Incidence of COVID-19: Connections with Air Pollution Exposure

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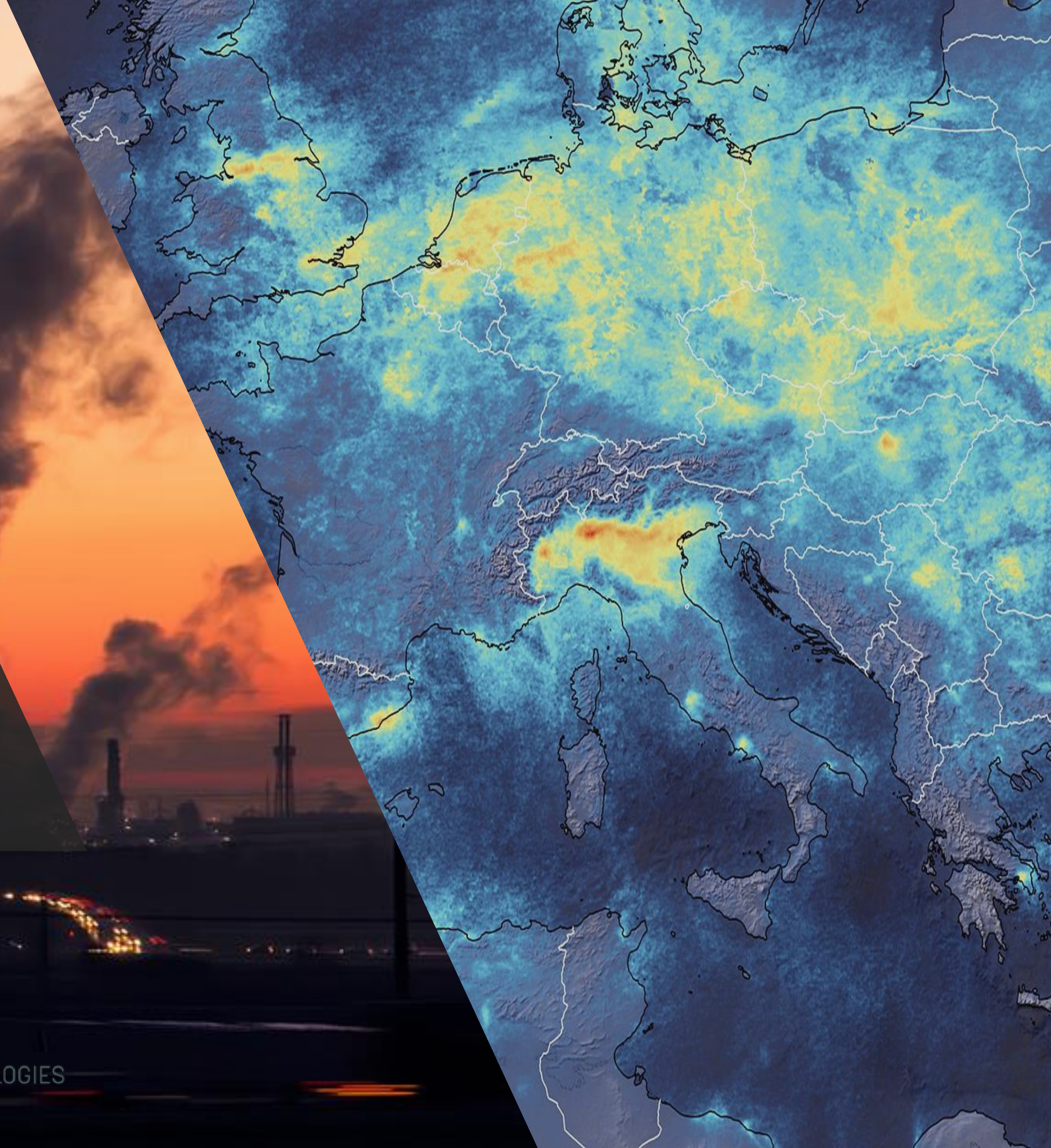
Air Pollution Exposure and COVID-19: Evidence and Unanswered Questions,
June 11, 2020



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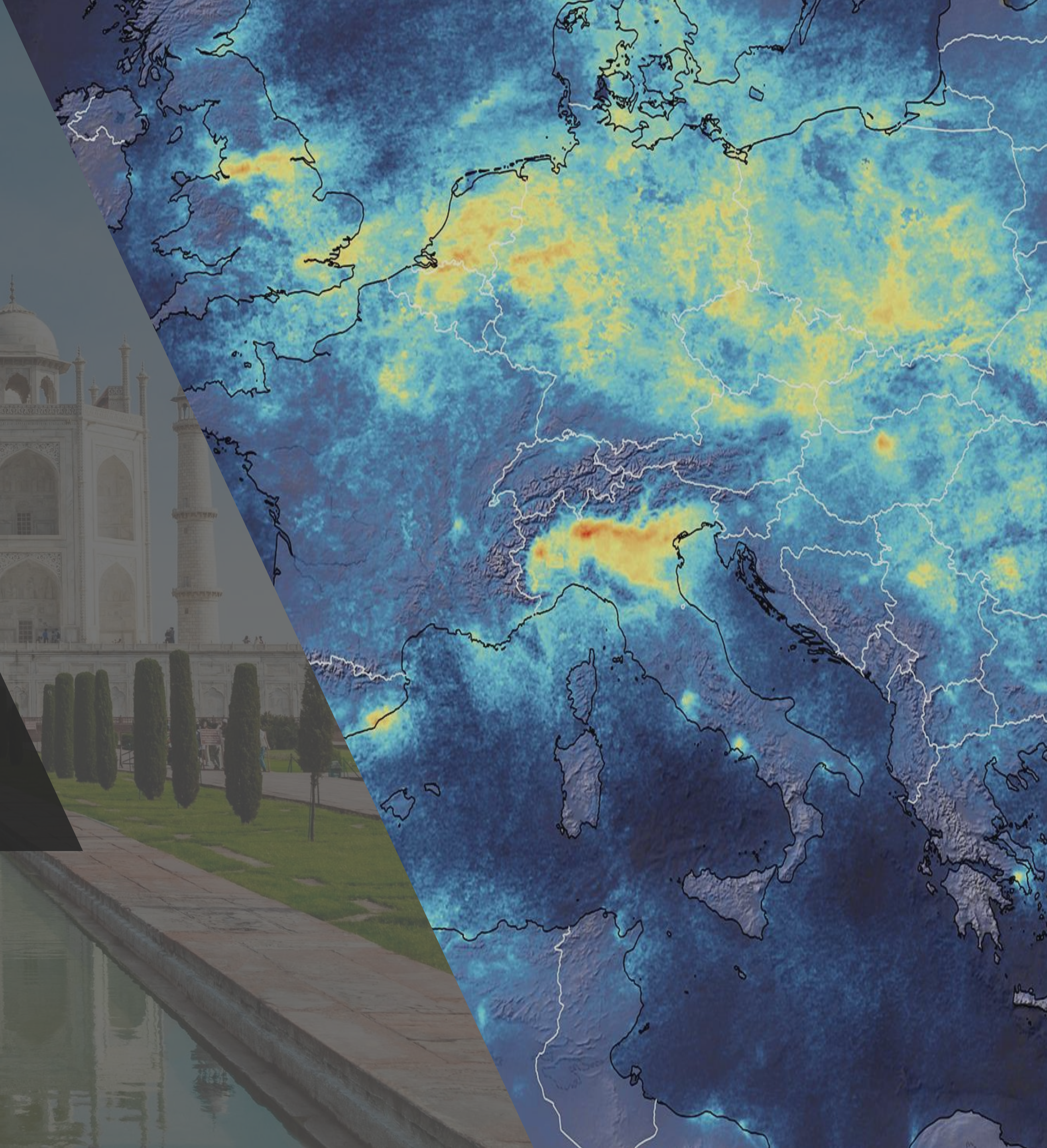
DT4D
DISRUPTIVE TECHNOLOGIES FOR DEVELOPMENT


"Airborne spread of COVID-19 is not believed to be a major driver of transmission based on available evidence."
Report of the WHO-China Joint Mission on COVID-19 (Feb 24, 2020)

“SARS-CoV-2 can survive up to three days on some surfaces and aerosol transmission is plausible since the virus can remain viable and infectious in the air for hours.”

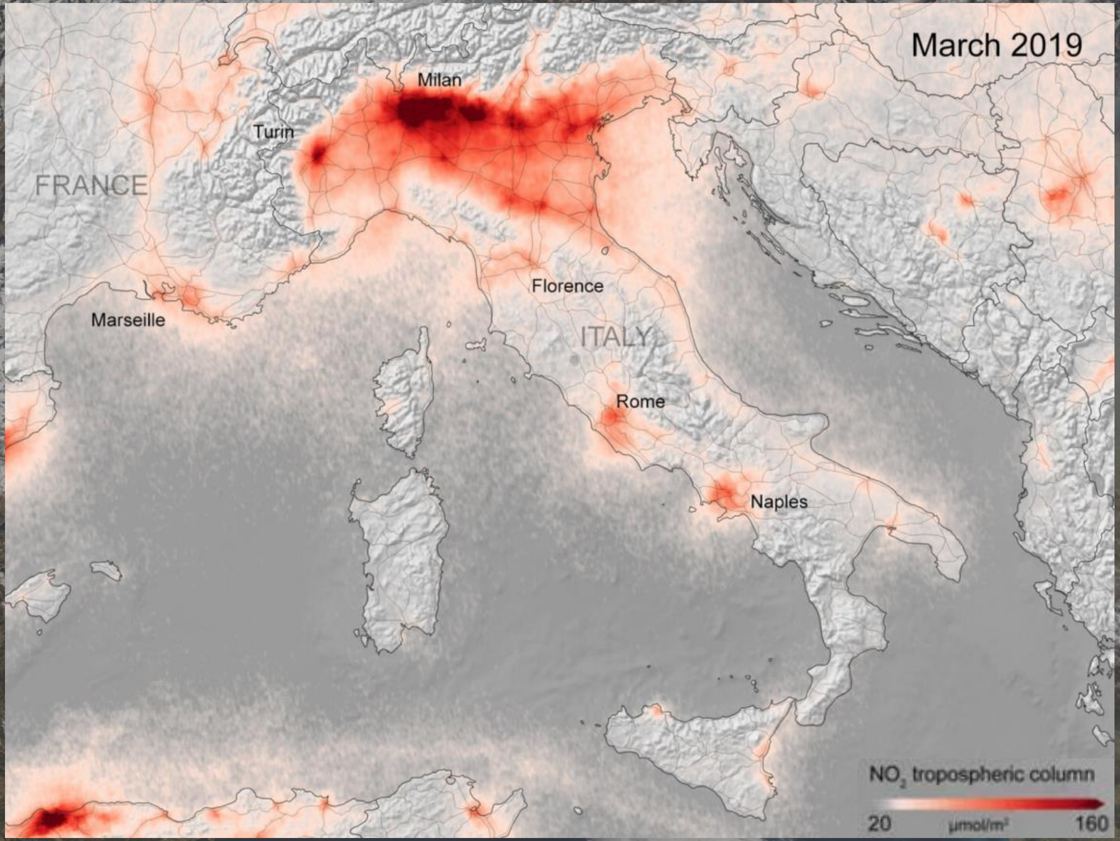
van Dorenmalen et al. (March, 2020)

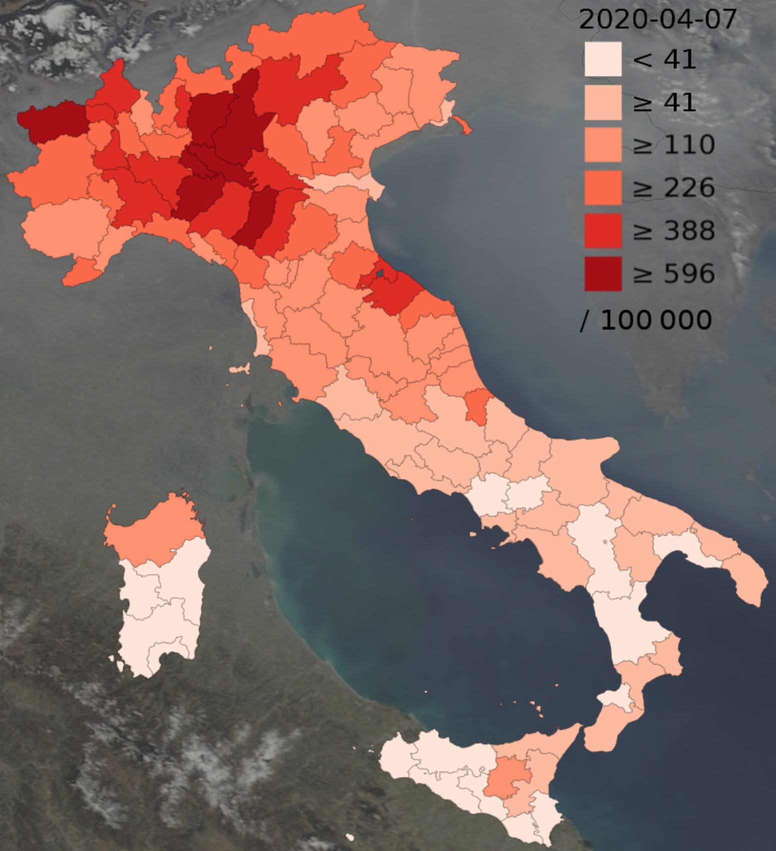


“Airborne transmission of some classes of viruses increases in the presence of fine particulate matter … confirmed covid-19 cases double in areas where PM2.5 increases 20% above WHO guidelines”

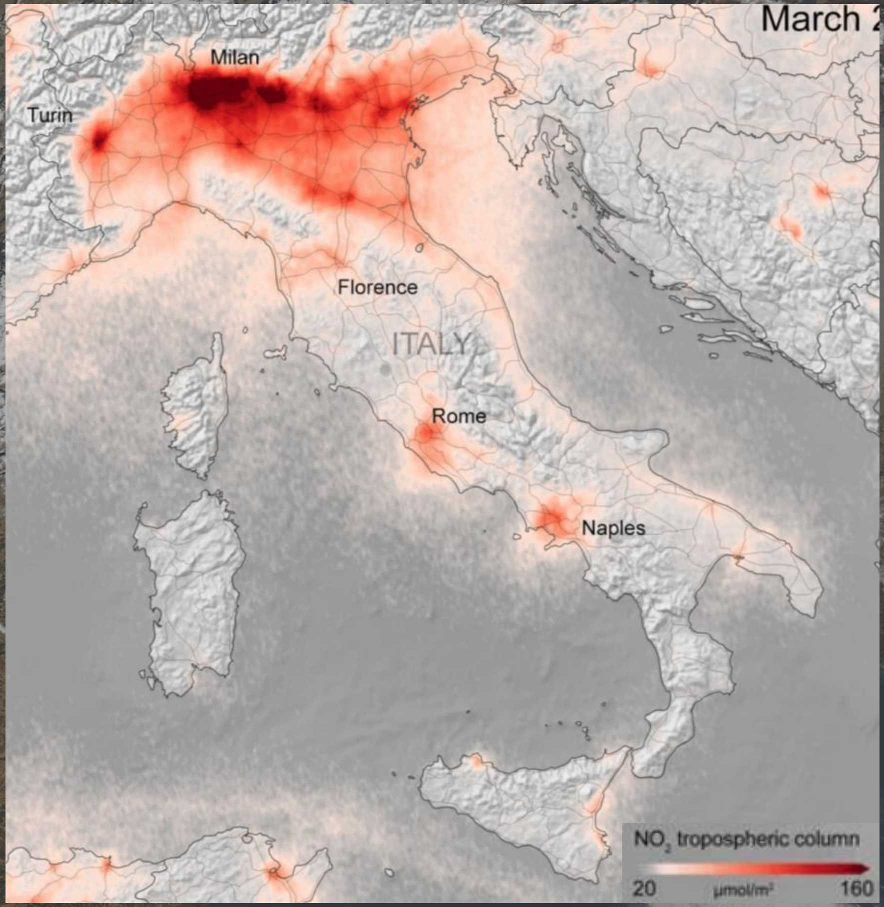
Andrée, B.P.J. (April, 2020)

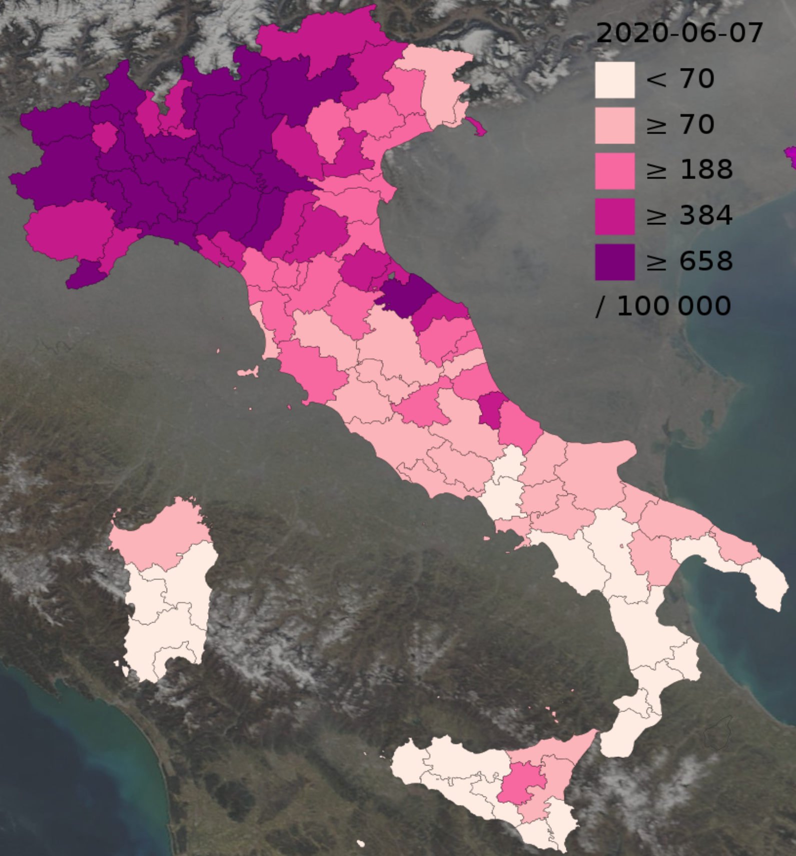

Italy


March 2019
Milan
Turin
FRANCE
Florence
Marseille
ITALY
Rome
Naples
NO_2 tropospheric column
20
µmol/m²
160

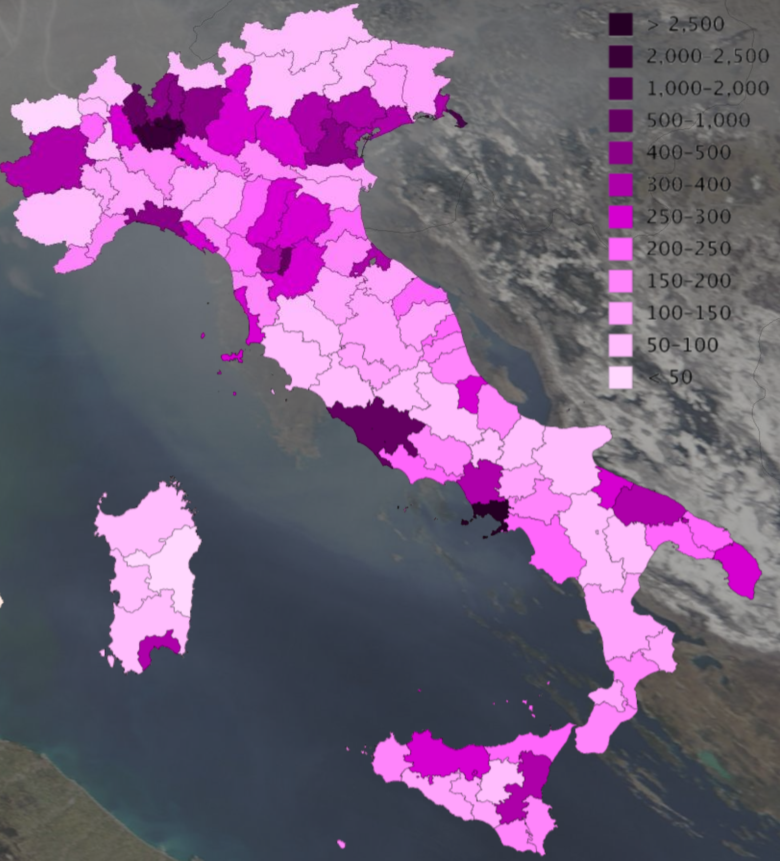

2020-04-07
< 41
≥ 41
≥ 110
≥ 226
≥ 388
≥ 596
/ 100 000

Italy, March



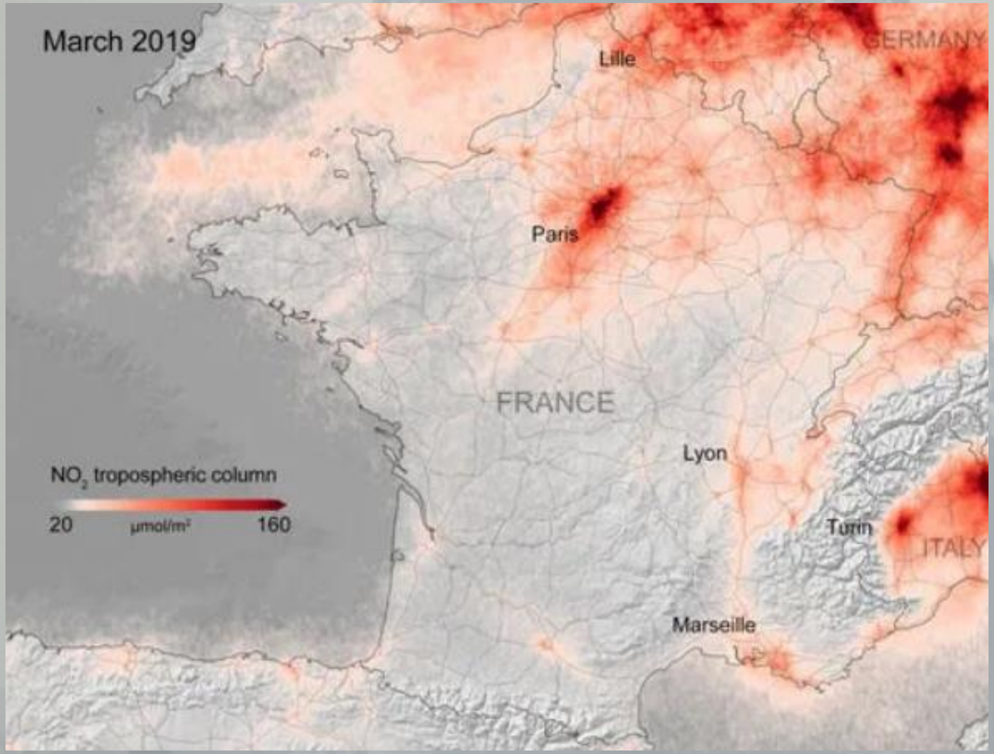


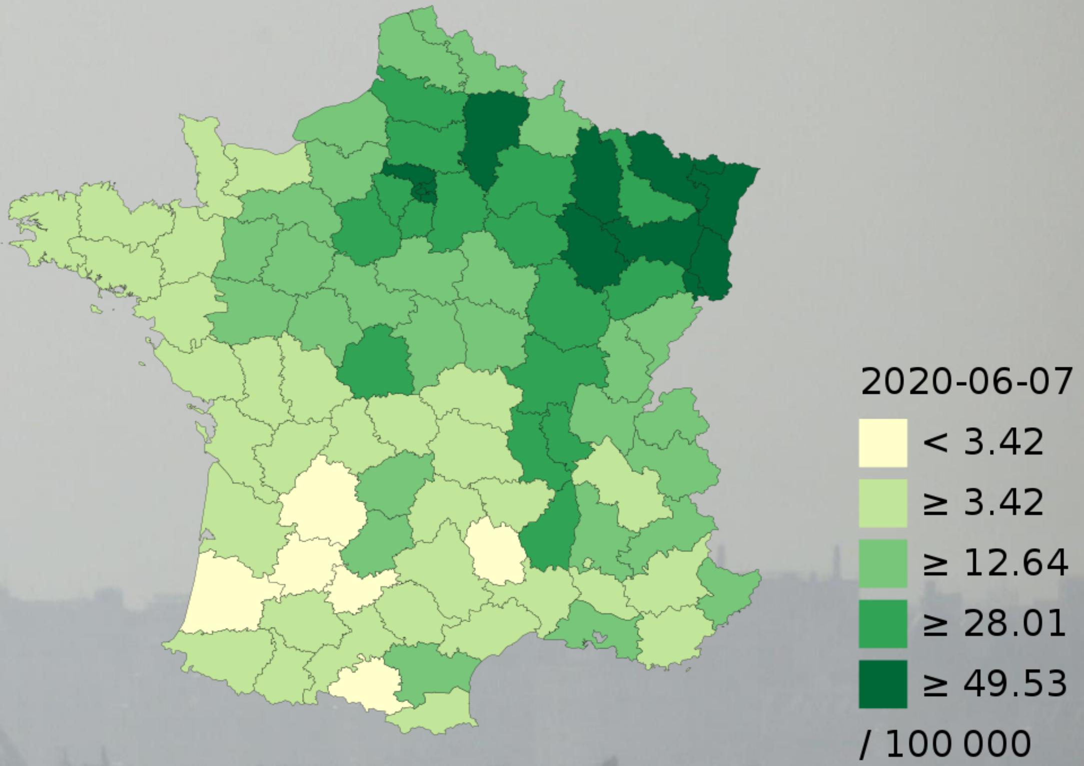
Cases



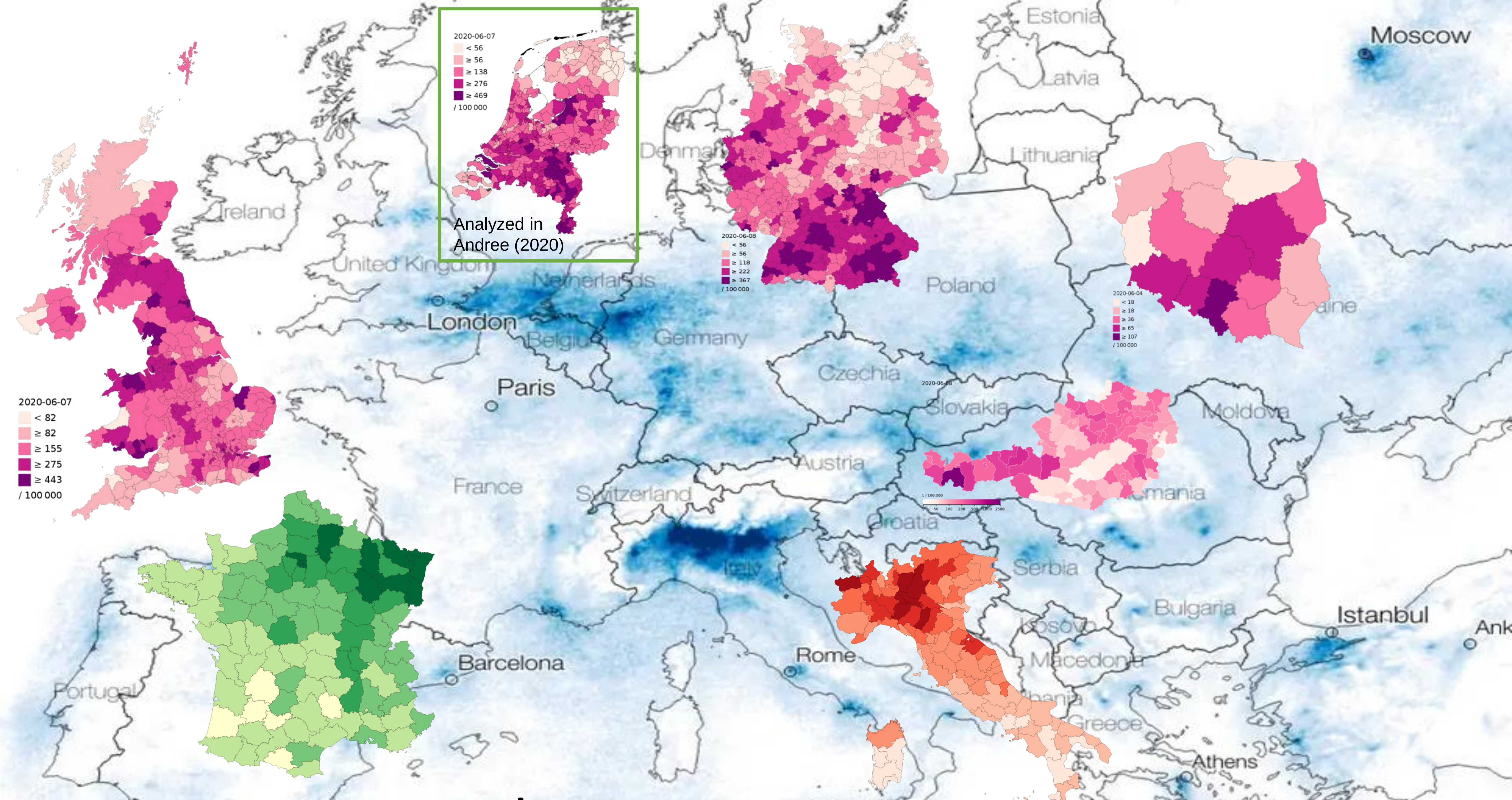
Population density

Italy, March


March 2019
Lille
GERMANY
Paris
FRANCE
Lyon
Turin
ITALY
Marseille
NO2 tropospheric column
20
µmol/m²
160

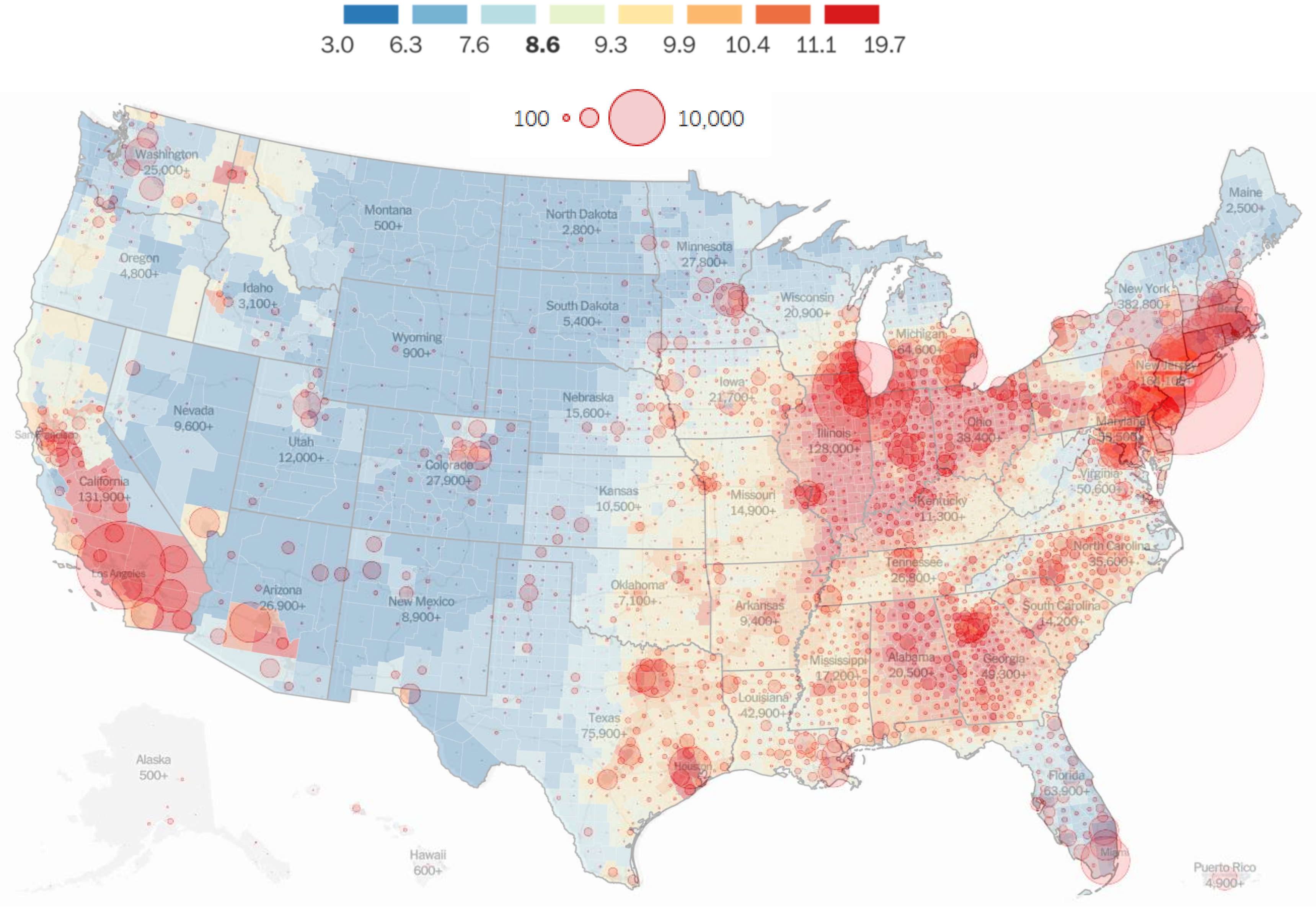

2020-06-07
< 3.42
≥ 3.42
≥ 12.64
≥ 28.01
≥ 49.53
/ 100 000

France, June



Europe NO2 march 10

Particulate Matter 2.5, Annual average (2014)



USA

Direct relationships

Increased susceptibility to virus
Pre-existing conditions
Throat irritation

Virus hitchhikes on particles
Increased (indoor) spread

Associated relationships

Air pollution proxies other risk factors
Increased economic and social activity
Economic activity associated with transmission environments

Confounding relationships
Population density
Income status
Convenience sampling

Incorrect relationships

Spurious relationships
Spatial trends

Air pollution and covid-19

One correlation
Multiple explanations

Analytical Strategy

The question becomes:

How robust is the correlation between covid-19 incidence and air pollution?

This requires

- Granular data on covid-19 and precise air pollution measurements
    - Ideally at the patient level, otherwise (very) small areal statistics
- Reliable data on important control variables
    - Importantly, on possible health pre-conditions
- A reasonable sample size to support enough degrees of freedom to capture important nuances

If this correlation is robust

- It raises questions about what is behind it
- May have implications for mitigation strategies

Analytical Strategy

COVID-19 data from 355 municipalities in the Netherlands, plus a wide range of controls

Dependent variables

- <u>Confirmed cases / 100,000</u>
- Confirmed Hospital Admissions / 100,000
- Confirmed cases
- Different dates

Air pollutants (annual average, 2017)

- <u>Ground measurements PM2.5</u>
- Ground measurements PM10
- Remotely sensed PM2.5

Controls

- Population densities
- Pre-existing health conditions and case severity
- Demographics

Methodological considerations

- Nonlinearities and alternative distributional assumptions
- (Influential) outliers
- Spatial trends, dependence, spatially varying relationships

Details can be found in the paper:

Bo Pieter Johannes Andrée. Incidence of COVID-19 and Connections with Air Pollution Exposure: Evidence from the Netherlands. *World Bank Policy Research Working Papers.* (2020).

http://documents.worldbank.org/curated/en/462481587756439003/Incidence-of-COVID-19-and-Connection-with-Air-Pollution-Exposure-Evidence-from-the-Netherlands

Main Estimation

Model 1: linear regression with 22 additional controls beyond what is shown

Model 2: step-wise variable selection using information criteria

Model 3: spatial error model (captures spatial trends)

Model 4: spatial-autoregressive (captures spatial clustering)

Model 5: separate spatial error and spatial autoregressive parameters

Model 5b: additional proxy for case severity

In additional analyses, PM2.5 remains significant.

Table 1: Dependent Variable: Confirmed COVID-19 cases per 100,000 inhabitants.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 5b
(Intercept)	-359.58	-402.51***	-202.58***	-200.63***	-207.50***	-185.43***
	(218.20)	(80.61)	(76.06)	(64.11)	(74.59)	(71.75)
Population density	-6.28**	-6.54***	-0.03	-1.10	-0.48	-0.48
	(2.58)	(2.38)	(2.05)	(1.87)	(2.06)	(1.94)
Share 25 to 44	3.55	2.62*	-0.80	0.47	-0.37	-.41
	(2.17)	(1.34)	(1.05)	(1.05)	(1.07)	(1.02)
Share above 65	5.58*	4.22***	2.12**	2.14*	2.08**	1.07*
	(2.26)	(1.27)	(1.03)	(1.00)	(1.05)	(1.00)
Share unmarried	4.94***	4.78***	4.01***	3.28***	3.83***	3.59***
	(1.33)	(0.97)	(0.96)	(0.78)	(0.94)	(0.89)
Share single household	-4.02***	-2.17***	-1.62***	-1.50***	-1.59***	-1.70***
	(1.47)	(0.57)	(0.49)	(0.45)	(0.49)	(0.46)
Share non-western immigrants	-1.32**	-1.23**	-0.57	-0.78**	-0.77*	-0.58
	(0.57)	(0.48)	(0.43)	(0.38)	(0.42)	(0.40)
Share of water surface	17.58	16.11	11.30	13.56*	13.53	11.53*
	(11.18)	(10.28)	(9.62)	(8.07)	(9.21)	(8.71)
Share with long-term illness	1.10	1.19	0.41	0.72	0.64	0.97
	(1.00)	(0.76)	(0.92)	(0.60)	(0.79)	(0.74)
Case severity						-0.065***
						(.01)
Mean $PM_{2.5}$	10.17**	10.84***	6.21***	3.52***	4.91**	4.47***
	(4.66)	(1.48)	(2.82)	(1.22)	(2.44)	(2.31)
λ			0.71***		0.42*	0.39
			(0.26)		(0.26)	(0.25)
ρ				0.68***	0.43	0.50**
				(0.25)	(0.25)	(0.21)
R2	0.24	0.22	0.52	0.51	0.50	0.55
AICc	3414.85	3391.40	3274.36	3274.12	3269.31	3237.91

Standard Errors in parenthesis, significance levels as: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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Additional Estimation

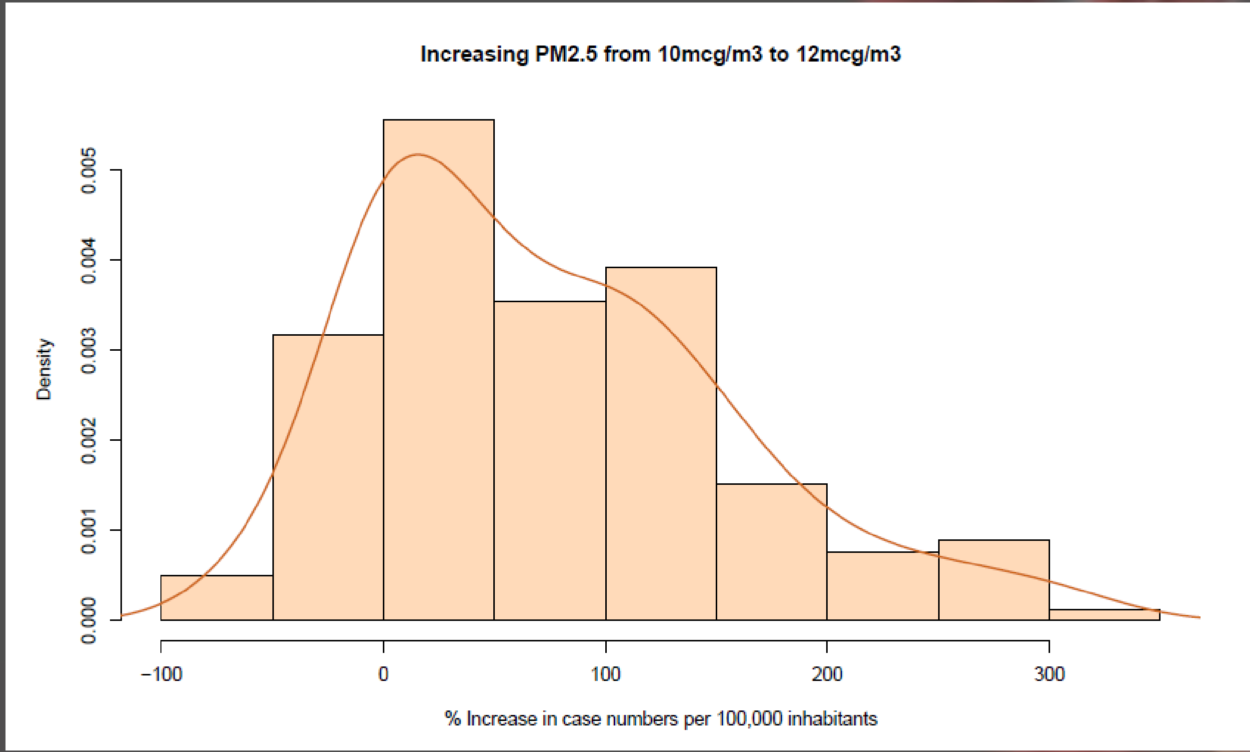
Correlation between PM2.5 and case incidence may be influenced by other factors

Model: Regularized Kernel Regression

- Allows relationships to vary depending on levels in the data
- By using longitude and latitude, the marginal effects can vary between regions

Reveals:

- The association centers around a doubling in cases when pollution increases 20% above WHO guidelines
- Substantial heterogeneity, which may relate to other environmental and economic factors



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What Emerges

1. PM2.5 is a known health risk and short-term exposure has been shown to increase infection risk of various viral infections.
2. Emerging analyses point toward PM2.5 as a predictor of COVID-19 incidence.
3. This is robust to a range of control variables and methodological considerations.

Cautionary notes are in order:

- The explanations for this correlation have yet to be clarified.
- Available data on covid-19 infections is sub-optimal.
- It has not yet been investigated how this relationship extrapolates to high PM2.5 concentrations.
- A systematic review on the applicability of these findings across countries is needed.
- The literature on this topic is in early stages, interpret results with caution.