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UV radiation and epidemic seasonality

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Abstract. There is some evidence of seasonal cycles of the epidemics, but it is not yet clarified what could be the main driver. In this short review, we investigate on the possible role of environment effects, in particular the seasonal variation of the solar UV radiation in Italy.

Key words. UV radiation – Epidemic

1. Introduction

The seasonality of the infectious deseases is known since very long ago. In the European historical tradition, yearly trends are recorded in most of the worst epidemies. An analysis of non random emerging infectious deseases can be found in Jones et al. (2008) but the time and spatial dependence of the deseases spread is complicated by several overlapping factors. Moreover, according to a recent study by Martinez et al. (2018), different diseases are not synchronized in phase and vary also with their location. Historical study of epidemics are complicated because some deseases disappeared or were suppressed by the introduction of vaccines, but in general there is some evidence of seasonality. One of the most evident is the winter trend of the flu, with a late winter peak. The end of the winter-beginning of the spring are the typical peak seasons for most of the infectuous deseases, but there are also relevant exceptions. The diffusion of the epidemic deseas depends on several factors (or steps), starting with the pathogen reservoirs, the transmission vectors to the human bodies, the host sensitivity (including immunology sensitivity) and the human host to host transmission. The last is modulated by the lifestyle, including socio-economic factors. Environmental factors, including meteorology and solar radiation can play a role on all the described steps. It would be very relevant to identify the most important ambient parameters (Nicastro et al. , 2020). In order to study the seasonality of COVID-19 it would be important to specifically check the seasonality of coronaviruses. Kronfeld-Schor et al. (2021) found evidence for winter-spring peaks against very low values in autumn. Recent papers show the correlation between solar radiation and COVID-19 describing the UV radiation effects on the virus, see Nicastro et al. (2021) and Biasin et al (2022)). Several regional environment contributions have been investigated, with in situ tests or from statistical data, including absolute humidity Shaman et al. (2009); dust pollution Pozzer et al. (2020), or temperature Sajadi et al. (2020). All these 3 factors are positively correlated with COVID-19 (and SARS) spread, but there is also some degeneracy between these parameters. In the specific case of northern Italy, where COVID-19 diffusion was faster, the synchronization with the PM10 aerosol concentration is not so evident because its concentration follows mainly the domestic heating, with a January peak, rapidly falling down between February and April (ARPAV annual report, 2019). Here we present a short summary of a possible modulation, in Italy, by the open air solar UV radiation.

2. The seasonality of the solar UV radiation

It is very well known that the ground level solar UV radiation depends mainly on the atmospheric absorption and diffusion by Rayleigh scattering and ozone absorption (for a review on the atmospheric ozone see Antonello et al. (2021). Rayleigh scattering is fairly constant in the time and season because it depends on the air molecules scattering cross section which in turn can be parametrized by the ground pressure. The ozone density column, instead, is very variable with the season and location. In addition, it varies with the Sun zenith distance (airmass) due to the effect of solar radiation. According to Antonello (2021) the atmosphere ozone distribution can be separated into two main components, the stratospheric and the low tropospheric (anthropic) ozone. The stratospheric ozone is mapped by TOMS satellites since Nimbus 7 1978 first records. Its distribution and seasonal variation is complex and depends on solar activity and also on meteorological parameters Antonello et al. (2021). The daily noon data above northern Italy, in the 1996-2002 time interval, show a distribution, with a maximum at 350 Dobson units (DU), between the end of January and the end of March, and a minimum between October and November, with about 280 DU (Figure 1). DU is a unit of measurement of the gas amount in an Earth's atmosphere vertical column. The tropospheric, anthropic contribution, typical of the Po Valley, has been published by ARPA. The data from 2003 to 2018 show a peak corresponding to the maximum solar insolation, between June and July, and a deep minimum in December. The typical total tropospheric contribution is around 33+/-10 Dobson, accounting for about 1/10 th of the total ozone column. From these data, it is evident that the main seasonal trend is driven by the stratospheric ozone. In order to estimate the solar UV absorption the basic equation linking it to the airmass is used:

$$I = I_0 \cdot e^{-K \cdot m(0_3)} \tag{1}$$

where K is the ozone absorption coefficient and m is the airmass. This coefficient is rapidly growing below 350 nm, and variable with pressure and temperature, with typical values of 2.4 at 310 nm and 10 at 300 nm. By assuming K=5.0 for simplicity (corresponding to about the monochromatic wavelength between 308 and 300nm), we calculated the seasonal variation of the UV radiation in northern Italy, Milan (45 degrees latitude), and in southern Italy, Catania (37 degrees), from February to July. The different cloud coverage has been also taken into account assuming a constant number of 8 covered days in Milan and 7 in Catania, in February, and only 1 in July. The calculations show that the UV radiation seasonal ratio is up to more than 110 in Milan and about 22 in Catania. In both cases, the dominant factor is the different Sun zenith distance in the two considered months. Diffuse background atmospheric light has not been taken into account. This result indicates a strong outdoor solar UV radiation seasonal variability, with a pronounced summer peak, mainly in the northern Italy where the Sun airmass variation is higher, from 2.06 in February to 1.09 in July in Milan, compared to 1.66 and 1.04, respectively, in Catania.

3. Future Prospects

It would be interesting to explore the UV solar radiation at ground along the solar activity cycle. These is affected by two different,

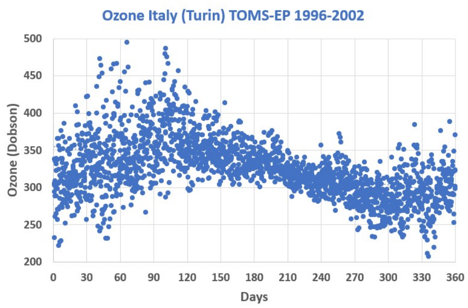

Fig. 1. Stratospheric ozone thickness. Italy, Turin, during the year (1996-2002), TOMS-EP (Dobson unit).

and counteracting, factors. UV radiation produces more stratospheric ozone, so the ozone layer increases, in turn, decreases the amount of UV radiation passing through. It is very likely that the balance between the two effects depends on the geographic location and on the ozone stratospheric re-distribution due to high altitude winds. There are very few measurements reported in the literature, but preliminary data collected in Brazil by Rampelotto et al. Rampelotto et al (2009) seem to indicate a roughly constant ground radiation. More measurements, in different locations, would be interesting.

References

Antonello, E., 2021, Mem. Sait

Biasin, M., et al., 2022, UV and violet light can Neutralize SARS-CoV-2 Infectivity, Journal of Photochemistry and Photobiology, 10

Jones, K.E., et al., 2008, Nature, 451

Kronfeld-Schor, N., et al., 2021, Journal of Biological Rhythms, 20

Martinez, M. E., 2018, PLOS Pathogens, 14

Nicastro et al, 2020, Forcing Seasonality of Influenza-like Epidemics with Daily Solar Resonance, iScience, 23

Nicastro, F., Sironi, G., Antonello, E., et al., 2021, Solar UV-B/A radiation is highly effective in inactivating SARS-CoV-2, Sci Rep, 11

Pozzer, A., et al., 2020, Cardiovascular Research, 112

Rampelotto, P.H., da Rosa, M.B., Schuch, N.J., 2009, AIP Conference Proceedings, 1100

Sajadi, M.M., et al., 2020, JAMA Netw Open, 3

Shaman, J., Kohn, M., 2009, PNAS, 106