Atmos. Chem. Phys. Discuss., 11, C13729–C13735, 2012
www.atmos-chem-phys-discuss.net/11/C13729/2012/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The direct effect of aerosols on solar radiation over the broader Mediterranean basin" *by* C. D. Papadimas et al.

A. di Sarra (Referee)

alcide.disarra@enea.it

Received and published: 2 January 2012

General comments

The paper presents an analysis of the shortwave direct radiative effect of aerosol over the Mediterranean region. The aerosol optical properties are obtained as the combination of satellite observations and climatological data. Monthly average aerosol direct radiative effects are calculated with a radiative transfer model for observed sky conditions (including clouds) and for cloud-free conditions.

The estimate of the aerosol shortwave direct radiative effect for the Mediterranean basin is an important contribution to the literature, given the large role of the radiative processes in this region. The use of observed data over the basin adds relevance to the

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

retrieved estimates. The study allows to investigate spatial and temporal distribution of the aerosol radiative effects in the Mediterranean in cloudy and cloud-free conditions. I would recommend publication after some aspects are clarified and improved.

In particular:

- as often found in the literature, radiative effecs are calculated from monthly average aerosol optical properties. However, aerosol optical properties change at a much faster rate, and an accurate calculation should take into account its high temporal resolution evolution. Calculations of the monthly average radiative effect which use monthly average aerosol optical properties imply that the radiative effects depend linearly on changes in the aerosol optical properties (although the progressive changes of the solar zenith angle daily course and clouds should tend to produce non linearities). The analysis in section 4 of the paper suggests that for small changes of the optical properties the radiative effect responds linearly, and it is probably possible to proceed by using monthly average aerosol properties. However, the behaviour may be non linear for larger changes; and changes in the wavelength dependence of AOD (i.e., of the Angstrom exponent; see also comments below) are not taken into account. A comment on this aspect, and on possible additional associated uncertainties, should be added.

- it is not clear to me how the aerosol optical properties from GADS and MODIS are combined. The GADS dataset provides a broad seasonal (winter and summer) and spatial distribution of the aerosol properties, while spatially distributed monthly mean values are derived from MODIS. How the two datasets are integrated? How is the spectral single scattering albedo associated with the observed optical depth? Is there any aerosol type attribution, to associate the GADS single scattering albedo with the MODIS AOD?

- the analysis shows that the radiative effects strongly depend on the surface albedo. This is an expected result. I would suggest thata data are first grouped according to classes of surface albedo (at least ocean and desert separately), and results are discussed separately. I assume that the regional averages (tables 1, 2, S2-S5) include areas with different albedoes. I would add to the tables also the results for the sea and land separately.

- the derived radiative effects are discussed throughout the paper in terms of AOD, surface albedo, single scattering albedo, and daytime duration. I believe that the spectral dependence of the aerosol optical depth (or the Angstrom exponent) plays an important role in modulating the radiative effects. As discussed for example by di Sarra et al. (2008), the spectral behaviour of the AOD in the solar spectrum largely affects the radiative efficiency and effects. This effect may be probably sorted out, for example by grouping data in different Angstrom exponent classes, and may help explaining the retrieved results and the role of desert dust.

- the authors show that there is a reasonable agreement between surface measurements and modelled values of downwelling shortwave irradiance (Table S1). The mean differences are however of the order of 10 W/m2 or more, i.e. of the same order of the estimated radiative effects. Since the comparison is based on monthly mean values, the model data are available at a broad resolution, and the surface stations are located in areas with complex albedo, the results do not provide a direct verification of the model performance. In order to obtain a better assessment of the significance of the results, I would suggest including a comparison of the retrieved radiative effects (mainly forcing efficiencies) with those obtaned in previous campaigns/measurements.

- the paper would benefit from a discussion of the estimated uncertainties on the retrieved forcings. For instance, section 2.2 gives an overview of the uncertainties associated with the MODIS AOD, which may be used in conjunction with the sensitivity study of section 4 to derive a first estimate of the uncertainties. Is there an estimate of the uncertainties on the used values of asymmetry parameter and single scattering albedo?

ACPD

11, C13729–C13735, 2012

Specific comments

- p. 30016, l. 11-12: the CO_2 amount is fixed at 345 ppm. The average CO_2 in the Mediterranean in the period 2000-2007 is about 380 ppm (Artuso et al., 2009). CO_2 has a negligible influence on the SW radiative budget, but why was used such a low value?

- p. 30019, line 22: I would add also the low ocean albedo, to which are associated the largest negative values of DRE(TOA).

- p. 30020, lines 1-6: the seasonality of DRE(TOA) does not come out clearly from figure S2. It is not possible on the basis of the plotted colours to distinguish different negative values of DRE over the sea. I would suggest using the same colour scale in the different seasons (also for figures S3 and S4), in order to allow a comparison among the different seasons. In addition, the available climatology for the central Mediterranean suggests a spring-summer maximum, and not an autumn maximum (see e.g. Moulin et al., 1998; Israelevich et al., 2002; Meloni et al., 2007; Di Iorio et al., 2009). also, the study by Papadimas et al. (2008) does not clearly show a double peak in AOD in the central Mediterranean. The double peak in spring and autumn is typical of the Greek region, dominated by Etesian winds in summer. The DRE is maximum in summer in the central Mediterranean; I believe that this is due also to the summer peak in AOD.

- p. 30022, l. 20-22: the schematization that DRE(TOA) depends on aerosol scattering and DRE(netsurf) on extinction is too simplistic. DRE(TOA) also depends on aerosol absorption.

- p. 30023, l. 6-9: in general, contribution of high absorbing particles from forest fires in summer is not negligible in the Mediterranean (see e.g., Pace et al., 2005; Péré et al., 2011) and may produce low single scattering albedo. It should be clarified here if the climatological values of single scattering albedo from GADS may capture interannual variations of this parameter, and which may be the effect on the retrieved radiative

ACPD

11, C13729–C13735, 2012

effects.

- p. 30024, l. 12-13: the statement "On the contrary, the aerosol effects at TOA depend much less on AOD" does not seem correct. The radiative efficiency at TOA is smaller than at the surface mainly because the DRE at TOA is smaller than at the surface. The relative change in DRE, as shown by the behaviour of the ARBE, is generally larger at TOA.

- p. 30026, l. 16: there is a factor of 6 between the maximum and minimum monthly radiative effect both at the surface and at TOA. Thus, the seasonality is similar for both effects (although the effect at TOA is smaller).

- p. 30033, l. 23: EARLINET stations are located on the coastal regions of the Northern Mediterranean. Few datasets provide information on the aerosol vertical distribution also inside the basin (e.g., Gobbi et al., 2000; Di Iorio et al., 2009).

- p. 30026-30027, section 3.5: the discussion of the interannual variations should take into account interannual variations in aerosol properties, mainly Angstrom exponent and single scattering albedo. It is not clear if interannual changes of the single scattering albedo are included (see previous comments).

- p. 30032, l. 7-8: according to tables S2-S4, the largest DRE at TOA and netsurf are found in summer in the central Mediterranean.

- p. 30033, l. 1-3: the effects on the temperature profile, and consequently on the vertical stability, cloud processes, etc., critically depend on the aerosol vertical distribution. In many cases the dust absorbing particles travel above the boundary layer, and the associated heating takes place in specific altitude ranges. Thus, the temperature lapse rate may increase in some vertical intervals, affecting in a more complex way atmospheric stability and cloud processes.

- p. 30033, l. 14: not necessarily "benefits". I would suggest "effects".

- p. 30033, l. 28: as far as I know, CALIPSO provides backscatter vertical profiles, not

ACPD

11, C13729–C13735, 2012

only AOD.

- Figure 3: please, clarify if the plotted values are monthly or annual averages. Part of the large spread may be due to varying illumination conditions (latitude + time), in addition to changing aerosol properties and surface albedo.

Technical corrections

- the papers by Hatzianastassiou et al. (2007) is often cited as (2007a). See e.g. p. 30013, line 20; p. 30015 l. 21, etc.

- p. 30024, l. 2-3: DRE, not E(AOD), is plotted versus AOD to derive the forcing efficiency.

- p. 30031, l. 6: have been used.

References

Artuso, F., P. Chamard, S. Piacentino, D. Sferlazzo, L. De Silvestri, A. di Sarra, D. Meloni, and F. Monteleone (2009), Influence of transport and trends in atmospheric CO2 at Lampedusa, Atmos. Environ., 43, 3044-3051.

Di Iorio, T., A. di Sarra, D. M. Sferlazzo, M. Cacciani, D. Meloni, F. Monteleone, D. Fuà, and G. Fiocco (2009), Seasonal evolution of the tropospheric aerosol vertical profile in the central Mediterranean and role of desert dust, J. Geophys. Res., 114, D02201, doi:10.1029/ 2008JD010593.

Gobbi, G.P., F. Barnaba, R. Giorgi, and A. Santacasa (2000), Altitude-resolved properties of a Saharan dust event over the Mediterranean, Atmos. Envrion., 34, 5119-5127.

Israelevich, P. L., Z. Levin, J. H. Joseph, and E. Ganor (2002), Desert aerosol transport in the Mediterranean region as inferred from the TOMS aerosol index, J. Geophys. Res., 107(D21), 4572, doi:10.1029/2001JD002011.

Meloni, D., A. di Sarra, G. Biavati, J. J. DeLuisi, F. Monteleone, G. Pace, S. Piacentino,

ACPD
11, C13729–C13735, 2012

and D. Sferlazzo (2007), Seasonal behavior of Saharan dust events at the Mediterranean island of Lampedusa in the period 1999- 2005, Atmos. Environ., 41, 3041-3056

Moulin, C., et al., 1998. Satellite climatology of African dust transport in the Mediterranean atmosphere. J. Geophys. Res., 103, 13137-13144.

Pace, G., D. Meloni, and A. di Sarra (2005), Forest fire aerosol over the Mediterranean basin during summer 2003. J. Geophys. Res., 110, D21202, doi:10.1029/2005JD005986.

Péré, J. C., M. Mallet, V. Pont, and B. Bessagnet (2011), Impact of aerosol direct radiative forcing on the radiative budget, surface heat fluxes, and atmospheric dynamics during the heat wave of summer 2003 over western Europe: A modeling study, J. Geophys. Res., 116, D23119, doi:10.1029/2011JD016240.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 30009, 2011.