REMOTE SENSING IN THE THERMAL INFRARED OF MINERAL DUST OVER ARID LAND FROM SATELLITE AND GROUND SURFACE

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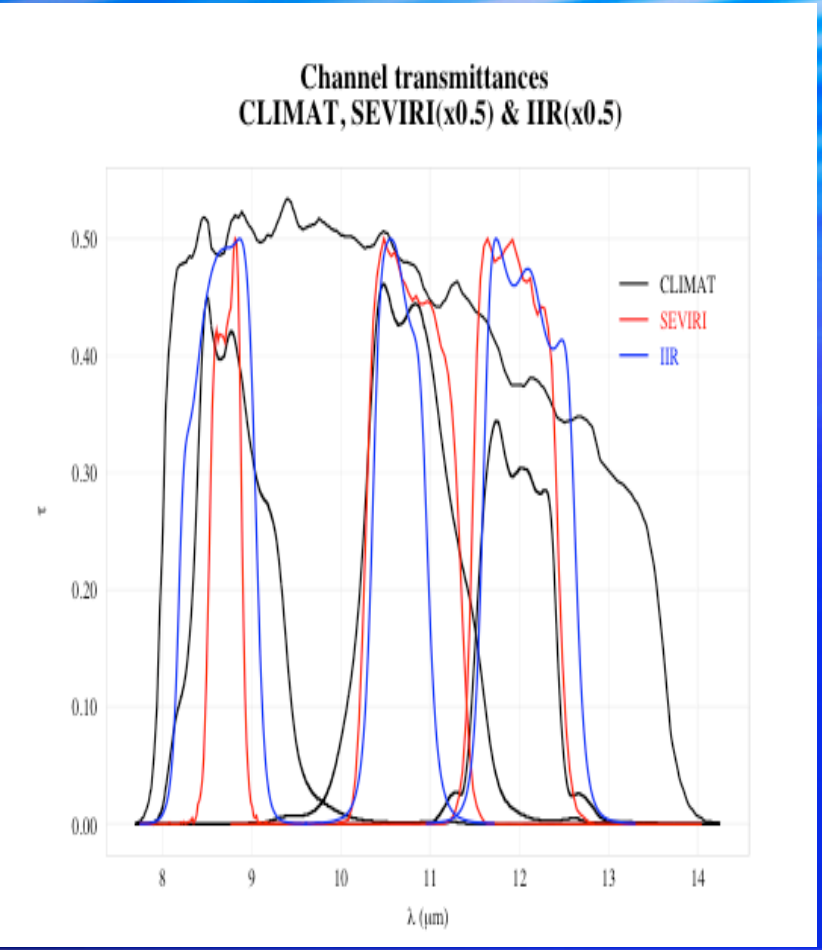
Objective of the project

- Primary aim of this project:
  - skill for estimating dust loading over deserts from space;
  - the thermal infrared is suitable to this object, so the TIR is involved in this study for the radiative properties of dust (including AOD), of clean atmosphere and of surface.
- Study based on radiometric measurements collected in the framework of AMMA (2006):
  - a. from space: MSG/SEVIRI and CALIPSO/IIR (ICARE);
  - b. ground-based from CLIMAT, on the site of Tamanrasset.
- Similar channels for CLIMAT (narrow), SEVIRI (TIR) & IIR; centered at 8.7, 10.8 & 12.0 µm.



Tamanrasset Super-site

¬ ***Ground-based instrumentation:***

(Cuesta et al. 2008)

Active Remote Sensing

Backscatter Mini-Lidar

- 532 nm //
- 532 nm ⊥
- 607 nm (Raman channel)
- 1064 nm

Passive Remote Sensing

1) CIMEL **Sunphotometer**
6 channels: 440, 500, 670, 870, 936, 1020 nm

2) CLIMAT 4 channels IR Radiometer: 1) 8-13 μm, 2) 8.2-9.2 μm, 10.3-11.3 μm, 11.5-12.5 μm

4) Pyranometer
Pyrgeometer
Periheliometer

3) IR Radiometer
9.5-11 μm

Meteorological variables

Ultrasonic Anemometer at 10m

Radiosoundings
4 per day

In-situ

Scatterometer
920nm

Optical Particle Counter
0,15 < r < 10 μm

Chemical analysis

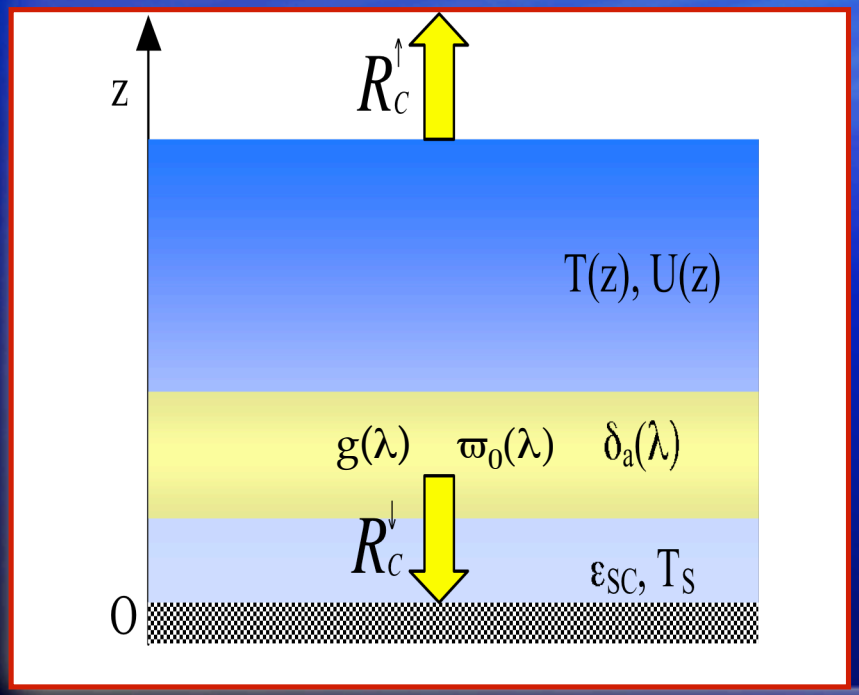
ONM | Automatic | IOP1 | IOP2 | IOP3 | IOP4

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

“Ground truth” method

- The method consists in controlling the coherence between (i) measurements of IIR and SEVIRI from space and (ii) measurements of CLIMAT from ground surface (ground truth).

- This control is realized with a radiative transfer code to simulate the radiances. Then the measured and simulated radiances can be compared (i) at TOA and (ii) at BOA, for each channel.

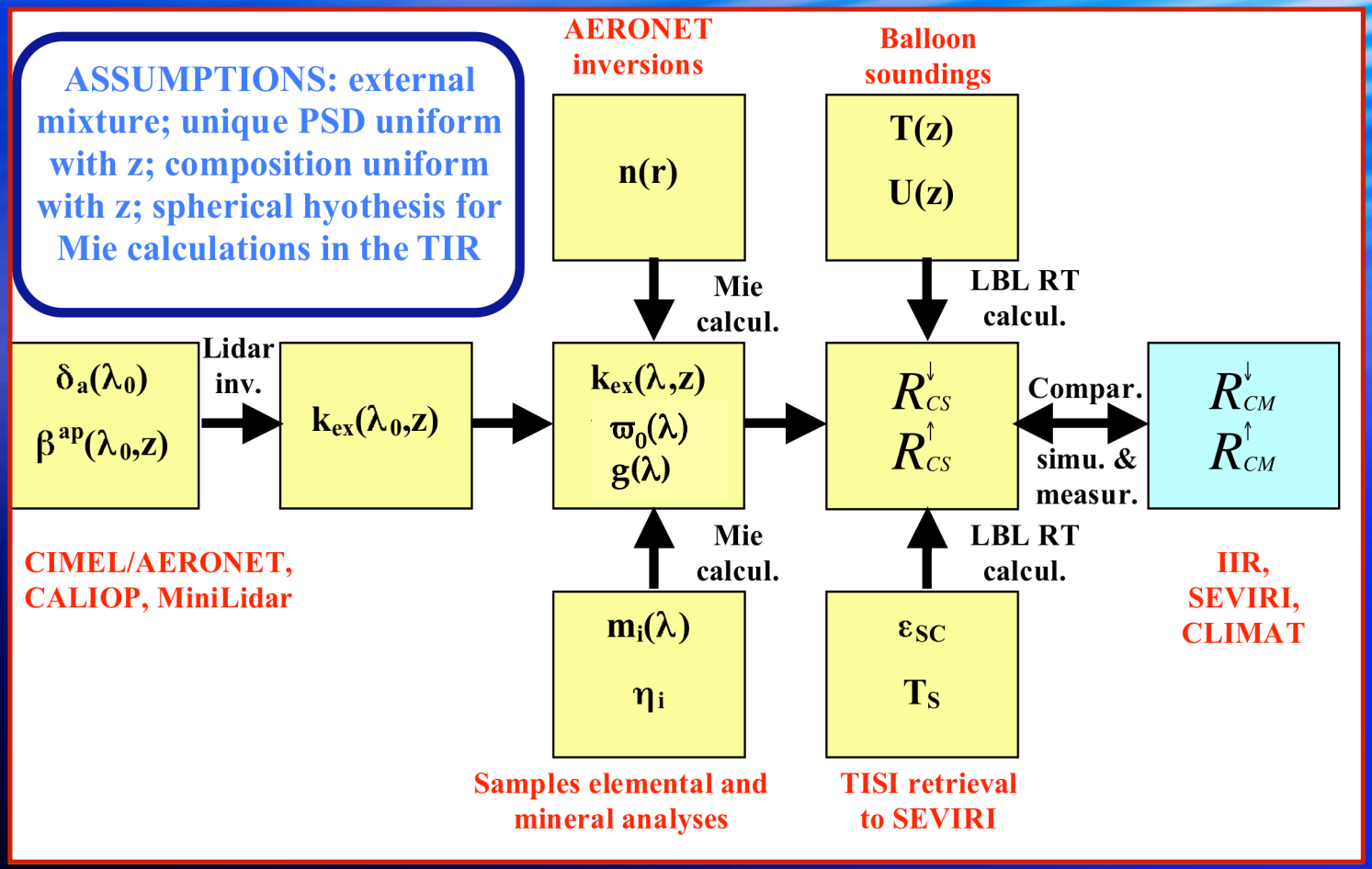


$R_C^{\uparrow}$ is measured with IIR or SEVIRI in channel C (8.7µm, 10.8µm, 12.0µm);

$R_C^{\downarrow}$ is measured using CLIMAT in channel C;

$R_C^{\uparrow}$ and $R_C^{\downarrow}$ are calculated using the radiative transfer code LBLDOM with a high spectral resolution (Dubuisson et al. 1996), using as input, ε_{SC}, T_S (TISI method, Becker and Li, 1990), and T(z), U(z), $k_e(\lambda,z)$, $\varpi_0(\lambda)$, $g(\lambda)$.

Scheme of the calculations



Selected cases

Selection of fully documented cases, in daytime and nighttime, with various dust and water vapor atmospheric loadings.
Careful elimination of cases with cloud presence using:

- the cloud filters of AERONET AOD & CLIMAT radiance;
- the MiniLidar quicklooks apparent backscatter.

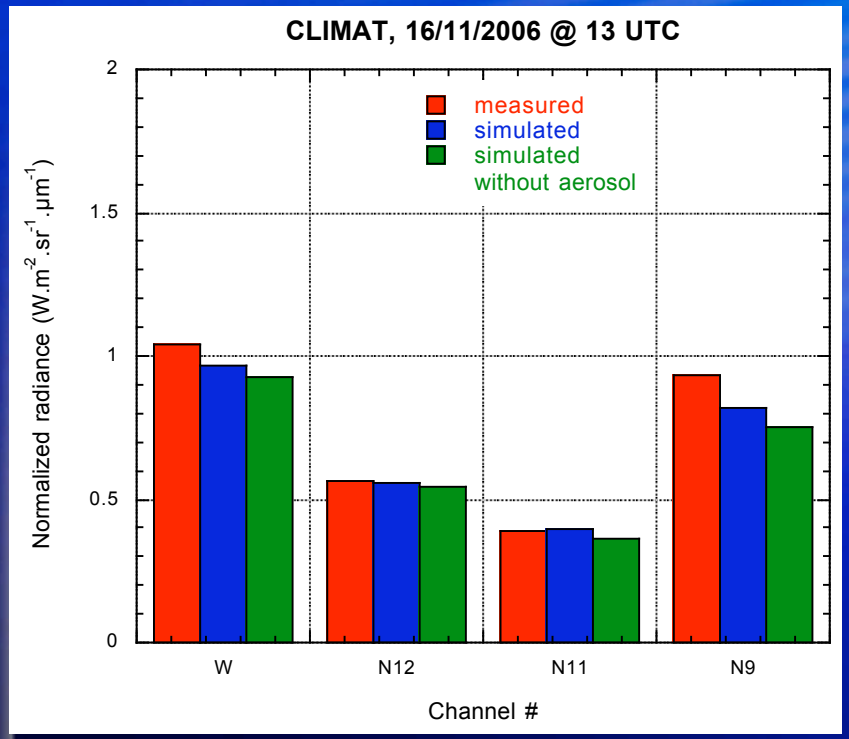
in progress | achieved

Day & Time UTC	Water vapor	Aerosol
16 Nov 2006 @ 13:00	very dry	weak (0.05)
06 Nov 2006 @ 01:40	moderate	weak (0.05)
01 Jul 2006 @ 06:08	dry	moderate (0.2)
01 Jul 2006 @ 01:40	dry	moderate (0.2)
17 Sep 2006 @ 12:15	moderate	significant (0.6)

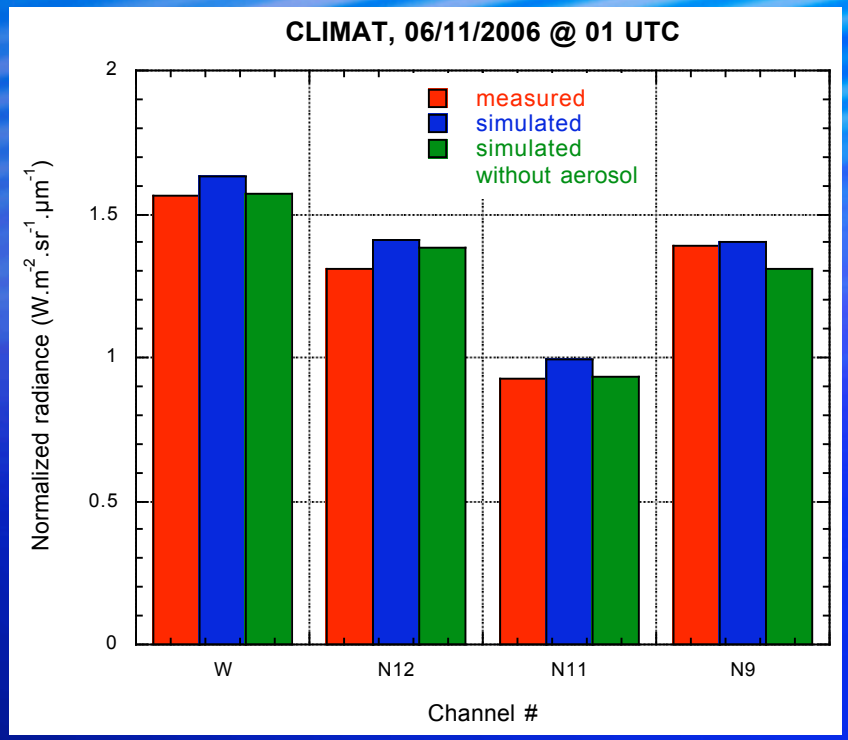
Comparisons: graphics

CLIMAT: 16/11/2006, 06/11/2006

Day

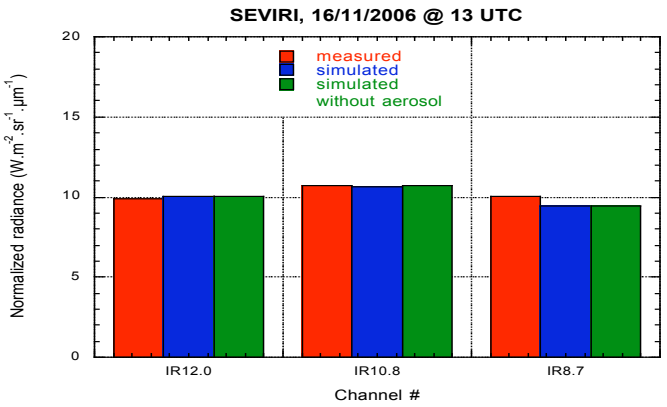


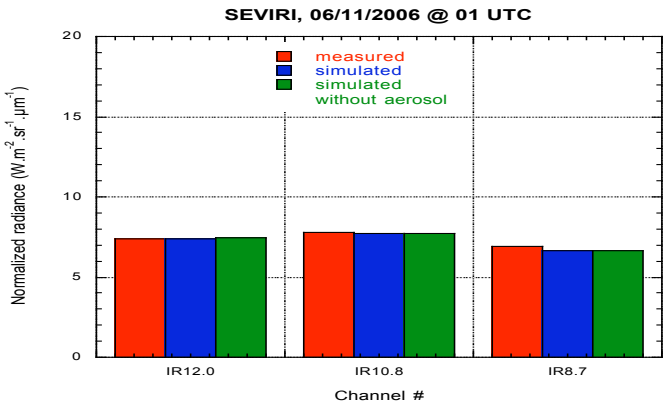
Night

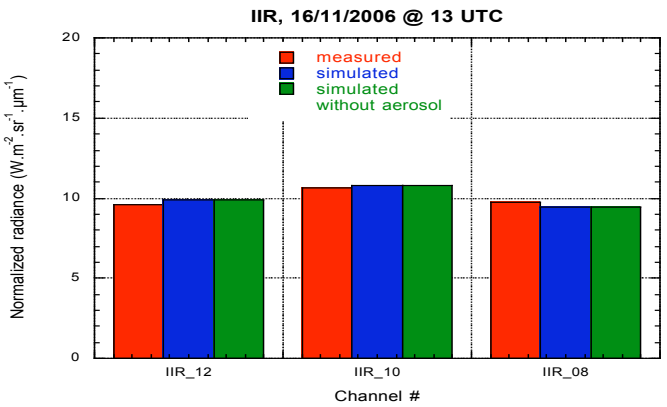


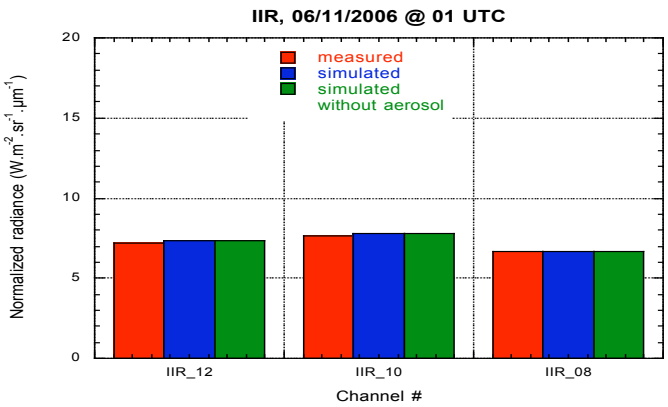
Comparisons: graphics

Day | SEVIRI & IIR | Night



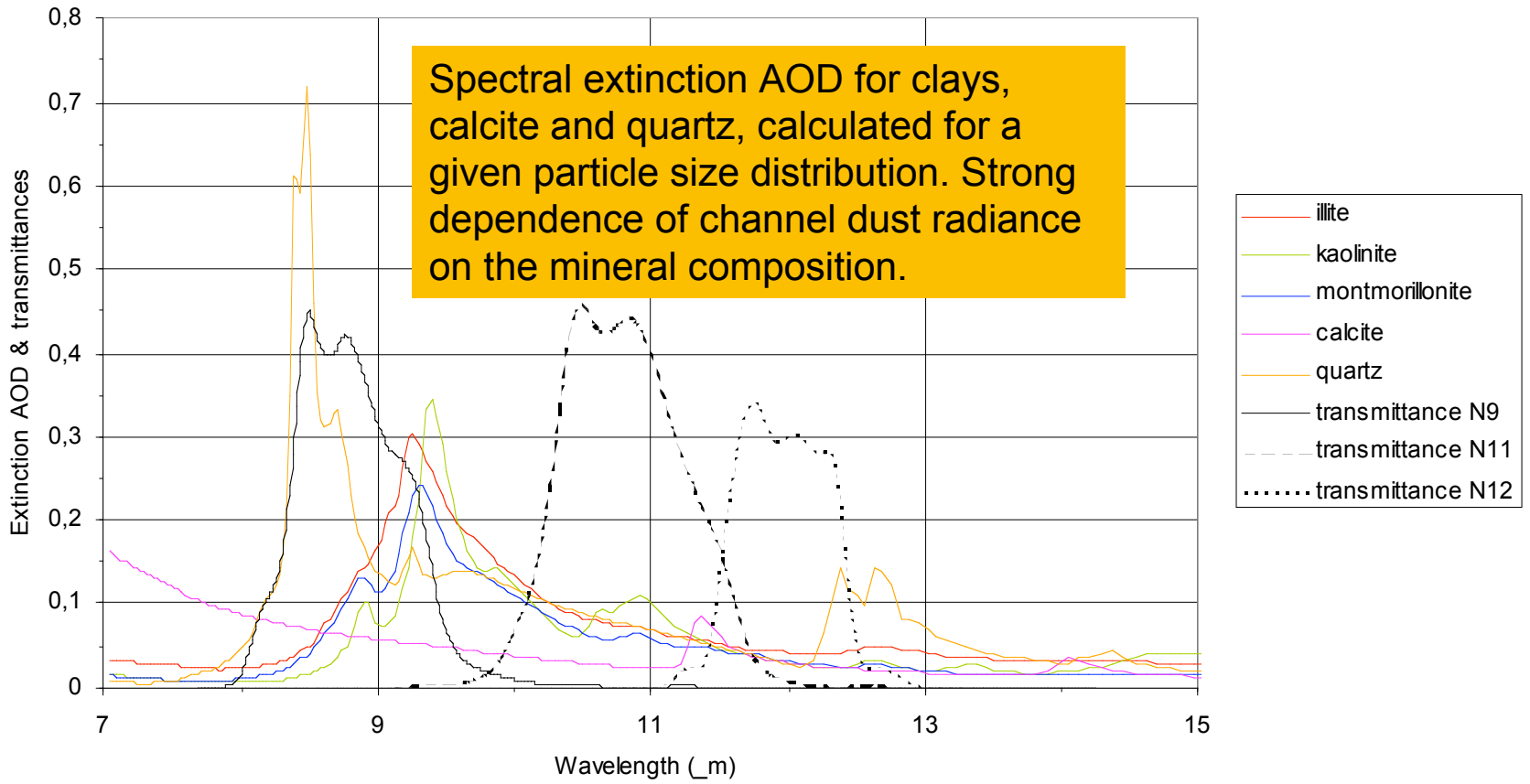




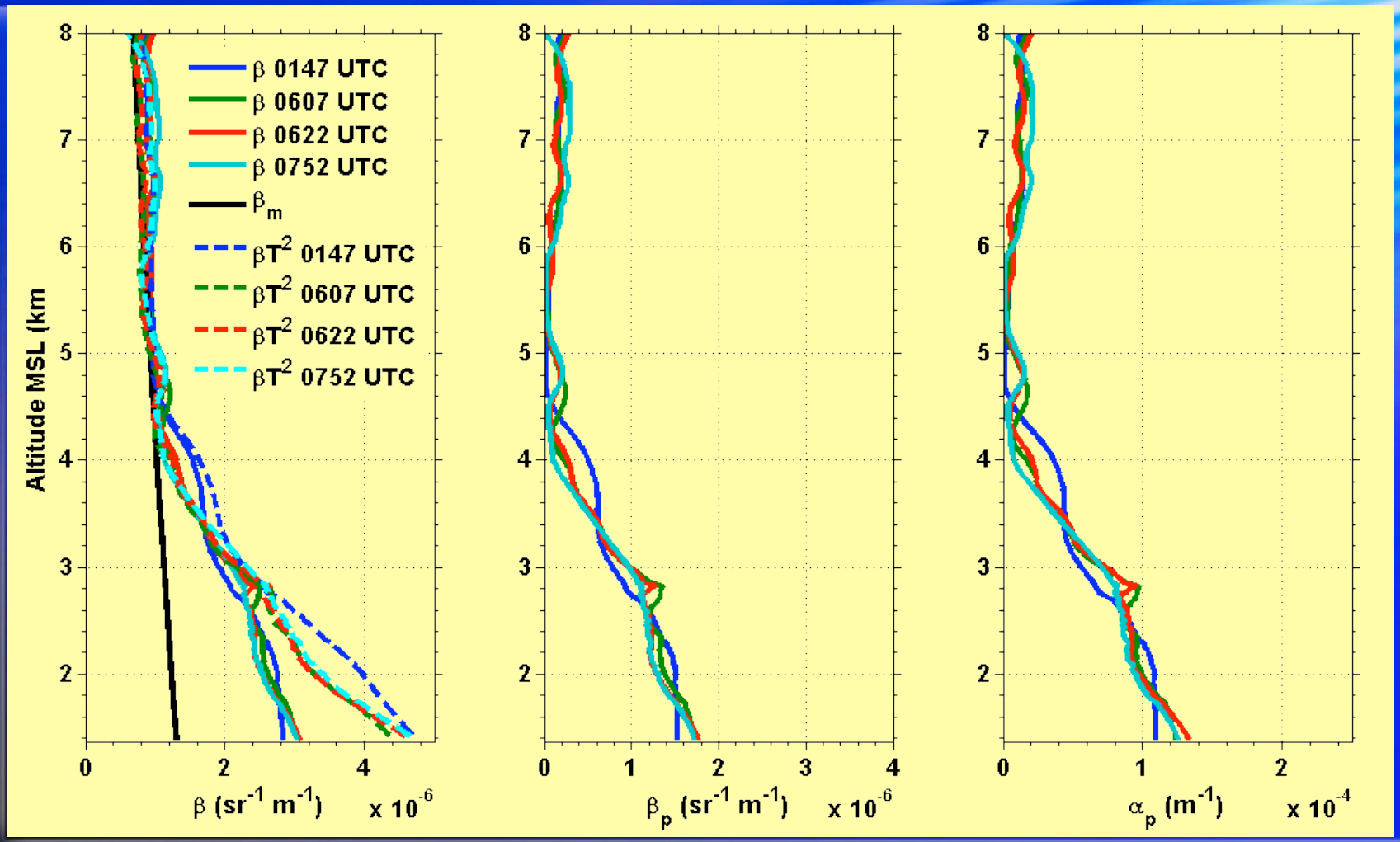


Minerals radiative properties in the TIR

Note minor differences between clays, compared to quartz or to calcite.

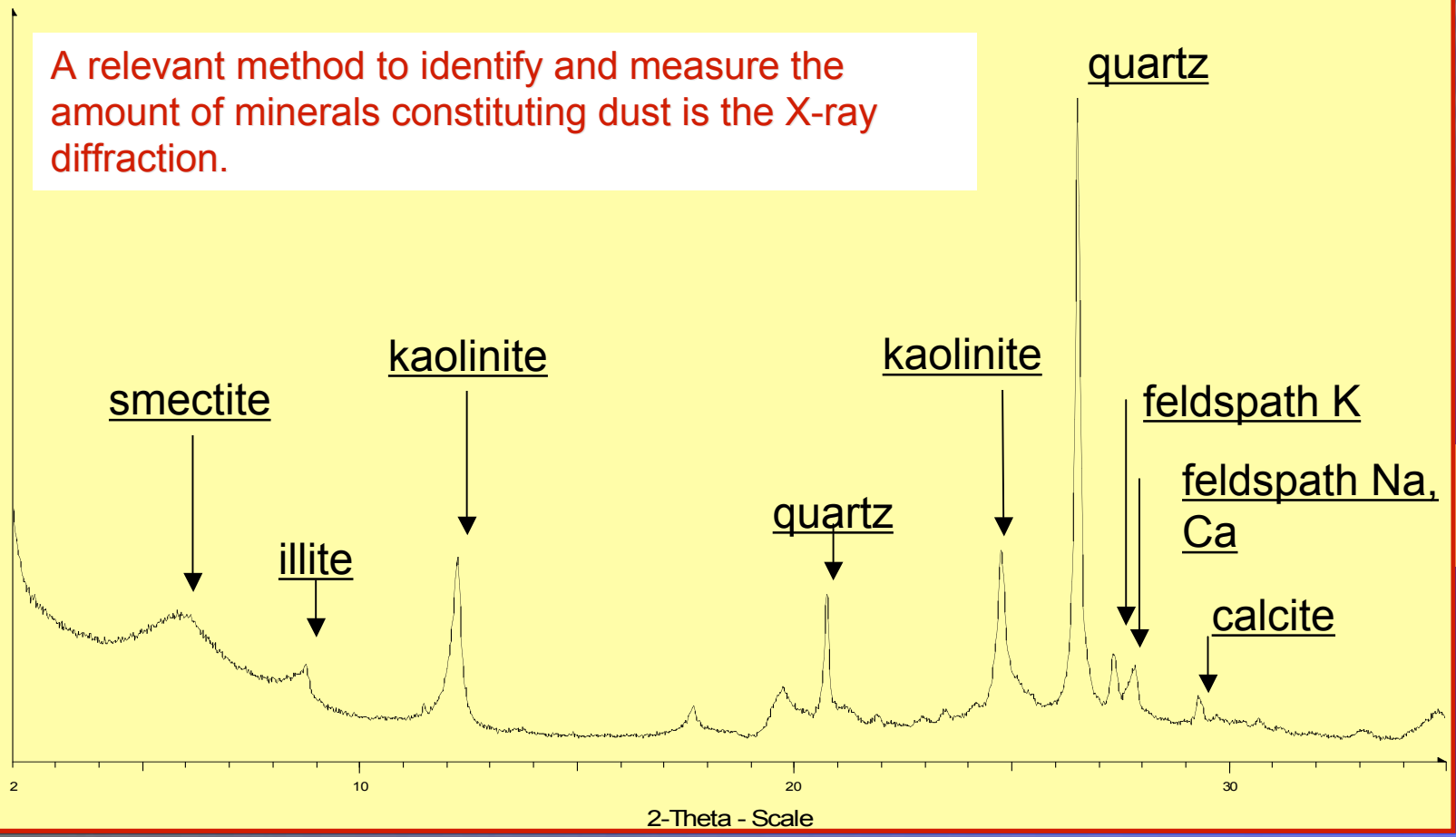


MiniLidar dust profiles: 01 July 2006



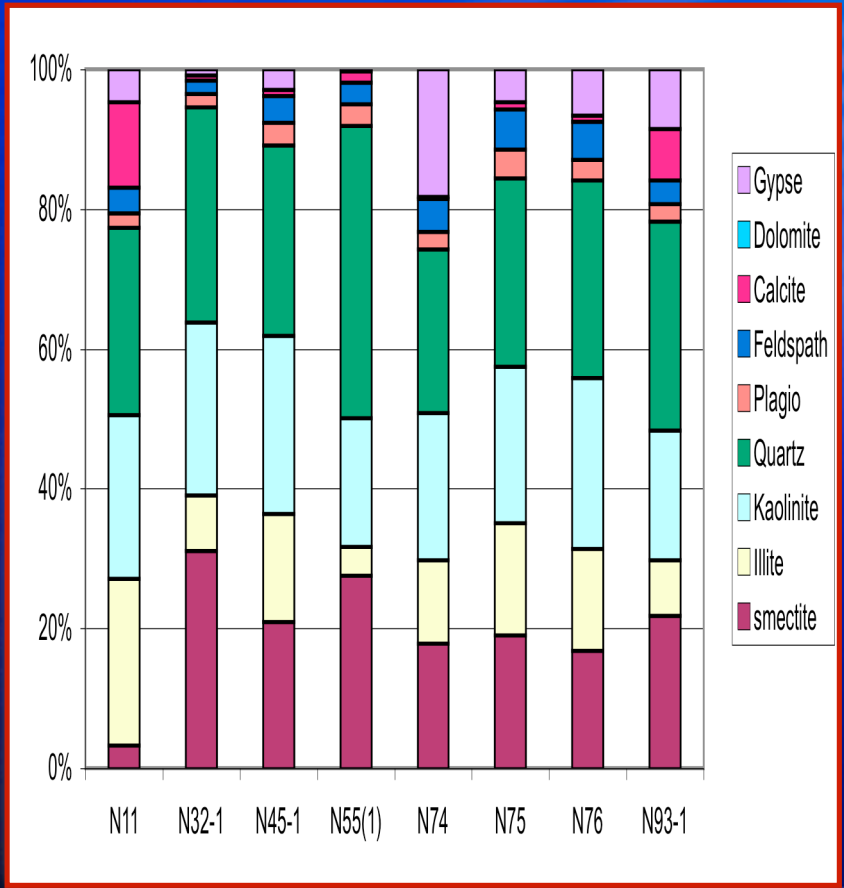
X-ray diffraction and mineral composition (N55)

A relevant method to identify and measure the amount of minerals constituting dust is the X-ray diffraction.



Mineral composition of dust samples from Tamanrasset

(N11: sample for 01 July, 2006)



The mineral percentages are for measured peaks intensity I.

The graph displays the pseudo-composition of various samples from Tamanrasset, using the X-ray diffraction technique. To have a mass composition, it is necessary to calibrate the diffractometer, i.e. to determine a coefficient *k* for each mineral, so that:

$$I = k.m$$

k has been determined for quartz, calcite, gypsum, feldspar and plagioclase so that mass is known for them. *k* is undetermined for clays: only total clay mass (kaolinite + illite + smectite) is obtained by difference with total mass.

Conclusions and prospects

- For clean atmospheres, during both day and night, we obtain a suitable agreement between measured and simulated TOA and BOA radiances in TIR, validating the descriptions of atmosphere (T(z), U(z)) and ground surface (T_S, ε_{CS}) and proving the consistency between the radiances measured from space and from ground surface. With AOD = 0.05, the dust impact is weak on BOA radiance (<10%) and negligible on TOA radiance.

- For dusty atmospheres, the determination of clays composition is under investigation: only percentages in weight for the non-clay minerals and for the total clay, are known.

- So the study is still in progress. Its completion could validate the dataset and the approach which could be used in turn, to test the satellite and ground-based radiometric sensitivities to mineral dust in the TIR.