

The retrieval of the atmospheric humidity parameters from NOAA/AMSU data for winter season.

Izabela Dyras, Bożena Łapeta, Danuta Searfin-Rek – Satellite Research Department, Institute of Meteorology and Water Management, P. Borowego 14, 30-215 Krakow, Poland (Izabela.Dyras@imgw.pl)

Abstract

The passive microwave AMSU data from the NOAA-KLM satellite series allow obtaining the information on atmosphere's humidity. The regression algorithms were developed to retrieve the cloud liquid water path (LWP), rain rate (RR) and total precipitable water (TPW) over the land surfaces. The algorithms were created using the satellite observations calibrated by the ground-based precipitation measurements as well as radiosounding data from Central Europe. The obtained results were in qualitative agreement with the standard meteorological data for snow-free surfaces. However, the use of RR and LWP algorithms in cloud-free conditions over snow cover on land led to erroneous results. The paper presents the method enabling elimination of the snow impact in estimating RR and LWP values. The proposed solution uses another AMSU derived parameter – total precipitable water. The application of the RR and LWP algorithms is restricted to the areas where TPW is higher than the established threshold value. The method was used for the NOAA 16 data in winter season and the obtained results are discussed in the paper.

Methods – regression algorithms

The algorithms for the atmospheric humidity parameters' retrieval from NOAA/AMSU data were developed by the method of multiple linear regression between AMSU channels' brightness temperature and radiosounding or ground measurements. The following equations were worked out for total precipitable water (TPW), liquid water path (LWP) and rain rate (RR) over land:

$$TPW = -26.94 + 0.32 \cdot TB(50) + 1.0198 \cdot TB(89) - 0.404 \cdot TB(150) - 0.789 \cdot TB(183 \pm 7) \text{ [mm]} \quad (1)$$

$$LWP = 12.6574 + 0.0263 \cdot TB(89) - 0.06875 \cdot TB(150) \text{ [kg/m}^2\text{]} \quad (2)$$

$$RR = 47.75 - 0.096 \cdot TB(50) + 0.123 \cdot TB(89) - 0.158 \cdot TB(150) - 0.037 \cdot TB(183 \pm 7) \text{ [mm/h]} \quad (3)$$

Standard errors of the above estimations were found to be of 4.58mm, 0.6 kg/m² and 2.26 mm/h for TPW, LWP and RR, respectively.

The examples of the product obtained with the algorithms defined by eq. (1)-(3) applied for NOAA/AMSU data on the 13th August 2004 are presented on the Figures 1a-c. The calculations were performed only over land. To illustrate the cloudiness distribution, the false colour composite of NOAA/AVHRR ch421 (RGB) data is shown on the Figure 1d. The area of high TPW, LWP and RR values (Fig.1a-c) correspond to the cloudiness on the warm front stretching over Central Europe.

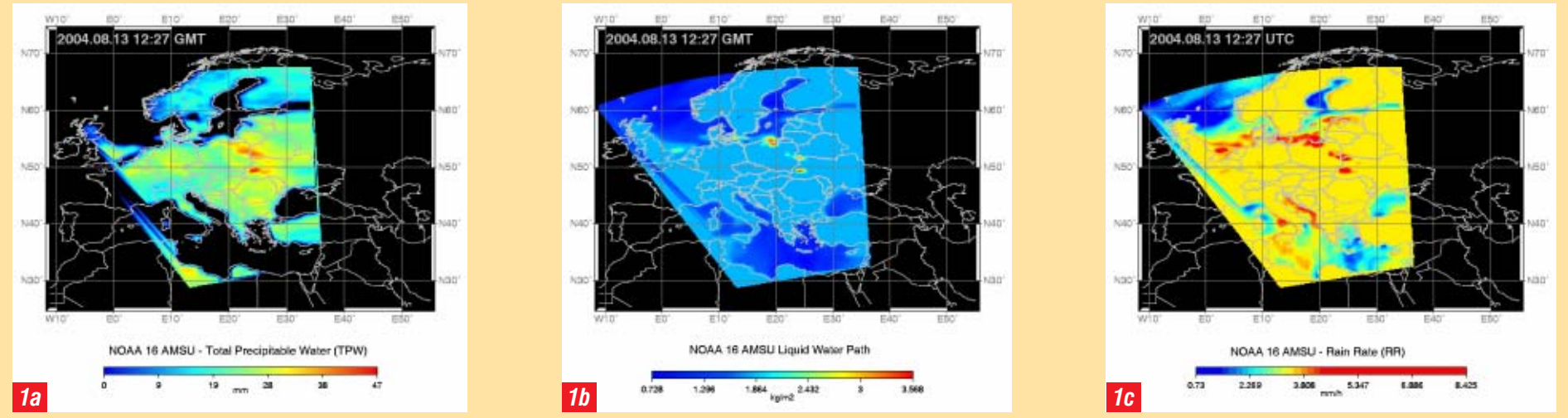
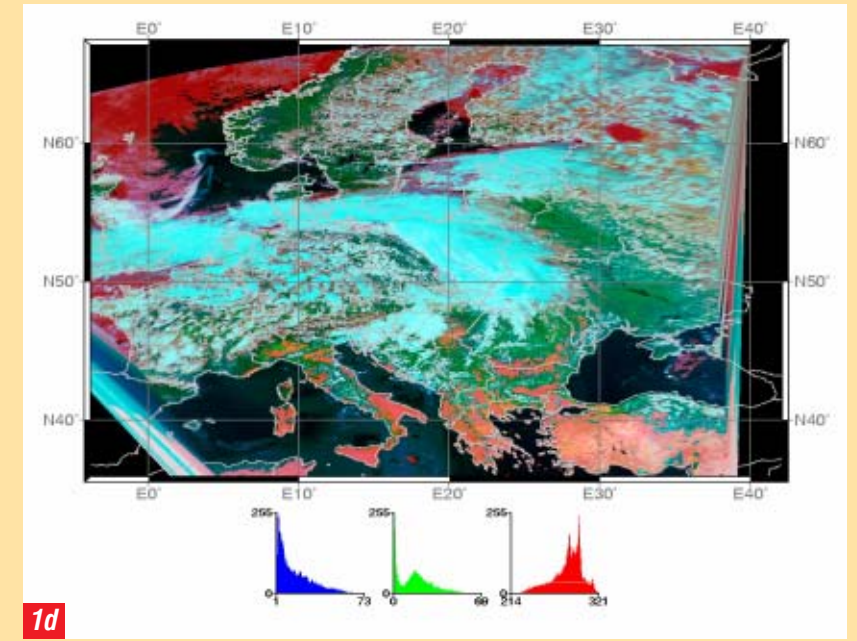


Figure 1 Total precipitable water (a), cloud liquid water path (b) and rain rate (c) derived from NOAA-16/AMSU data, 13 August 2004, using the regression algorithms.



Algorithms for winter season

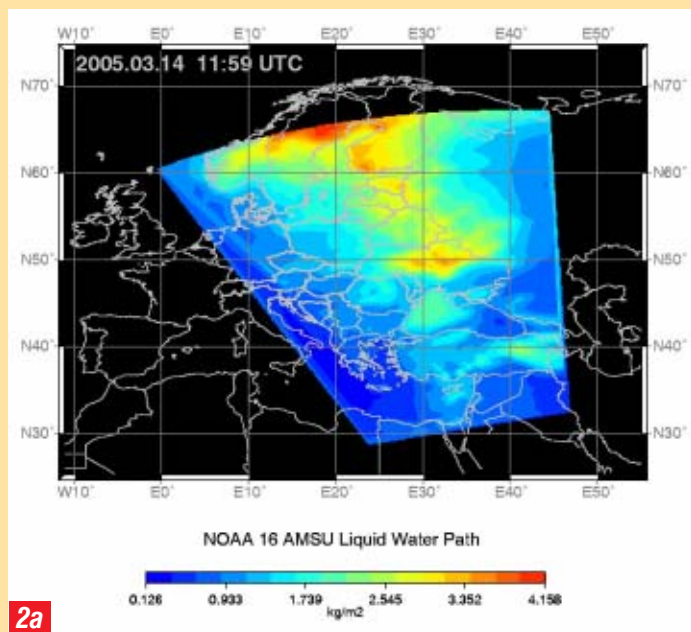


Figure 2. Cloud liquid water path (a) and rain rate (b) derived from NOAA-16/AMSU data, 14 March 2005, using the regression algorithms.

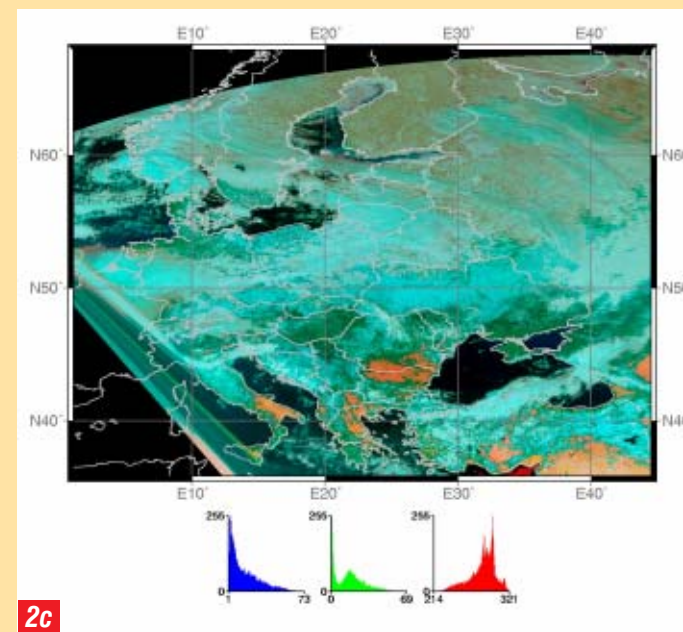
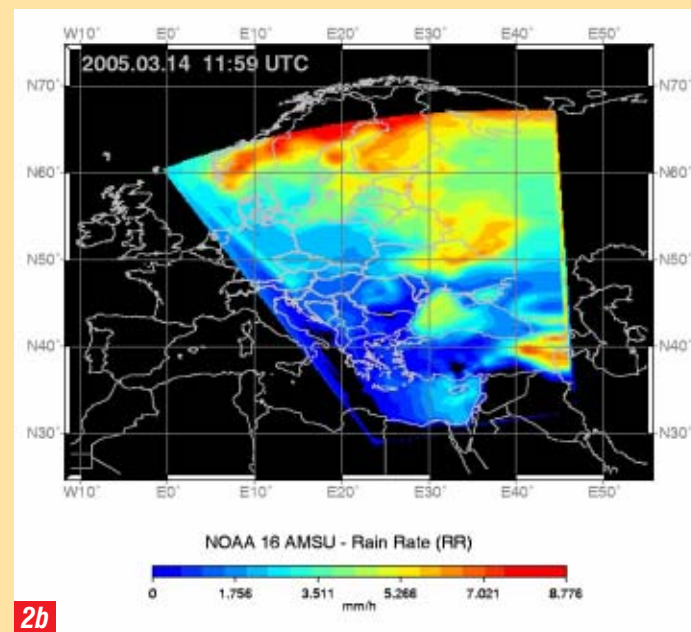


Figure 2c. False Colour Composite 421 (RGB), NOAA/AVHRR, 14 March 2005.

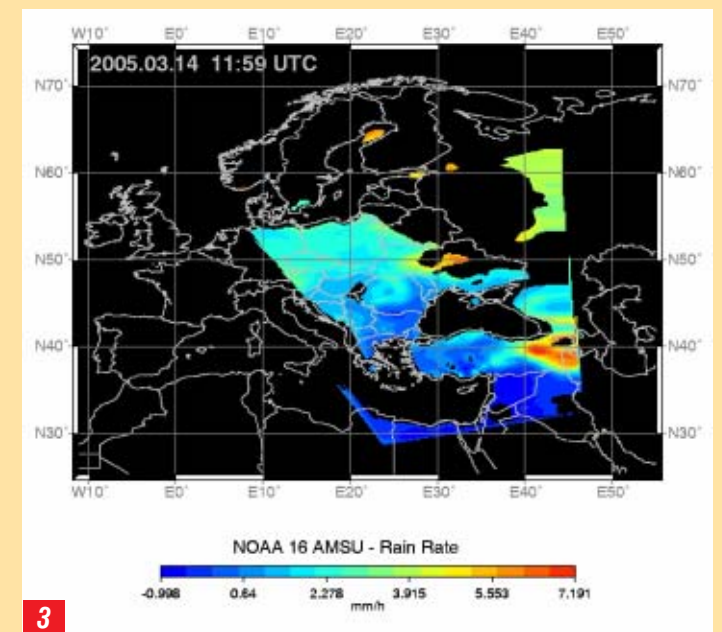


Figure 3. Rain rate derived from NOAA/AMSU data using the regression algorithms and TPW threshold of 5 mm, 14 March 2005.

Due to strong influence of snow, the use of RR and LWP regression algorithms in cloud-free conditions over snow cover on land led to erroneous results. Figures 2a-b presents the results of the application of the algorithms for the situations with snow (14 March 2005, NOAA-16). The false colour composite of NOAA/AVHRR ch421 (RGB) for this granule is shown on the Figure 2d. Both, LWP and RR take high values over the cloud free parts of the Scandinavian and Kola Peninsula. To eliminate the snow impact in estimating RR and LWP values, the fact that the TPW values over cloud free land are smaller for low temperature and Polar Regions is used. Therefore the following solution was used: the application of the RR and LWP algorithms is restricted to the areas where TPW is higher than the experimentally established threshold value. From the data analysis the TPW threshold value of 5mm has been found for March. Figure 3 illustrates the application of the threshold algorithm for rain rate, for the same granule as on the figures 2a-c.

TPW algorithm verification

Comparison with stations' data

The adaptation of the regression algorithms for winter conditions was based on the TPW threshold. Therefore, the quality of this parameter retrieval for this season should be known. To achieve this, the TPW values derived from AMSU data were compared with the radiosounding data for the period of February-March 2005. For each considered station, the closest pixel was found. The maximum accepted distance was set to 1deg. The comparison results are presented on the Figures 4 and 5a.

The application of the developed TPW regression algorithm led to overestimation of TPW for dry atmospheres and underestimation – for wet ones (Fig.4).

The agreement between AMSU and radiosounding TPW values is not very bad, the correlation coefficient is equal 0.58 and the mean difference between AMSU and radiosounding TPW is of 0.8. The quality of TPW for summer autumn season is only slightly better (Fig.5b)

Comparison with IAPP outputs

Since 2005, the IAPP package with numerical weather prediction model has been used for NOAA/ATOVS retrievals. The correlation between IAPP and radiosounding derived TPWs is very high (0.9) (see Fig.6a). However, IAPP overestimates the TPW values for all types of the atmosphere (see Figure 6b) for the data set used for AMSU regression algorithm.

The obtained satisfactory results encouraged performing the comparison of TPW derived by both methods.

A result of this comparison is shown on the Figure 7a. Figure 7b presents the histogram of the differences.

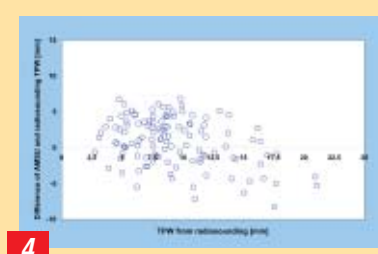


Figure 4. Difference of AMSU and radio-sounding derived TPWs versus radiosounding TPW.

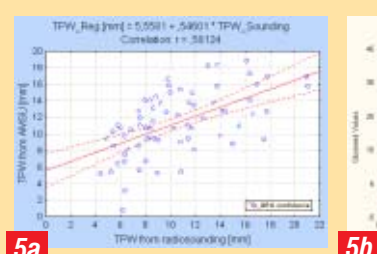


Figure 5. Scatterplot of AMSU and radiosounding TPW obtained for the wintertime conditions (a) and summer-autumn situations (b). The red solid line corresponds to the best linear fit with 95% confidence (marked with red dashed lines)

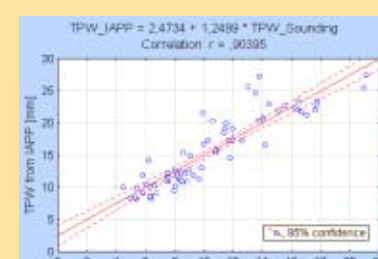
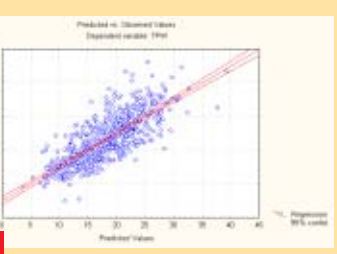


Figure 6a. Difference of IAPP and radiosounding derived TPWs versus radiosounding TPW.

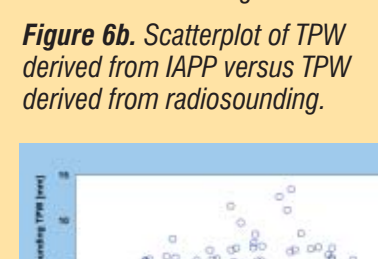


Figure 6b. Scatterplot of TPW derived from IAPP versus TPW derived from radiosounding.



Figure 7a. Distribution of the differences between TPW derived from AMSU regression algorithms and IAPP, respectively

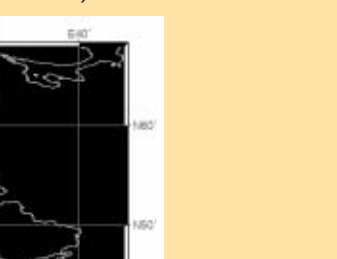


Figure 7b. Histogram of the differences between TPW derived from AMSU regression algorithms and IAPP, respectively

Conclusions

- The regression algorithms for the derivation of the atmospheric humidity parameters from NOAA/AMSU data have been developed for land surface and summer-autumn season. The TPW, LWP and RR values calculated for summer NOAA data were in qualitative agreement with the standard meteorological data.
- The summer algorithms were adjusted for winter season using empirical TPW threshold values separately defined for each winter month. Yet, the problems occur for the areas with broken cloudiness over snow. The quality of the adapted algorithms is strongly depends on the quality of the AMSU TPW retrievals.
- AMSU TPW results for the wintertime were only slightly worse than those obtained for summer-autumn season as the comparison with the radiosounding data showed. Moreover, the application of the AMSU TPW regression algorithm leads to overestimation of TPW from radiosounding for the dry atmosphere and underestimation – for the wet one.
- The quality of the IAPP TPW retrievals is much better than the TPW derived from NOAA/AMSU data using the regression algorithm. However, the IAPP overestimates the TPW for all conditions. The value of this systematic error should be found.
- The use of numerical weather prediction model in IAPP calculations has improved the IAPP TPW results' quality and therefore AMSU regression algorithms can be only used as a source of a qualitative estimation.