ATOVS navigation and calibration.
Comparison between local AAPP and global NESDIS methods.

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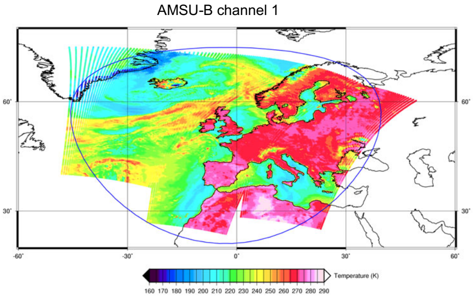
Test data

The ATOVS global level1b data are sent by NESDIS to The Met Office in Bracknell.The AAPP code atovin is used to convert to brightness temperatures, then the output files are converted to BUFR format and sent to ECMWF and Météo-France.

The local HRPT data are taken from the CMS archive. The HRPT data are processed by AAPP V3.2. The conversion from 1b to brightness temperature is done by atovin, the same code as for the global data. The comparison of the final data sets shows the differences in navigation and calibration methods.

It has been chosen to extract ATOVS for 4 days for NOAA-16 in 2001, the selection is March 21st , June 21st , September 21st and December 21st.

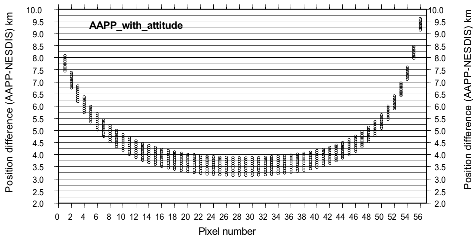


Navigation

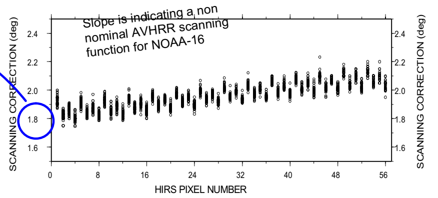
The inputs for a navigation calculation are the orbital elements, the line datation, the attitude error and the instrument scanning function. An attitude pitch error is similar, to a line datation error and to an orbital element extrapolation error, the effect is mainly a displacement along the track. For AAPP the orbital elements are the NESDIS TBUS which are not used by NESDIS (NORAD ephemeris), this is one of the major reasons for differences in position of the pixels.
AMSU results are somehow as expected, the **maximum value reached is less than 7km** which corresponds to one second error. If we remove the attitude estimated by AVHRR we reduce the value of the standard deviation to a maximum of 0.46km.
The performance for HIRS is not as expected. The reasons are explained on the following graphics.

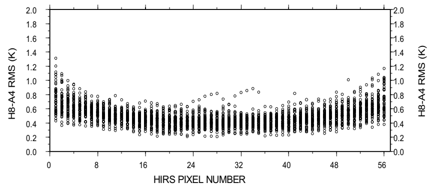
	bias		st. dev		r.m.s.		Min	Max
	min	max	min	max	min	max		
amsua	0.344	5.469	0.153	0.799	0.406	5.471	0.016	6.550
amsub	0.418	5.578	0.150	0.784	0.471	5.580	0.000	6.750
hirs	3.044	7.490	0.951	2.431	3.226	7.719	1.914	15.897

Results of navigation comparison between nominal AAPP V3.2 using attitude estimation and global NESDIS 1b, unit is km. Bias, standard deviation r.m.s and minimum and maximum are the extreme values encountered in an orbit for all pixels all lines of the 25 orbit passes of this test case.

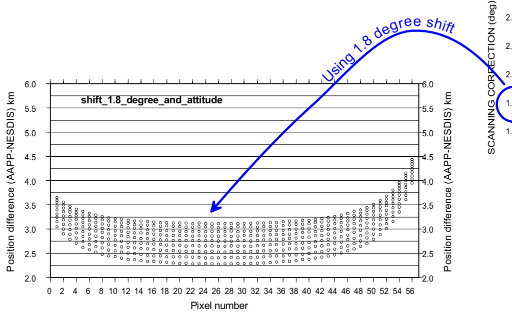


Navigation for HIRS NOAA16 orbit pass 5148 September 21st 2001 with nominal AAPP processing including the estimation of attitude





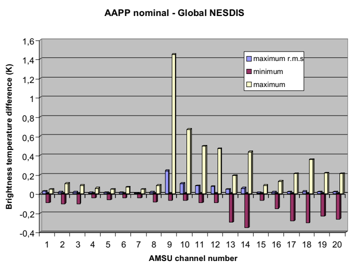
Scanning correction and r.m.s. difference for the best adjustment of AVHRR channel 4 and HIRS channel 8, applied on NOAA16 February 1st to 20nd 2002.



Navigation for HIRS NOAA16 orbit pass 5148 September 21st 2001.
The shift of the instrument scanning function is 1.8 degree, same value as NESDIS.
The results are similar to AMSU

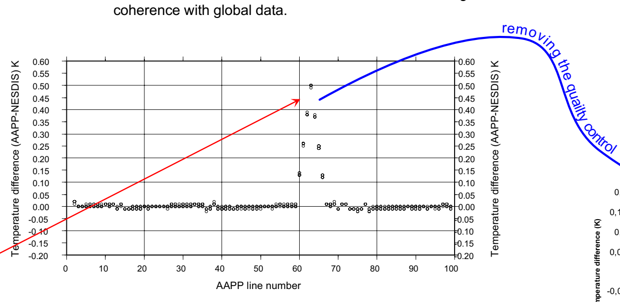
In November 2000 we suspected a misalignment of the HIRS on the platform NOAA16. The mapping of AVHRR onto HIRS field of view enable us to compare the brightness temperature of AVHRR channel 4 to the HIRS channel 8. The best mapping results were obtained with a shift of the HIRS scanning function of 2 degrees.NESDIS did not confirm this value and choose to take one pixel shift. If we apply the same correction we finally get results similar to AMSU.

AMSU calibration



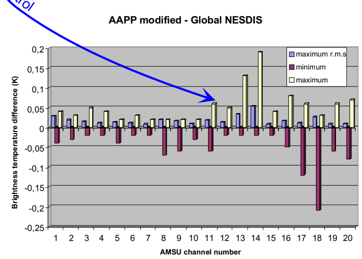
AMSU brightness temperature difference. AAPP is nominal version 3.2 High maximum values are not acceptable

AMSU results are satisfactory, for most channels the maximum value of the r.m.s. difference is less than 0.10K but we observe some high values especially for AMSU-A channel 9.
In more details the maximum values for channels 9 to 12 are reached for the same orbit 6427 on December 21st 2001, the error is concentrated on seven lines with all pixels having the same error. The figures show that differences are due to differences in the quality control tests. Changing some tests in AAPP gives very good results.
The maximum r.m.s. is less than 0.060K which is enough to enable the use of local AMSU data in an assimilation system in coherence with global data.



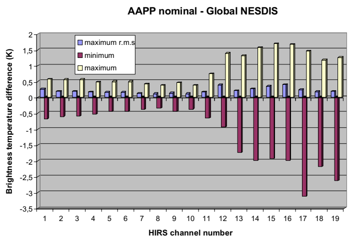
AAPP quality control rejects line 63 for invalid black body target and space target compared to the preceeding lines

AMSU-A temperature difference for channel 11 orbit 6427 (21/12/2001) as function of the AAPP line number.
All pixels for all lines are plotted. Differences are constant for all pixels of one line



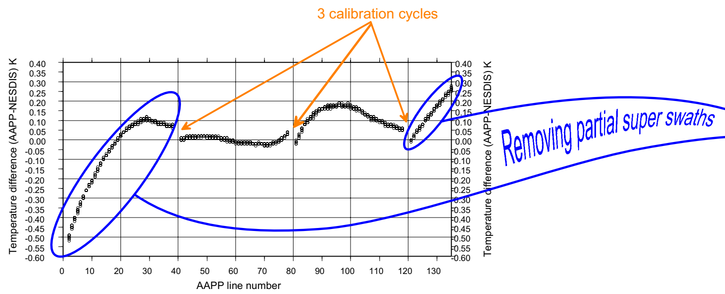
AMSU brightness temperature difference without quality control for space and internal target view counts and some other minor modifications

ATOVS navigation and calibration.
Comparison between local AAPP and global NESDIS methods.
HIRS/3 calibration

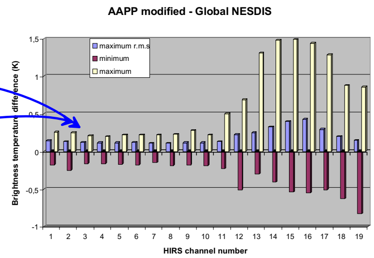


The HIRS/3 has a calibration cycle each 256 seconds (40 scan lines). The raw results (on left) are very bad and are such important that there is no possibility to use them in an assimilation system together with global data. This kind of difference has been showed up by the Met Office in March 2001 for NOAA-15 data.
The main reason is that the calibration methods are not the same for AAPP and NESDIS (Wark 1994).

NESDIS HIRS calibration algorithm is founded on the following assumptions:
The calibration coefficient slope a1 does not change appreciably during 24 hours which represents around 350 calibration cycles
The intercept a0 is linearly related to the second telescope temperature (STT)
This requires storage of historical data for full orbits, this is not possible for local HRPT stations.

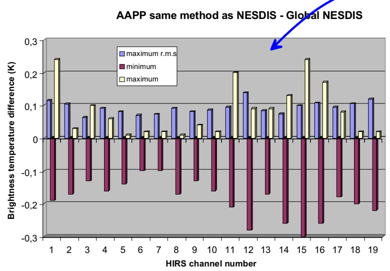


HIRS temperature difference for channel 1 orbit 3852 (21/06/2001) as function of the AAPP line number. All pixels for all lines are plotted. The 3 gaps in lines are for the calibration cycles. See in particular that the largest errors are for partial super swaths.



Same as top left results without considering the partial super swaths (before first calibration cycle and after last calibration cycle).

b1 coefficients calculated from global data and applied to local pass.



AAPP HIRS calibration
a0 and a1 are computed on the current orbit without ancillary data.
Constant coefficients are used for partial super swaths

NESDIS HIRS calibration
Coefficients for partial super swaths are function of nearest calibration cycle and STT

$$\bar{a}''_{100} = \frac{1}{N}\sum_{i=1}^{i=N} a_{1i}$$

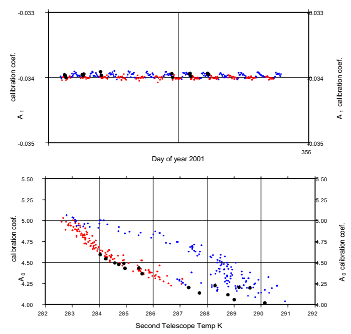
$$a_{000} = b_0 + b_1 T'_{s00}$$

$where\ T'_{s00}\ is\ STT\ for\ space\ view$

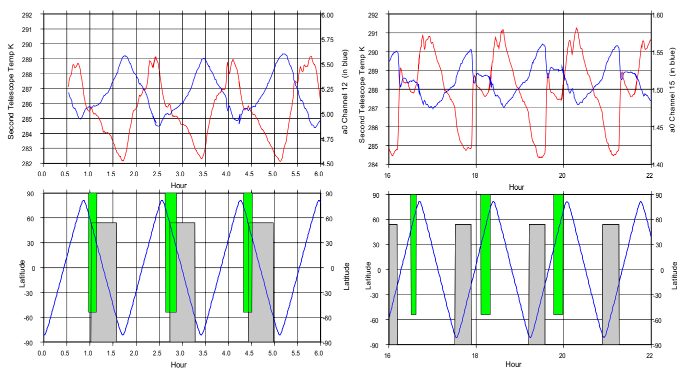
$$a_{1nn} = \bar{a}''_{100}$$

$$a_{0nn} = a''_{000} + nn\frac{(a''_{040} - a''_{000})}{40} + b_1\left[(T'_{snn} - T'_{s00}) - \frac{nn(T'_{s40} - T'_{s00})}{40}\right]$$

AAPP has been modified to use b1 coefficients and the Wark formulation (but a variable a1 from local data).
The b1 coefficients have been calculated using the global level 1b data for the corresponding day. **The results show that we can reach enough quality on all channels for super swaths when the b1 coefficient is accurate.** The maximum r.m.s. is less than 0.140K (channel 12) and is always lower than the signal to noise of the instrument.



NOAA-16 HIRS/3 channel 12 calibration coefficients as function of second telescope temperature and time for 21st December 2001. Red points are for a nadir view during night, blue points for a nadir view in day light and black points are calibration coefficients available during a local HRPT acquisition in Lannion station.
b1 is deduced by linear regression. Could it be done for local HRPTwith so few and concentrated points?
a1 is considered constatnt during 24 hours. Assumption is valid.



On top, variation of the STT and HIRS channel 12 intercept calibration coefficient, STT in red, a0 in blue. The bottom plot shows the latitude (in blue) of the satellite sub-point, the gray area indicates that the satellite is flying in night and the green area is the period of time for Lannion acquisition (could be any other station in Europe).
On left NOAA-16 March, 21st 2001 morning, on right Noaa-15 June 5th 2001 afternoon.
The STT is highly affected when the satellite passes from daylight to night vice versa, so the calibration coefficients. The phenomena is really important for NOAA15 in the tropics (5K in few seconds). HRPT stations receiving data in a day-night crossing region have a lot of problems to take care of this phenomena, especially for partial super swaths.

Proposed recommandations

NESDIS should verify the NOAA-16 HIRS scanning function by comparing the channel 8 radiances with the AVHRR channel 4 after mapping. The shift value of 1.8 degree seems too small to us.

NESDIS and AAPP should converge for the tests applied to the calibration for AMSU instruments. The small differences that we observed can be removed by a simple code upgrade.

AAPP should prepare an evolution to enable the use of the Wark method as an (option?) .The use of historical a1,b1 should be more secure if some threshold could be applied to the non linear term, to prevent the use of bad regressions.

NESDIS may help users in giving access to historical files of the triplets a0, a1, STT or to the values of b1 and average a1. An alternative could be to provide an average b1 for the life of the satellite if its variation with time is small. Could NESDIS publish statistics on these parameters?

EUMETSAT ATOVS Retransmission Service should rebuild large HIRS orbit passes from the local HRPT stations to avoid problems at each start and end of the individual passes. With one long orbit pass (up to 45 minutes) the quality will be improved. The maximum possible loss of data due to partial super swaths is 2x256 seconds.

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