MAUSAM, **54**, 1 (January 2003), 107-110

551.501.724:551.501.86

Retrieval of atmospheric parameters from NOAA-16 AMSU data over Indian region - Preliminary results

DEVENDRA SINGH, R. C. BHATIA, S. K. SRIVASTAV

Satellite Meteorology Division

India Meteorological Department, New Delhi-110 003, India

and

BIRBAL SINGH

R.B.S. College, Agra, India

e mail : dschahar@hotmail.com

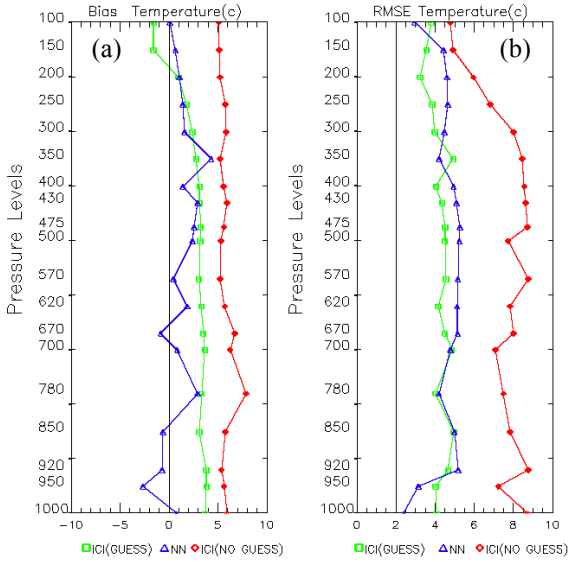
सार – भारत मौसम विज्ञान विभाग, नई दिल्ली में नवीन उच्च विभेदन चित्र संप्रेषण (एच.आर.पी.टी.) अभिग्रहण प्रणाली की स्थापना होने से उपग्रहों के नोआ–के.,एल,एम. और एन. सीरिज में लगे सूक्ष्म तरंग सांउडिंग उपकरणों से प्राप्त वास्तविक समय के आँकडें भी उपलब्ध हो जाते हैं। दो अलग अलग योजनाओं: इनवर्शन कपल्ड इमेजर (आई.सी.आई.) और न्यूरल संजाल (एन.एन.) पद्धति का उपयोग करते हुए नोआ 16 उपग्रह के ए.एम.एस.यू. आँकड़ों से लिए गए तापमान और नमी के आँकड़ों की जाँच करने के लिए अभी हाल ही में प्राप्त किए गए ए.टी.ओ.वी.एस. और ए.वी.एच.आर.आर. प्रीप्रोसेसिंग पैकेज (ए.ए.पी.पी.) के साथ अपरिष्कृत एच. आर.पी.टी. आँकड़ें सामने आ रहे हैं। इस अध्ययन में जनवरी 2002 के महीने में तापमान और नमी के आँकड़ों की प्रोफाइल की जानकारी के लिए भारतीय क्षेत्र पर नोआ 16 उपग्रह डाटा का उपयोग किया गया है। बायस और रूटमीन स्केयर (आर.एम.एस.) के परिकलन से वहीं पर किए गए ई.सी.एम.डब्ल्यू.एफ. विश्लेषण का उपयोग करते हुए तापमान और नमी के प्राप्त किए गए परिणामों का मूल्यांकन किया गया है। जनवरी 2002 के महीने के डाटा सेटों के विश्लेषण पर आधारित परिणामों से सभी वायुमंडलीय परतों के लिए आई.सी.आई. पद्धति के सुपरिणामों का पता चलता है। तापमान प्रोफाइलों में आर.एम.एस. त्रुटि सभी दाब सतहों पर 4° सें., से कम पाई गई है। सापेक्षिक आर्द्रता में आर.एम.एस. त्रुटि सभी दाब सतहों पर 20% से कम पाई गई है। पूर्वानुमान क्षेत्र और न्यूरल संजाल पद्धति का उपयोग किए बिना आई.सी.आई. की तुलना में पूर्वानुमान क्षेत्र का उपयोग करते हुए इन परिणामों की पारस्परिक तुलना करने से यह तथ्य सामने आया है कि बायस और आर.एम.एस. त्रुटि आई.सी.आई. प्रणाली के लिए कम है।

ABSTRACT. With the establishment of a new High Resolution Picture Transmission (HRPT) reception system at IMD, New Delhi, the real time data from microwave sounding instruments onboard the NOAA-K, L, M and N series of satellites has also become available. The raw HRPT data is being interfaced with the recently acquired new 'ATOVS and AVHRR Preprocessing Package (AAPP)' to perform temperature and moisture retrievals from AMSU data of NOAA-16 satellite using two separate schemes: Inversion Coupled Imager (ICI) and Neural Network (NN) approach. In this study, NOAA-16 satellite data over Indian region were used for retrieving temperature and moisture profiles for the month of January, 2002. The temperature and moisture retrieval results are evaluated by computing the bias and root mean square (RMS) difference using collocated ECMWF analysis. The results based on the analysis of data set for the month of January, 2002 shows that ICI approach yields better results for all atmospheric levels. The RMS errors in temperature profiles are found to be less than 4ºC at all pressure levels. The RMS errors in relative humidity are found to be less than 20% at all pressure levels. Intercomparison of the results revealed that bias and RMS error are less for ICI scheme using forecast field compared to ICI without using forecast field and Neural Network approach.

Key words – ICI Inversion Coupled Imager, NN Neural Network, ECMWF European Center for Medium Range Weather Forecasting, Remote sensing.

1. Introduction

The vertical structure of temperature and water vapor plays an important role in the meteorological processes of the atmosphere. Information of temperature and moisture distribution in the vertical is useful in aviation, synoptic forecasting and numerical modeling. For years the radiosonde network has been the primary observing system for monitoring tropospheric temperature and water vapor. Routine observations are very difficult over the vast oceanic regions due to logistics problems and high cost factor, and are limited only over land regions.



Figs. 1(a&b). Comparisons of bias and RMS error for temperature profile with and without guess using ICI and NN scheme for January, 2002

Further, the conventional radiosonde data has inherent problems of solar radiation during daytime. Therefore, the retrievals of temperature and humidity profiles from satellites data are very much important for applications such as weather analysis and data assimilation in numerical weather predictions models.

The Advance Microwave Sounding Unit (AMSU-A and AMSU-B) is a 20 channel microwave radiometer onboard the new generation of NOAA polar orbiting satellites. The first satellite of this series NOAA-15 was launched on 13 May, 1998. Due to problem in few AMSU-B channels, the second satellite NOAA-16 was launched. The NOAA-16 is in circular sunsynchronus near polar orbit at an altitude of 833 km. The orbital period is 101.35 minutes and the local time for equator crossing is 0730 hr for ascending node and 1930 hr for descending node. The AMSU is cross-track line scanned instrument. The sensor scan in a stepped scan fashion. The sensor is designed to provide the temperature and moisture profiles from surface to 45 km. Preliminary results obtained using new 'ATOVS and AVHRR Preprocessing Package (AAPP)' installed at India Meteorological Department (IMD), New Delhi for retrieval of the temperature and moisture profiles from the AMSU data using two different retrieval schemes, viz. Neural Network and ICI, have been summarized in this study. In the present study retrievals were made on land and ocean simultaneously. Therefore, these retrieval profiles are combined for land and ocean.

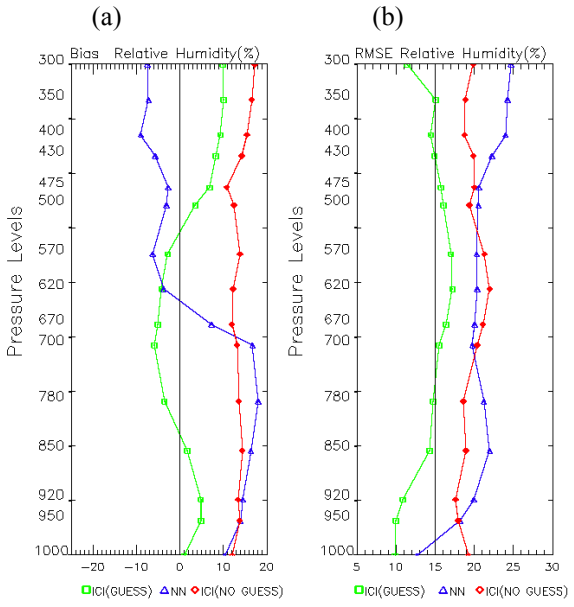
2. Retrieval schemes and model data sets

A new HRPT (High Resolution Picture Transmission) system capable of receiving the data of latest series of NOAA Satellite (K, L and M) data has been installed at India Meteorological Department (IMD), New Delhi. In the present study, the ATOVS data for the month of January 2002 has been taken. The atmospheric temperature and moisture profiles have been derived combinedly for land and ocean. The atmospheric temperature and moisture profiles from AMSU measurements have been retrieved using Neural Network approach (Butler *et al*., 1996). The conversion of AMSU channels measurements to moisture profiles contains non-linear processes. Neural Network has advantage over traditional statistical methods (Singh *et al.,* 2002) in that they can build non-linear models based on the data used to train them and thus provide more accurate results. Moisture profiles were also retrieved from AMSU data using ICI approach. The ICI inversion system was developed at the Centre de Météorologie Spatiale (CMS), where it has been operational since 1996. Its structure is based on independent modules, which work separately and could be easily replaced. The key components are, initial profiles library, inversion module and the tuning module, which is responsible for the periodic ICI calibration (Lavanant *et al*. 1997; Lavanant *et al*. 1999a). The ICI version used in the current study uses the RTTOV-6 model, a fast radiative transference code (Eyre 1991; Sanders *et al.* 1998) to simulate the brightness temperature during the retrieval process. Cloud cover classification is performed from the MAIA algorithm (Lavanant *et al*. 1999b) and applied in the last step of the AAPP model. A mean clear percentage of cloud cover on HIRS field of view is calculated from AVHRR channels with the aid of ancillary data (surface temperature and Total Precipitable Water Contents (TPWC)). The TPWC is estimated over sea following Grody *et al*. (1999) methodology, while over land a multiple-regression algorithm using various channels was applied.

The analysis of Europian Centre for Medium Range Weather Forecasting (ECMWF) global model at 0000, 0600,1200 and 1800 UTC for January 2002 were used for the collocated data sets. The ECMWF data consists of the temperature and moisture profiles at the pressure levels starting from 1000 hPa to 0.1 hPa. The collocated data sets are constructed based on the moisture profiles retrieved using ICI and Neural Network data that are within 1.5 hour of the temporal resolution and within 1°× 1° latitude and longitude grid of ECMWF analysis.

3. Results and discussion

Figs. 1(a&b) and Figs.. 2(a&b) show the bias and RMS error in degree Celsius for temperature and relative



Figs. 2(a&b). Comparisons of bias and rmse for relative humidity profile with and without guess using ICI and NN scheme for January,2002

humidity profile using the ECMWF analysis for the month of January, 2002 respectively. These bias and rmse were computed from the temperature profiles retrieved using ICI scheme with and without using LAM (Local Area Model, operational at IMD) forecast as initial guess profile. It is necessary to provide realistic initial guess in ICI scheme. Generally the analysis of NWP model is more representative of the real atmosphere than climatological data. In our processing, the analyses of the LAM are utilized to create a rolling library of vertical profiles over the last ten days. Once an initial guess profile has been obtained, inversion consists of perturbing this profile under certain limits in order to minimize the error between the measurement and the synthetic brightness temperature of the final profile. It is observed that bias and RMSE error have been reduced significantly using the LAM forecast as first guess compared to the bias and error computed without using the LAM forecast. This is because of the facts that 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. 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. Upward and downward 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 microwave surface emissivities are so much variable with surface conditions that brightness temperature for surface viewing channels can differ from several tens of degrees with a same atmospheric profile. 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 and to make routine analyses. A multilinear regression with stratospheric, microwave observations and zenith angle is used for the correction of the RTTOV biases.

The Figs. 1(a&b) and Figs. 2(a&b) show the comparison of bias and rms error of temperature and relative humidity using two different retrieval schemes for the month of January, 2002. It may be seen from Figs. 1(a&b) and Figs. 2(a&b) that the bias and rms errors from ICI scheme using LAM forecast as initial guess are less (about 4° C) compared to ICI without using LAM forecast (about 8° C) as initial guess and Neural Network approach (about 5° C). The rms error for relative humidity profiles is less than 10% at all pressure levels ICI using LAM forecast as initial guess compared to ICI without using LAM forecast (about 20%) as initial guess and Neural Network where it is about 20%.

There are regions where the retrieval still presents problems. The comparison of the errors with the French NWP center at 1000 hPa to 100 hPa pressure levels (Lavanant *et al.* 1999 a&b), indicate more than 15% deviations, given of course bad error statistics when the ICI Indian retrievals are compared to the French ICI retrievals. This may be due to the possibility of high quality ECMWF analyzed fields tuned over Europe as compared to the other parts of the globe. Further, ICI package should be run continuously at least for one year to make the rolling library as representative of all possible meteorological conditions for the running day. Therefore, further improvements in the temperature and moisture profiles are expected after in near future. Further, there is significant difference between the time of observation (analysis) and NOAA-16 over pass in the study region (1.5 hr). Normally, two data sets that are within half an hour of each other are preferred for comparison. Large diurnal temperature variations in the tropical region could affect the temperature comparison significantly whenever two data sets are more than half hour apart. Also the moisture fields usually have large spatial and temporal variability, especially in tropical region, which makes these comparisons more difficult.

4. Conclusions

The ATOVS preprocessing and the physical retrieval method ICI have been briefly described in the present

work. The temperature and relative humidity profiles retrieval results from ATOVS observation are compared and validated with ECMWF analyses over Indian regions. These results show reasonable good agreements between ICI retrievals and ECMWF analyses. Based on these results, it may be conclude that in general, the ICI scheme yield good quality retrievals compared to Neural Network. Further work is in progress to improve these results and also to extend this analysis to different seasons over Indian region. Many Indian meteorologists are very much interested in the retrieved atmospheric parameters for the weather analysis and forecasting etc. The ATOVS retrieved profiles are also needed to enable the assimilation of satellite data in a numerical weather prediction model. With AMSU data, the atmospheric parameters can be derived in all weather conditions, which is an added advantage over TOVS measurements.

Acknowledgements

Authors are grateful to Director General of Meteorology, Dr. R. R. Kelkar for his constant encouragement during the course of study. Thanks are also due to Mr. S. K. Mukharjee for his assistance. Authors are very much thankful to Dr. Lavanant Lydie, Meteo-France for his tremendous help for the installations of the AAPP 3.0 and ICI 3.0 software packages.

References

Butler, C. T. R, Meredith, V. Z. and Stogryn, A. P., 1996, "Retrieving atmospheric temperature parameters from DMSP SSM/T-1 data with Neural Network", *J.Geophys. Res.*,**101**, 7075-7083,

Eyre, J. R., 1991, "A fast radiative transfer model for satellite soundings system", ECMWF Tech .Memorandum, p176.

Grody, N, Weng, F. and Ferraro, R., 1999, "Application of AMSU for obtaining water vapour, cloud liquid water, precipitation, snow cover and sea ice concentration", Tech. Proc. of the Tenth International TOVS Study Conference.

Lavanant, L., Brunel, P., Rochard, G., Labrot, T. and Pochic, D., 1997, "Current Status for the ICI Retrieval Scheme", Tech. Proc. of the Ninth International TOVS Study Conference.

Lavanant, L., Brunel, P., Rochard, G. and Labrot, T., 1999a, "NOAA15 Soundings profiles retrieved with the ICI scheme", Tech. Proc. of the Tenth International TOVS Study Conference.

Lavanant, L., LeGleau, H., Derrien, M., Levasseur, S., Monnier, G., Ardouin, L., Brunel, P. and Bellec, B., 1999b, "AVHRR cloud mask for sounding applications", Tech. Proc. of the Tenth International TOVS Study Conference.

Sanders, R., Matricardi, M. and Brunel, P., 1998, "An improved fast radiative transfer model for assimilation of radiance observations", *Quart. Jour. R. Met. Soc*., **102**, 1407-1425.

Singh, Devendra, Bhatia, R. C. and Srivastav, S. K, 2002, "Validation of Atmospheric temperature profiles derived using Neural Network approach from AMSU-A measurements onboard NOAA-15 and NOAA-16 satellites and their applications for tropical cyclone analysis", Twelfth International TOVS/ATOVS workshop, Lorne, Australia , 27 February-5 March.

Singh, Devendra, Bhatia, R. C. and Srivastav, S. K, 2002, "ATOVS retrievals for local HRPT at New Delhi", National symposium and workshop on forecasting and mitigation of meteorological disasters: tropical cyclones and floods and droughts, held at Bhubneswar from 11-14,February.