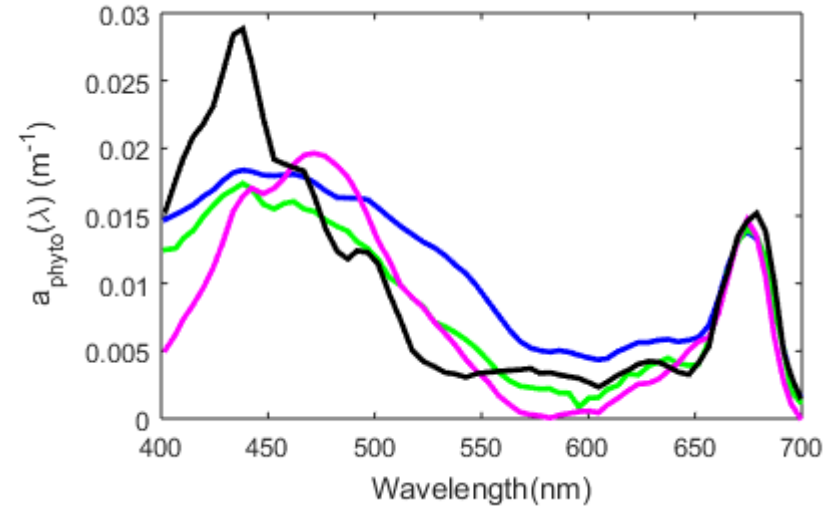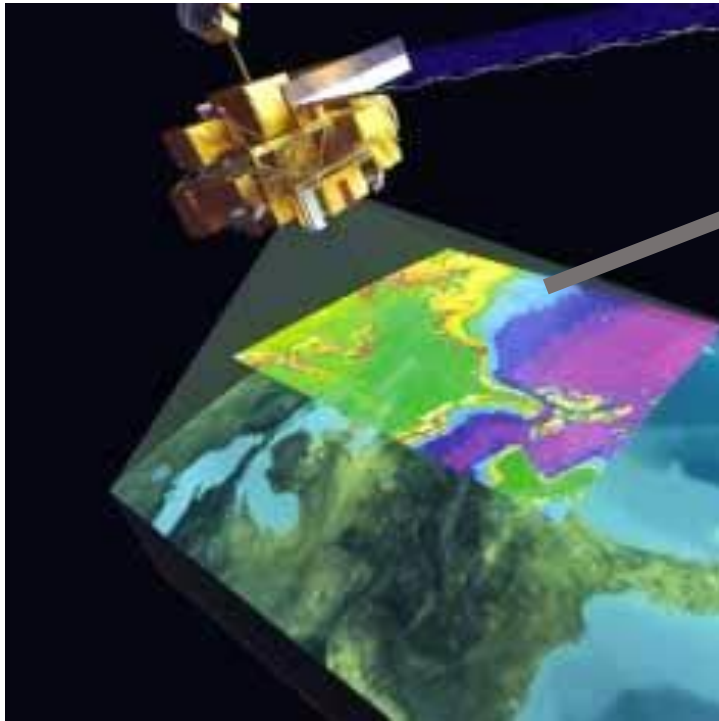# Quantifying uncertainties in phytoplankton absorption coefficients for accurate validation of the PACE ocean color sensor: moving towards satellite retrieved phytoplankton functional types (PFTs)

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One of the PACE objectives is to support the estimation of IOPs in general and optically-based Phytoplankton Functional Types

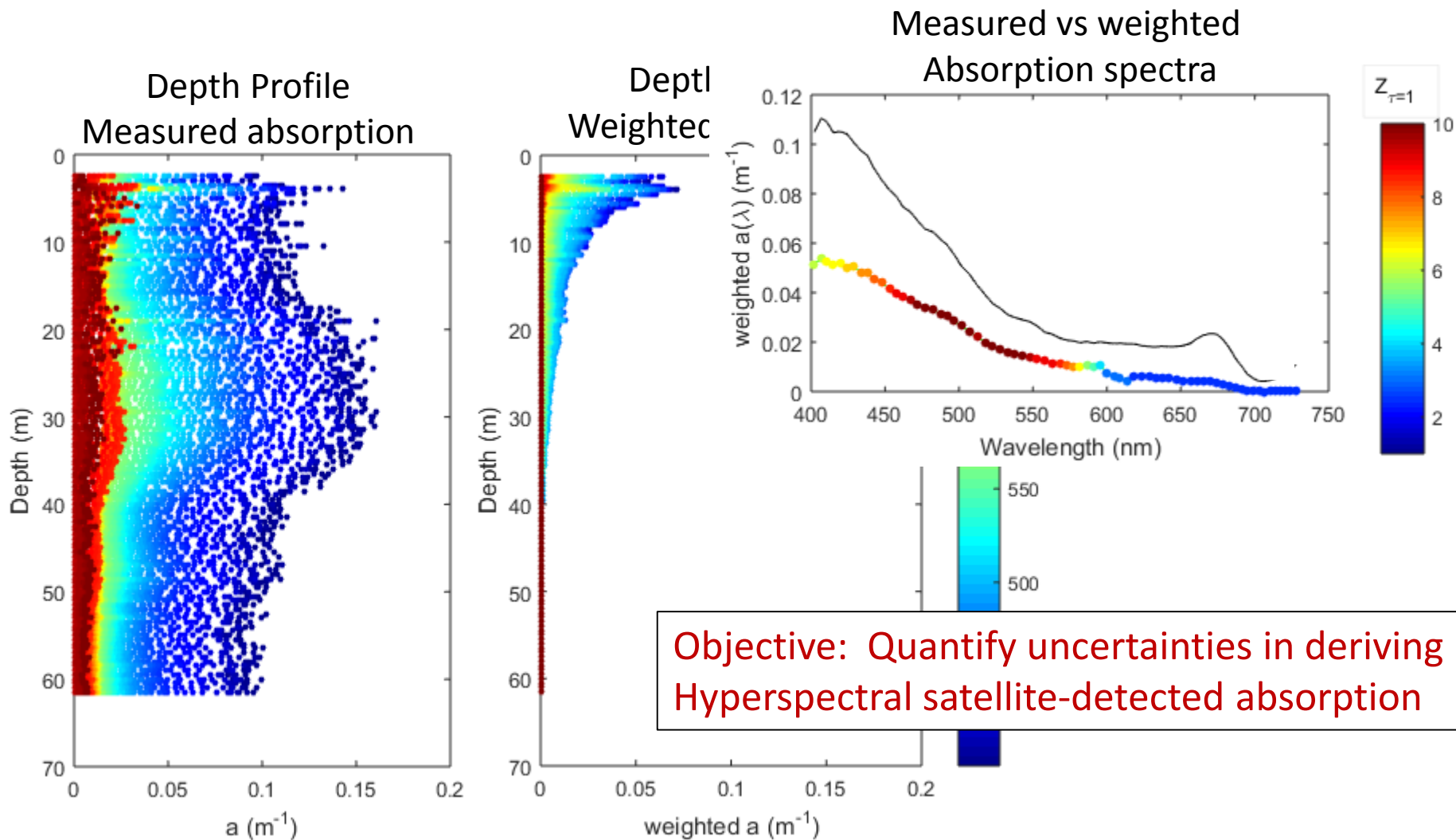http://wamis.meraka.org.za/modis-basics

- Invert ocean color signal to retrieve hyperspectral phytoplankton absorption coefficients

- Requires capability to **validate with uncertainties**

Stepwise approach to constructing validation 1a. In situ absorption vs $a_{sat}(\lambda)$

- Satellite sees exponentially-weighted absorption

Depth Profile
Measured absorption

Depth
Weighted

Measured vs weighted Absorption spectra

Objective: Quantify uncertainties in deriving Hyperspectral satellite-detected absorption

Stepwise approach
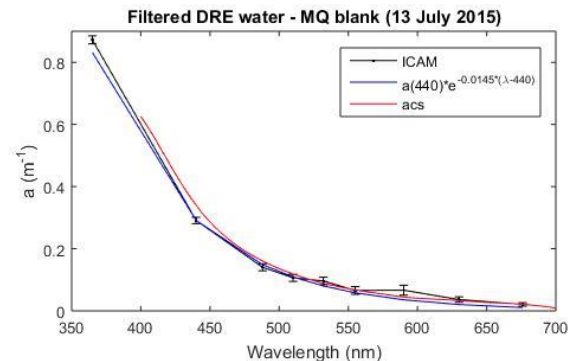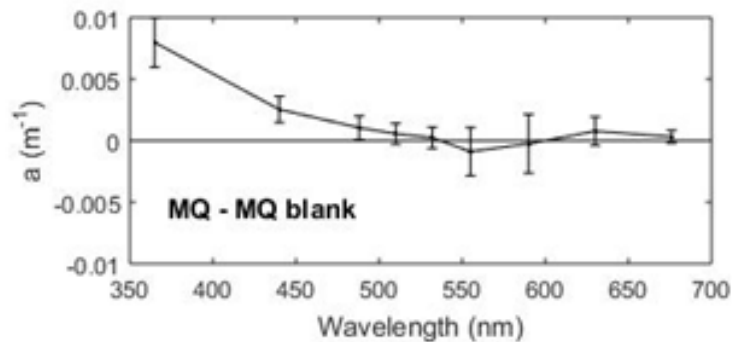# Step 1b. In situ hyperspectral absorption

- In situ sensors cannot extract phytoplankton signal
  - acs - hyperspectral but has scattering errors, no UV
  - ICAM - "no" scattering error, 9 wavelengths, 1 UV
  - a-sphere - hyperspectral but poorly constrained drift/baseline
  - Requires merging the best of each sensor
    - Use ICAM to determine scattering correction and extrapolate to UV

Objective: Quantify uncertainties in deriving Hyperspectral satellite-detected absorption

Objective 1b

Quantify uncertainties in deriving Hyperspectral satellite-detected absorption

- Progress to date
  - Received and began initial tests of ICAM late summer
    - Sensor resolution is comparable to acs
    - UV channel for PACE validation
    - Lack of >700 nm channel limits investigation of NIR scattering correction
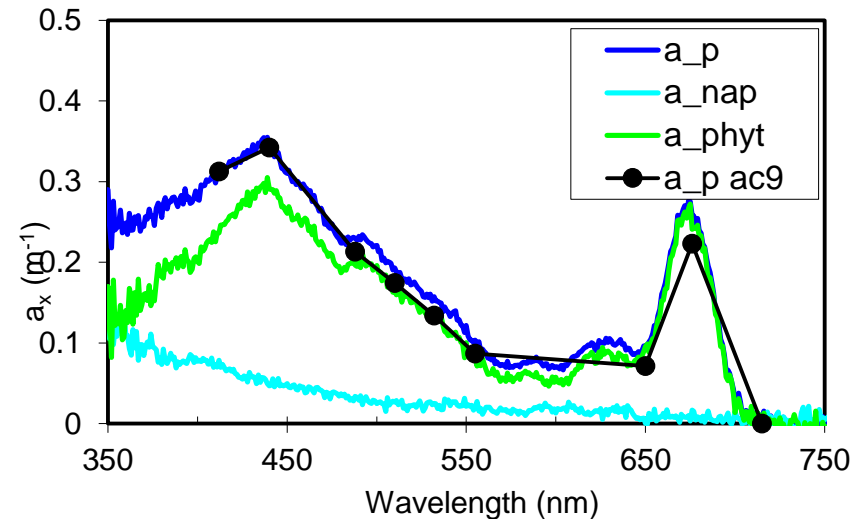   - Good comparison of CDOM measurements with acs

Filtered DRE water - MQ blank (13 July 2015)

  - Field comparisons (ac9, acs, ICAM, a-sphere; UltraPath and IS) at Boussole mooring in October
- Received second ICAM in late December

Stepwise approach
Step 1c. In situ hyperspectral absorption

- In situ sensors cannot extract phytoplankton signal
  - Requires modelling
  - laboratory analysis of discrete samples to physically separate material and therefore absorption properties

Objective: Quantify uncertainties associated with absorption inversion models

Stepwise approach
Step 2. Discrete analysis of phytoplankton absorption

- Samples are concentrated on glass fiber filters
  - Increases signal to noise
  - Removes CDOM from analysis
  - Separation of phytoplankton from other particulates
  - But there are scattering losses and pathlength amplification

- Improved spectrophotometric configuration
  - Center mounted integrating sphere
  - Mitigates scattering losses
  - Reduces uncertainty in pathlength amplification

Objective: Quantify uncertainties in estimating phytoplankton absorption coefficients on discrete samples
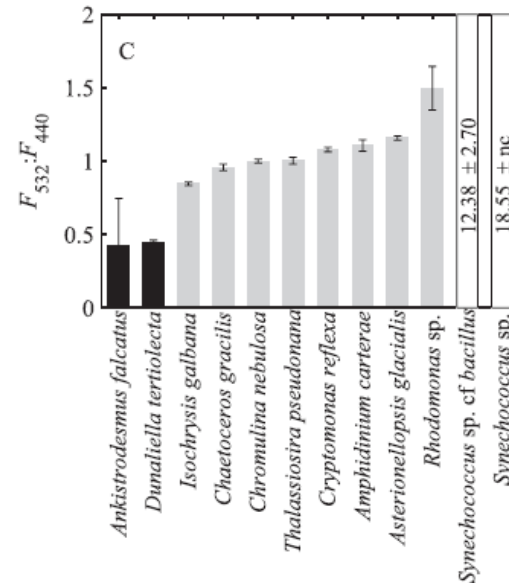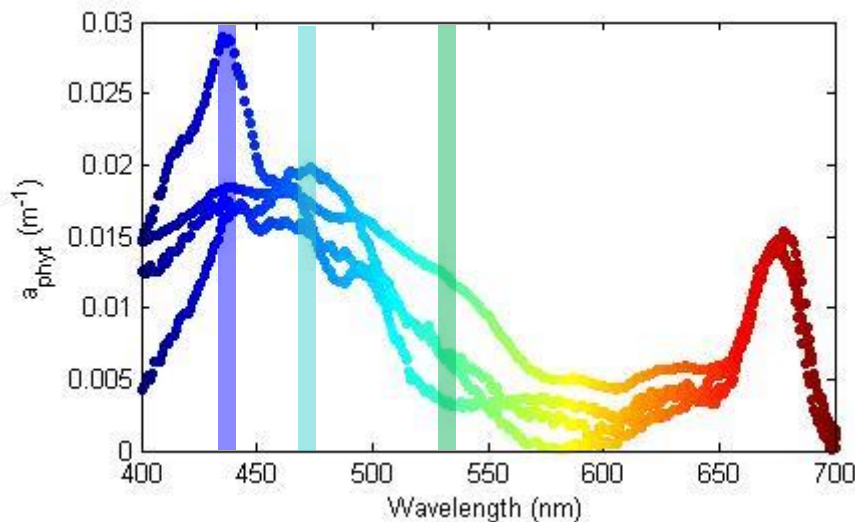
Objective 2

Quantify uncertainties in estimating phytoplankton absorption coefficients on discrete samples

- Progress to date
  - Experiments to isolate/characterize uncertainties due to
    - Scattering loss
    - Pathlength amplification

- Half-way into my experiments I received a manuscript for review that was identical to my approach

- Conclusions to date
  - Dariusz, Rick, Slawomir, Julia, Guangming and I think alike
  - Can I count a peer review as a pub?
  - Replication and validation on two systems (consensus)

Stramski, D, Reynolds RA, Kaczmarek S, Uitz J, Zheng G. 2015. Correction of pathlength amplification in the filter-pad technique for measurements of particulate absorption coefficient in the visible spectral region. Applied Optics. 54:6763-6782.: OSA

Objective 3

Discerning absorption-based phytoplankton functional types from multispectral fluorescence
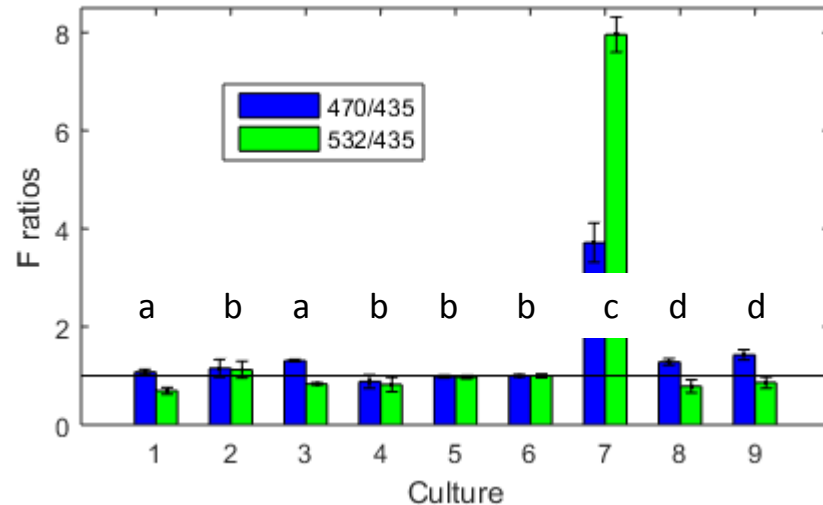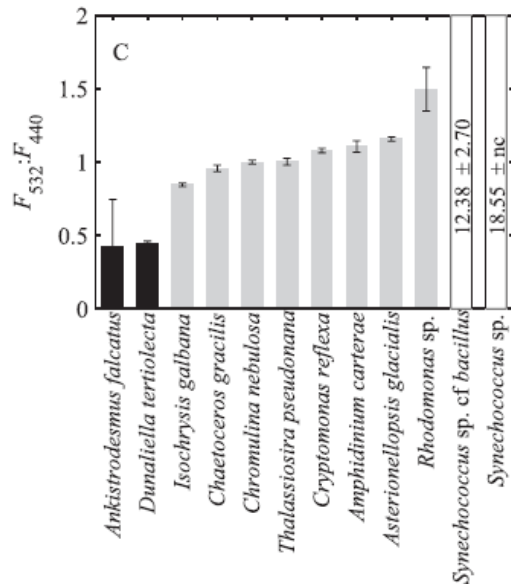
- Platforms for validation not optimal for ac meters

- To increase opportunities for validation, small, low power optical sensors are *also* needed

- Multichannel fluorometers (3X1M) provide means for discerning absorption ratios and pigmentation (*Proctor and Roesler 2010; Thibodeau et al. 2014*)

Objective 3

Discerning absorption-based phytoplankton functional types from multispectral fluorescence

- Progress to date
    - Laboratory experiments (8 new species; 3 sensors)
    - Comparable values between projects
    - Comparable values with replicate species

Objective 3

Discerning absorption-based phytoplankton functional types from multispectral fluorescence

- Progress to date
  - Deployment of 3X1M in coastal **Gulf of Maine** mooring
  - Deployment of 3X1M on Med Sea Boussole mooring

Biomass

Fratios
(~taxonomy)

Dinoflagellates

Diatoms

Opportunity for Field Observations

- Southern Ocean - Reunion to Kerguelen Islands
  - Oligotrophic gyre, HNLC, naturally Fe-enriched waters
- Underway observations/samples
  - IOPS: acs, ICAM, bb3, BBFL2, 3X1M, LISST
  - Radiometry: RRS(L_w, L_{sky}, E_d)
  - PFT: HPLC, ImagingFlowCytoBot
- ~ten stations

If you are interested in collaborating (Heidi D, I promise white caps!) and can lend the equipment, the data will be available to support your PACE efforts

Some thoughts on spectral resolution and band width

- Four phytoplankton cultures, absorption spectra
- Mean and standard deviation spectra
- Auto decorrelation spectral scales

Conclusions

Pigment-based Phytoplankton Functional Types ← **Hyperspectral Phytoplankton Absorption Coefficients** ← **Modeled from in situ profiles of total absorption** ← **spectrophotometric analysis discrete filter pad samples,**

- Pigment-based Phytoplankton Functional Types → Uncertainties in PFT approach

- Hyperspectral Phytoplankton Absorption Coefficients → Uncertainties in situ measured absorption (fluorescence proxy)
  - → Environmental Uncertainties
  - → Measurement Uncertainties

- Modeled from in situ profiles of total absorption → Uncertainties phytoplankton absorption models

- spectrophotometric analysis discrete filter pad samples, → Uncertainties spectrophotometric analysis
  - → Scattering loss Uncertainties
  - → Amplification Uncertainties