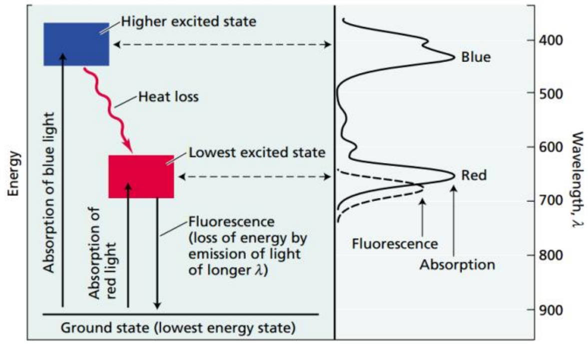
# REVIEW ON

# FCHLA DATA QC

OCTOBER 2019

ADMT-20

# CHLA FLUORESCENCE




- **Chlorophyll-a fluorescence**

$F(\lambda_{em}) = E(\lambda_{ex}) \times [Chla] \times a^*_{ph}(\lambda_{ex}) \times \varphi_f \times Q^*_a(\lambda_{em})$

Emission Light intensity $E(\lambda_{ex})$ is assumed constant (If no sensor decay);

Reabsorption coefficient $Q^*_a(\lambda)$ is close to 1 at 700nm (Receiver band of Wetlabs ECO Chla fluorometer);

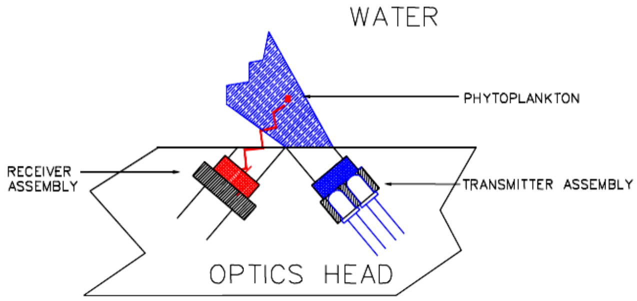
Fluorescence quantum yield $\varphi_f$ is related to physiology;

Specific-absorption coefficient $a^*_{ph}(\lambda_{ex})$ is related to physiology, algal species, and package effect.

**IF $(a^*_{ph}(\lambda_{ex}) \times \varphi_f)$ is assumed as constant, a linear relationship between Fluorescence signal $(F(\lambda_{em}))$ and [Chla] may be expected.**

# ECO IN-SITU FLUOROMETER

➢ **ECO Chlorophyll-a Fluorometer**




1. Emitting blue light (at 470 nm)

   Receiving red light (at 700 nm)

2. Linear assumption and calibration

   FChla = Slope * (Counts – Dark)

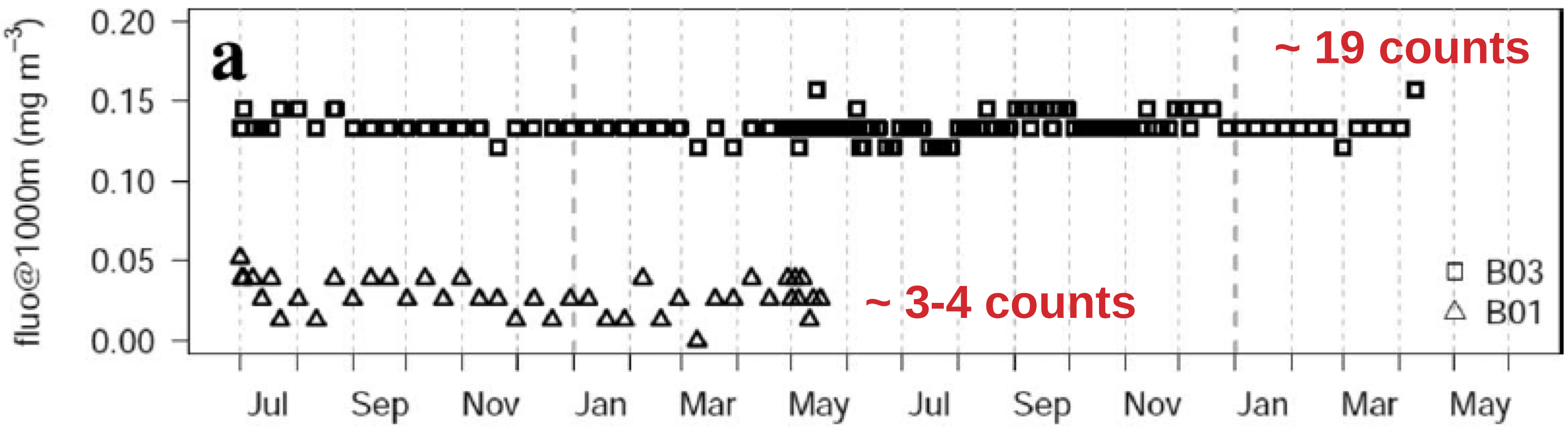
3. Calibration

   “The relationship between fluorescence and chlorophyll-a concentrations in-situ is highly variable. The scale factor listed on this document was determined using a mono-culture of phytoplankton (Thalassiosira weissflogii). The population was assumed to be reasonably healthy and the concentration was determined by using the absorption method. To accurately determine chlorophyll concentration using a fluorometer, you must perform secondary measurements on the populations of interest.” – ECO calibration sheet

# ERROR SOURCES

➢ **1. Dark count change**

(Due to the change of dark currents of sensor on float)



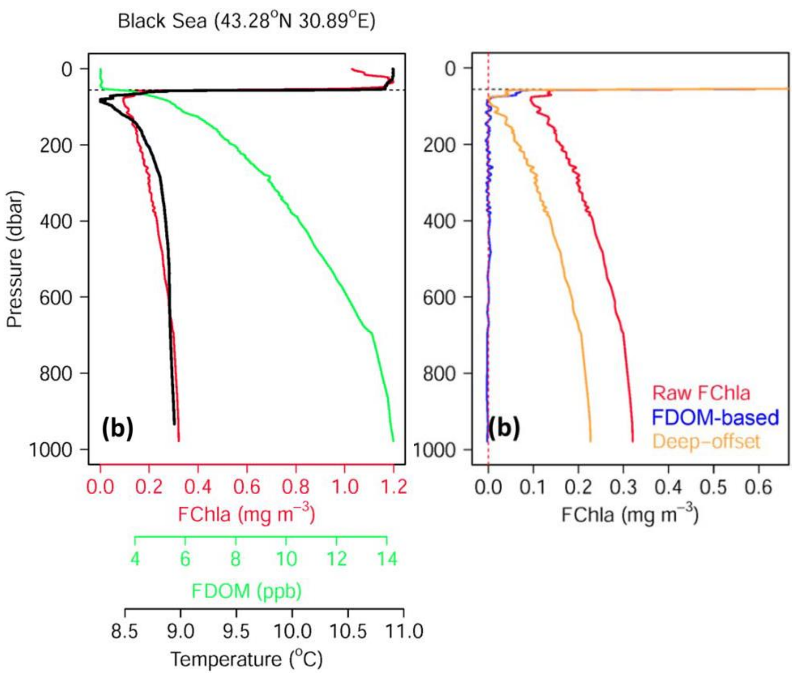

***Xing et al. (2014) JGR***

# ERROR SOURCES

- **2. FDOM interference**

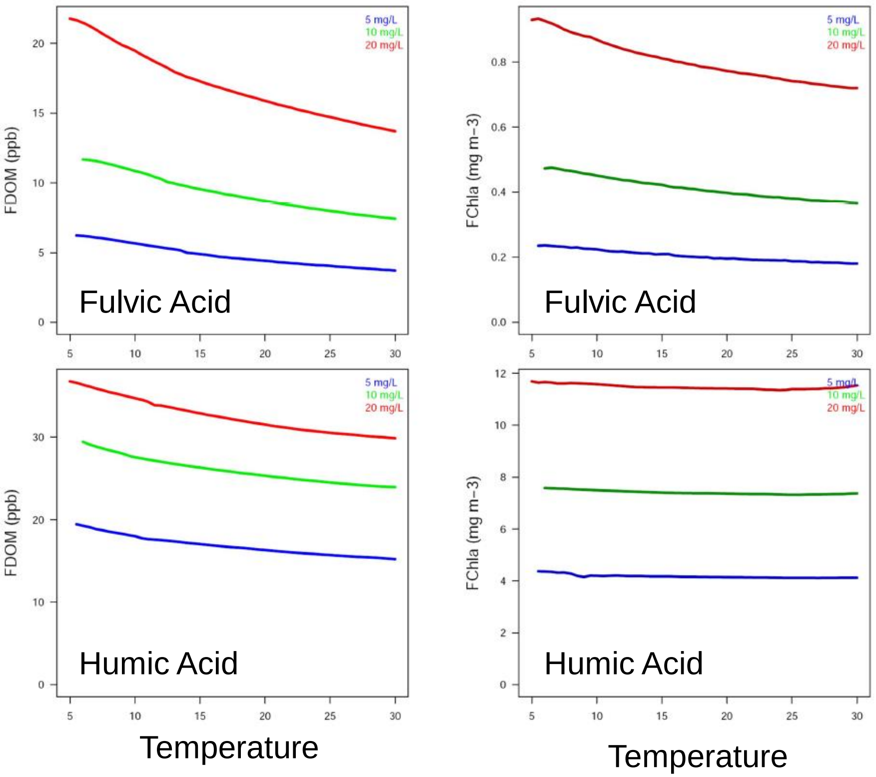
  (Due to the CDOM fluorescence excited by Chla fluorometer)

BGC-Argo float data




*Xing et al. (2017) L&Omet*

Experiments in lab

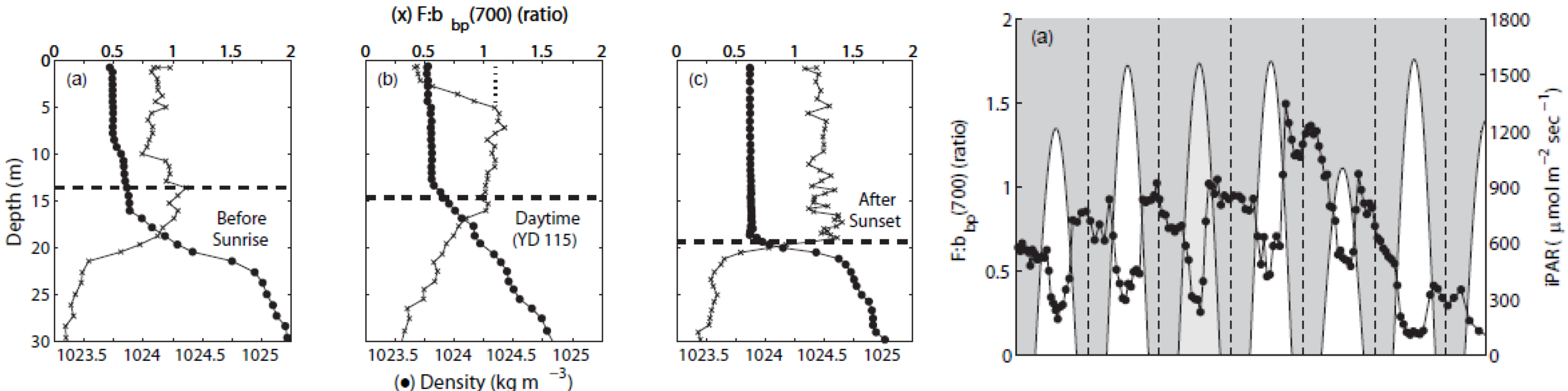



*Xing et al. Unpublished*

# ERROR SOURCES

- **3. NPQ (Non-Photochemical Quenching)**

  (Due to the fluorescence dynamics of in vivo chlorophyll-a at high-light condition)

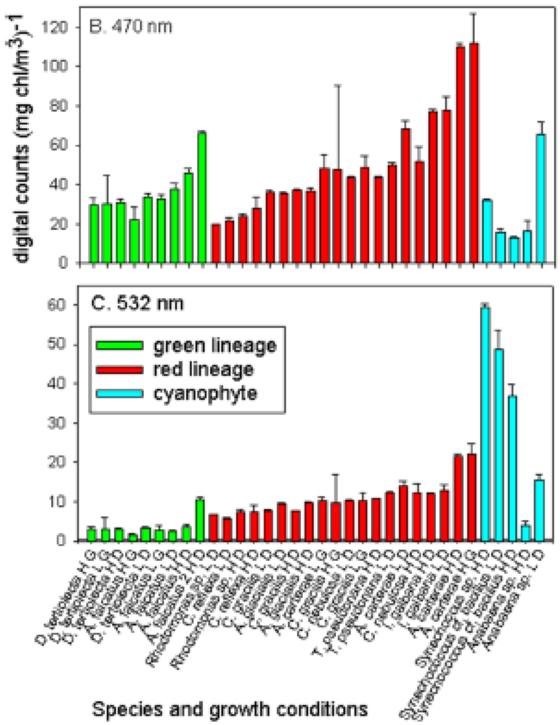



***Sackmann et al. (2008) BGD***

# ERROR SOURCES

➢ **4. Slope variability**

(Due to the factory-calibration issue and fluorescence variability)



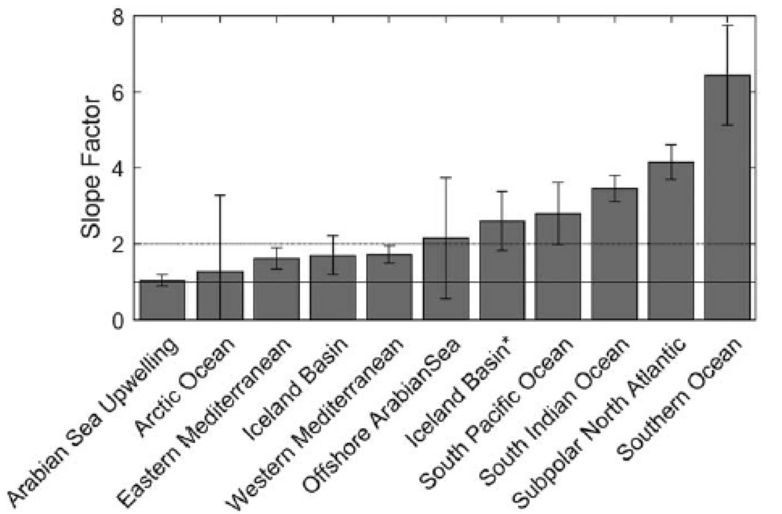




**Fig. 2.** Mean slope factors derived from observations of paired HPLC and in situ Chl fluorescence from major oceanographic regions (Table 1). Error bars indicate 95% confidence limits on slope from linear regression of all observations within each region. Lines indicate slope factors of 1 (solid) and 2 (dotted).

***Proctor and Roesler (2010) LOmet***

***Roesler et al. (2017) LOmet***

# QC FRAMEWORK

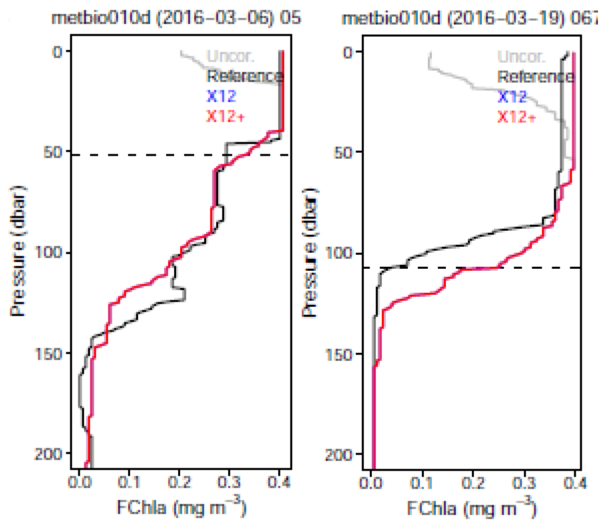
**RTQC**

Dark correction

Dark = median of deep FChla profile (profile by profile)

NPQ correction

Xing12




Slope correction

Roesler17 = 0.5

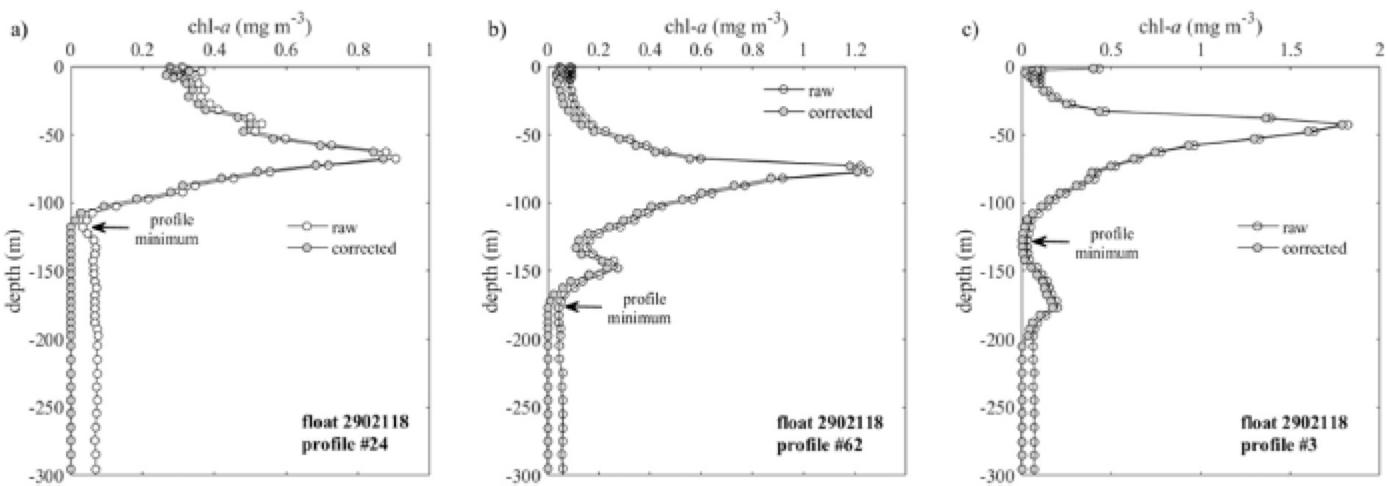
# IN DMQC

- All these processing above are SIMPLE & ROBUST and potentially adapted for RTQC;
- But in DMQC, we re-consider if they are sufficient enough or not.

# 1. DARK CORRECTION IN DMQC

➢ **Option 1: Minimum for each profile (after median filter)**

*Xing et al. (2011) JGR*
*Xing et al. (2017) LOmet*
*Wojtasiewicz et al. (2018) JMS*




*Wojtasiewicz et al. (2018) JMS*

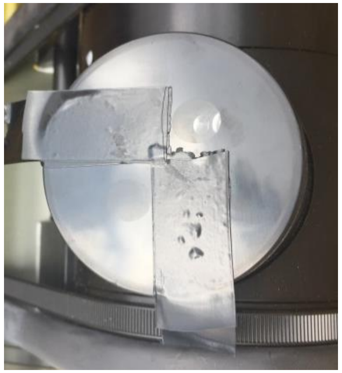
# 1. DARK CORRECTION IN DMQC

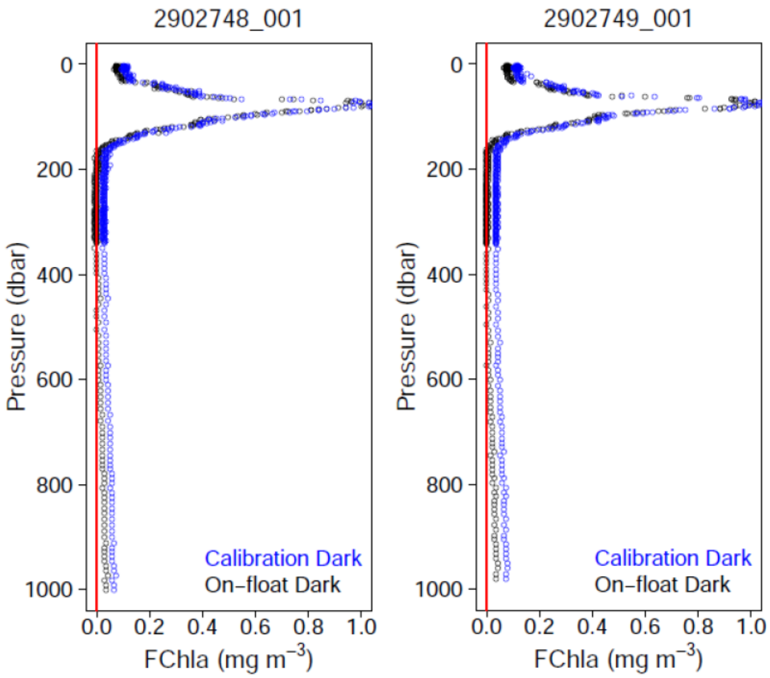
- **Option 2: On-Float Dark**

***Boss et al. (2008) LO***

| WMO | ECO_SN | Cali. Dark | On-Float Dark |
|---|---|---|---|
| 2902748 | 4880 | 47 | 51 |
| 2902749 | 4881 | 45 | 50 |
| 2902750 | 4882 | 48 | 50 |
| 2902751 | 4883 | 47 | 52 |
| 2902752 | 4908 | 45 | 46 |
| 2902753 | 4914 | 44 | 50 |
| 2902754 | 4894 | 46 | 50 |
| 2902755 | 4895 | 45 | 50 |

**Difference of 3-5 counts, which means, for FChla, 0.02 to 0.035 mg m$^{-3}$**
**(without considering of the slope correction)**

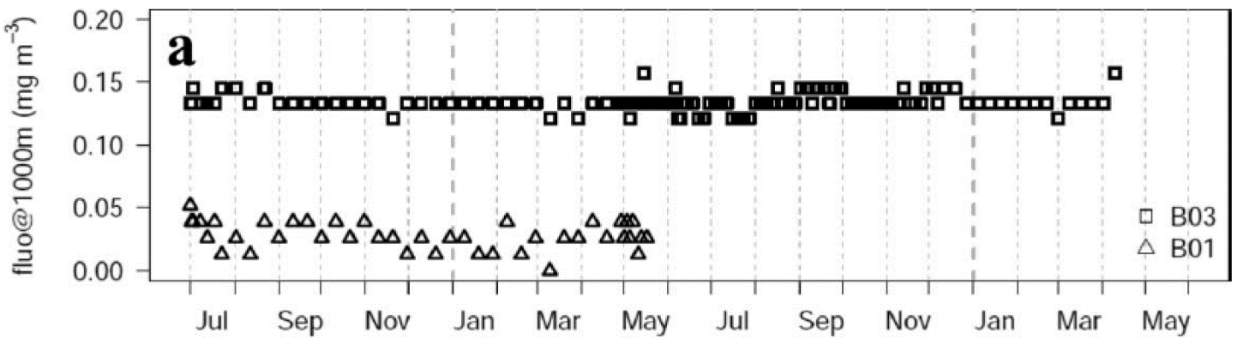


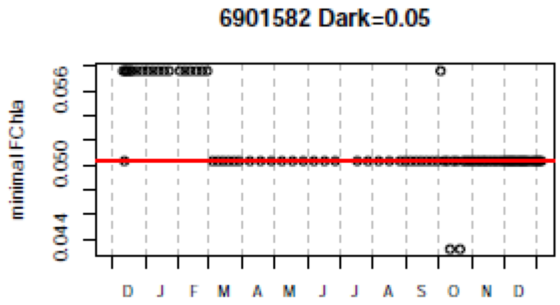


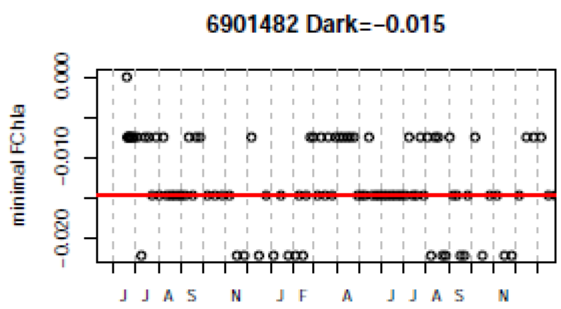
# 1. DARK CORRECTION IN DMQC

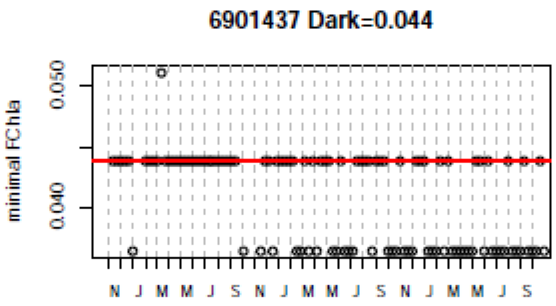
➢ **Option 3: Median of all minima (after median filter)**

***Xing et al. (2014) JGR***



# 2. NPQ CORRECTION IN DMQC

- **Backgrounds:**
  - 1. Xing12 has the “over-correction” issue in very deep waters
  - 2. Xing12 (and other extrapolation methods) cannot solve the NPQ correction in the shallow mixing waters (NPQ effect in the stratified layer)
- **Option 1: Xing18**

Research Article | Vol. 26, No. 19 | 17 Sep 2018 | OPTICS EXPRESS 24734

Optics EXPRESS

**Improved correction for non-photochemical quenching of *in situ* chlorophyll fluorescence based on a synchronous irradiance profile**

XIAOGANG XING,[1,*] NATHAN BRIGGS,[2] EMMANUEL BOSS,[3] AND HERVÉ CLAUSTRE[4]

# 2. NPQ CORRECTION IN DMQC

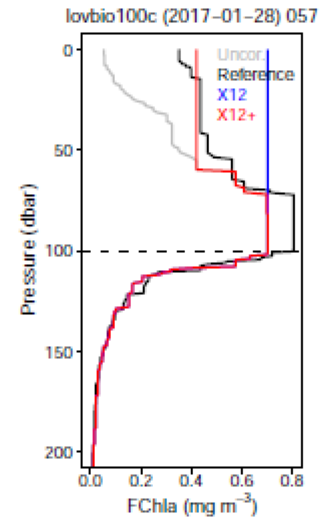
- **Xing18:**
  - 1. Using PAR profile to determine a NPQ threshold depth ($z_{iPAR15}$), the extrapolation of Xing12 is applied from surface to min($z_{iPAR15}$, MLD) for well-mixing waters

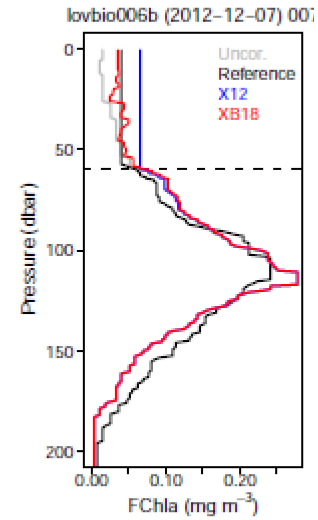
$$z_{X12+} = z\left(FChla = max\left(FChla\left(z \le \min\left(MLD, z_{iPAR15}\right)\right)\right)\right).$$

$$X12+(z) = \begin{cases} FChla\left(z_{X12+}\right) & \left(z \le z_{X12+}\right) \\ FChla(z) & \left(z > z_{X12+}\right) \end{cases}.$$

  - 2. Using PAR profile and empirical relationship (XB18) to correct NPQ for shallow-mixing waters (DCM>MLD)

$$XB18(z) = \begin{cases} FChla(z) / \left(0.092 + 0.908 / \left(1 + \left(iPAR(z)/261\right)^{2.2}\right)\right) & (z \ge 10\mathrm{m}) \\ XB18(z = 10\mathrm{m}) & (z < 10\mathrm{m}) \end{cases}.$$



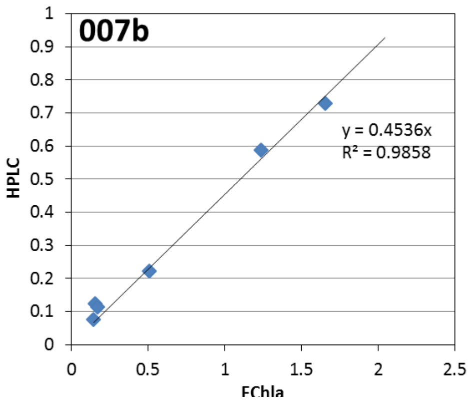



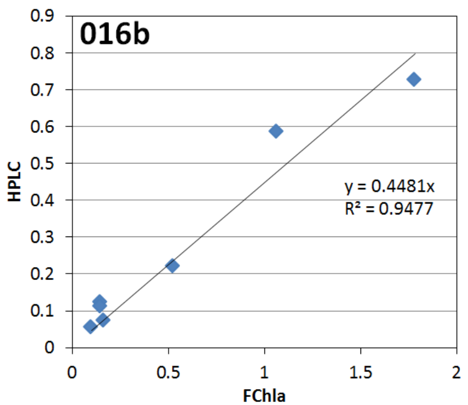
# 3. SLOPE CORRECTION IN DMQC

- **Option 1: Onboard-based correction**

  ***Haentjens et al. (2017) JGR***

  - 1. Water-sampling at deployment place
  - 2. [Chla] is determined by HPLC or fluorometery
  - 3. A linear (or exponential) regression on [Chla] vs. FChla (after Dark and NPQ correction) without intercept to acquire SLOPE



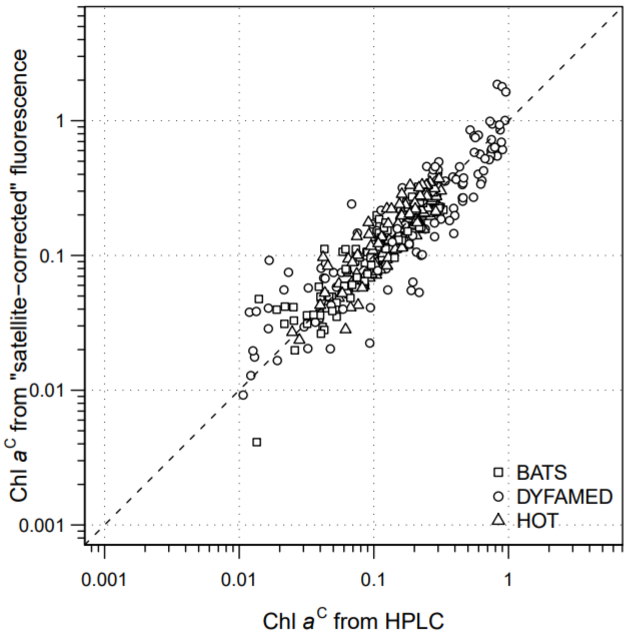




**HPLC measurement is not valid always, and in fact, very few floats have HPLC matchup data**

# 3. SLOPE CORRECTION IN DMQC

➢ **Option 2: Satellite-based correction**

***Lavigne et al. (2012) BG***

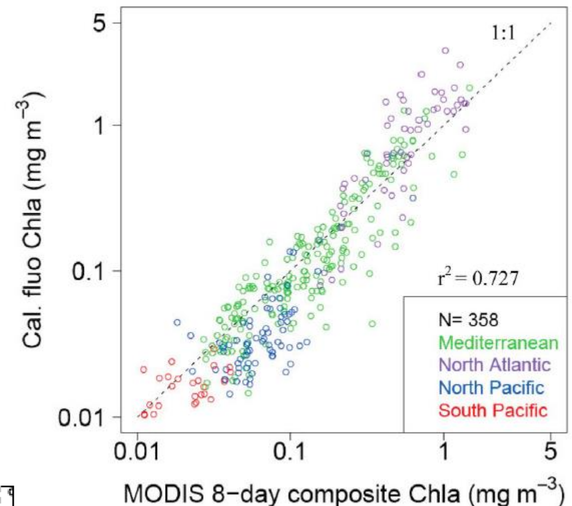


# 3. SLOPE CORRECTION IN DMQC

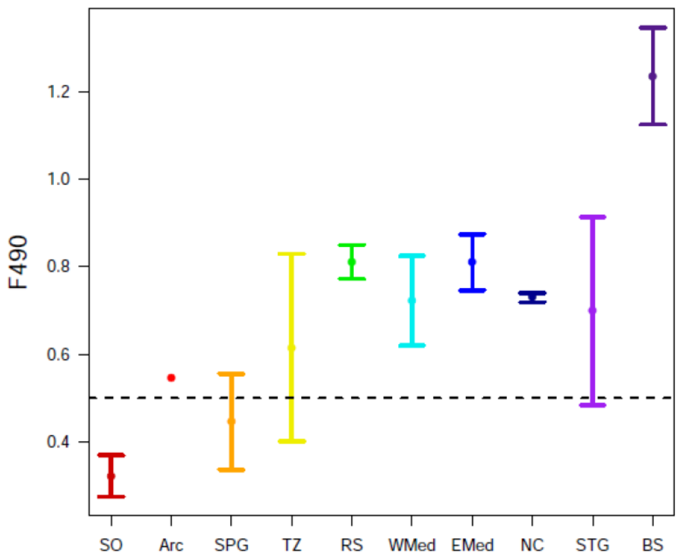
- **Option 3: Irradiance-based correction**

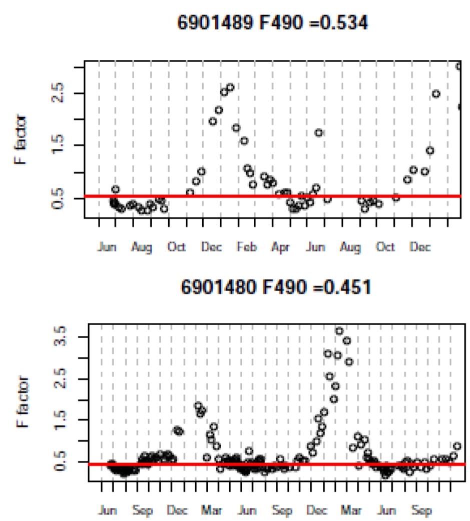
  ***Xing et al. (2011) JGR***

  - Based on the empirical relationship between $K_d(490)$ and [Chla]
  - $F_{490}$ is known to change with regions and seasons




***Xing et al. (2011) JGR***




***Xing et al. (Unpublished)***

# QC FRAMEWORK

| | **RTQC** | **DMQC** |
|---|---|---|
| Dark correction | Dark = median of deep FChla profile (profile by profile) | Option 1: Minimum for each profile<br>Option 2: On-Float Dark<br>Option 3: Median of all minima |
| NPQ correction | Xing12 | Option 1: Xing18<br>Option 2: Josh's method |
| Slope correction | Roesler17 = 0.5 | Option 1: Onboard-based correction<br>Option 2: Satellite-based correction<br>Option 3: Irradiance-based correction |