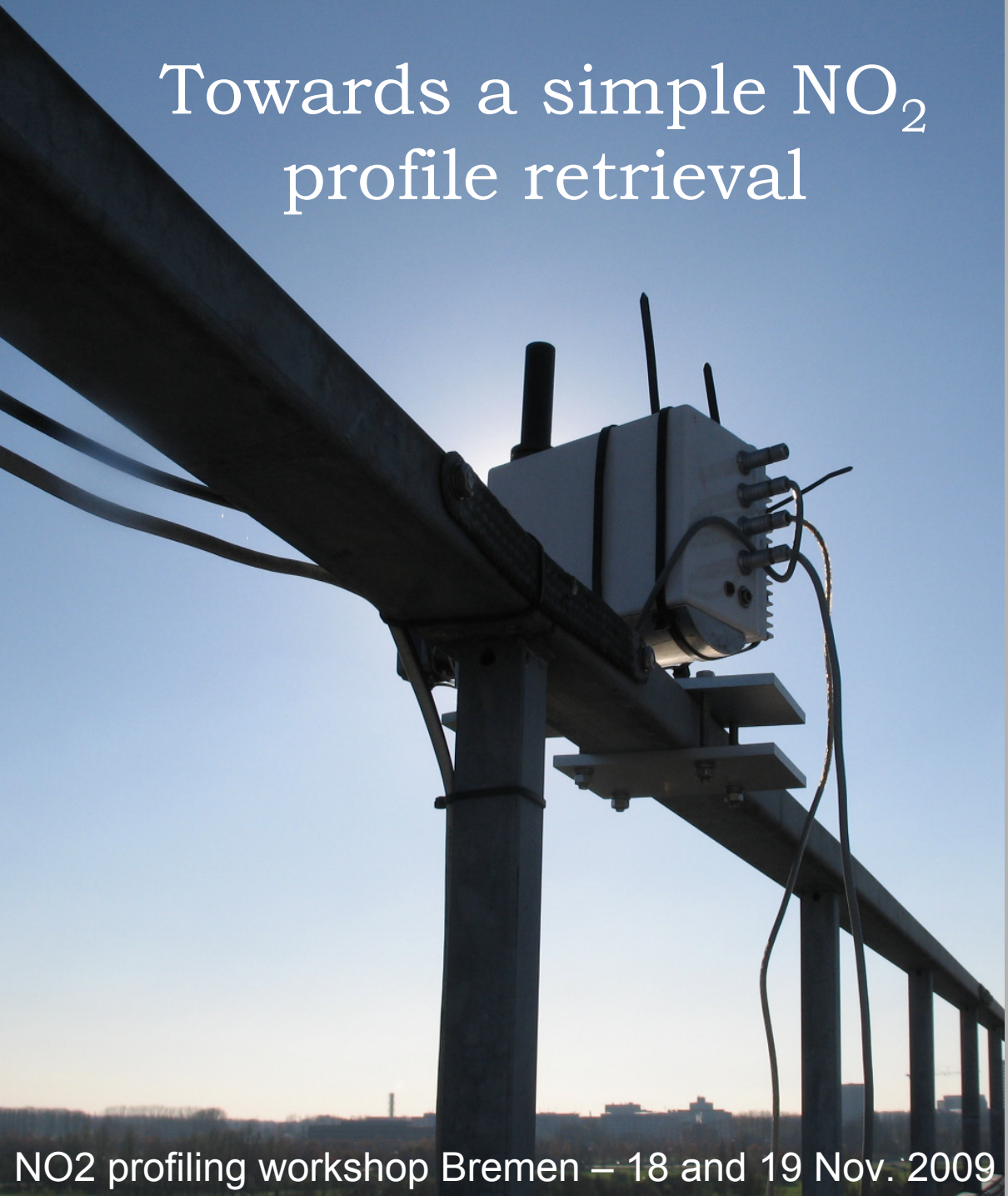

Towards a simple NO_2 profile retrieval

NO2 profiling workshop Bremen – 18 and 19 Nov. 2009

MAX-DOAS KNMI

Tim Vlemmix
Ankie Piters
Piet Stammes

Overview

MAX-DOAS TVCD retrieval based on AOT estimation from relative intensity (RI)

Choosing a reference for the RI (CINDI)

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Conclusions

DAK radiative transfer model comparison

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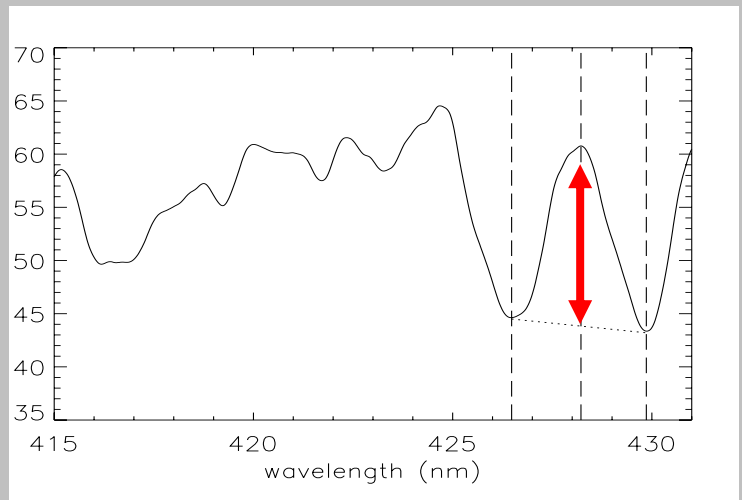
MAX-DOAS differential air mass factors

→DAK radiative transfer model

→Atmosphere with NO_2 and aerosol in same layer (block profile)

→Direct calculation of DAMF from three wavelengths (similar to DOAS)

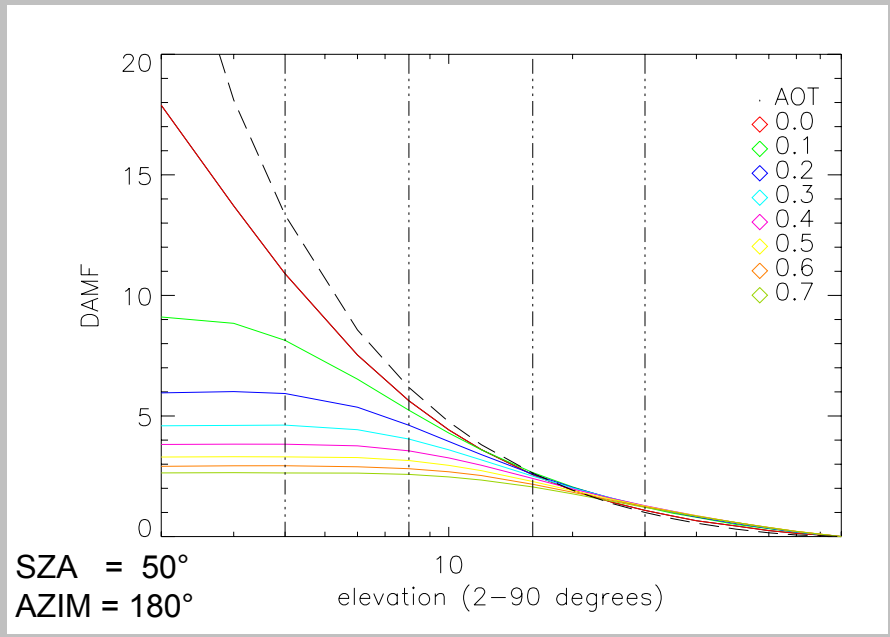


$$DAMF_{\alpha} = \frac{DSCD_{\alpha}}{TVCD}$$

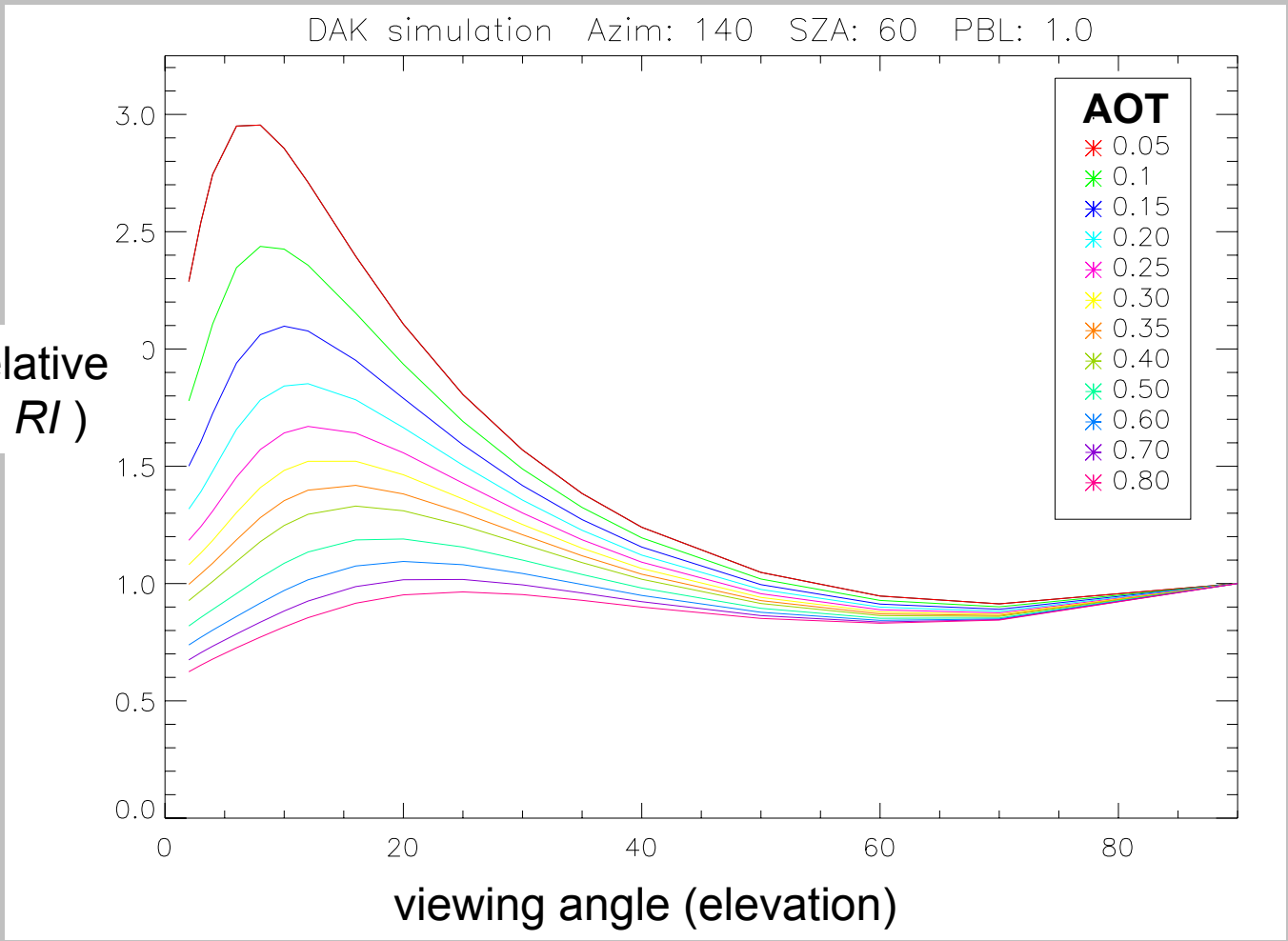
Look-up tables: RI and DAMF

→Depends on viewing geometry (sun, instrument), AOT, boundary layer height

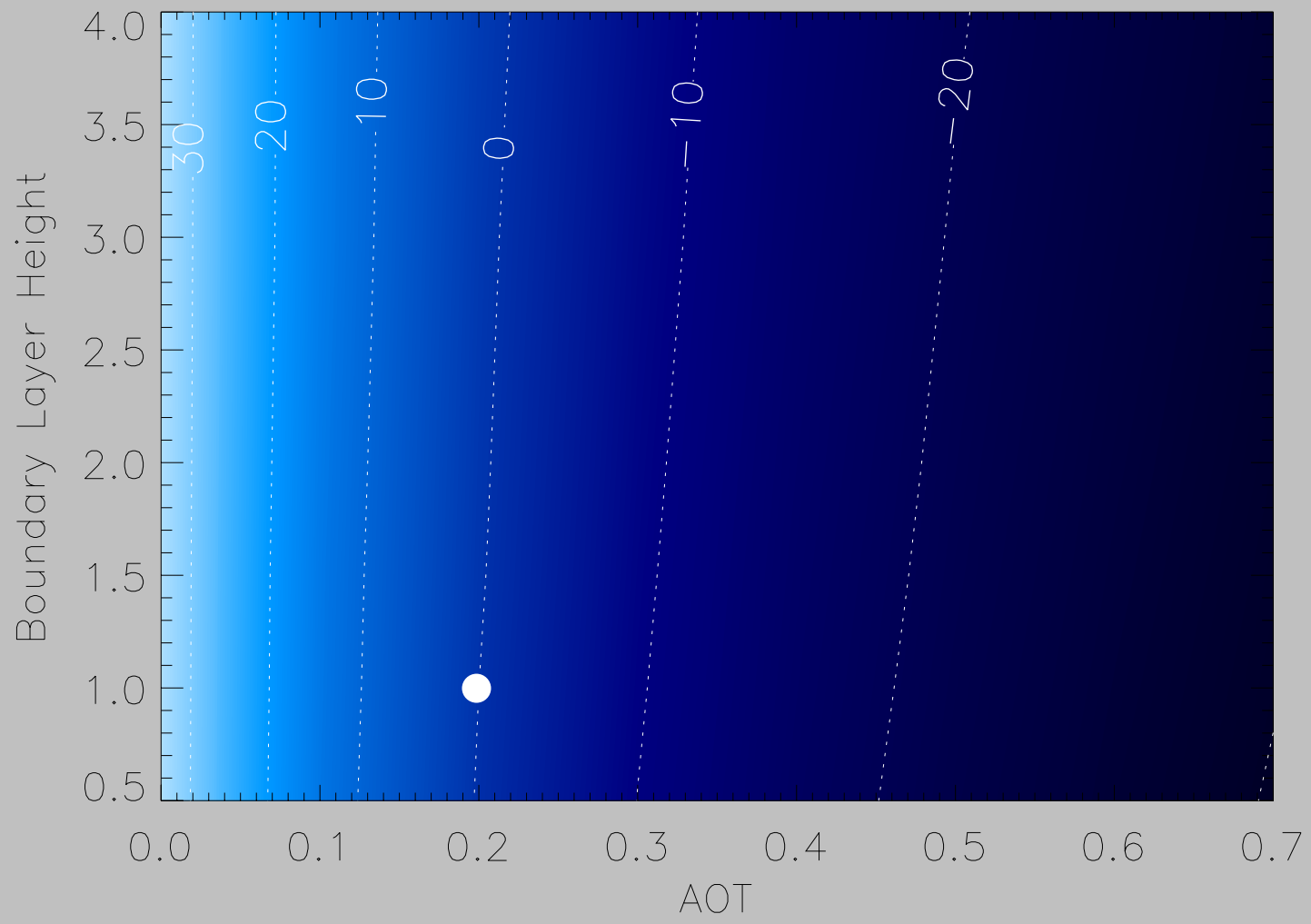
→Fixed parameters: profile shapes, asymmetry parameter, surface albedo etc.



Intensity relative to zenith (*RI*)

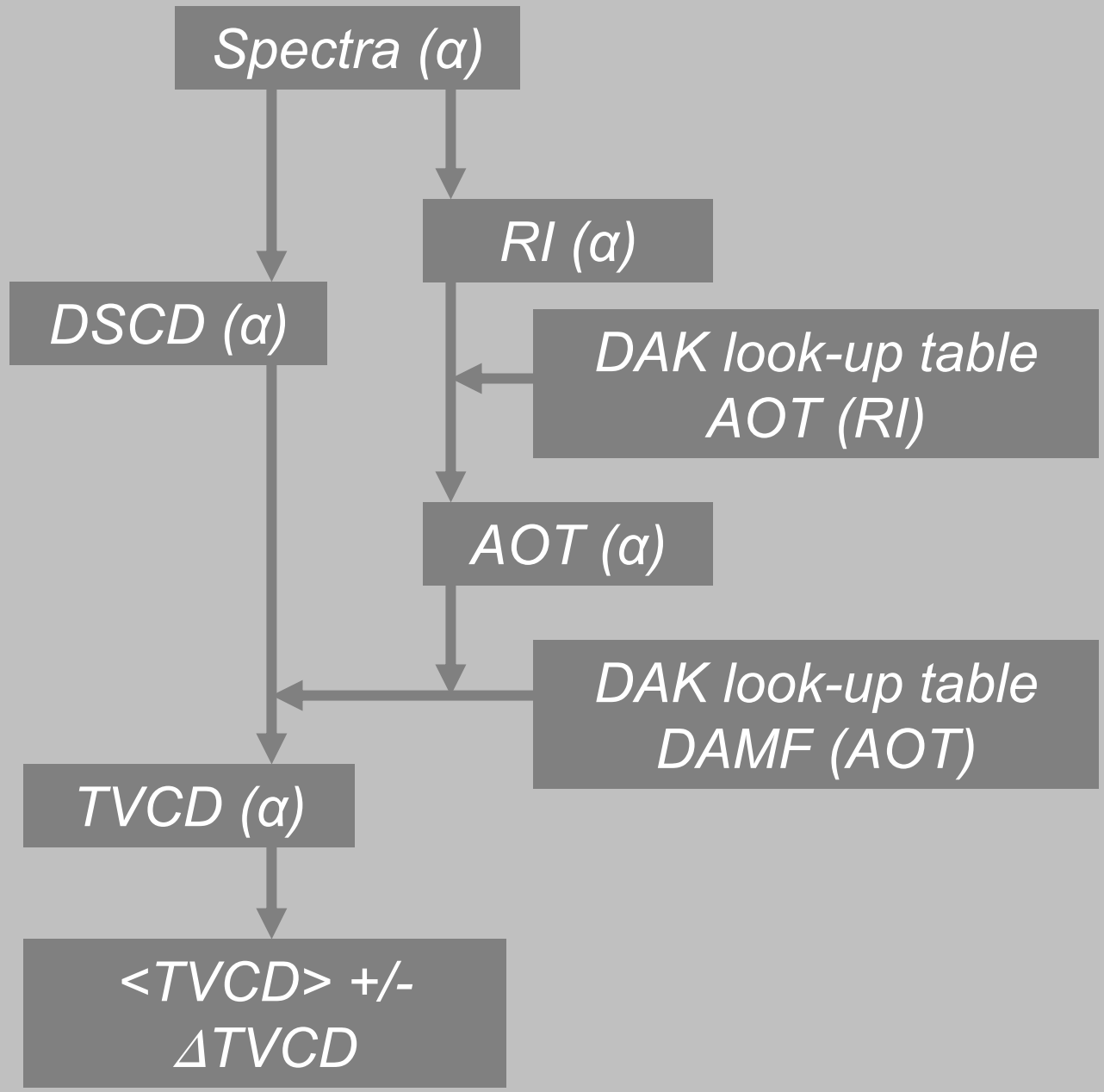


All values are % difference relative to:



Relative Intensity @ 30°

TVCD retrieval algorithm

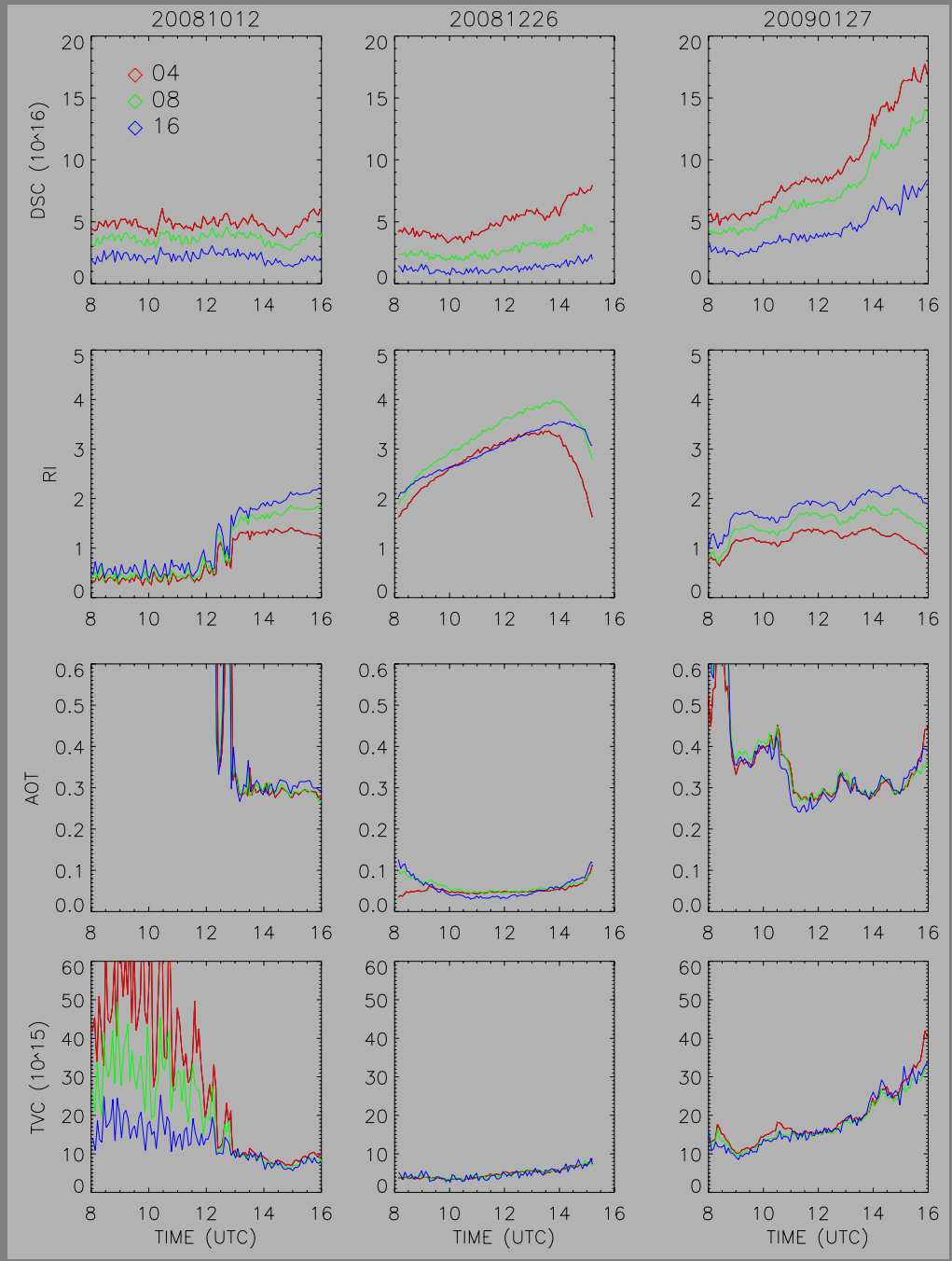


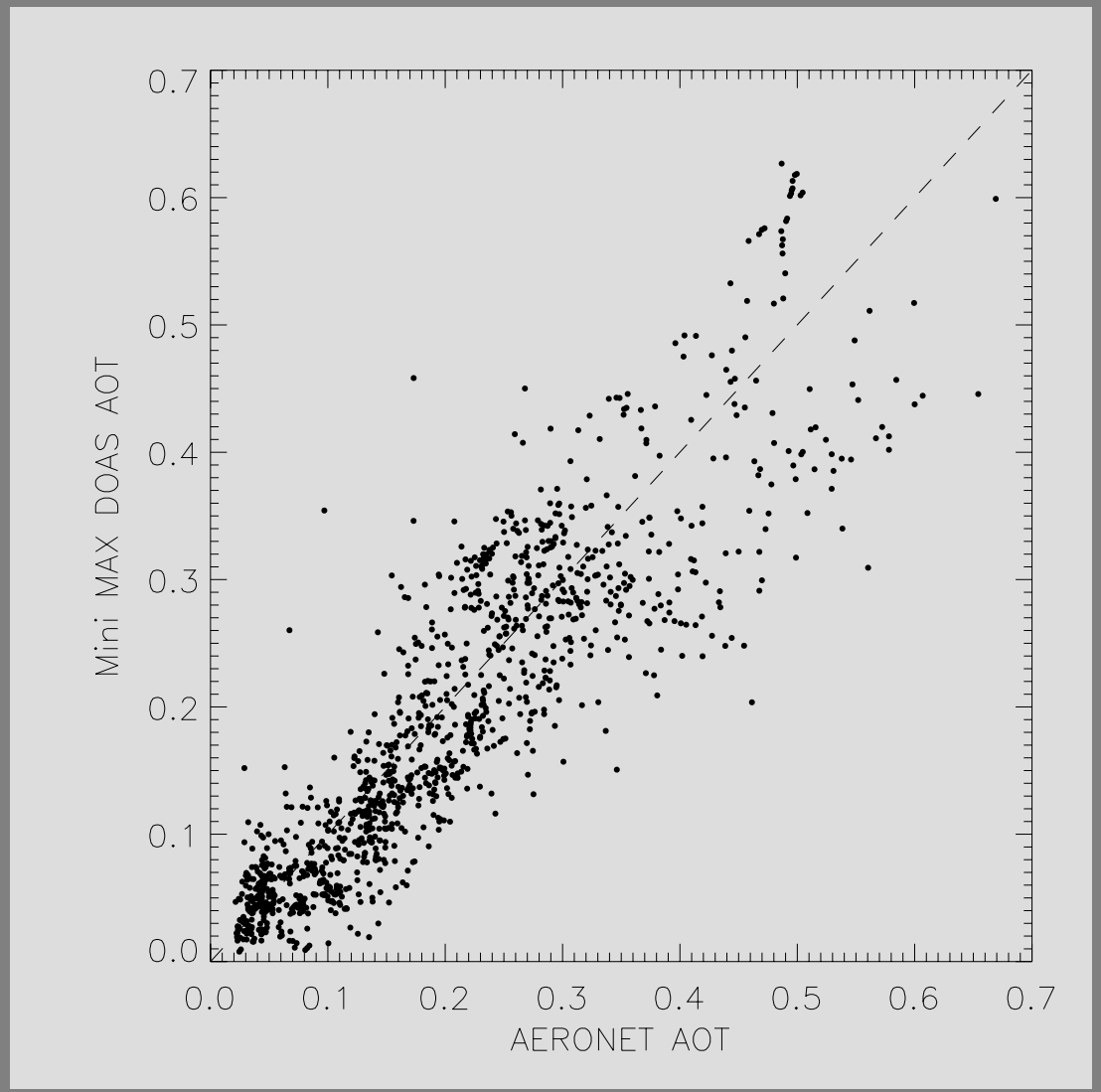
Differential Slant Column

Relative Intensity

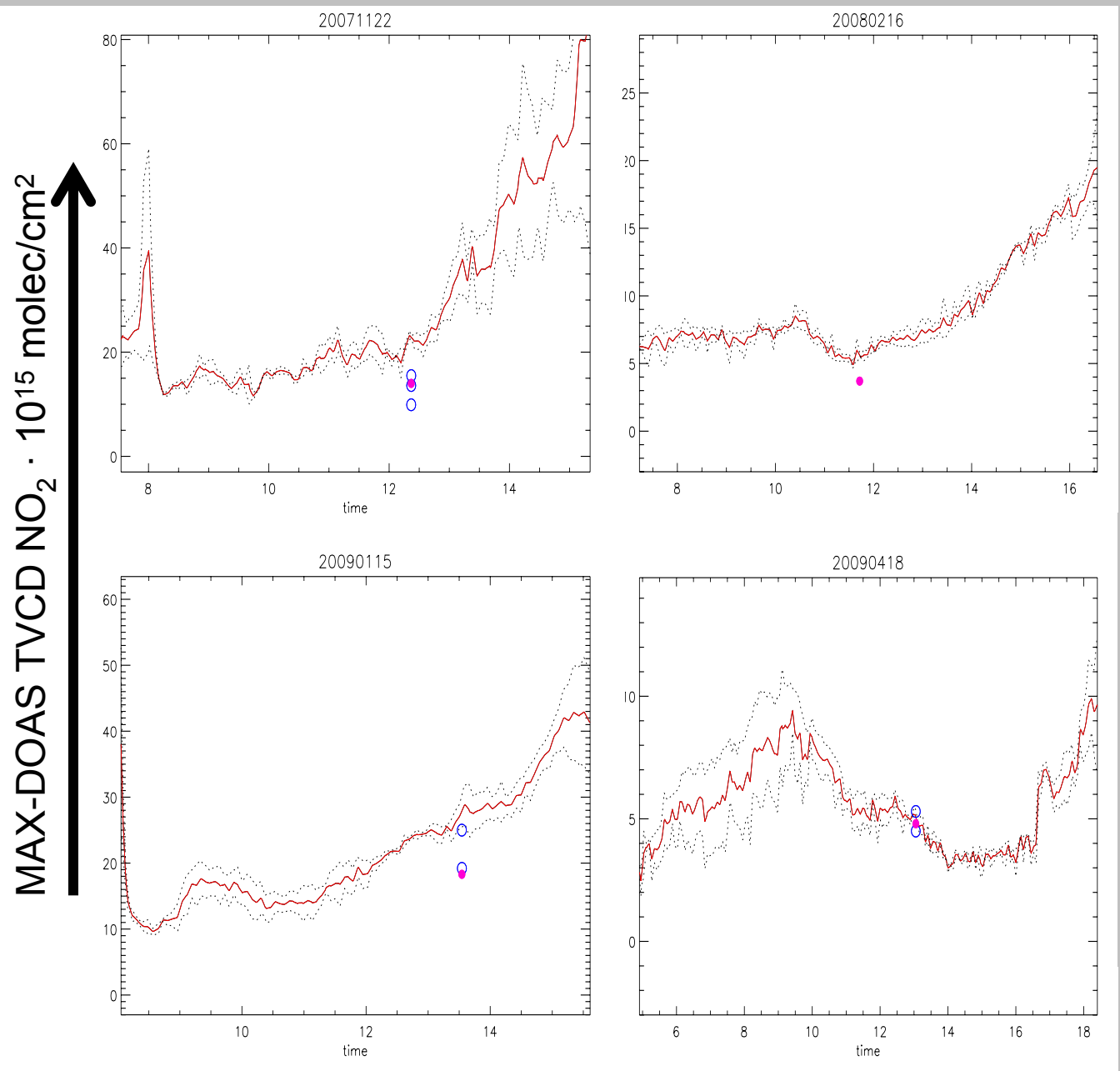
AOT

TVCD




Mini MAX DOAS AOT
AERONET AOT
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Tropospheric Columns: Example Days



TVCD averaged over 4°, 8°, 16° elevation

Spread in TVCD derived from these elevations

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The RI-based retrieval was not so successful during the CINDI-campaign

Some possible reasons:

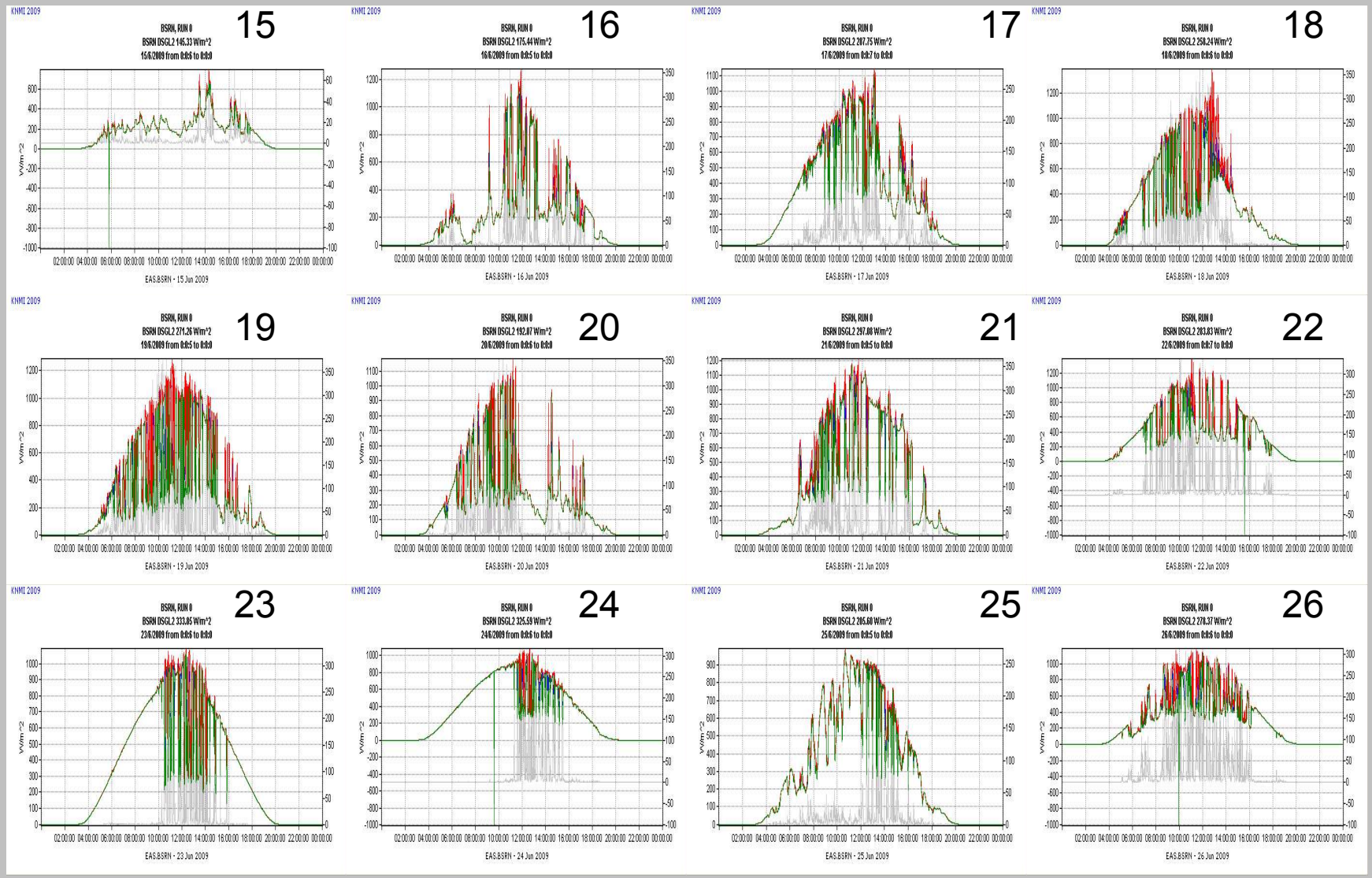
-many periods with clouds (homogeneous or scattered)

-the position of the sun

-we changed to longer integration times (2 minutes instead of 30 seconds per elevation which → no longer semi-simultaneous off axis and zenith contributions to RI)

Direct and Diffuse radiation in Cabauw for CINDI semi blind period

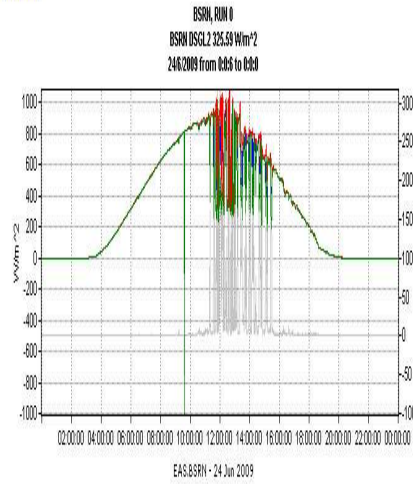
2009 / 06 / 15

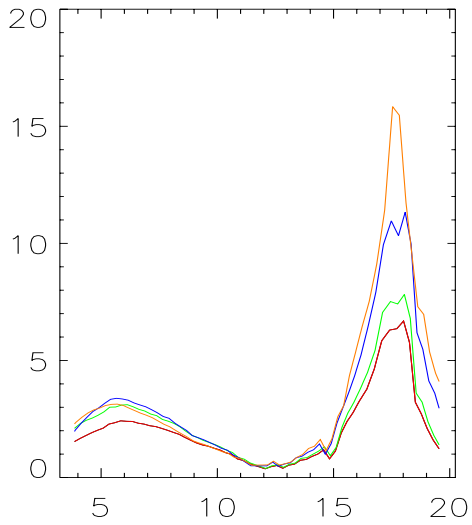


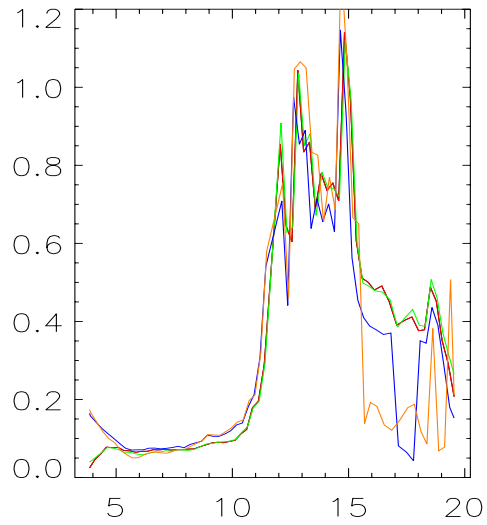
2009 / 06 / 26

source: http://bxpm62/isapi/knmi_acq.dll/BSRN#IWURL10

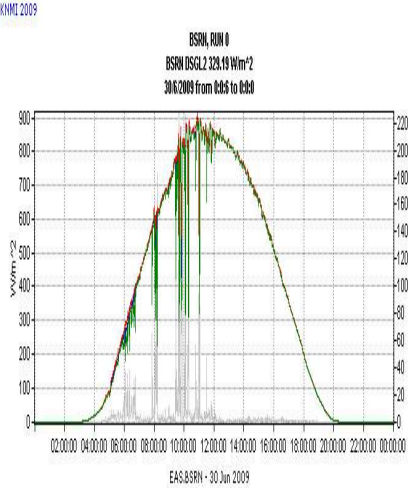
2009 / 06 / 24

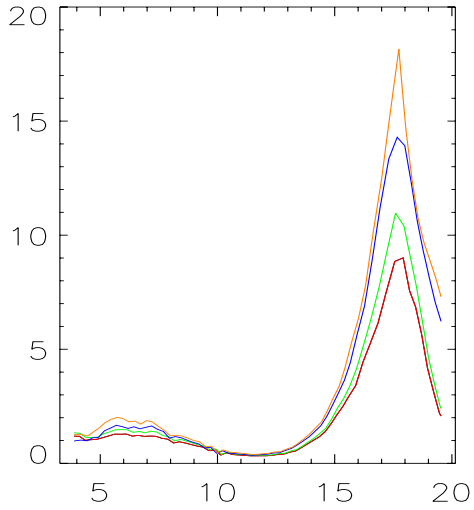


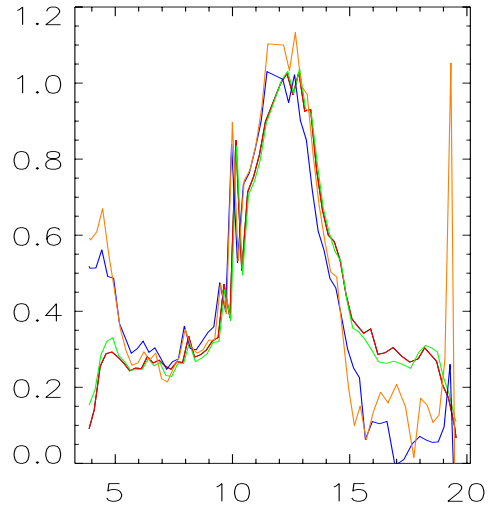




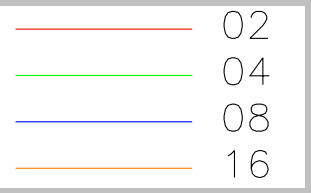
2009 / 06 / 30







Elevation



CINDI: sun high in the sky around noon (SZA ~30°);
low sun in evening and close to the field of view

RT simulations of RI in viewing directions close to the sun depend more critically on the right choice of parameters in the model atmosphere

One of the main reasons is the shape of the aerosol phase function that is strongly peaked in a forward direction

RT simulations of RI in viewing directions close to the sun depend more critically on the right choice of parameters in the model atmosphere

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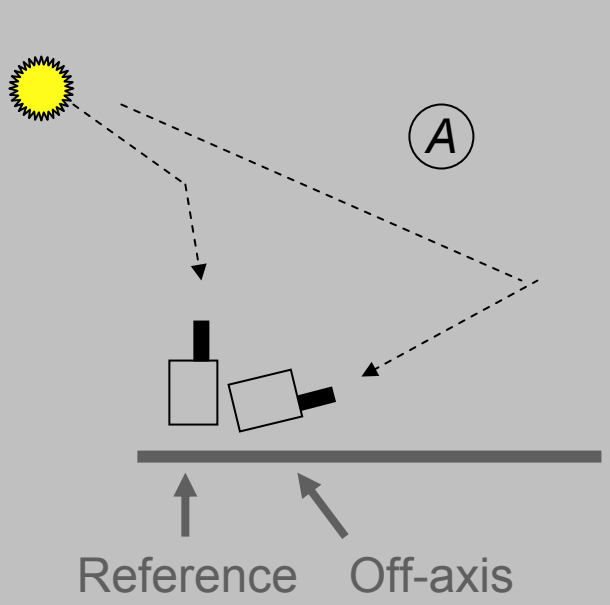
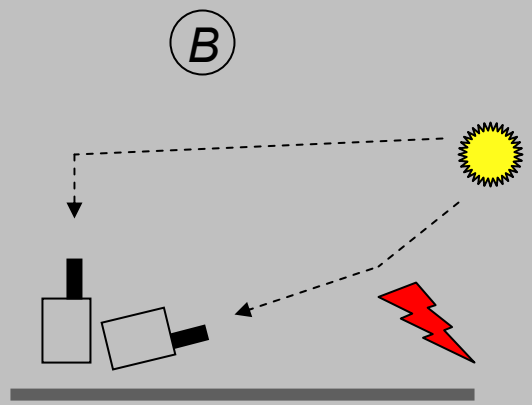
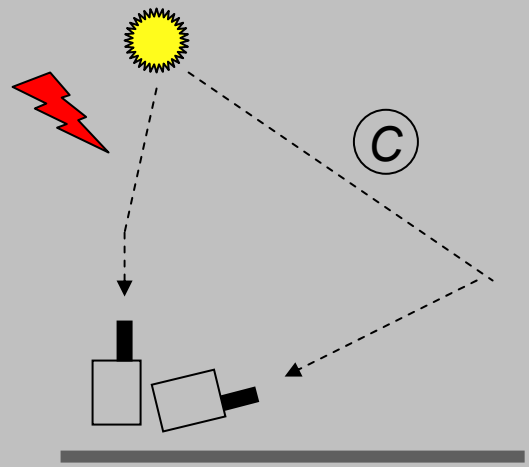




Low angular distance to sun in off-axis direction

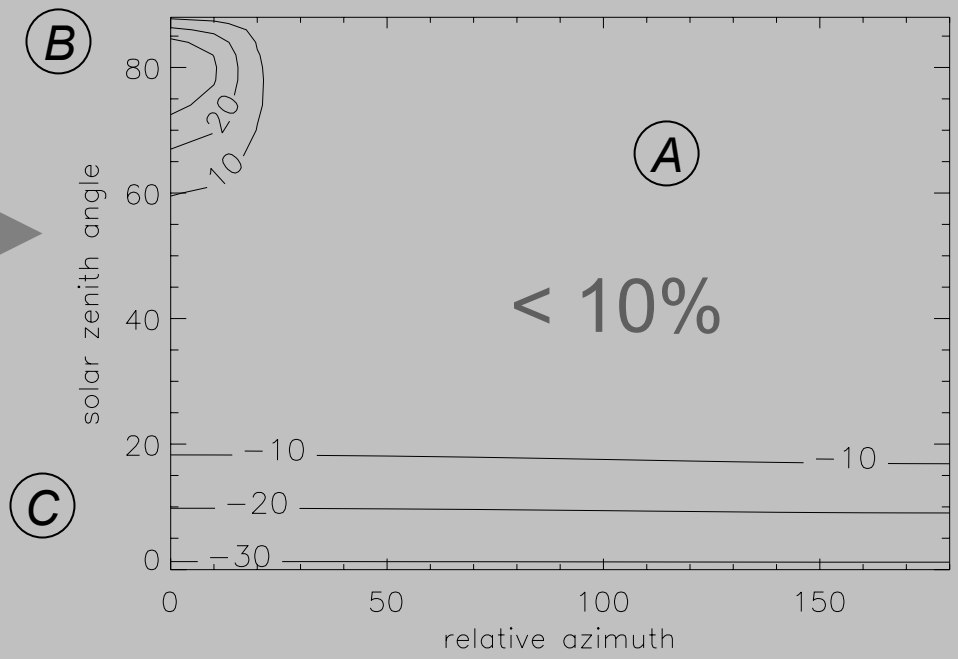


Low angular distance to sun in zenith direction

What does the DAK model say on this?

Change in RI (%) when **asymmetry parameter** is changed from 0.70 to 0.75 for elevation 8°

$$RI = \frac{I_{8^\circ}}{I_{90^\circ}}$$

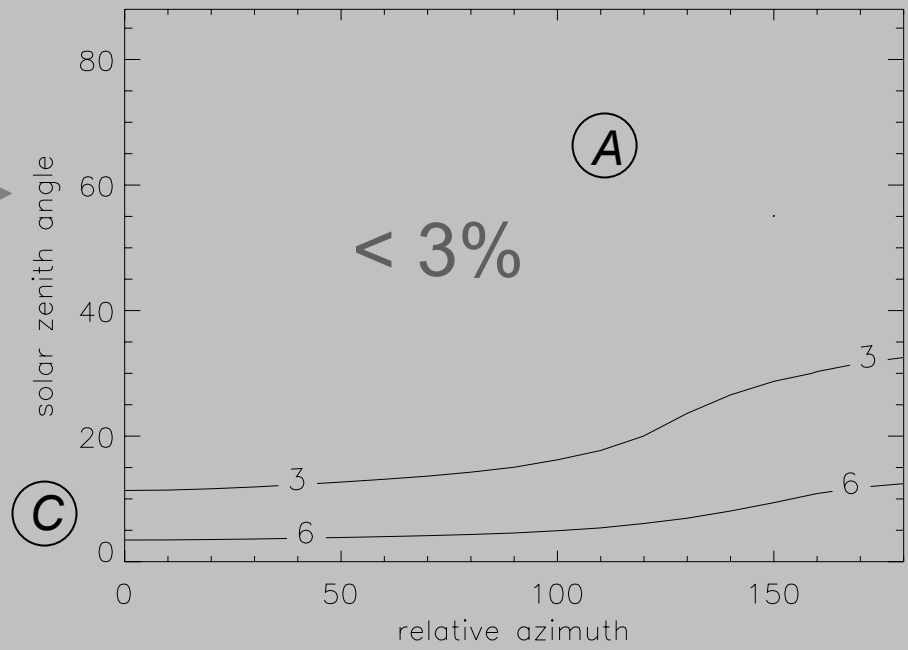


Inaccurate estimation of asymmetry parameter mainly affects measurements at low angular distance from the sun

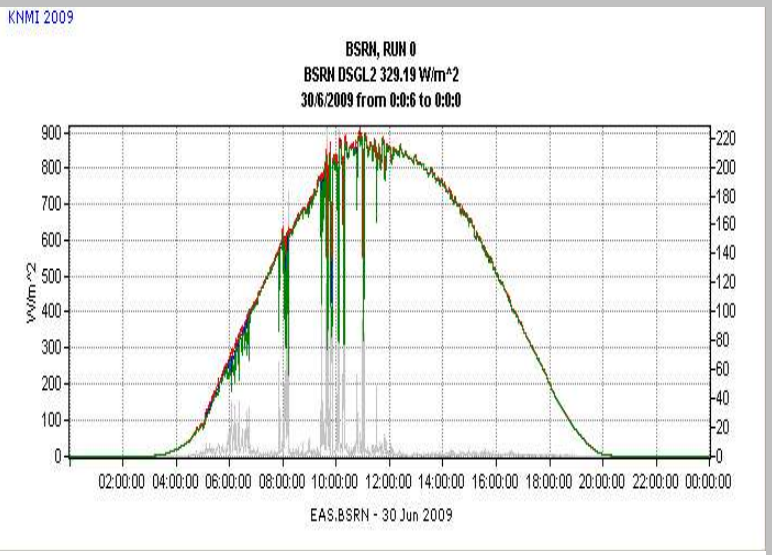
A possible solution: change reference of RI

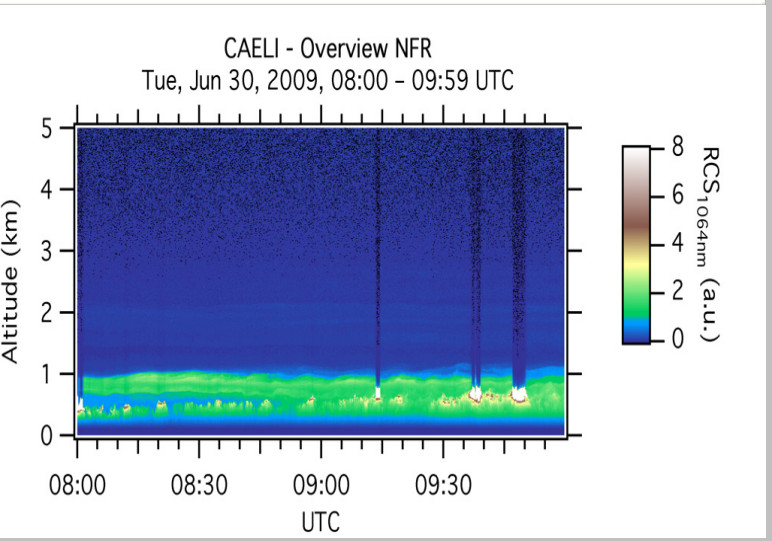
Relative Intensity now relative to 30°

$$RI = \frac{I_{8^\circ}}{I_{30^\circ}}$$



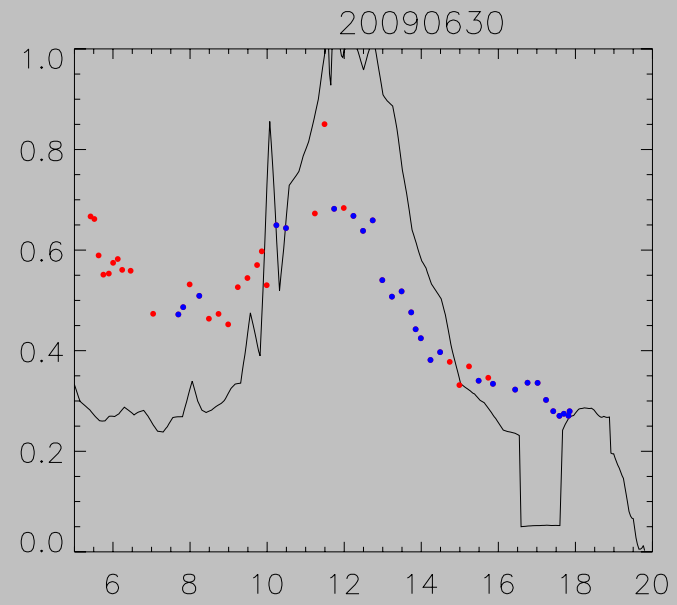
Effect on the measurements





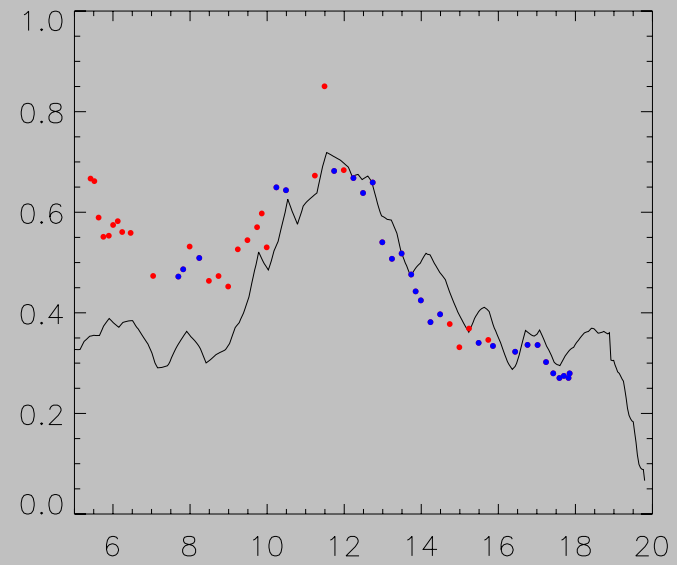
AOT

$$RI = \frac{I_{4^\circ}}{I_{85^\circ}}$$



$$RI = \frac{I_{4^\circ}}{I_{30^\circ}}$$

AOT



Black line: AOT derived from RI

● AERONET level 1.0 ● AERONET level 1.5

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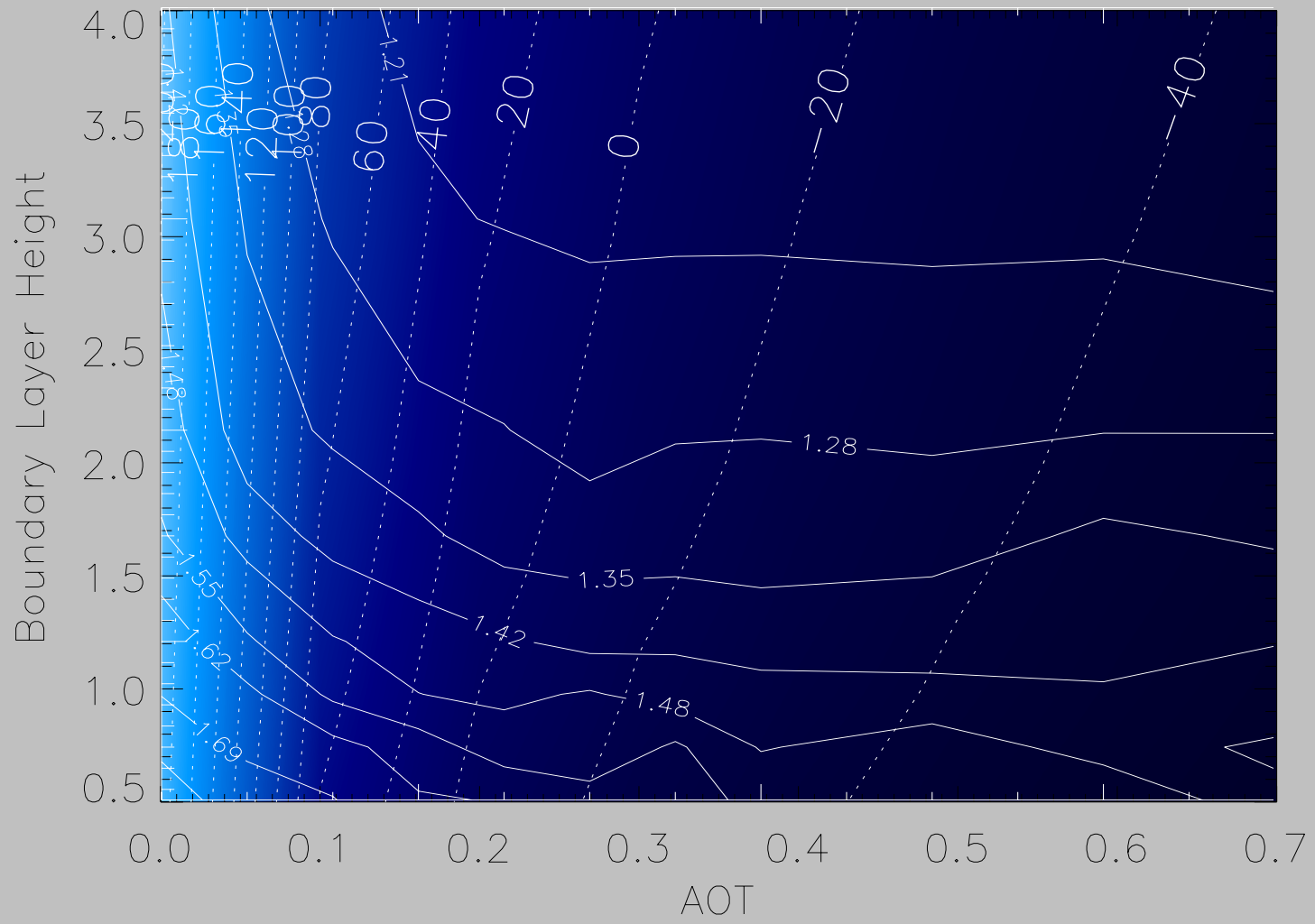
General Approach:

Assume majority of NO_2 and aerosol in boundary layer (BL)

Retrieve only AOT and BL-height

Combine RI and O_4 absorption observations

Find orthogonal quantities in “AOT-BL space”



Example of orthogonal quantities in "AOT-BL space"

$$RI = \frac{I_{4^\circ}}{I_{90^\circ}} \qquad \frac{DSCD\_O_4(4^\circ)}{DSCD\_O_4(16^\circ)}$$

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In order to retrieve NO_2 TVCD for MAX-DOAS an estimation of the AOT is needed

Relative Intensity (RI) provides a simple way to make a first order estimate of AOT in the BL

RTM simulations of RI require accurate knowledge of model parameters if observations are at close angular distance to the sun

>> This limits the approach depending on fixed settings

>> Change of reference may be a solution

A simple scheme is proposed to simultaneously derive AOT and BL-height from a combination of RI and O_4 measurements

The simplified profile shape for NO_2 is then a block function with the height of the BL

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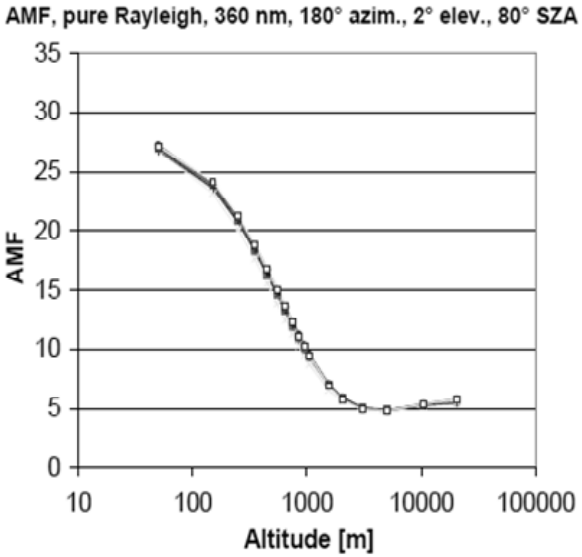
How does DAK RTM compare to other radiative transfer models?

Wagner *et al.*, JGR 2007

Comparison of box-air-mass-factors and radiances for Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) geometries calculated from different UV/visible radiative transfer models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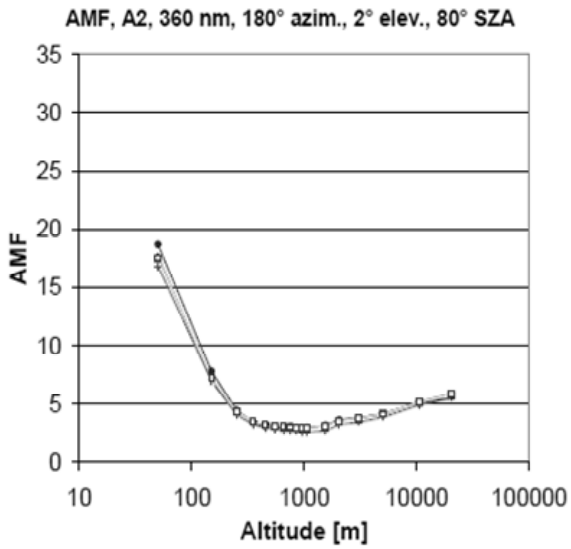
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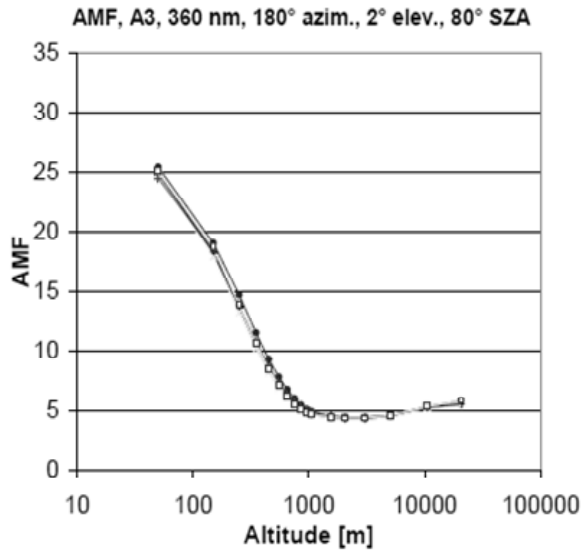
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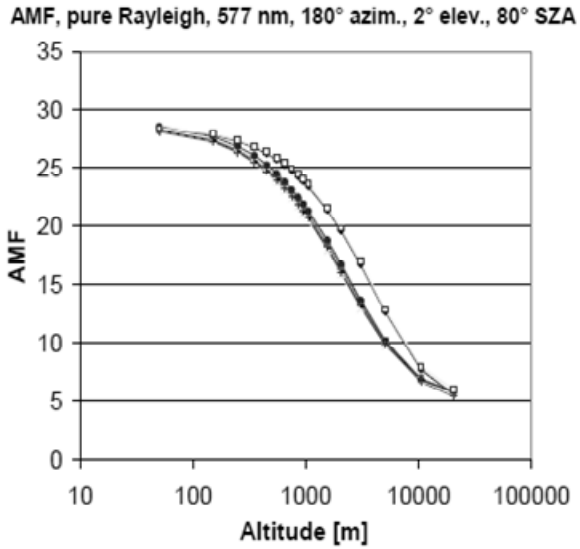
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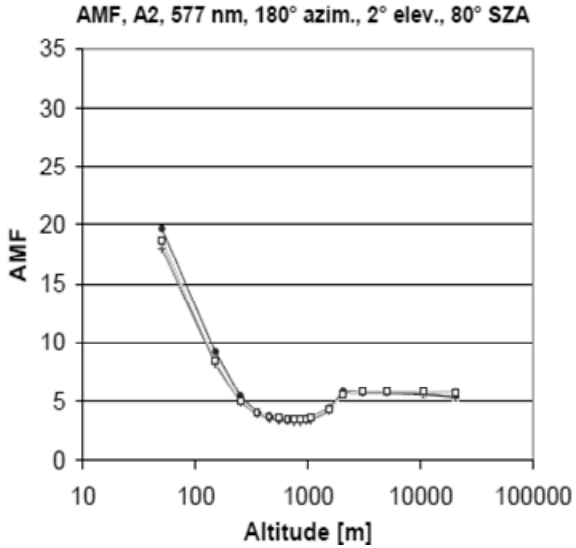
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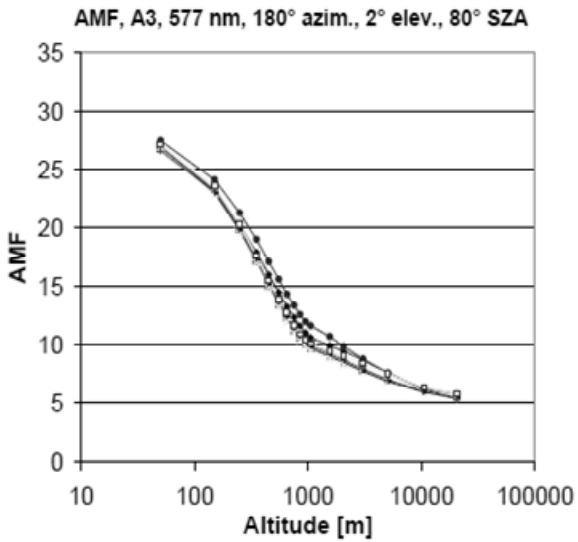
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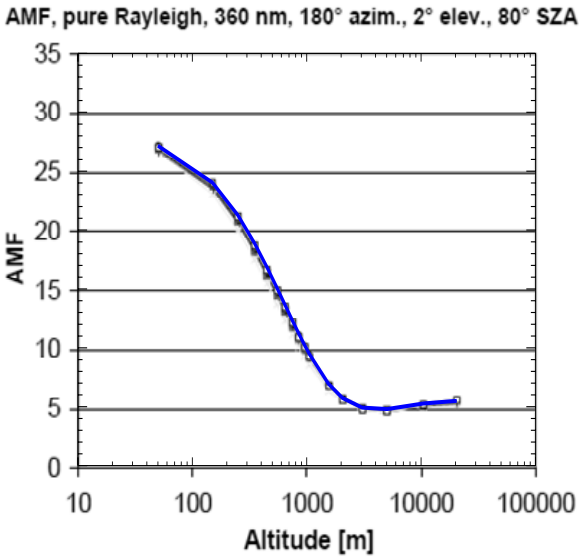
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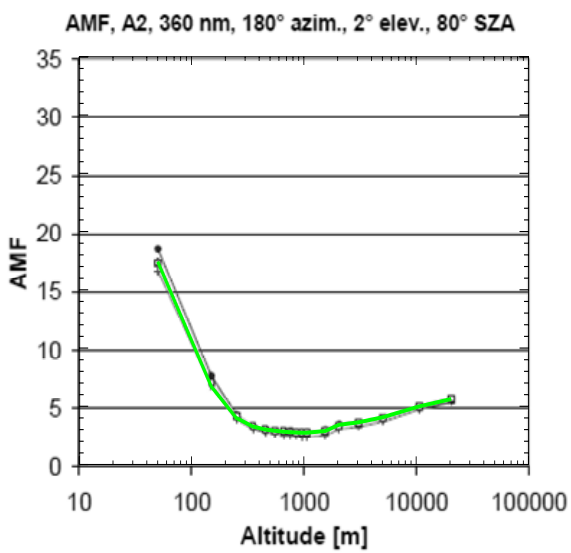
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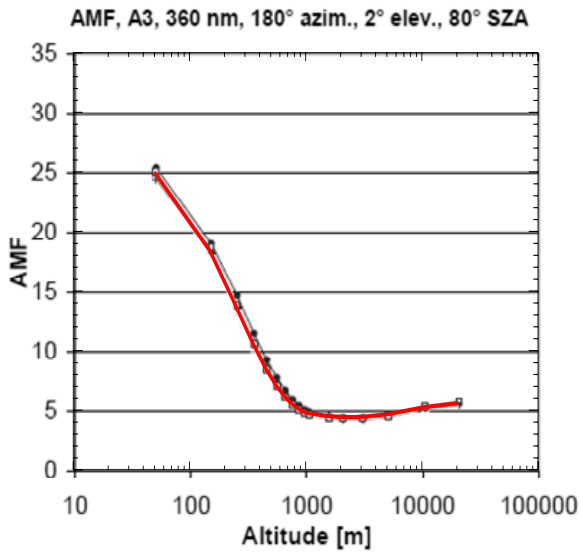
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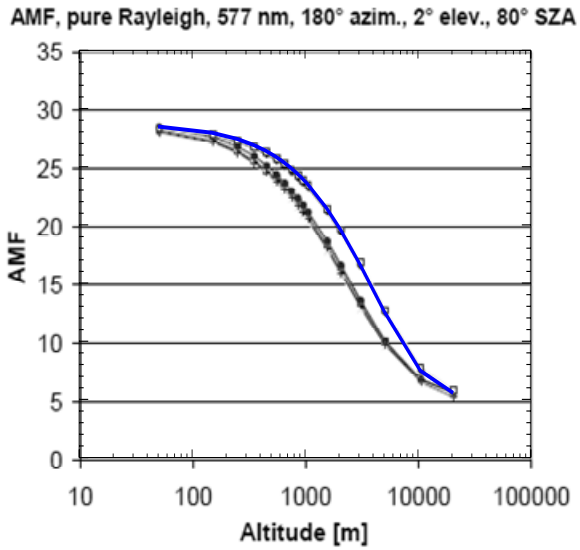
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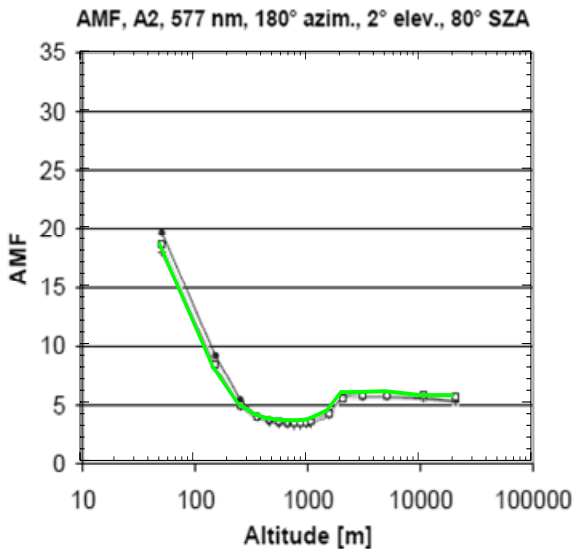
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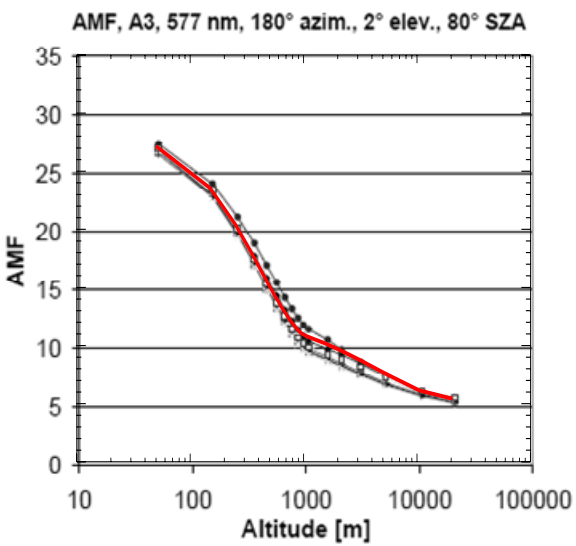
AMF, A3, 577 nm, 180° azim., 2° elev., 80° SZA
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