COVID-19 affects social activities in Indonesia

Nina Yulianti, Kitso Kusin (Univ. Palangka Raya), Masafumi Ohashi (Kagoshima Univ.), Masahiro Kawasaki, Manabu D. Yamanaka Osamu Kozan (Res. Inst. Humanity & Nature) and Daisuke Naito (Kyoto Univ.)

The nitrogen dioxide (NO_2) pollution over a region is linked to traffic, industrial and agricultural activities since NO_2 is released by power plants, industrial facilities, motor vehicles and biomass burning. The column density of NO_2 measured by satellite is a first-level indicator of resident activity in the region. For example, recent Tropomi instrument on board the Copernicus Sentinel-5P satellite has shown a decline of air pollution over northern Italy and Chine coinciding with its nationwide lockdown to prevent the spread of the Coronavirus disease 2019 (COVID-19). The spread led to the dramatic reduction in NO_2 concentrations in all major cities of China between late-January and February 2020. The NO_2 drop in late-January is visible on images of the satellite site, coinciding with the nationwide quarantine.[1]

About the pollution map, GOME-2/SCIAMACHY DOAS nadir data browser shows the reduction of NO_2 concentrations over China and Indonesia between December 2019 and May 2020 in Fig. 1. The eye-inspected data of Indonesia are summarized in Table 1 for the heavily polluted Jakarta and mildly polluted central Sumatra under weak monsoon conditions. In the Jakarta area, the drop is almost 1×10^{16} /cm^2. This amount is five times larger than the increment of NO_2 during the extremely large forest/peatland fire season of Central Kalimantan in the El Niño event year 2015.

The NO_2 drop is also seen in imageries of NASA worldview OMI/Aura. Figure 2 shows about 2E15 /cm^2 difference in Jakarta area of west Java between March 6 and April 20, 2020, which is consistent with the GOME-2 observation.

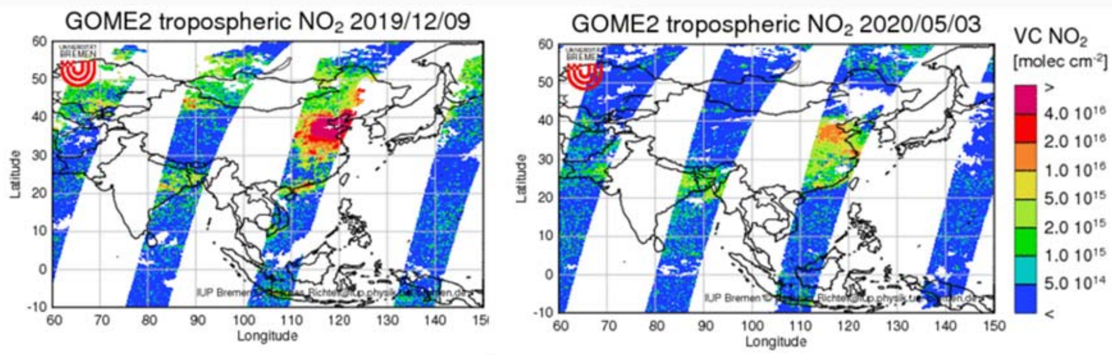

Fig. 1 Nitrogen dioxide NO_2 change observed by GOME-2/SCIAMACHY DOAS nadir before and after COVID-19 in West Java and South Sumatra: December 9 2019 and May 3 2020
Note a weak orange area over Jakarta in the left picture turned to green in the right picture.
Data source: http://www.iup.uni-bremen.de/doas/scia_data_browser.htm

The nation-wide total number of the COVID-19 cases stood 18,010 on May 18, 2020. [2] Positive cases were reported in early-March 2020. Since then, the daily number has increased from 113 on April 2 to 433 on May 1. In Jakarta of Java on May 18 the total number was 6,059 or 33.6% of the nation-wide cases.

Google reported Jakarta people's visits and length of stay at different places change compared to a baseline that is a median value during the 5-week period Jan 3–Feb 6, 2020.[3] Google calculates these changes using the same kind of aggregated and anonymized data used to show popular times for places in Google Maps. The mobility data at workplace started decreasing in early-March reaching 67% in late-March while that in residential increased up to 127%.

Accordingly, the NO_2 concentration in late-April 2020 has dropped down to the average level of South Asian area from the high level of a typical megacity in early-December 2019.

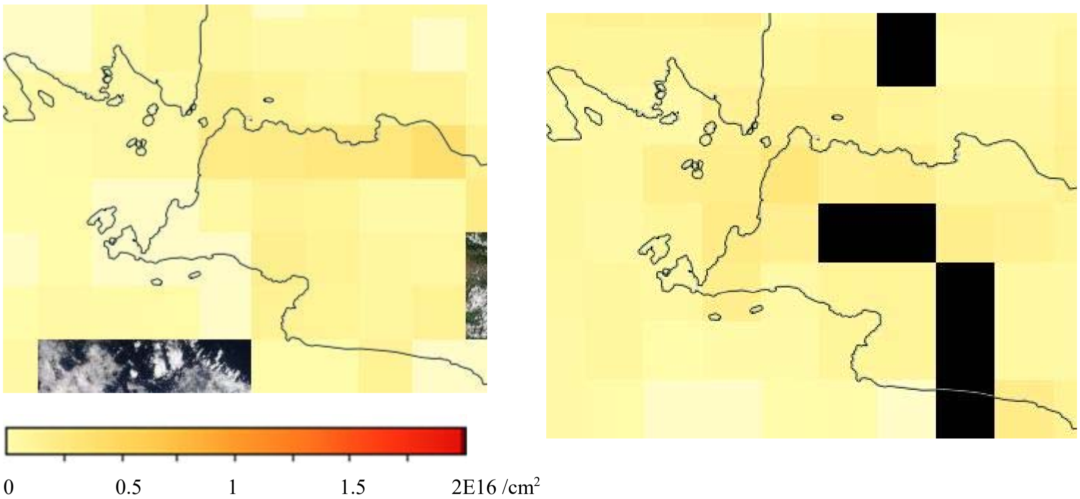

Fig. 2 NO_2 tropospheric columns on (left) March 6 and (right) April 20, 2020 in west Java

Data source: https://worldview.earthdata.nasa.gov/

On the contrary, in Riau of Sumatra the total number of cases is low, 101 (0.6% of nation-wide) on May 18. Hence the NO_2 drop is smaller than in Jakarta, suggesting a smaller effect of COVID-19 on the activity in Sumatra. Google also reported Riau people's mobility change at workplace reaching a rather high value 89% and in residential increasing to 116%. These mobility changes are smaller than those of Jakarta. Note that these social data depend also on Ramadan starting April 23, 2020.

Table 1 Column density of nitrogen dioxide (NO_2) before and after COVID-19

	column density of NO_2 in units of 10^{16} /cm^2	
Date / location	Jakarta, Java	Riau, Sumatra
2019.12.9	1	<0.2> in December
2019.12.14-24	<0.5>	
2020. 4. 4	0.5	<0.1> in April
2020. 4. 4-28	<0.1−0.2>	

Note 1: The first COVID-19 case was reported in early-March.
Note 2: <*x*> is a mean value.
Note 3 The average value of NO_2 in South Asia 2020 is estimated to be 0.2×10^{16} /cm^2 after Ul-Haq et al. Zia ul-Haq, Salman Tariq, Muhammad Ali, *Advances in Meteorology,* 2015, Article ID 959284, http://dx.doi.org/10.1155/2015/959284

Indonesian society consists of some number of large cities and a numerous number of small villages. We have investigated how COVID-19 affects those different types of local societies using the SIR numeric model.[4] This mathematical model is simply described by four differential equations.

$$N = S(t) + I(t) + R(t),$$
$$dS(t)/dt = -\beta I(t)S(t),$$
$$dI(t)/dt = \beta I(t)S(t) - \gamma I(t),$$
$$dR(\mathrm{t})/dt = \gamma I(t),$$

where N is total population, t time delay after the first patient, $I(t)$ infectious, $S(t)$ susceptible, $R(t)$ for recovery/removed, β for an infection rate constant, and γ for a recovery/remove rate constant from infection. For these equations, a basic reproduction number, R_0, is a measure of infection strength, which is given by $R_0 = N\beta/\gamma$.

According to the reported epidemiological statistics of China, Europe and Japan, R_0 are presently estimated to be 5, 2-3 and 1.5, respectively.[5] This number can be reduced to R by a factor of $(1 - c)$ by lifestyle habits including social communication and distancing, washing hands, masks *etc*.,

$$R = R_0(1 - c).$$

With proper prevention of epidemic, R in Japan was reduced to 1.06. Based on information about China, Europe and Japan, we assume in the present model calculation that a) day of double infection is 10 days, b) γ is around 0.055 day^{-1} to calculate $I(t)$ as a function of population, N = 5,000 for a village community and 1,000,000 for a big city. Although small population density in village makes social distancing (*SD*) large, in the following calculation we assume that human relationship among people of the village community under closed circumstances is much closer than in the city, resulting in a larger $(1 - c)$ value. For simplicity purpose, using a doubled R value for village as shown in Table 2, we numerically calculate epidemic curves in Fig. 3. The number of cases in village peaks on 6^{th} day while 45^{th} for city. Almost all residents in the village suffer from COVID-19 within two weeks while less than a half of people are infected in the city with a seven times slower infection speed. People in city have time to prepare against pandemic while village people do not. Since the local community of the village get easily collapsed with chaos spread among residents, a small society should take very quick prevention of epidemic to save its community.

Table 2. Results of epidemic curves of a model calculation for village and city[a)]

	Population N	Area (km^2)	SD[b)] (m)	Reproduction number, R	Infectious function, $I(t)$ max	day of max	total (T)	T/N (%)
Village	5,000	100	140	2.52	1,459	6	4,710	94
City	1,000,000	200	14	1.26	24,078	45	390,582	39

a) day of double infection = 10 day corresponding $N\beta = 0.07\ \mathrm{day}^{-1}$: day of half-recovery = 12 day corresponding $\gamma = 0.055\ \mathrm{day}^{-1}$

b) Social Distance ~ $(\text{population density})^{-1/2} = (\text{Area}/N)^{1/2}$

References

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2. https://covid19.go.id/peta-sebaran
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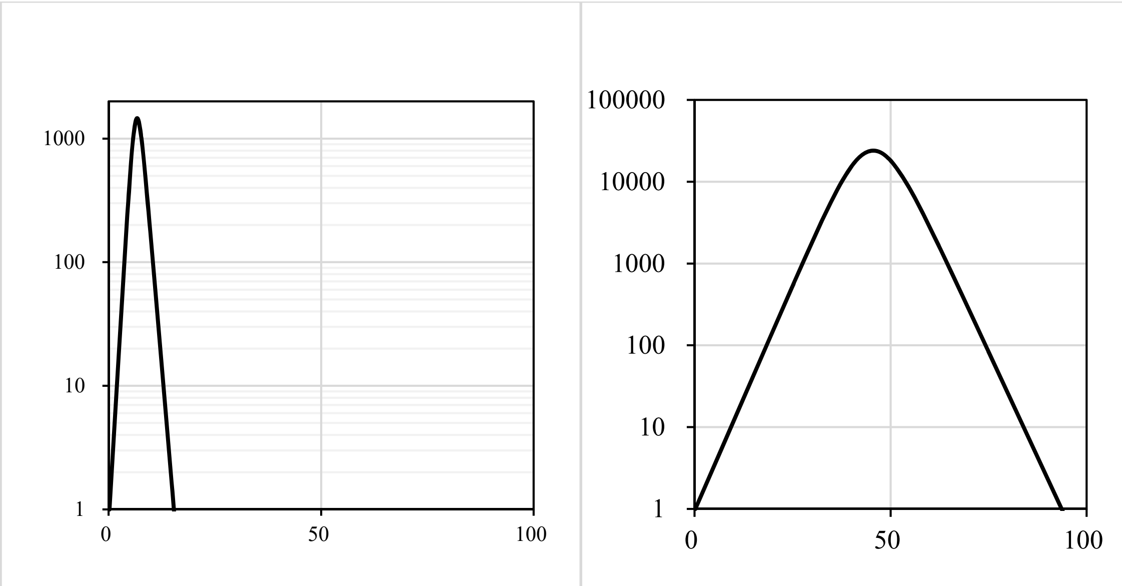

Fig. 3 Calculated epidemic curves in *logarithmic scale* for (left) village $N = 5{,}000$ and (right) city $N = 1{,}000{,}000$ as a function of time delay in units of day. See Table 2 for epidemic parameters.