Spectrally Resolved Shortwave Flux at Atmospheric Radiation Measurement Program: History and the Present Status of Rotating Shadowband Spectroradiometer

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Overview

The rotating shadowband spectroradiometer (RSS) implements the same automated shadowbanding technique used by the multi-filter rotating shadowband radiometer. Like the multi-filter rotating shadowband radiometer, it provides simultaneous spectrally-resolved, direct-normal, diffuse-horizontal, and total-horizontal irradiance measurements (see Figure 1) and can be calibrated in situ using the Langley regression. Calibrated bi-weekly with external lamp calibrators traceable to the National Institute of Standards and Technology radiometric scale, the accuracy of irradiance data produced by the RSS is expected to be better than ±5% at all pixels in 360_nm-1050_nm spectral range, including calibration and instrument stability errors. Higher accuracy can be obtained when responsivity is tied to the solar extraterrestrial irradiance via Langley regression. The calibration constant from Langley regression (or Vo's) are available from intensive operational period (IOP) Archives. This approach is recommended when high precision (±0.01) measurements of optical depths are required (see Figure 2).

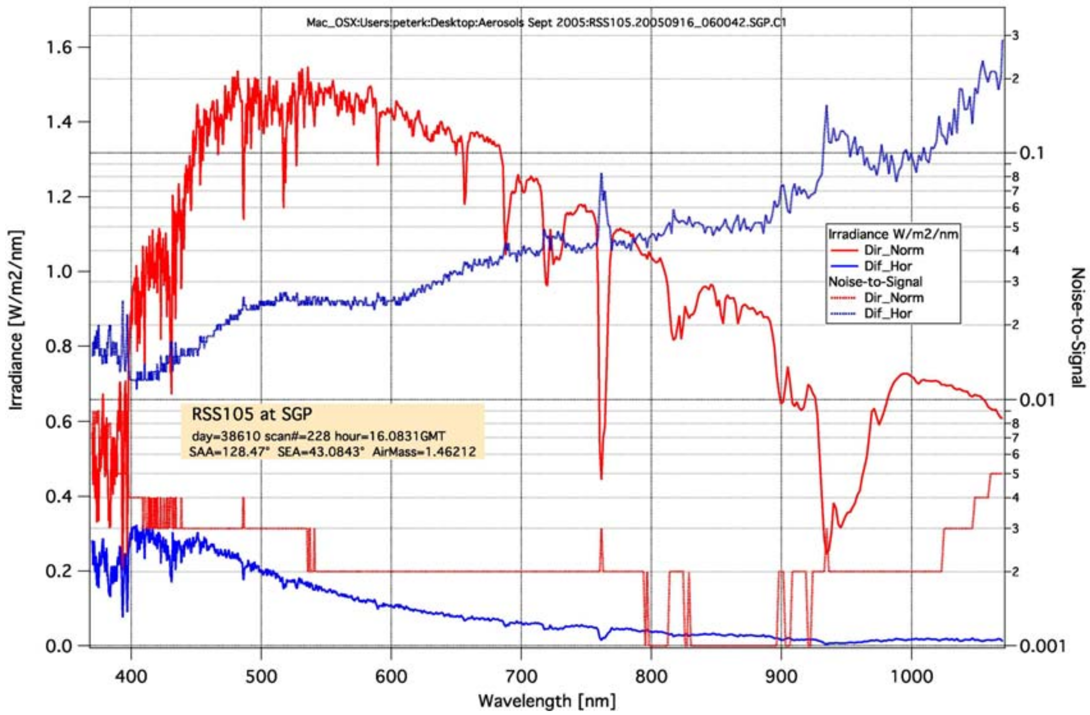

Figure 1. Example of diffuse horizontal and direct normal irradiances in (W/m^2/nm) obtained with RSS105 (solid lines). Dotted lines indicate 1-sigma precision.

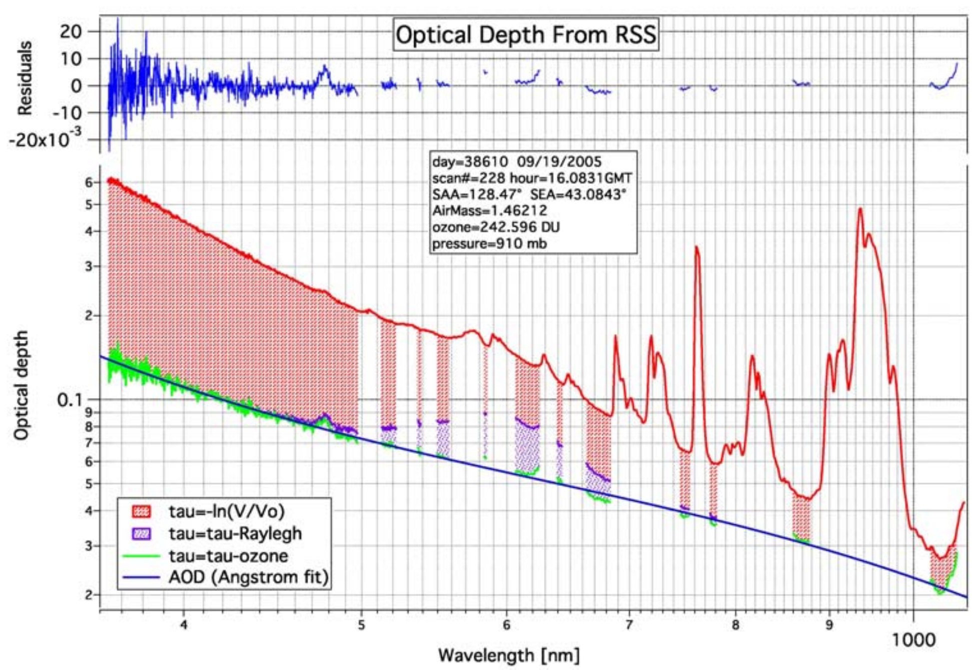

Figure 2. Example of retrieval of optical depth and aerosol optical depth from direct normal irradiance and Vo obtained from Langley regression.

RSS Data

Irradiance data from the RSS are now collected routinely and distributed via the Data Archive. The current RSS—known as the RSS105—is deployed at the Central Facility and is the first commercially built RSS manufactured by Yankee Environmental Systems, Inc. Since its deployment in May 2003, the RSS has operated continuously with only a 2.5% down time in the first 1035 days of operation (see Figure 3).

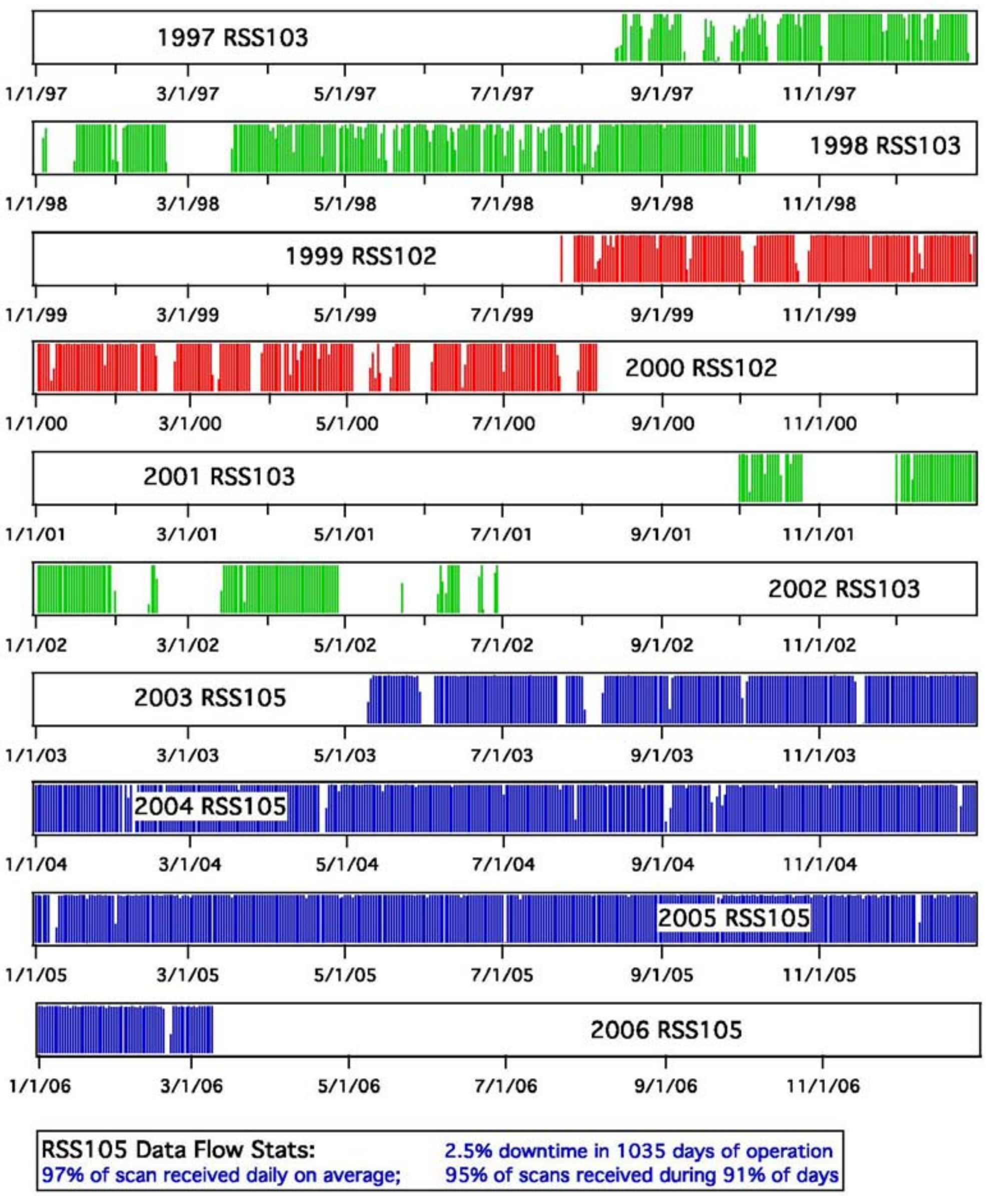

Figure 3. Data availability from two RSS prototypes (RSS102 and RSS103) and from the presently deployed RSS105.

Two prototypes (RSS102 and RSS103), designed and built at the Atmospheric Sciences Research Center, were tested in several prolonged deployments between 1997-2003 at both the Southern Great Plains (SGP) site and North Slope of Alaska (NSA) locale. In addition, an ultraviolet-RSS prototype was deployed at the SGP site for two field campaigns—Diffuse IOP 2001 and Aerosol IOP 2003—and provided measurements in the 295-385 nm range. All beta data from the RSS102, RSS103, and RSS105 are available from the IOP Archive at http://iop.archive.arm.gov/arm-iop/0special-data/asrc-rss/.

Application of RSS Data

Irradiances from RSSs were used in research resulting in several significant scientific contributions. Michalsky et al. (1999) determined absorption cross sections of O_2-O_2; Min et al. (1999, 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) used RSS in irradiance standards intercomparison; Mlawer et al. (2000) used RSS direct and diffuse spectra to validate line-by-line clear-sky shortwave model (see Figure 4); Schmid et al. (1999) used aerosol retrieved from the RSS; Harrison et al. (1999, 2003) detected significant accuracy issues in solar source functions below 450 nm (see Figure 5); Michalsky et al. (2001) retrieved water vapor column; Kiedron et al. (2001, 2003) retrieved water vapor column in the Arctic in both clear-sky and overcast conditions (see Figures 6 and 7); most recently, Gianelli et al. (2005) used RSS data to retrieve NO_2 column at the SGP site.

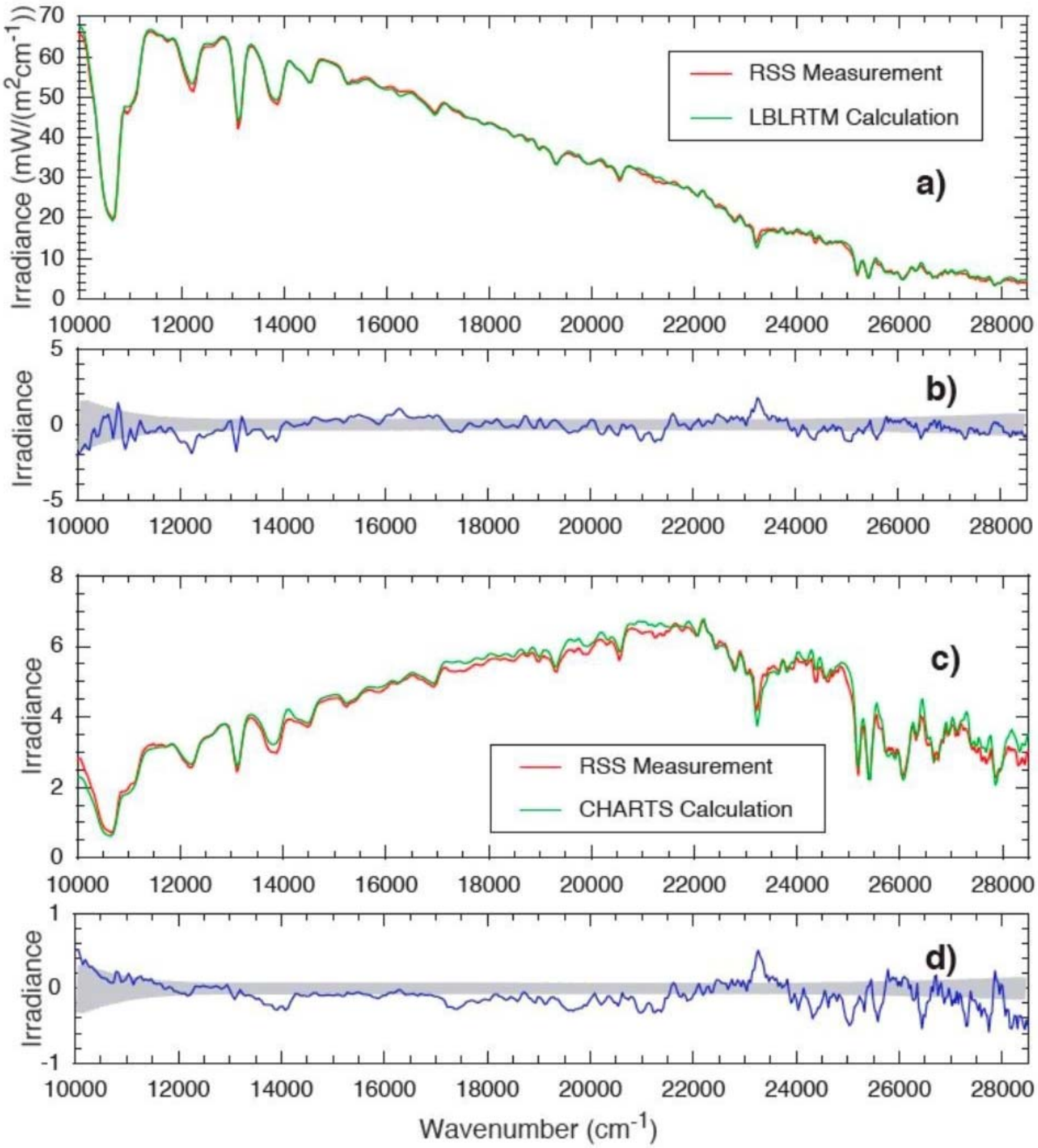

Figure 4. October 2, 1997, case (1.3 airmasses; 2.5 cm vertical precipitable water vapor); a) direct normal irradiance, b) direct normal difference (RSS-Line-by-Line Radiative Transfer Model [LBLRTM]), c) diffuse horizontal spectral irradiance, d) diffuse horizontal difference (RSS-Code for High-resolution Accelerated Radiative Transfer and Scattering [CHARTS]).

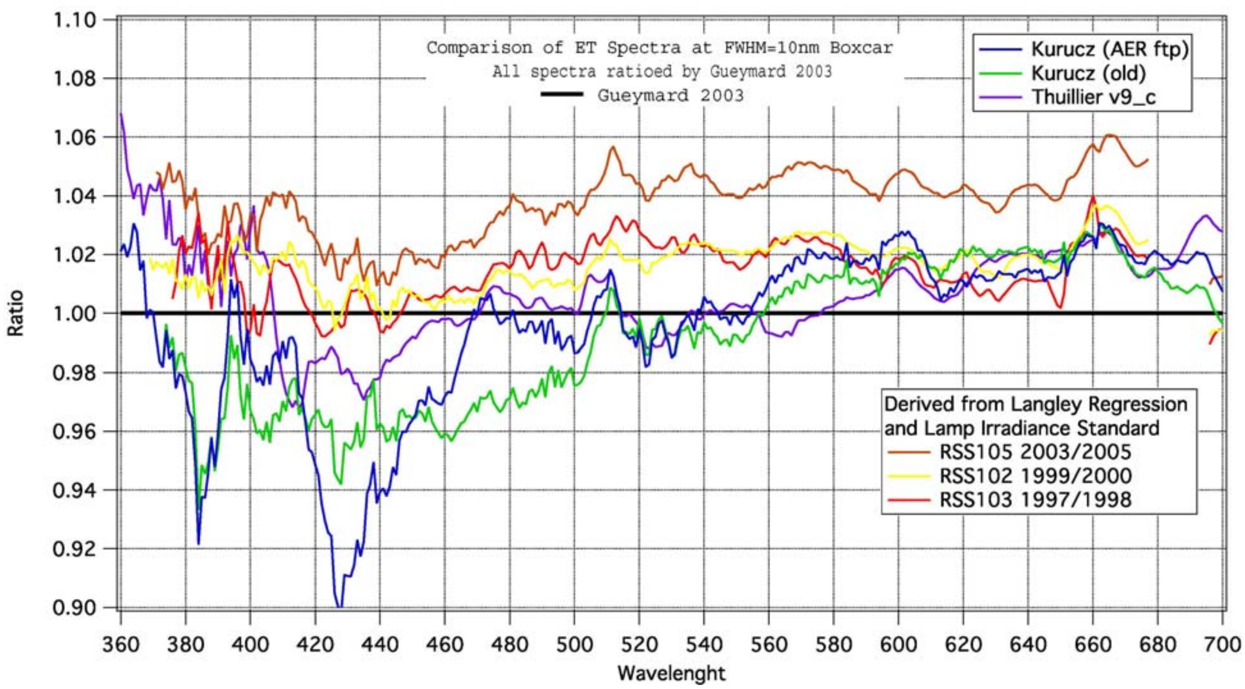

Figure 5. Extraterrestrial irradiance obtained with three RSS instruments based on National Institute of Standards and Technology lamp calibrations compared with Kurucz, Thuillier, and Gueymard extraterrestrial spectra.

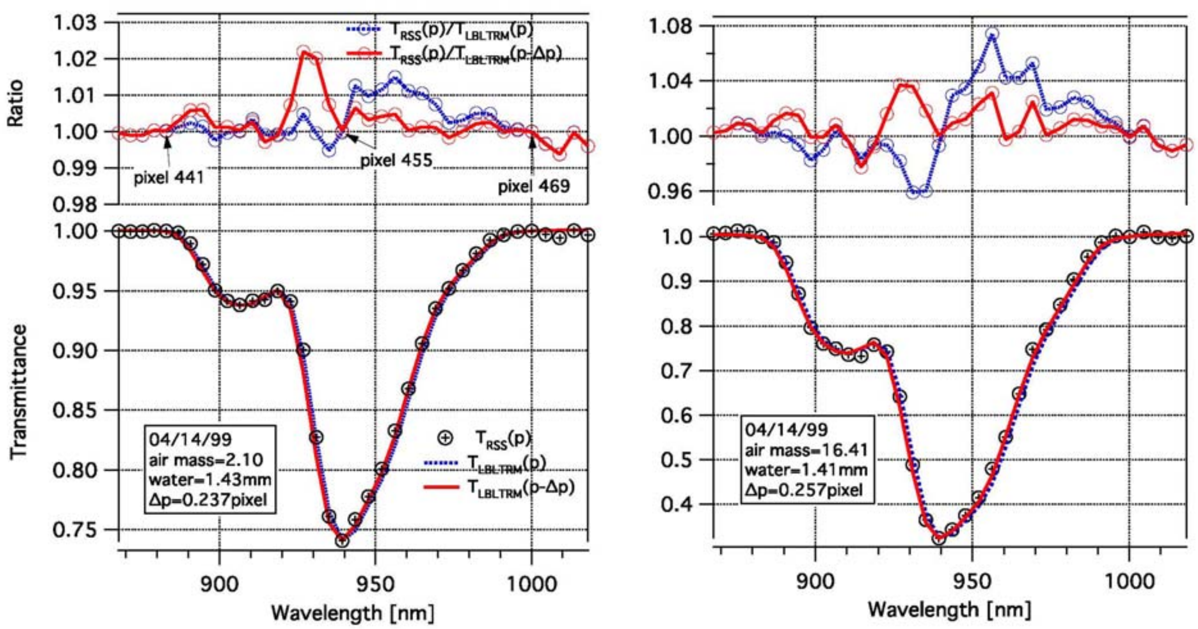

Figure 6. Comparison of 940-nm water vapor band obtained with RSS103 in the Arctic at the NSA with absorption band from LBLTRM model.

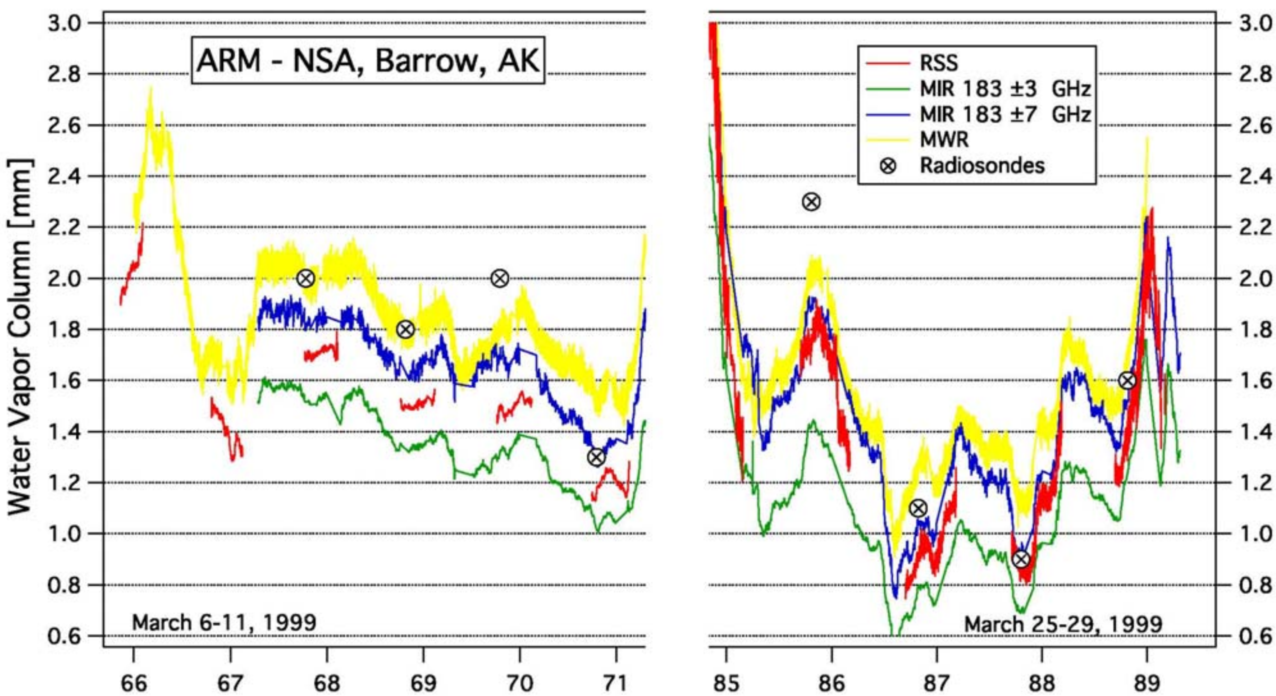

Figure 7. Water vapor column retrieved with RSS103 from 940-nm band in the Arctic at the NSA compared against retrievals from microwave radiometers.

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