PAR Measurements in the Gulf of Trieste (northern Adriatic Sea)

Borut Umer[1] and Vlado Malačič[1]

[1]National Institute of Biology

November 23, 2022

Abstract

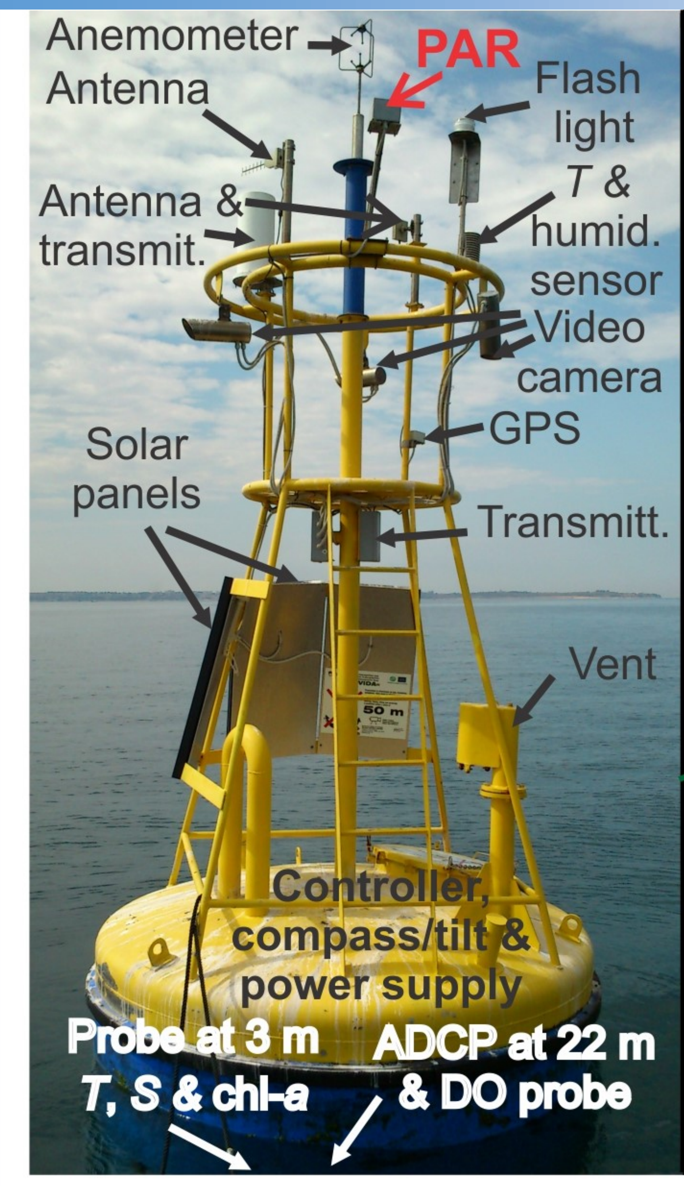
PAR (Photosynthetic Active Radiation) vertical profiles that were obtained from casts with the Sea and Sun MSS90 microstructure probe in the southern part of the Gulf of Trieste near buoy Vida were analyzed in the years from 2011 to 2015. PAR fortnightly profiles were explored with the linear fit of decrease with the depth of logarithm of PAR, normalized with its value in the air. The inverse relation between the coefficient of PAR attenuation and the Secchi disk depth was also validated. Also, other relations (e.g. the bi-exponential non-linear decrease of PAR with depth) were explored. Our findings about the attenuation of PAR and the Secchi disk depth are in line with the study conducted decades ago for the north-eastern part of the Gulf of Trieste (Stravisi, 1999). Furthermore, the initial values of PAR profiles measured with the Sea & Sun probe in the air before the cast were validated with the PAR values measured continuously on buoy Vida, about 100 m away from the profiling measurement station.

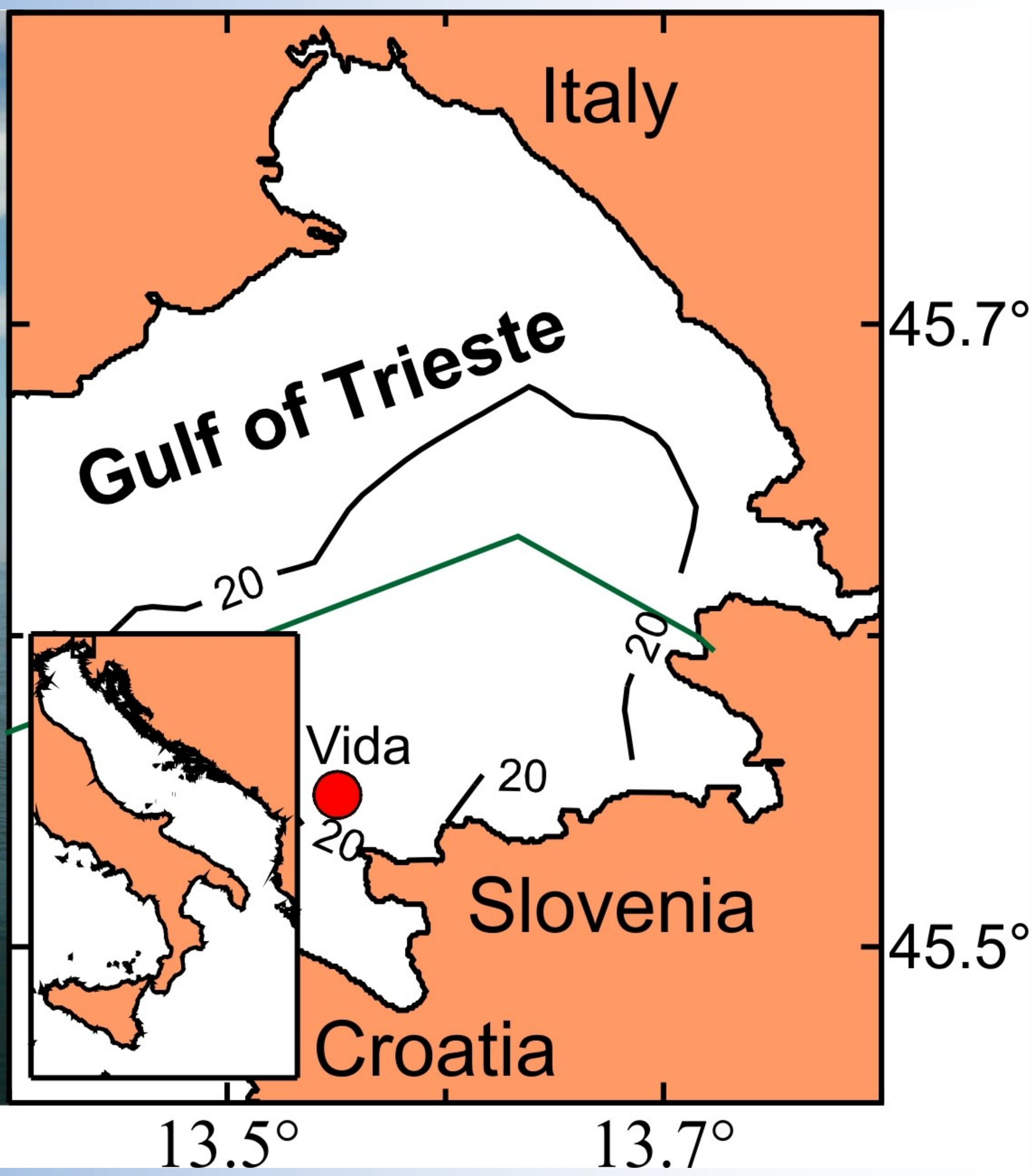
PAR Measurements in the Gulf of Trieste (northern Adriatic Sea)

NATIONAL INSTITUTE OF BIOLOGY
MARINE BIOLOGY STATION

Borut Umer, Vlado Malačič

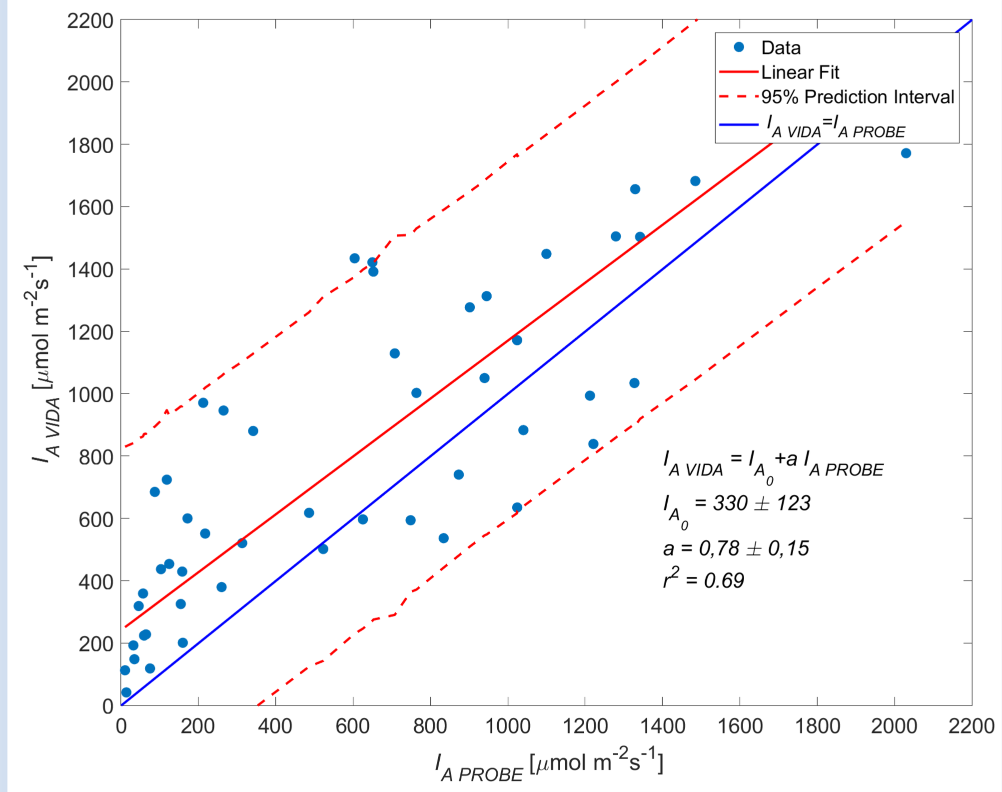
National Institute of Biology, Marine Biology Station, Fornače 41, 6330 Piran, Slovenia





The coastal buoy Vida is located in the northernmost part of the Adriatic Sea, the Gulf of Trieste. PAR sensor on buoy Vida (LI-COR LI 190 SL 50) is mounted at the height 4.5 m. PAR data are streaming with a frequency 4.26 Hz to the land receiving station 3.7 km away.

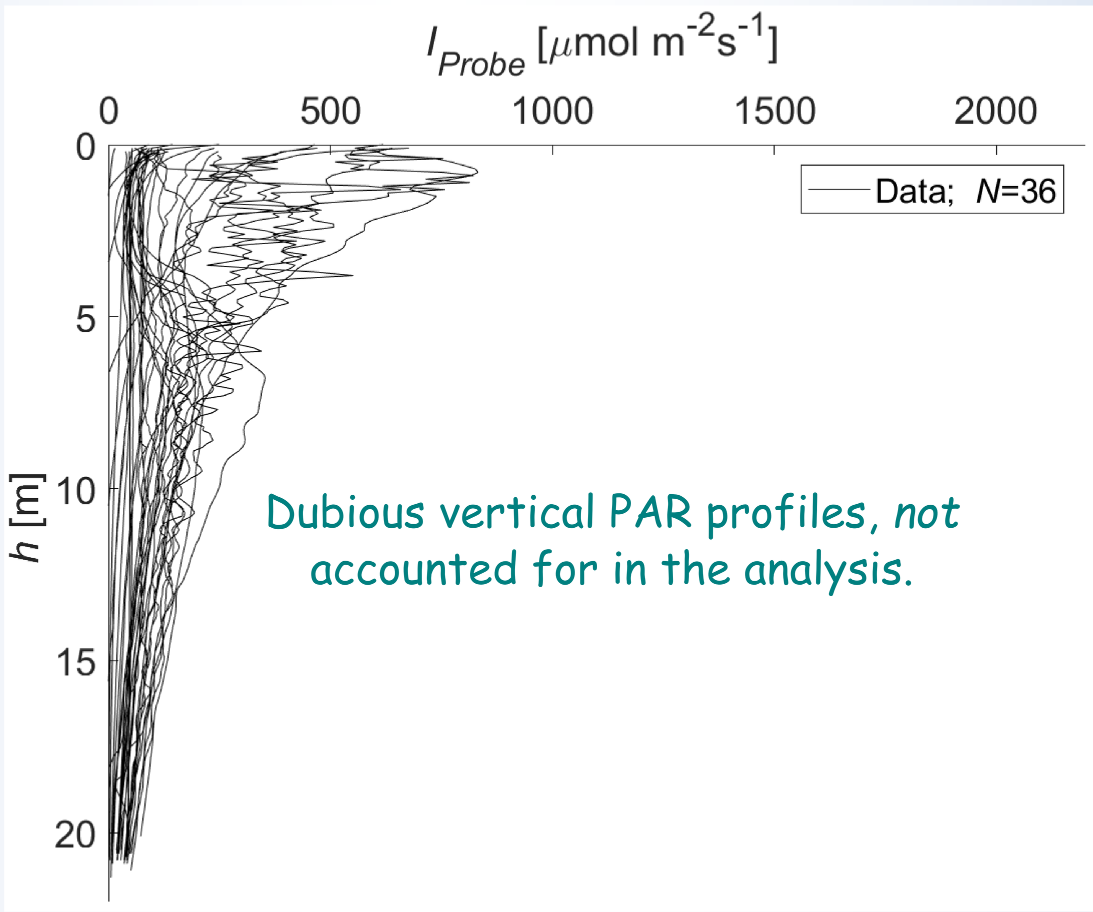
PAR sensor (LI-COR LI 192 SA) is also installed on top of a micro-structure probe (MSS90 Sea&Sun). The probe records data from each sensor with a frequency 1024 Hz. At the beginning of vertical cast, the probe records PAR in air for at least 10 s. Vertical distance between PAR sensor and the pressure sensor is 1.2 m, accounted for in data pairs (depth, PAR).

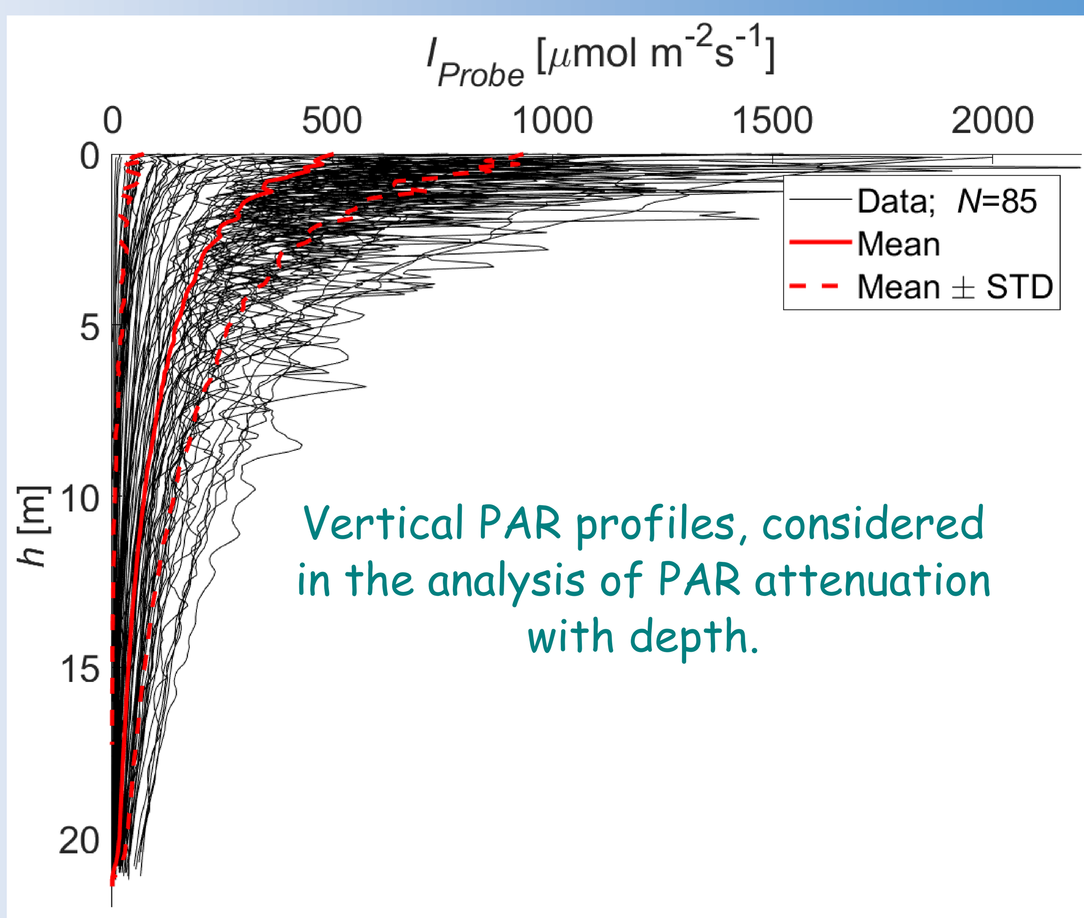


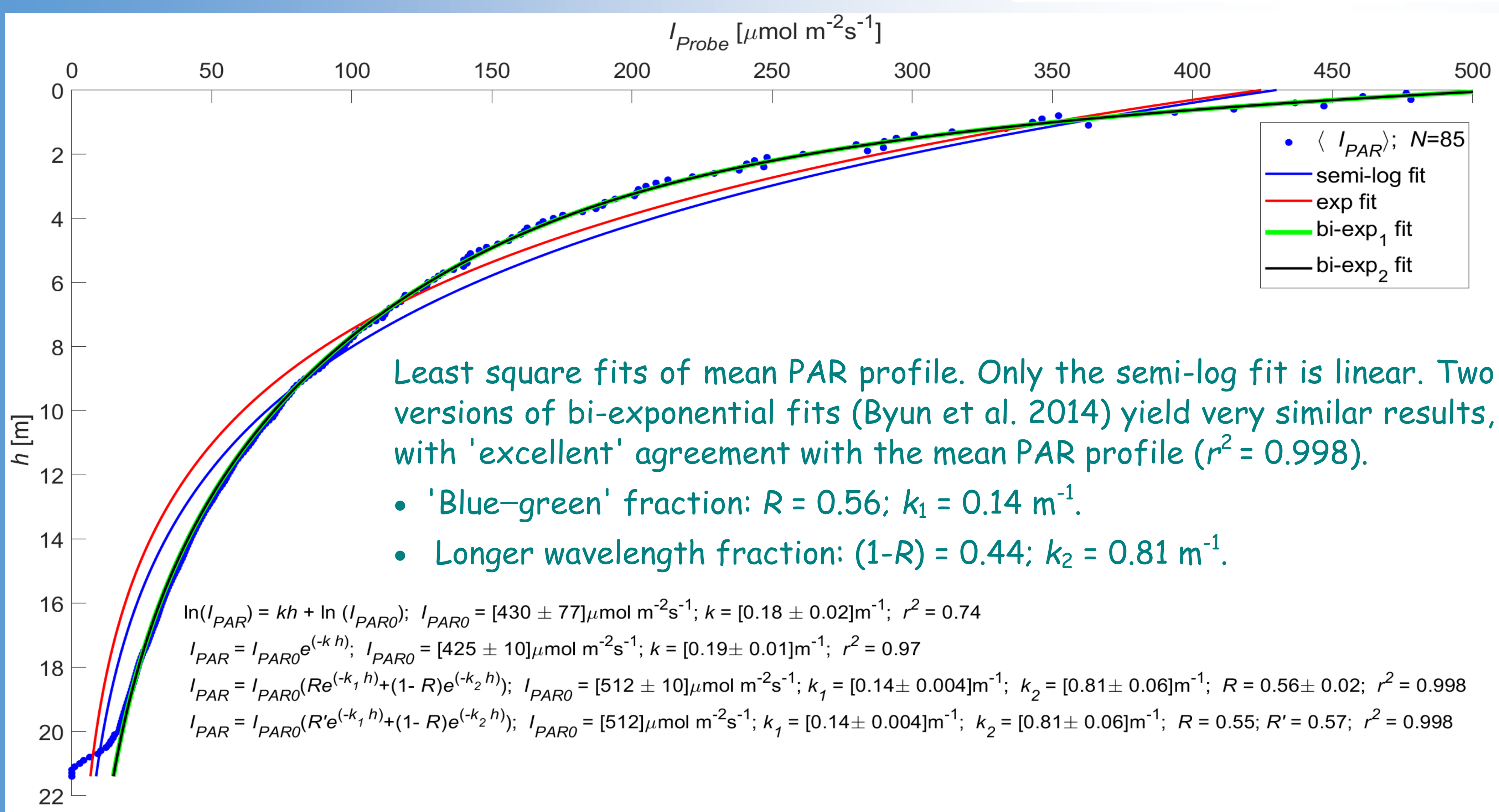
PAR data measured on Vida (15 min ⟨ ⟩) versus PAR data retrieved by casts by MSS90 probe (10s ⟨ ⟩) from July 2011 to December 2015. The majority of PAR values on Vida were higher than probe values. PAR sensor on the buoy is at height 4.5 m above the sea surface, while PAR sensor on the probe is 1 m above the sea surface at most, influenced by the shadow of the research boat (12 m in length).

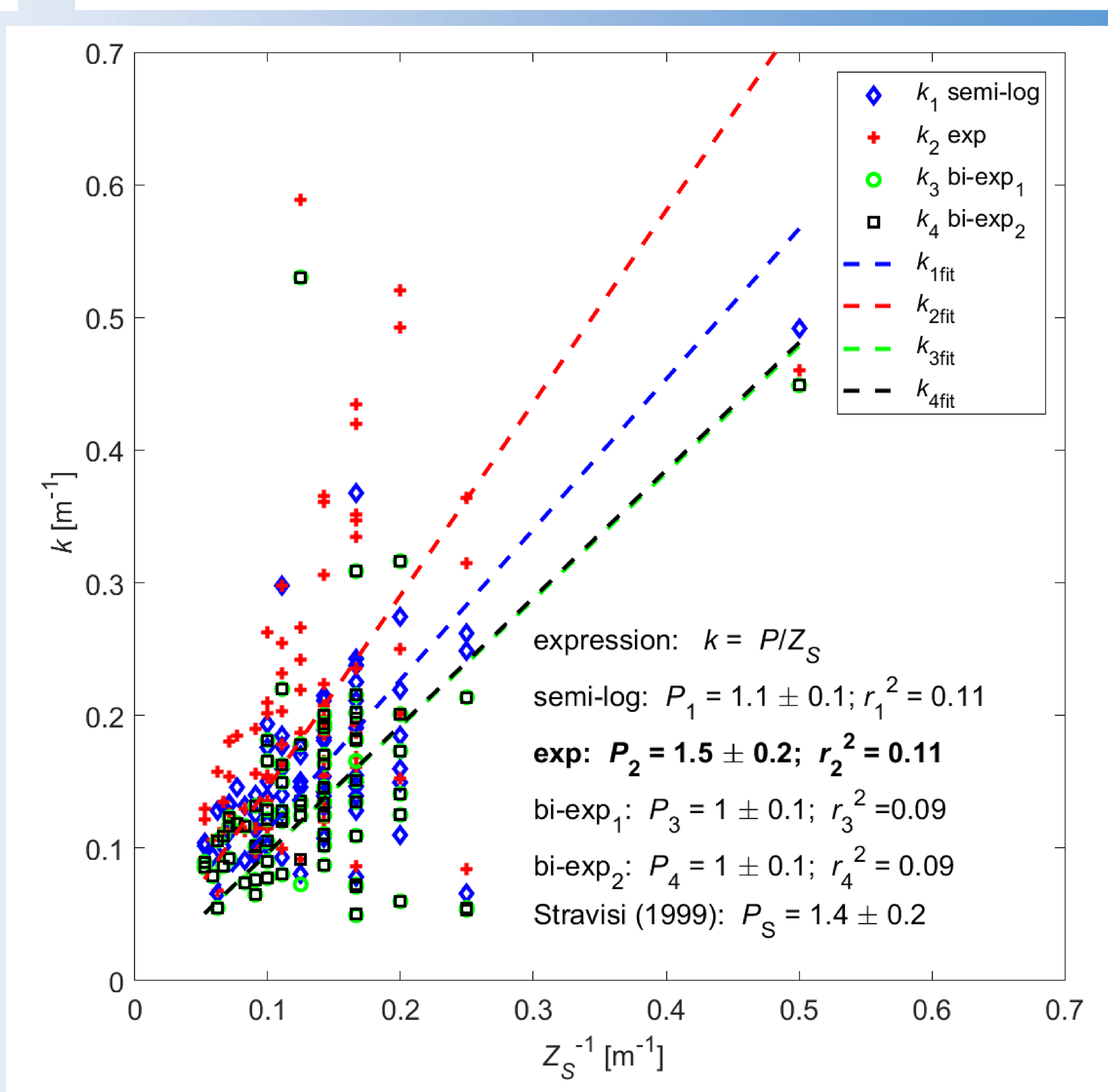
Type	Spring	Summer	Autumn	Winter	All
Reliable	18	22	26	19	85
Dubious	15	10	6	5	36

Number of PAR vertical profiles taken biweekly near buoy Vida for the period January 2010 to December 2015. Profiles for which PAR does not decrease with depth are marked as 'dubious'. Their number dominates by far in spring (surface fresh and turbid waters).









Poor agreement between attenuation coefficients and the inverse of (white) Secchi disk depth.

Best correlation: PAR profile is a single exponential function of depth. The parameter P then matches the value of previous study (Stravisi, 1999).

	$\ln(I_{PAR}) = -kh + \ln(I_0)$			$I_{PAR} = I_0\exp(-kh)$			$I_{PAR} = I_0[R\exp(-k_1h) + (1-R)\exp(-k_2h)]$					$I_{PAR} = I_0[R'\exp(-k_1h) + (1-R)\exp(-k_2h)]$								
	I_0 [mmol/(m^{2}s)]	k [m^{-1}]	r^2	I_0 [mmol/(m^{2}s)]	k [m^{-1}]	r^2	I_0 [mmol/(m^{2}s)]	k_1 [m^{-1}]	k_2 [m^{-1}]	R	r^2	I_0 [mmol/(m^{2}s)]	k_1 [m^{-1}]	k_2 [m^{-1}]	R'	R	r^2	$I(h=0)$ [mmol/(m^{2}s)]	Z_S [m]	k_S [m^{-1}]
⟨ ⟩	363	0.17	0.97	455	0.21	0.92	583	0.14	1.8	0.48	0.96	523	0.14	1.7	0.56	0.44	0.96	523	8.8	0.19
median	289	0.14	0.98	401	0.19	0.94	544	0.13	0.9	0.49	0.98	488	0.12	0.9	0.53	0.44	0.98	492	8.0	0.18
STD	319	0.09	0.03	389	0.11	0.07	485	0.08	3.8	0.15	0.05	445	0.08	3.8	0.22	0.20	0.05	445	3.7	0.09

Statistics of 71 vertical PAR profiles (out of 85), for which apportioning constants R and R' > 0. Z_S is the (white) Secchi disk depth. I_0(z=0) is the first PAR value ($0 \le h \le 0.1$ m) in the water column. k_S is the attenuation coefficient determined from the Secchi disk depths, according to Stravisi (1999): $k_S = 1.4/Z_S$. Mellor (2004) for the water type III (Jerlow, 1876) k = 0.13 m^{-1}.

Conclusions

When PAR is fitted with one exponential term: k = [0.2 ± 0.1]m^{-1}, with two exponential terms: k_1 = [0.13 ± 0.08] m^{-1} – the attenuation of the blue-green part of PAR, $k_1 < k$. This value for k_1 is found also by Byun et al. (2014) (k_2 and k_1 are exchanged). The apportion coefficient R is close to 0.5. Waters around buoy Vida are more turbid than the most turbid oceanic water Type III. Preliminary results: by fitting PAR values from coastal water Types (1,3,5,7,9) and oceanic Type III, digitized from Jerlov (1976, Fig. 130), we obtain that three attenuation coefficients of the PAR fraction that belong mostly to the blue-green wavelengths (k = 0.19 m^{-1}; k_1 = 0.14 m^{-1}) fall in the range between the *oceanic water Type III* (k = 0.18 m^{-1}; k_1 = 0.13 m^{-1}) and the *coastal water Type 1* (k = 0.22 m^{-1}; k_1 = 0.15 m^{-1}). However, the surface attenuation of PAR, dominated by the fraction with longer wavelengths (k_2 = 0.8 m^{-1}), is close to the *coastal water Type 7* (k_2 = 0.7 m^{-1}; Type 9: k_2 = 1.9 m^{-1}).

Literature:

***Byun, D.-S.**, X. Hua Wang, D. Hart, and M. Zavatarelli,* 2014: Review of PAR parameterizations in ocean ecosystem models. *Estuarine, Coastal and Shelf Science*, **151,** 318-323.
Jerlov, N. G., 1976: *Marine Optics.* Elsevier, 231 pp.
Mellor, G. L., 2004: Users guide for a three-dimensional, primitive equation, numerical ocean model (June 2003 version), 53 pp.
***Paulson, C. A.**, and J. Simpson,* 1977: Irradiance measurements in the upper ocean. *Journal of Physical Oceanography*, **7,** 952-956.
Stravisi, F., 1999: Optical properties in the Gulf of Trieste. *Bollettino della Società Adriatica di scienze*, **29,** 61-75.

Acknowledgment:

This work was supported by the Slovenian Research Agency (research core funding No. P4-0165) and program for young researchers in 2018.