GOMOS middle atmosphere measurements from 2002-2012

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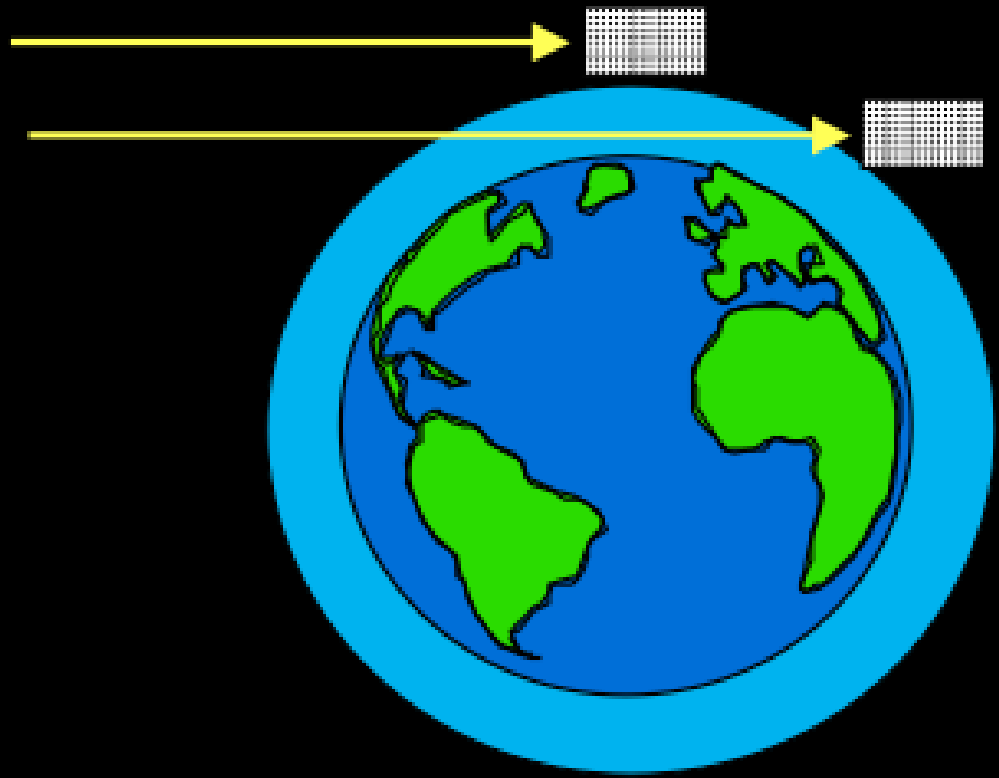
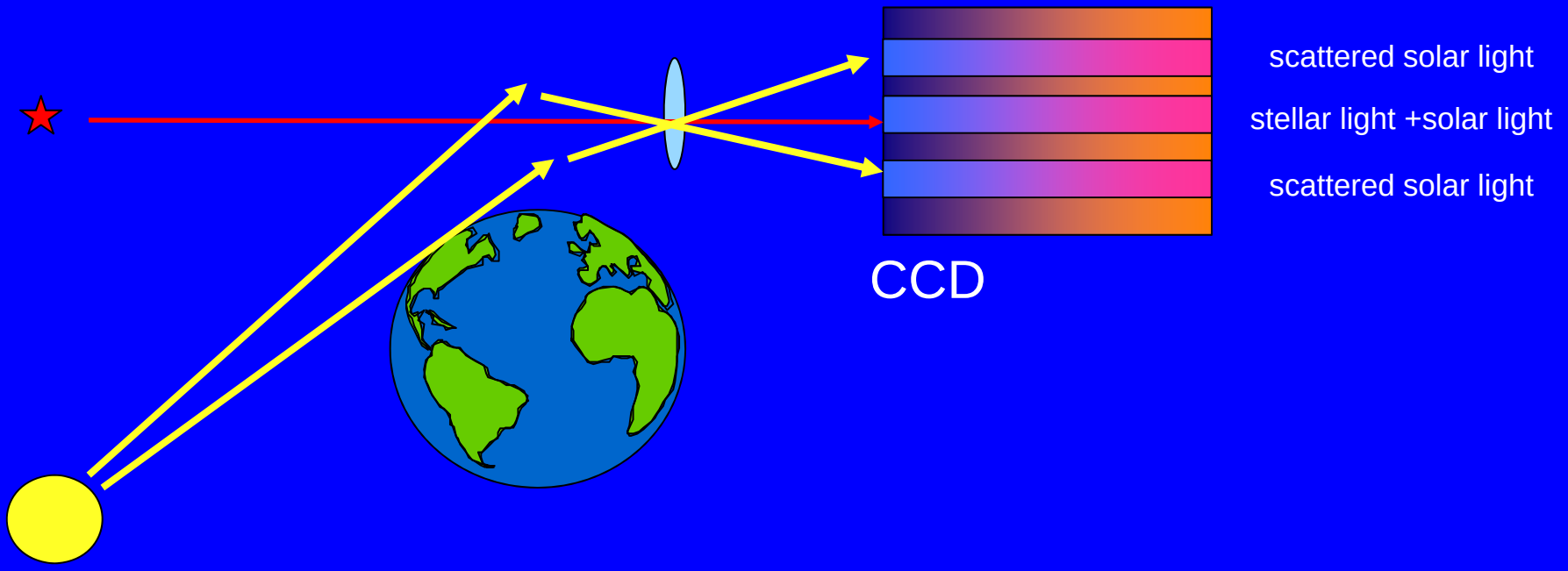
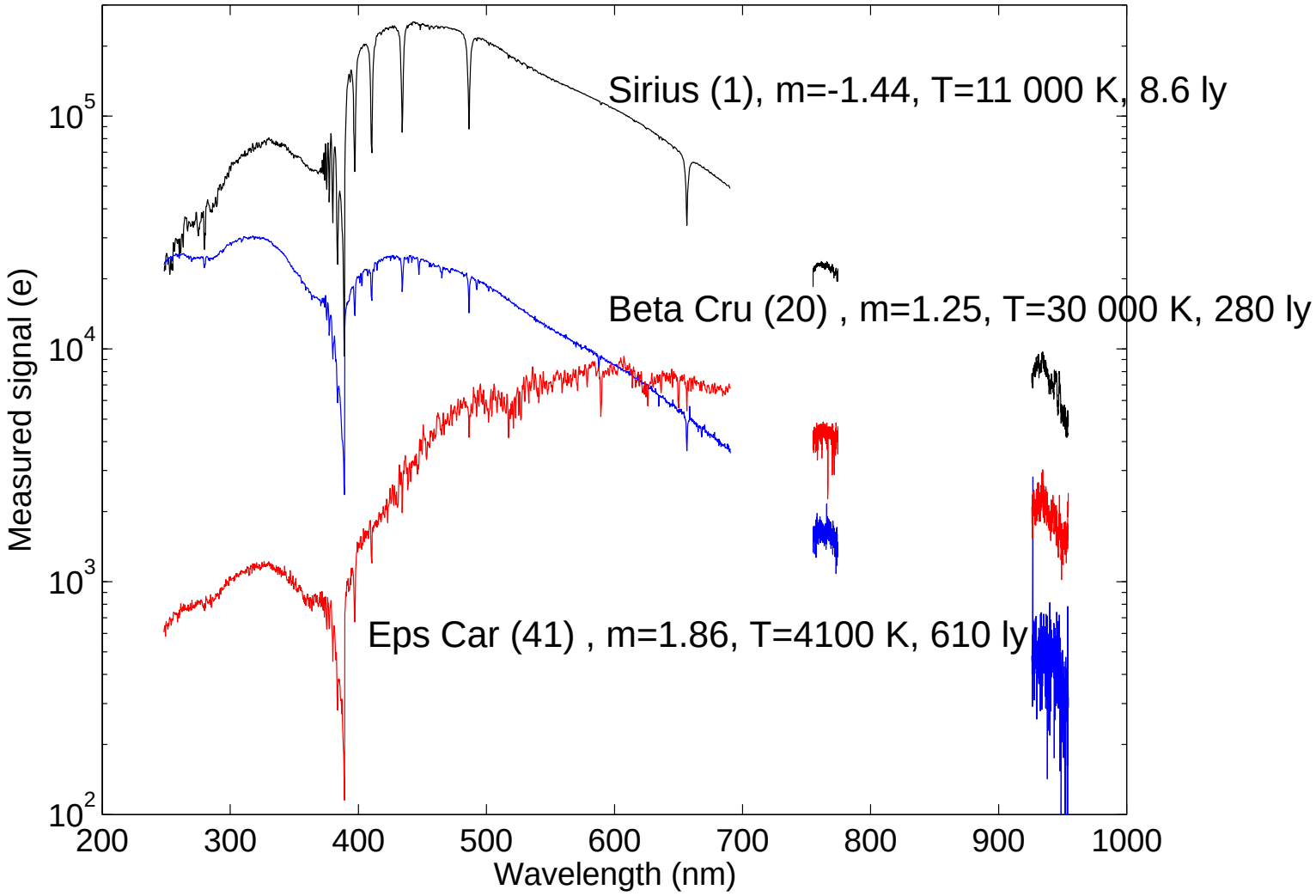


Stars and the Sun

Central band: Retrieval from night and day stellar occultations (ESA)
Upper/lower bands: Retrieval from limb scattered solar radiation (FMI, New)



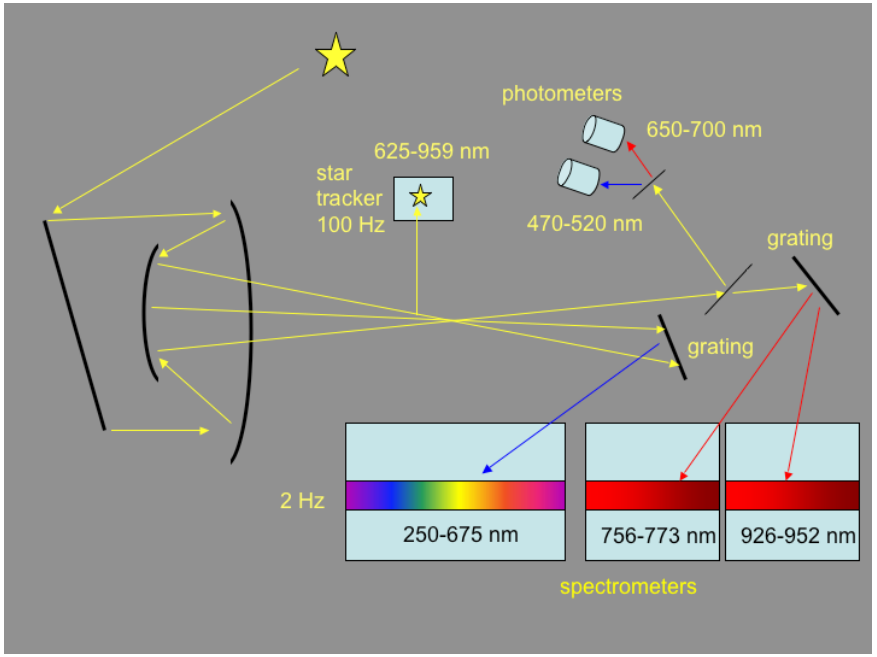
Our ancient light sources

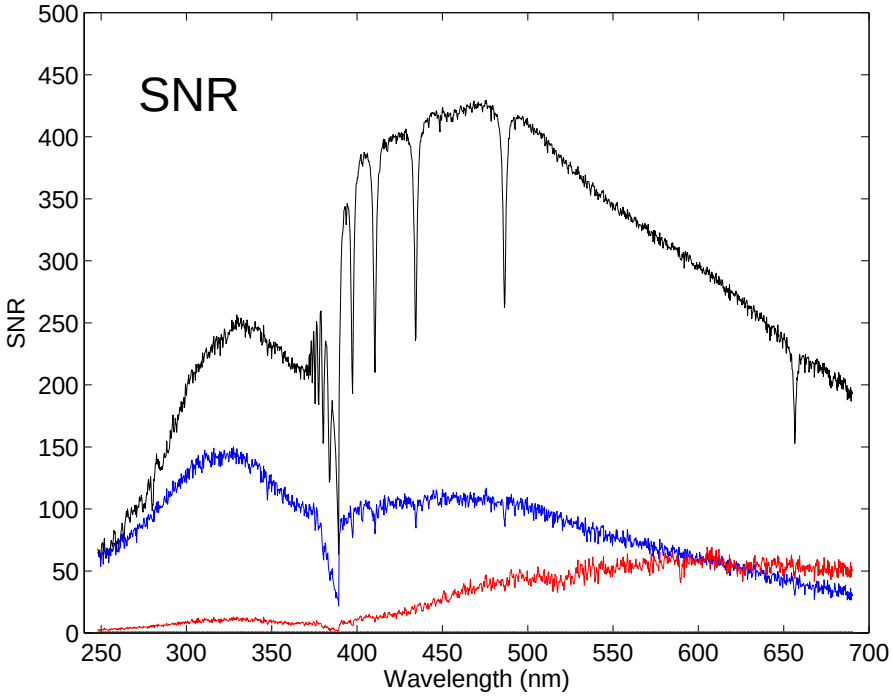


Farthest 2000 ly (Eps Aur star 165)

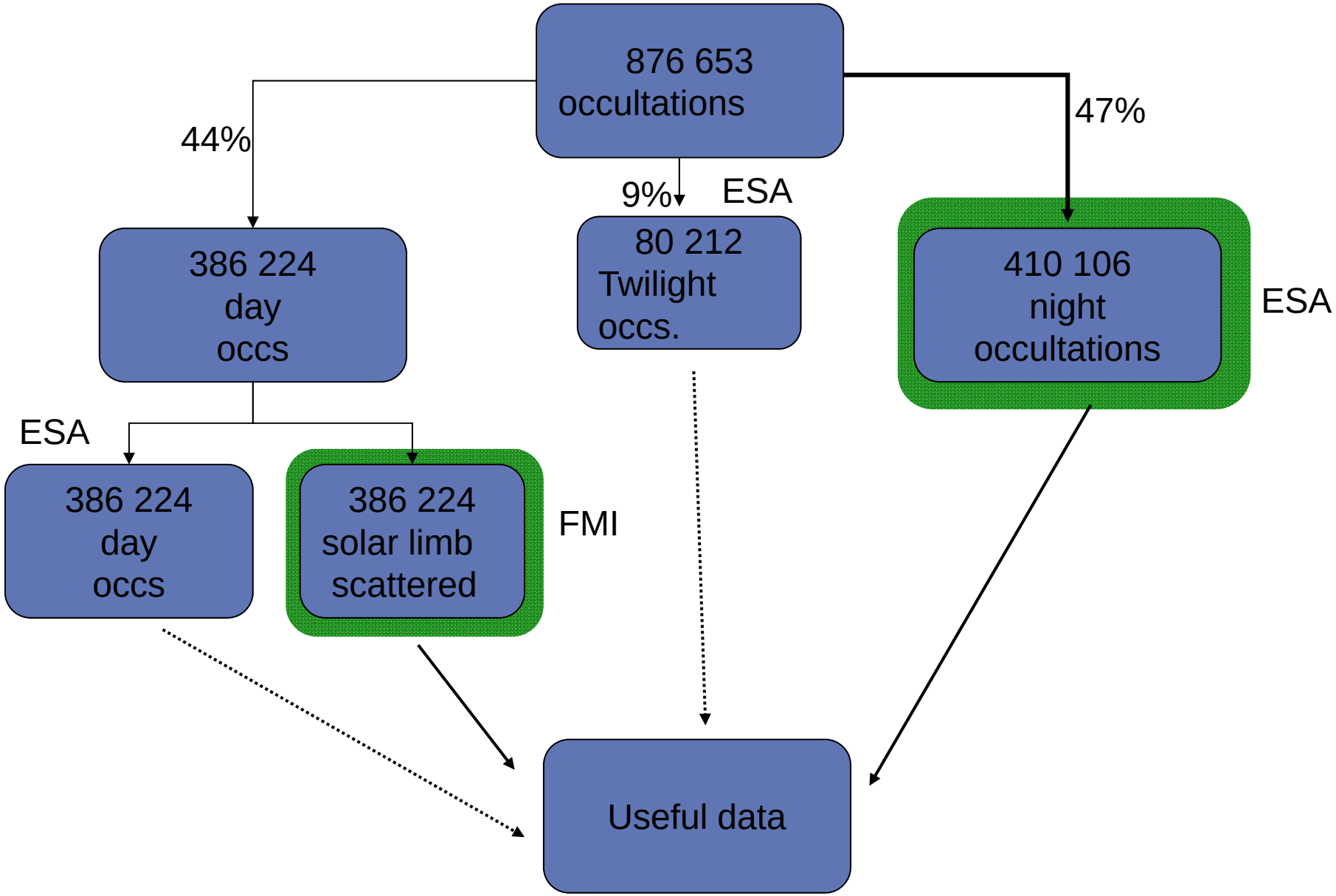
GOMOS instrument

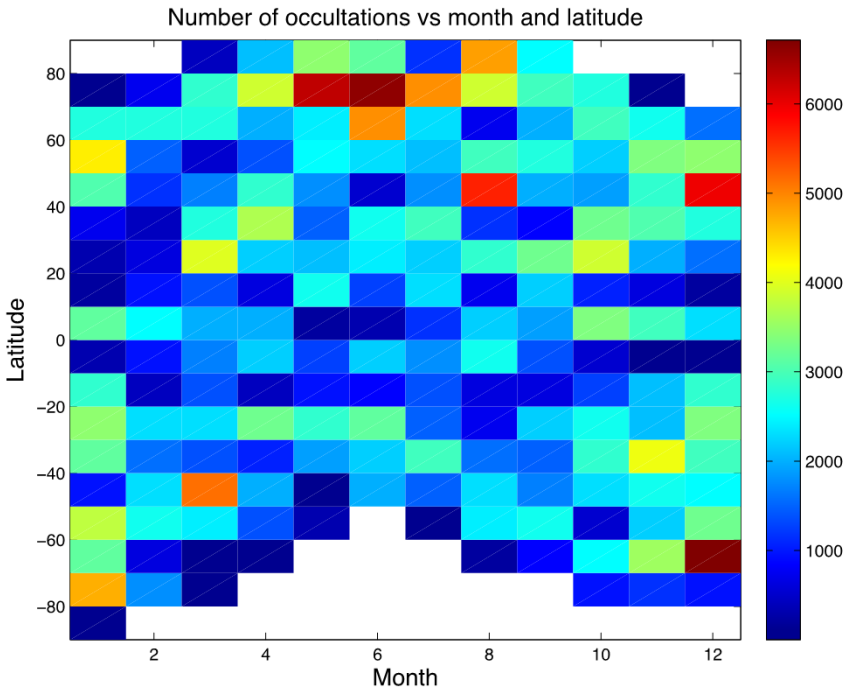
- **4 spectrometers**
  - UV-VIS:
    - A1: 248 - 389nm
    - A2: 389 - 690 nm
    - Resolution 0.8 nm
  - NIR:
    - B1: 760 nm
    - B2: 936 nm
    - Resolution 0.13 nm
- **Photometers (1 KHz)**
  - Blue (470-520 nm)
  - Red (650-700 nm)



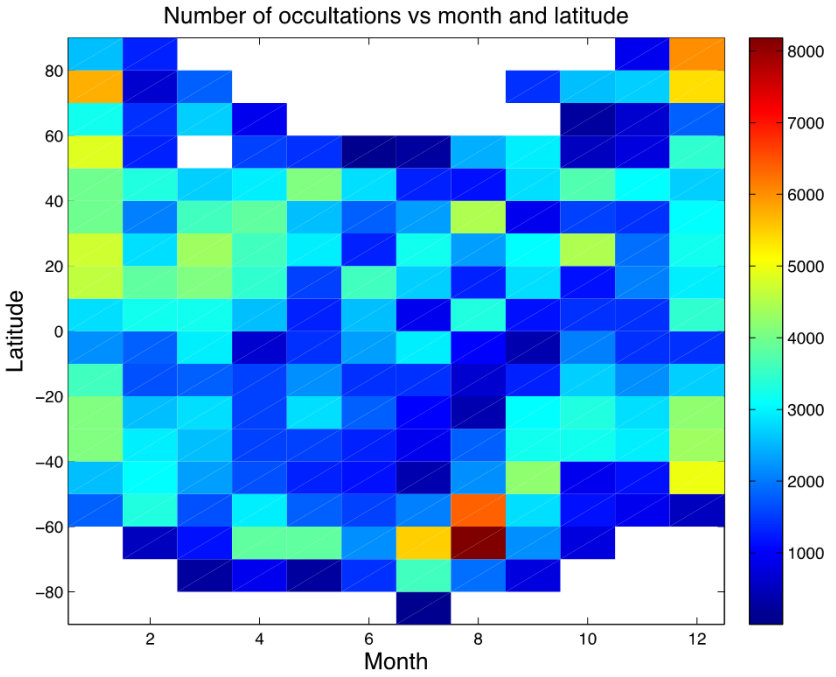


GOMOS trace gas profile data

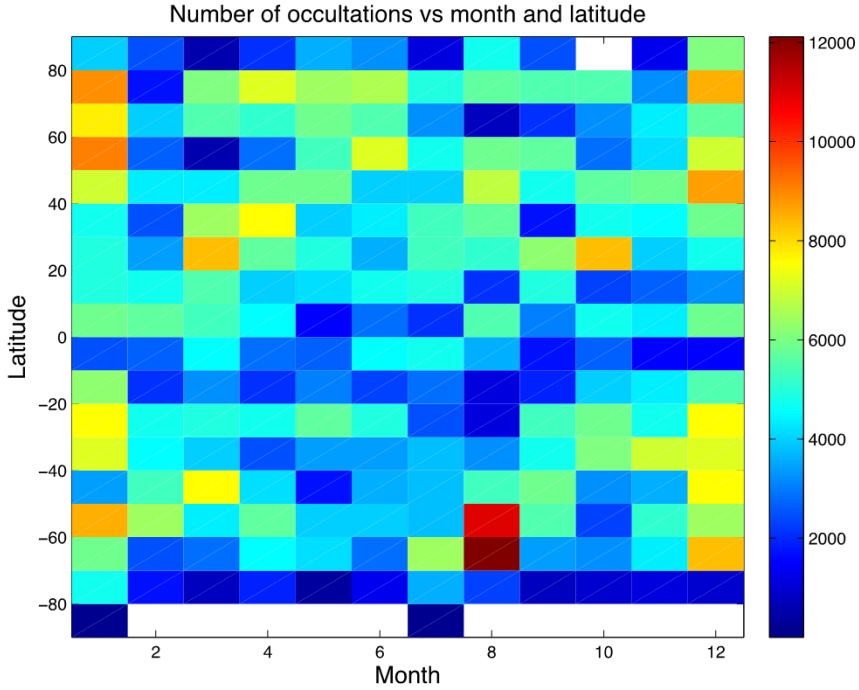




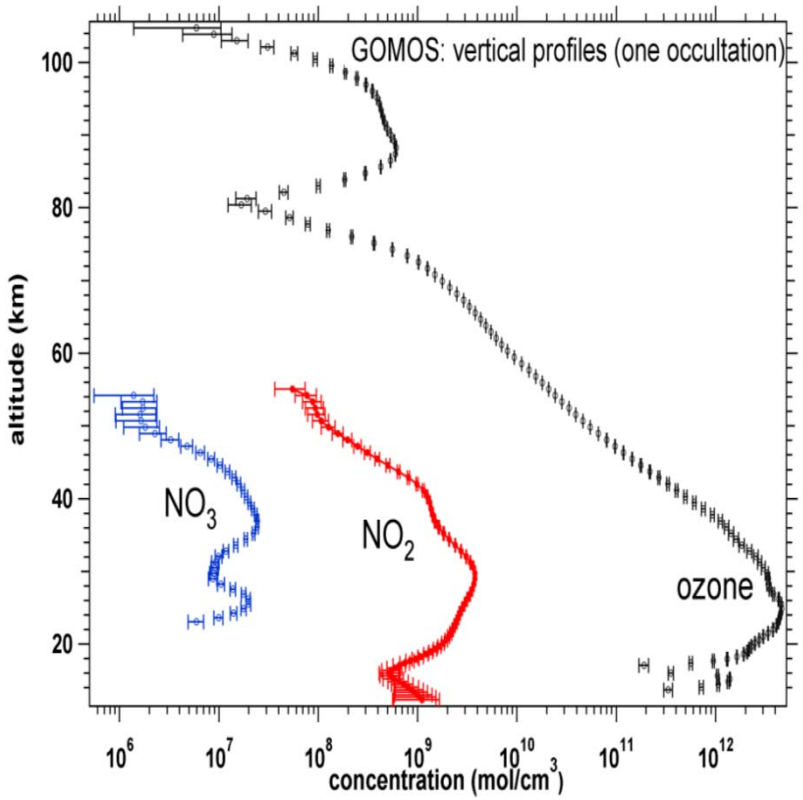
Day



Night

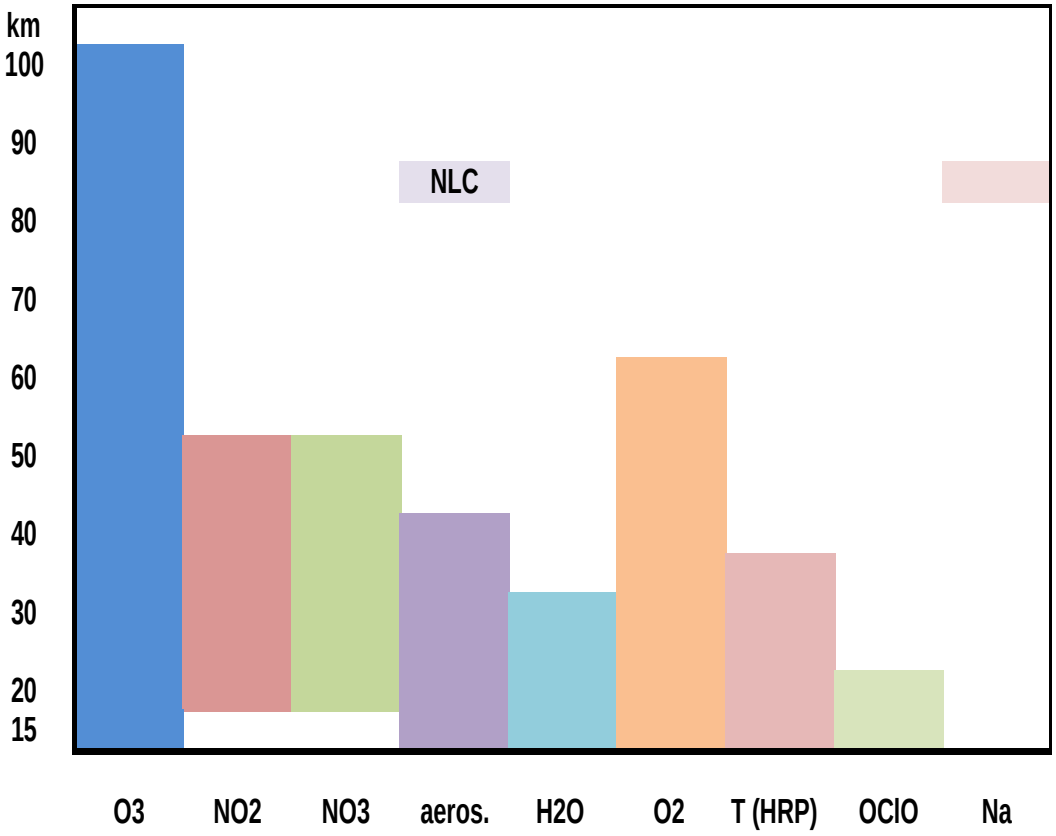


Day + Night



- **O3, NO_2, NO_3**
- **aerosol extinction, PSC, PMC**
- **H_2O, O_2**
- **turbulence and air density irregularities**
- **high resolution temperature profile**
- **Na, OClO**

Vertical sampling resolution
0.2 – 1.7 km
Pointing uncertainty < 30 m.
Vertical resolution of ozone 2-3 km
NO2, NO3, aerosols, H2O, O2:
4 km



GOMOS data quality from other measurements

Validation with sondes and ground based instruments
O3,Gijsel, ACP, 2010

Collocated comparisons with satellite instruments
SAGE II, SAGE III, OSIRIS, MLS, SMILES, MIPAS

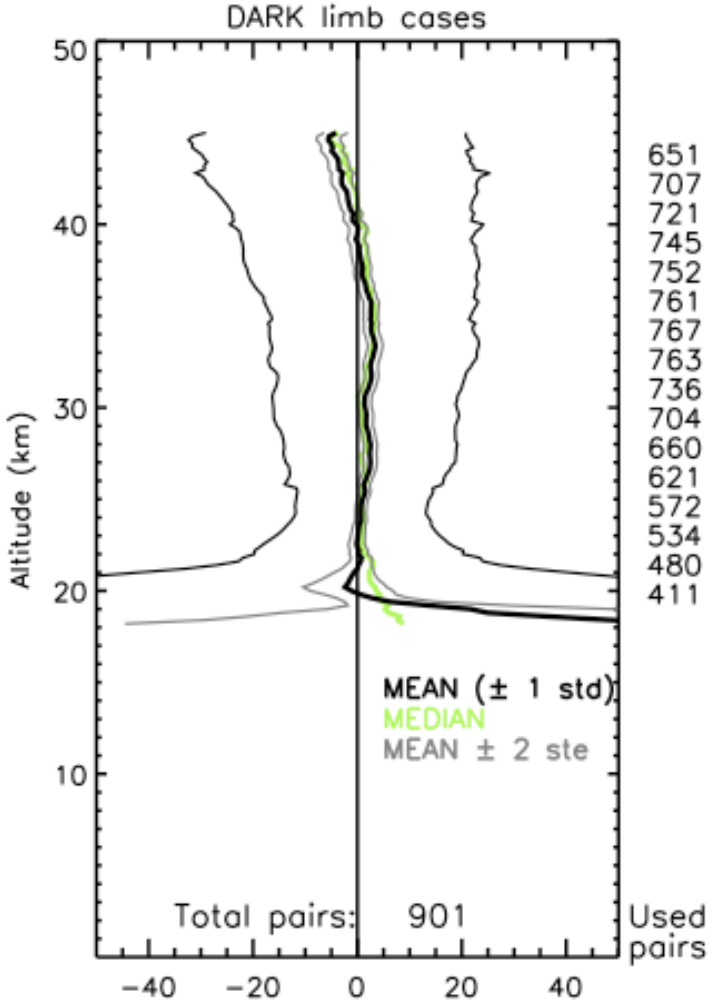
Climatologies (including comparisons):
O3, NO2, NO3, Kyrölä, ACP, 2010
Third O3 peak, Sofieva, ACP, 2010
Aerosols, Vanhellemont, ACP, 2010
Sodium, Fussen ACP 2010
PMC, Perot, ACP, 2010
O3 mesosphere, Smith, JGR, 2013
OClO, Tetard, AMT discuss., 2013

O3, NO2, aerosols, SPARC DI 2013
O3, ESA O3-CCI, 2013
O3 (night + GBL), ESA SPIN, 2013

Time series (including comparisons)
SAGE II-GOMOS O3, Kyrölä, SI2N ACP discuss, 2013

Validation of ozone

- **J. Meijer et al 2004 detailed comparison using soundings, lidars and microwave instruments:**
  - Insignificant difference at 14-64 km.
  - Bias independent on star type a nd latitude
  - Slightly larger difference at polar latitudes at 40 km.
- **Similar study by A. van Gijsel et al. 2010 compared GOMOS ozone (V5) profiles**
  - Good agreement btw 20-40 km: ±2%
  - At 15-20 km GOMOS larger by 5-20%

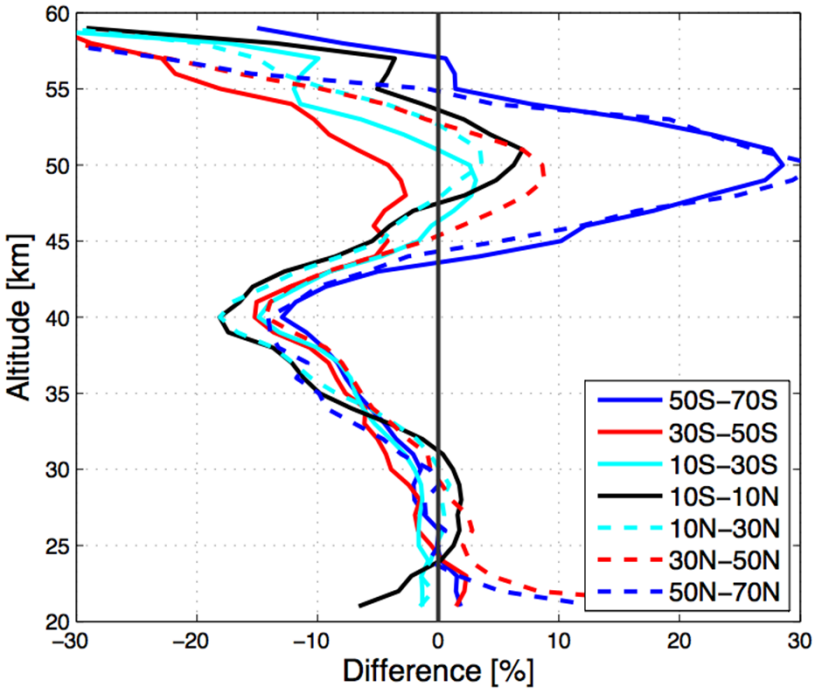


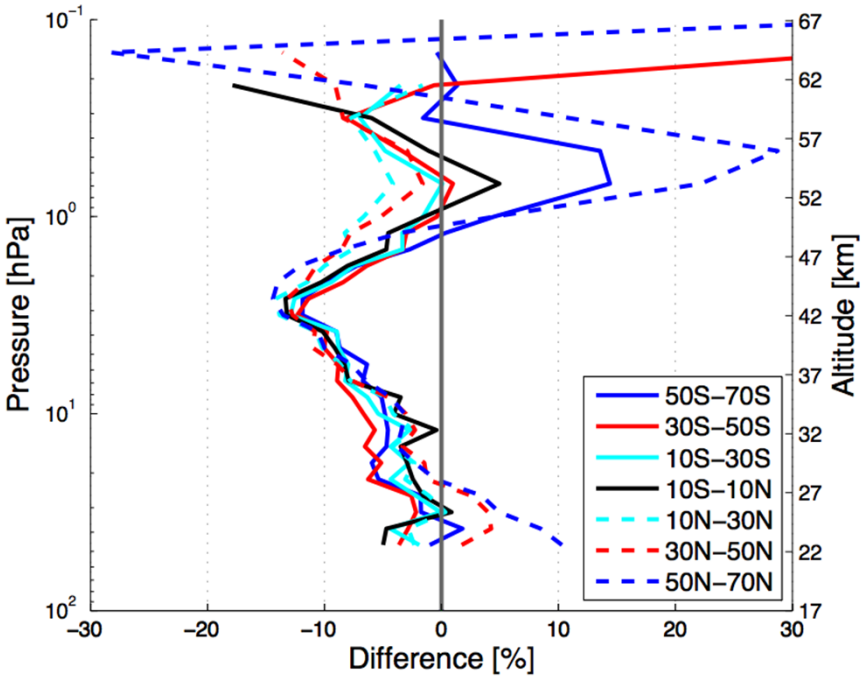
A.Van Gijsel et al. ACP GOMOS special issue 2010

GOMOS Brigh Limb Ozone

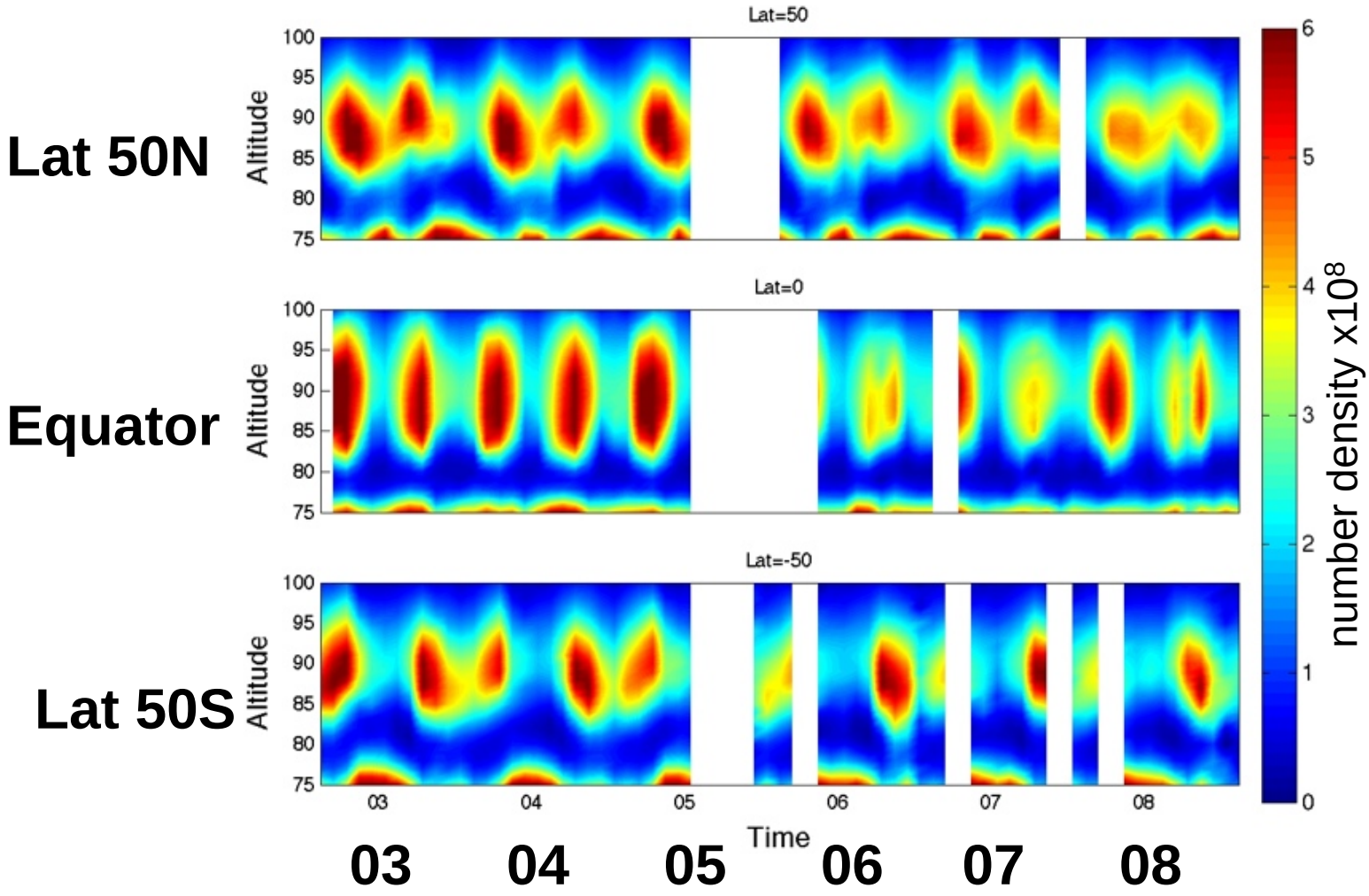
Using GOMOS night occultations:
time difference < 1 day
spatial difference < 250 km

Using MLS
time difference < 12 h
spatial difference < 200 km





GOMOS ozone measurements: mesosphere

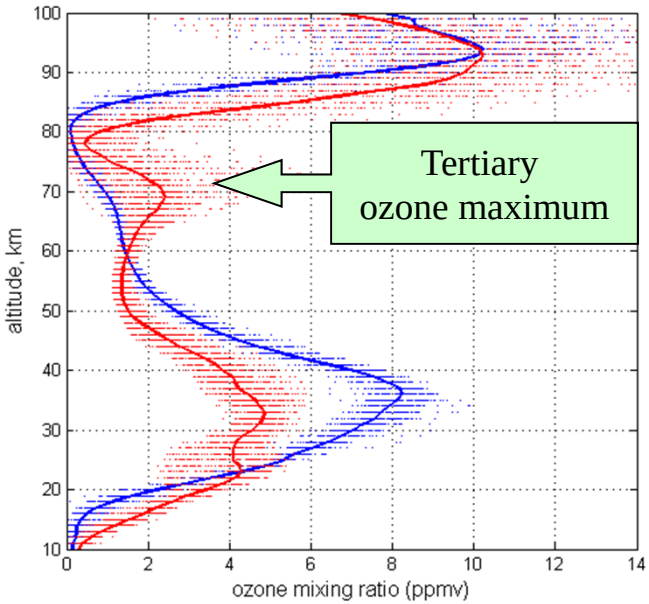


E. Kyrölä et al., GOMOS O3, NO2, and NO3 observations in 2002-2008. ACP GOMOS special issue 2010

Monitoring tertiary ozone maximum

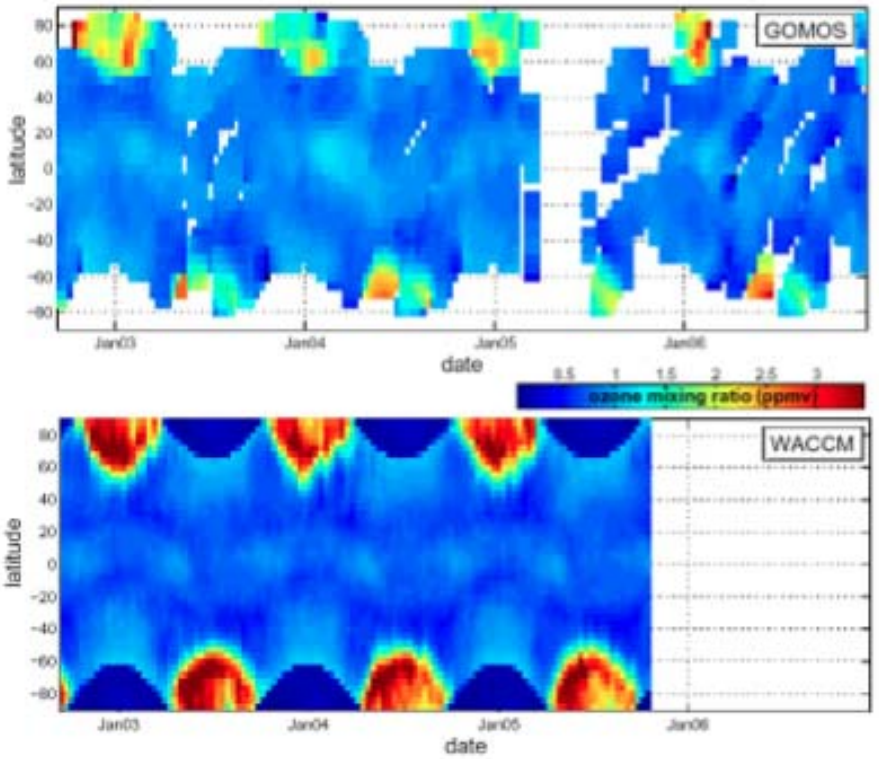
30S-40S, 15-23 Sep 2004

72N-73N, 20-30 Dec 2004



Ozone mixing ratio.

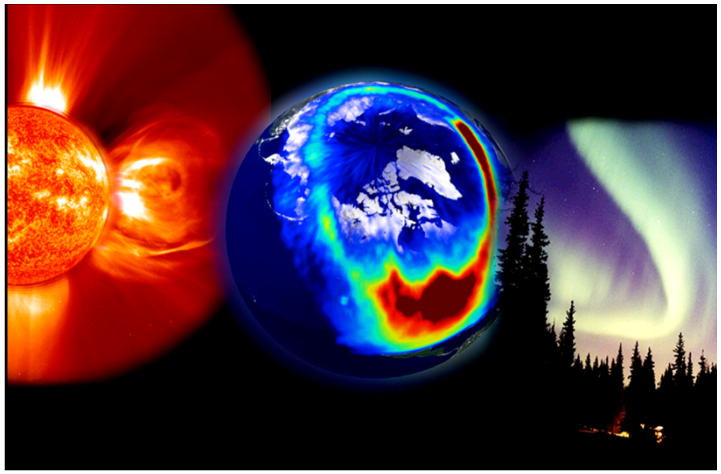
Tertiary ozone maximum is observed in winter close to polar night terminator



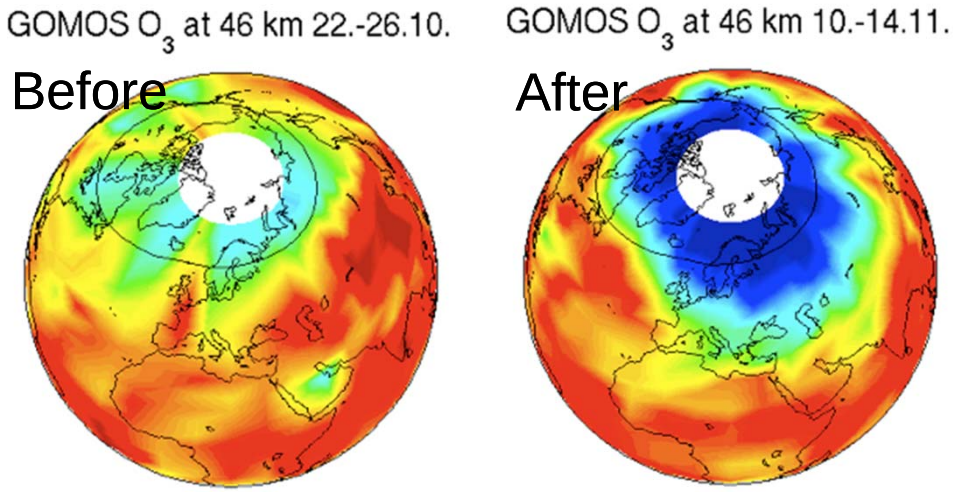
Ozone mixing ratio at 72 km.
Top: GOMOS, bottom: WACCM

Sofieva et al., 2009, ACP

Solar Storm effects on atmospheric composition



- **GOMOS observations were the first to show ozone loss from solar storms in the polar wintertime atmosphere.**

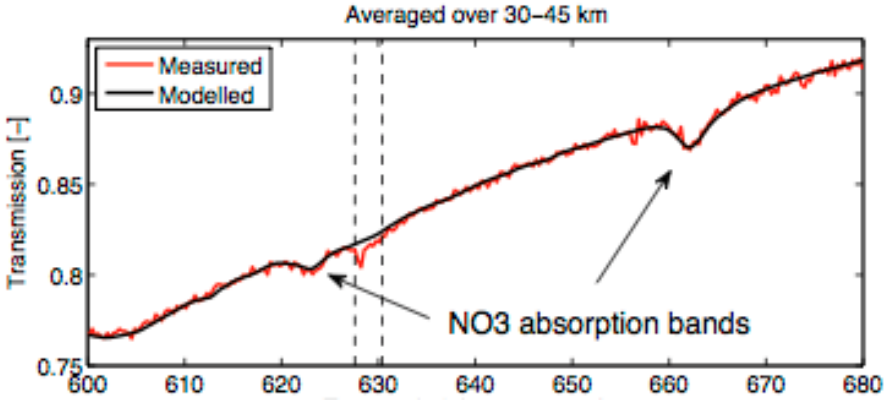


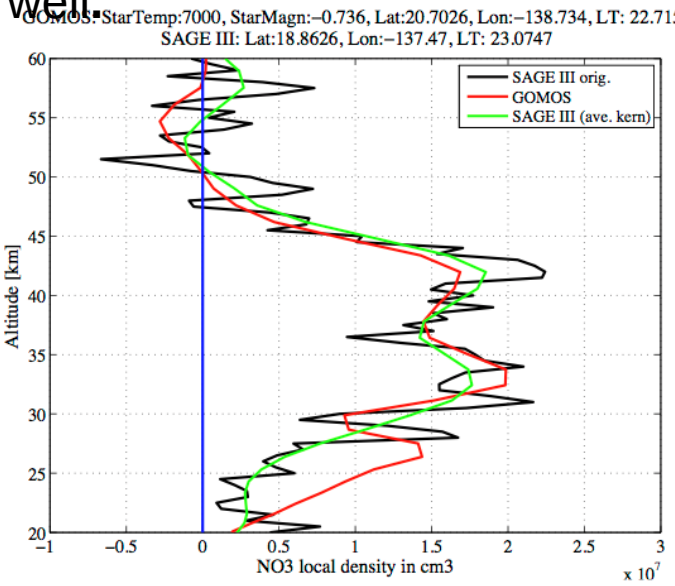
Big solar storms in Oct-Nov 2003 resulted in large amounts of charged particles being blasted out from the Sun. Storms travel through the space and arrive at Earth causing beautiful displays of Aurora in the polar regions. GOMOS observations showed that these particles also lead to large ozone loss in the polar atmosphere.

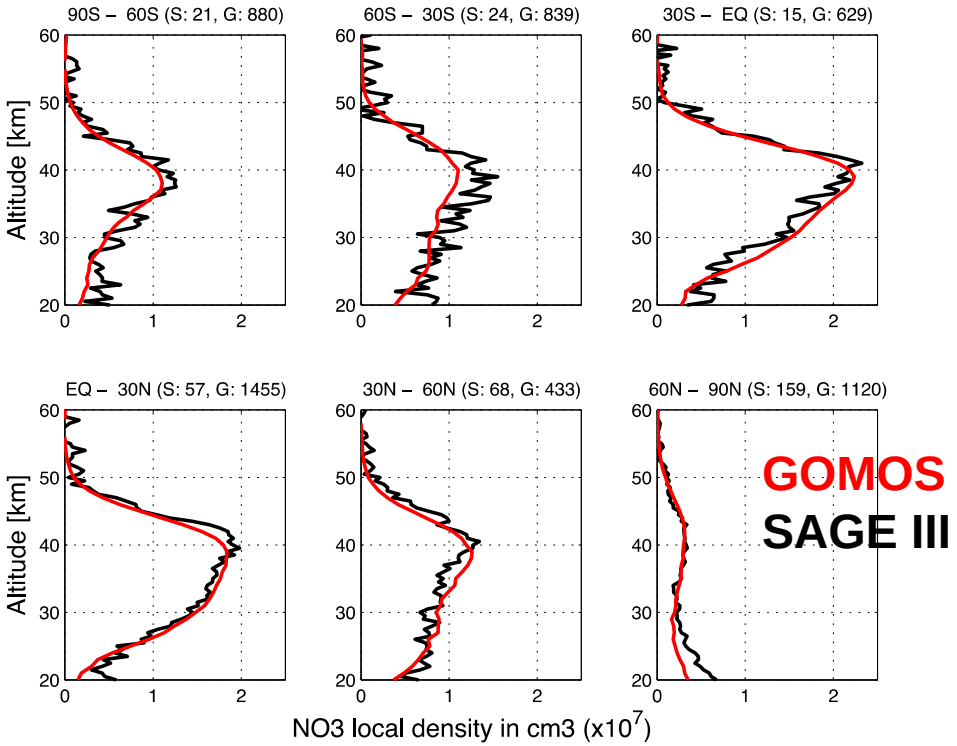
Seppälä et al. GRL, 2004

NO_3 measurements

- Only few validations exist (Renard et al. JGR 2008, Hakkarainen et al 2012, AMTD)
- Good agreement with GOMOS and SAGE III lunar occultations : median difference is within ±25% at 25-45 km
- Zonally averaged profiles agree also well.



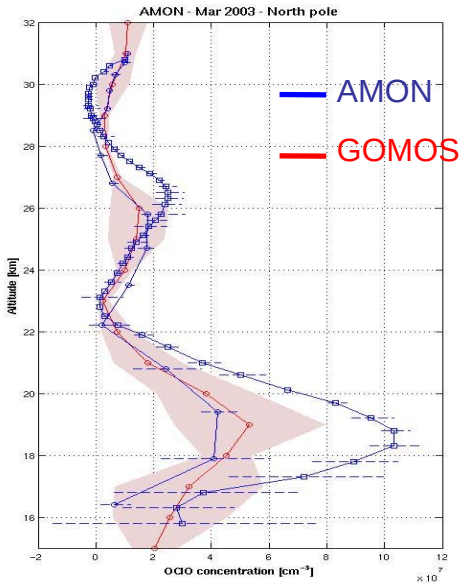


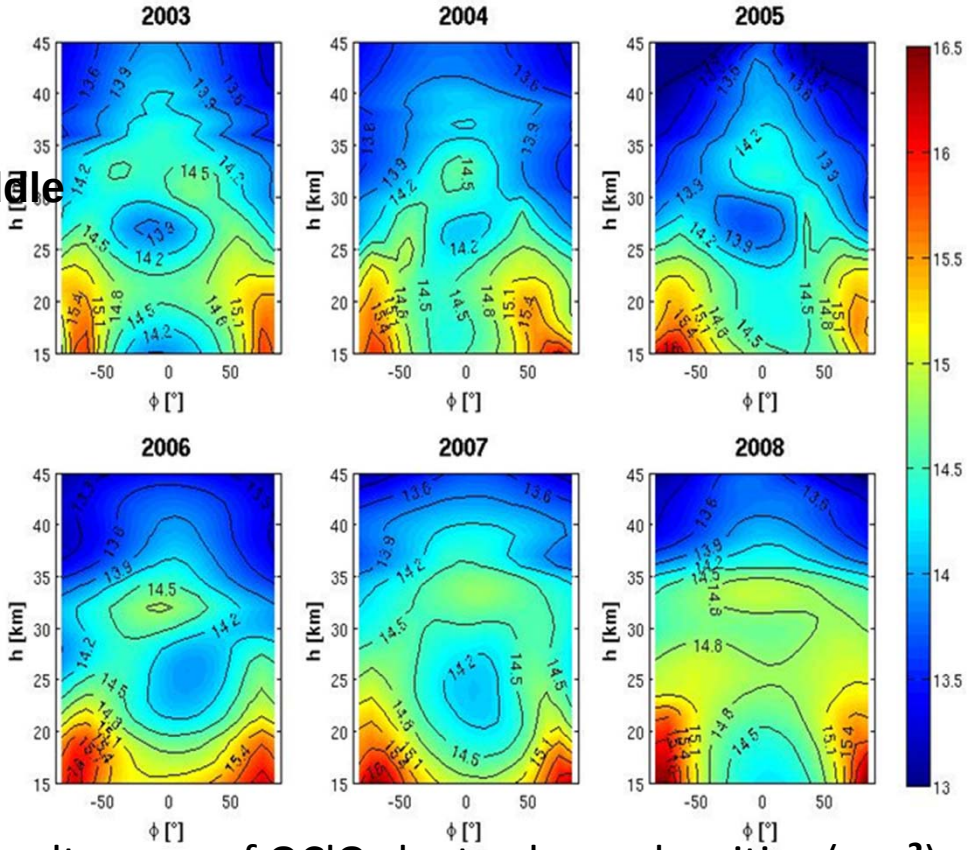


Zonally averaged profiles

OClO measurements

- Also based on virtual occultations and on a DOAS method
- Comparisons with occultation measurement of balloon-borne instrument AMON : good agreement.
- **First night-time OClO Climatology**:
  - **Expected high polar values**
  - **New finding: OClO layer in the middle stratosphere (30 - 38 km)**

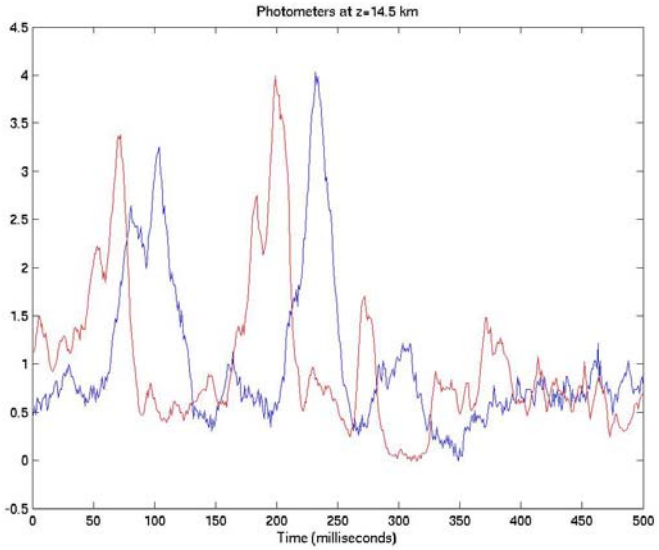




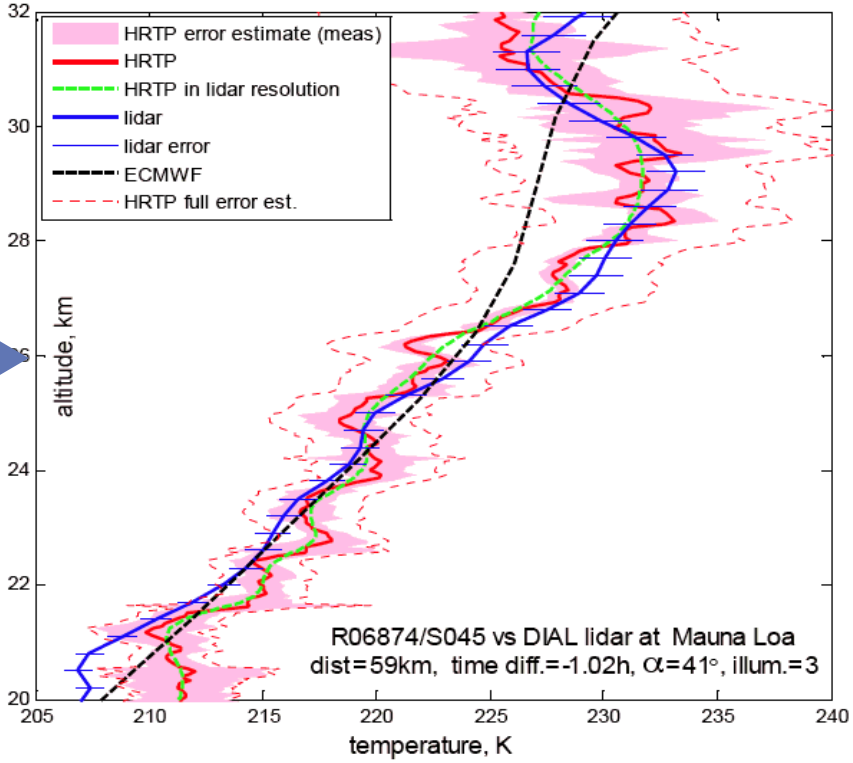
Lat –alt maps of OClO slant column densities (cm^{-2})

Fussen et al., 2006, Tetard et al, ACP 2010, Tetard, ACP, 2013

High-resolution temperature profiling (HRTP)



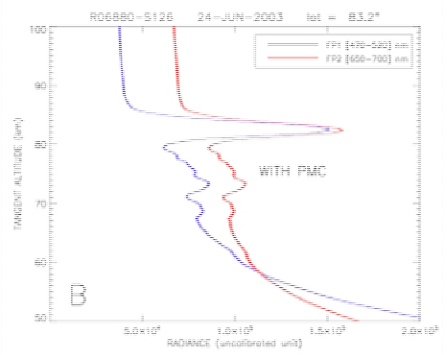
Exemplary HRTP and comparison with lidar



- **Temperature profile is retrieved from the time difference between blue and red photometer signal.**
- **Altitude range 15 – 35 km.**
- **Vertical resolution 200 m**
- **Estimated accuracy 1-2 K**

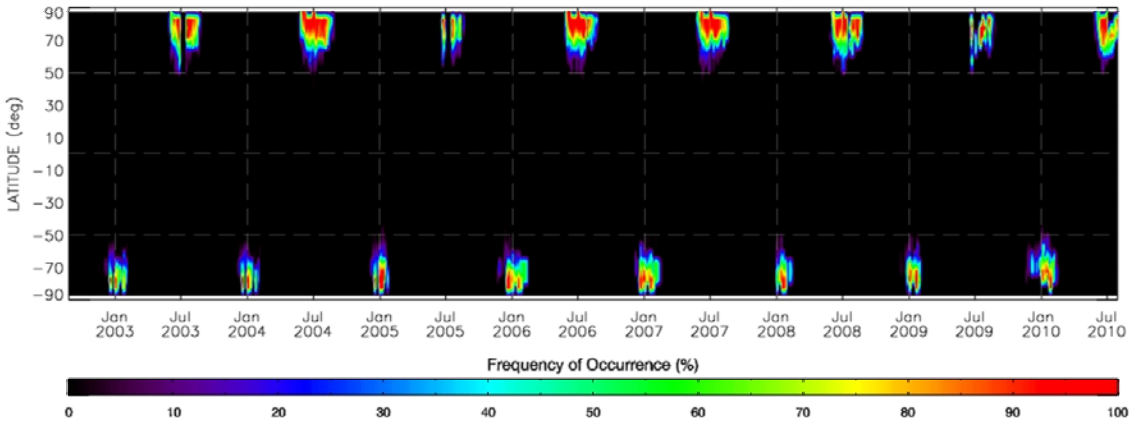
Dalaudier et al. 2006
Sofieva et al., 2009

Polar mesospheric clouds



- Detection from the solar light scattered by the ice particles

  → characteristic signature on GOMOS photometers vertical profiles
- Formation in the high latitude summertime mesopause region, in both hemispheres
- Detection and retrieval of their main properties (occurrence frequency , altitude, radiance) using GOMOS photometers



→ Comprehensive climatology over 8 years of GOMOS data (2002-2010):

more than 21 000 clouds detected: unique data set

- Particle size retrieval using GOMOS spectrometers

Pérot et al, ACP, 2010

Summary

- In 2002-2012 GOMOS measured 880 000 occultations
- Nighttime ozone data are validated
- Daytime occultations are presently poor quality
- Ozone data from daytime limb scattering are under validation
- HRTP data provides a new promising temperature data set
- H2O data are better quality in the new version 6
- New aerosol product from IASB (AERGOM) -> Vanhellemont
- GOMOS data are presently used for making climatologies and time series

- The next reprocessing will improve error estimates and improve cool/weak star ozone profiles. Improvements expected also in UTLS ozone. A change in ozone cross sections is under discussion (ACSO).

Original GOMOS data can be obtained from ESA. Vertically gridded data can be obtained from FMI in Matlab format or in standard binary format. Also GOMOS bright limb data are available from FMI.

More info on GOMOS: ACP special issue and GOMOS ATBD.