Response to L. Flynn (Referee)'s comments

We would like to appreciate earlier your comments. The followings are responses to comments.

Comment #1: Much of the improvement comes from the better A Priori (Figure 6).
Response #1: Yes. The motivation of this paper is to improve the climatological a priori information through tropopause information so as to improve the retrievals especially in the extratropical upper troposphere and lower stratosphere. The retrievals further significantly improve over the a priori by bringing in OMI information.

Comment #2: How much do the averaging kernels change between TB, AB and LLM (Figure 8)?
Response #2: Due to smaller a priori errors around the extratropical tropopause, the values of averaging kernels are smaller with the use of TB a priori than with that of other a priori around the tropopause. But the changes at other altitude ranges and in the tropics are very small. On average, the total Degree of Freedoms for Signal (DFS) changes range from ~0.1 at Sodankyla and HohenpeiBenberg and to ~0.01 at Nairobi and Ascension Island.

Comment #3: What are the biases for the A Prioris for these stations?
Response #3: The following figure shows priori comparison at six stations, corresponding to Figure 8. Standard deviations for the TB a priori are significantly smaller in the UT/LS at three middle and high latitude stations than those for the other a priori climatologies. The a priori profiles do not necessarily agree better with ozonesondes at individual stations than other climatologies as the a priori profiles are derived from multiple stations within a 10° latitude band. The retrieval comparisons typically show better agreement in mean biases with ozonesonde observations, and very significant reduction in standard deviations through the altitude range at all stations. The differences between TB a priori and ozonesonde presents larger negative biases in the stratosphere and larger standard deviations in the upper part of the stratosphere at Hohenpeiβenberg and Wallop Island. This large difference arises because the TB a priori is defined as the weighted mean between the tropical (25°N) and extratropical TB climatology when tropopause height is greater than 13 Km, especially during summer and fall. In the lower troposphere, AB a priori values show slightly better agreement with ozonesonde than do TB a priori values because sonde profiles were separated in the tropical and extratropical groups for developing TB climatology whereas AB climatology derived using all sonde profiles without additional tropopause constraint. LLM a priori show significantly larger positive biases above the tropopause and negative biases below the tropopause than TB/AB a priori, which is consistent with the comparison between retrievals and ozonesonde not convolved with OMI avgk. This is probably because of more ozonesonde stations in the northern tropical regions and longer time periods of data for use in developing the TB/AB climatologies as mentioned in manuscript.

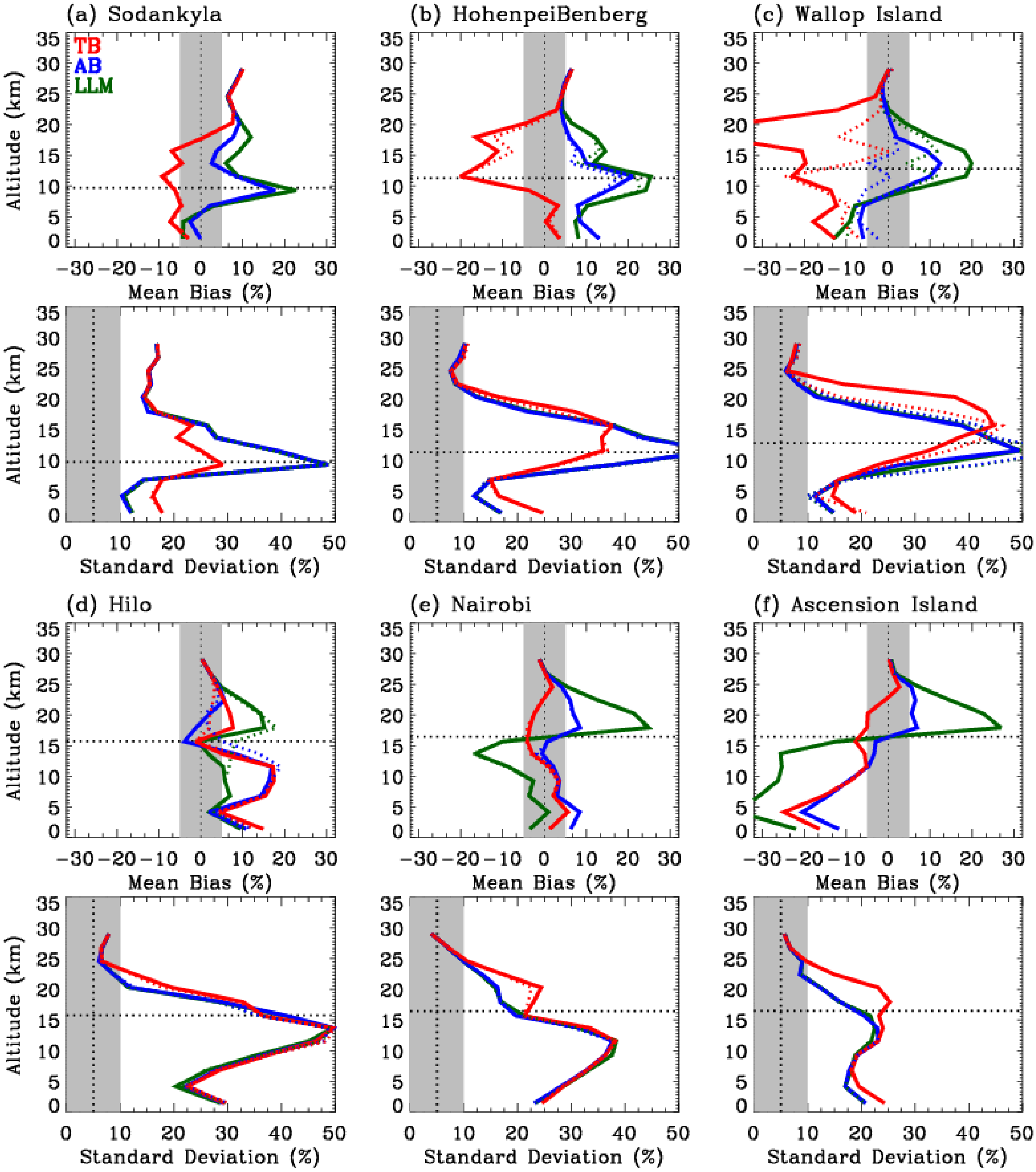

Figure: Same as Figure 8 in the manuscript, but for relative differences between a priori and ozonesonde profile without convolution using OMI averaging kernels. The solid lines represent the comparison from all samplings used in Figure 8. The dotted lines represent the comparison with tropopause height ≤ 13 km at extratropical stations and with tropopause height ≥ 15 km at tropical stations, respectively.

Comment #4: Were the sondes used in these comparisons used in constructing the A Priori statistics?

Response #4: Most of the sondes used in comparisons are used in the development of the climatology. However, the climatology is derived from 25 years of data and includes multiple stations within a 10° latitude range. Unlike neural network methods, which use different data for training and testing, developing a priori climatology for the optimal estimation typically includes ozone profile from all stations.

Comment #5: How much information does the Tropopause Pressure bring in without a measurement?
Response #5: Tropopause provides additional O3 a priori information only with the use of TB climatology. The information that the tropopause (with TB climatology) brings in without a measurement, i.e., TB a priori, has been addressed in response 3.

Comment #6: How was the non-stationarity of the sonde data set handled? There are trends in both tropospheric and stratospheric ozone over this time period.

Response #6: As described in the paper, we just used the mean profiles within a certain latitude band and month (all years) and their standard deviations. We have not attempted to produce a time dependent climatology (except for monthly variation) accounting for the trend.

Comment #7. How do posed regime shifts influence/interact with the authors' categorization of airmasses? See literature by Fusco and Salby, Hood et al., and Hudson et al. (E.g, Hudson et al.: The total ozone ïnˇA˛eld separated into meteorological regimes. Part I:DeïnˇA˛ning the regimes, J. Atmos. Sci., 60, 1669–1677, 2003. and references therein.)

Response #7. The regime could be separated by both total ozone and tropopause height. Many previous studies have used 13-15 km tropopause height to separate the tropical and extratropical regimes. In this study, a threshold value of 13-15 km is used to separate the ozonesonde profiles (for construction TB climatology) into tropical and extratropical groups, in order to remove ozone variability caused by the mixing of tropical and extratropical air masses, especially in the subtropics. The use of TB coordinate is efficient around the tropopause (see Figure 1) and thereby we confine the use of TB coordinate to within +/- 5 km around the tropopause with a variable shifting offset (defined in Equation 1 on the manuscript). So the shifts around the tropopause are separate from the categorization of air masses.