

Name of research institute or organization:

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**Physikalisch-Meteorologisches Observatorium Davos,  
World Radiation Center (PMOD/WRC)**

Title of project:

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Comprehensive Radiation Flux Assessment (CRUX)

Part of this programme:

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GAW-CH

Project leader and team:

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Julian Gröbner, project leader  
Christine Aebi  
Stefan Wacker

Project description:

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The project CRUX – Comprehensive Radiation Flux Assessment – is financed by the Swiss contribution to the Global Atmosphere Watch Programme of the WMO (GAW-CH). The project investigates the effect of clouds on the radiation balance of the Earth by assimilating measurements of total solar and terrestrial irradiance measured with pyranometers and pyrgeometers at four stations in Switzerland: Payerne, Locarno-Monti, Davos, and Jungfrauoch.

Hemispherical sky cameras are used to estimate cloud cover and cloud type using sophisticated algorithms to distinguish between up to seven cloud-types, using textual and ancillary information available at the four sites (Wacker et al., 2015). In this study, sky camera pictures from Jungfrauoch from the years 2012 and 2013, taken every minute, were used to determine cloud types and total cloud cover (see an example in Figure 3). In an inter-comparison of total cloud cover, 78 (90) % and 80 (90) % of the outputs between sky camera and APCADA algorithm as well as sky camera and human observer were within  $\pm 1$  (2) octa, respectively.

Due to its high altitude, the Jungfrauoch site is often not beneath but in (or even over) the clouds and cloud conditions can change rapidly. Therefore, a modification of the cloud classification scheme was necessary in which only cloud-free conditions, cirrus-cirrostratus, cirrocumulus-altocumulus, altostratus and fog are discriminated. Furthermore, an additional training set was required to train the algorithm for these particular conditions and the specific camera and hardware characteristics of the MOBOTIX camera. Up to 70 % of the Jungfrauoch test set images were correctly classified using this individual training set. While cloud-free conditions were correctly recognized in over 95 % of cases, the classification of altostratus and cirrus-cirrostratus was more problematic. Indeed, only 44 and 47 % of the respective images were correctly classified. The frequent misclassification of cirrus-cirrostratus as cloud-free may be explained by the bright pixels near the sun and/or the poor camera quality. The success rate for cirrocumulus-altocumulus and fog was substantially higher at 58 and 76 %, respectively (see Figure 2).



Figure 1. Hemispherical Cloud Camera of type MOBOTIX mounted on the radiation platform of Meteoswiss on the Sphinx terrace at Jungfraujoch. The weather protection dome has been removed on this picture (picture courtesy Ch. Aebi, June 2014).

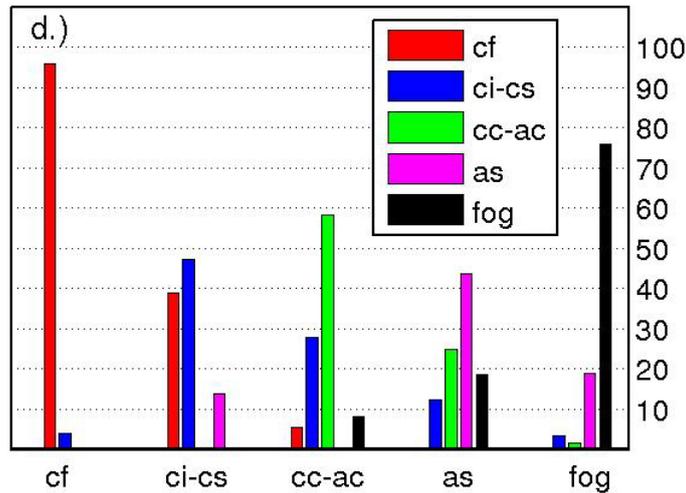


Figure 2. Relative frequencies of correctly and incorrectly classified cloud classes for the test set at Jungfraujoch. The mean success rate is 70 % using a training set of 195 images. The images do not necessarily show a single cloud class and were randomly selected (Wacker et al., 2015).

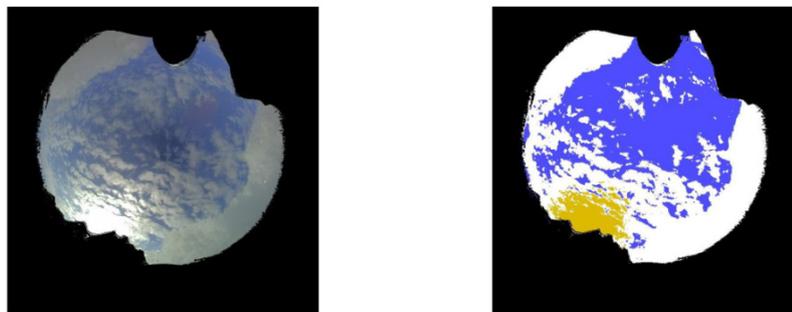


Figure 3. Image of the sky camera at 14:25 UT on 6 November 2014 (left picture), and analysed image on the left, with the sky in blue, the horizon in black, and the detected cloud as white pixels.

Key words:

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Climate change, radiation, cloud, cloud type classification, sky camera

Internet data bases:

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[ftp://ftp.pmodwrc.ch/stealth/002\\_payerne/liras/cloudcam/jf/](ftp://ftp.pmodwrc.ch/stealth/002_payerne/liras/cloudcam/jf/)

Collaborating partners/networks:

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MeteoSwiss

Scientific publications and public outreach 2014:

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**Refereed journal articles and their internet access**

Wacker S., J. Gröbner, C. Zysset, L. Diener, P. Tzoumanikas, A. Kazantzidis, L. Vuilleumier, R. Stöckli, S. Nyeki, and N. Kämpfer, Cloud observations in Switzerland using hemispherical sky cameras, *J. Geophys. Res.*, accepted, Jan. 1, 2015.

**Conference papers**

Aebi, Ch., J. Gröbner, and N. Kämpfer, A comprehensive radiation flux assessment at different sites in Switzerland, poster presentation at International Swiss Climate Summer School, Grindelwald, Switzerland, August 31 – September 5, 2014.

Aebi, Ch., J. Gröbner, and N. Kämpfer, A comprehensive radiation flux assessment at different sites in Switzerland, poster presentation at the conference Graubünden forscht, Davos, Switzerland, September 10 – 11, 2014.

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