SIMULATIONS OF THE ATOVS INSTRUMENT CHANNELS BY RADIATIVE TRANSFER
MODELING ON SYNOPTIC SITUATIONS OVER EUROPE

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1. INTRODUCTION

By 1996 the polar orbiting satellites of the NOAA/TIROS-N series will have their instrumentation improved considerably. There will be a new set of sounding instruments for the retrieval of the three dimensional thermodynamic structure of the atmosphere from space. The current TIROS Operational Vertical Sounder (TOVS) will be replaced by the Advanced TOVS (ATOVS). ATOVS will consist of the High Resolution Infrared Radiation Sounder HIRS/3, an improved 20 channel infrared sounder, the Advanced Microwave sounding Unit A (AMSU-A, 15 channels) for temperature sounding and the advanced Microwave Sounding Unit B (AMSU-B, 5 channels) for humidity sounding. The latter microwave instruments will replace the currently used Microwave Sounding Unit (MSU) and the Stratospheric Sounding Unit (SSU).

The new instrument set will provide data which allow retrieval more independently from cloud cover and with a higher vertical resolution in the atmosphere. Figure 1a and Figure 1b show the weighting functions of the AMSU-A and AMSU-B instruments.

To introduce software for the processing of locally received data preparations have been begun to allow for the pre processing of the data (Klaes and Perrone, 1993, Klaes, 1995). To prepare the data processing, knowledge has to be gained on the effects of atmospheric state on the radiances, measured by the new instruments. In order to provide a first assessment of radiance data arriving at the satellite instrument, two ways of simulation of the data are in principle possible. One way is to simulate the atmospheric conditions, including (the) contamination effects, like cloud particles, rain etc., and estimate the radiances, arriving aloft, by direct forward calculation of the radiative transfer.
Fig 1  Weighting Functions of the AMSU-A (a) and AMSU-B (b) instruments.
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The second way would be to use real space based measurements, by similar instruments, like the DMSP-embarked SSM/I, SSM/T and SSM/T-2 instruments, and simulate the ATOVS instrument channels. This would give the possibility to evaluate real contamination effects and thus give an idea on pre-processing strategies. The first way is outlined here, whereas the second way is pursued in a second contribution to these Proceedings, with SSM/T-2 data to address AMSU-B effects (Klaes, 1995).

2. PROCESSING AND DATA

To provide a first assessment of radiance data arriving at the satellite instrument, radiative transfer calculations have been performed, using as input the model analyses for two synoptic situations over Europe in summer 1990 and 1991. The data used are ECMWF model analyses of temperature and relative humidity on 13 August 1990 and 31 July 1991, 1200 UTC. The RADTRAN PC based version (Falcone et al., 1982, Isaacs et al., 1989) was used. To provide an objective cloud information (since the observations were not available, specially in vertical resolution) a relative humidity threshold model (Geleyn, 1979) was used. A critical relative humidity according to

\[ rh_{\text{crit}}(\sigma) = 1 - \alpha \sigma (1 - \sigma)(1 + \beta (\sigma - 0.5)) \]  

(1)

where \( \sigma = p / p_0 \), \( p_0 = 1013.25 \) hPa, \( \alpha = 1 \) and \( \beta = 3 \). If the actual relative humidity is greater than the critical one, the cloud cover in the respective level is calculated according to

\[ \text{cov}(\sigma) = \frac{(rh - rh_{\text{crit}})^2}{1 - rh_{\text{crit}}} \]  

(2)

A midlatitude stratiform cloud type was chosen. Multiple layered clouds were allowed for by statistical overlapping (Klaes, 1984). The radiative transfer calculations were performed for the 15 AMSU-A channels and the 5 AMSU-B channels for both synoptic situations (3772 data profiles each, CPU time on a 486-DX2 66MHz PC 1.5 h for each channel and situation). The surface types were distinguished
between land and sea, on land between wet snow, wet soil and vegetation.

To verify simulations of the four microwave channels were done and compared to the actual measurements of NOAA-11 based TOVS data of 13 August 1990. A good agreement was achieved.

3. RESULTS

Figure 1 shows the simulated cloud cover for the 13 August 1990, 1200 UTC. The important cloud features were reproduced, however the total cloud amount is underestimated, compared to AVHRR imagery. The goal here was not to reproduce the actual cloud pattern in an exact way, but to provide objective cloud information, based on the real situation, which enters in a consistent way into the Radiative Transfer Calculations. The expected accuracy of two octas (Klaes, 1984) was retained in average. Figure 2 shows as an example the results of AMSU channel 16 simulations (AMSU-B channel 1, 89 GHz), Figures 3 and 4 show simulations of the AMSU channels 8 (55.5 GHz) and 18 (AMSU-B Channel 3, 183 ± 1 GHz), respectively. The simulation reveals the degradation of the Brightness Temperatures in the region of cloud coverage. However no decision can be made where there is rain or ice particle contamination. In order to provide a consistent and definitive statement, the next step will be to use real space based data, and converge both approaches to a consistent decision tree.

4. CONCLUSIONS

This study was a first attempt to approach the contamination problem of micro wave radiances by using synoptic scale data sets for simulation and to show a way to create simulated, contaminated data. Only restricted means were available for this study, both in terms of processing power and data. More work is required to allow for scan angle effects as well as to introduce quantitative information on pollution effects, like cloud parameters, particle sizes etc. Simulations are required, along with comparisons of real satellite based data from the comparative DMSP instruments SSM/I and SSM/T-2. Studies like the SSM/T-2 analyses (Klaes, 1993), need to be extended and combined with forward modeling results in
Fig 1 Simulated Cloud Cover from ECMWF analyses, 13 August 1990, 1200 UTC, according to Equations (1) and (2).
Fig 2  Simulated AMSU Channel 16 Brightness Temperatures, using ECMWF analyses from 13 August 1990, 1200 UTC with the Cloud Cover as in Fig. 1.
Fig 3  Simulated AMSU Channel 8 Brightness Temperatures, using ECMWF analyses from 13 August 1990, 1200 UTC with the Cloud Cover as in Fig. 1.
Fig 4  Simulated AMSU Channel 18 Brightness Temperatures, using ECMWF analyses from 13 August 1990, 1200 UTC with the Cloud Cover as in Fig. 1.
order to obtain simulated contaminated radiance data. With these a first simulation of contamination
detection and treatment could be obtained.

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