DOWNWELLING SOLAR IRRADIANCE AS A CRITICAL PARAMETER FOR IN-SITU MEASUREMENTS IN THE MERMAID DATABASE

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ABSTRACT

The MERIS MAtchup In-situ Database (MERMAID) provides an essential tool for MERIS calibration and validation activities of ESA's Medium Resolution Imaging Spectrometer (MERIS). MERMAID comprises in-situ ρ_w from several measurement approaches, from fixed buoys and towers to floating instrumentation rigs. Analysis of the provided measurement protocols and the matchup data (in-situ and MERIS) has identified that sensor tilt seriously affects measurements of surface irradiance, and has consequent impacts on the accuracy of water reflectance, ρ_w, and matchup results. Activities intrinsic to the third MERIS reprocessing, such as the development of the vicarious adjustment gains computation, depend intrinsically on the MERMAID matchups and as such it is essential to ensure the quality of in-situ irradiance data. Results indicated the need to include in MERMAID 'homogenised' versions of datasets (consistent with MERIS assumptions), and stressed the need to investigate further the potential for tilt correction of E_s.

1 INTRODUCTION

1.1 MERIS QWG and the third MERIS Reprocessing

Within the framework of the MERIS Data Quality Working Group (QWG) and the MERIS Validation Team (MVT) fall the calibration and validation (CalVal) activities essential for product assessment and quality assurance of ESA's Medium Resolution Imaging Spectrometer instrument (MERIS; onboard ENVISAT). Current activities are focused on the forthcoming MERIS third reprocessing, and include analysis and assessment of MERIS atmospheric correction over water, e.g. [1] and revision of the Bright Pixel Atmospheric Correction [2] , vicarious gain adjustment [3], and field validation campaigns [2, 4].

An integral requirement of these activities is a reliable source of quality in-situ radiometric data (namely water reflectances, ρ_w) inclusive of the metadata and parameters, with concurrent MERIS matchup data. Vicarious adjustment, for instance, requires in-situ ρ_w for computations of near-infrared (NIR) and visible calibration gains by which MERIS ρ_w is adjusted.

The requirement for a MERIS-dedicated database of in-situ to MERIS matchups to support QWG CalVal activities and enable the assessment of the MERIS L2 products delivered by the ENVISAT ground segment has driven the creation and development of the MERis MAtchup In-situ Database [5]. Given the dependence of certain aspects of the third reprocessing on MERMAID data, it is essential to know the accuracy of in-situ ρ_w, which is inherently dependant on surface irradiance, E_s, as in Eq. 1:

$$\rho_w(\lambda) = \frac{\pi . L_w(\lambda, \theta_v, \theta_s, \Delta\phi_{vs})}{E_s(\lambda, \theta_s)} \quad (1)$$

in which L_w is the water-leaving radiance at wavelength λ, and θ_s, θ_v, $\Delta\phi_{vs}$, respectively the solar and view zenith angles, and the relative azimuth angle between the sun/view directions.

1.2 Objective

This paper aims to demonstrate how inaccuracies in E_s may impact on the in-situ ρ_w and MERIS matchup data in the MERMAID database, and therefore on any studies relying on them. Furthermore, we discuss the current solution to the issue and possibility of an operational tilt correction in MERMAID in the future.

2 MERMAID

2.1 The database

MERMAID provides a valuable tool for the CalVal activities essential for MERIS Level 2 product assessment and quality assurance, and is the only repository for ESA MERIS matchup data, for both in-situ and MERIS acquisitions. Principle Investigators (PI) may contribute to the development of this valuable resource by submitting their radiometric data for matchup with reduced resolution (RR) MERIS imagery. Any data format is accepted from the researcher, as long as it includes ρ_w, or the parameters required for computing ρ_w (i.e. water-leaving radiances, L_w, and the surface irradiance, E_s or E_d (0^+)), and the meta data (such as latitude, longitude, date and time). Additionally, PI's may submit the illumination geometry (sun zenith angle, θ_s) and chlorophyll-a (Chl) if available. The latter two are not essential as they may be computed. Finally, and crucially, PI's are required to provide a detailed written description of their measurement and processing protocols (see section 2.2).

Fully normalised water reflectance, ρ_{wn} (λ) constitute the main matchup datasets in MERMAID (in-situ and MERIS); ρ_w are fully normalized to zenith sun or nadir viewing angle following [6, 7, 8]. MERMAID recently evolved and expanded to provide in-situ ρ_{wn} at up to 13 MERIS bands (the 2 strong O_2 and H_2O absorption bands at 761 and 900 nm being discarded). Recently, in-situ aerosol optical parameters (AOPs) were included for matchup, such as the aerosol optical thickness (τ_a(λ)) and the Angström exponent (α(λ)). These AOPs mainly derive from the solar extinction measurements stored in the AERONET-OC database (AErosol RObotic NETwork for Ocean Colour) [9].

MERIS parameters, from the matchup extraction procedure for Level 1 (L1) to Level 2 (L2) processing, include (in addition to ρ_{wn} and ρ_w, the aerosol model and AOPs) and atmospheric functions (*i.e.*, the total upwelling, T_u (λ,θ_s), and downwelling, T_d (λ,θ_v), transmittances for the molecules and the aerosols), atmospheric gaseous (water-vapour and ozone content), surface parameters (wind-speed and surface pressure), water constituents and data quality flags. The radiance at the top of atmosphere in each of the 13 MERIS spectral bands are also stored.

MERMAID data is accessed via a versatile web interface at http://hermes.acri.fr/mermaid (Fig. 1), allowing users to specify their own extraction criteria for any date range and matchups site, of which there are now 14 in the database, including the AERONET-OC sites , NOMAD , MOBY , BOUSSOLE , SIMBADA and a number of coastal sites [references can be found in 10]. Extraction data is password restricted and a strict data policy applies. MERMAID is a joint effort between ARGANS Ltd (UK) and ACRI-ST (France), funded by ESA.

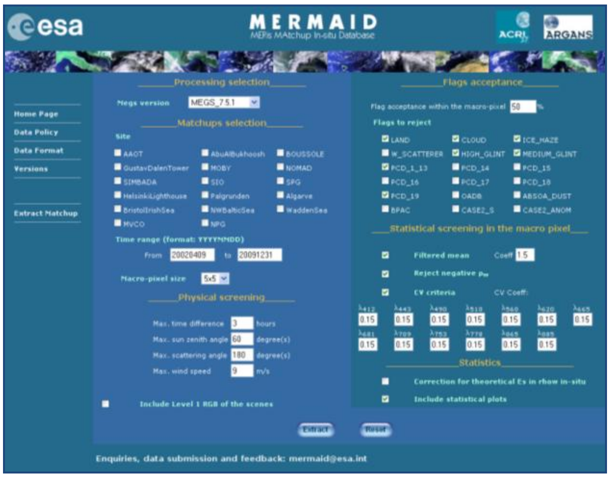

Figure 1: The MERMAID data extraction webpage on the MERMAID website.

2.2 MERIS Optical Measurement Protocols

MERMAID comprises in-situ ρ_w from several measurement approaches and instruments, from fixed buoys and towers to floating instrumentation rigs. Instrumentation systems include the AERONET-OC SeaPRISM (CIMEL) network, handheld radiometers, TACCS (Tethered Attenuation Coefficient Chain Sensor radiometer, Satlantic), fixed buoys, and freefall profilers. The measurement protocols of all the datasets in MERMAID have been provided by the respective PI and reported in a comprehensive document covering MERMAID and its optical datasets, with the specific focus on the measurement systems and processing of the in-situ radiometric data. The document, the MERIS Optical Measurement Protocols [10], will be made available on the MERMAID website.

The preparation of the document highlighted some areas of methodologies which are particularly sensitive to measurement errors, thereby having consequences for the data being included in MERMAID. In particular, the measurement of E_s (λ), which is necessary for computing ρ_w, was found to be sensitive to buoy/instrument tilt (thus this is not an issue for the AERONET-OC platforms) resulting in an underestimate of measured E_s compared with what is derived from MERIS matchup data. Some other sources of error on ρ_w may also be present, but they will not be examined here.

3 IMPACT OF SENSOR TILT ON SURFACE IRRADIANCE MEASUREMENTS

3.1 The principle of sensor tilt

The surface spectral irradiance, E_s (W.m^{-2}.nm^{-1}) collected by a horizontal flat detector at sea level is computed as the integral of the radiation field, L (φ, θ), weighed by the cosine of θ, over the upper hemisphere (downward directions). E_s is the sum of two contributions: the direct flux, corresponding to the sunlight extinction, and the diffuse flux from the scattered light by atmospheric particles (aerosols and molecules). Because of wind just above sea level and/or marine currents a surface collector, although ballasted by a weight, may not always be parallel to a flat sea surface. In this case, the sensor is tilted in an off-nadir direction defined by (θ_t, ϕ_t), the tilt zenith and azimuth angles, respectively When sensor tilt occurs the sky contribution viewed by the irradiance collector differs from the one observed by a perfectly horizontal detector. Consequently, the tilt effect must be accounted for in the computation of the total downwelling flux. Figure 2 illustrates a case of sensor tilt with the TACCS system employed at Sagres (South West Portugal). We can see that even relatively calm waters may cause significant tilt on the sensor.

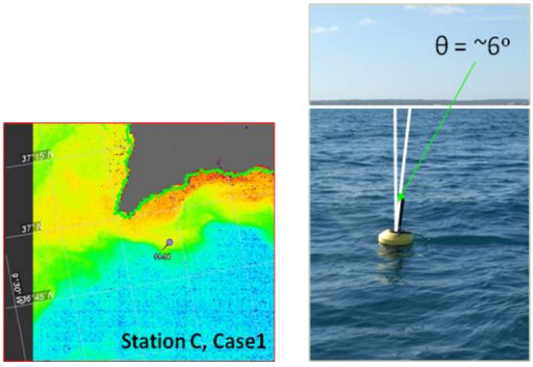

Figure 2: Tilt on the TACCS buoy at station C, Sagres, Portugal.

To illustrate the effect of tilt on the irradiance measurement, assume, for the sake of simplicity that for a perfectly horizontal flat detector (and omitting λ for brevity), in-situ E_s (termed 'E_{s_IS}') is defined as Eq. 2:

$$E_s = (F_o\, T_d(\theta_{s\_IS}))\cos(\theta_{s\_IS}) \qquad (2)$$

with: $$T_d(\theta_{s\_IS}) = T_R(\theta_{s\_IS})\cdot T_a(\theta_{s\_IS})\cdot T_{O3}(\theta_{s\_IS}) \qquad (3)$$

where:

- E_0 is the extraterrestrial solar irradiance [11 corrected for the square of sun-earth distance (d^2).
- θ_{s_IS} is the solar zenith angle computed for/measured at the time of the in-situ measurement,
- $T_R(\theta_{s\_IS})$ is the total downwelling *Rayleigh* transmittance, given by [12] $T_R(\theta_{s\_IS}) = \exp\left[-0.5\cdot\tau_R/\cos(\theta_{s\_IS})\right]$, with τ_R the *Rayleigh* optical thickness,
- $T_a(\theta_{s\_IS})$ is total downwelling aerosol transmittance, given by [12]. $T_R(\theta_{s\_IS}) = \exp\left[-0.16\cdot\tau_a/\cos(\theta_{s\_IS})\right]$, with τ_a the aerosol optical thickness, determined at a given λ by using the spectral dependence of the aerosol model, (*Angström* exponent, α) as:

  $$\tau_a(\lambda) = \tau_a(865)\cdot(\lambda/865)^{-\alpha}$$

- $T_{O3}(\theta_{s\_IS})$) is the ozone transmittance in the downward direction, expressed as,

  $$T_{O3}(\theta_{s\_IS}) = \exp\left[-\tau_{O3}\cdot u_{O3}/\cos(\theta_{s\_IS})\right]$$

  with u_{O3} the ozone amount (*cm-atm*), and τ_{O3} the ozone optical thickness.

The aerosol parameters (model, τ_a, α) can be extracted from MERIS L2 aerosol product, u_{O3} and τ_a. The Rayleigh optical thickness (τ_R) is computed for each MERIS wavelength with the formulation of [13], and corrected for the sea surface pressure given in the MERIS L2 product. The τ_{O3} have been calculated for a reference amount u_{O3} of 1cm-in the 15 MERIS bands. See [14], the MERIS Reference Model Document (RMD), for further details.

For a tilted collector, the direct surface irradiance can be expressed as Eq.4:

$$E_s = F_o\cdot\left[\cos(\theta_s).\cos(\theta_t).-\sin(\theta_s)\cdot\sin(\theta_t)\cdot\cos(\phi_s-\phi_t)\right]\cdot t_d(\theta_s) \qquad (4)$$

in which ϕ_s and ϕ_t stand for the solar and tilt azimuth angles, respectively (considering the North geographic direction as the reference), and t_d (θ_s) is the direct downward transmittance, defined as: $e^{-\tau/\cos(\theta_s)}$. The total optical thickness (τ) is defined as: $\tau = \tau_R + \tau_a + \tau_{O3}$

For small angles of zenith tilts (θ_t < 5°), Eq. 3 can be expressed as Eq. 5:

$$E_s \approx F_0\cdot[\,\cos(\theta_s)\cdot\cos(\theta_t) - \sin(\theta_s)\cdot\theta_t\cdot\cos(\phi_s-\phi_t)\,]\cdot t_d(\theta_s) \qquad (5)$$

This means that the relative error on E_s due to the tilt effect can be approximated by Eq. 6:

$$\frac{\Delta E_s}{E_s} \approx -\tan(\theta_s)\cdot\theta_t\cdot\cos(\phi_s-\phi_t).t_d(\theta_s)/T_d(\theta_s) \qquad (6)$$

In the worst configuration case where the sensor tilt is in the solar plane, and for a tilt in the backward scattering region ($\phi_s = \phi_t$) we can expect for θ_t=5°, a relative error from 5% (θ_s=30°) up to 15% (θ_s=60°) on E_s by assuming that the ratio t/T is close to 1 for small τ_a's. These approximate figures are dependent on λ.

3.2 Error on E_s induced by the sensor tilt

An investigation of E_s was carried out initially for a site in South West Portugal (PI: John Icely, Sagremarisco Lda, Portugal), a site of interest due its relatively dust-free atmospheric composition. A dataset of E_s measured in-situ with a Satlantic radiometer was selected, and, using the location, date and time of each in-situ acquisition, the theoretical value of E_s was estimated with Eq. 1 using atmospheric parameters from MERMAID. Fig. 3 displays the comparison between computed and measured E_s, in which it clearly appears that the theoretical E_s is overestimated by about 20% in relative value, whatever the wavelength.

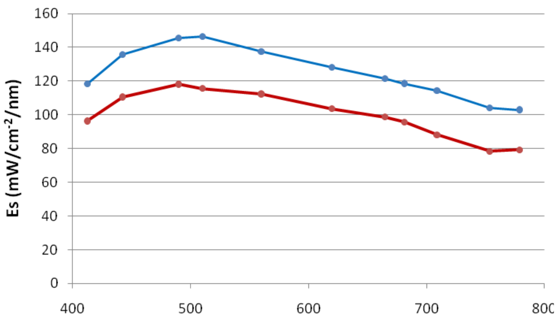

Figure 3: Comparison between theoretical E_s value (blue line) using MERIS extractions and measured E_s (red line) by a tilted irradiance collector at station 'C' (Sagres, Portugal).

Fig.4 illustrates the impact of tilt added in the half of solar plane (φ_s-φ_t=0°) including the sun direction, on E_s. The red curve represents the E_s spectrum simulated, for a tilt angle (θ_t) of 10° above the sun direction, while the yellow one stands for the case of a tilt of -10 ° below the sun direction. Some deviations (up to 40% in relative value) clearly appear between each of these two spectra with the nominal spectrum without tilt (thin black curve). Moreover, the measured E_s spectrum (thick black curve) from the TACCS (Satlantic) remains very close to the E_s spectrum simulated with a tilt of -10°, implying that this TACCS spectrum was affected by tilt.

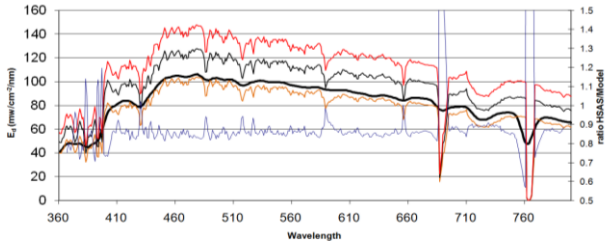

*Figure 4: Comparison of E_s measured by the TACCS buoy at station C (Sagres, Portugal) on 2nd October 2008. Legend: - **in-situ E_s**; Modeled E_s with -10° tilt; Modeled E_s with +10° tilt; total E_s (modeled, no tilt); ratio in-situ: modeled (no tilt).*

The impact of tilt on surface irradiance has been further investigated by [15] using the Successive Orders (SO) of scattering code to compute separately the two contributions of E_s:

- the direct solar flux (Φ_D) corresponding to the attenuated part of the solar beam weighted by the cosine of the incident angle to the collector (θ_t),
- the diffuse flux (Φ_d) from the scattered light by the atmospheric particles (aerosols and molecules).

They simulated the total downwelling irradiance ($E_s = \Phi_D + \Phi_d$) at bottom of the atmosphere (BOA) for a realistic maritime atmosphere (MAR90 + Continental +H2SO4) with two AOT-550 (0.2 and 0.5) over a wind-roughened black sea surface (*ws*=3 *m/s*), which would be measured by a horizontal flat sea detector and a tilted collector. These SO computations were conducted at 442.5, 560, 665 and 865 nm for four solar zenith angles (θ_s=30, 45, 60 and 75°) and tilt angles included in the solar plane (ϕ_t=0°) for the backscattering region. Results, in essential agreement with our Eq. 6, are depicted in Fig.5 and stress that the tilt effect clearly increases on the surface irradiance with θ_s. This increasing impact becomes less sensitive while the AOT increases.

3.3 Why account for the sensor tilt?

It was shown in Fig. 2 through to Fig. 5 that data submitted to MERMAID might contain serious errors that will propagate through to ρ_w and to any models using in-situ E_s and/or ρ_w.

Clearly, it is essential to any downstream uses of MERMAID to ensure the best quality data, and to retain as much of the matchups as possible, if not all.

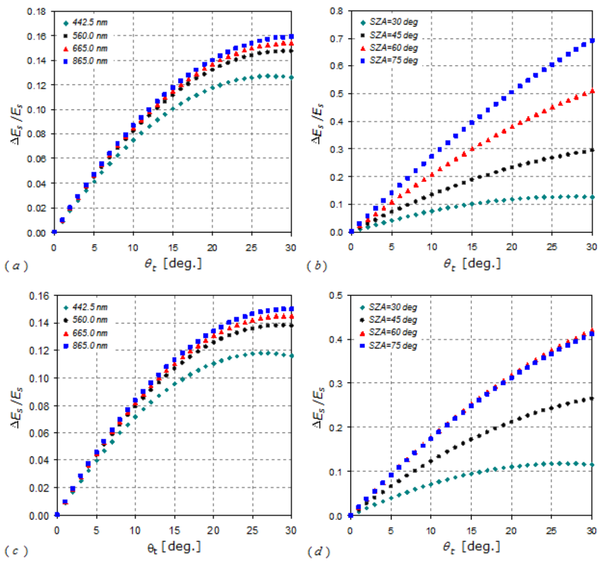

Figure 5: Relative error ($\Delta E_s / E_s$) on surface irradiance caused by a sensor tilt (φ_t) ranged within [0; 30o] included in solar plane ($\varphi_t = 0^o$) for the backscattering region. Simulations are completed with the SO code: a, c: for θ_s=30^o and 4 wavelengths, where $\tau_a(550)$=0.2 ; b, d: for 442.5 nm and 4 θ_s and where $\tau_a(550)$=0.5.

An investigation was therefore carried out on other MERMAID datasets to identify tilt impacts on the datasets used for MERIS CalVal activities. Those sites not subject to buoy tilt (i.e. AERONET-OC) were also investigated for the potential of inconsistency in surface irradiances.

4 SURFACE IRRADIANCE AND WATER REFLECTANCE IN MERMAID DATASETS

4.1 Source of data and computation of E_s

In the MERMAID matchup process, MERIS E_s is exactly determined at sea surface level using Look-Up Tables (LUTs) implemented in the MERIS processor, and uses the θ_s corresponding to the time of the matchup to compute T_d (i.e. in-situ T_d = T_d_MERIS $^{(\cos(\theta s\_MERIS)/\cos(\theta s\_in\text{-}situ))}$. The LUTs, which comprise $T_d(\lambda,\theta_s)$ and $T_u(\lambda,\theta_v)$, have been generated with the SO code for a set of 16 standard aerosol models (SAMs), a set of 7 AOT-550 values (including the pure Rayleigh case) and a set of 25 Gaussian angles, including zenith/nadir direction. T_d (λ,θ_s) includes the Fresnel reflection.

Now included in the MERMAID database are a number of atmospheric parameters: τ_a (870), τ_a (665) and α. Presently, just AERONET-OC sites provide τ_a (870) and τ_a(665) s to MERMAID, and α, is computed as Eq. 7:

$$\alpha(870,779) = -\frac{Log(\tau_s(870)/\tau_s(779))}{Log(870/779)} \qquad (7)$$

Where unavailable as a measurement, in-situ E_s was computed as in the approximations of Eq. 2, using where available, the τ_a and α from the PI and where not, the the MERMAID atmospheric parameters and intermediate MERIS products from the atmospheric correction over ocean (T_d (λ), $T_a(\lambda,\theta_s)$, $T_R(\lambda,\theta_s)$, $T_{O3}(\lambda,\theta_s)$). For AERONET-OC sites pressure, uO3 and τ_a (865) are available on the AERONET-OC website.

To make clear the two different E_s values in-situ E_s is hereafter termed E_{s_IS} and MERIS E_s is termed E_{s_MERIS}.

4.2 In-situ E_s versus computed E_s

As an example of the accuracy possible, the majority of AAOT and other AERONET-OC E_s matchups fell within a relative error of ±10% (Fig. 6) but for other sites such as at Sagres errors may reach ± 20% were observed (as in Fig. 3).

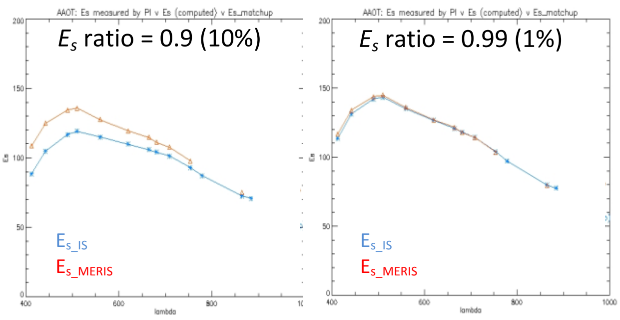

Figure 6: Comparison between $E_{s\_ISME}(\lambda)$ computed with MERIS transmittance LUTs and $E_{s\_IS}(\lambda)$ measurements over AAOT (Aqua Alta Oceanographic Tower, Venice).

Discrepancies observed between E_{s_IS} and E_{s_MERIS} stress the difficulty to get an agreement between the in-situ and MERIS acquisitions. The stability of the atmospheric conditions relies on the aerosol variability; therefore, as observed over AAOT, the difficulty in achieving good agreement may be explained by the temporal and spatial variability of aerosols over a given site, during concurrent acquisitions (MERIS and in-situ) even if they were close in time.

These results indicated the need to 'homogenise' the data such that a consistency with MERIS definitions is brought, to make consistent the definition of E_s and ρ_w with MERIS L2 definitions and thereby negate any potential for error in ρ_w associated with sensor tilt. The MERIS-like irradiance estimated at ground level (E_{s_MERIS}) can be used to do this, using the ratio between E_{s_IS} and E_{s_MERIS}, following Eq. 8. The resulting water reflectance is termed ‘ρ_{w_ISME} (λ)’ (where ‘$_{IS}$’ is for ‘in-situ’ and ‘$_{ME}$’ is for ‘MERIS’).

$$\rho_{w\_ISME}(\lambda) = \rho_{w\_IS}(\lambda) \cdot \frac{E_s^{IS}(\lambda)}{E_s^{MERIS}(\lambda)} \qquad (8)$$

As a demonstration of the adjustment, Fig. 7 shows, using *the same matchup spectra* as in Fig. 6 the difference between ρ_w and ρ_{wn_ISME},- i.e. the difference the E_s ratio adjustment makes.

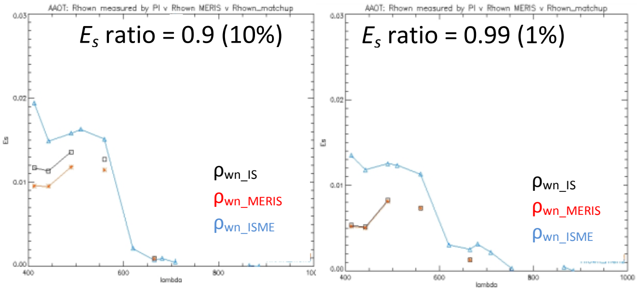

Figure 7: Comparison between ρ_{wn_IS}, ρ_{wn_ISME}, and ρ_{wn_MERIS} for the same two selected spectra at AAOT as in the E_s comparison, illustrating the difference an adjustment with the E_s ratio can make, even for a site not subject to tilt impact.

The larger the relative error on E_s the greater will be the adjustment to be applied to; therefore, although relative errors observed over AAOT remains largely lower than 5%, for other datasets $\rho_{wn}(\lambda)$ this may prove significant and ultimately necessary to bring in-situ $\rho_{wn}(\lambda)$ in-line with MERIS definitions.

5 CURRENT AND POTENTIAL SOLUTIONS FOR MERMAID

5.1 Inclusion of new parameter, ρ_{wn_ISME} (λ), in MERMAID

The approach currently considered as the most appropriate for MERMAID to negate error propagation through to ρ_w is to acquire from PIs the separate in-situ components used to compute ρ_w, i.e. L_w and E_s (whether computed as in Eq. 2 or measured directly with instrumentation). For the sites using CIMEL instruments (namely AERONET-OC), an extra stage is added to the pre-matchup processing: E_s is computed as in section 4.1.

Now included in MERMAID, in parallel to ρ_{wn_IS} and at the same 13 bands is the new parameter, ρ_{wn_ISME}, computed as in Eq. 8, and fully normalised, following [6, 7, 8]. In this way all in-situ water reflectances are given the same definition in MERMAID and the MERIS vicarious adjustment is based on this homogeneous dataset.

5.2 In-situ E_s flagging

Flags have been designed and implemented to define the level of quality control (QC) applied to the in-situ data. Two flags are now defined in MERMAID for both the optical and the atmospheric parameters: The MQC (Measurement Quality Control) flag defines the quality control checks and protocol facets made by the PI, prior to submission. The PQC (Processing Quality Control) flag defines the post-submission quality control performed on the in-situ data after submission to MERMAID. One of the PQC flags indicates the extent of error on E_{s_IS} based on the ratio with E_{s_MERIS}. Five options for the flag are available (shown in Tab. 2).

Table 1: PQC flag 5 criteria for the E_s ratio (E_{s_IS} to E_{s_MERIS}) – used as the indication of error on E_s_IS and so on ρ_{wn_ISME}

PQC flag 5 String	*Range of error in % based on E_{s_IS} / E_{s_MERIS}*
0	no in-situ E_s data available
1	[15 – 20]
2	[10 – 15 [
3	[5 – 10 [
4	[0 – 5 [

The vicarious adjustment studies have found comparable results in visible gains computation between use of ρ_{wn_IS} and ρ_{wn_ISME}; however, only those data with lower than 10% on the E_s ratio are selected. This further illustrates the importance of homogenised datasets with which these extra checks on quality can be performed and, importantly, what are the impacts on downstream uses of the matchups with each.

5.3 Tilt correction potential

Presently no correction for tilt effects or other potential inaccuracies such as the effect of the sky dome is carried out as part of MERMAID processing. However, tilt correction of E_s is potentially feasible to obtain reliable estimates of E_s. A correction for the inclination of the sensor’s angular geometry relative to the horizon must be corrected, and for this a measurement in-situ of the both the azimuth and zenith angle of inclination (tilt) would be required. David Antoine provides to MERMAID zenith tilt angles for BOUSSOLE (mean of around 4.5^o), but this is unique. Furthermore, little information is known regarding some of the in-situ measurement systems. BOUSSOLE and MOBY exhibit random tilt Like BOUSSOLE, MOBY exhibits a random tilt up to 5^o, truncated and azimuth but with no correction performed on E_s, on the latter. TACCS (Tethered Chain Coefficient Sensor) also exhibit random tilt, up to 15^o. For a tilt correction, additional in-situ information would be required: information on the atmospheric aerosols, and τ_a and α, and wind speed.

Measurement of these parameters in-situ would be the ideal requirement, although, they are also available from the MERIS extraction.

For an approximation of sensor tilt effect two E_s measurements with and without sensor tilt and close enough in time to consider the same acquisition conditions (atmosphere and sea surface state) would be needed. A corrective factor can then be computed as the ratio between these two measurements to be applied to other E_s measurements acquired in the same conditions. However, this represents a crude approximation that cannot be systematically used for all other sites.

An approach being followed by [4] is to use the data from the in-situ measurement system, the TACCS, on which a K-Chain hangs straight in the water even in rough conditions. A standard log regression is used to compute E_d (0^-), which is then propagated to above surface and this is used to normalise the E_s to the E_d (0^+) value. This research is in the very initial stages, but once verified is not universally applicable.

A feasible option for operational use in MERMAID could be the use of synthetic databases of downwelling flux generated with SO code i.e. [15, 16]. For a given tilt geometry, knowing aerosol type (and model) and wind-speed, a corrective factor for tilt can be computed for any site.

6 DISCUSSION AND CONCLUSIONS

Bio-optical modelling of in-situ parameters relies on ρ_w for inherent optical property modelling and computation of, for example, chlorophyll-a. Without E_s this is difficult to do, and it becomes essential to ensure the best quality in-situ E_s data. Knowledge that tilt may impact E_s measurement is not new; however, the realisation of magnitude of errors, and inclusion of ρ_{wn_ISME} in MERMAID represents an important moment in the evolution of the QC of the MERMAID database. Any downstream use of MERMAID will benefit greatly from this additional stage in the QC process.

At present, in the frame of the MERIS Cal/Val purposes, the best approach to be adopted for MERMAID is to make the database consistent with MERIS processing, by using E_{s_MERIS} and the ratio with $E_{s\_IS,,}$ and ρ_{wn_ISME}. Inclusion of ρ_{wn_ISME} was timely and important in regard to the third MERIS reprocessing, and the coexistence in ρ_{wn_IS} (λ) and ρ_{wn_ISME} (λ) in the database now provides a tool by which both the MVT and the QWG can make essential quality checks of in-situ and MERIS ρ_w data. In addition ρ_{wn_ISME} presents the advantage of consistency with MERIS, accuracy due to LUT use, and it standardises the datasets which derive from a variety of sources. Furthermore it provides a basis for investigation into tilt and sky dome correction.

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