THE STUDY OF MULTIFREQUENCY MICROWAVE SATELLITE IMAGES FOR VEGETATION BIOMASS AND HUMIDITY OF THE AREA UNDER RAMSAR CONVENTION

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ABSTRACT

Wetland ecosystems keep large amounts of organic carbon and have large influence on global climate change. Net ecosystem exchange (NEE) have been modeled by means of microwave satellite images. Assessment of biomass and soil moisture has been essential for the study to elaborate the methodology for evaluating carbon sink at the ecosystem under Ramsar Convention. Backscattering coefficient (σ˚) calculated from microwave images acquired by ENVISAT, ALOS and Sentinel-1 radar sensors was analyzed along with ground truth measurements of biomass, LAI, soil moisture (SM) and NEE carried out for vegetation classes distinguished from MERIS image. The models for NEE were developed using IS4 VV which represented vegetation biomass and IS4 HH representing SM. Application of the independent set of microwave data which were possible to gather gives a valuable opportunity to verify the accuracy in assessment of biomass and humidity based on various available sensors.

Index Terms— NEE, biomass, soil moisture, microwave satellite data

1. INTRODUCTION

The role of carbon (C) in the climate evolution causes that knowledge about C exchange between surface and atmosphere has been under intensive studies during the last years. Wetland ecosystems keep large amounts of organic carbon and may have large influence on global climate change. The amount of carbon exchange depends on such factors as soil, hydrological components of water balance and vegetation. The carbon fluxes have been associated with the vegetation type and biomass. Net ecosystem exchange (NEE), defined as difference between CO_2 uptake in gross primary production and ecosystem respiration should be modeled by means of microwave satellite images. Assessment of biomass and soil moisture has been essential for the study to elaborate the methodology for evaluating carbon sink at the ecosystem under Ramsar Convention. Application of the independent set of microwave data which were possible to gather gives a valuable opportunity to verify the accuracy in assessment of biomass and humidity based on various available sensors. The possibility of gathering radar-based data have been limited to existing satellites, however, since 2015 it is possible to obtain the Sentinel-1 and ALOS-2 data.

2. DATA AND METHODS

Backscattering coefficient (σ˚) calculated from microwave images acquired by ENVISAT and ALOS radar sensors was analyzed along with ground truth measurements of biomass, LAI, soil moisture (SM) and NEE carried out for vegetation classes distinguished from MERIS image. ALOS.PALSAR HV and ENVISAT ASAR IS6 VV gave the best results for LAI estimation, [1], [2]. The relationship between LAI and σ˚ was adversely proportional – the higher values of LAI the lower values of σ˚ what may be explained that the vegetation attenuates the wave while penetrating vegetation through the way to soil [3]. The Figure 1 presents results of statistical analyses between LAI and σ˚ calculated from ALOS.PALSAR HV. The highest correlation has been obtained for reeds, the lowest for pastures – the class not typical in wetlands communities. Concerning ASAR IS6 VV data, there is only trend with very week correlation. There is high correlation between LAI and biomass for particular vegetation classes, which has been examined.

The Figure 2 presents the map of LAI assessed from ALOS.PALSAR HV image using the equations, which shows Fig.1.

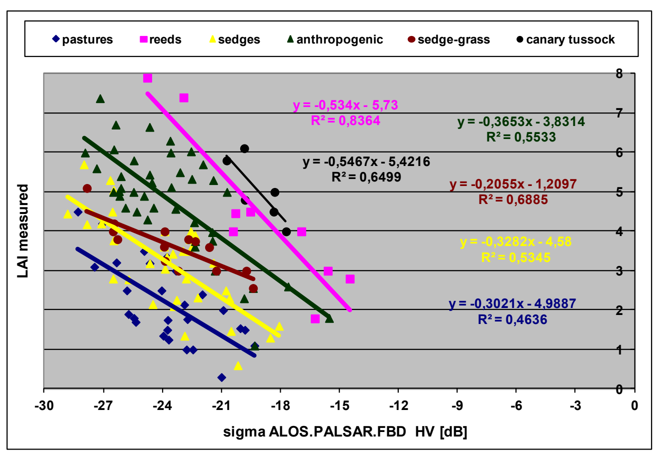

Fig.1. Relationship between LAI and backscattering coefficient (sigma) calculated from ALOS.PALSAR HV.

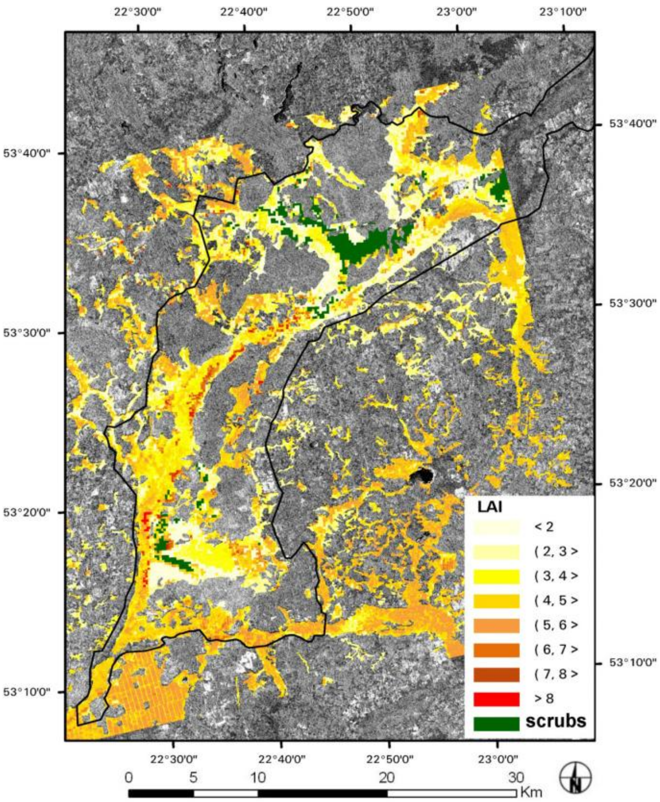

Fig.2. Map of LAI calculated from ALOS.PALSAR HV.

Assessment of LAI (and then biomass) and soil moisture is essential for modelling carbon sink at the ecosystem and evaluating carbon balance.

The Figure 3 presents relationship between Net Ecosystem Exchange and LAI, both as mean values of measurements carried out at the test site during Sentinel-1 overpass. There is high carbon sequestration by sedge-grass and reeds characterized by high LAI values and moisture (Fig 3, 4, 5).

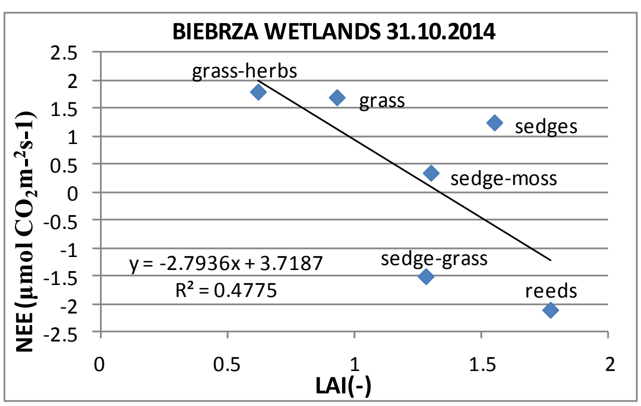

Fig.3. The relationship between Net Ecosystem Exchange and LAI.

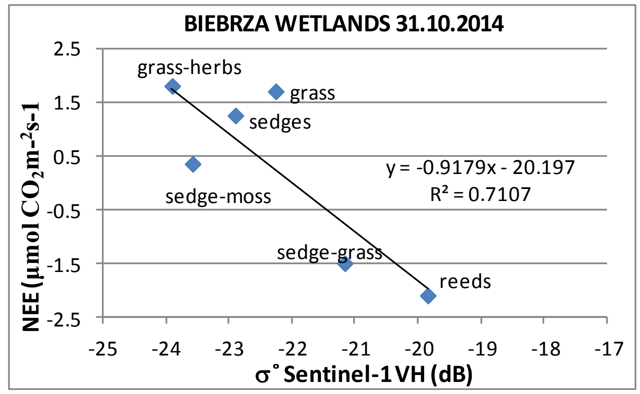

Fig.4. Relationship between NEE and backscattering coefficient (sigma) calculated from Sentinel–1VH.

Grass herbs and grass with low values of LAI (regrowth after harvest) do not assimilate carbon. That's why estimates of LAI is very important. ENVISAT ASAR images have been used for the assessment of soil moisture. For each of the classified wetlands vegetation habitats the relationship between soil moisture and backscattering coefficient has been examined and the best combination of microwave variables (wave length, incidence angle, polarization), has been used for mapping and monitoring of soil moisture applying ASAR IS4 HH. Since 2015 the Sentinel1 data are available. The mean values of σ˚ calculated from Sentinel-1 data and NEE data measured have been correlated for particular vegetation habitats, Fig. 4.

It is shown that large sequestration of carbon is connected to reeds and sedge grass (Fig. 4) with higher sigma values representing also moist conditions (Fig. 5).

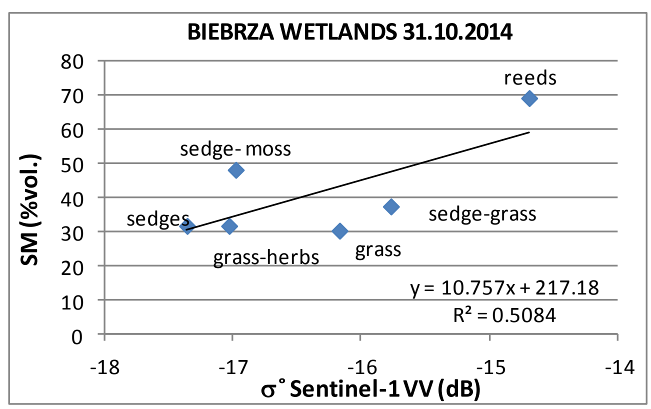

Fig.5. Relationship between soil moisture (SM) and sigma of Sentinel–1VV.

3. RESULTS

The relationship between NEE and biomass wet (Bw) was consistent with literature, i.e. directly proportional (the higher biomass, the higher uptake of CO_2 from the atmosphere). The models for NEE were developed using IS4 VV which represented vegetation biomass and IS4 HH representing soil moisture (SM), Table 1. At the time of NEE measurements the data of ALOS were not available anymore and that is why IS4 VV replaced PALSAR HV data.

Tab.1. NEE models developed from ASAR IS4 VV and HH.

HABITAT	R^2 (%)	MAE	P-VALUE	EQUATION
sedges	65.7	1.83	0.0401	NEE = -19.86 - 0.54*IS4VV - 1.81*IS4HH
reeds	70.0	1.80	0.0494	NEE = -17.22 - 3.58*IS4VV + 1.70*IS4HH
sedge-grass	88.6	0.82	0.0380	NEE = -4.54 - 1.45*IS4VV + 0.9*IS4HH
canary-tussock	86.5	1.04	0.0493	NEE = -5.94 - 3.15*IS4VV + 2.61*IS4HH
anthropogenic	45.0	1.28	0.0003	NEE = -7.48 + 0.10*IS4VV - 0.90*IS4HH
all	12.4	2.19	0.0423	NEE = -4.43 - 0.02*IS4VV - 0.56*IS4HH

11. REFERENCES

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