Comparison of the optical depth of total ozone and atmospheric aerosols for Poprad-Gánovce, Slovakia

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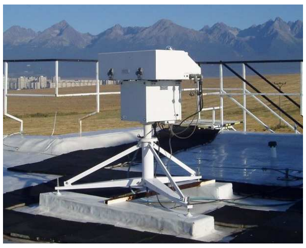
Introduction

As it is widely known, anthropogenic changes in total ozone and atmospheric aerosols significantly affect the sun's UV radiation hitting the Earth surface. Depletion of the global ozone layer began gradually in the 1980s and reached a maximum of about 5% in the early 1990s. Nowadays the depletion has lessened and currently is about 3.5% averaged over the globe. Reduction of the ozone layer subsequently led to an increased amount of UV radiation released through the atmosphere. On the other hand, in the early 90s it was found that in non-urban areas of industrialized countries, solar UV - B radiation decreased since the industrial revolution by about 5-18% as a result of air pollution. In developed countries slowly occur the limitation of aerosols emissions and for some locations is observed a decrease of aerosols optical depth (AOD). This study shows the impact of the mentioned two factors to the attenuation of UV radiation for Gánovce, which is located near the High Tatras. Optical depth of ozone stagnates in the last 22 years, while on the other hand aerosols optical depth recorded a decline. Determining of AOD by Brewer spectrophotometer is not united. This study represents one of possible approach to determining of AOD.

Instrument

Brewer ozone spectrophotometer (Model MKIV) works in the ultraviolet and visible range of the solar spectrum. Measurements of direct UV sun radiation is carried out at selected wavelengths. Based on the varying absorption of radiation after passing through the atmosphere, it is possible to derive the total amount of O3 and SO2. This measuring principle is known as the differential optical absorption spectroscopy (DOAS). Measurements of direct sunlight for wavelengths 306,3nm, 310.1 nm, 313.5 nm, 316.8 nm and 320.1 nm are also used to calculate the AOD.

Since the beginning of measurements (18.8.1993) device undergoing regular 2-year calibration and daily tests using internal lamps (mercury and standard lamp). The instrument is calibrated according to the global reference group (Brewer Triad), maintained at Environment Canada, through travel reference instrument n. 097. From a technical point of view measurements can be considered as homogeneous.



Measurement site

Brewer ozone spectrophotometer is placed on the roof of Upper Air and Radiation Centre of Slovak hydrometeorological institute in Gánovce near town of Poprad. Its coordinates are 49.03 ° N. and 20.32 ° E. and the altitude is 706 m. n. m. The content of aerosols in the atmosphere, either the total amount or the species composition is determinated by the local sources and also by the atmospheric circulation, which can relocate the air mass together with the aerosols several thousand kilometres from its source. In rare cases, there may be for example the transport of Saharan dust. Among the major local resources include products of combustion of solid fuel in the surrounding villages and agriculture. Often is occurring the wind erosion of dry soil or the occurrence of plant products in the air because the region is quite windy. The proximity of the town of Poprad (about 1.5 kilometres) with about 53,000 inhabitants and various industrial activities also play a role.

Method

Basic equation

- Beer-Bouguer-Lambert law:

$$S_\lambda = S_{0,\lambda}\, e^{-m_r \tau_\lambda} = S_{0,\lambda}\, e^{-\mu_{O_3} \tau_{\lambda,O_3} - \mu_r \tau_{\lambda,r} - \mu_a \tau_{\lambda,a}}$$
$$= S_{0,\lambda}\, e^{-\mu_{O_3} \alpha(\lambda,T)\, \Omega_{O_3} - \mu_r \frac{\beta(\lambda)\, P}{P_{std}} - \mu_a \tau_{\lambda,a}}$$

- S_λ is solar irradiance on the Earth's surface
- $S_{0,\lambda}$ is solar irradiance at the top of the atmosphere (the extraterrestrial constant - ETC)
- τ_λ is optical depth for all components together
- τ_{λ,O_3}, $\tau_{\lambda,r}$, $\tau_{\lambda,a}$ is optical depth for O_3, Rayleigh (molecular) scattering and aerosols
- m_r is air mass factor for all components (thin layer at an altitude of 5 km)
- μ_{O_3} is air mass factor for the ozone layer (thin layer at an altitude of 22 km)
- α(λ,T) je absorption ceoficient for O_3 (T = 228,15 K)
- Ω_{O_3} is total ozone in Dobson units
- μ_r is air mass factor for the Rayleigh scattering (thin layer at an altitude of 5 km)
- $\beta(\lambda)$ is normalized optical depth for Rayleigh scattering (for P_{std} and vertical column)
- P is atmospheric pressure at the site of observation (long year average)
- P_{std} is standard atmospheric pressure (101 325 Pa)
- μ_a is air mass factor for aerosols (thin layer at an altitude of 2 km)

Langley plot conditions

a) determination of ETC - selection of appropriate days

I. Number of direct sun measurements is > 6

II. Stable conditions during a day:

- Standard deviation of ozone (per day) is < 2
- Standard deviation of aerosols (per day) is < 0.05

III. A day with very good linear interpolation:

- coefficient of determination is > 0.98

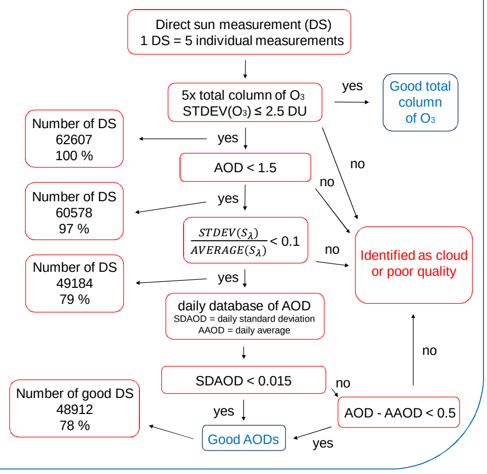
b) determination of ETC - selection of appropriate ETC for the whole calibration period

For a given wavelength was used one ETC for the whole standard calibration period (2 years). The ETC for calibration period was determined as an average from ETCs which satisfy next condition:

$$\frac{|ETC - AVERAGE(ETCs)|}{STDEV(ETCs)} < 1.5$$

Conditions a) and b) satisfy in average only 10 individual days in one calibration period.

Cloud screening



Results