Cloud cover estimation based on ceilometer measurements: a comparison with visual observations

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1. Introduction

In the present study, we analyze the temporal averaging of ceilometer data as an estimator of cloud cover (CC), given that a measured cloud base height (CBH) means that there is a cloud occurrence overhead (CO). Although standard ceilometers only see in the zenithal direction, clouds usually move, so a temporal averaging of occurrence measurements must be an approximation of the areal extension of clouds [1].

Eight years (2007-2014) of CO from ceilometer measurements at a site in Girona (Spain) are compared with the corresponding human CC observations at the airport nearby. The comparison of the total cloud cover (TCC) and low clouds cover (LCC) is performed on one hand in daily mean basis, and then at the time when the instantaneously observations where done (i.e.: 7, 13 and 18 h), for which 15 different time periods have been tested for the temporal averaging.

2. Methodology

Cloud cover estimations from the “Agencia Estatal de Meteorología” (AEMET) made at Girona - Costa Brava Airport (41.96°N, 2.77°E) have been compared with cloud cover estimations from a Vaisala ceilometer CL-31 located in the roof of the Polytechnical School of the University of Girona (41.96°N, 2.83°E) [2] (distance: 10 km).

The ceilometer laser emits at a central wavelength of 910 ± 10 nm, and by analyzing the received backscatter signal it can retrieve up to 3 CBH every 12 s. It is able to detect clouds up to ~7500m, and it was configured with a height resolution of 10 m.

3. Results:

Frequency distributions of daily mean TCC and LCC for the airport observations and the ceilometer estimations for the whole period of years (2007-2014):

Mean coefficient of determination between the cloud cover observed in the airport and the cloud occurrence measured with the ceilometer (daily means) for the period 2007-2014 is 0.70 (and 0.61 for low clouds). The mean bias is -0.79 (-0.65 for low clouds).

Results for instantaneous observations, for each of the 3 obs. times:

4. Conclusions and future work

The results are encouraging since the correlation (det. coeff) for the period 2007-2014 between the daily mean TCC observed at the airport and the CO measured with the ceilometer is 0.70 and 0.61 for LCC.

However, there is a clear tendency of the ceilometer to underestimate TCC and LCC (negative biases: -0.79 and -0.60 oktas respectively), probably due to its limited range (7.5km) and the consequent missing of high clouds [2]. This behavior has been already found in the past e.g. when ASCOS meteorological network was implemented in the US [3]. In particular, the ceilometer detects a larger amount of clear or almost clear cases (≤ 1 okta) than the observations (Fig. 2). The highest bias values are found between April and September. In the future, an expression to correct the estimate of CC from CO will be suggested.

• 15 time periods (from 5min to 360min) have been analyzed to estimate CO to be compared to instantaneous observations of CC. For short time periods (<60min) the correlation values are lower than for the longer ones, whereas the optimum time lapse seems to be usually, but not in all cases, around 300 min. So, the next step will be to look for the optimum time period. It will not only be based on $r^2$ but on a combination with other statistics (see box in Fig. 5). Future studies will also be done regarding the level of CC. Therefore, eventually stabilizing different optimal time lapses for clear sky, broken clouds, and overcasts cases.

• In general, better estimation of TCC than LCC is found despite that the ceilometer should better detect the low clouds (note that its range is up to 7.5 km). Nevertheless, their particular nature (e.g. usually scattered, short lifetime) makes them become difficult to detect, so sometimes low clouds can be missed by the ceilometer [3].

• Despite the differences found and the limitations described, this kind of studies are of interest to extend long-term traditional measurements of CC as the number of human observers at meteorological stations tends to decrease, while the number of ceilometers is increasing.

References


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