An Assessment of Relation of Environmental Parameters and COVID-19 Transmission at the Early Stage During March-may 2020 in India

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Abstract

Background

The Corona virus disease 2019 (COVID-19) mainly caused by the novel severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) became a global pandemic by March 2020. Actually, there is no strong evidence of weather and COVD-19 spread relation as it is a new virus. This study mainly focuses on the tropical weather impact on the spatio-temporal spread of COVID-19 during the early stages i.e. March-May 2020 in India, which is a large country where the disease has shown an exponential growth.

Methods

This study is an attempt to assess the relationship of major environmental parameters like solar radiation, air temperature and relative humidity with the positive cases of COVID-19 for the period March-May 2020 which is the summer season or pre-monsoon season over India. The time series and significant correlation analysis at daily, weekly scale and the spatial analysis of weather and COVID-19 cases are presented.

Results

The results show a significant correlation of solar radiation and atmospheric temperature with COVID-19 cases, both at daily and weekly scale in India whereas relative humidity has low correlation in the study period. But the temperature humidity index (THI), a measure of the thermal stress, shows positive correlation with the disease spread.

Conclusions

These results could be a good input for developing the integrated modelling framework for the COVID-19 forecasting using state of art numerical weather prediction model and disease process modelling.

Background

Whole world affected with the spread of an epidemic the Corona virus disease 2019 (COVID-19), initially started in Wuhan, China in late December 2019 [17,16,20]. COVID-19 mainly caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)[9]. In first quarter of 2020, COVID-19 spread across the globe exponentially and the World Health Organisation (WHO) declared the pandemic on 11 March 2020 [32]. The first positive case of COVID-19 in India was reported in Kerala on 30 Jan 2020 in a student who had a travel history of flying from Wuhan, China. The positive cases crossed 500 by 23 March 2020 and then India faced a nation wide full lockdown for 21 days. The number of positive crossed 100,000 on 18 May, 2020 i.e. in 111 days from date of incidence. The present trend of the new infected cases shows exponential growing rate and it varies differently over different regions in world. As COVID-19 is a new disease, there is no evidence of the relation of weather parameters on the disease transmission or spread. There is a need of better understanding of the disease-climate parameter

interaction by quantifying their relation so that weather parameter enabled modelling effort can be useful in predicting the COVID-19 incidence and the disease spread well in advance.

COVID-19 mainly causes the respiratory illnesses like flu which include influenza A and influenza B but it spreads more faster and easily than flu and also the death rate is higher in this disease. There are several studies related to transmission of seasonal flu (influenza) virus which largely controlled by the seasonal climatic factors like temperature and relative humidity, population density, city size and its structure, etc. [10,8] . In the temperate regions, the seasonal variation of influenza transmission is controlled by the conditions of absolute humidity, levels of susceptibility and changes in population-mixing and contact rates [25] and past studies have shown seasonal patterns of human coronavirus species and annual variation in species [14]. Study by Chan et al. [7] showed in subtropical area during spring season the SARS coronavirus have better stability at low temperature and humidity. The specific climatic condition like the optimal temperature, humidity and wind velocity will help for the survival and transmission of SARS virus, whereas low humidity, high barometric pressure and daily temperature fluctuations will reduce the transmission [33].

Low absolute humidity during winter increases influenza virus survival and thus increases influenza virus transmission efficiency [27] . Relative humidity and temperature is sensitive to the aerosol route and insensitive to the contact route in the transmission of the influenza [19]. In a temperate region, influenza incidence increase with low temperature and low/high humidity and also with high diurnal temperature range [22]. The efficiency of transmission of influenza virus is affected by the humidity and temperature conditions and the transmission of influenza virus is less dependent on humidity and temperature in the absence of immunity[30].

After the widespread establishment of SARACoV-2 infection, the intensity, and timing of pandemic and post pandemic outbreaks will depend on the time of year. The transmission and the level of cross-immunity that present between beta corona viruses is less dependent on the magnitude of seasonal variation[15]. The seasonality of the SARS-CoV-2 has not been established so far but the climate might play a role in the spread of the disease[28, 29]. Some studies have reported that the COVID-19 spread can be affected by a large number of factors including the climate conditions[24,31]. Several recent studies is being carried out by researchers to find the relation of weather parameters and COVID-19 in different regions, countries and at global scale[1,2,3,4,5,6,21,23,33] but there is lot of divergence in the results as some studies indicated the expansion of COVID-19 is not driven by climate at global scale [6]. A recent study also finds the impact of environmental temperature on COVID-19 exponential growth for US and Italy at regional scale [18]. In few other studies the results shows insignificant correlation of temperature and UV radiation with COVID-19 transmission [23,33]. Similarly another time series study over mainland China explains the relation of temperature and humidity with the transmission of COVID-19 [24].

Our study is mainly focussed on finding the evidence of influence of the weather conditions particularly air temperature, relative humidity and solar radiation flux in the early stage spreading of COVID-19 epidemic in India using the data for the period March to May 2020.

Material And Method

In this analysis, we have considered the period March 1 to May 20 as the number of positive cases of COVID-19 became 100,000 on May 18, 2020 in India. The COVID-19 infection data is being collected from sources like Ministry of Health and Family Welfare (MoHFW), Government of India (https://mohfw.gov.in) [11] and Worldometers (https://www.worldometers.info) [13] at daily scale. As mentioned in previous section, no significant relation is established with climate and COVID-19 at regional scale, so here we emphasized our analysis over country as a whole instead of city or state scale as there was migration of people from one place to other during March 2020 and after May 03, 2020 when Lockdown-2.0 started in India. The analysis of major climate parameters which affect the virus i.e. solar radiation, temperature and relative humidity are considered. Mean daily downward solar radiation Flux at surface [1.9^o x 1.9^o], mean daily air temperature at 2m [1.9^o x 1.9^o] and mean daily relative humidity at surface [2.5^o x 2.5^o] is obtained from NCEP-NCAR Reanalysis 1 data from the link

(http://www.psl.noaa.gov/data/gridded/data.ncep.reanalysis.html) [12]. All the parameters are averaged over continental India for each day. For the weekly analysis, the composite plot of 7 days for each parameter is computed and presented for the analysis period i.e. 01 March 2020 to 16 May 2020. The Pearson correlation coefficients (CC) between the climate variables and COVID-19 cases are computed and presented at daily and weekly scale. The Temperature-Humidity Index (THI) is also an important parameter which generally used for determining the heat stress and in this study, THI computed using the temperature and humidity at all India scale and the correlation of THI and COVID-19 cases is explored.

Results

COVID-19 Spread in India

The daily number of cumulative COVID-19 positive cases reported in India for the period 01 March to 20 May are presented in logarithmic scale in Fig. 1 which shows there is a steady exponential growth in the epidemic numbers for the analysis period. It is clearly indicated that March 4 cases was at 29 and quite linear till April 11 with 8446 cases and there after the growth phase increased very fast and the number became 10453 on April 13 and close to 50000 cases by May 06 and the number crossed 100000 on May 19, 2020. The curve of the COVID-19 spread in India initiated with a pre-exponential phase, which is characterized by a mild logarithmic growth, followed by the exponential growth resulting the disease outbreak. The spatial distribution of the COVID-19 is presented in Fig. 2 represents the number of cases in each state on 14th March and 16th May 2020, which clearly shows Maharastra, Tamilnadu and Delhi were the most affected states in India so far. There is a challenge in understanding the regional variation in the growth rates as it is different for different countries and states and one can consider the weather parameters like temperature and relative humidity etc. as factors affecting the COVID-19 outbreak.

Weather Parameter distribution in India

The spatial distribution of weekly averaged solar radiation flux at surface is presented in Fig. 3, clearly indicates the start of strong radiation in the 4th week onwards all over India. Due to lockdown, a reduction in concentration of the pollutants and aerosol contents in atmosphere is seen in the year 2020, which resulted in more surface radiation compared to other years in summer season. During 29 March-18 April almost all the regions experienced high solar radiation flux. Same spatial distribution analysis for 2m air temperature shows a increasing trend from March to April and in several parts of the country, weekly average temperature crossed $36^{o}C$ in the month of May 2020 (Fig. 4). The distribution also shows a gradual increase in temperature, starting in western India, followed by central India and finally eastern India recording high temperature during summer 2020. The relative humidity variability is also presented week wise in Fig. 5 and it clearly indicates the spatio-temporal variability in the distribution of water vapour and shows a increasing trend in first 2 weeks of March then decreasing trend from March 20 to 2nd week of April and increased in the last week of April and again decreased in May over most of regions in India. In general, the western and central part showed a comparative low humidity as against the north, east, south and north-east India regions during the study period.

Discussion

Relation of Weather parameter and COVID-19 cases

The daily time series of all India averaged relative humidity (upper panel), air temperature (middle panel) and downward solar flux are presented along with the daily reported number of COVID-19 cases in India (Fig. 6) for the period i.e.01 March to 16 May 2020. Daily variation of COVID-19 infected cases observed in India and weather parameters i.e. relative humidity (upper panel), air temperature (middle panel) and downward solar flux (bottom panel) averaged over continental India for the period 01 March- 16 May 2020. The correlation analysis of daily time series for 76 days shows there is strong and significant relation (CC=0.82) of 2m. air temperature and COVID-19 and the value is only 0.39 with 95% significant in case of downward solar radiation flux but it is insignificantly having zero correlation with the relative humidity. Then the same analysis is carried out by considering the weekly average values in the time series and it is observed that at weekly scale also temperature, solar flux and relative humidity have correlation 0.86, 0.45 and 0.11 respectively with COVID-19 cases in India in the summer season. The relation of temperature and solar flux is more significant in weekly scale(presented in Fig. 7).

As generally the summer season prevails from March to May, THI a measure of the thermal stress, is also compared with COVID-19 cases at all India scale and it is observed that both in daily and weekly averaged analysis, there is strong correlation between the THI and COVID-19 cases (Fig. 8) and the correlation found to be 0.6 at 95% significant level.

Conclusions

The COVID-19 spread showing exponential growth rate by May 2020 in India, is going to be more in coming months as the summer season strengthening this year due to low emission and aerosol in

atmosphere, both solar radiation and temperature is increasing. The present study confined over India shows significant correlation of solar radiation and atmospheric temperature with COVID-19 cases whereas humidity has low correlation in the study period. Also, the THI a measure of the thermal stress shows positive correlation with the COVID-19 spread. In the coming days, there is a need of finding these relations as the COVID-19 shows rapid transmission in India for robust estimation and evidence. Along with the weather parameter, there is also a requirement of other prevention activities for the control of the ongoing pandemic.

Abbreviations

COVID-19: Corona Virus Disease of 2019

SARACoV-2: Severe Acute Respiratory Syndrome

THI: Temperature-Humidity Index

WHO: World Health Organization

MoHFW: Ministry of Health and Family Welfare

NCAR: National Center for Atmospheric Research

NCEP: National Centers for Environmental Prediction

Declarations

Ethics approval and consent to participate :Not applicable

Consent for publication: Not applicable

Competing interests: The authors declare they have no competing interests.

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Authors' contributions : KCG contributed to the conceptualization of this paper and wrote sections of the paper. All authors contributed to study design, data collection, data analyses, interpretation of data, and drafting of the manuscript. All authors have read and approved the manuscript.

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Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

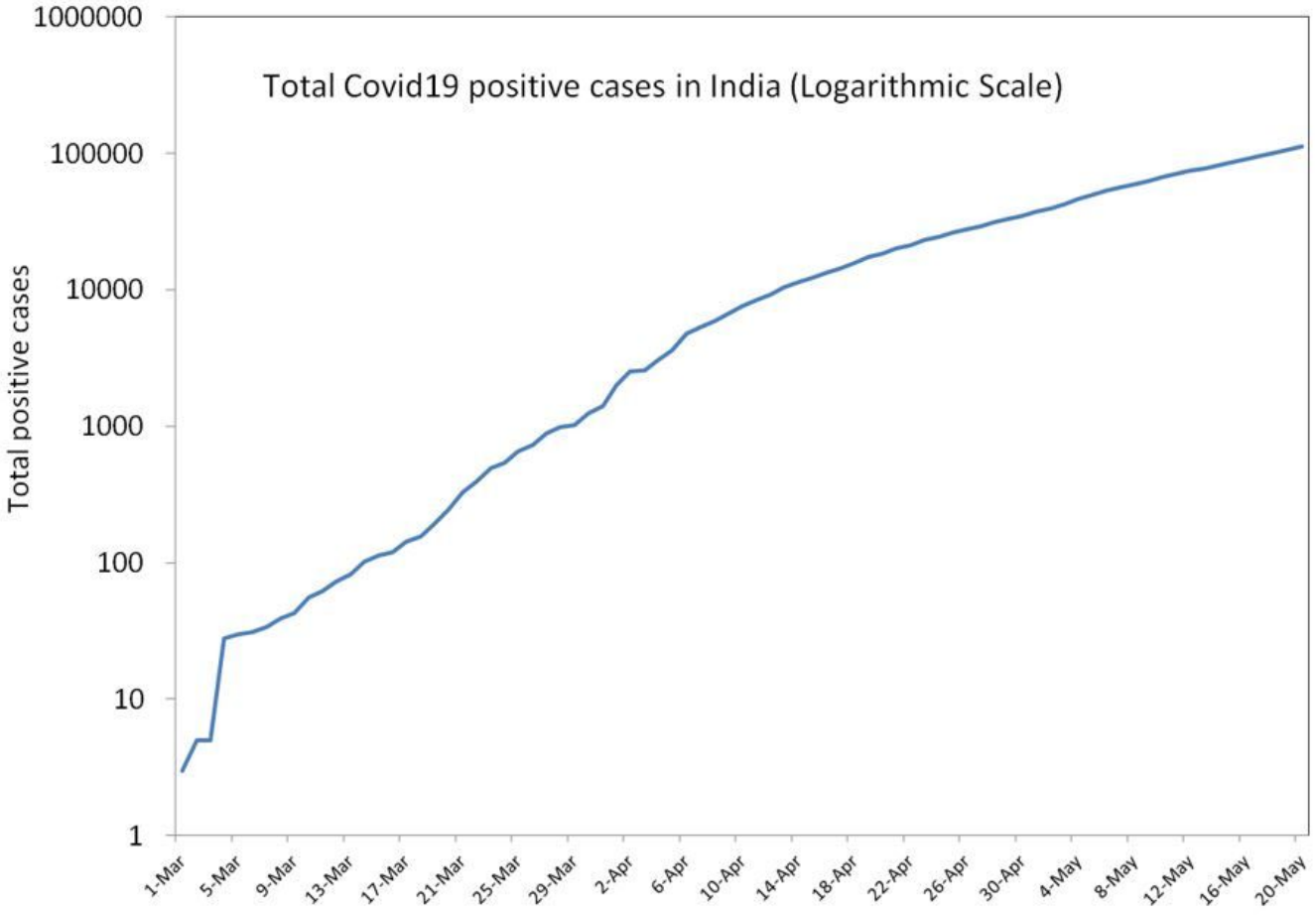

Figure 1

Cumulative number of confirmed reported positive cases of COVID-19 cases in India

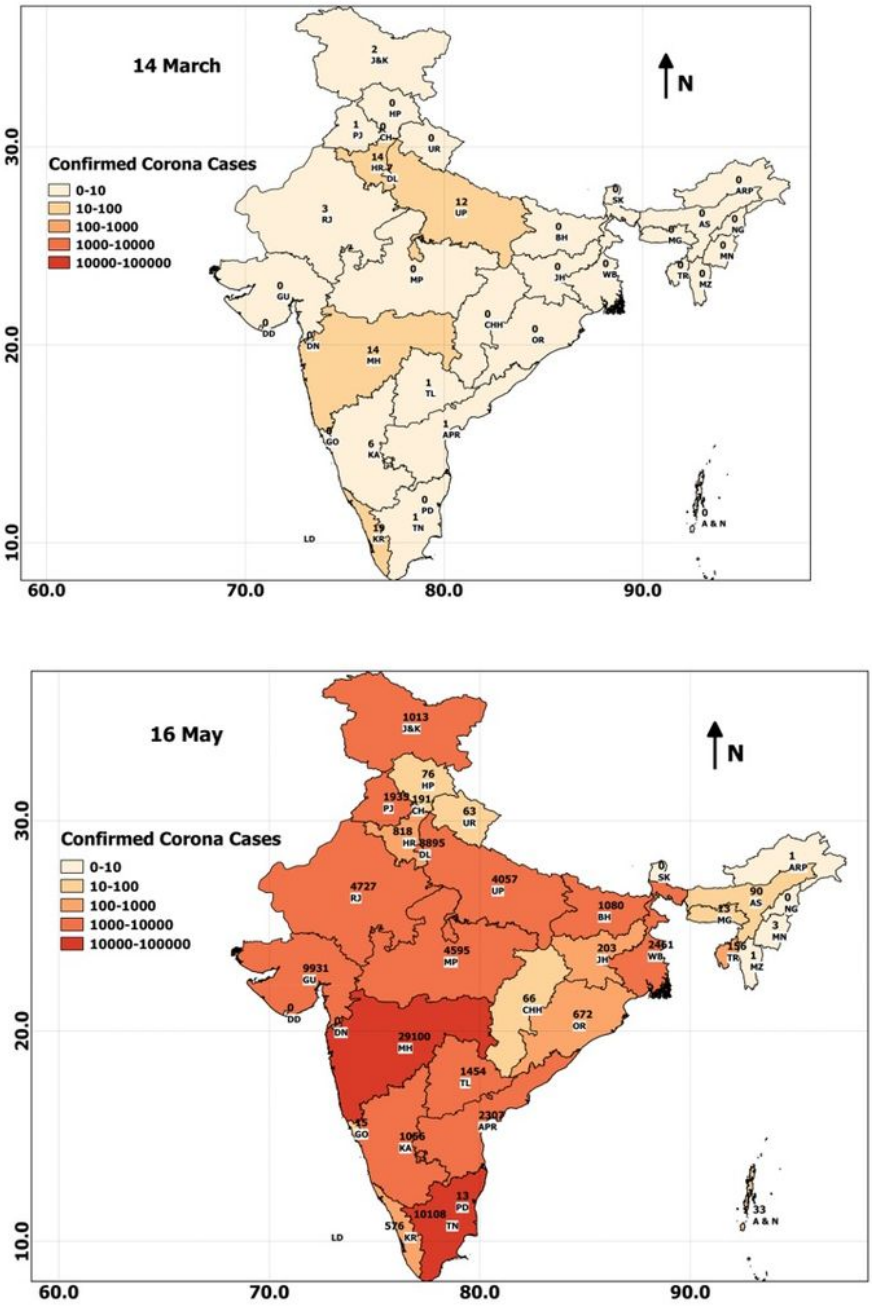

Figure 2

Spatial distribution of COVID-19 positive cases reported in states in India till (a) 14th March and (b) 16 May 2020.

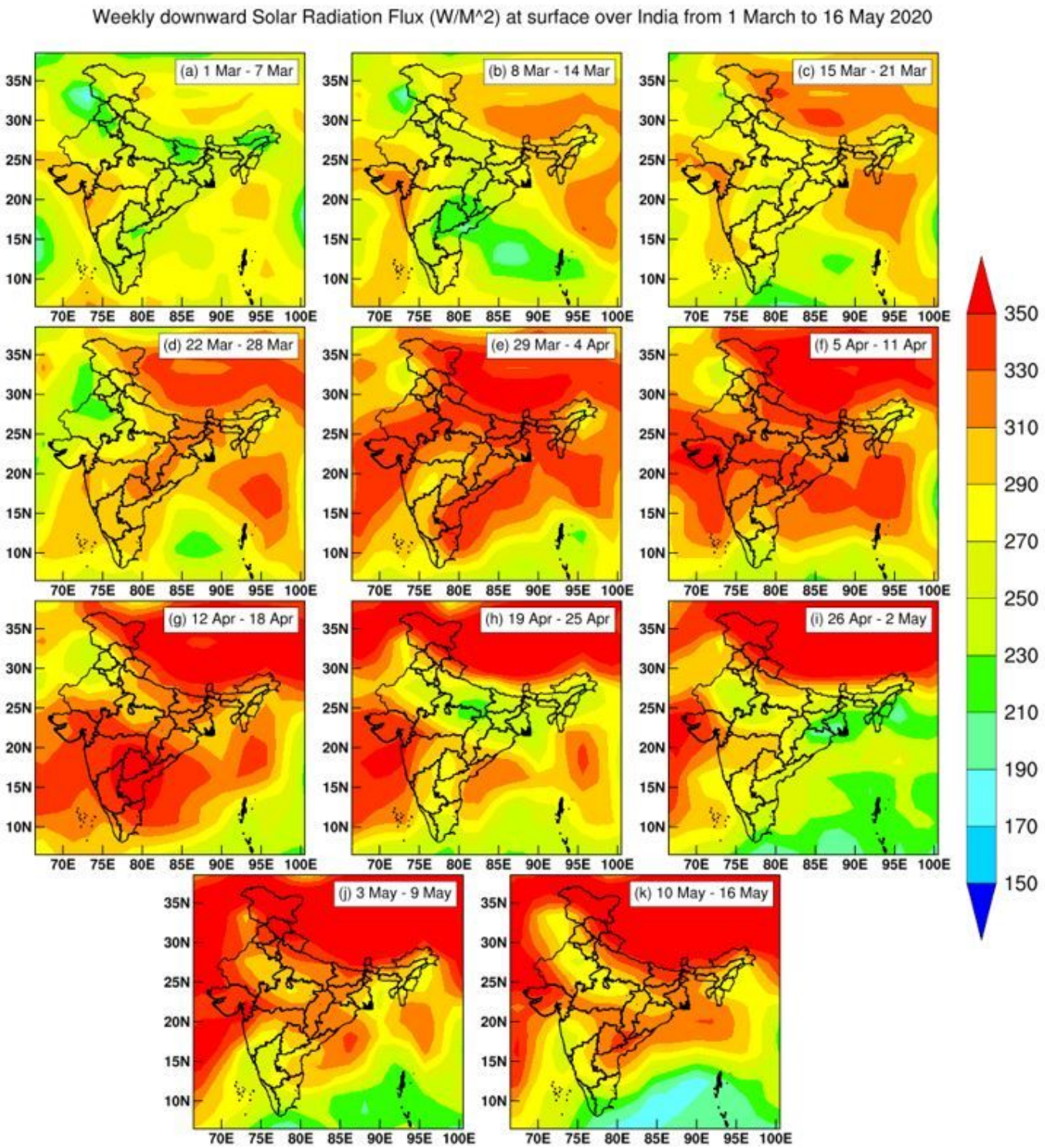

Figure 3

Spatial distribution of weekly averaged downward solar radiation flux (w/m2) over Indian region for the period 01 March- 16 May 2020.

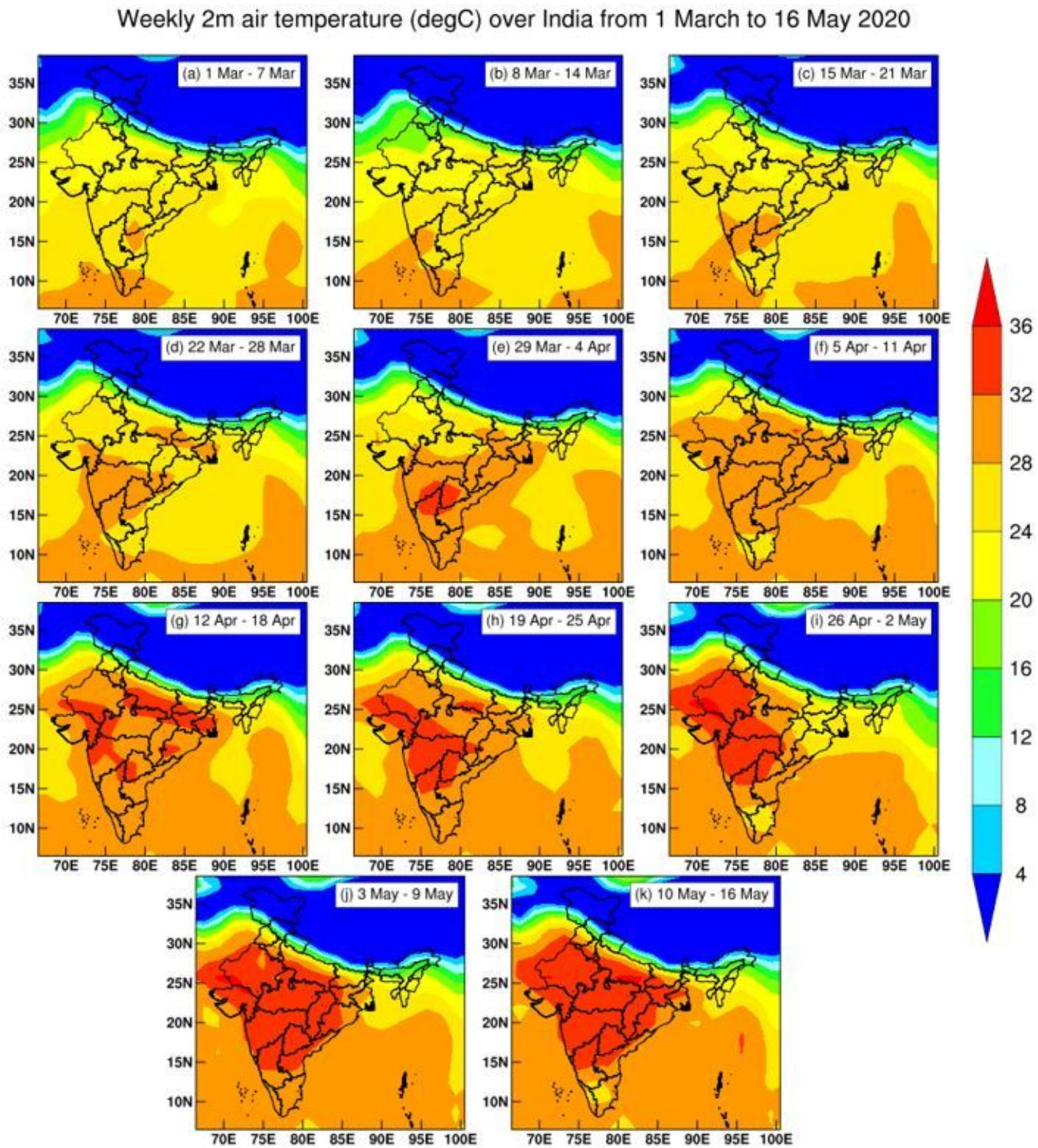

Figure 4

Spatial distribution of weekly averaged air temperature (oC) over Indian region for the period 01 March-16 May 2020

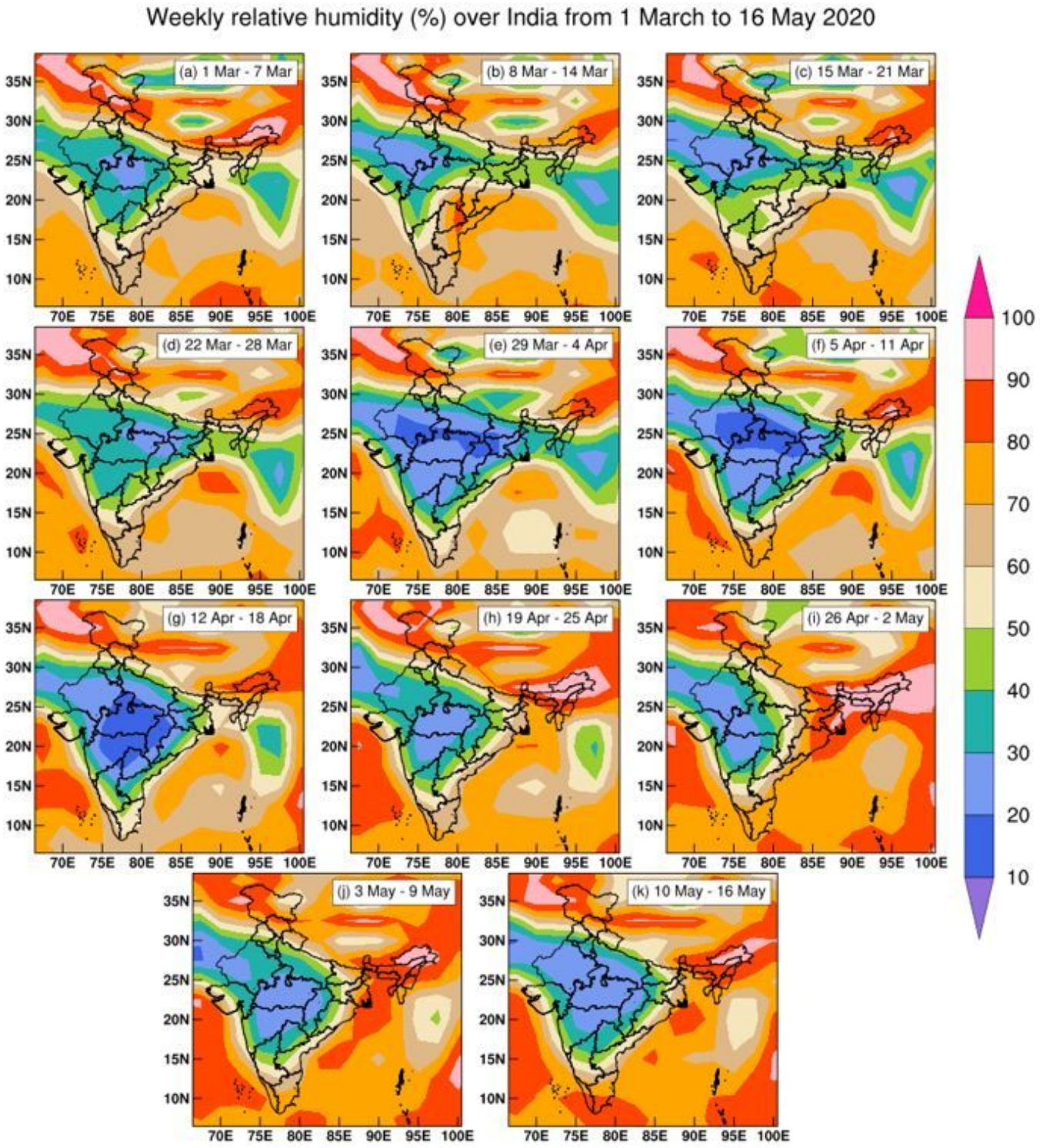

Figure 5

Spatial distribution of weekly averaged relative humidity (%) over Indian region for the period 01 March-16 May 2020

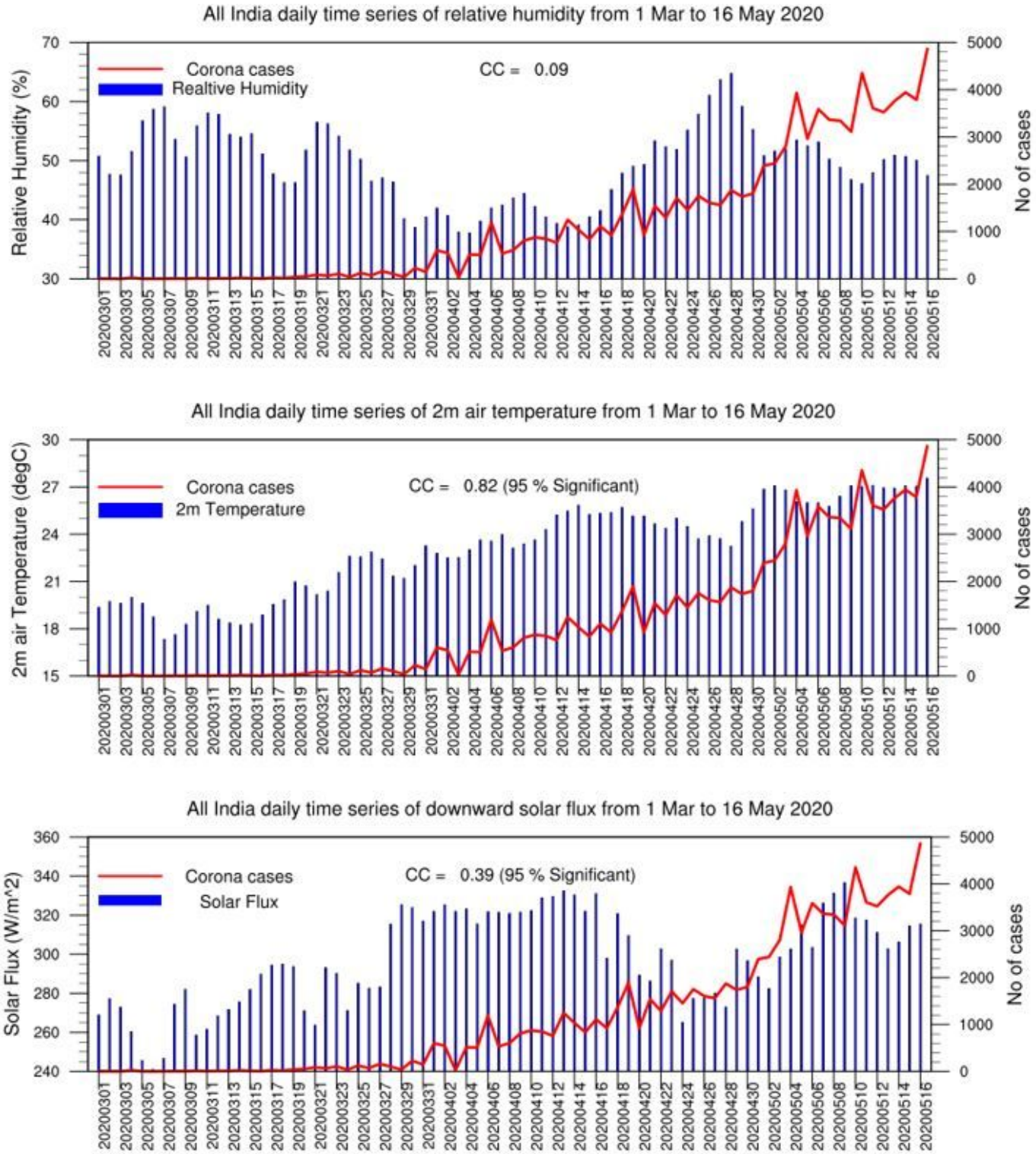

Figure 6

Daily variation of COVID-19 infected cases observed in India and weather parameters i.e. relative humidity (upper panel), air temperature (middle panel) and downward solar flux (bottom panel) averaged over continental India for the period 01 March- 16 May 2020. The correlation between COVID-19 cases and weather parameter are presented in each panel.

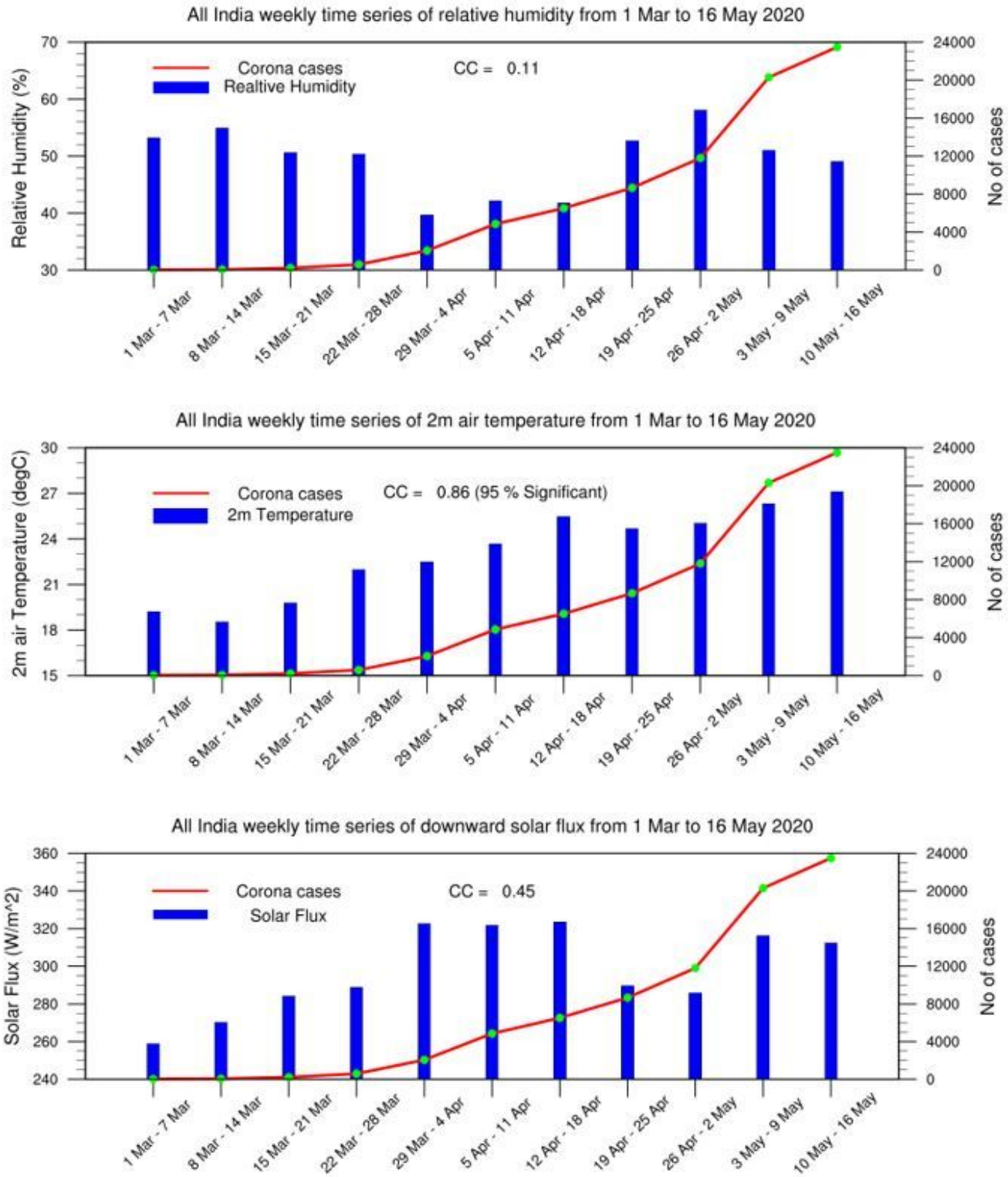

Figure 7

Weekly variation of COVID-19 infected cases observed in India and weather parameters i.e. relative humidity (upper panel), air temperature (middle panel) and downward solar flux (bottom panel) averaged over continental India for the period 01 March- 16 May 2020. The correlation between COVID-19 cases and weather parameter are presented in each panel.

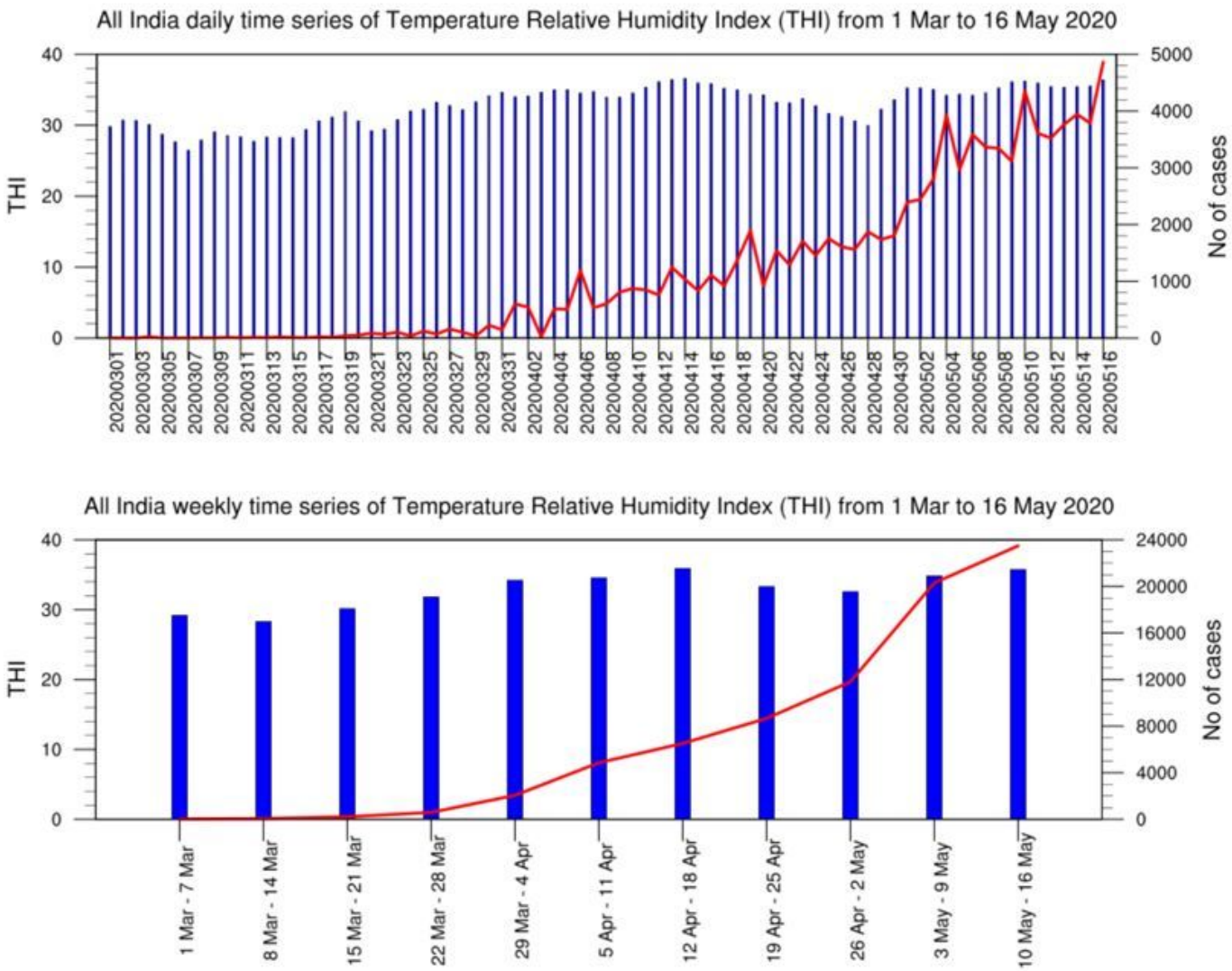

Figure 8

Daily (upper panel) and weekly (lower panel) variation of COVID-19 infected cases observed in India and THI averaged over continental India for the period 01 March- 16 May 2020. The correlation between two time series is 0.6 in both the cases.