

# Time-specific population grids for pandemic scenarios using Population24/7

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# Presentation overview

- Context: time-specific population modelling and Population24/7
- COVID-19 changing population bases and time profiles
- Reweighting Population24/7 models
  - Illustrative results
- Conclusion
- Data acknowledgements

# Context: time- specific population modelling and Population24/7

# Context

- Increasing focus on methodologies for time-specific gridded population distributions, typically incorporating:
  - Census/register population base data
  - Workplace/economic activity data +
  - LULC data/site location information
  - Estimated activities at different locations over time
  - Allocation of population (groups) to activity and location at target time
- Potential importance for rapid re-estimation of unconventional COVID-19 pandemic population scenarios

# ENACT, LandScan USA, +

Home Gallery Map Scene Groups



## ARTICLE

<https://doi.org/10.1038/s41467-020-18344-5>

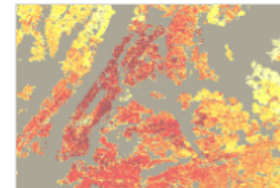
OPEN

## Uncovering temporal changes in Europe's population density patterns using a data fusion approach

Filipe Batista e Silva<sup>1,2</sup>, Sérgio Freire<sup>1</sup>, Marcello Schiavina<sup>1</sup>, Konstantin Rosina<sup>1,2</sup>, Mario Alberto Marin-Herrera<sup>1</sup>, Lukasz Ziemba<sup>1</sup>, Massimo Craglia<sup>1</sup>, Eric Koomen<sup>3</sup> & Carlo Lavalle<sup>1</sup>

The knowledge of the spatial and temporal distribution of human population is vital for the study of cities, disaster risk management or planning of infrastructure. However, information on the distribution of population is often based on place-of-residence statistics from official sources, thus ignoring the changing population densities resulting from human mobility. Existing assessments of spatio-temporal population are limited in their detail and geographical coverage, and the promising mobile-phone records are hindered by issues concerning availability and consistency. Here, we present a multi-layered datametric approach that combines official statistics with geospatial data from emerging sources to produce and validate a European Union-wide dataset of population grids taking into account intraday and monthly population variations at 1 km<sup>2</sup> resolution. The results reproduce and systematically quantify known insights concerning the spatio-temporal population density structure of large European cities, whose daytime population we estimate to be, on average, 1.9 times higher than night time in city centers.

## LandScan USA



This raster dataset provides population estimates for (HIFLD) database (<https://gii.dhs.gov/HIFLD>).

File Geodatabase by [kiersten.hudson\\_geoplatform](#)

Created: Apr 3, 2020 Updated: Aug 6, 2020 Number of

## Description

LandScan USA Population Database 2019 provides estimated population counts at 3 the contiguous United States, Hawaii, and Alaska (as well as the U.S. Territories of Am Puerto Rico, and U.S. Virgin Islands). Residents, Prisoners, Workers, Students, and Sho estimates, which do not include transitory populations such as business travelers and

## Terms of Use

None (Public Use). Users are advised to read the data set's metadata thoroughly to ur Dataset may only be used in its native coordinate system; do not resample or project cell size.

<https://www.nature.com/articles/s41467-020-18344-5>

<https://geoplatform.maps.arcgis.com/home/item.html?id=e431a6410145450aa56606568345765b>

# Population24/7 – key reference

## Developing a Flexible Framework for Spatiotemporal Population Modeling

David Martin,<sup>\*</sup> Samantha Cockings,<sup>\*</sup> and Samuel Leung<sup>†</sup>

<sup>\*</sup>*Geography and Environment, University of Southampton*

<sup>†</sup>*School of Civil Engineering and Surveying, University of Portsmouth*

This article proposes a general framework for modeling population distributions in space and time. This is particularly pertinent to a growing range of applications that require spatiotemporal specificity; for example, to inform planning of emergency response to hazards. Following a review of attempts to construct time-specific representations of population, we identify the importance of assembling an underlying data model at the highest resolution in each of the spatial, temporal, and attribute domains. This model can then be interrogated at any required intersection of these domains. We argue that such an approach is necessary to moderate the effects of what we term the *modifiable spatiotemporal unit problem* in which even detailed spatial data might be inadequate to support time-sensitive analyses. We present an initial implementation of the framework for a case study of Southampton, United Kingdom, using bespoke software (SurfaceBuilder247). We demonstrate the generation of spatial population distributions for multiple reference times using currently available data sources. The article concludes by setting out key research areas including the enhancement and validation of spatiotemporal population methods and models. *Key Words: GIS, modifiable spatiotemporal unit problem, population, spatiotemporal.*

Martin, D., Cockings, S., & Leung, S. (2015). *Developing a flexible framework for spatiotemporal population modeling*. *Annals of the Association of American Geographers*, 105(4), 754-772 doi: 10.1080/00045608.2015.1022089

Locations  
(origins and destinations)

Spatial domain

Background features

Background

Time profiles

Magnitudes

Temporal domain

Attribute domain

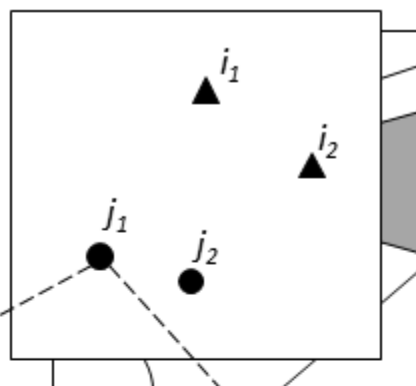
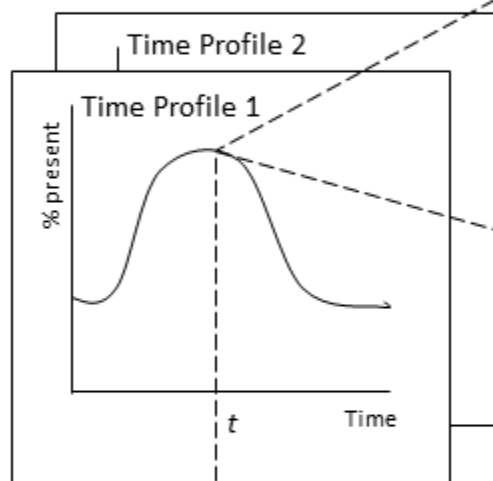
Data  
system

Analysis  
system

Query  
(space-time-attribute)

Modelled  
output

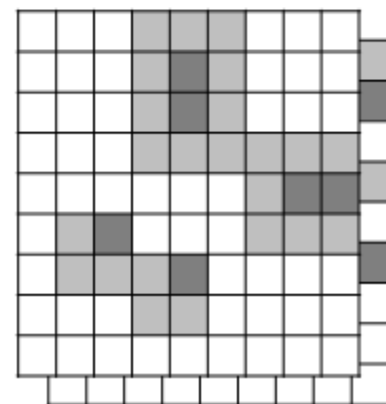
Mapped  
representation



Origins			
	$PR_{c1}$	$PR_{c2}$	...
$i_1$	100	20	...
$i_2$	80	150	...

Destinations					
	$PNR_{c1}$	$PNR_{c2}$	$TProf$	$W$	...
$j_1$	250	50	1	10	...
$j_2$	100	25	2	5	...



# Population24/7 features

- Modelled population is sum of populations of residential locations (e.g. centroids of census output areas, postcodes)
- Estimated population ‘capacity’ for every location (e.g. workplaces, universities, schools, hospitals, etc.)
- Time profiles of population present relative to capacity
- Reallocation of population across all locations and activities at a target time
- Separate estimation for population sub-groups (e.g. age)
- Separation treatment of ‘seasons’ such as university term-times to reflect large scale population redistribution

## South Hampshire: Input layers

Term-time weekday 02:00

Background: (C) OSM Contributors

● Residential output area centroids

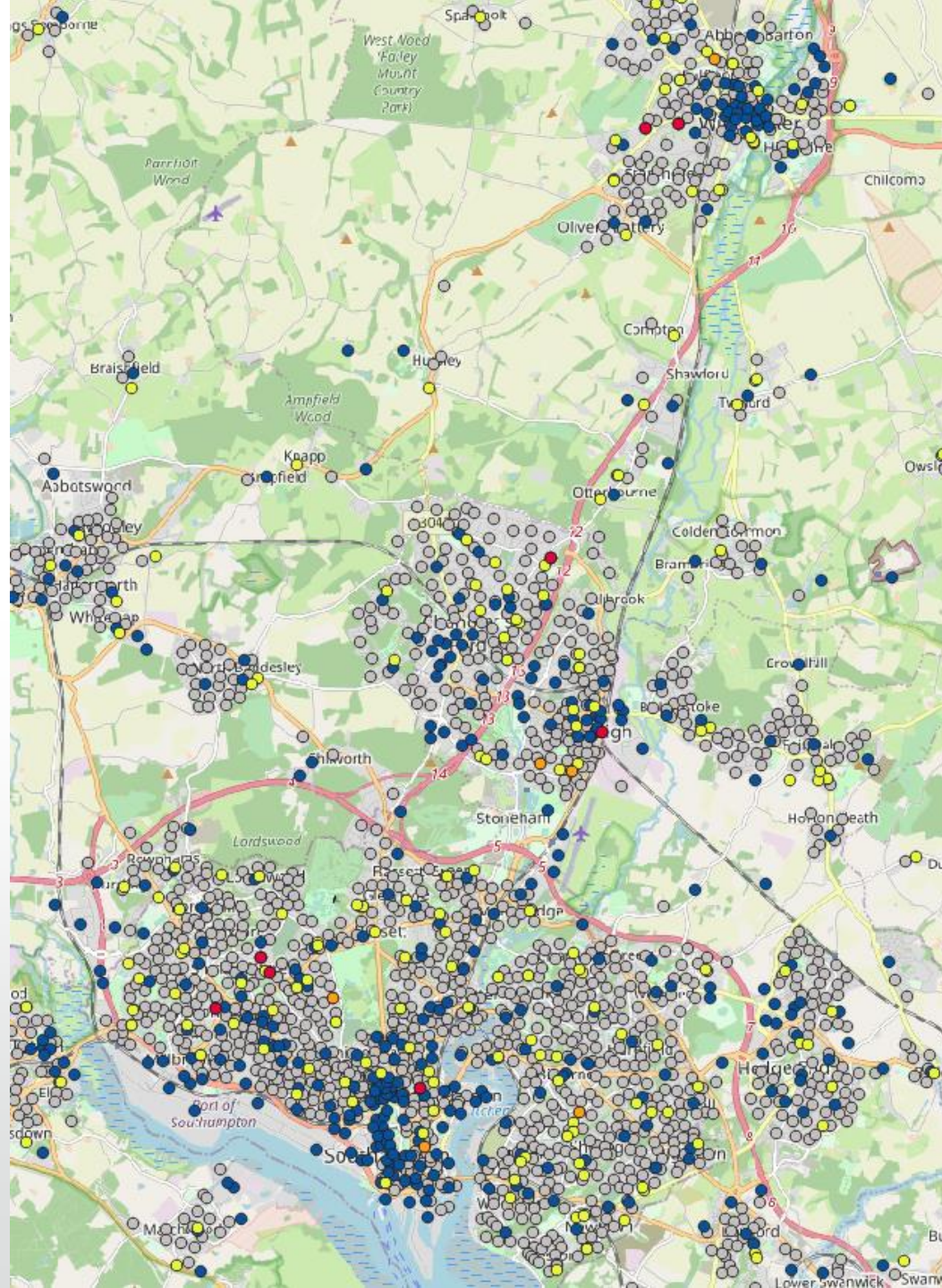
● Workplaces

● Schools

● Colleges

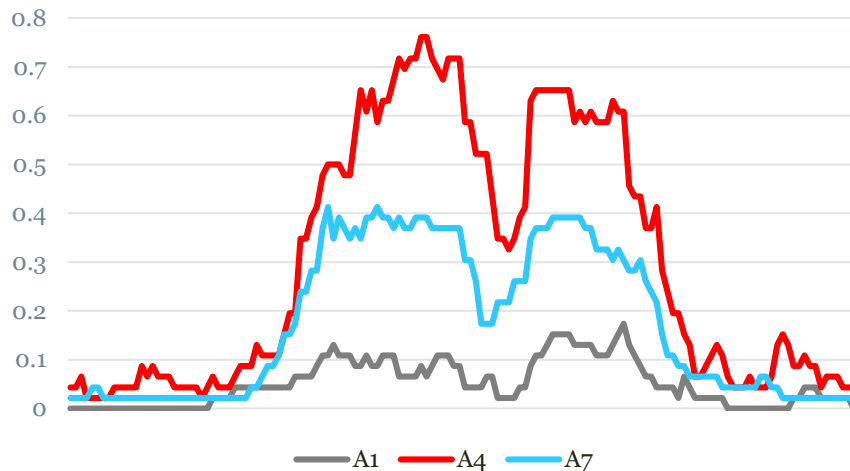
● Hospitals

2km

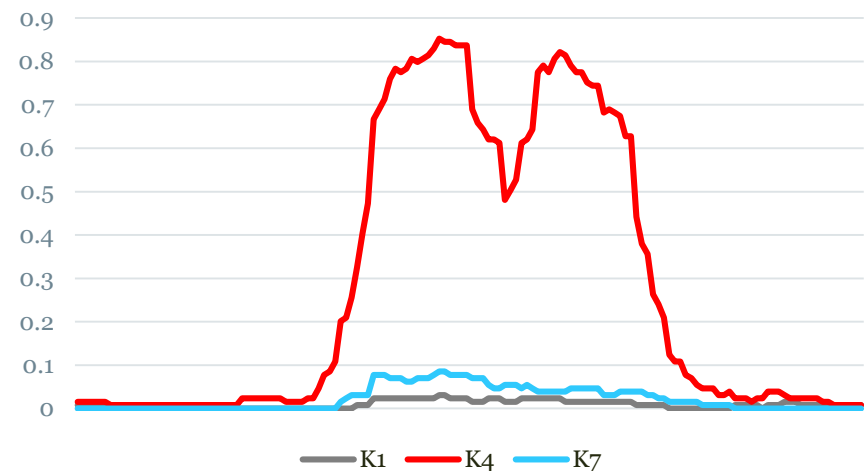


# Workplace time profiles: examples

A: Agriculture, forestry and fishing



K: Financial and insurance activities



- Time Use Survey 2015 – diary based data collection
- Individuals coded to employment in Standard Industrial Classes
- Can be apportioned to workforce of census workplace zones

# SurfaceBuilder247

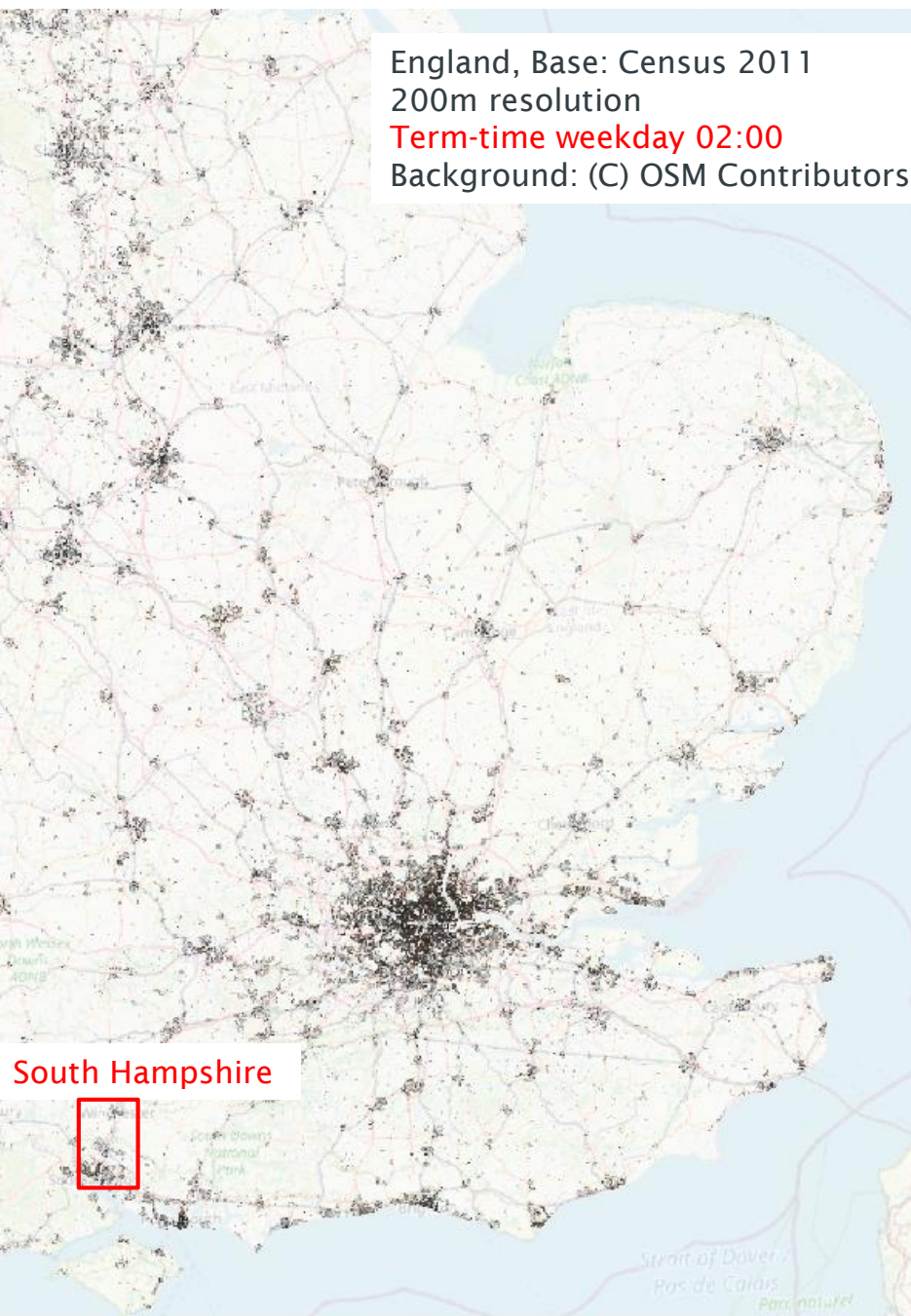
The screenshot displays the SurfaceBuilder247 software interface. On the left, a map shows a geographical area with a red rectangular selection box. The right side of the interface is divided into several panels:

- Data selection:** Includes fields for 'Locate directory' (C:\Users\Dave\Documents\F), 'Select bkgmd file' (pop247bkglayer.txt), and 'Analysis area' (0.0,3500,3500,200). It also has a 'Buffer' field set to 10000. A 'Read and display background' button is present.
- Select time series file:** A list of files with checkboxes: SICClusters TimeProfiles.xls, TimeSeries1.xls, TimeSeries2.xls, TimeSeries3.xls (checked), and TimeSeries4.xls.
- Select dest file:** A list of destination files with checkboxes: Dests\_EN\_Secondary2005x0.csv, Dests\_Solent\_Workplace2001.csv, NFDests\_Solent\_Workplace2001.csv, NFHighfieldTestDest.csv (checked), NFHighfieldTestDestJustUni.csv, and NFSolentExtraTestDest.csv.
- Select origin file:** A list of origin files with checkboxes: CEN01TERM\_Origins\_EW\_PopIMMx0.csv, NFSolentExtraTestOrigin.csv (checked), NFSolentExtraTestOriginAllZero.csv, Origins\_EW\_CEN01TERM\_MOV.csv, Origins\_Solent\_PopIMM.csv, and Origins\_Solent\_PopIMMx0.csv.
- Validation:** Includes a 'Validate single file' button and a 'Show validation log' dropdown.
- Read data:** Includes a 'Data session name' dropdown (TestDAve), a 'Save data session' button, a 'Read data' button, and a 'Show data log' dropdown (TestDAveDataLog.txt). A 'Dests read' field shows the value 7.
- Run parameters:** Includes fields for 'Run name' (Default), 'Choose dest pop band' (18\_74), 'Origin pop band used' (POP06\_1874ST\_PC), 'Model Date' (03/02/2011), and 'Model time' (12:00). It features 'Run', 'Show run log', and 'Save results file' buttons.
- Run details:** Displays 'Elapsed Time: 37.3464'.
- Display results:** Includes buttons for 'Show background', 'Show destinations', 'Show destinations In Travel at 12:00', 'Show destinations On Site spread at 12:00', 'Show Night Time Origin Pop', 'Show origins Pop at 12:00', and 'Show origins On Site spread at 12:00'.

The Windows taskbar at the bottom shows the Start button and several open applications: Pop247, 24-7, Microsoft PowerPoint, and 24/7. The system clock in the bottom right corner indicates the time is 11:41.

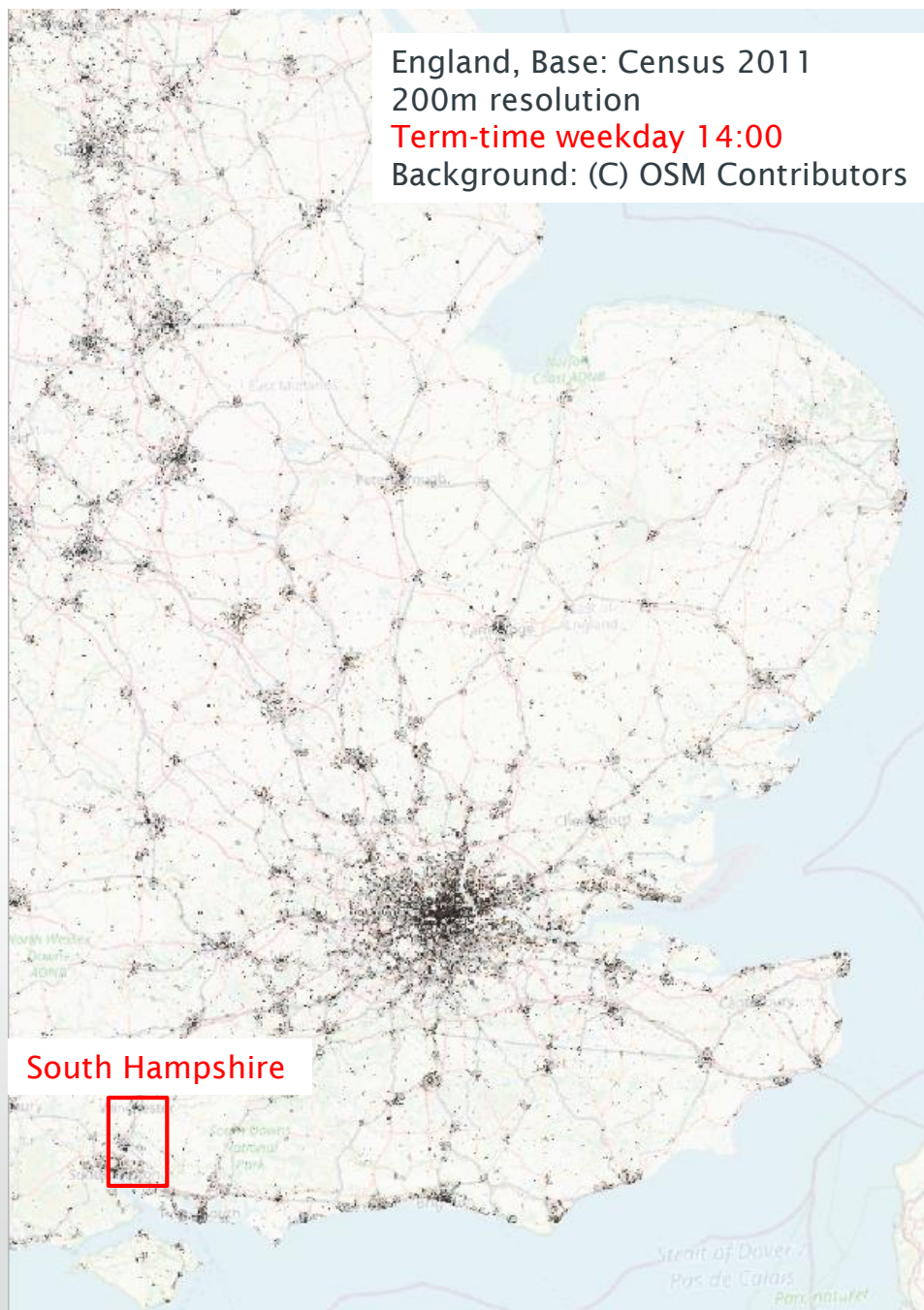
England, Base: Census 2011  
200m resolution  
Term-time weekday 02:00  
Background: (C) OSM Contributors

South Hampshire



England, Base: Census 2011  
200m resolution  
Term-time weekday 14:00  
Background: (C) OSM Contributors

South Hampshire



# COVID-19 changing population bases and time profiles

# Major perturbations to population system

- University disruption: neither fully term-time nor fully out of term-time (estimated 10% students remained May 2020)
- School disruption: schools open but reduced (and varying) pupil attendance
- Workplace disruption: greatly reduced numbers of workers at usual place of work, much working from home (proportions differ by industry and current policy)
- Many permutations during different COVID-19 lockdown/protection phases – ongoing change
- Correct denominators important for understanding rates

# Indicators of variation: daily and seasonal

## Hampshire

### Retail & recreation

-85% compared to baseline



### Grocery & pharmacy

-45% compared to baseline



### Parks

-48% compared to baseline



### Transit stations

-74% compared to baseline



### Workplace

-54% compared to baseline



### Residential

+15% compared to baseline



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Family & Education Young Reporter Global Education

**Cambridge University: All lectures to be online-only until summer of 2021**

19 May 2020

Coronavirus pandemic

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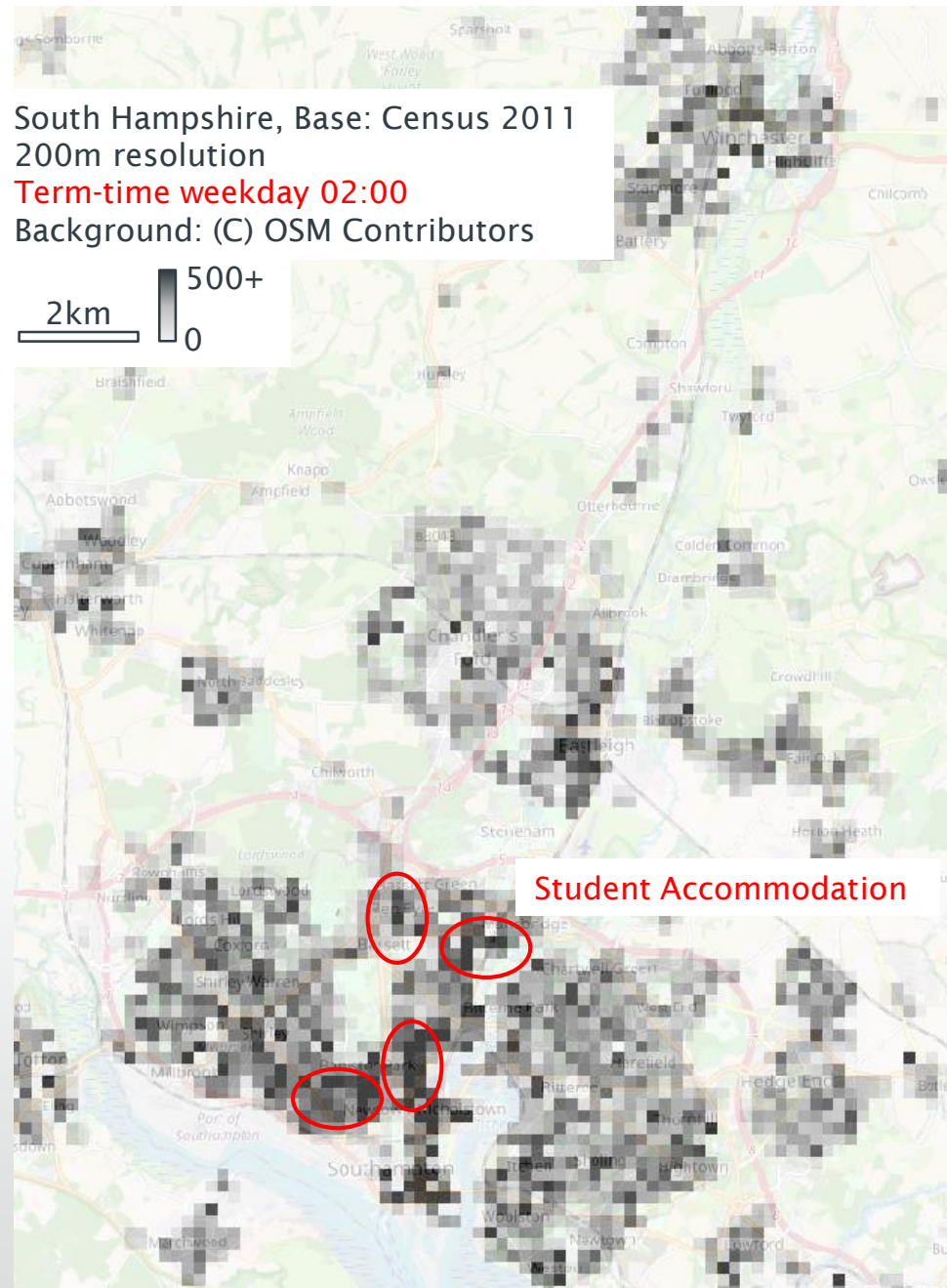
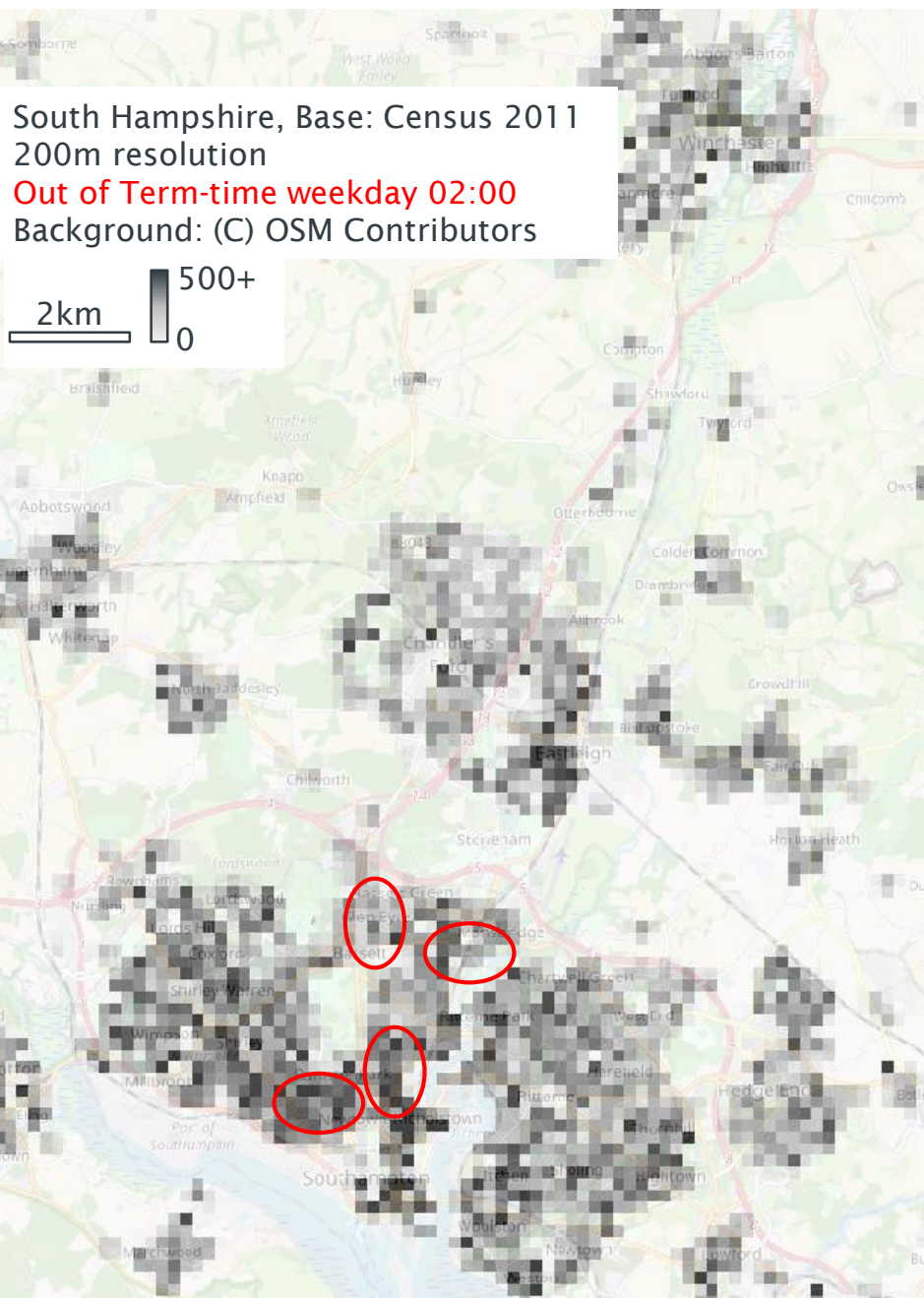
There will be no face-to-face lectures at the University of Cambridge over the course of the next academic year due to coronavirus, it has been announced.

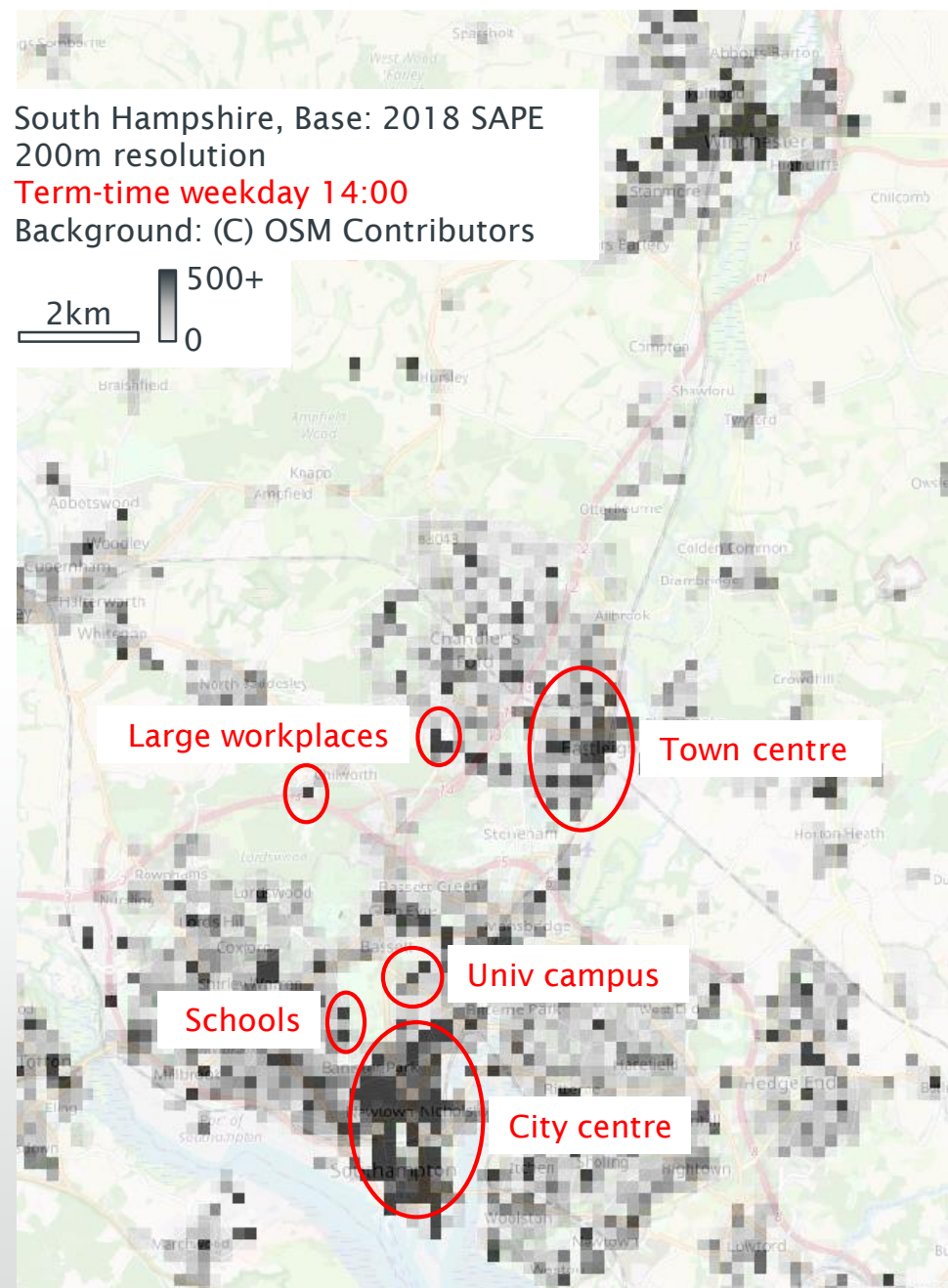
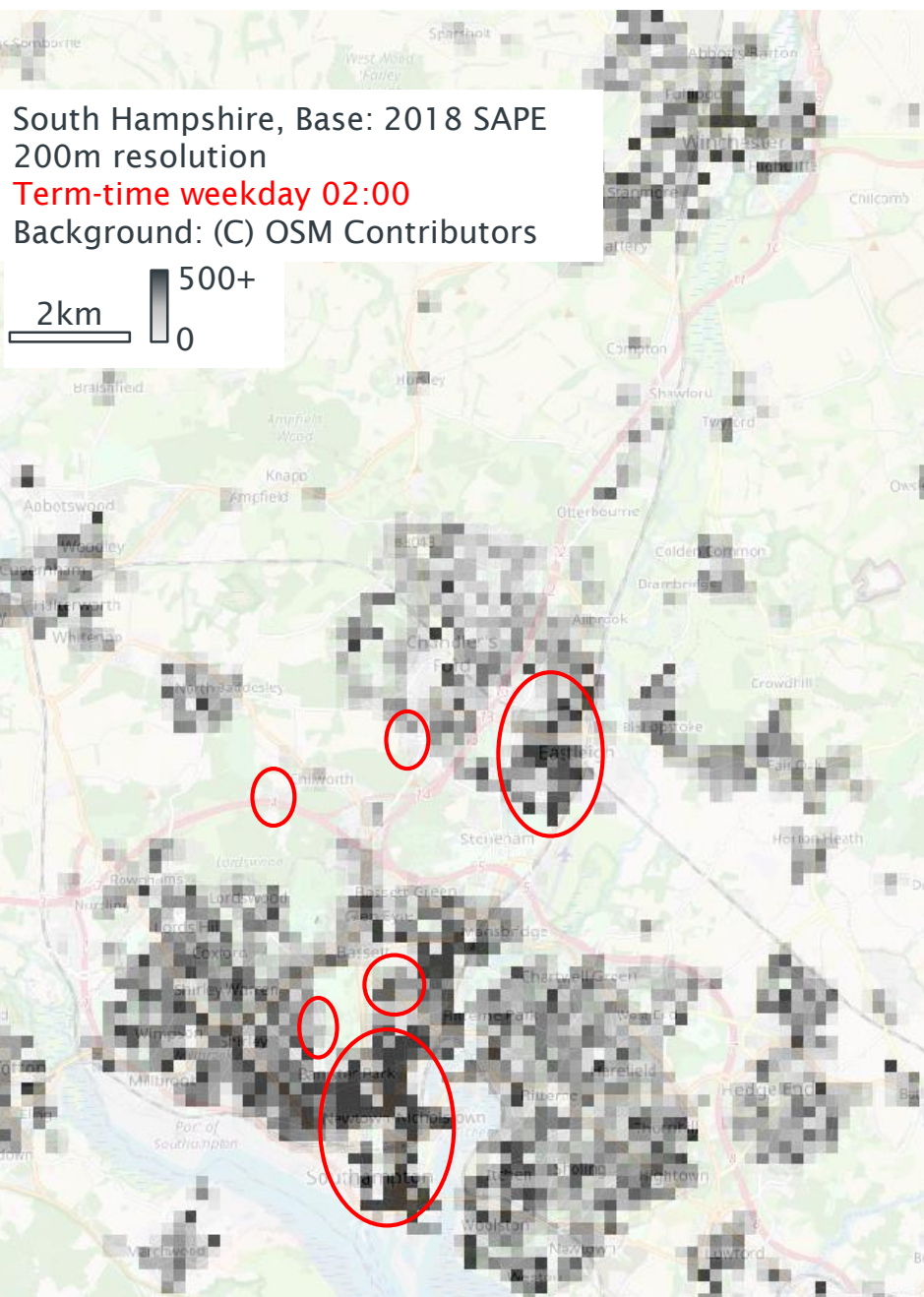
<https://www.google.com/covid19/mobility/>  
<https://www.bbc.co.uk/news/education-52732814>

# Reweighting Population24/7 models

# Population24/7 COVID-19 workflow:

- Estimate student population ratios: term-time/non term-time from census; re-scale attendance rates from data for subset of individual universities
- Update modelled population to latest available (2018 mid-year, small area estimates)
- Re-scale time profiles by estimated attendance rates e.g.
  - National schools data; could be regional or local
  - National Google mobility data by industry; could be regional
  - Unemployed/working from home remain at residential locations
- Run model for target dates/times – Hampshire study area

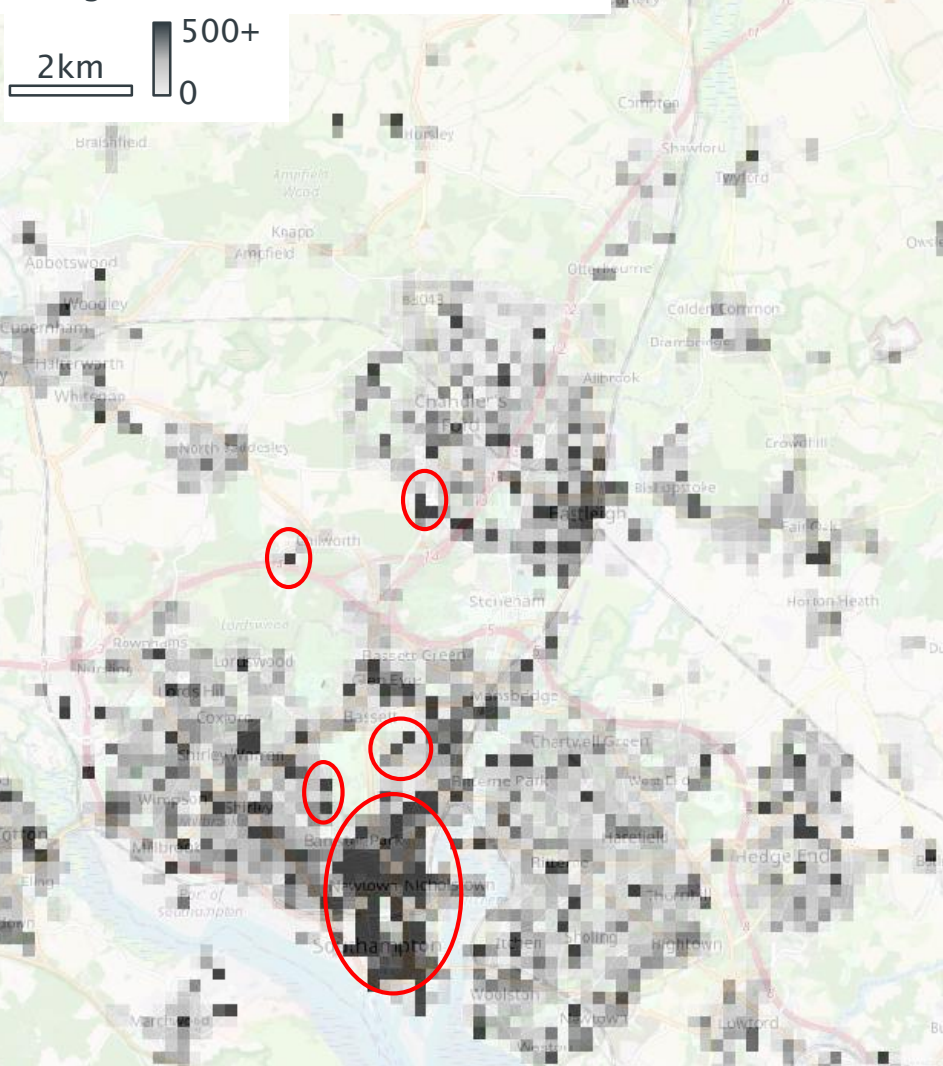




South Hampshire, Base: 2018 SAPE  
200m resolution

Term-time weekday 14:00

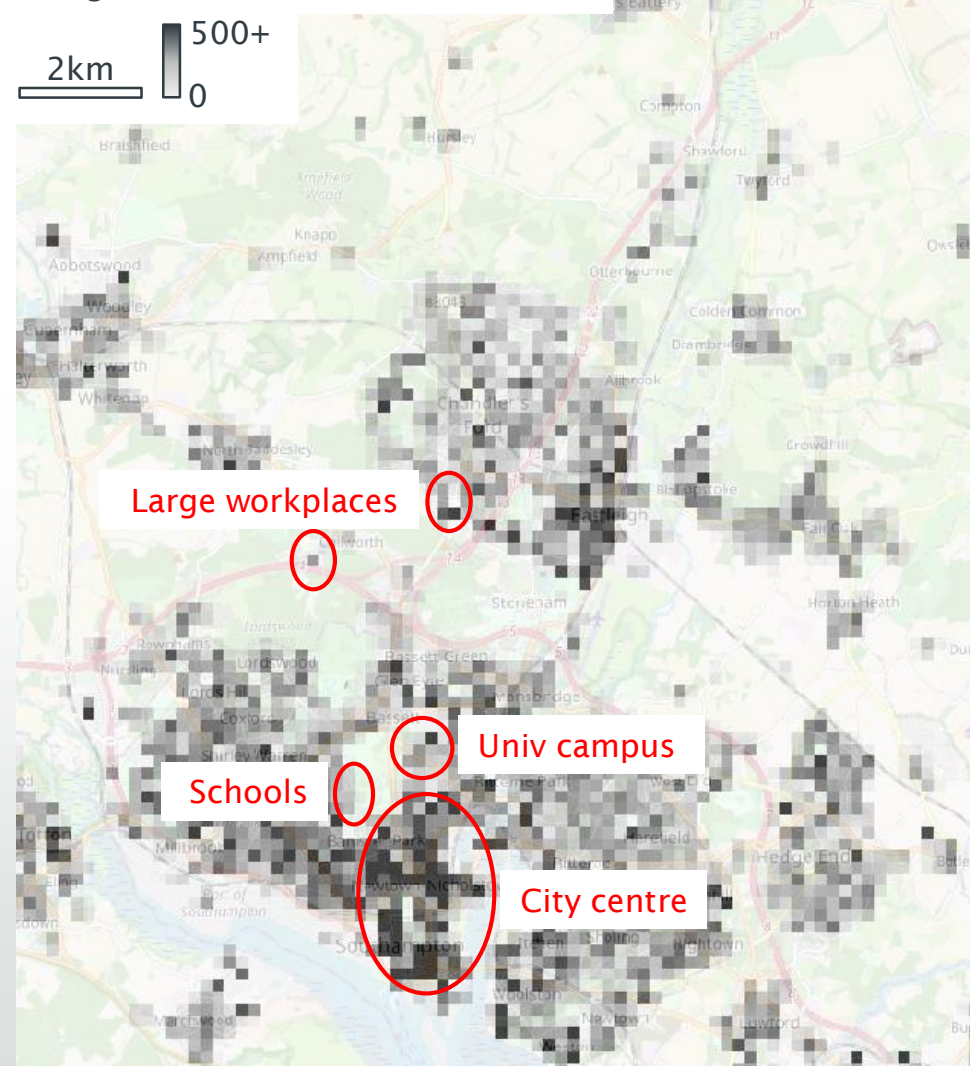
Background: (C) OSM Contributors

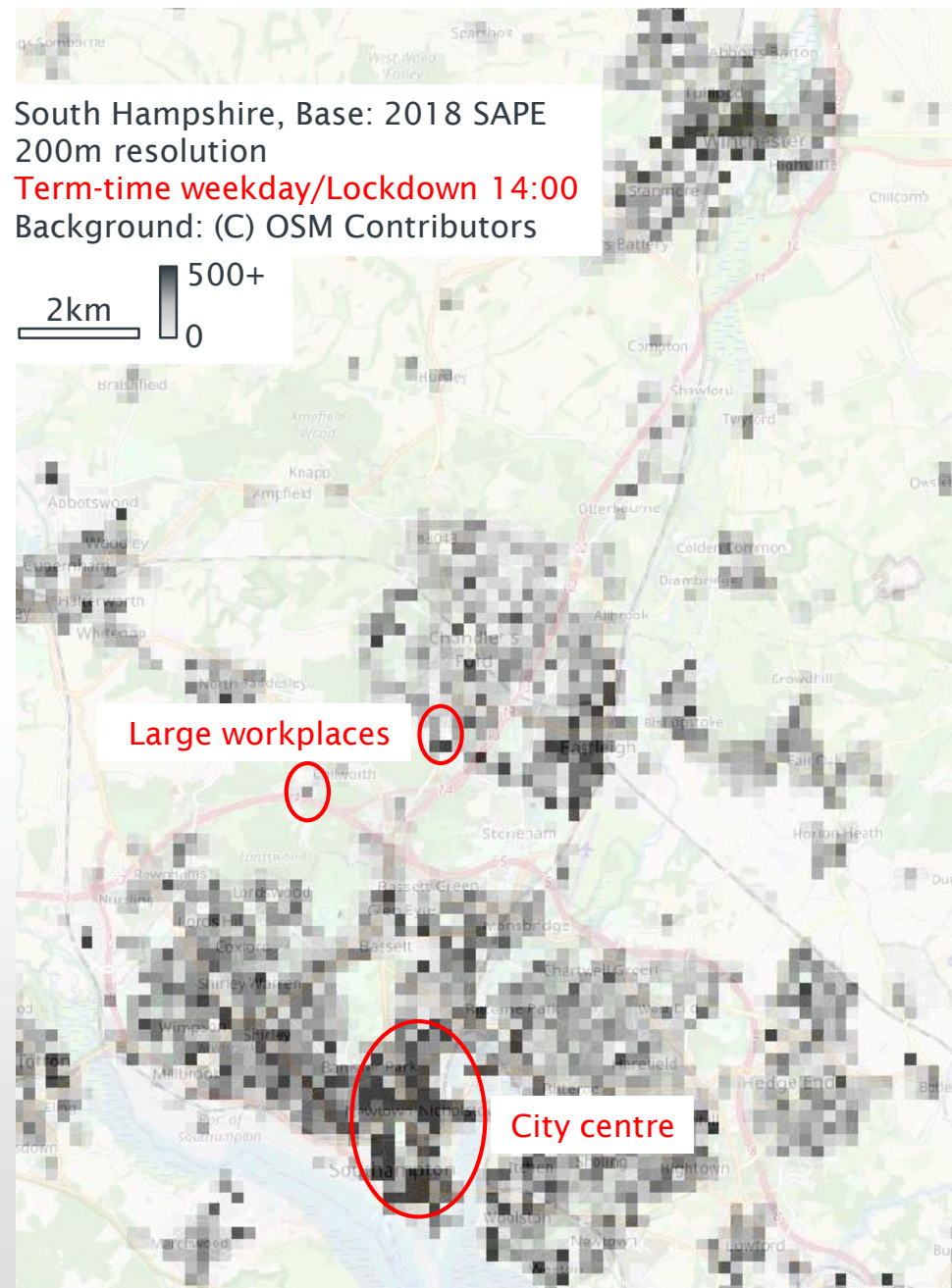
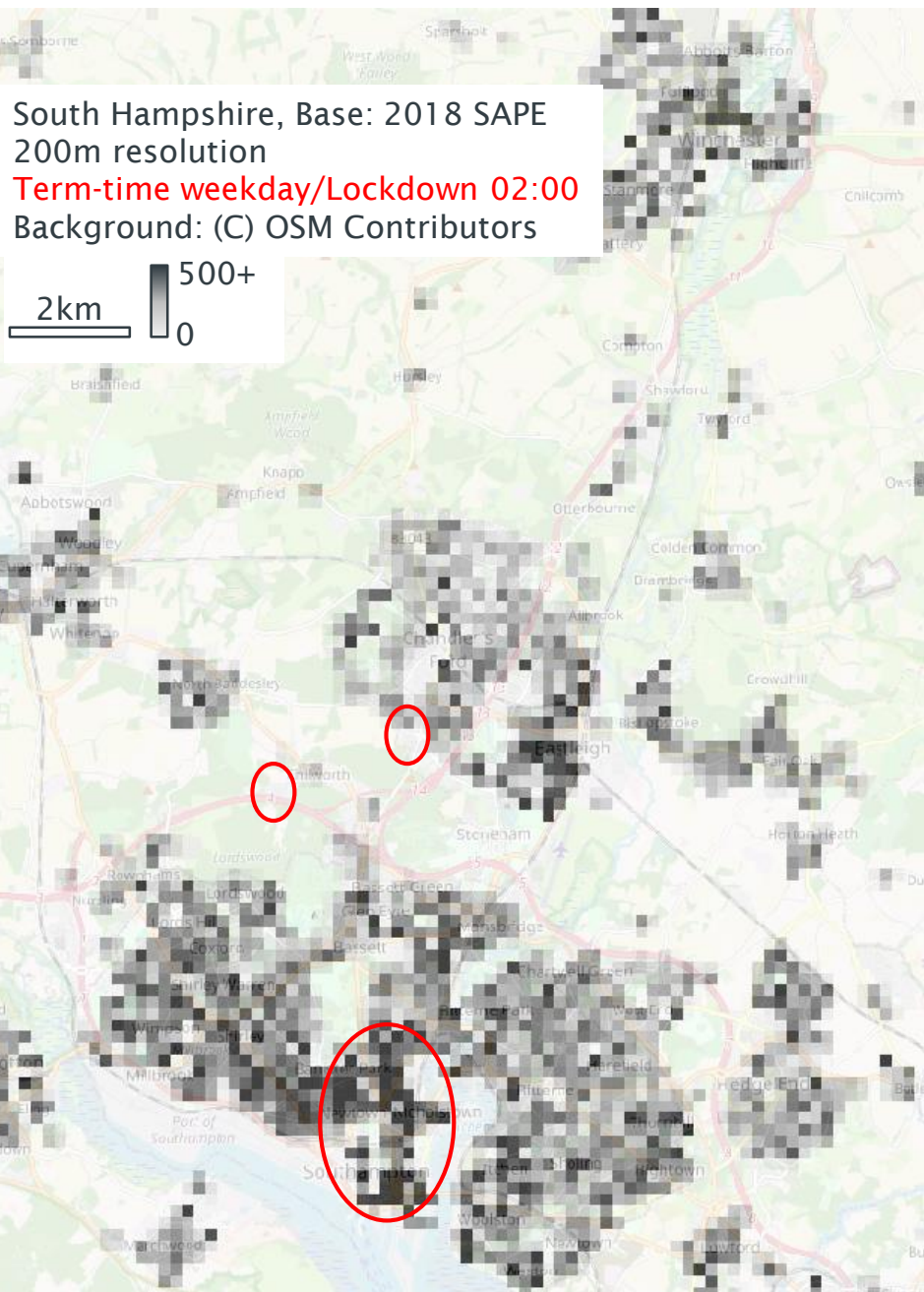


South Hampshire, Base: 2018 SAPE  
200m resolution

Term-time weekday/Lockdown 14:00

Background: (C) OSM Contributors





# Conclusion

# Conclusion

- Regrettably, a cycle of COVID restrictions will be with us for an extended period
- It is important to make adjustments in population bases and daily activity mapping – both to obtain case denominator values and for service delivery planning
  - Student populations and working from home have major impacts on local distributions
- Population24/7 (and cognate approaches) offer a readily scalable way to apply different scenarios and rapidly re-weight high-resolution spatial databases

# Data acknowledgements

2011 Census residential and workplace data, 2018 Small Area Population Estimates: Office for National Statistics licensed under the Open Government Licence v.3.0, <http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3>

National Statistics Postcode Lookup: Contains OS data © Crown copyright and database rights 2020; Contains Royal Mail data © Royal Mail copyright and database rights 2020; Contains National Statistics data © Crown copyright and database rights 2020

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NHS Attendance Figures: Contains data from NHS Digital licensed under the Open Government Licence v.3.0

AADF traffic flow data: Department for Transport licensed under the Open Government Licence v.3.0

Time profiles derived from Gershuny, J., Sullivan, O. (2017). United Kingdom Time Use Survey (TUS), 2014-2015. Centre for Time Use Research, University of Oxford. UK Data Service. SN: 8128, <http://doi.org/10.5255/UKDA-SN-8128-1>

OpenStreetMap background mapping: © OSM Contributors