HIRDLS observations of polar stratospheric clouds, cirrus near the tropopause, and background stratospheric aerosol

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Outline of Presentation

Demonstrate that HIRDLS can detect
- background stratospheric aerosol
- polar stratospheric clouds (PSCs)
- subvisible cirrus

Demonstrate that the
- geophysical structure and
- extinction values
of the HIRDLS observations are very reasonable

Discuss how this data can be used in science studies
HIRDLS Experiment

21 Spectra Channels

Radiometer, limb view

Several spectral channels are sensitive to aerosol and clouds
- gas contributions are minimal

<table>
<thead>
<tr>
<th>Channel</th>
<th>Wavelength</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.3 µm</td>
<td>N₂O</td>
</tr>
<tr>
<td>6</td>
<td>12.0</td>
<td>“IR Window”</td>
</tr>
<tr>
<td>9</td>
<td>10.8</td>
<td>CFC12</td>
</tr>
<tr>
<td>13</td>
<td>8.1</td>
<td>near sulfate peak</td>
</tr>
<tr>
<td>19</td>
<td>7.1</td>
<td>H₂O, O₃</td>
</tr>
</tbody>
</table>
One Day’s Retrieval 1/27/05

HIRDLS Temperature

Latitude

200

hPa

20

Temperature (k)

185 190 195 200 205 210 215 220 230 240 250

HIRDLS Extinction

Latitude

Aerosol

PSC

Cirrus

Extinction (km⁻¹)

1.0e⁻³ 2.0e⁻³ 3.0e⁻³ 4.0e⁻³ 5.0e⁻³ 6.0e⁻³ 1.0e⁻⁴ 3.0e⁻⁵ 6.0e⁻⁵ 1.0e⁻⁵ 3.0e⁻⁶ 1.0e⁻⁶ 3.0e⁻⁷
June 19 WB-57 Flight
Reeves / Wilson (DU) aerosol size distributions
Comparison to HIRDLS extinction

Channel 13 (8.1 µm) extinction (km⁻¹)

Latitude

HIRDLS
Channel 13
data
HIRDLS – HALOE Comparison

Comparison of HIRDLS and HALOE extinction
HALOE data scaled to HIRDLS channel 13 wavelength
January 27, 2005 10-15 N

- Extinction (km⁻¹)
- Pressure (hPa)

Tropopause
Correction uncertainty

HALOE data is shown as solid lines, while HIRDLS data is shown as squares.

1 std uncertainty is indicated by dashed lines.
Examples of PSC radiance profiles

![Graph showing PSC radiance profiles with labels: PSC I, T > T_{ice}, PSC II, Ice, single obs, average curve, and log Radiance.](image)
PSCs Observations on January 27

450 K vortex geometry

- T < 195 K contour is given by the green line, Tice by the blue line, Nash vortex by the red line.

HIRDLS Observations

- PSCs are denoted by the red crosses, and blue crosses are non-PSCs.
HIRDLS and POAM Comparison
HIRDLS Channel 13 (8.1 µm), POAM 1.02 µm
February 21, 68 N, 347 E

- Pressure (hPa)
- Extinction (km⁻¹)

1 std HIRDLS
1 std POAM

averaged 4 HIRDLS profiles
distance between obs < 200 km
PSC Observations

Volume Density
HIRDLS, January 27, 2005
Ternary (Carslaw), NAT (Worsnop)
40 - 70 hPa

CH 6 Extinction
January 27, 2005

Volume Density (µm^3 / cm^3)

Temperature (K)

Theory: Carslaw, Worsnop, Tabazadeh
Extinction -> Volume density, Massie et al. JGR, 103, p5773, 1998
Tropospheric Clouds
Opaque and Subvisual Cirrus

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**Figure:**
- **Title:** Opaque and Cirrus Layer
- **Axes:**
  - Vertical: Altitude (km)
  - Horizontal: Radiance (log scale)
- **Data Points:**
  - Single observations
  - Average curves
- **Legend:**
  - Opaque
  - Cirrus Layer

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**Note:**
- The data points are plotted on a log scale for radiance to better visualize the distribution of measurements.
Subvisual Cirrus Clouds
Involved in UT/LS Dehydration Processes

Cirrus Laminar Layers
Tropics
January 27, 2005

Temperature Profiles
Tropics
January 27, 2005

Pressure (hPa)

Temperature (K)

Pressure (hPa)

Exinction (km\(^{-1}\))

1 km
Comparison to Climatology


HALOE
5 yrs data

Alt ~ 16 km, 2005 July - August

HIRDLS
~ 100 hPa

Approx Ch 6 Layer Cirrus Extinction (0.001 km-1)
**Multi-Wavelength Extinction Ratios**

**HIRDLS Observations**
June 19, July 7

<table>
<thead>
<tr>
<th>Type</th>
<th>Theory</th>
<th>Obs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td>Cirrus</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Theory - Mie**

Ratio of Extinction (Ch 13 / Ch x)

Wavenumber (cm⁻¹)

Pressure (hPa)

Latitude

Extinction Ratio, CH 13 / Ch 6

- Sulfate: ~2.5
- Cirrus: ~1
Cirrus Radii - Reality Check

Theory

HIRDLS Observations

Extinction Ratio for Cirrus
CH 13 / CH 6

Observed Extinction Ratios
Jan 27, June 19, July 7, 2005
CH 13 / Ch 6

Counts

Extinction Ratio (CH 13 / CH 6)

Effective Radius (µm)

Extinction Ratio

Peak ~ 1
Radius ~ 5 µm
Observational Goals

Quantify the seasonal variations in the background stratospheric aerosol

Relate PSC temporal and spatial distributions to the production of active chlorine in the northern polar region

Relate subvisible cirrus to the seasonal variations of H$_2$O near the tropopause (i.e. the H$_2$O “tape recorder”)