

Brief analysis of Night-Time lights of Russian Federation measured from satellite

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1. Introduction

In this brief analysis, I show that since the invasion of Ukraine, Russia's nighttime lights (NTL), as measured by satellite, have exhibited highly unexpected values¹. The data for this analysis includes NASA's Black Marble project for NTL measurements, GADM data for borders, OpenStreetMap data for cities and towns, and EOG Data Mines for gas flare mapping.

The measurements reveal a significant increase in night-time lights in Russia starting from the year of Ukraine's invasion, in strong contrast to other European countries. Past literature has shown a big correlation between night-time lights and GDP. Among the others, [Henderson et al. \(2012\)](#) and [Chen and Nordhaus \(2011\)](#) have shown that satellite observations of nighttime lights can effectively serve as proxies for economic activity.

Initially, I was surprised to observe a substantial increase in NTL in Russia starting from the year of Ukraine's invasion, especially compared to other European countries. Given the historical correlation between NTL and economic activity, one might expect economic disruptions due to conflict to lead to a decrease in NTL. My current hypothesis is that this increase could be attributed to autarchy and the war economy.

¹Code soon availabe at <https://github.com/nbadino/Russia-NTL>

2. Some details on data

Some of the main sources of measurable nighttime lights, in addition to cities, roads, and other infrastructure, are gas flares and greenhouses. Gas flares, the results of gas

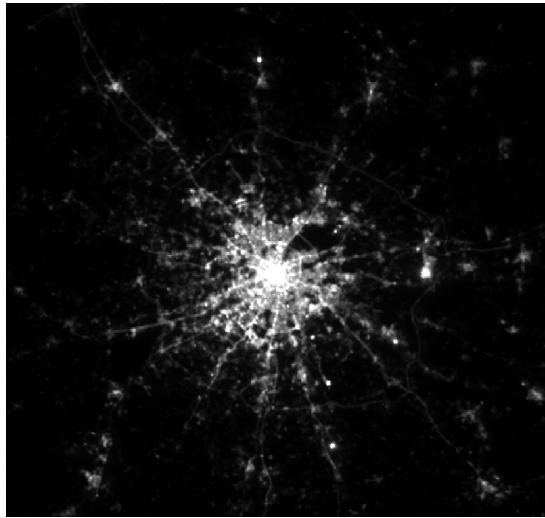


FIGURE 1. Moskow Night-time lights

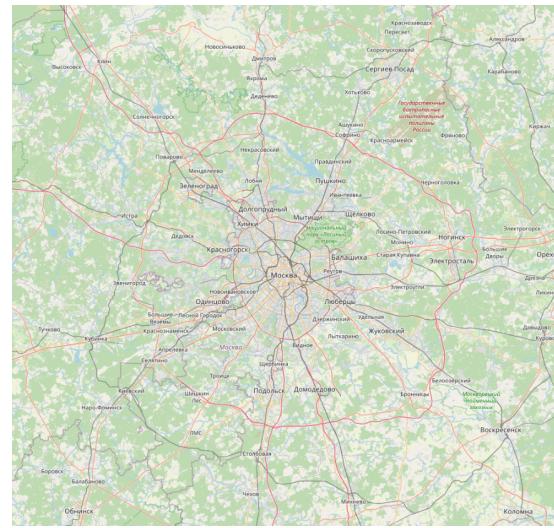


FIGURE 2. Moskow OSM map



FIGURE 3. Greenhouse



FIGURE 4. Gas Flare

extraction, produce significant light visible from space (figure 4). Similarly, greenhouses emit considerable light, particularly those used in large-scale agricultural production (figure 3). To ensure the accuracy of my analysis, I conducted computations both with and without gas flares using EOG Data Mines mapping data of Visible Night Fires

(VNF). This approach allowed to isolate the impact of gas flares on the overall NTL measurements and ensure that the observed increases were not solely attributable to changes in gas flare activity.

3. Some results

I extracted and aggregated the NTL values for Russia and a subset of European countries, including France, Germany, and Italy. Using 2018 as the baseline year (indexed to 100), I generated some graphs to illustrate the trends. For the European countries, NTL

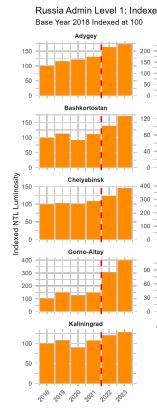


FIGURE 5. Russia group 1



FIGURE 6. Russia group 2

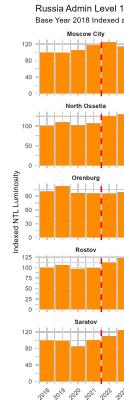


FIGURE 7. Russia group 3



FIGURE 8. Russia group 4

values have shown a slight increase over the past five years (Fig 9, 10, 11). In contrast, Russia's NTL observations have strongly increased. Figures 5, 6, 7, 8 display the NTL measurements for Russian regions from 2018 to 2023. It is evident from these figures that a significant increase in NTL has occurred in all regions since the invasion of Ukraine. I initially suspected that the main source of this increase of NTL was gas flares. With the

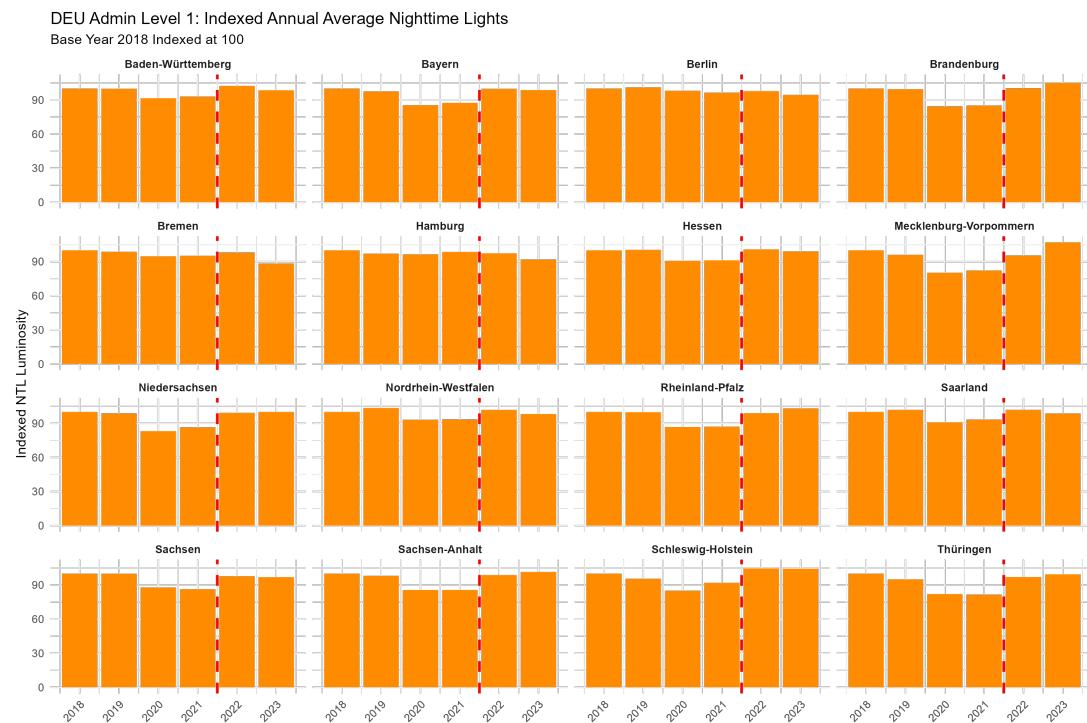


FIGURE 9. Germany NTL 2018-2023. $NTL_{2018} = 100$



FIGURE 10. France NTL 2018-2023. $NTL_{2018} = 100$

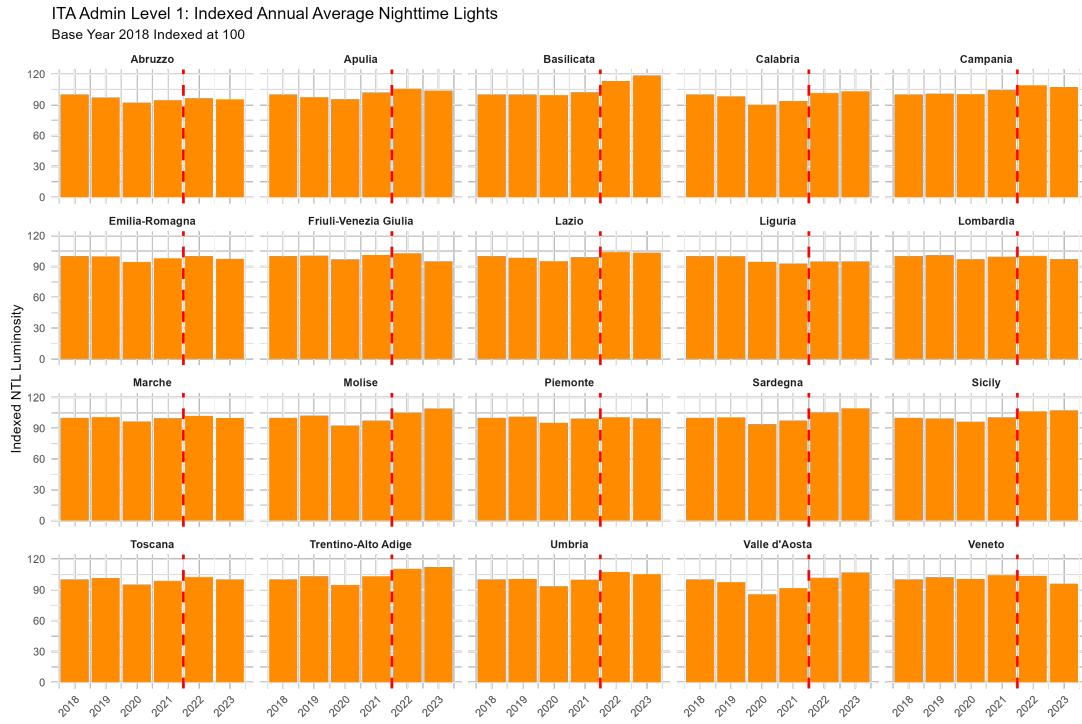


FIGURE 11. Italy NTL 2018-2023. $NTL_{2018} = 100$

reduction of export to Europe, exceeding gas had to be burned. However, masking gas flares sites led only to slightly different results. In table 1 I computed for each region the 5 years percentage variation (1=100%) of NTL for the whole region, for urban areas, and for non-urban areas. Something immediately evident is that night-time lights increased much less in urban areas than elsewhere.

4. Further work

The next step will be computing the distance to military sites using a dataset obtained from the OSINT community. This will allow to investigate whether there is a correlation between the distance to military bases and the percentage growth of Night-Time Lights (NTL). Further analysis should focus on identifying any patterns that may exist and investigating potential sources of NTL anomalies.

TABLE 1. Aggregated Delta Values by Region with and without Gas Flares

Metric	with_flares	without_flares
Adygey		

Non_urban	1.0398878	1.0398878
Overall	0.7321151	0.7321151
Urban	0.1622389	NA

Altay

Non_urban	2.1518866	2.1518866
Overall	1.3039909	1.3039909
Urban	0.7708012	NA

Amur

Non_urban	1.8401915	1.8401915
Overall	1.1845079	1.1845079
Urban	0.4038955	NA

Arkhangel'sk

Non_urban	1.1914880	1.1914880
Overall	1.1610137	1.1610137
Urban	0.8100874	NA

Astrakhan'

Non_urban	0.6158764	0.6493244
Overall	0.4739038	0.4790079
Urban	0.1943851	NA

Bashkortostan

Non_urban	1.0227160	1.1817663
Overall	0.7062831	0.7714205
Urban	0.2298906	NA

Belgorod

Non_urban	0.3231357	0.3231357
Overall	0.2574026	0.2574026
Urban	0.1291160	NA

Bryansk

Non_urban	1.2601974	1.2601974
Overall	0.7918922	0.7918922
Urban	0.3942654	NA

Buryat

Non_urban	3.2745710	3.2745710
Overall	1.3518183	1.3518183
Urban	0.3075080	NA

Chechnya

Non_urban	0.2328748	0.2500013
Overall	0.2899059	0.3052267
Urban	0.4280100	NA

Chelyabinsk

Non_urban	1.2945397	1.2945397
Overall	0.4527137	0.4527137
Urban	-0.0098709	NA

Chukot

Non_urban	2.8269340	2.8269340
Overall	2.8233958	2.8233958
Urban	0.4143318	NA

Chuvash

Non_urban	2.2170074	2.2170074
Overall	1.1964288	1.1964288
Urban	0.5944663	NA

City of St. Petersburg

Non_urban	0.3567383	0.3567383
Overall	0.2458788	0.2458788
Urban	0.2282829	NA

Dagestan

Non_urban	0.4114896	0.4194119
Overall	0.3126316	0.3172930
Urban	0.1762707	NA

Gorno-Altay

Non_urban	3.7661282	3.7661282
Overall	2.9978139	2.9978139

Urban	0.9064460	NA
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Ingush

Non_urban	0.1764083	0.1763706
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Overall	0.1117383	0.1116979
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Urban	-0.0277792	NA
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Irkutsk

Non_urban	0.8611719	1.0731875
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Overall	0.7777847	0.9239691
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Urban	0.4783415	NA
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Ivanovo

Non_urban	2.4053457	2.4053457
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Overall	0.9319525	0.9319525
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Urban	0.2453785	NA
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Kabardin-Balkar

Non_urban	1.1757360	1.1757360
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Overall	0.8410910	0.8410910
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Urban	0.5044288	NA
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Kaliningrad

Non_urban	0.5185546	0.5361474
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Overall	0.2863495	0.2914112
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Urban	0.1408701	NA
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Kalmyk

Non_urban	0.6548097	0.6474985
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Overall	0.7024577	0.6997887
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Urban	0.7837759	NA
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Kaluga

Non_urban	1.1658992	1.1658992
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Overall	0.6023271	0.6023271
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Urban	-0.1032890	NA
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Kamchatka

Non_urban	22.2268873	22.3331771
Overall	17.1815557	17.2450707
Urban	0.3009843	NA

Karachay-Cherkess

Non_urban	0.6644209	0.6644209
Overall	0.3995713	0.3995713
Urban	0.1369126	NA

Karelia

Non_urban	9.9268815	9.9268815
Overall	5.9641192	5.9641192
Urban	0.8015383	NA

Kemerovo

Non_urban	1.2014414	1.2151873
Overall	0.5929161	0.5962976
Urban	0.1692697	NA

Khabarovsk

Non_urban	11.0457172	11.3788526
Overall	4.9914744	5.0525519
Urban	0.5463245	NA

Khakass

Non_urban	1.9089260	1.9089260
Overall	1.5895295	1.5895295
Urban	0.4593278	NA

Khanty-Mansiy

Non_urban	1.4568809	1.8389553
Overall	1.1798764	1.4248395
Urban	-0.1005314	NA

Kirov

Non_urban	1.7603670	1.7603670
Overall	0.7436394	0.7436394
Urban	0.2167646	NA

Komi

Non_urban	4.2474648	4.8458664
Overall	3.4079236	3.7749086
Urban	0.2581763	NA

Kostroma

Non_urban	1.8294609	1.8294609
Overall	0.7505402	0.7505402
Urban	0.2187888	NA

Krasnodar

Non_urban	0.3589050	0.4656483
Overall	0.2622029	0.3165019
Urban	0.1382696	NA

Krasnoyarsk

Non_urban	1.0363326	1.0326848
Overall	1.0196922	1.0160923
Urban	0.3487903	NA

Kurgan

Non_urban	4.2478841	4.2478841
Overall	1.1684427	1.1684427
Urban	0.2564840	NA

Kursk

Non_urban	1.5226232	1.5226232
Overall	0.8957305	0.8957305
Urban	0.4559370	NA

Leningrad

Non_urban	1.2526272	1.2641641
Overall	0.7886216	0.7933294
Urban	0.1852258	NA

Lipetsk

Non_urban	0.4573609	0.4573609
Overall	0.3709206	0.3709206

Urban	0.1116806	NA
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Magadan

Non_urban	8.2844216	8.2844216
Overall	7.2502197	7.2502197
Urban	0.2728498	NA

Mariy-El

Non_urban	1.5170847	1.5404140
Overall	0.5818941	0.5839612
Urban	0.1158236	NA

Mordovia

Non_urban	0.7534641	0.7534641
Overall	0.6552031	0.6552031
Urban	0.3598410	NA

Moscow City

Non_urban	0.2153809	0.2153809
Overall	0.1396876	0.1396876
Urban	0.1221492	NA

Moskva

Non_urban	0.5127551	0.5127551
Overall	0.3869993	0.3869993
Urban	0.1468392	NA

Murmansk

Non_urban	3.7506578	3.7506578
Overall	3.1365825	3.1365825
Urban	1.1542169	NA

Nenets

Non_urban	1.7892410	1.9553412
Overall	1.7601542	1.9206410
Urban	0.2337669	NA

Nizhegorod

Non_urban	0.8373572	0.8447292
Overall	0.4349866	0.4350768
Urban	0.1513736	NA

North Ossetia

Non_urban	0.4067324	0.4067324
Overall	0.2965040	0.2965040
Urban	0.1036274	NA

Novgorod

Non_urban	1.6210239	1.6210239
Overall	1.0044770	1.0044770
Urban	0.1265066	NA

Novosibirsk

Non_urban	1.3202869	1.3341747
Overall	0.8117713	0.8164103
Urban	0.3724947	NA

Omsk

Non_urban	2.2271456	2.7952822
Overall	0.7038046	0.7419663
Urban	0.2500375	NA

Orel

Non_urban	1.9383817	1.9383817
Overall	1.1382137	1.1382137
Urban	0.3136218	NA

Orenburg

Non_urban	-0.0301752	0.0511926
Overall	-0.0195831	0.0568633
Urban	0.0889939	NA

Penza

Non_urban	0.6819607	0.6819607
Overall	0.3088477	0.3088477
Urban	0.1048735	NA

Perm'

Non_urban	1.9102508	2.1791475
Overall	0.9715292	1.0269334
Urban	0.2336668	NA

Primor'ye

Non_urban	1.5641112	1.5641112
Overall	0.8552641	0.8552641
Urban	0.3420112	NA

Pskov

Non_urban	2.8814704	2.8814704
Overall	1.1168777	1.1168777
Urban	0.1586316	NA

Rostov

Non_urban	0.5217173	0.5240340
Overall	0.2256234	0.2258575
Urban	0.0263035	NA

Ryazan'

Non_urban	1.4273511	1.4662238
Overall	0.8867311	0.8977739
Urban	0.4138006	NA

Sakha

Non_urban	1.6981583	1.7000171
Overall	1.6854466	1.6872584
Urban	0.2317105	NA

Sakhalin

Non_urban	0.7595972	0.9784443
Overall	0.6243673	0.6964821
Urban	0.4904772	NA

Samara

Non_urban	0.5128190	0.5963607
Overall	0.1971859	0.2029875

Urban	-0.0168795	NA
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Saratov

Non_urban	0.5427445	0.7259981
Overall	0.2440187	0.2826595
Urban	0.0241561	NA

Smolensk

Non_urban	2.0939688	2.0939688
Overall	1.3095321	1.3095321
Urban	0.6668708	NA

Stavropol'

Non_urban	0.6607220	0.7854512
Overall	0.5253918	0.5836456
Urban	0.3043191	NA

Sverdlovsk

Non_urban	0.9043259	0.9043229
Overall	0.4692953	0.4692939
Urban	0.0917561	NA

Tambov

Non_urban	1.3365715	1.3365715
Overall	1.2937430	1.2937430
Urban	1.2375017	NA

Tatarstan

Non_urban	0.6561413	0.7453911
Overall	0.4194031	0.4448587
Urban	0.2205981	NA

Tomsk

Non_urban	0.4951881	0.8111738
Overall	0.4485184	0.6795927
Urban	0.2242659	NA

Tula

Non_urban	0.8654094	0.8654094
Overall	0.5879335	0.5879335
Urban	0.1998987	NA

Tuva

Non_urban	4.5422694	4.5422694
Overall	1.8032658	1.8032658
Urban	0.6430642	NA

Tver'

Non_urban	1.7000984	1.7000984
Overall	1.0309023	1.0309023
Urban	0.2084947	NA

Tyumen'

Non_urban	1.9125569	2.2146111
Overall	0.9477447	0.9955361
Urban	0.3454999	NA

Udmurt

Non_urban	1.1015337	1.1001522
Overall	0.7488611	0.7393803
Urban	0.3766830	NA

Ul'yanovsk

Non_urban	1.3032866	1.3032866
Overall	0.7639909	0.7639909
Urban	0.1567503	NA

Vladimir

Non_urban	1.4409567	1.4409567
Overall	0.9234143	0.9234143
Urban	0.3225844	NA

Volgograd

Non_urban	0.4227483	0.5366310
Overall	0.3772247	0.4166195
Urban	0.3475098	NA

Vologda

Non_urban	4.5367318	4.5367318
Overall	2.1699536	2.1699536
Urban	0.5620933	NA

Voronezh

Non_urban	1.0029359	1.0029359
Overall	0.5677536	0.5677536
Urban	0.2157114	NA

Yamal-Nenets

Non_urban	1.0645459	1.1287277
Overall	1.0603704	1.1220606
Urban	0.9060437	NA

Yaroslavl'

Non_urban	1.5128095	1.5391783
Overall	0.8453211	0.8523091
Urban	0.1518772	NA

Yevrey

Non_urban	1.0313258	1.0313258
Overall	0.6462542	0.6462542
Urban	0.0963679	NA

Zabaykal'ye

Non_urban	1.8572596	1.8572596
Overall	1.2284378	1.2284378
Urban	0.3920175	NA

NA

Non_urban	NA	NA
Overall	NA	NA
Urban	0.8091173	NA

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