Single Field of View IASI/AMSU Retrieval Under All Sky Condition

An ultra fast Physical retrieval algorithm has been developed to carry out combined Infrared/Microwave (IR/MW) retrieval for collocated IASI/AMSU measurements. The retrieval algorithm uses Principal Component Based Radiative Transfer Model (PCRTM) for the IR forward simulation and Community Radiative Transfer Model (CRTM) for the MW part. PCRTM has been developed to effectively perform cloud radiative transfer calculations using pre-computed cloud transmittance and reflectance, enabling the retrieval algorithm to obtain cloud properties along with atmospheric variables and surface properties simultaneously from single field of view (FOV) measurements. While fully utilizing IR instrument’s higher spatial and vertical resolution, the combined IASI/AMSU retrieval takes advantage of the MW instrument’s ability to penetrate cloud so that accurate information for under the cloud atmosphere profiles and surface parameters can be retrieved from top-of-atmosphere (TOA) radiation measurement with high yield rate.

Physical retrieval algorithm

I. Forward Model:
PCRTM is designed for hyperspectral IR forward simulation with useful features including:
- multiple scattering in clouds
- 15 variable trace gases
- short wave solar radiation and Non-LTE
- radiative kernel/Jacobian

PCRTM can be used for hyperspectral forward simulation for instruments on satellite – IASI, CRIS, AIRS, CLARREO or airborne – NASTI, S-HIS.

Cloud is simulated as one indefinitely thin and homogeneously distributed plane parallel layer (or multiple layers) in the forward model. For a single layer forward model, integrated contribution to radiance from the real cloud with vertical structures is approximated as the contribution from the single effective layer.

\[ \int R(T, \tau) \exp(-\int R(T, \tau) d \tau) d \tau \]

where \( \tau \) is the optical thickness of the real cloud and \( \tau \) is the optical path for a point along the optical path. \( \hat{\beta} \) is the Planck function at temperature \( \hat{T} \). \( T \) is defined as the effective cloud temperature.

II. Inversion

The physical retrieval process follows a standard maximum likelihood estimation procedure, i.e. mathematical inversion for a radiative transfer system which can be briefed using a linear form,

\[ Y = X \cdot F + e \]

where \( Y \) - the radiance measurement; \( F \) - the forward model; \( X \) - the input parameter of the forward model; \( e \) - the deviation of the forward model from the real measurement. By minimizing the cost function defined within a posteriori framework,

\[ J(Y,X,F|Y,F,X) = (Y-F)^T \Sigma^{-1} (Y-F) + X^T \Sigma^{-1} X \]

the solution is given as

\[ X = X_0 - K \Sigma^{-1} (Y-F) \]

where \( X_0 \) is the background vector (a priori) and \( S \) is the associated covariance matrix, \( K \) is the Jacobian.

Technical Highlights

I. Be ultra fast, suitable for application on data of massive volume
II. utilize all the channels, keeping fine scale spectral information
III. retrieve cloud properties along with atmospheric and surface properties using single FOV observations
IV. Can incorporate two forward model (PCRTM + CRTM) to do IR/MW combined retrieval. Application examples: CRIS/ATMS, IASI/AMSU

Conclusion and future work

The application of the PCRTM based, nonlinear physical retrieval algorithm for all sky IASI observations has been demonstrated and validated. Our results indicates that single FOV observations provided by hyperspectral infrared sensors like IASI/AMSU can be used to locate the cloud height, extract cloud micro-physical characteristics and thermal-dynamic parameters of the atmosphere simultaneously.

We are currently working on the IASI/AMSU data aggregation and collocation, and started to prepare collocated ECMWF data to be used as in-situ truth for the validation. MODIS, CLIPS/O), CLOUDSAT cloud products will be used to validate cloud properties.