Name of research institute or organization:

MeteoSwiss, Payerne

Title of project:

Global Atmosphere Watch Radiation Measurements

Project leader and team

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Project description:

In 2004, the Swiss Atmospheric Radiation Monitoring program (CHARM) continued measuring solar and atmospheric irradiance at Jungfraujoch (JFJ) in the framework of climate change monitoring. Such long-term monitoring is motivated by the fact that the most direct effect of an increased greenhouse gas concentration is an enhanced emission of long-wave radiation from the atmosphere to the surface. Particularly, the long-wave downward irradiance at the ground has been singled out as a candidate for the early detection of the greenhouse signal (*Wild et al.*, 1997, *Wild and Ohmura*, 2004). This activity implies a constant effort to sustain the highest achievable accuracy, stability and continuity in the measurements.

The observations were performed in the configuration described in the 2002 HFSJG Activity Report. The automatic CHARM station design and the maintenance by the MeteoSwiss CHARM team allowed reducing the data loss due to instrument failure to less than 2% for all instruments, except one PFR sunphotometer that suffered a failure resulting in a loss of about 5%. However, problems affecting the dome protecting the sun tracker system hindered direct irradiance measurement, with a corresponding data loss estimated at 10-15%. Heavy maintenance of the dome has been performed in 2004 to solve this problem, and the situation will be carefully monitored in 2005.

In addition, significant progress was accomplished in deriving secondary information on the atmospheric content of water vapor and aerosol from CHARM measurements of direct spectral irradiance using sunphotometers.

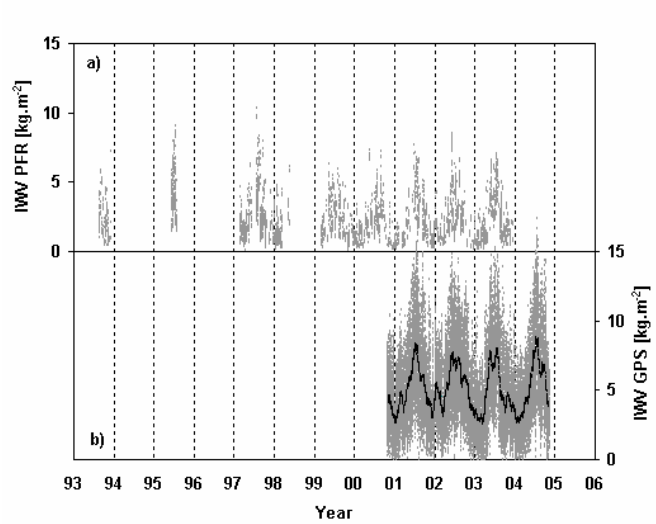

Figure 1. Time-series of IWV at the Jungfraujoch from: a) PFR sun photometers, and b) GPS data. The entire GPS data set is shown to illustrate the variability during cloudy as well as clear-sky periods.

Continuous measurements of IWV have been conducted since October 1995 at Davos and since March 1999 at JFJ, although sporadic JFJ data are available for the period 1993–1999. Figure 1a shows the available 1-hr IWV dataset for the JFJ. While a high temporal IWV variability exists a seasonal cycle is evident.

Maximum IWV values in summer reach ~8.5 kg m^{-2} and minimum values ~0.1 in winter, with an annual average of ~2.1 kg m^{-2}. A PFR rotation scheme was implemented in February 2004 whereby PFRs are rotated from high-alpine to valley stations on an annual basis. The aim is to ensure better long-term calibration of the CHARM network. Due to the logistical complexity involved, IWV from PFRs for 2004 has not been determined yet, but is expected to exhibit the same cycle as in previous years. Figure 1b illustrates the GPS IWV dataset for both clear-sky and cloudy periods in order to illustrate the difference to PFR IWV (Figure 1a) which is only for clear-sky periods when the sun is above the horizon. A comparison of concurrent PFR and GPS IWV gave a correlation factor r^2 = 0.73 (slope m = 0.97; bias = 1.8), and is somewhat poorer than a similar comparison for IWV at Davos (Switzerland; r^2 = 0.96; m = 0.97; bias = 0.7). While the agreement at Davos is considered as good, the poorer performance at JFJ is assumed to be due to the heated GPS dome (prevention of ice/snow build-up). Antennae multi-path effects or other un-modeled aspects would then lead to discrepancies in calculation of IWV [*Haefele et al.*, 2004]. On the other hand, one could argue that PFR IWV results may be at fault. However, evidence supporting the validity of PFR IWV measurements comes from the MATRAG (Measurement of Alpine Tropospheric delay by Radiometers And GPS) campaign conducted at the JFJ during Autumn 2004 [*Haefele et al*., 2004]. Comparison between PFR IWV and microwave radiometer measurements (MWR) from MATRAG gave a MWR-PFR bias of 0.04 kg m^{-2} over a 7-day period. This therefore suggests that further study is still required to provide accurate GPS-derived IWV at the JFJ.

Monthly PFR IWV statistics are shown in Figure 2 as a box-and-whisker plot. Monthly averages range from ~3.9 kg m^{-2} in August to ~1.0 kg m^{-3} in January, representing a factor 3.9 difference. Fairly low and stable IWV appear to occur from January to April which are followed by a large increase in May (~ factor 2). The most likely reasons are the southward movement of the polar front, and the increase in solar irradiation at this time of year.

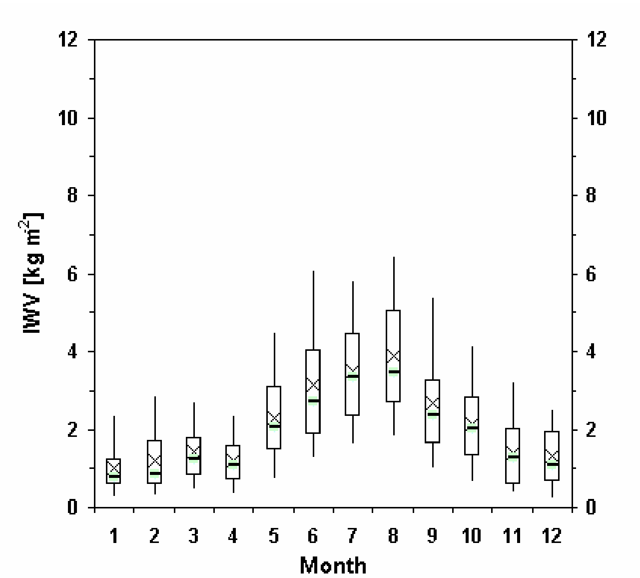

Figure 2. Box-and-whisker plot (5, 25, median, 75, 95 percentiles) of monthly PFR IWV values at the JFJ from 1999–2004. The symbol "x" represents the average IWV.

As part of the CHARM program, UV erythemally-weighted broadband irradiance is measured continuously since summer 1996 at Jungfraujoch using SolarLight 501A UV broadband radiometers (biometers). The biometers were initially calibrated, and had their spectral response determined by the manufacturer. Thereafter, they have been calibrated periodically by comparison with a reference biometer at the World Radiation Center (PMOD/WRC) at Davos. The calibration performed at the WRC only provided a single calibration factor averaged over ozone values and solar zenith angles. However, biometer calibration is known to depend on ozone and solar zenith angle, and concerns have been expressed about uncertainties caused by such averaging.

A project has therefore been initiated in 2004 at MeteoSwiss to calibrate UV biometers by comparison to measurements obtained with reference biometers whose response dependence on ozone and solar zenith angle has been well characterized in international reference centers. This project demonstrated the feasibility of such a calibration method and allowed the assessment of uncertainties in the characterization of the reference biometers by the international reference centers. The calibration technique by comparison to a reference will be finalized in 2005 and will be applied to biometers from the CHARM network, thus improving the accuracy of the UV erythemally-weighted broadband irradiance measurements at Jungfraujoch.

References:

Wild M., A. Ohmura, and U. Cubasch, 1997. GCM simulated surface energy fluxes in climate change experiments. *J. Climate*, **10**, 3093-3110.

Wild M., and A. Ohmura, 2004. BSRN longwave downward radiation measurements combined with GCMs show promise for greenhouse detection studies. *GEWEX News*, **14(4)**, 9-10.

Key words:

Solar irradiance, ultraviolet, visible, infrared, spectral irradiance, precision filter radiometer (PFR), pyranometer, pyrheliometer, UV biometer, total aerosol optical depth (AOD), integrated water vapor (IWV).

Internet data bases:

http://www.iapmw.unibe.ch/research/projects/STARTWAVE/startwave_dbs.html
(IWV STARWAVE data)

Collaborating partners/networks:

- Short- and long-wave global irradiance data shared with the Alpine Surface Radiation Budget network under the responsibility of the Word Radiation Center / Physikalisch-Meteorologisches Observatorium Davos
- Integrated water vapor data submitted to the NCCR Climate P2.4 STARTWAVE database at the Institute for Applied Physics, University of Bern.
- UV erythemal broadband radiometer calibration program in collaboration with the European Reference Centre for Ultraviolet Radiation measurements (ECUV) from the Joint Research Centre at Ispra, Italy in the framework of COST action 726 and with U.S. Central UV Calibration Facility (CUCF) of US National Oceanic and Atmospheric Administration
- MATRAG campaign in collaboration with the Institute for Applied Physics, University of Bern, the University of the Bundeswehr, Munich and the Swiss Federal Office of Topography
- Inter-comparison of AOD data from sunphotometers operated at Jungfraujoch by the Royal Netherlands Meteorological Institute (KNMI), Kipp & Zonen, Delft, the Netherlands, and the Word Radiation Center / Physikalisch-Meteorologisches Observatorium Davos

Scientific publications and public outreach 2004:

Conference papers

Haefele, P., L. Martin, M. Becker, E. Brockmann, J. Morland, S. Nyeki, C. Matzler, and M. Kirchner, Impact of radiometric water vapor measurements on troposphere and height estimates by GPS, Institute of Navigators GNSS Conference, 21-24 Sept., Long Beach, California, 2004.

Knap, W., S. Nyeki., A. Los., P. Stammes, Sunphotometry at the High Altitude Research Station Jungfraujoch, International Radiation Symposium, Seoul, Korea, 2004.

Data books and reports

"Le rayonnement atmosphérique et son réseau de mesure suisse" in Annalen 2003 MeteoSchweiz, Zürich (August 2004).

"Ozone, rayonnement UV et aérosols (GAW)" in Annalen 2003 MeteoSchweiz, Zürich (August 2004)

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