Massive open mobile phone derived human mobility data is coming to the EU

@ Geomob · Berlin

Egor Kotov

Max Planck Institute for Demographic Research

Universitat Pompeu Fabra

June 4, 2025

Egor Kotov

The Moscow Urban Forum 2016 - "Moscow: heading towards polycentricity"

Mobile Tartu Conference 2020 - "The role of land use and transport accessibility in trip generation: evidence from the Moscow mobile phone data"

Egor Kotov

- 15+ years of experience working with spatial data

The Moscow Urban Forum 2016 - "Moscow: heading towards polycentricity"

Mobile Tartu Conference 2020 - "The role of land use and transport accessibility in trip generation: evidence from the Moscow mobile phone data"

Egor Kotov

- 15+ years of experience working with spatial data
- 10+ years of experience working with mobile phone based mobility data

The Moscow Urban Forum 2016 - "Moscow: heading towards polycentricity"

Mobile Tartu Conference 2020 - "The role of land use and transport accessibility in trip generation: evidence from the Moscow mobile phone data"

Egor Kotov

- 15+ years of experience working with spatial data
- 10+ years of experience working with mobile phone based mobility data
- Developer and maintainer of R packages

The Moscow Urban Forum 2016 - "Moscow: heading towards polycentricity"

Mobile Tartu Conference 2020 - "The role of land use and transport accessibility in trip generation: evidence from the Moscow mobile phone data"

Egor Kotov

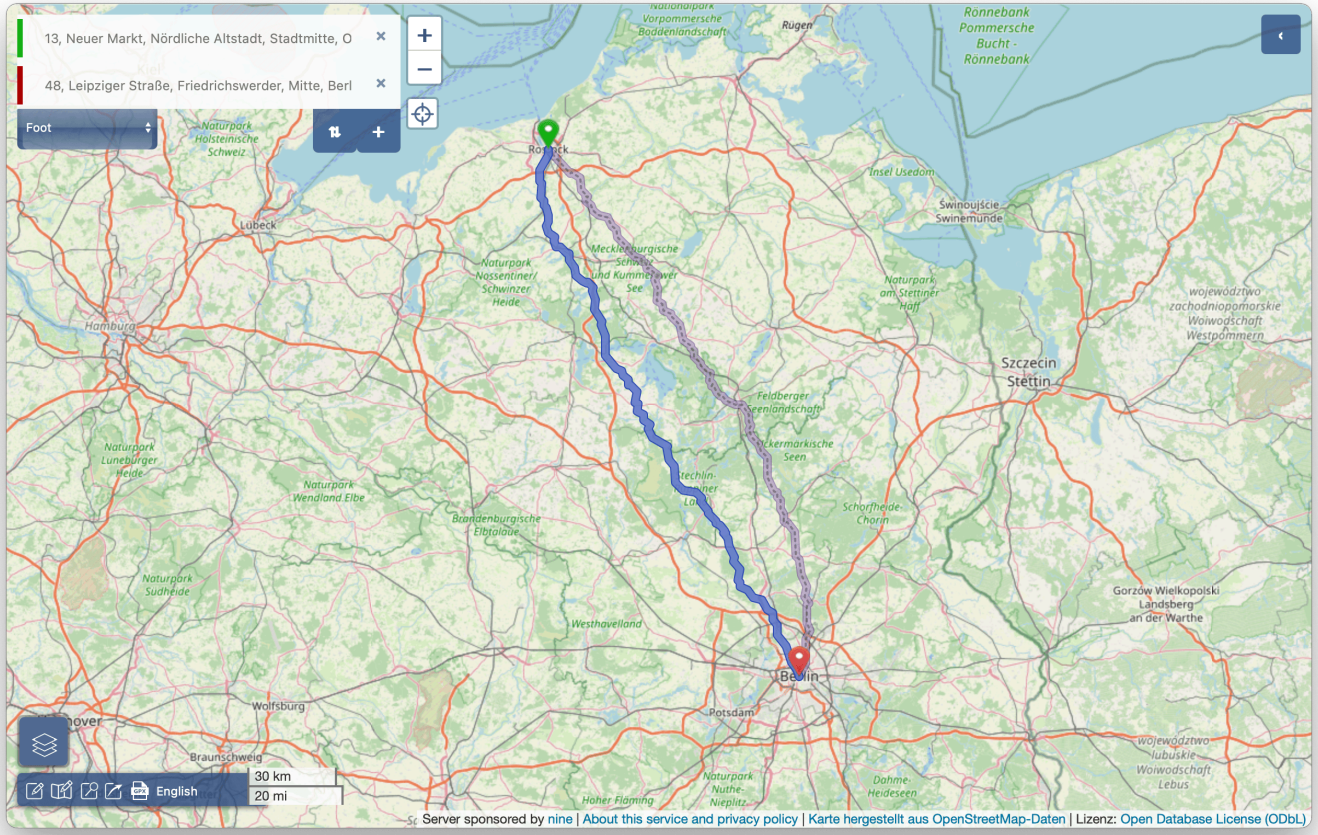
- 15+ years of experience working with spatial data
- 10+ years of experience working with mobile phone based mobility data
- Developer and maintainer of R packages
- Not affiliated with any of the companies or entities mentioned in this presentation from this point on

The Moscow Urban Forum 2016 - "Moscow: heading towards polycentricity"

Mobile Tartu Conference 2020 - "The role of land use and transport accessibility in trip generation: evidence from the Moscow mobile phone data"

Hello from Rostock

I came from Rostock to do this talk at Geomob Berlin



Contents

- What do we know about human mobility?
- Spanish Open Mobility Big Data
- The future of human mobility in the EU

What do we know about human mobility?

Survey-based human mobility

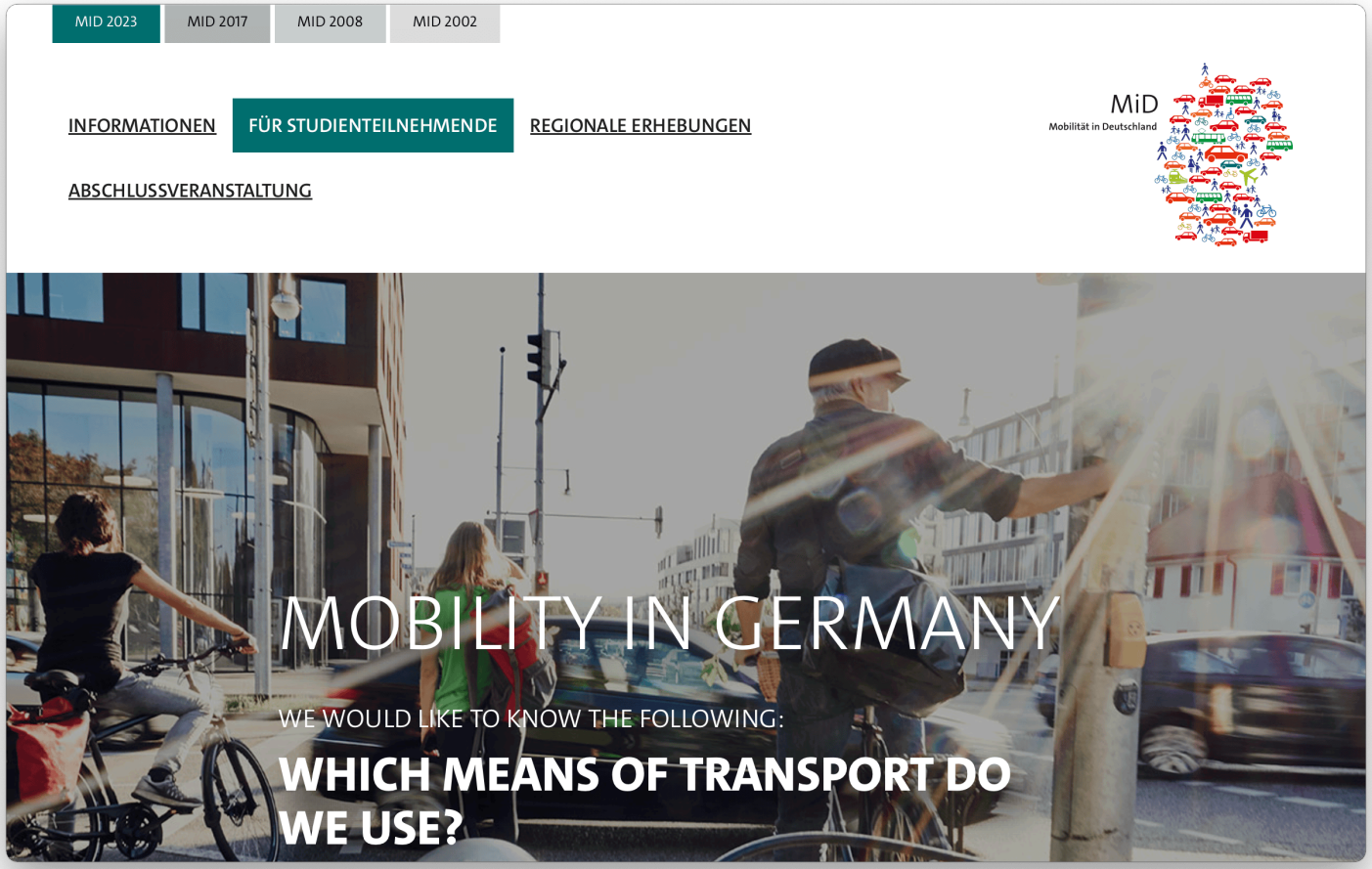
European Labour Force Surveys

Source: ***https://ec.europa.eu/eurostat/web/microdata/european-union-labour-force-survey***

Image source: ***https://ec.europa.eu/eurostat/documents/345175/17780010/2021-NUTS-3-map-ES.pdf***

Survey-based human mobility

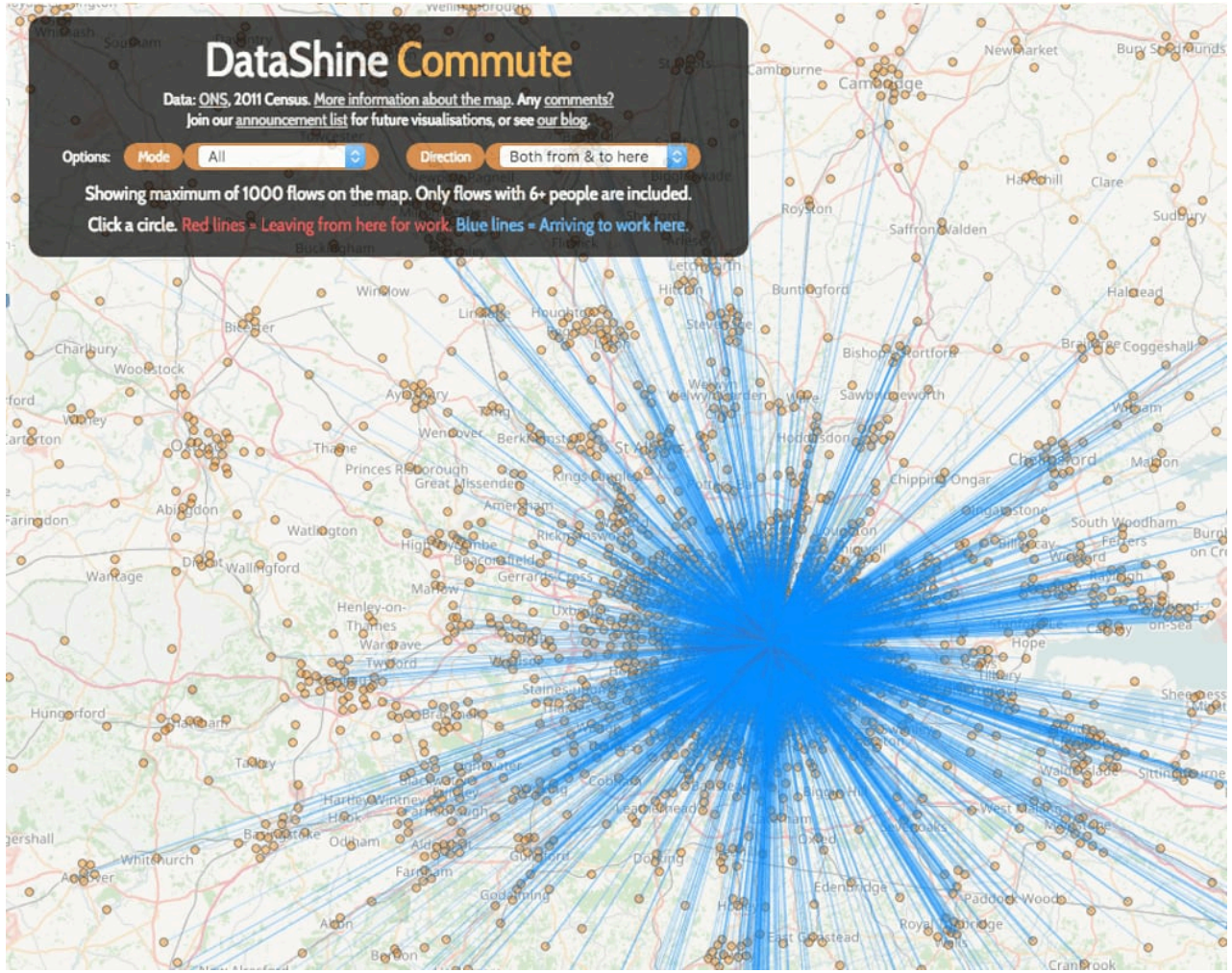
German Mobility Survey



Source: ***https://www.mobilitaet-in-deutschland.de/***

Census-based human mobility

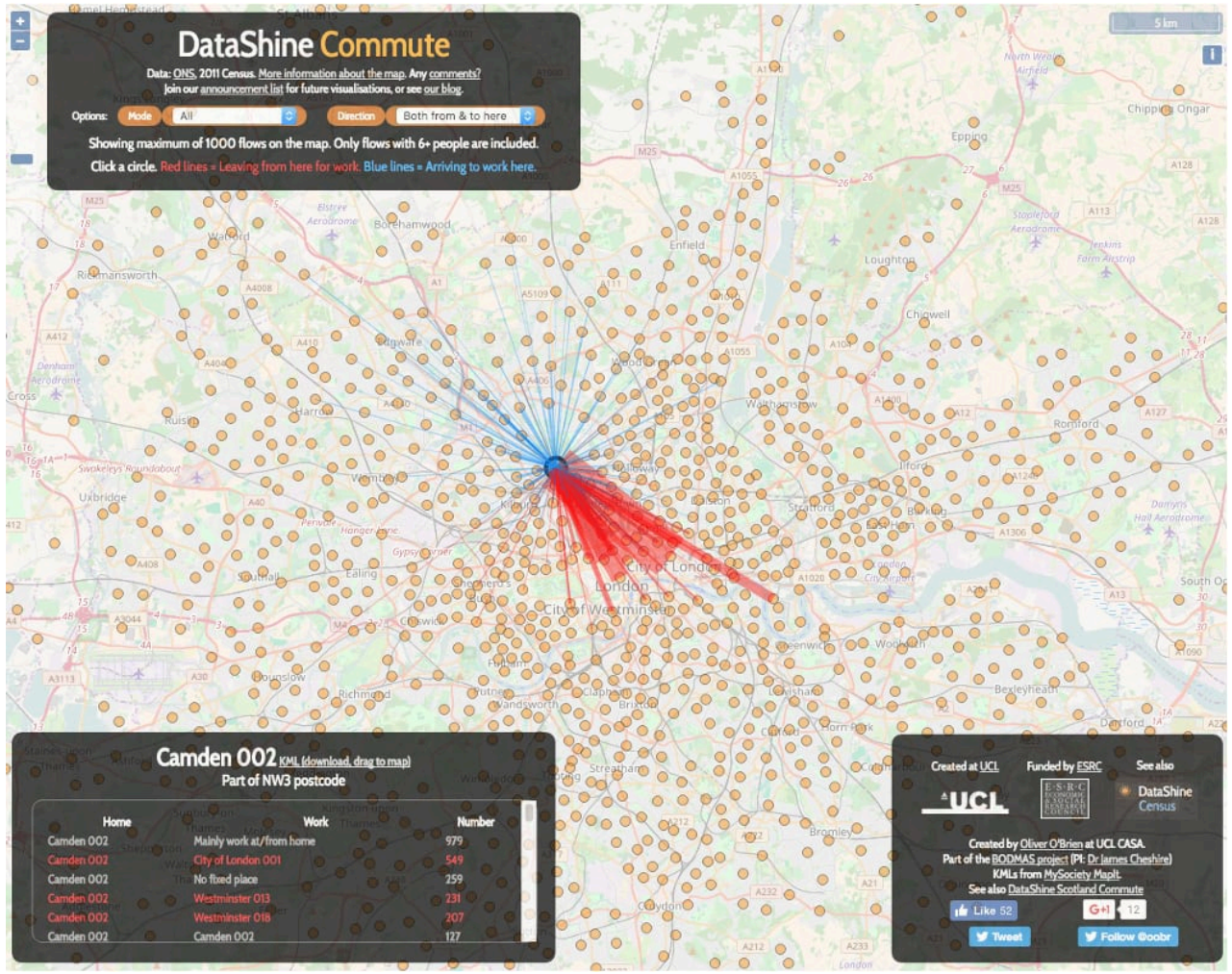
UK Census



Source: ***https://commute.datashine.org.uk/***

Census-based human mobility

UK Census



Source: *https://commute.datashine.org.uk/*

Register-based human mobility

Netherlands Register Data

Source: https://www.flowmap.blue/1Oe3zM219uSfJ3sjdRT90SAK2kU3xIvzdcCW6cwTsAuc

Data: https://opendata.cbs.nl/#/CBS/nl/dataset/83628NED/table?dl=F076

IOT GPS Data

The Volkswagen leak

Source: *https://media.ccc.de/v/38c3-wir-wissen-wo-dein-auto-steht-volksdaten-von-volkswagen*

Mobile Apps + Mobile Network GPS Data

App usage by Orange customers in France

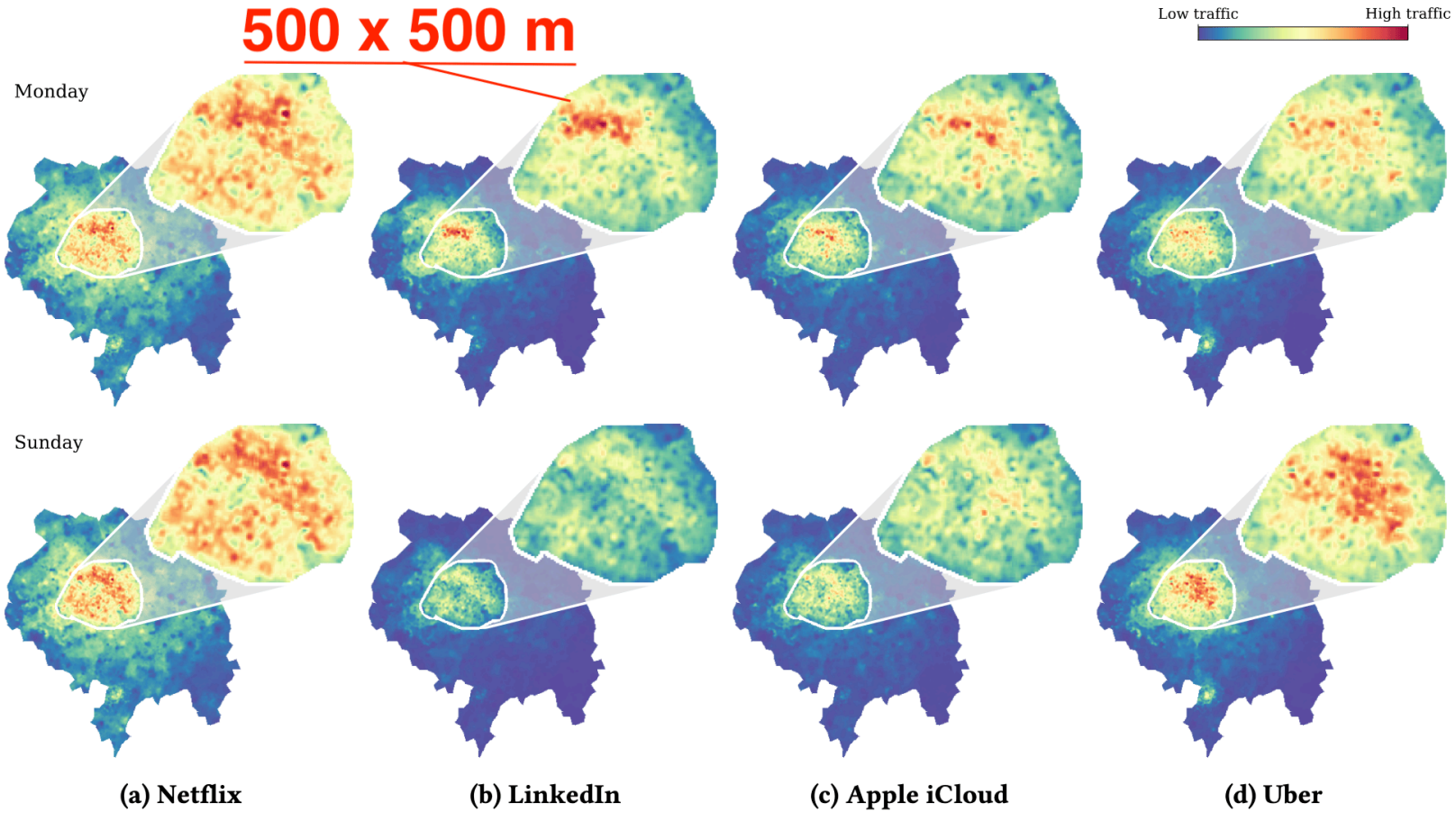
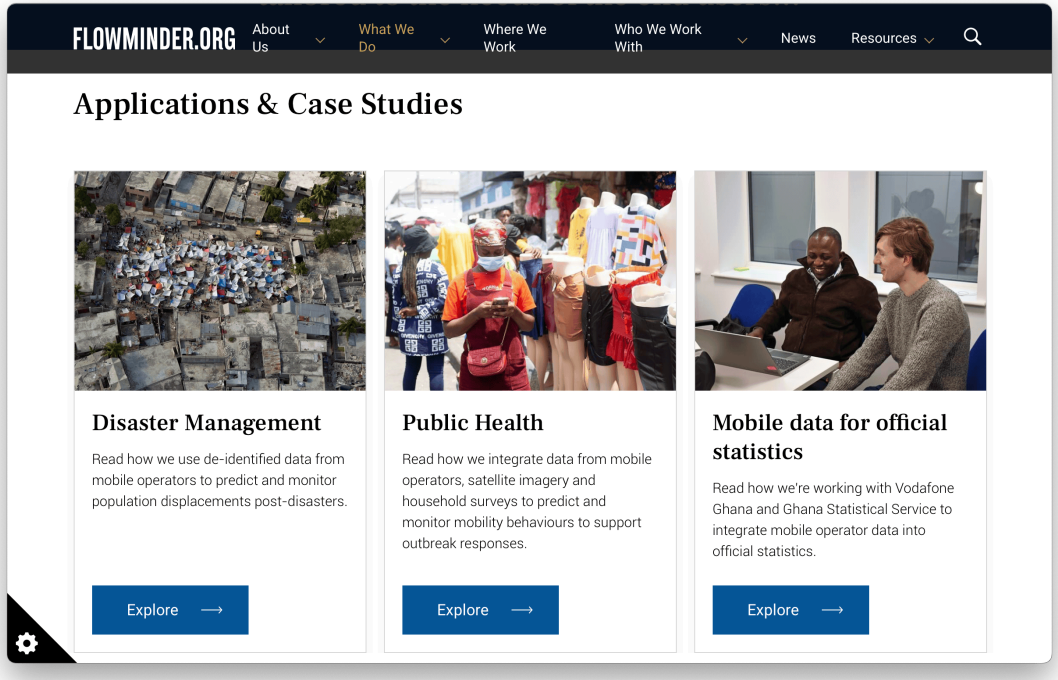


Figure 8: Spatial traffic generated by four applications in Paris, on Mondays (top) and Sundays (bottom).

Image source: Martínez-Durive et al. (2023)

Mobile phone data

Flowminder

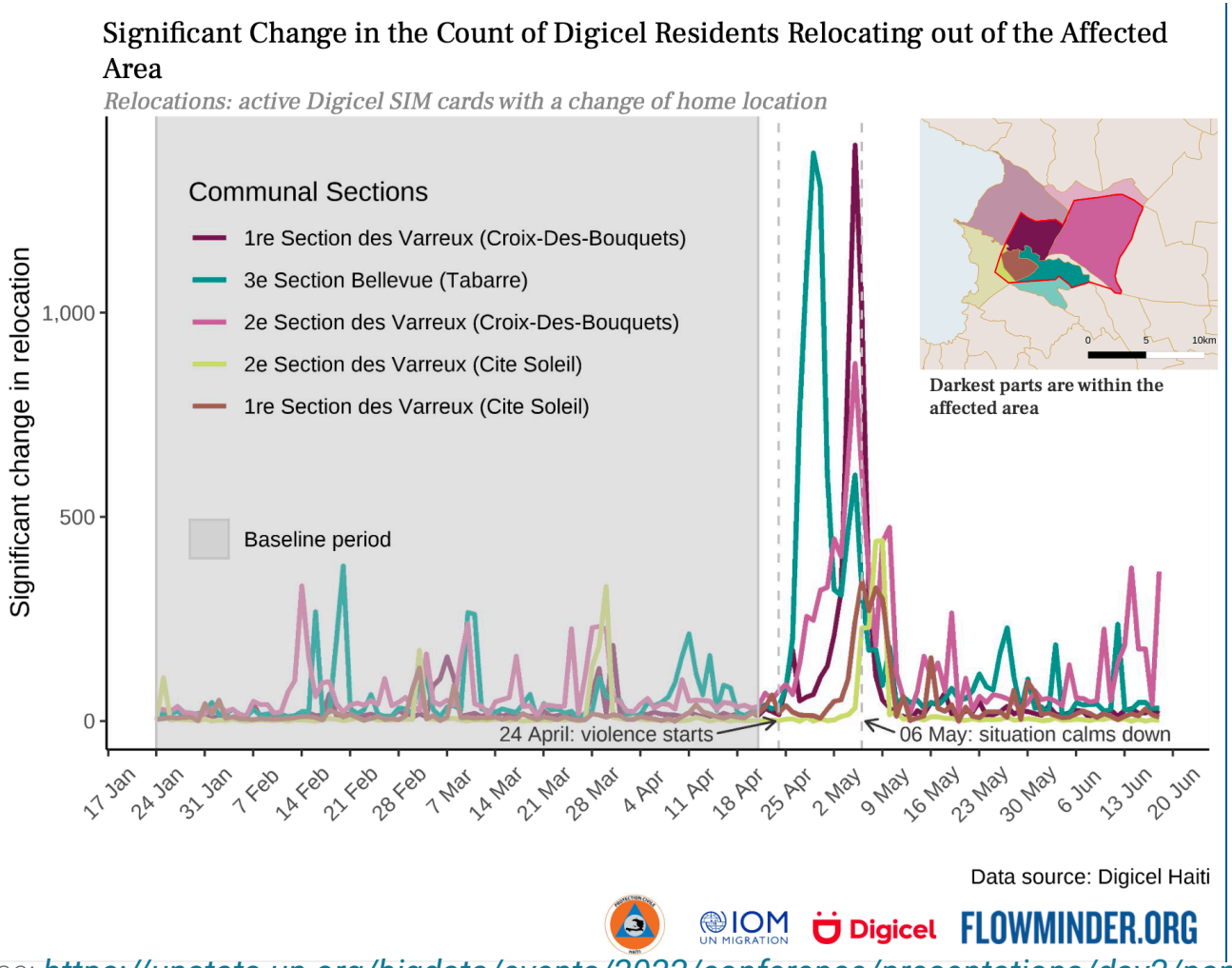


Mobile phone data for humanitarian and development efforts in low- and middle-income countries

Source: ***https://www.flowminder.org/what-we-do/population-distribution-and-mobility-analysis#data-applications***

Flowminder Example

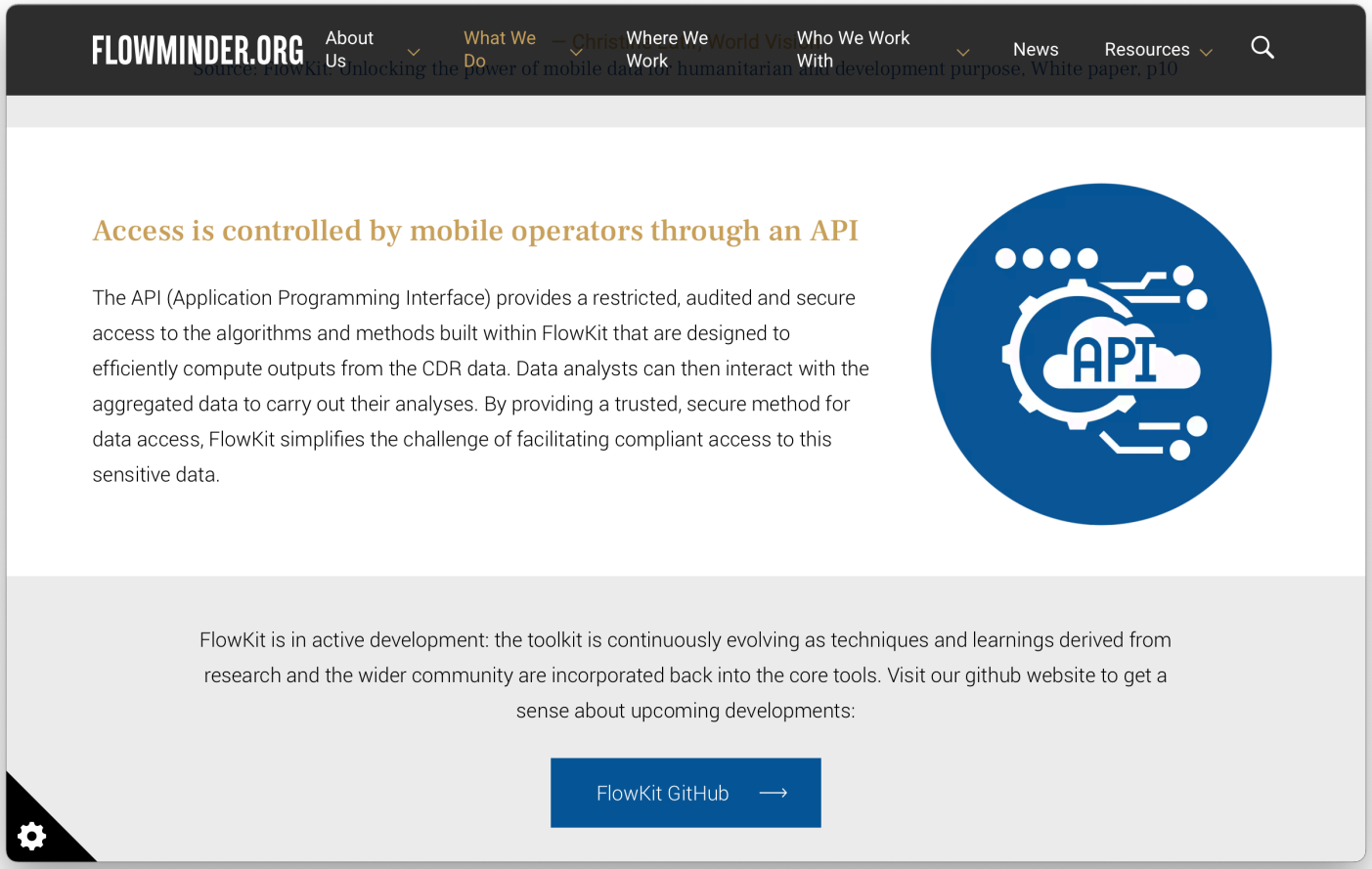
Effects of gang violence in Haiti



Source: https://unstats.un.org/bigdata/events/2022/conference/presentations/day2/panel1c/5.%20Thomas%20-%20Flowminder%20-%20UNSD%20Conference%20on%20Big%20Data%20Panel%20%E2%80%93%202022.pdf

Flowminder Software

FlowKit - privacy preserving mobile phone data aggregation

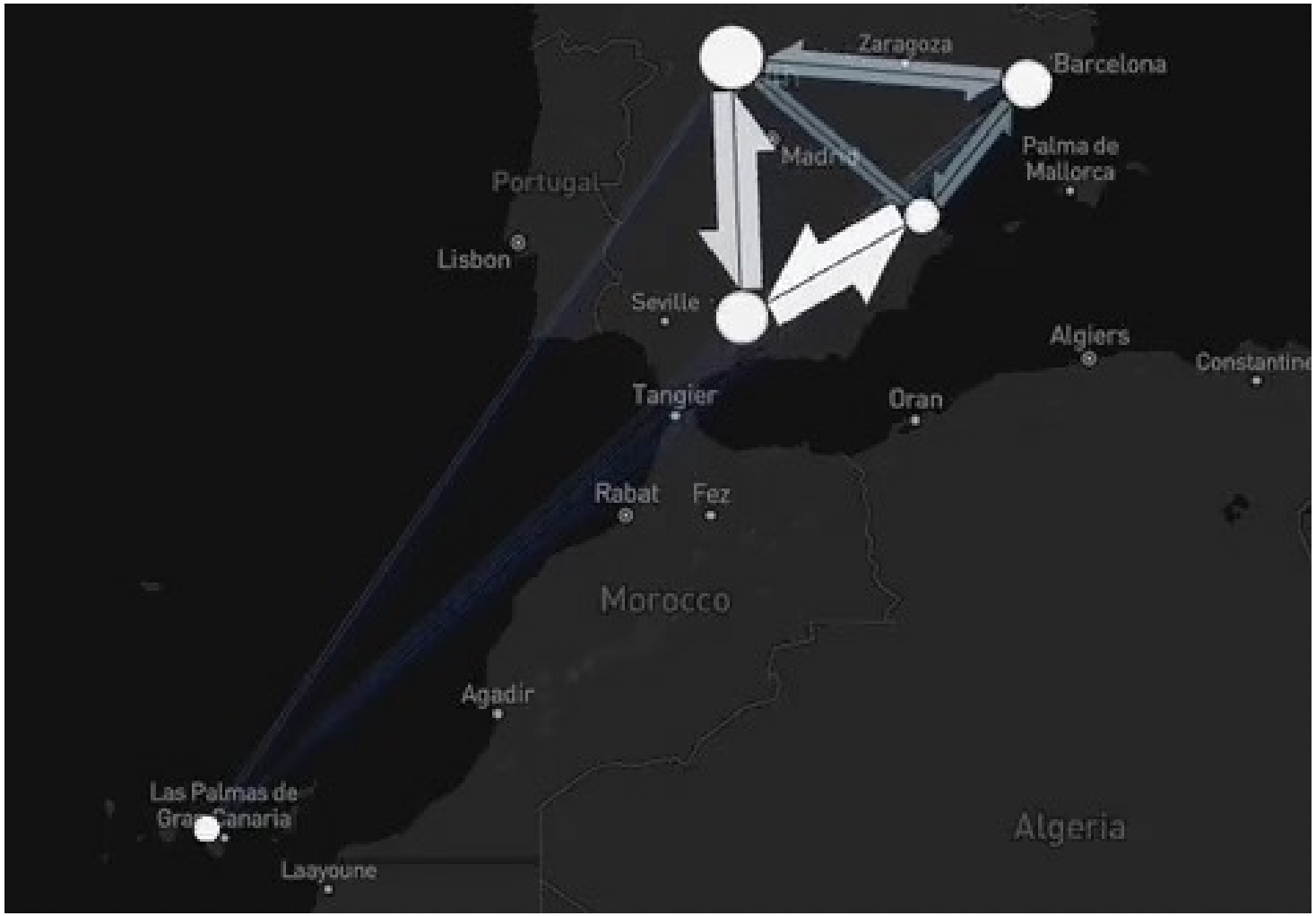


Learn more: ***https://github.com/Flowminder/FlowKit***, ***https://www.flowminder.org/what-we-do/mobile-data-partnerships/flowkit***

Spanish Open Mobility Big Data

Spanish Open Mobility Big Data

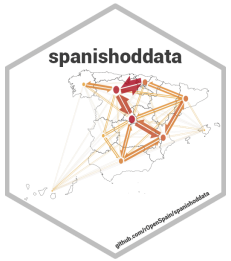
3500+ zones across Spain and beyond



Data by Ministerio de Transportes y Movilidad Sostenible (MITMS) (2024)

Based on 13 million customers of Orange Spain, expanded to full population of Spain

Data interface



Data visusalization

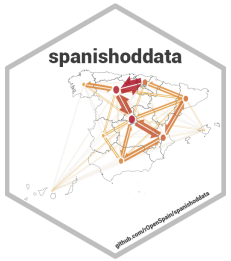
Spanish Open Mobility Big Data

3500+ zones across Spain and beyond

Data by Ministerio de Transportes y Movilidad Sostenible (MITMS) (2024)

Based on 13 million customers of Orange Spain, expanded to full population of Spain

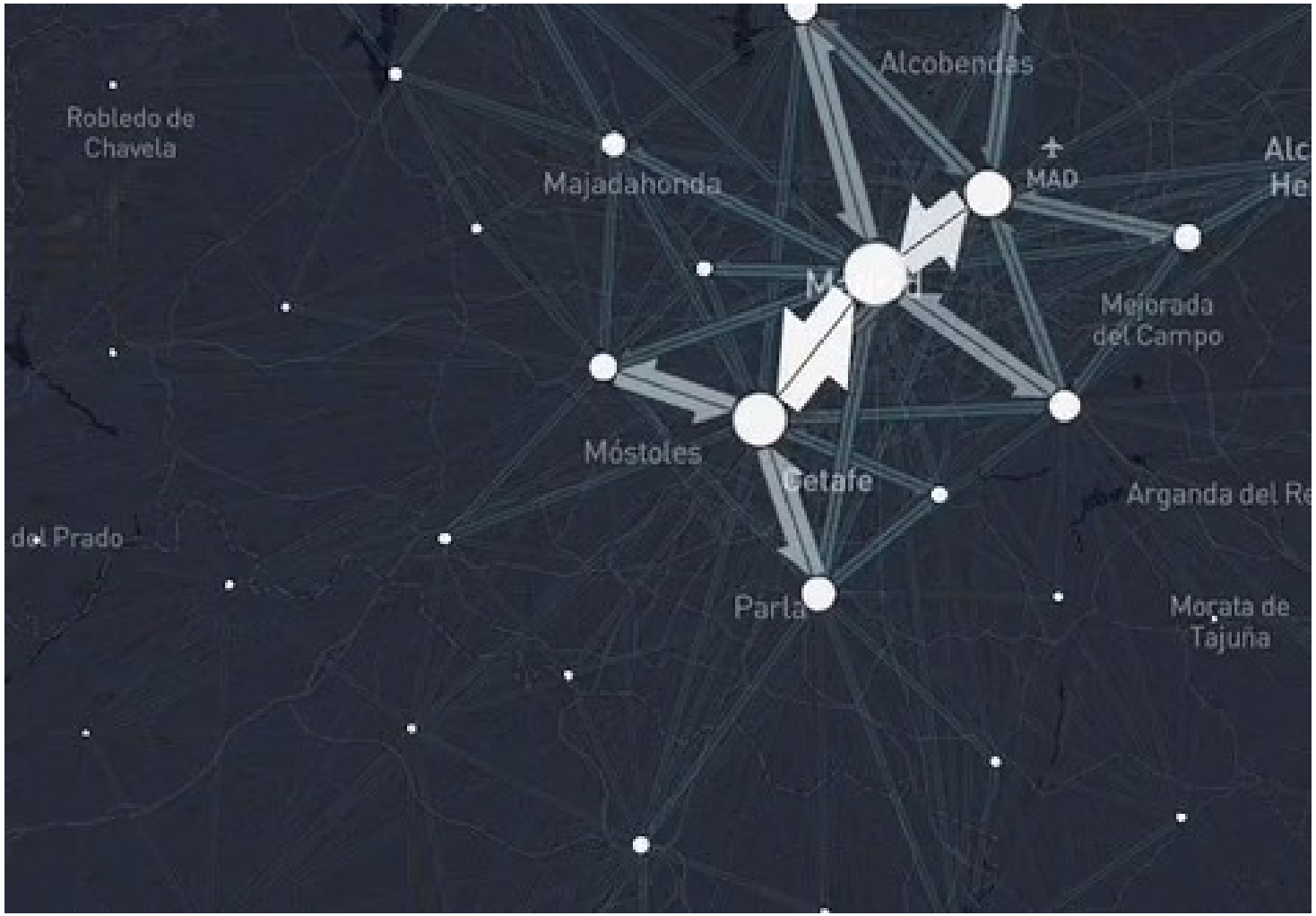
Data interface



Data visusalization

Spanish Open Mobility Big Data

3500+ zones across Spain and beyond



Data by Ministerio de Transportes y Movilidad Sostenible (MITMS) (2024)

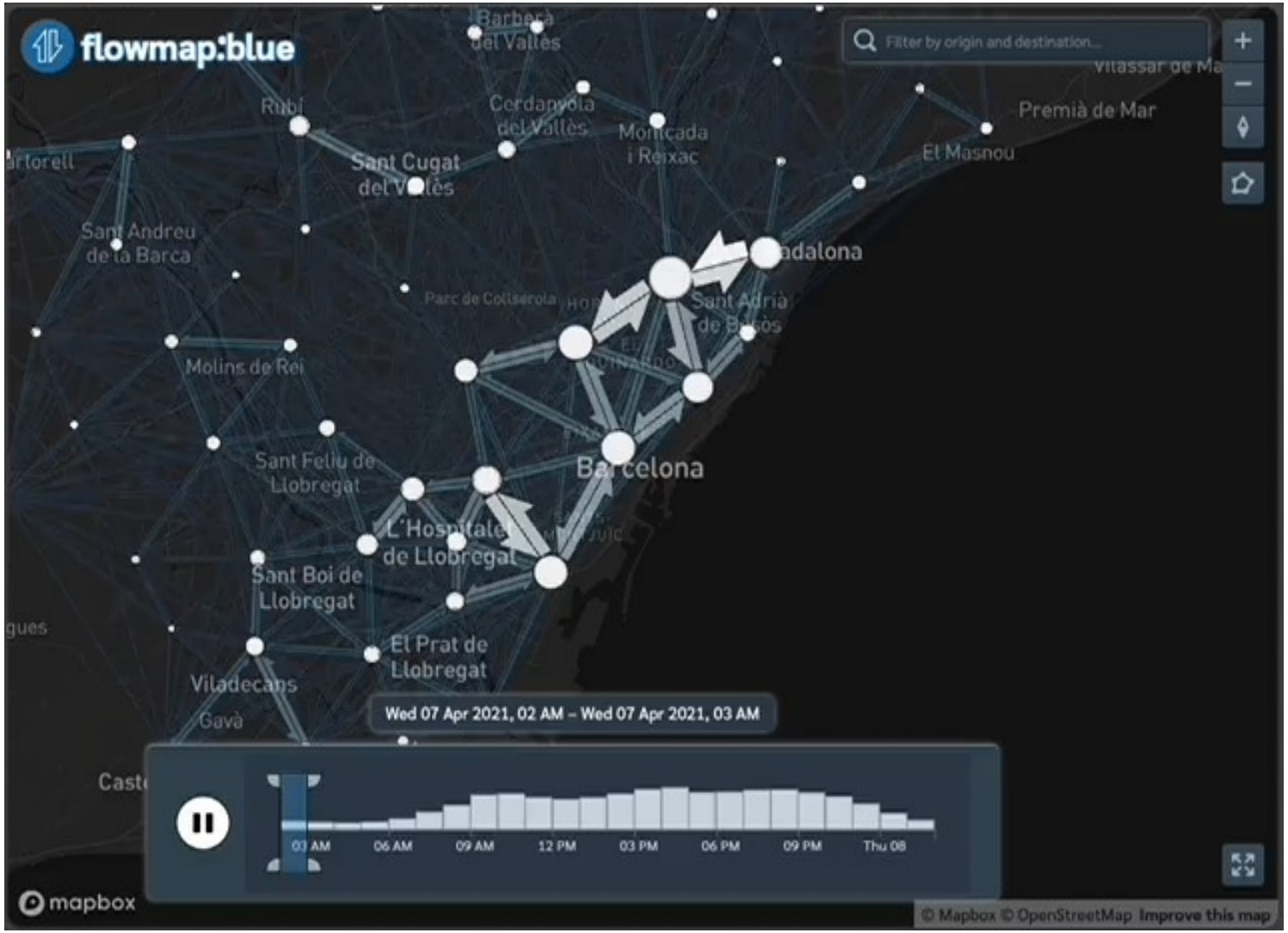
Based on 13 million customers of Orange Spain, expanded to full population of Spain

Data interface

Data visusalization

Spanish Open Mobility Big Data

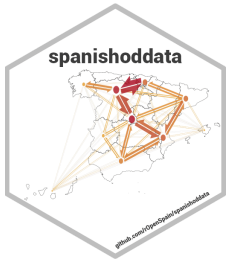
~ 5 years of daily hourly flows



Data by Ministerio de Transportes y Movilidad Sostenible (MITMS) (2024)

Based on 13 million customers of Orange Spain, expanded to full population of Spain

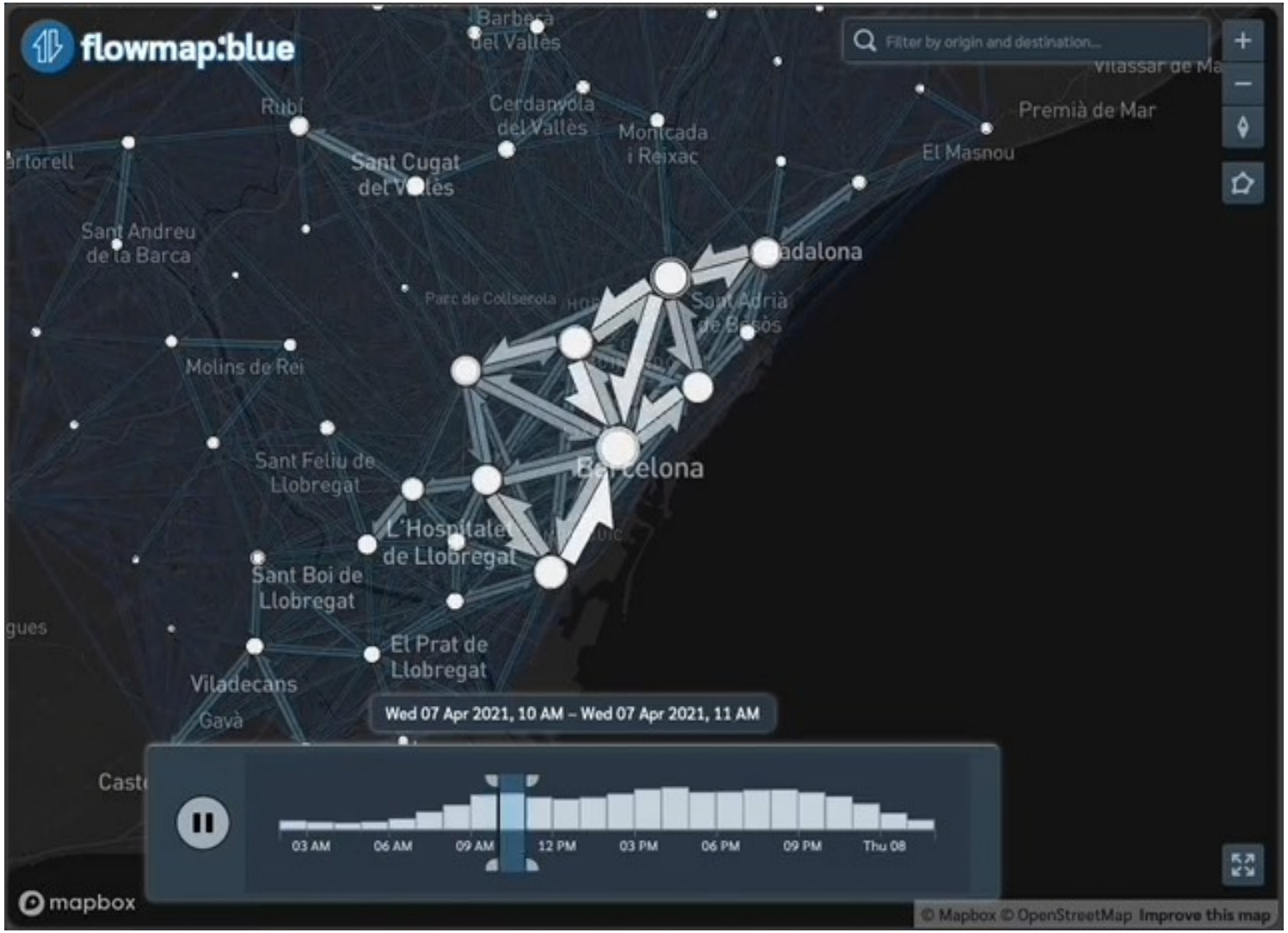
Data interface



Data visusalization

Spanish Open Mobility Big Data

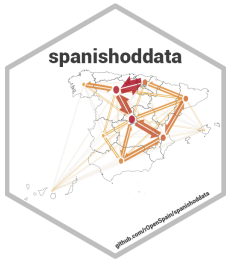
~ 5 years of daily hourly flows



Data by Ministerio de Transportes y Movilidad Sostenible (MITMS) (2024)

Based on 13 million customers of Orange Spain, expanded to full population of Spain

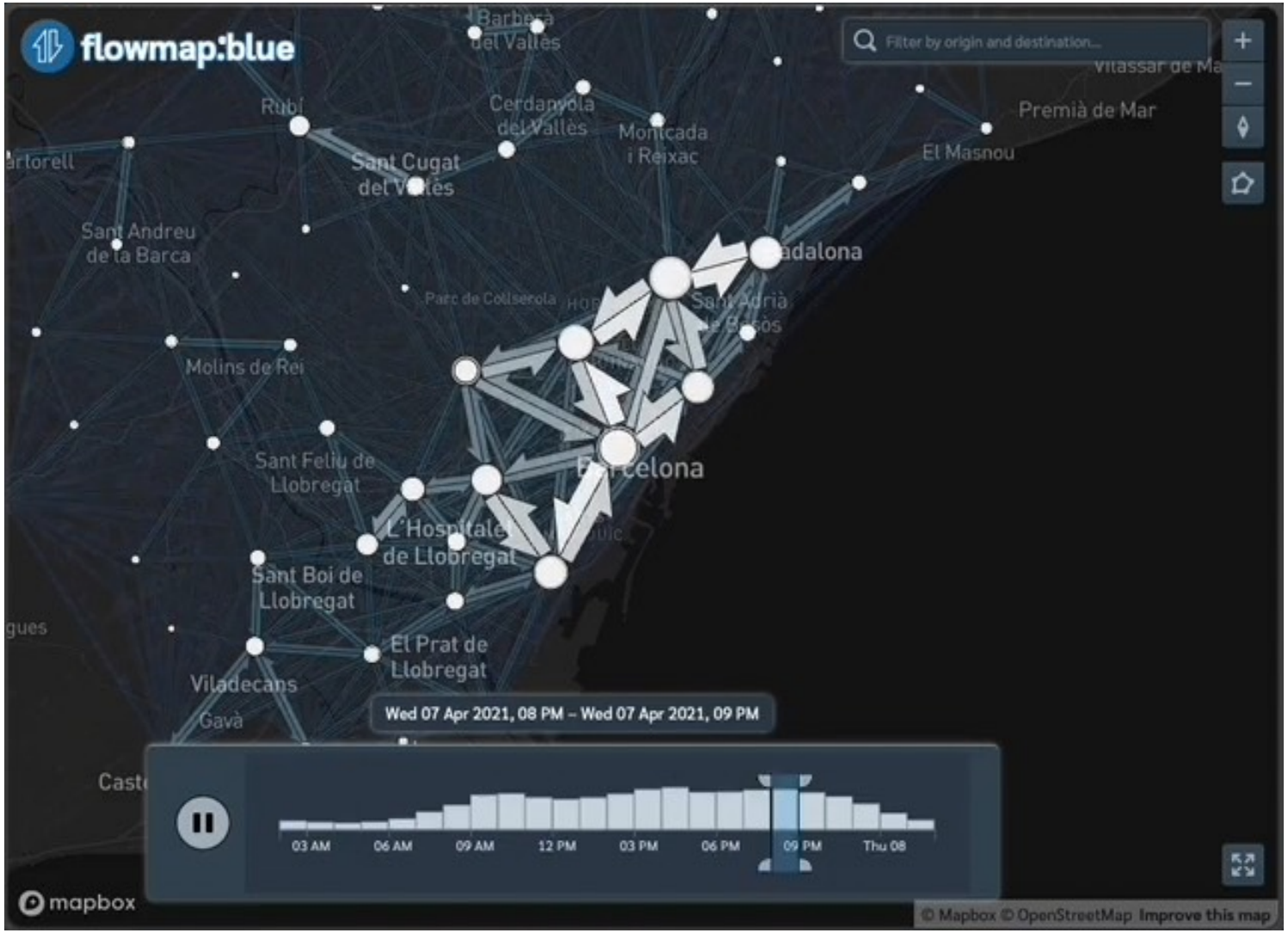
Data interface



Data visusalization

Spanish Open Mobility Big Data

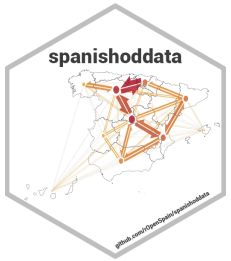
~ 5 years of daily hourly flows



Data by Ministerio de Transportes y Movilidad Sostenible (MITMS) (2024)

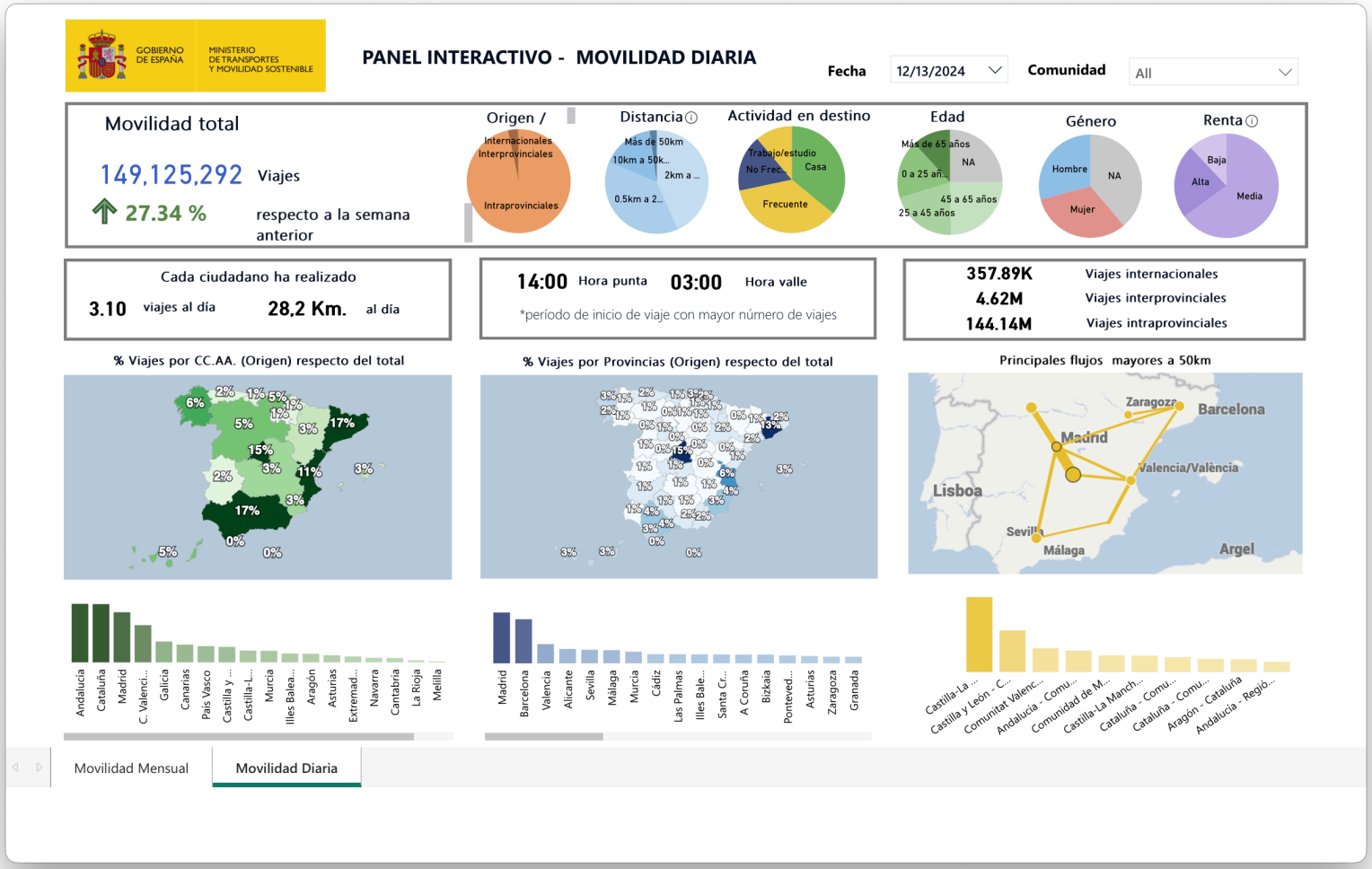
Based on 13 million customers of Orange Spain, expanded to full population of Spain

Data interface



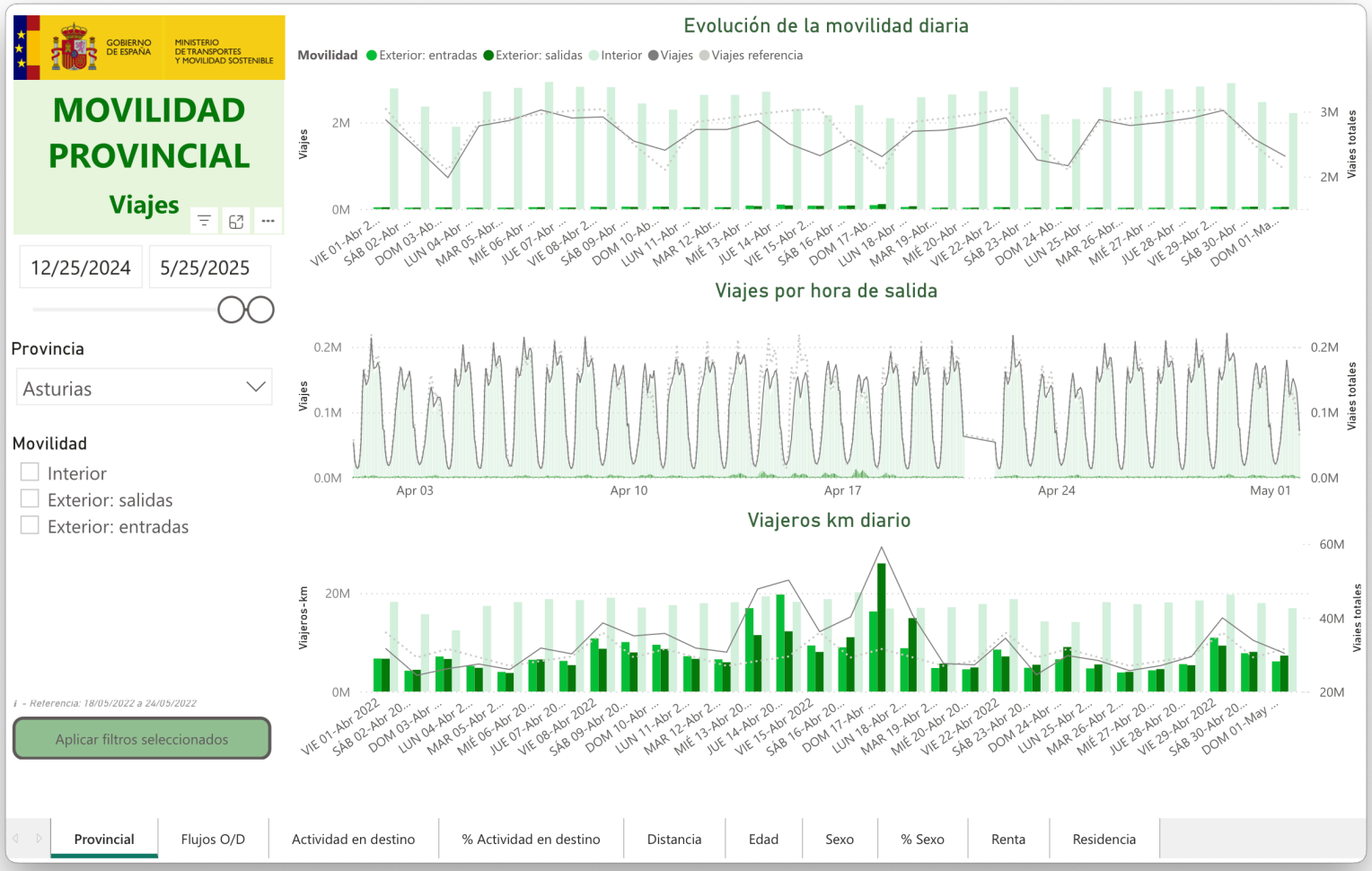
Data visusalization

Spanish Open Mobility Big Data



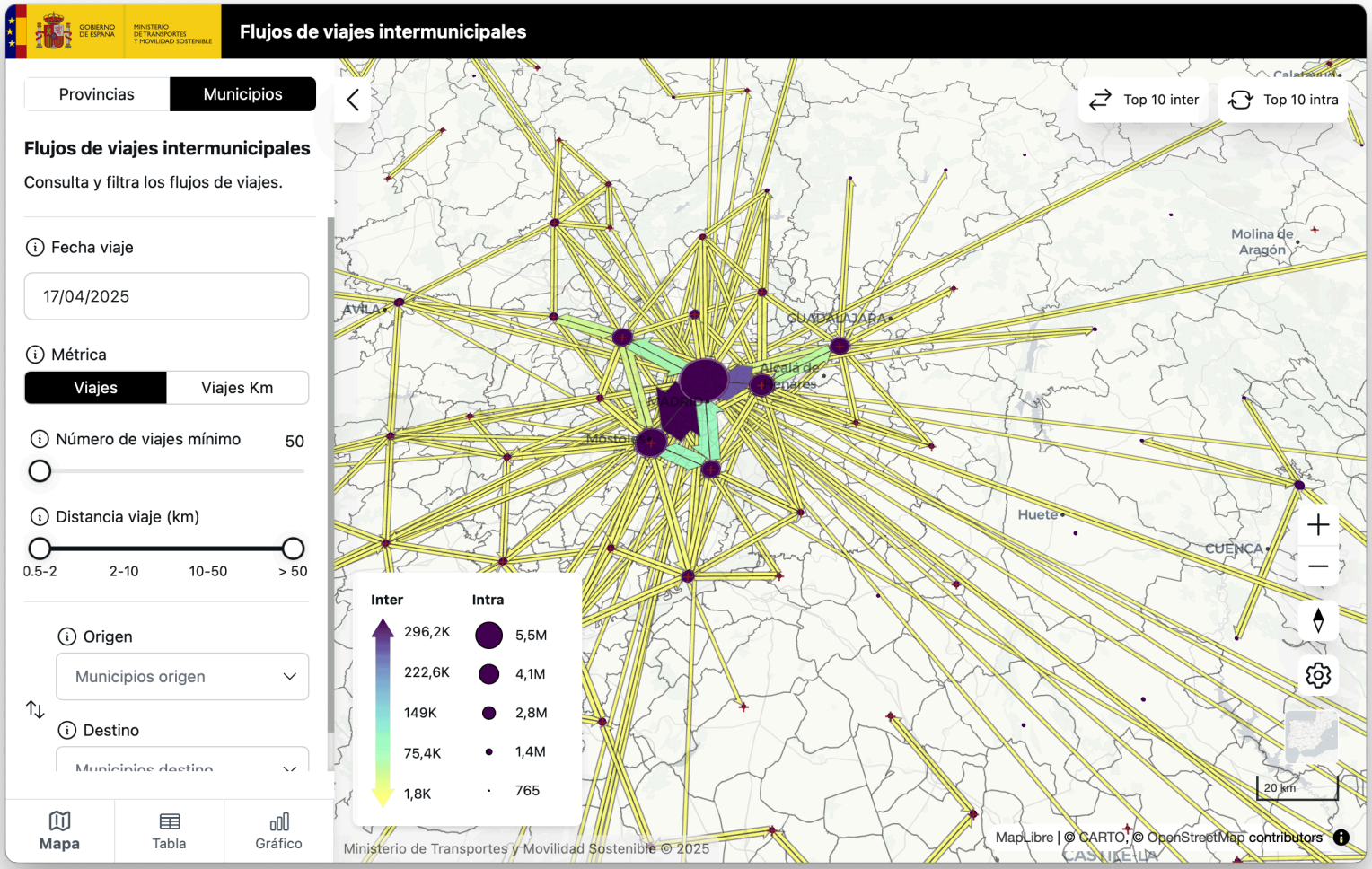
View the dashboard at ***https://data.transportes.gob.es/public/mov-diaria-mensual***

Spanish Open Mobility Big Data



View the dashboard at ***https://data.transportes.gob.es/public/mov-provincial***

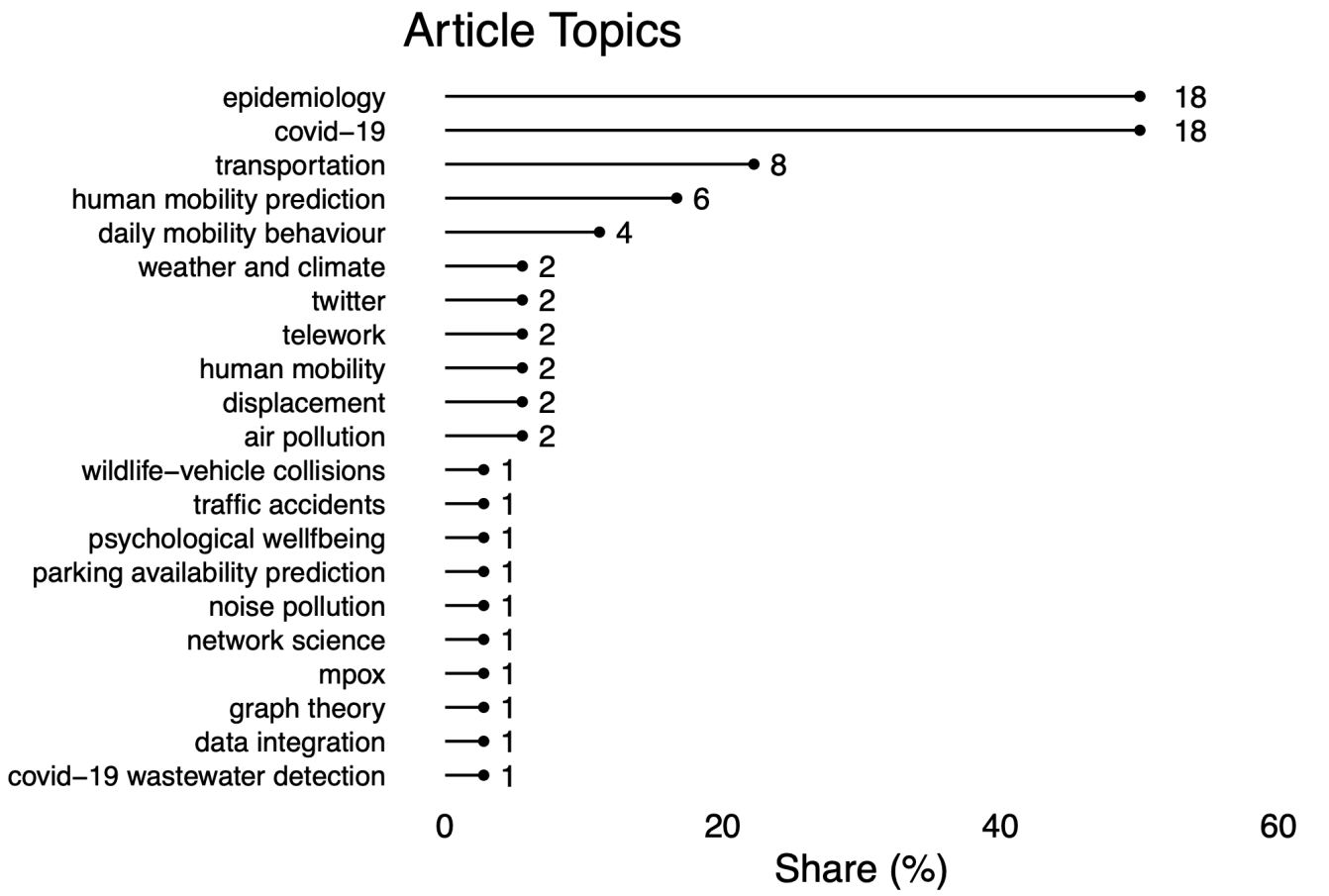
Spanish Open Mobility Big Data



View the dashboard at ***https://mapas-movilidad.transportes.gob.es/?date=2025-04-16T22***

Spanish Open Mobility Big Data

Academic research



May not sum to 100%

Share (on x axis) and Number (on plot) of Articles by Article Topic

Source: *https://github.com/e-kotov/spanishoddata-paper-supplement*

https://doi.org/10.5281/zenodo.15207374

Spanish Open Mobility Big Data

Effects of human mobility on dispersal of disease-transmitting mosquitoes

www.nature.com/scientificreports

scientific reports

Check for updates

OPEN

Multiple invasions, *Wolbachia* and human-aided transport drive the genetic variability of *Aedes albopictus* in the Iberian Peninsula

Federica Lucati[1,2], Sarah Delacour[3], John R.B. Palmer[2], Jenny Caner[1], Aitana Oltra[1], Claudia Paredes-Esquivel[4], Simone Mariani[1], Santi Escartin[1,5], David Roiz[6], Francisco Collantes[7], Mikel Bengoa[8], Tomàs Montalvo[9,10], Juan Antonio Delgado[7], Roger Eritja[1,11], Javier Lucientes[3], Andreu Albó Timor[1], Frederic Bartumeus[1,11,12] & Marc Ventura[1]

The Asian tiger mosquito, *Aedes albopictus*, is one of the most invasive species in the world. Native to the tropical forests of Southeast Asia, over the past 30 years it has rapidly spread throughout tropical and temperate regions of the world. Its dramatic expansion has resulted in public health concerns as a consequence of its vector competence for at least 16 viruses. Previous studies showed that *Ae. albopictus* spread has been facilitated by human-mediated transportation, but much remains unknown about how this has affected its genetic attributes. Here we examined the factors that contributed to shaping the current genetic constitution of *Ae. albopictus* in the Iberian Peninsula, where the species was first found in 2004, by combining population genetics and Bayesian modelling. We found that both mitochondrial and nuclear DNA markers showed a lack of genetic structure and the presence of worldwide dominant haplotypes, suggesting regular introductions from abroad. Mitochondrial DNA showed little genetic diversity compared to nuclear DNA, likely explained by infection with maternally transmitted bacteria of the genus *Wolbachia*. Multilevel models revealed that greater mosquito fluxes (estimated from commuting patterns and tiger mosquito population distribution) and spatial proximity between sampling sites were associated with lower nuclear genetic distance, suggesting that rapid short- and medium-distance dispersal is facilitated by humans through vehicular traffic. This study highlights the significant role of human transportation in shaping the genetic attributes of *Ae. albopictus* and promoting regional gene flow, and underscores the need for a territorially integrated surveillance across scales of this disease-carrying mosquito.

Uses Labour Force Survey data
(Lucati et al. 2022)

ICA International Cartographic Association
ACI Association Cartographique Internationale

Effects of Human Mobility on the Spread of Disease-Transmitting Mosquitoes in Spain: Insights from Mobile Phone Data

Egor Kotov [a,b]*, Frederic Bartumeus [c,d], John Palmer [b]

[a] *Max Planck Institute for Demographic Research (MPIDR), kotov@demogr.mpg.de*
[b] *Universitat Pompeu Fabra (UPF)*
[c] *Centre d'Estudis Avançats de Blanes (CEAB-CSIC)*
[d] *Institució Catalana de Recerca i Estudis Avançats (ICREA)*

* Corresponding author

Keywords: human mobility, mobile phone data, mosquito dispersal, Spain, disease ecology

Abstract:

Motivation and Objective. Using mobile phone data in Spain, this study aims to (1) better define the association between human mobility and the dispersal of tiger mosquitoes (*Aedes albopictus*); and (2) build a predictive model that can forecast *Ae. albopictus* spreading into previously unaffected municipalities. This will enable more effective mosquito control measures and more accurate projections of possible disease spread.

Mosquito-borne diseases such as Zika, dengue, and chikungunya are not yet widespread in the EU, but local outbreaks are becoming more frequent, as highlighted by the European Centre for Disease Prevention and Control[1], and are triggered by imported cases in areas where vector mosquitoes are present(Trojánek et al., 2023). For most of these outbreaks, the primary vector (disease transmitter) is the tiger mosquito (*Ae. albopictus*). Without mosquitoes, the transmission rates between humans would be much lower.

Tiger mosquitoes are an invasive species that has been present in Spain for more than a decade and continues to spread. The favourable habitat conditions for these mosquitoes in Europe, further exacerbated by climate change, highlight the need for a deeper understanding of their dispersal mechanisms (Oliveira et al., 2021). This study aims to bridge the existing knowledge gap in mosquito dispersal models that traditionally focus on environmental habitat suitability but often overlook the critical role of human mobility. Recent evidence suggests the potential for mosquitoes to be transported by cars (Eritja et al., 2017); however, research on the influence of human mobility on mosquito dispersal is still in its nascent stages and relies on province-level survey data (Lucati et al., 2022) rather than high-resolution digital trace data at the municipality level.

Builds on previous research using mobile phone based data
(Kotov, Bartumeus, and Palmer 2024)

`spanishoddata` R package

spanishoddata

access Spanish Open Mobility Big Data from R

2.1. Origin-Destination data

The origin-destination data contain the number of trips and distance travelled between `districts` or `municipalities` in Spain for every hour of every day between 2020-02-14 and 2021-05-09. Each flow also has attributes such as the trip purpose (composed of the type of activity (`home` / `work_or_study` / `other`) at both the origin and destination), province of residence of individuals making this trip, distance covered while making the trip. See the detailed attributes below in a table. Figure 2 shows an example of total flows in the province of Barcelona on Feb 14th, 2020.

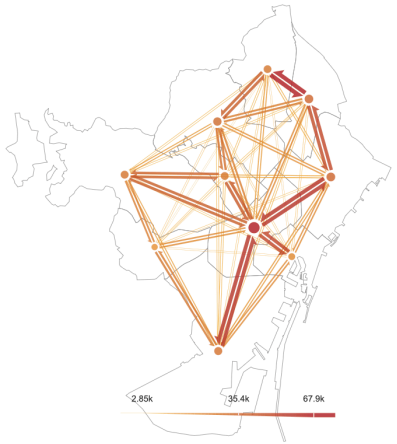


Figure 2: Origin destination flows in Barcelona on 2020-02-14

On this page

Source: ***https://ropenspain.github.io/spanishoddata/articles/v1-2020-2021-mitma-data-codebook.html***

`spanishoddata` - access open human mobility data

A package with many companions

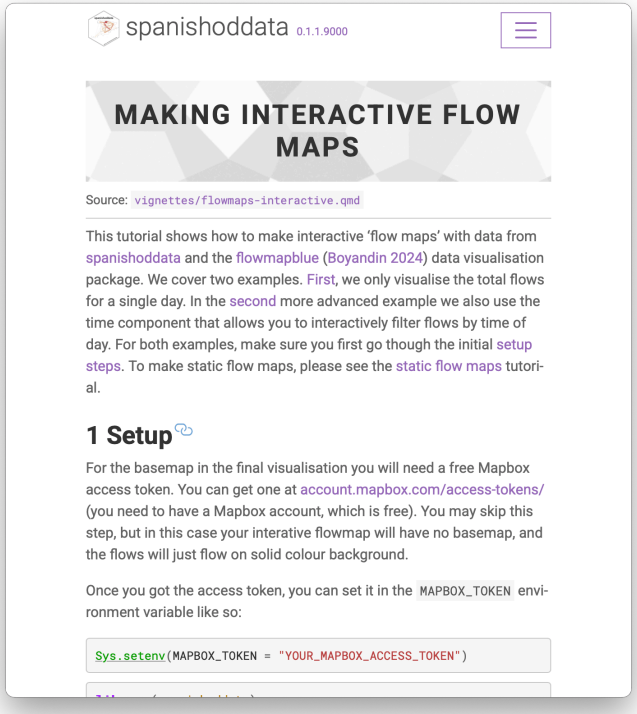
spanishoddata

flowmapper

{flowmapblue}

DuckDB

Detailed documentation



spanishoddata 0.1.1.9000

MAKING INTERACTIVE FLOW MAPS

Source: `vignettes/flowmaps-interactive.qmd`

This tutorial shows how to make interactive 'flow maps' with data from spanishoddata and the flowmapblue (Boyandin 2024) data visualisation package. We cover two examples. First, we only visualise the total flows for a single day. In the second more advanced example we also use the time component that allows you to interactively filter flows by time of day. For both examples, make sure you first go though the initial setup steps. To make static flow maps, please see the static flow maps tutorial.

1 Setup

For the basemap in the final visualisation you will need a free Mapbox access token. You can get one at account.mapbox.com/access-tokens/ (you need to have a Mapbox account, which is free). You may skip this step, but in this case your interative flowmap will have no basemap, and the flows will just flow on solid colour background.

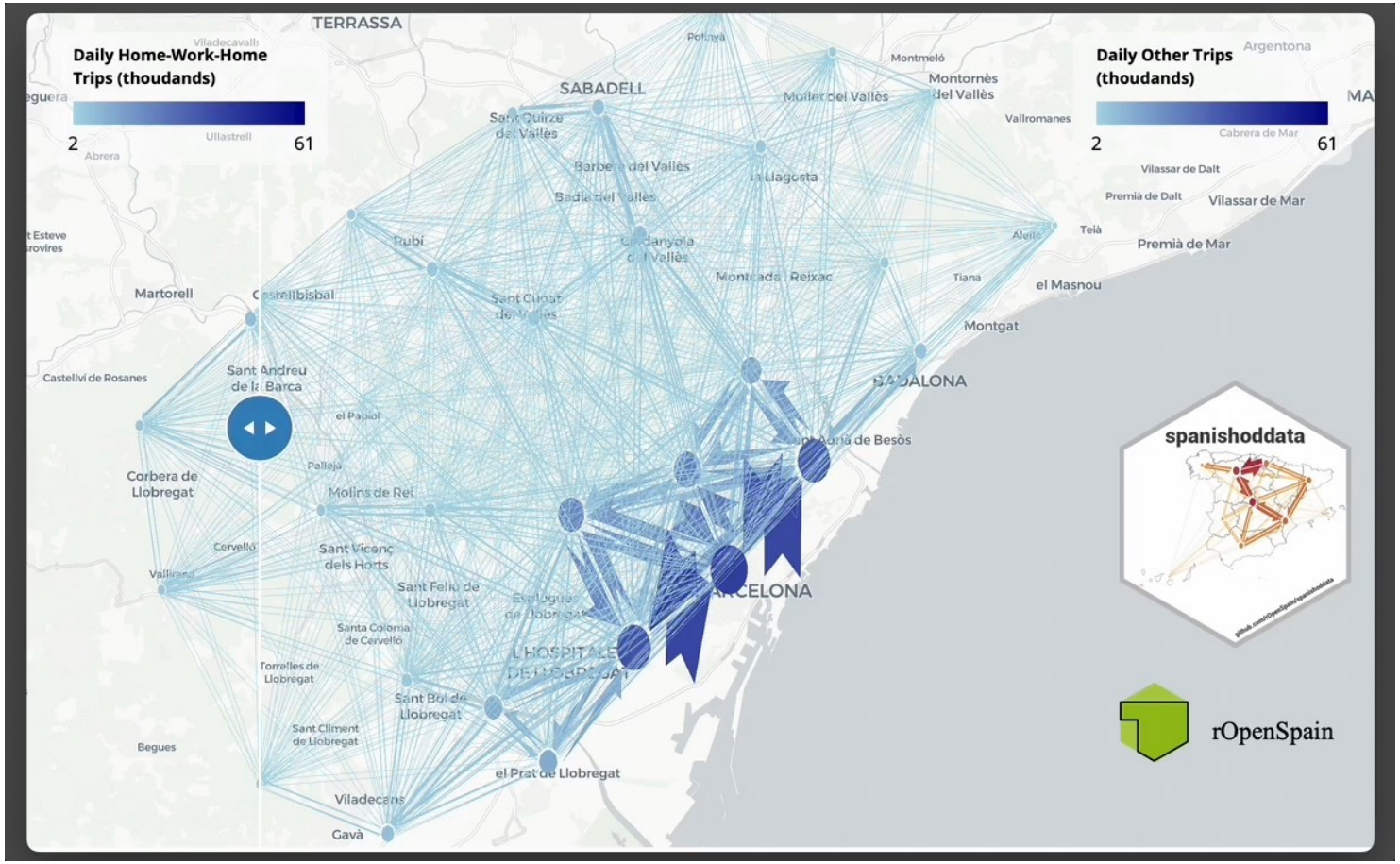
Once you got the access token, you can set it in the `MAPBOX_TOKEN` environment variable like so:

```
Sys.setenv(MAPBOX_TOKEN = "YOUR_MAPBOX_ACCESS_TOKEN")
```

Logos are the property of their respective owners.

`spanishoddata` use cases

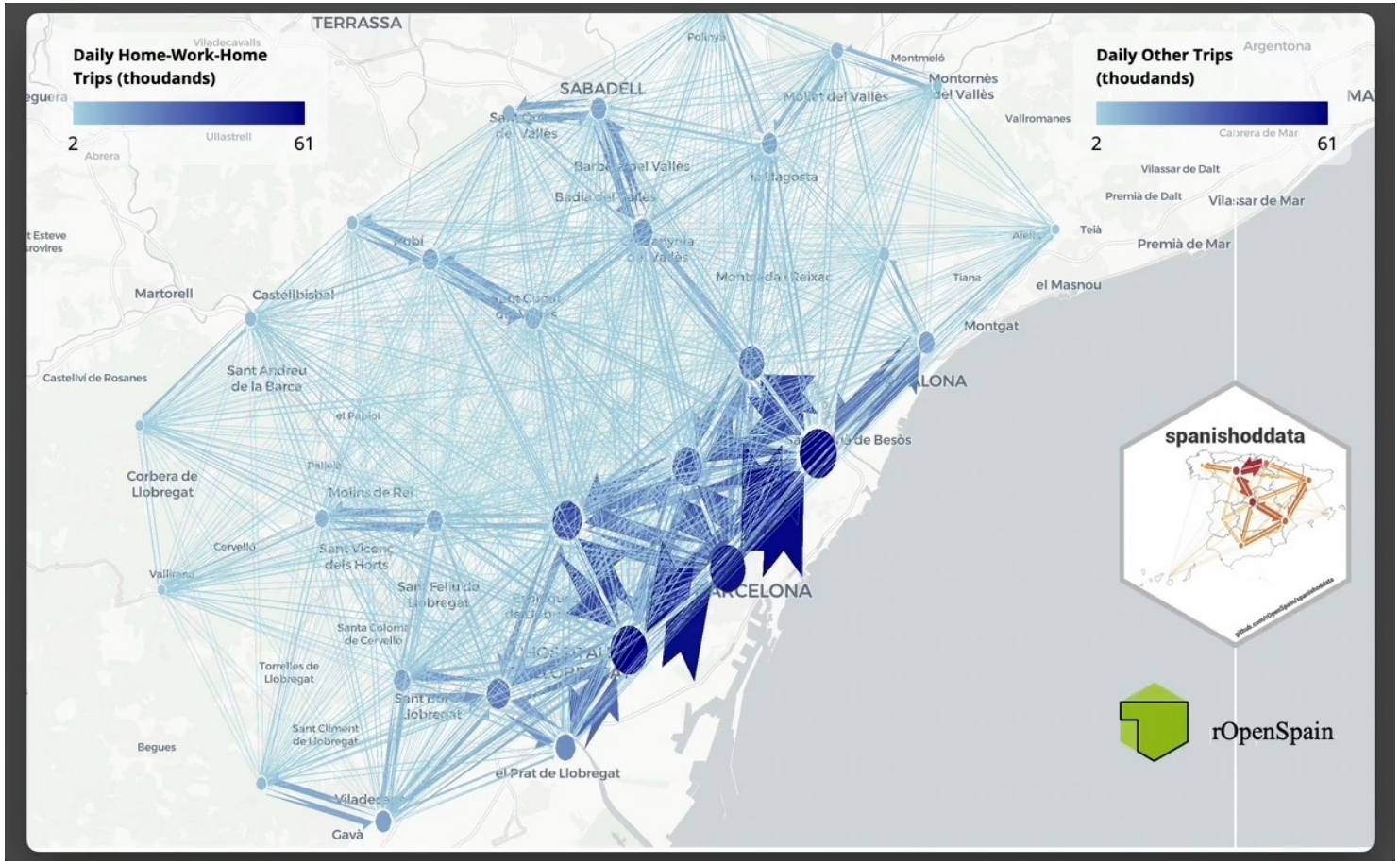
Split work and non-work trips



Source: *https://github.com/e-kotov/2024-30DayMapChallenge*

`spanishoddata` use cases

Split work and non-work trips

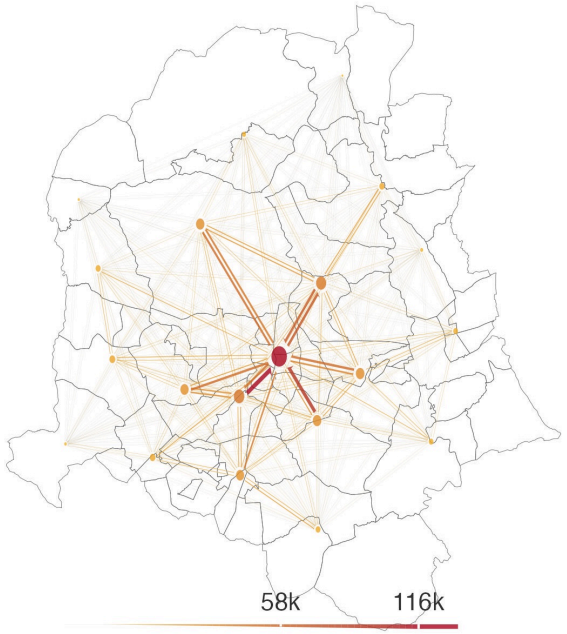


Source: *https://github.com/e-kotov/2024-30DayMapChallenge*

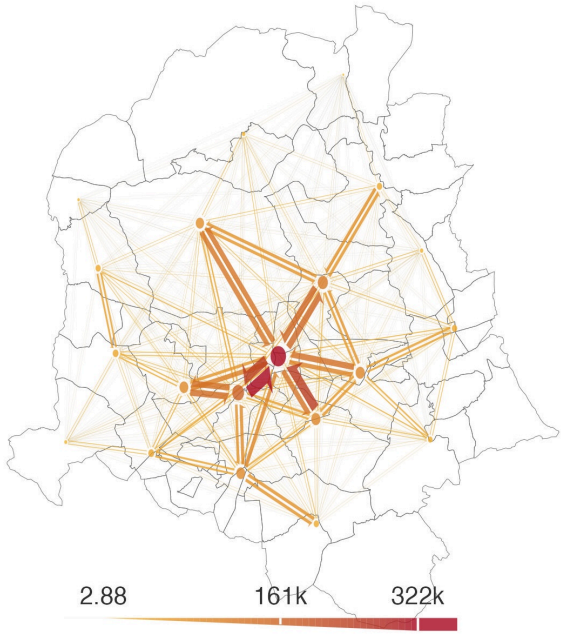
`spanishoddata` use cases

Split into different trip types

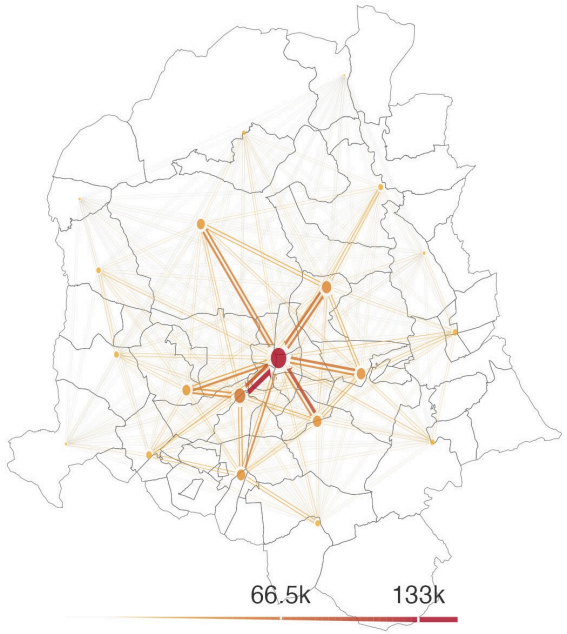
A:
Home <-> Work/Study
Morning (7–11) trips



B:
Home/Work/Study <-> Frequent activity
Morning (7–11) trips



C:
Home/Work/Study <-> Infrequent activity
Morning (7–11) trips

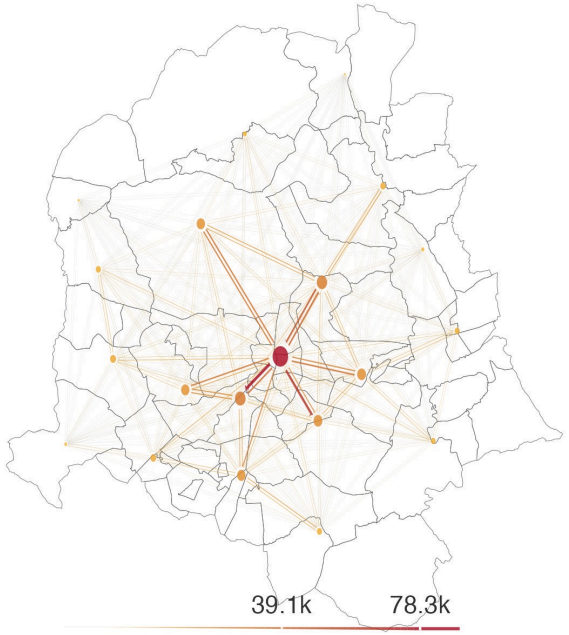


Source: *https://github.com/e-kotov/spanishoddata-paper-supplement*, *https://doi.org/10.5281/zenodo.15207374*

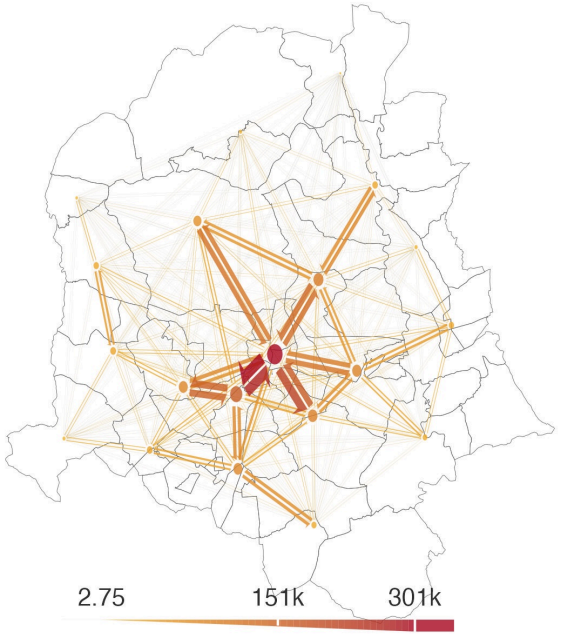
`spanishoddata` use cases

Split into different trip types

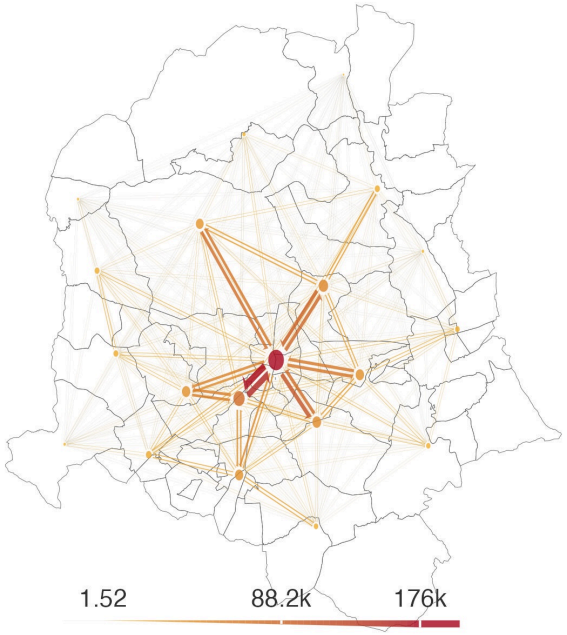
D:
Home <-> Work/Study
Evening (17–21) trips



E:
Home/Work/Study <-> Frequent activity
Evening (17–21) trips



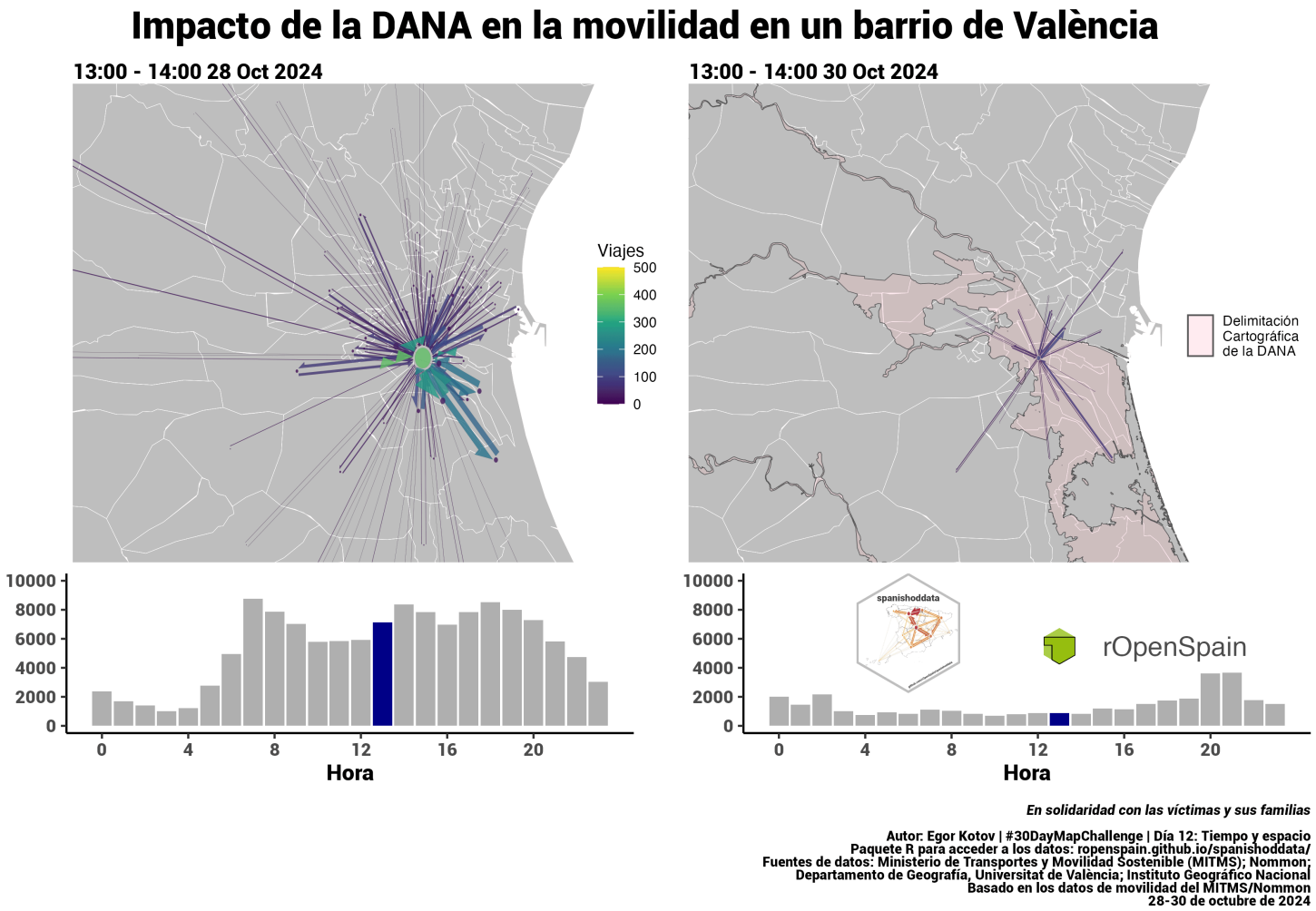
F:
Home/Work/Study <-> Infrequent activity
Evening (17–21) trips



Source: https://github.com/e-kotov/spanishoddata-paper-supplement, https://doi.org/10.5281/zenodo.15207374

`spanishoddata` use cases

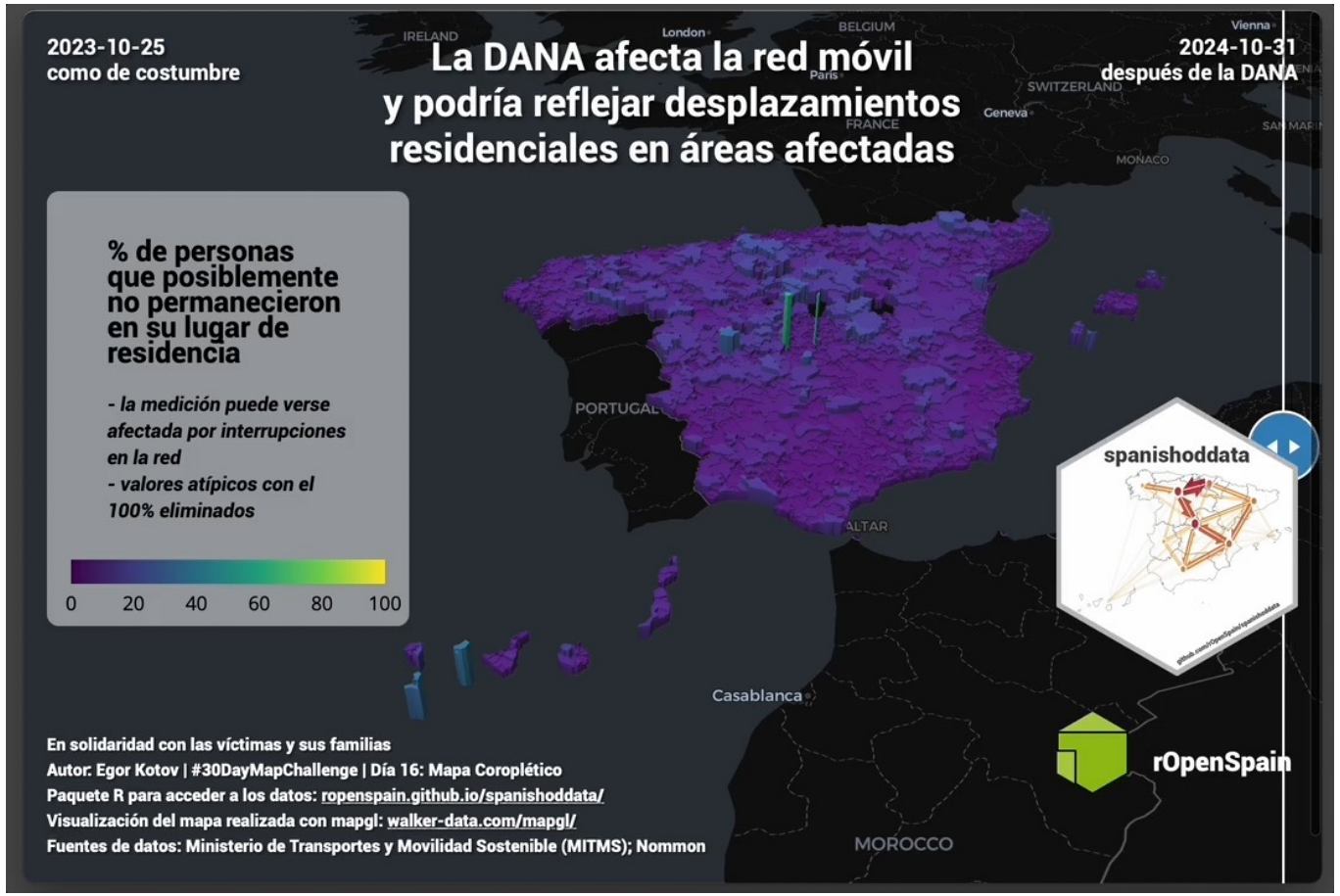
Valencia flood (DANA) in October 2024



Source: *https://github.com/e-kotov/2024-30DayMapChallenge*

`spanishoddata` use cases

Valencia flood (DANA) in October 2024

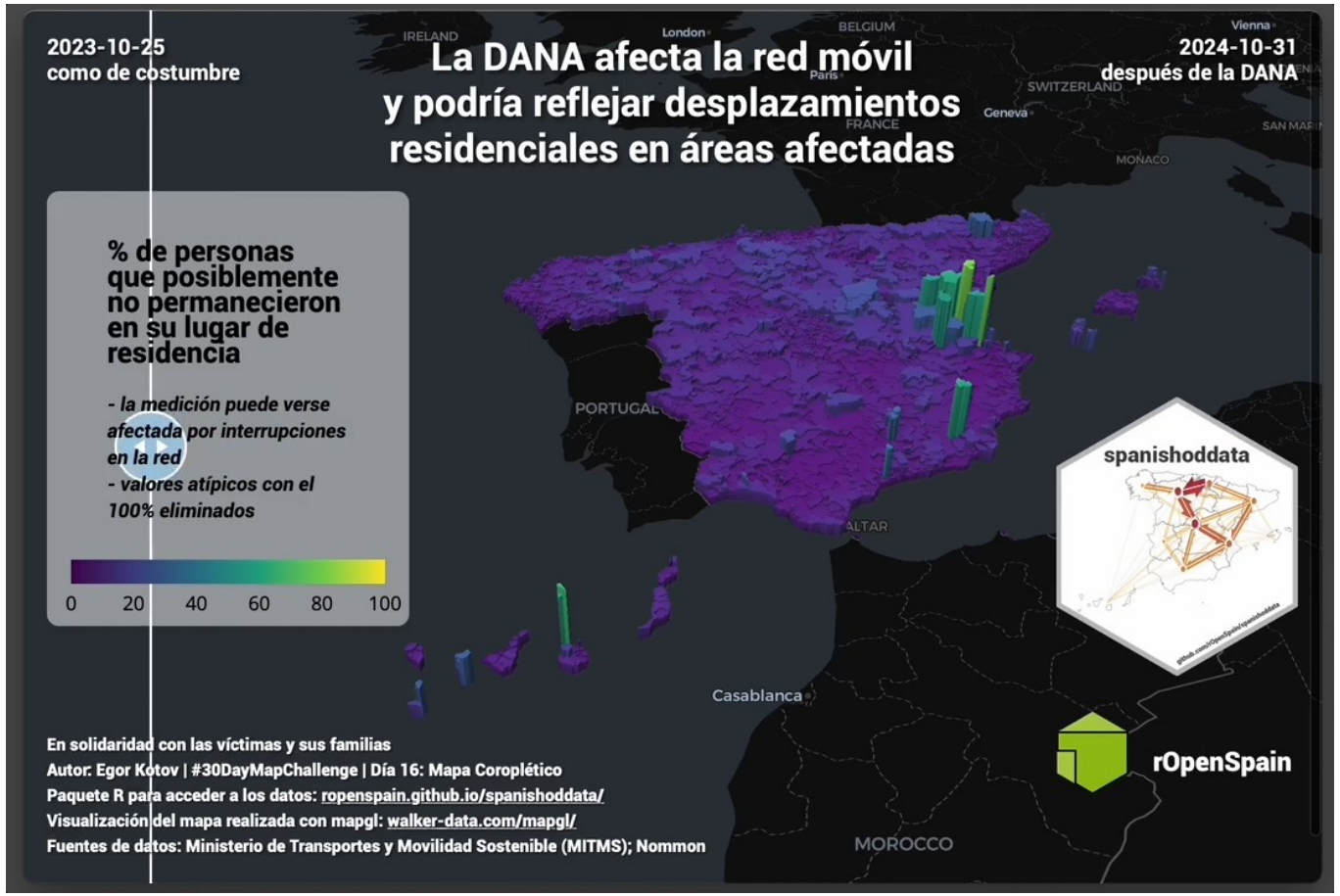


The share of people who have not spent the night at home.

Source: *https://github.com/e-kotov/2024-30DayMapChallenge*

`spanishoddata` use cases

Valencia flood (DANA) in October 2024

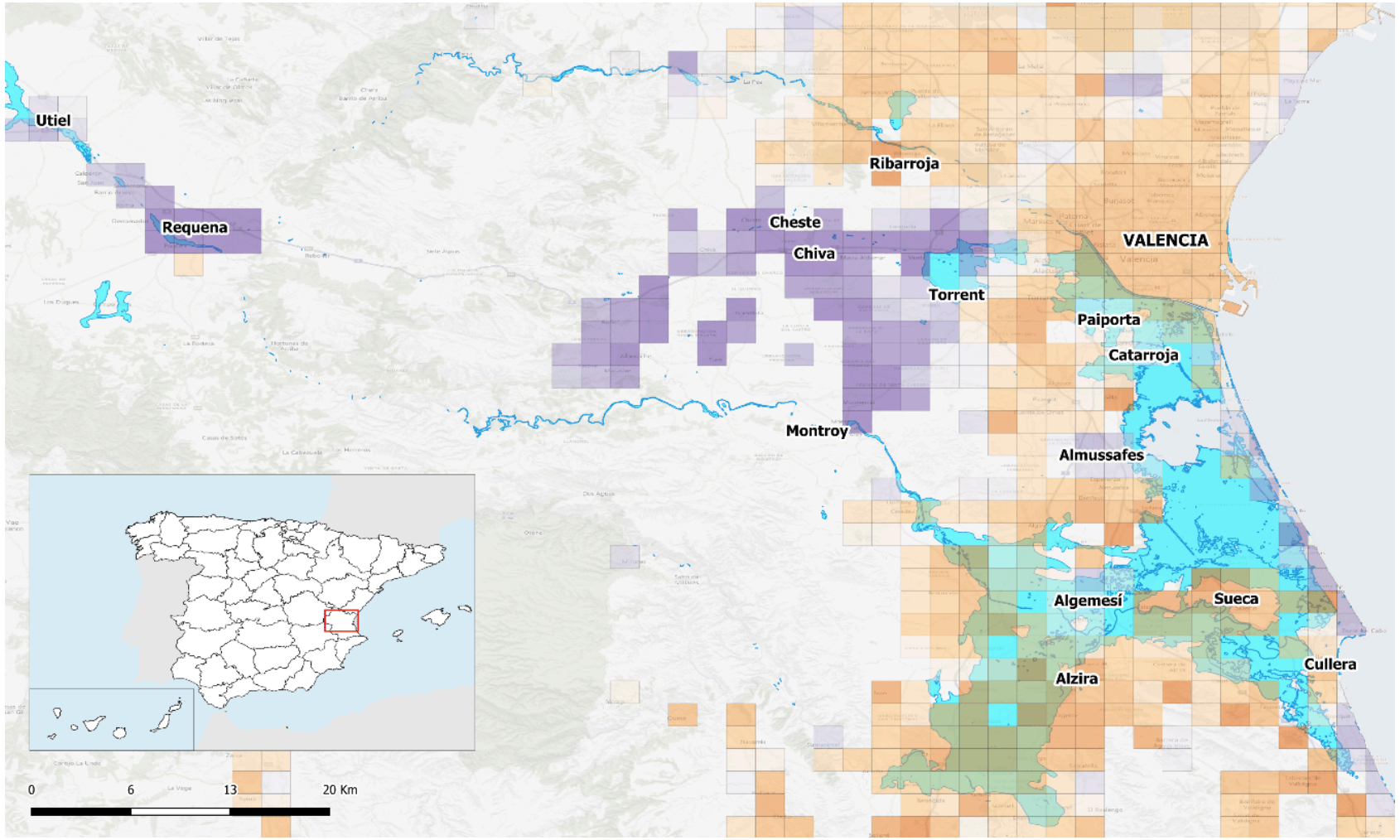


The share of people who have not spent the night at home.

Source: *https://github.com/e-kotov/2024-30DayMapChallenge*

`spanishoddata` use cases

Anntennas were offline - Facebook shows a slightly different picture



Source: *https://population-europe.eu/research/policy-insights/harnessing-digital-data-strengthen-disaster-response-valencias-2024-floods*

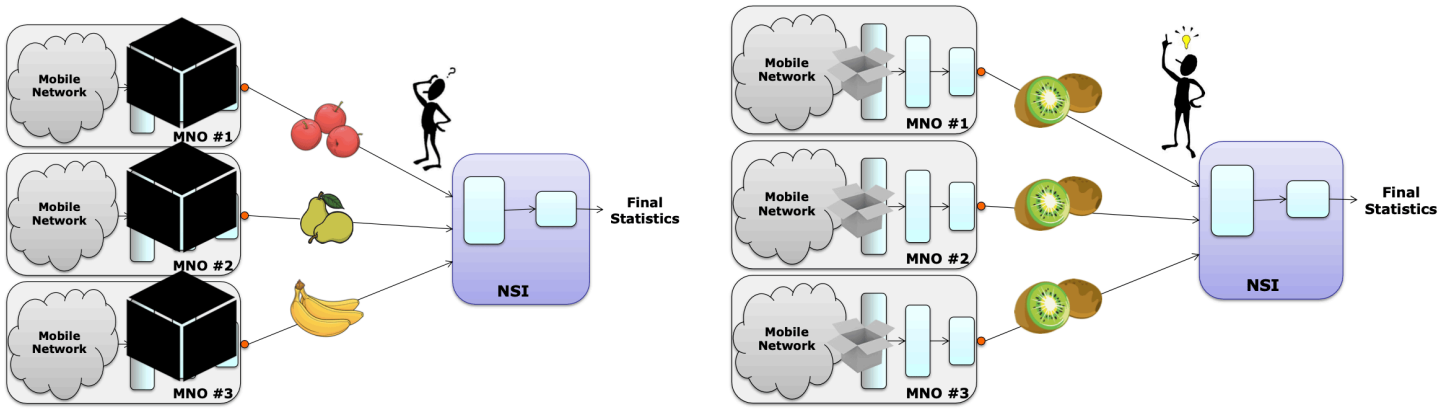
Multi-MNO Project

Multi-MNO Project

Source: *https://cros.ec.europa.eu/landing-page/multi-mno-project*

Multi-MNO Project

Mobility data aggregation using unified methodology

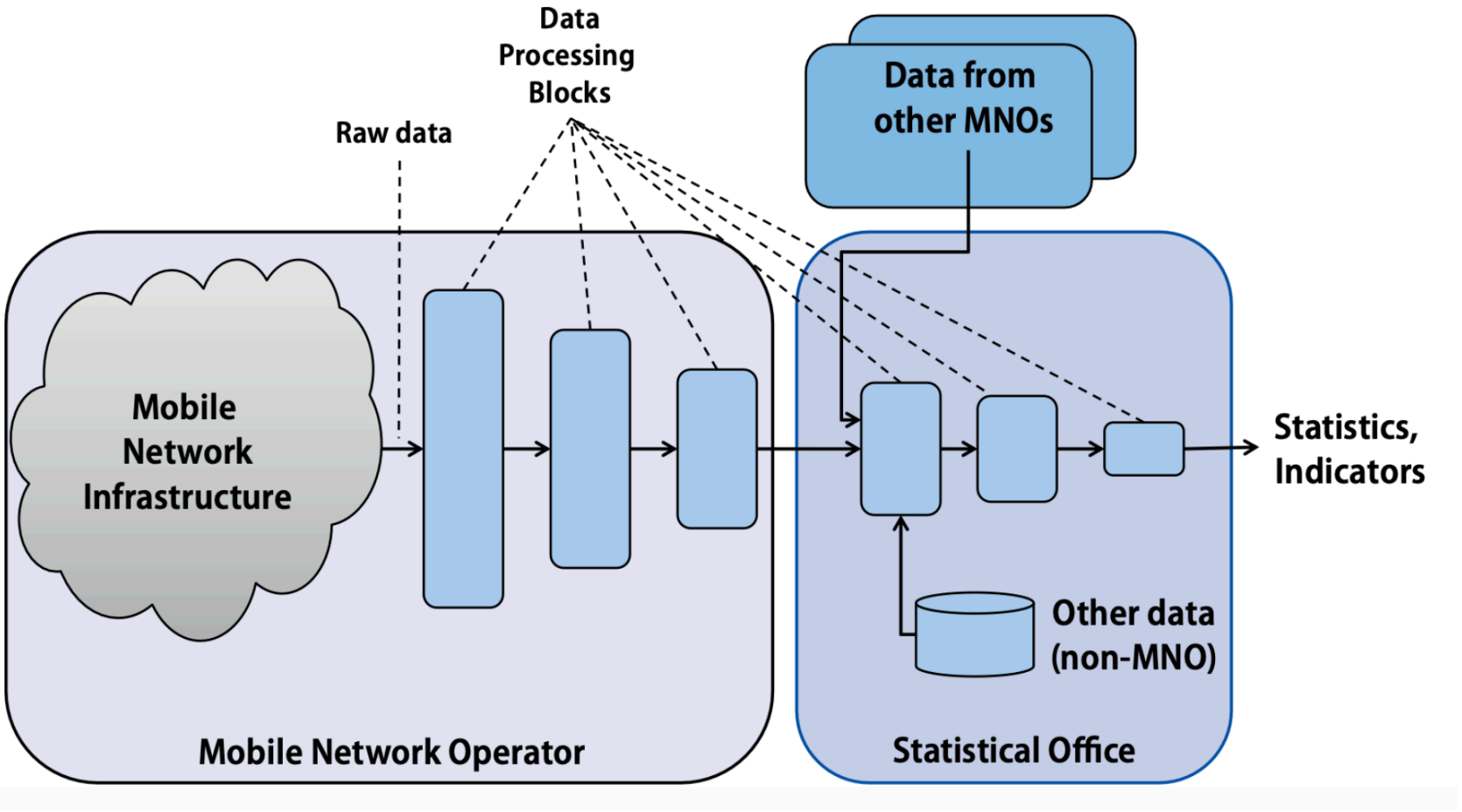


Source: https://cros.ec.europa.eu/system/files/2023-12/20231109_dimeitdg_mnoposition_paper_ricciato_ho%20%281%29.pdf

Learn more: https://ec.europa.eu/eurostat/web/products-statistical-reports/w/ks-ft-23-001

Multi-MNO Project

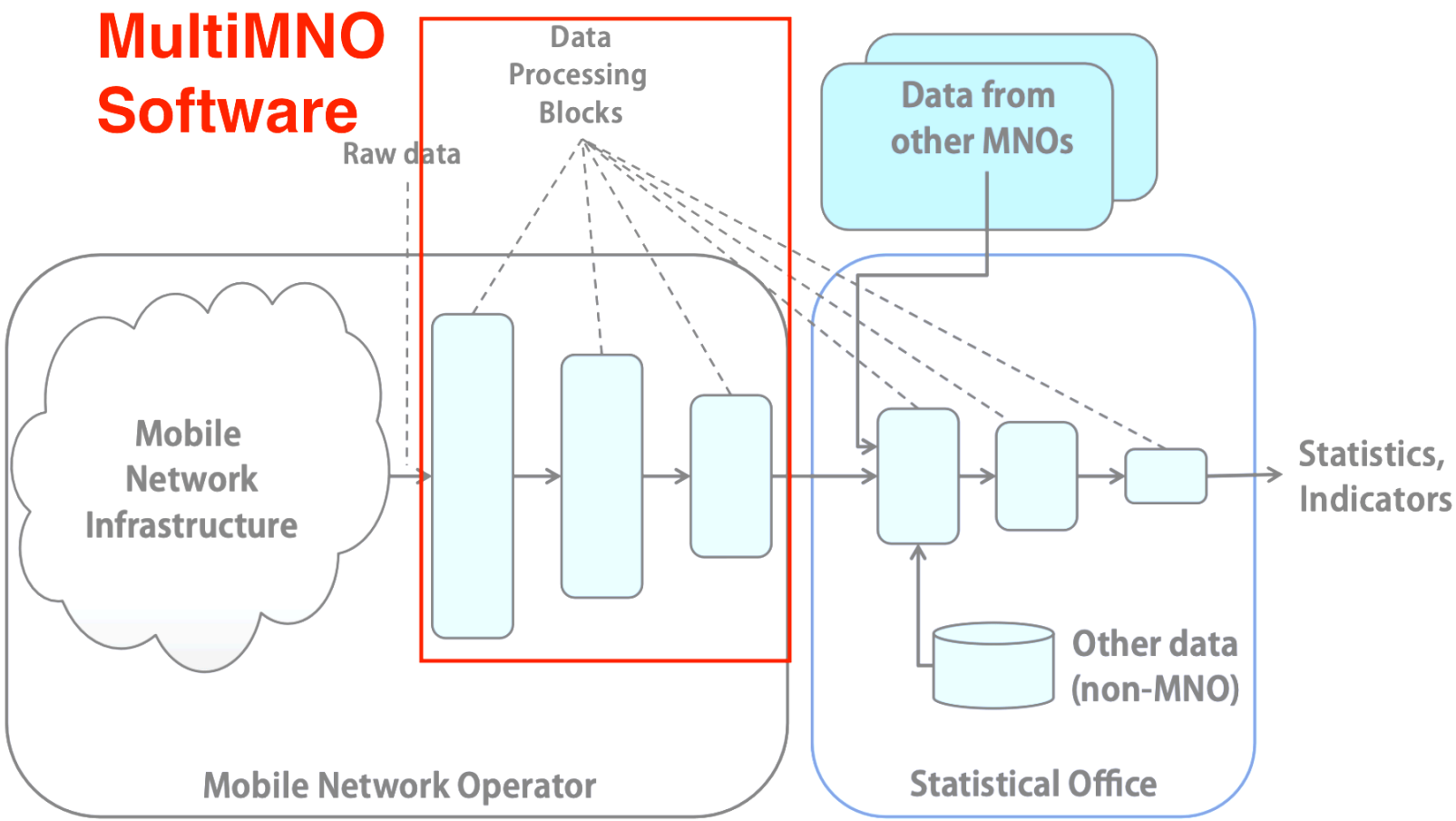
How it works



Source *https://cros.ec.europa.eu/system/files/2024-02/20240226_MultiMNO_2021-0400-internal-meeting-MNOs-ricciato.pdf*

Multi-MNO Software

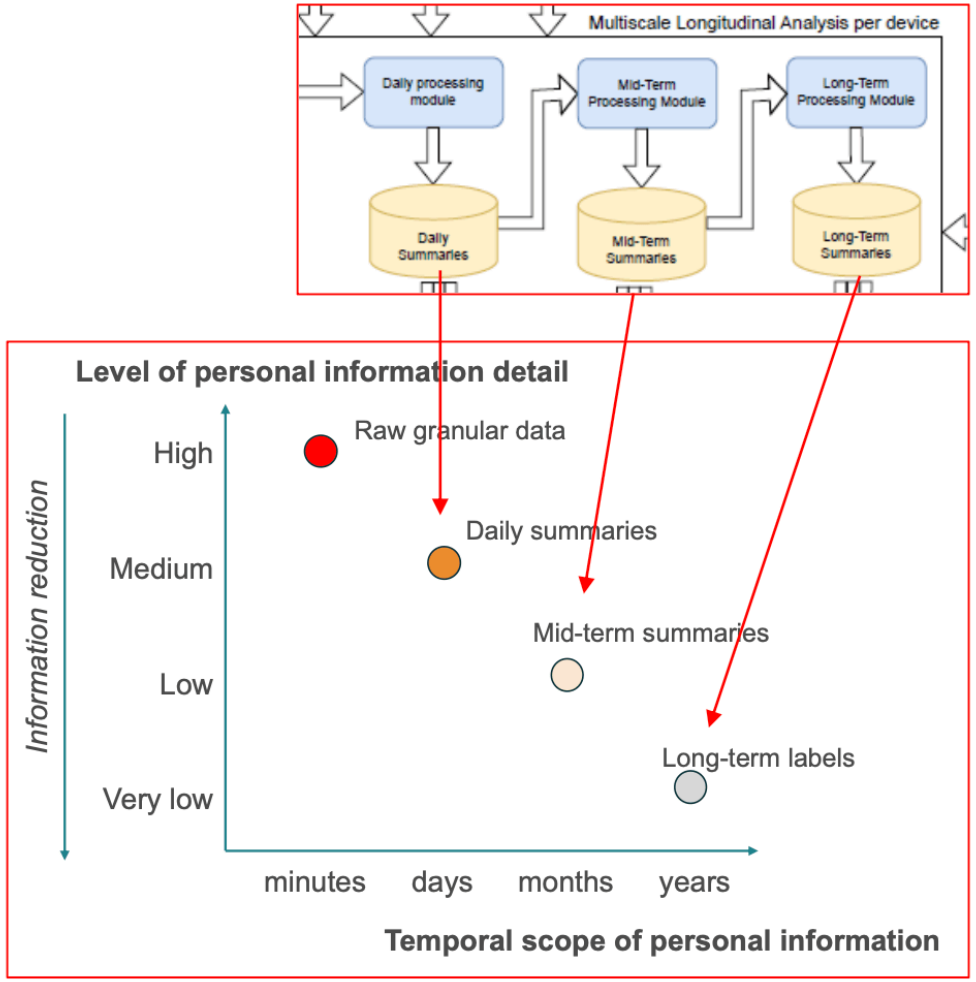
https://github.com/eurostat/multimno



Source *https://cros.ec.europa.eu/system/files/2024-02/20240226_MultiMNO_2021-0400-internal-meeting-MNOs-ricciato.pdf*

Multi-MNO Outputs

What to expect?

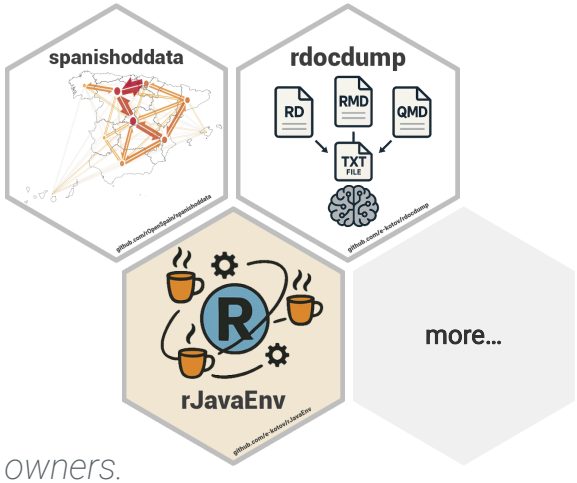


Source *https://cros.ec.europa.eu/system/files/2024-02/20240226_MultiMNO_2021-0400-internal-meeting-MNOs-ricciato.pdf*

Get in touch

Egor Kotov

ekotov.pro



Logos are the property of their respective owners.

References

Kotov, Egor, Frederic Bartumeus, and John Palmer. 2024. “Effects of Human Mobility on the Spread of Disease-Transmitting Mosquitoes in Spain: Insights from Mobile Phone Data.” *Abstracts of the ICA* 7: 78. https://ica-abs.copernicus.org/articles/7/78/2024/ica-abs-7-78-2024.pdf.

Lucati, Federica, Sarah Delacour, John R. B. Palmer, Jenny Caner, Aitana Oltra, Claudia Paredes-Esquivel, Simone Mariani, et al. 2022. “Multiple Invasions, Wolbachia and Human-Aided Transport Drive the Genetic Variability of Aedes Albopictus in the Iberian Peninsula.” *Scientific Reports* 12 (1): 20682. https://doi.org/10.1038/s41598-022-24963-3.

Martínez-Durive, Orlando E., Sachit Mishra, Cezary Ziemlicki, Stefania Rubrichi, Zbigniew Smoreda, and Marco Fiore. 2023. “The NetMob23 Dataset: A High-resolution Multi-region Service-level Mobile Data Traffic Cartography.” arXiv. https://doi.org/10.48550/arXiv.2305.06933.

Ministerio de Transportes y Movilidad Sostenible (MITMS). 2024. “Estudio de La Movilidad Con Big Data (Study of Mobility with Big Data).” https://www.transportes.gob.es/ministerio/proyectos-singulares/estudio-de-movilidad-con-big-data.

For additional resources and references, see the footnotes on individual slides.