New Aerosol Models for Ocean Color Retrievals

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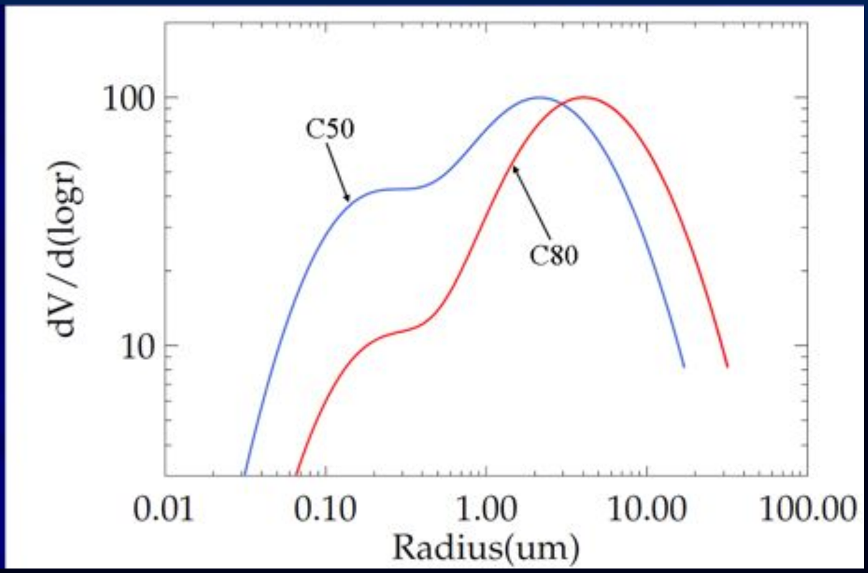
Overview

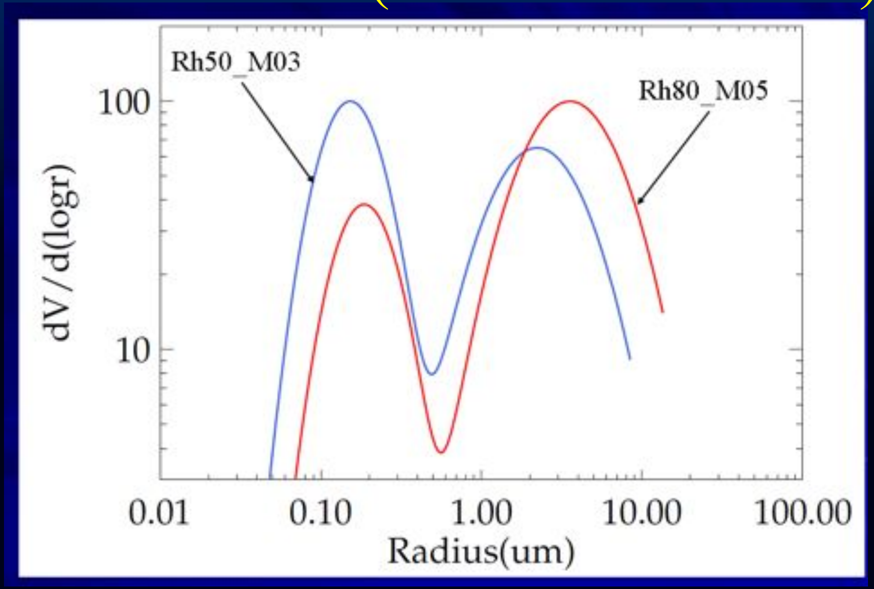
- Background
- Characteristics of AERONET Aerosol Size Distributions Over Ocean
- Details of New Aerosol Models
- Validation Results
- Summary and Conclusions

Background

Old Models (Gordon-Wang)



New Models (AERONET Based)

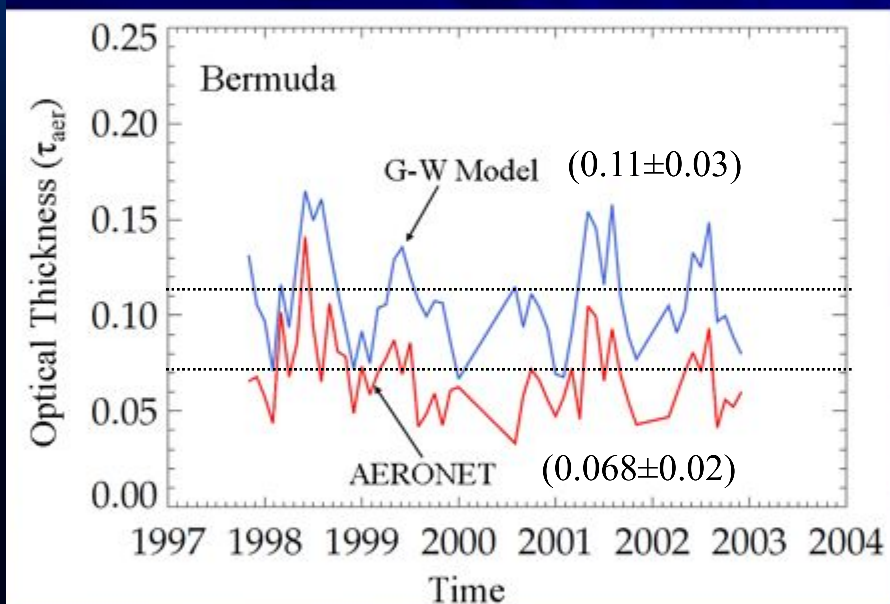


- Gordon-Wang models are based on Shettle-Fenn's models proposed for climate and radiation studies in 70s

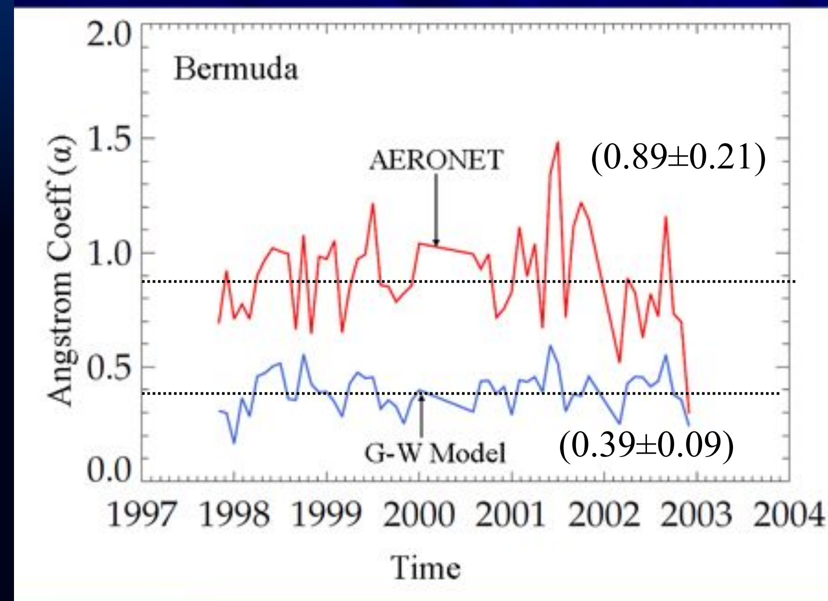
- Width of Gordon-Wang models are much broader than AERONET based models. For example, Fine mode: 0.806 vs. 0.437; Coarse mode: 0.921 vs. 0.672

Background (cont.)

Aerosol Optical Thickness (τ_{aer})



Angstrom Coefficient (α)



- $\langle\tau\rangle$ retrieved from Gordon-Wang (G-W) models is almost 1.6 time as large as retrieved from AERONET

- $\langle\alpha\rangle$ (443:865 *nm*) retrieved from Gordon-Wang (G-W) models is less than half (0.44) as retrieved from AERONET

AERONET Data

- Open Ocean

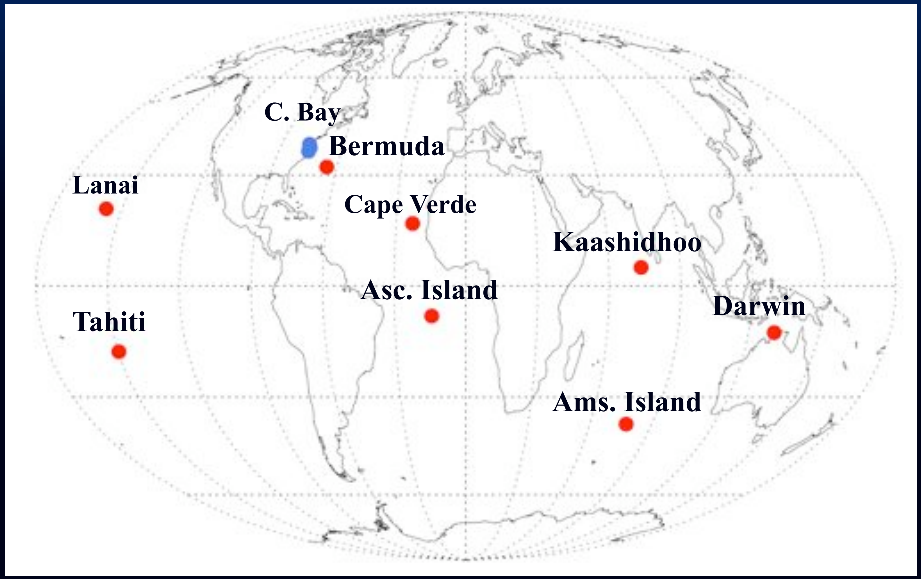
  No. of Sites: 8

  No. of Daily Obs. 2543

- Chesapeake Bay Region

  No. of Sites: 3

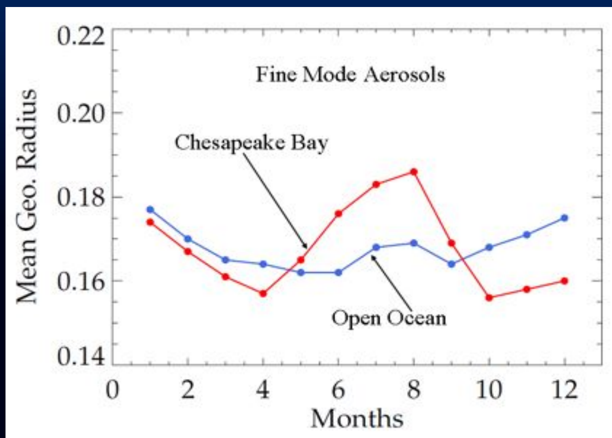
  No. of Daily Obs. 2193



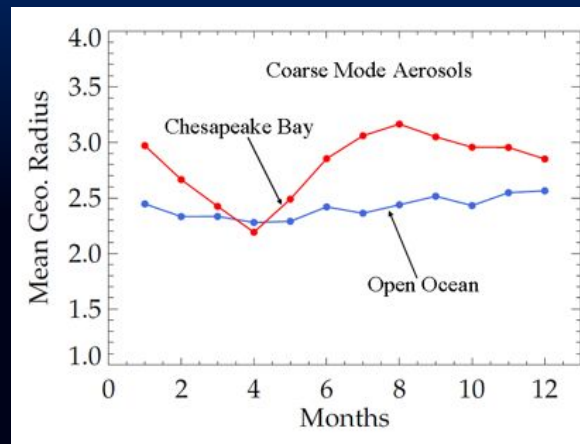
- Each site had 150 or more daily observations
- Only observations with $\tau_{aer} \leq 0.3$ were considered

Seasonal Characteristics of Aerosol Size Distributions (AERONET)

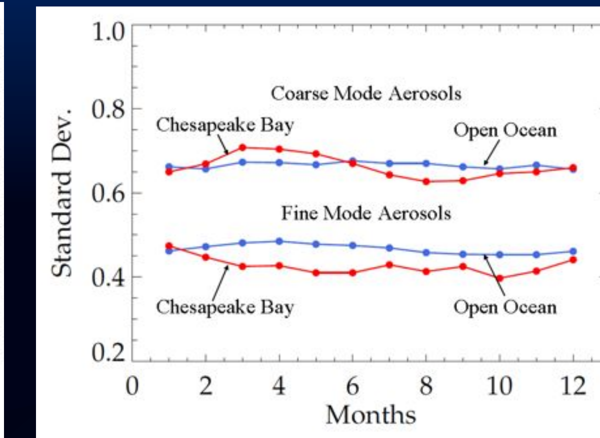
Fine Mode Radius



Coarse Mode Radius



Standard Dev.



- Over the Chesapeake Bay region, mean geometric radius of fine and coarse mode aerosols show strong seasonal dependence.

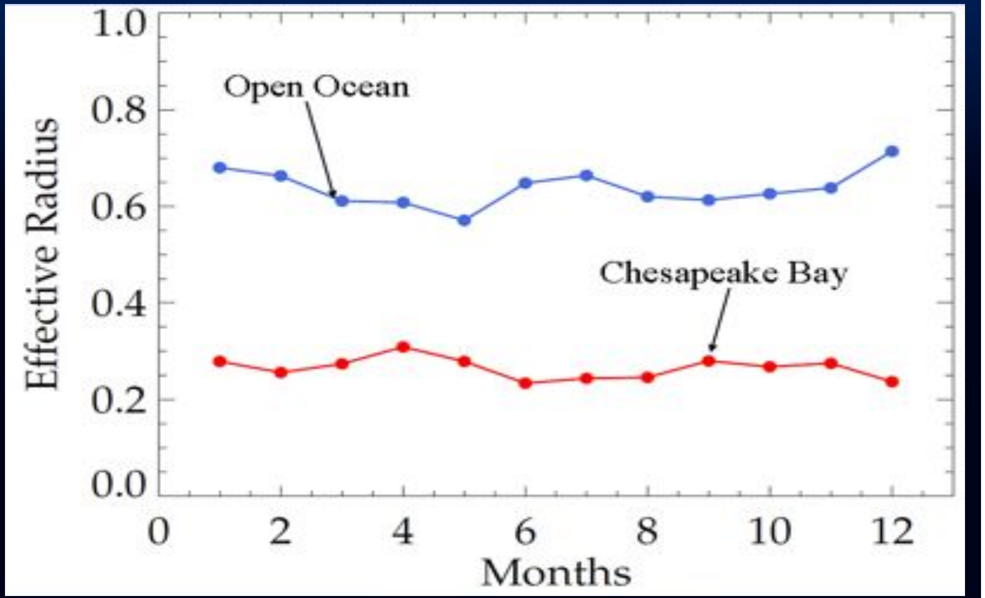
- Over open ocean, fine mode radius show a weak seasonal dependence, whereas, coarse mode radius is practically constant.

- Std. dev. of fine and coarse mode distributions are practically constant throughout the year. ($\langle\sigma_f\rangle$=0.44 and $\langle\sigma_c\rangle$=0.67)

Seasonal Characteristics of Aerosol Size Distributions (AERONET)

$$r_{eff} = \int_{r_{min}}^{r_{max}} \pi r^3 n(r) dr \Big/ \int_{r_{min}}^{r_{max}} \pi r^2 n(r) dr$$

Effective radius

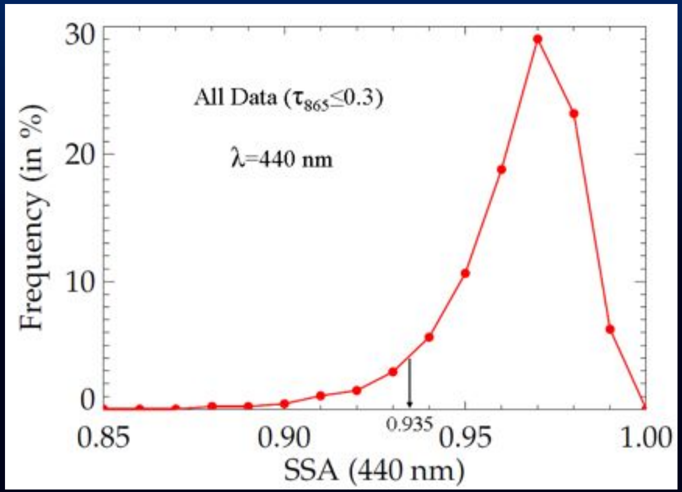


- Effective radius of aerosols shows weak seasonal dependence over both the Chesapeake Bay region and the open ocean.
- $\langle r_{eff} \rangle$ over the Chesapeake Bay region is ~ 0.27 μm

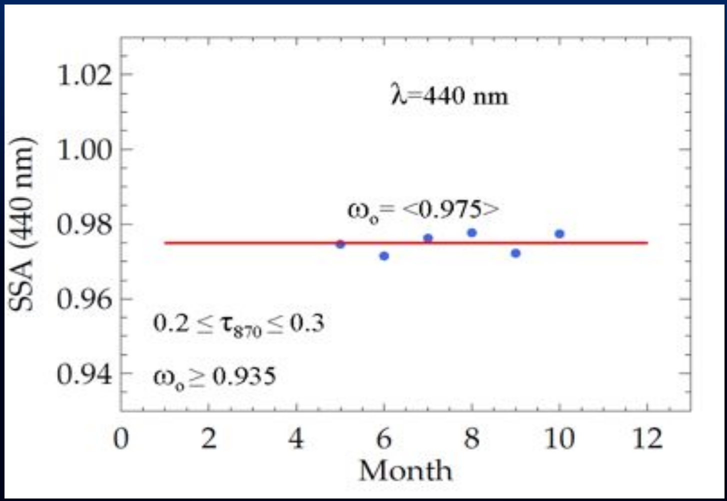
and over open ocean $\langle r_{eff} \rangle$ is ~ 0.67 μm

Single Scattering Albedo Over Chesapeake Bay

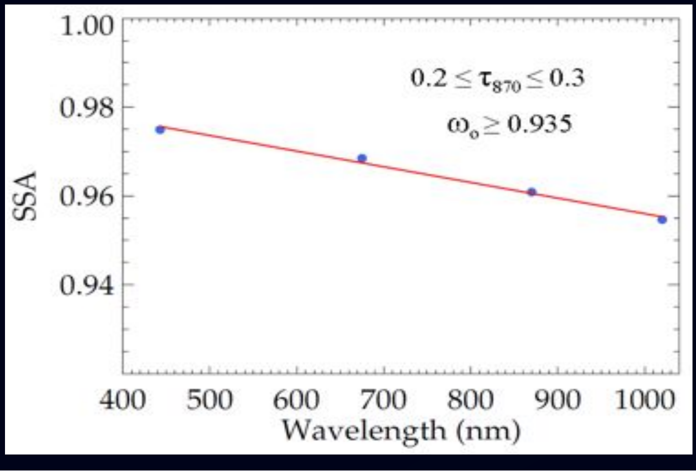
SSA Frequency Dist.



SSA (440 nm)



SSA vs. Wavelength



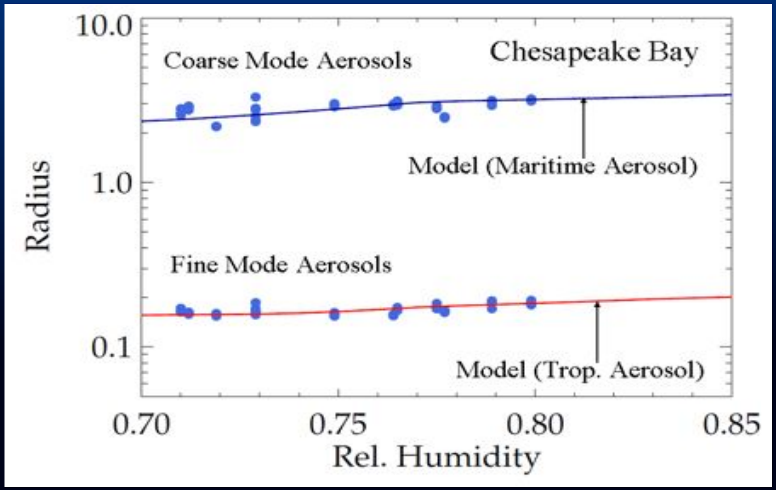
- 5% of the data had SSA < 0.935

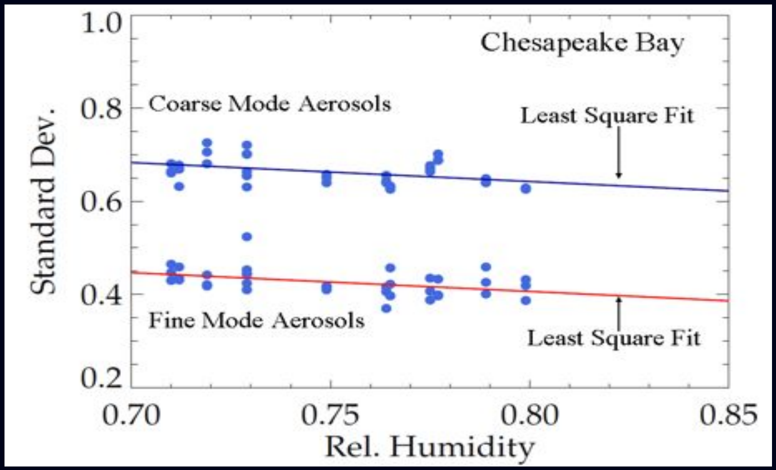
- No data for the months of Jan, Feb, Mar, Apr, Nov and Dec

-SSA shows linear Spectral Dependence

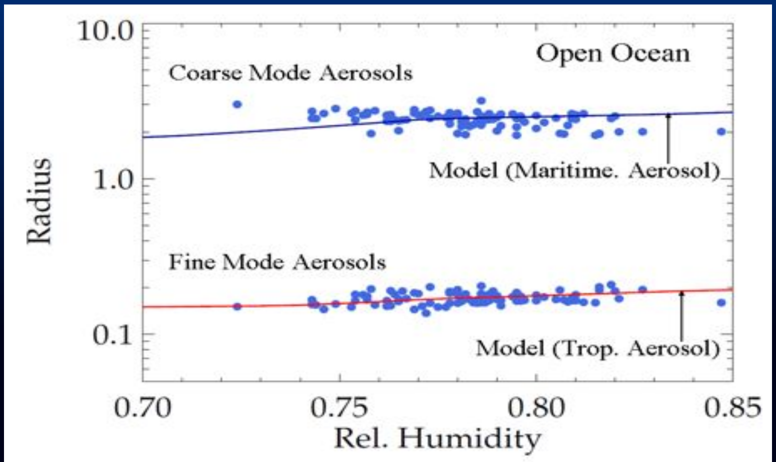
Modal Radius and Standard Dev vs. R Humidity

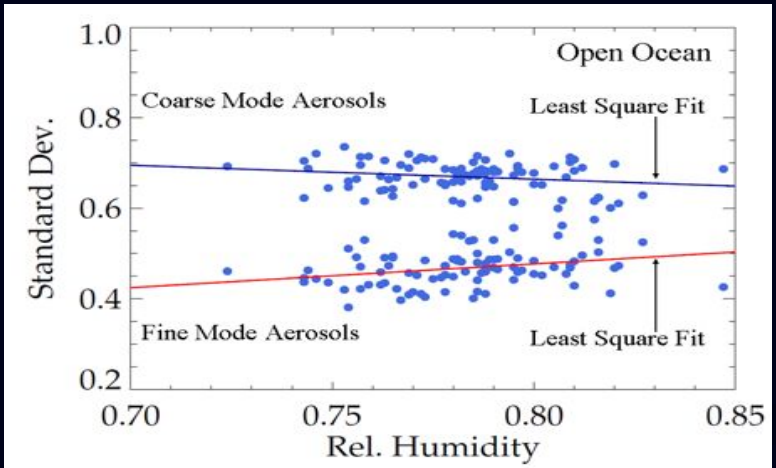
Chesapeake Bay Region





Open Ocean



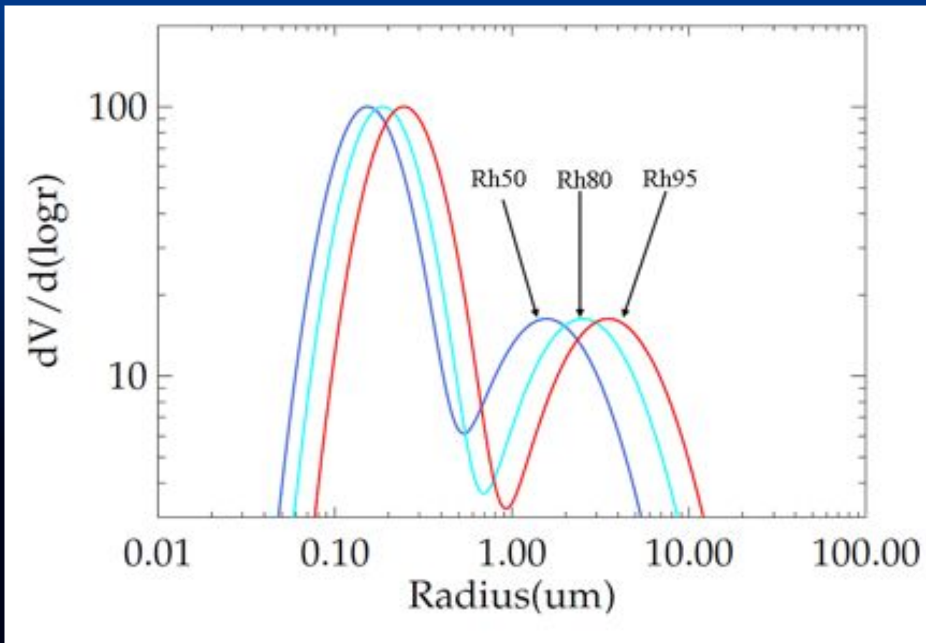


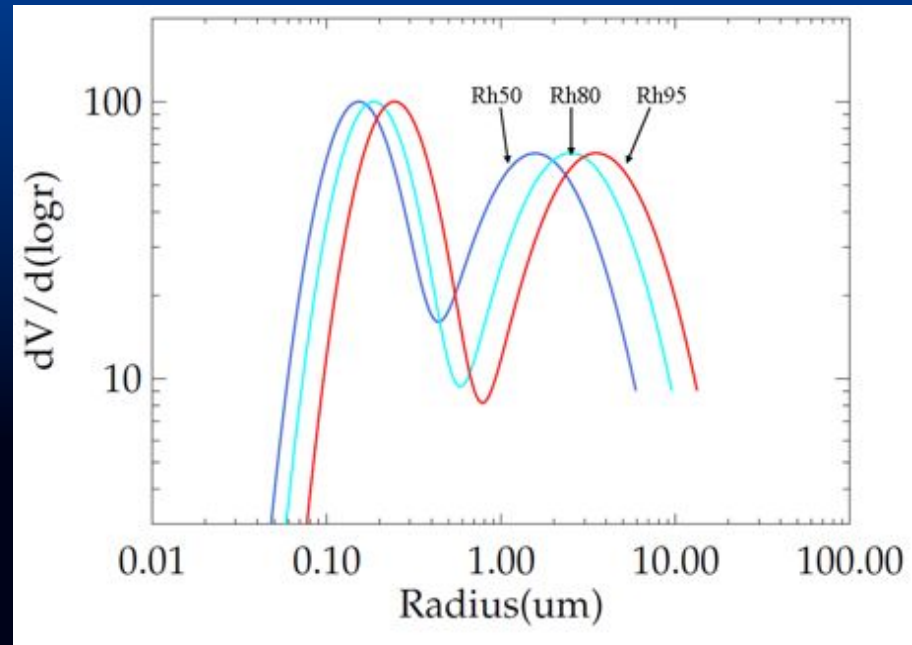
- Fine mode radius shows a strong correlation with RH
- Std. dev. and coarse mode radius are weakly dependent on RH

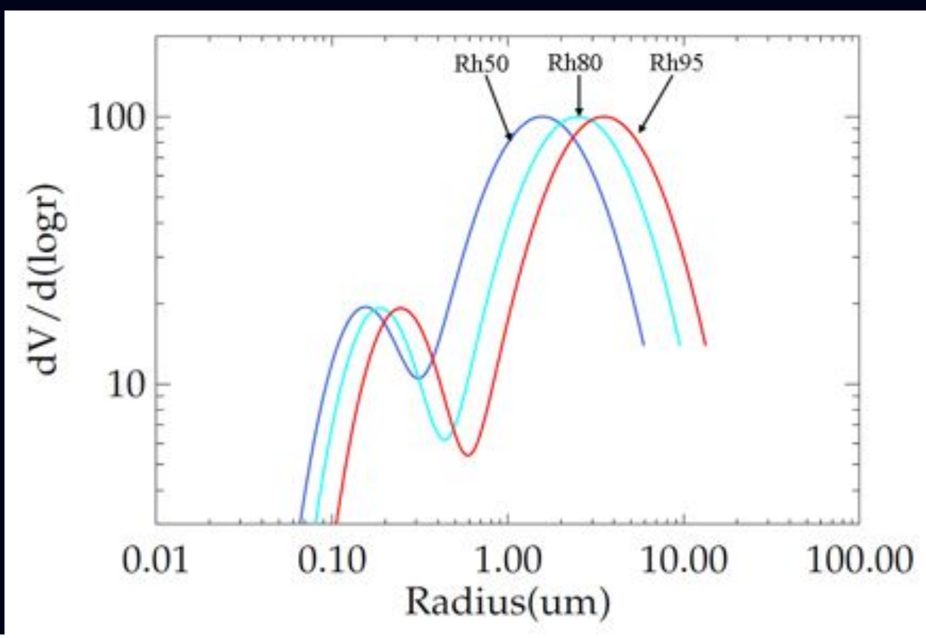
Details of the New Aerosol Models

- Type of distribution:	Lognormal bimodal
- Fine mode:	Similar to coastal region aerosols
- Coarse mode:	Similar to open ocean aerosols
- Modal radii:	Vary with RH
- Std. dev.:	Constant with RH
- Refractive Index:	Vary with RH
- Absorption:	All absorptions due to fine mode
- No. of RH :	Eight (30, 50, 70, 75, 80, 85, 90 and 95)
- No. of aerosol models/RH:	10 (constructed by varying fine mode fraction from zero to one)
- Total no. of aerosol models:	80 (8RH x 10 models/RH)

Examples of the New Aerosol Models

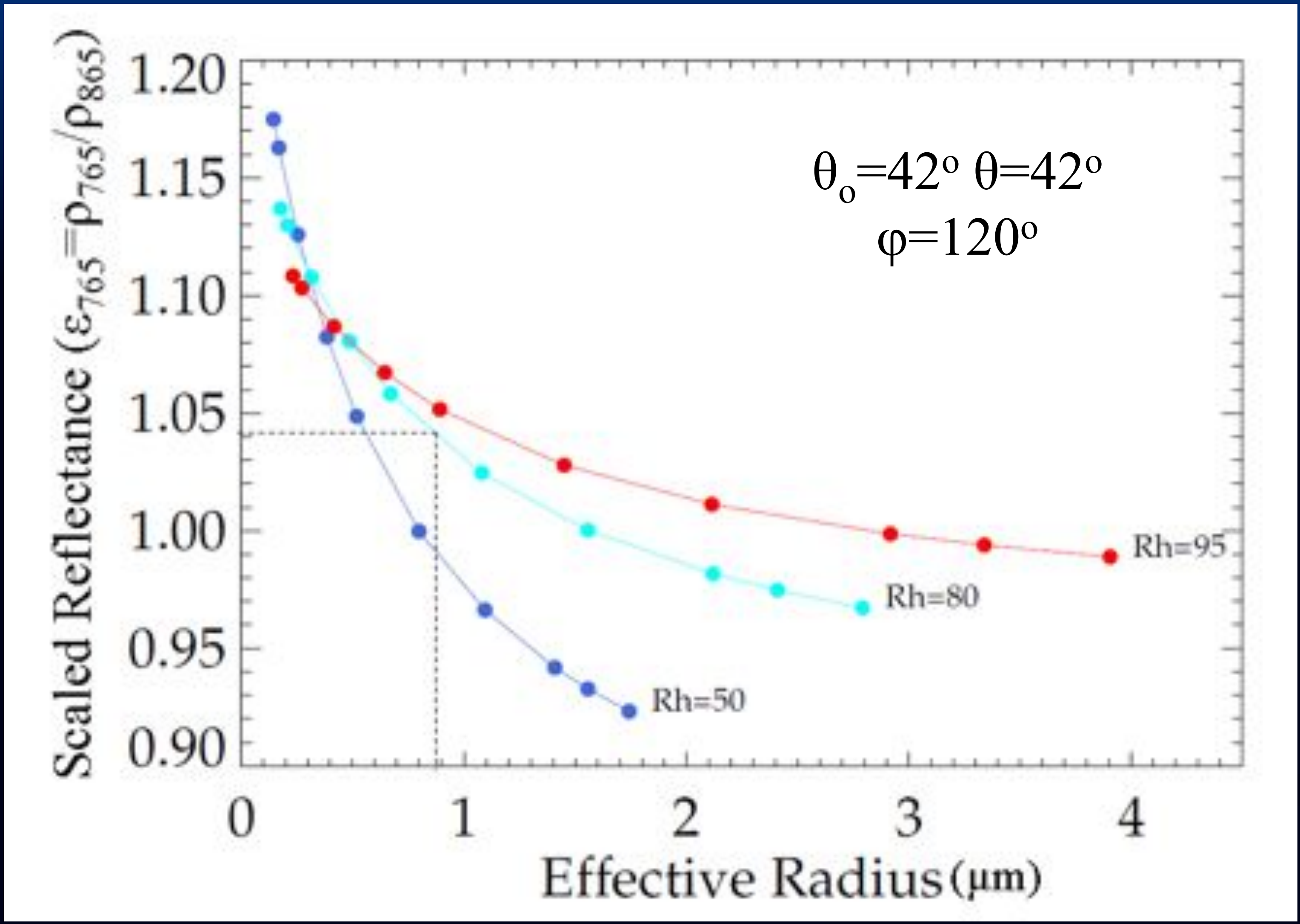






- Aerosol Models are selected based on:
  - Relative humidity (NCEP)
  - Scaled reflectance ($\varepsilon_{\lambda}=\rho_{\lambda}/\rho_{\lambda o}$)

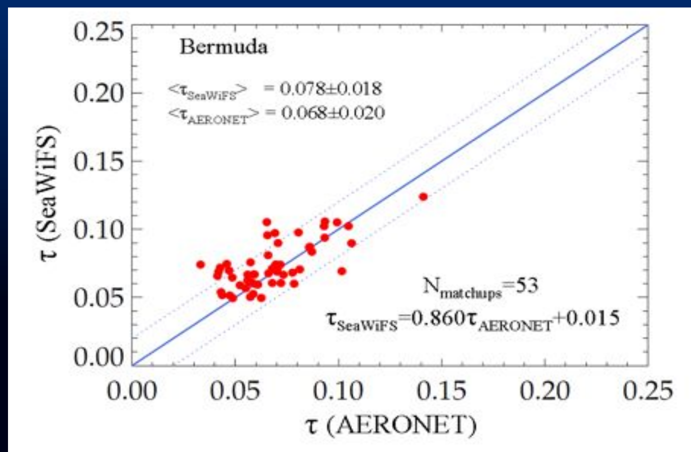
Scaled Reflectance vs. Effective Radius



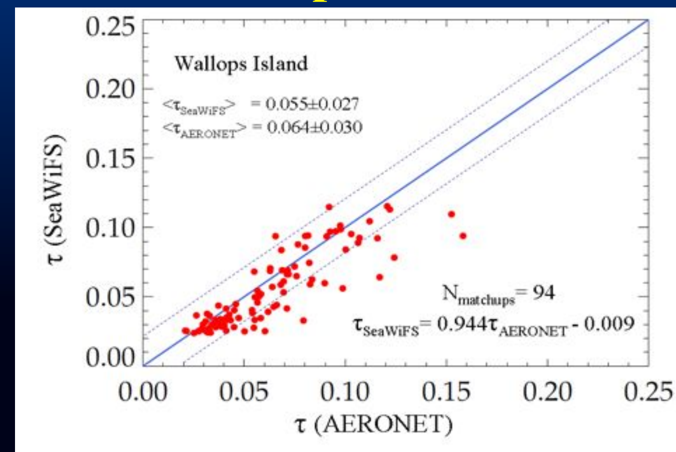
Comparison of τ (SeaWiFS vs. AERONET)

Scatter Plot

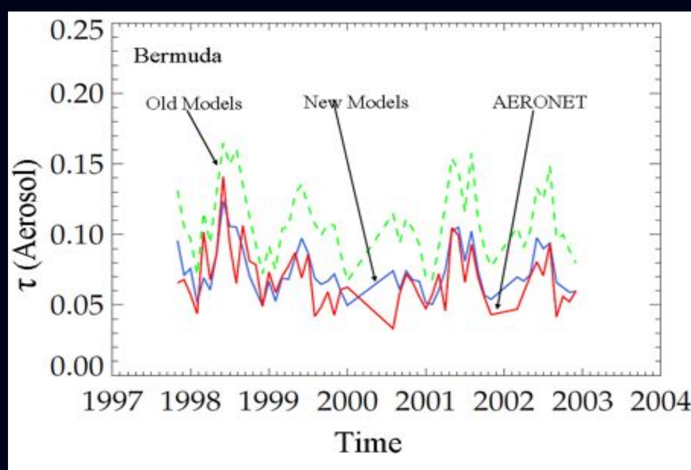
Bermuda

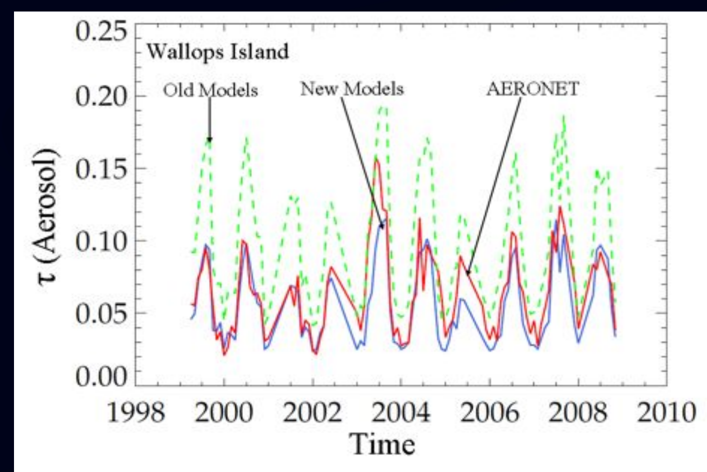


Wallops Island



Time Series

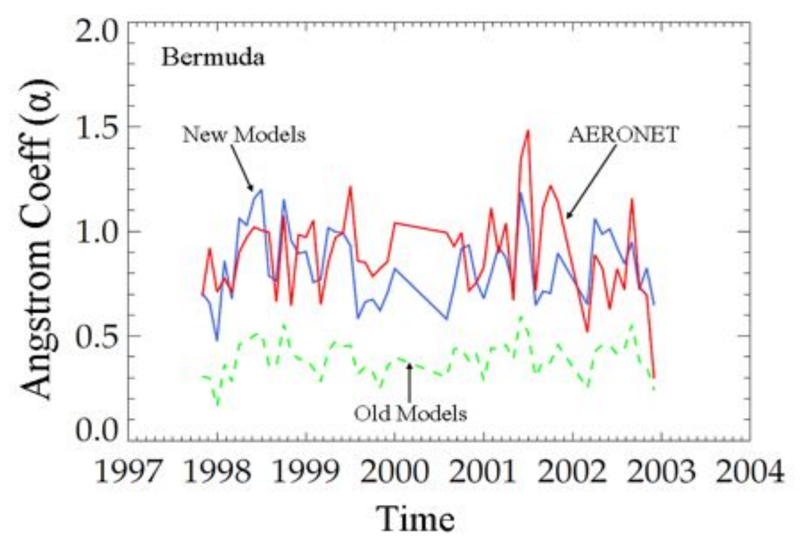




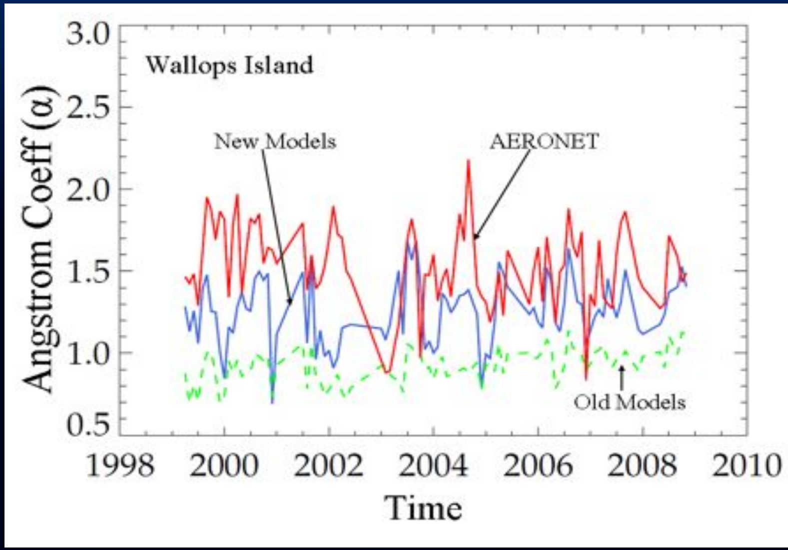
- 81% of the retrieval at Bermuda and 78% of the retrievals at Wallops Island fall within an uncertainty of ±0.02 in τ

Comparison of α (SeaWiFS vs. AERONET)

Bermuda



Wallops Island

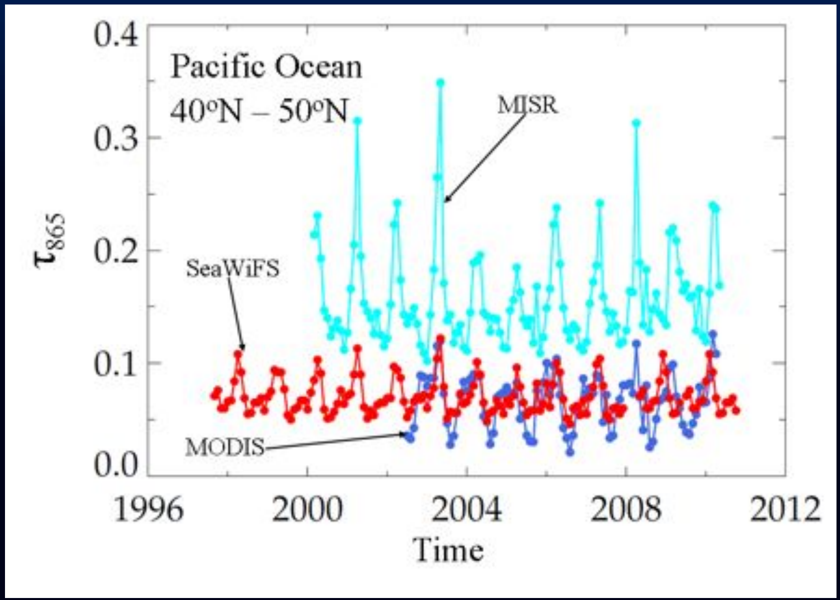


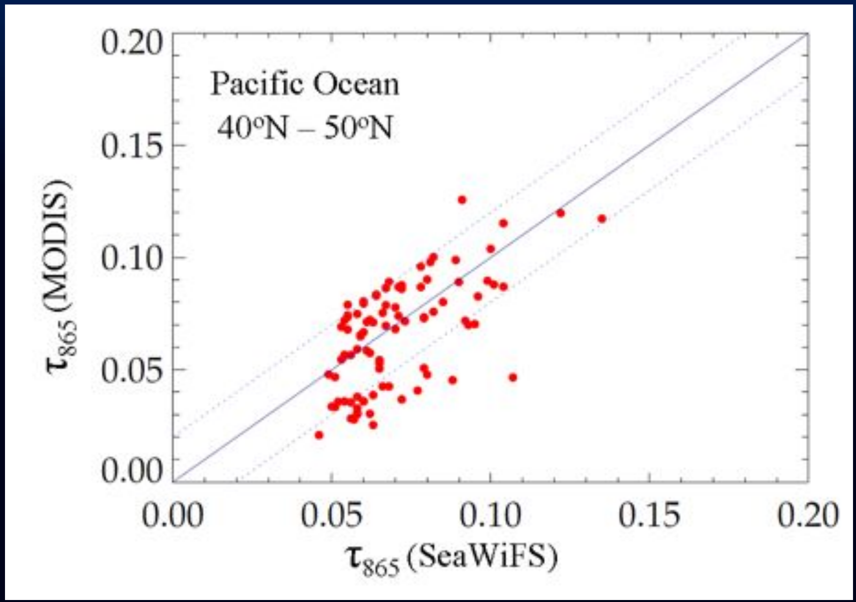
- For new models, the Angstrom coeff. (α) shows better agreement over Bermuda than over Wallops Island

- For old models, the α values are almost one-half of AERONET Values

Comparison of τ_{865}
(SeaWiFS vs. MODIS vs. MISR)

Pacific Ocean (40°N – 50°N)



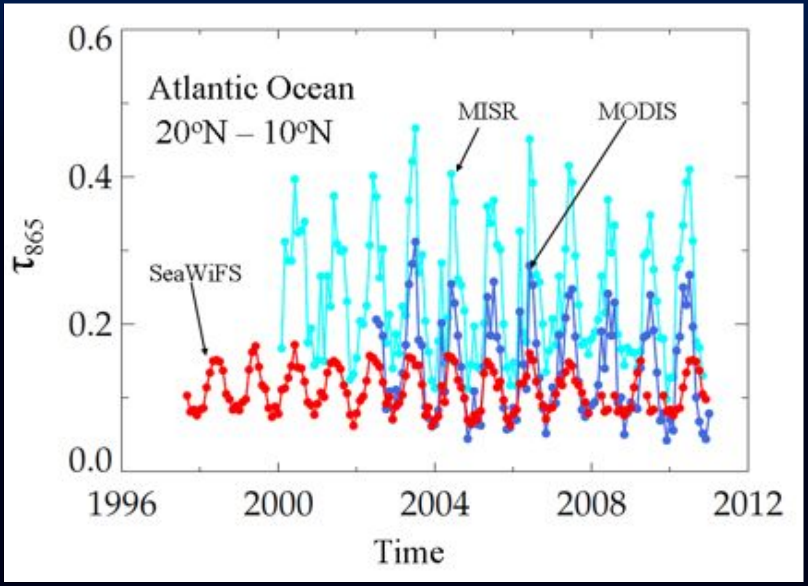


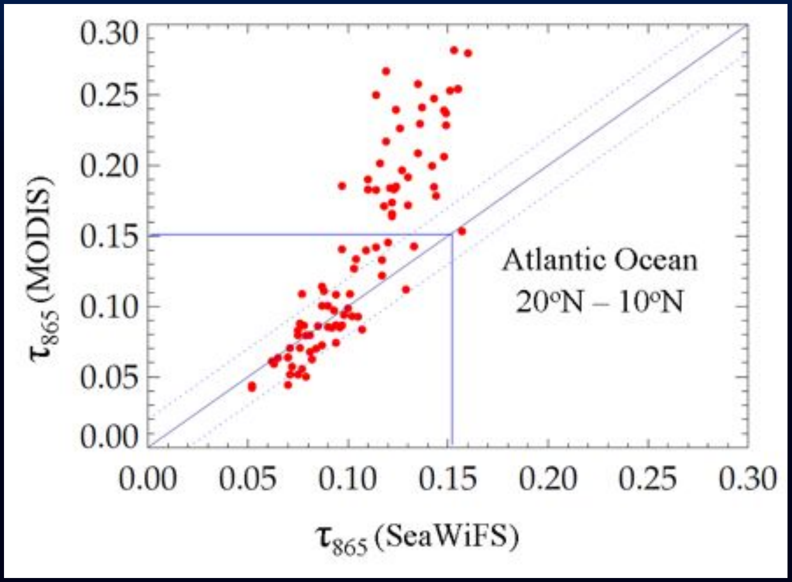
- τ_{865} from the SeaWiFS and MODIS sensors are very close to one another (~ ±0.02)

- The minimum values of τ_{865} from the MISER sensor are higher than SeaWiFS & MODIS values by ~ 0.05

Comparison of τ_{865} (SeaWiFS vs. MODIS vs. MISR)

Atlantic Ocean (10°N – 20°N Dust Belt)





- For small τ_{865} (< 0.15) SeaWiFS and MODIS values agree very well one another over the entire overlapping time period.
- Since ocean color retrievals are made in pristine environment, SeaWiFS screens out large values of τ_{865}. This results in large bias when τ_{865} exceeds 0.15

Future Plan

• Absorbing Aerosols (Dust and Smoke)

- Sensitivity studies to detect smoke and Saharan dust under low aerosol loading

• Response Versus Scan Angle (RVS)

- Sensitivity study to determine any dependence on phase function

• RT Code

-Output lookup tables at finer angular resolution to minimize the use of interpolation

• Multiple Scattering Epsilon (ε_λ)

- Use multiple scattering epsilon (ε_λ) to select aerosol models for atmospheric correction

Summary and Conclusions

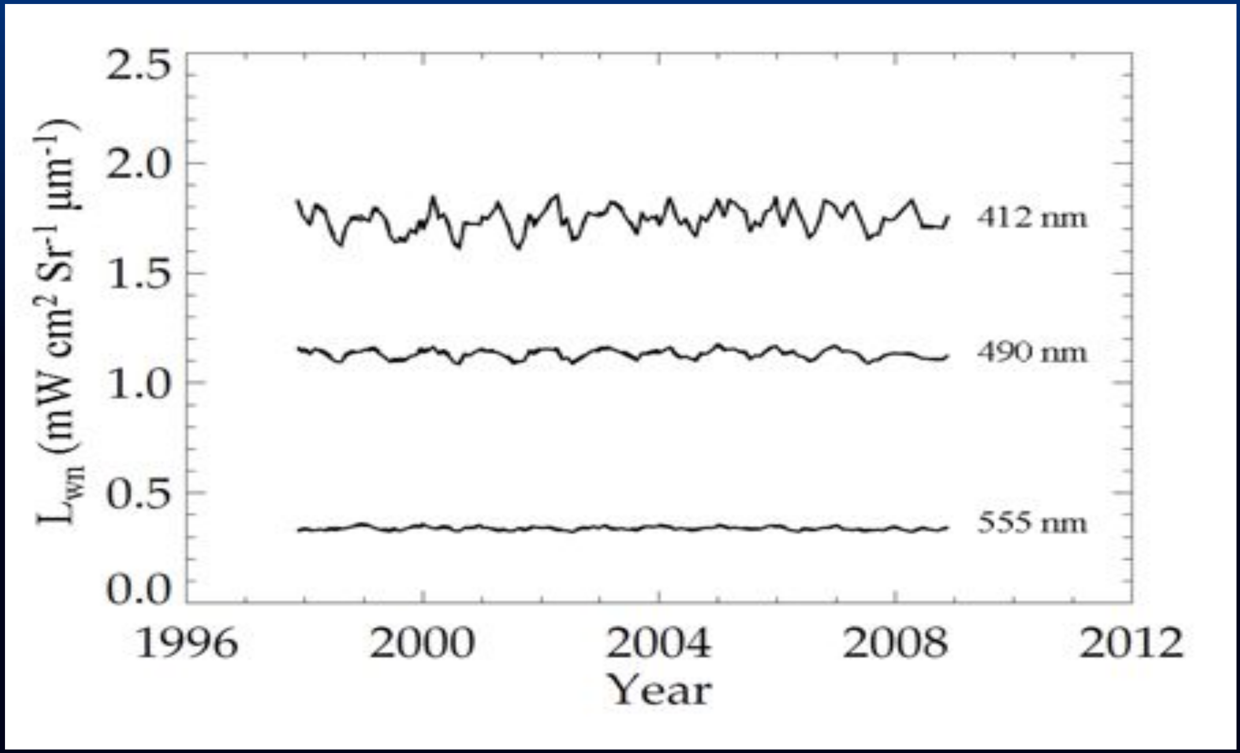
• A suite of 80 new aerosol models (based on AERONET retrievals) were developed to process ocean color data from MODIS and SeaWiFS sensors. In the new models, the modal radii and refractive index of the constituents are explicitly dependent on relative humidity.

• The new models significantly improve the comparison of optical thickness (τ) and Angstrom coefficient (α) with in situ measurements.

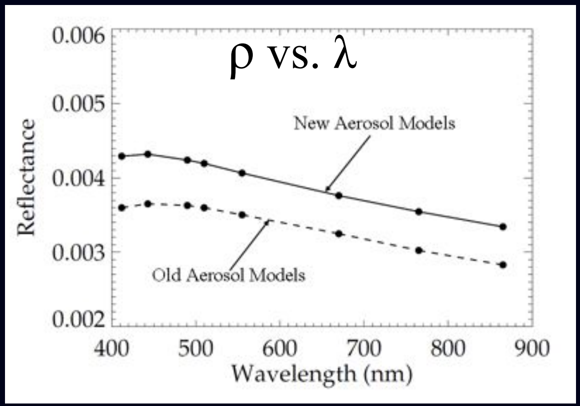
• For τ_{865} less than 0.15, SeaWiFS and MODIS agree very well with one another, even in the dust belt regions. Also, in general, MISR values are higher than SeaWiFS and MODIS.

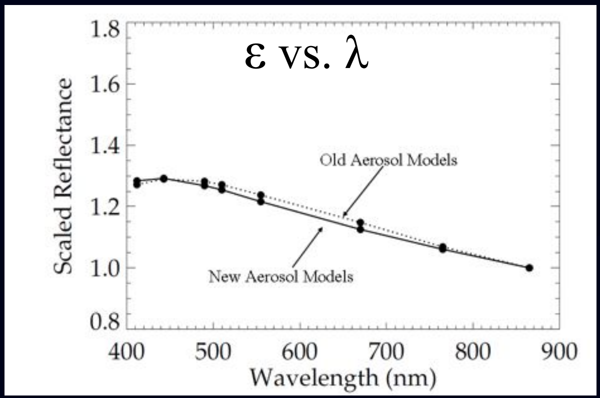
Backup Slides

Water-Leaving Radiances (New & Old Models)



- Old Model: M70
- New Model: RH80M06





$\theta o=30^o$

$\theta=42^o$

$\varphi=120^o$

$\tau=0.1$