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Meteorological parameters and COVID-19 spread-Russia a case study

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18.1 Introduction

COVID-19 was reported during December 2019, in Wuhan, China, led to a serious acute respiratory disorder, with a high probability of human to human transmission (Gorbalenya, 2020; Wu et al., 2020). Hence, the spread was pandemic and has affected the entire international community (C. Wang et al., 2020; M. Wang et al., 2020; Bagyaraj et al., 2020). It was on 11th, March 2020 the World Health Organization (WHO) categorized it as a global pandemic after considering the global fatality (WHO, 2020a) and number of infected cases (WHO, 2020b). Respiratory disorder, cough, and fever are common symptoms of this pandemic. The average duration of the viral incubation may vary from a minimum of 5 days to a maximum of 14 days (Holshue et al., 2020). The extreme stages of infection may lead to, kidney failure, severe acute respiratory disorder, pneumonia, and even death. Perlman, (2020) had reported that, fever was predominant in most of the cases, with infection in both the lungs leading to breathing disorder.

The temperature increase was inferred to reduce the COVID 19 cases, reflecting the influence of meteorological parameters to pandemic (Oliveiros et al., 2020; C. Wang et al., 2020; M. Wang et al., 2020). Though few studies have correlated the pandemic spread and mortality to meteorological parameters, its relation to the COVID 19 in the global scale still needs to be authenticated. Earlier studies have also related long-term climatic variation to the outbreak of the virus observed in Europe and USA to that of the West Nile virus (Epstein, 2001). Severe acute respiratory syndrome (SARS) was also considered to be significantly influenced by the climatic factors. The SARS-CoV virus was primarily transport to human by biological contact, but other meteorological factors like wind, humidity, and optimal temperature range influence the spread (Yuan et al., 2006). There is a strong positive correlation observed between mortality rate due to the virus and climatic variables (Bull, 1980) and the correlation of viral spread to meteorological parameters (viz. humidity, population density, and temperature) confirms this statement (Dalziel et al., 2018).

Apart from transmission of virus, the survival destination and propagation of virus is governed by meteorological parameters (Zhu and Xie, 2020). A temperature < 3°C had a possible positive relationship to infected cases in China, and similar observation on the role of temperature was also reported in Indonesia (Toepu et al., 2020). The
mortality rate and daily infection was also studied by Ma et al (2020). A positive relationship between temperature, humidity, and death cases was studied by Chen et al (2020). The wind speed, temperature, and humidity were also referred as key factors controlling the daily infection rate (Wang et al., 2020b). But most of the studies have proved that temperature plays a crucial role in the transmission of virus.

It was found that the COVID-19 transmission was significantly reduced (Syed Emdadul and Rahman, 2020) at high temperature. It was also reported that cold climate with less humidity (i.e. 20% to 25%) in most of the cities of Brazil, promotes the virus spread and other parameters like visibility, wind speed, and humidity are influencing the sustainability of the viruses. (Biktasheva, 2020) The regions which is in the range of absolute humidity from 3 g/m$^3$ to 10 g/m$^3$ were identified with confirmed cases of about 73.8%. COVID-19 virus seems to spread towards greater latitudes. It was identified that in the ambient environment, the concentration of COVID-19 virus increase at an optimal climate zone (Huang et al., 2020). The greater temperature, efficient ventilation, and air pressure reduces the transmissibility of COVID-19 whereas it can be increased with the greater ambient concentration (Shaowei et al., 2020).

Regardless of improved socioeconomic circumstances, as compared to warmer climatic countries, the COVID-19 virus is spreading rapidly in moderate to lesser temperate regions (Muhammad et al., 2020). Thus, Brazil is becoming the world’s new epicenter for COVID-19 (Ribeiro, et al., 2020) and the spread is homogeneous throughout the country. Thus, implementation of conventional control measure is needed as soon as possible. The COVID-19 pandemic has brought improved environmental eminence in countries, such as China, the United States, Italy, and Spain (Mohammad et al., 2020). These countries (Table 18.1) were severely suffering from COVID-19 transmission and governments have taken various measures to reduce the pollution and retain the quality of the environment.

In Russia, few research works related to COVID 19 have already been carried out. According to the reports, SARS-CoV-2 can be transmitted in many ways, with the main route of transmission being through contact with infected individuals (e.g., through secretions, especially droplets). There were more than 21 million laboratories-confirmed cases of CoV-2 infection as of August 15, 2020, and more than 7,50,000 deaths have been reported (Logunov et al., 2020). It was emphasized that each government has taken the important preventive measures, which shows that strict control can significantly reduce COVID-19 spread (Wang et al., 2020). However, if strict controls are implemented on population movement and clustering, the actual case counts might deviate from the predicted values (Chen et al., 2020). A better understanding of climate predictor ties and climatologically suitable areas related to COVID-19 transmission would help to develop a climate-based early warning system to allow rapid response to the increasing COVID-19 cases and deaths. Improved understanding of these relationships is critical to control rapidly growing cases and deaths through better climate-responsive interventions, a fundamental element for controlling and preventing the COVID-19 pandemic (Pramanik et al., 2020). Although few research works related to COVID 19 have been carried out in Russia, the meteorological analysis is not deeply considered.

Several studies have reported direct human to human transmission of this virus through contact or secondary transmission through aerolization (Chan et al., 2020; Li et al., 2020; Wang et al., 2020a). Considering this fact community interaction and social distancing are followed as the key factors to control the pandemic spread (Lai et al., 2020). But there are limited studies regarding secondary sources of Covid-19 (viz. wastewater, meteorological parameters, etc.), its transmission, and measures taken to control the transmission. Thus, the study aims to understand the influence of meteorological parameters, as a secondary source in transmission of this novel virus.

The current research is mainly concerned with the total number of cases of infection rather than the mortality rate, as the mortality rate depends on the community’s immune system to the virus. Hence, the current study may help raise public and policy-makers’ concerns about the COVID-19 pandemic in the second wave.

### 18.2 Study area

Russia, the world’s largest land area, has continental climate. European Russia has a warm continental climate like the southern parts of Siberia and the Far East. Northern Siberia and Cold’s Northern Pole are subarctic, with winters being severely cold. The Arctic Ocean islands show a polar atmosphere. (Weather Atlas) A small portion along the coast of the Black Sea has a humid subtropical climate, while the area along the coast of the Caspian Sea and southernmost Siberia experiences a semi-arid climate.

Russia is situated in Eastern Europe and North Asia, and shares borders 16 countries. The atmosphere is mainly influenced by high latitudes, air masses from the Arctic and Atlantic Oceans and proximity to large water bodies. In the north, Russia has a largely forested region, with a tundra zone along the north coast. The rest of the country consists mainly of large plains in the South, with extensive steppe grasslands. The mountain ranges of the Caucasus and Altai rise along the southern frontiers, while the Kamchatka Peninsula volcanoes are situated in eastern Siberia.
TABLE 18.1 Literature on the recent studies on COVID 19 in different parts of the world.

| S.no | Title of the research | Research area | Inference | References |
|------|-----------------------|--------------|-----------|------------|
| 1.   | Assessing the relationship between ground levels of ozone (O3) and nitrogen dioxide (NO2) with coronavirus (COVID-19) | Milan, Italy | The distribution of airborne bio aerosols can be attributed to positive correlations of ambient ozone levels and negative correlations of NO2, with increased rates of COVID19 infections (Total number, Daily New positive and Total Deaths cases). The results show a positive correlation with air temperature and relative humidity and negative with respect to precipitation. | Maria A. et al., 2020 |
| 2.   | Association between temperature, humidity, and COVID-19 outbreaks in Bangladesh | Bangladesh | COVID-19 peak spread happened at an average temperature of 26°C. Under a linear regression framework, high temperatures and high humidity considerably reduced the COVID-19 transmission, respectively. | Syed Emdadul and Rahman, 2020 |
| 3.   | Besides the climate model, other variables driving the COVID-19 spread in Brazil | Brazil | Winter viruses are known to be more stable and spread better in cold and low humidity places (20–50%) than in most Brazilian cities. Indeed, the SARS-CoV-2 is spreading rapidly across the country regardless of weather conditions and Brazil is unfortunately on its way to becoming the world’s new epicentre of the COVID-19 pandemic. | Ribeiro et al., 2020 |
| 4.   | Containing the spread of coronavirus disease 2019 (COVID-19): Meteorological factors and control strategies | Global | Found that elevated temperature mitigates disease transmission. Higher relative humidity promotes COVID-19 transmission when temperature is low but when temperature is high, it tends to reduce transmission. Implementing conventional control measures can dramatically slow the disease’s spread. | Jun et al., 2020 |
| 5.   | COVID-19 and the environment: A critical review and research agenda | Global | The COVID-19 pandemic has resulted in improved quality for the environment. In countries with severe COVID-19 transmission such as China, the USA, Italy and Spain, actions taken by governments around the world have led to significant reductions in environmental pollution and improvements in environmental quality. | Mohammad et al., 2020 |
| 6.   | Effect of lockdown due to SARS COVID-19 on aerosol optical depth (AOD) | urban and mining regions in India | The coal mining regions of India’s various coalfields showed a positive anomaly (~11 to 40%) due to ongoing mining operations during the lockdown periods. In short, the results of the study indicated a huge drop in the level of AOD over Indian Territory during lockdown periods. The pandemic is expected to influence some policy decisions aimed at proposing methods for controlling air pollution. Lockdown events may possibly play a crucial role in future as a potential solution for reducing air pollution. | Ranjan et al., 2020 |
| 7.   | Correlation between weather and Covid-19 pandemic | Jakarta, Indonesia | Meteorological factors such as humidity, visibility and wind speed can affect the stability of the environment or the viability of the viruses. In addition, absolute air temperature and humidity were indicated to significantly affect the transmission of COVID 19. | Ramadhan Tosepu et al., 2020 |
| 8.   | Impact of city lockdown on the air quality of COVID-19-hit Wuhan city | Wuhan city | O3 pollution was highly negatively correlated with the concentration of NO2 after the lockdown, and the increase in radiation caused by the reduction of PM2.5 was not the principal reason for the increase in O3. This indicates that secondary pollutant generation is influenced by multiple factors and is not governed solely by emission reductions. | Xinbo Lian et al., 2020 |
| 9.   | Impact of Covid-19 lockdown on PM10, SO2 and NO2 concentrations Salé City (Morocco) | Salé City (Morocco) | The difference for PM10, SO2 and NO2 between the concentrations recorded before and during the lockdown period was 78%, 49% and 96% respectively. The levels of PM10 were much less than those of NO2. The three-dimensional air mass reverse trajectories, using the HYSPLIT model, demonstrated the benefits of PM10 local lockdown-related emission reductions were overwhelmed by the long-range contribution. | Anas et al., 2020 |
| 10.  | Influence of Chinese New Year overlapping COVID-19 lockdown on HONO sources Shijiazhuang | Shijiazhuang | The natural HONO sources were dominated by heterogeneous reaction of NO to the ground surface, followed by Heterogeneous aerosol surface reaction, vehicle emission, NO/ OH reaction and soil emission on pollution days throughout the observation. | Yongchun Liu et al., 2020 |

3. Air and water quality: Monitoring, fate, transport, and drivers of socio-environmental change
TABLE 18.1 (Cont’d)

| S.no | Title of the research                                                                 | Research area | Inference                                                                                                                                                                                                 | References                     |
|------|----------------------------------------------------------------------------------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 11.  | Optimal temperature zone for the dispersal of COVID-19                                 | Globally      | Around 73.8% of confirmed cases were concentrated in regions with absolute humidity between 3 g/m$^3$ and 10 g/m$^3$. SARS-CoV-2 seems to spread towards higher latitudes. The findings suggest there is an optimal climate zone in which the concentration of SARS-CoV-2 in the ambient environment increases markedly. | Zhongwei Huang et al., 2020     |
| 12.  | Possible environmental effects on the spread of COVID-19                                | China         | Statistically significant in several cities was the effect of AQI on confirmed cases associated with an increase in each unit of AQI. The effect of the AQI upon the Confirmed cases could be higher in the temperature range of 10°C / 20°C than in other temperature ranges, whereas the RR of COVID-19 transmission associated with AQI was higher in the relative humidity range (RH) of 10% / RH b 20%. | Hao Xu et al., 2020             |
| 13.  | Reductions immortality resulting from reduced air pollution levels due to COVID-19 mitigation measures | Globally      | Reduction of PM$_{2.5}$ during the mitigation period reduced total and cause-specific deaths related to air pollution. In urban areas of California, an estimated 483 (95 per cent CI: 307, 665) PM$_{2.5}$-related deaths were avoided. The findings have implications for the effects of mitigation efforts and provide insight into the possible mortality reductions from reduced levels of air pollution. | Ji-Young et al., 2020          |
| 14.  | Region-specific air pollutants and meteorological parameters influence COVID-19: A study from mainland China | China         | The study focuses on the impact of the meteorological parameters and the air pollution on COVID | Shaowei et al., 2020            |
| 15.  | Role of a habitat’s air humidity in COVID-19 mortality                                 | German federal states | Habitat’s air humidity is negatively correlated with COVID-19 morbidity and mortality and supports this hypothesis on the example data from German federal states. | Irina V. Biktsheva. 2020        |
| 16.  | SARS-CoV-2 pandemic lockdown: Effects on air quality in the industrialized             | Gujarat state of India | Power plant operation may have resulted in less CO reduction (3–55 percent) and decreased NO emissions have helped to improve O$_3$ content (16–48 percent). In the first four months of 2020, they observed an overall improvement of 58% in AQI compared to the same interval of the previous year. | Selvam et al., 2020             |
| 17.  | Significant changes in the chemical compositions and sources of PM$_{2.5}$ in Wuhan since the city lockdown as COVID-19 | Wuhan         | Source contributions of PM$_{15}$ transported from potential geographic regions showed reductions ranging from 0.22 to 4.36 μg m$^{-3}$ with mean values. However, increased contributions have been observed from firework burning, secondary inorganic aerosol, road dust, and vehicle emissions from trans boundary transport. This study highlighted the complex and nonlinear response of chemical compositions and PM$_{15}$ sources to control measures against air pollution, suggesting the importance of regional-joint control. | Huang Zheng et al., 2020        |
| 18.  | Spatial and temporal differentiation of COVID-19 epidemic spread in mainland China and its influencing factors | China         | In terms of temporal change, the epidemic quickly spread to most regions from January 24 to February 6. The epidemic Spread rates slowed from 6 February to 20 February, though the epidemic in some cities deteriorated sharply. | Zhixiang Xie. 2020             |
| 19.  | The effects of regional climatic condition on the spread of COVID-19                   | Globally      | Most countries with the relatively lower temperature region exhibit a rapid increase in COVID-19 cases, despite better socio-economic conditions, than countries in warmer climatic regions. | Muhammad et al., 2020          |
| 20.  | The temperature and regional climate effects on communitarian COVID-19 contagion      | Mexico        | Meteorological factors influenced the trend on regional outbreaks in the states of Mexico likely due to host predisposition and susceptibility during the cold winter season. In Mexico, the climate characteristics played a crucial role in the phase 1, local infection being the more vulnerable temperate regions than the dry or tropical areas. | Fabiola, 2020                  |
The Ural Mountains run north-south separating Russia from Europe and Asia. The broad 22,991-mile coastline stretches along the Arctic and Pacific Oceans and at least a dozen lakes. The Volga is Russia’s longest river, and Europe’s longest. The Rivers Ob and Yenisei are among the longest in the world. Lake Baikal is the largest freshwater lake in the world, which provides a quarter of the world’s liquid freshwater along with big lakes, such as Ladoga and Onega.

Mount Elbrus is Russia’s highest peak (5642 m amsl). Much of Russia has only two seasons, summer and winter. Summers range from mild in the north coast to hot in the south and in the interior. Frequent thunderstorms and rain are characteristics of the north-western area during summer season. The area has hot and sunny summers near the Caspian and Black Seas. The Sukhoviev are warm winds which blow in summer from Central Asia. In northern Russia and Siberia, winters are extremely intense, with average low temperatures sometimes dropping below an astounding −40°C (−40°F). In the winter, much of the precipitation falls like snow.

Russia’s southern parts have moderate winters, yet the temperatures during January remain below freezing. During winter days, the Arctic coast and the northern islands remain below freezing. Cold air carries permafrost in much of Siberia and Yakutia, with mostly grey skies. In summary, the Asian Monsoon reaches Russia’s southeast regions. In most areas, Russia’s average annual rainfall ranges from 381 mm to 762 mm, but predominantly in the form of snow. In the East, the Kamchatka Peninsula and the Kuril Islands receive ample rainfall from 1016 mm to 1524 mm per year. Most of the tundra region gets heavy snowfall and is under permafrost protection.

The extremely variable annual sunshine in Russia and ranges from 1200 hours in the extreme north to 2400 hours in the warm south. From November to January the northern coast of the Arctic Ocean does not even see the sunrise. But for the brief summer months, the seawater stays frozen in Tiksi. Russia’s highest recorded temperature at Kalmikia is 45.4°C (113.7°F), set in July 2010. The lowest recorded temperature is −71.2°C (−96.2°F), set at Oymyakon on 26 January 1926 (Jeff Masters on Winter, 2010).

The peninsula of Kamchatka and the Kuril Islands have a tradition of volcanic eruptions and are vulnerable to seismic disorders. Mt. Kliuchevskoi erupted in 2007 and 2010 and is one of the regions with active volcanoes. Siberia’s vulnerable to summer spring flooding and forest fires. Far East and central Russia are also vulnerable to flooding and heatwaves. In 2010, freezing rain brought Moscow to a standstill, with power outages, flight cancellations, and dangerous roads. In the northern territories, blizzards are common in the winter, bringing heavy snowfall and a total loss of visibility.

### 18.3 Methodology

For the current research, we have considered the meteorological parameters such as temperature, relative humidity, wind speed, dew point, and precipitation. The above data for Russia was gathered from the NASA website (https://power.larc.nasa.gov) for the period January 31st, 2020 to August 23rd, 2020. Since the data were available for specific locations, an average of these daily parameters from various stations covering all directions of Russia (North, South, East, and West) during the study period was considered to reflect the country’s daily meteorological condition. At the same time, the COVID-19 data was obtained from www.worldometers.com for Russia’s respective dates.

The following were the cities identified representing the entire country (Fig. 18.1). The locations selected for study in Southern Russia are—Elista, Derbent, Krasnodar, Makhachkala, Mineralnye Vody, Rostov-on-Don; Northern Russia—Yakutsk, Murmansk, Petropavlovsk-Kamchatsky, Norilsk, Noyabrsk, Novy Urengoi, and Magadan; Eastern Russia—Vladivostok, Khabarovsk, Ulan-Ude, Chita, Komsomolsk-on-Amur, Blagoveshchensk, Yakutsk, Petropavlovsk-Kamchatsky; and Western Russia—Moscow, St. Petersburg, Novosibirsk, Yekaterinburg, Nizhny Novgorod, Kazan, Chelyabinsk, Omsk.

Correlation analysis and factor analysis were used to analyze the data. Pearson correlation has been adopted for COVID-19 and meteorological parameters and those with values greater than 0.50–0.75 have been considered to show strong correlation and those above 0.75–1.00 have excellent correlation (Vasanthavigar et al., 2012). In order to determine the factors representing the COVID-19 variables and meteorological parameters, main component analysis was also performed for the selected results. Using Varimax Rotation and Kaiser Normalisation, Eigen values greater than one were extracted (Thivya et al., 2015).

### 18.4 Results and discussion

The information on the number of COVID-19 cases have been acquired from the media reports acquired through the Russia Government websites. The information on the disease was gathered from the first day of COVID-19 positive confirmation, i.e. January 31st, 2020 to August 23rd, 2020. Apart from the data on the number of COVID-19
cases, accessible data on gender, age, and travel history was additionally acquired from the media reports delivered by the Russian government. The distributed reports did not contain any close to home recognizing data of the patients. In Russia, 966189 peoples were notified COVID-19 positive in 207 days through various sources such as travel and contact with the infected people. The outbreak was spread across the country, of which average daily new cases 0.480% (n = 4645) and the average daily death cases of 0.0082% (n= 80) was recorded. Descriptive overview of the weather data indicates (Table 18.2) the temperature ranges from 17.59°F to 73.08°F with an average of 49.83°F during the study period. In addition to that, 0.17 mm was the least recorded rainfall, while 9.89 mm was the highest precipitation. In the selected period, the range of absolute humidity was 50.21% to 82.64% with the average of 68.57%. The least wind speed recorded as 4.9 m/h and increased to 12.35 m/h.

It is observed that COVID-19 cases increased from March 31st, 2020 and immediately after the implementation of lockdown (Fig. 18.2). During the study period, the highest number of new cases (11656) was noted on May 11th, 2020. The lockdown was implemented on March 27th, 2020 and lifted on May 11th, 2020. The highest number of daily deaths were noticed on May 29th with 232 cases. It was also observed that the daily death cases increased exponentially

| TABLE 18.2 | Statistical summary of meteorological parameters and COVID cases in Russia. |
|-------------|--------------------------------------------------------------------------------|
| Parameters  | Minimum | Maximum | Average | Std Dev |
| Total Cases | 2       | 966189  | 343582  | 347042  |
| Daily new Cases | 0    | 11656  | 4645   | 3642    |
| Active Cases | 0       | 246098  | 119973  | 99858   |
| Total Deaths | 0       | 16568  | 5089   | 5719    |
| Daily Deaths | 0       | 232    | 80     | 69      |
| Total Recovered | 0   | 777960 | 218519 | 265804  |
| Temperature (°F) | 17.59 | 73.08 | 49.83 | 16.05 |
| Dew (°F)     | 12.13   | 60.36  | 38.67   | 14.66   |
| Precipitation (mm) | 0.17 | 9.89  | 2.22   | 1.59    |
| Humidity (%) | 50.21   | 82.64  | 68.57   | 6.2     |
| Wind (m/h)   | 4.9     | 12.35  | 8.08    | 1.49    |

FIG. 18.1 Meteorological stations considered for study across the country.
during the lock down period and stabilized after the lockdown period. The total recovered cases increased day by day during the study period. The total number of recovered cases were 777,960 as on August 25th. Overall, it was observed that the number of daily new cases, daily deaths, and the total recovery had a similar decreasing and stable trend after the lock down period. It indicates the effectiveness of movement controls, which had restricted the pandemic spread further.

The temperature varies from 17.59°F to 73.0°F with an average of 49.7°F. The highest temperature (73.08°F) was recorded on July 7th, 2020 and lowest temperature (17.59°F) was noted on February 8th, 2020. The maximum dew (60.35°F) was noted on July 8th, 2020 and the minimum dew (12.13°F) was noted on February 9th, 2020. The precipitation ranges between 0.169 mm and 9.894 mm with an average of 2.25 mm. Whereas humidity ranges from 50.21% to 82.64% with an average of 68.55%. The highest humidity values were observed on January 31st, 2020 and the lowest value was observed on April 8th, 2020. Likewise, the wind speed was recorded to range from 4.9 m/h to 12.35 m/h with an average of 8.08 m/h.

From the results, the temperature and dew were observed to have an increasing trend during the study period. When the temperature and dew point increases, the COVID-19 death cases also increased (Fig. 18.3). In other hand, the humidity slightly decreased during the increase of death cases. It is interesting to observe the increase of temperature with the increase of daily death rate at the beginning of the release of lock down period. Later, the temperature was stabilized with the decreasing of death cases. It indicates that, temperature is the key parameters and controls the pandemic spread in comparison to other parameters. Precipitation and wind speed don’t show much variations throughout the study period. The humidity trend varied from high to low during the study period. Overall, the death cases slowly decreased after the post lockdown period.

18.4.1 Statistical analysis

The correlation coefficients between the variables of COVID-19 and the meteorological parameters show that the temperature is positively correlated with total cases, daily new cases, active cases, total deaths, daily deaths, and total recovery (Table 18.3). Similarly, dew point has a good relationship with total cases, daily new cases, active cases, total deaths, daily deaths, total recovery, and temperature. Humidity was negatively correlated with daily new cases, active cases, and daily deaths, except for total cases, total deaths, and total recovery. Wind speed shows a negative correlation with all the COVID-19 variables. The results show that the effects of temperature and dew play an important role in COVID-19 cases, with less influence on precipitation and humidity.
In the present study, the total variance, component, and rotated component matrix are shown in Table 18.4 and the cross plot between each factor is depicted in Fig. 18.4. The principal component analysis (PCA) shows that a total of two factors were extracted based on Eigenvalues (Table 18.4). Factor 1 was loaded with total cases, active cases, total deaths, daily deaths, total recovery, temperature, dew, precipitation, and negative loading of wind speed (Fig. 18.3). Factor 2 was represented by daily new cases, active cases, daily deaths, temperature. It is interesting to observe that the negative relationship of humidity with the COVID cases, which indicate the decreasing humidity increase the spread. Overall, factor 1 and 2 clearly identified that, temperature, dew point and humidity are the most controlling key parameters for the pandemic spread.

**TABLE 18.3** Pearson’s correlation analysis of COVID-19 cases and meteorological parameters.

|     | TC   | DNC  | AC   | TD   | DD   | TR   | Temp | Dew   | Precip | Humid | Wind |
|-----|------|------|------|------|------|------|------|-------|--------|-------|------|
| TC  | 1.00 |      |      |      |      |      |      |       |        |       |      |
| DNC | 0.53 | 1.00 |      |      |      |      |      |       |        |       |      |
| AC  | 0.82 | 0.87 | 1.00 |      |      |      |      |       |        |       |      |
| TD  | 0.99 | 0.42 | 0.73 | 1.00 |      |      |      |       |        |       |      |
| DD  | 0.75 | 0.82 | 0.93 | 0.66 | 1.00 |      |      |       |        |       |      |
| TR  | 0.98 | 0.35 | 0.68 | 1.00 | 0.62 | 1.00 |      |       |        |       |      |
| Temp| 0.90 | 0.75 | 0.92 | 0.85 | 0.87 | 0.81 | 1.00 |       |        |       |      |
| Dew | 0.92 | 0.72 | 0.92 | 0.87 | 0.88 | 0.83 | 0.98 | 1.00  |        |       |      |
| Precip| 0.44 | 0.40 | 0.45 | 0.42 | 0.45 | 0.40 | 0.43 | 0.49  | 1.00   |       |      |
| Humid| 0.02 | -0.26 | -0.11 | 0.05 | -0.08 | 0.07 | -0.21 | -0.02 | 0.25  | 1.00  |      |
| Wind| -0.50 | -0.26 | -0.43 | -0.49 | -0.38 | -0.48 | -0.44 | -0.48 | -0.13 | -0.25 | 1.00 |

TC-Total cases; DNC-Daily new cases, AC-Active Case; TD-Total deaths; DD-Daily deaths, TR-Total Recover, Temp-Temperature; Precip-Precipitation; Humid-Humidity.
TABLE 18.4  Principal component analysis (PCA) of COVID-19 cases and meteorological parameters.

| Parameters | F1  | F2  |
|------------|-----|-----|
| TC         | 0.90| 0.36|
| DNC        | 0.35| 0.82|
| AC         | 0.67| 0.69|
| TD         | 0.90| 0.26|
| DD         | 0.63| 0.67|
| TR         | 0.90| 0.21|
| Temp       | 0.73| 0.66|
| Dew        | 0.82| 0.54|
| Precip     | 0.54| 0.12|
| Humid      | 0.42| -0.72|
| Wind       | -0.67| 0.07|
| TC         | 0.73| 0.66|
| DNC        | 0.35| 0.82|
| AC         | 0.67| 0.69|
| TD         | 0.90| 0.26|
| DD         | 0.63| 0.67|
| TR         | 0.90| 0.21|
| Temp       | 0.73| 0.66|
| Dew        | 0.82| 0.54|
| Precip     | 0.54| 0.12|
| Humid      | 0.42| -0.72|
| Wind       | -0.67| 0.07|
| Eigenvalues|  5.52| 3.10|
| % of Variance  | 50.16  | 28.16|
| Cumulative % | 50.16  | 78.31|

TC-Total cases; DNC-Daily new cases, AC-Active Case; TD-Total deaths; DD-Daily deaths, TR-Total Recover, Temp-Temperature; Precip-Precipitation; Humid-Humidity.

FIG. 18.4  Cross plot between the two factors extracted by PCA, by adopting Varimax rotation.

18.5 Conclusion

This chapter investigates the meteorological influence on the COVID-19 pandemic spread in Russia. A total of seven months of data on COVID cases and meteorological parameters were analyzed. Statistical tool, such as correlation analysis and factor analysis, were used to further infer the results. COVID cases (daily new cases and daily deaths) sharply increased during the lockdown period, and gradually decreased during post lockdown period. Hence it was inferred that the effectiveness of movement control during the lock down period further restrict the spread in
the post lock down period. Increased temperature and dew point increase the death rates particularly during the lock down period. It was also observed that slight decrease in the temperature decreases the death rates during post lock down period. There was a negative relationship between humidity and death rates (i.e., decrease humidity with increase death rates). The outcome of this research will give the knowledge on the meteorological controls on pandemic spread in Russia. This research will also helpful for the policy makers to create a suitable environment in terms of weather condition for the future outbreak of SARS-CoV-2 virus.

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