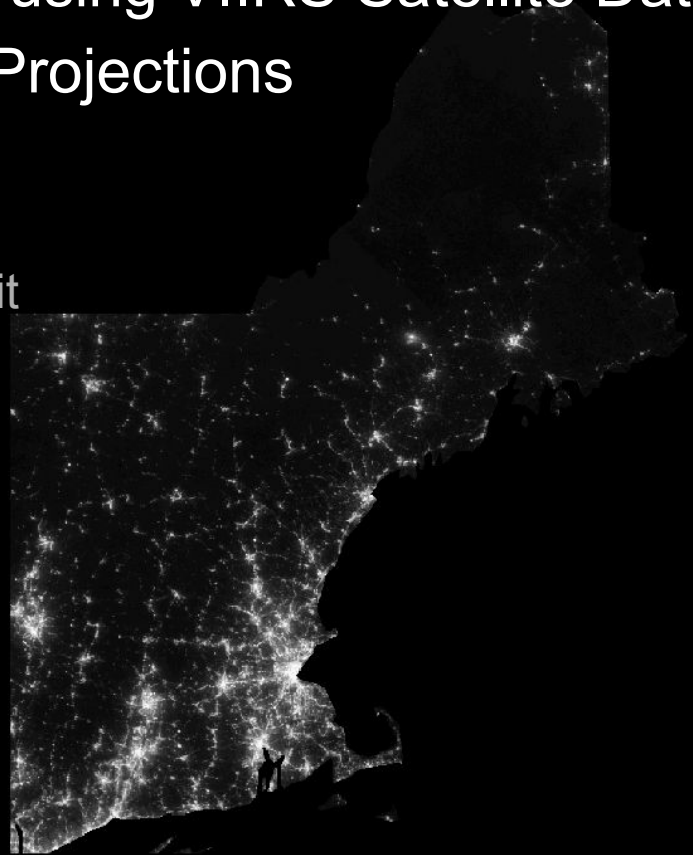# Predicting Light Pollution in 2060 using VIIRS Satellite Data and OECD GDP Projections

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Abstract

Previous studies have shown a very strong link between GDP and the amount of light pollution a country produces at night. Using OECD projections of future GDP, each country in this study was plotted using 2019 satellite data as a measure of current light output. Then, using a quadratic equation modeled on over 100 countries, and the OECD-projected GDP numbers, a value for the 2060 light output is calculated for the country and plotted (taking into account urbanization trends). This process was repeated for the 15 largest economies by PPP in 2019. In this study, it is found that light pollution is likely to increase substantially in each of the 15 countries by 2060, with India seeing the largest increase (+506%) and Russia seeing the smallest (+32%).

Dataset

- The dataset is originally from the NASA/NOAA Suomi Satellite,
- Average of all cloud-free nighttime observations in the year 2019
- The dataset is 10GB in size and contains about 3 billion observations
- Measures radiance value

Drawbacks:

- Does not account for intrinsic reflectivity of ice or moon phase
- Only measures certain wavelengths (infrared and visible)

Countries Investigated

- This analysis analyzes the light output of the 15 largest economies by purchasing power parity in 2019

- United States
- Mexico
- Brazil
- United Kingdom
- France
- Spain
- Italy
- Germany
- Turkey
- Russia
- China
- South Korea
- Japan
- India
- Indonesia

Created with mapchart.net
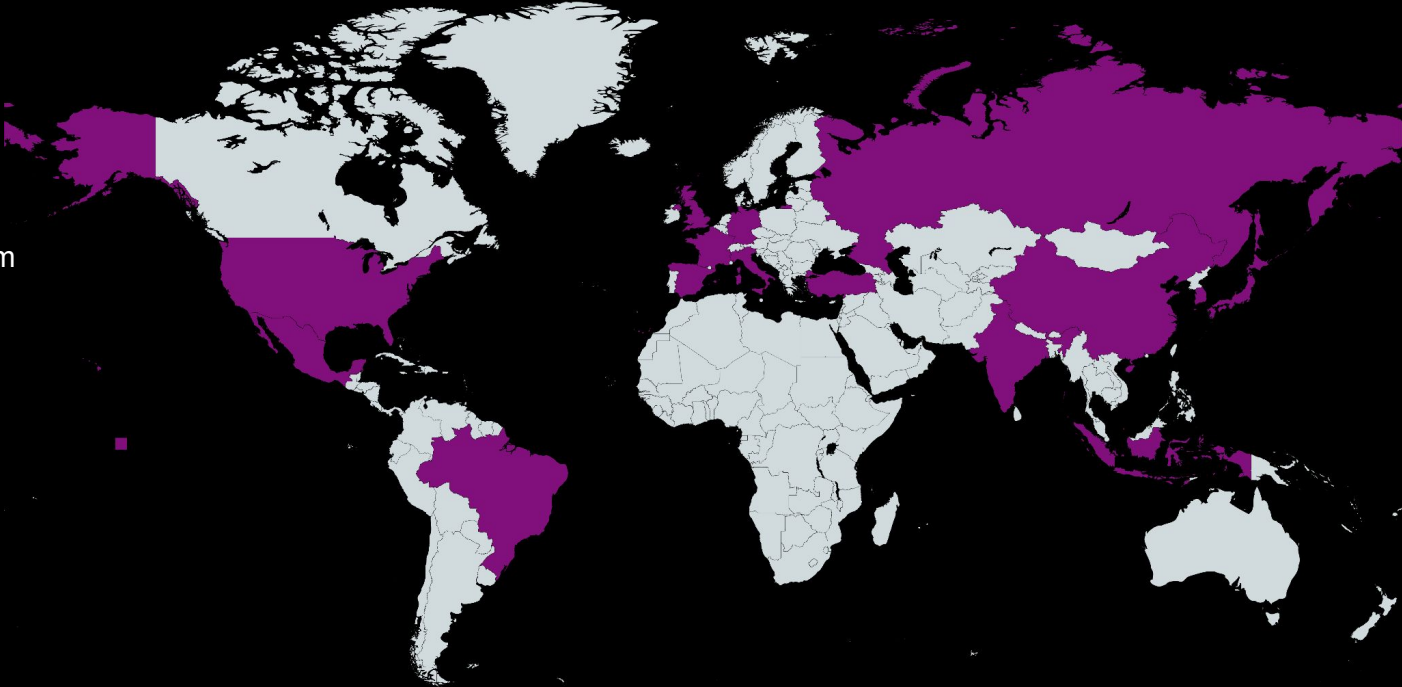
Research Questions

- Which major countries produced the most light pollution in 2019?
- Based on a GDP-to-light regression equation, which countries will produce the most light pollution in 2060?
- How severe will light pollution become by 2060?

Relating GDP to Light

- All countries with a population over 2,000,000 were evaluated
- Light Output per capita was calculated from satellite dataset, GDP (PPP) per capita was obtained from the IMF
- Quadratic function was used, which, as expected, yielded a strong fit (R^2=0.702)
- Most residual variance came from type of economy (oil-dependent economies like Venezuela and Iraq were large positive residuals). According to Yao & Hu (2019), who used data from many years in their analysis, when the country is accounted for, the R^2 is over 0.98! Since the data in this analysis is for only one year, a country variable cannot be introduced.
- When predicting future light pollution, original residual was kept for this reason

GDP-to-Light function

Letting O = ln(light pollution per capita) and G = ln(GDP per capita), the GDP-to-Light function was estimated as

O = -19.93 + 2.432*G - 0.0741*G^2
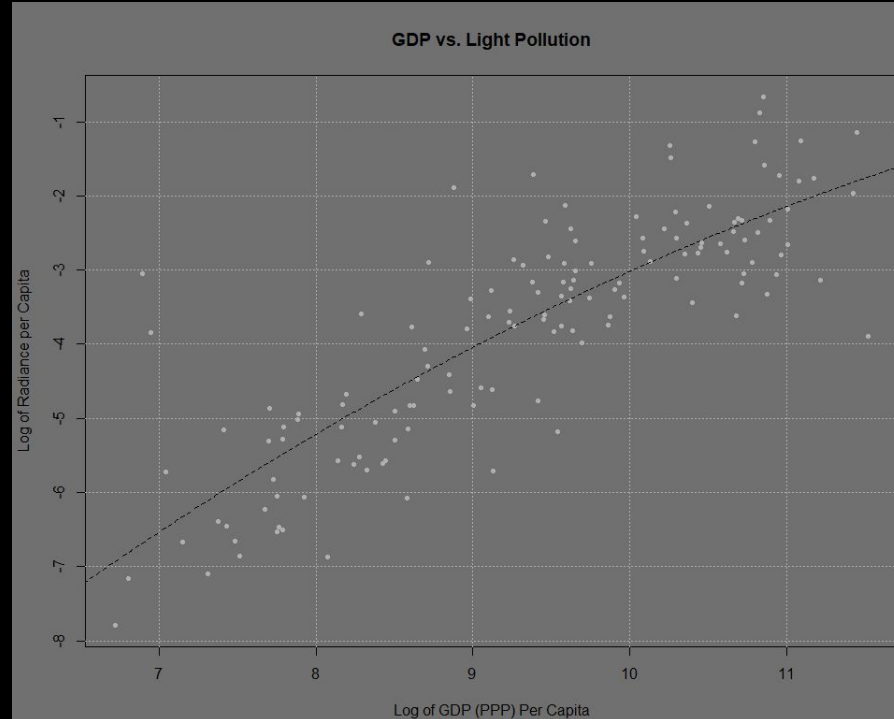
Which Countries Produced the Most Light in 2019?

Rank	Country	Total Radiance
1	United States (continental)	54,095,977
2	Russia (European part)	33,252,254
3	China	26,663,029
4	Brazil	15,177,722
5	India	13,205,936

Which Countries Will Produce the Most Light in 2060?

Using the OECD's projections for future GDP (PPP), then applying the GDP-to-light equation, the following output was obtained.

Rank	Country	Estimated Radiance	Estimated Change from 2019
1	United States (continental)	100,728,969	+86%
2	India	80,000,794	+506%
3	China	64,662,130	+143%
4	Russia (European part)	43,814,644	+32%
5	Brazil	19,439,680	+111%

Modeling Change in Light Output

- Not all areas in a country develop equally!
- According to a UN study, urban areas on average grow 3% per year relative to rural areas, in both developed and developing countries.
- Rural areas in developed countries often got <u>dimmer</u>, even as the country overall got brighter
- US: Rural areas projected to get over 25% dimmer while urban areas more than double in brightness
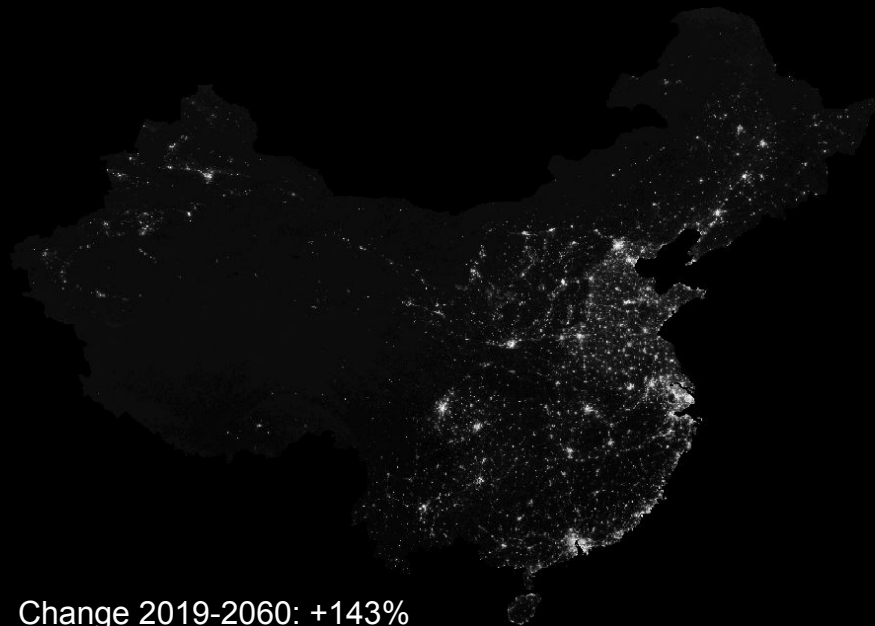
United States, 2019 vs. 2060

USA 2019
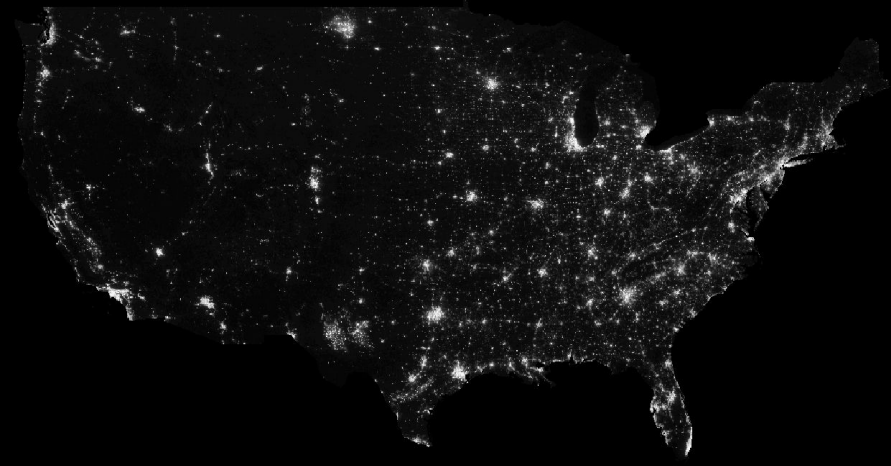
USA 2060

Change 2019-2060: +86%

China, 2019 vs. 2060

China 2019

China 2060

Change 2019-2060: +143%

India, 2019 vs. 2060

India 2019
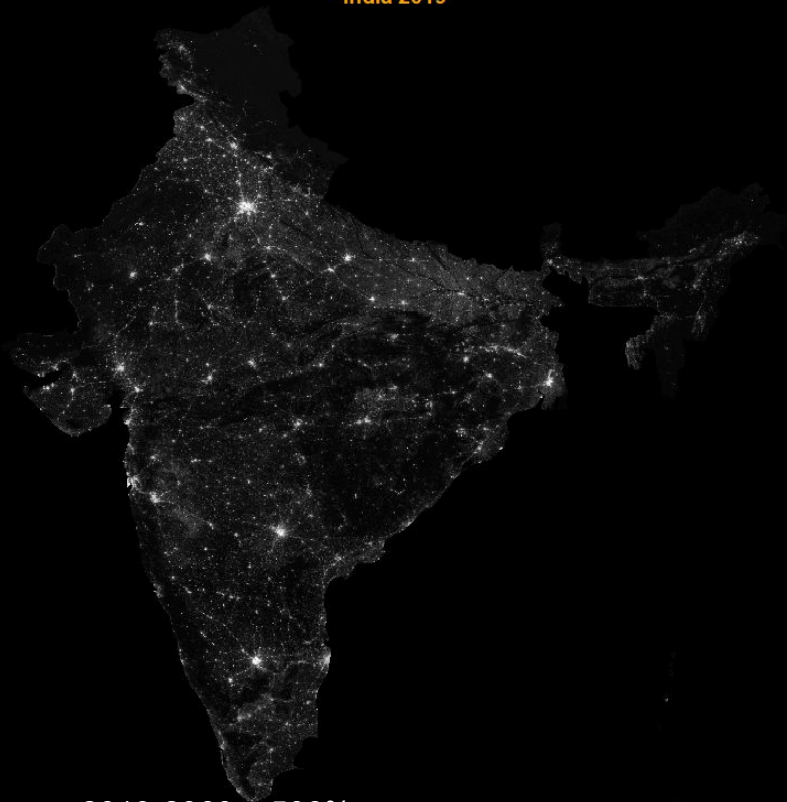
India 2060
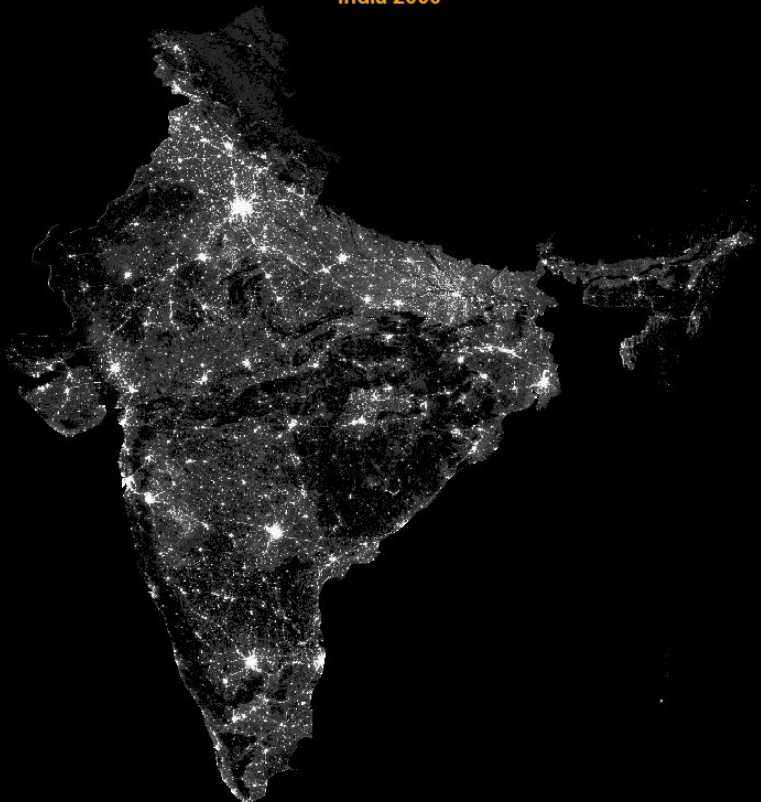
Change 2019-2060: +506%

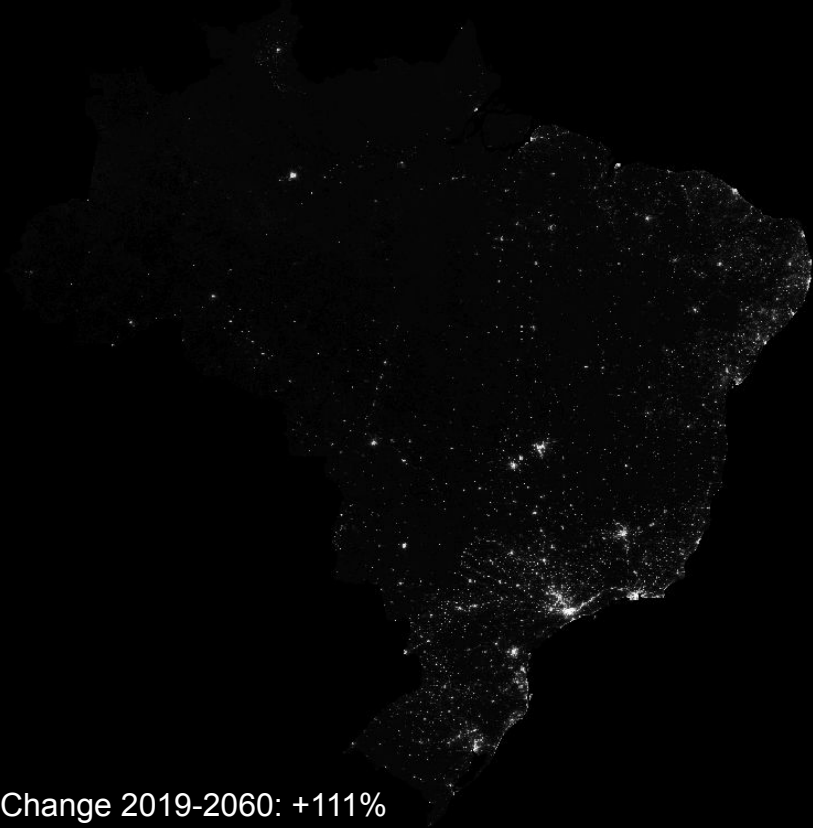Russia, 2019 vs. 2060

Russia 2019

Russia 2060

Change 2019-2060: +32%

Brazil, 2019 vs. 2060

Brazil 2019

Brazil 2060

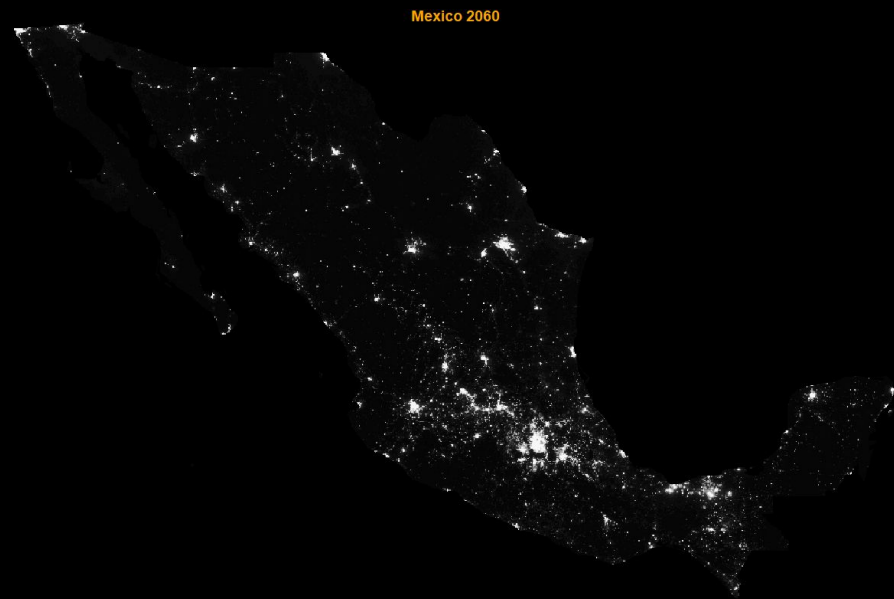Change 2019-2060: +111%

Turkey, 2019 vs. 2060

Turkey 2019

Turkey 2060

Change 2019-2060: +204%

Mexico, 2019 vs. 2060

Mexico 2019

Mexico 2060

Change 2019-2060: +154%

Indonesia,
2019 vs. 2060

Indonesia 2019

Indonesia 2060

Change 2019-2060: +299%

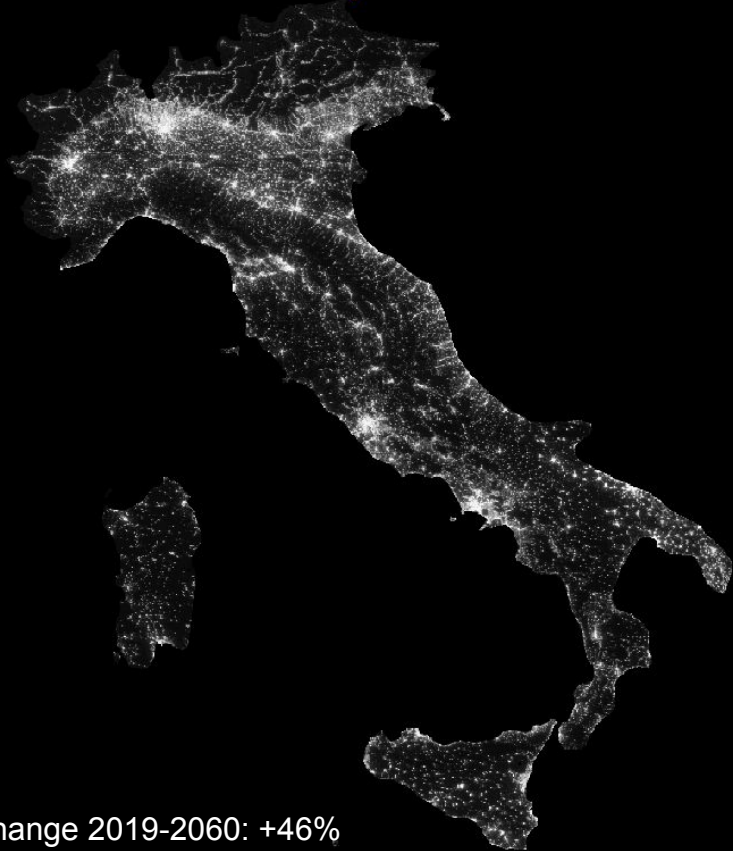# France, 2019 vs. 2060
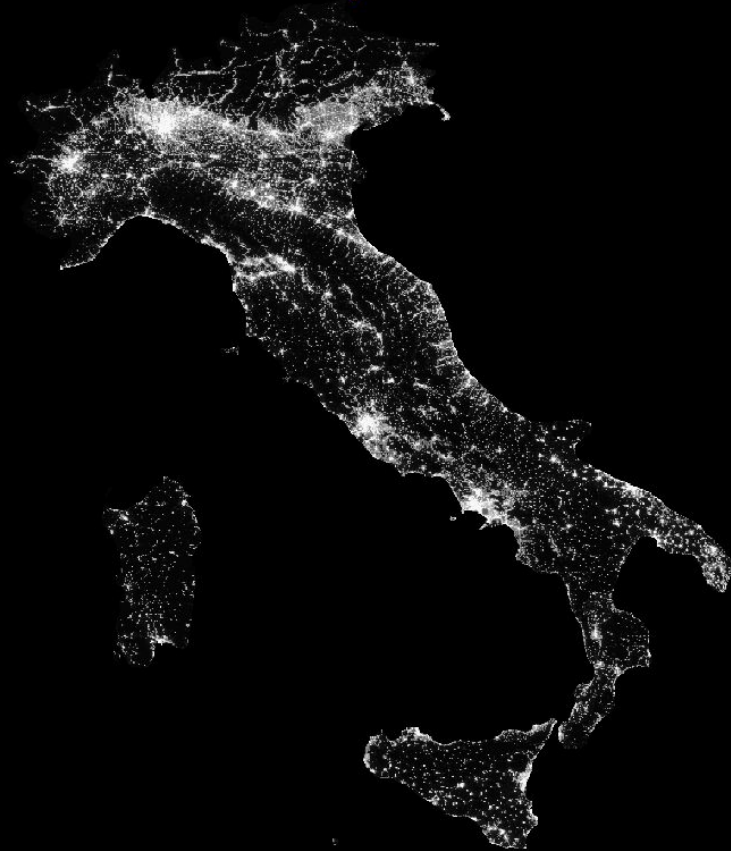

France 2019
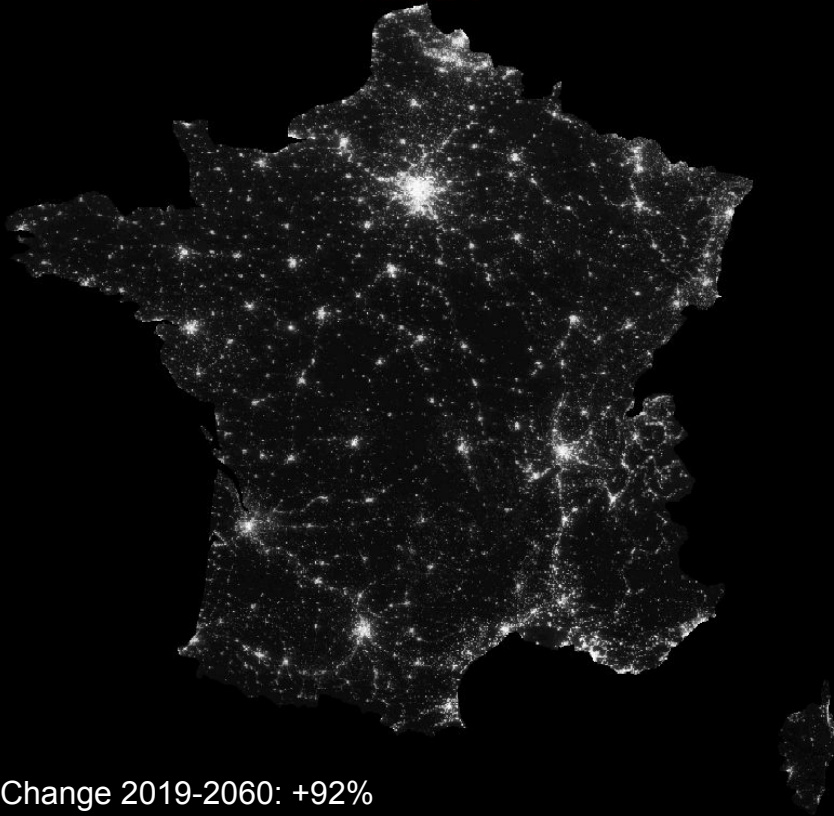
France 2060

Change 2019-2060: +92%

Italy, 2019 vs. 2060

Italy 2019

Italy 2060

Change 2019-2060: +46%

United Kingdom, 2019 vs. 2060

UK 2019

UK 2060

Change 2019-2060: +102%

Spain, 2019 vs. 2060

Spain 2019

Spain 2060

Change 2019-2060: +60%

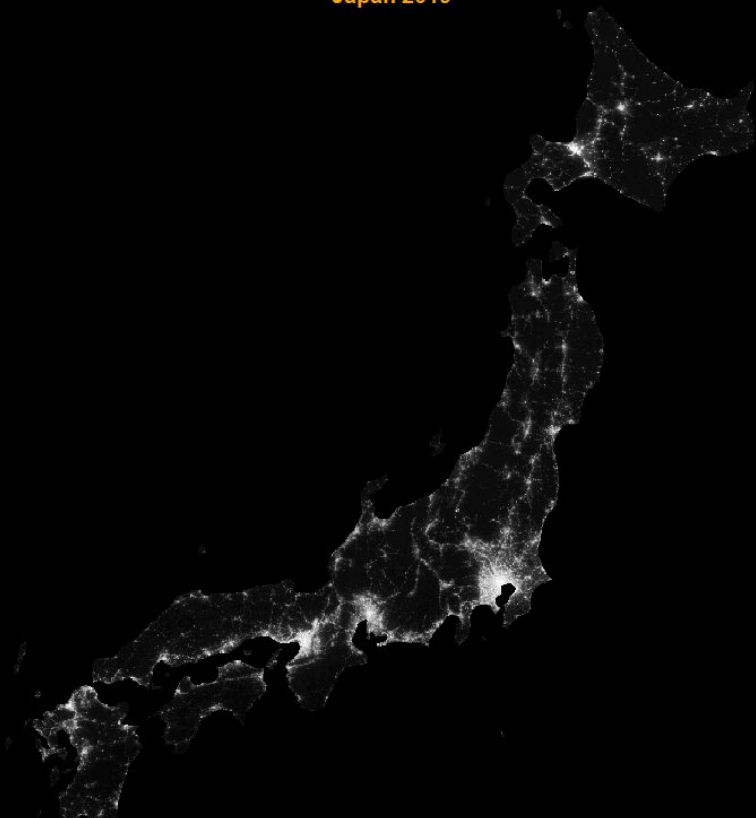# Germany, 2019 vs. 2060

Germany 2019
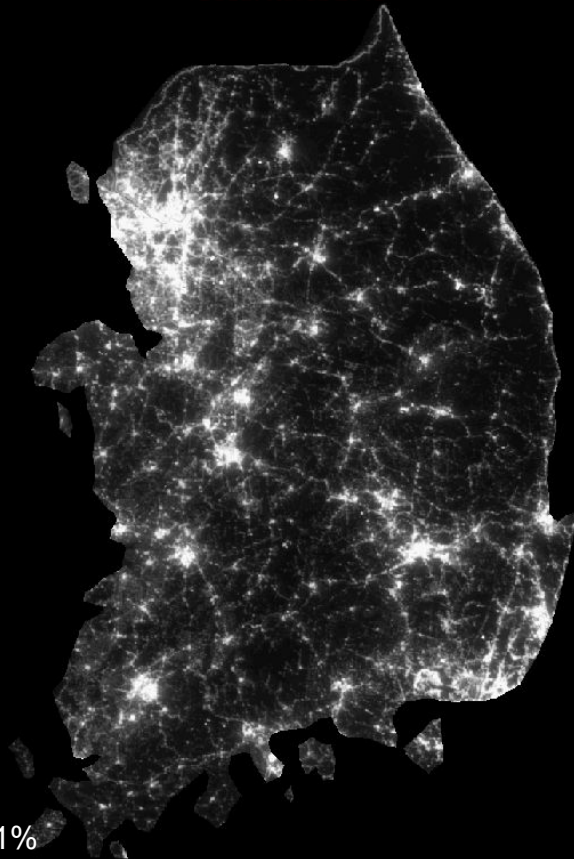
Germany 2060
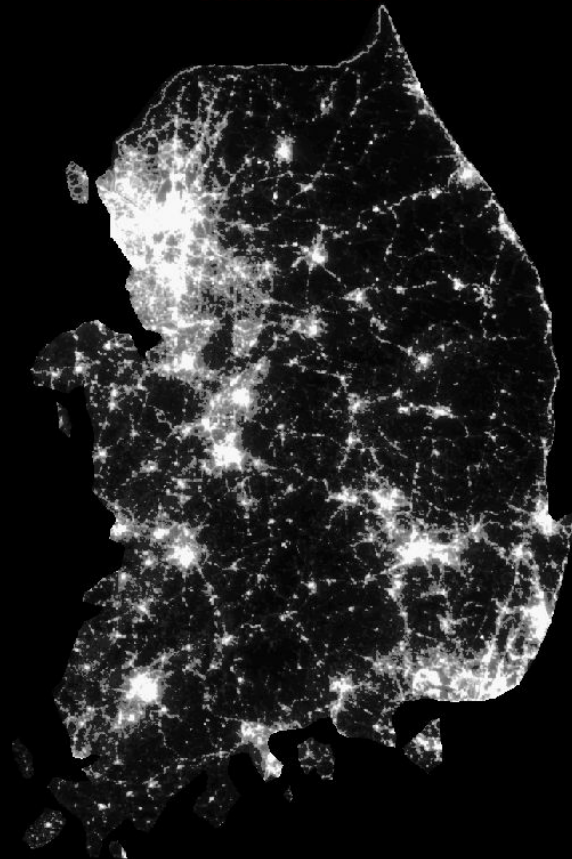
Change 2019-2060: +53%

Japan, 2019 vs. 2060

Change 2019-2060: +39%

South Korea, 2019 vs. 2060

South Korea 2019

South Korea 2060

Change 2019-2060: +71%

Conclusions

- In developed countries, light pollution in rural areas is forecasted to improve
- Light pollution in cities is forecasted to become much more severe
- India, Indonesia, Turkey, and Brazil are on track to see the biggest increase in total radiance output by 2060

References

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- Hu Y., Yao J. "*Illuminating Economic Growth*" (2019) doi: 10.1016/j.jeconom.2021.05.007