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On a new fast principal component based retrieval code

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The Havemann-Taylor Fast Radiative Transfer Code allows fast and exact calculations and is ideally suited for the simulation of hyperspectral instruments with hundreds or thousands of channels. The code works in any part of the spectrum and may be used in the shortwave, the infrared and microwave.

During a training phase, the code is trained on a wide variety of different atmospheric and surface conditions. The line-by-line calculations carried out during this training phase are based on the recent spectroscopy of LBLRTM From the radiance spectra obtained during the training, up to 100 Principal Components are derived, which contain the information of all the partly correlated channel radiances in a much more compact form. With a k-means clustering algorithm, a few hundred frequencies are selected. Monochromatic radiances obtained from line-by-line calculations at these centroid frequencies are then used as the predictors for the Principal Components (PC) Scores. The HT-FRTC can simulate a spectrum for any atmosphere/surface within a fraction of second, because it does only monochromatic calculations and it saves computer memory since it works in the low-dimensional PC space.

For the simulation of scattering by clouds and aerosols and Rayleigh scattering in the short-wave, a spherical harmonics line-by-line code has been integrated into the HT-FRTC, which is very similar to the Edwards-Slingo radiation code. Scattering calculations with the HT-FRTC for a complete spectrum take on the order of a second.

The HT-FRTC has been incorporated into a one-dimensional variational retrieval system that also works solely in PC space, which keeps the dimensions of the matrices involved small. The solution of the full non-linear problem is achieved with an iterative Levenberg-Marquardt minimization procedure. The variational retrieval system creates a lot of diagnostics in addition to the solution, like the averaging kernel, the Jacobians, the gain matrix and the degrees of signal as a measure of information gained. The state vector includes the vertical profiles of atmospheric temperature, water vapour and ozone, as well as the surface temperature and surface emissivity (which is represented as principal components). For a scattering atmosphere, cloud parameters and aerosol parameters can be added to the state vector.

All state vector elements can be retrieved simultaneously or alternatively some elements of the state vector can be kept fixed and not retrieved. The cloud part of the state vector for cirrus cloud includes cloud top pressure, water content, cloud fraction and cloud optical depth. For water cloud there is also an effective droplet size.

This code has been used to retrieve atmospheric and cloud parameters from ARIES (Atmospheric Research Interferometer Evaluation System), flying on board of the Met Office BAe-146 research aircraft, and IASI. The effect of cloud on the retrieval of the temperature and humidity profiles will be investigated.

Furthermore, the code has been used to retrieve the surface properties from airborne/spaceborne hyperspectral radiance measurments, both in the visible and the infrared. Here, we will focus on surface retrievals based on radiance measurements made by Hyperion EO1.