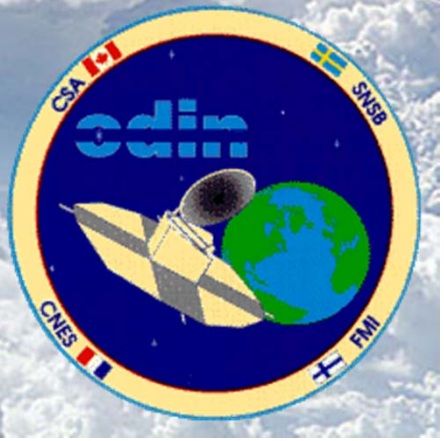
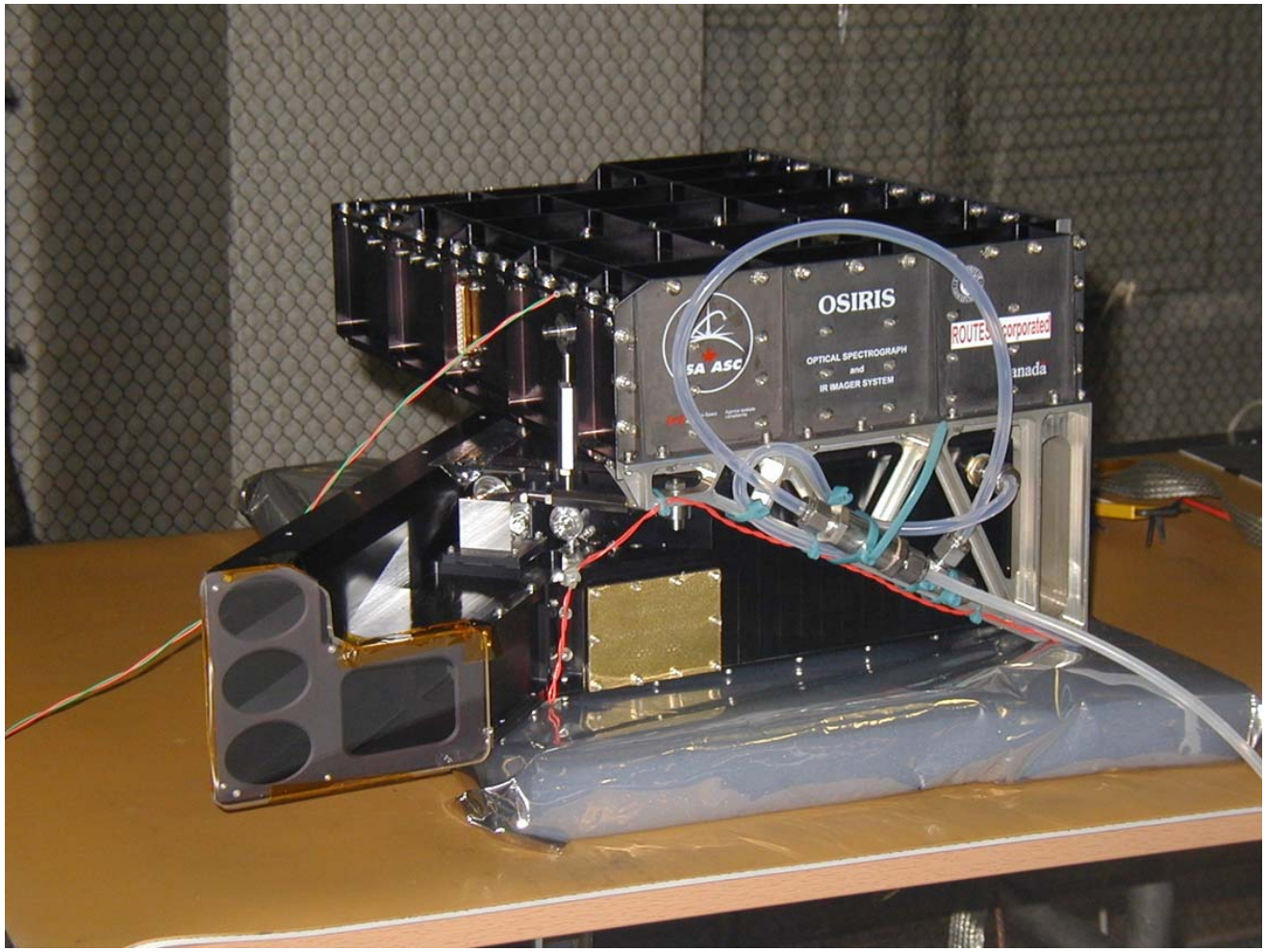
Odin-OSIRIS: A Summary of the Past Twelve Years

Limb Workshop
June 17, 2013

Bremen, Germany



OSIRIS



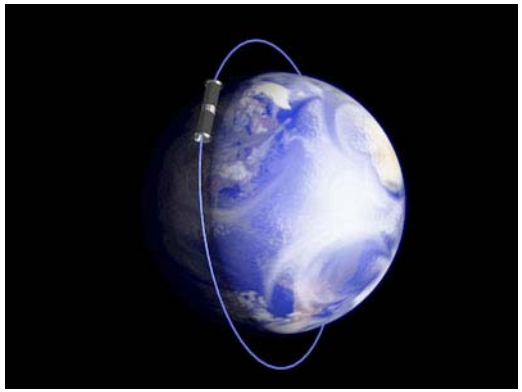
- Designed and built by ROUTES Inc. in Ottawa
- Original PI was Ted Llewellyn from the University of Saskatchewan
- Started in 1993 and was ready in 1999
- Integrated onto the Odin spacecraft in 2000

Odin

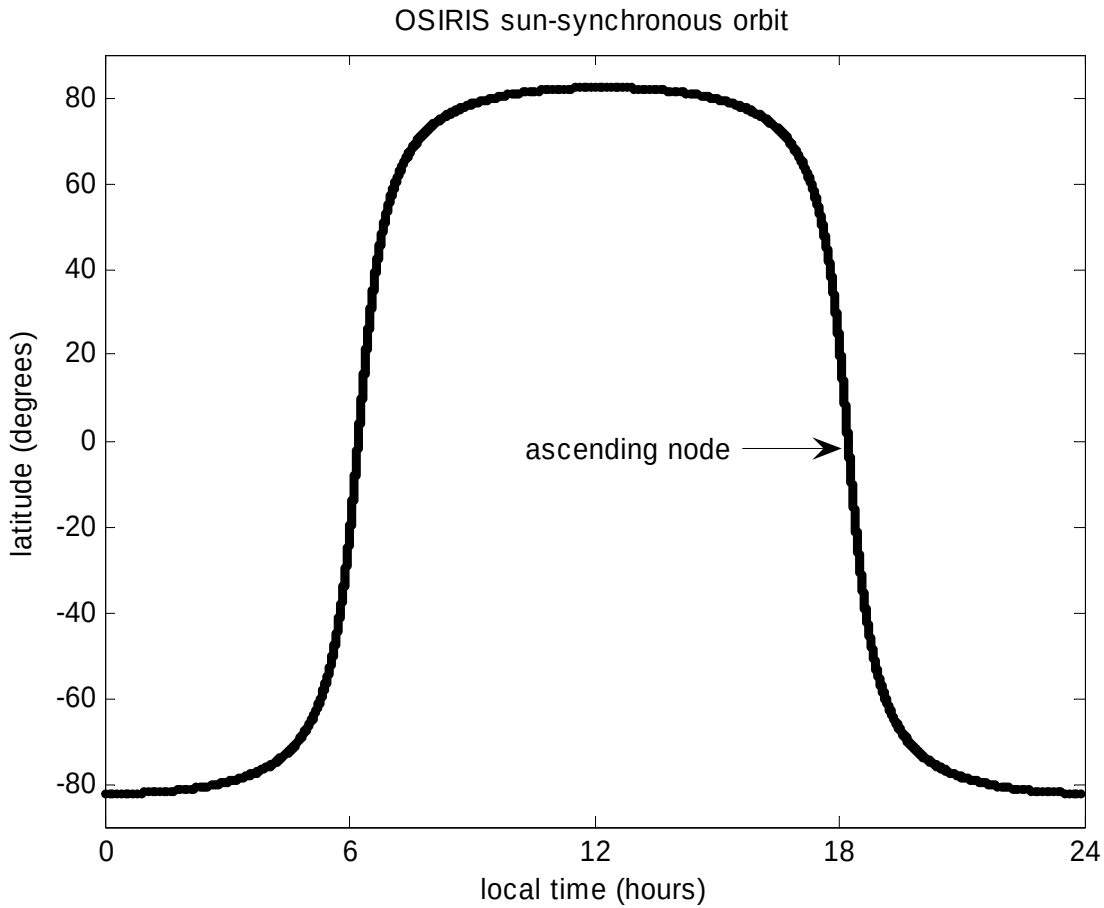
- Designed and built by SSC in Sweden
- Project is an international venture that also includes Finland and France
- Includes a submillimeter radiometer that was also designed for astronomy
- Launched in 2001 out of Russia

Odin Launch – February, 2001

The Odin Orbit

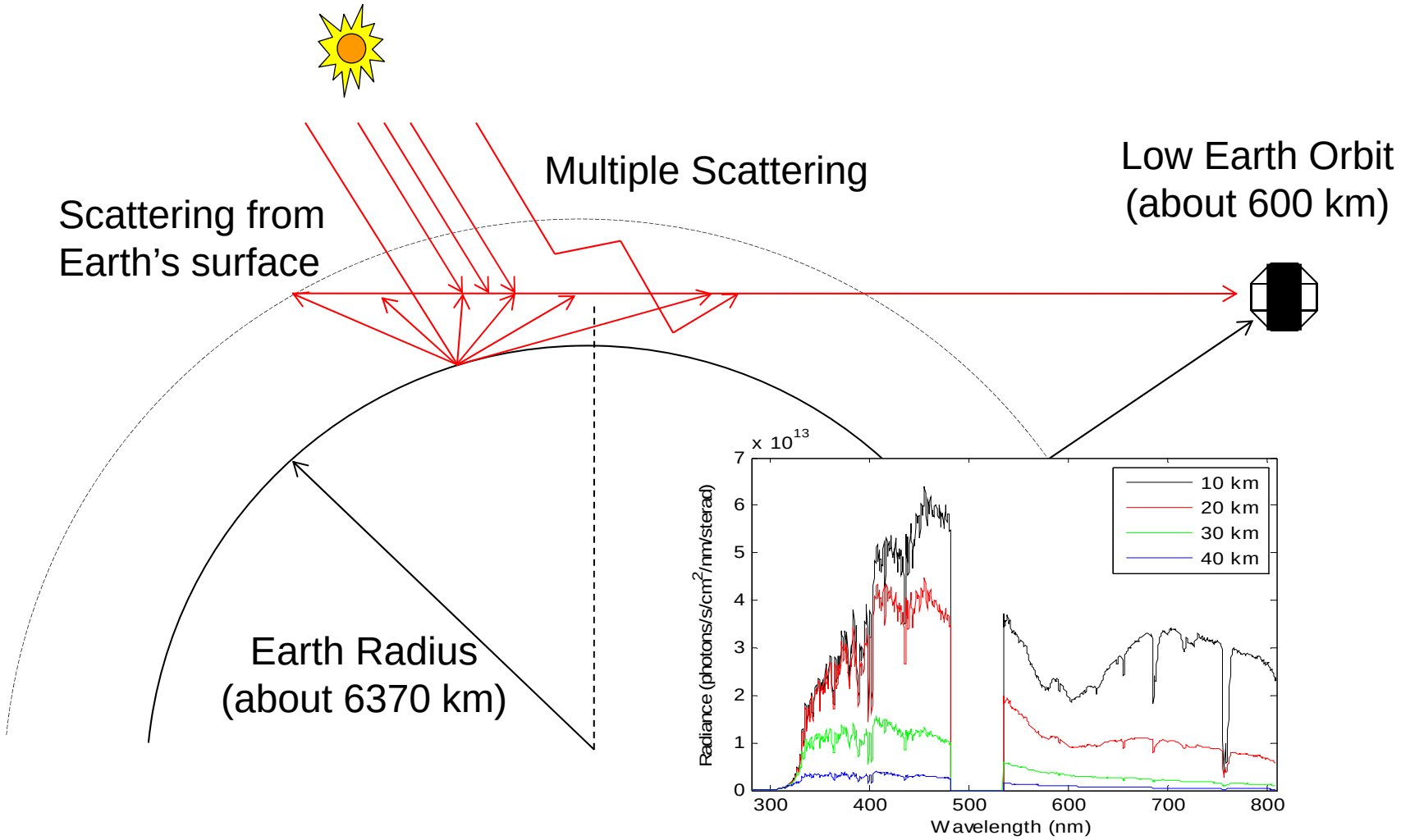


- sun-synchronous
- near-terminator
- 98 degree inclination
- 1800h ascending node
- 0600h descending node
- 96 minute period
- 600 km altitude

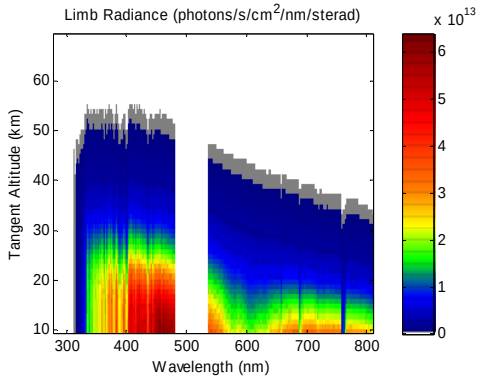


Limb Scattering

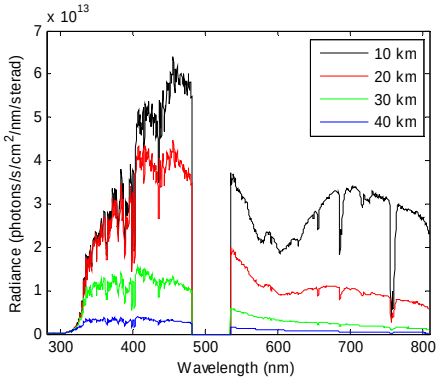
A measurement of the intensity of sunlight scattered from the atmosphere



Optical Spectrograph and Infra-Red Imager System (OSIRIS)



1) Optical Spectrograph
   - Single line of sight along satellite track
     - Narrow horizontal slit (1 arc minute)
   - Grating spectrograh
     - 280-810 nm, 1 nm resolution
   - Measures spectrum of scattered sunlight
     - Tangent altitudes 0 to 100 km
     - Odin moves to point OSIRIS
2) Infrared Imager
   - Three channel filtered vertical imager
   - 1.26 and 1.27 micron Singlet Delta O_2
   - 1.53 micron OH Meinel



O_3

Dust

Forest Fires

NO

NO_2

BrO

Noctilucent Clouds

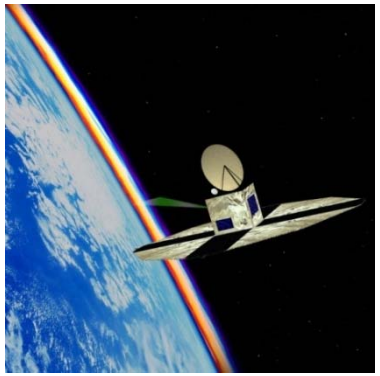
Sodium

Sulphate Aerosol

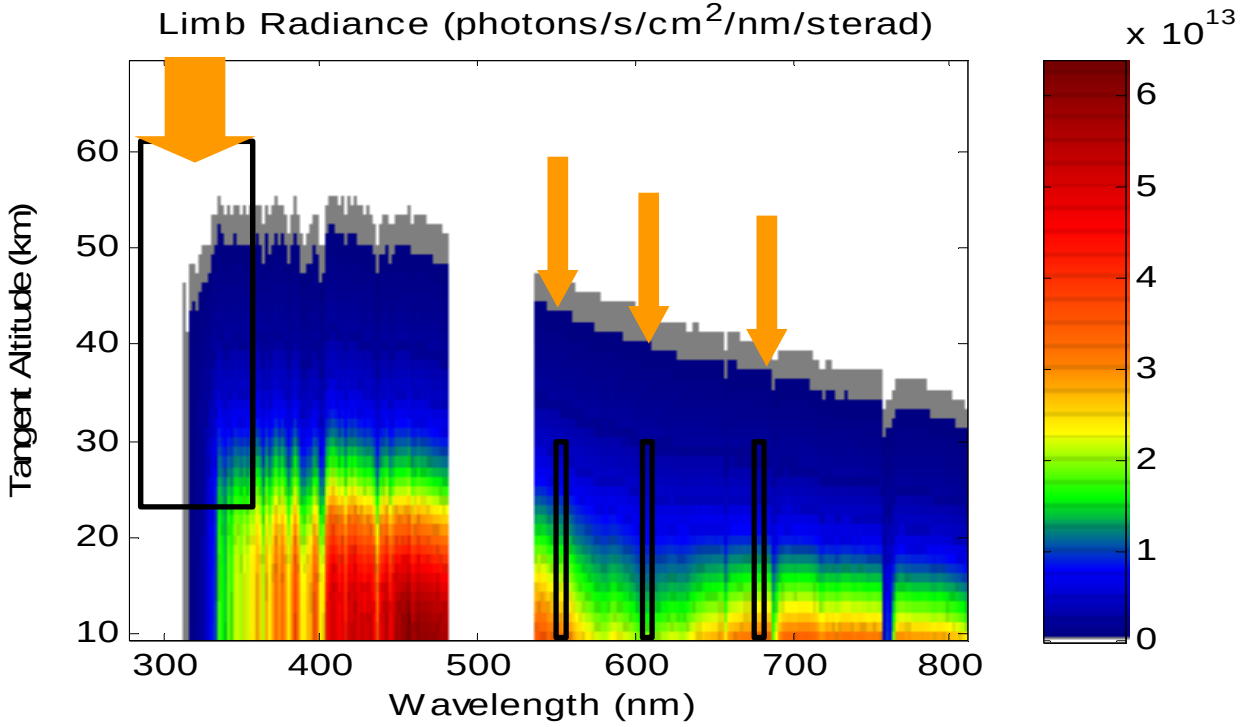
The Aurora

OH

Subvisual Cirrus



Ozone


Limb Radiance (photons/s/cm^2/nm/sterad)
x 10^{13}
Tangent Altitude (km)
60
50
40
30
20
10
300
400
500
600
700
800
Wavelength (nm)
6
5
4
3
2
1
0

OSIRIS ozone is used in four international data initiatives

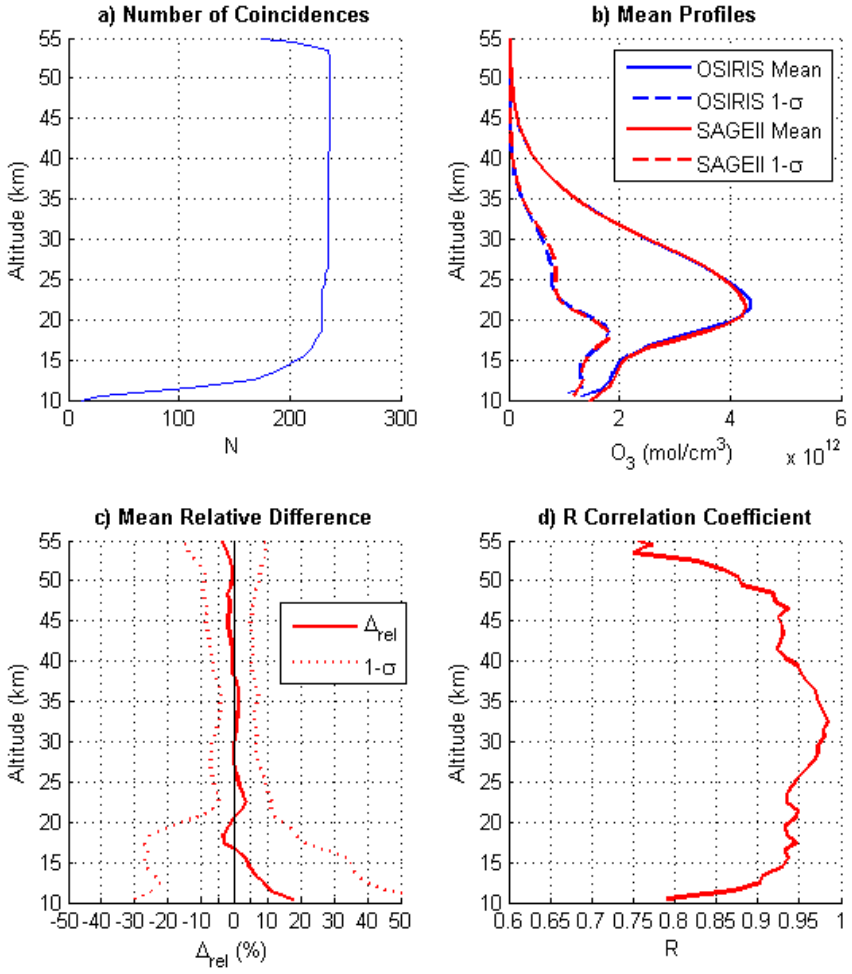
- SPIN
- SPARC Data Initiative
- SI^{2}N
- ozone_cci

Strengths of the OSIRIS ozone data product

- Overall accuracy at all altitudes
- Accuracy in the UTLS
- Stability over time

The Data Quality

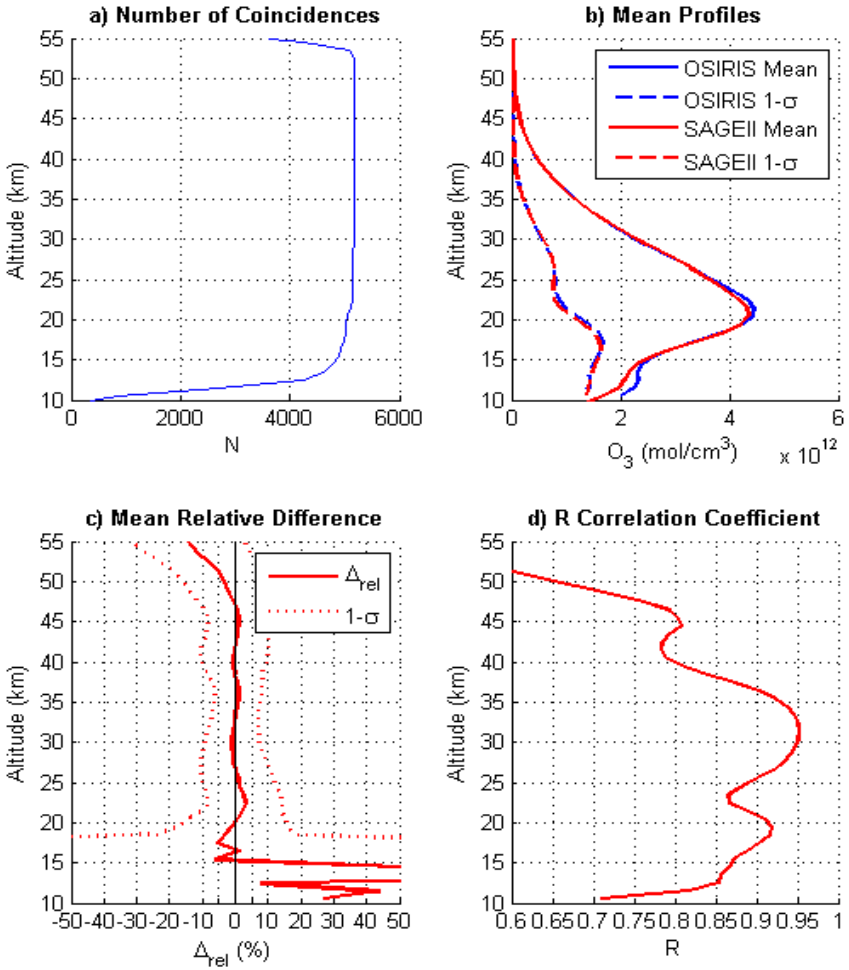
Ozone: OSIRIS - SAGE II Version 7.0 Comparison



Over 200 coincidences with very strict requirements (+/- 1 hour, +/- 1 degree latitude and +/-500 km).

- Retrieved profiles are very well correlated.
- Small positive bias at 22.5 km.
- Below 17 km the level of agreement decreases.

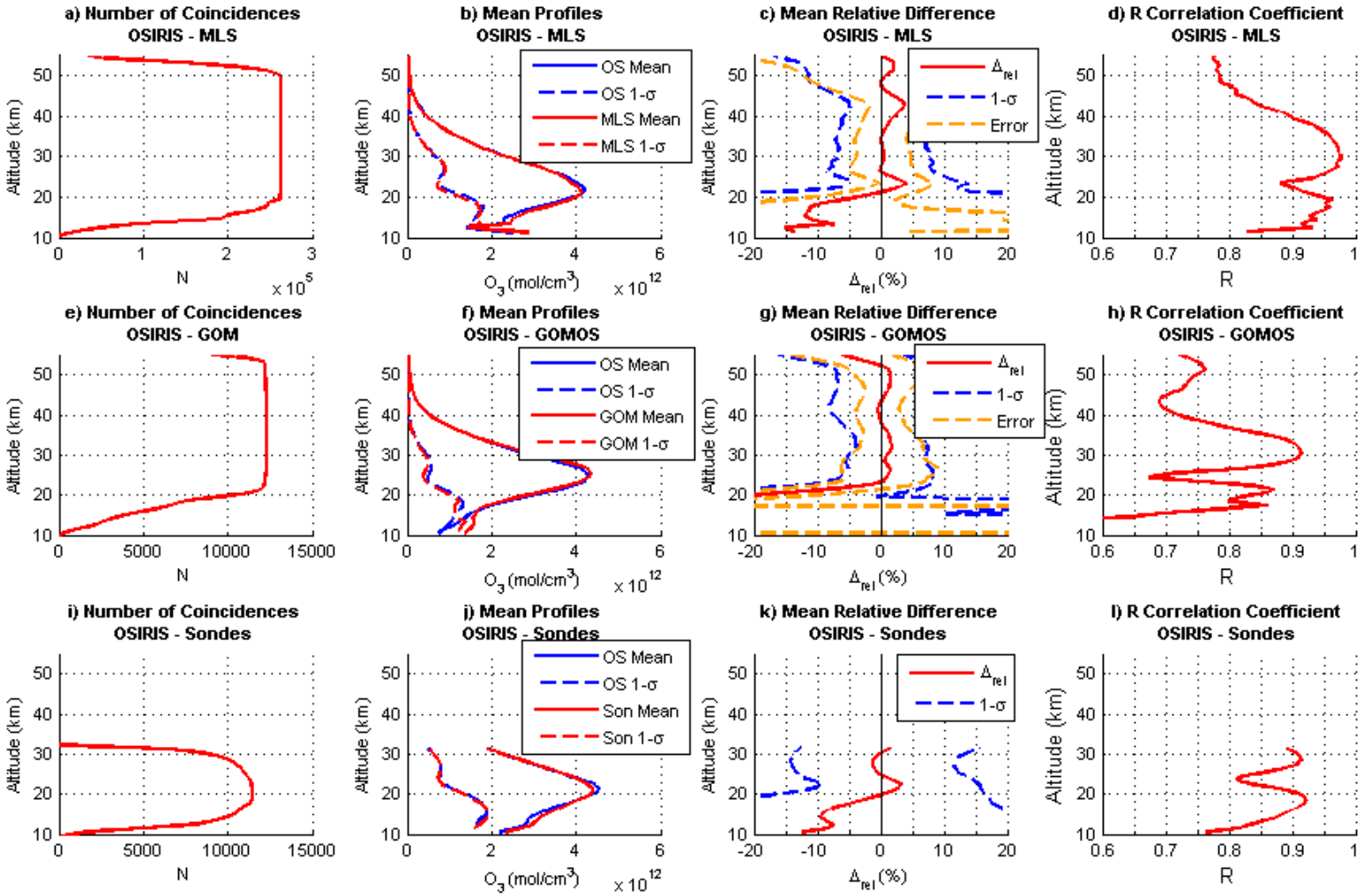
Ozone: OSIRIS - SAGE II Version 7.0 Beta Comparison



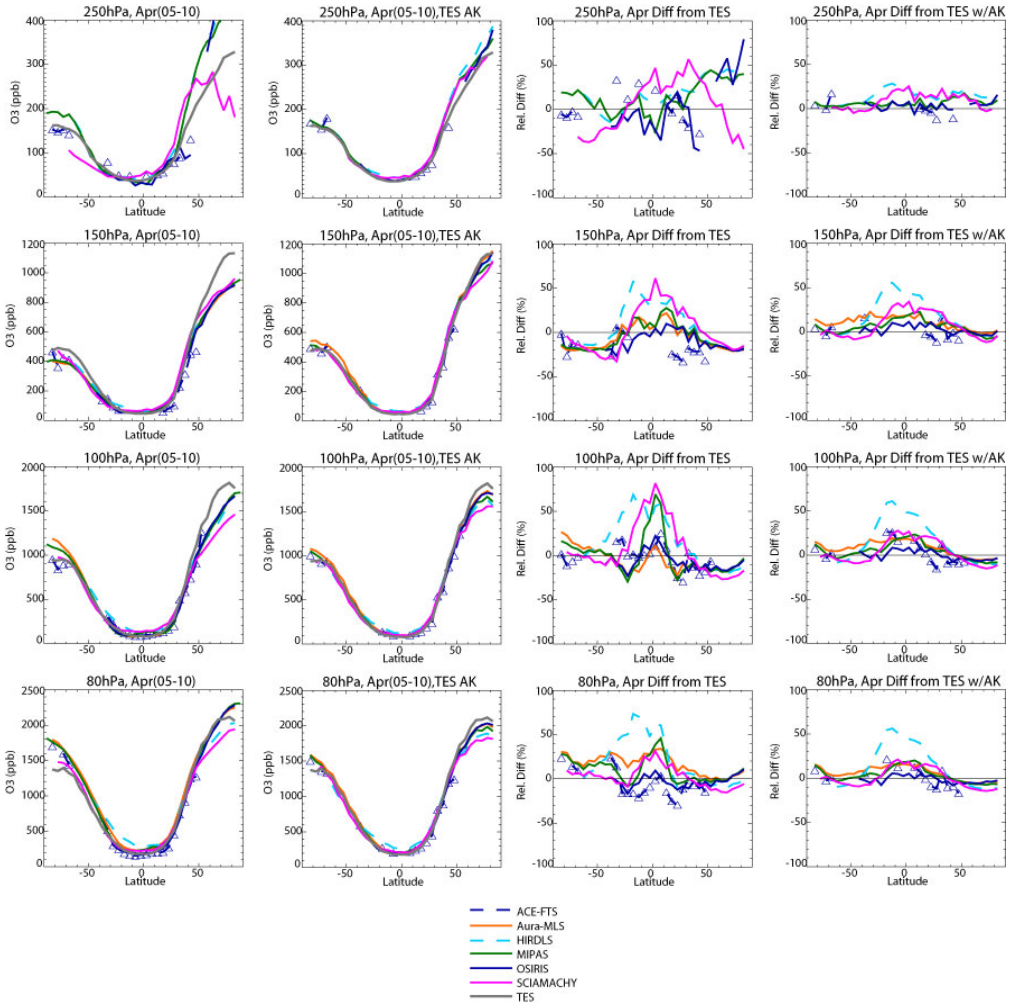
Almost 5000 “coincident” profiles compared with less that 3% bias between 20 and 45 km. The coincident criteria is +/- 24 hours, +/- 1 degree latitude and +/- 1000 km.

- Retrieved profiles are not as well correlated.
- Small positive bias still exists at 22.5 km.
- Below 15 km the level of agreement decreases.

Ozone: OSIRIS – MLS – GOMOS - Sonde Comparisons

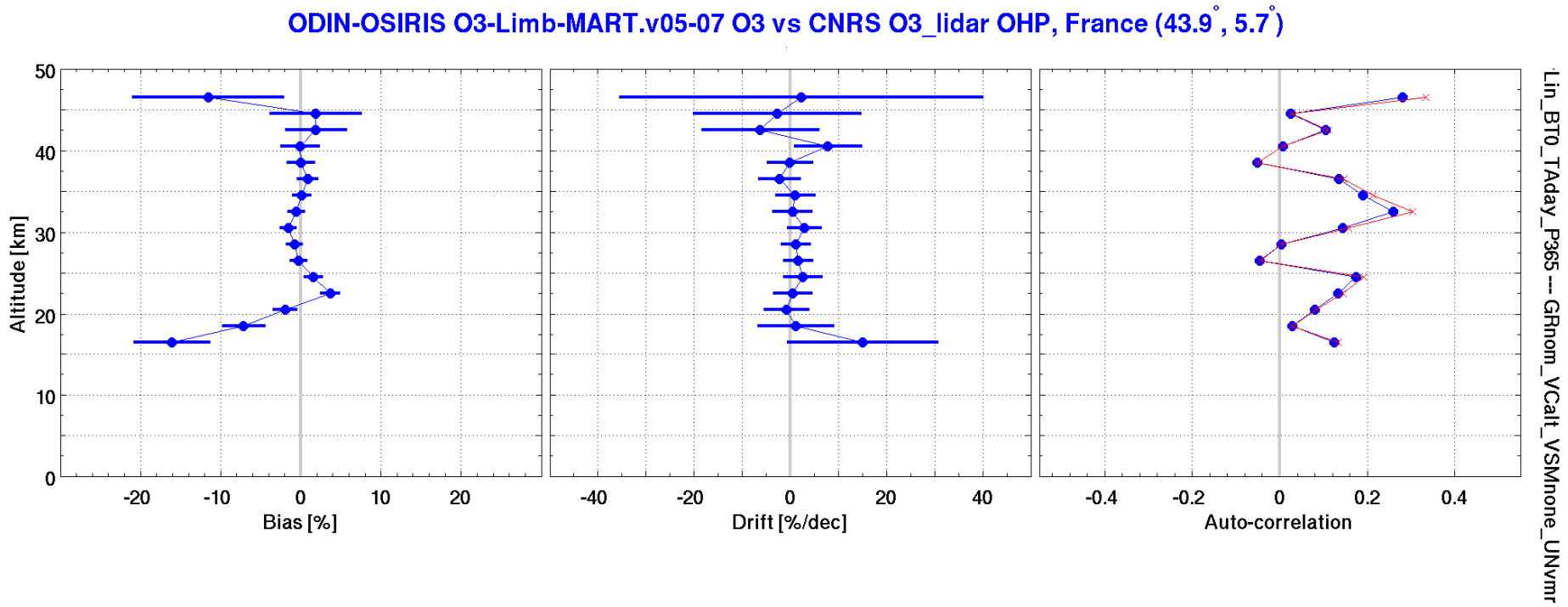


SPARC DI UTLS Ozone Aanlysis



- Study by Jessica Neu with the SPARC DI climatologies
- This figure is preliminary as the paper is just about to be submitted
- Meridional profiles of monthly mean zonal mean ozone for 2005-2010
- OSIRIS ozone compared very well in the UTLS with TES measurements

The Stability of the OSIRIS Ozone



- Work by Daan Hubert and presented at many meetings shows no significant drift in OSIRIS ozone data when compared with lidars and sondes.

- These lidar results are from one station but are consistent with entire analysis

Papers in Progress, Submitted or Recently Accepted

ACP
- Kyrola et al., SAGE-OSIRIS Trends
- Eckert et al., MIPAS trends
- Gebhardt et al., SCIAMACHY trends
- Sioris et al., tropical lower stratospheric trends using SAGE II and OSIRIS

AMT
- Adams et al., GOMOS-MLS-OSIRIS and sonde comparisons
- Adam et al., OSORIS – SAGE II characterization
- Kasai et al., SMILES ozone retrievals

ESS
- Sofieva et al., harmonized ozone_cci data

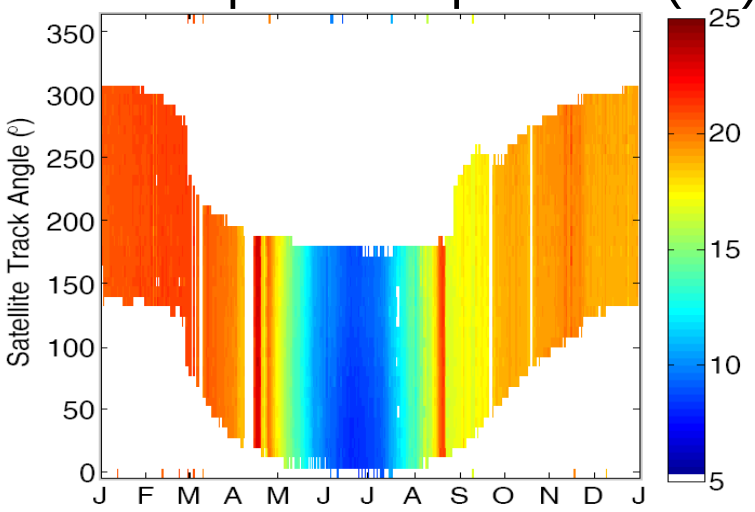
GRL
- Cooper et al., convective ozone depletion

JGR
- Whaley et al., mid-latitude polar vortex intrusions
- Tegtmeier et al., SPARC DI ozone climatologies
- Neu et al., SPARC DI UTLS ozone analysis

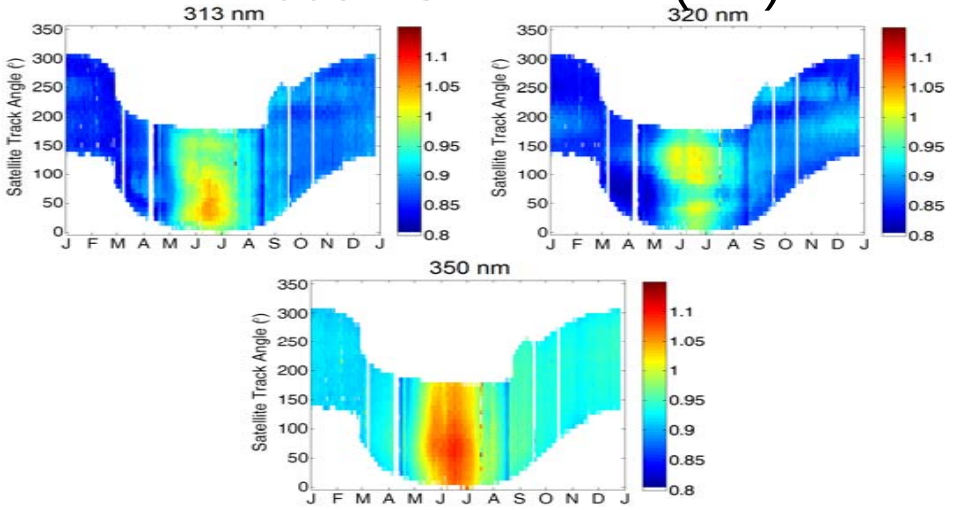
Improvements to the Data Quality

The OSIRIS Spectral Point Spread Function

2008 Optics Temperature (°C)



2008 PSF FWHM (nm)

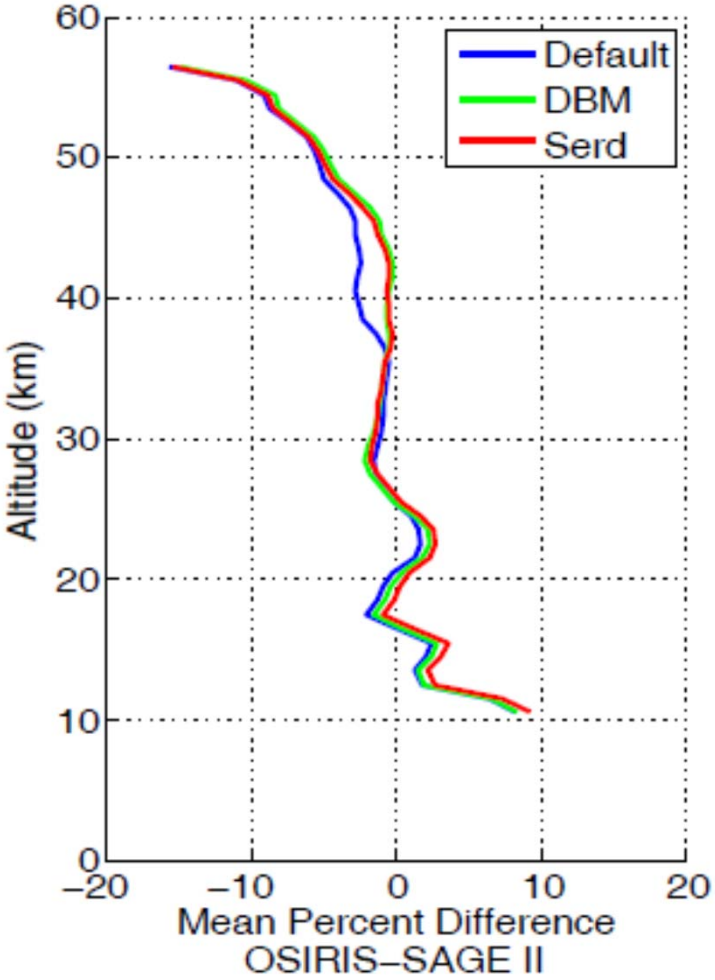


- We found a definite correlation between the OSIRIS optics temperature and the spectral point spread function
- This issue has been diagnosed and is now accounted for

- Comparisons for a low optics temperature subset of the previously shown SAGE II coincident data set

- Implementing the modelled time-dependent SPSF and the new cross-sections improves the mean percent difference between OSIRIS and SAGE II scans by 1-2% from 35-48 km.

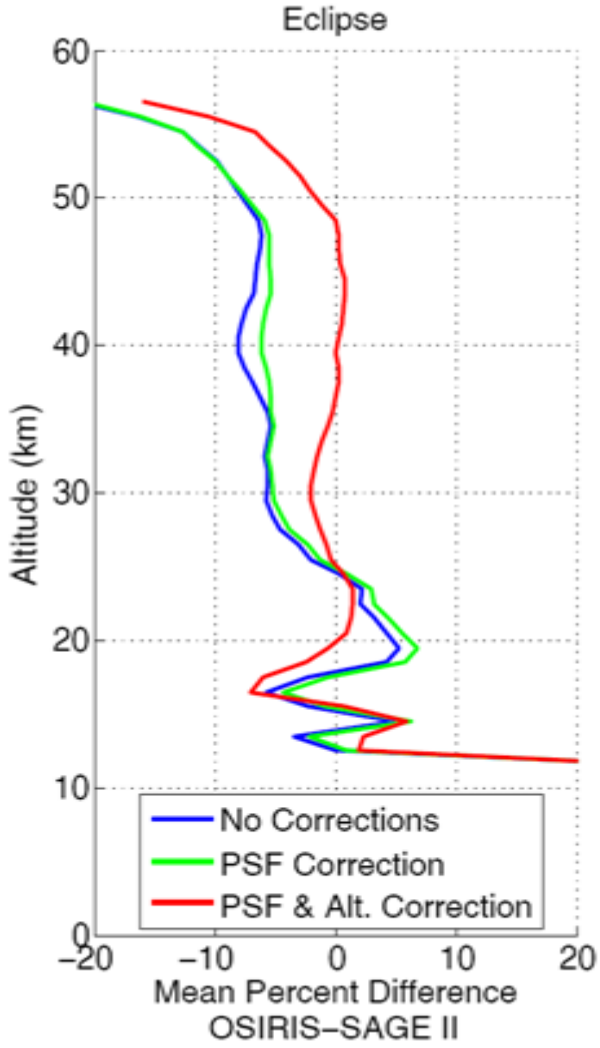
- Both cross-section data sets used within ASCO yield similar results



Altitude Re-registration During Eclipse

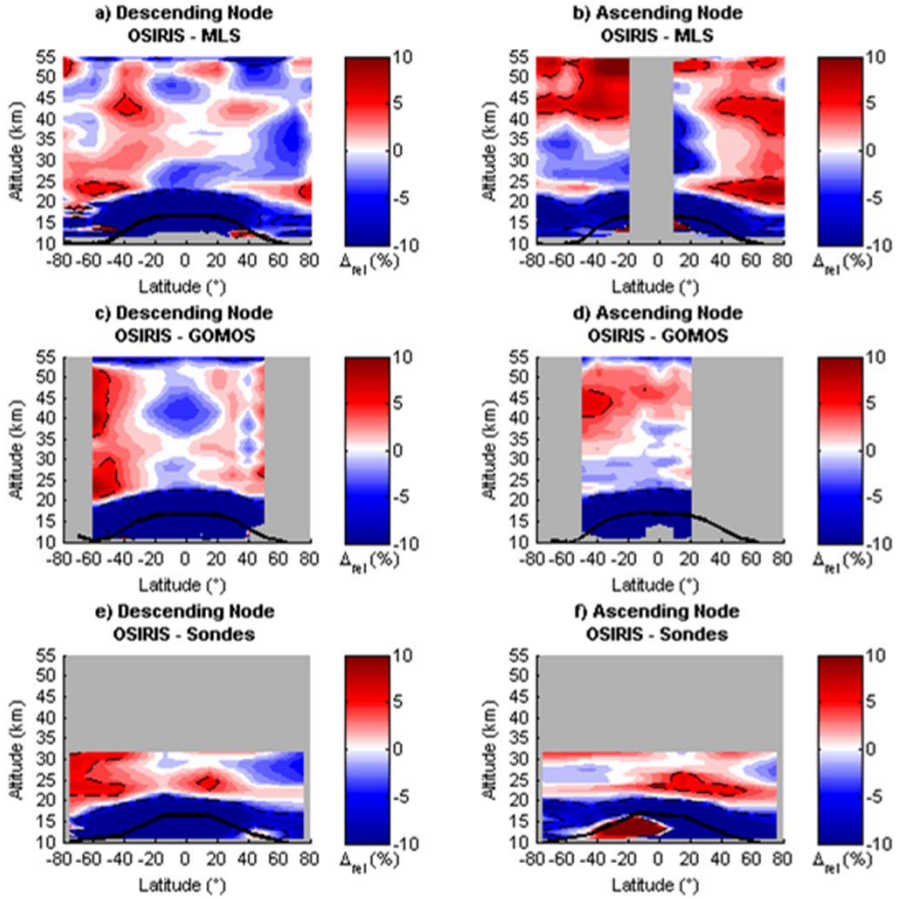
- Accounting for the spectral point spread function and a diagnosable altitude shift appears to vastly improve comparisons between SAGE II and OSIRIS when the spacecraft temperature is low

- These improvements will be implemented in a new version that we will begin processing shortly



OSIRIS Ozone – It's All About the Aerosols

- We have a new aerosol retrieval that Adam will discuss later this week
- We are somewhat confident that this will help out with the 22.5 km bias we see for certain scattering angles.



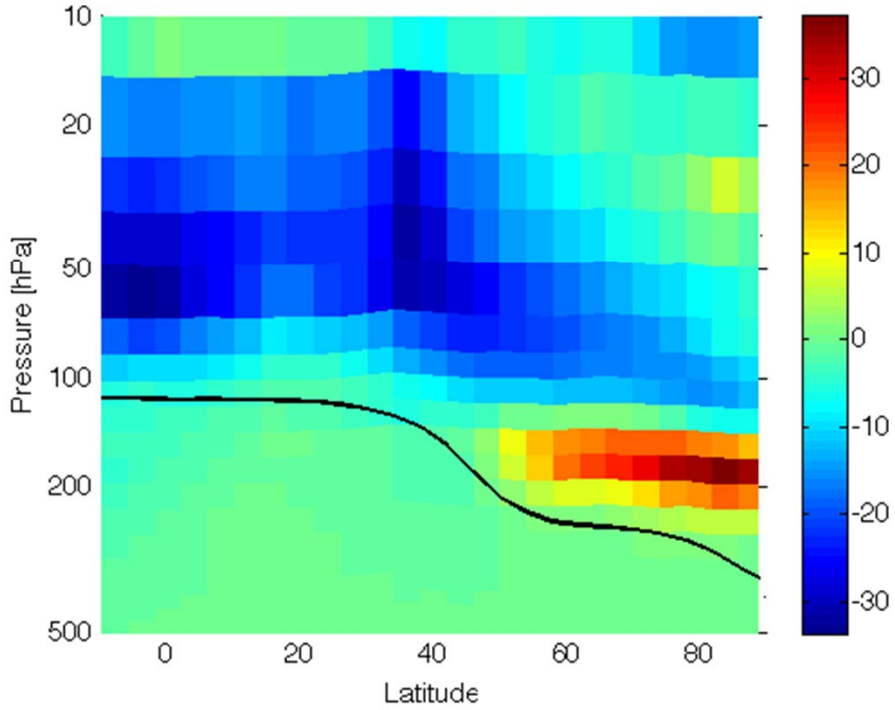
Data Exploitation

Assimilation of OSIRIS O3 into GEOS-Chem

Thomas Walker, Dylan Jones, et al. at the U of T

Zonal Mean Change in Initial Condition

Percent change (posteriori – prior) in zonal mean ozone

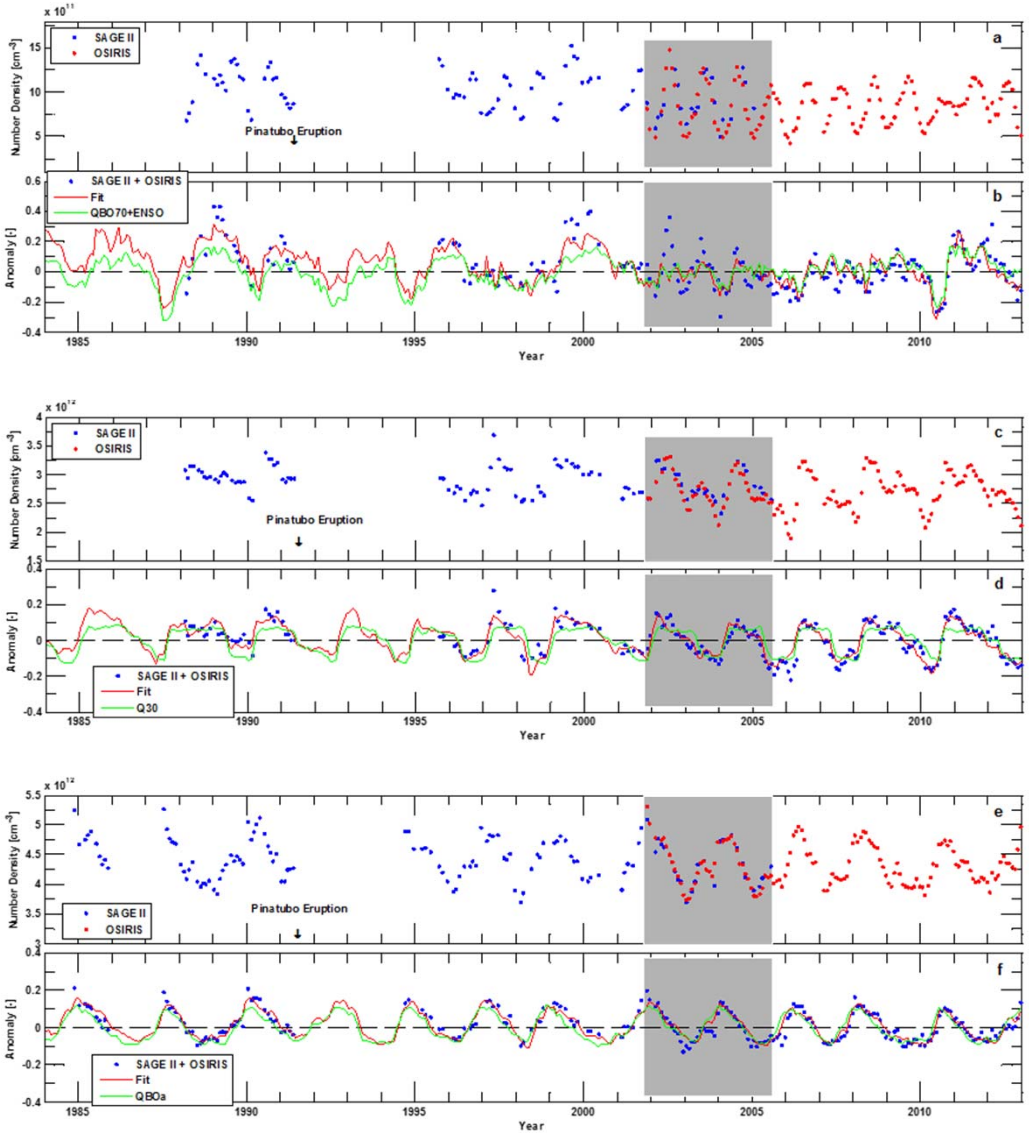


Consistent with the assimilation of TES data in the UTLS, the assimilation of OSIRIS ozone reduced the positive model bias in the lower stratosphere, relative to independent ozonesonde data, in the low and middle latitudes.

The assimilation of OSIRIS ozone reduced the negative model bias in polar ozone in the lowermost stratosphere.

The results also suggest that assimilation of OSIRIS data should provide useful upper boundary constraints for inverse modeling of tropospheric ozone data to better quantify lightning NOx emissions

Trend Analysis with OSIRIS and SAGE II

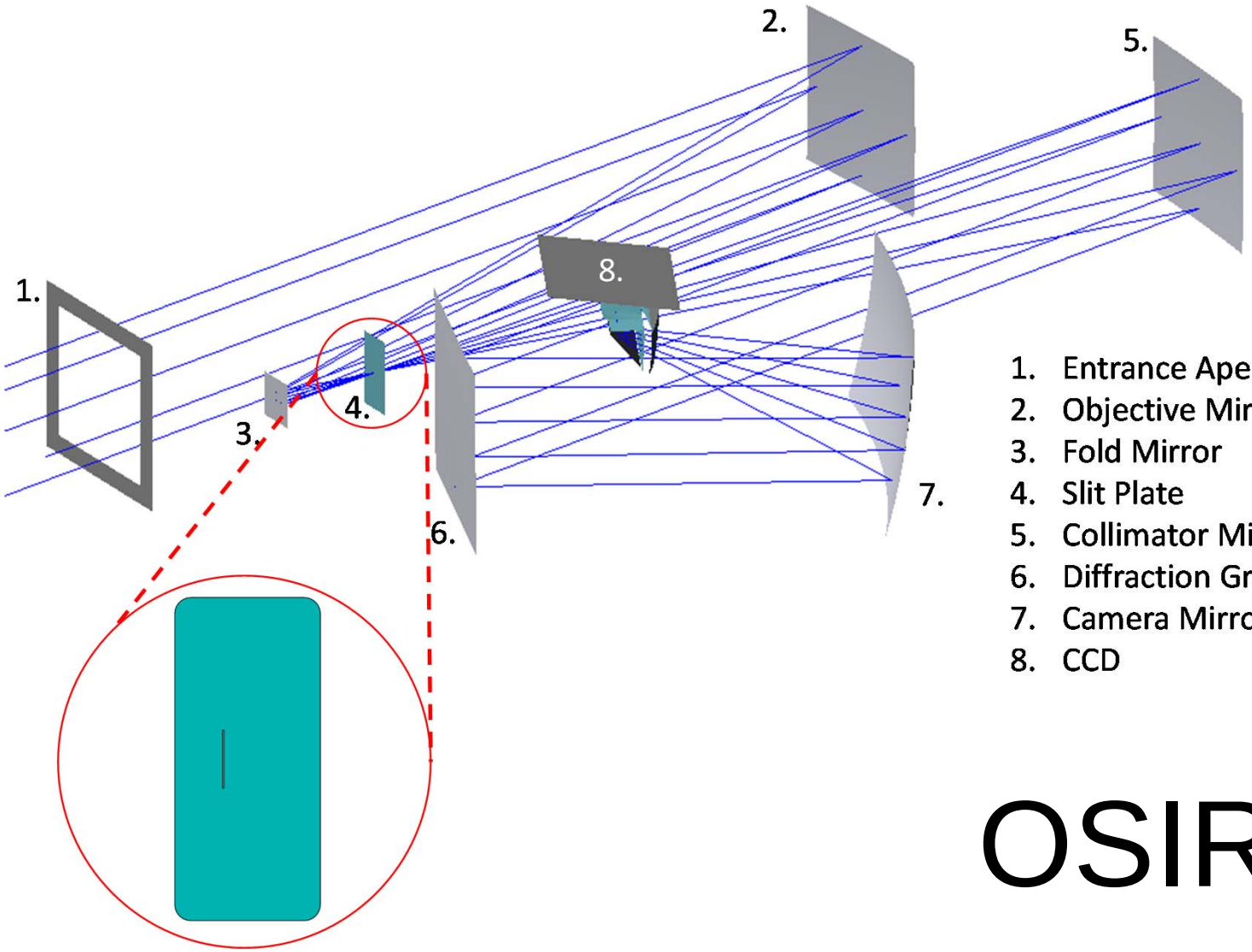


- Time series of the de-seasonalized anomalies at three different altitudes in the tropics
- Very little bias correction is required to merge the SAGE II and OSIRIS records from 1984 to the present
- Analysis of these time series shows a slightly negative trend in the ozone at altitudes lower than 25 km

The Next Generation

CATS

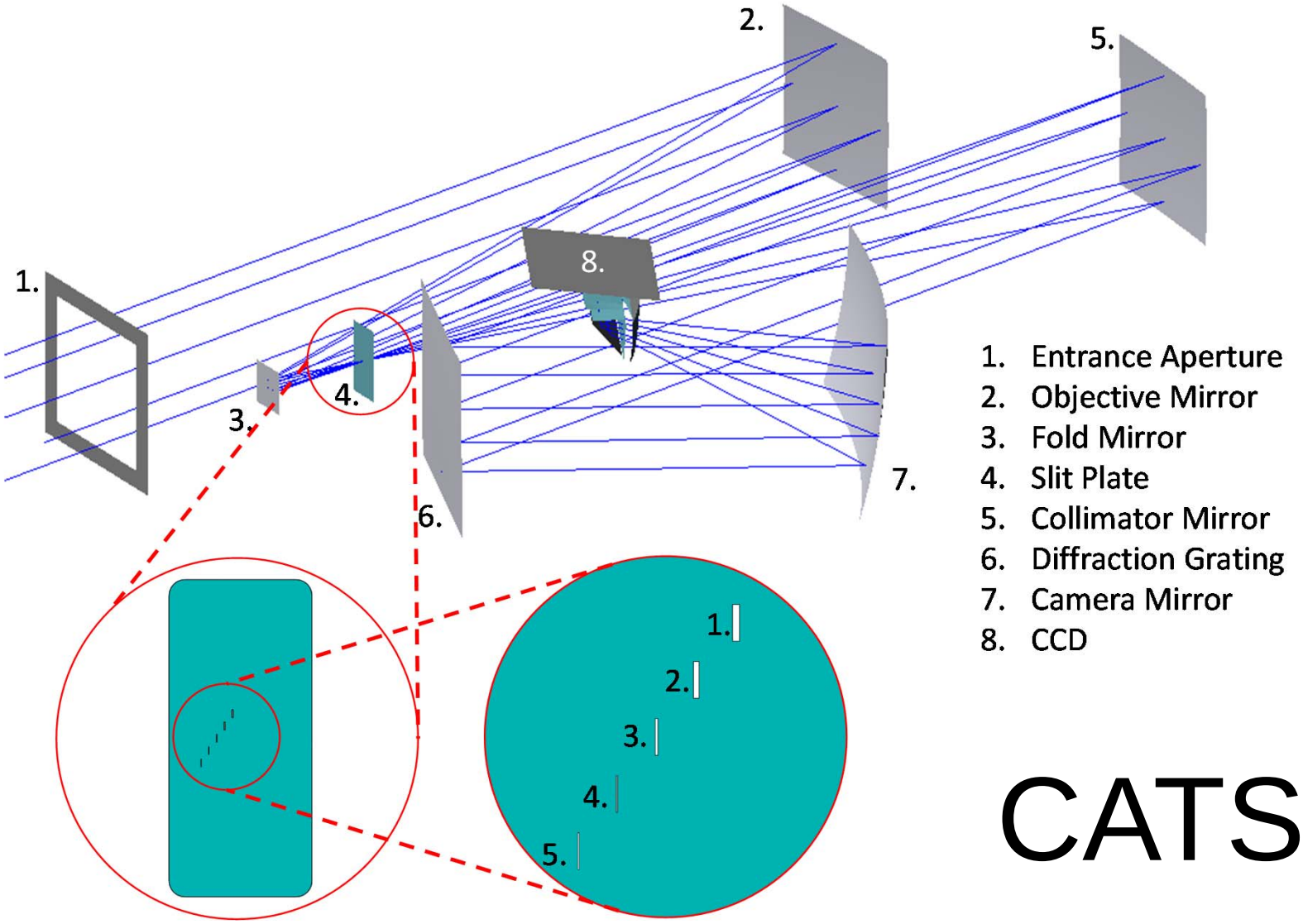
The Canadian Atmospheric Tomography System



1. Entrance Aperture
2. Objective Mirror
3. Fold Mirror
4. Slit Plate
5. Collimator Mirror
6. Diffraction Grating
7. Camera Mirror
8. CCD

OSIRIS

CATS – The Canadian Atmospheric Tomography System



- This instrument is currently under development by the CSA
- COM DEV is wrapping up a technology development study
- A new study RFP for further technology development will be released very soon
- The CSA is very interested in flying this improved version in the near future

- The goal will be to continue the heritage for time series analysis related to climate science and improve the spatial and temporal resolutions to increase the utility of the data for process studies and numerical weather prediction

Summary

- OSIRIS on Odin has collected data for over a decade
- We have learned much about the retrieval of ozone etc. from limb scattered sunlight

We hope for many more years of OSIRIS and CATS results to add to the existing data sets

Thank You!