



# The SAGE III Test Occultation Instrument: Ground-based Observations for Satellite Validation

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SOSST Meeting

1. Science Applications International Corporation, Hampton, VA
2. NIWA – Lauder, New Zealand
3. NASA – Langley Research Center
4. CIRES – Boulder, CO



# TOI Optics



- SAGE III TOI first of five functional spectrometer/telescopes built by Ball Aerospace Corp. and delivered to NASA-LaRC
- CCD Array Detector – 809 x 11 pixels
- Grating Dispersion – 275nm to 1030 nm
  - Resolution  $\approx$  2.2 nm in UV & NIR, 1.3 nm in VIS
- Effective Field of View  $\approx$  5 x 0.5 arcminutes





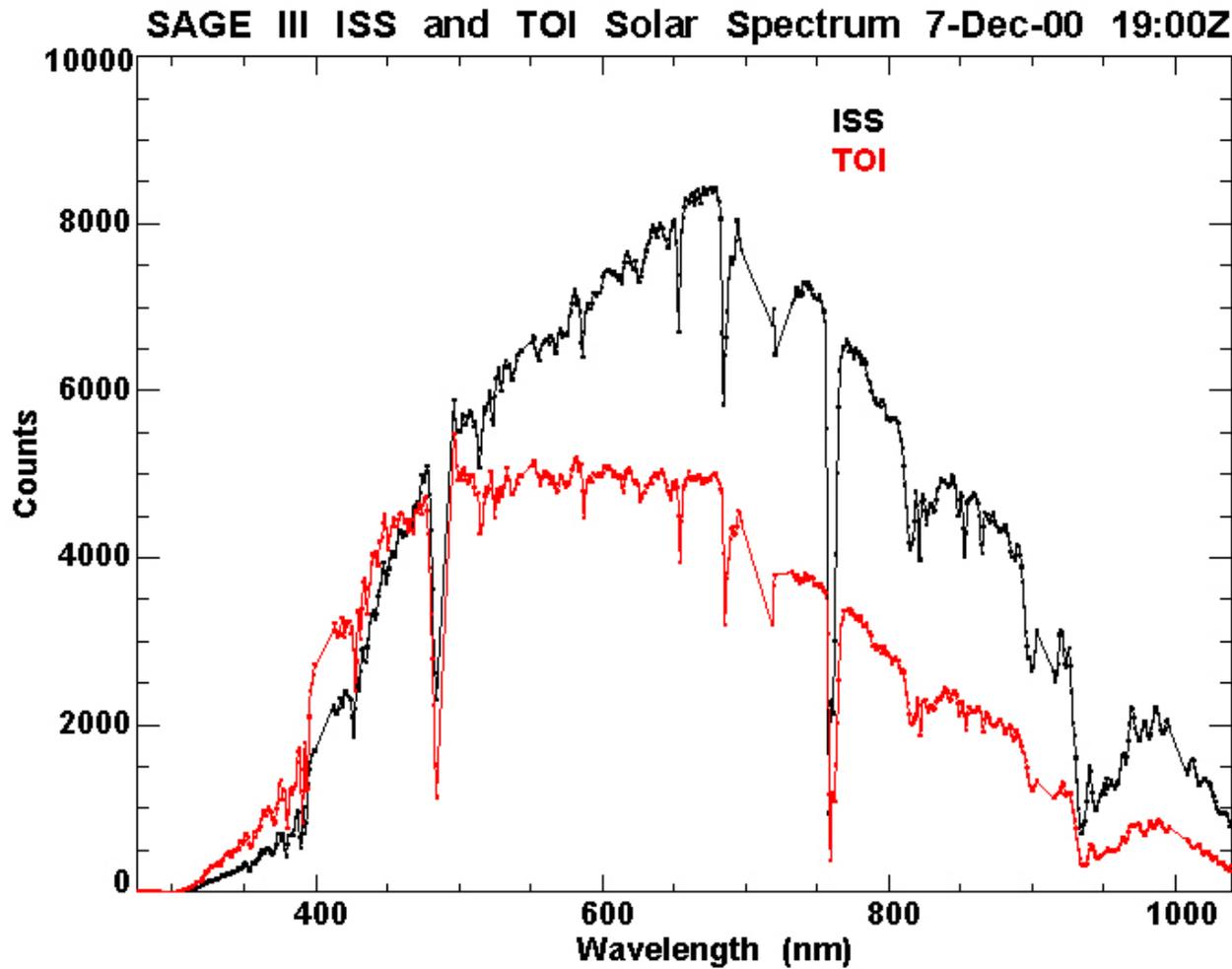
# Purpose



- Test model for flight instrument operations
  - Radiometric and spectral performance studies
  - Testing to support software changes in M3M – Sage III instrument
- Develop capabilities as a ground-based validation tool for SAGE III science products
  - NO<sub>2</sub> and O<sub>3</sub> vertical profile

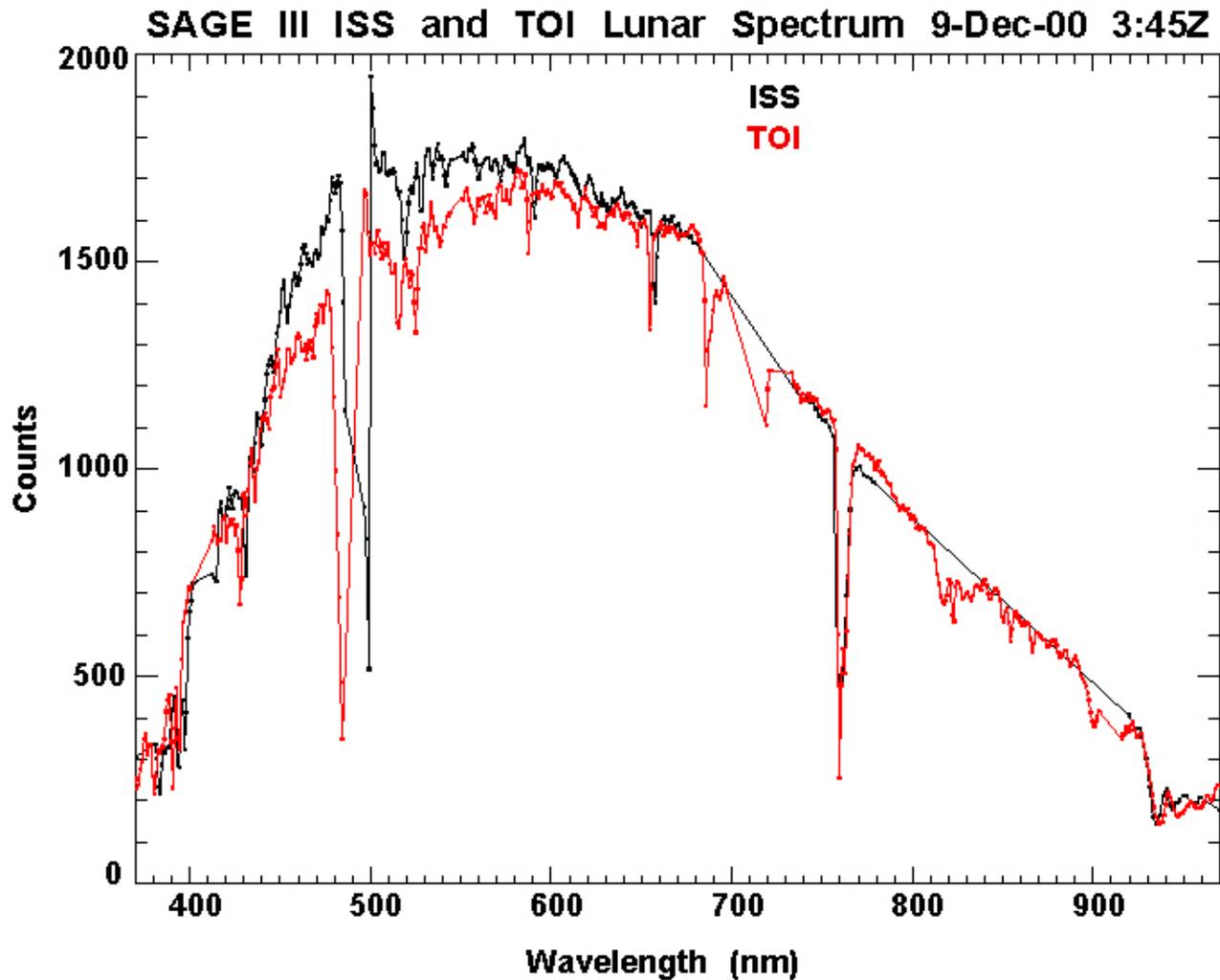


# TOI/ISS Comparison - Solar





# TOI/ISS Comparison - Lunar





# TOI as a SAGE III Validation Tool



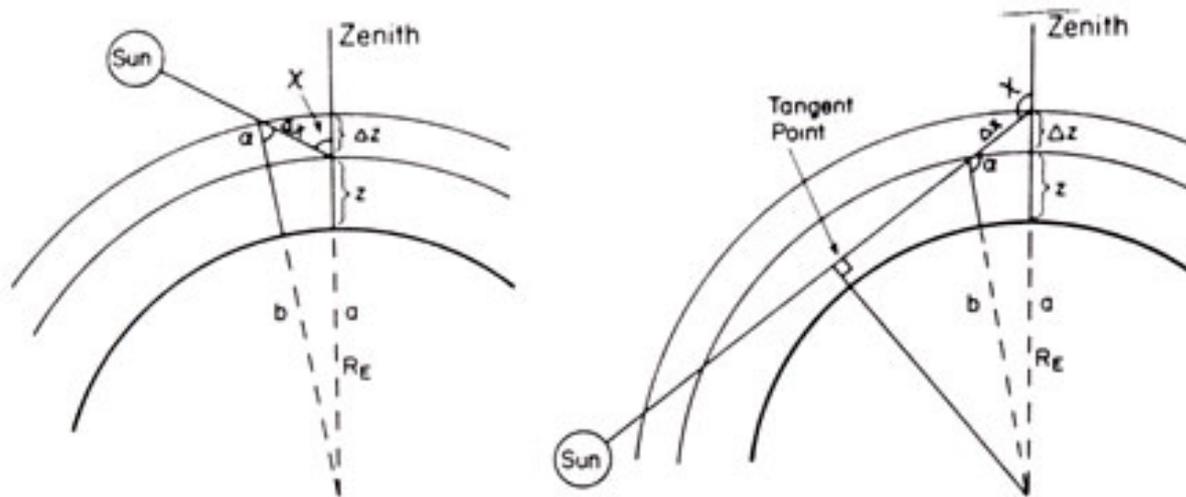
- Advantages:
  - Identical optics as flight instrument
  - Ability to run identical CCD code
  - Transportable, self-contained system
  - Obtains both solar and lunar measurements
    - Direct sun, moon & zenith sky radiance
  - Science Products:
    - Gaseous species vertical profiles and total column amount
    - Aerosol optical depth



# Twilight Measurement Geometry



SOLOMON ET AL.: INTERPRETATION OF SKY ABSORPTION



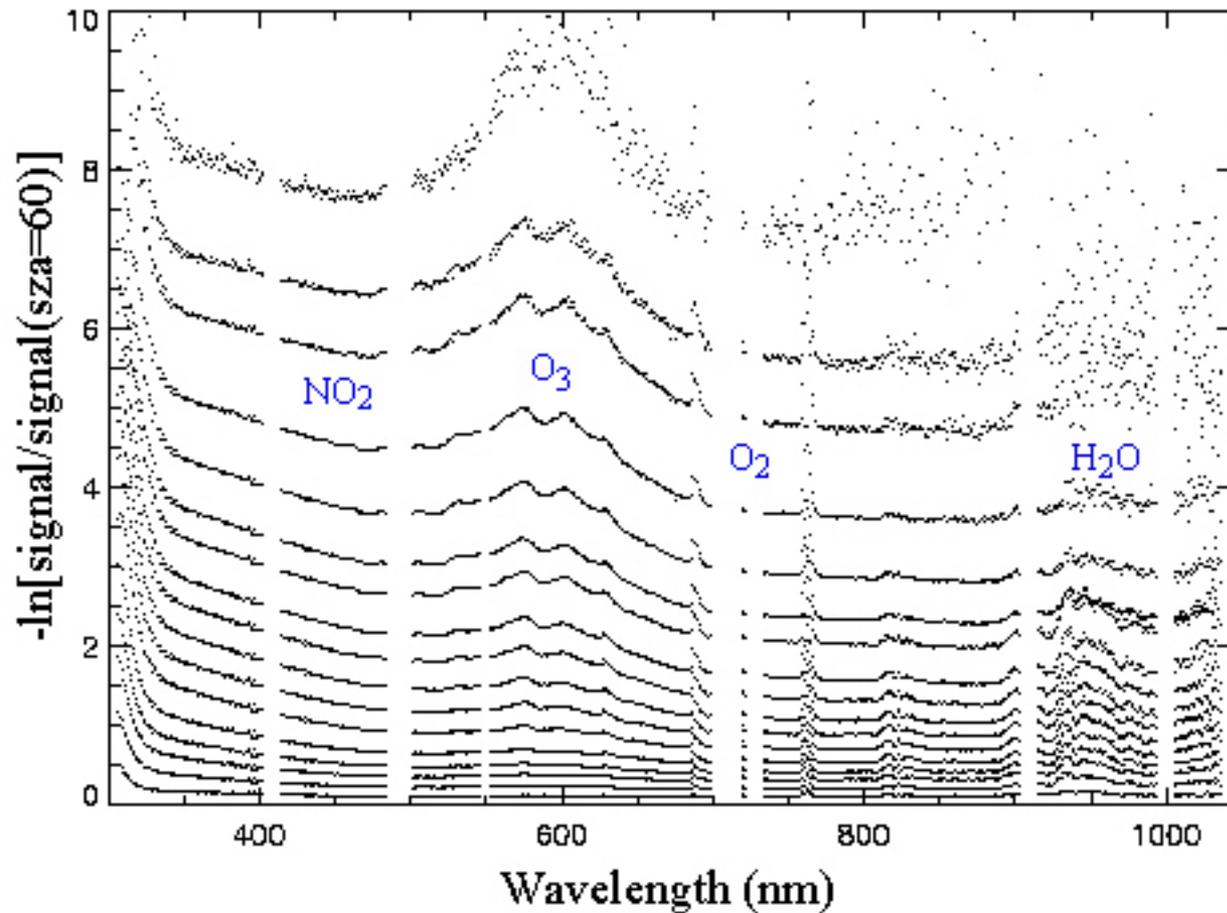
- Absorption depends on SZA & altitude of absorbers
- Sunlight passes tangentially through atmosphere before scattering – absorption is enhanced due to relative increase in path length



# Twilight Zenith Sky Radiance



TOI Zenith 042402





# Twilight Retrieval Algorithm



- Parallel efforts using two methods:
  - NIWA-Lauder twilight algorithm –  $\text{NO}_2$  &  $\text{O}_3$  profile (in collaboration with Paul Johnston)
  - Umkehr-type  $\text{O}_3$  retrieval (in collaboration with Irina Petropavlovskikh)



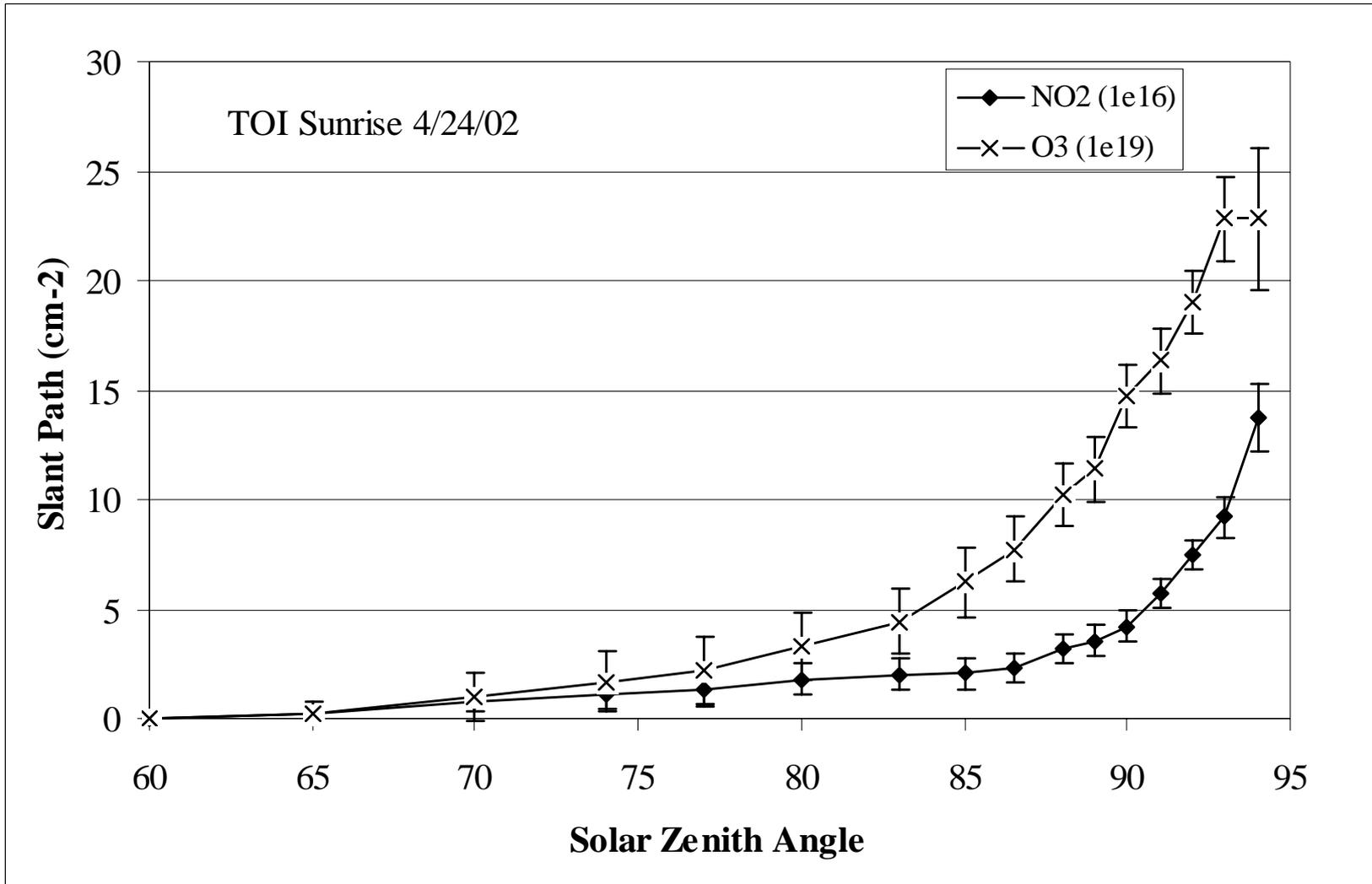
# Lauder NO<sub>2</sub> Algorithm Status



- Currently can produce slant path abundances from twilight measurements – inversion to profile has proved problematic
- Planned improvements:
  - Optimization of shift and stretch of twilight and reference spectra
  - Polarization measurements to account for the Ring Effect
  - Assess differences between TOI and Lauder instruments

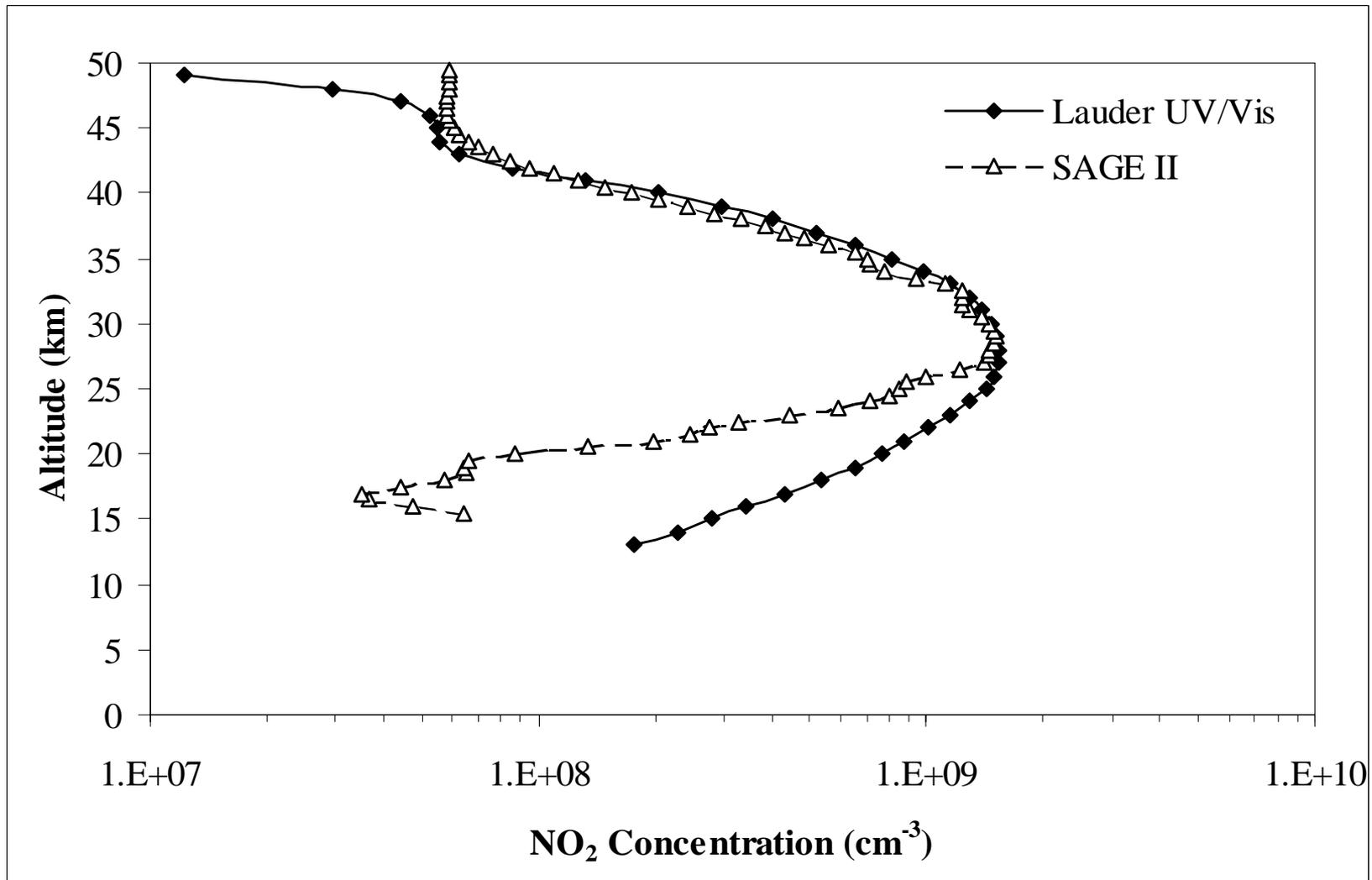


# NO<sub>2</sub> & O<sub>3</sub> Slant Path





# Lauder / SAGE II NO<sub>2</sub> Comparison





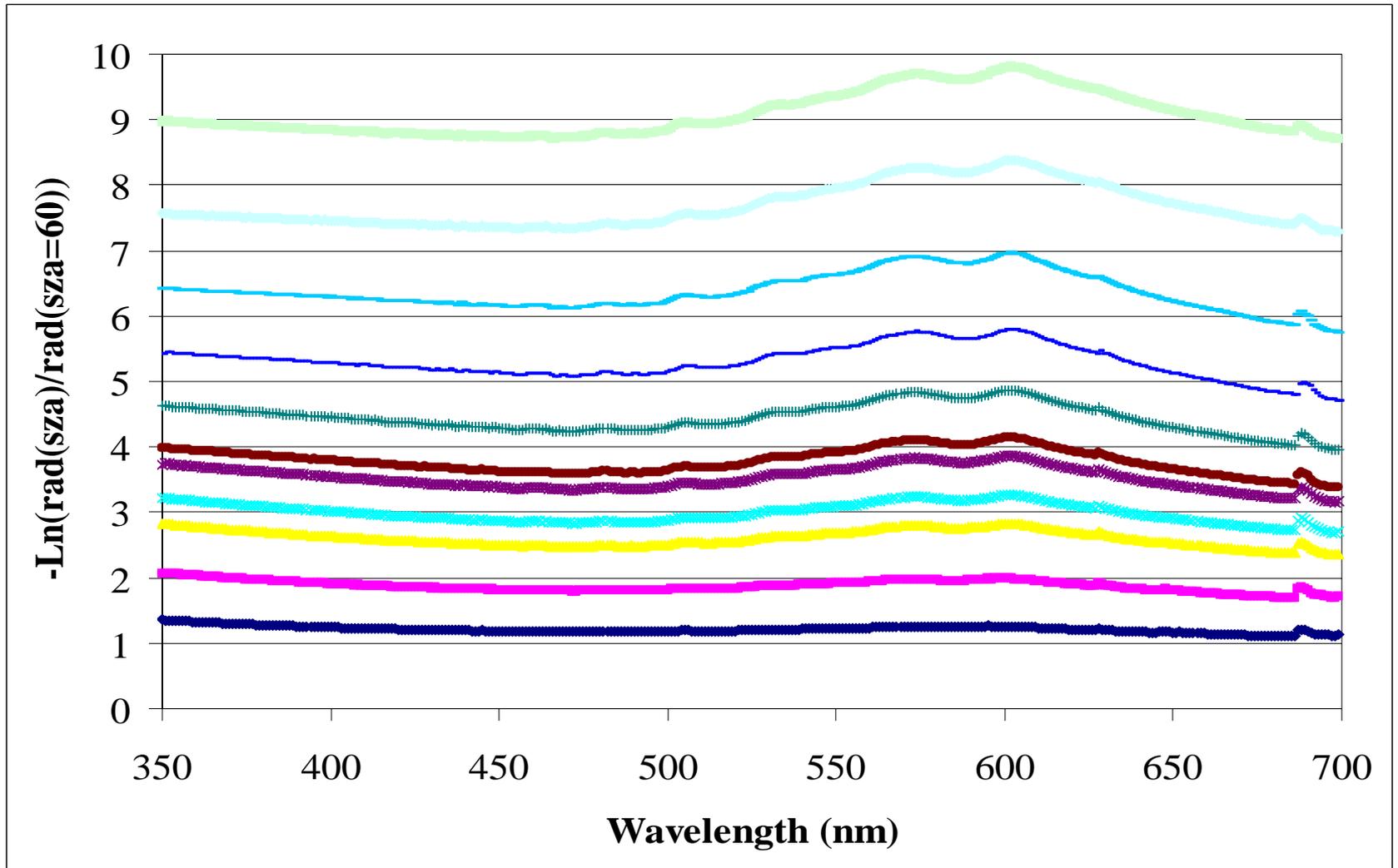
# Umkehr Retrieval Status



- Currently developing the forward model to be used in retrieval
  - Optical characteristics of TOI
  - Studying effects of temperature and ozone profile changes on measurements
- Advantage over current Umkehr method – larger number of wavelengths measured compared to Brewer & Dobson instruments

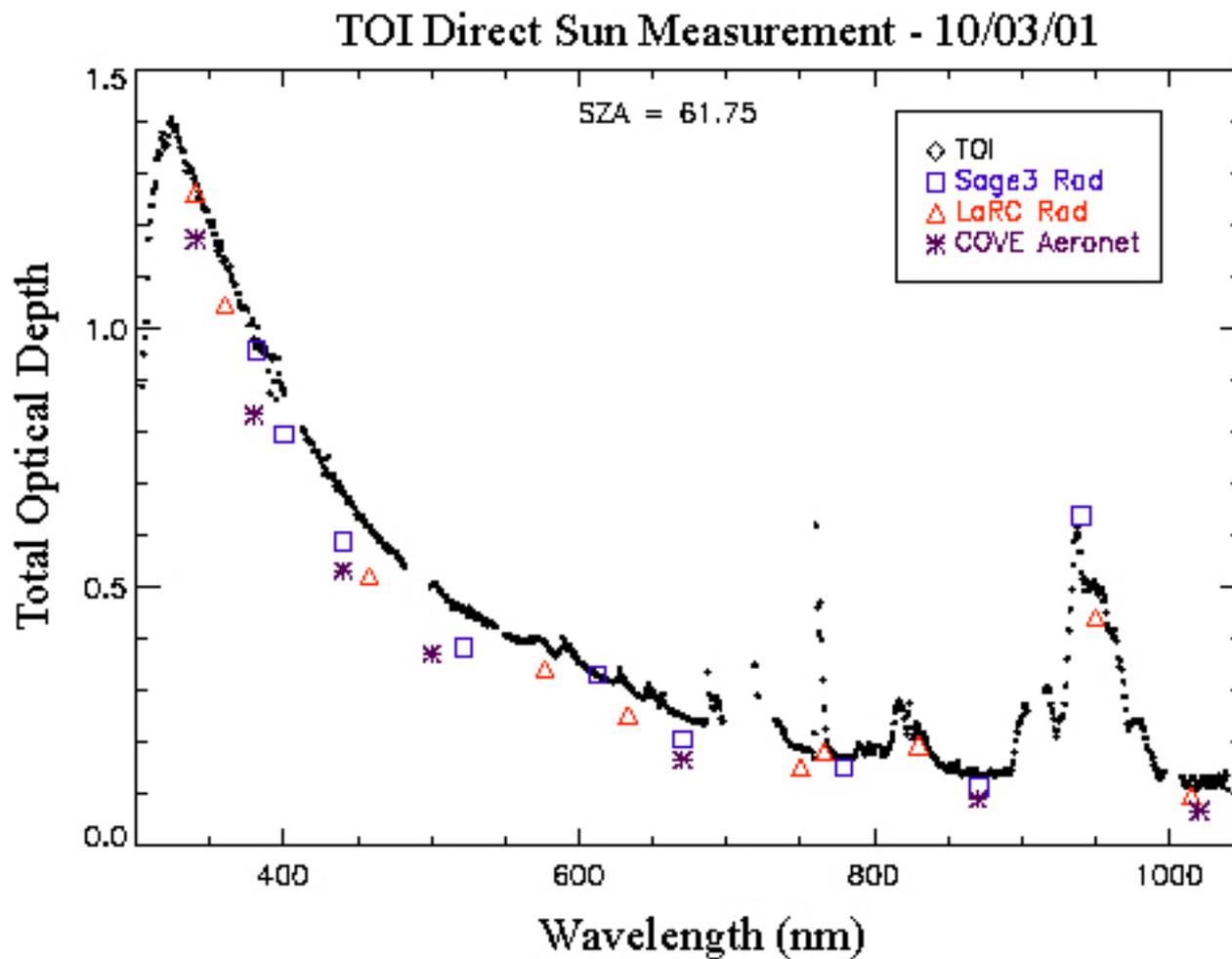


# Forward Model Zenith Sky Radiance Simulation





# Direct Sun Measurement





# Field Deployment Plan



- Continue measurements at LaRC to refine techniques and procedures
  - Develop standard retrieval methods for TOI science products most useful for SAGE III validation
  - Establish long-term northern mid-latitude database
  - Investigate lunar science capabilities
- Off-site deployment necessary to obtain measurements coincident with satellite overpass and SAGE III solar occultation events



# Field Deployment Plan



- Deploy TOI to Lauder, New Zealand NIWA site
  - Latitude coincident with SAGE III solar and lunar occultation events
  - Network for Detection of Stratospheric Change primary site
  - Side-by-side comparison of zenith sky retrievals with the NIWA-Lauder system



# Instrument Modifications



- TOI upgrades in progress
  - New telescope/tracking system
    - Requires redesign of mounting hardware
  - Rack mount computer and support hardware
  - Alter CCD codes to improve signal collection at high solar zenith angles during twilight
  - Acquire polarization measurements