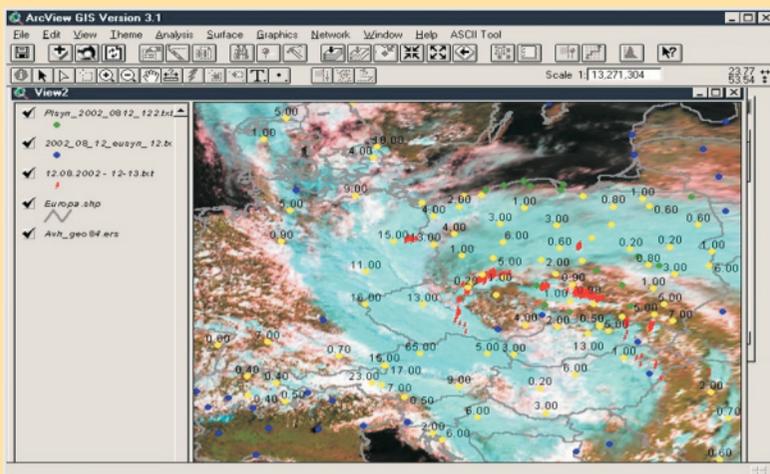


DATA

Data Type	Range	Resolution	Frequency	Scale
SYNOP	Europe	synoptic/	1 h	regional
KLIMAT	Poland	climatic	3 h	regional
AEROLOGICAL SOUNDING	Poland/Europe	stations	6 h/12 h/24 h	global
NOAA AVHRR		1.1 km		regional
NOAA AMSU	Central Europe	17/40 km	6/day	regional
NOAA HIRS		10 km		regional
SAFIR	Poland	1 km	1 min	regional
NUMERICAL WEATHER PREDICTION MODEL	Central Europe	13 km	6/12 h	mezoscale

Table 1. Meteorological and climatological data.

The satellite observations, ground measurements and numerical weather prediction (NWP) models provide the continuous information on the state of the atmosphere that are used for weather analysis and forecast. Combining these data into one system encounters problems due to the data various range as well as temporal and spatial resolution, however, GIS can provide the useful tool for the data analysis and presentation. Table 1 has been assembled in order to



Satellite data with the SYNOP stations overlay, 12.08.2002 (ArcView).

visualise the variety data used and potential problems caused by different spatial resolution, frequency – temporal resolution and scale.

The temporal and spatial characteristics of NOAA satellites data are summarised in Table 1. There has been significant progress in developing methods using the satellite information over the sea and oceans. However, the methods of sounding in microwave spectrum over land are still inadequate and these problems are researched in the Satellite Research Department, IMWM, Poland.

Vertical profiles of temperature, dew point as well as geopotential height from TEMP, at standard pressure levels (925, 850, 700, 500, 300, 200 hPa) were used to calculate air relative humidity and cloud water content. Water vapour mixing ratio, relative humidity and liquid water contents and consequently - cloud liquid water path (LWP) were calculated at the standard pressure levels.

SYNOP data provided information concerning temperature, dew temperature at the surface, as well as present and past weather, cloud cover and cloud type. Precipitation data was used from SYNOP at 12.00 GMT (precipitation sum for the last 6 hours).

The figure above shows a good example of combining different information. In the background there is a False Colour Composite FCC (channels 321) from the Very High resolution Radiometer (AVHRR) on board the polar orbiting meteorological satellite - NOAA 16. The clouds appear in white to blue colours, sea in black and land in shades of green and brown. Several different thematic layers are laid on top of the FCC; the locations of the SYNOP stations in Europe and Poland are shown as blue and green dots, respectively. Yellow dots show the marked SYNOP stations with the recorded precipitation over 1 mm. The labels show the recorded lightnings from Safir system are shown in red.

METEOROLOGICAL PRODUCTS

Precipitation is a highly variable parameter with time and space therefore the use of satellite data allows obtaining the global information.

The prepared meteorological products for Poland based on microwave data include the precipitation intensity (Rain Rate – RR) and precipitation range (based on Scattering Index – SI_land) on top of the satellite FCC. The data was obtained from NOAA AMSU data using Advanced ATOVS Processing Package package.

SYNOP	SATELLITE PRECIPITATION SI_land >=3	NO PRECIPITATION SI_land <3
PRECIPITATION	338	2
NO PRECIPITATION	27	4

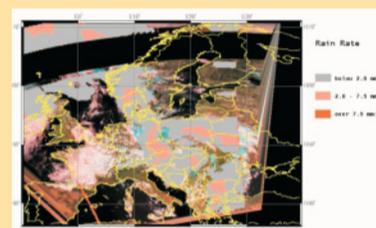
Table 2. Precipitation detection results using scattering index – comparison of the results obtained from AMSU data vs. SYNOP for the summer-autumn season in 2002 (371 cases).

Rain Rate is calculated according to the regression algorithm -1

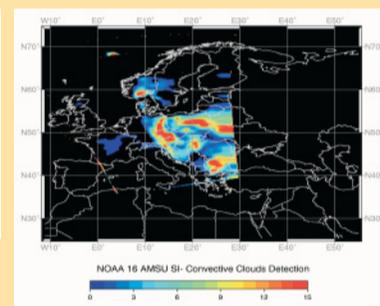
$$RR = 47,75 - 0,096 * TB(50) + 0,123 * TB(89) - 0,158 * TB(150) - 0,037 * TB(183 \pm 7)) [\text{mm/h}] \quad (1)$$

Scattering Index is used for convective clouds detection (SI_land). It is assumed that the precipitation occurs if SI_land >= 3. The horizontal size of cloud is important – big systems are recognised better than small, which sometimes are ignored. It is calculated according to the regression algorithm -2

$$SI_land = 42,72 + TB(89) - TB(150) \quad (2)$$



Precipitation Intensity map from AMSU data, NOAA 16, 12.08.2002, 12:24 GMT. Intensity is broken into 3 classes – light, moderate and high.



Scattering Index over land map – areas of detected convection from AMSU, NOAA 16, 12.08.2002, 12:24 GMT.

Microwave data NOAA/AMSU are valuable for the recognition of extreme situations such as convective cloud systems or extended storm clouds. Testing and verification of the precipitation detection versus ground measurements for the summer-autumn season in 2002 is shown in Table 2;

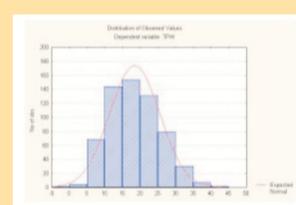
Total Precipitable Water (TPW) algorithm-3 allows to estimate the water vapour content in the air over the land. The obtained coefficient of determination $R^2 = 0.59$ with standard deviation 4.6 mm, for 618 cases. The regression analysis is shown in Table 3.

$$TPW = -26,94 + 0,32 * TB(50) + 1,0198 * TB(89) - 0,404 * TB(150) - 0,789 * TB(183 \pm 7)) [\text{mm}] \quad (3)$$

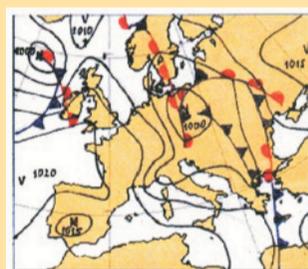
The location of the low and system of fronts shown on the surface analysis map has a good representation on the satellite image. The microwave algorithms adequately define the areas of the high humidity values, rain rate intensities as well as ranges.

STATISTICA MULTIPLE REGRESSION		Regression Summary for Dependent Variable: TPW			TPW	
		R=0,76699883 R ² =0,58828720 Adjusted R ² =0,58560066			F(4,613)=218,98 p=0,0000 Std.Error of estimate: 4,5781	
N=618	BETA	St. Err. of BETA	B	St. Err. of B	(613)	p-level
Intercept			-26,9441	13,23545	-2,03576	0,042204
T50_3	0,323232	0,096127	0,3202	0,12521	2,47831	0,013469
T89_0	0,918632	0,165788	1,0198	0,18104	5,54101	0,000000
T150	-0,444990	0,140871	-0,4043	0,12798	-3,15886	0,001662
T183_7	-0,667865	0,067999	-0,7887	0,08030	-9,82171	0,000000

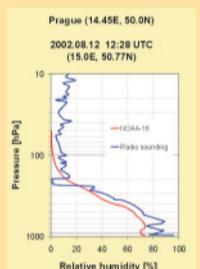
Table 3. The results of the regression analysis for TPW



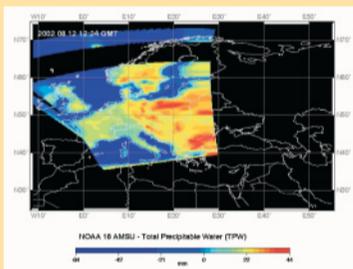
Distribution of TPW values of 618 cases from summer-autumn season 2002.



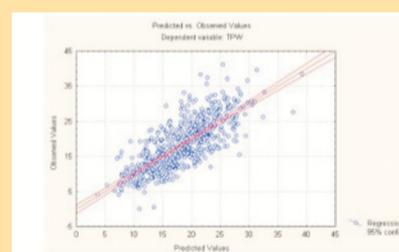
Meteorological situation on 12.08.2002, analysis at the surface. (source: <http://www.chmi.cz/hydro/pov02/flood.htm>)



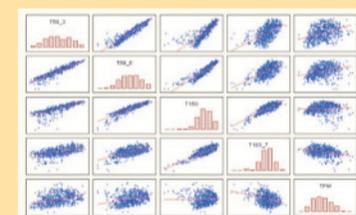
Vertical relative humidity profile obtained from NOAA-16 data (red) and measured by radiosondes (blue) at station Prague 12.08.2002 -12 GMT.



Total Precipitable Water (kg/m²), calculated from microwave AMSU data, NOAA 16 12.08.2002; 12:24 GMT (ErMapper).

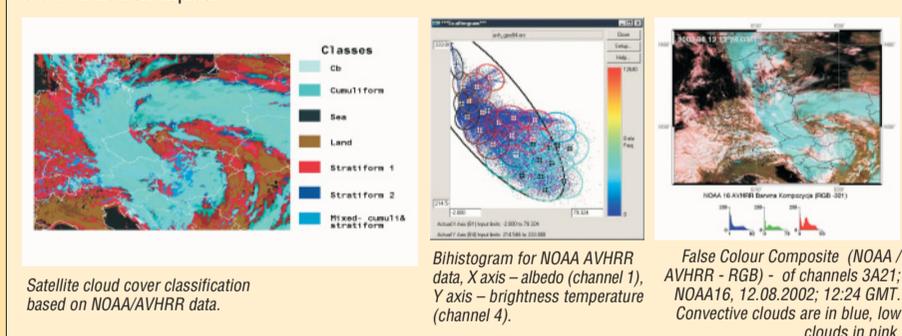


The spread between TPW values calculated from radiosonde data – axis Y and TPW values determined from brightness temperature in several AMSU channels – axis X (STATISTICA).

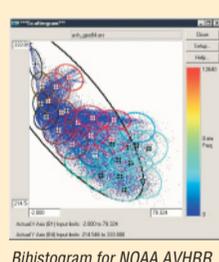


Correlation between brightness temperatures in several AMSU channels and the Total Precipitable Water (STATISTICA).

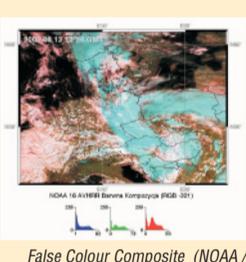
The False Colour Composite (FCC) is very simple technique for cloud cover enhancement. It simultaneously combines satellite images from three channels of AVHRR data into one color image product. Discrimination between low clouds and fog, thin and thick cirrus, cloud free land ocean, and thick non-precipitating clouds from nimbostratus can be performed more successfully and more confidently when using multi-spectral infrared and visible color imagery in conjunction in one another. More advanced techniques – supervised or unsupervised classification can also be applied as shown on the attached examples.



Satellite cloud cover classification based on NOAA/AVHRR data.

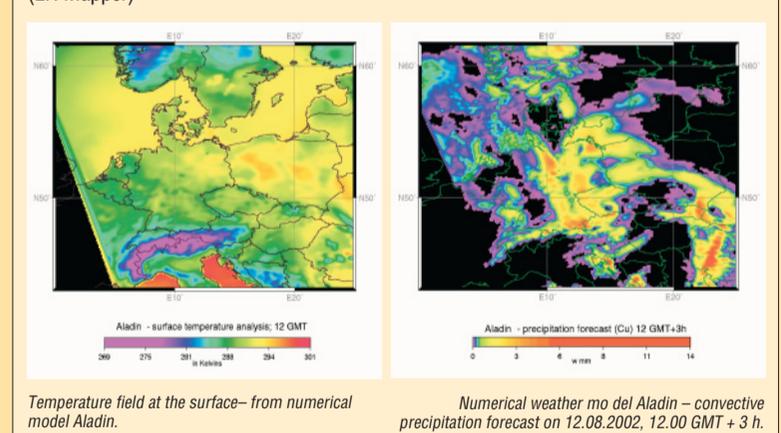


Bihistogram for NOAA AVHRR data, X axis – albedo (channel 1), Y axis – brightness temperature (channel 4).



False Colour Composite (NOAA / AVHRR - RGB) - of channels 3A21; NOAA16, 12.08.2002; 12:24 GMT. Convective clouds are in blue, low clouds in pink.

Temperature and precipitation forecast fields are created from the NWP model Aladin analysis. Thematic layers are imported from ASCII format and rectified by triangulation (ER Mapper)



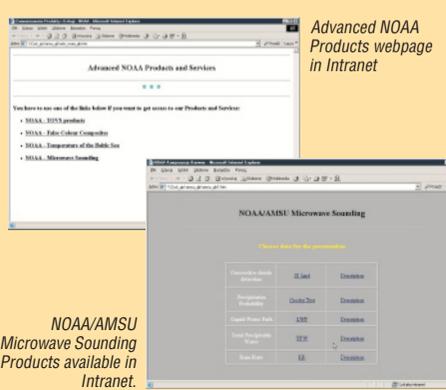
Temperature field at the surface – from numerical model Aladin.

Numerical weather model Aladin – convective precipitation forecast on 12.08.2002, 12:00 GMT + 3 h.

CONCLUSIONS

The Geographic Information System (GIS) methods and tools used for the joint analysis and presentation of satellite and meteorological data allow preparing:

- Maps of the integrated information from all satellite sensors (AVHRR, HIRS and AMSU) such as TPW, RR, SI;
- Classification and visualisation of the multi-spectral data with the vector overlays (i.e. geographic or administrative boundaries);
- Development, testing and verification of the suitable algorithms for various meteorological parameters;
- Combining different information (raster and vector) into one thematic layers and their Internet distribution.



NOAA/AMSU Microwave Sounding Products available in Intranet.

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