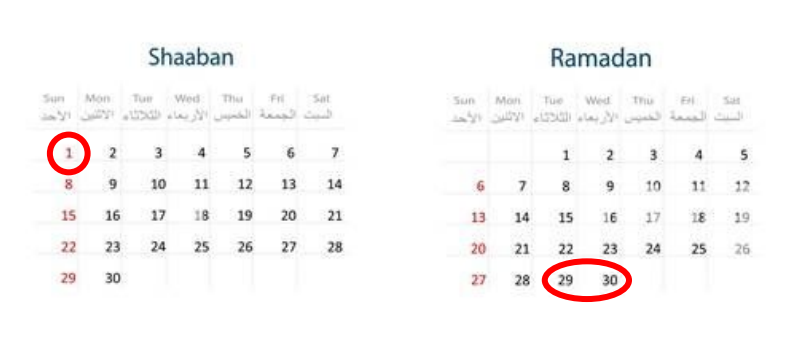
CAN WE “MEASURE” RELIGIOSITY IN CENTRAL ASIA USING SATELLITE DATA?

Ainur, Madina and Shohruh

Scope

Control date: first day of 8th Hijri month (Shaaban month)

Focus date: last day of 9th Hijri month (Ramadan month)



Year	Control date	Focus date
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2015	19 May 2015	16 July 2015*
2016	8 May 2016	5 July 2016
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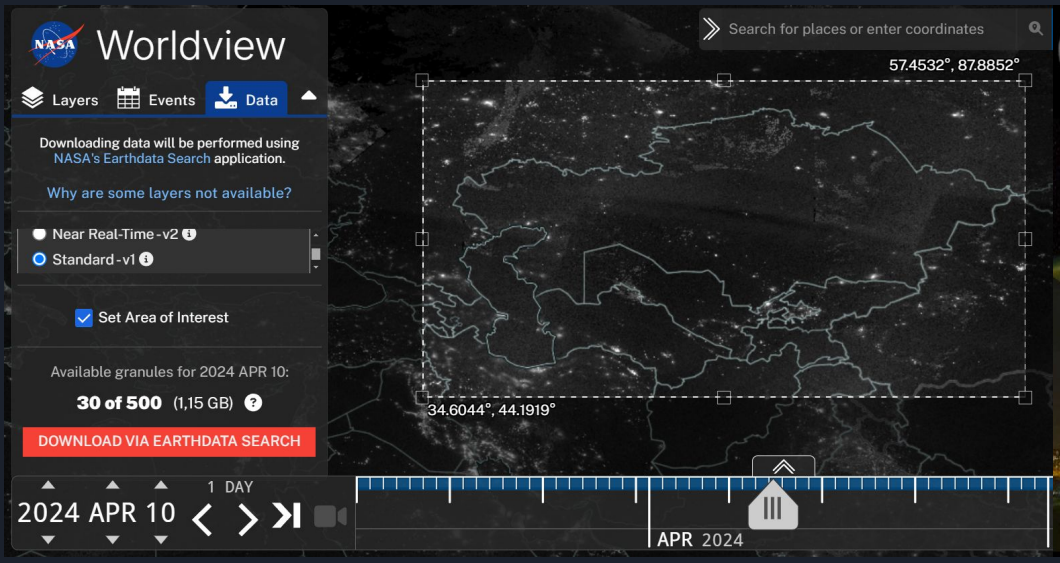
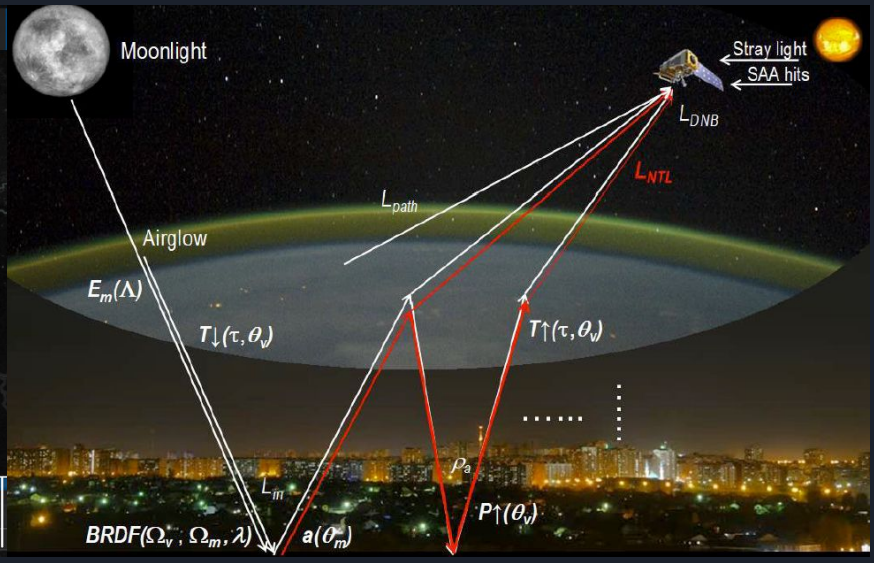
*Note: Ramadan in that year had only 29 days.

Satellite Data Source

- **NASA Worldview** (https://worldview.earthdata.nasa.gov/) - VNP46A1 (Visible Infrared Imaging Radiometer Suite (VIIRS) supports a Day-Night Band (DNB) sensor)





Methodology

- Extract Nighttime Radiance figures

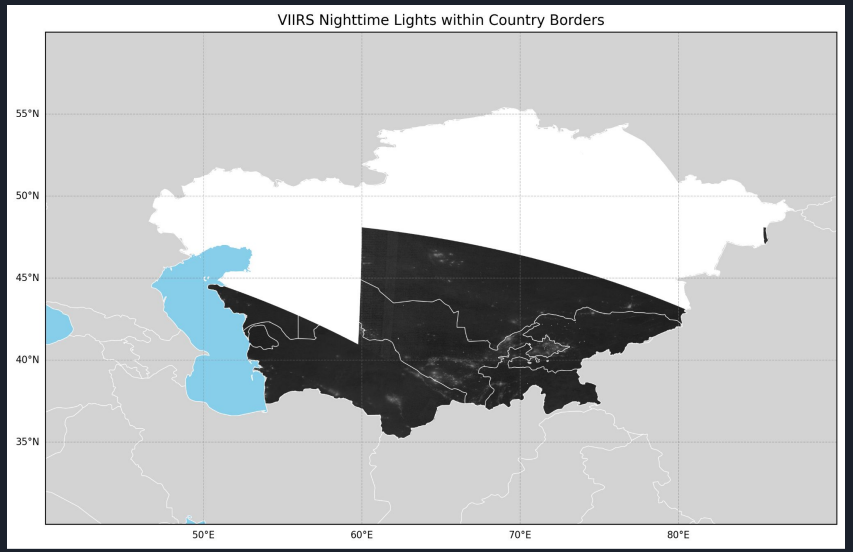
  Range: Treat date and Control date of each year

  Geography: Country or Regions of Countries

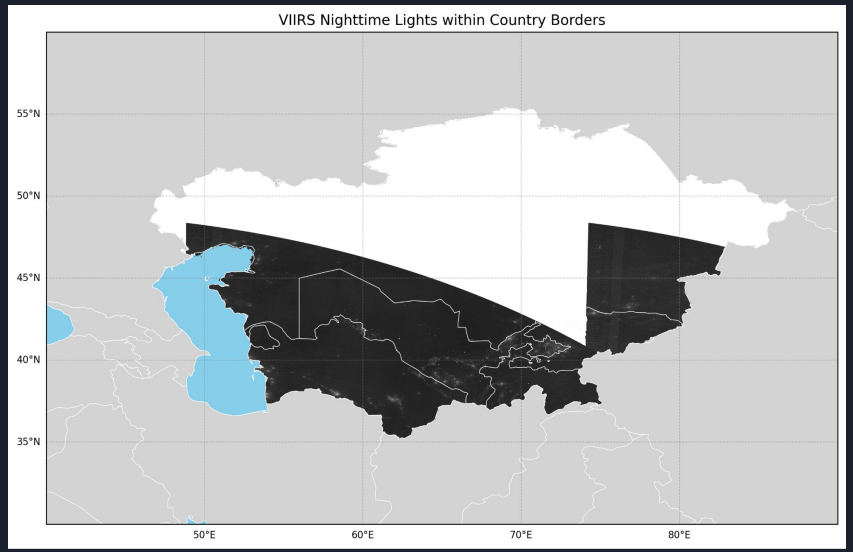
- Calculate Delta: Change of luminosity in Percentage
- Compare Deltas over time

$$\Delta\text{Radiance} = \frac{\text{Radiance}_{\text{Treat}} - \text{Radiance}_{\text{Control}}}{\text{Radiance}_{\text{Control}}}$$

Issues encountered

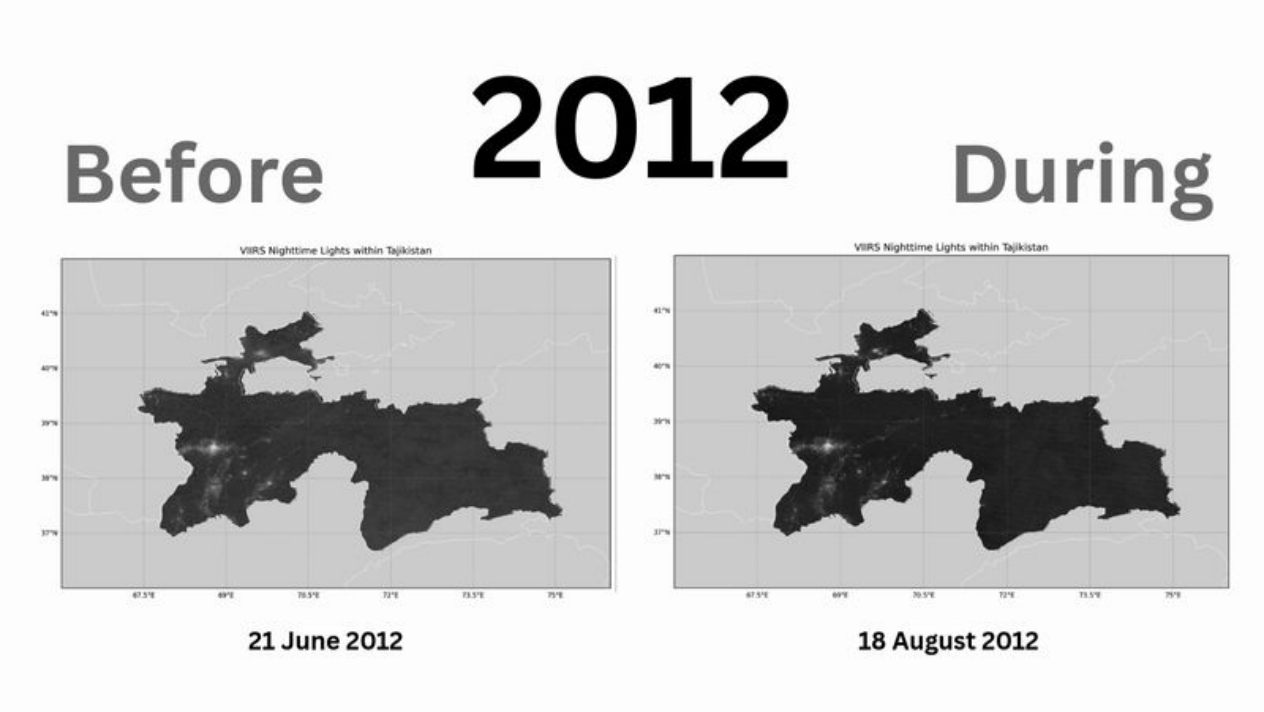


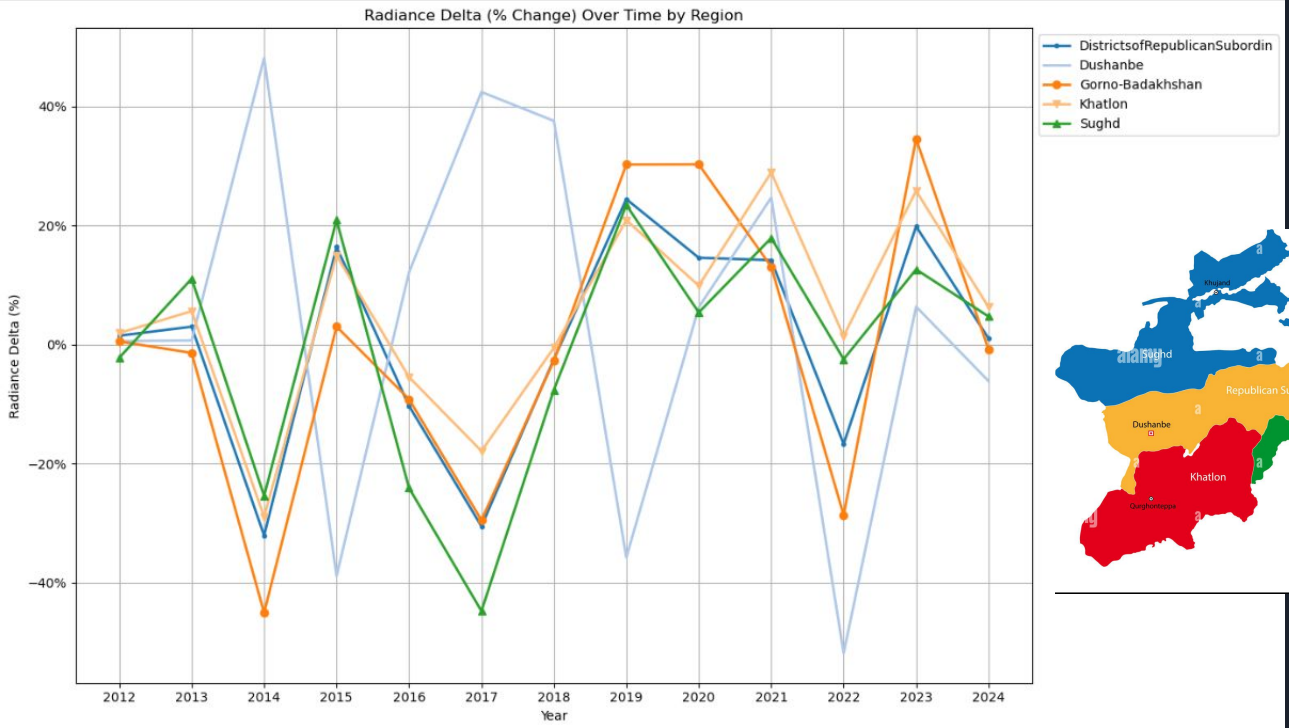
30 May 2014

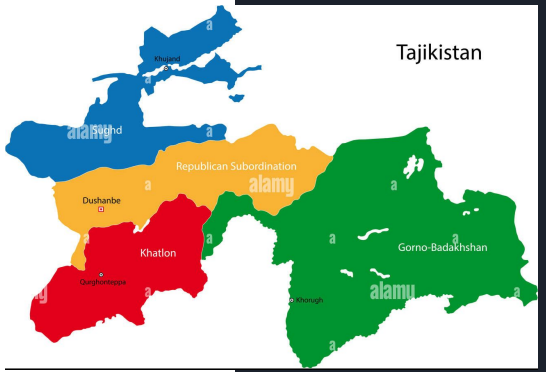


10 June 2013

Tajikistan


Before
2012
During
VIIRS Nighttime Lights within Tajikistan
VIIRS Nighttime Lights within Tajikistan
21 June 2012
18 August 2012





2014, 2017, 2022: Radiance decline across regions — possible reasons might be longer fasts (summer), economic issues, or energy shortages.

2019, 2023: Radiance spikes — possibly reflecting economic recovery or post-COVID effects.

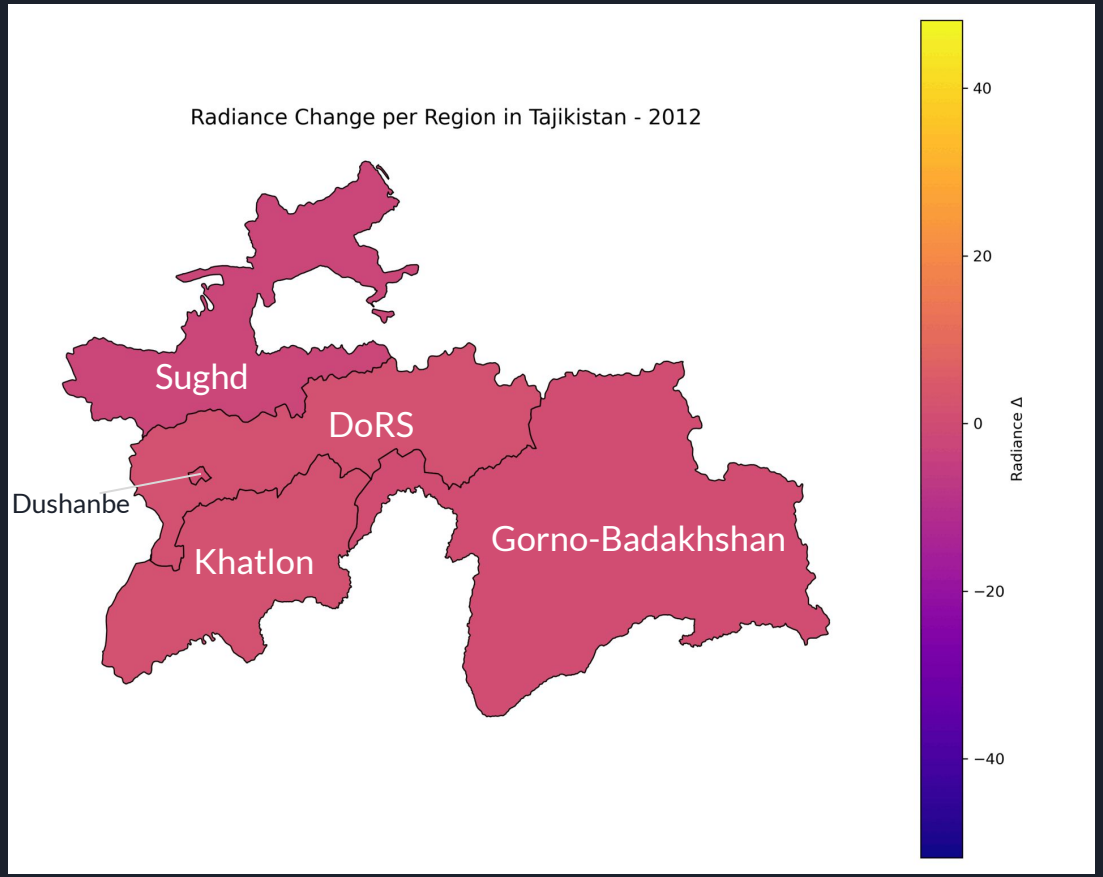
Dushanbe: Shows high variability and the highest radiance, likely due to being most populated and highly urbanized.

Gorno-Badakhshan: Also shows variability, possibly linked to infrastructure shifts.

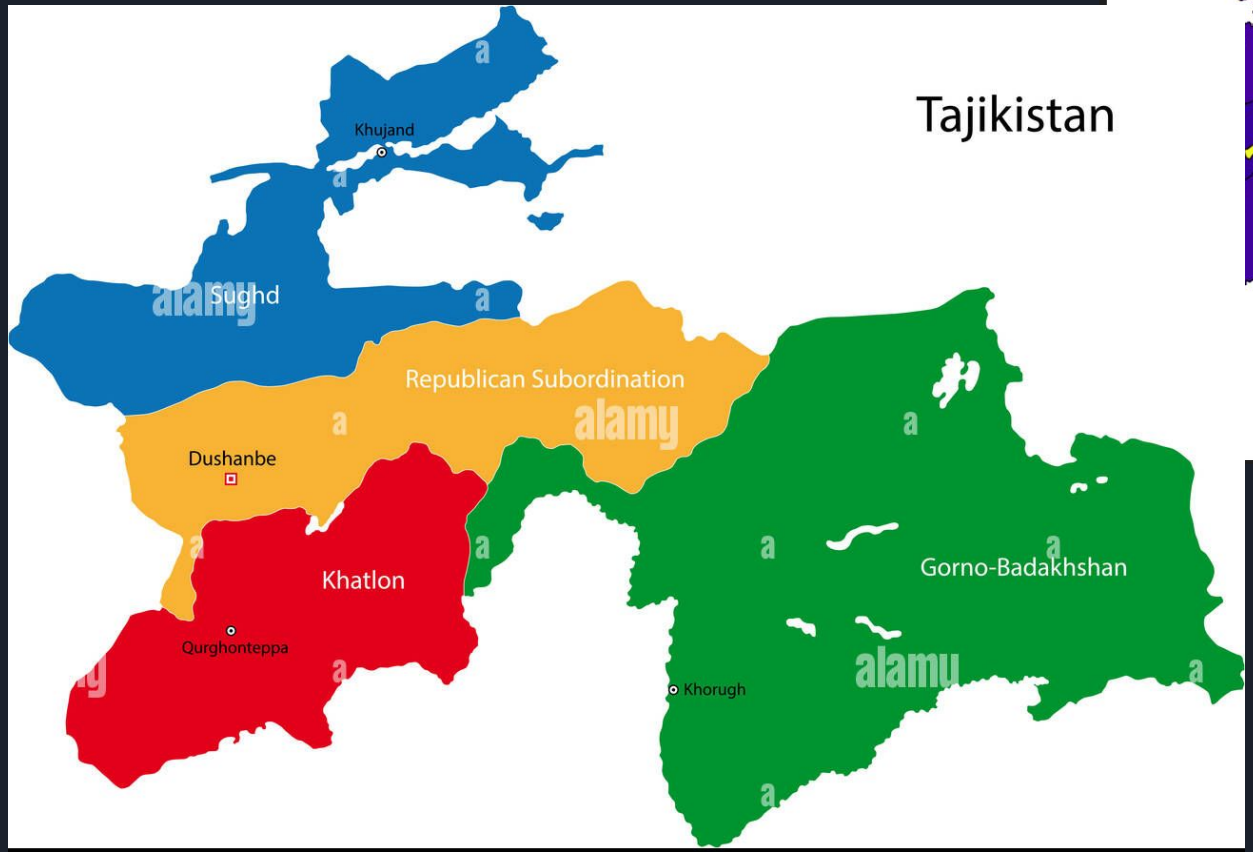
Sughd, Khatlon, DoRS: Stable patterns → consistent, less intense Ramadan shifts.

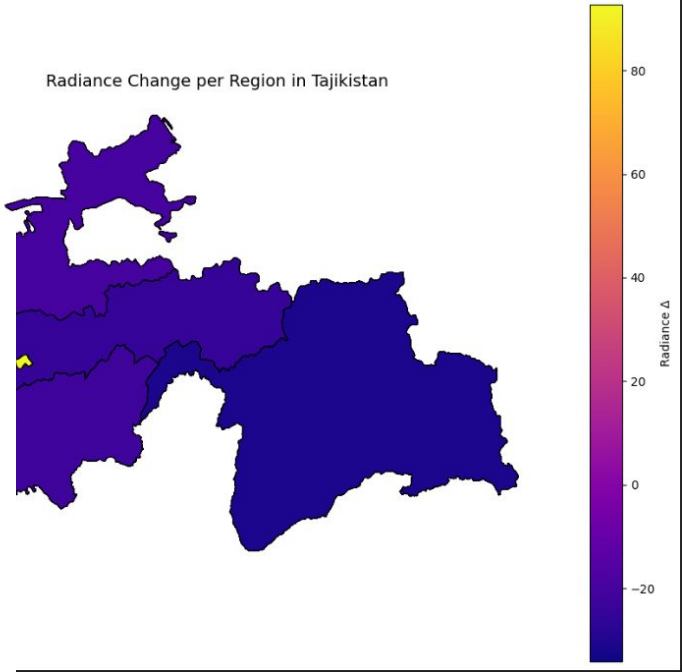
Limitations: Clouds & atmosphere can obscure satellite data, reducing accuracy.

Potential Improvements: With more data & storage, ML models could help remove cloud/noise interference.



Thank you!


Tajikistan
Khujand
Sughd
Republican Subordination
Dushanbe
Khatlon
Qurghonteppa
Gorno-Badakhshan
Khorugh


Radiance Change per Region in Tajikistan
80
60
40
20
0
−20
Radiance Δ

CAN WE “MEASURE” RELIGIOSITY IN CENTRAL ASIA USING SATELLITE DATA?

Ainur, Madina and Shohruh

Night Activity during Ramadan month

Ramadan:

- Holy month for Muslims
- Fasting from Dawn till Sunset
- Last meal with Prayers is at Dawn
- Increased Nighttime activity at Mosques and Cafes
- 9th month of Islamic Hijri calendar (based on lunar months)

Inspired by Livny (2021)

Hypothesis: The study hypothesizes that night-lights are affected by the behavior of fasting Muslims during Ramadan, especially where daytime activities remain unchanged.

Method: The author proposes using satellite imagery to estimate religiosity across small geographic units.

Case Study: Turkey

Public Opinion Quarterly, Vol. 85, Special Issue, 2021, pp. 371–398

CAN RELIGIOSITY BE SENSED WITH SATELLITE DATA?
AN ASSESSMENT OF LUMINOSITY DURING RAMADAN IN TURKEY

AVITAL LIVNY*

Abstract Social scientists have long been interested in how religious beliefs and practices impact and are impacted by socio-political and economic processes. Most recently, scholarly attention has focused on the interplay between religiosity and local actors, events, and institutions. Until now, measures of religiosity have relied heavily on self-reports in surveys, but these cannot always be safely collected and tend to be costly. Even where available, survey-based measures may be too obtrusive and are rarely representative of sub-national units. Here, I propose an inexpensive method that uses satellite imagery to unobtrusively estimate religiosity across small geographic units. I hypothesize that night-lights are affected by the behavior of fasting Muslims during Ramadan, especially in places where daytime activities are otherwise unchanged (i.e., where there is no "day-night inversion"). I explore and confirm the validity of this measurement strategy in the Turkish case, using a series of high-quality surveys and electoral results, representing 973 administrative districts. I conclude with a discussion of the external validity of this method and an overview of the ethical concerns raised by the use of remote sensing to estimate religiosity, in the Muslim world and elsewhere.

AVITAL LIVNY is an assistant professor in the Department of Political Science at the University of Illinois at Urbana-Champaign, Urbana, IL, USA. The author thanks Adi Greif, Laura Sellers, Dan Shalmon, Jared Rubin, four anonymous reviewers, and the editorial team at *POQ* for their comments and advice. The author also thanks participants at conferences organized by the American Political Science Association, the Association for Analytical Learning about Islam and Muslim Societies, and the Association for the Study of Religion, Economics, and Culture, as well as those at seminars hosted at the Middle East Initiative at Harvard Kennedy School, the University of Illinois at Urbana-Champaign, the University of Wisconsin, Madison, and Vanderbilt University. Thanks to Lingyi Xu, Eli Yu, and Dennis Zhao for exceptional research assistance, to the Cline Center for Advanced Social Research for technical support, and to KONDA Research and Consultancy for the generous use of their data. *Address correspondence to Avital Livny, University of Illinois at Urbana-Champaign, Department of Political Science, 1407 West Gregory Drive, Urbana, IL 61801, USA; email: alivny@illinois.edu.

doi:10.1093/poq/nfab013 Advance Access publication September 1, 2021

Inspired by Livny (2021)

Data: The study uses raw images from NASA satellites from January 2012 through January 2020, covering 97 lunar months, including eight Ramadans (2012–2019).

Findings: The study finds consistent evidence that Ramadan luminosity is related to self-reported religiosity.

Conclusion: The study concludes that changes in nighttime luminosity during Ramadan is a valid proxy for religiosity across sub-national units in Turkey.

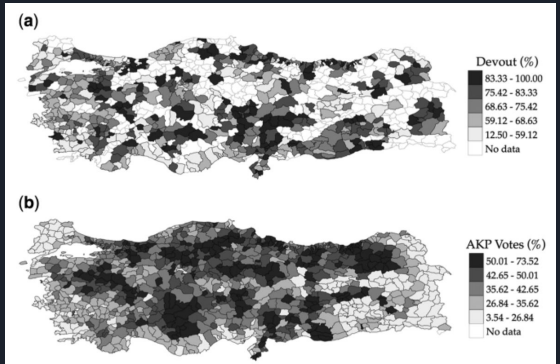


Figure 1. Variation in religiosity, across Turkish districts (*İlçeler*). Figure 1a illustrates variation in the percentage of survey respondents who say they are devout, calculated from 146,973 respondents across 55 KONDA Barometer surveys (March 2010–September 2015). Figure 1b illustrates district-level variation in average support for the AKP across all general elections in which it has competed (2002–2018).

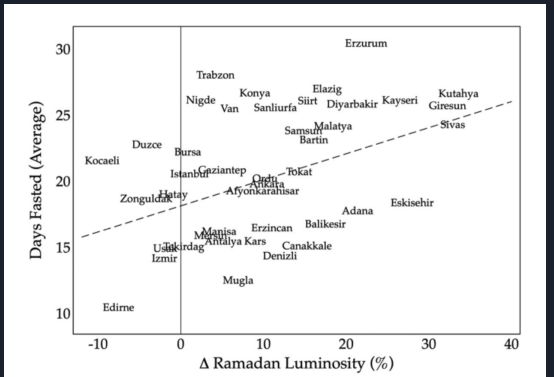


Figure 3. Changes in Ramadan night-lights and self-reported fasting. Percent change in night-lights during Ramadan (2012–2019), compared to average number of days fasted during Ramadan, within provinces (*iller*).

Researches

- **Bahammam and et al., 2013**
  - Research indicates that Muslims tend to delay their bedtime and wake-up times during Ramadan, due to late-night prayers and meals
- **NASA Earth Observatory, 2014**
  - Scientists using a NASA-NOAA satellite announced that they had detected significant changes in the amount and distribution of nighttime lighting during Ramadan. For instance, nighttime lights in some Middle East cities were 50 to 100 percent brighter during the holy month of Ramadan
- **Alahmadi and et al., 2023**
  - during Ramadan, there was a noticeable increase in nighttime light intensity, reflecting heightened nocturnal activities associated with the holy month post-COVID-19

Our Project

Statistics of Muslim Population in CA

Kazakhstan: 71% of the population (2021)

Kyrgyzstan: Around 90.6% (2022)

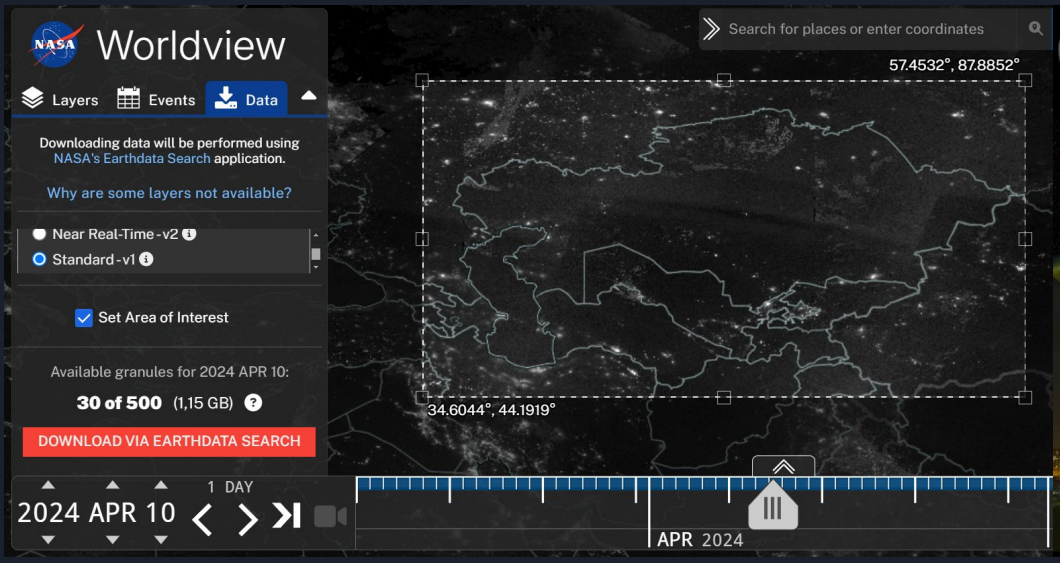
Tajikistan: Approximately 98% (2022)

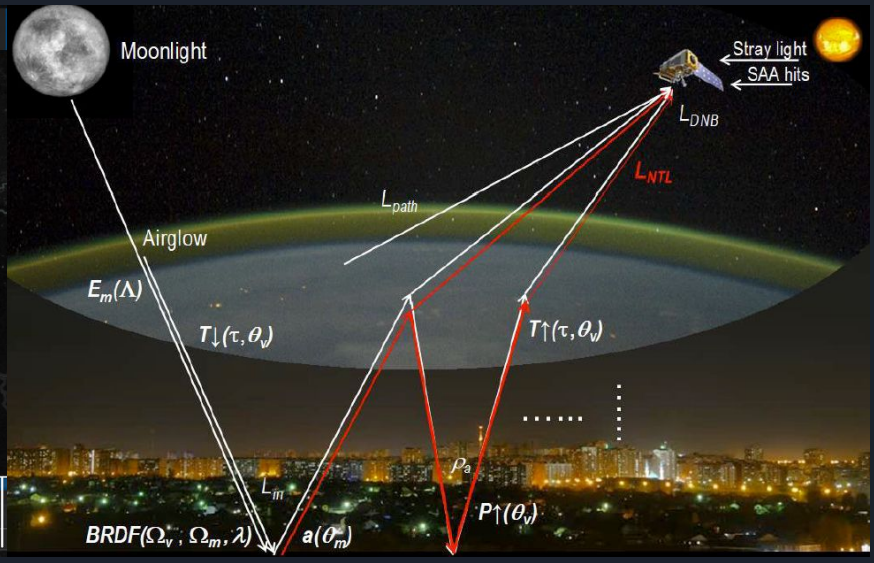
Turkmenistan: About 96.1% (2022)

Uzbekistan: Approximately 96.5% (2022)

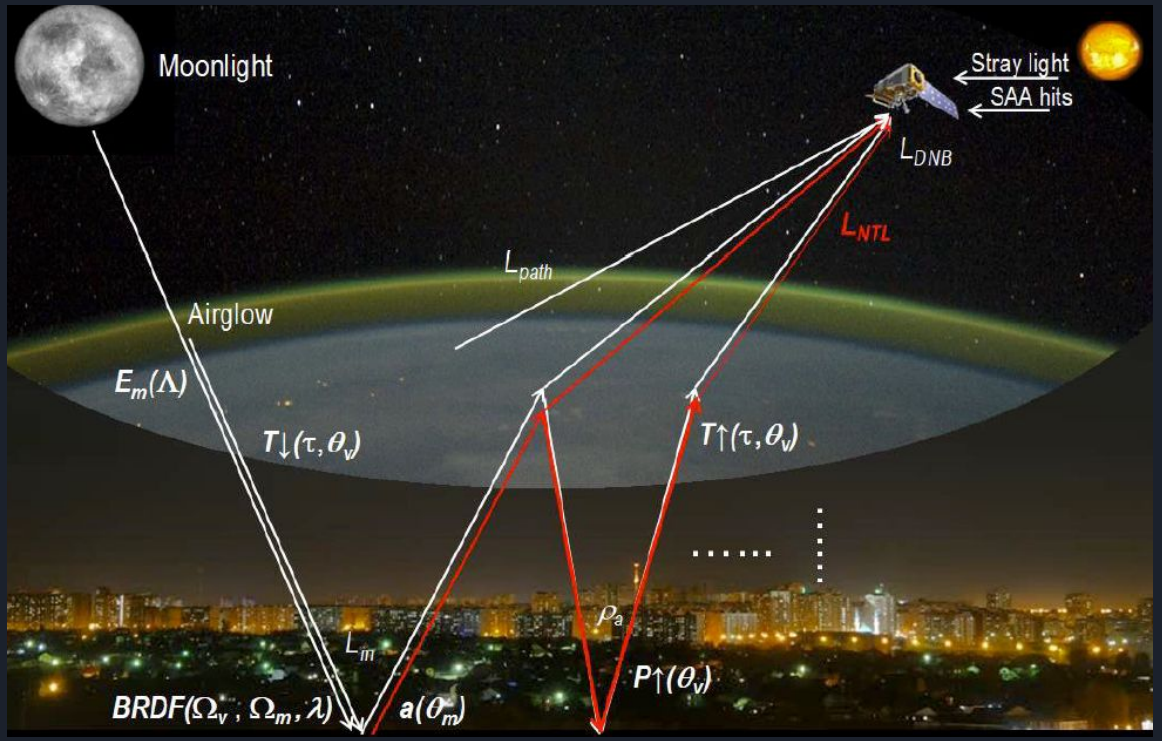
Satellite Data Source

- **NASA Worldview** (https://worldview.earthdata.nasa.gov/) - VNP46A1 (Visible Infrared Imaging Radiometer Suite (VIIRS) supports a Day-Night Band (DNB) sensor)

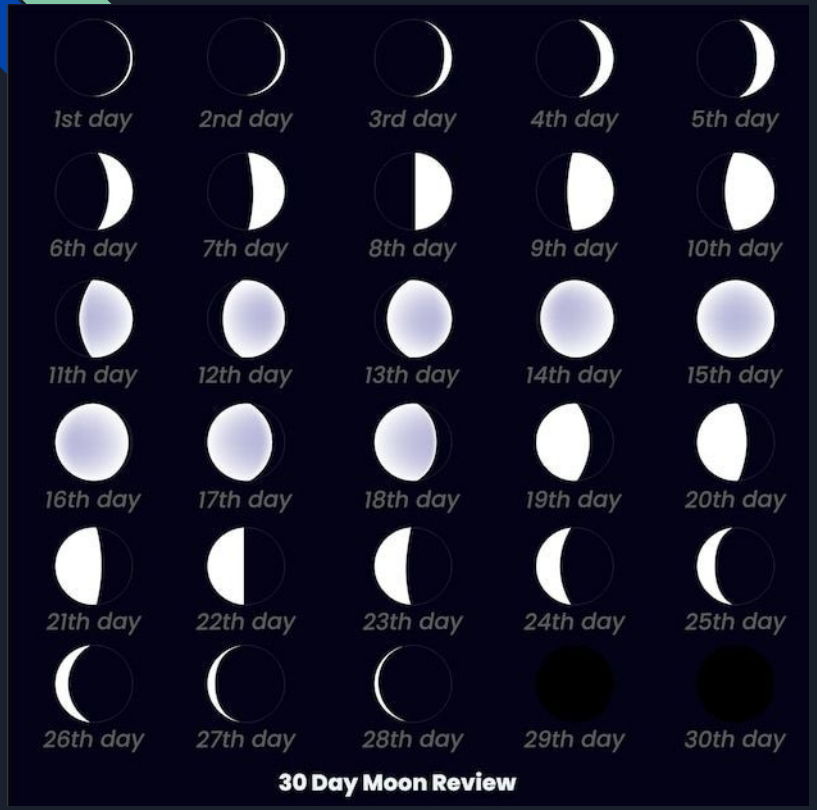




Overview of NASA's Black Marble retrieval strategy



(Wang, 2022)


1st day
2nd day
3rd day
4th day
5th day
6th day
7th day
8th day
9th day
10th day
11th day
12th day
13th day
14th day
15th day
16th day
17th day
18th day
19th day
20th day
21th day
22th day
23th day
24th day
25th day
26th day
27th day
28th day
29th day
30th day
30 Day Moon Review


New
First Quarter
Full
Third Quarter

Scope

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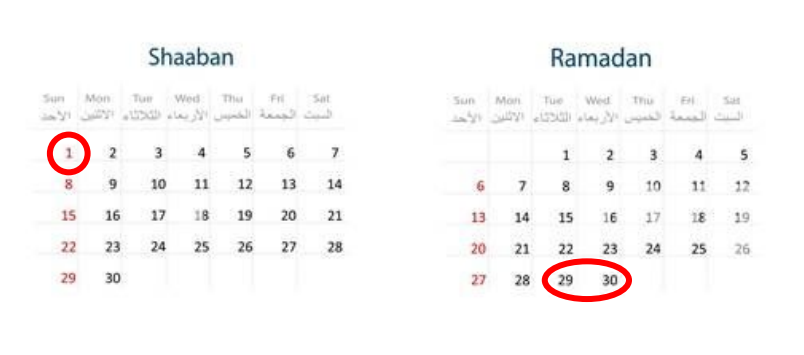
Focus date: last day of 9th Hijri month (Ramadan month)



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*Note: Ramadan in that year had only 29 days.

Scope

5 Central Asian countries:

- Kazakhstan
- Uzbekistan
- Kyrgyzstan
- Tajikistan
- Turkmenistan

Methodology

- Extract Nighttime Radiance figures

  Range: Treat date and Control date of each year

  Geography: Country or Regions of Countries

- Calculate Delta: Change of luminosity in Percentage
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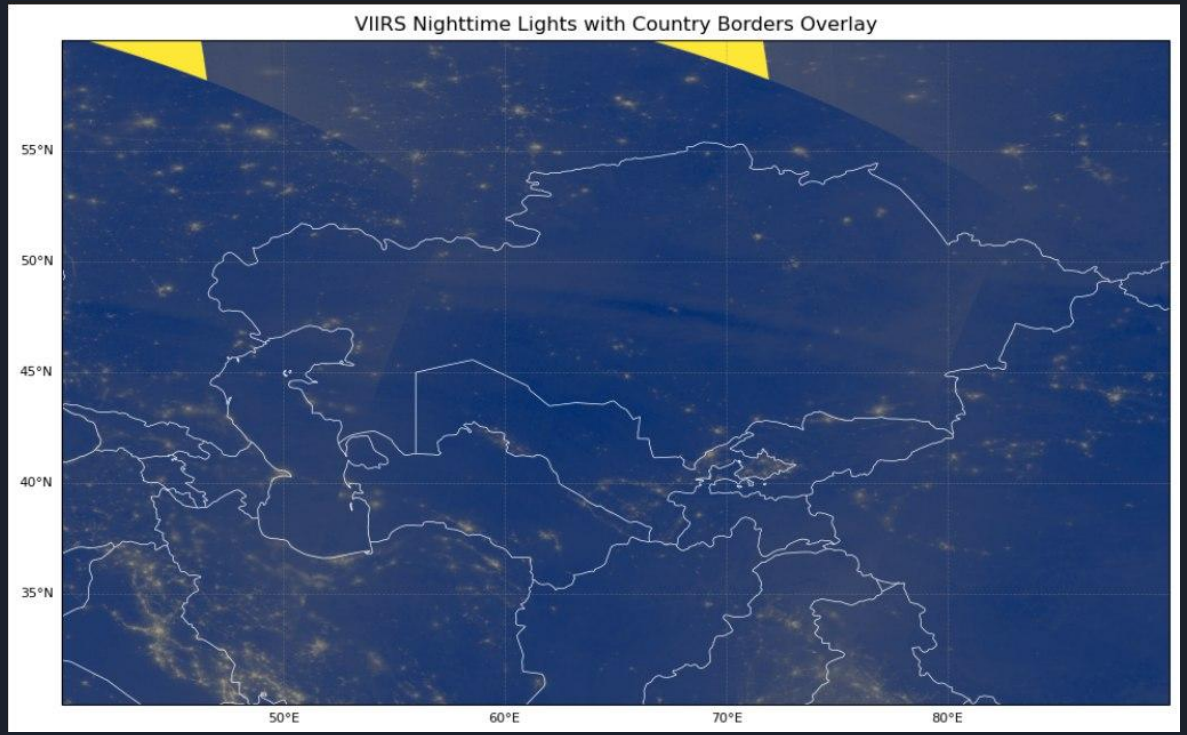
Progress


VIIRS Nighttime Lights with Country Borders Overlay
55°N
50°N
45°N
40°N
35°N
50°E
60°E
70°E
80°E


Russia
Kazakhstan
Caspian Sea
Uzbekistan
Kyrgyzstan
Turkmenistan
Tajikistan
Georgia
Armenia
Azerbaijan
China


Petropavl
SOLTÜSTIK QAZ.
Qostanai
QOSTANAİ
Kökşetau
AQMOLA
ASTANA
Pavlodar
PAVLODAR
Oral
BATYS QAZ.
Aqtöbe
AQTÖBE
Semei
Öskemen
ŞYĞYS QAZ.
ABAİ
Qarağandy
QARAĞANDY
ATYRAU
Atyrau
ÜLYTAU
Jezqazğan
JETISU
Taldyqorğan
QYZYLORDA
Aqtau
MAŃGYSTAU
Qyzylorda
JAMBYL
Qonaev
Almaty
ALMATY
Taraz
Türkıstan
Şymkent
TÜRKISTAN


Uzbekistan


Balkan
Daşoguz
Lebap
Ahal
Ashgabat
Mary