Validation of OMPS LP Ozone Profiles with Satellite, Ozonedonde and Lidar Measurements

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ABSTRACT

The Ozone Mapping and Profiler Suite (OMPS) on board Suomi National Polar-orbiting Partnership (S-NPP) was launched on October 28, 2011. It consist of three instruments: Nadir Mapper (NM), Nadir Profiler (NP) and Limb Profiler (LP). The OMPS LP instrument is designed to provide high vertical resolution ozone profiles from measurements of the scattered solar radiation in the 290-1000 nm spectral range. It collected its first Earth limb measurement in January 10, 2012, and continues to provide daily global measurements of ozone profiles from the cloud top up to 60 km.

This presentation will describe the recent changes implemented for the OMPS LP ozone product and discuss the results of comparisons with co-located measurements from the MLS on-board Aura, GOMOS and SCIAMACHY on-board ENVISAT, and OSIRIS on-board ODIN, as well as ozonesonde and lidar measurements.

In general, the agreement with MLS and OSIRS is within 5% over an altitude range of 20-40 km. Above 40 km, the difference is ~5-10% in the southern and northern hemispheres. In the lower stratosphere above the tropopause, the lack of aerosol corrections is evident, where OMPS is 5-10% smaller in the tropics and northern hemisphere. The difference is smaller in the southern hemisphere, where the retrieval algorithm is less sensitive to aerosol due to the large single-scattering angle and small aerosol scattering phase function.

INTRODUCTION

- The limb scatter technique combines relatively high spectral resolution (1-3 km) and a near global coverage of the sunlit hemisphere.
- The main goal of the mission is to produce accurate long-term measurements for total column ozone and ozone concentration vertical distribution over the whole Earth atmosphere.
- The OMPS LP sensor is a triple-slit prism spectrometer that simultaneously image the whole vertical extent of the Earth's limb over the wavelength region of 290-1000 nm. One slit is centered above the satellite ground track, and the other two are 4.25 deg on each side, 250km in space and full global coverage is obtained in 4 days. See Figure 1.
- For the ozone profile retrieval, the measurement vector is made of altitude normalized wavelength pairs and triplets, following the technique described by Flittner et al., (2000). Retrievals using radiance data from both the ultraviolet (UV) and visible (VIS) wavelength are performed separately. The final product is 3 separate profiles; Visible profile 0-35 km, UV profile, 26-60 km, and combined profile 0 to 60 km, merged at 26.5 km.
- Version 2 data was released on August 2014. Main changes are
  - Implement static tangent height adjustment (500 m), a total 1750 m, plus intra-orbit TH adjustment.
  - Implement intra-orbit and seasonal wavelength scale adjustment.
  - Improved multiple gain/aperture merging
  - Use of GMAO products for ancillary data instead of NCEP
  - Use 1% instrument error term for SNR used for retrieval
  - Turn off explicit aerosol correction in ozone retrieval
  - Revised retrieval normalization altitude and wavelength selection
  - Report ozone products for all three slits, but recommend center slit for use.
- Ozone profile retrieved in number density and altitude, also available in mixing ratio vs. pressure.

(A)

(B)

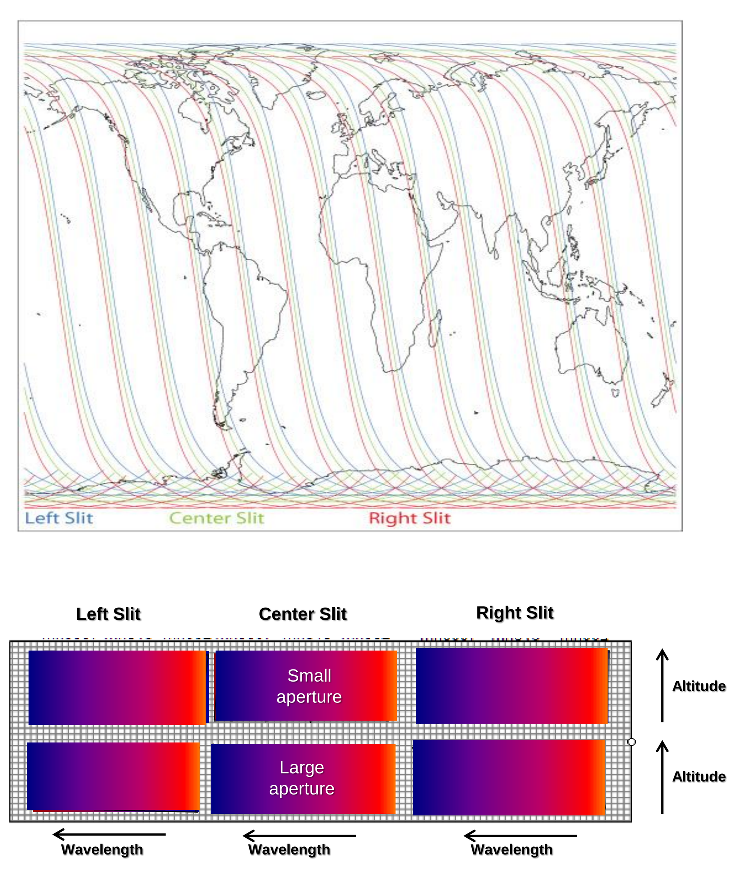

Figure 1A: Plot of typical daily ground track of OMPS LP for three slits. (1B) is for OMPS 6 CCD images. Each image is collected twice, long and short integration. Uploaded sample table control downloaded pixels.

Approach

Dataset used

- OMPS v2.0, combined profile, center slit only. For sondes and lidars comparison, visible profile is used.
- OSIRIS MART v5.07 provided by University Saskatchewan.
- MIPAS v6.0 provided by ESA.
- SCIAMACHY v5.02 provided by ESA.
- GOMOS v6.01 provided by ESA.
  - ENVISAT and OMPS measurement overlapped on March/April 2012 only.
- Ozonesondes and Lidars were collected by the AVDC, downloaded from NDAAC, WOUDC, SHADOZ, NOAA CMDL archives.

Coincidence criteria

- 3° latitude, 10° longitude, same day measurement, 250km apart (50km for MLS).
- Percent difference was calculated and averaged for 10° latitude zone.

Tangent height offset

- TH offset was estimated by adjusting OMPS ozone profile's TH vs correlative measurement using maximum correlation.

RESULTS

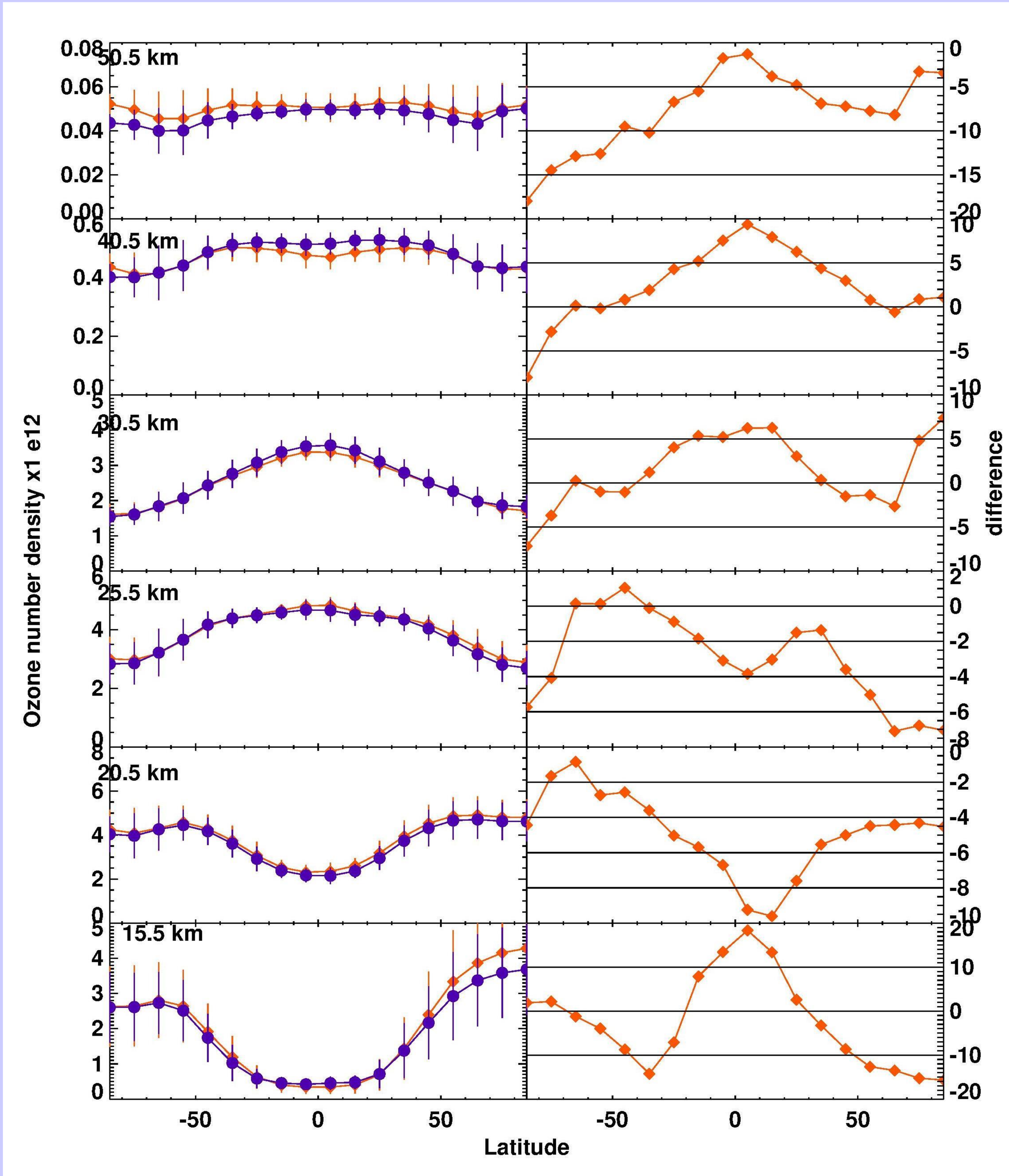

Figure 2: Left panel is mean ozone profile at selected altitudes for MLS (red) and OMPS LP (blue) vs. latitude. Right panel is the percent difference between the two instruments.

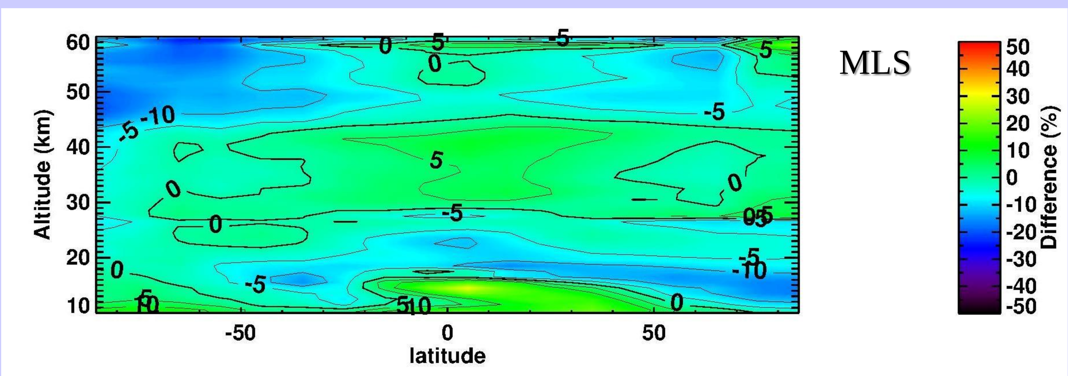

Figure 3: Zonal mean plot of the relative difference for OMPS LP – MLS in percent (2012-2014).

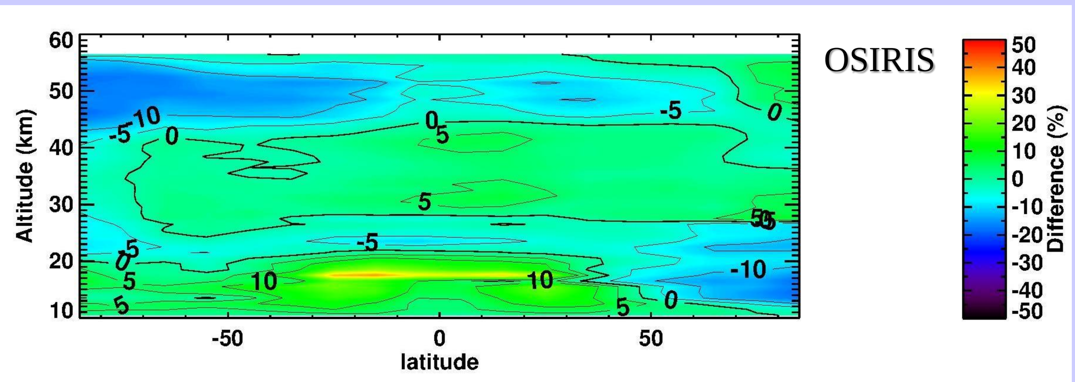

Figure 4: Same as fig. 3 but for OMPS LP - OSIRIS

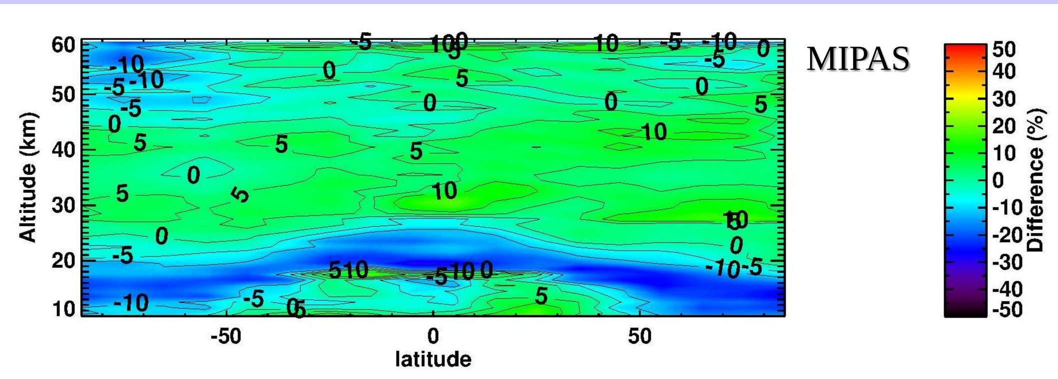

Figure 5: Same as fig. 3 but for OMPS LP – MIPAS for Mar/Apr 2012.

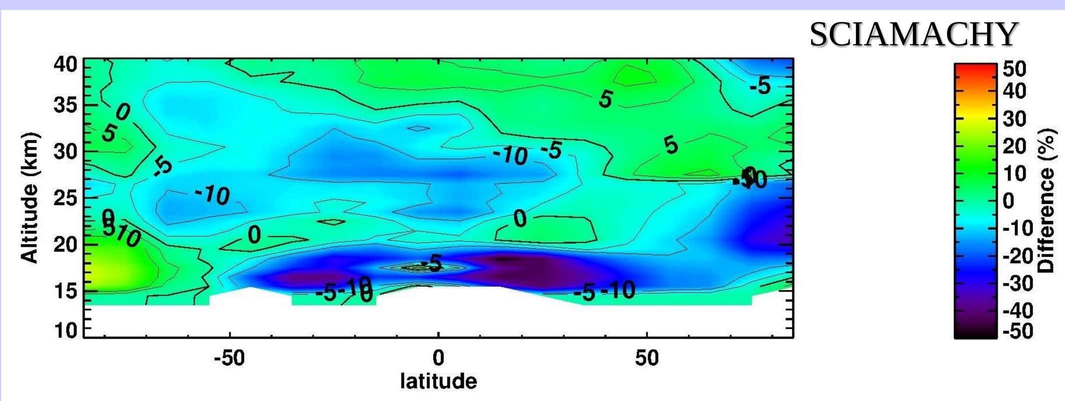

Figure 6: Same as fig. 4 but for OMPS LP – SCIAMACHY.

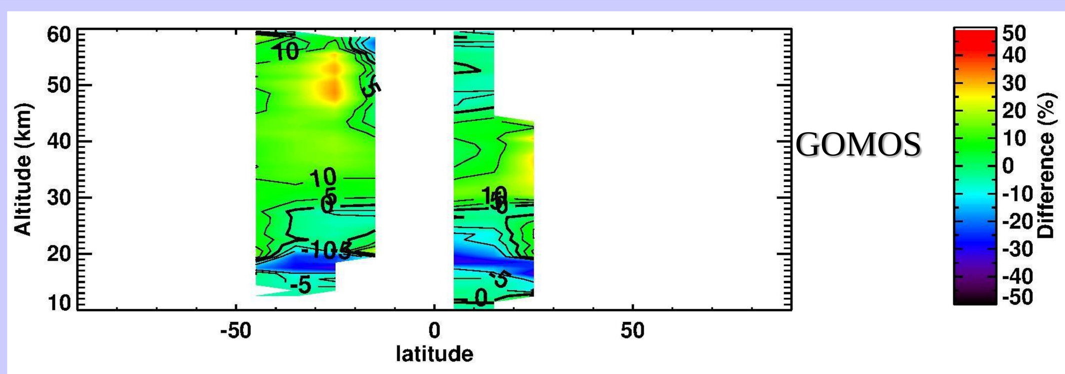

Figure 7: Same as fig. 4 but for OMPS LP – GOMOS.

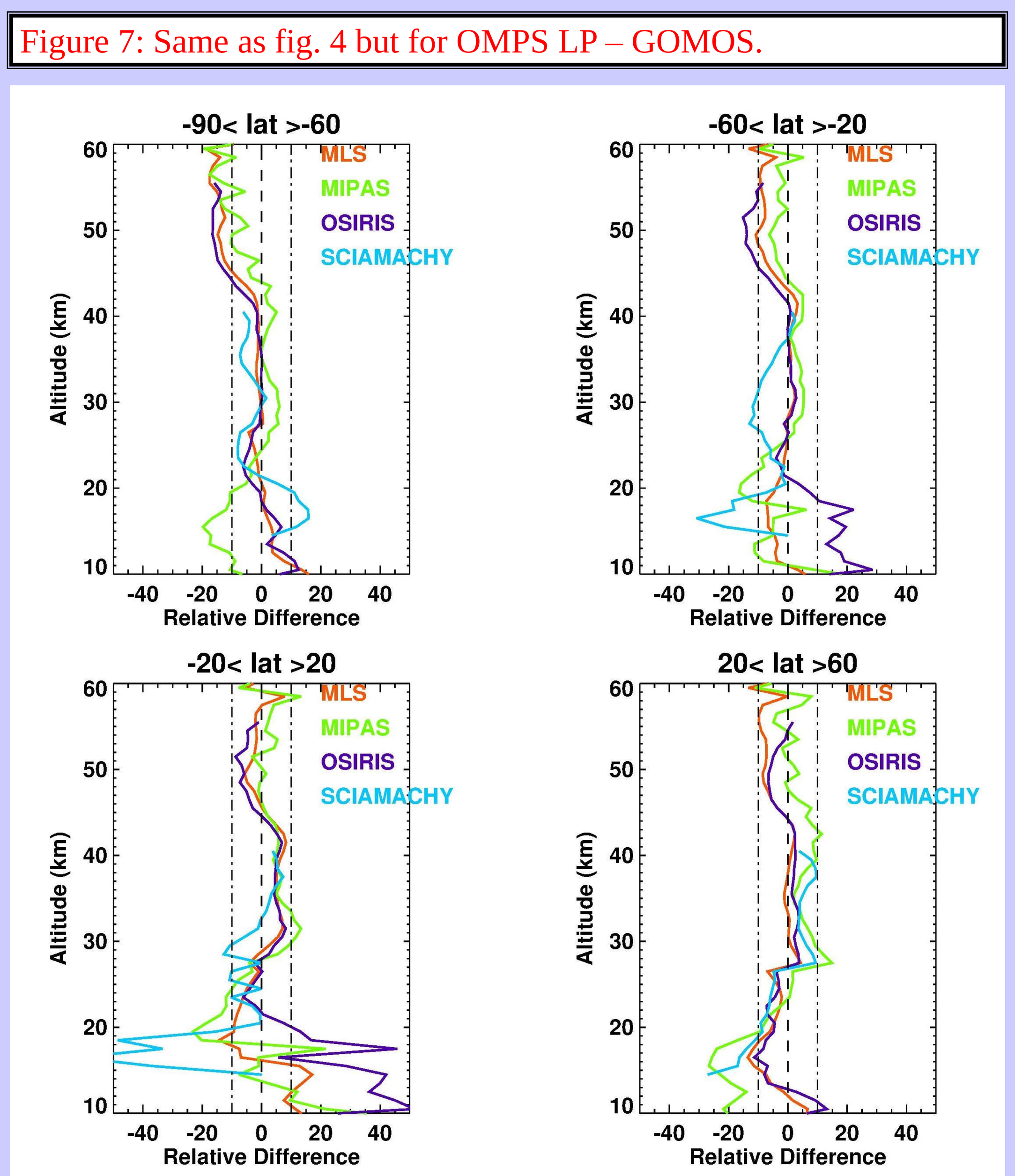

Figure 8: Summary plot of the relative difference of OMPS vs. various sensors for different latitude zones

RESULTS

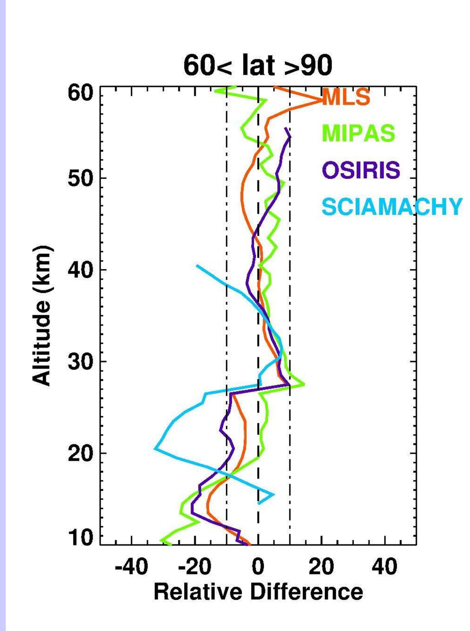

Figure 8, continued

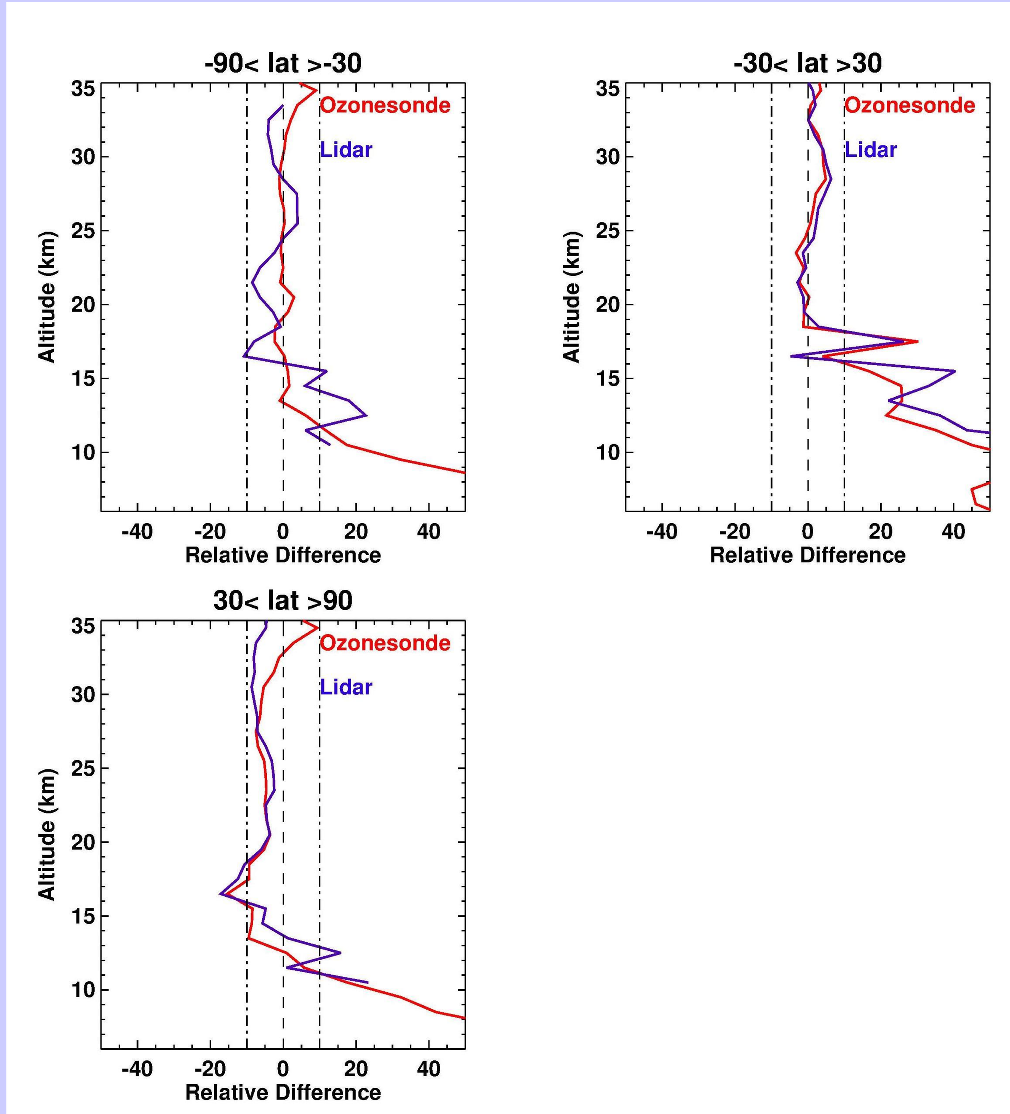

Figure 9: Plot of the relative difference of OMPS vs. Lidars and Ozonesondes for different latitude zones

Altitude Registration

Sources of altitude registration errors:

- Error in alignment of S-NPP star tracker and OMPS-LP.
- Relative alignment errors between 6 OMPS LP slits.
- Flexing of S/C bus at OMPS location with respect to star tracker.
- Distortion of LP focal plane due to thermal effects.

Correlative measurements can provide estimate of the tangent height errors.

- Estimated TH error within -150m, except for the tropics, -350m.

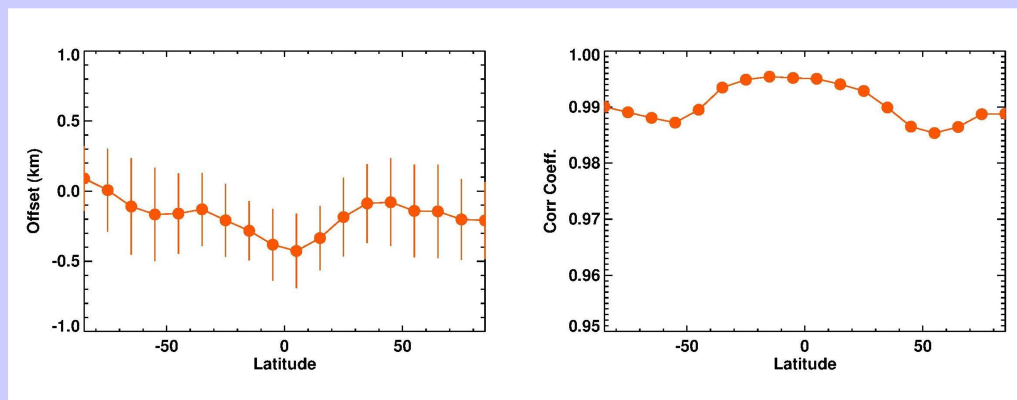

Figure 10: Left is plot of the estimated tangent height offset of OMPS LP profiles against MLS for different latitude zones. Right panel is the correlation coefficient.

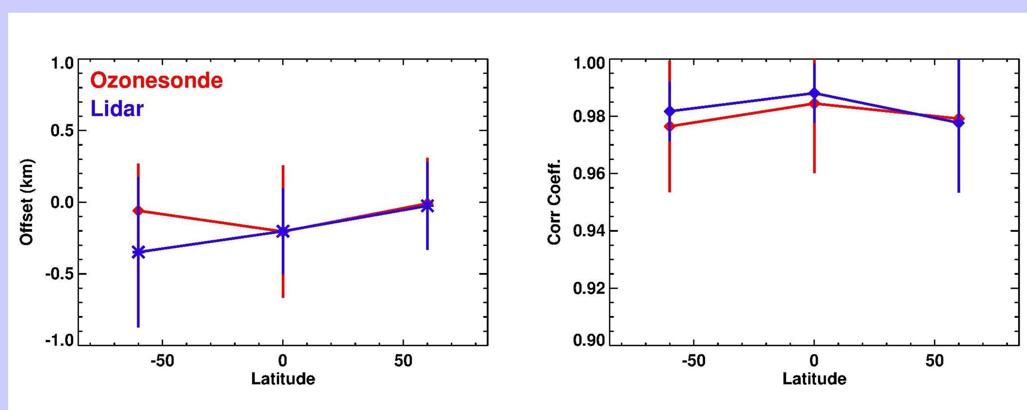

Figure 11: Same as fig. 10 but for ozonesondes and Lidars

SUMMARY

- In general, the agreement with correlative measurements is within 5% over an altitude range of 20-40 km.
- Above 40 km, the difference is ~5-10% in the southern and northern hemispheres.
- In the lower stratosphere above the tropopause, OMPS is 5-10% smaller in the tropics and northern hemisphere.

Known Issues

- Altitude registration errors, ~150-200 m
- Aerosol effect; Negative bias in the lower stratosphere, mostly in the tropics and northern hemisphere.
- Straylight errors could be the reason for the bias above 40 km in the NH/SH.
- Polar Mesospheric clouds (PMCs) and Polar Stratospheric Clouds (PSCs) interference.
- Disagreement between UV and visible retrievals, mainly in the northern hemisphere. Possible cause is straylight and aerosol contamination/

Planned improvements

- New aerosol dataset and corrections
- New and improved clouds dataset
- Improved straylight corrections