Spatial distribution of Covid-19, a modeling approach: case of Algeria

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Abstract

The objectives of this study are to modeling the spatial distribution of Covid-19 at the regional scale (Case of Algeria) based on geostatistcal study of covid-19 cases spatial distribution and Hybrid Kriging. The data analysis of a published officially Covid-19 reports by the Algerian Ministry of Health. a map of contamination by covid-19 has been obtained and a new model of risk evaluation has been developed and proposed to predict the propagation of this pandemic in Algeria. To conclude this work show areas with high population density are most exposed to virus propagation and death arising. Simulation show that infection by Covid-19 will arise to 14 000 cases in Algeria in the last of April also the velocity of transmission of this virus is rapid. Map obtained help the local authority to manage Covid-19 infections at the spatial scale.

Introduction

Pneumonia of unknown cause was detected in Wuhan City, Hubei Province, China – the seventh-largest city in China with 11 million residents. As of January 23, there are over **800 cases** of 2019-nCoV confirmed globally, including cases in at least 20 regions in China and nine countries/territories (Dong E et al, 2020; Paul s CI et al,2020). The first reported infected individuals, some of whom showed symptoms as early as December 8, were discovered to be among stallholders from the Wuhan South China Seafood Market. The virus causing the outbreak was quickly determined to be a novel corona virus the new Wuhan corona virus, namely 2019-nCoV, a beta corona virus, related to the Middle Eastern Respiratory Syndrome virus (MERS-CoV) and the Severe Acute Respiratory Syndrome virus (SARS-CoV) ((Guan WJ et al , 2020; Corman VM et al,2020; Chan JF et al ,2020 ; Dong E et al,2020 ; Paules CI et al, 2020 ; Li Q et al ,2020). However, the mortality and transmissibility of 2019-nCoV are still unknown, and likely to vary from those of the prior referenced corona viruses (Dong E, Du H, Gardner 2020).

Until April 7, 2020, 1 337 749 cases and 74 169 deaths have been reported worldwide. We are currently witnessing a spread of the epidemic in most countries. In Algeria, 1423 cases and 173 deaths have been recorded by the Ministry of Health. (Algerian health ministry, 2020).

The international ratio infected/death cases is across 5.54% contrariwise the Algerian Ratio is higher than the International standard 12.15 %.

Our study aims to establish a map of risk of corona virus in Algeria. By using data about infected cases from two spaced date, the model developed gives a prediction of infection risk at the regional scale. The methodology developed can help the government to manage the Covid-19 crisis at the spatial planning of the crisis.

Area Of Study

Algeria is located along the North African coast (Fig.1), bordered to the east by Tunisia and Libya, to the southeast by Niger, to the southwest by Mali, and to the west by Mauritania and Morocco. It is the first largest country in Africa, with area about 2.7 millions km², coastline of 1200km.

Algeria holds a special place in the Mediterranean basin with its geostrategic position and its demographic and economic weight. 42 millions habitants were estimated in the end of December 2018 by the National office of statistic (ONS). The most important population density was concentrated in the North of the country.

Insert Figure 1 here.

Methods

Mapping of the contamination risk of Covid-19 is a very important in this time. It can help policymaker to tack decision and analyze an emergency state at spatial levels. Now the entire world faces to a serious problem about detecting the velocity of propagation of this virus. The mechanisms of transport of contagious diseases can be classified into four modal: Air traffic; Direct Contact from seek person, atmospheric circulation, Animal -Human contact.

Mapping of spatial distribution of Covid-19 infections is realized by using geostatistcal analysis methods (Hybrid Kriging technique). Analysis based on the statistical data reported by the Algerian Ministry of Health. The geographic data are provided by the Algerian water company.

Results And Discussion

The main results of the mapping procedure were discussed in this part. The plot in figure.2 shows the relation between the covid-19 and population density. The figure.3 show the evolution of Covid-19 infected cases in function of time (given in Days).

Insert Figure 2 here.

The figure .2 shows the mathematical relation between the covid-19 and the density of population by sequare kilometers. A correlation of R^2=0.329 ($R \approx 0,6$) express a good relationship between the two factors. The model in equation.1 gives the Covid-19 contamination cases in function of the population density.

$$\text{Pcovid} = 0.63 * \text{Popdensity} + 11.30 \qquad \text{(eq.1)}$$

Pcovid: is the predicted covid-19 cases; Popdensity : is the density of population by km².

A new model is derived from the analysis of cases, to predict evolution of contamination risk in function of time (Figure.3). Analysis concludes that very person can contaminate 4 people.

Insert Figure 3 here.

The model obtained have an exponential form, it is given by the equation (eq.2):

$$Pcovid = 1180 * \exp(0.085 * t) \quad (eq.2)$$

Pcovid : is the predicted covid-19 infection; t: is time given in days

By taking an incubation time of 14 days, we suppose that every person can contaminate 3 persons we can establish a time function of Virus propagation in Algeria.

A simulation of the actual situation by taking into account our scenario show that the cases of Covid-19 in Algeria can be arise from 1400 cases actually to 14 000 infections cases.

The analysis of these results allows us to formulate a new model to predict the Covid-19 infections. The new equation was given as below:

$$Covid19_{cases} = 5753000 * \left(\frac{Obc}{Popdensity}\right) + 64.08 \quad \text{(eq.3)}$$

Map in figure.4 show the spatial variation of Covid-19 cases in Algeria as reported by the national ministry of health.

Insert Figure 4 here.

The spatial distribution of infected cases shows that the center of the infection is localized in the North of Algeria. The isolation of the epicenter of the diseases can reduce the propagation along the country.

The map in figure.5 shows the spatial predicted value of covid-19. The simulation period is ranged from 7/04/2020 to 30/04/2020.

Insert Figure 5 here.

The velocity of propagation is high which can damage the health structure and the capacity of the hospital to manage the arising cases (Shannon 2020, Wendy 2020). Our work gives a global idea about the propagation risk of this virus. A lot of parameters can accelerate this velocity (Road traffic, density of contact, space markets and commercial centers, Administrations and services local) all of this kind of structures can accelerate the propagation of contagious virus (ACSS 2020).

In this work a map of spatial covid-19 was established to demonstrate the evolution of this contagious virus in Algeria. The map show regions with low evolution are located in the south of the country. Regions of medium evolution are located in the high steppes and finally regions of high propagation risks are located in the North.

The high propagation of this virus in the north of the country is due to the high population density, high transport and air traffics .These factors are the primary causes of the rapid evolution of this dangerous contagions virus.

In conclusion, the velocity of propagation of COVID-19 is high which need an intensified efforts to reduce the contagious and contamination Risk. This study illustrates a geographic analysis of the propagation of this virus.

The simulation shows a high propagation of this virus in Area with high population density. The simulation also show that the number of cases will achieves 14 000 cases in 30/04/2020. Map show that COVID-19 epicenter is localized in the north of the region. Algerian authority work hardly to reduce the propagation of this virus. The efforts of all sectors in Algeria concentrated to reduce the death number by application of Chloroquine protocol which gives good results according to the clinical recovered persons. The Algerian ministry of health affirms the good results of this medicaments type.

Declarations

Authors' Contributions

Writing review and editing, A.R.S.E and CB; visualization, ARSE., C.B .; supervision, C.B, H.F and B.N

Conflict of interest

The authors declare that they have no conflicts of interest.

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Figures

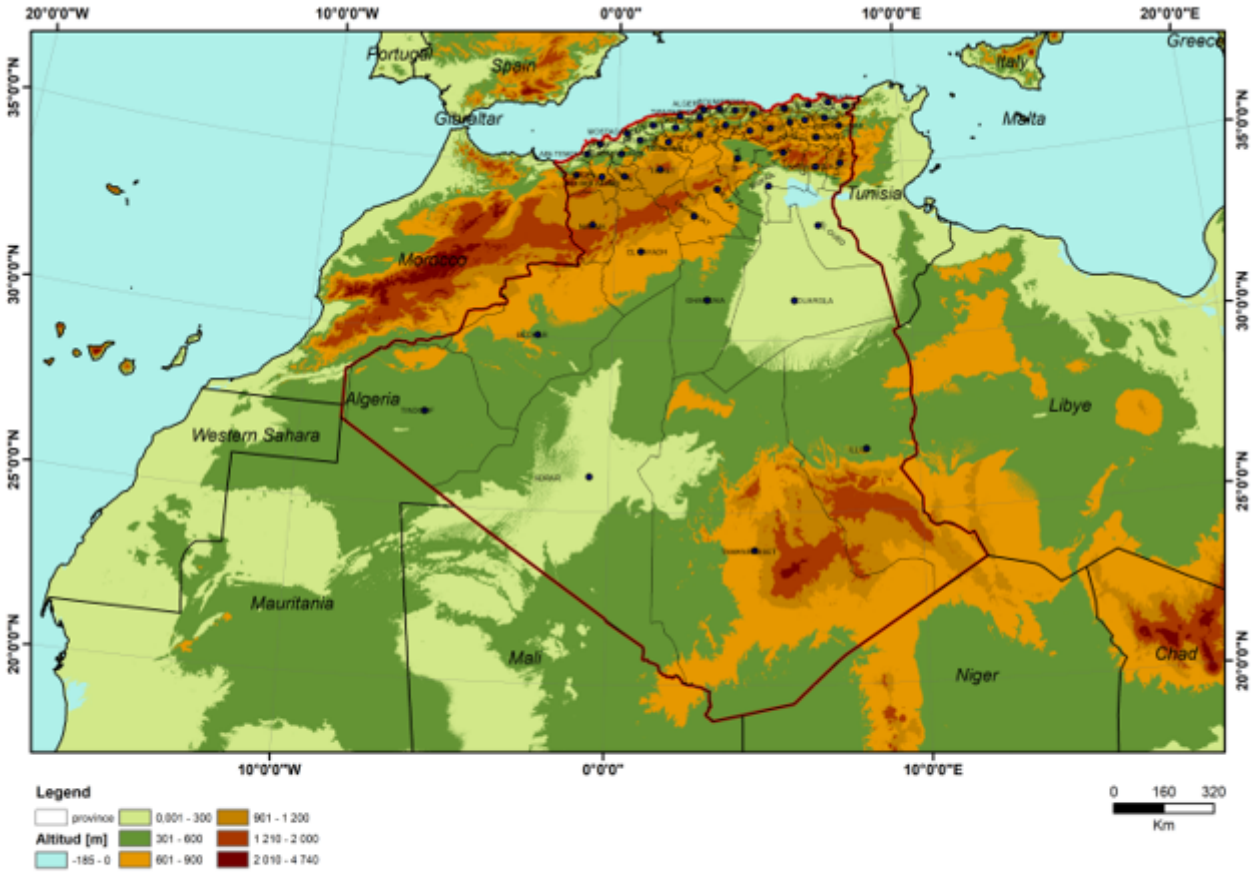

Figure1. Presentation of study Area

Figure 1

Presentation of study Area

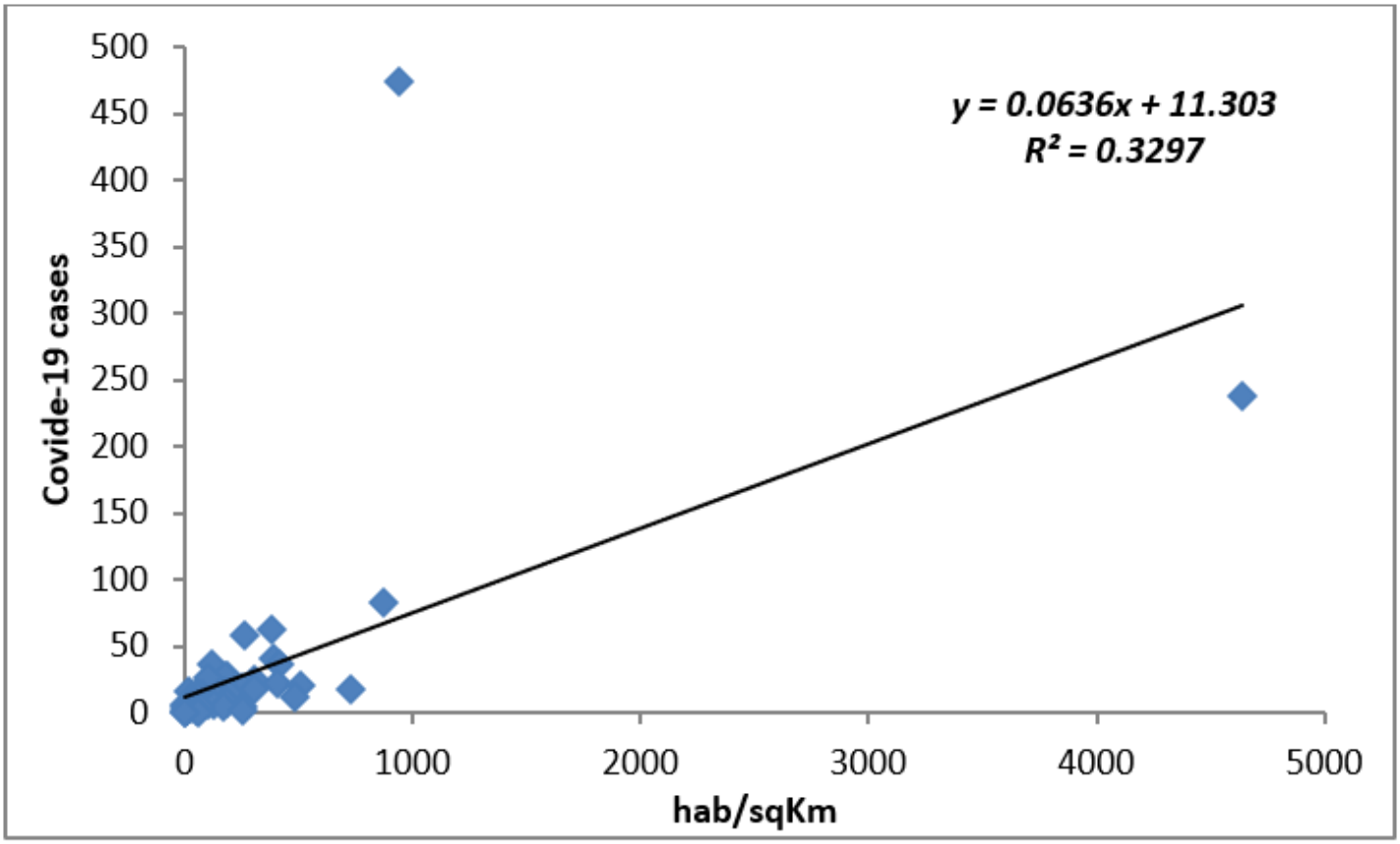

Figure.2 *Covid-19 = f(Population density)*

Figure 2

Covid-19 = f(Population density)

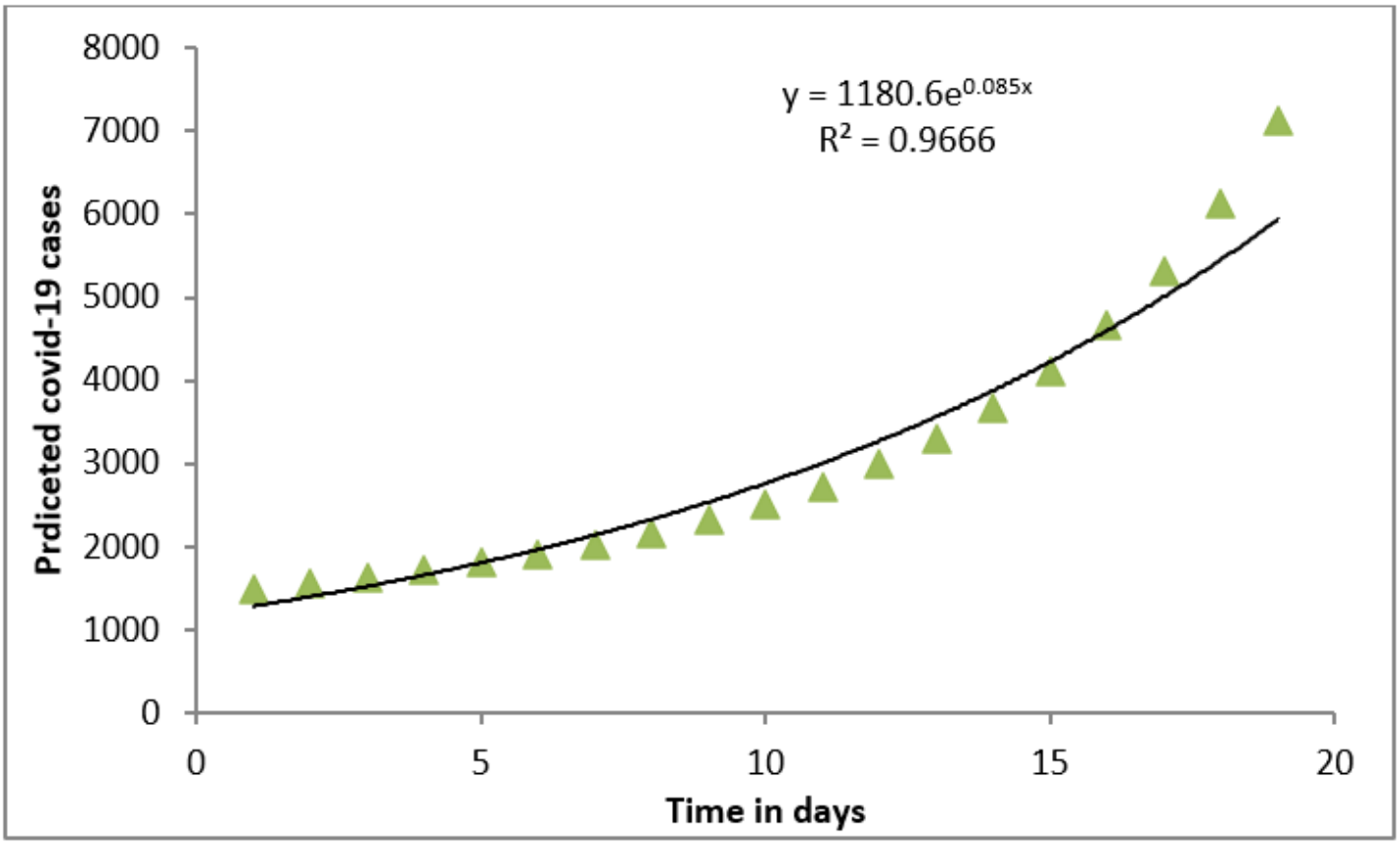

Figure.3 Evolution of Covid-19 cases in function of time

Figure 3

Evolution of Covid-19 cases in function of time

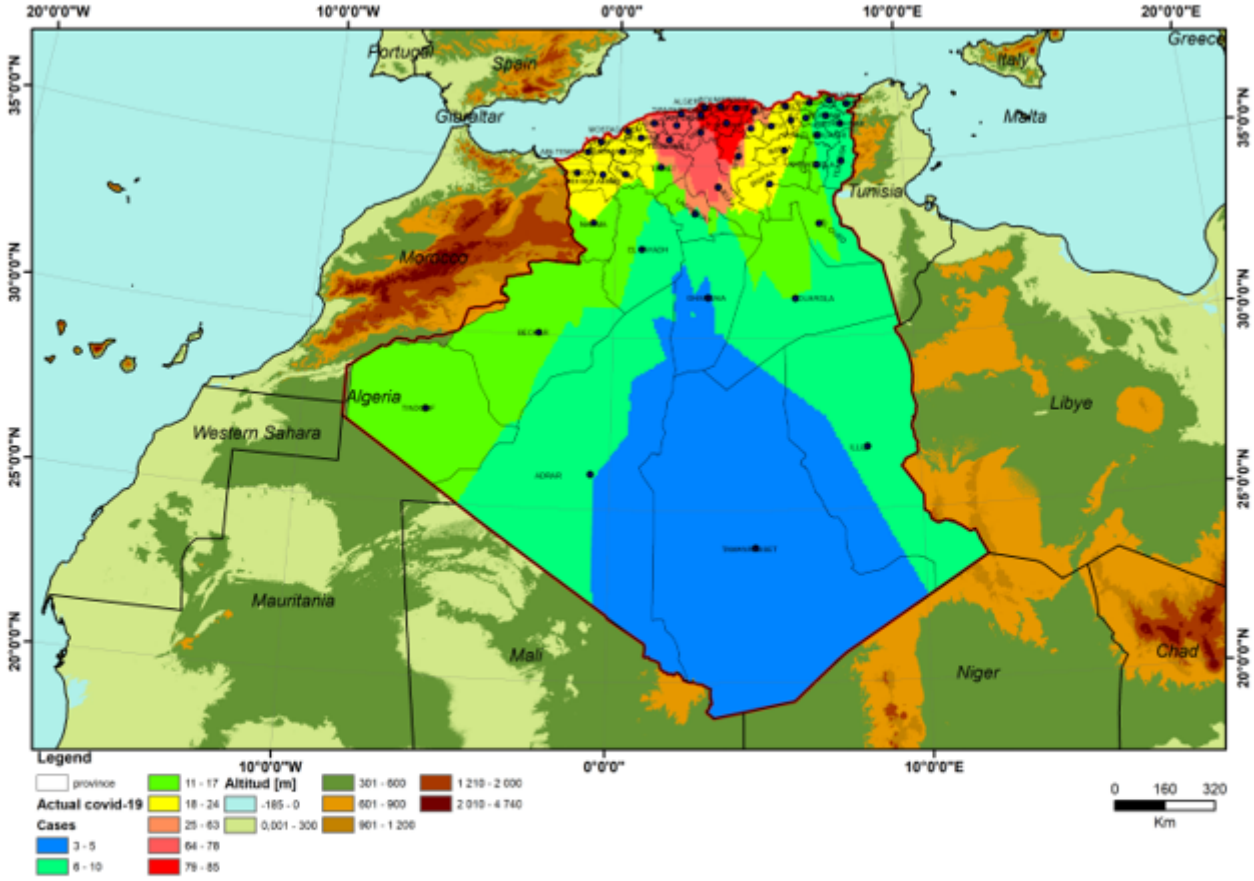

Figure.4 Spatial variation of Covid-19 in Algeria situation in 07/04/2020

Figure 4

Spatial variation of Covid-19 in Algeria situation in 07/04/2020

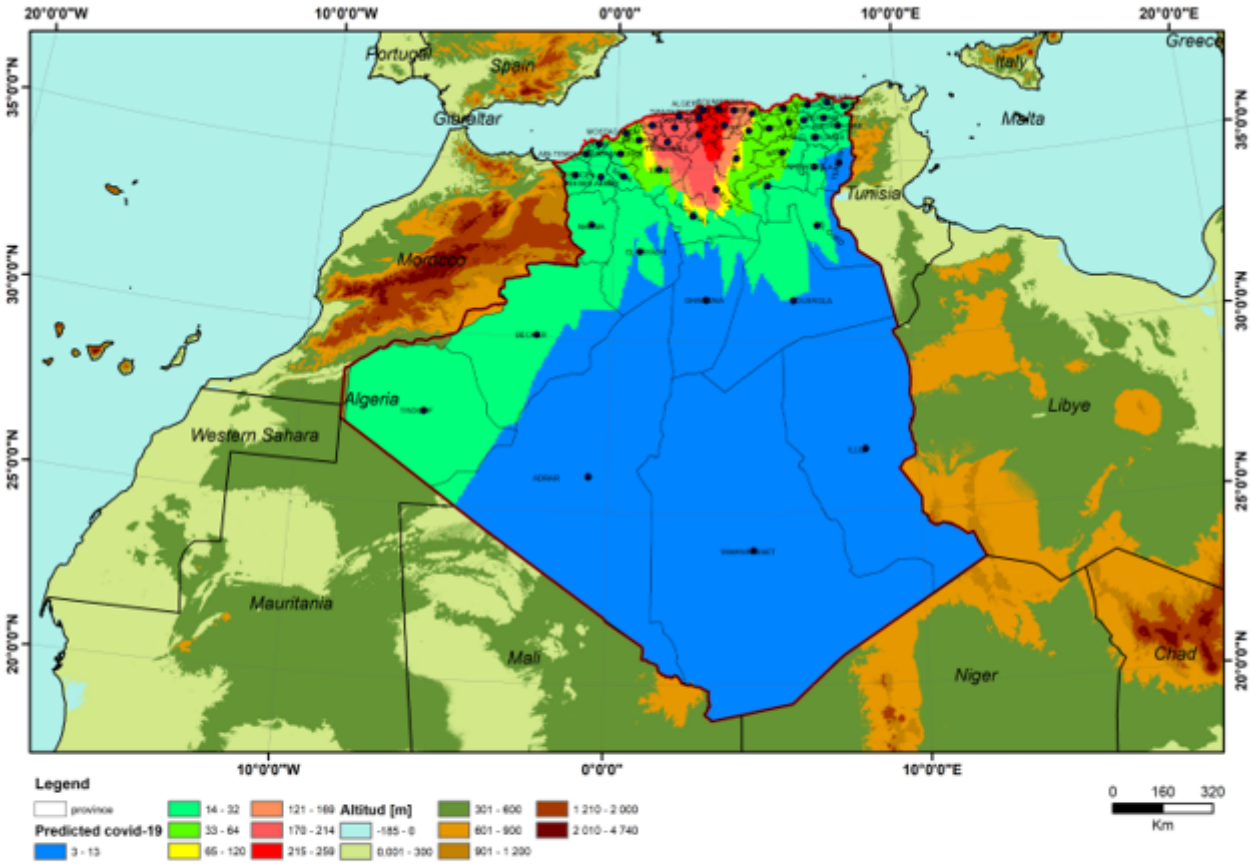

Figure.5 Spatial variation of Covid-19 in Algeria prediction date (30/04/2020)

Figure 5

Spatial variation of Covid-19 in Algeria prediction date (30/04/2020)