Validation of the Atmospheric Infrared Sounder Retrieval Products over China and Their Application in Numerical Model*

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ABSTRACT

The atmospheric infrared sounder (AIRS) instrument onboard Aqua Satellite is a high spectral resolution infrared sounder. In recent years, AIRS has gradually become the primary method of atmospheric vertical observations. To examine the validation of AIRS retrieval products (V3.0) over China, the AIRS surface air temperature retrievals were compared with the ground observations obtained from 540 meteorological stations in July 2004 and January 2005, respectively. The sources of errors were considerably discussed. Based on the error analysis, the AIRS retrieved surface air temperature products were systemically corrected. Moreover, the AIRS temperature and humidity profile retrievals were compared with T213 numerical forecasting products. Because T213 forecasting products are not the actual atmospheric states, to further verify the validation, the AIRS temperature and humidity profile products were assimilated into the MM5 model through the analysis nudging. In this paper, the case on February 14, 2005 in North China was simulated in detail. Then, we investigated the effects of AIRS retrievals on snowfall, humidity field, vertical velocity field, divergence field, and cloud microphysical processes. The major results are: (1) the errors of AIRS retrieved surface air temperature products are largely systematic deviations, for which the influences of terrain altitude and surface types are the major reasons; (2) the differences between the AIRS atmospheric profile retrievals and T213 numerical prediction products in temperature are generally less than 2 K, the differences in relative humidity are generally less than 25%; and (3) the AIRS temperature and humidity retrieval products can adjust the model initial field, and thus can improve the capacity of snowfall simulation to some extent.

Key words: validation, AIRS (atmospheric infrared sounder), retrieval, MM5, snowfall

1. Introduction

The AIRS instrument (Aumann et al., 2001) onboard Aqua Satellite is a high spectral resolution infrared sounder, designed to provide high resolution atmospheric temperature and water vapor profiles (combined with the advanced microwave sounding unit: AMSU) under clear or partly cloudy conditions, and expected to be able to improve numerical weather prediction. AIRS has a spectral coverage from 3.7 to 15.4 μm with 2378 channels, and provides IR information at spatial resolution of 13.5 km at nadir. The local equatorial crossing time of Aqua Satellite is approximately 0130 BT (ascending). The AIRS retrieval goals are 2-K RMS errors for surface air temperature, 1-K RMS errors in 1-km vertical layers below 100 hPa for temperature profile, and 20% RMS errors in 2-km vertical layers below 100 hPa for humidity profile. In recent years, AIRS has gradually become the primary method of atmospheric vertical observations. Many researches related to the validation of AIRS retrieved atmospheric products (Susskind et al., 2003; Tobin et al., 2006; Divakarla et al., 2006) have been done by using the atmospheric radiation measurement (ARM) data. We are interested in the accuracy of the AIRS temperature and humidity retrieval products (V3.0), especially in the region of China. However, the related investigations are quite few until now.

It has been several decades for the study on satellite retrieved atmospheric temperature and

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humidity products to improve the initial field of numerical model. Shen et al. (1996) conducted the variational analysis and numerical simulation by conventional soundings and unconventional cloud imagery data in the limited areas. Zhu et al. (2000) performed the analyses of precipitation probability and precipitation intensity by the satellite imagery, revealed the distribution of the atmospheric water vapor, and carried on the regression analysis between the satellite observations and the relative humidity data of every level. Qi et al. (2003) took the abnormal moist adiabatic equation as the integral equation, and replaced the humidity field in the background field with the humidity field retrieved from satellite TBB data. These methods mentioned above can improve the forecasting capacity of precipitation to some extent, but most of these methods are empirical. With the development of the satellite retrieval technology and the improvement of retrieval accuracy, these experiential methods will be gradually replaced. Moreover, Smith (1991) pointed out that it is difficult to further improve the TOVS retrieved atmospheric profiles, and to improve the forecasting accuracy in normal situations. At present, AIRS is the first of a new generation instrument that is designed to retrieve atmospheric profiles with high resolution. However, the investigations on the AIRS retrieval products used in weather prediction model have not carried out yet.

Section 2 describes the validation of AIRS retrieved surface air temperature products. By the method of error analysis, the AIRS surface air temperature retrieval products were corrected. Then, the comparisons between AIRS retrieved temperature and humidity profile products, and T213 numerical forecasting products were conducted. Section 3 presents the numerical simulation experiments. The corrected AIRS surface air temperature as well as the AIRS temperature and humidity profile products were assimilated into MM5 model in the period from December 2004 to February 2005. In this paper, we only depict the case on 14 February 2005 when the snowfall amount is the largest in Beijing, and discuss the effects of AIRS retrievals on the simulated snowfall.

2. Data processing and analysis

2.1 Data processing

The data format of AIRS level 2 products is in HDF-EOS. An AIRS granule is set as 6 min of data, which is corresponding to approximately 1/15 of the orbit data. Altogether six granules that overpassed the region of China are required to process per day. The AIRS level 2 standard products contain surface air temperature, as well as temperature and humidity profiles of 28 pressure levels. The SDS (Scientific Data Set) size of surface air temperature is 30×45, and that of temperature and humidity profiles are 30×45×28. The details can be referred to Aumann et al. (2001) for a thorough overview of the AIRS retrieval products and algorithms.

2.1.1 Surface air temperature

The total data of 540 meteorological stations in the region of China are collected, which located at 15°-55°N, 75°-130°E. The sampling times are in July 2004 and January 2005. The surface air temperature observations obtained from meteorological stations are taken from the National Meteorological Information Center of China, and are treated as the truth. Due to the low spatial resolution of AIRS, the Newtonian interpolation scheme (Xu and Sun, 2002) is used. We ingest the AIRS retrieval values at the nearest footprint to meteorological stations, and treat them as the AIRS retrieval values at the meteorological stations. Because data analyses were performed only when the distance between the footprint and the meteorological station is less than 20 km, the spatial non-coincident errors can be neglected.

The time of conventional surface air temperature observation is at 0600 UTC. To reduce the temporal mismatch errors, we only extract the surface air temperature data from AIRS products during 0450-0710 UTC when Aqua satellite overpasses. Therefore the differences between satellite observations and surface observations in time are no more than 70 min, and the temporal mismatch errors can be overlooked. In addition, the AIRS retrieved surface air temperature is questionable at the edge of scan line. Thus analyses
were performed only when satellite zenith angle is less than 50° (Paul et al., 2002).

In the paper, setting $T_{\text{bias}}$ as the mean errors, and $T_{\text{rms}}$ as the RMS errors, we have

$$T_{\text{bias}}_j = \frac{1}{n} \sum_{i=1}^{n} (T_{re,ij} - T_{ij}),$$

$$T_{\text{rms}}_j = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (T_{re,ij} - T_{ij})^2},$$

where $T$ is the surface air temperature observations obtained from meteorological stations, $T_{re}$ is the AIRS retrieved surface air temperature, $i$ is the index of observation, ranging from 1 to 31, and $j$ is the index of meteorological station, ranging from 1 to 540.

2.1.2 Temperature and humidity profiles

Because of no conventional sounding data at 0600 UTC, the comparisons between the AIRS retrieved temperature and humidity profile products and the 6-h forecasting products of T213 at 0000 UTC (not the actual atmospheric states) were performed. The AIRS standard atmospheric profile retrieval products contain 28 pressure levels. We only selected the same levels as T213 model, i.e., 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, and 50 hPa. Then, the AIRS temperature and humidity profile retrievals were interpolated to the T213 grids, and the same methods were taken for dealing with the surface air temperature.

2.2 Results analysis

2.2.1 Surface air temperature

Figure 1 illustrates the distributions of mean errors and the RMS errors AIRS retrieved surface air temperature products over China in July 2004. It can be seen from Fig.1a that there are almost the negative biases in the region south of 42°N, i.e., the AIRS retrieval values are smaller than the truth values. In southeastern China, the mean errors are $-4$-$-6$ K; in the Northeast and North China Plains, the mean errors are smaller and do not exceed $-3$ K; in the Tibetan Plateau, the mean errors are the maximum $-11$ K. The primary causes are the influences of terrain altitude and surface types. Figure 1b shows that the RMS errors in the Tibetan Plateau are the largest 12 K; the RMS errors are about 3-6 K in the other regions. Note that the meteorological stations are sparsely distributed in the Tibetan Plateau, the validation of AIRS retrievals may be uncertain in that region.

Comparing Fig.1a with Fig.1b, we can see that the values and the distributions of errors are quite consistent. It indicates that the errors of AIRS retrieved surface air temperature in summer are mainly attributed to the mean errors, which represent the systematic deviations. Therefore, with a statistical method, the accuracy of retrievals can be improved to some extent. For example, in the region of 22°-42°N, 105°-125°E, there are altogether 280 matching meteorological stations, negative deviations occur at 269 stations, and the mean errors are $-3.3$ K. When adding 3.3 K to the AIRS retrieved surface air temperature products, the accuracy of retrievals is improved to a certain extent.

The error distributions of AIRS retrieved surface

![Fig.1. Mean errors (a) and RMS errors (b) of surface air temperature (K) retrieved from AIRS in July 2004.](image-url)
air temperature in the region of China in January 2005 are displayed in Fig.2. There are three centers of mean errors, corresponding to the three centers of RMS errors, located in the Tibetan Plateau, the Tianshan Mountains, and the Northeast Plain, respectively. As mentioned above, the RMS errors in the Tibetan Plateau are also the largest 17 K. In the region between 105° and 120°E, the RMS errors are 2-4 K. The AIRS surface air temperature retrievals have good performance in that region in winter.

The comparison between Figs.1b and 2b indicates that the RMS errors in the Tianshan Mountains and the Northeast Plain are 3-5 K in summer, but increase to 8-12 K in winter. It is the snow cover in winter that induces the change of surface leaving radiance. The errors centers increase to three in winter, which illustrates that the effects of surface types have not been reasonably considered in the AIRS retrieval algorithm.

Furthermore, the comparisons between the RMS errors of AIRS retrieved surface air temperature and terrain altitudes data of China (figure omitted) suggest that the distributions of RMS errors and the terrain altitudes have close relationship. There are usually large RMS errors in the high altitude, and RMS errors are small in the low altitude. For example, the Tibetan Plateau is always the region of the maximum errors, and the errors are usually smaller in the North China Plain.

It is well known that the surface leaving radiance plays an important role in the surface air temperature retrieved from satellite. Considered the size of the AMSU (Advanced Microwave Sounding Unit) footprints and the spatial non-homogeneity, it is difficult to estimate the surface leaving radiance. Moreover, due to the deserts in the northern and southern Tianshan Mountains, the perennial snow cover in the Tibetan Plateau, and the complex surface types (e.g., hill, vegetation, and wetland) in southeastern China, it is more difficult to accurately estimate the surface leaving radiance, which will induce larger retrieval errors in those areas.

2.2.2 Temperature and humidity profiles

Because of no conventional sounding data at 0600 UTC, the AIRS retrieved temperature and humidity profile products over China cannot be quantitatively assessed by the truth. Therefore the AIRS temperature and humidity profile retrievals were compared with the numerical forecasting results of the T213 model at the same time. The preliminary analyses show that the differences in temperature are generally less than 2 K, and the differences in humidity are generally less than 25%, but sometimes can reach 35%.

Figure 3 describes the 500-hPa temperature (Fig.3a) and the 700-hPa relative humidity (Fig.3b) at 0600 UTC 14 February 2005. The dashed lines represent the AIRS retrievals at about 0600 UTC 14 February, and the solid lines represent the 6-h forecasting products of T213 model at the initial time of 0000 UTC 14 February. It can be seen from Fig.3a that the former are in general agreement with the latter, and the differences generally do not surpass 2 K. Figure 3b displays that their differences are larger, but generally are less than 25%. There are many small
closed centers in the AIRS retrieval products, which indicate the fractional clouds. The humidity is relatively high in these areas. These specific details are not depicted in the simulated products of T213 model (The central blank regions in Fig.3 are the scanning blind regions).

Figure 4 shows the temperature profile (Fig.4a) and humidity profile (Fig.4b) at 33°N, 118°E at 0600 UTC 14 February 2005. The dashed lines denote the AIRS retrievals, and the solid lines denote the 6-h prediction products of T213 model at initial time of 0000 UTC 14 February. From Fig.4a, we know that they are quite consistent with each other, and the difference in the mid-troposphere is the smallest. Because of the influence of land surface, the difference is approximately 2 K below 850 hPa. In the upper troposphere, the difference is large too. In addition, it can be seen from Fig.4b that the difference in relative humidity is about 10%-25%.

As a numerical forecast model, the outputs of T213 do not represent the real atmospheric states. Strictly speaking, we cannot evaluate the AIRS temperature and humidity profile retrievals by contrasting the products of AIRS with those of T213. To further assess the accuracy of AIRS temperature and humidity profile products, the corrected AIRS surface air temperature together with the AIRS temperature and humidity profile products were assimilated into MM5 through analysis nudging. In this paper, we only performed the contrast simulation experiment on 14 February 2005 in North China, analyzed the effects of AIRS retrievals on snowfall amount, humidity field, vertical velocity field, divergence field, and cloud microphysical processes. The experiment results indicate that the simulated snowfall more approaches to the actual snowfall after assimilating the AIRS retrieval products, suggesting that the AIRS retrieval results reasonably represent the real atmospheric conditions at that moment.

3. Numerical simulation experiments

3.1 Satellite data processing

The AIRS retrieved surface air temperature as well as temperature and humidity profile products at 0600 UTC 14 February 2005 (Fig.3) were used in the simulation experiments. According to the conclusions that the errors of AIRS retrieved surface air temperature are small between 105° and 120°E in winter, and large in the Northeast Plain, and thus the AIRS retrieval products located at 20°-45°N, 105°-120°E were collected. Generally, the water vapor of atmosphere concentrated in the troposphere, and thus the AIRS atmospheric profile retrievals below 100 hPa were
selected. In addition, there are total 260 meteorological stations in the selected region, and positive deviations occur at 215 stations, i.e., the retrieval value is larger than the observation value. The mean errors of AIRS retrieved surface air temperature in this area are 1.58 K in winter. Therefore, the corrected formula can be written as: \[ T = 1.58 + T_{re}. \]

Figure 3a displays that in the region of taking AIRS retrieval data, the AIRS retrieved temperature field is generally in agreement with the T213 objective analysis field. Figure 3b shows that there are some differences between the AIRS retrieved humidity field and the T213 objective analysis field, e.g., in south of Beijing, the AIRS retrieved relative humidity is 60%-80%, but the relative humidity in T213 model is 80% or more. The differences indicate that the simulated results will be different between the following controlled experiment and the sensitivity experiment.

### 3.2 Experimental schemes

#### 3.2.1 Designed schemes

Two kinds of experimental schemes are designed: (1) Take the T213 global analysis field as the first guess field, and carry out the reanalysis through Cressman objective analysis. Only the conventional surface and sounding observations are used to estimate the initial value. The model is integrated for 36 h. It is named the controlled experiment (CE); (2) On the basis of CE, the AIRS retrieved surface air temperature together with temperature and humidity profile products at about 0600 UTC are assimilated into MM5 model through the analysis nudging. That is to say, the atmospheric information retrieved from AIRS is ingested into the model initial field. It is named the sensitivity experiment (SE). In addition, the experimental starting time is 0000 UTC 14 February; the experimental ending time is 1200 UTC 15 February; the step length of time integration is 90 s; the simulated results are output once per 6 h. The time period of snowfall in Beijing are mostly from 1200 UTC 14 February to 1200 UTC 15 February. Therefore, the simulated results from 12- to 36-h integration are analyzed.

#### 3.2.2 Designed parameters

Two-way nested grids are applied in the numerical simulation experiments. The grid spacing of coarse domain is 45 km; the sizes of coarse domain are 80×80; the center is at 39.9°N, 116.3°E; the grid spacing of
nested domain is 15 km; the sizes of nested domain are 61×61; the vertical coordinate is the σ-coordinate with unequal thickness of 23 levels. The model terrain altitude data are the USGS (United States Geological Survey) elevation data with a resolution of 10 min. The vegetation data are the 25-category USGS land cover data with a resolution of 10 min. The first guess field is the T213 objective analysis field. The conventional data come from the meteorological surface and sounding observation data at 0000 UTC 14 February. The AIRS retrieved surface air temperature together with temperature and humidity profiles products at 0600 UTC 14 February are analytically assimilated into the MM5 model to adjust the model initial field. As the case is a snowfall process in winter, the explicit moisture scheme of Reisner graupel is selected. This scheme adds supercooled water, allows slow melting of snow, and includes the number concentration prediction equations of water vapor, cloud water, rain water, cloud ice, snow, graupel, and so on. The cumulus parameterization scheme adopts the Kain-Fritsch Scheme 2. The planetary boundary layer scheme is the high resolution Blackadar Scheme. The atmospheric radiation scheme is the cloud radiation. The lateral boundary condition scheme is the relaxation/inflow-outflow. The simulated results in Beijing and in the nested domain are mainly discussed.

3.3 Experimental results analysis

3.3.1 Snowfall amount

Figure 5 gives the observed snowfall in the period from 1200 UTC 14 February to 1200 UTC 15 February. There are two snowfall centers in the nested domain: one is at 35.4°N, 119.5°E with the snowfall amount of 22 mm; the other is at 37.3°N, 115.4°E, with the snowfall amount of 18 mm. The snowfall in Beijing is relatively bigger, and almost reaches 10 mm, but not shown in Fig.5. From the figures of observed snowfall in a 6-h period (figure omitted), we know that the snowfall intensity in Beijing is the strongest in the period from 0000 to 0600 UTC 15 February. Therefore, the simulated results along Beijing at 0600 UTC 15 February are mostly analyzed.

Figure 6 displays the simulated snowfall in a 24-h period between 1200 UTC 14 February and 1200 UTC 15 February in CE (Fig.6a) and SE (Fig.6b). Comparing Fig.6 with Fig.5, we can see that a large-scale snowfall has been simulated in both experiments. The closed snowfall centers increase slightly, and some false snowfall centers appear. Considering the snowfall in Beijing, the simulated position is quite right, but the simulated snowfall amount is more than the truth in SE and CE. Regarding the snowfall center at 37.3°N, 115.4°E, the simulated snowfall amount approaches the actual snowfall, but the simulated position has a deviation about 150 km to northwest in both experiments. Regarding the snowfall center at 35.4°N, 119.5°E, both the position and the snowfall amount in SE are quite consistent with the reality, and the snowfall in CE is larger than the reality. In the southern part of the nested domain, the simulated snowfall in SE is less than that in CE, and approaches the actual snowfall. Moreover, from the distribution of 10-mm heavy snowfall, we know that the simulations are larger in SE and CE, but the SE simulation is in agreement with the reality mostly. As a result, the simulated results in SE are better than those in CE.

The simulated snowfall in SE and CE are non-convective. It indicates that there is no strong convection activity in the whole processes. This can be confirmed from the diagnostic analysis later.

3.3.2 Humidity conditions

The humidity fields at 12 pressure levels retrieved
from AIRS were assimilated into MM5 model, which modified the model humidity fields. Figure 7 describes the distribution of relative humidity at 700 hPa at 0600 UTC 15 February. In CE, the relative humidity is about 95% in the southeastern part of the nested domain; and there is a relatively dry area with humidity less than 90% in the northwestern part of the nested domain. However, in SE, the area of higher humidity does not exist. It implies that the humidity decreases in the southeastern part of the nested domain, which is the primary cause for the decrease of snowfall in the southern part of the nested domain in SE. The simulated snowfall in SE is in agreement with the actual snowfall.

3.3.3 Vertical velocity and divergence fields

Figure 8 presents the latitude-height cross-sections of vertical velocity field (Fig.8a) and divergence field (Fig.8b) along 116.3°E at 0600 UTC 15 February in SE. In order to analyze the large-scale atmospheric conditions, the simulated results of the coarse domain are output. It is shown in Fig.8a that there are the ascending motions over the south of 42°N; the central position is located at 39.2°N; the central height is approximately at 400 hPa; the maximum vertical speed is 0.08 m s\(^{-1}\); it corresponds to the snowfall center in Beijing at that time. Moreover, there are descending motions over the area north of 42°N; the maximum vertical speed is \(-0.06\) m s\(^{-1}\). Figure 8b illustrates that the convergence and divergence are unordered, and the values generally range from \(-3\times10^{-5}\) to \(3\times10^{-5}\) s\(^{-1}\). It is consistent with the vertical velocity field, indicating that this is a weak convective activity, and it is a process of stable snowfall.

3.3.4 Cloud microphysical processes

In order to investigate the characteristics of the
cloud vertical structure, the latitude-height cross-sections of cloud microphysics along 116.3°E are produced, and the horizontal dashed lines denote the air temperature distribution. The air temperatures at all levels are below 0°C, which means that the supercooled water is extremely little and will be ignored. The whole snowfall processes are controlled by the cold cloud, composed of ice and snow. The value of ice crystal mixing ratio ranges from 0.01 to 0.025 g kg\(^{-1}\), with the corresponding position at about 300 hPa, and is being stable in the entire simulation processes. The change of water content is mainly displayed by the change of snow water mixture ratio. Therefore, we perform the analysis of the change of snow water mixing ratio and the movement of its central position.

The model is integrated for 18 h, i.e., at 1800 UTC 14 February, it has not snowed in Beijing yet, and the snowfall occurs in south of Beijing (Fig.9). In SE, the central position of snow water is at 400-500 hPa, and the value of snow water mixing ratio is 0.03 g kg\(^{-1}\). In the south of 40.0°N, there are two centers with value about 0.04 g kg\(^{-1}\), and they have already reached the ground. This implies that it is snowing at that moment, and the snowfall intensity is very weak, which is consistent with the actual situations. But this process has not been simulated in CE.

The model is integrated for 24 h, i.e., at 0000 UTC 15 February, the synoptic system is in the development period (Fig.10). The content of snow water in every level obviously increases; the snow water mixing ratio at 500 hPa is about 0.03 g kg\(^{-1}\); the central position gradually shifts to the near surface layer (approximately 1000-900 hPa), and locates in the southern part of Beijing; the maximum snow water mixing ratio increases to 0.21 g kg\(^{-1}\). This indicates that it is snowing in Beijing, moreover, the snowfall intensity is strong at that time. This evolvement process has been well simulated both in SE and CE.
The model is integrated for 30 h, i.e., at 0600 UTC 15 February, when the system is in the mature phase (Fig. 11). The position of snow water content of about 0.03 g kg$^{-1}$ develops upward to 300 hPa; the central position locates in the near surface layer. The snow water content continues to increase to 0.30 g kg$^{-1}$ in CE. The snow water content is about 0.27 g kg$^{-1}$ in SE, slightly smaller than that in CE. The major cause is due to assimilating the AIRS retrieved temperature and humidity products in SE, which induce the snowfall a little smaller than that in CE. The simulated snowfall in SE approaches the reality.

The model is integrated for 36 h, i.e., at 1200 UTC 15 February, the simulated snow water content at every level is almost the same as that of previous 6 h, as shown in Fig. 12. There are many differences between the simulated and the actual snowfall amount. In fact, the synoptic system is in the weakening phase, the snowfall tends to reduce, and the snow water content should have a bigger decrease at that time. The evolution process has not been well simulated both in SE and CE.

In the whole simulation processes, the precipitation system extends slowly from southwest to northeast and intensifies significantly. The system has the features of long time period, large-scale range, and large snowfall amount. In the initial phase of snow cloud, the cloud layer is thin. With the development of the synoptic system, the range of snow cloud gradually enlarges, the cloud layer continuously accumulates, and eventually reaches the ground. It has the features of continuing snowfall of cold stratus (Sun, 2003).

4. Conclusions

The surface air temperature observations obtained from 540 meteorological stations were processed. The AIRS retrieved surface air temperature products over China were analyzed by comparing with the ground observations, and the sources of errors were
discussed in detail. Based on the error analysis, the AIRS retrieved surface air temperature data were corrected. Moreover, the AIRS retrieved temperature and humidity profile products over China were compared with the T213 model products, and the differences between them were quantitatively analyzed. Because T213 simulated results cannot replace the real atmospheric states, to further verify their validation, the AIRS retrieved surface air temperature together with the temperature and humidity profile products were assimilated into MM5 model. Then, we investigated the effects on snowfall, humidity field, vertical velocity field, divergence field, and cloud microphysical processes. A snow case on 14 February 2005 in North China was simulated. The primary conclusions are as follows:

1. The errors of AIRS retrieved surface air temperature are largely systematic errors. The major cause is the influence of terrain altitude, which can induce a negative deviation of more than 10 K.

2. The surface types have a tremendous effect on the AIRS surface air temperature retrievals. For example, the snow cover in winter can cause a systematic deviation of 5 K. In addition, the accuracy of AIRS retrieved surface air temperature is better between 105° and 120°E in winter, and the RMS errors are only 2-4 K. But the retrieval accuracy is bad in that region in summer, and the RMS errors increase to 4-6 K. With a statistical method, the AIRS retrieved surface air temperature products can be improved to some extent.

3. The differences between the AIRS retrieved temperature and humidity profile products and the T213 numerical simulated results in temperature are generally less than 2 K; the differences in relative humidity are generally less than 25%.

4. The temperature and humidity fields retrieved from AIRS are assimilated into MM5 model through the analysis nudging, which will adjust the model initial field. The snowfall prediction is improved to a certain degree.

5. Because the air temperature of all levels is below 0°C in the whole simulation processes, hardly no liquid cloud-water or rain-water exists. The ice crystal mixing ratio rarely changes, and the change of water content is mainly displayed by the change of snow water mixture ratio. From the cloud microphysical processes, we can conclude that the case has the features of continuing snowfall of cold stratus.

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