Clouds intervene in the energy and water balances in the atmosphere through multiple, intricate processes, affecting in turn the climate balance and its change. Therefore, reliable descriptions of cloud climatology and trends are crucial to understand climate change, and to test climate models. In the past, observations of cloud amount and typology have been performed by human observers at selected stations, giving place to many long-term cloud climatologies. Besides, other modern methodologies to monitoring cloudiness from earth surface, as those based on ceilometer measurements and on digital cameras, are receiving increasing interest. In this work we present a comparison among these methodologies, taken out from a year of observations at Girona (NE of Iberian Peninsula). Diurnal periods from 10:00 to 16:00 UTC, have been included in the analyses; these periods are centered at 13:00 UTC, a mandatory time for human observations of cloudiness at official meteorological stations. Also human observations at a nearby site have been available in the comparison.

### 2. Original data

#### At the Airport (10 km away)
- Human observations at 7, 13, and 18 h
- Visual inspection
- Estimation of Total Cloud Cover (TCC) and Low Cloud Cover (LCC) every hour in the 10-16 h interval
- At 13 h: TCC, LCC
- TCC, WSC
- WSC

#### Clouds
- Conversion to okta
- Total Cloud Occurrence (TCC)
- Average 10-16 h
- TCO

#### LCC
- Average 10-16 h
- LCC

#### Ceilometer data
- TCC and WSC av
- TCC and WSC
- WSC
- TCO

### 3. Building the daily series

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cover</th>
<th>Location</th>
<th>Source</th>
<th>Time/Period</th>
<th>Aggregation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCC_OBS_13</td>
<td>Total</td>
<td>Airport</td>
<td>Observer</td>
<td>13 h</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>LCC_OBS_13</td>
<td>Low</td>
<td>Airport</td>
<td>Observer</td>
<td>13 h</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>TCC_WSC_13</td>
<td>Total</td>
<td>GFA station</td>
<td>WSC</td>
<td>13 h</td>
<td>Instantaneous</td>
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<tr>
<td>TCC_WSC_av</td>
<td>Total</td>
<td>GFA station</td>
<td>WSC</td>
<td>10-16 h</td>
<td>Average</td>
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<tr>
<td>LCC_WSC_av</td>
<td>Low</td>
<td>GFA station</td>
<td>WSC</td>
<td>10-16 h</td>
<td>Average</td>
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<td>TCC_CEL_av</td>
<td>Occurrence</td>
<td>GFA station</td>
<td>C131</td>
<td>10-16 h</td>
<td>Average</td>
</tr>
</tbody>
</table>

### 4. Results: daily comparison

- TCC and TCO:
  - TCC: 2007-2008
  - TCO: 2007-2008
  - LCC: 2007-2008

- When assessing the total cloud cover fraction (TCC) and low cloud cover fraction (LCC) on daily scale the mean deviation between the methods are quite small, only tenths of okta, with the exception of the method based on the ceilometer TCO, which underestimates the TCC used as a reference by more than one okta.

### 4.2 Results: monthly comparison

- TCC: evaluation at 13 h is very representative of the 10-16h period. Observations 10 km away gives slight <1 okta differences. TCO clearly underestimates (>1 okta). LCC: TCO is also a very good estimator

### 5. Summary and conclusions

We have presented a comparison between TCC and LCC evaluated at Girona with different techniques: human observations at a nearby site, analysis of camera images and cloud occurrence in ceilometer measurements. The average TCC and LCC obtained by inspection of images in the period from 10 to 16 h have been taken as the references.

The TCC and LCC obtained from the single image taken at 13h are very representative of the average TCC and LCC along the period from 10 to 16 h. Also the human observations at the Airport give a good mean estimation of both TCC and LCC estimated at Girona from the camera images. Relative high dispersion is found when comparing series day by day.

TCC clearly underestimates the mean TCC (as expected from the ceilometer limitations in field of view and detection altitude range). Contrarily, TCO constitutes a reasonably good estimator of mean LCC, at least for monthly averages.

Results show that despite their limitations, ceilometers allow describing some sky conditions more satisfactorily than by performing only single visual observations. TCO estimation of daily LCC is (when compared to the reference) better than the estimation with the image inspection at 13 h in 31% of cases. It is also better than the human observations at the Airport at 13 h in 43% of cases.

Future work: compare against co-located human observations, extend analysis to night-time periods (with a camera system with tunable exposition), analyze accurately the cases of remarkable disagreement between methods.

### References


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