Aerosol First Guess Sensitivity in the Atmospheric CO$_2$ Observations from Space (ACOS) XCO$_2$ Retrieval Algorithm

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In this work we investigate how modifying the first guess of various aerosol parameters impacts space-based measurements of the column-averaged dry-air mole fraction of carbon dioxide and corresponding aerosol properties. Based on sensitivity experiments, it has been shown that approximately 1-5 pieces of aerosol information can be retrieved from Orbiting Carbon Observatory-2 (OCO-2) measurements. However, the NASA Atmospheric CO$_2$ Observations from Space (ACOS) XCO$_2$ retrieval algorithm attempts to measure 8 aerosol parameters: the height and amount of four types. Because of this, there may be multiple valid optimizations of the state vector, which may significantly impact the retrieved XCO$_2$.

We find that, as hypothesized, the ACOS XCO$_2$ retrieval algorithm is generally sensitive to the first guess of aerosol parameters. Perturbing the first guess of aerosol heights and amounts often results in 1-2 ppm variations in the retrieved XCO$_2$, which indicates non-linearity in the retrieval algorithm. These results suggest that more information may be needed to help constrain the aerosol solutions. Incorporating other satellite measurements, adjusting the algorithm's aerosol parameterization, and improving the *a priori* information may help solve this problem.
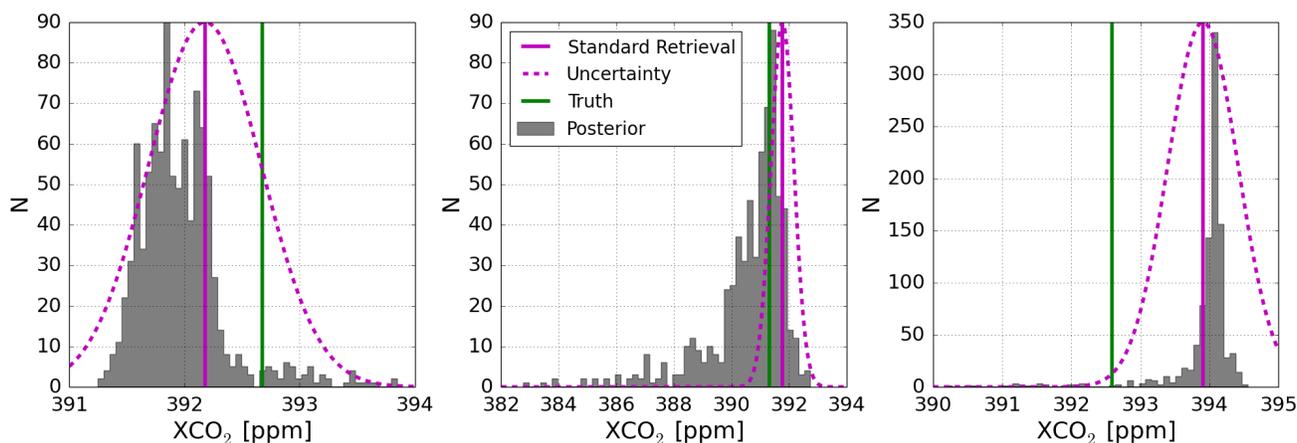

Figure 1. Sensitivity of the ACOS XCO$_2$ retrieval algorithm to "first guess" changes for three unique measurements. The true XCO$_2$ is the solid green line, the retrieved XCO^2 using the standard prior heights and amounts of all four aerosol types is the solid purple line, and the retrieved posterior uncertainty of the standard XCO$_2$ is the dashed purple line. The grey distribution is 1000 test cases with modified aerosol first guesses and constant a priori.