Zusammenfassung Jahresbericht 2006

Vorwort

Das Expertenteam für meteorologische Strahlung der Weltorganisation für Meteorologie (WMO) tagte im Februar am PMOD/WRC und beurteilte die verschiedenen Tätigkeitsbereiche des Weltstrahlungszentrums. Die Experten gaben uns für alle Bereiche eine ausgezeichnete Bewertung[1]. Von grosser Bedeutung für die Zukunft des WRC war die Einschätzung des Bereichs, der Forschungs- und Kalibrierzentrum für atmosphärische Trübungsmessungen genannt wird, bzw. World Optical Depth Research and Calibration Center (WORCC). Die Dienstleistung dieser Abteilung wurde als ausserordentlich wertvoll gewürdigt, gleichzeitig wurde aber festgestellt, dass die Abteilung personelle Verstärkung benötigt. In diesem Sinn verfassten die Experten einen Bericht zuhanden der WMO-Kommission für Instrumente und Methoden (CIMO). Aus diesem Bericht resultiert eine von den Delegierten aus aller Welt akzeptierte Empfehlung, die im Dezember anlässlich der vier-jährlichen Tagung dieser Kommission erarbeitet wurde.

Dieser Expertenbericht und eine ähnliche Empfehlung einer WMO Beratergruppe im Jahr zuvor, hatte zur Folge, dass die Finanzierung des WORCC um 75 % erhöht wurde, um ab Anfang 2007 die Dienstleistung auszubauen. Gegenwärtig ist das WORCC noch nicht offizieller Bestandteil des Weltstrahlungszentrums, sondern ein Zusatzbereich des WRC, der mit einem schweizerischen Beitrag zum Global Atmosphere Watch Programm der WMO (GAW-CH) durch die MeteoSchweiz ermöglicht wird. Parallel zu der Aufstockung der Drittmittel wurden Schritte eingeleitet, um das WORCC langfristig zu etablieren: Auf der obersten politischen Ebene bat die WMO die Schweiz noch im Berichtsjahr um eine Übernahme des WORCC in den Dienstleistungsauftrag des Weltstrahlungszentrums. Aufgrund der WMO Anfrage wurde nun beim Erneuerungsgesuch an Bund, Kanton und Landschaft Davos für die Finanzierung des Weltstrahlungszentrums in der nächsten Finanzperiode (2008 bis 2011) nebst den bisherigen Aufgaben auch die Erweiterung des WRC-Auftrags um die Sektion für atmosphärische Trübungsmessungen beantragt.

Zwei der drei Weltraumprojekte, die gegenwärtig am Observatorium entwickelt werden, nähern sich ihrer Fertigstellung und baldigen Ablieferung zur Integration. Wenn sich das Observatorium auch langfristig weiterhin für Weltraumforschung engagieren möchte, wird es nötig, zukünftige Weltraumprojekte zu definieren. Die grundsätzliche Schwierigkeit besteht darin, dass die Europäische Weltraumorganisation ESA mit Solar Orbiter erst für das Jahr 2015 die nächste Sonnenmission plant. Die Arbeitsgruppe des *International Living With a Star* Programms ermöglichte den Kontakt zur chinesischen Mission KuaFu, die im Jahr 2012 starten soll. Dank einer vereinbarten Zusammenarbeit mit dem Institut CIOMP in Changchun, das auch Radiometer baut, stehen die Chancen

1) Der Bericht kann über die Webseite der WMO, http://www.wmo.ch/web/www/IMOP/, unter reports 2003-2007 im Dokument ET-MR&ACM-1_Final Report.pdf eingesehen werden.

auf einen Platz für ein schweizerisch-chinesisches Doppelexperiment auf der chinesischen Mission gut. Allerdings hat die chinesische Weltraumbehörde die Realisierung des KuaFu Projektes noch nicht definitiv beschlossen.

Die Gründung des Physikalisch-Meteorologischen Observatorium Davos durch Carl Dorno im Jahr 1907 gibt uns die Möglichkeit, sich mit diversen Aktivitäten im Rahmen des 100-Jahr Jubiläums in der Öffentlichkeit besser bekannt zu machen. Die Verantwortliche für den SFI-Newsletter, Katrin Weber, verfasste die Festschrift „100 Jahre Physikalisch-Meteorologisches Observatorium Davos“. In Zusammenarbeit mit dem Heimatmuseum Davos wurde eine Sonderausstellung mit den noch zahlreich erhaltenen historischen Instrumenten des PMOD vorbereitet. Die Elektrizitätswerke Davos AG stellte die Werbefläche eines Linienbusses der Verkehrsbetriebe Davos für ein Jahr zur Verfügung, die von der Grafikerin Heidi Roth gestaltet wurde. Frau Roth hat auch das neue Logo für das PMOD/WRC entworfen. Damit wurden beste Voraussetzungen geschaffen um ins Jubiläumsjahr 2007 zu starten.

Dienstleistungen und Messnetze

Mit Beschluss der CIMO-XIV Tagung werden die verschiedenen Bereiche am Weltstrahlungszentrum Sektionen genannt. Zurzeit bestehen zwei Sektionen: Solare Radiometrie und Infrarot-Radiometrie. Das Europäische UV Kalibrierzentrum und das Forschungs- und Kalibrierzentrums für atmosphärische Trübungsmessungen sind Zusatzbereiche, die aus Drittmitteln finanziert werden.

Zwei Jahre nach der Einführung eines Qualitäts-Managements entsprechend ISO/IRC 17025 für den Betrieb der Sektion Solare Radiometrie sind die dafür definierten Abläufe alltäglich geworden. Es wurden 43 Instrumente mit der Standardgruppe verglichen, davon 32 Pyranometer und zehn Geräte zur Messung der direkten Sonneneinstrahlung. Die Sektion für IR Radiometrie charakterisierte 24 Pyrgeometer mit einem Schwarzkörper Strahler und kalibrierte diese Geräte anschliessend mit der Welt-IR-Standardgruppe. Acht Filterradiometer wurden durch das Kalibrierzentrum für atmosphärische Trübungsmessungen kalibriert.

Der Bericht über die IPC-X in 2005 wurde fertig gestellt und gedruckt. Das wichtigste Ergebnis ist, dass die Weltstandardgruppe (WSG) innerhalb der geforderten Toleranz stabil geblieben ist. Die Referenz wurde erfolgreich auf die an den Vergleichen teilnehmenden Instrumente übertragen. Die Sektion für solare Radiometrie musste im letzten Drittel des Jahres ohne die Standardgruppe auskommen, da die alte Messhütte abgerissen und durch einen Neubau ersetzt wurde. Als Ersatz wurde eine Gruppe von drei Radiometern auf einer mobilen astronomischen Dreibein-Nachführung eingerichtet, wobei ein Instrument der Standardgruppe entnommen wurde. Diese mobile Kalibrier-referenz nahm im Herbst an den Regionalvergleichen am NREL in Golden, USA, teil.

Die Sektion für Infrarot Radiometrie wurde von der CIMO Expertengruppe evaluiert. Diese hat als wichtigste Schlussfolgerung die Empfehlung ausgesprochen, dass die Gruppe von vier Pyrgeometern, die eine Standardgruppe für IR Strahlung bilden, als Interims-Referenz benutzt wird. Ein fünftes modifiziertes Pyrgeometer, mit einem Block-Filter für Sonnenstrahlung, wurde im Sommer zur Referenzgruppe hinzugenommen. Für die Entwicklung eines neuen Absolut-IR-Radiometers wurde bis Ende Jahr die Design-Studie beendet, so dass im neuen Jahr mit der Konstruktion begonnen werden kann.

Seit Anfang des Jahres 2006 betreiben wir das Europäische UV Kalibrierzentrum mit dem vom Joint Research Center der Europäischen Kommission in Ispra als Dauerleihgabe überlassenen Instrumentarium. Im Rahmen einer durch die COST Aktion 726 organisierten europäischen Kampagne wurden 36 Breit-Band UV Geräte am Observatorium verglichen. Zusätzlich wurden mit dem mobilen Spektroradiometer *QASUME* vier Stationen besucht um deren Spektroradiometer vor Ort zu kalibrieren.

Die Filterradiometer des von uns betreuten GAW-Netzwerkes für die Messung der atmosphärischen Trübung liefen an neun Stationen operationell und reibungslos. Das Gerät auf Izaña wurde in einem Sturm beschädigt und musste in Davos repariert werden. Die Izaña Messungen wurden im März wieder aufgenommen. Die Messungen auf dem Jungfraujoch sind seit August unterbrochen, da die Station der MeteoSchweiz dort erneuert wird. Eine Arbeitsgruppe der Aerosol Beratungskommission der WMO empfahl die Installierung einer Gruppe Instrumente am PMOD/WRC, die in Zukunft bei Vergleichen von Messinstrumenten zur Bestimmung der atmosphärischen Trübung als Referenz dienen soll. Für diese Gruppe wurden zwei kommerzielle Radiometer bestellt, die im operationellen Betrieb von Netzwerken vielfach eingesetzt werden. Die Beratergruppe empfahl auch ein Filterradiometer des PMOD/WRC auf Mt. Waliguan, China, zu installieren, um die Vergleichbarkeit zu den Messungen des chinesischen Messnetzes zu gewährleisten.

Der Betrieb des *Alpine Surface Radiation Budget* (ASRB) Messnetzwerks, das bis 2004 als Forschungsprojekt betrieben wurde, ist nun weitgehend operationell in das automatische Messnetz der MeteoSchweiz, dem SwissMetNet, eingebaut und um neun weitere Stationen erweitert worden.

Entwicklung und Bau von Instrumenten: Ein neues Absolut-Radiometer und die Weltraumexperimente SOVIM, PREMOS und LYRA

Im Berichtsjahr konnten zwei vom Observatorium gebaute Pyrheliometer des Typs PMO6-CC, sechs Filterradiometer und fünf Ventiliersysteme verkauft werden. Ausserdem wurden fünf IR Radiometer mit zusätzlichen Thermistoren ausgerüstet.

Die Untersuchungen der Eigenschaften von Radiometern mittels Computer-simulationen im Rahmen eines Nationalfonds Projekts wurden weiter vertieft. Der nächste Schritt wird der Bau eines Prototyps sein, der mit den entsprechenden Neuerungen ausgerüstet sein wird und mit dem die theoretischen Erwartungen überprüft werden sollen. Das Ziel der Entwicklung ist ein neuer Typ Absolut-Radiometer.

Das eigentlich im Jahr 2005 fertig gestellte, getestete und kalibrierte Weltraum-experiment SOVIM für die Internationale Weltraumstation musste nochmals überarbeitet werden, da der Strahlungsschirm des Experimentes von der ESA wegen kleiner Sprünge in der Oberflächenverspiegelung nicht akzeptiert wurde. Auch das Weltraumexperiment LYRA war schon 2005 fertig gebaut. Im Berichtsjahr hat man

LYRA noch diversen Tests unterzogen und die Instrumente sorgfältig an der Physikalisch-Technischen Bundesanstalt in Berlin kalibriert. Das Gerät ist nun bereit für die Integration auf der PROBA2 Plattform. Das dritte Weltraumexperiment, PREMOS für den französischen Satelliten PICARD, befindet sich in der Bauphase. Wir haben einen Prototyp mit einem Filterradiometer und einem Absolut-Radiometer gebaut, um vor der Fertigung des Flugmodells alle Komponenten ausführlich überprüfen zu können.

Der solare Einfluss auf das Erdklima

In Zusammenarbeit mit dem Institut für Atmosphäre und Klima der ETH Zürich (IACETH) wurde in verschiedenen Teilprojekten weiter an der theoretischen Erforschung des solaren Einflusses auf das Erdklima geforscht. Das grundlegende Arbeitsmittel aller Projekte ist das am Observatorium Davos entwickelte Klimamodell (Chemistry-Climate Model, CCM), *SOCOL,* das stetig weiter ausgebaut wird. Ein Teilprojekt untersucht die Chemie der Stratosphäre während des ganzen 20. Jahrhunderts. Diese Simulation ist ausserordentlich zeitaufwendig und wird mit neun, in den Anfangsbedingungen leicht verschiedenen Modellen zur Erfassung der natürlichen Variabilität parallel gerechnet. Zum Berichtszeitpunkt waren die Jahre 1900 bis 1927 fertig berechnet und interessanterweise sind in der oberen Stratosphäre der Elf-Jahreszyklus der Sonnenaktivität und in der unteren Stratosphäre die Einflüsse der Vulkaneruptionen von St. Maria 1902 und Mt. Katnai 1912 in Alaska klar zu erkennen.

Die Reaktion von Ozon in der Stratosphäre auf die Variabilität der Sonnenstrahlung ist Gegenstand eines weiteren Teilprojekts. In diesem Projekt wurden der Modellrechnung die beobachteten atmosphärischen Bedingungen von 1995 zu Grunde gelegt und nur die solare Einstrahlung verändert. Damit kann die chemische Reaktion auf die variable Sonnenstrahlung von anderen Einflüssen isoliert untersucht werden. Es wurde festgestellt, dass der direkte Einfluss der Sonne auf die Ozonkonzentration auf einer Höhe von 40 km am stärksten ist.

Während des Betriebs des Experimentes LYRA auf dem Satelliten PROBA2 werden wir die gemessenen UV Strahlungswerte benutzen, um in Fast-Echtzeit den Ist-Zustand und Kurzzeitprognosen der mittleren Atmosphäre zu berechnen. Diese Prognosen werden der internationalen Gemeinschaft als Beitrag zur Erfassung des so genannten Weltraumwetters zur Verfügung gestellt. Das Weltraumwetter ist der Zustand der Atmosphäre, verursacht durch Veränderung der Sonne und andere extraterrestrische Einflüsse. Die nötigen Vorbereitungsarbeiten am Klimamodell SOCOL und die für diese Anwendung erarbeitete Ausweitung auf die Ionosphäre sind grösstenteils abgeschlossen und wir sind bereit für die Anwendung. Der Start des Satelliten PROBA2 hat sich jedoch auf 2008 verzögert, so dass unser Beitrag zur COST Aktion 724, die das Weltraumwetter zum Thema hat aber nur noch bis Ende 2007 läuft, erst nach dem Ende der Aktion operationell sein wird.

Kalibrieren von Pyrgeometern: Der Einfluss der spektralen Empfindlichkeit

Die Energieverteilungen der Strahlung eines Schwarzkörpers und diejenige der atmosphärischen Strahlung sind unterschiedlich. Werden diese Strahlungsquellen zur

Charakterisierung von Pyrgeometern verwendet, resultieren unterschiedliche Kalibrierungen, da die spektrale Empfindlichkeit von Pyrgeometern nicht flach ist. Normalerweise basiert die Kalibrierung von Pyrgeometern auf dem Vergleich zu Standard Instrumenten unter atmosphärischen Bedingungen. In einem Forschungsprojekt konnte in einer Untersuchung von zwei Pyrgeometern mit bekannten spektralen Transmissionskurven gezeigt werden, dass die zwei Kalibrierungsarten zueinander konsistent werden, wenn die Einflüsse der individuellen Transmissionseigenschaften der Messgeräte rechnerisch berücksichtigt werden. Dies ist ein wichtiger Durchbruch für die Kalibrierung von Pyrgeometern, da so deren Kalibrierung direkt auf die SI-Skala via Schwarzkörper-Strahler zurückgeführt werden kann. Die kritische Komponente, die normalerweise nicht zur Verfügung steht, ist ein Gerät zur Ausmessung der spektralen Transmission der Messinstrumente. Das PMOD/WRC hat einen IR Spektrographen bestellt und wird diese viel versprechende neue Methode weiter untersuchen. Es gilt nun aufzuzeigen, mit welcher Genauigkeit Pyrgeometer mit dieser Methode kalibriert werden können.

Vergleich der AERONET und GAWPFR Messnetze

Die atmosphärische Trübung wird weltweit mit verschiedenen Messnetzen erfasst. Das vom Observatorium betreute GAWPFR Messnetz, bei dem Filterradiometer des Observatoriums, die Precision Filter Radiometer (PFR), an GAW Stationen eingesetzt werden, und das AERONET Messnetz betreiben Instrumente an drei gemeinsamen Stationen. Eine der zentralen Aufgaben des Kalibrierzentrums für atmosphärische Trübungsmessungen ist der Vergleich und die Homogenisierung der Messungen von verschiedenen Messnetzen. Untersuchungen in früheren Jahren haben gezeigt, dass die verschiedenen Instrumente, die beim AERONET und GAWPFR zum Einsatz kommen, sehr gut übereinstimmen. Eine Untersuchung der Messresultate von den gemeinsamen AERONET und GAWPFR Stationen zeigt, dass die Übereinstimmung nicht überall den geforderten Kriterien genügt. Die Gründe dafür müssen noch weiter abgeklärt werden.

Sehr viel Sorgfalt wird beim GAWPFR Netzwerk in die Qualitätssicherung der Messungen investiert. Langzeit-Untersuchungen der Kalibrierungen von PFR Instrumenten zeigen, dass diese sehr stabil bleiben. Langzeit-Stabilität war ein wichtiges Ziel bei der Konzeption der PFR Instrumente. Erfreulicherweise konnte beim operationellen Betrieb von PFR-Instrumenten eine rund 10-fache Verbesserung gegenüber der typischen Instrumentengenauigkeit vor 15 Jahren erreicht werden.

Untersuchungen von UV Instrumenten

In Zusammenarbeit mit der Universität Innsbruck wurde ein systematischer Effekt bei der Kalibrierung von UV Spektroradiometern untersucht. Der Effekt stammt vom Unterschied im Abstand der Kalibrierlampen im Labor relativ zum Einsatz im Freien, wo die Sonne praktisch unendlich weit entfernt ist. Es wurde eine Methode entwickelt, um diesen Effekt für verschiedene optische Elemente auszumessen und es konnten systematische Abweichungen der Laborkalibrierungen von rund zwei Prozent festgestellt werden. Die operationellen Kalibrierungen müssen in Zukunft entsprechend verbessert werden.

Sonnenphysik

Im Rahmen eines vom Nationalfonds finanzierten Projektes werden akustische Wellen in der Sonnenatmosphäre untersucht. Die bisherigen Interpretationen von Messungen der zeitlichen Variation der Form von Spektrallinien durch akustische Wellen wurden mit Berechnungen von synthetischen Linienprofilen verfeinert. Mit diesen Modellrechnungen wird es nun möglich, Phasenunterschiede zwischen dem Linienzentrum und den Linienflügeln zu berücksichtigen. Damit wird die Charakterisierung dieser Wellen verbessert und es kann unter anderem genauer bestimmt werden, wie viel Energie durch diese Wellen in die Chromosphäre und Korona transportiert wird, was für das Verständnis der noch nicht vollständig geklärten Heizung dieser Regionen von Bedeutung ist.

Die totale Bestrahlungsstärke der Erde durch die Sonne ist eine zentrale Grösse für die Klimamodellierung, da das Erdklima auf die Schwankungen der Einstrahlung reagiert. Dieser Einfluss der variablen Sonne auf das Klima wird erst seit 1978 genau erfasst. Seit damals wird die Sonneneinstrahlung ausserhalb der Erdatmosphäre mit Weltraumexperimenten gemessen. Um das Klima in der Vergangenheit mit Modellrechnungen simulieren zu können, muss man daher die Sonneneinstrahlung mit Hilfe von indirekten Informationen rekonstruieren, d.h. man verwendet Proxy Daten. Bei unserem Ansatz basieren wir die Rekonstruktion der Sonneneinstrahlung auf die in Eisbohrkernen enthaltene Konzentration des Isotops ^{10}Be und die beobachteten Sonnenfleckenzahlen als Proxy-Messdaten. Die erste Grösse wird zur Rekonstruktion des Langzeittrends der Sonnenleuchtkraft eingesetzt und die zweite Grösse für die Kurzzeitvariationen. Beim jetzigen Stand des Projektes haben wir Radionuklid-Daten ab 1935 verwendet und erhalten für die Periode von 1935 bis ca. 1955 eine Zunahme der Sonneneinstrahlung während den Minima des solaren Aktivitätszyklus. Für die Zeit danach ergibt unsere Rekonstruktion, dass die Stärke der Sonnenstrahlung während den Minima im Wesentlichen konstant blieb.

Prognostizierter Verlauf der Ozonkonzentration in der Stratosphäre

Ein SCOPES Projekt mit dem Main Geophysical Observatory in St. Petersburg versucht, die zukünftige Entwicklung der Ozon Konzentration in der Stratosphäre zu berechnen. Die russischen Partner arbeiten wie die Davoser mit dem Klimamodell *SOCOL.* Die Simulationen ergeben eine Erholung des gegenwärtigen Ozondefizits in der Stratosphäre auf die Werte vor 1975 bis ca. zum Jahr 2030. Ein neues Resultat ist, dass die Geschwindigkeit des Wiederaufbaus der Ozonkonzentration durch die vorhergesagten steigenden Methankonzentrationen gefördert wird. Generell führt die weltweite Klimaerwärmung dazu, dass die Ozonkonzentration voraussichtlich über die Werte vor 1975 weiter ansteigen wird, so dass man also in Zukunft einen Ozonüberschuss in der Stratosphäre haben wird.

Lehrverpflichtungen

In den Wintersemestern 2005/2006 und 2006/2007 hielt ich gemeinsam mit PD Dr. H. M. Schmid die Vorlesung „Astronomie“ an der ETH Zürich. Seit einem Jahr bekommen die Studenten für diese Vorlesung Kreditpunkte, wenn sie sich in diesem Fach prüfen lassen. Die Beliebtheit des Fachs Astronomie spiegelt sich in der grossen Anzahl Studenten, die zur Prüfung antreten. PD Dr. R. Philipona las in beiden Wintersemestern „Strahlungsmessung in der Klimaforschung“ und neu wurde die Vorlesung „Solar Ultraviolet Radiation“ von Dr. Julian Gröbner im Wintersemester 2006/2007 an der ETH Zürich angeboten.

Personelles

Drei Personen haben ihre Ausbildung im Jahr 2006 erfolgreich beendet und ich gratuliere herzlich zu den erfolgreichen Abschlüssen: Es sind dies Dr. Marcel Sutter, Christian Gubser, Elektroniker-Lehrling, und Annika Weber, die als erste am Observatorium zur Kauffrau ausgebildet wurde. Frau Weber unterstützt uns noch ein Jahr lang als Teilzeitangestellte und besucht die Schule um die Berufsmatura zu erwerben. Neue Auszubildende sind Samuel Prochazka in der Elektronik Abteilung und Joka Sarcevic in der Administration. Ein weiterer Wechsel in der Administration betrifft Angela Knupfer, die uns verliess und mit ihrem Hobby den Schritt in die Selbständigkeit gemacht hat. Ab 1. Oktober haben wir Stephanie Ebert angestellt, um sicher zu stellen, dass die durch die Ausweitung unserer Dienstleistungen immer zahlreicher werdenden Administrationsaufgaben bewältigt werden können.

Mit Prüfung und Abgabe der Dissertation von Dr. Marcel Sutter sank die Zahl der Doktoranden am Observatorium auf zwei Personen. Wir erwarten aber, dass bald wieder mehr Doktorierende bei uns arbeiten werden, wenn auch die höchste Anzahl von sieben im Frühjahr 2004 kaum in nächster Zeit erreicht werden wird. Markus Suter leistete als Zivildienstleistender während der IPC-X im Jahr 2005 sehr wertvolle Unterstützungsarbeiten. Er war daher mehr als willkommen um die Bachelor Arbeit für sein Studium an der Uni Zürich bei uns zu machen.

Dr. Gregor Hülsen ist seit Anfang des Jahres als Post Doktorand für das Europäische UV Kalibrierlabor angestellt, das mit einem Schweizerischen Beitrag zur COST Aktion 726 finanziert wird. Für die Vorbereitung und Betreuung der diversen Aktivitäten im Jubiläumsjahr haben wir Cornelia Lindner als Projektleiterin eingestellt.

Nach zwölf Jahren Betreuung des Alten Schulhauses und der Wetterstation Davos trat Klara Maynard in den wohlverdienten Ruhestand und ist nun nicht mehr durch tägliche Augenbeobachtungen an Davos gebunden. Ich danke Klara Maynard ganz herzlich für die langjährige kompetente Betreuung des Hauses. Für mich waren es vor allem die von ihrem verstorbenen Mann Guy liebevoll gepflegten Pflanzen, die dem Haus eine besonders angenehme Atmosphäre gaben. Die menschlichen Wetterbeobachtungen wurden von der MeteoSchweiz durch eine automatisierte Station ersetzt und die Pflege des Hauses inklusive Pflanzen wurde von Denise Dicht übernommen, die mit ihren drei Mädchen in die Abwartswohnung im Observatorium eingezogen ist.

Infrastruktur

Das Bundesamt für Bauten und Logistik hat wieder einen Budgetbetrag für die Unterhaltung der Infrastruktur des Weltstrahlungszentrums vorgesehen und nach einem Jahr Pause eine sehr grosse Investition ermöglicht: Ein Neubau des Gebäudes in dem die Weltstandardgruppe untergebracht ist. Bisher mussten die Messinstrumente, die auf einer Plattform montiert sind, auf Schienen ins Freie geschoben werden. Dieser Betriebsablauf hatte den Nachteil, dass die elektrische Verkabelung bewegt wurde und daraus Störungen des Messbetriebs resultierten. Im neuen Konzept wurde nun vorgesehen, dass die Instrumentenplattform fix installiert wird und fest bleibt und der vordere Teil des Gebäudes zur Sonnenbeobachtung weggefahren werden kann. Diese Idee wurde nun mit einem zweiteiligen Glasgebäude im letzten Drittel des Jahres unter der Leitung von Valentin Feubli (BBL) und Hansruedi Wagner, Architekt aus Klosters, realisiert. Zur selben Zeit konnte auch der Kaffeeraum unter Einbezug des ehemaligen Vorraumes vergrössert, sowie die Küche und das Bad erneuert werden.

Sponsoren

Eine Spende von Daniel Karbacher aus Küsnacht, Zürich, im Jahr 2005 ermöglichte den Kauf eines Radiometers für die Bestimmung der atmosphärischen Trübung und zur spektralen Messung der Globalstrahlung. Dieses ist nach langem Warten eingetroffen und erweitert die Anzahl von Instrumententypen zur Trübungsbestimmung, die vom Kalibrierzentrum für atmosphärische Trübungsmessungen betrieben werden.

Herr Karbacher hat auch im Jahr 2006 das Observatorium sehr grosszügig beschenkt um die geplanten Aktivitäten im Jubiläumsjahr zu finanzieren. Es wurden weitere Sponsoren zur Unterstützung des Jubiläumsjahres angefragt, die uns fast alle ihre Unterstützung zugesichert haben. Von diesen hat die UBS ihre Spende schon im Berichtsjahr ausbezahlt.

Der Förderverein SFI überwies die vierte und letzte Tranche für die Finanzierung unseres Druckers und Kopierers.

Dank

Schon im Normalbetrieb sind meine Mitarbeiter voll ausgelastet. Es zeigt sich, dass wir aber noch in jedem Jahr mit zusätzlichen Aktivitäten speziellen Einsatz benötigten. Sei dies für eine Tagung oder Instrumentenvergleiche oder, wie im vergangenen Jahr, mit den Vorbereitungen zum Jubiläumsjahr. Es ist schön zu erleben, dass alle Mitarbeiter immer wieder bereit sind, diese zusätzlichen Arbeiten zu unterstützen, ohne dass die gute Arbeitsatmosphäre darunter leidet. Dies ist nicht selbstverständlich und ich möchte es hier mit einem ganz herzlichen „Danke“ an alle Mitarbeiter würdigen.

Die Mitglieder des SFI-Ausschusses waren dem PMOD/WRC sehr wohlwollend eingestellt. Im Berichtsjahr möchte ich den Einsatz von Klaus Huber, Vizepräsident SFI, besonders hervorheben, der sich mit Erfolg um Sponsorengelder für unser Jubiläumsjahr bemühte. Unsere Ideen dafür waren zahlreich, aber entsprechend gross wurde das Budget. Die zugesicherten Unterstützungen erlauben nun die Realisation von fast allen Projekten und ich danke Daniel Karbacher und der UBS, die ihre Spenden schon einbezahlt haben. Im Voraus möchte ich die GKB und den Landeslotteriefonds erwähnen und ganz besonders die Elektrizitätswerk Davos AG, die mit der Werbefläche auf einem Linienbus der Verkehrsbetriebe Davos im Jubiläumsjahr eine besonders wirksame Werbung für 100 Jahre Klimaforschung ermöglicht.

Der Aufsichtskommission, insbesondere dem Präsidenten Gerhard Müller und den zusätzlich involvierten Mitarbeitern der MeteoSchweiz, die sich alle für die Anliegen des PMOD/WRC einsetzten, gebührt für das vergangene Jahr eine spezielle Anerkennung, da die Eingabe der Erneuerung der Finanzierung des Weltstrahlungszentrums an Bund, Kanton und Gemeinde fällig war. Wie schon vor vier Jahren war auch dieses Mal besonderer Einsatz nötig, da wir erneut eine Erweiterung der WRC Aufgaben beantragten.

Dem Bund, dem Kanton Graubünden und der Landschaft Davos Gemeinde verdanke ich die Finanzierung des Weltstrahlungszentrums und dem Bundesamt für Bauten und Logistik den Neubau des WSG Gebäudes und die Umbauten im Haus. Ich danke Valentin Feubli (BBL) und Hansruedi Wagner, Klosters, für die Organisation und Leitung der Bautätigkeit. Unsere Forschung basiert auf Drittmittelbeiträgen von PRODEX, SNF, ETH Zürich und schweizerischen Beiträgen zu COST Aktionen.

Davos, im April 2007 Werner Schmutz, Prof. Dr. sc. nat.

Annual Report 2006

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Introduction

Werner Schmutz

In February, the international team of experts in meteorological radiation met in Davos at the PMOD/WRC. The team is appointed by the World Meteorological Organization (WMO) to assess and support the various activities and departments of the World Radiation Center (WRC). I am pleased to report that these experts gave top marks to all the operational aspects of the WRC[2]. Most important for the future of the center was the team's evaluation of the World Optical Depth Research and Calibration Center (WORCC), which supports global assessments of the optical turbidity of the atmosphere. The team reported that the contributions of the WORCC to the world-wide community were extremely valuable, highly regarded, and greatly appreciated. However, it noted that this department is understaffed relative to its duties and tasks and recommended that the department be strengthened and expanded. The team's report was sent to the WMO Commission for Instruments and Methods of Observation, which held its quadrennial meeting in December. The WMO Commission delegates formally accepted the report and its recommendations at this meeting.

In response to the expert team's report and an earlier, similar conclusion regarding understaffing, which was reached by the WMO's Science Advisory Group on aerosols, the funding of WORCC through the Swiss contribution to WMO's Global Atmosphere Watch (GAW-CH) was increased by 75 % in order to expand the WORCC operations beginning in 2007. Currently, the WORCC is not formally a part of the WRC as its operation is financed as an add-on by GAW-CH. On the highest political level WMO approached the Swiss government with the question of whether it would be the possible to fully integrate the functions of the atmospheric turbidity department into the chartered tasks of the WRC. In accordance with the WMO's appeal and the Commission's recommendations, the proposal submitted last year to the Swiss government, the regional government, and the local community to renew the financial support for the WRC for the next fiscal period (2008-2011) included additional funds for the support of the WORCC.

Two of the three space experiments under development at the PMOD/WRC are approaching completion and the delivery for integration with their satellites. As the efforts on these projects wind down, it is prudent to consider the next endeavors the PMOD/WRC should undertake. Unfortunately, the next solar mission by the European Space Agency (ESA) is the Solar Orbiter, whose launch is not scheduled to occur until 2015. However, through the efforts of the working group of the International Living With a Star initiative, the PMOD/WRC was able to establish a dialogue with the Chinese satellite mission KuaFu, which should be launched in 2012. Collaboration with the institute CIOMP, located in Changchun was started as CIOMP also builds radiometers and is planning to have an experiment aboard KuaFu. The prospects for a joint Chi-

2) The report can be accessed via the WMO webpage at http://www.wmo.ch/web/www/IMOP/reports/2003-2007/ document ET-MR&ACM-1_Final Report.pdf.

nese-Swiss experiment look quite promising, provided that the Chinese Space Agency approves the KuaFu mission.

This year (2007) marks the 100th anniversary of the founding of the PMOD by Carl Dorno. The jubilee celebration will serve as an opportunity for the observatory to increase its public awareness. In preparation of this effort, Mrs. Katrin Weber, writer of the SFI newsletter, authored the anniversary book "100 Jahre Physikalisch-Meteorologisches Observatorium Davos". In addition, a special exhibition of numerous historical instruments from the PMOD is being held at the Davos museum for local history. The local power company Elektrizitätswerk Davos AG has sponsored the repainting of a local bus to advertise the 100th anniversary of the PMOD. The new artwork on the bus was designed by the graphic artist Heidi Roth. Finally, Mrs. Roth also designed the new logo for the PMOD/WRC. The inauguration of the bus, the publication of the anniversary book, and the opening of the exhibition all occurred shortly after the start of the year. I can report that these as well as other efforts on the part of the observatory have been very successful in attracting the attention of both the press and the public.

Operational Services

Statistics of Calibrations

PMOD/WRC

Thirty-two pyranometers, seven actinometers and three pyrheliometers were calibrated. Three pyranometers failed to comply with quality requirements for calibration.

The infrared radiometry section of the World Radiation Center calibrated 24 pyrgeometers in 2006. Each instrument was first characterized with a black-body source; the final calibration was obtained by direct outdoor comparison of downwelling long-wave irradiance against the World Infrared Standard Group (WISG) of pyrgeometers.

Eight Precision Filter Radiometers (PFR) were calibrated in sunlight by comparison to WORCC standards; three of them were recalibrations within the GAW network, and five were original calibrations of instruments sold to customers.

The Ultraviolet Radiation Calibration Center of the PMOD/WRC calibrated four spectro-radiometers at their respective field sites using the traveling reference spectro-radiometer QASUME. In August 2006, 36 broadband radiometers were calibrated in the frame of the PMOD/WRC-COST726 broadband radiometer campaign.

Quality Management System for Calibrations of Pyrheliometer and Pyranometer

Silvio Koller

Forty-two instruments were calibrated according to EN ISO/IEC 17025 in 2006: Ten devices for direct solar irradiation, and 32 devices for global solar irradiation.

Two *Calibration and Measurement Capabilities* (CMC), which are termed *"Responsivity for direct solar irradiance"* and *"Responsivity for global solar irradiance"*, have been proposed to Euromet and BIPM and are under review by the approval process.

During 2006 there was an external review of all activities of the World Radiation Center by the CIMO Expert Group on *Meteorological Radiation and Atmospheric Composition Measurements*. In their final report, they assessed the worldwide dissemination of "WRC Solar Radiometry" as very positive, confirming the conclusion of the ad hoc committee of IPC-X.

Solar Radiometry Section

Wolfgang Finsterle

The evaluation of the IPC-X results was finalized and the final report was printed in August 2006. The most important result was that the WSG was stable within the CIMO requirements. However, a small drift (~ 0.05%) of the WSG with respect to most regional and national standard instruments cannot be ruled out. The Solar Radiometry Section of the WRC will therefore evaluate procedures and technologies to improve the stability of the WSG. The small drift of the WSG was also confirmed during the U.S. National Pyrheliometer Comparison (NPC-2006) held in September and October at the National Renewable Energy Laboratories (NREL) in Golden, Colorado, U.S.A. The WRC participated in this comparison with PMO5 of the WSG and two other pyrheliometers (PMO6-0401 and AHF-32455). For this purpose a mobile data acquisition and solar tracking system had been purchased.

The mobile data acquisition and solar tracking system was also used for calibrating customer instruments during the renovation of the WSG housing, starting late September. The WSG instruments and solar tracker were dismounted and the "doghouse", that is how the PMOD staff used to call the wooden hut that contained the WSG, was demolished. A new glass building was erected, featuring a sliding roof, so the solar tracker will no longer have to be pushed outside when taking measurements. At the same time the hydraulics system of the tracker was replaced and new cable ducts were installed in the renovated data acquisition room. Apart from the more stable tracking and pointing capabilities the new azimuth drive with 270° travel (as opposed to the ~90° in the old system) is able to track the Sun throughout the year from sunrise to sunset without the need for manual resetting of the tracker during the day. The stepless access from the data acquisition room to the tracker not only respects safety considerations but will also be much appreciated by the PMOD technicians, especially when moving heavy equipment, such as the vacuum tank or space experiments, to or from the solar tracker.

New Sun Tracker Building

Hansjörg Roth

After the PMOD institute moved into the old school-house in Davos Dorf in 1976, the sun tracker or so-called "Big Tracker", was installed outside in front of the main building. The World Standard Group (WSG) and other instruments were mounted on heavy plates, attached to the tracker table. During a measuring campaign, these plates used to be installed in the morning and removed in the evening to protect instruments from bad weather.

A wooden cabin was used to protect the WSG instruments as of the mid-1980s. The big tracker and its electronics were installed on rail-tracks, so that the entire assembly could be moved in/out of the cabin and into the sunlight. Despite the better ease of operation, there were several disadvantages to this design. The twisting of cables occasionally led to breakage, and cables were susceptible to being cut by the rail-track wheels if the operator did not pay attention. In addition, the space around the tracker table in the cabin was not sufficiently large to work on the instruments.

For these reasons a proposal for a protective building has been submitted in 2003 to the Bundesamt für Bauten und Logistik (BBL), which is responsible for federal buildings. The main objective was to have the tracker mounted at a fixed position and that, instead of the instrument mounting, the building would slide back to enable solar measurements.

After feasibility studies it was decided to construct a glass-building which was constructed in the 4th quarter of 2006 under the management of Mr. V. Feubli, BBL and Mr. H. Wagner, Architect Office, Klosters. Installation of the instruments will be completed in the first quarter of 2007. We take the opportunity, to thank both gentlemen for their support and successful completion of the new glass-building.

Figure 1 and 2. New glass-building that houses the World Standard Group. Left: Building closed. Right: The front part of the building has been moved back to expose the sun tracker and to enable solar measurements.

Infrared Radiometry Section (IRS)

Julian Gröbner

The world infrared radiometer center (IRC) operated continuously for the whole of 2006, providing a stable atmospheric longwave irradiance reference realized through the World Infrared Standard Group (WISG) of pyrgeometers. The long-term stability of the WISG is better than ±1 W/m^2 since its start in September 2003. Currently four instruments form the WISG; a fifth candidate instrument, a modified CG4 pyrgeometer with a solar blind filter starting at approximately 6 µm, was deployed in the summer of 2006.

The CIMO expert team on meteorological radiation and atmospheric composition measurements visited the PMOD/WRC in February 2006 and evaluated the status of the IRC; the results of this review can be found in the final report of the meeting at http://www.wmo.ch/web/www/IMOP/ under reports 2003-2007 the document ET-MR&ACM-1_Final Report.pdf.

The main recommendations concerning the IRC were to:

- rename the IRC to infrared radiometry section as a component of the World Radiation Center (IRS-WRC).
- Establish the interim WMO Pyrgeometer Infrared Reference using the procedures and instrumentation that make up the WISG.

Item 1h) of the future work plan of this CIMO expert team mentions the need to develop an additional longwave radiometer traceable to SI units in collaboration with NPL. Currently the goal is to have a working instrument by 2008. The design study was finished by the end of 2006, and construction of this new radiometer has been initiated in January 2007.

The construction of a new reference cavity for the characterization of pyrgeometers was started early 2006 and is nearing completion. The current cavity was built in 1995 and is still operational; after validation of the new cavity and comparison to the current one routine operations should begin in 2007. Key features of the new cavity are an inclined bottom for enhancing the effective emissivity of the cavity and the possibility to flush the whole cavity with nitrogen.

A travel reference pyrgeometer system with dedicated data acquisition unit was developed in 2006. The instrumentation was calibrated at PMOD/WRC and shipped to the SRRB/NOAA Boulder site to take part in a small scale intercomparison of pyrgeometers which were previously calibrated at PMOD/WRC against the WISG. The intercomparison underlined the consistency of the calibrations performed at PMOD/WRC.

In addition to the characterization of pyrgeometers using black-body cavities, a new facility was developed for the determination of the angular response of pyrgeometers. Measurements were performed on Epply PIR pyrgeometers and CG4 Pyrgeometers from Kipp & Zonen and the results presented during the ninth session of the BSRN in Lindenberg, Germany.

Ultraviolet Calibration Centre (UVC)

Julian Gröbner and Gregor Hülsen

The Ultraviolet Calibration Centre became fully operational in the course of 2006 due to the support by the Swiss COST Office through the project "Quality Assurance of solar UV filter radiometer networks" which finances one post-doctoral position for the period 2007 to 2008.

The collaboration between the PCE Unit of the Institute for Health and Consumer Protection of the JRC-Ispra was put on a sound formal basis through the signing of the collaboration agreement 2004-SOCP-22187 between the two institutes.

One important objective of this collaboration is to homogenize solar UV measurements across Europe through the dissemination of calibrations traceable to a single stable reference. This has been successfully achieved within the EU-funded FP5 project QASUME from 2001 to 2005; this activity continued in 2006 through calibration visits of the transportable reference spectroradiometer QASUME to four European institutes monitoring spectral solar UV radiation.

The QASUME reference itself consists of a set of transfer standards traceable to the primary irradiance standard of the PTB in Germany. This irradiance reference is realized yearly in the UVC laboratory (and formerly at ECUV) and transferred to a set of portable low-power lamps which are used during site visits to calibrate the QASUME reference spectroradiometer.

A large-scale calibration and intercomparison campaign of Radiometers measuring erythemally weighted solar irradiance was organized at PMOD/WRC in August 2006 as part of the activities of working group four of COST Action 726 "Long Term changes and Climatology of UV radiation over Europe". 36 radiometers from 31 institutions participated in the campaign. The specific tasks of the campaign were to individually characterize each radiometer with respect to the relative spectral and angular responsivity in the laboratory immediately prior to the absolute calibration of the instrument. The absolute calibration was then obtained by direct comparison of solar irradiance measurements with the traveling reference spectroradiometer QASUME on the roof platform of PMOD/WRC.

Preliminary results from the campaign were presented during the MC Meeting of the COST Action 726 in Stockholm in September 2006 and subsequently at the adjoined SPIE UV Session. The results of the campaign are currently being summarized in a dedicated COST 726 report which will be finalized in 2007.

WORCC and GAW-PFR Network

Christoph Wehrli

Operations of the PFR network continued smoothly for most of the 9 stations. The PFR at Ny-Ålesund was again recalibrated at Davos, and participated in the international comparisons of the PolarAOD network together with 2 other PFR. The instrument at Izaña was damaged by a tropical storm in December 2005 and had to be repaired at Davos, measurements were resumed in mid March. At Jungfraujoch, measurements are interrupted since August 2006 due to remodeling of the MCH station.

Measurements of all 9 GAW stations were evaluated and submitted to WDCA as hourly means up to the end of 2005. A total of 507 data months of hourly AOD values from the PFR network are now available at the archive. After the FRC-II, the new CIMEL radiometer was returned for further calibration by AERONET and has resumed measurements in May. A comparison of results can be found in this report. Delivery of the MFRSR radiometer ordered in 2005 was still pending by end of 2006.

Based on the favorable review of the Swiss GAW program by an international team of experts and the endorsement by CAS/EPAC of SAG recommendations for the PFR network, additional manpower to support WORCC operations was granted for the period 2007 to 2009 by MeteoSwiss.

The SAG sub-group on AOD (chaired by C. Wehrli) held their first meeting on 8. – 9. November in Shanghai and recommended, amongst other action items, that a reference group of Sunphotometers should be established at WORCC to serve as reference for periodic Filter Radiometer Comparisons akin to the IPC. In a meeting to establish a GAW Regional Calibration Centre (RCC) for AOD in China the parties involved discussed ways to provide traceable links between this new RCC and WORCC through a PFR at the Mt. Waliguan observatory, where a Sun tracker will be installed in 2007.

The training course on AOD observations was held again for the participants of the 12th GAWTEC course at Schneefernerhaus. A presentation of the FRC-II results was given at the BSRN workshops.

ASRB Measurements in the New SwissMetNet

Rolf Philipona

The Alpine Surface Radiation Budget (ASRB) network, which started as collaboration between PMOD/WRC and MeteoSwiss is presently being integrated in the new SwissMetNet network of MeteoSwiss. Surface radiation budget measurements will continue at the six alpine stations: Cimetta, Weissfluhjoch, Gornergrat, Männlichen, Eggishorn and Jungfraujoch. In order to provide radiation budget records over all Switzerland nine additional stations comprising Altdorf, Basel-Binnigen, Changins, Davos, Magadino, Napf, Payerne, Plaffeien and Tänikon will be equipped with pyranometers and pyrgeometers measuring downward and upward radiation fluxes. About one third of these new radiation stations are already in operation and are presently tested and compared to original stations and to the ASRB traveling standard instruments.

Within the NCCR-Climate (National Center of Competence in Research), the surface radiation budget in Switzerland is presently investigated in relationship with possible water vapor and surface temperature changes. Examination of the individual radiation fluxes over longer time periods allows distinguishing between radiative effects and forcings that are due to clouds, aerosols, water vapor or anthropogenic greenhouse gases. Hence ASRB, aerosol optical depth, water vapor and surface temperature measurements allow differentiating between climate effects of different atmospheric constituents and will help to understand the rapid temperature rise over the last two decades.

Instrument Sales

PMOD/WRC

Six PFR instruments and control units have been purchased from PMOD/WRC which is a similar number as last year. In addition, we also sold two PMO6-CC units and five ventilation systems (VHS).

We installed additional thermistors to five Precision Infrared Radiometers (PIR). This allows the thermal distribution of the instrument's dome to be characterized with higher precision.

Instrument Development

Development of a New Absolute Radiometer for Space and Ground-Based Use

Uwe Schlifkowitz and Wolfgang Finsterle

The computer model of a PMO6 radiometer described in PMOD/WRC annual reports 2004 and 2005 has been rewritten and generalized in order to be able to vary physical properties, such as materials and their thermal conductivity, and thus thermal constants of the instruments cavity, etc.

After a thorough analysis of the phase-sensitive signal detection scheme in conjunction with the instrument's data, it turned out that the radiometer must be fully characterized to obtain satisfying results. In particular, the thermal flow from the cavity, both the cone and the surrounding wall, towards the heat sink must be well known to eliminate perturbing factors such as the so-called non-equivalence of the cavity heating.

Furthermore, the analog heater control was replaced by a digitally controlled, pulsed heater. The benefits of this so-called pulse width modulated heater are, that this approach reduces system costs and power consumption.

For example, in a regular analog heater control, the power is always on full scale and is then reduced to match the needed consumer load. In the reduction process, the power is converted to heat, which could disturb the measurement. Contrary, in a pulse width modulated heater system, the power is always either fully on or fully off. The heater is supplied with power by means of a repeating series of on/off pulses. The on-time is the time during which the power is applied to the heater, the off-time is the period during which the power supply is switched off. Additionally, the signal remains digital, no conversion to an analog signal is necessary. This reduces noise effects as well, as noise can only affect a digital signal if it is strong enough to change a logic 1 to 0 or vice versa.

The next steps include the building of a prototype with all the above mentioned features and its test in front of the sun. On-board data analysis and data transfer have to be developed as well.

Space Experiments

PMOD/WRC

SOVIM

In 2006, SOVIM was awaiting integration and was therefore kept in our clean-room facility. During fall, we manufactured a new sun-shield due to a firm request by ESA because of small cracks in the back-surface mirrors.

In addition, ESA recommended that we replace all SOVIM structural fasteners with new ones, specially certified for space applications.

LYRA

The Lyman-Alpha Radiometer “LYRA” will detect UV radiation in different wavelength bands and will be integrated on the satellite PROBA-2 (see also previous reports for further explanations). The mission “Project for On-Board Autonomy” (PROBA-2) is a technology demonstration of the European Space Agency.

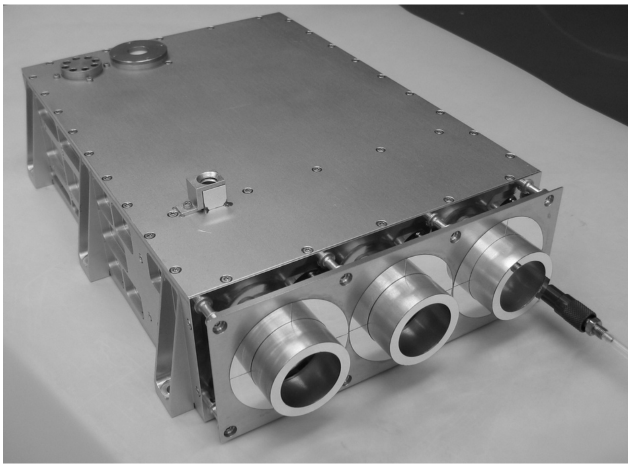

Figure 3. LYRA Flight Model.

The “flight unit” of LYRA was finished in 2005 but several qualification tests and calibration tasks have had to be performed in 2006. At the beginning of the year, mechanical parameters (mass and moments of inertia) had to be verified. In March 2006, vibration tests were performed at Contraves Space AG, Zurich. These tests will verify the structural analysis and simulate vibrations during the launch of the satellite carrier. A thermal vacuum test was conducted at the end of March at PMOD.

The experiment is carried out in a vacuum chamber and undergoes eight cycles of its thermal range. Alignment measurements were subsequently performed at PMOD in order to verify the co-alignment of the optical axis to the instrument mechanical axis. Further measurements using the sun as a source were performed at PMOD to check the opacity of UV channels with respect to visible light.

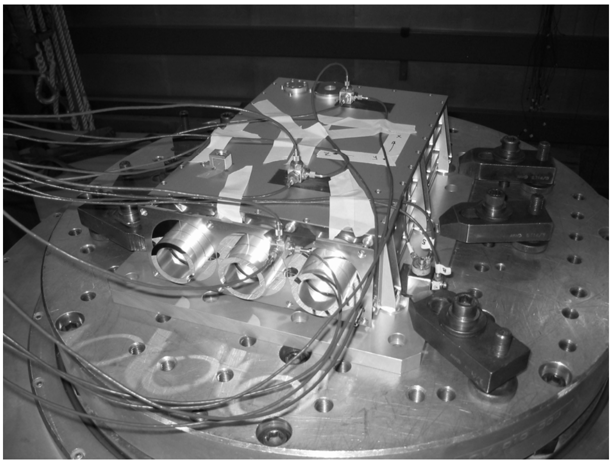

Figure 4. LYRA FM on vibration adapter.

According to the original schedule, LYRA should have been delivered to ESA by March 2006. But due to several project delays the whole satellite schedule has been delayed by almost a year. Thus LYRA was kept in the PMOD clean-room for most of the year while awaiting integration. Currently, it is foreseen that LYRA will be delivered at the beginning of 2007. The launch of PROBA-2 is now planned in early 2008. It will be launched from Plesetsk Cosmodrome in northern Russia together with another ESA satellite (SMOS).

PREMOS

PREMOS is a collaboration with the French space agency (CNES) and the Centre National de la Recherche Scientifique, Service d`Aéronomie Paris (SA/CNRS). It will be integrated on the French micro satellite PICARD.

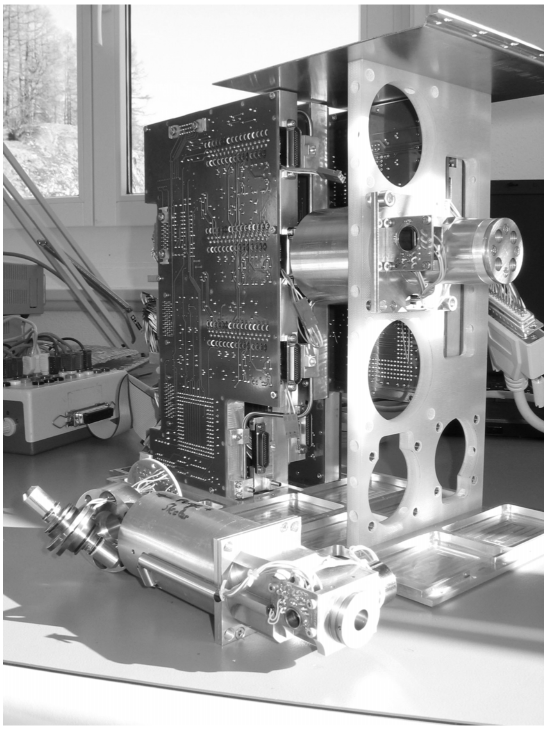

Figure 5. Picture of the PREMOS prototype showing part of the mechanics and the entire electronic unit.

After the Preliminary Design Review at the end of November 2005, we began constructing the prototypes for the entire electronics, the cover mechanism, one PMO6 radiometer, and one filter radiometer. The basic idea behind the prototype is: to check the compatibility of the different mechanical elements and electronics. For instance, this entails checking interfaces between instruments and electronics. The instrument prototypes will undergo trials using the sun as a source (radiometer) or with calibration lamps filter radiometer to compare requirements with real operating conditions.

The prototype cover mechanism is not mounted on aluminum but a plastic framework, which is fabricated using a new laser sputtering technique. This plastic framework is much cheaper than milled aluminum, and the manufacturing time is shorter.

Figure 5 shows the assembled unit on the base plate. The next step will be the installation of the entire mechanical structure.

It is planned to power-up the prototype unit and then conduct EMC/EMI tests to check compatibility with satellite requirements. In addition, it is foreseen that interface tests will be conducted at SA/CNRS at the end of 2007.

The current timetable foresees delivery of PREMOS in February 2008. PICARD is scheduled to be launched at the end of 2008.

Scientific Research Activities

Development of the Improved Version of the CCM SOCOL

Eugene Rozanov, Tatiana Egorova, and Werner Schmutz in collaboration with IACETH, Zurich and MGO, St. Petersburg

The comparison of the CCM SOCOL results with observations and other models (Eyring et al., J. Geophys. Res., 2006) revealed several flaws in the model. A number of improvements of the transport and chemical codes were implemented to overcome the discovered problems. In the transport part we have applied family transport approach to prevent artificial destruction of the active chlorine in the high-latitudes lower stratosphere. The mass-fixer scheme for the ozone was changed to avoid artificial ozone loss during the early winter over the southern high-latitudes. We have also updated the chemical solver, description of the heterogeneous chemistry and the properties of the stratospheric aerosol. To fix the overall overestimation of the stratospheric water vapor we have introduced the removal of the water vapor in the lower stratosphere due to freezing and sedimentation of the ice particles. We have carried out 25-year long (1976-2000) transient model run with the improved model version in off-line mode with fixed meteorology. Figure 6 illustrates the time evolution of the zonal mean total ozone for the year 1980 and Cly in the southern polar lower stratosphere. The total ozone in the improved version is higher over the extra tropical area and wintertime ozone depletion over the southern high latitudes disappears. The Cly mixing ratio does not suffer from artificial destruction and is much closer to the observation data. The analysis of the other quantities also confirmed a substantial improvement of the model performance in comparison with the previous version (Egorova et al., ACP, 2005).

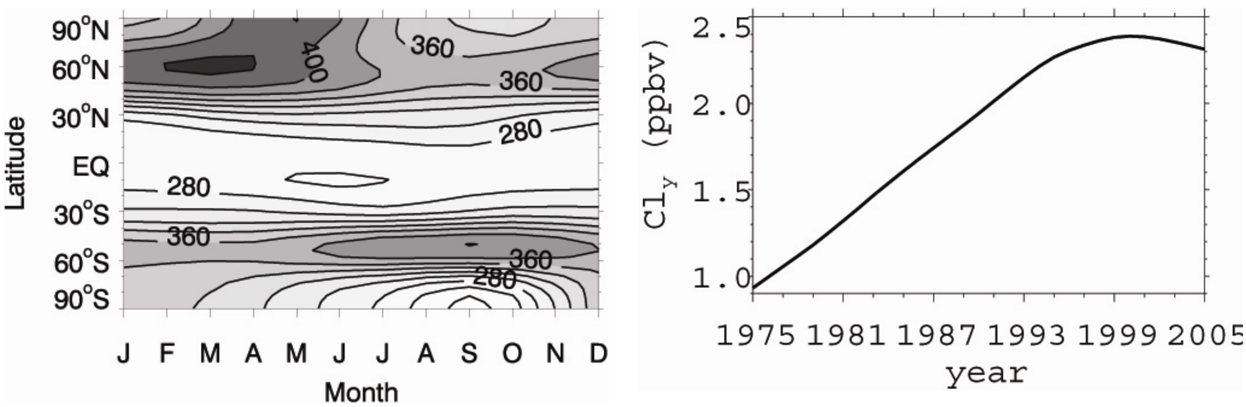

Figure 6. Left panel: Zonal mean total ozone (DU) distribution for 1980. Right panel: Time evolution of the October zonal mean Cly mixing ratio (ppbv) at 50 hPa over 80°S.

Stratospheric Chemistry and Climate During the 20th Century

Eugene Rozanov in collaboration with Andreas Fischer and Stefan Brönnimann IAC ETH, Zurich

To understand the long-term changes in the stratospheric climate and ozone, model-based studies with a middle atmosphere models over several decades are needed. In the framework of the ETH CASTRO project we commenced transient simulations with the chemistry-climate model (CCM) SOCOL, spanning the whole 20th century. The simulations are carried out in ensemble-mode (9 members) prescribing sea surface temperature, sea ice distribution, volcanic aerosols, solar spectral irradiance variability, greenhouse gases, ozone depleting substances, land surface changes, and QBO. At the moment, first 27 years of the run have been completed. Interesting features of this period are the 11-year cycle of the solar activity and eruptions of the tropical volcano St. Maria in 1902 and the high-latitude volcano Mt. Katmai (Alaska) in 1912. Figure 7 shows the anomalies of the smoothed tropical temperature (averaged over 25°S-25°N) in the lower (at 70 hPa) and upper (at 1 hPa) stratosphere for the simulation period. The warming in the lower stratosphere reaching 2 K in 1903 is the result of the heating caused by the injection of the sulphate aerosol after St. Maria eruption in 1902. The solar signal with magnitude of 0.5 K (which is about 2 times smaller than for the last decades of 20th century) in the upper stratospheric temperature is also visible in the model output.

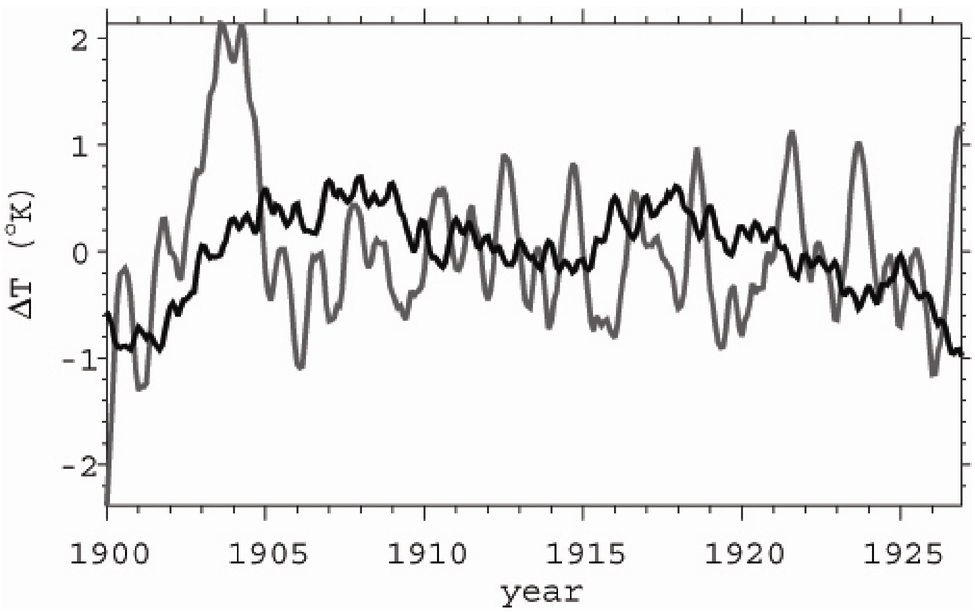

Figure 7. Temperature anomalies in the lower (gray line) and upper (black line) tropical stratosphere for 1900-1927 simulated with the CCM SOCOL.

The Chemical Ozone Response to the Solar Irradiance Variability

Eugene Rozanov, Tatiana Egorova and Werner Schmutz

The contribution of the dynamics and chemistry to the solar signal in the stratospheric ozone is under intensive discussion. To elucidate the role of the chemical processes we have carried out 26-year long transient run with CCM SOCOL in off-line mode using daily circulation for 1995 from the transient run with complete CCM SOCOL version. Such experiment assures that the solar signal in the stratospheric ozone is a result of pure chemical perturbations caused by the increase of the solar UV irradiance. Figure 8 illustrates annual mean solar signal in ozone obtained from this run using regression analysis. The ozone response reaches its maximum (~4%) at 40 km over middle latitudes and its magnitude steadily decreases toward the tropopause and mesopause. The ozone response is slightly higher than in the experiments with interactive model (Rozanov et al., Mem. S.A. It., 2005) due to the absence of solar induced warming and is substantially different in the lower stratosphere and over the high latitudes where the dynamical perturbations play an important role.

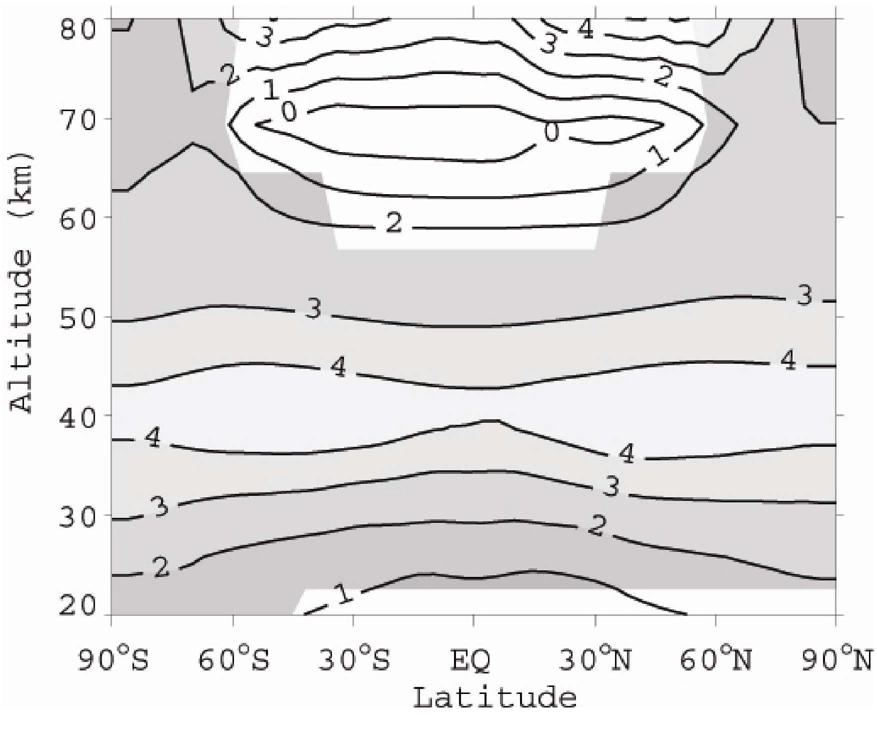

Figure 8. Zonal and annual mean solar signal in ozone (%). The areas where the simulated signal is statistically significant with 99% confidence are shaded.

Ionospheric Module for Nowcasting of the Ionic and Neutral State of the Middle Atmosphere

Tatiana Egorova, Eugene Rozanov and Werner Schmutz in collaboration with MGO, St. Petersburg, Russia

PMOD/WRC participated in the development of LYRA instrument for the PROBA2 satellite. LYRA measures the solar irradiance at Lyman-alpha (121.6 nm) and in the Herzberg band 200-220 nm wavelength range. The LYRA data will be used for nowcasting of the neutral and ionized chemical species in the middle atmosphere with chemistry-ionosphere-climate model (CICM) SOCOL. For the treatment of the ionospheric chemistry we have developed a new module for SOCOL which includes electrons, 51 positive and negative ions and 186 reactions integrated to the neutral chemistry scheme. As ionization sources we use ionization by solar irradiance, galactic cosmic rays (GCR) and energetic particles. We have tested this scheme in the framework of 1-D model to show the sensitivity of the ionized and neutral species to the variability of the ionization sources. Figure 9 shows the difference of some neutral and ionized species between solar maximum and minimum cases at 50°N.

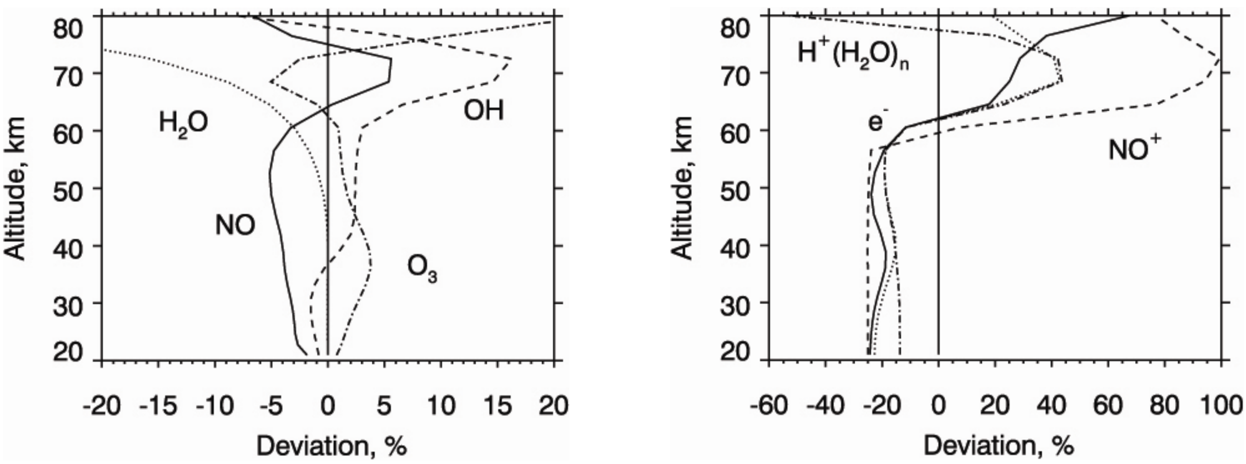

Figure 9. Relative difference of neutral and ionized species between solar maximum and minimum cases. Left: NO (solid), H_2O (dotted), OH (dashed), O_3 (dash-dotted). Right: e^- (solid), total negative ions (dotted), NO^+ (dashed), $H^+(H_2O)_n$ (dash-dotted).

Calibration of Pyrgeometers: The Influence of the Spectral Sensitivity

Julian Gröbner

Pyrgeometers are used to measure the longwave atmospheric radiation at the Earth's surface in the wavelength range between approximately 3 and 50 micrometers. Even though well characterized black-body radiators produce stable thermal longwave radiation, their spectrum differs significantly from that of the atmospheric longwave radiation which exhibits a strong spectral feature in the wavelength region 8 to 14 micrometers, commonly called the "atmospheric window".

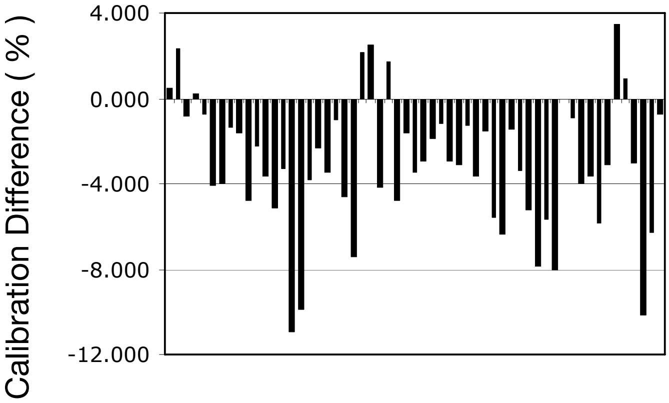

Figure 10. Relative difference of the calibration factor C determined either with the blackbody or during the outdoor calibration in percent.

Due to this spectral difference between black-body radiation and atmospheric radiation, pyrgeometer calibrations using laboratory sources have shown inconsistencies between individual instruments when deployed outdoors (see Figure 10).

The observed differences in calibration have been analyzed with two pyrgeometers with known spectral dome transmission. These two spectral transmission functions show substantial differences due to manufacturing differences. Model calculations using the radiative transfer model Modtran were used to estimate the dependence of each pyrgeometer to spectral changes of the incoming longwave radiation, assuming an uniform spectral responsivity of the thermopile detectors. As shown in Figure 11, the calculated differences between the calibration factors derived for pure Black-Body radiation and atmospheric radiation are consistent with the measurements obtained at PMOD/WRC with these two pyrgeometers.

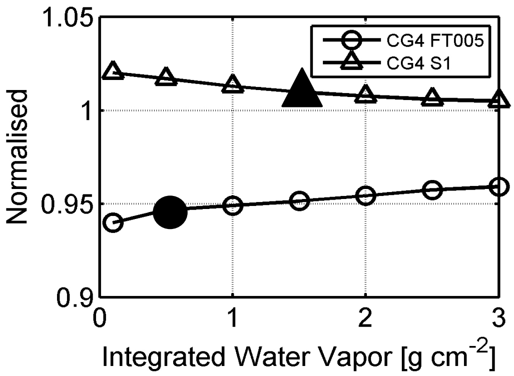

Figure 11. Model calculations showing the spectral dependence of the calibration factor C normalized to the blackbody calibration with respect to the integrated water vapor for the two pyrgeometers CG4 FT005 (lower curve) and CG4 S01 (upper curve). The measurements are shown as a large triangle and circle for the CG4 S1 and CG4 FT005 pyrgeometer respectively.

This study shows that the absolute calibration of a pyrgeometer based on atmospheric radiation is consistent with a black-body based calibration if the spectral transmission of the pyrgeometer is known.

Relationship Between Surface Specific Humidity, Integrated Water Vapor and Longwave Radiation

Rolf Philipona in collaboration with Christian Ruckstuhl IACETH, Zürich

Atmospheric water vapor and surface humidity strongly influence the radiation budget at the Earth's surface. Water vapor not only absorbs solar radiation in the atmosphere, but as the most important greenhouse gas it also largely absorbs terrestrial longwave radiation and emits part of it back to the surface. Using surface observations, like longwave downward radiation (*LDR*), surface specific humidity (*q*) and GPS derived integrated water vapor (*IWV*), we investigated the relation between *q* and *IWV* and show how water vapor influences *LDR*. Radiation data from the Alpine Surface Radiation Budget (ASRB) network, surface humidity from MeteoSwiss and GPS *IWV* from the STARTWAVE database are used in this analysis. Measurements were taken at four different sites in Switzerland at elevations between 388 and 3584 meter above sea level and for the period 2001 to 2005. On monthly means the analysis shows a strong linear relation between *IWV* and *q* for all-sky as well as for cloud-free situations. The slope of the *IWV-q* linear regression line decreases with increasing altitude of the station. This is explained by the faster decrease of *IWV* than of *q* with height. Both, *q* and *IWV* are strongly related with *LDR* measured at the Earth's surface. *LDR* can be parameterized with a power function, depending only on humidity (Figure 12 for cloud-free situations). The estimation of *LDR* with *IWV* has an uncertainty of less than 4% on monthly means (Ruckstuhl et al., JGR, 2007).

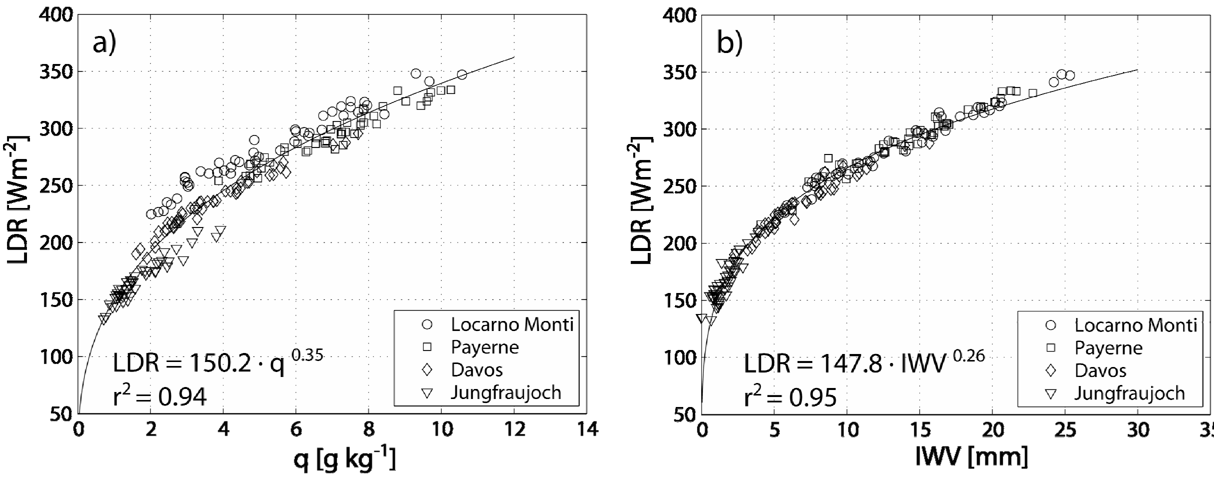

Figure 12. Monthly means of LDR: (a) as a function of q and (b) as a function of IWV.

Comparison of AERONET and GAWPFR AOD Networks

Christoph Wehrli

Aerosol optical Depth (AOD) has become a crucial parameter in understanding radiative forcing of climate on regional to global scales. Thus comparability of observations by different national and international networks is strongly desired and can be *estimated* by dedicated campaigns (e.g. FRC-II, Davos 2005), or by intercomparison of operational observations at sites where several networks are overlapping.

AOD observations in 2006 by PFR instruments were compared with simultaneous results of AERONET at 3 co-location sites Bratt's Lake (BLO), Davos (DAV) and Mauna Loa (MLO). The data sets compared are not final quality assured results, but quality controlled, near real-time (NRT) values.

Current GAW recommendations for traceability call for a 95% uncertainty of differences between AOD observations of U95 < 0.005 + 0.010/m based upon at least 1000 samples. This criterion was well achieved for most instruments participating in the FRC-II campaign at Davos in 2005, while the current exercise demonstrates that traceability is not always achieved for operational NRT observations of AOD. The mean and rms differences are, however, well within expectations. Further analysis with quality assured data is needed to establish realistic field comparability of AOD observations.

Table 1: Statistics of AOD annual average and differences between AERONET and GAW results at 3 co-location sites. Mean differences are well below, but RMS values slightly larger than 0.01 optical depths. Fraction gives the relative number of samples satisfying the GAW air mass dependent criterion for traceability.

	BLO	BLO	DAV	DAV	MLO	MLO
Wavelength	500 nm	865 nm	500 nm	865 nm	500 nm	865 nm
Average AOD	0.101	0.043	0.099	0.048	0.017	0.006
Mean(diff)	0.001	0.005	-0.003	0.001	-0.003	0.002
RMS (diff)	0.013	0.007	0.017	0.015	0.004	0.0034
Fraction	0.567	0.937	0.791	0.861	0.987	0.998
N	13996		1658		3827	

Quality Assurance: Calibration of GAWPFR AOD Network

Christoph Wehrli

Calibration of the exoatmospheric value (EAV) of spectral radiometers dominates the uncertainty of AOD observations and represents a large part in the effort of network operations. Instruments in the GAWPFR network are periodically calibrated, either by comparison to reference instruments maintained at Davos or by statistical evaluation of routine Langley extrapolations at their proper locations. Final, quality assured AOD results can be obtained only after instrument calibration to an uncertainty of 1 % or better has been established. PFR measurements taken between calibration dates are re-evaluated using linearly interpolated calibration coefficients before AOD results are submitted to WDCA.

Multiyear calibration sequences have demonstrated the excellent stability of PFR instrument with annual drift rates of typically 0.5 %, which represents a ten-fold improvement over typical instrument performance around 1990.

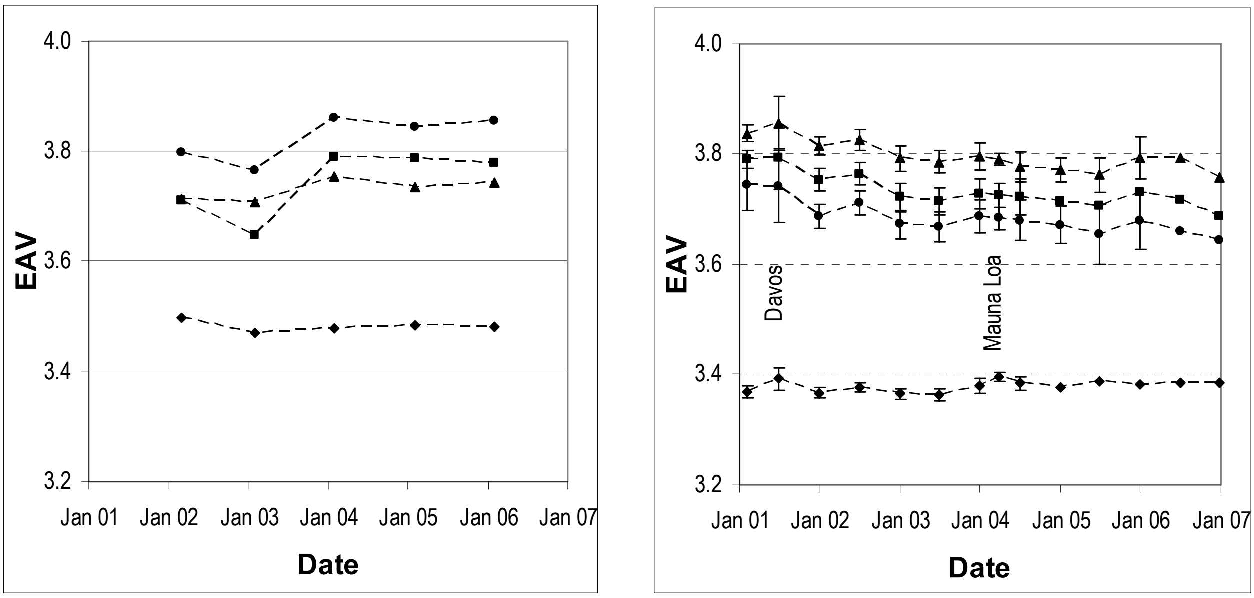

Figure 13. Evolution of EAV calibration coefficients for two PFR instruments in the GAWPFR AOD network. Left panel: Calibrations by annual comparison to reference PFR at Davos. Right panel: Calibrations by semi-annual statistical evaluation of 12 month periods of typically 60 *in-situ* Langley calibrations. In April 2004, a high altitude calibration obtained at Mauna Loa has confirmed the adjacent local calibrations to within <0.4%. The error bars are indicating 1σ standard deviations of typically 0.3 % to 1 %.

Results from the PMOD/WRC-COST 726 Broad-Band UV Radiometer Intercomparison Campaign

Gregor Hülsen

A broadband calibration campaign was organized at the PMOD/WRC from 30 July to 25 August 2006 on behalf of the working group four of the COST Action 726.

A total of 36 Radiometers from 16 countries participated in the campaign, including one radiometer from the Central UV Calibration Facility, NOAA, U.S.A; 9 Yankee UVB-1, 5 Kipp & Zonen, 2 Scintec, 10 analog and 8 digital Solar Light Ver. 501, 1 Eldonet and 1 SRMS (modified Solar Light Ver. 501). The absolute calibration of the characterized broadband radiometer was obtained by simultaneous solar irradiance measurements relative to the transportable reference spectroradiometer QASUME. A second spectroradiometer from the Medical University of Innsbruck participated as well to provide redundant global spectral solar UV irradiance measurements. This spectroradiometer agreed with the QASUME spectroradiometer to within +-2% over the two week measurement campaign. The atmospheric conditions during the campaign varied between fully overcast to clear skies and allowed a reliable calibration for the majority of instruments.

A novel calibration methodology using the spectral as well as the angular response functions measured in the laboratory provided remarkable agreement with the reference spectroradiometer, with expanded uncertainties (k=2) of about 7% for most instruments.

Figure 14. The new platform installed on the roof of the PMOD/WRC with 30 broadband filter radiometers.

Experimental Determination of the Reference Plane of Shaped Diffusers by Solar UV Measurements

Julian Gröbner in collaboration with University Innsbruck

Solar UV spectroradiometers are calibrated in the laboratory at fixed distances of either 500 mm or 700 mm from spectral irradiance standard lamps, whereas for solar measurements the relevant distance to the source (Sun) is practically infinite. Therefore errors in the distance measurement during the calibration process will introduce non negligible systematic errors in solar measurements if the reference plane of the entrance optic is not determined correctly. Here, a new methodology to determine the reference plane of solar entrance optics is presented.

The method uses the sun as a source to determine the spectral reference plane of solar UV diffusers, using a flat Teflon diffuser as reference. In this study, the optical reference plane of the J1002 shaped solar UV diffuser was determined from simultaneously measured direct normal irradiance solar spectra by two spectroradiometers which were calibrated relative to the same irradiance standard. The reference plane of the shaped Teflon diffuser obtained with this method is 5.3 mm behind the top of the dome, with an uncertainty of 1.0 mm. This determination of the offset of the J1002 diffuser is in perfect agreement with published results[2] and confirms that solar UV irradiance measurements with this type of diffuser need to take that offset of 5.3 mm into account. Solar UV irradiances measured with this type of diffuser are expected to be 1.5 % or 2.1 % too high for a calibration distance of 700 mm and 500 mm respectively if this offset is not taken into account. The consequence of this and previous studies indicate that the optical reference plane of shaped dome diffusers need to be determined experimentally and cannot be derived from geometrical considerations alone. It is likely that this affects not only the J1002 diffuser described in this study but also custom made Teflon diffusers used by other instruments.

Figure 15. Direct solar measurement setup with the two entrance optics mounted on the solar tracker. The upper figure shows the entrance optics pointed towards the sun with the mounted shading tubes. In the lower figure, the shading tubes have been removed and the diffusers can be seen.

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On the Observation of Traveling Acoustic Waves

Margit Haberreiter and Wolfgang Finsterle in collaboration with Stuart Jefferies, IfA Hawaii, USA

Acoustic waves traveling in the solar atmosphere may contribute to the heating of the chromosphere. For a correct determination of the energy transported by these waves it is essential to know at which height in the solar atmosphere they are detected.

Acoustic waves were observed with the MOTH instrument by Finsterle et al. (ApJL 613, 185, 2004). From the measured intensity time series in the blue and red wing of the K I λ 7699 Å and Na I λ 5890 Å absorption lines the Doppler velocity $v_D = (I_R - I_B)/(I_R + I_B)$ is calculated for both lines. The assumption here is that the blue and red wings of the lines are simultaneously affected by the acoustic wave. We investigate whether this analysis holds for both low and high frequency waves.

From radiative transfer calculations with COSI (COde for Solar Irradiance) we calculate the line profile of K I λ 7699 Å. Furthermore, the theoretical Doppler velocity is calculated for different frequencies and included in the calculation of the line profiles. Figure 16 shows the resulting line profiles modulated with the frequency ν=6.5 mHz (panel a) and ν=14 mHz (panel b). The high frequency wave clearly leads a change of line shape. This can be explained by the fact that the wavelength of the wave is of the order of the height range where the spectral line is formed. In particular, the center of the line is formed at higher heights in the solar atmosphere than the wings of the line. Therefore the wings and the center of the line are not modulated simultaneously. This effect is important for the determination of the correct Doppler velocity and energy carried by these waves.

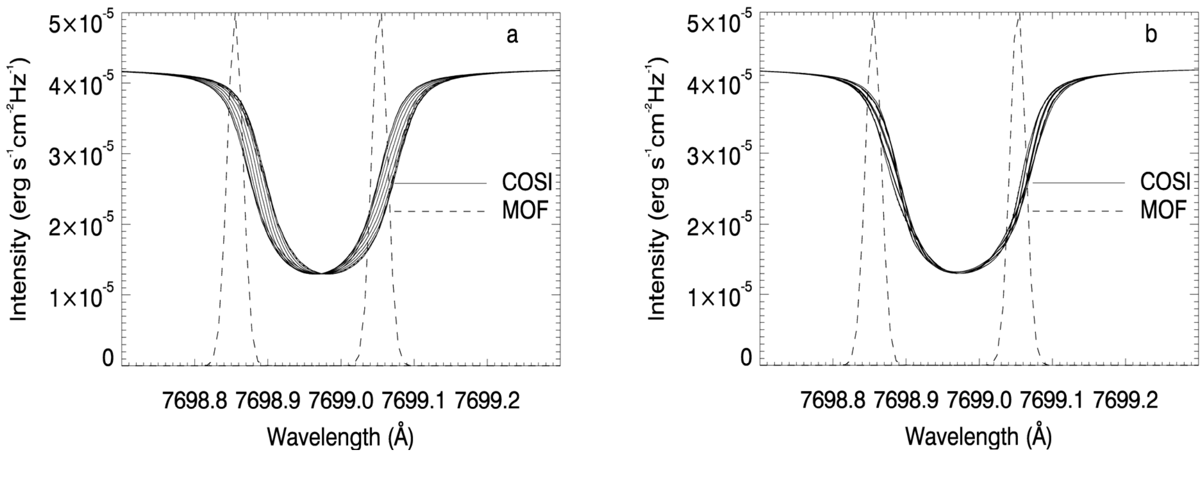

Figure 16. Line profiles (solid line) of K I λ 7699 Å modulated by an acoustic wave with the frequency ν=6.5 mHz (panel a) and ν=14 mHz (panel b). In the case of the low frequency the whole line undergoes an almost pure shift, whereas the high frequency wave causes a considerably change of the line profile. The dashed lines indicate the filters used in the MOTH instrument.

Reconstructing the Total Solar Irradiance

Micha Schöll, Margit Haberreiter, Werner Schmutz in collaboration with Friedhelm Steinhilber and Jürg Beer (EAWAG)

The total solar irradiance (TSI) reconstruction is needed for climate models. It is known that the climate reacts to a changing solar irradiance. Also the solar irradiance changes over all time-scales, from days to millennia. Prominent events in recent history are the Maunder minimum from 1610 to 1690 AD and the Spörer minimum (1415-1534 AD). The Maunder minimum is of special interest because it is assumed to have caused the little ice age.

However, precise and continuous measurements of the TSI were only possible with the advent of space based measurements. Continuous data exists since 1978. The variation of irradiance influences the climate and hence it is interesting to know the past irradiance. Several proxies that can be measured from the ground show a TSI-like variations, e.g. the sunspot number (SSN), measured since 1610, the neutron monitor data (NM). Furthermore, Beryllium 10, archived in ice, can be measured and dated back to a hundred thousand years. NM and ^{10}Be are sensitive to the cosmic ray flux incident on the Earth's atmosphere.

We reconstruct the TSI using annually smoothed NM and the daily SSN. For the reconstruction a spectral analysis is applied to determine the long-term and short-term trends of the data sets yielding Eq. (1),

(1) $TSI_{rec}=\alpha\cdot \text{longterm(NM)}+\beta\cdot \text{shortterm(SSN)}+\gamma$.

The reconstructed TSI is shown in Figure 17 with a small but significant long term trend. The error of the reconstruction is below 0.16 Wm^{-2}. We intend to replace the NM data with ^{10}Be to reconstruct back to the Maunder Minimum and beyond.

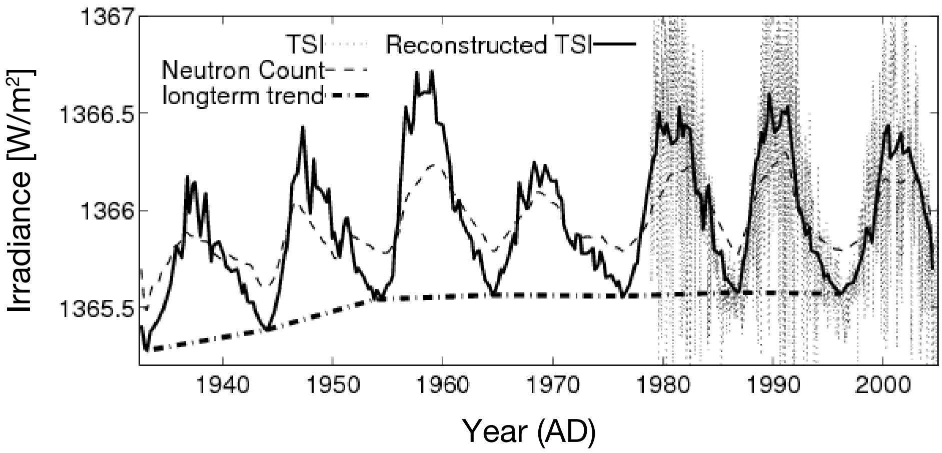

Figure 17. Reconstructed TSI (solid line) compared to the observed TSI (dotted), the long-term trend (dash-doted) and the NM (dashed). The short-term variation in the reconstruction is solely due to the SSN.

International Collaborations – SCOPES

Evolution of the Ozone Layer in the Future Simulated with the CCM SOCOL

Eugene Rozanov, Tatiana Egorova, and Werner Schmutz in collaboration with MGO, St. Petersburg, Russia

PMOD/WRC participates in the SCOPES (Scientific Co-operation between Eastern Europe and Switzerland) joint research project "Modeling of the global ozone and climate evolution in the first half of the XXI century". The main aim of the project is to simulate future evolution of the ozone and climate using current and improved CCM SOCOL. In 2006 the MGO team has developed new modules to better represent the tropospheric ozone and the ion chemistry. The evolution of the global mean total ozone is depicted in Figure 18. The results obtained show that the recovery of the global mean total ozone will occur around ~2030. In the future, due to stratospheric cooling and intensification of the meridional circulation caused by the greenhouse effect, the pre-ozone hole level will be exceeded. At PMOD/WRC we have carried out a simulation without a methane increase in order to understand its role in the evolution of the future ozone and climate. If methane is kept constant then the recovery of the ozone level occurs at a lower rate.

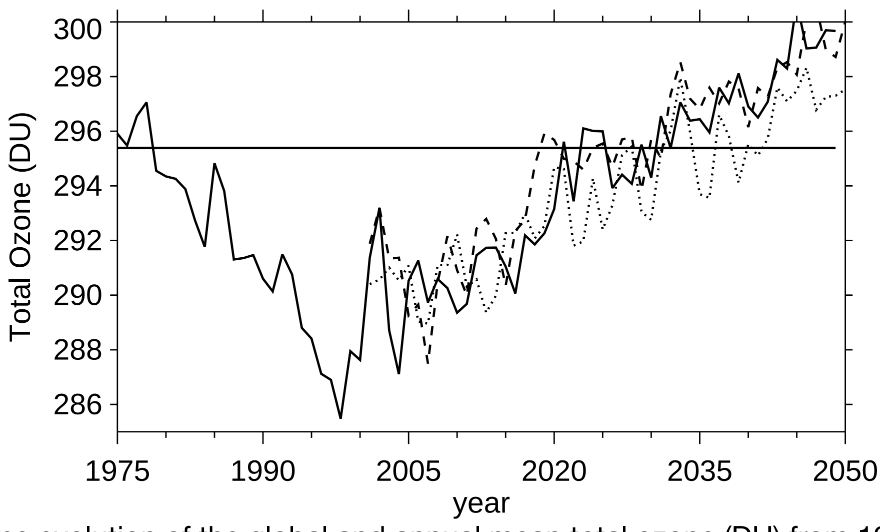

Figure 18. Time evolution of the global and annual mean total ozone (DU) from 1975 to 2050 simulated with CCM SOCOL. Simulations by PMOD/WRC (solid line), PMOD/WRC w/o methane increase (dotted line), and MGO (dashed line).

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Dr. Marcel Sutter	*PhD student (until 01/2006), Postdoc (01 - 03/2006)*
Patricia Kenzelmann	*PhD student, ETHZ, ETH-Polyproject (1.2. - 31.3.2006)*
Sandra Moebus	*Physicist engineer (until 10.1.2006)*
Denise Hofer	*Practical (until 28.2.2006)*
Markus Suter	*Bachelor Thesis (since 23.10.2006)*
Jaime Rocca	*visiting scientist from Spain (27.7. - 9.10.2006)*
Veijo Aaltonen	*visiting scientist from Finnish Meteorological Institute, Helsinki, Finland (10.1. - 3.3.2006)*

Expert Advisor

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

Public Relations/Media

Cornelia Lindner	*Project Manager 100 year anniversary (since 1.7.2006)*

Technical Personnel

Hansjörg Roth	*Deputy director, department head technical support, electronic engineer, experiment manager VIRGO, SOVIM, PREMOS*
Daniel Bühlmann	*Laboratory technician*
Silvio Koller	*Electronic engineer, LYRA experiment manager, quality system manager*
Daniel Pfiffner	*Electronic engineer, SOVIM and PREMOS*
Marcel Spescha	*Laboratory technician*
Christian Thomann	*Laboratory technician*
Jules U. Wyss	*Mechanic, general mechanics, 3D design and manufacturing of mechanical parts*
Christian Gubser	*Electronics apprentice, 4th year (left 15.9.2006)*
Chasper Buchli	*Electronics apprentice, 2nd/3rd year*
Samuel Prochazka	*Electronics apprentice, 1st year (since 1.8.2006)*

Administration

Sonja Degli Esposti	*Department head administration, personnel, book keeping*
Angela Knupfer	*Secretary, part time (left 31.10.2006)*
Stephanie Ebert	*Secretary, part time (since 1.10.2006)*
Annika Weber	*Administration apprentice, 3rd year (since 19.8.2006 Secretary, part time)*
Joka Sarcevic	*Administration apprentice, 1st year (since 14.8.2006)*

Caretaker

Klara Maynard	*General caretaker, cleaning (retired 30.4.2006)*
Denise Dicht	*General caretaker, cleaning (since 1.5.2006)*
Regula Dicht	*Cleaning, part time (since 1.5.2006)*

Civilian Service Conscripts

Stefan Moser	*31.10.2005 - 16.3.2006*
Lukas Itin	*2.1. - 31.3.2006*
Diego Wasser	*3.4. - 30.6.2006*
Silvio Koller	*17.4. - 30.6.2006*
Fabian Nater	*24.7. - 22.12.2006*
Simon Strässle	*17.7. - 18.8.2006*
David Moser	*28.8. - 1.12.2006*
Florian Ruesch	*since 4.12.2006*

Miscellaneous Activities

Participation in Meetings and Courses

Werner Schmutz

9.1.-11.1.	*KuaFu scientific working team meeting, MPS Lindau, Germany*
6.-10.2.	*CIMO Expert Team meeting, Davos*
13.3.-16.3.	*Swiss-Russian seminar, Davos*
27.-30.3.	*COST 724, meeting, Antalya, Turkey*
5.-7.4.	*Meeting of ISO TC180, Gran Canaria, Spain*
5.-6.6.	*Kickoff Meeting SCOPES project, MGO St. Petersburg, Russia*
7.-8.6.	*WMO Ad-hoc inter-commission group meeting WRDC, St. Petersburg, Russia*
20.-22.6.	*SWAP-LYRA Science Consortium, ISSI workshop, Bern*
6.7.	*Vortrag am Seminar über Kernstruktur-, Elementarteilchen und Astrophysik, Uni Basel*
22.-23.7.	*4th general meeting of International Living With a Star, Beijing, China*
2.-3.8.	*Seminar talk at NPL, London, England*
13.-16.9.	*Second International Symposium on Space Climate, Sinaia, Romania*
24.-25.10.	*PICARD science team meeting, Paris, France*
13.-16.11.	*COST 724 meeting and Third European Space Weather Week, Brussels, Belgium*
29.-30.11.	*Second SWAP-LYRA science consortium ISSI meeting, Bern*
7.-12.12.	*CIMO-XIV, WMO, Geneva*

Tatiana Egorova

13.3.-16.3.	*Swiss-Russian seminar, Davos*
24.-25.10.	*PICARD science team meeting, Paris, France*
13.-17.11.	*Third European Space Weather Week, Brussels, Belgium*

Wolfgang Finsterle

6.-10.2.	*CIMO Expert Team meeting, Davos*
26.-31.3.	*PHOEBUS Workshop, Fréjus, France*
6.-13.5.	*SOHO 17 / GONG 2006, Giardini Naxos, Italy*
24.-27.9.	*HELAS Roadmap Workshop, Nice, France*
24.-25.10.	*PICARD science team meeting, Paris, France*
3.-6.12.	*TECO 2006, Geneva*

Julian Gröbner

6.-10.2.	*CIMO Expert Team meeting, Davos*
10.-31.3.	*LKO, Arosa*
6.-7.4.	*MCM6, COST 726 MC-Meeting, Larnaca, Cyprus*

16.5.	*METAS, Bern*
22.-26.5.	*Univ. “La Sapienza”, Rome, Italy*
29.5.-2.6.	*BSRN Workshop, Lindenberg, Germany*
3.-7.7.	*RIVM, Netherlands*
5.7.	*NPL, London, England*
11.-16.9.	*SPIE Conference, Stockholm, Sweden*
11.-13.9.	*MCM7, COST 726 MC-Meeting, Stockholm, Sweden*
26.10.	*JRC, Ispra, Italy*
10.-19.11.	*WMO-UV Campaign, Buenos Aires, Argentina*
29.-30.11.	*JRC, Ispra, Italy*
Margit Haberreiter	
4.4.-7.7.	*Scientific visit at the Institute for Astronomy, Kula, Hawaii, USA*
10.-13.7.	*Workshop on time-distance helioseismology, acoustic imaging and holography, Stanford, USA*
25.-27.9.	*HELAS workshop: Roadmap for European Local Helioseismology, Nice, France*
24.-25.10.	*PICARD science team meeting, Paris, France*
20.-21.11.	*ISSI workshop Relationship between Solar Magnetism and Irradiance, Bern*
Eugene Rozanov	
24.-26.7.	*Workshop “Climate Variability and Extremes During the Past 100 years”, Gwatt*
24.-25.10.	*PICARD science team meeting, Paris, France*
4.-6.10.	*First SOLARIS Meeting Boulder, Colorado, USA*
13.-17.11.	*Third European Space Weather Week, Brussels, Belgium*
Christoph Wehrli	
19.-21.4.	*EUSAAR kick-off, Clairmont-Ferrand, France*
29.5.-2.6.	*BSRN meeting, Lindenberg, Germany*
24.-25.10.	*PICARD science team meeting, Paris, France*
6.-8.11.	*GAW/SAG Aerosol meeting, Shanghai, China*
9.11.	*GAW/SAG subgroup AOD meeting, Shanghai, China*
22.-23.11.	*GAWTEC XII course, Schneefernerhaus, Germany*
Uwe Schlifkowitz	
7.-12.5.	*SOHO 17: 10 Years of SOHO and Beyond, Giardini Naxos, Italy*
Micha Schöll	
12.-16.9.	*ISSC2 – International Symposium on Space Climate 2, Sinaia, Romania*
24.-25.10.	*PICARD science team meeting, Paris, France*

Course of Lectures, Participation in Commissions

Werner Schmutz

International Radiation Commission (IAMAS)
Comité consultatif de photométrie et radiométrie (OICM WMO)
Expert Team on Meteorological Radiation and Atmospheric Composition Measurements (CIMO, WMO)
Swiss Committee on Space Research (SCNAT)
International Living With a Star Working Group
Executive board of the Swiss Society Astronomy Astrophysics (SCNAT)
GAW-CH working group (MeteoSwiss)
Swiss management committee delegate to the COST action 724 (ECF)
Course of lecture „Astronomie", WS 2005/2006 and WS 2006/2007 ETH-ZH
Examination expert in Astronomy, BSc ETHZ

Wolfgang Finsterle

Expert Team on Meteorological Radiation and Atmospheric Composition Measurements (CIMO, WMO)

Julian Gröbner

GAW-CH Working Group (MeteoSwiss)
Swiss management committee delegate to the COST action 726 (ECF)
Working group leader of COST action 726
Course of lecture "Solar Ultraviolet Radiation" WS 2006/2007

Rolf Philipona

Working group of Baseline Surface Radiation Network (WMO/WCRP)
Atmospheric Chemistry and Physics (ACP) Commission of SCNAT
Working group on Surface Fluxes (WMO/WCRP/WGSF)
Course of lecture „Strahlungsmessung in der Klimaforschung" WS 2005/2006 and WS 2006/2007 ETHZ

Christoph Wehrli

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)
Course of lecture "Aerosol Optical Depth" at the GAWTEC

Public Seminars at PMOD/WRC

6.-10.2.	CIMO Expert Team Meeting	
13.-16.3.	Swiss-Russian Seminar	
6.2.	Experimentelle Charakterisierung des Einflusses der Blendenerwärmung auf das Messresultat von PMO6 Absolutradiometern	M. Suter
3.3.	Polar AOD measurements by FMI and cloud filtering study	V. Aaltonen
9.3.	Surface Radiation and Climate and High Latitudes. Homogenization and Analyses of Data from Arctic and Antarctic BSRN sites	M. Sutter
9.5.	SwissCube, the first Swiss space mission	M. Borgeaud
27.11.	Solar cycle Variations from helioseismology and links to irradiance changes	A. Kosovichev
8.12.	Understanding solar luminosity variations with the Virial theorem	A. Ferriz
8.12.	Neutral Winds in the Photosphere and Sunspots	J. Kuhn
21.12.	Aerosol Optical Depth (AOD) Measurements in the MeteoSwiss CHARM network	S. Nyeki

Guided Tours at PMOD/WRC

In 2006 the PMOD/WRC was visited by 11 groups.

Participants Swiss-Russian Seminar (13.-16.3.2006)

Participants from Russia

Prof. Dr. G. Golitsyn	Inst. of Atmospheric Physics, Russian Academy of Science, Moscow
Prof. Dr. Y. Timofeyev	Res. Inst. of Physics, St. Petersburg State Univ., St. Petersburg
Prof. Dr. I. Karol	Voeikov Main Geophys. Observatory, St. Petersburg
Prof. Dr. I. Mokhov	Oboukhov Inst. f. Atmospheric Phys., Russ. Ac. of Science, Moscow
Dr. A. Poberovsky	Res. Inst. of Physics, St. Petersburg State Univ., St. Petersburg
Prof. Dr. E. Volodin	Inst. of Numerical Mathematics, Russ. Ac. of Science, Moscow
Dr. V. Yushkov	Central Aerological Observatory, Moscow Region

Participants from Switzerland

Prof. Dr. W. Schmutz	PMOD/WRC
Prof. Dr. A. Ohmura	Inst. of Atm. and Climate science of ETH Zurich
Prof. Dr. T. Peter	Inst. of Atm. and Climate science of ETH Zurich
Prof. Dr. J. Beer	EAWAG, Dübendorf
Prof. Dr. J. Stähelin	Inst. of Atm. and Climate science of ETH Zurich
Prof. Dr. S. Brönimann	Inst. of Atm. and Climate science of ETH Zurich
Prof. Dr. N. Kämpfer	Institute of Applied Physics, University of Berne, Berne
Dr. R. Stübi	MeteoSwiss, Payerne
Dr. M. Wild	Inst. of Atm. and Climate science of ETH Zurich
Dr. E. Rozanov	Inst. of Atm. and Climate science of ETH Zurich and PMOD/WRC
Dr. T. Egorova	PMOD/WRC

Participants from other countries

Dr. P. Hartogh	MPI for Solar system studies, Kattlenburg-Lindau, Germany

Abbreviations

AOD	*Aerosol Optical Depth*
ACRIM	*Active Cavity Radiometer for Irradiance Monitoring*
AGU	*American Geophysical Union*
ARM	*Atmospheric Radiation Measurement*
ASRB	*Alpine Surface Radiation Budget*
ATLAS	*Shuttle Mission with solar irradiance measurements*
AU	*Astronomical Unit (1 AU = mean Sun-Earth Distance)*
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*
BUSOC	*Belgian User Support and Operation Centre of ESA*
BUWAL	*Bundesamt für Umwelt, Wald und Landschaft, Bern*
CART	*Cloud and Radiation Testbed*
CCM	*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*
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*
COST	*Co-operation in the field of Scientific and Technical Research, an intergovernmental framework program of the ESF*
CPC	*Climate Prediction Center, USA*
CPD	*Course Pointing Device*
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*
EGS	*European Geophysical Society*
EGSE	*Electrical Ground Support Equipment*
ERBS	*Earth Radiation Budget Satellite*
ESA	*European Space Agency, Paris, F*
ESF	*European Science Foundation*
ESOC	*European Space Operations and Control Center, Darmstadt, D*
ESTEC	*European Space Research and Technology Center, Noordwijk, NL*

ETH	*Eidgenössische Technische Hochschule (Z: Zürich, L: Lausanne)*
EURECA	*European Retrievable Carrier, flown August 1992 - June 1993 with SOVA experiment of PMOD/WRC*
EUV	*Extreme Ultraviolet Radiation*
FWHM	*Full width half maximum (e.g. filter transmission)*
GAW	*Global Atmosphere Watch, an observational program of WMO*
GAWTEX	*GAW Training & Education Center*
GCM	*General Circulation Model*
GEWEX	*Global Energy and Water Cycle Experiment of WCRP*
GHG	*Greenhouse Gases*
GOLF	*Global Oscillations at Low Frequencies= experiment on SOHO*
GONG	*Global Oscillations Network Group*
GSFC	*Goddard Space Flight Center, Maryland, USA*
HALOE	*Halogen Occultation Experiment on board UARS*
HECaR	*High sensitivity Electrically Calibrated Radiometer*
HF	*Hickey-Frieden Radiometer manufactured by Eppley, Newport, R.I., USA*
IACETH	*Institute for Climate Research of the ETH-Z*
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*
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*
IPASRC	*International Pyrgeometer and Absolute Sky-scanning Radiometer Comparison*
IPC	*International Pyrheliometer Comparisons*
IPHIR	*Inter Planetary Helioseismology by Irradiance Measurements*
IR	*Infrared*
IRMB	*Institut Royal Météorologique de Belgique, Brussel, B*
IRS	*International Radiation Symposium of the Radiation Commission of IAMAS*
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*
JRC	*Joint Research Center of the European Commission in Ispra, Italy*
KIS	*Kiepenheuer-Institut für Sonnenphysik, Freiburg i.Br.*
LOI	*Luminosity Oscillation Imager, Instrument in VIRGO*
LYRA	*Lyman-alpha Radiometer, ROB & PMOD/WRC experiment on PROBA 2*
MCH	*MeteoSwiss, Zürich*
MDI	*see SOI/MDI*
metas	*Swiss Federal Office of Metrology and Accreditation*
MODTRAN	*Moderate Resolution Transmission Code (in Fortran)*
MSC	*Meteorological Service of Canada, Toronto*
NASA	*National Aeronautics and Space Administration, Washington, USA*

NCEP	*National Center for Environmental Prediction, NOAA, USA*
NIMBUS7	*NOAA Research Satellite, launched Nov.78*
NIP	*Normal Incidence Pyrheliometer*
NMC	*National Meteorological Center, USA*
NOAA	*National Oceanographic and Atmospheric Administration, Washington, USA*
NPL	*National Physical Laboratory, Teddington, UK*
NRL	*Naval Research Laboratory, Washington, USA*
NREL	*National Renewable Energy Lab*
ODS	*Ozone Destroying Substances*
PCB	*Printed circuit board*
PDR	*Preliminary Design Review*
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 2009)*
PIR	*Precision Infrared Pyrgeometer von Eppley*
PMOD	*Physikalisch-Meteorologisches Observatorium Davos*
PMO6-V	*VIRGO PMO6 type radiometer*
PREMOS	*Precision Monitoring of Solar Variability, PMOD/WRC experiment on PICARD*
PROBA 2	*ESA technology demonstration space mission (launch 2007)*
PRODEX	*Program for the Development of Experiments der ESA*
PTB	*Physikalisch-Technische Bundesanstalt, Braunschweig & Berlin, D*
QASUME	*Quality Assurance of Spectral Ultraviolet Measurements in Europe*
RA	*Regional Association of WMO*
ROB	*Royal Belgian Observatory*
SAG	*Scientific Advisory Group of the GAW program*
SARR	*Space Absolute Radiometer Reference*
SCOPES	*Scientific Collaboration between Eastern Europe and Switzerland, grant of the SNSF*
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*
SMM	*Solar Maximum Mission, Satellite of NASA*
SNF	*Schweizer. Nationalfonds zur Förderung der wissenschaftlichen Forschung*
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*
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*
SOVA	*Solar Variability Experiment on EURECA*
SOVIM	*Solar Variability and Irradiance Monitoring, PMOD/WRC experiment for the International Space Station Alpha*
SPC	*Science Programme Committee, ESA*

SPM	*Sun photometer*
SSD	*Space Science Department of ESA at ESTEC, Noordwijk, NL*
SST/SI	*Sea Surface Temperature and Sea Ice*
STEP	*Solar Terrestrial Energy Program of SCOSTEP/ICSU*
SUSIM	*Solar Ultraviolet Spectral Irradiance Monitor on board UARS*
SW	*Short Wave*
SWT	*Science Working Team*
TSI	*Total Solar Irradiance*
UARS	*Upper Atmosphere Research Satellite of NASA*
UV	*Ultraviolet radiation*
VIRGO	*Variability of solar Irradiance and Gravity Oscillations, Experiment on SOHO*
WCRP	*World Climate Research Program*
WDCA	*World Data Center for Aerosols, Ispra*
WISG	*World Infrared Standard Group of pyrgeometer, maintained by WRC*
WMO	*World Meteorological Organization, a United Nations Specialized Agency, Geneva*
WORCC	*World Optical Depth Research and Calibration Center (since 1996 at PMOD/WRC)*
WRC	*World Radiation Center, Davos*
WRDC	*World Radiation Data Center, St. Petersburg*
WRR	*World Radiometric Reference*
WSG	*World Standard Group, realizing the WRR, maintained by WRC*
WWW	*World Weather Watch, an observational program of WMO*

Donations

A donation from Mr. Daniel Karbacher (from Küsnacht, ZH) in 2005 was used to purchase a radiometer for the measurement of atmospheric turbidity and spectral global radiation. The radiometer has finally arrived and it increases the number of different instruments that are based at the World Optical Depth Research and Calibration Center.

In 2006 Mr. Karbacher also generously donated a large sum to support the activities of the PMOD for its 100th anniversary in 2007. We have also approached additional potential donors for contributions to pay for expenses related to the anniversary celebration and most have confirmed their support. Among these, the bank UBS transferred its donation before the end of last year (2006).

The association for the benefit of the SFI foundation paid the last annual installment that reimburses the PMOD/WRC for the purchase of the institute's color printer/ copy machine.

Annual Accounts PMOD/WRC 2006

(excl. third-party funds)

Ertrag	31.12.2006 CHF
Beitrag Bund Betrieb WRC, IRC	1'092'594.00
Beitrag Bund Betrieb WORCC	161'660.00
Beitrag Kanton Graubünden	173'285.00
Beitrag Landschaft Davos	259'927.50
Beitrag Landschaft Davos, Mieterlass	145'111.00
Beitrag Landschaft Davos, Stiftungstaxe	118'191.05
Beitrag MeteoSchweiz, Kyoto Beitrag	75'000.00
Forschungsbeitrag SFI, ASRB	90'000.00
Instrumentenverkauf	220'863.00
Diverse Einnahmen/Eichungen	114'238.15
Wertschriftenertrag/Aktivzinsen	27'234.70
	2'478'104.40

Aufwand	CHF
Gehälter	1'479'796.80
Sozialleistungen	262'507.90
Investitionen	152'273.98
Unterhalt	13'933.00
Verbrauchsmaterial	135'004.78
Verbrauch Commercial	34'427.03
Reisen, Kongresse, Kurse	73'399.09
Bibliothek und Literatur	7'684.25
Raumkosten	145'111.00
100-Jahr Feier	24'711.45
Verwaltungskosten	162'042.95
	2'490'892.23
Ergebnis 2006	-12'787.83
	2'478'104.40

The costs of the new WSG-building of CHF 430'000.00 have been directly paid by BBL and are not included in the annual accounts of 2006.

Balance Sheet PMOD/WRC 2006

(excl. third-party funds)

	31.12.2006	31.12.2005
Aktiven	CHF	CHF
Kassa	1'291.20	2'087.30
Postchek	113'821.19	8'186.44
Bankkonten	673'737.71	637'180.20
Debitoren	115'435.75	44'288.45
Verrechnungssteuer	742.55	488.10
Mehrwertsteuer	39'315.57	
Kontokorrent Mitarbeiter	0.00	-561.95
Kontokorrent SNF 200020-101848	0.00	2'130.22
Kontokorrent SNF 200020-112183	35'207.15	43'757.30
Kontokorrent SNF 21-68171.02	0.00	516.25
Kontokorrent SNF 200020-109420	36'792.70	11'584.10
Kontokorrent PREMOS-2	233'137.87	207'977.95
Kontokorrent SOVIM	58'779.35	107'713.65
Kontokorrent INTAS	1'969.60	1'971.40
Kontokorrent LYRA-Projekt	58'835.90	192'318.74
Kontokorrent COST-724	8'191.28	-42'332.81
Kontokorrent COST-726	96'049.72	-122.40
Kontokorrent SCOUT-03	5'911.95	5'836.95
Kontokorrent SCOPES	5'990.10	437.50
Kontokorrent NEWRAD	0.00	189.70
Kontokorrent UV-Conference 2007	207.00	
Transitorische Aktiven	4'151.00	12'795.35
	1'489'567.59	1'236'442.44

Passiven		
Kreditoren	124'680.61	69'939.60
Zahllast Mehrwertsteuer		-2'845.72
Kontokorrent Stiftung	88'618.80	15'375.50
Transitorische Passiven	557'940.55	575'710.00
Rückstellungen 100 Jahre Obs/IPC-XI/UVC	104'551.35	60'500.00
Rückstellungen	461'338.45	352'537.40
Eigenkapital	152'437.83	165'225.66
	1'489'567.59	1'236'442.44