Phytoplankton composition algorithms for PACE

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Objective:

"Attempt to develop relationships between water leaving radiances and phytoplankton composition using a radiation model, in situ data, and an established global biogeochemical model"

How?

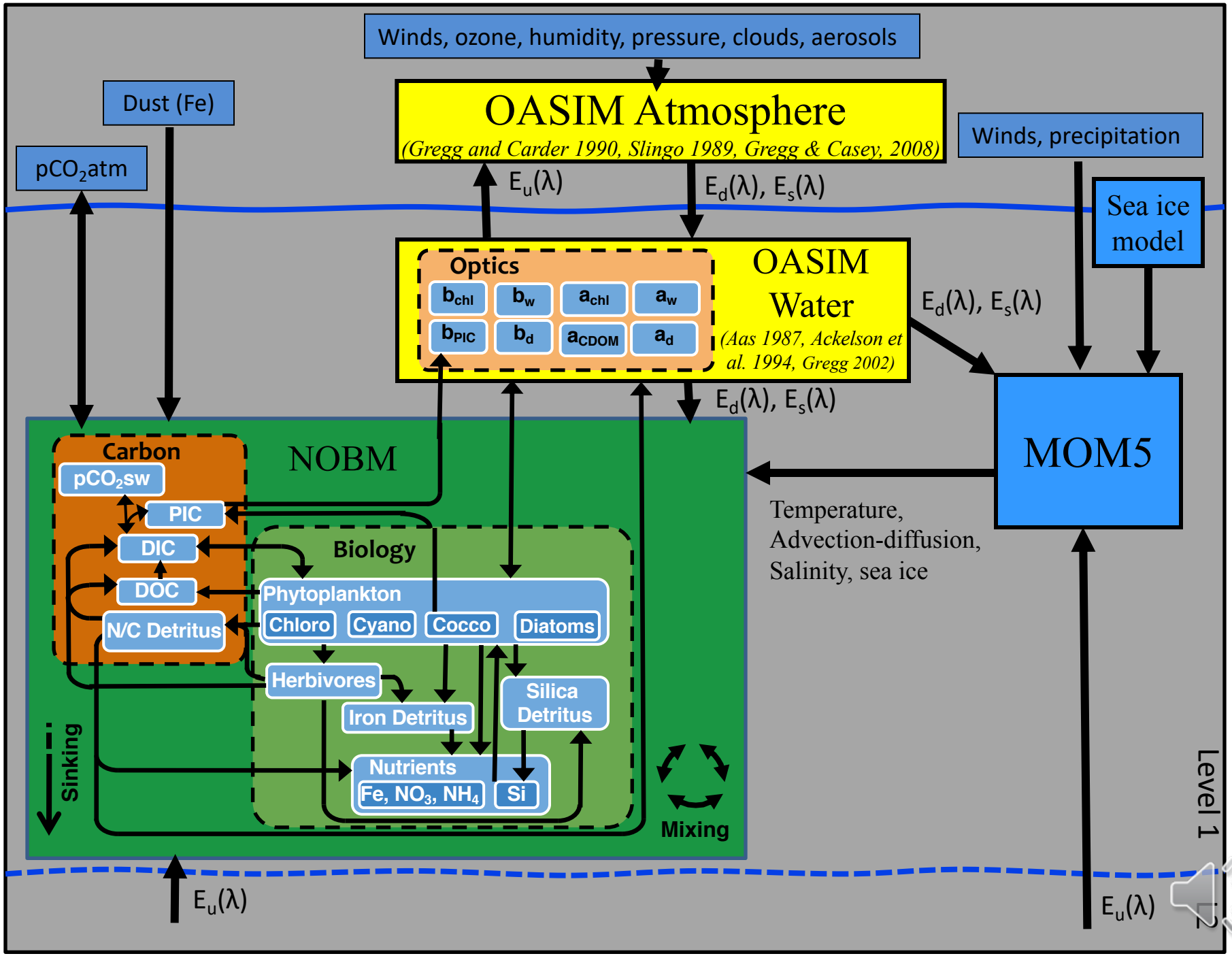
(1) Simulated hyperspectral water leaving radiances

(2) Assess whether we can derive phytoplankton composition from these hyperspectral water leaving radiances

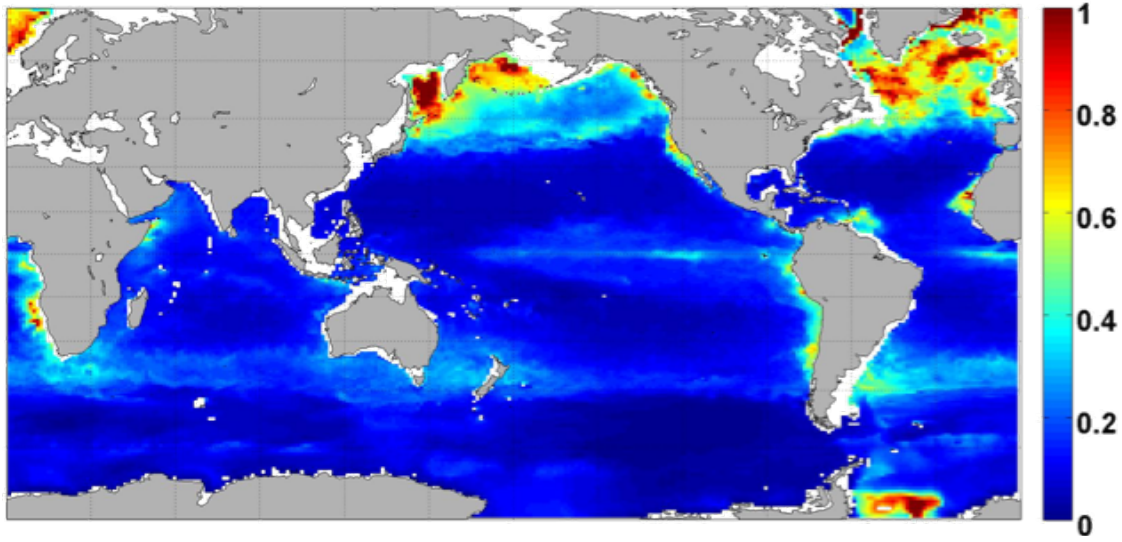
PACE Science Team Meeting - January 16-18th 2018 – Harbor Branch, FL

Assimilated NOBM-OASIM model

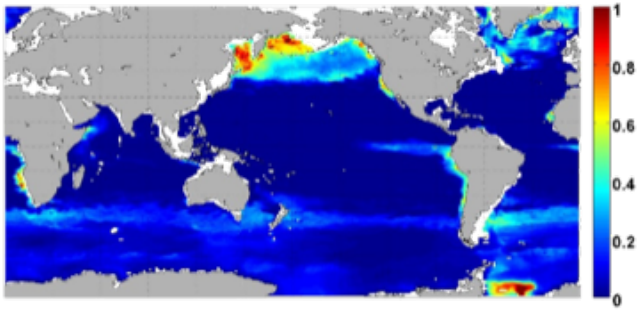
- NOBM assimilates satellite chlorophyll, PIC and aCDOM
- Coupled with circulation model and radiation model
- Each phytoplankton groups has its own growth rate, sinking rate and nutrient uptake
- Output from NOBM-OASIM provide hyperspectral water leaving radiance for variable phytoplankton distribution


Winds, ozone, humidity, pressure, clouds, aerosols
Dust (Fe)
OASIM Atmosphere
(Gregg and Carder 1990, Slingo 1989, Gregg & Casey, 2008)
Winds, precipitation
pCO2atm
Eu(λ)
Ed(λ), Es(λ)
Sea ice model
Optics
bchl
bw
achl
aw
bPIC
bd
aCDOM
ad
OASIM Water
(Aas 1987, Ackelson et al. 1994, Gregg 2002)
Ed(λ), Es(λ)
Ed(λ), Es(λ)
MOM5
NOBM
Carbon
pCO2sw
PIC
DIC
DOC
N/C Detritus
Biology
Phytoplankton
Chloro
Cyano
Cocco
Diatoms
Herbivores
Iron Detritus
Silica Detritus
Nutrients
Fe, NO3, NH4
Si
Sinking
Mixing
Temperature,
Advection-diffusion,
Salinity, sea ice
Eu(λ)
Eu(λ)
Level 1
Level 2

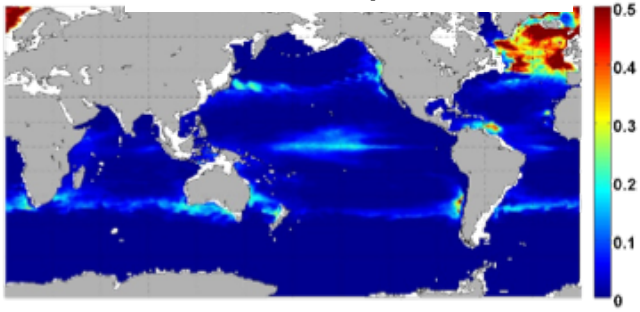
Total chlorophyll



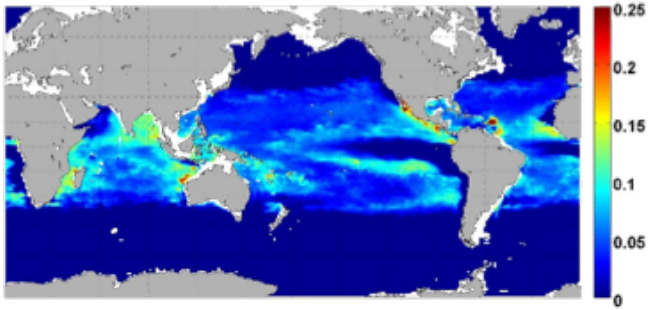
Diatoms



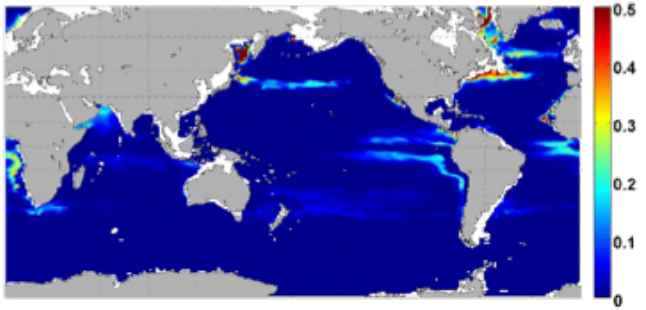
Coccolithophores

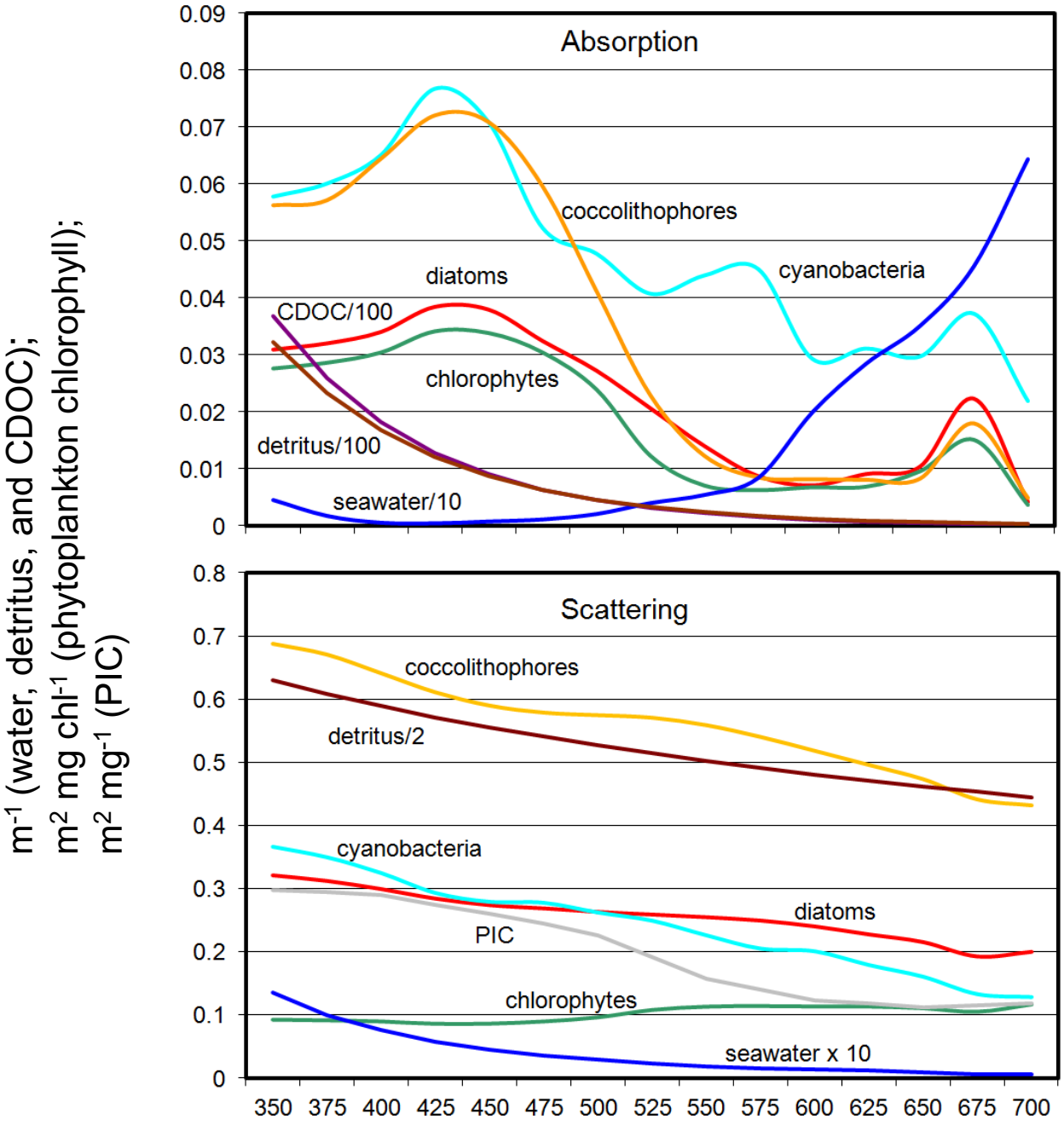


Cyanobacteria

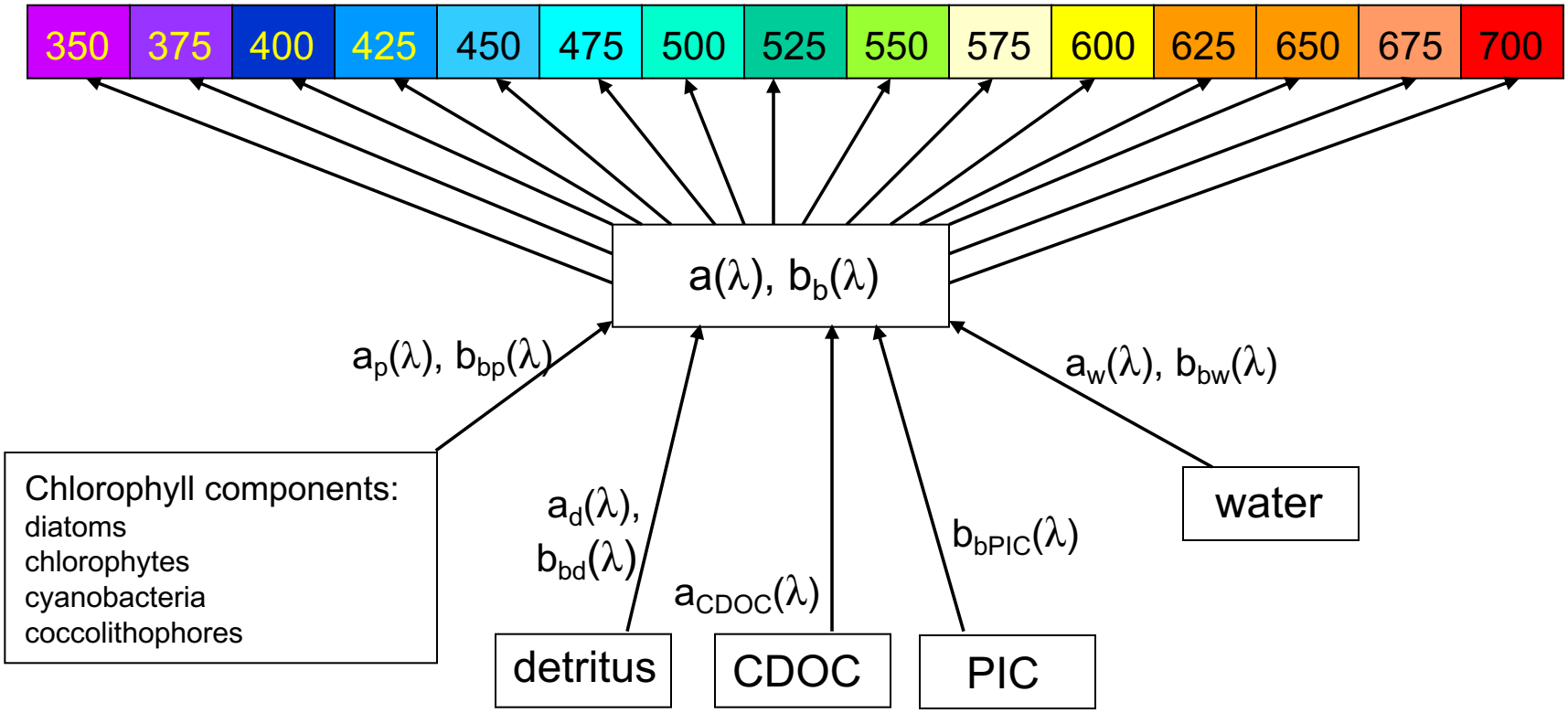


Chlorophytes




m-1 (water, detritus, and CDOC);
m2 mg chl-1 (phytoplankton chlorophyll);
m2 mg-1 (PIC)
Absorption
coccolithophores
diatoms
cyanobacteria
CDOC/100
chlorophytes
detritus/100
seawater/10
Scattering
coccolithophores
detritus/2
cyanobacteria
diatoms
PIC
chlorophytes
seawater x 10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
350 375 400 425 450 475 500 525 550 575 600 625 650 675 700

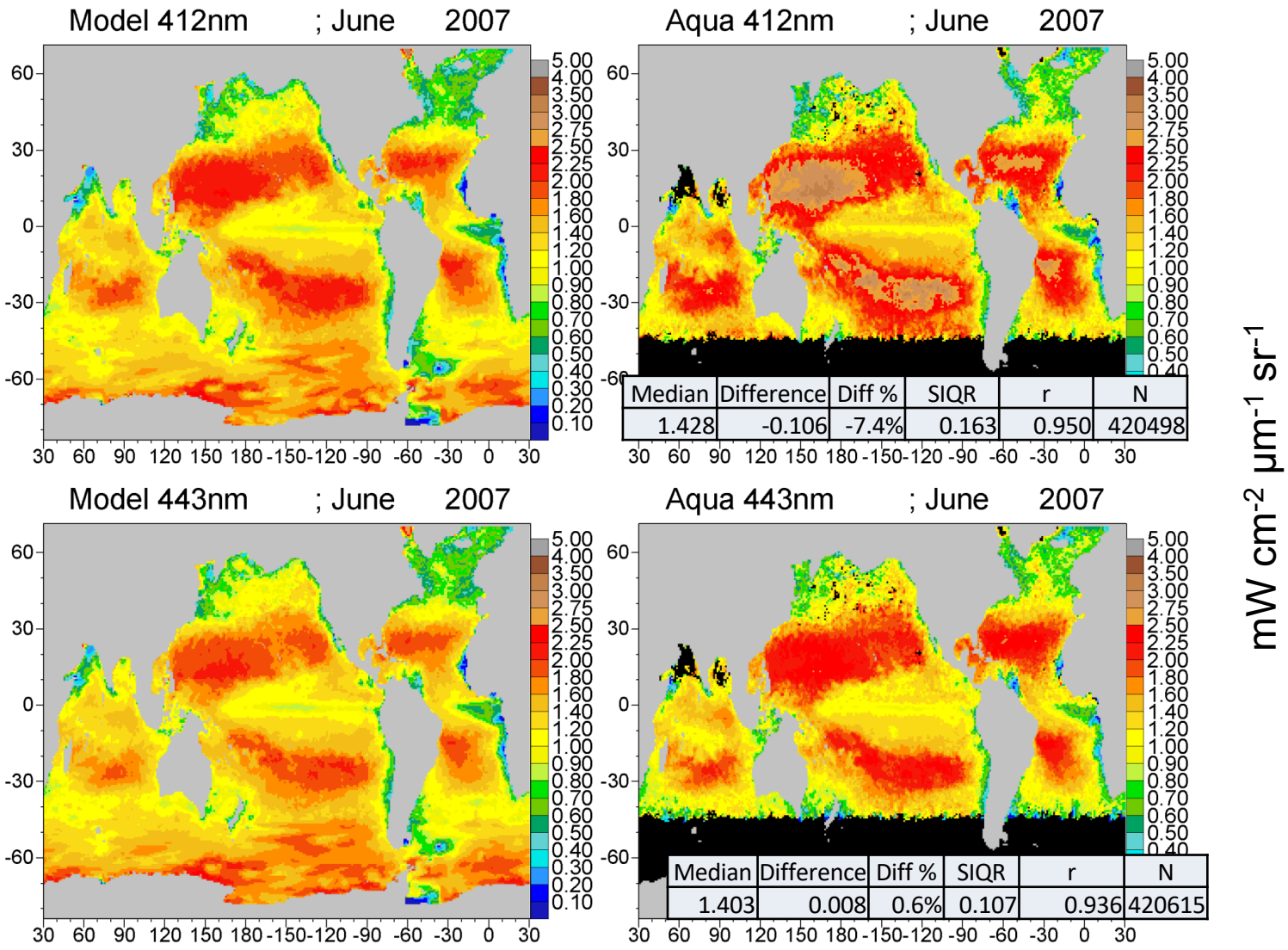
OASIM Upwelling Radiance



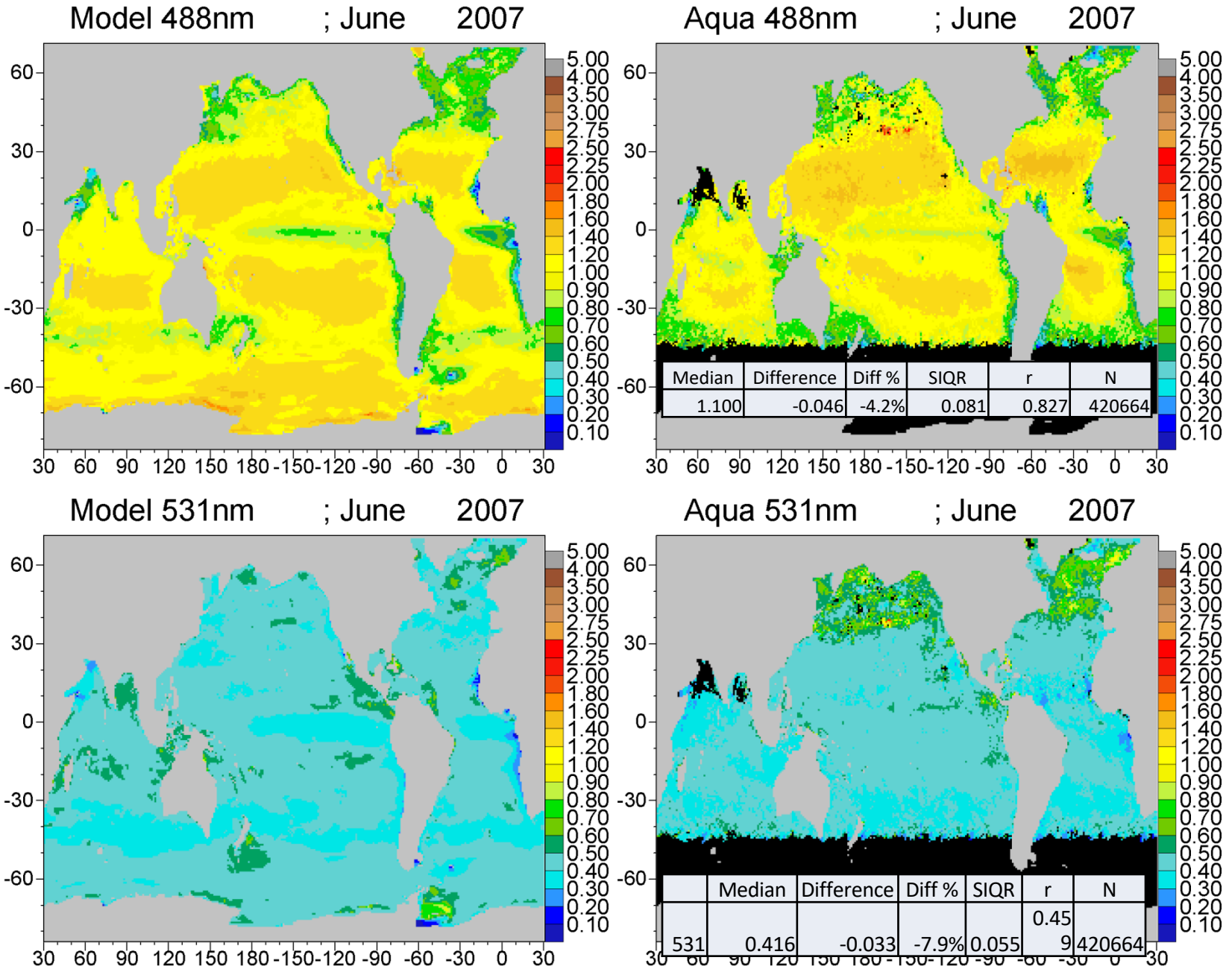
Full Spectral Range = 200nm to 4µm

25nm spectral resolution for E_d, E_s, and E_u
1nm spectral resolution for LwN

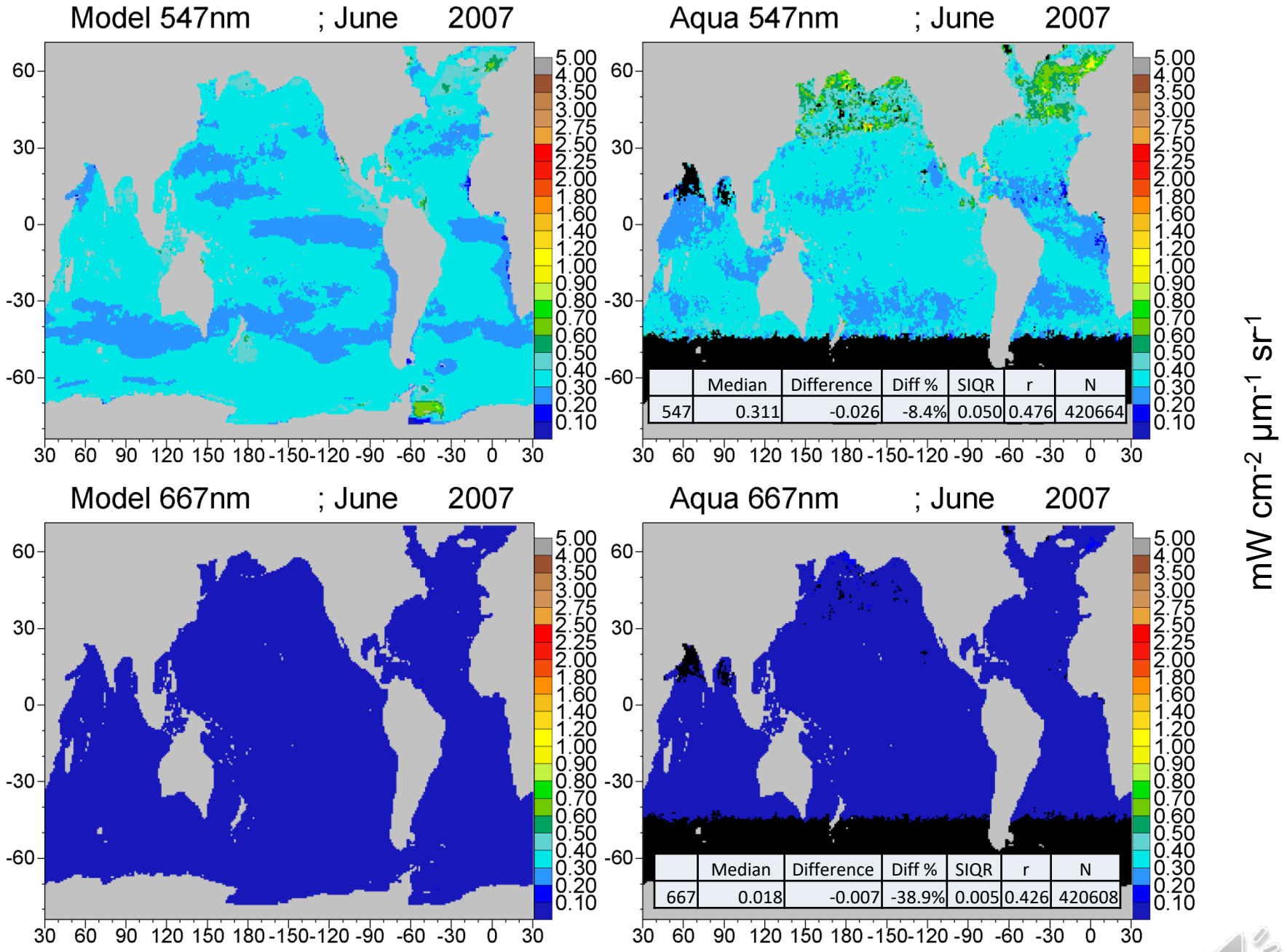
(1) Simulated hyperspectral water leaving radiances



Model normalized water-leaving radiances $L_wN(\lambda)$ for 412nm and 443nm compared to MODIS-Aqua radiances.



Model normalized water-leaving radiances $L_wN(\lambda)$ for 488nm and 531nm compared to MODIS-Aqua radiances.



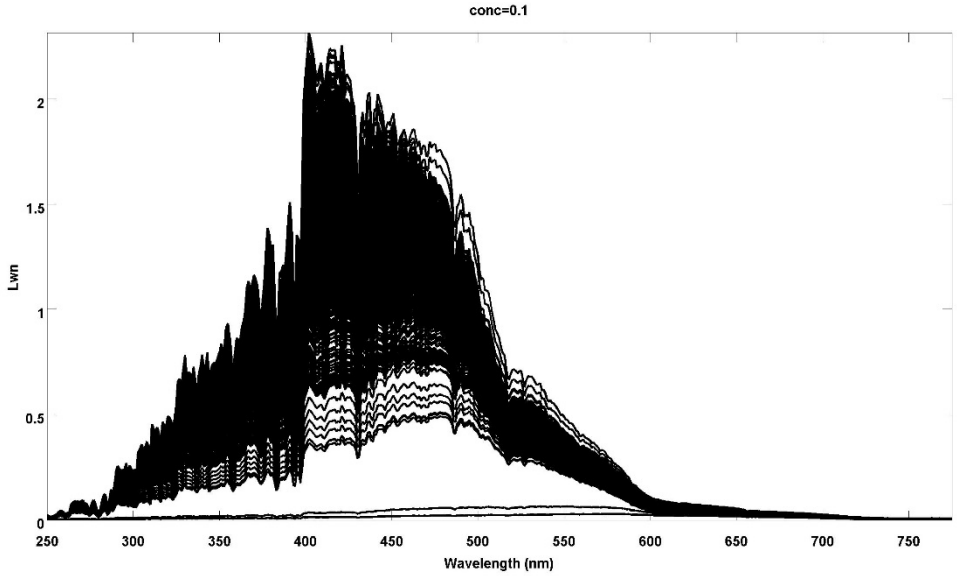
Model normalized water-leaving radiances $L_wN(\lambda)$ for 547nm and 667nm compared to MODIS-Aqua radiances.

(2) Assess whether we can derive phytoplankton composition from these hyperspectral water leaving radiances

Model's simulated water leaving radiances compared well with those from MODIS-Aqua.

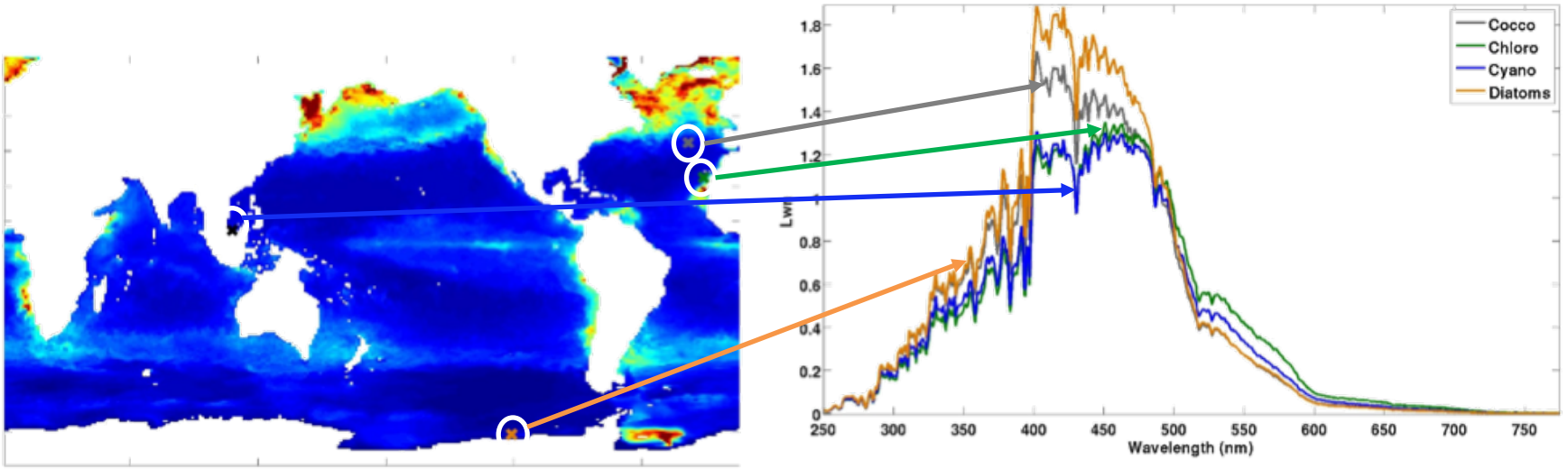
The challenge:
For one specific chlorophyll concentration, there is a diversity of water leaving radiance spectra (=different phytoplankton composition possible).

For example, at a total phytoplankton concentration of 0.1 $\mu g\ chl\ L^{-1}$:

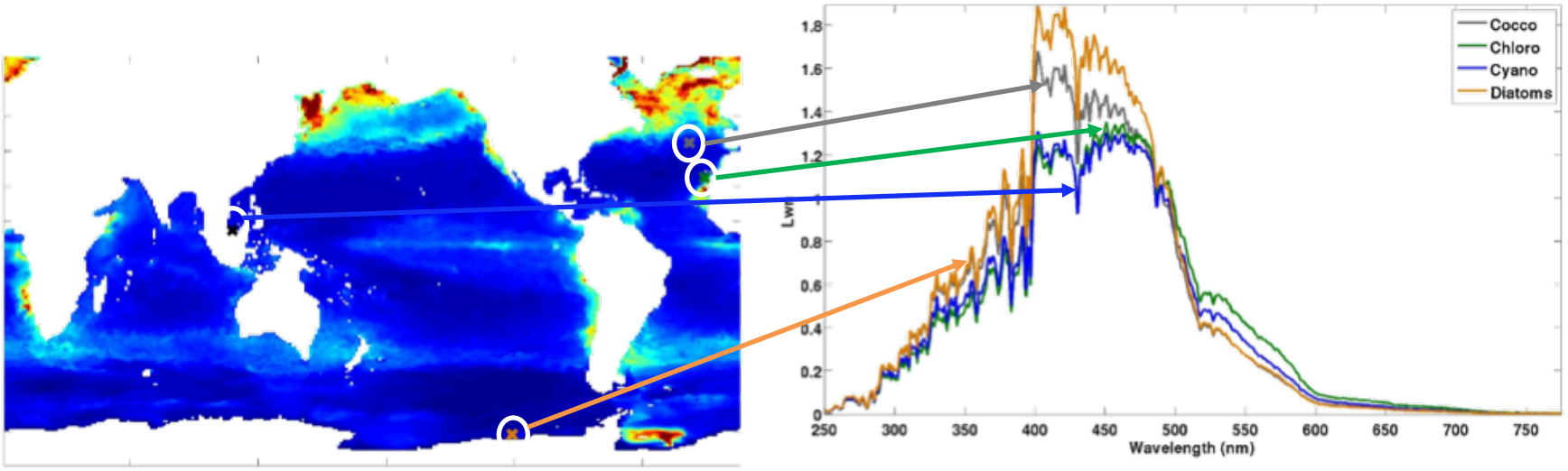


- All these locations have a total chlorophyll concentration of 0.1 μg chl L^{-1} but the Lwn differs because of their different phytoplankton composition

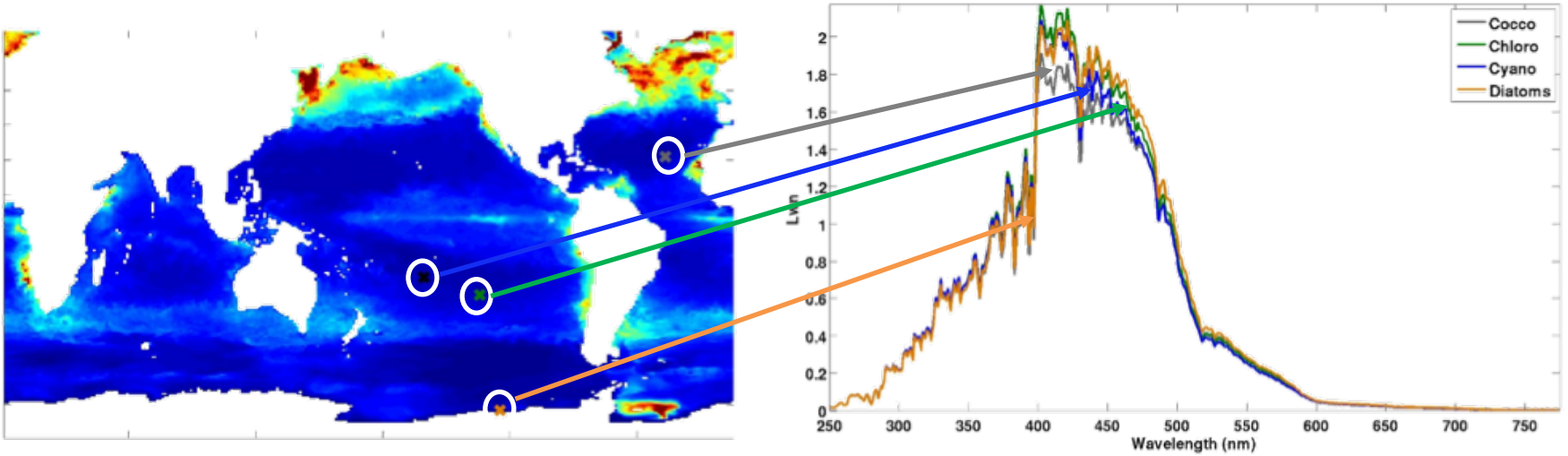
- Each location is characterized by the dominance (>90% for cyano and diatoms and >70% for chloro and cocco) of one of the phytoplankton groups



0.1 μg chl L^{-1} & >90% for cyano and diatoms and >70% for chloro and cocco



0.5 μg chl L^{-1} & >90% for cyano and diatoms, >50% for chloro and >30% cocco



Conclusions

- Many applications for the simulated dataset (instrument development, sensitivity analysis, algorithm developments, etc)
- For one specific concentration various Lwn spectra
- Next: explore the use of LUT derived from theoretical phytoplankton composition to assess the use of these LUT to derive phytoplankton composition from hyperspectral Lwn

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