Use of Ceilometer Data for Cloud Validation

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AEMET Ceilometer Network

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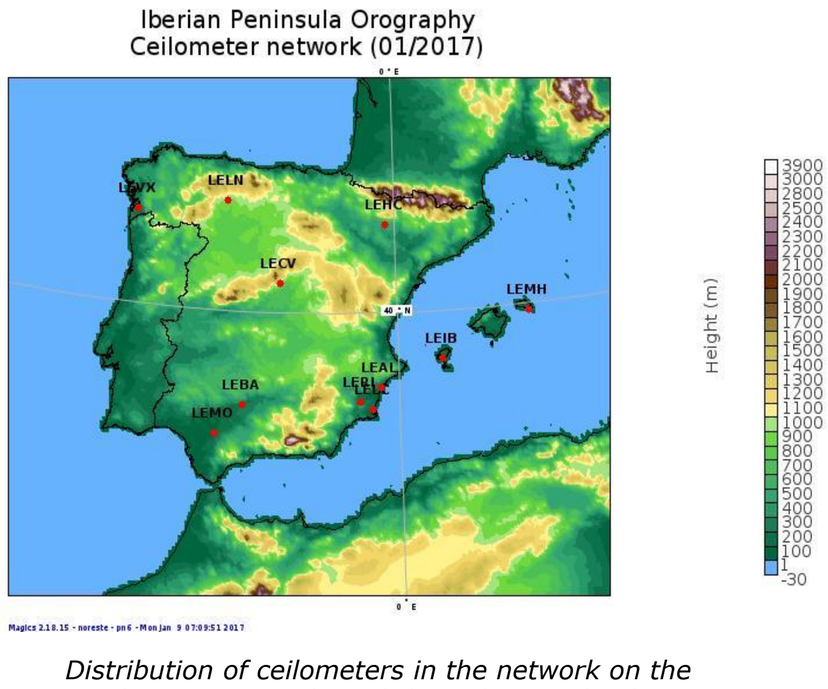
- Type of Ceilometers: Vaisala CL31 (Wavelength: 910 nm)
- Number of airports: 11 (Iberian Peninsula and Balearic Islands)
- The ceilometers send data every 10 minutes to the AEMET headquarters
- Main purpose is the aerosol detection
- In collaboration with EUMETNET E-PROFILE program



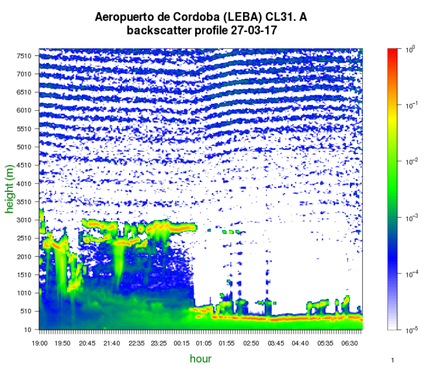
Distribution of ceilometers in the network on the Iberian Peninsula and the Balearic Islands

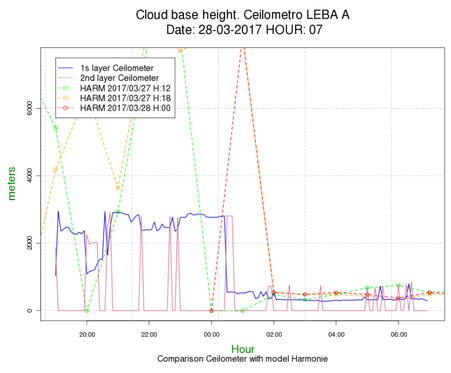
Ceilometer Data

Cloud Base Height: The ceilometers give the instantaneous base height of up to 3 cloud layers. Maximum height: 6000 m

Vertical Visibility: In case of precipitation or fog the ceilometer reports the vertical visibility

Backscatter profile: The signal returned from the atmosphere due to Rayleigh scattering or to the aerosol and cloud droplets

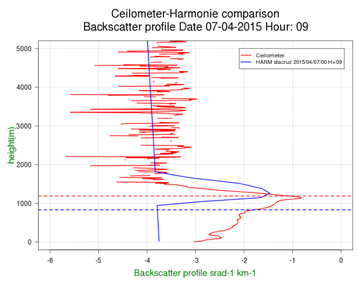




Left: *Quick look of backscatter profile for a 12 hour period*
Right: *Instantaneous height of the 2 lower cloud layers measured by the ceilometer compared with model output.*

Backscatter from model

Backscatter profile from model data. The two main contributions to the backscatter profile, apart from the solid particle aerosol:
- The Rayleigh scattering obtained from the temperature and pressure profiles.
- The scattering by the cloud droplets. The liquid water content is used for it.



Comparison of backscatter profiles, in red the one of the ceilometer and in blue the one obtained from model data. Difference in BL are due to aerosol.

CLOUD ALGORITHM (applied to ceilometer data)

Cloud cover algorithm

In order to compare the model with the ceilometer data, it is needed to obtain the cloud cover and the cloud base height from them.

- Cloud cover calculation based on algorithm reported by Larsson and Esbjörn (1995) and Wauben
- Uses cloud base height of the three layers (C1, C2, C3) and visibility (VV) of the last **30 min**
- Give data of last 10 minutes double weight
- Parameter valid only if 75% of data is available
- The total weight of clouds of the lower cloud layer given by the ceilometer (C1) determines the total cloud cover

Cloud base height

The model and the METAR consider the cloud base height as that of the lower layer covering more than 4 octas of the sky. The algorithm characteristics are:

- Up to 4 layers can be obtained
- In order to distinguish between two layers, the distance between them is fixed to be 250 m or 20 percent of the cloud base height.
- The cloud base will be the one of the lower layer with more than **4 octas coverage**.

Biblio: *Wauben, W.M.F., KNMI, Automatation of visual observations at KNMI*

Larsson, B. and Esbjörn, E., 1995, SMHI, Cloud Cover Algorithm.

COMPARISON RESULTS (ceilometer vs. METAR)

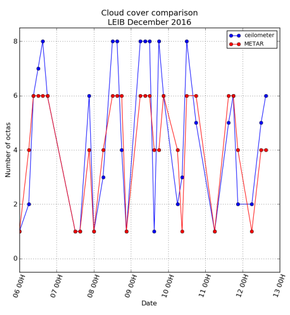
CLOUD COVER. (Ceilometer vs. METAR)

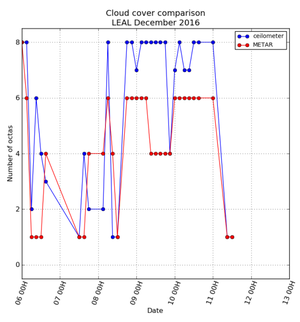
Comparison of the calculated cloud cover from ceilometer data with cloud cover from METAR.

For cloud cover METAR messages only report:
- FEW: 1 to 2 octas
- SCT: 3 to 4 octas
- BKN: 5 to 7 octas
- OVC: 8 octas

METAR \ CEILOMETERS	0	1	2	3	4	5	6	7	8	TOTAL
0	0	0	0	0	0		0	0	0	0
1	0	76	0	0	28	0	36	0	37	177
2	0	0	0	0	0		0	0	0	0
3	0	0	0	0	0		0	0	0	0
4	0	35	0	0	28	0	64	0	61	188
5	0	0	0	0	0		0	0	0	0
6	0	2	0	0	9		101	0	198	310
7	0	0	0	0	0		0	0	0	0
8	0	0	0	0	0		5	0	68	73
TOTAL	0	113	0	0	65	0	206	0	364	748

Table showing the comparison of cloud cover observed by METAR and Ceilometer for Dec 2016 and 9 airports.





Cloud cover. Time plot comparison for the airports of Ibiza (LEIB) and Alicante (LEAL) for a 7 days period.

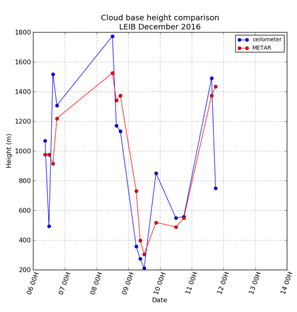
The algorithm seems to overestimate the cloud cover mainly for high coverage.

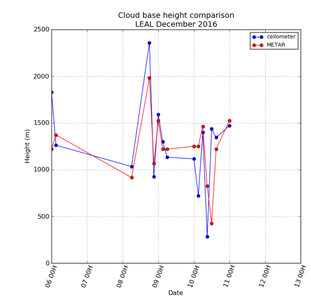
CLOUD BASE HEIGHT. (Ceilometer vs. METAR)

Cloud base height. Similar results are obtained (METAR messages often take the height from ceilometer observation).

The table on the right and the plots bellow show this agreement.

METAR \ CEILOMETERS	<50	<100	<200	<300	<600	<1000	<1500	<2000	<2500	>2500	TOTAL
<50	2	2	0	0	0	0	0	0	0	1	5
<100	1	7	1	0	0	0	0	0	0	0	9
<200	0	0	2	0	0	0	0	0	0	0	2
<300	0	0	3	7	1	0	1	0	0	0	12
<600	0	0	0	10	36	2	1	0	0	0	49
<1000	0	0	0	10	24	68	3	3	1	2	109
<1500	0	0	0	0	8	36	81	7	8	2	142
<2000	0	0	0	1	3	3	18	14	2	0	41
<2500	0	0	0	0	0	0	0	0	2	1	3
>2500	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	9	6	28	72	107	104	24	13	6	372



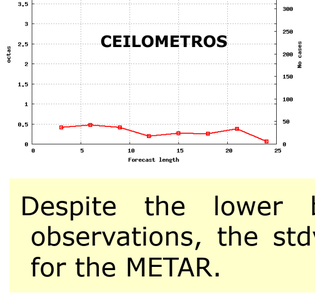


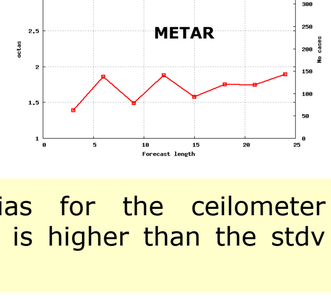
Cloud base height. Time plot comparison (Ceilometer vs. METAR) for the airports of Ibiza (LEIB) and Alicante (LEAL) for a 7 days period.

HARMONIE VERIFICATION

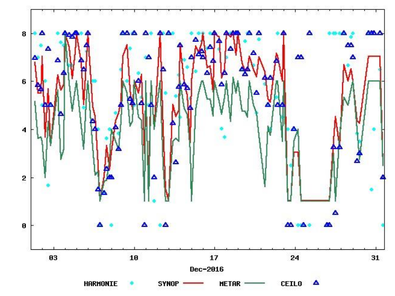
CLOUD COVER

- Model verification of the cloud cover against the ceilometer and the METAR observations.
- Period: 1 month. Dec 2016.
- Model Cycle 40h11.
- Number of stations:7
- Monitor software





Despite the lower bias for the ceilometer observations, the stdv is higher than the stdv for the METAR.

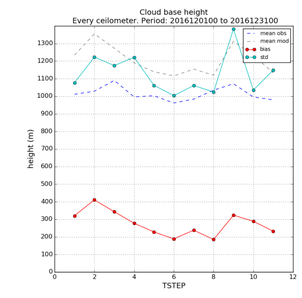


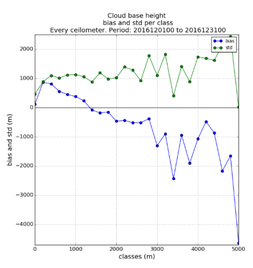
Time plot comparing model (AIB) against METAR, SYNOP and Ceilometer observations.

The time plot shows that the model seems to follow the cloud cover given by the ceilometers closer than the one obtained from METAR messages.

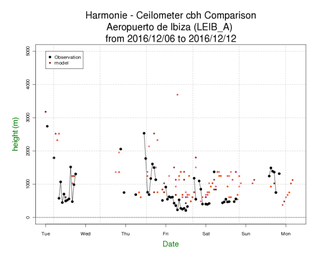
CLOUD BASE HEIGHT

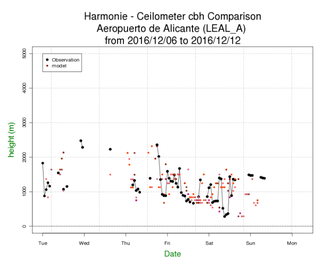
- The cloud base height calculated from the ceilometers has been used for model verification
- Number of ceilometers considered:8
- Model cycle: 40h11b5
- Period of time: Dec 2016



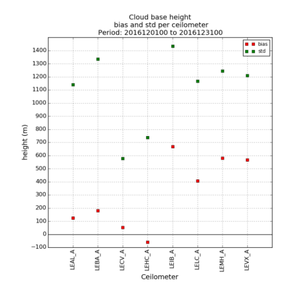


- For the cloud base height the model has a positive bias for every forecast length.
- For heights over 1200 m. the bias becomes negative.
- There is little dependence of the stdv with height.





Cloud base height. Time plot Model-Ceilometer comparison for the airports of Ibiza (LEIB) and Alicante (LEAL) for a 7 days period.

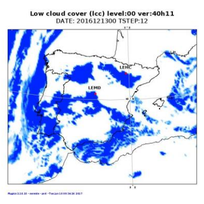


In general, the coastal locations have higher stdv and bias than the interior locations.

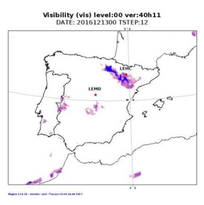
Vertical Visibility

The vertical visibility given by the ceilometers has been compared with the visibility given by the model and the one of the METAR for a single case.

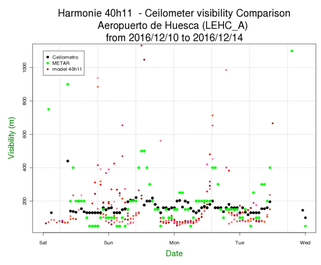
Fog at the airport of Huesca from Dec 10th until Dec 14th.



Low clouds



Visibility



The time plot shows:

- Vertical visibility from ceilometer is comparable with the METAR visibility
- The visibility given by the model seems to be lower in most cases.

CONCLUSIONS

- The ceilometers are valid instruments for cloud verification due to the continuous operation, the distribution of the instruments and reliability of the measurements.
- The basic ideas of the cloud cover algorithm applied to the ceilometer data seems to be appropriate, although some study is needed in order to correct the cases of overestimation.
- The cloud base height verification of the model shows a positive bias in most of the cases, mainly on islands and coastal areas
- The vertical visibility given by the ceilometers seems to be comparable to the one obtained with other instrumentation.
- The visibility given by the model seems to be lower in most cases.
- It must be taken into account that only one month verification has been done.

Use of ceilometer data for cloud validation

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