Name of research institute or organization:

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

Title of project:

Cloud Climatology and Surface Radiative Forcing over Switzerland (CLASS)

Project leader and team:

Julian Gröbner
Stefan Wacker
Stephan Nyeki

Project description:

The CLASS project aims at quantifying changes in the short-wave and long-wave radiative fluxes and the effect of clouds on the surface radiation budget by differentiating between cloud types and cloud coverage using ancillary instrumentation and datasets. In order to discriminate between different cloud types and to calculate more precisely fractional cloud cover, hemispherical sky cameras were deployed at four stations across Switzerland. The systems at Davos, Payerne and Zimmerwald were already installed in 2010 and 2011. At Jungfraujoch, the installation was delayed due to technical problems with the camera system and the particular requirements at the high alpine station. Finally in July 2012, we were also able to successfully deploy a camera at this site (see Fig. 1). The camera delivers images from the sky during the daytime with a 1-minute cadence. The camera has been operational without any technical difficulties so far and data availability is at 100 %. Pictures from any particular day are stored for 10 days on the PMOD/WRC FTP server.

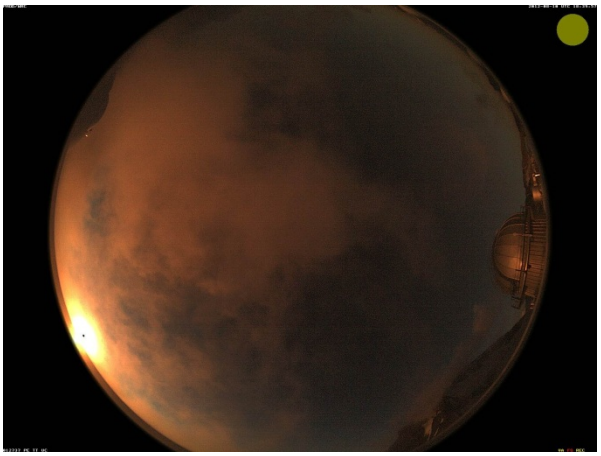

Figure 1: Hemispherical sky image taken on the 10.8.2012 at sunset.

The camera system allows the fractional cloud cover to be calculated on a routine basis. This is accomplished by calculating the ratios of the blue to the green channel and blue to the red channel for each pixel, which are then compared to a reference value. If the calculated value is higher than the reference value due to an atmosphere with no clouds which scatters more blue than red light, the pixel is classified as cloud-free. On the other hand, if the value is below the reference value due to clouds which scatter more red light compared to a cloud-free sky, the pixel is classified as cloudy (see Fig. 2). The validation of our results, however, is not trivial because alternative surface-based observations of the fractional cloud cover are limited at these stations. Therefore, we plan to compare our results to fractional cloud cover derived from Meteosat in the upcoming year.

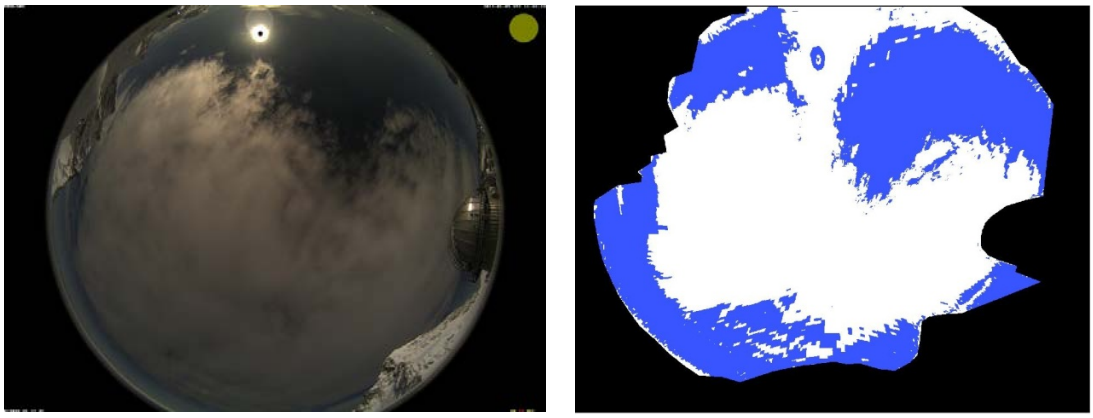

Figure 2: Original image of the sky over Jungfraujoch on the 5.1.2013 11:42 (left). The cloud cover algorithm produces a simplified image in which the cloud-free and cloudy sky is represented by blue and white pixels, respectively. The calculated cloud cover is 58 % for this image. Problematic is the cloud cover detection near the sun where the pixels due to the brightness of the sun are often misinterpreted as being cloudy.

Besides the calculation of fractional cloud cover, we have developed and tested an algorithm to classify the images into seven different cloud classes: cirrus-cirrostratus (ci-cs), cirrocumulus-altocumulus (cc-ac), stratus-altostratus (st-as), cumulus (cu), stratocumulus (sc), cumulonimbus-nimbostratus (cb-ns) and cloud-free (cf). The cloud type classification algorithm is based on a set of statistical features describing the color and the texture of an image. For the actual classification of an image, the k-nearest-neighbor (kNN) classifier is used. The kNN method belongs to the "supervised", non-parametric classifiers. "Supervised" implies that the separating classes are known and a training set is used to train the algorithm. We generated such a training sample from the Payerne data set by visual inspection of the images. This data set was chosen to train the algorithm because a large number of ancillary data including synoptic observations and ceilometer data have facilitated the generation of the training set. In order to correctly train the algorithm, the images of the training set may contain only one single cloud class as previously defined. The training set contains 200 pictures for each cloud class.

Eleven statistical features were computed for each pre-classified image of the training set and stored with its assigned cloud class. The eleven features consist of seven color features (mean of red and blue channel, standard deviation and skewness of blue channel, and difference of red and blue, red and green, and green and blue channel) and four textural features (energy, entropy, homogeneity and contrast of the blue channel).

We have tested the cloud type algorithm using independent test samples also containing images which do not necessarily show one unique cloud class as the training sample does. The score of the correctly classified images is currently between approximately 20 and 80 % (see Fig. 3). While the score of a correct classification for cumulonimbus-nimbostratus and cloud-free conditions is between 60 and 100 %, the classification of the other cloud classes is more problematic. The classification of cumulus, for example, is particularly difficult. Indeed, only every fifth and every third cumulus is correctly recognised by the algorithm at Davos and Payerne, respectively.

We are currently adapting the algorithm to the atmospheric conditions at Jungfraujoch. Indeed, clouds with a low cloud base such as stratus, stratocumulus, cumulus, cumulonimbus and nimbostratus no longer occur above but below the station due to its high altitude at 3580 meters above sea level. In addition, when the station is within these clouds their type cannot be discriminated. Therefore, a separate training set may be required for Jungfraujoch and the number of cloud classes has to be reduced.

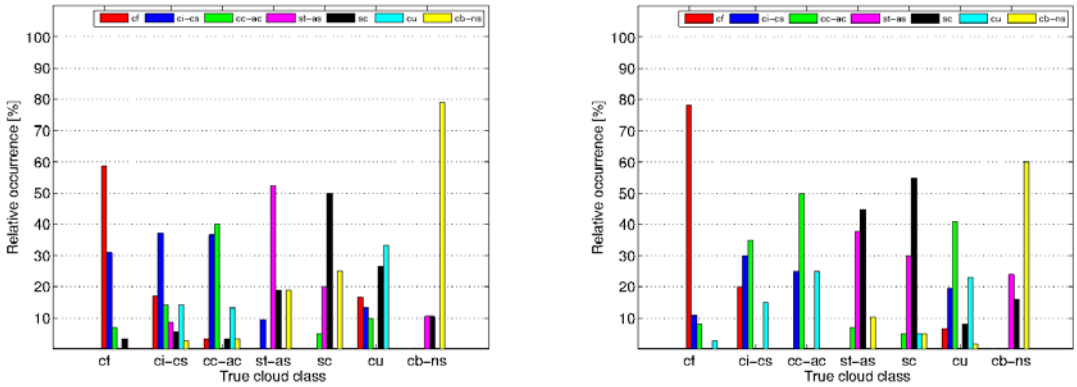

Figure 3: Scores of correct and incorrect classified cloud types for Payerne (left) and Davos (right). The Payerne and Davos test samples contain 184 and 204 pictures, respectively.

For the upcoming year, we plan to refine and to completely automate the cloud type algorithm. This will be the first time in Switzerland that a cloud algorithm will be operational on a routine basis which does not only calculate fractional cloud cover but also classifies the clouds into individual classes.

Key words:

Hemispherical sky cameras, cloud cover, cloud type classification

Internet data bases:

ftp://ftp.pmodwrc.ch/stealth/002_payerne/liras/cloudcam/jf/

Collaborating partners/networks:

MeteoSwiss

Address:

PMOD/WRC
Dorfstrasse 33
7260 Davos Dorf

Contacts:

Julian Gröbner
Tel.: +41 81 417 51 57
Fax: +41 81 417 51 00
e-mail: julian.groebner@pmodwrc.ch

Stefan Wacker
Tel.: +41 81 417 51 33
Fax: +41 81 417 51 00
e-mail: stefan.wacker@pmodwrc.ch

Stephan Nyeki
Tel.: +41 81 417 51 39
Fax: +41 81 417 51 00
e-mail: stephan.nyeki@pmodwrc.ch