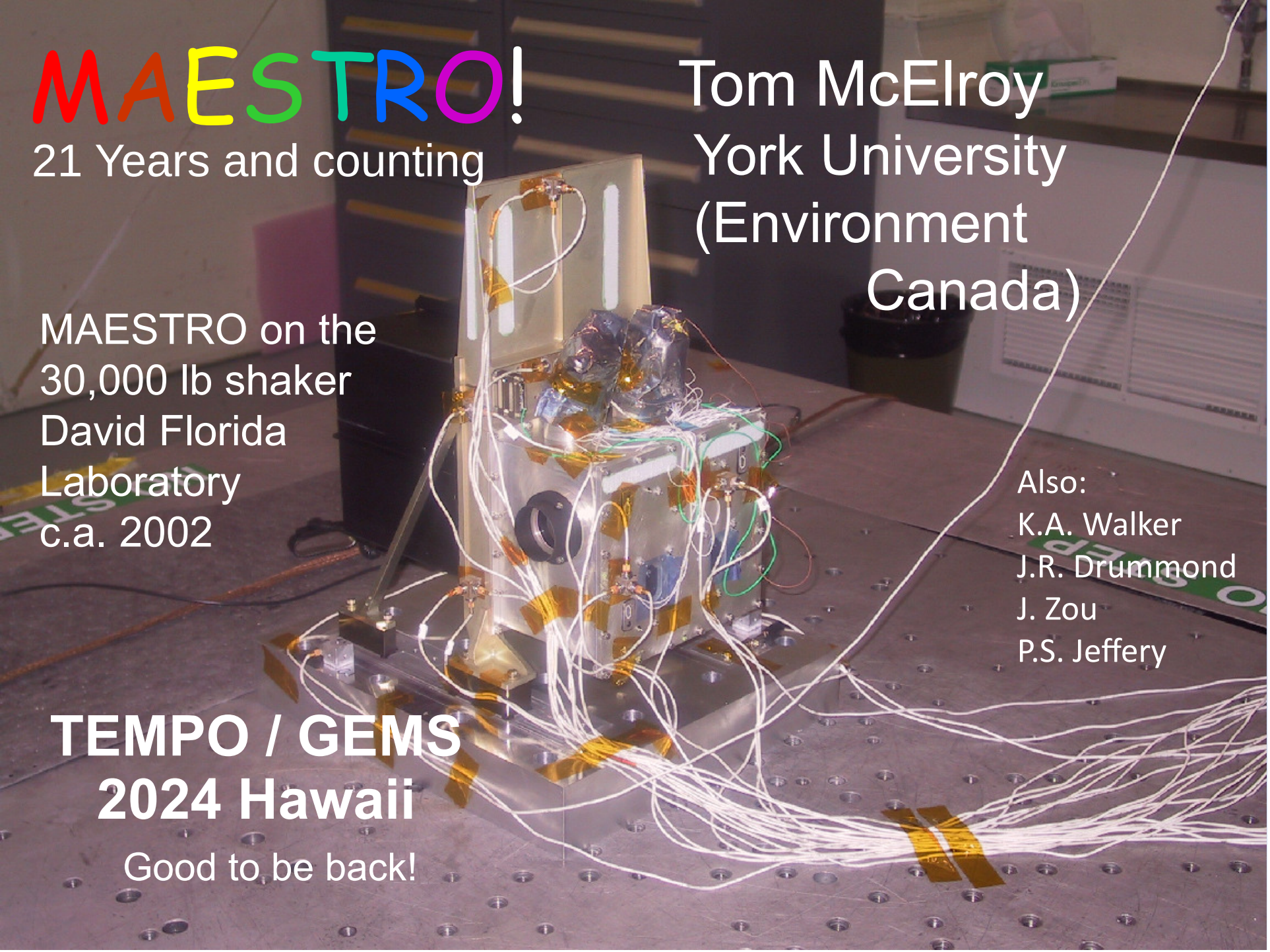
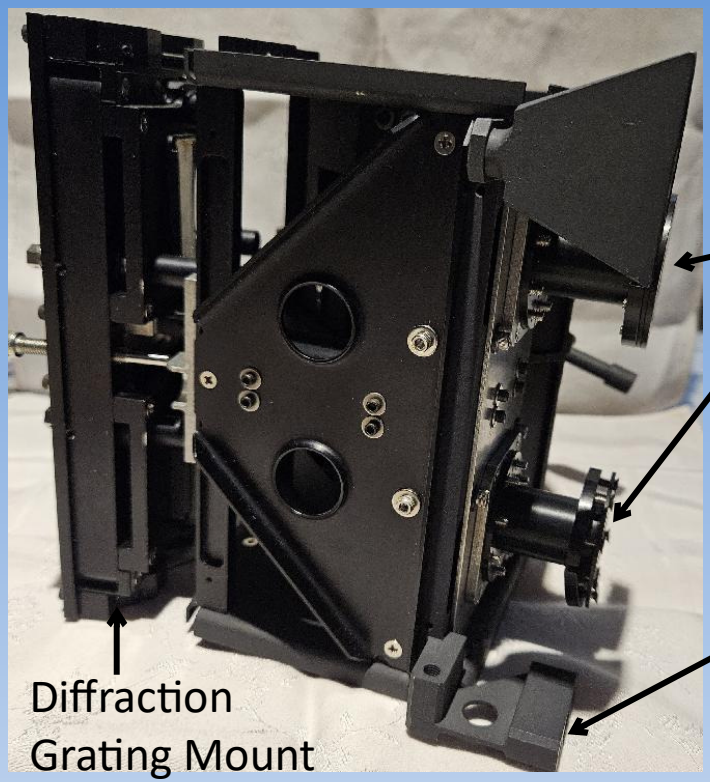

MAESTRO!
21 Years and counting
Tom McElroy
York University
(Environment
Canada)
MAESTRO on the
30,000 lb shaker
David Florida
Laboratory
c.a. 2002
Also:
K.A. Walker
J.R. Drummond
J. Zou
P.S. Jeffery
TEMPO / GEMS
2024 Hawaii
Good to be back!

Topics for Today

- Introduction to MAESTRO
- The instrument
- The measurement problem
- A few results
- Aging of the instrument
- A minor ‘miracle’

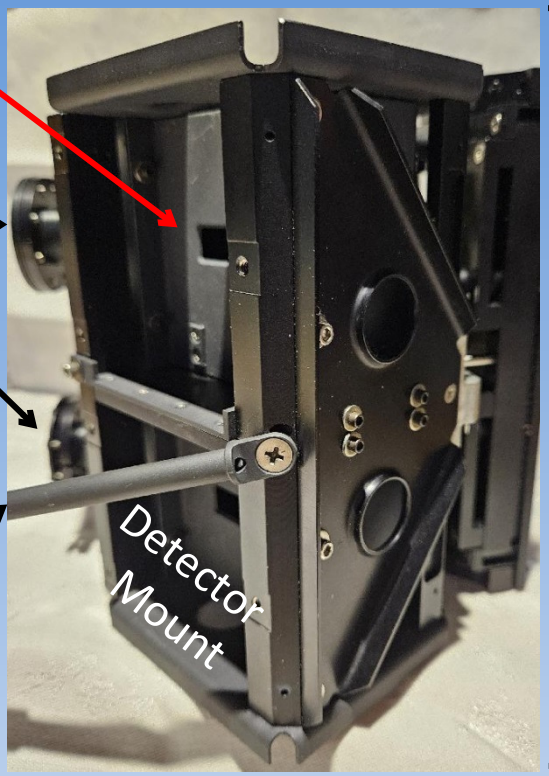
MAESTRO - the Instrument



Stray
Light
Mask

Field
Lenses

Kinematic
Mounts



15cm

- Material: 1 mm Aluminum sheet
- Two ‘channels 1 UV-Vis, 1 Vis NIR
- Each half has a concave holographic grating
- Separate field lenses
- Polkadot beam splitter in external foreoptics
- Grating focus thermally compensated

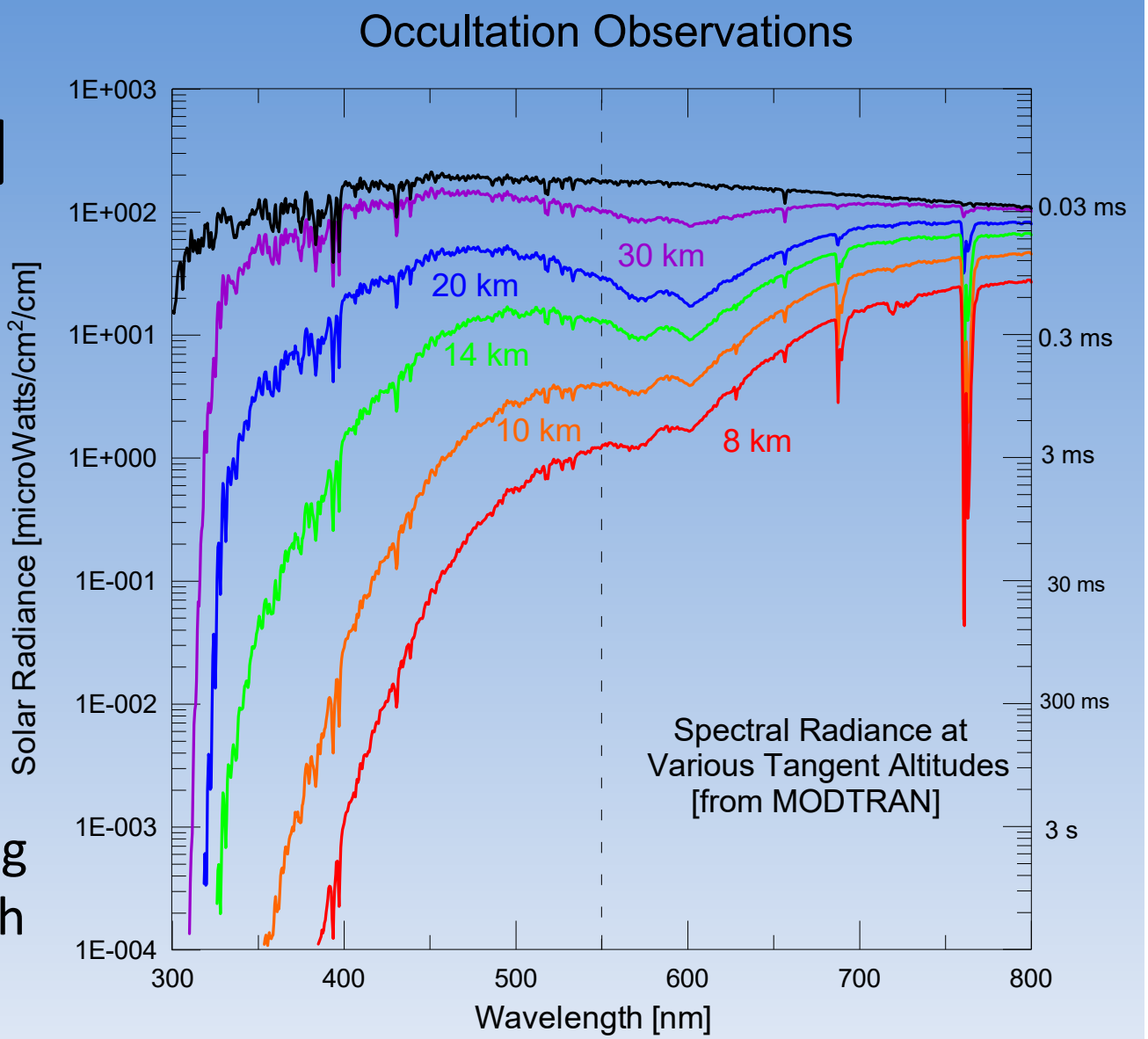
- Spectrometers carried in an external enclosure
- Two 1024pixel Reticon diode-array detectors
- Precision grating angle adjustment
- Kinematic mount to external enclosure
- Roughly 15 x 15 x 15 cm
- Power 15 W Mass 15 kg Spectrometer 1.5 kg

Occultation Observations

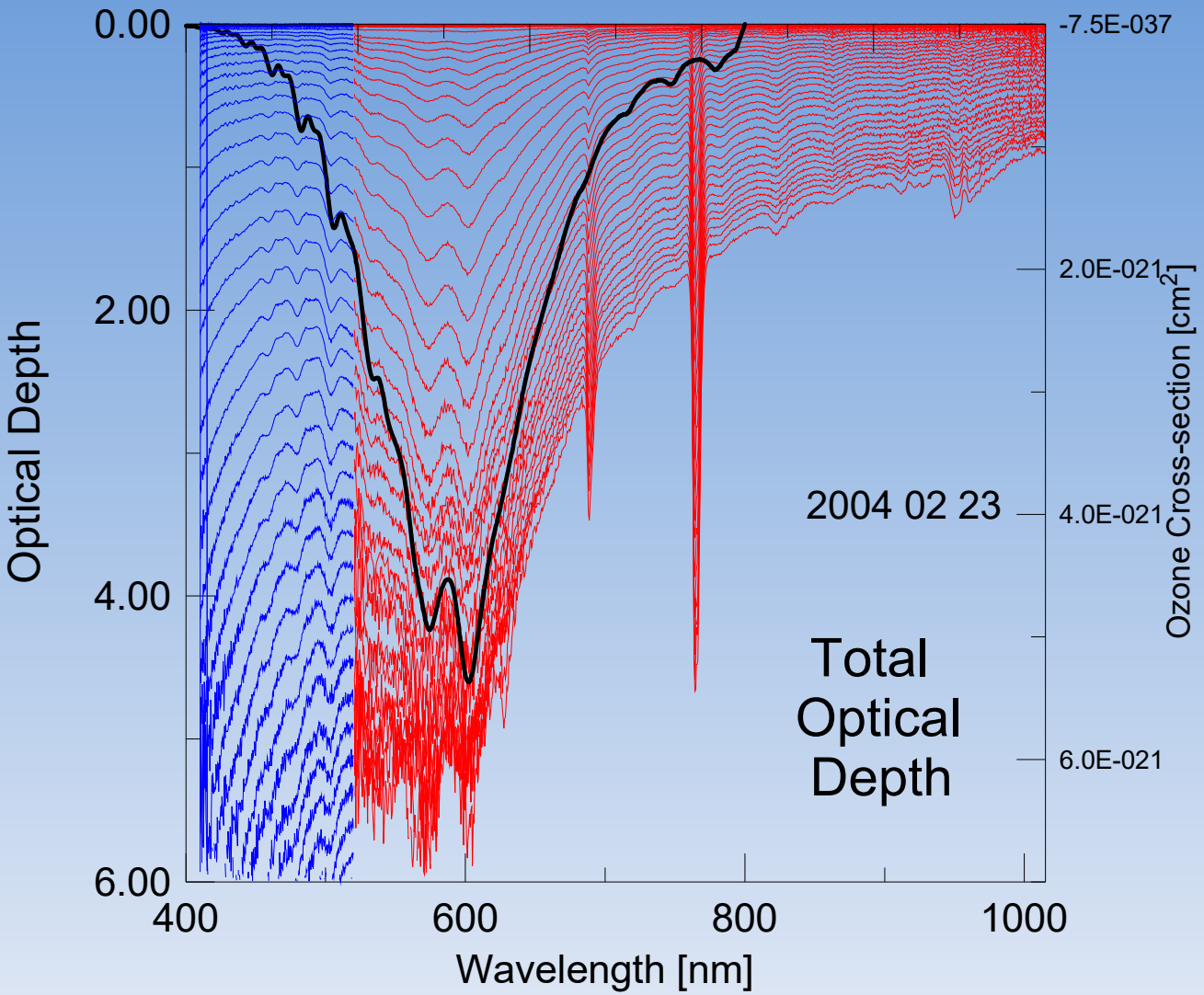
MODTRAN

MAESTRO
Data Simulated
Using MODTRAN

These files were log-interpolated at 1-km intervals to generate optimized observing parameters for each altitude



Optical Depth Spectra

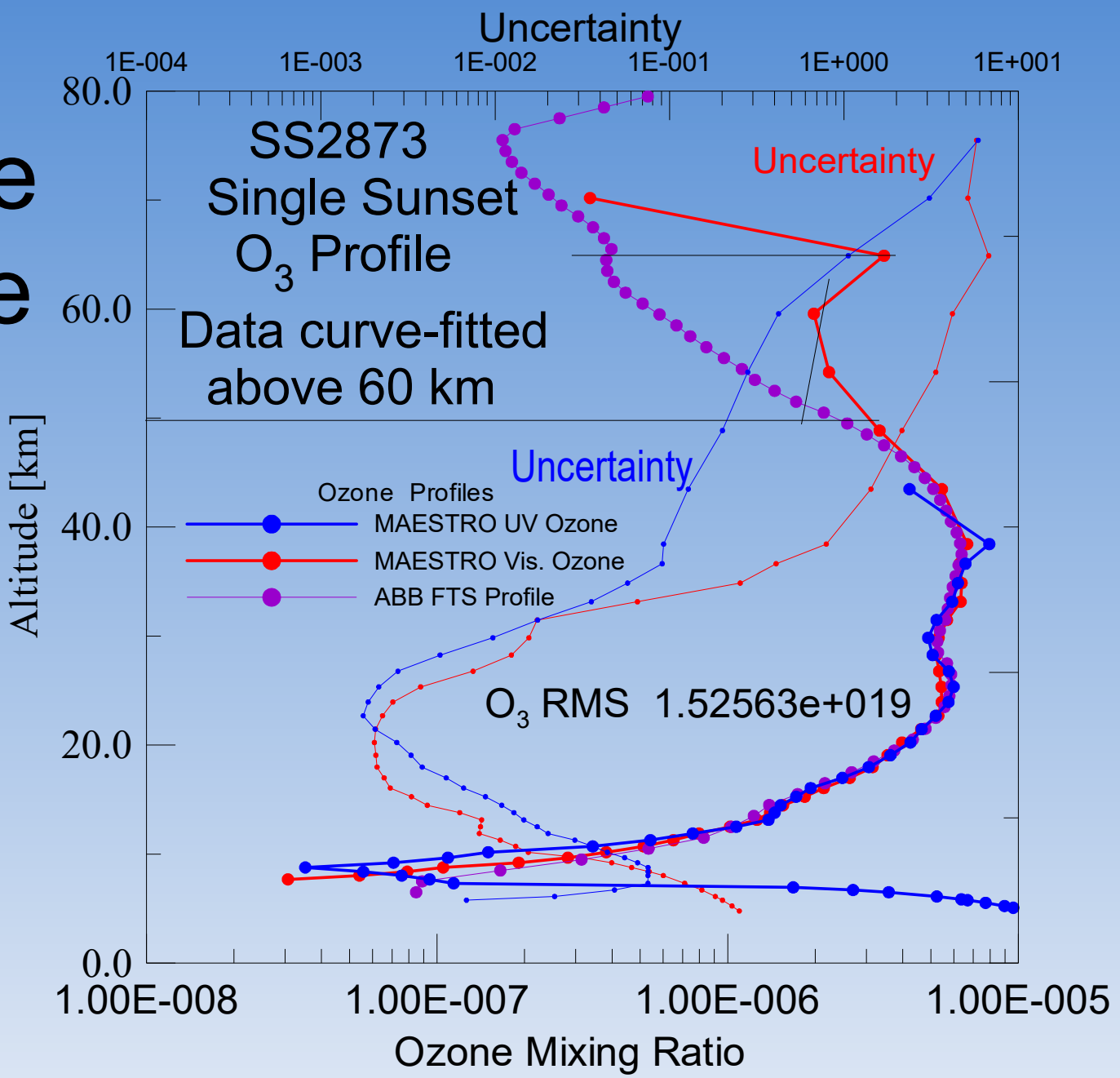


The optical depth, O.D., spectra are the log of the ratio of the observed spectra to an extraterrestrial reference spectrum

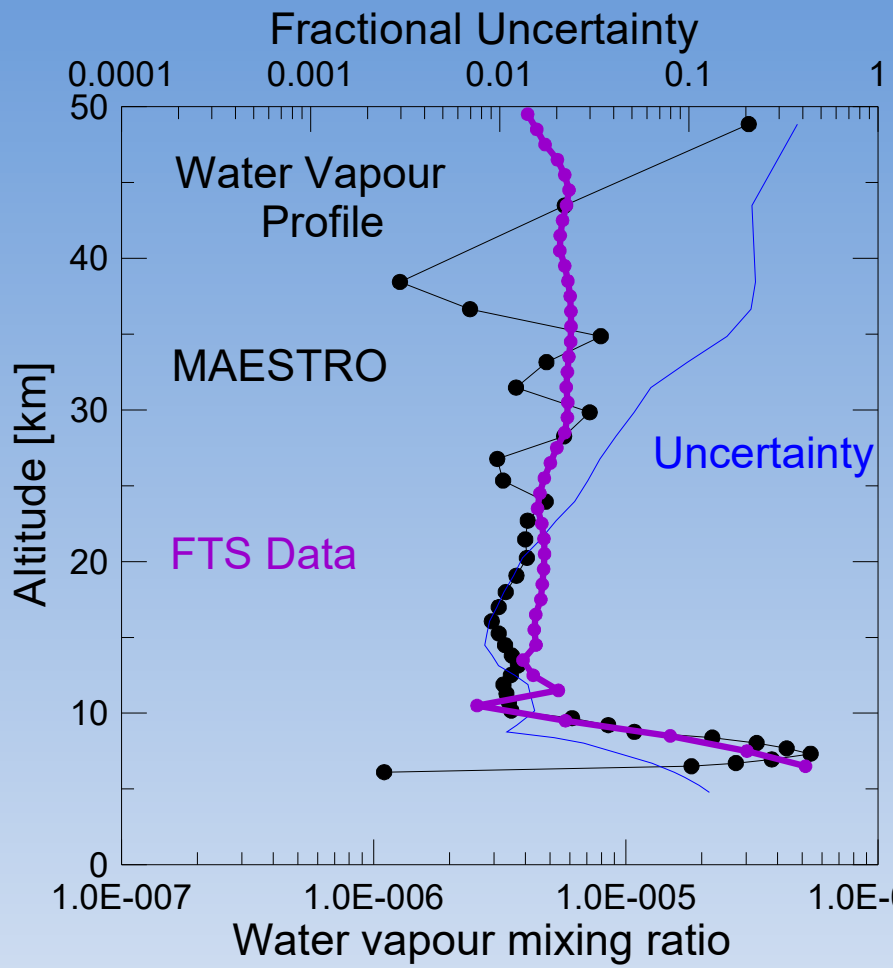
Blue is the UV O.D.
Red is the Vis NIR O.D.
Black is the ozone spectrum

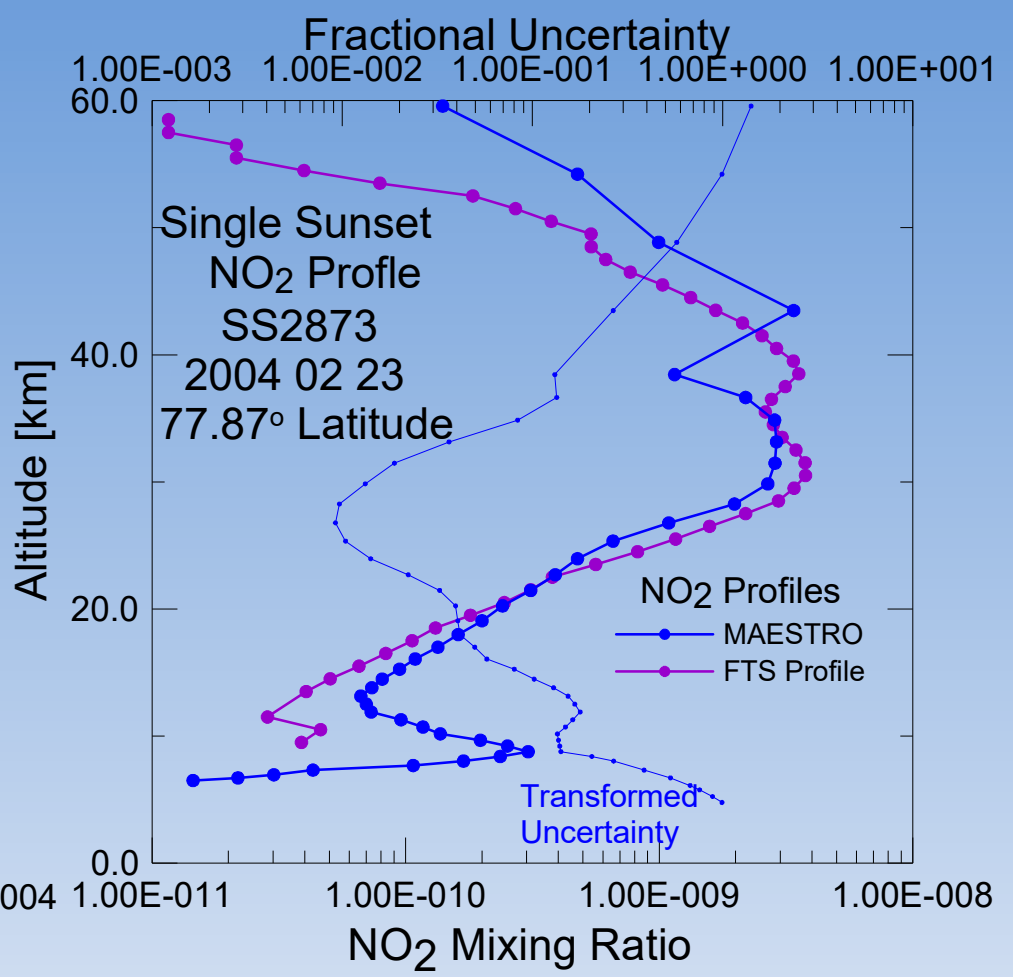
A spectral model is then fitted to these data to determine the amount of each absorber in the optical path from the sun

Ozone Profile



Water & NO_2

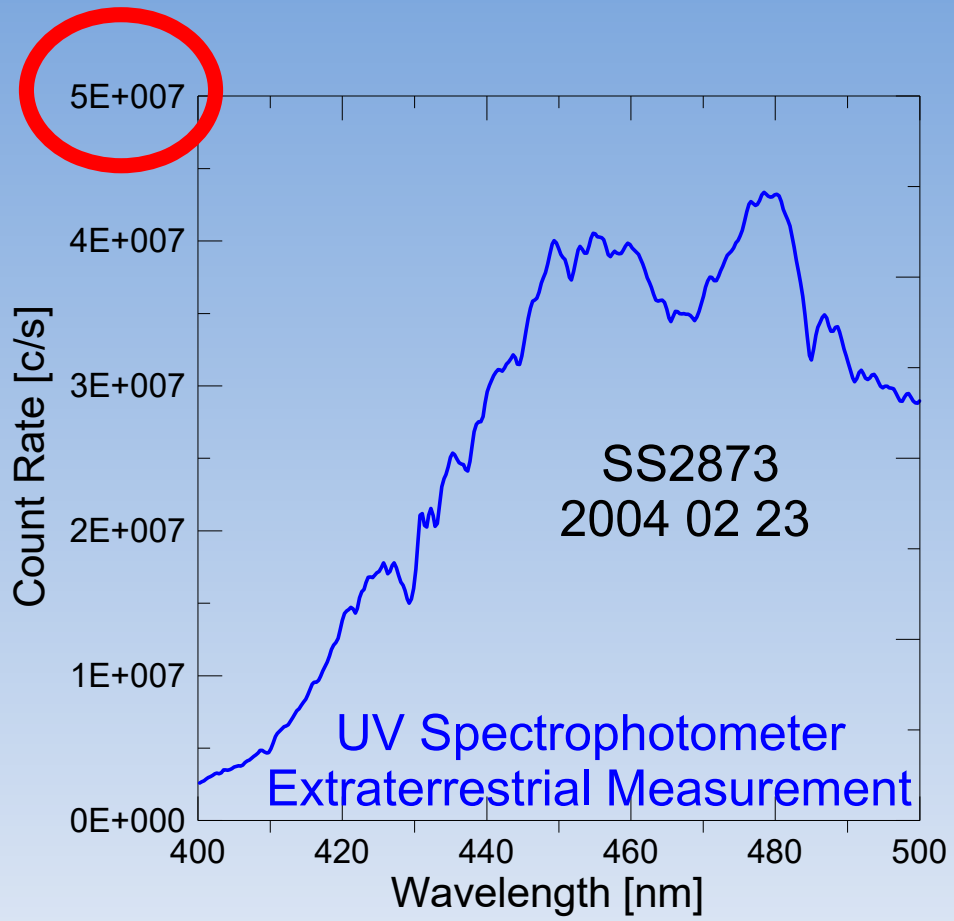

Fractional Uncertainty
0.0001
0.001
0.01
0.1
1
Water Vapour Profile
MAESTRO
FTS Data
Uncertainty
Altitude [km]
50
40
30
20
10
0
1.0E-007
1.0E-006
1.0E-005
1.0E-004
Water vapour mixing ratio

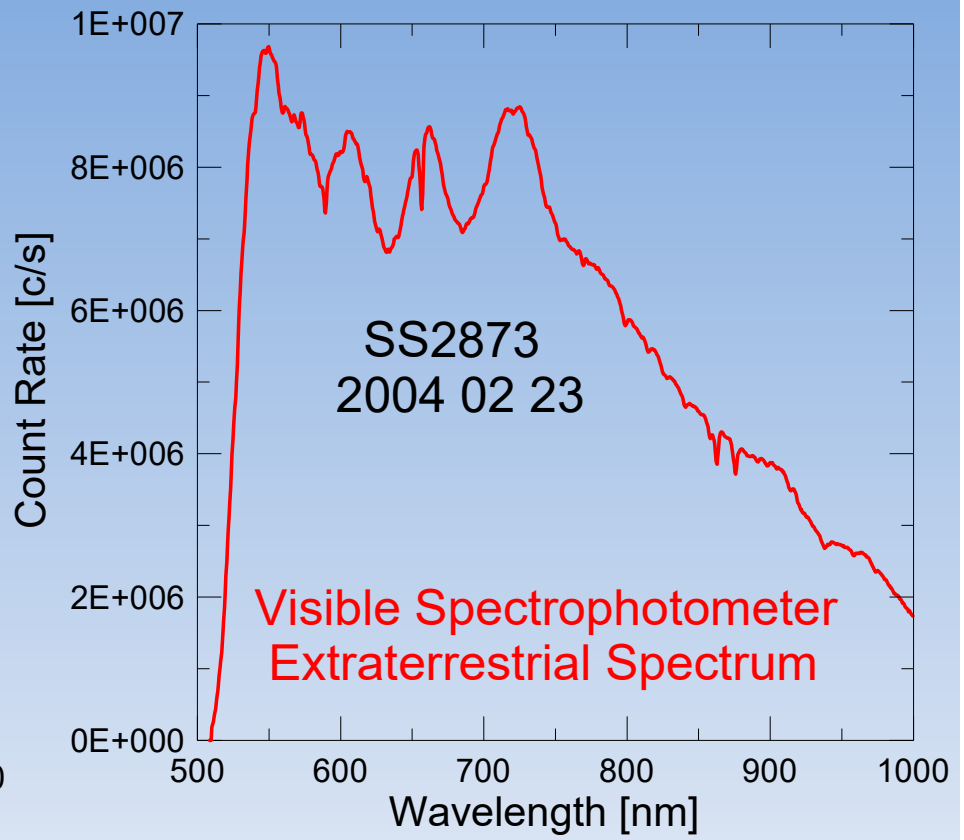

Fractional Uncertainty
1.00E-003
1.00E-002
1.00E-001
1.00E+000
1.00E+001
Single Sunset
NO2 Profle
SS2873
2004 02 23
77.87° Latitude
NO2 Profiles
MAESTRO
FTS Profile
Transformed Uncertainty
Altitude [km]
60.0
40.0
20.0
0.0
1.00E-011
1.00E-010
1.00E-009
1.00E-008
NO2 Mixing Ratio

Now for something completely different!

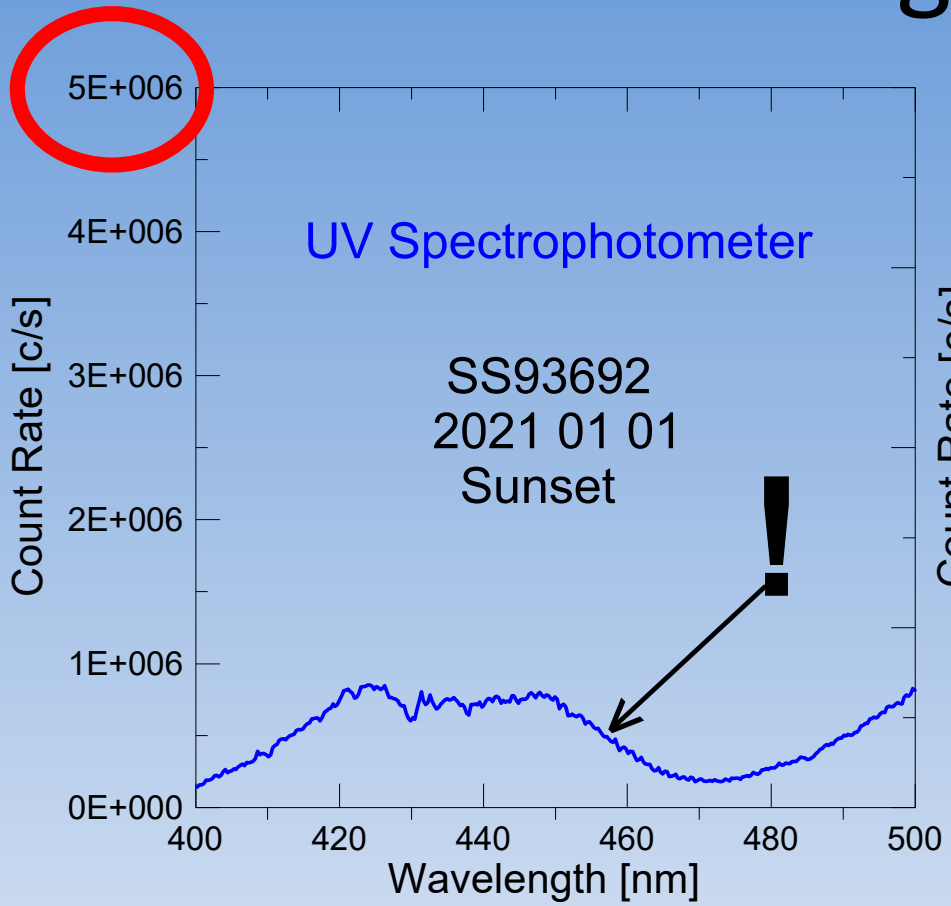
Reference Spectra 2004 02 23

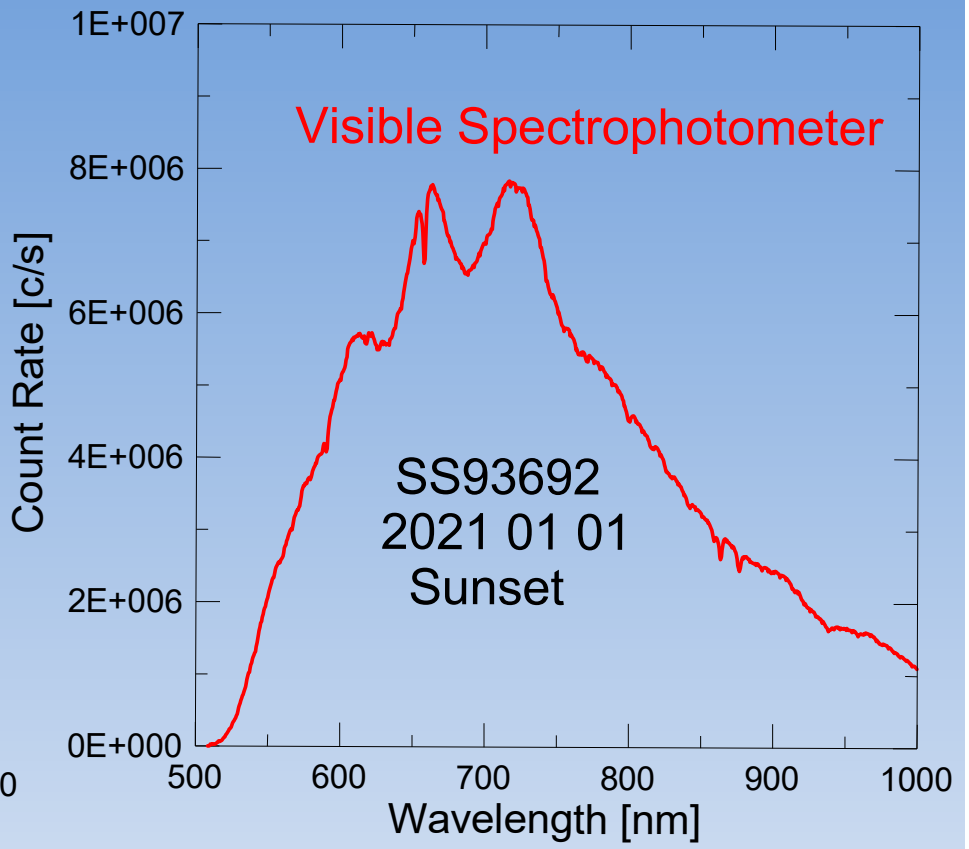
... 6 months after launch





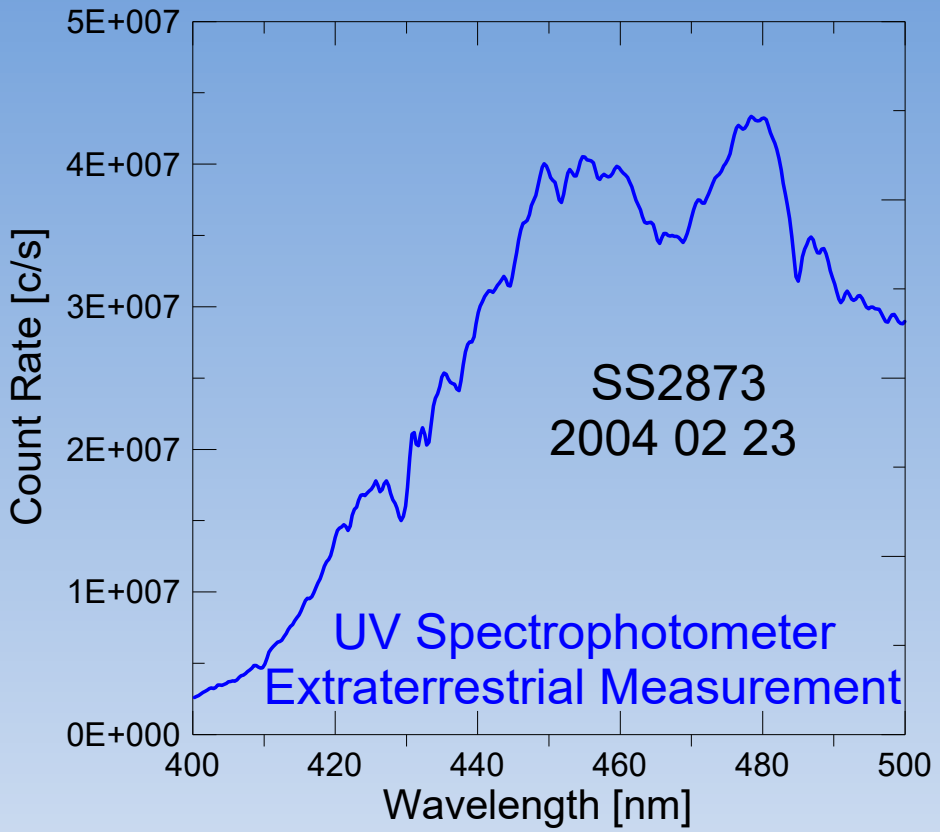
By 2021...
Short Wavelengths Attenuated

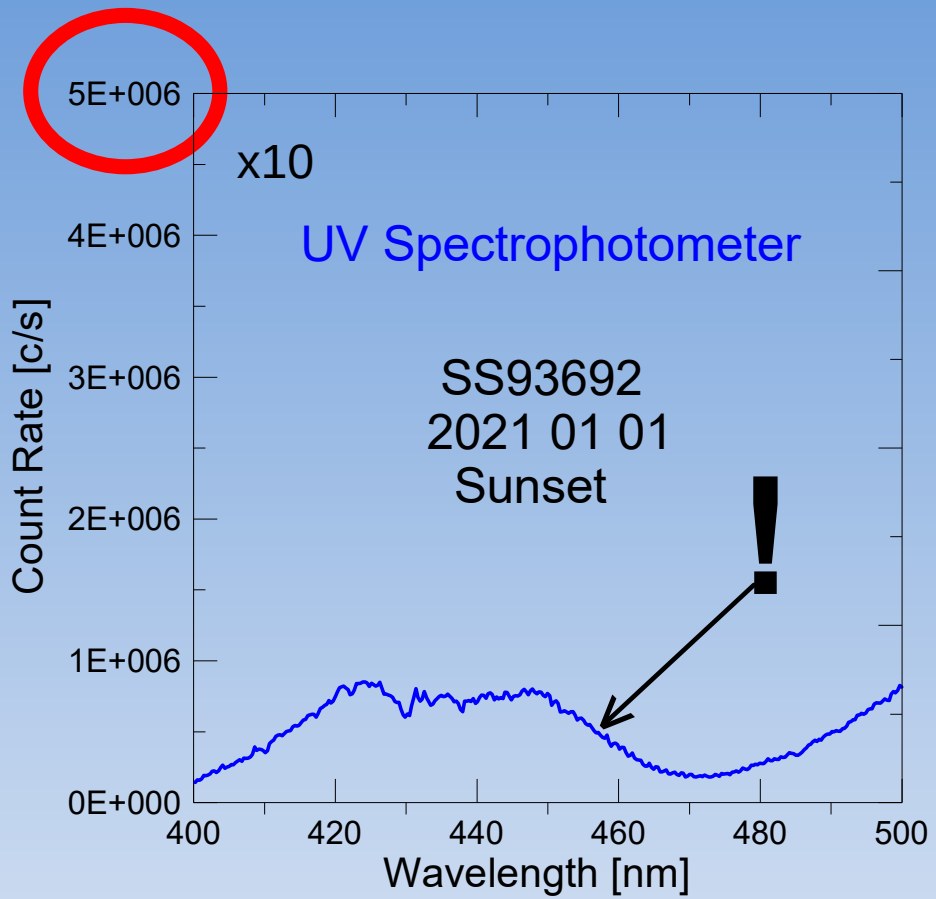




Note: Same scale for Visible but not for the UV from the previous graphs.

UV is Almost Gone…



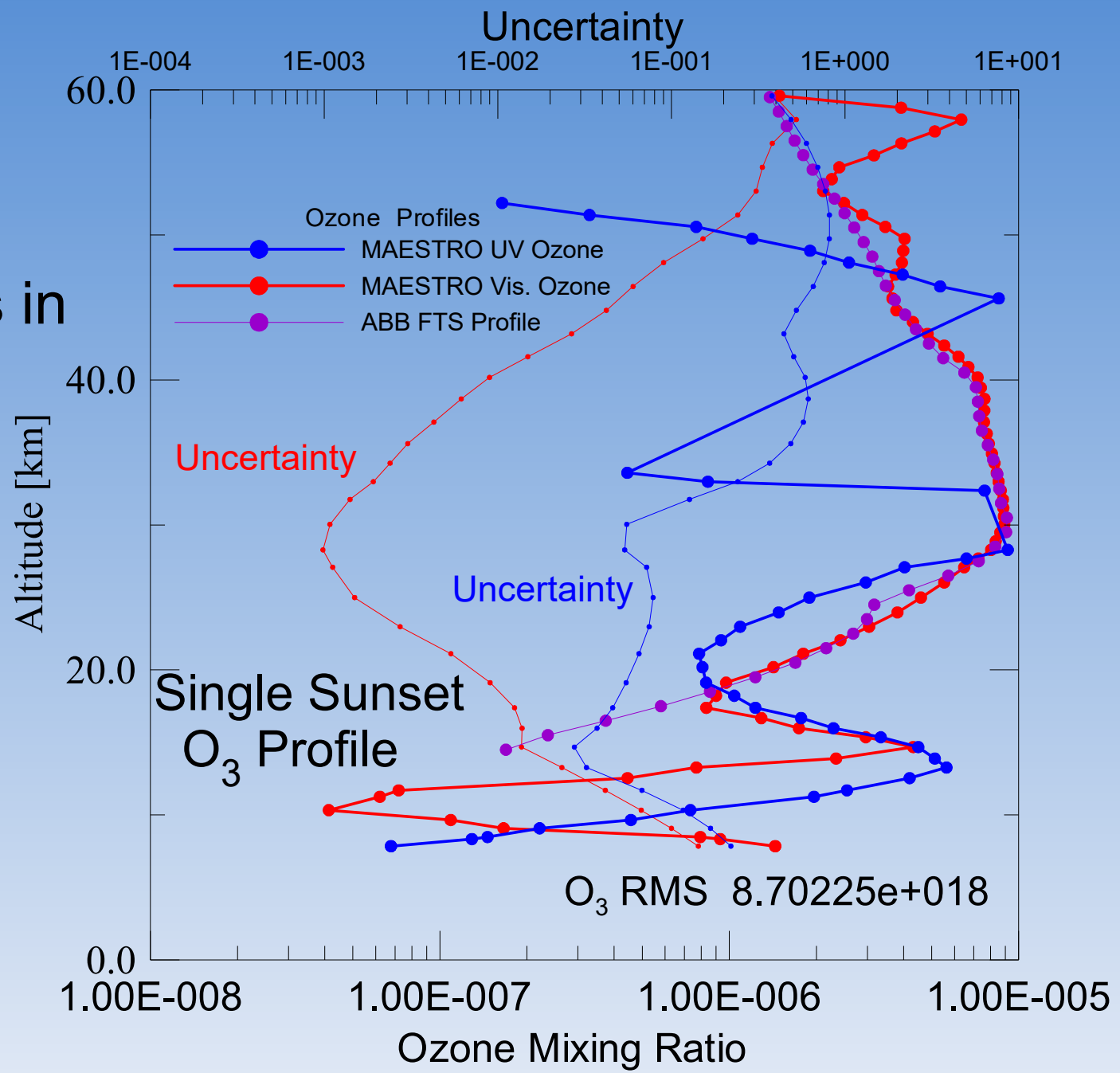


Ozone

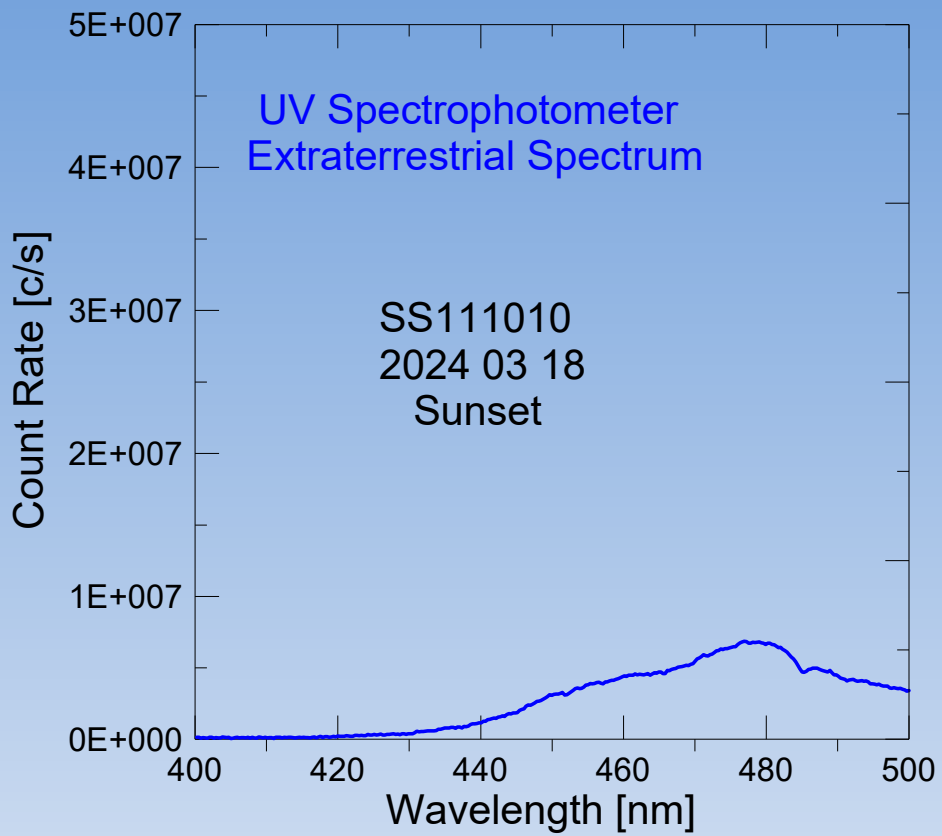
UV Ozone is in real trouble

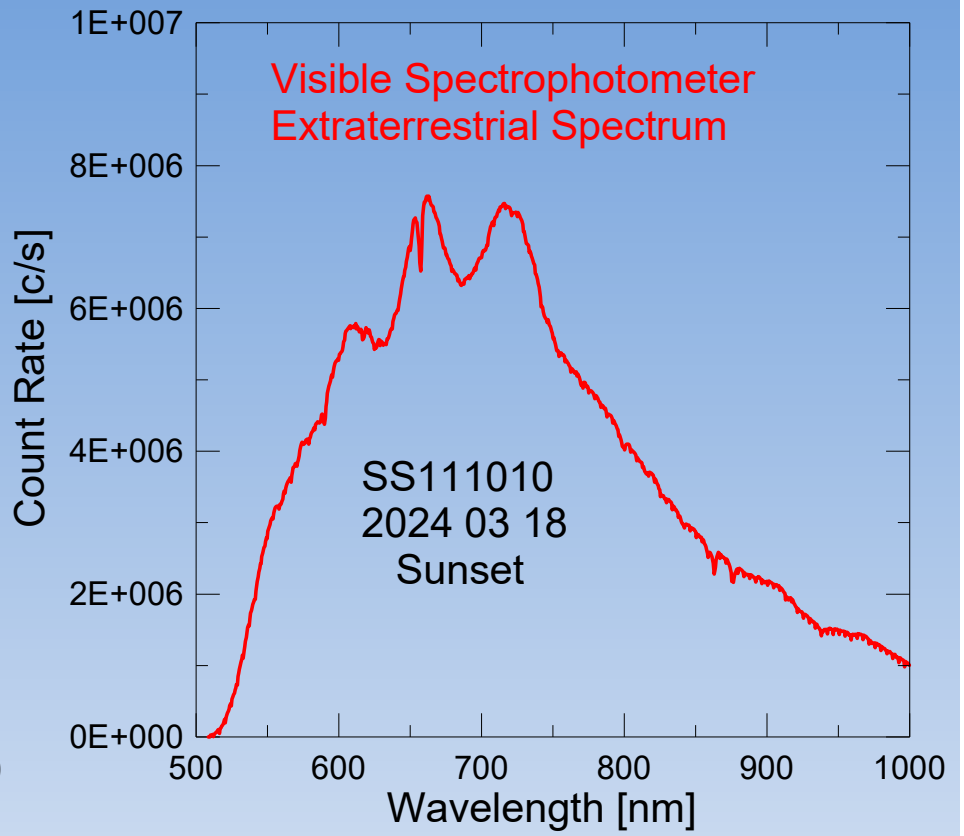
NO_2 is hopeless

SS93692
2021 01 01
Sunset



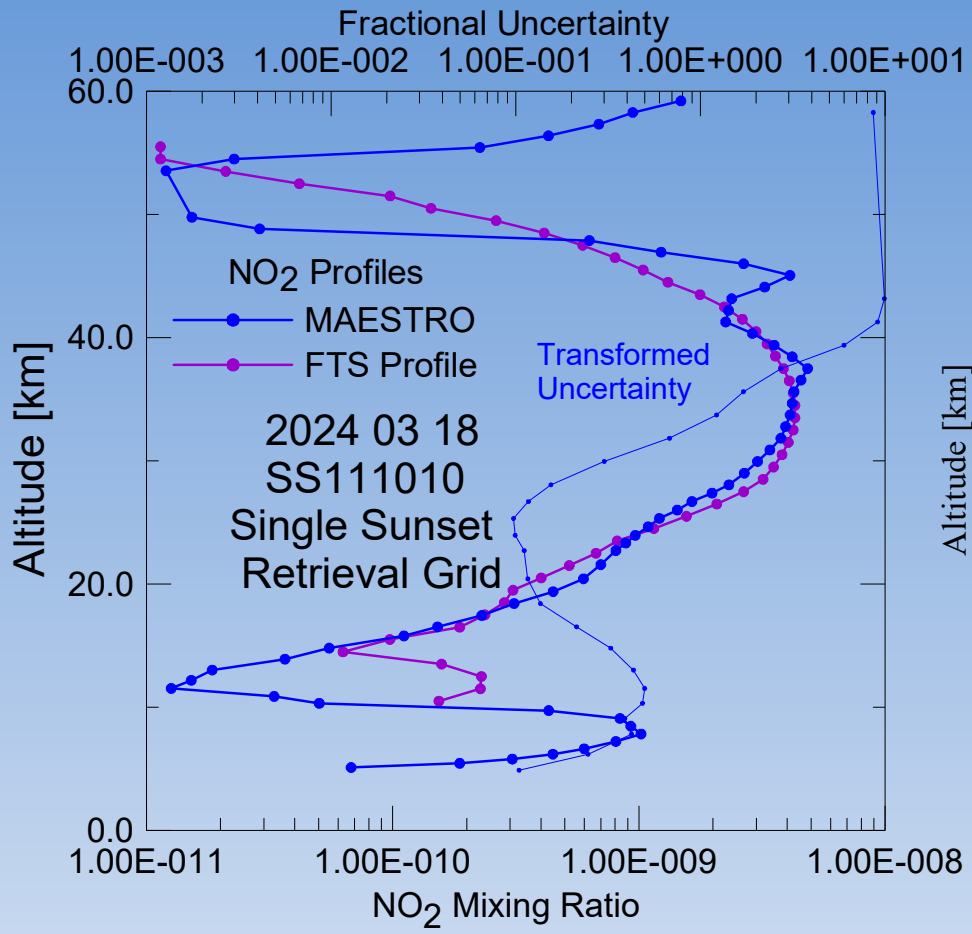
The UV Returns!

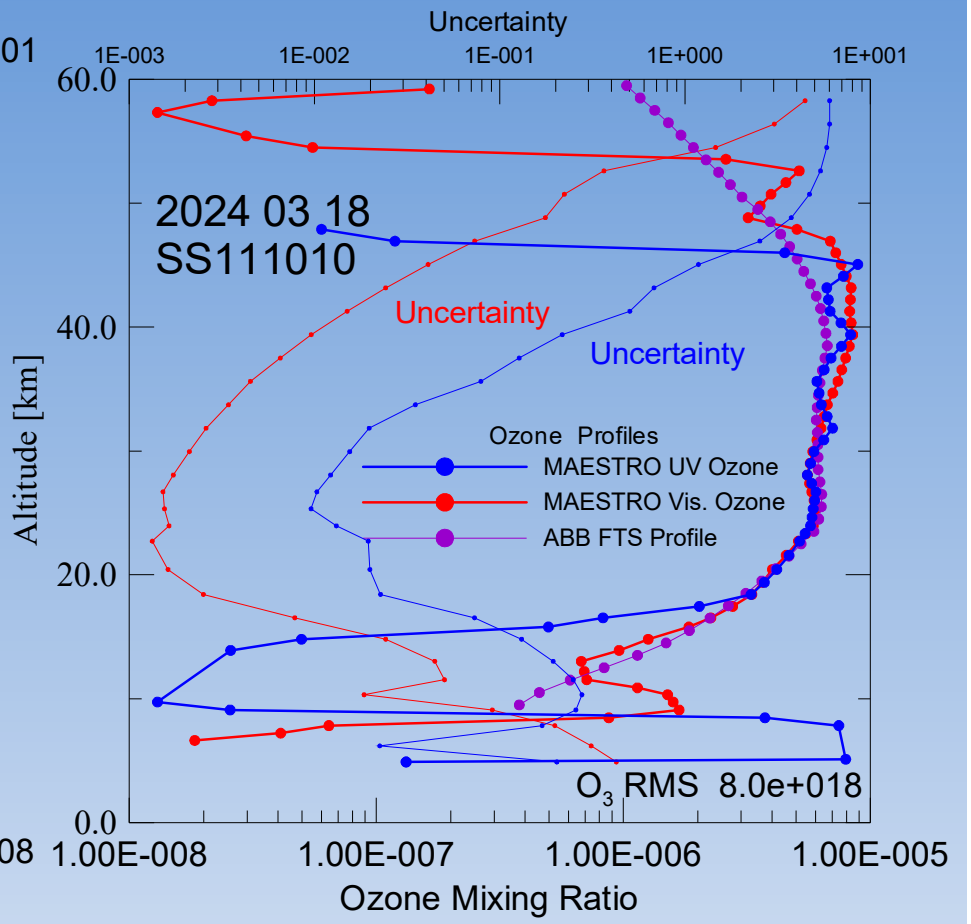




The intensity in the UV is about 1/6 of the original value. But S/N varies as the square root of intensity, the signal-to-noise ratio should be about 0.4 of the original S/N

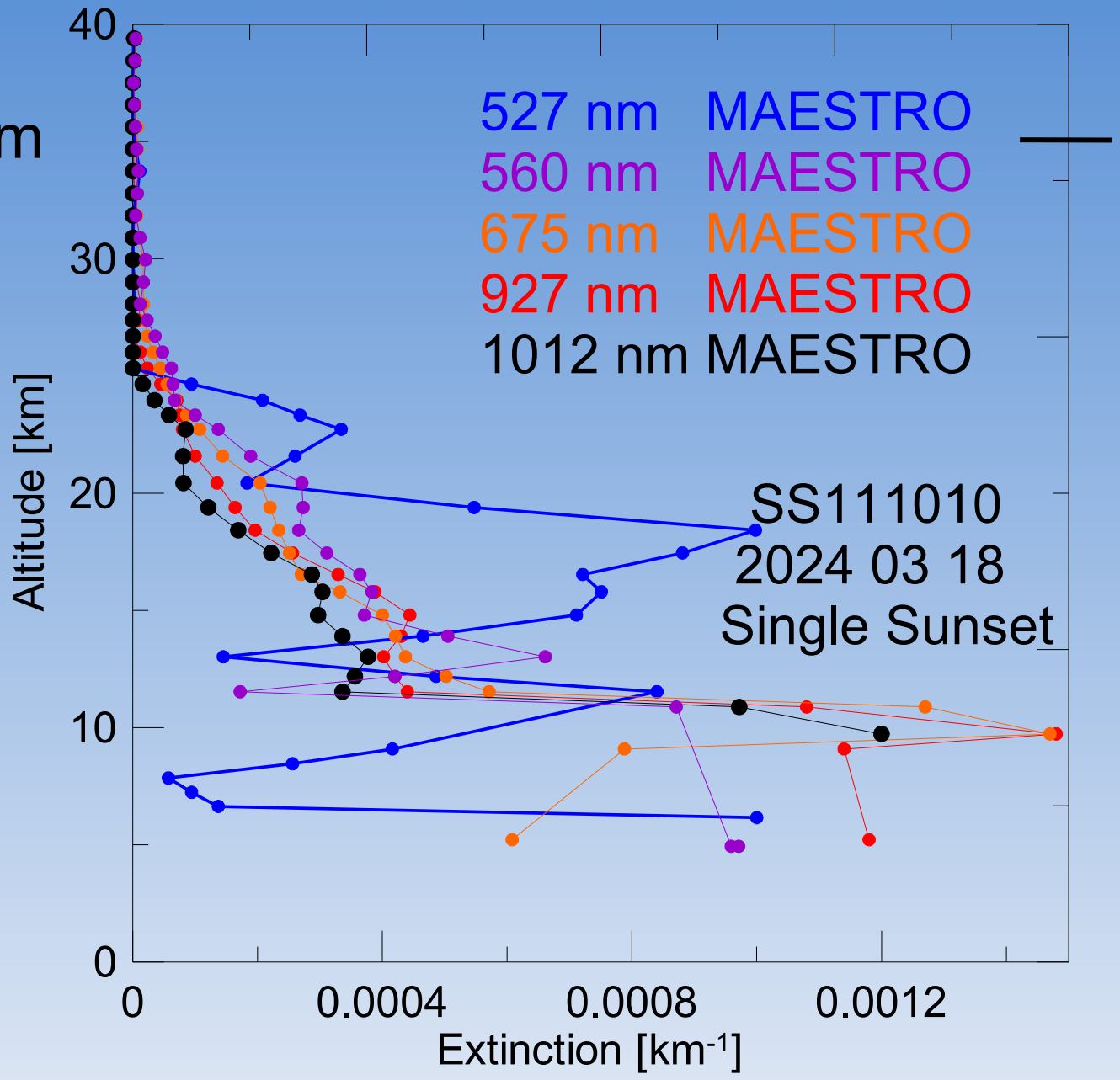
Both UV Products are back! (A bit...)





2024 03 18 Single Sunset Latitude 73.73
SS111010 O3 Profile Beta -0.64

Aerosol too: although 527 nm seems rather large without further analysis...



Recent Progress

- Refraction code used to extend MAESTRO altitudes below FTS measurements
- Above 40 – 50 km S/N falls off
- Curve fitting above ~60 km stabilizes the inversion >50 km
- Paul Jeffery has just completed a detailed comparison analysis of MAESTRO v. 4.5 data with 11 other satellite instruments. In press with AMT. The conclusion:

  MAESTRO ozone and NO_2 data are within a few percent of the consensus of the ensemble between 15 or 20 km and 50 km

Two general conclusions

The agreement between temperature-corrected Chappuis measurements and the FTS data provides important validation of the value of both datasets

The agreement between FTS and MAESTRO compared to the agreement among instruments on different satellites illuminates the limitation of cross-satellite comparisons. Even with close location matching (<100km) there is a limit to the accuracy of such comparisons for measurement validation. Looking at quantifying that conclusion...

Occultation measurements are an essential component of the Earth observation system for their hign vertical resolution and long-term stability.


MAESTRO at the U of T Thermal-Vacuum Facility For Test and Characterization 2003
The End
Thank you for Your Attention
MAESTRO

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CSA
The Canadian Space Agency

ASC
Agence spatiale canadienne

Environment Canada

Environnement Canada

Acknowledgement:
David Barton, York University

References

DOAS
Brewer, A.W., C.T. McElroy, and J.B. Kerr, Nitrogen dioxide concentrations in the atmosphere, Nature, 246, n. 5429, 129-133, 1973.

DOAS occultation
Kerr, J.B., and C.T. McElroy, Measurement of atmospheric nitrogen dioxide from the AES stratospheric balloon program, Atmosphere, 14, 166-177, 1976.

MAX DOAS
McElroy, C.T., Stratospheric nitrogen dioxide concentrations as determined from limb brightness measurements made on June 17, 1983,
J. Geophys. Res., 93, 7075-7083, 1988.

Brewer prototype displayed at Boulder QOS, 1980.

Brewer first three commercial units delivered, 1982.

First double monochromator Brewer, 1992.

Launch of UV Index forecast, 1992.

Launch of SCISAT, 2003.