The Endemic-Epidemic Modelling Framework

Leonhard Held

University of Zurich UZH

23.3.2022

Deutsche Forschungsgemeinschaft
German Research Foundation

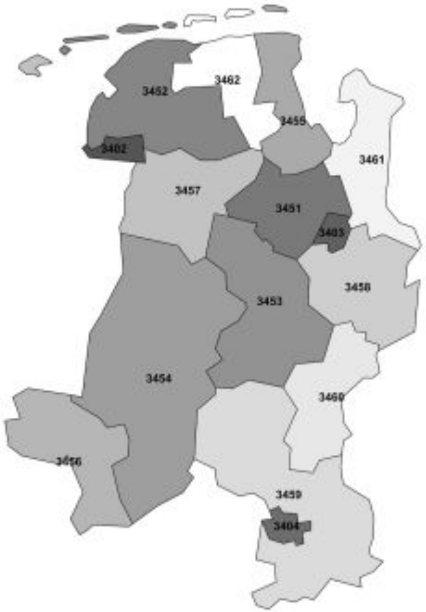
Fonds National Suisse
Schweizerischer Nationalfonds
Fondo Nazionale Svizzero
Swiss National Science Foundation

When it all started …

Statistical Modelling 2005; **5**: 1–13

A statistical framework for the analysis of multivariate infectious disease surveillance counts

Leonhard Held, Michael Höhle and Mathias Hofmann
Department of Statistics, University of Munich, Munich, Germany



- Branching process with immigration
- Negative binomial count outcomes
- Likelihood inference

To these data, we fitted a model adopted from Equation (3.3),

$$\mu_{it} = \lambda y_{i,t-1} + \phi \sum_{j \sim i} y_{j,t-1} + n_{it} \nu_{it}$$

Extending the model

STATISTICS IN MEDICINE
Statist. Med. 2008; **27**:6250–6267
Published online 17 September 2008 in Wiley InterScience
(www.interscience.wiley.com) DOI: 10.1002/sim.3440

Multivariate modelling of infectious disease surveillance data

M. Paul[1], L. Held[1,*,†] and A. M. Toschke[2]

[1]*Biostatistics Unit, Institute of Social and Preventive Medicine, University of Zurich, Switzerland*
[2]*Department of Public Health Sciences, Division of Health and Social Care Research, King's College London, U.K.*

- **Weights** to capture dependence
    - between pathogens
    - (influenza and meningococcal disease)
    - Between geographical regions (air traffic information)

Research Article

Statistics in Medicine

Received 24 September 2009, Accepted 2 December 2010 Published online 17 January 2011 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/sim.4177

Predictive assessment of a non-linear random effects model for multivariate time series of infectious disease counts

M. Paul*† and L. Held

- **Random effects**
    - IID or CAR
    - Penalized likelihood inference
    - Proper scoring rules for predictive model assessment

Early applications

Epidemiol. Infect., Page 1 of 11.
doi:10.1017/S0950268810001664

Heterogeneity in vaccination coverage explains the size and occurrence of measles epidemics in German surveillance data

S. A. HERZOG[1]*†, M. PAUL[2]† AND L. HELD[2]

[1] *Institute of Social and Preventive Medicine, University of Bern, Switzerland*
[2] *Biostatistics Unit, Institute of Social and Preventive Medicine, University of Zurich, Switzerland*

- Vaccination coverage as explanatory variable
- Mass action principle determines functional form

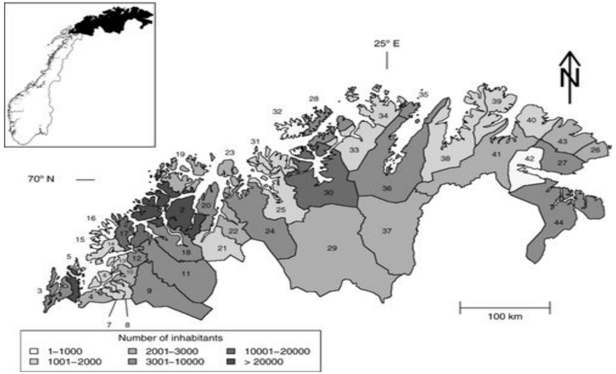
- Air, road and sea traffic approximated with power law

Biometrical Journal **56** (2014) 3, 363–382 DOI: 10.1002/bimj.201200262 363

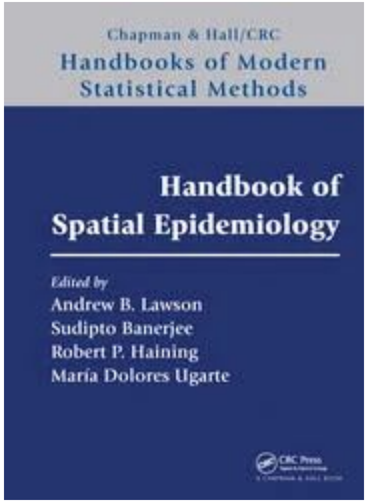
Power law approximations of movement network data for modeling infectious disease spread

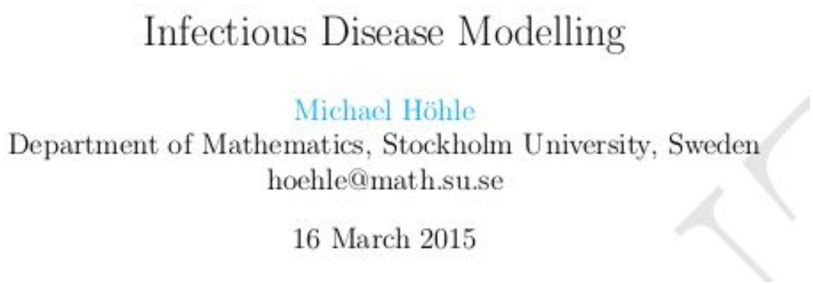
Marc Geilhufe*[,1], **Leonhard Held**[2], **Stein Olav Skrøvseth**[3], **Gunnar S. Simonsen**[4,5], and **Fred Godtliebsen**[1]

[1] Department of Mathematics and Statistics, Faculty of Science and Technology, University of Tromsø, 9037 Tromsø, Norway
[2] Division of Biostatistics, Institute of Social and Preventive Medicine, University of Zurich, Hirschengraben 84, 8001 Zurich, Switzerland
[3] Norwegian Centre for Integrated Care and Telemedicine, University Hospital of North Norway, 9038 Tromsø, Norway
[4] Department of Microbiology and Infection Control, University Hospital of North Norway, 9038 Tromsø, Norway
[5] Research Group for Host-Microbe Interaction, Faculty of Health Sciences, Institute of Medical Biology, University of Tromsø, 9037 Tromsø, Norway



Relationship to time-discrete SIR models




Infectious Disease Modelling

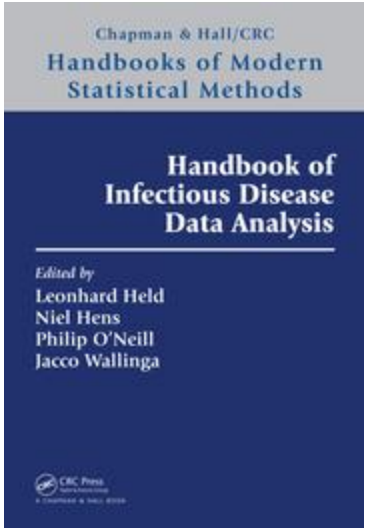
Michael Höhle
Department of Mathematics, Stockholm University, Sweden
hoehle@math.su.se

16 March 2015


23

Spatio-Temporal Analysis of Surveillance Data

Jon Wakefield, Tracy Qi Dong, and Vladimir N. Minin



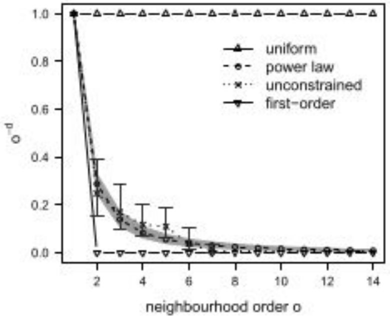
Power law and social contact data

The Annals of Applied Statistics
2014, Vol. 8, No. 3, 1612–1639
DOI: 10.1214/14-AOAS743

POWER-LAW MODELS FOR INFECTIOUS DISEASE SPREAD[1]

BY SEBASTIAN MEYER AND LEONHARD HELD

University of Zurich

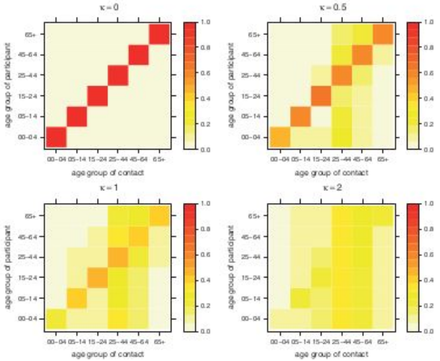


(a) Power-law (10) and unconstrained weights (11) with 95% confidence intervals

Incorporating social contact data in spatio-temporal models for infectious disease spread

SEBASTIAN MEYER*
Institute of Medical Informatics, Biometry, and Epidemiology, Friedrich-Alexander-Universität Erlangen-Nürnberg, Waldstraße 6, DE-91054 Erlangen, Germany
seb.meyer@fau.de

LEONHARD HELD
Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Hirschengraben 84, CH-8001 Zürich, Switzerland



Software

Journal of Statistical Software

April 2017, Volume 77, Issue 11. doi: 10.18637/jss.v077.i11

Spatio-Temporal Analysis of Epidemic Phenomena Using the R Package surveillance

Sebastian Meyer
Friedrich-Alexander-Universität Erlangen-Nürnberg

Leonhard Held
University of Zurich

Michael Höhle
Stockholm University

Probabilistic forecasting and higher-order lags

Research Article

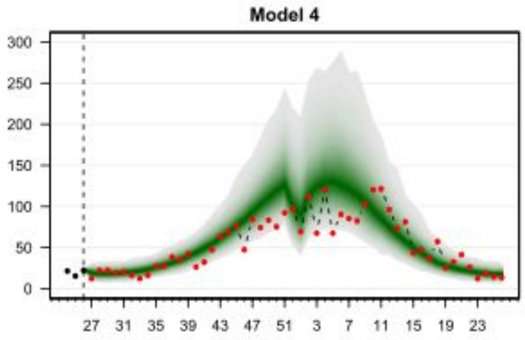
Statistics in Medicine

Received 27 January 2017, Accepted 14 May 2017 Published online in Wiley Online Library

(wileyonlinelibrary.com) DOI: 10.1002/sim.7363

Probabilistic forecasting in infectious disease epidemiology: the 13th Armitage lecture

Leonhard Held,[a*†] Sebastian Meyer[a,b] and Johannes Bracher[a]



Contents lists available at ScienceDirect

International Journal of Forecasting

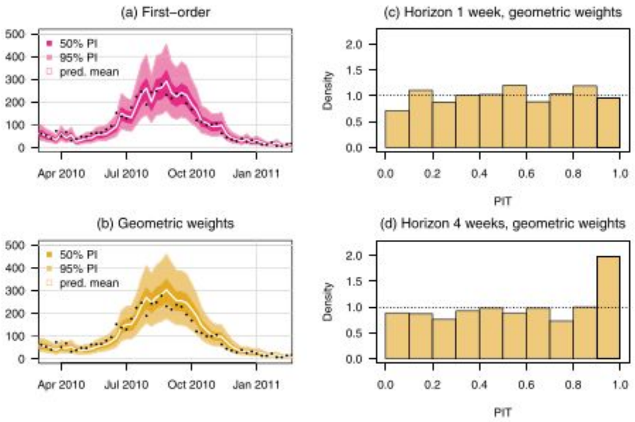
journal homepage: www.elsevier.com/locate/ijforecast

ELSEVIER

Endemic-epidemic models with discrete-time serial interval distributions for infectious disease prediction

Johannes Bracher *, Leonhard Held

Epidemiology, Biostatistics and Prevention Institute, University of Zurich, 8001 Zurich, Switzerland



Summary and outlook

- Flexible regression framework for infectious disease time series
- Various options to model dependence between regions/agegroups/pathogens

Recent extensions:

- Underreporting (Bracher and Held)
- Zero-inflation and proportions (Lu and Meyer)
- Time-dependent weights (Dunbar and Held)

Outlook session in the afternoon!