Latest Development in Radiative Transfer Models and Retrieval Algorithms Using Principal Components

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ABSTRACT

The radiative transfer model (RTMs) has a wide range of applications in satellite remote sensing and atmospheric radiation applications. However, millions of line-by-line (LBL) radiative transfer calculations at fine monochromatic frequencies are needed in order to properly calculate spectral contributions of water vapor and trace gases in the atmosphere in infrared and solar spectral regions. Therefore, fast and accurate RTMs are needed to efficiently process large amount of satellite data. A Principal Component-based Radiative Transfer Model (PCRTM) was first developed in 2004 at NASA Langley Research Centre to fulfil this need. By using PC-compression, one can reduce the data dimension significantly while maintaining original information content. The PCRTM can directly compute PC-scores and their derivatives with respect to retrieved parameters. The PCRTM can simulate the top-of-atmosphere (TOA) radiance or reflectance spectra from 0.250 μm (400000 cm^{-1}) to 2000 μm (50 cm^{-1}) with several orders of magnitude faster speed as compared to a LBL RTM. It is also extremely accurate compared to LBL RTM benchmarks (0.03 K RMS error in IR and 0.05% in solar). The PCRTM model has been developed for hyperspectral sensors such as AIRS, CrIS, IASI, NAST-I, SHIS, FIRST, and CLARREO-IR in thermal IR spectral region and CLARREO-Solar, CPF, TEMPO, EMIT, OMI, and SCIAMACHY in solar spectral region. The PCRTM accuracy has been demonstrated via RTM intercomparisons and with real satellite observations from AIRS, CrIS, IASI, SCHIAMACHY, and EMIT etc.

In this presentation, we will describe two PCRTM-based inversion algorithms to retrieve atmospheric temperature, water vapor, and trace gas profiles, as well as cloud and surface properties from hyperspectral sounders such as AIRS, CrIS, IASI, and NAST-I. The first one is called Single Field-of-view Sounder Atmospheric Product (SiFSAP) algorithm. It provides L2 products with 9-times higher area spatial resolution as compared to current cloud-clearing sounder algorithms. The SiFSAP L2 and L3 products are available at NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC) for public access. The second inversion algorithm is called Climate Fingerprinting Atmospheric Product (ClimFiSP) algorithm. It is designed to produce high quality climate products (trends, anomalies, daily, and monthly profiles of temperature, water vapor, traces, clouds, and surface properties) from multiple satellite sensors such AIRS on Aqua and CrIS on multiple satellites. This product will be available at NASA GES DISC later this year. The PCRTM-based high fidelity simulators for CLARREO and CPF have been used for sensor performance trade studies, algorithm development, and inter-satellite calibrations. We have also used PCRTM generated TOA radiance spectra to train an AI-based algorithm and successfully retrieved cloud properties from EMIT solar hyperspectral imagers.