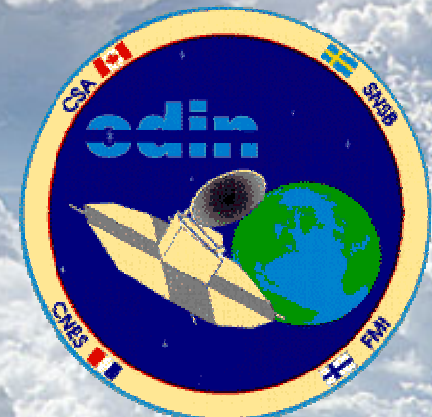
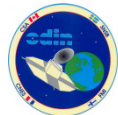
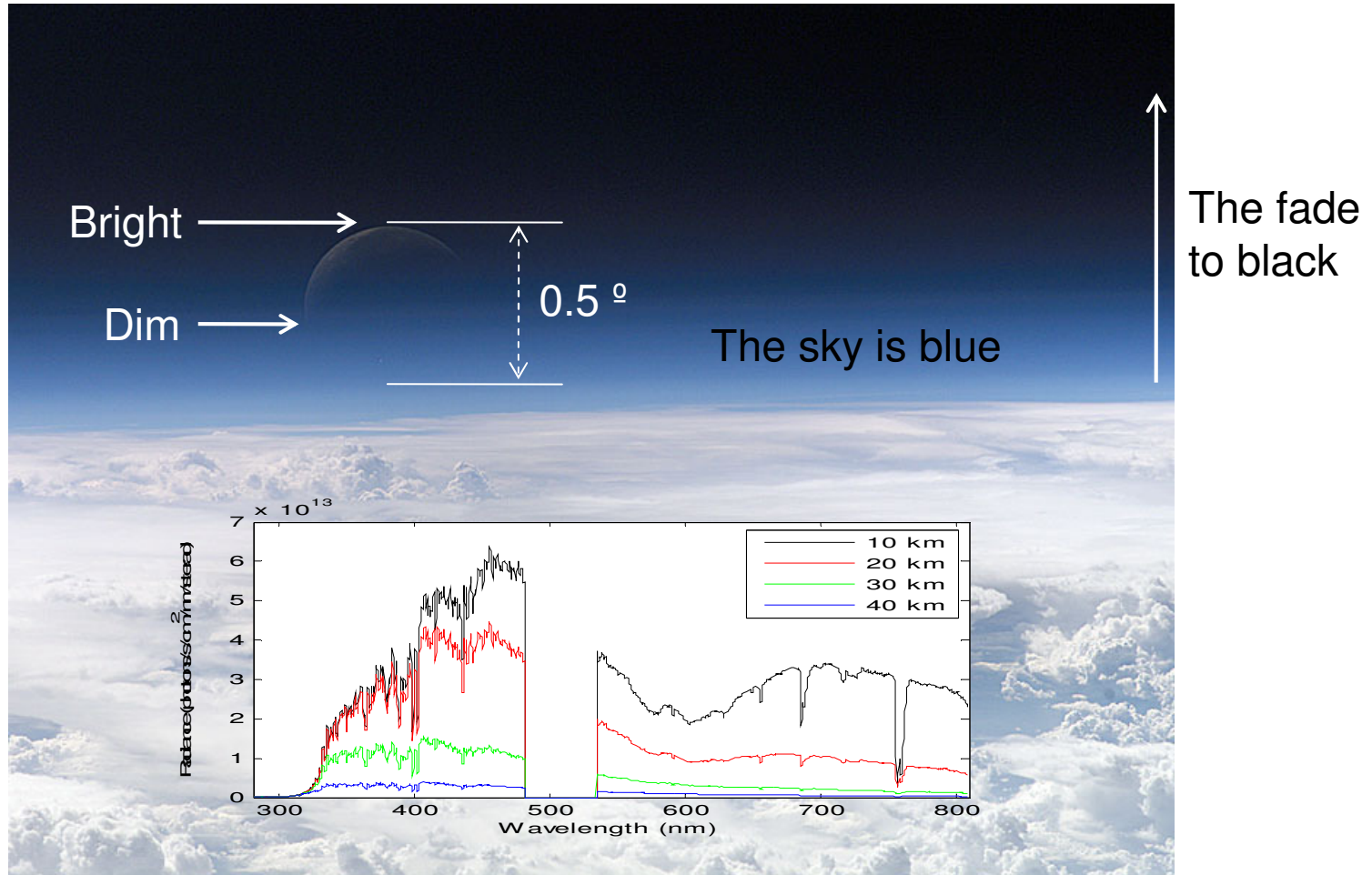


# The Odin/OSIRIS time series from 2001 to now

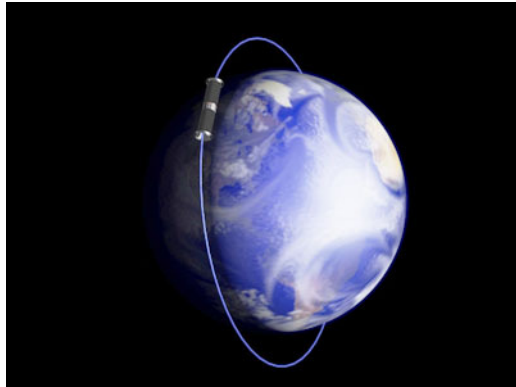
**SPARC/IOC/WMO-IGACO workshop on  
Past Changes in the Vertical Distribution of  
Ozone  
Geneva, January 25-27 2011**



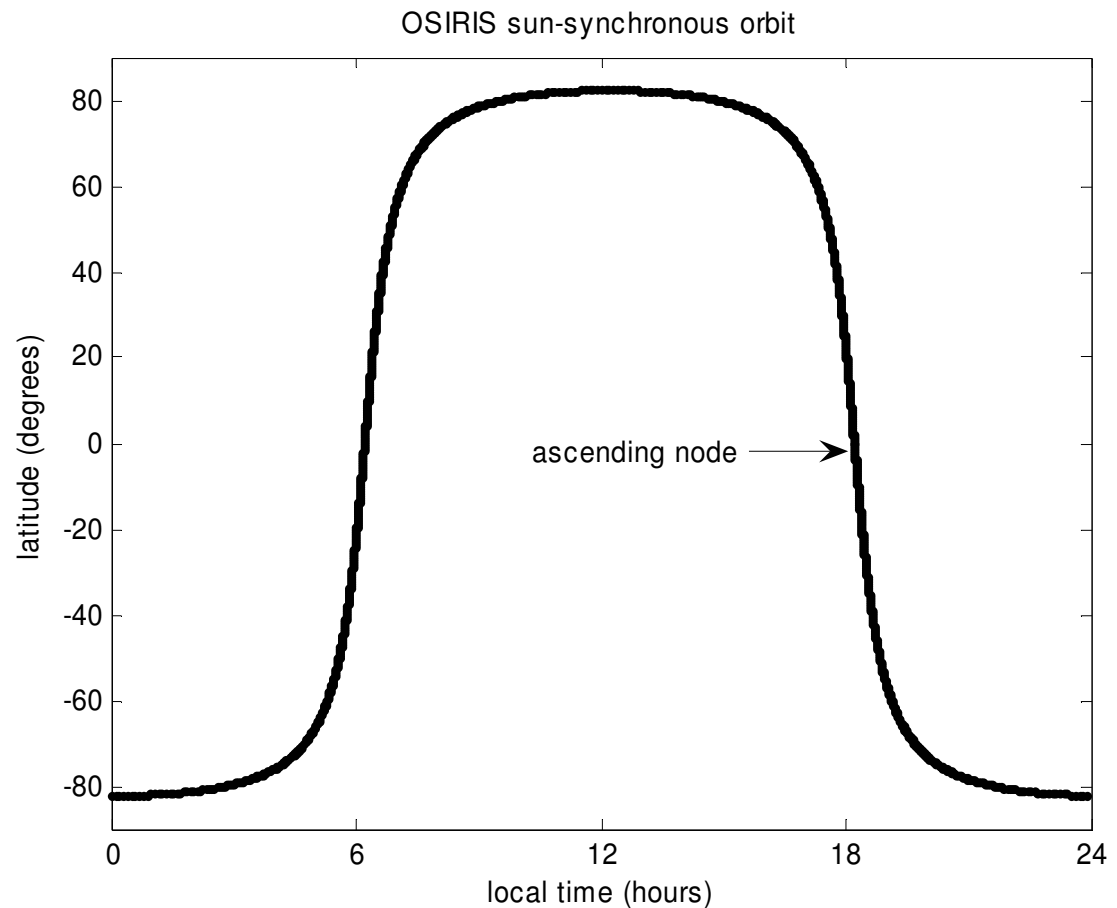
# The Atmosphere as Seen from Odin



# The Odin Orbit

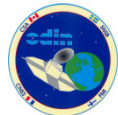
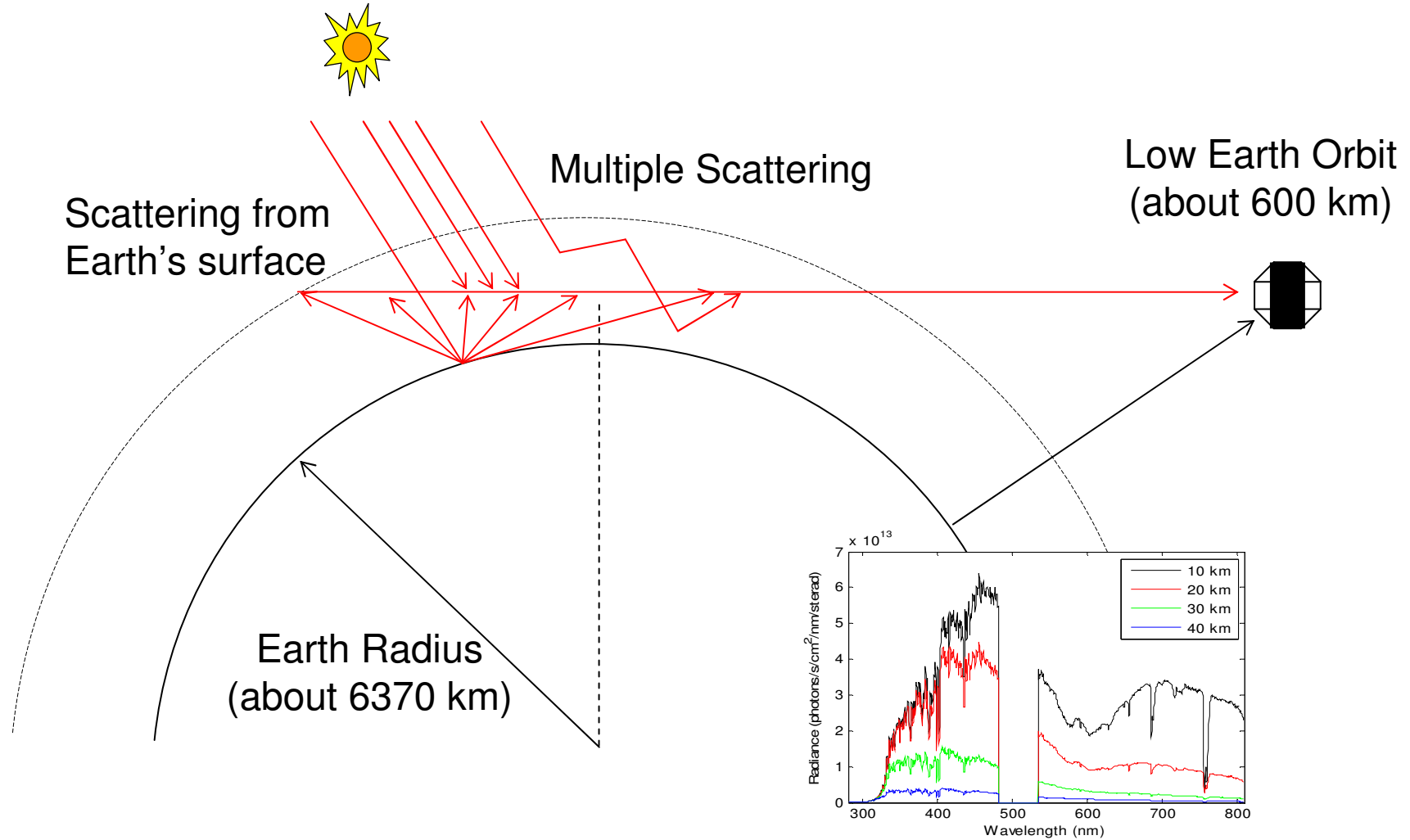


- launch Feb 2001
- sun-synchronous
- near-terminator
- 98 degree inclination
- 1800h ascending node
- 0600h descending node
- 96 minute period
- 600 km altitude



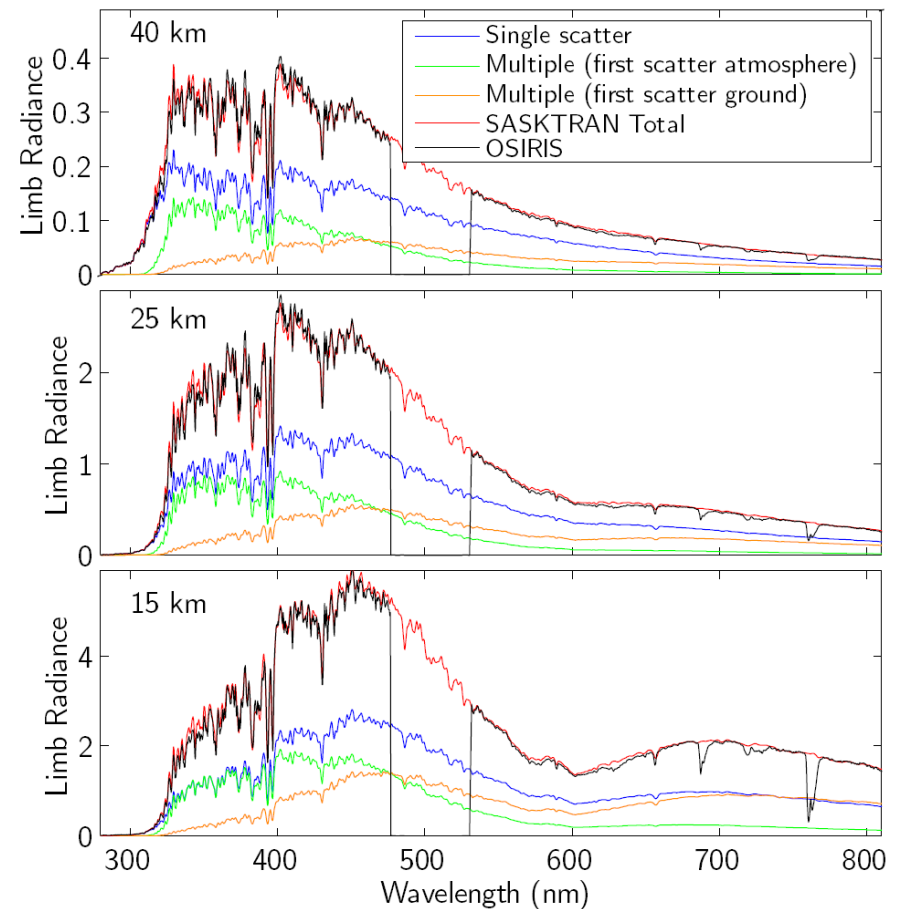
# Limb Scattering

A measurement of the intensity of sunlight scattered from the atmosphere

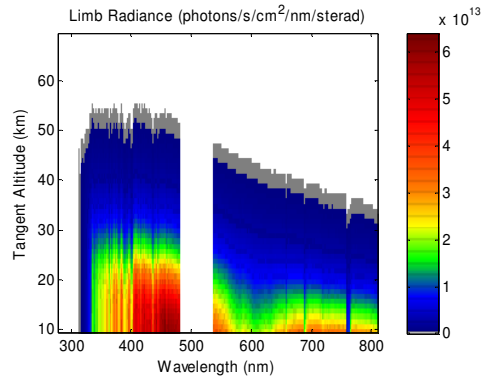


## SASKTRAN and OSIRIS Observations

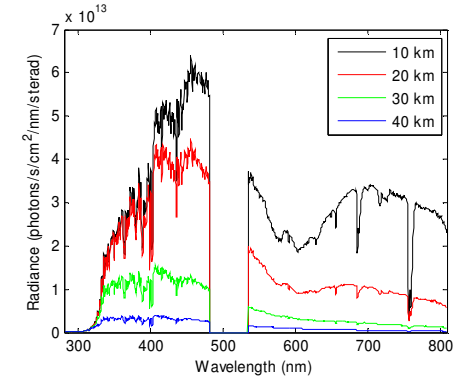
- Retrieve effective scene albedo
- Retrieve stratospheric aerosol profile
- Retrieve the nitrogen dioxide profile
- Retrieve ozone profile
  
- Use the retrieved state profiles to model the measured spectra



## 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 spectrograph
    - 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<sub>2</sub>
  - 1.53 micron OH Meinel



O<sub>3</sub>      Dust  
Forest Fires

NO      NO<sub>2</sub>  
BrO

Noctilucent Clouds

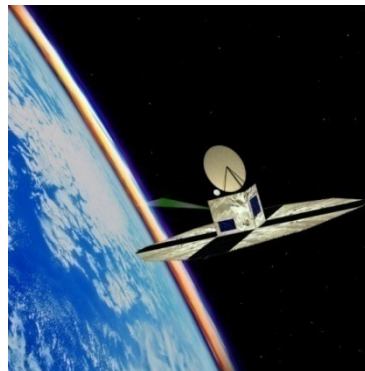
Sodium

The Aurora

Sulphate Aerosol

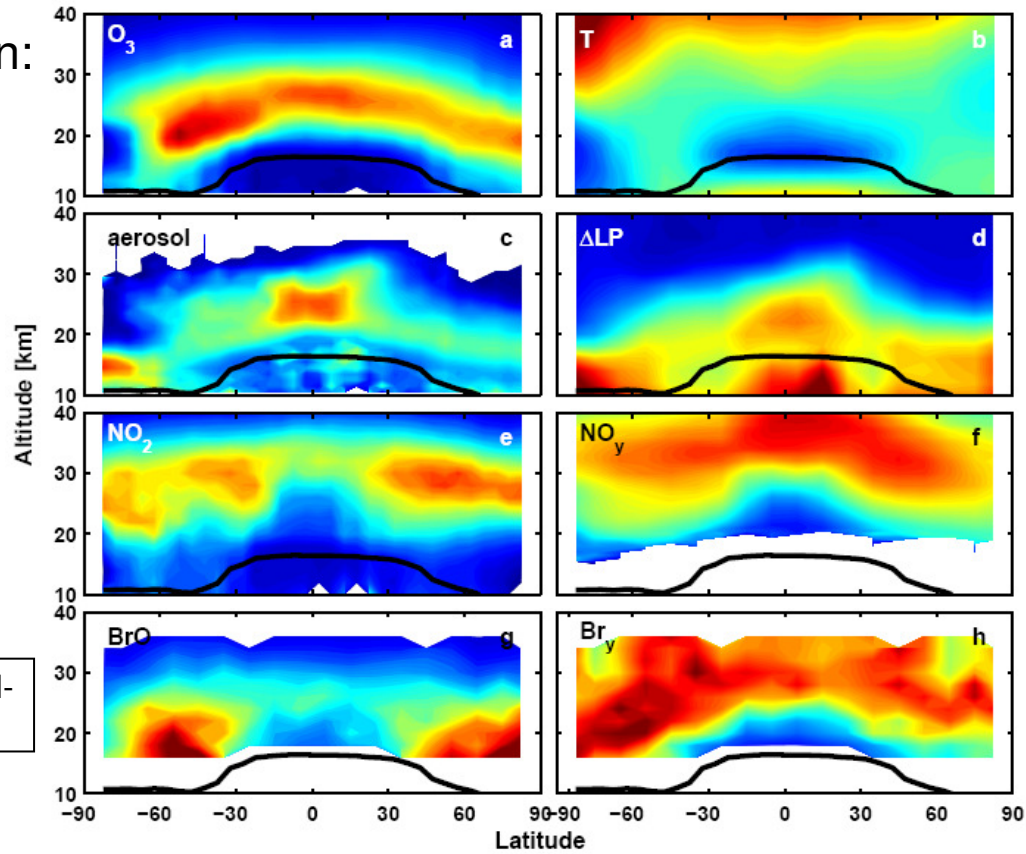
OH

Subvisual Cirrus



# Odin-OSIRIS Data Products

3-day zonal mean:  
1-3 Oct 2007



ECMWF Temperature

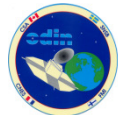
Change in linear polarization

NO<sub>y</sub> based on OSIRIS  
NO<sub>2</sub> + SMR HNO<sub>3</sub> +  
photochemical modelling

BrO is based on a zonal-mean Level 1 product

Bry based on OSIRIS BrO  
+ Odin NO<sub>y</sub> +  
photochemical modelling

|       |       |       |                 |                                   |
|-------|-------|-------|-----------------|-----------------------------------|
| 0.0   | 3.0   | 6.0   | O <sub>3</sub>  | K                                 |
| 180.0 | 225.0 | 270.0 | T               | 10 <sup>12</sup> cm <sup>-3</sup> |
| 0.0   | 1.3   | 2.6   | aerosol         | -                                 |
| -0.0  | 0.1   | 0.1   | ΔLP             | -                                 |
| 0.0   | 8.0   | 16.0  | NO <sub>2</sub> | 10 <sup>9</sup> cm <sup>-3</sup>  |
| 0.0   | 10.0  | 20.0  | NO <sub>y</sub> | ppbv                              |
| 0.0   | 1.0   | 2.0   | BrO             | 10 <sup>7</sup> cm <sup>-3</sup>  |
| 0.0   | 12.5  | 25.0  | Bry             | pptv                              |



### **There are four operational data products maintained at the Odin/OSIRIS Data Centre in Saskatoon:**

- 1) Ozone,  $O_3$  – cloud tops up to 55 km
- 2) Nitrogen Dioxide,  $NO_2$  – cloud tops up to 40 km
- 3) Stratospheric Sulphate Aerosols – tropopause up to 30 km
- 4) Bromine Monoxide,  $BrO$  – 18 to 34 km (zonal mean)

### **There are derived and climatological data products:**

$NO_y$ ,  $Br_y$ , and zonal, monthly-mean  $O_3$ ,  $NO_2$ , aerosol,  $BrO$

### **There are a number of research grade data products:**

sodium, ground state hydroxyl, mesospheric ozone, mesospheric temperature, water vapour, atomic oxygen, atomic hydrogen, nitric oxide, ...





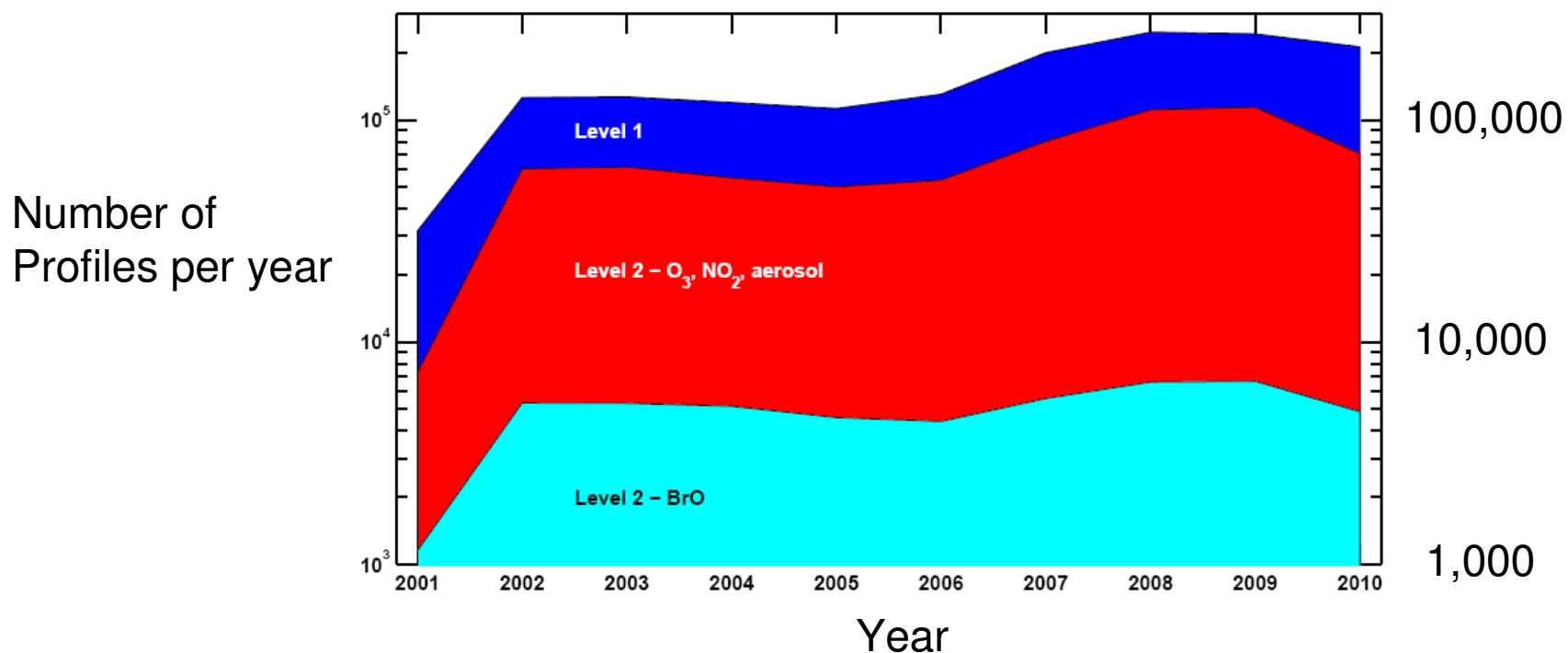
# Operational Data Products

## Data Inventory:

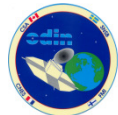
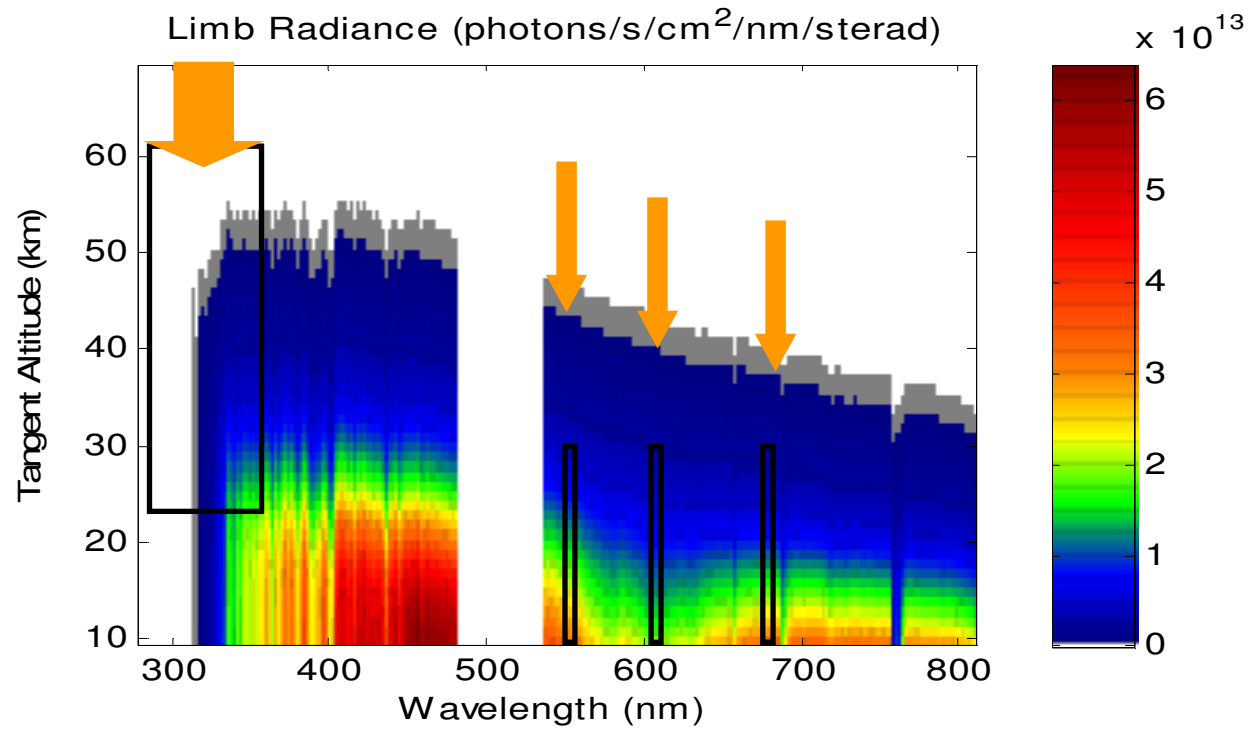
**Data extends from 2001-present (about 9.5 years)**

Ozone, NO<sub>2</sub>, aerosol extinction – ~750,000 profiles

BrO (zonal mean) – ~50,000 profiles



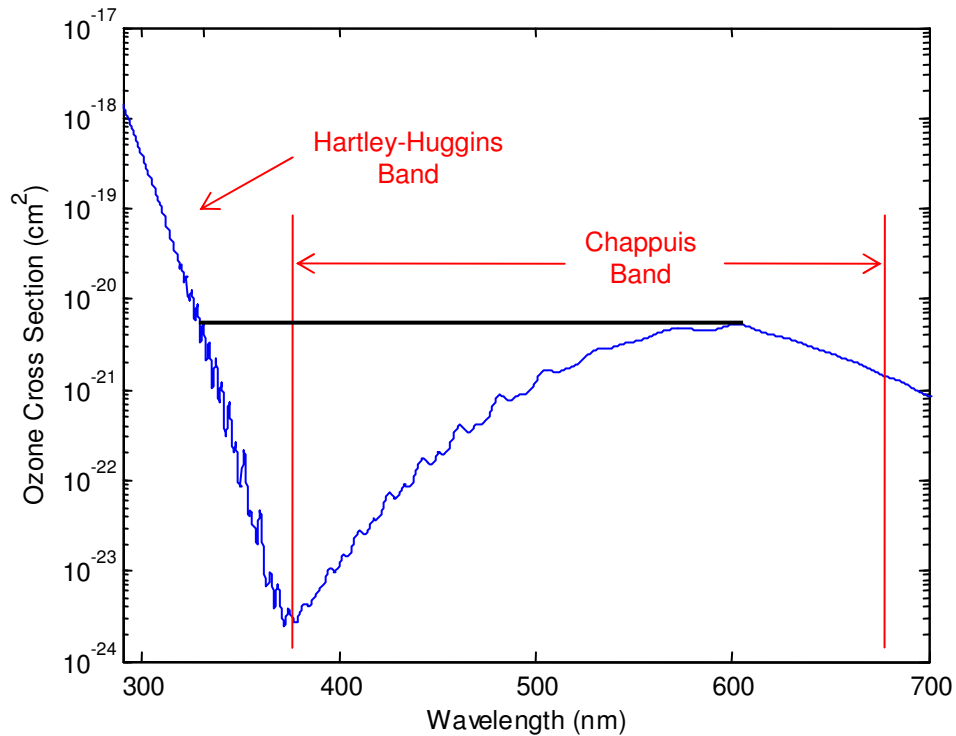
# Ozone



# Ozone: Limb Scatter Signature

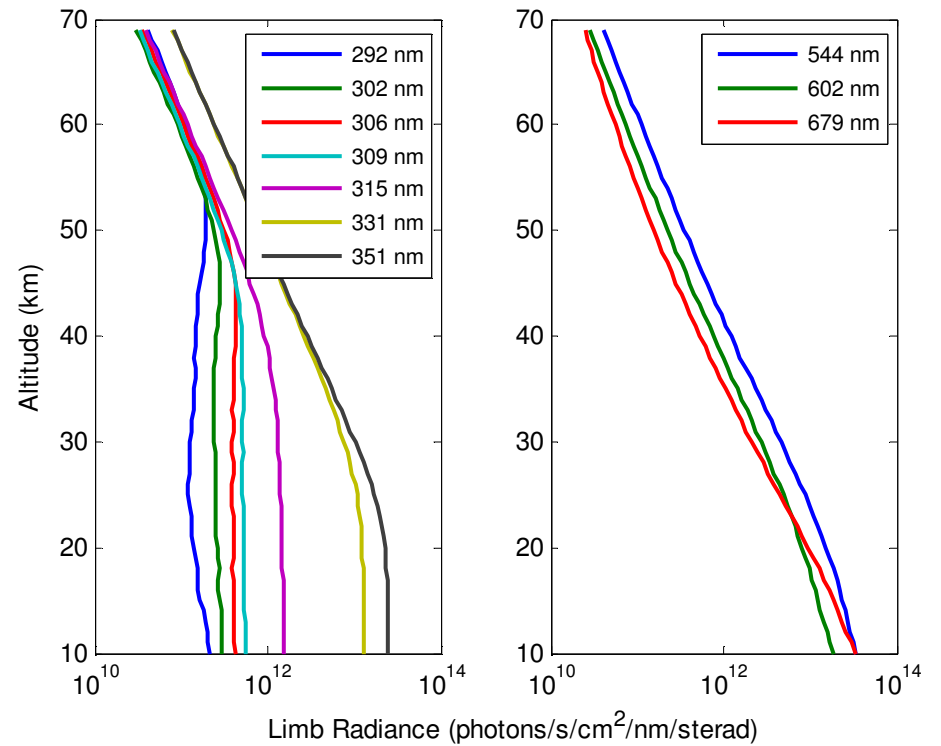
## Ozone Retrieval at Optical Wavelengths

- UV wavelengths (Hartley-Huggins bands)
- Visible wavelengths (Chappuis bands)



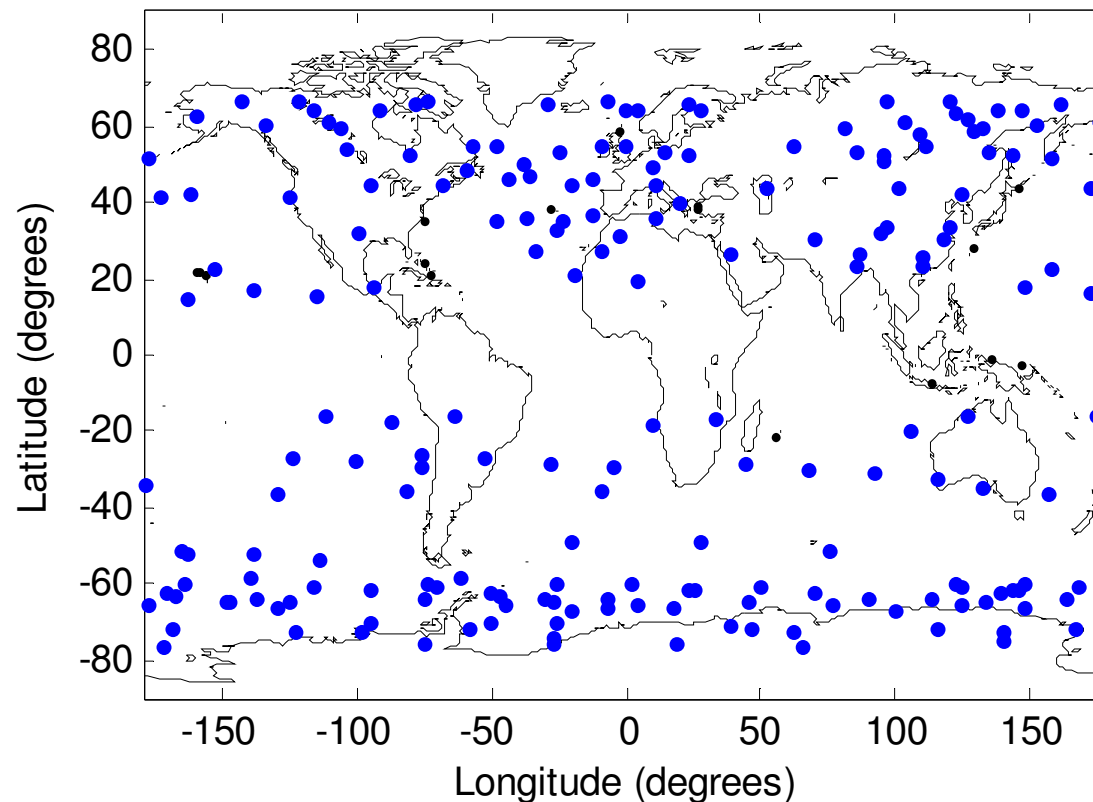
## Limb Signature of Ozone

- Minimum altitude probed by a line of sight identified by a “knee” in the radiance profile (optically thick)

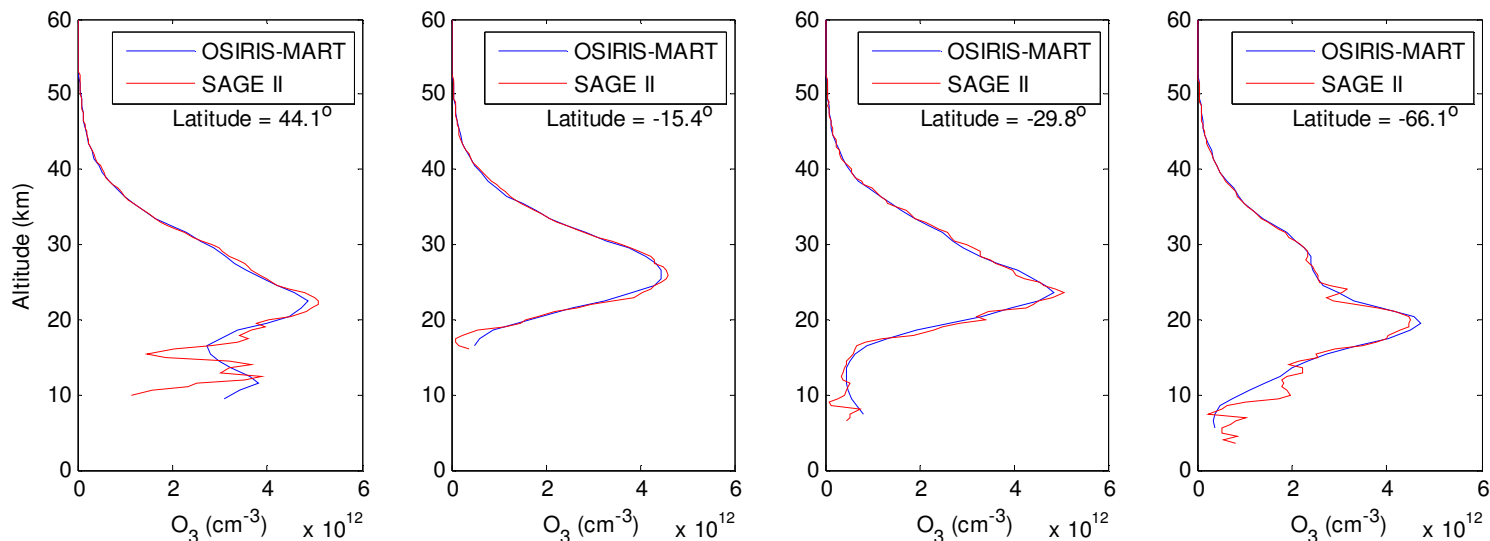


## Ozone: Odin-OSIRIS Comparison

- **SAGE II Ozone is the “Gold Standard” 1984-2005 (Langley Team)**
- Four years of overlap with OSIRIS mission
- Coincidence criteria: 200 km, 2 hours
  - 196 measurement events

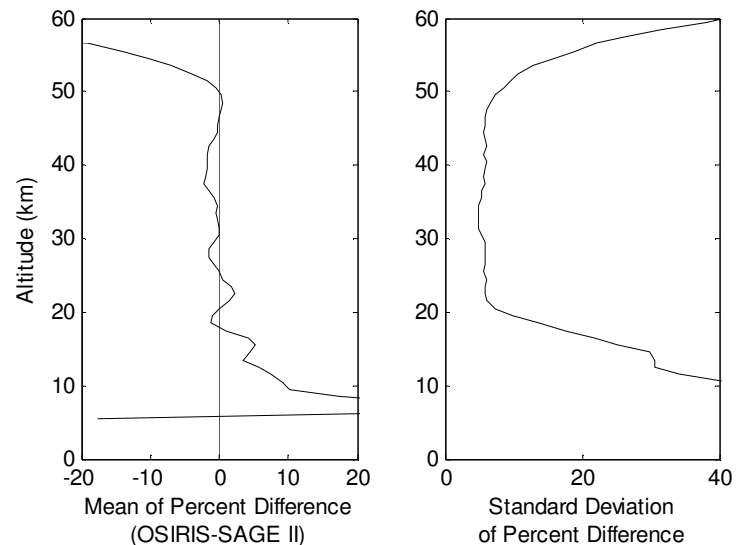


# Ozone: Odin-OSIRIS Comparison

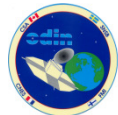
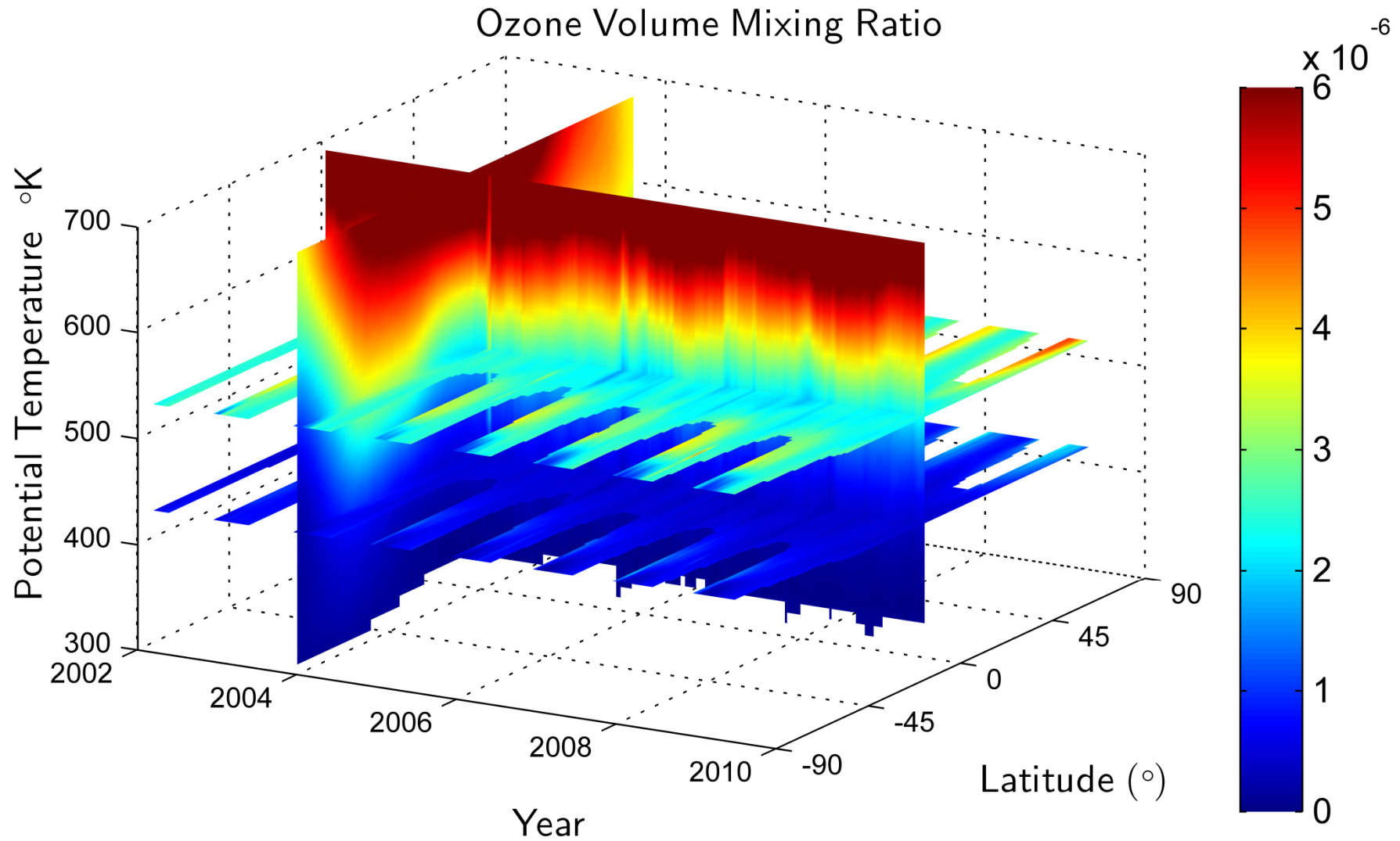


Individual profiles show main vertical structure is well captured, even at lowest altitudes

- Statistics on the entire 196 profile set
- Mean bias of <2% from 18-50 km
  - Standard dev ~5% from 20-50 km



# OSIRIS Ozone



## 1. The Odin Mission has stable funding until the end of 2012

- a. ESA has agreed to continue the Third Party Mission status
- b. SNSB and CSA have agree to continue funding data collection

## 2. The Canadian Space Agency has also agreed to fund the ozone-cci (ECV) efforts of the OSIRIS Team

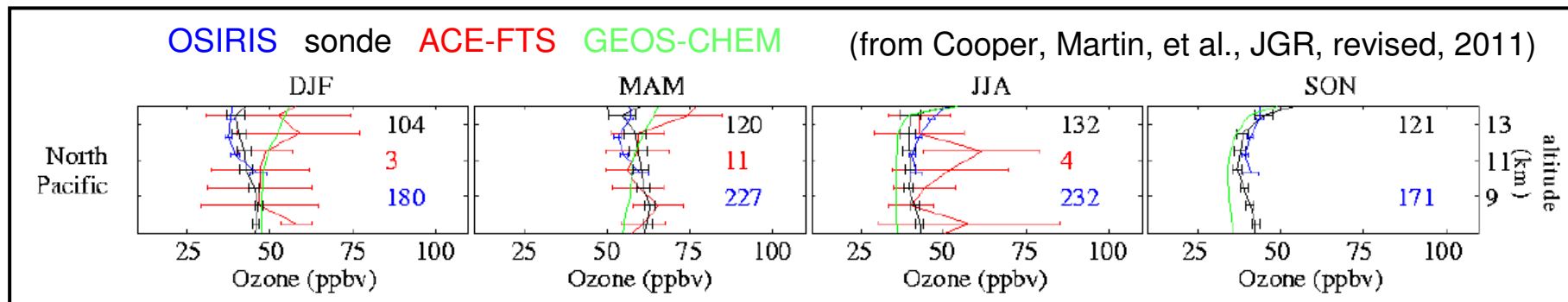
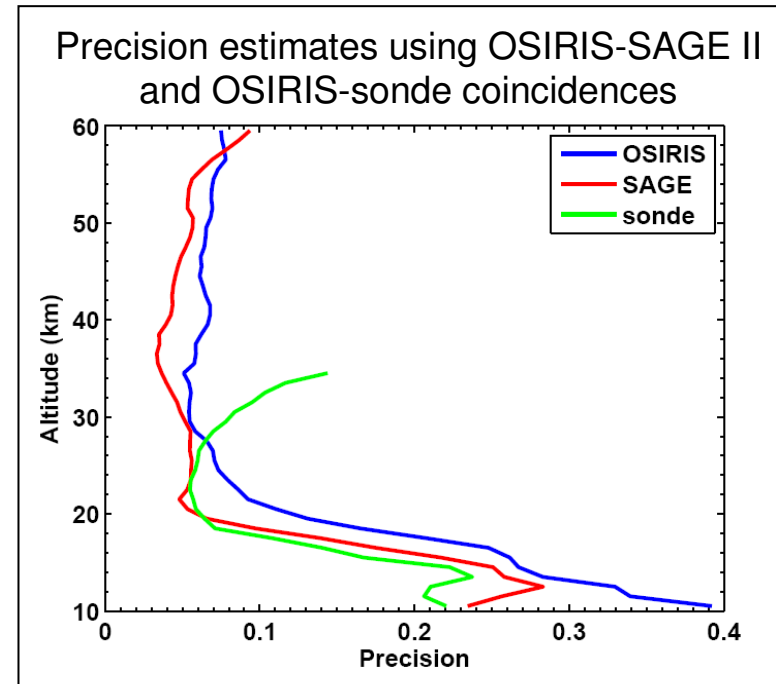
One person has been hired for eighteen months to remove outliers, finalize the precision analysis, characterize the systematic biases, fully document the retrieval process, produce time series and produce climatologies.

## 3. The OSIRIS ozone data is also an integral part of the new SPARC data initiative



## 4. OSIRIS characterization and validation efforts include:

- Slit function and O<sub>3</sub> cross-section analysis
- assimilation of OSIRIS O<sub>3</sub>
- validation of UT ozone and NO<sub>2</sub>
- understanding seasonal “eclipse”-effects ( $\leq 300$  m altitude shift, resolution)
- Developing monthly-mean timeseries and climatologies for all species
- Trend analysis

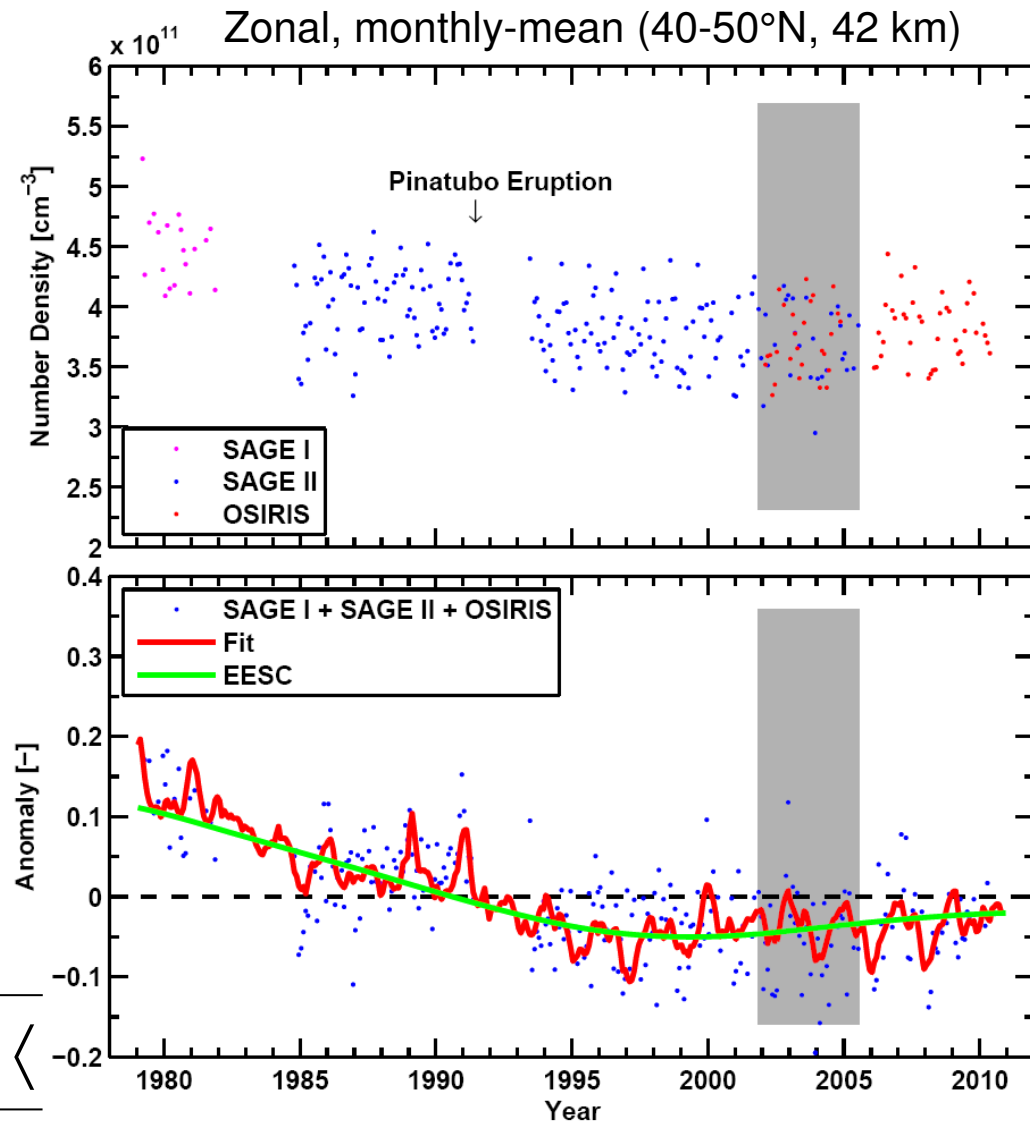




# Preliminary Ozone Trend Analysis Done using Odin/OSIRIS

- Work has begun at Environment Canada to add OSIRIS data to the end of the SAGE I+II time series
- The precision and stability of the OSIRIS data plays a key role in extending the data record from 2005 to the present.
- The four year overlap and  $\sim 10^5$  coincidences with SAGE II is very useful in assessing relative biases
- Assessing stability of OSIRIS pointing and ozone is critical

SAGE I+II EESC fit: -9.6%/decade  
 SAGE I+II+OSIRIS EESC fit: -9.6%/decade



## Summary

- OSIRIS has collected data for almost ten years
- The operational data products are quite mature and provide an excellent data set for time series analysis
- There are many ongoing research based efforts
- There are many new research based efforts
- We hope for many more years of results to add to our data sets

