Model - Ceilometer Network: Comparison of cloud base height and visibility

Daniel Martin (AEMET)

Cloud Workshop, 16-18 January 2016,Toulouse

Outline

- AEMET Ceilometer Network
- Backscatter profiles from Ceilometers
- Comparison cloud base height with the model
- Fog cases, visibility from ceilometers.

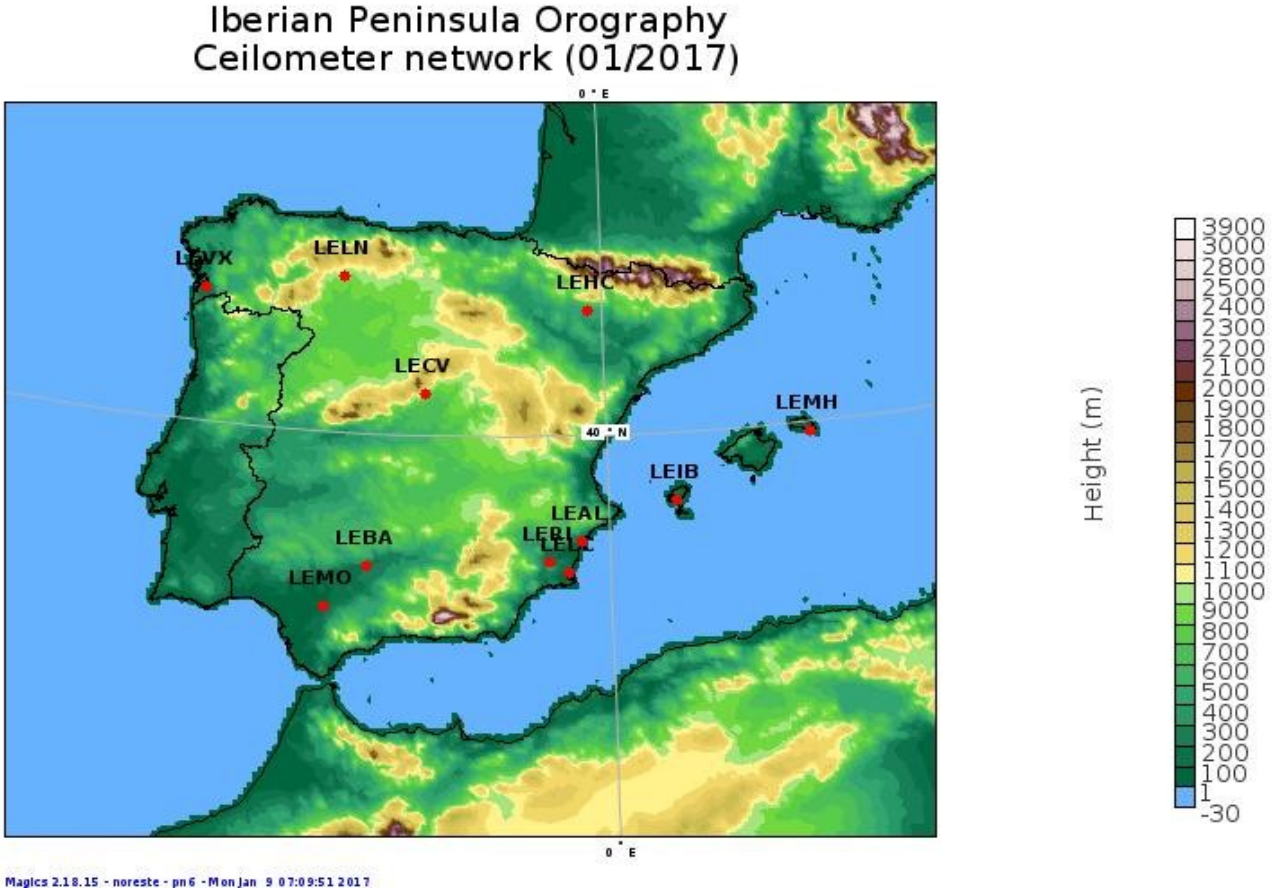
Ceilometer Network

- Ceilometer network
  - Type of ceilometers: Vaisala CL31 (Wavelenght: 910 nm)
  - Number of airports: 11 (Iberian peninsula and balearic islands).
  - The ceilometers send the data every 10 minutes to the headquarters.
  - Main purpose: Aerosol detection
  - Program E-PROFILE

    http://eumetnet.eu/activities/observations-programme/current-activities/e-profile/alc-network/
  - Calibration of the profiles is done in the hub of E-PROFILE where the files are sent to.

Ceilometer Network

- Distribution of Ceilometers (01/2017)
  - Lack of ceilometer at the valleys convenient for fog studies.
  - Ceilometers are keeping incorporating to the Network

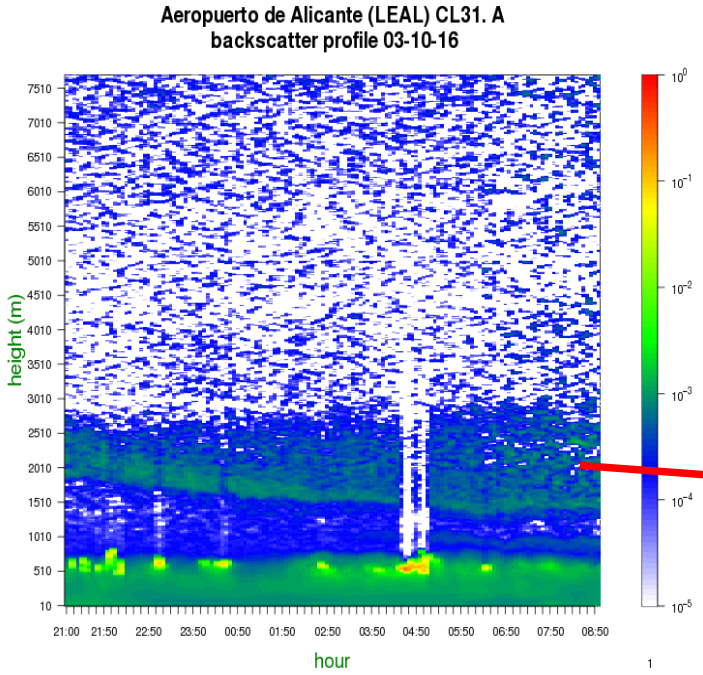


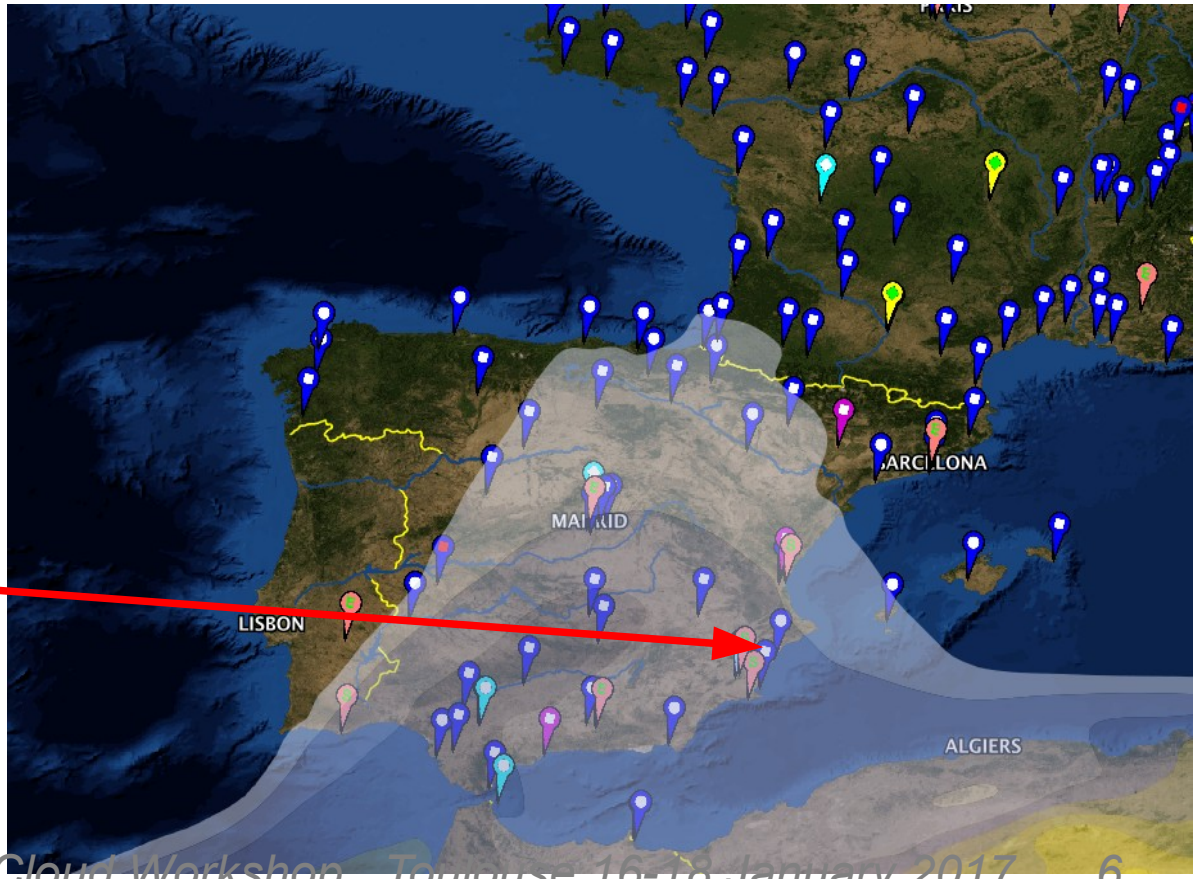
Ceilometer Network

- Information received from the ceilometers:
  - Observations every 30s.
  - Observations are cat in files that are sent to the headquarters every 10 minutes.
  - These files contain:
    - backscatter profiles (Intensity of light scattered at every height).
    - cloud base height (cbh) obtained with the Vaisala algorithm (takes the maximum value of the profile as the cbh.)
    - **Vertical visibility on the surface** for cases when the cbh is not detected (fog cases)
  - This permits to have a continous measurement of the cloud base height.

Ceilometer Network

- Aerosol detection case (03/10/2016)
  - The ceilometers are valid instruments for aerosol detection, although the information that give is not complete.
  - In this example, it can be seen an aerosol layer over de boundary layer.
  - http://www.dwd.de/DE/forschung/projekte/ceilomap/ceilomap_node.html





Backscatter profiles from model.

On April 2015 one Vaisala CL31 was sent to Sta Cruz de Tenerife for an intercomparison with the Vaisala CL51 installed there.

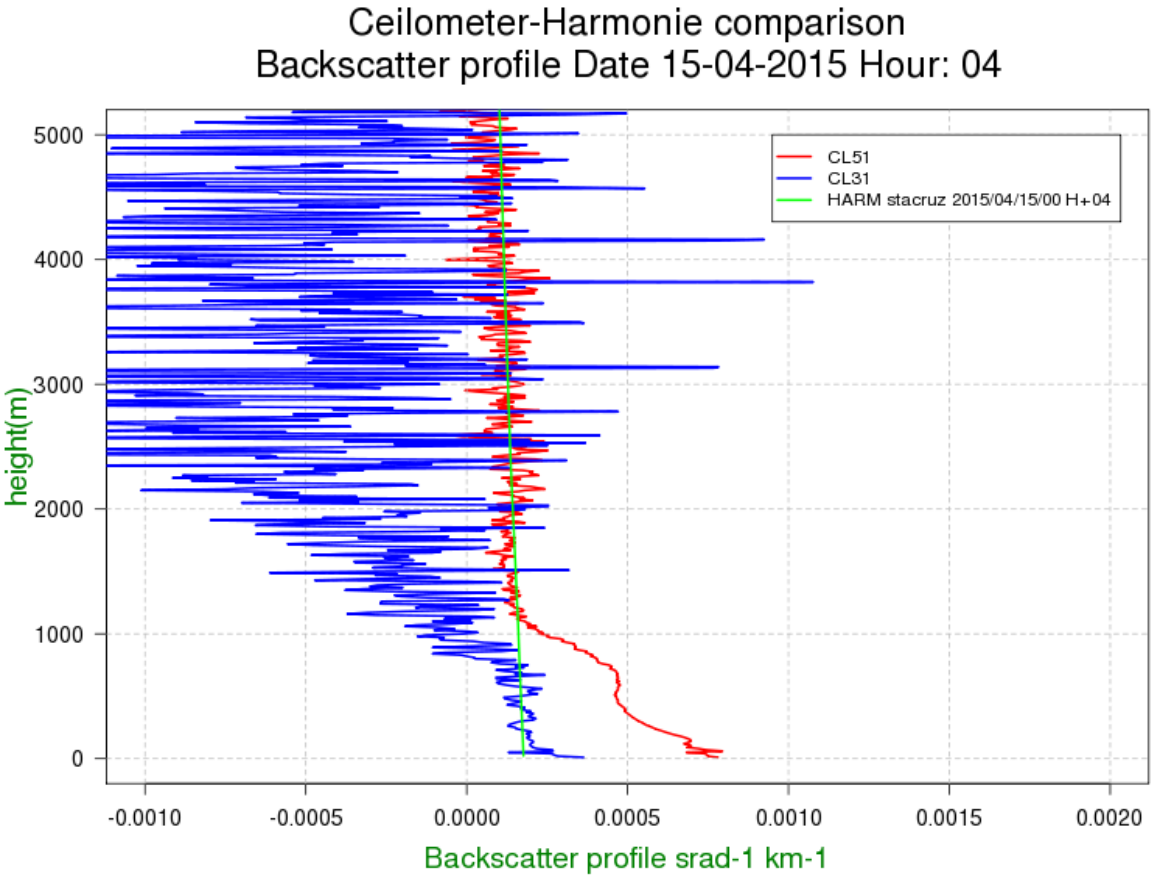
Rayleigh Scattering

Fujii T and Fukuchi T.: Laser Remote Sensing.

$$\beta(\pi,\lambda,z)=\sigma_R(\pi,\lambda)n_R(z)=2.938\times10^{-3}\frac{P(z)}{T(z)}\frac{1}{\lambda^{4.0117}}$$

Backscatter profile of the ceilometers CL51(red) and CL31(blue) compared with the **Rayleigh scattering (green) obteined from the temperarure and pressure variables of v38h12** of Harmonie for Sta Cruz de Tenerife.

An offset was detected for Ceilometer CL31.



Backscatter profiles from model.

Backscatter profile obtained from model variables (T, P + LWC)

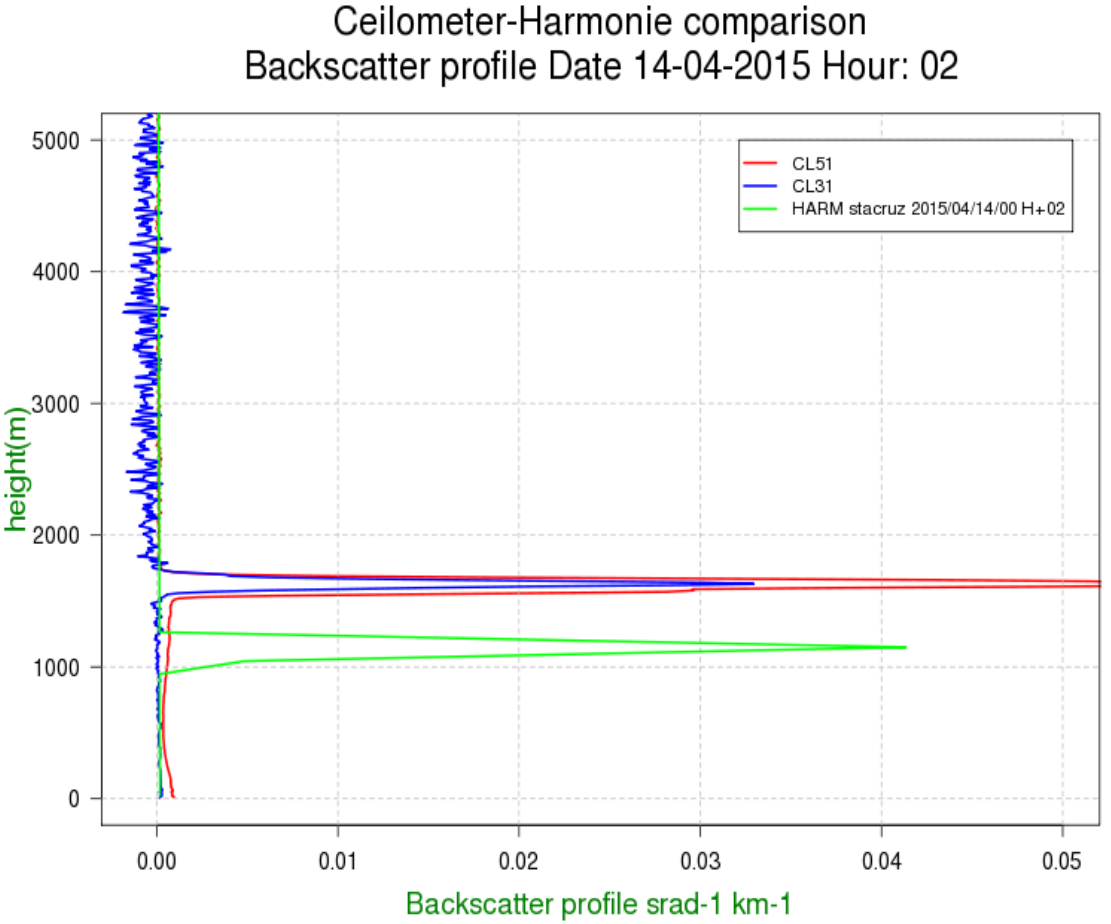
$$\beta_{att} = k\,\sigma(z)\exp\{-2\int_0^z \sigma(z')\,dz'\}$$

being k=0.03 and the extinction coeficient:

$$\sigma(z) = \frac{LWC(z)}{\rho_w}\,\frac{3\,\mu(\mu+2)(\mu+1)}{2\,a_0}\,\frac{\Gamma(\mu+1)}{\Gamma(\mu+4)}$$

A modified gamma distribution (Kokhanovsky, 2006) for the cloud droplets size has been considered

$$f(a) = \frac{\mu^{\mu+1}}{\Gamma(\mu+1)\,a_0^{\mu+1}}\,a^{\mu}\,e^{-\mu(a/a_0)}$$



cloud parameter	Continental clouds	**Marine clouds**	Average
N, cm-3	254,0	**91,0**	172,5
LWC, gm-3	0,2	**0,17**	0,185
a_0, µm	4,0	**6,0**	5,0
µ	7,0	**8,0**	7,5

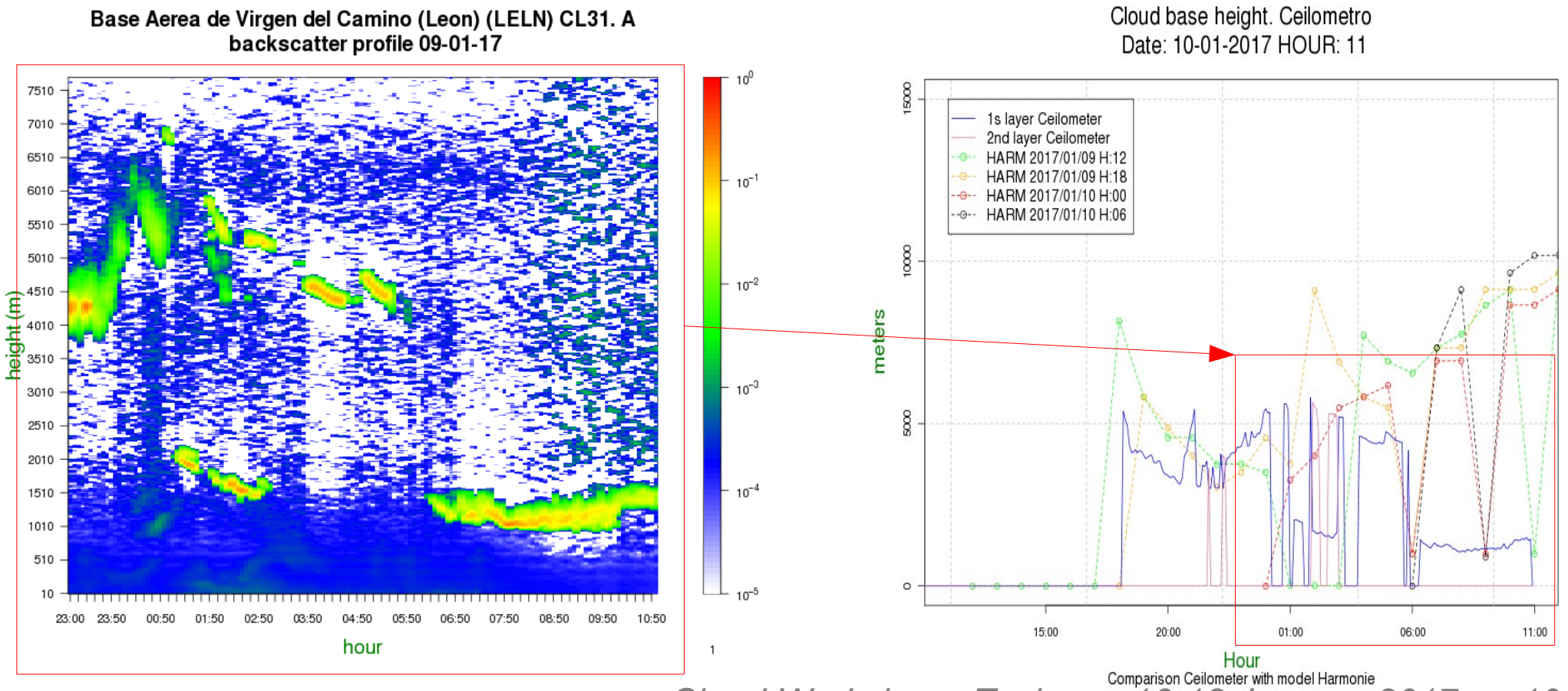
From Kokhanovsky, 2006, with data from Miles et al., 2000.

Cloud base height comparison with ceilometer data.

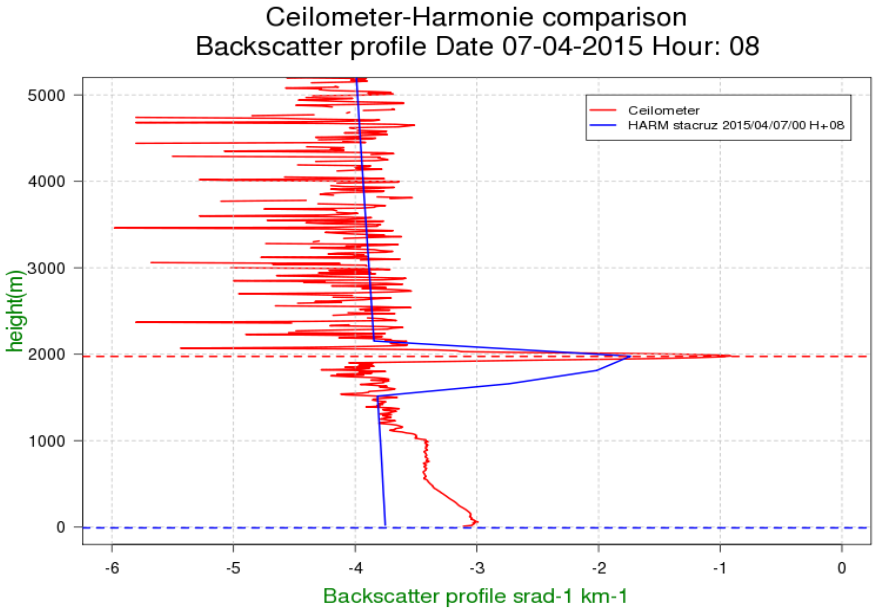
- Comparison Observation-Model
  - Period of time: 41 Days from 20161016
  - Model versions: 38h11 and 40h11b5
  - Time steps: 24.
  - Number of ceilometers: 12 at 9 airports.
  - It has been stablished an upper limit of 6000 m. The ceilometer seems not to detect over this limit.
  - For the comparison it has been calculated the mean value of the ceilometer measurement for periods of 5 minutes.

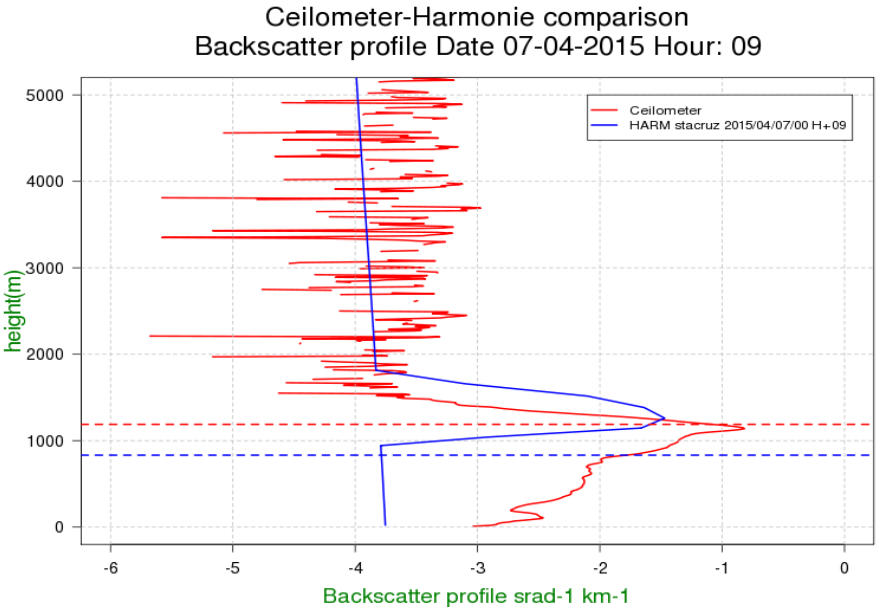
Cloud base height comparison with ceilometer data.

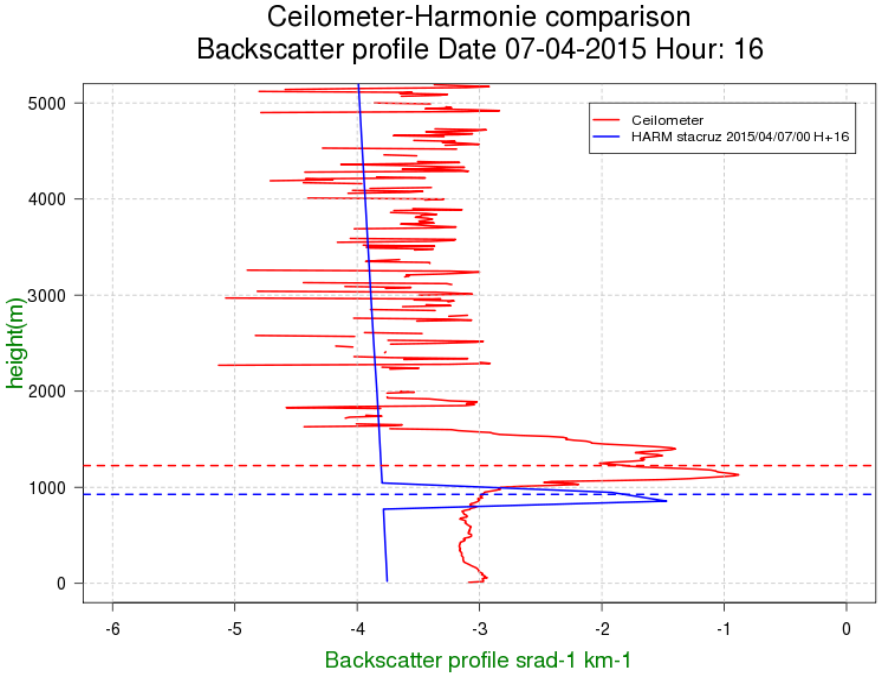
- The ceilometer gives up to 3 cloud layers
- This fact cause difficulties when we try to obtain the mean value for periods of time.



Cloud base height comparison with ceilometer data.







Some problems have been detected

Top left: Maximum coincidence but the model doesn't give a cbh value

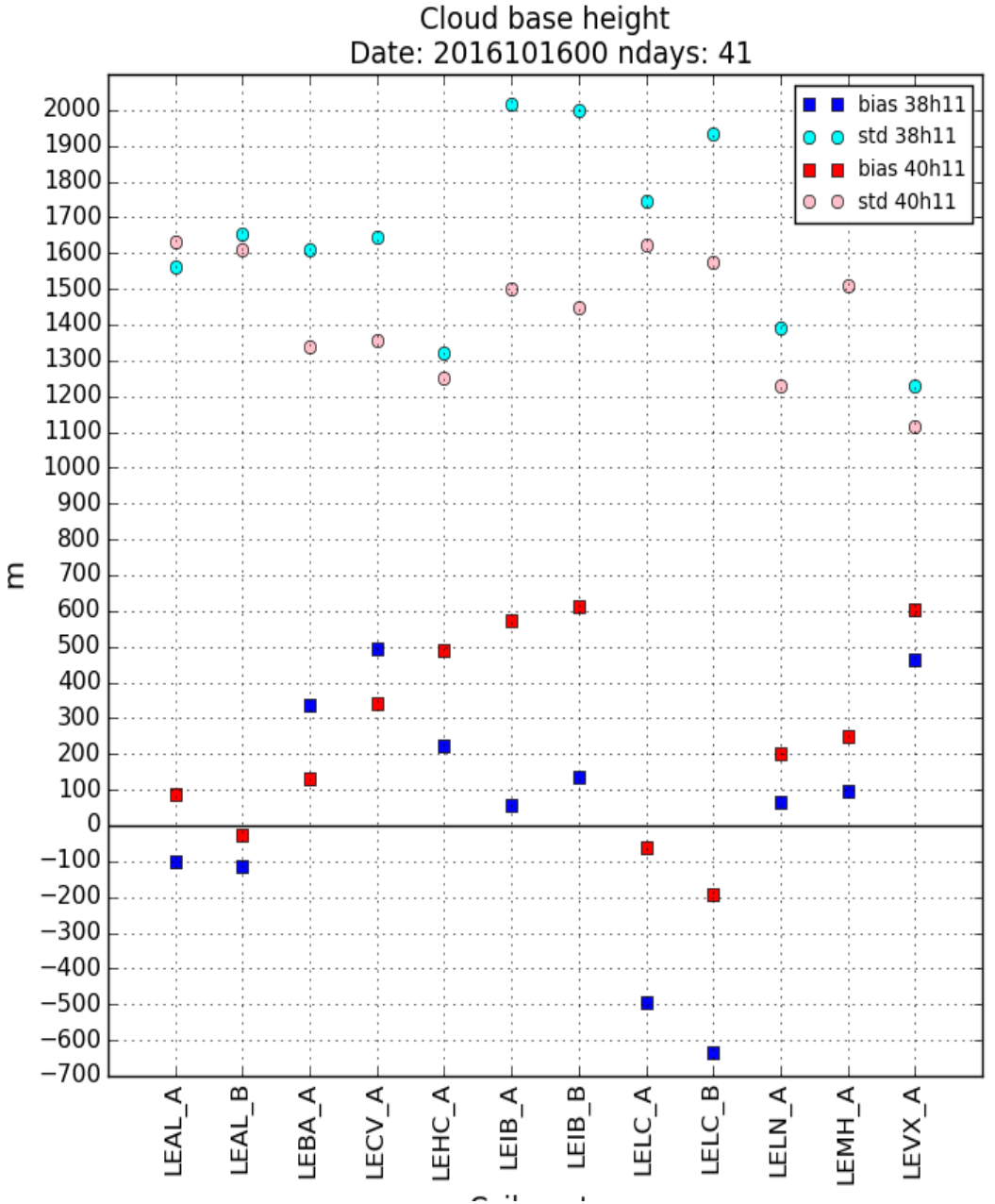
Top right: The cbh given by the ceilometer is given at the maximum of the signal, but not for the model.

Bottom left: Not always the cbh given by the model is at the bottom of the “cloud”.

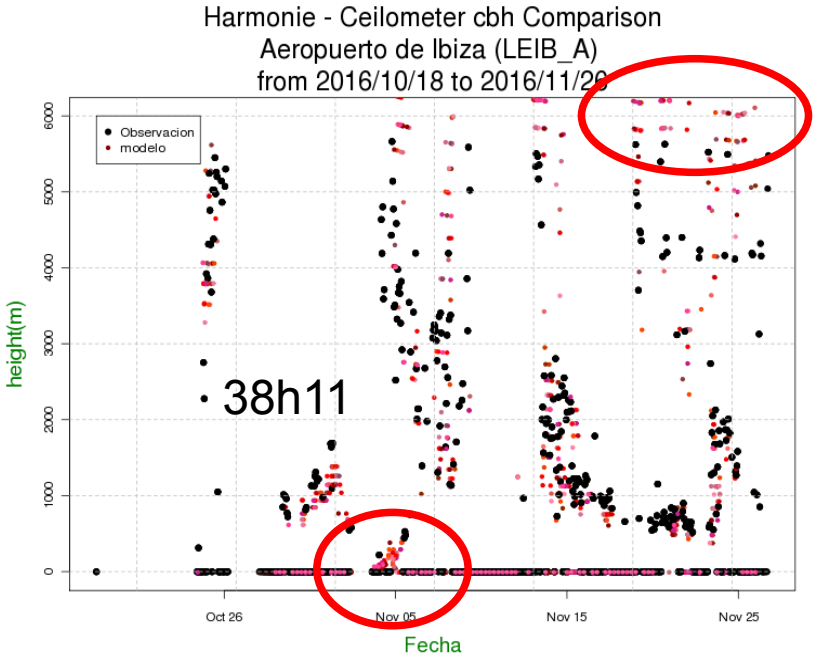
(logarithmic scale)

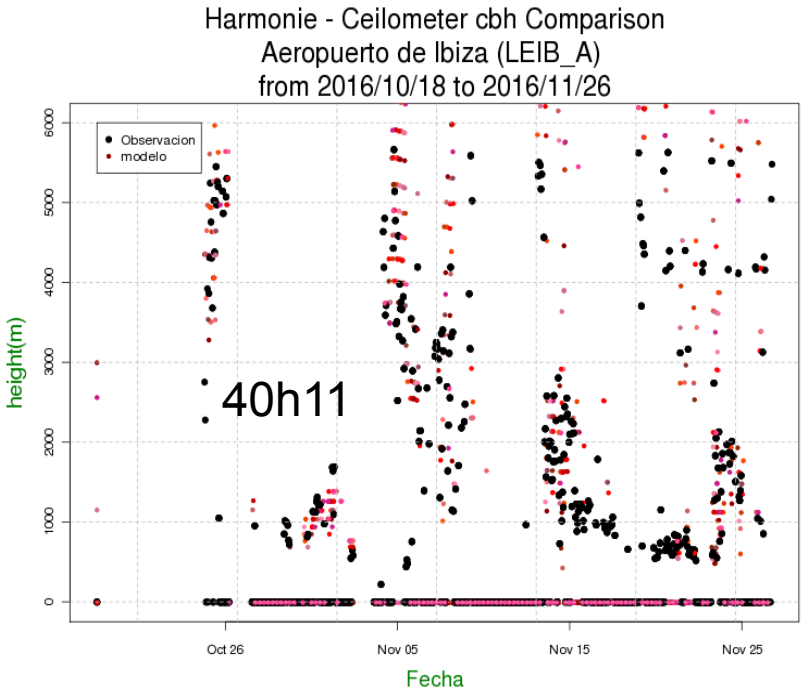
Cloud base height comparison with ceilometer data.

- Comparison Observation-Model
  - Bias and std have been calculated for the each ceilometer.
  - *Bias: none of the versions seems to give better results than the other*
  - *Standard deviarion: 40h11 seems to perform better.*
  - The case of Ibiza (LEIB) is analyzed.



Cloud base height comparison with ceilometer data.

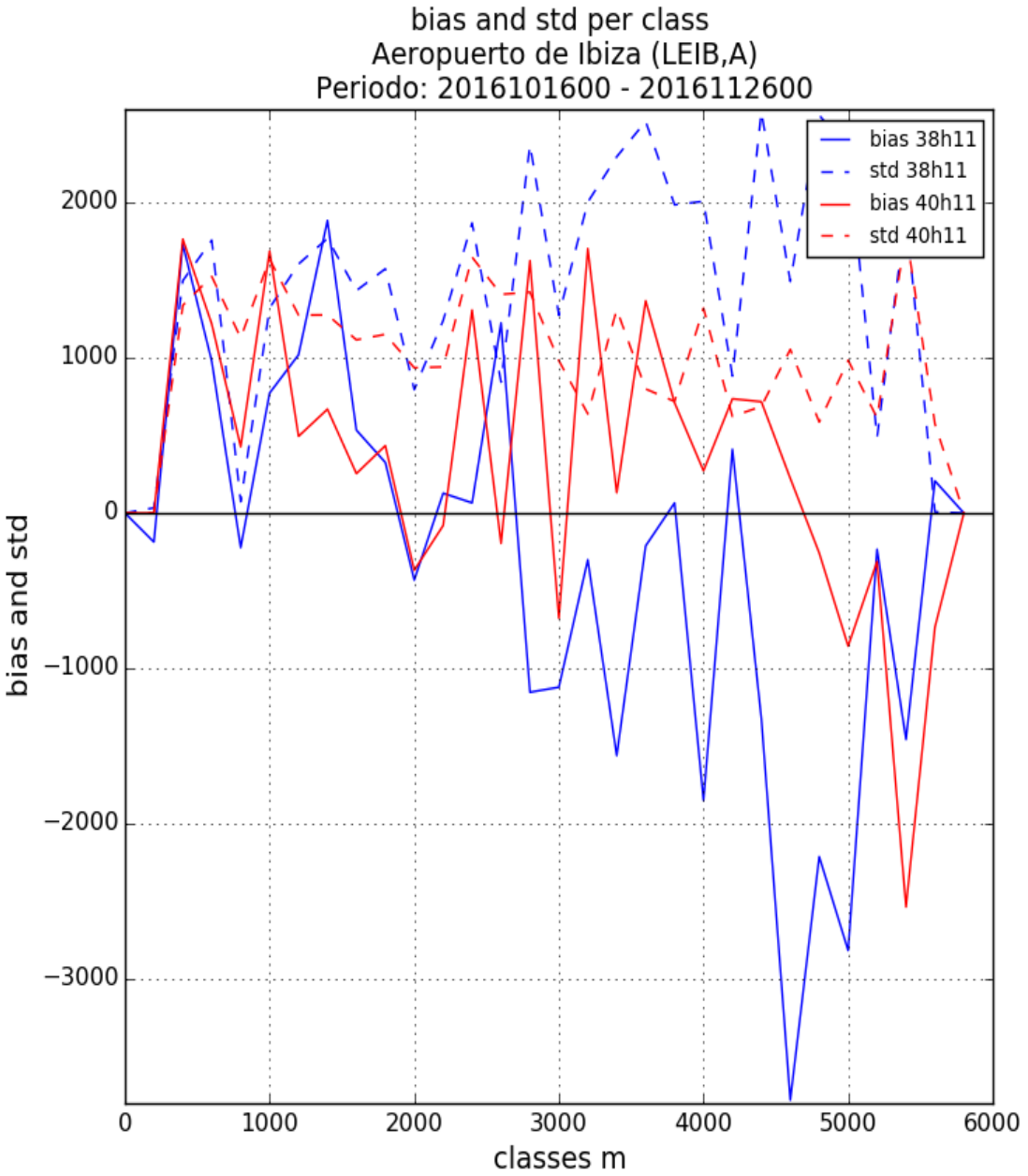




- Ibiza Airport (LEIB)
  - Temporal plots are shown. In black the observation and in red the model output of cbh for every time step.
  - Version 40h11 gives a worse bias than 38h11, but improves the standard deviation.
  - The value -9.0 is given when there is no measurement or no cloud is given by the model.
  - Not concluyent

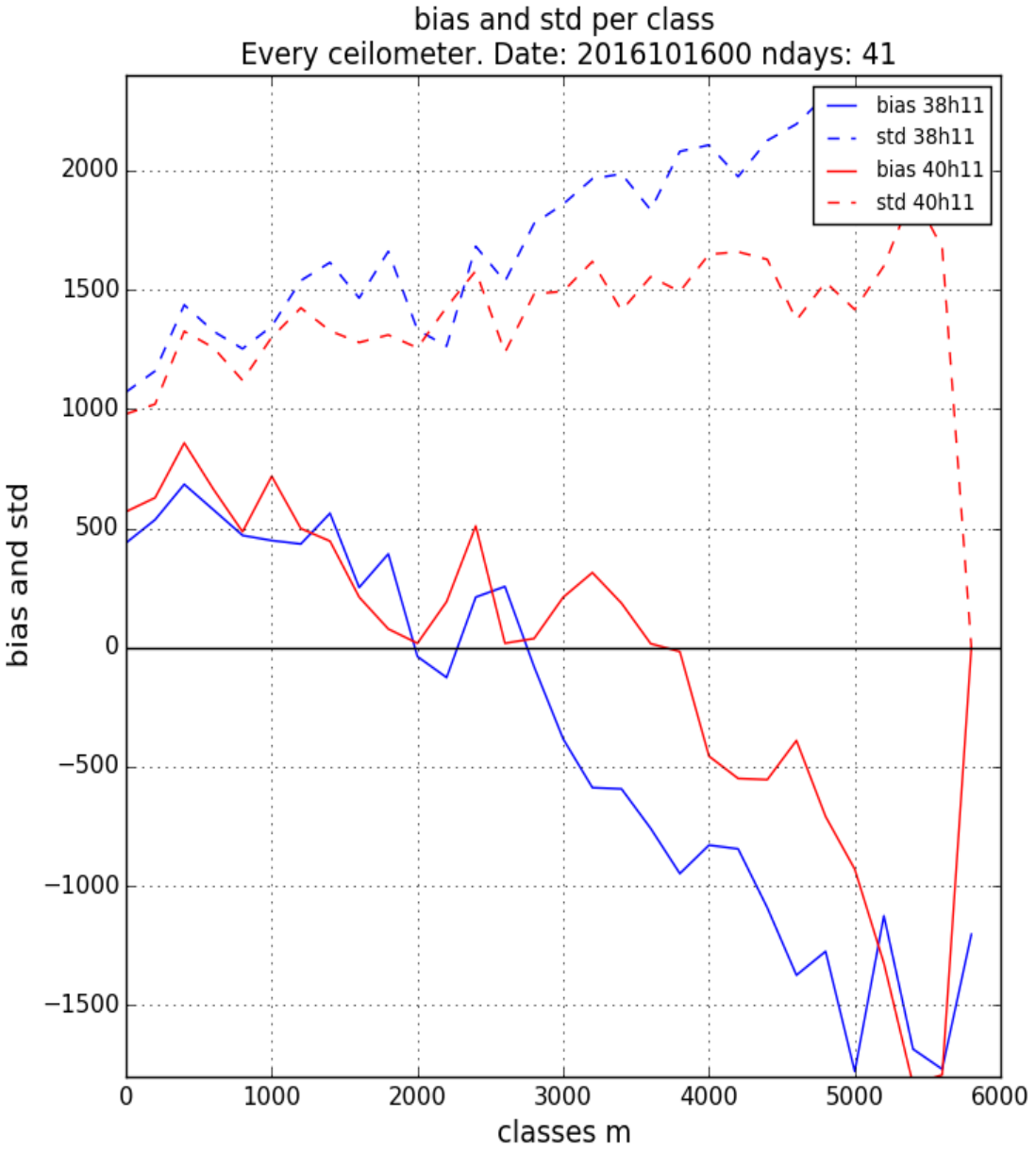
Cloud base height comparison with ceilometer data.

- IBIZA (LEIB)
  - Bias and standar deviation as a function of the classes.
  - Classes are considered every 200 m.
  - The bias for the 38h11 version is negative for classes bigger than 2500 m. Which helps to cancel the positive values and give smaller bias than the 40h11 version despithe its higher std.



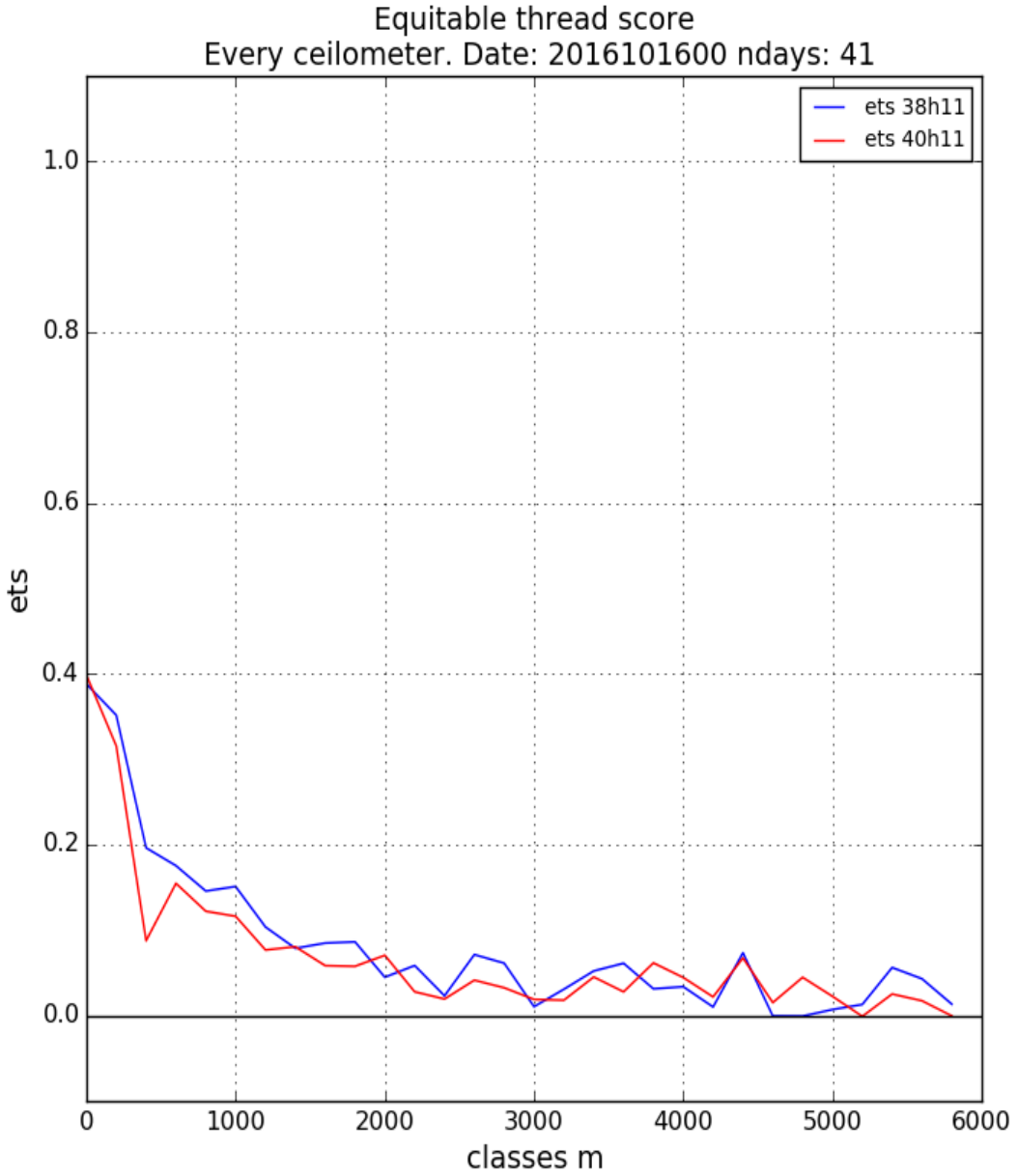
Cloud base height comparison with ceilometer data.

- Comparison Observation-Model
  - **Considering all the ceilometers**
  - Only the bias for classes lower than 1500 m for 40h11 version is worse than those for 38h11 version.
  - This result seems to indicate that the version 40h11 gives less low cloud that could reduce the bias for classes of high values.



Cloud base height comparison with ceilometer data.

- Comparison Observation-Model
  - Equitable thread square s calculated.
  - Both lines are very similar.



Fog cases.

We can get the vertical visibility from the ceilometers.

When the cloud base height can not be obtained, an estimation of the vertical visibility is given. This happens during the fog events.

Can the vertical visibility be compared with the visibility given by the model?

No deep search into algorithms used for the calculation of visibility has been done.

Fog cases are studied:

12/11/2016

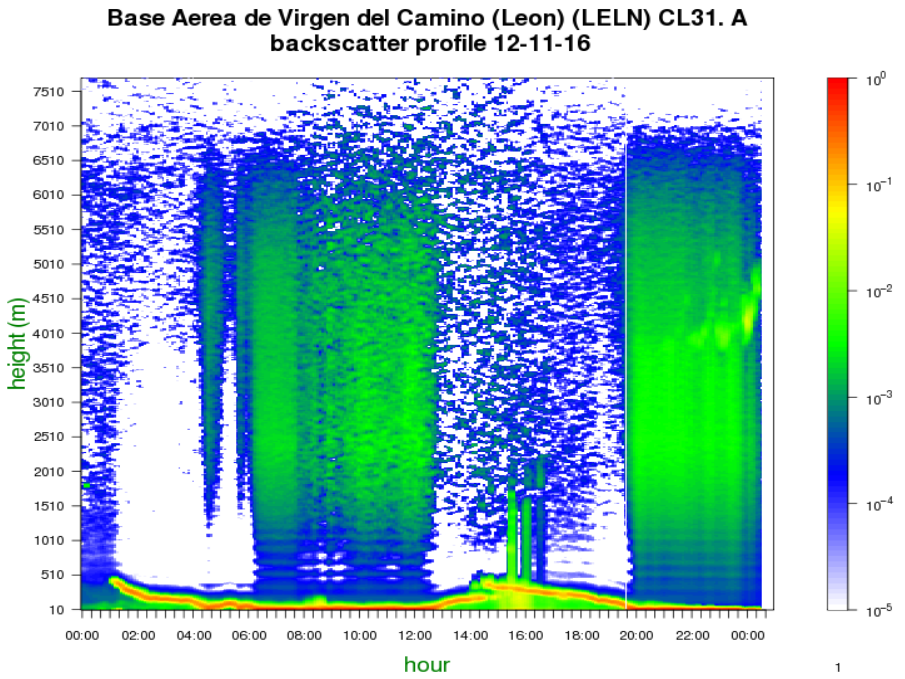
11-13/12/2016

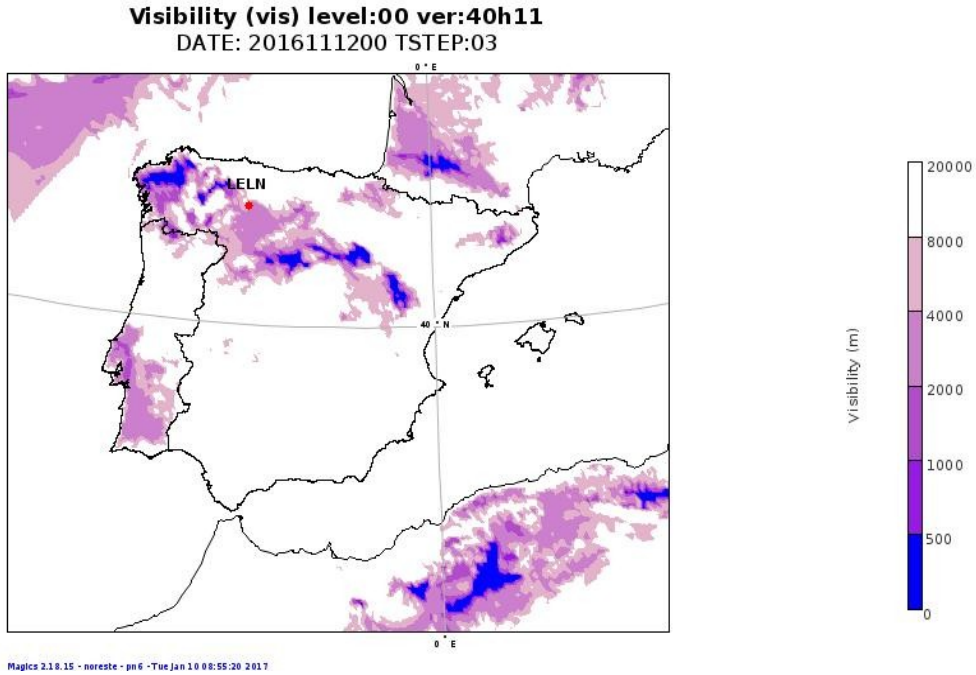
Fog cases (12/11/2016).

Date 12/11/2016. Airport of Leon. North west of the northern plateau.

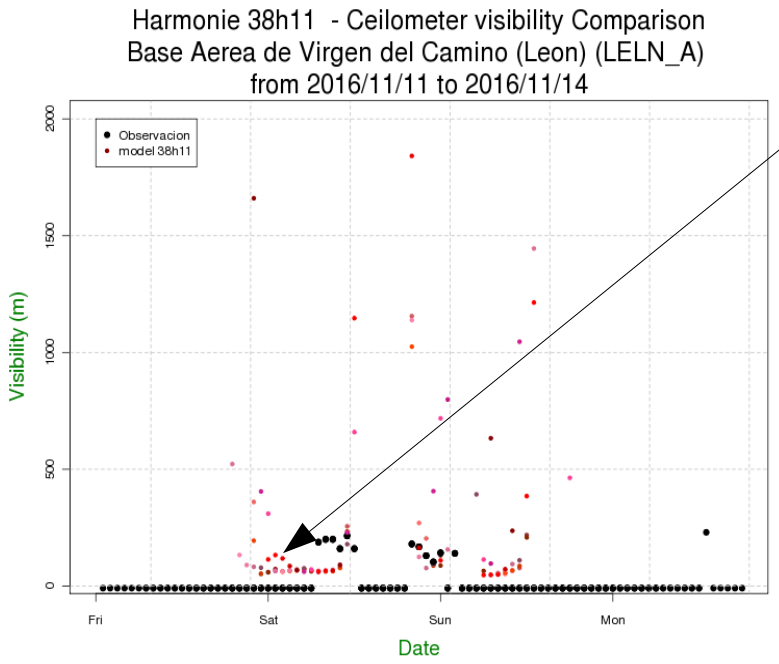
Two periods: from 06 to 12, approximately and from 20 to 24.

No satellite information is used due to the presence of high clouds





Fog cases (12/11/2016).

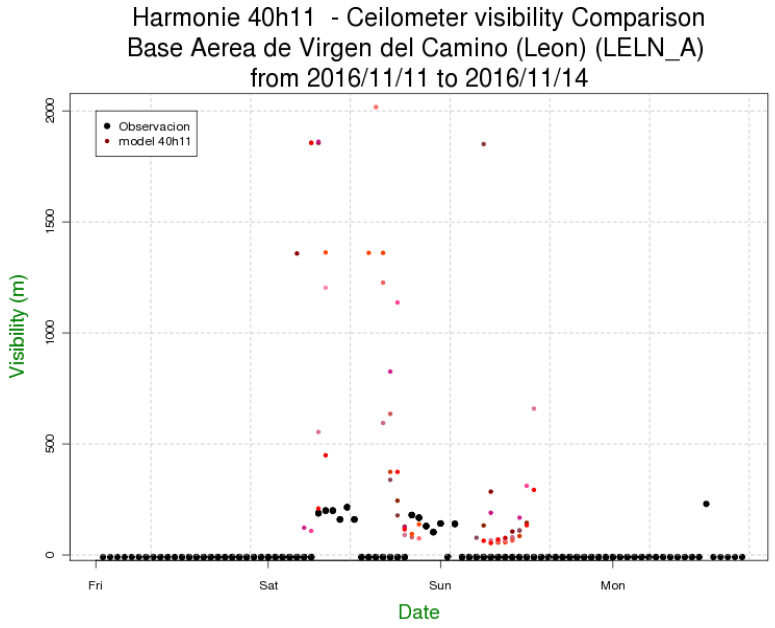


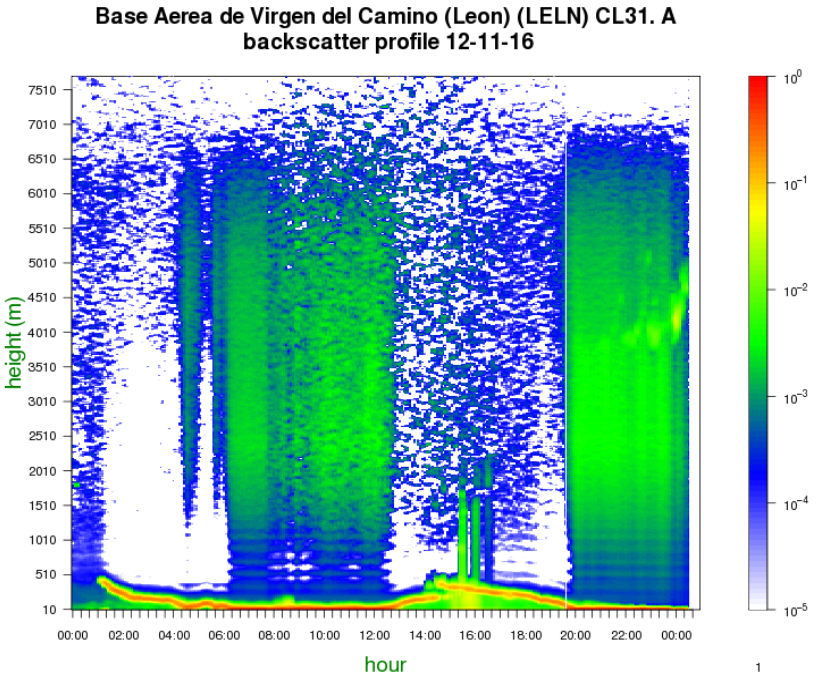
* The 38h11 version starts the fog on the previous day with lower values of the visibility

* 40h11 version starts the fog just before the ceilometer detects it, but inmediately gives higher values of visibility.

* Both versions seems to behave better for the second period, showing 38h11 a better agreement

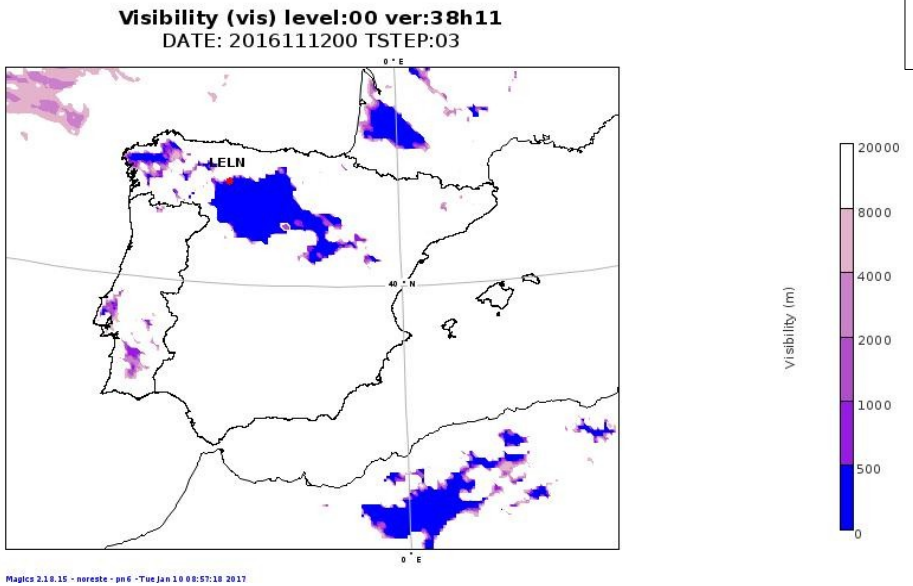
* Fog not detected is given by both versions during the morning of the 13th.



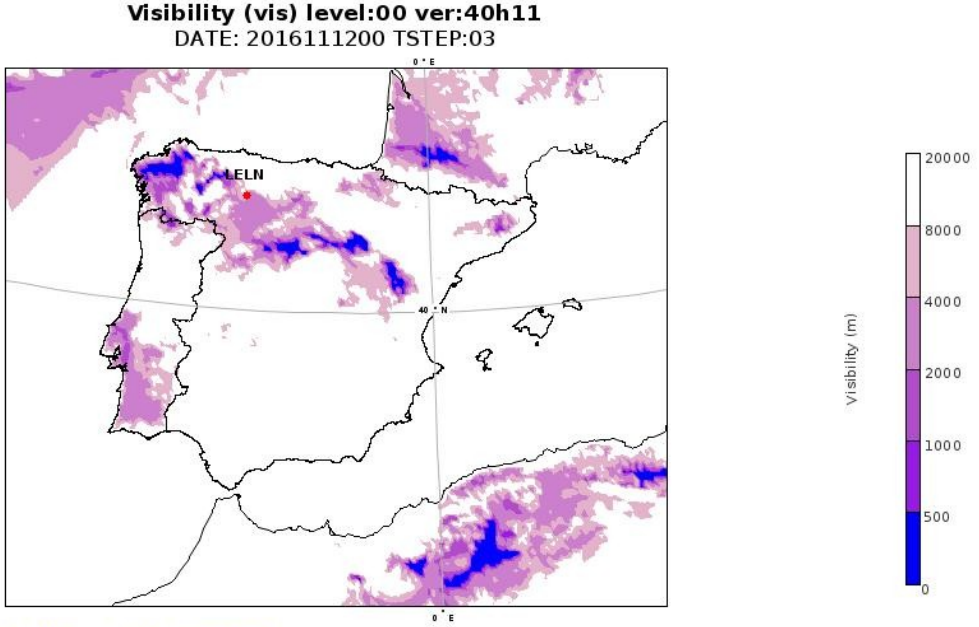


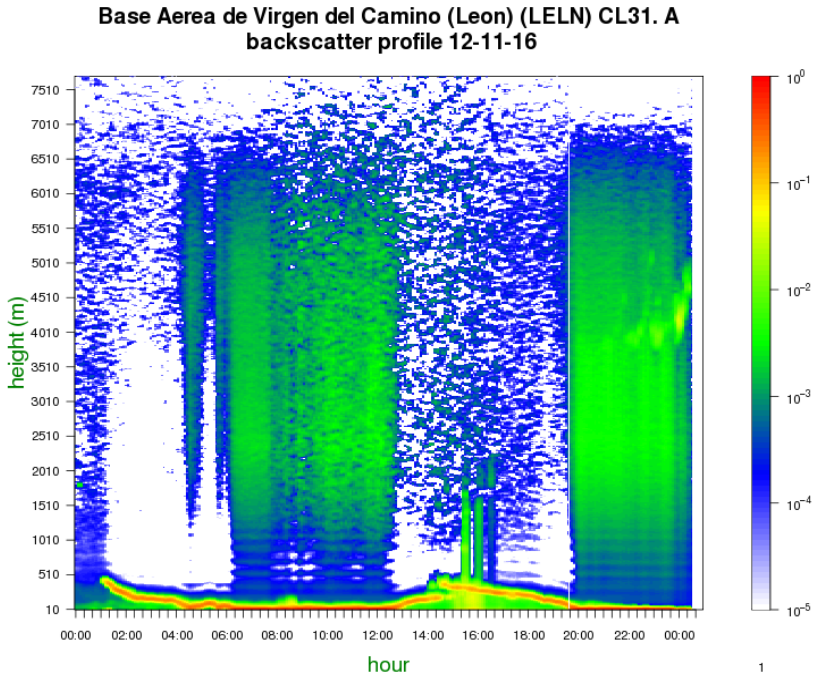
Fog cases (12/11/2016).

* The version 38h11 starts the fog on the previous day with lower values of the visibility

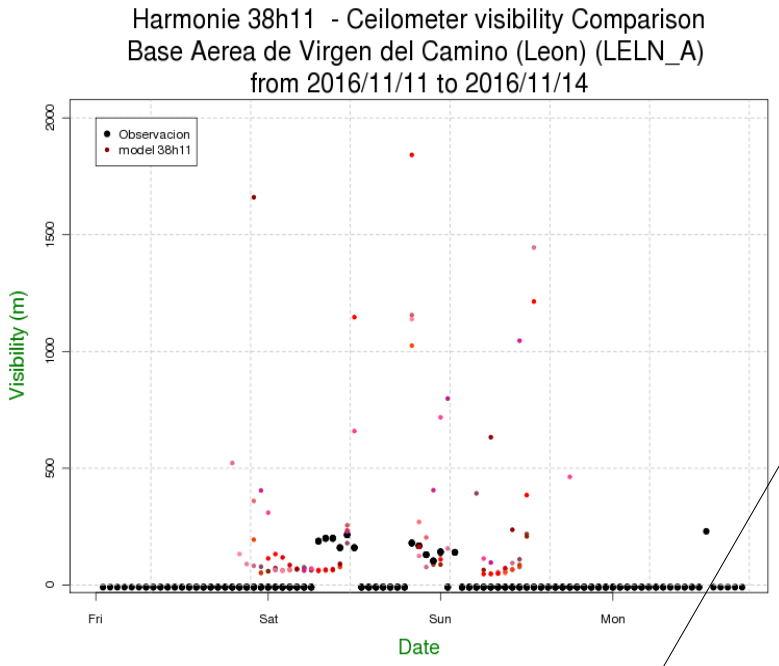


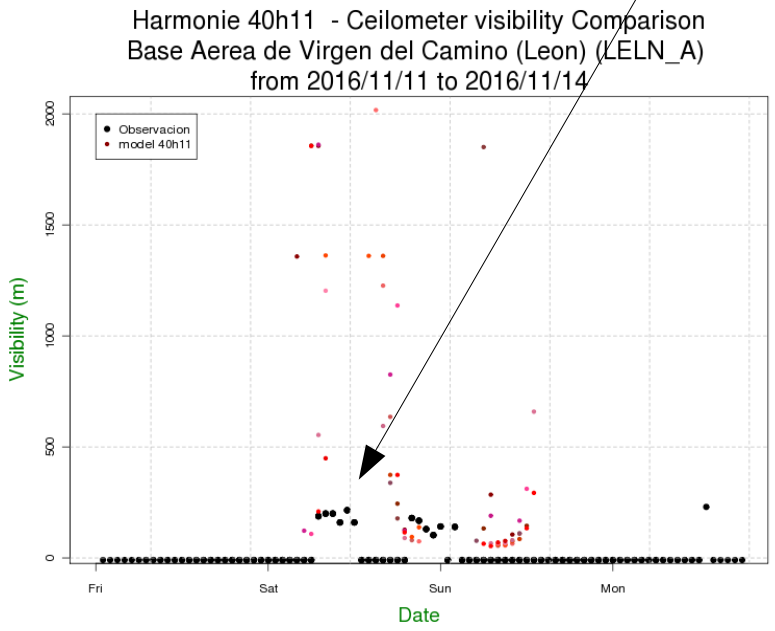
The map on the top shows the visibility given by the 38h11 model for 2016111200 and TSTEP +03.
The visibility is much lower than for the 40h11





Fog cases (12/11/2016).



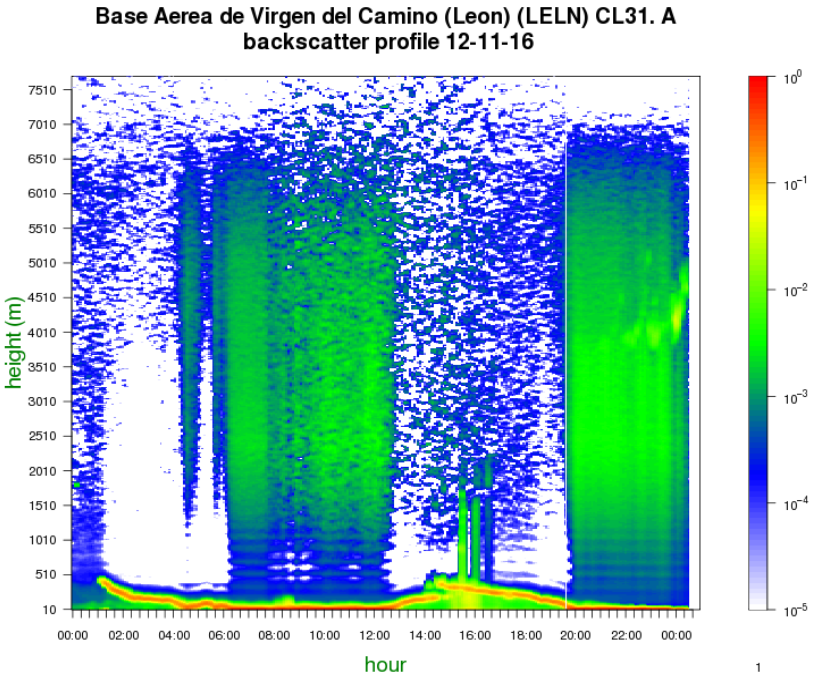


* The 38h11 version starts the fog on the previous day with lower values of the visibility

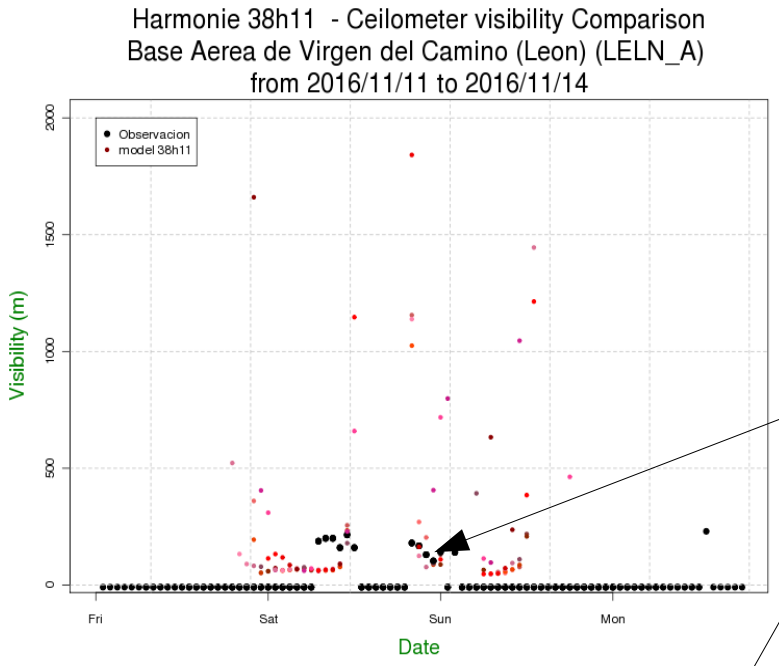
* 40h11 version starts the fog just before the ceilometer detects it, but inmediately gives higher values of visibility.

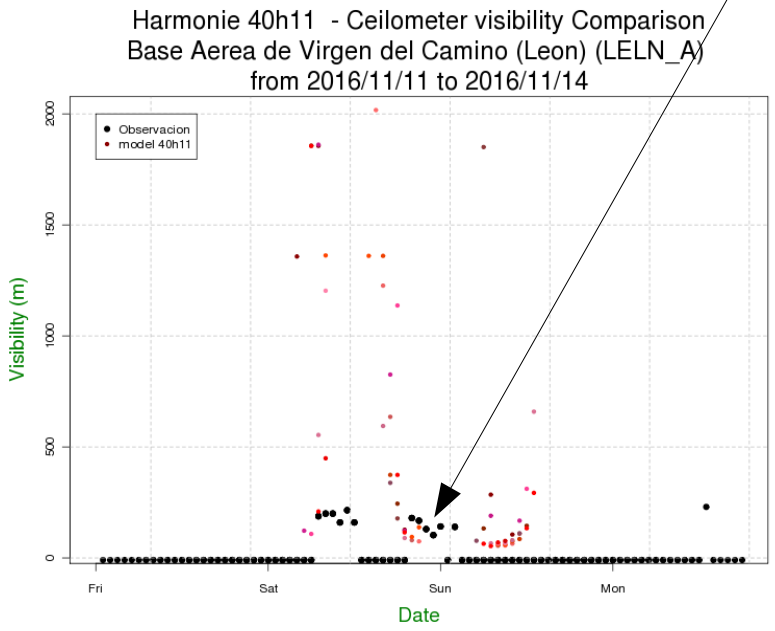
* Both versions seems to behave better for the second period, showing 38h11 a better agreement

* Fog not detected is given by both versions during the morning of the 13th.



Fog cases (12/11/2016).



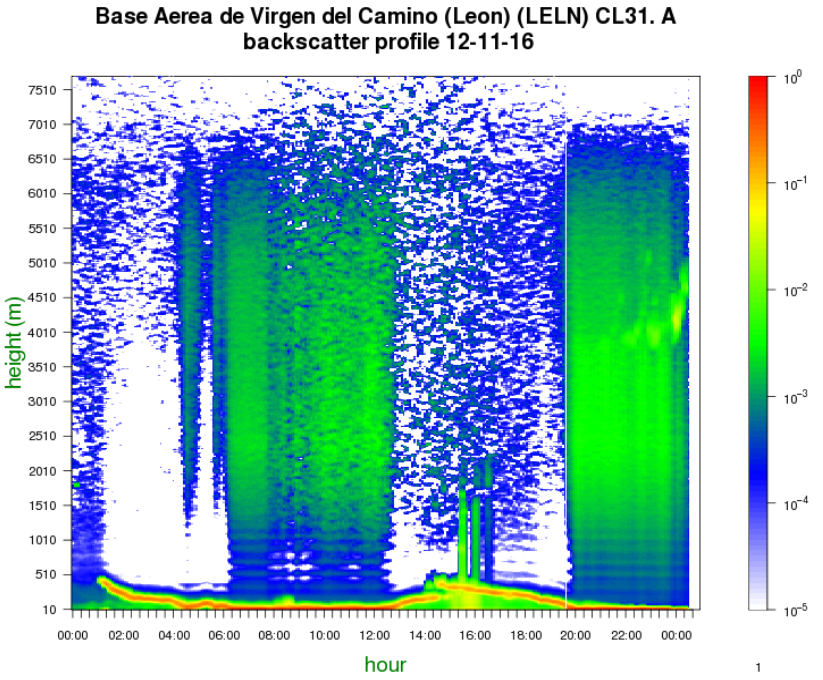


* The 38h11 version starts the fog on the previous day with lower values of the visibility

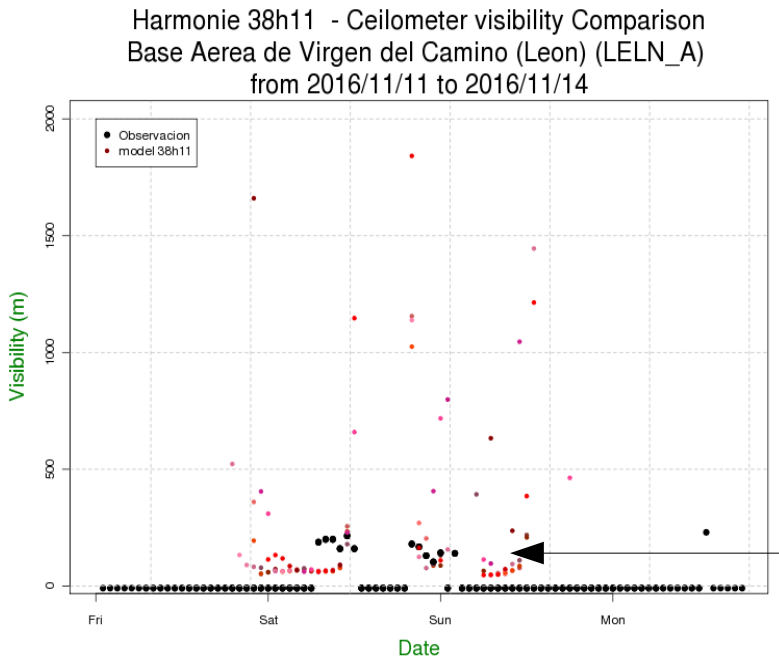
* 40h11 version starts the fog just before the ceilometer detects it, but inmediately gives higher values of visibility.

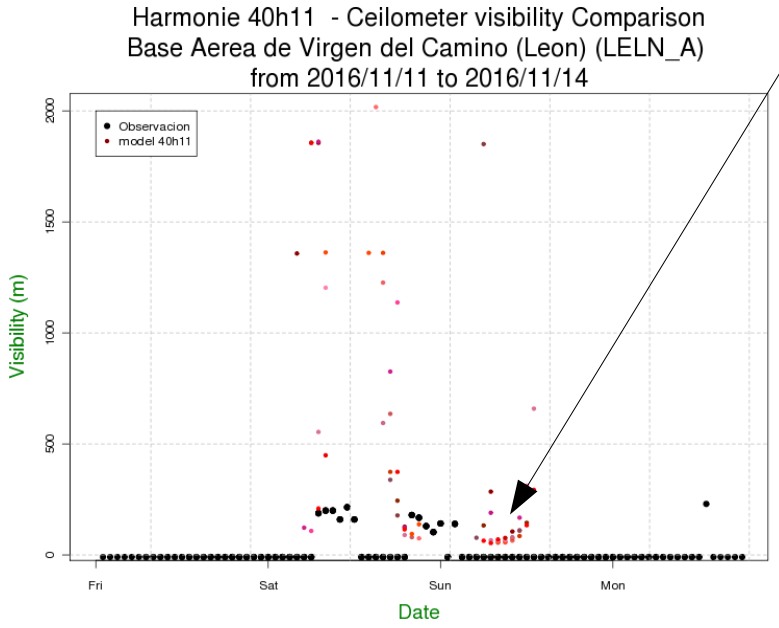
* Both versions seems to behave better for the second period, showing 38h11 a better agreement

* Fog not detected is given by both versions during the morning of the 13th.



Fog cases (12/11/2016).



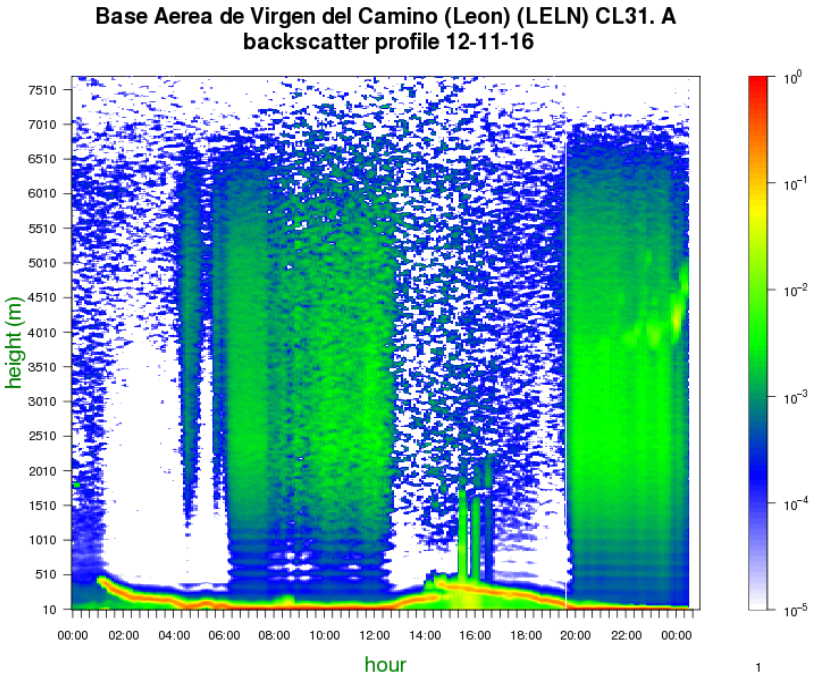


* The 38h11 version starts the fog on the previous day with lower values of the visibility

  * 40h11 version starts the fog just before the ceilometer detects it, but inmediately gives higher values of visibility.

  * Both versions seems to behave better for the second period, showing 38h11 a better agreement

* Fog not detected is given by both versions during the morning of the 13th.



Fog cases (10-13/12/2016)

Persistent fog during 4 days. (10-13/12/2016)

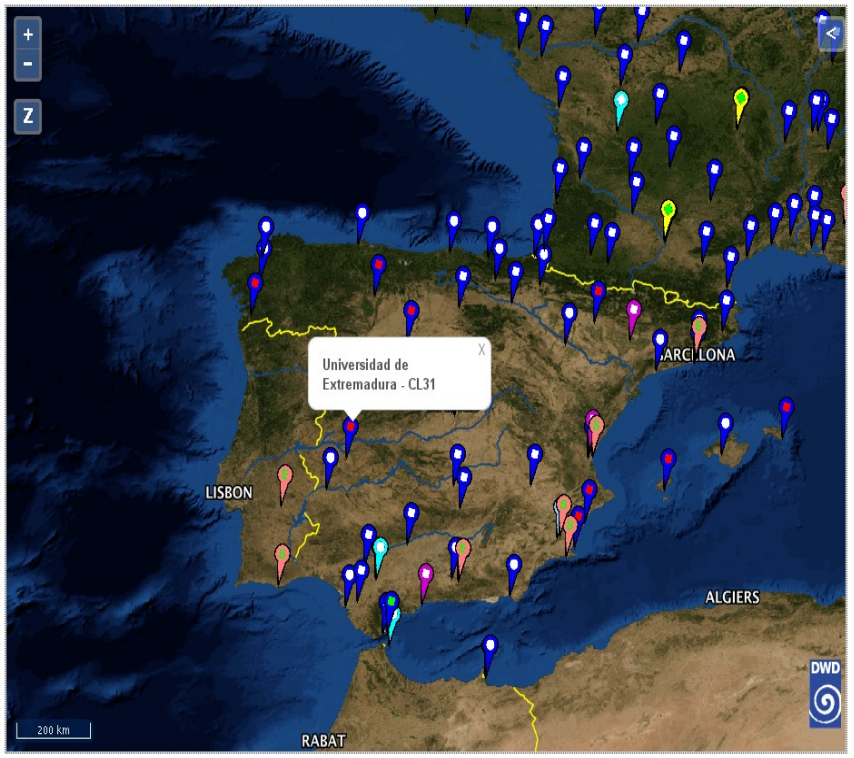
Data from the ceilometer at the airport of Huesca in the north east. (Not in the center of the valley but to the north, near the Pirineos)

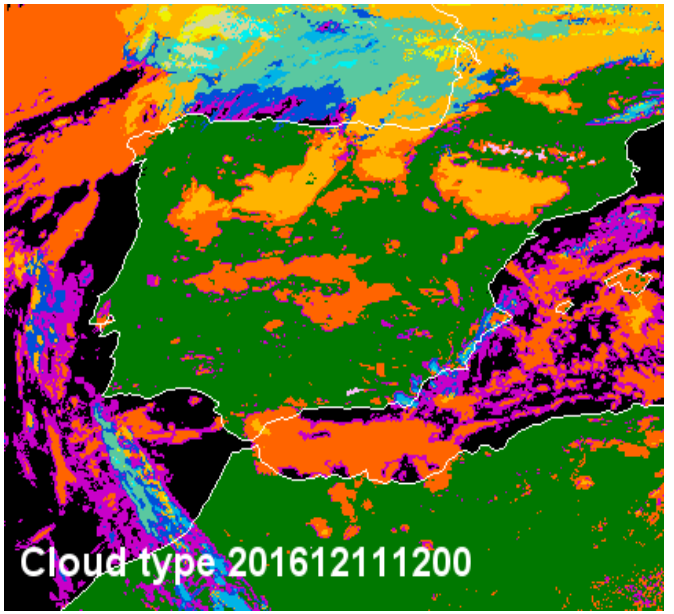
Another ceilometer has been used from the University of Extremadura.

Cloud type images from SAFNWC (Nowcasting)

Dark orange: very low clouds

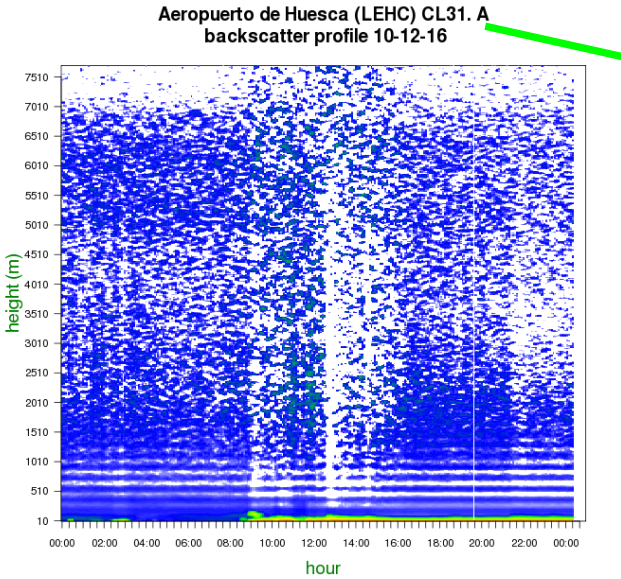
light orange: low clouds.

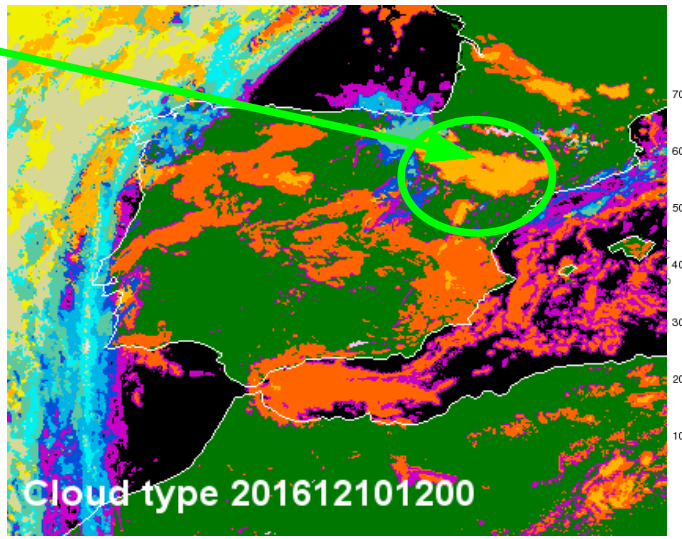


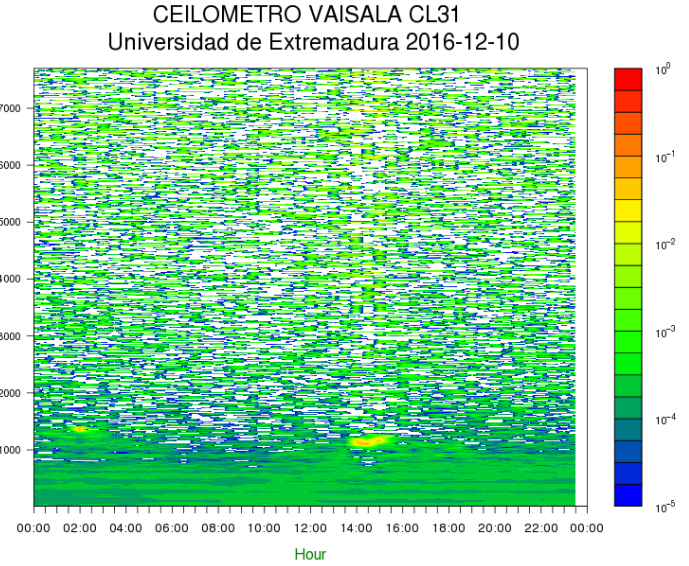


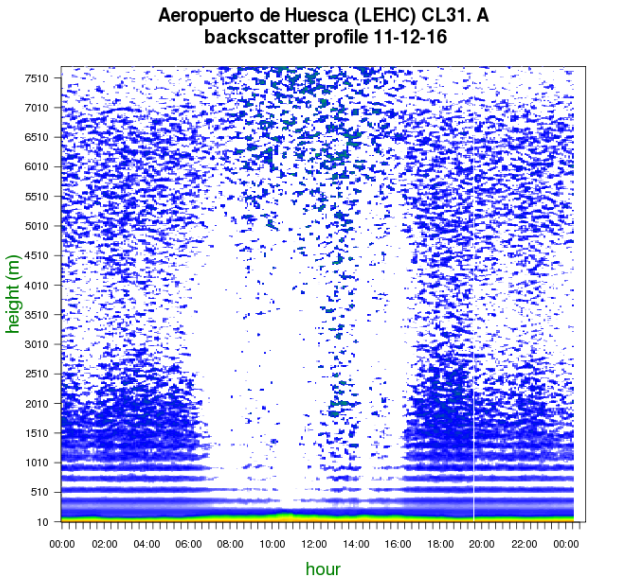
Fog cases (10-13/12/2016)

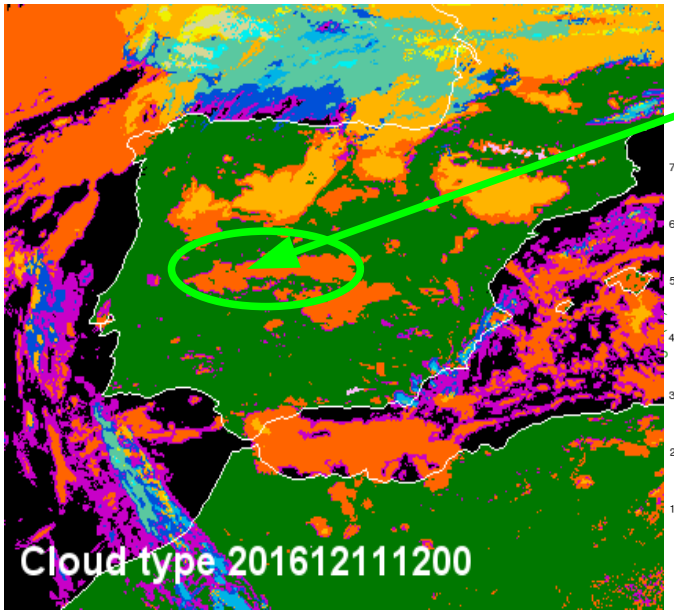
10/12/2016: The fog starts at the valleys of Ebro (NE) and Duero (N)
11/12/2016: Fog at te valley of Tajo (center)

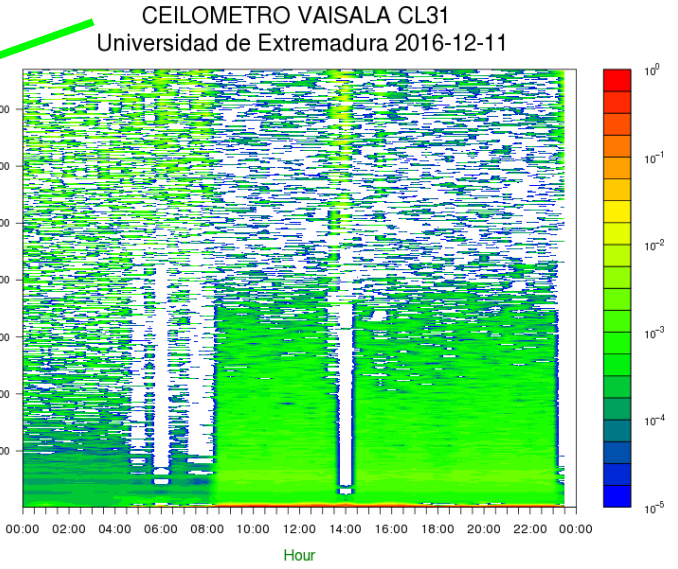






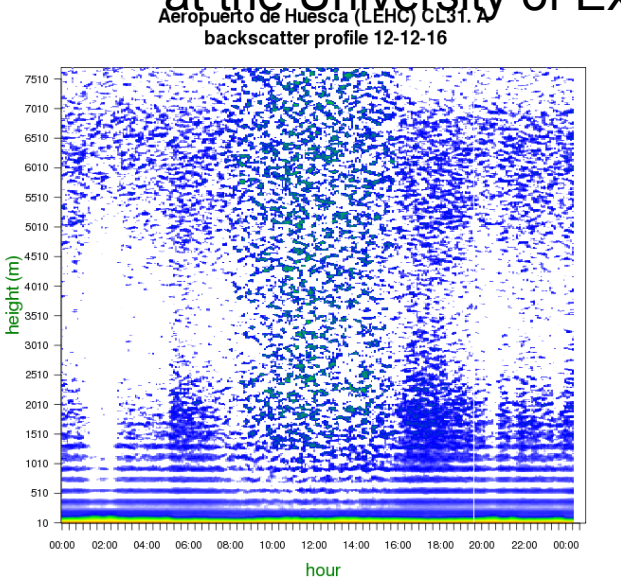


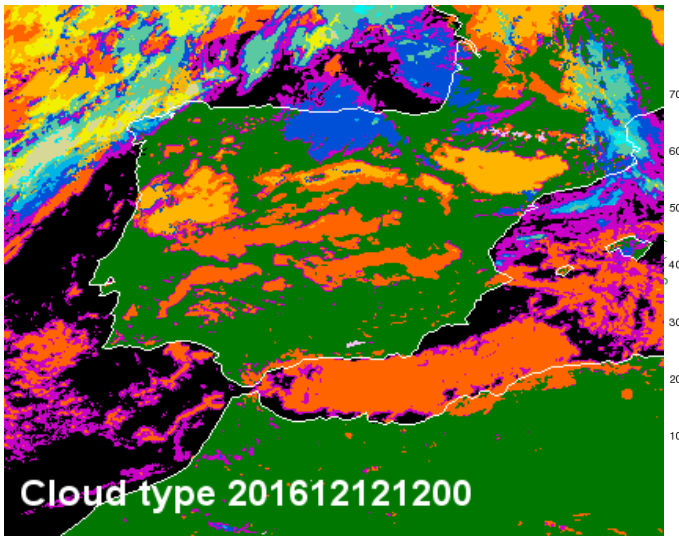


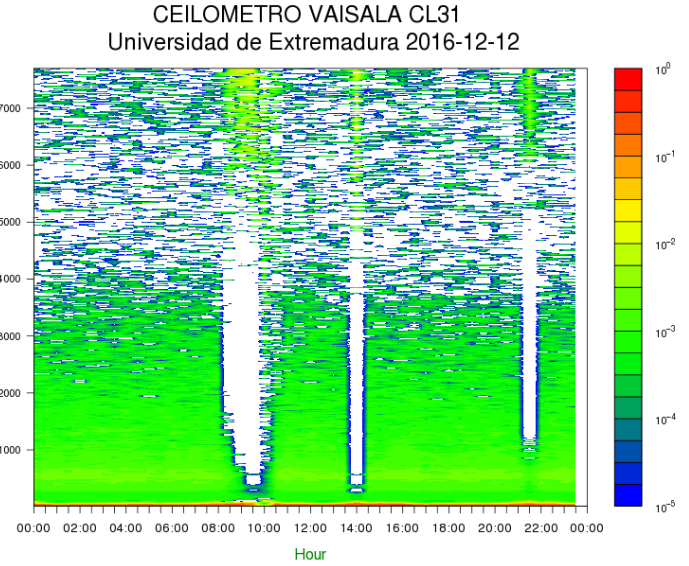


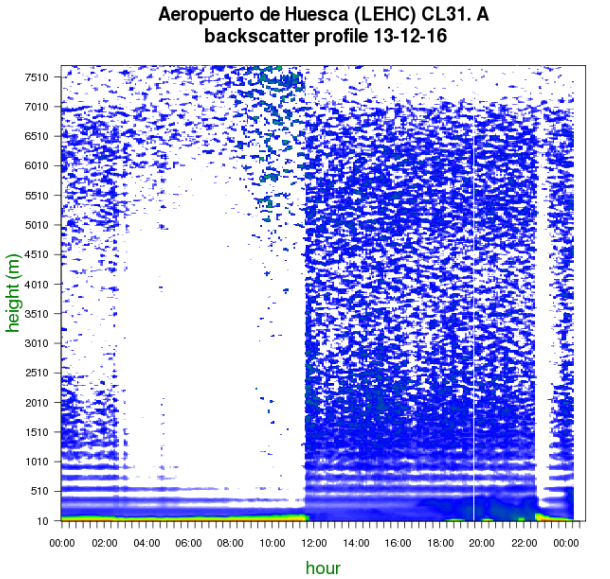
Fog cases (10-13/12/2016)

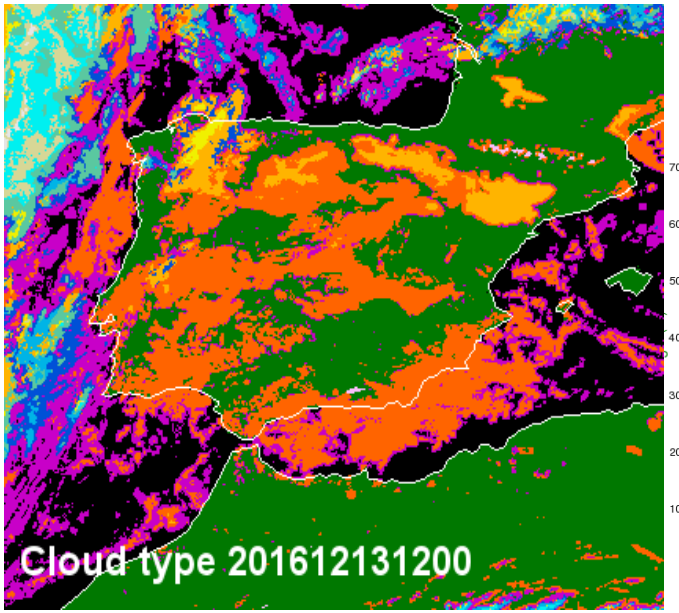
12/12/2016: Fog continues
13/10/2016: Fog disappears around 12 at the airport of Huesca and at 18 at the University of Extremadura

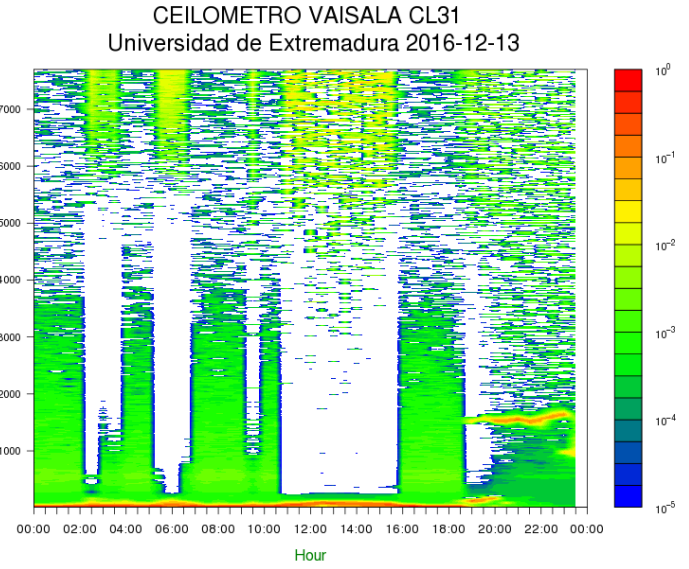




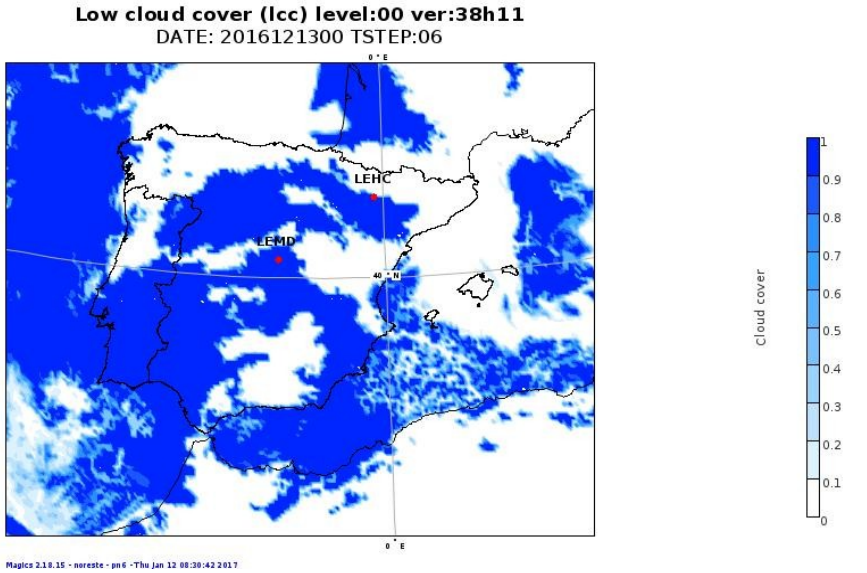


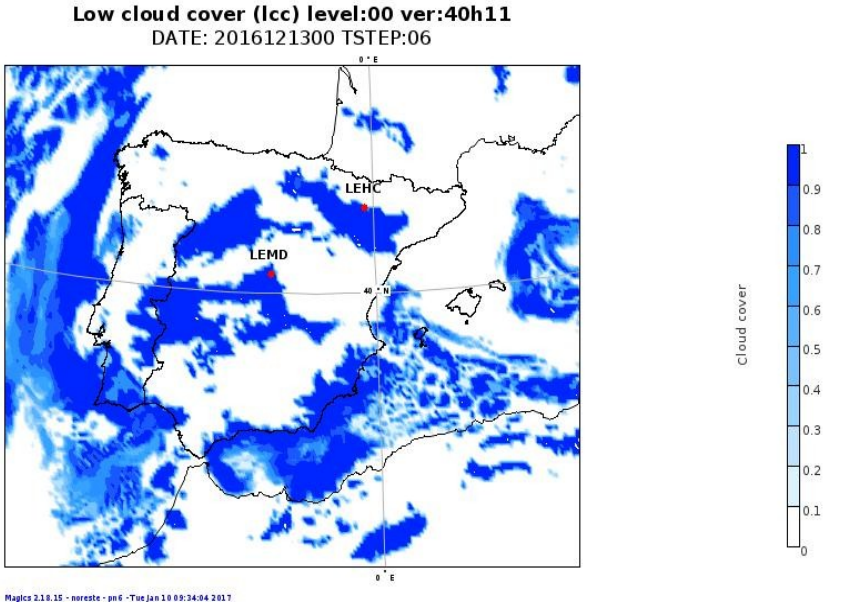






Fog cases (10-13/12/2016)

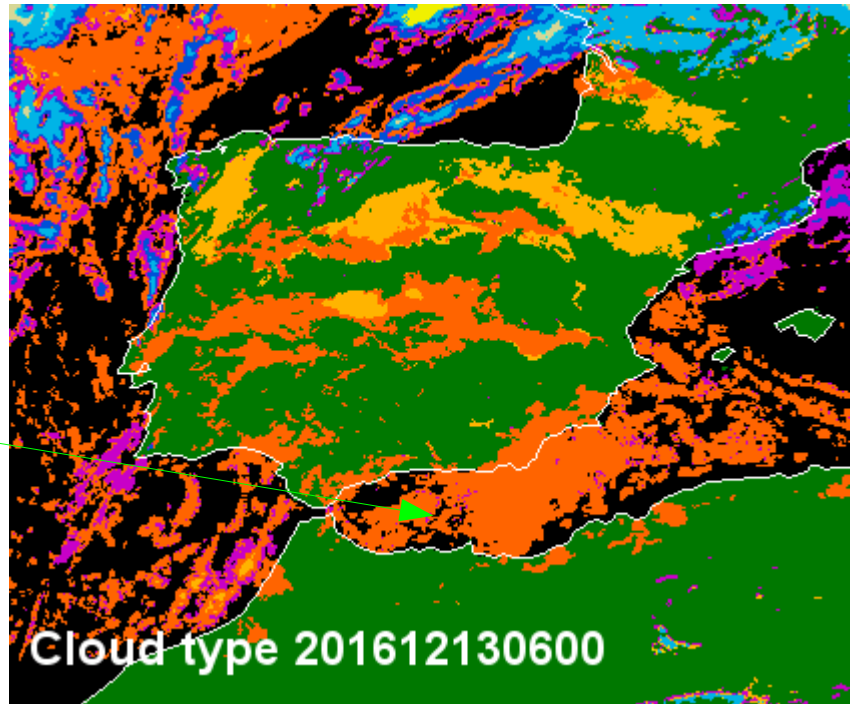




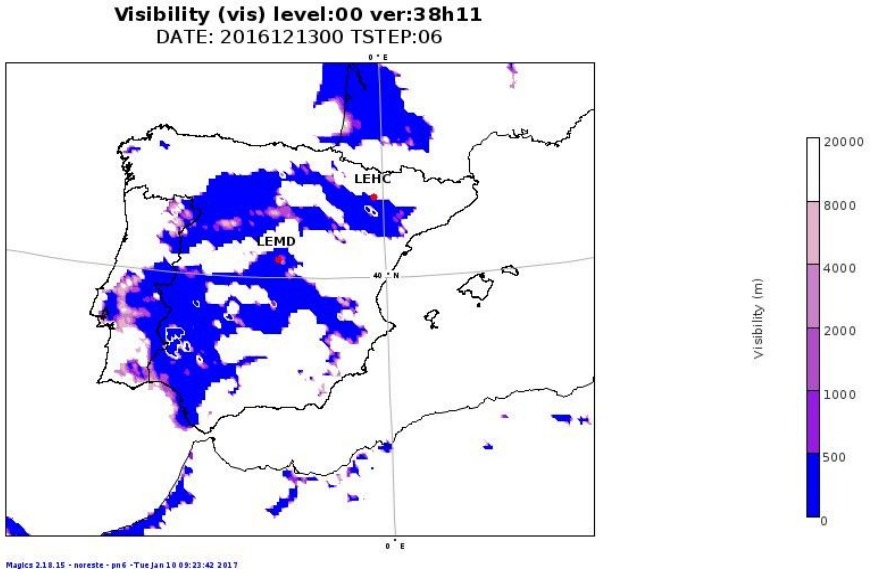
13/12/2016 HH:06
DTG=2016121300 +06

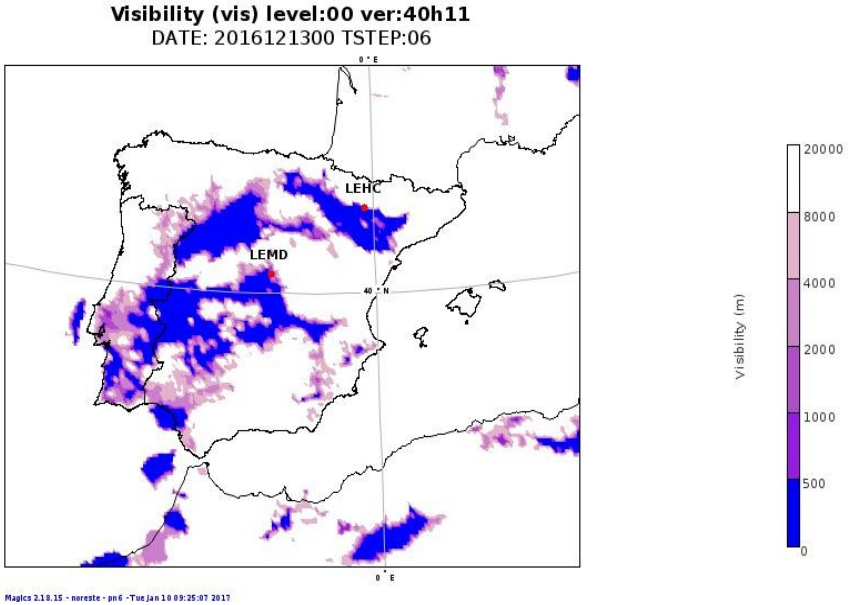
The amount of low clouds given by 40h11 version is lower than the 38h11 and shows a better agrement with the observation.

There are low clouds at the Alboran sea



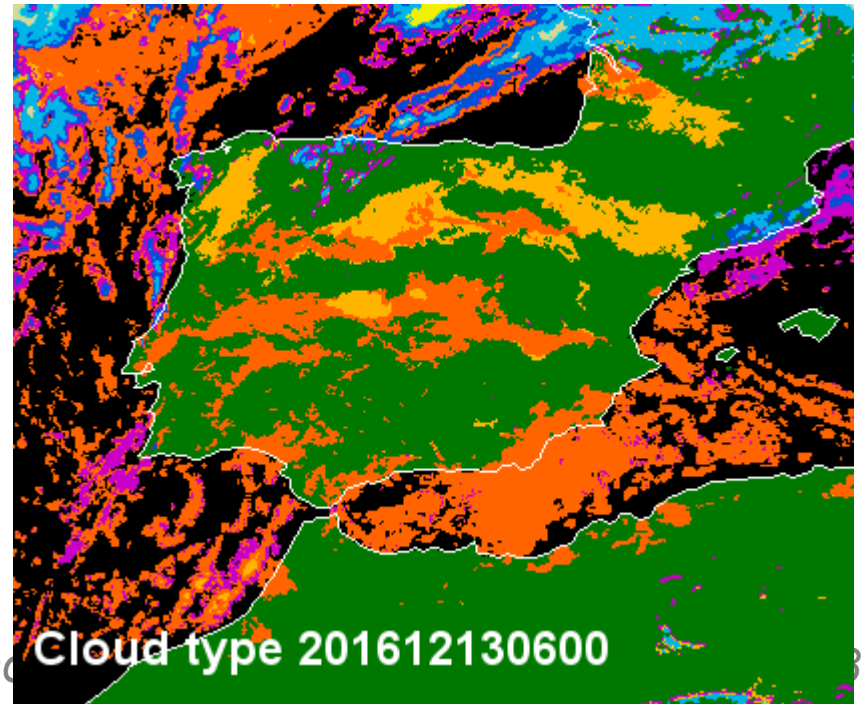
Fog cases (10-13/12/2016)



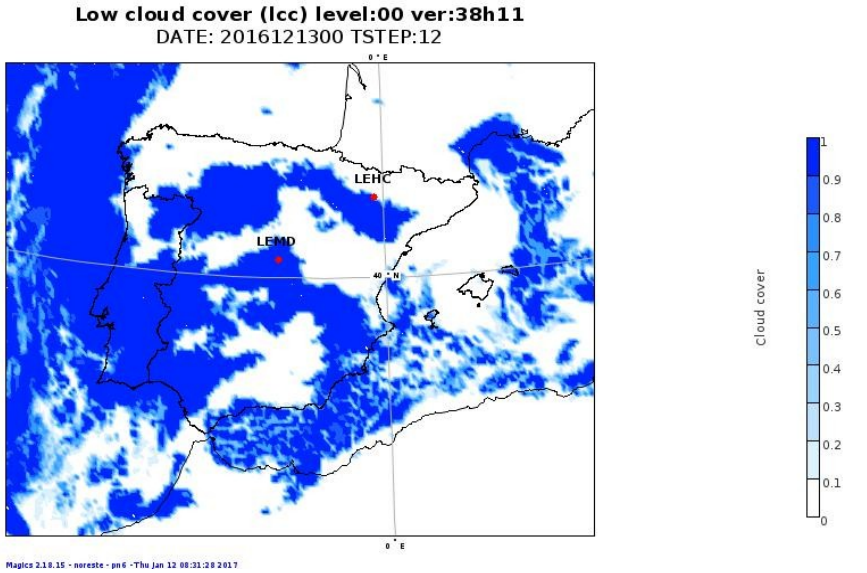


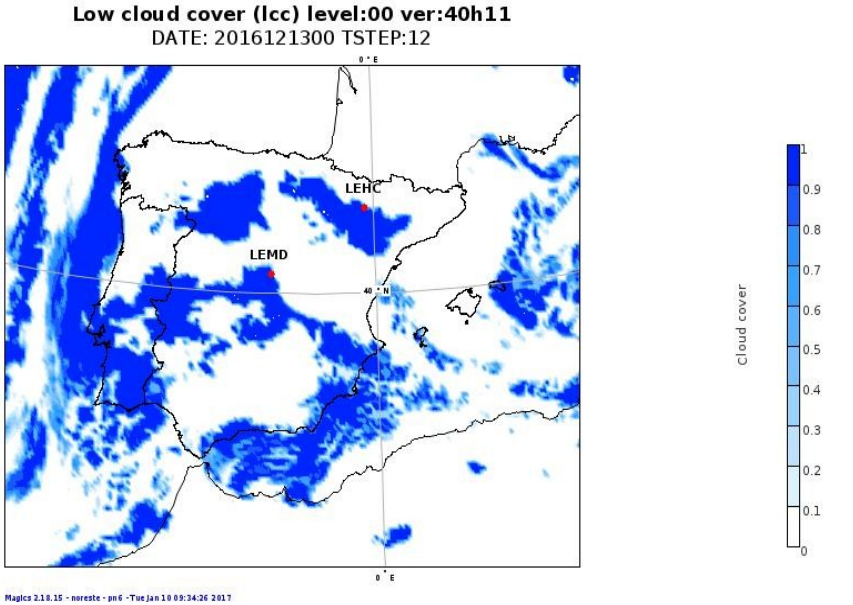
13/12/2016 HH:06
DTG=2016121300 +06

The amount of low clouds given by 40h11 version is lower than the 38h11 and shows a better agrement with the observation



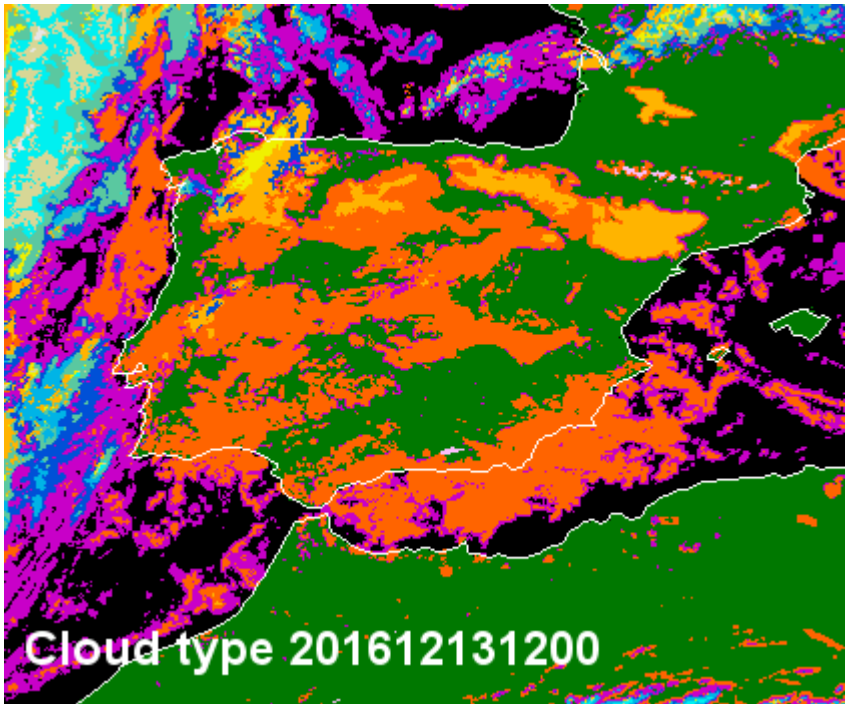
Fog cases (10-13/12/2016)



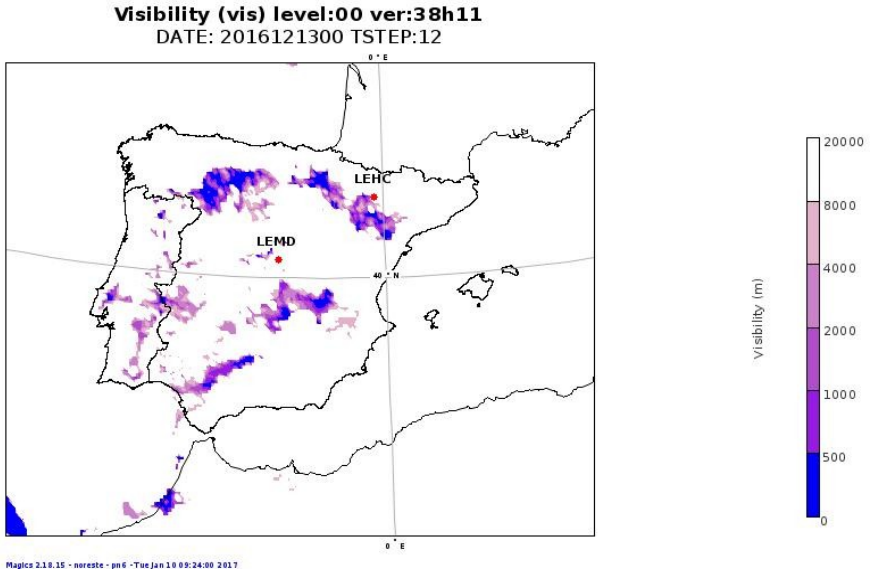


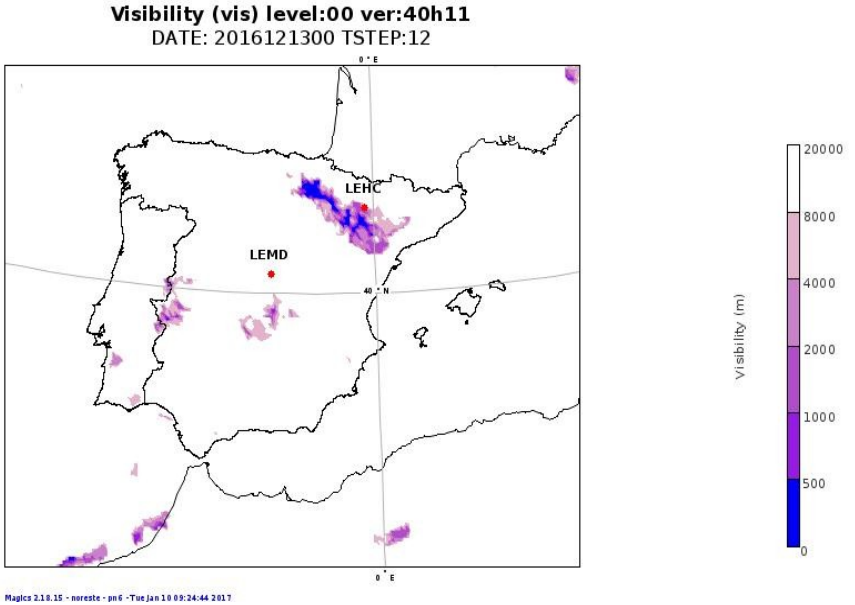
13/12/2016 HH:12
DTG=2016121300 +12

The amount of low clouds given by 40h11 version is lower than the 38h11 and shows a better agrement with the observation



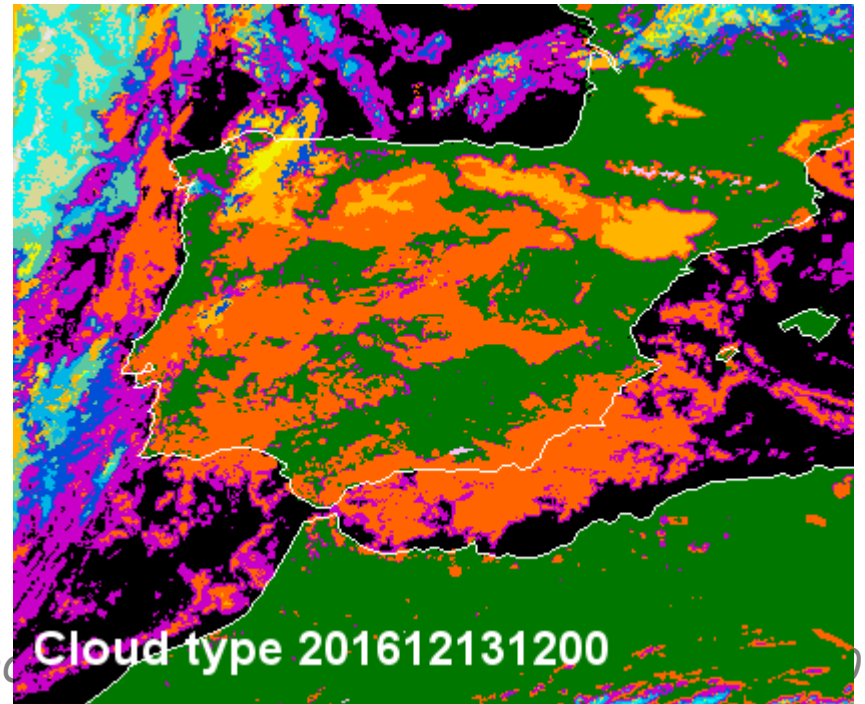
Fog cases (11-13/12/2016)



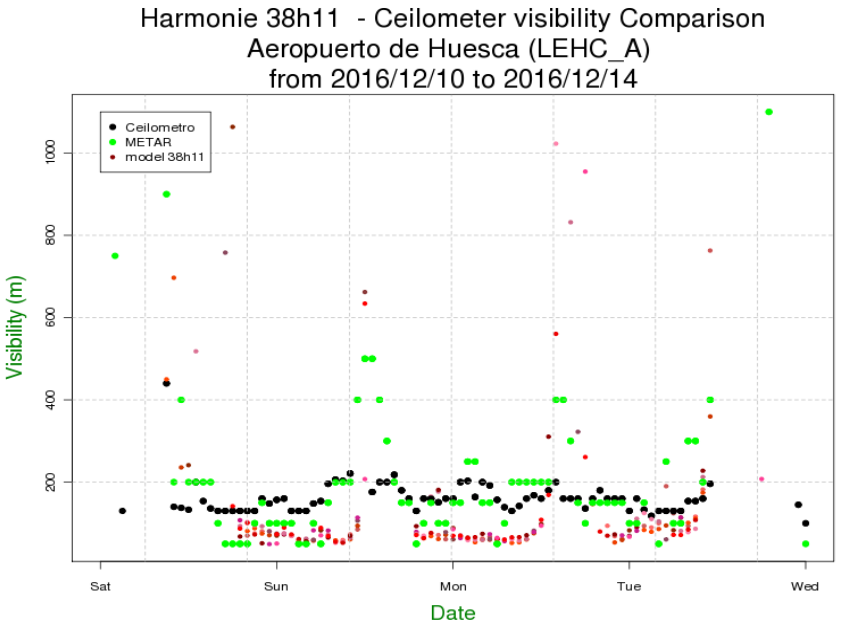


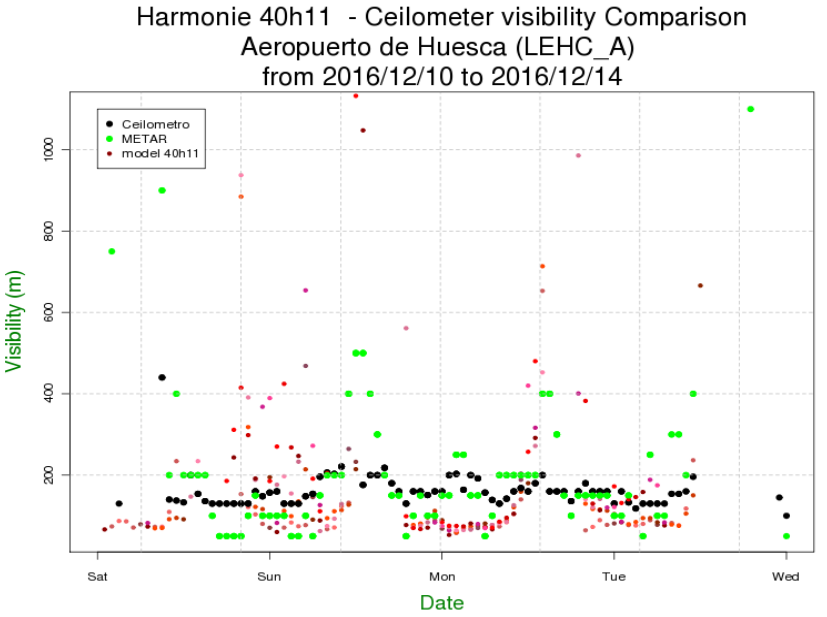
13/12/2016 HH:12
DTG=2016121300 +12

The amount of low clouds given by 40h11 version is lower than the 38h11 and shows a better agrement with the observation



Fog cases (11-13/12/2016)





The visibility given by the model compared with the visibility given by the ceilometer and the one obtained from METAR messages (Automatically generated during nighttime)

For both versions, the model gives lower values than the ceilometer. Better agreement with the METAR values only for the first day.

Ceilometer doesn't seem to give visibilities over values of 200m. Under 200m the agreement between METAR and ceilometer is good, although the first gives lower values in general.

There are not big differences between the two model versions.

Conclusions

- Measurements of cbh from ceilometer show an improvement in the cloud forecast in 40h11 version of HARMONIE-AROME.
- 40h11 gives less low clouds
- Visibility given by the ceilometers is comparable with the one given in the METAR