RSS history and current status

Peter Kiedron
ASRC/SUNY at Albany
14 March, 2005

RSS at ARM

RSS's 103, 104, 105: 2003 Billings, OK

Data Availability			
	RSS105	**RSS103**	**RSS102**
Location	SGP	SGP	SGP
Operational epochs	05/09/03 - Present	09/29/01-06/27/02 08/12/97–10/05/98	07/22/99–08/04/00
Measurement period	From sunrise to sunset		
Measurement rate	1 shadowbanding cycle per min		
Number of spectra per day	From 570 spectra in Winter to 870 spectra in Summer		

RSS102: 2001 Billings, OK

RSS103: 1999 Barrow, AK

Principal Measured Quantity

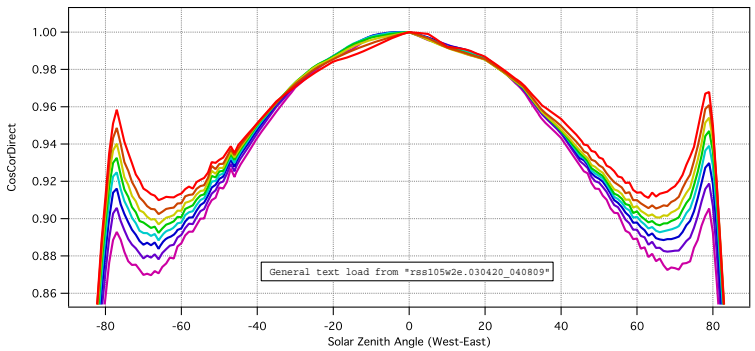
RSS103, UV-RSS104, RSS105 (from left to right)
Aerosol IOP at SGP. May 2003.

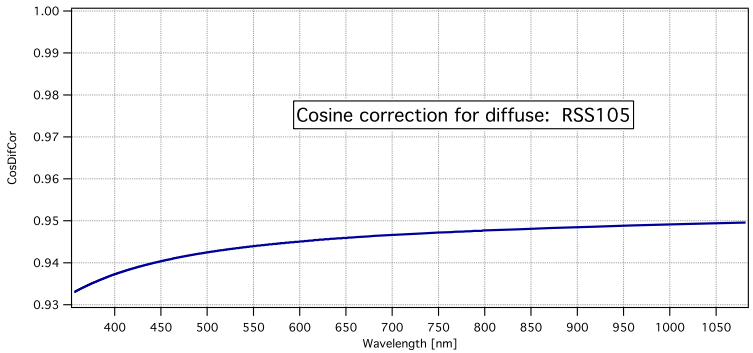
Shadowbanding Geometry			
	RSS105	RSS103	RSS102
Diffuser aperture	0.25″		
Shadowband witdth	8.1°		
Shadowband radius	3.50″		
Shadowband length	135°		
Shadowband position at corrections	±9°		
Shadowband axis angle	45°	Parallel with Earth axis	Parallel with Earth axis
Shadowband center on diffuser	yes		

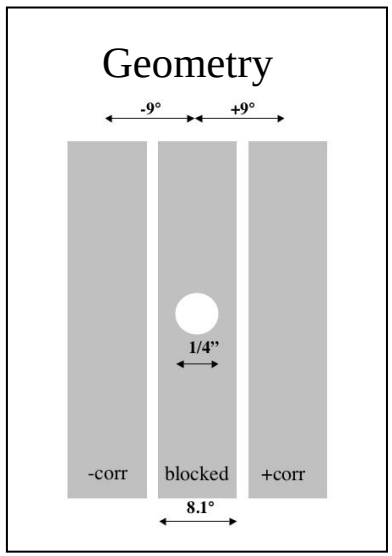
$$I_{Diffuse} = [Unblocked - \tfrac{1}{2}(Cor^{+} + Cor^{-}) + Blocked] / A_{Diff}$$

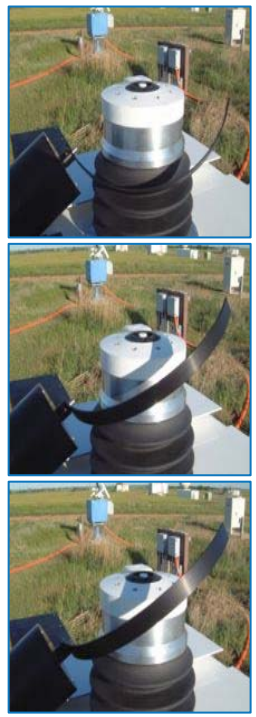
$$I_{Direct} = [\tfrac{1}{2}(Cor^{+} + Cor^{-}) - Blocked] / A_{Dir}(\alpha, \zeta)$$

$$I_{Total} = I_{Diffuse} + I_{Direct}$$



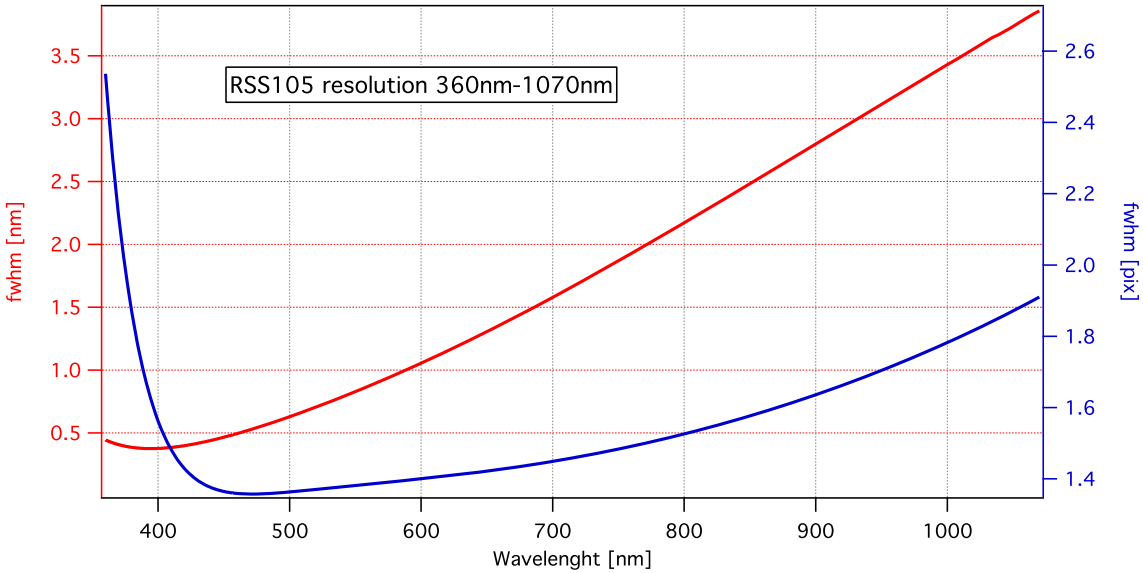


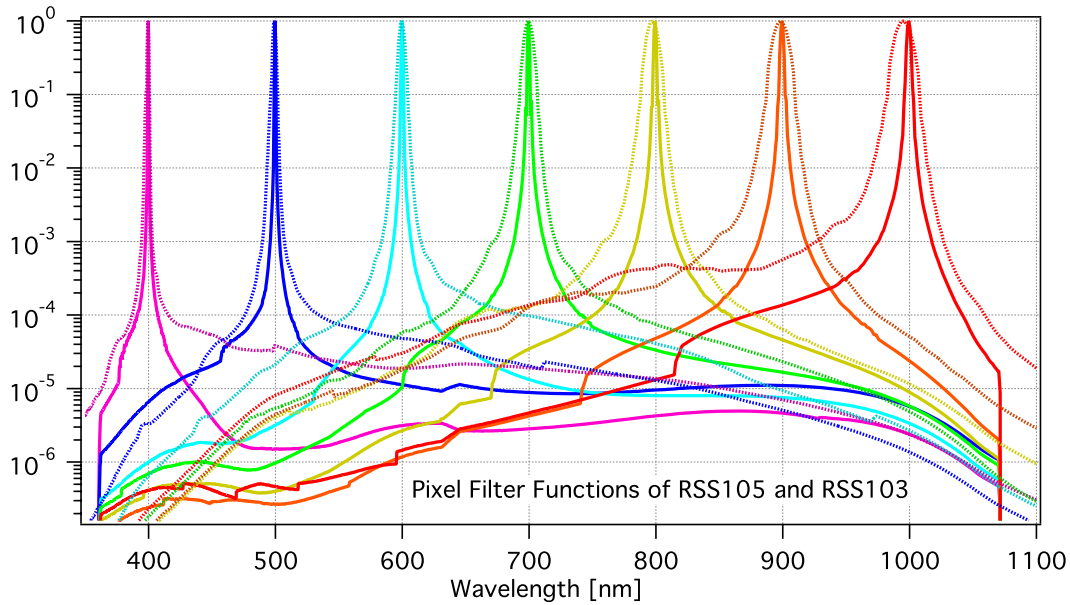




Spectral Characteristics			
	RSS105	**RSS103**	**RSS102**
Number of pixels	1024	512	1024
Nominal Spectral Range (NSR)[nm]	360-1050	360-1050	360-1050
Number of Pixels within NSR	1001	442	988
Resolution (FWHM) [nm]/[pixels]			
@400nm	0.37/1.56	1.24/2.32	0.37/1.52
@500nm	0.62/1.36	2.57/2.47	1.14/2.44
@600nm	1.05/1.40	4.84/2.81	1.77/2.32
@700nm	1.57/1.44	7.80/3.12	2.21/2.00
@800nm	2.16/1.52	11.02/3.37	2.53/1.75
@900nm	2.79/1.63	14.32/3.61	2.81/1.62
@1000nm	3.42/1.78	17.11/3.83	3.10/1.58
Filter functions			
95% below maximum	Gaussian	Gaussian	Gaussian
Gaussian parameter from	rss105_GaussWidth	rss103_GaussWidth	rrs102_GaussWidth
Below 95% is defined by following files	rss105_ff_respEQ1 rss105_respQM rss105_RespW	rss103_ff_respEQ1 rss103_RespQM rss103_RespW	rss102_ff_respEQ1 rss102_RespQM rss102_RespW

Resolution and Stray Light

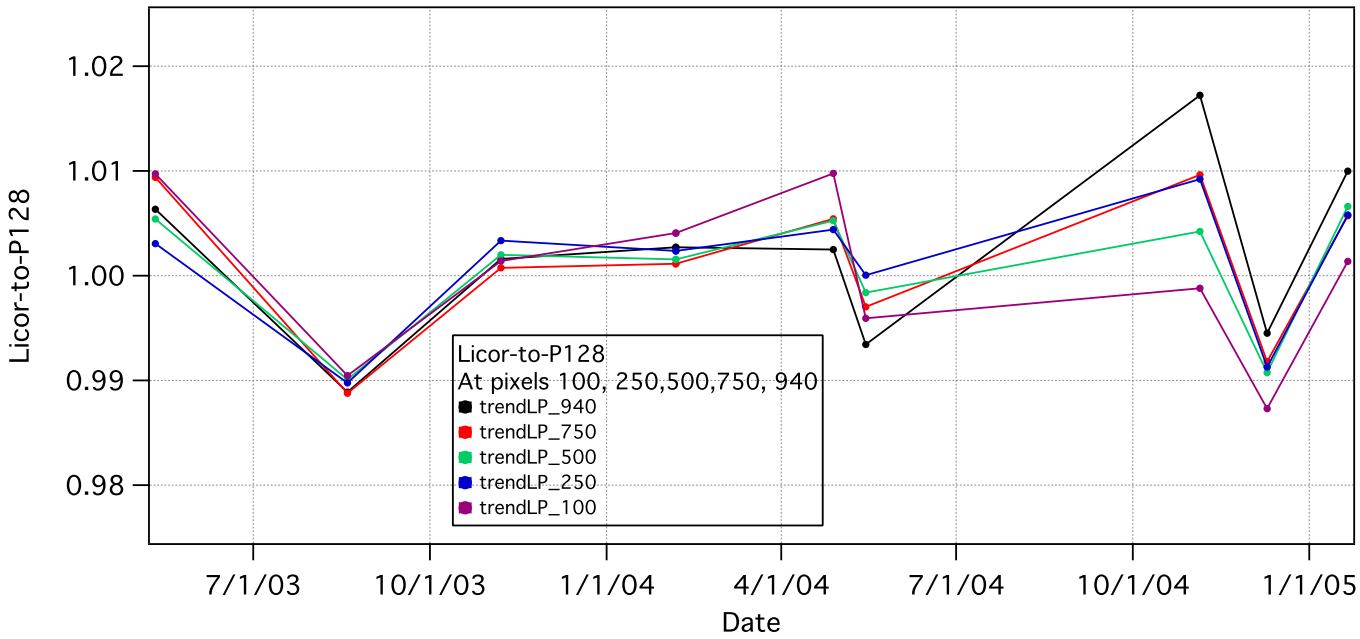




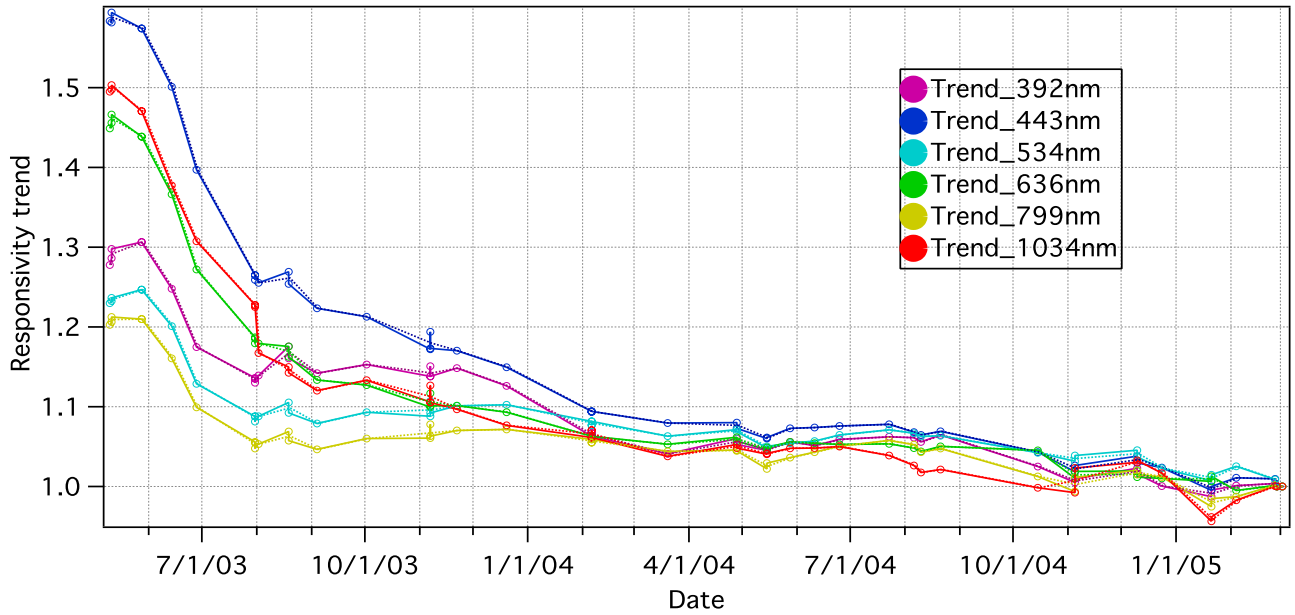
RSS105 Performance

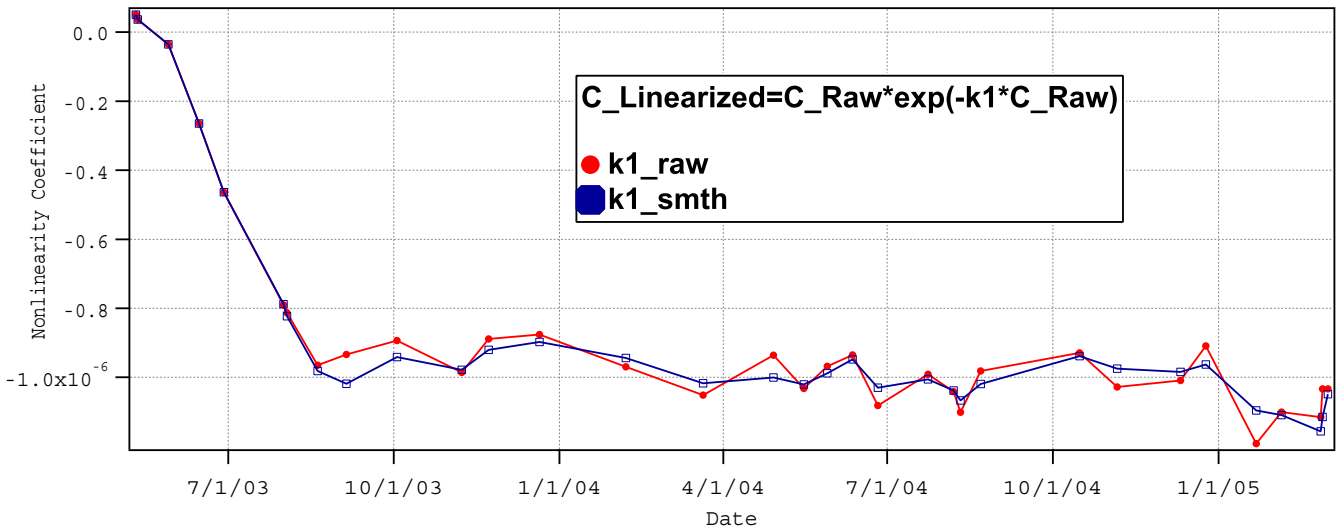
Calibration Schedule

Portable Calibrator: 2/month
Licor Calibrator: 1/month
Oriel Spectral Lamp: 1/month

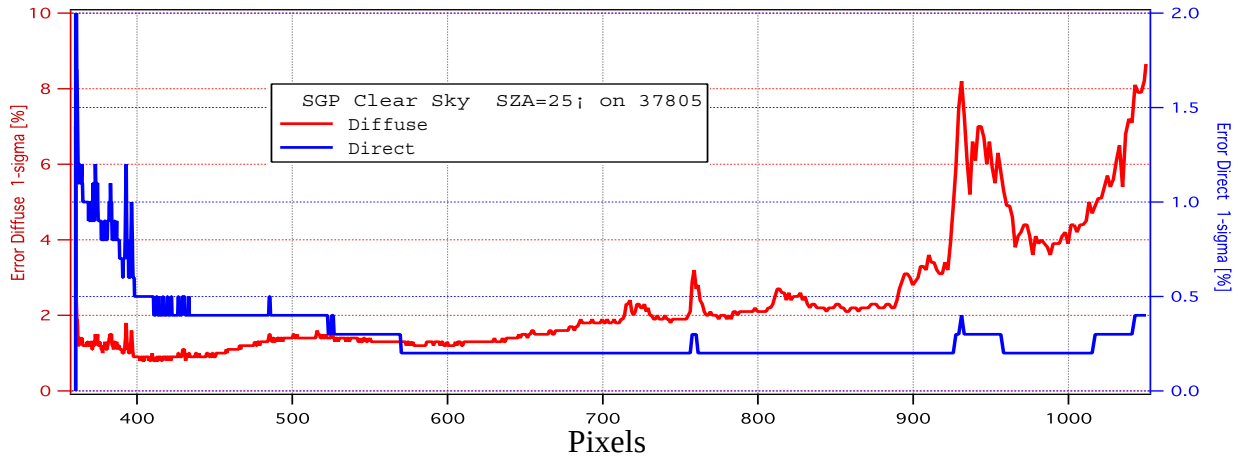


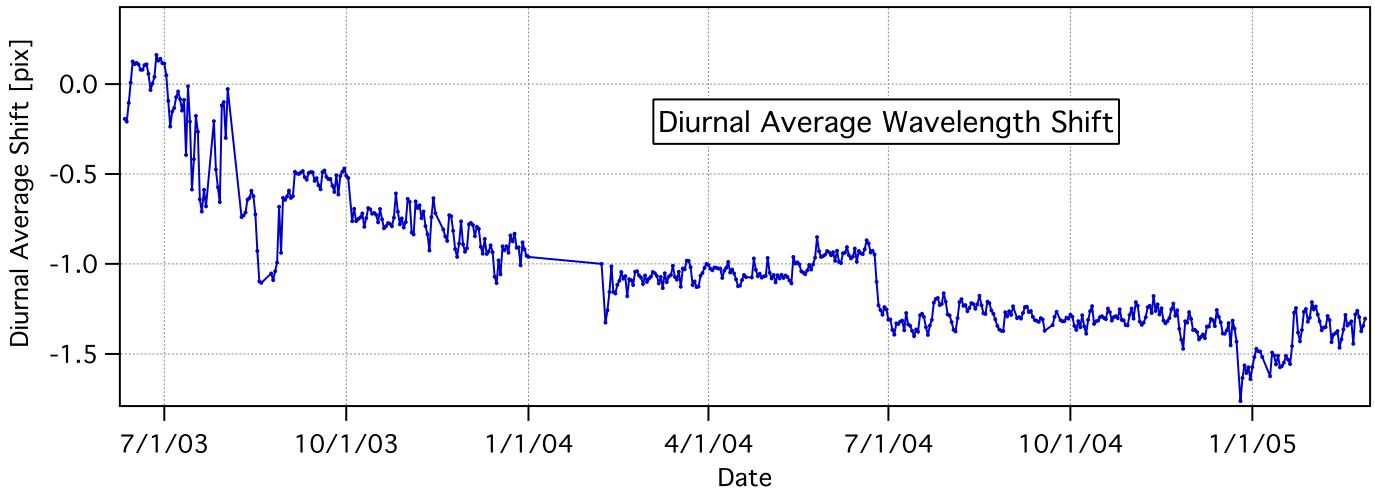
RSS105 Performance





RSS105 Performance





Corrections and Data Quality Control

✓Calibration data analysis: nonlinearity, offset, dark vs. exposure, responsivity drift

✓Wavelength shift: scan-to-scan correction

✓Nonlinearity compensation: interpolated between calibration events

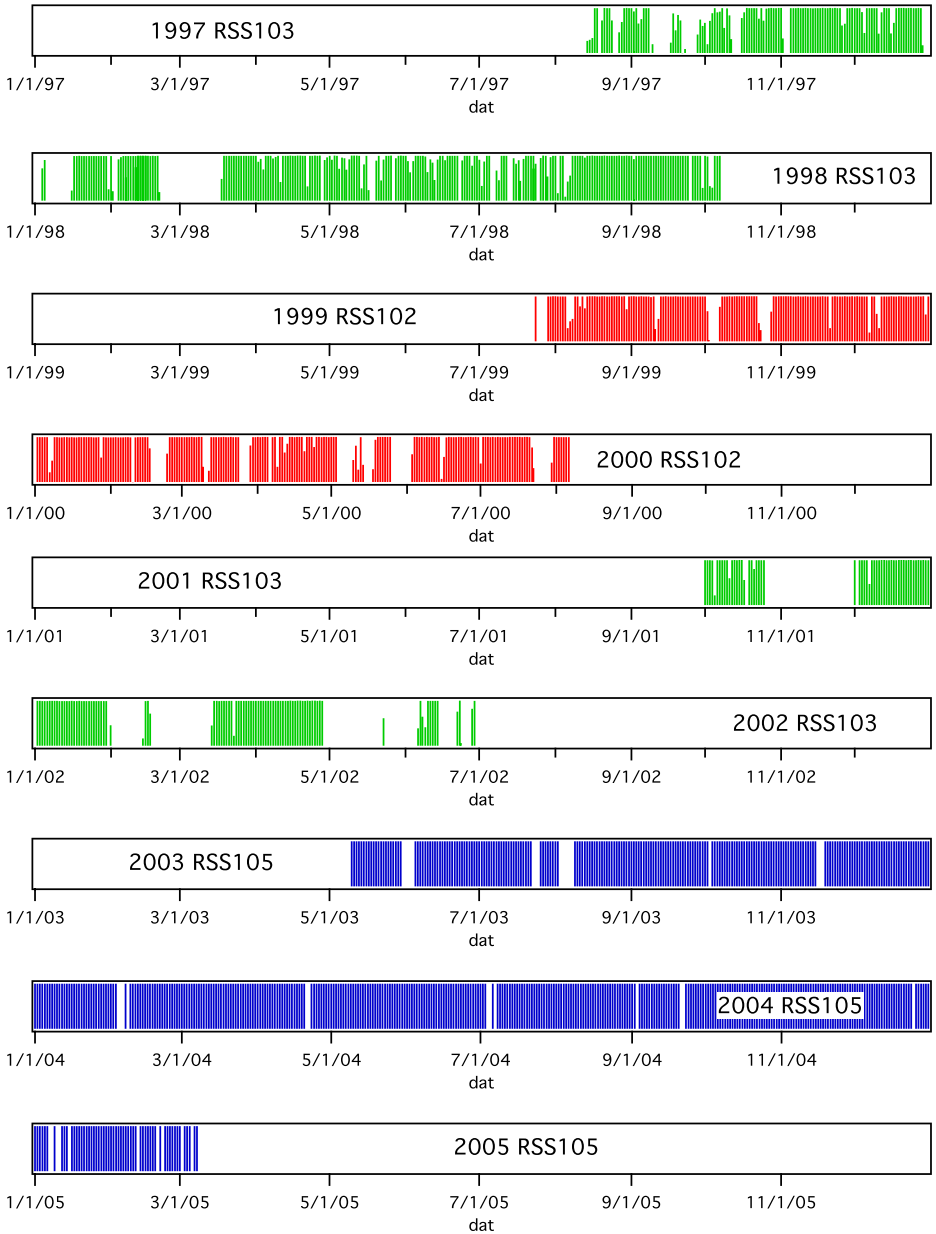
✓Automatic responsivity correction: interpolated between calibration events

➢Comparison with MFRSR channels: verification (poms)

➢Langley regression responsivity drift: Forgan method

➢Automatic calibration data analysis

Data Availability



ARM IOP Server
cialella@bnl.gov

ARM Archives
sutanay.choudhury@pnl.gov

RSS105 QC Reports: http://oink.asrc.cestm.albany.edu/~rss/RSS105/qc/

What can we get from RSS data?

Peter Kiedron
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Value Added Products

Primary measured quantities: direct, diffuse, total horizontal spectral irradiances in 360nm-1050nm range, one per minute

Irradiance

Langley regression: calibration correction and daily (0, 1 or 2 per day) optical depth (OD).

Instantaneous optical depth (OD): τ = ln[Direct/Extraterrestrial] (once every minute).

Ozone column (O_3): from Chappuis ozone absorption band (440-760nm).

Water vapor column (H_2O): from 820nm and/or 940nm absorption bands.

Nitrogen dioxide (NO_2): from absorption maximum in 415nm region or correlation method

Aerosol optical depth (AOD): Angstrom coefficients from multi- wavelength fit to IOD (with NO_2 correction).

Aerosol effective radius: paper by Scott Gianelli

Oxygen A-band

Diffuse effective airmass: from O2 A-band (760nm).

Photon path-length: first and second(?) moments from O2 A-band (760nm).

All sky conditions retrievals: H_2O, O_3 and NO_2 using diffuse effective airmass.

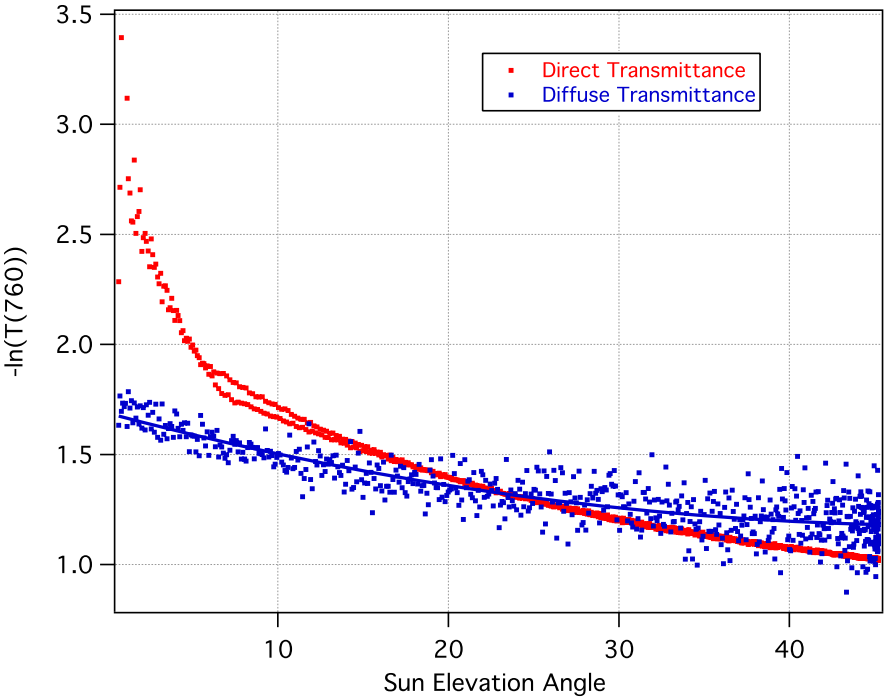
Subvisual cirrus detection: papers by Qilong Min

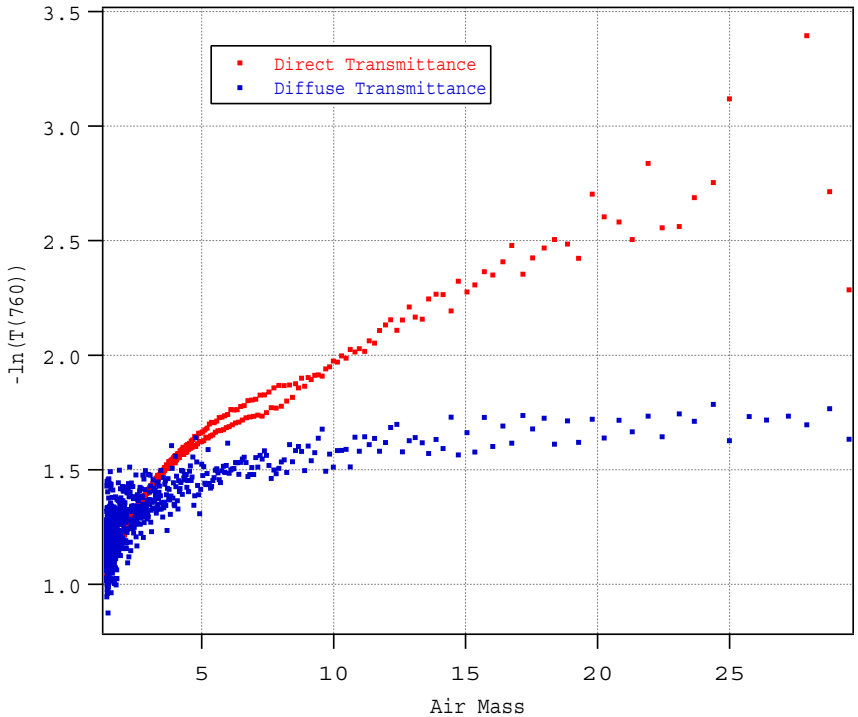
Direct-to-diffuse

Single scattering albedo (SSA): from direct-to-diffuse ratio (B. Herman et al. *J. Atm. Sci.,* 32, 918-925 (1975))

Surface albedo (SA): from direct-to-diffuse ratio.

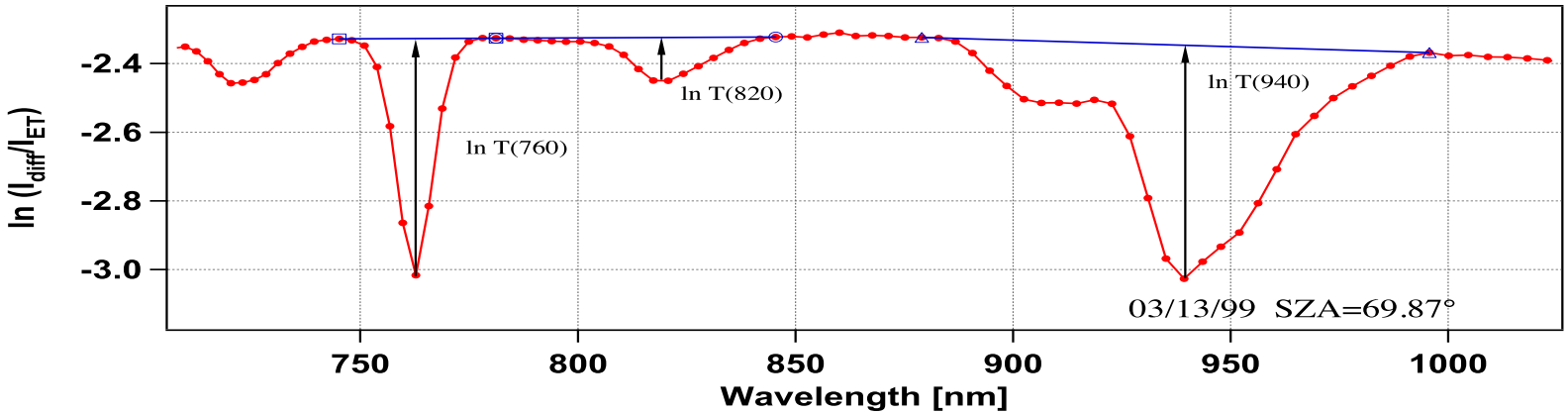
Equivalent diffuse air mass - photon path length

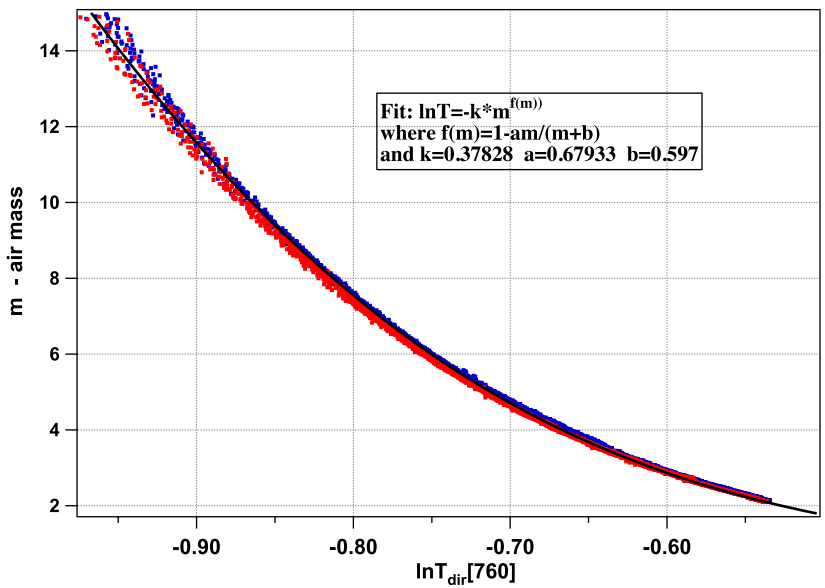


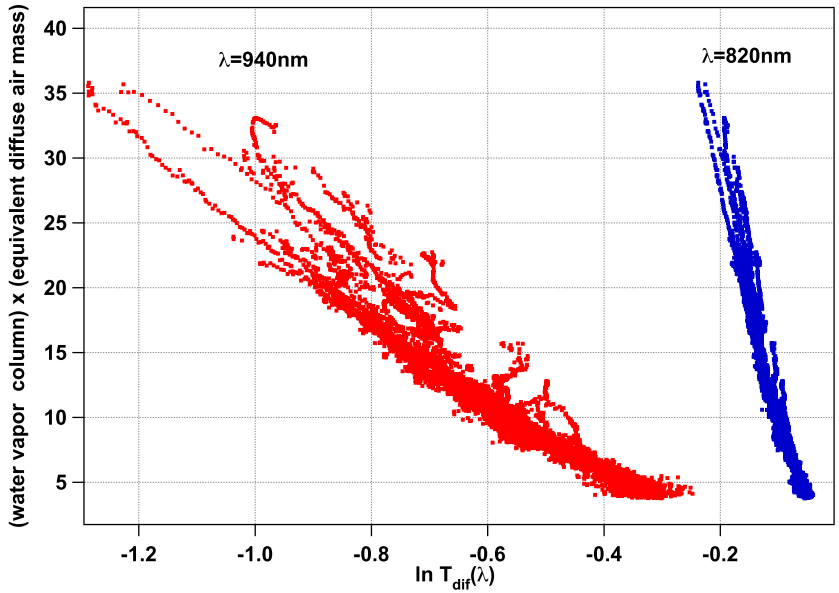


Q. Min et al., *J. Geophys. Res.*, 109, D02202, (2004)
Q. Min and L. Harrison, *Geophys. Res. Lett.*, 26, 1425-1428, (1999)

Equivalent diffuse air mass







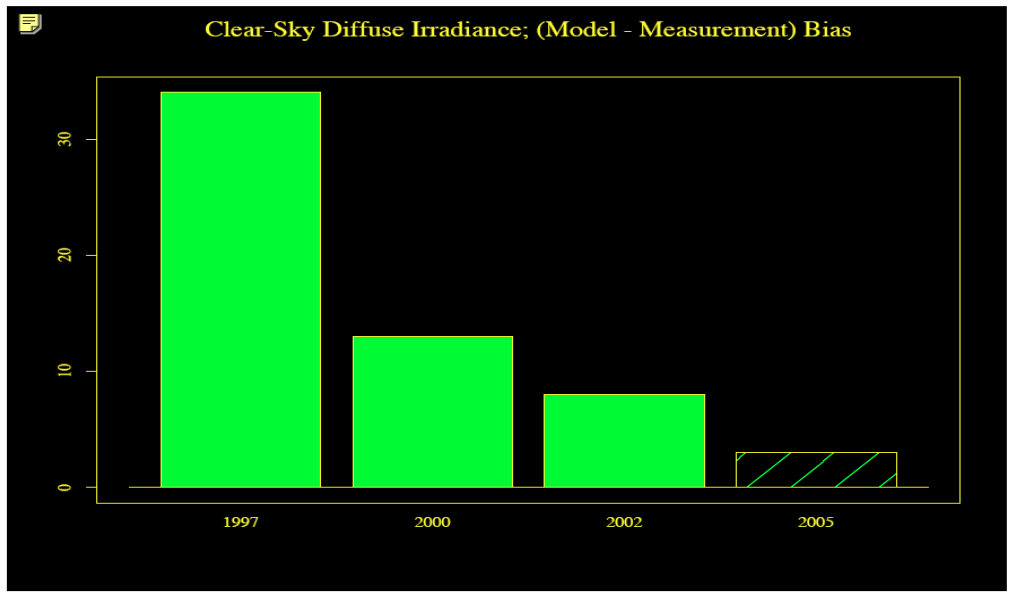
P. Kiedron et al. *Geophys. Res. Lett.* Vol. 30, No. 11, 1565, (2003)

Clear-sky diffuse discrepancy

Table 1. Bias (Model-Obs) and Aerosol Forcing in Wm^{-2} at SGP during 2000.

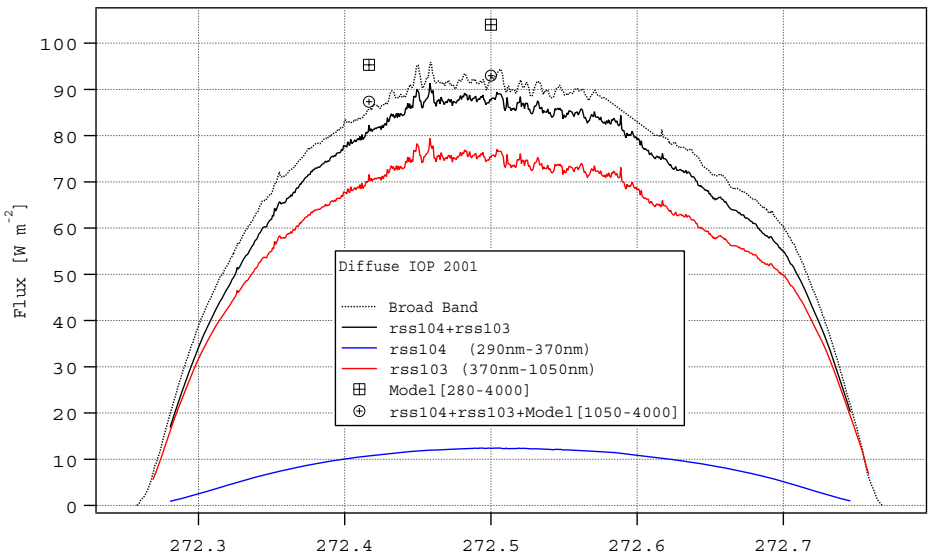
	Model-Obs		Sample N	Aerosol Forcing
	E13	C01		
Surface				
Direct Normal	-4.1	-10.0	500	-131.3
Diffuse	6.7	5.2	500	58.6
Total	3.3	-2.1	500	-27.5
Direct horizontal = (dir norm)*cosSZA	-3.4	-7.3	500	-86.1
TOA reflected	13.2	27.0	44	←This N is tiny!

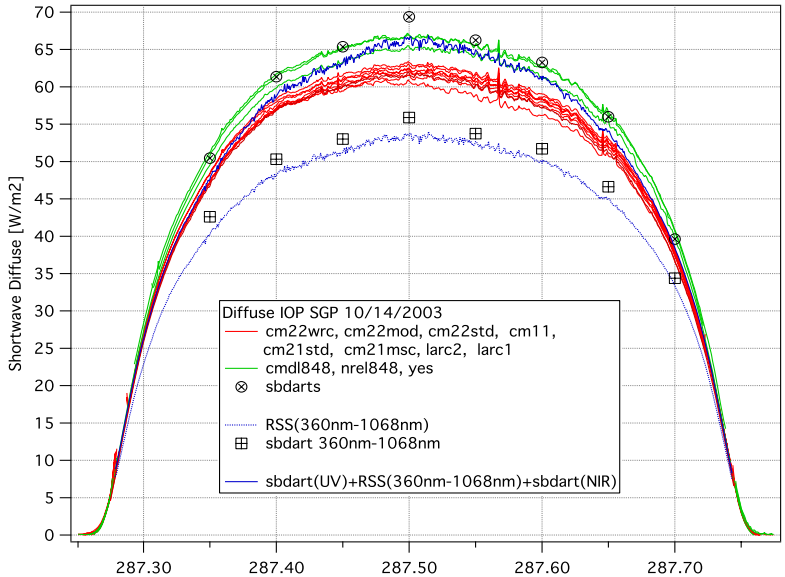
- Measurement errors
- Model inputs
- Model



J. Michalsky et al. *J. Geophys. Res.,* 108(D8), 4254, (2003)
T. Charlock, et al., *ARM Scientce Team Meeting* (2001)
S. Kato et al. *J. Geophys. Res.,* 102, 25, 881-25898 (1997)

Diffuse IOP 2001 and 2003





RSS and line-by-line model LBLRTM

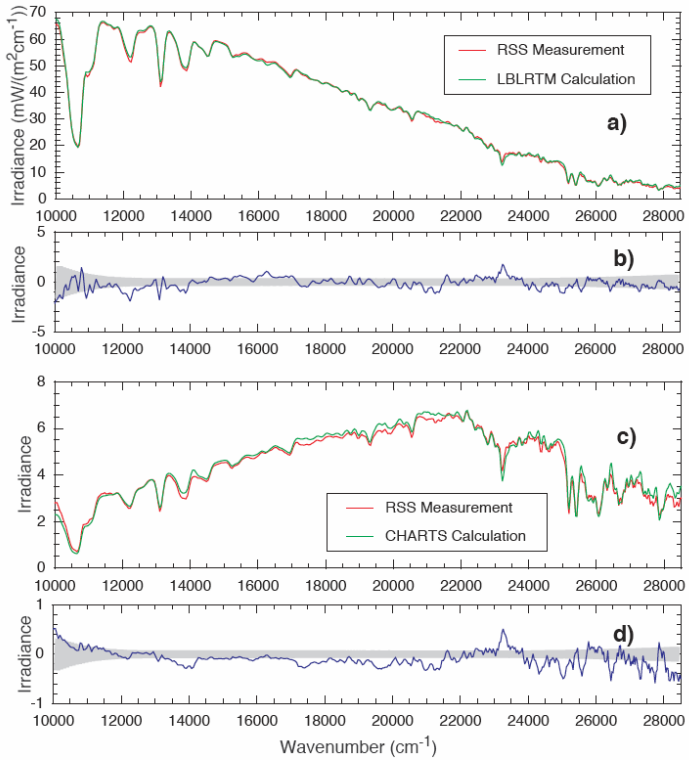


Figure 1. October 2, 1997 case [1.3 airmasses; 2.7 cm vertical PWV]: a) direct-beam spectral irradiances; b) direct-beam differences (RSS-LBLRTM); c) diffuse spectral irradiances; d) diffuse differences (RSS-CHARTS).

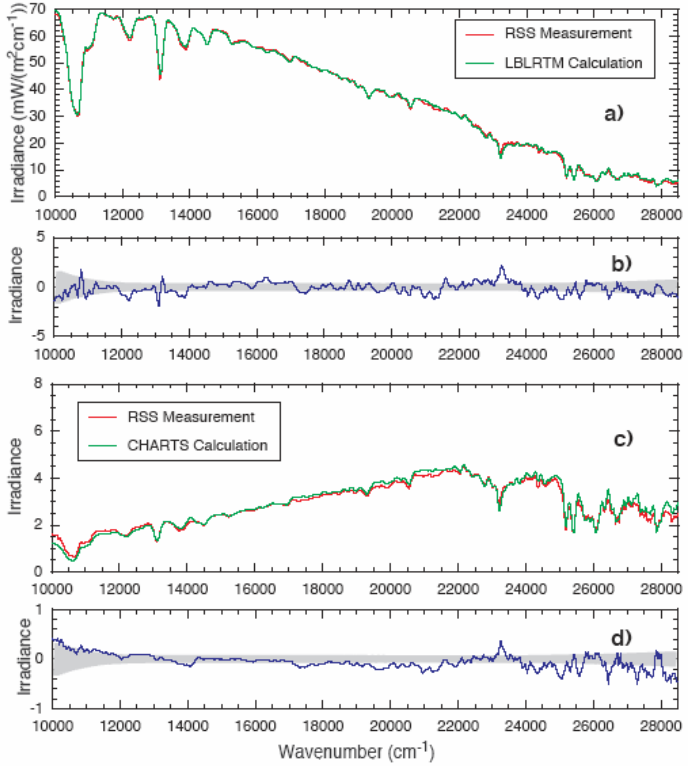


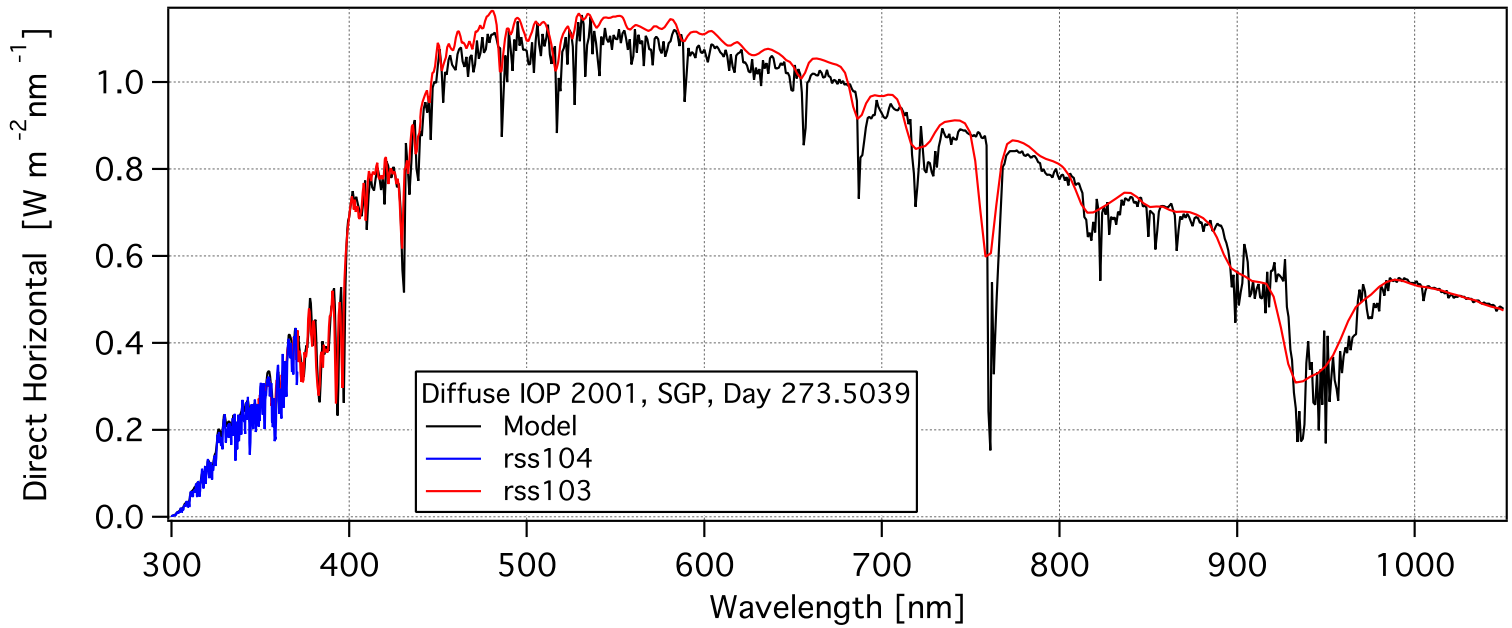
Figure 3. September 29, 1997 case [1.3 airmasses; 1.4 cm vertical PWV]: a) direct-beam spectral irradiances; b) direct-beam differences (RSS-LBLRTM); c) diffuse spectral irradiances; d) diffuse differences (RSS-CHARTS).

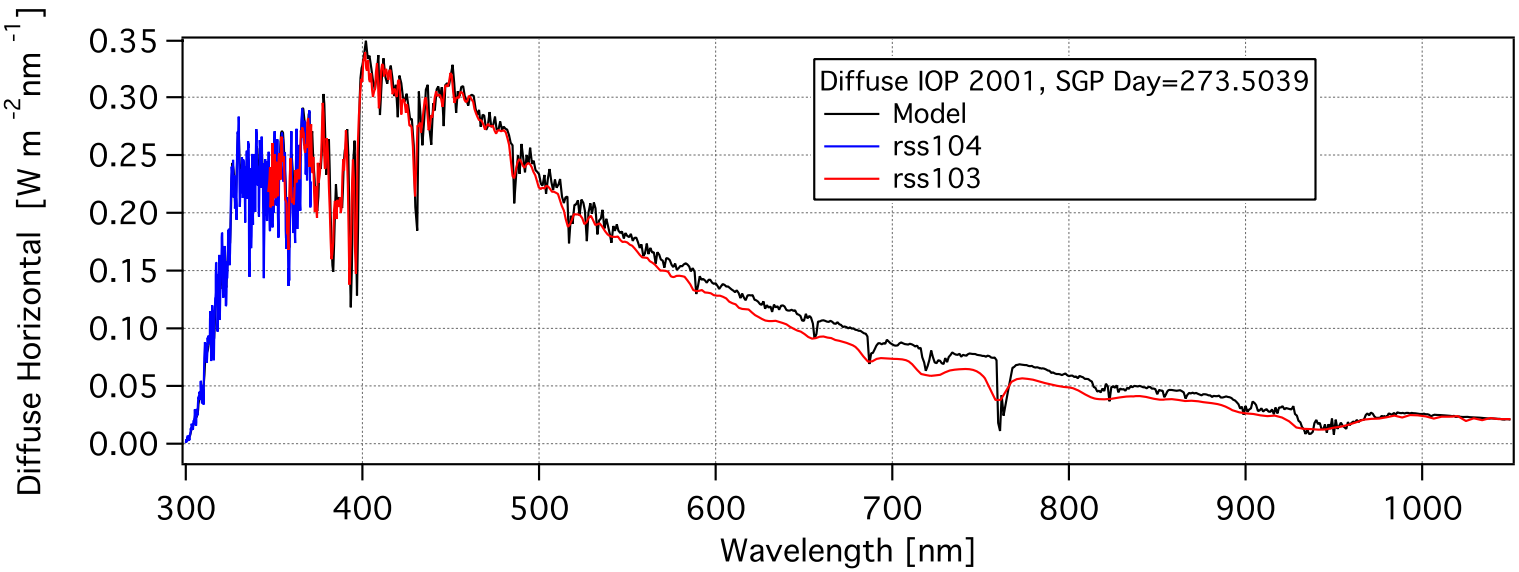
Case	Time	Solar Zenith Angle	Precipitable Water Vapor, cm: Vertical	Precipitable Water Vapor, cm: Path	Direct-normal Irradiance, W/m²: RSS(u)	Direct-normal Irradiance, W/m²: LBLRTM(u)	Direct-normal Irradiance, W/m²: Residuals(u)	Diffuse Irradiance, W/m²: RSS(u)	Diffuse Irradiance, W/m²: CHARTS(u)	Diffuse Irradiance, W/m²: Residuals	Aerosol Properties Used in Calculations*: Optical Depth(u)*	Aerosol Properties Used in Calculations*: Angstrom Exponent(u)	Aerosol Properties Used in Calculations*: Single-scattering Albedo(u)
October 2, 1997	17:32 Z	41.8°	2.7	3.5	637.6(6.4)	640.2(1.8)	-2.6(6.6)	82.2(1.3)	83.8(1.5)	-1.6	0.084(11)	1.82(20)	0.85(05)
September 18, 1997	23:28 Z	77.7°	4.2	19.2	306.8(3.1)	308.9(0.7)	-2.2(3.2)	44.9(1.1)	46.4(0.6)	-1.5	0.375(10)	1.45(04)	0.85(02)
September 29, 1997	17:26 Z	41.2°	1.4	1.8	700.9(7.0)	702.9(0.6)	-2.0(7.0)	52.5(1.1)	53.6(0.4)	-1	0.036(10)	1.06(33)	0.60(10)

Irradiances correspond to spectral range 10000-28500 cm^{-1} (1.0-0.35 μm)
u - uncertainty in associated quantity
*evaluated at 14,286 cm^{-1} (0.7 μm)
†asymmetry parameter = 0.7

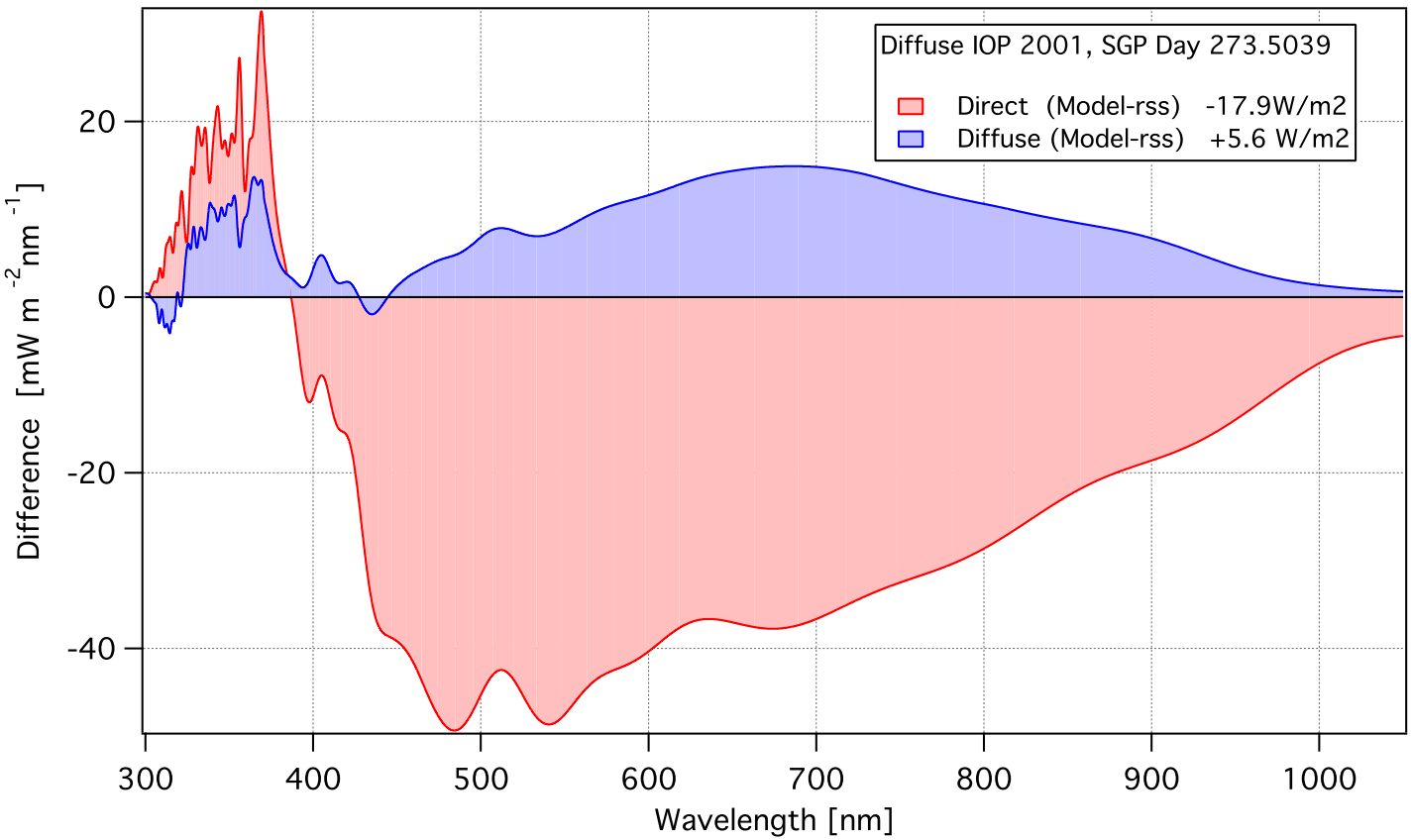
E. Mlaver et al., *Geophys. Res. Lett.*, 27, 2653-2656, (2000)

RSS - Model

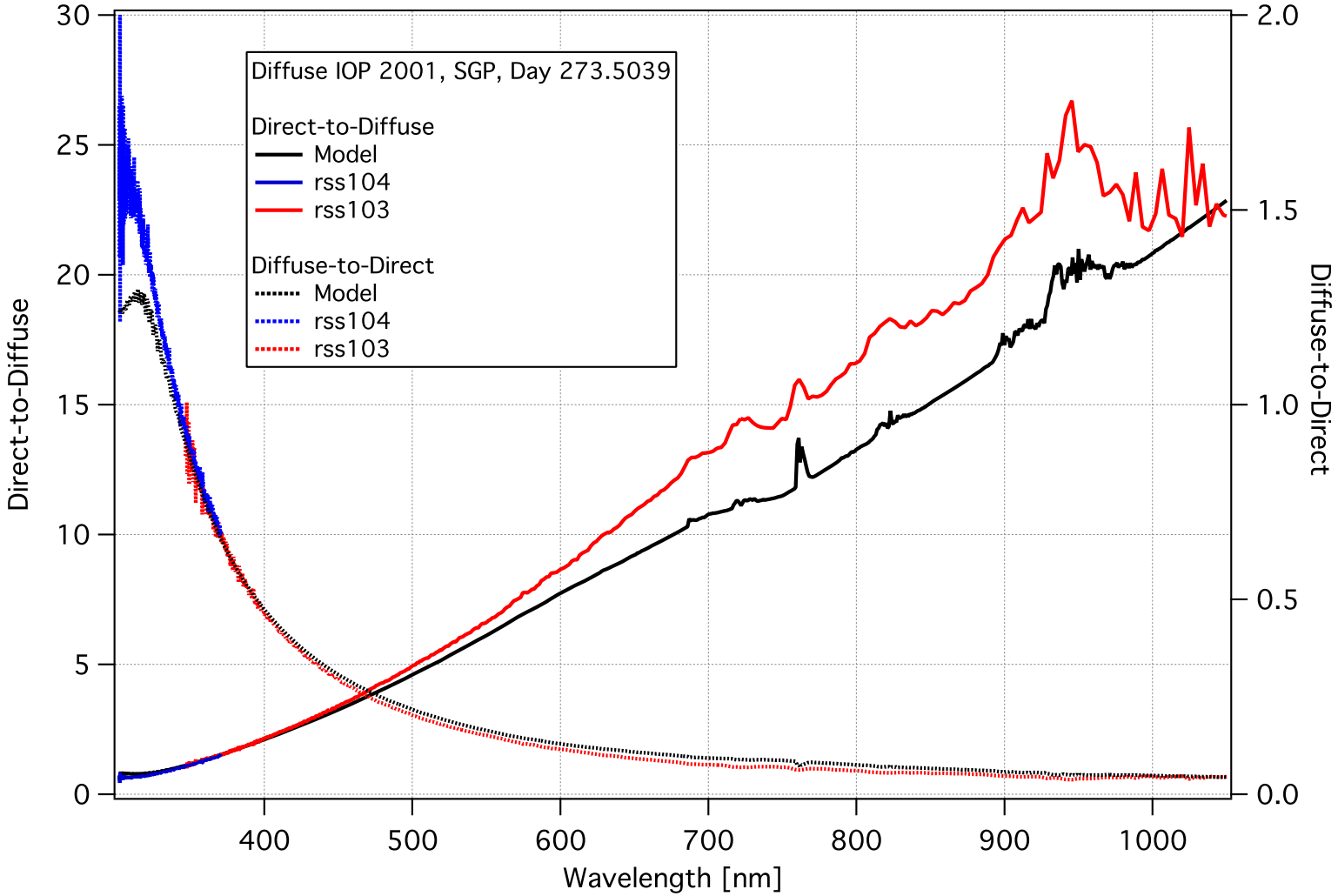

Direct Horizontal [W m -2 nm -1]
1.0
0.8
0.6
0.4
0.2
0.0
300
400
500
600
700
800
900
1000
Wavelength [nm]
Diffuse IOP 2001, SGP, Day 273.5039
Model
rss104
rss103


Diffuse Horizontal [W m -2 nm -1]
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
300
400
500
600
700
800
900
1000
Wavelength [nm]
Diffuse IOP 2001, SGP Day=273.5039
Model
rss104
rss103

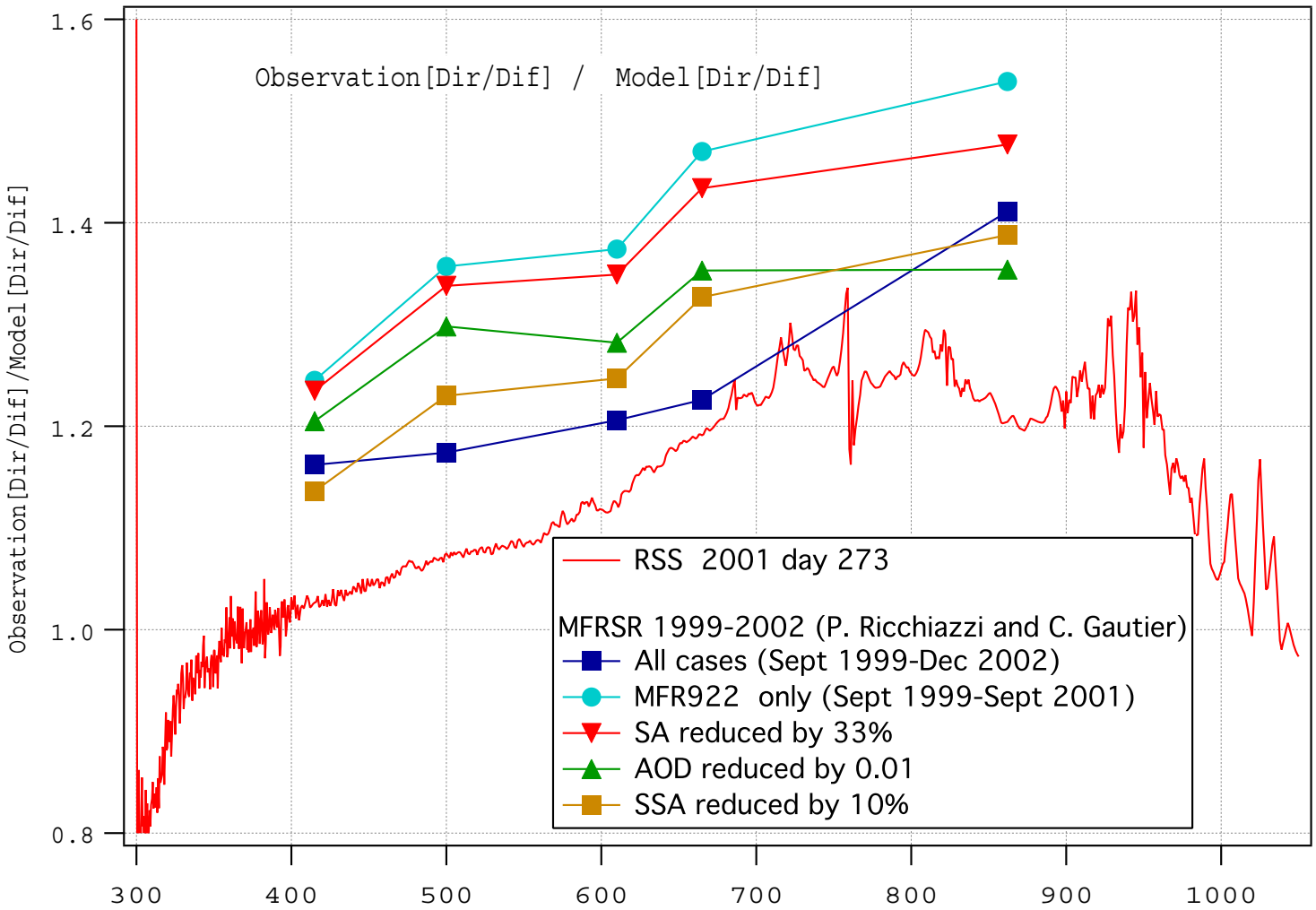
RSS - Model


Diffuse IOP 2001, SGP Day 273.5039
Direct (Model-rss) -17.9W/m2
Diffuse (Model-rss) +5.6 W/m2
Difference [mW m -2 nm -1]
20
0
-20
-40
300
400
500
600
700
800
900
1000
Wavelength [nm]

RSS - Model

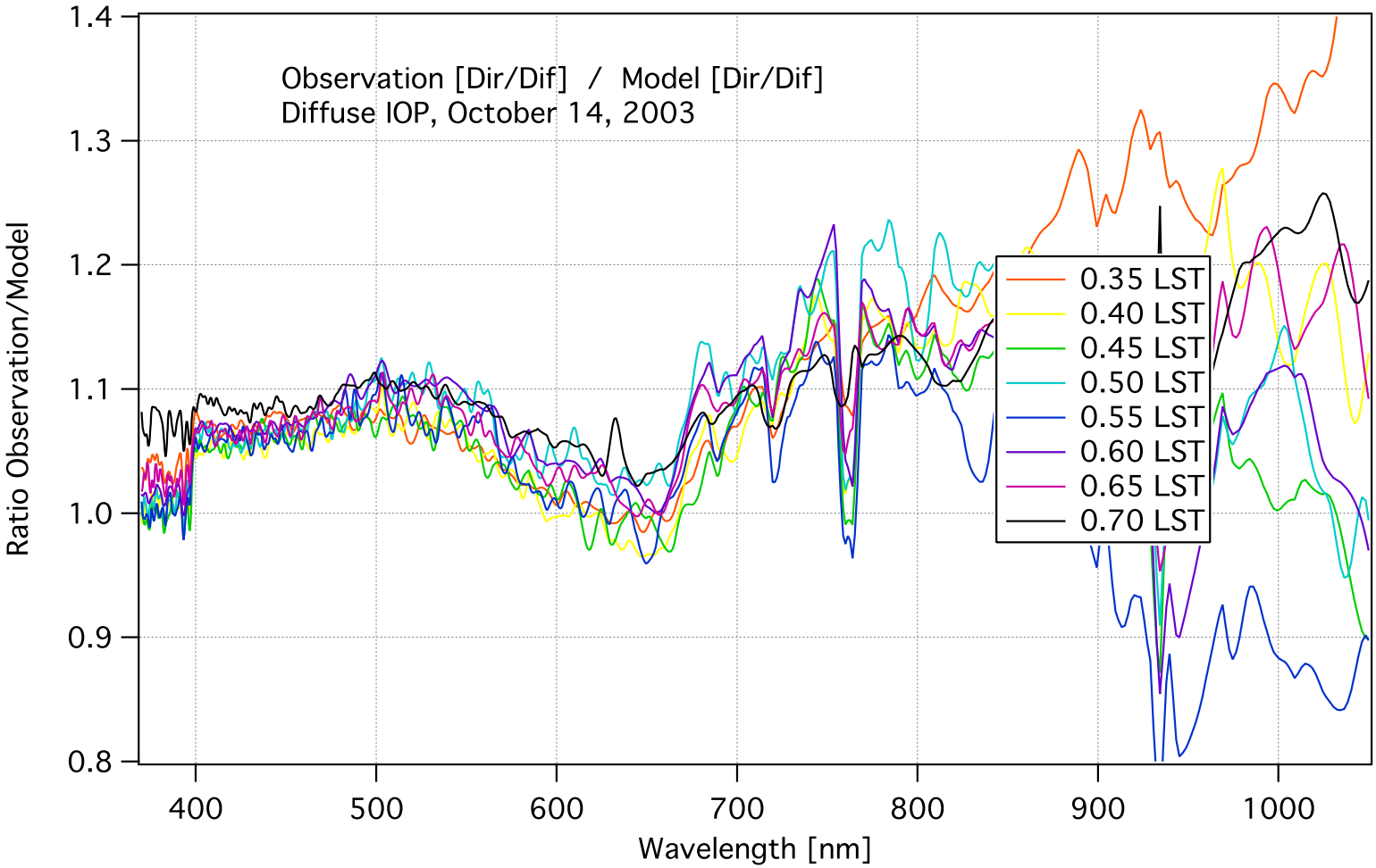

Diffuse IOP 2001, SGP, Day 273.5039
Direct-to-Diffuse
Model
rss104
rss103
Diffuse-to-Direct
Model
rss104
rss103
Direct-to-Diffuse
Diffuse-to-Direct
Wavelength [nm]
0
5
10
15
20
25
30
0.0
0.5
1.0
1.5
2.0
400
500
600
700
800
900
1000

MFRSR and RSS Direct-Diffuse Ratio

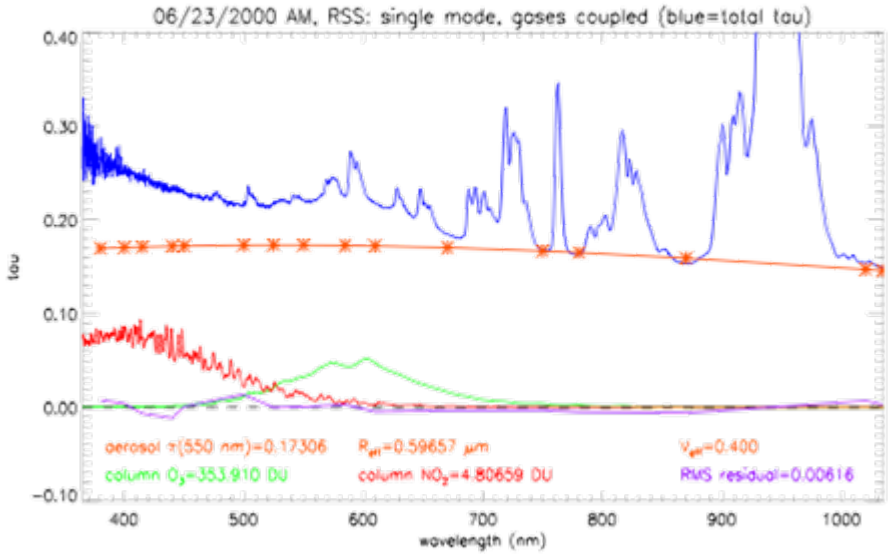


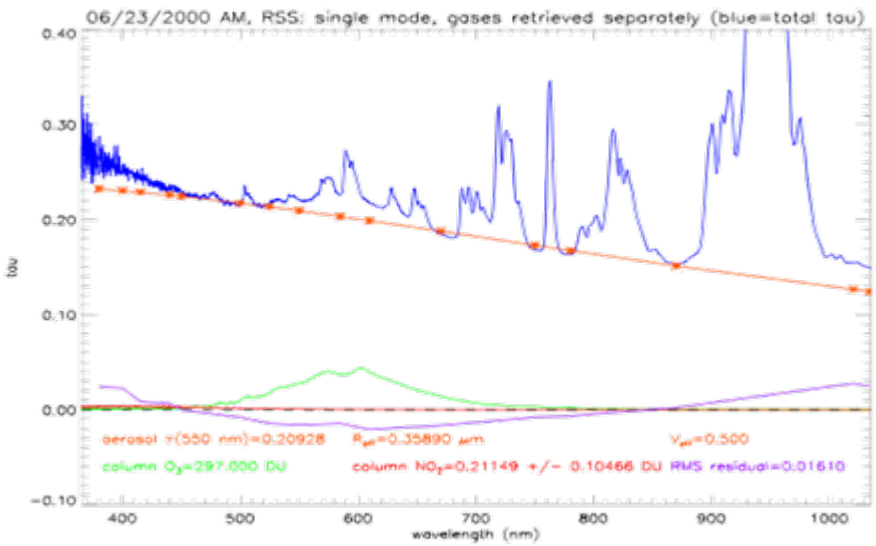
P. Ricchiazzi and C. Gautier, *ARM Science Team Meeting Proceedings*, Broomfield, Colorado, March 31-April 4, (2003)

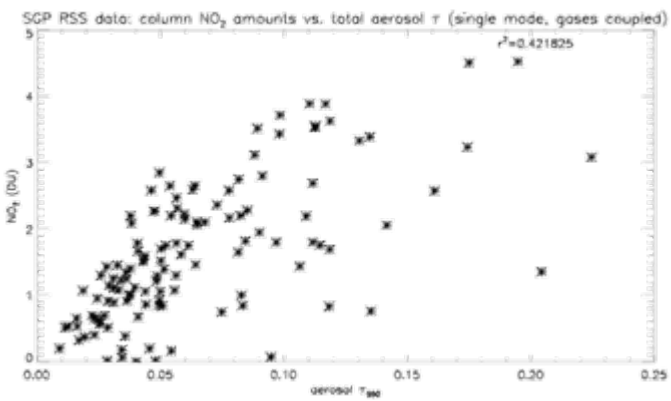
RSS Direct-Diffuse Ratio IOP 2003

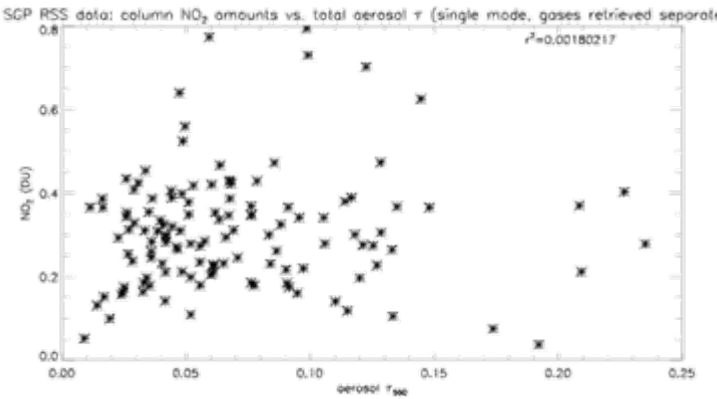


Aerosols and NO_2





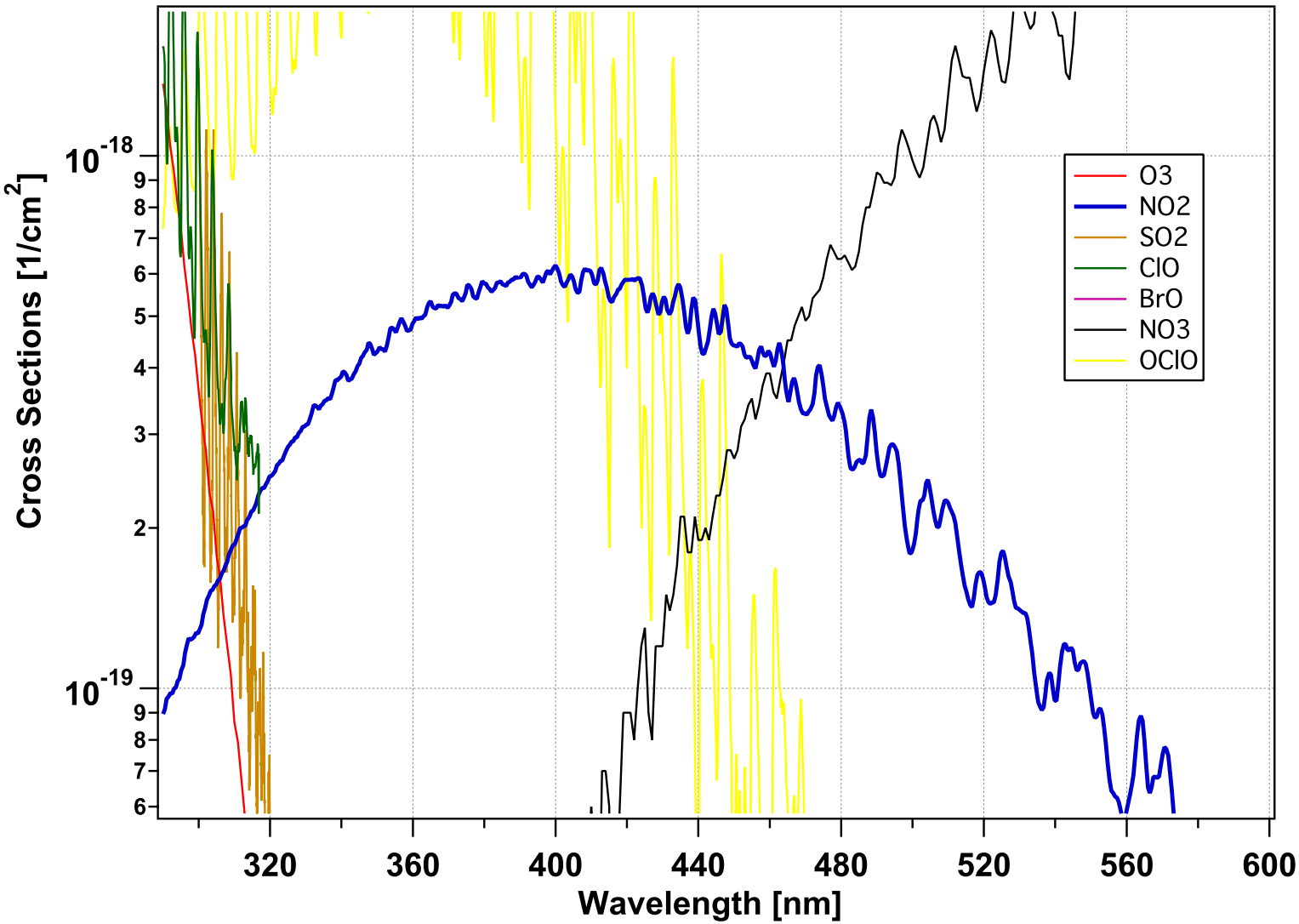


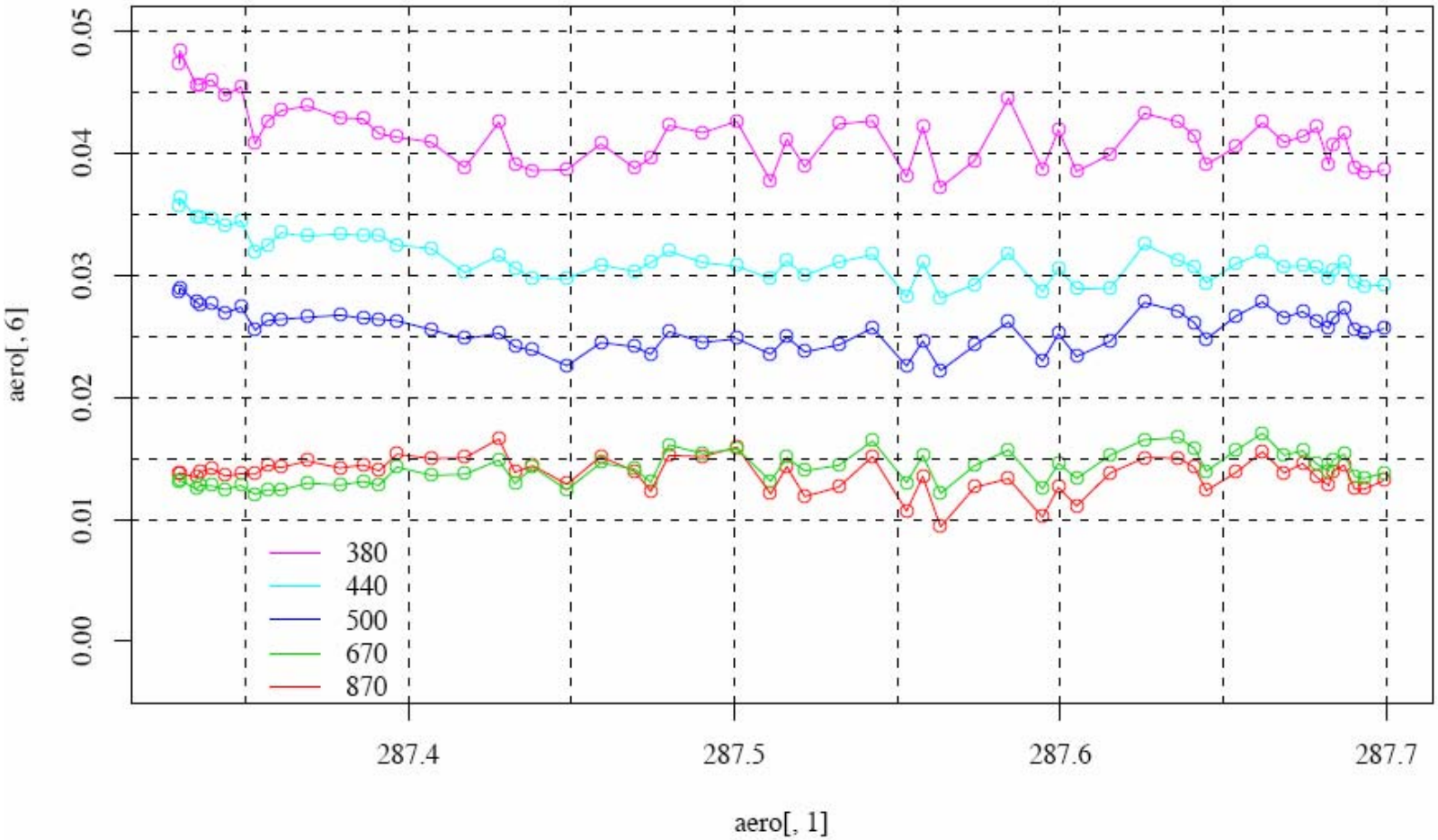


S. Gianelli, et al. *J. Geophys. Res.* (2005 submitted)

Extra Slides

NO_2 absorption




Aeronet Aerosol 14 Oct 2003
aero[, 6]
0.00
0.01
0.02
0.03
0.04
0.05
287.4
287.5
287.6
287.7
aero[, 1]
380
440
500
670
870

MFRSR Diffuse-to-Direct Ratio

Table 1. Modeled ratio of diffuse/direct divided by observed diffuse/direct. Row Labels: **ALL** – nominal values of AOD, surface albedo and SSA, includes ALL data from September 3, 1999, to December 31, 2002; **Nom** – Same as "ALL" case, but observations limited to those obtained with MFR Head 922 (September 3, 1999, to September 18, 2001); **0.67A** – Same as nominal case, but surface albedo reduced by 33%; **T-0.01** – Same as nominal case, but AOD reduced by 0.01; **0.90ω** – Same as nominal case, but SSA reduced by 10%.

	415 nm	500 nm	610 nm	665 nm	862 nm
ALL	1.162	1.174	1.206	1.226	1.411
Nom.	1.245	1.357	1.374	1.470	1.539
0.67A	1.235	1.338	1.349	1.434	1.477
τ-0.01	1.205	1.298	1.282	1.353	1.354
0.90ω	1.136	1.230	1.247	1.327	1.388

Table 2. Required perturbations in model inputs of AOD or SSA that bring modeled results into agreement with observed diffuse/direct ratio. No surface albedo greater than zero can be used to achieve the same effect.

	415 nm	50 0nm	610 nm	665 nm	862 nm
AOD	τ -0.063	τ -0.062	τ -0.041	τ -0.040	τ -0.029
SSA	0.77 SSA	0.72 SSA	0.71 SSA	0.67 SSA	0.64 SSA

P. Ricchiazzi and C. Gautier, *ARM Science Team Meeting Proceedings*, Broomfield, Colorado, March 31-April 4, (2003)
J. Petters et al., *J. Geophys. Res.* 108, 4288, (2003)
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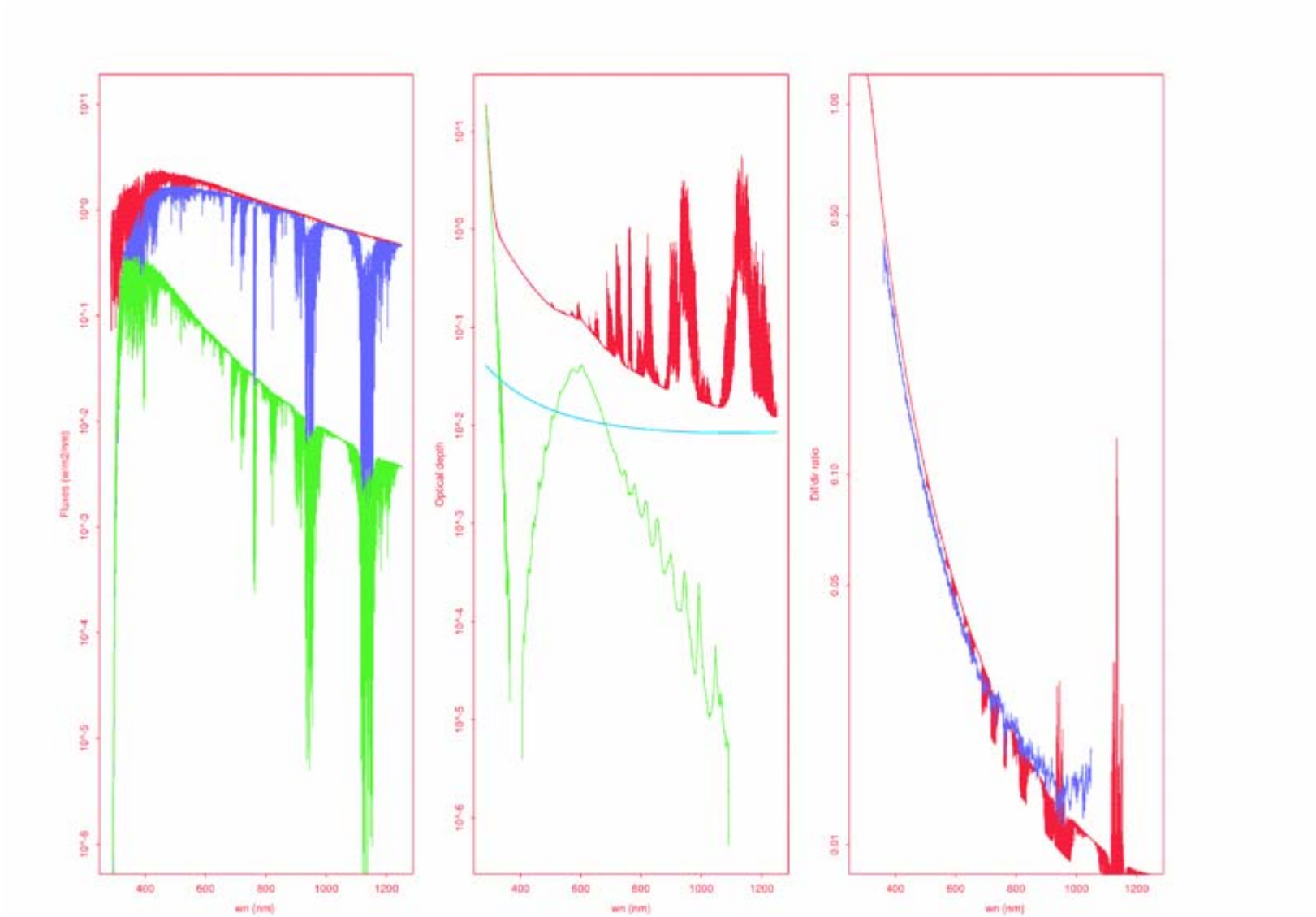
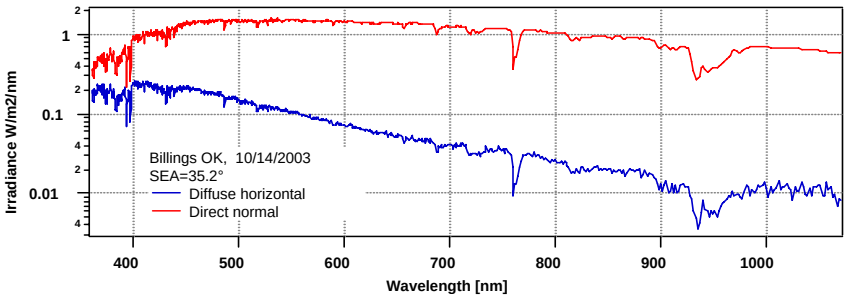
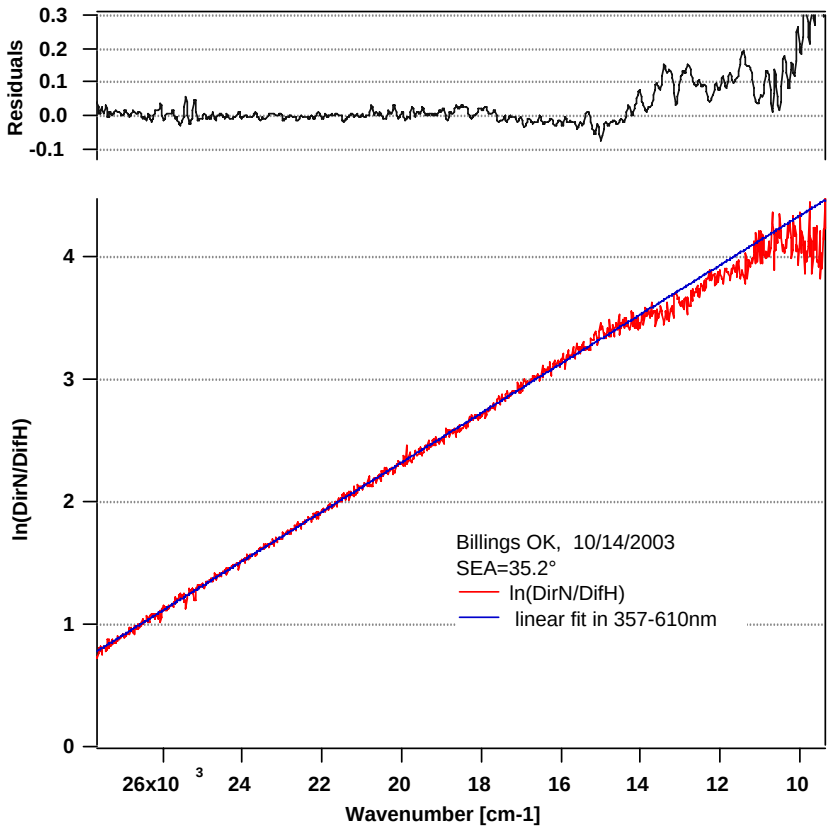


From Qilong Min, March 2005

Parametrization of direct-to-diffuse ratio





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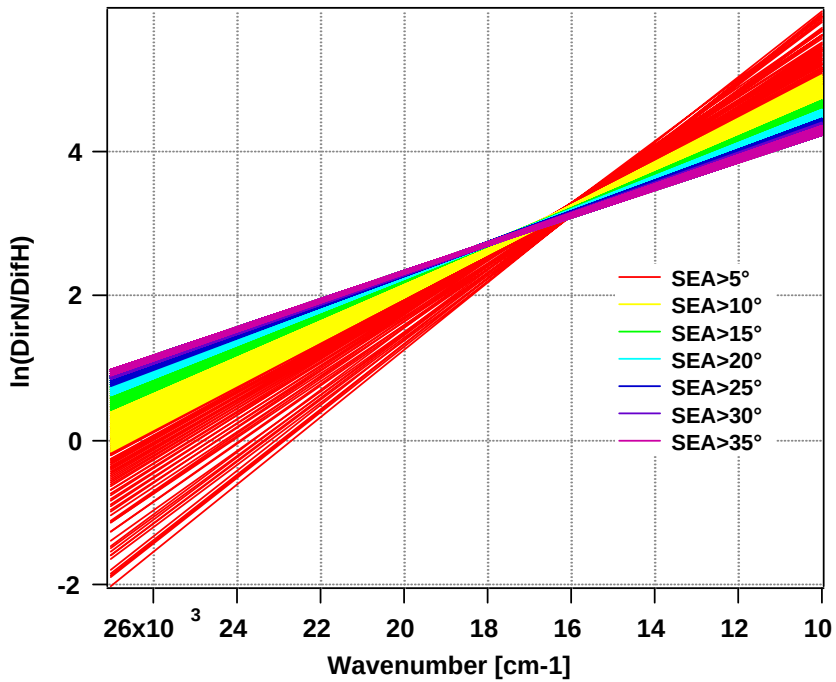
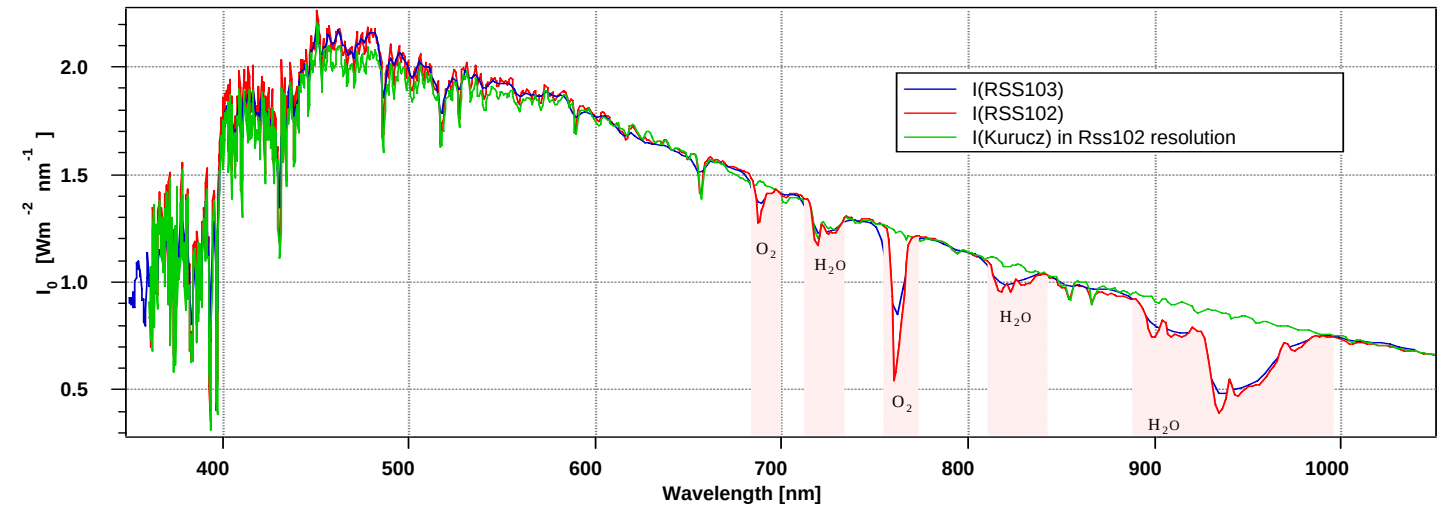
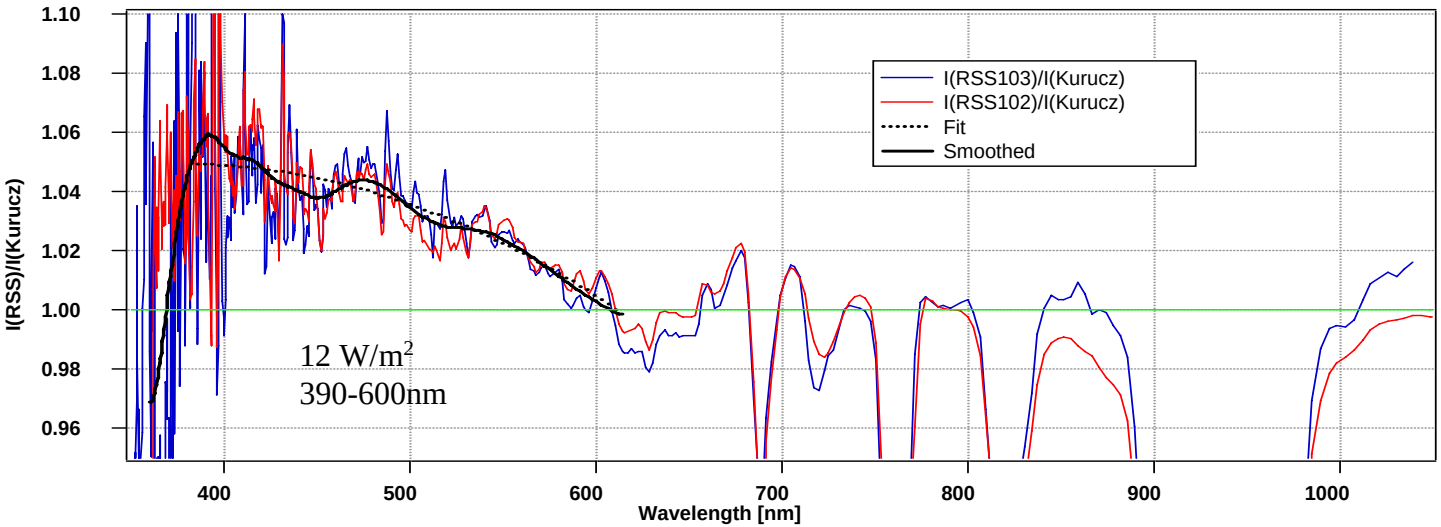


Extraterrestrial irradiance discrepancy





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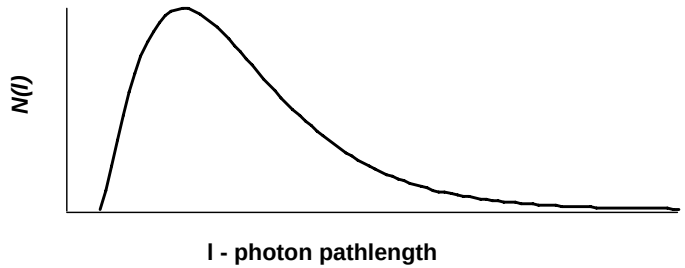


$$I(a) \propto \int N(l) e^{-al} dl$$

$$I(a) \propto L\{N(l)\}$$

$$N(l) \propto L^{-1}\{I(a)\}$$

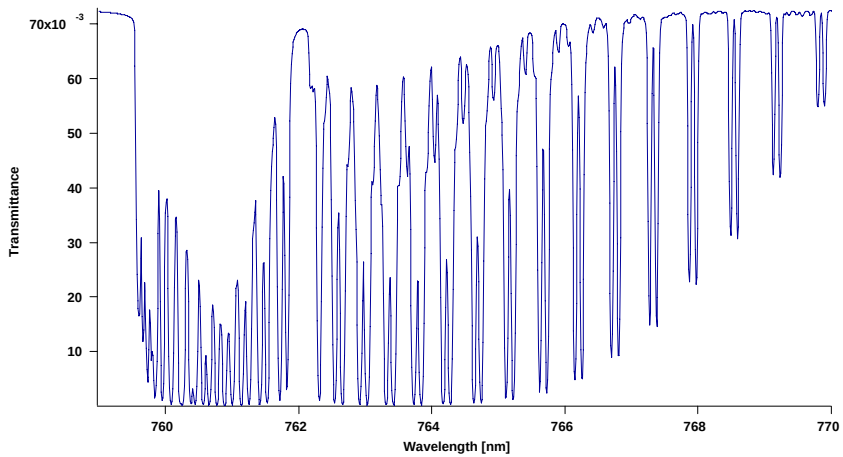
$$\frac{d^n I(a)}{da^n} \propto \int l^n N(l) e^{-al} dl$$

$$M^n \propto \lim_{a \to 0} \frac{d^n I(a)}{da^n}$$

$$a(\nu) \propto \frac{1}{(\nu - \nu_o)^2 + \alpha^2}$$

$$\bar{I}(a) = I(a) * s(\nu)$$

$$N(l) \propto L^{-1}\{\bar{I}(a)\} / L^{-1}\{s(\nu)\}$$



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