Overview of ATOVS Data Processing and Applications at NSMC of China

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2. OUTLINE of ATOVS PROCESSING SYSTEM

Figure 2 illustrates the flow chart of the ATOVS processing system at NSMC operational sounding products of CMA in China. Form Figure 2 we can see that ATOVS processing system are comprised of 3 primary subsystems, that is satellite navigation, preprocessing, and retrieval which are developed based on the situation of Unix system for workstations or severs. And that the validation and display subsystems are developed based on the situation of PC-Windows.

The satellite navigation subsystem is running daily at specified time. The preprocessing and retrieval subsystems are running by orbital in real time. And distributions of ATOVS products to users have been done immediately after generated. At present, the validation and display of ATOVS products are done on the PC, they are not running every day.

2.1 Satellite Navigation

The satellite navigation subsystem has been built based on a part (Tbusing and Satpost) of AAPP and the situation of NSMC. The major input data is TBUS bulletin issued by NOAA/NESDIS and got from the GTS. The major out file is so-called SATPOS file used for ATOVS/AVHRR earth location. This subsystem is running daily on the server of HP system.

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3. 1 Vertical Accuracy Statistics (continue)

Figure 3.1 shows the statistics of temperature (top) and relatively humidity (below) made from the IAPP retrievals and first guess for NOAA-16 at the period of 1 to 31 in July of 2002. The total collocations are about 10000 samples.

Similarly, Figure 3.2 shows the statistics of temperature (top) and relatively humidity (below) made from the ICI retrievals and first guess for the same situations as IAPP. But the total collocations are less than IAPP, and about 8000 samples.

From these figures, it can be seen that the accuracy of temperature retrievals from IAPP and ICI are about 2K(RMS), the accuracy of relatively humidity for IAPP is about 15-20%, while the ICI is about 20%(RMS).

3. 2 Horizontal Fields

Horizontal field analysis provides better meteorological context concerning the characteristics of the derived satellite products than the vertical accuracy statistics, and is an important component of the product validation function.

Figures 3.3 and 3.4 illustrate examples of temperature (°C) and water vapor mixing ratio (g/kg) analysis over the regional around China for the level of 500 hPa from NOAA-16 ATOVS retrievals produced by IAPP at time 17-22UTC of July 23, 2002. The background image is made from HIRS/3 channel 8 brightness temperatures. The corresponding water vapor image made from AMSU-B channel 3 brightness temperatures is shown in Figures 3.5.

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Fig 3.3 (left top) and 3.4 (right top) show the temperature (°C) and moisture (g/kg) analysis fields over the regional around China for the level of 500 hPa from NOAA-16 ATOVS retrievals produced by IAPP at time 17-22UTC of July 23, 2002
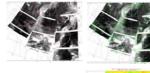

Fig 3.5 (right) shows the water vapor image over the regional around China made from NOAA-16 AMSU-B channel 3（183±1GHz）brightness temperatures at time 17-22UTC of July 23, 2002.(dry air in dark yellow, wet air in green)

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4.2 Applications of ATOVS Sounding Products in Synoptic Analysis

During 20-24 of Jun 2002, the big rainstorms were happened in the region of Changjiang valley. It was reported that the rainstorm is caused by sequence 3 middle βconvective scale (MβCS) air mass based on the analysis from several kinds of data. Fig 4.4 shows the total precipitation for 20-24 of Jun 2002 (left top).

When the third MβCS is grown up mature phase at 18UTC of June 22, it can be seen from the ATOVS temperature and moisture fields that there are a cold air core at low level, a wet air belt at middle level, and a warm air core at upper level in the MβCS air mass (see Fig 4.4) These results are consistent with the characterization of middle convective scale (MCC)

(provided by QinDanyu, 2004).

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1. INTRODUCTION

Since the middle of 1999, the National Satellite Meteorological Center (NSMC) of China Meteorological Administration (CMA) has been receiving and processing the HRPT/ATOVS data in real time. The HRPT data received from the 3 stations of Beijing, Guangzhou and Urumqi as shown in Fig.1 are relayed to the NSMC in real time. The HRPT/ATOVS data processing system was built based on the AAPP and ICI/IAPP processing packages in which the AAPP is used for ATOVS data preprocessing and the ICI/IAPP are used for temperature and moisture profiles retrieving. Some adaptations were made for the AAPP and ICI/IAPP according to the situation of NSMC. Before 2003, the ATOVS retrieval products are generated using the ICI model. After that, the IAPP retrieval model is used instead of the ICI for several reasons.

In order to check the ATOVS products generated from the preprocessing of AAPP and retrieving of ICI/IAPP. The PC-ATOVS display systems have been developed by using IDL and C++ languages for checking the ATOVS preprocessed products (L1C, L1D) from the AAPP and retrieved sounding products from ICI/IAPP, respectively. Also, the validations of the sounding products have been completed on the PC.

The progress of ATOVS data applications has been made for recently years, such as, the AMSU-B L1C data are directly applied to monitor the typhoon, rainstorm in NSMC routinely, the ATOVS L1D data are applied to the variational assimilation system of NWP models in the several centers of CMA, the ATOVS the atmospheric temperature and moisture profiles are used in the case study of weather analyses, and so on.

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2.2 Preprocessing

The preprocessing subsystem has been built based on the AAPP. The some adaptations were made according to the situation of NSMC. For the AAPP, it is designed for processing ATOVS /AVHRR data received from a single HRPT station. However, there are 3 HRPT stations in the NSMC, and the position and coverage for them are shown in Fig.1. From that, it can be seen that the data received from Beijing and Guangzhou stations are normally in the same orbit, when both of station's data are relayed to NSMC, they are put together into the one file. So the modification must be made according to the coverage of two joined stations. The major modifications for AAPP are a maximum number of scan lines specified in a head file for each instrument. This subsystem is running in real time by orbital after the new HRT data available on the server of HP system.
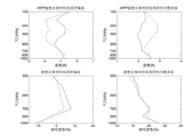
2.3 Retrieval

The ATOVS retrieval subsystems have been built based on the ICI and IAPP. The some adaptations were made according to the situation of NSMC. Before 2003, the ATOVS sounding products are generated using the ICI. After that, they are generated with the IAPP.

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2.4 ATOVS Data Distributions

- ATOVS operational products are distributed to users at the conclusion of orbital processing. The operational products that are routinely distribute to users include
    - ATOVS L1C data (AMSU-A, AMSU-B, HIRS)
    - ATOVS L1d data (AMSU-A, AMSU-B, HIRS)
    - ATOVS sounding products
- Two dedicated links to distribute these data to users out of NSMC:
    - NSMC → NMC /QIKEYUAN users (inside CMA)
    - NSMC → CMA users (9210 net work)
- For the NSMC users, the AMSU-A and AMSU-B L1C data are distributed routinely in real time for monitoring the typhoon, rainstorms, etc.
- For NMC users, the AMSU-A, AMSU-B and HIRS L1D data are distributed routinely in real time for applying to the variational assimilation of NWP system.
- For CMA users, the temperature and moisture soundings are distributed routinely in real time for analyzing or assimilation of NWP system.

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Figure 3.1 The statistics for temperature (top) and relatively humidity (below) from IAPP retrievals and first guess for NOAA-16 at the period of 1 to 31 in July of 2002, the sold line is IAPP retrievals and the dash line is first guess, the left side is bias, the right is RMS (total samples is about 10000)

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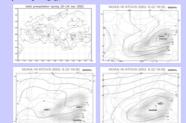## 4 EXAMPLES FOR ATOVS DATA APPLICATIONS

The progress of ATOVS data applications has been made for recently years, such as, the AMSU-B L1C data are directly applied to monitor the sound storm in NSMC routinely, the ATOVS L1D data are applied to the variational assimilation system of NWP models in the several centers of CMA, the ATOVS the atmospheric temperature and moisture profiles are used in the case study of weather analyses, and so on. We believe that the more and more meteorological centers of China will be take the ATOVS data into their NWP model in the future in order to improve the weather forecast. As the following, we just show the two examples of ATOVS data Applications.

4.1 Applications of ATOVS Radiances in NWP System

During the past several years, the NSMC has a cooperation with the Research Center for Numerical Meteorological Prediction (RCNMP) of Chinese Academy of Meteorological Sciences (CAMS) to study a direct assimilation of ATOVS radiances in GRAPES/ 3DVAR system. The ATOVS radiances are processed at NSMC by using the AAPP. Experiments to show the impact of these data on the forecasts give clear improvements (provided by Zhang Hua).

The following example is to show the course of the WeiMaXun typhoon developing and landing (die out) to the Korea byland during 4-7 July of 2002. The experiments of the model configuration are as follows:

- assimilation model: GRAPE/ 3DVAR
- forecast model: WRF£ Weather Region Forecast£ ©
- Background: T213

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Fig 4.4 Total precipitation during 20-24 Jun 2002 (left top) and temperature and water vapor analysis fields at (a) 850hPa(right top),(b)500hPa(left below), and (c)300hPa(right below) from the ATOVS sounding products (IAPP). In the Figures, the sold line is Temperature (°C), the dot line is water vapor mixing ratio (g/kg),the shadow area is MβCS.

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We believe that the more and more meteorological centers of China will be take the ATOVS data into their NWP model in the future in order to improve the weather forecast.
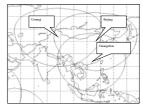

Fig.1 Receiving Coverage for 3 HRPT stations of NSMC,CMA,China

The following section describes the ATOVS processing system. The section 3 will introduce the Validation of ATOVS Sounding Products. The section will show the examples of ATOVS Data Applications in CMA.

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2.3.1 ICI

The major modification is about creating initial guess rolling library. The analyses of regional NWP model HLAFS (High-resolution Limited Area Forecasting System) of the National Meteorological Center (NMC) of CMA are utilized to create a rolling library over the last ten days at a zone of 10°by 10°. The HLAFS covers an area of 5–64°N/55—145°E and provide 4 times analyses per day with a special resolution of 1°by 1° and vertical resolution of 14 levels up to 50 hPa for temperature and 8 levels up to 200 hPa for relatively humidity. The HLAFS is running based the T106. At the beginning of 2003, the T106 is updated by the T213, since then the HLAFS is not available, therefore the ICI retrieval system is terminated. The retrieval processing for the ICI is based on a field-of-regard (BOX) containing 2 by 2 adjacent HIRS/3 FOVs. So the special resolution of sounding products is about 50km. The temperature profiles were retrieved by using the data from the AMSU-A and HIRS instruments, and the moisture profiles were made by using the data from AMSU-B and HIRS instruments.

2.3.2 IAPP

There were not so much modifications made for IAPP. The regression retrieval is selected for the first guess profile. The retrieval processing for the IAPP is based on a field-of-regard (BOX) containing 3 by 3 adjacent HIRS/3 FOVs. In order to make higher resolution of retrievals, the retrieval box was selected with 2 by 2 HIRS/3 FOVs instead of 3 by 3. Same as ICI, the temperature profiles were retrieved by using the data from the AMSU-A and HIRS instruments, and the moisture profiles were made by using the data from AMSU-B and HIRS instruments.
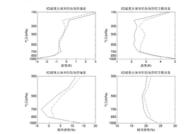
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3. VALIDATION OF ATOVS SOUNDING PRODUCTS

The sounding products produced by the ICI and IAPP are validated by using the radiosonde data, respectively. The collocations are made between the radiosonde and ATOVS soundings. A collocated the radiosonde and satellite sounding is compiled if the candidate radiosonde and satellite sounding data:

- are within specified time (6 hours) and distance (1°) windows,
- differ by less than 10K for any temperature levels below 10 hPa,
- have similar surface.

The primary validation strategies consist of
- vertical accuracy statistics, and
- horizontal field analysis

3. 1 Vertical Accuracy Statistics

The vertical accuracy statistics based on satellite minus radiosondes differences computed from collocations made for NOAA-16 from the period of 1 to 31 in July of 2002. The statistics were made from total collocations which include the types of land and sea, and clear and cloudy and the coverage of collocated data shown in the Fig.1.

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Figure 3.2 The statistics for temperature (top) and relatively humidity (below) from ICI retrievals and first guess for NOAA-16 at the period of 1 to 31 in July of 2002, the sold line is ICI retrievals and the dash line is first guess, the left side is bias, the right is RMS (total samples is about 8000)

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The experiments include two tests:
Test 1: radiosondes data only
Test 2: radiosondes data + ATOVS/AMSU-A radiances

Fiures 4.1(see below) is shown the analysis geopotential height fields for 850 hPa at 15UTC of July 4, 2002, which are generated from Test 1(left) and Test 2 (right), respectively. From those analysis filed, we can see that there are some differences available.
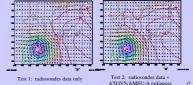

Test 1: radiosondes data only

Test 2: radiosondes data + ATOVS/AMSU-A radiances

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Fig. 4.2 The analysis geopotential height fields for 850 hPa at 00Z of July 6, 2002 produced by the T213 operational system (right top) .

Fig.4.3 The 45 hours forecast geopotential height fields for 850 hPa at 00Z of July 6, 2002 produced based on the Test 1 and Test 2 (below).

Comparing the 45 hours forecasts with T213 analysis field, we can see that the center position for 45 hours forecast produced based on the Test2 is improved about 200-300km.

Fig. 4.2 Analysis field

45 hours forecast based on Test 1

45 hours forecast based on Test 2

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