$K_d(490)$ models characterisation

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Gilbert Barrot, ACRI-ST

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$K_d(490)$ is the diffuse attenuation coefficient at 490 nm. It is one indicator of the turbidity of the water column. This is one candidate for the merging activity between SeaWiFS, MODIS and MERIS instruments data.

K_{490} is a direct level-2 output product for the MODIS and SeaWiFS instruments. Purely empirical algorithms, historically developed by Austin and Petzold for the CZCS, and recently revisited by Mueller and Werdell (using SeaBAM and NOMAD data sets) are currently used.

The following discussion has been presented in a poster session by A. Morel, Y. Huot and B. Gentili during the Ocean Color Research Team meeting held in Newport, Rhode Island, USA, in April 2006.

For MODIS, K_{490} was historically computed as an exponential formulation (Mueller 2000):

$$K_d(490) = K_w(490) + A \cdot \left[\frac{L_w(\lambda_1)}{L_w(\lambda_2)}\right]^B$$

where: $K_w(490)$ is the diffuse attenuation coefficient for pure water = 0.016 m^{-1}
λ_1 = 488-490 nm
λ_2 = 551-555 nm
A = 0.1565
B = -1.540

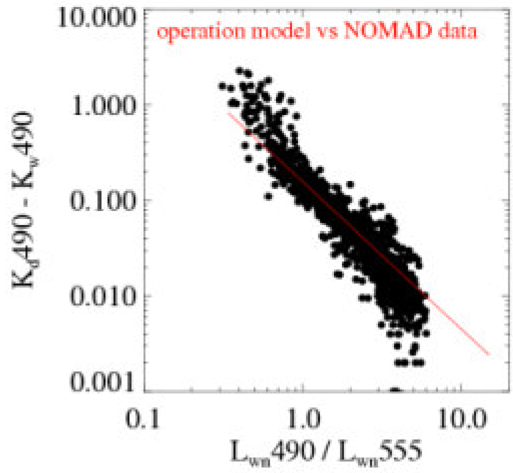
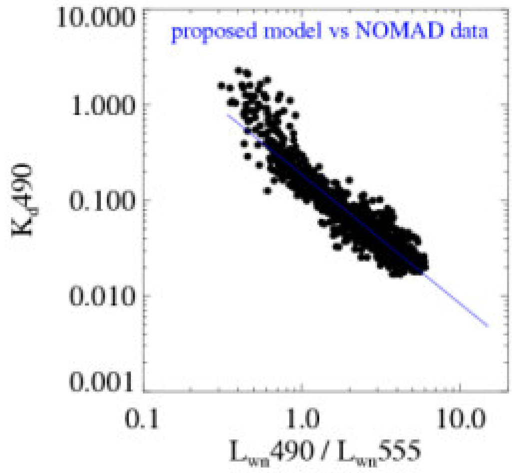
For reprocessing 1.1, the constant term has been suppressed and new coefficients have been used, identical to the ones used for SeaWiFS (see below).

For SeaWiFS, K_{490} is computed as an exponential formulation with no constant term (Werdell 2000), configuration used for the reprocessing 5.1:

$$K_d(490) = A \cdot \left[\frac{L_w(\lambda_1)}{L_w(\lambda_2)}\right]^B$$

where: λ_1 = 488/490 nm
λ_2 = 551-555 nm
A = 0.1853
B = -1.349

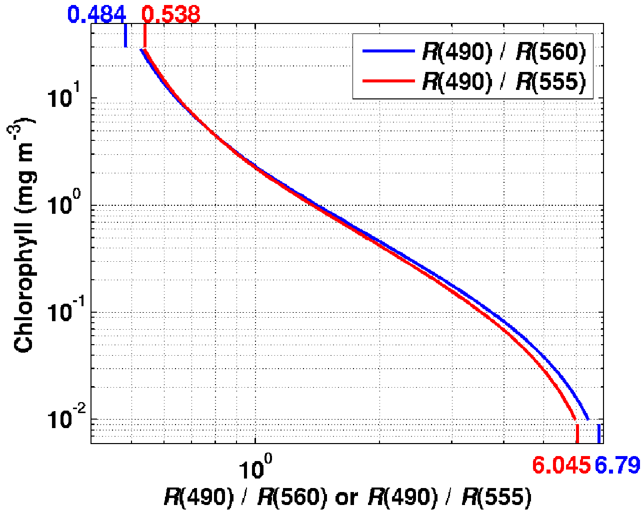
Important feature: these formulations do not show any curvature in log space. However, the comparison of the computed K_{490} values with the NOMAD data shows a curvature as presented in the following figures where the $K_d(490)$-$K_w(490)$ is plotted versus $L_w(490)/L_w(555)$ for both formulations

	
Mueller, 2000	Werdell, 2005

The curvature must be maintained in any relationship between $K_d(490)$ and the ratio of water leaving radiances $L_w(490)/L_w(560)$ or $L_w(490)/L_w(555)$

How to introduce a curvature in the model ?

Yet, the curvature exists in the chl-algorithms (both empirical, OC4V4, and semi-analytical OC4Me), because of asymptotic values of $L_w(\lambda_i)/L_w(\lambda_2)$ when Chl tends towards 0 or towards ∞, as shown in the following figure (OC4Me semi-analytical relationships, obtained from Morel and Maritorena 2001 for two waveband ratios).



Furthermore, K_d has been empirically related to Chl in a monotonic way, Morel-Maritorena 2001, as:

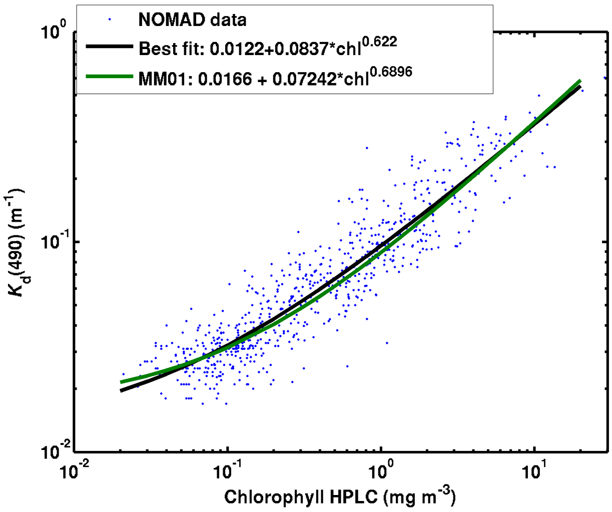
$$K_d(\lambda) = K_w(\lambda) + \chi(\lambda) \cdot chl^{e(\lambda)}$$

$K_w(490) = 0.0166\ m^{-1}$

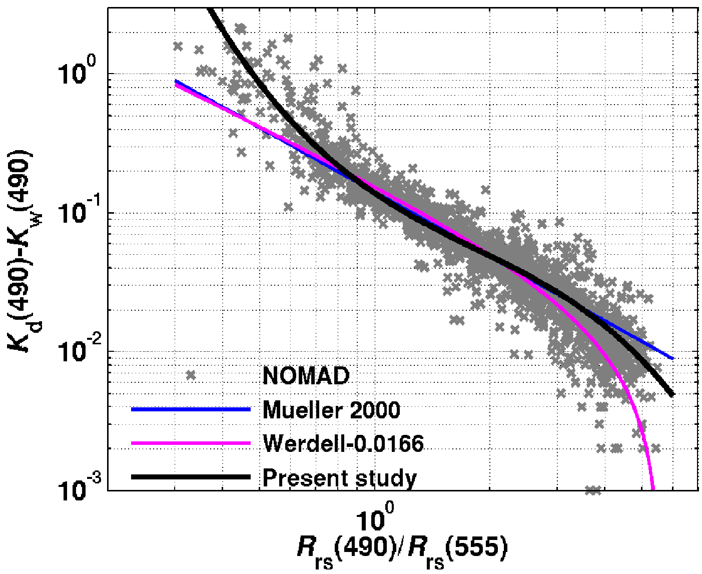
$\chi(\lambda) = 0.07242$

$e(\lambda) = 0.6896$

The next figure presents the results obtained with this model compared to the NOMAD data, for which the best fit is slightly different.



Combining the two previous relationships, that link chl & $K_d(490)$ and chl & nLw, we obtain a semi-analytical algorithm that follows the curvature of the data at both extremities while the Mueller and Werdell formulations miss it, as shown in the following figure.



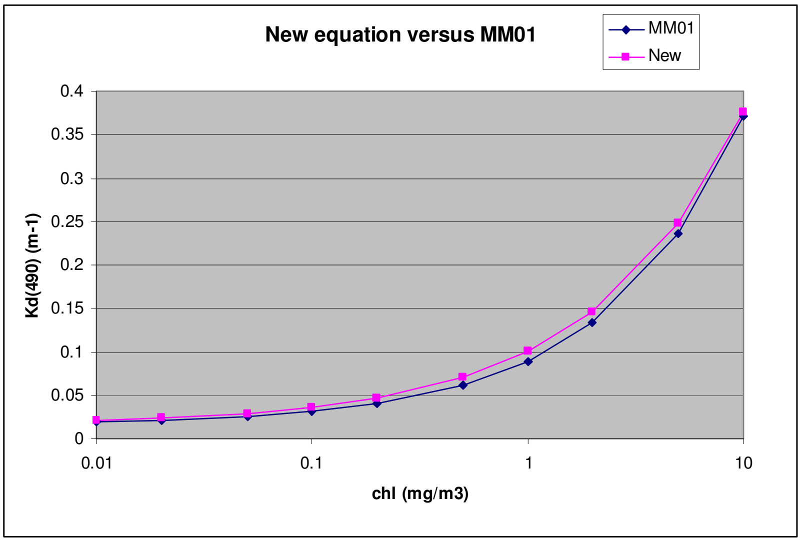
To obtain an internal coherency between the input data, we propose to implement this semi-analytical algorithm in the globCOLOUR project. Chlorophyll concentration provided by each instrument will be converted into $K_d(490)$ before any merging. This approach has also the advantage to avoid the problem of the slightly different spectral bands of the three captors, which is in fact taken into account during the chlorophyll concentration determination.

The common equation is:

$$K_d(\lambda) = K_w(\lambda) + \chi(\lambda) \cdot chl^{e(\lambda)}$$ with:

$K_w(490) = 0.0166\ m^{-1}$
$\chi(\lambda) = 0.08349$
$e(\lambda) = 0.63303$

Note that the parameter values of the present study differ from the previous ones (MM01) as they have been adjusted after the ingestion of new in-situ measurements from several campaigns: BIOSOPE, BENCAL, AOPEX. The following figure presents the difference between the two sets of parameters.



A preliminary comparison has already been applied to the MODIS, SeaWiFS and MERIS data to verify the consistency of the new formulation with respect to the data directly provided by the MODIS and SeaWiFS products.

The test samples are daily products for 02/mar/2005:

- MODIS level 3 SMI product for CHLO and K490
- SeaWiFS level 3 SMI product for CHLO and K490
- MERIS level 3 product for CHLO

The following figures present scatter plots of the comparison of the MERIS, SeaWiFS and MERIS K_d using the two formulations. Notation: Kd is used when initial data are used (i.e. MODIS and SeaWiFS K490 data) and Kd2 is used when the new formulation is used. The MERIS data is always computed using Kd2. The equation below the plot is the result of a linear regression applied in log space.

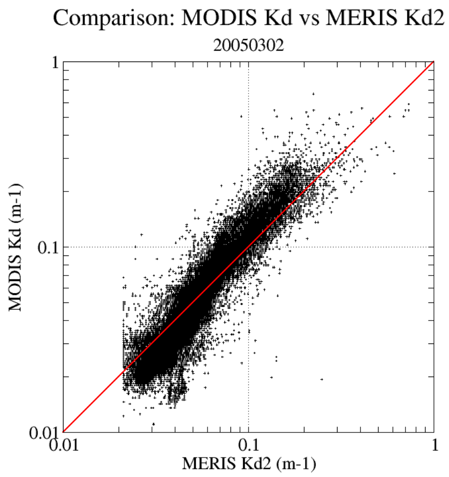
The scatter plot is build from available data for each instrument at the same bins. The comparison is applied to all available data and not only for the deep water data.

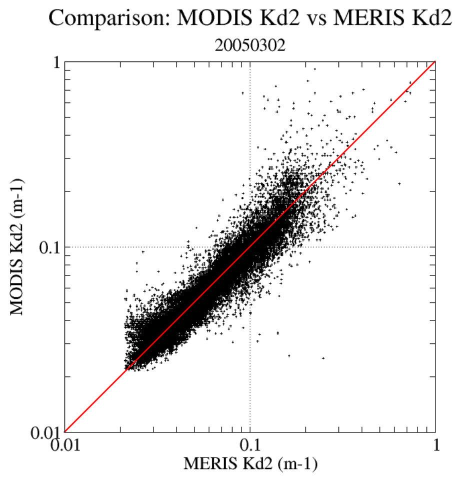
The first two plots compare MERIS and MODIS values. Using the new formulation for the two instruments obviously improves the consistency between the two data sets. Values below $K_w(490)$ can been found in the MODIS data set, as the Werdell formulation used in the reprocessing 1.1 does not used the $K_w(490)$ value as a lower limit.

These remarks also apply to the SeaWiFS-MERIS comparison.

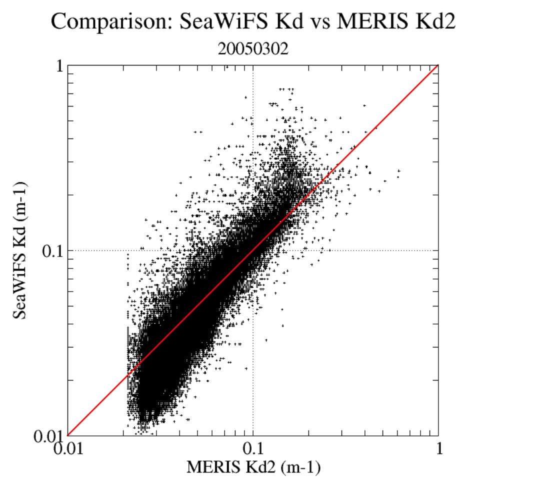
The last two plots shows the comparison between the two formulations for the same instrument. The new formulation obviously decreases drastically the dispersion of the points, especially below K_d=0.1 m^{-1}.

In all cases, the new formulation improves the linear regression. This was expected for the two first cases as we compare MODIS and SeaWiFS data with respect to MERIS data using different and identical formulations. The last comparison is important as it shows that the new formulation also improves the comparison between the MODIS and SeaWiFS data: linear regression is almost perfectly aligned with the reference identity function and the dispersion is much lower, especially for small values of Kd.

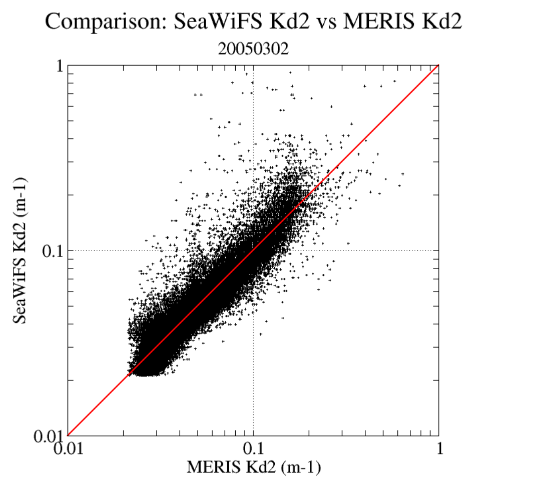




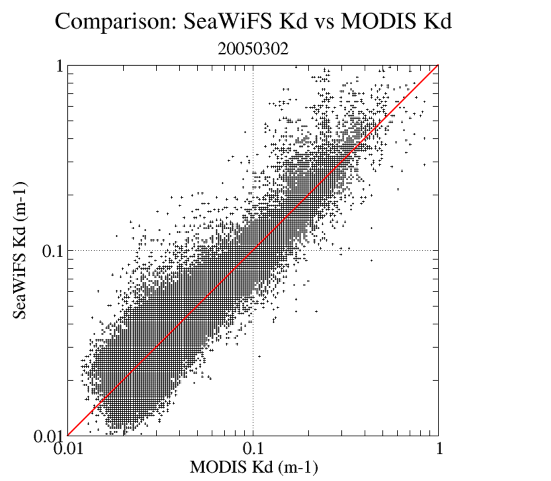
y=0.365+1.307.x (r=0.95)	y=-0.050+0.974.x (r=0.96)



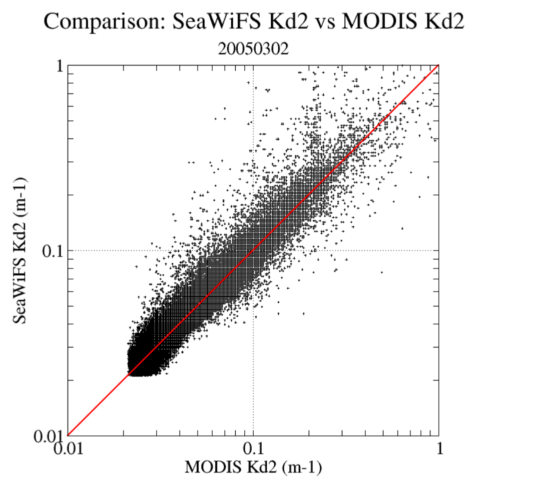
y=0.336+1.306.x (r=0.91)



y=-0.074+0.956.x (r=0.93)



y=-0.0246+1.002.x (r=0.93)



y=-0.0001+0.9978.x (r=0.96)