

# The Behavome: the next frontier in environmental exposure modelling?

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[with thanks to Dr Miranda Loh, Institute of Occupational Medicine]

- Person – disease/ailment; what genetic and behavioural factors might be at play?
- Time – for how long, what is the latency, and when did causative exposures occur?
- Place, or ‘Location’ – where did exposure to the relevant contributing and compounding factors occur?

## What have we done up to now?

- Traditional approach to environmental epidemiology ...
- Assumption that where you live determines your exposure to potentially harmful substances. Reliance on static secondary data.
- Think about how we all move day-to-day and then throughout our lifetimes.
- **We don't currently estimate exposure by tracking individuals through their daily lives**



# Why the exposome?

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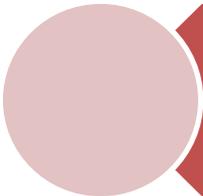
Two-thirds of deaths caused by non-communicable diseases



Only about 10% due to genetic variants alone



Much has been done to characterise the human genome



Exposure science has not yet caught up to genomics

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**New Approach - Exposome:**  
Totality of exposure from physical and social environments, lifestyle, behaviour, etc. - during all stages of life



The New Game of Human Life. London: John Wallis, 1790

# Big push in understanding and sequencing the **Human Genome** over the past 2 decades but considerably less research in understanding the role of **Environmental Exposure in disease causation**

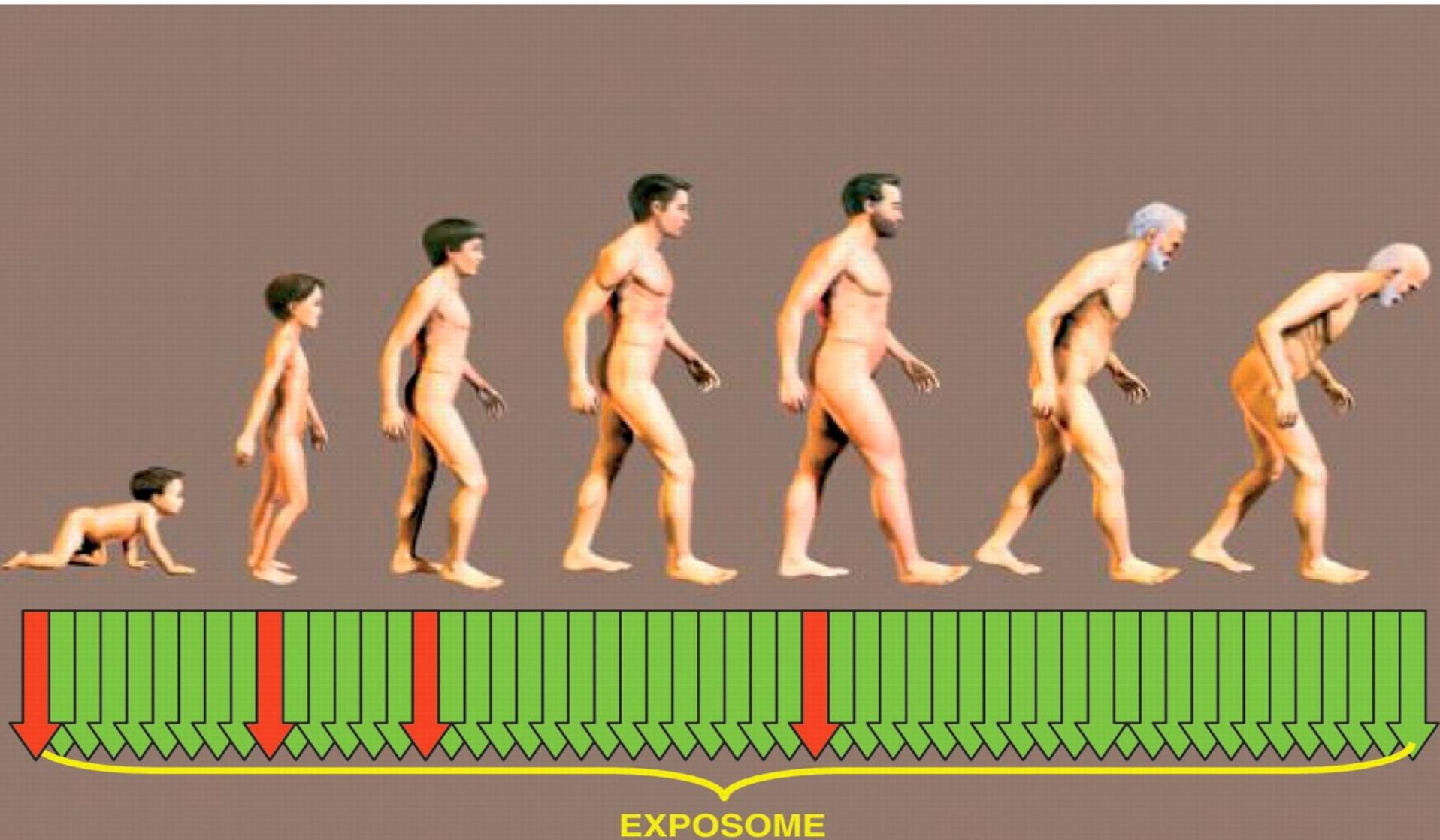


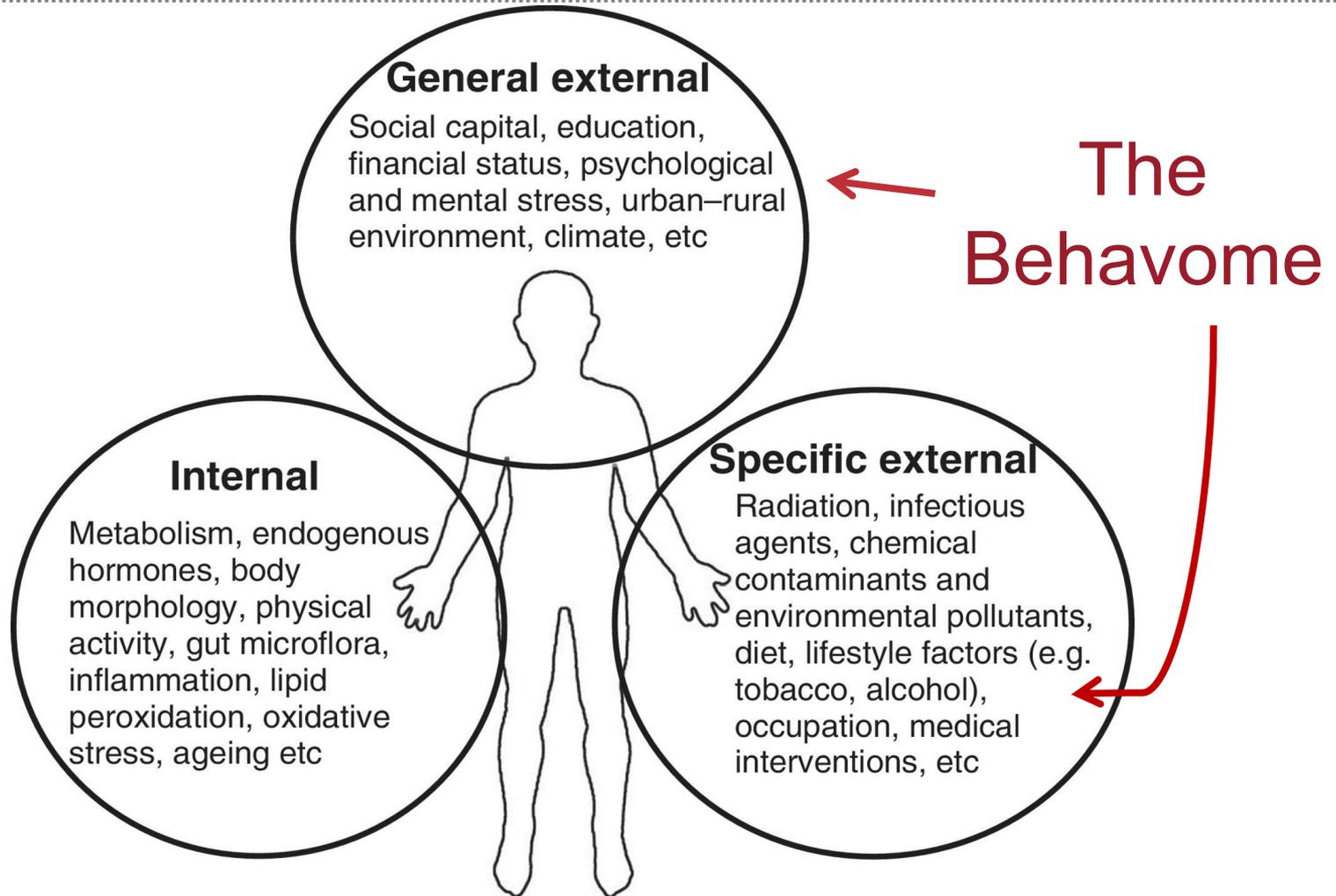
Recognizing the disparity in current knowledge between genes and environmental exposures, Chris Wild defined the “exposome”

Representing all environmental exposures (including those from diet, lifestyle, and endogenous sources) from conception onwards, as a quantity of critical interest to disease etiology

Wild, C.P., Complementing the genome with an "exposome": the outstanding challenge of environmental exposure measurement in molecular epidemiology. *Cancer Epidemiol Biomarkers Prev* 14 (8), 1847-1850 (2005).

# The exposome - whole lifecourse – critical periods





- Citi-Sense €12 million, FP7 <http://citi-sense.nilu.no/>  
largely sensor and citizen science focussed
  - Exposomics, €8.7 million, FP7 <http://www.exposomicsproject.eu/>  
Imperial College, Paulo Vineis
  - Helix, €8.6 million, FP7 <http://www.projecthelix.eu/>  
CREAL, Spain
  - **HEALS, €12 million, FP7 <http://www.heals-eu.eu/>**  
Total lifetime exposure mobility tracking to physical and  
social environments. 2013-2018.
  - NIEHS/NIH US initiatives  
National Institute of Environmental Health Sciences (NIEHS)  
awarded May 2013 a \$4 million Grant to Emory University,  
focused on the exposome.
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# Don't forget the social ...

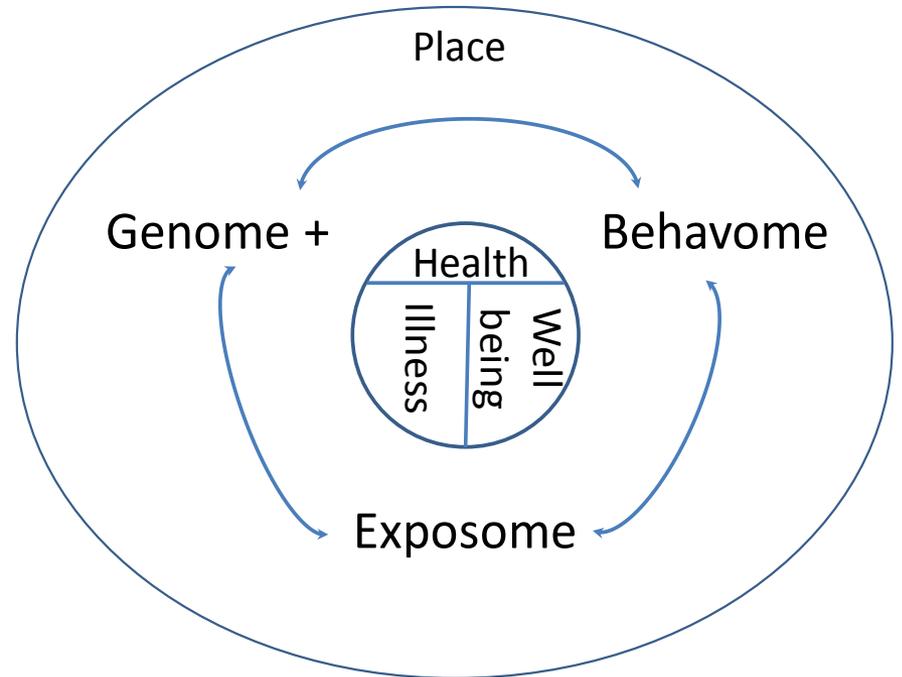
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- Postulated that **social 'exposures'** could be as **important** as physical environmental exposures.
- How does our **wellbeing** respond to differing social environments?
- **Health related behaviours** such as smoking, alcohol consumption and diet are partially explained by the social contexts in which people live
- Burden falls particularly in **vulnerable populations** young, elderly, low-SES, ethnic minorities, sick, females ...



# A New Age of Measurement

- Genome+
  - Genome
  - 'omics
  - ...



- Envirome =(genome+, exposome, behavome)
- Improved understanding of the foundations of illness and wellness based on the egome and its relation to society

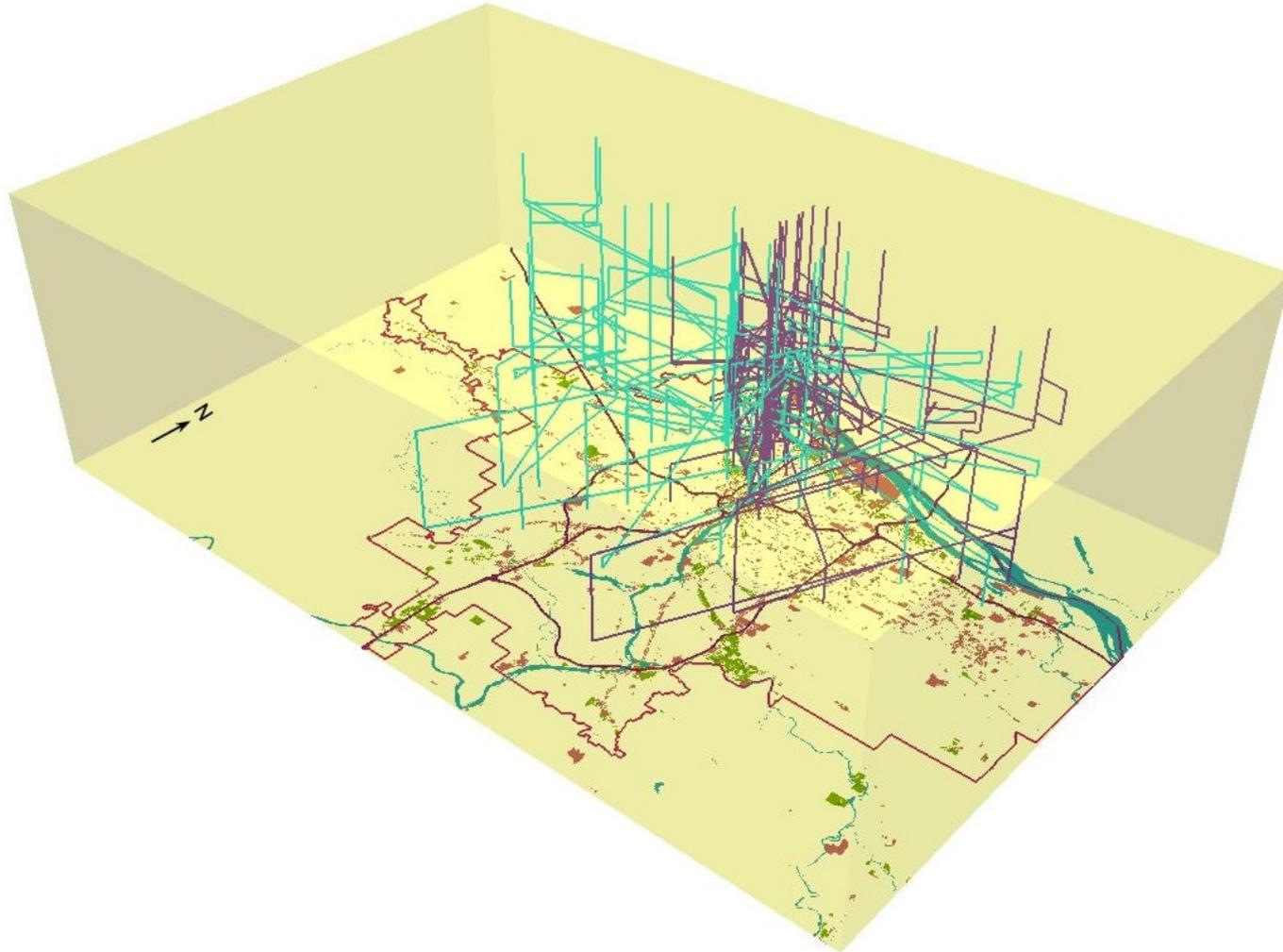
## The Behavome ...

Jacquez G, **Sabel C E** and Shi C (in press) Genetic GIS: Towards a place-based synthesis of the genome, exposome and behavome, Annals AAG.

**So where does GISc  
come into all this?**



# Space-time "aquarium"



...Paths of African American (purple) and Asian American (blue) women in Portland, Oregon, over.....  
the course of a typical day. The vertical dimension is time.

[bristol.ac.uk](http://bristol.ac.uk)

Mei-Po Kwan, Department of Geography, Ohio State University.

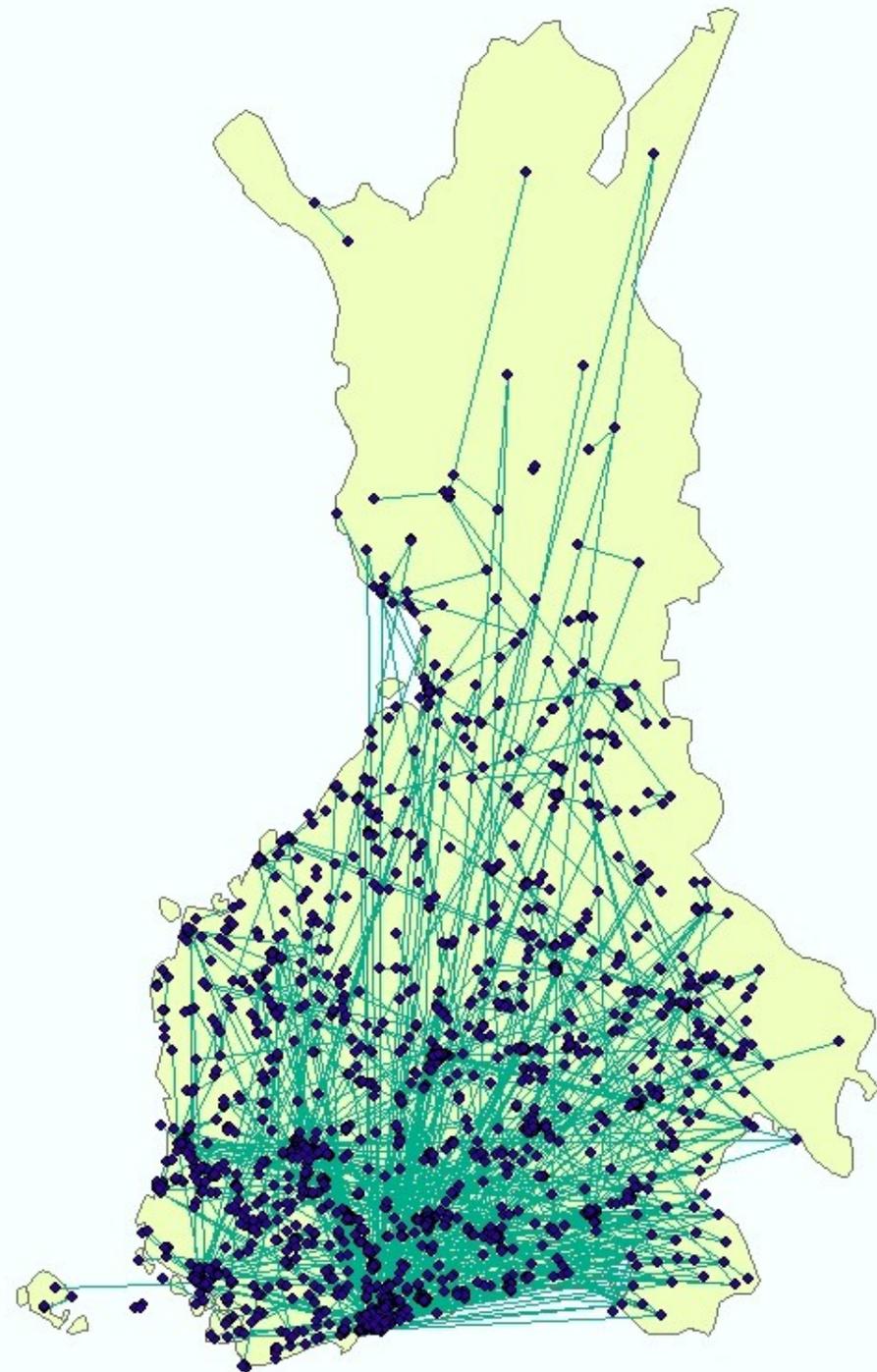
# All residential moves

- 2D All Finland
- All 1000 cases
- 3077 residential moves

**Sabel, C. E.,** A. C. Gatrell, et al. (2000). Modelling exposure opportunities: estimating relative risk for Motor Neurone Disease in Finland. *Social Science & Medicine* **50** (7&8): 1121-1137.

**Sabel, C E,** P Boyle, Raab G, Löytönen, M, and Maasilta, P (2009) Modelling individual space–time exposure opportunities: A novel approach to unravelling the genetic or environment disease causation debate. *Spatial and Spatio-temporal Epidemiology* **1**: 85–94.

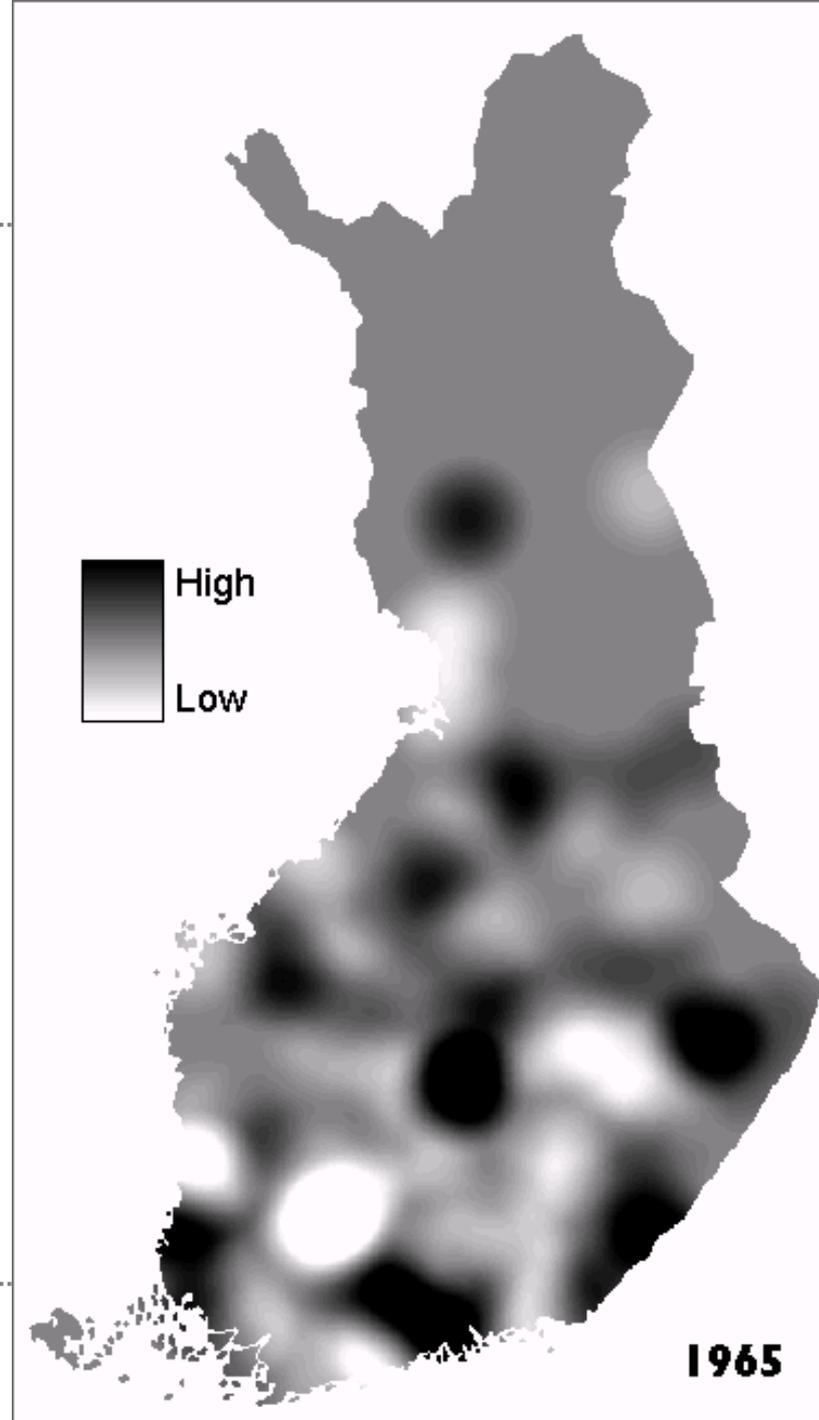
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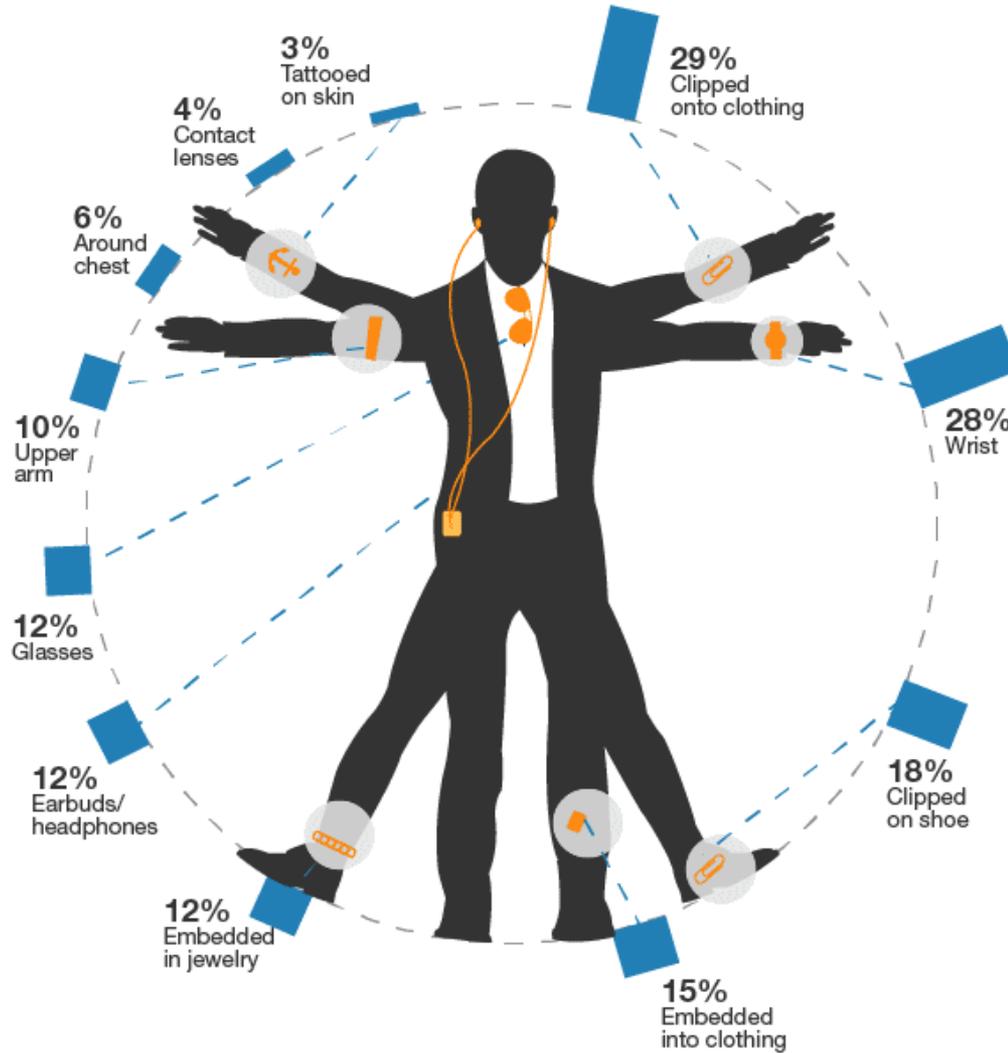
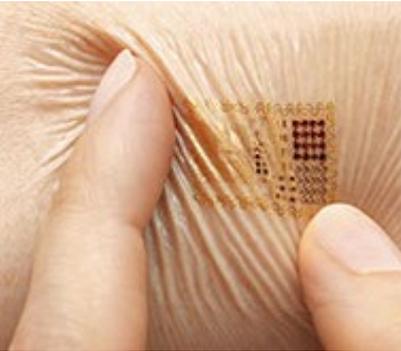


# Motor Neurone Disease Space-Time Visualisation

- **Spatial and Temporal variation**
- Residential Migration
- Space: Finland
- Time: 1965 – 1990



# Personal tracking and monitoring



Base: 4,657 US online adults (18+)  
(multiple responses accepted)



# Its all connected - Big Data

- Gov't collected [health] registries, census etc
- Social media interactions – twitter, facebook
- Crowd sourced
- Data-mining of trends



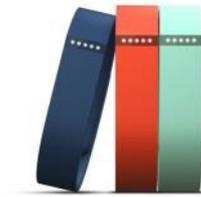
# Health and Environment- wide Associations based on Large population Surveys



FP7-ENV-603946

# Location/Activity Pilot Study

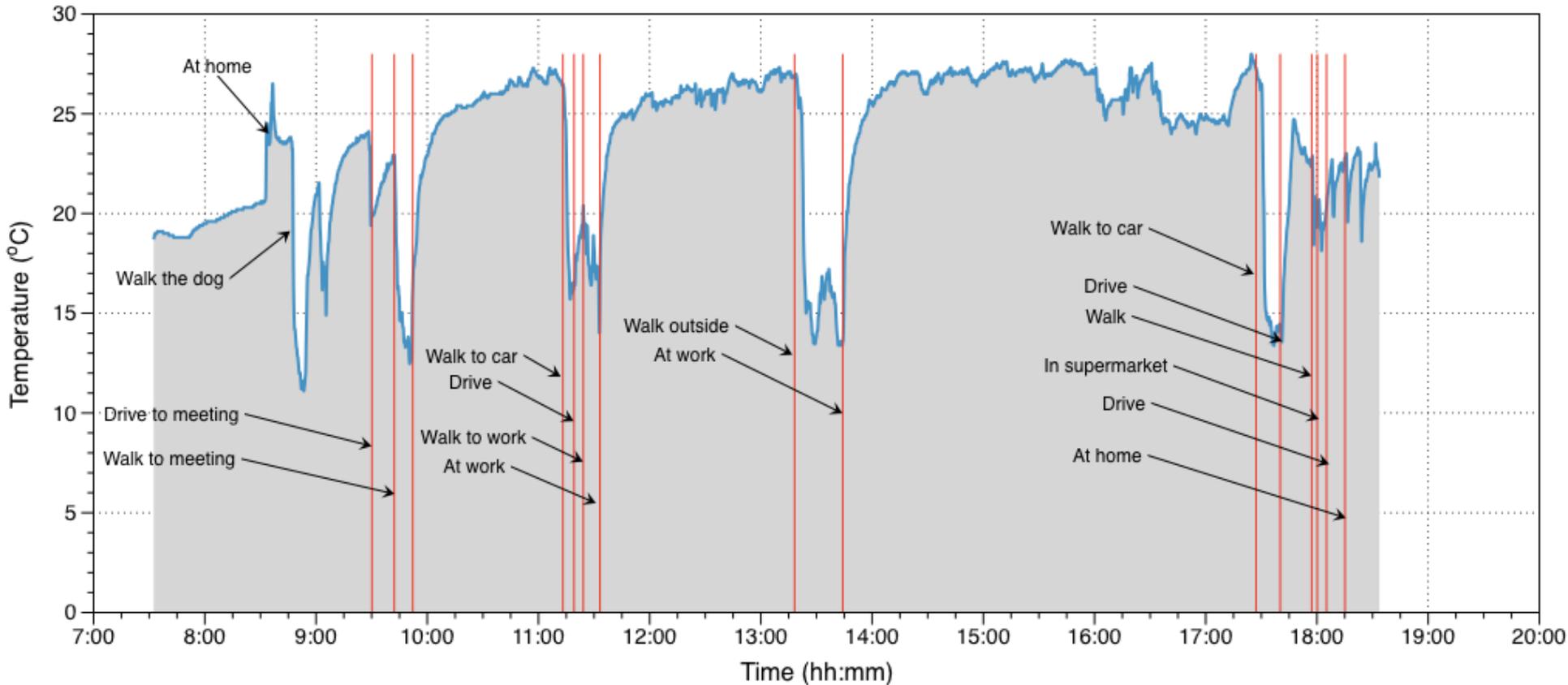
- Purpose: Investigate methods for determining location and activity and indoor/outdoor position.
- Methods:
  - Fitbit
  - Activ8
  - Moves
  - Temperature
  - UV meter (limited)
  - Actigraph (validation)
  - GPS (Qstarz) (validation)
  - Paper log (validation)

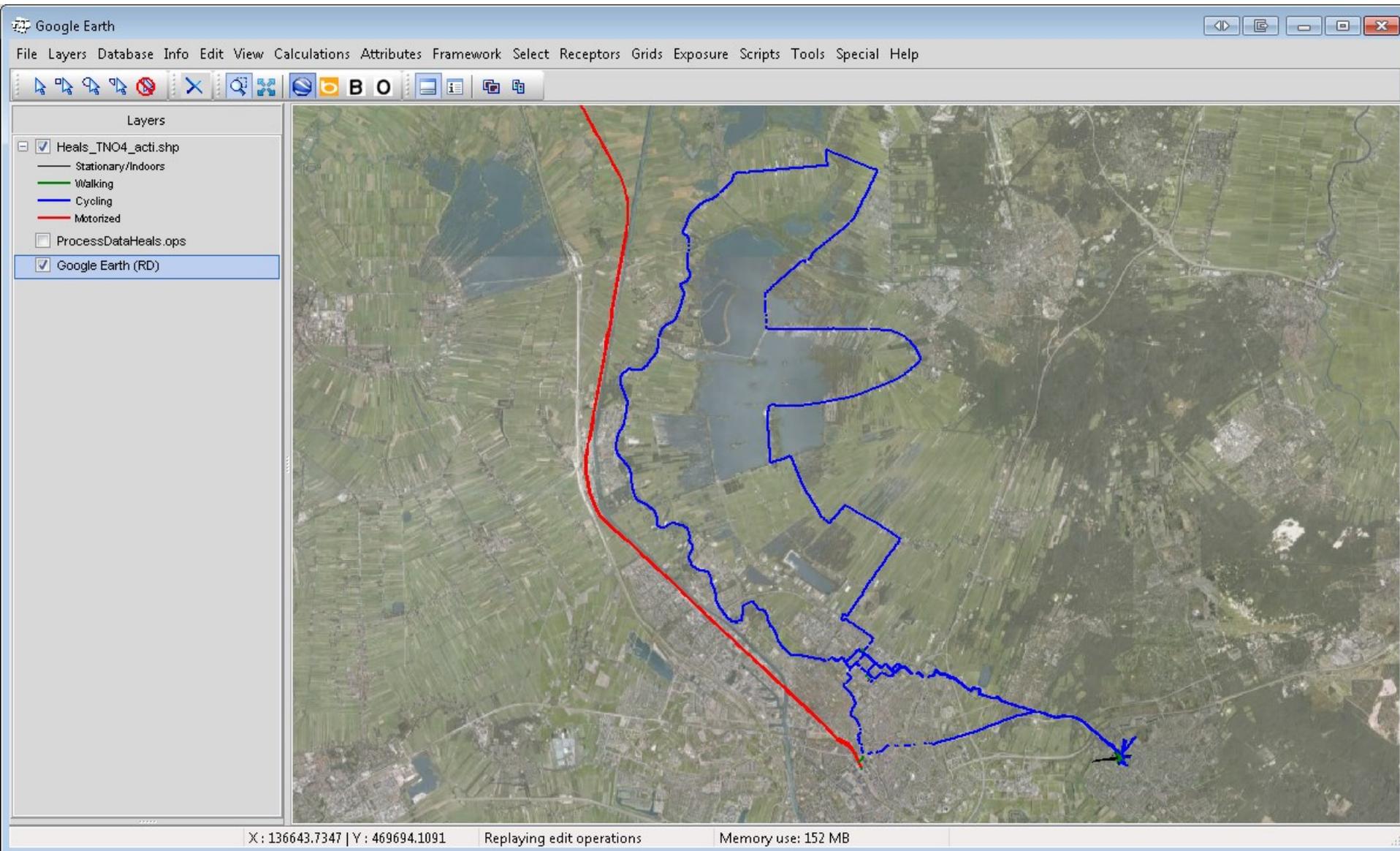


- **7 cities**
  - Edinburgh, Zeist, Stuttgart, Zagreb, Thessaloniki, Kozani, Athens
- **4 participants/institute**
- **7 days of data collection**
- **Data analysis underway**



# Temperature + Moves

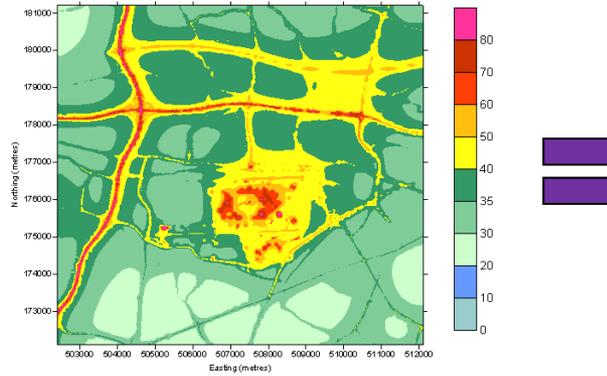


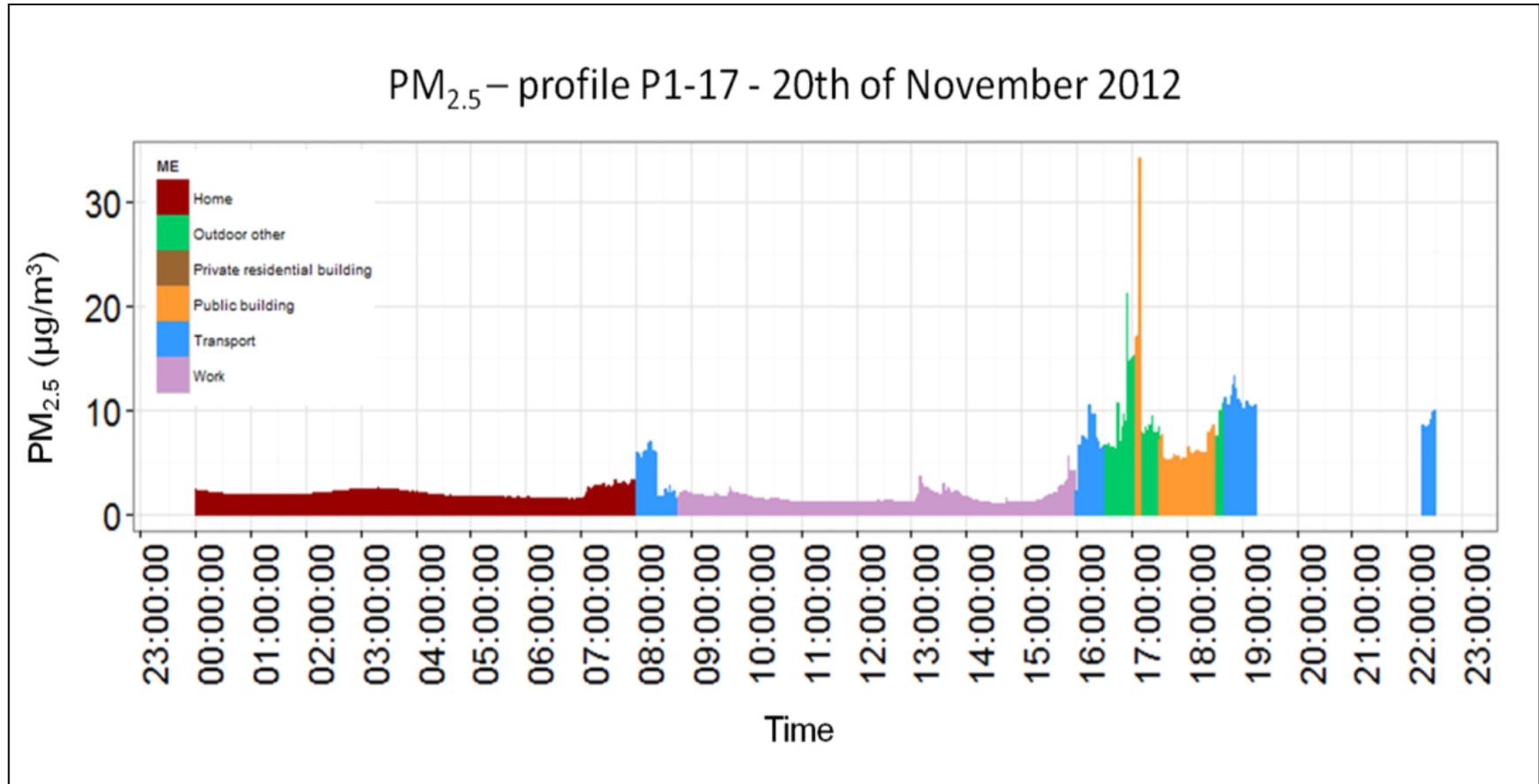


# Agent-Based Modelling

- Substantial technical and ethical hurdles involved in collecting real individual space-time movement data for whole populations
- Simulating movement and interaction behaviour using **agent-based models** (ABM) informed by sensor technologies.
- Assign behaviours and characteristics (SES, ethnicity, gender etc)
- Use to understand Cohort variation in behaviours & exposure







# Thank You

- Follow-up to:
- Clive Sabel, [c.sabel@bristol.ac.uk](mailto:c.sabel@bristol.ac.uk)