THE OPTICAL PROPERTIES OF THE ATMOSPHERE IMPACT ON CO_2 EXCHANGE BETWEEN THE WETLAND ECOSYSTEM AND THE ATMOSPHERE

BOGDAN H. CHOJNICKI

LABORATORY OF BIOCLIMATOLOGY

POZNAN UNIVERSITY OF LIFE SCIENCES

Uniwersytet Przyrodniczy w Poznaniu

Laboratory of Bioclimatology

UNIWERSYTET WARSZAWSKI

KusCO2 POLIMOS

esa European Space Agency

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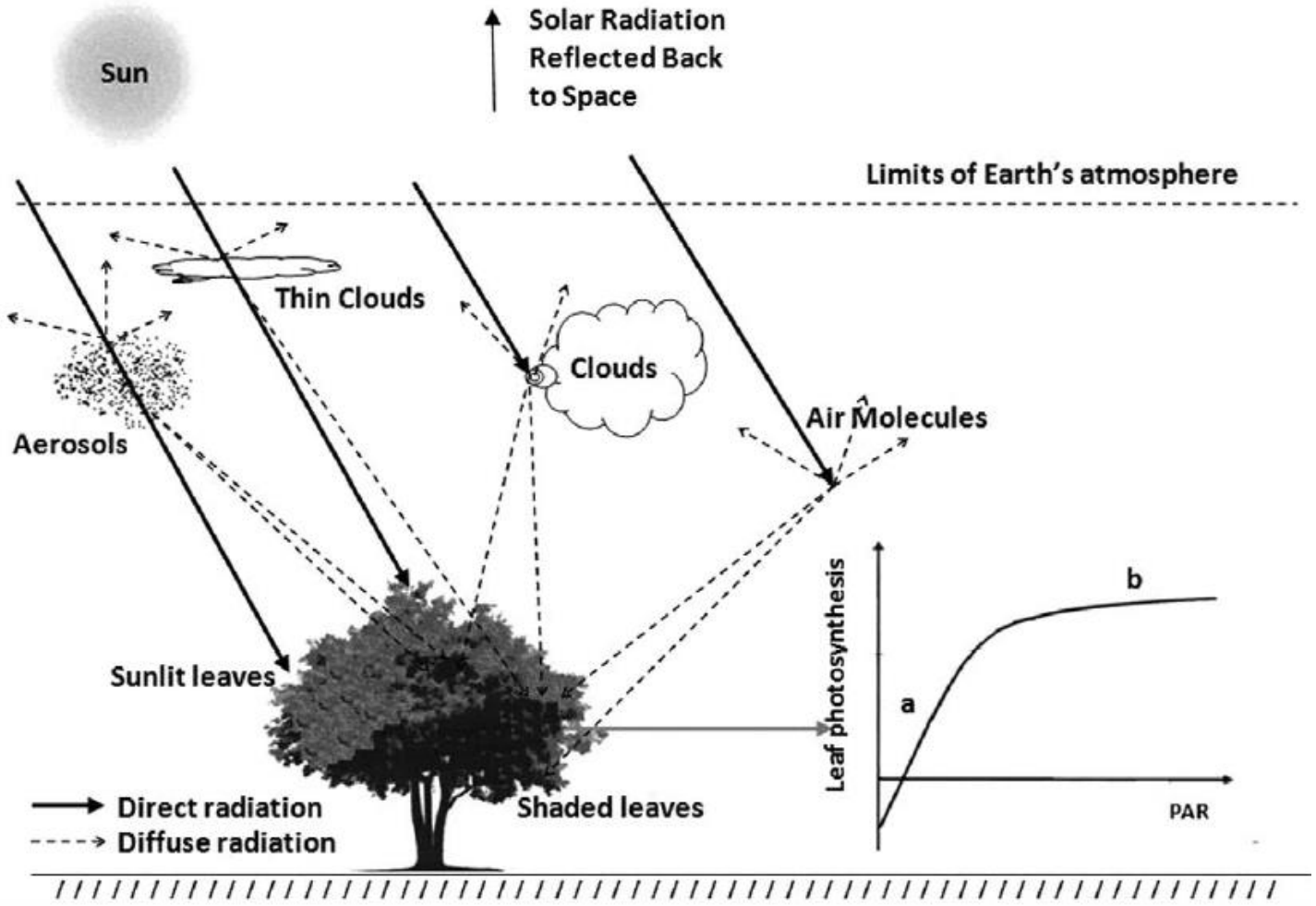
PEATLANDS

- Peatlands cover only **3% of terrestrial area but maintain 30% global soil carbon**
- Complex ecosystem, rich in biodiversity and **directly dependent on water** conditions
- The temperature increase and the water balance disturbances determined by human activity may convert these ecosystems into **net sources of atmospheric carbon**
- **Diffuse radiation impact?**

DIRECT AND DIFFUSED RADIATION



Kasturi Devi Kanniah et al. 2012

RADIATION SCATTERING

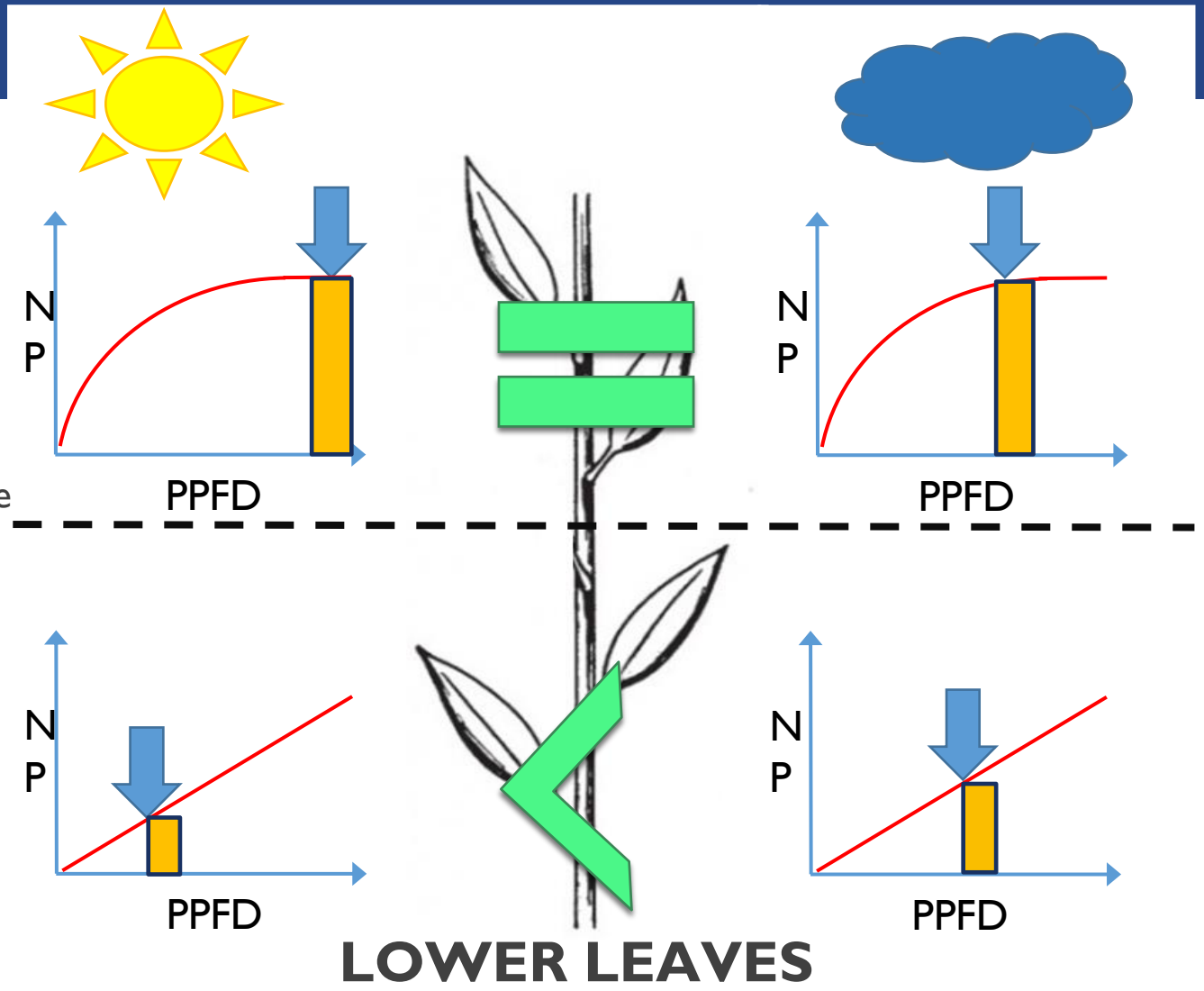
DIRECT
RADIATION

DIFFSED
RADIATION

LOWER LEAVES ACTIVATION

NP – leave net CO_2 exchange

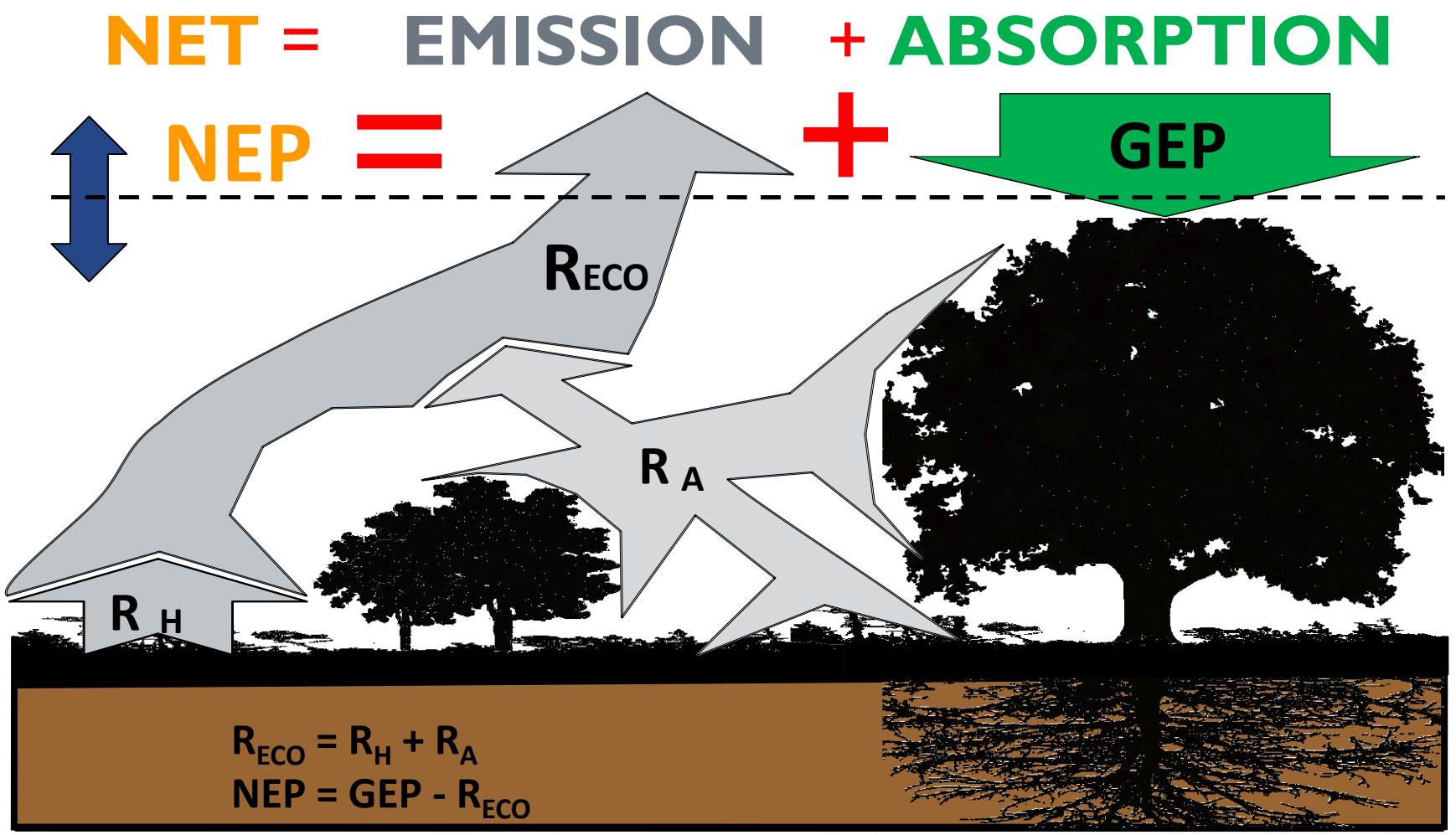
PPFD – photosynthetically active photon flux density



RADIATIVE TRANSFER IN THE ATMOSPHERE AND ECOSYSTEM PRODUCTION

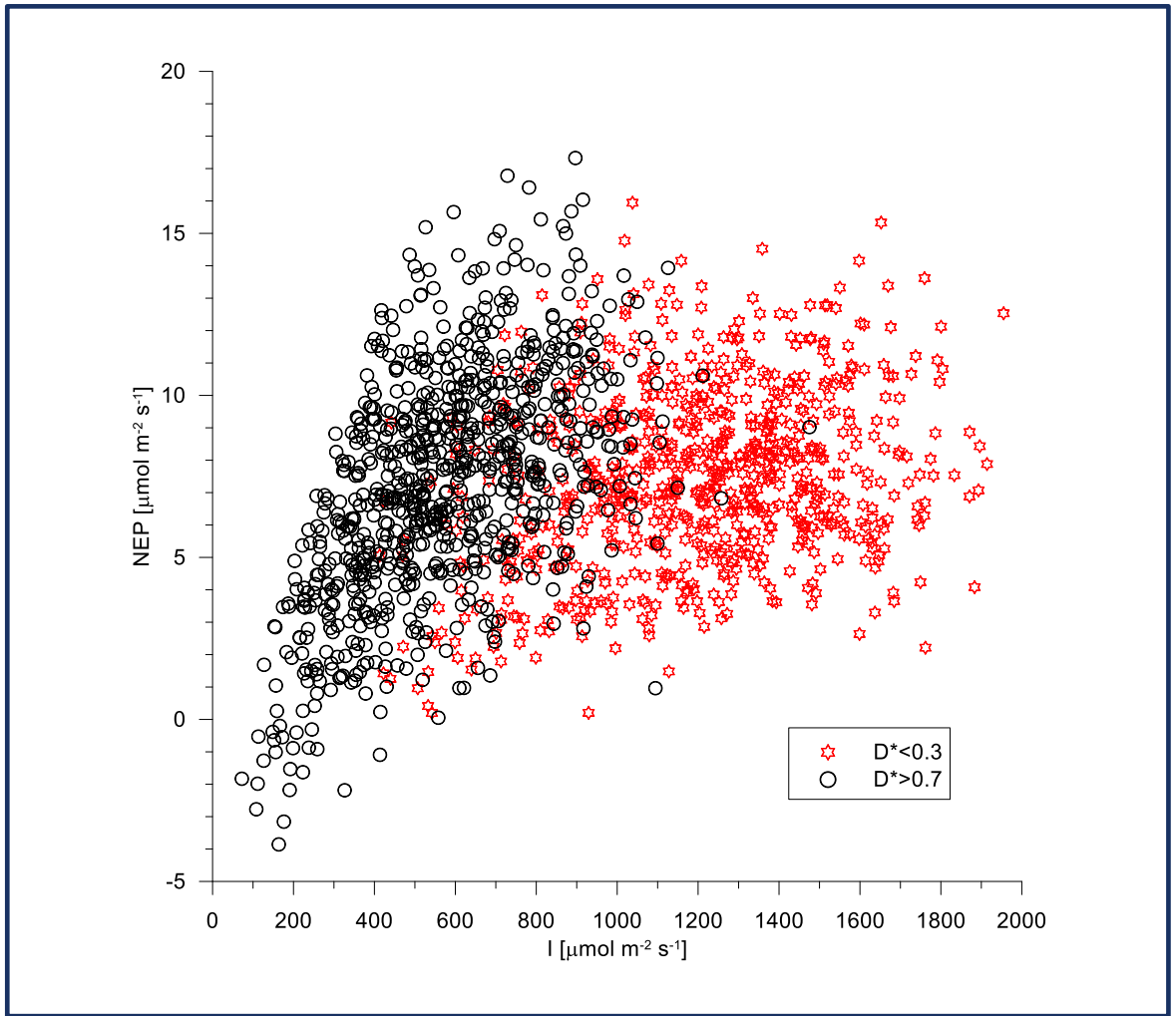
- **SCATERING** ***increases*** the ecosystem's CO_2 absorption capacity
- **ATTENUATION** ***reduces*** the ecosystem's CO_2 absorption capacity

ECOSYSTEM CO_2 BALANCE



Net Ecosystem Production (NEP) vs. Photosynthetically Active Photon Flux Density (I)

red stars – cloudless conditions
black circles – cloudy conditions



MEASURING SITE

- PolWET site located in Rzecin village (52°45'N, 16°18'E, ca. 54 m a.s.l.)

SITE DESCRIPTION

- The Rzecin peatland is classified as a transitional peatland
- P = 550mm,
- Tair = 8.2 °C

RZECIN POLWET STATION

Photometer CIMEL

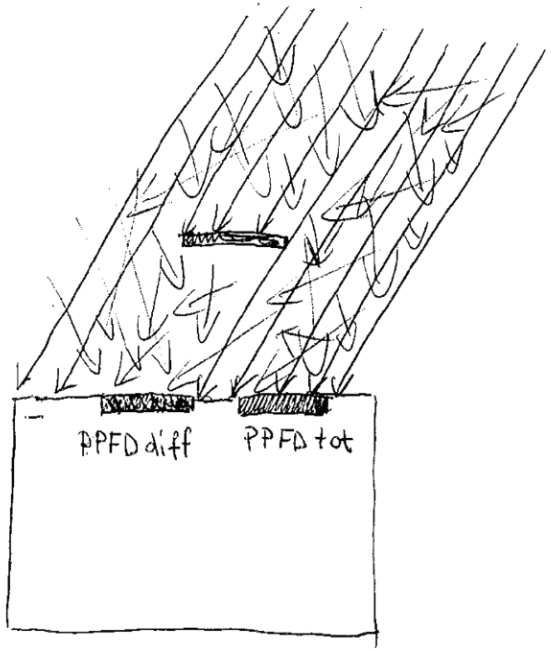
Sunshine sensor BF5

Eddy Covariance system

DIFFUSION INDEX (DI)

$$DI = I_{diff} / I_{tot}$$

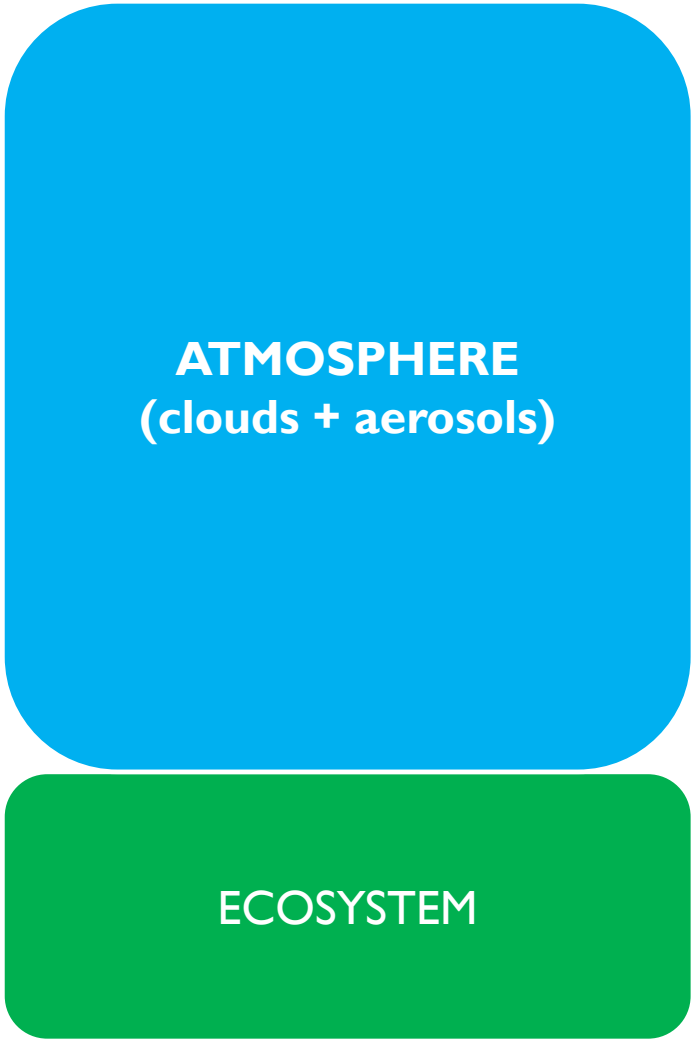
I_{diff} – diffused PAR
I_{tot} – total PAR



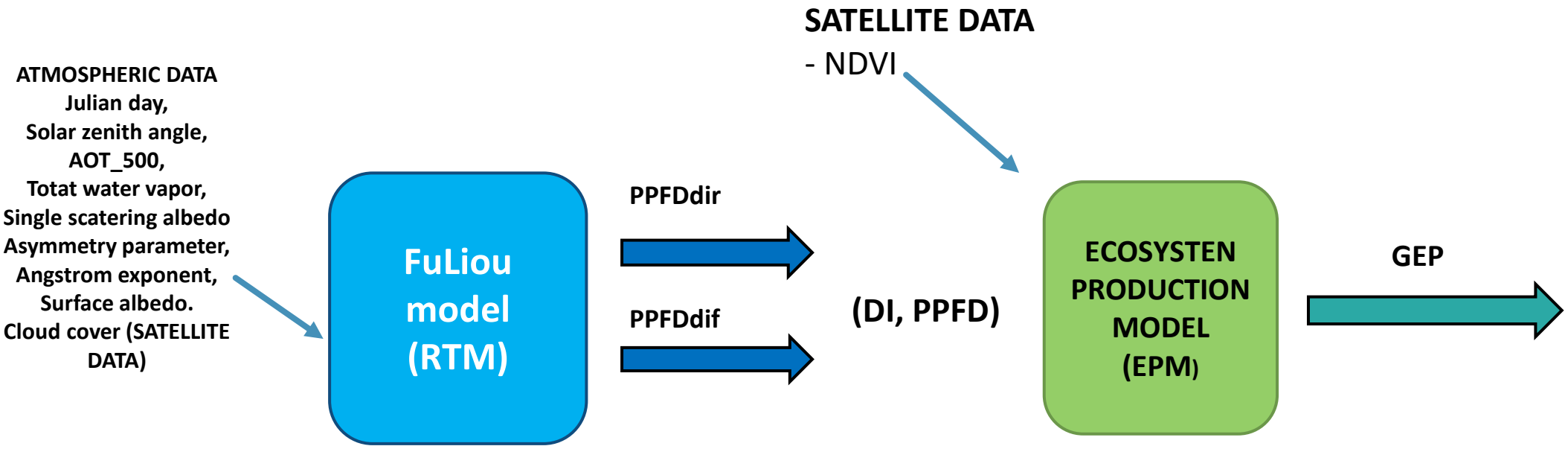
COMPLEX MODEL CONCEPT

The assessment of the ecosystem's response to the optical parameters changes has been made using a parallel application of two models:

1. Radiative Transfer Model (RTM)
2. Ecosystem Production Model (EPM)



MODELS STRUCTURE



Fu, Q., and K.-N. Liou, 1992: On the correlated k-distribution method for radiative transfer in nonhomogenous atmospheres. J. Atmos. Sci., 49, 2139–2156.

DATA SET

Period : May 20, 2018- September 30,2018

Flux data

1. GEP-Gross Ecosystem Production

Meteorological data

1. TA – air temperature
2. VPD – vapor pressure deficit
3. DI – diffusion index

Satellite data

1. NDVI – normalized difference vegetation index
2. CC – cloud cover fraction

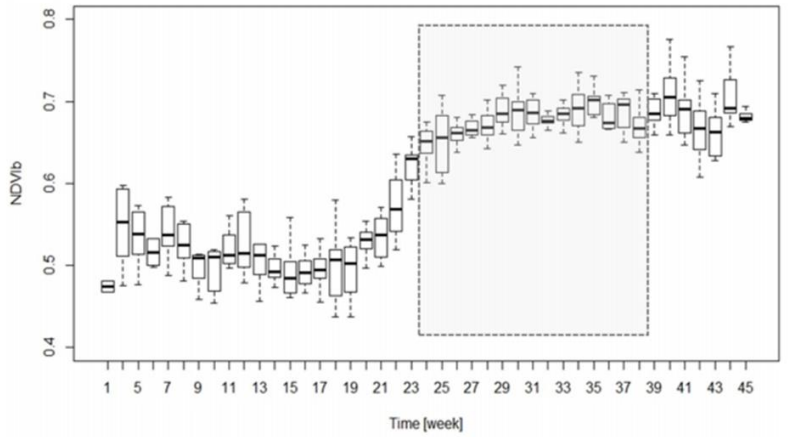


Figure 3. The seasonal run of weekly populations of broad–band normalized difference vegetation index (NDVIb) collected at Rzecin peatland in 2016. The grey rectangle indicates the extracted period (weeks 24–38). Error bars indicate minimum and maximum values, the top of the boxes shows 25th percentile and the bottom 75th percentile, and horizontal line is median value.

DI ESTIMATION - RADIATIVE TRANSFER MODEL (RTM)

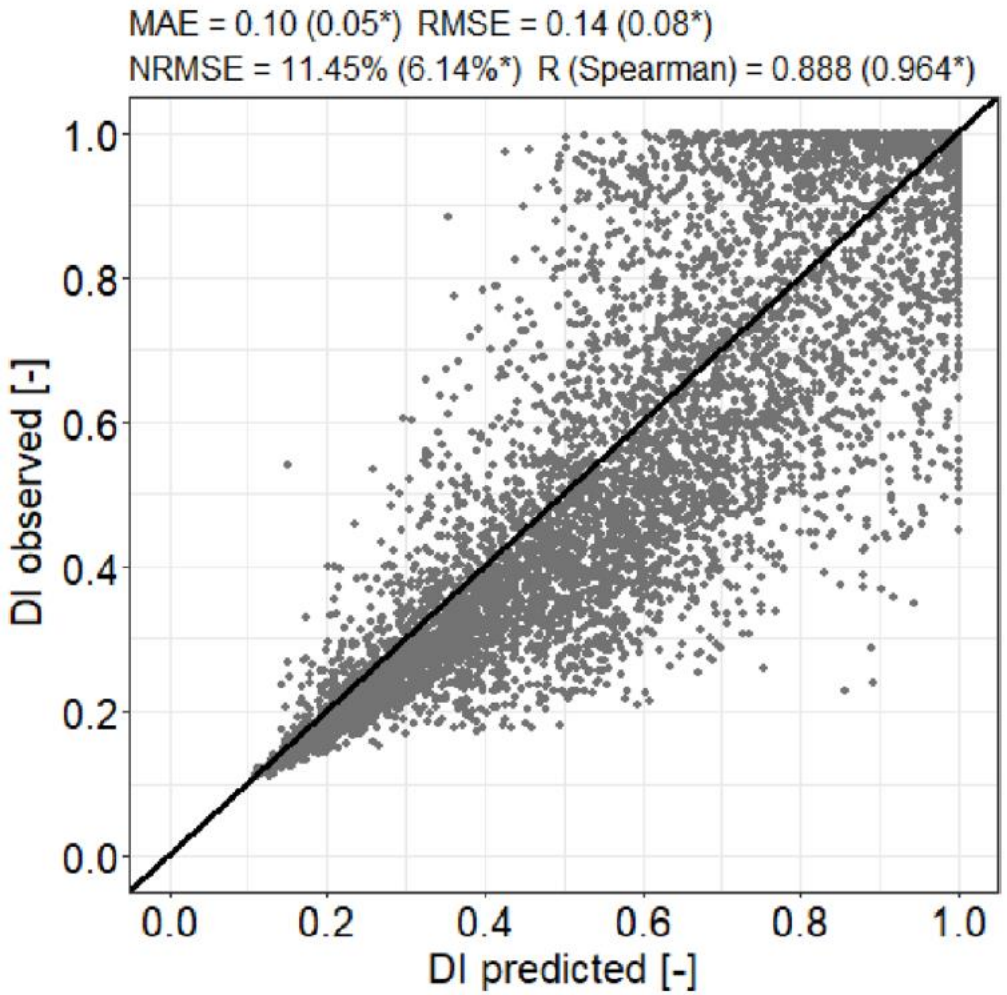
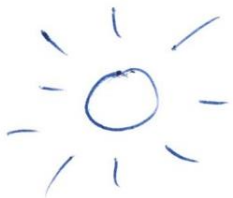


Figure 1. Predicted versus observed diffusion index (DI) values

DIFFUSE RADIATION REGIMES – EPM MODEL DEVELOPMENT

'SUNNY'

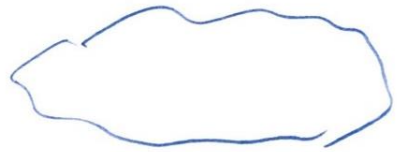


DI = 0.0 - 0.3

'INTERMEDIATE'

DI = 0.3 - 0.8

'CLOUDY'



DI = 0.8 - 1.0

JULY

$GEP = (Vmax \cdot PPFD) / (Km + PPFD)$

DI = 0.0 - 0.3

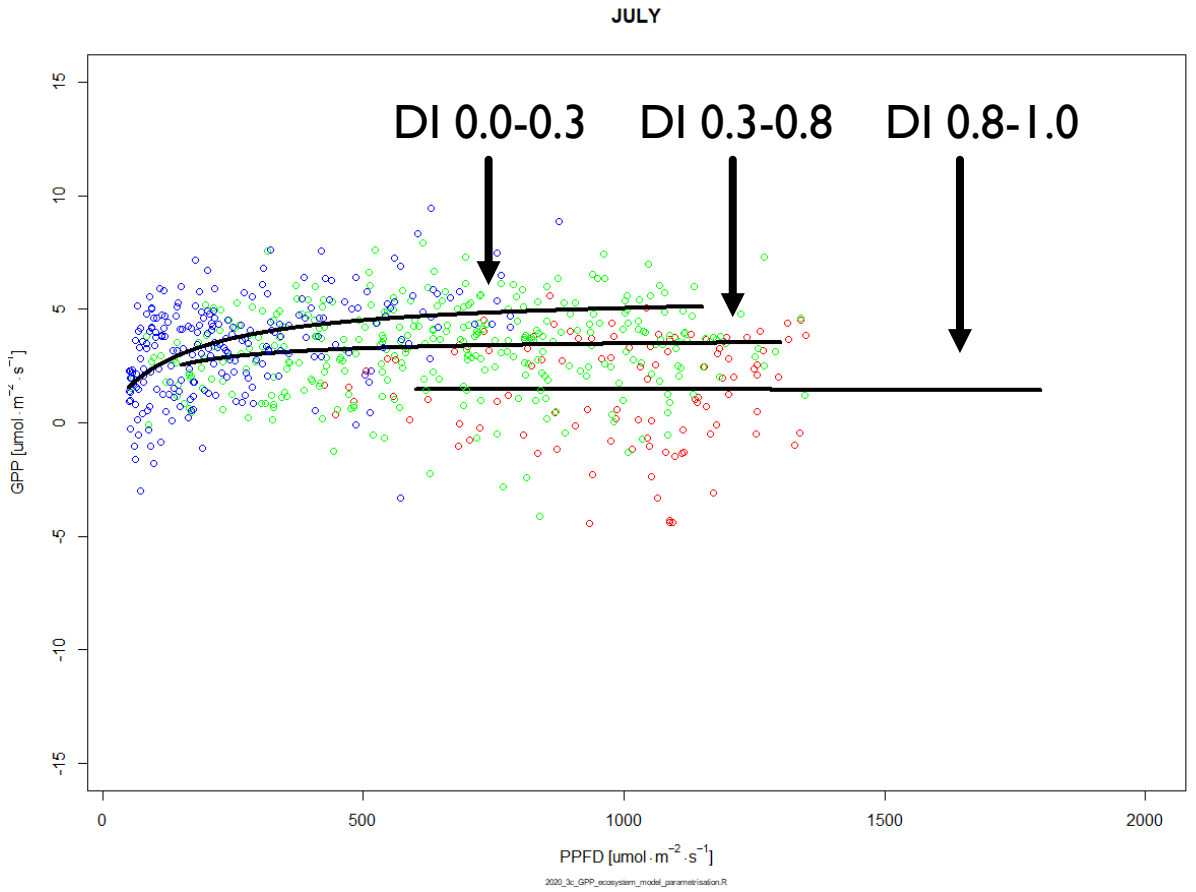
	Estimate	Std. Error	t value	Pr(>|t|)	
Vmax	-8.659	0.776	-11.159	<2e-16	***
Km	321.672	132.068	2.436	0.0158	*

DI = 0.3 - 0.8

	Estimate	Std. Error	t value	Pr(>|t|)	
Vmax	-12.6667	0.9308	-13.608	< 2e-16	***
Km	526.9796	99.1510	5.315	1.67e-07	***

DI = 0.8 – 1.0

	Estimate	Std. Error	t value	Pr(>|t|)	
Vmax	-15.691	1.327	-11.825	< 2e-16	***
Km	389.641	67.075	5.809	1.93e-08	***



$GEP = (VMAX \cdot PPFD) / (KM + PPFD)$

$$Vmax = A*NDVI + B*DI + C$$

$$Km = A*NDVI + B*DI + C$$

Table 2. Parameters values and statistics

Parameter	A	B	C	R^2
Km	245.7 **	487.5 **	-1868.3 **	0.622
Vmax	-6,643 ***	-10.4 ***	45.4 ***	0.933

GEP SIMULATIONS

Gross Ecosystem Production (GEP) simulations were carried out according to following assumptions**:**

1. reference conditions
2. AOT +0.05
3. AOT +0.10
4. AOT +0.15
5. AOT +0.20
6. SSA = 0.8
7. SSA = 1.0

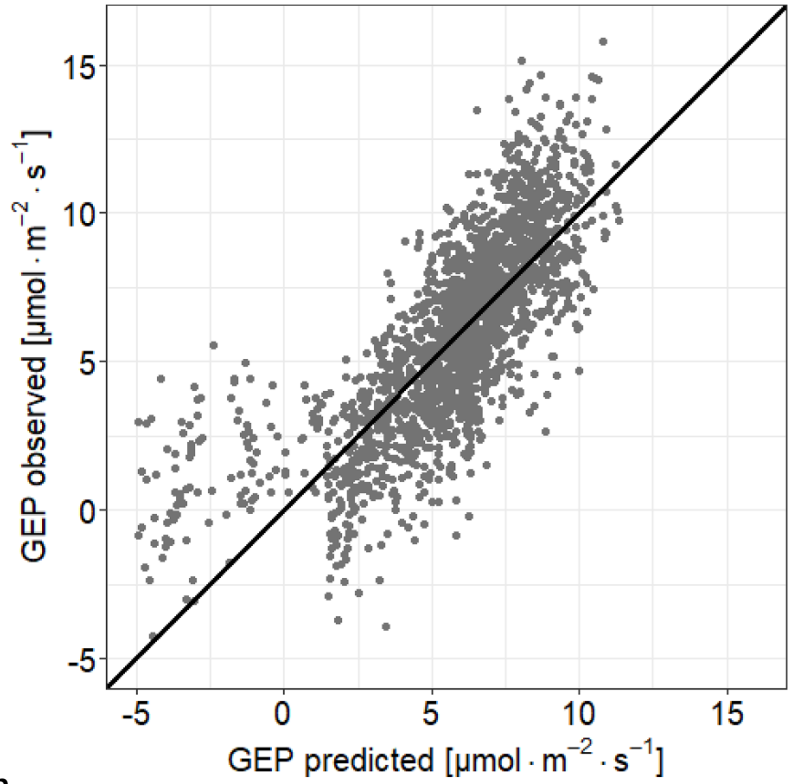


Figure 3. Predicted vs. observed Gross Ecosystem Production (GEP) values

RESULTS

Table 2
The monthly values of GEP (μmol CO_2•m^{-2}•s^{-1}), PPFD (μmol•m^{-2}•s^{-1}), DI (dimensionless), NDVI (dimensionless) as estimated for different optical properties of the atmosphere for increasing aerosol optical depth (ΔAOD), non-absorbing and absorbing aerosol for different single scattering albedo (SSA) during growing season of 1st May – 30th September of 2018 at Rzecin peatland. Note that: * denotes% of relative changes of estimated values and ** denotes% of relative changes calculated for AOD (dimensionless) change in a given range.

		ΔAOD observed SSA					**SSA observed AOD**		**NDVI**
		real AOD	**+0.05**	**+0.1**	**+0.15**	**+0.2**	**1.0**	**0.8**	**Mean**
MAY	**GEP**	**5.52**	**5.73 (3.8%)****	**5.92 (7.2%)****	**6.08 (10.1%)****	**6.22 (12.7%)****	**5.59 (1.3%)***	**5.28 (−7.9%)***	0.711
	PPFD	1018	1005 (−1.3%)**	992 (−2.6%)**	979 (−3.8%)**	967 (−5.0%)**	1033 (1.5%)*	966 (−3.8%)*	
	DI	0.51	0.55 (7.8%)**	0.58 (13.7%)**	0.61 (19.6%)**	0.64 (25.5%)**	0.52 (2.0%)*	0.49 (−10.9%)*	
JUN	**GEP**	**8.03**	**8.13 (1.2%)****	**8.22 (2.4%)****	**8.30 (3.4%)****	**8.37 (4.2%)****	**8.05 (0.2%)***	**7.79 (−4.2%)***	0.774
	PPFD	956	947 (−0.9%)**	937 (−2.0%)**	928 (−2.9%)**	918 (−4.0%)**	961 (0.5%)*	912 (−3.7%)*	
	DI	0.6	0.63 (5.0%)**	0.66 (10.0%)**	0.69 (15.0%)**	0.71 (18.3%)**	0.6 (0.0%)*	0.58 (−7.9%)*	
JUL	**GEP**	**7.18**	**7.33 (2.1%)****	**7.45 (3.8%)****	**7.57 (5.4%)****	**7.66 (6.7%)****	**7.21 (0.4%)***	**6.98 (−4.8%)***	0.749
	PPFD	979	968 (−1.1%)**	957 (−2.2%)**	947 (−3.3%)**	937 (−4.4%)**	986 (0.7%)*	938 (−3.1%)*	
	DI	0.54	0.58 (7.4%)**	0.61 (13.0%)**	0.64 (18.5%)**	0.67 (24.1%)**	0.55 (1.9%)*	0.52 (−10.3%)*	
AUG	**GEP**	**6.22**	**6.39 (2.7%)****	**6.54 (5.1%)****	**6.66 (7.1%)****	**6.77 (8.8%)****	**6.26 (0.6%)***	**5.94 (−7.0%)***	0.717
	PPFD	929	918 (−1.2%)**	907 (−2.4%)**	896 (−3.6%)**	886 (−4.6%)**	938 (0.9%)*	868 (−5.4%)*	
	DI	0.57	0.61 (7.0%)**	0.64 (12.3%)**	0.67 (17.5%)**	0.7 (22.8%)**	0.58 (1.8%)*	0.55 (−9.8%)*	
SEP	**GEP**	**5.13**	**5.31 (3.5%)****	**5.45 (6.3%)****	**5.57 (8.6%)****	**5.68 (10.7%)****	**5.17 (0.7%)***	**4.91 (−7.5%)***	0.649
	PPFD	708	698 (−1.4%)**	689 (−2.7%)**	679 (−4.1%)**	670 (−5.4%)**	714 (0.8%)*	671 (−3.8%)*	
	DI	0.63	0.67 (6.3%)**	0.7 (11.1%)**	0.73 (15.9%)**	0.75 (19.0%)**	0.63 (0.0%)*	0.61 (−9.0%)*	
AVG	**GEP**	**6.42**	**6.58 (2.5%)****	**6.72 (4.7%)****	**6.84 (6.5%)****	**6.94 (8.2%)****	**6.46 (0.6%)***	**6.18 (−6.0%)***	0.718
	PPFD	918	907 (−1.2%)**	896 (−2.4%)**	886 (−3.5%)**	876 (−4.6%)**	926 (0.9%)*	871 (−4.0%)*	
	DI	0.57	0.61 (7.0%)**	0.64 (12.3%)**	0.67 (17.5%)**	0.69 (21.8%)**	0.58 (1.1%)*	0.55 (−9.5%)*	

SUMMARY

- AOD increase of 0.20 relative to reference conditions resulted in an increase of GEP by 8.2% during the growing season
- SSA increase from reference level 0.96 to 1.0 resulted in a negligible increase in GEP (0.6%)
- SSA reduction from the reference level (0.96) to 0.8 resulted in a reduction of peatland GEP by 6.0%
- The AOD decrease observed over Poland will result in a reduction in the CO_2 absorption capacity of peatlands in the future

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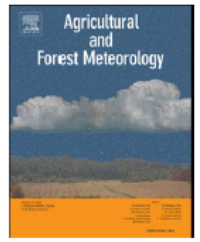

Check for updates

Estimation of the effects of aerosol optical properties on peatland production in Rzecin, Poland

Kamila M. Harenda [a,*], Krzysztof M. Markowicz [b], Patryk Poczta [a,c], Iwona S. Stachlewska [b], Jędrzej S. Bojanowski [d], Bartosz Czernecki [e], Alasdair McArthur [f], Dirk Schütemeyer [g], Bogdan H. Chojnicki [a]

[a] Laboratory of Bioclimatology, Department of Ecology and Environmental Protection, Faculty of Environmental and Mechanical Engineering, Poznan University of Life Sciences, Poznan 60-649, Poland
[b] Faculty of Physics, Institute of Geophysics, University of Warsaw, Warsaw 02-093, Poland
[c] Department of Grassland and Natural Landscape Sciences, Faculty of Agronomy, Horticulture and Bioengineering, Poznan University of Life Sciences, Poznan 60-632, Poland
[d] Remote Sensing Centre, Institute of Geodesy and Cartography, Warsaw 02-679, Poland
[e] Department of Meteorology and Climatology, Faculty of Geographical and Geological Sciences, Adam Mickiewicz University, Poznan 61-680, Poland
[f] School of Geosciences, University of Edinburgh, Grant Institute, James Hutton Road, King's Buildings, Edinburgh EH9 3FE, UK
[g] European Space Research and Technology Centre, European Space Agency (ESA), Noordwijk 2201, The Netherlands

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