living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

Validation of remote-sensing algorithms for diffuse attenuation of downward irradiance using BGC-Argo floats

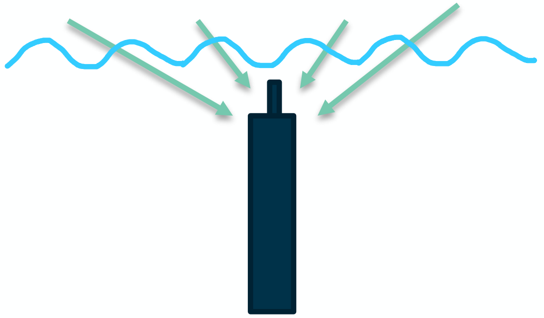
Charlotte Begouen Demeaux[1], Emmanuel Boss[1]

1. University of Maine, USA

23/05/2022

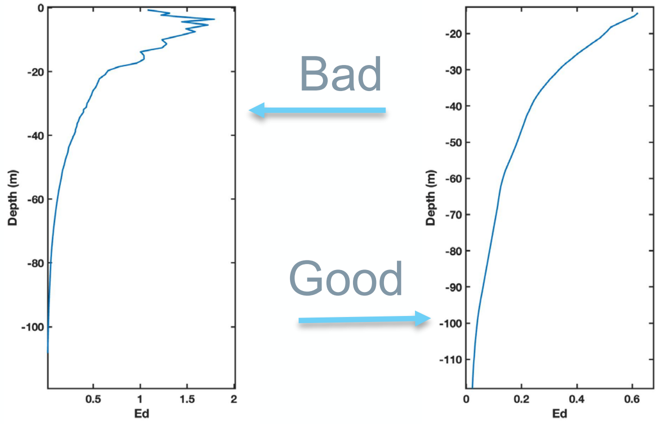
Downwelling Irradiance and BGC-Argo floats

Downwelling Irradiance (E_d)



Downloaded from GDAC utility between 0-250m at 380nm, 412nm, 490nm and for PAR

Quality Control of the shape of the profile (Organelli et al., 2017)



Extrapolate E_d to the surface ($Ed(0^-)$, Xing and Boss, 2020)

Compute the diffuse attenuation coefficient

$$K_d(\lambda, z) = \frac{1}{z} \times \ln\left(\frac{E_d(0^-)}{E_d(z)}\right)$$

$$K_d(PAR)^{float}_{z_{pd}} = \frac{1}{z_{pd}(PAR)} \times \ln\left(\frac{iPAR(0^-)}{iPAR(z_{pd})}\right)$$

Why retrieve K_d from space ?

➔ K_d(PAR) is used in many **NPP production models** : Amount of available light for photosynthesis and depth at which light is available for photosynthesis is crucial.

➔ How solar radiation is attenuated ($K_d(\lambda)$) plays an important role in heating, and **biogeochemical processes** such as photo-chemistry

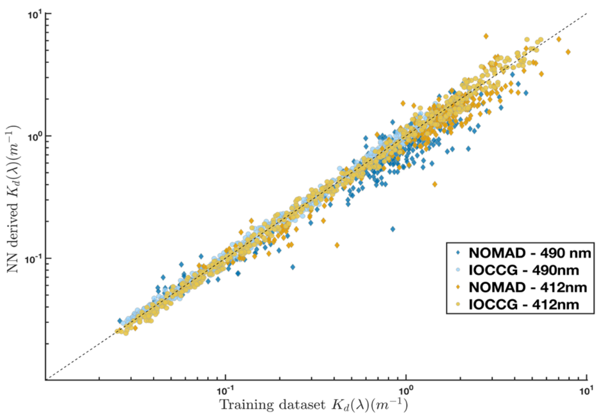
BGC- Argo vs. In-situ databases

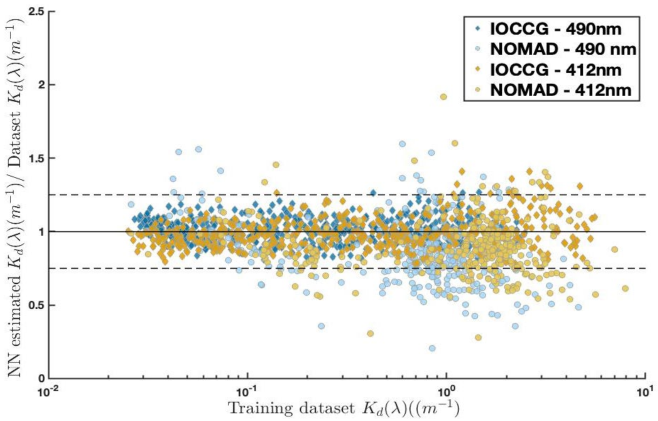
Current State : Retrieval $K_d(\lambda)$ from Satellite R_{rs}.

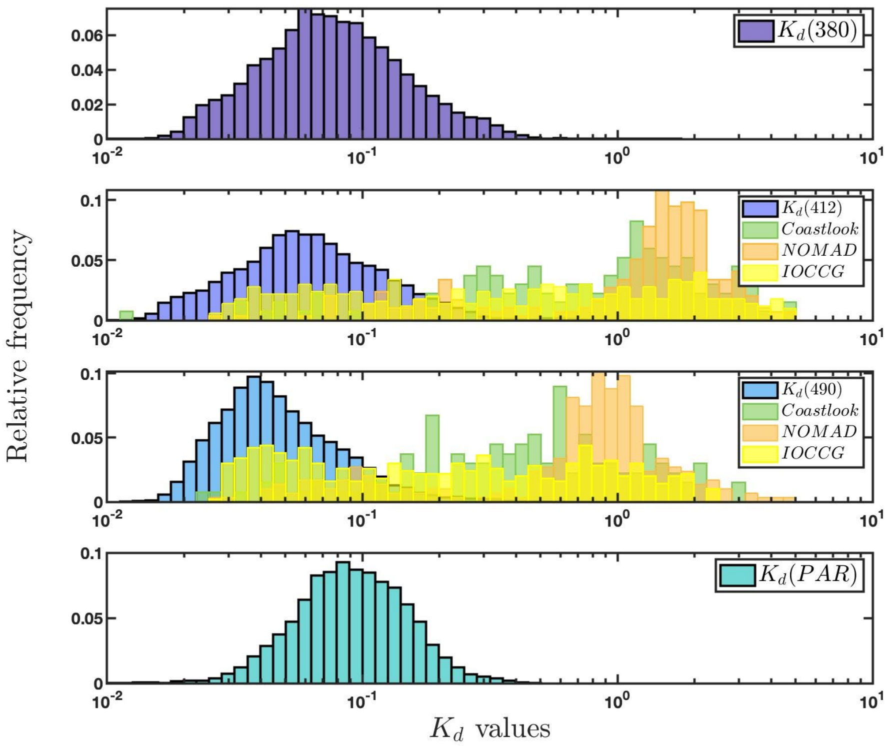
$K_d(490)$: Operational product from both NASA and ESA.

Several algorithms were developed to estimate $K_d(\lambda)$

➔ **Constrained & validated using in-situ and simulated databases**







BGC- Argo : provide much larger database

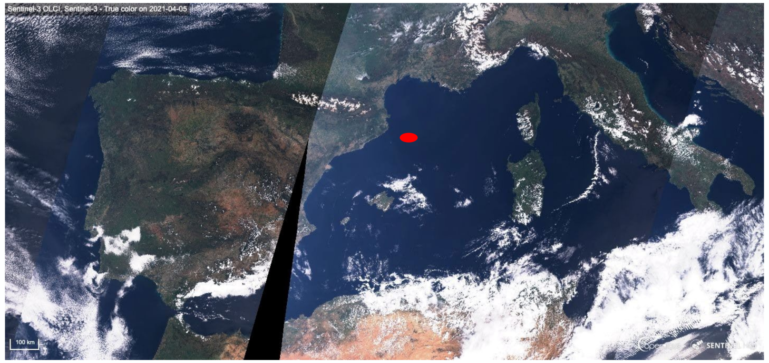
- No shading
- No spatio-temporal bias

6 Satellite sensors : Matchup method

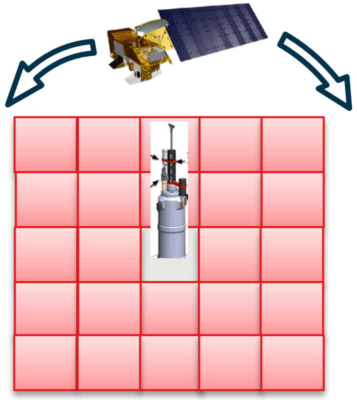
Location, datetime and sun angle of each float compiled

- MODIS - Aqua
- MODIS - Terra
- VIIRS - SNPP
- VIIRS - JPSS
- OLCI - S3A
- OLCI - S3B

Level 2 data and flags downloaded for each overpass of a float surfacing



~ 5x5 km^2 box of pixels around the float location (depending on Sensor resolution)



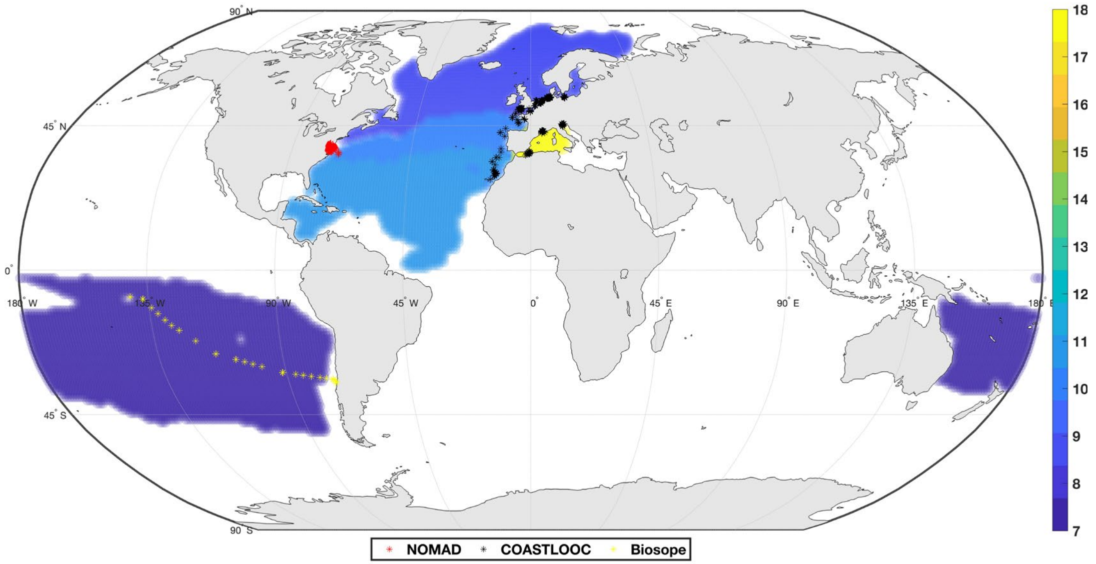
Each box was QC-ed according to matchup criterias from Bailey and Werdell, 2005

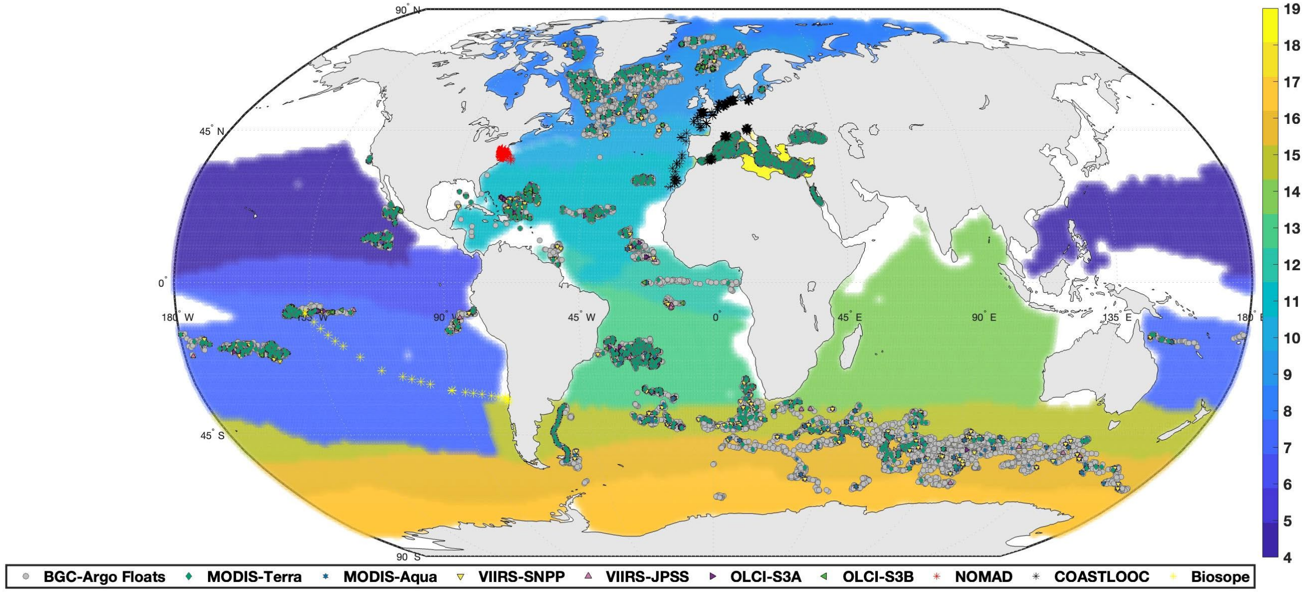
- < 3 hours between float surfacing and overpass
- Solar Zenith Angle < 75 °
- Half of the pixels in the box must be unflagged

Average Rrs spectrum taken for non-flagged pixel

Global coverage obtained from radiometric BGC-Argo floats and Satellite matchups

➔ Separation of the ocean into 19 biomes of similar characteristics from Fay et al., 2014





In-situ databases :

~500 datapoints in 5 biomes :

Spatio-temporal bias

BGC- Argo :

> 9 000 matchups covering 14 oceanic biomes

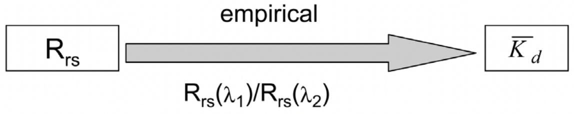
$K_d(\lambda)$ & $K_d(PAR)$ algorithms evaluated

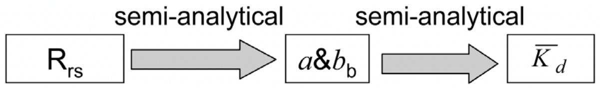
$K_d(\lambda)$: 3 different types algorithms

Implicit Empirical : NASA/ ESA product based on Austin and Petzold, 1981 or Morel, 2007 (ESA)

Semi-analytical : Based on *a*, b_b retrieved from QAA, Lee 2005.

Neural network : Jamet et al., 2012.



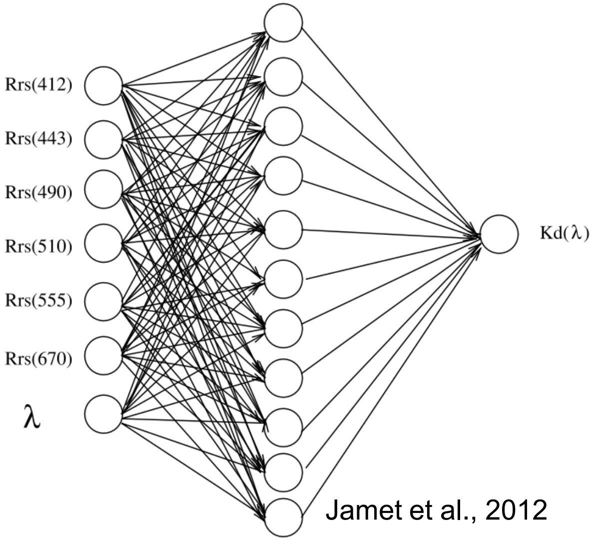


Lee et al., 2005

$K_d(PAR)$: 2 different types algorithms

Semi-analytical : Lee 2013, based on QAA retrieval of IOPs.

Implicit Empirical : Morel 2007, based on relationship between $K_d(PAR)$ and $K_d(490)$



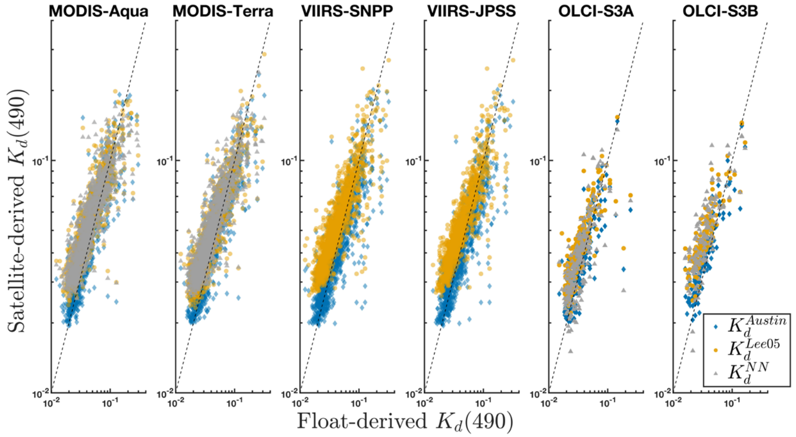
Jamet et al., 2012

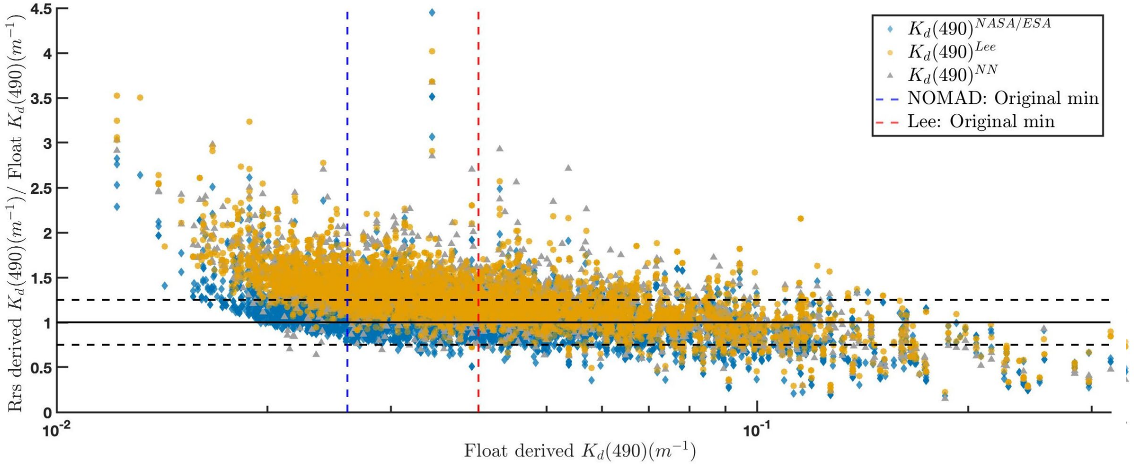
Observed Bias in clearest waters

Inter-sensor comparison

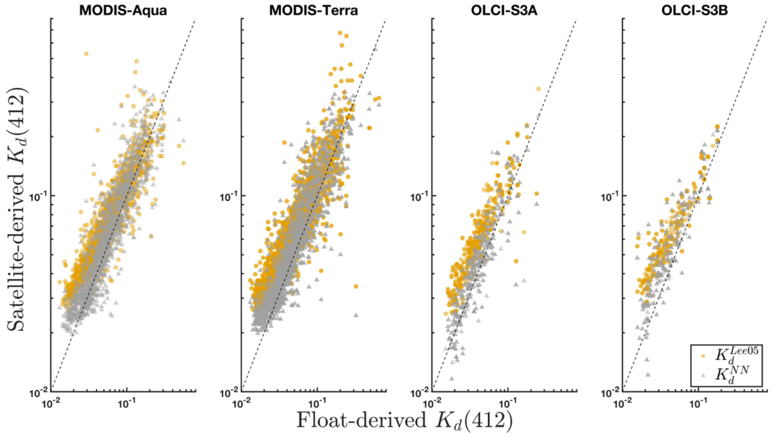
Retrieval bias – grouped sensors

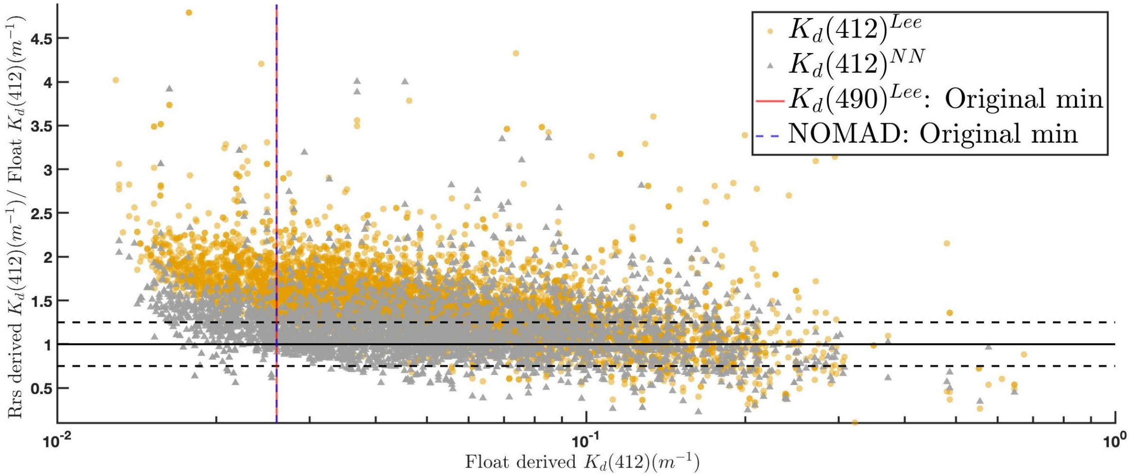
490 nm





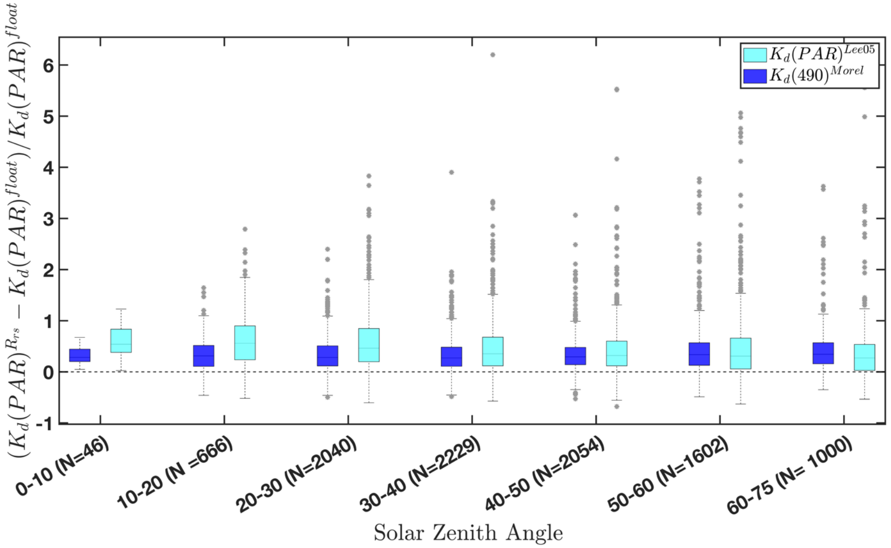
412 nm

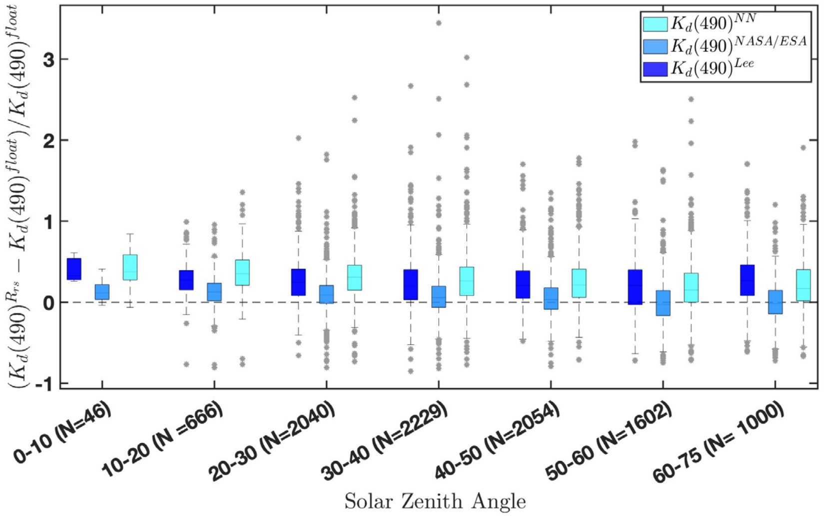




Biases associated with the sun angle

Relative difference between K_d^{Rrs} and K_d^{float}





➔ No significant difference according to sun angle.

➔ Less accurate retrieval for **low sun angle.**

➔ Validation databases have fewer data points at low sun angle.

➔ New satellites that will tilt to reduce glint will need to take it into account

CCL & Future of the BGC- Argo Network

➔ Significant bias in K_d was discovered for clear water likely due to limitation of datasets used to derive algorithms.

➔ BGC-Argo K_d dataset could be use to recompute current algorithms so can be better constrained

➔ Future/current algorithms need to take into account solar angle.

Next Steps for BGC-Argo :

- Equip BGC-Argo float with **hyperspectral radiometer** so can be used as validation of Hyperspectral mission (NASA PACE).
- **Global coverage** so all biomes could be represented : Especially in the Pacific.
- BGC-Argo : Essential part of validation of Satellite product (K_d, Chl, etc …)

Special thanks to

- NASA PACE for funding.
- Emmanuel Boss for supervision.
- Nils Haentjens/ Guillaume Bourdin for advice/support/coding help.
- Cédric Jamet for discussion about NN algorithm.
- Hubert Loisel & lab for access to Hydrolight runs.
- Hervé Claustre and LOV for largest amount of BGC with radiometry.

And many more !