United States Nighttime Radiance during the COVID-19 Pandemic: February 16th – May 7th, 2020

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Abstract:

In March 2020, the alarming discovery that the coronavirus disease (COVID-19) was spreading rapidly throughout the United States prompted each state to initiate quarantines or other preventative measures. As a result, many businesses, factories, and educational institutions closed their doors as people were told to stay home. This cessation of public activity had a devastating toll on the economy, emphasized by the heightened unemployment and fatality rates. Another potential measure of how much activity ceased during this time is the radiance of light during nighttime hours. In this report, nearly three months of remotely sensed radiance data from the VIIRS (Visible Infrared Imaging Radiometer Suite) satellite was analyzed in three regions of the United States and compared to 2019 data, to determine if less light was produced after the COVID-19 pandemic was declared. The results suggested that this was the case, but are not strong enough to definitively conclude so because of atmospheric obstructions.

Supplementary Online Materials:

The discourse on the results of my analysis can be found online, inside of my StoryMap. I briefly explain my methods and results, and direct the reader to the graphics that are in this document's appendix. Lastly, the StoryMap contains numerous interactive maps that visualize the appendix results. My ArcGIS StoryMap can be found at:

https://storymaps.arcgis.com/stories/27f6524134444efaa1be69b2948aedc7

Additionally, my nightly timelapse videos can be found at:

- **Northwest:** https://youtu.be/a7FkLXg_FV8
- **Northeast:** https://youtu.be/hGtZfypzHos
- **Southeast:** https://youtu.be/ZEd-av2k4fA

Appendix

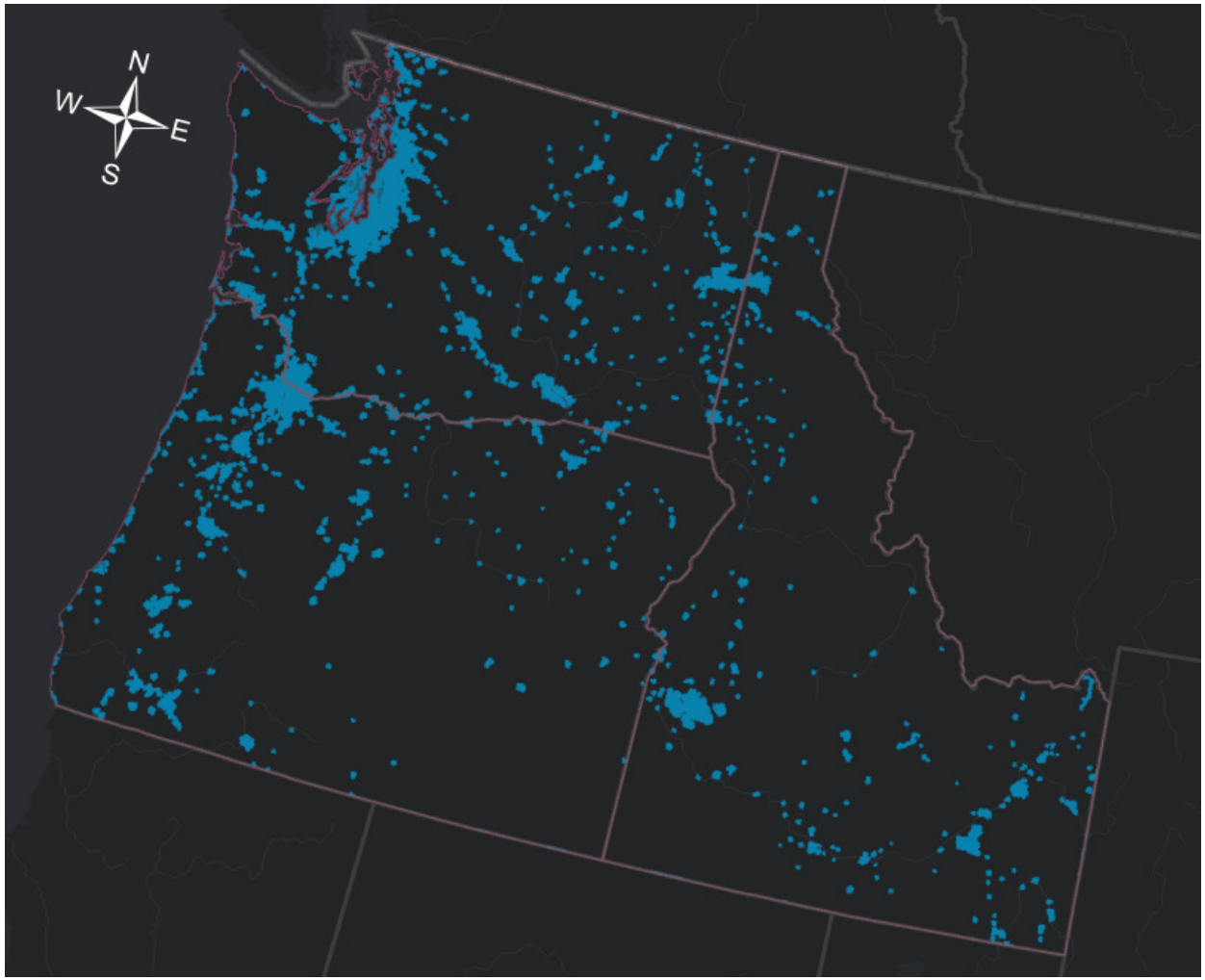

Figure 1: Northwest study area, and urban regions (blue). Raster Dimensions: 3284 x 1684. # of Pixels (500 m^2 resolution): 4,239,579. Area (sq. km): 656,484. Rural: 93.0% ; Urban: 7.0%.

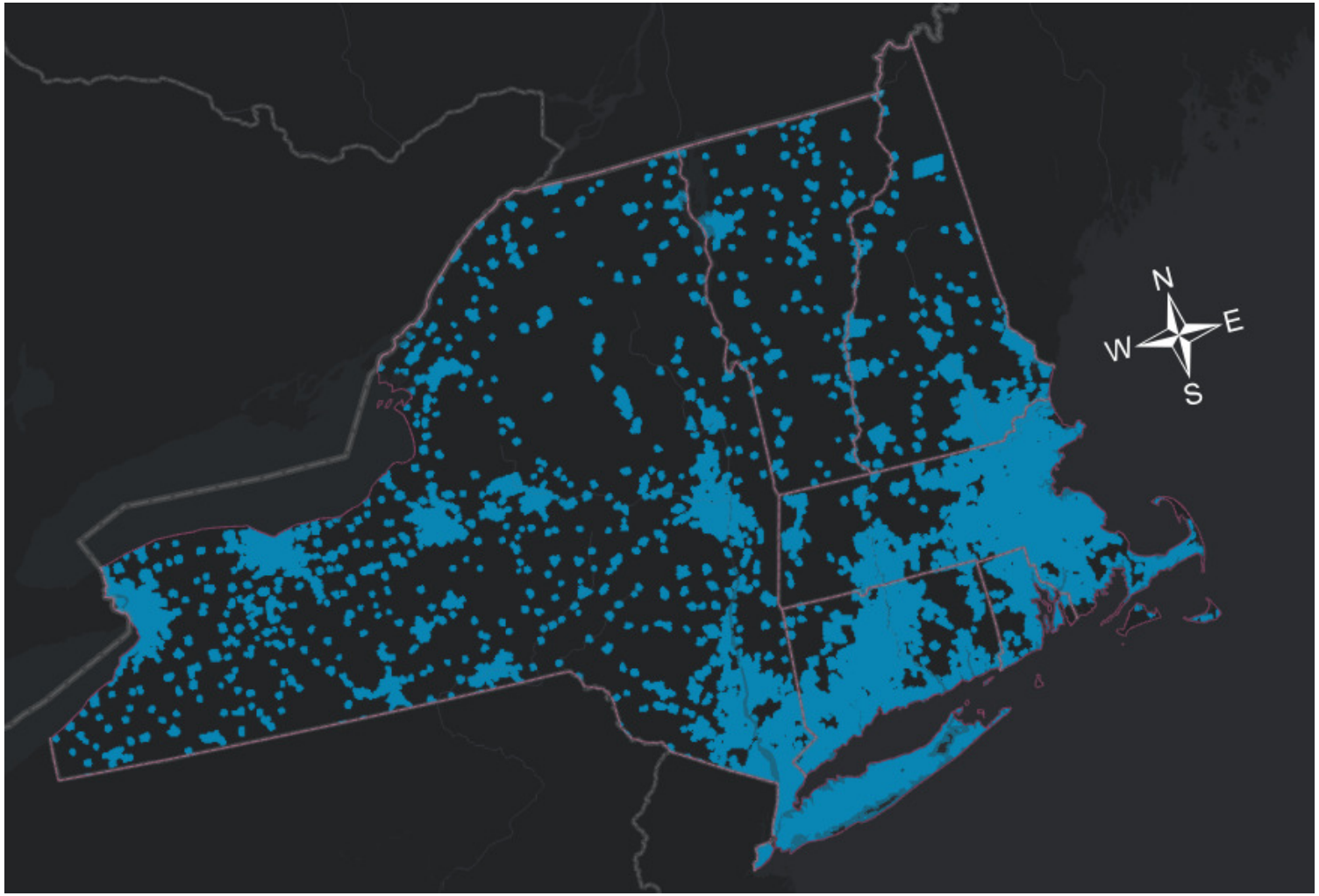

Figure 2: Northeast study area, and urban regions (blue). Raster Dimensions: 2361 x 1153. # of Pixels (500 m^2 resolution): 1,354,231. Area (sq. km): 235,298. Rural: 68.8% ; Urban: 31.2%.

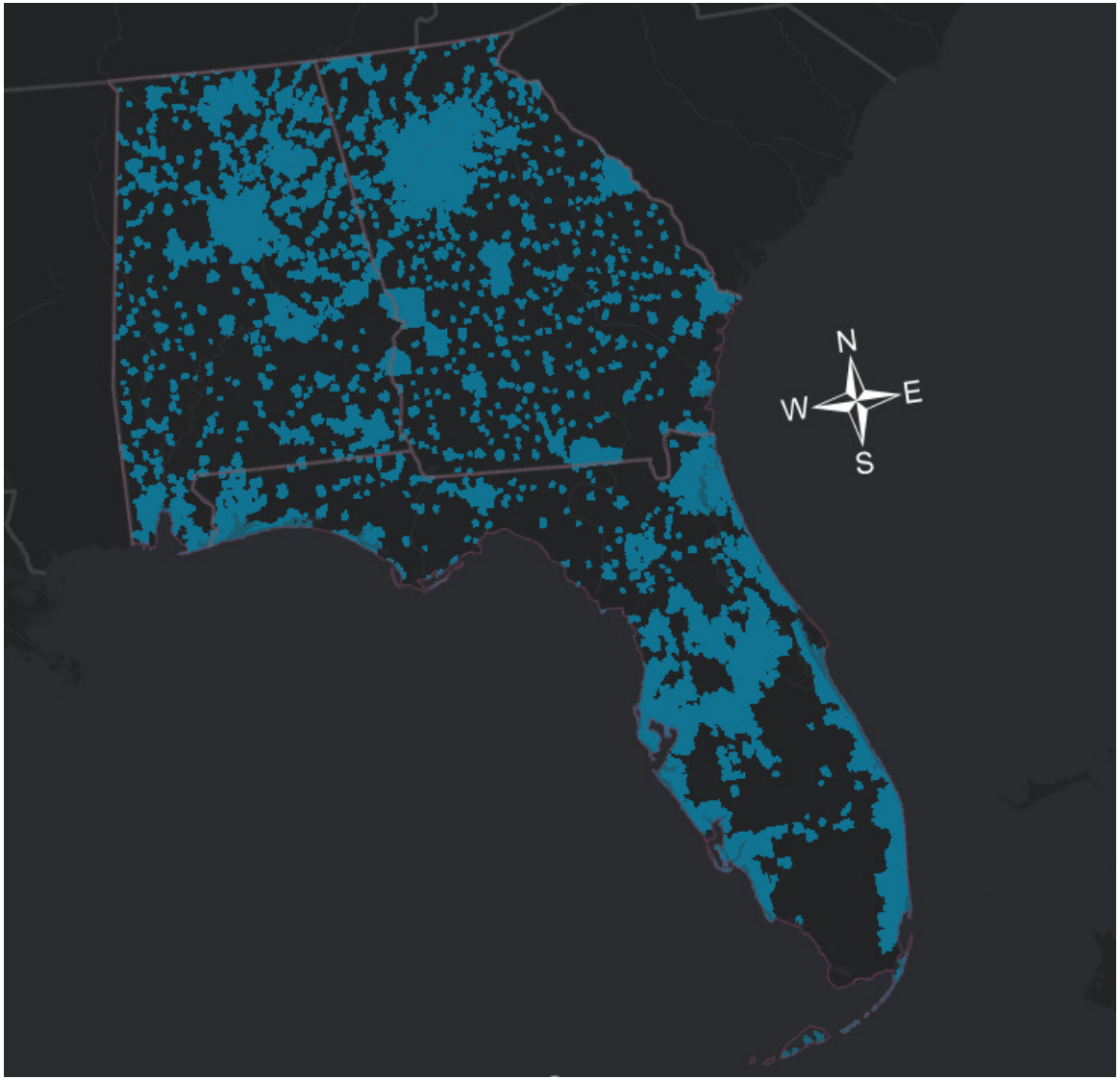

Figure 3: Southeast study area, and urban regions (blue). Raster Dimensions: 2025 x 2519. # of Pixels (500 m^2 resolution): 2,392,847. Area (sq. km): 459,979. Rural: 70.4% ; Urban: 29.6%.

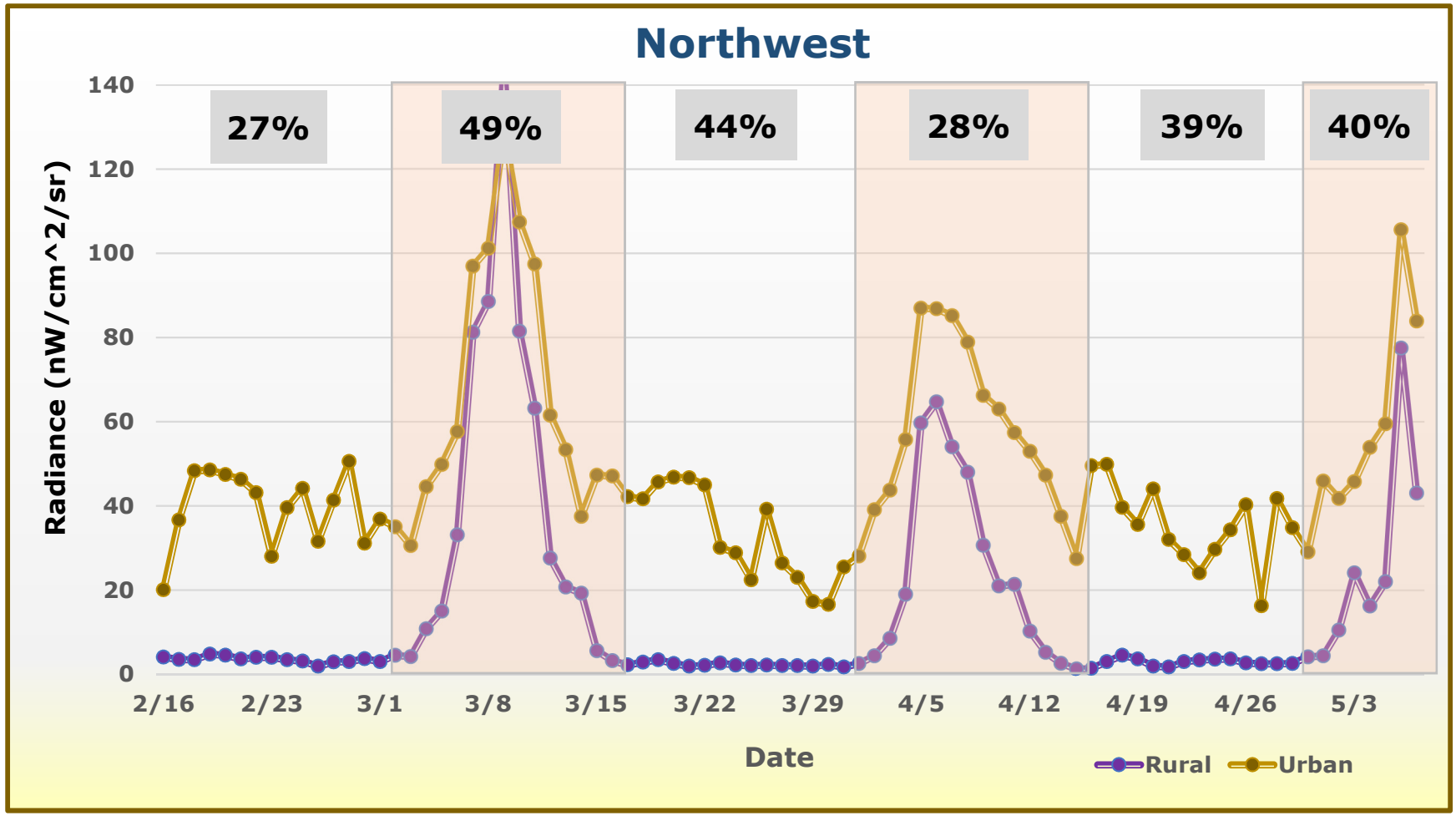

Figure 4: Summary of nighttime radiance, cloud cover, and moon phase by night for the Northwest United States (2/16/20 - 5/7/2020). The "Northwest" region includes Idaho, Oregon, and Washington. Rural (purple) and Urban (gold) regions are differentiated. Radiance values are given in nW/cm^2/steradian. Cloud cover (gray text box) reported as average for the specified time period. Orange shaded areas indicate moon illumination of over 50%, which denote timeframes of inaccurate data. The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata.

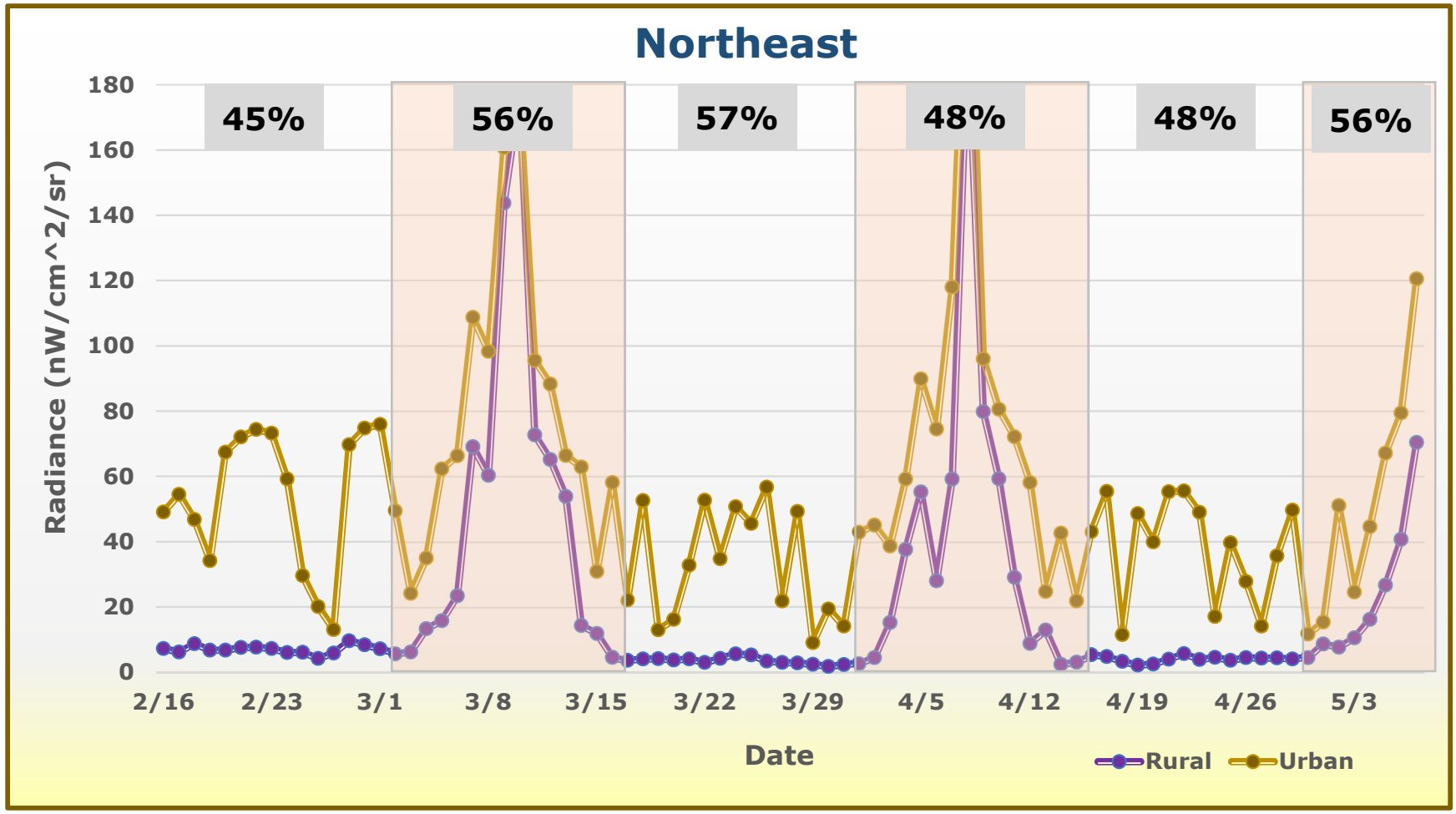

Figure 5: Summary of nighttime radiance, cloud cover, and moon phase by night for the Northeast United States (2/16/20 - 5/7/2020). The "Northeast" region includes New York, Massachusetts, Connecticut, Rhode Island, Vermont, and New Hampshire. Rural (purple) and Urban (gold) regions are differentiated. Radiance values are given in nW/cm^2/steradian. Cloud cover (gray text box) reported as average for the specified time period. Orange shaded areas indicate moon illumination of over 50%, which denote timeframes of inaccurate data. The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata.

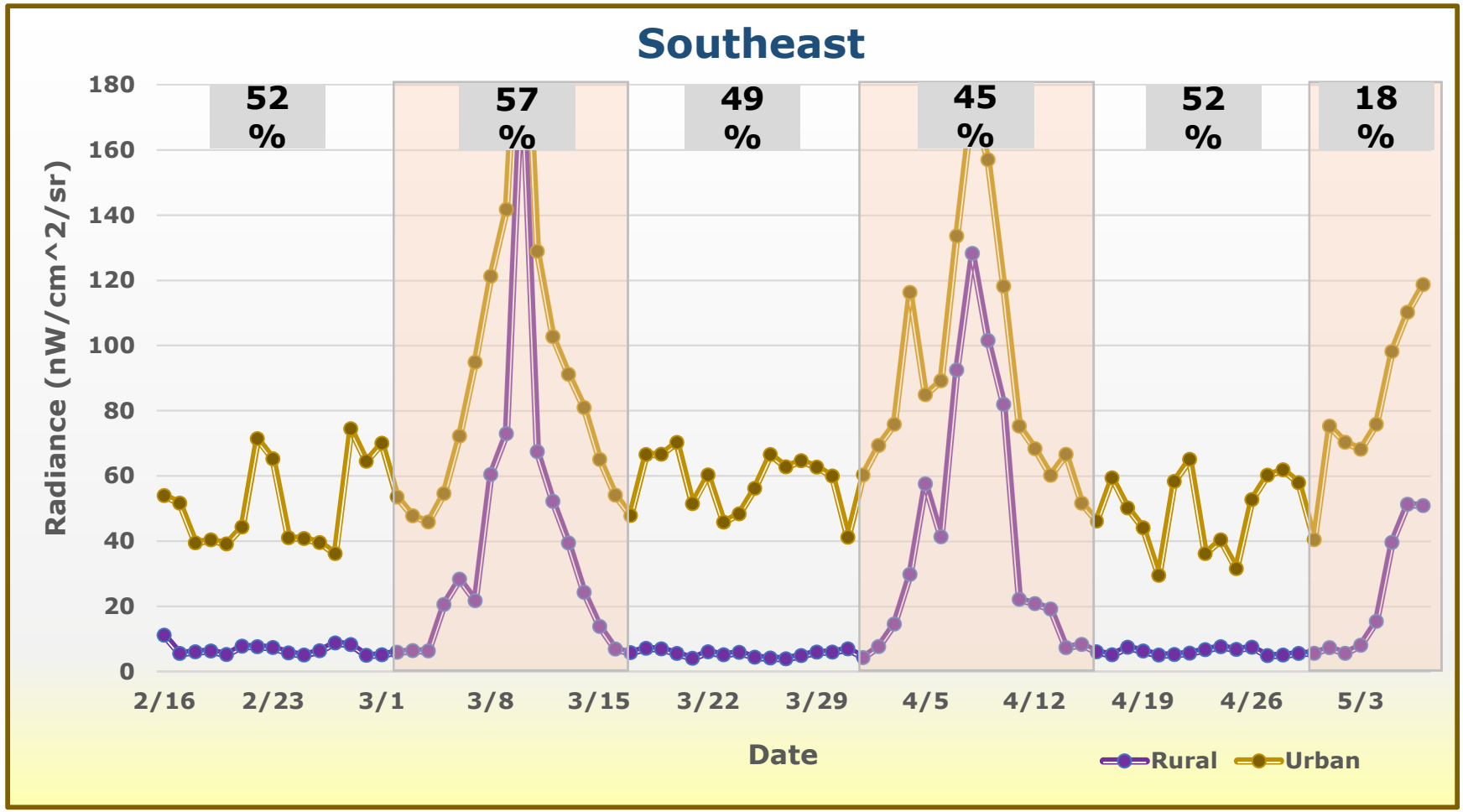

Figure 6: Summary of nighttime radiance, cloud cover, and moon phase by night for the Southeast United States (2/16/20 - 5/7/2020). The "Southeast" region includes Alabama, Georgia, and Florida. Rural (purple) and Urban (gold) regions are differentiated. Radiance values are given in nW/cm^2/steradian. Cloud cover (gray text box) reported as average for the specified time period. Orange shaded areas indicate moon illumination of over 50%, which denote timeframes of inaccurate data. The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata.

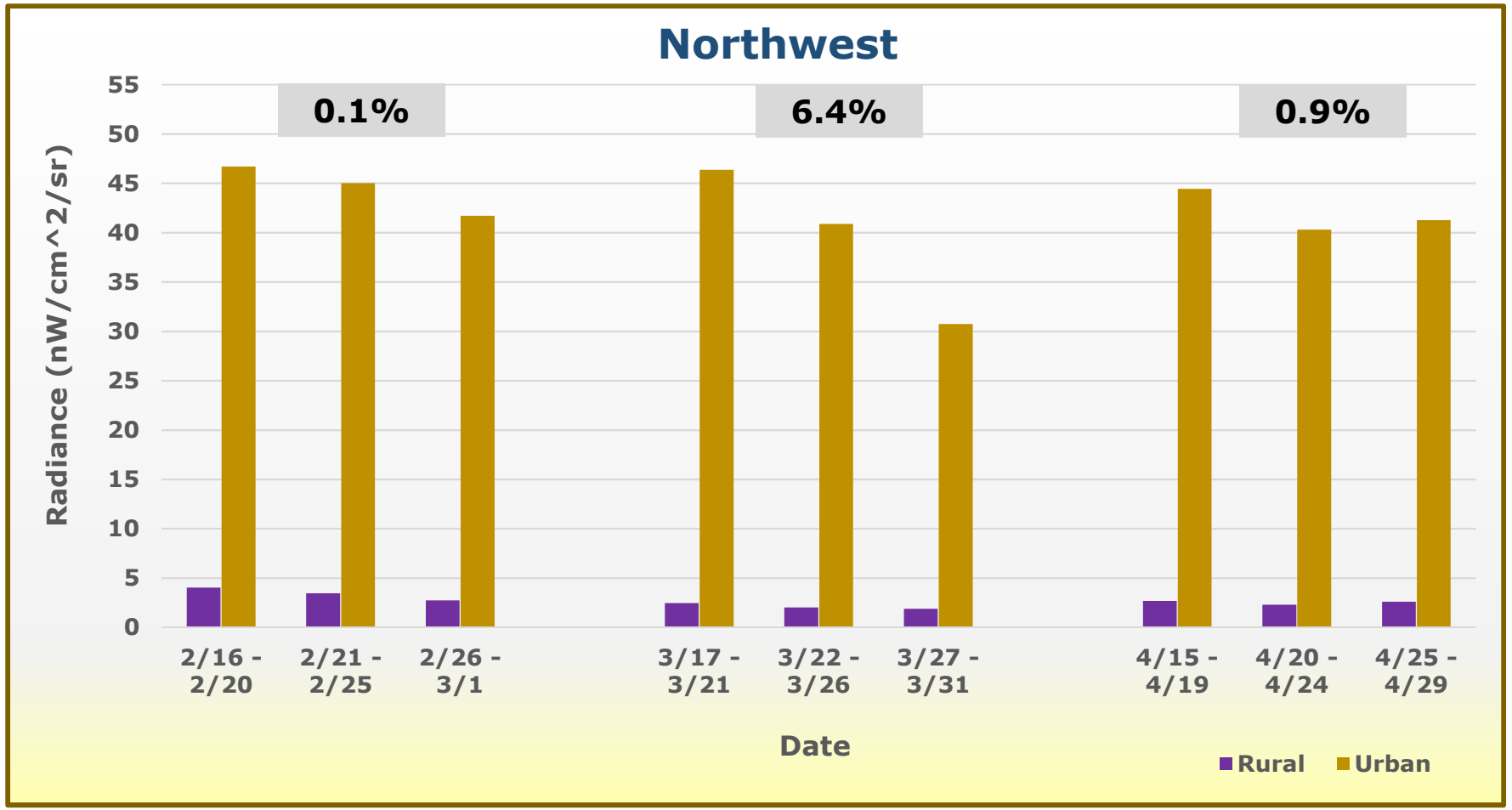

Figure 7: Summary of Northwest radiance in 5-night timeframes, during which the moon was less than 50% full, between 2/16/2020 and 4/29/2020. Radiance values are given in nW/cm^2/steradian. The "Northwest" region includes Idaho, Oregon, and Washington. Percentages in gray text box describe the area that was clouded all five nights. **Quarantine orders were declared between 3/22 - 3/26.** The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata.

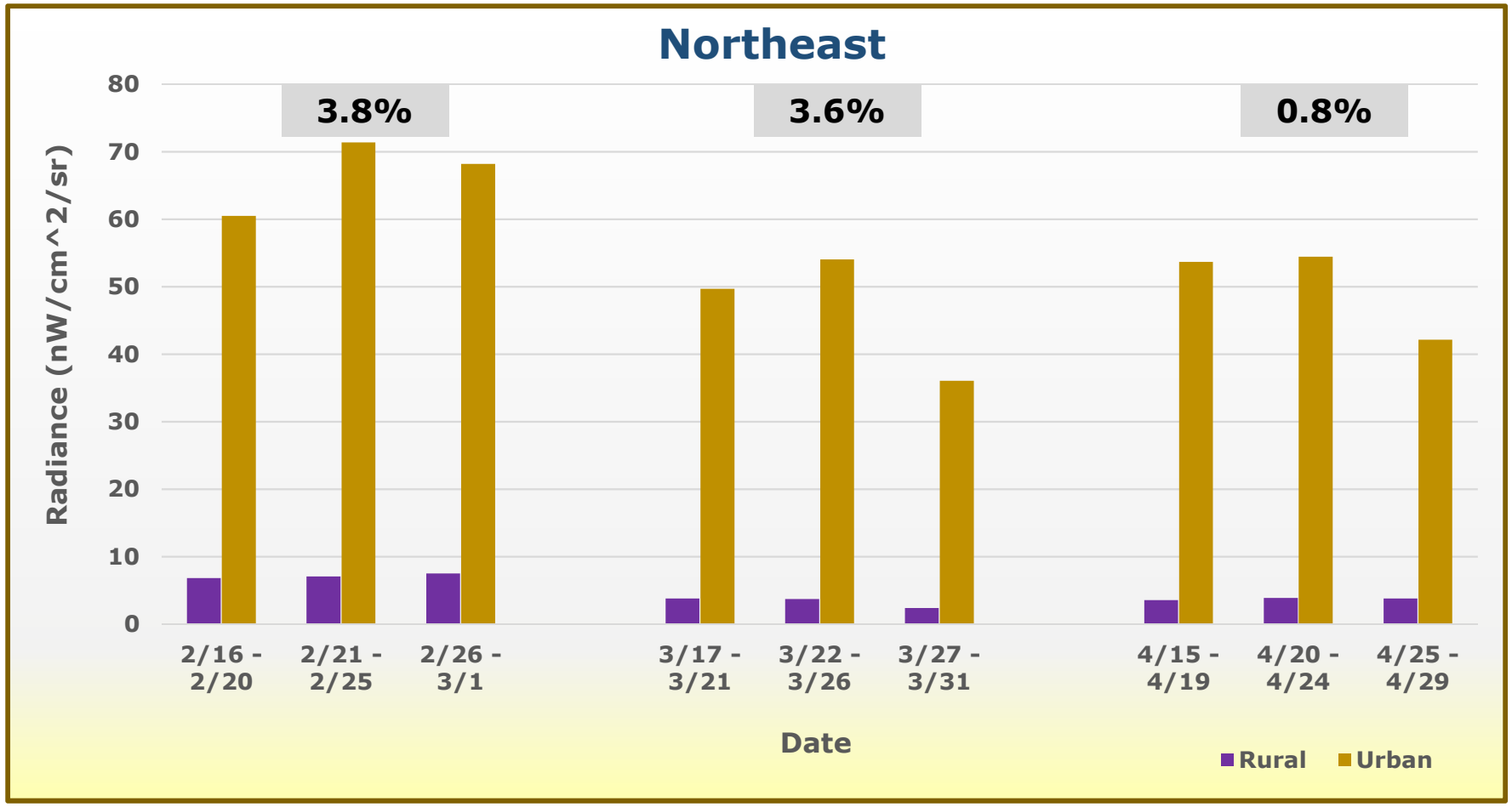

Figure 8: Summary of Northeast radiance in 5-night timeframes, during which the moon was less than 50% full, between 2/16/2020 and 4/29/2020. Radiance values are given in nW/cm^2/steradian. The "Northeast" region includes New York, Massachusetts, Connecticut, Rhode Island, Vermont, and New Hampshire. Percentages in gray text box describe the area that was clouded all five nights. **Quarantine orders were declared between 3/22 - 3/26.** The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata.

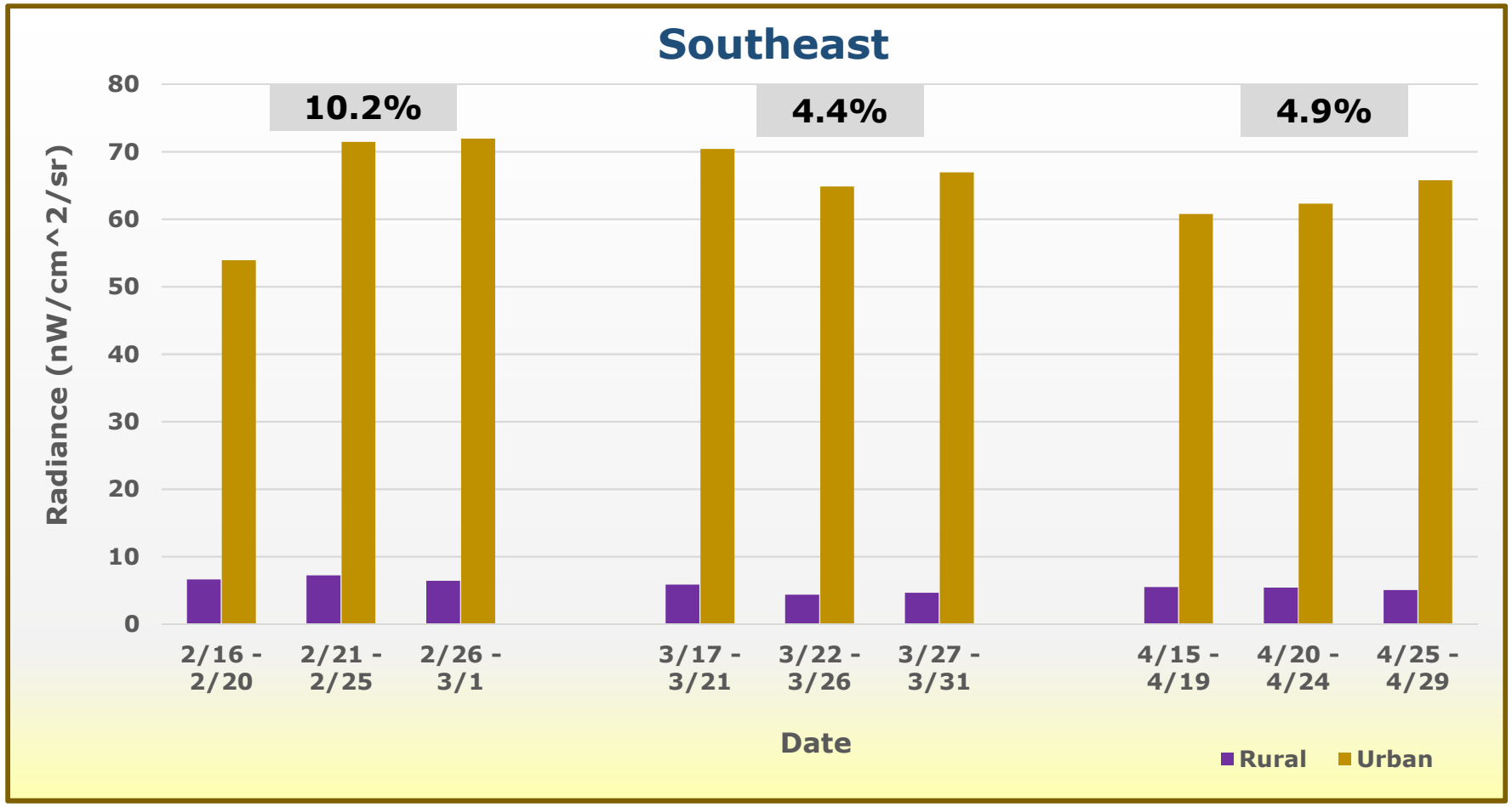

Figure 9: Summary of Southeast radiance in 5-night timeframes, during which the moon was less than 50% full, between 2/16/2020 and 4/29/2020. Radiance values are given in nW/cm^2/steradian. The "Southeast" region includes Alabama, Georgia, and Florida. Percentages in gray text box describe the area that was clouded all five nights. **Quarantine orders were declared between 4/3 – 4/4, outside these time intervals.** The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata.

Monthly Averaged Statistics												
Month/ Region	Northwest				Northeast				Southeast			
	February	March	April	Feb-Apr	February	March	April	Feb-Apr	February	March	April	Feb-Apr
2019 Rural	3.46	2.83	3.01	3.10	6.03	6.91	4.34	5.76	4.90	6.01	6.20	5.70
2020 Rural	3.41	2.13	2.52	2.69	7.13	3.31	3.76	4.74	6.77	4.98	5.31	5.69
2019 Urban	75.42	54.01	43.12	57.52	75.73	91.42	51.99	73.04	65.25	71.95	67.19	68.13
2020 Urban	44.46	39.31	42.00	41.92	66.66	46.59	50.08	54.44	65.77	67.37	62.94	65.36
% Change, Entire Region	-26.10%	-26.24%	-9.20%	-20.51%	-7.55%	-49.51%	-5.24%	-20.77%	6.05%	-8.13%	-7.76%	-3.28%

Table 1: Summary of radiance by month and region, Feb - April 2019 & 2020. 2020 values only include nights when the moon was less than 50% illuminated, in order to minimize error; 2019 values encompass the entire month. Radiance values are given in nW/cm^2/steradian. Yellow cells indicate time when a COVID-19 quarantine order was in effect. "Northwest" region includes ID, OR, and WA. "Northeast" region includes CT, MA, NH, NY, RI, and VT. "Southeast" region includes AL, FL, and GA. The data were detected by the Visible Infrared Imaging Radiometer Suite (VIIRS), and provided by NASA Earthdata and the Colorado School of Mines.