Name of research institute or organization:

MeteoSwiss, Payerne

Title of project:

Global Atmosphere Watch Radiation Measurements

Project leader and team:

Dr. Laurent Vuilleumier, project leader
Dr. Stephan Nyeki, Armand Vernez

Project description:

Long-term monitoring of surface radiation flux at the Jungfraujoch in the framework of the GAW Swiss Atmospheric Radiation Monitoring program (CHARM) was conducted in 2005 with a high degree of data availability considering the challenging conditions at Jungfraujoch: only 6.3% of data were lost or of bad quality, mainly due to some sun-tracking problems during the summer, and the loss of power and communication resulting from flooding in central Switzerland. Such continuous monitoring 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.

Surface radiation flux measurements at Jungfraujoch are included in the dataset of the Alpine Surface Radiation Budget network (ASRB). The ASRB data were used to analyze the evolution of the radiation flux over the Alps, and demonstrated a strong increase of total surface absorbed radiation, concurrent with rapidly increasing temperature [Philipona et al, 2005]. Such an increase was attributed in major part (70 percent) to a strong water vapor feedback, the remaining part being most likely directly linked to increasing manmade greenhouse gases. This research was the object of a press release from the American Geophysical Union and received a strong echo in the media.

Our 2004 report emphasized the progress accomplished in deriving secondary information on the atmospheric content of water vapor and aerosol from CHARM measurements of direct spectral irradiance using sunphotometers. In 2005, the analysis of the Integrated Water Vapor density (IWV) time series from Jungfraujoch (JFJ) and Davos was finalized.

The analysis was performed on data measured continuously from 1995 to 2005 at Davos and from 1999 to 2005 at JFJ (although sporadic JFJ data available for the period 1993–1999 were also included in some analyses), and is reported by Nyeki et al. [2005]. The IWV time series exhibited clear annual cycles at both Davos and Jungfraujoch with a maximum in summer and minimum in winter (see Figure 1). They also showed a decrease in absolute values with increasing station altitude. The annual mean IWV at Davos is 6.7 (±3.9; 1 std) kg m^{-2}, and 2.2 (±1.5) kg m^{-2} at JFJ. Respective monthly averages range from ~13.3 (Davos) and 3.9 kg m^{-2} (JFJ) in August to ~3.5 (Davos) and 1.0 kg m^{-2} (JFJ) in January, representing a factor 3.8 and 3.9 variation in maximum to minimum. Low and stable IWV values from January to April are observed at both stations, which are then followed by a large increase in May (by a factor ~2).

An IWV trend analysis was conducted for both Davos and JFJ, and the JFJ linear trend and sinusoidal fits of the seasonal cycle, based on monthly values, are shown in Figure 1a. The resulting linear trends were found to be -3.6×10^{-4} and 3.4×10^{-4} kg m^{-2} per year for Davos and Jungfraujoch (95% confidence limits: -0.003 to 0.004 kg m^{-2} and -0.002 to 0.003 kg m^{-2}). As such, both trends are compatible with zero. IWV is strongly correlated with atmospheric temperature (T) and specific humidity (q). In a study of the trends in ground temperature T2 (at 2 m) and q, Philipona et al. [2004] found increases of 1.32°C and 0.51 g m^{-3} for the 1980–2002 period over Switzerland. Part of the reason for such difference with our results may lie in our analysis giving a higher weight to periods of the year when clear-sky period are more frequent, but statistical analysis disproved this idea. The other restriction to the data set is clearly its limitation to clear-sky periods. Restricting the analysis of Philipona et al. [2004] to the same periods gave much smaller increases (R. Philipona, personal communication, 2005). This observation is therefore a likely explanation for the absence of discernible trends in our analysis. The question of interest is whether IWV is increasing as a consequence of increasing ground temperature during all-weather conditions, which may be resolve when long GPS IWV time series at Davos and the JFJ will be available.

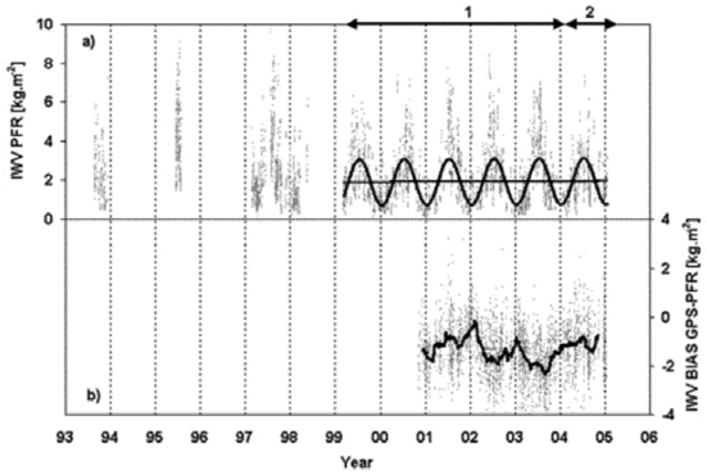

Figure 1. Time-series of 1-hr IWV averages at Jungfraujoch: (a) PFR-derived values with superposed seasonal and linear trend analyses, and (b) GPS – PFR IWV bias with superposed 60-day running mean. Periods 1–2 correspond to use of different sun photometers. (From [Nyeki et al., 2005])

In the framework of the GAW CHARM program, UV erythemally-weighted broadband irradiance is measured at JFJ using SolarLight 501A UV broadband radiometers (biometers). In 2004, a project was initiated for setting up yearly calibration checks of CHARM biometers. These checks are done by comparison to measurements obtained with reference biometers whose response dependence on ozone and solar zenith angle are well characterized by international reference centers. Such procedures are developed in order to follow guidelines that are being elaborated in a joint project between WMO and the action 726 of the European Co-operation in the field of Scientific and Technical Research (COST). Such procedures should allow a standardization of UV erythemal observations at the European level.

Three instruments (SL1903, SL1904 and SL1905) were chosen to be used as reference for the CHARM program based on the availability of past characterizations and stability. One instrument (SL1903) was sent for characterization to the European Reference Centre for Ultraviolet Radiation measurements (ECUV) from the Joint Research Centre at Ispra, Italy, while the two others were sent to the U.S. Central UV

Calibration Facility (CUCF) at Boulder, U.S.A. These reference biometers were then used to check the calibration of the biometers installed at JFJ.

After applying in October 2005 the calibration check procedure mentioned above, comparisons of UV erythemal irradiances measured concurrently at JFJ by two biometers showed good agreement compatible with the expected uncertainty of about 5% (see Figure 2). This represents a significant improvement of the accuracy of the JFJ UV erythemally-weighted broadband irradiance measurements and of the derived quantities such as the UV index.

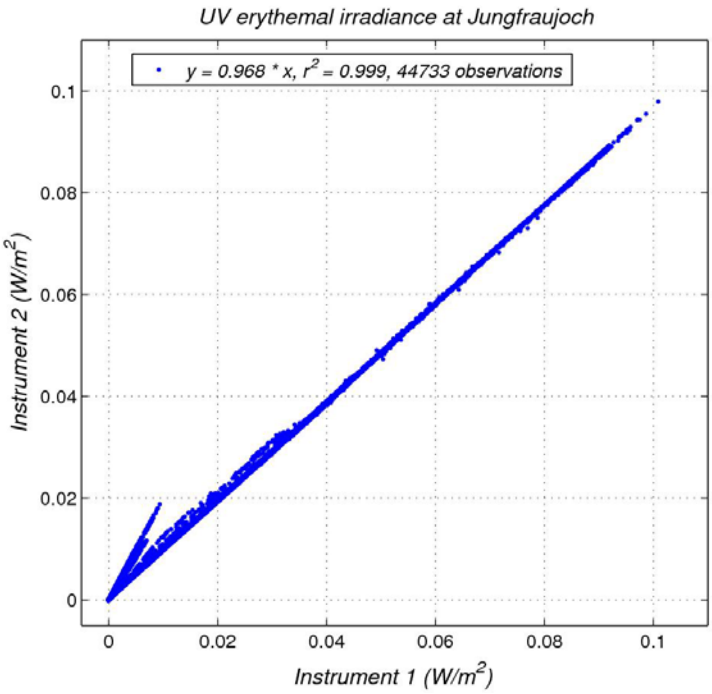

Figure 2. Comparisons of concurrent erythemally-weighted irradiance measurements by two collocated biometers at Jungfraujoch (26/10/2005-31/12/2005).

References:

Nyeki, S., L. Vuilleumier, J. Morland, A. Bokoye, P. Viatte, C. Mätzler, and N. Kämpfer (2005), A 10-year integrated atmospheric water vapor record using precision filter radiometers at two high-alpine sites, *Geophys. Res. Lett.*, **32**, L23803, http://dx.doi.org/10.1029/2005GL024079

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Philipona, R., B. Dürr, A. Ohmura, and C. Ruckstuhl (2005), Anthropogenic greenhouse forcing and strong water vapor feedback increase temperature in Europe, *Geophys. Res. Lett.*, **32**, L19809, http://dx.doi.org/10.1029/2005GL023624.

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)
http://wrdc.mgo.rssi.ru/ (World Radiation Data Centre – WRDC)

Collaborating partners/networks:

- Integrated water vapor data submitted to the NCCR Climate P2.4 STARTWAVE database at the Institute for Applied Physics, University of Bern.
- Radiation data submitted to the World Radiation Data Centre (WRDC, St. Petersburg, Russian Federation) within the framework of the Global Atmosphere Watch
- Standardization of UV erythemal measurement program within the framework of the action 726 of the European Co-operation in the field of Scientific and Technical Research (COST).
- Inter-comparison of AOD data from sunphotometers operated at Jungfraujoch by MeteoSwiss, 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 2005:

Refereed journal articles

Nyeki, S., L. Vuilleumier, J. Morland, A. Bokoye, P. Viatte, C. Mätzler, and N. Kämpfer (2005), A 10-year integrated atmospheric water vapor record using precision filter radiometers at two high-alpine sites, *Geophys. Res. Lett.*, **32**, L23803, http://dx.doi.org/10.1029/2005GL024079

Morland J., B. Deuber, D. G. Feist, L. Martin, S. Nyeki, N. Kämpfer, C. Mätzler, P. Jeannet, and L. Vuilleumier (2005), The STARTWAVE atmospheric water database, *Atmospheric Chemistry and Physics Discussions*, **5**, pp 10839-10879

Conference papers

Knap, W. H., S. Nyeki, A. Los and P. Stammes (2005), Aerosol optical thickness measurements at the High Altitude Research Station Jungfraujoch, Switzerland, EGU General Assembly 2005, Vienna, 24-29 April 2005, *Geophysical Research Abstracts*, **7**, 04838.

Vuilleumier, L. and J. Gröbner (2005) Operational mode uncertainty for broadband erythemal UV radiometers, *Proceedings of the 9th international conference on new developments and applications in optical radiometry*, 11-19 October, 2005, Davos, Switzerland, pp 71-72.

Data books and reports

"Ozone, rayonnement et aérosols (GAW)" in Annalen 2004 MeteoSchweiz, Zürich (July 2005) pp. 126-129.

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