HNO_3 Subgroup Session

Aura Validation Meeting

21 September 2005

HNO_3 measurements from HIRDLS and TES

- **HIRDLS** — Doug Kinnison
  - The first retrievals of HNO_3 were produced last week, and preliminary comparisons of one day's worth of data look very promising.
- **TES** — Greg Osterman
  - 73 Global Surveys with limb scans were taken between September 2004 and April 2005.
  - In May 2005 the limb mode was removed from the Global Surveys to preserve instrument lifetime (NB: HNO_3 is not available from nadir mode).
  - But, limb measurements will still be possible as Special Observations (during campaigns, for example).
  - TES averaging kernels show sensitivity between 8 and 32 km.
  - HNO_3 retrievals are planned to be available in spring 2006.
  - Validation efforts are planned to include comparisons with MLS, CIMS and SAGA aircraft data, and INTEX-B measurements.

EOS MLS HNO_3 Measurements: Overview

- The standard product for EOS MLS version 1.5 HNO_3 is taken from the 240 GHz retrieval at and below 10 hPa and from the 190 GHz retrieval at and above 6.8 hPa.

  Useful range: 147–3.2 hPa

  Vertical resolution: 3.5–4.5 km

  Horizontal resolution: ∼300–400 km along-track, ∼10 km cross-track; adjacent profiles separated by 1.5° (165 km)

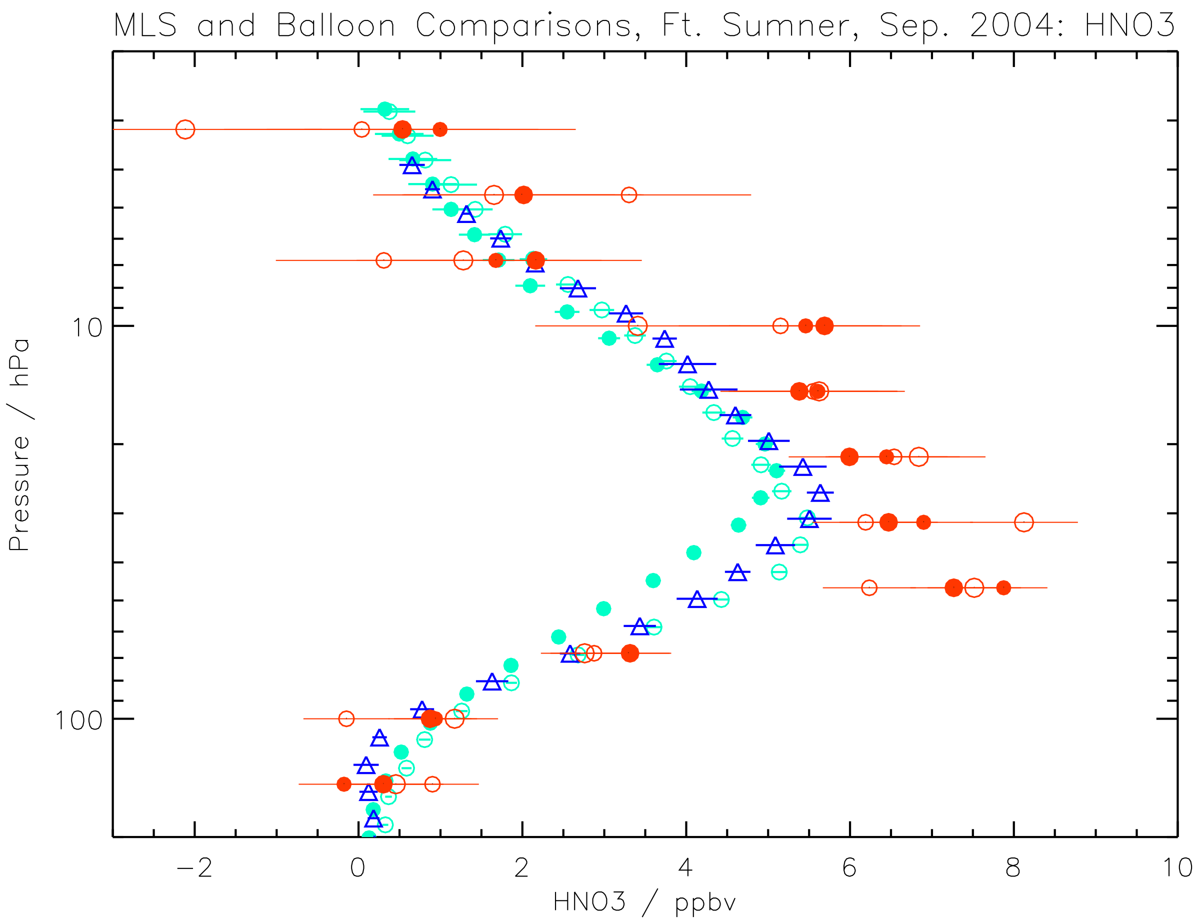
  Precision: ∼1 ppbv throughout the vertical range

  Accuracy: MLS HNO_3 generally agrees with balloon and satellite measurements to within ∼30%, with agreement slightly better at the top and bottom of the profile but worse around the peak.

  Artifacts: Based on comparisons with nearly-coincident satellite and balloon measurements, and a climatology of stratospheric HNO_3 based on 9 years of UARS MLS data, the MLS v1.5 HNO_3 retrievals appear to be biased high by as much as 3 ppbv (∼30%) near the profile peak.

- Priorities for Version 2 MLS HNO_3 data:
  - Understand and mitigate (if possible) the apparent large positive bias in HNO_3 abundances at the levels surrounding the profile peak.
  - Reduce oscillations in the HNO_3 vertical profile.
  - Attempt to improve the retrievals at 215 hPa.

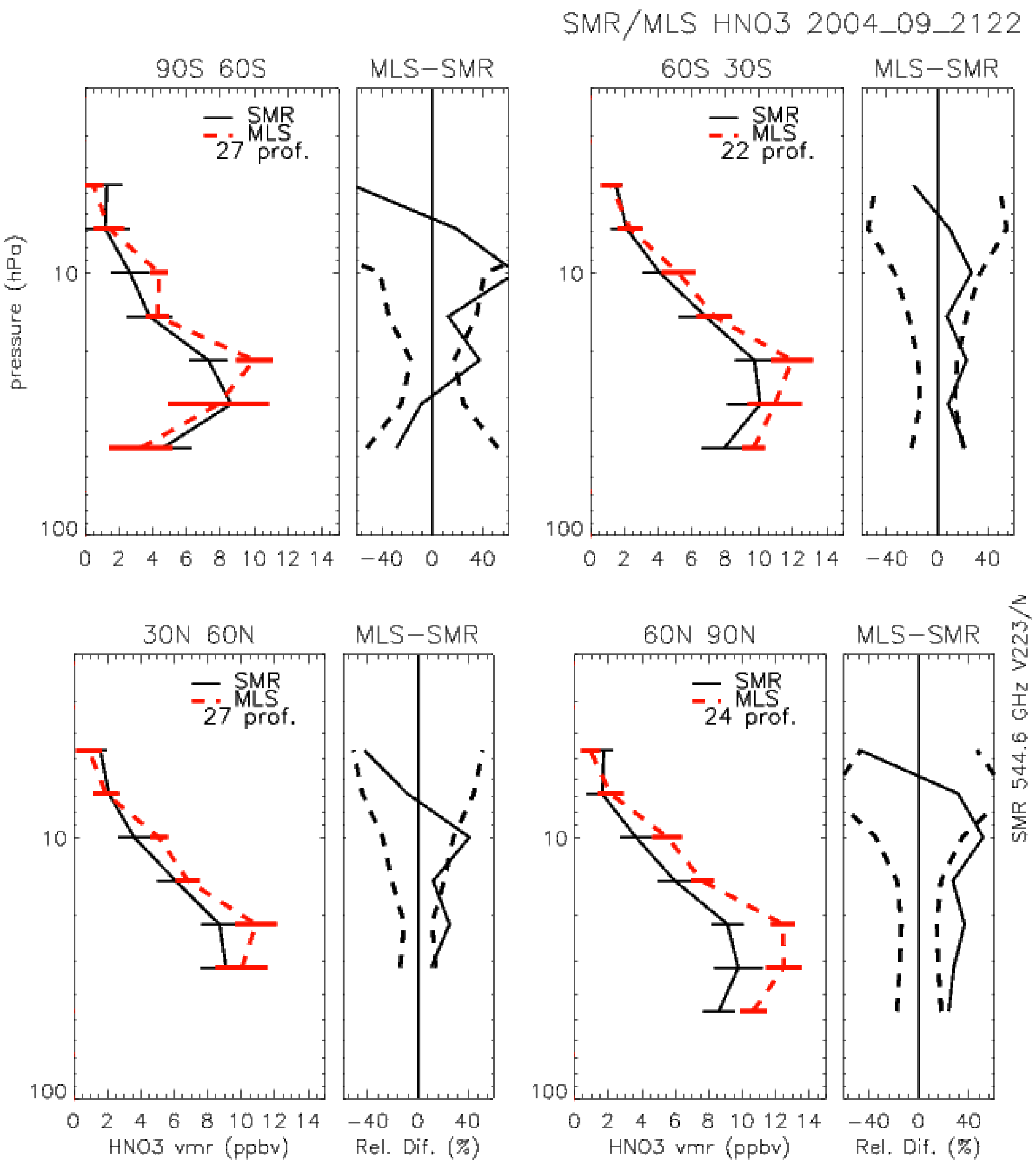
Comparisons with balloon measurements



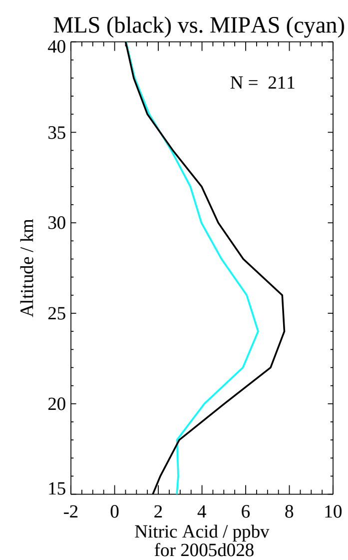
- Measurements were made near Aura overpasses during a balloon campaign from Ft. Sumner, NM on 23/24 September 2004.
- Remote HNO_3 measurements are available from:
  - the Smithsonian Astrophysical Observatory far-infrared spectrometer **FIRS-2** for both day (open circles) and night (closed circles) using the mid-IR (350–700 cm^{-1}) channel.
  - the JPL **MkIV** solar occultation Fourier transform infrared spectrometer (sunset)

- The two closest day (open circles) and night (closed circles) **MLS** HNO_3 profiles are compared, with the larger symbol representing the profile closer to the corresponding **FIRS-2** profile.
- **MLS** HNO_3 mixing ratios can exceed those measured by the balloon instruments by as much as 3 ppbv at the levels around the profile peak.
- The magnitude of this discrepancy is well outside the combined error bars in some cases.
- Agreement is typically much better away from the peak at the top and bottom of the vertical range.
- This plot is included in Froidevaux et al., IEEE, submitted, 2005.

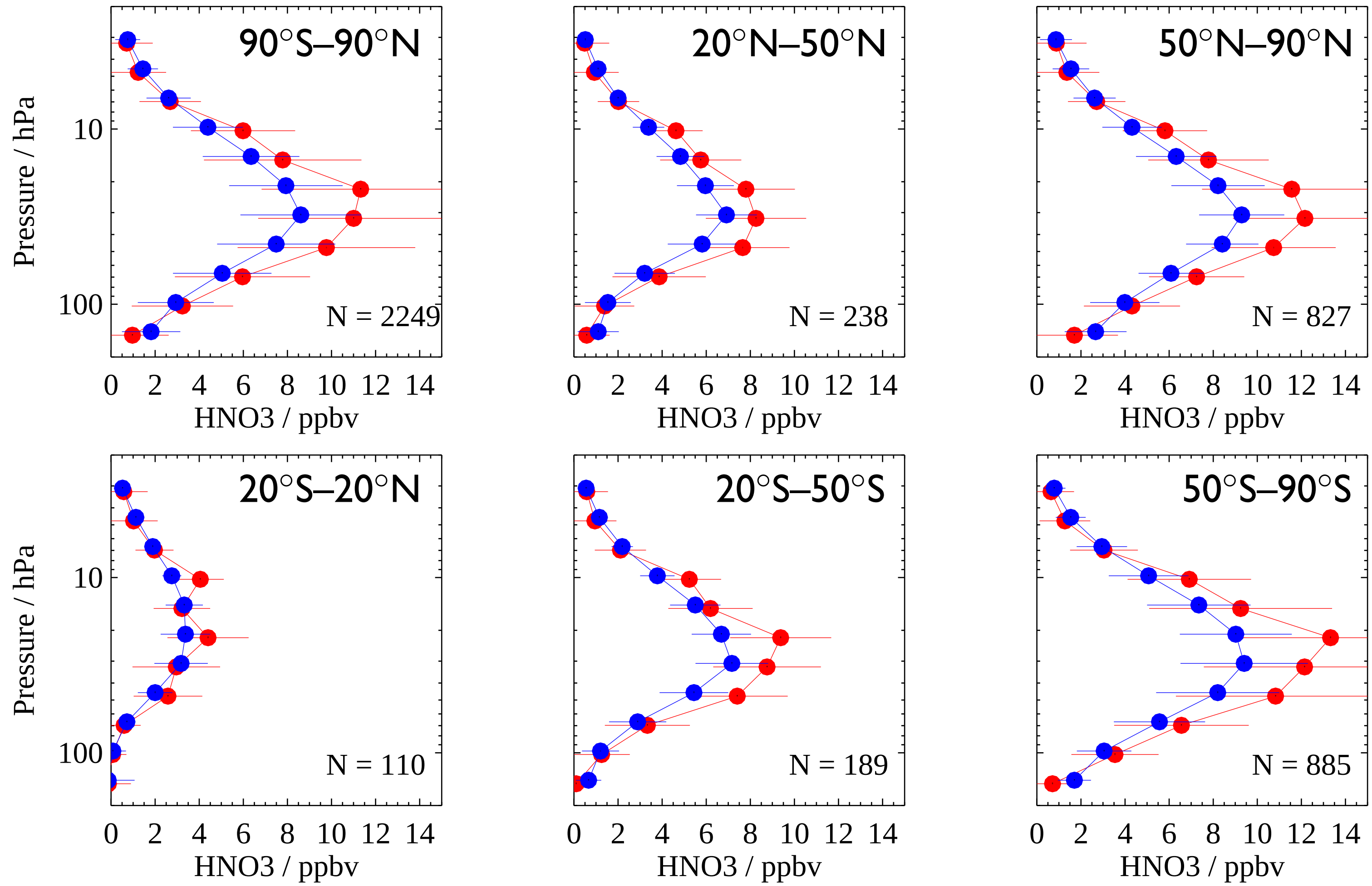
Comparisons with Odin/SMR and MIPAS satellite measurements



- Brice Barret showed zonal mean comparisons indicating that **MLS** HNO_3 exceeds that from the French "CTSO" **SMR** retrievals by ~2 ppbv (20–40%) near the profile peak.
- The "Chalmers-v2.0" SMR retrievals provide a less clear picture, with MLS and SMR HNO_3 values matching almost exactly at 24 km, but MLS larger above and smaller below.
- Similarly, comparisons with **MIPAS** results based on "Preliminary Oxford Retrievals" from Claire Waymark (**not** the ESA operational retrievals) indicate average differences of about 1.5 ppbv (~20%) near the profile peak, with **MLS** higher.



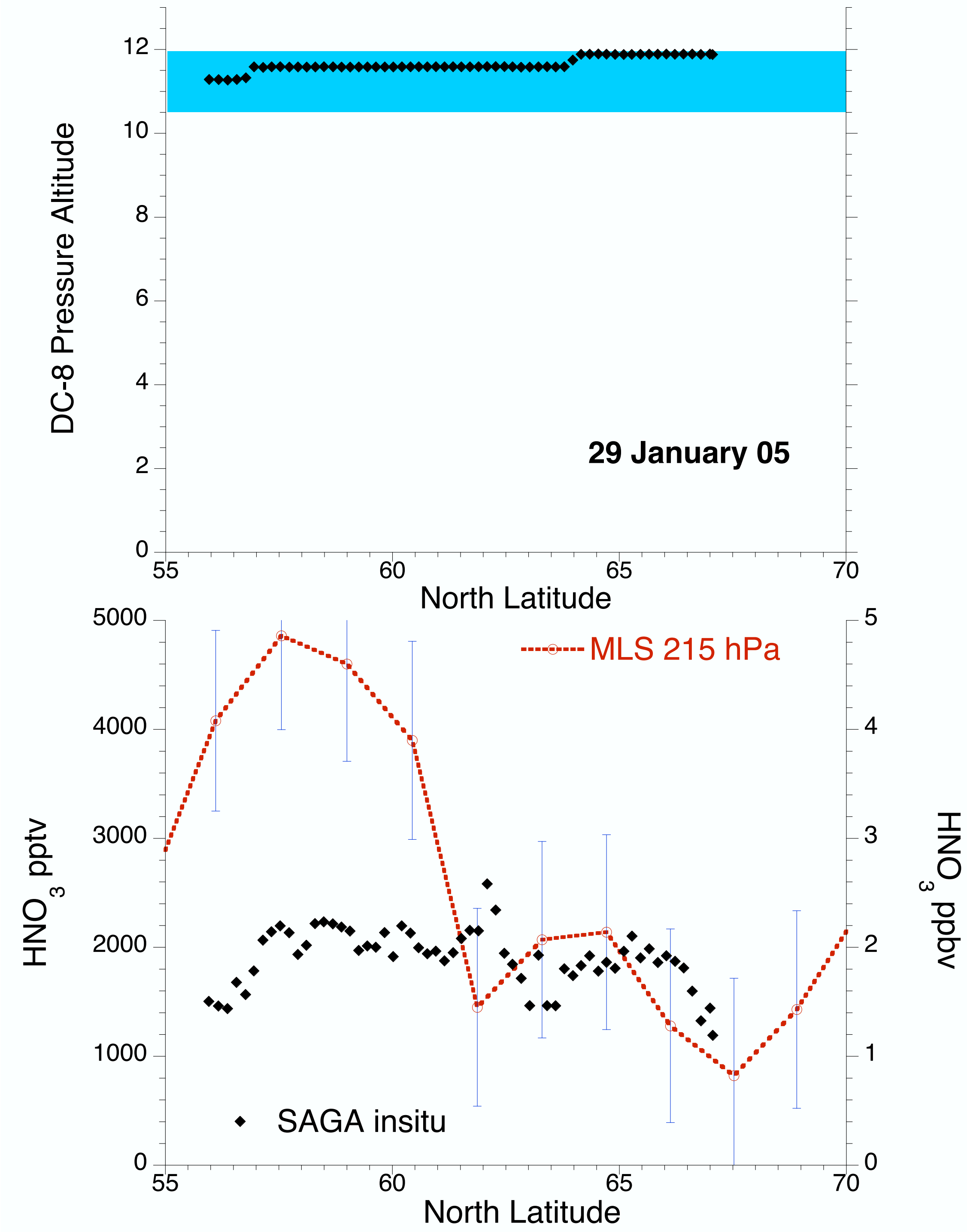
Comparisons with ACE: latitude band averages



Adapted from Froidevaux et al., IEEE, submitted, 2005

- Here we compare **MLS** HNO_3 with **ACE** v2.2 data over the interval 8 August 2004 to 10 August 2005, averaged in various latitude bands.
- **ACE** and **MLS** HNO_3 typically agree within ~10–20% near the top and bottom of the profile.
- **MLS** HNO_3 mixing ratios are high relative to **ACE** by 2–3 ppbv (~20–40%) at the levels surrounding the profile peak at middle and high latitudes.

Comparisons with UNH SAGA in situ HNO_3 measurements



From this plot on, SAGA data are only shown for the correlative portion of the DC-8 flight track (56 - 68°N in this case).

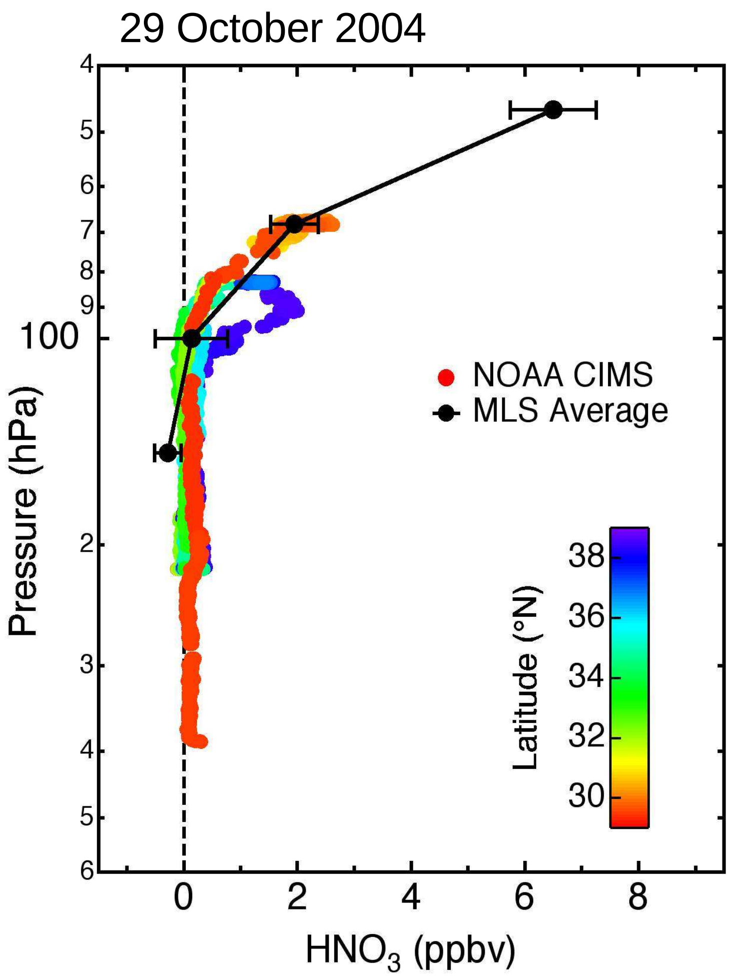
Times:

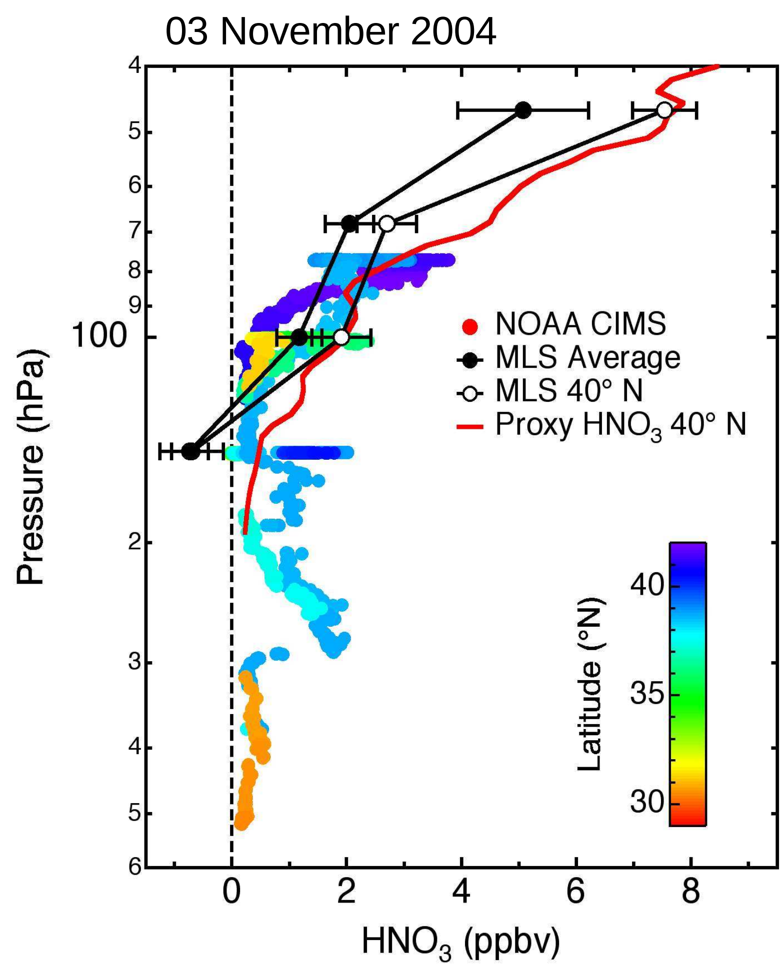
DC-8 18:02 to 19:42

Aura 18:17 to 18:21

- Jack Dibb compared **SAGA** in situ HNO_3 measurements taken on Aura underpasses during PAVE in January/February 2005 to **MLS** HNO_3 mixing ratios at 215 hPa.
- Note that the MLS HNO_3 retrievals at 215 hPa are not currently recommended for scientific use.
- Data from 6 flight legs have been compared; results are sometimes encouraging, sometimes not, as illustrated on the leg shown here.
- Fortuitous agreement?

Comparisons with NOAA CIMS in situ HNO_3 measurements





- Peter Popp compared CIMS in situ HNO_3 measurements taken on Aura underpasses during AVE in October/November 2004 to MLS HNO_3 mixing ratios at 68, 100, and 147 hPa.
- Preliminary results indicate good agreement between MLS and CIMS HNO_3 measurements in the UT/LS.
- Because of the tight linear correlation between HNO_3 and O_3 in the lower stratosphere, HNO_3-O_3 correlations were suggested as a useful validation tool.

General Discussion

- How can the satellite measurements, which represent "average" conditions over a relatively large volume of air, be effectively compared to in situ measurements, which represent conditions at a local point?
- Are comparisons of such fundamentally different measurements actually meaningful?
- Now that the initial comparisons have been undertaken, rather than pursuing every conceivable opportunity for further comparisons, the satellite teams should identify outstanding issues and prioritize which correlative data sets are most useful in resolving them.
- What has been or can be learned from these sorts of comparison efforts that will directly influence retrieval strategies in the future?
- In particular for HNO_3, where the discrepancy in the magnitude of the profile peak may arise at least in part from uncertainties in either the infrared or microwave spectroscopy, could HNO_3-O_3 or other correlation relationships be brought to bear to address this issue?
- Would in situ measurements near the peak (~25 km) be either possible or helpful in resolving this issue?