

SAGE III

Stratospheric Aerosol and Gas Experiment

An Earth Science Mission on the International Space Station

The SAGE III/ISS Lunar Algorithm

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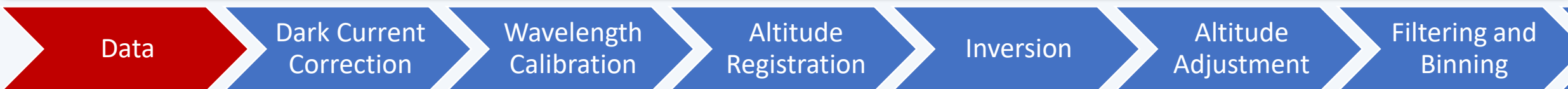




The SAGE III/ISS Lunar Algorithm

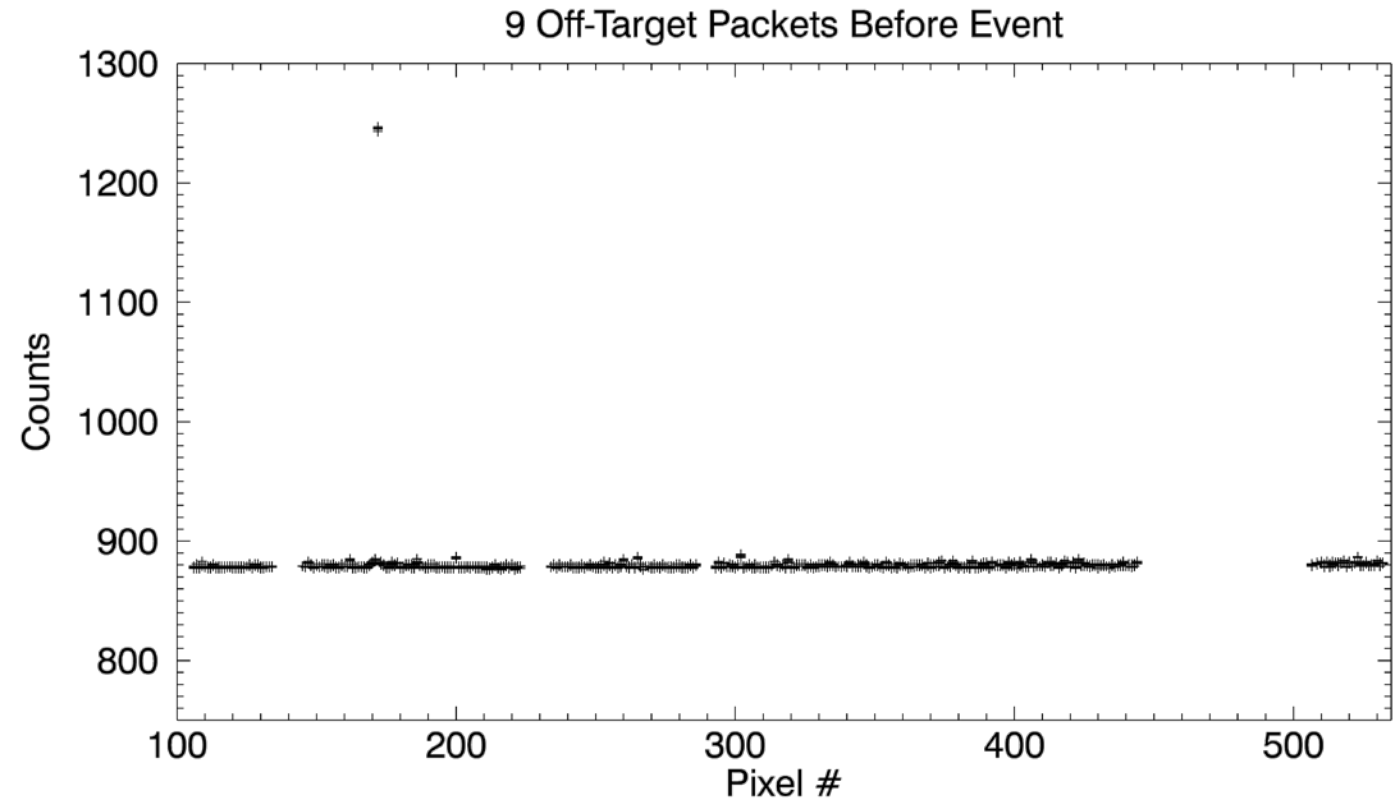
Data

- Using the moon as a target
 - More geographical coverage
 - Monitor nighttime species
 - Illuminated portion of the moon varies in shape and brightness
 - Moon is not very bright overall
- Instrumental field of view is increased for lunar events
 - More “counts” on the CCD, increased signal-to-noise
 - Coarser resolution (altitude)
- Packet rate for lunar science data is 1/16 s compared to 1/64 s for solar data
 - Fewer temporal data points
 - More spectral data points
- This presentation will focus on the progression of data through a single moonset event.
Date: 2018.07.23 | Time: 0234 UTC
Lat: 28.0N | Lon: 12.7W



Dark Current Correction

- The CCD begins collecting data packets prior to target acquisition.
- The counts measured in these space-looking packets are used to correct all counts measured through the event.



Data

Dark Current
Correction

Wavelength
Calibration

Altitude
Registration

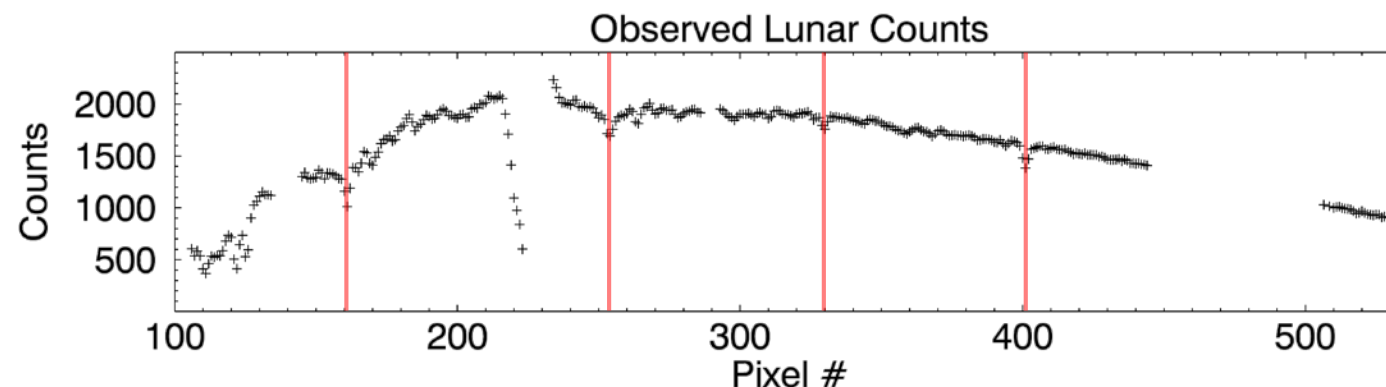
Inversion

Altitude
Adjustment

Filtering and
Binning

Wavelength Calibration

- Start with a nominal pixel-to-wavelength map.
- Consider the brightest exoatmospheric packet(s).
- Shift the counts spectrum to best echo the features of a reference solar spectrum.
- So far, we see shifting from nominal of less than ± 0.05 nm.



Data

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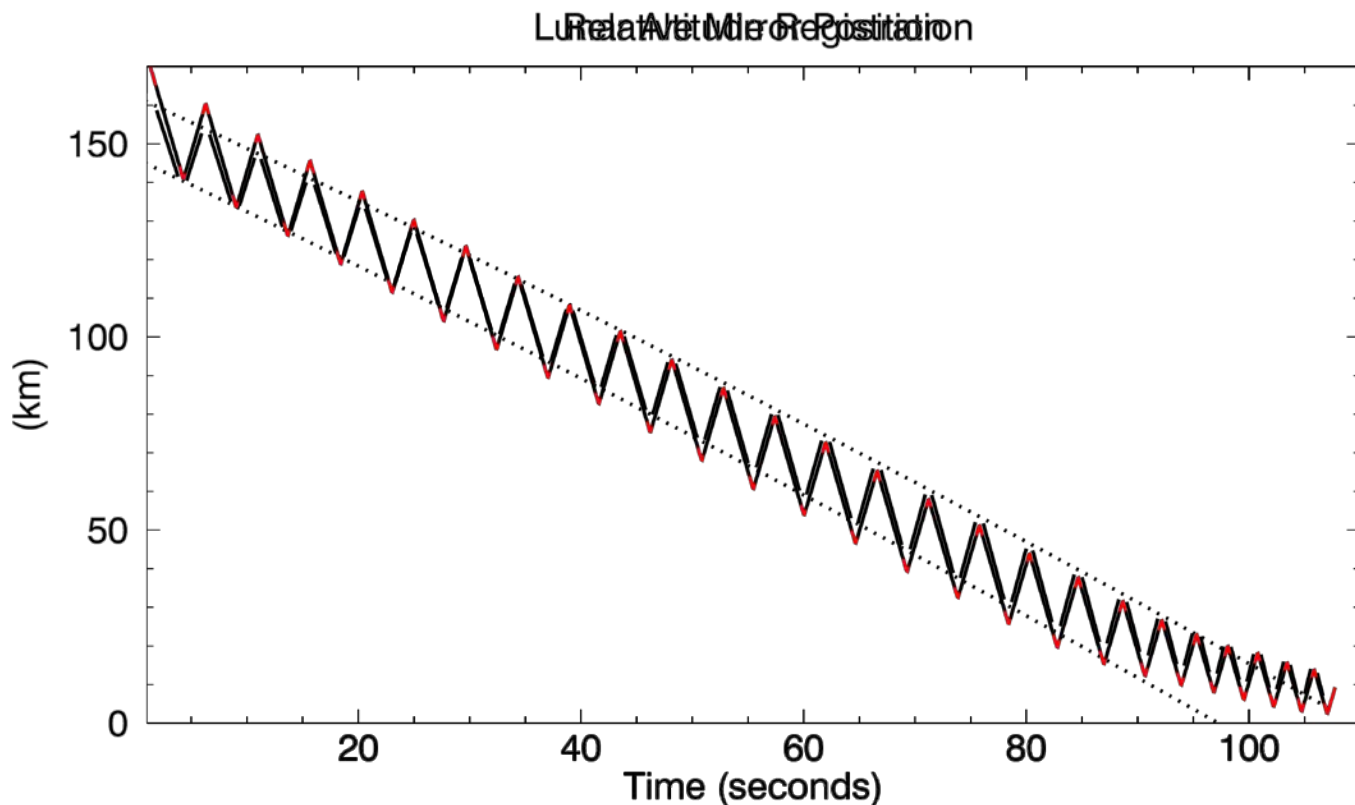
Altitude
Registration

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Altitude
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Altitude Registration



- The instrument scans through the brightness centroid of the target.
- Given the geometry of the occultation and the fullness of the moon, we can reference a lunar model to predict this centroid and the chord along which the instrument scans.
- Comparing the observed edges of the target to the model edges helps register the relative location of each packet on the target.
- Refraction is also considered when determining the tangent altitude of the optical path.

Data

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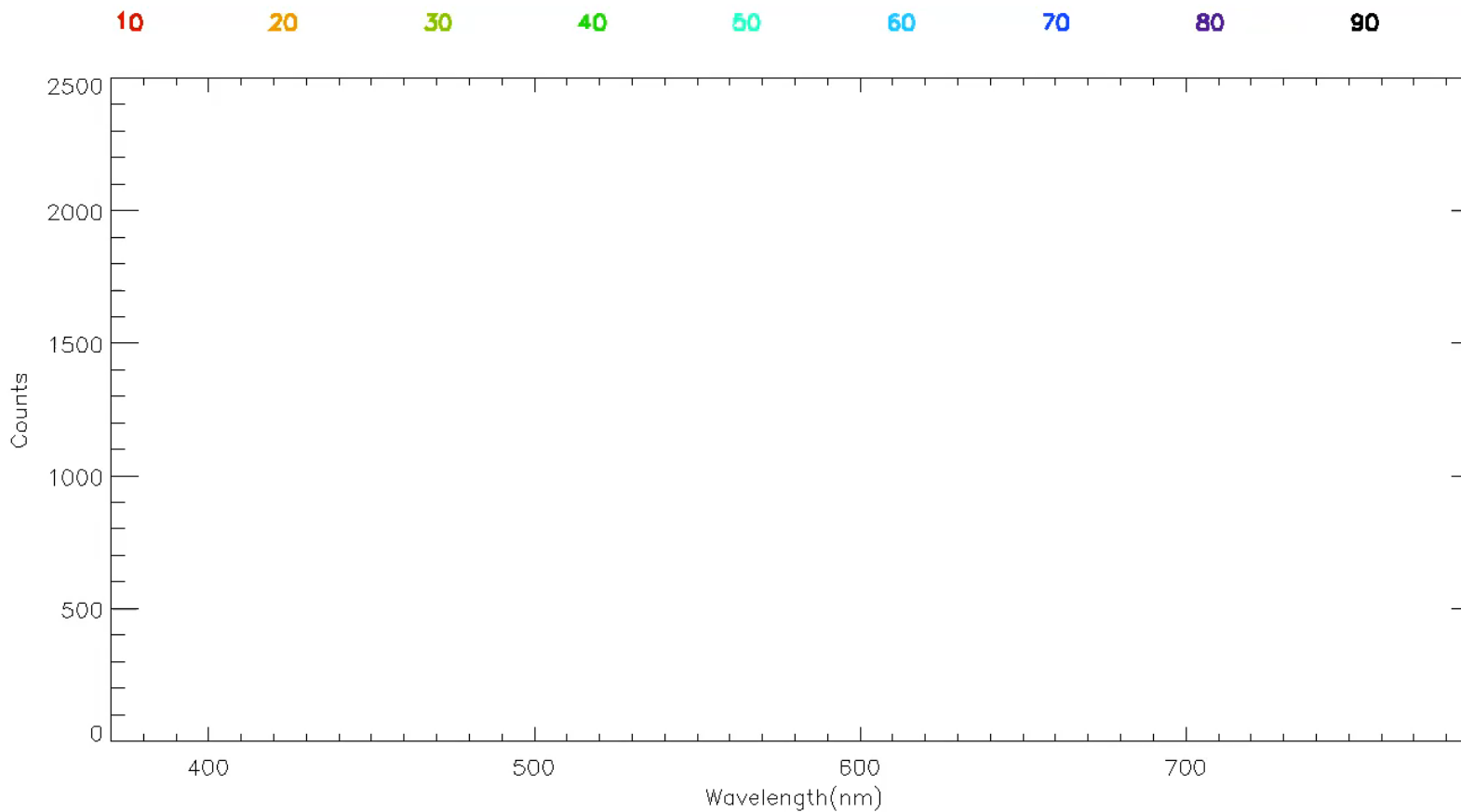
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Exoatmospheric Scans



Dark Current
Correction

Wavelength
Calibration

Altitude
Registration

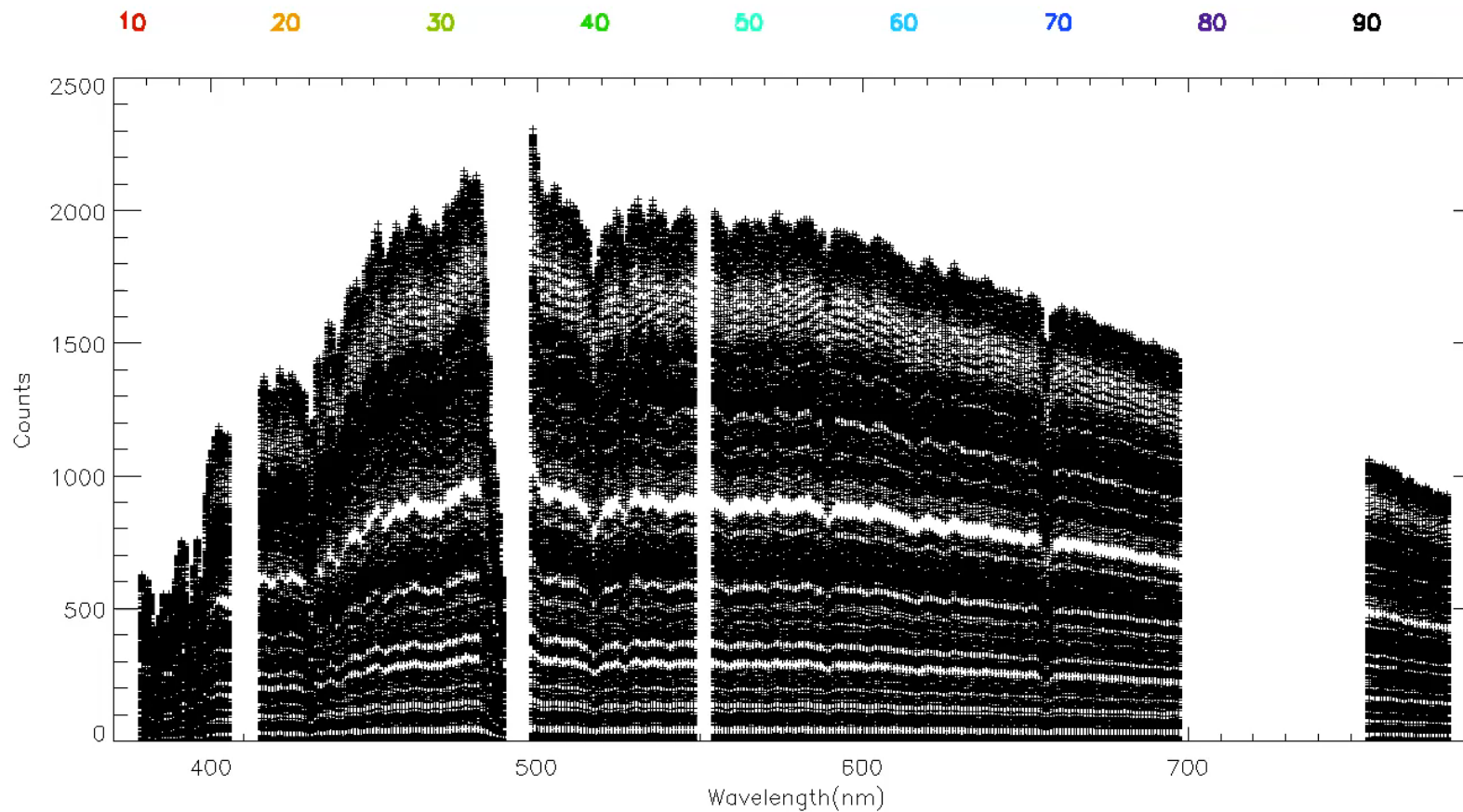
Inversion

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Filtering and
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Peeling

Attenuated Scans



Dark Current
Correction

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Inversion

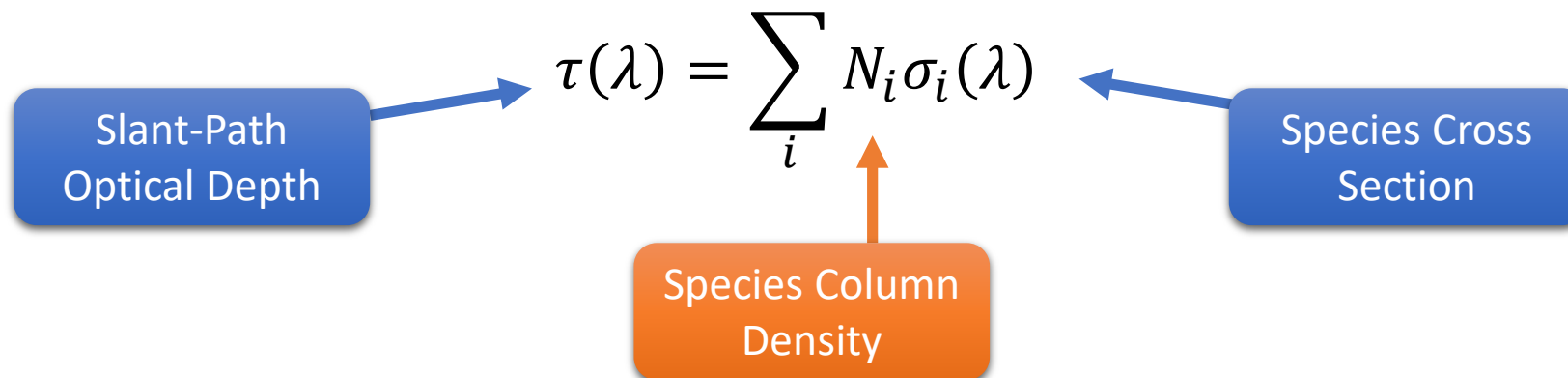
Altitude
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MLR Retrieval

- We want to perform a packet-by-packet retrieval through the use of a Multiple Linear Regression (MLR) which attempts to simultaneously solve for slant-path concentrations of all the absorbing gas species.
- The MLR is constructed such that the optical depth is explained by the sum of the optical depth contribution from each absorbing gas species. This can be presented as the equation


$$\tau(\lambda) = \sum_i N_i \sigma_i(\lambda)$$

The diagram illustrates the equation $\tau(\lambda) = \sum_i N_i \sigma_i(\lambda)$. A blue box labeled "Slant-Path Optical Depth" has an arrow pointing to the left-hand side of the equation. A blue box labeled "Species Cross Section" has an arrow pointing to the $\sigma_i(\lambda)$ term. An orange box labeled "Species Column Density" has an arrow pointing to the N_i term.



Slant Path Optical Depth

$$\tau(\lambda) = \sum_i N_i \sigma_i(\lambda)$$

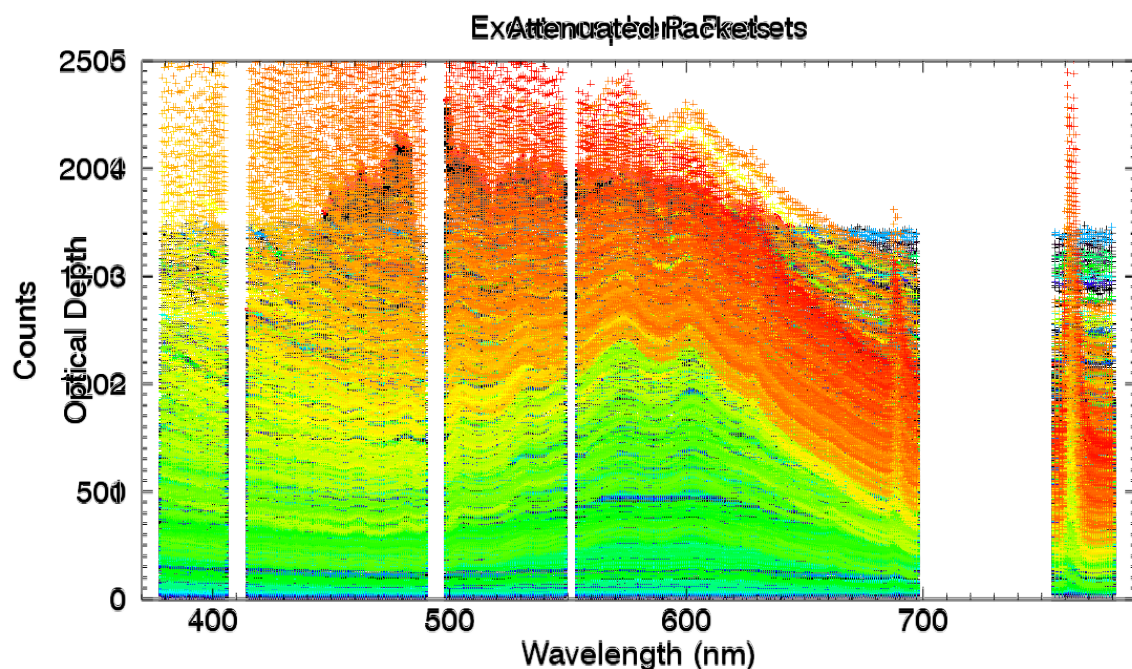
- For each counts spectrum sample, or “packet”, we calculate the atmospheric transmission, t , as

$$t = \frac{\text{packet counts}}{\text{average exoatmospheric counts}}$$

and the optical depth, τ , as

$$\tau = -\ln t$$

- Because the lunar surface is characterized by gradients in albedo, the reference average intensity is insufficient for obtaining a true optical depth value for every packet. Therefore, the algorithm must correct for albedo as necessary.



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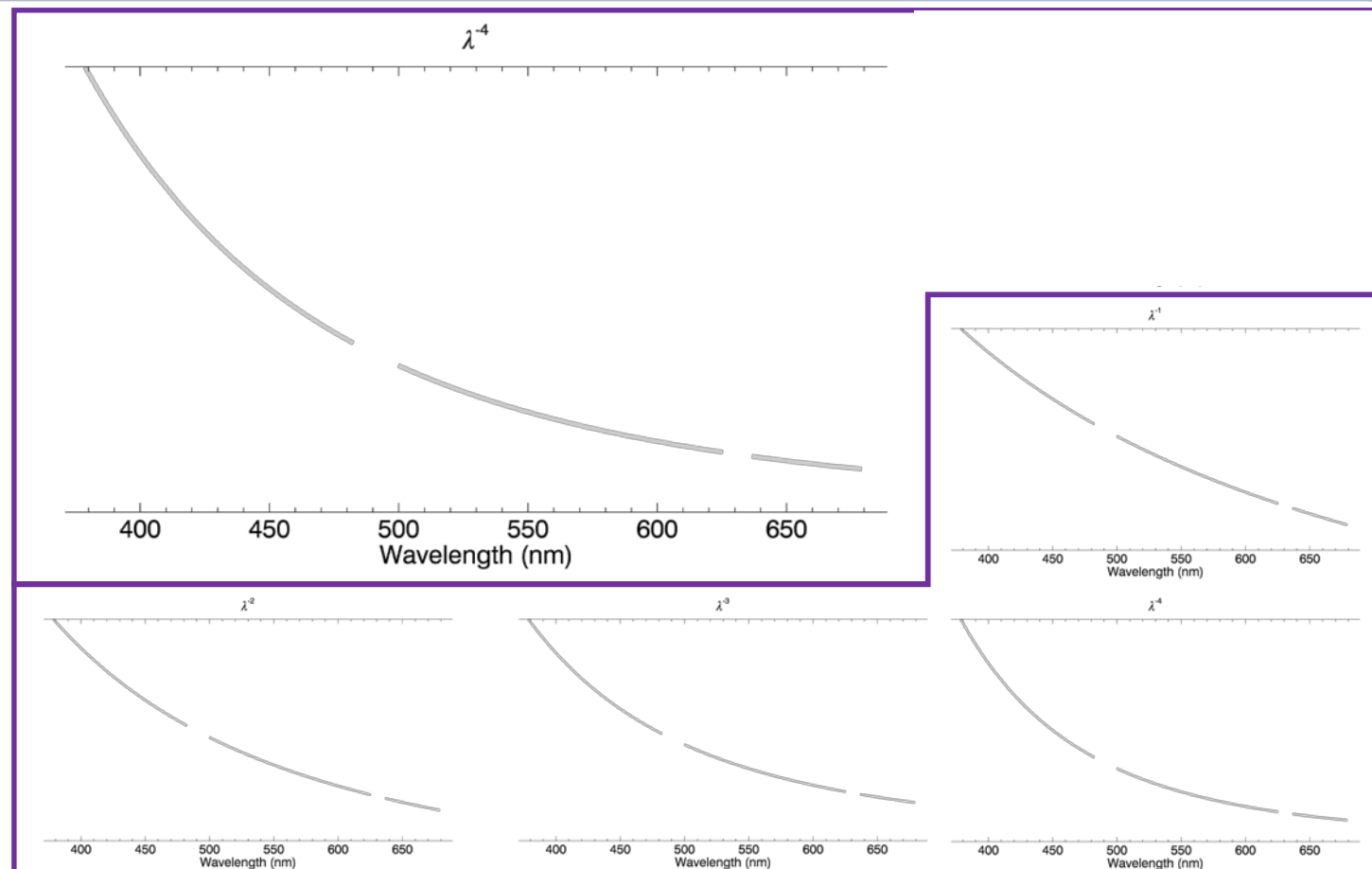
Filtering and
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Peeling

Cross Sections

$$\tau(\lambda) = \sum_i N_i \sigma_i(\lambda)$$

- Cross section spectra for O₃, NO₂, NO₃, OClO, and O₄.
- Four filters (plus a constant) are added in with the cross sections to account for the optical depth contribution from Rayleigh scattering, aerosols, and differences in lunar albedo.



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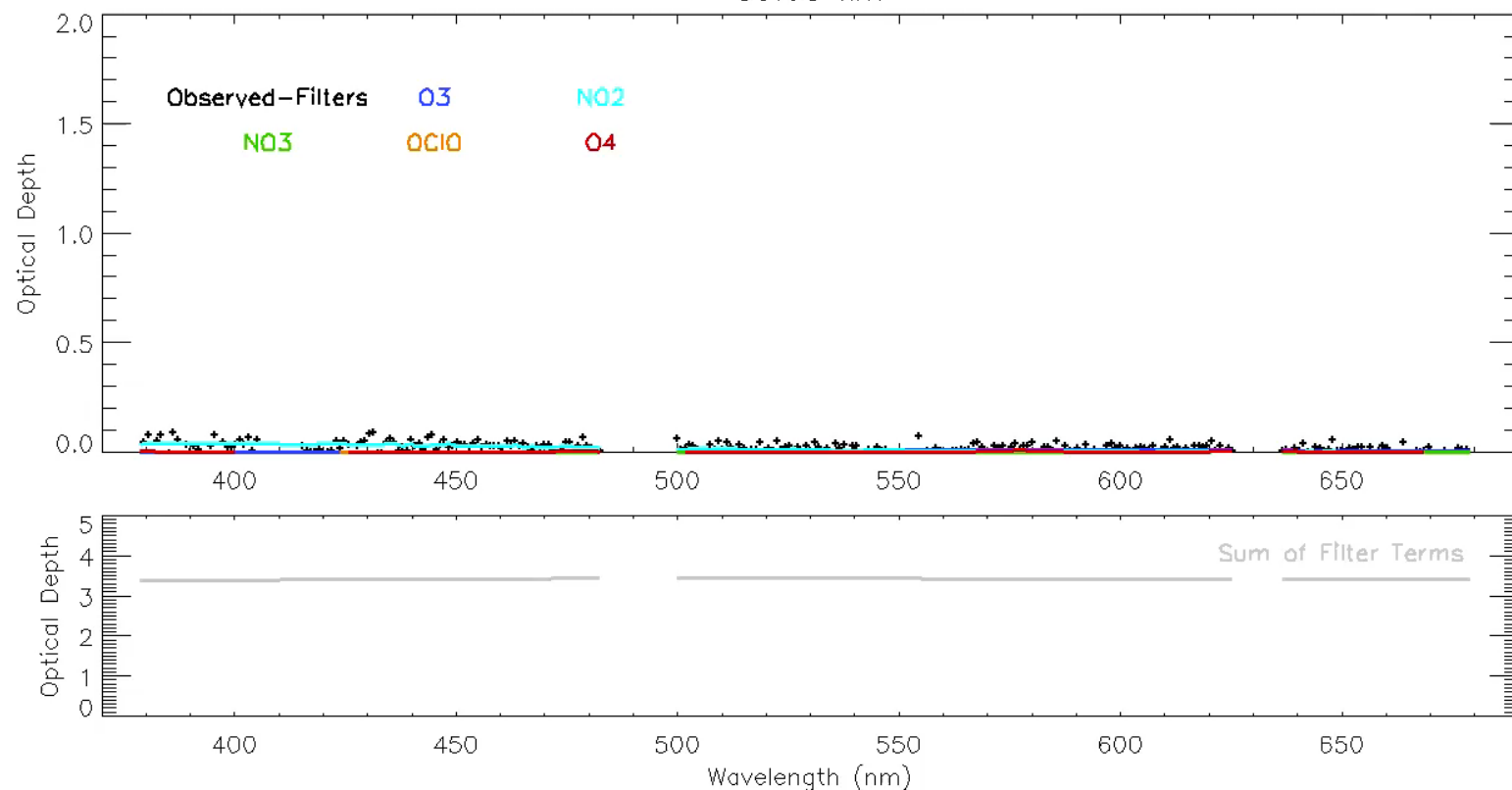
Altitude
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Filtering and
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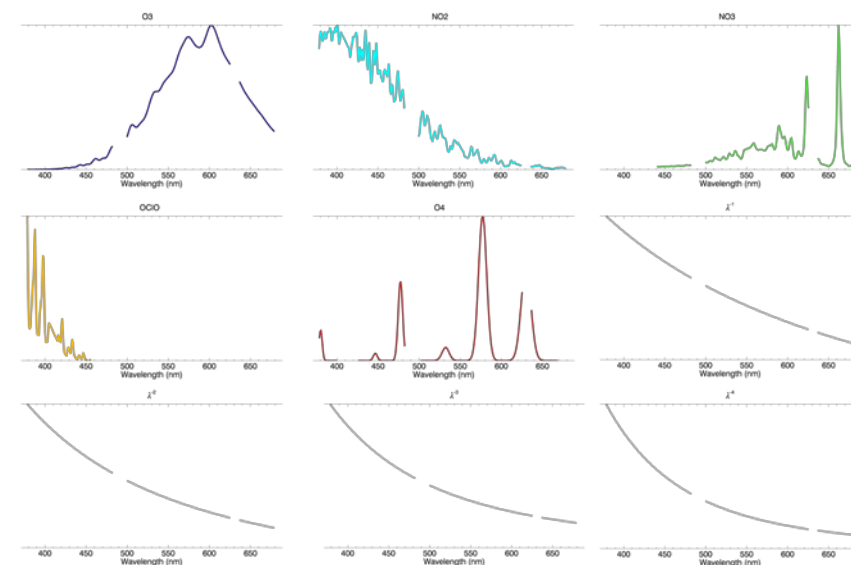
Peeling

Inversion

59.08 km



$$\underbrace{\tau(\lambda)}_{\text{+symbols+}} = \sum_i \underbrace{N_i \sigma_i(\lambda)}_{\text{-lines-}}$$



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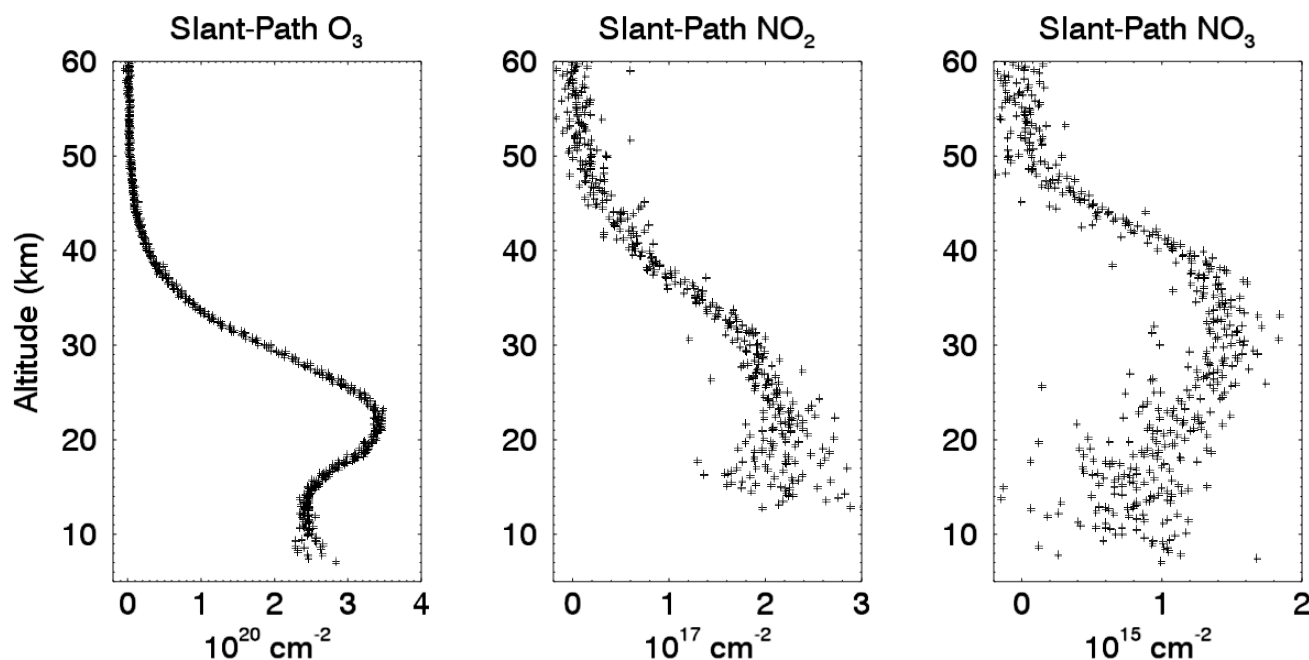
Altitude
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Altitude Adjustment

- The retrieved Ozone in each scan is compared to overlapping scans to line up the scan altitudes. A-band O₂ optical depth is also used in this comparison.
- Additional adjustment is made on a packet-by-packet basis by comparing A-band O₂ signal to a forward model.



Wavelength
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Altitude
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Inversion

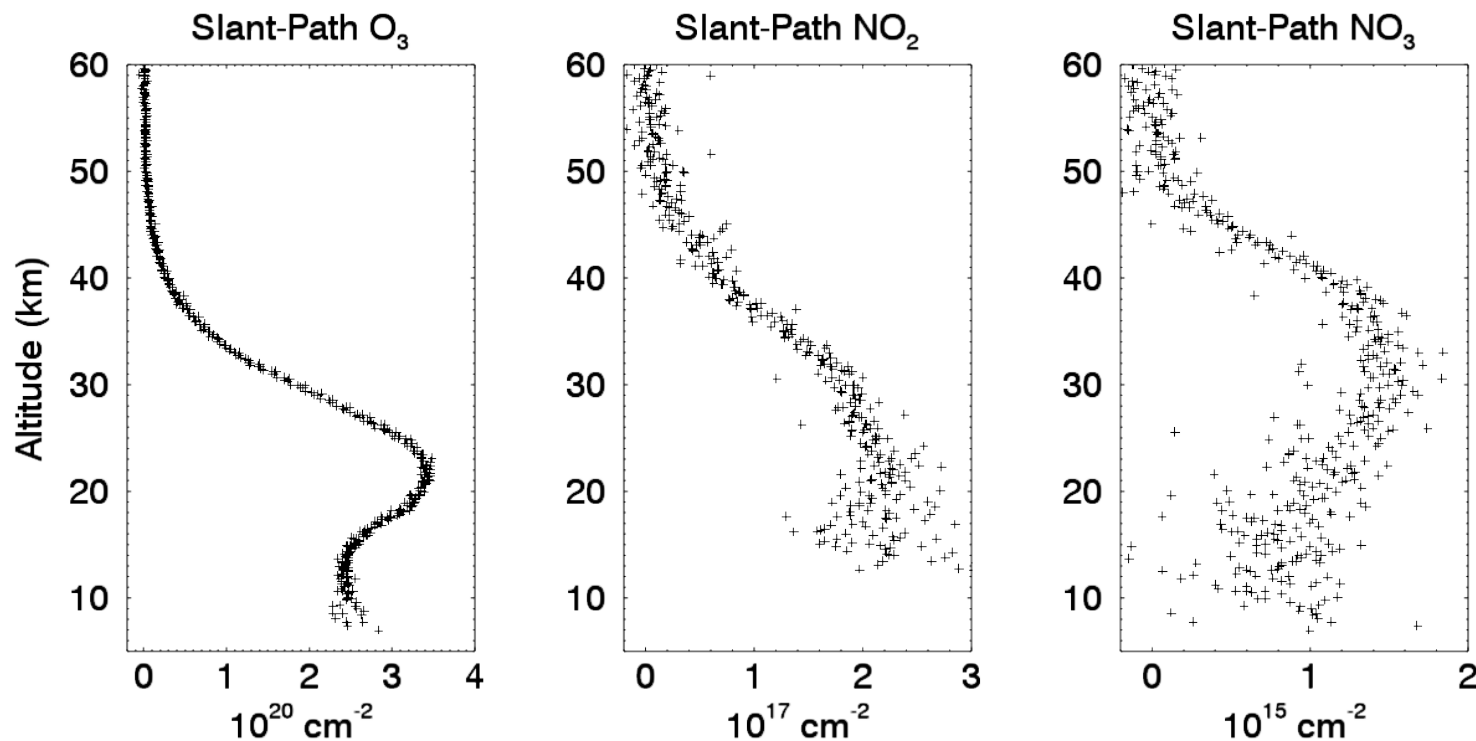
Altitude
Adjustment

Filtering and
Binning

Peeling

Products

Filtering, Binning, and Peeling



Wavelength
Calibration

Altitude
Registration

Inversion

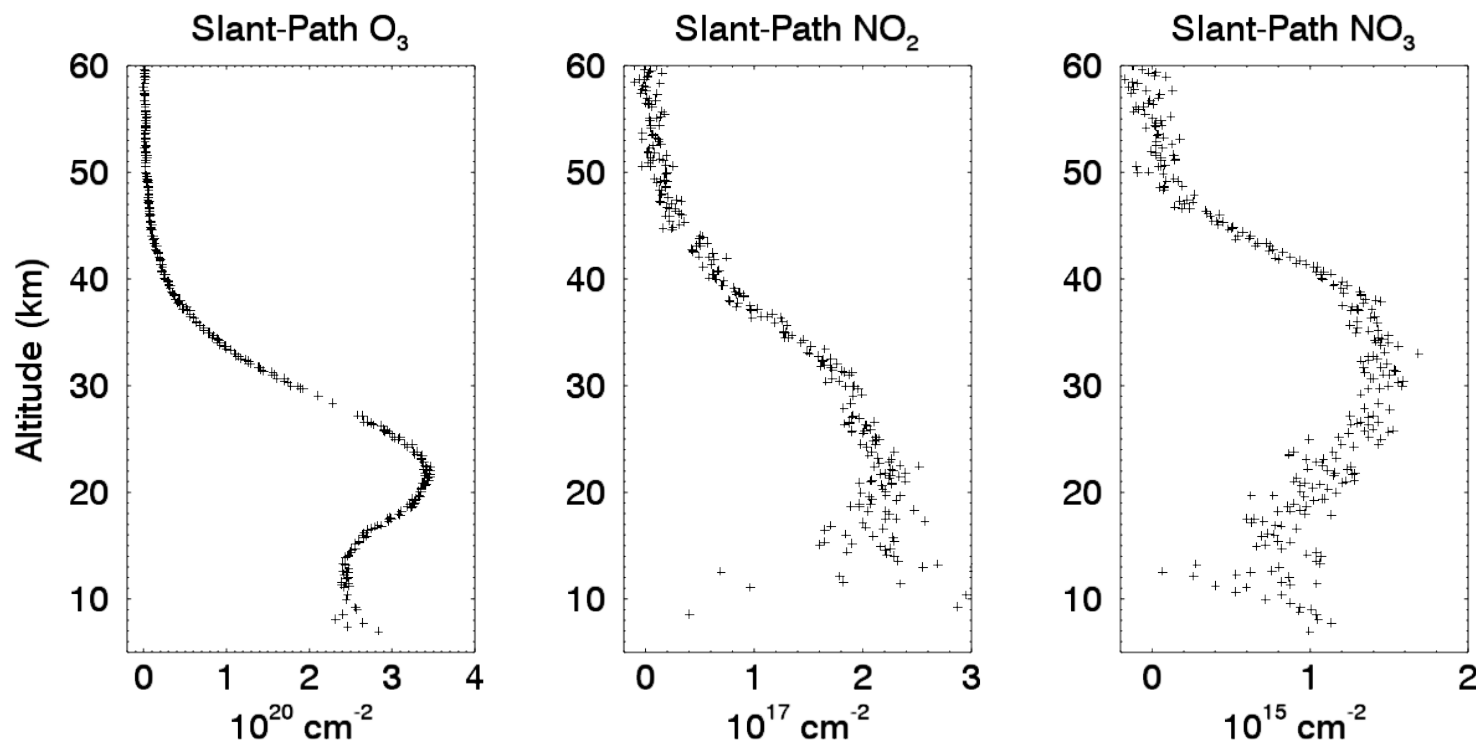
Altitude
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Products

Filtering, Binning, and Peeling



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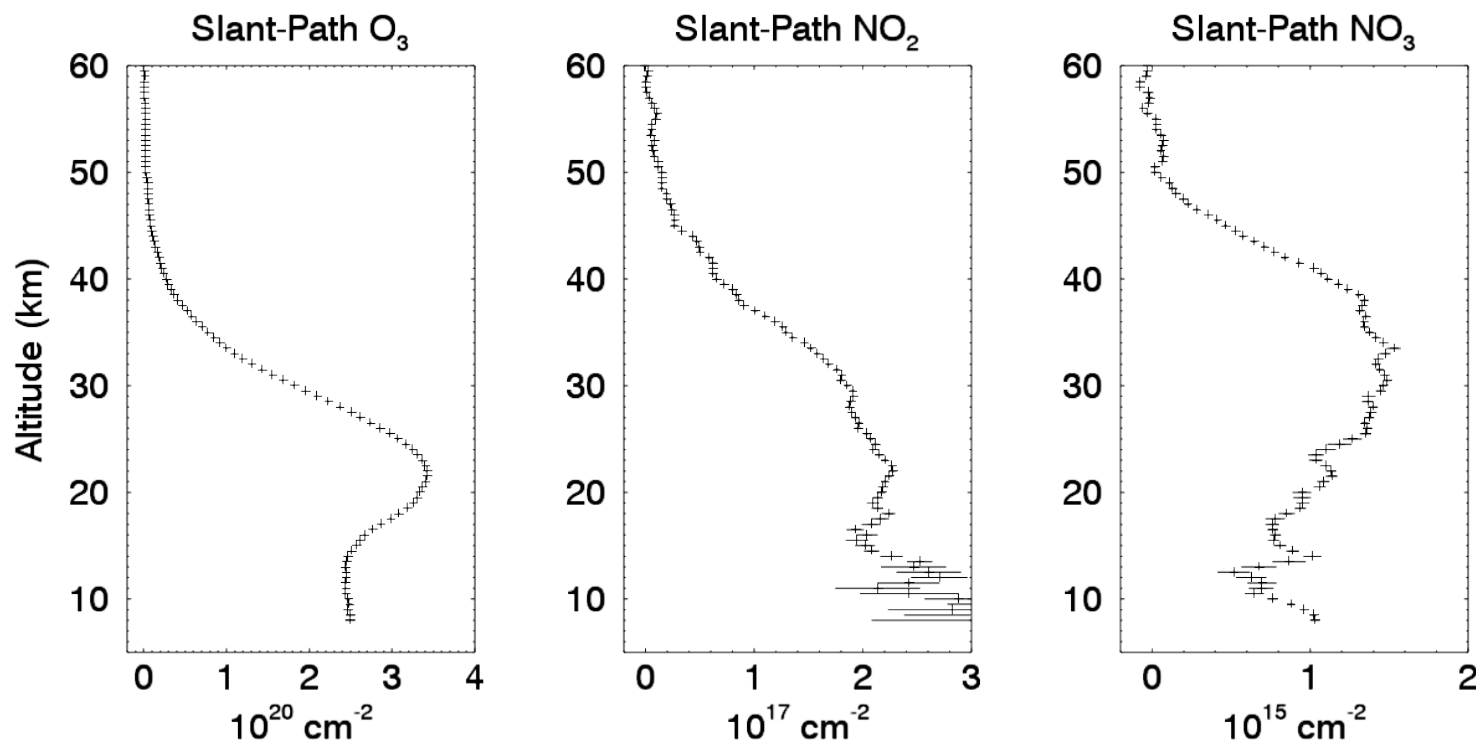
Altitude
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Filtering, Binning, and Peeling



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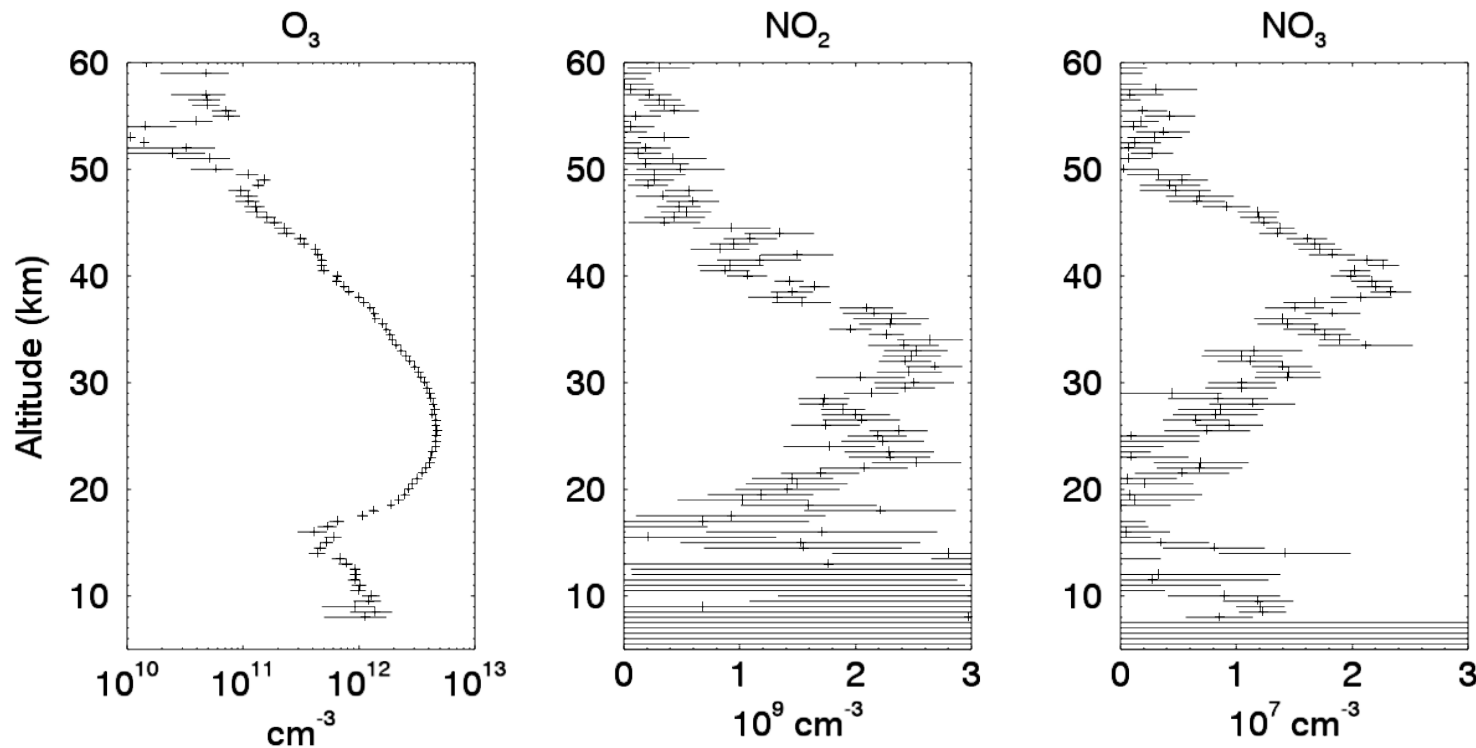
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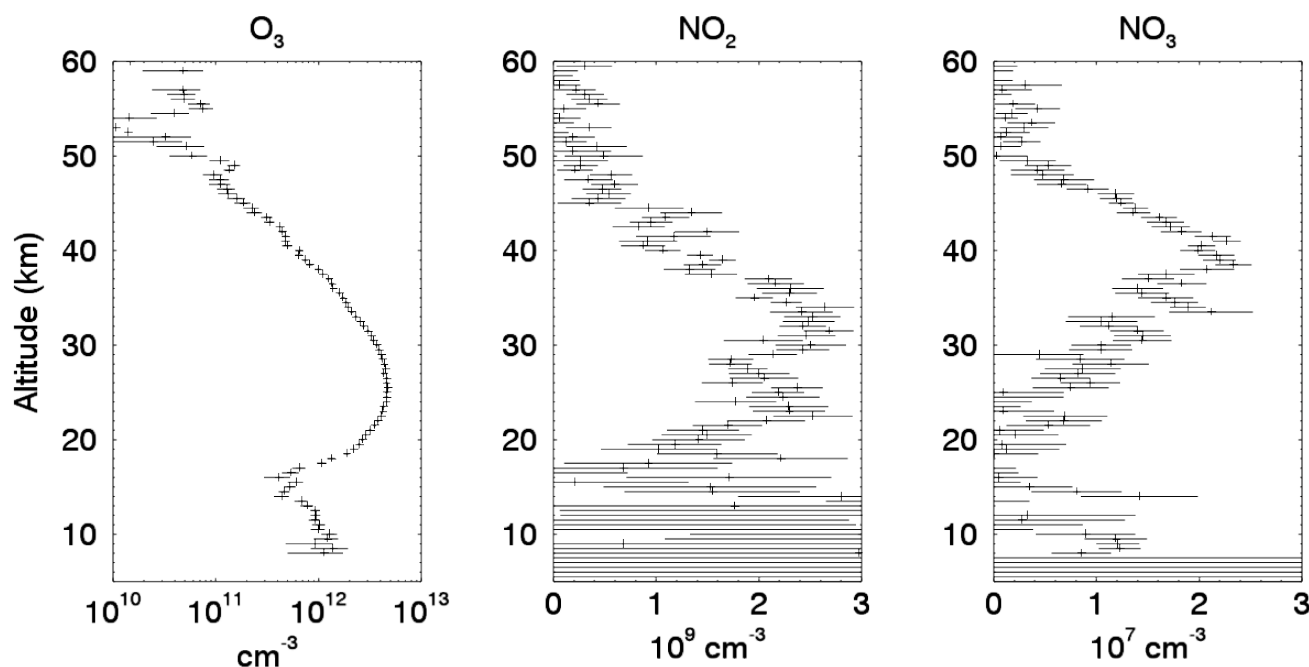
Filtering and
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Products

Products

- In V5.1 we have released Ozone as a provisional product and NO_3 as a research product.
- NO_2 is being worked on.
- OClO retrieval is challenged by the lower counts on the ISS instrument compared to Meteor.



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