Delta-T Devices

Technical Note

An investigation of the use of an SPN1 for measuring atmospheric light scattering.

One way of modelling air quality is to measure the way sunlight is scattered or absorbed by the atmosphere. For a single wavelength λ this can be modelled with a simple exponential equation,

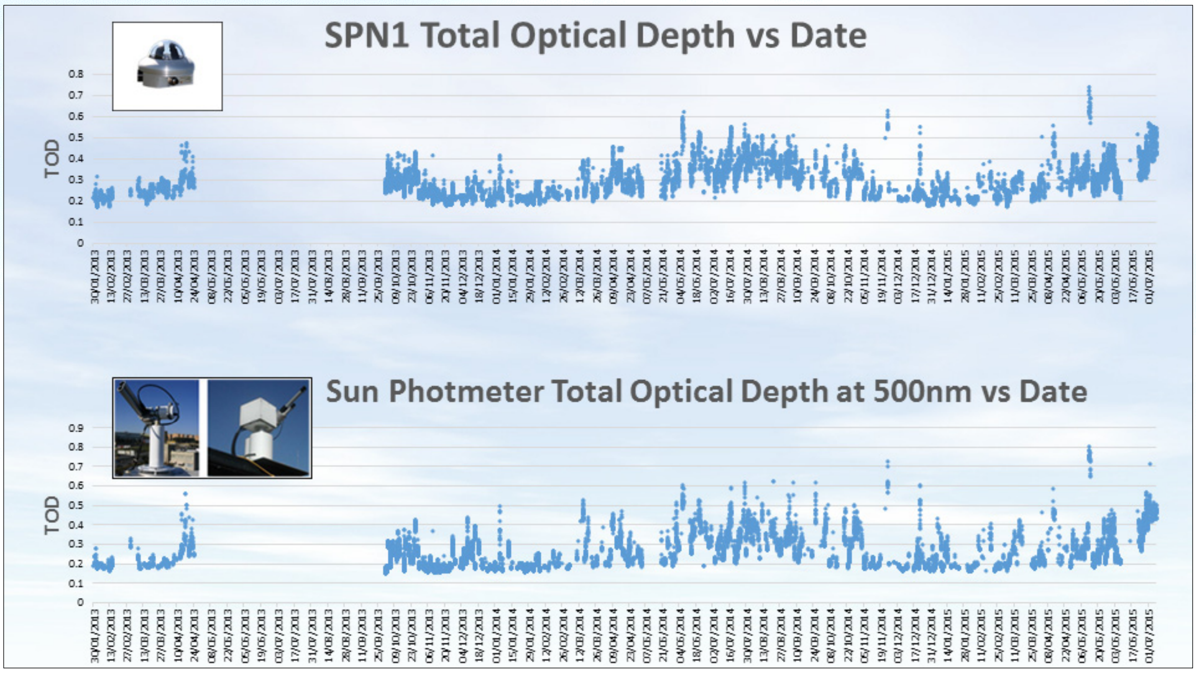
$$E_{\lambda} = E_{o\lambda}\, e^{-\tau_{\lambda}.m}$$

This says the intensity E_{λ} of direct sunlight on the ground decreases exponentially from the value $E_{o\lambda}$ at the top of the atmosphere, at a rate which depends on the total optical depth τ_{λ} and a factor m representing the air mass that the ray has passed through. So m takes into account the fact that slanting rays have to travel further through the atmosphere as compared to vertical rays.

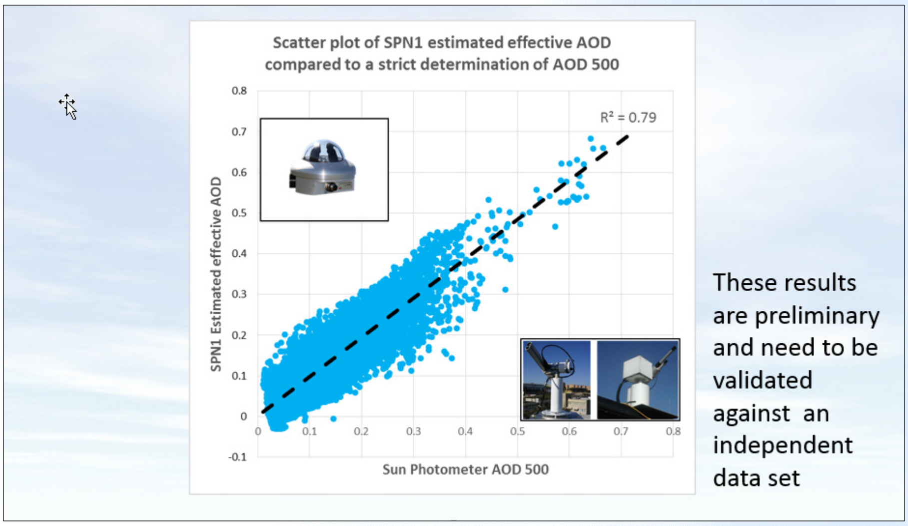
The other coefficient in the exponential, the optical depth, can be represented as a sum of terms representing all the different sources which scatter or absorb light, with contributions from aerosols, including dust, salt crystals, pollutants, water vapour, atmospheric gases and other factors.

The standard equipment for doing these measurements uses moving, precise sun photometers made by manufacturers such as Cimel and Prede. These measure the extinction of the solar beam at a small set of defined wavelengths, following and looking directly at the sun. These give the best data but are expensive both to buy and maintain. Does the SPN1, with no moving parts and relatively easy to maintain, have a useful role to play here?

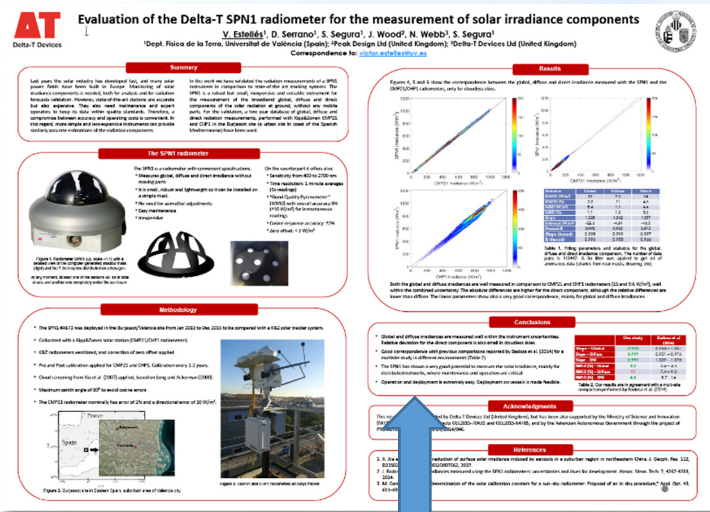
The SPN1 measures Global and Diffuse solar radiation from which the Direct Normal Irradiance can be derived. From this – and also because we know from satellite data how much sunlight arrives at the top of the atmosphere - it should be possible to infer something about the atmosphere. The SPN1's broad spectral response precludes the use of the Lambert-Bouguer exponential law, because the scattering varies with wavelength. But what we have done is to ask - if you do use such an equation – how well does it correlate **empirically** with the data from sun photometers?

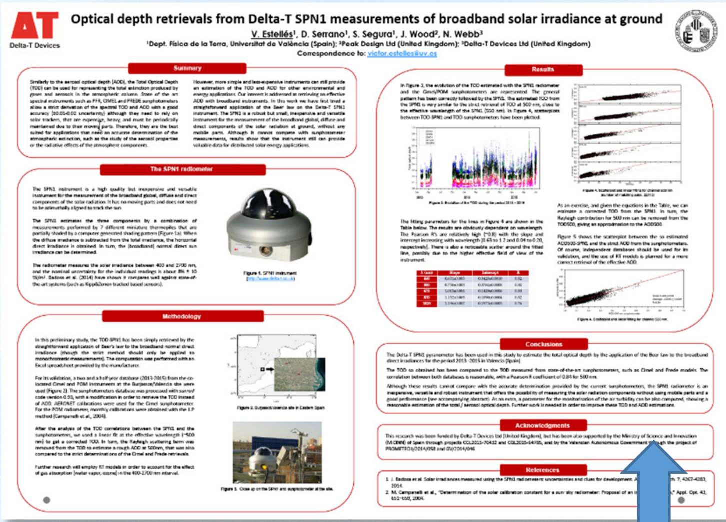


The graph shows a year of Total Optical Depth data from an SPN1 along with data at several specific wavelengths from sun photometers.



This is work in progress, courtesy of the Solar Radiation Group at the University of Valencia. Was presented as two posters at the Rome SKYNET meeting on 2-4 March 2016 and at the European Geophysical Union conference in Vienna 17-22 April 2016.





Conclusions

- Global and diffuse irradiances are measured well within the instrument uncertainties. Relative deviation for the direct component is also small in cloudless skies.
- Good correspondence with previous comparisons reported by Badosa et al. (2014) for a multisite study in different environments (Table 2).
- The SPN1 has shown a very good potential to measure the solar irradiance, mainly for distributed networks, where maintenance and operation are critical.
- Operation and deployment is extremely easy. Deployment on vessels is made feasible.

	Our study	Badosa et al (2014)
Slope – Global	0.998	0.955 – 1.021
Slope – Diffuse	0.999	0.901 – 0.976
Slope – DNI	0.997	1.009 – 1.076
RMSD (%) – Global	3.2	3.4 – 4.5
RMSD (%) – Diffuse	11	7.4 – 9.3
RMSD (%) – DNI	4.4	8.7 - 14

Table 2. Our results are in agreement with a multi-site comparison performed by Badosa et al. (2014)

Conclusions

The Delta-T SPN1 pyranometer has been used in this study to estimate the total optical depth by the application of the Beer law to the broadband direct irradiances for the period 2013 -2015 in Valencia (Spain).

The TOD so obtained has been compared to the TOD measured from state-of-the-art sunphotometers, such as Cimel and Prede models. The correlation between both databases is reasonable, with a Pearson R coefficient of 0.84 for 500 nm.

Although these results cannot compare with the accurate determination provided by the current sunphotometers, the SPN1 radiometer is an inexpensive, versatile and robust instrument that offers the possibility of measuring the solar radiation components without using mobile parts and a good performance (see accompanying abstract). As an extra, a parameter for the monitorisation of the air turbidity can be also computed, showing a reasonable estimation of the total / aerosol optical depth. Further work is needed in order to improve these TOD and AOD estimations.

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