Spectrally resolved shortwave flux at ARM: History and the present status of RSS

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RSS105 being calibrated

The Rotating Shadowband Spectroradiometer (RSS) implements the same automated shadowbanding technique used by the MFRSR, and so it too provides spectrally-resolved, direct-normal, diffuse-horizontal, and total-horizontal irradiances, and can be calibrated in-situ via Langley regression.

Two prisms refractive spectrograph with charge couple device (CCD) is used to separate and measure spectrally resolved irradiance. The irradiance spectra are measured simultaneously at all spectral elements (approx 1000 pixels) in 360nm to 1050nm range.

RSS's were deployed at ARM sites since 1997 on trial basis. Two prototypes (RSS102 and RSS103) built at Atmospheric Sciences Research Center (ASRC) were tested in several prolonged deployments between 1997-2003 both at SGP and NSA. On two occasions (Diffuse IOP 2001 and Aerosol IOP 2003) also a UV-RSS prototype was deployed at SGP. The UV instrument provided the measurements in 295nm-385nm range. In May 2003 RSS105, a first commercial instrument (built by YES, Inc.), was deployed at the SGP Central Facility. RSS105 operates continuously since its deployment.

Irradiances from RSS's were used in research resulting in several significant scientific contributions. Michalsky et al. (1999) determined absorption cross-sections of O2-O2; Min et al. (1999 and 2001) developed methods to measure cloud optical depth from oxygen A-band that lead to cloud detection beyond microwave radar sensitivity; Kiedron et al. (1999) utilized RSS in irradiance standards intercomparison; Mlawer et al. (2000) used RSS direct and diffuse spectra to validate line-by-line clear sky shortwave model; Schmid et al. (1999) used aerosol retrieved from RSS; Harrison et al. (1999 and 2003) detected significant accuracy issues in solar source functions below 450nm; Michalsky et al. (2001) retrieved water vapor column; Kiedron et al. (2001 and 2003) retrieved water vapor column in Arctic in both clear sky and overcast conditions; most recently Gianelli et al. (2005) used RSS data to retrieve NO2 column at SGP.

RSS Shadowbanding Principles

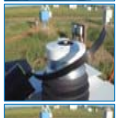
RSS103, UV-RSS104 and RSS105 Aerosol IOP at SGP, May 2003

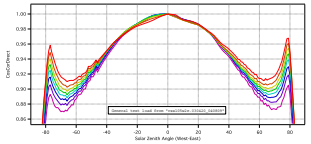
Shadowbanding Geometry	RSS105	RSS103	RSS102
Diffuser aperture	0.25"		
Shadowband width	8.1"		
Shadowband radius	3.55"		
Shadowband lenght	135°		
Shadowband position at corrections	±9°		
Shadowband axis angle	45°	Parallel with Earth axis	Parallel with Earth axis
Shadowband center on diffuser	yes		

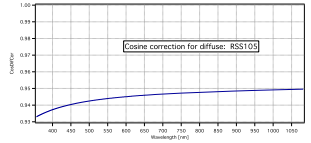
$$I_{Diffuse} = [Unblocked - \tfrac{1}{2}(Cor^{+} + Cor^{-}) + Blocked] / A_{Diff}$$

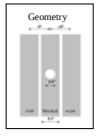
$$I_{Direct} = [\tfrac{1}{2}(Cor^{+} + Cor^{-}) - Blocked] / A_{Dir}(\alpha,\zeta)$$

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



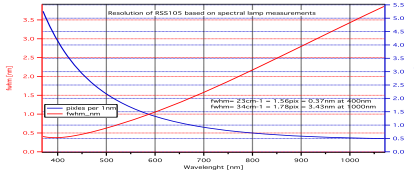


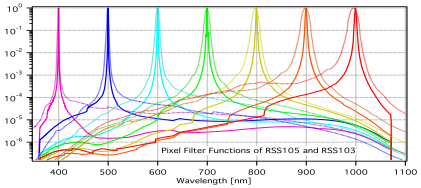




Spectrometric Specifications

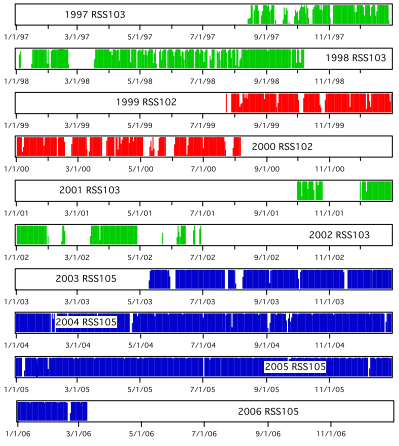
Spectral Characteristics	RSS1 05	RSS1 03	RSS1 02
Number of pixels	1024	512	1024
Nominal Spectral Range [N,M] [nm]	360 - 1050	360 - 1050	360 - 1050
Number of Pixels within NSR	1001	442	988
Resolution (FWHM) [nm] / [pixels]			
@400 nm	0.32 / 1.56	1.44 / 2.92	0.37 / 1.52
@500 nm	0.42 / 1.49	2.58 / 2.91	1.14 / 2.44
@600 nm	1.09 / 1.40	4.84 / 2.91	1.77 / 2.32
@700 nm	1.52 / 1.43	7.80 / 3.12	2.21 / 2.60
@800 nm	2.16 / 1.52	11 .02 / 3.37	2.53 / 1.75
@900 nm	2.79 / 1.63	14 .32 / 3.61	2.83 / 1.62
@1000 nm	3.42 / 1.78	17 .11 / 3.83	3.10 / 1.58
Slit functions			
95% below maximum	Gaussian	Gaussian	Gaussian
Gaussian parameters from	rss105_ Gau ssWidth	rss103_ Gau ssWidth	rss10 2_G aussWidth
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





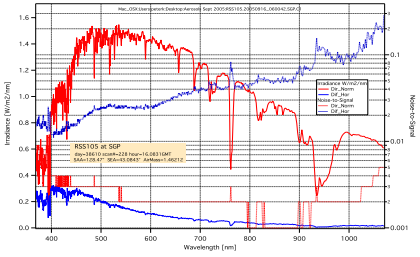
RSS Data Availability

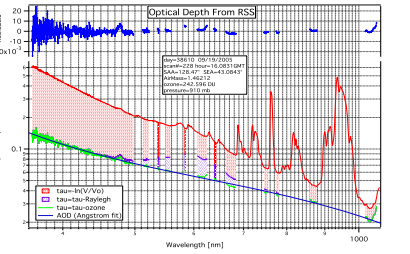
Data Availability	RSS105	RSS103	RSS102
Location	SGP	SGP	SGP
Operational epochs	05/09/03 - Present	09/29/01-08/27/02 08/12/97-10/05/98	07/22/99-08/04/00
Measurement period	From sunrise to sunset		
Measurement rate	1 shadowbanding cycle per min		
Number of spectra per day	From 570 spectra in Winter to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



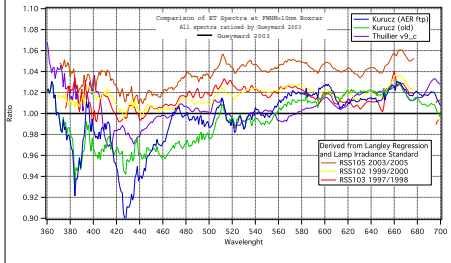
RSS105 Data Flow Stats: 2.5% downtime in 1035 days of operation
97% of scan received daily on average; 95% of scans received during 91% of days

RSS Irradiance and Optical Depth

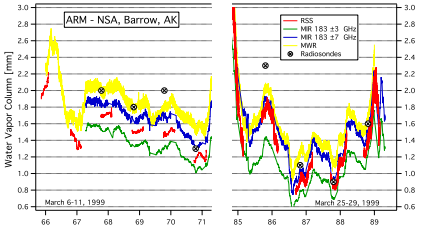




Extraterrestrial Spectrum Estimates



Water Vapor Retrieval in Arctic



LBLRT Model Verification

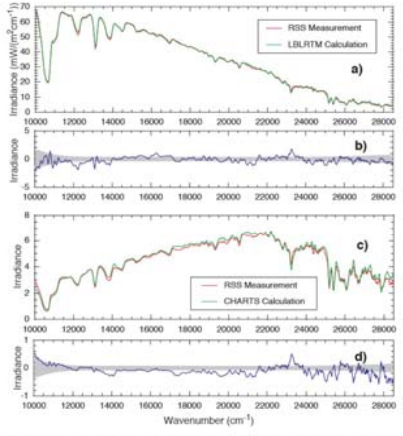
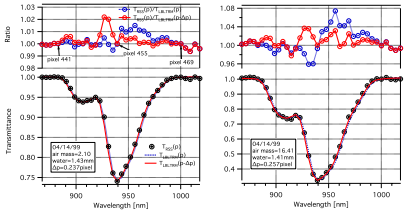


Figure 1. October 2, 1997 case [1.3 airmasses; 2.7 cm vertical PWV]: a) direct-beam spectral irradiances; b) direct-beam differences (RSS-LBLRTM); c) diffuse spectral irradiances; d) diffuse differences (RSS-CHARTS).

Figure from Mlawer et. al. 2000. *Geophys. Res. Lett.*, Vol. 27, 2653-2656

940nm H2O Band Verification



Publications with RSS Data

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Schmid, B., et al. (1999) "Comparison of Aerosol Optical Depth from Four Solar Radiometers during the Fall 1997 ARM Intensive Observation Period." *Geophys. Res. Lett.* Vol.26, 2725-2728.