AEROSOL RADIATIVE FORCING ESTIMATION USING GROUND BASED MEASUREMENTS AND MODTRAN4

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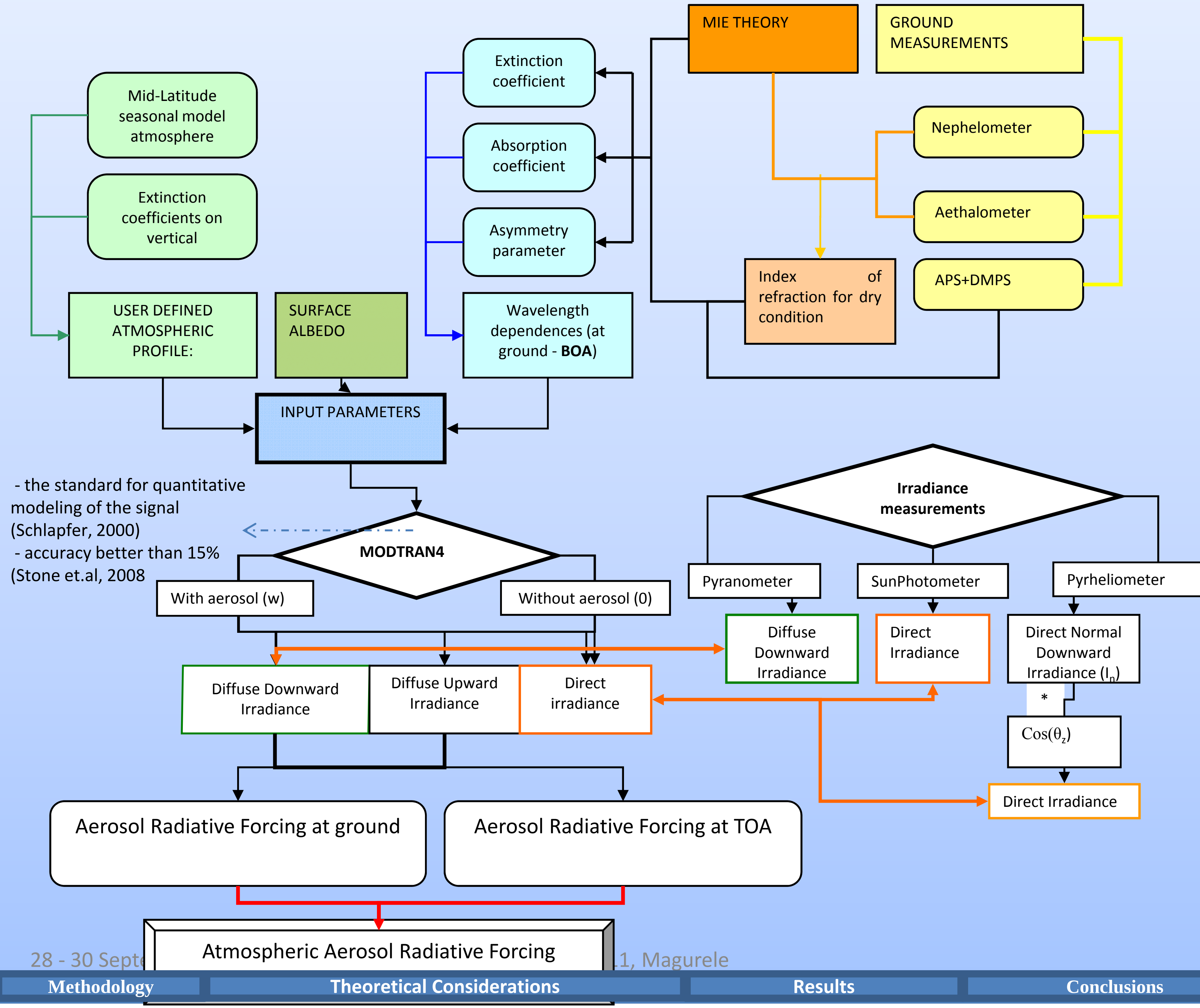

MIE THEORY
GROUND MEASUREMENTS
Extinction coefficient
Absorption coefficient
Asymmetry parameter
Wavelength dependences (at ground - BOA)
Mid-Latitude seasonal model atmosphere
Extinction coefficients on vertical
USER DEFINED ATMOSPHERIC PROFILE:
SURFACE ALBEDO
Nephelometer
Aethalometer
APS+DMPS
Index of refraction for dry condition
INPUT PARAMETERS
- the standard for quantitative modeling of the signal (Schlapfer, 2000)
- accuracy better than 15% (Stone et.al, 2008
MODTRAN4
With aerosol (w)
Without aerosol (0)
Irradiance measurements
Pyranometer
SunPhotometer
Pyrheliometer
Diffuse Downward Irradiance
Direct Irradiance
Direct Normal Downward Irradiance (I_n)
*
$\cos(\theta_z)$
Direct Irradiance
Diffuse Downward Irradiance
Diffuse Upward Irradiance
Direct irradiance
Aerosol Radiative Forcing at ground
Aerosol Radiative Forcing at TOA
Atmospheric Aerosol Radiative Forcing

Methodology

INPUT PARAMETER

```
KM  7   2   2   1   3   3   3   3   3   3   1   1   0 270.900    -91
ST  8T   5 365.00000                 T F F T      0.000
                                                  4
   7   2   1   3   0   0   0.00000   0.00000   0.00000   0.00000   0.00000
  63    1    2   user def.profiles
    0.00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00

0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
0.000e+00
       0.912            0.000     0.000     0.000
    0.24 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
0.000e+00
      ......................................................................
       0.000            0.000     0.000     0.000
   29.82 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00 0.000e+00
0.000e+00
       0.000            0.000     0.000     0.000
   1    0    0    0
1.000e+000  20070201fall-winter;default atmospheric profile
 0.202.775980.607110.7994  0.302.092160.435030.7754  0.341.870790.390370.7690
 0.551.000000.233570.7286  0.690.685200.178670.7011  1.060.319830.107400.6592
 1.540.162190.068340.6597  2.000.103000.050000.6747  2.250.084840.043630.6812
 2.500.071650.038670.6860  2.700.063500.035440.6884  3.000.054000.031480.6896
 3.390.044920.027450.6890  3.750.038790.024580.6882  4.500.029930.020140.6839
 5.000.025840.017970.6789  5.500.022690.016220.6743  6.000.020190.014780.6714
 6.200.019330.014270.6699  6.500.018160.013570.6700  7.200.015900.012180.6703
 7.900.014130.011050.6701  8.200.013480.010620.6722  8.700.012520.009980.6717
 9.000.012000.009630.6718  9.200.011680.009420.6731 10.000.010540.008630.6747
 10.590.009810.008130.6713 11.000.009370.007820.6701 11.500.008880.007470.6681
 12.500.008020.006850.6609 14.800.006550.005750.6404 15.000.006450.005680.6375
 16.400.005800.005180.6219 17.200.005490.004930.6156 18.500.005040.004580.6014
 21.300.004280.003960.5509 25.000.003570.003370.5075 30.000.002910.002800.4384
 40.000.002140.002090.2564 50.000.001690.001670.1606 60.000.001400.001390.1106
 80.000.001040.001040.0622100.000.000830.000830.0399150.000.000550.000550.0178
200.000.000420.000420.0100300.000.000280.000280.0045
   70.000    0.000   180.000    0
   1    2   32    0
   45.800   351.380    0.000     0.000     02.00     0.000     0.000     0.000
     100     50000        5       10RN      \tW3AA  f 0
```

Sensitivity selections:

-*solar irradiance on the top of the atmosphere* was extracted from the build in Thuillier plus corrected Kurucz MODTRAN database

-mid – latitude *atmospheric profile* was chose from Anderson database

-fluxes were integrated over a spectral range of 0.2 – 40 µm, with a spectral resolution of 5 cm^{-1}

-radiative transfer equation was solved using the Discrete Ordinate Radiative Transfer (DISORT) multiple scattering algorithm with 8 streams and correlated – k treatment, using 17 absorption coefficients per spectral bin of 1 cm^{-1} (Stamnes et al., 1988)

For each hour it is generated one input file .tp5 using Matlab codes

OUTPUT PARAMETERS

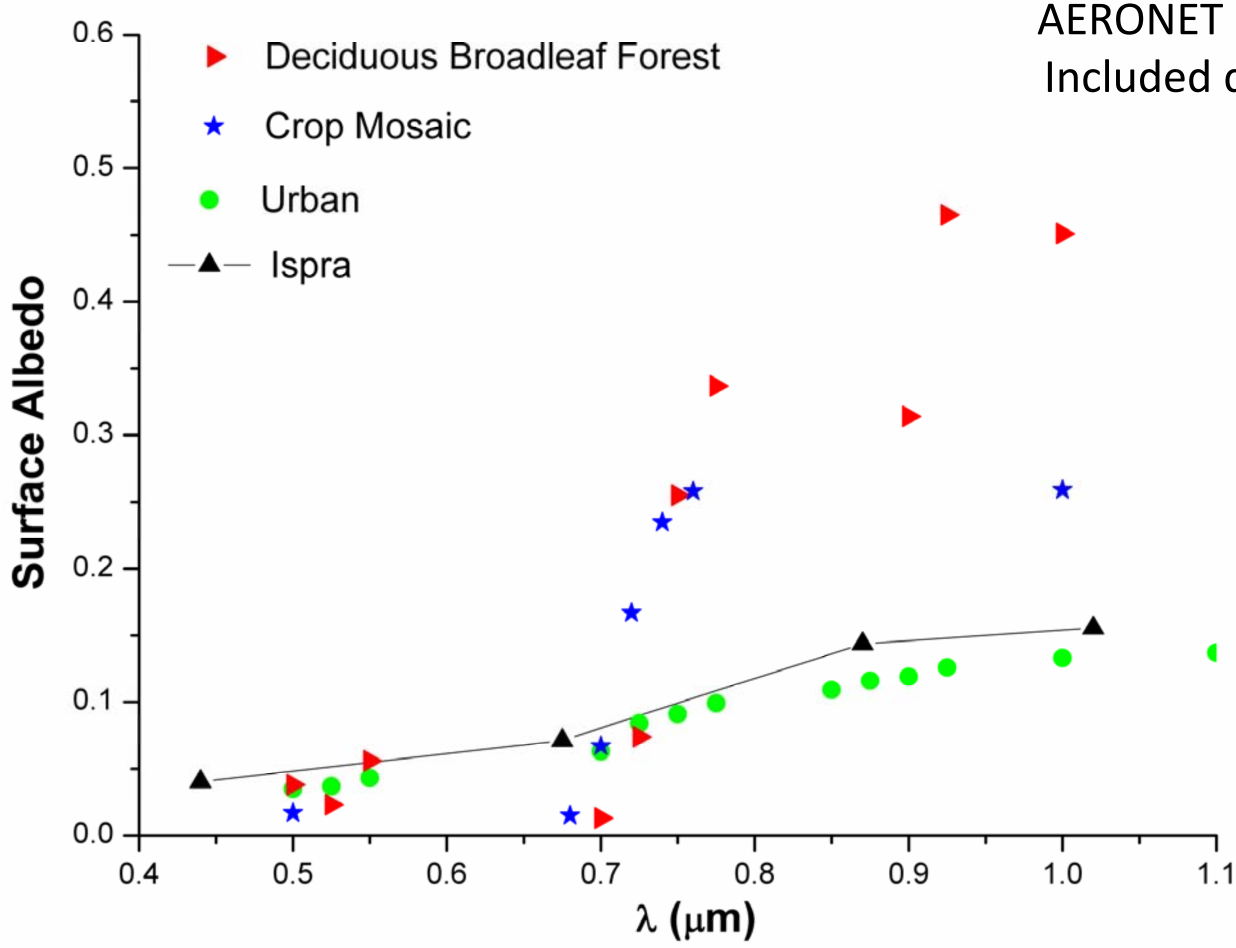
LAYER	CALC ALTITUDE (KM)	PRESSURE (MB)	COOLING RATE TOTAL (K/DAY)	COOLING RATE NO DIRECT SUN (K/DAY)	TOTAL FLUX UP-DN-DIR (W/M2)	TOTAL THERMAL FLUX UP (W/M2)	TOTAL THERMAL FLUX DOWN (W/M2)	SCATTERED SOLAR FLUX UP (W/M2)	SCATTERED SOLAR FLUX DOWN (W/M2)
1	0.000000	1018.004944	-14.183376	-3.840154	-245.907196	360.950562	226.751755	43.575005	95.234718
	0.060000	1010.325073	-11.399036	-0.883534	-258.005585	352.411499	225.501572	45.076332	92.061821
	0.120000	1002.703125	-9.072850	1.595899	-268.334839	345.473816	224.250900	46.553566	88.666054
	0.180000	995.138672	-7.204819	3.598143	-276.894958	340.137482	222.999725	48.006702	85.047401
2	0.240000	987.631470	-5.794942	5.123200	-283.685974	336.402496	221.748077	49.435741	81.205879

Methodology

Joint Research Centre
($45^0 48'$N, $08^0 37'$E), Ispra, Italy
IT04 station - EMEP network

Rural and forests area
(Clerici and Melin, 2008)

Methodology



MODIS
AERONET network
Included database

FIG1. The surface albedo measured at Ispra compared with the urban, deciduous braodleaf forest and crop mosaic (standard values from internal data of MODTRAN4) .

Methodology

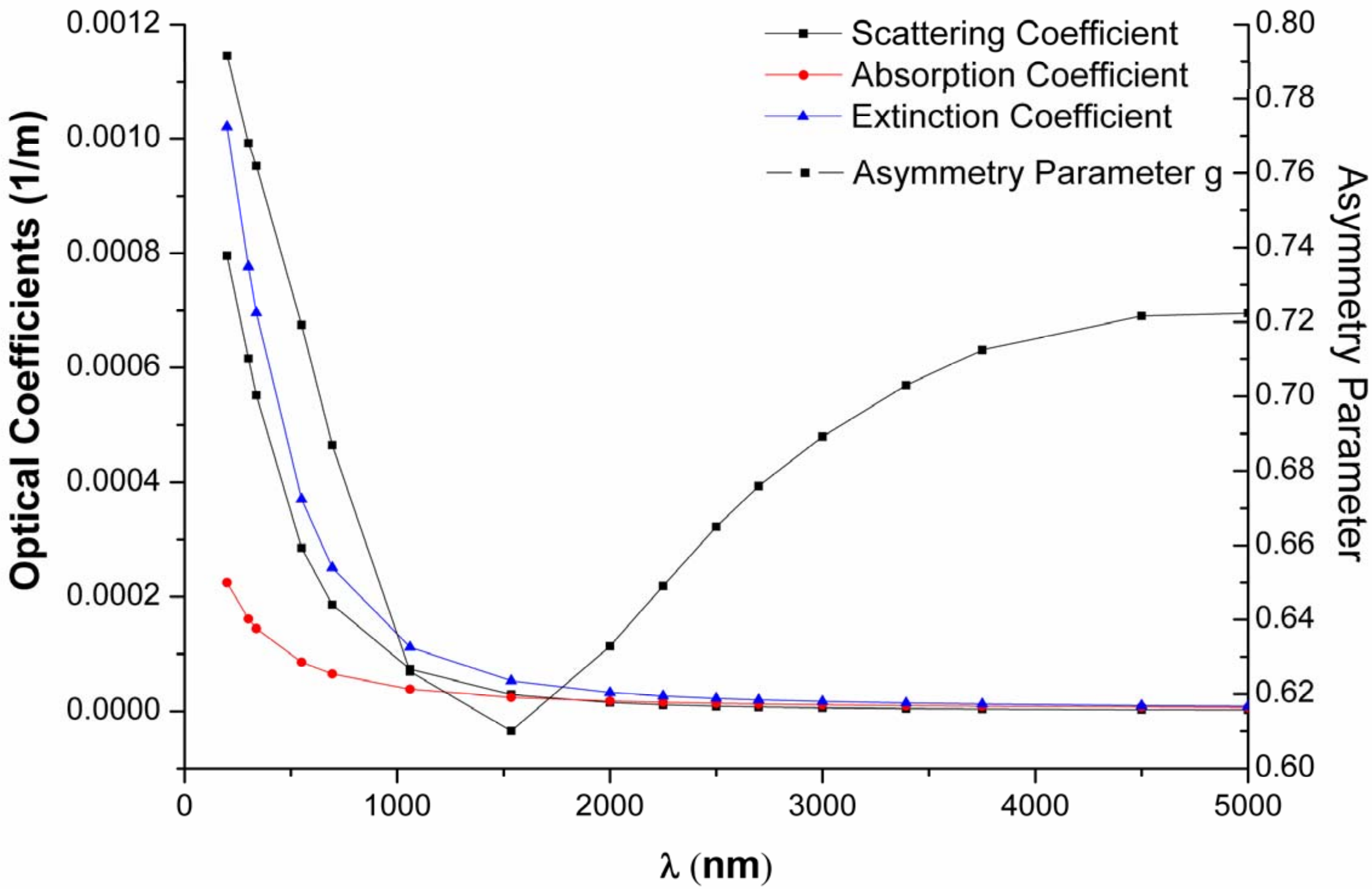


FIG2. The optical parameters determined from in situ measurements for 1st February 2007 at IT04 EMEP Station – Ispra. The parameters were used as input parameter for MODTRAN4.

Theoretical considerations

$$\Delta F_{ATM} = \Delta F_{TOA} - \Delta F_{BOA}$$

$$\Delta F_{BOA} = (F^{W}_{BOA\downarrow} - F^{0}_{BOA\downarrow}) - (F^{W}_{BOA\uparrow} - F^{0}_{BOA\uparrow})$$

$$\Delta F_{TOA} = -(F^{W}_{TOA\downarrow} - F^{0}_{TOA\downarrow}) + (F^{W}_{TOA\uparrow} - F^{0}_{TOA\uparrow})$$

$$F_{\downarrow} = F_{dir} + F_{diff\downarrow} + F_{therm\downarrow}$$

$$F_{\uparrow} = F_{therm\uparrow} + F_{diff\uparrow}$$

$$\Delta F_{BOA} = (F_{dir} + F_{\downarrow diff} - F_{\uparrow diff})^{W} - (F_{dir} + F_{\downarrow diff} - F_{\uparrow diff})^{0}$$

(Gomez et.al., 2010; Henzing et.al., 2004)

$$\Delta F_{BOA} = (F_{dir} + F_{\downarrow diff})^{W} - (F_{dir} + F_{\downarrow diff})^{0}$$

(Clerici and Melin, 2008)

$$\Delta F_{TOA} = -F_{\uparrow diff}{}^{W} + F_{\uparrow diff}{}^{0}$$

(Roger et.al., 2006)

Results

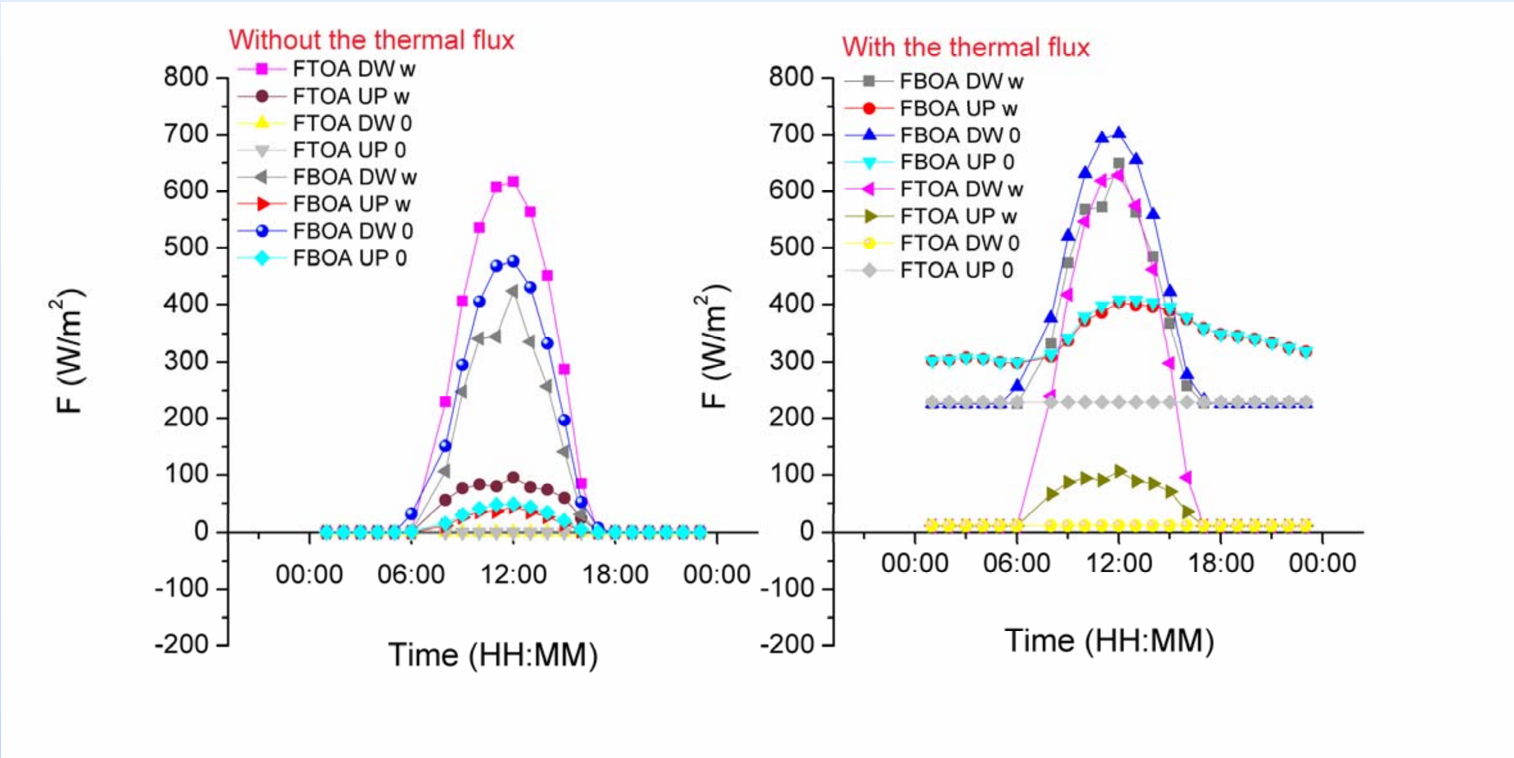


FIG3. Net fluxes (at the bottom of the atmosphere and top of the atmosphere) calculated on downward (DW) and upward (UP) directions for two situations: considering the thermal component of net flux and without this component. Both graphs were made for loaded (w) and clear atmosphere (0).

Results

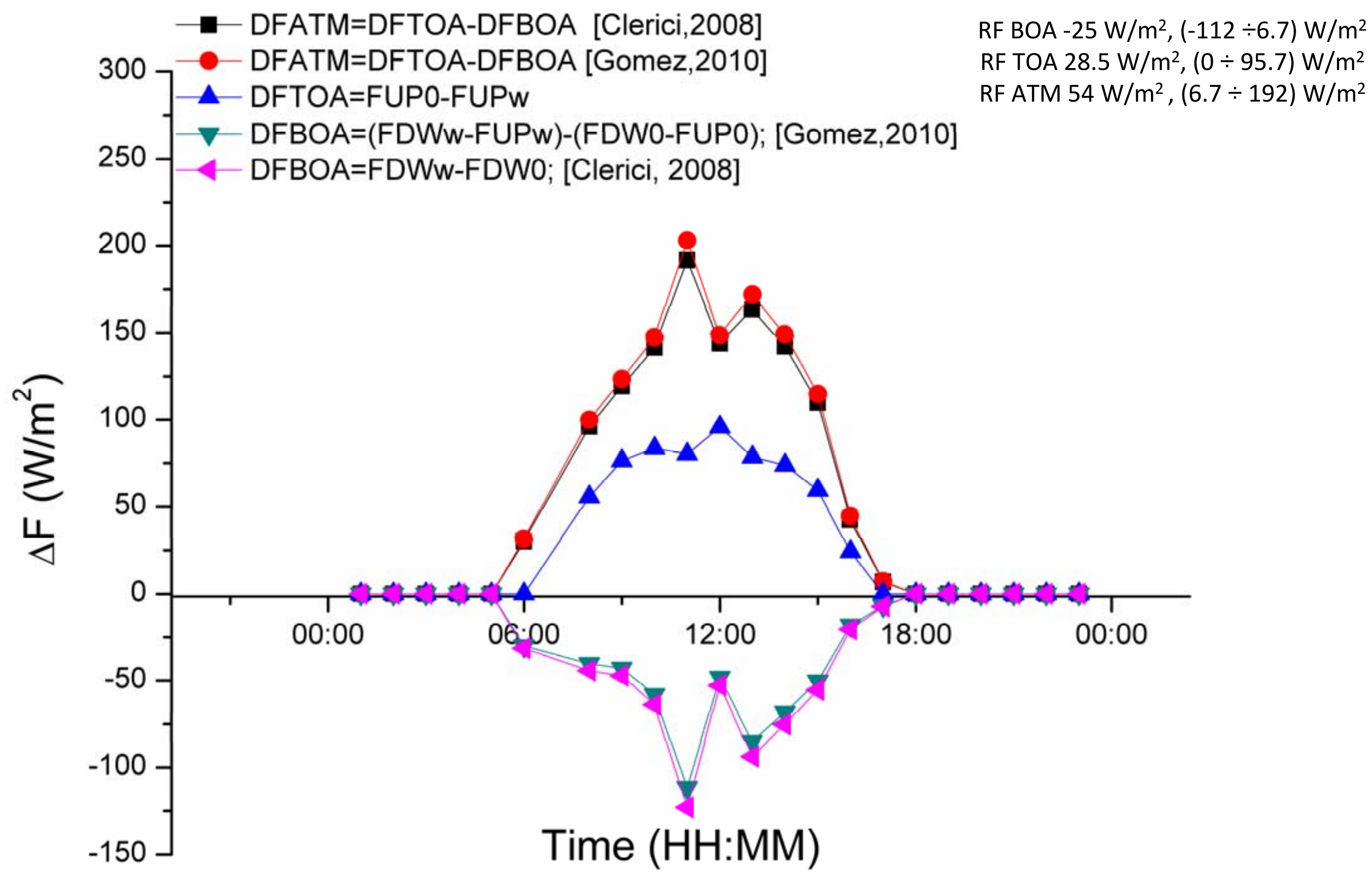


FIG4. The radiative forcing at the bottom of the atmosphere (BOA), top of the atmosphere (TOA) and atmospheric column (ATM).

Results

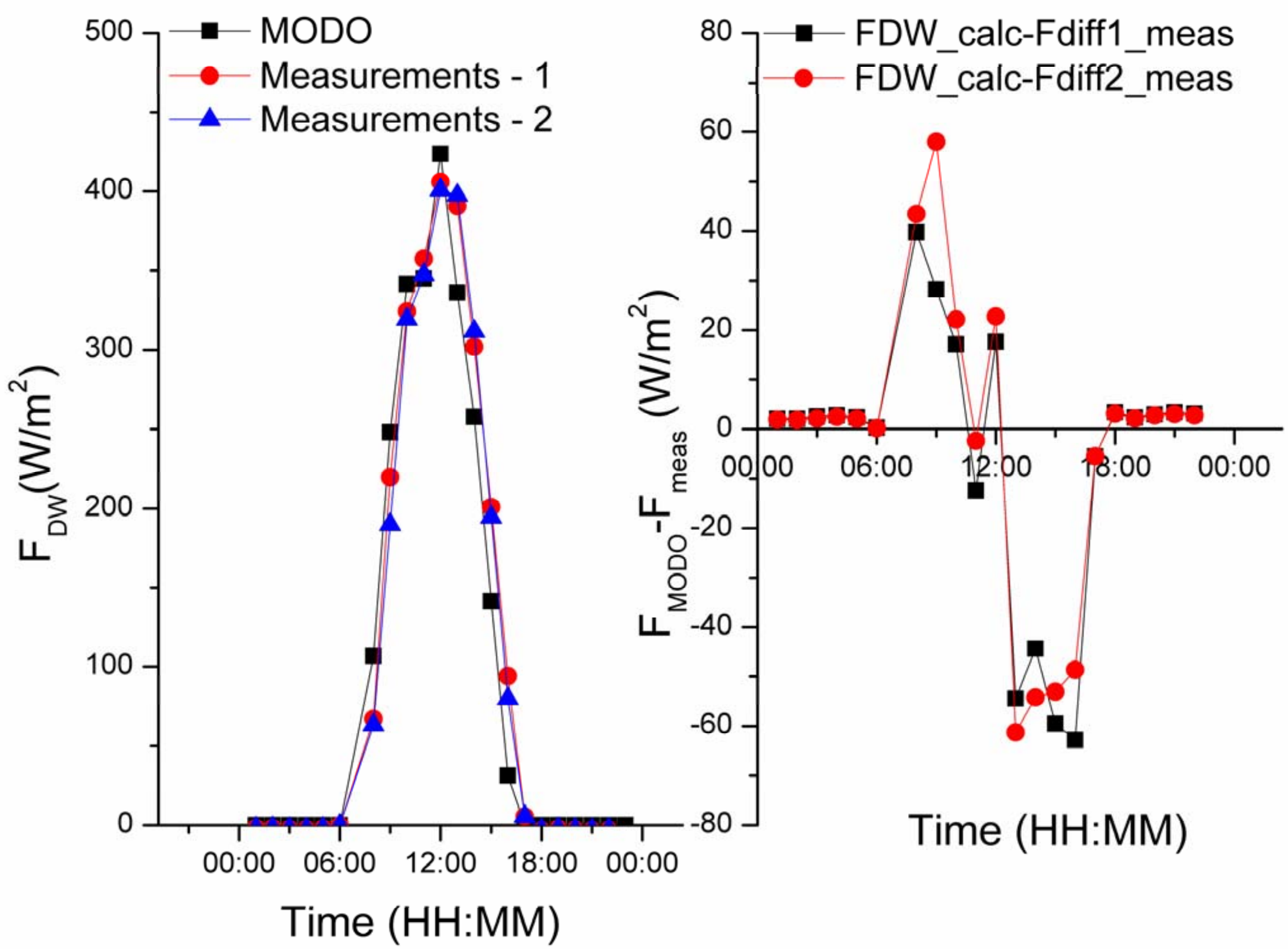


FIG5. Calculated and measured downward flux at the surface (left) and their difference (right).

Conclusions and Final Remarks

•Measurements data and Mie calculations were used to obtain the input parameters for MODTRAN for the entire spectral range of 0.2 – 40 µm.

•The clouds effects were noticed on the thermal fluxes at BOA and especially at TOA.

•The mean values for radiative forcing at BOA =–25 W/m^2 → cooling and at TOA and ATM RF= 28.5 W/m^2 and respective 54 W/m^2 respectively → warming effect of aerosols on the atmosphere and top of the atmosphere and cooling effect at the surface.

•Downward flux at the surface obtained from measurements was compared with the model output and the results showed a good agreement, the major differences being related to the cloudy periods.

Thank you for your attention!