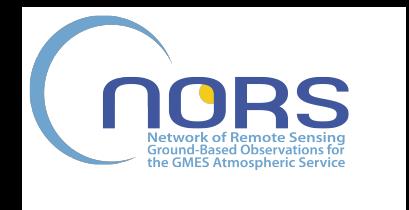
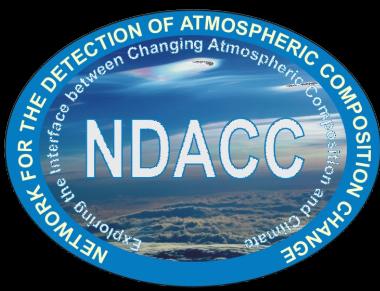


Surface O₃ from MaxDOAS measurements



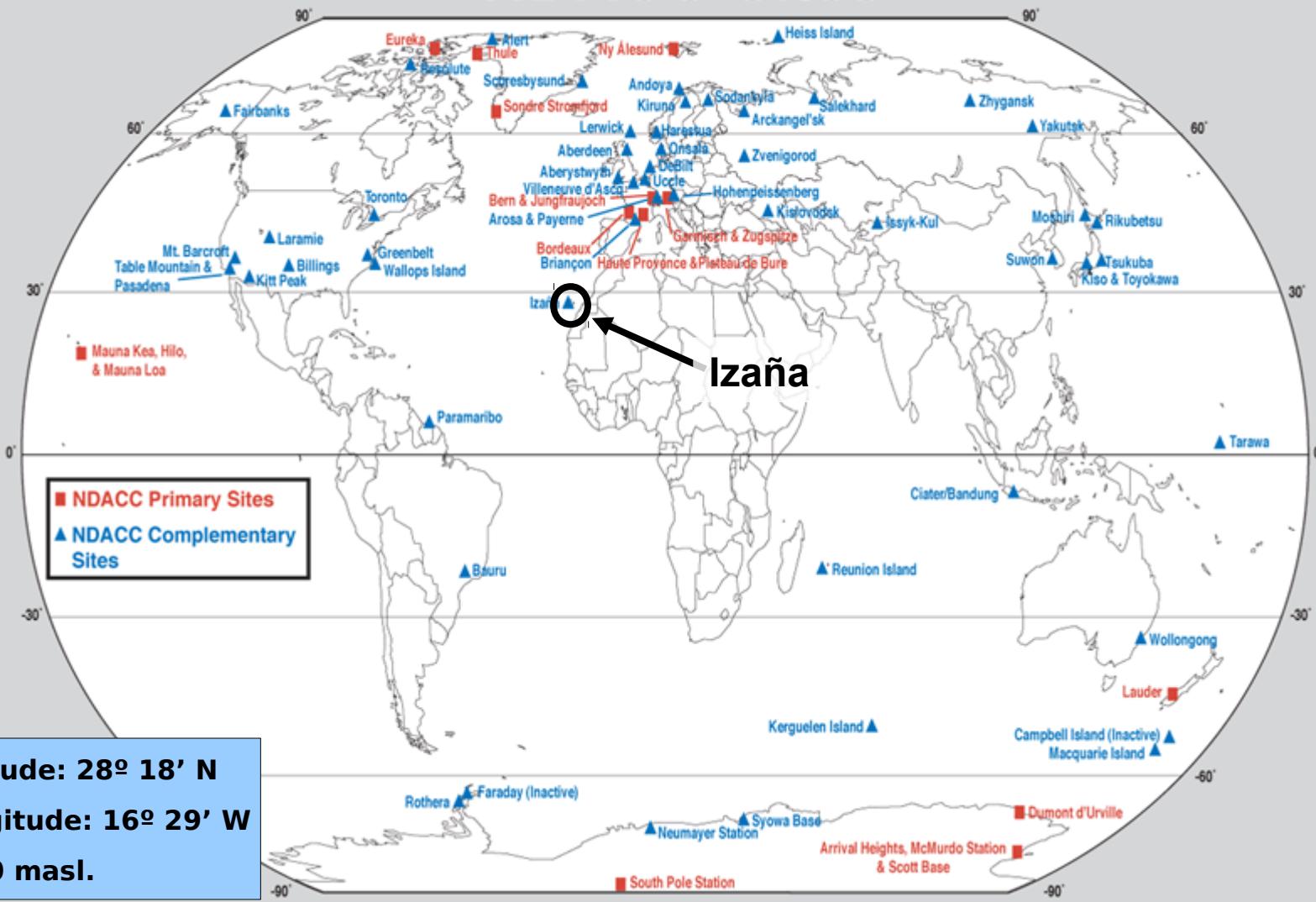
Area de Investigación e Instrumentación Atmosférica
Instituto Nacional de Técnica Aeroespacial (INTA)

- NORS: Commitment to provide tropospheric O_3 and NO_2 measurements (Izaña station) to compare with in situ measurements (WP5).
- OEM Rodgers on going:  Difficulty: Low gases concentrations with low variation at the Izaña Station (free troposphere)
- Geometrical approaches attempts:
 - 1) Path from O_4 MAXDOAS measurements
 - 2) Path from LibRadTran

1. IZAÑA STATION:

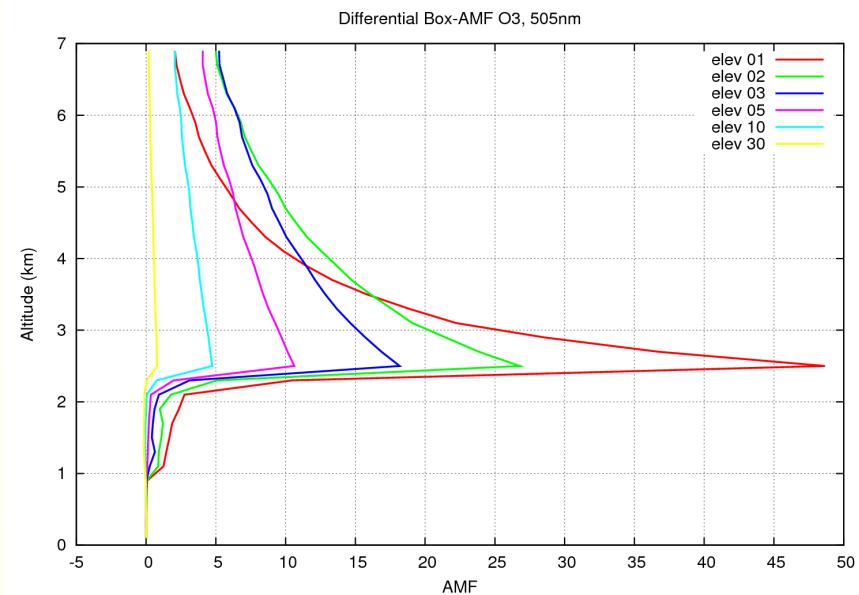
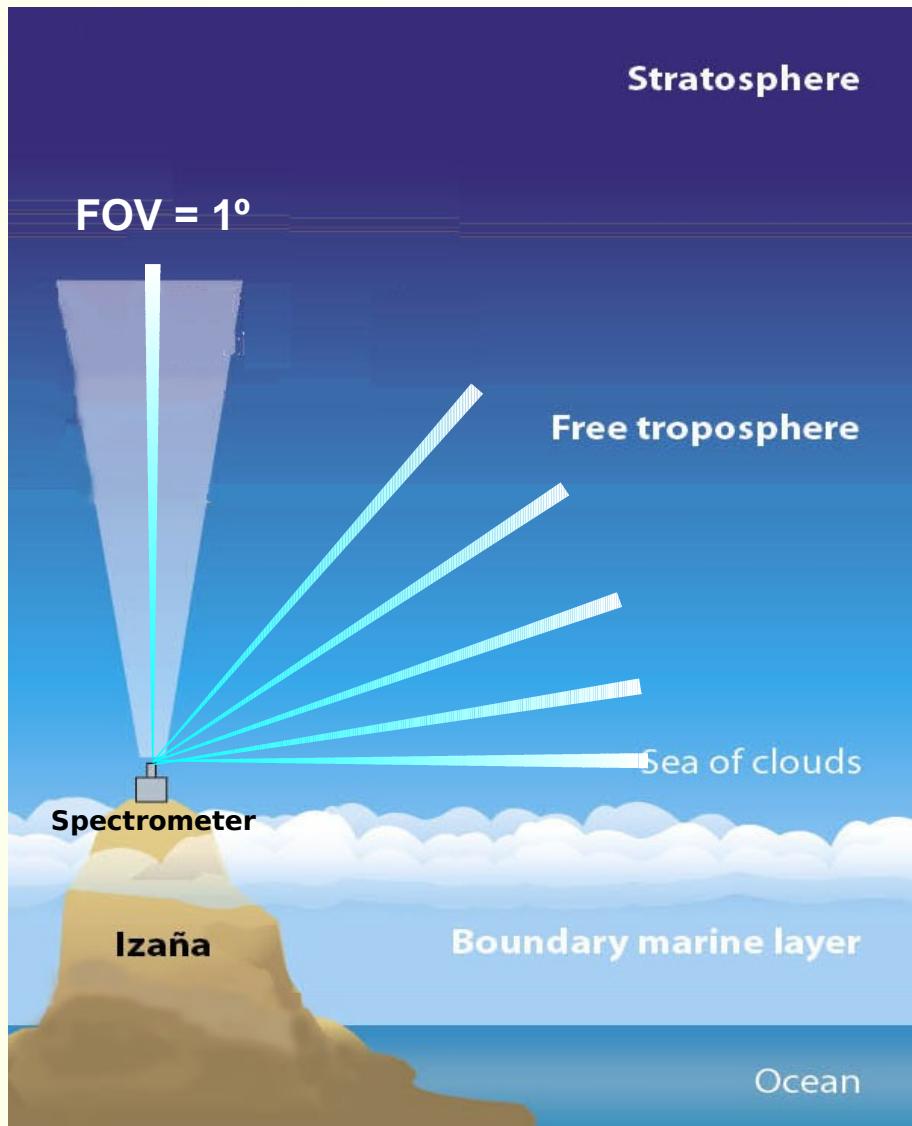
1.1. Location

NDACC Sites



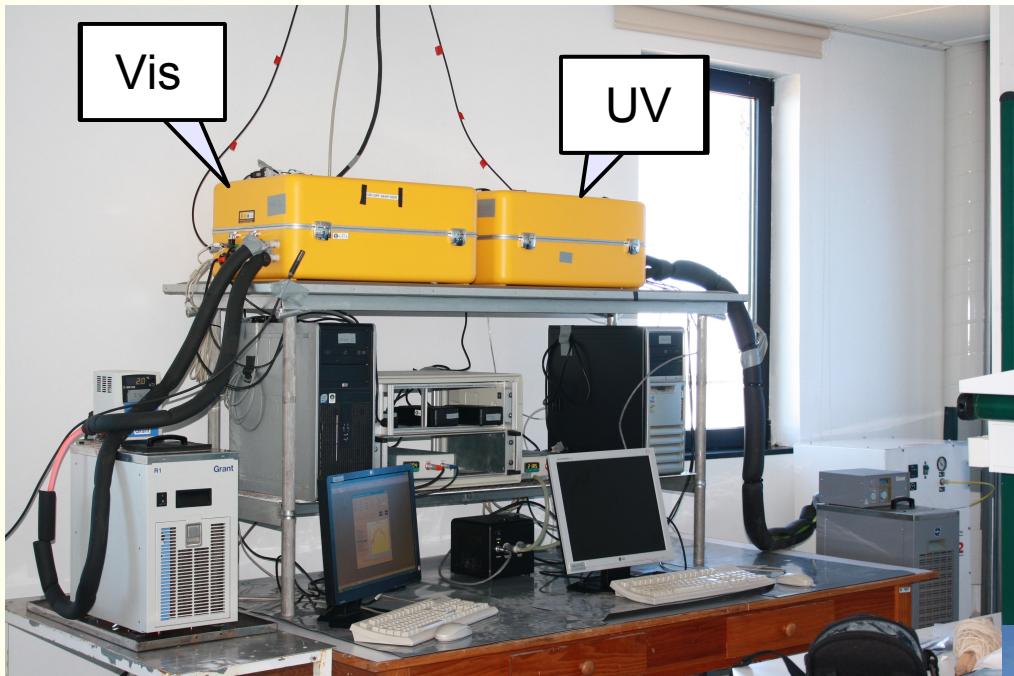
1. IZAÑA STATION:

1.1. Location



1. IZAÑA STATION: 1.2. RASAS II

4



Indoor

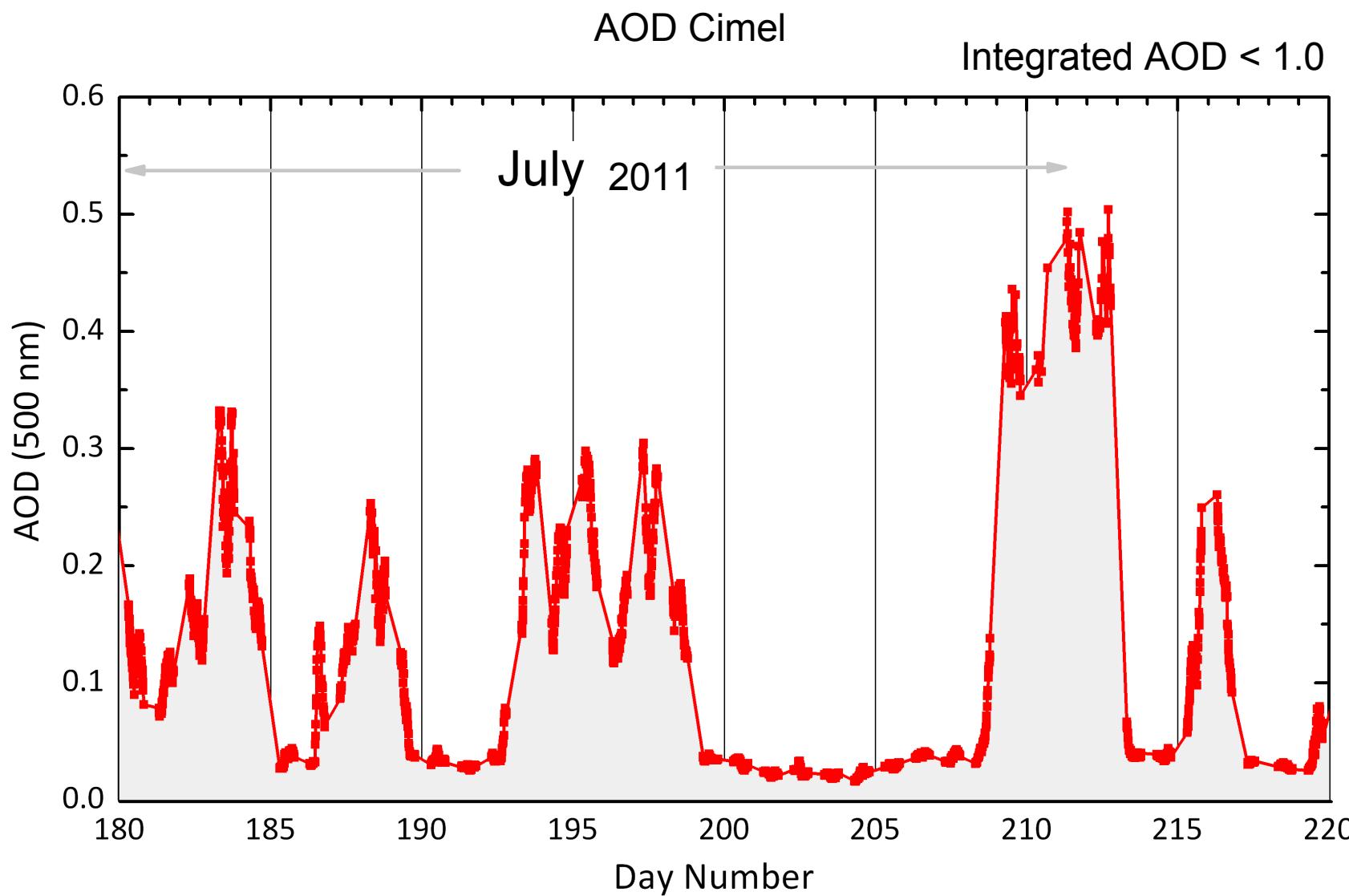
Outdoor



1. IZAÑA STATION:

1.3. Selected period

5



1. IZAÑA STATION:

1.3. Selected period

AOD Cimel

Integrated AOD < 1.0

0.6



0.1

0.0

180

185

190

195

200

205

210

215

220

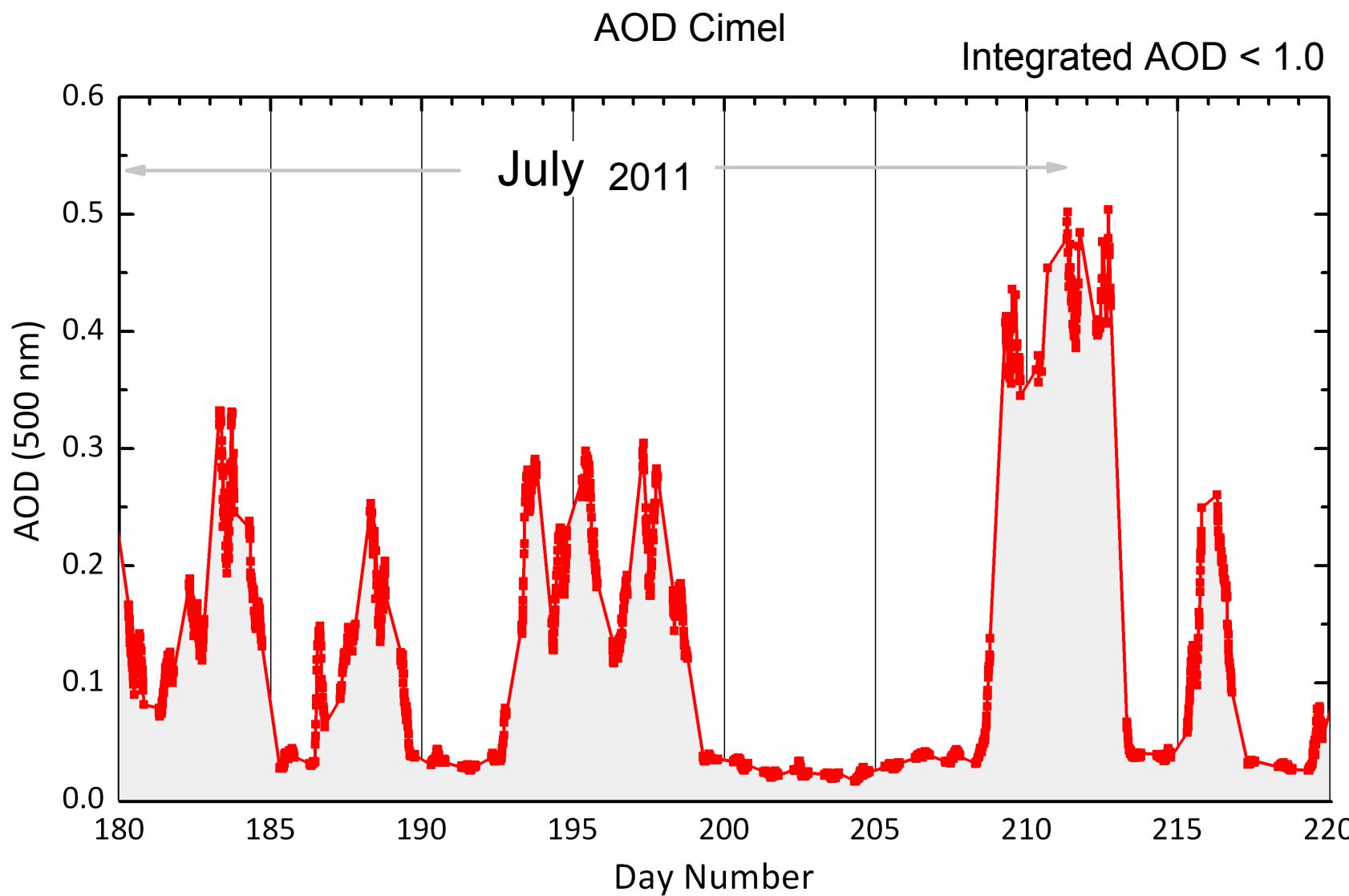
Day Number



1. IZAÑA STATION:

1.3. Selected period

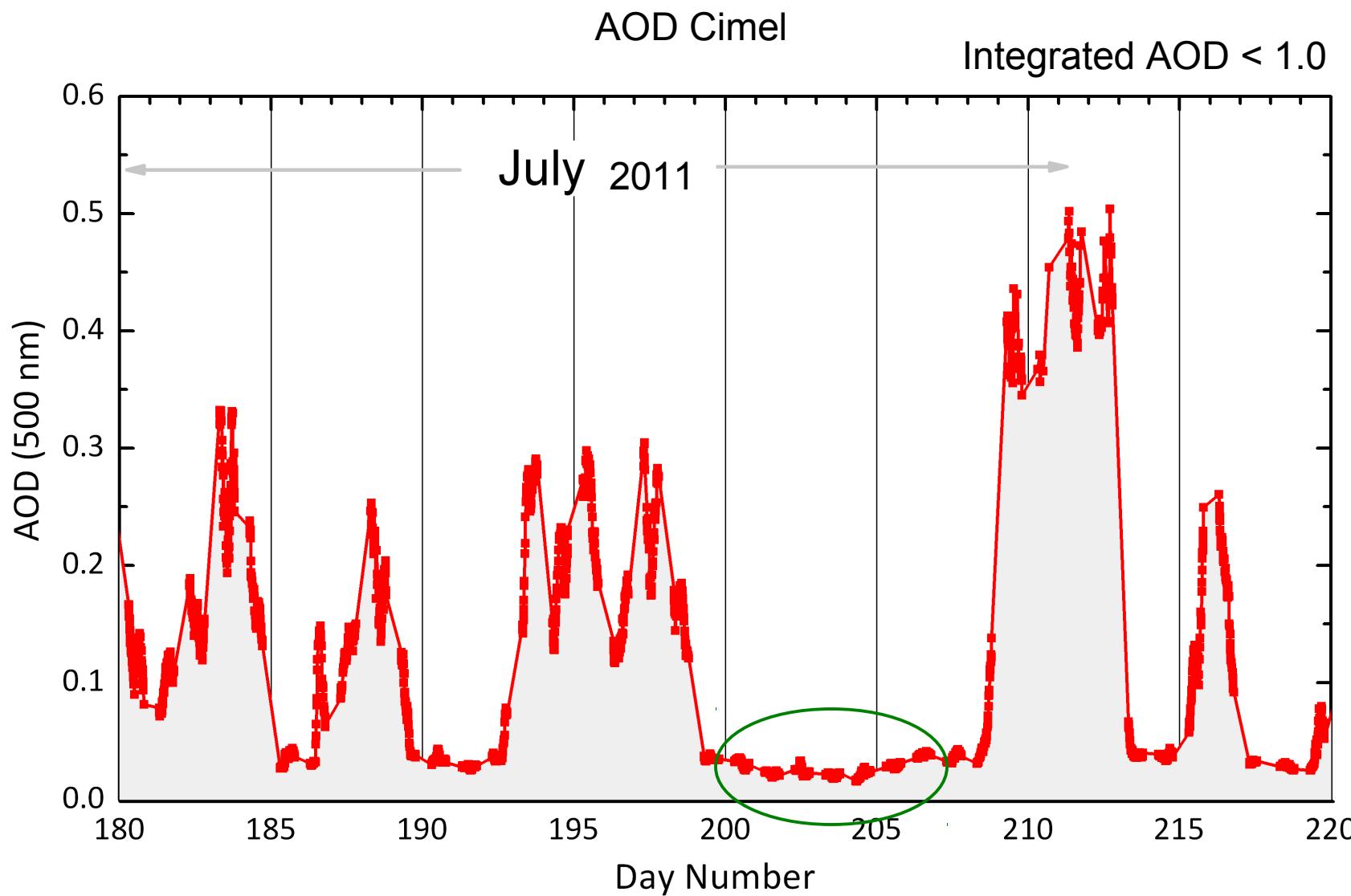
5



1. IZAÑA STATION:

1.3. Selected period

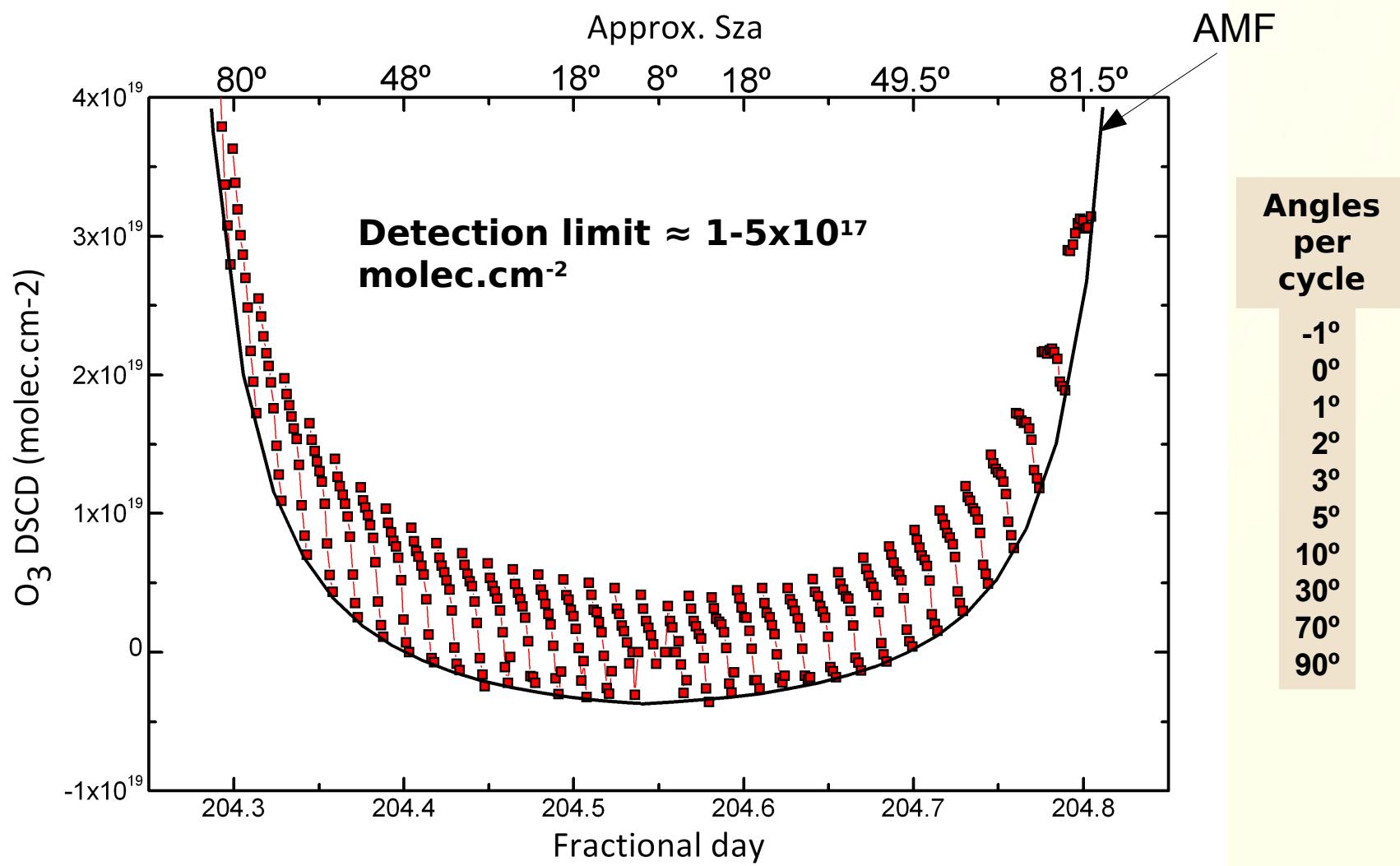
5



1. IZAÑA STATION:

1.4. Measurements

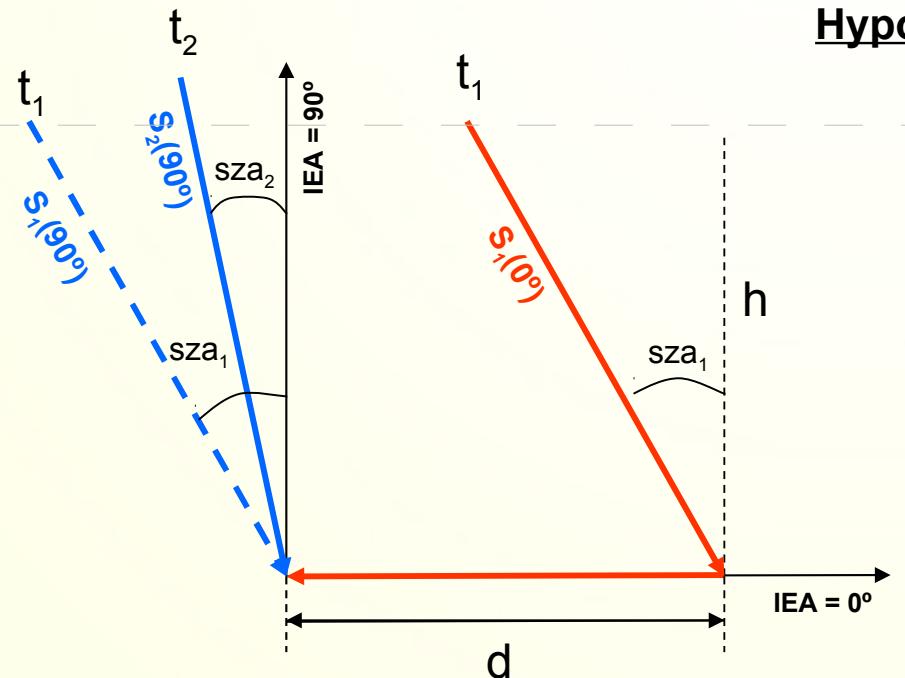
6



2. GEOMETRIC APPROXIMATION:

2.1. Reminder

7



Hypothesis: same scattering for both paths

$$\left. \begin{aligned} \cos(sza_1) &= \frac{h}{s_I(90^\circ)} \\ \cos(sza_2) &= \frac{h}{s_2(90^\circ)} \end{aligned} \right\}$$

$$s_I(90^\circ) = s_2(90^\circ) \frac{\cos(sza_2)}{\cos(sza_1)}$$

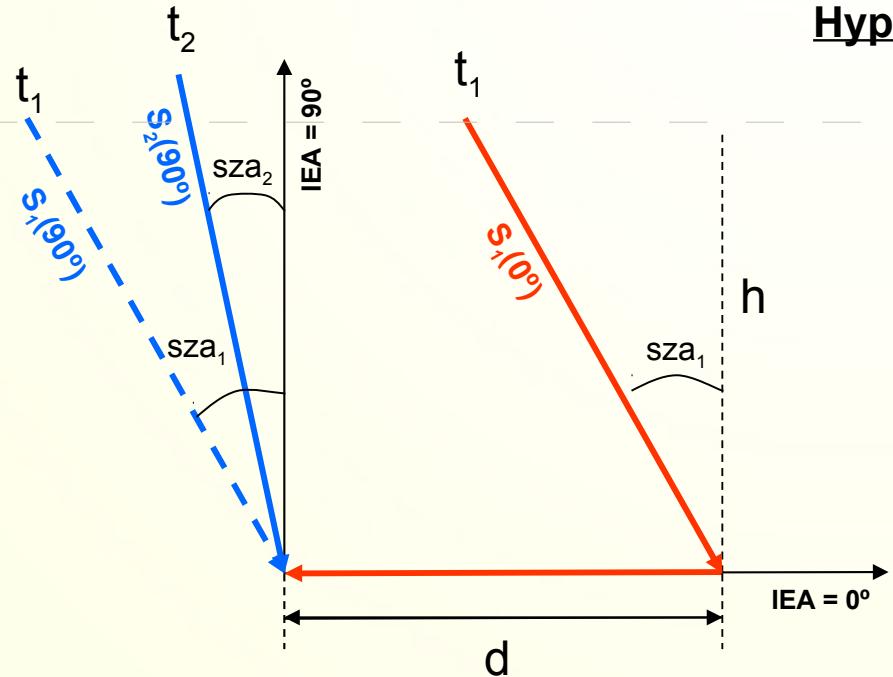
$$[O_3] = \frac{SCD_I(O_3, 0^\circ) - SCD_I(O_3, 90^\circ)}{d} = \frac{SCD_I(O_3, 0^\circ) - SCD_2(O_3, 90^\circ)f}{d}$$

$$d = \frac{SCD_I(O_4, 0^\circ) - SCD_2(O_4, 90^\circ)f}{[O_4]}$$

$[O_4]$: Obtained from the average value of O_2 at the station level in July 2011

2. GEOMETRIC APPROXIMATION:

2.1. Reminder



Hypothesis: same scattering for both paths

$$\cos(sza_1) = \frac{h}{s_1(90^\circ)}$$

$$\cos(sza_2) = \frac{h}{s_2(90^\circ)}$$

$$s_1(90^\circ) = s_2(90^\circ) \frac{\cos(sza_2)}{\cos(sza_1)}$$

$$[O_3] = \frac{SCD_1(O_3, 0^\circ) - SCD_1(O_3, 90^\circ)}{d} = \frac{SCD_1(O_3, 0^\circ) - SCD_2(O_3, 90^\circ)f}{d}$$

$$d = \frac{SCD_1(O_4, 0^\circ) - SCD_2(O_4, 90^\circ)f}{[O_4]}$$

$[O_4]$: Obtained from the average value of O_2 at the station level in July 2011

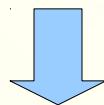
2. GEOMETRIC APPROXIMATION:

8

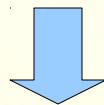
2.1. Reminder

Actually:

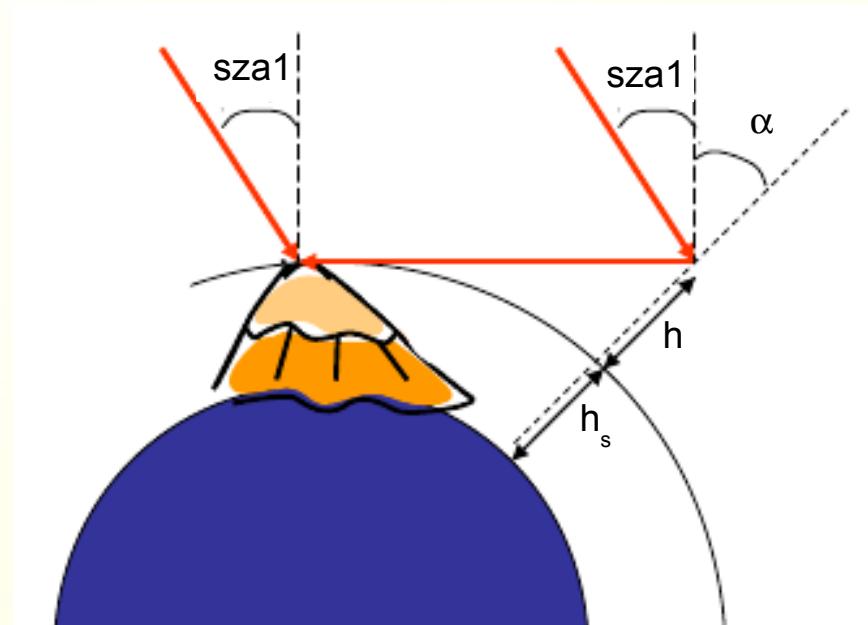
$$s_I(90^\circ) = s_2(90^\circ) \frac{\cos(sza_2)}{\cos(sza_1)}$$



$$s_I(90^\circ) = s_2(90^\circ) \frac{\cos(sza_2)}{\cos(sza_1 + \alpha)}$$



$$f = \frac{\cos(sza_2)}{\cos(sza_1 + \alpha)}$$



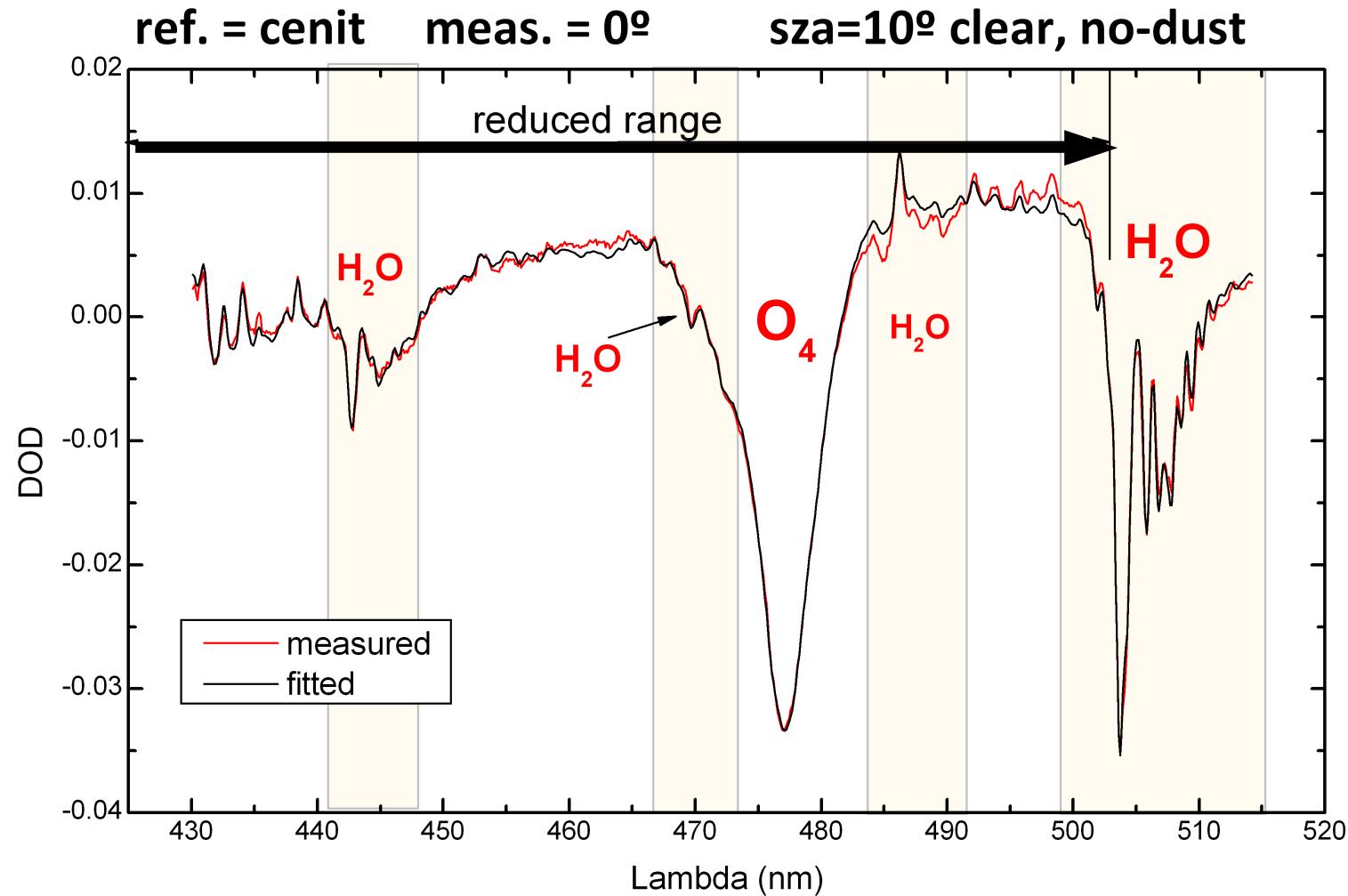
$[O_4]$ is the average value of the O_4 concentration over h

2. GEOMETRIC APPROXIMATION:

9

2.2. Selected spectral range for O_4

Strong water absorption with respect to zenith reference

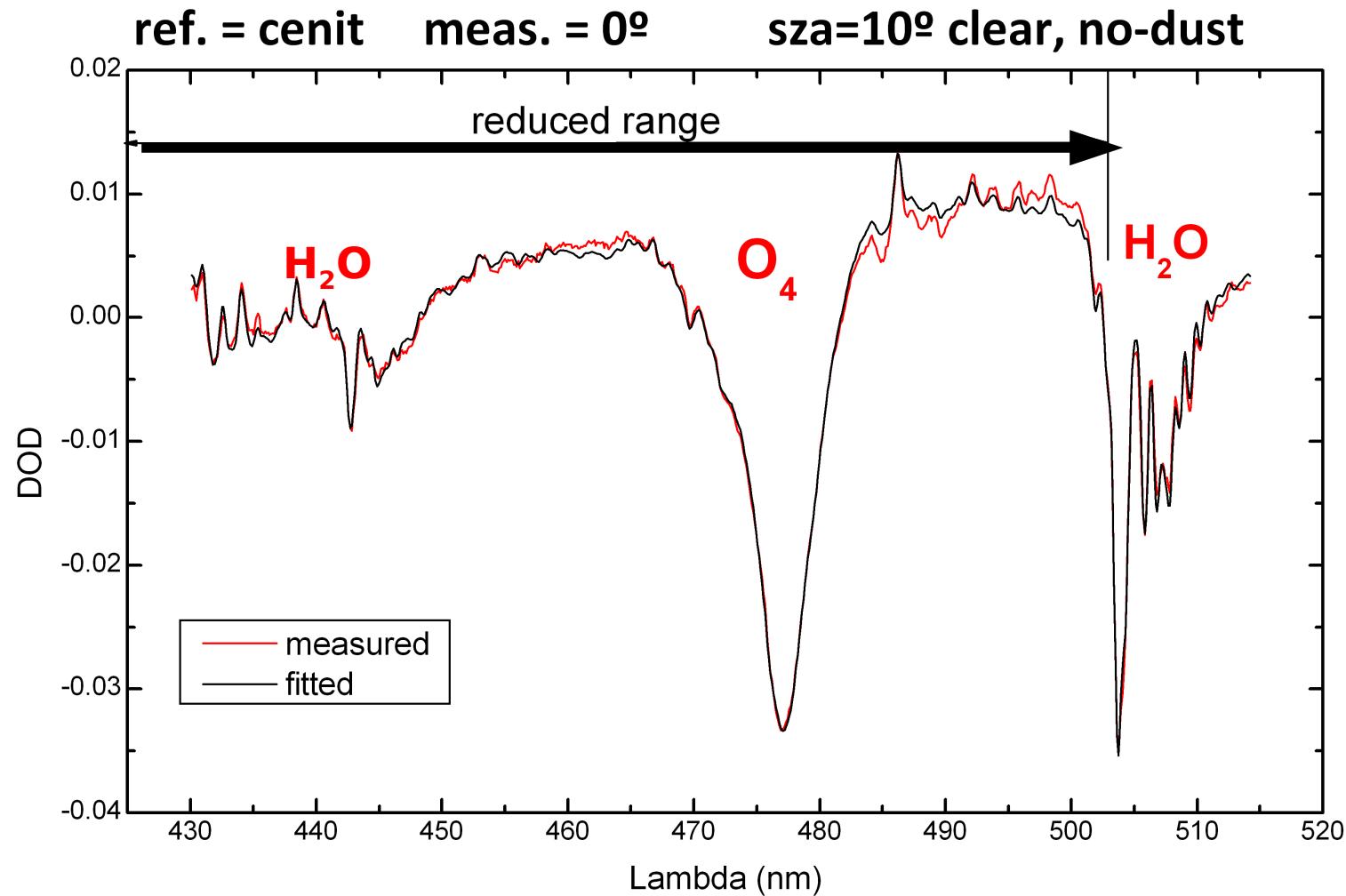


2. GEOMETRIC APPROXIMATION:

10

2.2. Selected spectral range for O_4

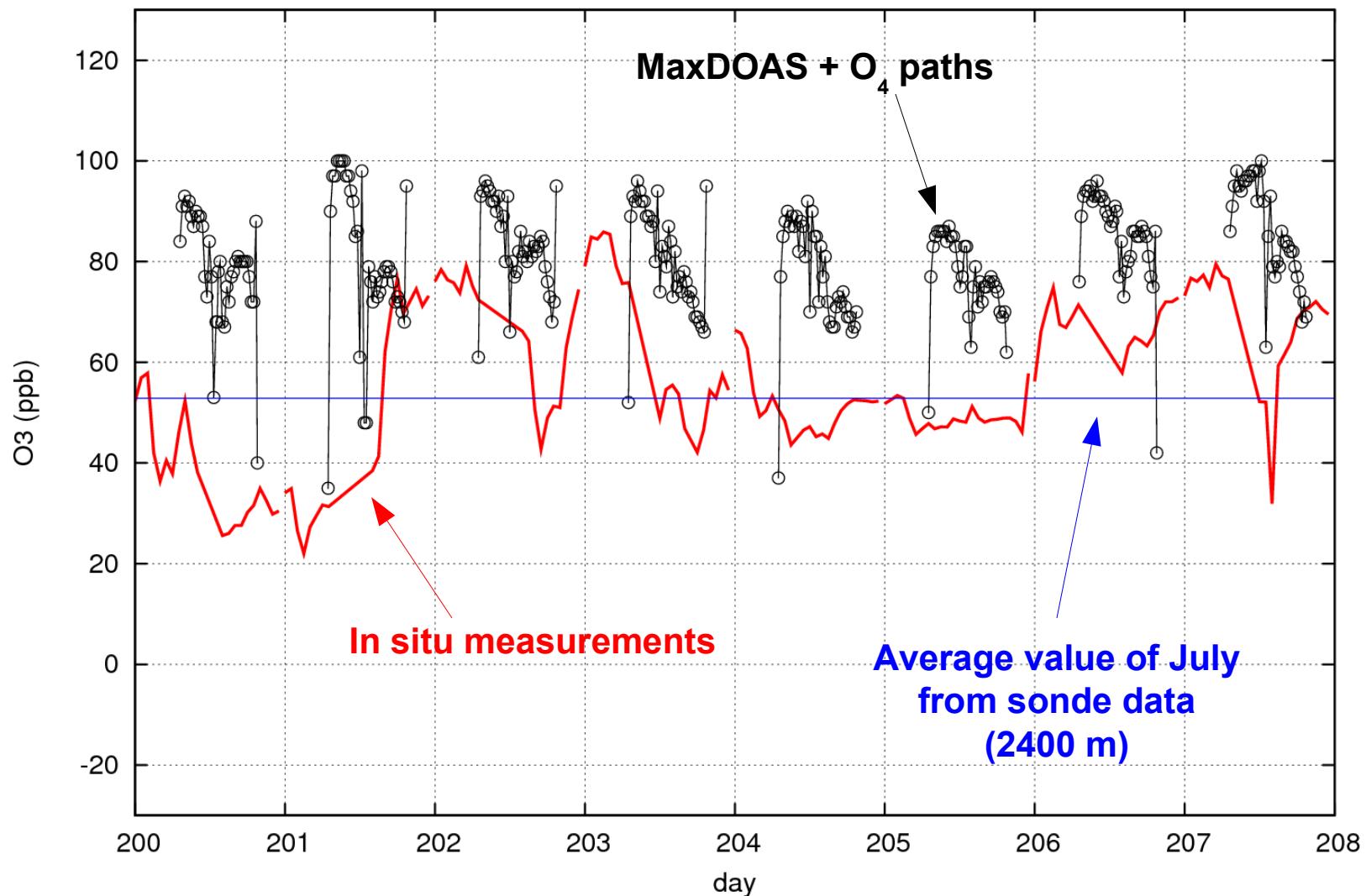
Range reduced to avoid large water band in horizontal path



2. GEOMETRIC APPROXIMATION:

2.3. Results

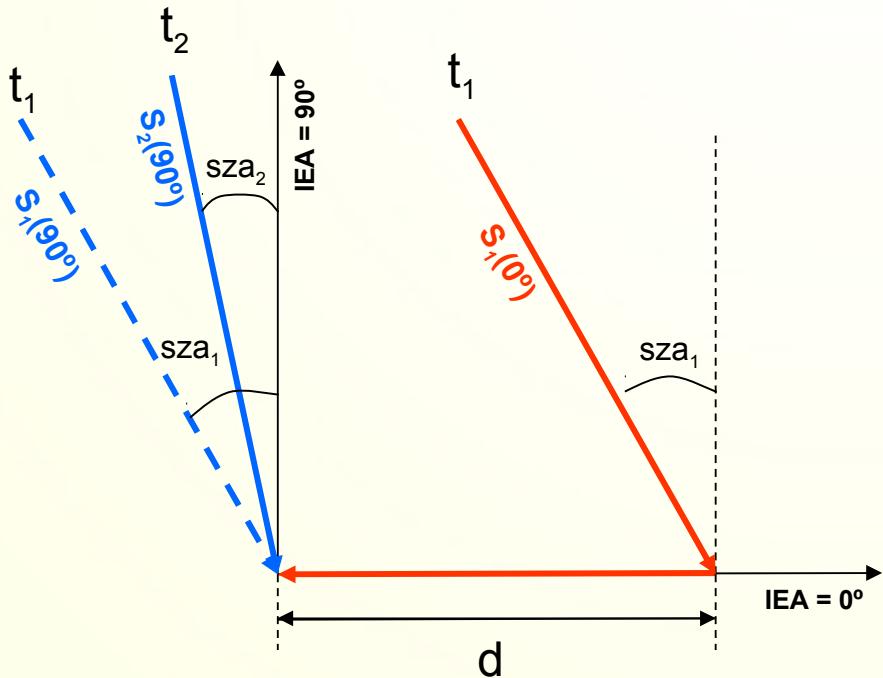
11



3. SIMULATED OPTICAL PATHS:

12

3.1. Introduction



$$AMF_1 = \frac{SCD_1(90^\circ)}{VC}$$

$$AMF_2 = \frac{SCD_2(90^\circ)}{VC}$$



$$SCD_1(90^\circ) = SCD_2(90^\circ) \frac{AMF_1}{AMF_2} = SCD_2(90^\circ) \frac{s_1(90^\circ)}{s_2(90^\circ)}$$

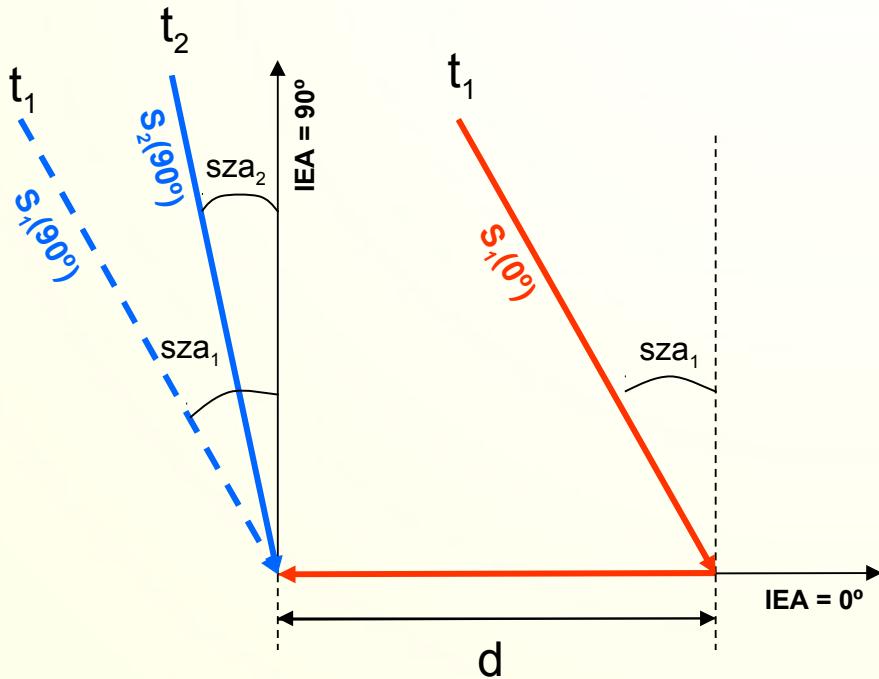
$$[O_3] = \frac{SCD_1(0^\circ) - SCD_1(90^\circ)f'}{d}$$

$$d = s_1(0^\circ, sza_1) - s_2(90^\circ, sza_2)$$

3. SIMULATED OPTICAL PATHS:

12

3.1. Introduction



$$AMF_1 = \frac{SCD_1(90^\circ)}{VC}$$

$$AMF_2 = \frac{SCD_2(90^\circ)}{VC}$$



$$SCD_1(90^\circ) = SCD_2(90^\circ) \frac{AMF_1}{AMF_2} = SCD_2(90^\circ) \frac{s_1(90^\circ)}{s_2(90^\circ)}$$

$$[O_3] = \frac{SCD_1(0^\circ) - SCD_1(90^\circ)}{d}$$

$$d = s_1(0^\circ, sza_1) - s_2(90^\circ, sza_2)$$

3. SIMULATED OPTICAL PATHS:

3.2. Calculations

Atmosphere model: afglt

No aerosols

Cloud: 0.6 – 1.1 km, $\tau = 0.5$

Surface albedo = 0.07

Instrument Azimuth = 0°

Relative Azimuth = 0°

Station Altitude = 2.37 km

IEA = 0.1° and 70°

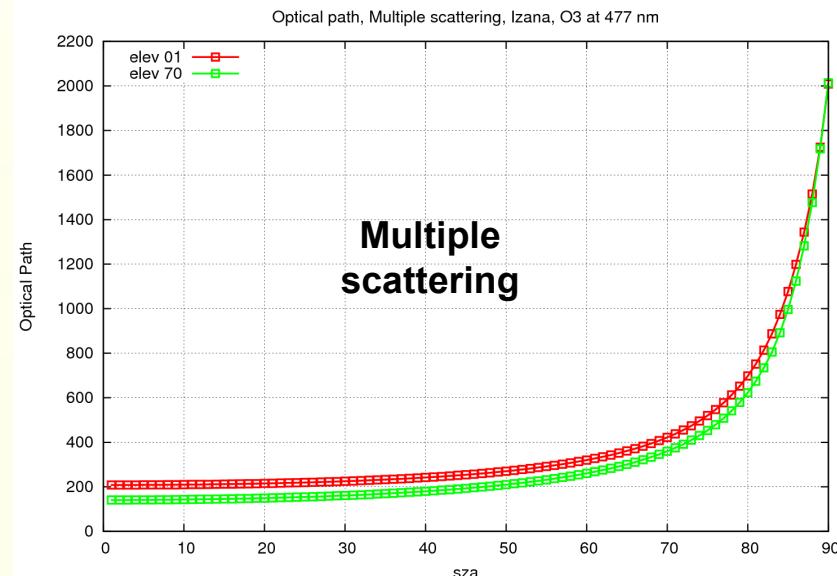
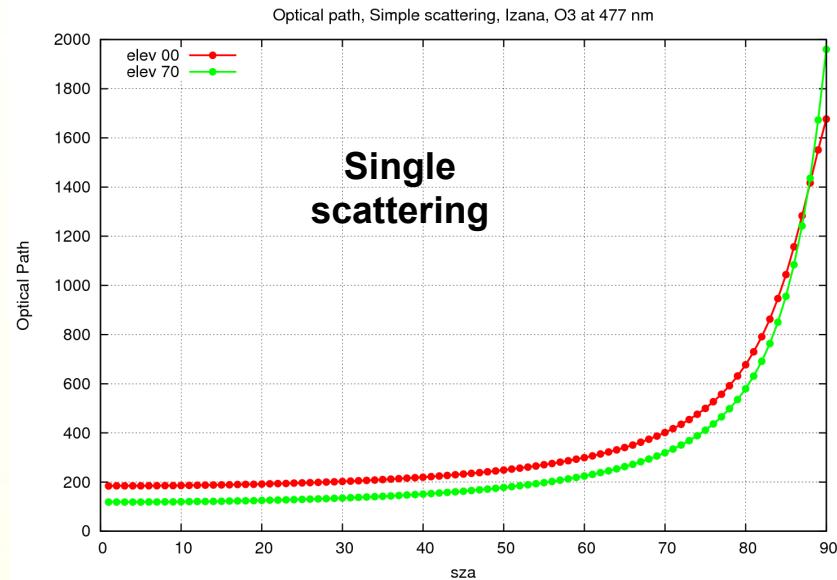
Sza = 1° – 90°

$$\sigma(O_3) = 5.63681 \cdot 10^{-22} \text{ cm}^2/\text{molec}$$

$\lambda = 477 \text{ nm}$

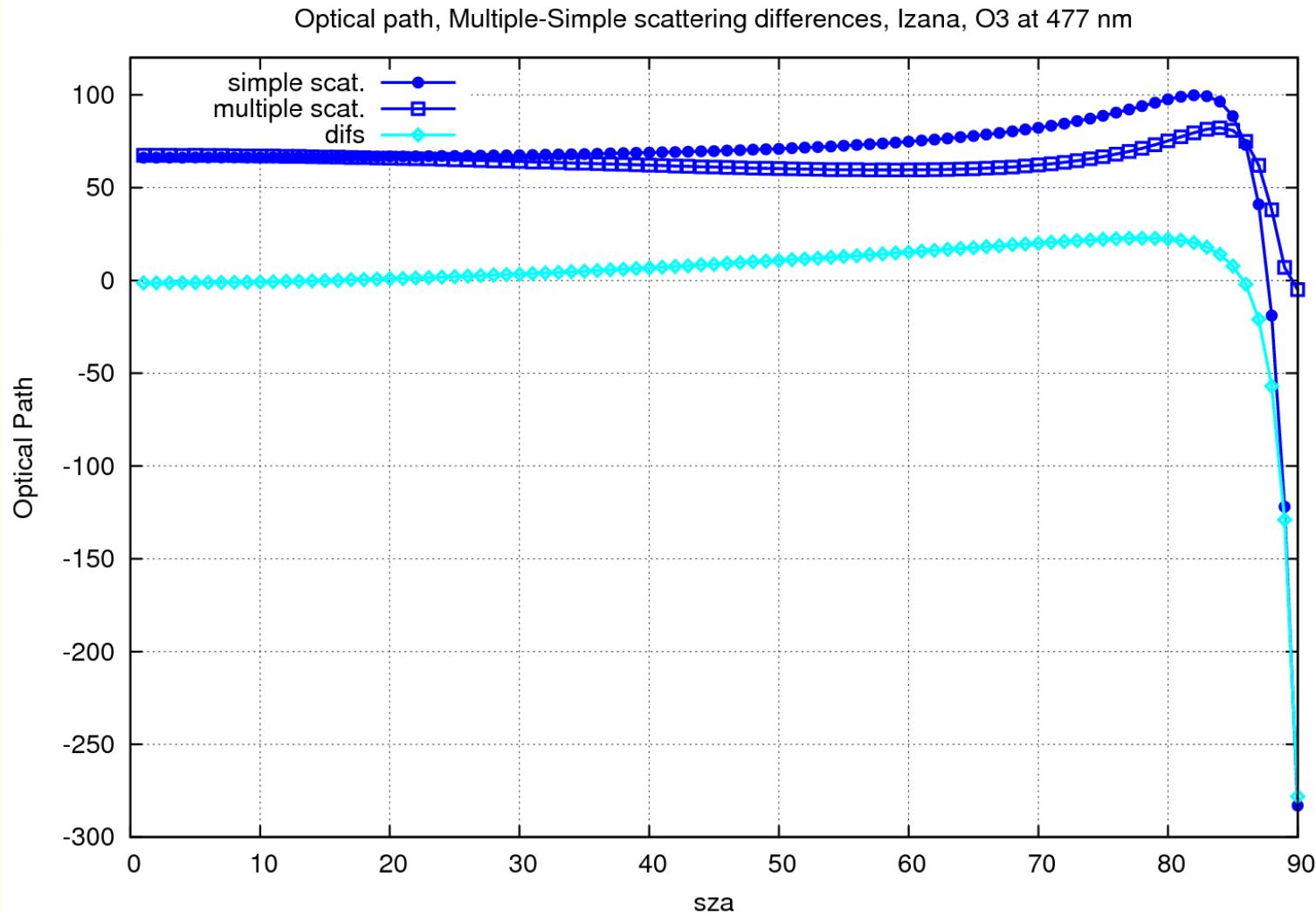
Single and Multiple Scattering

Solver: sdisort (libRadTran)



3. SIMULATED OPTICAL PATHS: 3.2. Calculations

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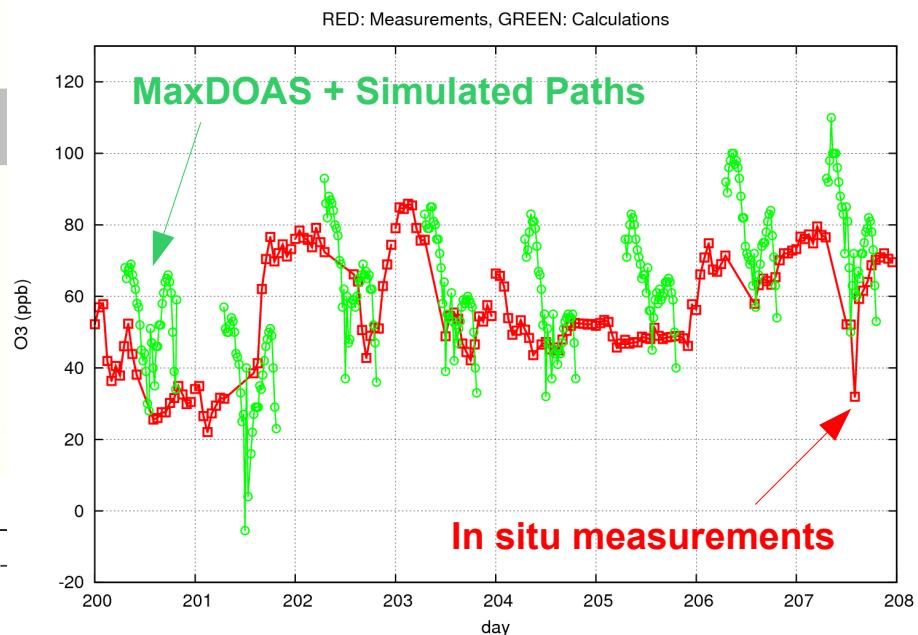
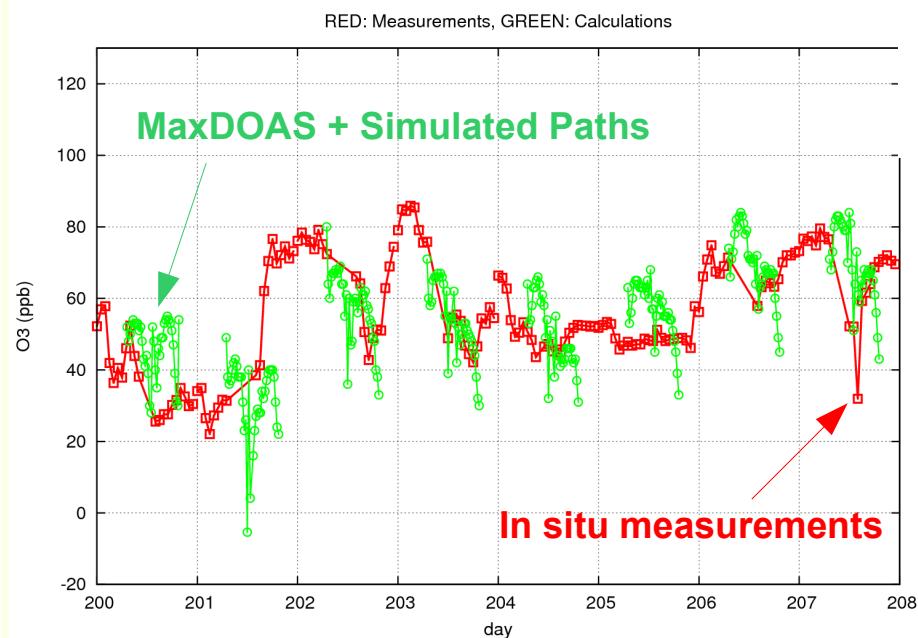


3. SIMULATED OPTICAL PATHS:

3.3. Results

Multiple scattering

Daily variations ~ 55 ppb



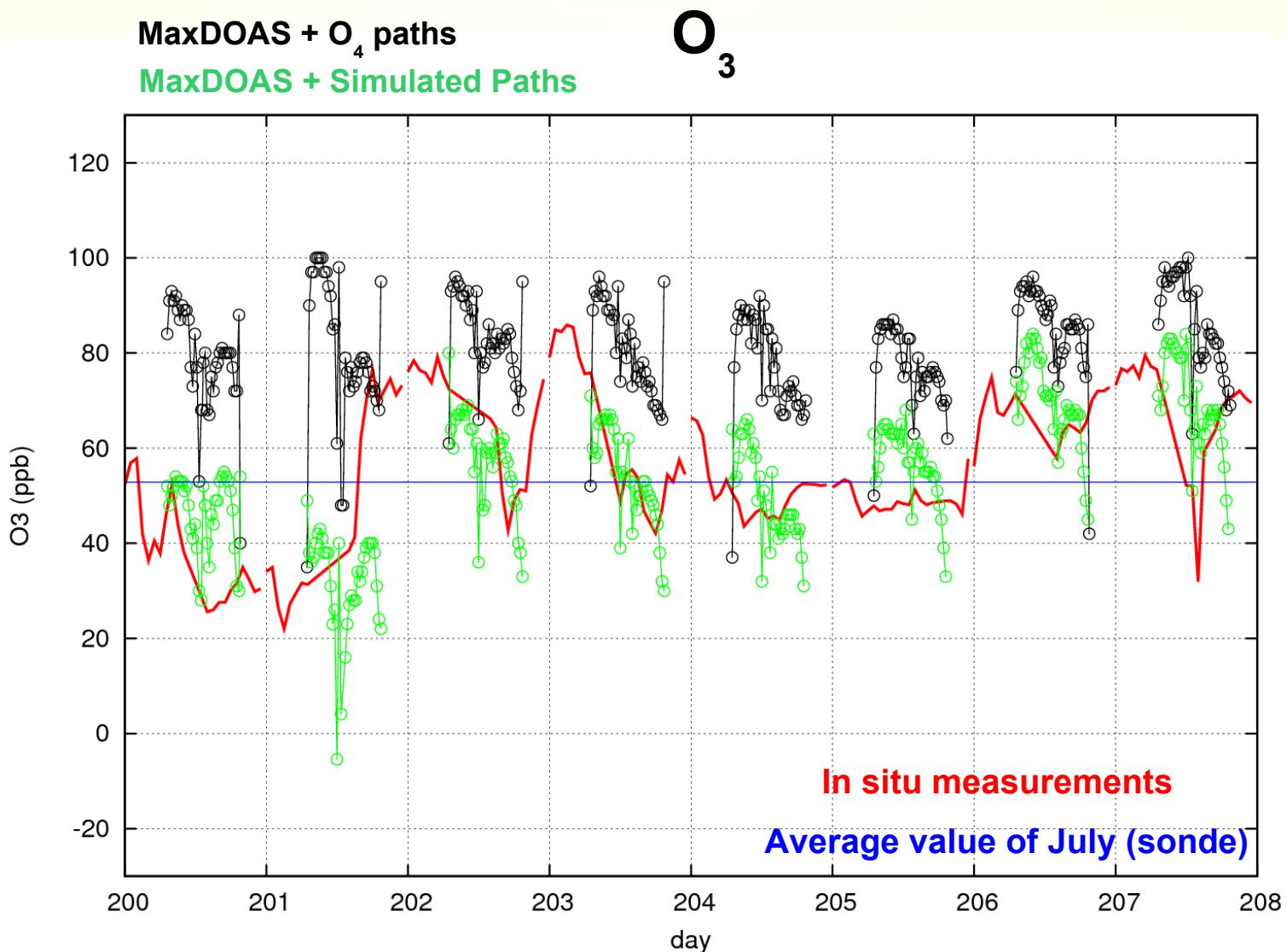
Single scattering

Daily variations ~ 40 ppb

3. SIMULATED OPTICAL PATHS:

16

3.4. Comparison



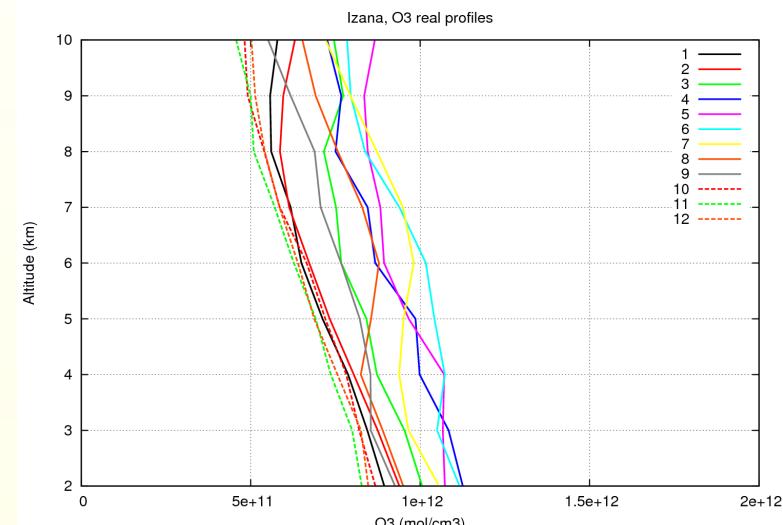
4. CONCLUSIONS, SUGGESTIONS...

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- Using the geometrical approximation with the simulated optical paths (libradtran) we obtain a good estimation of the surface O₃ concentration.
-

FUTURE WORKS:

- Same study for NO₂
- Extension to other than “clean days” conditions.
- Is OEM appropriated for surface data at Izaña?
- OEM for stratospheric component and comparison with ozone-sonde data.



THANK YOU