1D-VAR RETRIEVAL USING SUPER CHANNELS

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1. INTRODUCTION

Since modern ultra-spectral remote sensors have thousands of channels, it is difficult to include all of them in a 1D-var retrieval system. We will describe a physical inversion algorithm, which includes all available channels for the atmospheric temperature, moisture, cloud, and surface parameter retrievals. Both the forward model and the inversion algorithm compress the channel radiances into super channels. These super channels are obtained by projecting the radiance spectra onto a set of pre-calculated eigenvectors. The forward model provides both super channel properties and jacobian in EOF space directly. For ultra-spectral sensors such as Infrared Atmospheric Sounding Interferometer (IASI) and the NPOESS Airborne Sounder Testbed Interferometer (NAST), a compression ratio of more than 80 can be achieved, leading to a significant reduction in computations involved in an inversion process. Results will be shown applying the algorithm to real IASI and NAST data.

2. RAPID RADIATIVE TRANSFER MODEL

The rapid radiative transfer model used in the 1D-var retrieval is a Principal Component-based Radiative Transfer Model (PCRTM). The theoretical basis of the PCRTM has been described by Liu et al. [1]. Unlike traditional rapid radiative transfer models, which either predict channel radiances or transmittances, the PCRTM predicts the PC scores of the radiance spectrum, which contains information for all the channels. The relationship between the PC scores and the predictors, monochromatic radiances, is derived from the properties of eigenvectors and instrument line shape (ILS) functions. Each PC score (Y_i) is calculated via a dot product of the corresponding eigenvector ($\vec{U}_i$) and the channel spectrum ($\vec{R}^{chan}$) as shown in equation 1.

$$Y_i = \vec{U}_i \cdot \vec{R}^{chan} \qquad (1)$$

PCRTM is much faster than channel-based RTM since it predicts PC scores (or "Super Channel") directly instead of channel radiance or transmittance individually. The radiance variation as a function of temperature, H_2O, O_3, CH_4, N_2O, CO, surface emissivity and observation geometry is captured via monochromatic radiative transfer calculations. The redundant spectral information is captured via EOF representation.

3. METHODOLOGY OF 1D-VAR RETRIEVAL

The first step in 1D-var retrieval is to convert the observed radiance into super channels by projecting the observed radiance spectrum onto each individual principal component determined during the PCRTM training process. The current inversion algorithm is based on a non-linear Levenberg-Marquardt method with climatology covariance and *a priori* information as constraints:

$$x_{n+1} - x_a = (K^T S_y^{-1} K + \lambda D + S_a^{-1})^{-1} K^T S_y^{-1} [(y_n - y_m) + K(x_n - x_a)] \qquad (1)$$

where the subscripts *n* and *a* represent iteration number and *a priori*, respectively. Y_m is the super channel from observation. Y_n is the forward model calculated super channel using the state vector obtained from the *nth* iteration. S_y and S_a are error

covariance matrices associated with y and background state vector x_a, respectively, $\boldsymbol{D}$ is a diagonal matrix whose elements are determined by the diagonal elements of the $K^T S_y^{-1} K$ matrix. The Jacobian (or K matrix) is generated by the PCRTM model. The dimension of the super-channel used in our retrieval system is on the order of 100, which is about a factor of 84 less than the original channel radiance spectrum.

4. RESULTS AND CONCLUSIONS

We will show results obtained during a Joint Airborne IASI Validation Experiment (JAIVEx), which was held during April and May 2007. 1D-var retrievals were performed using super channels obtained from the IASI (Infrared Atmospheric Sounding Interferometer) and NAST-I (NPOESS Airborne Sounder Testbed Interferometer) instruments. The IASI has 8461 spectral channels and NAST-I has 8632 channels. It would be very time consuming to perform a 1D-var retrieval using all 8000 channels if a channel-based retrieval approach was taken. However, using the PCRTM retrieval approach, we can effective including information from all 8000 channels in the retrieval, while reducing the dimension of data by more than one order of magnitude.

6. REFERENCES

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