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The Spectral Mapping Atmospheric Radiative Transfer (SMART) Model

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Spectrum-resolving multiple scattering (SRMS) models can provide reliable results for a wide range of planetary atmospheres because they can explicitly accommodate all of the available information about the wavelength and altitude dependent optical properties of the environment. However, these models, which are also known as line-by-line multiple scattering models, are often too computationally expensive for routine use in remote sensing and climate modeling applications that span the entire solar and/or thermal wavelength range. The Spectral Mapping Atmospheric Radiative Transfer (SMART) model maintains the versatility of conventional SRMS models, but provides large improvements in speed by reducing the number of monochromatic multiple scattering calculations needed in broad spectral regions. SMART does this by (i) identifying all spectral grid points within a broad spectral region that have similar optical properties along the entire optical path, (ii) mapping these grid points into a smaller number of quasi-monochromatic bins, (iii) calculating angle-dependent radiances for each bin, and then (iv) mapping these radiances back to their original spectral grid points to create a high-resolution spectrum. This approach can reduce the number of multiple scattering calculations by a factor of $\sim$100 to 1000 without introducing radiance or heating rate errors larger than 1% at spectral resolutions high as $\sim$1 cm^{-1}. Over the past decade the SMART model has enabled a broad range of radiative transfer and remote sensing applications. Here, we will describe recent upgrades to SMART, including an efficient method for generating linearized "radiance Jacobians" or "weighting functions", for use in remote sensing retrieval models. These improvements substantially improve its speed, accuracy, and range of utility.