New inverse algorithm for CO2 retrieval from satellite observations

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Atmospheric carbon dioxide (CO2) is a primary greenhouse gas that has persistently increased over the past few decades. It is a major driver of regional and global climate change. Most CO2 sources and sinks are located near the surface. Observations from shortwave infrared sounders loaded on satellite, such as the Greenhouse Gases Observing SATellite (GOSAT) and Orbiting Carbon Observatory (OCO-2) can provide accurate measurements of the column-averaged atmospheric CO2 concentration.

The atmospheric radiative transfer equation (RTE) is a Fredholm integral equation of the first kind, which is recognized as likely to be ill-conditioned. Thus, the inverse problem based on the RTE is not well posed. The inverse method for atmospheric gas profiles retrieval is usually based on optimization theory.

In a recent paper, an improved constraining method for satellite CO2 remote sensing in the (short-wave infrared) SWIR band was proposed, which combines a pre-processing step applied to the a priori state vector prior to retrievals, with the modified damped Newton method (MDNM).

MDNM contains two constraining factors that stabilize the retrieval iterations. The Levenberg-Marquardt parameter (γ) is used to ensure a positive Hessian matrix, and a scale factor (α) is used to adjust the step size. The algorithm iteratively searches for an optimized solution using observed spectral radiances, and parameters (γ and α) are appropriately adjusted. A pre-processor for initializing the first guess (X0) prior to the

retrievals, when the algorithm detects that X0 is far from the true state vector. A new data-screening method for detecting cloud scenes is also presented based on the different spectrum shapes in the oxygen-A and two micron bands.

This research aims to stabilize the retrieval iterations. Preliminary validations indicate that the quality of the MDNM-based retrieval results is relatively stable.

More information: MingMin Zou et al, An improved constraint method in optimal estimation of CO2 from GOSAT SWIR observations, *Science China Earth Sciences* (2016). DOI: 10.1007/s11430-015-0247-9

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