ATSR and SAR data for vegetation monitoring

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ABSTRACT

The data applied for the project include ATSR-1, ATSR-2, SAR from 1995, 1996 and 1997 for the agriculture area in western part of Poland.

The objective of the study was to characterise the vegetation, its stage, roughness and growing conditions. The visible data from ATSR were used to calculate indices, which were used to depict the roughness of vegetation. From the surface temperature the indices were calculated characterising soil moisture conditions. Also on the bases of surface temperature and meteorological parameters measured at the ground station latent heat was calculated to characterise vegetation – soil moisture conditions at the study area. The SAR backscatter values from the closest time of acquisition were averaged to the area covered with each of ATSR pixel and the relation between backscattering coefficient and indices has been analysed. These three years differed due to moisture conditions.

Introduction

The research has been carried out in the agriculture test site within the ESA AO2-PL102 project concerned application ERS/SAR and ATSR data for examination of soil vegetation status. Due to clouds cover it has been possible to obtain the following ATSR acquisitions: 23.05.95, 27.06.95, 28.07.95, 23.07.96, 11.08.96, 16.06.97. For these acquisitions time matching SAR data have been selected i.e. 20.05.95, 24.06.95, 29.07.95, 14.07.96, 18.08.96 and 29.06.97.

At the test site located at the western part of Poland the ground measurements for agriculture area have been carried out during the time of satellite acquisition. The measurements represented 18 ATSR pixels (7 measurements within the pixel) and referred to soil moisture, biomass, LAI and meteorological parameters.

Data description

Each of ATSR images (nadir) has been overlaid on SAR data. The average backscattering coefficient values have been calculated for each ATSR pixel.

For ATSR data: temperature and albedo have been considered. Temperature values were used to calculate the values of the rate of loss of sensible heat by convection (H):

$$H = \frac{\rho \cdot C_p \cdot (T_s - T_a)}{r_a} \qquad (1)$$

where:

ρ - air density ($kg \cdot m^{-3}$),

C_p - specific heat of air ($J \cdot kg^{-1} \cdot K^{-1}$),

T_s - surface temperature (°C) from ATSR,

T_a - air temperature measured at the study area (°C),

r_a - air resistance for heat transfer ($s \cdot m^{-1}$).

Data analysis

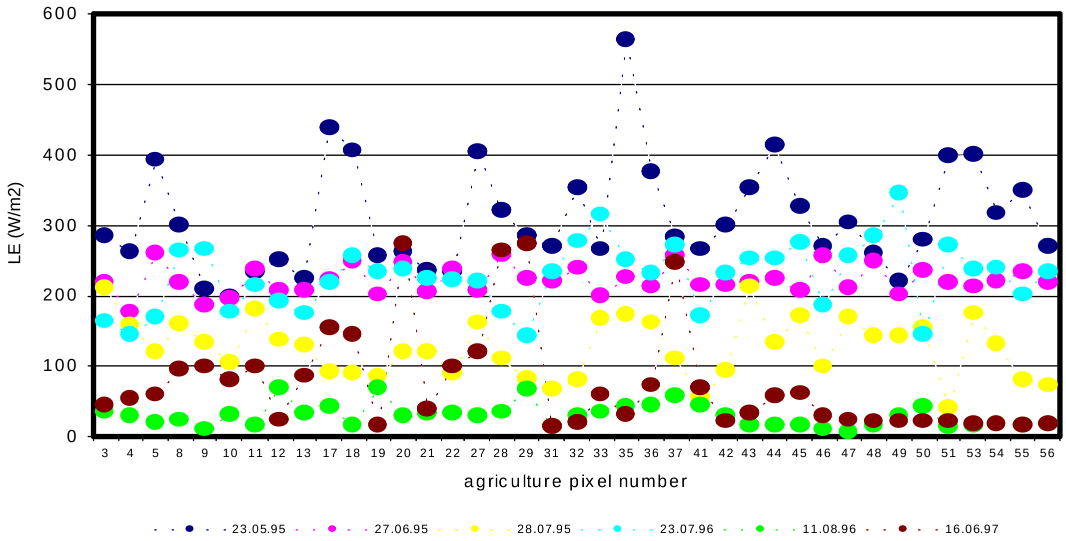

Fig.1.Latent heat fluxes for agriculture test site

The sensible heat values were used to calculate latent heat flux:

$$LE = RN - H - G \qquad (2)$$

where:

LE - the rate of loss of latent heat by evapotranspiration ($W \cdot m^{-2}$),

RN - the rate of net gain of heat from radiation ($W \cdot m^{-2}$),

H - the rate of loss of sensible heat by convection ($W \cdot m^{-2}$),

G - the rate of heat loss into the ground (measured, or statistically obtained - as a function of meteorological data) ($W \cdot m^{-2}$).

The lowest temperature recorded by ATSR and corrected for atmosphere influences occurred for the day 23.05.95 what indicated that the values of sensible heat calculated (equation 1) was low. The highest value occurred at the 11.08.96 giving high values of sensible heat. Figure 1 presents values of latent heat calculated for agriculture pixels (equation 2). The analysis of precipitation values recorded at the meteorological station located in the region has been carried out in order to examine and distinguish soil moisture conditions for 6 dates of ATSR measurements. It was assumed that the

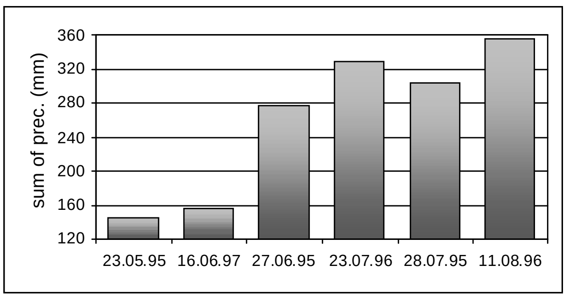

Fig.2.Sums of precipitation for dates of SAR acquisitions

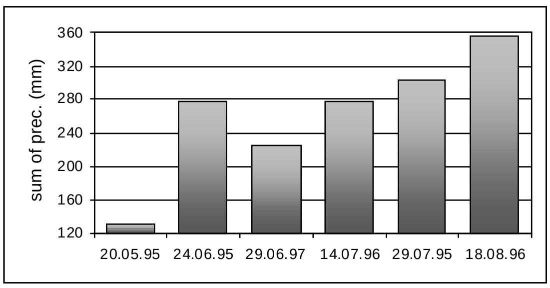

Fig.3.Sums of precipitation for dates of ATSR acquisitions

sum of precipitation calculated from the day when the vegetation starts to grow (>5°C) up to the day of satellite acquisition characterises soil moisture conditions. Figure 2 presents the sums of precipitation. Considering similar periods of time (24.06.95, 29.06.97, 14.07.96), the best soil moisture conditions occurred at 24.06.95 and conditions in these two days - Fig.2). Also low backscattering values were at the day 29.07.95 and 20.05.95.

In general there is the correlation between soil moisture and evapotranspiration for the time when the demand of vegetation for water is high. It was noticed that the relationship did not occurred for

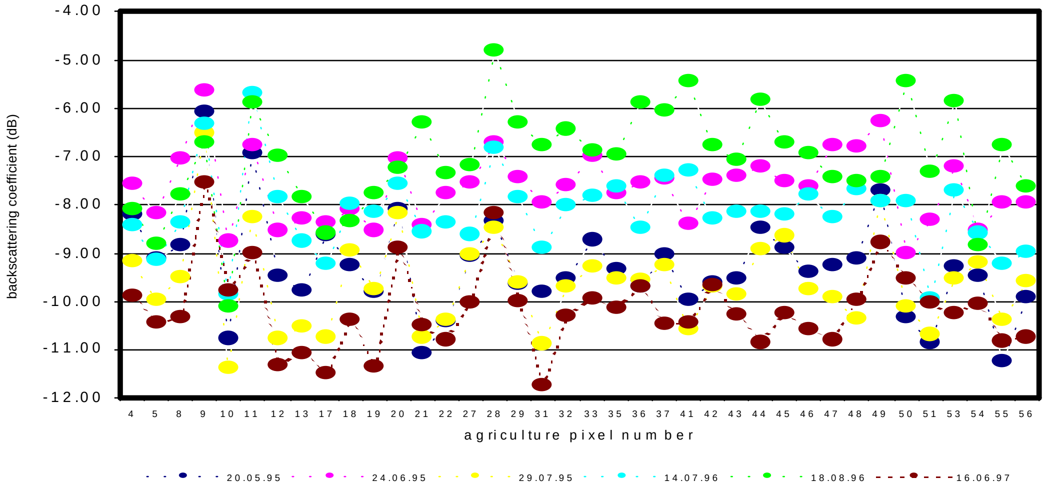

Fig.4.Backscattering coefficients for ATSR pixels - agriculture test site

14.07.96 and much worse at 29.06.97. Figure 2 shows that soil moisture conditions at the day 18.08.96 were good (however long period of considered precipitation) and low at 16.06.97 and very low at 20.05.95 (difficult to compare with the other dates due to very short period of considered precipitation). The sum of precipitation up to the date 29.07.95 (300 mm) has been considered as better than up to the date 14.07.96 (280 mm). Figure 4 presents the values of backscattering coefficient for ATSR pixels. It has been noted that the highest values of σ° refered to the day 18.08.96 (highest considered moisture (Fig.2). The lowest values of σ° occurred at the day 29.06.97, was also considered as a day of poor moisture conditions (Fig.2). Sigma values for 24.06.95 and for 14.07.96 have been similar representing alike soil water senescence period when vegetation did not transpired water even when the conditions were moist. Figure 1 shows that the highest values of latent heat, which represents evapotranspiration, occurred for the day 23.05.95.and very low for the day 11.08.96 for senescence time. Latent heat fluxes for the day 27.06.95 and for the day 23.07.96 were similar i.e. 200-300 W/m^2. These days of ATSR acquisition corresponded to 24.06.95 and 14.07.96 of SAR measurements. Evapotranspiration values for the day 28.07.95 were rather low (100-200 W/m^2) and corresponded to low values of backscatter for the day 29.07.95. Figure 3 presents the sum of precipitation values up to the days of ATSR acquisition.

Figure 5 presents the relationship between soil moisture (SM) measured at the test site and latent heat flux (LE) calculated for these agriculture pixels which represented soil moisture measurements. There is no relationship between latent heat and soil moisture for the day 11.08.96. The equation,

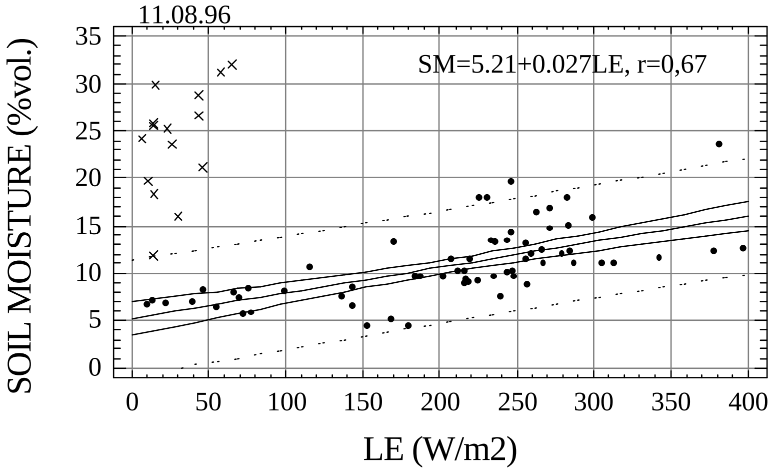

Fig.5.Relationship between backscattering coefficient and NDVI for ATSR agriculture pixels

which describes this relationship, is as follows:

$$SM = 5.21 + 0.027 \cdot LE \qquad (3)$$

The relationship between backscattering coefficient and NDVI has been examined for ATSR data of 1996 and 1997 (Fig.6). The relationship is negative, describing that high NDVI represented smooth surface and low values of backscattering coefficient and high NDVI values represented rough surface and much higher values of backscatter:

$$\sigma^\circ = -4.65 - 8.66 \cdot NDVI \qquad (4)$$

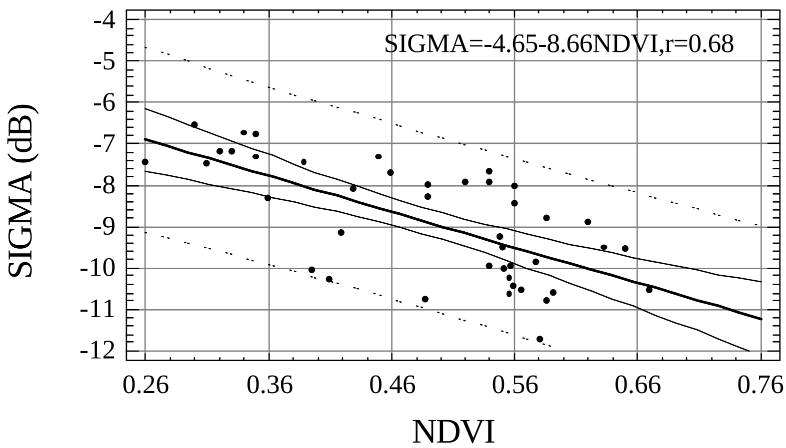

Fig.6.Relationship between soil moisture and latent heat fluxes for ATSR pixels

It has been analysed the relationship between backscattering coefficient and soil moisture which has been represented by latent heat and surface roughness expressed by NDVI. The correlation coefficient is equal to 0.78 (Fig.7):

$$\sigma^\circ = -9.19 + 0.009 \cdot LE - 2.33 \cdot NDVI \quad (5)$$

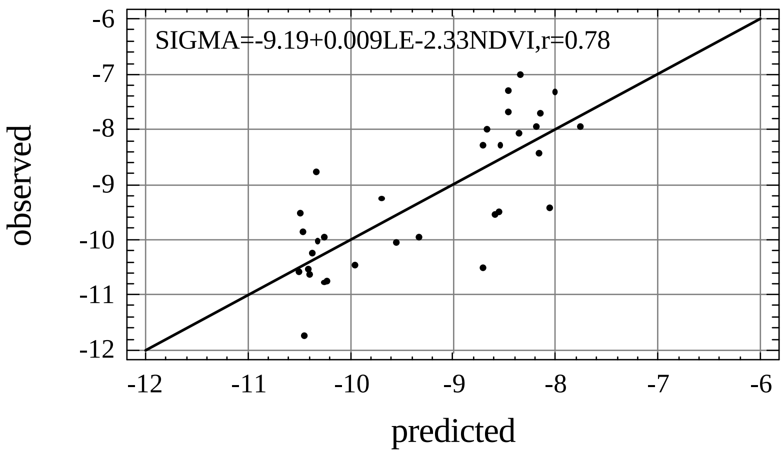

Fig.7.Backscattering coefficient for ATSR pixels calculated from LE and NDVI

Conclusions

Soil moisture conditions were well described by latent heat values calculated from temperature recorded by ATSR and meteorological data. Surface roughness has been represented by NDVI.

The relation has been found between sums of precipitation and backscattering coefficient and also between latent heat and sums of precipitation.

The relationship between backscattering coefficient and evapotranspiration and NDVI has been found.

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