Bias correction of satellite data at Météo-France

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1. Introduction

Bias correction at Météo-France is a manual task in its estimation, maintenance and update. When a new satellite is launched or when the radiative transfer model is updated, a screening run is performed over a certain period to get statistics of model departure from observation. Bias correction coefficients are then estimated and injected into assimilation runs that induce updated statistics on model departure from observation. A second and even a third update of the bias correction coefficients is generally necessary when a new observation is introduced as in the first estimation the model does not have any signature of these observations. Bias correction coefficients are updated whenever there is a change in the instrument stability, in the radiative transfer modelling or in the meteorological model. The update frequency is determined on the basis of monitoring and the 6-hour forecast, called first guess, is taken as a non biased reference for this purpose.

Six types of satellite observations are assimilated at Météo-France, in operational, pre-operational or test mode, as shown in Table 1. Corrections are flat or multi-linear with predictors derived from the model in most cases or from the observations themselves, as for QuikSCAT. For ground-based GPS data bias correction is done for each station. A scan correction is applied to ATOVS-like (i.e. AMSUA, AMSUB, MHS, HIRS) or SSM/I data. The period over which statistics are collected is different from one instrument to another and depends on the data coverage required by the model, i.e. global model ARPEGE or limited area model ALADIN. The update frequency is yearly to seasonal for ATOVS-like, SSMI and AIRS instruments and higher for SEVIRI and ground-based GPS data. This paper gives an overview of the bias correction for the following instruments: (1) ATOVS-like and SSM/I, (2) AIRS, (3) SEVIRI, and (4) ground-based GPS. The bias correction of QuikSCAT data is not presented here as coefficients used at Météo-France are exactly the ones used at ECMWF.

Instrument	ARPEGE (global)	ALADIN (LAM)	No. of predictors	Scan corr.	Period [days]	Update [/year]
AMSUA/B, MHS, HIRS	oper	oper	4 (model)	✓	30	1-4 times
SSM/I	test	test	4 (model)	✓	30	1-4 times
AIRS	test	test	0		7	1-4 times
QuikSCAT	oper	pre-oper	2 (obs)			
SEVIRI	test	oper	4 (model)		21	> 4 times
Ground-based GPS	test	test	1 (station)		10	running average

Table 1 Overview of bias correction of satellite data at Météo-France.

2. ATOVS-like and SSMI data

Bias correction coefficients for AMSUA, AMSUB, MHS, HIRS and SSMI data are computed according to Harris and Kelly (2001), namely an air-mass correction based on 4 predictors and a scan correction for super-scan positions (positions are gathered together 3 by 3 for AMSUB, MHS and HIRS or 5 by 5 for

SSM/I to make it easier to handle), as shown in Table 2. Air mass correction is performed globally and scan corrections by 10° latitude bands.

	AMSUA	AMSUB MHS	HIRS	SSM/I
Predictors	1000-300 hPa thickness 200-50 hPa thickness surface temperature total column water vapour			surface pressure surface temperature total column water vapour surface wind speed
Scan angles	30 from initial 30	30 from initial 90	18 from initial 56	13 from initial 64

Table 2 Characteristics of the air-mass and scan angle corrections for ATOVS-like and SSM/I data.

For the global model ARPEGE, the same bias correction is applied to both sources of data we use in the model, i.e. NESDIS disseminated data as well as locally received EARS data. This same bias correction file is used for the regional model ALADIN as well. Results obtained from locally derived bias correction coefficients are presented in this workshop by R. Randriamampianina. Research experiments are being carried out at Météo-France to assimilate surface sensitive AMSUA and AMSUB channels over land (Karbou et al., 2005). In this perspective it is expected to benefit from a specific land bias correction as model departure from observations is highly sensitive to surface emissivity in these channels.

3. AIRS data

When first introduced into the global model, 4 predictors (surface temperature, viewing angle, first guess brightness temperature, latitude) were used to bias correct the 64 most informative AIRS channels with a neural network bias correction procedure. The training process was done on 56 analyses (2 weeks). In order to get a positive impact of AIRS data on the analysis/forecast scores, it was then decided to increase the number of channels. For technical reasons and as a first step, knowing moreover that it was successful at ECMWF, it was decided to replace the neural network bias correction by a flat one. Figure 1 shows to which extent the first guess departure is reduced when applying a flat bias correction to the observations. This method has the advantage of requiring a shorter learning period (1 week), as shown in Figure 2.

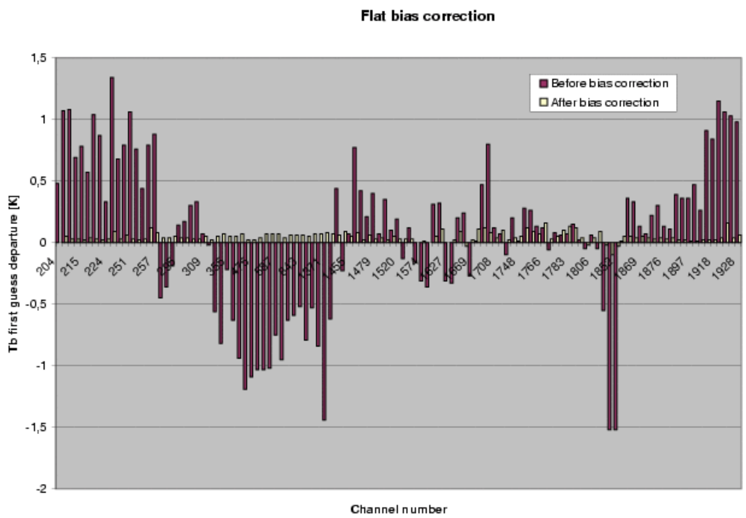

Figure 1: AIRS data flat bias correction: mean value of first guess departure from observation as a function of channel number, before and after bias correction. Statistics are obtained over 1 day (21 Jan 2005, 00/06/12/18 UTC, active data).

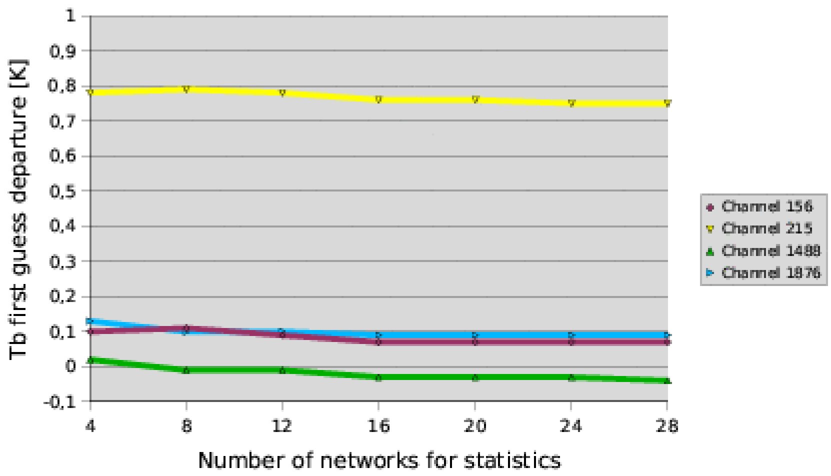

Figure 2: Mean value of first guess departure from observation as a function of the number of cycles used for estimating the bias correction. Four different AIRS channels are considered: channel 156 (weighting function peaking at 194 hPa), channel 215 (weighting function peaking at 521 hPa), channel 1488 (water vapour channel peaking at 749 hPa) and channel 1876 (surface channel). With 7 days of statistics, the equilibrium is reached.

4. SEVIRI data

High resolution data from the visible and infrared imager SEVIRI on board Meteosat-8 are considered in the 3DVar assimilation system within the limited area model ALADIN-France which is running operationally at Météo-France since July 2005. Channel selection is performed thanks to the cloud classification produced by CMS in the framework of the nowcasting SAF: infrared channels 8.7, 10.8 and 12 μm are used only in clear air over sea and water vapour channels 6.2 and 7.3 μm are kept above low-level clouds. The sampling is about 25 km (use of 1 pixel out of 5) for a model resolution of about 10 km and a thinning is performed within 70 km^2 boxes. The predictors used in the bias correction of SEVIRI data are the same as the ones used for ATOVS-like data, but in this case only air-mass correction is considered. Multi-linear regressions are trained on clear air datasets for all the channels and restricted to sea points only for infrared channels.

The bias correction using predictors appears to be much more robust than a flat bias correction, for these particular data. Figure 3 presents the monitoring time series obtained in March-April 2005 from a bias correction with predictors and from a flat bias correction. Both coefficients sets are tuned on the same period, i.e. July 2004. In the case of a flat bias correction, the corrected and non corrected biases almost superimpose and are not satisfactory (~ -0.4 K for that channel) whereas in the second case, the bias is largely reduced after bias correcting the data. This shows that the bias correction with predictors, built from 2004, is still efficient in 2005, which is not the case for the flat bias correction.

For most of the channels the bias correction is efficient in the sense that the first guess departure from observation is reduced after correcting the observations. However for a particular channel, i.e. 13.4 m, a bias of about 0.4 K persists after bias correction (see Figure 4). If computed with weighted Planck functions and the corresponding radiative transfer coefficients provided by CMS (compatible with RTTOV-8), the bias is slightly reduced, but not enough to prevent those data from a massive blacklisting when quality controlled. This problem is still under investigation.

(a) Flat bias correction (b) Bias correction with predictors

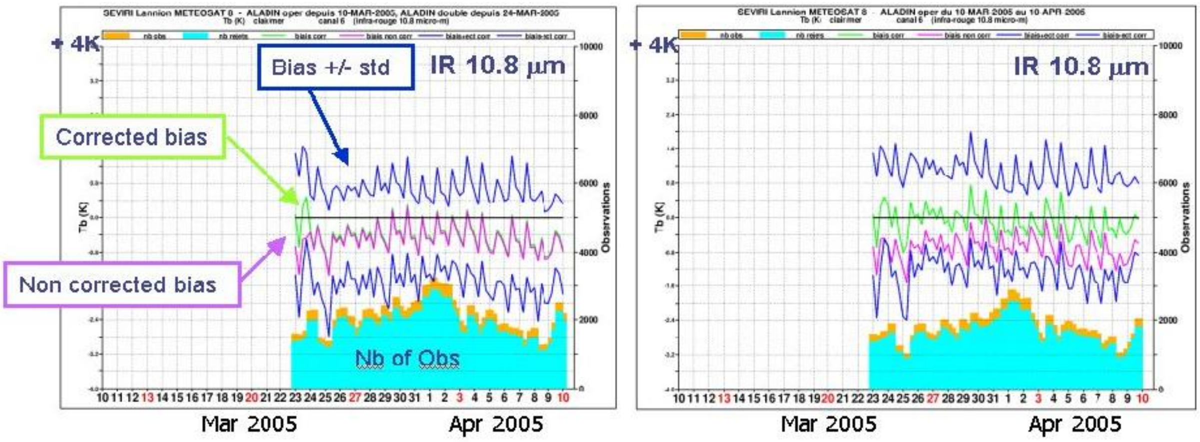

Figure 3: Monitoring time series obtained for channel IR 10.8 µm in March-April 2005 with (a) a flat bias correction and (b) a bias correction with predictors, both approaches being tuned on the July 2004 period. Pink curve represents the raw or non corrected bias, green curve the corrected bias and blue curves this last value +/- standard deviation.

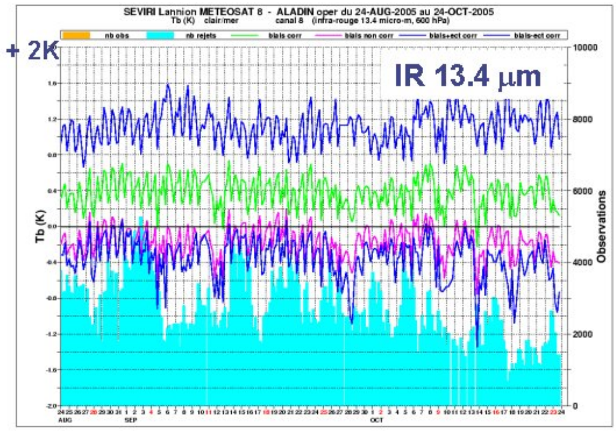

Figure 4: Monitoring time series obtained for channel IR 13.4 mm in March-April 2005. Pink curve represents the non corrected bias, green curve the corrected bias and blue curves this last value +/- standard deviation.

Because of limited area sampling in the ALADIN-France domain, bias correction coefficients need to be often revised, i.e. at least 4 times a year over a 3 week period. Soon in the global model ARPEGE, EUMETSAT 40 km horizontal resolution CSR data will be introduced with a bias correction built on 3 predictors, excluding surface temperature as no surface sensitive channel will be used.

5. Ground-based GPS data

The Zenith Total Delay (ZTD) data collected by the various European networks of ground-based GPS stations have been made available in near-real time since 2004 thanks to the efforts of the TOUGH project. Assimilation experiments have been run with these data at Météo-France in the global model ARPEGE (Poli et al., 2005).

Several centres process the data and distribute them in near real time via the GTS. But processing is different for each centre. In the case of stations processed by several centres, we retain the processing centre for which the standard deviation is the smallest or which presents the most Gaussian histogram. Bias correction is necessary as for some of them the biases are larger than the standard deviations. Because of the limited observation network in space and time and in the perspective of assimilating these data in an operational environment, bias correction is calculated from a running average of observation minus first guess differences on a time period extending before the analysis time. A flat bias correction is preferred to a bias correction with predictors as it would require a longer history. The correction is estimated for each centre and each station from the mean value of observation minus first guess differences over 10 days and this correction is applied to the observations during 3 weeks after the date the biases were calculated. Table 3 presents statistics obtained for 4 centres over the population of stations they process, during the bias correction estimation and after correcting the data. Both bias and standard deviation are reduced after bias correction, thanks to a bias specific to each station.

			Training period 17 - 26 Jan 2005 Bias (obs-first guess) [mm]					Screening with bias correction 27 Jan – 16 Feb 2005 Bias (obs-first guess) [mm]				
	CEN	DT	no	min	mean	std	max	no	min	mean	std	max
Switz.	LPT	5	37	3.8	13.5	5.1	25.6	36	-11.5	3.4	4.1	10.7
France	ACR	15	43	-3.3	6.4	4.8	20.5	43	-3.3	0.5	2.1	5.4
UK	MET	15	64	-91.7	0.2	23.5	26.0	58	-3.2	-0.3	1.2	2.6
Germ.	GFZ	30	82	-14.4	10.1	4.8	24.7	82	-14.4	-0.9	2.2	3.5

DT: averaging time period [min]

CEN: processing centre

Reduced bias and std thanks to a bias specific to each station

Table 3: Example of statistics obtained during the 10 day training of ZTD bias correction and when applying the bias correction during the next 3 week period for 4 particular processing centres.

6. Future work

A revision of the list of predictors seems to be necessary, as no investigation has been done on this purpose since the list was first established. For example using surface temperature as a predictor for a global air-mass bias correction, knowing that its error is much larger over land than over sea (model error set to 1 K over ocean and 5 K over land), must be somehow dangerous as the global bias correction file does not have the signature of the continental and diurnal effects. Experiments will be performed with a distinction between land and sea by the means of two sets of bias correction coefficients. This development is expected to be beneficial to research experiments we are currently running, where more surface sensitive AMSUA and AMSUB channels are assimilated over the continents (Karbou et al, 2005).

Acknowledgements

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7. References

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Acronyms

AIRS	Atmospheric Infrared Sounder
ALADIN	Aire Limitée Adaptation Dynamique Développement InterNational
AMSUA/B	Advanced Microwave Sounder Unit A/B
ARPEGE	Action de Recherche Petite Echelle Grande Echelle
ATOVS	Advanced TIROS Operational Vertical Sounder
CMS	Centre de Météorologie Spatiale, Lannion, France
CSR	Clear Sky Radiances
EARS	EUMETSAT ATOVS Retransmission System
ECMWF	European Centre for Medium-Range Weather Forecasts, Reading, UK
EUMETSAT	European Organisation for the Use of Meteorological Satellites
GPS	Global Positioning System
GTS	Global Transmission System
HIRS	High-resolution Infra-Red Sounder
MHS	Microwave Humidity Sounder
NESDIS	NOAA National Environmental Satellite, Data Information Service
NOAA	National Oceanic and Atmospheric Administration
QuikSCAT	Quik Scatterometer
SAF	Satellite Application Facility
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SSM/I	Special Sensor Microwave/Imager
TIROS	Television Infrared Observation Satellite
TOUGH	Targeting Optimal Use of GPS Humidity measurements in meteorology
ZTD	Zenith Total Delay