What Can We Learn From Performing Simplified X_{CO_2} Retrievals on Synthetic Near-Infrared Observations?

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Introduction

- The primary goal of OCO-2 is to use hyperspectral measurements of reflected near-infrared sunlight to retrieve the column-averaged dry-air mole fraction of carbon dioxide (X_{CO_2}) with high accuracy[1].
- One of the primary sources of uncertainty in the algorithm remains its cloud and aerosol parameterization. This is because near-infrared measurements are highly sensitive to even small levels of cloud or aerosol contamination.
- Here, we investigate multiple simplified aerosol schemes in an attempt to minimize errors in X_{CO_2} by reducing the number of retrieved aerosol parameters (9 in OCO-2 B8) to be within the range of actual degrees of freedom (2-6)[2]. Expected benefits of reduced algorithm complexity include faster convergence, less nonlinearity, and greater throughput.
- We also present work on the use of instantaneous modeled aerosols as *a priori* information and its impact on real retrievals of X_{CO_2}.

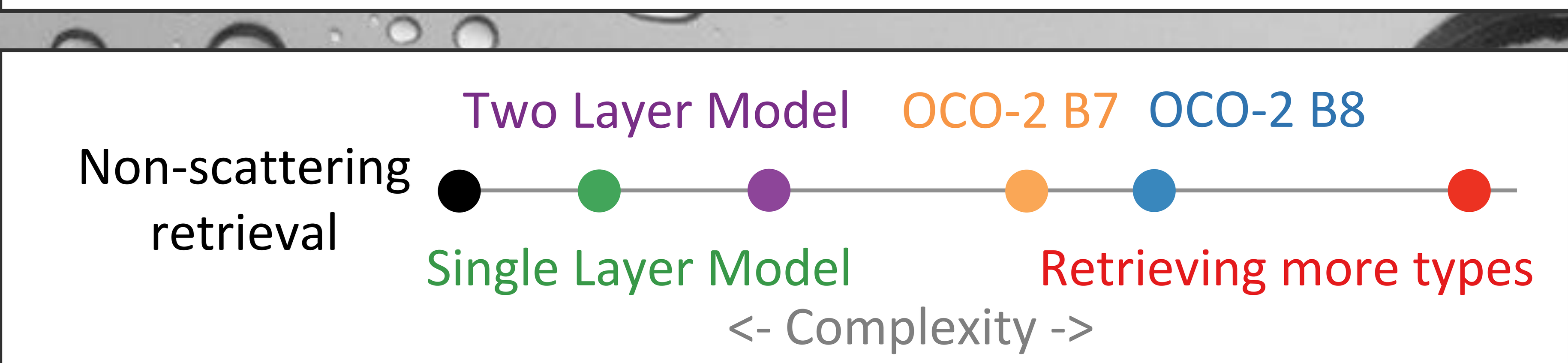


***Figure. 1**. The OCO-2 B8 aerosol parameterization may be more complicated than necessary.*

Name	# Aero. Layers	# Aerosol Types per Layer	Retrieve Particle Size Information	Note or Aerosol Types Used
B8	5	1	No	Operational Algorithm
1-Layer Multi-Type	1	2	No	Dust and sulfate
2-Layer Multi-Type	2	2	No	Dust/sulfate in lower layer, ice/sulfate in upper
1-Layer Effective Radius	1	2	Yes	Retrieve AOD, height, and r_eff of one generic type

***Table 1**. Different simplified X_{CO_2} retrieval schemes.*

Data & Methodology

- For this work, we've developed two new synthetic OCO-2 datasets:
  - The first using the Colorado State University OCO Simulator[3] and ingesting realistic GEOS-5 FP-IT aerosol profiles as a function of size bin and relative humidity (results in Fig. 3).
  - The second using a synthetic matrix of aerosol profiles designed to cover the full range of physical aerosol layer optical depths, heights, widths, and types (results in Figs. 4 and 5).
- Information content analyses have shown that OCO-2 should primarily be sensitive to an aerosol layer's optical depth, height, and effective radius[2].
- All four simplified retrievals (Table 1) were run on one orbit of synthetic radiances generated using the 1st method described above (Fig. 3). Three retrievals were run using radiances generated via the 2nd method (Figs. 4 & 5).
- Six retrieval variants were run on a large set of real OCO-2 radiances co-located with TCCON (Fig. 6). The top row ingested instantaneous optical depths with varying levels of uncertainty while the bottom row ingested optical depth, height, and width information with varying levels of uncertainty (all from the GEOS-5 FP-IT model).

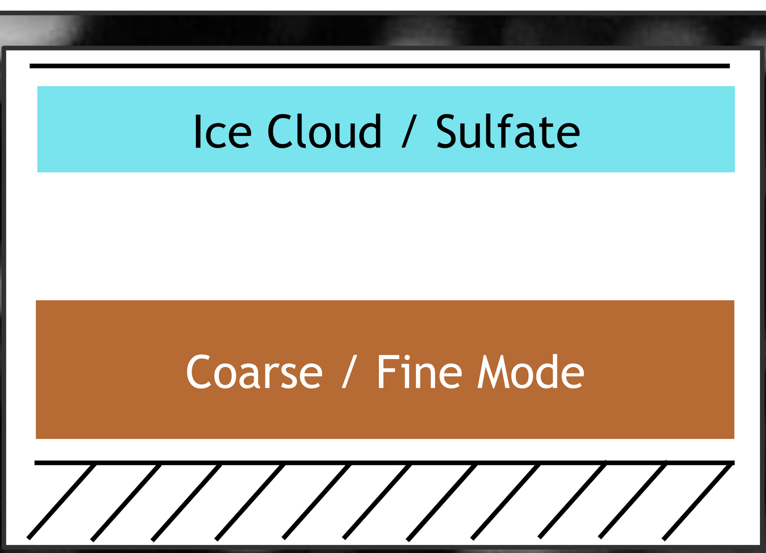


***Figure 2**. Schematic of the 2-layer multi-type aerosol model designed to retrieve fewer aerosol parameters than the operational OCO-2 retrieval algorithm.*

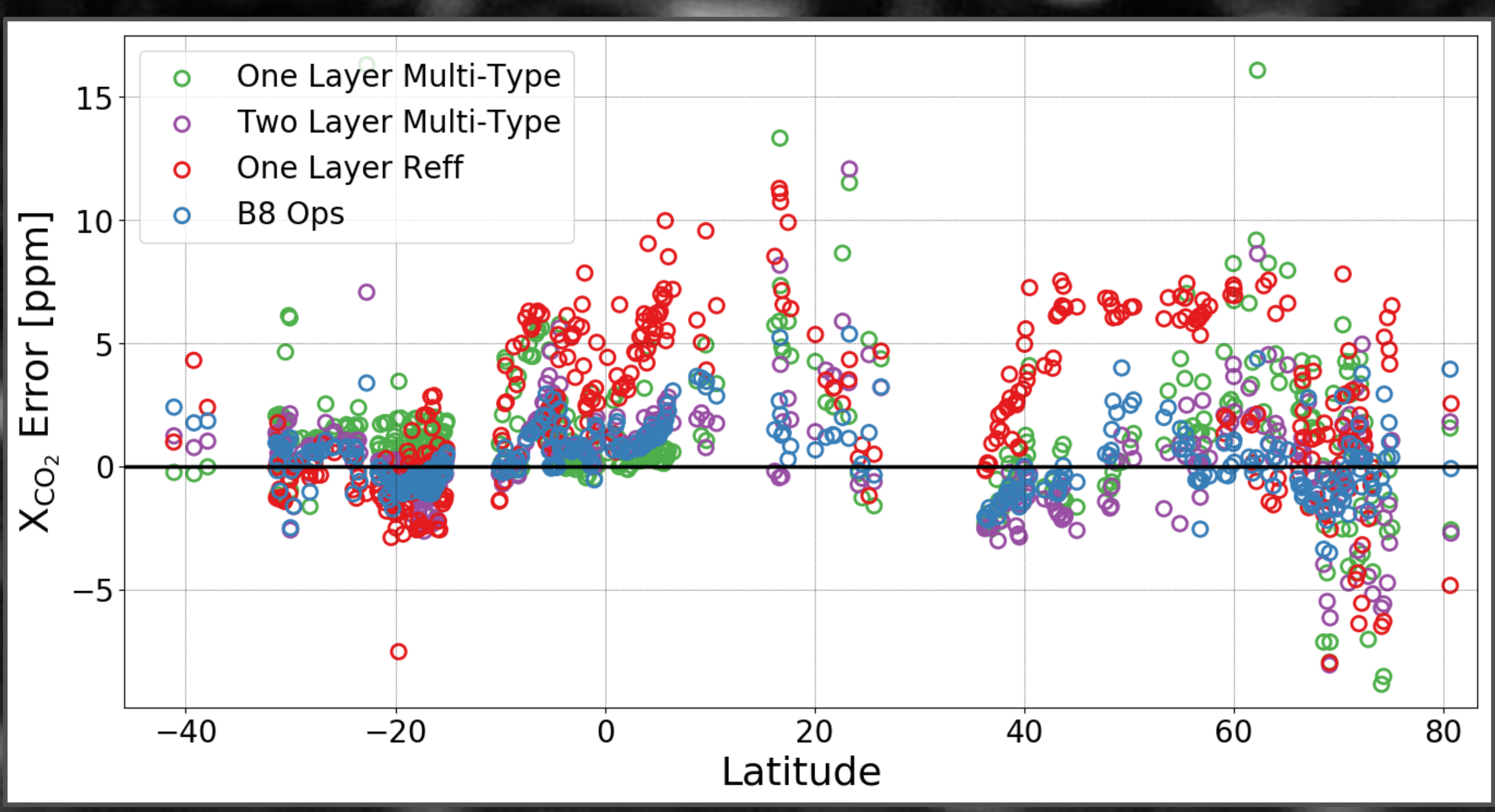
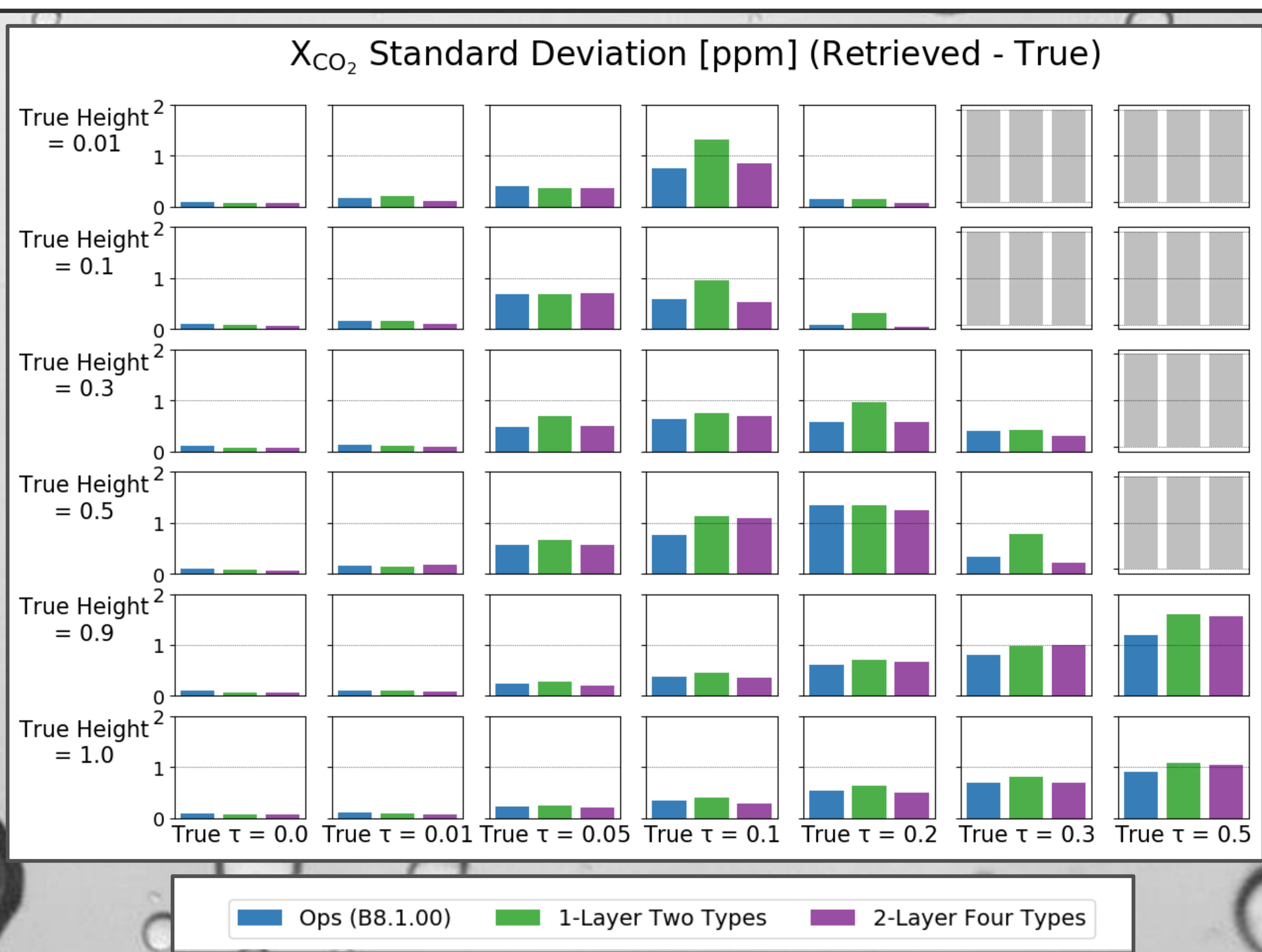
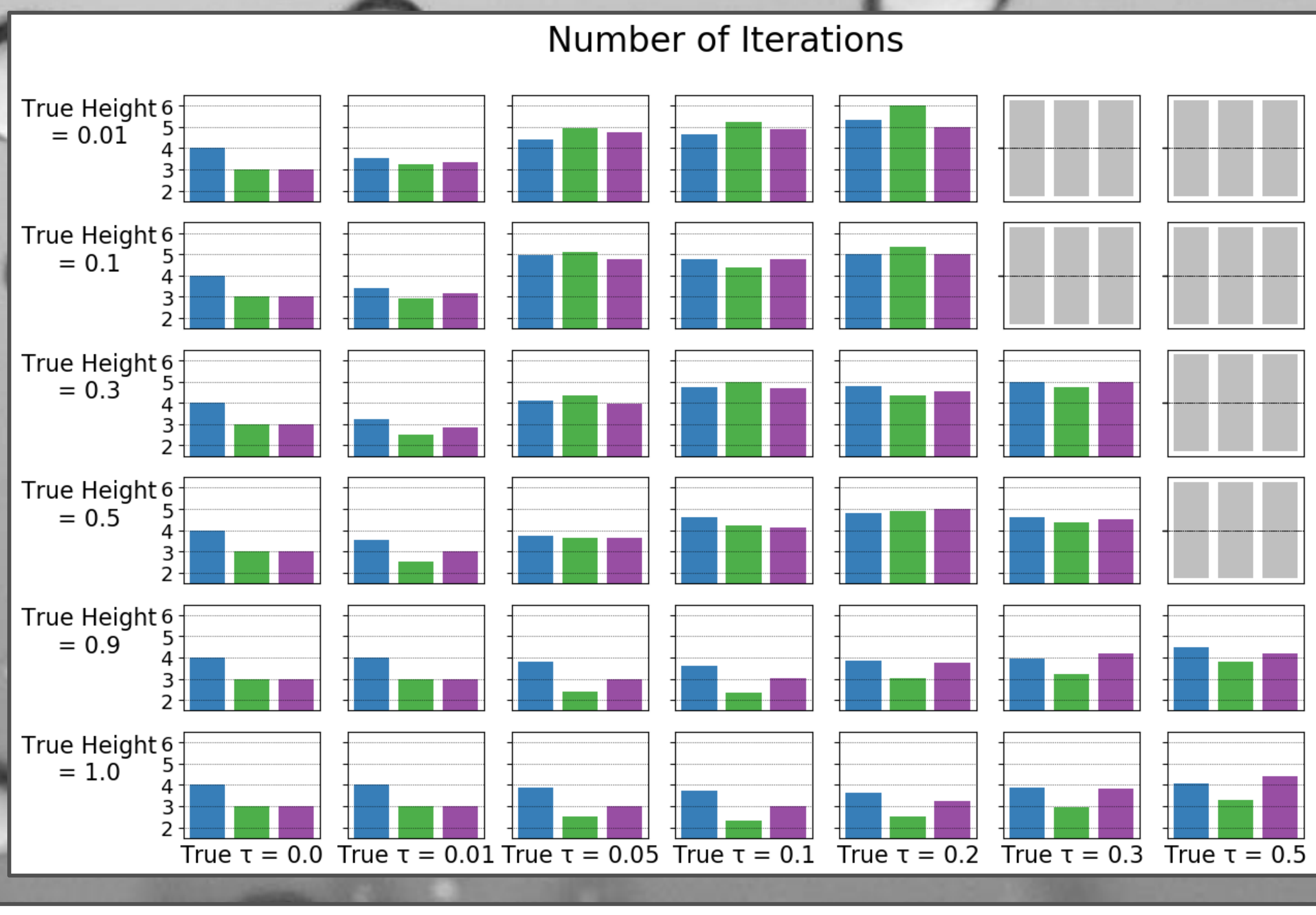


***Figure 3**. X_{CO_2} error of the four retrieval types for one synthetic OCO-2 orbit.*



*Synthetic aerosol matrix showing the standard deviation of the retrieved X_{CO_2} error (**Figure 4**, above) and number of iterations (**Figure 5**, below).*



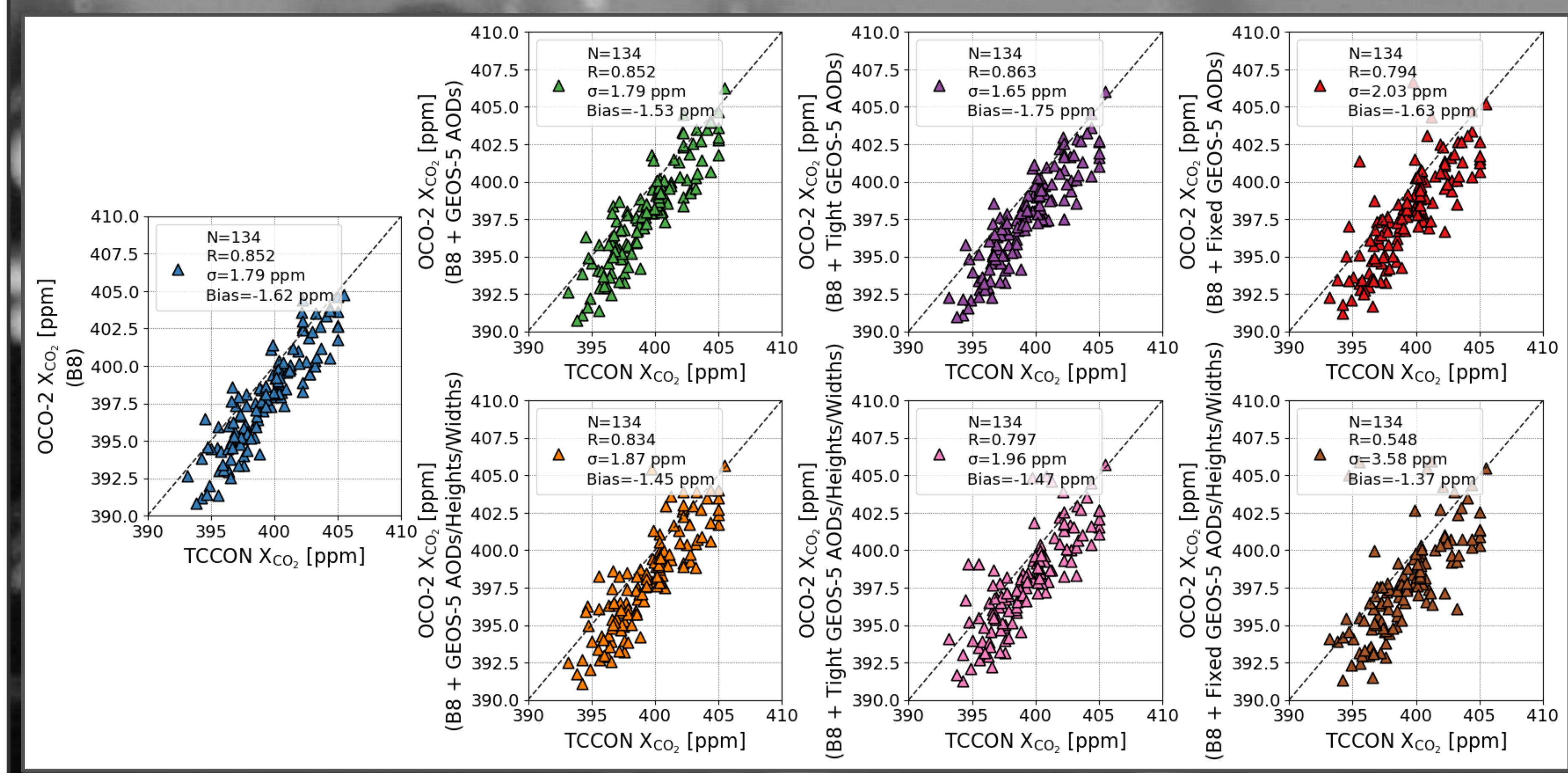


***Figure. 6**. Retrievals run on real measurements co-located with TCCON. Different combinations of GEOS-5 aerosol information and uncertainty were ingested as a priori.*

Results

- 1- and 2-layer models perform about as well as B8, but can be computed faster due to fewer iterations being needed to converge (Figs. 4 and 5).
- New 1-layer effective radius retrieval performs poorly (Fig. 3)
- Improved aerosol prior tests (Fig. 6) reveal a small reduction in X_{CO_2} scatter when using instantaneous modeled optical depths but not our Gaussian profile fit technique. This is likely due to the limitations of fitting a single Gaussian to a full atmospheric profile of aerosol.
- Next steps:
  - Continue to investigate the effective radius retrieval
  - Create customized filtering & bias corrections for simplified retrievals
  - Analyze information content in retrieved aerosol properties

References

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[2] Frankenberg et al.: Aerosol information content analysis of multi-angle high spectral resolution measurements and its benefit for high accuracy greenhouse gas retrievals, Atmos. Meas. Tech., 5, 1809{1821, doi:10.5194/amt-5-1809-2012, 2012.

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