Supplementary materials:

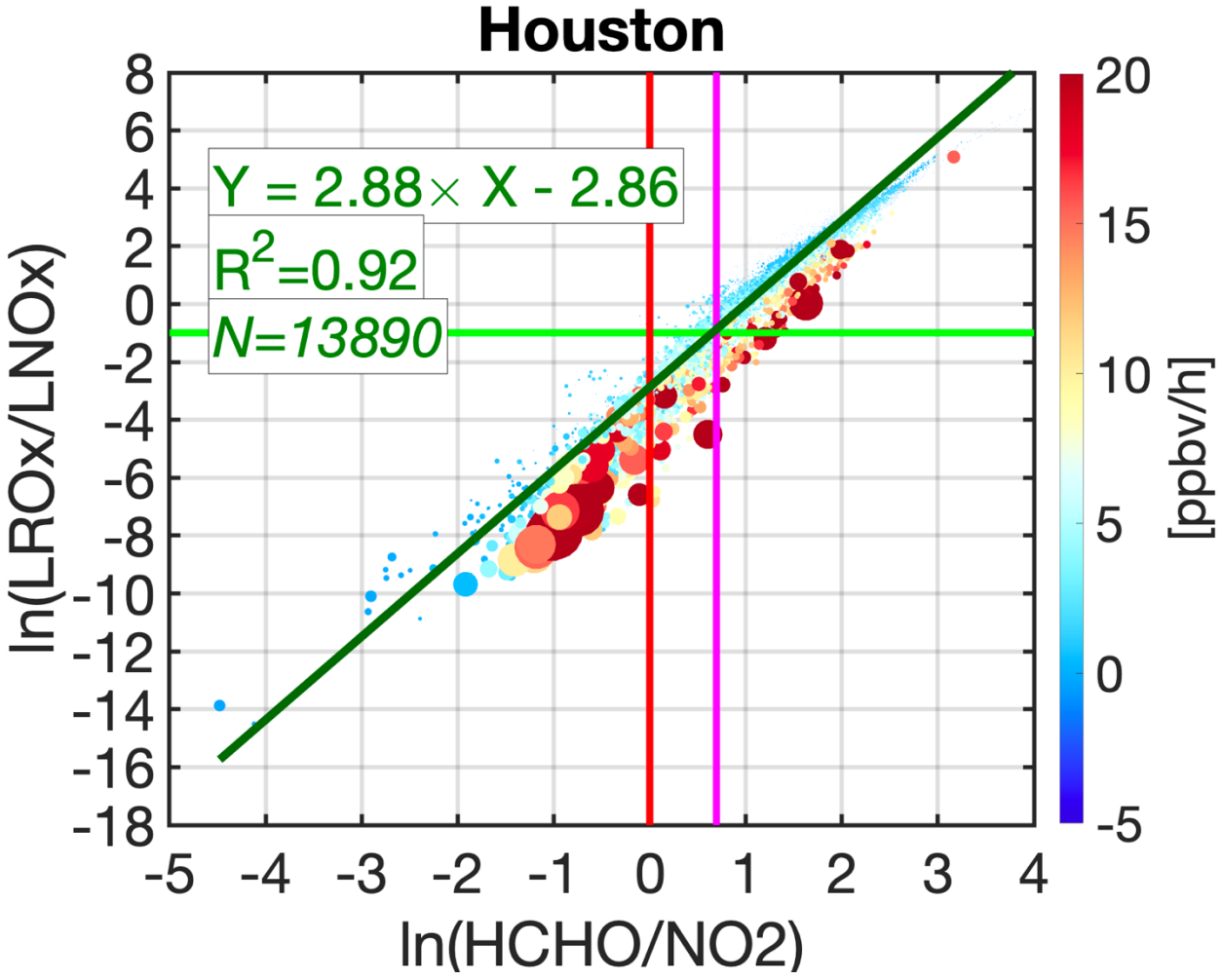

Figure S1. The scatterplot of natural logarithm-transformed of $HCHO/NO_2$ versus LROx/LNOx based on the simulated values performed by the F0AM box model during DISCOVER-AQ Texas 2013. The heat color indicates the calculated ozone production rates (PO_3). The size of each data point is proportional to $HCHO \times NO_2$. The light green line is the baseline separator of NOx-sensitive (above the line) and VOC-sensitive (below the line) regimes. We overlay $HCHO/NO_2=1$ and $HCHO/NO_2=2$ as red and purple lines, respectively. The dark green line indicates the least-squares fit to the paired data.

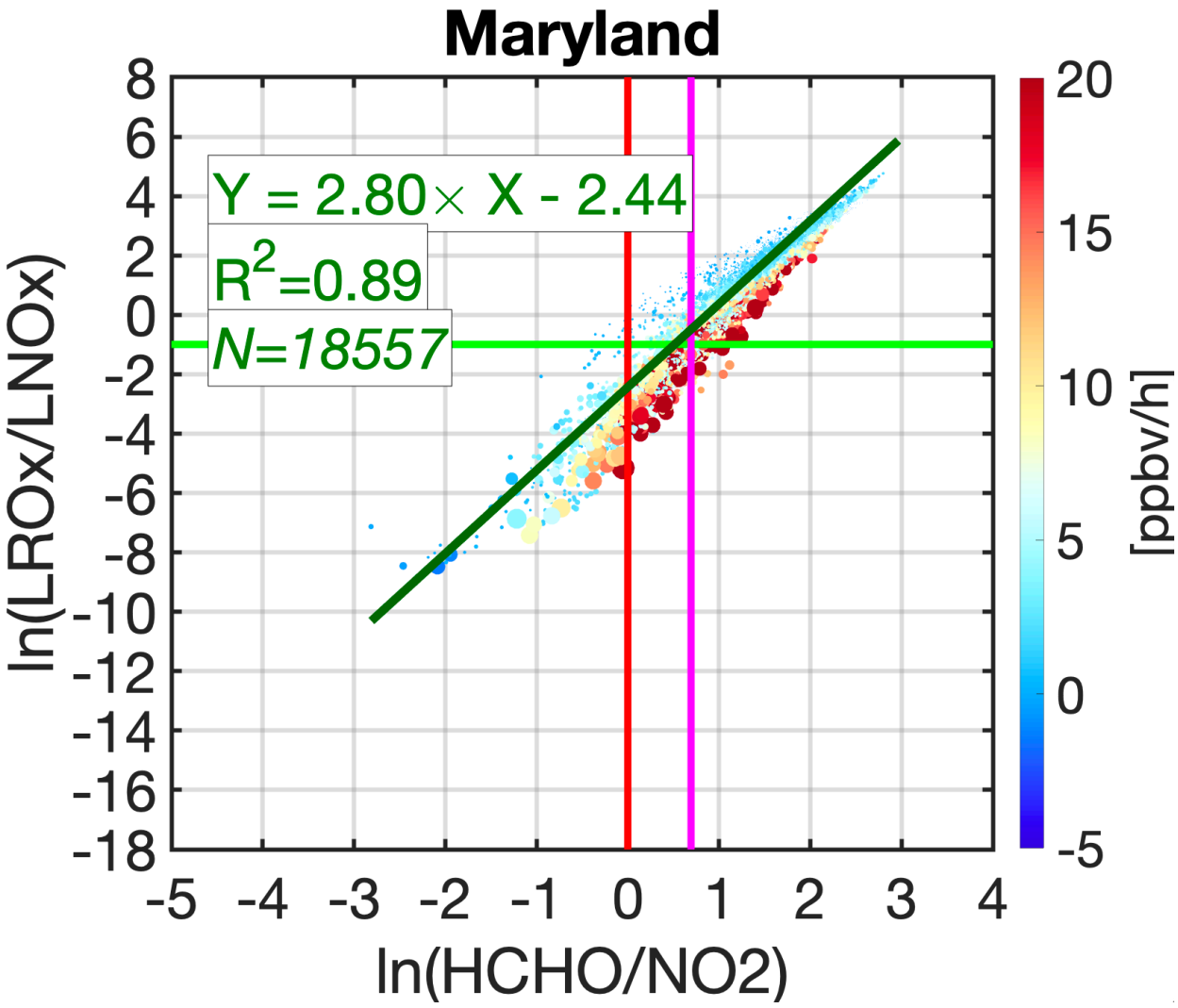

Figure S2. Same as Figure S1 but for DISCOVER Maryland 2011.

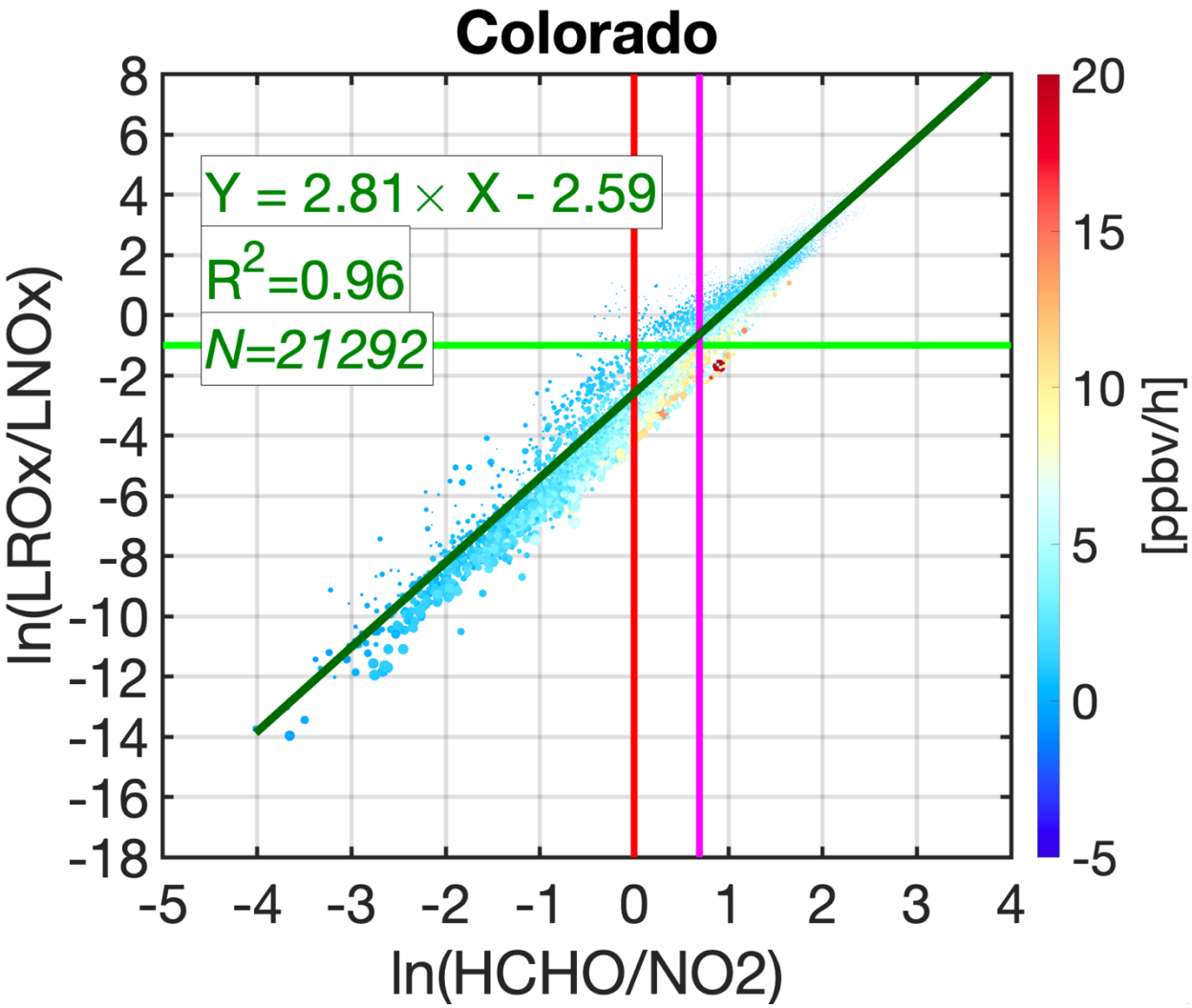

Figure S3. Same as Figure S1 but for DISCOVER Colorado 2014.

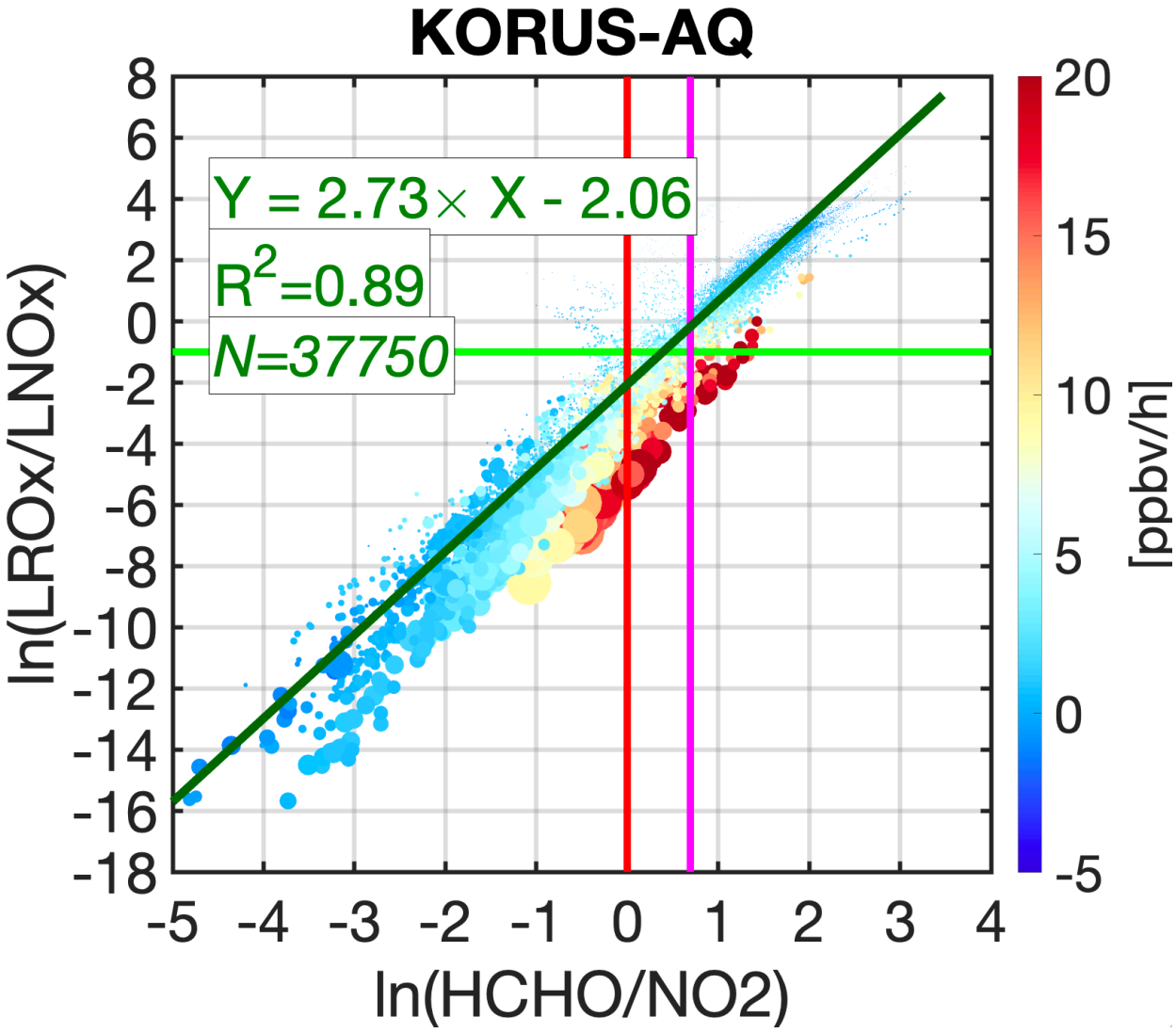

Figure S4. Same as Figure S1 but for KORUS-AQ 2016.

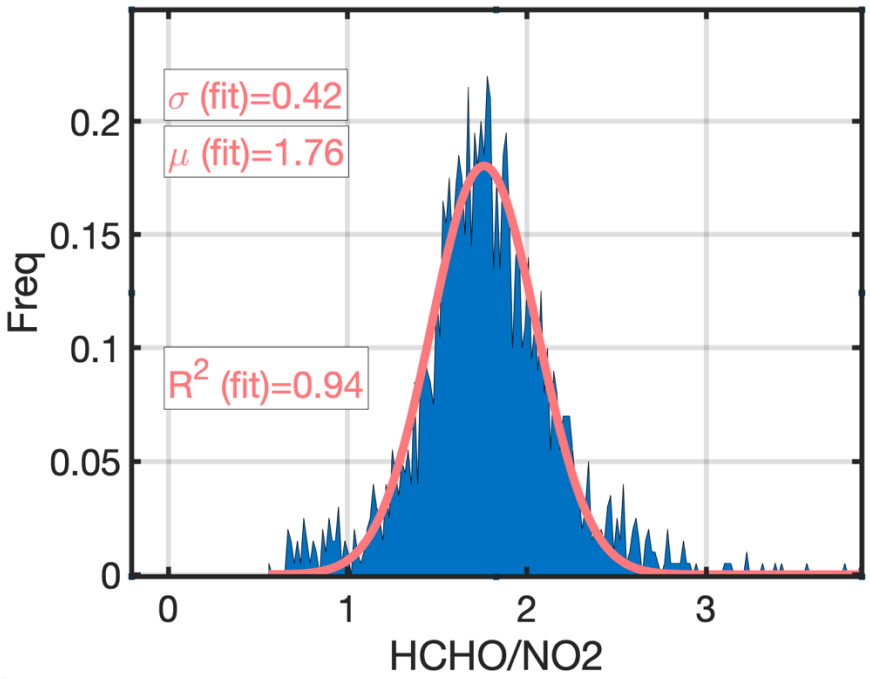

Figure S5. The histogram of transitioning ratios based on simulated values of ln(LROx/LNOx) = -1.0±0.2.

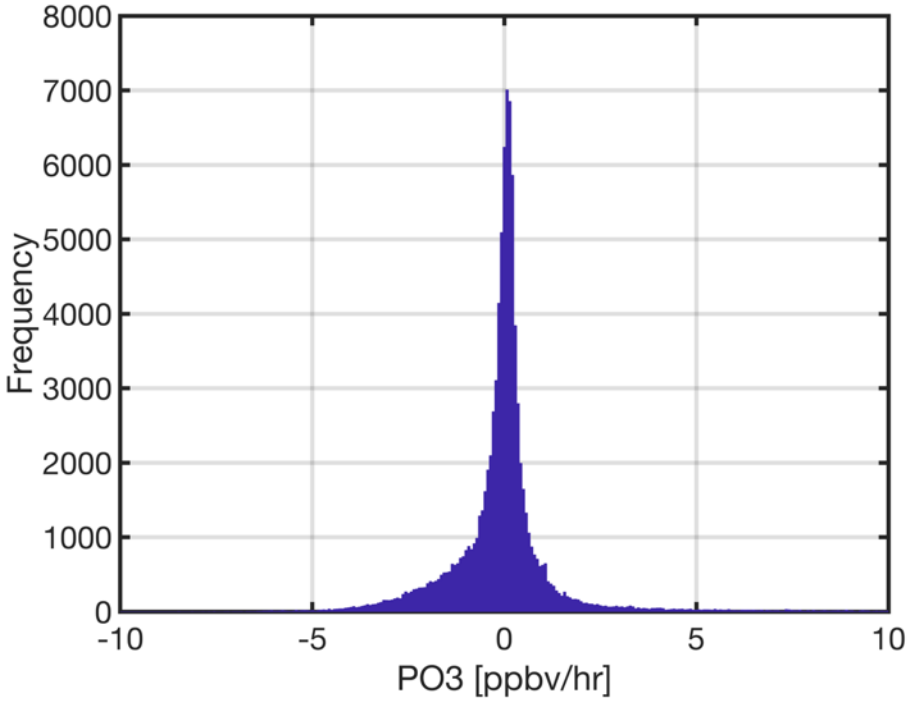

Figure S6. The residuals for the fit described in Eq4 in the main text.

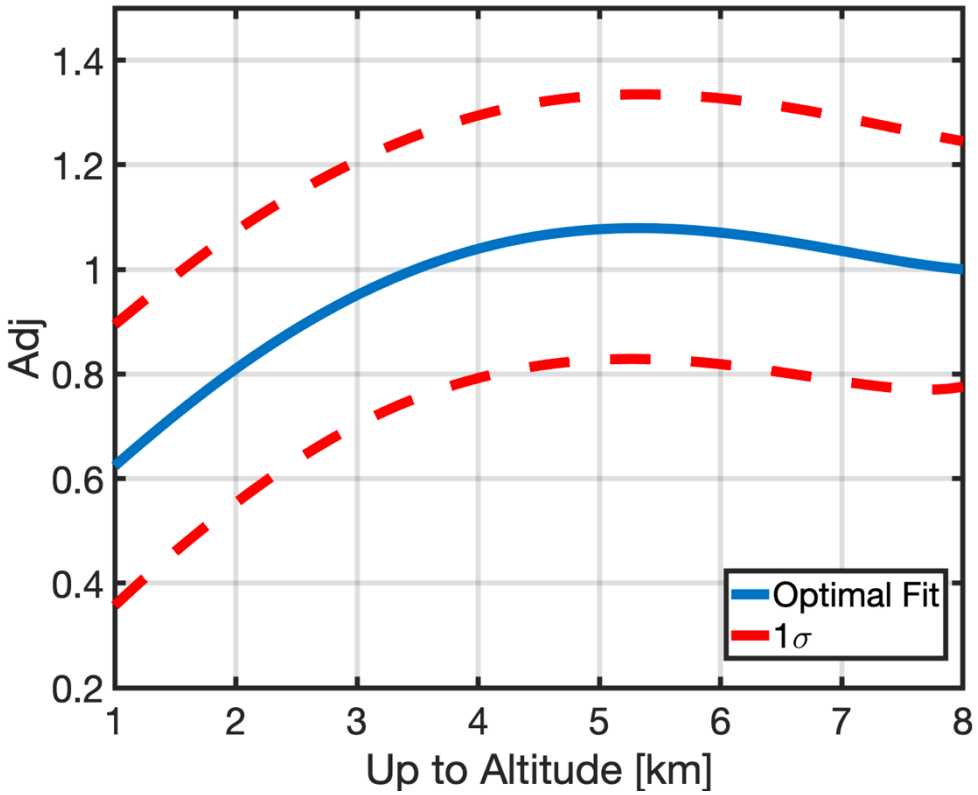

Figure S7. The adjustment factor defined as the ratio of the centriod (first moment) of the polygon bounding 1st and 75th percentiles of the observed HCHO/NO_2 columns by the NASA's aircraft between the surface to 8 km to the ones between the surface and a desired altitude. This factor can be easily applied to the observed HCHO/NO_2 columns to translate the value to a desired altitude streteching down to the surface (i.e., PBLH).

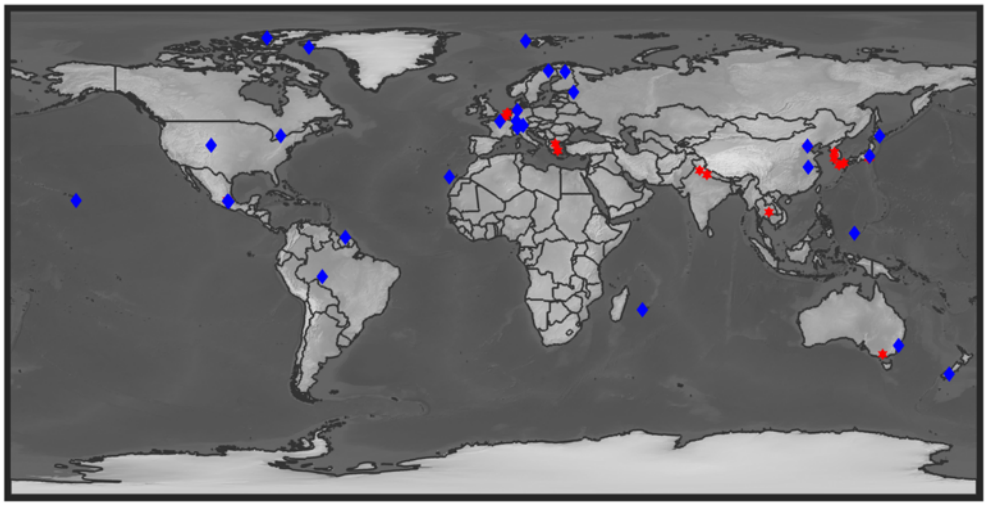

Figure S8. The location map of MAX-DOAS (red) and FTIR (blue) stations.

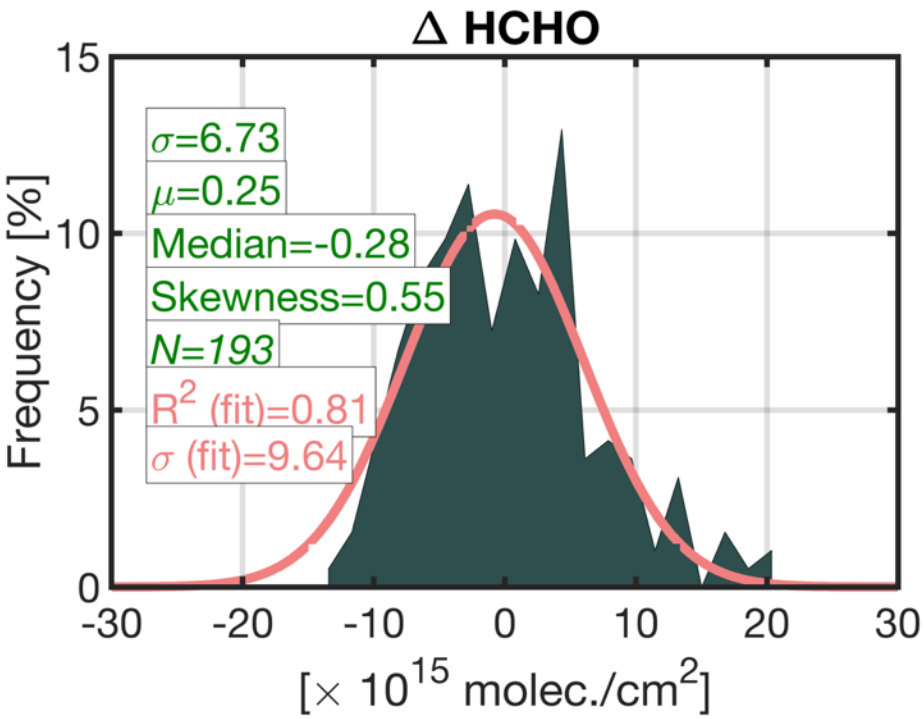

Figure S9. The histogram of the differences between OMI and corrected GEOS-Chem simulations on monthly basis. The statistics in green color are based on all data, whereas those in pink are based on the fitted Gaussian function.

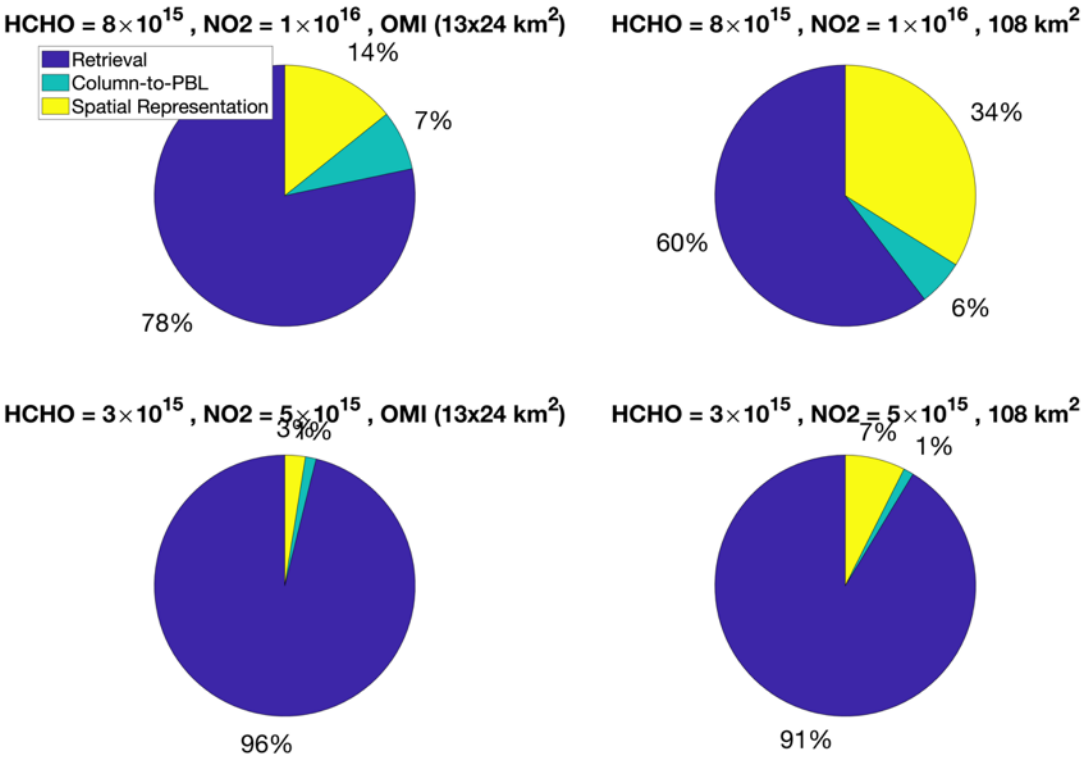

Figure S10. The fractional errors of retrieval (blue), column to PBL translation (green), and spatial representation (yellow) of the total error budget for different concentrations and footprints based on OMI sigma values. HCHO OMI sigma is from monthly comparison (Figure S9).