Long-term evaluation of SKYRAD pack MRI version 2 retrievals and estimation of the vertical profile of the short-wave aerosol radiative effect in an alpine site

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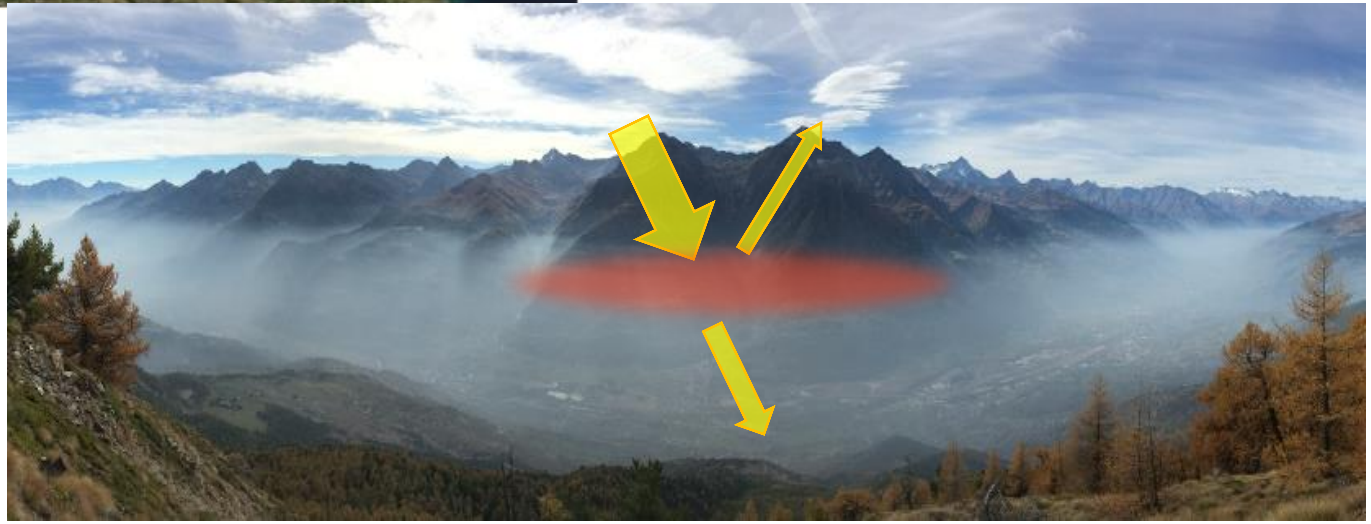
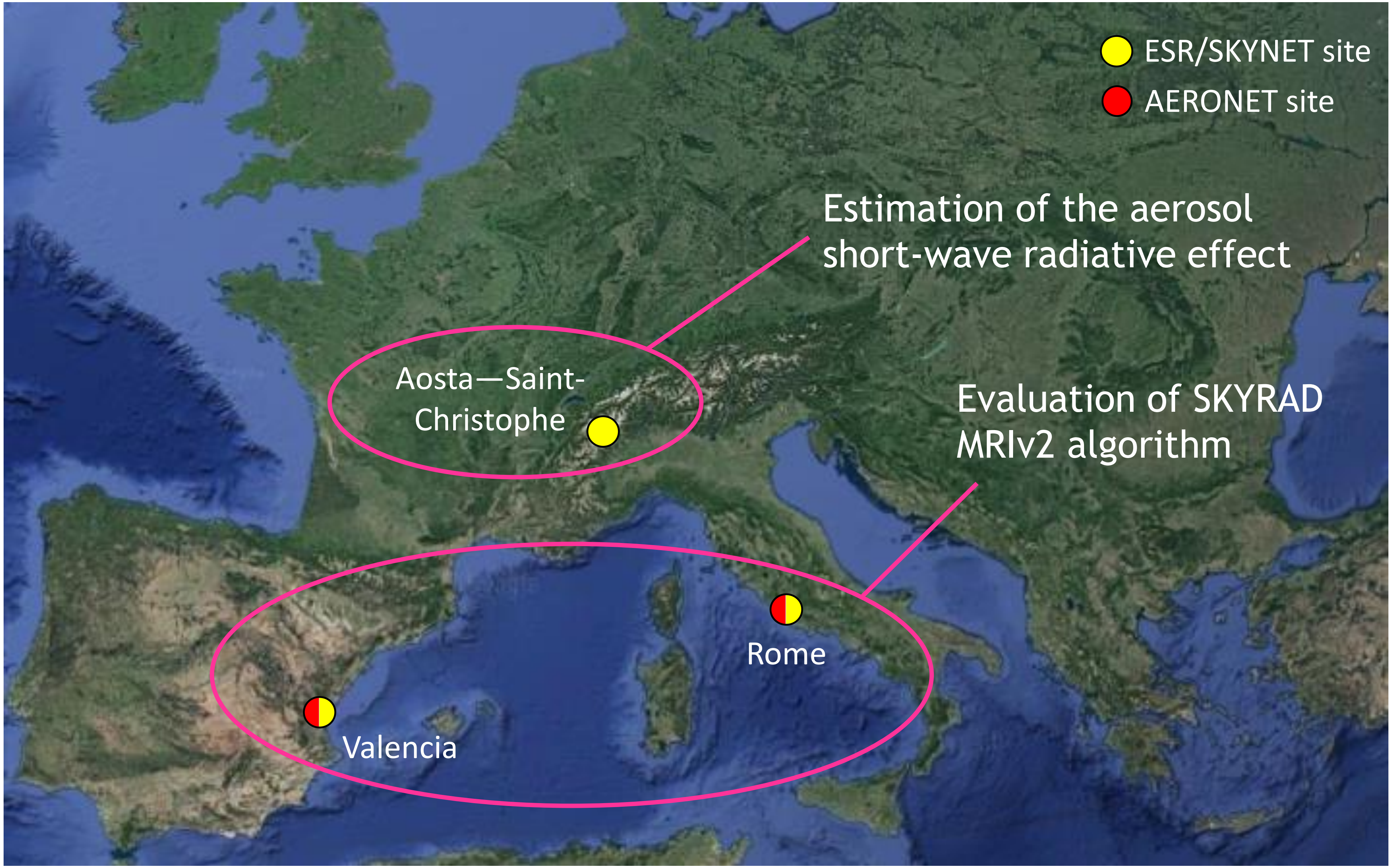


Sites


ESR/SKYNET site
AERONET site
Estimation of the aerosol short-wave radiative effect
Aosta—Saint-Christophe
Evaluation of SKYRAD MRIv2 algorithm
Rome
Valencia

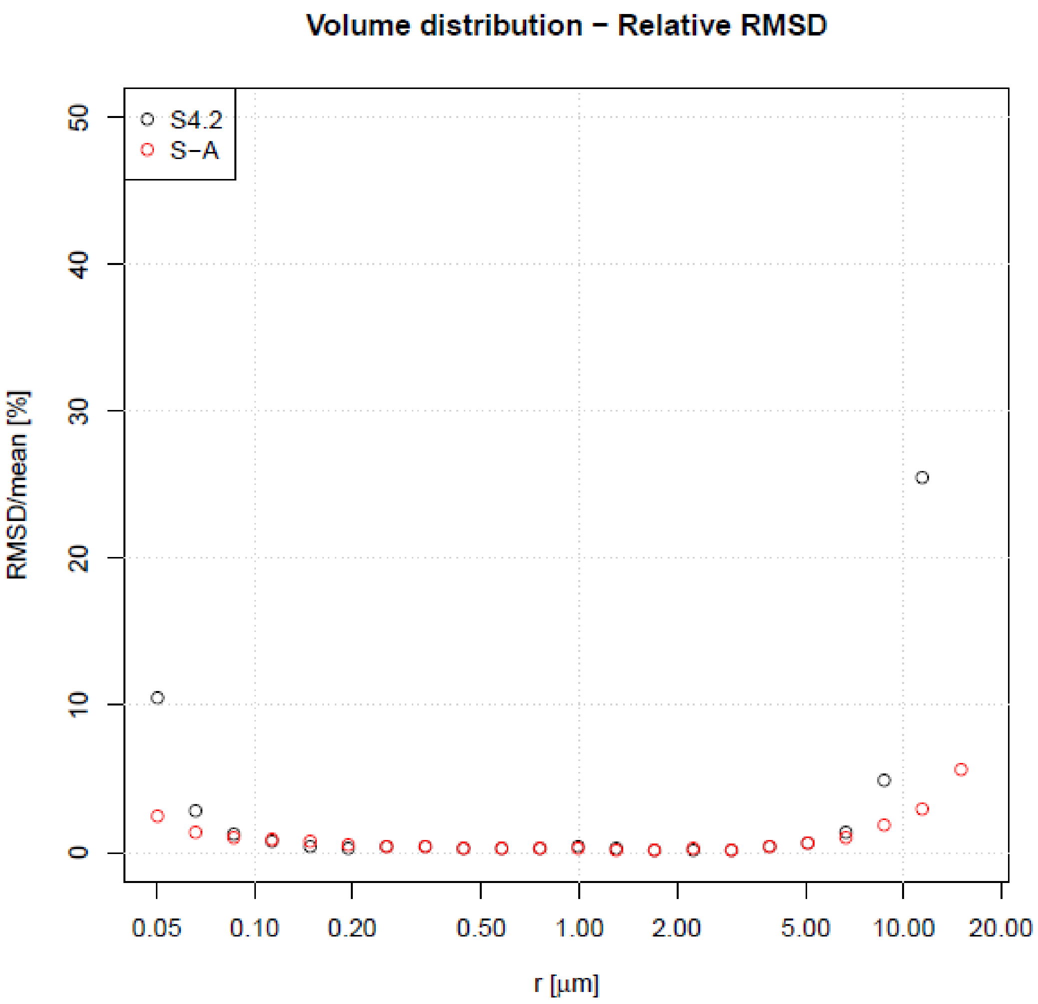
Evaluation of SKYRAD MRIv2 algorithm: instruments and methodology

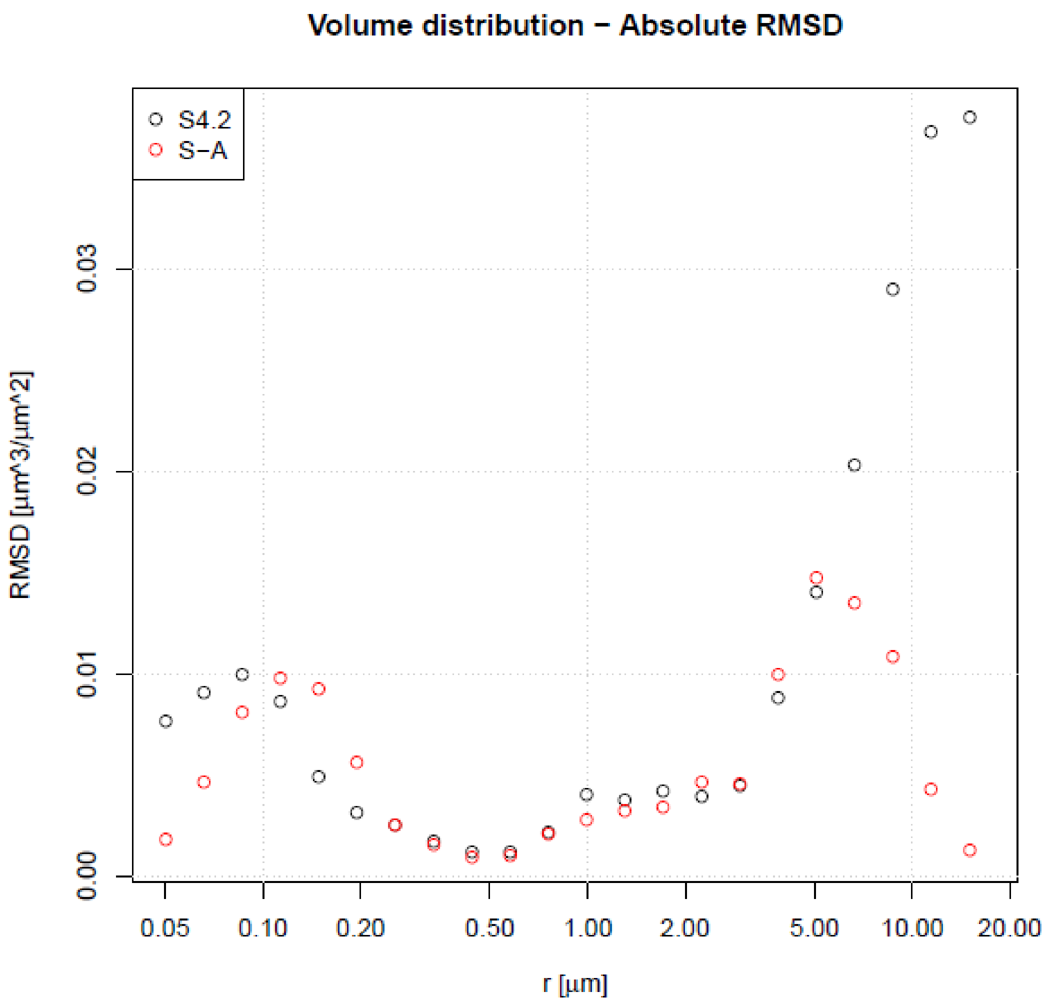
PREDE POM-02 sky radiometer

CIMEL CE318 sunphotometer

- Comparison between SKYRAD MRIv2, SKYRAD 4.2 and AERONET V3 retrievals
- Dataset: all corresponding retrievals (Δt≤10 mins) within the 2017-2019 period, AOD>0.1
- Aerosol Optical Properties: aerosol optical depth, single scattering albedo, asymmetry factor, refractive index at 4 common wavelengths: 440, 675, 870 e 1020 nm; volume size distribution

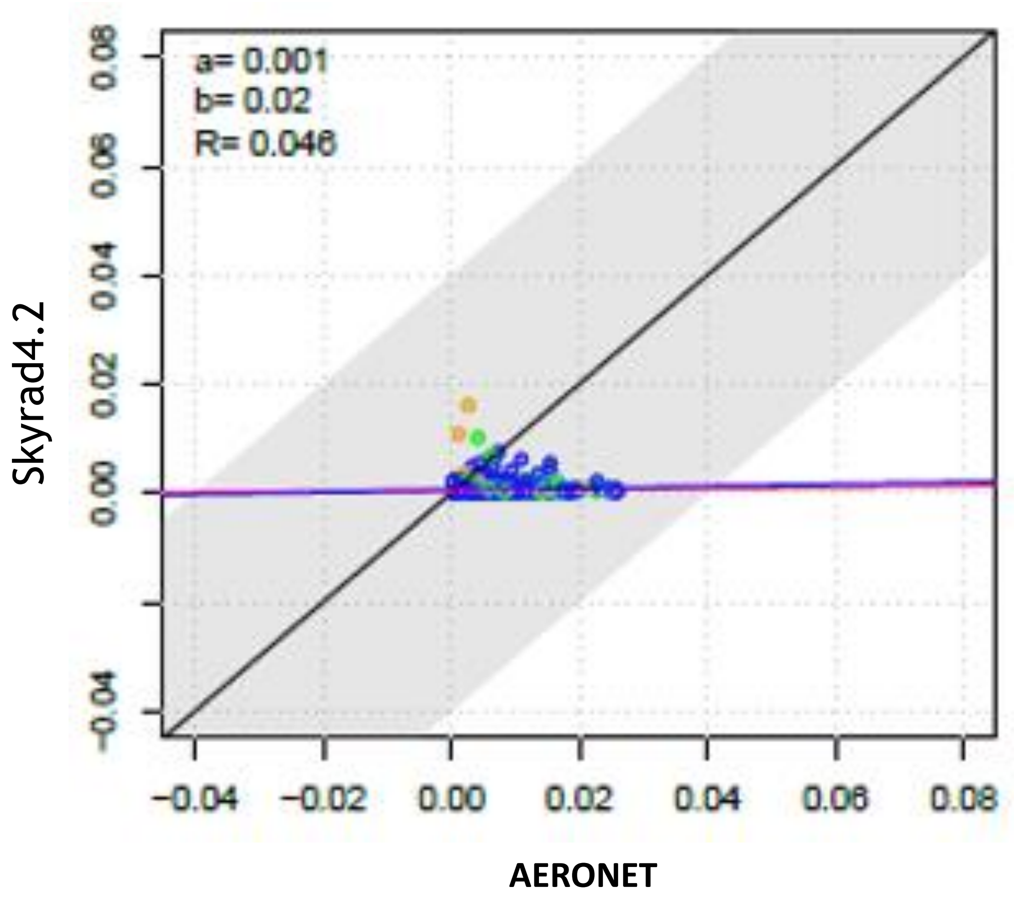
Evaluation of SKYRAD MRIv2 algorithm

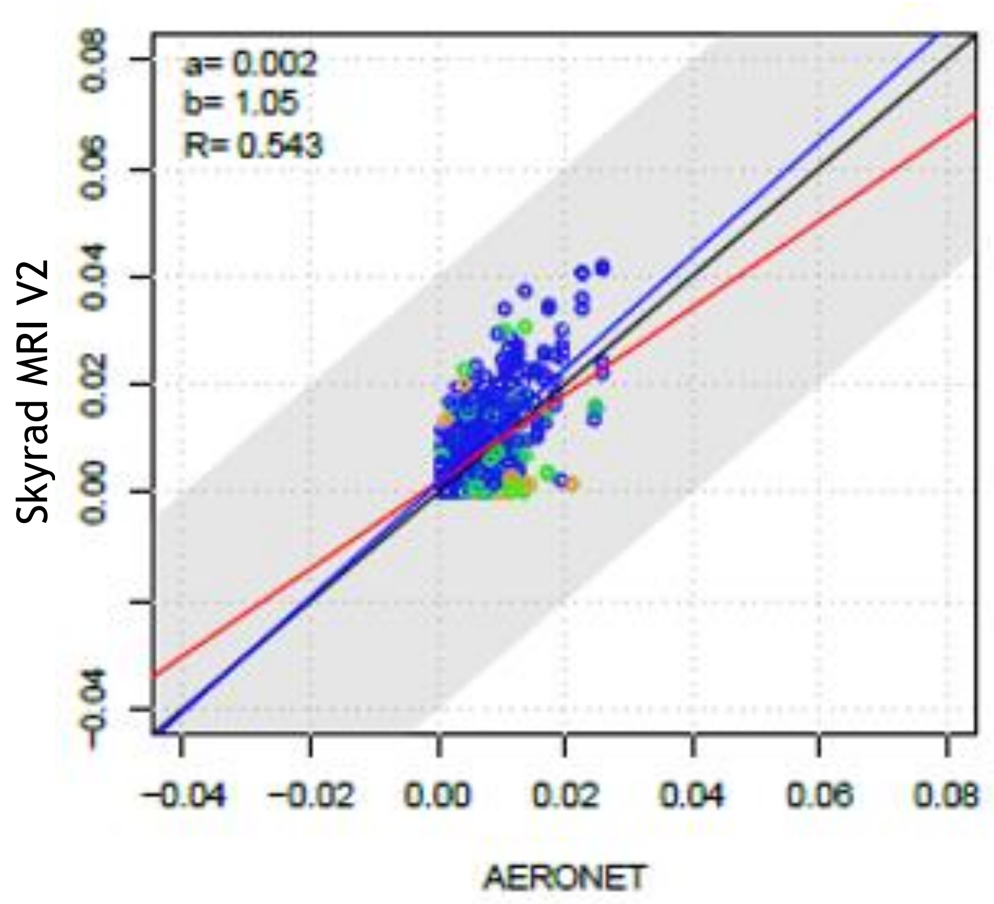




Evaluation of SKYRAD MRIv2 algorithm

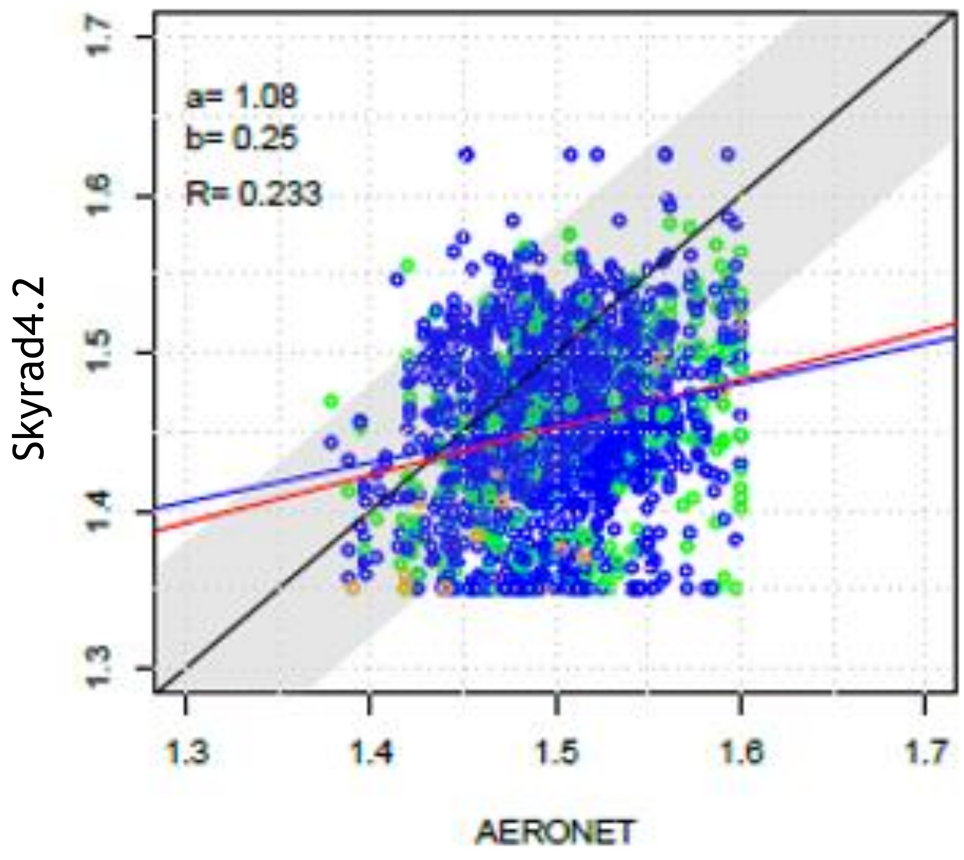
IRI 675 nm Valencia

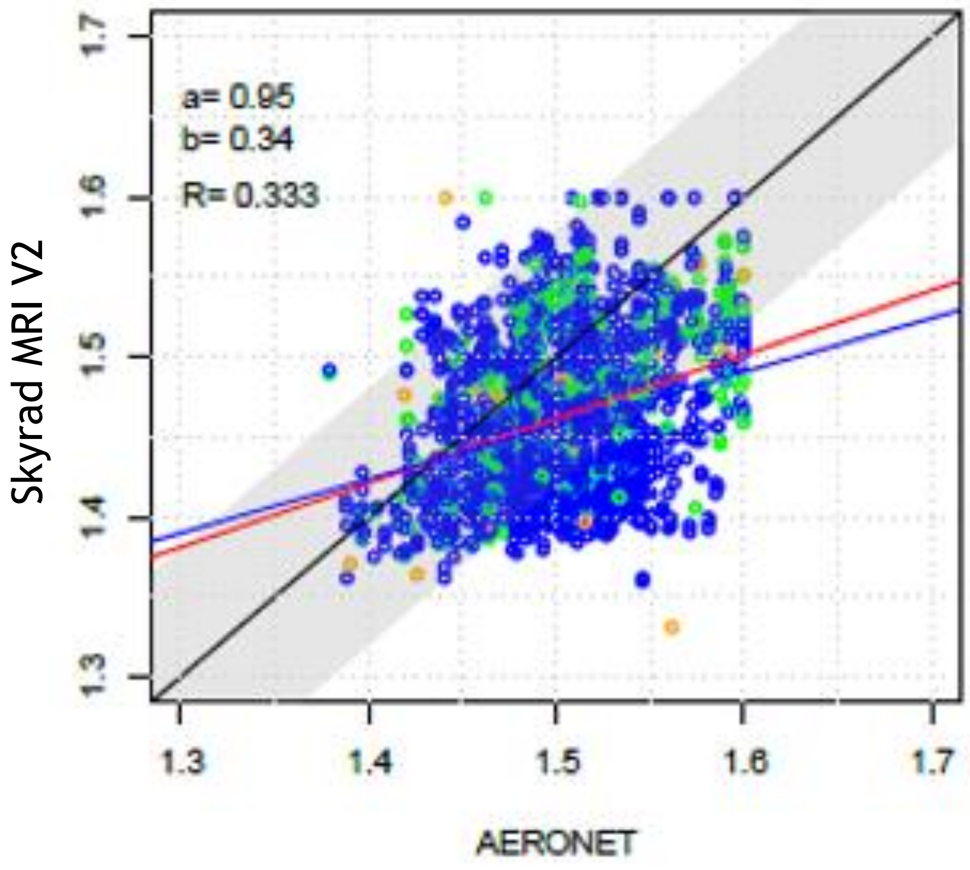




Evaluation of SKYRAD MRIv2 algorithm

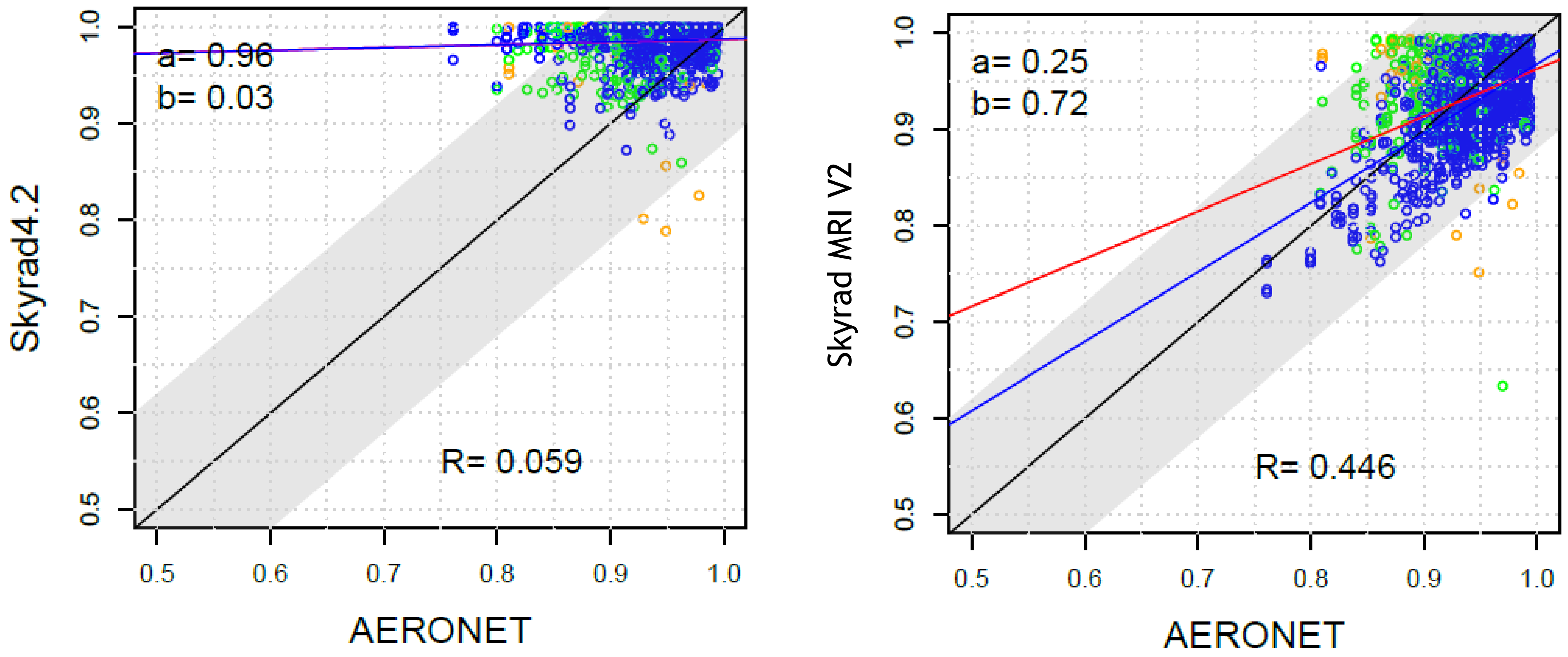
RRI 675 nm Valencia





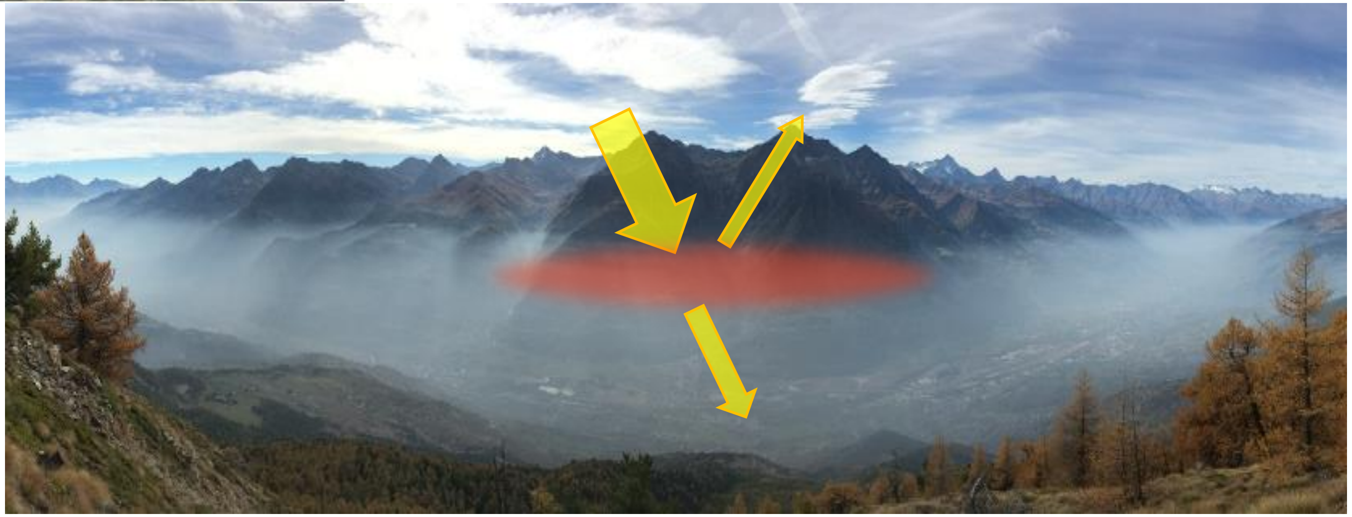
Evaluation of SKYRAD MRIv2 algorithm

SSA 675 nm Valencia



Estimation of the aerosol short-wave radiative effect

- Aosta—Saint-Christophe site (570 m asl)
- Inside an Alpine valley, surrounded by high mountains (>3500 m)
- Near Po Valley, polluted hotspot in Europe



Estimation of the aerosol short-wave radiative effect: instruments and methodology

PREDE POM-02 sky radiometer

Lufft CHM15k-Nimbus
Automated Lidar Ceilometer

Aerosol columnar properties retrieved with MRIv2

+

Aerosol extinction profile estimated with the ALC

↓

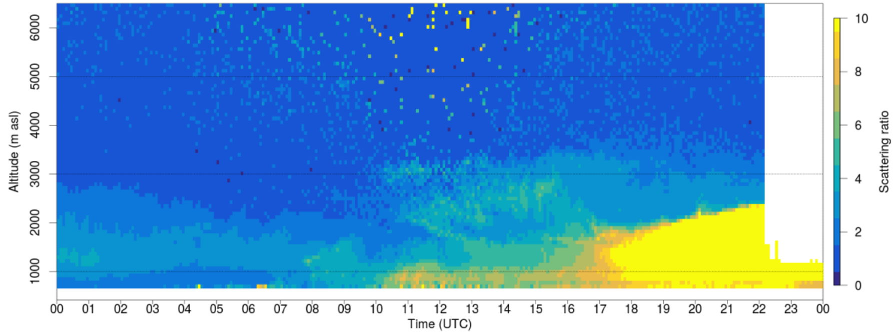
libRadtran RTM

↓

Short-wave radiant flux: difference with and without aerosol

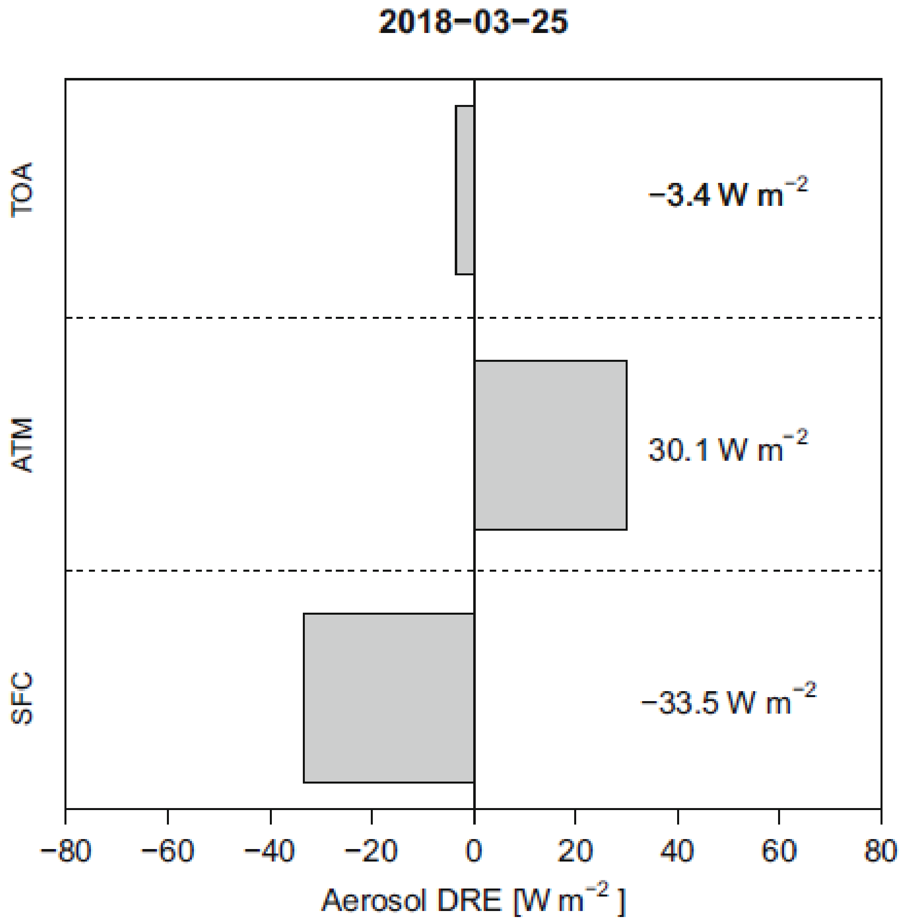
&

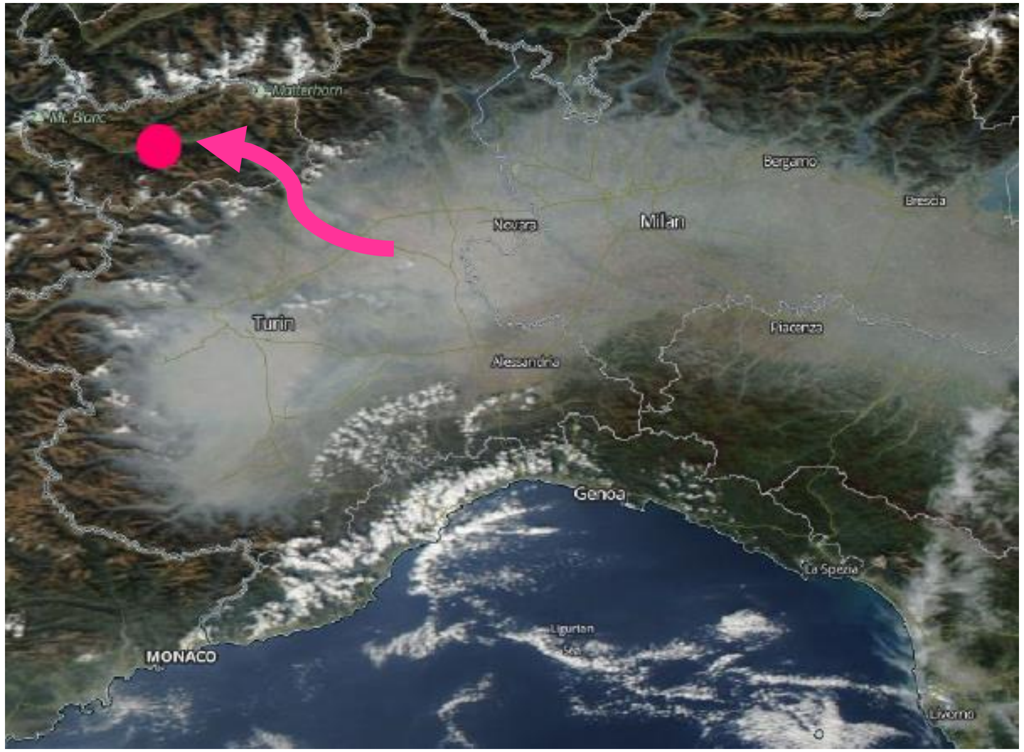
Profile of the **heating rate** caused by aerosols in the troposphere



Estimation of the aerosol short-wave radiative effect

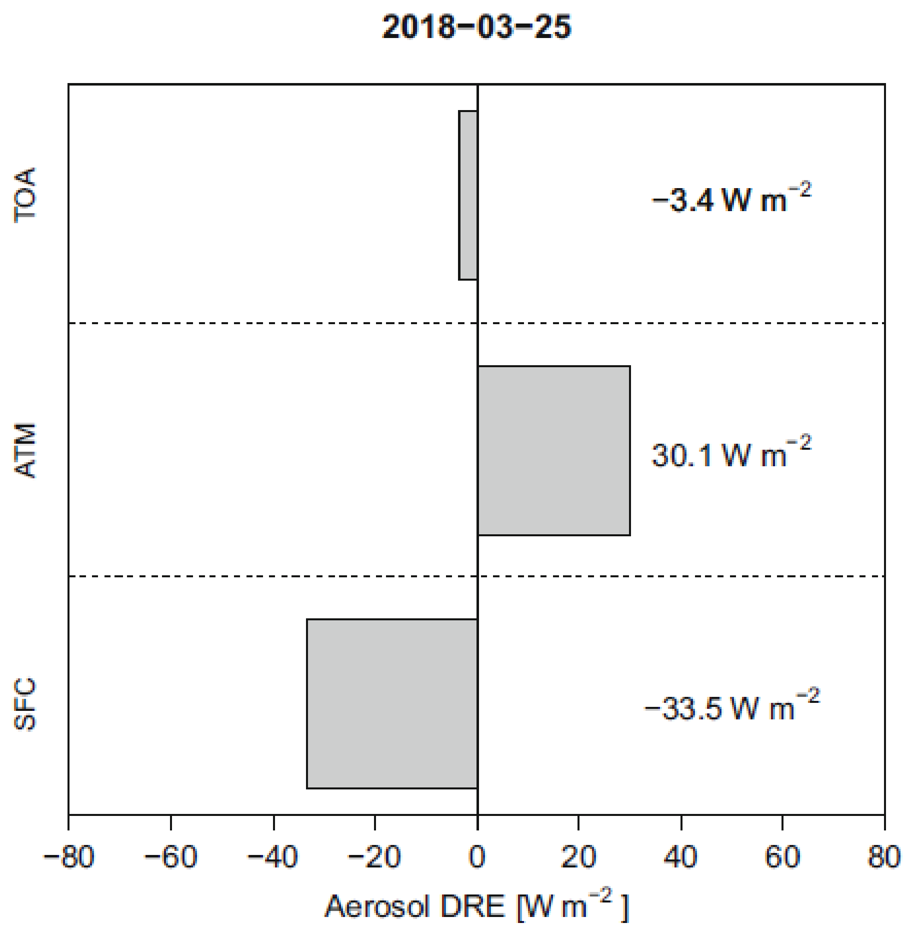
Example: secondary fine aerosol of urban/industrial origin

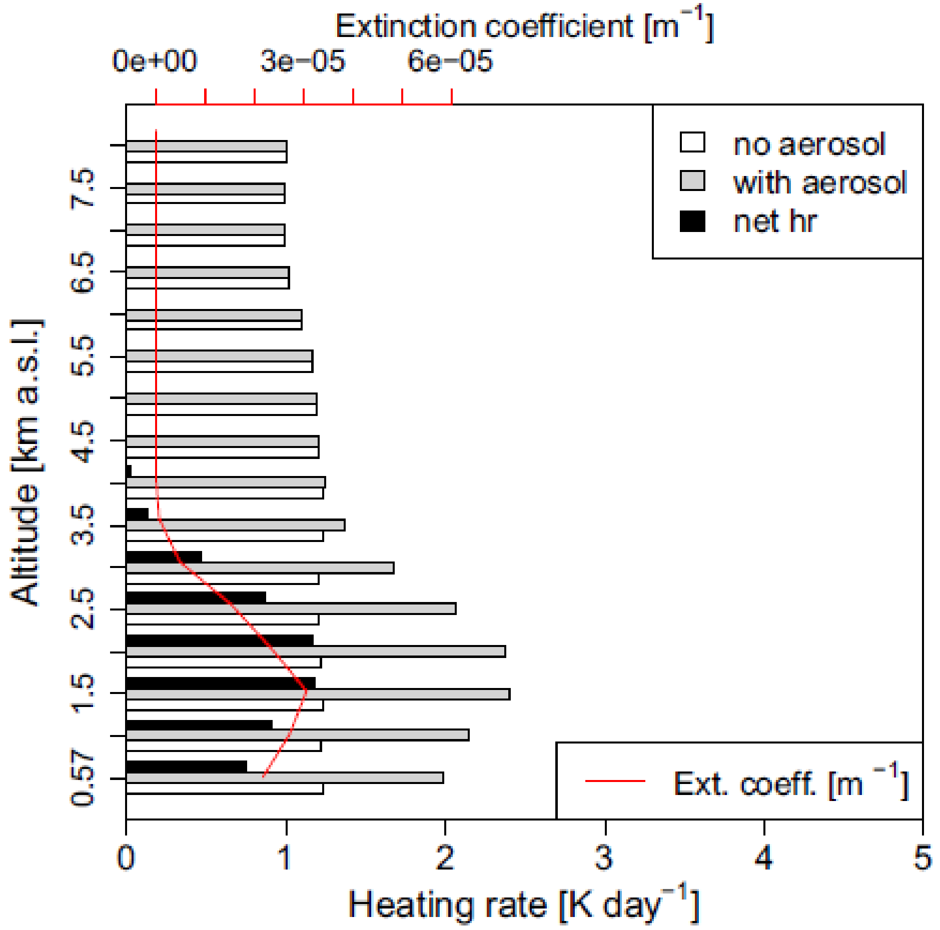




Estimation of the aerosol short-wave radiative effect

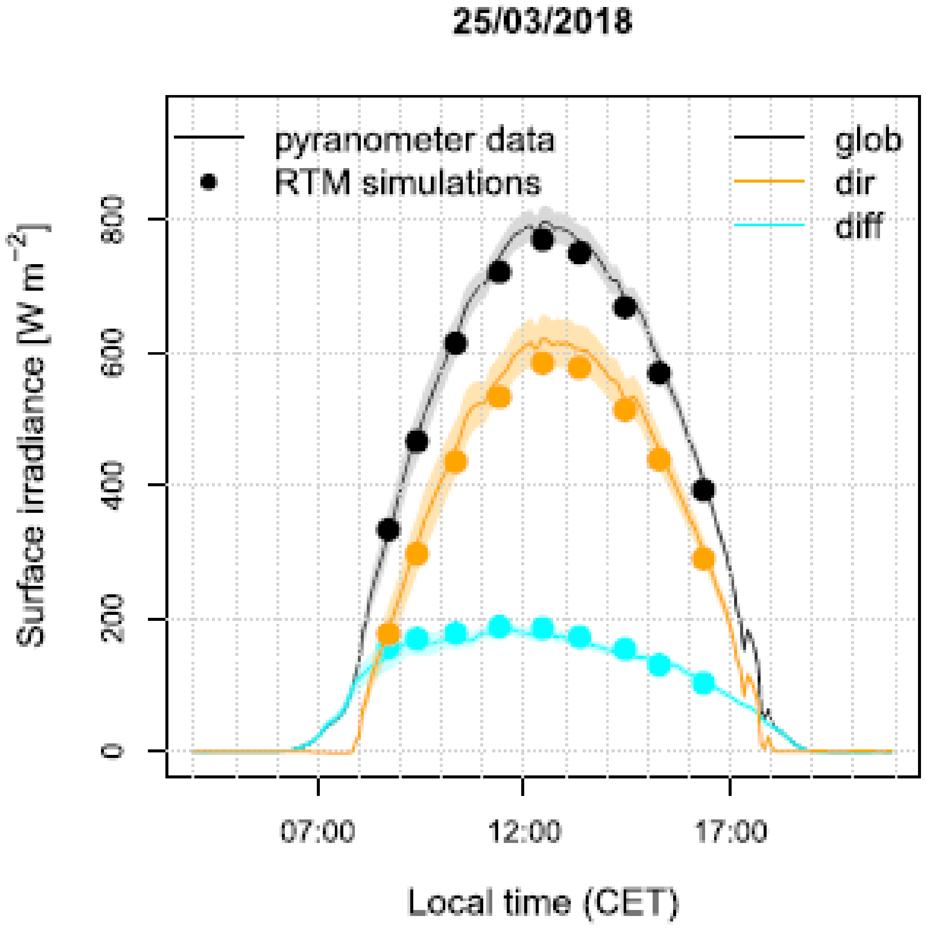
Example I: secondary fine aerosol of urban/industrial origin

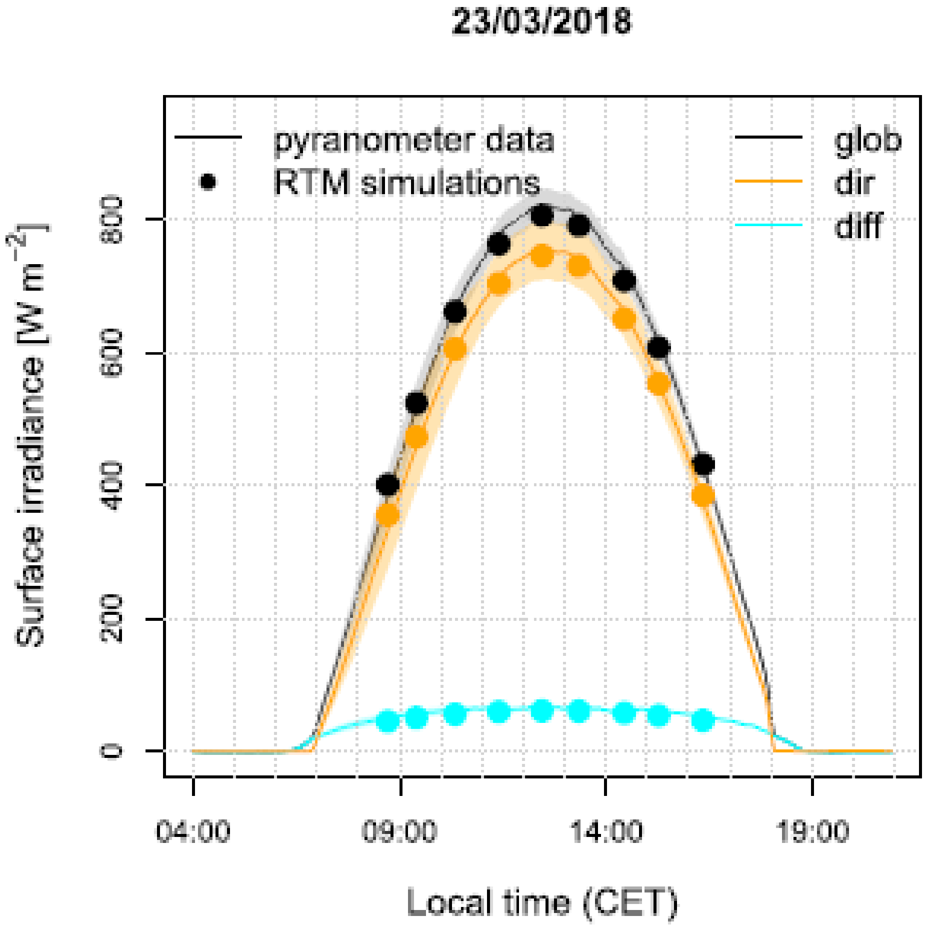




Radiative closure at the surface

- Surface irradiances simulated with RTM have been compared to co-located pyranometer data, in both turbid and clean atmospheric conditions
- The RTM simulations agree very well with pyranometer observations





Results

Evaluation of SKYRAD MRIv2 algorithm

- **Overall**: SKYRAD MRIv2 retrievals show a better agreement with AERONET V3 ones, for every aerosol property and in both sites
- Remarkable improvement in the agreement of **SSA** and **IRI**: more stable and physically consistent values. This is crucial in order to assess the aerosol radiative effects

Estimation of the aerosol short-wave radiative effect

- The effect of atmospheric aerosol on the short-wave radiative fluxes can be significant even in the Alpine environment, usually considered as pristine
- The Alpine environment is particularly challenging for this kind of studies: for example, taking correctly into account the surface albedo (due to the possible presence of snow) is crucial to accurately retrieve aerosol absorbing capacity (SSA and IRI).

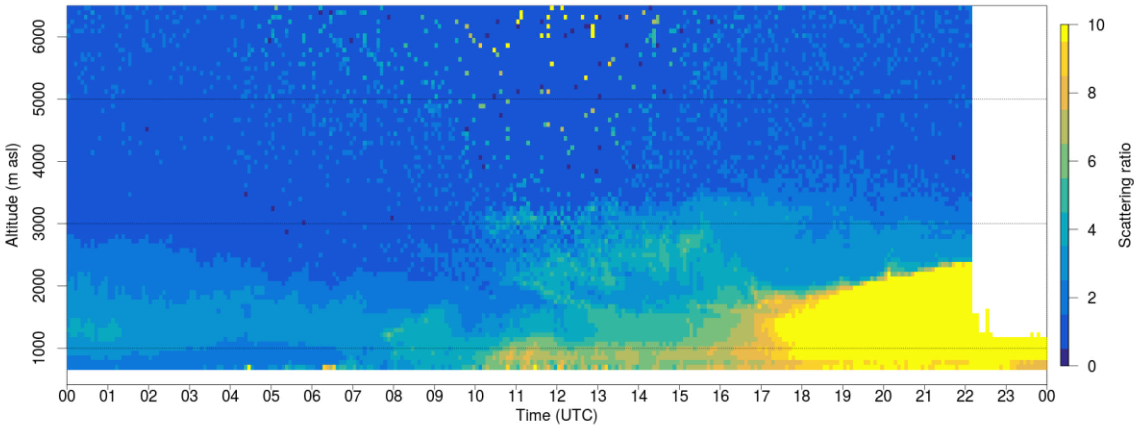
Thank you for your attention!

References:

- Kudo et al., *Optimal use of the Prede POM sky radiometer for aerosol, water vapor, and ozone retrievals*, Atmos. Meas. Tech., 2021. DOI: 10.5194/amt-14-3395-2021
- Fasano et al., *Vertical profile of the clear-sky aerosol direct radiative effect in an Alpine valley, by the synergy of ground-based measurements and radiative transfer simulations*, B. Atmos. Sci. Tech., 2021. DOI: 10.1007/s42865-021-00041-w

Instruments and methodology – part II

Automated LiDAR Ceilometer (ALC)



- Takes advantage of the backscattering of a laser pulse (1064 nm) by aerosol particles

- From the attenuated backscatter coefficient:

$$\beta_{att}(z,t) = \beta_T(z,t)\, e^{-2\int_{z_{min}}^{z} \alpha_T(s,t)\, ds}$$

- It is possible to estimate the aerosol extinction coefficient (*forward Klett* method):

$$\alpha_T = \alpha_p + \alpha_m \;; \qquad \beta_T = \beta_p + \beta_m$$

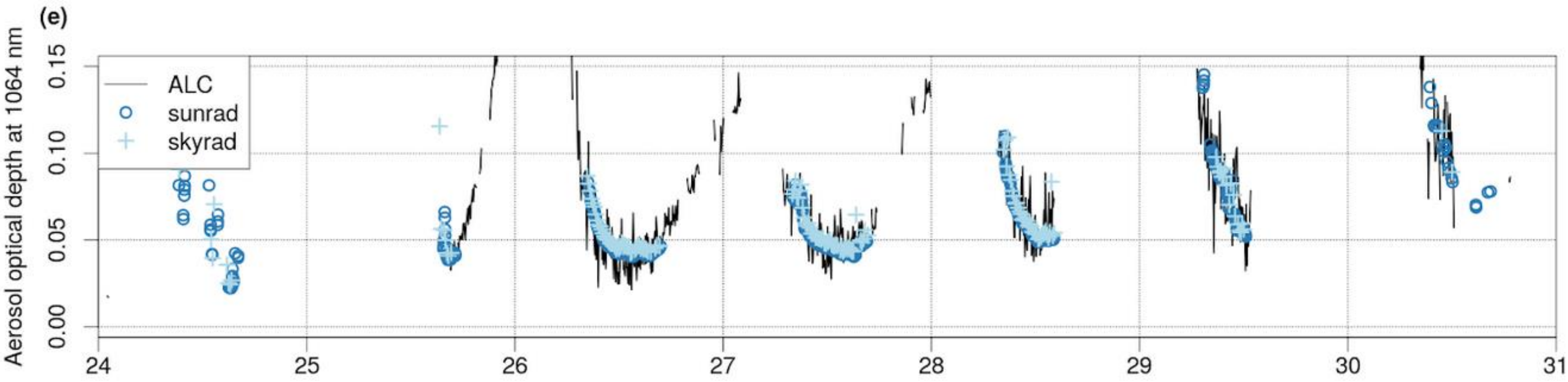
- The technique is based on an independent or *a priori* estimate of the *lidar ratio*. To this purpose, we use validated functional relationships

$$LR = \frac{\alpha_p}{\beta_p}$$

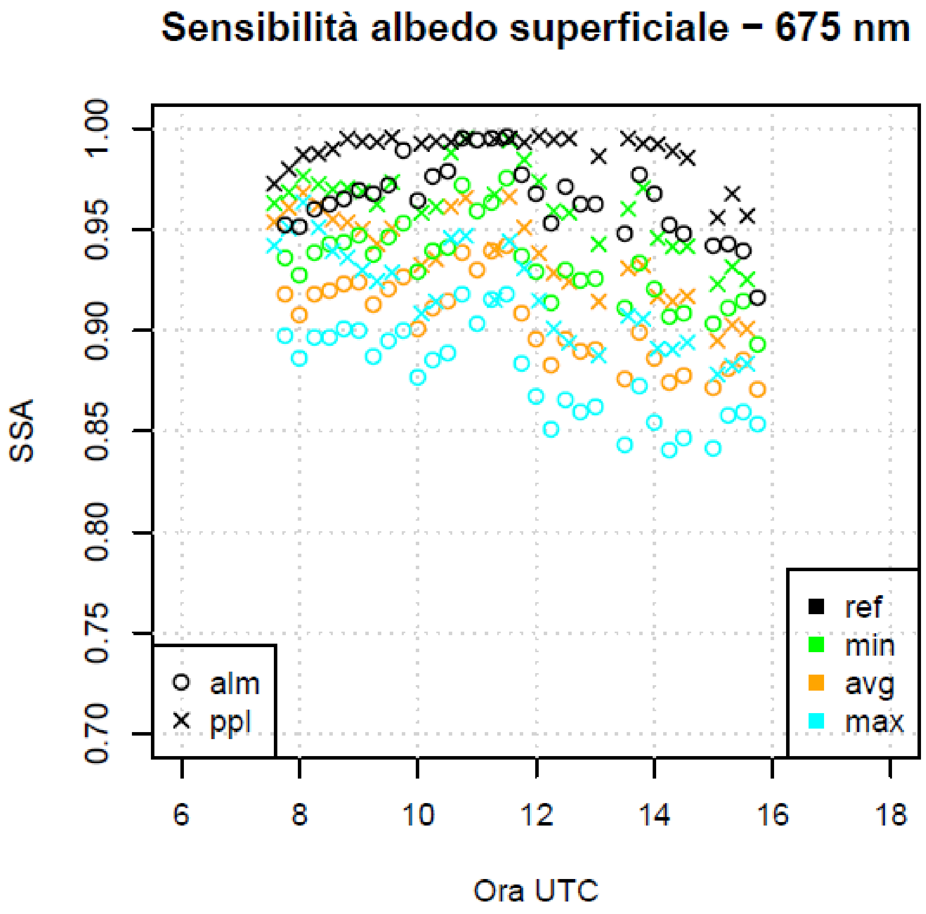
Instruments and methodology – part II

Automated LiDAR Ceilometer (ALC)

- Comparison between the AOD retrieved by the sky radiometer and the AOD obtained by vertical integration of the ALC-derived aerosol extinction coefficient

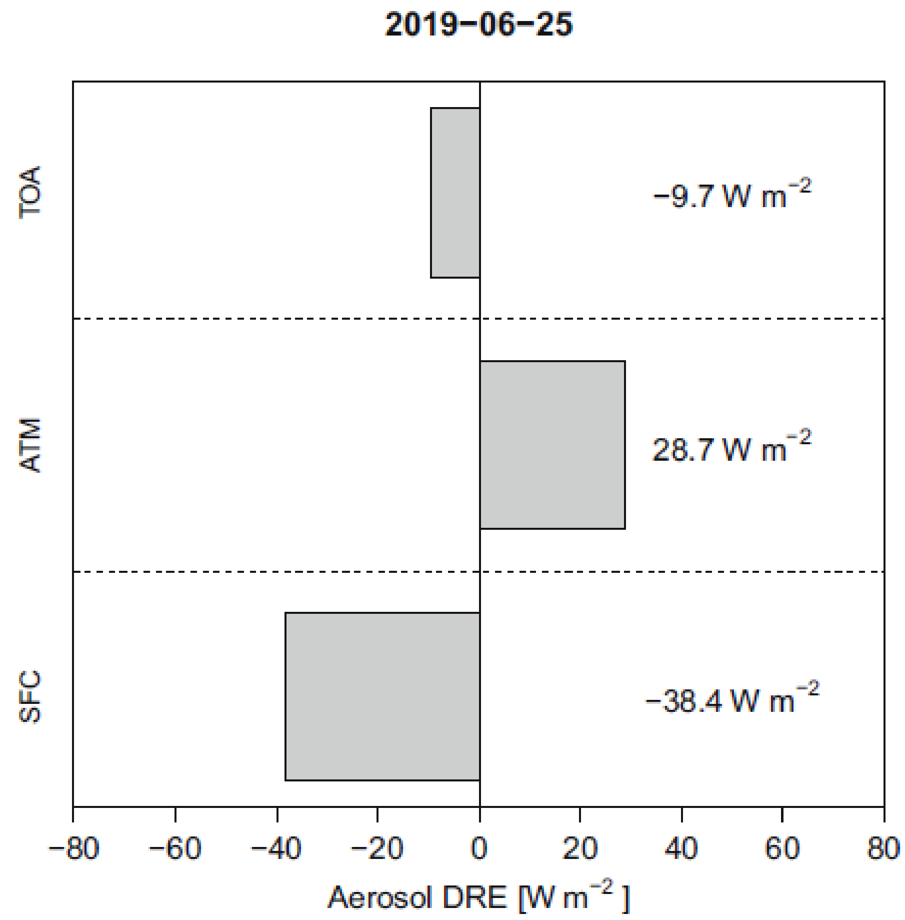


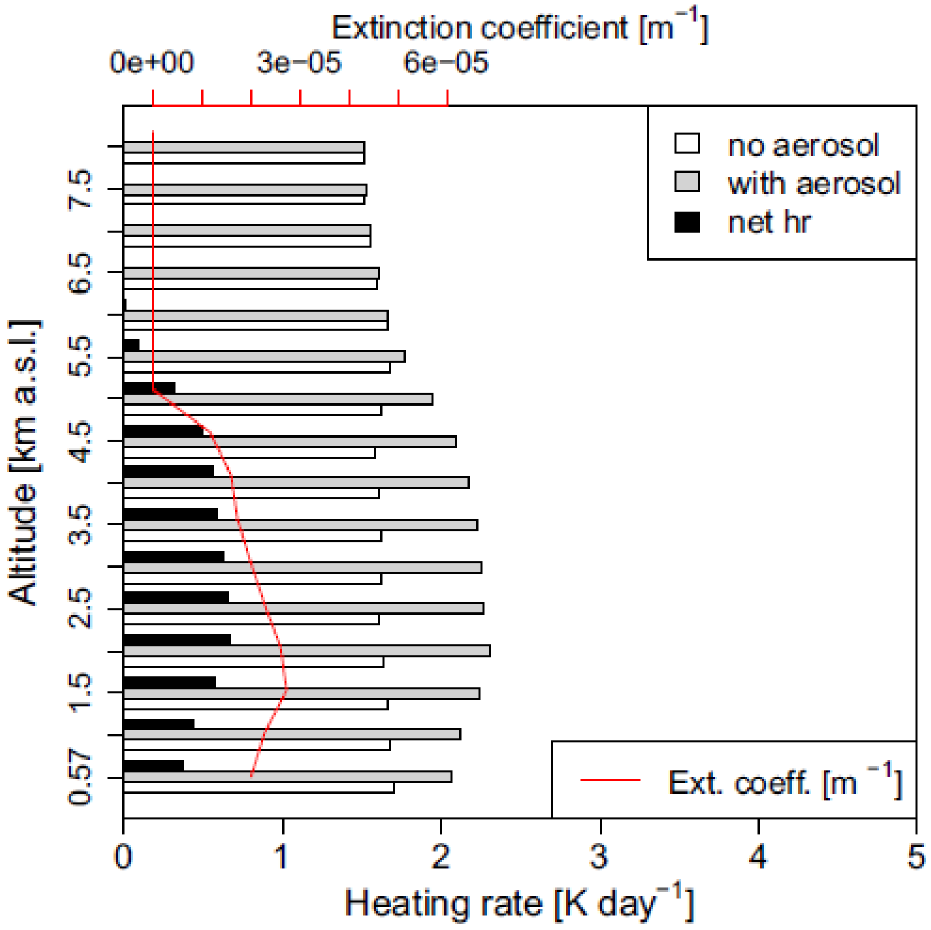
Part I: evaluation of SKYRAD MRIv2 retrievals



Part II: estimation of the short-wave aerosol radiative effect

Example II: coarse mineral aerosol from the Sahara desert





Part II: estimation of the short-wave aerosol radiative effect

Hourly values

- Net balance [W m^{-2}], 25/03/2018

Ora UTC	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16
TOA	-15.1	-9.2	-3.1	-0.7	-0.7	3.9	1.6	-0.1	-3.1
ATM	30.7	30.4	30.0	29.2	25.8	34.1	30.2	27.2	24.0
SFC	-45.8	-39.6	-33.1	-29.9	-26.5	-30.1	-28.6	-27.3	-27.1

- Net balance [W m^{-2}], 25/06/2019

Ora UTC	6-7	7-8	8-9	9-10	10-11	12-13	13-14	14-15	15-16	16-17
TOA	-21.9	-14.7	-9.0	-5.4	-3.5	-0.3	-2.0	-6.4	-10.1	-15.5
ATM	25.5	24.0	23.5	23.2	24.7	38.5	40.7	36.2	37.1	38.5
SFC	-47.4	-38.7	-32.4	-28.5	-28.2	-38.7	-42.7	-42.6	-47.2	-53.9

- Heating rate [K day^{-1}], 25/03/2018

Ora UTC	7	8	9	10	11	12	13	14	15
7-8 km	0.004	0.003	0.002	0.001	0.001	0.000	0.001	0.001	0.002
6-7 km	0.006	0.004	0.002	0.002	0.001	0.001	0.001	0.002	0.003
5-6 km	0.009	0.006	0.004	0.003	0.003	0.002	0.002	0.004	0.006
4-5 km	0.037	0.037	0.036	0.031	0.029	0.035	0.037	0.111	0.222
3-4 km	0.429	0.467	0.529	0.482	0.518	0.712	0.688	0.702	0.668
2-3 km	1.157	1.140	1.092	1.093	0.983	1.307	1.153	0.974	0.734
1-2 km	1.115	1.077	1.003	1.020	0.797	1.035	0.845	0.659	0.512
0.57-1 km	0.351	0.436	0.619	0.510	0.380	0.521	0.441	0.382	0.398

- Heating rate [K day^{-1}], 25/06/2019

Ora UTC	6	7	8	9	10	12	13	14	15	16
7-8 km	0.006	0.004	0.003	0.002	0.002	0.002	0.003	0.004	0.005	0.007
6-7 km	0.012	0.008	0.005	0.004	0.004	0.004	0.006	0.007	0.010	0.013
5-6 km	0.186	0.216	0.187	0.182	0.223	0.433	0.507	0.443	0.410	0.411
4-5 km	0.313	0.374	0.337	0.304	0.392	0.897	1.018	0.904	0.908	0.931
3-4 km	0.522	0.484	0.465	0.470	0.518	0.898	0.935	0.855	0.913	0.957
2-3 km	0.718	0.600	0.602	0.615	0.632	0.803	0.779	0.688	0.712	0.746
1-2 km	0.532	0.486	0.518	0.508	0.499	0.609	0.613	0.519	0.521	0.527
0.57-1 km	0.203	0.294	0.361	0.394	0.299	0.303	0.368	0.330	0.333	0.297

Part II: radiative closure at the surface