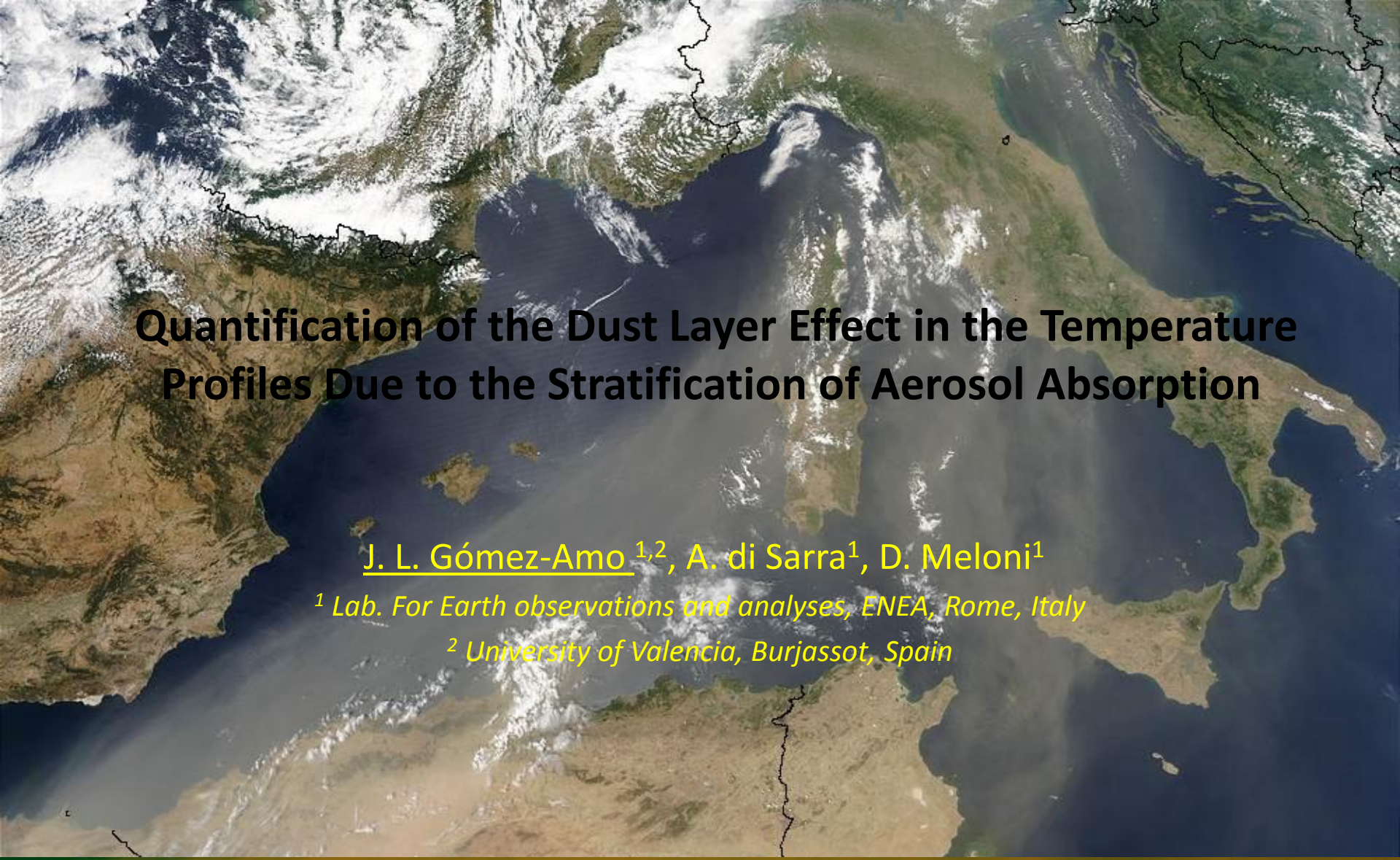


Quantification of the Dust Layer Effect in the Temperature Profiles Due to the Stratification of Aerosol Absorption

J. L. Gómez-Amo [1,2], A. di Sarra[1], D. Meloni[1]

[1] Lab. For Earth observations and analyses, ENEA, Rome, Italy

[2] University of Valencia, Burjassot, Spain

ENEA esa

→ 7th INTERNATIONAL WORKSHOP
ON SAND/DUSTSTORMS AND ASSOCIATED DUSTFALL

2–4 December 2013 | ESA–ESRIN | Frascati (Rome), Italy

Background - Motivation

Uncertainties on the aerosol effect on climate are mainly due to:

a. uncertainties in the aerosol vertical profile
b. uncertainties in the aerosol absorption

Errors in the model determination of temperature profiles are related with the aerosol load (Carmona et al., 2008)

Background - Motivation

Carmona et al., (2008)

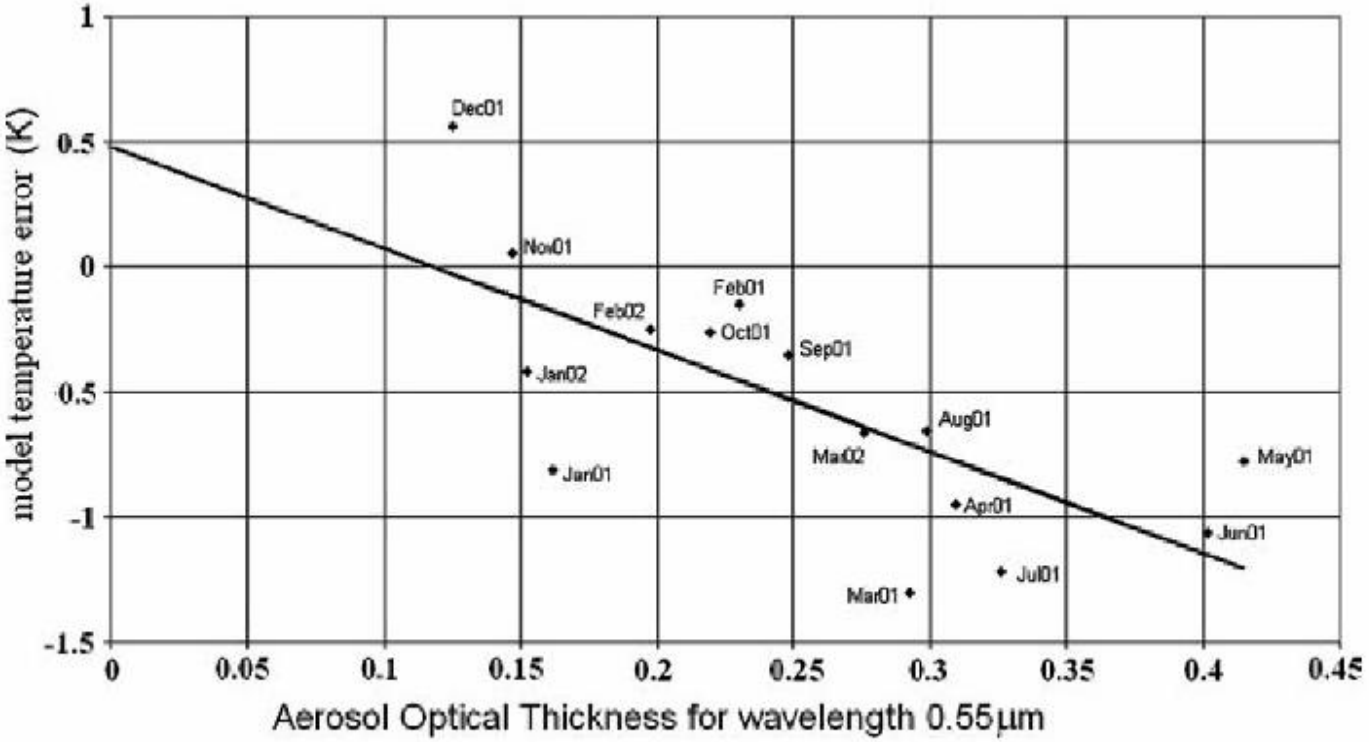


Fig. 3. Model temperature error (in K; observed temperature minus ECMWF temperature prediction to 24 h after interpolation to the station coordinate) vs. MODIS Terra aerosol optical thickness (AOT) in central Italy during January 2001–March 2002.

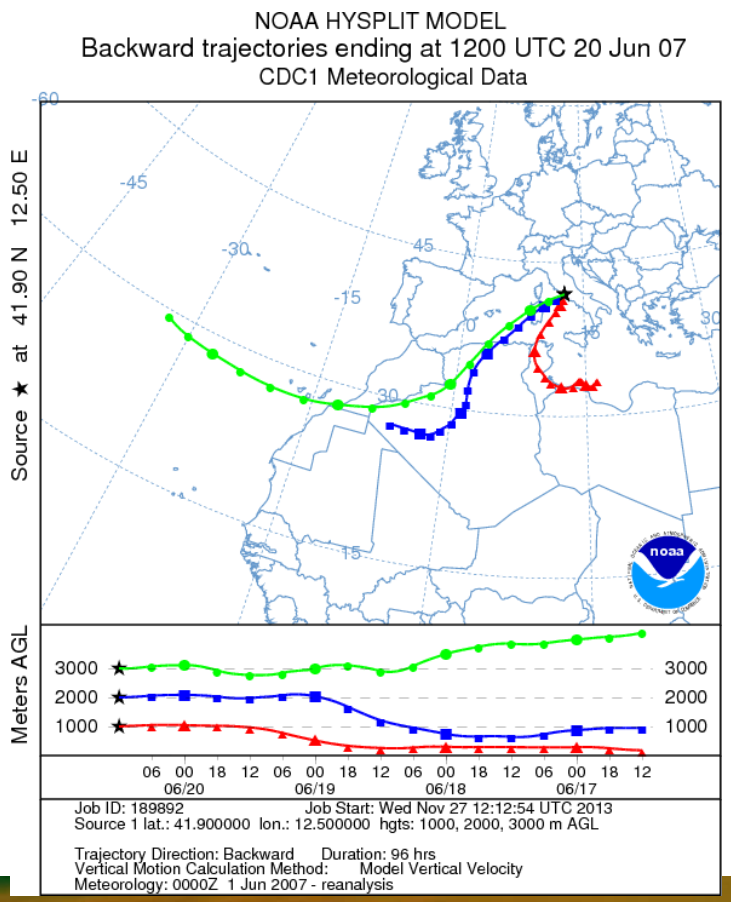
Objective

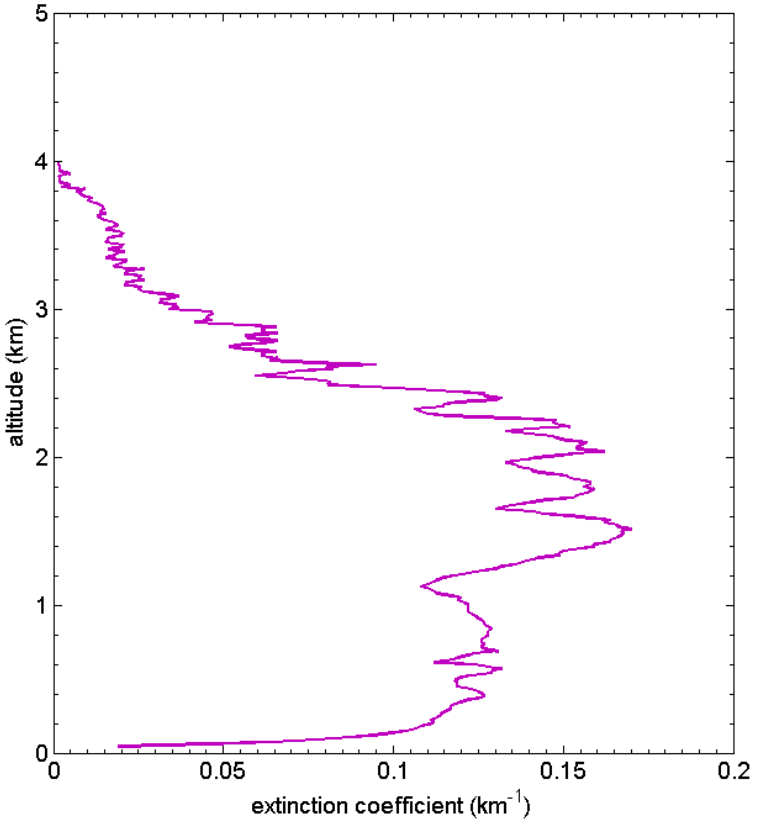
How much the aerosol absorption can affect the temperature profiles?

Using a simple approach based on:

a. a detailed aerosol stratification (measurements)
b. radiative transfer simulations

Case study: Rome, 20 June 2007





Wavelength (nm)	AOD	SSA	AE = 0.3
415	0.318	0.76	
550	0.292	0.81	
868	0.253	0.92	

Radiative Transfer simulations

Modtran 4.2

a. *input parameters:*

- *Lidar extinction profile (125 m resolution)*
- *Meteorological profile (radiosonde, Pratica di Mare)*
- *aerosol optical properties (2 Layers)*

b. *output:*

- *Radiative fluxes (vertically resolved): shortwave and longwave*

Radiative Transfer simulations

Aerosol radiative forcing

$$ARF = \left(F^{\downarrow} - F^{\uparrow}\right)_{aerosol} - \left(F^{\downarrow} - F^{\uparrow}\right)_{aerosol\ free}$$

Aerosol forcing efficiency

$$AFE = \frac{ARF}{AOD_{550nm}}$$

Heating rate profiles

$$\frac{\Delta T}{\Delta t} = -\frac{g}{Cp}\frac{\Delta Fnet}{\Delta p}$$

Aerosol scenarios

- *Aerosol extinction and asymmetry are kept fixed (column-integrated measurements)*

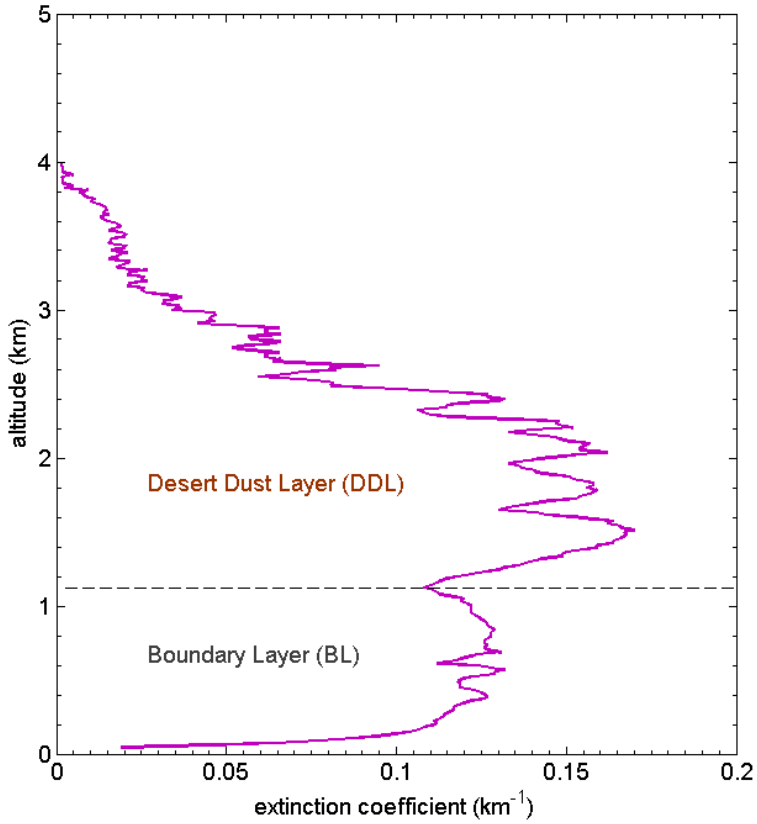
- *Aerosol absorption (2 Layers):*

  ABL: *Absorbing BL aerosol type (Urban)*

  SBL : *Scattering BL aerosol type (clean marine)*

  HL: *Homogeneous layer (column-integrated measurements)*

- *Spectral absorption in BL by OPAC database (Hess et al., 1998)*



Aerosol scenarios

- *In the shortwave, the absorption of the dust layer:*

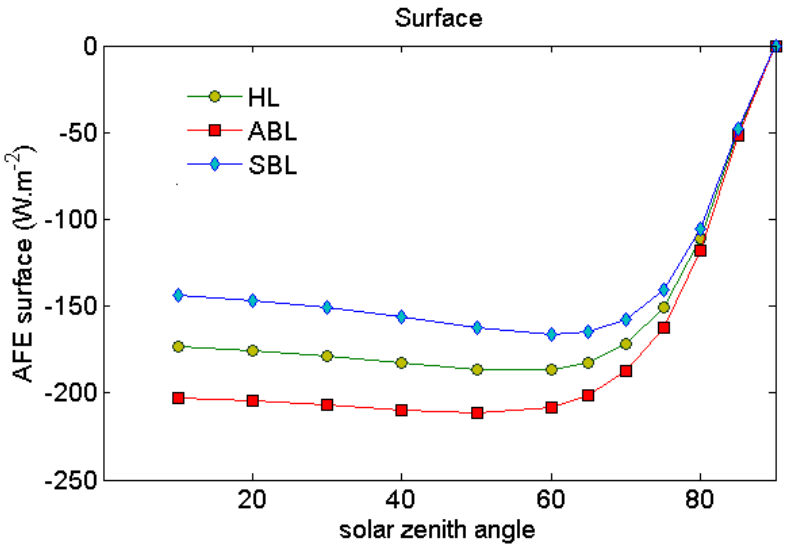
$$AOD_{Column}(\lambda) = AOD_{BL}(\lambda) + AOD_{DDL}(\lambda)$$

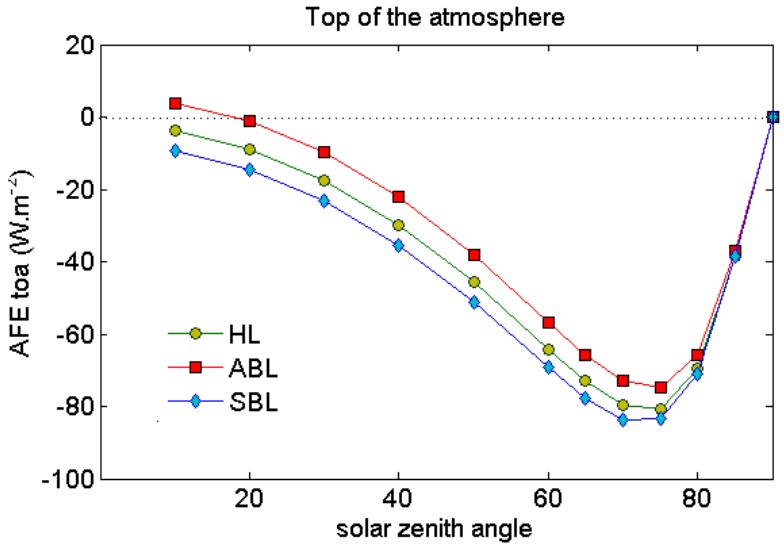
$$SSA(\lambda) \cdot AOD(\lambda)_{Column} = SSA(\lambda) \cdot AOD(\lambda)_{BL} + SSA(\lambda) \cdot AOD(\lambda)_{DDL}$$

- *In the longwave, the aerosol optical properties of BL and DDL:*

  OPAC database (Hess et al., 1998)

Aerosol radiative effects

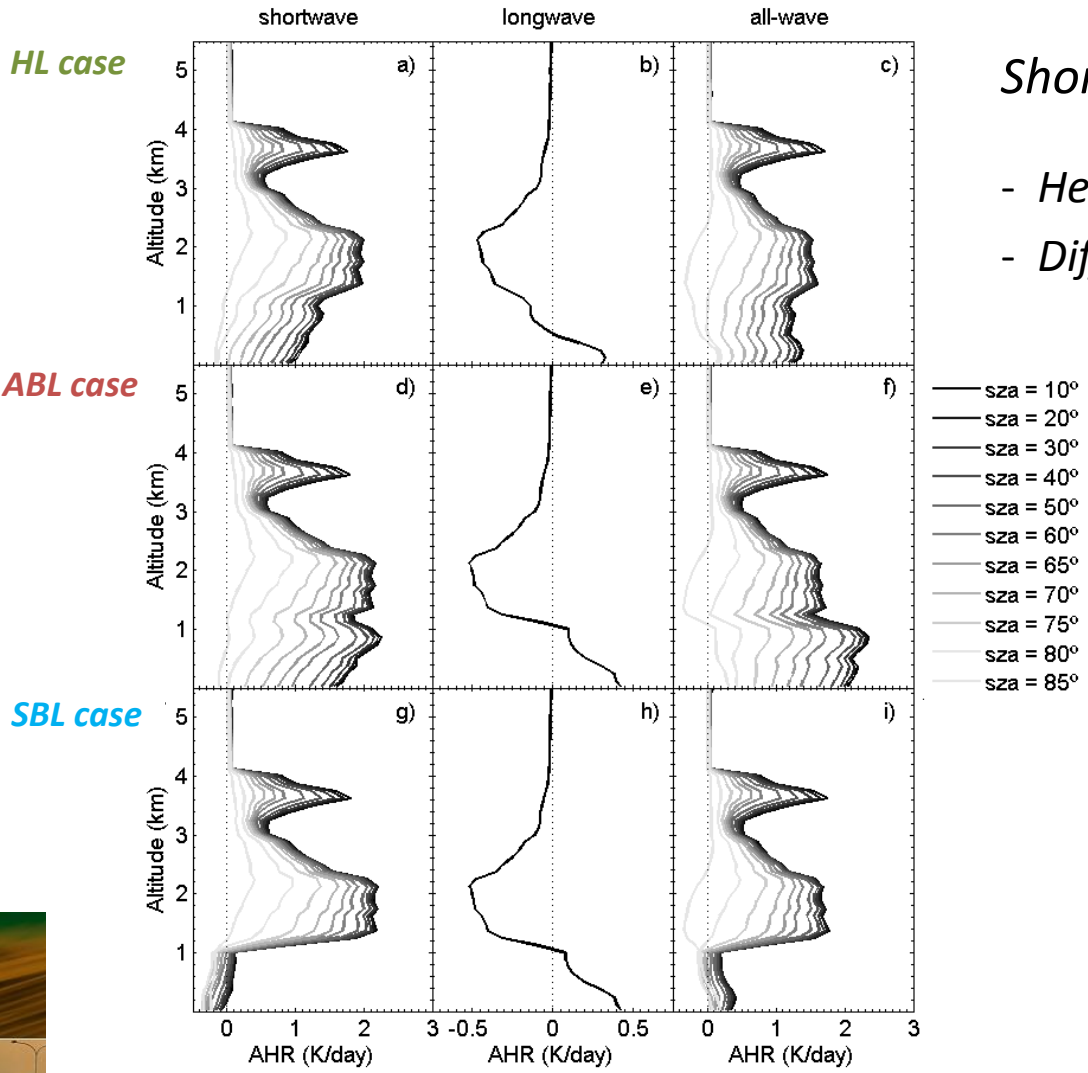




In a daily basis:

(HL-ABL)/HL (%)			(HL-SBL)/HL (%)		
surface	toa	atm	surface	toa	atm
-13	16	-22	11	-13	17

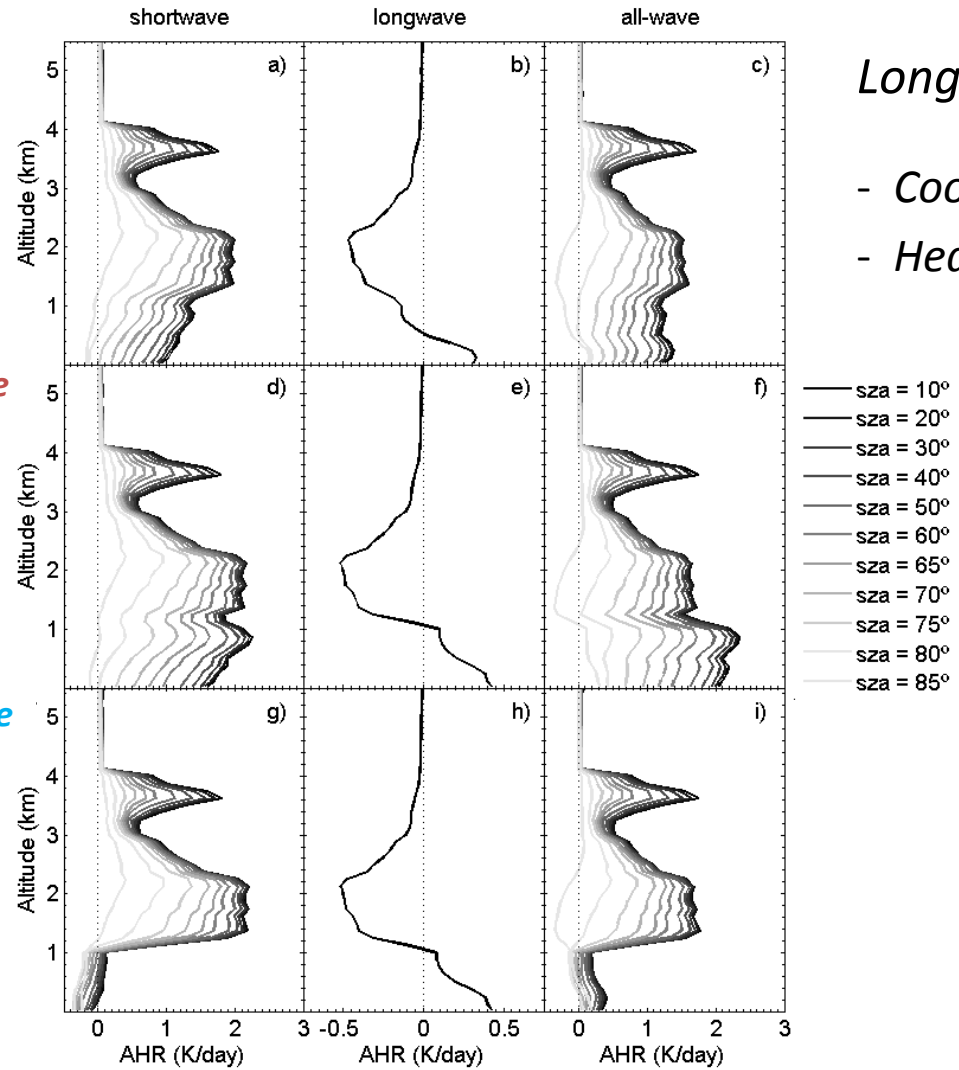
Heating rate profiles



Shortwave

- *Heating in the dust layer (up to 2.2 K/day)*
- *Differences in the boundary layer:*
  - ***HL:** heating (up to 1.3 K/day)*
  - ***ABL:** heating (up to 2 K/day)*
  - ***SBL:** cooling*

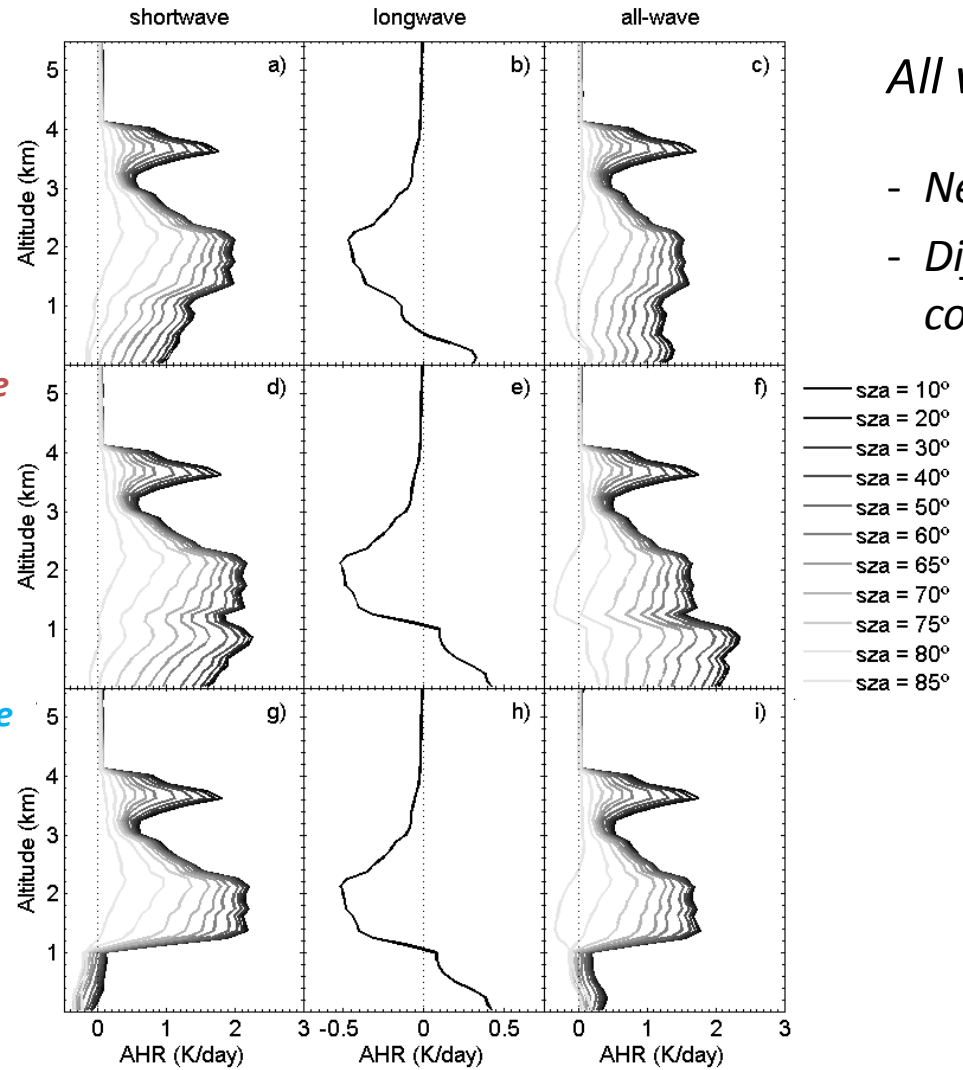
Heating rate profiles



Longwave

- *Cooling in the dust layer (up to -0.5 K/day)*
- *Heating in the boundary layer:*
  - ***HL:** mean HR = 0.1 K/day*
  - ***ABL:** mean HR = 0.25 K/day*
  - ***SBL:** mean HR = 0.25 K/day*

Heating rate profiles



All wave = shortwave + longwave

- *Net heating*
- *Different longwave/allwave contributions:*
  - ***Dust layer:*** *23-26%*
  - ***Boundary layer:***
    - ***HL:*** *9%*
    - ***ABL:*** *12%*
    - ***SBL:*** *88%*

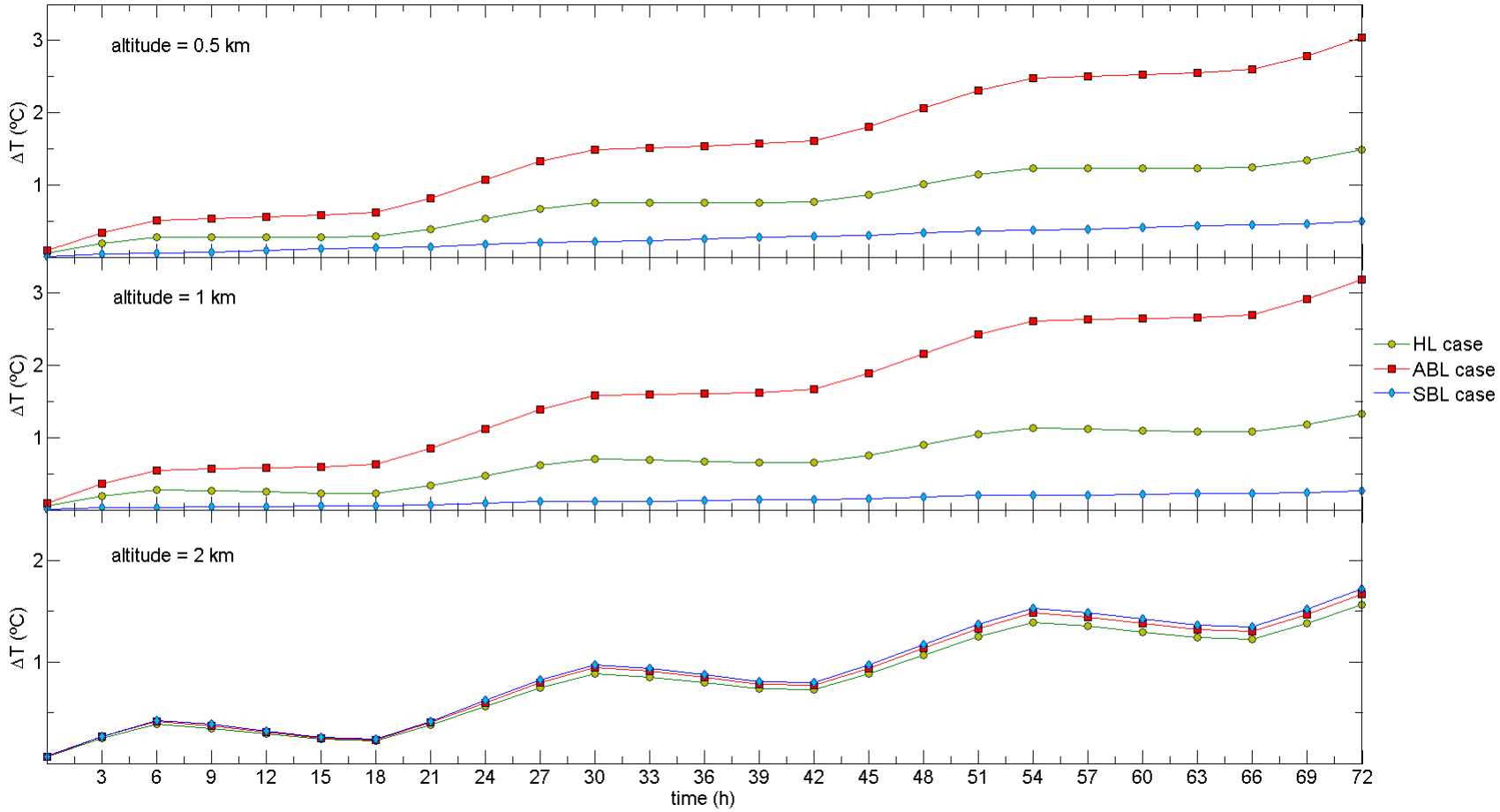
Effects on the temperature profiles

- *72h forward run*

$$\Delta T = HR_{aerosol} \cdot \Delta t + T_1$$

- *Assumptions:*
  a. *Aerosol situation is not varying during the 72h*
  b. *The temperature evolution is due to the aerosol radiative heating/cooling*

Effects on the temperature profiles



Summary and conclusions

- ✓ The aerosol radiative impact present strong dependence on the vertical distribution of the aerosol absorption
- ✓ The ABL and SBL cases present an opposite deviation with respect to the forcing efficiency obtained for the HL case
- ✓ The relative differences larger than 10% of the HL case values

Regarding to the heating rate profiles

- ✓ A net heating effect is obtained within the whole aerosol layer
- ✓ Part of the shortwave heating is offset by the longwave cooling within the dust layer
- ✓ Different longwave/allwave contributions are observed in the BL that cause different evolution of the temperature
- ✓ Larger absorption in the boundary layer cause a notable increase of the temperature after 24h