17th International Conference on Environmental Science and Technology

Athens, Greece, 1 to 4 September 2021

Do the weather conditions drive the spread of COVID-19? The Case of Greece

TOUNTA D.[1], NASTOS P.T.[1], PARASKEVIS D.[2], SARANTOPOULOS A.D.[3]

[1]Laboratory of Climatology and Atmospheric Environment, Department of Geology and Geoenvironment, National and Kapodistrian University of Athens

[2]Department of Hygiene Epidemiology and Medical Statistics, Medical School, National and Kapodistrian University of Athens

[3]Hellenic National Meteorological Service

*corresponding author: Despoina Tounta
e-mail: tountadesp@gmail.com

Abstract The new global pandemic of COVID-19 declared on March 11, 2020, by the World Health Organization, has already caused unprecedented health and socio-economic impacts, worldwide. The second wave of the COVID-19 pandemic has been sweeping the Unites States of America and Europe since late September 2020. The northern countries of Europe (Germany, France, Austria, Finland, Sweden) faced this second wave of the pandemic earlier in September 2020 against other southern countries, such as Greece, where there was a significant increase in cases in late October 2020.

To understand the spread of COVID-19 in Greece, from the environmental perspective, we try to examine the effect of air temperature, humidity and wind on the emergence of COVID-19. More specifically, we concern whether warm and wet conditions have a positive effect by decreasing the number of COVID-19 cases, while on the contrary, cold and dry conditions are associated with increasing cases. We apply Pearson correlation analysis and Generalized Linear Models taking as dependent variable the confirmed admissions in intensive care units (ICU) of COVID-19 from the National Public Health Organization and the corresponding air temperature, humidity and wind speed from the Hellenic National Meteorological Service, as independent variables. The analysis concerns Athens and Thessaloniki, the two largest cities in Greece.

Keywords: COVID-19 pandemic, meteorological conditions, Generalized Linear Models, Greece

1. Introduction

Coronavirus SARS-CoV-2 appeared in December 2019 in Wuhan City, Hubei Province in China and by January 30, 2020 had spread to 18 countries outside China. On February 12, 2020, the World Health Organization (WHO) announced that the disease would be called COVID-19, and a month later in the light of the rapid increase in cases (more than 118,000 cases in 114 countries and 4,292 deaths), declared disease, as a pandemic.

SARS-CoV-2, belonging to the same family (Coronaviridae-b) as the SARS-CoV and MERS-CoV coronaviruses that caused epidemics in 2002 and 2012, has a positive polarity RNA genome and a cellular structure consisting of from structural proteins (S, E, M, N) and the non-structural replicase polyprotein. S protein is involved in the recognition of receptors and the binding and entry of the virus into human cells (Carfì et al., 2020). The virus is transmitted by coughing or sneezing of an infected person and by human contact or contact with contaminated surfaces (copper, cardboard, stainless steel and plastic). The disease is manifested by cough, fever, myalgia, fatigue and in severe cases shortness of breath, while the clinical picture of the disease ranges from asymptomatic or mild respiratory infection to uncontrolled pneumonia with acute respiratory distress syndrome, multi-organ failure and death (Huang et al., 2020). COVID-19 was transmitted worldwide through aviation, travel and trade, with countries still adopting even today restrictive measures to curb the disease. Sixteen months after the pandemic began, with vaccination campaigns continue (751,452,536 doses of vaccine have been administered in total), humanity has been irreparably affected as the planet counts 139,501,934 confirmed cases and 2,992,193 deaths, 6:43pm CEST, 17 April 2021; WHO, 2021), while the socio-economic consequences are enormous,.

In Greece, the first confirmed case of COVID-19 was reported on February 26, 2020. The country's reaction was immediate, as on March 23, 2020 it imposed a national lockdown. At that time there were a total of 695 confirmed cases and 17 deaths (EODY, 2021). On 4 May 2020 and while the daily cases began to decrease, the restrictive measures were gradually eased and on 1/7/2020 the arrival of flights from abroad was allowed. From the beginning of August 2020, the cases showed an increasing trend, with the country gradually entering the second wave of the pandemic. In the months of October-November there is a rapid increase in cases and on 7/11/2020 a new national lockdown is imposed. On 20/11/2020 the epidemiological curve reaches its peak with 2,581 daily cases. After a gradual drop in cases until 31/1/2021 (484 daily cases), the country enters the third wave of the pandemic from the beginning of February. In the months of March - April, the daily cases increased rapidly. On 6/4/2021 the epidemiological curve reaches its highest point, with 4,309 daily cases. Greece from the beginning of the pandemic until 9-4-2021 counts a total of 290,964 cases and 8,758 deaths (EODY, 2021). The effect of weather on the spread of SARS-COV-2 has been studied by many researchers around the world. The result of most studies showed that high values of temperature and humidity led to a decrease in the rate of disease spread (Wang and Di, 2020; Wu et al., 2020) while others showed a negative correlation of temperature but not of humidity with transmission of COVID-19 disease (Tosepu et al., 2020; Demongeot et al., 2020). However, the effect of temperature on the transmission of SARS-COV is not entirely clear, as according to some researchers, climatic conditions alone cannot reduce the cases and prevent the recurrence of COVID-19 outbreaks in the absence of protection measures in public health (Paraskevis et al., 2020).

In this paper we study the effect of air temperature, humidity, and wind on the spread of COVID-19 in Greece. More specifically, we examine the effect of weather conditions on COVID-19 admissions in intensive care units (ICU) in the two major cities Athens in central and Thessaloniki in north Greece.

2. Data and Methodology

The COVID-19 datasets used in the analysis concern daily admissions in the intensive care units (ICU) in Thessaloniki, the second largest city of Greece, and in the central area of Athens, the capital of Greece, for the period February 26 to March 17, 2021. The daily mean, maximum and minimum values of air temperature, relative humidity and wind speed were acquired from the Hellenic National Meteorological Service (Helliniko station for Athens and Makedonia station for Thessaloniki), for the respective period. Figure 1 depicts the COVID-19 ICU time series for Thessaloniki and Athens. We perform the statistical analysis within the period from May 4, 2020 (partial suspension of curfew and reopening of shopping centers and restaurants) to November 3, 2021 (local lockdown in Thessaloniki). The effects of weather on COVID-19 spread were estimated by the Generalized Linear Models (GLM) with a Poisson distribution (McGullagh and Nelder 1997). In the models fitting procedure we used as dependent variable the daily counts of COVID-19 ICU, while as independent covariates the aforementioned

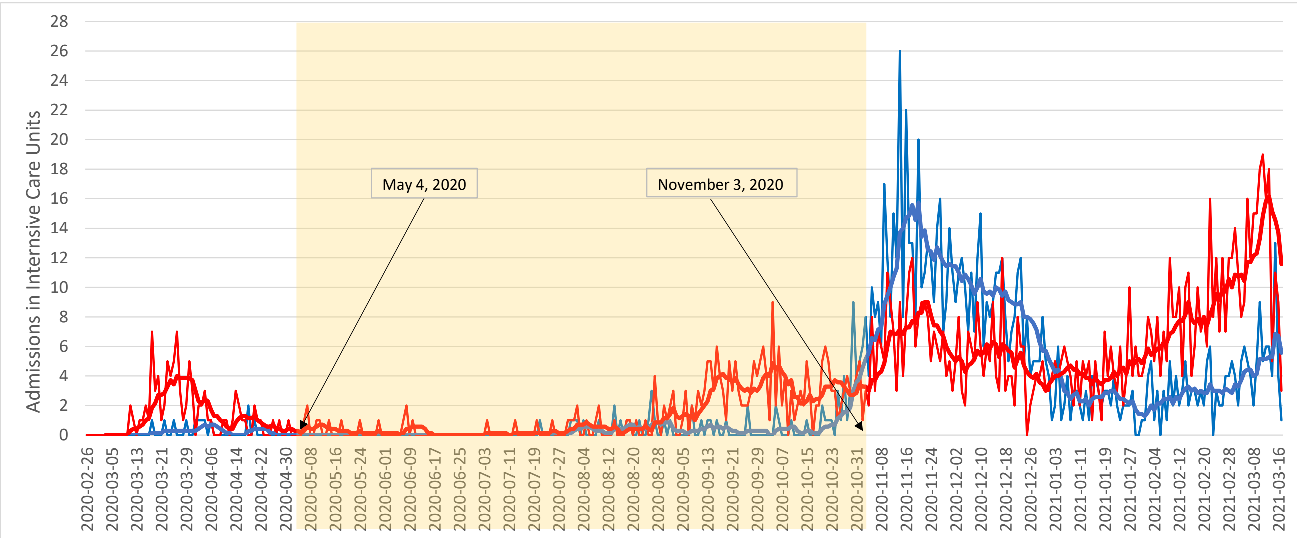
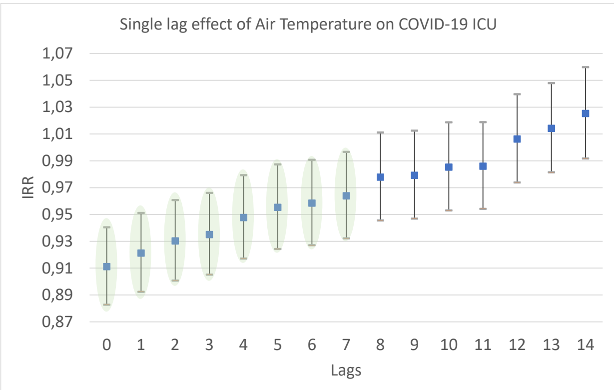
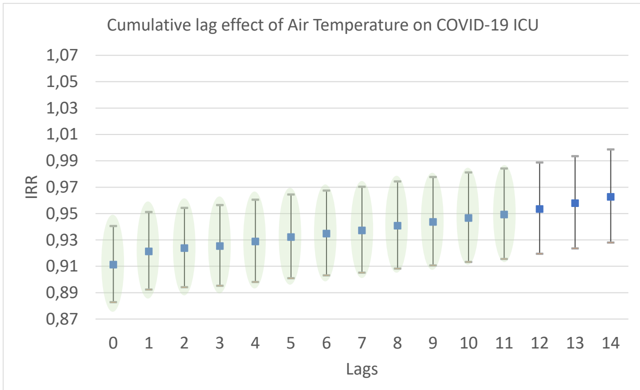


Figure 1. Time series of COVID-19 admissions in Intensive Care Units (ICU) for Athens (red curve) and Thessaloniki (blue curve), from February 26, 2020 to March 16, 2021. The frame indicates the period used in the study.

meteorological parameters. The models' goodness-of-fit was evaluated through the deviance residuals (McGullagh and Nelder 1997). Single lag and cumulative lag effect estimates were calculated as the exponential form of the regression coefficients (i.e., exp(β) for each of the meteorological factors), which reported as the incidence rate ratios (IRRs), along with the corresponding p-values to show significance.





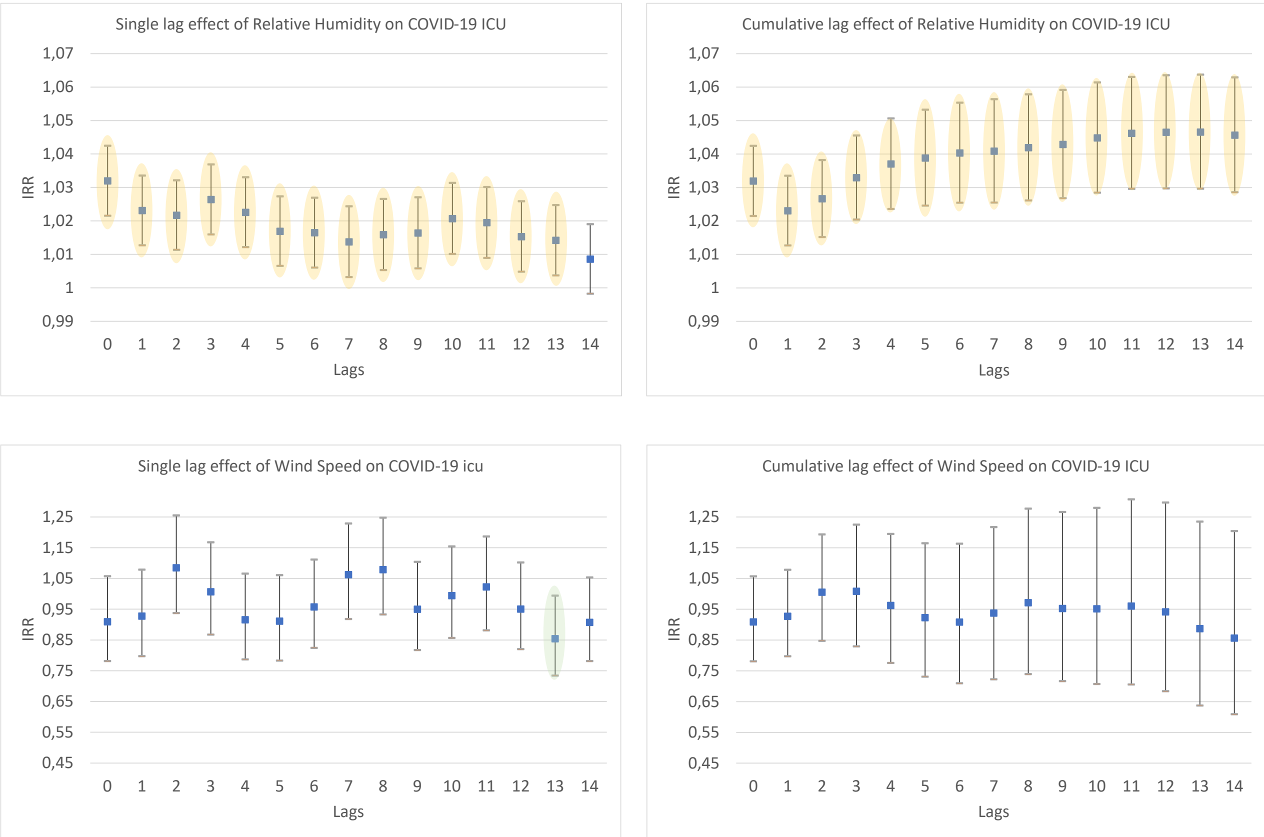
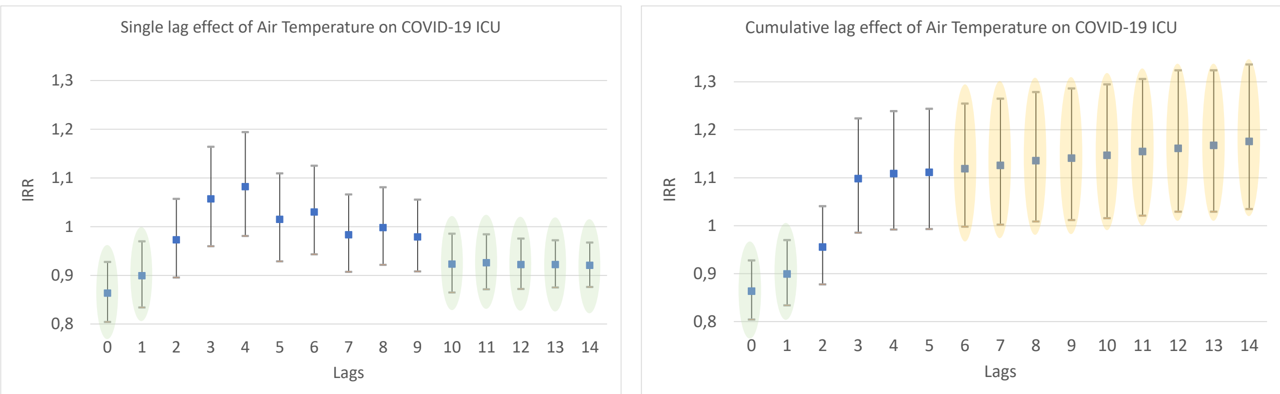


Figure 2. Single lag effect (left graphs) and cumulative lag effect (right graphs) of Incidence of Relative Risk (IRR) for air temperature (upper), relative humidity (middle) and wind speed (lower) on COVID-19 ICU, for Athens. Highlighted bars (green for negative and yellow for positive correlations) indicate statistically significant at $p < 0.05$.

3. Results and Discussion

Changes of IRRs and statistical significance ($p < 0.05$) for ICU with respect to lag-day values are presented in Figure 2 for Athens and Figure 3 for Thessaloniki. We found that the strongest estimated IRR ($p < 0.05$) for Athens was observed at lag7 (lag11), lag 3 (lag13) for single and cumulative (in parentheses) effects of air temperature and relative humidity, respectively, while statistical significant IRR appeared only at lag 13 for wind single lag effect. More specifically, each 1 unit increase in mean daily: air temperature was significantly associated with a decrease of -3.6% (-5.1%) in daily confirmed ICU of COVID-19; relative humidity was significantly associated with an increase of +2.6% (+4.7%) in daily confirmed ICU of COVID-19; wind speed was significantly associated with a decrease of -14.6% in daily confirmed ICU of COVID-19. Regarding Thessaloniki, the strongest estimated IRR ($p < 0.05$) was observed at lag11 (lag14), lag 5 (lag14) and lag7 (lag 4) for single and cumulative (in parentheses) effects of air temperature, relative humidity, and wind speed, respectively. More specifically, each 1 unit increase in mean daily: air temperature was significantly associated with a decrease of -7.4% (+17.6%) in daily confirmed ICU of COVID-19; relative humidity was significantly associated with an increase of +6.2% (+21 %) in daily confirmed ICU of COVID-19; wind speed was significantly associated with a decrease of -20.7% (-26.8%) in daily confirmed ICU of COVID-19.



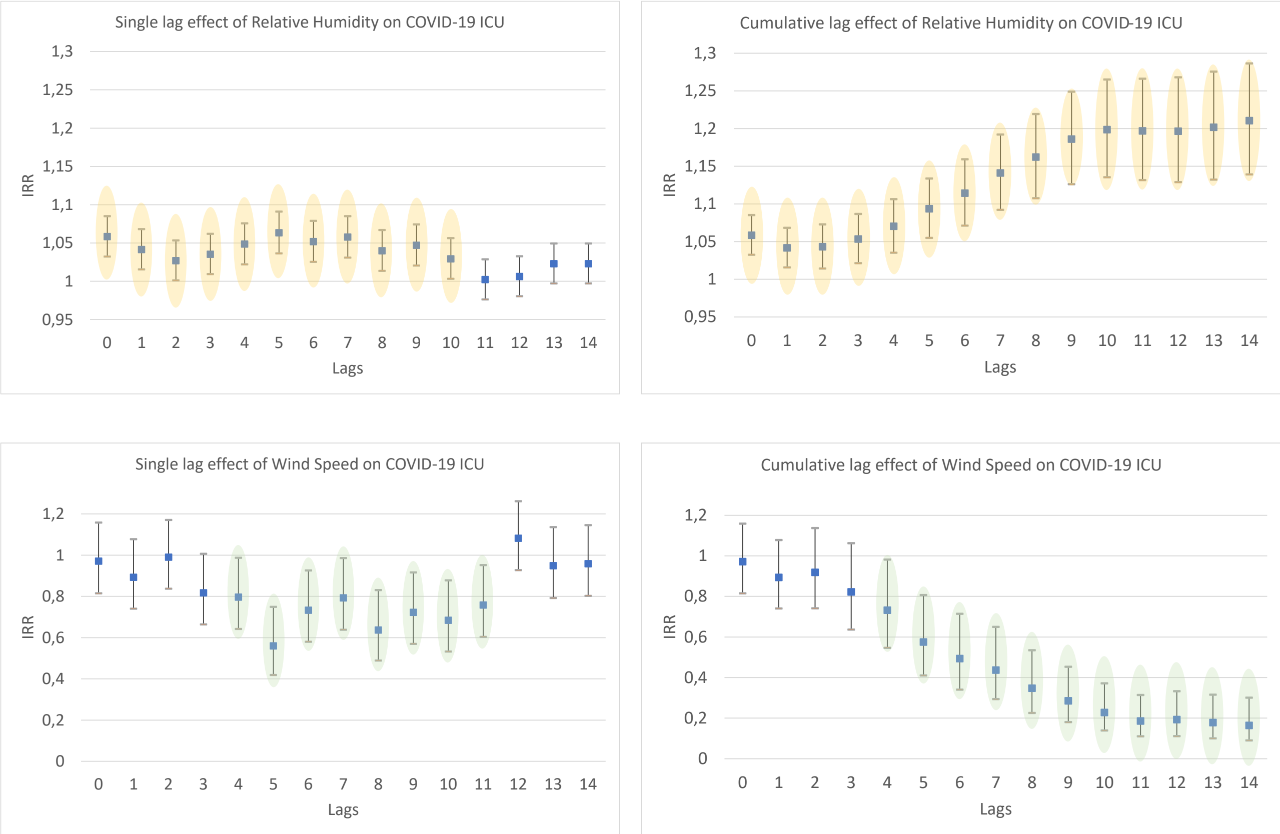


Figure 3. Single lag effect (left graphs) and cumulative lag effect (right graphs) of Incidence of Relative Risk (IRR) for air temperature (upper), relative humidity (middle) and wind speed (lower) on COVID-19 ICU, for Thessaloniki. Highlighted bars (green for negative and yellow for positive correlations) indicate statistically significant at $p < 0.05$.

In conclusion, one could assume that the IRR cumulative lag effect appears to be stronger against IRR single lag effect for all the meteorological parameters examined. Cold and wet weather for central Athens and warm and wet weather for Thessaloniki seem to be associated with higher ICU. Also, another finding is the remarkable influence of wind in decreasing ICU, for both cities. Further analysis is needed to understand better the weather influence on COVID-19 spread, in addition to protection measures should be taken.

References

Carfì A., Bernabei R. and Landi F. (2020), Persistent symptoms in patients after acute COVID-19, *Journal of American Medical Association (JAMA)*, **324**, 603-605.

Demongeot J., Flet-Berliac Y. and Seligmann, H. (2020), Temperature decreases spread parameters of the new COVID-19 case dynamics, *Biology*, **9**, 94.

EODY (National Public Health Organization), (2021), Daily report of epidemiological surveillance of new coronavirus infection (COVID-19), available on line: https://eody.gov.gr/wp-content/uploads/2021/04/covid-gr-daily-report-20210409.pdf (accessed on 9 April 2021).

Huang C., Wang Y., Li X., Ren L., Zhao J., Hu Y., Zhang L., Fan G., Xu J., Gu X., Cheng Z., Yu T., Xia J., Wei Y., Wu W., Xie X., […] and Cao, B. (2020), Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China, *Lancet*, **395**, 497–506.

McGullagh P. and Nelder J.A. (1997), Generalized Linear Models. 2nd ed. Chapman & Hall.

Paraskevis D., Kostaki E.-G., Alygizakis N., Thomaidis, N., Cartalis C., Tsiodras S. and Dimopoulos M.-A. (2020), A review of the impact of weather and climate variables to COVID-19: In the absence of public health measures high temperatures cannot probably mitigate outbreaks, *Science of the Total Environment*, **768**, 144578.

Tosepu R., Gunawan J., Effendy D.S., Ali L.O., Ahmad I., Lestari H., Bahar H. and Asfian P. (2020), Correlation between weather and Covid-19 pandemic in Jakarta, Indonesia, *Science of the Total Environment*, **725**, 138436.

Wang Y. and Di Q. (2020), Modifiable areal unit problem and environmental factors of COVID-19 outbreak, *Science of the Total Environment*, **740**, 139984.

WHO (World Health Organization) (2021), WHO Coronavirus (COVID-19) Dashboard, Available online: https://covid19.who.int/ (accessed on 9 April 2021).

Wu Y., Jing W., Liu J., Ma Q., Yuan J., Wang Y., Du M. and Liu M. (2020), Effects of temperature and humidity on the daily new cases and new deaths of COVID-19 in 166 countries, *Science of the Total Environment*, **729**, 139051.