MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

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Verification of Low Clouds using a spatial verification method

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1. INTRODUCTION

The representation of clouds in numerical models is a difficult problem affecting many atmospheric processes. We hope that with the new generation of convection permitting models clouds will be improved but these models try to represent scales that are less predictable. Besides cloud verification is a complex issue (see WMO TD No. 1485 for a review). In this study we try to verify low clouds and fog in the HARMONIE/AROME model using ECMWF model as reference. Subjective evaluation by operational forecaster lead to the conclusion that HARMONIE improves significantly the forecasts of low clouds and fog but with many false alarms.

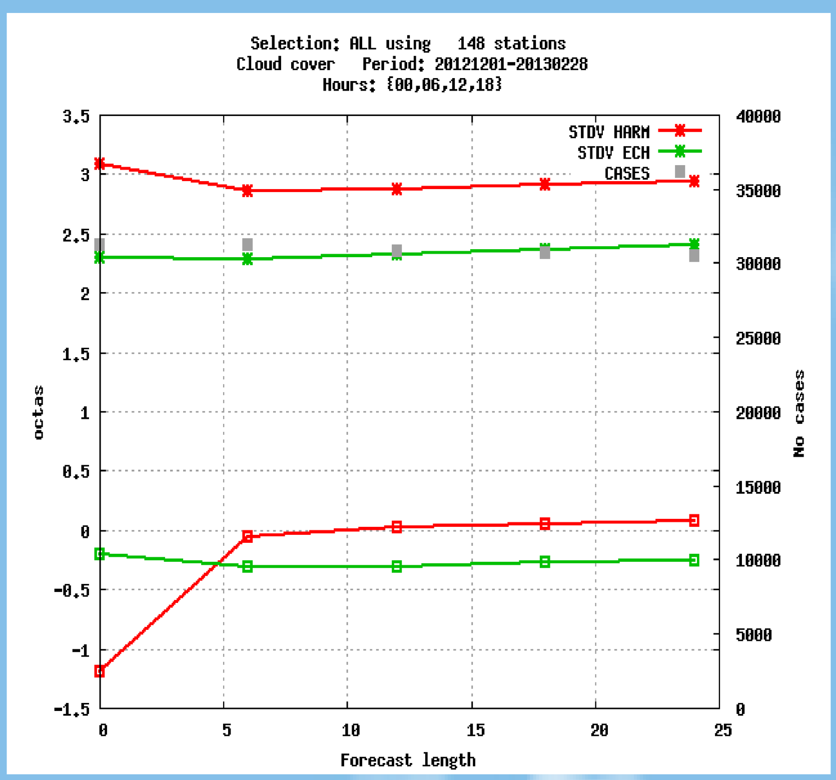


Fig. 1: Comparison of ECMWF and HARMONIE cloud cover using SYNOP observations. STDV and BIAS as function of the forecast length. The errors are bigger for HARM with some negative BIAS but this is probably due to the model resolution, 2.5 km, compared to the 16 km of EC closer to the wide observer point of view. A slight increase of the error with the forecast length can be seen.

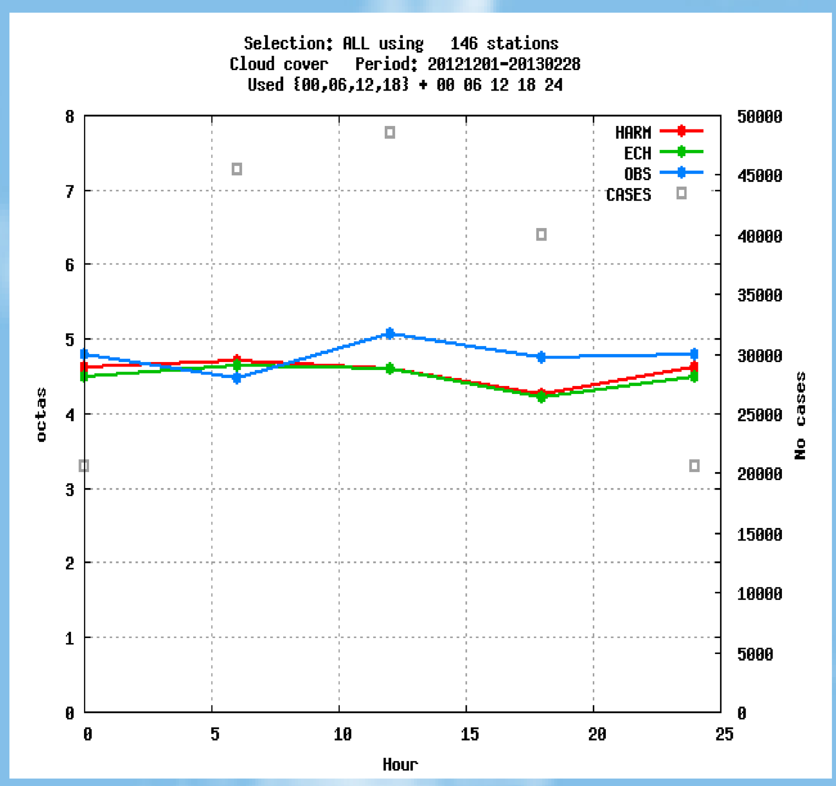
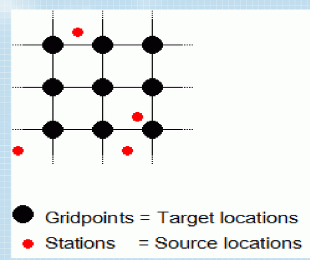


Fig. 2: Diurnal variation of clouds compared to observations. Both models show some underestimation during the central hours of the day.

2. TRADITIONAL POINT VERIFICATION



Traditional point verification has many limitations as

- Scarce observations that represent the atmosphere only locally
- Many types of clouds possible
- Different meaning of cloud cover from ground observer (wide view) and model calculation (vertical column)
- Lack of observations in sea areas
- Difficulties comparing models with different resolutions due to double penalty problems

3. PERIOD USED

We selected some periods where low clouds and fog occurred frequently: 201201, 201212, 201301 and 201311. We will apply the traditional point verification and a spatial verification method using a satellite derived product from Nowcasting SAF. For point verification we are assessing all types of clouds for the domain chosen (Northern Spanish Plateau) and it is expected that for this period many of these clouds will be low clouds and fog.

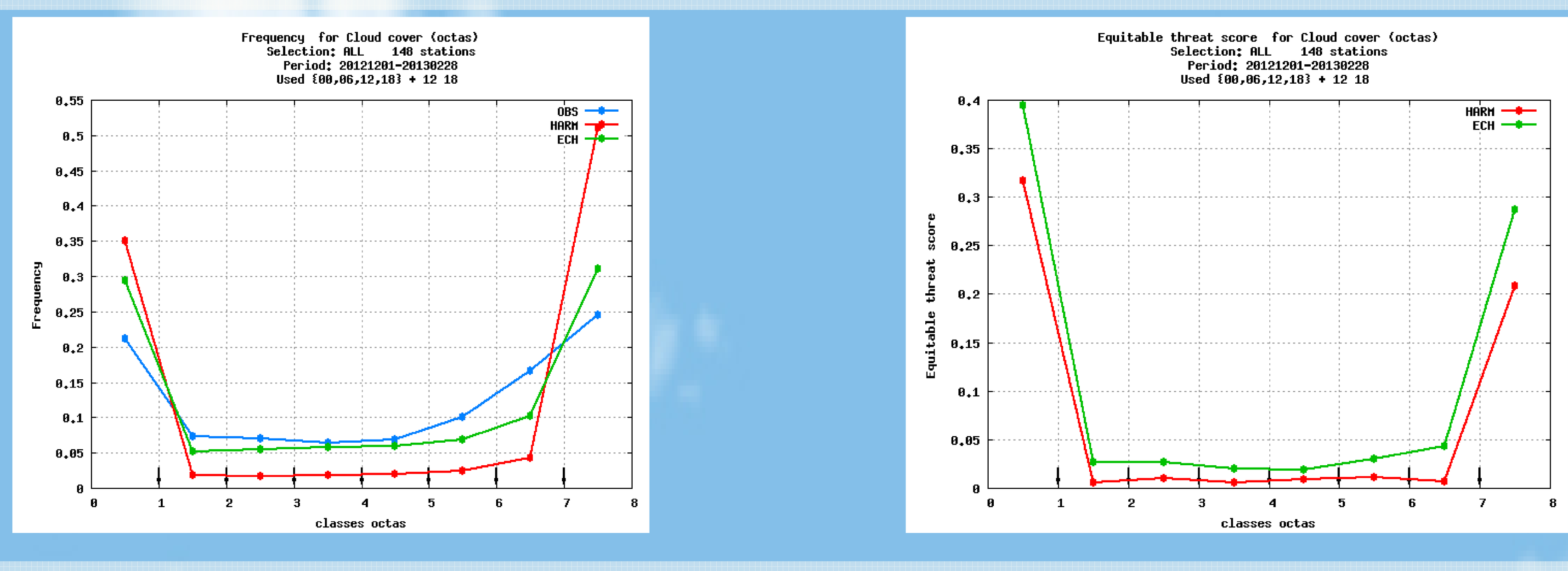


Fig. 3: Distribution of the observed and forecast frequencies for different cloud cover categories. We can see that HARMONIE underestimates partial cloud covers tending to produce too much overcasts. EC suffers less this problem but this is probably related to the different resolution. Accordingly, the ETS of cloud cover is very low for partially cover conditions.

4. SPATIAL VERIFICATION: SAL METHOD

The SAL method (Wernli et al., 2008) is a feature-oriented approach which describes a model forecast skill when verified against gridded observations. Using this method it is possible to estimate the goodness of a model forecast attending not only the quantity of the magnitude but the spatial distribution of the field. The method computes three parameters:

- **S** (Structure): compares the shape and the size of the objects.
- **A** (Amplitude): compares quantitatively the objects, in this case, cloud fraction.
- **L** (Location): compares the location of the objects in a relative and absolute way

Generally SAL method is applied to precipitation field. One of the aims of this study is to evaluate if it can be useful for cloud cover. The observations come from 'cloud type' of the NowSAF that is computed using several MSG channels. We use the low cloud type estimates the clouds below 650 hPa. For the cloud level assignment, the algorithm uses information from ECMWF model what bias a little its use to evaluate ECMWF clouds. As we focus on low clouds we disregard observations having clouds above. From the model point of view de WMO definition of low clouds is used.

5. INTERPRETATION OF THE SAL PLOTS

The SAL plot can help in understanding the distribution and patterns of the field when the model and the observations are compared. Every point in the plot describes SAL results for one comparison (e.g., forecast 2010123100+H006 with observation at 2010123106).

X and Y-axes measure the S and A components respectively, while L is plotted in different colors.

S = [-2,2]   A = [-2,2]   L = [0,2]

- The closer to cero at any parameter, the better.
- S > 0 and A > 0 mean that the model overestimate the observations. High values of L means bad location of the structures.
- Large S corresponds to wide structures predicted by the model in a situation of small observed objects. Negative S means forecasting of too small and/or peaked structures.
- The dashed lines show the median of the S and A distributions, while the shadowed rectangle shows the inter-quartile ranges (IQR).

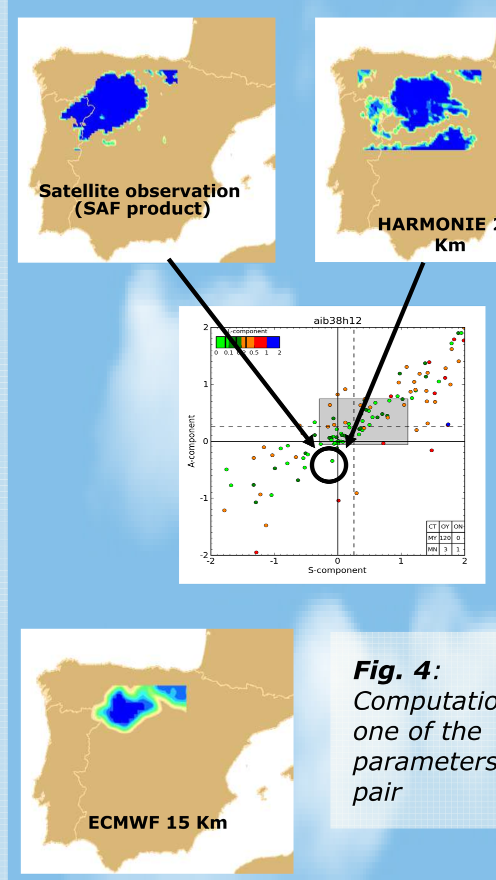


Fig. 4: Computation of one of the S-A-L parameters for a pair

6. SAL results for the 4 months selected

HARMONIE forecast are indeed based on cycle 36 an 37. In fig 5 we see that the dispersion of the SAL points is much smaller for HARM than for EC showing the added value of the high resolution model. Also the location errors are smaller for HARM. Besides HARM shows a general positive bias meaning a tendency to overestimate size and magnitude of cloud cover. Note that there is a clear correlation between Structure and Amplitude partially justified by the use of constant threshold to define the spatial objects.

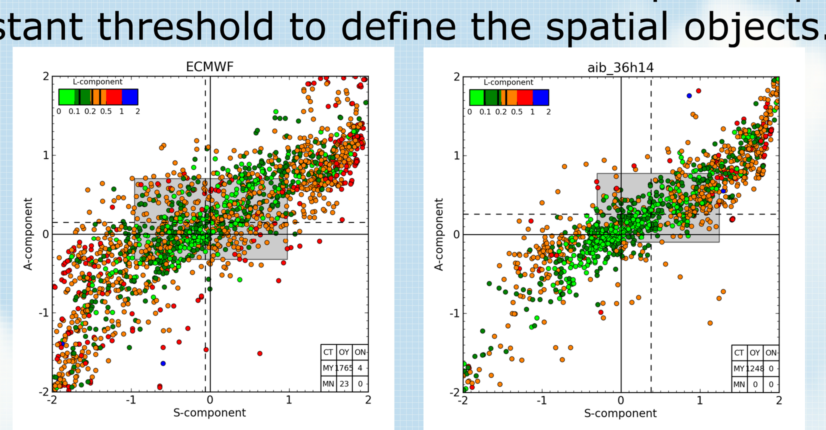


Fig. 5: SAL results for the 4 months of the study- Comparison of ECMWF (left) and HARMONIE (right)

7. Errors function of forecast length and time of the day

From the evolution of the **S**tructure errors with the **forecast length** we can see a slight deterioration which gives us confidence that the method is sensible enough as to capture this type of feature. Contrarily the ECMWF show little dependence of the error with the forecast length.

We conclude that over land there is a diurnal cycle of the error showing underestimation of clouds in the central part of the day despite the general tendency to overestimate the low clouds in the case of HARMONIE. Although there maybe some sensitivity of the satellite estimation to the diurnal cycle we can also see this diurnal cycle of the errors in the point verification (fig. 2).

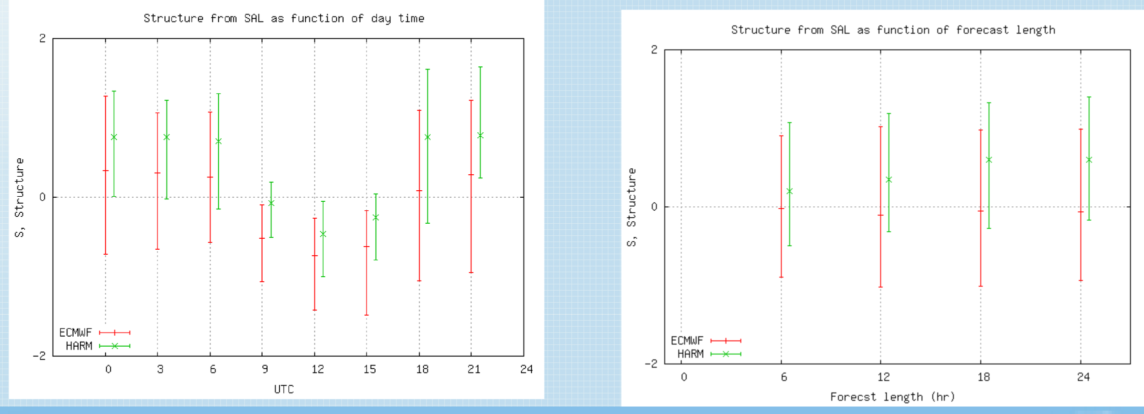


Fig. 4: Left. Diurnal variation of clouds compared to observations. Both models show some underestimation during the central hours of the day.

Right. Variation of clouds according the forecast length.

8. Errors for different regions

We know that SAL algorithm works better for limited spatial domains to limit the number of objects to deal with. Also the use of relatively small domains allows to focus on a specific type of clouds and in a region with a specific climatology. Here we address the question of whether the model shows different climatologies for different regions including sea areas. We have compute SAL for **January 2015** (cycle 38 for HARM) and for different regions: The **Northern Spanish Plateau**, The **Cantabric Sea** (N Spain) and the **Alboran Sea** (S Spain).

The SAL verification has been carried out for one month what might be not enough to draw firm conclusions.

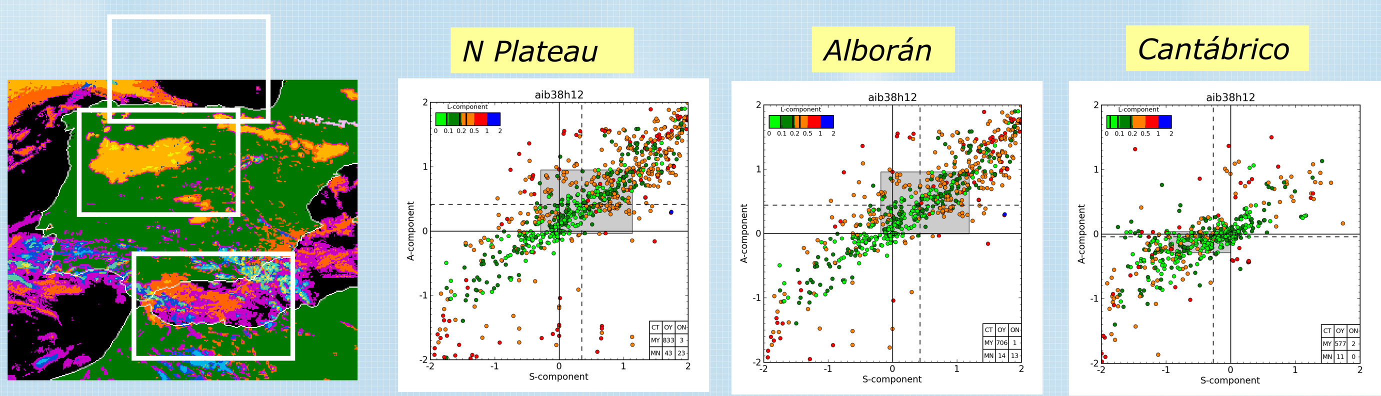


Fig. 6: Cantabric Sea shows an underestimation of low clouds as a whole compared to the other two regions. In addition for this area, the model seems to reproduce the clouds structure fairly well as the spread is small.

9. CONCLUSIONS

- Cloud verification is a difficult task and it is recommended to use different observations sources and different verification methods to tackle the problem
- In this study, SAL method has been extended to verify low clouds using low clouds from the 'cloud type' estimate of the Nowcasting SAF.
- Although the method applied is cumbersome, it works well for complementing the traditional point verification
- There is a regional dependence of the results:
  - HARMONIE/AROME overestimate low clouds over the Northern Plateau and the Alboran Sea. Nevertheless, we think that the model performs better than the ECMWF one because the dispersion in results is lower.
  - Surprisingly, over the Cantabric Sea the HARMONIE model provides quite good results with a slight underestimation (in agreement with the operational forecasters subjective evaluation).
- The models seem to have a diurnal cycle inland producing less clouds in the central part of the day where it could even have an underestimation of low clouds. As expected there is no diurnal cycle over the sea.

REFERENCES

1. Wernli et al., 2008: *SAL- A Novel Quality Measure for the Verification of Quantitative Precipitation Forecastas.* Monthly Weather Review, 136, 4470-4487
2. WMO TD No. 1485,2009: *Recommendations for the verification and intercomparison of QPFS and PQPFS from operational NWP models*
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