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Aerosol radiative effects and their trends under clear-sky situations over Europe

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In the literature great uncertainties ca be found regarding radiative effects of aerosols on the energy budget of the atmosphere (IPCC, 2013). In the study the aerosols radiative effects on clear-sky solar radiation are quantified over Europe using empirical and physical modelling approaches. The values of aerosol radiation effect are determined by the MAGIC radiation code. In the first run clear-sky radiation is calculated integrating KINEE/MPI/Aerocom aerosol climatology and ERA-INTERIM water vapour multiannual monthly means. In the next run the clear-sky radiation are also calculated ignoring aerosol data (adjusted to 0) from the algorithm. Both runs were carried out for each months of the year, taking into account the varying astrological factors. The difference between the aerosol-included and aerosol-free clear-sky radiation is equal to the absolute aerosol radiative effect in W/m2. The annual mean of the surface aerosol radiative effects in clear-sky situations over Europe is -7.1 $\pm$ 2.9 W/m2, high values are representing the central part of the continent and the Mediterranean Basin. Furthermore the trends of the aerosol radiative effects are also determined for the period of 2001-2012. First a linear fitting is elaborated between the aerosol optical depth (AOT) built in the MAGIC code and its aerosol radiative effect calculated by the code. Next, based on these linear functions a radiative effect values are assigned to each monthly AOT500 value available from the Moderate Resolution Imaging Spectroradiometer (MODIS) Terra Level-3 experiment. In this way a new dataset of aerosol radiative effect for the period of 2001-2012 has been created. Beside of this approach the changes in aerosol radiative effects are also calculated based on ground-based clear-sky radiation trends. This approach is used as a validation of the method applied in earlier stage, mainly for the linear fitting. The starting point of this approach is to elaborate the trends of clear-sky radiation controlled by the effects of aerosols and water vapour. If we subtract the water vapour effects also calculated by MAGIC radiation code from this trend, the magnitude of the trends in aerosol radiative effects can be estimated. In this case it is assumed that the two effects do not amplify and do not cancel each other, and their arithmetic sum gives the change in clear-sky radiation trend. The two approaches give good fit, based on the direct (modelled) approach the annual trend of the aerosol radiative effects on clear-sky solar surface radiation is -4.41 W/m2 per decade for the period of 2001-2013, while in the case of the indirect approach (based on clear-sky trends) this trend is found to be -4.46 W/m2 per decade.