Investigation of the application of local ATOVS data in Budapest

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INTRODUCTION

In 2001 a complex study was performed to compare the quality of locally pre-processed ATOVS radiances from CMS (Centre de Météorologie Spatiale, Météo-France) in Lannion with those from NOAA/NESDIS[1] (Randriamampianina and Rabier, 2001). According to the results of this study, the quality of the locally pre-processed ATOVS data is better than the quality of NESDIS data. Moreover, the positive impact of the locally pre-processed ATOVS data on the forecast of the ARPEGE model over Europe (Lannion reception area) was more significant than that of NESDIS.

These encouraging results were one of the reasons to choose the ATOVS data as potential observations to complete the observation database at the Hungarian Meteorological Service (HMS). In 2002 the implementation of the locally pre-processed ATOVS data was performed. Hence, a new concept of data pre-processing was worked out, followed by the implementation of a bias correction program to estimate the systematic error of the local ATOVS data. Furthermore, the debugging and implementation of ATOVS radiances into the AL15 library was performed.

This paper gives an overview of how the above-mentioned tasks were solved to ensure the use of ATOVS data in the ALADIN three-dimensional variational analysis (3D-Var). I also use this opportunity to share my experience on first implementation of satellite data into a limited area model.

DATA PRE-PROCESSING

The earlier version of data processing - prior to the satellite data implementation - consisted of pre-processing of TEMP and SYNOP data in two steps : the initial observation files (in NetCDF format) were converted into ASCII format at first, then the MANDALAY program was applied to create CMA files. CMA files used to be the input files of the ALADIN model up to AL13. The MANDALAY program is rather complicated to use with the 1C ATOVS (more explanation later) radiances, so we adapted the pre-processing scheme from Toulouse consisting of programs OULAN and BATOR.

The implementation of the ATOVS radiances was performed into the AL15 model that requires ODB files as input instead of CMA file. We have created ODB as follows :

At the HMS we receive HRPT (High Resolution Picture Transmission) files from the NOAA satellites (NOAA-15 and NOAA-16). These files are pre-processed by the AAPP[2] package until the level 1C. The AAPP package has 4 pre-processing levels, namely 1A (instrument count), 1B (instrument count, navigation and calibration information appended), 1C (instrument reflectance factors or brightness temperatures, navigation and calibration information appended) and 1D (instrument reflectance factors or brightness temperatures, mapped on one common instrument grid, navigation, calibration and contamination information appended). As the level 1C radiances do not contain information about the contamination (e.g. cloudiness), the use of infrared radiances became problematic. Hence data from the microwave sensor AMSU-A are investigated at the moment. We use direct read-out of the AAPP output. The OULAN program converts the TEMP and SYNOP

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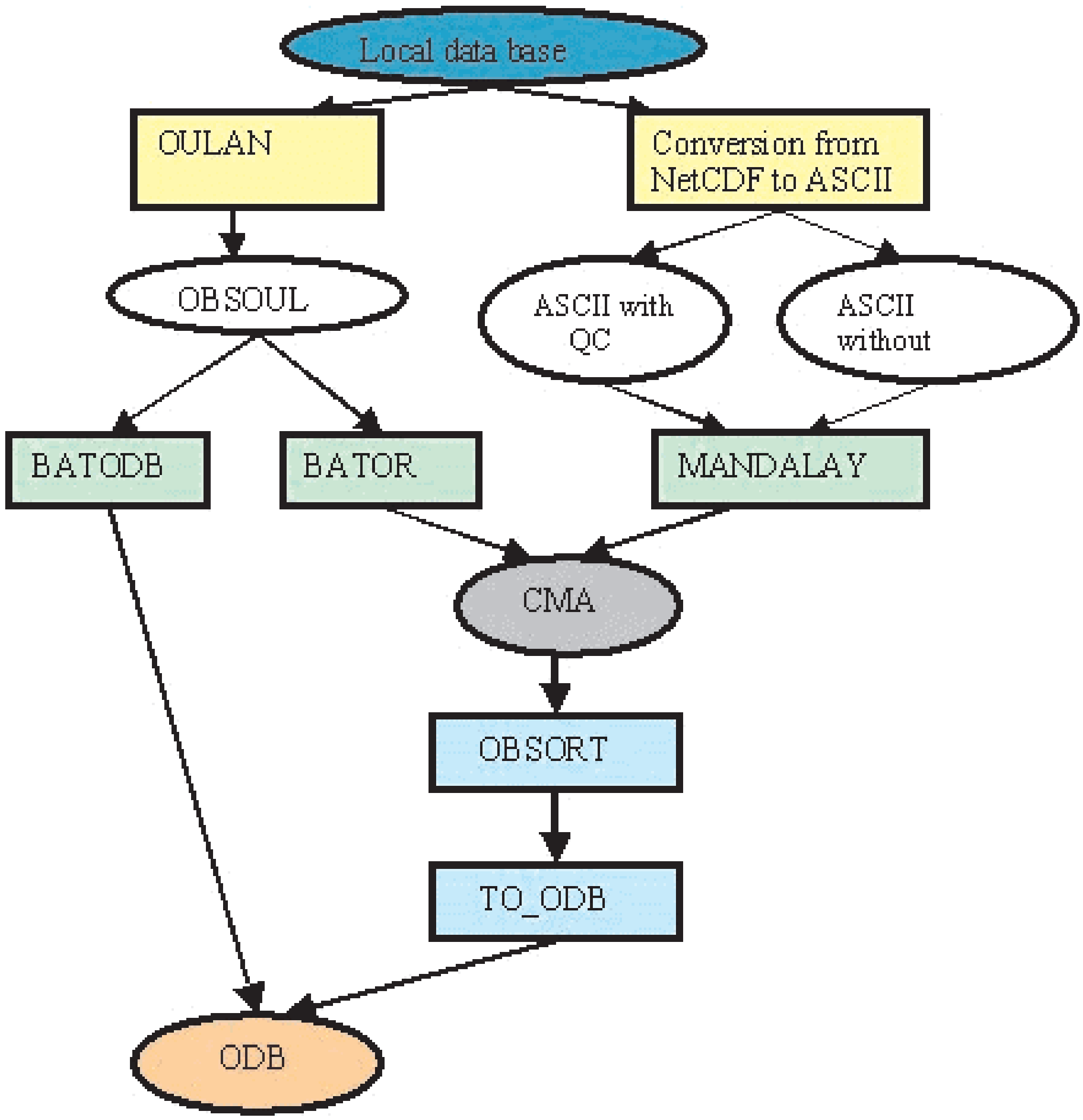
[1] NOAA/NESDIS- National Oceanic and Atmospheric Administration/National Environmental Satellite Data and Information Service

[2] AAPP - ATOVS (Advanced TIROS Operational Vertical Sounder) and AVHRR (Advanced Very High Resolution Radiometer) Processing Package

data, extracted from the local database as well as the ATOVS data into a well-organized file in ASCII format (OBSOUL). From this stage there are three possible approaches : we could use the BATOR program in case we would need CMA files. We receive ODB files from the ASCII format either by applying directly BATODB or using BATOR, OBSORT and TO_ODB in the given order (see Figure 1). Due to some technical requirements the latter scheme was chosen.

Figure 1. Different ways to create ODB at HMS

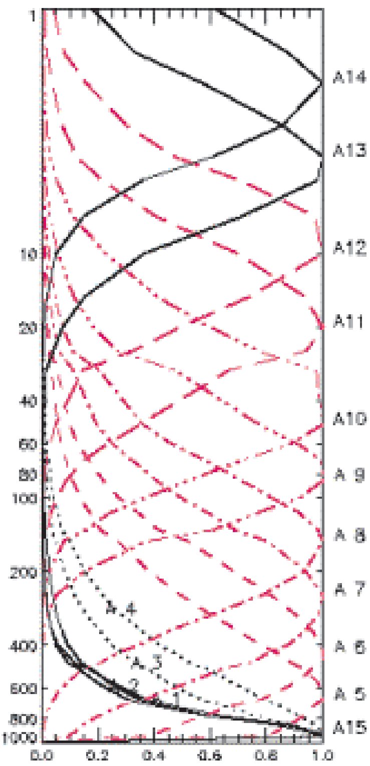


BIAS CORRECTION

Well known that satellite data contain systematic errors. As it was reported by Harris and Kelly (2001), the bias of data measured by the NOAA satellites varies along the scan angles (from the nadir) and depends on air-mass. The first conclusion means, that the bias varies along the different latitude bands. Since the "observation minus first-guess" information is used to evaluate the bias, the "air-mass bias" is model dependent. Thus, the bias correction coefficients have to be calculated for our latitude band (domain) as well as for our model (ALADIN/HU). The bias correction procedure (script and programs) used in Toulouse computes biases for the globe. The particularity of our case is that we compute bias for a relatively small domain, 90 percent of which is over land. According to this, we have to solve the following problems :

– We do the computation of biases at each assimilation time. In case the satellite path does not "hit" the C+I zone, a division by zero appears. To avoid this problem some modifications were done.
– The land/sea proportion or the distribution of territories with different altitudes in the domain is important to compute biases for channels used over sea only or for those used over land with some restrictions on altitude, respectively. These channels are sensitive to lower atmospheric layers (see Figure 2). Increasing the size of the domain we increase the amount of data available. Thus, the probability of getting "representative" statistics for a certain channel increases. As an example, in case of old domain (Figure 3) the bias at scanning angles 1, 5 and 6 for channels 3-6 equals zero (see Figure 5). So, at these conditions there is no data available. This is not the case for the new domain (Figure 4) that includes bigger territory and more pixels over sea. The bias at scanning angles 1, 5 and 6 for channels 3-6 is not equal to zero (Figure 6), so more data can be used for statistical calculations. In our case a 3-week period was not enough to compute "representative" statistics for the mentioned channels neither for the old, nor for the new domain. Note that channels 3 and 4 are not used in ARPEGE, so we are not going to use them as well. We are to compute statistics for channels 5, 6 and 7 for a longer period. In case we do not get "representative" statistics, we will not use these channels in the 3D-Var ALADIN.
– Other important thing is that the bias computation procedure uses a routine (the one that computes eigenvalue and eigenvector) from the NAG package. Since we do not have the NAG software, we had to perform this computation with other routines.

Figure 2. Example of weighting function for the AMSU-A channels



The left-hand side vertical scale refers to the height in hPa. The channel numbers are given on the right hand side.

Source:
http://www.meteorologie.eu.org/ici

Figure 3. Satellite observations inside of the old domain of the ALADIN/HU (C+I zone)

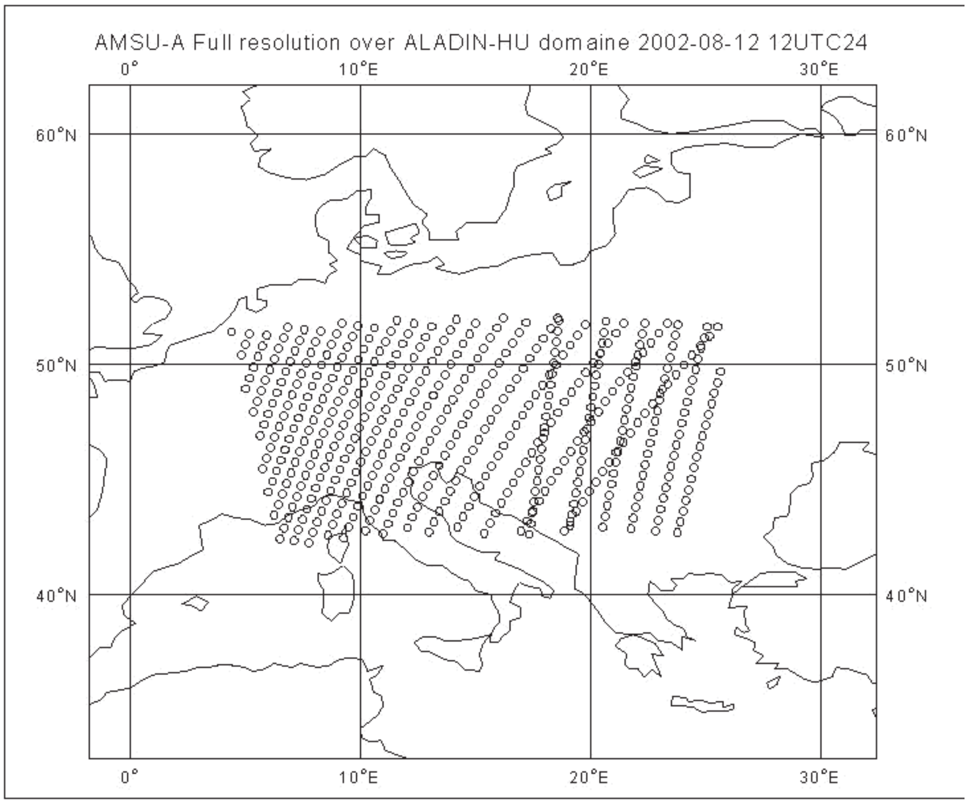
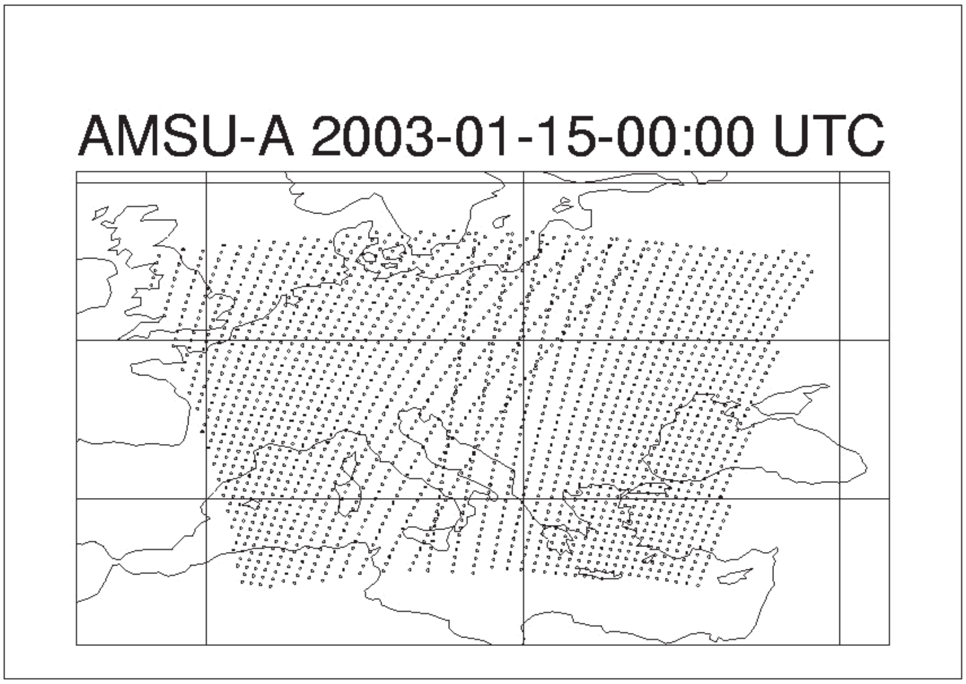


Figure 4. Satellite observations inside of the new domain of the ALADIN/HU (C+I zone)



DEBUGGING AND IMPLEMENTATION

The results of screening with AL15 are presented in Figures 7a-b. One of the modifications in the model consisted in the insertion of TOVS/ATOVS data as a control variable when performing the minimization of the cost function. This modification was done in the *yemecain.F90* routine plus all modifications from Elisabeth Gérard. The TOVS variable was put after the one-dimensional mean wind.

Routine *fgchk.F90* was modified as well - we fill up the first-guess error array (`ZFGERR`) for ATOVS data only in case we have ATOVS data in the ODB. Otherwise the model blows up when there is not ATOVS data in the ODB, that may happen in our case. The problem is that this local array is defined with `NMXTCH` (total number of TOVS/ATOVS channels), which is initialized only in case of presence of satellite data (`MNSERIES` not equal to zero) in the ODB (see *surad.F90* and *rtsetup.F90*). If we do not have ATOVS data in ODB, `NMXTCH` is not defined, thus, in *fgchk.F90* we fill up an array with an undefined number of elements.

Some practical advises for the first implementation of TOVS/ATOVS data

- Note, that constant files (*bcor_noaa.dat*, *rt_coef_ieee.dat*, *bcor_noaa.dat*, *chanspec_noaa.dat*, *rmtberr_noaa.dat* and *cstlim_noaa.dat*) are needed for the processing of TOVS/ATOVS data. These files are very important. They have to be updated according to the version of the RTTOV used as well as to the level of the TOVS/ATOVS radiances (eg. 1C or 1D) and to the series of the satellite we are using. We have to take care about these conditions when copying these files from another centre. A rather confusing problem appeared in my case. The model did not stop but gave wrong results and very short comments just because one of the above-mentioned files was not updated.
- Note, that the switch `LTOVSCV` should be set to `TRUE` for both screening and minimization.

CONCLUSIONS AND PERSPECTIVES

The implementation of the locally pre-processed ATOVS radiances into the 3D-Var assimilation scheme was successful. Figure 8 illustrates the difference between the analysis with ATOVS and analysis without ATOVS data (using TEMP and SYNOP only).

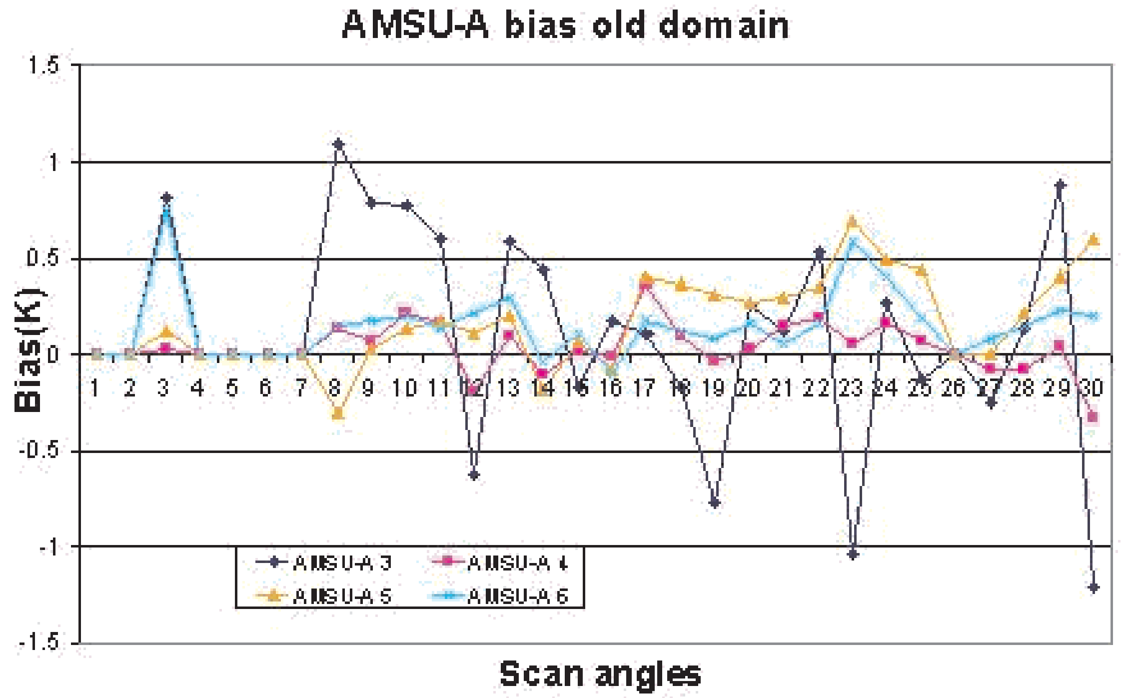
We are about to start the impact study. Different thinning strategies are to be investigated.

REFERENCES

Harris B. A. and Kelly G., 2001: Satellite radiance bias correction scheme for radiance assimilation, *Q.J.R. Meteorol. Soc.,* **127**,1453-1468

Roger Randriamampianina and Florence Rabier, 2001: Use of locally received ATOVS radiances in regional NWP, SAF NWP report, available at Météo-France, HMS or UK Met. Office.

Figure 5. Scan angles bias calculated over the old domain of the ALADIN/HU (NOAA-16). Note, that AMSU-A channels 3 and 4 are used over sea, while channels 5 and 6 are used over sea and over land with restriction on altitude. Channels 7-14 can be used anywhere.



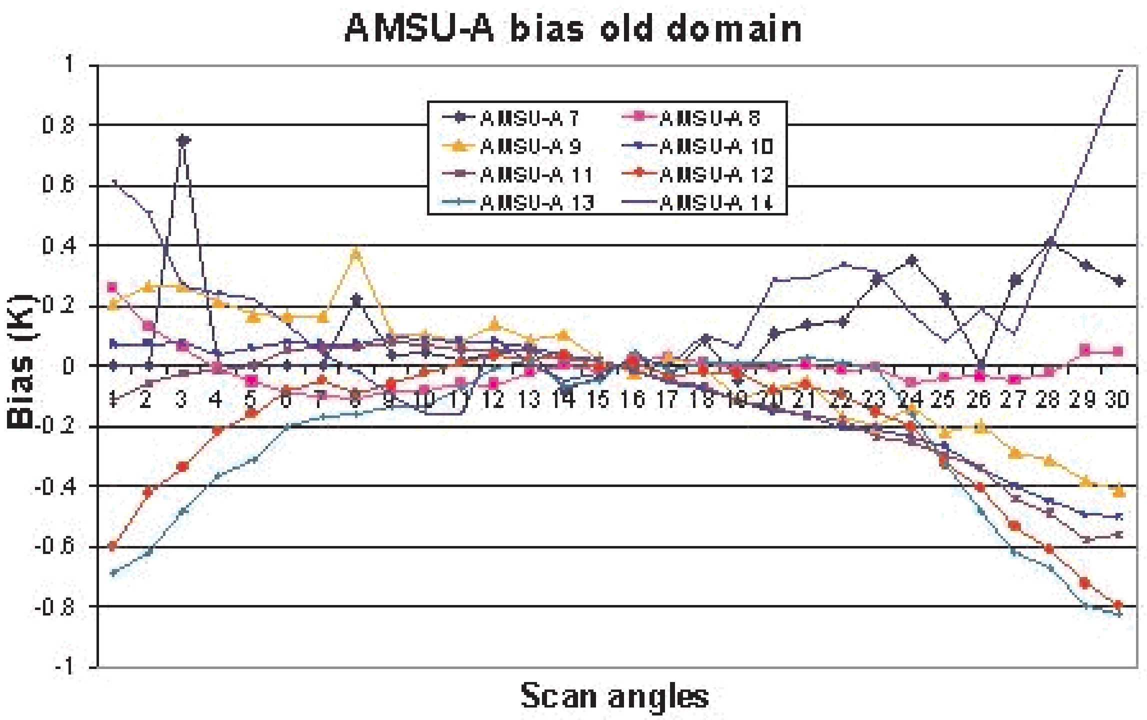
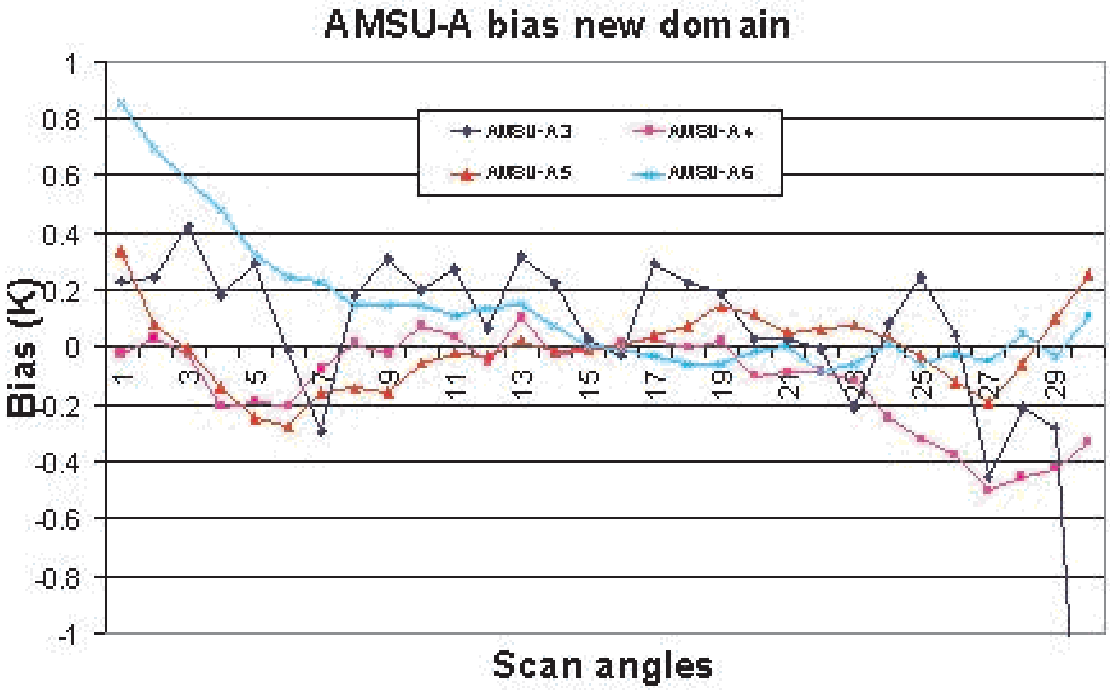


Figure 6. Scan angles bias calculated over the new domain of ALADIN/HU (NOAA-16). Note, that AMSU-A channels 3 and 4 are used over sea, while channels 5 and 6 are used over sea and over land with restriction on altitude. Channels 7-14 can be used anywhere.



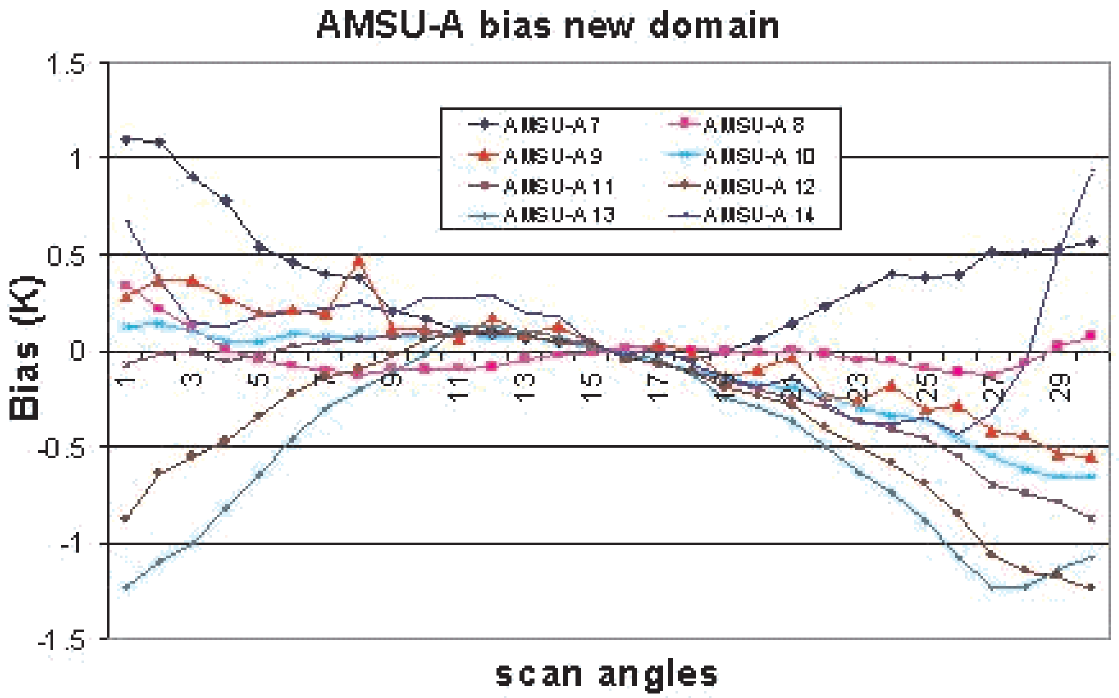
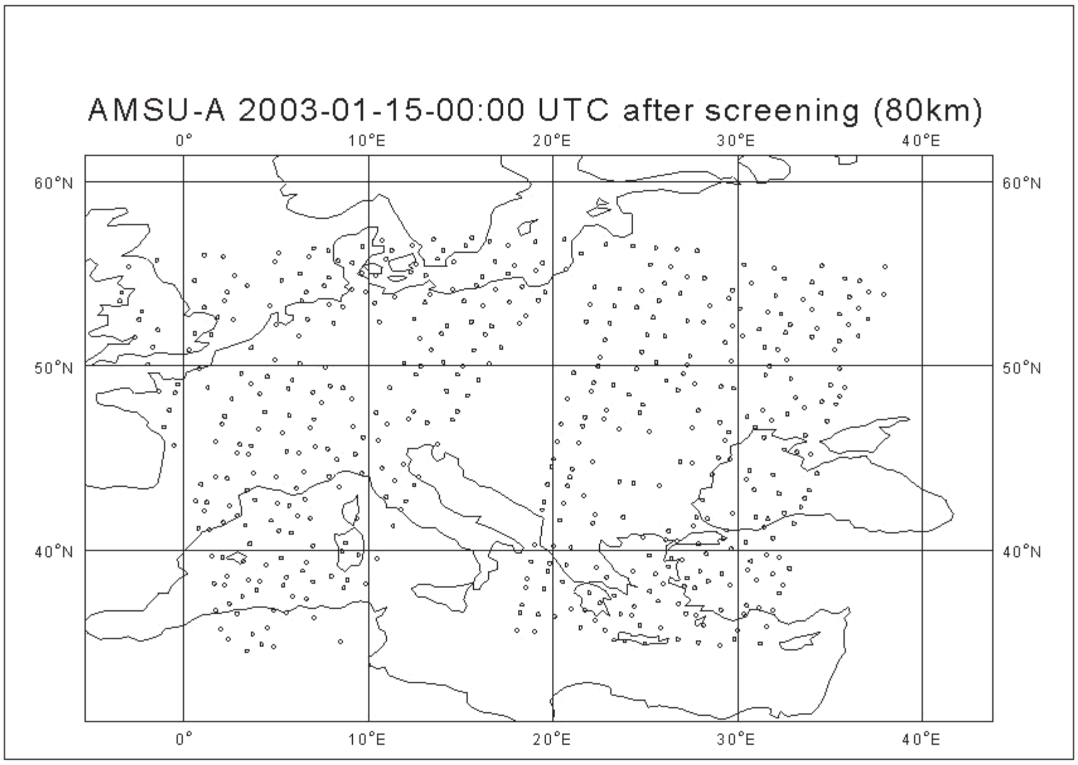


Figure 7. Result of the screening with thinning at 80km (a) and 120km (b)

a)



b)

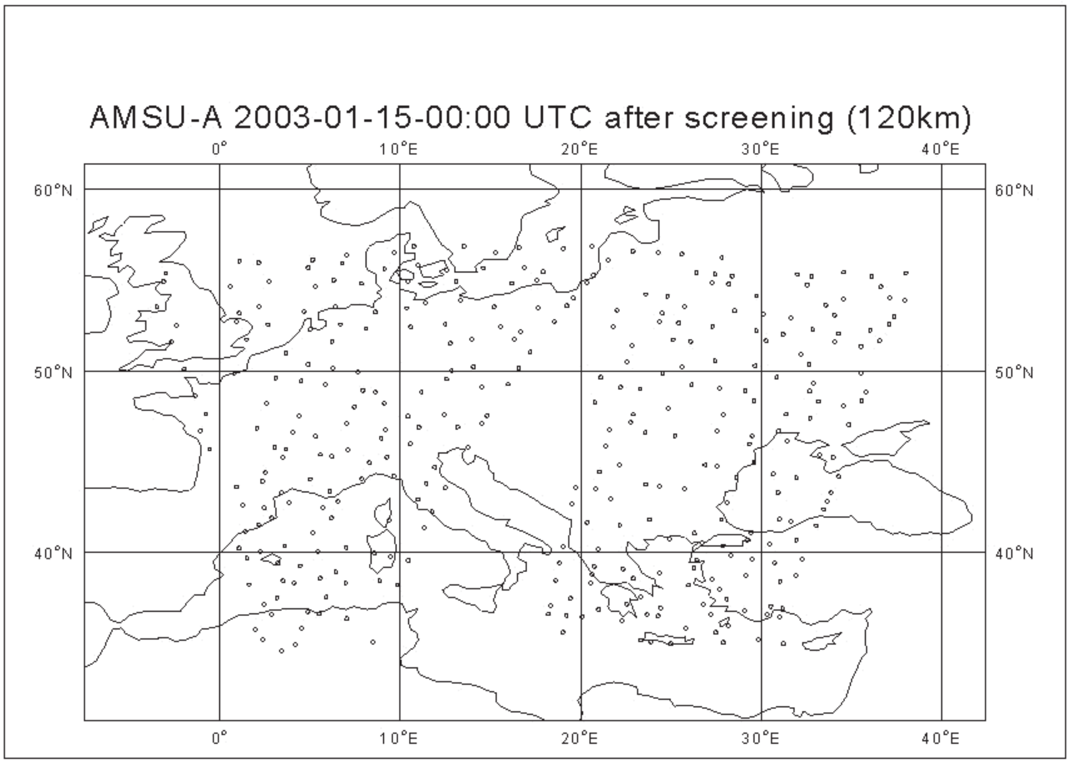


Figure 8. Difference between the analyses performed with ATOVS and without ATOVS (TEMP and SYNOP only) data over the ALADIN/HU domain (thinning distance 80km, level 16)