The Research Scanning Polarimeter (RSP), in INTEX-B /MILAGRO:
Science Goals and Measurement Description

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Tropospheric aerosols play a crucial role in climate and can cause a climate forcing directly by absorbing and reflecting sunlight, thereby cooling or heating the atmosphere, and indirectly by modifying cloud properties. The indirect aerosol effect may include increased cloud brightness, as aerosols lead to a larger number of smaller cloud droplets (the so-called Twomey effect), and increased cloud cover, as smaller droplets inhibit rainfall and increase cloud lifetime. Both forcings are poorly understood and currently represent the largest source of uncertainty about historical and current forcing of climate.

Remote sensing of aerosols from satellites is unfortunately plagued by the need to make prior assumptions about the composition and size of the aerosols that are present, whether this is to calculate the phase functions of the aerosols for passive remote sensing, or the extinction to backscatter ratio for elastic backscatter lidar measurements. The NASA Glory mission will therefore fly an Aerosol Polarimetry Sensor (APS) that makes measurements of the intensity and degree of linear polarization over a broad spectral (400 - 2250 nm) and angular (±60° from nadir) range (Mishchenko *et al.* 2004). Similar measurements made by the Research Scanning Polarimeter (RSP) have been used to demonstrate the capability to accurately retrieve aerosol and cloud properties (Chowdhary *et al.* 2005).

Goals

The focus for the Research Scanning Polarimeter in INTEX-B/MILAGRO is therefore to test the algorithms being developed for the APS on the NASA Glory mission. These algorithms are expected to retrieve both aerosol and cloud microphysical properties and burden. In particular the following retrievals will be made:

- **Aerosols**
  - Optical depth, location and width of both modes of a bimodal size distribution, real and imaginary refractive indices and effective mixed layer depth. The capability to estimate the size and amount of accumulation mode aerosols above clouds has also been demonstrate experimentally and operational approaches to this type of retrieval will be evaluatedduring INTEX-B/Milagro.

- **Clouds**
  - Optical depth, effective radius and effective variance of cloud droplet size distribution, estimate of effective radius vertical profile, cloud top height (pressure), cloud base height (pressure). Derived products are liquid water path and cloud droplet number concentration.

The primary goal of the retrievals is to effectively constrain the direct and indirect radiative forcing of climate by aerosols and provide a diagnostic measure (shape, refractive index) of the aerosols that are causing the forcing.

Measurements

The RSP allows the total and linearly polarized reflectance to be measured simultaneously in nine spectral channels for each instantaneous field of view (IFOV) (*Cairns et al.* 1999). This is accomplished by six boresighted telescopes that have the same IFOV of 14 mrad. The refractive telescopes are paired, with each pair making measurements in three spectral bands. One telescope in each pair makes simultaneous measurements of the linear polarization components of the intensity in orthogonal planes at 0° and 90° to the meridional plane of the instrument (using Wollaston prisms to spatially separate the orthogonal polarizations onto a pairs of detectors), while the other telescope in a pair simultaneously measures equivalent intensities in orthogonal planes at 45° and 135°. These measurements provide the simultaneous determination of the Stokes parameters *I*, *Q*, and *U* in nine spectral bands with a wide dynamic range (14-bit digitization) and high signal-to-noise ratio (greater than 250 at radiance levels typical of aerosols over the ocean) with a radiometric and polarimetric uncertainty of ≤5% and ≤0.5%, respectively. This measurement approach ensures that the polarization signal is not contaminated by scene intensity variations during the course of the polarization measurements, which could create "false" or "scene" polarization.

Photograph showing the RSP installed under the tail of the J31 for the ARM SGP Lidar Validation Experiment (ALIVE).

The RSP spectral bands are divided into two groups based on the type of detector used: visible/near infrared (VNIR) bands using UV-enhanced silicon photodiodes at wavelengths of 412 (30), 470 (20), 555 (20), 672 (20), 865 (20) and 960 (20) nm and short-wave infrared (SWIR) bands using HgCdTe photodiodes (cooled to 163K) at wavelengths of 1590 (60), 1880 (90), and 2250 (120) nm. Dichroic beam splitters are used for spectral selection, while interference filters define the spectral bandpasses of each band. The parenthetic figures are the full width at half maximum (FWHM) bandwidths of the spectral bands. These spectral bands are capable of sampling most of the spectral variations in reflected sunlight due to particle scattering in the atmosphere. That is, the 412-, 470-, and 555-nm reflectances are significantly affected by molecular scattering in addition to scattering by sub-micron and super-micron (including cloud) particles. The 672- and 865-nm reflectances on the other hand are predominantly caused by scattering due to sub-micron and super-micron particles, and the 1590-, 1880-, and 2250-nm reflectances by scattering due to super-micron particles only. The 960- and 1880-nm bands are sensitive to the amount of water vapor and to the presence of cirrus clouds, respectively. The 14 mrad IFOV's are continuously scanned by a polarization-neutral two-mirror system which allows 152 viewing-angle samples (with a dwell time of 1.875 msec for each sample) to be acquired over a 120° angular range.

References

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