SC-HIR-1511
Initial Release

# HIRDLS

## High Resolution Dynamics Limb Sounder
## Earth Observing System (EOS)

# Data Description and Quality
# Version 2.00

## 30 June 2006

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## 1.0 Introduction

As the following sections describe, the entrance aperture of the High Resolution Dynamics Limb Sounder (HIRDLS) was largely obscured by a piece of plastic material that came loose during launch. This resulted in a loss of signal from the atmosphere, and the addition of extraneous signals from the plastic blockage material. In addition, coverage of Antarctica was lost, as well as loss of the higher longitudinal resolution expected, although latitudinal resolution has been increased.

The HIRDLS team has been working since the discovery of this anomaly to understand the nature of the blockage and, to develop 3 major correction algorithms to make the resulting radiances as close as possible to those originally expected. Corrections for some channels, and therefore the products retrieved from them, have been successful earlier than others, which has led to this initial group of retrieved data products. This document provides a description of the first released version of the data, which includes retrieved temperature, ozone, and nitric acid, as well as cloud top pressure.

Work is ongoing to improve the radiances, and therefore the retrievals, for these channels, as well as for those channels whose products are not included in this release. At this time, corrections are evolving rapidly as algorithms are improved and extended to new channels. These changes will be designated by increasing the digits following the decimal point in the version number. An Algorithm Change sheet is included as Section 8, to allow a user to track improvements in the versions. Note that some versions will have numbers for use in internal development, and will not be released.

It is recognized that these data are not yet of the higher quality we expect in future. Some of the known problems with the data are described below, but these are almost surely not the only ones. This work is ongoing, and further improvements are being developed and implemented. The HIRDLS team is releasing these data for validation, with the expectation that those who look at the data will provide feedback on deficiencies that need to be addressed in future versions, as well as strengths of the data. This document will be updated as additional data products are released, and as other changes dictate.

We strongly suggest that anyone wishing to work with the data contact the HIRDLS team. In the first instance, this should be one of the Principal Investigators (PI's):

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## 2.0 The HIRDLS Experiment

### 2.1 The Experiment as Designed

HIRDLS is an infrared limb-scanning radiometer designed to sound the upper troposphere, stratosphere, and mesosphere to determine temperature; the concentrations of $O_3$, $H_2O$, $CH_4$, $N_2O$, $NO_2$, $HNO_3$, $N_2O_5$, CFC11, CFC12, ClONO2, and aerosols; and the locations of polar stratospheric clouds and cloud tops. The goals were to provide sounding observations with horizontal and vertical resolution superior to that previously obtained; to observe the lower stratosphere with improved sensitivity and accuracy; and to improve understanding of atmospheric processes through data analysis, diagnostics, and use of two- and three-dimensional models.

HIRDLS performs limb scans in the vertical, measuring infrared emissions in 21 channels ranging from 6.12 to 17.76 μm. Four channels measure the emission by $CO_2$. Taking advantage of the known mixing ratio of $CO_2$, the transmittance is calculated, and the equation of radiative transfer is inverted to determine the vertical distribution of the Planck black body function, from which the temperature is derived as a function of pressure. Once the temperature profile has been established, it is used to determine the Planck function profile for the trace gas channels. The measured radiance and the Planck function profile are then used to determine the transmittance of each trace species and its mixing ratio distribution.

The overall science goals of HIRDLS are to observe the global distributions of temperature 10 trace species and particulates in the stratosphere and upper troposphere at high vertical and horizontal resolution. Observations of the lower stratosphere are improved through the use of special narrow and more transparent spectral channels.

## 2.2 The Launch-induced Anomaly

### 2.2.1 History and Present Status

HIRDLS was launched on the EOS Aura spacecraft on 15 July 2004. All steps in the initial activation were nominal until the initialization of the scanner on 30 July 2004 indicated more drag than anticipated, and a subsequent health test of the scan mechanism indicated that the damping of the elevation mechanism was ~ 20% greater than on the ground. After the cooler was turned on and the detectors reached their operating temperature range, initial scans showed radiances much larger and more uniform than atmospheric radiances, except for a region of lower signals at the most negative azimuths. The HIRDLS team immediately identified this as indicating a probable blockage of a large part of the optical aperture.

Tests confirmed that the blockage emits a large, nearly uniform radiance, and covers all of the aperture except a small region 47° from the orbital plane on the side away from the sun.
A number of scan mirror and door maneuvers were conducted in an attempt to dislodge the obstruction, now believed to be a piece of plastic film that was installed to maintain the cleanliness of the optics. None of these maneuvers were successful in improving HIRDLS' view of Earth's atmosphere.

However, these studies and subsequent operations of the instrument have shown that, except for the blockage, HIRDLS is performing extremely well as a stable, accurate and low noise radiometer. These qualities have allowed the HIRDLS team to develop methods for extracting the atmospheric radiance from the unwanted blockage radiance and to retrieve a significant portion of the original science objectives.

### 2.2.2 Impact of Loss of Azimuth Scan Capability

In its present configuration, HIRDLS can view past the blockage only at the extreme anti-sun edge of the aperture. Vertical scans are made at a single azimuth angle of 47° line of sight (LOS) to the orbital plane, on the side away from the sun. (This differs from the original design, in which HIRDLS would have made vertical scans at several azimuth angles, providing orbit-to-orbit coverage with a spacing of ~ 400-500 km in latitude in longitude.) The inability to make vertical scans at a range of azimuths is a definite loss in data gathering, but not a major loss of scientific capability for many of the mission goals. Some of the impacts of the inability to observe at different azimuth angles are:

<u>Changes in coverage</u>
The single-azimuth coverage is plotted in Fig. 2.1, which shows that coverage only extends to 65°S, thus missing all of Antarctica and the S. Polar cap.

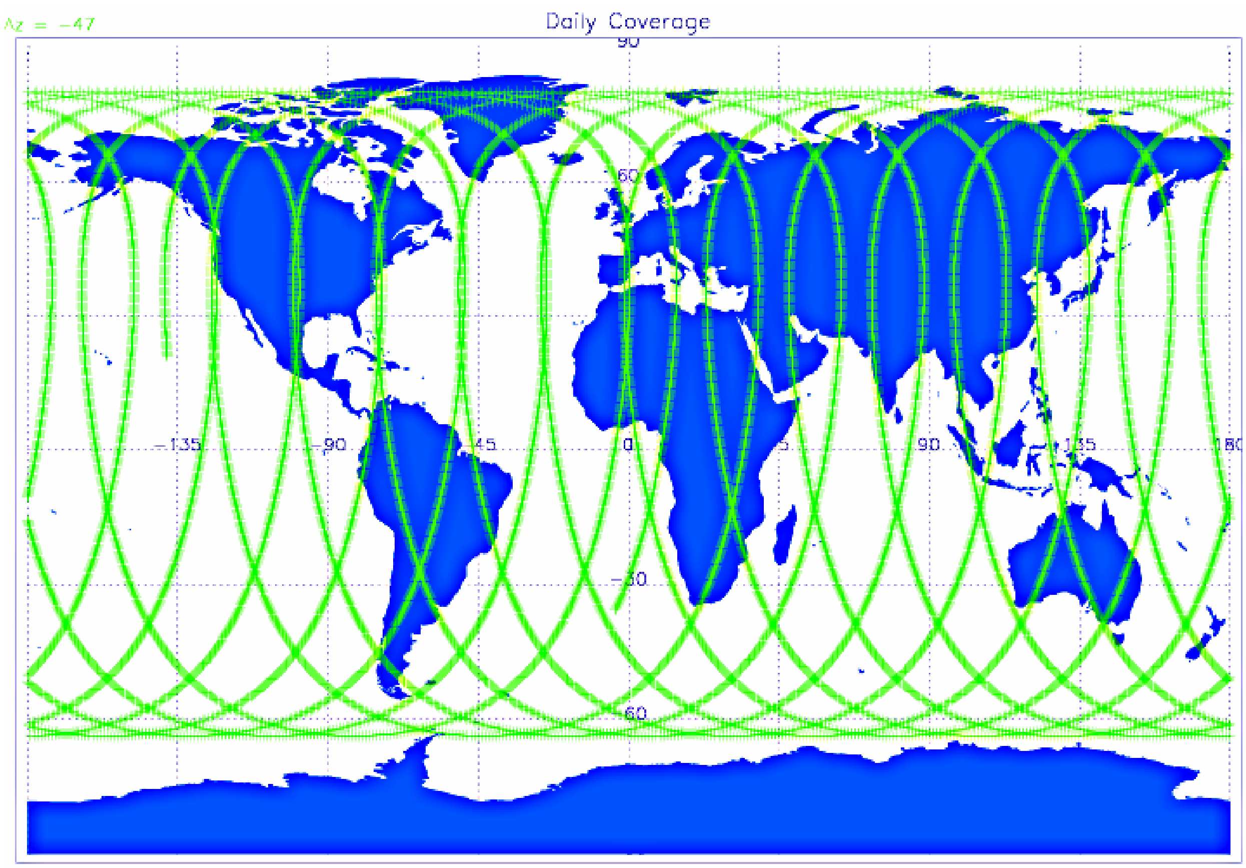


**Figure 2.1 HIRDLS Daily Coverage**

Inability to View the Same Air Mass as MLS, TES or OMI Within 15 Minutes

The HIRDLS scan track is compared with the MLS scan track in Fig. 2.2. HIRDLS views nearly the same volume as MLS at night, but on successive orbits; thus HIRDLS views the same volume 84 minutes earlier than MLS (one orbit, or 99 minutes, minus the 15 minutes that separates MLS and HIRDLS measurements). In the daytime, HIRDLS observations fall 17° to the east of the MLS track in the same orbit, or 8° to the west of the MLS track in the previous orbit. Especially in the daytime, this difference impacts making comparisons, the planning of correlative measurements, and the opportunities to do combined science. However, comparisons and science can easily be done at night where desired.

A corollary feature is that, in the daytime, HIRDLS and MLS combined observe more longitude at a given latitude, which will improve the spatial resolution. At night, together they look at the same volume 84 minutes apart, increasing the temporal resolution.

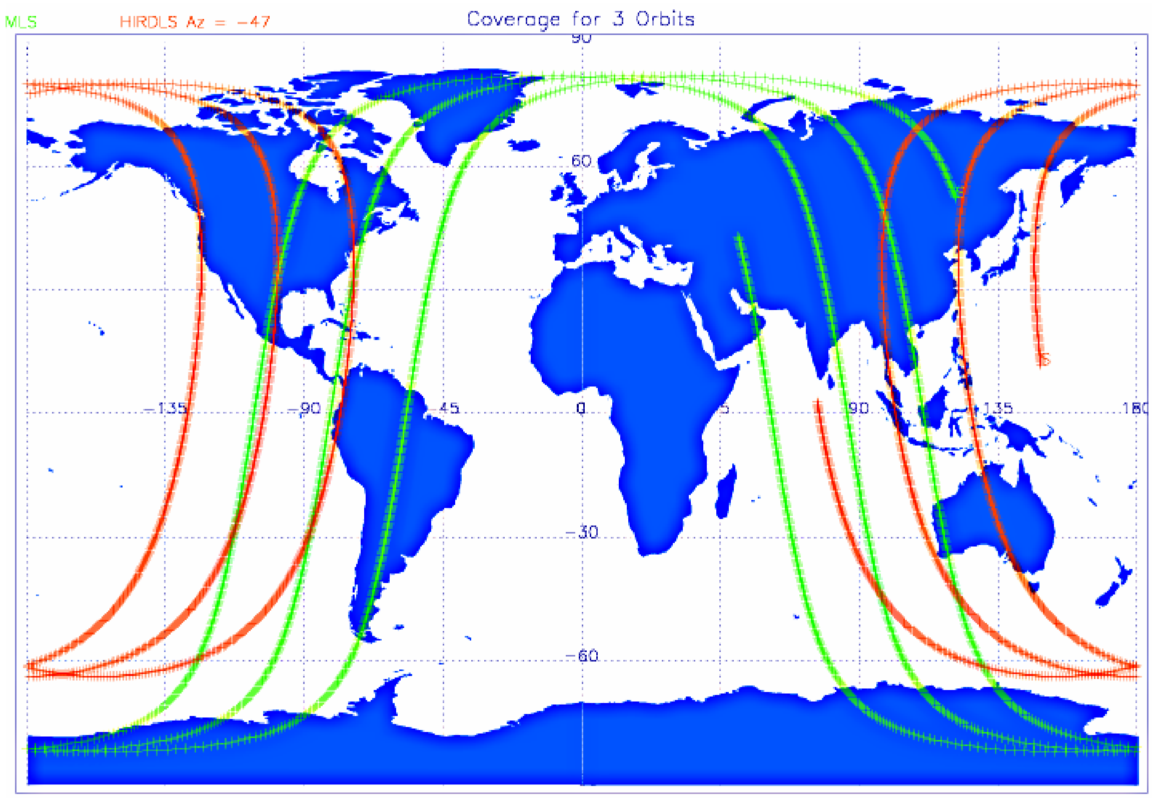


**Figure 2.2.** Comparison of 3 orbits of HIRDLS (red) measurement locations to MLS (green). HIRDLS is measuring the atmosphere at one azimuth angle (i.e., -47° from the orbit plane). The day and night portion of the orbits are on the right and left side of the figure respectively. During the day part of the orbit, HIRDLS is trailing MLS by one orbit (99-minutes). During the night part of the orbit, the coincidence is much better and HIRDLS is leading MLS by one orbit.

Some compensating effects:

With the azimuthal limitation, the profiles will have closer latitudinal separation, facilitating gravity wave studies. It has also been suggested that transects through tropopause folds might be improved by continuous views at one azimuth.

Since HIRDLS views a long way off the orbital track, as seen above, it measures at a different local time from MLS, TES and OMI. At the northern and southern extremes it means that HIRDLS will get data at a significantly different local time from the other instruments, which could help constrain data assimilation models.

## 3.0 Revised Operational Scan Patterns

The limited angle at which HIRDLS can see the atmosphere necessitates a revision to previous scan patterns. Scans of the atmosphere are done in the region in which the view of the atmosphere is the clearest, at -23.5° azimuth shaft angle, or -47° LOS from the orbital plane (on the side away from the sun).

Science Modes

Scan Table 23: (Used since 4 May 2006) Makes 27 vertical up and down scans of ~ 15.5 sec. duration each, followed by a 1-2 second space before the next 27 scans. For data processing reasons, the space-ward and earth-ward limits of the scans are at fixed elevation scan angles, resulting in some overscanning due to Earth's oblateness.

Scan Table 22: (25 April 2006 to 3 May 2006) Similar to ST 23, but with lower space-ward limit on the scans.

Scan Table 13: (28 April 2005- 24 April 2006). Upper and lower limits of scans vary around the orbit, following Earth's oblateness. This was discovered to cause different types of oscillations in the signals, complicating attempts to remove these artifacts.

Scan Table 30: (21 January 2005-28 April 2005) Initial scan used more rapid vertical scan speed, which generated larger amplitude oscillations in the signals. This scan also made vertical scans at an LOS azimuth angle of -44.8°, which were found to be inferior to those at -47°.

## 4.0 Method for Processing HIRDLS Data

The modified science scans described in Sec. 3 and the need to account for blockage of the scene and radiance from the blockage require substantial modifications to the operational data processing. A diagram of the flow of data in the HIRDLS processing is shown in Figure 4.1.

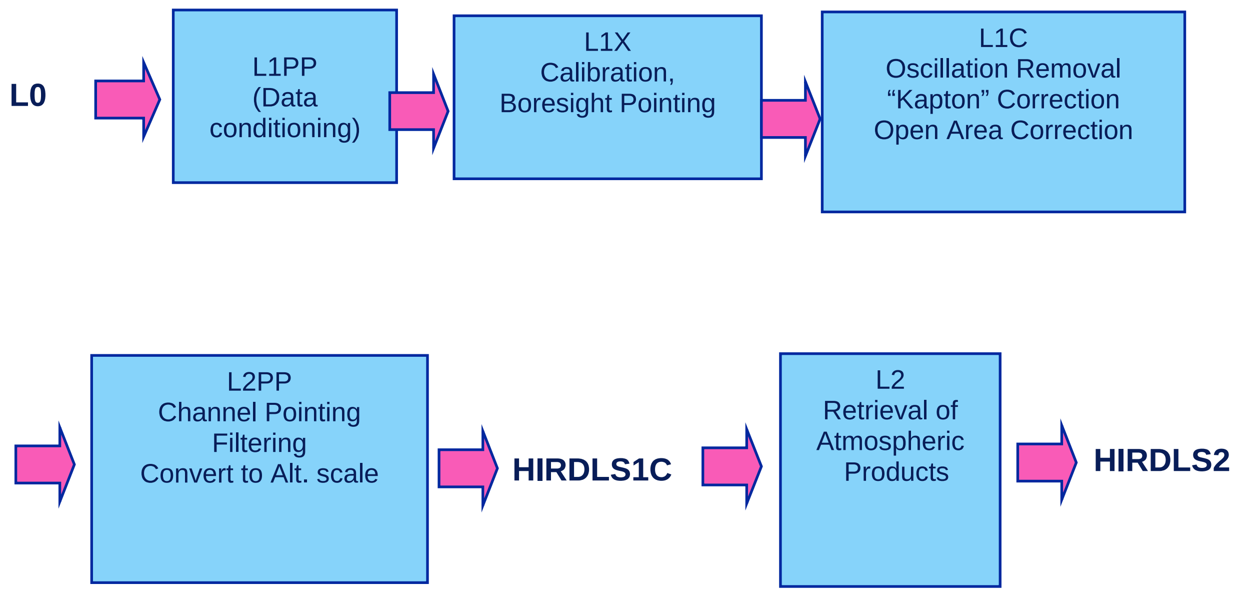


**Figure 4.1** HIRDLS Processing Flow

### 4.1 L0-1 Process (L1PP, L1X, L1C)

In the L0-1 suite of processor, L1PP corrects an occasional problem with the time in L0 data (raw data counts). L1X carries out the calibration, while L1C applies the 3 main correction algorithms to remove the effect of the blockage. Overall, the L0-1 processor creates a time series of calibrated radiances as well as housekeeping data necessary to the further data processing.

### 4.2 L2 Pre-processor (L2PP)

The L2PP process takes the time series of radiances from L1, separates it into individual geolocated vertical scans, determines the vertical registration in altitude, and performs field-of-view deconvolution and low-pass filtering to condition the radiances for retrieval by the L1-2 software.

### 4.3 L1-2 Processor (L2)

The L2 step accepts the conditioned radiance data from the L2PP, and performs the retrievals through a series of iterations. This code is designed to be flexible in handling combinations of radiance channels to retrieve the HIRDLS target species in a user-defined sequence. One of the major features is the determination of gradients along the line of sight, which are then incorporated in the next iteration to yield an improved retrieval. This processor is described in the L1-2 ATBD.

## 5.0 HIRDLS Standard Products

### 5.1 Temperature

| | |
|---|---|
| **Species:** | Temperature |
| **Data Field Name:** | Temperature |
| **Useful Range:** | 316 – 0.1hPa |
| **Vertical Resolution** : | 1 km |
| **Contact** : | Hyunah Lee |
| **Email**: | halee@ucar.edu |

**Valid range** : TemperaturePrecision > 0
Values at pressure levels where the temperature precision is negative should only be used in full recognition of the fact that most of their information comes from the a priori data.

**Retrieval**
The retrieval of temperature and pressure is performed jointly on a relative 1 km height grid, primarily using the radiance from four $CO_2$ channels (2, 3, 4, 5) in the range 15.27 – 16.26µm. The radiances are used to retrieve atmospheric temperature and reference pressure (Gille and House, 1971). Carbon dioxide volume mixing ratio for HIRDLS temperature retrieval is continuously updated with a $CO_2$ prediction model using age of air data (Mahowald et al., 2002), and the increase of $CO_2$ due to $CH_4$ oxidation is considered in the calculation (Andrews et al., 2001). The retrievals use a physically-based fast forward model that combines transmittance estimates from Curtis-Godson and Emissivity-Growth Approximation with a statistical regression (Francis et al., 2005). The retrievals are carried out using an optimized inversion method (Rodgers, 2000) and the temperature gradient effect along the line of sight (Roewe et al., 1982) is corrected using GMAO data. Details are contained in the HIRDLS Level 1-2 ATBD.

Channel 2 and channel 3 contribute to the temperature retrieval in the upper troposphere and lower stratosphere. Channels 3/4/5 contribute to the temperature retrieval in the middle and upper stratospheric regions.

**Random Errors**

Figure 5.1.1 shows the results of calculations of the predicted contributions to the random error, and the total random error. These suggest a random error of ~ 1 K through most of the stratosphere.

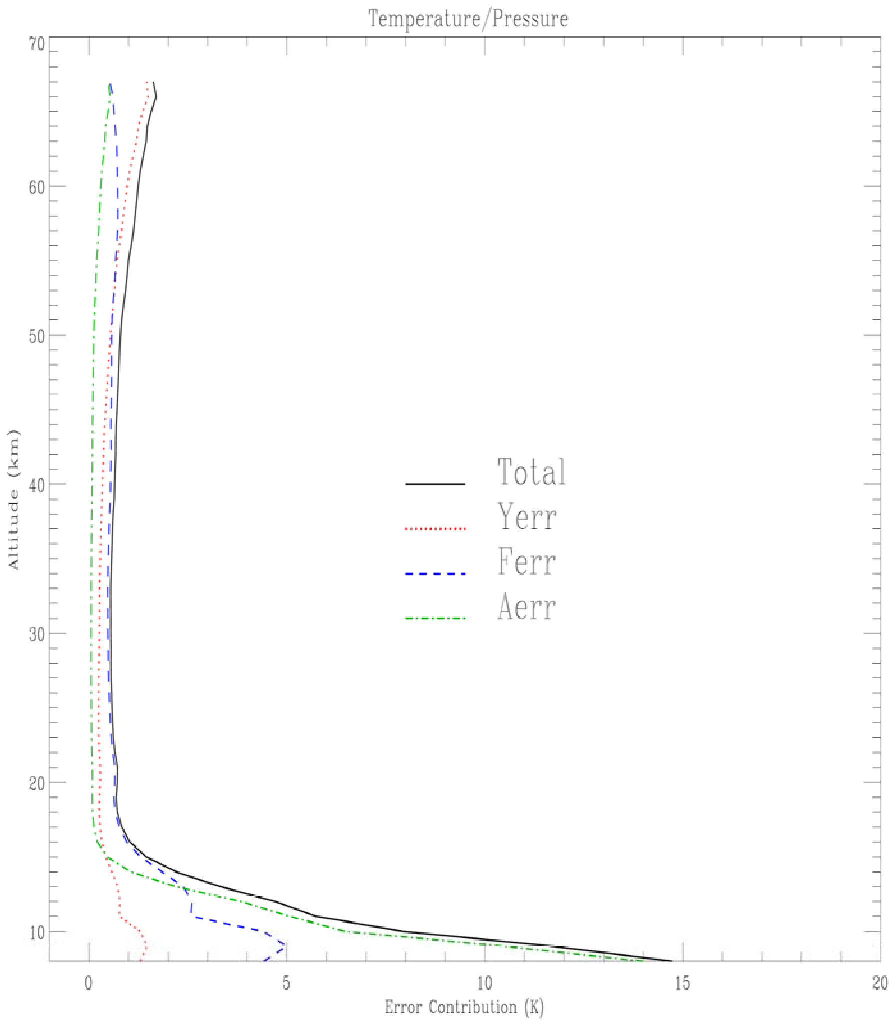


**Figure 5.1.1.** Random error contributions for the HIRDLS temperature retrieval channels for the first profile on 5 May 2006. Solid line is the total error. The dotted, dashed, and dot-dashed lines represent the measurement noise, forward model and a priori error contributions.

### Systematic bias

To check systematic biases in the HIRDLS temperature, the assimilated temperature produced by NASA's Goddard Earth Observation System (GEOS-4) is used to calculate the histogram of temperature difference. All the profiles on 5 May 2006 are used in this calculation. Figure 5.1.2 shows the histogram of the difference between the HIRDLS temperature and GEOS-4 temperature at three different pressure levels (1.0, 14.7, and 215.4 hPa). At 14.7 hPa, the mode is located near 0 K. However, the HIRDLS temperature shows about 5 K cold (warm) bias at 1.0 hPa (215.4 hPa) compared to GEOS-4 temperature. From 15 km to 40 km, the temperature difference between the HIRDLS temperature and GEOS-4 temperature is within 2 K. Histograms in a two dimensional domain are shown in Figure 5.1.3. The difference between the HIRDLS temperature and MLS temperature also shows similar systematic biases, i.e. cold bias at upper stratosphere and warm bias at lower stratosphere. In addition to its systematic linear bias, the difference between the HIRDLS temperature and MLS temperature shows a systematic wavy structure which seems to be produced by the systematic vertical oscillation in the MLS temperature (Livesey et al., 2005).

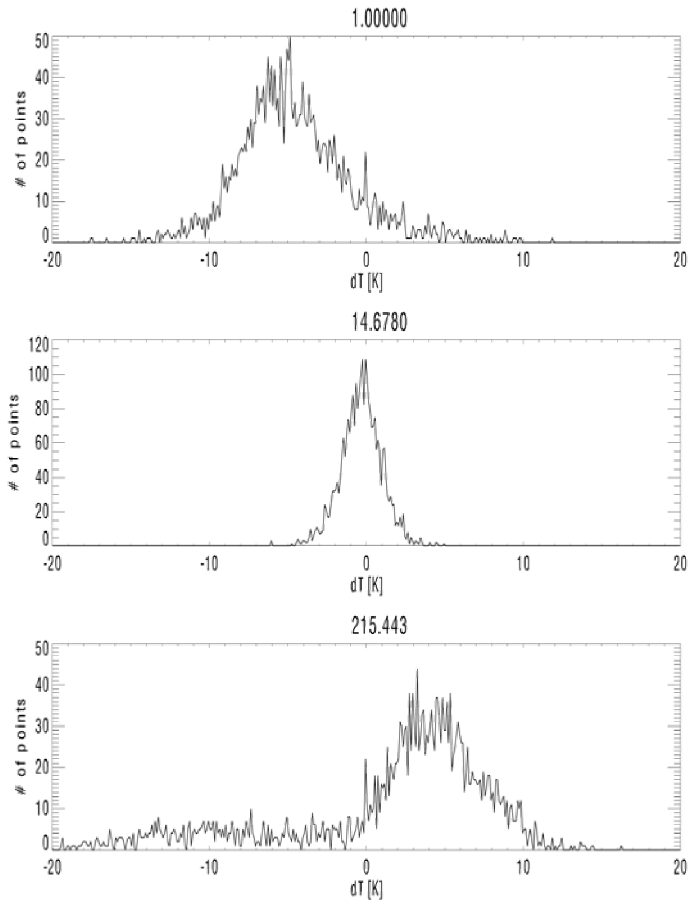


**Figure 5.1.2.** Histogram of the difference between the HIRDLS temperature and the GEOS-4 temperature on 5 May 2006. The top, middle, and bottom panels represent the histograms at 1.0 hPa, 14.7 hPa, and 215.4 hPa pressure levels.

The systematic biases in the HIRDLS temperature are mainly due to systematic biases in the HIRDLS radiance, believed to result from errors in correcting for the radiance coming from the plastic film (Gille et al., 2005).

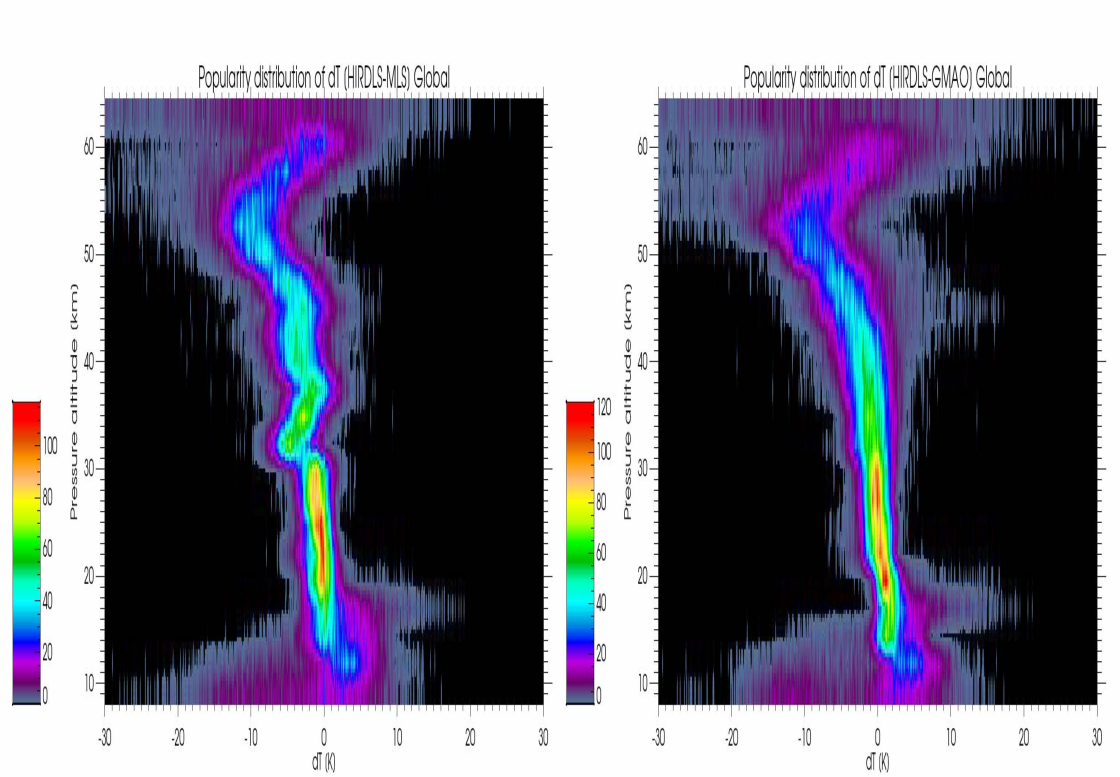


**Figure 5.1.3.** Histogram of temperature difference in a two dimensional domain. The left panel is for the difference between the HIRDLS temperature and MLS temperature. The right panel shows the difference between the HIRDLS temperature and GEOS-4 temperature on 5 May 2006.

## Scientific information

Due to its systematic biases, HIRDLS temperature might not be appropriate for climatology or any research related to long-term variation. Due to its high vertical resolution, it is expected to deliver qualitative information for atmospheric wave activities such as planetary waves, Kelvin waves, and gravity waves. HIRDLS temperatures show reasonable temporal/spatial variations for planetary waves and Kelvin waves. It was also shown that the HIRDLS temperatures can deliver information about waves with 4-5 km vertical scales

## Cautions

- **Temperature profile near cloud layer**

HIRDLS temperatures are not retrieved below the cloud top in the current version. When a cloud is detected in a HIRDLS radiance, the a priori value is taken as the solution, with a negative temperature precision in the levels with cloud. However, some profiles show very abnormal structure due to incorrect detection of the cloud top height. Figure 5.1.4 shows the example.

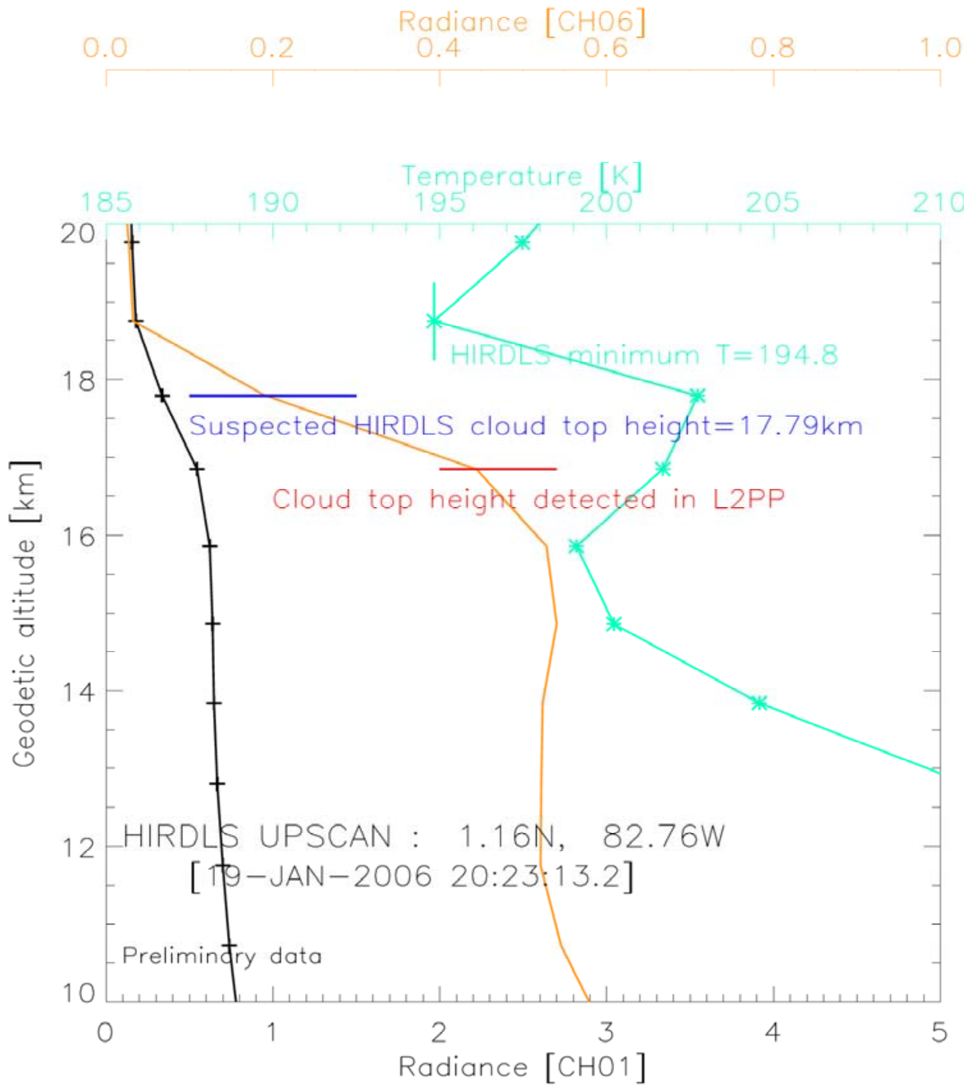


**Figure 5.1.4.** Profiles of the HIRDLS retrieved temperature and the HIRDLS radiances at channel 1 and channel 6 on 19 Jan 2006. The green line shows the retrieved HIRDLS temperature. The black and orange lines show the HIRDLS radiances in channel 1 and channel 6

.

HIRDLS radiances in channel 1 and channel 6 show the cloud top height at 17.79 km while the cloud top altitude detection algorithm denotes 16.8 km as the cloud top height. The retrieval processor retrieves temperature at 17.79 km by assuming a clear sky condition. The increased infrared radiance due to cloud at 17.79 km produces a significantly warm biased temperature at cloud top height where a minimum temperature is usually observed. If any similar structure is found in a temperature profile near a cloud layer, it is probably due to an incorrect detection of cloud top height in the current HIRDLS processor. The algorithm for cloud top detection has been improved and is in process to be implemented in the HIRDLS operational processor.

- **Banding and wavy patterns in the data**

As the scan mirror moves, it causes the plastic film to vibrate, creating a small oscillation in the radiometric signal. A major effort has been made to remove this, but some traces remain. Whenever any wavy structure is found in HIRDLS temperatures, the possibility that the oscillation is due to motion of the plastic film needs to be checked. In the current version, the magnitude of film oscillation is negligible compared to the magnitude of the radiance at each temperature channel. Film oscillation shows a significantly different pattern between up and down scans. Therefore it is recommended that a user compare the oscillation patterns from the up and down scans. The variable for the up/down scan flag is 'ScanUpFlag' in HIRDLS2 file. It is a byte variable (0: down scan, 1: up scan). If anyone finds any temperature profile with suspected film oscillation, please contact the HIRDLS temperature representative (Hyunah Lee, halee@ucar.edu).

**Improvements in process**：

Reduce systematic bias in temperature retrieval
Improve cloud detection method
Retrieve temperature at optically thin cloud layer
Increase vertical resolution of temperature retrieval (currently 1 km)

**References**

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Roewe, D. A., J. C. Gille, and P. L. Bailey, Infrared limb scanning in the presence of horizontal temperature gradients: an operational approach. *Applied optics*, **21**, 3775-3783, 1982.

## 5.2 Ozone

| | |
|---|---|
| **Species** | Ozone (O3) |
| **Data Field Name:** | O3 |
| **Useful Range:** | 100 hPa - 1 hPa |
| **Vertical Resolution:** | 1.5 - 2 km |
| **Contact:** | Bruno Nardi, |
| **Email:** | nardi@ucar.edu |

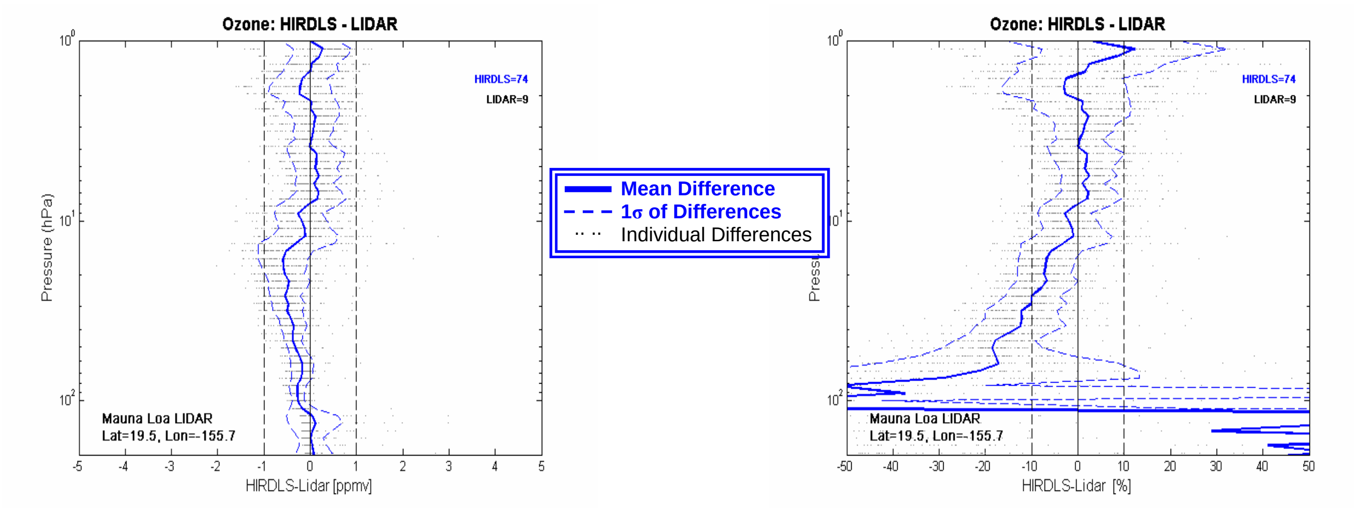
### Vertical Resolution

Radiance measurements made with a 200-250 meter spacing produce retrieved ozone and other species on a 1 km grid. Preliminary comparisons of ozone with lidar and ozonesondes in early validation work (below) suggest that actual vertical resolution is in the 1 to 2 km range.

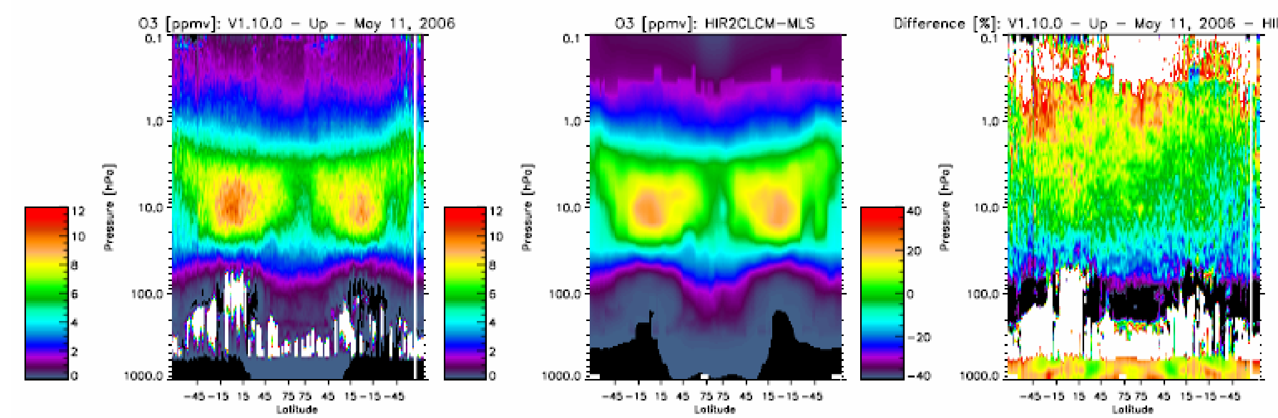
### Early Results and Validation

HIRDLS Ozone has been shown to agree well, as specified below, with various correlative data sources, especially in the stratosphere above 20 hPa. There is also strong preliminary evidence that HIRDLS is capable of detecting ozone layers on the 1 - 2 km scale. Retrievals are often not available below ~50hPa at low latitudes, probably due to the presence of clouds.

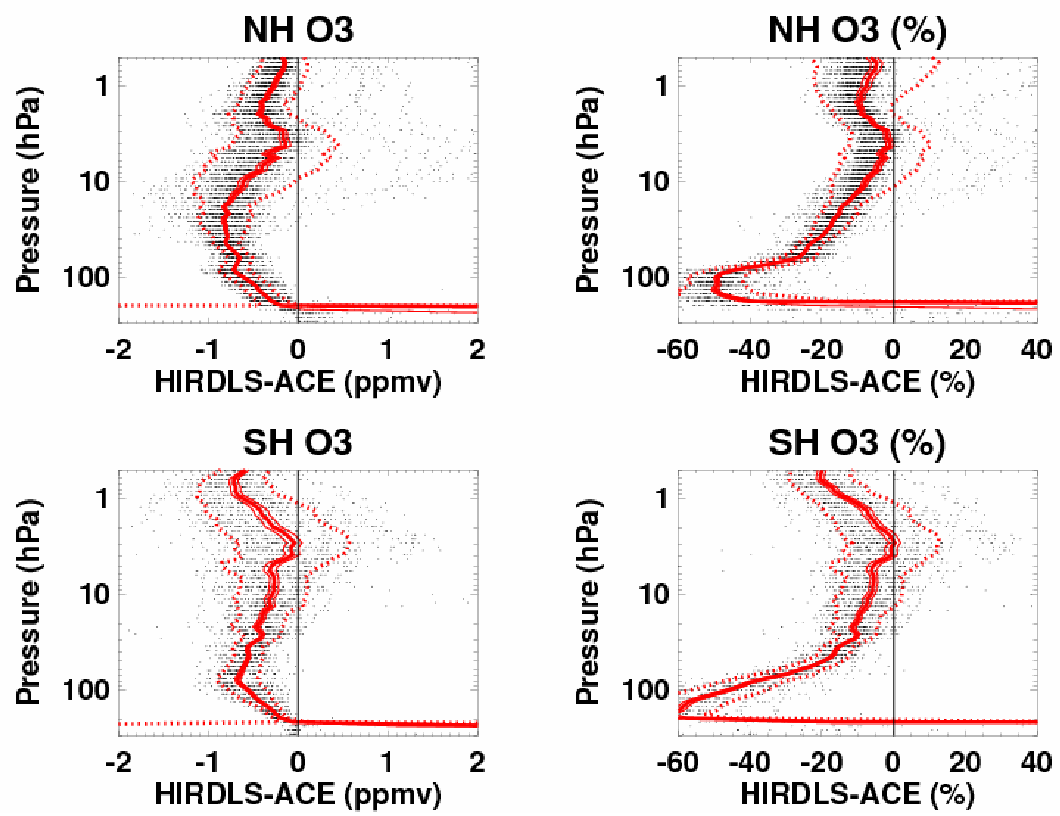
Lidar (below) and ozonesonde profile comparisons at low latitudes show a comparison to better than 10% between 1 hPa and 30 hPa with a low HIRDLS bias especially below 10 hPa and to within less than several percent at 2-10 hPa. These comparisons also give strong indication that HIRDLS is capable of detecting layers in the 1 - 2 km thickness regime: numerous coincident profiles with better than 500 km coincidence show similar layered features. This is strongly suggestive but not considered confirmed until more and closer coincidence comparisons are made.




MLS comparisons (below) indicate that HIRDLS is at least 10% lower below 20 hPa and is 10% or more high above 2 hPa.




ACE satellite solar occultation comparisons during 2006 May (below) show agreement to within ~10% between 1 hPa and 10 hPa with primarily a low HIRDLS bias and to within better than several percent at 2-4 hPa




**Data Screening**

Pressure Range: 30 hPa - 0.5 hPa
Clouds: Any profile for which the "CloudTopPressure" parameter is a positive number should be used with caution. The lower portion of these profiles, possibly also above the pressure indicated, may be severely effected by the presence of clouds; symptoms may be large spikes as well as very low values.

Quality Flag: Estimated Precision: Values of "O3Precision" that are negative indicate a strong *a priori* influence in the result and should be used with caution.

**Artifacts**

Upper Trop/Lower Stratosphere: It is known that in the Upper troposphere/lower stratosphere the ozone retrieval is sensitive to clouds in that region, especially channels 12 and 10, and that the effect of processing through the L2 retrieval may result in both very high and very low values of ozone in this region (200 hPa - 50 hPa). This is particularly true of low latitude profiles.

**Priorities for Future Data Screenings**

Better treatment of clouds in retrievals, especially at low latitudes.
Improvement of low ozone values below ~20 hPa, especially down to ~200 hPa.
Better determination of vertical resolution through increased number of and quality of comparisons.

## 5.3 Nitric Acid

**Species:** Nitric Acid ($HNO_3$)
**Data Field Name:** $HNO_3$
**Useful Range:** 147 hPa – 2.15 hPa
**Vertical Resolution:** ~ 1 km (estimated)
**Contact:** Douglas E. Kinnison, NCAR-HIRDLS
**Email**: dkin@ucar.edu

**Early Results and Validation:**
The HIRDLS $HNO_3$ data product should be considered very preliminary. The general morphology of $HNO_3$ is captured (Figure 6.3.1). There is higher abundance of $HNO_3$ at high latitudes, and a lower abundance at low latitudes in the stratosphere. Relative to MLS, HIRDLS underestimates the peak $HNO_3$ by 3-4 ppbv. HIRDLS derives higher abundance of $HNO_3$ in the polar upper stratosphere. This is attributed to issues connected with removing the "apparent Kapton blockage". In the high latitude region, one should use caution in using HIRDLS $HNO_3$ data above 10 hPa. The vertical resolution of the $HNO_3$ data products for HIRDLS and MLS are believed to be 1.0 km and 3-4 km (MLS Data Product Document, page 63) respectively. There is additional vertical structure in the $HNO_3$ data product relative to MLS. However, it is unclear at this time how much of this structure is real versus noise (due to the removal of the blockage).

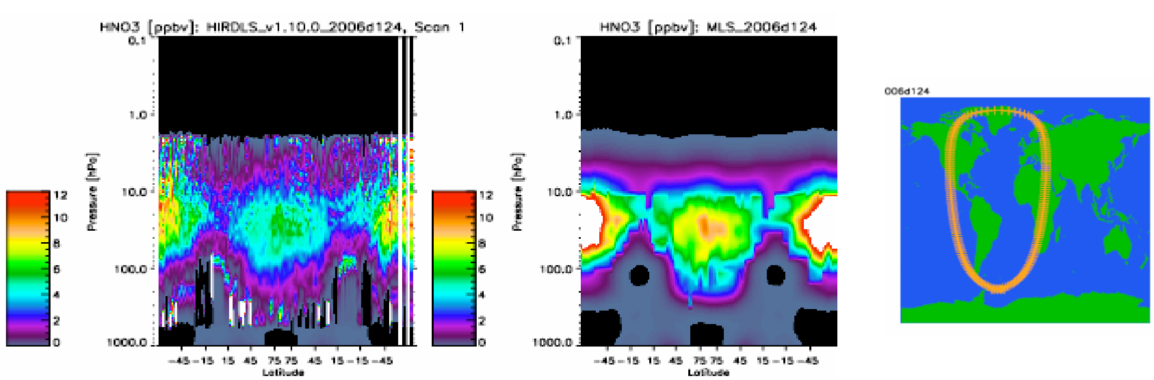



**Figure 5.3.1.** Latitude-height comparison of HIRDLS and MLS $HNO_3$ (ppbv) data products. The MLS Version 1.5 data has been interpolated to the observation points of HIRDLS data. The swath is for 4 May 2006.

HIRDLS also underestimates the peak $HNO_3$ relative to the Atmospheric Chemistry Experiment (ACE) instrument retrieved data (version 2.2) by approximately 2 ppbv (Figure 5.3.2). The HIRDLS pressure at the peak $HNO_3$ is also slightly lower (higher in altitude). The reason for this peak $HNO_3$ pressure discrepancy is being investigated. The HIRDLS precision is comparable to the ACE data (see standard deviation curves in Figure 5.3.2). There is also more HIRDLS $HNO_3$ above 10 hPa relative to ACE, similar to what is seen when HIRDLS $HNO_3$ is compared to MLS.

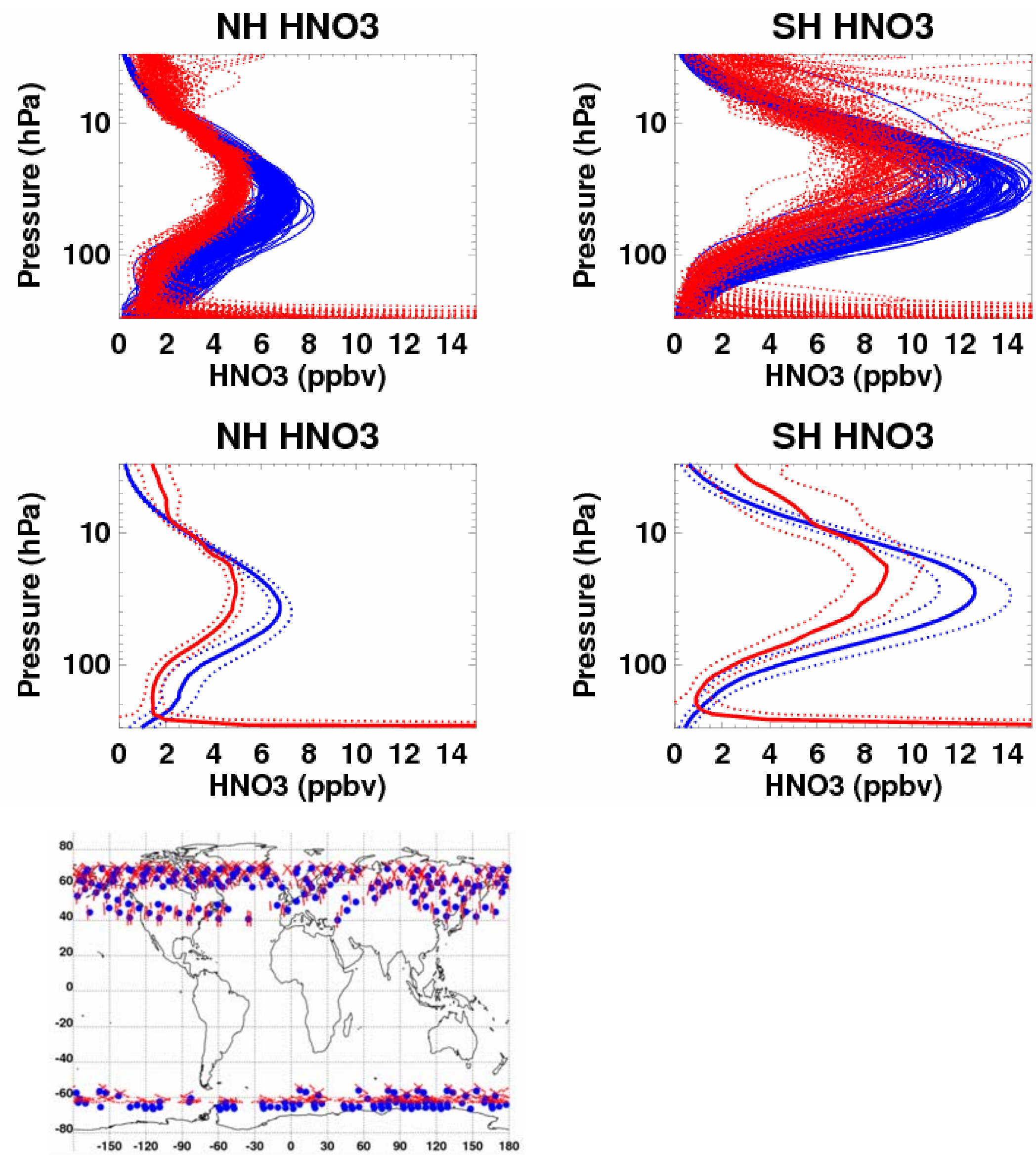



**Figure 5.3.2.** Coincident profile comparison of HIRDLS (red) and ACE $HNO_3$ (blue) data products for May 2006. The coincidence criteria is same day and within ±500 km. There were a total of 325 coincidences in the month of May 2006 (195 in NH; 130 in SH). The average separation distance was 170 km. The range for all profiles was 7-470 km. Dotted lines are ± 1-σ standard deviation (for an average of 1-10 HIRDLS profiles). The top row is shows all coincidence profiles. The middle row is the average of all HIRDLS and ACE profiles along with the standard deviation. The bottom row shows the latitude region where coincidences occurred.

**Acknowledgements:** The HIRDLS team would like to thank both the EOS Aura MLS science and the ACE science teams for making their data available for HIRDLS validation. The ACE / HIRDLS comparisons were made by Professor Cora Randall, CU/LASP.

### 5.4 Cloud Top Pressure

| | |
|---|---|
| **Species** | Cloud Top Pressure |
| **Data Field Name:** | CloudTopPressure |
| **Useful Range:** | 422-10 hPa |
| **Vertical Resolution:** | 1 km |
| **Contact:** | Steve Massie, |
| **Email:** | massie@ucar.edu |

The cloud top pressure (i.e. the 'CloudTopPressure' variable in the HIRDLS2 file) is determined in the following manner. For a single day's set of radiance profiles, the clear sky radiance profile for HIRDLS channel 6 (the 12 micron channel) is calculated by an iterative technique for several latitude bands. For the first iteration, the average profile, its standard deviation, and associated gradients from 5 to 30 km altitude, are calculated summing over all profiles. For the second iteration, profiles greater than the initial mean profile are removed from the ensemble average (based on the fact that a cloudy radiance profile deviates from the average curve). New standard deviations and associated gradients are recalculated. The iterative process continues for five iterations.

Once the clear sky radiance profile is calculated, we determine the altitude level at which cloud radiance perturbations are first noted. The cloud top pressure (in hPa) is the pressure derived by the operational retrieval that corresponds to the cloud top altitude. Since the cloud top altitudes are on an altitude grid with one kilometer spacing, the cloud top pressure has a granularity reflective of the altitude grid spacing, e.g. for pressure level P, the cloud top pressure could be large by $\Delta P \sim P\,(\exp(1\ \text{km}/7\ \text{km}) - 1.0) \sim 0.15\,P$.

There are many cases in the V2 delivery for which clouds were not detected .For these cases mixing ratios and temperatures are abnormally large, since the retrieval assumes that no clouds are present, while in fact there is cloud opacity present. Future data versions will rectify this situation.

## 6.0 HIRDLS Validation

HIRDLS measurements are subject to more extensive manipulation in order to reach the retrieved geophysical products. This requires that extra attention be given to the validation of these products, and providing feedback to their improvement. In particular, we expect that HIRDLS data will be able to globally resolve features in atmospheric temperature and constituents on a vertical scale smaller than has previously been possible from satellite-based instruments (about 1.0 km) other than the solar occultation instruments, which have only sparse coverage. It is estimated that the pre-launch vertical resolution has not been degraded from the original specifications due to the apparent Kapton blockage.

## 7.0 Data File Structure and Content

**Contact:** Cheryl Craig
**Email:** cacraig@ucar.edu

HIRDLS Level 2 data is stored in the HDF-EOS5 format and the fields are as described in the HDF-EOS Aura File Format Guidelines document [1]. These data files can be read via C/C++ or Fortran using either the HDF-EOS5 or HDF5 library. Also, a HIRDLS developed IDL routine "get_aura" is available upon request for those users who wish to use IDL to access the HIRDLS data.

Users should obtain the pre-compiled HDF5 library for their operating system, if possible, otherwise source code is also available (see http://hdf.ncsa.uiuc.edu). These are prerequisite in order to compile the HDF-EOS5 library (see http://www.hdfeos.org/). Both libraries are needed to fully access the Aura HIRDLS data files. For additional help contact the GES DISC at help-disc@listserv.gsfc.nasa.gov or telephone 301-614-5224.

Each HIRDLS Level 2 file contains one day's worth of data and contains all species that HIRDLS measures. In V2.00 and following, a number of the fields will be filled completely with missing values until correction algorithms are refined for these species. For users who require only a subset of the HIRDLS species, the Goddard DAAC has the ability to subset data before distributing it to users. Contact the DAAC directly for more information on this service.

Individual HIRDLS data values for a product are stored in fields labeled with the species name (see the appropriate section above for the exact Data Field Name). The estimated precision of each data point is a corresponding field named *Species*Precision (for instance, Temperature and TemperaturePrecision). Two additional fields for each species, *Species*NormChiSq and *Species*Quality, are both filled with missing for V2. CloudTopPressure does not have Precision, NormChiSq or Quality fields.

There are two time fields in the HIRDLS data file, *Time* and *SecondsInDay*. *Time* is stored in TAI time (seconds since the epoch of UTC 12 AM 1-1-1993). This time includes leap seconds and can cause problems with simplistic conversions. For this reason, HIRDLS is also storing *SecondsInDay* which is seconds since midnight of the data day. Leap seconds do not pose a problem when using this field. Note that the first data point may be negative which indicates a time stamp before midnight. This is the case for scans which span a day boundary.

[1] http://www.eos.ucar.edu/hirdls/HDFEOS_Aura_File_Format_Guidelines.pdf

## 8.0 Algorithm Changes

| **Version** | **Changes** |
|---|---|
| **2.00** | **[Baseline]** |
| **2.01** | **Modified to process Scan Table 22** |

## 9.0 Acronyms

| | |
|---|---|
| ACE | Atmospheric Chemistry Experiment |
| ATBD | Algorithm Theoretical Basis Document |
| CU | Colorado University |
| EOS | Earth Observing System |
| DAAC | Distributed Active Archive Center |
| GEOS-4 | Goddard Earth Observation System |
| GMAO | Goddard Modeling and Assimilation Office |
| HDF5 | Hierarchical Data Format Version 5 |
| HDF-EOS5 | HDF for EOS Version 5 |
| HIRDLS | HIgh Resolution Dynamics Limb Sounder |
| IDL | Interactive Data Language |
| JPL | Jet Propulsion Lab |
| L0 | Level 0 |
| L0-1 | Level 0-1 |
| L0PP | Level 0 Pre-processor |
| L1 | Level 1 |
| L1-2 | Level 1-2 |
| L1C | Level 1 Corrector |
| L1PP | Level 1 Pre-processor |
| L1X | Level 1 Excellorator |
| L2 | Level 2 |
| L2PP | Level 2 Pre-processor |
| LASP | Laboratory for Atmospheric and Space Physics |
| LOS | Line Of Sight |
| MLS | Microwave Limb Sounder |
| NASA | National Aeronautics and Space Administration |
| NCAR | National Center for Atmospheric Research |
| NH | Northern Hemisphere |
| OMI | Ozone Monitoring Instrument |
| PARB | Project Anomaly Review Board |
| PIs | Principal Investigators |
| PMs | Project Managers |

| | |
|---|---|
| SPIE | International Society for Optical Engineering |
| TAI | International Atomic Time |
| TBS | To Be Supplied |
| TES | Tropospheric Emission Spectrometer |
| UK | United Kingdom |
| USA | United States of America |
| UTC | Coordinated Universal Time |
| UTLS | Upper Troposphere/Lower Stratosphere |