Monitoring of Light Pollution

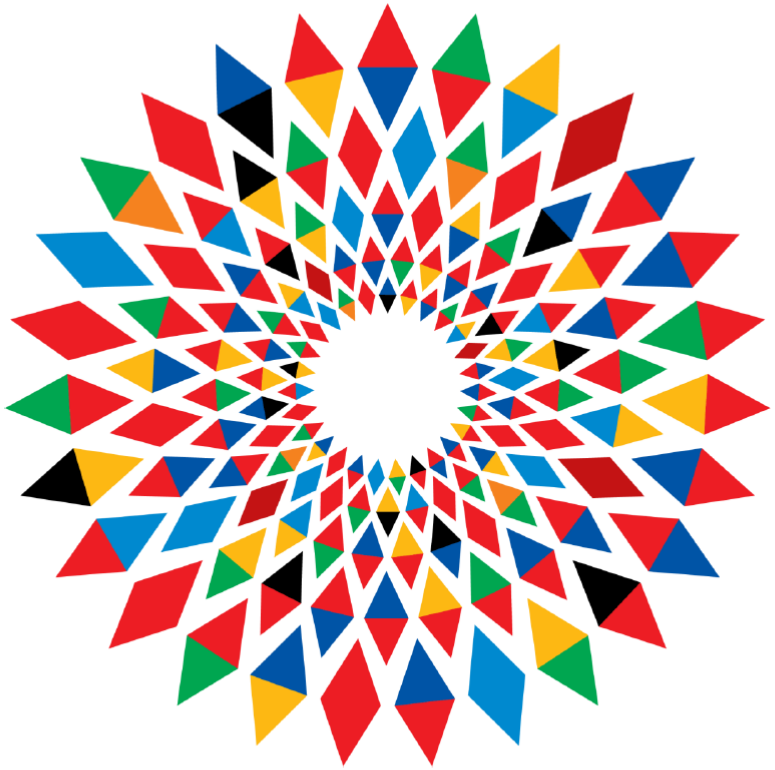
Dr. Alejandro Sánchez de Miguel

Summary of the Meeting on Light Pollution:
Challenges and Responses for Monitoring it.
Granada 14-15 of November 2023

PRESIDENCIA ESPAÑOLA CONSEJO DE LA UNIÓN EUROPEA
RED ESPAÑOLA DE ESTUDIOS SOBRE CONTAMINACIÓN LUMÍNICA
IAA INSTITUTO DE ASTROFÍSICA DE ANDALUCÍA
CSIC
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

EU2022.CZ

Czech Presidency of the Council
of the European Union



The 'Brno appeal to reduce light pollution in Europe'

We, participants of the international workshop Light Pollution 2022, held on October 26th 2022 in Brno, Czech Republic,

acknowledging the scientific evidence on effects of light on living organisms during the night, including sleep disturbance, suppression of hormone secretion, alteration of migration, mating, feeding, predatory and other types of behaviour, distortion of vegetation periods, and others,

expressing concern over satellite data showing that global light pollution has increased by at least 49% over the 25 years to 2017[1] and that there are hardly any areas with complete night darkness left in Europe[2],

emphasizing the need to protect the night environment and thus to prevent and reduce light pollution and its impacts on biodiversity and ecosystems, human health and well-being, and astronomy,

recalling the many internationally accepted documents in support of the protection of the night environment, such as, but not limited to: Declaration on the Reduction of Adverse Environmental Impacts on Astronomy, adopted at the meeting IAU/ICSU/UNESCO (1992), the IAC/UNESCO/UNWTO/IAU/UNEP-CMS/Ramsar-Convention International Declaration in Defence of the Night Sky and the Right to Starlight, adopted during the Starlight Conference (2007), the UN CMS Resolution 13.5 on Light Pollution Guidelines for Wildlife, the UNEP/EUROBATS Resolution 8.6 Bats and Light Pollution and the Dark and Quiet Skies for Science and Society,

noting that switching to LED light sources, although they may be more energy-efficient than many predecessing light sources, may lead to a rebound effect of increased lighting levels and a higher amount of blue light emitted due to their spectral composition,

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[1] Sánchez de Miguel, Alejandro, Bennie, Jonathan, Rosenfeld, Emma, Dzurjak, Simon and Gaston, Kevin J. (2021) First Estimation of Global Trends in Nocturnal Power Emissions Reveals Acceleration of Light Pollution. *Remote Sensing* [online]. **13**(16). ISSN 2072-4292. doi:10.3390/rs13163311

[2] Falchi, Fabio, Cinzano, Pierantonio, Duriscoe, Dan, Kyba, Christopher, Elvidge, Christopher, Baugh, Kimberly, Portnov, Boris, Rybnikova, Nataliya and Furgoni, Riccardo. (2016) The new world atlas of artificial night sky brightness. *Science Advances*. 2. e1600377-e1600377. 10.1126/sciadv.1600377.

Scientific Advice for Policy-Makers

Light Pollution: Challenges and Responses for Monitoring

Introduction

This document encapsulates the outcomes of the Light Pollution Meeting convened in Granada during the Spanish Presidency of the European Council from 14-15 November 2023. It delineates shared perspectives and considerations regarding the imperative to confront light pollution at the European Union (EU) level through the formulation of policies and legislation. Additionally, it addresses methodologies and approaches for the measurement and monitoring of light pollution.

The principal objective of formulating the manifesto is to instigate a political discourse on the escalating concern of light pollution and to facilitate the adoption of appropriate measures aimed at mitigating the adverse impacts of light pollution on the night sky, the environment, human health, and energy efficiency.

Ecosystems have developed with natural patterns of daylight, darkness, or twilight. Light pollution can disrupt these patterns altering physiology, behaviour, orientation, organism fitness, food web interactions, and biotope connectivity. Environmental protection laws do not address the adverse effects of artificial light at night on biodiversity adequately.

To achieve global goals and targets aiming to protect and restore nature for current and future generations, the nighttime environment cannot be forgotten and must be protected.

Participants concurred on the imperative need for urgent action to address significant changes and ensure the formulation of a robust policy for the protection of the night.

List of signatures(see annex document).

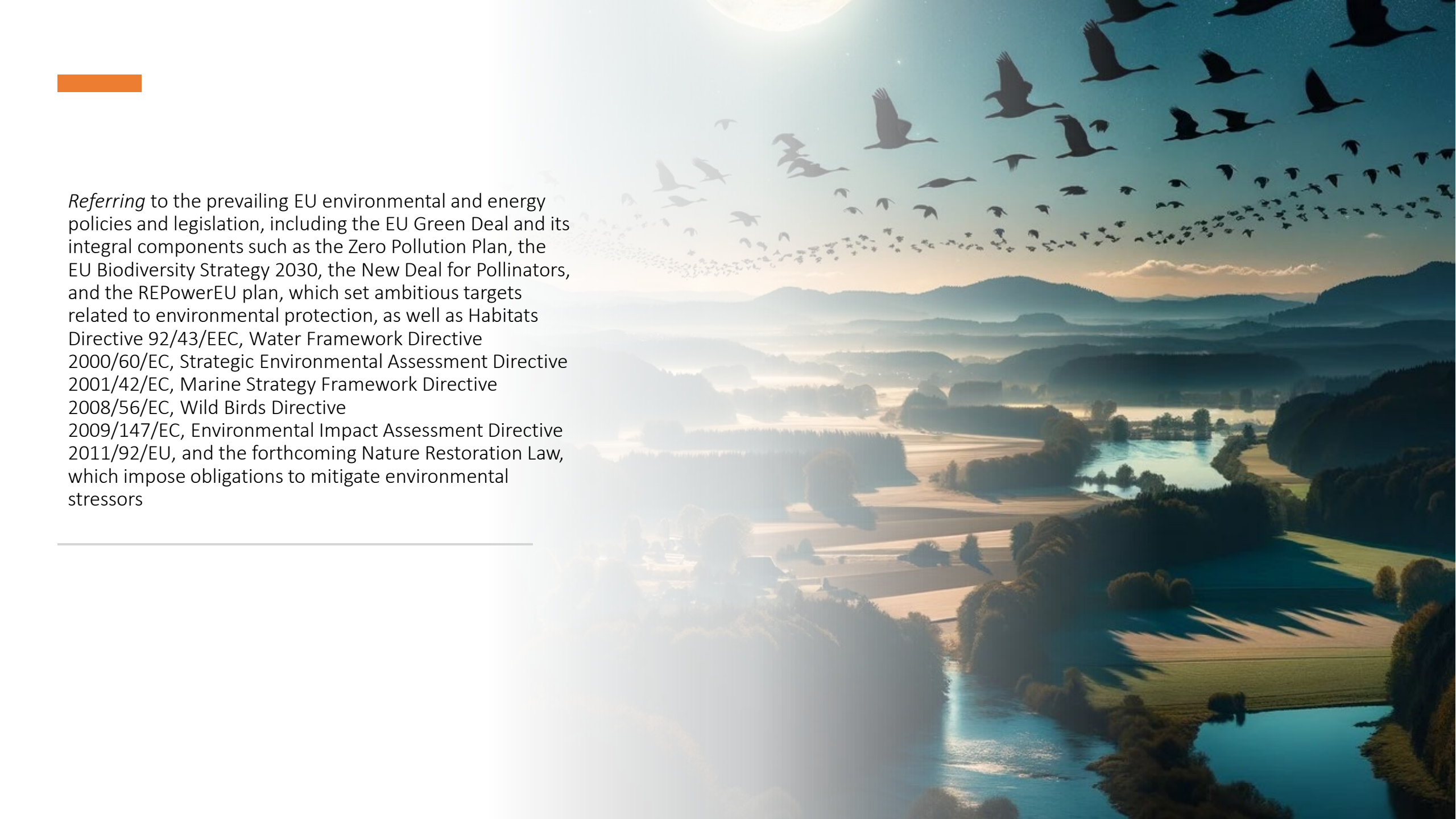
Disclaimer: Participants in this document are not acting as representatives of their respective institutions(except if is mentioned explicitly).

Authors: Yana Yakushina, David Smith, Alejandro Sanchez de Miguel

https://zenodo.org/records/10637467

Considering that nighttime activities constitute 50% of overall environmental functioning and encompass all living organisms, especially more than 70% of species of both flora and fauna exclusively exhibiting nocturnal behavior, including at least 51% of threatened
species

Referring to the prevailing EU environmental and energy policies and legislation, including the EU Green Deal and its integral components such as the Zero Pollution Plan, the EU Biodiversity Strategy 2030, the New Deal for Pollinators, and the REPowerEU plan, which set ambitious targets related to environmental protection, as well as Habitats Directive 92/43/EEC, Water Framework Directive 2000/60/EC, Strategic Environmental Assessment Directive 2001/42/EC, Marine Strategy Framework Directive 2008/56/EC, Wild Birds Directive 2009/147/EC, Environmental Impact Assessment Directive 2011/92/EU, and the forthcoming Nature Restoration Law, which impose obligations to mitigate environmental stressors



Light pollution has big impact on pollinators

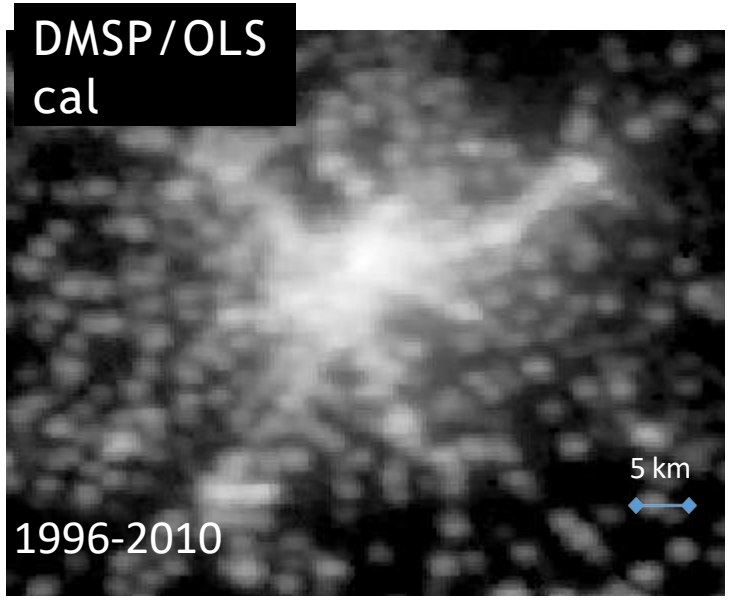
Connectivity

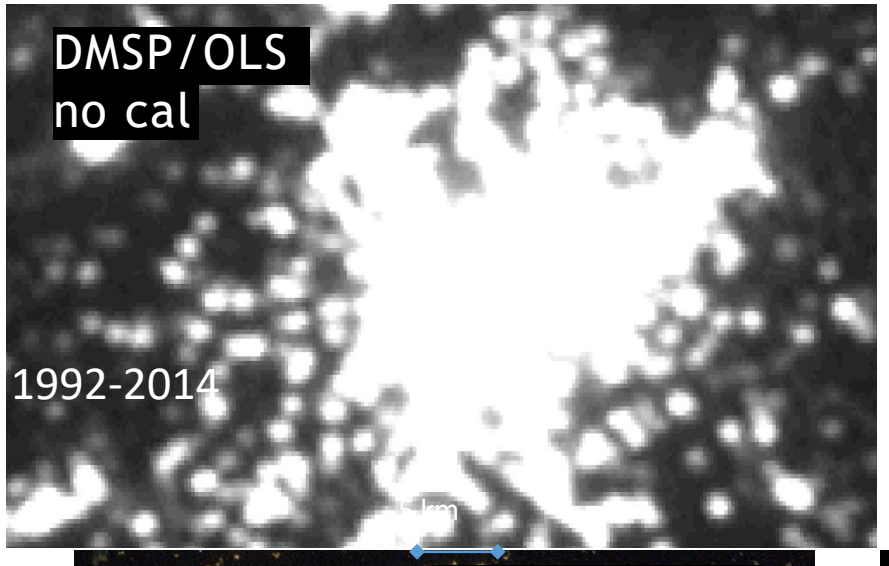
Total emissions

Landscape

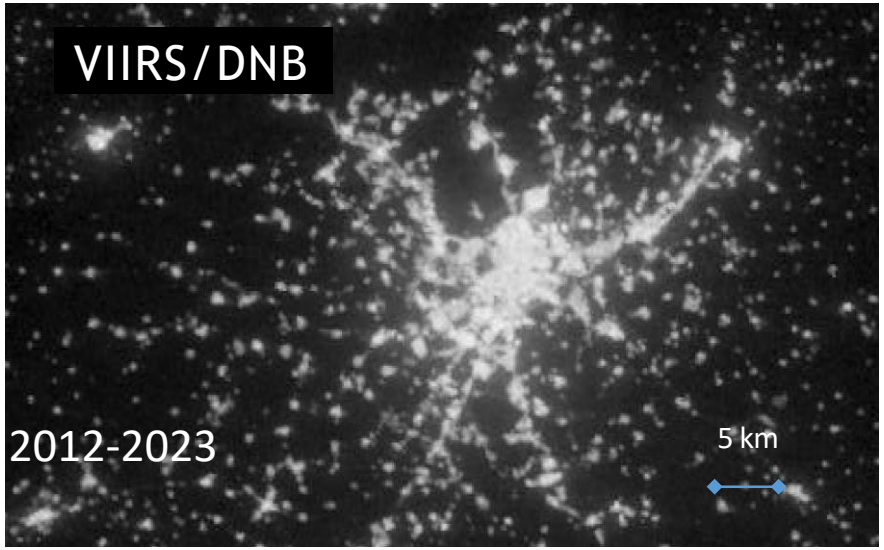
Satellite data

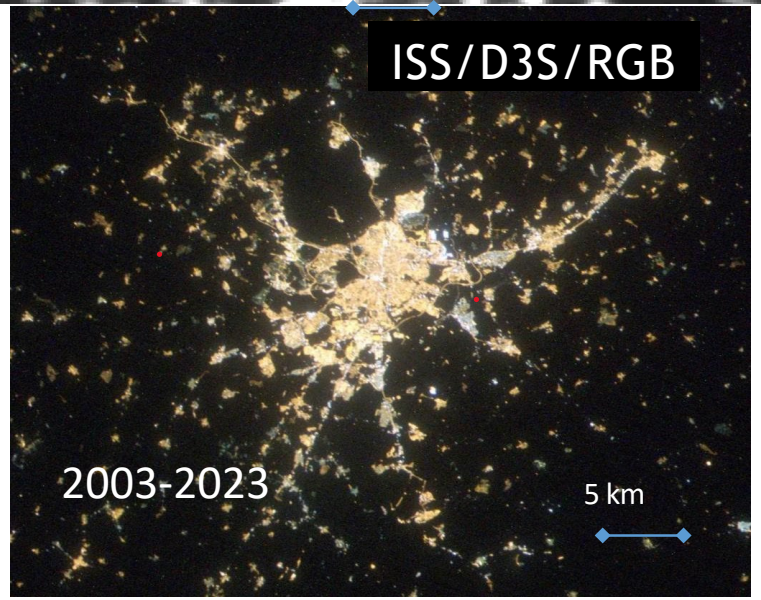
COMPARING SATELLITE IMAGES
DMSP + VIIRS + ISS +SDGSAT-1

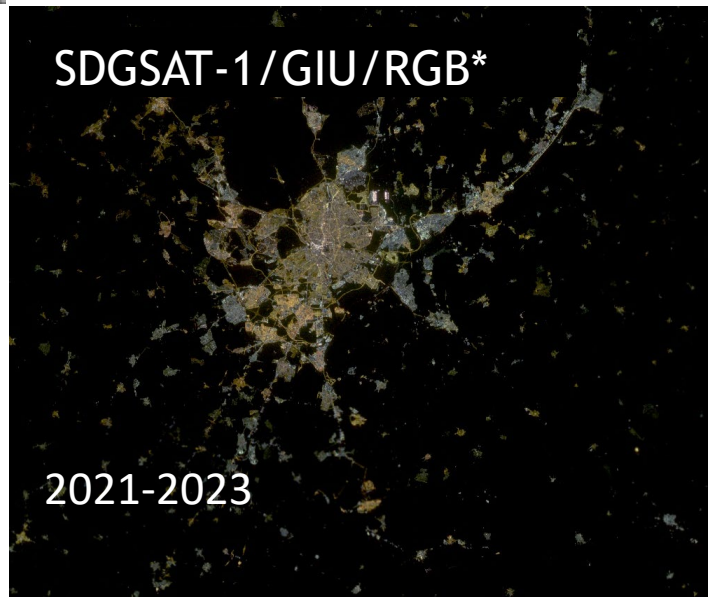




Madrid from space captured by 4 different satellites

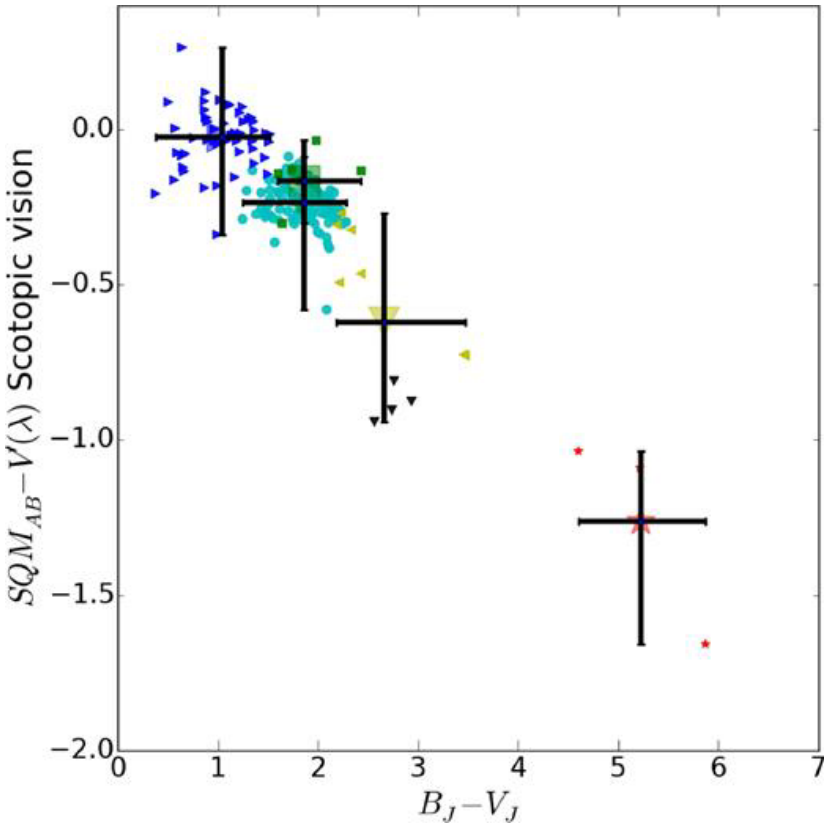




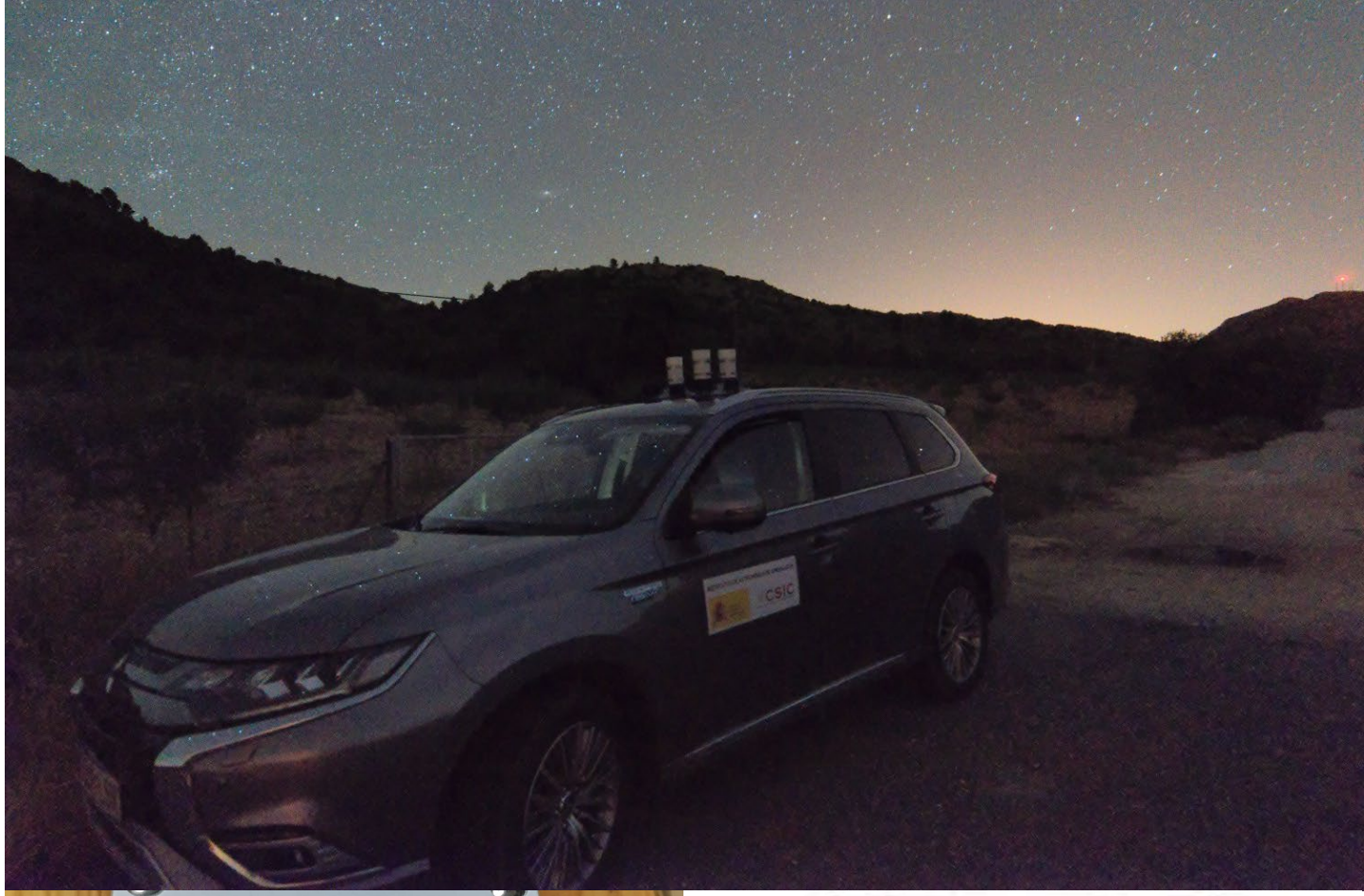


Lighting inventories

Multispectral Photometers

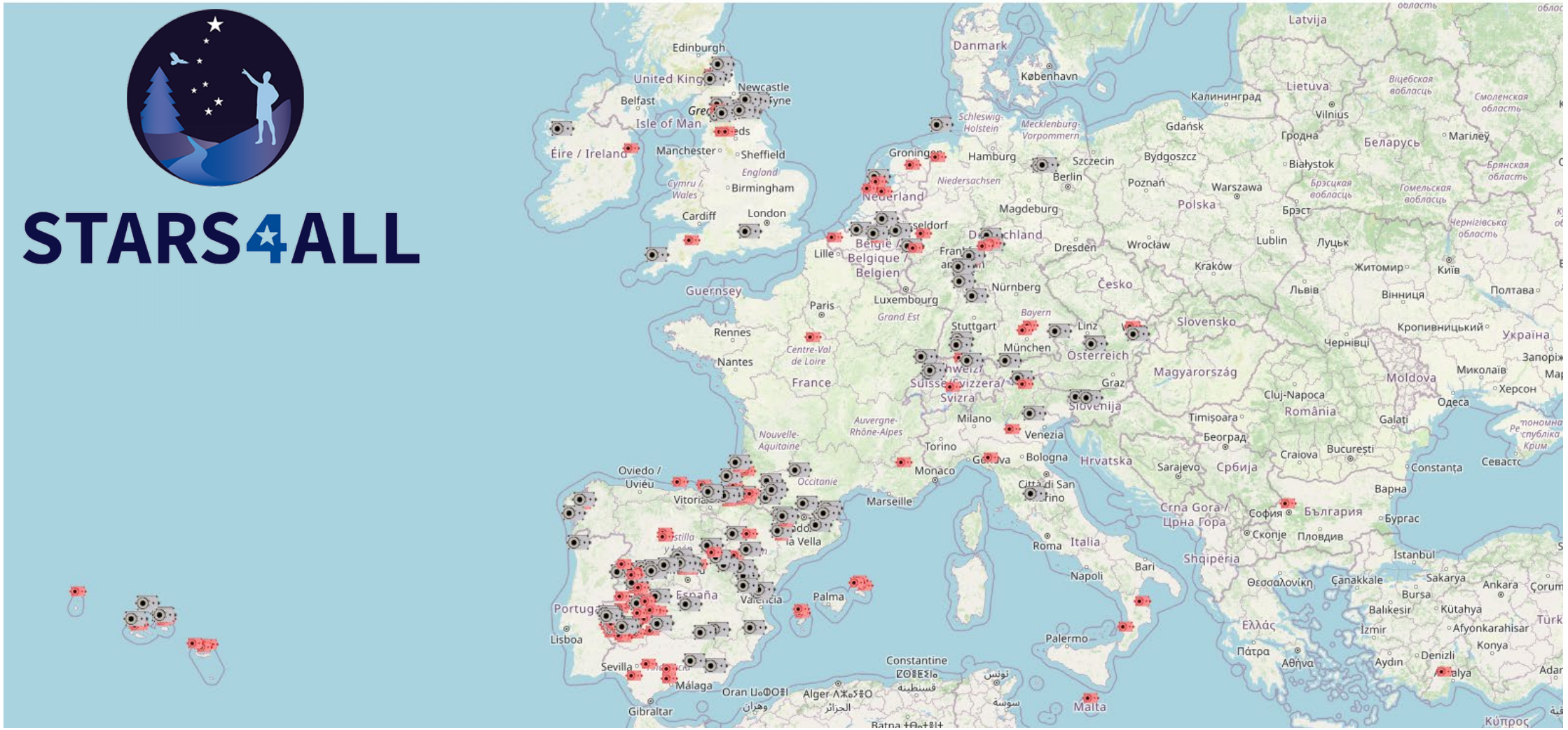


Sánchez de Miguel, A., et al. "Sky Quality Meter measurements in a colour-changing world." *Monthly Notices of the Royal Astronomical Society* 467.3 (2017): 2966-2979.

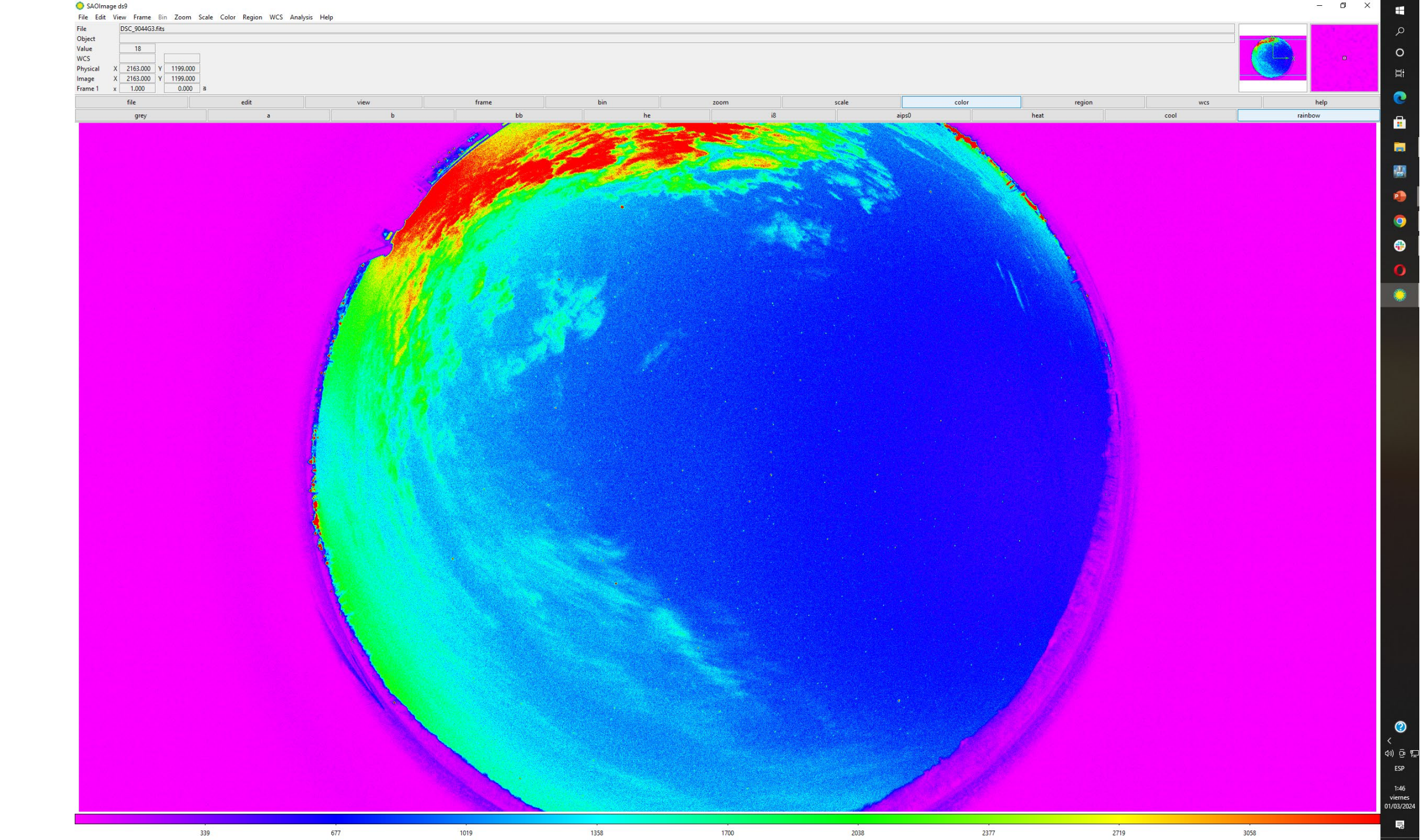


TESS Network

STARS4ALL



Cameras to measure light pollution


SAOImage ds9
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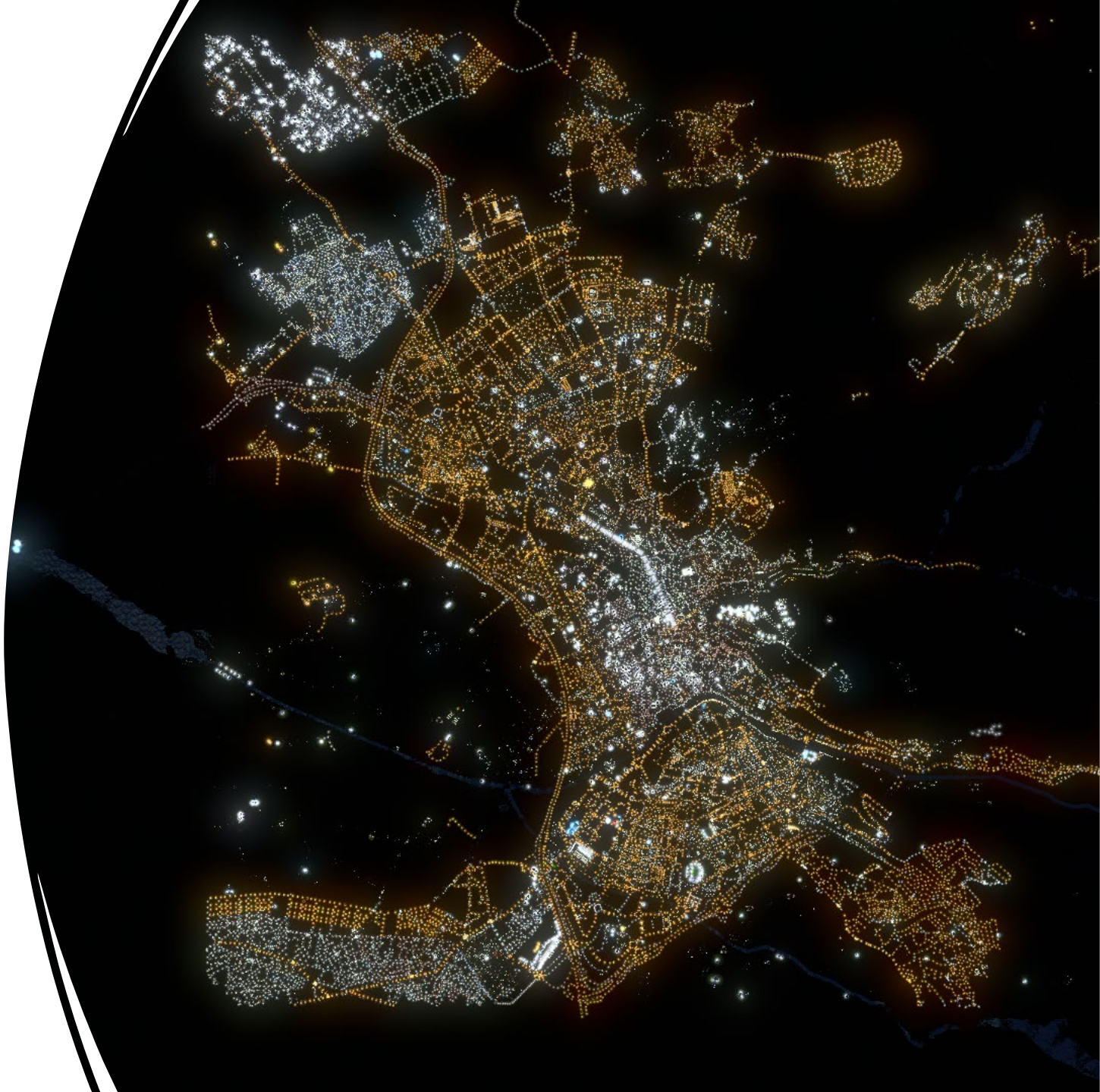
01/03/2024

Modelling



STARS4ALL

PLN
PIRINEOS / PYRÉNÉES
La Nuit

ACTION

PLAN-B

STARLIGHT

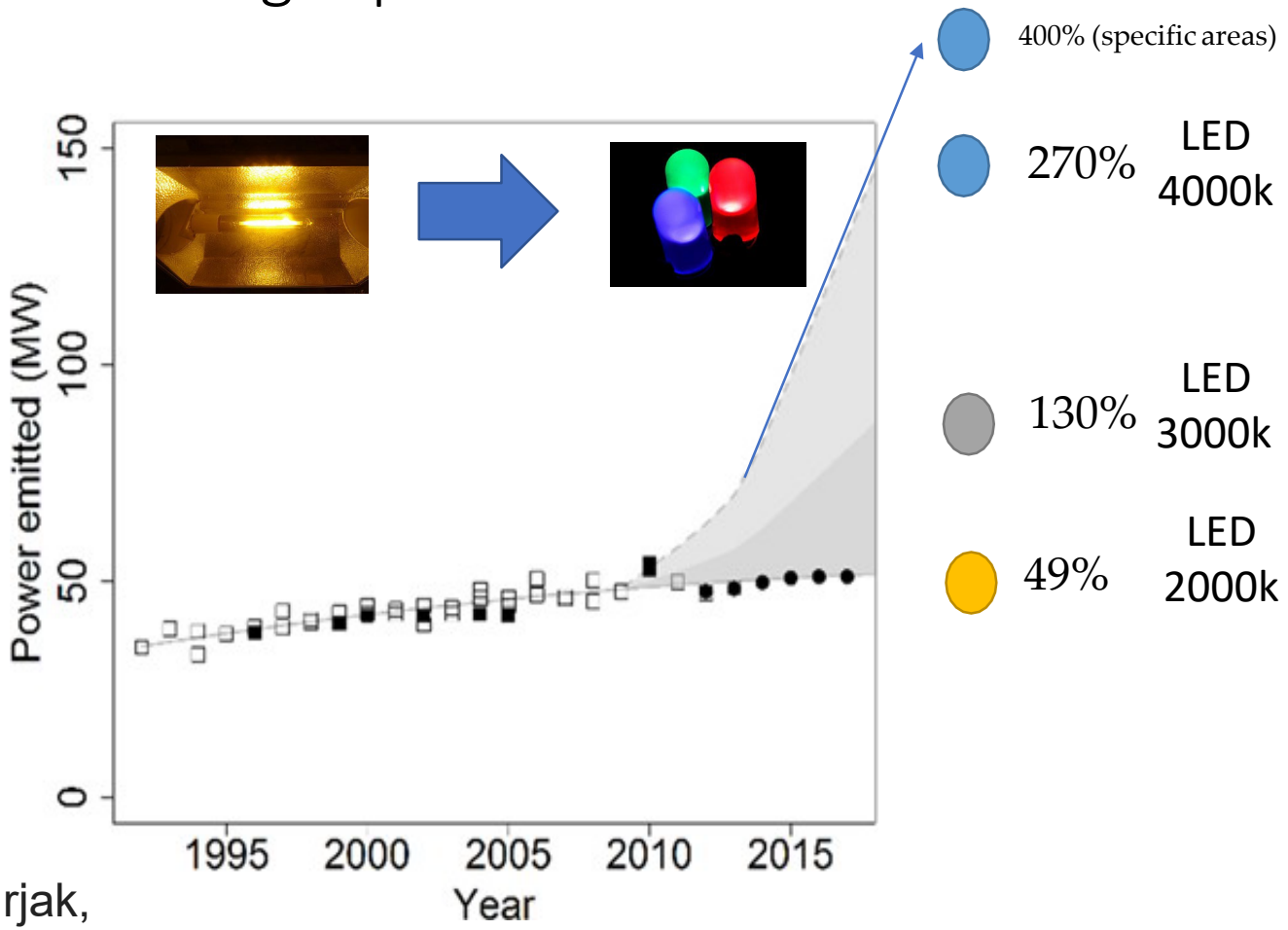
Interreg
CENTRAL EUROPE
European Union
European Regional
Development Fund

Dynamic Light

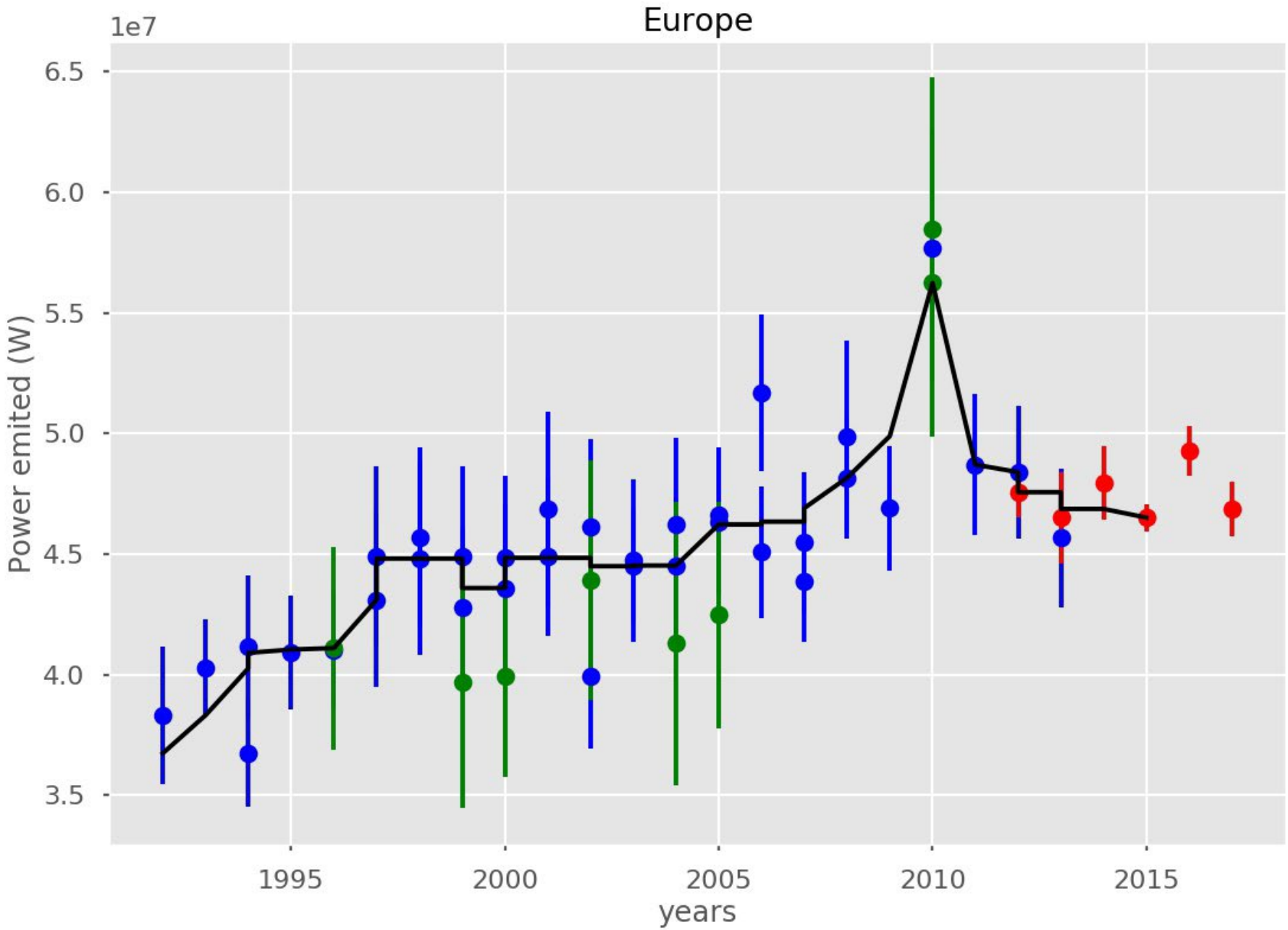
KID

AquaPLAN

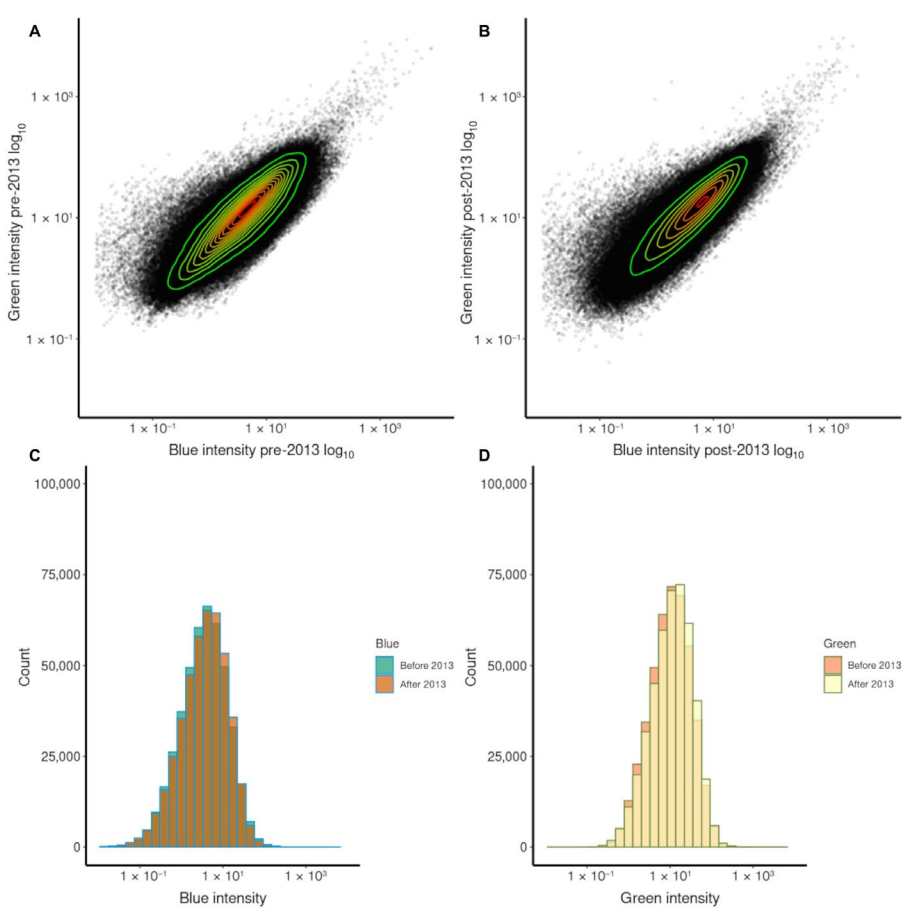
First estimation of global trends in nocturnal power emissions reveals acceleration of light pollution

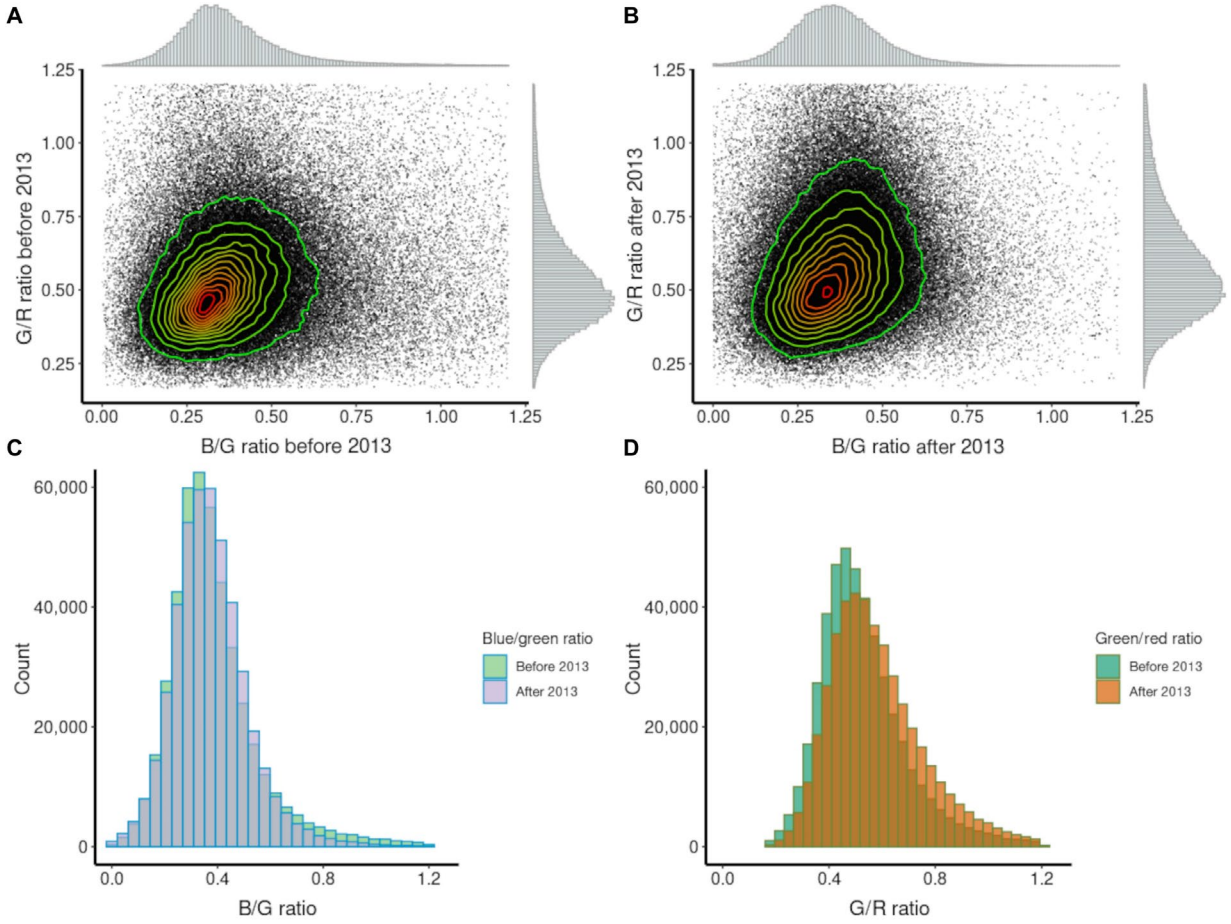


Sánchez de Miguel, A., Bennie, J., Rosenfeld, E., Dzurjak, S., & Gaston, K. J. (2021). First estimation of global trends in nocturnal power emissions reveals acceleration of light pollution. *Remote Sensing*, *13*(16), 3311.


Europe
1e7
6.5
6.0
5.5
5.0
4.5
4.0
3.5
Power emited (W)
1995
2000
2005
2010
2015
years

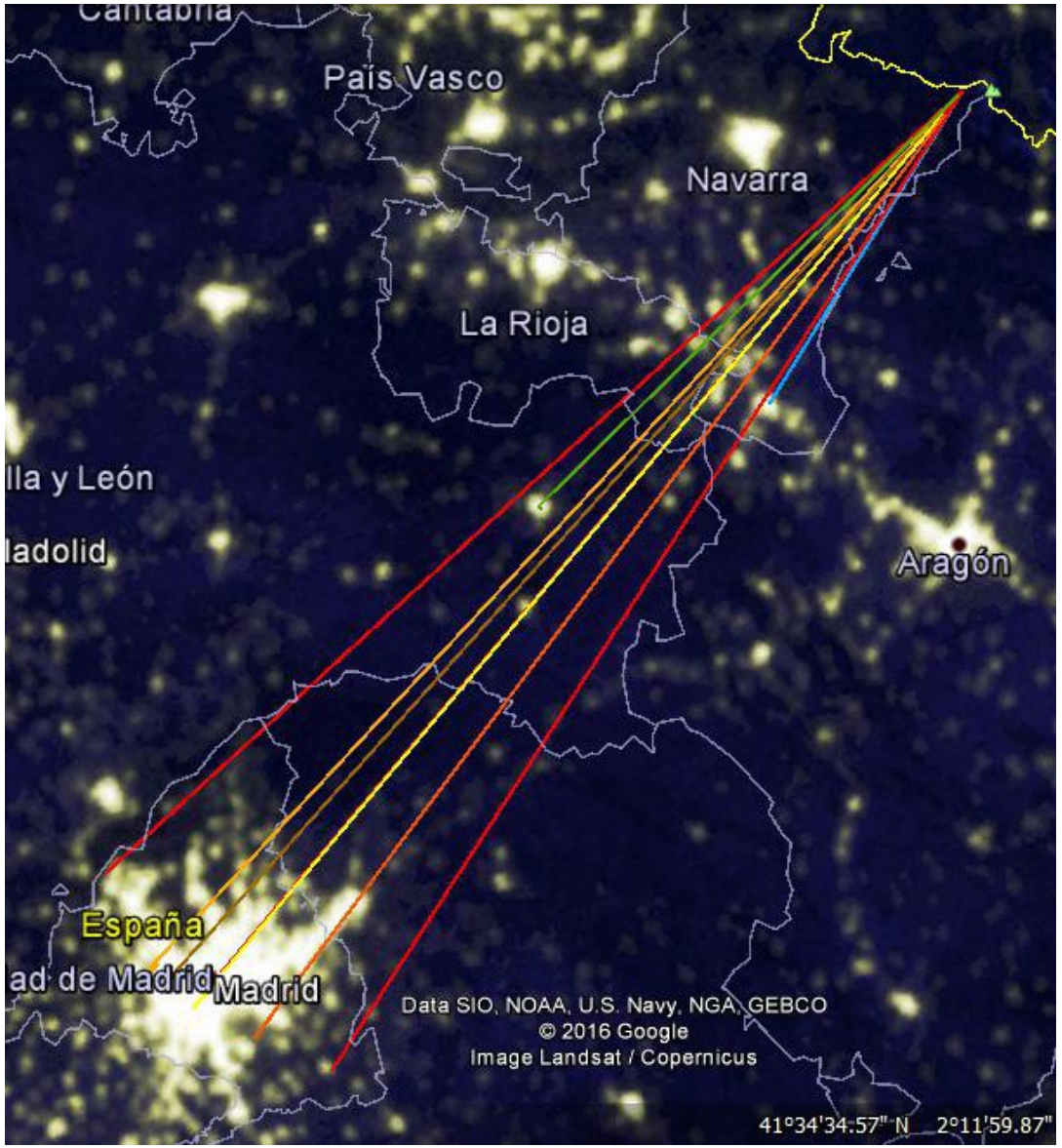
Light pollution is increasing fast in Europe

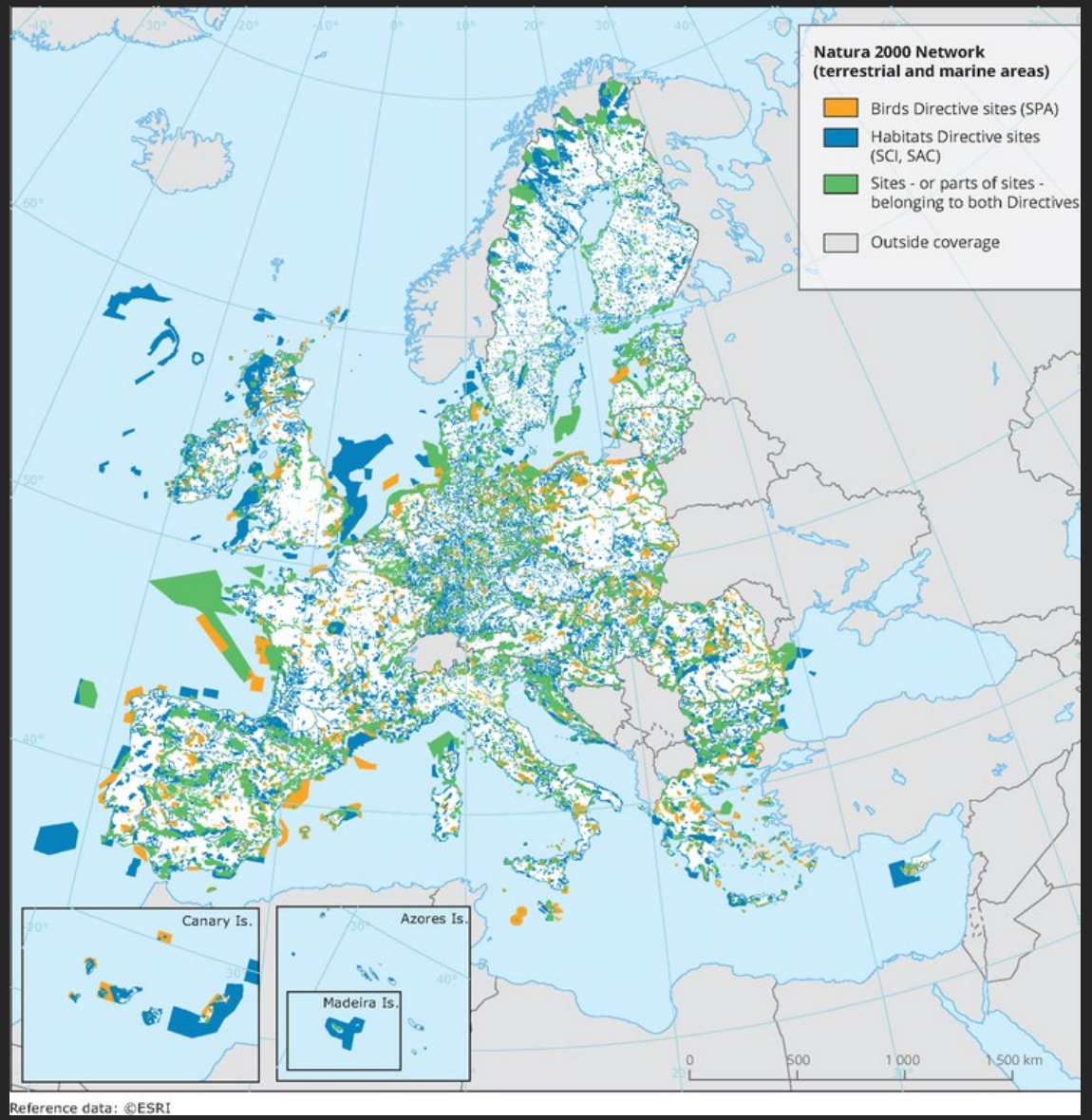


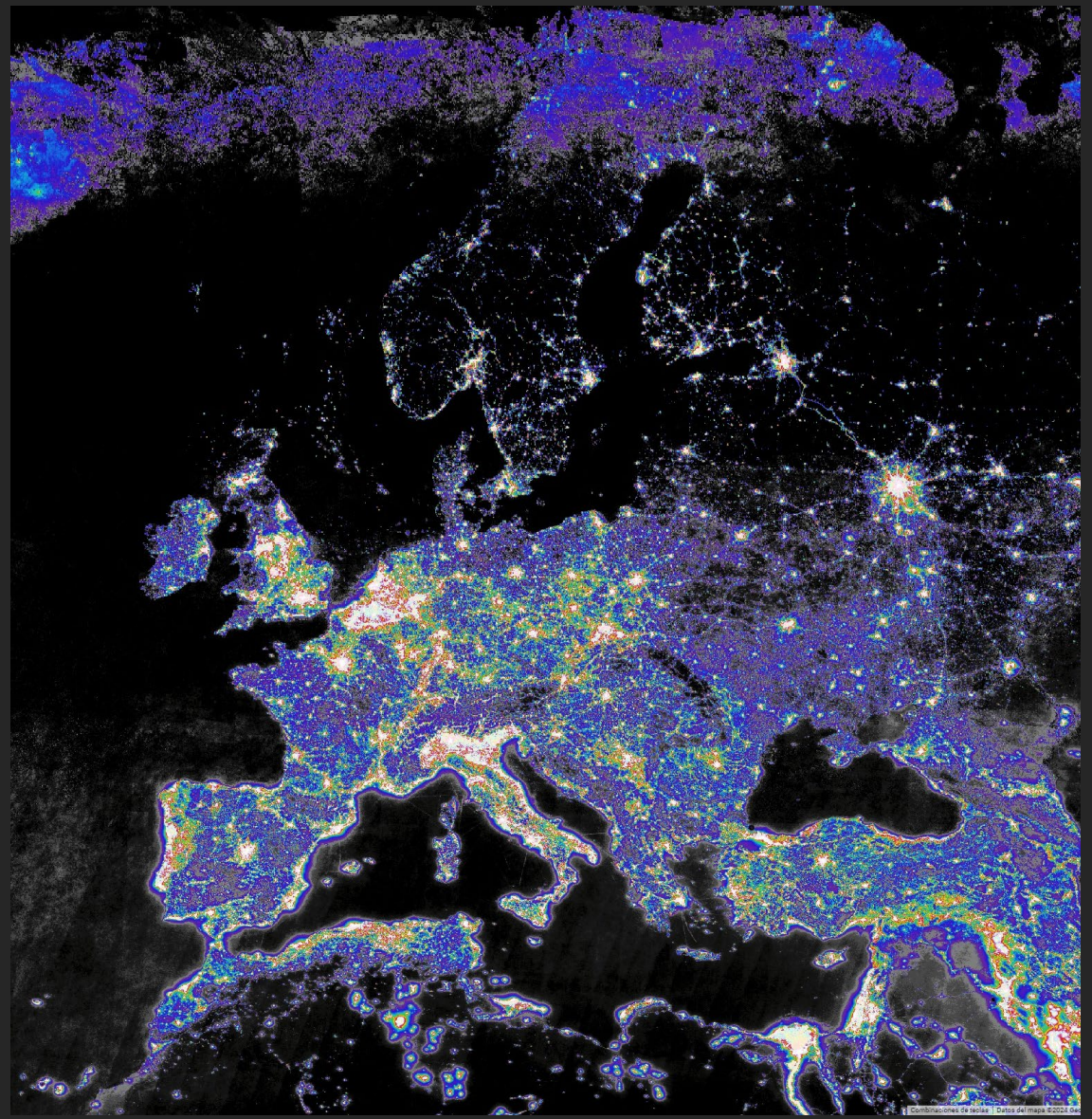


Sánchez de Miguel, Alejandro, et al. "Environmental risks from artificial nighttime lighting widespread and increasing across Europe." *Science Advances* 8.37 (2022): eabl6891.

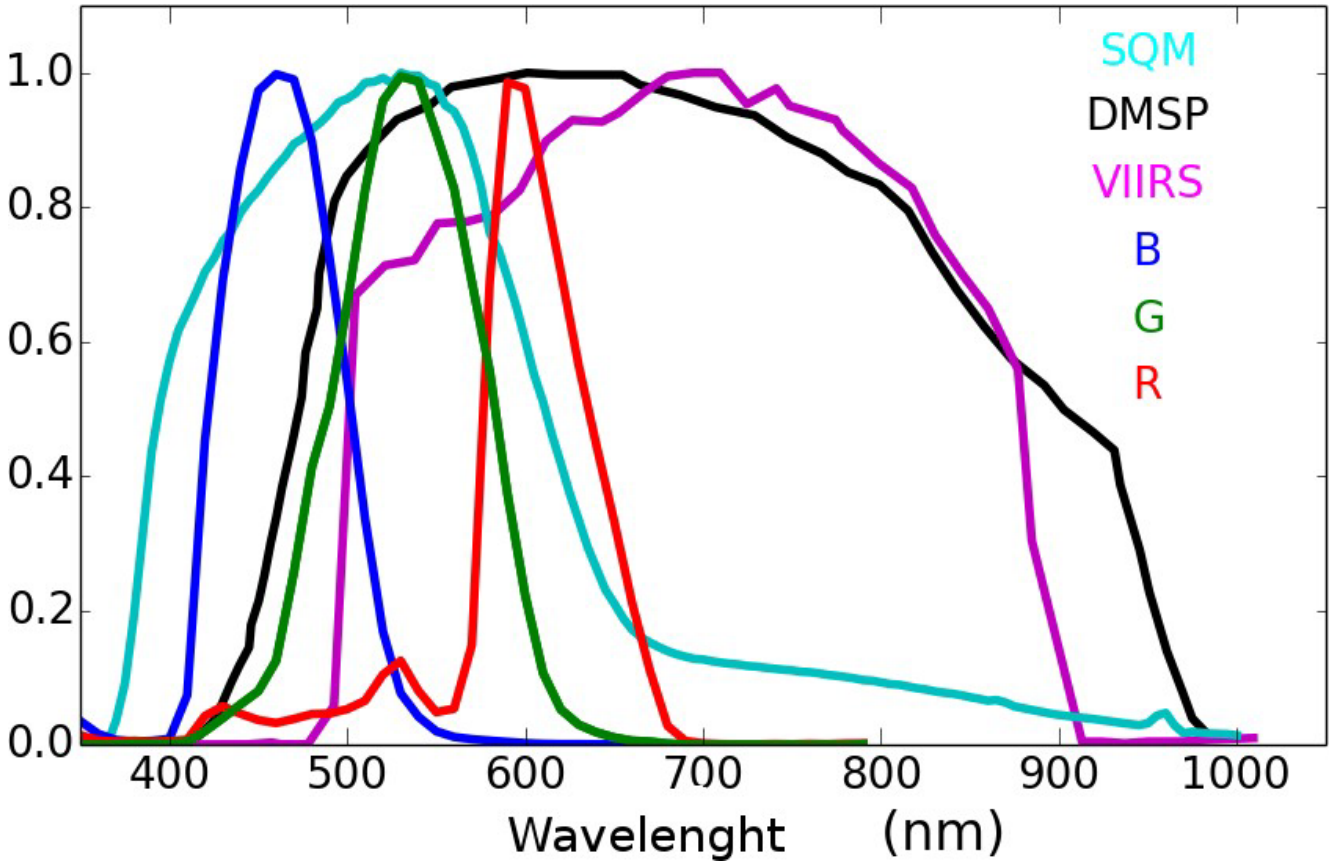

Tudela
Extremo
area de
influencia
de Madrid
Guadalajara
y corredor
del henares
El
Madrid
Isaba
ernando Jauregui, Planetario de Pamplona/Celfosc/IDA
s: Alejandro Sánchez de Miguel, IAA-CSIC/IDA/UCM/Ce

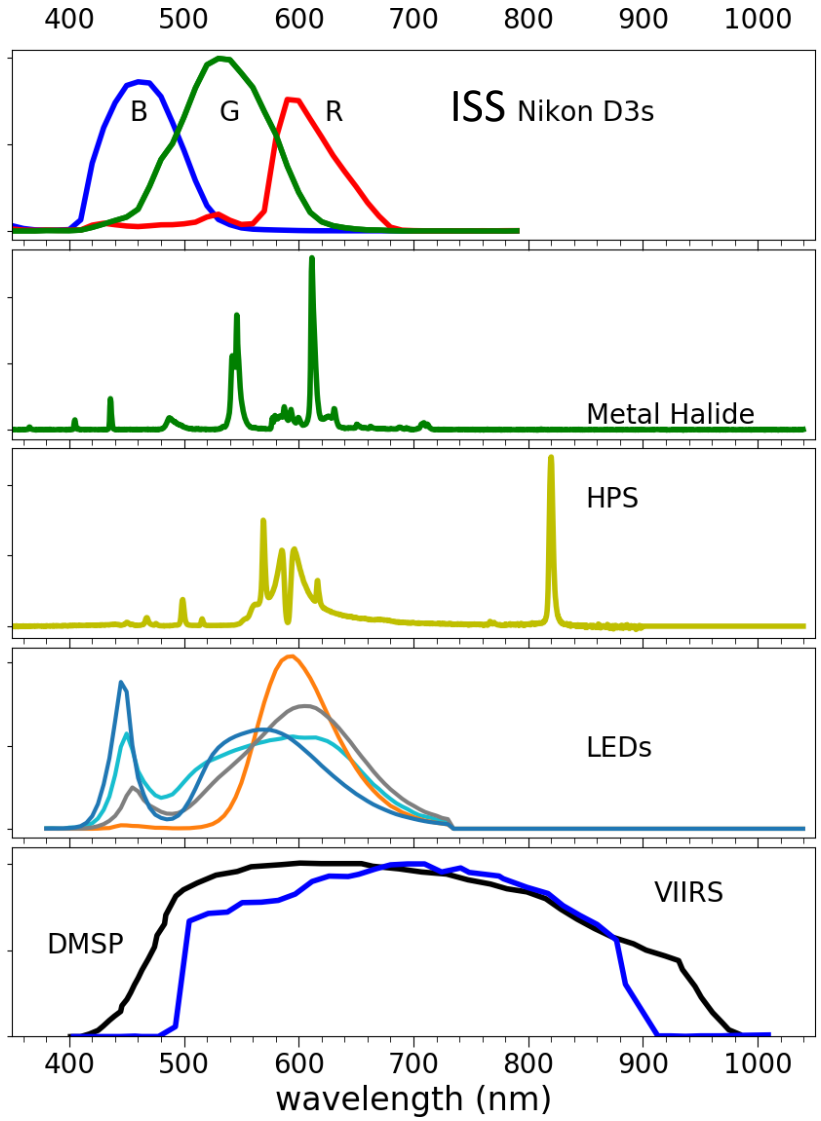

País Vasco
Navarra
La Rioja
lla y León
ladolid
Aragón
España
ad de Madrid
Madrid
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2016 Google
Image Landsat / Copernicus
41°34'34.57" N 2°11'59.87"


Natura 2000 Network
(terrestrial and marine areas)
Birds Directive sites (SPA)
Habitats Directive sites (SCI, SAC)
Sites - or parts of sites - belonging to both Directives
Outside coverage
Canary Is.
Azores Is.
Madeira Is.
0
500
1 000
1 500 km
Reference data: ©ESRI

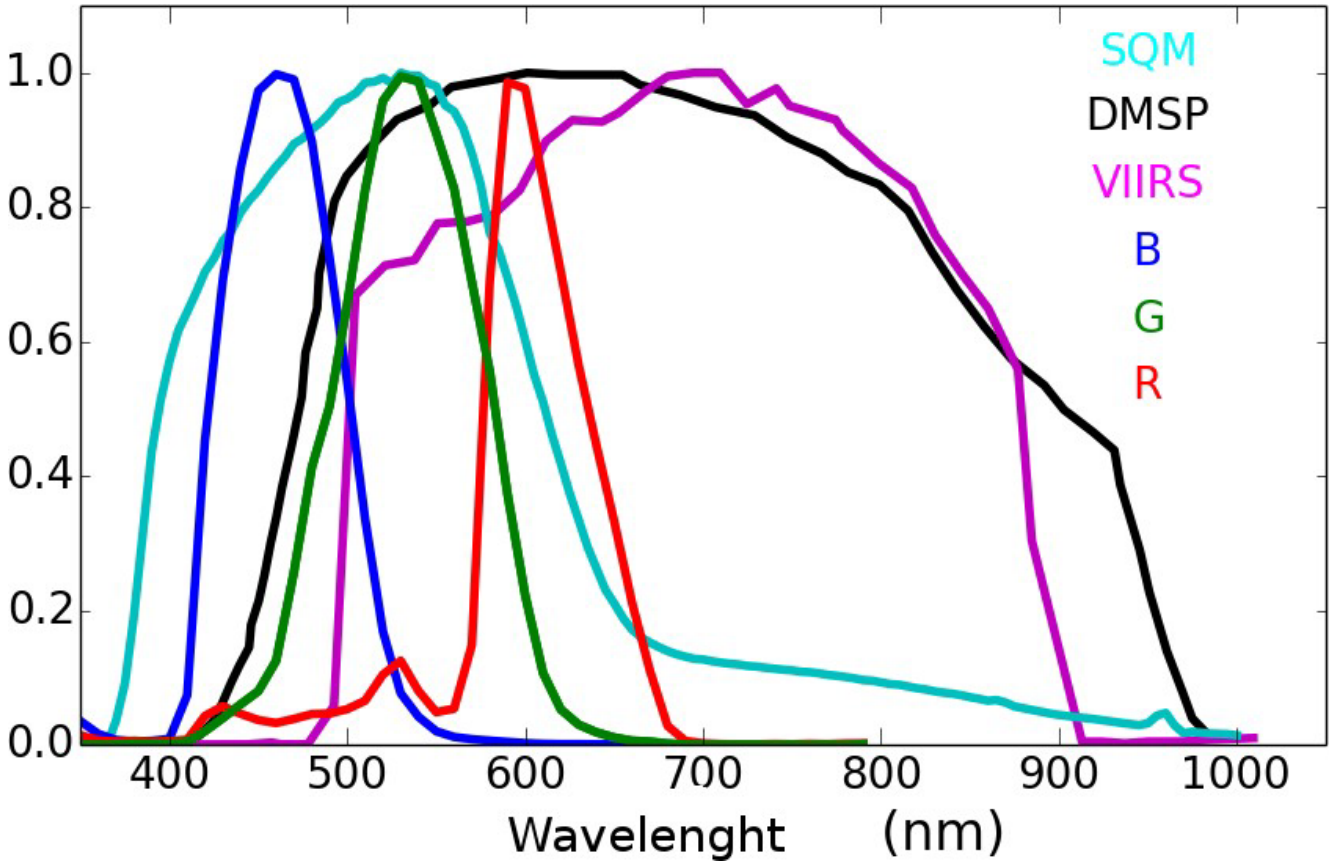


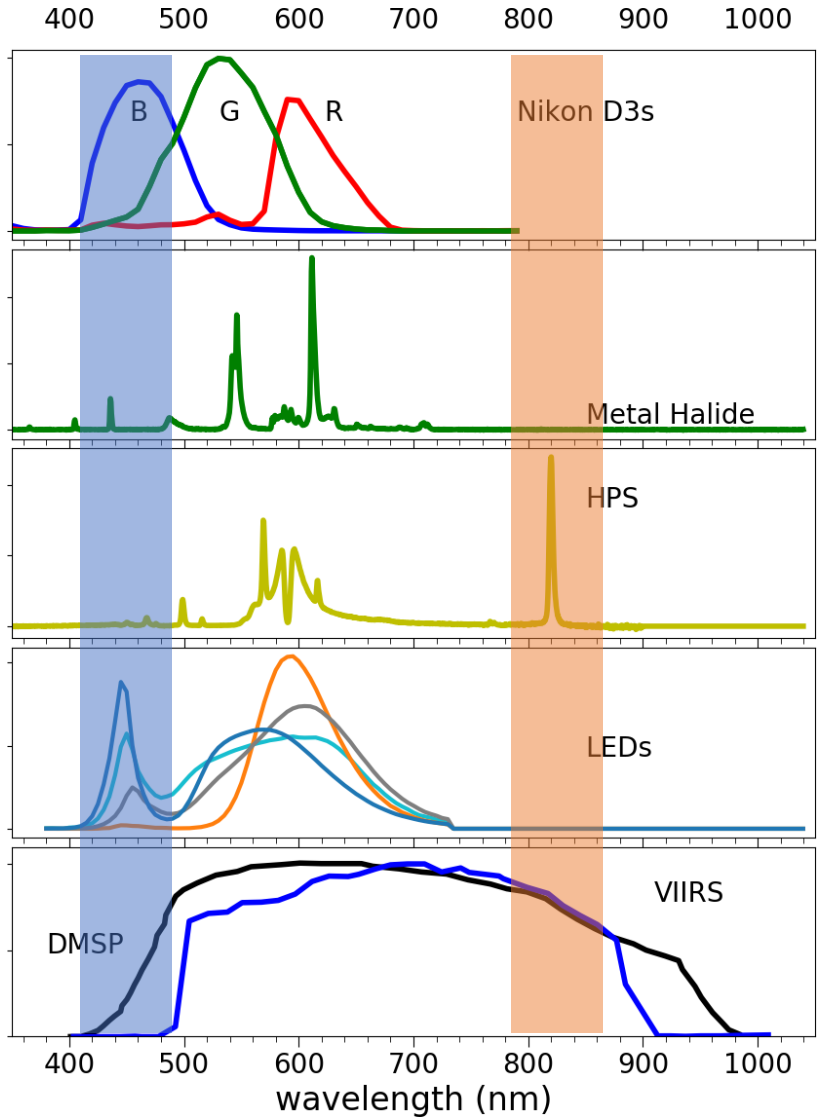
LED light sources have been responsible for many false and inaccurate measurements. To avoid inaccuracy in the future it is fundamental that only colour sensitive satellites are used.

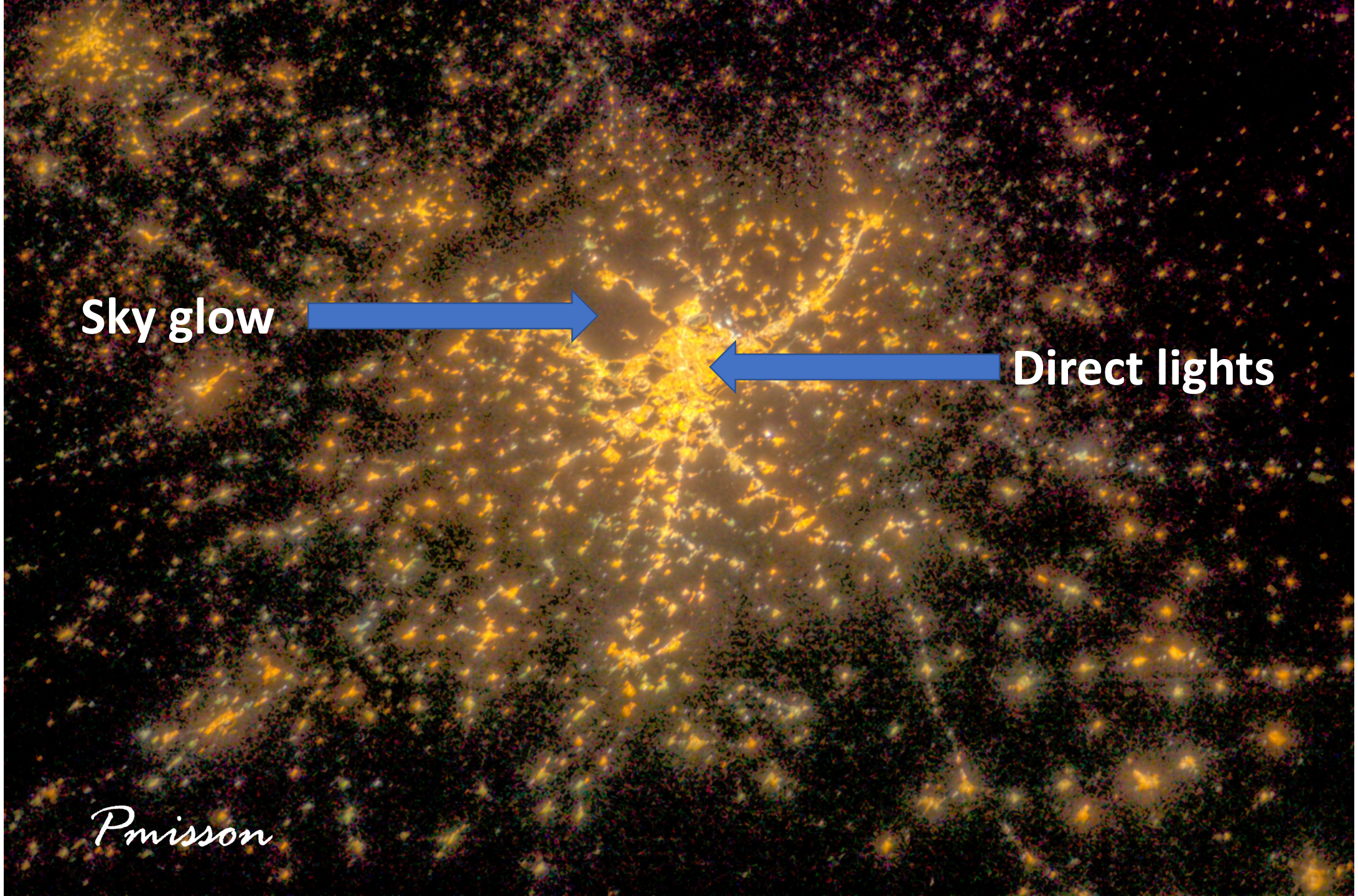




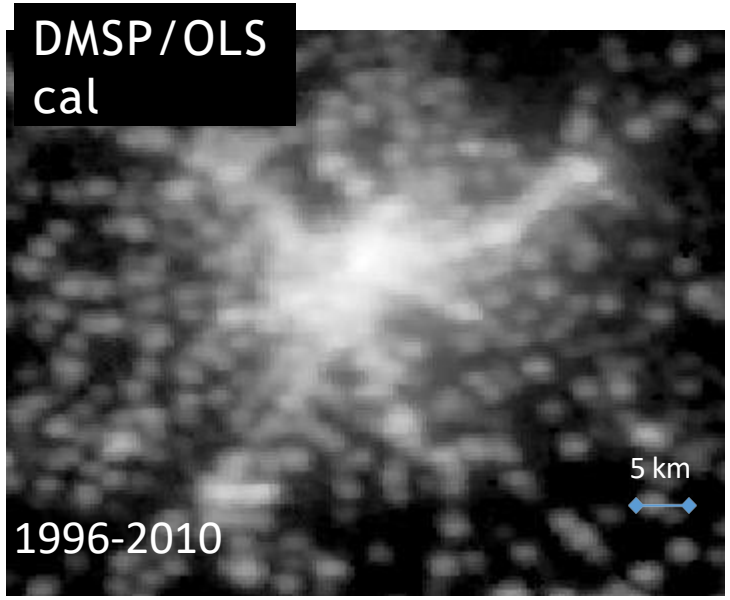
Satellites that are not colour sensitive, such as the DMSP and the VIIRS do not detect blue lights (such as many of the new LED streetlights worldwide) and detect spurious infrared lights

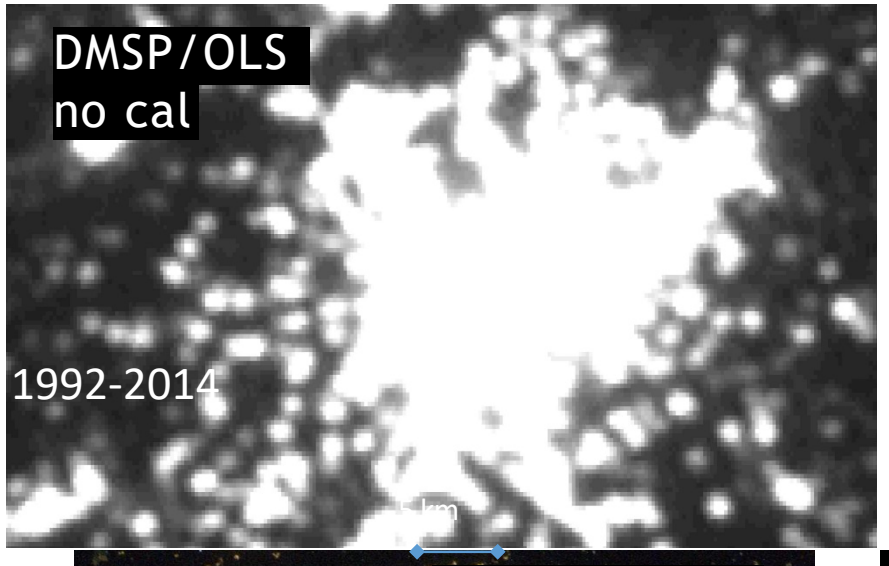




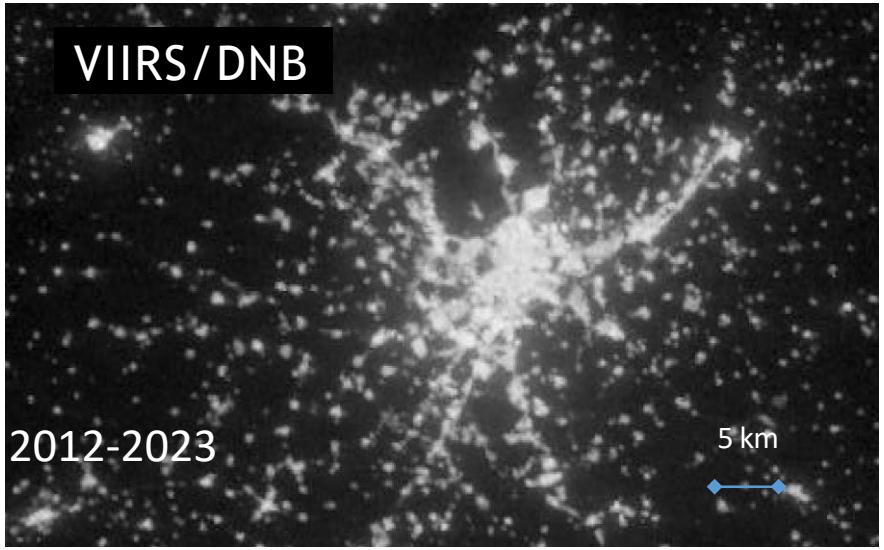

Sky glow
Direct lights
Pmisson

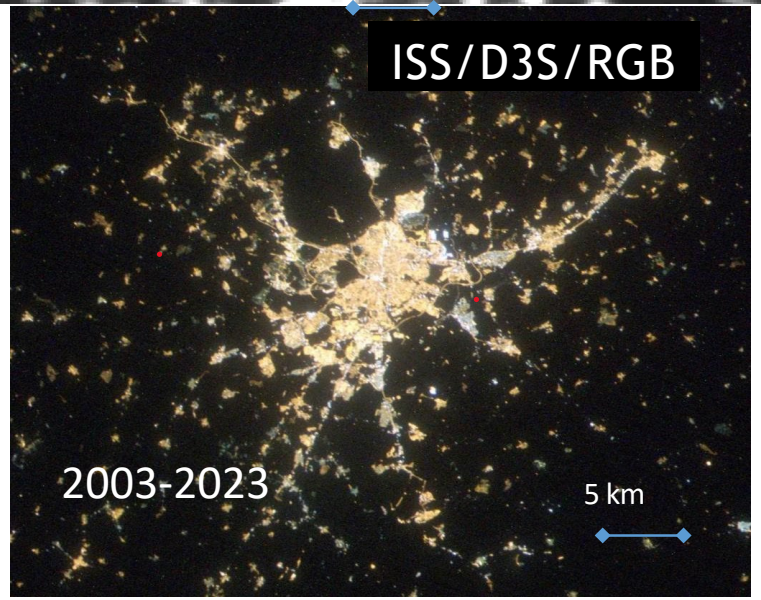
COMPARING SATELLITE IMAGES
DMSP + VIIRS + ISS +SDGSAT-1

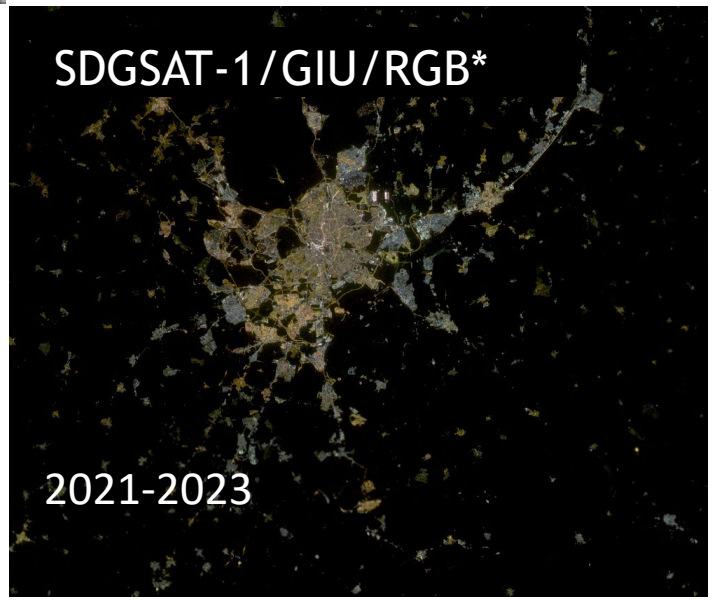




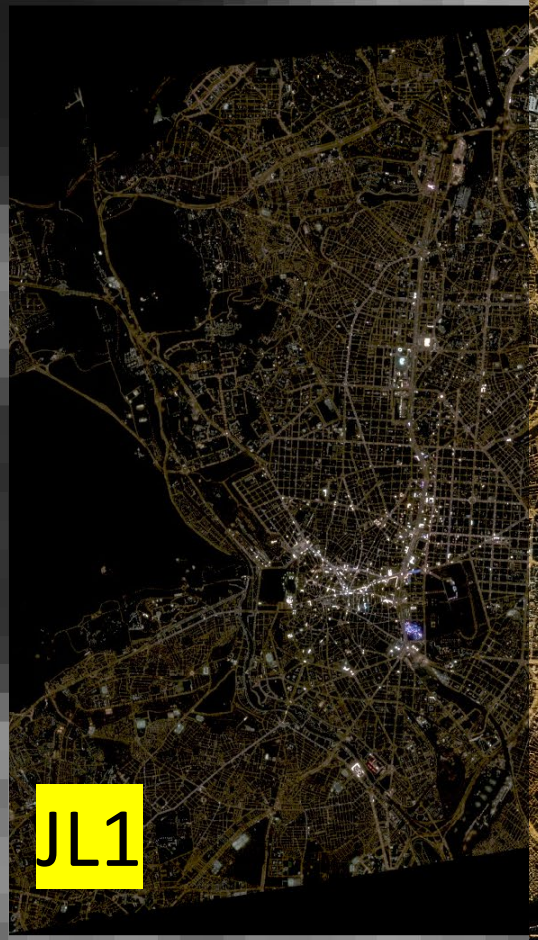
Madrid from space captured by 4 different satellites



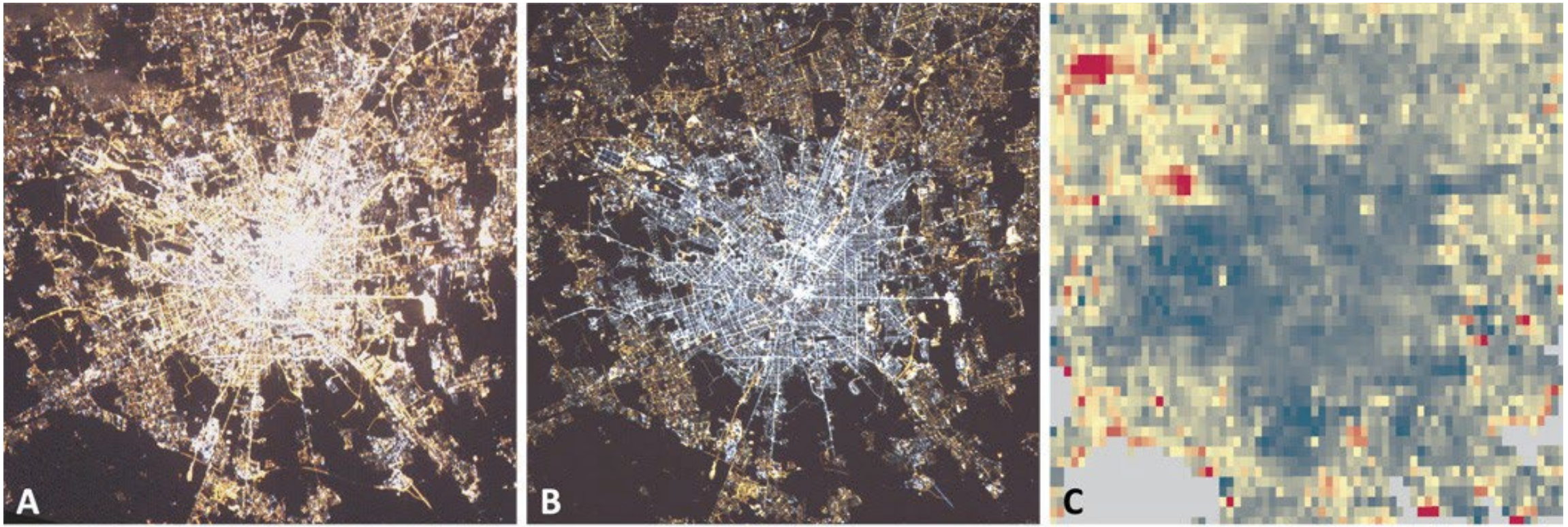




Comparison between VIIRS - ISS - JL1

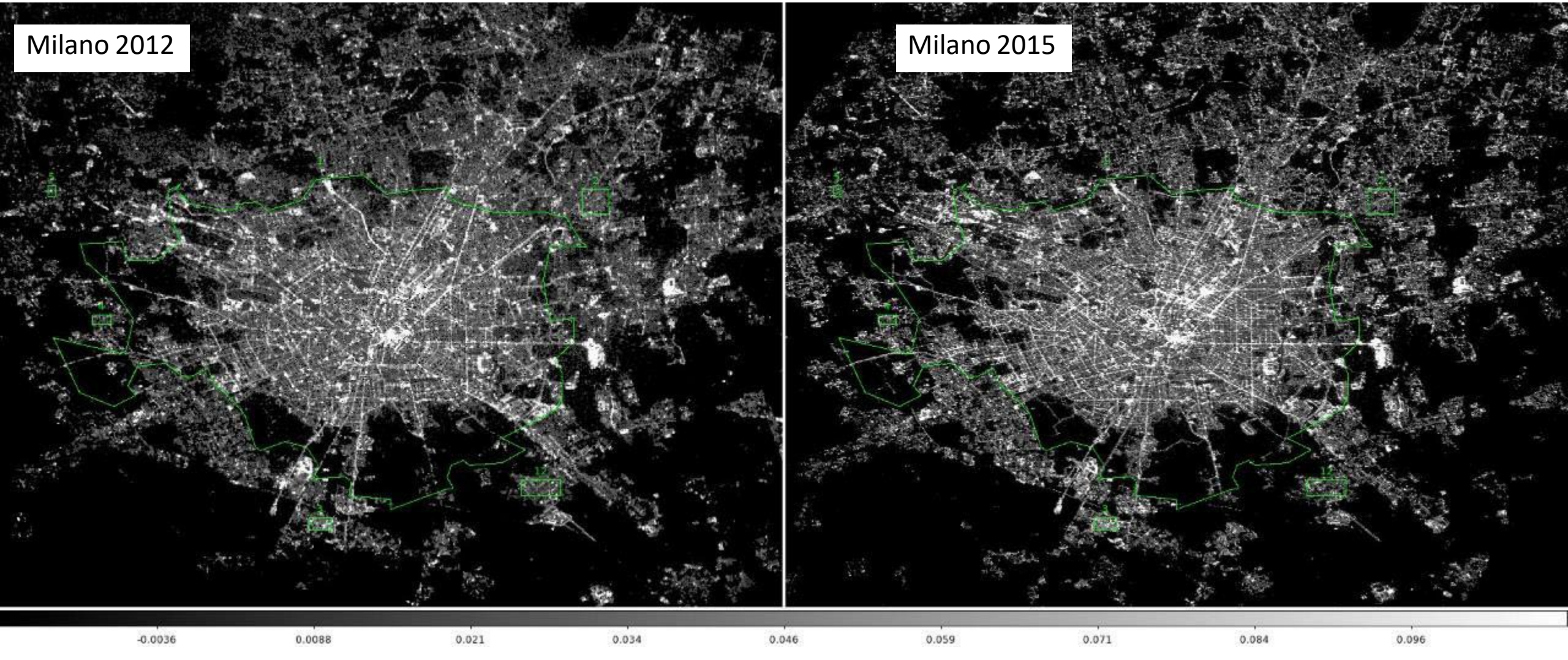


VIIRS


A
B
C
Milan, Italy
0 5 10 15 km
Fractional radiance change 2012/2016
0.5
Decreased
1.0
No change
2.0
Increased

Milano before and after: same large scale illumination level

Sánchez de Miguel, A. , Kyba, C. C., Aubé, M., Zamorano J., Cardiel, N., Tapia, C., ... & Gaston, K. J. (2019). Colour remote sensing of the impact of artificial light at night (I): The potential of the International Space Station and other DSLR-based platforms. *Remote Sensing of Environment*, *224*, 92-103.

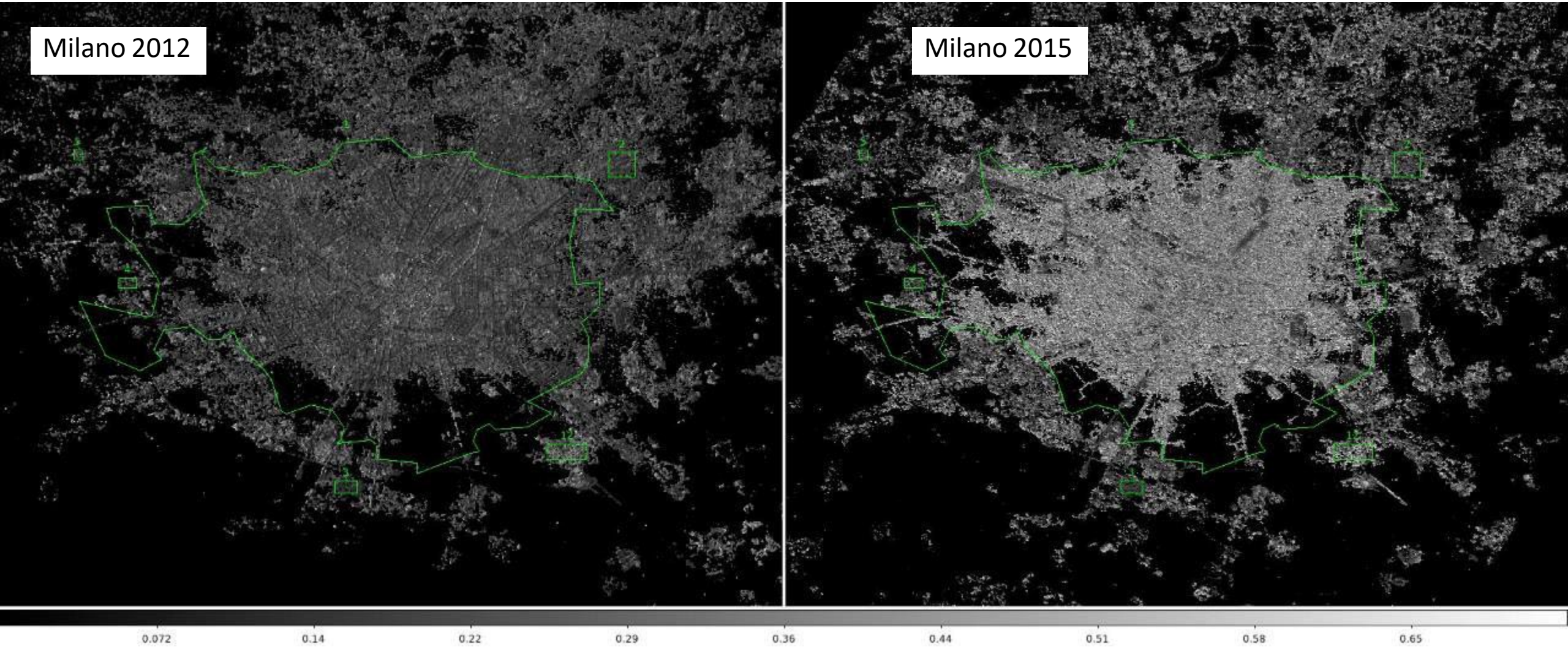


No same color

Health related

Melatonin suppression Impact

MSI 37% higher

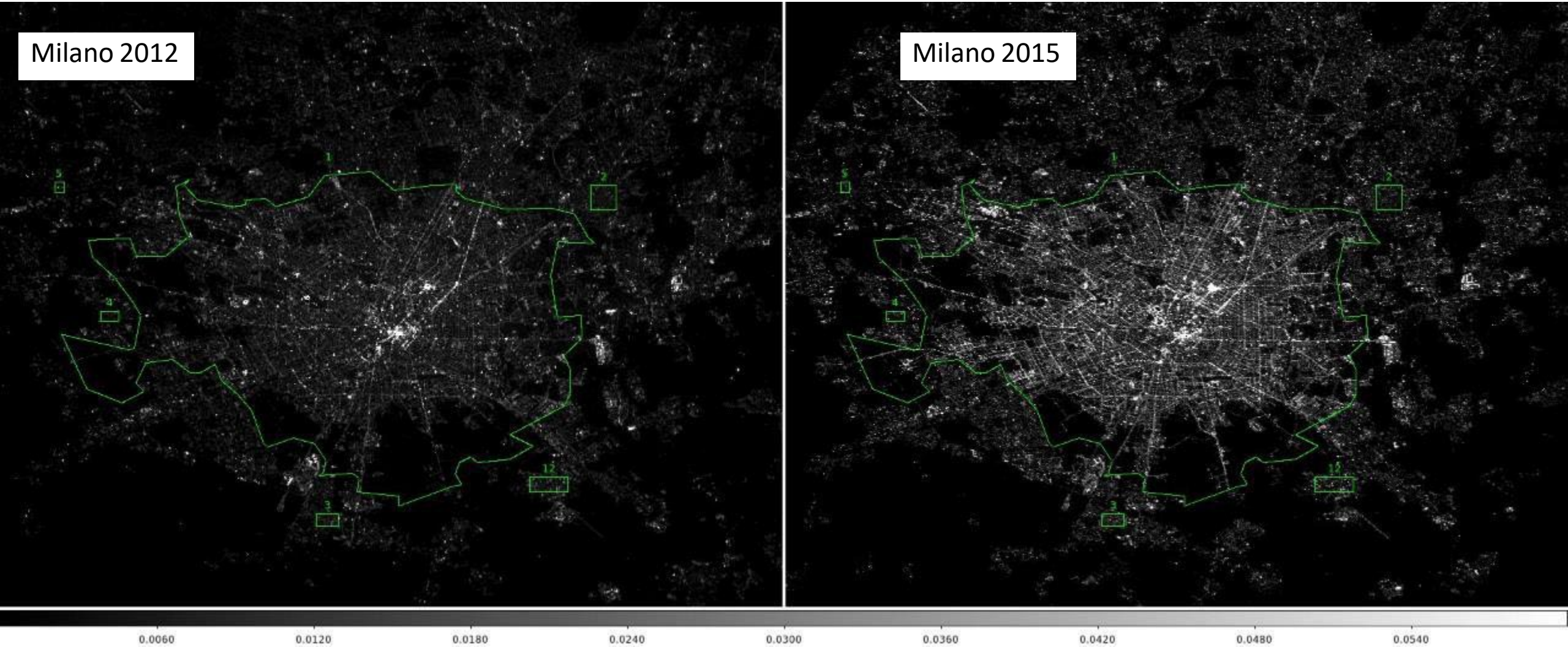


No same impact

Health related

Impact increased by 27%

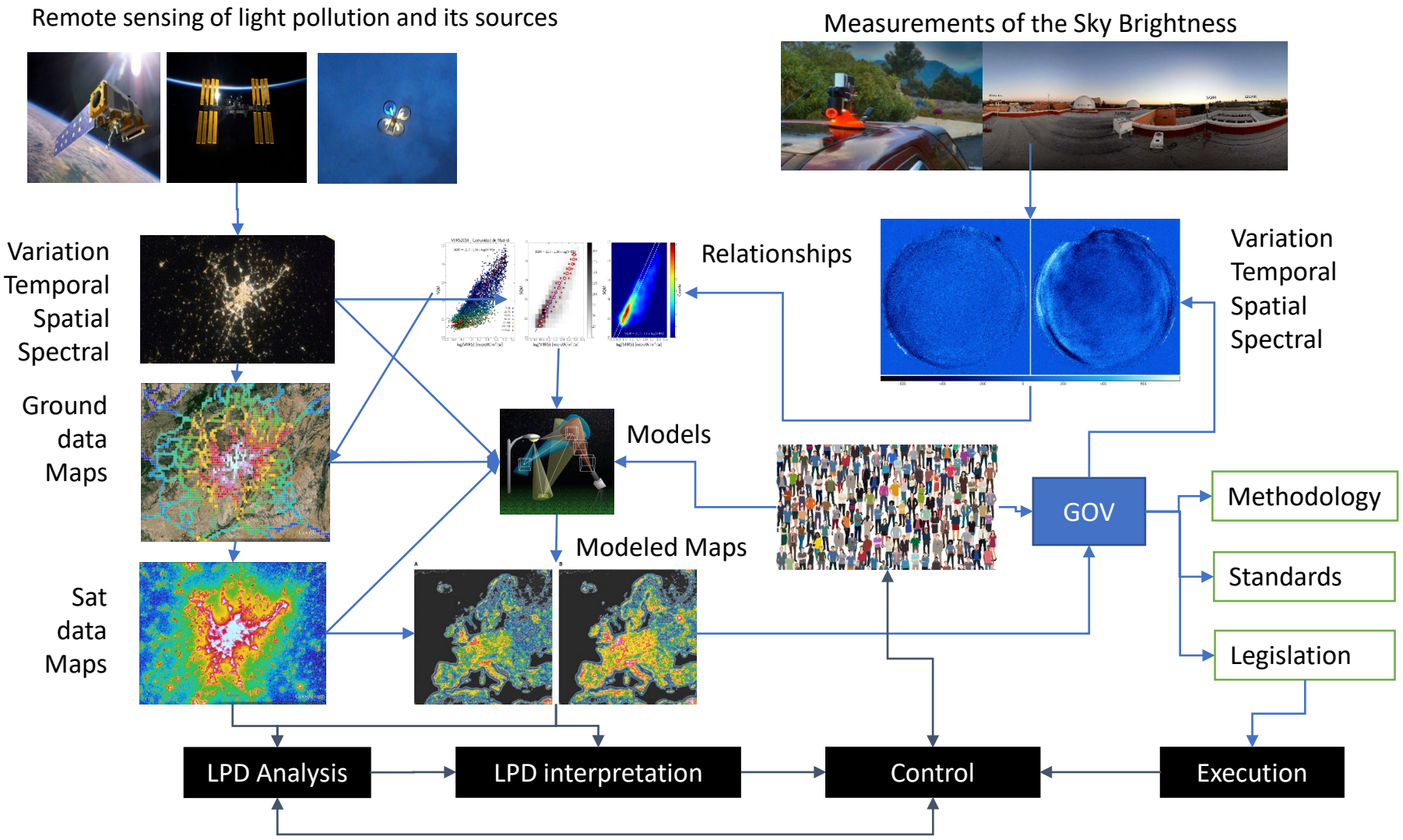
Melatonin suppression Impact




Layers
Mapa
Satélite
RALAN-MAP
Google
Combinaciones de teclas
Datos de mapas ©2022 GeoBasis-DE/BKG (©2009), Google, Inst. Geogr. Nacional
100 km
Términos de uso

Work flow of „light pollution data“ process

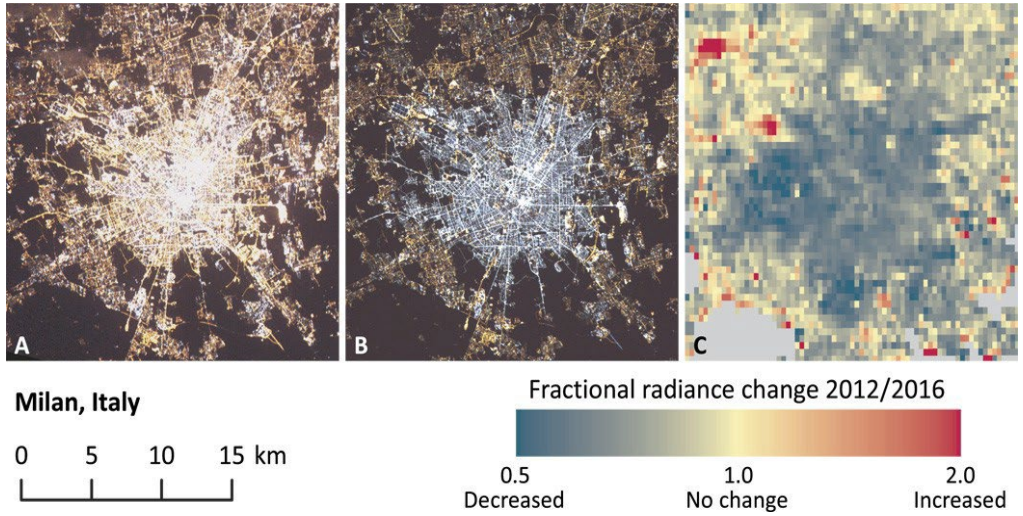
based on prediction models for



Basic Cycle Process “Control Mechanisms Definition and implementation of points for application will help us to put into practice the basic cyclical process leading to the achievement of the set targets. We propose to divide this cyclical process into the following process steps

1. Goal definition
   - Guarantee,
   - Legislative,
   - Manage methodically
   - Communicate - interdepartmental / with the public / with partners
2. Identify the deviation
   - Use tool that allows you to comprehensively, systematically, regularly and independently monitor the condition of light pollution
   - Centrally record subjects' complaints about light pollution
   - Effectively identify and measure bottlenecks
   - Register and manage a registry of problematic locations
3. Measure
   - Perform local investigations based on Identified Deviations
   - Measure according to the agreed methodology and legislative framework
4. Describe and analyse
   - Make a measurement analysis
   - Identify cases and their impact
   - Suggest a possible variant solution
5. Suggest changes
   - Present the proposed solutions
   - Negotiate with the site manager / owner
   - Make a legal commitment / set a legislative framework
6. Take action
   - New installations
   - Corrective measures

A. Definition of the goals a. Measure current situation b. Analysis c. Interpretation (Forecast) d. Standard definition e. Law	**Tools for A** 1. Satellite images (different satellites) 2. Ground measurements (mobile and stations) 3. Prediction software 4. Multidimensional Geospatial analysis 5. Interpretation
B. Pollution management a. Locate issues b. Measure them c. Analyse them d. Mitigation e. Enforcement	**Tools for B** 1. Same as A 2. Data portal 3. Citizens feedback 4. Enforcement units


A
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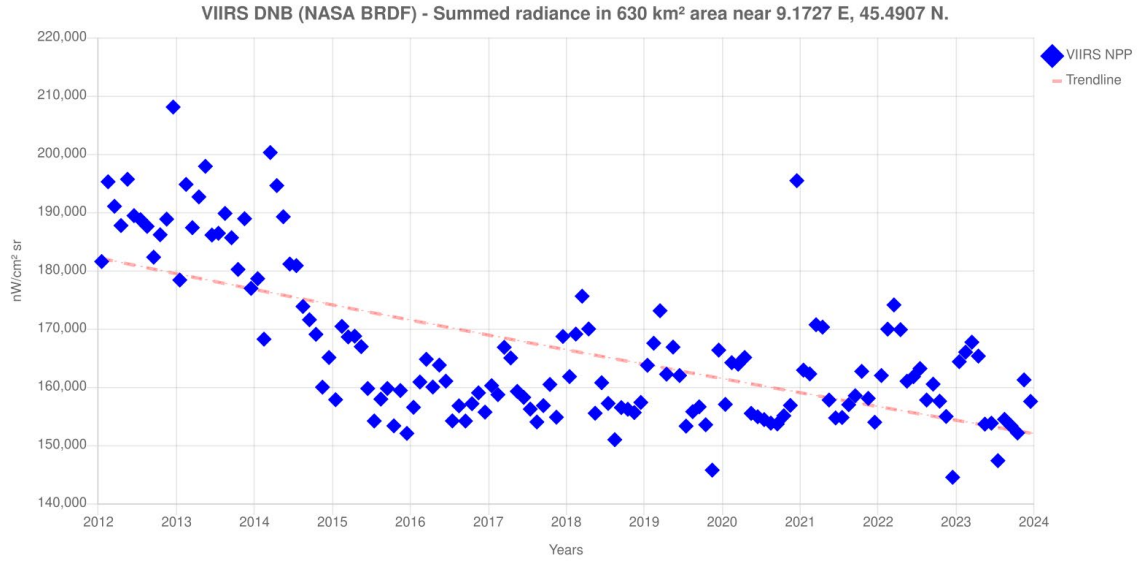
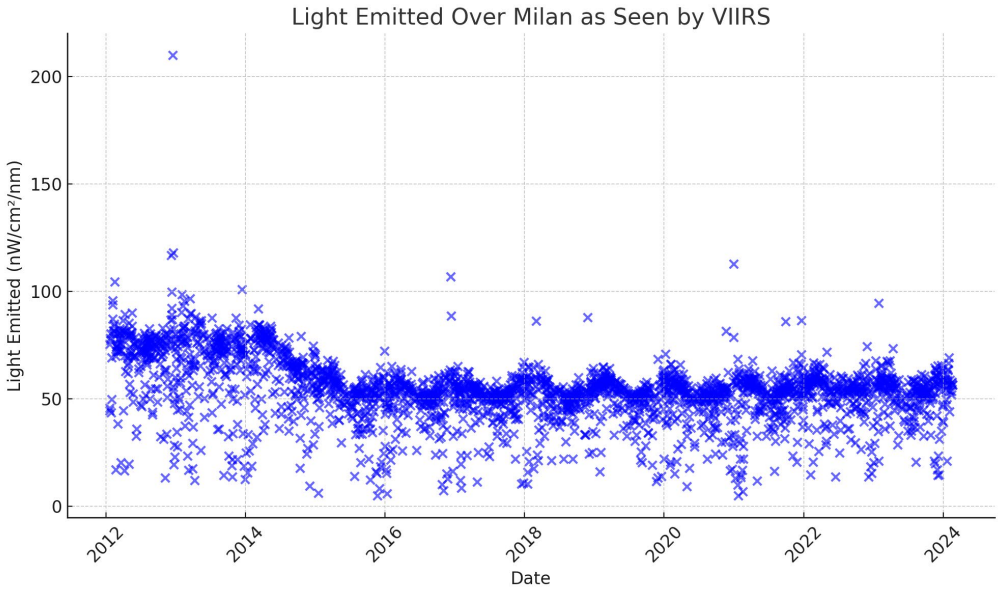
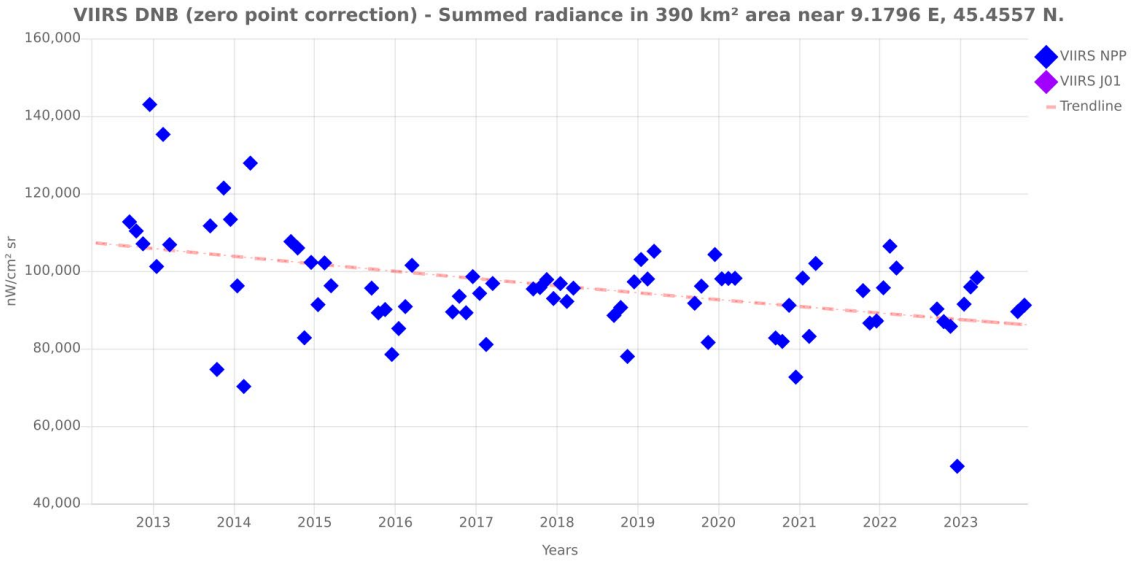
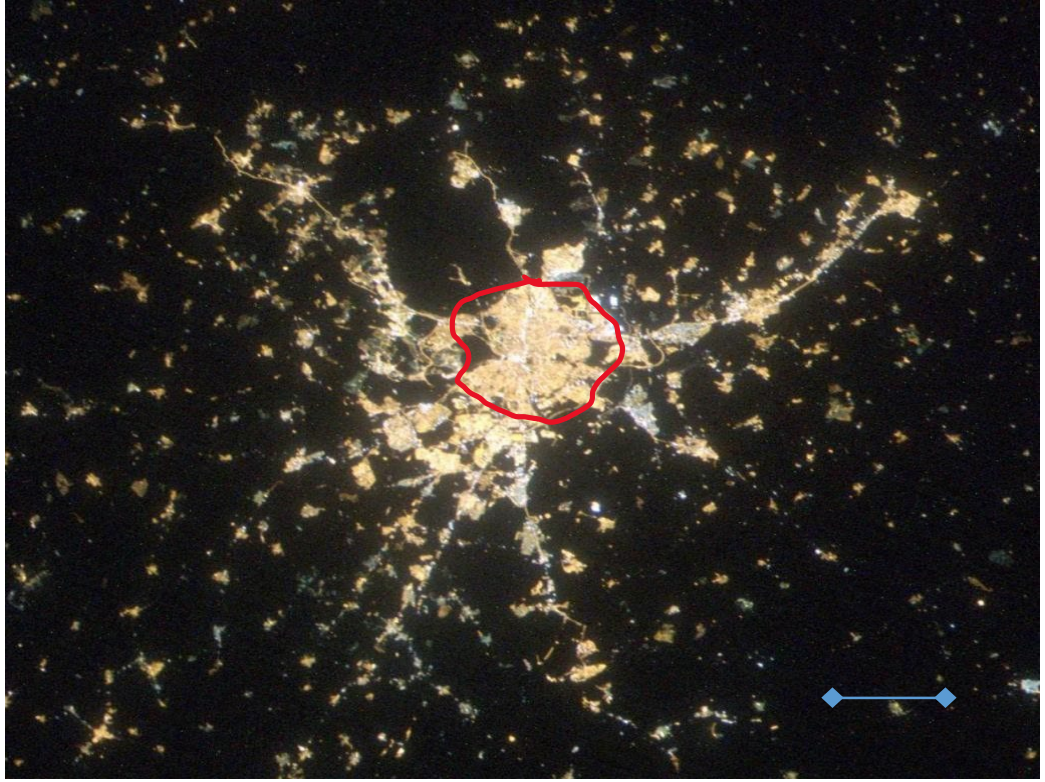
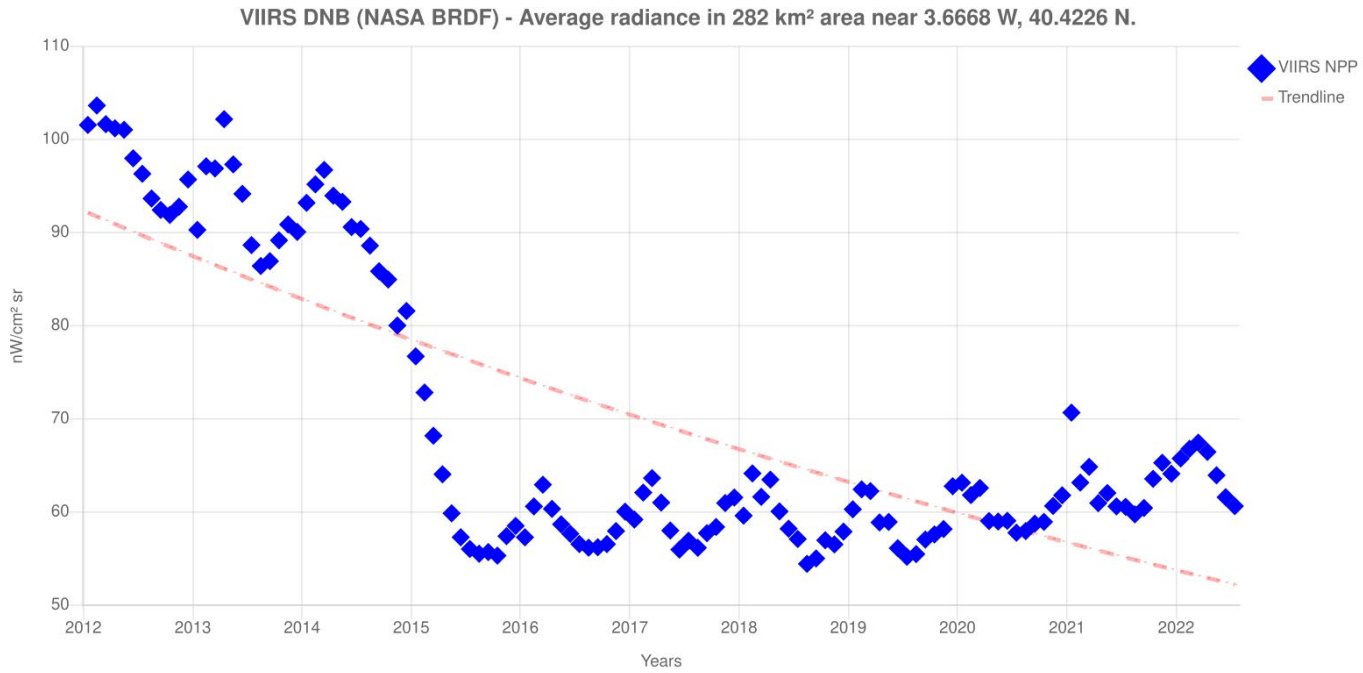
Decreased
1.0
No change
2.0
Increased

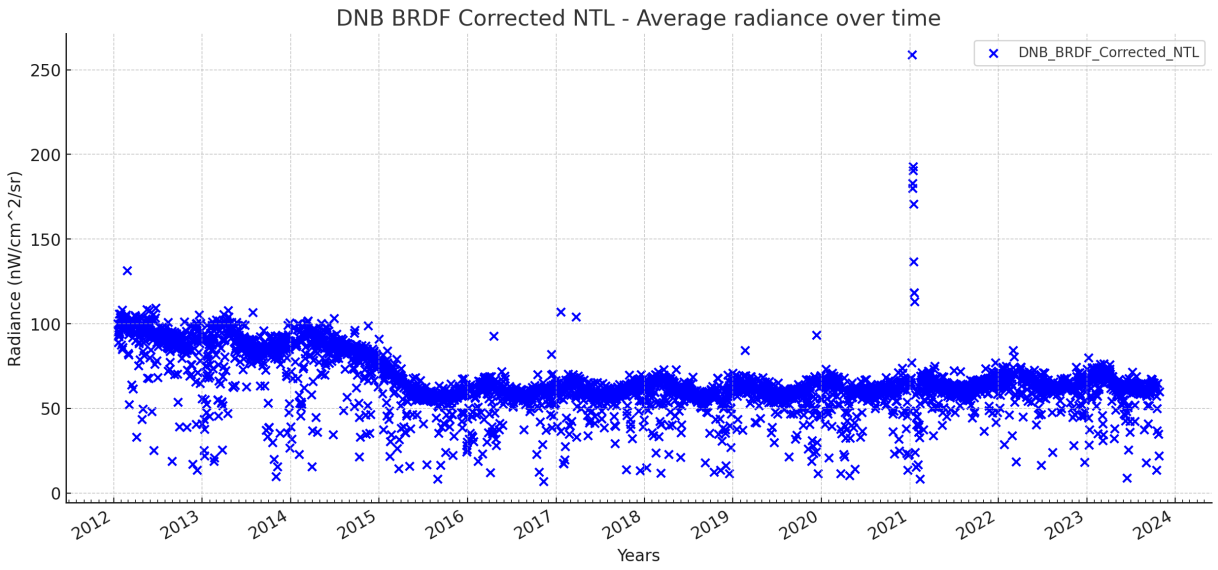

VIIRS DNB (NASA BRDF) - Summed radiance in 630 km² area near 9.1727 E, 45.4907 N.
VIIRS NPP
Trendline
nW/cm² sr
Years

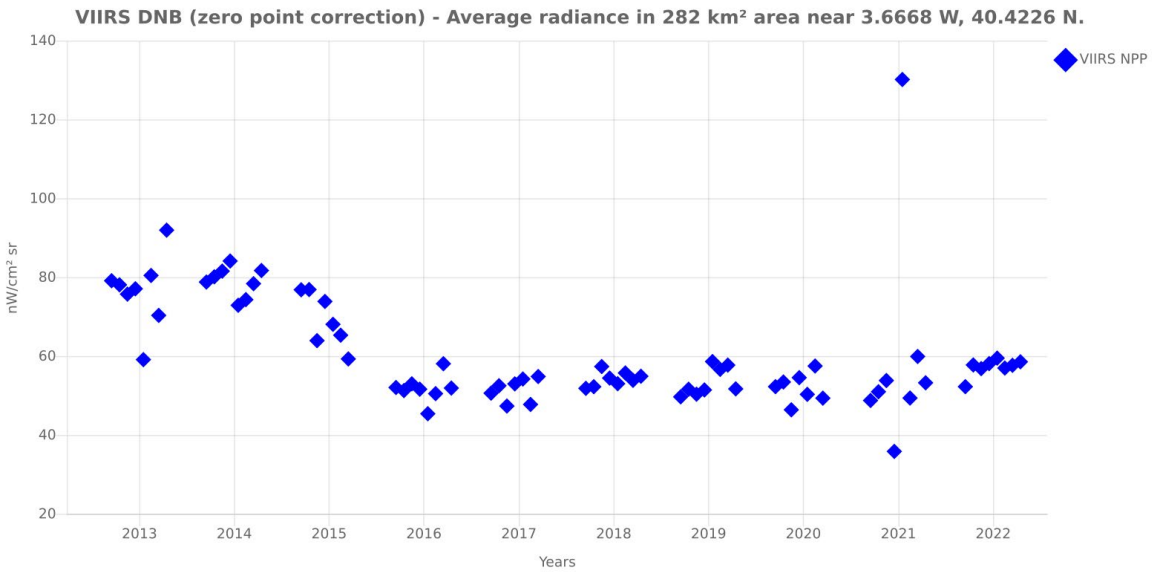

Light Emitted Over Milan as Seen by VIIRS
Light Emitted (nW/cm²/nm)
Date

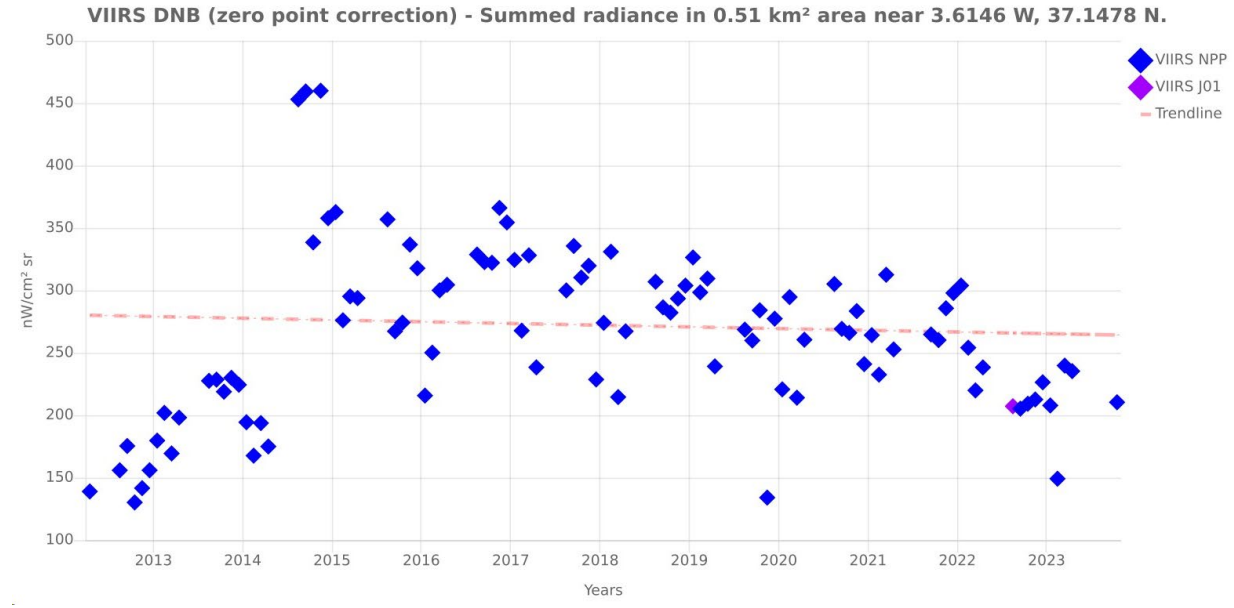

VIIRS DNB (zero point correction) - Summed radiance in 390 km² area near 9.1796 E, 45.4557 N.
VIIRS NPP
VIIRS J01
Trendline
nW/cm² sr
Years

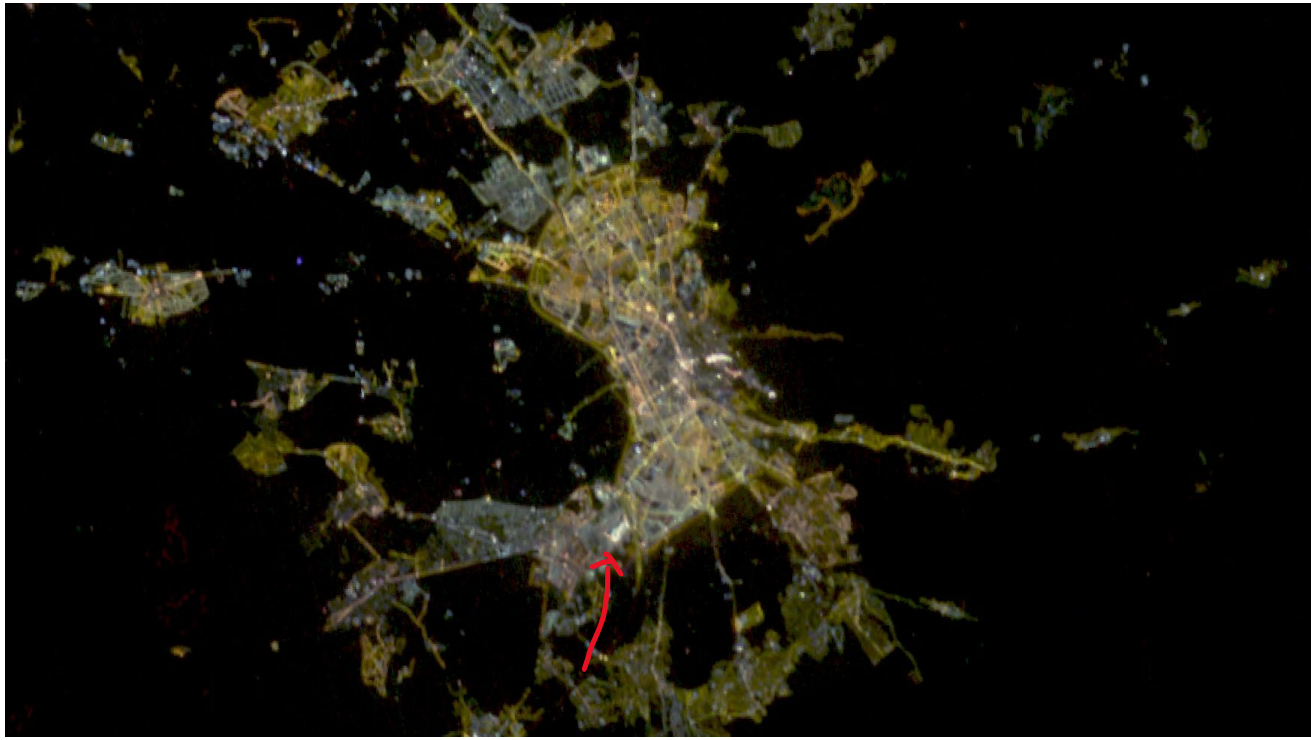


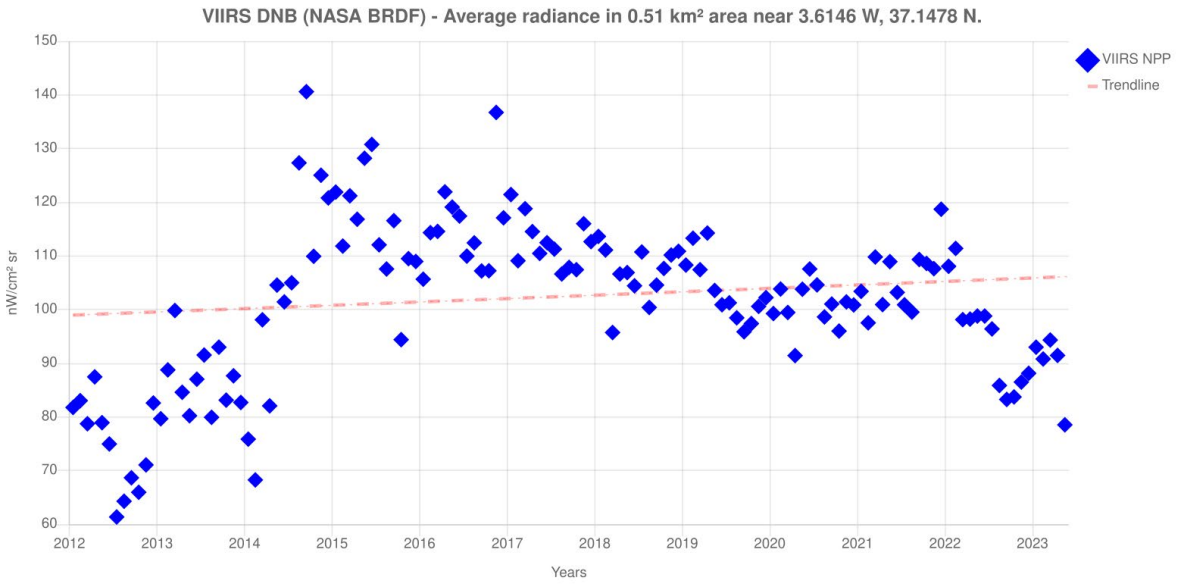

VIIRS DNB (NASA BRDF) - Average radiance in 282 km² area near 3.6668 W, 40.4226 N.
VIIRS NPP
Trendline
nW/cm² sr
110
100
90
80
70
60
50
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Years

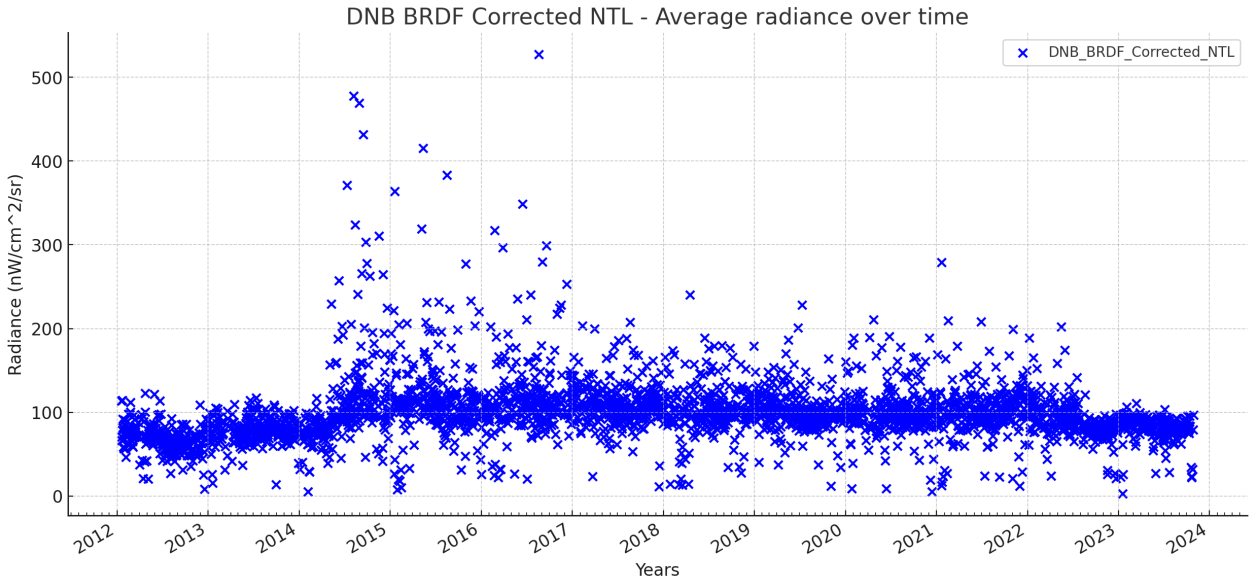

DNB BRDF Corrected NTL - Average radiance over time
DNB_BRDF_Corrected_NTL
Radiance (nW/cm^2/sr)
250
200
150
100
50
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Years


VIIRS DNB (zero point correction) - Average radiance in 282 km² area near 3.6668 W, 40.4226 N.
VIIRS NPP
nW/cm² sr
140
120
100
80
60
40
20
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Years


VIIRS DNB (zero point correction) - Summed radiance in 0.51 km² area near 3.6146 W, 37.1478 N.
VIIRS NPP
VIIRS J01
Trendline
nW/cm² sr
Years




VIIRS DNB (NASA BRDF) - Average radiance in 0.51 km² area near 3.6146 W, 37.1478 N.
VIIRS NPP
Trendline
nW/cm² sr
Years


DNB BRDF Corrected NTL - Average radiance over time
DNB_BRDF_Corrected_NTL
Radiance (nW/cm^2/sr)
Years

Monitoring of Light Pollution

Dr. Alejandro Sánchez de Miguel

Summary of the Meeting on Light Pollution:
Challenges and Responses for Monitoring it.
Granada 14-15 of November 2023

PRESIDENCIA ESPAÑOLA CONSEJO DE LA UNIÓN EUROPEA
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