Evaluation of the cloudy parameters with the CO2-Slicing algorithm for IASI in global and mesoscale models

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Introduction

Hyperspectral infra-red sounders are one of the most important observation instruments in the data assimilation system for numerical weather prediction. However, the presence of clouds in the instrument's field of view gave rise to develop the assimilation of satellite observations in cloudy areas.

Cloudy IASI radiances are currently assimilated in Météo-France numerical weather prediction models at global and convective scales since 2012. We use a simplified cloud model defined by two parameters (cloud top pressure and effective cloud fraction) in case of low-level and opaque clouds.

This method has been developed for AIRS observations (Pangaud et al, 2009) and extended to IASI observations (Guidard et al, 2011). The cloud parameters are retrieved using a CO2-slicing method (Menzel et al., 1983). Selected data have a cloud top pressure in the range of 650-900 hPa.

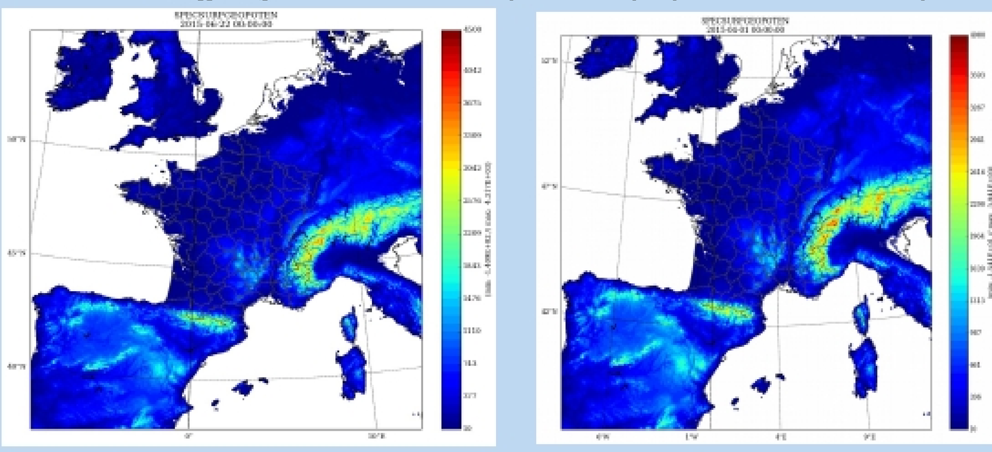
Therefore, this study aims to assess the cloud characterization using a CO2-slicing method by addressing the following points:

- Assessment of cloud characterization in ARPEGE and AROME models for both operational (Oper) and former operational (Old) model versions.
- Comparison of the cloud detection of IASI in ARPEGE / AROME over the same domain.
- Study of the 50-minute phase shift effect between IASI MetopA and MetopB on the cloud detection.

1-Methodology

Firstly, the cloud top pressure derived from IASI using the CO2-slicing method has been compared with the cloud top pressure product provided by the SEVIRI NWC-SAF. Then, a co-localization of IASI in ARPEGE and AROME was performed.

We have made a comparison in AROME between old and Oper models. The latter experienced recently a top level modification (from 1 hPa down to 10 hPa), as well as a horizontal resolution almost doubled from 2.5 to 1.3 km. The computational domain is extended slightly to the north (+ 10%). (see the example in figure below).



Arome in Oper   Arome in Old

Figure 1: Comparison of the orography in the Arome model version.

	Oper	Old
Nb vertical levels	90	60
Top model level	10 hPa	1 hPa
Lowest model level	5m	10m
Nb levels < 2000m	33	21

Table1 : characteristics of model AROME in Oper and Old version.

The phase shift effect between MetopA and MetopB was also verified in this study.

This was made using several situations (sea / land; day / night) and using many methods (histograms, statistics, differences CTP maps ...) in order to determine the performance of the CO2-slicing algorithm. In this study, we used data acquired during February 2015.

2-Evaluation of the characterization of clouds with CO2-Slicing

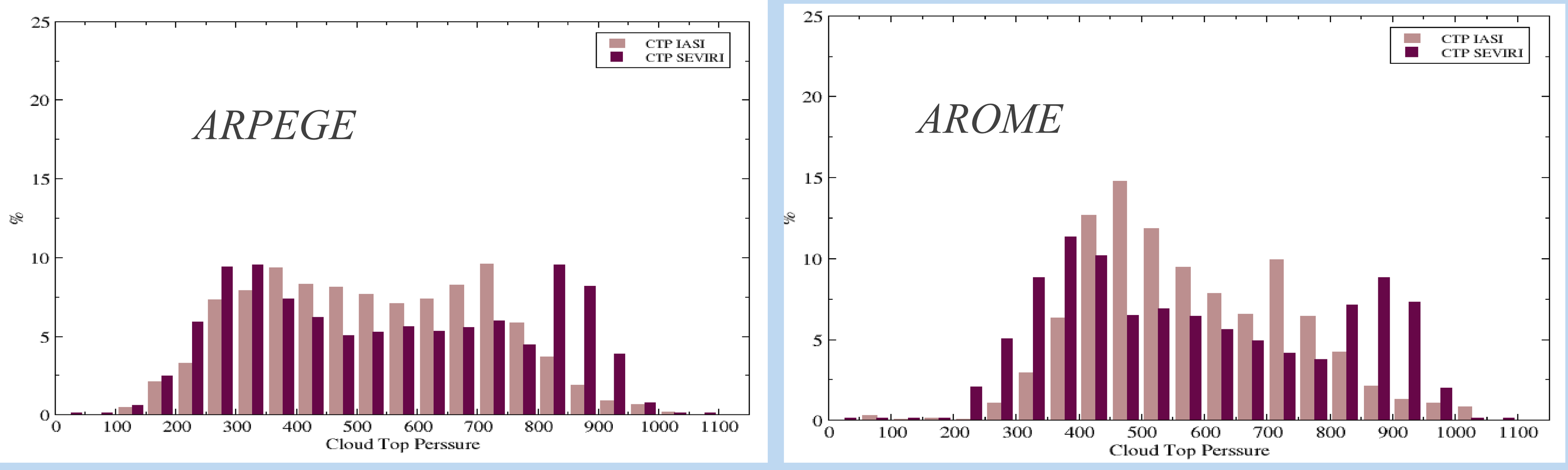


Figure 2: Distribution of cloud top pressure (hPa) from IASI and SEVIRI over sea during day-time in ARPEGE (left panel) and AROME (right-panel).

Over Sea during day-time:

- In ARPEGE, more mid level clouds detected with IASI than with SEVIRI.
- In AROME, more low-level clouds and high levels clouds detected with SEVIRI than with IASI.

Comparison of IASI in AROME and in ARPEGE over AROME domain

	Sea	Land
MetopA Day	0 .92	0.92
MetopB Day	0.93	0.92
MetopA night	0.94	0.95
MetopB night	0.94	0.95

Table 2: IASI correlation coefficient between AROME/ ARPEGE in Old .

	Sea	Land
MetopA Day	0.85	0.79
MetopB Day	0.86	0.78
MetopA night	0.84	0.69
MetopB night	0.84	0.74

Table 3: IASI correlation coefficient between AROME/ ARPEGE in Oper

- Generally in Old we have a better correlation between ARPEGE and AROME than in Oper.
- In Old, a better correlation above 0.92 found over sea than over land during daytime, and over Land than over Sea at night.
- In Oper, a better correlation found over sea than over land, and during daytime than at night but below 0.85.

3-Comparison between MetopA and MetopB in cloud detection

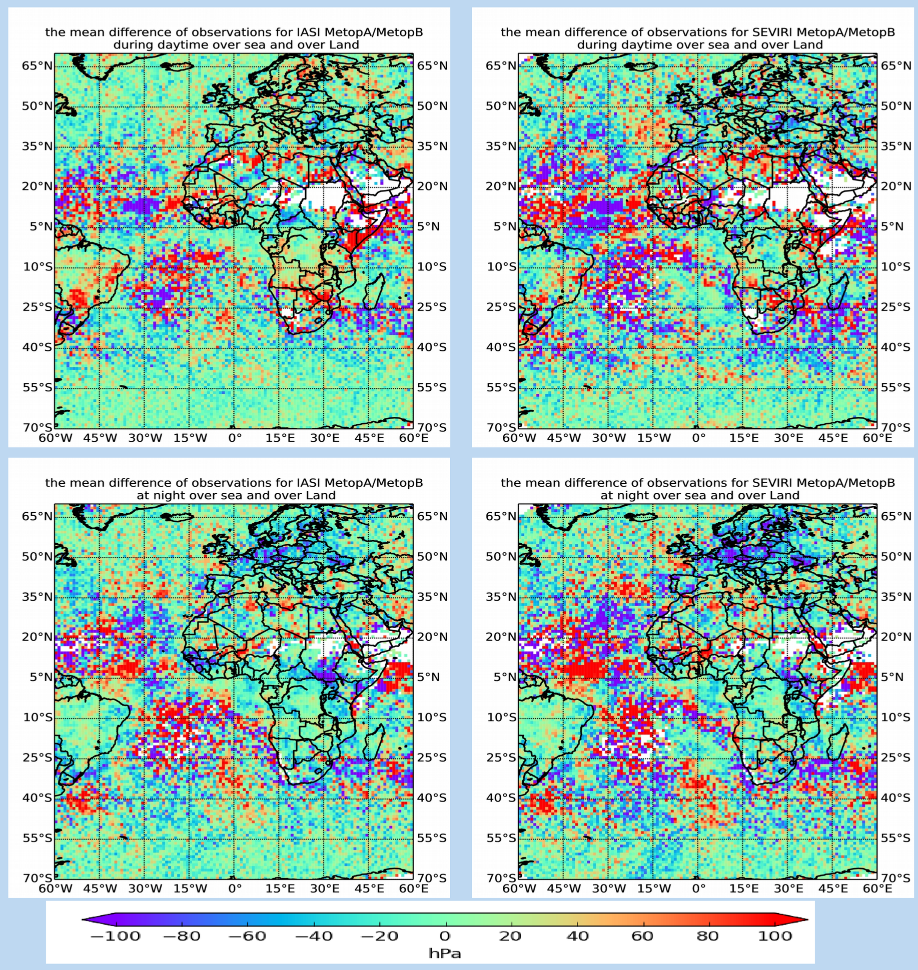


Figure 3: Difference of Cloud Top pressure (hPa) retrieved from Metop A and Metop B over the period for IASI (left panel) and SEVIRI (right panel).

- we have several areas between -100 and 0 hPa of difference, for exemple in the area 20 - 30N and 30 - 45w during daytime and over Europe and Russia at night.
- We find also positive differences where Metop A puts more low-cloud than Metop B for exemple in area 5-20N and 30-45E during daytime and in area 5-20N 30-45W at night.
- For SEVIRI, the same difference in the same areas are observed between SEVIRI data co-localised with Metop A data and those co-localised with Metop B but with a stronger way for exemple in mediterranean area.

4-Comparison of IASI in Old and Oper

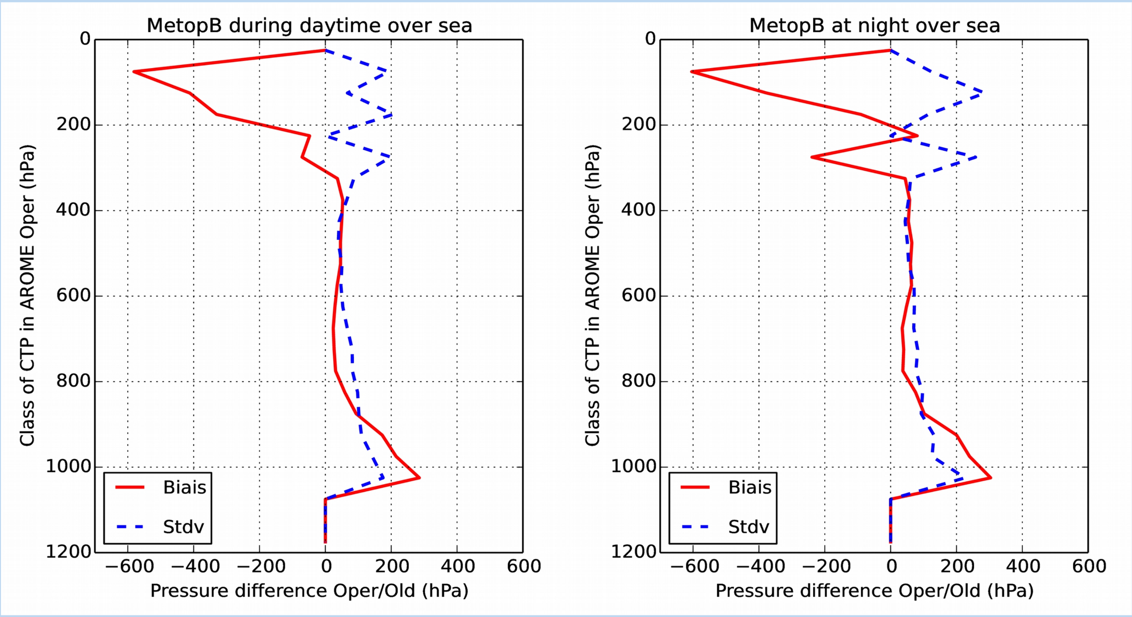


Figure 4: Bias and standard deviation of the mean differences between CTP IASI MetopB in AROME Old /Oper during daytime (left pannel) and at night (right pannel) over Sea.

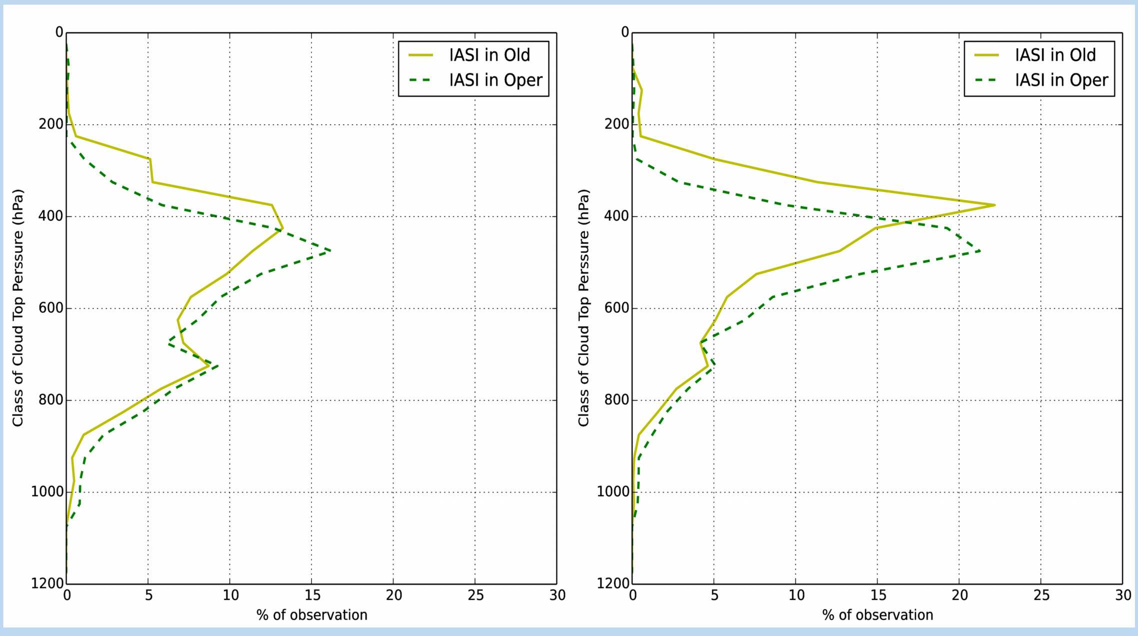


Figure 5: Distribution of the cloud top pressure retrieved from IASI MetopB in AROME Oper and Old during daytime (left pannel) and during nighte-time (right pannel) over Sea.

- Between 200 and 800 hPa, the mean bias between both versions is close to 64 hPa, during daytime and at night.
- On average, the standard deviation is close to 52 hPa during daytime and to 60 hPa at night..
- Above 200 hPa and below 800 hPa, a very large bias and stdv are found because of very reduced data numbers in these layers, shown in the data distribution histograms, since we have more observations between 200 and 800 hPa.
- The same calculations are made in ARPEGE, the Bias and standard deviation are always lower than in AROME (Biais closest to 59 hPa and average standard deviation closest to 24 hPa).

	ARPEGE						AROME					
	POD		FAR		Correlation		POD		FAR		Correlation	
	Old	Oper	Old	Oper	Old	Oper	Old	Oper	Old	Oper	Old	Oper
MetopB over sea during Daytime	73.10	73.15	2.67	2.66	0.81	0.80	73.98	71.46	4.82	4.75	0.83	0.79
MetopA over sea during Daytime	72.79	72.32	2.6	2.61	0.81	0.80	74.06	68.59	4.59	4.64	0.82	0.77
MetopB over sea at night	65.96	65.85	6.48	6.39	0.84	0.83	69.12	65.94	9.42	8.1	0.82	0.79
MetopA over sea at night	65.1	65.19	6.15	6.15	0.84	0.83	74.64	72.89	10.35	12.16	0.83	0.77
MetopB over land during Daytime	60.97	60.75	4.08	4.22	0.85	0.85	56.91	55.74	0.88	0.88	0.80	0.70
MetopA over land during Daytime	60.29	59.95	2.80	2.93	0.84	0.84	57.54	55.1	0.93	0.98	0.81	0.68
MetopB over land at night	64.43	64.48	9.06	9.14	0.86	0.86	50.38	50.52	2.88	2.26	0.86	0.71
MetopA over land at night	65.38	65.87	8.45	8.75	0.83	0.84	49.28	50.93	2.28	2.44	0.80	0.67

Table4: Verification scores for CO2-slicing for situations of daytime (sea / land) and night (sea / land) in ARPEGE and AROME, verified against SEVIRI.

<u>In ARPEGE :</u>

- The best POD and FAR are found during daytime over sea for the two Metop A and B.
- The verification scores are almost identical between Oper and Old despite a slightly lower difference between 0.05 and 0.3%.
- The best correlation found over land than over sea.

<u>In AROME :</u>

- The best POD is marked Oper during daytime over sea for MetopB and at night for MetopA.
- The best FAR is marked over land for two Metop A and B, and higher at night over sea
- The POD is better in Old than in Oper (between 1 % and 6%) except at night over land.
- The best correlation found in Old.

5-Conclusions and perspectives

- The change in model vertical resolution for AROME is not neutral in terms of detection / characterization of clouds, because we find better results in Old than Oper. The channel selection used for the CO2 slicing should be adapted.
- When comparing cloud characterization from ARPEGE and AROME, better results are obtaine with the old version because there was less differences between the global model and the convective scale model in terms of vertical and horizontal resolution.
- The phase shift between Metop A and Metop B seems to have an effect on their cloud characterization over different areas. This result was confirmed also by SEVIRI data. Further, the study period should be extented to strengthen this conclusion, this result is confirmed by SEVIRI, using a succession of images of different analysis times and we observed that it is an convection area of North-west to south west, thus the phase shift of the two Metop allows to detect a different way the development of this convection.

References

*Guidard, V., Fourrié, N., Brousseau, P. et Rabier, F. (2011). Impact of iasi assimilation at global and convective scales and challenges for the assimilation of cloudy scenes. Quarterly Journal of the Royal Meteorological Society, 137(661) :1975–1987.

*Menzel, W., Smith, T., et Stewart, T. (1983). Improved cloud motion wind vector and altitude assignment using VAS. J. appl. Meteorol, 22 : 377–384.

*Pangaud, T., Fourrie, N., Guidard, V., Dahoui, M., et Rabier, F. (2009). Assimilation of AIRS radiances affected by mid-to low-level clouds. Monthly Weather Review, 137(12) :4276–4292.

*Faijan F, Lavanant L, Rabier F, 2012. Towards the use of cloud microphysical properties to simulate IASI spectra in an operational context. J. Geophys. Res., 117, D22205

*Martinet P, Fourrié N, Guidard V, Rabier F, Mont-merle T and Brunel P, 2013. Towards the use of microphysical variables for the assimilation of cloud- affected infrared radiances. Quart.J.Roy.Meteor.Soc., doi: 10.1002/qj.2046

*Martinet, P., Fourrié, N., Bouteloup, Y., Bazile, E. and Rabier, F. (2014). Toward the improvement of short-range forecasts by the analysis of cloud variables from IASI radiances. Atmospheric Science Letters, 15(4), 342-347.