ATOVS RETRIEVALS FOR LOCAL HRPT

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1. INTRODUCTION

The ICI sounding scheme developed at CMS/Météo-France for the processing of HRPT data is interfaced with the 'Atovs and Avhrr Preprocessing Package' level1d files and performs retrievals for ATOVS channels since summer 1998. The results on the first year in the operational context are shown.
The scheme is now being implemented in other HRPT stations than CMS and first results done independently from CMS by foreign teams are now available and presented. It appairs that at each implementation, the access to NWP outputs, for running ICI in similar conditions than at CMS, is difficult and we present a study, which we expect, could solve this problem.
Concerning the humidity profile retrieval, we have implemented the RTTOV5 forward model in ICI and some first statistics will be presented from ICI runs using AMSU-B channels.

2. OPERATIONAL RETRIEVALS

2.1 ICI V2 status

The ICI software is interfaced with AAPP (*Klaes*, 1997) output level1d files. The main data of AAPP output files are located, calibrated and mapped (MSU/AMSU on HIRS grid) observations.

The three pieces of information of AAPP files resulting from the AVHRR cloud mask are used in ICI : mean clear cover in HIRS fov, skin surface temperature (AVHRR split-window), the forecast air surface temperature (on land) or a SST climatology when the situation is cloudy. Two information items extracted from the AMSU pre-processes are also considered : a type of surface in terms of µ-waves and a clear/ cloudy/ precipitating flag. For ATOVS, the cloud class depends on the AVHRR cloud mask but also on the AMSU preprocessing results. The cloud clearing stage is not applied for ATOVS : cloudy and partly-cloudy situations are treated in terms of IR in the same way.

Two coding routines are available for reading the NWP fields in ASCII or GRIB format. Concerning forecast data, ICI reads the sea pressure and the air surface temperature and the 10m wind speed. The software can run without but they largely improve the accuracy of the retrieved temperature profile over all the levels, because inversion is done by considering all channels together.
Four result coding routines (ASCII, SATEM, GRIB, AAPP level2) are available to read the binary ICI output file and are activated on request.

On sea, the IR surface emissivity is computed from MASUDA tables and depends on the frequency and the scanning angle. On land, the emissivity is always considered to a constant and set to 1.
On sea, the micro-wave emissivity is greatly affected by the wind speed, the skin surface temperature, the foam, the scanning angle and the channel polarization. The FASTEM routine of *English*, 1998, implemented in ICI, estimates the micro-wave emissivities of the sea surface on the basis of the input surface temperature from AAPP cloud mask and the wind module forecast. A default value of 0.6 is taken when no other data is

available. On land, two constant default values (the second for altitudes over 1000m) are allocated in ICI. However, the micro-wave surface and water vapor channels are not used in this version.

The guess profile is selected by comparing the sounder observations (after applying RTTOV3 forward model biases and if necessary cloud clearing) with computed brightness temperatures for a set of profiles representing atmospheric conditions for the acquisition area and the date considered.
At CMS in the operational context, the retained profiles are analyses of the ten passed fields at 00H supplied by the French NWP center and sampled at a 10*10 degree pitch. The data set is reviewed every day so as to avail of a rolling library as representative as possible of the meteorological conditions for running day. However, it is also possible to use one of the two worldwide static climatological library available with the ICI package : TIGR2 (*Chedin*, 1985) and NESDISPR (*NOAA /CIMSS*)
Upwards and downwards radiances, total transmittances are computed off-line for each profile and archived. The synthetic brightness temperatures are computed in real time for each new observation with surface temperature and emissivity values adapted to the situation. This has been done because the µ-wave surface emissivities are so variable with surface conditions that Tbs for surface viewing channels can differ from several tenths of degrees with a same atmospheric profile.

The inversion is based on a 1D-Var minimization but with only one iteration (because the water vapor channels are not used).

The ICI scheme includes a tuning module for the reset of all ICI internal coefficients (RTTOV3 biases, guess covariance matrixes). This module is important to achieve accurate retrievals but implies to get in a routine way radio soundings and analyses. A multi-linear regression with stratospheric, micro-wave observations and zenithal angle is used for the correction of the RTTOV biases.

2.2 Temperature retrieval accuracy

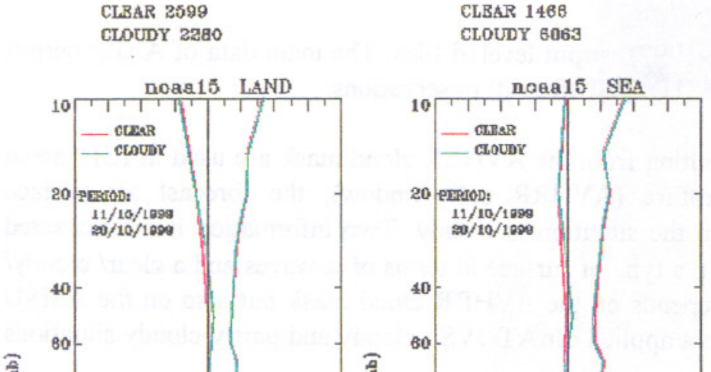

Figure 1: Temperature statistics for a 10 days period on RTTOV3 levels

Figure 1 shows for Noaa15 the error statistics concerning the mean and standard deviation of the inversions compared to the analyses and radio soundings for land (left) and sea (right) situations on the RTTOV3 working levels. Statistics have been performed for a 10 days period and 2 cloud types.

Figure 2 shows similar statistics but in RMS of errors for the past one year period at CMS. Lower figure corresponds to clear situations, the upper one is for all IR cloud covers greater than 10%. Statistics were computed on 10 days periods and on the RTTOV3 levels. Blue colors are for RMS values less than 1K, green colors between 1K and about 1.8K, browns/yellows show values less than 2.5K and reds afterwards. Results are better in summer than in winter and for clear situations. In troposphere the errors on levels are never more than 1.5K for clear observations but can reach 2.5K for cloudy situations in winter.
We observe with Noaa15 a seasonal effect in the stratosphere but very less dramatic than for Noaa14, thanks to AMSU 11 and 12 which sound atmospheric layers around 10hpa whereas we don't use noaa14 SSU channels. We expect to solve the stratospheric deviation in the next months by using the ECMWF analysis profiles going up to 0.1hPa for creating the initial profile library. This will avoid a climatological extrapolation of the profiles in ICI.

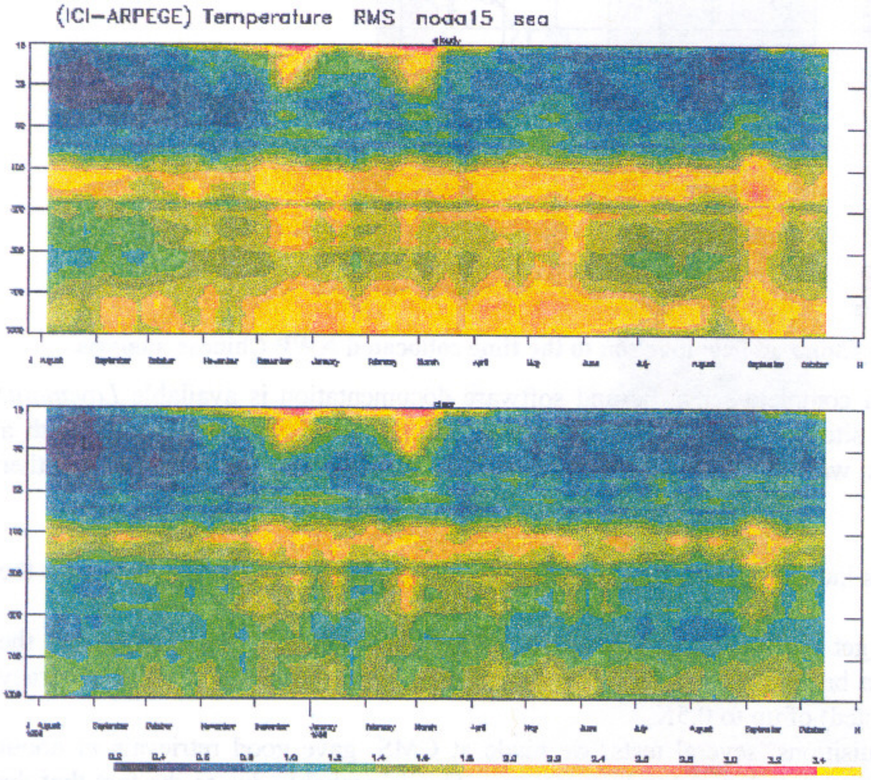

Figure 2 : RMS of error on RTTOV levels between temperature retrievals and radiosonde /analyses profiles.

3. EXPORTABILITY

The ICI package is being implemented in other stations than CMS.

To make this possible, we have updated the AAPP AVHRR cloud mask which was originally developed for CMS needs with thresholds determined for mid-latitude area. In this release, the thresholds are variable and depend on the meteorological conditions of the processed area, through climatologies of SST and albedo, forecast fields of T2m and total water vapor content (over land) and also estimated TWVC from AMSU-A observations (over sea). This version has been validated for almost 10 different HRPT stations in different part of the world by qualitatively comparing the AVHRR multispectral composite images to the cloud cover outputs, with the help of a nephanalyst.

The ICI scheme itself has been tested on different HRPT data (Halifax, La Réunion,Sénégal) and is now implemented in Hungary and China (since last July). The first validation results for Hungarian operational retrievals have been presented in Borbas, 1999. A first study of the retrieval accuracy for the West Africa tropical area is given in Gendrier, 1999. Figure 3 shows an example, we get from Beijing, of the ICI retreived field (left) for 3 successive orbits over China togeteher with the difference with the collocated HLAF Chinese NWP field (right).The gaps in the second orbit correspond to losses of HRPT acquisitions.

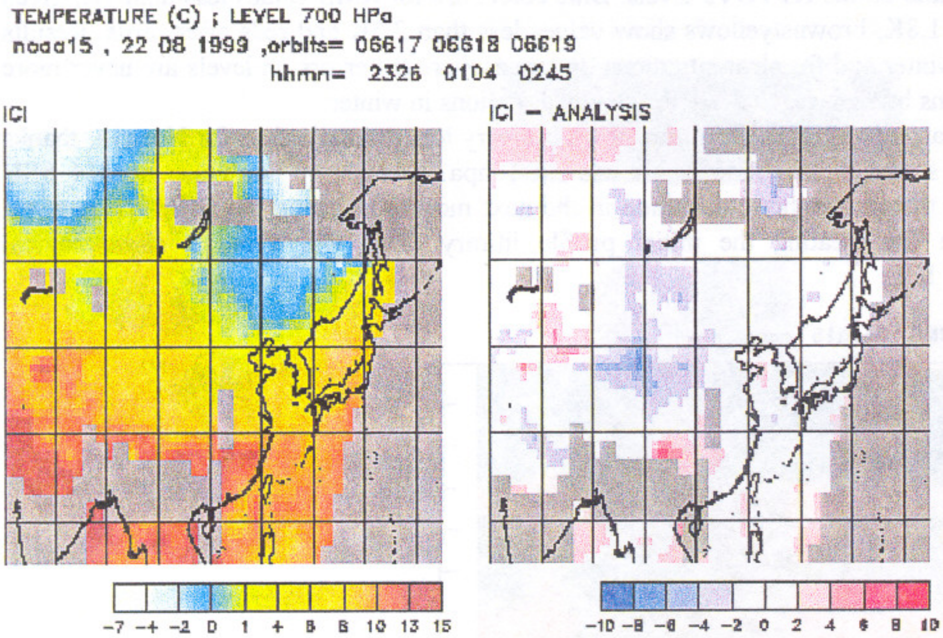

Figure 3 : Noaa15 retrieval field over China and comparison to the time collocated NWP Chinese analysis.

For helping the new users of ICI, a complete scientific and software documentation is available *Lavanant, 1999*. We also have created a web site on which each foreign team can put their validation results with a common graphic tool. It is an easy way to verify that the software is well working all the year in other climatological areas and to interact.

These first exportability experiments indicate that the main problems are always due to the interface with the NWP outputs:

4. In Hungary, they only get the NWP profiles up to 100Hpa. To run ICI, we extrapolated the profiles from 100 to 0.1Hpa but the consequence is a degradation of the retrieved profiles accuracy (compared to what we expected) of up to 0.5K.
5. For West African acquisitions, several tests, we made at CMS, gave good retrievals of about 1.1K of RMSE when compared to colocated radiosoundings. This is probably due to the fact that the meteorological situations are very stable over long periods. In these tests we used the French NWP fields available at CMS. The implementation of ICI is now planned at Dakar but we have the problem of the NWP avaibility in Africa. For founding a solution, the african acquisitions were also processed by using the TIGR dataset for the guess selection. The accuracy of the retrievals in that case is degraded by an amount of about 0.5K, specifically near the surface and in the stratosphere.
6. In China, ICI is runned with a rolling data set of HLAF Chinese analyses and the internal coefficients are tuned using retrievals collocated to HLAF analyses and radio soundings. The retrieval validations give correct results and are very similar to those we obtain over Europe. However, comparisons of the French and the Chinese NWP at 1000Hpa levels indicate more than 10 K deviations in several area over China, given of course bad error statistics when the ICI Chinese retrievals are compared to the French analyses. These bad statistics seem to be confirmed if done with radio soundings only. Tuning with analyses is possible over Europe because the NWP fields are of high quality but has to be done more carrefully elsewhere.

To avoid the NWP problems, we have began a study: we expect being able with ICI to inverse the NOAA/NESDIS observations, with a few hours delay, near all the radio soundings stations of the world and to globally perform the ICI tuning at CMS. The resulting small files of updated coefficients could be put on the Web and every ICI user could get them.

4. HUMIDITY PROFILES

The AMSU-B observations are now corrected from frequency interferences and we have began a study for retrieving the water vapor profiles with the AMSU-B 18, 19, 20 sounding channels and the H11, 12 IR water vapor channels.

First, we have implemented in ICI the RTTOV5 version which should better simulates brightness temperatures of water vapor channels. Figure 4 gives the statistics in bias and standard deviation of RTTOV5 when compared to the observations. The channels in red are those used in this study. Channel 24 (AMSU-A 4) were used only over sea. We can see that the 3 AMSU-B channels have standard deviations of large amplitude. For comparison, the standard deviations of the observations for the same situations are of about 4K for the 3 channels.

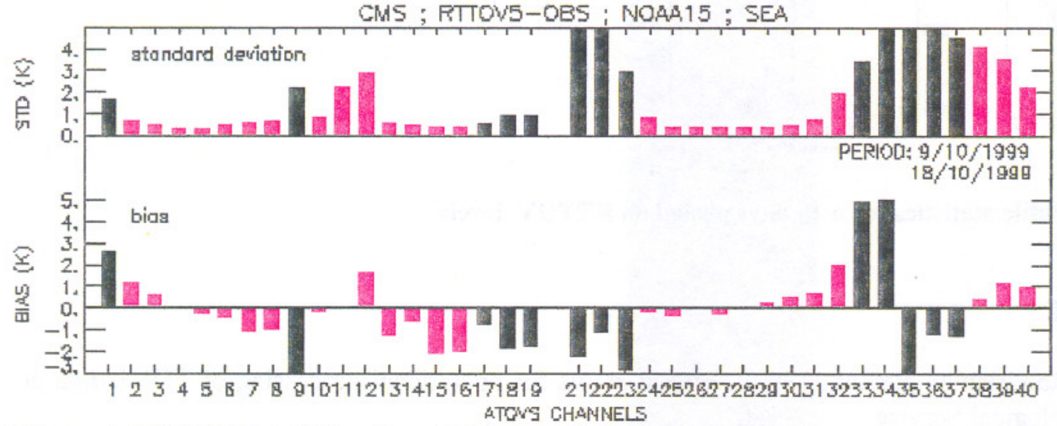

Figure 4: RTTOV5 statistics for a 10 day period.

In this study we also have updated the correction of the forward model biases with the viewing angle, the shape of the angle variation being very different for the two sides of the satellite and far from linear.

Figure 5 shows the error statistics in bias and standard deviation for the humidity profile in percent. The 1D-Var minimization has been used with up to 5 iterations. However, we don't reach the expected 10% of accuracy and more work has to be done in the next future. For clear situations, using AMSU-B channels in extra only improves the standard deviation of less than 5%.

5. NEXT DEVELOPMENTS

The main scientific developments in the future months will be :

- to study the implementation of a micro-wave surface emissivities atlas for land situations
- to improve the tuning scheme (forward model biases..)
- to supply the ICI software with ECMWF analysis fields instead of French analyses.
- To develop a simplest ICI scheme for foreign HRPT users

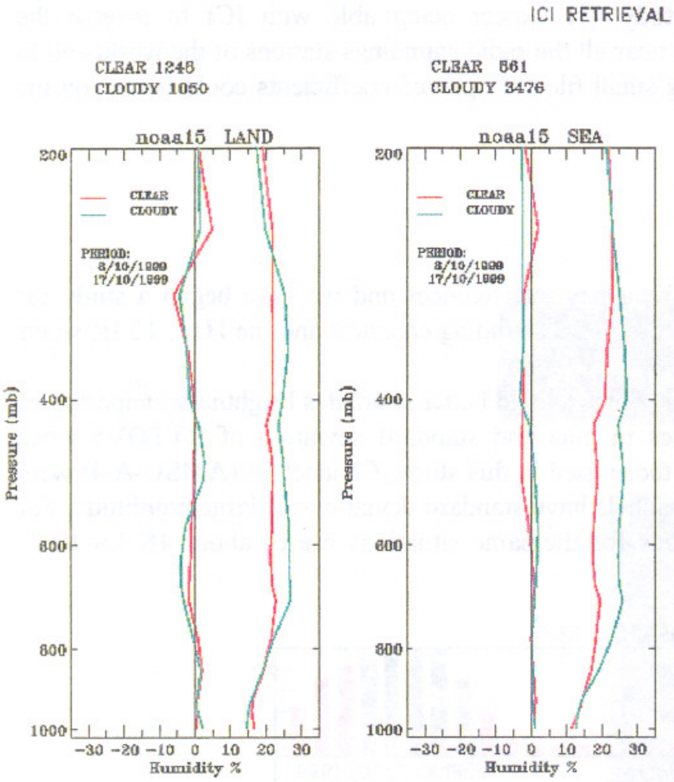

Figure 5: humidity profile statistics for a 10 days period on RTTOV levels

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