European Commission

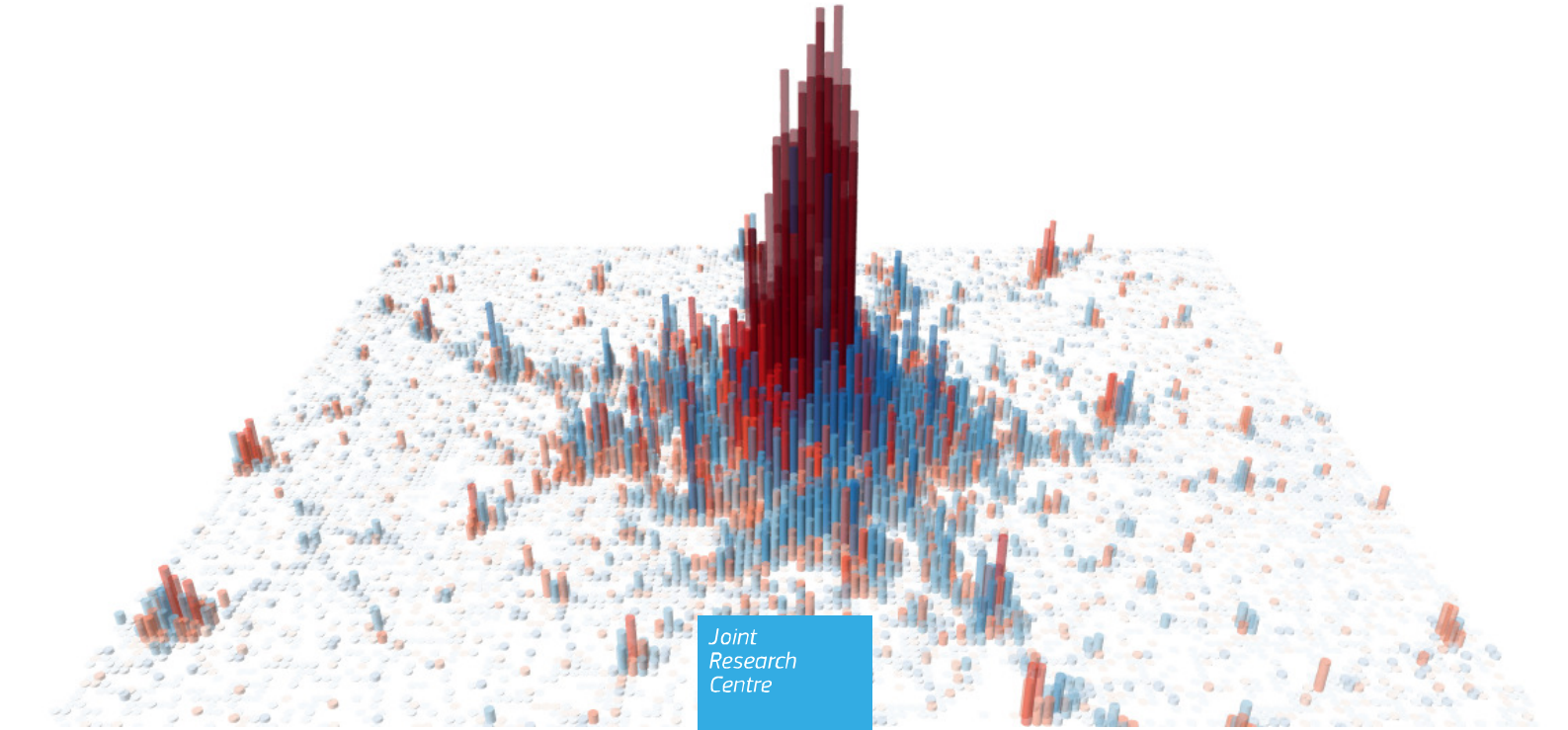
JRC SCIENTIFIC INFORMATION SYSTEMS AND DATABASES REPORT

ENACT 2011 Population grids

Fine-scale day- and night-time population density estimates for the EU

Schiavina, M.; Freire S.; Rosina, K.; Ziemba, L.; Marin Herrera, M.A.; Craglia, M.; Lavalle, C.; Kemper T.; Batista e Silva, F.

2020



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Abstract

The ENACT grids are a set of consistent, seamless, multi-temporal and validated population density grids for the European Union that take into account major daily and monthly population variations. These grids were produced by combining official statistical data at regional level with geo-spatial data from conventional and non-conventional data sources. The grids display maximum population density at day- and night-time for each month of the year (i.e. 24 population grids in total), at a spatial resolution of 1 x 1 km resolution for the whole EU-28. This is a major contribution to the state-of-the-art information on population density in Europe, as prior grids considered only static residential population (i.e. night-time). The newly released grids were produced in the context of the JRC ENACT exploratory research project, "ENhancing ACTivity and population mapping. This document accompanies the public release of the ENACT 2011 Population Grids and describes the contents.

Prior to cite this report, please access the updated version available at:
http://ghsl.jrc.ec.europa.eu/documents/ENACT_R2020A.pdf

1 Introduction

1.1 Overview

The ENhancing ACTivity and population mapping (ENACT) project aimed at producing a set of seamless day- and night-time population density grids for each month of the year, taking into account human activities and induced major daily and monthly variations, and covering all EU Member States (as of 2019). These spatio-temporal grids are created by mining and combining official statistical data at regional level with geospatial data from conventional and non-conventional data sources.

This product is named according to the standard ENACT naming convention:

ENACT_<name>_<temporalCoverage>_<spatialExtent>_<releaseId>

Therefore the product name "ENACT_POP_2011_EU28_R2020A" indicates the ENACT population grid (ENACT-POP) for 2011 and a EU28 spatial extent, release R2020A.

Each dataset is named according to the standard ENACT naming convention:

ENACT_<name>_<epochCode>_<extent>_<releaseId>_<EPSG>_<resolution>_<version>.<ext>

The dataset unique identifier "ENACT_POP_D012011_EU28_R2020A_3035_1K_V1_0.tif" indicates the ENACT Population layer (ENACT-POP) of the January 2011 daytime with EU28 extent, release R2020A in Lambert Azimuthal Equal Area (ETRS89) projection at 1 km resolution v1.0 in GeoTiff format.

1.2 Rationale

Open data and free access are in-line with the Directive on the re-use of public sector information (Directive 2003/98/EC[1]). The free and open access policy facilitates the information sharing and collective knowledge building, thus contributing to a democratisation of the information production.

The ENACT 2011 population grids contain the new ENACT data produced at the European Commission Directorate General Joint Research Centre as a collaboration of three units from two Directorates: the Disaster Risk Management Unit (E.1) from the Directorate for Space, Security and Migration; and the Territorial Development Unit (B.3) and the Digital Economy Unit (B.6), from the Directorate for Growth and Innovation.

1.3 Terms of Use

[1] http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32003L0098

[1] JRC Data Policy https://doi.org/10.2788/607378

2 ENACT 2011 Population Grid (ENACT-POP), R2020A [ENACT_POP_2011_EU28_R2020A]

This spatial raster dataset depicts the distribution/density of population, expressed as the number of people per cell, during night-time and daytime for each month of 2011 (Figure 1). The grids were produced following four main tasks. Each of the tasks constitutes an important step of the methodological workflow: 1) estimation of regional and monthly stocks of population sub-groups; 2) detailed mapping of land uses and location of socioeconomic activities; 3) disaggregation of population stocks to grid level; 4) cross-comparison of the grids against independent sources. These tasks involve the assembly and combination of statistical and geo-data from multiple sources, both conventional (e.g. official statistics, information derived from remote sensing) and non-conventional (e.g. volunteered geographic information, data from web services, proprietary thematic datasets, mobile phone data). This document accompanies the public release of the ENACT 2011 Population Grids and describes the contents.

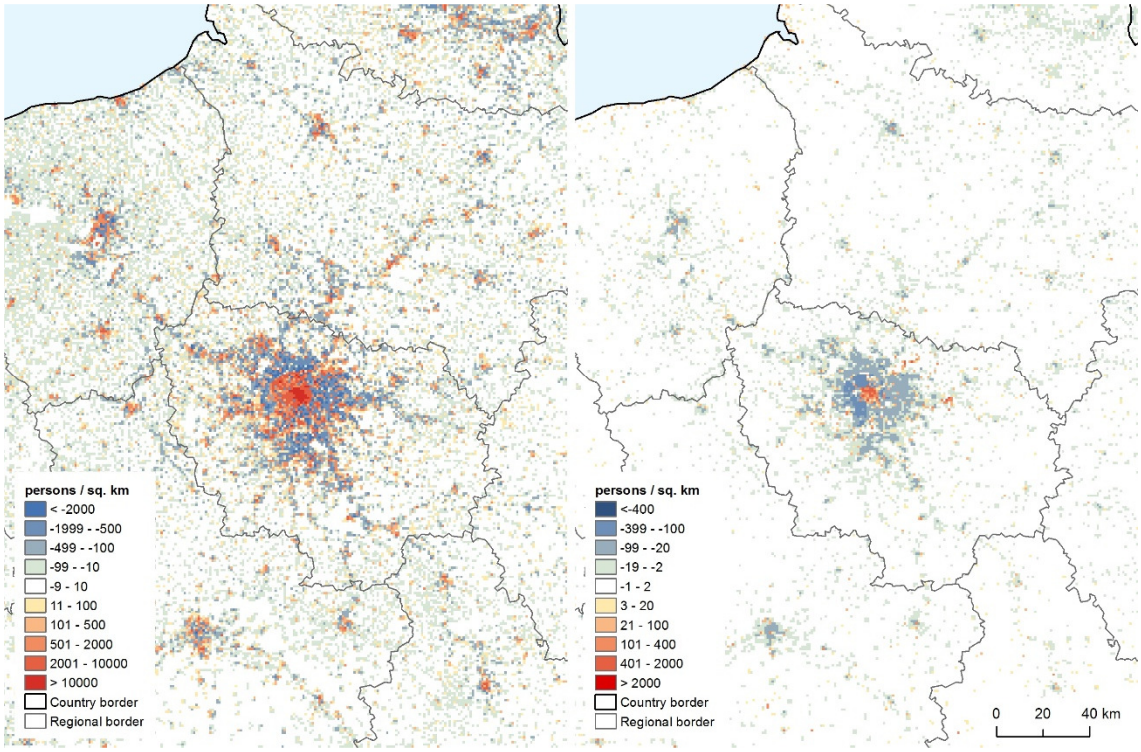

Figure 1 Difference in population in the area of Paris per 1 x 1 km grid cells. Left: difference between day and night; Right: difference between August and January (at night-time)

2.1 Input data and methods

2.1.1 Regional and monthly population stocks

The population dataset has been compiled using data from various sources with different characteristics regarding the spatial and temporal detail, data structure and format. Table 1 summarizes the main data inputs used and their characteristics. The data were then integrated following a set of operations to obtain results at NUTS-3 level for 2011 for each population stock.

For almost all population stocks a "gap-filling" procedure was conducted at the given administrative level to complete the dataset, by applying different techniques for missing NUTS population value, such as: using the difference between total population in the upper NUTS and the population of all other NUTS nested in it; splitting the total population of upper NUTS according to historical fraction of all nested units; interpolating or extrapolating values from time series constraining results to equal the upper NUTS population values.

Stocks of **Residents** were available from EUROSTAT in table format and gridded format (GEOSTAT grid).

Workers are aggregated from NACE classes obtaining nine different groups in Workers stock, namely: A, BDE, C, F, GHI, J, K, L, MN, OPQ and RSTU (see Eurostat – Reference and management of nomenclature for details).

Students were subdivided into two main classes according to the International Standard Classification of Education (ISCED) levels. ISCED levels 0-1-2-3-4 were combined into a single low to mid educational level, and downscaled to NUTS-3 according to the under 19-years-old population abundance. ISCED levels 5-6 were combined into a single high educational level, and downscaled to NUTS-3 according to the abundance of university students enrolled as reported in the ETER database[3]. Schools and University calendar are obtained from European Commission/EACEA/Eurydice (2016a; 2016b) reports.

Non-working & Non-studying stock is calculated at NUTS-3 level as the fraction of residual population at the corresponding NUTS-2. Residual population at NUTS-2 is obtained as the inactive population (i.e. total population minus the active population) minus the students plus the unemployed.

Monthly **inbound Tourists** were obtained by downscaling yearly nights-spent from NUTS-2 level to NUTS-3 level according to the number of beds reported per NUTS-3 and disaggregated by month according to the average monthly percentage of tourists at the available administrative level, obtained from each country National Statistical Office. Origin-Destination matrix (OD) of non-resident component of tourism is built by using the country-of-origin composition of tourists to obtain per-country stock of **outbound Tourists**. Details on estimating Tourists stock are presented in Batista e Silva et al. 2018. Monthly inbound and outbound Tourists are used to transform the annual stocks of Residents, Workers, Students and Non-Working & Non-Studying into monthly stocks by proportionally subtracting the NUTS-3 outbound Tourists value.

Table 1 Data and sources used for population database compilation

Population Stock	Variable dataset(s) description	Spatial Resolution	Temporal Resolution	Source(s)
Resident population	Residents	NUTS-3	Annual (2011)	Eurostat
	GEOSTAT-1km grid	1 km	Annual (2011)	Eurostat
Workers (11 subgroups)	Employed persons per NACE sector	NUTS-3	Annual (2011)	Eurostat
Students (2 subgroups)	Students by level of education	NUTS-2	Annual (2011)	Eurostat
	Residents grouped by age	NUTS-3	Annual (2011)	Eurostat
	European Tertiary Education Register (ETER) University database	NUTS-3	Annual (2011)	ETER project
	Calendars of Schools and Universities	NUTS-0	Monthly (2011)	EACEA
Tourists (2 subgroups)	Nights-spent at tourist accommodation (plus non-EU per country)	NUTS-2	Annual (2011)	Eurostat
	Nights-spent or arrivals at tourist accommodation establishments and country of origin composition	NUTS-0/1/2/3	Quarterly - monthly (2011)	NSIs
	Number of bed-places	NUTS-3	Annual (2011)	Eurostat
Non-working & non-studying	Economically active people	NUTS-2	Annual (2011)	Eurostat
	Unemployed people	NUTS-2	Annual (2011)	Eurostat

[3] https://www.eter-project.com/

2.1.2 Population Grids

The ENACT 2011 Population Grids for the EU-28 are generated using a dasymetric mapping technique, relying on the 100m resolution European Settlement Map 2017 (ESM2017, update of (Ferri et al. 2014) and on a spatially and thematically refined version of the Corine Land Cover 2012 (CLC2012; (Rosina et al. 2018) as ancillary information. The ESM2017 represents the settlement map of Europe in 2011-12 and it is based on SPOT satellite imagery. The CLC2012 has been refined by integrating additional finer geospatial layers from various sources (e.g. Copernicus High Resolution Layers, Urban Atlas, OSM-Open Street Map, TomTom) to increase the spatial resolution to a minimum mapping unit of 1 hectare (for Artificial surfaces) and the thematic information to 50 land use/land cover classes. OSM and TomTom datasets were also used to generate additional target layers for Workers subgroups by rasterizing Point Of Interest (POI) data (avoiding overlaps with the related class in the final CLC2012) categorized according to NACE sectors. Each population stock targets specific CLC2012 classes and additional layers using specific weights for each class. Night-time weights were obtained through a sampling method (Freire, Florczyk, and Ferri 2015); while day-time weights were compiled using an expert survey.

Night-time population distribution maps were obtained by disaggregating the GEOSTAT 1km grid to ESM built-up in the targeted land use at 100m, then multiplied by one minus the estimated monthly NUTS-3 fraction of outbound tourists at 100m and summing with the inbound tourists at 100m, disaggregated using the additional point layer of bed-places as target. Results are summed to a single value for night-time and daytime and then aggregated at 1 km for dissemination. Day-time population distribution maps were obtained by disaggregating each population group stock available at NUTS-3 (1,311 regions) to ESM built-up in the targeted CLC2012 land use and additional layers at 100m. Non-working & non-studying population stock is used to determine the fraction of resident population at NUTS-3 level in such class. Those fractions are applied to the night-time population grids to obtain the Non-working & non-studying distribution map. Results are summed to a single value for day-time and then aggregated at 1 km for dissemination.

2.2 Validation of outputs

The quality of the produced day- and night-time population grids was assessed for European countries where adequate reference data were available, obtaining high levels of agreement. Census-based estimates of day- and night-time population for the whole of Italy and Portugal per municipality were used along with similar data specifically for three cities in Spain (i.e. Madrid, Barcelona and Valencia). Finally, for Belgium, we compared the day- and night-time population grids with data procured from a Mobile Network Operator. The validation methodology and results are documented in a paper currently under review (see section 2.4).

2.3 Technical Details

Authors: Schiavina, Marcello; Freire, Sergio; Rosina, Konstantin; Ziemba, Lukasz; Marin, Mario; Craglia, Massimo; Lavalle, Carlo; Kemper, Thomas; Batista e Silva, Filipe, Joint Research Centre (JRC) European Commission

Product name: ENACT_POP_2011_EU28_R2020A

Spatial extent: EU-28

Temporal extent: 24 time frames (i.e. day- and night-time for the 12 months of 2011

Coordinate Systems: Lambert Azimuthal Equal Area (EPSG: 3035) and WGS 1984 (EPSG: 4326)

Resolutions available: 1 km, 30 arcsec

Encoding: Population data float32 [0, ∞); NoData: -200

Data organisation: The grids are provided as GeoTIFF file as single global layer with pyramids.

Table 2 outlines the technical characteristics of the datasets released in this data package.

Table 2. Technical details of the datasets in ENACT_POP_2011_EU28_R2020A

ENACT_POP_2011_EU28_R2020A			
ID	**Description**	**Resolution (Projection/Coordinate system)**	**Size**
ENACT_POP_N012011_ EU28_R2020A_3035_V1_0	Night-time population density for January 2011 Values are expressed as decimals (Float) from 0 to 53018 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N022011_ EU28_R2020A_3035_V1_0	Night-time population density for February 2011 Values are expressed as decimals (Float) from 0 to 53000 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N032011_ EU28_R2020A_3035_V1_0	Night-time population density for March 2011 Values are expressed as decimals (Float) from 0 to 52993 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N042011_ EU28_R2020A_3035_V1_0	Night-time population density for April 2011 Values are expressed as decimals (Float) from 0 to 53034 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N052011_ EU28_R2020A_3035_V1_0	Night-time population density for May 2011 Values are expressed as decimals (Float) from 0 to 53014 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N062011_ EU28_R2020A_3035_V1_0	Night-time population density for June 2011 Values are expressed as decimals (Float) from 0 to 53004 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N072011_ EU28_R2020A_3035_V1_0	Night-time population density for July 2011 Values are expressed as decimals (Float) from 0 to 52947 NoData [-200]	1 km (LAEA)	10 MB
ENACT_POP_N082011_ EU28_R2020A_3035_V1_0	Night-time population density for August 2011 Values are expressed as decimals (Float) from 0 to 52800 NoData [-200]	1 km (LAEA)	10 MB
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ENACT_POP_N102011_ EU28_R2020A_3035_V1_0	Night-time population density for October 2011 Values are expressed as decimals (Float) from 0 to 53024 NoData [-200]	1 km (LAEA)	10 MB
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ENACT_POP_N122011_ EU28_R2020A_3035_V1_0	Night-time population density for December 2011 Values are expressed as decimals (Float) from 0 to 53012 NoData [-200]	1 km (LAEA)	10 MB
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2.4 How to cite

Dataset:

Schiavina, Marcello; Freire, Sergio; Rosina, Konstantin; Ziemba, Lukasz; Marin Herrera, Mario; Craglia, Massimo; Lavalle, Carlo; Kemper, Thomas; Batista e Silva, Filipe (2020): ENACT-POP R2020A - ENACT 2011 Population Grid. European Commission, Joint Research Centre (JRC) [Dataset] doi:10.2905/BE02937C-5A08-4732-A24A-03E0A48BDCDA PID: http://data.europa.eu/89h/be02937c-5a08-4732-a24a-03e0a48bdcda

Concept & Methodology:

Batista e Silva, F; Freire, S; Schiavina, M; Rosina, K., Marin, M; Ziemba, L; Craglia M; Koomen, E; Lavalle, C (2020) Uncovering temporal changes in Europe's population density patterns using a data fusion approach. Nat Commun 11, 4631. https://doi.org/10.1038/s41467-020-18344-5

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