Version 1.0 of the CRTM Transmittance Coefficient Generation Package

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Introduction:
A core part of the Community Radiative Transfer Model (CRTM) is the fast parameterization of gaseous transmittance for fast and accurate radiative transfer. This is achieved by means of a regression approach that fits accurate but expensive line-by-line results for a given instrument. A downside of this process is that a set of regression data in the form of a coefficient file for each new instrument that is to be used in conjunction with the CRTM is required. The purpose of the CRTM Transmittance Coefficient Generation Package is to streamline and automate the combined line-by-line computation and regression process as far as possible and allow a maximum of flexibility when it comes to the specifics of the instrument under investigation. Furthermore, expert CRTM users should be enabled to compute CRTM transmittance coefficients for new instruments themselves. This presentation provides an overview of the current state of the CRTM Transmittance Coefficient Generation Package and showcases a number of instrument examples that were processed using the package.

Theoretical Background:
The CRTM Emissivity Radiative Transfer solver finds an approximate solution to the **Schwarzschild Equation**:

$$\mu \frac{dI_\nu(\tau,\mu)}{d\tau} = \mathrm{I}_\nu(\tau,\mu) - \mathrm{B}_\nu(\tau),$$

where $\mathrm{B}_\nu(\tau)$ is the Planck function, τ is the optical depth, and μ is the cosine of the emergent angle. From the basic ODE the solution for the upward radiance measured by the instrument at TOA in pressure space can easily be found:

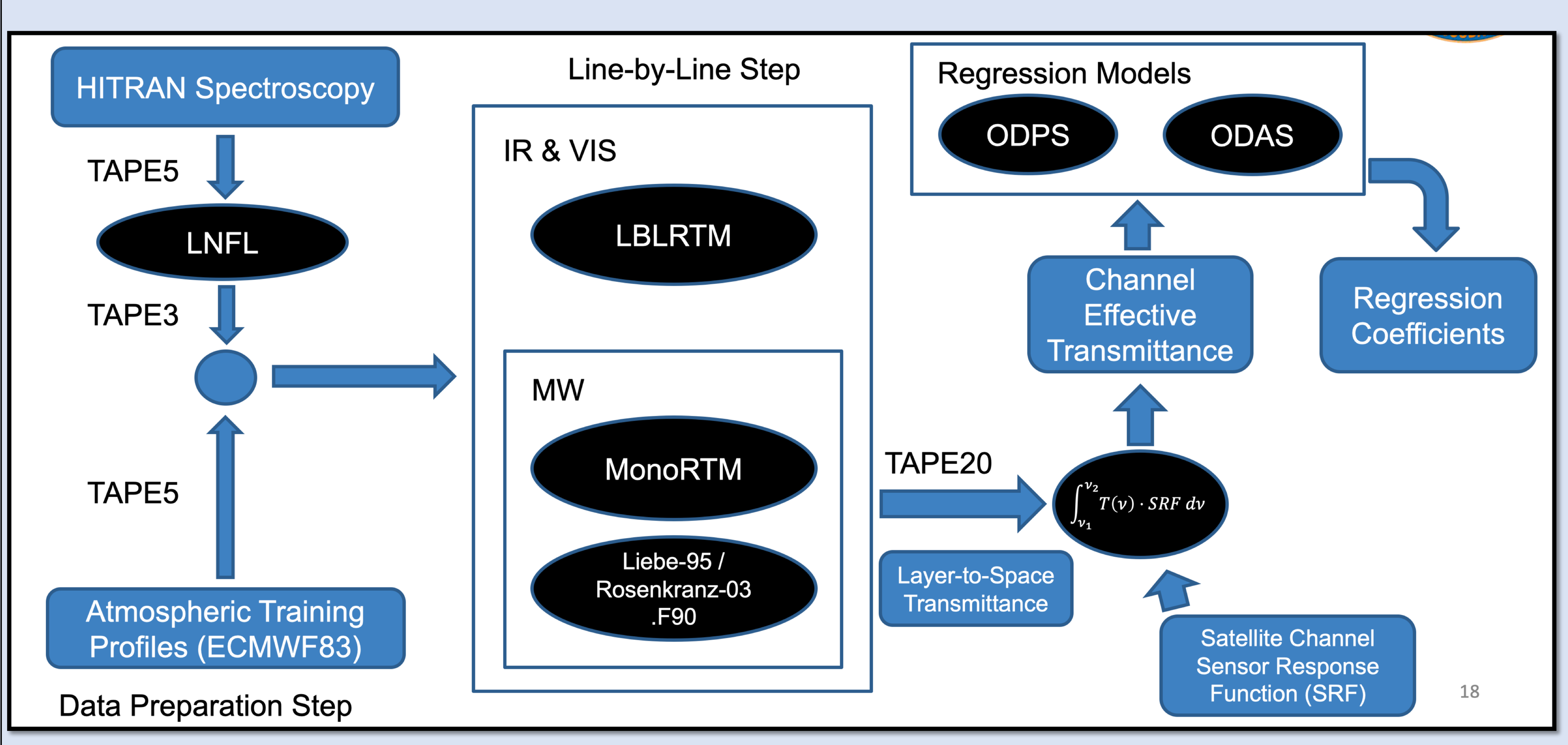
$$I_{ch}(0) = B_{ch}(T_S)\cdot T_{ch}(p_s) + \int_{p_s}^{0} B_{ch}[T(p)]\cdot\frac{\partial T_{ch}(p)}{\partial p}\,dp$$

Solving this integral equation requires knowledge of the <u>**spectral transmittance**</u>:

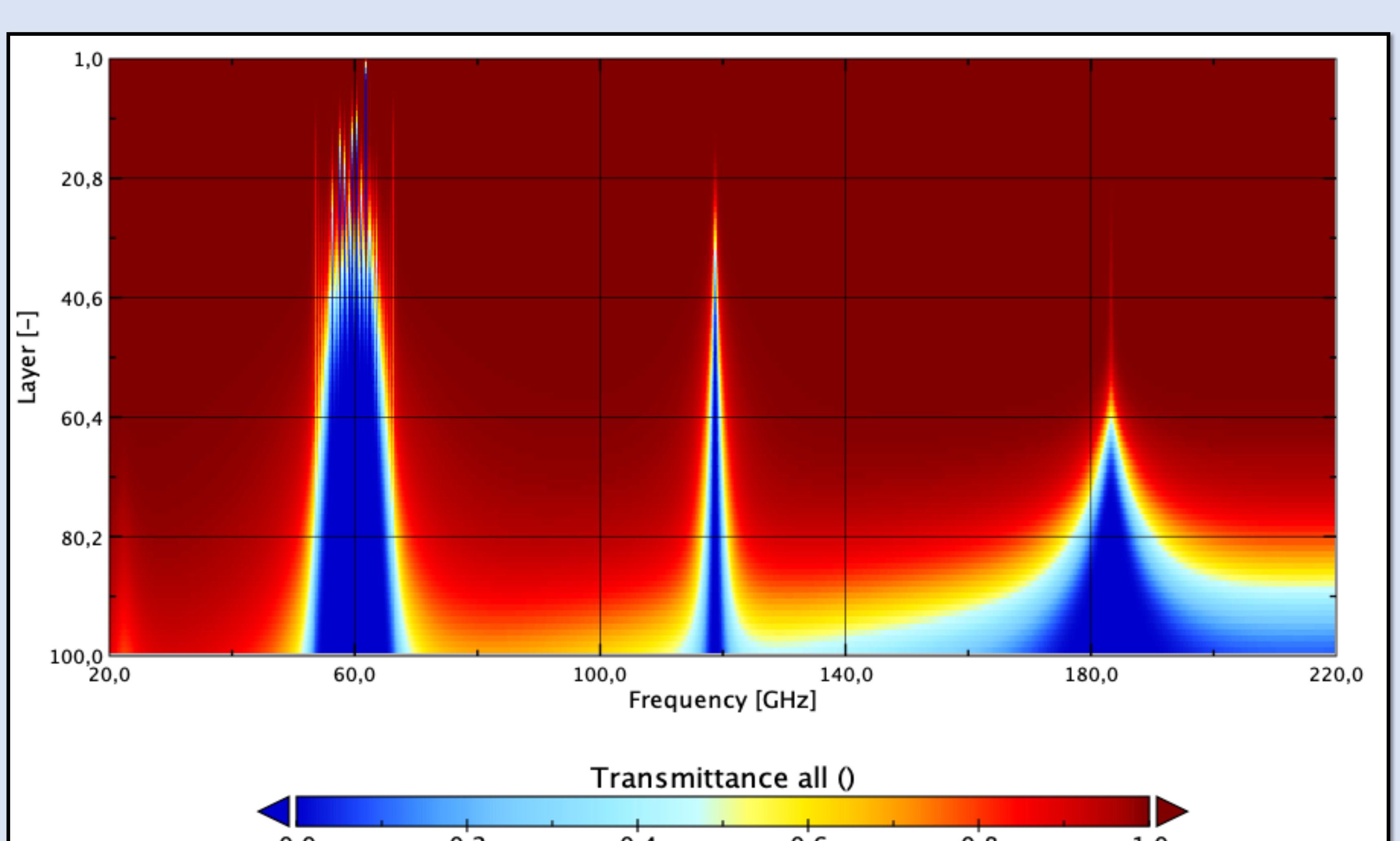
$$T_{ch}(p) = \int_{\nu_1}^{\nu_2} \Phi(\nu_{ch},\nu)\cdot\exp\left[-\frac{1}{g}\int_0^p k_\nu(p')\,q(p')\,dp'\right]d\nu \Big/ \int_{\nu_1}^{\nu_2}\Phi(\nu_{ch},\nu)\,d\nu$$

The CRTM transmittance coefficient generation process is conceptually easy and straightforward.

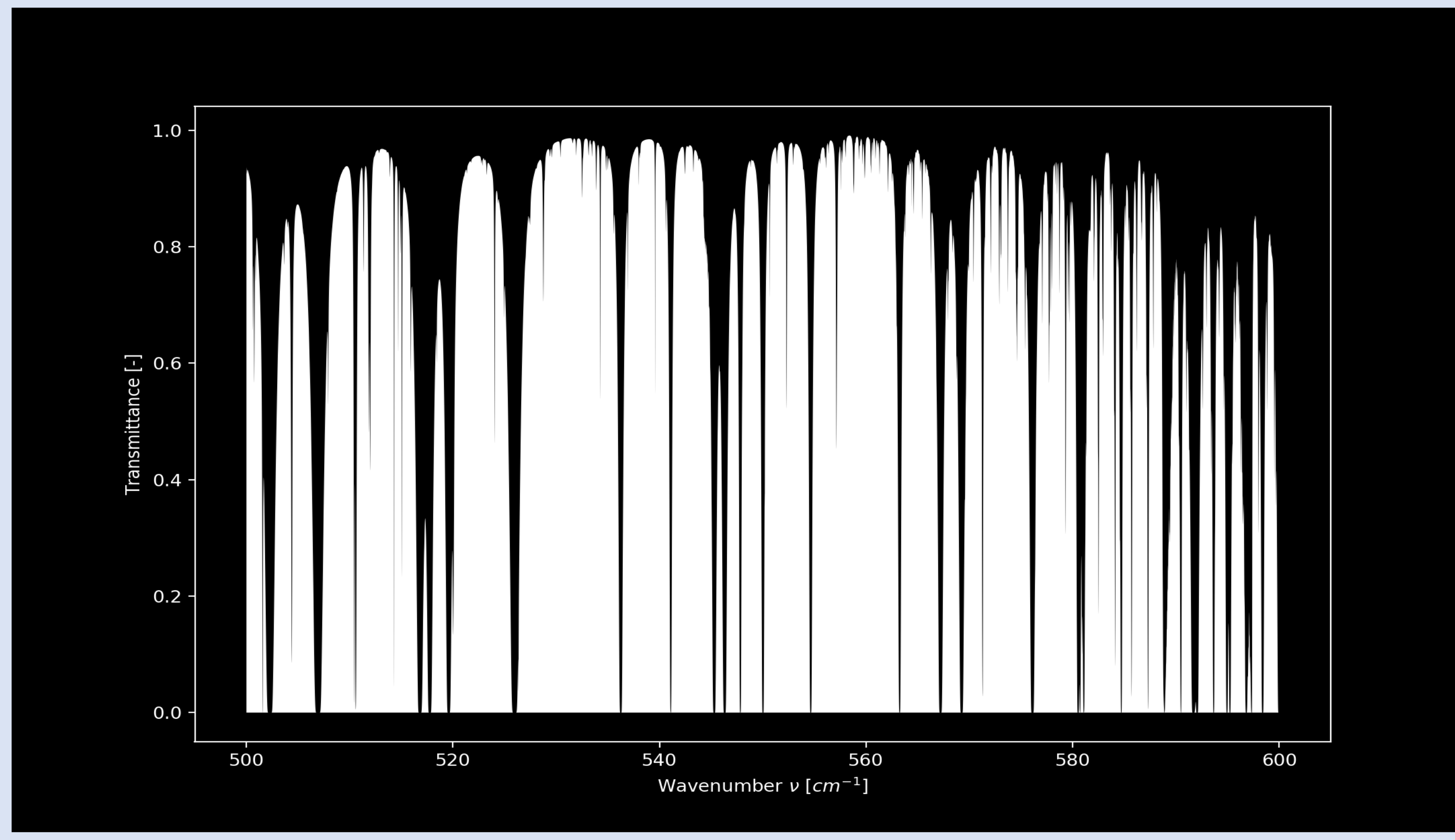
The detailled process is much more complex, however, as illustrated by the flowchart below.



Line-by-line Radiative Transfer Calculations
The basis for the regression algorithm that provides the basis for the CRTM fast transmittance calculations are the synthetic data produced by line-by-line radiative transfer models. These include the Rosenkranz03 model and AER's LBLRTM for IR, Visible, and UV.

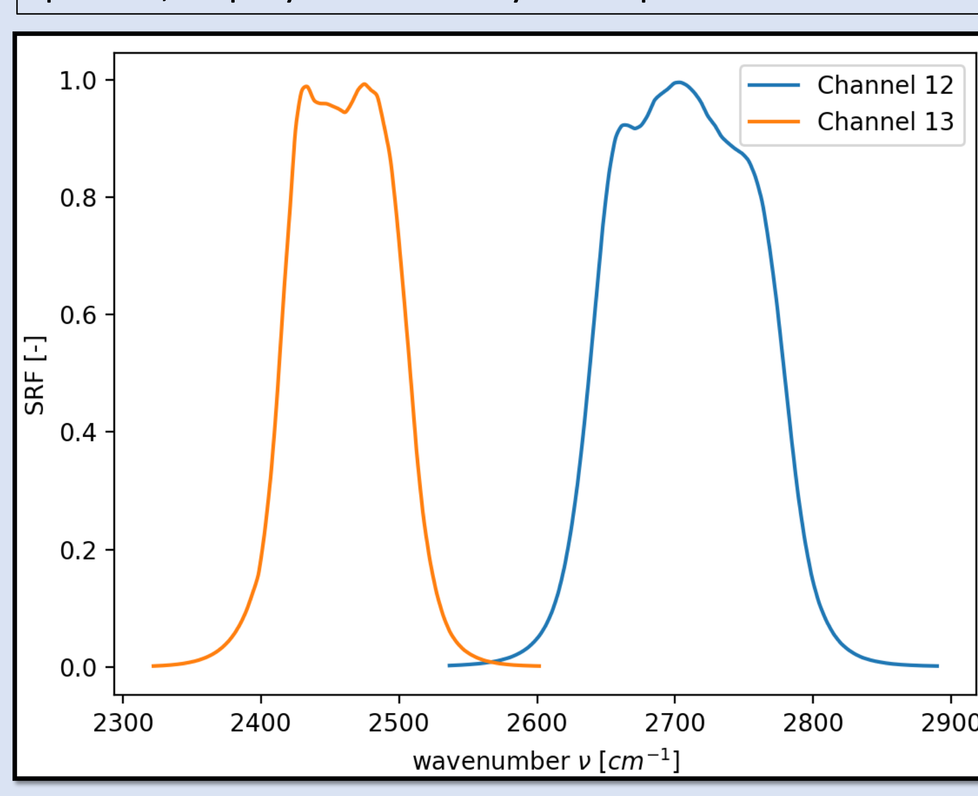


Top: Roesnkranz03 model monochromatic transmittance in the MW region

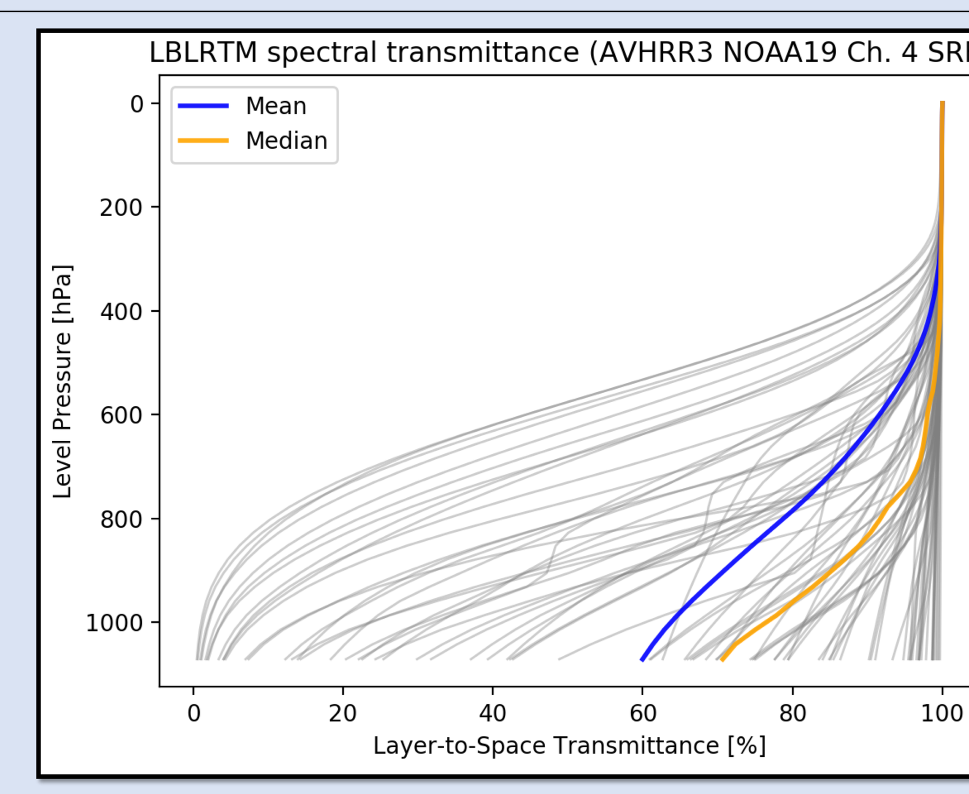


Top: LBLRTM monochromatic layer-to-space transmittance spectra for the 500-600 cm^-1 region.

SRF Convolution
Before the regression, the monochromatic LBL transmittances are convolved with the instrument SRF to obtain the spectral, or polychromatic layer-to-space transmittances.

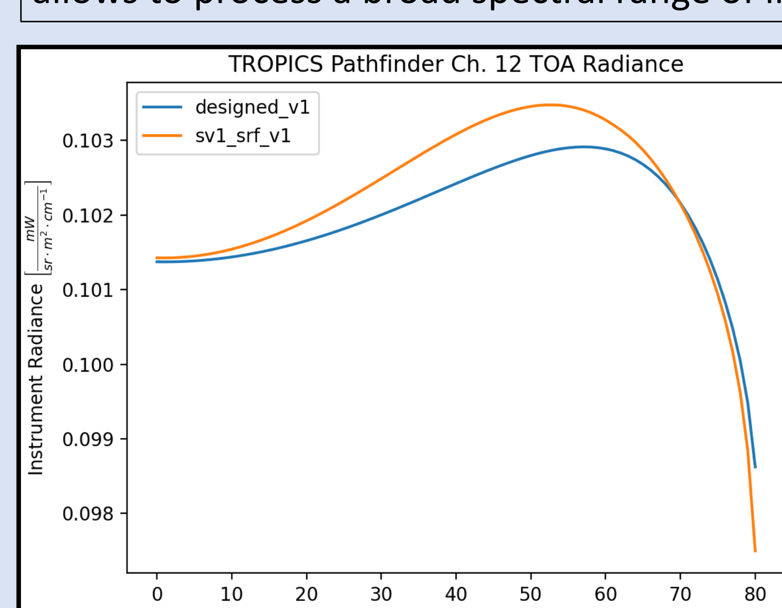


Top: VIIRS SRFs.



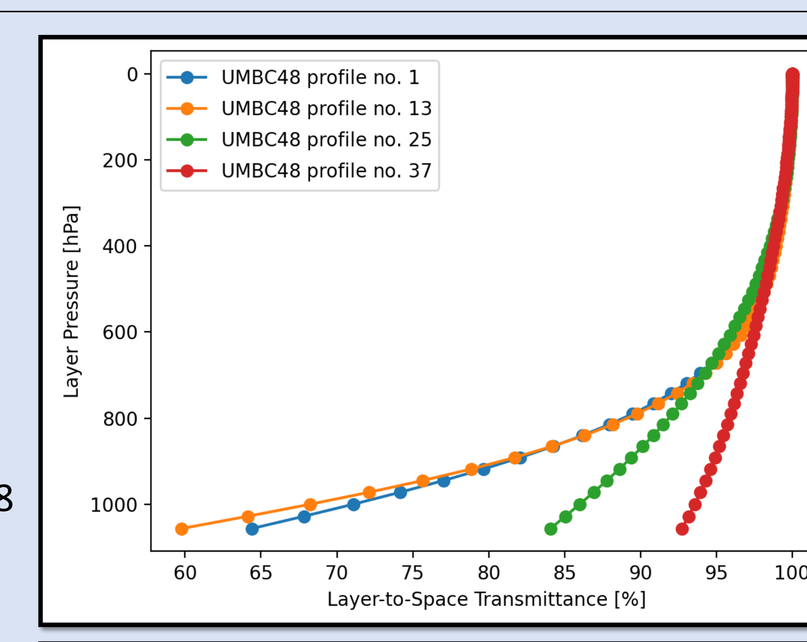
Top: VIIRS transmittances at channel resolution.

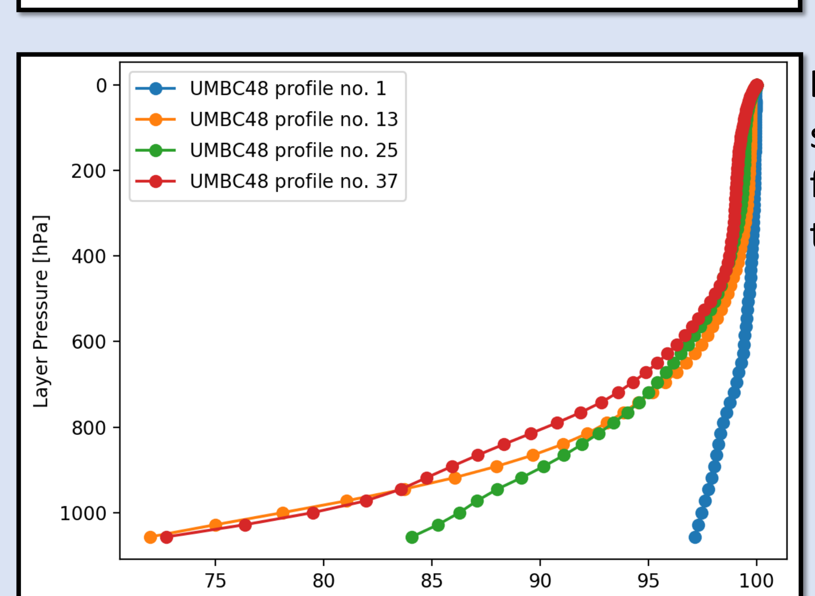
Results
Some results of the coefficients produced with the new coefficient generation package are shown below. The package allows to process a broad spectral range of instrument coefficients.



Left: TROPICS Pathfinder radiance vs. Instrument zenith angle.

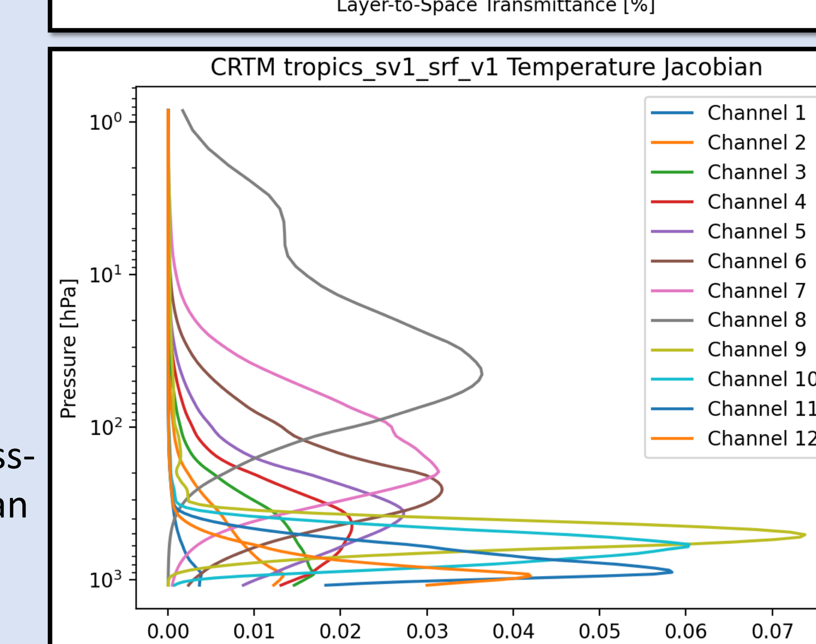
Right: TROPICS Pathfinder layer-to-space transmittance for selected UMBC48 test profiles.

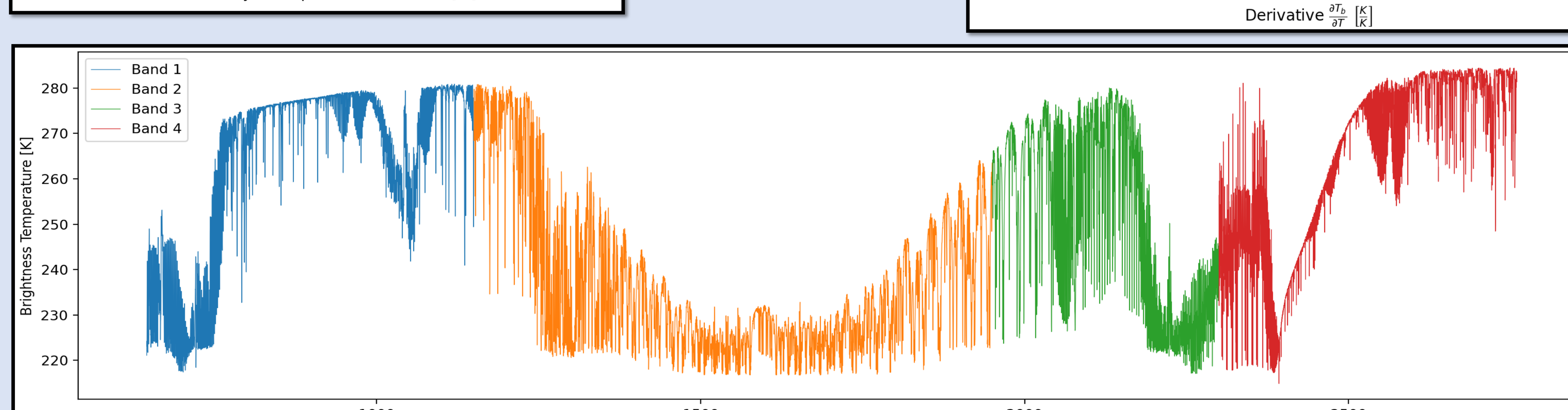




Left: VIIRS Layer-to-space transmittaance for selected UMBC48 test profiles.

Right: TROPICS Pathfinder brightness-temperature Jacobian w.r.t. layer temperature.





Top: Preliminary CRTM brightness temperature results for IASI-NG MetOp-SG-A.