Simultaneous retrieval of Aerosol and Chlorophyll from MODIS Aqua radiances

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Radiative Transfer
Dave Flitner
Zia Ahmad
Chlorophyll
Watson Gregg

Introduction

Goal: ***Construct algorithm that simultaneously retrieves Aerosol and Ocean Chlorophyll.***
Simulates observed MODIS radiances

Observations, Reflectances

7 MODIS-Aqua level-2 channels (0.47 - 2.1um)
2 Additional level-1b (0.412, 0.443, 0.488)

Forward Model

- ***Aerosol 3D Transport MODEL (GOCART) provides spatial and size distribution of aerosols***

- ß ***3D Ocean Biogeochemical model provides first guess chlorophyll concentrations (Watson Gregg)***

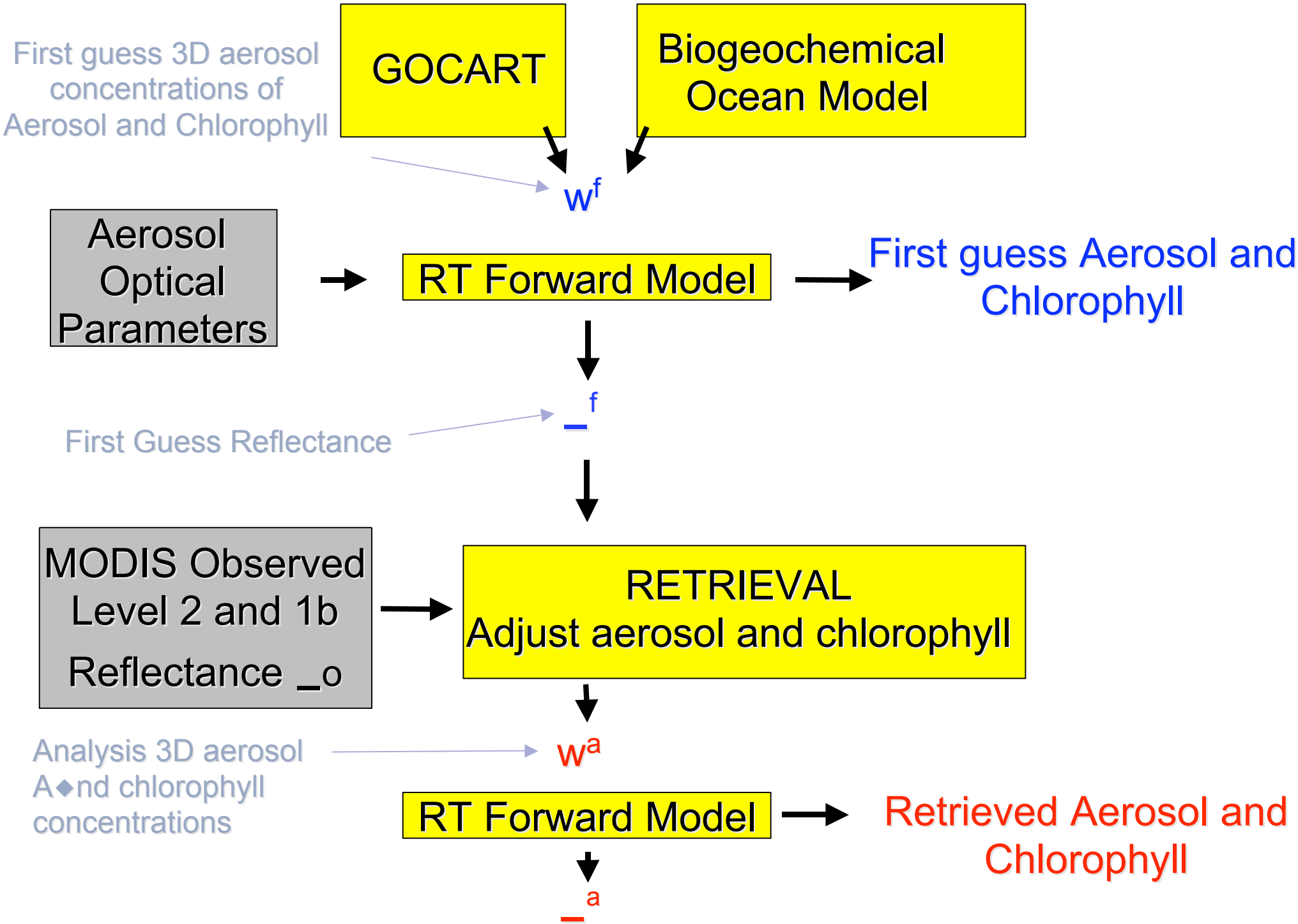
- ***Herman Radiative Transfer Model (Vector Code) converts aerosol chlorophyll concentrations to reflectance***

Motivation

Desire to retrieve absorbing aerosol information over Ocean using MODIS Radiances

Need to account for chlorophyll absorption

Approach: Use model based retrieval to use In Assimilation System


First guess 3D aerosol concentrations of Aerosol and Chlorophyll
GOCART
Biogeochemical Ocean Model
w^f
Aerosol Optical Parameters
RT Forward Model
First guess Aerosol and Chlorophyll
$\_^f$
First Guess Reflectance
MODIS Observed Level 2 and 1b Reflectance _o
RETRIEVAL
Adjust aerosol and chlorophyll
w^a
Analysis 3D aerosol A◆nd chlorophyll concentrations
RT Forward Model
Retrieved Aerosol and Chlorophyll
$\_^a$

Radiative Transfer Forward model

Many look-up-tables per MODIS channel generated by the University of Arizona radiative transfer model

Variants: Aerosol species, Relative humidity

Species

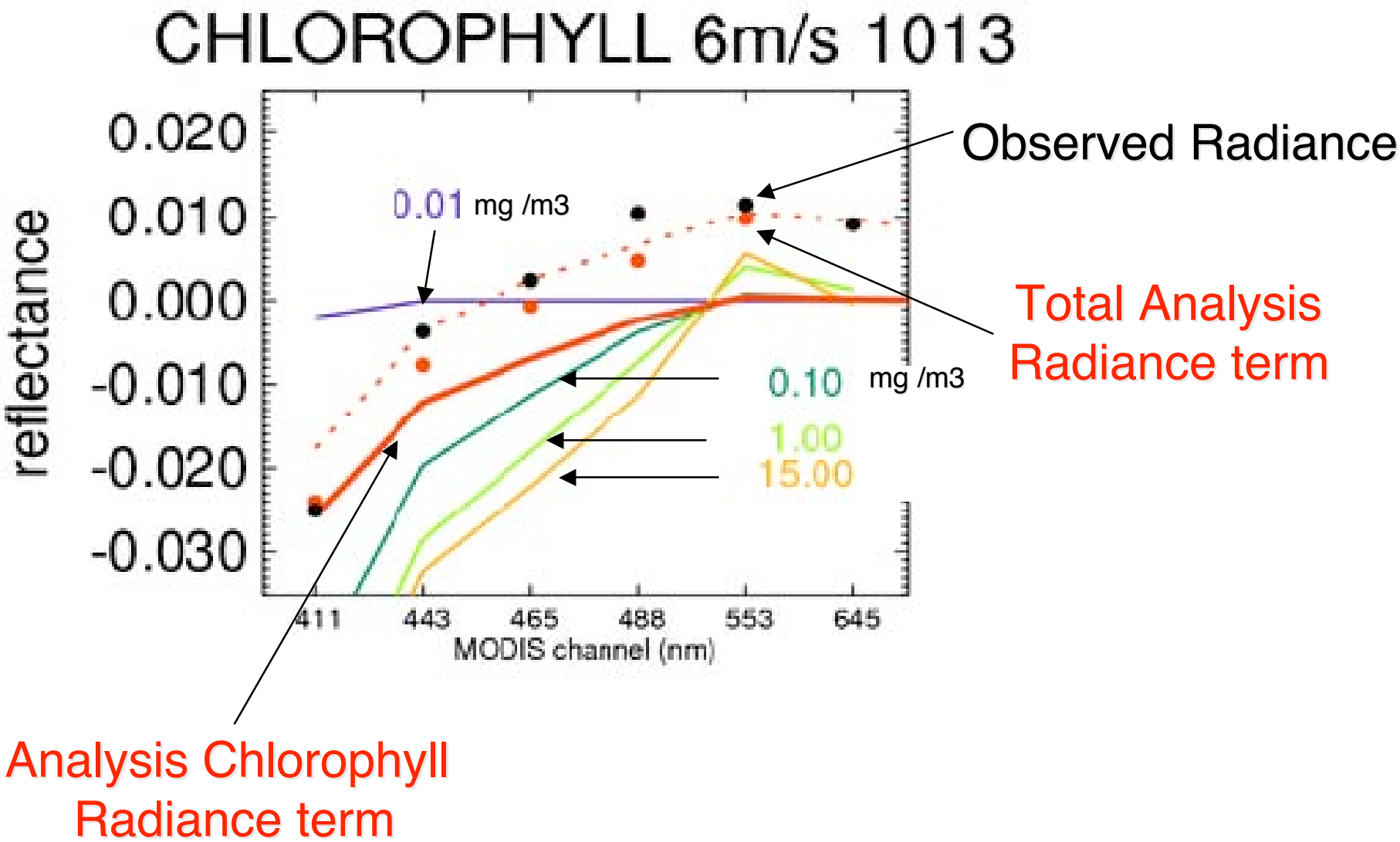
Dust (dry R_{eff} = 1.0, 1.4 µm)
Sulfate
Seasalt (dry R_{eff} = 1.0, 1.3 µm)
Black Carbon-Organic Carbon mixtures

Variant: Chlorophyll

- ***Spectral Absorption from Morel and Maritorena (2001)***

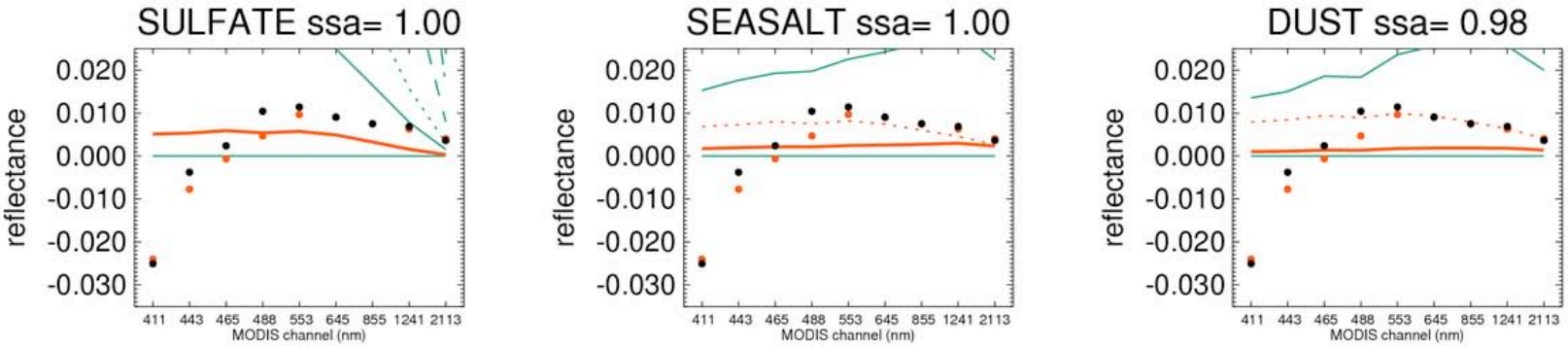
Variants: Underlying Surface Properties

Rough Ocean (2, 6, 12 m/s wind speeds
Ocean wind speed is from GMAO meteorological assimilation

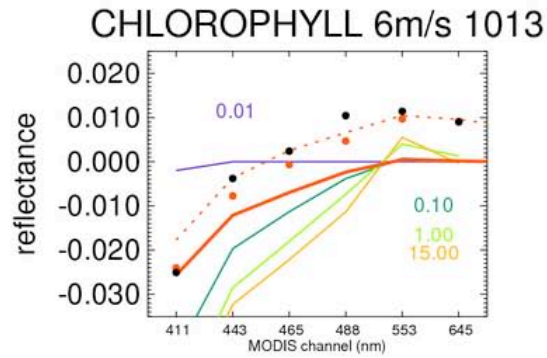

CHLOROPHYLL 6m/s 1013
reflectance
0.020
0.010
0.000
-0.010
-0.020
-0.030
411
443
465
488
553
645
MODIS channel (nm)
0.01 mg /m3
0.10 mg /m3
1.00
15.00
Observed Radiance
Total Analysis Radiance term
Analysis Chlorophyll Radiance term

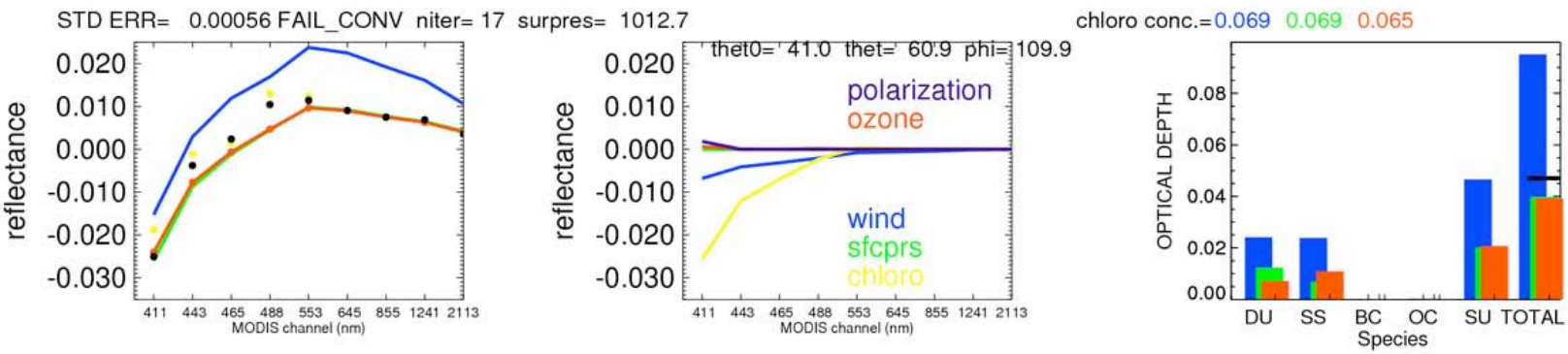
OBS-Black FG-Blue ANAL-Red LUT(tau=0,.2,.5,1.0)-Green

Lat=-26.94 Lon= -9.46 Depth= -3974.1 Scat angle= 99.8 BC frac= 0.651 Wind= 1.554 RH= 48.7% SSA= 0.994



Low Chlorophyll - Low aerosol

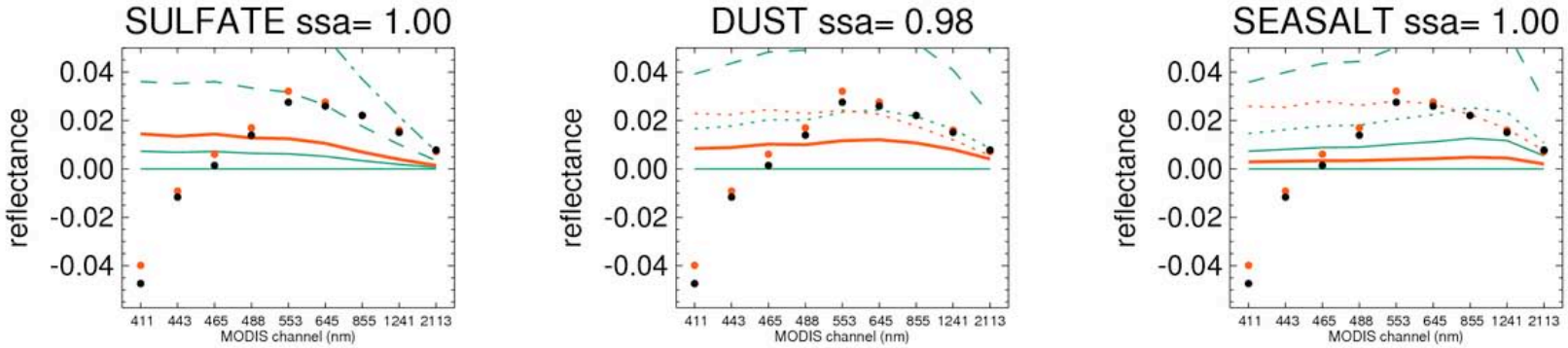




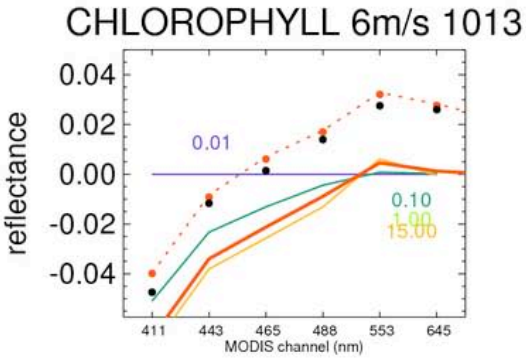
modis_convergence.sat_A.20050824_12z.dat

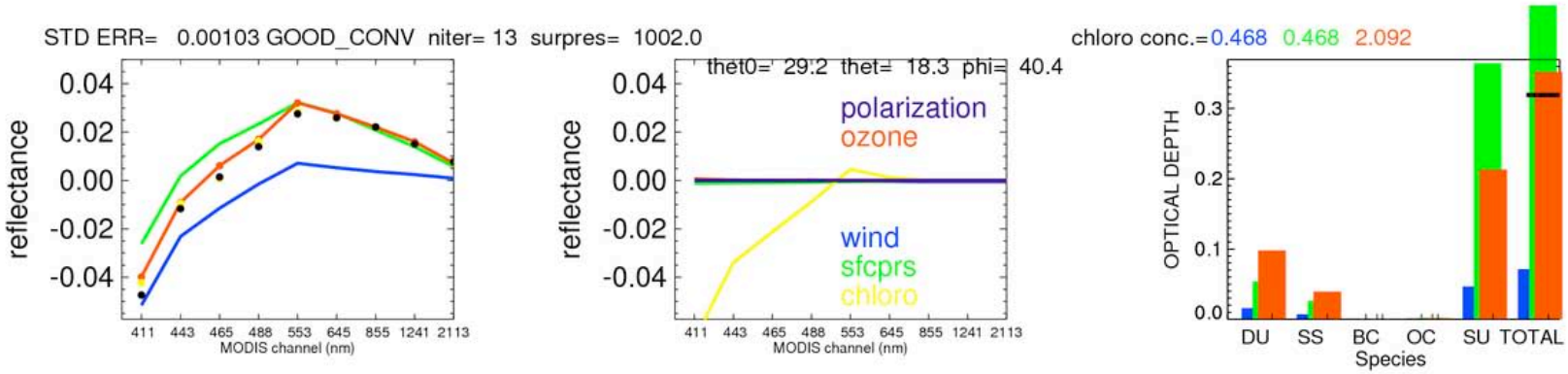
OBS-Black FG-Blue ANAL-Red LUT(tau=0,.2,.5,1.0)-Green

Lat= -4.47 Lon= -2.27 Depth= -4721.5 Scat angle= 161.0 BC frac= 0.581 Wind= 5.223 RH= 68.1% SSA= 0.994



High Chlorophyll - High aerosol

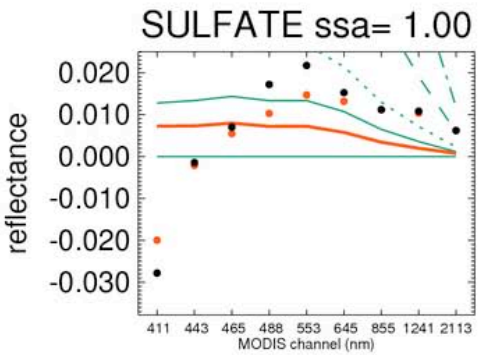


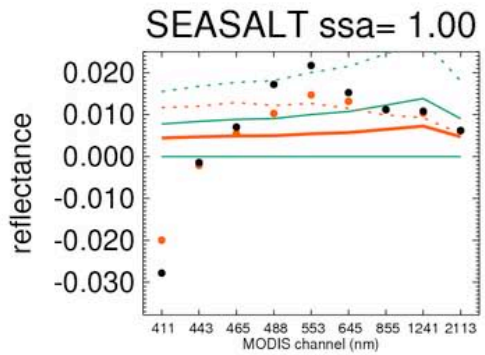


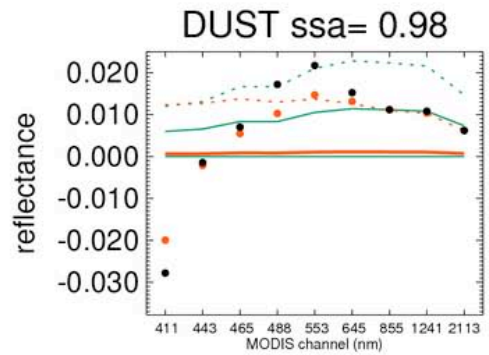
modis_convergence.sat_A.20050824_12z.dat

OBS-Black FG-Blue ANAL-Red LUT(tau=0,.2,.5,1.0)-Green

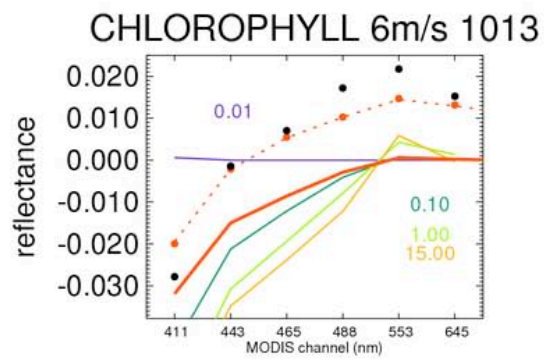
Lat=-34.72 Lon= 58.25 Depth= -4504.4 Scat angle= 133.0 BC frac= 0.612 Wind= 8.603 RH= 32.9% SSA= 0.997



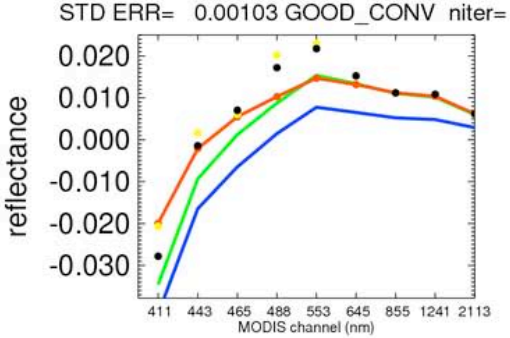


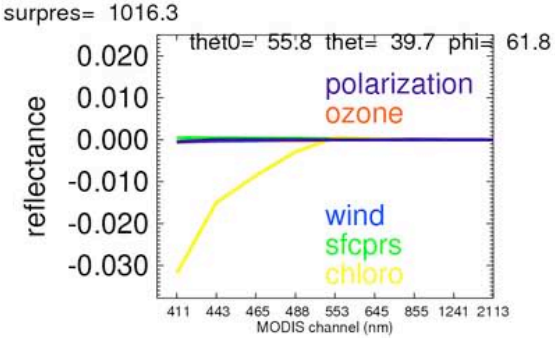


Low Chlorophyll
Moderate aerosol

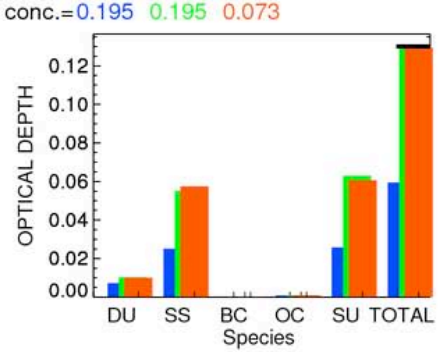


STD ERR= 0.00103 GOOD_CONV niter= 5 surpres= 1016.3





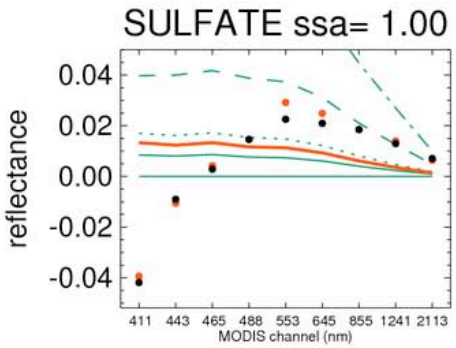
chloro conc.=0.195 0.195 0.073

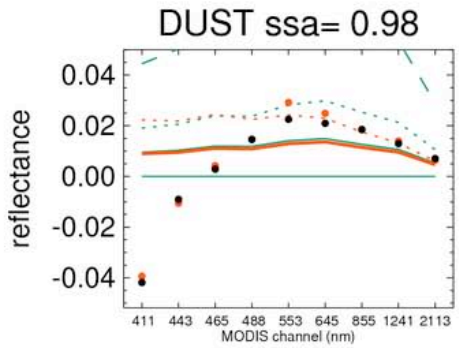


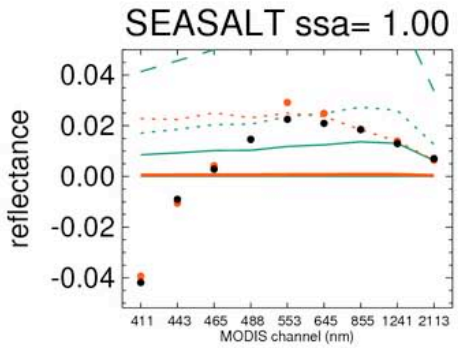
modis_convergence.sat_A.20050824_12z.dat

OBS-Black FG-Blue ANAL-Red LUT(tau=0,.2,.5,1.0)-Green

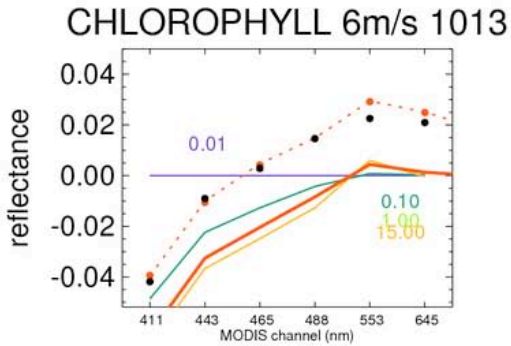
Lat= -0.47 Lon= -0.05 Depth= -4823.6 Scat angle= 158.2 BC frac= 0.751 Wind= 4.910 RH= 79.9% SSA= 0.992



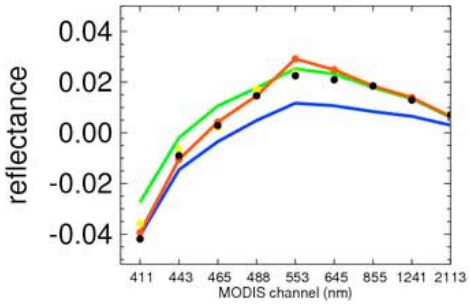


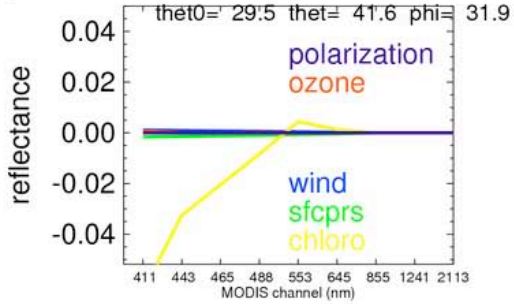


High Chlorophyll - High aerosol

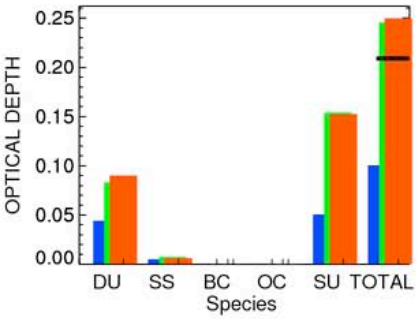


STD ERR= 0.00140 GOOD_CONV niter= 12 surpres= 1001.0



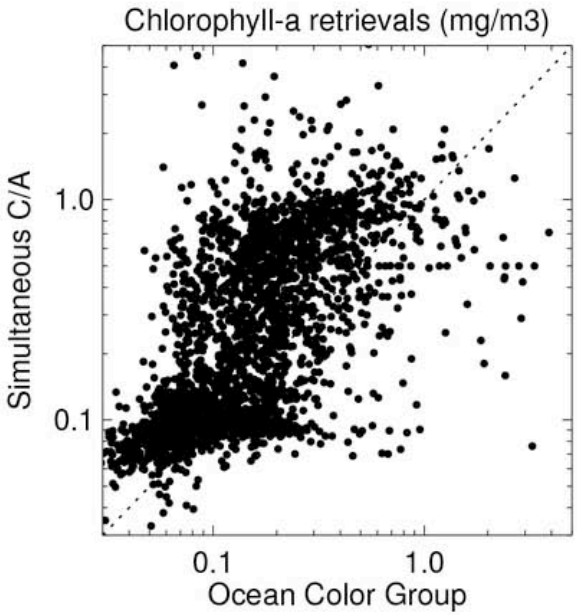


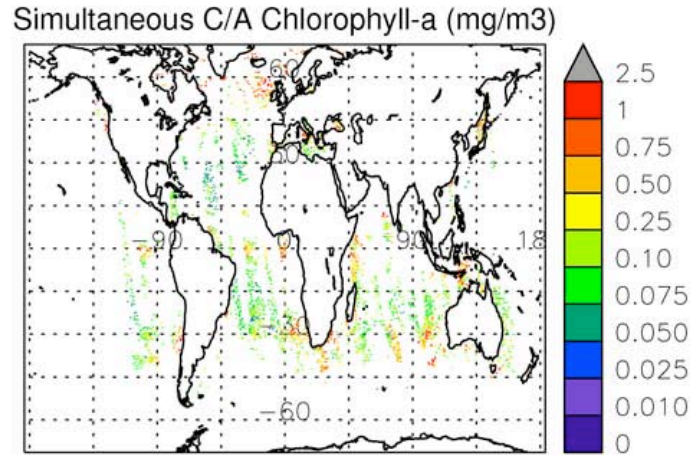
chloro conc.= 0.202 0.202 1.512

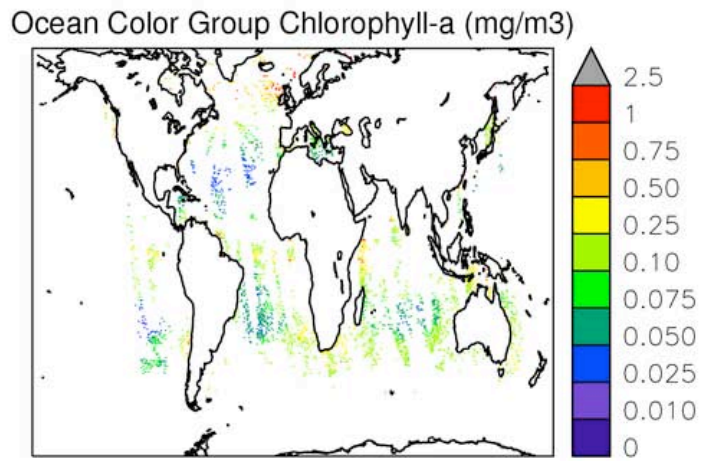


modis_convergence.sat_A.20050824_12z.dat

Comparison of Simultaneous Chlorophyll-Aerosol (C/A) retrevial with standard MODIS-Atmos and Ocean Color Products
All Retrievals use AQUA radiances for August 24, 2005







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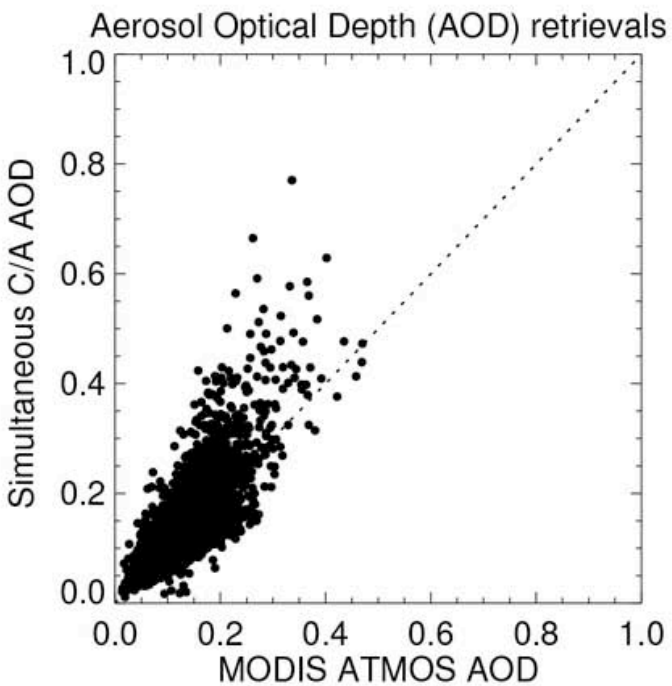
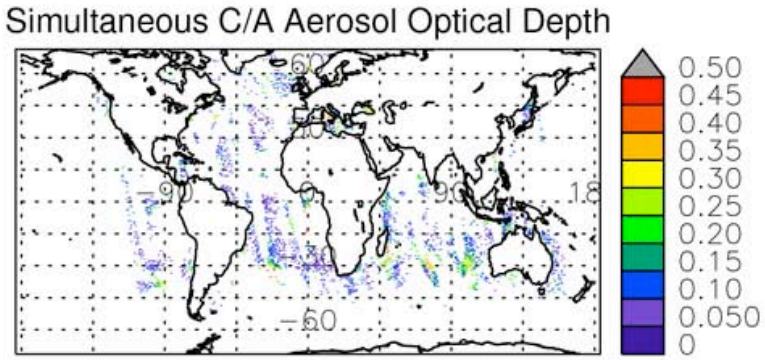
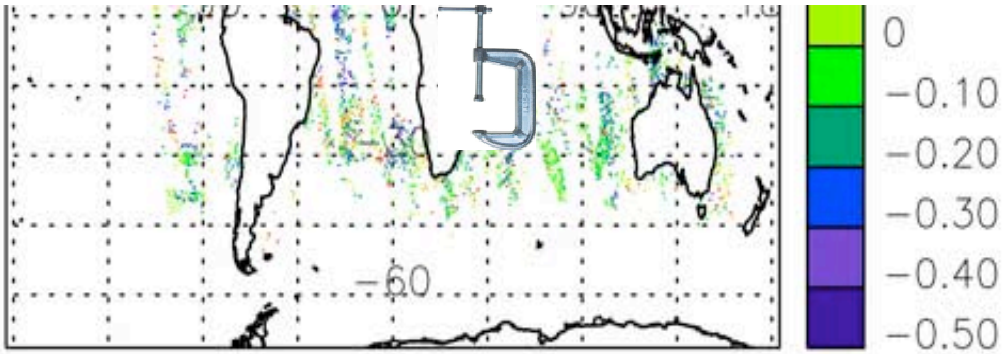
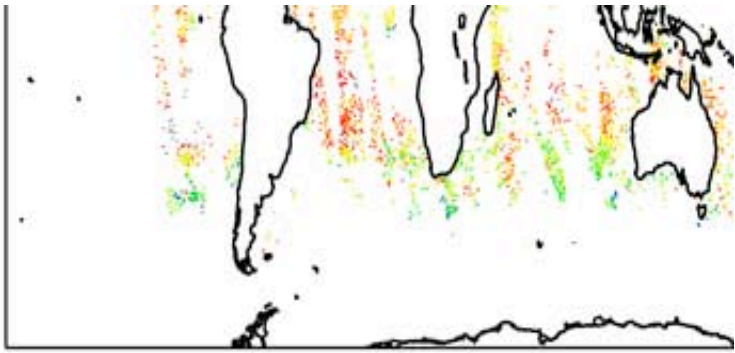
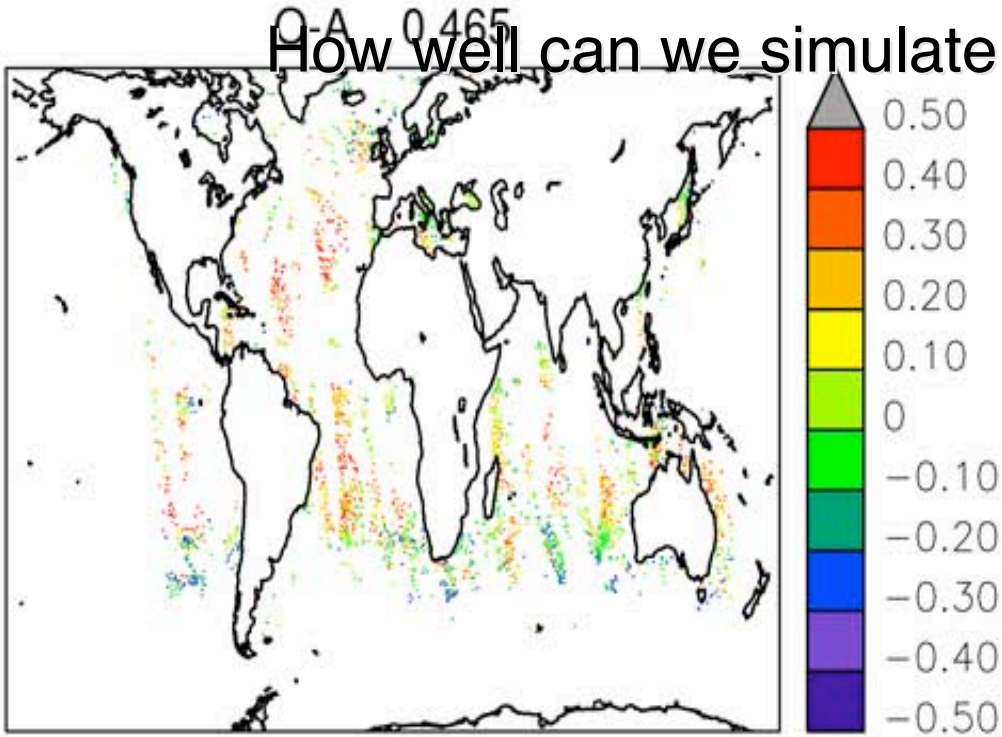


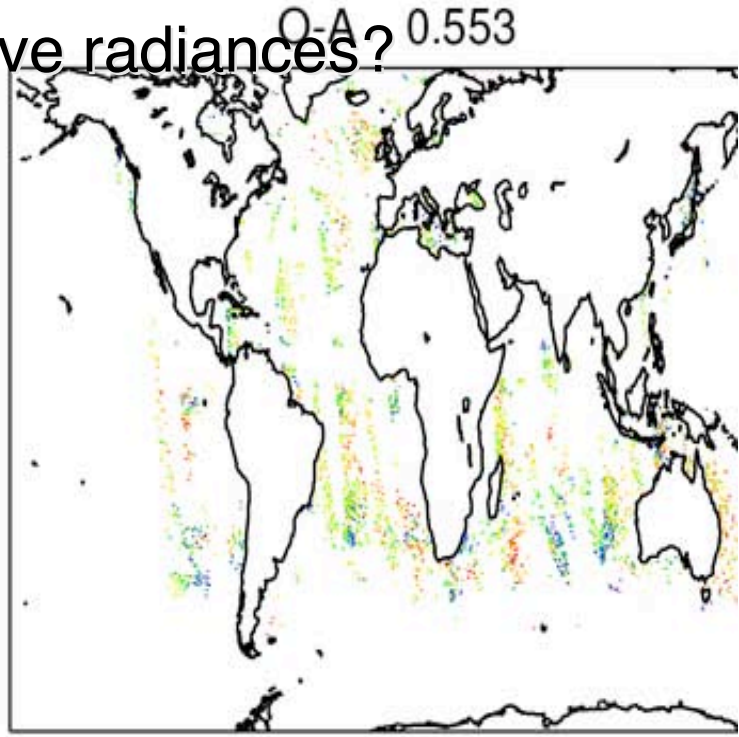


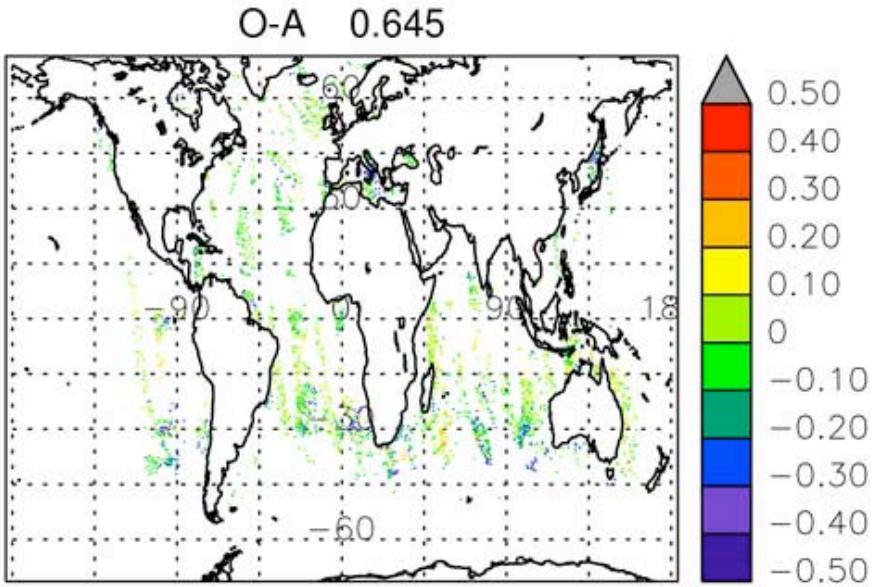


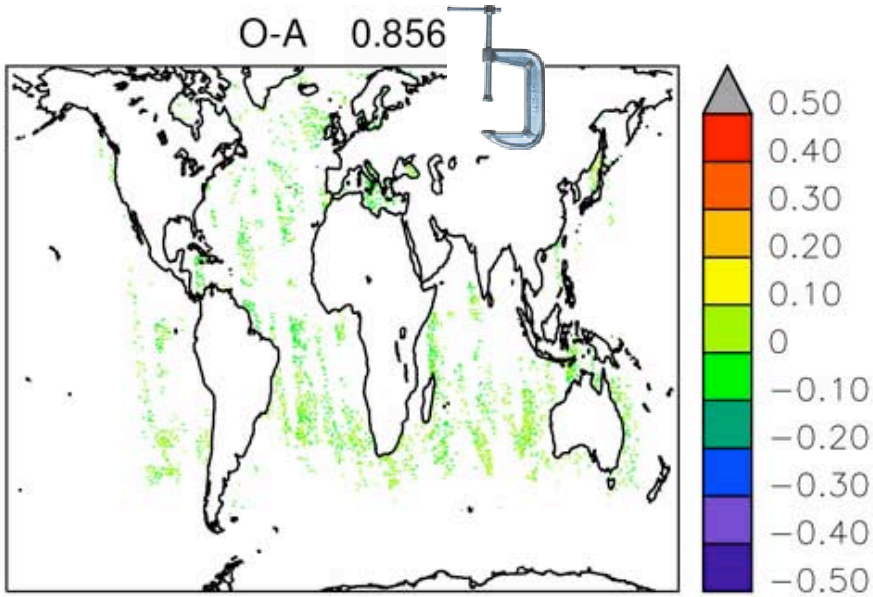


How well can we simulate the observe radiances?

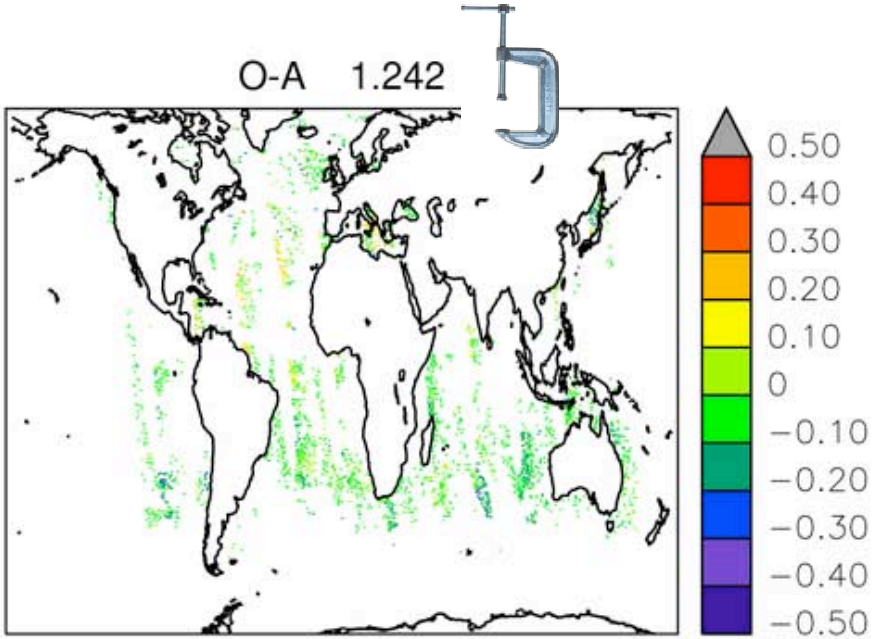


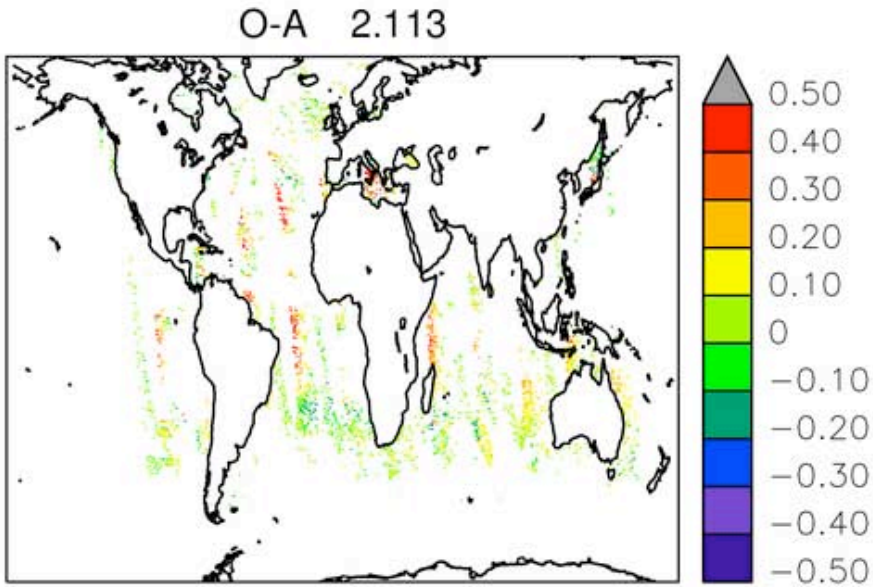




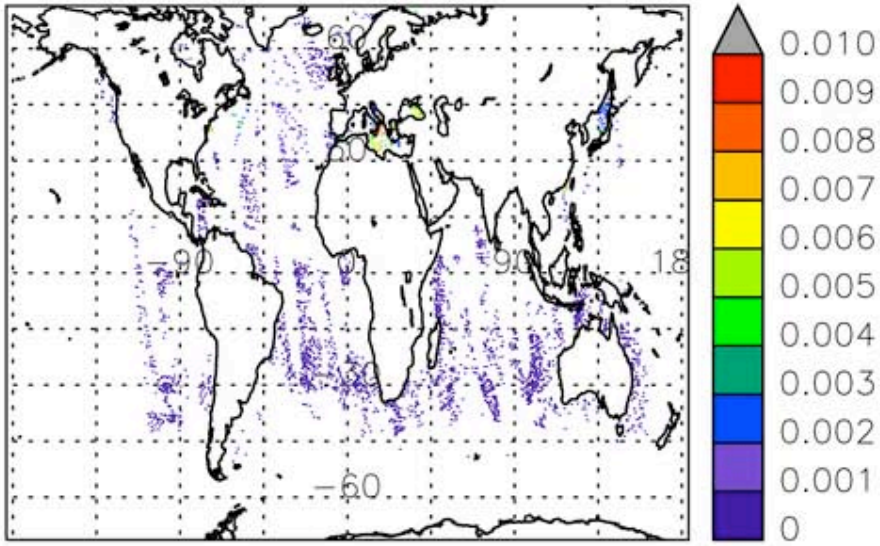


How well can we simulate the observe radiances?

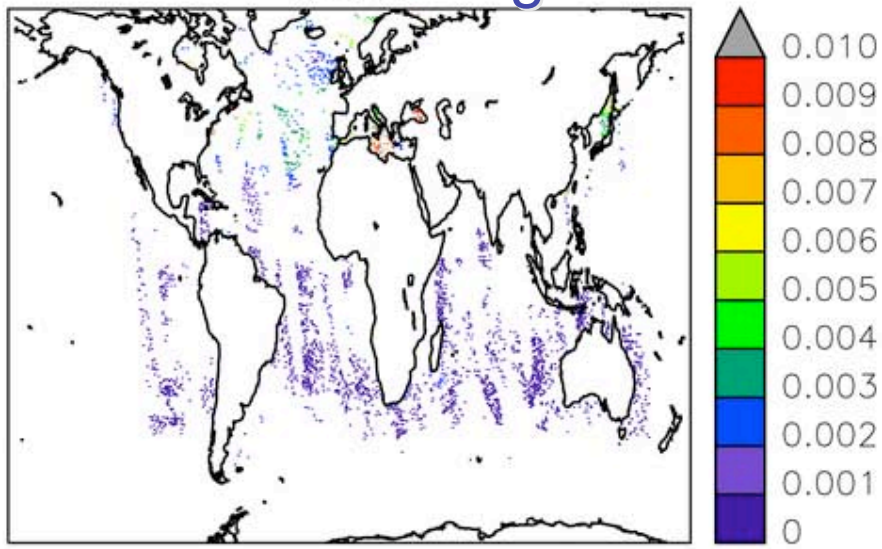




BC FG Black Carbon

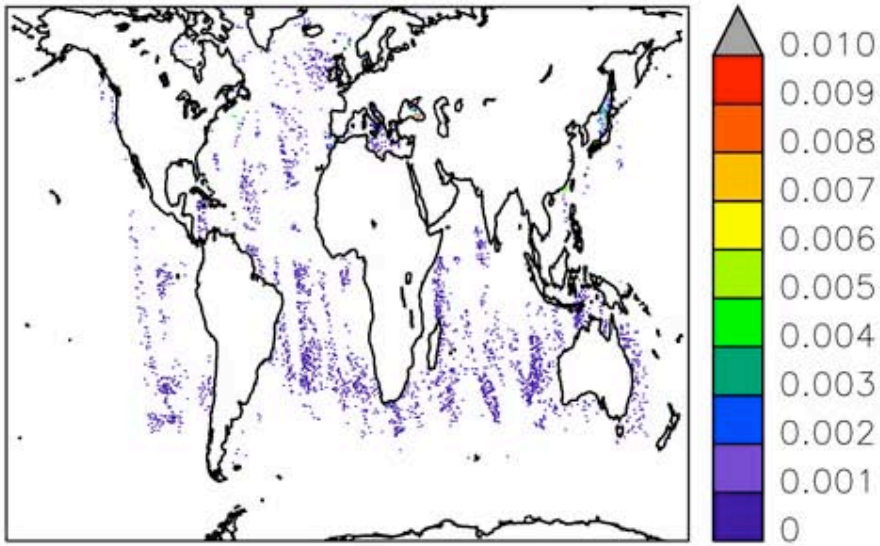


OC FG Organic Carbon

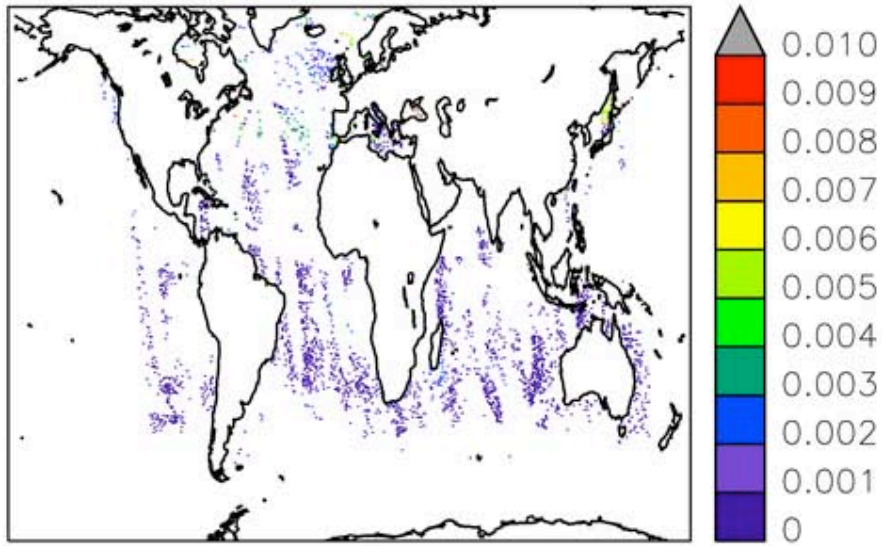


Is the Analysis remembering the First Guess species distribution ?

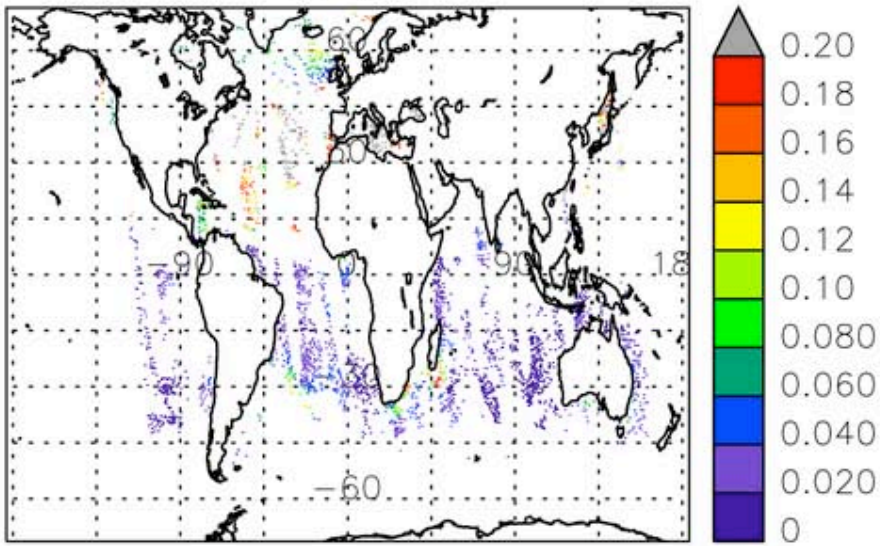
BC ANAL Black Carbon



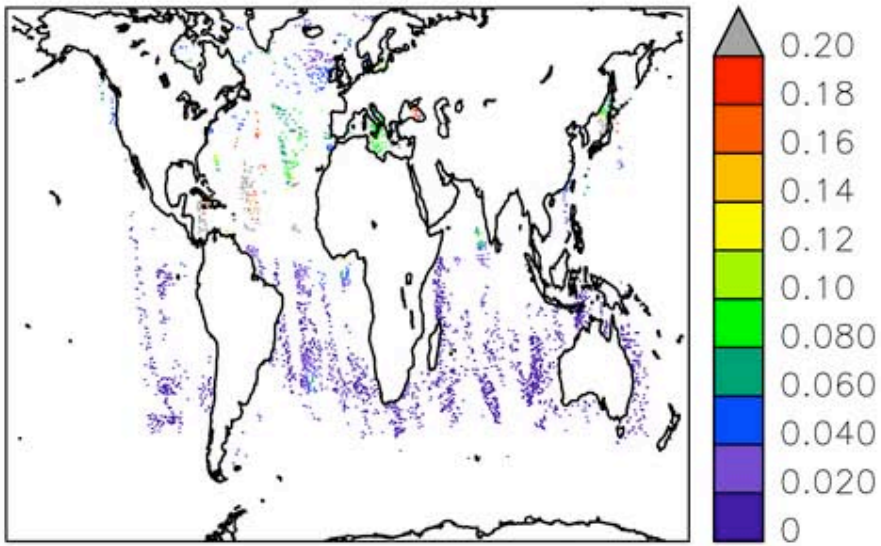
OC ANAL Organic Carbon



SU FG Sulfate



DU FG Dust



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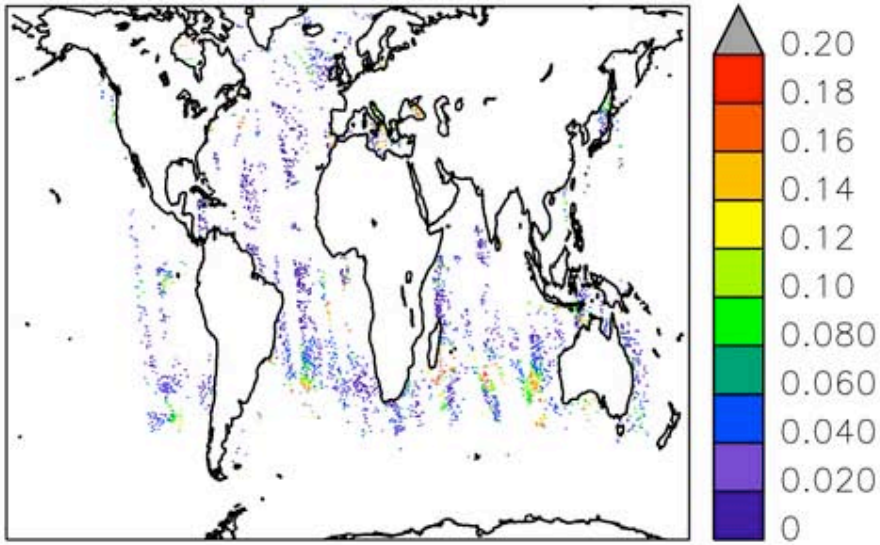
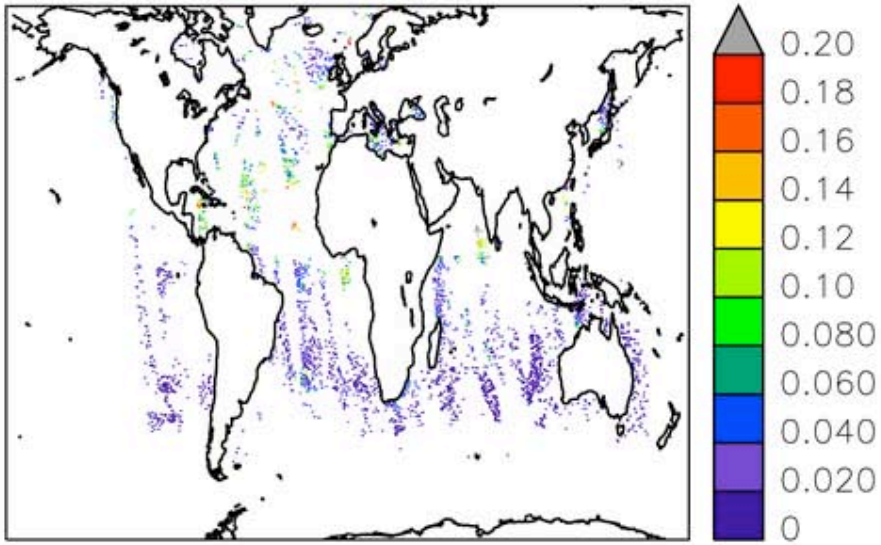
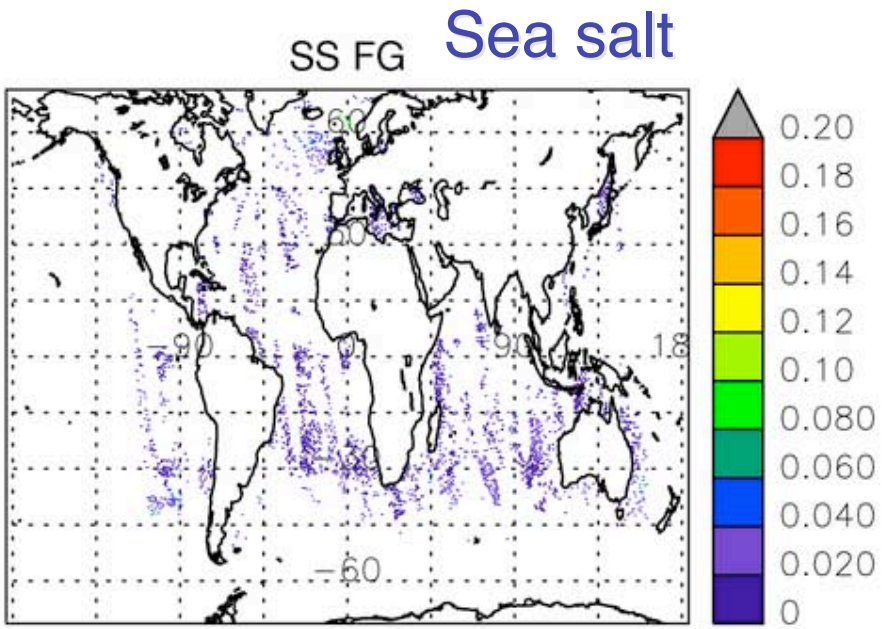
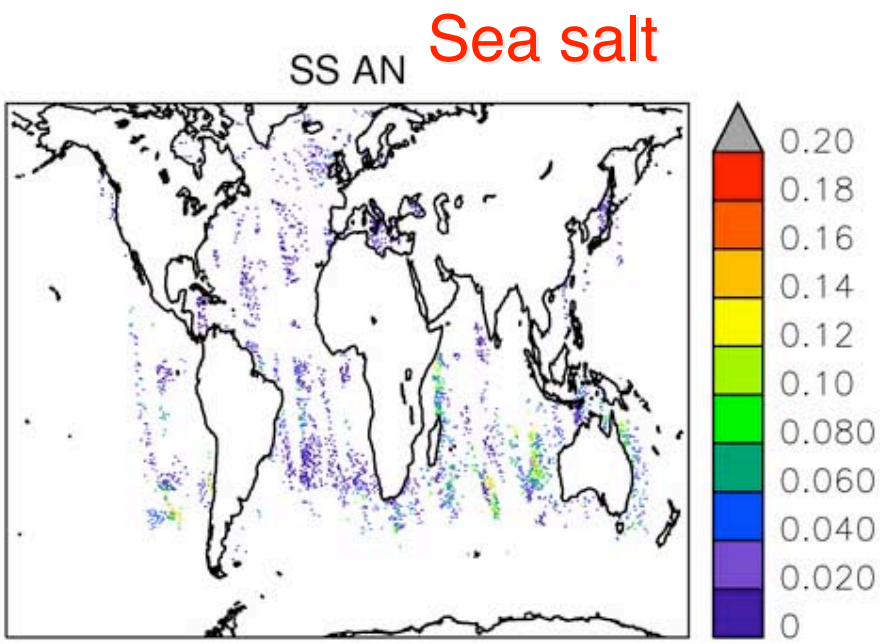
SU AN Sulfate



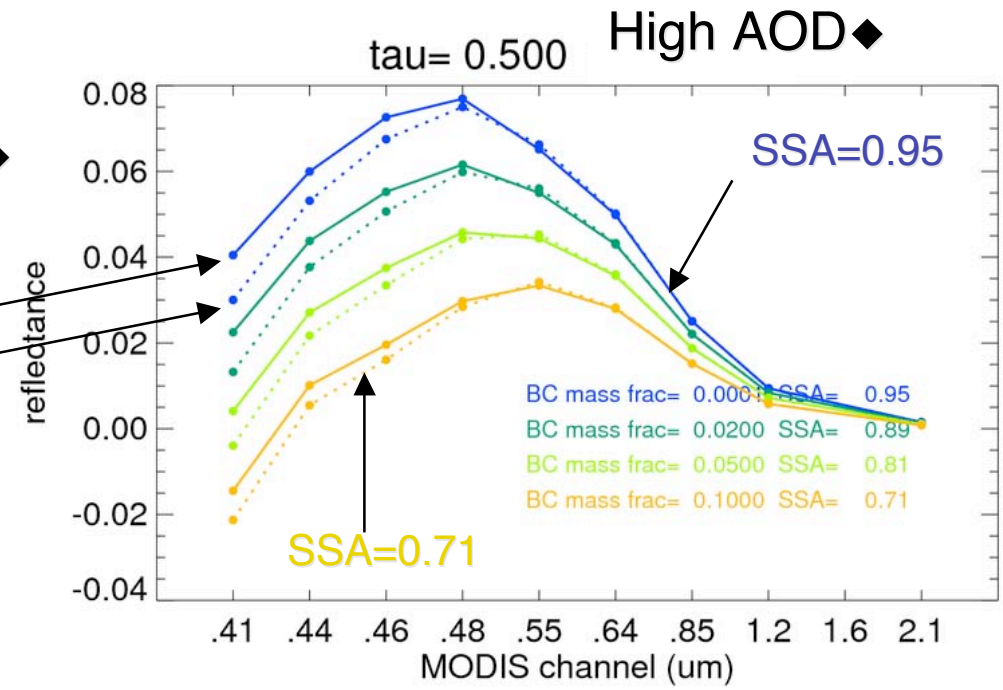
DU AN Dust




SS FG
Sea salt
0.20
0.18
0.16
0.14
0.12
0.10
0.080
0.060
0.040
0.020
0


SS AN
Sea salt
0.20
0.18
0.16
0.14
0.12
0.10
0.080
0.060
0.040
0.020
0

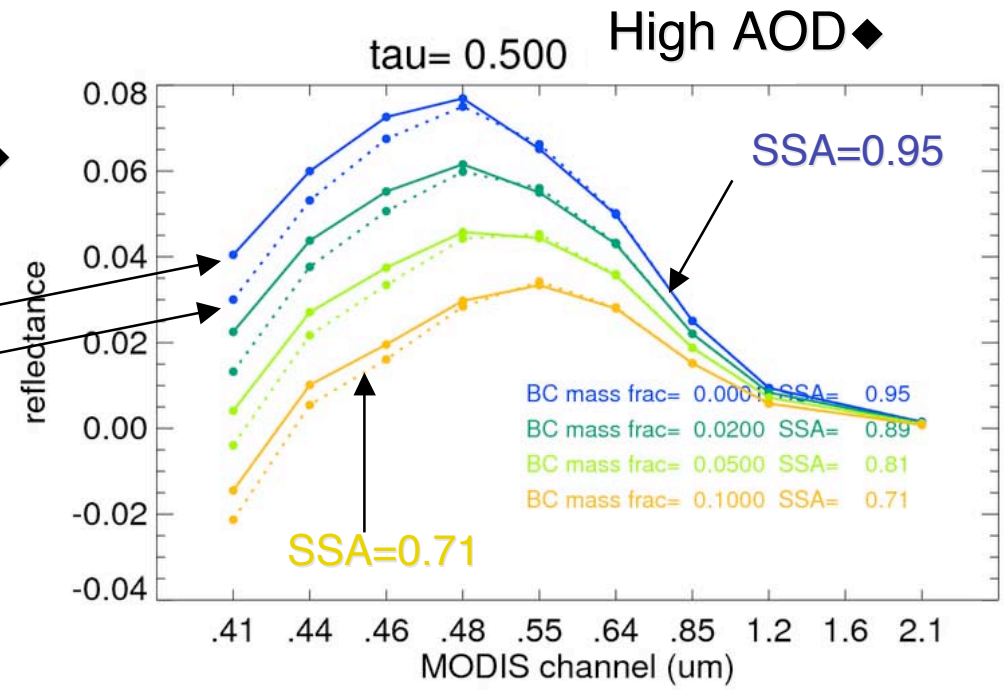
Solid chlorophyll = 0.04 mg/m3
Dashed chlorophyll = 0.20 mg/m3◆

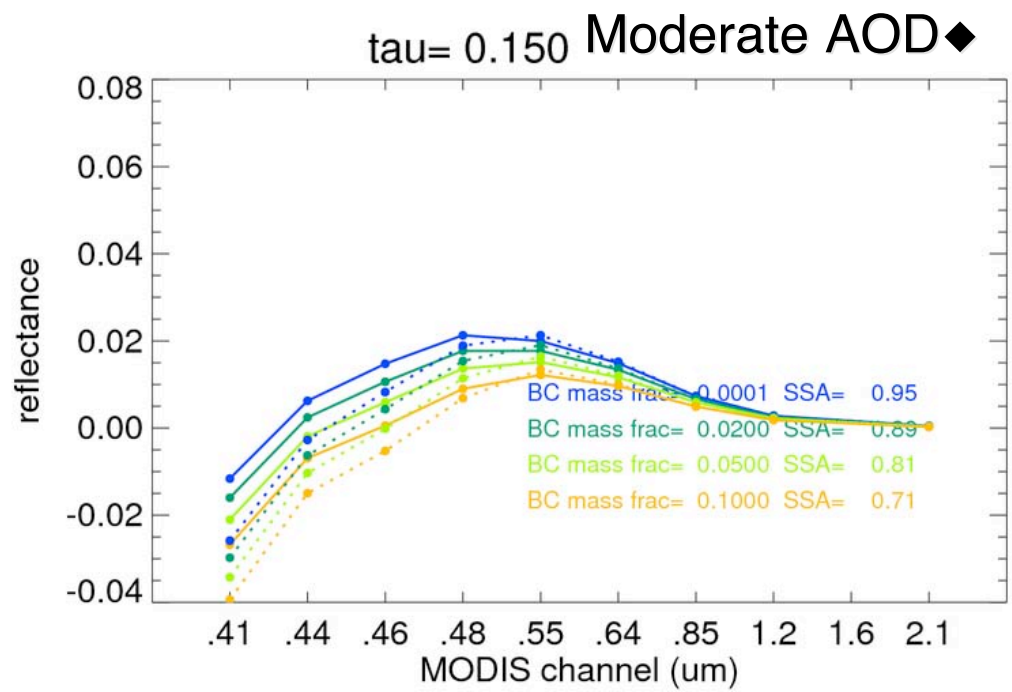


Solid chlorophyll = 0.04 mg/m3
Dashed chlorophyll = 0.20 mg/m3◆

Low Chlorophyll

High Chlorophyll





Current Directions

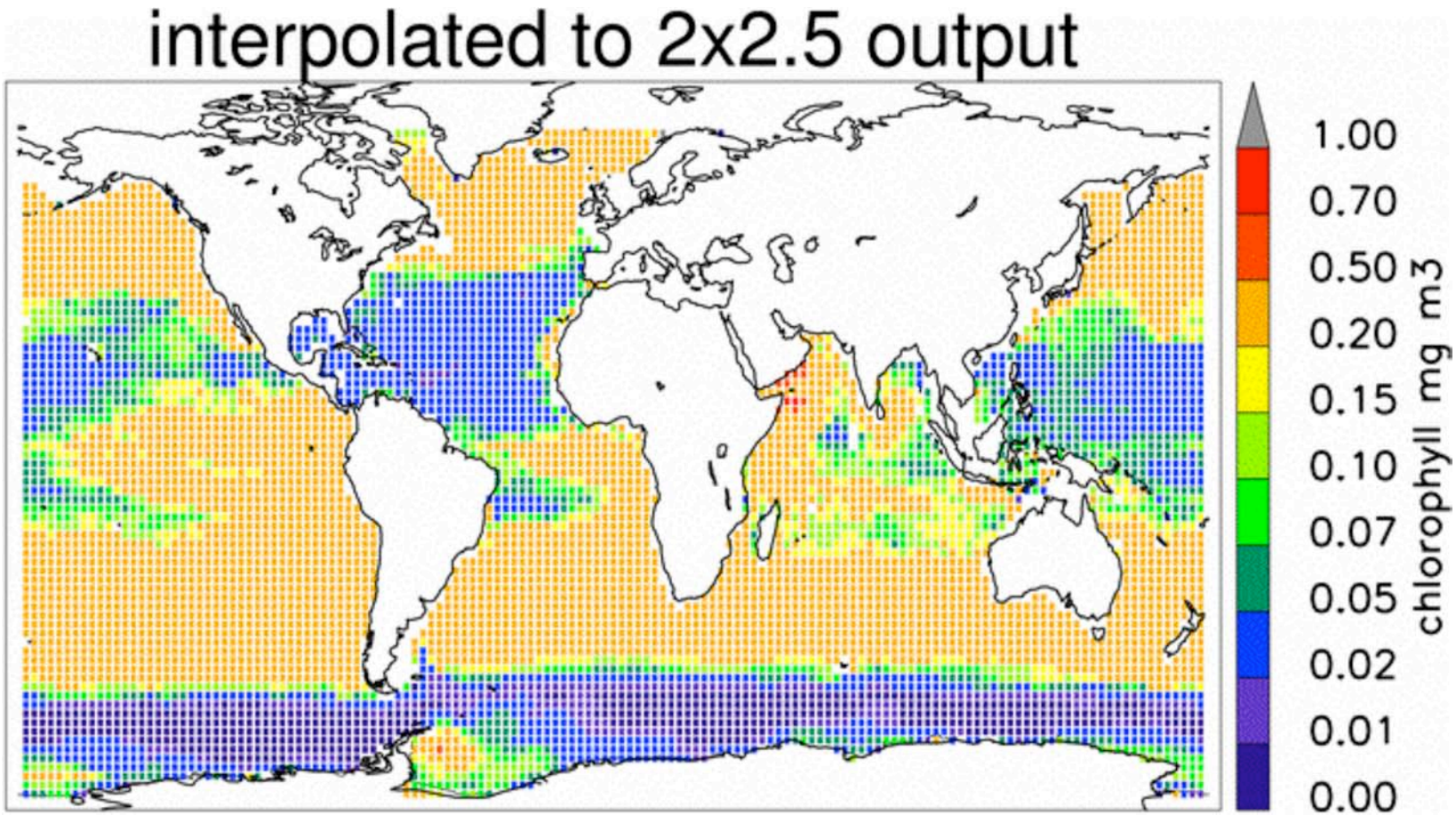
Developing Look-up-tables for absorbing aerosol and chlorophyll

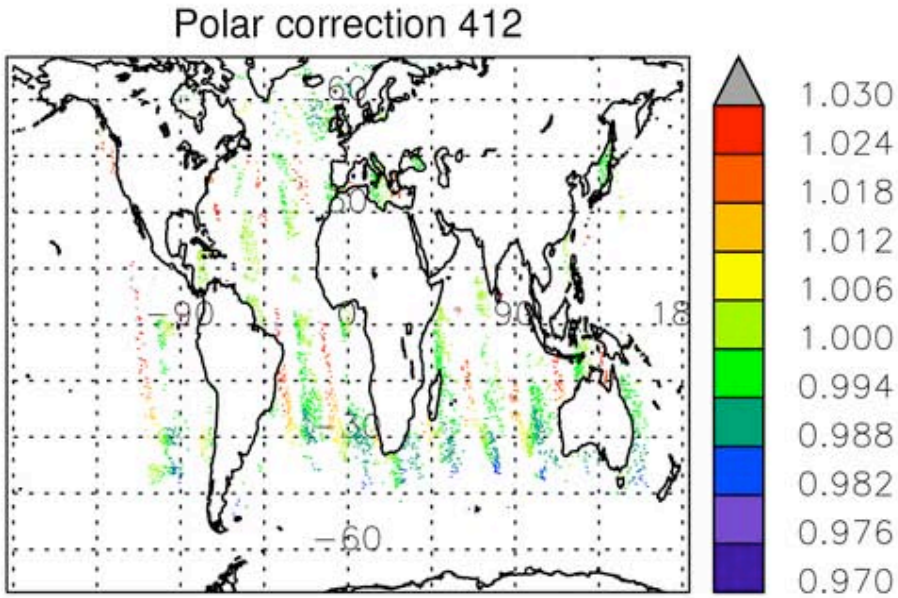
$$\rho_{\text{Chlorophyll=0.1 Absorbing AOD=0.1}} \neq \rho_{\text{Chlorophyll=0.1}} + \rho_{\text{Absorbing AOD=0.1}}$$

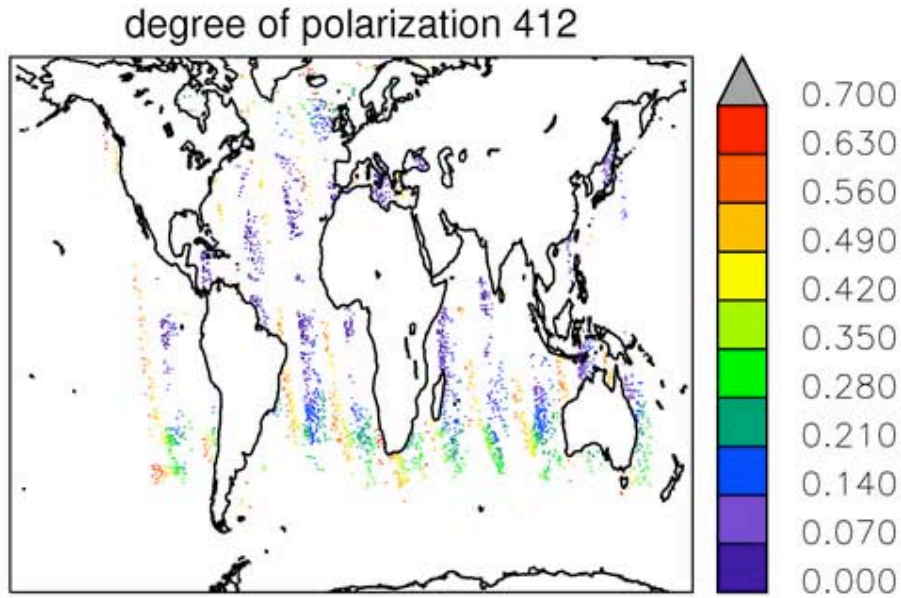
Neural networks to replace Look-up-tables

Model base retrieval algorithm

Chlorophyll (simulated) from Biogeochemical model
1 September 2001




Polar correction 412
60
30
-90
0
90
180
-30
-60
1.030
1.024
1.018
1.012
1.006
1.000
0.994
0.988
0.982
0.976
0.970


degree of polarization 412
0.700
0.630
0.560
0.490
0.420
0.350
0.280
0.210
0.140
0.070
0.000