verantwortlich ist.

Letztes Jahr ist kein neuer Doktorand zu uns gestossen, dafür aber der ETH Diplomand Christian Ruckstuhl. Somit ist die Zahl der Studenten am Observatorium auf sieben angestiegen oder mehr als ein Viertel der Belegschaft. Weiterhin sind wir beliebter Einsatzbetrieb für Zivildienst-leistende und wir hatten praktisch das ganze Jahr hindurch beide uns zur Verfügung stehenden Stellen besetzt. Im Jahr 2003 waren es sieben Zivis die den Observatoriumsbetrieb für jeweils einige Monate unterstützten.

Christoph Wehrli konnte im Jahr 2003 sein 25-Jahr-Jubiläum am PMOD/WRC feiern – herzlichen Dank für die Treue zum Observatorium.

Sponsoren

Wir profitieren immer noch von dem grösseren Geldbetrag den Herr Daniel Karbacher aus Küsnacht (ZH) dem PMOD/WRC im Jahr 2002 geschenkt hat. Im Berichtsjahr konnten wir uns damit eine Lötanlage leisten, die doppelt soviel kostete, als uns vom PRODEX Projekt LYRA für diese Anschaffung zur Verfügung stand. Die gewählte bessere Version dieser Anlage hat diverse Vorteile, die sich in der besseren Qualität der Elektronik niederschlagen und so die Verlässlichkeit unserer Weltraumexperimente verbessern wird.

Dank

Die Einrichtungsphase des Infrarot-Radiometer Kalibrierzentrums hat zwei Jahre gedauert und ich wiederhole daher den Dank vom letzten Jahres-bericht an die MeteoSchweiz und die Stiftung SFI, die gemeinsam den Aufbau des Zentrums ermöglicht haben. Ebenso ausserhalb der regulären Einnahmen war der Geldbetrag, den Daniel Karbacher dem PMOD/WRC im Jahr 2002 geschenkt hat. Da vorletztes Jahr dieser Betrag noch nicht aufgebraucht wurde, konnten wir uns auch im Berichtsjahr eine

Zusatzinvestition über das ordentliche Budget hinaus leisten – dafür besten Dank.

Für die wichtigen Beiträge im Hintergrund zum PMOD/WRC Betrieb danke ich herzlich der Aufsichtskommission und dem Stiftungsrat-Ausschuss sowie den kommunalen, kantonalen und nationalen Behörden, dem Schweizerischen Nationalfonds, der ETH Zürich und dem PRODEX Programm für die positive Unterstützung und Finanzierung unserer Projekte.

Die PMOD/WRC Belegschaft hat sich mehrmals über die normale Arbeitszeit hinaus für das Institut eingesetzt und damit gezeigt, dass sie gerne am Observatorium arbeitet. Ich möchte mich dafür bei allen Mitarbeitern bedanken.

Davos, im April 2004 Werner Schmutz, Prof. Dr. sc. nat.

Annual Report 2003

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Introduction

Werner Schmutz

Last year the PMOD/WRC was officially designated the Infrared Radiometer Calibration Center (IRC). In May 2003, the XIV Congress of the World Meteorological Organization (WMO), following the recommendations of the Commission for Instruments and Observations (CIMO) and the Commission for Atmospheric Sciences (CAS), approved the installation of the radiometer calibration center at PMOD/WRC. The build-up phase, financed jointly by MeteoSwiss and the foundation SFI, has been completed and beginning this year the PMOD/WRC contract will be expanded to include the operation of the IRC. At present, however, the contract between the state of Switzerland, the Kanton Graubünden, the Landschaft Davos, and the foundation SFI for the financing of the World Radiation Center has not yet been signed by all parties, as the Kanton Graubünden must first address legal issues related to the support of the World Radiation Center. Nevertheless, all parties involved have indicated that this is merely a formality and that they intend to ratify the contract as proposed. Therefore, although it is technically too early for the PMOD/WRC to celebrate its new function, we can already take pride in the official recognition and recommendation from the WMO.

The PMOD/WRC is presently manufacturing three space experiments. The oldest, SOVIM (Solar Variability Irradiance Monitor), will be delivered soon and integrated into the tracker structure. SOVIM comprises absolute radiometers as well as filter radiometers. The two newer experiments, PREMOS and LYRA, are both filter radiometers that will measure the solar irradiance in only selected wavelength bands. In order to keep the PMOD/WRC at the forefront of the field of absolute radiometry, it will be necessary for us in the future to develop absolute radiometers for measurements in space. The opportunities for placing a radiometer in space are very rare. Last year we missed such an opportunity by a narrow margin. The US space agency NASA offered space on its “Solar Dynamic Observatory” (SDO) satellite to the PMOD/WRC, conditional to the participation of ESA in the SDO mission. Unfortunately, ESA decided not to get involved in SDO.

The collaborative theoretical project with the ETH Zürich on the investigation of the solar influence on the terrestrial climate is making progress and we are obtaining interesting results. The funding of the project by the ETH Zürich has been extended one more year. This decision was expected because the initial two-year period was too short to allow the PhD students involved in the project to finish their theses. This year, the six-year project reaches its mid-point and our task will be to convince the ETH Zürich that our research is outstanding and that the funding should be extended for the second 3-year phase.

Operational Services

Statistics of Calibrations

PMOD/WRC

During 90 clear-sky days PMOD/WRC calibrated 31 instruments (5 absolute radiometers, 5 pyrheliometers and 21 pyranometers) belonging to 11 different institutions. For these calibrations, the Sun was used as the source and the World Standard Group, realizing the World Radiometric Reference, was used as a reference.

As Infrared Radiometer Calibration Center we also calibrated 10 Eppley PIR and 4 Kipp & Zonen CG4 pyrgeometers. Each instrument was calibrated first against a regulated black-body radiation source and then against a reference group of infrared radiometer instruments. The latter procedure was carried out on the roof of the observatory building.

In addition, 15 UV-B instruments were calibrated relative to the Swiss UV-B reference instrument at PMOD/WRC.

We also calibrated four Precision Filter Radiometers (PFR) both in the PMOD/WRC laboratory as well as outside, with the Sun as radiation source, and four PFRs have been calibrated only with the Sun. In order to monitor the stability of the standard instruments of the GAW network, the PFR N-01 and N-26 instruments were calibrated once in the laboratory with a trap detector.

Infrared Radiometer Calibration Center - Preparation Phase II

Rolf Philipona

As reported last year the radiometric reference for longwave radiation measurements is based on the PMOD/WRC Absolute Sky-scanning Radiometer (ASR). The ASR was compared to pyrgeometer measurements, to Atmospheric Emitted Radiance Interferometer (AERI) measurements and to radiative transfer model calculations during two International Pyrgeometer and Absolute Sky-scanning Radiometer Comparisons IPASRC-I and IPASRC-II (Marty, 2003). The ASR has been used and will be used in the future on a regular basis to recalibrate the World Pyrgeometer Standard Group (WPSG), which consists of two Eppley PIR pyrgeometers and two Kipp & Zonen CG4 pyrgeometers. The four pyrgeometers of the WPSG are now installed on the roof platform of PMOD/WRC. All instruments are installed in a PMOD-VHS ventilation and heating system and are mounted on a solar tracker, which allows shading the pyrgeometer dome from direct solar radiation. A CR23 data logger is used to measure the thermopile signals as well as body and dome temperatures of the four WPSG pyrgeometers.

Network pyrgeometers or pyrgeometers, which in the future will be used in Regional Pyrgeometer Standard Groups (RPSG), are precalibrated in the PMOD/WRC blackbody calibration apparatus in the laboratory. The final calibration is made on the roof platform of the observatory, where pyrgeometers are field compared to the WPSG. For this purpose four ventilation and heating systems are mounted on the roof platform close to the WPSG, which allow to simultaneously field calibrate two Eppley PIR and two Kipp & Zonen CG4 pyrgeometers. Network pyrgeometers are field compared during two to three weeks, whereas RPSG pyrgeometers will stay three to six month on the roof platform. Thermopile signals and body and dome temperature of the four host pyrgeometers are measured identically on a CR23 data logger.

GAW Trial Network

Christoph Wehrli

Eight international and one Swiss PFR stations were operational and have delivered data to WORCC for evaluation; failing sun trackers were repaired at three stations and have caused some data gaps. The PFR at Ny Ålesund was installed again in March, after calibrations in Davos, and resumed measurements until October. An algorithm to correct the intermittent gain errors of the PFR at Izaña was developed and has successfully retrieved the measurements for both affected wavelengths.

Hourly mean values of aerosol optical depth from 6 stations, where quality assurance was possible by on-site calibrations, were generated up to 2002 and successfully submitted to the World Data Centre for Aerosols (WDCA) for public access.

The 12-channel Sun-photometer at Davos that was in operation since October 1995 broke down in March 2003. Equivalent measurements with 12 PFR channels are made by MeteoSwiss since August 2002, but these data are not available online to PMOD for cross calibrations. A standard PFR is thus operated continuously like a GAWNET station.

A training course on "Aerosol Optical Depth: theory, measurements and evaluation techniques" was given for 13 participants of the 6th GAWTEC course at Schneefernerhaus.

Final results from the field comparison of AOD networks at Bratt's Lake in 2001 found good agreement of <0.01 (2σ) for individual observations between pointed instruments and a significant improvement in precision and intercomparison through cloud-screening algorithms. (McArthur et al. 2003)

The ASRB Network

Rolf Philipona and Bruno Dürr

The Alpine Surface Radiation Budget (ASRB) network consists at present of 10 stations (The station Les Diablerets was discontinued in 2002). The stations were built between 1994 and 1996 and over the years all ASRB stations were field calibrated twice. Measured data at the stations are downloaded every four hours over telephone lines by a network computer at PMOD. The data of all stations are checked routinely day by day. Quality assessment and quality control is made at a monthly interval on the data of each station. Different levels of data sets (presently going from level 0 to level 5) are stored in the database. Up to level three, data is stored in its original 2-minute time frame. From level four on data are averaged over 10 minutes and ancillary data like temperature and humidity at the stations are added. Level five shows additional information on the clear-sky index as well as on the cloud amount during the measurement. ASRB data have been extensively used to determine radiation climatology in the Alps, and more recently trends on radiative fluxes, temperature and humidity where analyzed and compared to predictions of general circulation models. These investigations show a uniform increase of longwave downward radiation, which manifests radiative forcing that is induced by increasing greenhouse gas concentrations and water vapor feedback, and proves for the first time the “theory” of greenhouse warming with direct observations (see also “Radiative forcing – measured at Earth’s surface – corroborate the increasing greenhouse effect” in this annual report).

Instrument Sales

PMOD/WRC

Despite a collaboration with the Dutch company Kipp & Zonen for the marketing of pyrheliometers, we found that there is little commercial market for absolute radiometers. In 2003 we sold only a new computer controlled PMO6-cc electronics, which updates an older radiometer. In contrast, however, there seems to be a larger demand for PMOD/WRC Precision Filter Radiometers. In fact, demand exceeded supply, as our remaining three units were sold to Finland. We also sold two heating and ventilation systems as an addition to commercial pyrgeometers to improve their performance.

Instrument Development

Future Space Experiment SOVIM

Claus Fröhlich, Dany Pfiffner, Hansjörg Roth, Isabelle Rüedi, Werner Schmutz, Christoph Wehrli, and Jules Wyss

The launch of the Swiss-Belgian experiment SOVIM (Solar Variability Irradiance Monitor) is scheduled for October 2006. The delivery of the experiment for integration into the Sun tracker built by Alenia is due in June 2004. Last year, the manufacturing of the hardware was finished and the instruments (three PMOD radiometers, two Sun-photometers (SPM), the Two Axis Sun Sensor (TASS), and the Belgian radiometer DIARAD) were integrated into the SOVIM package to verify their full functionality at different temperatures in air and vacuum in the context of the complete SOVIM package.

Characterization of the SOVIM Radiometer and Comparison with a Cryogenic Radiometer

Isabelle Rüedi, Claus Fröhlich, Werner Schmutz, Christoph Wehrli, and Simon Salzmann

The absolute radiometers to be flown on the SOVIM experiment on the ISS were compared to a cryogenic radiometer at the National Physical Laboratory (NPL) in Teddington, UK. Similar comparisons with other radiometers have taken place in the past. However, for this latest test, the NPL cryogenic radiometer was modified to enable it to measure intensity levels similar to that of the Sun and to accommodate the SOVIM radiometers directly within its vacuum tank. The latter modification allows a direct comparison of radiometers’ performance under vacuum. Because of the significantly lower operating temperature, a cryogenic radiometer yields measurements with much higher precision than those of room-temperature radiometers. However, cryogenic radiometers must be operated under vacuum. The air-to-vacuum transfer of a radiometer is a major source of its measurement uncertainty. Since the SOVIM radiometer will eventually be operated under vacuum on the ISS, a direct vacuum comparison enables a much more accurate transfer of the instrument’s calibration to space. However, during the tests at NPL, several problems arose in connection with the practical realization of the experiment. The geometry of the cryogen vacuum tank did not allow both radiometer cavities to be placed at exactly the same position. This turned out to be a problem, since the geometry of the laser beam used for the comparison could not be determined with adequate precision. Consequently an indirect measurement procedure had to be adopted. The analysis of the results indicates that at present, the comparison yielded results that were not accurate enough. We will improve the experimental setup so as to provide the required accuracy. New comparisons are planned for early 2005.

The SOVIM radiometers were characterized in the laboratory as well as with the Sun. During the procedures, new characteristics of the radiometers were discovered. The air-vacuum nonequivalence was found to depend on the illuminated area of the precision aperture due to the heating of that aperture. This heating results in infrared radiation directly shining into the radiometer cavity. An indirect effect is also significant and comes from air convection and conduction.

Future Space Experiment PREMOS

Werner Schmutz, Hansjörg Roth, Daniel Pfiffner, Isabelle Rüedi, Christoph Wehrli, and Jules Wyss

PMOD/WRC, in collaboration with the French space agency (CNES) and the Centre National de la Recherche Scientifique, Service d'Aéronomie Paris (CNRS), is developing and building PREMOS, a filter radiometer experiment to be included on the French microsatellite PICARD. The PICARD project is currently frozen by CNES due to financial problems. CNES is expected to decide this year when PICARD will be reactivated. This has forced us to significantly reduce our development efforts on PREMOS. The only progress involved a new definition of the data interface between the central control unit and PREMOS and updates of the documentation.

Future Space Experiment LYRA

Silvio Koller, Werner Schmutz, Hansjörg Roth, Isabelle Rüedi, Christoph Wehrli, and Jules Wyss

LYRA (Lyman-Alpha Radiometer) is a solar UV radiometer experiment to be flown on the micro-satellite PROBA-2 in the framework of ESA's technology program. The launch of PROBA-2 is scheduled for mid 2006. The experiment is being designed, built and calibrated by a consortium of Belgian, German, and Swiss institutes[1]. LYRA will monitor the solar irradiance in four UV ranges whose wavelengths were chosen for their relevance to aeronomy, space weather and solar physics:

- Channel 1: Lyman-alpha (121.6 nm);
- Channel 2: 200-220 nm Herzberg continuum range;
- Channel 3: Al filter (17-70 nm) including He II 30.4 nm;
- Channel 4: XUV Zr filter (1-20 nm).

Our contribution to the experiment comprises three identical instruments (without detectors), the cover mechanism, and the electronics. PROBA-2 is a technology-oriented mission and the innovations incorporated into LYRA include newly-developed diamond detectors, which will be used for the first time in space. Diamond is a wide band gap material that renders the sensors "solar-blind". The advantage of solar-blind detectors is that they eliminate the need to block the unwanted visible light with filters, the use of which usually results in a serious reduction in the throughput in the UV wavelength region that is intended for observation.

As with all Swiss space experiments, LYRA is funded by PRODEX along with a contribution from Swiss industry. LYRA's cover mechanism is being designed and developed by Contraves who will also analyze the LYRA package for stability and thermal performance.

The detector design derives from the well-known PMOD/WRC Sun-photometers. The instruments are mounted onto the package heat-sink, which assures sufficient thermal contact to the spacecraft platform through the package mounts. It is expected that due to the large thermal capacity of the heat-sink, the detector temperatures should exhibit only slow variations.

1 Royal Observatory of Belgium, Brussels; Instituut voor Materiaal Onderzoek, division of IMEC, Belgium; Centre Spatial de Liège, Belgium; Max-Planck-Institut für Aeronomie, Lindau, Germany; and PMOD/WRC, Davos, Switzerland

Two of the instruments will be switched on only occasionally in order to determine the degradation of filters and detectors of the operational instrument relative to the rarely exposed instruments. The cover design is similar to the one used on SOVIM except for the locking device, which will be replaced by less power consuming paraffin actuators. A new design for the interconnection of the printed circuit boards has also been implemented which reduces internal harness and simplifies the assembly procedure.

Construction of a prototype was started in 2003; it should be finished and ready for operation by the end of May 2004. All interface definitions have been prepared in cooperation with the ESA, the Belgian partners and Verhaert (the spacecraft contractor). Procurement of the parts for the prototype and the flight model was initiated and the statement of work for several industry tasks to be outsourced to Contraves Space, Zurich was defined. Currently, first functional tests with the prototype parts are in progress. In spring 2004 the preliminary design review will be held and the experiment design fixed. LYRA is subject to a very tight schedule since delivery of the flight model is currently planned for October 2005.

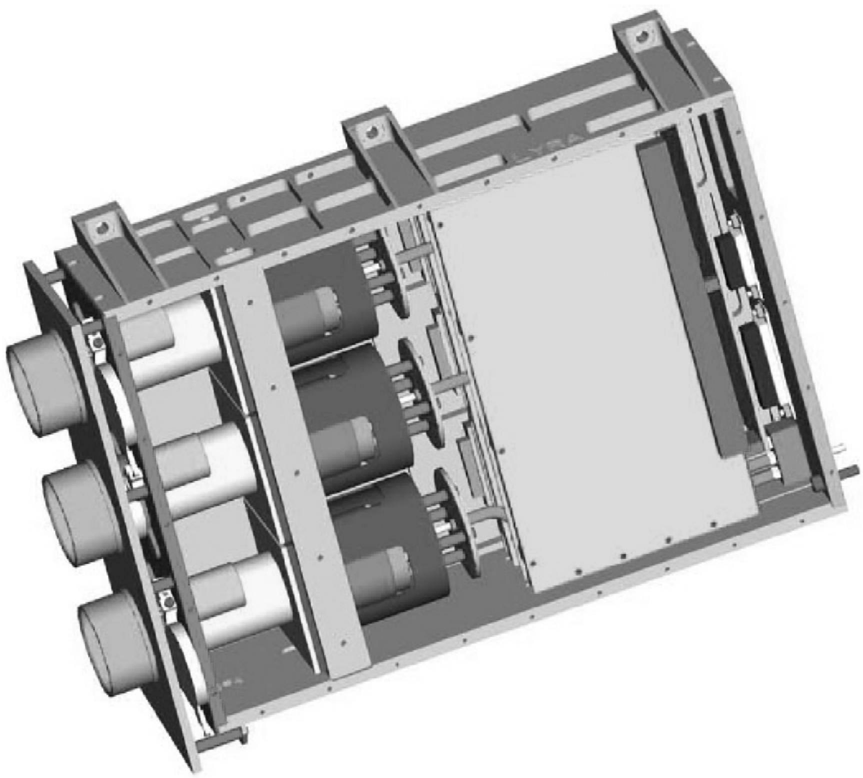

Figure 1. The LYRA instrument box cut open to allow a view of the three instruments and the electronic boards. The Sun-pointing direction is to the left.

Scientific Research Activities

ETH-Polyproject – *Variability of the Sun and Global Climate*

Overview

Eugene Rozanov, Tatiana Egorova, Margit Haberreiter, and Werner Schmutz in collaboration with IACETH and IfA-ETH

The Polyproject "Variability of the Sun and Global Climate" is a collaboration between the PMOD/WRC and the Swiss Federal Institute of Technology in Zürich. Its aim is to investigate the effects of solar irradiance variability on global chemistry and the global climate.

In order to study the influence of the solar UV irradiance on the global chemistry and climate of the Earth it is important to describe the solar UV irradiance for times when no observations are available. With the updated radiation transfer code COSI we calculated the solar UV spectra for different radial distances from the center to the limb of the solar disk, for the quiet Sun as well as for different active region types. We are applying the analysis of magnetograms to reconstruct 25 years of the solar UV variability starting from 1975. In a next step, the reconstructions will be used to calculate the effect of the solar UV variability on the terrestrial climate.

The validation of SOCOL, our 3-D chemistry-climate modeling tool for the evaluation of the *So*lar-*C*limate-*O*zone *L*inks, against available observational and meteorological reanalysis data has been completed and we identified some weaknesses but overall, we conclude that the model performance meets our expectations. We completed the development of the SOCOL code to allow for simulations in transient mode and accomplished four simulations of the evolution of the atmospheric state during the last 25 years of the 20th century and compared the results with satellite data. In order to separate the model responses to the solar ultraviolet (UV) and visible irradiance variations, we carried out steady-state simulations of 20-year-long periods using different combinations of the irradiance level of the UV and the visible as input for SOCOL. Nine one-year-long simulations of the atmospheric response to the variability of the solar irradiance in the course of the 27-day solar rotation cycle were also performed.

Reconstruction of the Solar UV Irradiance

Margit Haberreiter, Eugene Rozanov, and Werner Schmutz

For the reconstruction of the variability of the solar UV irradiance we calculated synthetic solar intensity spectra with our radiative transfer code COSI (Code for Solar Irradiance) for different locations on the solar disk and for different activity types: quiet Sun, sunspots, and faculae. We then combined their output intensities according to their fractional area on the solar disk. The time-dependent fractional areas covered by the active regions were derived from magnetograms obtained by the Michelson Doppler Imager (MDI) onboard SOHO going back to 1996, and the ground-based NSO/KPVT magnetograms starting from 1974. For the different regions we adopted the temperature and density structures of the solar photosphere, which include the rising temperature profile of the chromosphere and transition region. This is particularly important for the UV, as in this wavelength region many spectral lines are formed beyond the temperature minimum. In Figure 2 we compare the synthetic spectrum calculated with COSI for the quiet Sun (Model C) with UV observations taken by the SUSIM instrument onboard UARS, and the synthetic spectrum calculated with the Kurucz' ATLAS9 code. In contrast to Kurucz' model, our spectrum agrees very well with the observations. This is due to the fact that COSI solves the occupation numbers of the atomic level populations in non-local thermodynamic equilibrium (non-LTE). The reconstructed variability of the UV irradiance will be used as input to SOCOL to study its effect on the terrestrial climate.

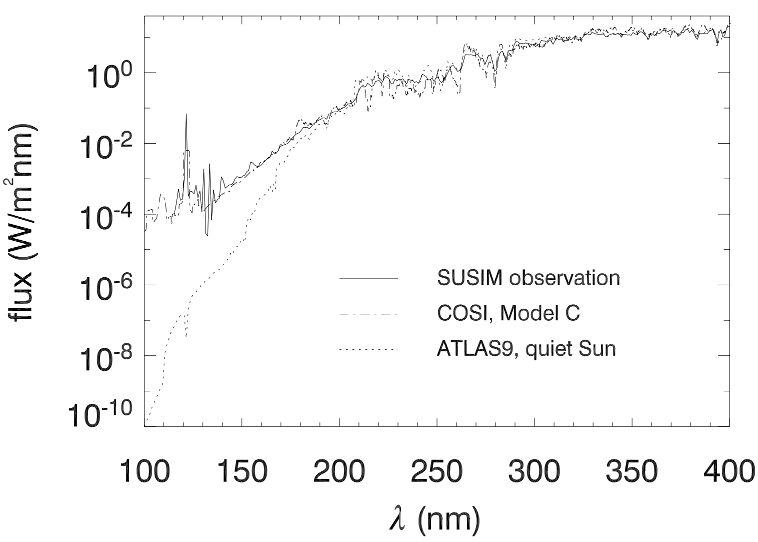

Figure 2. Comparison of the solar spectra calculated with COSI, Model C (dashed-dotted line) and the synthetic spectrum calculated with Kurucz' ATLAS9 code (dotted) with SUSIM observations (solid line). Below 200 nm the calculations with COSI show a substantial improvement in comparison to the ATLAS9 calculations due to the fact that the former is a LTE code, whereas COSI allows for non-LTE population numbers.

Present-Day Climate Simulated with SOCOL – Validation of the Code

Tatiana Egorova, Eugene Rozanov, and Christopher Hoyle

Due to sometimes contradictory discrepancies between the available observational data sets, it is very difficult to draw definite conclusions about the model performance and to find clues where the model needs improvement. We addressed this problem by compiling all available reanalysis data (UKMO, CPC, NCEP, ERA-15, ERA-40) into one data set, which consists in total of 71 years of observational data (only 35 years above 10 hPa), and applied statistical tools to define the areas where the deviations between model results and observations are statistically significant ("hot spots").

Figure 3 shows the differences between SOCOL simulations and observed zonal mean temperature and zonal wind for January. The difference map has "hot spots" (shaded areas) in regions at the tropopause and in the upper stratosphere over the summer hemisphere in high and middle latitudes. The analysis of the zonal mean temperature and zonal wind as well as of seasonal march (not shown) indicates that there is generally good agreement except during summer, the model has not enough heating over high latitude areas and at the equator. This might be connected to a problem in the radiation part of SOCOL which is based on the formulation of MA-ECHAM4.

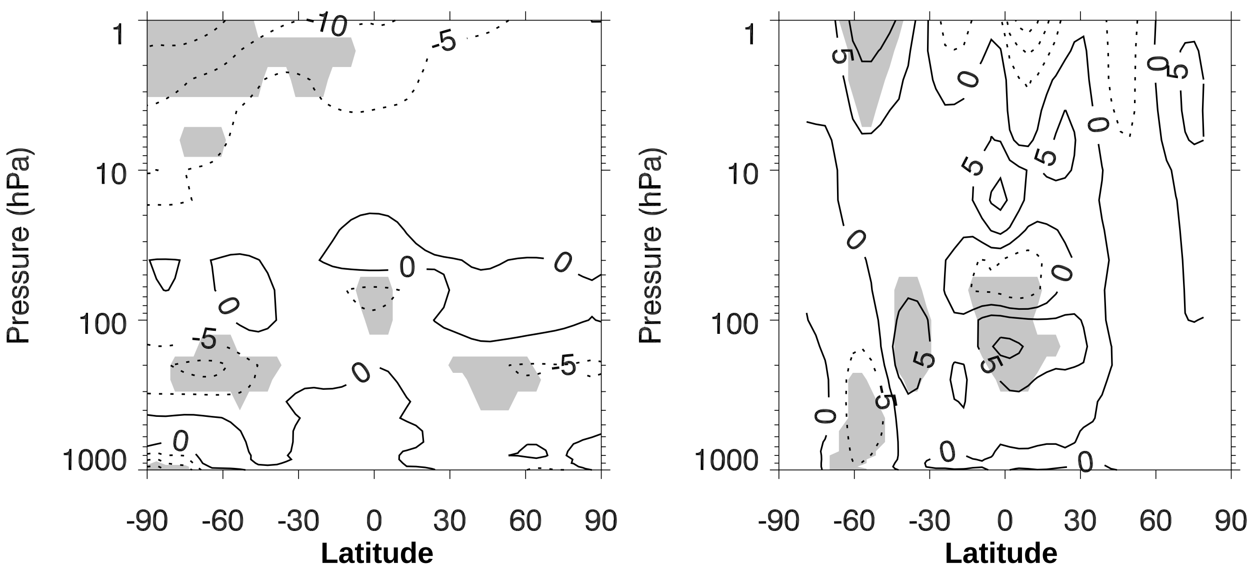

Figure 3. Areas of significant differences between model simulations and observations for zonal mean temperature (left plate) and zonal wind (right plate) in January.

Simulation of the Atmospheric State Evolution During 1975-2000

Eugene Rozanov, Tatiana Egorova in collaboration with IACETH

Four transient experiments have been performed to study the transient response of the climate system to the natural and anthropogenic forcing.

1) A control run for 1975-2000 with fixed mean spectral solar irradiance, concentrations of greenhouse gases (GHG), concentrations of ozone destroying substances (ODS) and aerosol loading (values of 1975). This run is driven by the prescribed, monthly and annual changing Sea Surface Temperature (SST) and Sea Ice (SI) cover obtained from the AMIP II data set.
2) As the control run, but with changing concentrations of GHG.
3) As the control run, but with changing concentrations of ODS.
4) As the control run, but with changing concentrations of GHG and ODS.

Figure 4 (left) illustrates the near global annual mean total ozone deviations simulated with SOCOL (experiments #1 and #4) in comparison with measurements. We find that the ozone depletion is better simulated if the temporal evolution of the ODS is taken into account. The substantial ozone depletion observed in 1992-1993 is not captured by the model, because of the lack of volcanic aerosols after the Pinatubo eruption in the experiment #4. Figure 4 (right) depicts the total ozone trend obtained from the experiment #4 and demonstrates that the formation of the ozone “hole” in spring over the Southern Hemisphere is well captured by the model.

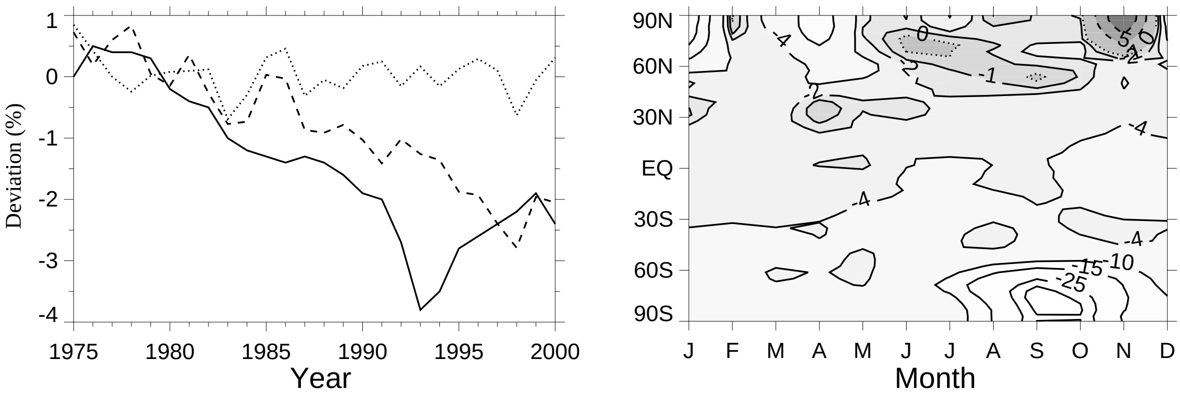

Figure 4. Left panel: Left: Near global total ozone deviation from the mean simulated with SOCOL (dotted and dashed lines) and obtained from the ground-based data (solid line, WMO-2002). The dotted line represents experiment #1; the dashed line illustrates the results of the experiment #4. Right panel: Trend in total ozone (DU/decade) for 1975-2000 simulated with SOCOL forced by time-dependant evolution of SST/SI, GHG and ODS (experiment #4).

Atmospheric Response to Variability of UV and Visible Irradiance

Tatiana Egorova, Eugene Rozanov, and Margit Haberreiter

In order to investigate separately the influence of UV and visible radiation on the global atmosphere we have carried out two additional 20-year-long steady state SOCOL simulations using observed solar fluxes: (1) solar maximum visible and solar minimum UV fluxes and (2) solar minimum visible and solar maximum UV fluxes. The results of these experiments have been analyzed in comparison with the solar minimum case for both wavelength regions. The increase of the UV flux yields a statistically significant warming in the tropical stratosphere and a dipole structure in the temperature response over high latitudes of both hemispheres. This is presumably caused by an acceleration of the Polar Night Jet (Figure 5). These dynamical changes lead to an alternation of the tropospheric circulation, which in turn, e.g., influences the November surface air temperature resulting in a statistically significant warming of 3 K over North America and 2 K over Siberia. The variation of the visible irradiation leads to a temperature increase over high latitudes in the troposphere. The surface effects of both irradiance variations have similar patterns and resemble the signal of the positive phase of the Arctic Oscillation.

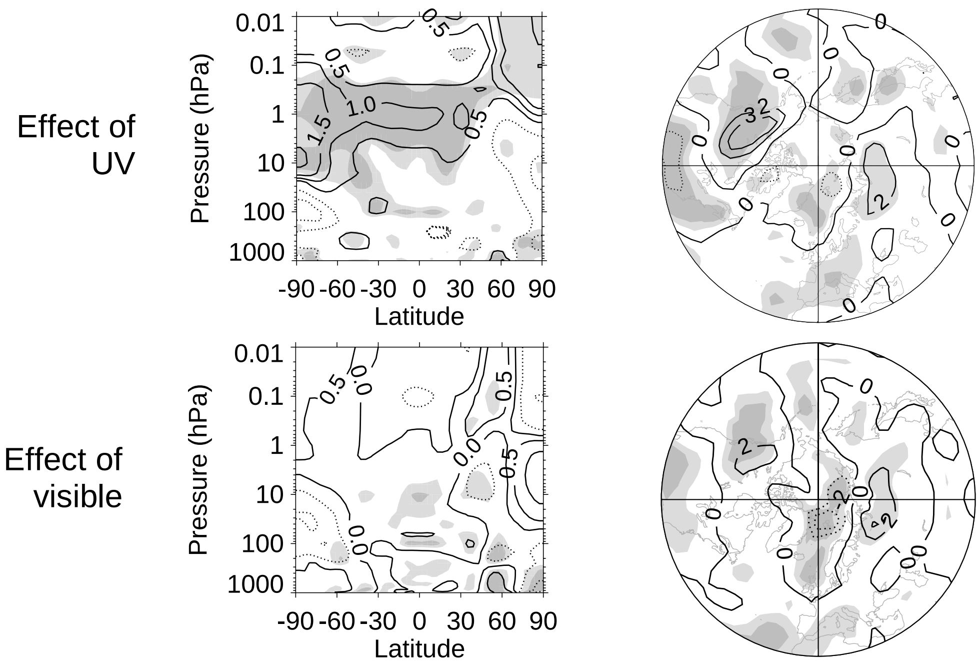

Figure 5. Temperature changes in °C due to the increase of the UV irradiation (top) and of the visible irradiation (bottom) on the zonal mean temperature (left) and November surface air temperature over the Northern Hemisphere (right).

Atmospheric Response to the Solar Irradiance Variability During the 27-Day Solar Rotation Cycle

Eugene Rozanov, Tatiana Egorova, and Margit Haberreiter

The study of the 27-day rotation cycle is suitable for model validation, because the observational data cover more then 100 cycles, while only two 11-year cycles occurred during the satellite era. We have performed nine 1-year long runs applying daily spectral solar irradiance compiled from the measurements performed by SUSIM instrument onboard UARS for the year 1992. The simulated daily zonal mean ozone and temperature averaged over the tropical area has been filtered and cross-correlated with the solar flux at 205 nm.

The simulated results show ozone-UV correlation up to 0.6 at 5 hPa with a rather small time lag. In the lower stratosphere the correlation decreases and the time lag is larger. Similar features can be seen in all 9 experiments, that means the obtained ozone-UV correlation is robust. The temperature-UV correlation is less pronounced (up to 0.3) and less robust. The same behavior has also been obtained from the satellite data. Figure 6 illustrates the ozone and temperature sensitivity for a 1% change of 205 nm solar flux for the time lag corresponding to the maximum correlation in comparison with the published elsewhere sensitivity obtained from the analysis of different satellite data sets. The simulated ozone sensitivity matches the observations satisfactory, while the simulated temperature sensitivity does not agree well with observational data analysis.

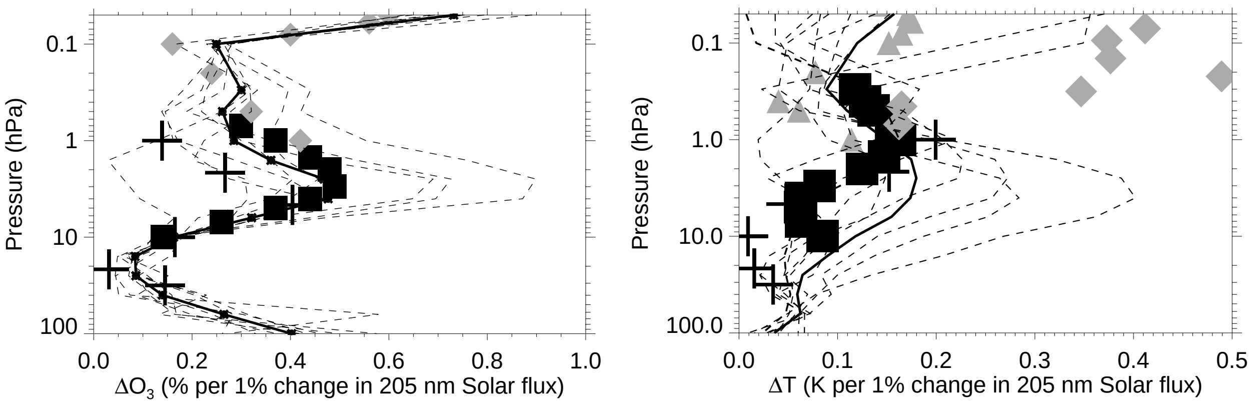

Figure 6. Ozone and temperature sensitivity for a 1 % change of 205 nm solar flux for the maximum correlation. Simulated sensitivity is shown by solid line (ensemble mean) and dotted lines (ensemble members). Observed sensitivities are from MLS (crosses), SBUV (squares), SME (diamonds) for the ozone and from MLS (crosses), SAMS (squares), SAMS (triangles) and MLS (diamonds) for the temperature.

ETH-TH-Project – Modeling of Ozone Related Atmospheric Chemistry and Transport Processes

Christopher Hoyle, Eugene Rozanov, and Tatiana Egorova in collaboration with IACETH

During the first year of the project "3-D model study of lifetimes of ozone depleting substances including their dependence on the state of the atmospheric general circulation", we used UKMO circulation data to drive our model "MEZON". Although we managed to simulate the time evolution of the lifetimes of several ozone depleting substances (ODS), we were limited by the fact that the UKMO circulation data is only suitable for use in our model for years after 1993. We have therefore switched to a new 40 year circulation data set, which is available from the ECMWF, for the second year of this project.

This opens the way for one of the most interesting phases of the project, namely, the study of the time evolution of various ozone related chemical species in the atmosphere, from 1960 up until 2002.

In Figure 7, we compare the results of a model simulation using the new circulation data, with the total ozone field from the NIWA (National Institute for Water and Atmospheric research, New Zealand) data set. The agreement between the two is very good. For most years in this model run, the output global ozone field was better than that from previous experiments, where the UKMO analysis data was used to drive the model.

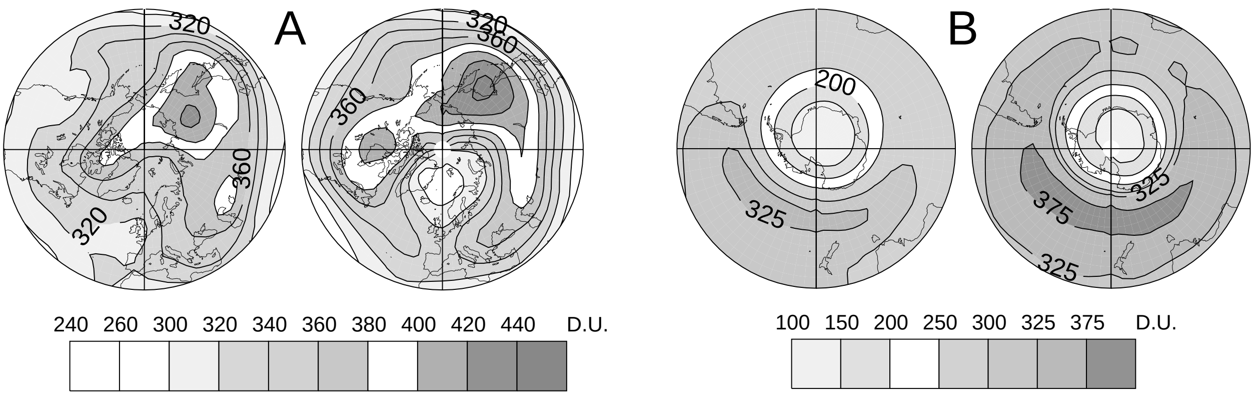

Figure 7. A) The monthly mean total ozone for the northern hemisphere, in March 1996. The left plot illustrates the results from our simulations with CTM, MEZON, forced by ERA-40 winds and temperatures. The right plot depicts observational data from the NIWA homogenized TOMS/GOME data set. B) Same as A, except they show the southern hemisphere monthly mean total ozone field for October 1996.

Monthly Averages of Aerosol Optical Depth at Four Sites of the GAWPFR Network

Christoph Wehrli

Aerosol optical depths have been measured at four stations of the GAW-PFR network since 4 years. While this period is not yet long enough to allow for a climatologic analysis, site-to-site or year-to-year comparisons are becoming possible. Monthly averages of AOD at 500nm for 2002 and 2003 are represented in Figure 8 (left panel) for a continental (Jungfraujoch, Switzerland) and an oceanic (Mauna Loa, Hawaii) high altitude site, and in right panel for a continental (Bratt's Lake, Canada) and a coastal (Ryori, Japan) site at low altitudes. Note the 10 times larger scale of the right panel.

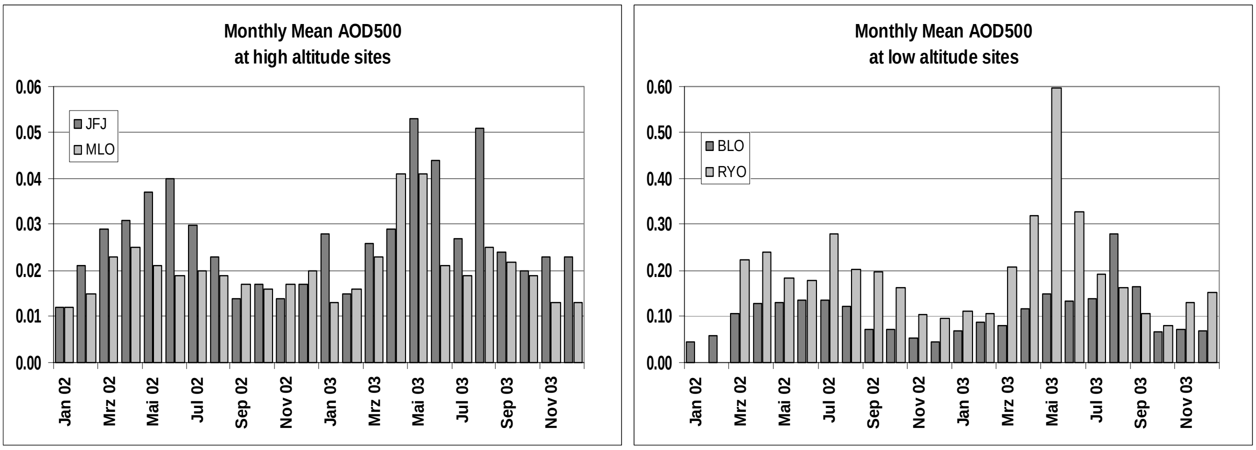

Figure 8. Monthly mean values of AOD.

Left panel: High altitude sites above 3000m: Jungfraujoch in Switzerland (JFJ) is a continental, midlatitude site with larger seasonal variations than the oceanic, tropical site on Mauna Loa on Hawaii (MLO). The annual mean for 2003, which was exceptionally warm in Switzerland, is about 30% larger than for 2002 at JFJ, but constant at MLO. The geometrical means of optical depths and their standard deviations for the period shown amount to $0.018*1.5^{\pm1}$ at MLO and $0.023*1.7^{\pm1}$ at JFJ. (The standard deviation of a geometrical mean being expressed as a factor instead of a term in arithmetic statistics).

Right panel: Low altitude sites. Bratt's Lake in Canada (BLO) is a continental and Riory in Japan (RYO, measurements started 3/02) a coastal site. In May 2003, enhanced AOD values, caused by large forest fires near lake Baikal, were observed at Ryori. A similar, but smaller influence from Canadian forest fires is noticeable at Bratt's Lake in August. Again, the continental site BLO had a 20% larger annual mean for 2003. Geometrical mean values are $0.099*1.9^{\pm1}$ at BLO and $0.165*2.0^{\pm1}$ at RYO.

Radiative Forcing – Measured at Earth's Surface – Corroborate the Increasing Greenhouse Effect

Rolf Philipona and Bruno Dürr

The Intergovernmental Panel of Climate Change (IPCC) confirmed concentrations of atmospheric greenhouse gases and radiative forcing to increase as a result of human activities. Nevertheless, changes in radiative forcing related to increasing greenhouse gas concentrations could not be experimentally detected at Earth's surface so far. Measurements at our Alpine Surface Radiation Budget (ASRB) network, which started in 1995, now show that atmospheric longwave downward radiation significantly increased (+5.2(2.2) Wm^{-2}) partly due to increased cloud amount (+1.0(2.8) Wm^{-2}). Model calculations show the cloud-free longwave flux increase (+4.2(1.9) Wm^{-2}) to be in due proportion with temperature (+0.82(0.41) °C) and absolute humidity (+0.21(0.10) gm^{-3}) increases, but three times larger than expected from anthropogenic greenhouse gases. However, after subtracting for two thirds of temperature and humidity rises, the increase of cloud-free longwave downward radiation (+1.8(0.8) Wm^{-2}) remains statistically significant and demonstrates radiative forcing due to an enhanced greenhouse effect.

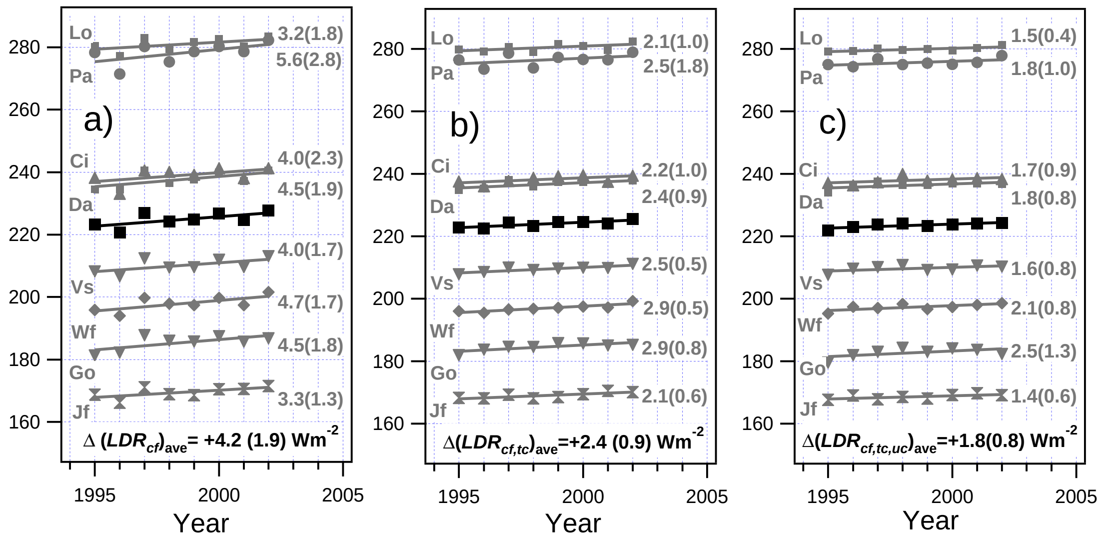

Figure 9: Annual mean values of a) cloud-free Longwave Downward Radiation (LDR_{cf}), b) temperature corrected Longwave Downward Radiation ($LDR_{cf,tc}$) and c) humidity corrected Longwave Downward Radiation ($LDR_{cf,tc,uc}$) measured at eight radiation stations, Locarno-Monti (Lo), Payerne (Pa), Cimetta, (Ci), Davos (Da), Versuchsfeld (Vs), Weissfluhjoch (Wf), Gornergrad (Go) and Jungfraujoch (Jf). Increases over the eight years and stdev are shown on the right.

Automatic Cloud Amount Estimation by APCADA

Bruno Dürr and Rolf Philipona

National weather services like MeteoSwiss have more and more difficulties to recruit personal for naked-eye observation of cloud properties. Hence automation of cloud observations has become an important task in meteorology. A new method (Dürr and Philipona, 2004) was developed at PMOD/WRC to estimate cloud amount from longwave downward radiation (LDR) measurements and temperature / humidity at the surface. First of all a theoretical LDR_{cfr} of a cloud-free sky is calculated from temperature and humidity. The measured LDR is divided by LDR_{cfr}. If the ratio is larger than one, low- or middle-height clouds are present. High clouds like cirrus, however, are not recognized because of the large distance (6 km and more) and low emittance temperature (-40 °C and lower). Secondly the variability of LDR within the past hour is used as an additional criteria: low LDR variability indicates cloud-free or totally overcast conditions, and high LDR variability indicates passing broken clouds. Thirteen rules were empirically deduced from these two variables to estimate cloud amount in real-time during day- and nighttime. The scheme is called automatic partial cloud amount detection algorithm (APCADA). APCADA estimates were compared to cloud amount observations at several radiation sites worldwide from the arctic to the tropics. APCADA is operating real-time in Davos and Payerne since autumn 2003. Real-time cloud amount estimates are available at www.pmodwrc.ch under “Projects”.

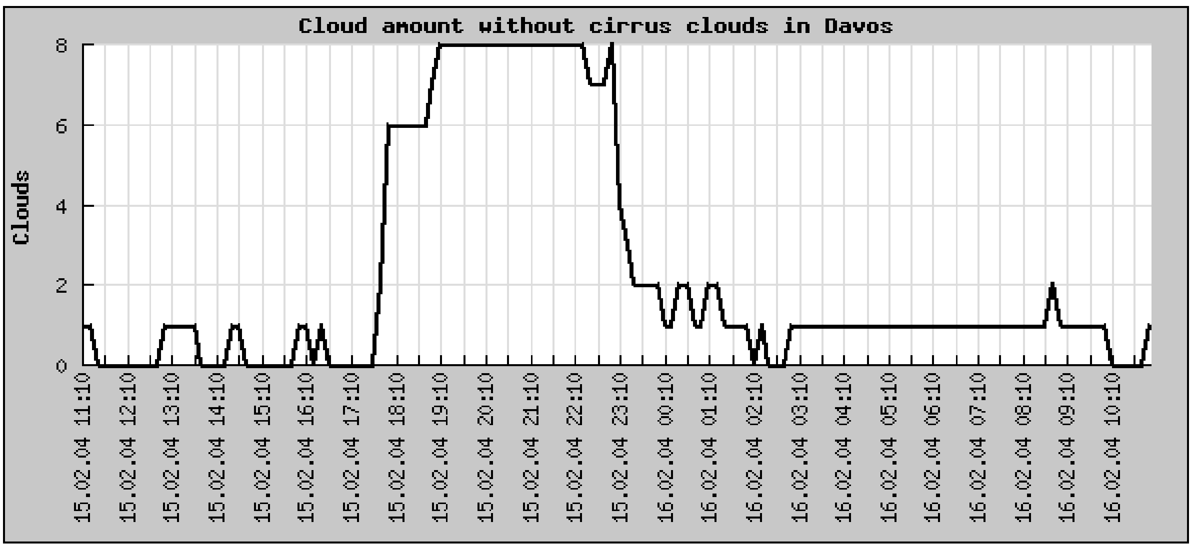

Figure 10. Example of real-time estimated cloud amount (octas) in Davos.

Comparison of Methods for Cloud-free Sky Detection

Marcel Sutter, Bruno Dürr, and Rolf Philipona

Identification of cloud-free skies is a requirement for various climatological studies. Measurements performed under cloud-free skies allow to draw conclusions about greenhouse effect, and comparing measurements from cloud-free skies to measurements taken under cloudy sky conditions provides insights into the effects of clouds on the Earth's climate. Beside the APCADA method (see above), there are other methods which allow to automatically identify cloud-free skies. One of these methods is an algorithm developed by C. Long and T. Ackerman (ARM program, Richland, WA) which uses shortwave downward radiation to detect cloud-free skies.

In the context of analyzing data from the Baseline Surface Radiation Network (BSRN), the two methods, which both only use standard climatological measurements, were applied to data from 5 BSRN stations located in Arctic, midlatitude and equatorial regions (see map). The subject was to find out about the quality of the two methods to identify cloud-free skies compared with each other and compared to observer reports from the Weather Service. This was done in the view of future studies about greenhouse effect with BSRN data. Both algorithms detect cloud-free skies equally well compared to observer reports, but show in some cases significantly lower percentages of detected cloud-free skies as a consequence of particular meteorological conditions like haze and strong inversions. The rates of falsely cloud-free evaluated skies are around 10% and the difference to observed cloud cover is usually small. The only significant deviation arises from thin high clouds which, under certain circumstances, are not detectable by both methods. The study validates both methods and offers insights into the limits and the assets and drawbacks.

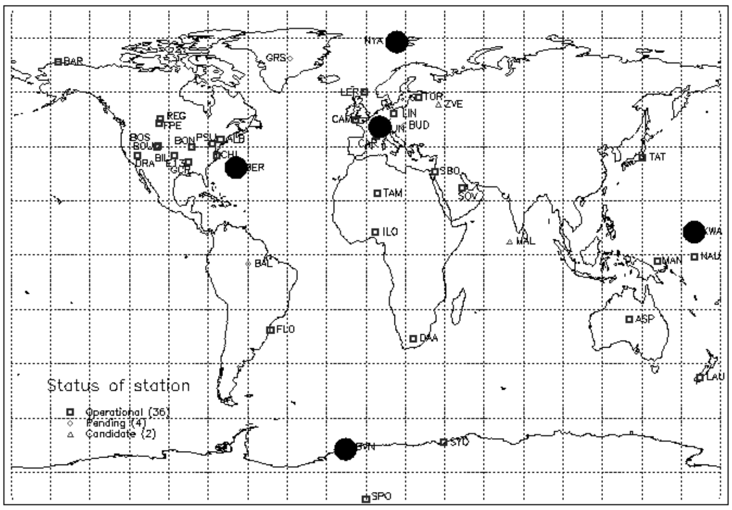

Figure 11. Baseline Surface Radiation Network (BSRN). Data used from marked stations.

PhD Thesis – *Interplay of Solar Oscillation Modes and Noise in Helioseismic Power Spectra*

Richard Wachter

Granular convection is presumably responsible for the excitation of solar p-modes. Simulations of Stein & Nordlund (2001, Astrophysical Journal 546, 585) of the upper solar convection zone suggest that their excitation occurs in the rapid downdrafts of intergranular lanes, where turbulence is highly developed. The same simulation show that the excitation occurs slightly below the photosphere. Still, there are visible imprints of this excitation process from radiative cooling at the solar photosphere. In p-mode spectra, this imprint is perceivable as correlated noise. The amount of correlated noise can be different in velocity and continuum intensity spectra. It is shown that estimates of amplitudes and phases of this correlated noise depend crucially on the model for solar oscillations. Power and cross spectra from medium-l p-modes from the Michelson Doppler Imager (MDI) could be accurately reproduced with numerically calculated oscillation spectra, which were obtained by solving the nonradial oscillation equations including the radiative energy flux. Parameters for the correlated noise can be directly inferred from this approach. In fractions of the entire additive background signal, the correlated noise is below 2% in velocity, and between 5% and 20% in intensity spectra. This result is qualitatively consistent with an excitation in thin intergranular lanes. Our results confirm that the correlated photospheric signal is lowering the emitted intensity during the excitation events.

The response of the MDI-Instrument on solar oscillations was investigated in detail by radiative transfer calculations of the MDI absorption line. Recent publications show, that radiative transfer effects influence high-l mode profiles substantially. This has immediate consequences for the inferred properties of the solar noise. Calculations for medium-l modes show a smaller influence of radiative transfer effects on mode profiles.

The above is an extract from the Thesis “Interplay of Solar Oscillation Modes and Noise in Helioseismic Spectra”. The thesis is available under the URL: http://www.pmodwrc.ch/staff/rwachter/rwachter.html.

VIRGO Radiometry and Total Solar Irradiance

Claus Fröhlich and Isabelle Rüedi

The performance of the PMO6V radiometers of VIRGO/SOHO has been reviewed. From the experiments with the SOVIM radiometers it became clear that the early increase may be explained by a change of the reflectivity of the precision aperture and a corresponding increase of the influence of its heating. Under solar irradiance the aperture darkens first and then bleaches which was confirmed by the appearance of the apertures of the two radiometers flown on EURECA: the one of the operational radiometer has a yellowish color whereas the much less exposed is darker than normal. This explains that there are two components that change the sensitivity of the radiometers, with an early increase (due to the darkening) and a short-term degradation (due to the bleaching). The time constant of this short-term decrease is very similar to a non-exposure dependent PMO6V correction determined from comparison of the corrected PMO6V-A and DIARAD-L. It is thought that the non-exposure dependent changes are residual of a too small amplitude of the short-term exposure dependent decrease. A re-evaluation of the corrections yielded that indeed the non-exposure effect became negligible. This is an a-posteriori confirmation of the correctness of the change in the amplitude of the short-term degradation and it demonstrates that the understanding of the long-term changes of the PMO6 type has substantially increased and most importantly, it shows that these type of radiometers have no non-exposure changes. This conclusion is very important as it applies also to the ACRIMs and ERBS radiometers meaning that the long-term correction by comparing with less exposed radiometers is a very valid approach.

This new analysis has also influenced the interpretation of the behavior of DIARAD which shows non-exposure effects, not only due to switch-off, but also as a long-term increase of its sensitivity which can be modeled with an exponential function with time constant of 1005 days and a rate at the beginning of 0.6 ppm/d. The details can be found on our web page at www.pmodwrc.ch → projects → space experiments → VIRGO.

VIRGO Sunphotometers and Spectral Solar Irradiance

Claus Fröhlich, Richard Wachter, and Christoph Wehrli

For the first time VIRGO provides reliable spectral measurements which measure the spectral irradiance at 402, 500 and 862 nm with a 5 nm bandwidth. The behavior of SPM-B is still not understood well enough to use these data to detrend the SPM-A channels as it is done for the radiometers. Thus, a detrending has been devised which allows us to analyze periods shorter than about 12 – 15 months. The time series of the detrended SPM-A channels can be compared with the detrended TSI (see www.pmodwrc.ch → Projects → Space experiments → VIRGO) and the resemblance of the four time series is indeed remarkable for periods shorter than about one year and the ratios of the variance of the red, green and blue channels to TSI amount to 0.82, 1.48, and 1.93.

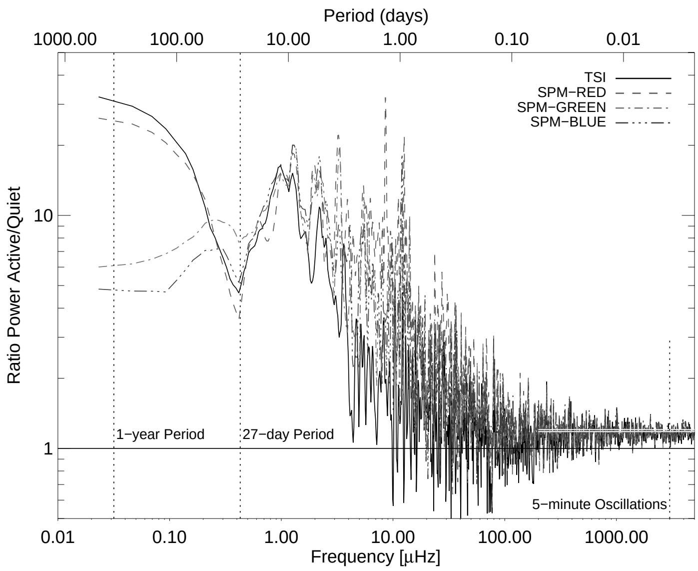

Figure 12. Comparison of the power spectra for the quiet and active periods for the three SPM channels on VIRGO/SOHO. Note the dip around the rotational period and the ratio at high frequency, which is about 1.2 for TSI and the spectral channels, and is due to a change of granulation with activity.

As TSI and the three SPM channels are available with a 1-minute sampling, power spectra can also be compared in the full range from the 5-minute oscillations to periods up to one year. This allows to asses spectral redistribution during changes of TSI and also to compare the power for an active and a quiet sun period. This is shown in Figure 12 for TSI and the three SPM channels. As expected the ratio increases with decreasing frequency, but most interestingly the power ratio has a distinct minimum at the solar rotational period. The difference of low frequency behavior of green and blue channels relative to TSI and the red is most probably due to the low frequency corrections and/or instrumental effects.

International Collaborations

INTAS

Eugene Rozanov and Werner Schmutz in collaboration with the Max-Planck-Institute for Aeronomy, Katlenburg-Lindau, Germany, the Arctic and Antarctic Research Institute, St. Petersburg, Russia, and the Main Geophysical Observatory, St.-Petersburg, Russia

The PMOD/WRC coordinates the project "Model assessment of the solar wind effects on the general circulation of the atmosphere and global ozone distribution" supported by INTAS (International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union). The main aim of the project is to simulate the influence of Joule heating rates in the lower stratosphere induced by solar wind on the global chemistry and climate. The collaborating institutes are the Max-Planck-Institute for Aeronomy, Katlenburg-Lindau, Germany (two scientist), the Arctic and Antarctic Research Institute, St. Petersburg, Russia (four scientists), and the Main Geophysical Observatory, St.-Petersburg, Russia (four scientists).

In the summer of 2003, Dr. V. Zubov from the MGO visited the PMOD/WRC in order to learn how to run and modify the CCM SOCOL, which was developed at PMOD/WRC as part of the ETH Polyproject. The model was modified to account for the Joule heating in the lower stratosphere induced by the solar wind. A simulation of a 10-year period was performed with the modified model. The first results revealed a noticeable temperature response in the lower stratosphere over the northern high-latitudes and tropics. Comparison of the simulated temperature with the observations showed reasonable agreement in the above-mentioned regions. A second 10-year simulation, which is necessary to estimate the statistical significance of the results, is currently in progress.

SCOPES

Richard Wachter, Claus Fröhlich, and Werner Schmutz in collaboration with the Solar Physics department of the Ulugh Beg Astronomical Institute Tashkent, Uzbekistan

The collaboration with the Ulugh Beg Astronomical Institute began in 2001 in the frame of a SCOPES (Scientific Collaboration between Eastern Europe and Switzerland) project, "Characteristics of Low Degree Solar

Oscillations from Observations in Brightness and Velocity." The project included travel money for collaborative visits in Davos and Tashkent, respectively. Dr. Shukur Kholikov stayed in Davos for two weeks in March 2003. During his visit, he refined the method of investigating low-l acoustic modes with autocorrelation functions of whole disk helioseismic instruments like IRIS, SPM, and GOLF. In addition, he gave a talk at the PMOD/WRC, presenting the activities of the Tashkent Astronomical Institute, and explaining the general situation of science in Uzbekistan.

The return visit took place in November and December 2003 when Richard Wachter visited Tashkent for the second time for three weeks. In the frame of his visit, a small seminar about various topics in helioseismology was set up. Moreover, the Tashkent group was introduced to a code calculating accurate artificial helioseismic spectra.

Publications

Refereed Articles

Austin J., Shindell D., Beagley S.R., Brühl C., Dameris M., Manzini E., Nagashima T., Newman P., Pawson S., Pitari G., Rozanov E., Schnadt C., Shepherd T.G.: 2003, Uncertainties and assessments of chemistry-climate models of the Stratosphere, Atmos. Chem. Phys. 3, 1–27.

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Egorova T.A., Rozanov E.V., Zubov V.A., Karol I.L.: 2003, Model for Investigating Ozone Trends (MEZON). Physics of atmosphere and ocean (Russian Academy of Sciences), Vol. 39, N3, pp.277–292.

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Karol I.L., Egorova T., Zubov V., Ozolin Y., Rozanov E.: 2003, Is the “ozonehole” disappearing?, Meteorology and Hydrology, N5, 106–110.

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Raassen A.J.J., van der Hucht K.A., Mewe R., Antokhin I., Rauw G., Vreux J.-M., Schmutz W., Güdel M.: 2003, XMM-Newton high-resolution X-ray spectroscopy of the Wolf-Rayet object WR 25 in the Carina OB1 association, Astronomy & Astrophysics, 402, p.653–666.

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Smyshlyaev S.P., Zubov V.A., Karol I.L., Rozanov E.V., Dvortsov V.L., Kurzeneva E.V.: 2003, Model Study of the Impact of Convective Processes on the Gas Composition of the Upper Troposphere and Lower

Stratosphere, Physics of atmosphere and ocean (Russian Academy of Sciences), Vol. 39, N4, 432–443.

Solanki S.K., Rüedi I.: 2003, Spatial and temporal fluctuations in sunspots derived from MDI data, Astronomy and Astrophysics 411, 249–262.

Other Publications

Crowther P.A., Abbott J.B., Drissen L., Schild H., Schmutz W., Royer P., Smartt S.J.: 2003, Wolf-Rayet Stars at 1-2 Mpc. In: K.A. van der Hucht, A. Herrero, C. Esteban (eds.), Proc. IAU Symp. 212, A Massive Star Odyssey, ASP, San Francisco, p. 547.

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Personnel

Scientific Personnel

Prof. Dr. Werner Schmutz	Director, physicist, astrophysics, Sun-Earth connection, PI ETH-Polyproject, PI PREMOS, CoI LYRA, SOVIM
PD Dr. Rolf Philipona	Physicist, surface radiation budget, calibration of longwave instruments, IR and UV instrumentation
Dr. Eugene Rozanov	Physicist, project manager ETH-Polyproject, GCM and CTM calculations
Dr. Isabelle Rüedi	Physicist, absolute radiometry, solar physics, calibration of shortwave instruments, CoI VIRGO, SOVIM, PREMOS, LYRA
Christoph Wehrli	Physicist, design and calibration of filter radiometers, atmosph. remote sensing, CoI VIRGO, SOVIM, PREMOS, LYRA
Bruno Dürr	PhD student, ETHZ, SNSF project
Dr. Tatiana Egorova	PhD student, ETH-Polyproject
Margit Haberreiter	PhD student, ETH-Polyproject
Chris Hoyle	PhD student, ETH-TH-project
Marcel Sutter	PhD student, ETHZ, SNSF project
Richard Wachter	PhD student, ETHZ, SNSF 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, electronic engineer, head electronics dept., experiment manager VIRGO, SOVIM, PREMOS, LYRA
Silvio Koller	Electronic engineer LYRA (since 1.4.2003)
Daniel Pfiffner	Electronic engineer SOVIM and PREMOS
Marcel Spescha	Laboratory Technician
Ursin Solèr	Physics Technician
Christian Thomann	Laboratory Technician
Jules U. Wyss	Mechanic, general mechanics, 3D design and manufacturing of mechanical parts
Christian Gubser	Electronics apprentice, 1st/2nd year
Marcel Knupfer	Electronics apprentice, 2nd/3rd year

Administration

Sonja Degli Esposti	Administration PMOD/WRC, personnel, book keeping
Annika Weber	Administration apprentice, 1st year (since 16.8.2003)

Caretaker

Klara Maynard	General caretaker, cleaning
Dostana Kostic	Part time cleaning

Civilian Service Conscripts

Lars Konersmann	4.11.2002 – 28.3.2003
Kurt Casutt	6.1. – 6.4.2003
Daniel Bayard	7.4. – 5.9.2003
Martin Lechmann	22.4. – 13.6.2003
Thomas von Allmen	16.6. – 17.10.2003
Colin Müller	since 20.10.2003
Simon Salzmann	since 17.11.2003

Guests, Students

Gian-Marco Frey	10.2. – 21.3.2003
Stefan Wacker	3.3. – 28.3.2003
Christian Ruckstuhl	since 1.10.2003

Miscellaneous Activities

Participation in Meetings and Courses

Werner Schmutz	
15.1. – 16.1.	European ILWS, Paris
5.4. – 6.4.	VIRGO meeting, Nizza
14.4. – 15.4.	European ILWS, Nizza
1.5. – 2.5.	HMI meeting, Stanford
17.6. – 19.6.	CCPR, Paris
30.6. – 5..7.	IUGG, Sapporo
3.9. – 7.9.	European ILWS, ESTEC
24.11.	COST-724 kick off, Brussels
27.11. – 28.11.	ESTAR, Strasbourg
1.12.	LYRA PDR, Brussels
Sonja Degli Esposti	
19.8. – 16.9.	Ausbildungskurs für Lehrmeister und Ausbilder
Bruno Dürr	
19. – 21.5.	ICAM2003, Brig
Tania Egorova	
24.3. – 29.3.	SOLICE and EuroSPICE workshops, Berlin
6.4. – 11.4.	EGS-AGU-EUG, Nice
30.6. – 11.7	XXIII IUGG General Assembly, Sapporo
17.11. – 19.11.	CCM validation workshop, November 2003, Greinau/Garmisch-Partenkirchen
1.12. – 4.12.	SOLICE workshop, Prague
Claus Fröhlich	
24. – 26.3.	SoHO SWT im GSFC
5. – 6.4.	VIRGO meeting, Nice
7. – 11.4.	EGS/AGU meeting, Nice
10.4.	CNES-CPS, Paris
6. – 7.5.	Leibniz Gesellschaft, Sitzung der Beiräte, Berlin
10. – 12.6.	FDR SOVIM, Alenia, Turin
23. – 27.6.	ISCS Symposium, Tatranska Lomnica, Slowakei
21. – 24.7.	BIPM Sommerschule, Sevres-Paris
1. – 2.10.	KSI Beiratssitzung, Freiburg i. Br.
8. – 11.10.	Stellar Workshop, Flagstaff, Arizona
24. – 25.10.	Jungfraujoch Stiftungsrat, Interlaken
31.10.	CNES-CPS, Paris
6.11.	KIS Stiftungsrat, Freiburg i. Br.
4. – 6.12.	SORCE science meeting, Sonoma, USA
8. – 12.12.	AGU fall meeting, San Francisco, USA
Margit Haberreiter	
6. – 11.4.	EGS-AGU-EUG Joint Assembly, Nice
23. – 28.6.	ISCS Symposium, Tatranska Lomnica, Slovak Republic

Christopher Hoyle	
24. – 30.3.	CANDIDOZ 1st annual meeting, Sodankylä, Finland
6. – 12.4.	EGS-AGU-EUG Joint Assembly, Nice, France
16. – 19.11.	CCM 2003, Greinau/Garmisch-Partenkirchen, Germany
Rolf Philipona	
31.1. – 6.2.	GAW meeting, Tamanrasset, Algeria
11.3.	ACP meeting, ETH, Zürich
4.4.	Swiss Global Change Day, Bern
6.4. – 12.4.	EGS, EGU, AGU, Nice, France
22.5.	NCCR, Review Panel, Zürich
28.6. – 9.7.	IUGG, Sapporo, Japan
8.10. – 10.10.	SGM, SANW, Fribourg
28.10.	ACP meeting, Bern
6.12. – 13.12	AGU, San Francisco, USA
Eugene Rozanov	
24.3. – 29.3.	SOLICE and EuroSPICE workshops, Berlin
6.4. – 11.4.	EGS-AGU-EUG Joint Assembly, Nice
14. – 17.5.	COSMOS workshop, MPI Hamburg
30.6. – 11.7	XXIII IUGG General Assembly, Sapporo
17.11. – 19.11.	CCM validation workshop, November 2003, Greinau/Garmisch-Partenkirchen
1.12. – 4.12.	SOLICE workshop, Prague
Isabelle Rüedi	
6.4.	VIRGO-meeting, Nice
7. – 11.4.	EGS, Nice
9. – 20.6.	NPL, Pyrheliometer comparison with cryogenic radiometer
21. –25.7.	NPL, Pyrheliometer comparison with cryogenic radiometer
Richard Wachter	
18.2. – 3.3.	Stanford University, USA: Visit /Scientific collaboration
6.4. - 11.4.	EGS-AGU-EUG Joint Assembly, Nice
18.11. -10.12.	Tashkent Astronomical Institute / Visit in frame of SCOPES
Christoph Wehrli	
1.4.	GAW-CH Landesausschuss, Zürich
25. – 28.3.	SAG/Aerosol meeting, Lille
2. – 3.6.	AEROCOM meeting, Paris
6. – 8. 10.	GAWTEC-XI course, Schneefernerhaus
21.10.	GAW-CH Landesausschuss, Zürich

Course of Lectures, Participation in Commissions

Werner Schmutz:

- International Radiation Commission (IAMAS)
- Comité consultatif de photométrie et radiométrie (OICM)
- Swiss Committee on Space Research (SANW)
- Commission for Astronomy (SANW)
- GAW-CH Working Group (MeteoSchweiz)
- Swiss management committee delegate in the COST action 724
- Course of lecture *Sternatmosphären* SS 2003 ETHZ
- Course of lecture *Astronomie*, WS 2002/2003 and WS 2003/2004 ETHZ

Claus Fröhlich:

- Beirat Kiepenheuer Institut, Freiburg, Germany
- SOHO Science Working Team
- Comité de Programme Scientifique de CNES

Rolf Philipona

- Course of lecture *Strahlungsmessung in der Klimaforschung* WS 2002/2003 and WS 2003/2004 ETHZ
- Working Group for Baseline Surface Radiation Network (WMO/WCRP)
- Atmospheric Chemistry and Physics (ACP) Commission of SANW

Christoph Wehrli

- GAW-CH Working Group (SMA)
- WMO/GAW Aerosol SAG
- Working Group for Baseline Surface Radiation Network (WMO/WCRP)
- Course of lecture “Aerosol Optical Depth” at the GAWTEC course

Public Seminars at PMOD/WRC

18.2.	Der Hochflussdichte-Sonnenofen des DLR: Experimente und Messtechnik-Entwicklung	Dr. A. Neumann, Köln, Germany
25.3.	Astronomy in Uzbekistan in the past and the present	Dr. S. Kholikov, Tashkent, Uzbekistan
10.7.	Materials subjected to intense synchrotron radiation: Old experiments, new experiments and models	Dr. A.D.O. Bawagan, Ottawa, Canada
29.7.	Solar wind and circulation of the lower stratosphere	Dr. V. Zubov, St. Petersburg, Russia
21.11.	Changes in radiation climate in Estonia (1955–2002)	Dr. Vivi Russak, Toravere, Estonia

Guided Tours at PMOD/WRC

In 2003 the PMOD/WRC was visited by 9 groups and 5 single persons.

Abbreviations

AOD	Aerosol Optical Depth
ACRIM	Active Cavity Radiometer for Irradiance Monitoring
ACU	Attitude Control Unit
AGU	American Geophysical Union
AMIP	Atmospheric models inter-comparison project
ARM	Atmospheric Radiation Measurement
ASRB	Alpine Surface Radiation Budget, PMOD/WRC Project
ATLAS	Shuttle Mission with solar irradiance measurements
ATLAS9	Radiative transfer code developed by Kurucz, version 9
AU	Astronomical Unit (1 AU = mean Sun-Earth Distance)
AVHRR	Advanced Very High Resolution Radiometer
BAG	Bundesamt für Gesundheitswesen
BBW	Bundesamt für Bildung und Wissenschaft, Bern
BESSY	Berliner Elektronen Speicher Synchrotron
BiSON	Birmingham Solar Oscillation Network
BOLD	Blind to optical light detector
BSRN	Baseline Surface Radiation Network of the WCRP
BUWAL	Bundesamt für Umwelt, Wald und Landschaft, Bern
CART	Cloud and Radiation Testbed
CCM	Coupled Chemistry-Climate Model
CAS	Commission for Atmospheric Sciences, commission of WMO
CHARM	Swiss (CH) Atmospheric Radiation Monitoring, CH-contribution to GAW
CIE	Commission Internationale de l'Eclairage
CIMO	Commission for Instruments and Methods of Observation of WMO, Geneva
CIR	Compagnie Industrielle Radioélectrique, Gals
CMDL	Climate Monitoring and Diagnostic Laboratory
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
COSPAR	Commission of Space Application and Research of ICSU, Paris, F
COSI	Code for Solar Irradiance
CPD	Course Pointing Device
CPC	Climate Prediction Center
CSEM	Centre Suisse de l'Electro-Mécanique, Neuenburg
CTM	Chemical Transport Model
CUVRA	Characteristics of the UV radiation field in the Alps
DIARAD	Dual Irradiance Absolute Radiometer of IRMB
DLR	Deutsche Luft und Raumfahrt
DU	Dobson Units
ECMWF	European Center for Medium Range Forecast
EDT	Eastern daylight saving Time
EGS	European Geophysical Society
EGSE	Electrical Ground Support Equipment
EISLF	Eidgenössisches Institut für Schnee- und Lawinenforschung, Davos
ENET	supplementary meteorological network of SMA
ERA-15	European reanalysis project for 1978-1994

ERA-40	European reanalysis project for 1960-2000
ERBS	Earth Radiation Budget Satellite
ERS	Emergency Sun Reacquisition
ESA	European Space Agency, Paris, F
ESO	European Southern Observatory
ESOC	European Space Operations and Control Centre, Darmstadt, D
ESTEC	European Space Research and Technology Centre, Noordwijk, NL
ETH	Eidgenössische Technische Hochschule (Z: Zürich, L: Lausanne)
EURECA	European Retrievable Carrier, flown August 1992 - June 1993 with SOVA Experiment
EUV	Extreme Ultraviolet Radiation
FDE	Fault Detection Electronics
FWHM	Full width half maximum (e.g. filter transmission)
GAW	Global Atmosphere Watch, an observational program of WMO
GAWTEC	GAW Training and Education Centre
GCM	General Circulation Model
GHG	Greenhouse Gases
GOLF	Global Oscillations at Low Frequencies= experiment on SOHO
GOME	Global Ozone Monitoring Experiment
GONG	Global Oscillations Network Group
GSFC	Goddard Space Flight Center, Maryland, USA
HECaR	High sensitivity Electrically Calibrated Radiometer
HF	Hickey-Frieden Radiometer manufactured by Eppley, Newport, R.I., USA
HST	Hubble Space Telescope
IAC	Instituto de Astrofísica de Canarias, Tenerife, E
IACETH	Institute for Climate Research of the ETH-Z
IAD	Ion assisted deposition of thin dielectric layers
IAMAS	International Association of Meteorology and Atmospheric Sciences of IUGG
IAS	Institut d'Astrophysique Spatiale, Verrières-le-Buisson, F
IASB	Institut d'Aéronomie Spatiale de Belgique, Bruxelles, B
IAU	International Astronomical Union of ICSU, Paris, F
IFU	Institut für Umweltwissenschaften, Garmisch-Partenkirchen
ICSU	International Council of Scientific Unions, Paris, F
IDL	Interactive Data-analysis Language
IKI	Institute for Space Research, Moscow, Russia
INTAS	International Association for the promotion of co-operation with scientists from the New Independent States of the former Soviet Union, EU grant
INTRA	Intelligent Tracker from BRUSAG
IPASRC	International Pyrgeometer and Absolute Sky-scanning Radiometer Comparison
IPC	International Pyrheliometer Comparisons
IPHIR	Inter Planetary Helioseismology by Irradiance Measurements
IR	Infrared
IRC	Infrared Radiometer Calibration Center
IRMB	Institut Royal Météorologique de Belgique, Brussel, B
IRS	International Radiation Symposium of the Radiation Commission of IAMAS
ISA	Initial Sun Acquisition
ISS	International Space Station
ISSA	International Space Station Alpha (NASA, ESA, Russia, Japan)

IUGG	International Union of Geodesy and Geophysics of ISCU
JPL	Jet Propulsion Laboratory, Pasadena, California, USA
KIS	Kiepenheuer-Institut für Sonnenphysik, Freiburg i.Br.
KrAO	Crimean Astrophysical Observatory, Ukraine
LASCO	Large Angle and Spectrometric Coronagraph
LOI	Luminosity Oscillation Imager, Instrument in VIRGO
LTE	Local thermo dynamical equilibrium
LYRA	Lyman-alpha Radiometer, experiment on PROBA 2
MAECHAM4	Middle atmosphere version of ECHAM4 model
MDI	see SOI/MDI
MEZON	Model for evaluation of the ozone trends
MLS	Microwave Limb Sounder onboard UARS
MODTRAN	Moderate Resolution Transmission Code (in Fortran)
NASA	National Aeronautics and Space Administration, Washington, USA
NCEP	National Center for Environmental Prediction, USA
NIMBUS7	NOAA Research Satellite, launched Nov.78
NIP	Normal Incidence Pyrheliometer
NIWA	National Institute for Water and Atmospheric Research, New Zealand
NOAA	National Oceanographic and Atmospheric Administration, Washington, USA
NPL	National Physical Laboratory, Teddington, UK
NREL	National Renewable Energy Lab
NSO/KPVT	National Solar Observatory / Kitt-Peak Vacuum Telescope
OCAN	Observatoire de la Côte d'Azur, Nice, F
ODS	Ozone destroying substances
PCB	Printed circuit board
PCSR	Planck Calibrated Sky Radiometer
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 (launch 2005)
PIR	Precision Infrared Pyrgeometer von Eppley
PMOD	Physikalisch-Meteorologisches Observatorium Davos
PMO6-V	VIRGO PMO6 type radiometer
PREMOS	Precision Monitoring of Solar Variability, PMOD experiment on PICARD
PROBA 2	ESA technology demonstration space mission
PRODEX	Program for the Development of Experiments der ESA
PTB	Physikalisch-Technische Bundesanstalt, Braunschweig & Berlin, D
RA	Regional Association of WMO
RASTA	Radiometer für die Automatische Station der SMA
ROB	Royal Belgian Observatory
RS422	Serial communication interface
SAMS	Stratospheric amd Mesospheric Sounder
SANW	Schweizerische Akademie der Naturwissenschaften, Bern
SARR	Space Absolute Radiometer Reference
SBUV	Solar Backscatter UltraViolet Instrument
SCOPES	Scientific Collaboration between Eastern Europe and Switzerland, grant of the SNSF
SI	Sea Ice
SLF	Schnee und Lawinenforschungsinstitut, Davos

SFI	Schweiz. Forschungsinstitut für Hochgebirgsklima und Medizin, Davos
SIAF	Schweiz. Institut für Allergie- und Asthma-Forschung, Davos
SIMBA	Solar Irradiance Monitoring from Balloons
SMD	Surface Mounted Devices
SME	Solar Mesospheric Explorer
SMM	Solar Maximum Mission Satellite of NASA
SNF	Schweizer. Nationalfonds zur Förderung der wissenschaftlichen Forschung
SNSF	Swiss National Science Foundation
SOCOL	Modeling tool for the evaluation of the *So*lar-*C*limate-*O*zone *L*inks
SOHO	Solar and Heliospheric Observatory, Space Mission of ESA/NASA
SOI/MDI	Solar Oscillation Imager/Michelson Doppler Imager, Experiment on SOHO
SOJA	Solar Oscillation Experiment for the Russian Mars-96 Mission
SOL-ACES	Solar Auto-Calibrating EUV/UV Spectrometer for the International Space Station Alpha by IPM, Freiburg i.Br., Germany
SOLERS22	Solar Electromagnetic Radiation Study for Solar Cycle 22, of STEP, ISCU
SOLSPEC	Solar Spectrum Instrument for the International Space Station Alpha by Service d'Aéronomie, Verriere-le-Buisson, France
SOVA	Solar Variability Experiment on EURECA
SOVIM	Solar Variability and Irradiance Monitoring for the International Space Station Alpha by PMOD/WRC Davos, Switzerland
SPC	Science Programme Committee, ESA
SPM	Sonnenphotometer
SSD	Space Science Department of ESA at ESTEC, Noordwijk, NL
SST	Sea Surface Temperature
STEP	Solar Terrestrial Energy Program of SCOSTEP/ICSU
STUK	Finish Center for Radiation and Nuclear Safety
SUMER	Solar Ultraviolet Measurements of Emitted Radiation
SUSIM	Solar ultraviolet spectral irradiance monitor
SW	Short Wave
SWT	Science Working Team
TOMS	Total Ozone Mapping Spectrometer
TSI	Total Solar Irradiance
UARS	Upper Atmosphere Research Satellite of NASA
UCL	University College London
UKIRT	United Kingdom Infrared Telescope
UKMO	United Kingdom Meteorological Office
USA	United States of America
UTC	Universal Time Coordinated
UV	Ultraviolet radiation
VIRGO	Variability of solar Irradiance and Gravity Oscillations, Experiment on SOHO
WCRP	World Climate Research Programme
WMO	World Meteorological Organization, Geneva
WORCC	World Optical Depth Research and Calibration Center (since 1996 at PMOD)
WRC	World Radiation Center
WRR	World Radiometric Reference
WSG	World Standard Group
WWW	*World Weather* Watch, an observational program of WMO

Donations

For the manufacturing of the LYRA electronics, PRODEX granted € 29'500.00 for a surface mount technology equipment. This price was based on a preliminary evaluation of the apparatus that we intended to buy. A later evaluation revealed that for our purpose, a more sophisticated device is needed but of course, the price of the soldering equipment that we requested was much higher than what we had to our disposition. As we were fortunate to have money left from a donation by Mr. Daniel Karbacher from Küsnacht (ZH) in 2001, we could cover the price difference.

In commercial applications the standard wired components are often replaced by so called “Surface Mounted Devices” (SMD). These components are much smaller, lighter and they can be placed on the printed circuit board (PCB) by automated processes. For space applications using SMD is of interest because of their small size and weight. The new surface mount technology equipment consists of a solder paste printer, a vapor phase reflow oven and a SMD repair-work station (Figure 13). All SMD’s are soldered at the same time in one step. The whole process is very efficient, reproducible and preserves board and components.

Figure 13. The new Surface Mount Technology equipment: solder paste printer (left), surface mounted devices repair-work station with micromanipulator (middle), and vapor phase reflow oven (right).

Rechnung PMOD/WRC 2003

Allgemeiner Betrieb PMOD/WRC (exkl. Drittmittel)

Ertrag	CHF
Beitrag Bund Betrieb WRC	821'700.00
Beitrag Bund Betrieb WORCC	155'823.00
Beitrag Kanton Graubünden	121'500.00
Beitrag Landschaft Davos	202'500.00
Beitrag Landschaft Davos, Mieterlass	133'500.00
Beitrag SFI, Stiftungstaxe	190'000.00
Beitrag SFI, Aufbau IR-Center	30'000.00
Beitrag MeteoSchweiz, Aufbau IR-Center	70'000.00
Instrumentenverkauf	67'558.40
Beitrag Bundesamt für Gesundheit	25'000.00
Diverse Einnahmen/Eichungen	46'259.60
Spende/Wertschriftenertrag/Aktivzinsen	53'350.75
	1'917'191.75

Aufwand	CHF
Gehälter	1'163'113.25
Sozialleistungen	233'622.05
Investitionen	128'354.95
Investitionen IR-Center	42'425.85
Unterhalt	21'566.60
Verbrauchsmaterial	36'559.70
Verbrauchsmaterial/Unterhalt IR-Center	4'979.85
Reisen, Kongresse, Kurse	35'707.53
Reisen, Kongresse, Administration IR-Center	12'594.30
Bibliothek und Literatur	16'610.23
Raumkosten	180'580.90
Verwaltungskosten	56'161.10
	1'932'276.31
Ergebnis 2003	-15'084.56
	1'917'191.75

Bilanz PMOD/WRC (exkl. Drittmittel)

	31.12.2003	31.12.2002
Aktiven	CHF	CHF
Kassa	2'013.05	3'136.60
Postcheck	17'252.94	19'200.14
Bankkonten	476'525.76	504'185.96
Debitoren	12'168.40	79'094.50
Verrechnungssteuer	1'413.84	937.59
Kontokorrent Mitarbeiter	-1'728.20	-146.00
Kontokorrent Stiftung	Passiv	44'698.40
Kontokorrent SNF-1	61'787.70	298.50
Kontokorrent SNF-2	12'125.85	28'379.90
Kontokorrent SNF-3	10'346.10	9'397.30
Kontokorrent PREMOS	164.30	845.10
Kontokorrent SOVIM	257'112.27	272'773.08
Kontokorrent POLY-Projekt	6'347.30	1'568.00
Kontokorrent SCOPES	-	2'561.52
Kontokorrent SoHO-11	-	18'510.50
Kontokorrent INTAS	6'553.00	6'553.00
Kontokorrent TH-Projekt	6'667.30	570.00
Kontokorrent LYRA-Projekt	65'092.50	2'341.51
Kontokorrent COST-724	1'230.65	-
Kontokorrent Saas-Fee Kongress	517.50	-
Transitorische Aktiven	38'837.85	16'739.10
	974'428.11	1'011'644.70
Passiven		
Kreditoren	73'339.05	59'826.08
Kontokorrent Stiftung	13'866.50	Aktiv
Transitorische Passiven	455'199.85	479'433.40
Rückstellungen	327'639.90	352'917.85
Eigenkapital	104'382.81	119'467.37
	974'428.11	1'011'644.70