MPS NPOESS

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JUN 19 2002

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The Ozone Mapping and Profiler Suite (OMPS) for NPOESS

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J. V. Rodriguez and R. Scarlotti
Ball Aerospace & Technologies Corp.
J. C. Larsen
Raytheon ITSS
H. E. Snell
Atmospheric and Environmental Research, Inc.

Ball Raytheon aer R·S·I

Overview

OMPS Mission: To Satisfy the Ozone Total Column / Profile EDR

MPS NPOESS

- Provide global maps every 24 hours of the amount of ozone in a vertical column of the atmosphere

Measurement Parameter	Requirement
Horizontal cell size	50 km @ nadir
Range	50 - 650 Dobson Units (milli-atm-cm)
Accuracy	15 DU or better
Precision	3 DU + 0.5% total ozone or better
Long-term stability	1% over 7 years or better

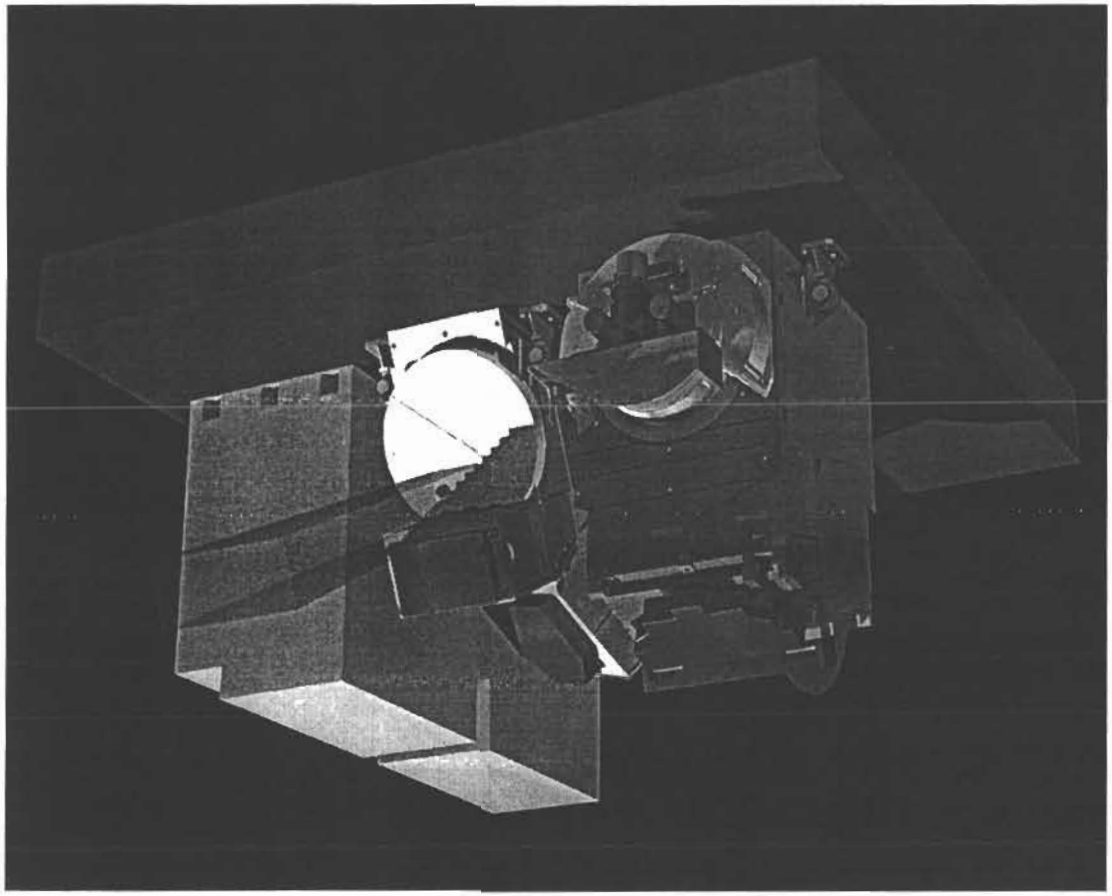
- Provide profiles of the volumetric concentration of ozone in specified segments of a vertical column of the atmosphere with a 4 day revisit

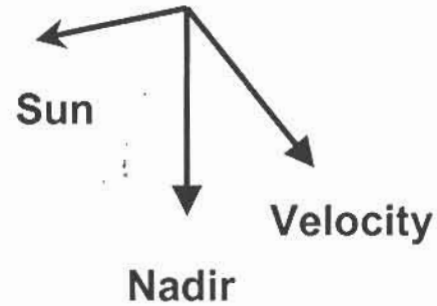
Measurement Parameter	Requirement
Vertical cell size	3 km
Horizontal cell size	250 km
Vertical coverage	tropopause height to 60 km
Range	0.1 - 15 ppmv
Accuracy	Greater of (20%, 0.1 ppmv) below 15 km Greater of (10%, 0.1 ppmv) above 15 km
Precision	3%, 15-50 km; 10%, TH-15 and 50-60 km
Long-term stability	2%

Overview

OMPS Consists of Flight Hardware and Software and Data Processing Algorithms

MPS NPOESS





Electronics Boxes

Limb Sensor

Nadir Sensor

Data Products:

Total Ozone Column

Limb Ozone Profile

Nadir Ozone Profile

IR Total Column

Calibrated Radiances

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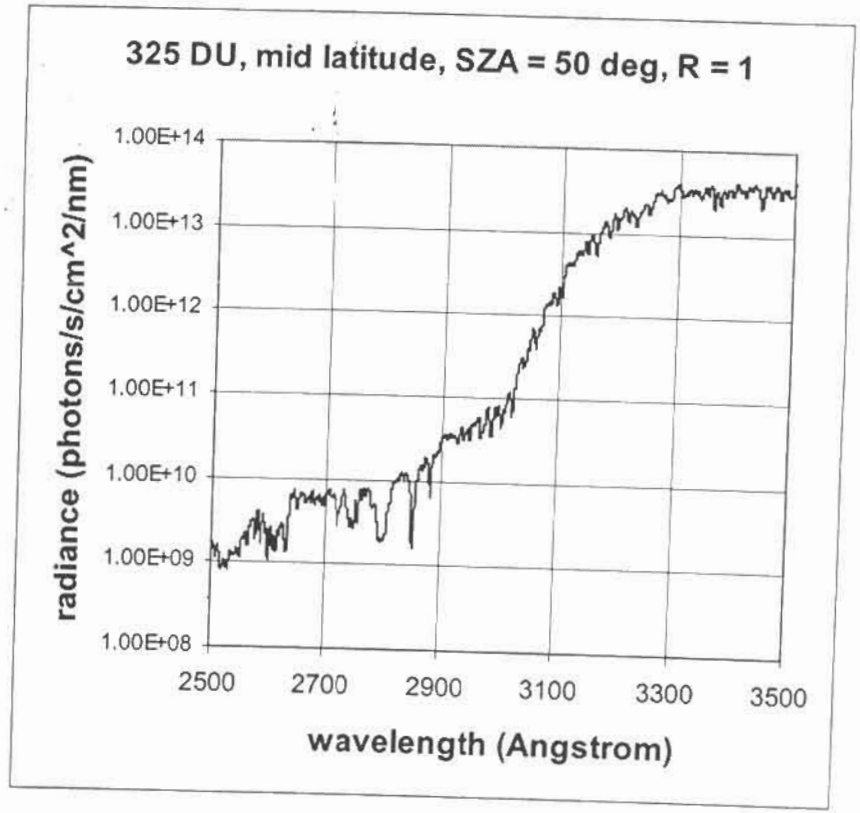
OMPS Nadir

Nadir Sensor Measures Solar Backscatter in the Near- and Mid-Ultraviolet

- Backscattered radiance increases by 5 orders-of-magnitude over 250-380 nm
- Two coregistered spectrometers in the OMPS nadir sensor
  - Total column spectrometer covers 300-380 nm with single grating
  - Nadir profile double spectrometer covers 250-310 nm



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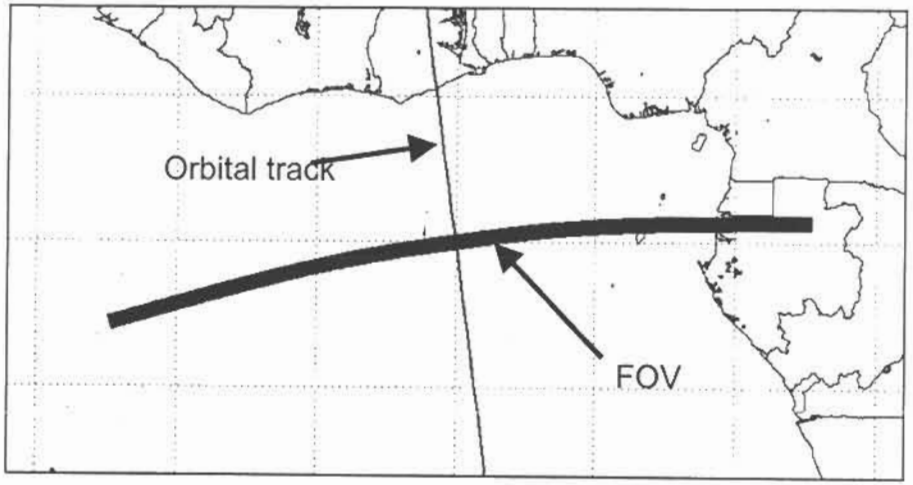

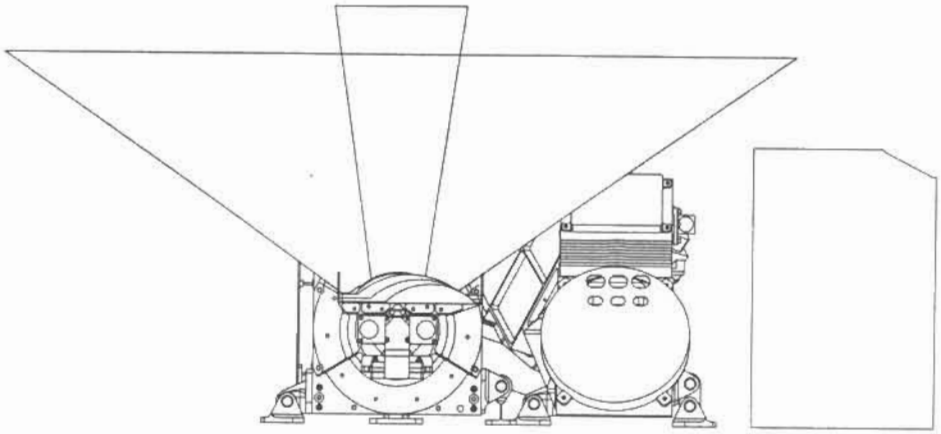

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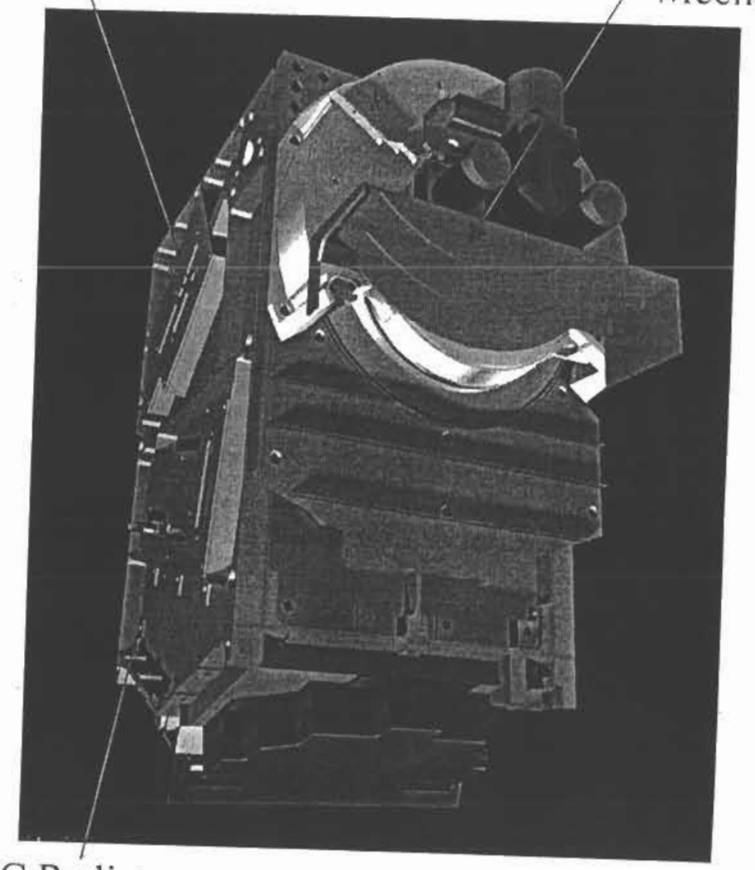

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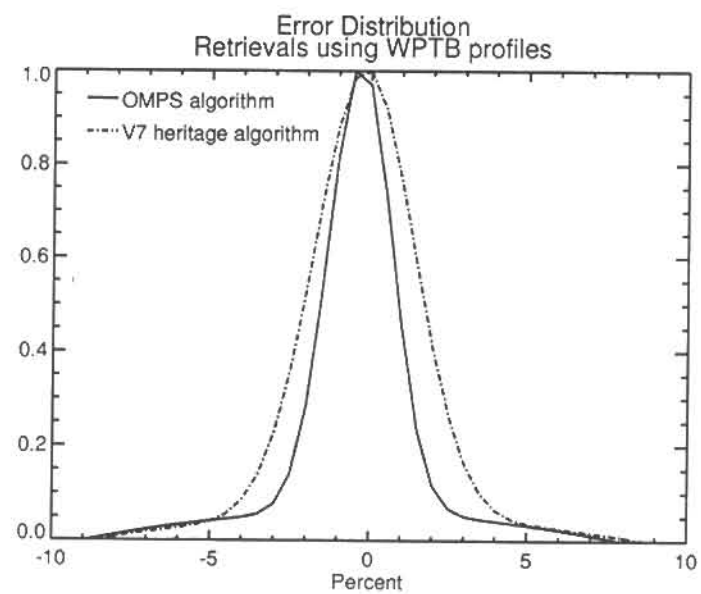

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- Vertical cell size met with limb geometry
  - Requirement: 5 km
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  - Limb sensor: 3 km
- Vertical coverage met with limb geometry
  - Requirement: tropopause - 60 km
  - Nadir profile: 30-50 km
  - Limb sensor: meets requirement with UV and visible channels
- Limb scatter flight heritage:
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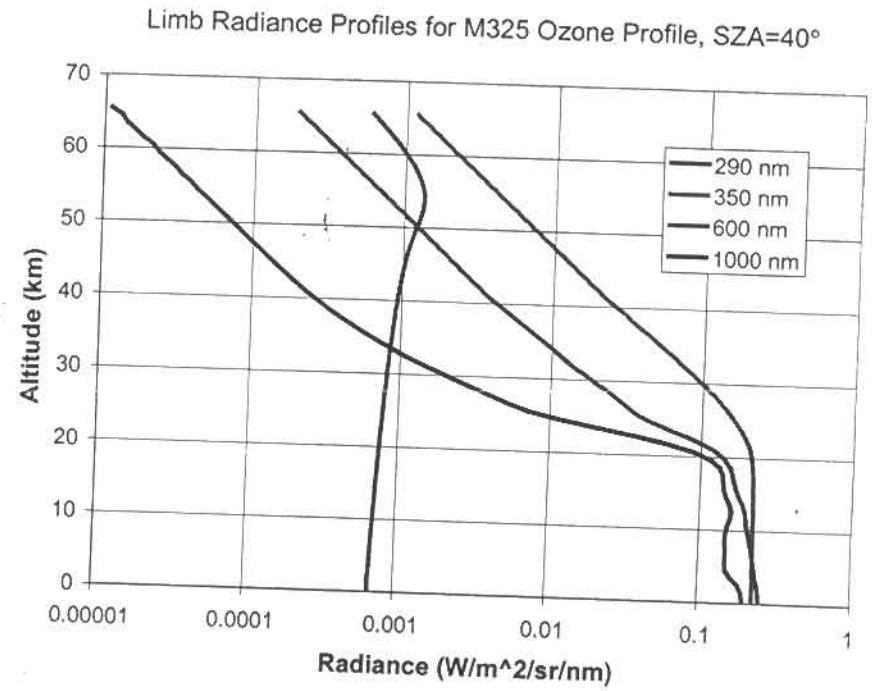

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OMPS Limb Sensor Stares at the Limb Along the Satellite Track

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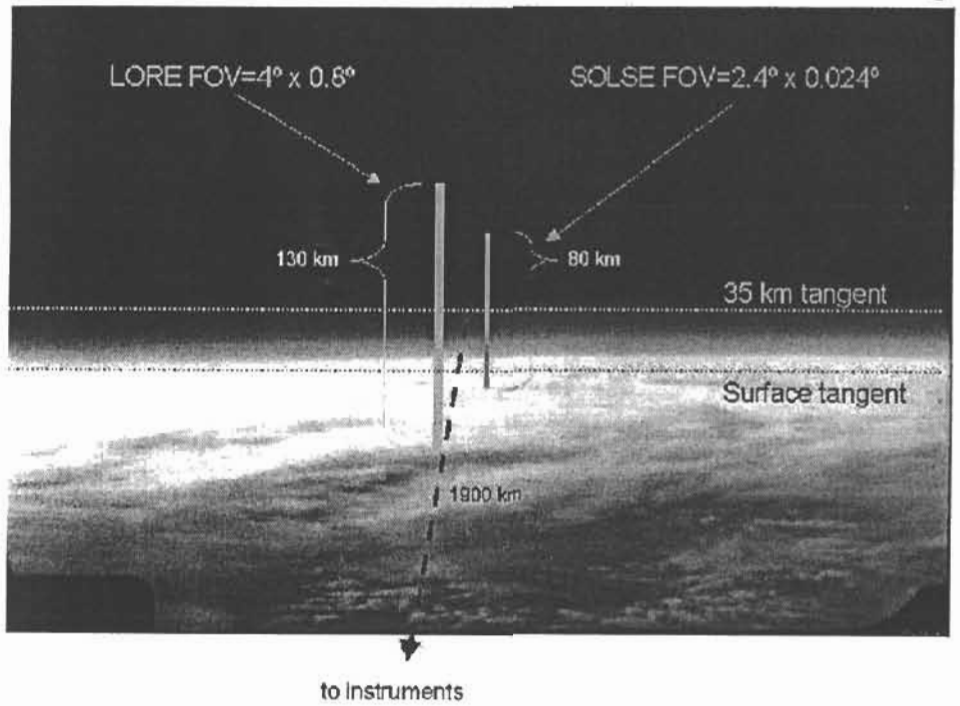

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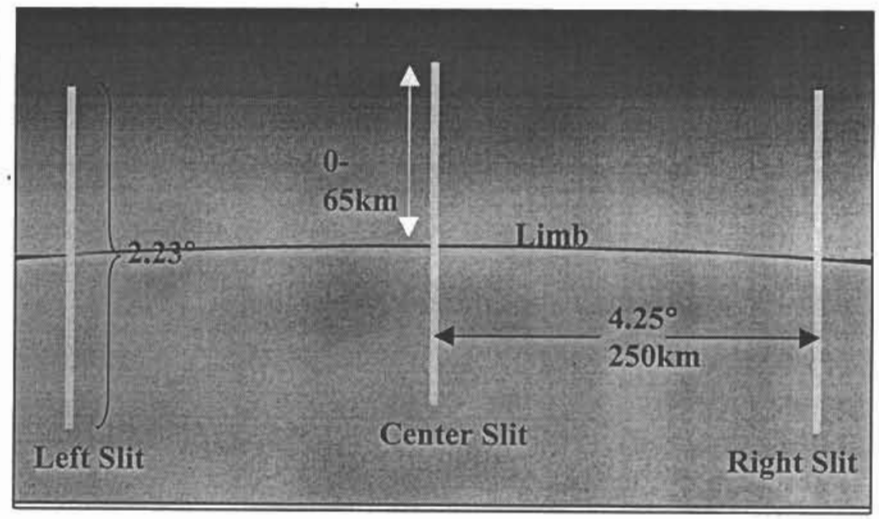

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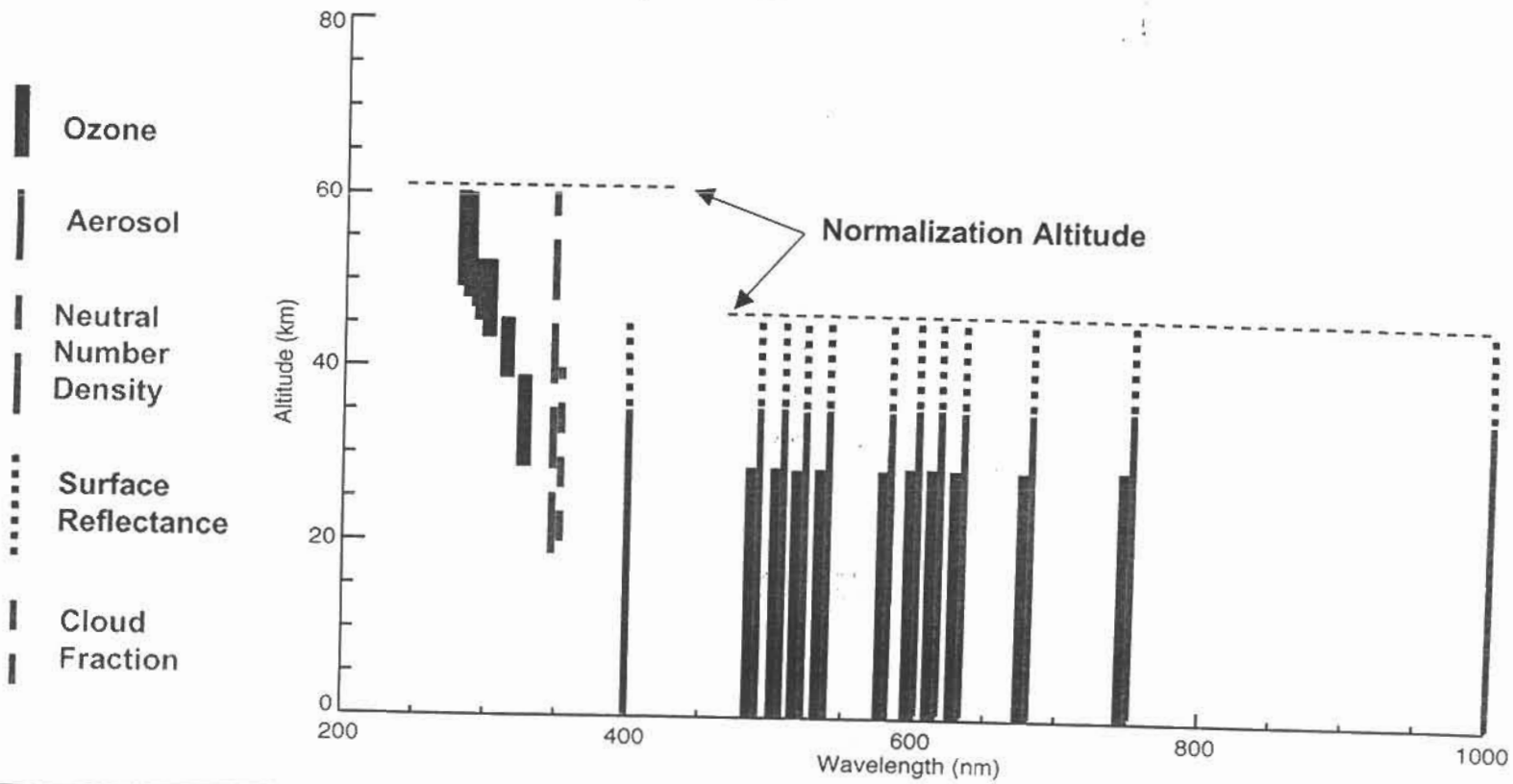

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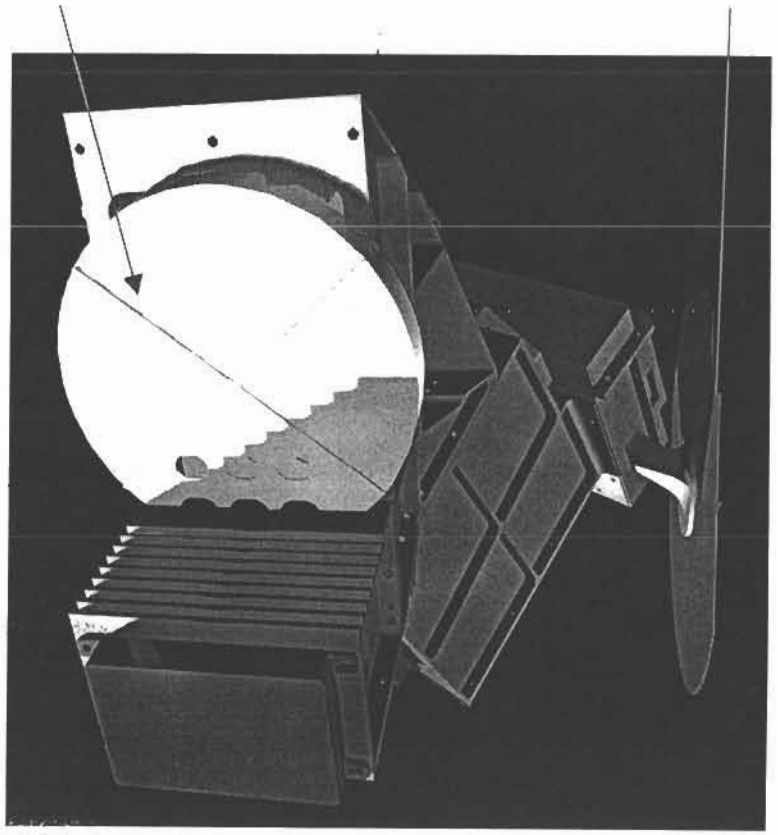

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- Adapting the SOLSE / LORE algorithm developed by Drs. Ben Herman and Dave Flittner (U. of Arizona)
- Heritage algorithm:
  - Multiple scattering solution in a spherical atmosphere
    - Molecular and aerosol scattering
    - Ozone absorption
  - Includes polarization
- Enhancements by OMPS team include:
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  - Bulk neutral density retrievals
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- SOLSE/LORE reflight in April 2002 will provide improved data for validation

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OMPS-IR Algorithm Uses CrIS Data to Obtain Ozone Column Measurements

- CrIS band 1 (635 - 1095 cm^{-1}) contains temperature, ozone, and surface information, along with some information about H_2O
- CrIS EDRs (Temperature, pressure and water vapor profiles) are used in conjunction with CrIS SDRs (950 - 1095 cm^{-1}) to retrieve ozone
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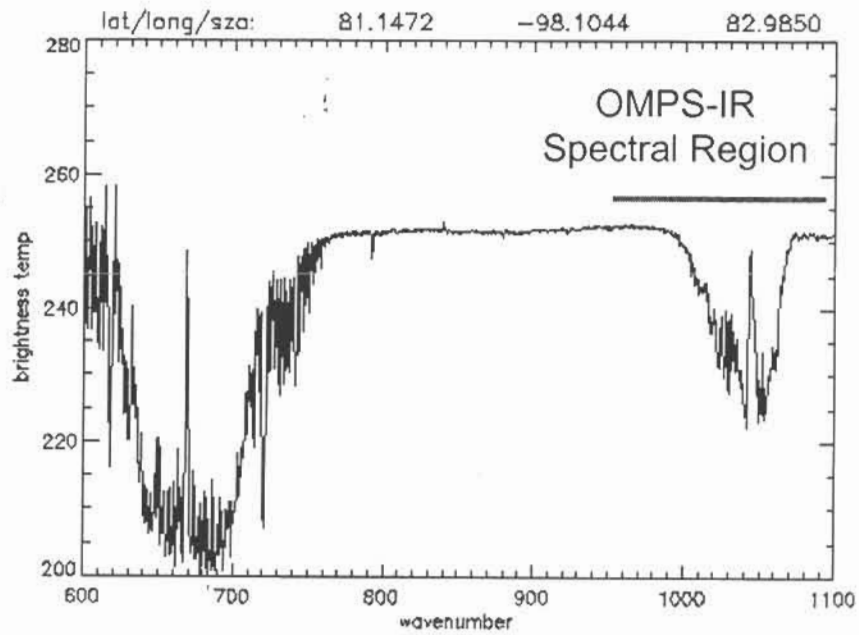

IMG Data from Mar/Apr 1997
Courtesy of Ryoichi Imasu (University of Tokyo)

Within a similar physical envelope, OMPS provides same functionality as TOMS and SBUV/2 with improved performance, plus a new operational capability (limb profile)

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	Mass (kilo-grams)	Power, average (watts)	Dimensions (meters)	Data Rate (kilobits per second)
SBUV/2 [from specification]	39	17	sensor: base 0.31 x 0.37 height 0.54 electronics: base 0.22 x 0.31 (base envelope 0.24 m^2) height 0.33	0.32
TOMS [ADEOS, QuikTOMS]	32	25	base 0.39 x 0.44 (area 0.17 m^2) height 0.51	0.70
TOMS + SBUV/2	71	42	base area ~0.40 m^2 maximum height 0.54	1.0
OMPS	50	50	base 0.68 x 0.70 (area 0.48 m^2) height 0.35	180

OMPS spectra provide potential for additional remote sensing products

P3I

Absorbing Aerosols Index Can be Used to Track Dust and Smoke

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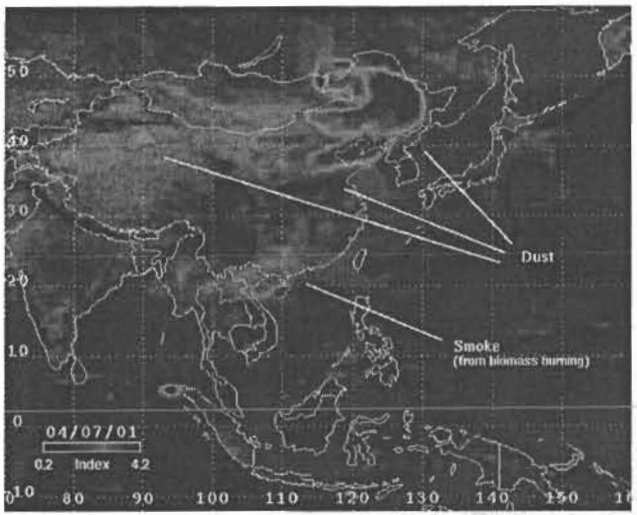
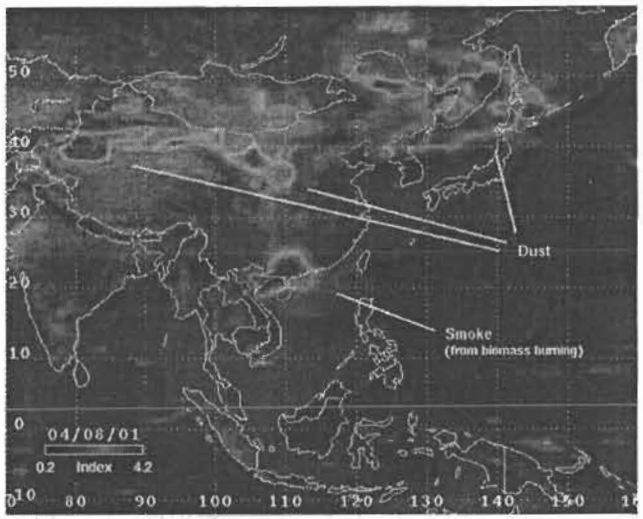
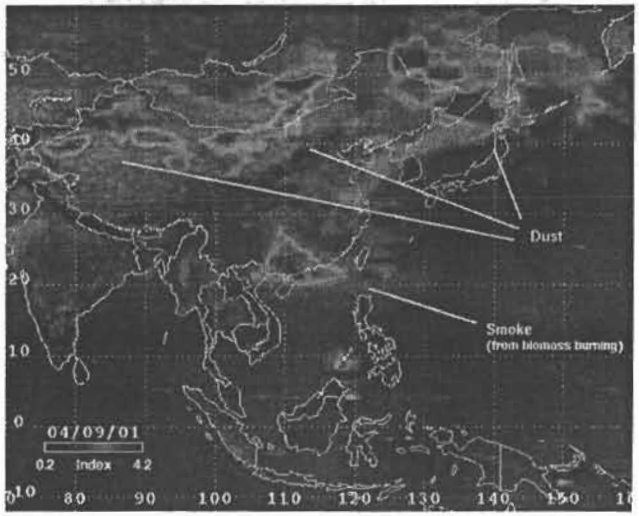
TOMS Aerosol Index (AI) data tracked the "Perfect Dust Storm" originating over the deserts of China as well as smoke from biomass burning



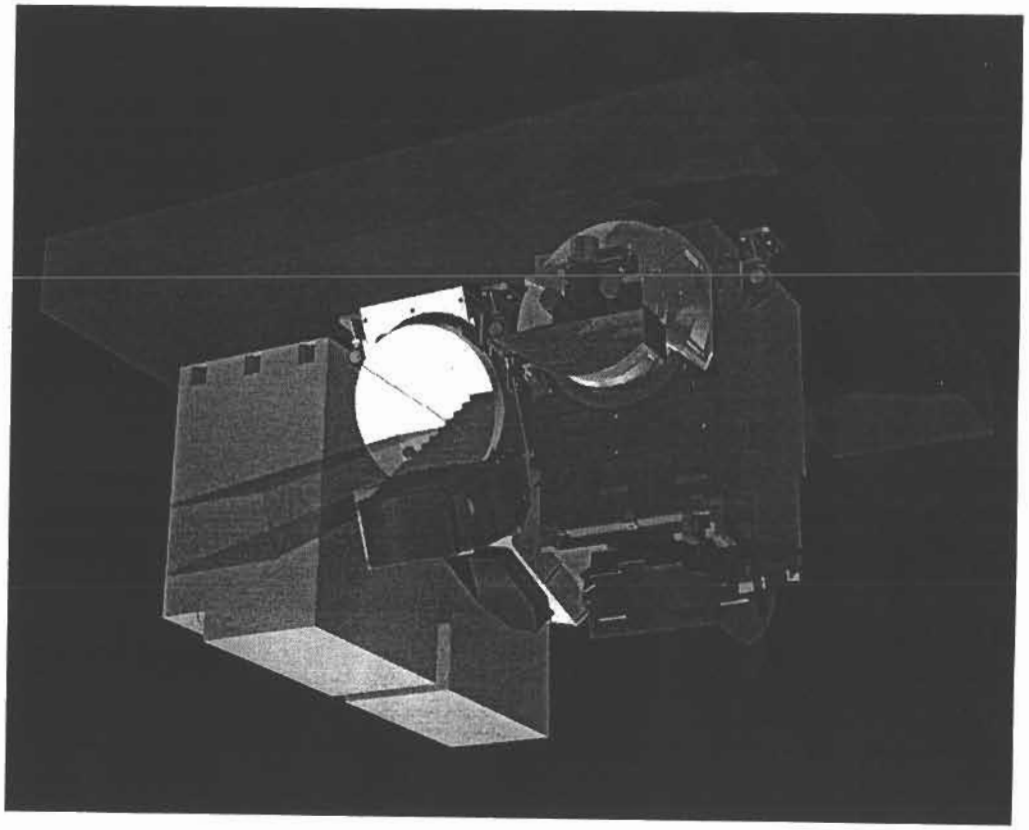


OMPS nadir 320-380 nm data can also be used to derive aerosol index, aerosol optical depth and single scattering albedo over all types of land and ocean surfaces



Conclusion

- Ozone Mapping and Profiler Suite (OMPS) will provide:
  - Global mapping of total column every 24 hours
  - High-vertical-resolution limb ozone profiles
  - Along-track vertical profile, continuing SBUV-SBUV/2 record
- Engineering unit built and tested fall-winter 2001-2002
- First flight planned for 2008
- Possible early flight is NRL experiment OMPS-AE (see talk by John Hornstein et al.)



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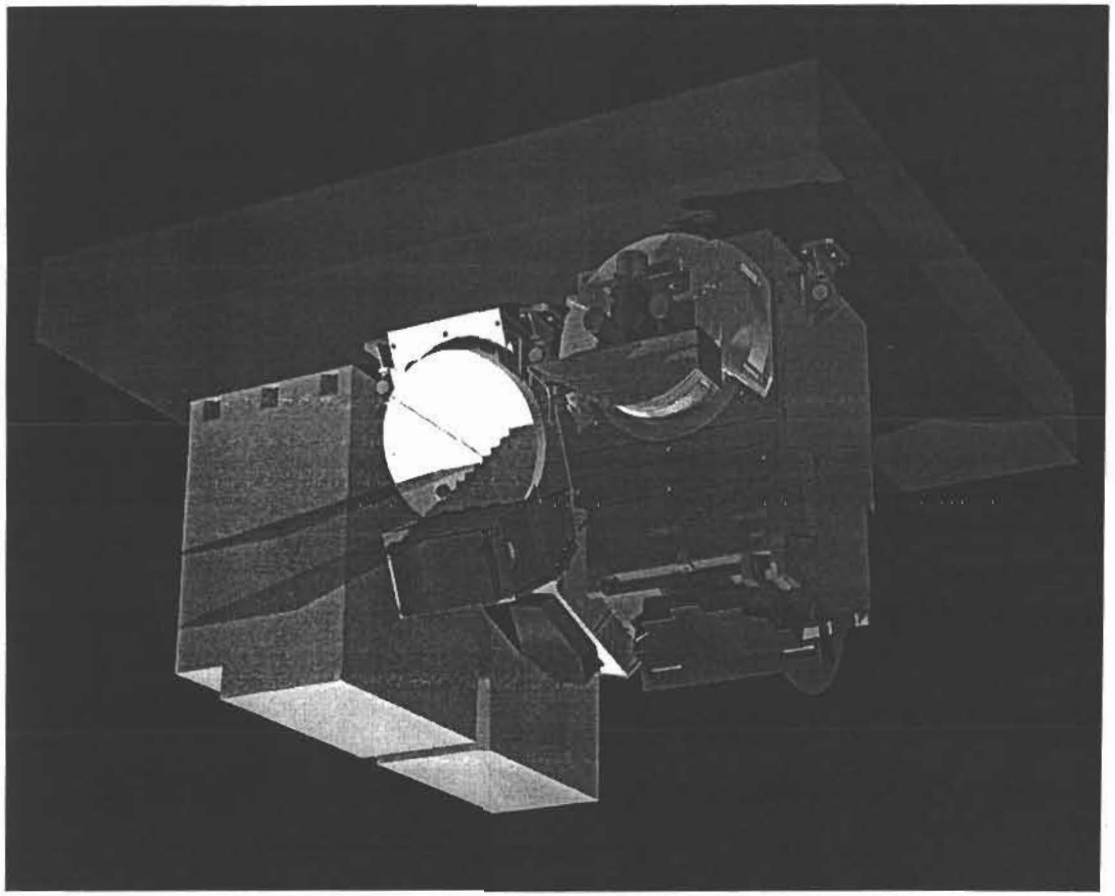

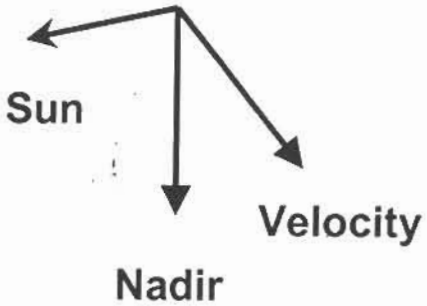

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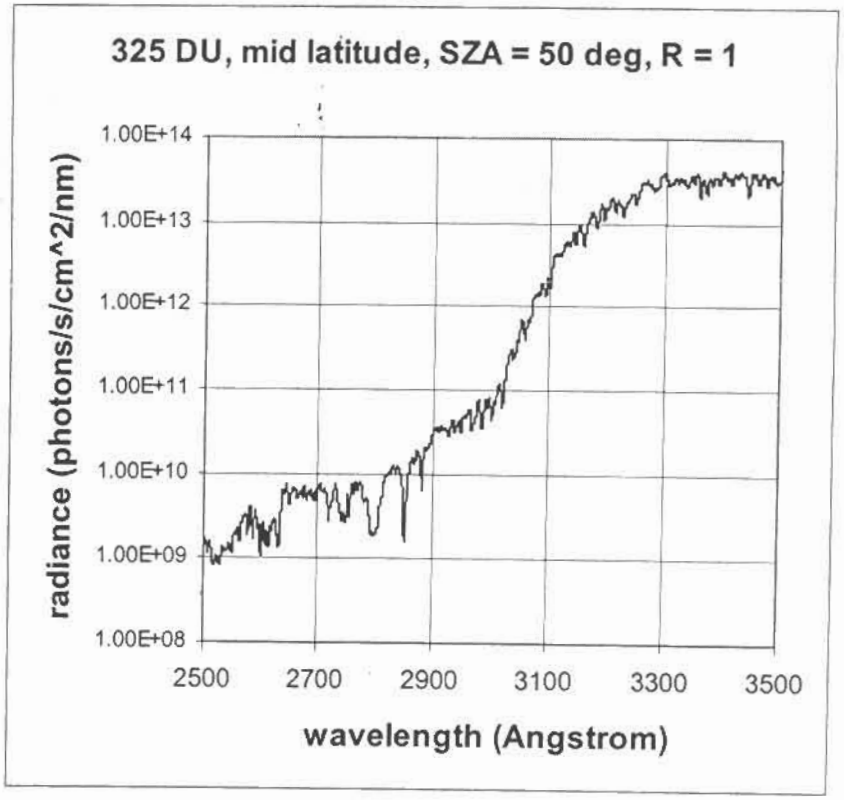

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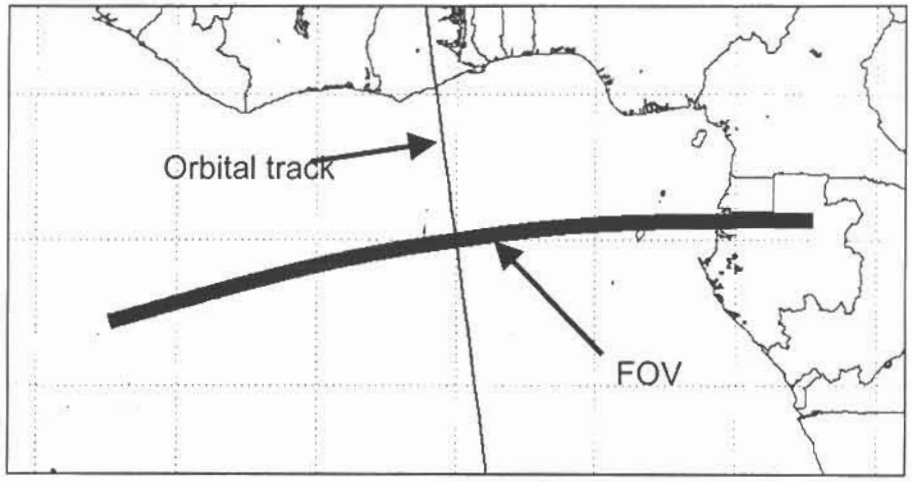

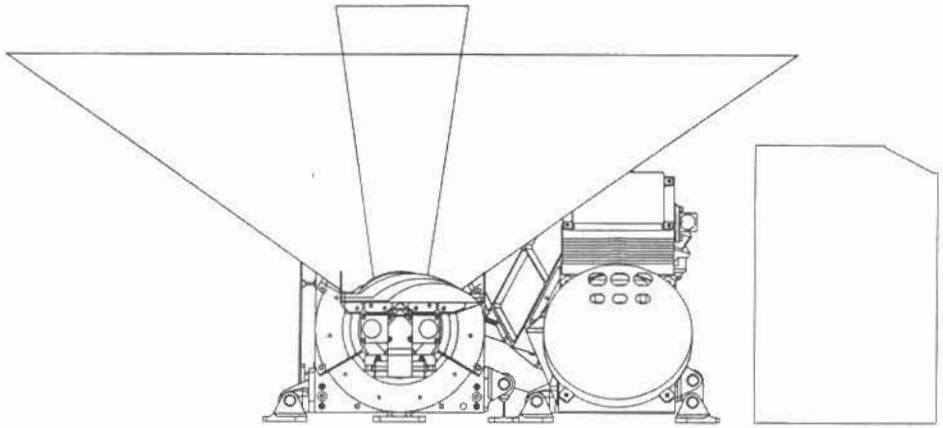

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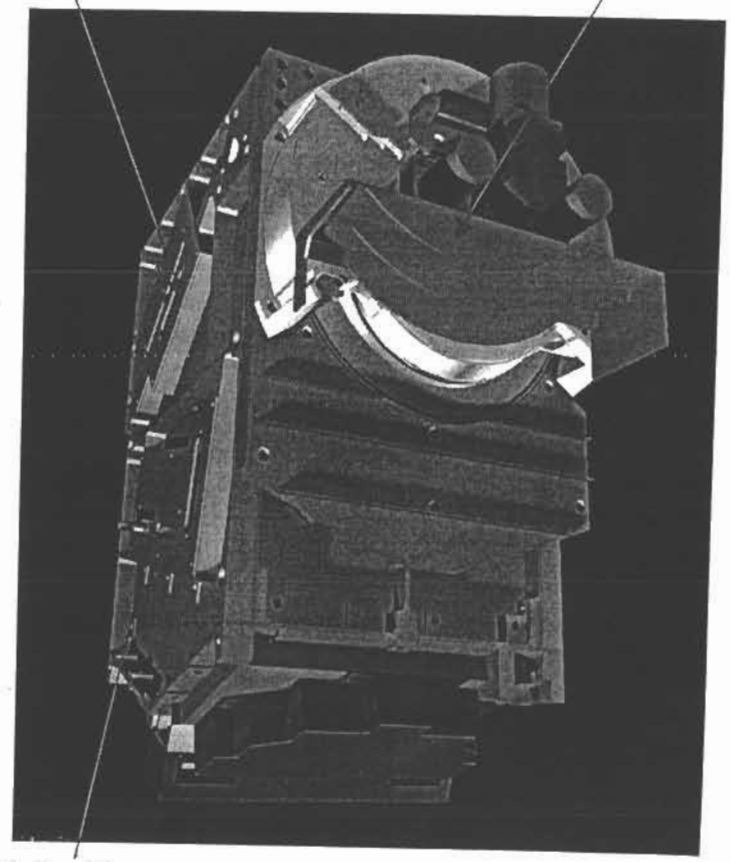

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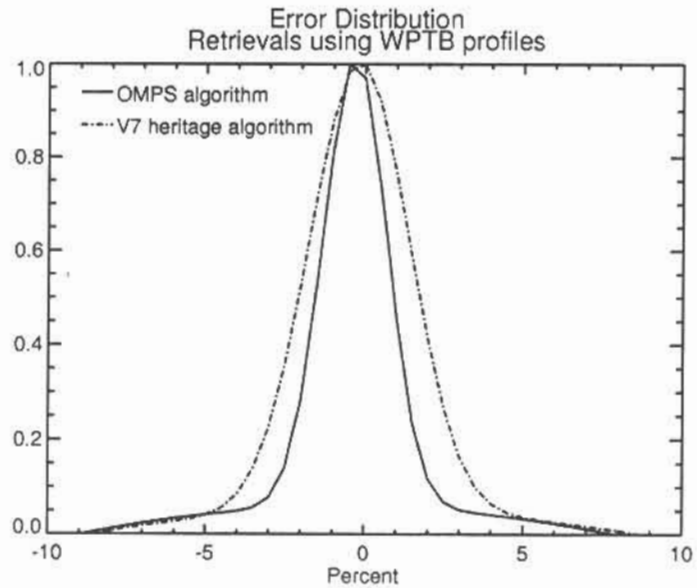

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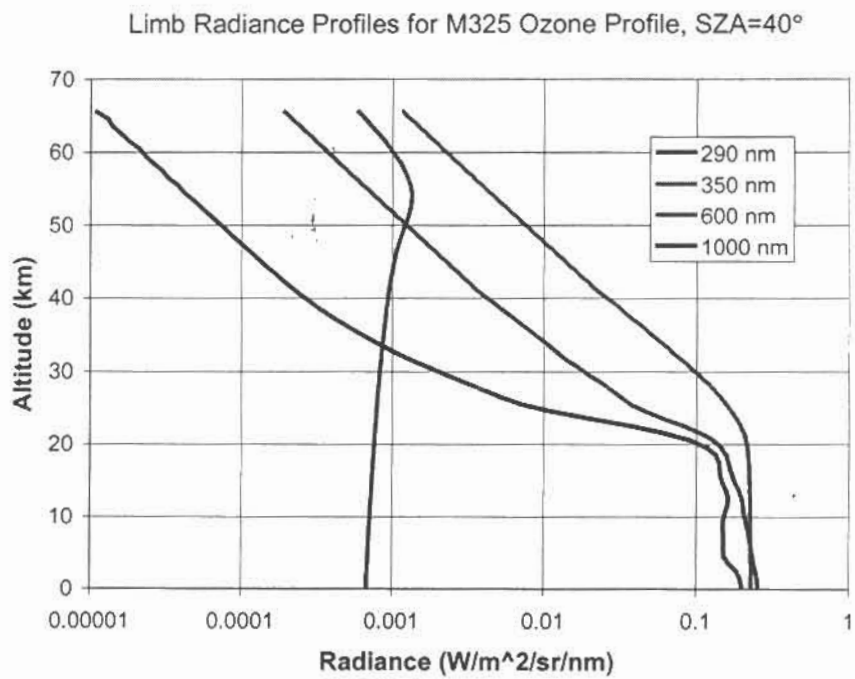

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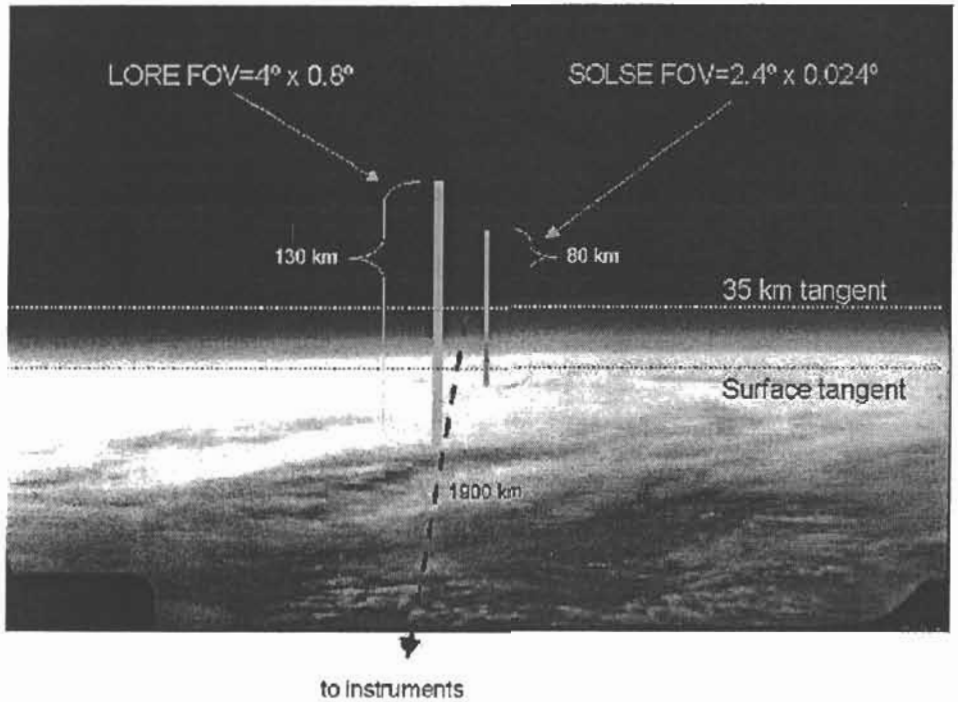

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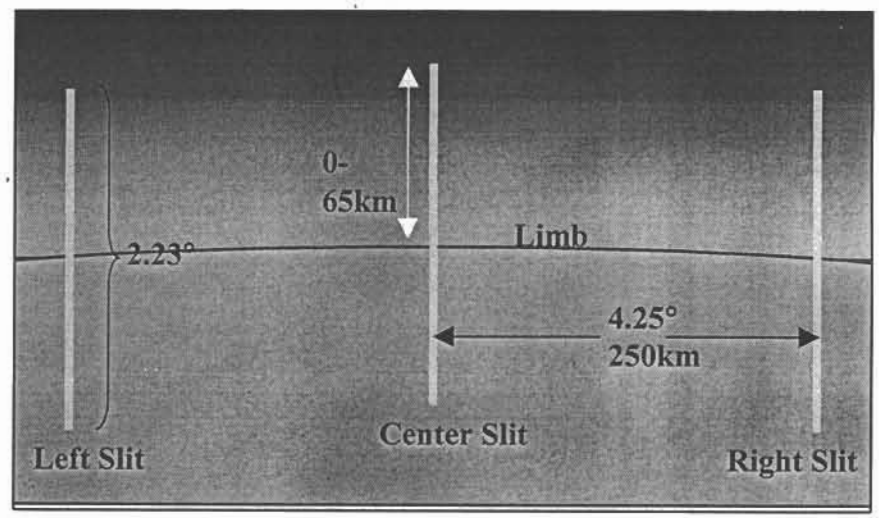

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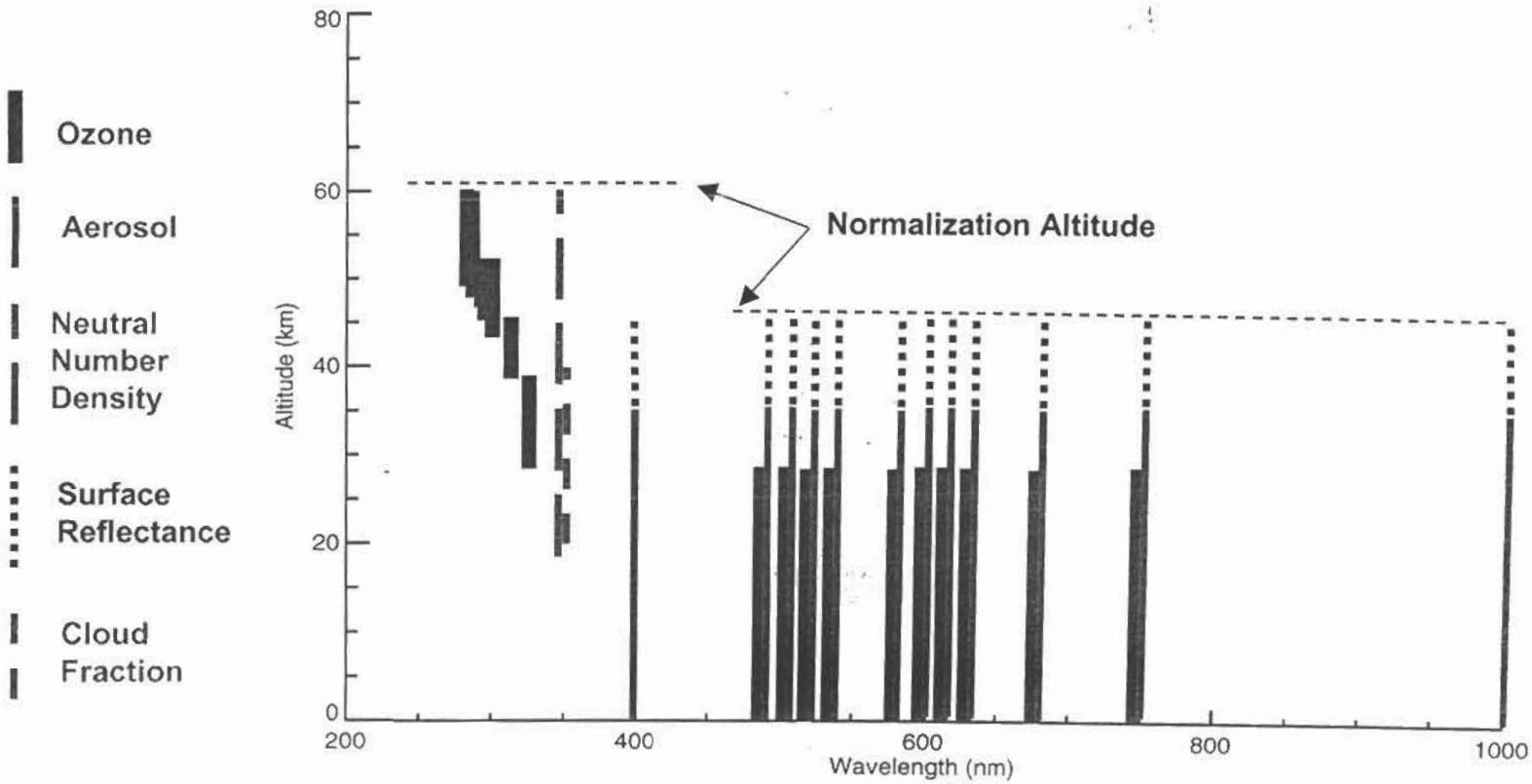

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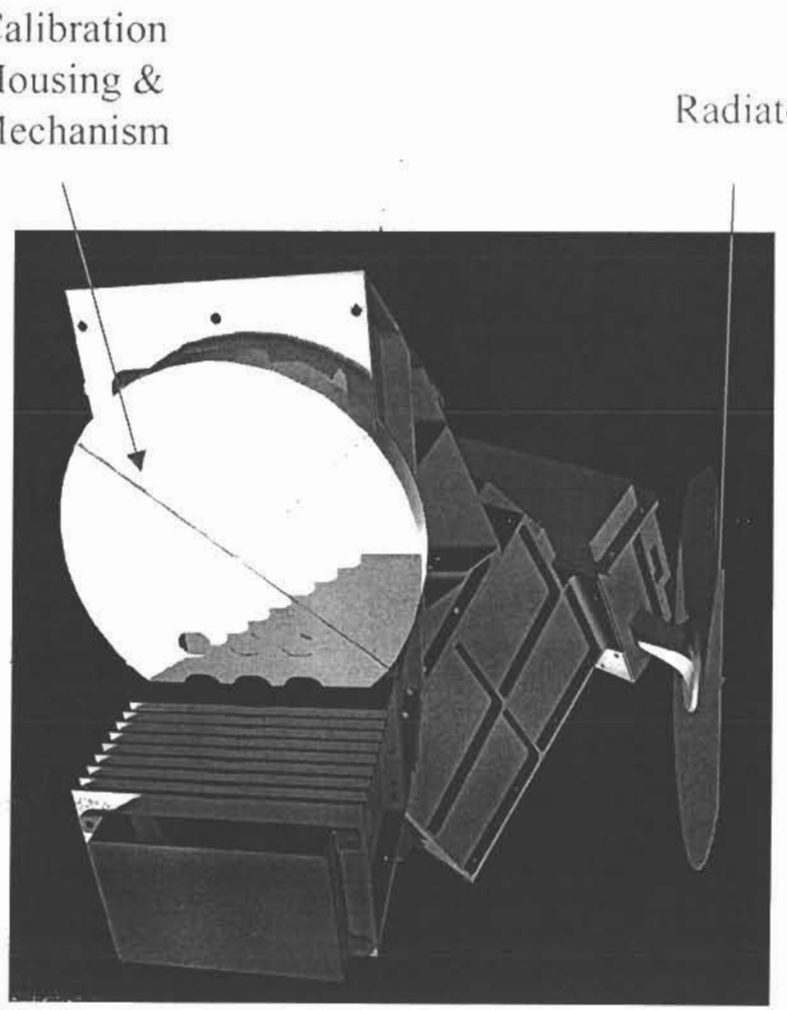

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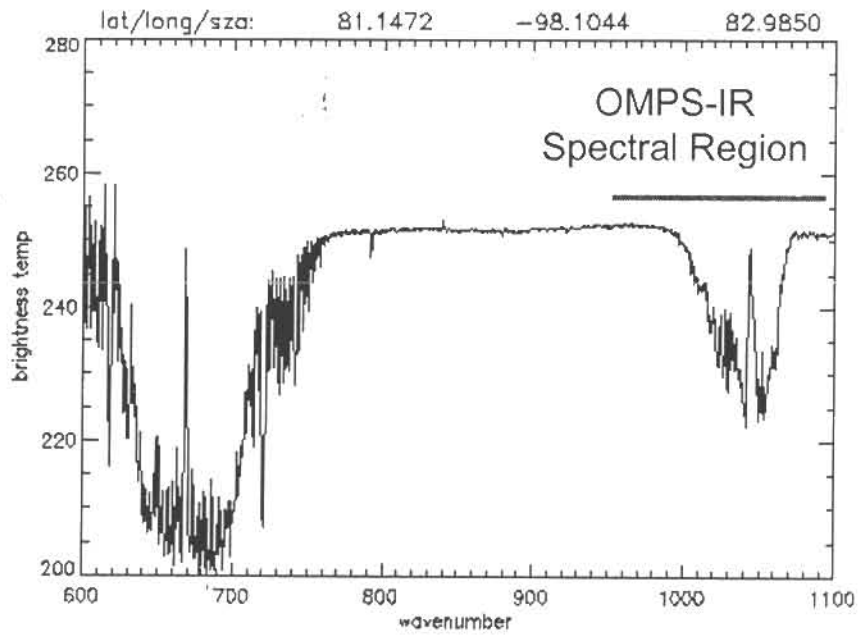

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MPS NPOESS

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OMPS spectra provide potential for additional remote sensing products

P3I

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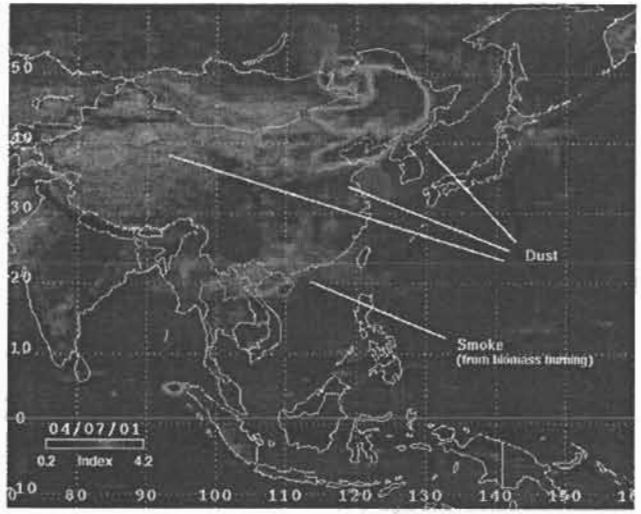

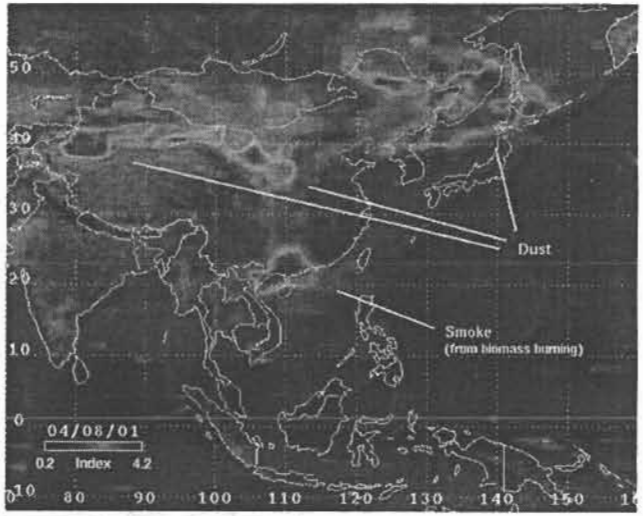

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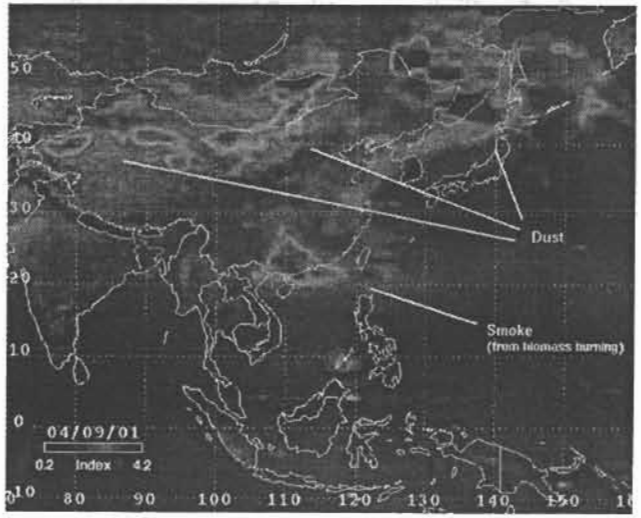

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FOR PUBLIC RELEASE

The Ozone Mapping and Profiler Suite (OMPS) for NPOESS

This is a SAF/PAS document
02 - - 0 3 3 4
Call 697-3222/697-8932 for pickup or return to 5D227

J. V. Rodriguez and R. Scarlotti
Ball Aerospace & Technologies Corp.
J. C. Larsen
Raytheon ITSS
H. E. Snell
Atmospheric and Environmental Research, Inc.

Overview

OMPS Mission: To Satisfy the Ozone Total Column / Profile EDR

MPS NPOESS

- Provide global maps every 24 hours of the amount of ozone in a vertical column of the atmosphere

Measurement Parameter	Requirement
Horizontal cell size	50 km @ nadir
Range	50 - 650 Dobson Units (milli-atm-cm)
Accuracy	15 DU or better
Precision	3 DU + 0.5% total ozone or better
Long-term stability	1% over 7 years or better

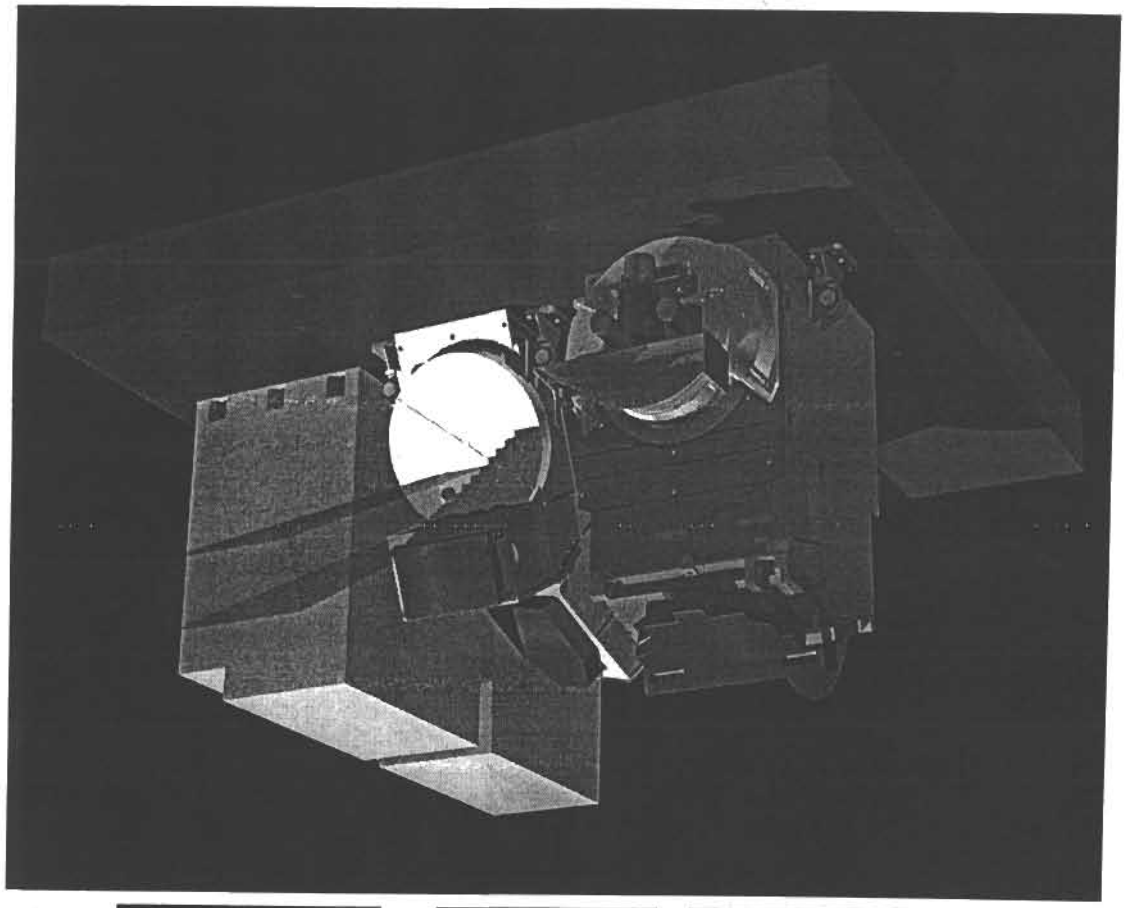
- Provide profiles of the volumetric concentration of ozone in specified segments of a vertical column of the atmosphere with a 4 day revisit

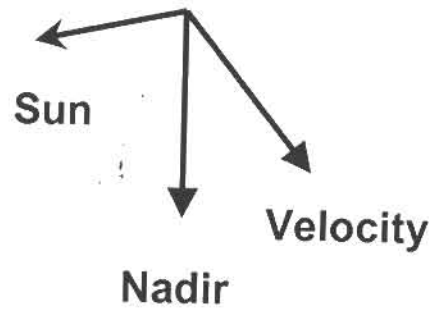
Measurement Parameter	Requirement
Vertical cell size	3 km
Horizontal cell size	250 km
Vertical coverage	tropopause height to 60 km
Range	0.1 - 15 ppmv
Accuracy	Greater of (20%, 0.1 ppmv) below 15 km Greater of (10%, 0.1 ppmv) above 15 km
Precision	3%, 15-50 km; 10%, TH-15 and 50-60 km
Long-term stability	2%

Overview

OMPS Consists of Flight Hardware and Software and Data Processing Algorithms

MPS NPOESS





Electronics Boxes

Limb Sensor

Nadir Sensor

Data Products:

- Total Ozone Column
- Limb Ozone Profile
- Nadir Ozone Profile
- IR Total Column
- Calibrated Radiances

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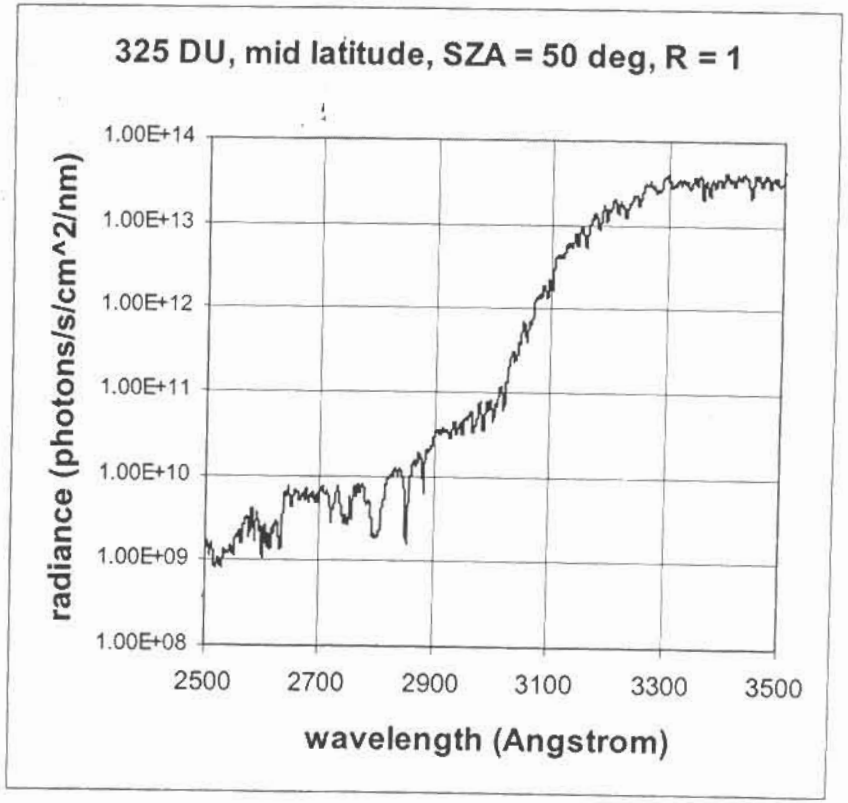
OMPS Nadir

Nadir Sensor Measures Solar Backscatter in the Near- and Mid-Ultraviolet

MPS NPOESS

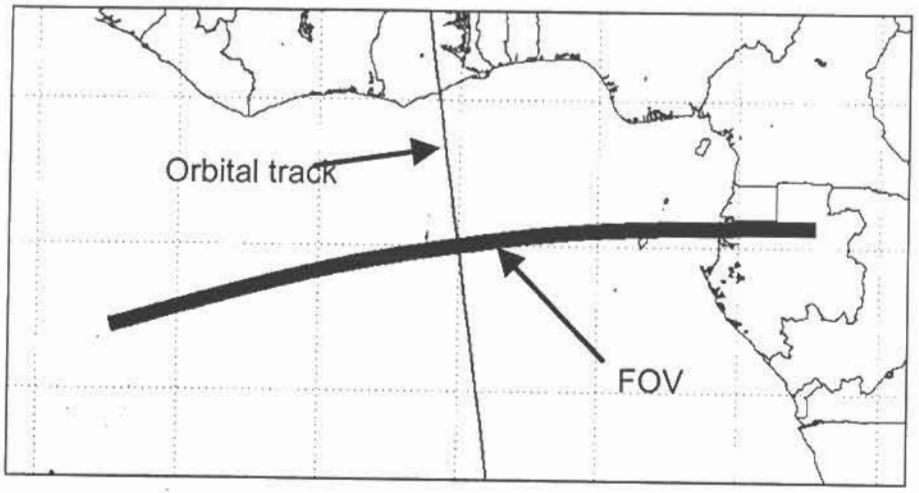
- Backscattered radiance increases by 5 orders-of-magnitude over 250-380 nm
- Two coregistered spectrometers in the OMPS nadir sensor
  - Total column spectrometer covers 300-380 nm with single grating
  - Nadir profile double spectrometer covers 250-310 nm

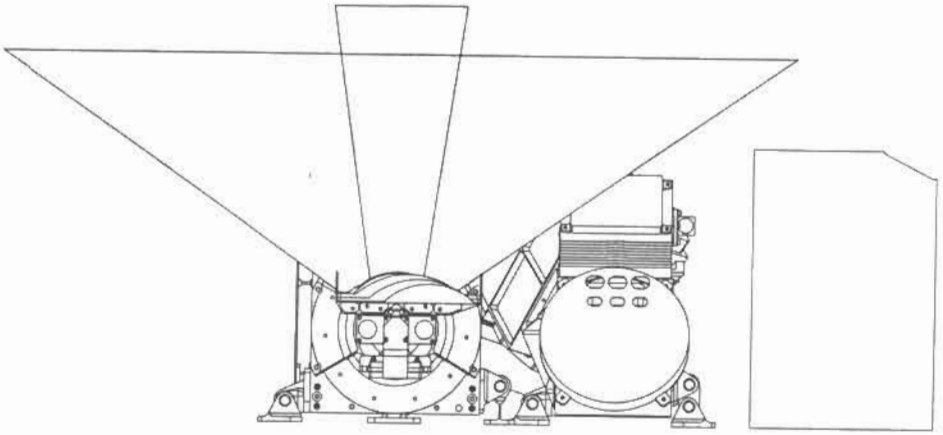


OMPS Nadir

Nadir Sensor Earth Observation Fields of View are Co-Boresighted

- Total Column:
  - 110° cross-track FOV, 0.27 ° along-track slit width, 8.5 ° FOV curvature on Earth
  - 35 cross-track bins: 3.35 ° (50 km) at nadir, 2.84 ° at ±55 °
  - 50 km along-track resolution at nadir (7.6 sec reporting period)
- Nadir Profile:
  - 16.6° cross-track FOV, 0.26 ° along-track slit width
  - One 250 km cell cross-track
  - 250 km along-track resolution (38 sec reporting period)

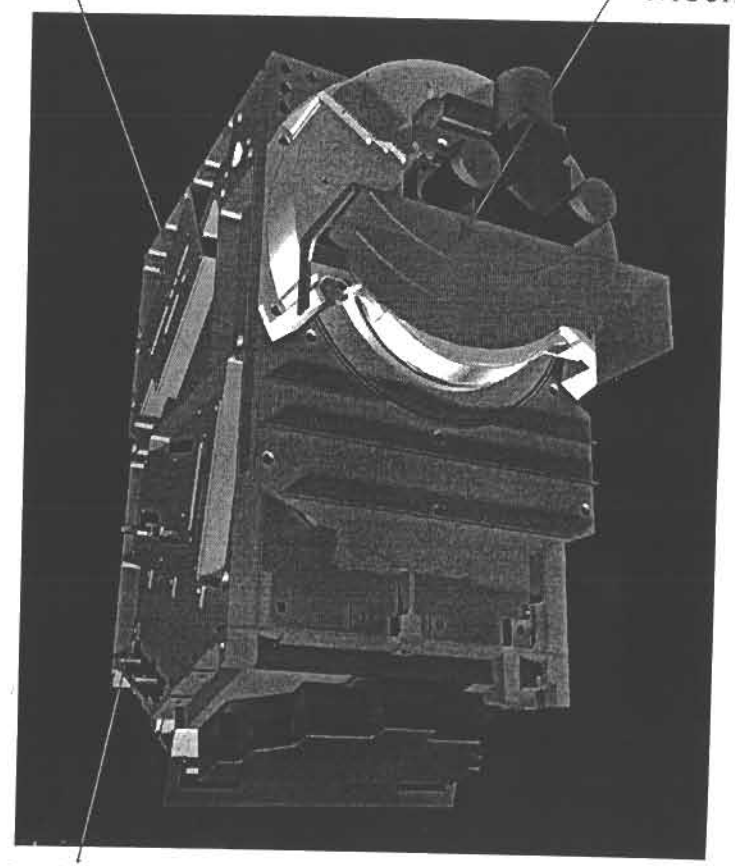




OMPS Nadir

Nadir Sensor Description

- Single pushbroom telescope
- Two grating spectrometers
  - Each spectrometer has a CCD detector array
  - Both sample spectrum at 0.42 nm, 1 nm FWHM end-to-end resolution
- Calibration stability maintained by periodic solar observations using dual reflective diffusers
- Electronics
  - CCD preamplifier electronics in sensor housing
  - Main electronics box
    - Analog-to-digital conversion
    - On-orbit pixel corrections

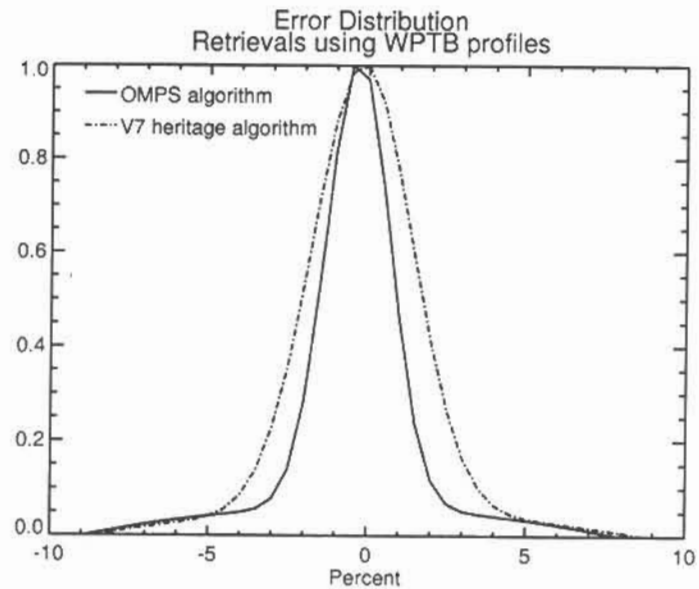


OMPS Nadir

OMPS Total Column Algorithm Builds on the Strong Foundation of TOMS Version 7

- Version 7 TOMS algorithm retrieves total column ozone with close to threshold performance
  - Uses logarithm of the ratio of backscattered radiance to incident solar irradiance, N
  - Assumes change in N value linear with wavelength
  - Uses a wavelength triplet
- Enhancements bring OMPS algorithm performance to within NPOESS requirements
  - Multiple triplets
  - Temperature-insensitive wavelengths
  - Temperature and ozone profile corrections
  - Tropospheric residual

See poster presentation by Seftor et al. for a complete description and results

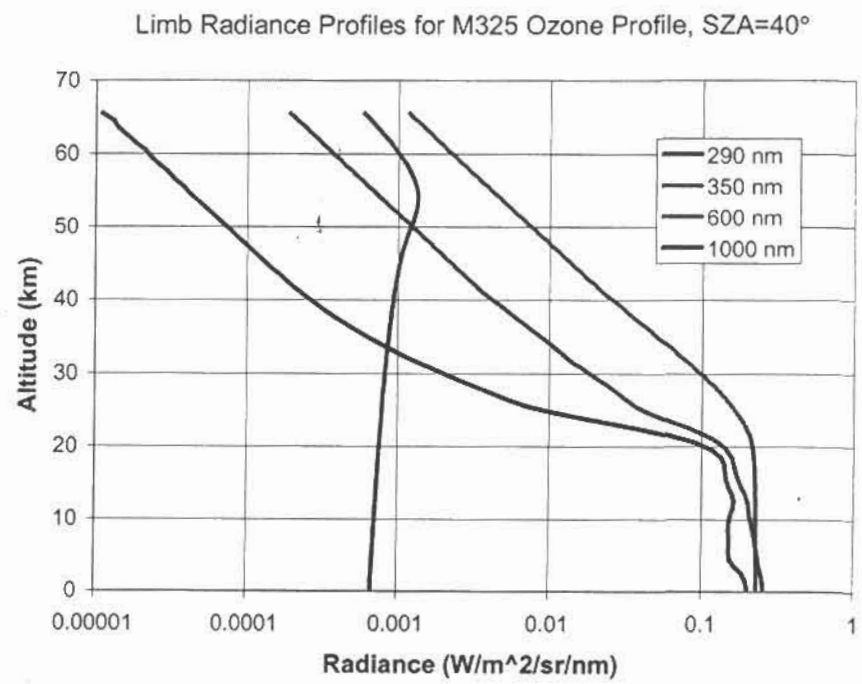


OMPS Limb

Limb Sensor Measures Limb Scatter in the Ultraviolet, Visible, and Near-Infrared

MPS NPOESS

- Vertical cell size met with limb geometry
  - Requirement: 5 km
  - Nadir profile: 8-12 km FWHM
  - Limb sensor: 3 km
- Vertical coverage met with limb geometry
  - Requirement: tropopause - 60 km
  - Nadir profile: 30-50 km
  - Limb sensor: meets requirement with UV and visible channels
- Limb scatter flight heritage:
  - Solar Mesosphere Explorer (SME)
  - Shuttle Ozone Limb Sounding Experiment / Limb Ozone Retrieval Experiment (SOLSE/LORE) on STS-87 (December 1997)



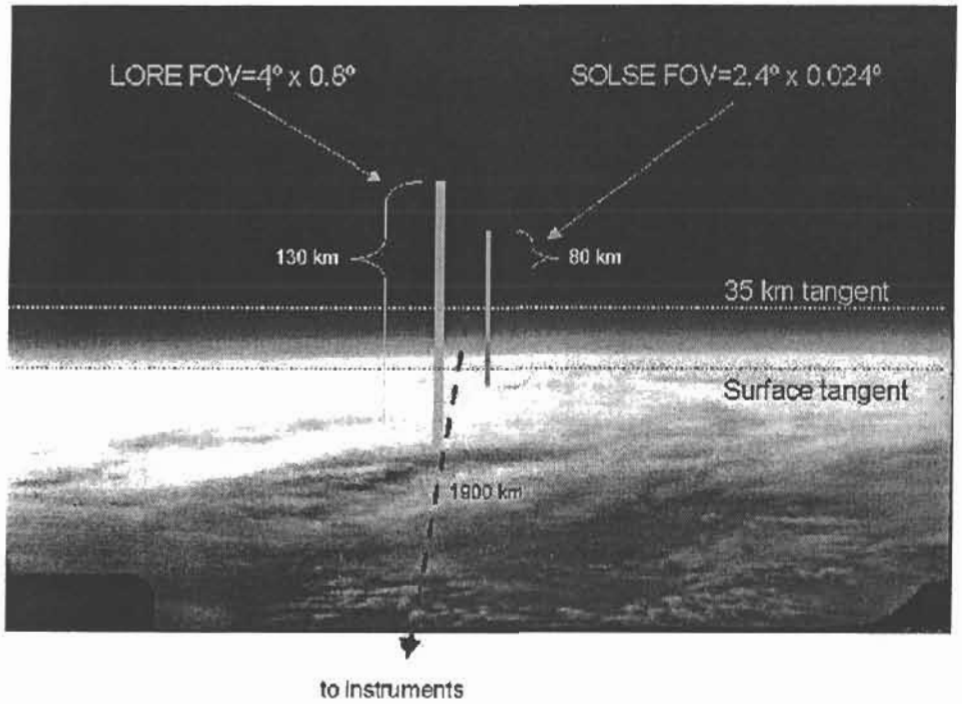
Remote Sensing of Limb-Scattered Solar Radiation Shares Atmospheric Radiative Transfer Physics, Calibration Techniques with OMPS Nadir Sensor

OMPS Limb

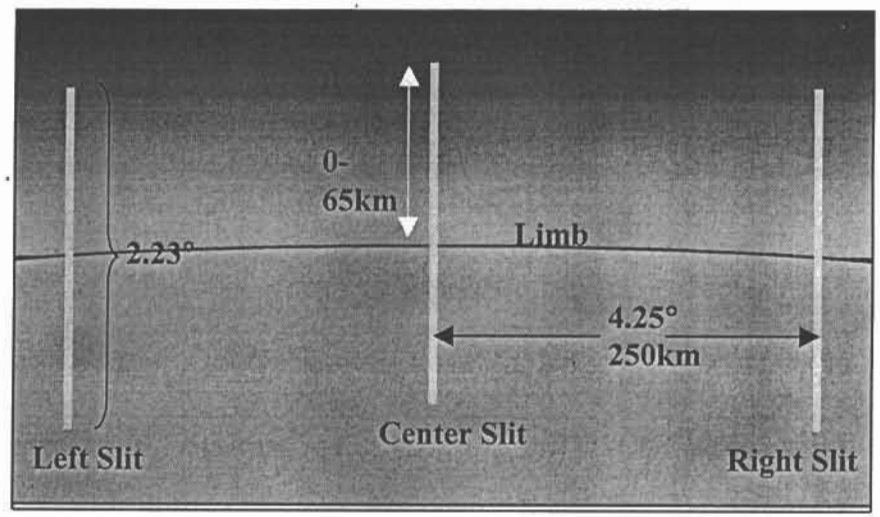
OMPS Limb Sensor Stares at the Limb Along the Satellite Track

MPS NPOESS

Photo from GSFC's SOLSE/LORE Shuttle flight



OMPS limb sampling (worst case pointing limit)

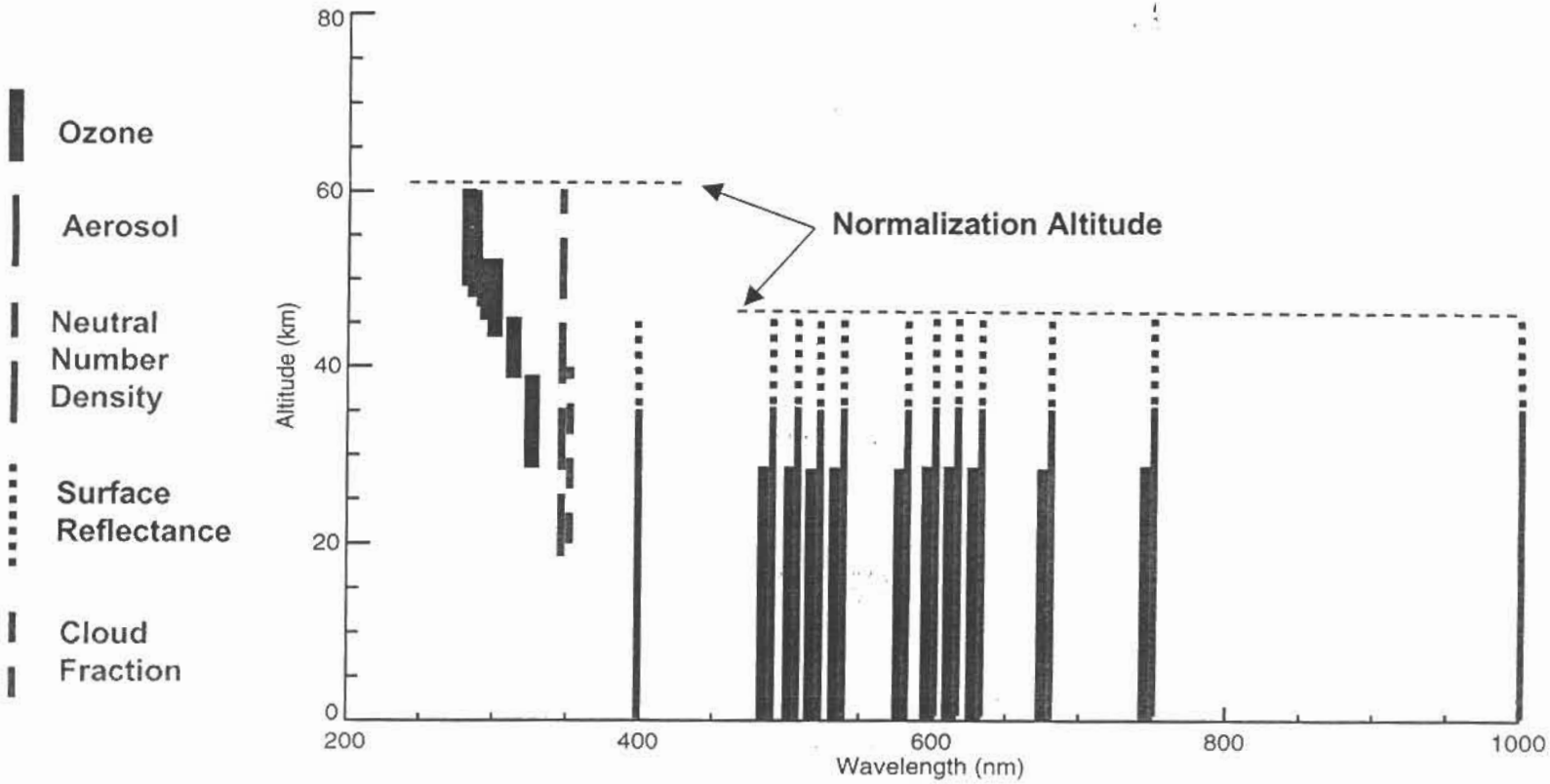


- OMPS limb sensor has 3 slits separated by 4.25 degrees
- 38 second reporting period: 250 km along track
- 130 km (2.23 degree) vertical FOV at limb for 0-60 km coverage plus offsets (pointing, orbital variation, Earth oblateness)

OMPS Limb

OMPS Limb Sensor Spectral Coverage is 290-1000 nm

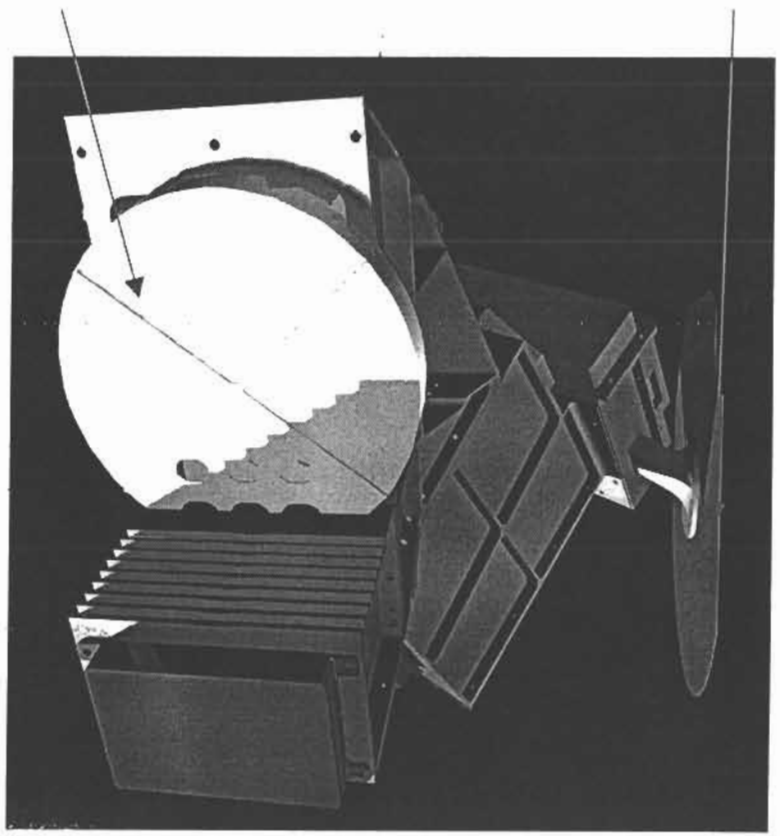
- Middle and near-ultraviolet channels provide coverage from 28 to 60 km
- Visible channels including 602 nm provide coverage from tropopause to 28 km
- Additional channels between 350 and 1000 nm provide characterization of Rayleigh and aerosol scattering background



OMPS Limb

Limb Sensor Description

- Six apertures, three slits, one prism, one focal plane
  - Two types of raw data records corresponding to different integration times
  - Bandpass varies from 2.5 to 50 nm over 290-1000 nm
- Calibration stability maintained by periodic solar observations using dual transmissive diffusers
- Electronics similar to nadir



OMPS Limb

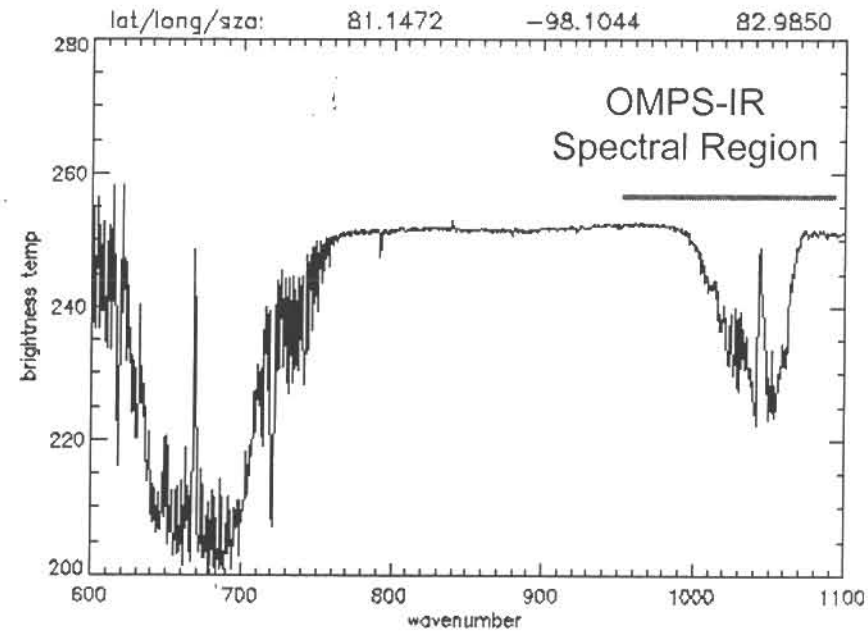
SOLSE/LORE Algorithm Provides Strong Foundation for OMPS Profile Ozone Retrieval

- Adapting the SOLSE / LORE algorithm developed by Drs. Ben Herman and Dave Flittner (U. of Arizona)
- Heritage algorithm:
  - Multiple scattering solution in a spherical atmosphere
    - Molecular and aerosol scattering
    - Ozone absorption
  - Includes polarization
- Enhancements by OMPS team include:
  - Additional ozone channels
  - Aerosol extinction profile retrievals at non-ozone-absorbing wavelengths
  - Bulk neutral density retrievals
  - Effective surface reflectance and cloud fraction retrievals
- SOLSE/LORE reflight in April 2002 will provide improved data for validation

OMPS IR

OMPS-IR Algorithm Uses CrIS Data to Obtain Ozone Column Measurements

- CrIS band 1 (635 - 1095 cm^{-1}) contains temperature, ozone, and surface information, along with some information about H_2O
- CrIS EDRs (Temperature, pressure and water vapor profiles) are used in conjunction with CrIS SDRs (950 - 1095 cm^{-1}) to retrieve ozone
  - OSS forward model provides high accuracy with minimal computation
  - Retrieval performed using optimal estimation algorithm
- Emphasis is on polar night



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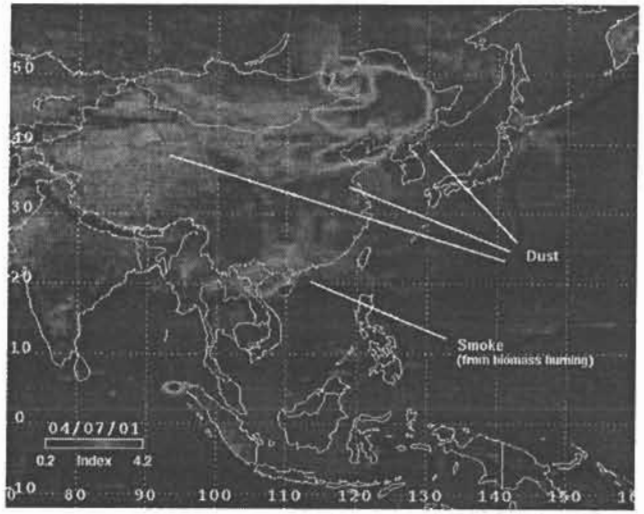

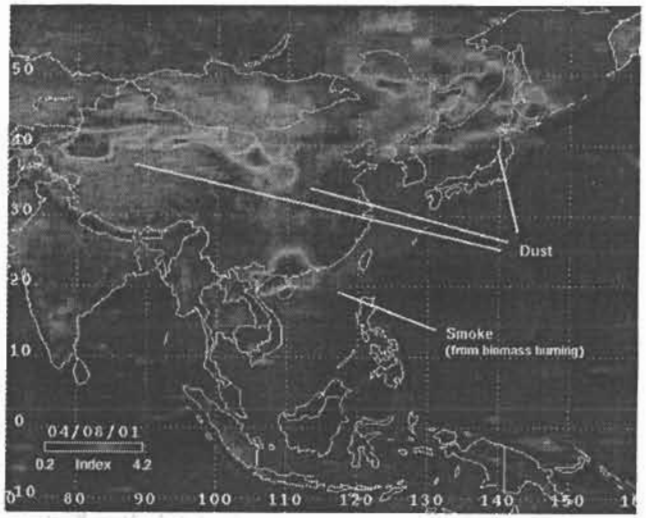

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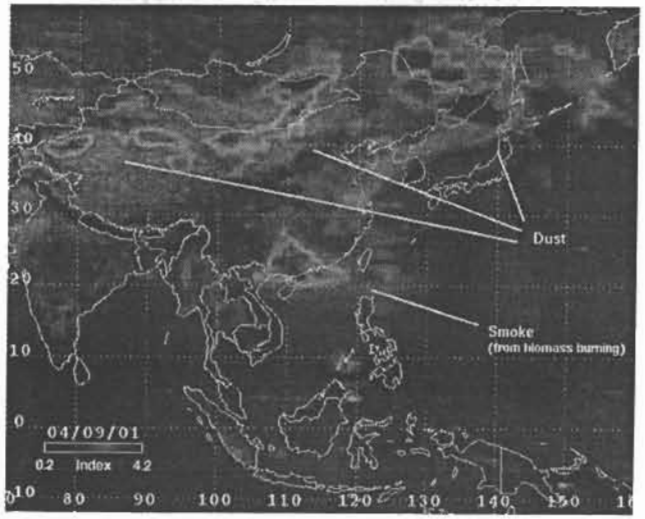
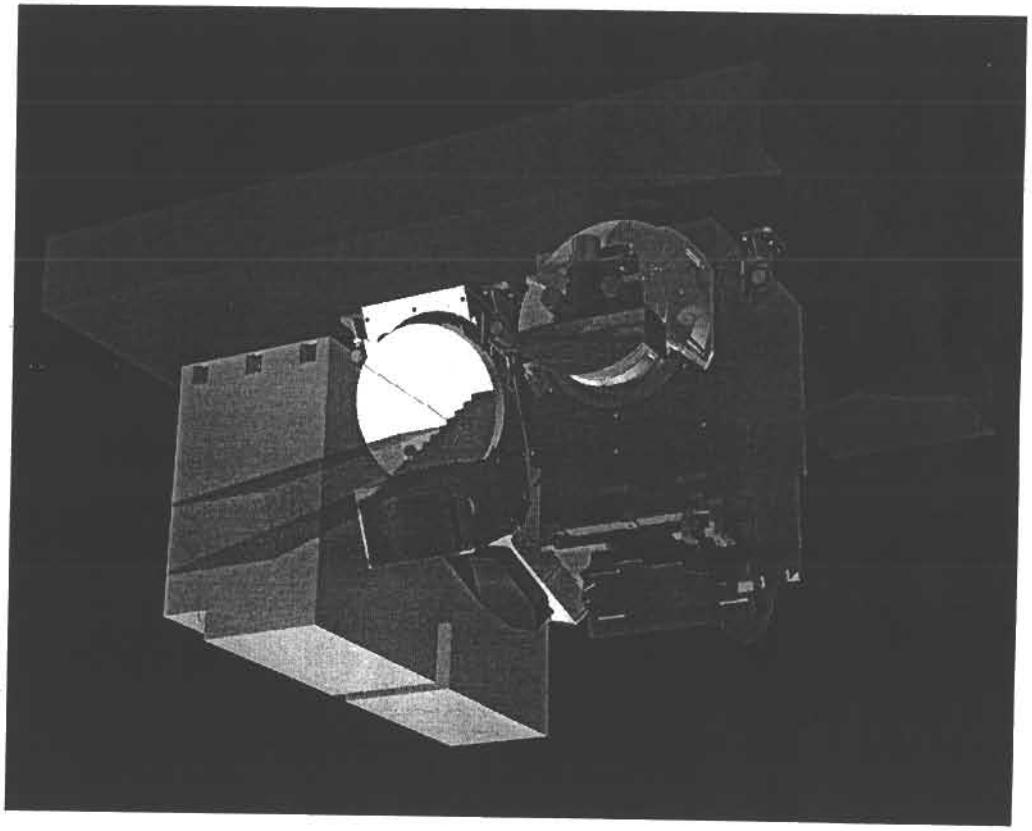


Conclusion

- Ozone Mapping and Profiler Suite (OMPS) will provide:
  - Global mapping of total column every 24 hours
  - High-vertical-resolution limb ozone profiles
  - Along-track vertical profile, continuing SBUV-SBUV/2 record
- Engineering unit built and tested fall-winter 2001-2002
- First flight planned for 2008
- Possible early flight is NRL experiment OMPS-AE (see talk by John Hornstein et al.)