UCLouvain

CRED
Centre for Research on the Epidemiology of Disasters

Introducing Empirical Approaches to

Mortality Baselines and **Excess Mortality** Calculation

Belgian and Greek City Case Studies

IRSS Seminar, 1200, Brussels
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Outline

- Introduction to Mortality Modelling & Excess Mortality
- Code Examples
- Mortality Modelling with Singular Spectrum Analysis
- Link to Code Examples
- Additional Q&A

Mostly graphical explanations
Almost no mathematics

Icons: www.flaticon.com

Excess Mortality

eurostat

- An **unusual** mortality increase…
- during a **specific period**…
- in a given **population**

// Anomaly detection

https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Excess_mortality

Challenges (Method sensitivity)

→ *How to define unusual vs. usual (i.e., baseline) mortality?*

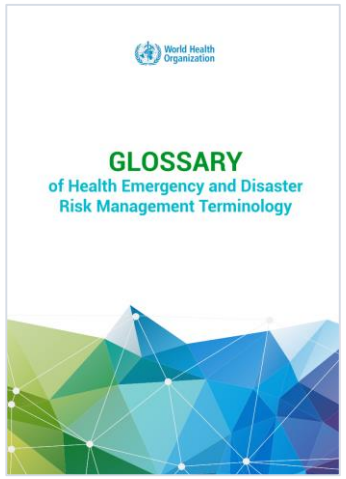
→ *How to define specific and reference periods?*

→ *What age group, gender, cause of death, region, socioeconomic conditions, or whatever population subset?*

Icons: www.flaticon.com

Why Excess Mortality?

- Indicator for Health Emergency and Disaster Risk Management
- Ideally combined with hazard and exposure monitoring



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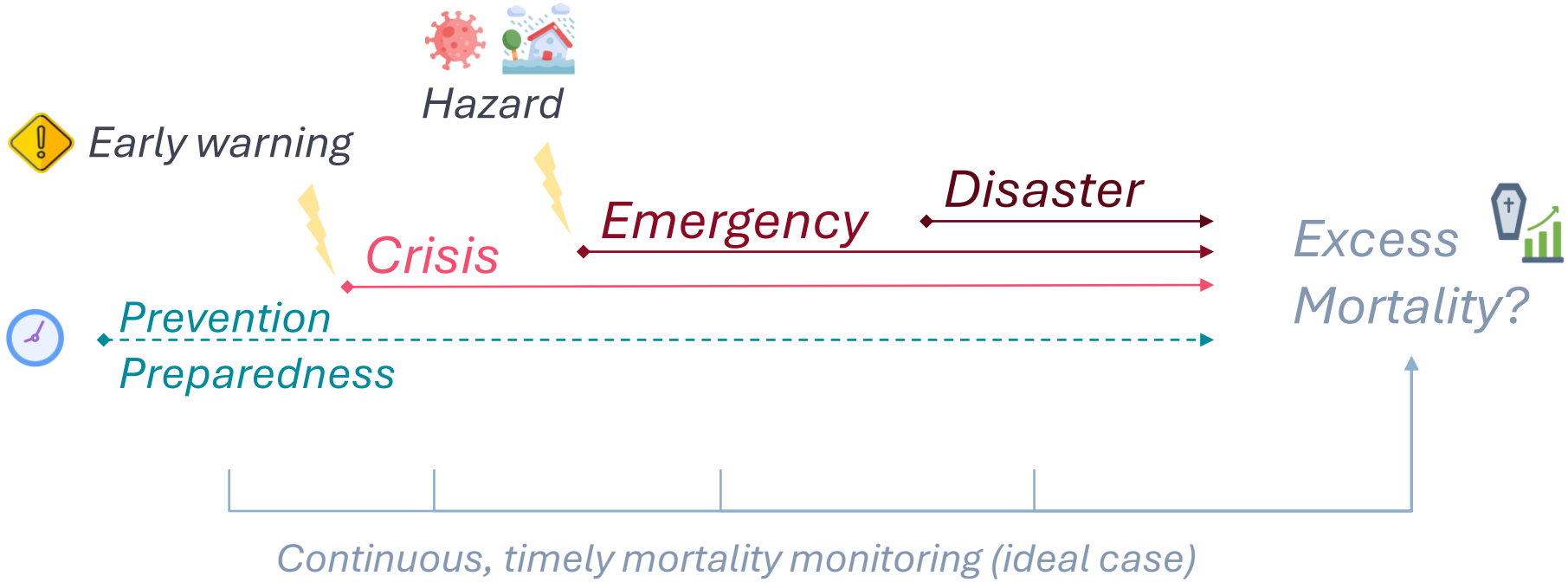
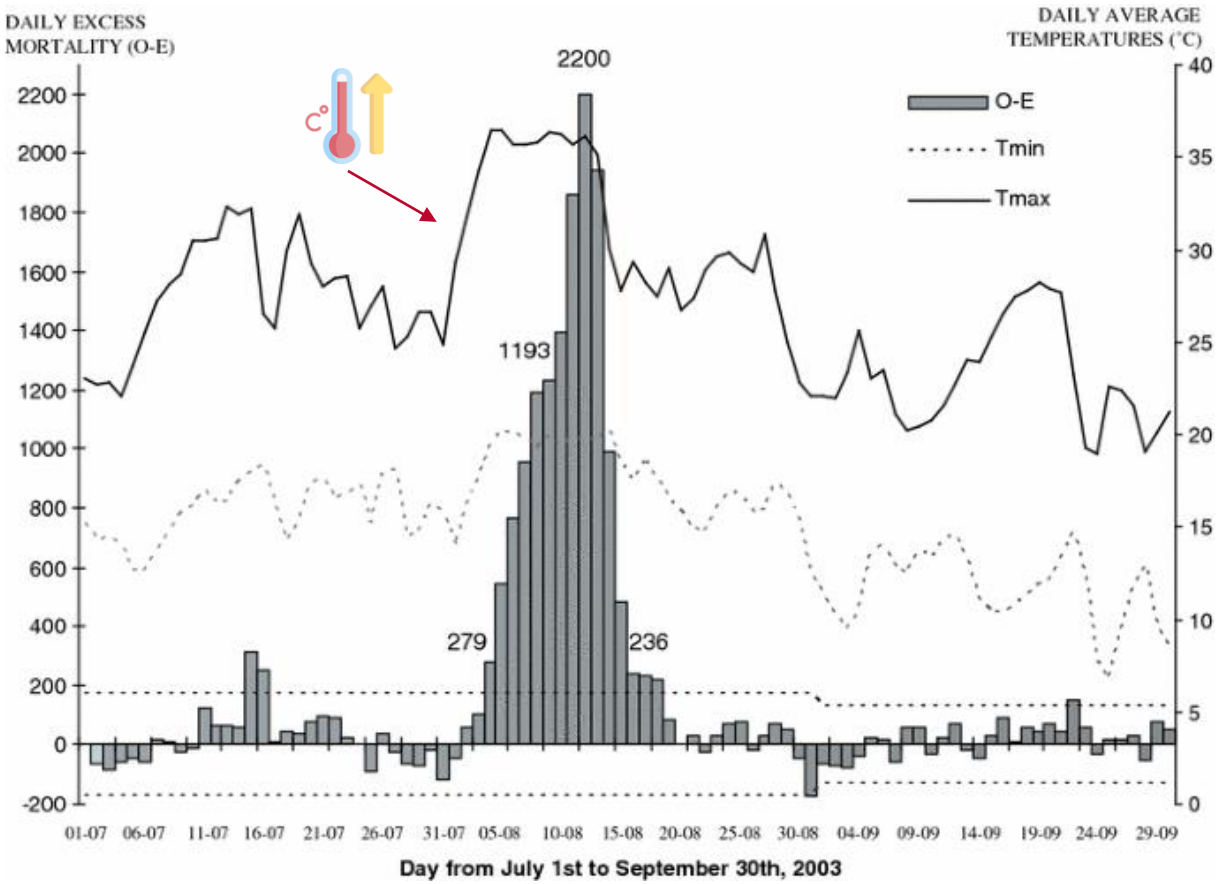


Icons: www.flaticon.com

Example: Summer 2003 (France)

Excess mortality related to the August 2003 heat wave in France

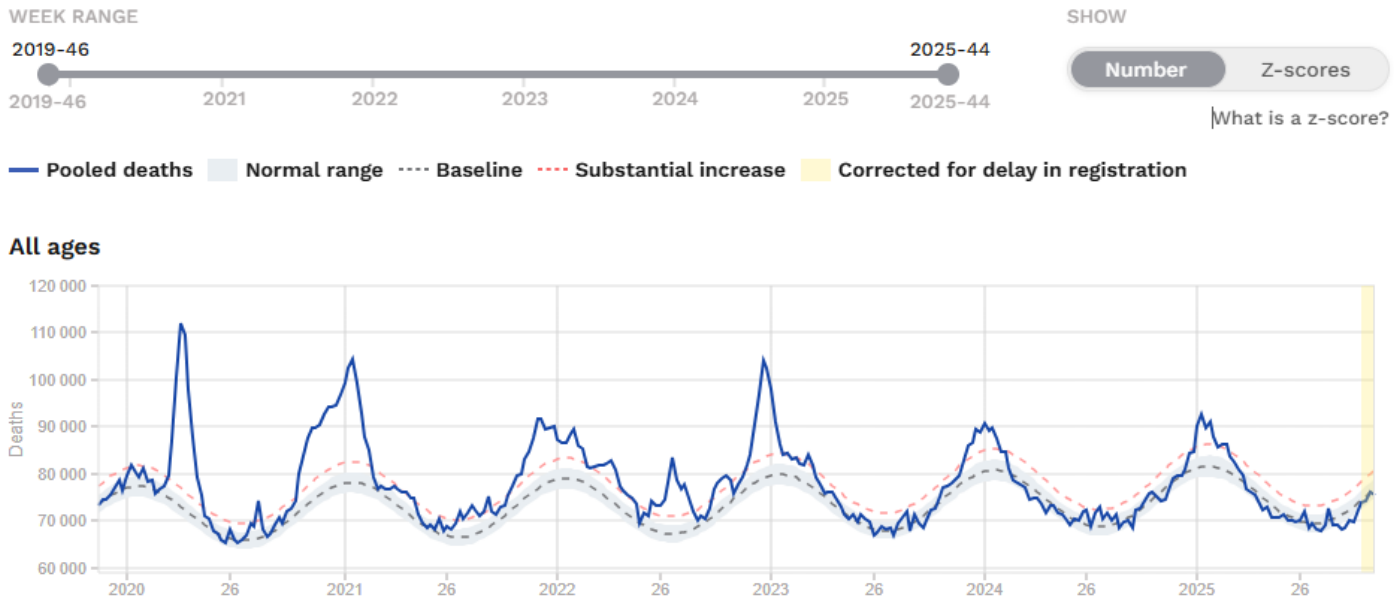


Fouillet et al., 2006. 10.1007/s00420-006-0089-4

Icons: www.flaticon.com

European Mortality Monitoring EUROMOMO

- Started in 2008, with 🇧🇪 as a pioneer Mølbak & Mazick (2013), 10.1093/eurpub/ckt126.113
- Coordinated approach to real-time mortality monitoring across Europe
- Capacity to assess and manage serious public health risks (e.g., influenza, heat waves, cold snaps)



Mortality monitoring & modelling

https://www.euromomo.eu/

BeMoMo

Be-MOMO is the surveillance of all-cause mortality in Belgium

In the concept of syndromic surveillance, the Belgian Mortality Monitoring (Be-MOMO) can detect and quantify in near real time **unusual mortality** that may result from **disease outbreaks** such as influenza, or from **extreme weather or environmental conditions** such as cold or heat waves, ozone or fine particle peaks. Be-MOMO sends alert reports to the authorities when the situation requires it.

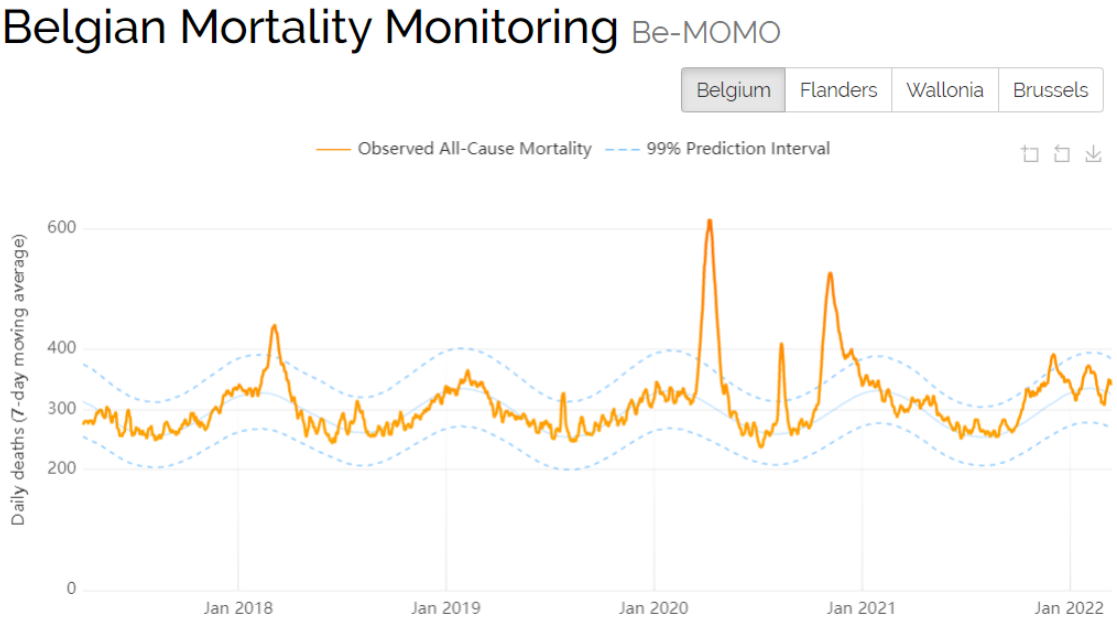
Early warning of excess mortality

The **Epidemiology of Infectious Diseases Service** of Sciensano analyses on a weekly basis the mortality data provided by the Belgian National Register. The mortality monitoring model is designed to serve as a tool for **rapid detection** and quantification of statistically significant **excess mortality**. We identify excess mortality by comparing the number of observed deaths with the number of expected deaths based on the mortality of the last 5 years. Excess mortality is calculated by age group, gender and region.

Be-MOMO assists public health decision-making

A timely assessment of the impact on all-cause mortality may be useful to **guide or reinforce new or existing public health measures**, e.g. vaccinations for influenza and the national heat action plan. Moreover, mortality monitoring can be used to evaluate possible effects of public health measures by comparing periods before and after the implementation of the intervention. Be-MOMO is also involved in the European mortality monitoring project, EuroMOMO.

For more information, follow Be-MOMO on **Epistat**.



https://www.sciensano.be/en/projects/belgian-mortality-monitoring

Icons: www.flaticon.com

Excess Mortality – How to?

1. Input Data
   ↓
2. Preprocessing
   ↓
3. Baseline (Expected Mortality) Modelling
   ↓
4. Z-score Calculation
   ↓
5. Threshold Application
   ↓
6. Excess Mortality Estimation
   ↓
7. Output Postprocessing & Evaluation

Data aggregation level, age/sex stratification, geographical units, Time resampling, bias correction, smoothing, log-transformation,... Reference periods, exclusion periods, other definitions

Parametric (e.g., Poisson Regression) vs Non-parametric methods (e.g., SSA)

Optional

Merging consecutive events, calculating mortality rates, and comparing with known events

Icons: www.flaticon.com

References

Excess mortality using a (quasi) Poisson Regression

Farrington, C. P., Andrews, N. J., Beale, A. D., & Catchpole, M. A. (1996). A Statistical Algorithm for the Early Detection of Outbreaks of Infectious Disease. *Journal of the Royal Statistical Society Series A: Statistics in Society*, *159*(3), 547–563. https://doi.org/10.2307/2983331

Excess mortality using a (quasi) Poisson Regression with Seasonality

Cox, B., Wuillaume, F., Van Oyen, H., & Maes, S. (2010). Monitoring of all-cause mortality in Belgium (Be-MOMO): A new and automated system for the early detection and quantification of the mortality impact of public health events. *International Journal of Public Health*, *55*(4), 251–259. https://doi.org/10.1007/s00038-010-0135-6

$$\log(\mu_t) = \alpha + \beta_1 t + \beta_2 \sin\left(\frac{2\pi t}{365}\right) + \beta_3 \cos\left(\frac{2\pi t}{365}\right) + \log(\text{pop}_t), \quad E(Y_t) = \mu_t, \quad V(Y_t) = \Phi\mu_t$$

Methods - EUROMOMO [online]. Accessed 2025-03-30, https://www.euromomo.eu/how-it-works/methods

Code Examples

https://github.com/dadelforge/irss_seminar_2025

Singular Spectrum Analysis

Singular Spectrum Analysis Library (SSALib)

Python Tests passing | python 3.9 | 3.10 | 3.11 | 3.12| 3.13 | coverage 97% | License BSD 3-Clause | Development Status beta | JOSS Under Review

Overview

The Singular Spectrum Analysis Library (SSALib) is a Python package for univariate (i.e., single) time series decomposition, designed for multidisciplinary applications like natural sciences, economics, epidemiology, and more. SSALib can be used to explore and extract trends, periodic patterns, and noise from time series.

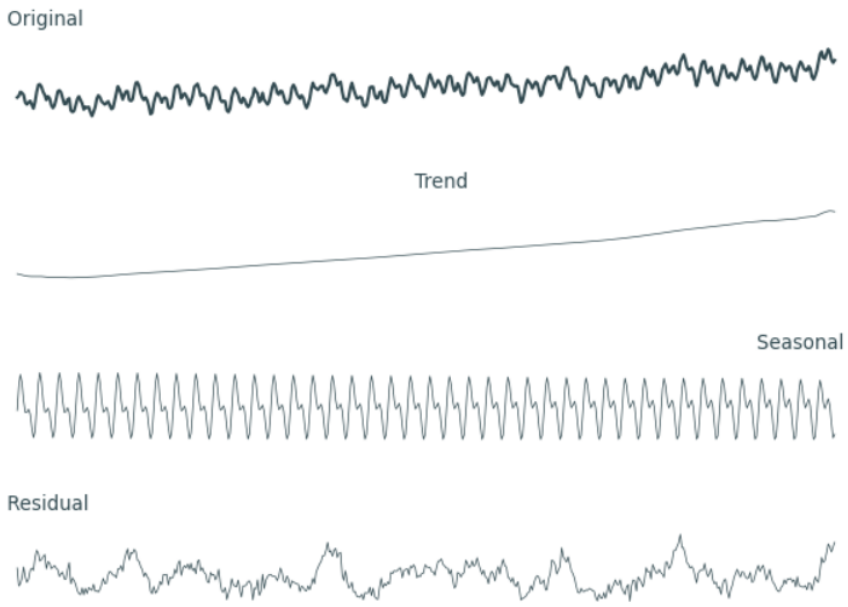


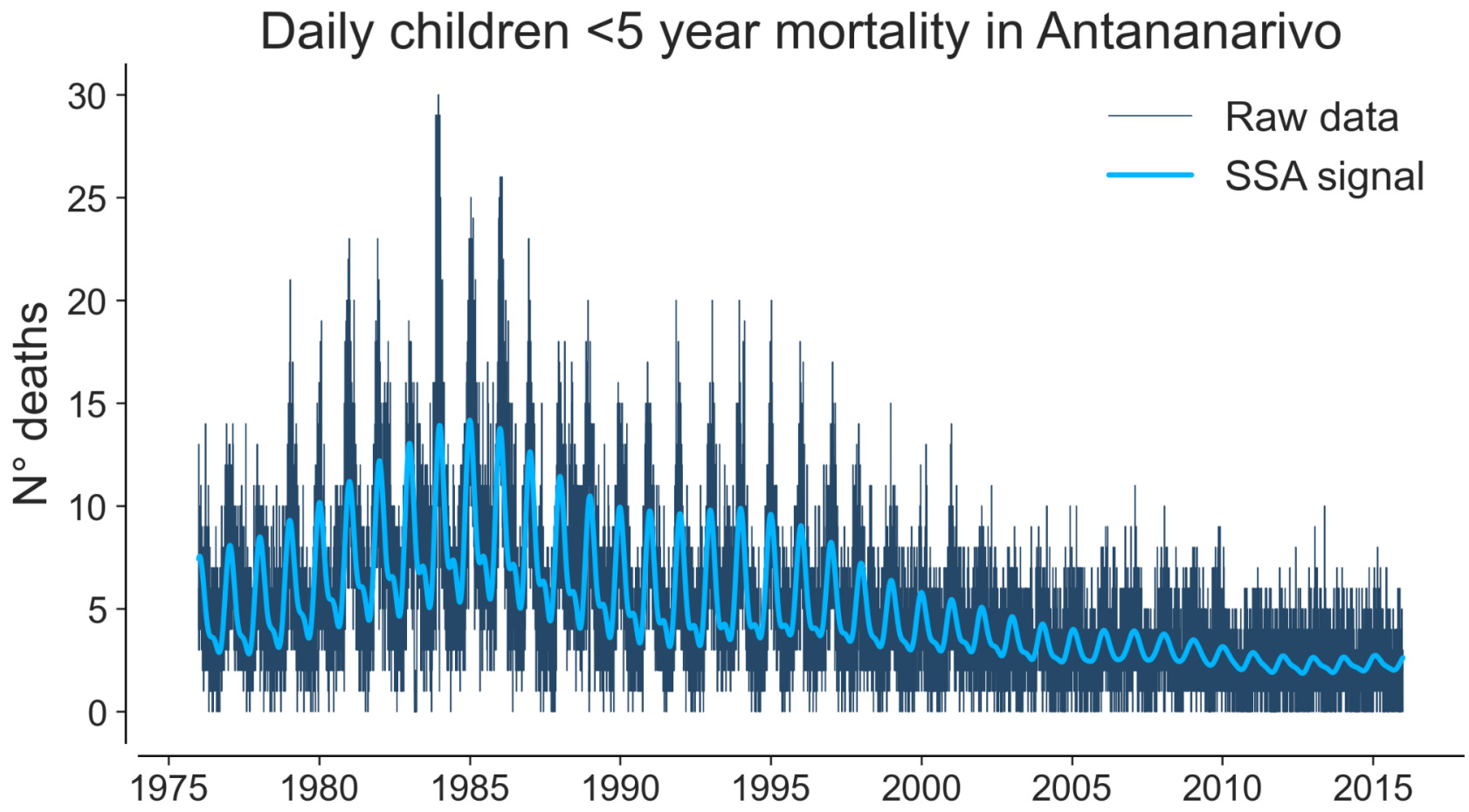
Figure: Example of Decomposition and Pattern Extraction (standardized) using the Sea Surface Temperature Time Series

Delforge, D., Alonso, A., de Viron, O., Vanclooster, M., & Speybroeck, N. (2025). *SSALib: A Python Library for Singular Spectrum Analysis* (Version 0.1.2b1) [Computer software]. https://github.com/ADSCIAN/ssalib

Under review at Journal of Open Source Software (JOSS)

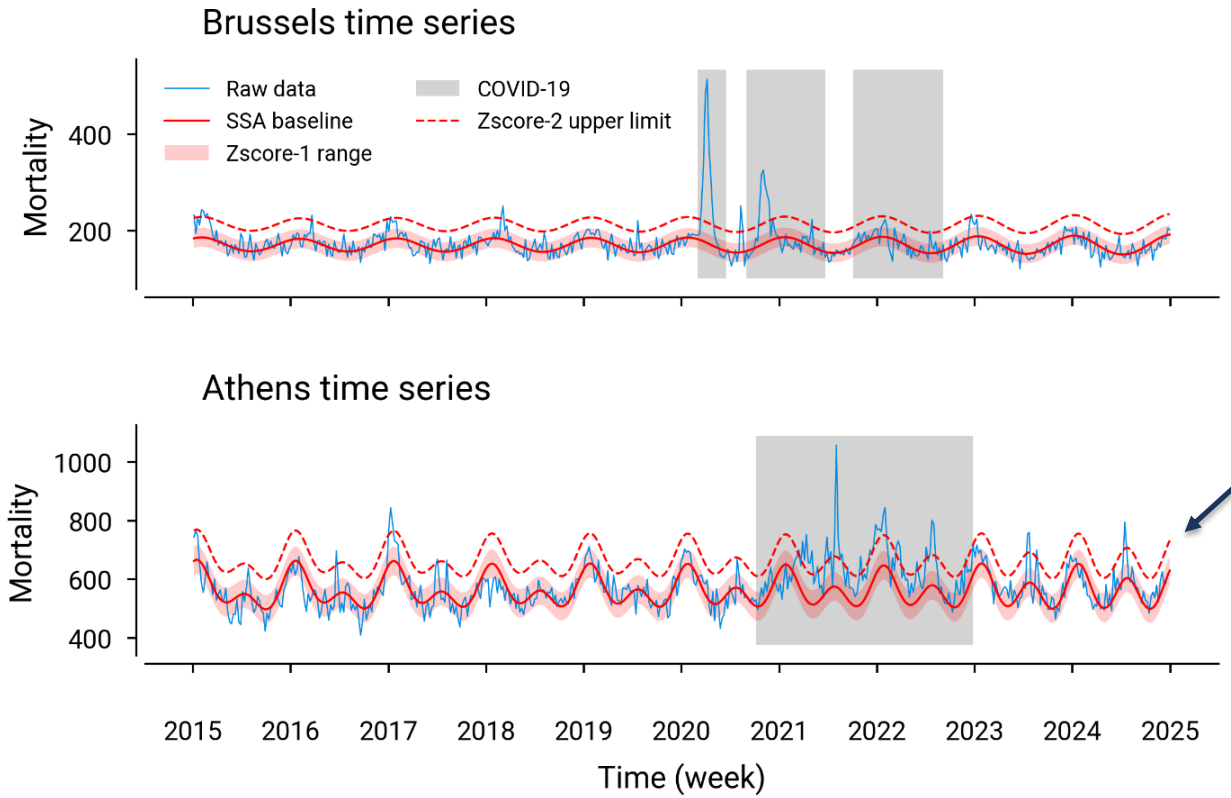
Suitable for mortality modelling

A Flexible Approach



Data: courtesy of Masquelier et al. (2019): 10.1186/s12963-019-0190-z

Current Research



Mortality modelling and excess mortality events for six cities in Belgium and Greece

Significant semiannual cycle
high mortality in winter and summer

Should we consider it in the baseline?

What are the policy/management implications?

Mortality modelling is not only about goodness of fit; it is about life.

↕

Expected mortality does not imply acceptable mortality

Learn More

- Read SSALib documentation and explore tutorials: https://github.com/ADSCIAN/ssalib
- MethodsNet Short Course Presentation and Code Examples: https://github.com/dadelforge/MethodsNET2_SSA
- Contact me: damien.delforge@uclouvain.be

Any Excess Information?