WASI Training V:
Spectral field data – measurements

Peter Gege

DLR, Earth Observation Center, Remote Sensing Technology Institute, Oberpfaffenhofen, 82234 Wessling, Germany. peter.gege@dlr.de

MONEO-WET Workshop

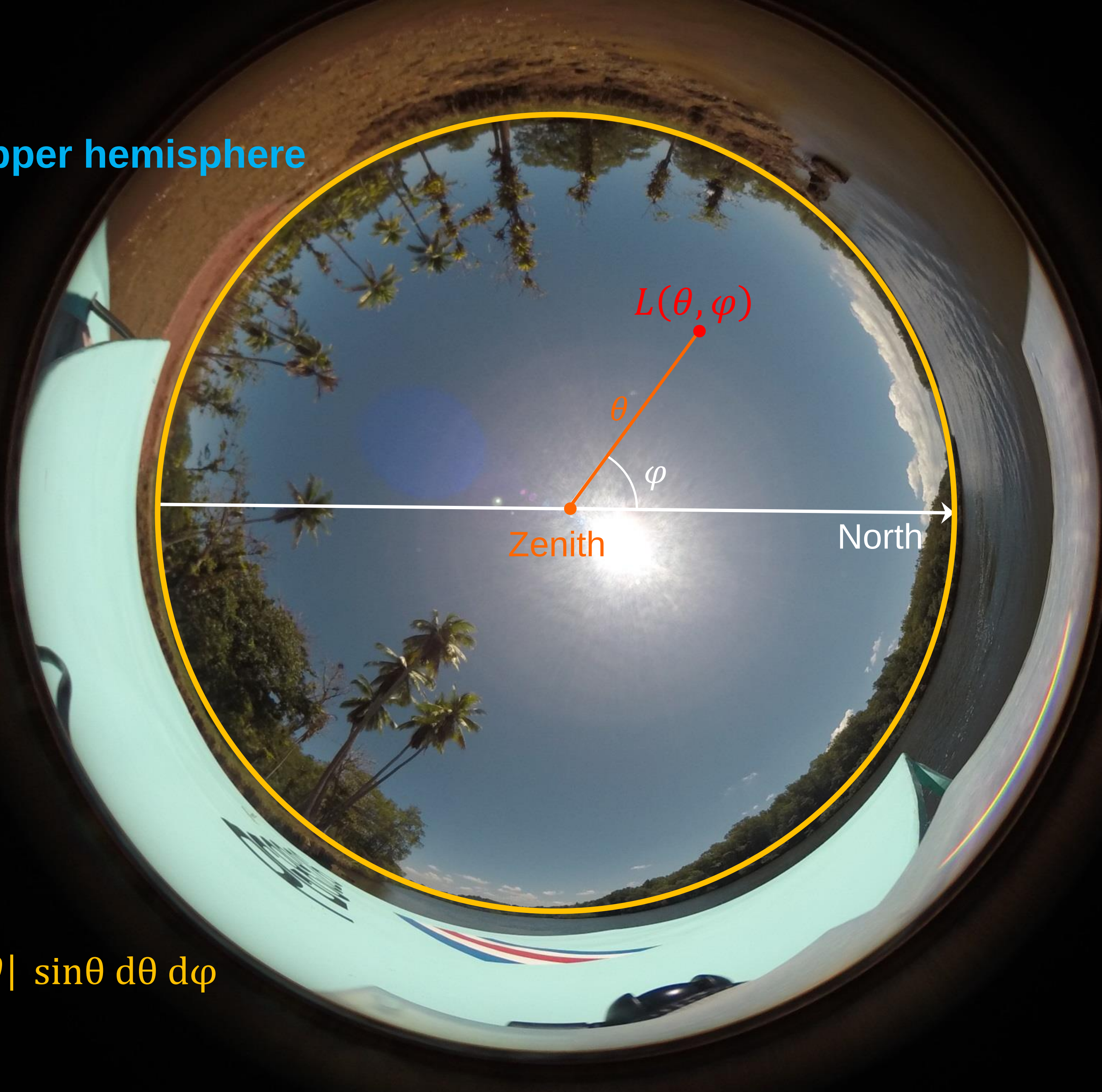
Sierpe, Costa Rica, 12-22 March 2019

DLR

Illumination

Light source is the upper hemisphere

θ: Zenith angle
φ: Azimuth angle



Upper hemisphere:

θ = 0..90° = 0.. $\pi/2$
φ = 0..360° = 0.. 2π

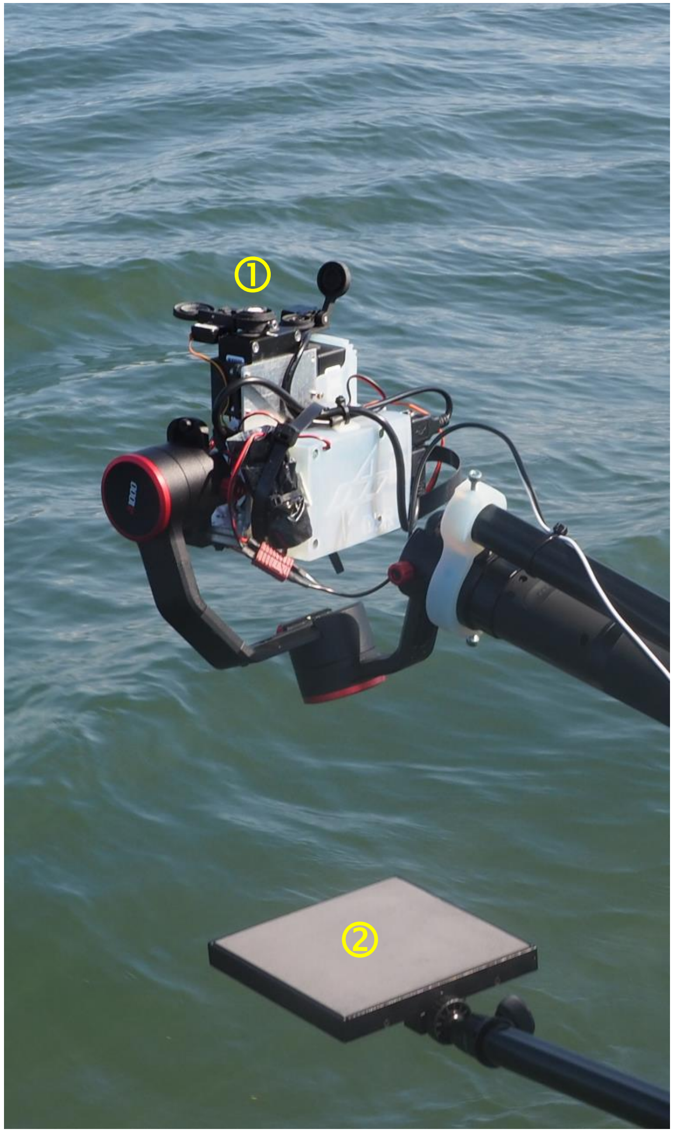
Downwelling irradiance:

$$E_d = \int_0^{2\pi} \int_0^{\pi/2} L(\theta, \varphi)\, |cos\theta|\, \sin\theta \, d\theta \, d\varphi$$

Irradiance Measurement
DLR‘s Ocean-Optics Sensor System (OOSS)

Two measurement methods

- Direct: Cosine collector ①
- Indirect: Diffusor plate („Spectralon“) ②



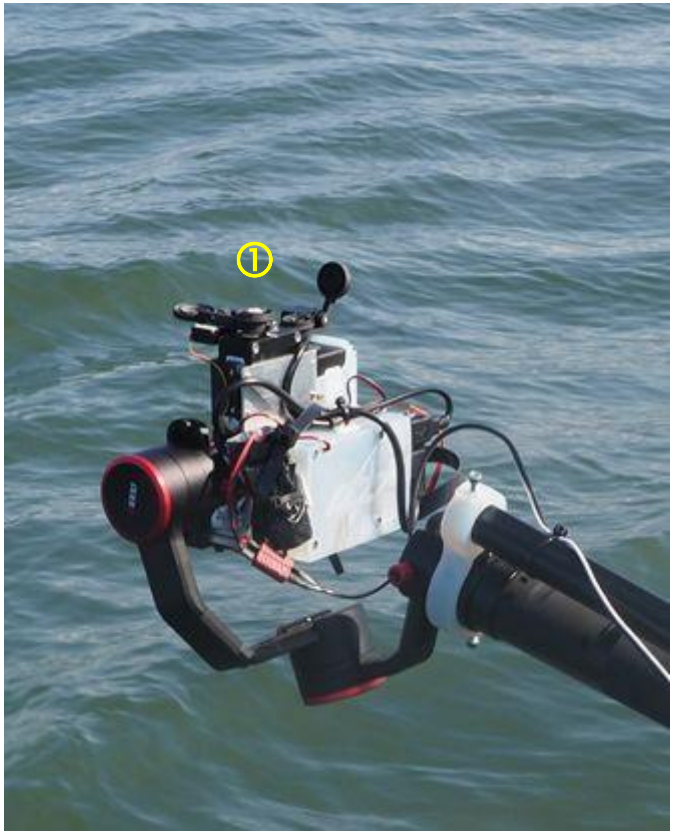
Irradiance Measurement
Cosine collector method

$$E_d(\lambda) = R_E(\lambda) \cdot (S_E(\lambda) - D_E(\lambda))$$

$R_E(\lambda)$: Irradiance response (from laboratory)
$S_E(\lambda)$: Signal of irradiance sensor [DN]
$D_E(\lambda)$: Dark current of irradiance sensor [DN]

Comments

- The angular response of $R_E(\lambda)$ must be proportional to $cos\theta$ to measure $E_d = \int_0^{2\pi} \int_0^{\pi/2} L(\theta,\varphi)\ |cos\theta|\ \sin\theta\ d\theta\ d\varphi$
- It is very difficult to produce a cosine collector with a good $cos\theta$ response
- The manufacturer Ocean Optics doesn‘t specify the uncertainty of its cosine collector, hence we do not trust these types of collectors to have an accurate cos characteristics
- We do not believe that our cosine collector is of „good quality“ w.r.t. the cosine law

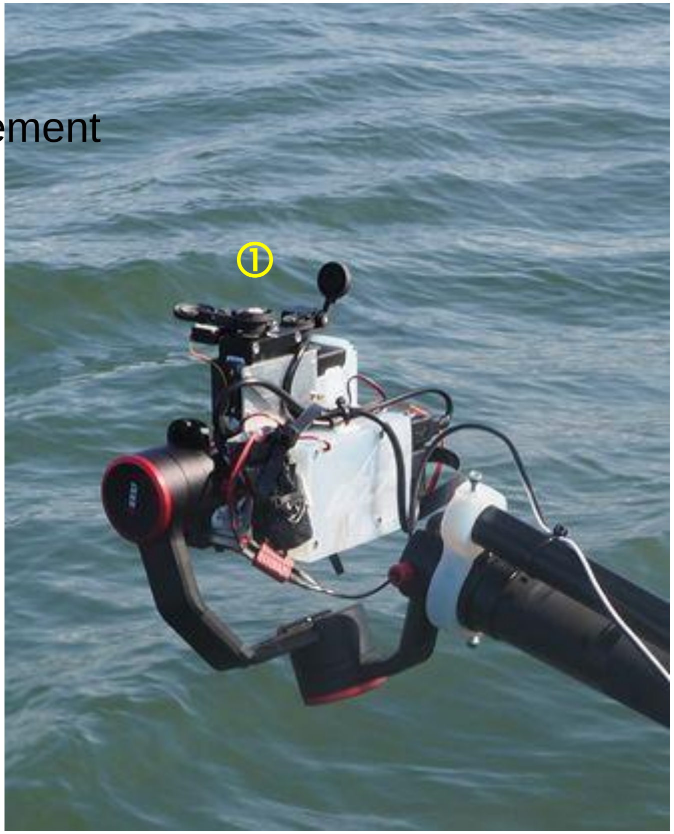


Irradiance Measurement
Cosine collector method

We use the cosine collector to measure the *changes* $\Delta_E(\lambda, t)$ of the downwelling irradiance

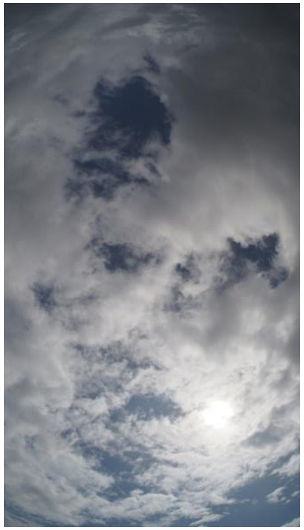
$$E_d(\lambda, t) = E_d(\lambda, t_0) \cdot (1 + \Delta_E(\lambda, t))$$

$E_d(\lambda, t_0)$: Irradiance at the time t_0 of the reference measurement
$E_d(\lambda, t)$: Irradiance at a later time t
$\Delta_E(\lambda, t)$: Relative change of irradiance

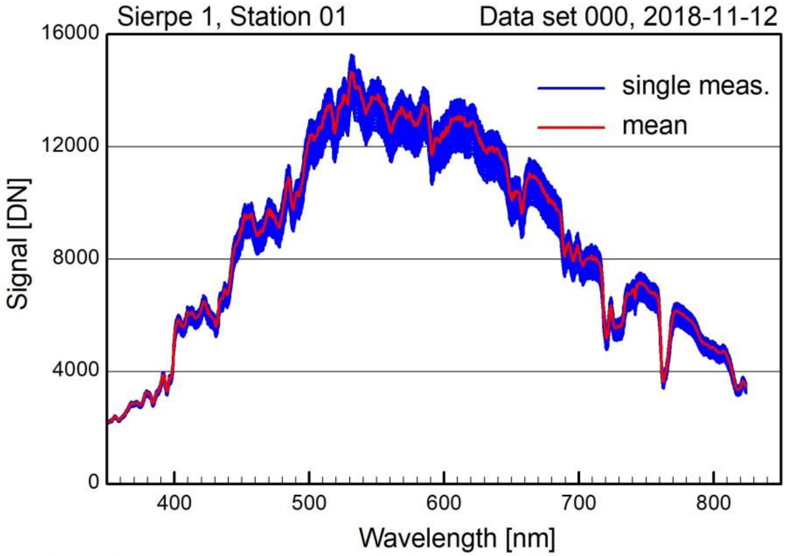


These relative measurements are not very much affected by imperfect cos charactics of the sensor head

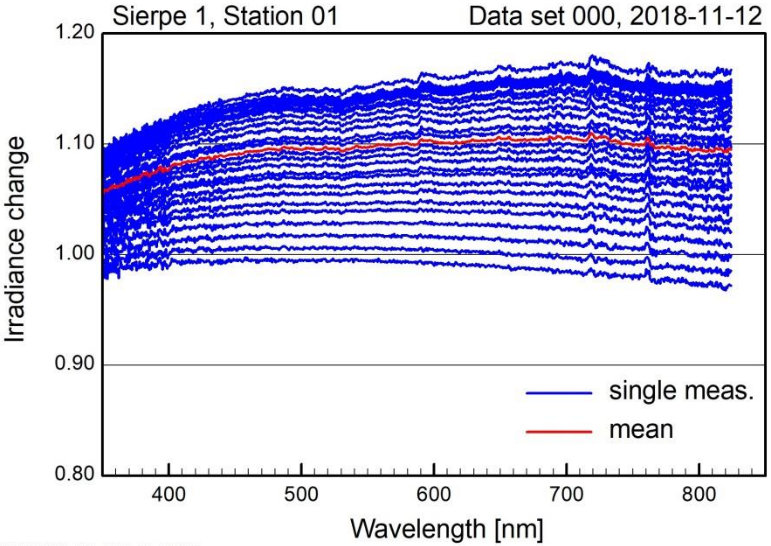
Irradiance Measurement
Cosine collector method



Example of irradiance change under unfavourable illumination conditions (broken clouds)

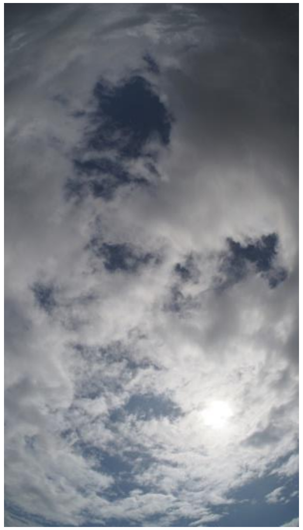


20181112_01_000_EDT | 18.1.2019

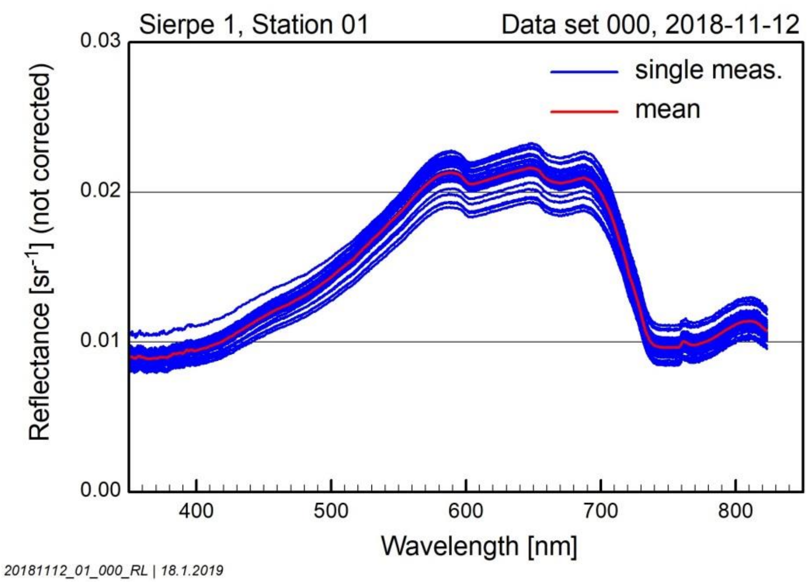


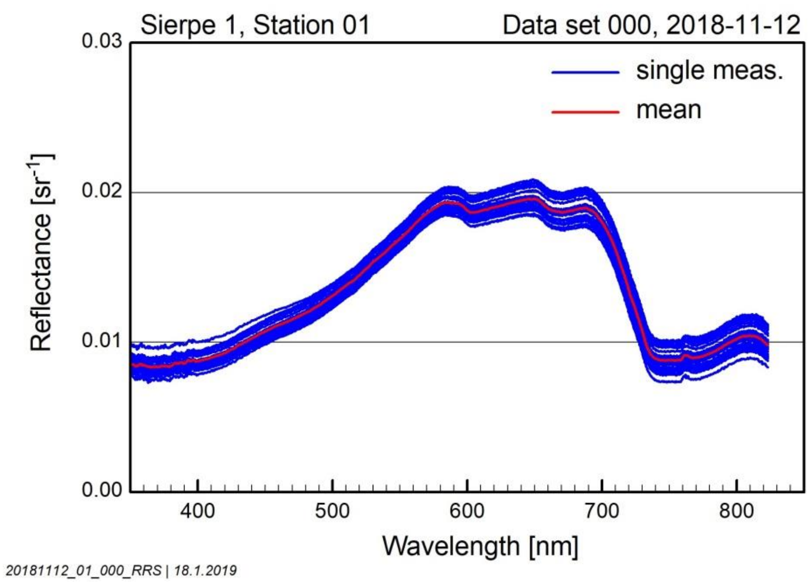
20181112_01_000_RE | 18.1.2019

Irradiance Measurement
Cosine collector method



Example of reflectance measurements and their correction under unfavourable illumination conditions (broken clouds)





uncorrected reflectance

reflectance corrected using cosine collector

Irradiance Measurement
Diffusor plate method

$$L_r(\lambda) = \rho_{plate} \cdot R_{Lr}(\lambda) \cdot (S_{Lr}(\lambda) - D_{Lr}(\lambda))$$
$$E_d(\lambda) = \pi \cdot L_r(\lambda)$$

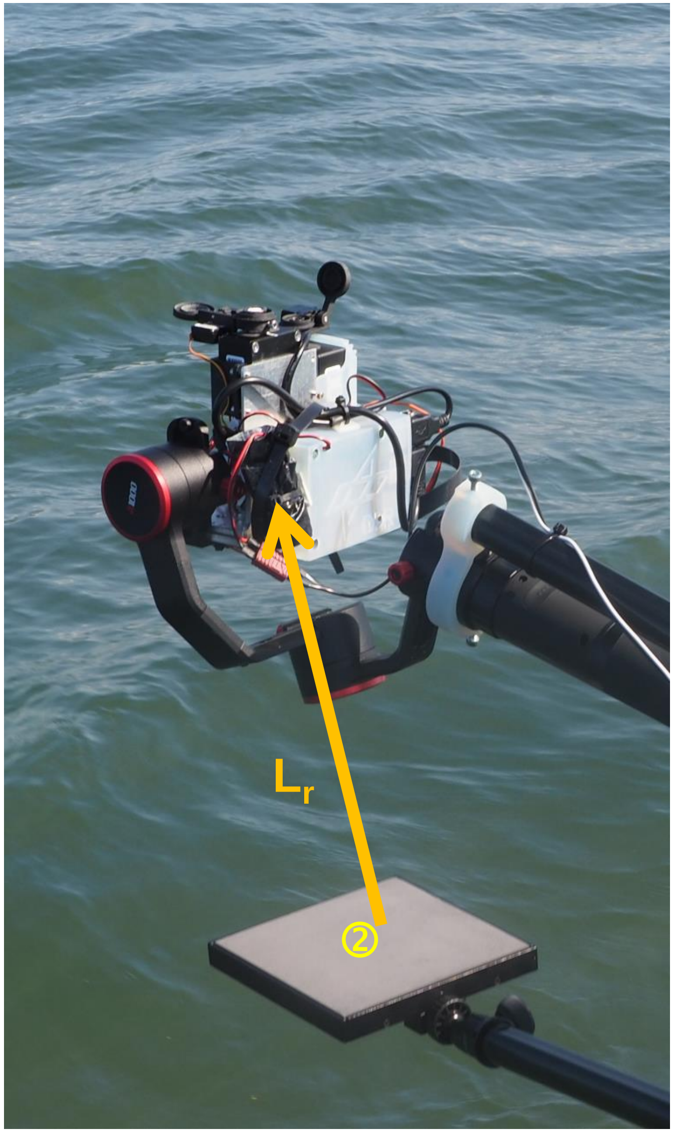
$L_r(\lambda)$: Radiance of diffusor plate

ρ_{plate}: Reflectance of plate (from laboratory)

$R_{Lr}(\lambda)$: Response of L sensor (from laboratory)

$S_{Lr}(\lambda)$: Signal of L sensor during reference meas. [DN]

$D_E(\lambda)$: Dark current of L sensor during ref. meas. [DN]



Comment

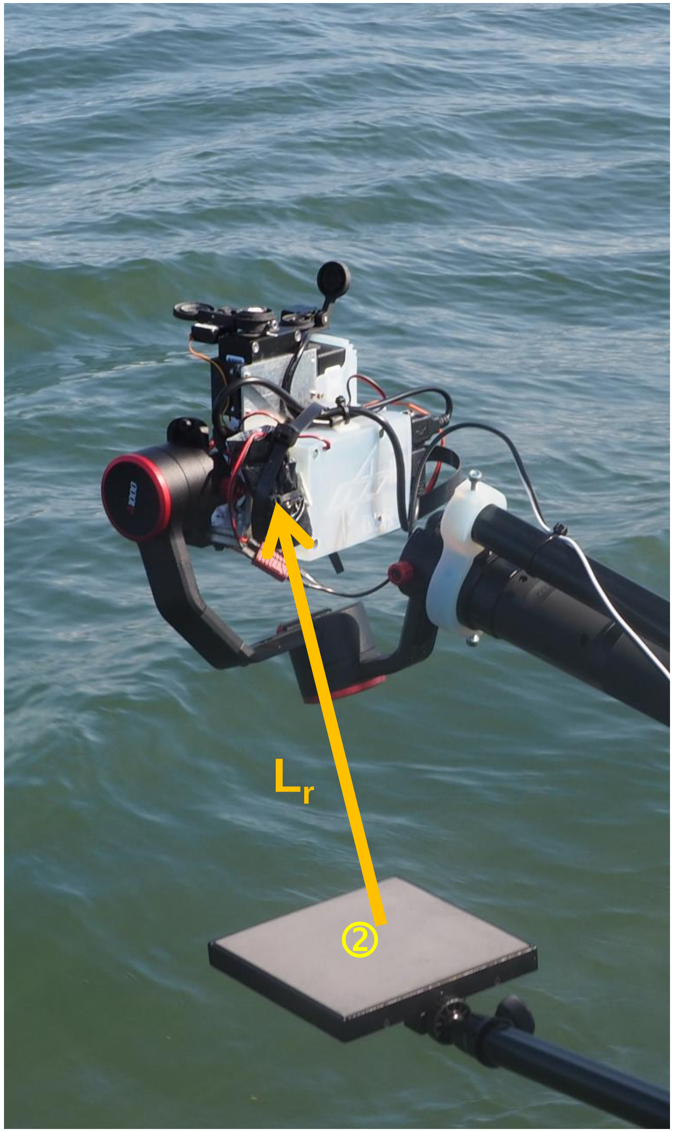
- Spectralon plates are known to have good cosine characteristics

Irradiance Measurement
Diffusor plate method

Main advantage of this method:

$E_d(\lambda)$ is measured with the same instrument as $L_u(\lambda)$ of the target

- No spectral artifacts from instrument differences
- Sensor response must not be known for deriving reflectance



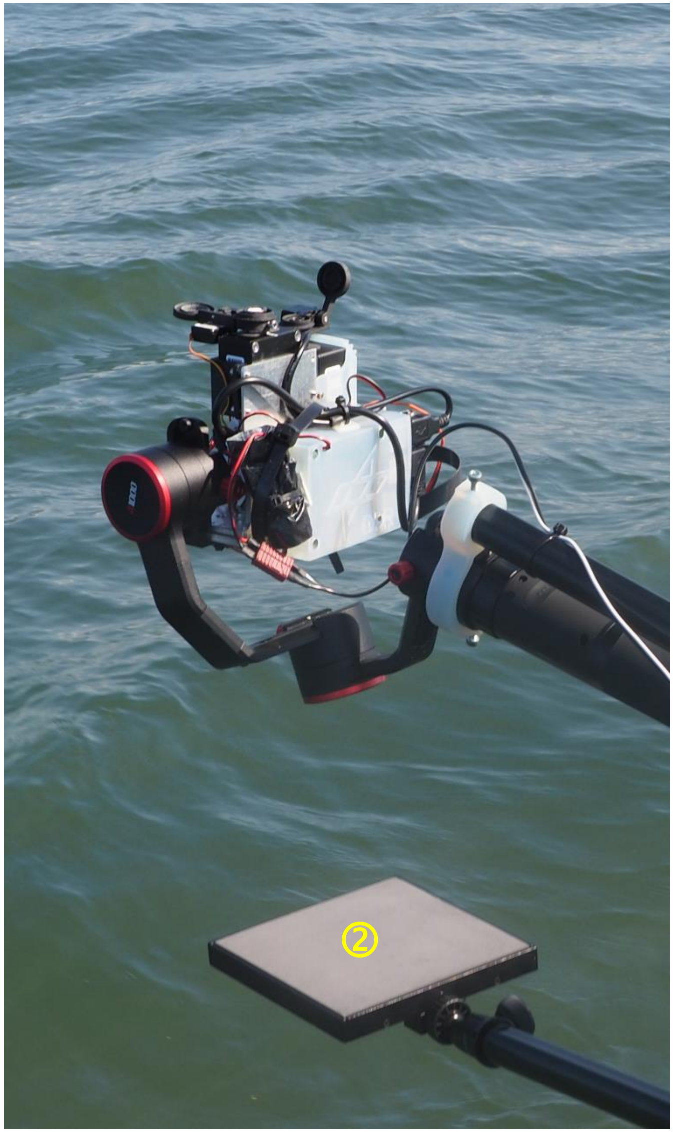
Irradiance Measurement
Diffusor plate method

Recommendations

Following Castagna et al. (2019)

- Chose viewing angle close to 0° for gray plate
- Chose sensor distance > 20 cm
- Ensure level orientation: trained operator or gimble mount
- Ensure that sensor field of view is inside plate
- Minimize impact of operator: dark clothing or plate at sufficient distance
- Select position on the boat which minimizes impact of surrounding structures
- Record at least 10 sequential measurements
- Flag stations with a coefficient of variation > 6 %

Best results are obtained for sun zenith angles between 20° and 60°, stable illumination and up to moderate sea-state



DLR