

***Badania wymiany  
ciepła i masy  
między ekosystemami a  
atmosferą.***

***Bogdan H. Chojnicki***

***Katedra Meteorologii  
UP w Poznaniu***

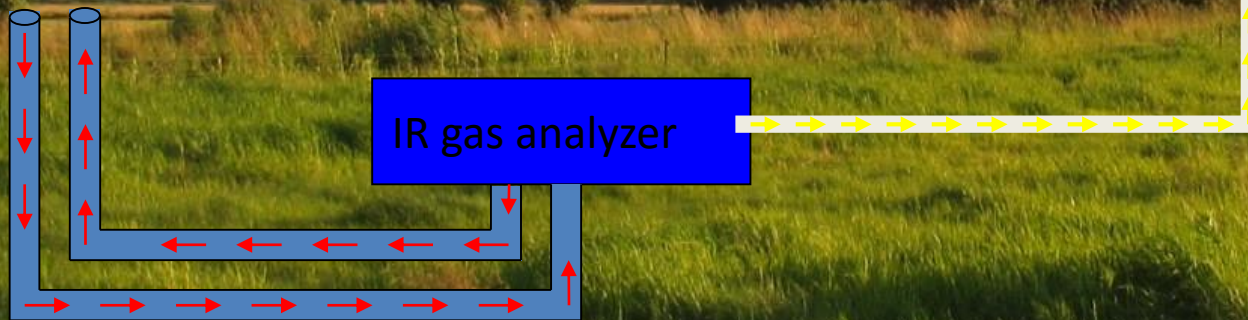
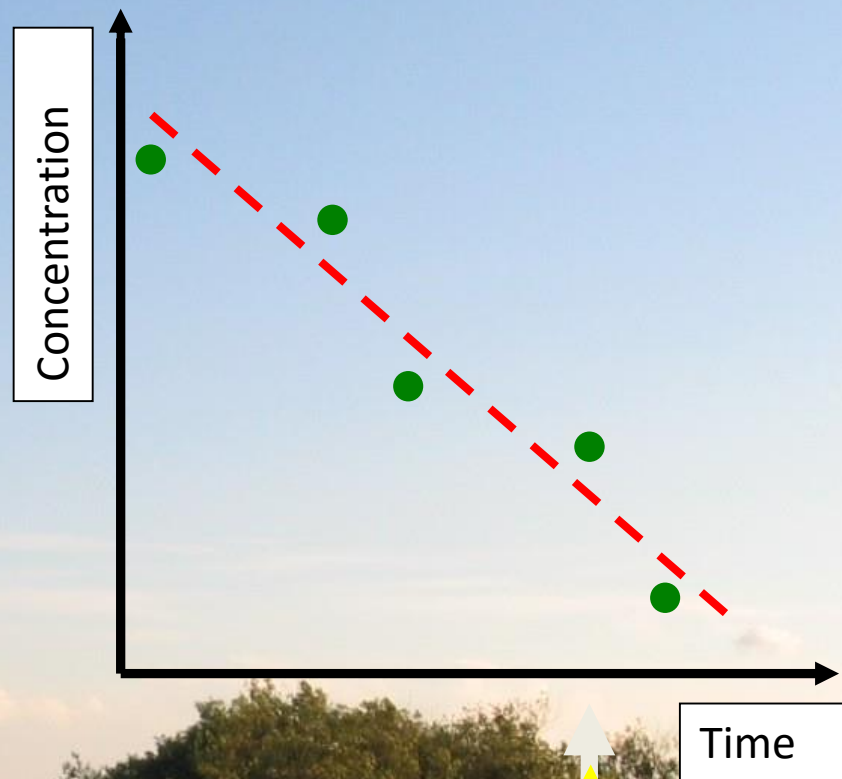
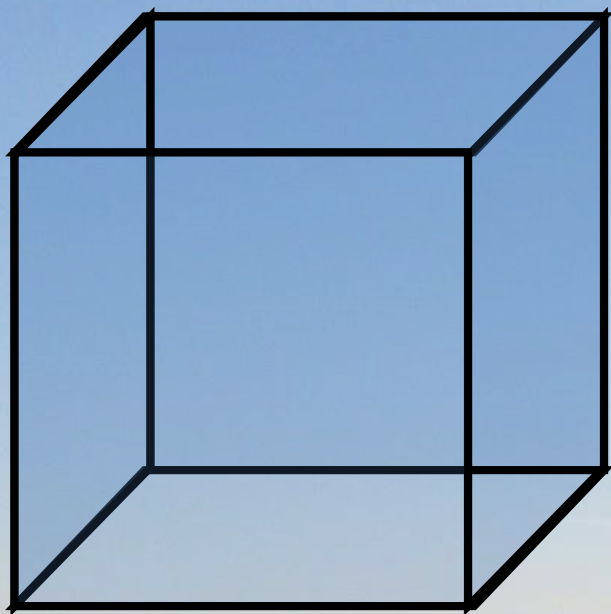


# Metoda komorowa





# Determination of net CO<sub>2</sub> fluxes: chamber system



$$F_{CO_2} = \frac{MPV\delta v f_1}{RTt}$$

$F_{CO_2}$  - CO<sub>2</sub> flux density [ $\mu\text{g}\cdot\text{CO}_2\text{-C}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ ],

$M$  - the molar mass [ $\text{g}\cdot\text{mol}^{-1}$ ] of CO<sub>2</sub>,

$P$  - atmospheric pressure [Pa],

$\delta v$  - concentration changes inside the chamber over time [ppm(v)·h<sup>-1</sup>],

$V$  - a total volume of chamber with installed collar [m<sup>3</sup>],

$f_1$  - the factor used for calculation of C atoms in CO<sub>2</sub> (12g/44g),

$R$  - gas constant [m<sup>3</sup>·Pa·K<sup>-1</sup>·mol<sup>-1</sup>],

$T$  - air temperature inside the chamber [K],

$t$  - closure time [h].



# Metoda kowariancji wirów



## Gęstość strumienia wielkości skalarnej.

$$F_c = \overline{\omega \cdot \rho_c} \quad (\text{Swinbank 1951}) \quad 1.$$

Gdzie:

$F_c$  - gęstością strumienia wielkości skalarnej,

$\omega$  - jest składową pionową prędkości wiatru,

$\rho_c$  - jest gęstością (lub stężeniem) transportowanej substancji

$$\omega = \overline{\omega} + \omega' \quad 2.$$

$$\rho_c = \overline{\rho_c} + \rho_c' \quad 3.$$

gdzie znak ` oznacza fluktuacje wokół średniej.

$$F_c = \overline{(\overline{\omega} + \overline{\omega}') \cdot (\overline{\rho_c} + \overline{\rho_c'})} =$$

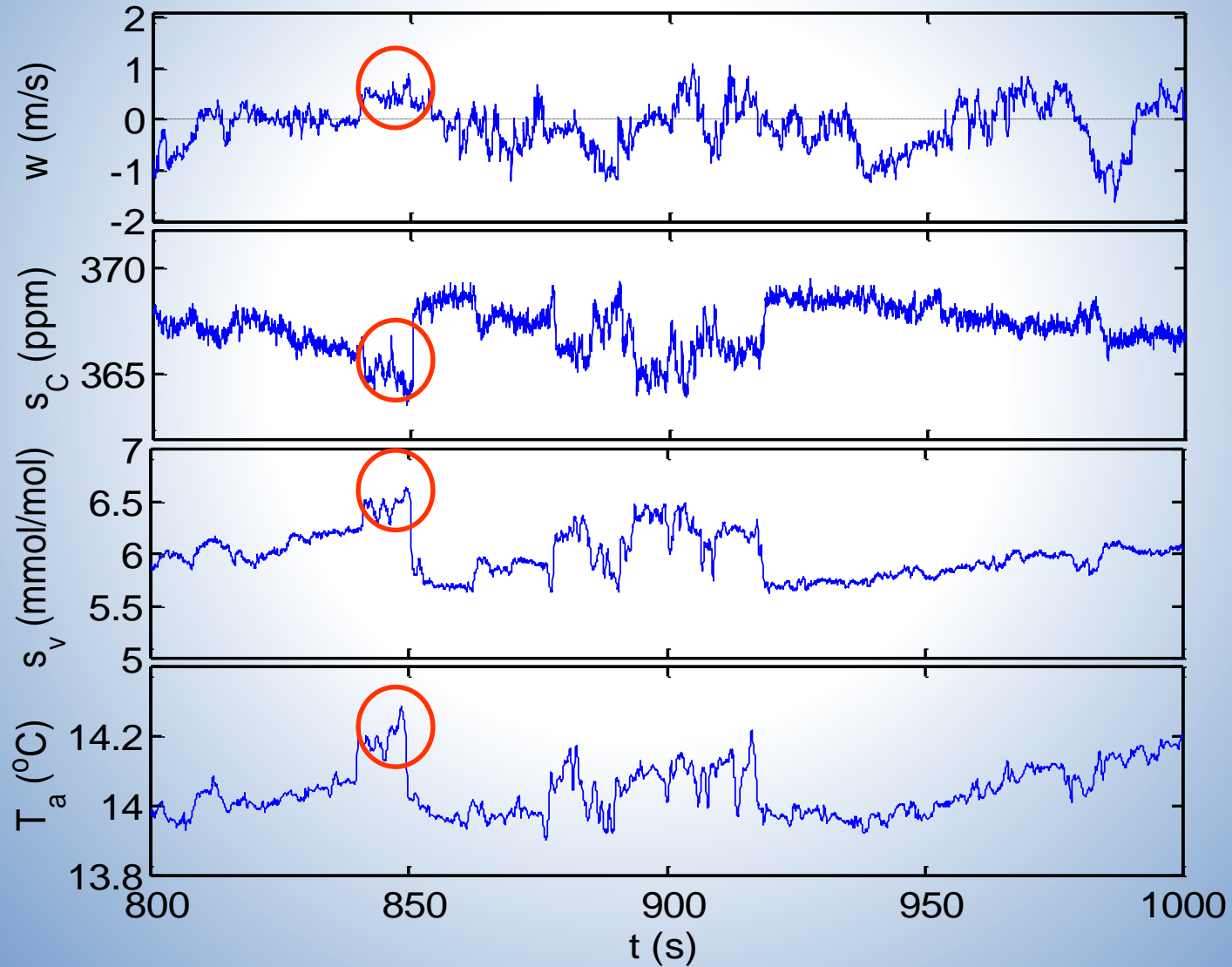
$$= \overline{\overline{\omega} \cdot \overline{\rho_c}} + \overline{\overline{\omega} \cdot \overline{\rho_c'}} + \overline{\overline{\omega}' \cdot \overline{\rho_c}} + \overline{\overline{\omega}' \cdot \overline{\rho_c'}} \quad 4.$$

$$F_c = \overline{\overline{\omega} \cdot \overline{\rho_c}} + \overline{\overline{\omega} \cdot \overline{\rho_c'}} + \overline{\overline{\omega}' \cdot \overline{\rho_c}} + \overline{\overline{\omega}' \cdot \overline{\rho_c'}} \quad 4a.$$

$$F_c = \overline{\overline{\omega}' \cdot \overline{\rho_c'}} \quad 5.$$



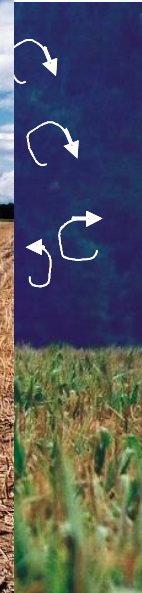
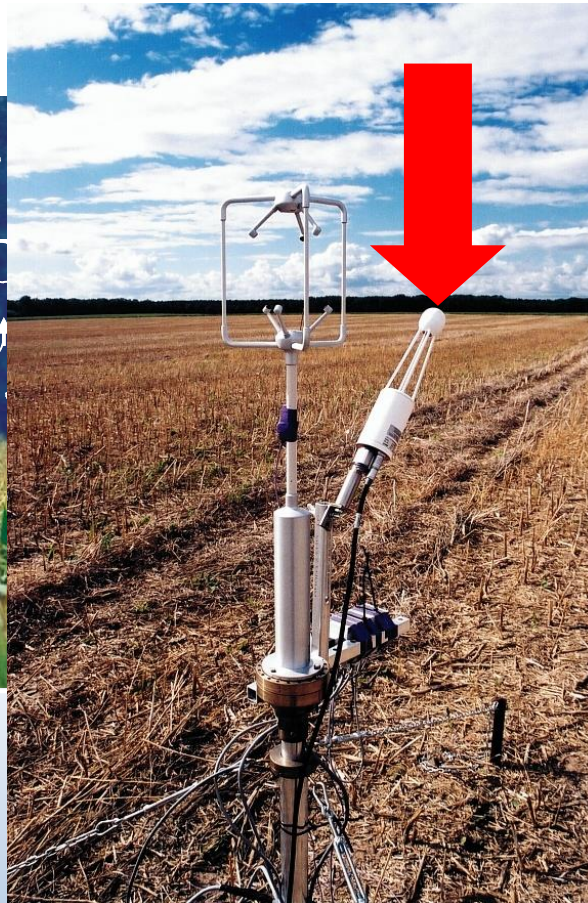
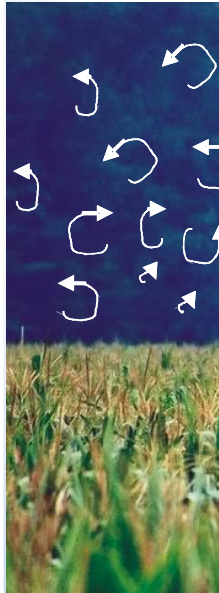
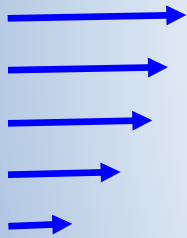
# Zależności między seriami pomiarowymi



# Metodyka badań

- Pionowy strumień wielkości skalarnej – kowariancja pomiędzy składową pionową ruchu powietrza a wartościami wielkości skalarnej
- Wymiana masy i energii pomiędzy podłożem a atmosferą odbywa się głównie dzięki turbulencji (wiry).
- Metoda opiera się na pomiarze składowej pionowej ruchu powietrza oraz innej wielkości skalarnej, której strumień jest badany.

Prędkość wiatru



Powierzchnia czynna



# Wieża EC



2002. 6. 18 12:31



06.6.02

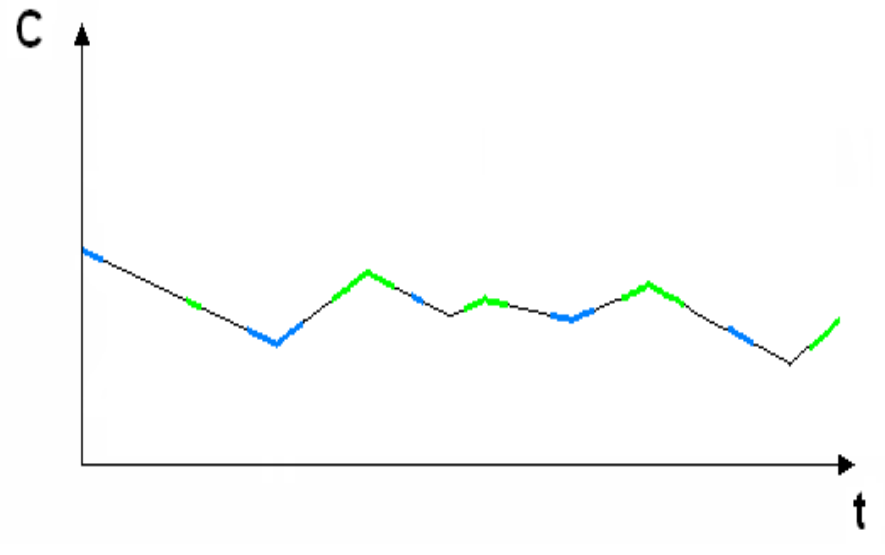
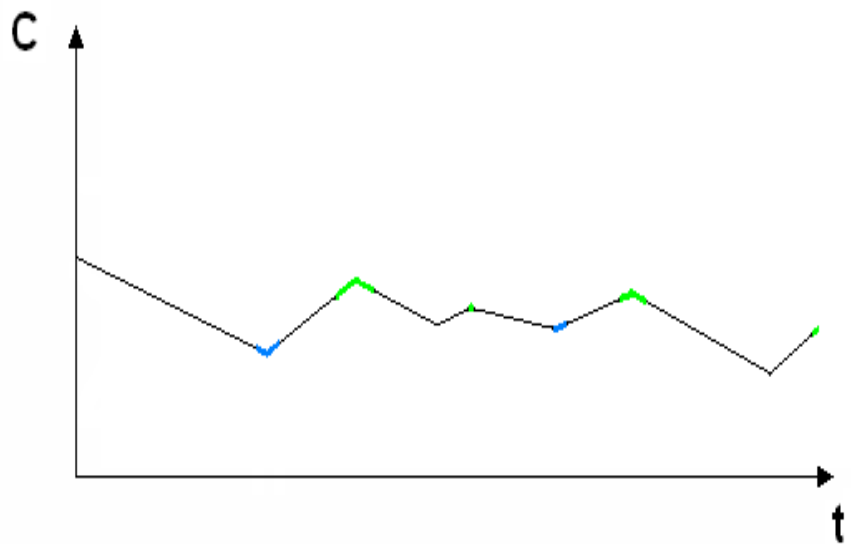
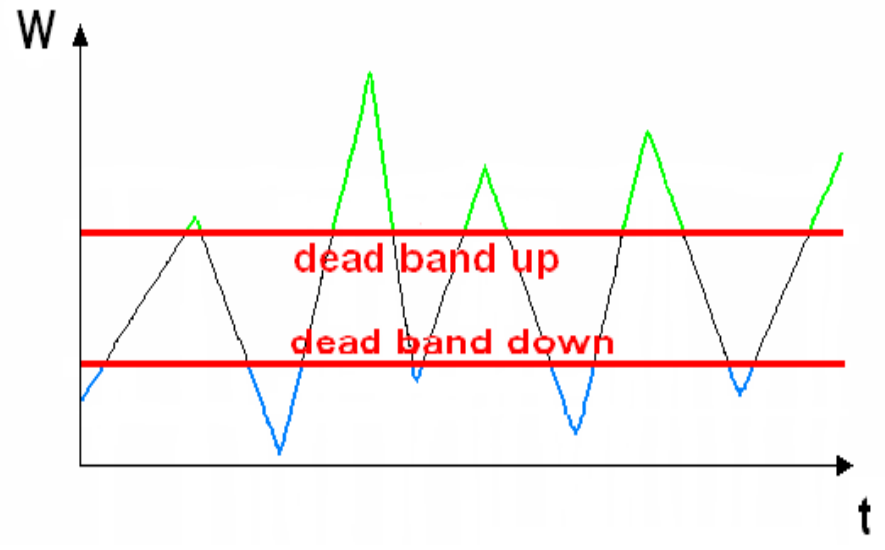
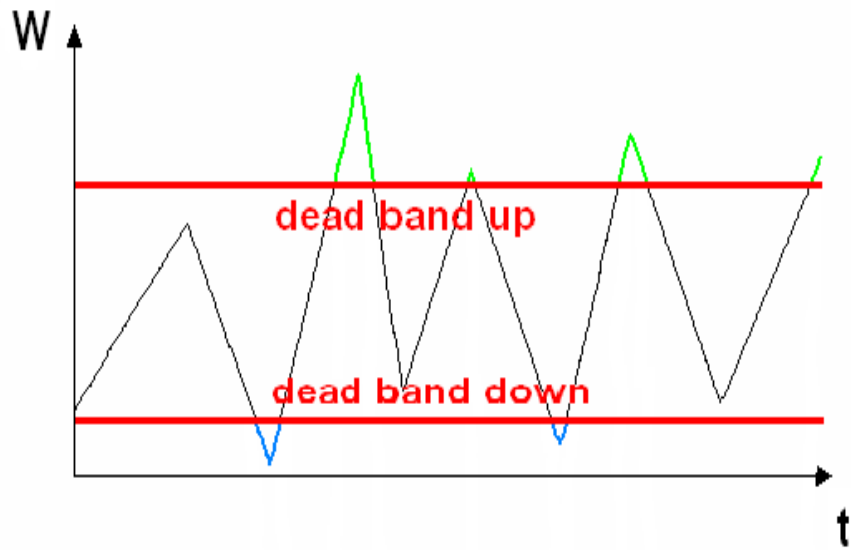


# Metoda akumulacji wirów

## *Relaxed Eddy Accumulation (REA)*

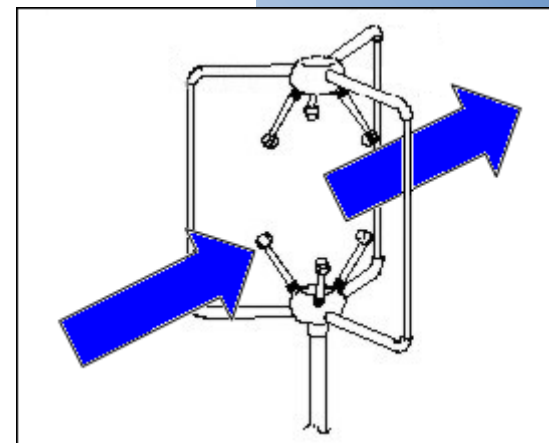
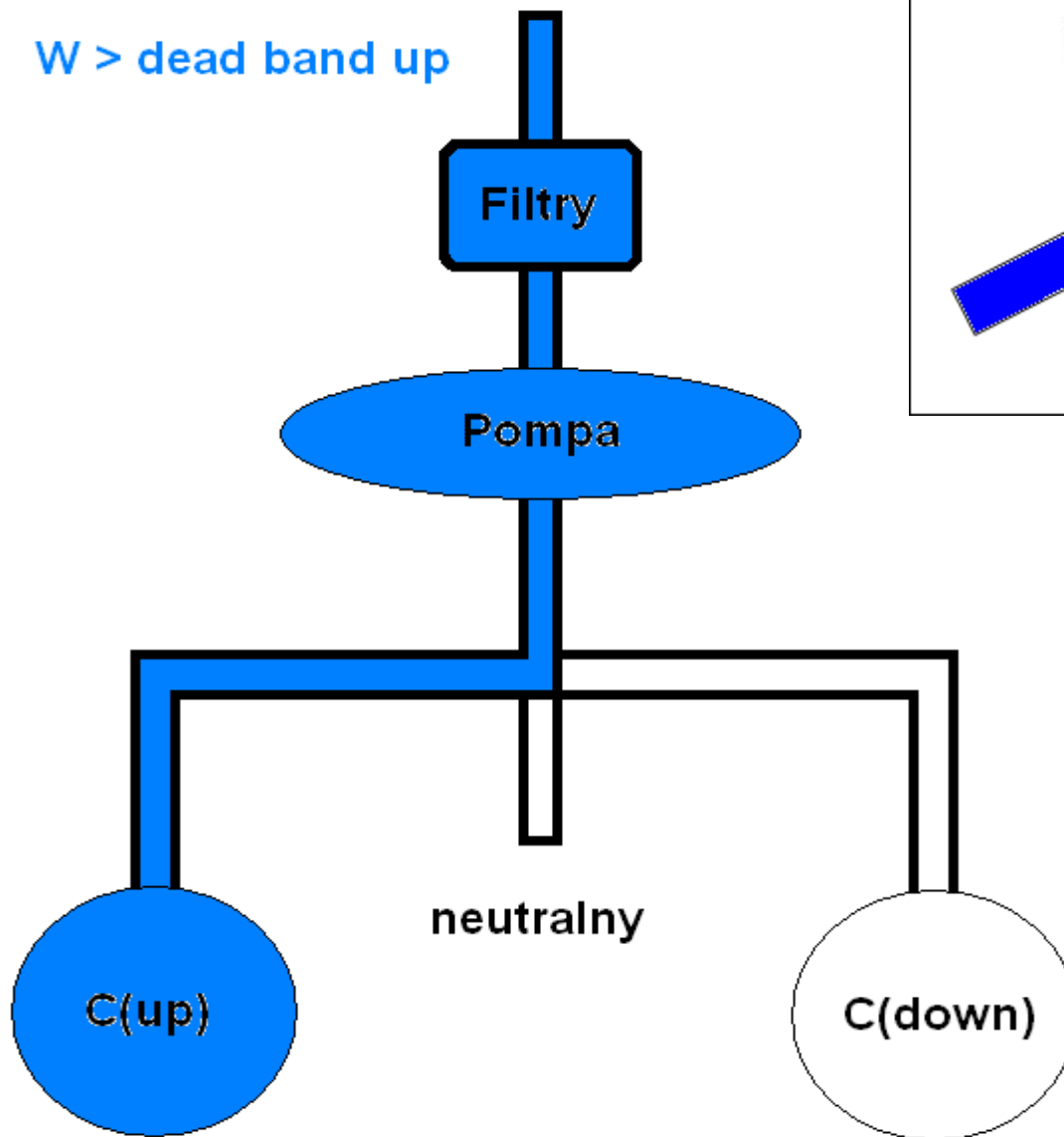


# Dead band



# REA – konstrukcja i działanie

$W > \text{dead band up}$





Wzór na dowolny pionowy strumień  
wartości skalarnej:

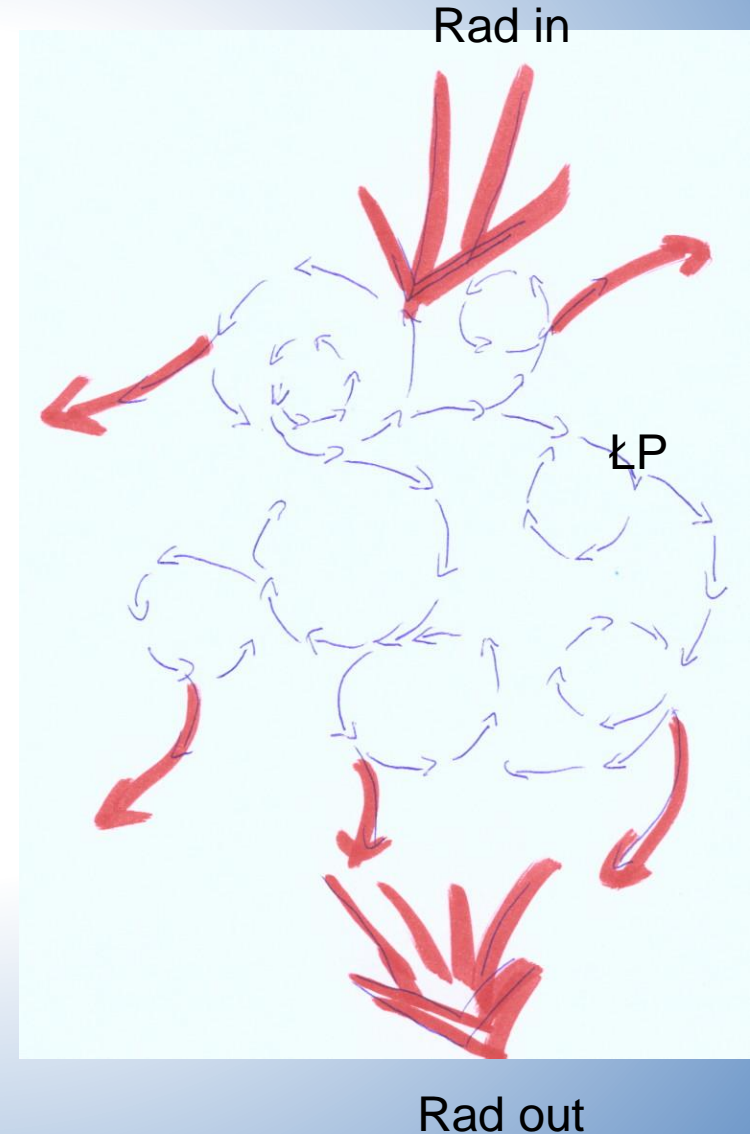
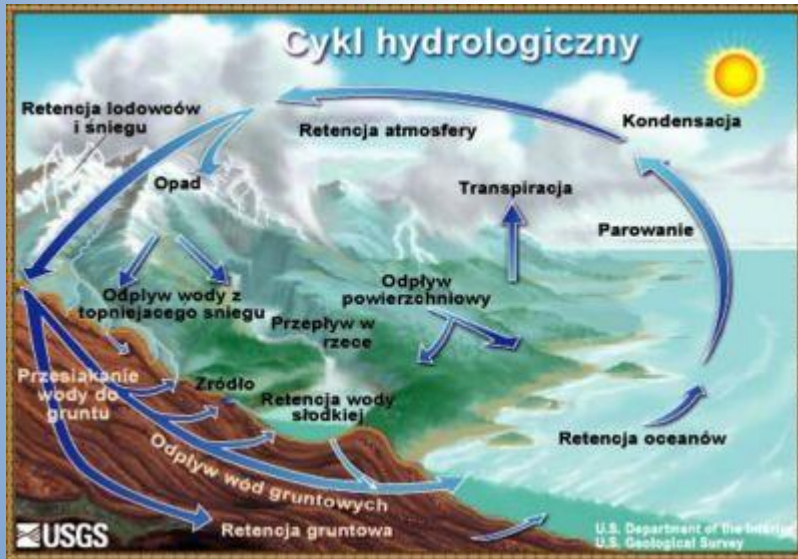
$$F = \overline{w'c'} = \beta \sigma_w (\overline{c_{up}} - \overline{c_{down}})$$

Businger & Oncley (1990)

Po co to wszystko?

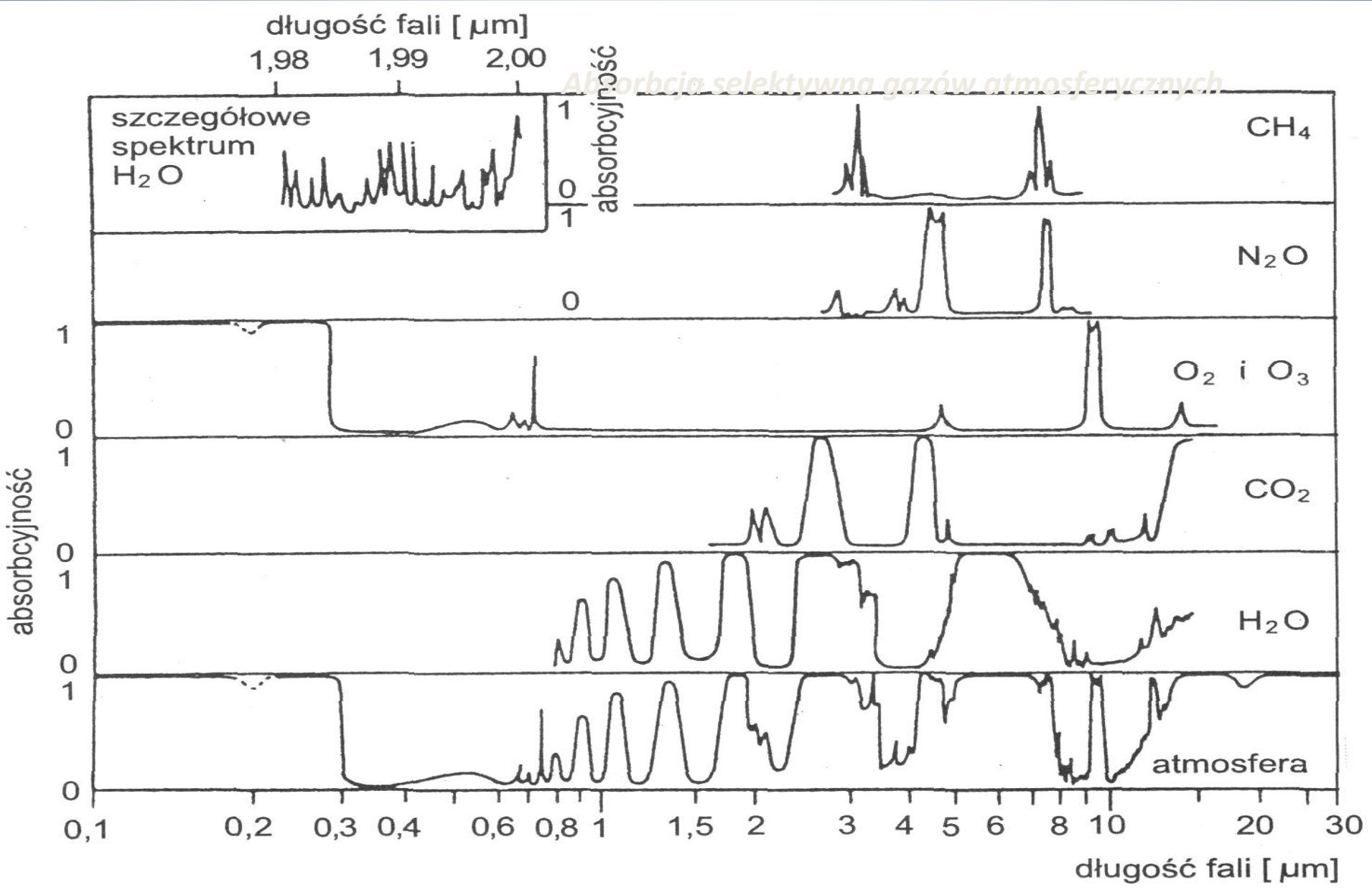


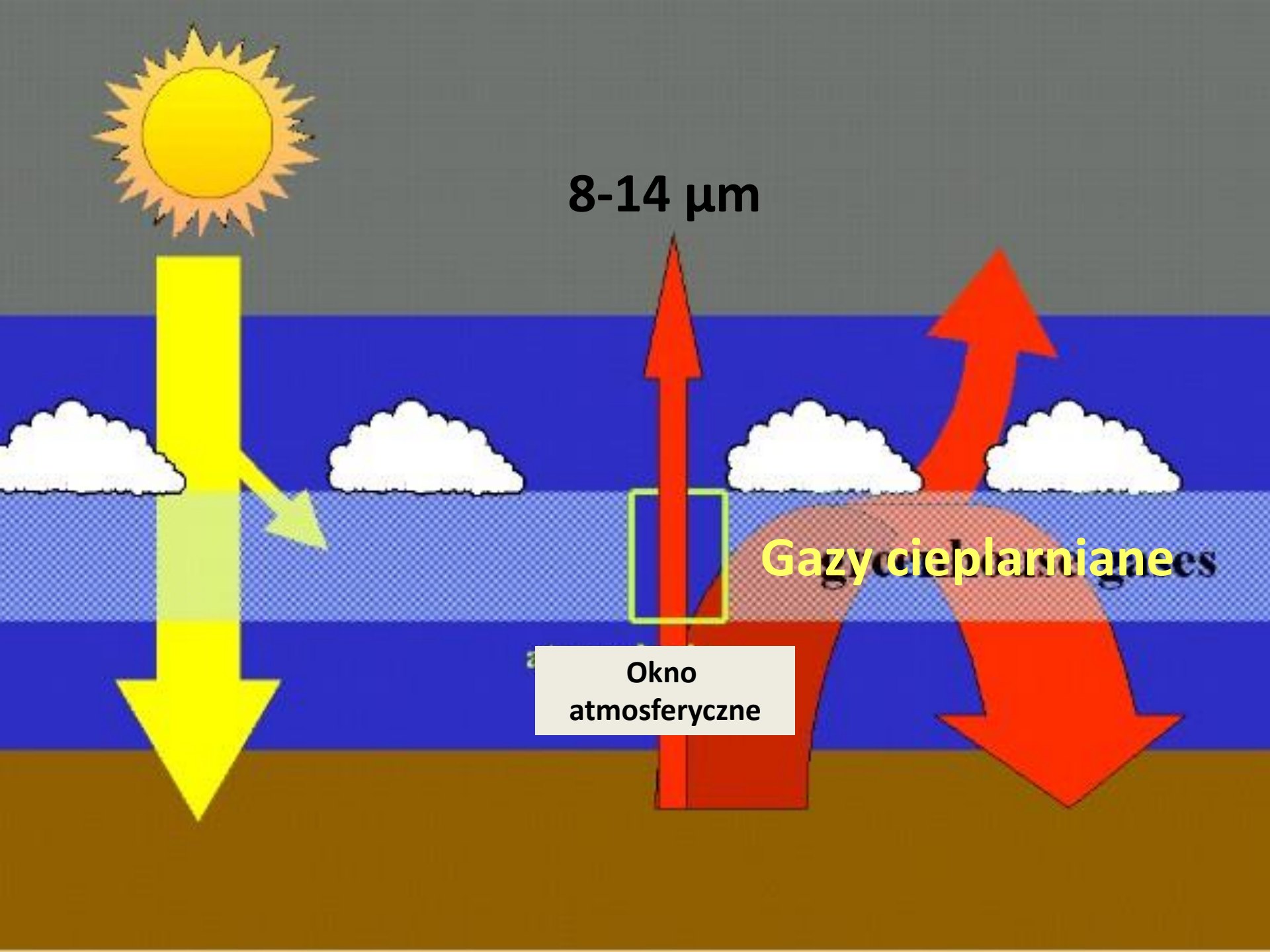
# System Ziemia-Atmosfera





*Absorbancja selektywna gazów atmosferycznych*

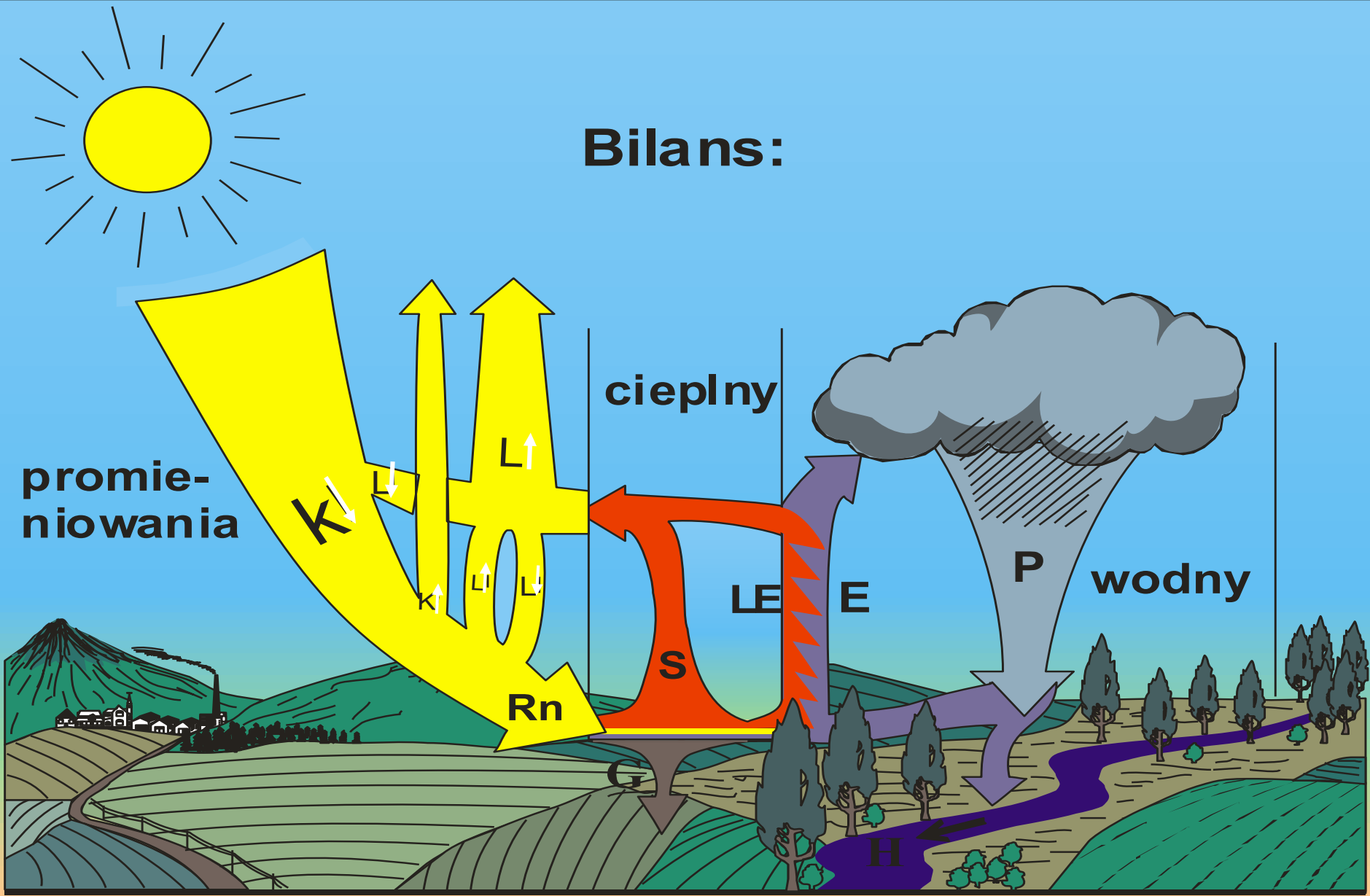




8-14  $\mu\text{m}$

Gazy cieplarniane  
greenhouse gases

Okno  
atmosferyczne



$$\downarrow K - \uparrow K + \downarrow L - \uparrow L = R_n$$

$$R_n = G + S + LE$$

$$E + H = P$$

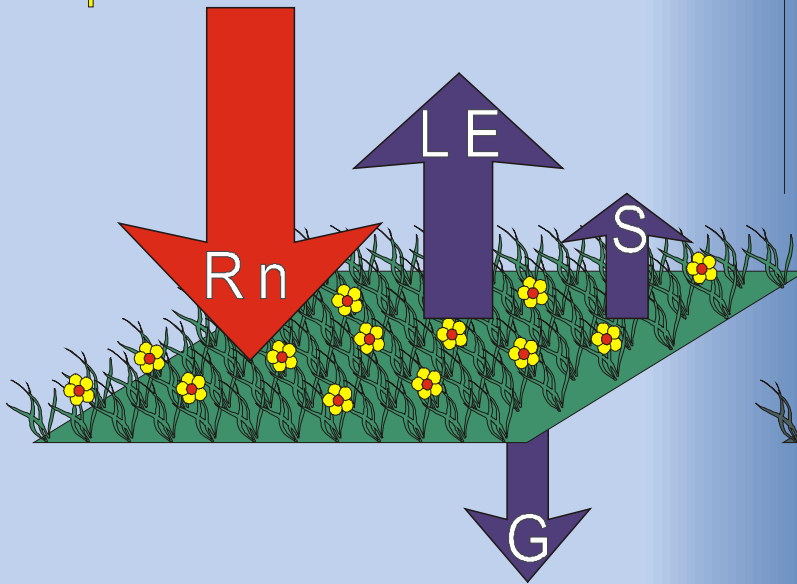
element wspólny

element wspólny

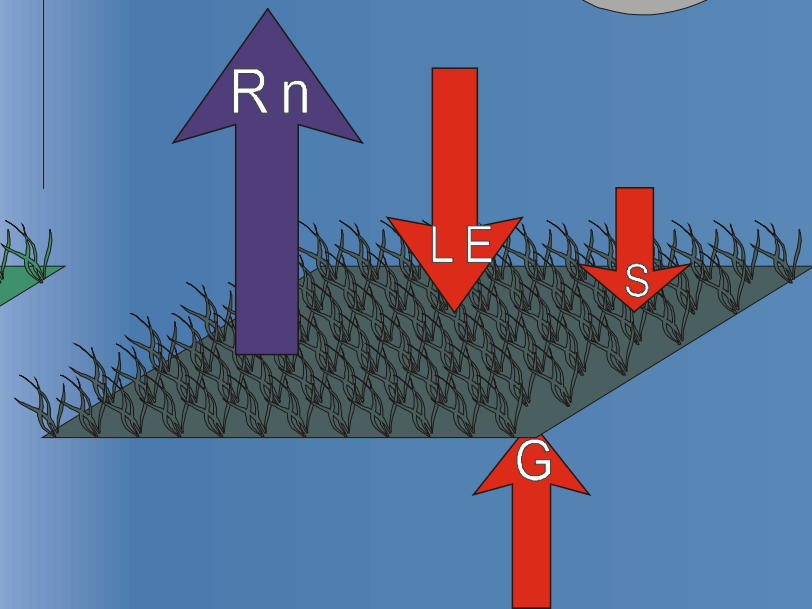


# BILANS CIEPLNY POWIERZCHNI CZYNNEJ

Dzień



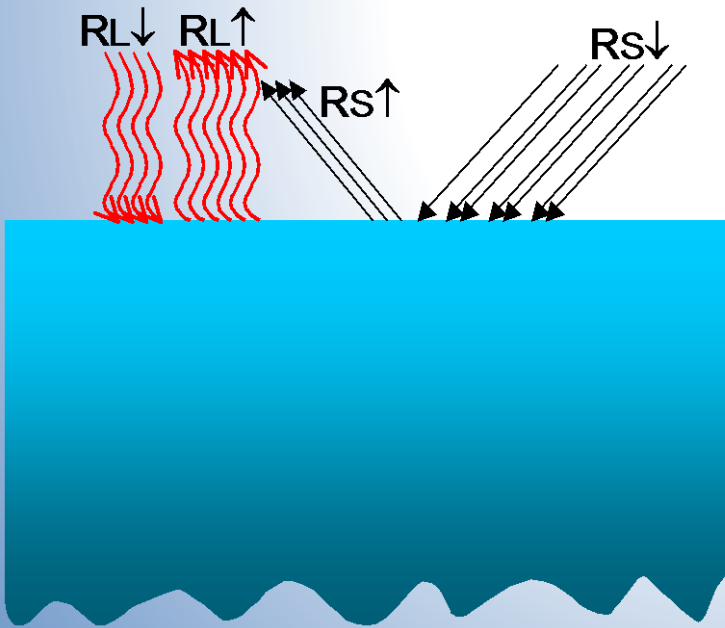
Noc



 Przychód energii

 Rozchód energii

$$R_n = R_{S\downarrow} + R_{S\uparrow} + R_{L\downarrow} + R_{L\uparrow}$$

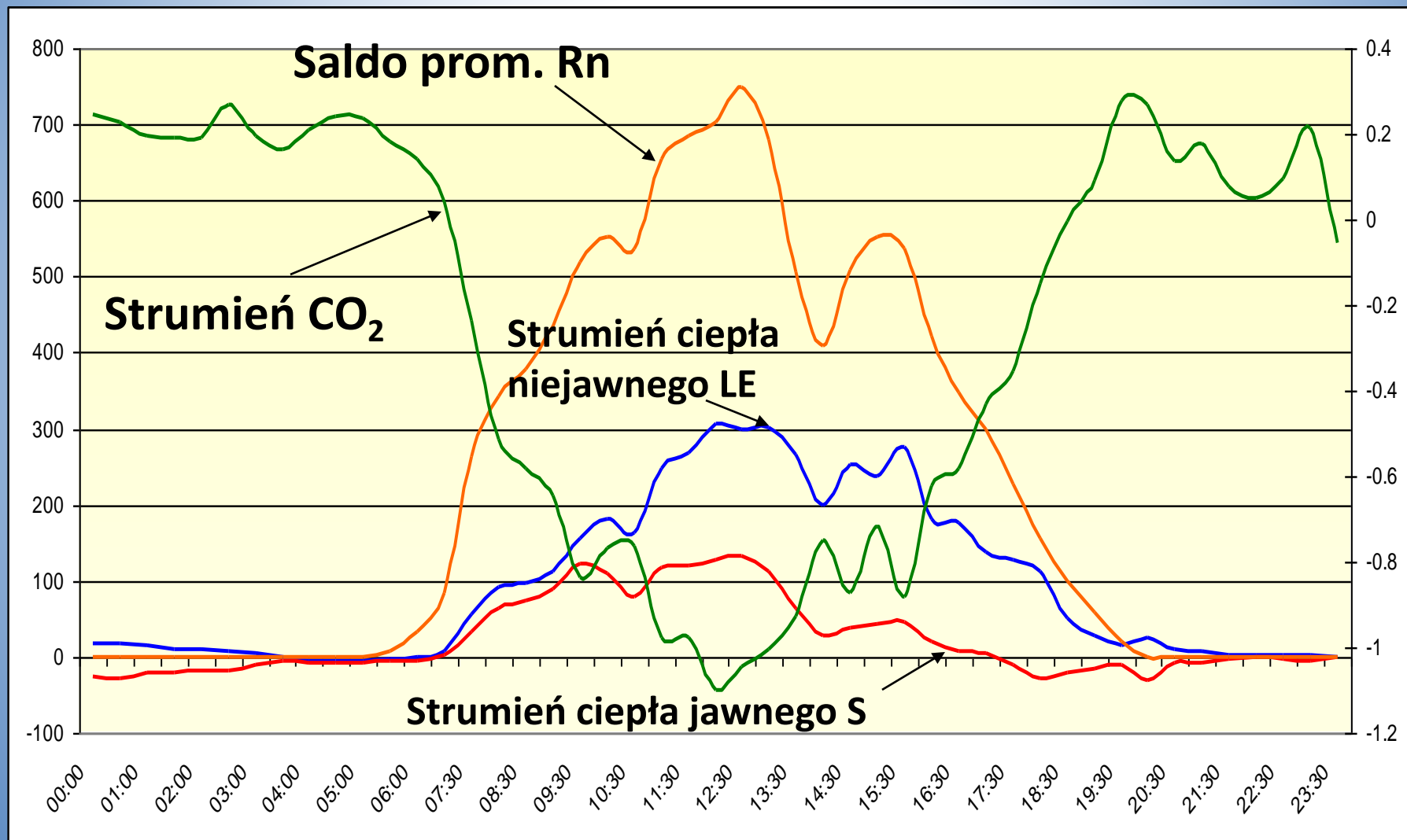


# Płytki glebowa

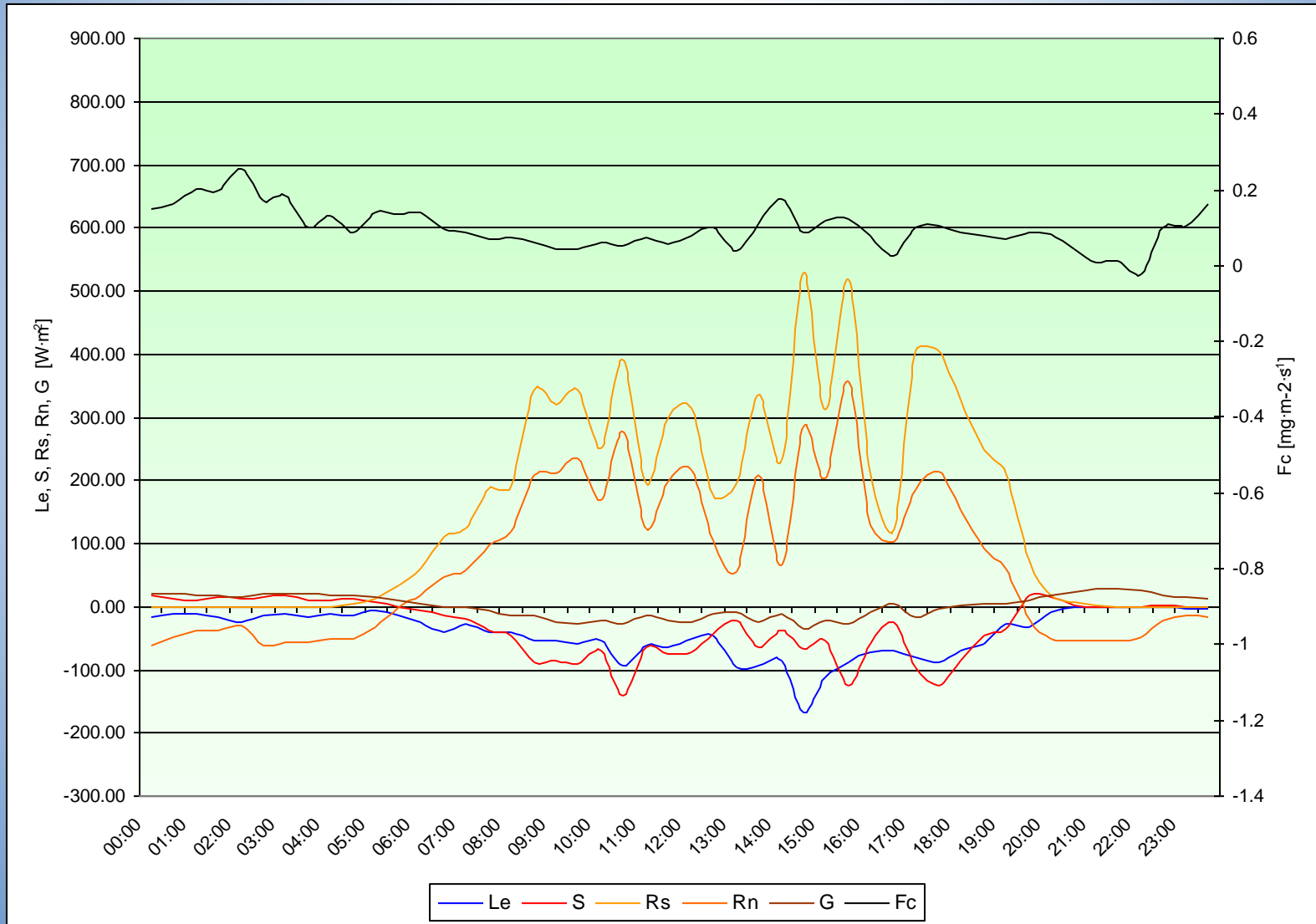


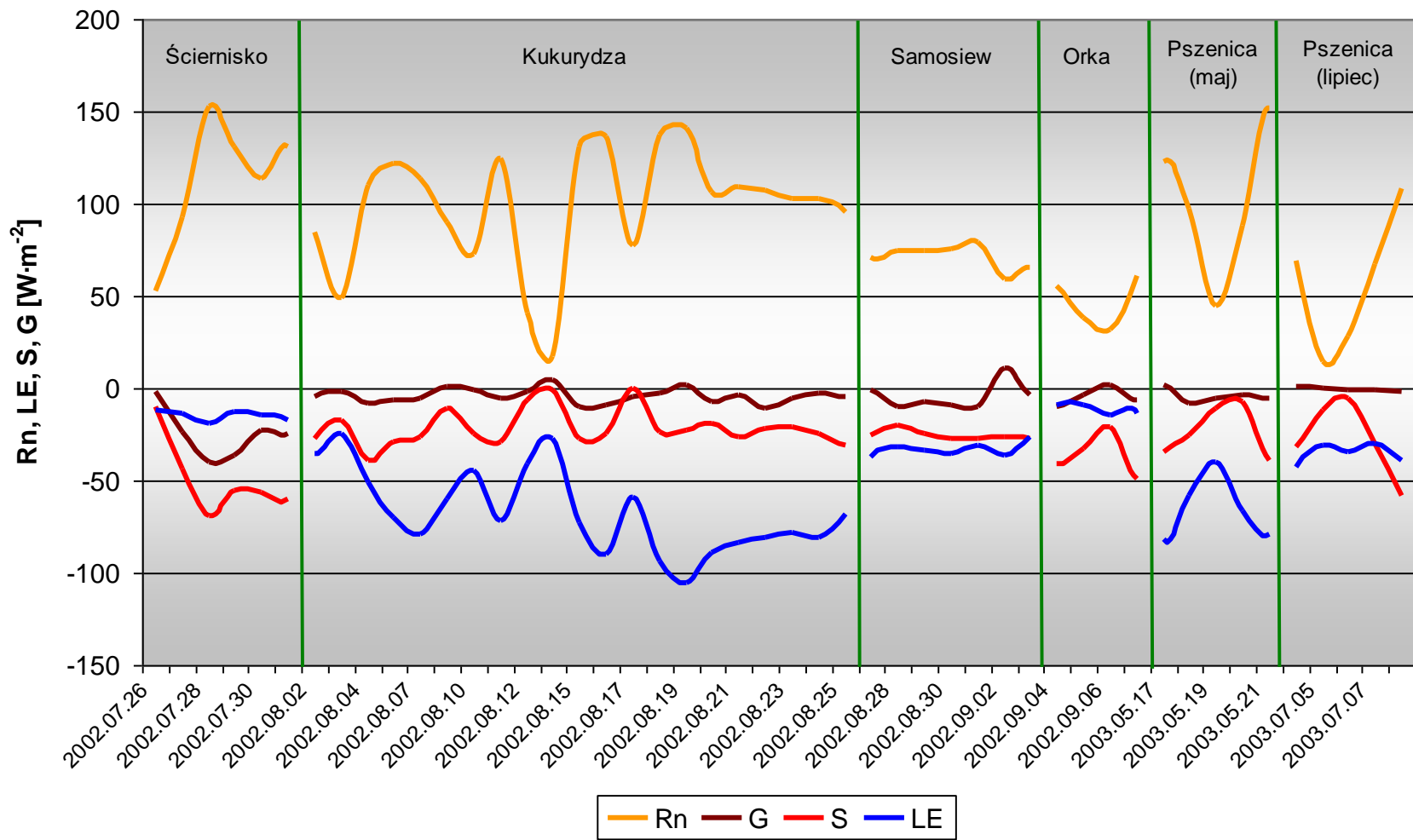


# Strumienie zmierzone nad kukurydzą

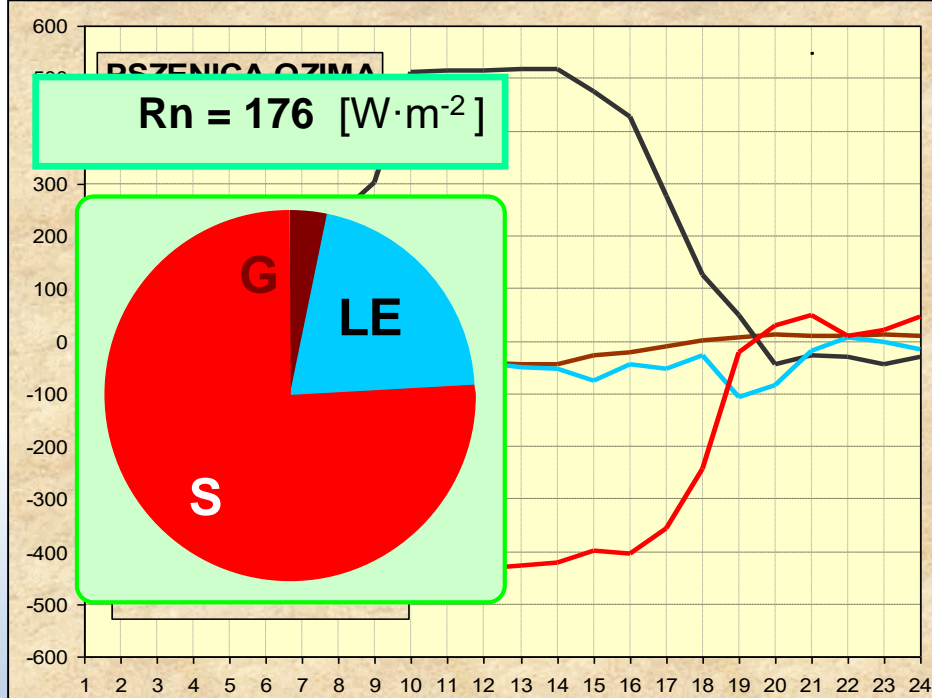
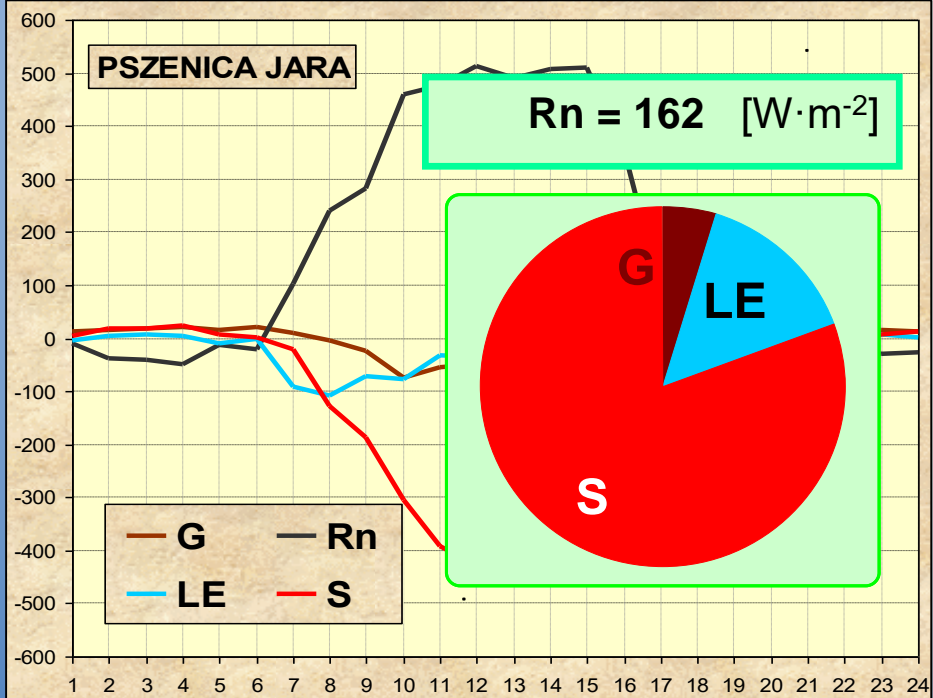
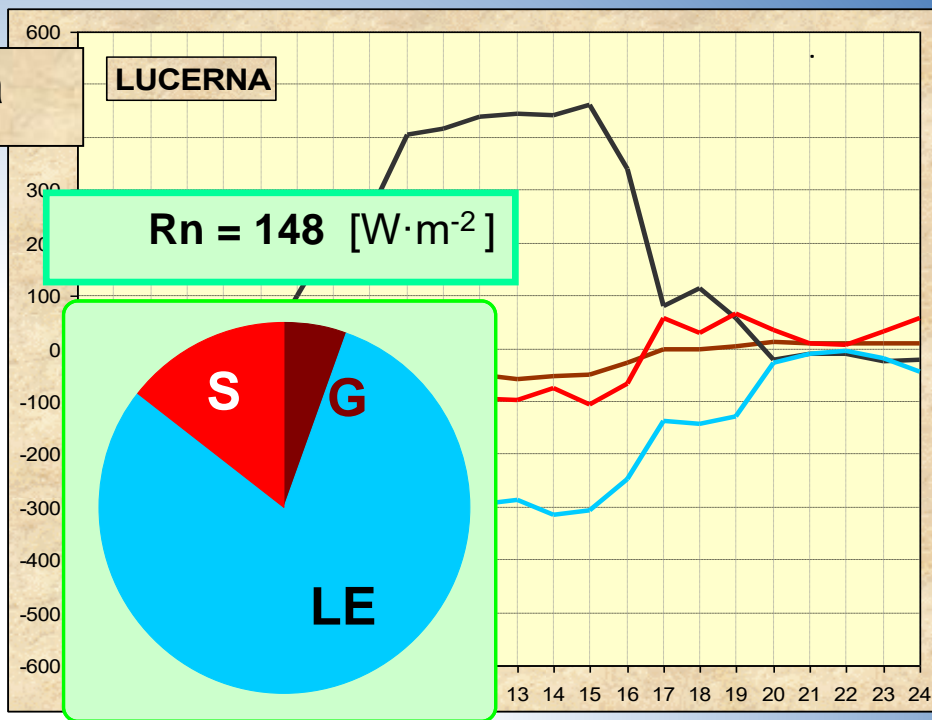
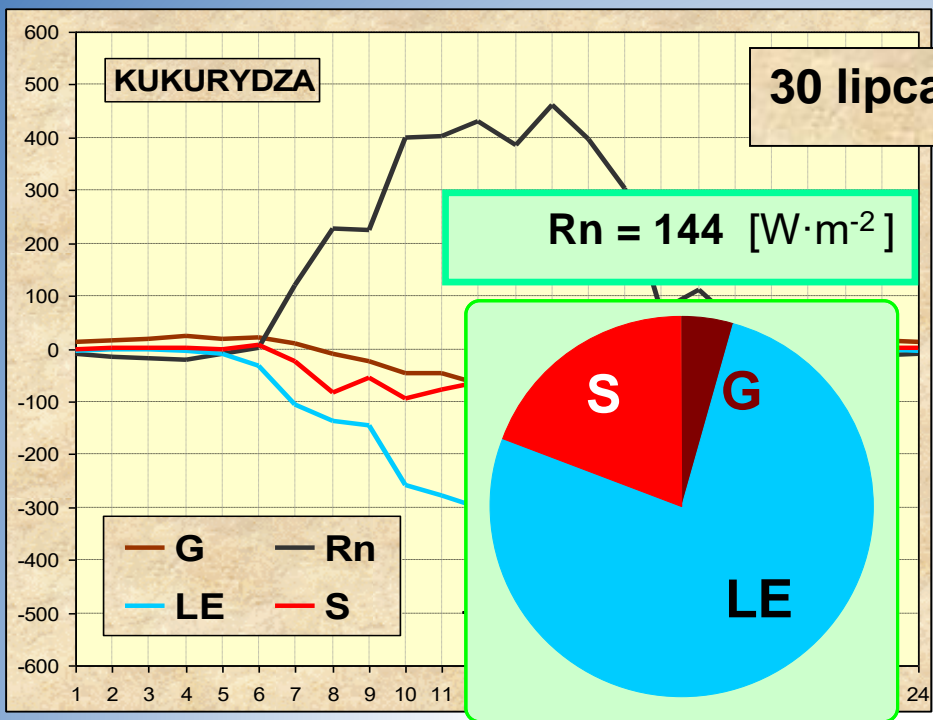


# Strumienie zmierzone nad ścierniskiem

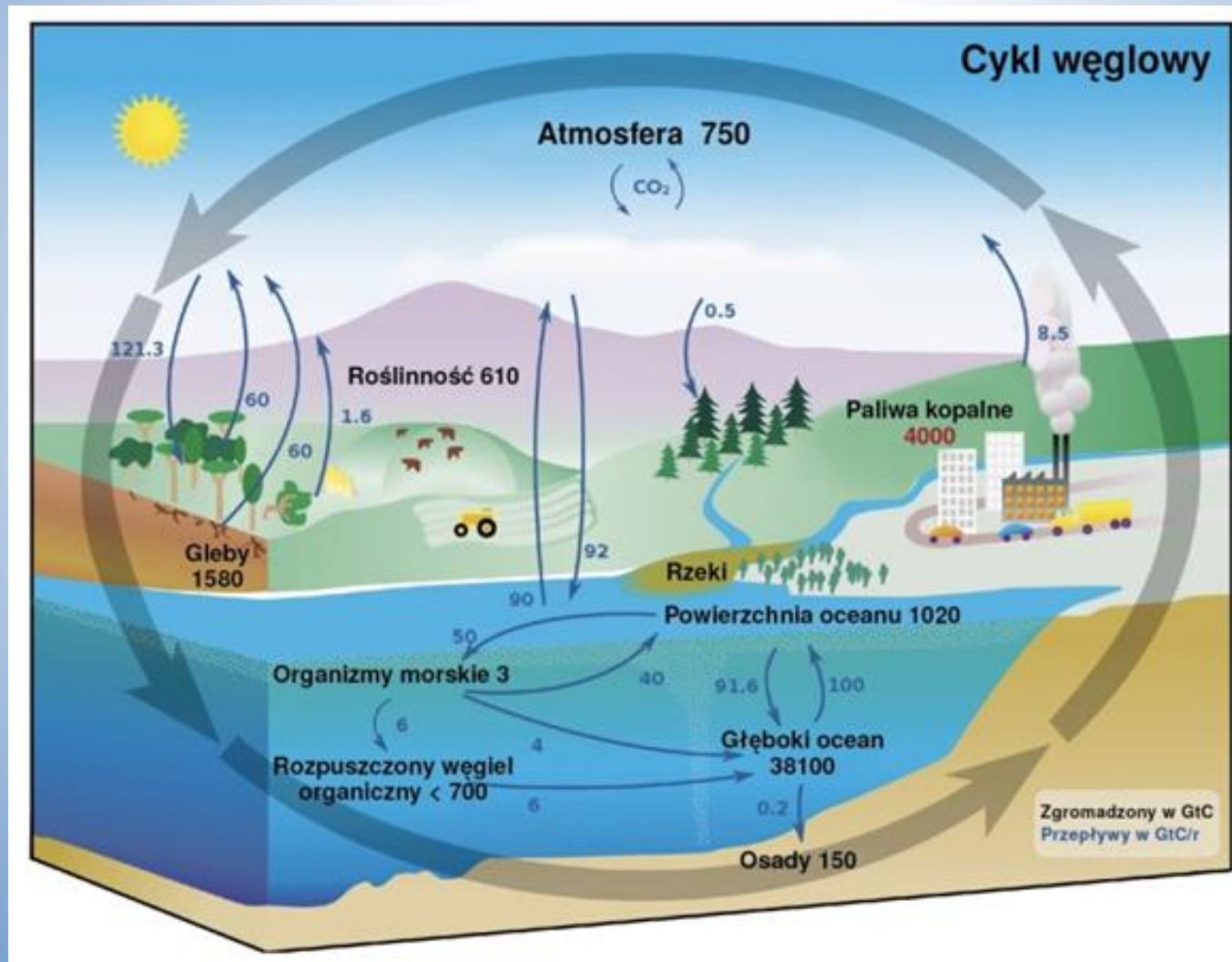




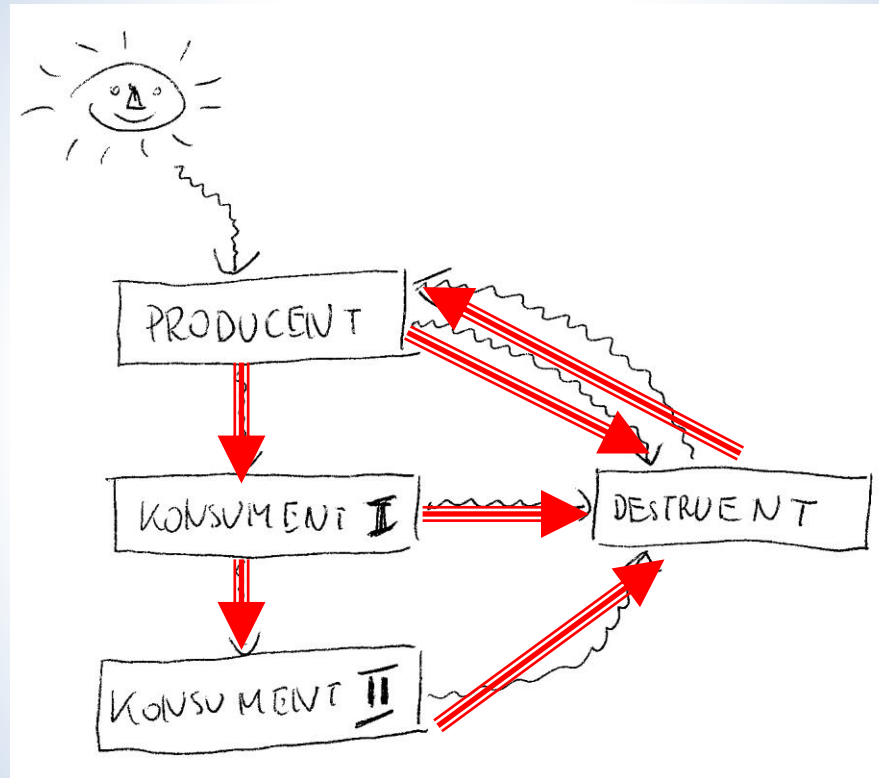




# Wymiana CO<sub>2</sub> między ekosystemem a atmosferą

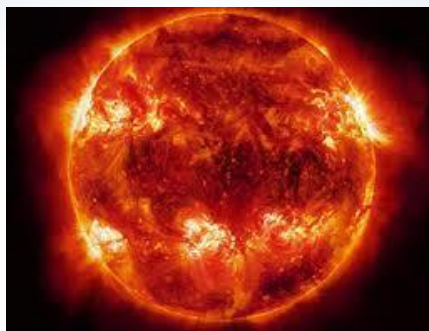


# Lańcuch pokarmowy ŁP

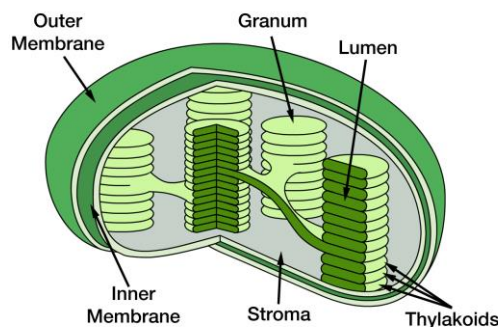




# Roślinność jako kolektor energii słonecznej



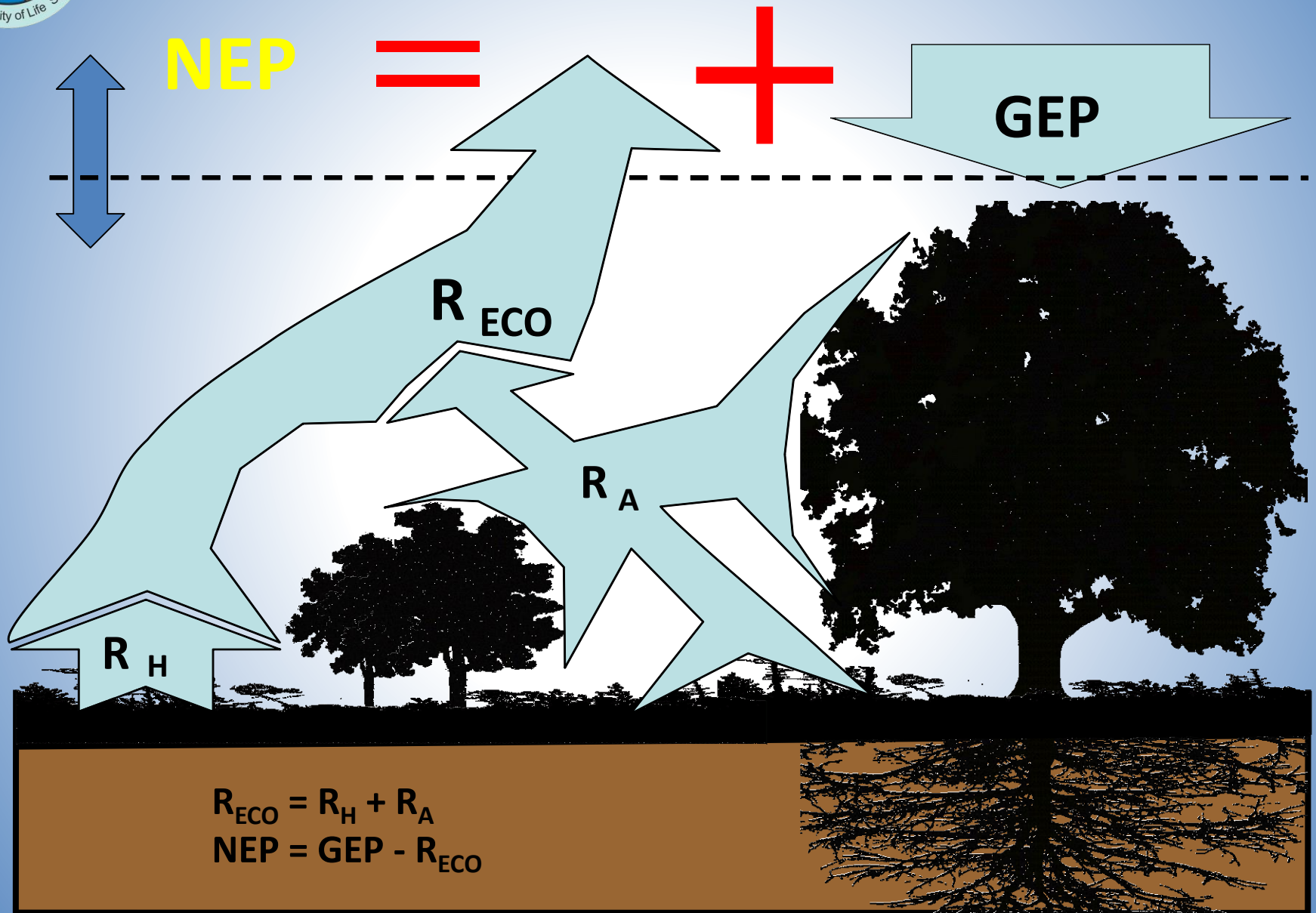
Chloroplast



Żywność – najważniejszy produkt ludzkości



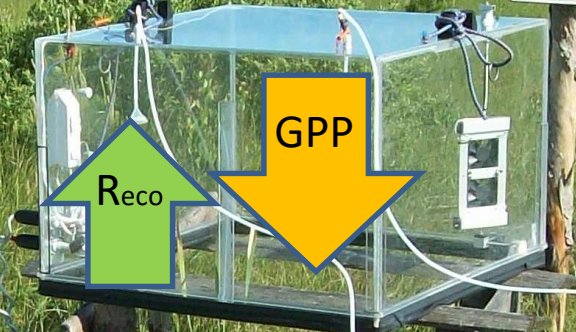
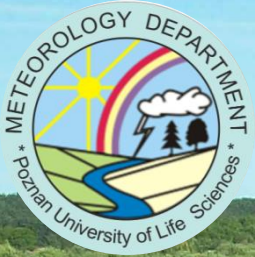
# Net Ecosystem Production



# CO<sub>2</sub> fluxes night/day







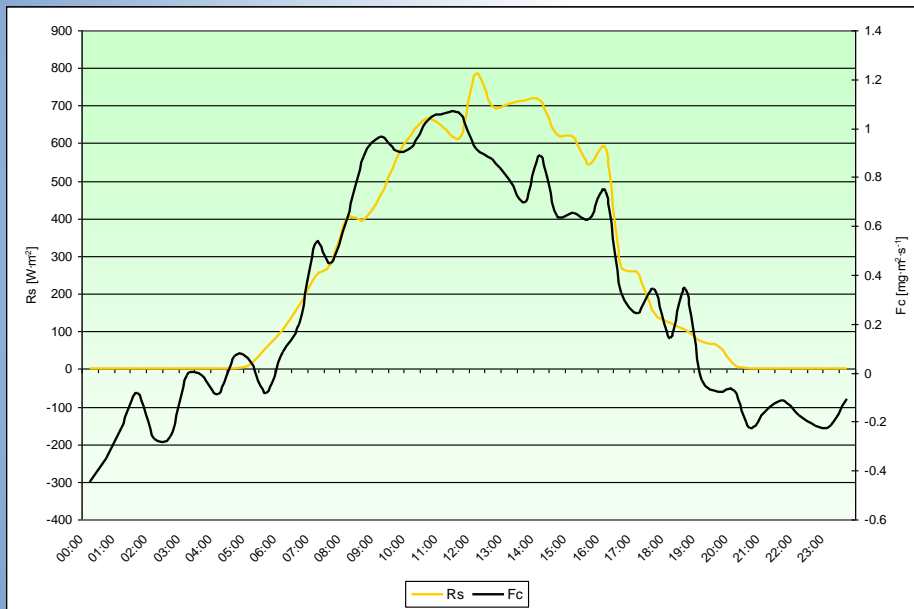
UWAGA!!  
NIEUPOWAZNIANYM  
WSTĘP WZBRONIANY



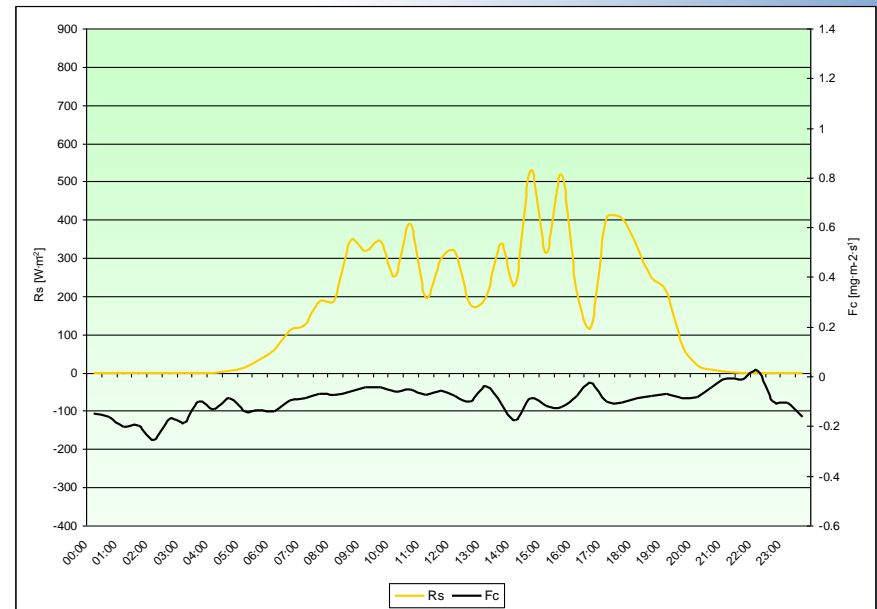


# Rs vs. $F_{CO_2}$

(17. maja 2003)  
Pszenica

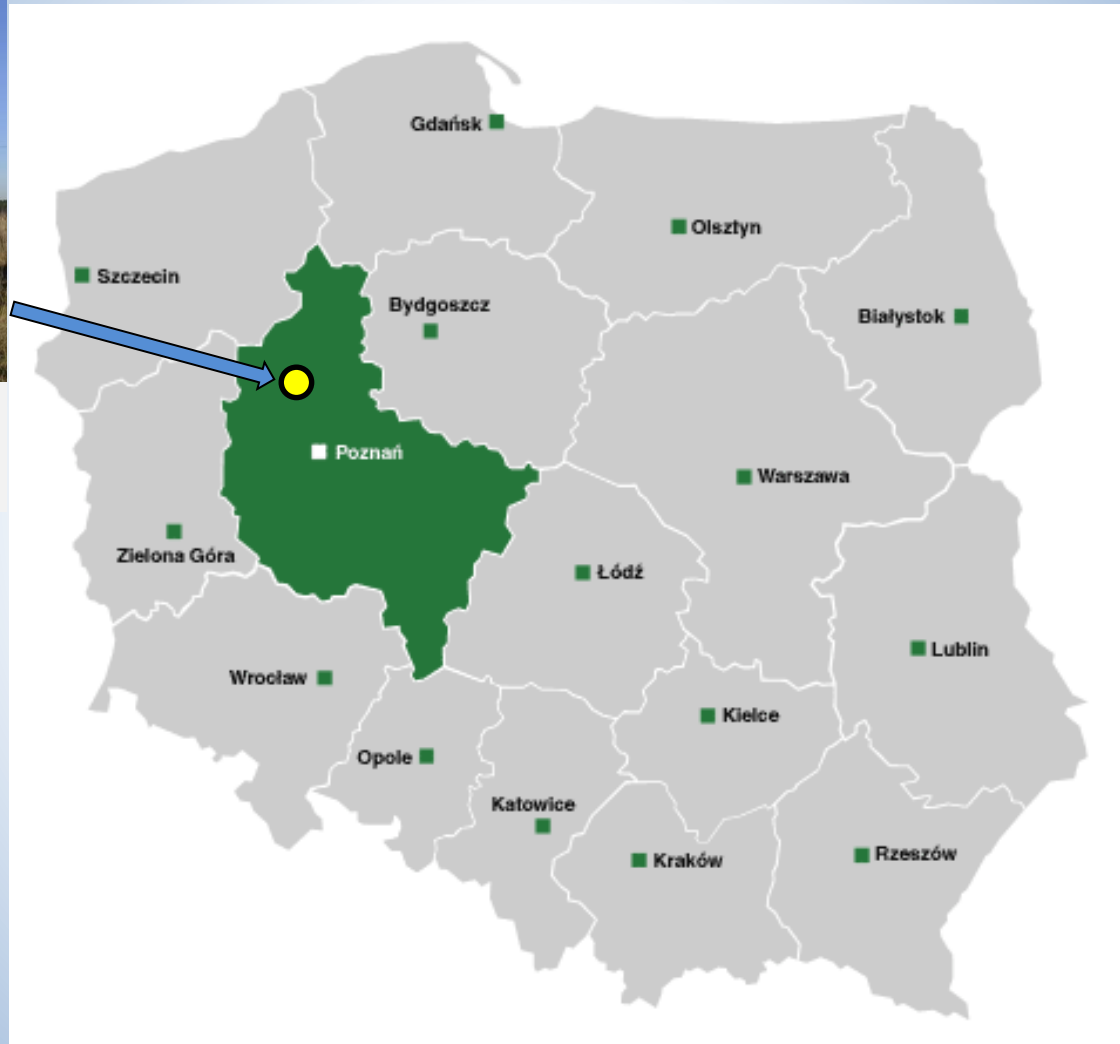


(4. lipieca 2002)  
Ściernisko





## RZECIN WETLAND



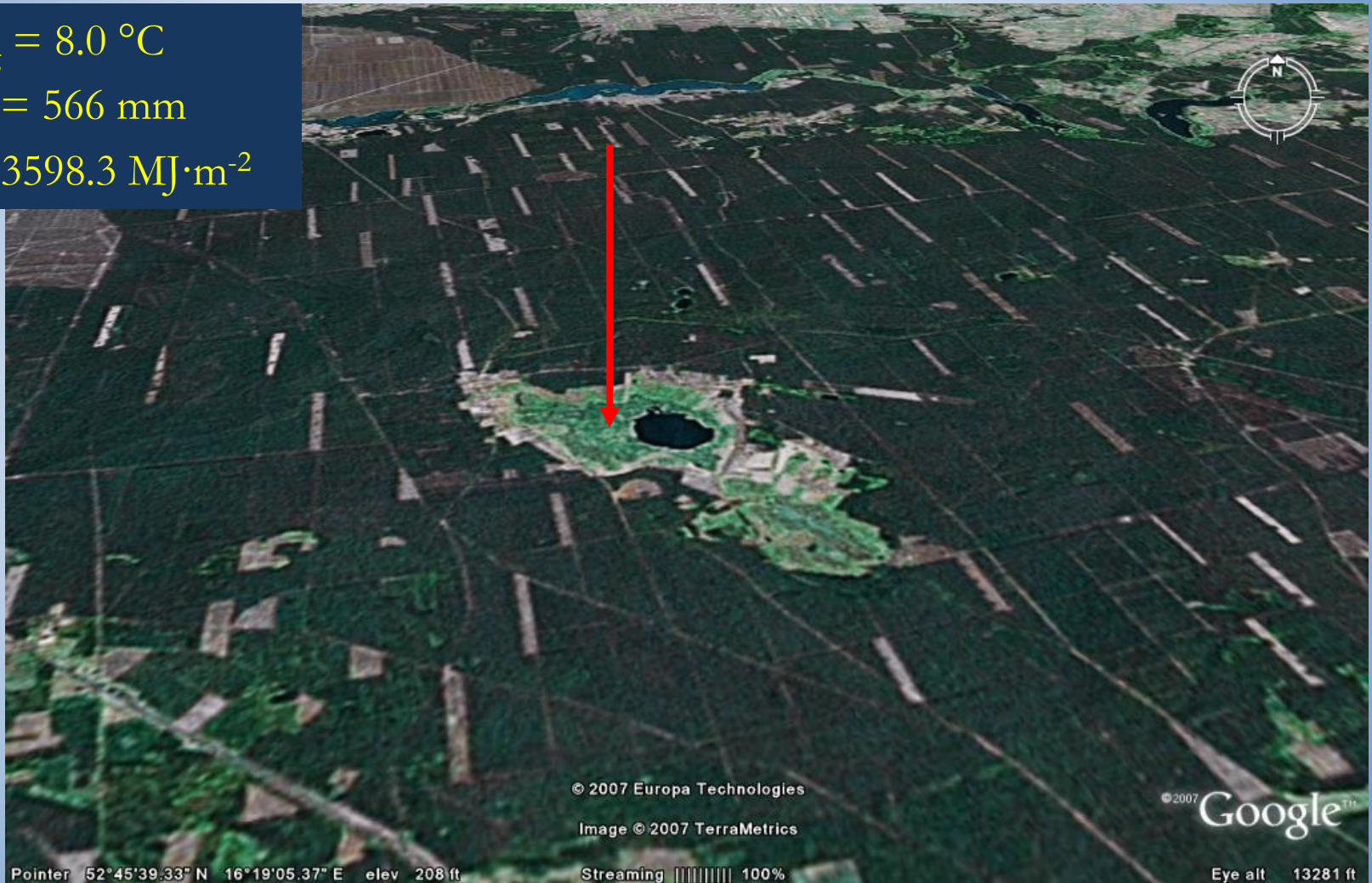


# Rzecin according to Google

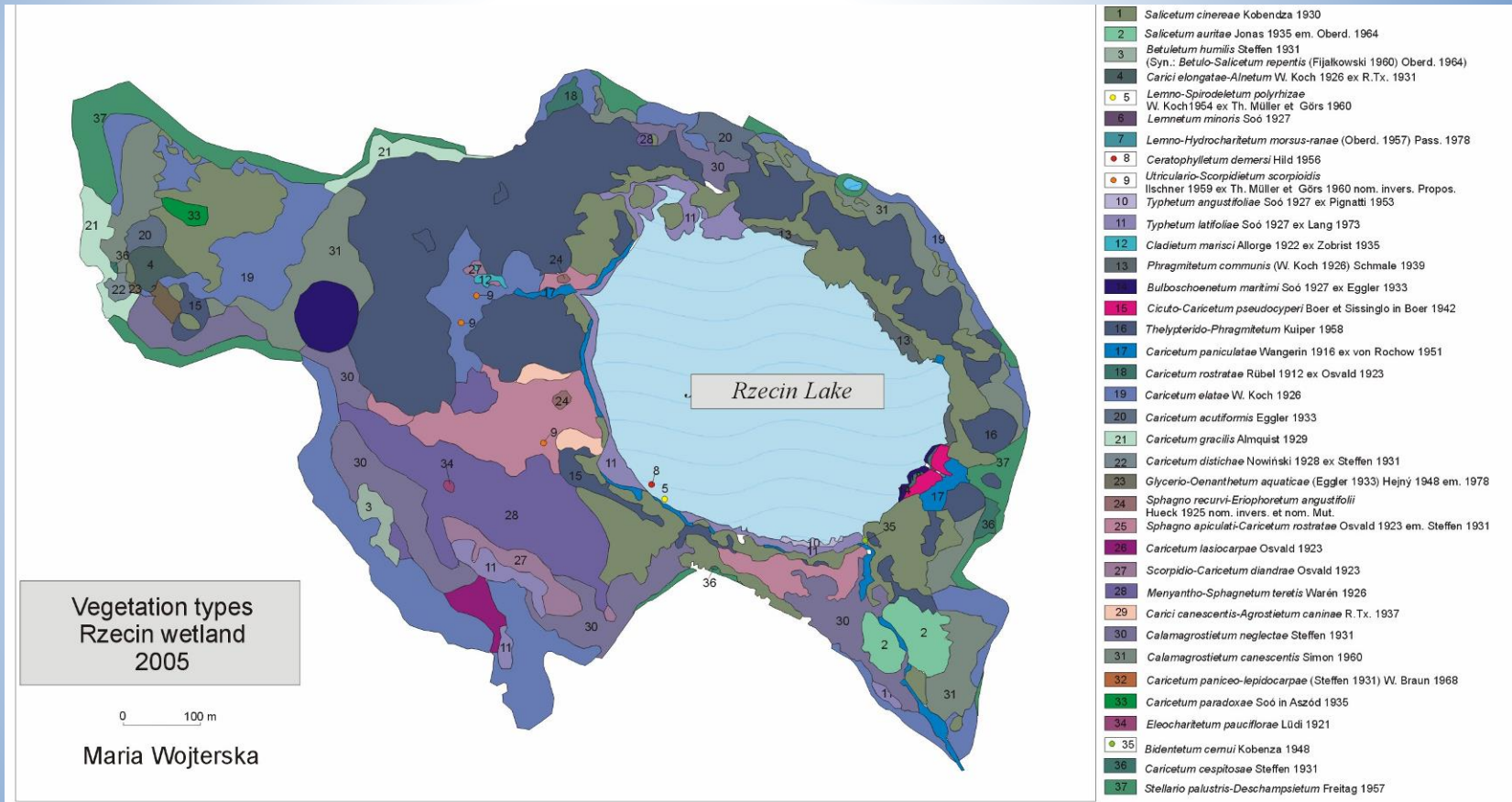
$$t_{\text{avg}} = 8.0 \text{ }^{\circ}\text{C}$$

$$P_{\text{sum}} = 566 \text{ mm}$$

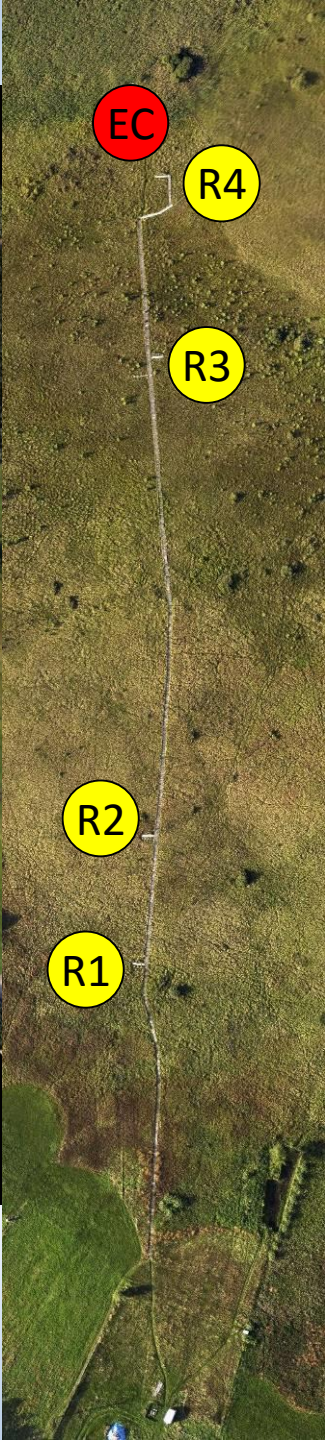
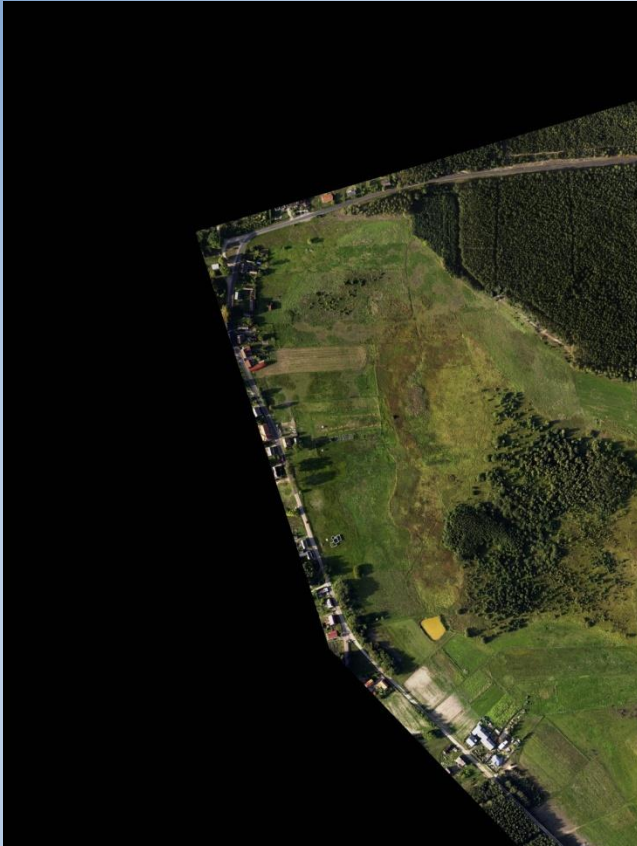
$$R_{g_{\text{sum}}} = 3598.3 \text{ MJ}\cdot\text{m}^{-2}$$



# Vegetation in Rzecin

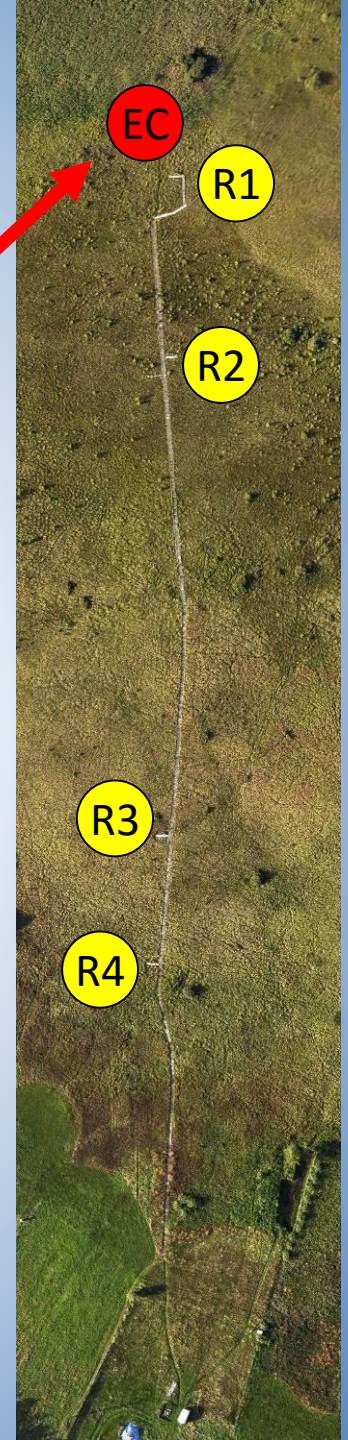






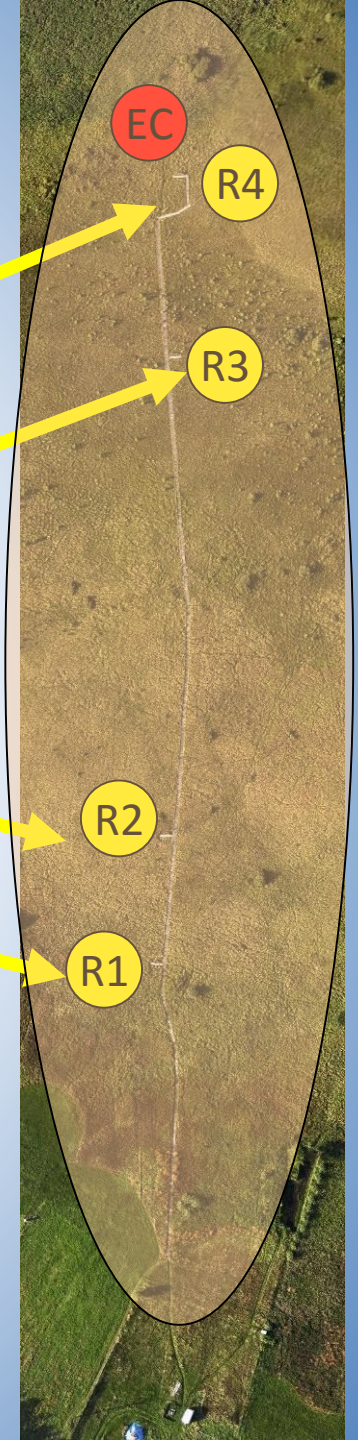
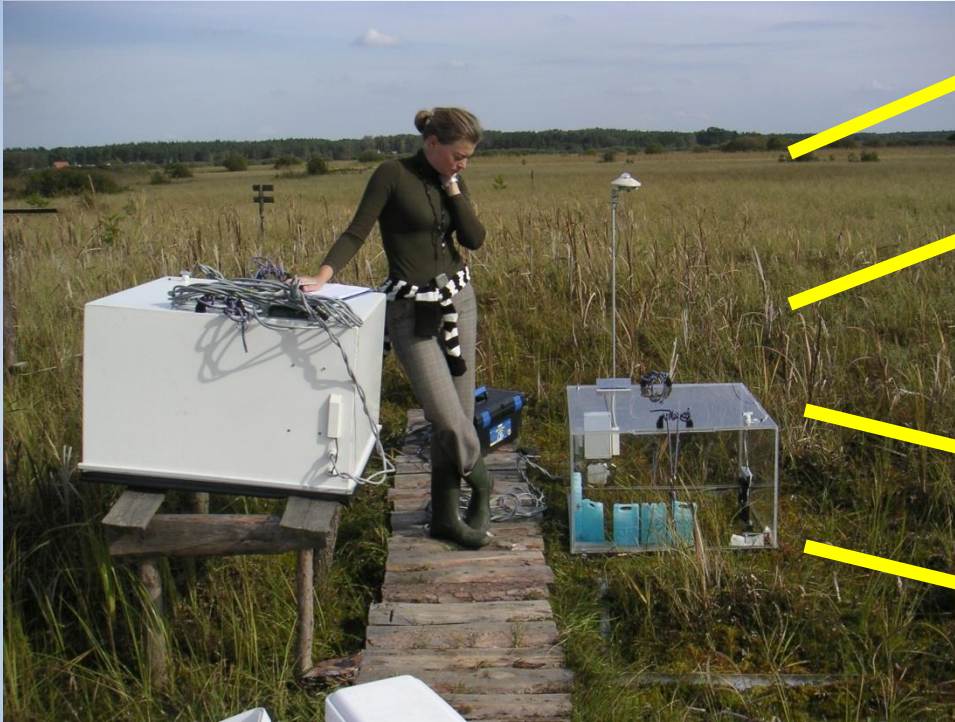


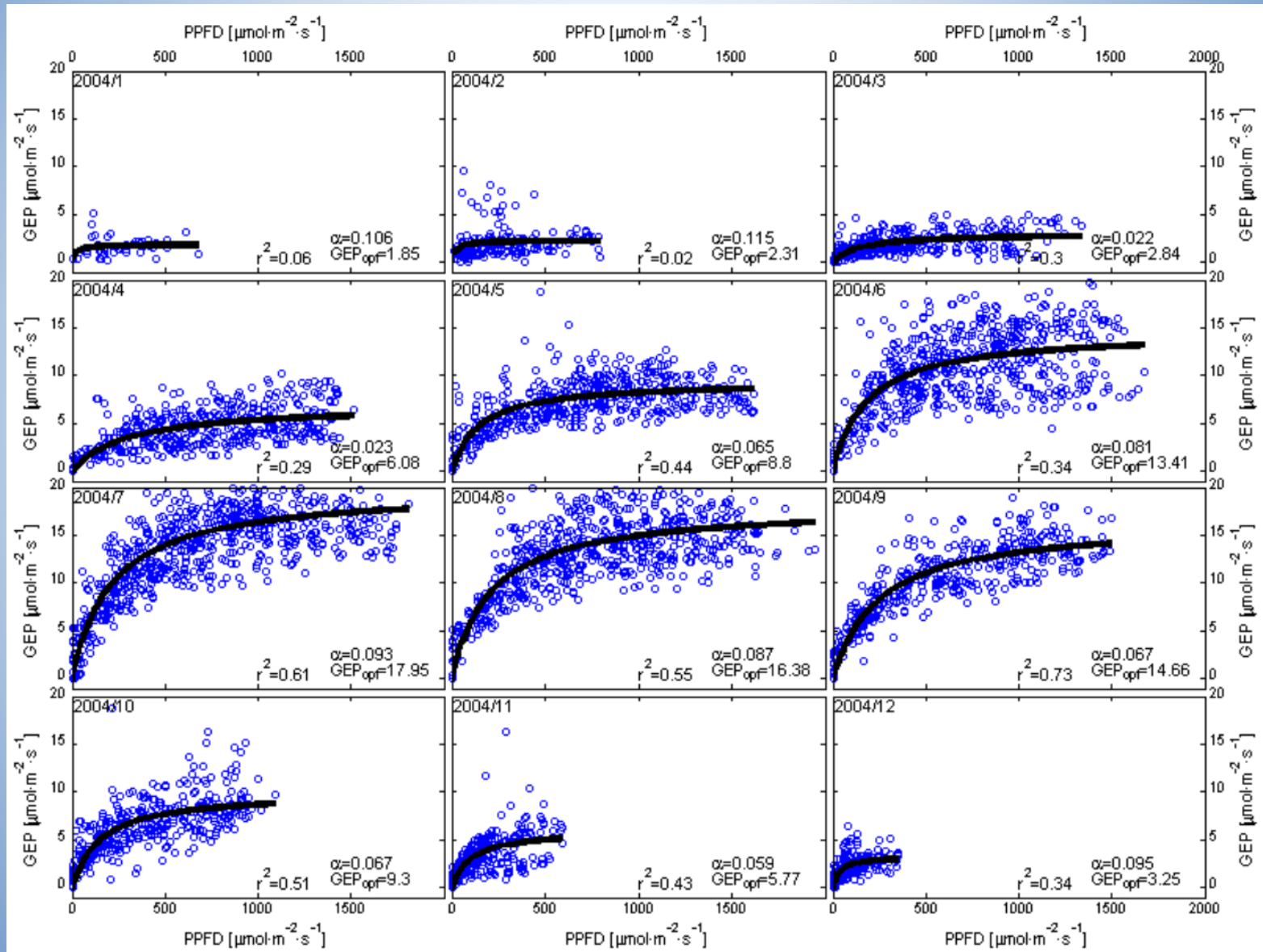
# Eddy Covariance Tower



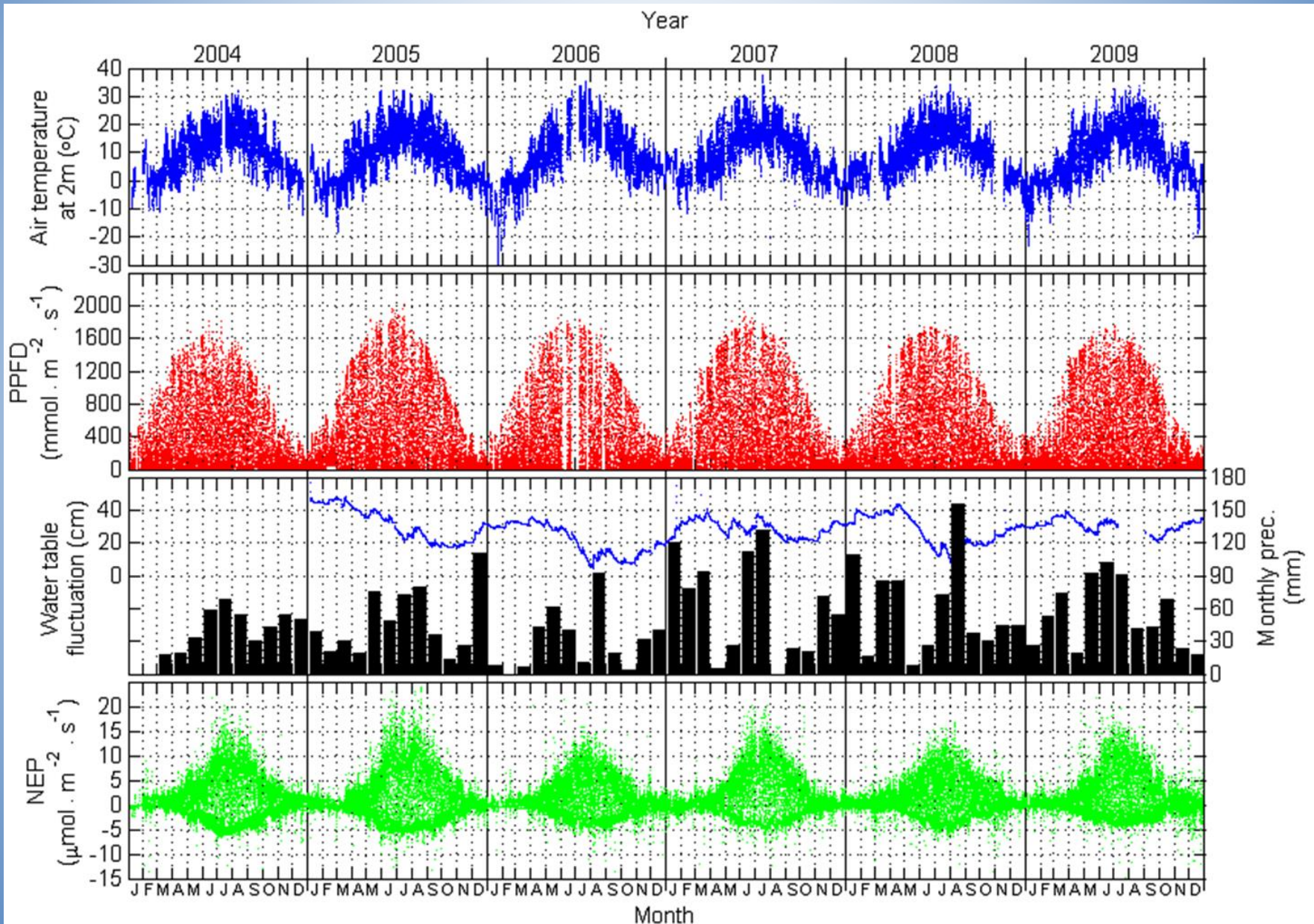


# Static Chamber Sites

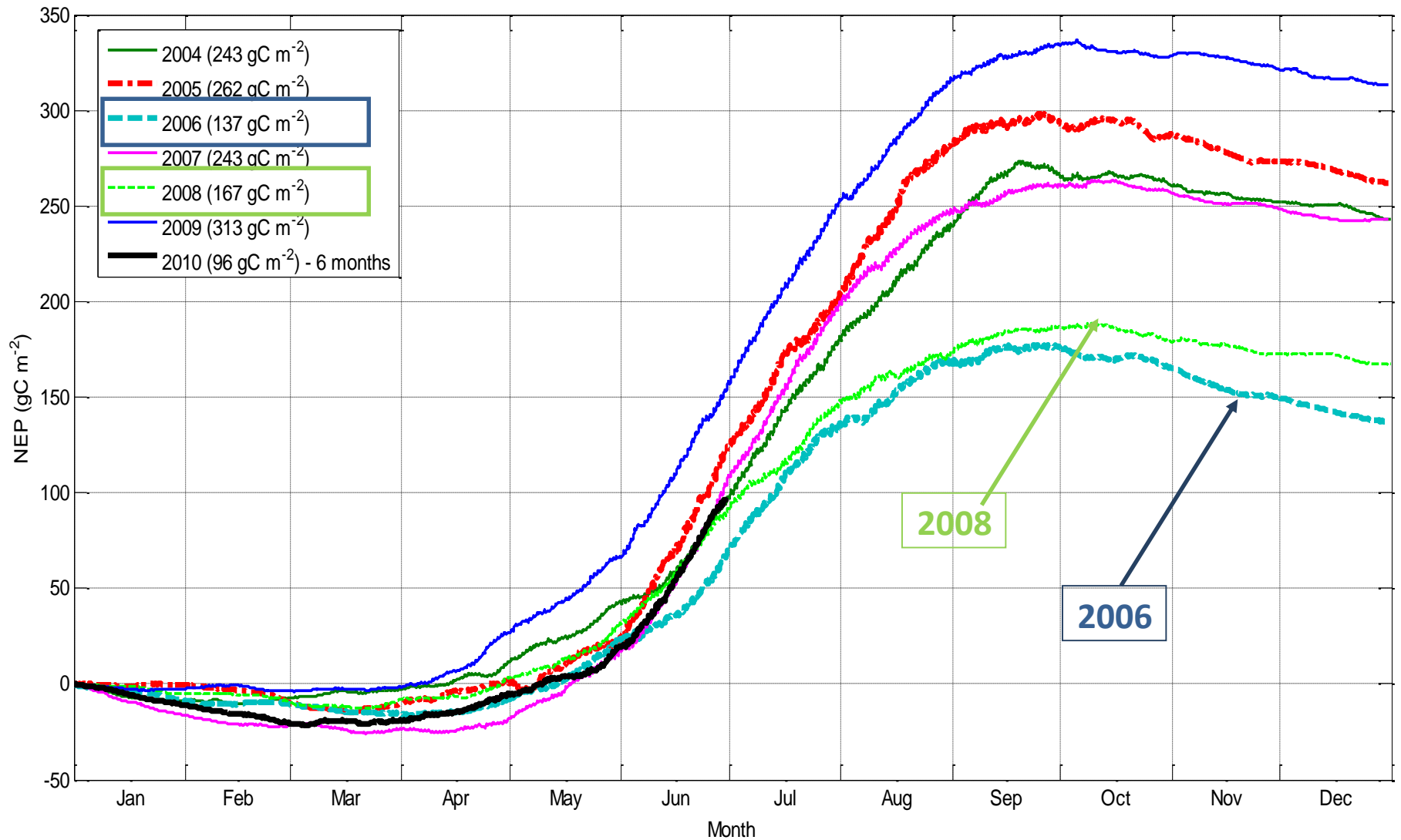








# Cumulative CO<sub>2</sub> annual runs in Rzecin wetland





# PRODUKTYWNOŚĆ TORFOWISKA A RPOMIENIOWANIE ROZPROSZONE



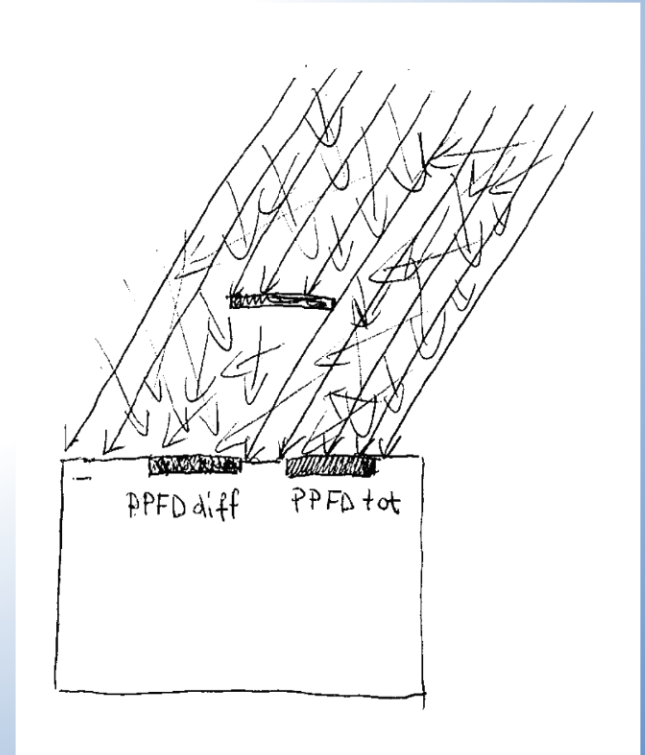


# Diffusion Index ( $D^*$ )

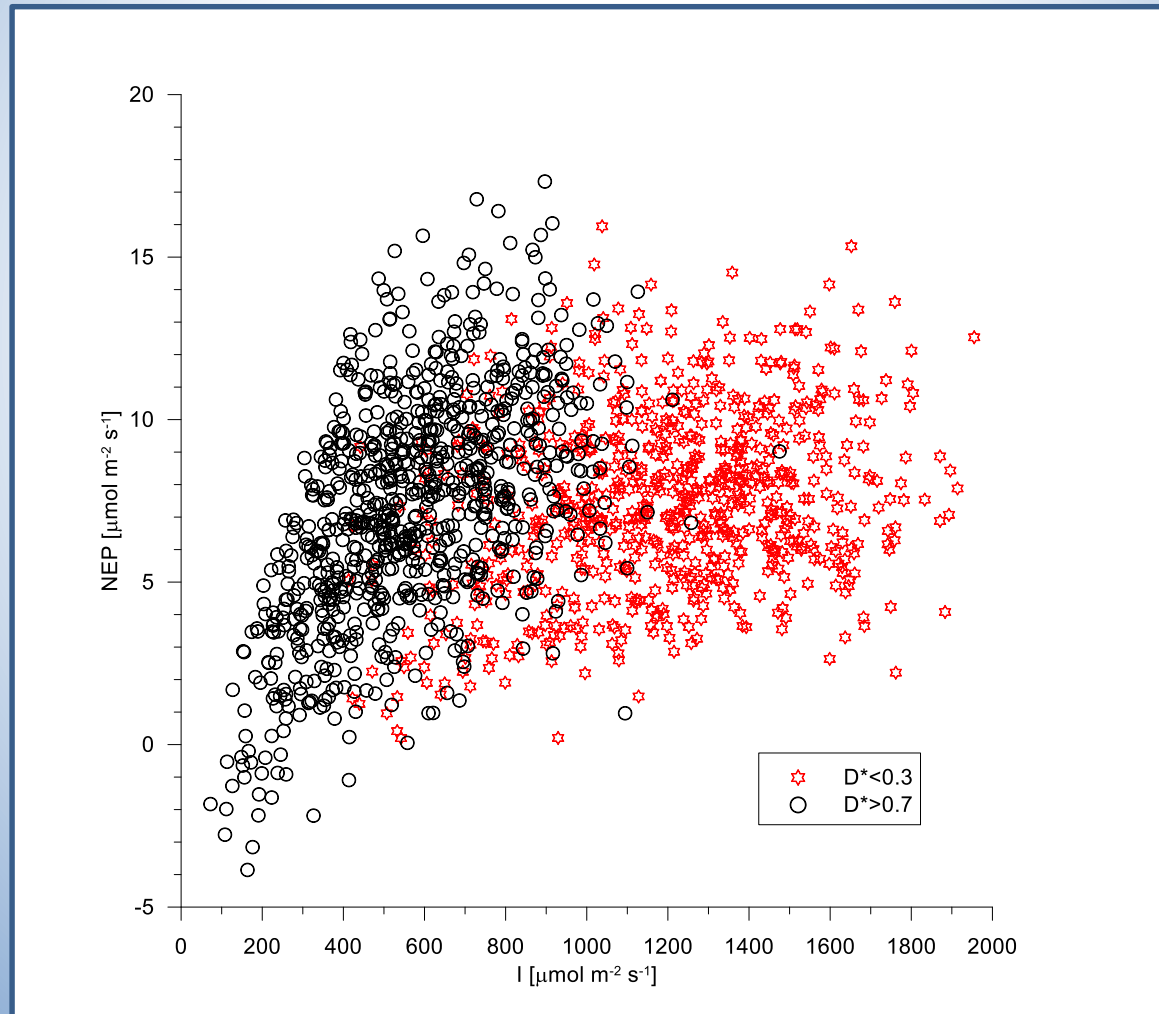
$$D^* = P_{diff} / P_{tot}$$

$P_{diff}$  – diffused  
Photosynthetic Photons  
Flux Density

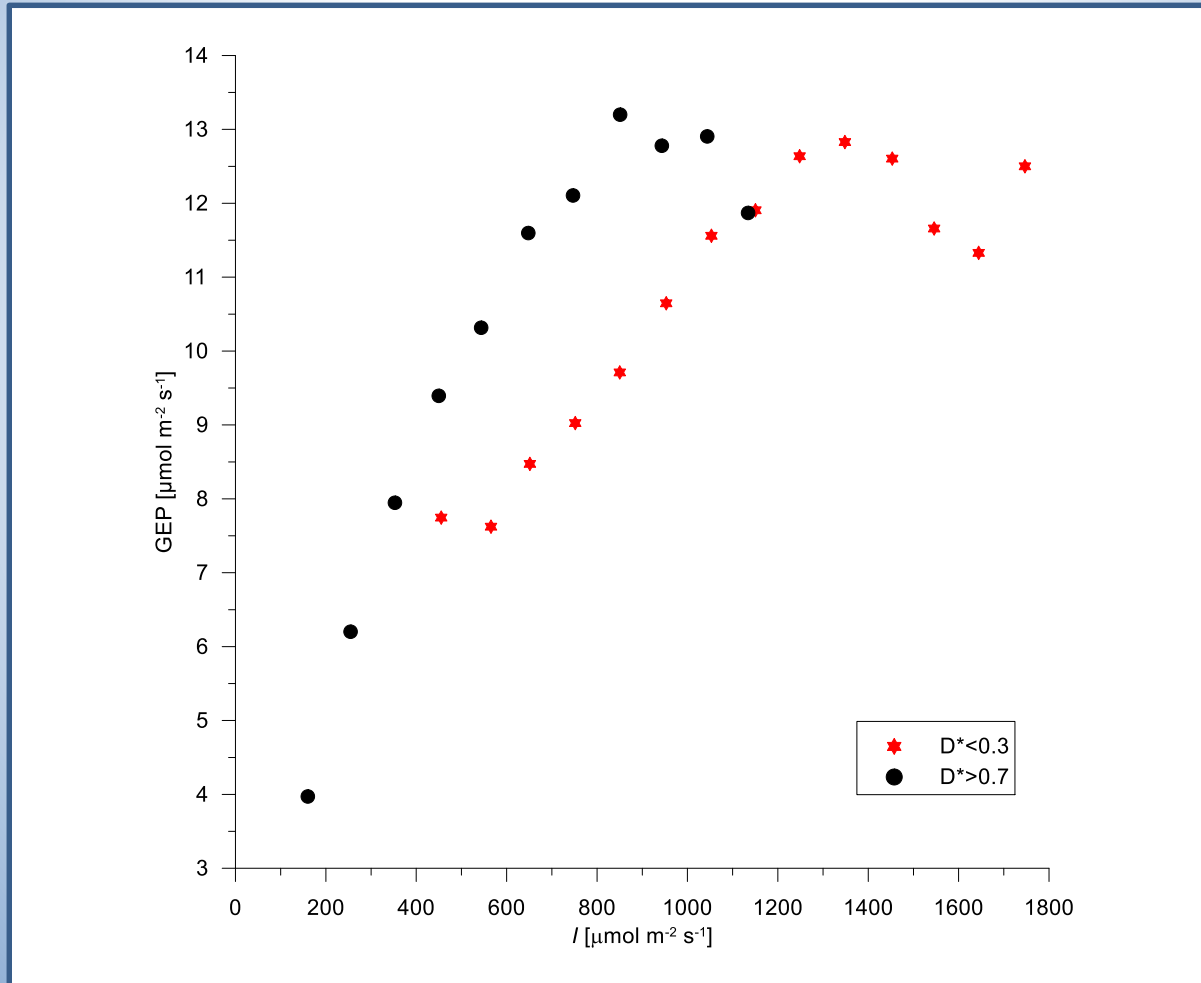
$P_{tot}$  – total Photosynthetic  
Photons Flux Density



# Produkcja (NEP) a ilość/rozproszenie promieniowania (I)



# Produkcja (GEP) a ilość/rozproszenie promieniowania (I)



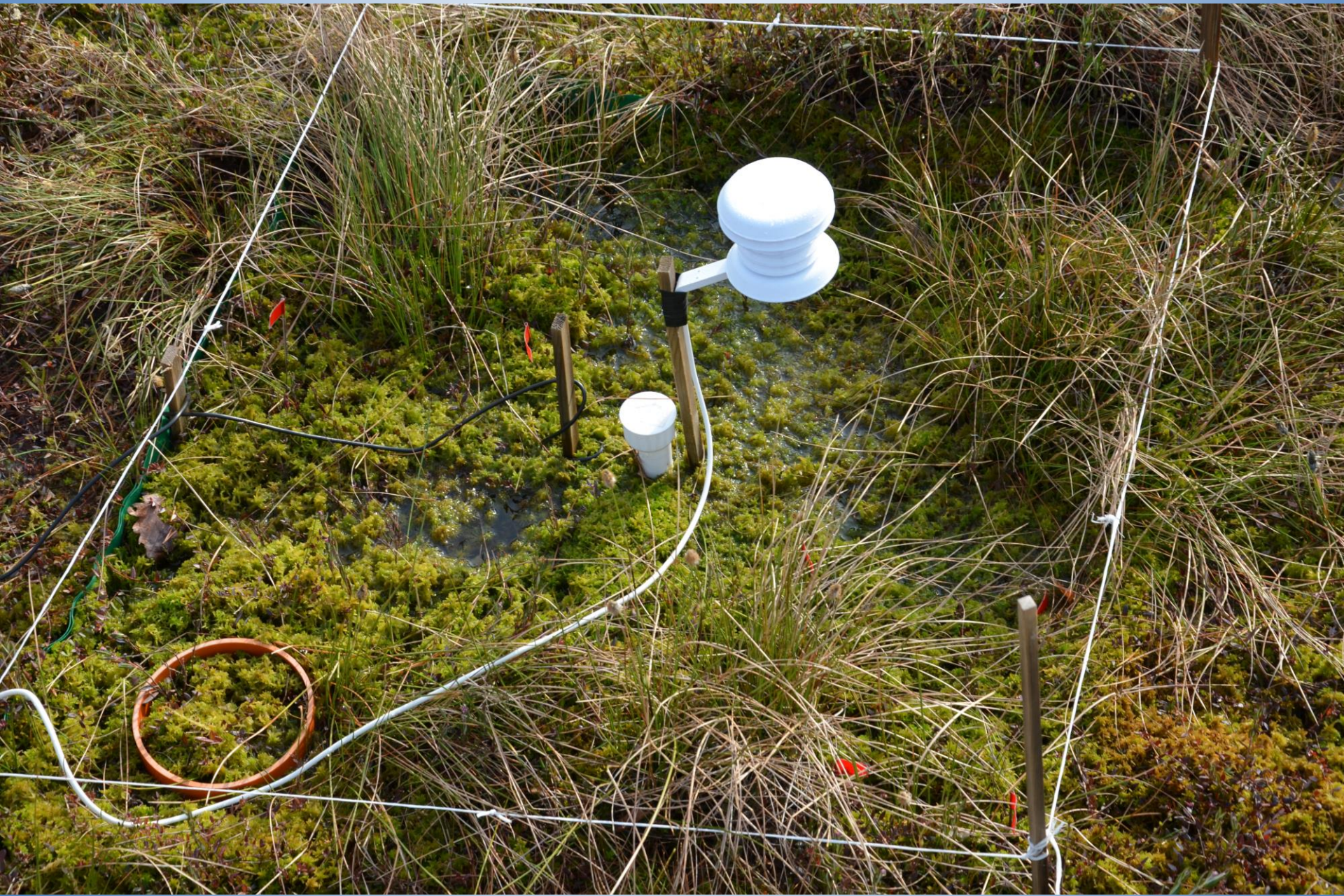


I	I	Ta	Ta	NEP	NEP	dN	rN	GEP	GEP	dG	rG	LUE	LUE	dL	rL
$\mu\text{mol m}^{-2} \text{s}^{-1}$		$^{\circ}\text{C}$		$\mu\text{mol m}^{-2} \text{s}^{-1}$		$\mu\text{mol m}^{-2} \text{s}^{-1}$	%	$\mu\text{mol m}^{-2} \text{s}^{-1}$				$\text{mmol mol}^{-1}$		$\text{mmol mol}^{-1}$	%
D* < 0.3	D* < 0.3	D* < 0.3	D* < 0.3	D* < 0.3	D* < 0.3			D* < 0.3	D* < 0.3			D* < 0.3	D* < 0.3		
-	7	3	7	-	7	-	-	-	7	-	-	-	7	-	-
-	160	-	13.4	-	0.87	-	-	-	3.97	-	-	-	25.0	-	-
-	255	-	14.3	-	2.95	-	-	-	6.20	-	-	-	24.3	-	-
-	353	-	15.2	-	4.46	-	-	-	7.95	-	-	-	22.5	-	-
455	450	14.4	16.4	4.39	5.54	1.15	126	7.75	9.40	1.65	121	17.1	20.9	3.8	122
565	544	16.2	17.1	3.56	6.22	2.66	175	7.63	10.32	2.69	135	13.5	19.0	5.5	140
651	648	16.7	18.5	4.49	6.93	2.44	154	8.48	11.60	3.12	137	13.0	18.0	4.9	138
752	747	18.0	18.9	4.60	7.55	2.95	164	9.03	12.11	3.08	134	12.0	16.2	4.2	135
850	851	18.7	19.6	5.09	8.35	3.26	164	9.71	13.20	3.49	136	11.4	15.5	4.1	136
953	943	19.9	19.9	5.64	7.62	1.97	135	10.65	12.78	2.13	120	11.2	13.5	2.4	121
1053	1044	20.7	20.3	6.20	7.43	1.22	120	11.56	12.91	1.34	112	11.0	12.4	1.4	113
1150	1134	22.0	19.8	6.04	6.78	0.74	112	11.91	11.87	-0.04	100	10.4	10.5	0.2	102
1248	-	23.1	-	6.40	-	-	-	12.64	-	-	-	10.1	-	-	-
1348	-	22.8	-	6.58	-	-	-	12.83	-	-	-	9.5	-	-	-
1453	-	23.4	-	6.25	-	-	-	12.61	-	-	-	8.7	-	-	-
1546	-	21.5	-	6.08	-	-	-	11.66	-	-	-	7.5	-	-	-
1644	-	22.4	-	5.73	-	-	-	11.33	-	-	-	6.9	-	-	-
1747	-	24.2	-	6.49	-	-	-	12.50	-	-	-	7.2	-	-	-

# ALBEDO TORFOWISKA













**Janusz Olejnik,  
Marek Urbaniak,  
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Paweł Siedlecki,  
Damian Józefczyk,  
Marcin Baran,  
Mateusz Samson,  
Damian Józefczyk,  
Klaudia Ziemblińska,  
Marcin Stróżecki,  
Natalia Kowalska,  
Józef Moczko,  
Jerzy Roszkiewicz,  
Olga Zawitowska –  
Blacha.**



**DZIĘKUJĘ ZA UWAGĘ**