AEROCOM Workshop

The AERONET Makeover

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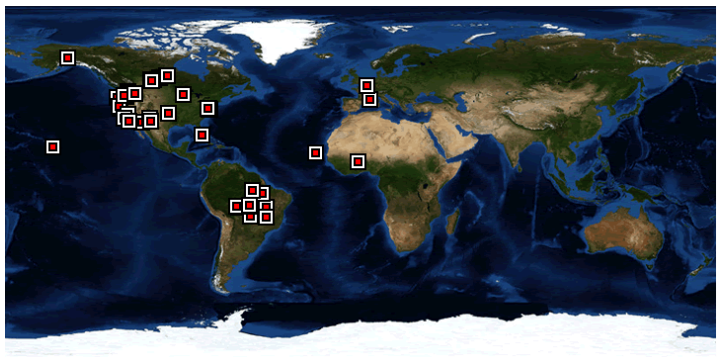
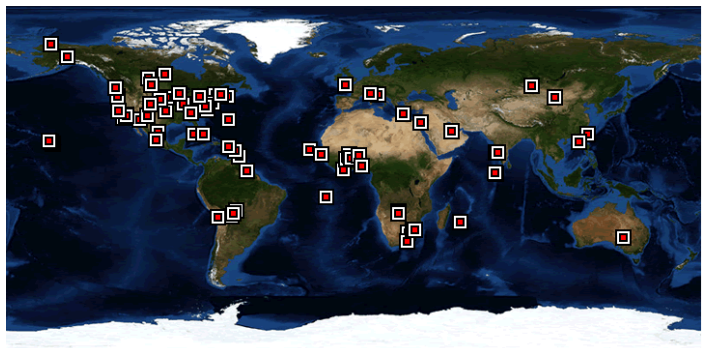
Outline

- Distribution
- Data Products
- Improvements
  - AOD retrievals (direct sun measurements)
  - Inversions retrievals (Sun and Sky)
- Synergism

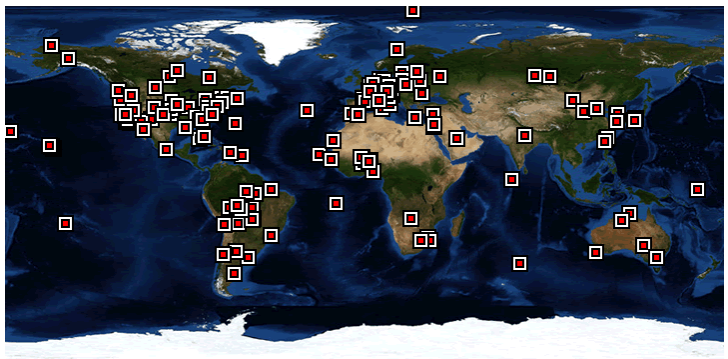
Data Distribution 1993-2006



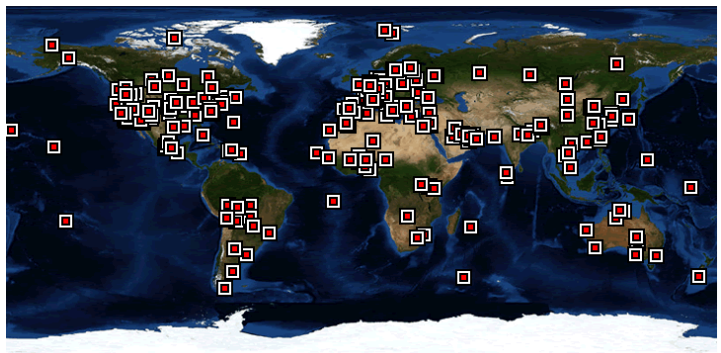
1994-22 Sites



1998- 78 Sites



2002- 162 Sites



2006- 192+ Sites

Version 1 Inputs & Processing Algorithms

- Extraterrestrial Solar Flux - Neckel and Labs 1981; and Frohlich and Wehrli 1981
- Rayleigh optical depth - Edlen 1966
- Ozone amount - LUT (5ºx 5º Lat Long) - London et al. 1976
- Water vapor content - Bruegge et al. 1992; Reagan et al. 1992
- Water vapor correction for AOD (1020 nm) - none
- CO2, CH4, WV for AOD (1640 nm)

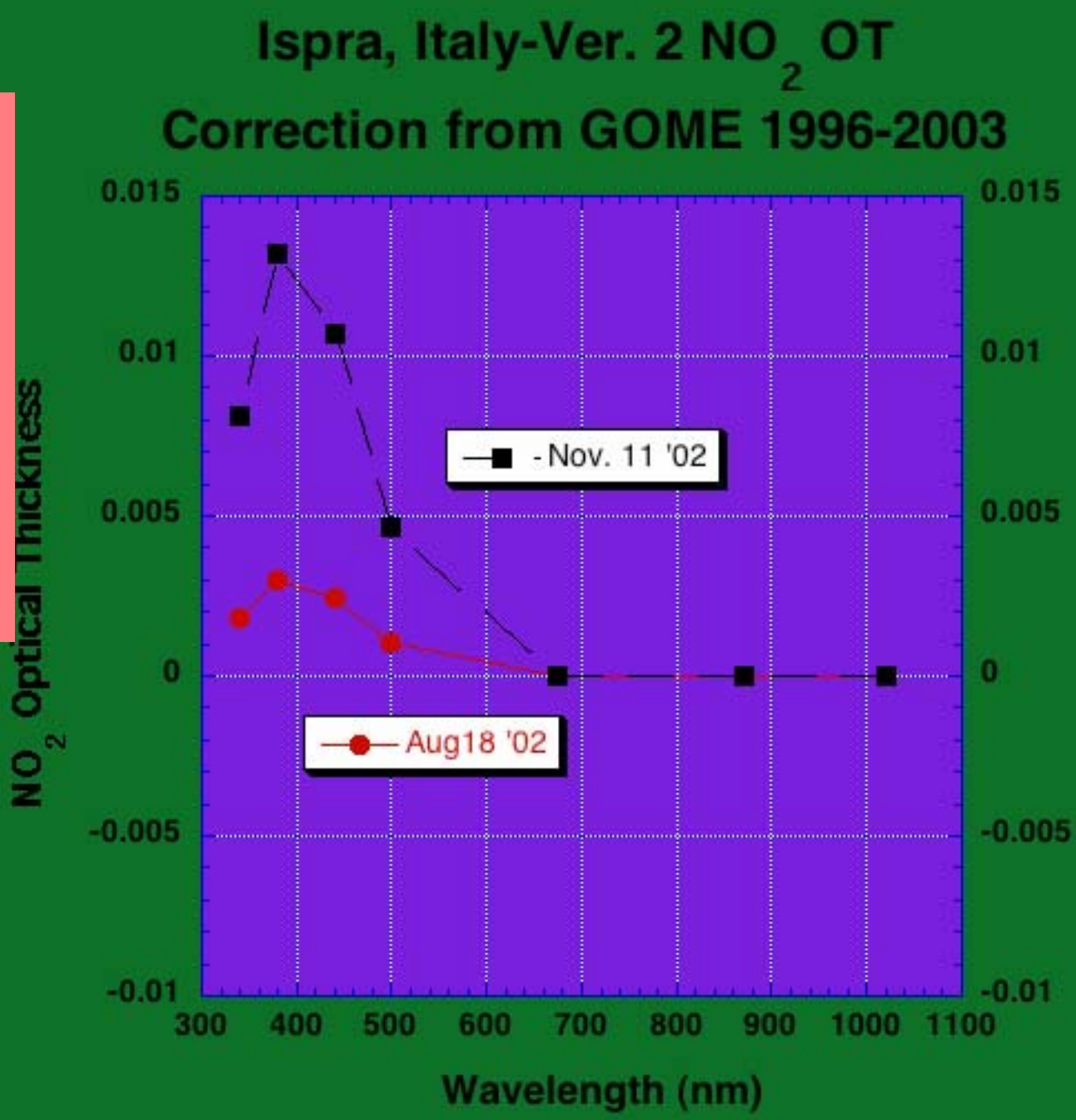
Version 2 Inputs & Processing Algorithms

- Extraterrestrial Solar Flux - Woods et al. 1996
- Rayleigh optical depth - Bodhaine et al. 1999
- NCEP surface air pressure 6 hrly
- NO_2 Sciamachie monthly climatology (3 yr)
- Ozone amount - Monthly LUT (1ºx 1.25º Lat Long) - from TOMS O_3 1979-2004
- Water vapor content - Michalsky et al. 1995; Schmid et al. 1996
- Water vapor correction for AOD (1020 nm) - LBLRTM
- CO2, CH4, WV for AOD (1640 nm) - LBLRTM

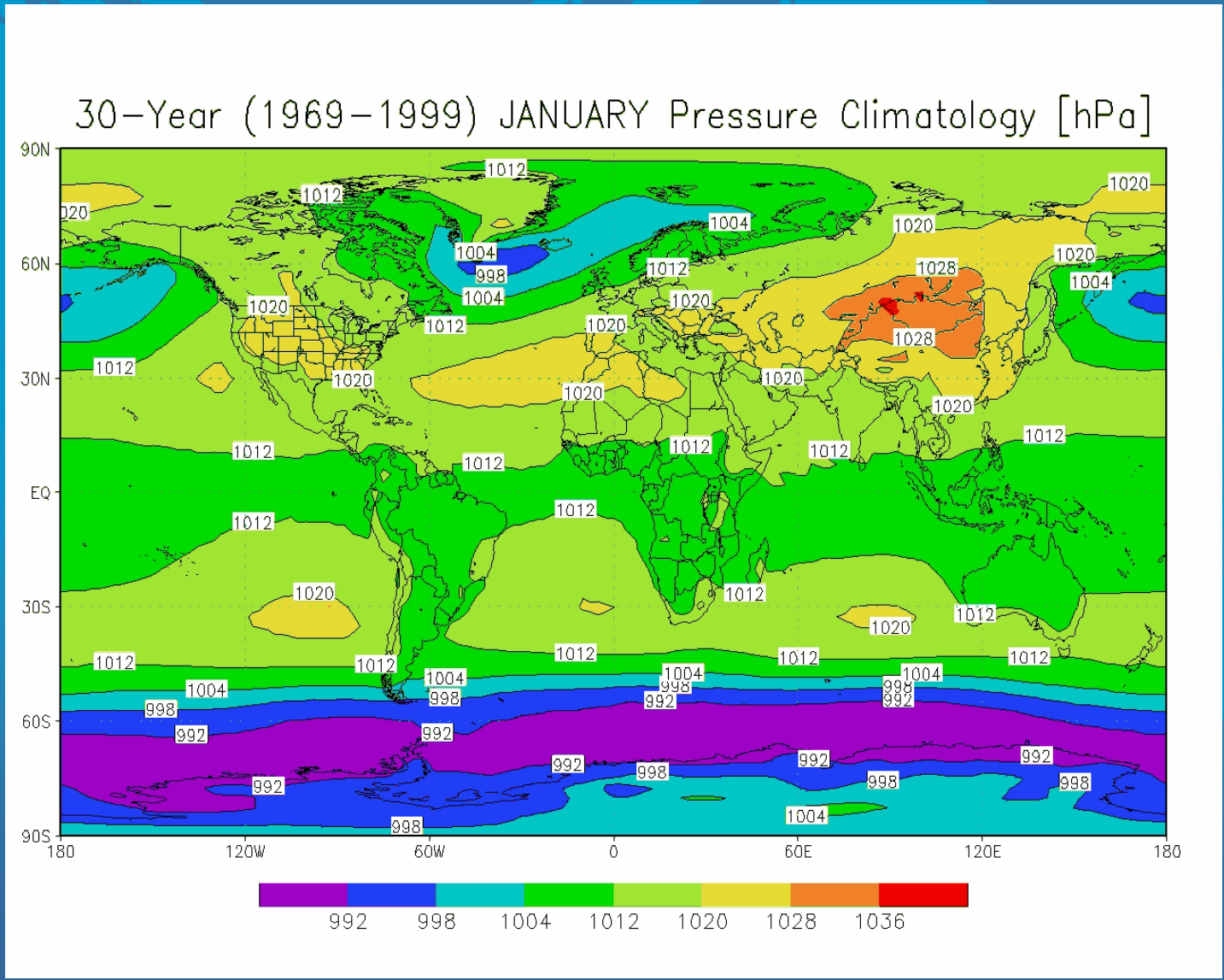
GOME data base:
Boersma et al., 2004

NO_2 Abs. Coef:
N. Oneil, P. Comm.

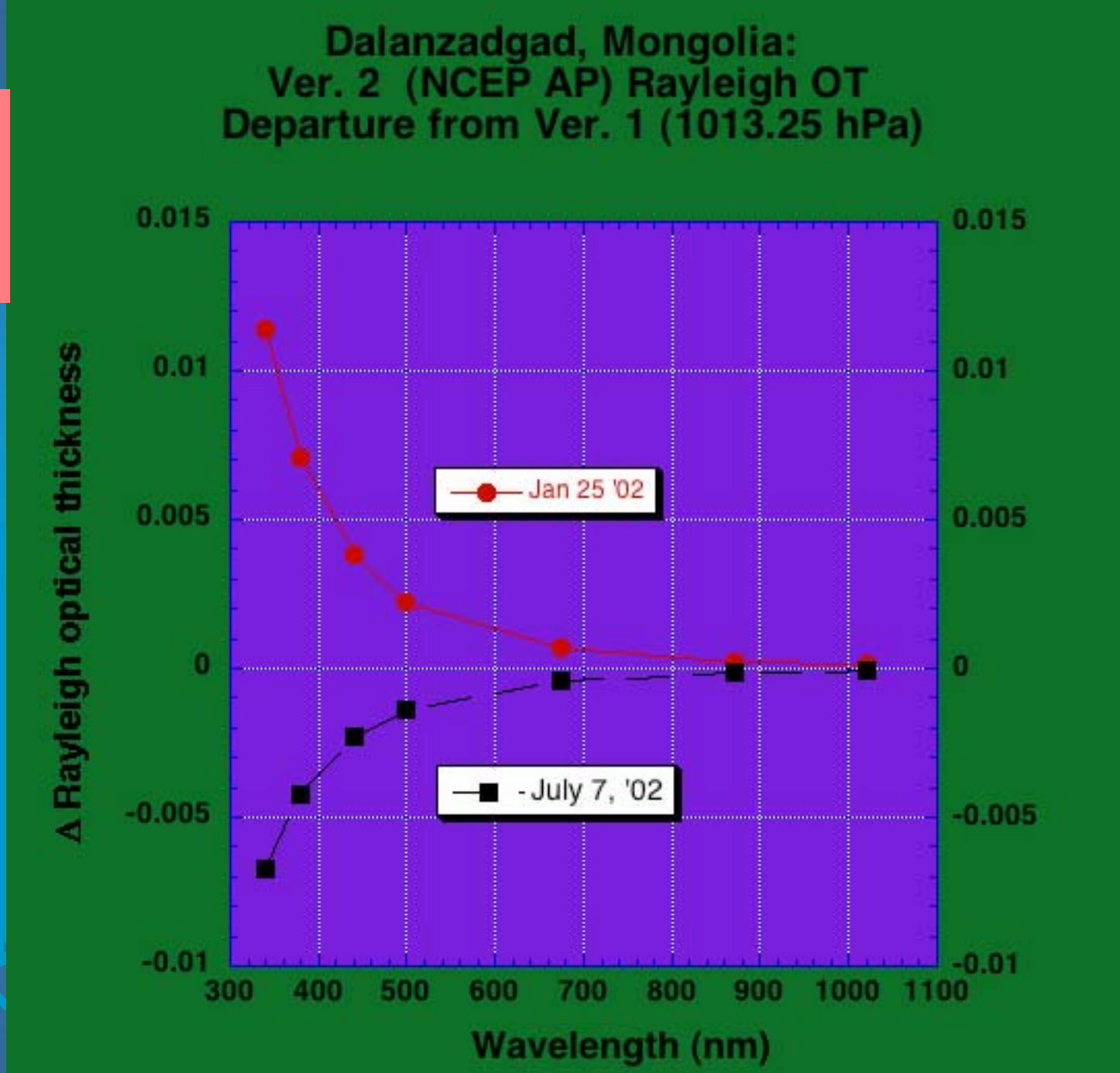
Absorption Spectra:
Harder, 1997
Schneider, 1987
Lurther (1976)



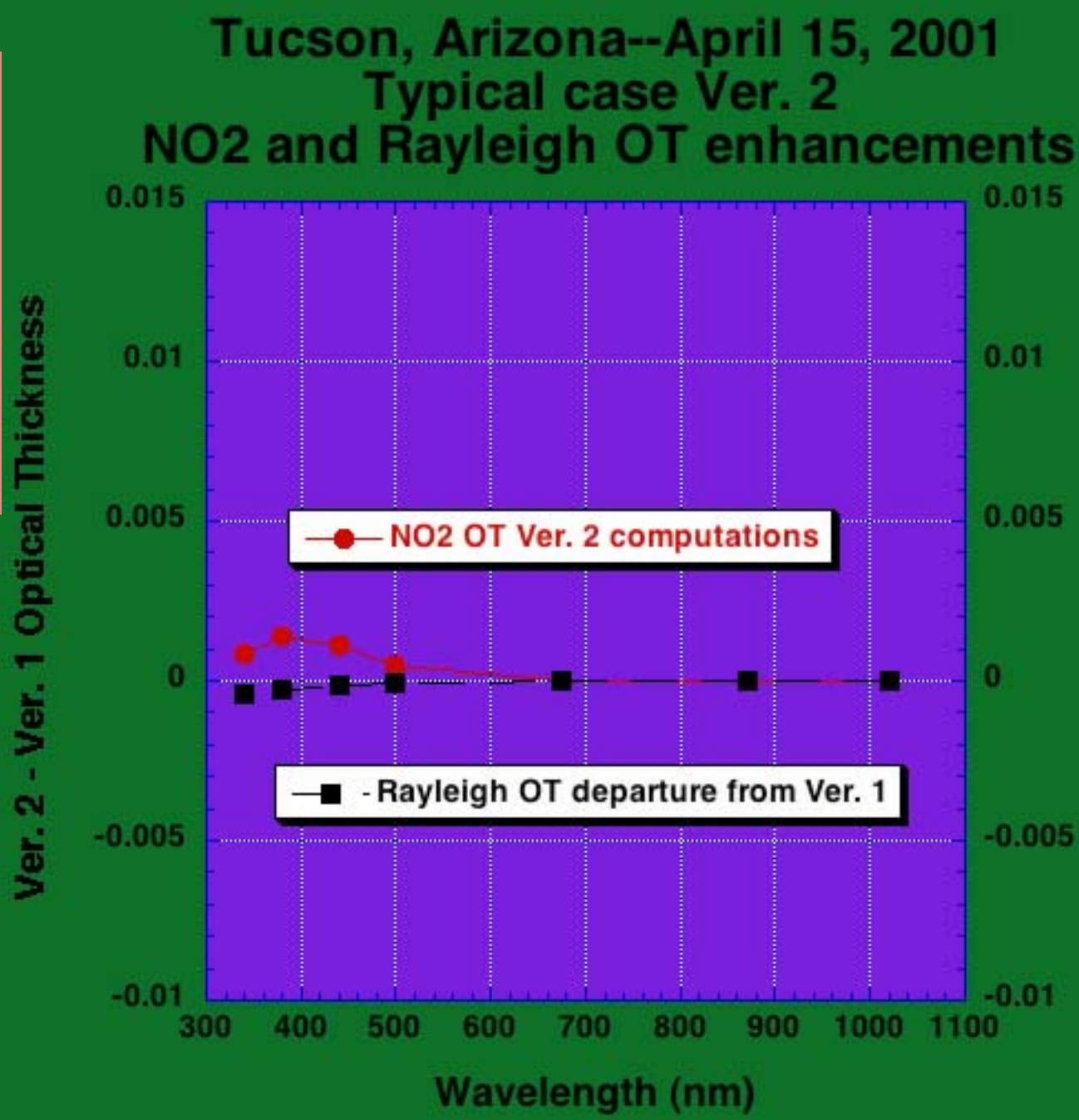
Thirty year NCEP surface pressure reanalysis climatology
Applied to real-time level 1.0 and 1.5 Rayleigh correction
AOT products, 6 hrly reanalysis applied to all levels ~+1Mo



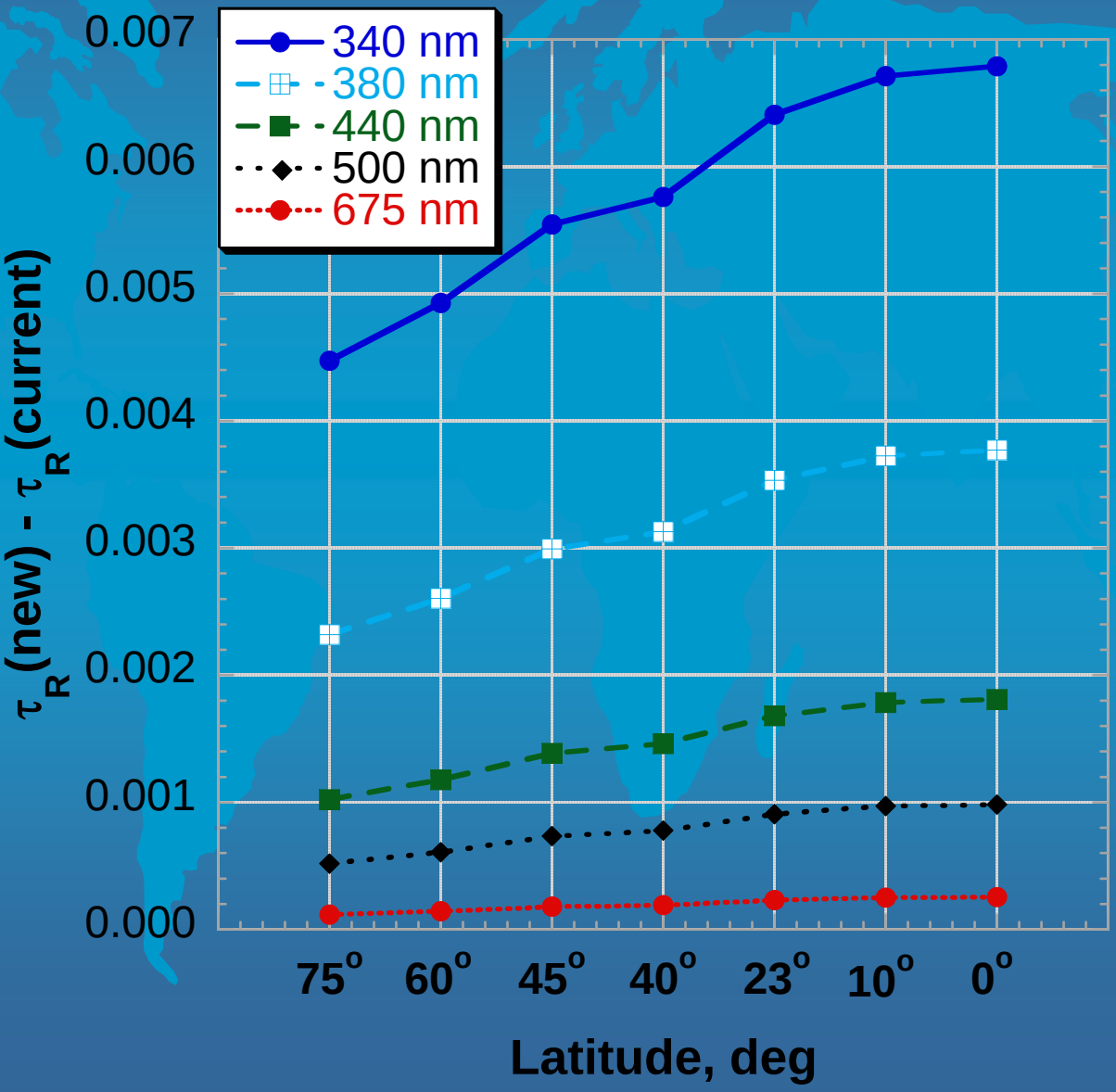
Bodhaine et al., 1999
Elevation (m)
NCEP (hPa, 1013.25)
Kistler et al., (2001)



Most sites are well within the ±0.01 to 0.02 uncertainty expected from a pre and post field calibrated instrument.



Rayleigh Optical Depth



Ver. 2 Inversion Products

- **Size distribution (volume)**
  - C_v, r_v, σ, r_{eff} for total, fine and coarse modes
- **% Sphericity Parameter**
- **Spectral Phase function; Asymmetry Parameter**
- **Spectral Extinction optical depth**
- **Spectral Absorption Optical depth**
- **Spectral Single Scattering Albedo**
- **Spectral Complex index of refraction**
- **Error bars for all individual retrievals**

Version 2 Calculated Products

Instantaneous:

- Spectral upward and downward fluxes (TOA and BOA)
- Broadband upward and downward fluxes (TOA and BOA)
- Radiative forcing (TOA and BOA)
- Radiative forcing efficiency (TOA and BOA)

Measurement sequences

- Almucantars ~ 8/day $\theta_o > 50°$
- Principal Plane ~9/day all day

Version 1

- Almucantar Retrievals (Four Wavelengths)
  - RadPak (Nakajima et al. 1996); Spherical particle model
  - Dubovik & King (2000)
    - Spherical particle model
    - Spheroid particle model

Complications: Additional wavelengths, PP inversions, two models, variable surface reflectance

Solution: Bi-component model Dubovik et al., (2006); Invert all available data (λ); Input dynamic reflectance

Version 2 Assumptions:

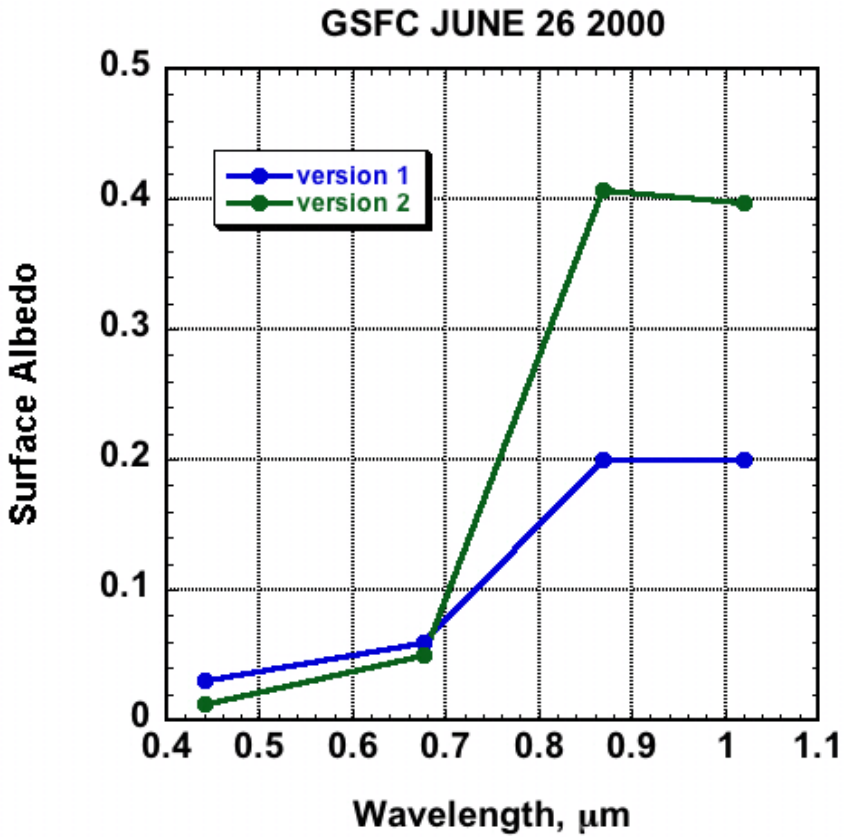
- Two component distribution
  - Spherical
    - Ensemble of polydispersed homogeneous spheres
    - Constant complex index of refraction for all sizes
  - Non-spherical
    - Mixture of polydispersed randomly oriented spheroids (Mishchenko et al. 1997)
    - Fixed Aspect ratio distribution (Dubovik et al. (2006a)
    - Fit to lab measured dust scattering matrix, Volten et al. (2001)

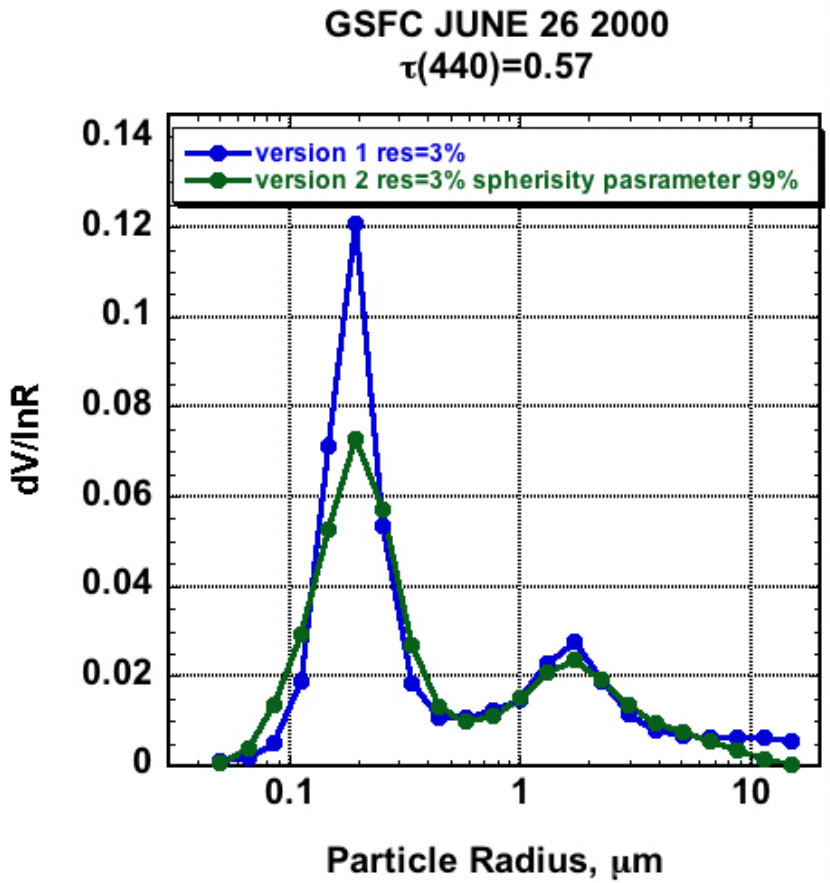
- Atmosphere is plane-parallel
- Vertical distribution of aerosol
  - Almucantars: homogeneous
  - Principal Plane: bi-layered (TBD)
- Retrieval errors are estimated under the assumption of uncorrelated log-normally distributed measurement errors
  - Optimization accounts for different levels of accuracy
    - $\tau(\lambda)$ assumed ±0.01
    - Std dev. Sky radiance error is assumed 5%, Dubovik et al. (2004)

Version 2 Assumptions (cont.):

- Dynamic Surface Reflectance (Sinyuk et al.,2006)
  - Water surface BRDF approximated by Cox-Munk
    - Wind speed from NCEP/NCAR reanalysis (6 hourly, 2.5x2.5°)
  - Terrestrial surface BRDF approximated by Li-Ross model (Lucht and Roujean, 2000)
    - BRDF parameters adapted from MODIS Ecotype generic BRDF models (Feng Gao, personal communication)
    - Albedo selected according to Ecotype map, Moody et al. (2005) [based on 16 day Modis composites]
    - Modified daily by:
      - NISE SSM/I snow and ice extent, Nolin et al. (1998)
      - Modis snow cover map, Hall et al. (2002)

Predominately Spherical Aerosols, GSFC





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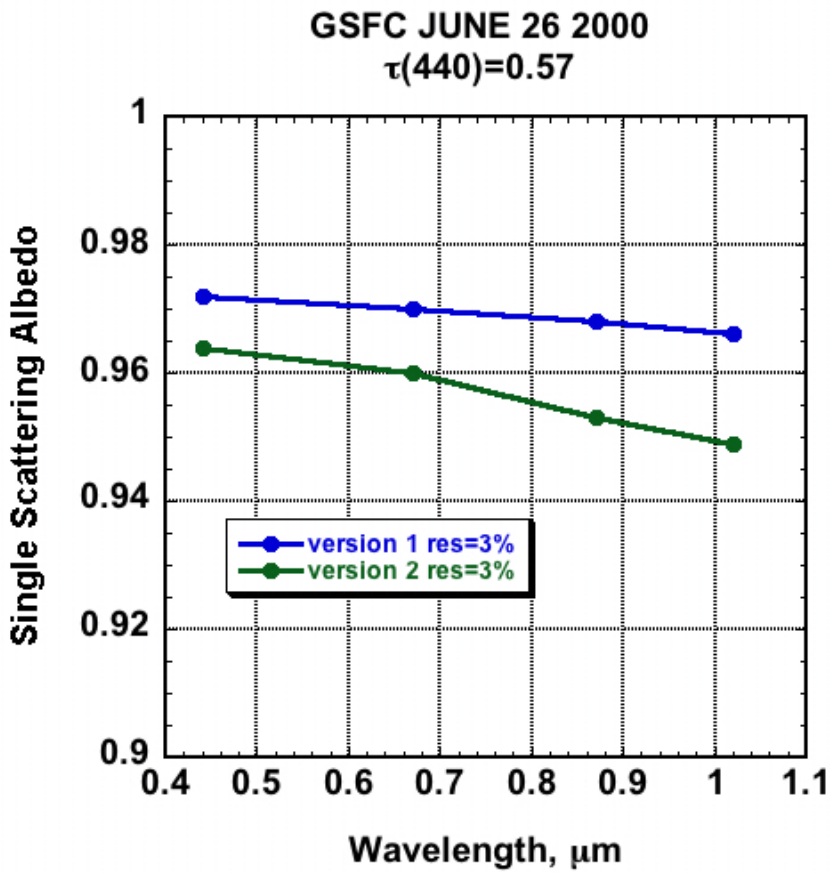
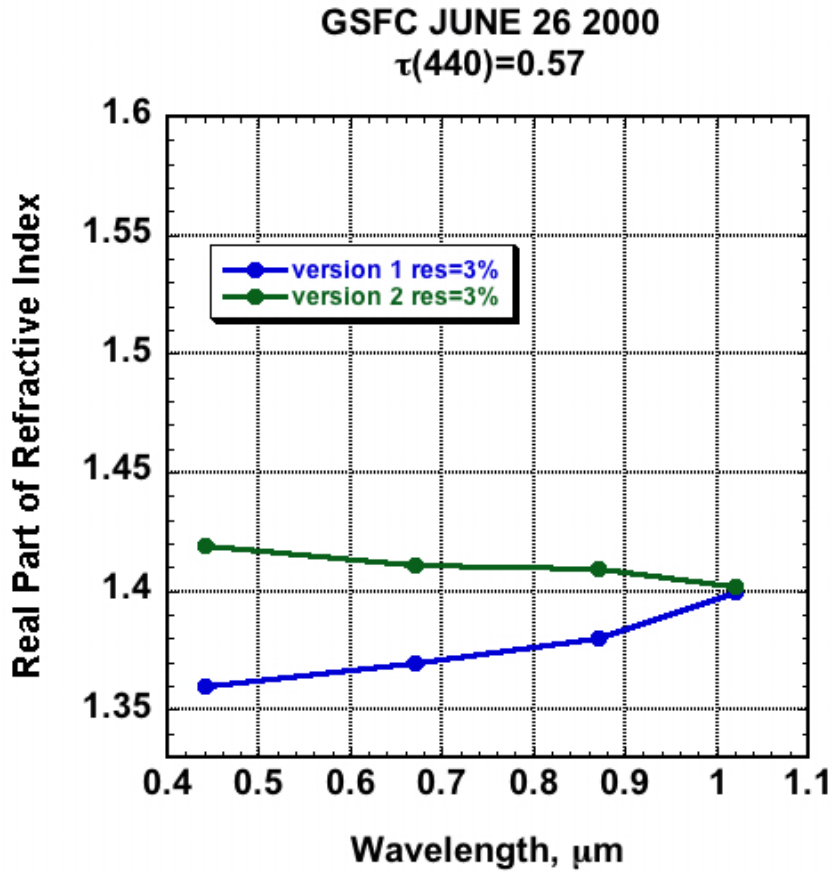
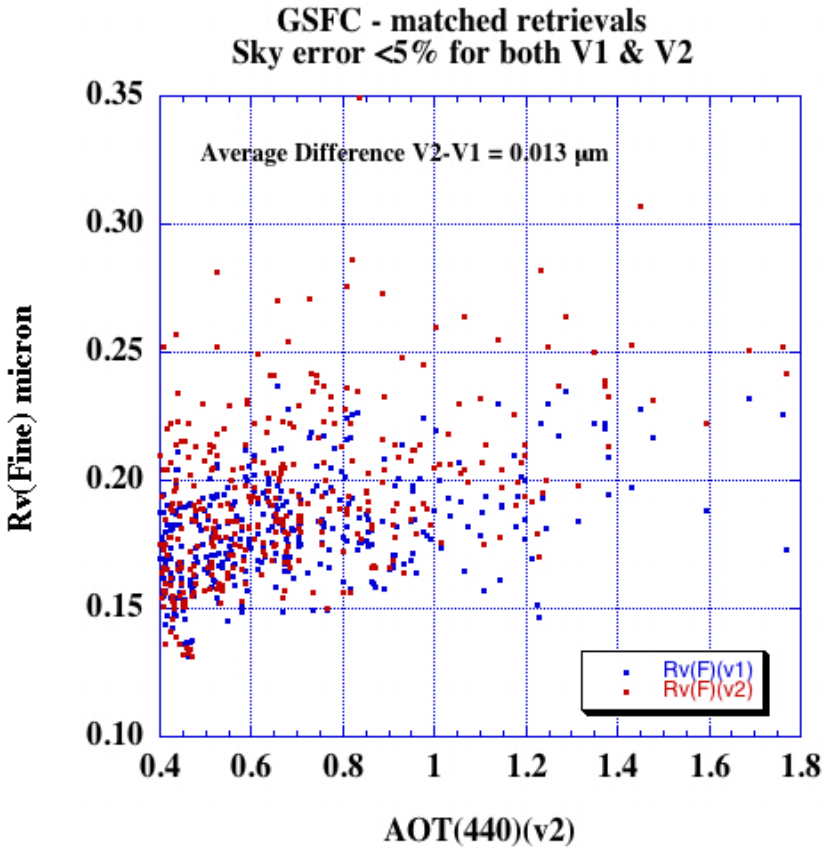
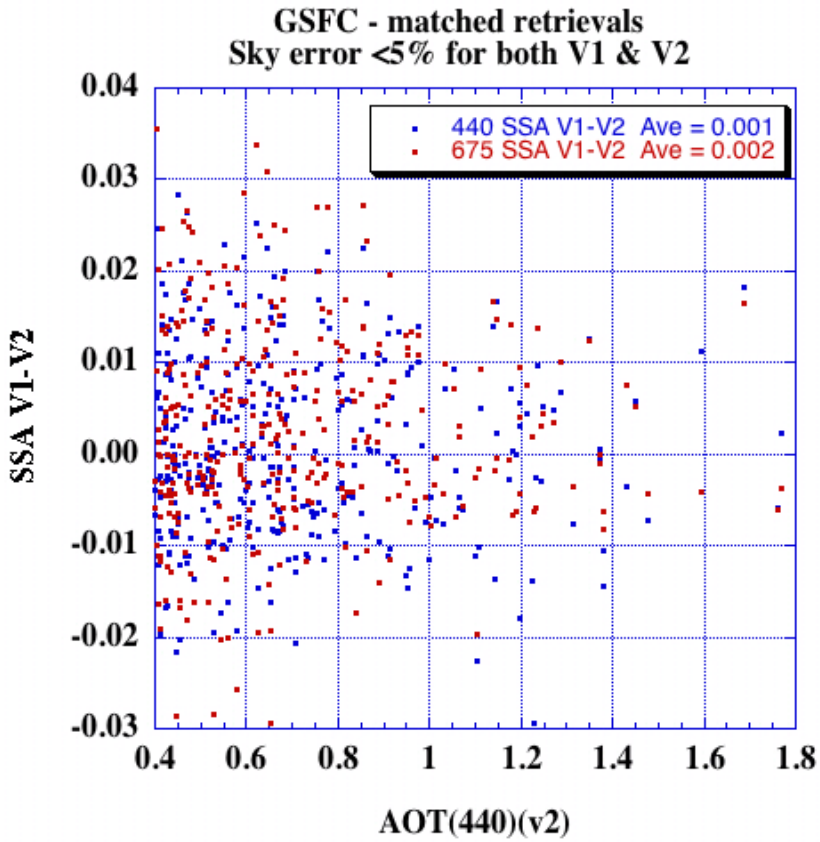




Predominately Spherical Aerosols, GSFC





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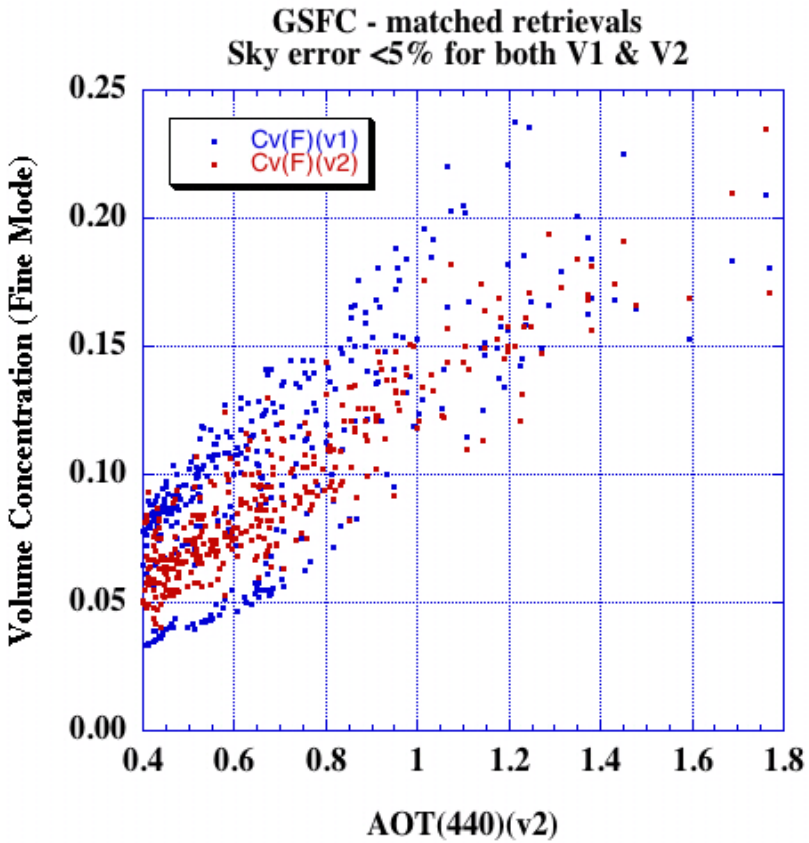
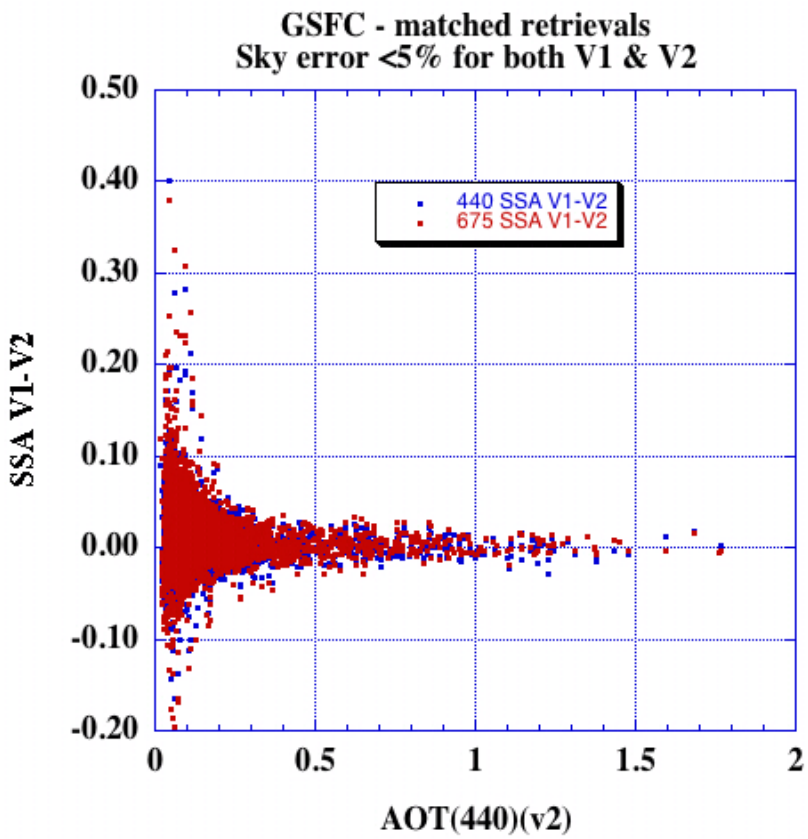
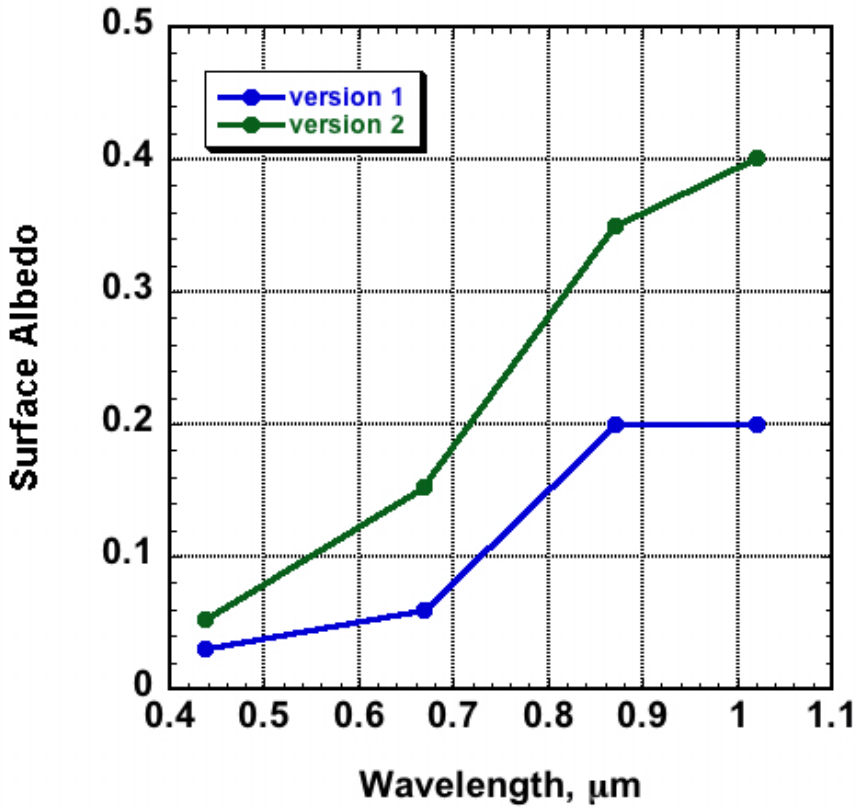
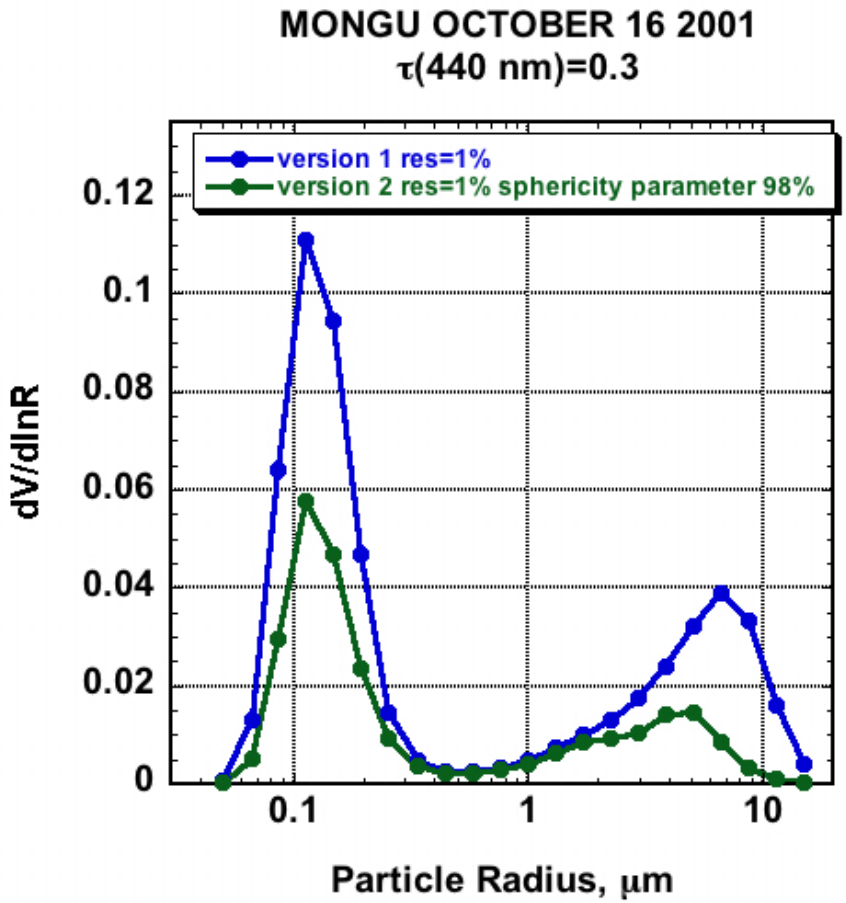




Predominately Spherical Aerosols, Mongu (BB)





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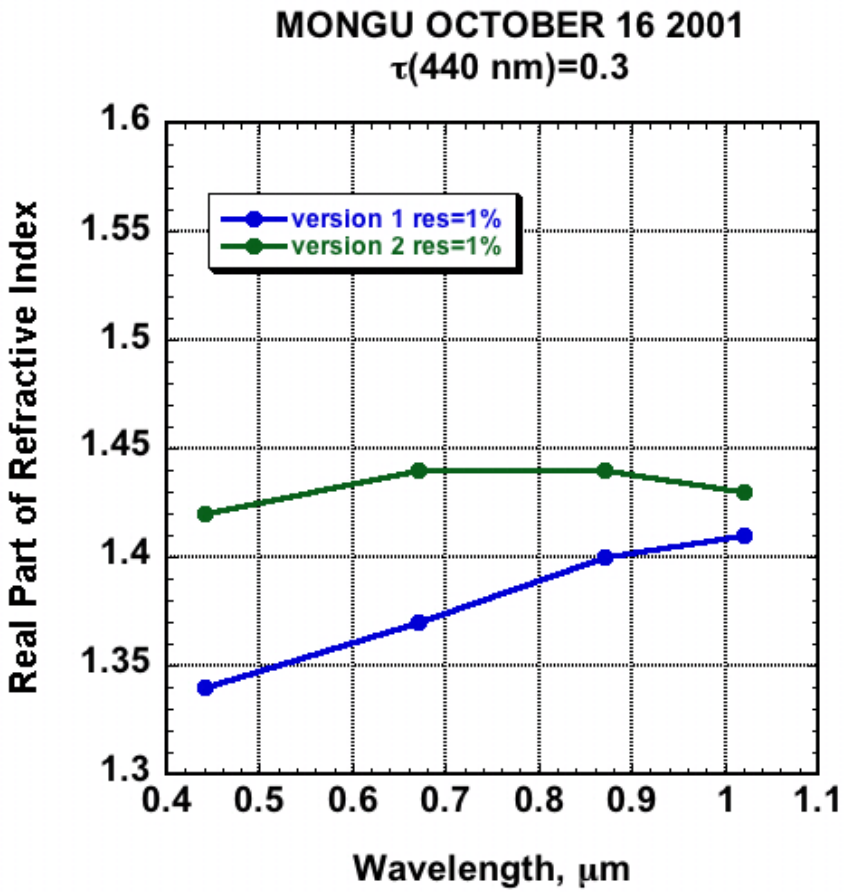

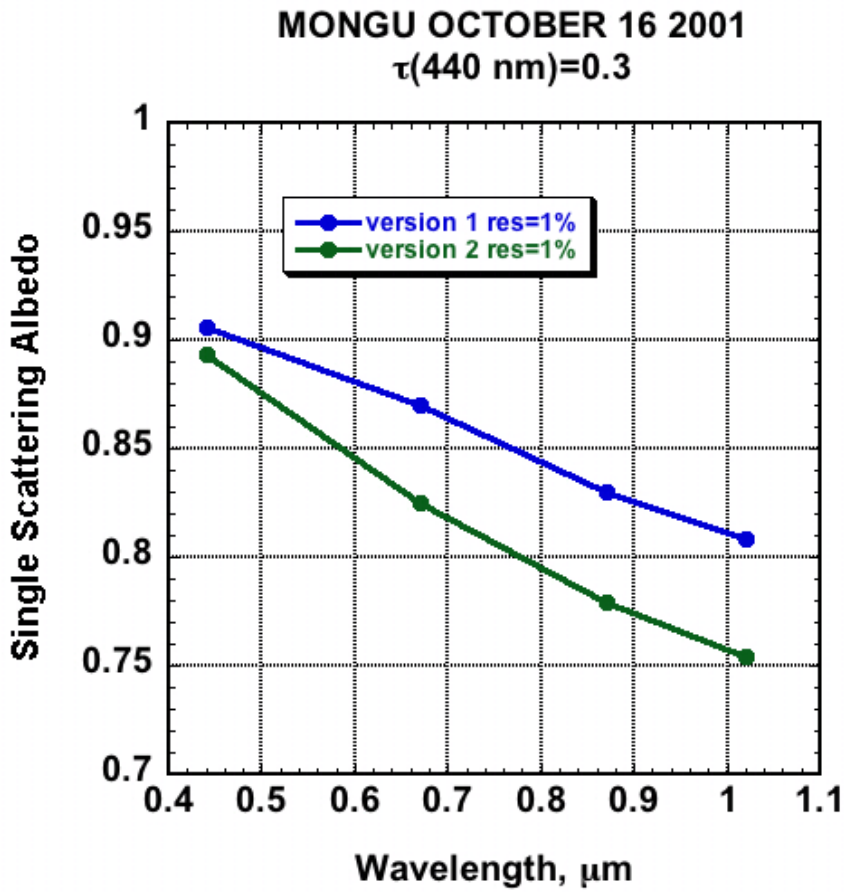

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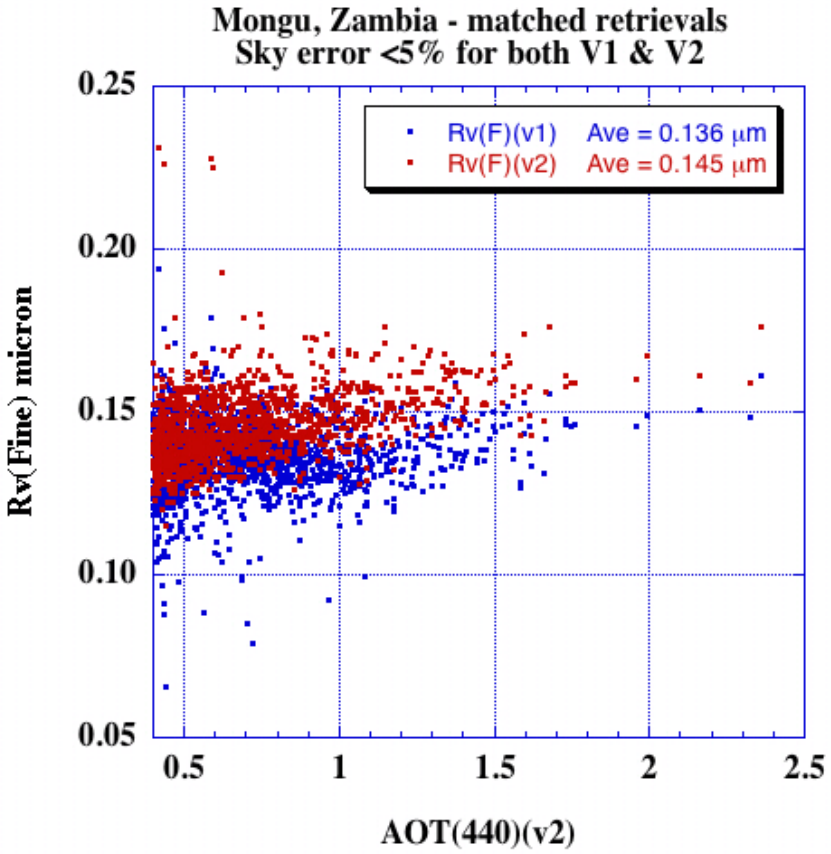
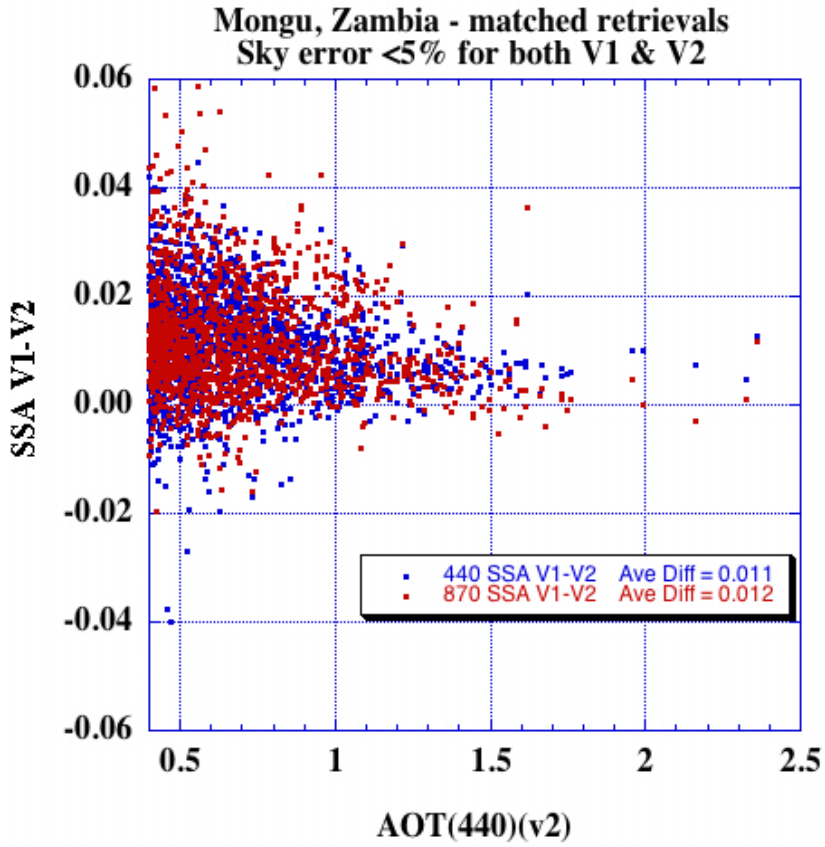
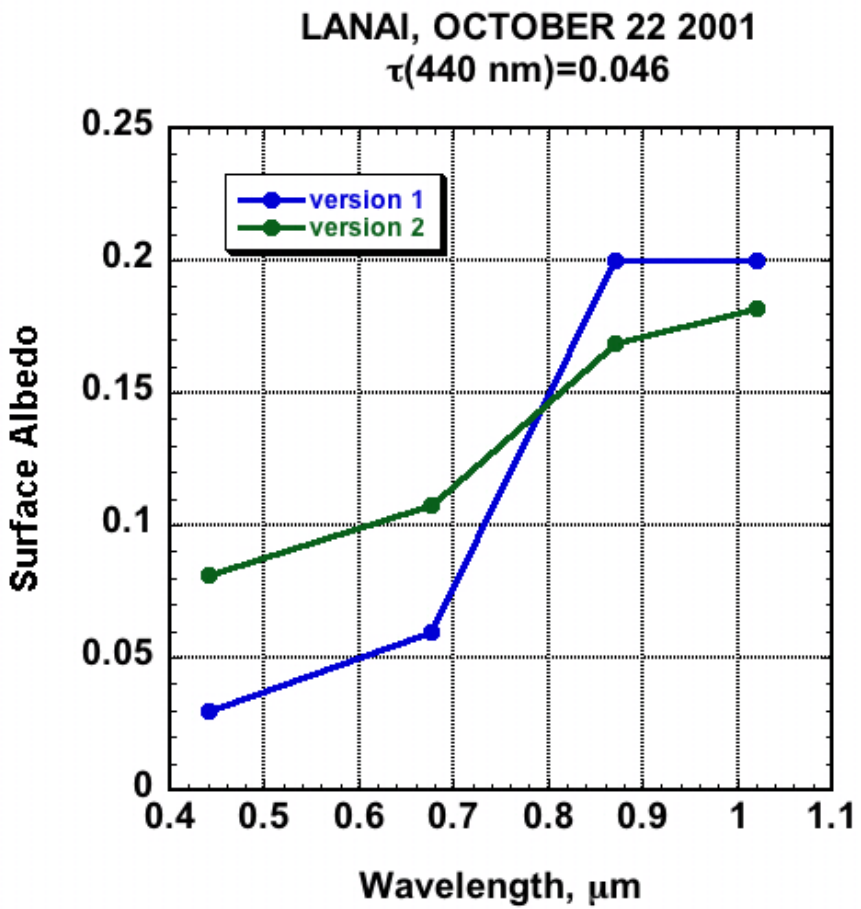
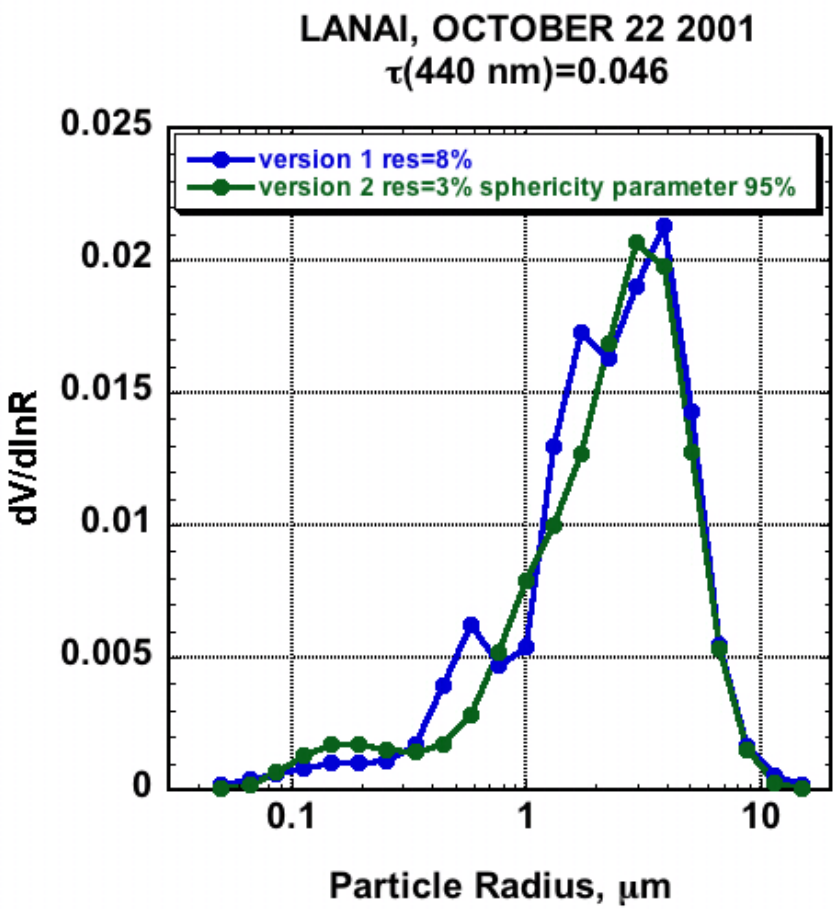


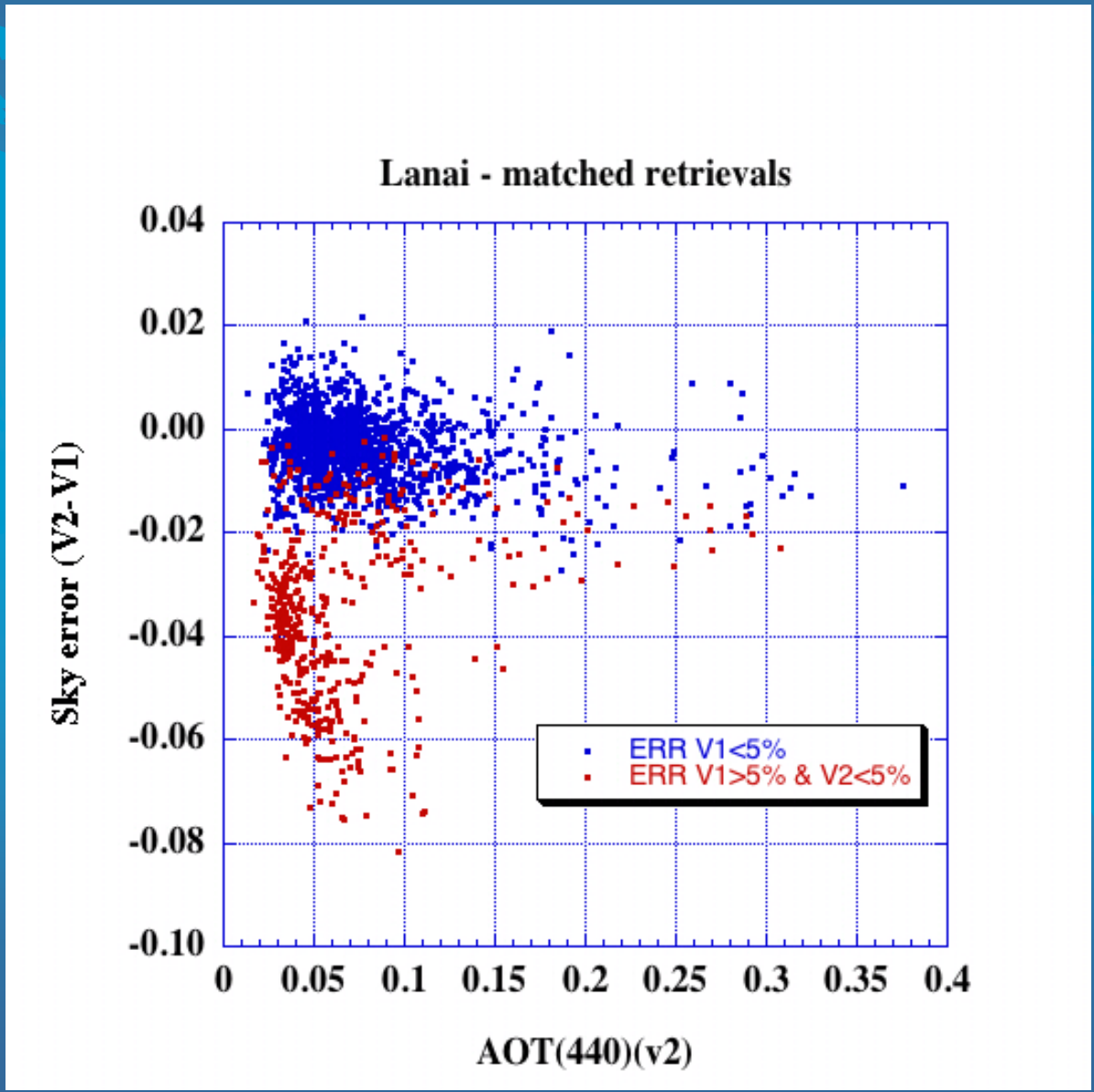


Predominately Coarse mode Aerosols, Lanai (Marine)

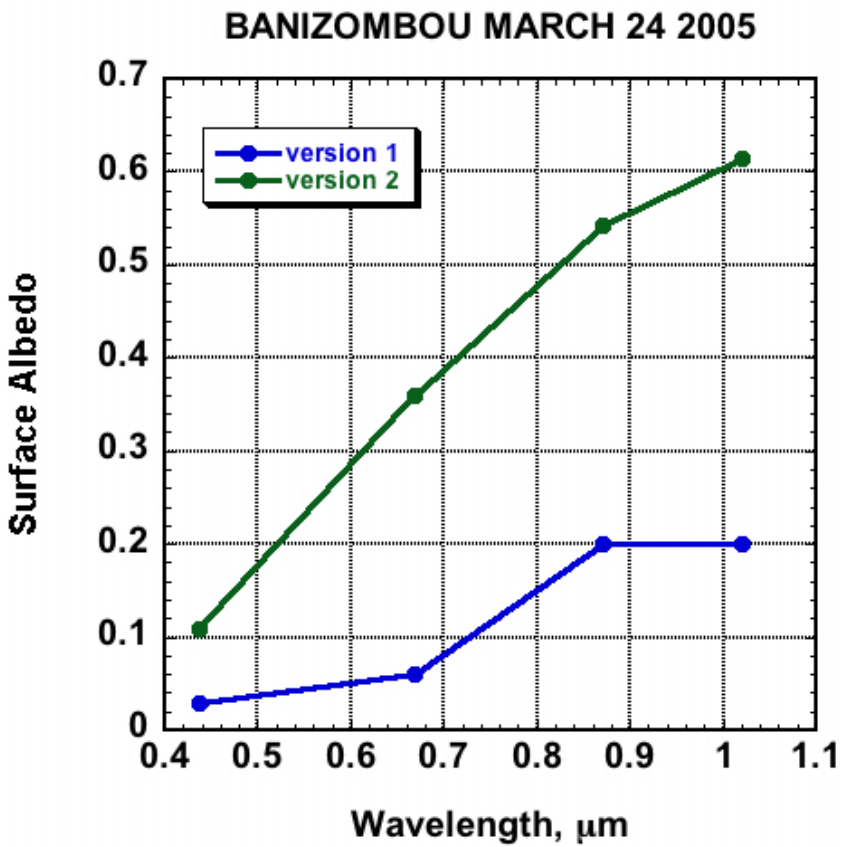


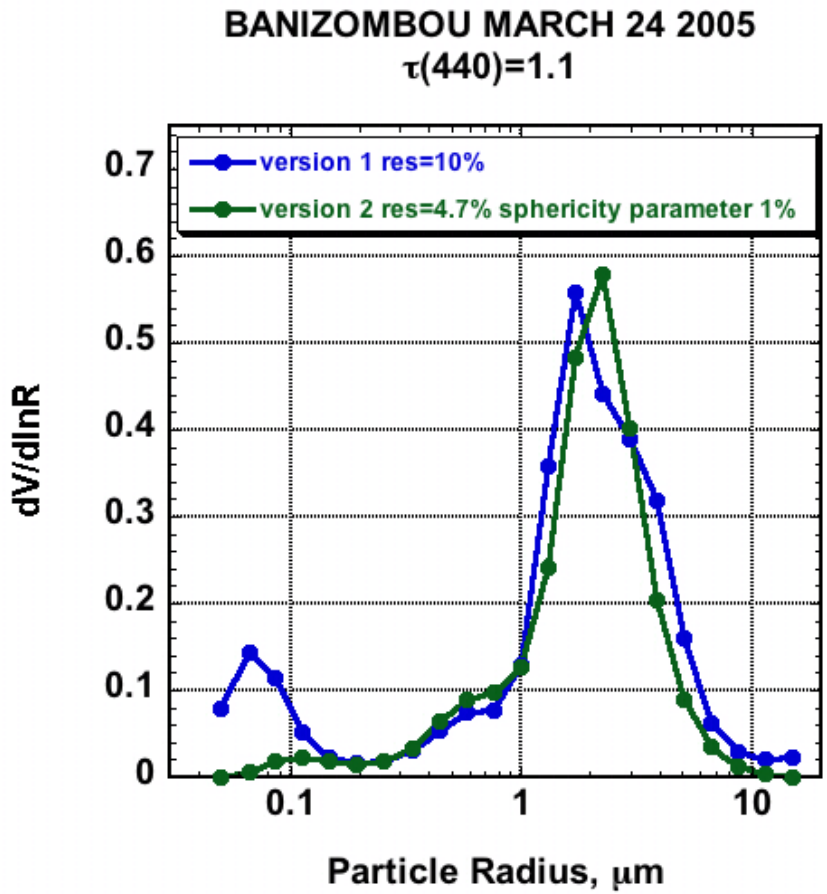


Predominately Coarse mode Aerosols, Lanai (Marine)

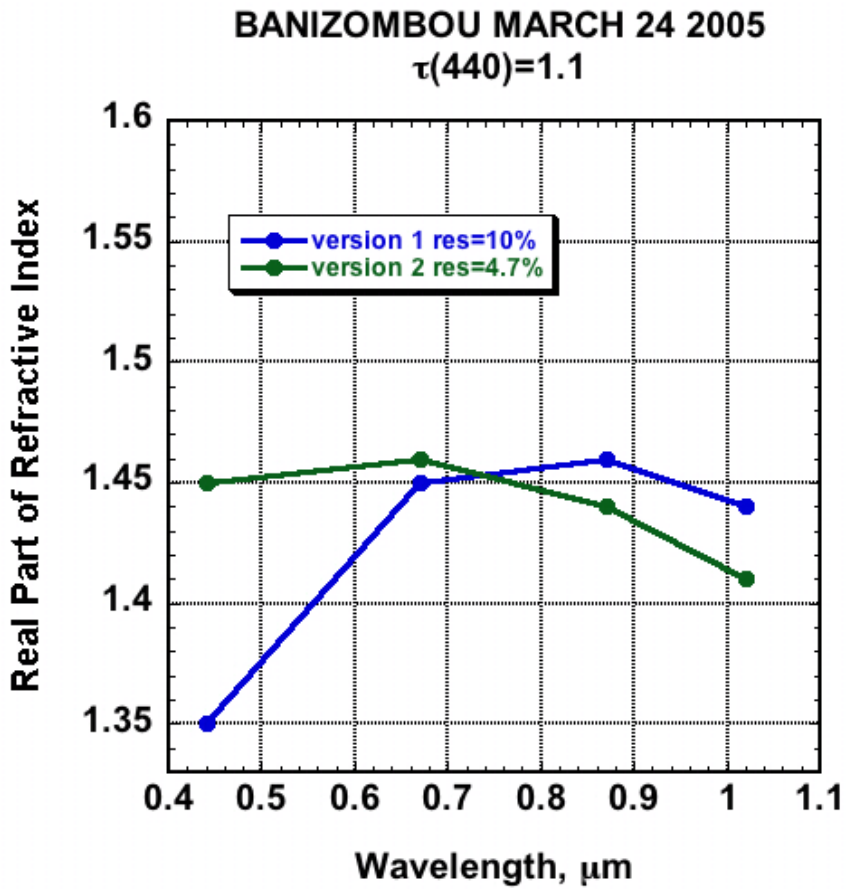


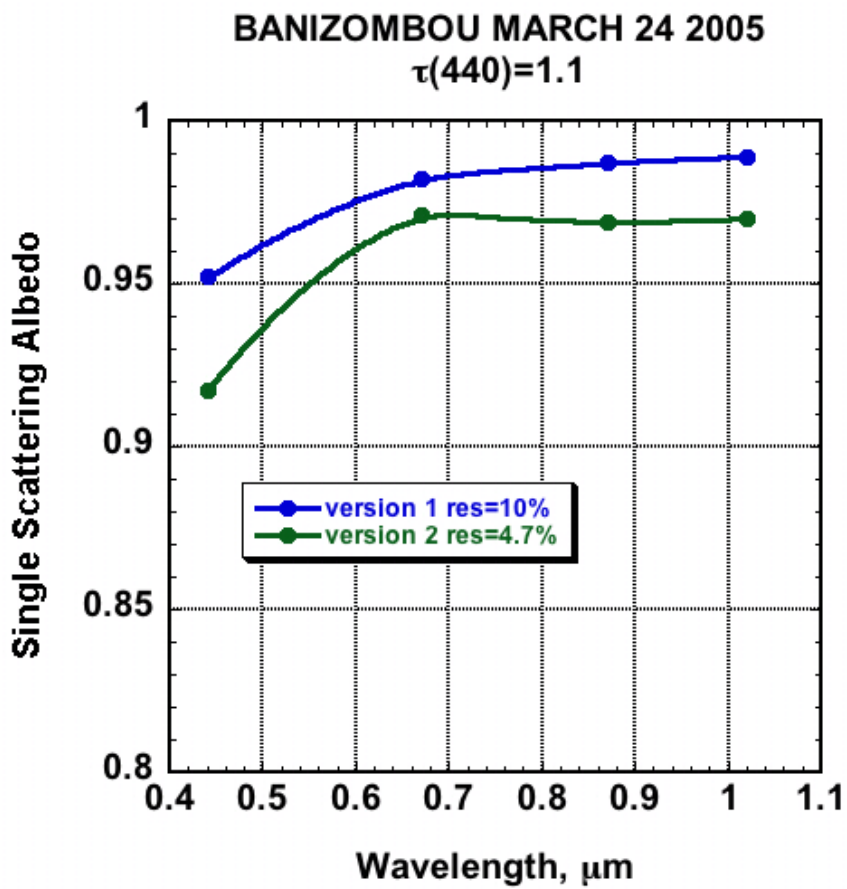
Predominately Coarse mode Aerosols, Banizoumbou (Dust)



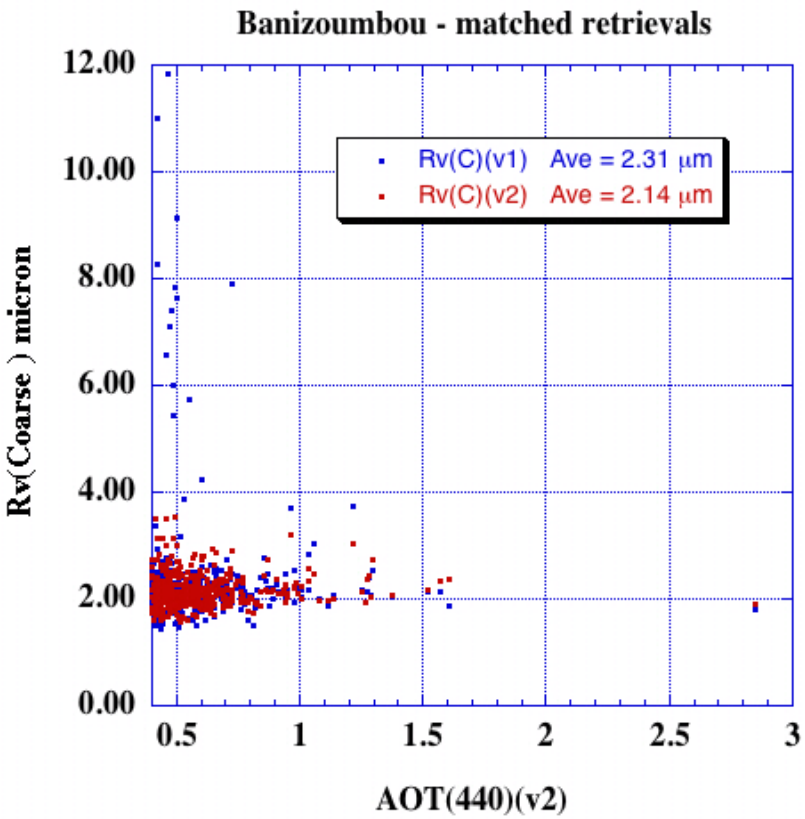


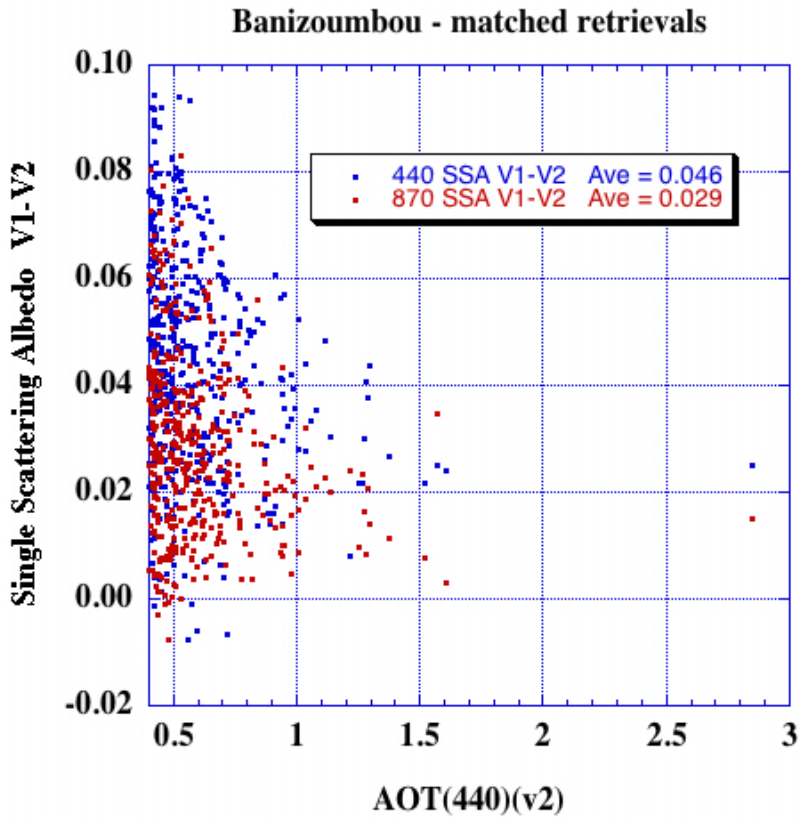
Predominately Coarse mode Aerosols, Banizoumbou (Dust)





Predominately Coarse mode Aerosols, Banizoumbou (Dust)





AERONET Data Synergy Tool

- Ground-based
  - AERONET
    - AOD, Inversions, AOD Fine and Coarse
  - Solar Radiation Network Flux (Solrad-Net)
  - Micropulse Lidar Network (MPLNET)
  - AERONET-Ocean Color (nLw)

AERONET Data Synergy Tool

- Satellite Products
  - True Color Modis Subsets (MODIS Rapid Response)
  - Daily and Monthly MODIS Atmospheric Products (via GIOVANNI)
  - TOMS and OMI atmospheric products (via GIOVANNI)
  - SeaWiFS and MODIS ocean products (via GIOVANNI)

AERONET Data Synergy Tool

- Model Data
  - Back trajectory analyses from 950 to 200 hPa
  - GOCART AOD for 350, 550, 900nm wavelengths by constituent aerosol (SU, OC, BC, DU, and SS)

AERONET Data Synergy Tool

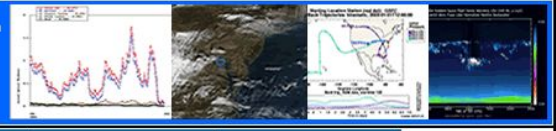
- Future Products
  - Via GIOVANNI
    - AIRS Daily Maps (Temperature, Pressure, and O3)
    - Nearby Aura Daily MLS Atmospheric Chemical Profiles (O3, H2O, ClO, CO, HNO3, HCl, N2O, OH)
  - Expand GOCART AOD historical data set

AERONET Data Synergy Tool

- Future Products
  - Provide additional MODIS true color subset images
  - Create interactive back trajectory analysis tool
  - Establish Link to meteorological data sets (e.g., GOES and MSAT imagery and NCEP/NCAR Reanalysis)

GODDARD SPACE FLIGHT CENTER

AERONET
DATA SYNERGY TOOL



+ AERONET | + MODIS | + BACK TRAJECTORY | + MPLNET | + GOCART | + GIOVANNI

Select the above buttons to find information for products provided by this data display

Use world map to find products for AERONET sites:

Select Map Browser

Master Controls

Initial Date: Year 2004 Month JUL Day 20

Enter Site Name:

Change Site

COVE
36.900000° N, 75.710000° W
Elevation: 37m

BAMGOMAS

AERONET
- [x] AOD
- [ ] Inversions (V2) (N/A)
- [x] Ocean Color
- [x] SolRad-Net Flux
- [x] AOD Modes (Provisional)
- [x] Inversions (V1)

- [x] MPLNET Retrievals
- [x] MODIS Rapid Response
- [x] Back Trajectory
- [x] GOCART

GIOVANNI

- [x] MOVAS (MODIS Monthly)
- [x] MOVAS (MODIS Daily)
- [x] OCEAN (SEAWIFS & MODIS Monthly)
- [x] OZONE (TOMS & OMI Daily)

- [ ] Select All

Change Image Size: (•) Small ( ) Large

Primary Contacts

+ Data Synergy Tool: David Giles
+ AERONET-AOD: Brent Holben
+ MODIS Rapid Response: Jeff Schmaltz
+ Back Trajectory: Tom Kuscera and Anne Thompson
+ MPLNET: Ellsworth Welton and James Campbell - Disclaimer
+ GOCART: Mian Chin and Thomas Diehl
+ GIOVANNI: Steve Kempler and Gregory Leptoukh
+ SolRad-Net: Joel Schafer and Brent Holben
+ AERONET-OC: Giuseppe Zibordi and Brent Holben
+ AERONET-AOD Modes: Norman O'Neill and Brent Holben
+ AERONET-Inversions: Alexander Sinyuk and Brent Holben

AERONET Data - Direct Sun

Current Site: COVE

2004 JUL 20

Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

AERONET Data Controls:

Version: 2

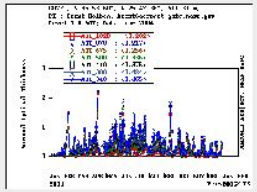
Level: 1.0

Data Type: AOT

Data Format: All Points

Error Bars: Off

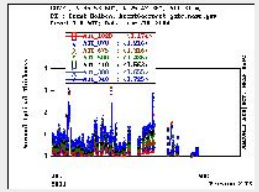
AERONET Yearly Product - Data Description



Download: AERONET Direct Sun Data

More AERONET Downloadable Products...

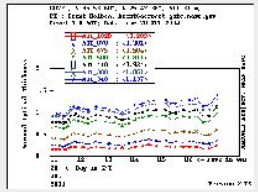
AERONET Monthly Product - Data Description



Download: AERONET Direct Sun Data

More AERONET Downloadable Products...

AERONET Daily Product - Data Description



Download: AERONET Direct Sun Data

More AERONET Downloadable Products...

AERONET Data - Inversions (V1)

Current Site: COVE

2004 JUL 20

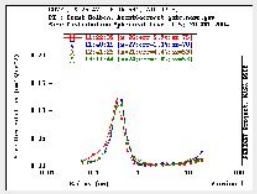
Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

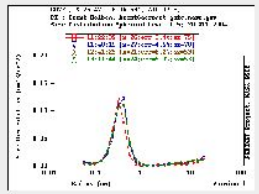
AERONET-Inversion Data Controls:

Level:

AERONET - Almucantar Inversion - Spherical Model



AERONET - Almucantar Inversion - Spheroid Model



Data Product:

- Size Distribution
- Refractive Index (Real)
- Refractive Index (Imaginary)
- Absorption Optical Depth

More AERONET Downloadable Products...

More AERONET Downloadable Products...

AERONET Data - Aerosol Modes

Current Site: **COVE**

2004 | JUL | 20

Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

AERONET-AOT Mode Data Controls:

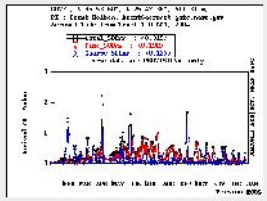
Level: 1.0

Data Format: All Points

Data Product: AOD Modes

Error Bars: Off

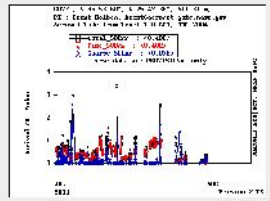
AERONET AOD Modes - Yearly Product



Download: AERONET-AOT Mode Data

More AERONET Downloadable Products...

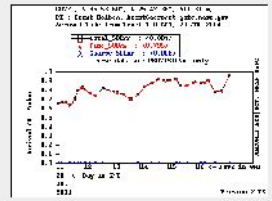
AERONET AOD Modes - Monthly Product



Download: AERONET-AOT Mode Data

More AERONET Downloadable Products...

AERONET AOD Modes - Daily Product



Download: AERONET-AOT Mode Data

More AERONET Downloadable Products...

SolRad-Net Data

No data available for COVE

Flux Yearly Product - Data Description

No Data Available

Flux Monthly Product - Data Description

No Data Available

Flux Daily Product - Data Description

No Data Available

MODIS Rapid Response/LandSat

Current Site: **COVE**

2004 | JUL | 20

Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

AQUA-MODIS True Color

Zoom image centered on COVE:
2000m | 1000m | 500m | 250m

AQUA-MODIS Granule Overpass Times:
1855, 1900, 1720, 1855 UTC

Download World Files (GIS)
2000m | 1000m | 500m | 250m

TERRA-MODIS True Color

Zoom image centered on COVE:
2000m | 1000m | 500m | 250m

TERRA-MODIS Granule Overpass Times:
1540, 1545 UTC

Download World Files (GIS)
2000m | 1000m | 500m | 250m

LandSat

No Image

MODIS-Land Data

TERRA MODLAND 8-Day Surface Reflectance
Starting 19 JUL 2004 Download Version 004

AQUA MODLAND 8-Day Surface Reflectance
Starting 19 JUL 2004 Download Version 004

Back Trajectory Analyses

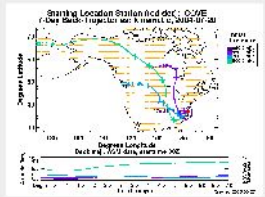
Current Site: **COVE**

2004 | JUL | 20

Available days for JUL 2004

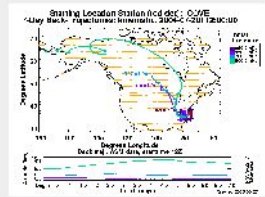
1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

00 UTC (950-500hPa)



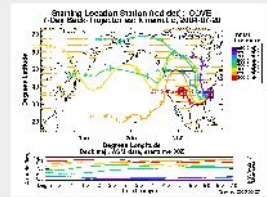
Download

12 UTC (950-500hPa)



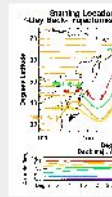
Download

00 UTC (950-200hPa)



Download

12 UTC



MPLNET

Current Site: **COVE**

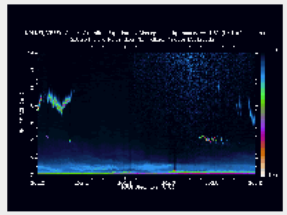
2004 | JUL | 20

Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

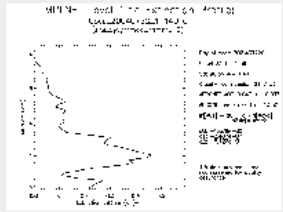
MPLNET PI: **Ken_Rutledge**
c.k.rutledge@larc.nasa.gov
MPLNET Contact: **Tim_Berkoff**
Timothy.A.Berkoff.1@gsfc.nasa.gov

Level 1 - Data Description



Download: **Level 1**

Level 1.5a - Data Description



Download: **Level 1.5a**

Level 1.5a Images for Level 1.5 AOT

11:13:31 **GMT**

GOCART 3-Hourly AOT

Current Site: **COVE**

2004 | JUL | 20

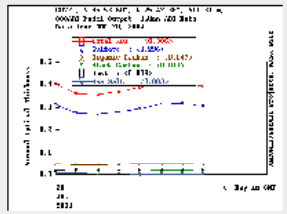
Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

GOCART Data Charts:

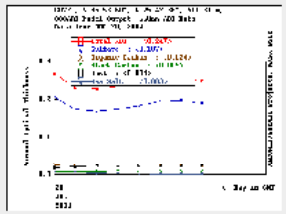
- Daily Average
- 3-Hour Daily
- 3-Hour Monthly
- 3-Hour Yearly

350nm Extinction - Data Description



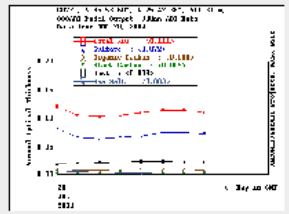
Download Data: **AOT**

550nm Extinction - Data Description



Download Data: **AOT**

900nm Extinction - Data Description



Download Data: **AOT**

GIOVANNI MOVAS Monthly Data

Current Site: **COVE**

2004 | JUL | 20

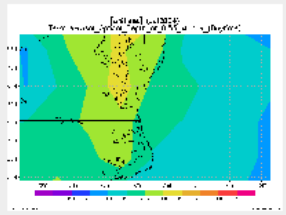
Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

Data Controls:

- Aerosol Optical Depth at 0.55um (Daytime)
- Aerosol Fine Mode Fraction (Daytime)
- Fine Mode Aerosol Optical Depth (Ocean/Daytime)
- Cirrus Fraction NIR Method (Daytime)

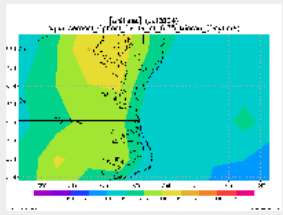
TERRA-MODIS Monthly Product - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

AQUA-MODIS Monthly Product - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

GIOVANNI MOVAS Daily Data

Current Site: **COVE**

2004 | JUL | 20

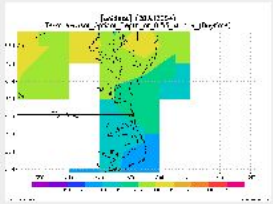
Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

Data Controls:

- Aerosol Optical Depth at 0.55um (Daytime)
- Aerosol Fine Mode Fraction (Daytime)
- Fine Mode Aerosol Optical Depth (Ocean/Daytime)
- Cirrus Fraction NIR Method (Daytime)

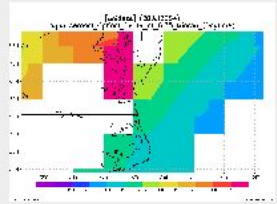
TERRA-MODIS Daily Product - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

AQUA-MODIS Daily Product - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

GIOVANNI Ozone Data

Current Site: **COVE**

2004 | JUL | 20

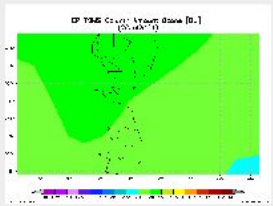
Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

Data Controls:

- Column Amount Ozone
- UV Aerosol Index
- Effective Surface Reflectivity

TOMS Ozone Daily Product (1.0°x1.25°) - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

OMI Ozone Daily Product (0.25°x0.25°) - Data Description

No Data Available

These data are available from 17 AUG 2004 to 15 AUG 2006

GIOVANNI Ocean Data

Current Site: **COVE**

2004 | JUL | 20

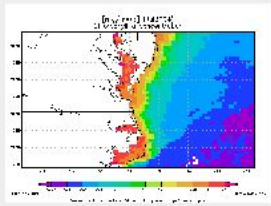
Available days for JUL 2004

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31				

Data Controls:

- Chlorophyll-a Concentration
- Normalized Water-Leaving Radiance
- Aerosol Optical Thickness
- Angstrom Coefficient

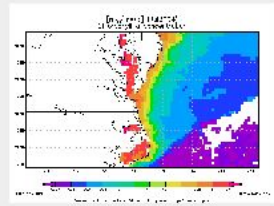
SEAWIFS Ocean Monthly Product - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

AQUA-MODIS Ocean Monthly Product - Data Description



Pixel | 1°X2° | 2°X4° | 4°X8° | 8°X16° | 32°X64° | Global Map

Download Data:
Pixel 1°X2° 2°X4° 4°X8° 8°X16° 32°X64° Global Map

AERONET-Ocean Color Data

No data available for COVE

Normalized Water-leaving Radiance Yearly Product - Data Description

No Data Available

Normalized Water-leaving Radiance Monthly Product - Data Description

No Data Available

Normalized Water-leaving Radiance Daily Product - Data Description

No Data Available

AERONET Makeover Summary

- ~200 permanent sites and counting
- V. 2 corrections incorporate modeled and satellite data
- AOD improvements due to NCEP air pressure & improved algorithms. NO_2??
- Inversion improvements from dynamic sfc. refl. inputs and bi-component inversion

AERONET Makeover Summary

- Fine mode spherical:
  - Improved sfc. refl. altered size dist $C_v \downarrow\uparrow$ and $r_v \uparrow$
  - SSA-Little change
  - Real imaginary index of refraction is spectrally neutral
- Marine:
  - All level 2 parameters almost no change
  - Increase in number of acceptable retrievals by ~10%

AERONET Makeover Summary

- Mineral Dust (coarse mode)
  - Significant surface reflectance effect
  - Fine mode artifacts removed (accumulation mode tail removed)
  - Blue channel real index of refraction artifact is removed
  - More absorption in blue channels (0.03-0.05)
- Synergy Tool allows daily comparisons between various aerosol products/related data sets