On the Use of NWP for Cloud Base Height Estimation in Cloud Camera-Based Solar Irradiance Nowcasting

Niels Killius[1], Christoph Prahl[2], Natalie Hanrieder[2], Stefan Wilbert[2], Marion Schroedter-Homscheidt[1]

[1]German Aerospace Center (DLR), German Remote Sensing Data Center (DFD), Oberpfaffenhofen, Germany
[2]German Aerospace Center (DLR), Institute of Solar Research (SF), Almería, Spain

contact: Niels.Killius@dlr.de

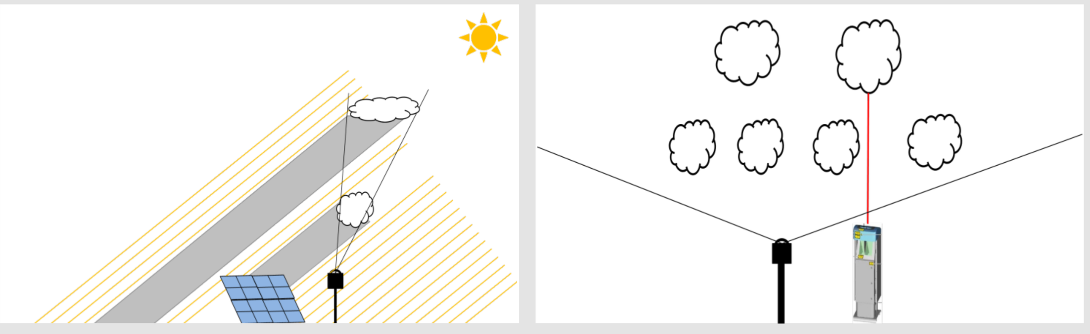

Fig. 1: Schematic Illustrations showing how cloud height determines the shadow location (left), and the possible error of cloud heights measured with a ceilometer (right).

Introduction

For the nowcasting of solar irradiance in solar power plants and for electricity grid control, sky cameras detecting cloud and cloud-free sky conditions are widely in use. Cloud base height (cbh) information is essential for the geolocation of any cloud feature detected and to determine the cloud speed relative to the ground. One quite precise source of cbh are ceilometers.

Ceilometer cbh is delivered as a single point measurement, but its value is often taken as "truth" for all clouds viewed by the camera – a procedure that may result in cbh errors for parts of the camera field of view. Cbh as a numerical weather prediction (NWP) output parameter surely is less accurate than a single point ceilometer measurement at the location of the instrument because of its spatial grid resolution. However, as NWP output is required anyhow for solar forecasting on the longer time horizon, the question arises if cbh from NWP can be used as an alternative to a ceilometer.

Methodology

To characterize errors occurring by taking one single point measurement for a whole cloud field of view, we analysed one year of data (from 5th November 2013 until 4th November 2014) from a Jenoptik CHM 15k - Nimbus ceilometer at the Plataforma Solar de Almería (PSA) with a temporal resolution of 15 seconds, creating cbh histograms for time intervals of various lengths (see example in Fig. 2). The tested time interval lengths represent the timespan that a cloud will need to cross the camera field of view, depending on cloud height and wind speed. For each time interval, the cbh variations can be regarded as a possible error that occurs when a single point ceilometer cbh is assigned to all clouds in the camera field of view. Then, ceilometer cbh mean values and variations are compared to cbh values delivered by ECMWF forecast (see Fig. 2). In a third step, the cloud retrieval APOLLO (Saunders & Kriebel,1988 , Kriebel et al., 2003) is used to separate overcast cases from those with broken clouds.

Conclusions and outlook

The density scatter plots in Figures 3 and 4 show a large spread in ceilometer cbh and ECMWF cbh during the observation period. In 50 % of all cases, cbh difference between ceilometer and ECMWF is below 1.5 km. In 18% of all cases, ECMWF cbh is within the ceilometer min/max interval. Other statistic numbers are listed in Table 1. We plan to extend the study to other locations.

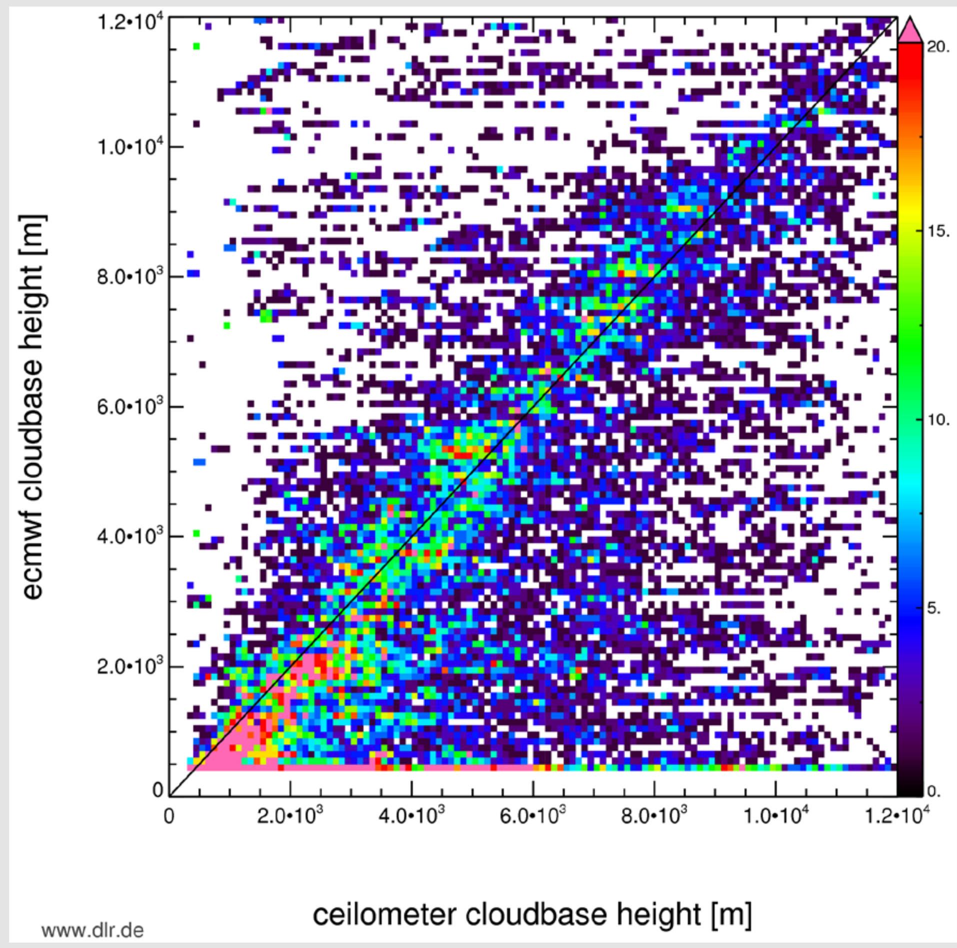

Fig. 3: Density scatter plot of the full observation period. Bin size is 100m.

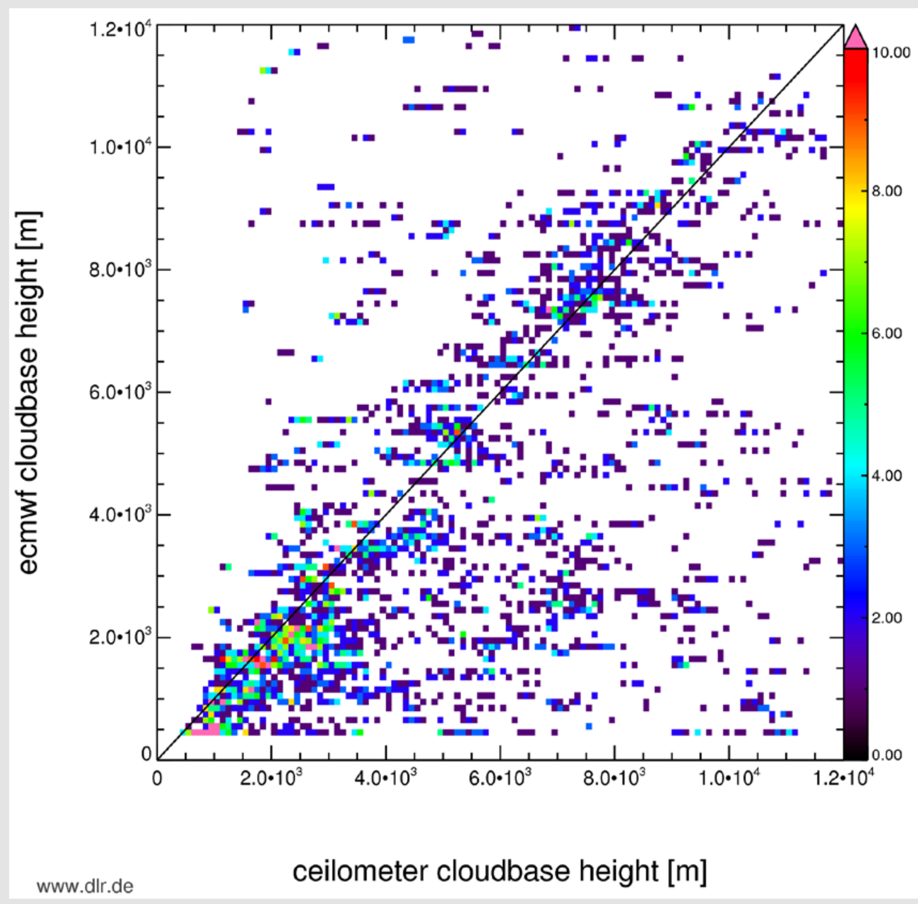

Fig. 4: Same as Fig. 3, but scattered cloud situations only.

	All cases	scattered
Rmsd	5527.28	5537.46
Bias	1092.44	1177.19
Pearson corr.	0.50	0.43

Tab. 1: Some statistic numbers for all cases, and for scattered cloud situations only.

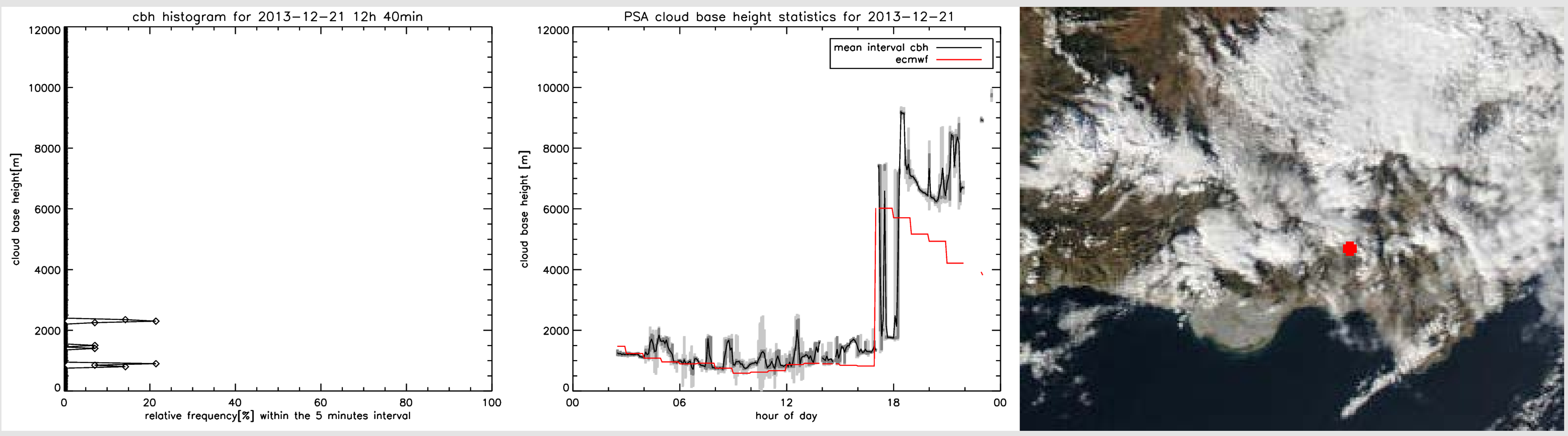

Fig. 2: Left: Ceilometer cbh histogram from 21st December 2013, 12:40 CET. Time interval length is 5 minutes. Middle: Comparison of ceilometer cbh and ECMWF cbh for 21st December 2013. Area between the 25% and 75% percentile is shaded in dark grey, min to max cbh for each time interval is shaded in bright grey. Right: MODIS image from Aqua satellite, showing cloud situation around Plataforma Solar de Almería (PSA) at 21st December 2013, 13:10 UTC. PSA is marked with a red dot.

References:

Kriebel, K.T., Gesell, G., Kästner, M., and Mannstein, H.: The cloud analysis tool APOLLO: improvements and validations, Int. J. Rem. Sens., 24, 2389-2408, 2003.

Saunders, R.W., and Kriebel, K.T.: An improved method for detecting clear sky and cloudy radiances from AVHRR data, Int. J. Remote Sens., 123-150, 9, 1988.

DLR Deutsches Zentrum für Luft- und Raumfahrt