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How many light bulbs does it take to put  
up a  $\text{nW}/\text{cm}^2\text{sr}$ ?

Christopher Kyba  
GFZ German Research Centre for Geosciences  
June 29, 2022



How many Canadians does it take  
to change a lightbulb?





# How many Canadians does it take to change a lightbulb?

Two. One to change the lightbulb and another to  
apologize to the darkness.



# How many remote sensing experts does it take to change a lightbulb?

Just one, and it's done correctly:

94.83% of the time with random forest

94.97% of the time with support vector machines

95.01% of the time with artificial neural networks









NASA MESSENGER, August 2, 2005





NOAA DSCOV, July 16, 2015





Bettymaya Foott  
International Dark-Sky Association







# Impact on plants

November 17



December 1



December 6



See Knop et al. *Nature* 2017, Bennie et al. *J Ecol* 2016



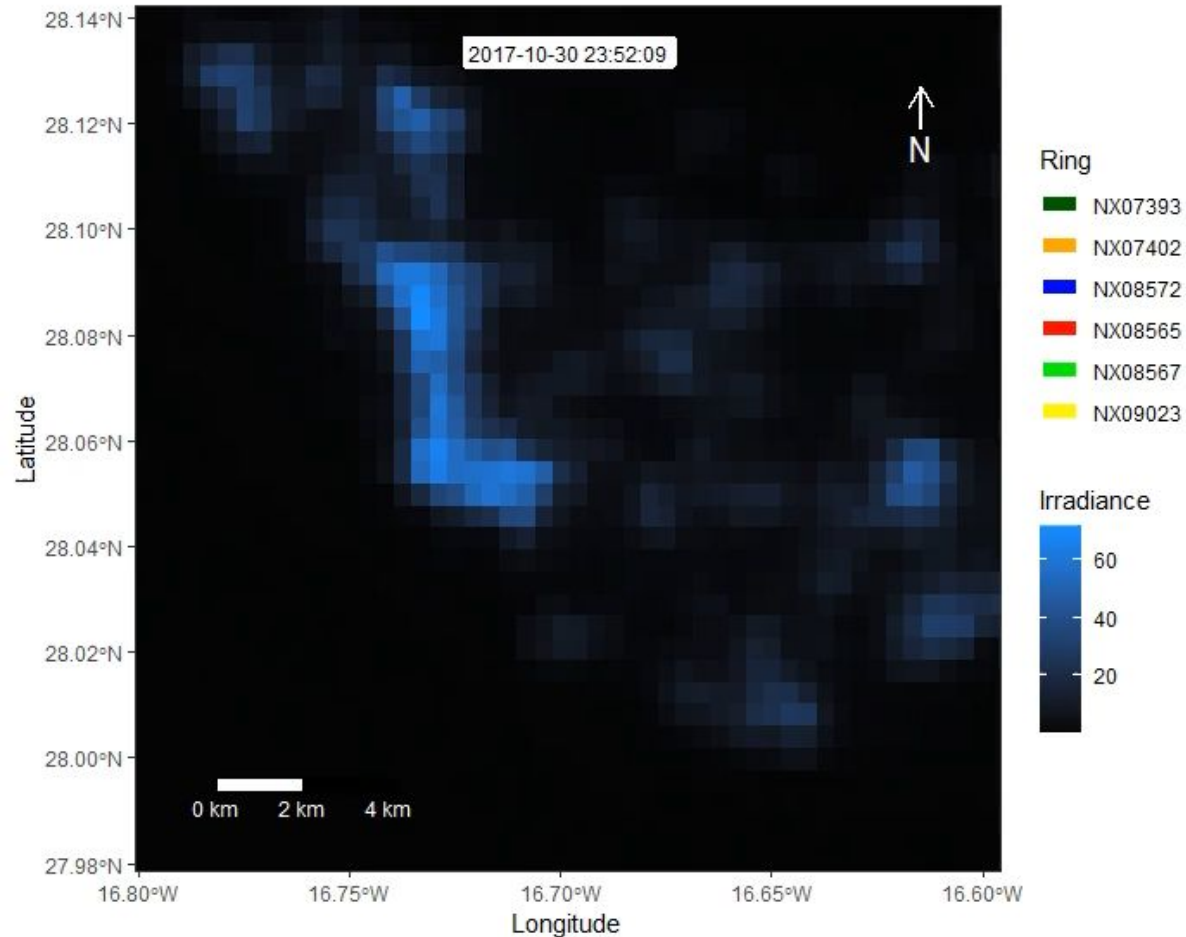
# Impact on animals



Airam Rodriguez



# Impact on animals



Airam Rodriguez

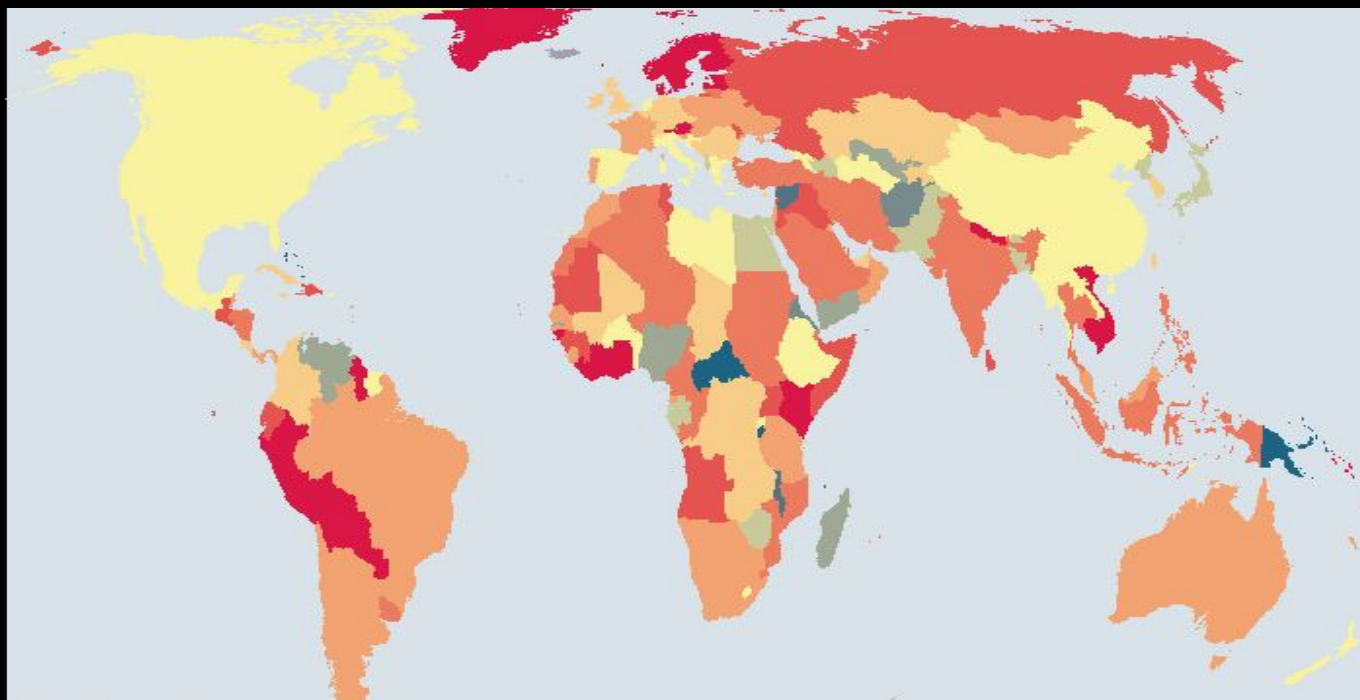


# ALAN research with VIIRS DNB

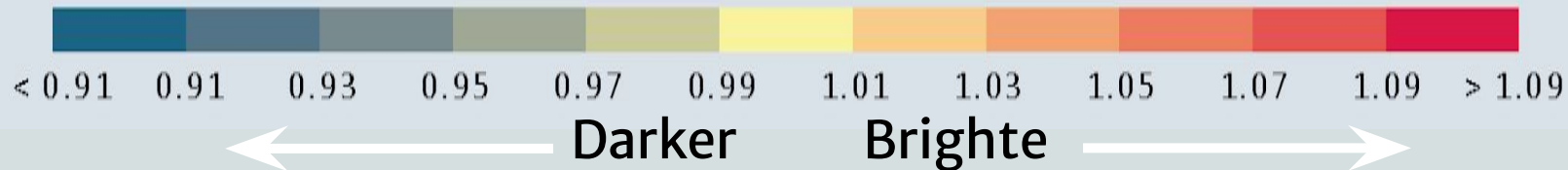
- Assessing exposure to ALAN
  - Animals, plants, & humans
- Modeling artificial night sky brightness
- Studying changes in night lights
- Remote sensing of:
  - Energy consumption for outdoor lighting
  - Lighting technology
  - Makeup of night lights (and how it is changing)
  - Population, GDP, etc.



# Annual change in radiance 2012–2016



Rate of change

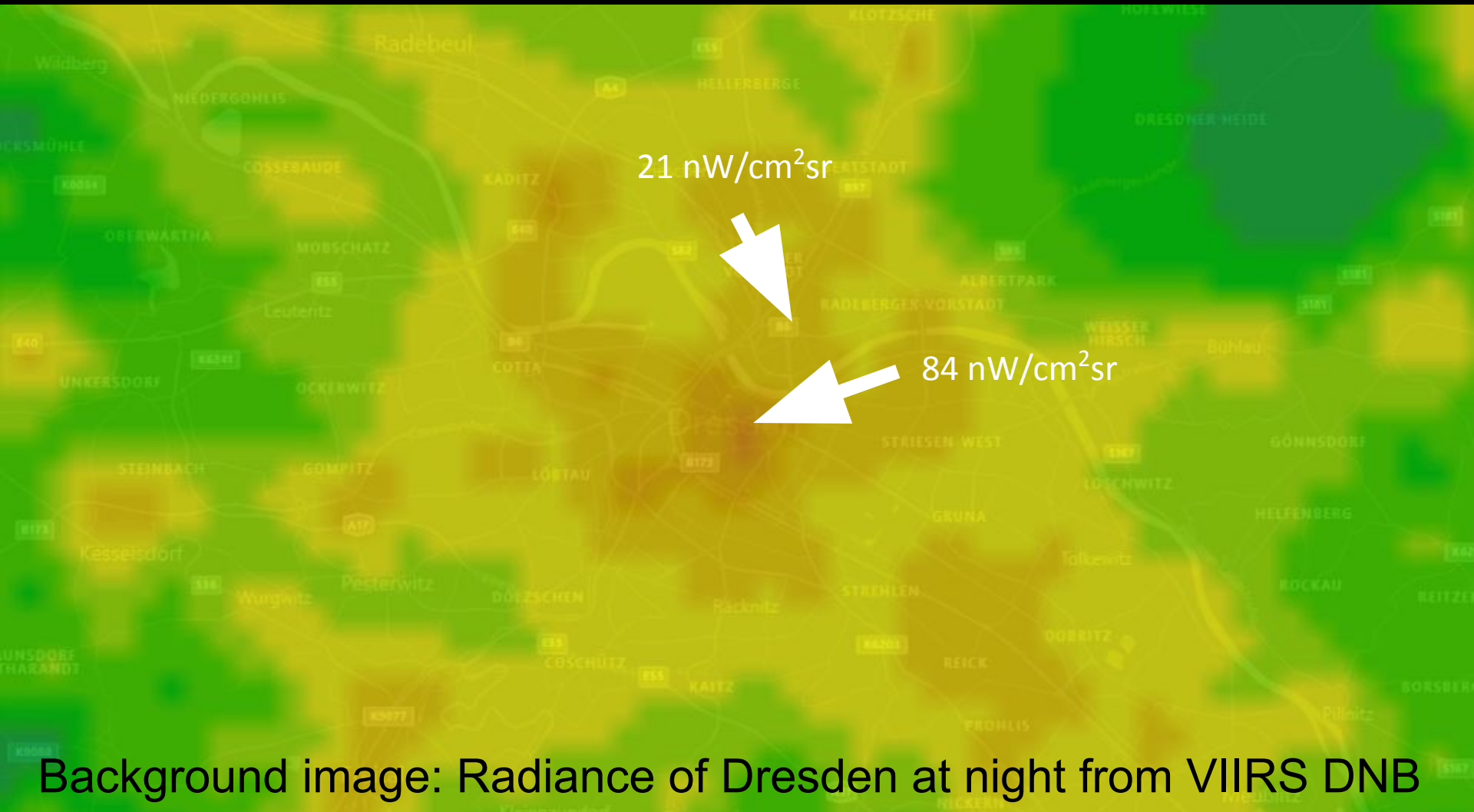








# What does VIIRS DNB “radiance” mean?









# Around 4,000 transects surveyed worldwide

NightLights 

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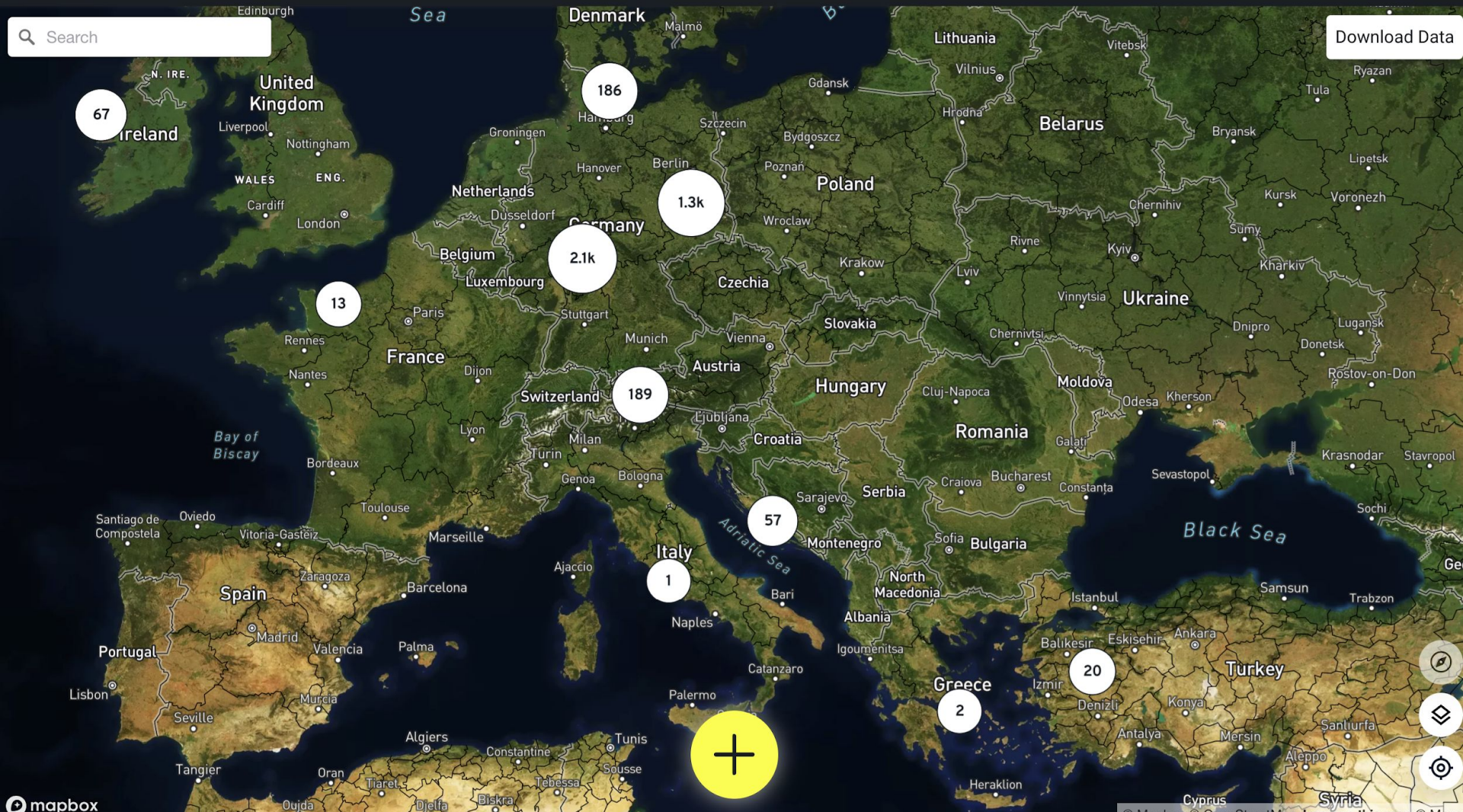
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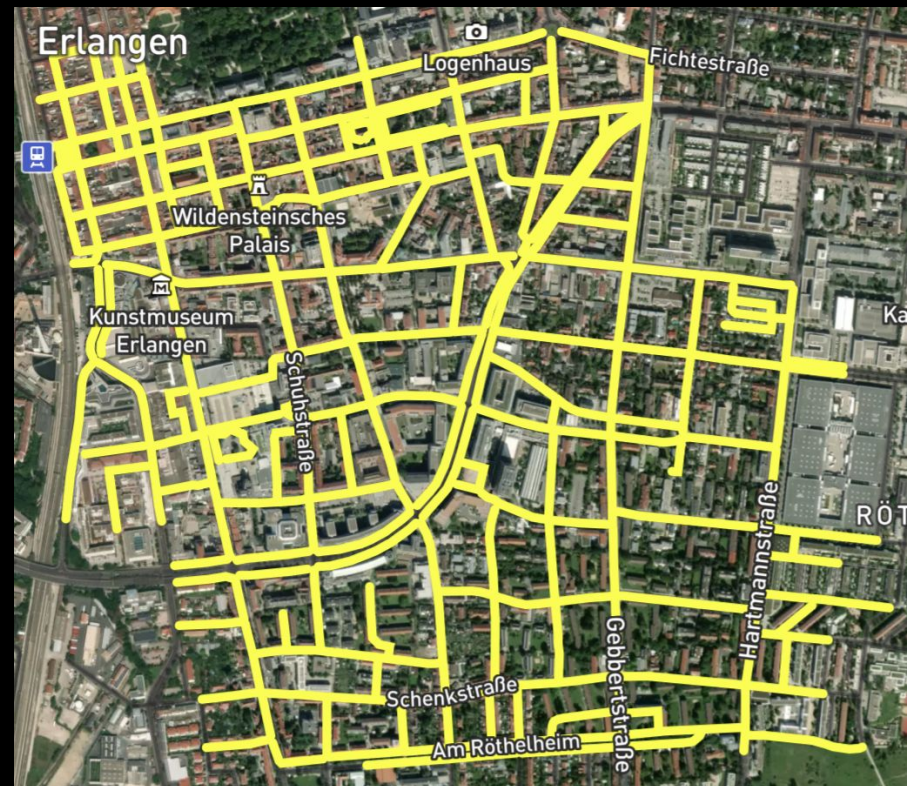
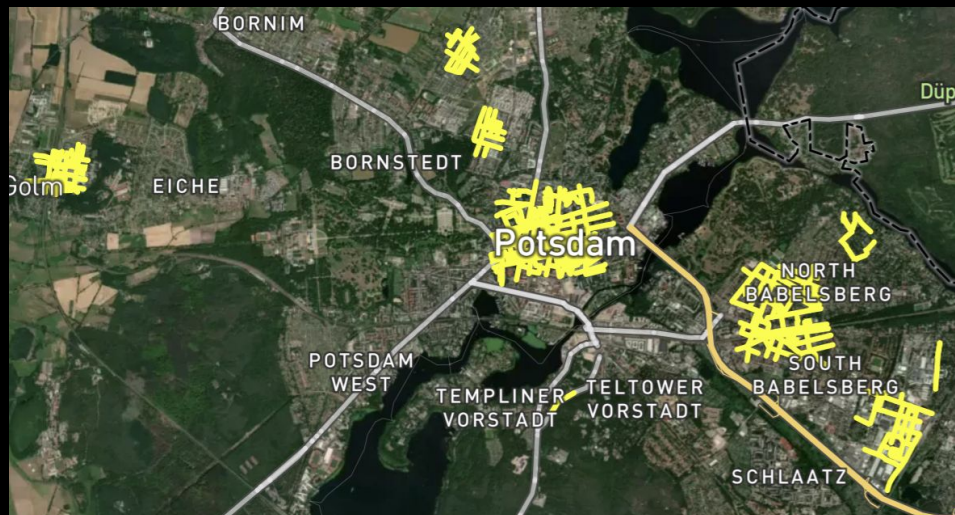
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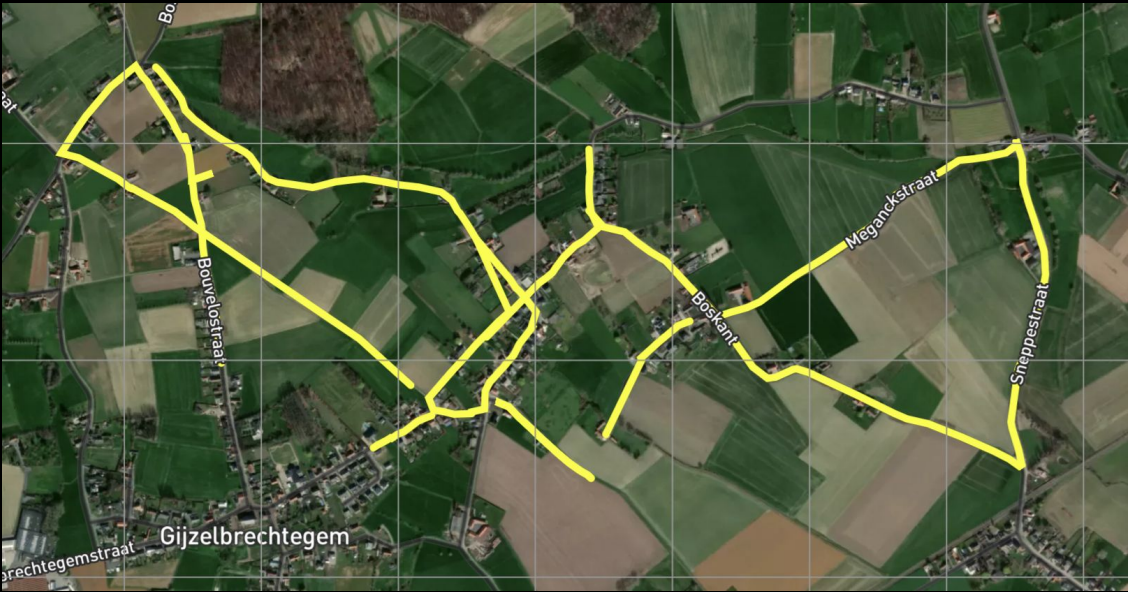
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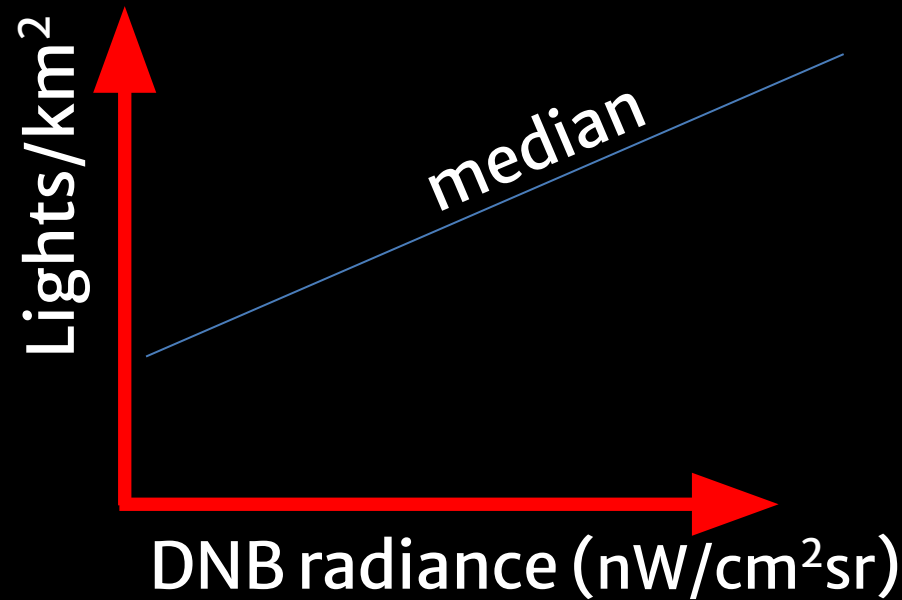






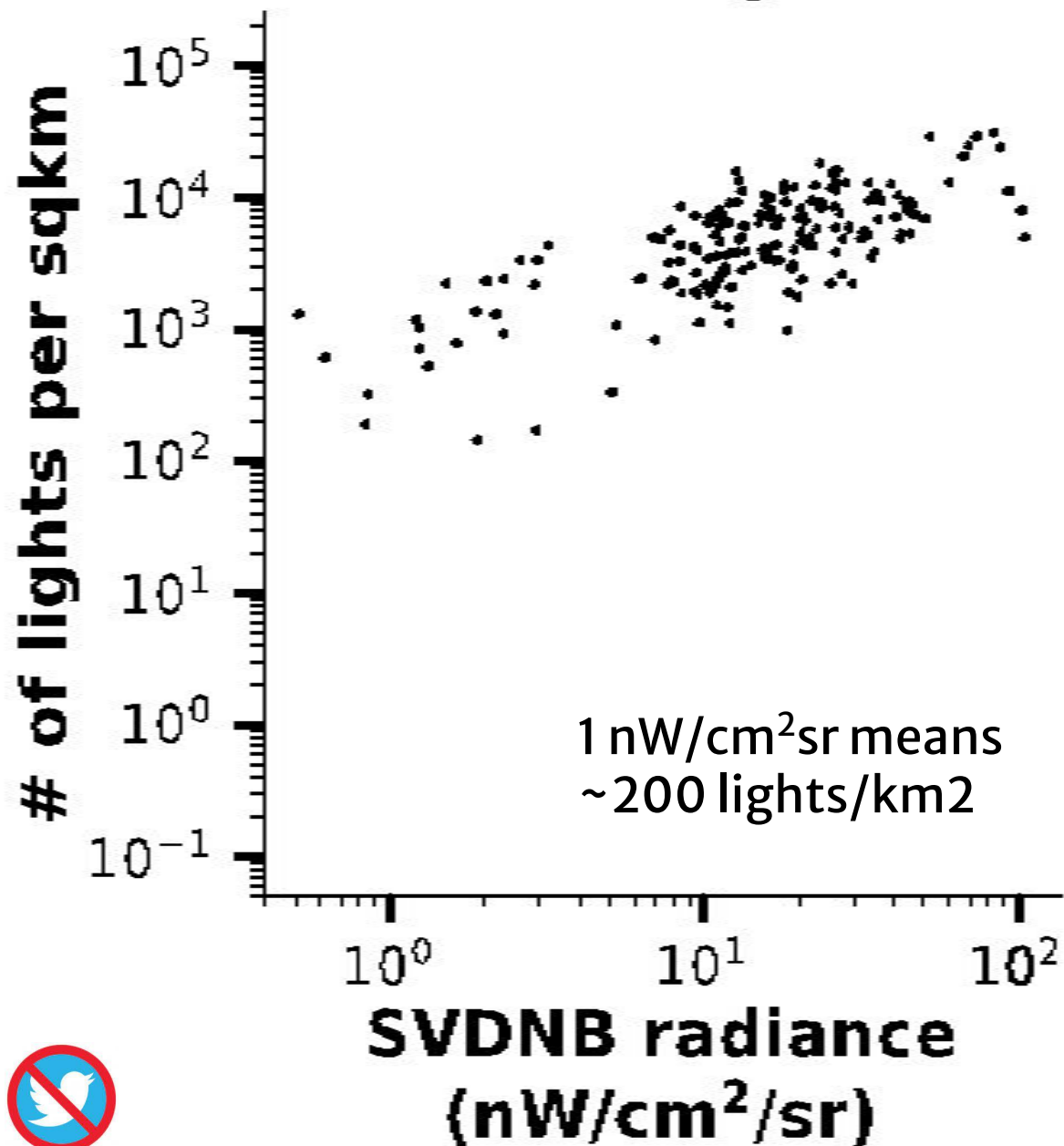


# Relation between DNB and lights on the ground



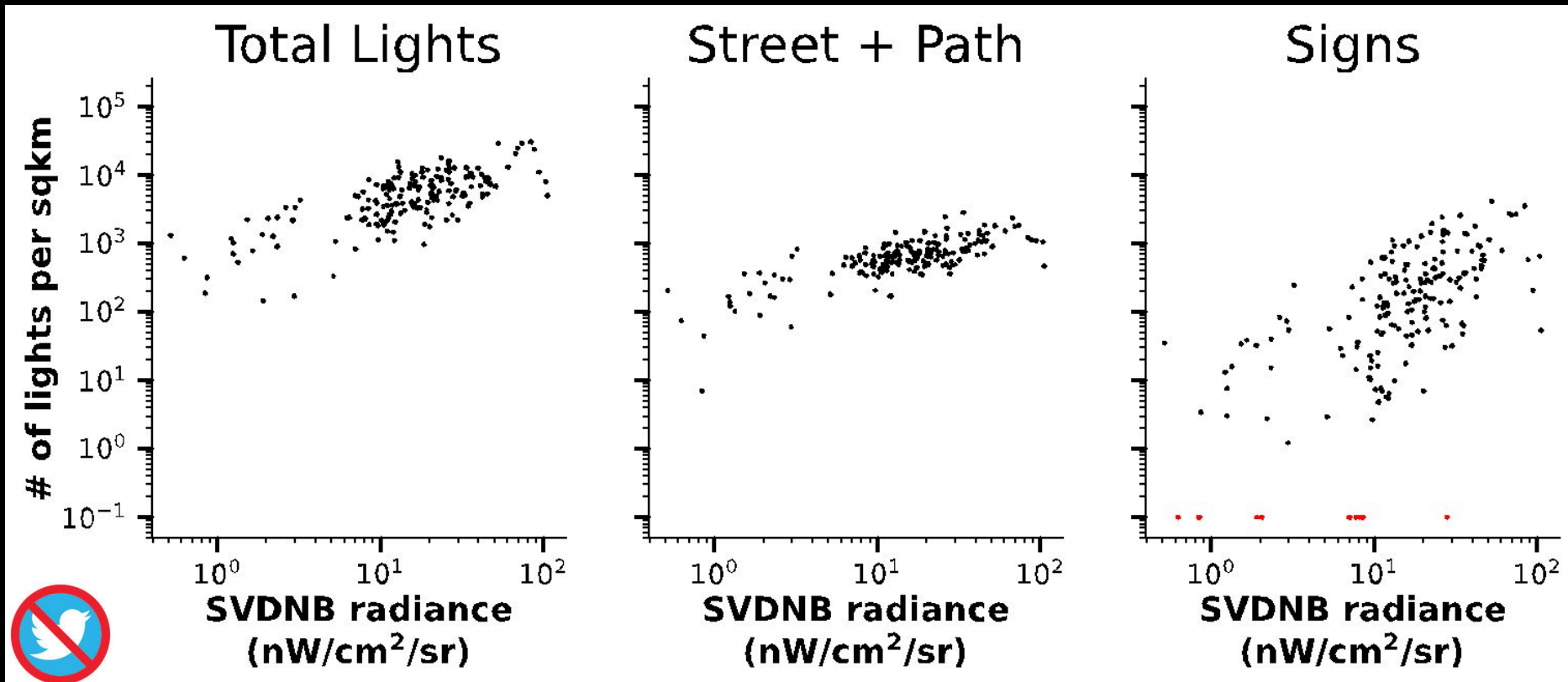


# Total Lights



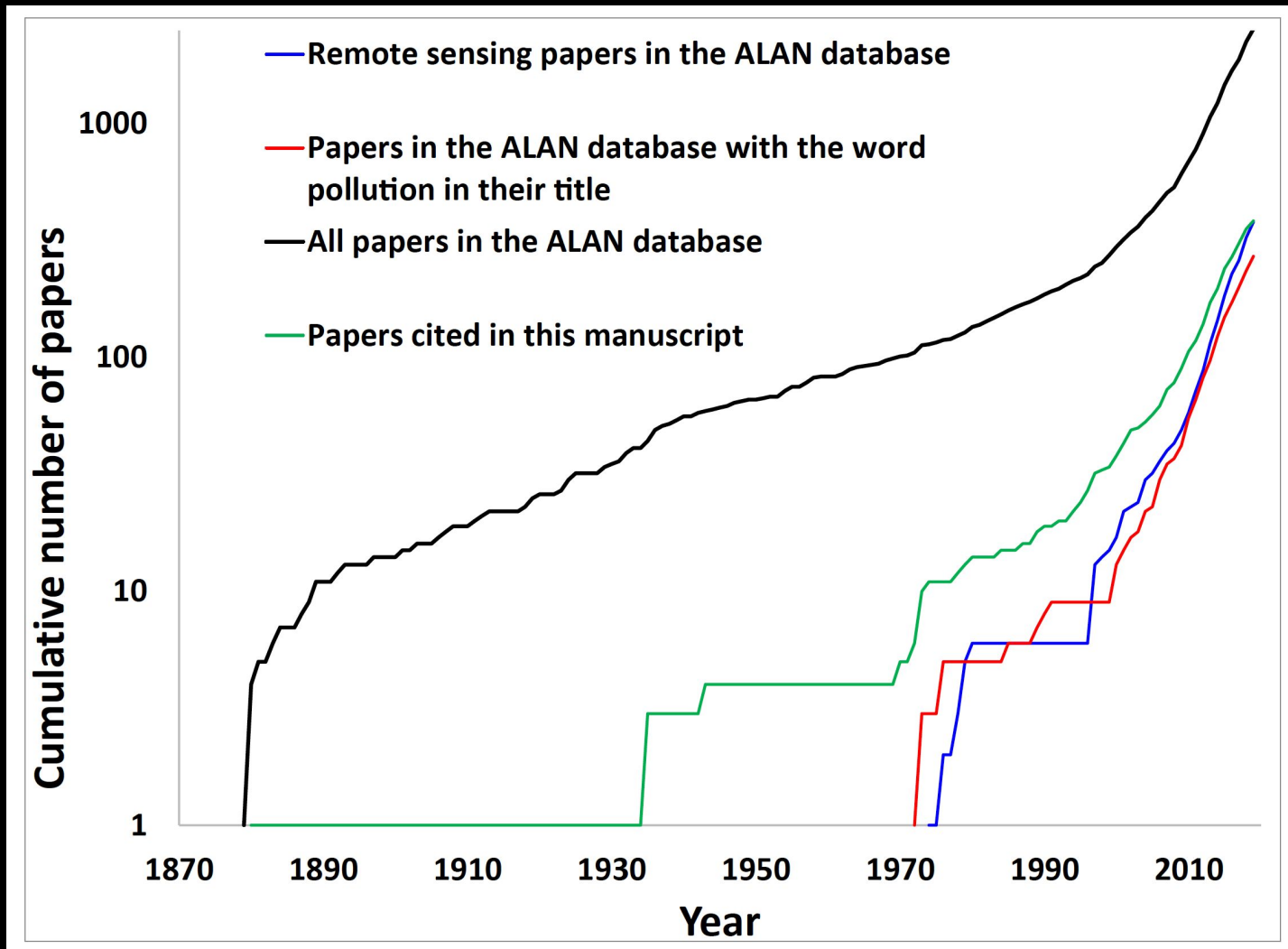


# Relation between DNB and lights on the ground





# DNB has had a dramatic impact on the field of ALAN research



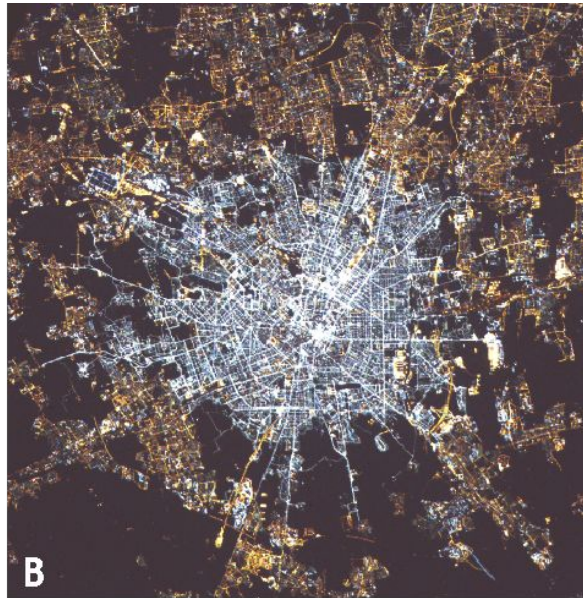
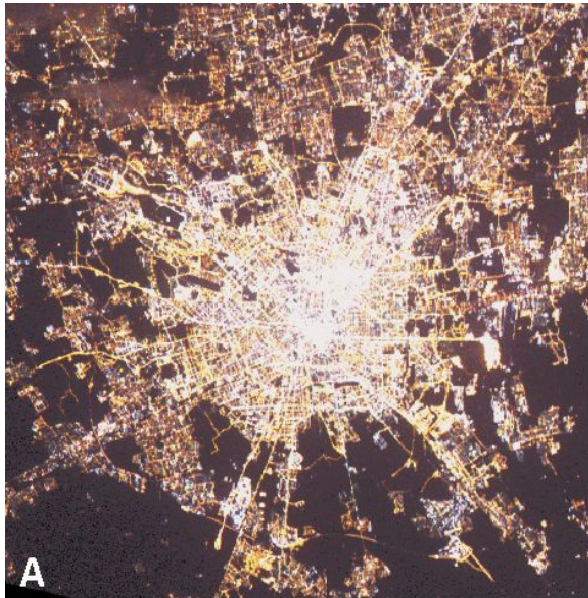


# Primary difficulties with VIIRS DNB

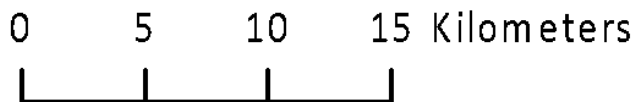
- Spectral band (doesn't match human vision)
- Single (late) overpass time
- Spatial resolution



# LED conversion in Milan, Italy



Milan, Italy





# Primary difficulties with VIIRS DNB

- Spectral band (doesn't match human vision)
- Single (late) overpass time
- Spatial resolution







# Primary difficulties with VIIRS DNB

- Spectral band (doesn't match human vision)
- Single (late) overpass time
- Spatial resolution



# How many remote sensing experts does it take to change a lightbulb?

1000. One to change the lightbulb, and a team of 999 to design, build, and operate a satellite to determine its properties.



# Thank you VIIRS team!

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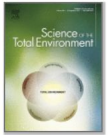
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Science of The Total Environment

Volume 841, 1 October 2022, 156782



Majority of artificially lit Earth surface associated with the non-urban population

[D.T.C. Cox](#) <sup>a,2</sup> 



International Journal of Hygiene and Environmental Health

Volume 241, April 2022, 113932



Association of exposure to artificial light at night with atopic diseases: A cross-sectional study in college students

[Zhenwei Tang](#) <sup>a, b, 1</sup>, [Shenxin Li](#) <sup>c, 1</sup>, [Minxue Shen](#) <sup>a, b, d, 2</sup> , [Yi Xiao](#) <sup>a, b, 2</sup> , [Juan Su](#) <sup>a, b</sup>, [Juan Ta](#) 

**Correlation Analysis Between Nighttime Light Data and Socioeconomic Factors on Fine Scales**

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