Name of research institute or organization:

Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center

Title of project:

Solar and atmospheric radiation measurements

Project leader and team

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Project description:

Within the Swiss Atmospheric Radiation Monitoring (CHARM) program, PMOD/WRC in collaboration with MeteoSwiss and IACETH conducts solar and atmospheric surface radiation measurements at Jungfraujoch and Gornergrat mainly for radiation budget, UV-radiation and aerosol optical depth (AOD) investigations. Within the CHARM program, Jungfraujoch and Gornergrat are key stations of the Alpine Surface Radiation Budget (ASRB) network, where shortwave solar and longwave atmospheric radiation is accurately measured to determine the altitude dependence of the surface radiation budget and possible changes related to climate change. Jungfraujoch being the highest site within CHARM is also extensively used as reference and calibration station and for comparisons of radiation instruments.

Eight years of radiation budget measurements (1995 – 2002) have now been thoroughly analyzed and investigated. The results show that atmospheric longwave downward radiation significantly increased (+5.2 Wm^{-2}) partly due to increased cloud amount (+1.0 Wm^{-2}), while solar shortwave radiation decreased (-2.0 Wm^{-2}) on average over all ASRB stations over the eight years of measurements (Figure 1). With cloud effects subtracted, model calculations show the cloud-free longwave flux increase (+4.2 Wm^{-2}) to be in due proportion to the increase of temperature (+ 0.82 °C) and absolute humidity (+0.21 g m^{-3}), but to be three times larger than expected from anthropogenic greenhouse gases, and therefore in part related to rising warm air

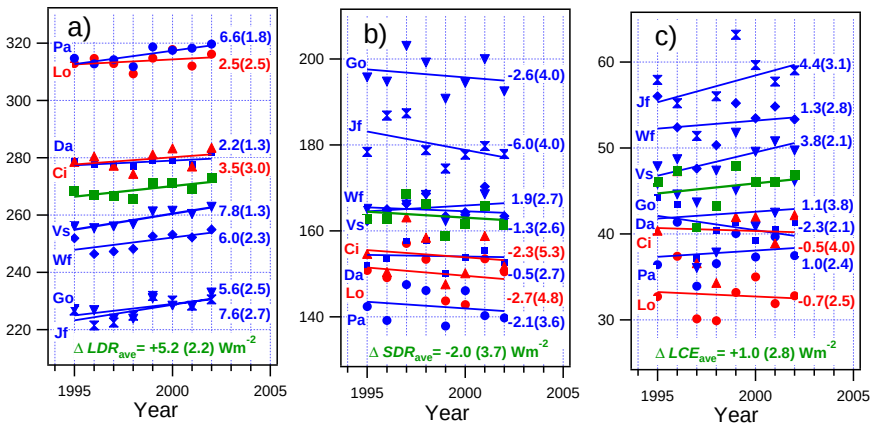

FIGURE 1. *Annual mean values of a) Longwave Downward Radiation (LDR), b) Shortwave Downward Radiation (SDR) and c) Longwave Cloud Effect (LCE) measured at eight stations from 1995 to 2002. Radiative flux changes over the eight years and stdev are given in [Wm^{-2}] on the right.*

advection under strengthened NAO conditions (Figure 2). However, after correcting for two thirds of the temperature and humidity rises, the increase of cloud-free longwave downward radiation (+1.8 Wm^{-2}) remains significant and demonstrates anthropogenic greenhouse gas radiative forcing (Figure 3).

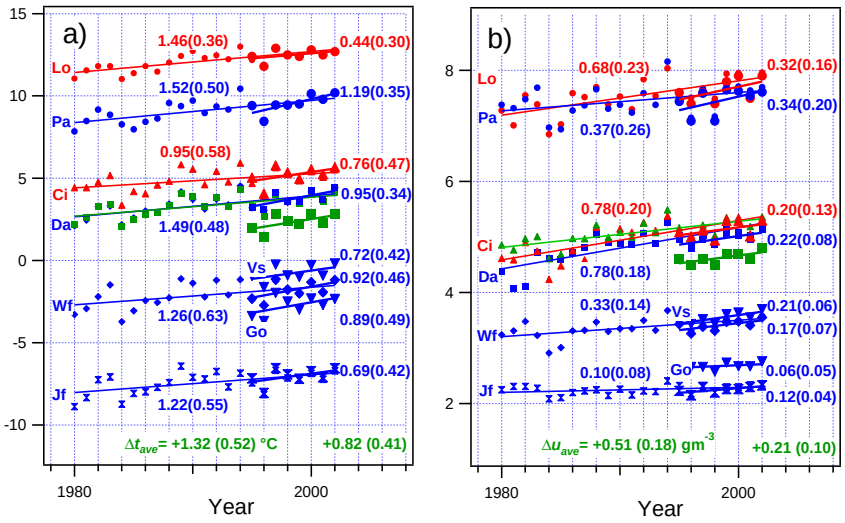

FIGURE 2. *Large increases of a) temperature (t) and b) absolute humidity (u) measured in the Alps from 1980 to 2002 at six MeteoSwiss stations, and from 1995 to 2002 at eight stations. Annual mean values of temperature [°C] and absolute humidity [g m^{-3}], with increases over the measuring period and stdev are shown from 1980 to 2002 (center), and from 1995 to 2002 (right). Stations south of the Alps are shown in red, all station average in green.*

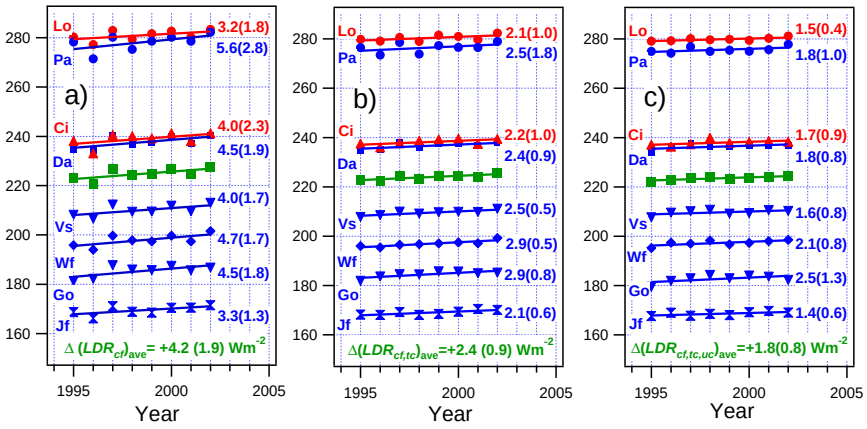

FIGURE 3. *Annual mean values of a) cloud-free Longwave Downward Radiation (LDR_{cf}), b) temperature corrected Longwave Downward Radiation ($LDR_{cf,tc}$) and c) humidity corrected Longwave Downward Radiation ($LDR_{cf,tc,uc}$) measured at eight stations. Increases over the eight years and stdev are shown.*

This analysis shows that longwave downward radiation flux increases at Earth's surface can be accurately measured, subdivided and explicitly explained and backed with model calculations as cloud-, temperature-, water vapor- and enhanced greenhouse gas radiative forcing effect. The resulting uniform increase of longwave downward radiation manifests radiative forcing that is induced by increased greenhouse gas concentrations and water vapor feedback, and proves for the first time the 'theory' of greenhouse warming with direct observations.

Key words:

Surface radiation budget; Radiative forcing; Longwave cloud effect; Greenhouse effect

Internet data bases:

http://www.pmodwrc.ch/

Collaborating partners/networks:

MeteoSwiss (MCH)
Institute for Atmospheric and Climate Science at ETH (IACETH)

Scientific publications and public outreach 2003:

Refereed journal article

Marty, C., R. Philipona, J. Delamere, E.G. Dutton, J. Michalsky, K. Stamnes, T. Stoffel, S.A. Clough and E.J. Mlawer, Downward longwave irradiance uncertainty under arctic atmospheres – measurements and modelling, J. Geophys. Res. **108**(D12), 4358, doi:10.1029/2002JD002937, 2003.

Conference papers

Philipona, R., Untersuchung des Treibhauseffektes in Bezug auf Klimaveränderungen, Antrittsvorlesung an der ETH-Zürich, Switzerland, 23 Jan. 2003

Philipona, R., Surface radiation measurements in the Alps reveal the increase of the greenhouse effect, XXIII General Assembly of the International Union of Geodesy and Geophysics (IUGG), Sapporo, Japan, 30 Jun. – 11 Jul. 2003.

Philipona, R., Strahlungsmessungen in den Alpen bestätigen die Zunahme des Treibhauseffektes. Schweizerische Gesellschaft für Meteorologie, Jahresversammlung, Fribourg, Switzerland, 8. Okt. 2003.

Philipona, R., B. Dürr, C. Marty, A. Ohmura and M. Wild, Radiative forcing – measured at Earth's surface - corroborate the increasing greenhouse effect. Poster at American Geophysical Union (AGU) Fall Meeting, San Francisco, USA, 8 – 12 Dec. 2003.

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