National Aeronautics and Space Administration

FY24 R&TD Innovative Spontaneous Concepts (ISC)

Multispectral retrievals of CO_2 and CH_4 for Improved Carbon Flux Source Attribution

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Strategic Focus Area: Innovative Spontaneous Concepts

Objective: To determine the sensitivity of vertical information for CO_2 and CH_4 using measurements in the near-infrared, thermal infrared or combination of those spectral regions in the presence and absence of aerosols.

Background: There is significant uncertainty in the timing and location of carbon sink-to-source transitions. Multi-spectral (SWIR+TIR) GHG retrievals can help quantify multiple trace gases (CO_2, CH_4, CO) and multiple pieces of vertical information (lower and upper troposphere) needed to isolate carbon flux location and process. We aim to use the multispectral PanFTS instrument developed at JPL to improve our ability to characterize the vertical information content of GHG retrievals under enhanced aerosol loads.

Approach and Results: We use the 2S-ESS RTM developed by PI Natraj (Natraj et al., 2023) coupled with an instrument model developed by Co-I Blavier and an inverse model developed by Co-I Luo. The retrieval methodology follows the Bayesian estimation approach commonly used in the remote sensing of atmospheric composition. We perform simulations over two locations (Tabatinga and Santarem; see Figure 1), two times of day (6 am and 6 pm), two dates/seasons in 2015 (March 15, September 15), and four spectral regions in the SWIR (4130–4300 cm^{-1}, 4810–4900 cm^{-1}, 5950–6150 cm^{-1}, 6170–6340 cm^{-1}) and three in the TIR (650–1100 cm^{-1}, 1210–1380 cm^{-1}, 2250–2450 cm^{-1}). The spectral radiance, showing the various gaseous absorption signatures, is plotted in Figure 2.

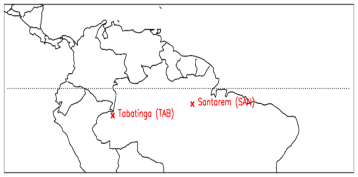

Figure 1: Simulation locations

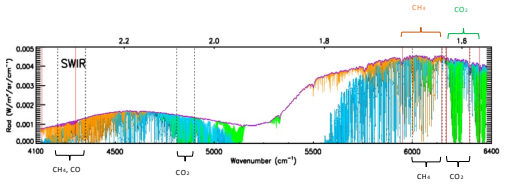

Figure 2. Spectral radiances

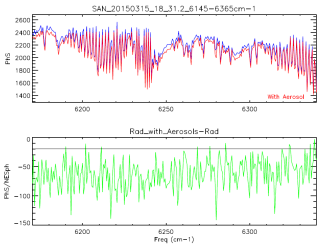

Figure 3. Spectra with and without aerosols

The degrees of freedom increase from 1.1 for CO_2 retrievals and ~1.25 for CH_4 retrievals to ~2 for both trace gases when we go from SWIR-only to SWIR+TIR measurements. A comparison of radiances with and without aerosols (Figure 3) indicates that the differences are much larger than the instrument noise, implying that it will be important to properly characterize the aerosols in order to minimize retrieval uncertainties. Future work will focus on the simultaneous retrieval of aerosol parameters together with the trace gas profiles.

Significance/Benefits to JPL and NASA: The work performed here is a critical step to understand the spectral characteristics required for an instrument designed to estimate GHG vertical profiles, which in turn is essential for making accurate measurements in regions impacted by humans. Further, the retrieval OSSE will enable flux inversions and reduce instrument costs needed for viable mission concepts.

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