Intercomparison between Aura MLS and ground-based millimeter-wave observations of stratospheric O_3 and HNO_3 from Thule

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In view of a growing need for long-term data sets of stratospheric constituents, in January 2009 a Ground-Based Millimeter-wave Spectrometer was installed at the NDACC Arctic station of Thule Air Base (76.5 N, 68.8 W), Greenland, in order to track the long- and short-term interactions between the changing climate and the seasonal processes tied to the ozone depletion phenomenon. Since then three winter campaigns were carried out from Thule during the period January-March 2009, 2010 and 2011. Observations of O_3, HNO_3, CO and N_2O were performed, mostly on a daily basis, except during periods characterized by poor weather conditions.
In this study we compare GBMS stratospheric O_3 and HNO_3 measurements obtained during 2010 and 2011 winter campaigns with colocated satellite observations from the Aura Microwave Limb Sounder (MLS) experiment.

Ground-Based Millimeter-wave Spectrometer (GBMS)

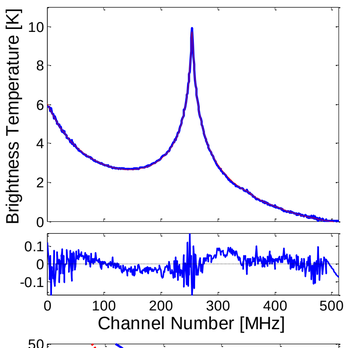
• Heterodyne spectrometer (tunable between **230-280 GHz**) observing rotational emission spectra of stratospheric trace gases [de Zafra, 1995]

•Bandwidth: **600 MHz**

•Spectral resolution : **1.176 MHz** (maximum resolution of 65 kHz used only for mesospheric studies)

• Deconvolution technique (to retrieve mixing ratio vertical profiles from the emission spectra): Optimal Estimation Method [Rodgers, 2000]

GBMS O_3 observations

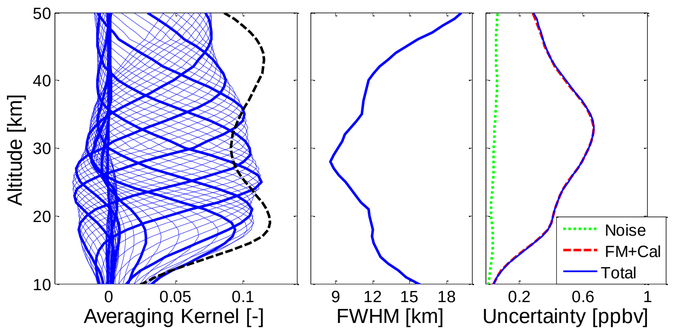


• Obtained observing the pure rotational transition lines at 276.923 GHz (superimposed on the wing of a second ozone line) or at 264. 926 GHz.

• Retrievals considered reliable in the altitude range 15-45 km (where sensitivity ~1.0 ± 0.2)

• Vertical resolution (FWHM of the kernels): ~10-12 km.

•1σ uncertainty on the retrieved profile (due to uncertainties on forward model parameters, instrumental calibration and spectral noise): 11%. [di Biagio et al., 2010]



GBMS HNO_3 observations

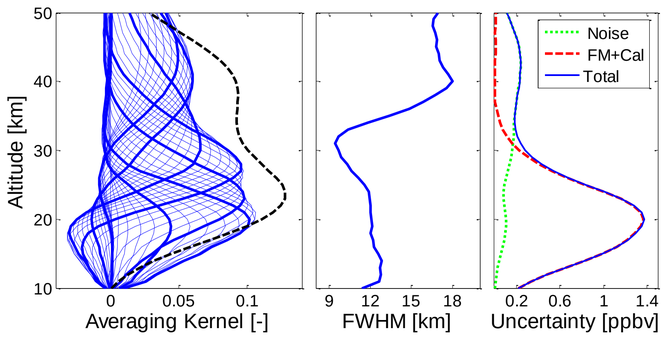
• Composite spectrum characterized by a cluster of emission lines centered at 269.210 GHz superimposed to an ozone line.

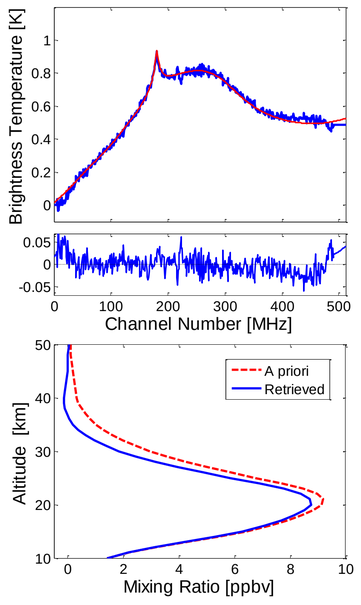
• Vertical range where inversions are considered reliable:18-42 km

• Vertical resolution:12-18 km.

• 1σ uncertainty: the larger of 15% or 0.3 ppbv.

[Fiorucci et al., 2011]





EOS Aura Microwave Limb Sounder

• Launched in July 2004 into a sun-synchronous near-polar orbit aboard the Aura satellite.

• Observes thermal microwave emission lines of many chemical species using five broad spectral regions between 118 GHz and 2.5 THz.

Ozone

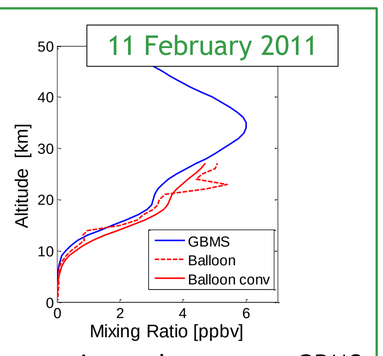
• Vertical range recommended for scientific use: 261 to 0.02 hPa.
• Vertical resolution: ~2.5-5.5 km. [Froidevaux et al., 2008]

Nitric Acid

• Vertical range recommended for scientific studies : 215 to 1.5 hPa.
• Vertical resolution: ~3-5km. [Santee et al., 2007].

GBMS - MLS intercomparison

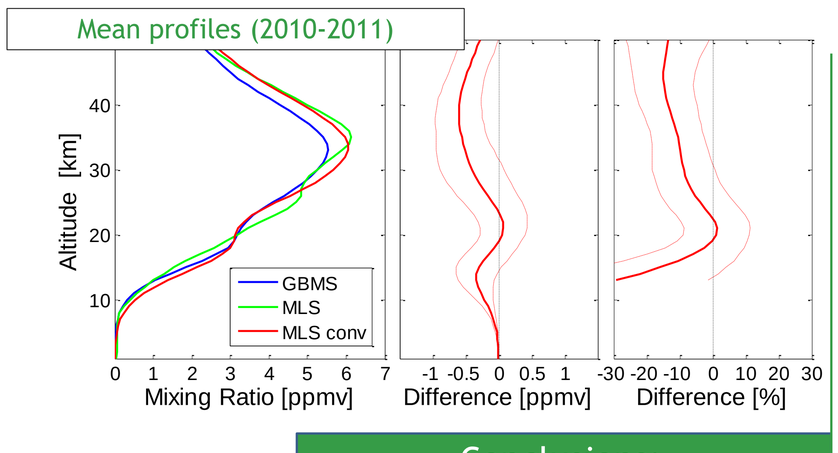
O_3 comparison



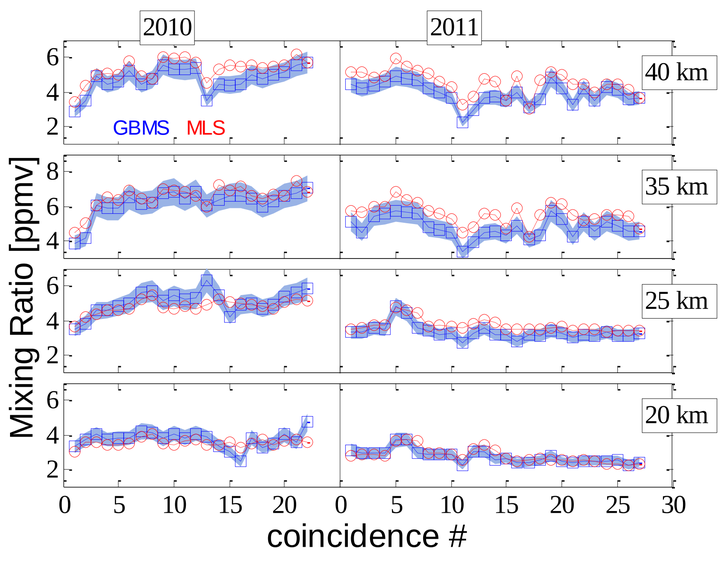
Comparison between GBMS and concurrent balloon-borne O_3 measurements carried out from the NDACC station of Thule [Courtesy of Danish meteorological Institute]

Coincidence criteria (for both O_3 and HNO_3 datasets):

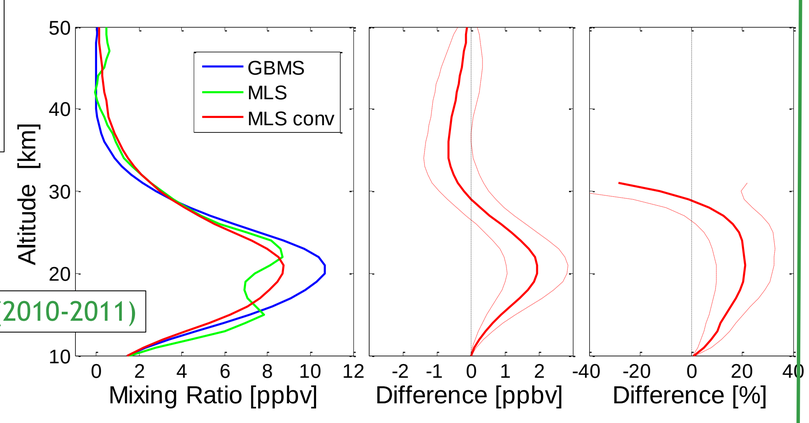
Each GBMS observation is compared to the closest MLS profile (in time), with coincidence criteria of ±8° longitude, ±1° latitude and ±6 h.

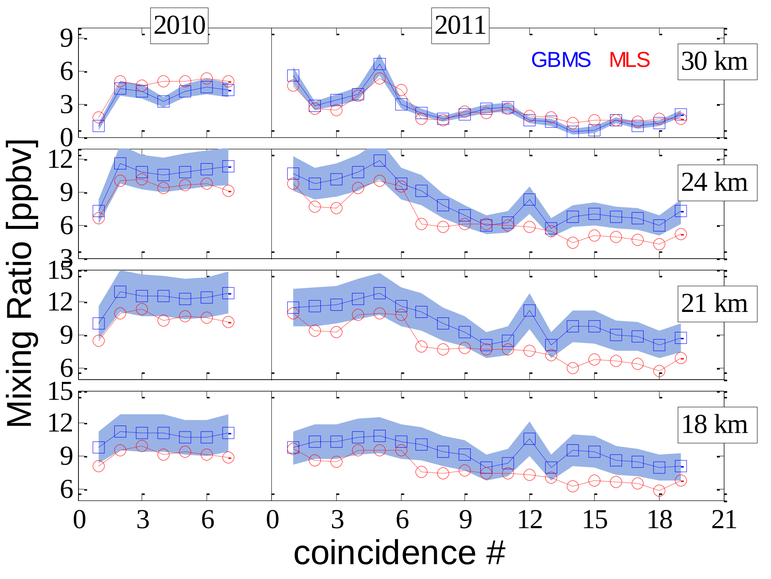


• Ozonosonde and MLS profiles (higher resolution) have to be "convolved" using the GBMS Averaging Kernels before the comparison.



HNO_3 comparison





Conclusions:

• GBMS O_3 measurements show a fairly good agreement with ozonosonde and MLS data (as for the satellite data see both average profiles and time series).

•GBMS O_3 measurements are very well correlated with the satellite data at all levels.

•GBMS O3 values display a small low bias (~10%) in the upper stratosphere.

•Time series show slight differences between 2010 and 2011 GBMS/MLS O_3 comparisons (especially at 35 km). These differences are under investigation (very different stratospheric conditions in 2011 with respect to 2010?)

Conclusions:

• GBMS HNO_3 measurements are larger than those obtained with MLS by about 2 ppbv (~20%) near the profile peak.

• Time series show that GBMS and MLS data are correlated well. Moreover differences between ground-based and satellite observations are systematic and consistent in 2010 and 2011.

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