Hybrid Radiative Transfer Scheme (HRTS), a solver for Advanced Radiative transfer Modeling System (ARMS)

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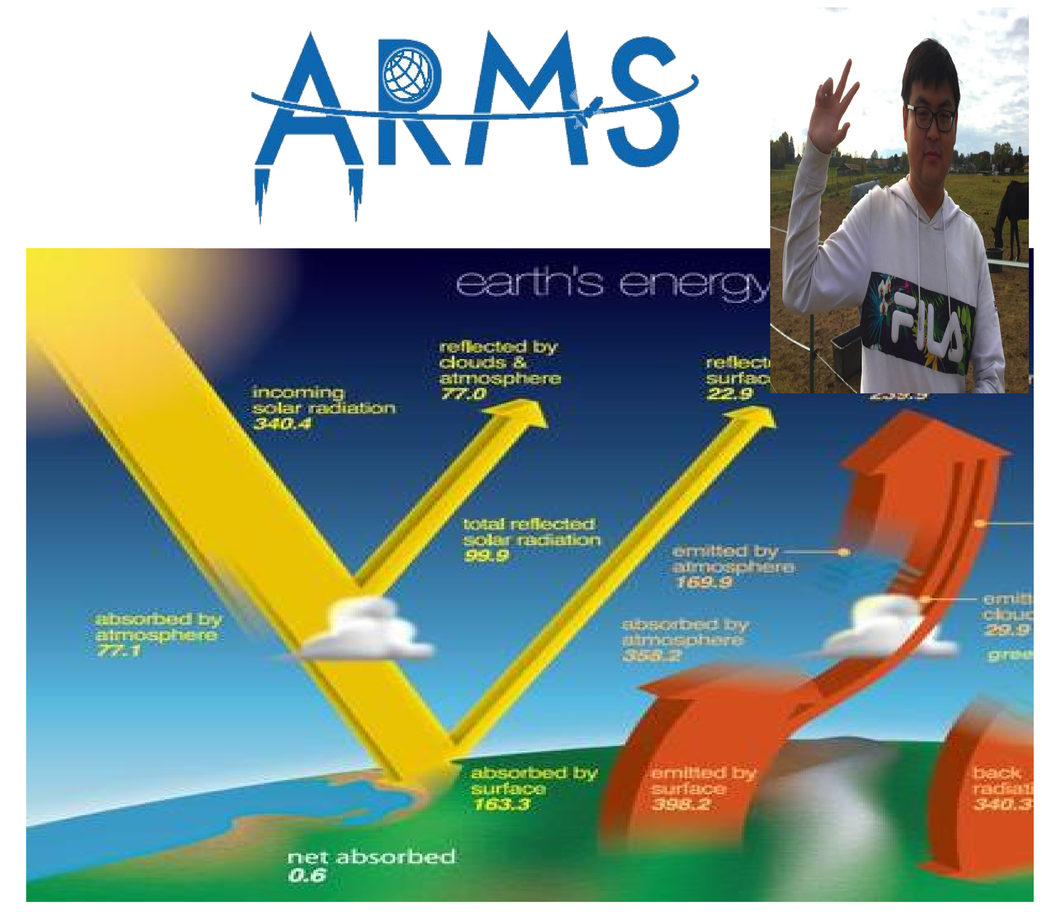
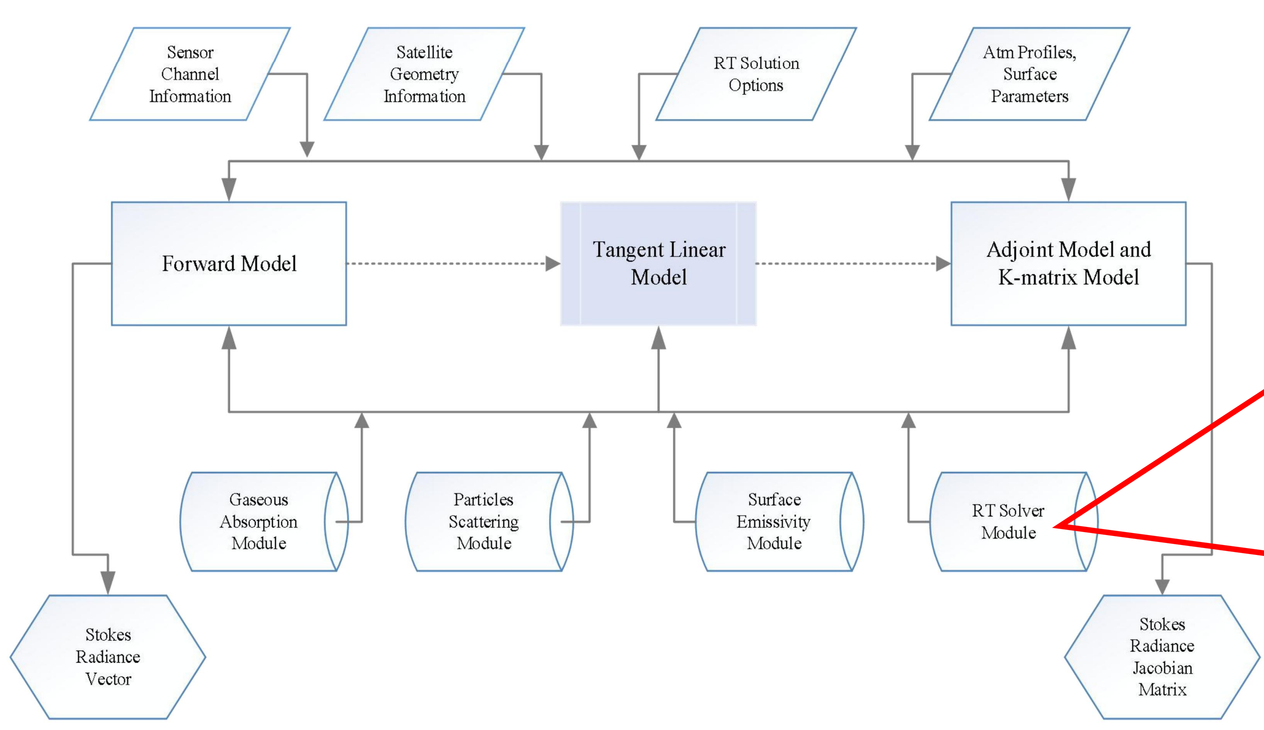


1. Abstract：

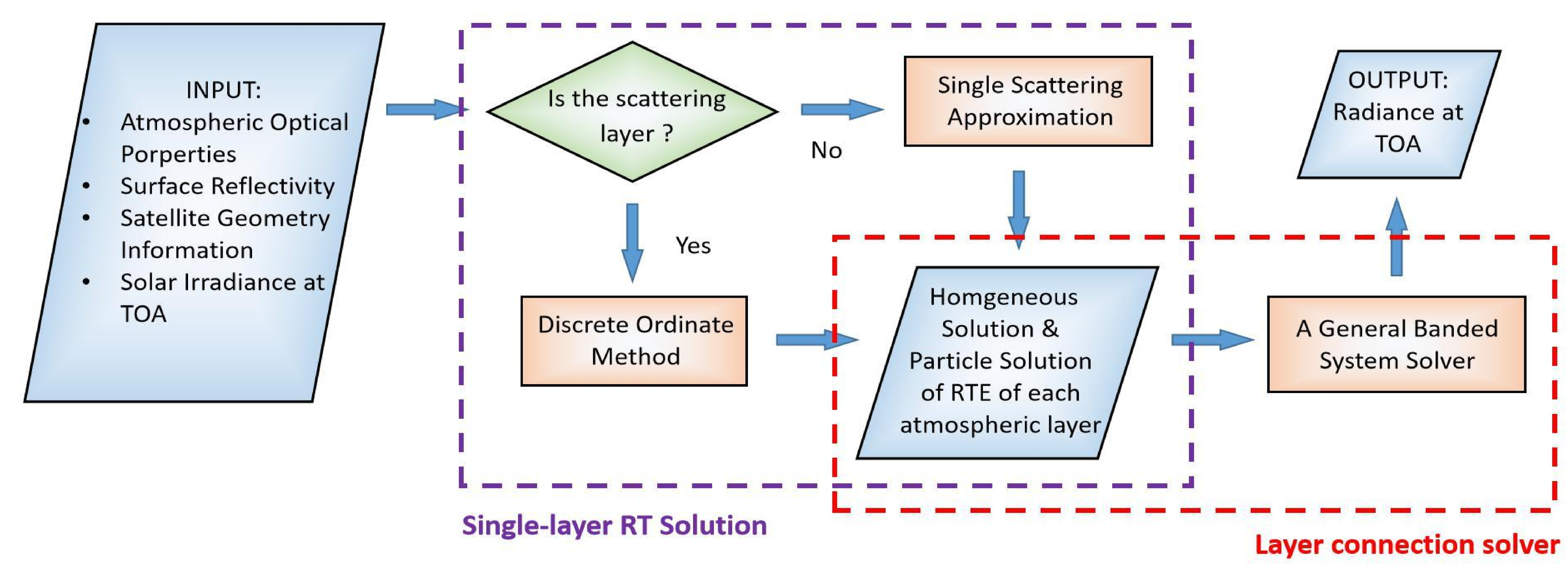
Currently, RTTOV, CRTM and ARMS are commonly used in the NWP for satellite data assimilation and remote sensing. Doubing Adding (DA) and Discrete Ordinate Method (DOM) are used to solve the RT process in CRTM and RTTOV, respectively. Both DA and DOM are accurate but time-comsuing. Therefore, we proposed Hybrid Radiative Transfer Scheme for ARMS to accelerate simulating RT process. In HRTS, the Single Scattering Approximation (SSA) and DOM are used to solve the single-layer Radiative Transfer Equation (RTE) in non-scattering and scattering medium, respectively. The layer connection is handled by a general banded system solver. The accuracy and efficiency of HRTS has been evaluated by comparing to DISORT. Results show that HRTS and DISORT have a similar accuracy and reliability, while HRTS is much faster than DISORT under same stream number. In addition, the tangent-linear and adjoint of HRTS are also working and it can be applied to support NWP data assimilation and remote sensing.

2. Flow Chart of HRTS：

- **Framework of ARMS:**

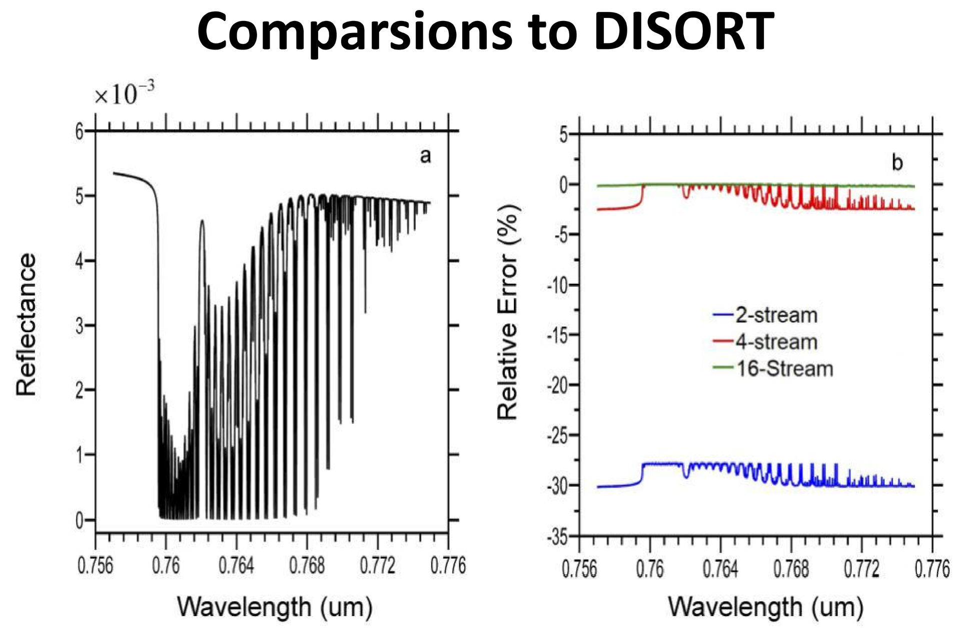


- **Flow Chart of HRTS:**

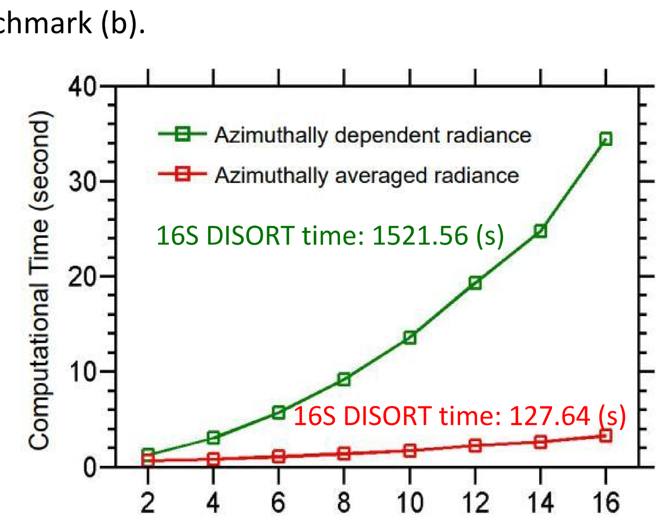


3. Proformance of HRTS：

Comparsions to DISORT

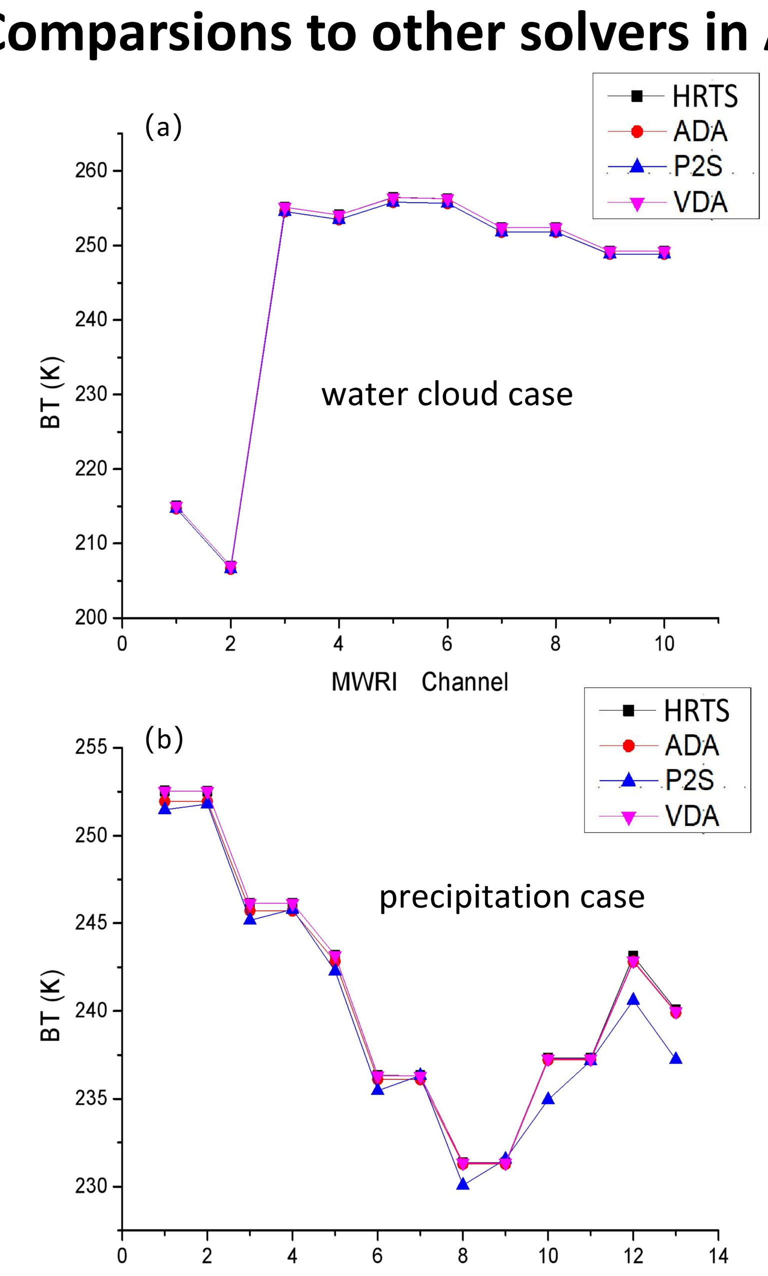


The benchmark of reflectance at TOA calculated by DISORT with 64 stream in hyper-spectral oxygen A-band (3000 profiles) (a). The relative error between 2-stream, 4-stream, 16-stream HRTS and benchmark (b).



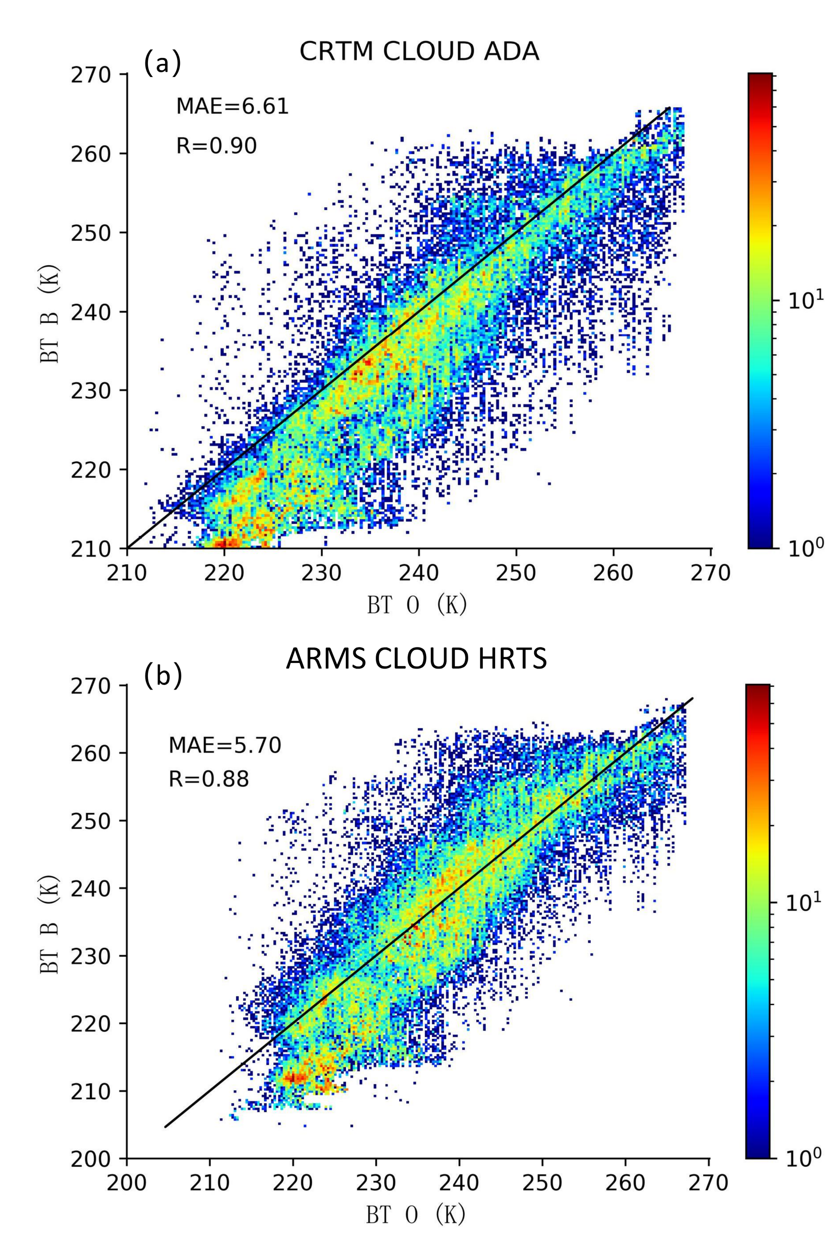
The computational time of HRTS vias number of streams for above case. The green line represent the case for calculating azimuthally dependent radiance while the red line refers to the case for calculating azimuthally averaged radiance.

Comparsions to other solvers in ARMS



The Brightness Temperature (BT) simulated by four solvers (HRTS, ADA, P2S and VDA) in ARMS. (a) is BT at MicroWave Radiation Imager (MWRI) channel for water cloud case. (b) is BT at Global Microwave Imager (GMI) channel for precipitation case.

Comparsions to Observation



The difference of BT between observations and CRTM simulations (a) at MicroWave Temperature Sounder (MWTS) channel. (b) same as (a) but for difference between observations and ARMS simulations.

4. Future Plan of HRTS：

1. Extend HRTS to solve polarized RT process and develop its tangent-linear and adjoint model.
2. Propose analyical Jacobian of HRTS and compare the accuracy and efficiency to the adjoint model