Name of research institute or organization:

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

Title of project:

Comprehensive Radiation Flux Assessment (CRUX)

Part of this programme:

GAW-CH

Project leader and team:

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Christine Aebi
Laurent Vuilleumier

Project description:

The objective of the project CRUX (Comprehensive Radiation Flux Assessment) is to analyse the effect of clouds on the radiation budget of the Earth and therefore on the climate system. This analysis is performed at three stations at three different altitude levels in Switzerland: Jungfraujoch (3471 m asl), Davos (1590 m asl) and Payerne (490 m asl). CRUX is financed by the Swiss contribution to the Global Atmosphere Watch Programme (GAW-CH) of the WMO.

At the aforementioned three stations the total solar and terrestrial irradiances are measured with pyranometers and pyrgeometers, respectively. Hemispherical all-sky cameras are used to calculate fractional cloud cover and to determine seven different cloud types by applying different algorithms (Wacker et al., 2015). The measure of the influence of clouds on the radiation budget of the Earth is the cloud radiative effect (CRE). CRE is defined as the difference between a surface radiation measurement and a clear sky model. CRE is determined for shortwave and longwave radiation and for all seven cloud types and stations separately.

In a first step, the CRE has been calculated for cases where only one cloud type is present. The corresponding values for the downwelling longwave cloud radiative effect (LCE) and the downwelling shortwave cloud radiative effect (SCE) for the Jungfraujoch are summarised in Table 1.

Table 1. Overview of the CRE in SW (SCE) and LW (LCE) for a cloud coverage of eight octas and the cloud types separately for Jungfraujoch (JFJ). In brackets are the 95 % confidence boundaries of the respective CRE.

Cloud type	**# cases**	**JFJ: LCE [W/m^2]**	**JFJ: SCE [W/m^2]**
Cirrus-Cirrostratus	91	19 (17, 21)	-42 (-66, -18)
Cirrocumulus-Altocumulus	54	48 (43, 53)	-79 (-149, -9)
Stratus-Altostratus	88	61 (57, 64)	-196 (-230, -163)
Cumulus	-	Not defined	Not defined
Stratocumulus	-	Not defined	Not defined
Cumulonimbus-Nimbostratus	-	Not defined	Not defined
Fog	101	79 (78, 81)	-352 (-412, -292)

The cloud class fog has with 79 W/m^2 the largest LCE, followed by Stratus-Altostratus (61 W/m^2), Cirrocumulus-Altocumulus (48 W/m^2) and Cirrus-Cirrostratus (19 W/m^2). Thus, the lower the cloud, the higher the LCE. The same conclusion is also applicable for the SCE, the lower the cloud, the larger the absolute value of the SCE. Low level clouds (e.g. Cumulus) are difficult to detect since their cloud base is often at a lower level than the instruments on the Jungfraujoch. Consequently, such situations are directly determined as fog.

In a second step, the calculation of the CRE has been expanded to a one year data set (August 2014 - June 2015) with a temporal resolution of ten minutes. For this period, all pictures have been taken into account, regardless the number of different cloud types present per time step. In 98 % of the time steps the cloud type fog has been detected and in the remaining 2 % the cloud class cirrus-cirrostratus. All the other cloud types have not been detected in this aforementioned period of eleven months. This fact shows the difficulty in the automatic detection of the cloud type on the Jungfraujoch. However, Figure 1 shows the LCE (left) per octa cloud coverage (yellow dots) and the SCE in percent (right) per octa cloud coverage for the automatic detected cloud class fog. The larger the cloud coverage, the larger the LCE. However, the correlations between LCE and cloud coverage as well as SCE and cloud coverage are both not linear. Also for the SCE, the larger the fractional cloud coverage the more negative the SCE values. In comparison to the values in Table 1, the LCE for a cloud coverage of eight octas is in the same range.

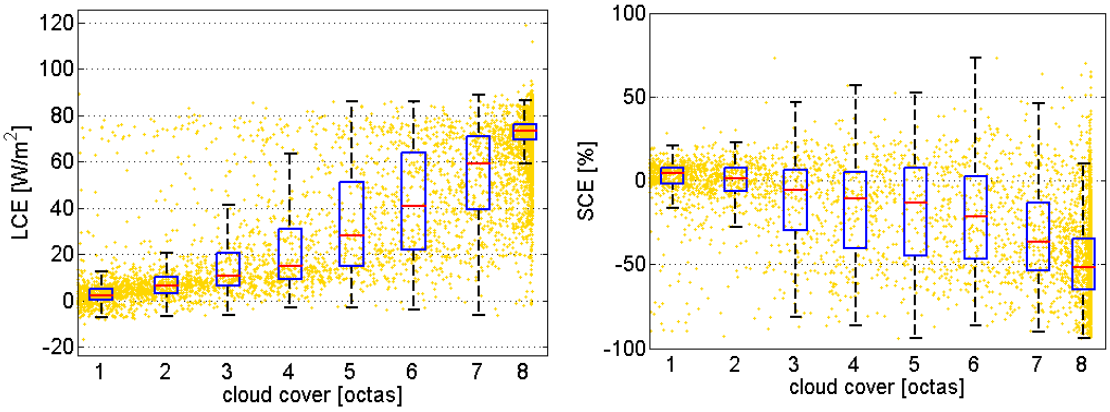

Figure 1. Correlation between cloud cover and longwave cloud effect (left; yellow dots) and cloud cover and shortwave cloud effect (right; yellow dots) for the cloud type fog for Jungfraujoch in the time period from August 1, 2014 to June 22, 2015. The median (red line), the 25- and 75-percentiles (blue box) and the spread (black line) are shown per octa cloud coverage. 1 octa: 5-18.74 %, 2 octa: 18.75-31.24 %, 3 octa: 31.25-43.74 %, 4 octa: 43.75-56.24 %, 5 octa: 56.25-68.74 %, 6 octa: 68.75-81.24 %, 7 octa: 81.25-93.74 %, 8 octa: 93.75-100 % cloud coverage.

Next steps will be the improvement of the cloud type detection algorithm in order to get a larger variety of cloud types. This improvement in necessary since it is not reasonable to detect the cloud type fog with a cloud coverage of for example one octa. One explanation for the wrong detection of the cloud type might be that the camera is not shaded and thus the picture is overexposed due to the sun. As soon as this problem is fixed it is planned to increase the calculation of the cloud radiative effect up to four years. As a last step it is planned to compare the results obtained at Jungfraujoch with the ones obtained in Davos and Payerne.

Key words:

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

Internet data bases:

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

Collaborating partners/networks:

MeteoSwiss

Scientific publications and public outreach 2015:

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. Atmos, **120**, 695-707, doi: 10.1002/2014JD022643, 2015. http://onlinelibrary.wiley.com/doi/10.1002/2014JD022643/abstract

Conference papers

Aebi Ch., J. Gröbner, N. Kämpfer and L. Vuilleumier, Cloud radiative effect in dependence on cloud type, poster presentation at EGU General Assembly, Vienna, Austria, April 12 – 17, 2015.

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