FAST AND ACCURATE RADIATIVE TRANSFER IN THE MICROWAVE WITH OPTIMUM SPECTRAL SAMPLING

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Optimal Spectral Sampling (OSS) is a rapid and accurate method for modeling sensor-band transmittances in media with non-homogeneous thermodynamic properties containing a mixture of absorbing gases with variable concentrations. The spectral response of a sensor channel is approximated by an optimally weighted average of monochromatic radiative transfer calculations at optimally selected points. The absorption coefficients for the selected points are obtained from pre-stored look-up-tables. One advantage of OSS is that its numerical accuracy is selectable, such that it is capable of fitting reference-model transmittance (or radiance) calculations arbitrarily closely. The method is readily coupled to multiple scattering calculations, an important factor for the extension of the models to treat cloudy radiances.

A microwave version of the OSS training algorithm and forward model has been developed in parallel with the infrared version. The forward model formulations are very similar, while the microwave uses a semi-linear approximation to the temperature dependence of the Planck function. Analytical Jacobians are produced in conjunction with the radiances with very little added computational burden. The microwave training process for selecting spectral points is similar to the simplest of the options available for the infrared, wherein a forward stepwise selection is done, with a process to avoid negative weights that could destabilize the solution. The more elaborate methods used in the infrared are not needed because the microwave sensor applications have relatively high spectral resolution in relation to the molecular absorption line structure. The microwave model treats O₂ and N₂ as fixed gases and H₂O and O₃ as variable gases. For computational economy, O₃ is treated only at spectral locations where it contributes significantly to the transmittance, while the significance is tested automatically during training. Several reference line-by-line models are available for training, including the one developed by Rosenkranz, Liebe, et al. [1],[2] and MonoRTM [3], and other models can be integrated. The method of tabulating and interpolating absorption coefficients has been optimized for execution speed, with respect to the coefficients themselves and their derivatives with respect to temperature and variable gas concentrations, which factor into the Jacobians.

OSS has been applied to AMSU, SSMIS, ATMS, AMSR-E, SSM/I and other sensors, including designs for an NPOESS conically-scanning sensor and for piloted or automated aircraft sensors. The training model accepts detailed spectral response functions for each channel. Simple square-impulse spectral response functions can be accepted when detailed functions are not available, such as in the early stages of sensor design trade-off studies. With a selected requirement of 0.05-K rms error (with respect to the reference line-by-line model), the number of monochromatic points required varies from one, for most window channels, to about five for some channels embedded in the 60-GHz O₂ line complex. Even in the cases where a single point is adequate, the optimal point does not necessarily coincide with the center frequency of the channel. For channels near absorption lines, a center frequency approximation would produce errors of around 2 K, in terms of rms.
REFERENCES

