Optimization of air mass factor calculation for GOSAT-GW satellite NO_2 observation

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Background and Purpose

The Greenhouse Gases and Water Cycle Observing Satellite (GOSAT-GW) is scheduled for launch in 2024 as the successor to the GOSAT-1 and GOSAT-2 greenhouse gas observation missions. NO2, a major atmospheric pollutant. It will also be equipped with a grating-type spectrograph and will make more than 3 million observations per day.

The air mass factor (AMF) is used to correct a tilted column of NO2 to a vertical column and is one of the largest sources of error in determining the vertical column of NO2 from observed spectra. The AMF is calculated using a radiative transfer model, but the computational cost of the radiative transfer model is generally high, so in the data processing of satellite observations with a large number of observation points, such as GOSAT-GW, the AMF is calculated for all possible observation cases in advance and stored as a look-up table (LUT). Conventionally, the observation conditions to be stored in the LUT are set empirically, and quantitative discussions are insufficient. In this presentation, we discuss the optimization of input variables and their nodes to be stored in the LUT in order to derive AMF with higher accuracy.

METHODS

We assume a Clear sky with no clouds or aerosols. The five input variables (x) considered are the solar zenith angle (SZA), satellite zenith angle (VZA), relative azimuth angle (RAA), ground surface albedo, and ground surface altitude. For these input variables, nodes were determined in the following manner. SCIATRAN V4.6.1 was used for the radiative transfer model.

1.Calculate the first derivative of the Total AMF (=V(x)) for each input variable (x).

2. Set nodes for input variable (x) so that the integral value of V(x) is equal

Results and Discussion

Using this method, LUTs with 2401 combinations (LUT2401) to 50625 combinations (LUT50625) were created. For each input variable, 100x100 test cases were calculated randomly along the density distribution assuming the GOSAT-GW observation pattern, and the AMFs interpolated from the calculation results stored in the LUTs according to the test case cases were compared with the AMFs calculated directly by the radiative transfer model. The interpolation method used was the Regular Grid Interpolator (RGI) built into the scipy module of Python. RMSE and RMSPE were used to evaluate accuracy; as the number of patterns stored in the LUT was increased from LUT2401 to LUT50625, the RMSE and RMSPE decreased from 0.0279 (1.286%) to 0.0194 (0.971%). For the conventional LUT (LUT35000) with a conservative 35000 combinations of nodes, the RMSE and RMSPE were 0.0609 (2.505%), and this method reduced the RMSE and RMSPE by only 0.0415 or 38%. On the other hand, the computation time was 0.59687 seconds for LUT2401 and 0.5359 seconds for LUT50625, and no significant difference was observed for the number of patterns to be stored.

Conclusion.

Optimizing the patterns to be stored in the LUTs using this algorithm reduced the RMSE and RMSPE by only 0.0415 and 38%, respectively, compared to the conventional conservatively created LUTs. On the other hand, no significant difference in computation time according to the number of storages was observed using this algorithm.

Keywords: GOSAT-GW, AMF