Validation and Comparisons of Suomi NPP OMPS Limb Profiler Ozone Measurements

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Introduction

The Ozone Mapping and Profiler Suite Limb Profiler (OMPS-LP) instrument on the Suomi-National Polar-Orbiting Partnership (SNPP) satellite measures limb-scattered radiances over visible and ultraviolet wavelengths. In an effort to further calibrate and validate OMPS-LP measurements, comparisons were made with measurements from the Microwave Limb Sounder (MLS) instrument on EOS Aura. In some respects, MLS measurements can be thought of as the standard for current ozone measurements, because of the length of time that it has been taking measurements. This project examined the differences, bias, and errors between the two instruments. Ozone measurements for individual days and months were examined and compared, and the process was automated in order to make comparisons for the entire lifespan of OMPS. Two different comparison methods were used for the daily comparisons: daily zonal mean comparisons, and collocation matchup comparisons. The monthly comparisons were done as zonal means.

The data used for this study came in the form of daily level 2 files for each instrument. Data files were retrieved for each instrument dating back to the start of 2012, which was the beginning of OMPS measurements, up through mid September of 2016. Ozone measurements were given in Volume Mixing Ratio (VMR) and Number Density for OMPS, but only in VMR for MLS. Thus, VMR was chosen as the standard unit for this study, to avoid unnecessary calculations. The daily profiles in this study will mainly focus on one day, April 18, 2016, which was chosen as a fairly clean day that also had a chasing orbit between Suomi NPP and Aura.

Daily Zonal Mean

The first comparison method examined was that of daily zonal means. This means that for each individual day of data, the ozone data was averaged longitudinally across the entire Earth to create a dataset that was in terms of pressure vs. latitude . An extra step was done when working with the MLS data, also averaging over both the ascending and descending measurements, as well as over longitude. From here, a two degree latitudinal average was taken on both data sets and then trimmed to restrict the range to between 60S and 60N to make the data easier to work with. This was done due to general lack of data and data quality issues poleward of 60^0. Figures 1 and 2 show plots of the trimmed data for OMPS and MLS, respectively.

Once the horizontal scale between the two datasets was the same, the vertical scale needed to be manipulated. OMPS and MLS report measurements at different vertical resolution – OMPS reports measurements with a smaller altitude. spacing To account for this, the OMPS resolution was brought down to that of MLS by using a cubic spline. The pressure levels were limited to between 100mb and 1mb, in order to focus on the stratosphere. From there, the spline was used on the OMPS data to make two datasets of the same size. Figure 3 shows the OMPS spline data at MLS levels.

With the two datasets of equal size, difference calculations could be made. For each day, residuals (OMPS subtracted from MLS), percent bias, and percent difference were calculated. Figures 4 and 5 show the residual measurements and the percent bias, respectively, with both given in a Red to Blue color scale. The red colors in these plots show where MLS had higher values, while the blue color indicate where OMPS measured higher. Percent difference plots were left out, as it was determined that they added little to no new information at this point, mainly due to the differences that occur near the tropopause. This area sees a much higher percent difference than anywhere else in the plots, due to the limited amount of ozone present in the area.

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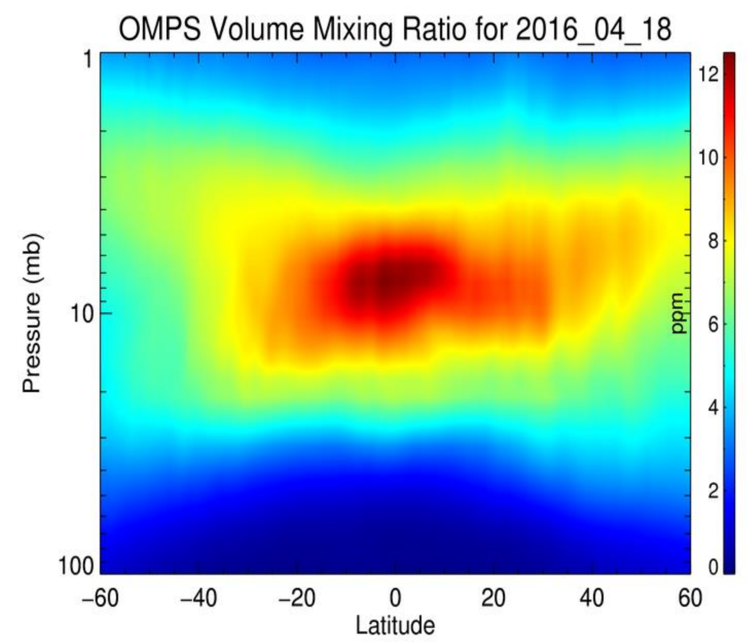

Figure 1: Original OMPS data for April 18, 2016

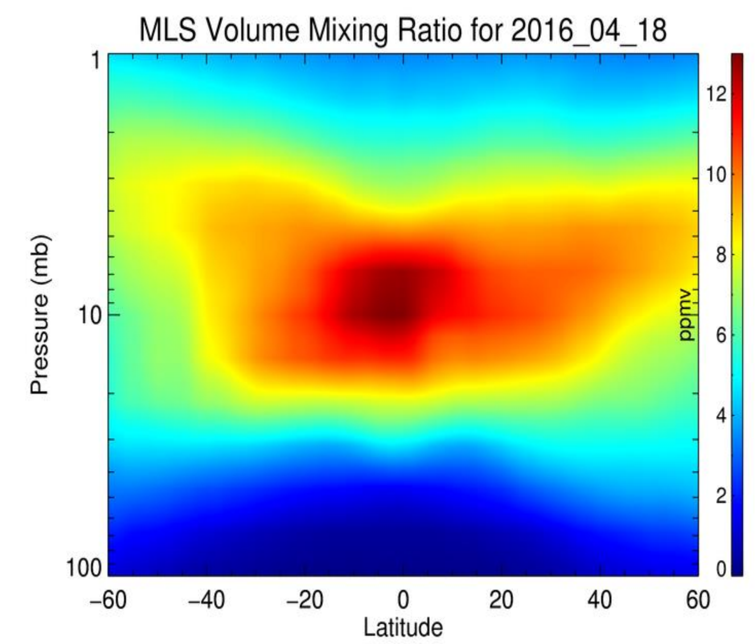

Figure 2: Original MLS data for April 18, 2016

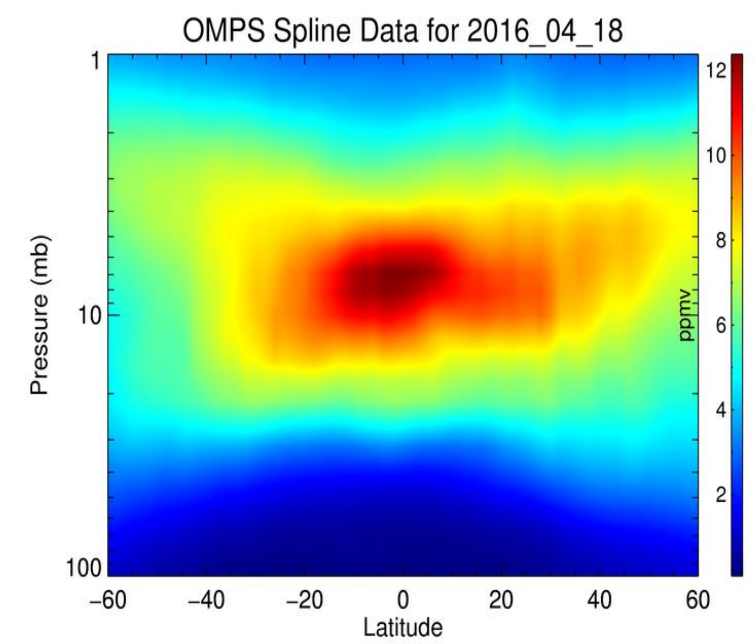

Figure 3: Spline OMPS data for April 18, 2016

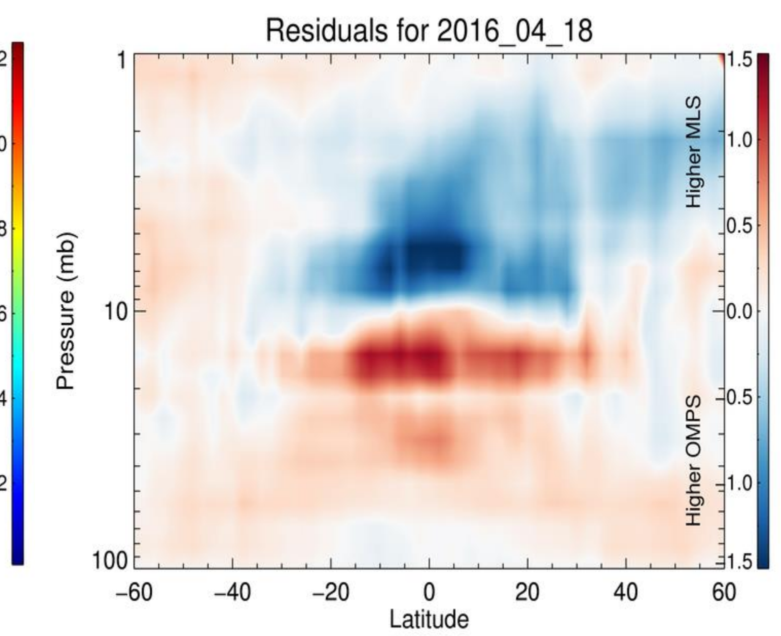

Figure 4: Residual Measurements for April 18, 2016

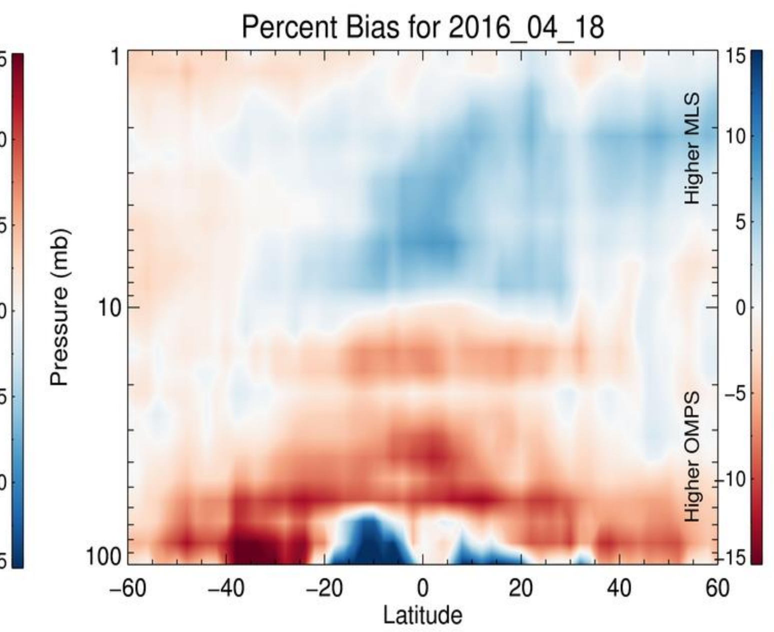

Figure 5: Percent Bias for April 18, 2016

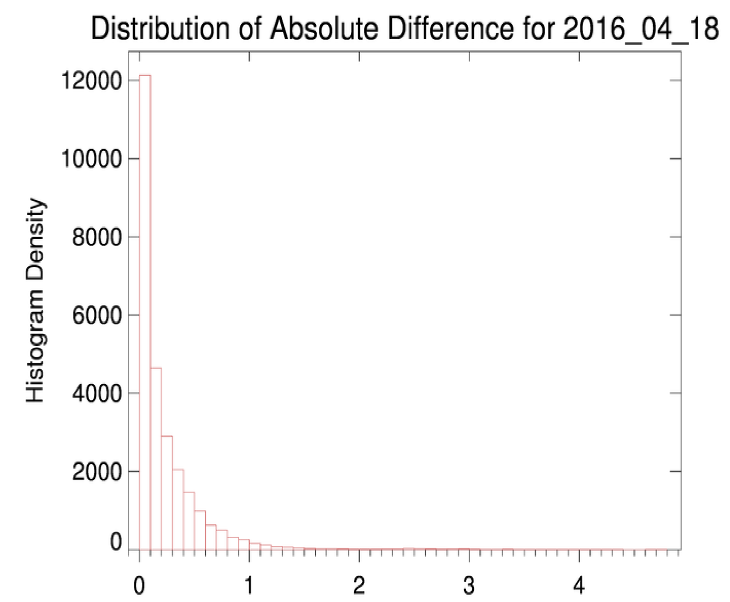

Figure 6: Absolute Difference for April 18, 2016

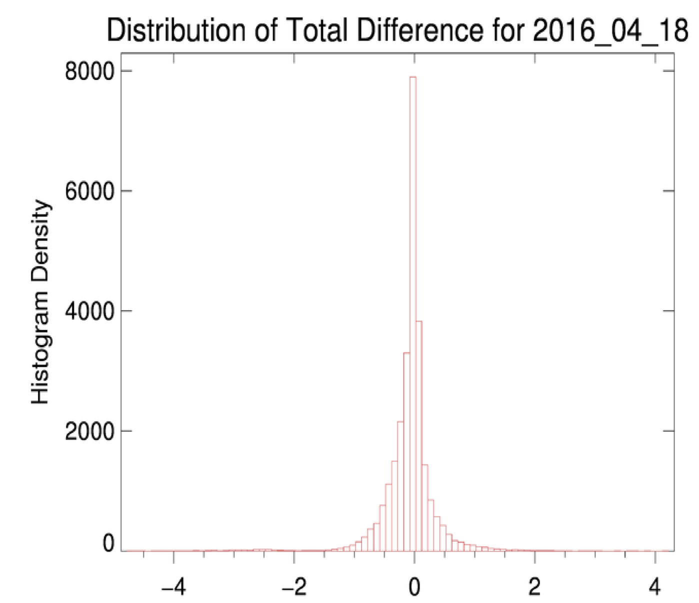

Figure 7: Total Difference for April 18, 2016

Correlation Values (%)

4/18/16 Collocation	98.975
4/18/16 DZM	99.112
Mean DZM	97.926
Max DZM	99.623
Min DZM	90.790
DZM Standard Deviation	2.249
Mean Collocation	96.023
Max Collocation	99.854
Min Collocation	32.353
Collocation Standard Deviation	5.577

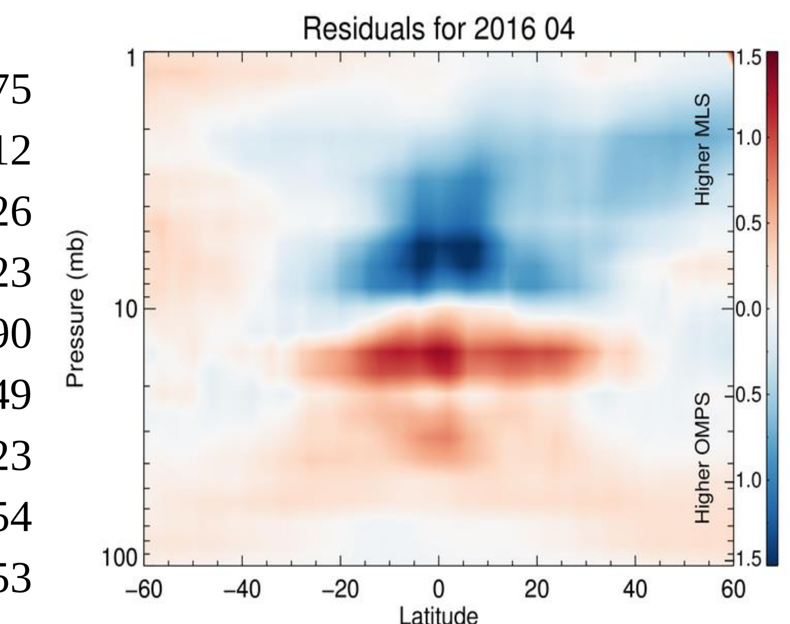

Figure 8: Monthly Residual for April 2016

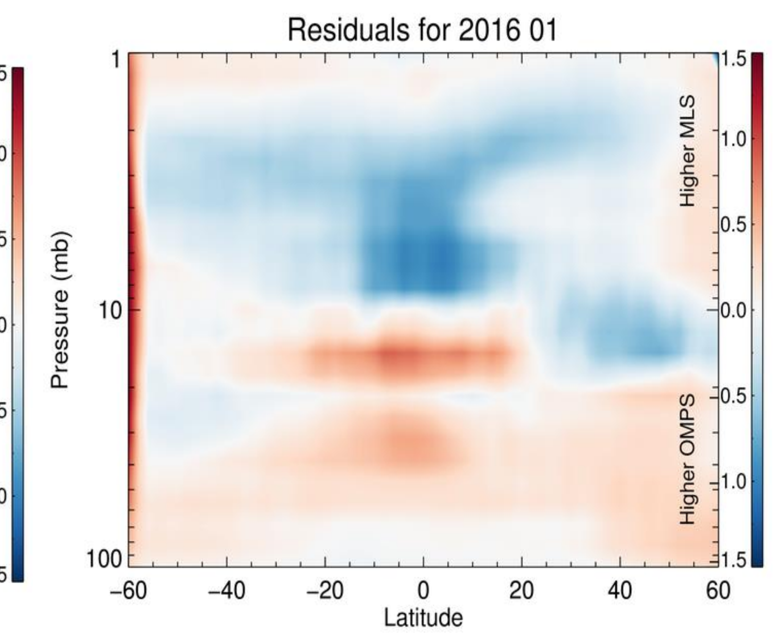

Figure 9: Monthly Residual for January 2016

Collocation Comparisons

The second type of comparisons done were collocation comparisons. For these measurements, individual days were examined , and instances where the two instruments made measurements within a 1-degree box of both latitude and longitude and within one half hour of each other were found. Once these instances were determined, another spline was done on the OMPS data to bring it to MLS resolution. A major difference in this case was that there was no other averaging done to the data. The full spatial scale was used, along with the full OMPS vertical scale (1000mb to 0.1mb). Similar one-to-one comparisons could now be made. For these comparisons, the outputs were contour plots and histograms of both absolute difference and total difference, and a contour plot of percent difference, along with several statistics. An example of the histograms for absolute difference and total difference can be seen in figures 6 and 7, respectively.

Monthly Comparisons

Monthly comparisons were done in a similar fashion to that of the daily zonal means. Daily zonal means were done for each day of a month for both OMPS and MLS. These means were then averaged together across the month to produce a monthly residual plot. This was done for every month from January 2012 through September 2016. This comparison yielded an average monthly correlation value of 98.369%. The monthly residual for April 2016 can be seen in Figure 8, while the monthly residual for January 2016 can be seen in Figure 9. It can be seen, comparing of Figure 8 to Figure 4, that many of the structures that exist in the daily zonal means also appear in the monthly zonal means.

Future Work

This study was done to further the validation efforts of OMPS in attempts to bring it up to MLS standards. The hope is to use this to also validate SAGE III on ISS when it launches in 2017. Work will be done to incorporate the OMPS LP Ozone data into the NOAA Unique Combined Atmosphere Processing System (NUCAPS), which combines the CrIS and ATMS instruments on Suomi NPP to get a full vertical profile of ozone. This will then be compared to similar results from TOAST, MLS, and JPL data. Attempts will also be made to further this study by classifying anomalies and filling in dates that have data that were otherwise filtered out in processing. An undergraduate at Hampton University s currently working on the latter

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Results and Discussion

As a whole, most of the daily zonal mean residual maps look fairly similar. The largest difference in values typically come right around 10mb in the tropics. Generally, OMPS has higher values at altitudes slightly above 10mb, and MLS has higher values at altitudes slightly below 10mb. At most other points in the map, the difference values are near 0, but with a slightly high MLS bias. OMPS has been known to have altitude registration issues, so that could be some of the cause of the difference. One difference to note occurs around the northern summer months. Starting in May and typically running through August, an anomaly occurs in the southern hemisphere where OMPS data starts to become less reliable or is unavailable. This tends to occur at latitudes poleward of between 50 and 60 degrees. There are several thoughts as to why this could be happening, including solar zenith angle issues and polar night. At this time, it has not been fully classified. The anomaly generally also causes some similar issues in the northern hemisphere during the splining process, though this is thought to be an edge effect. The compliment in northern winter is occasionally seen, but not nearly to the same effect as in the northern summer months.

The collocation measurements generally show very positive results. For this particular day, the correlation between the two datasets was 98.98%, which was a fairly typical value. The lower correlation values came on days where there were very few collocation instances, so that could explain some of the discrepancy. Some of the best correlation measurements came on days with chasing orbits, which resulted in a much higher number of coincidences. These chasing orbits happen about once every sixteen days.

The monthly comparisons, too, showed positive results, as well as highlighted some interesting features. As can be seen in Figures 4, 8, and 9, the OMPS/MLS separation in the tropics still persists in the monthly plots. One thing to note, however, occurs in Figure 9. During the months of December, January, and February, a higher OMPS bias occurs at an altitude slightly lower than 10mb, from about 20 degrees North to the edge of the plot at 60 degrees North. This bias has occurred in those 3 months for each year of measurements, but is not noticeably present at any other time of year. Throughout the year, a very slight east-west shift can be seen in the strong tropical bias between OMPS and MLS.