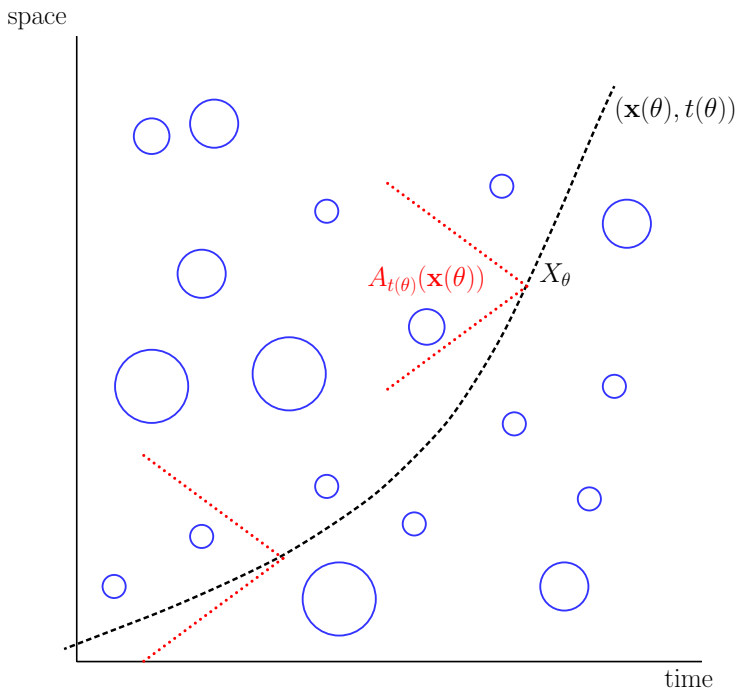
My journey into academia & a short introduction to Ambit Stochastics

Almut Veraart
Imperial College London
Women in Mathematics Day at the University of Reading
11 May 2022

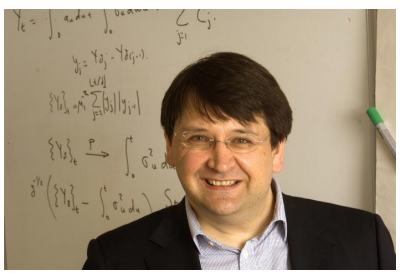


Journey into academia: University - My first degree(s) and PhD

- University - My first degree(s):
  - **Ulm, Germany:** Master (Dipl.-math. oec.) in Mathematics and Economics and Master (Dipl.-math.) in Mathematics, University of Ulm.
  - **Oxford, UK:** MSc in Applied Statistics, University of Oxford, UK.
  - **Munich, Germany:** Internship at HypoVereinsbank, Credit Research Group

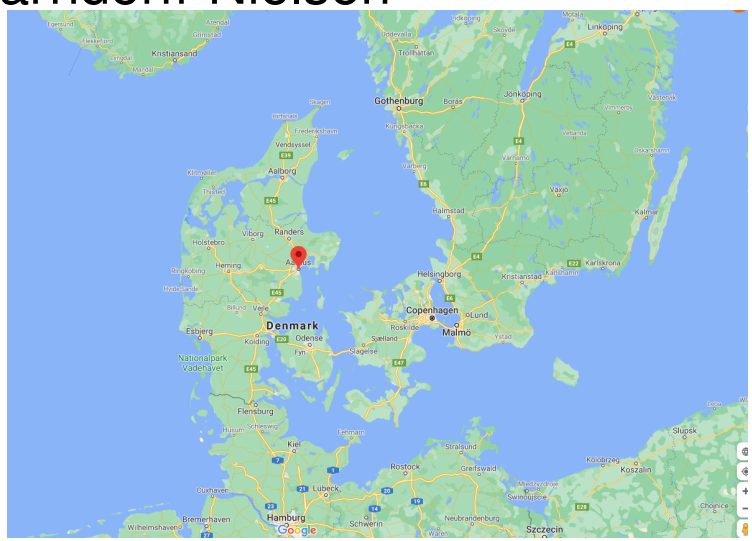


- PhD (DPhil) in Oxford:
  - **Oxford, UK:** DPhil in Statistics, University of Oxford, UK, Rhodes Scholar.
  - Topic: Volatility estimation and inference in the presence of jumps
  - Supervisors: Prof. Neil Shephard and Dr Matthias Winkel


Journey into academia: PostDoc and Assistant Professorship in Aarhus, Denmark

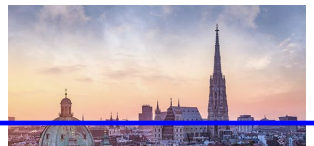
- **Aarhus, Denmark:** Postdoc and later assistant professor at Aarhus University
- Affiliations:
  - CREATES (Center for Research in Econometric Analysis of TimE Series), School of Economics and Management
  - Department of Mathematics
- Mentor: Prof. Ole E. Barndorff-Nielsen

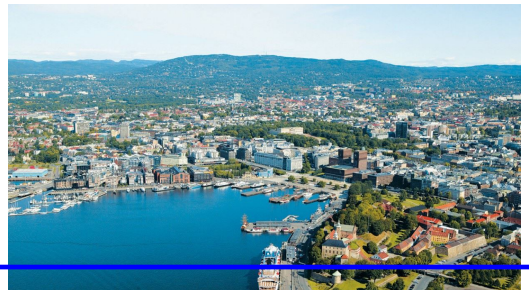


- What's next: Stay in Denmark or move (back to the UK)?

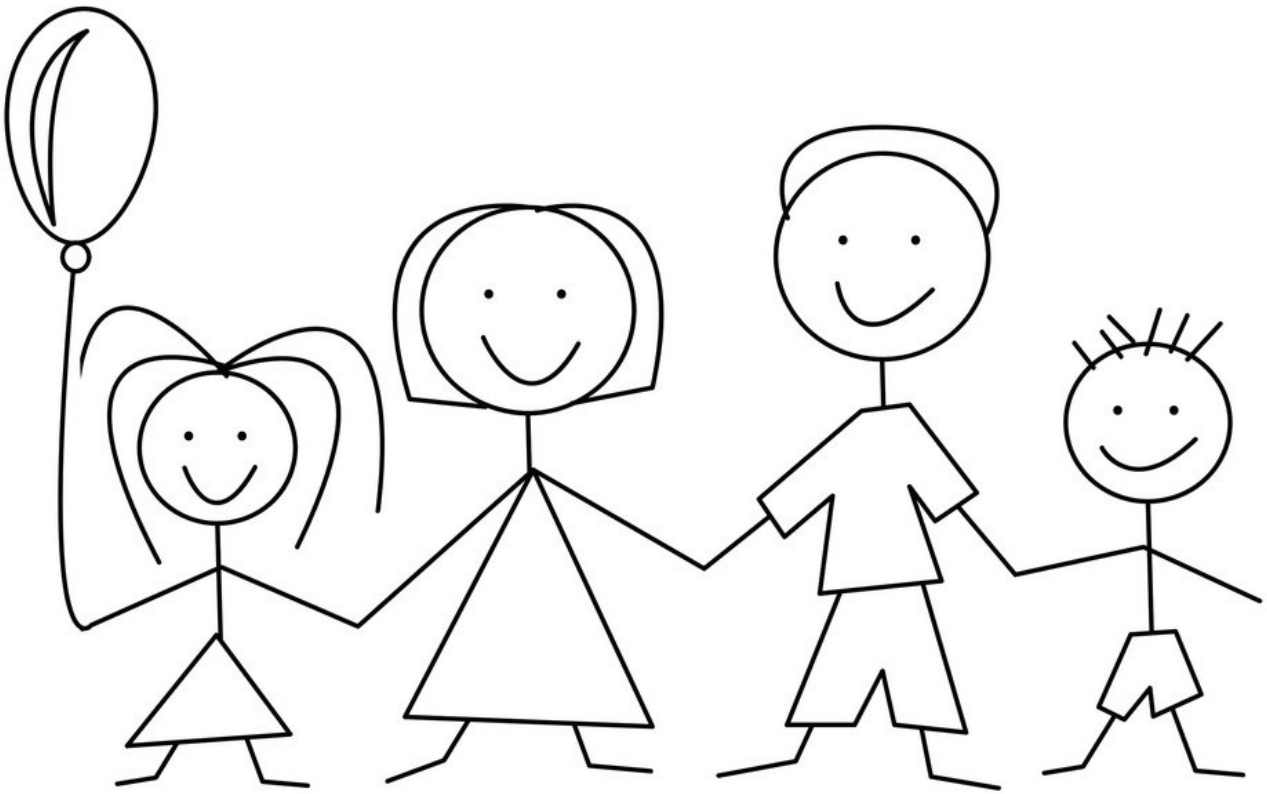
Journey into academia: Career at Imperial

- **London, UK (2011-present):** Joined the **Statistics Section** of the Department of Mathematics at Imperial in 2011 as a lecturer in statistics (reader in 2014, professor in 2018)
- Additional affiliations/stays:
  - International research fellow at CREATES, Aarhus, Denmark (2011-present),
  - Wolfgang Pauli Taussky Fellow, Vienna, Austria (2012 - present),
  - Visiting associate professor, University of Oslo, Norway (2014-2017),
  - 4-month sabbatical at the Isaac Newton Institute in Cambridge (Simons Fellow) in 2019.





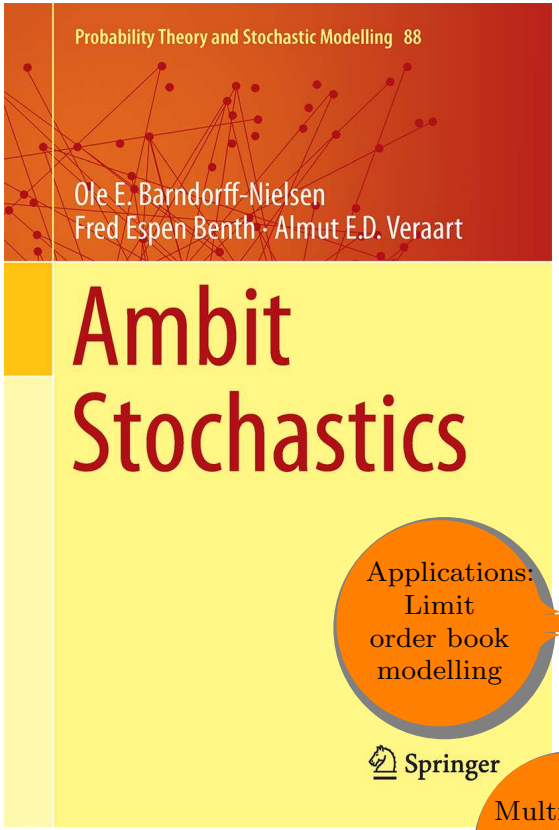
Combining an academic career with a family



Some practical things I learned during my career...

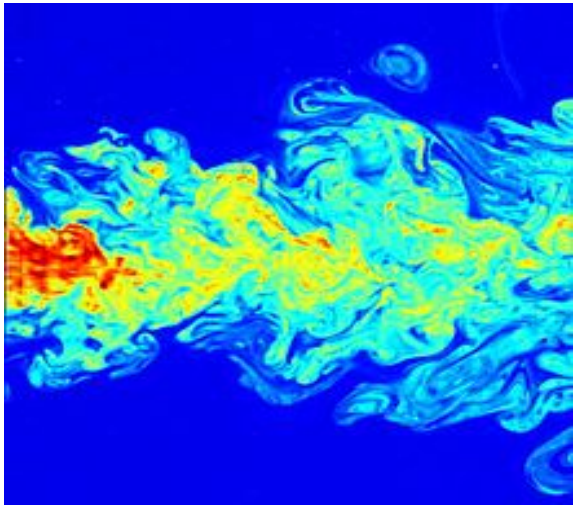
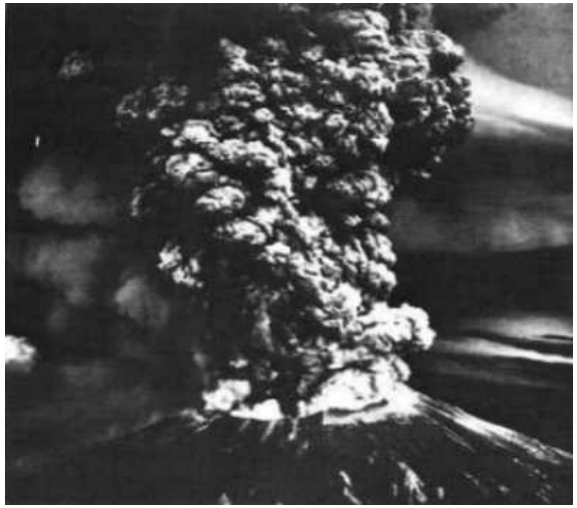
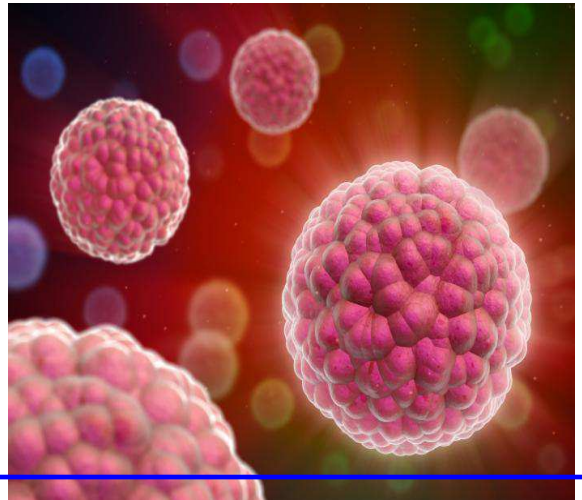
- Keep an open mind to your career plans: Plans are helpful, but be open to unexpected opportunities and lucky coincidences.
- Move to different countries/cities if/when opportunities present themselves there (Language should not be a barrier - you can go to non-English speaking countries, too!)
- Mathematics is a very broad subject which underpins many other sciences; you might find great (academic) opportunities also outside Mathematics departments.
- There is more than one ”typical” career path for a career in academia or industry: Find the path which works for you!
- ”Balancing” a family and a career: You need to make many choices and compromises. Speak to people who have chosen a similar path to what you would like to do, but at the end of the day, make your own decisions based on your own judgements. Whichever path you choose, it must work for you!

My research interests



Ambit stochastics

- **Probabilistic framework for spatio-temporal modelling**
- Ambit fields were introduced by O. E. Barndorff-Nielsen and J. Schmiegel (both from Aarhus University) in the context of modelling turbulence in physics.

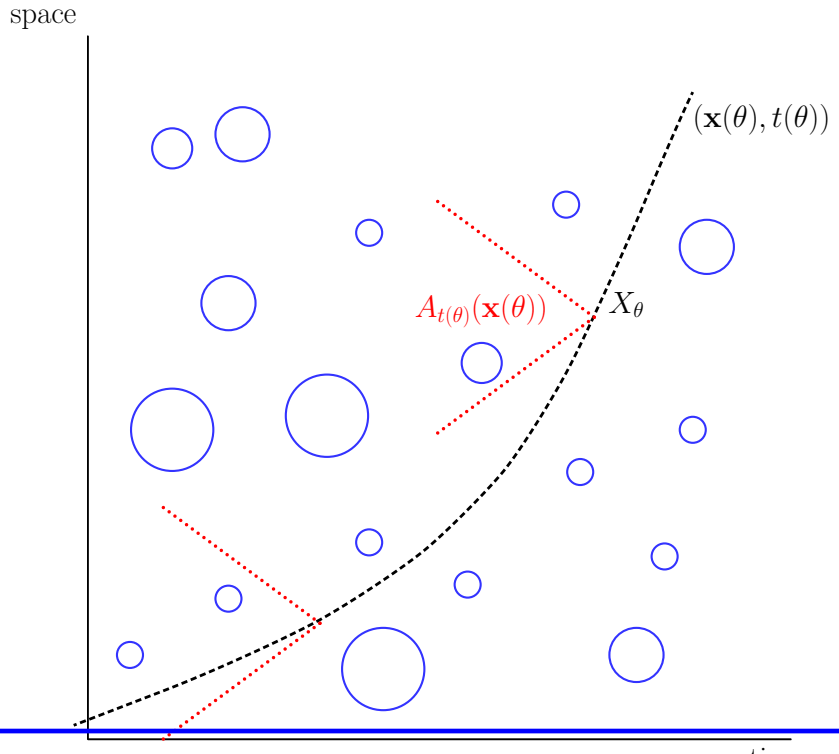
What is an ambit field?

- **Aim**: Model real-valued spatio-temporal object $Y_t(x)$, where $t \in \mathbb{R}$ is the temporal and $x \in \mathbb{R}^d$ the spatial variable ($d \in \mathbb{N}$).
- "Collect" all relevant random shocks L by integrating over the **ambit set** $A_t(x)$:

$$Y_t(x) = \int_{A_t(x)} h(x, t; \xi, s)\sigma(\xi, s)L(d\xi, ds)$$

to obtain an **ambit field**.

- "**ambit**" from Latin *ambitus*: border, boundary, sphere of influence etc.



Mathematical challenges in ambit stochastics

Theory:

- Probabilistic properties of general ambit fields.
- Stochastic integration theory for and of ambit fields and processes.
- Simulation methods for ambit fields.
- Inference for ambit fields.
- Limit theorems for ambit processes.

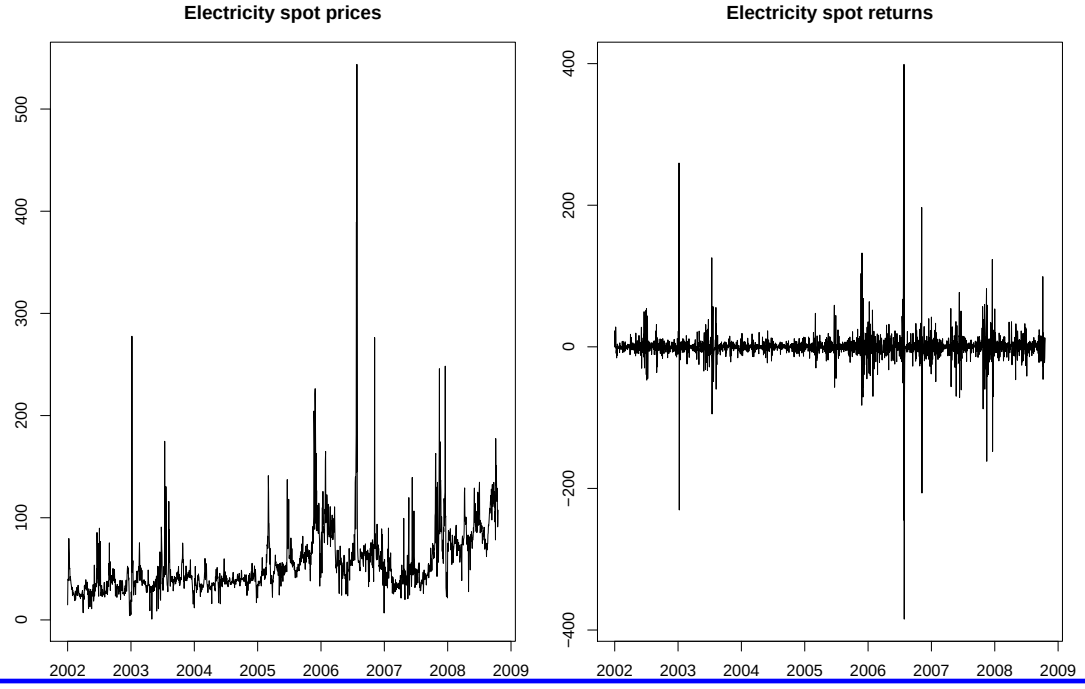
Applications:

- Turbulence
- Financial mathematics: High frequency financial data, stochastic volatility ('rough volatility')
- Energy mathematics.
- many more...

Case study 1: Modelling electricity spot prices

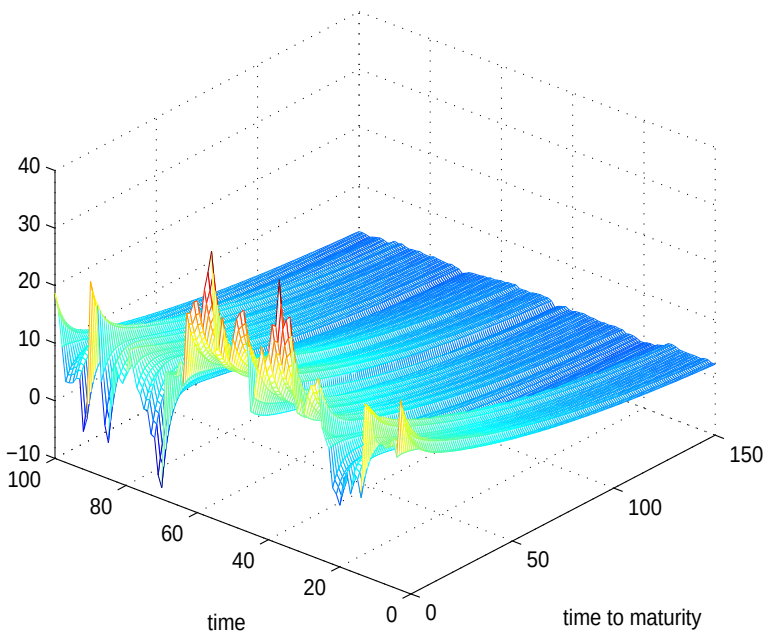


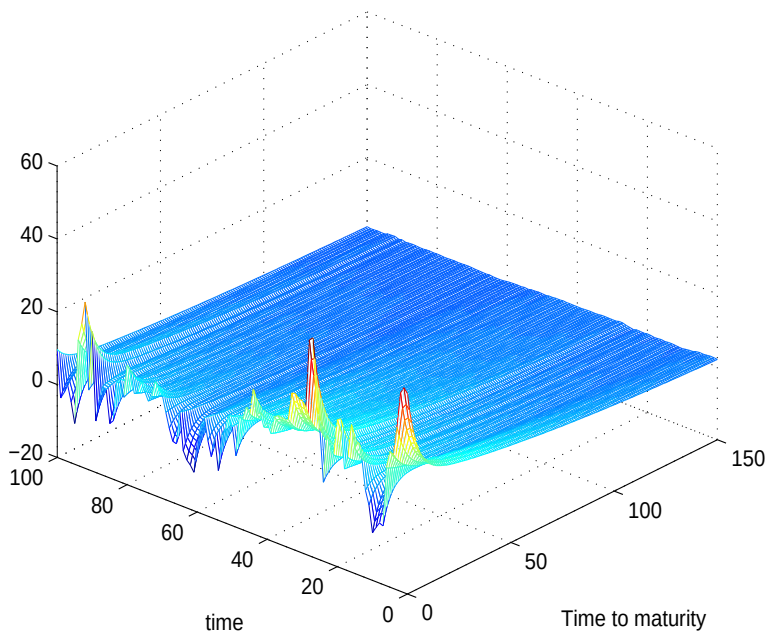

- Energy markets organise the trade and supply of energy such as electricity, oil, gas and coal.
- Related markets: Temperature and carbon markets.
- Main products traded at energy markets: Spot prices, futures and forward contracts, options.
- Daily Phelix peak load data: 01.01.2002 to 21.10.2008.



Case study 2: Modelling electricity forward prices

- **Forward contract**: Non–standardized contract between two parties to buy or sell an asset at a specified future time at a price agreed today.
- How can we model the forward price $f_t(x)$, where t denotes the current time and x the time to maturity/delivery (disregarding the length of the delivery period for now)?
- Use a (spatio-temporal) ambit field where the “spatial ” dimensions is “time to delivery”.





Case study 3: Sea surface temperature anomalies

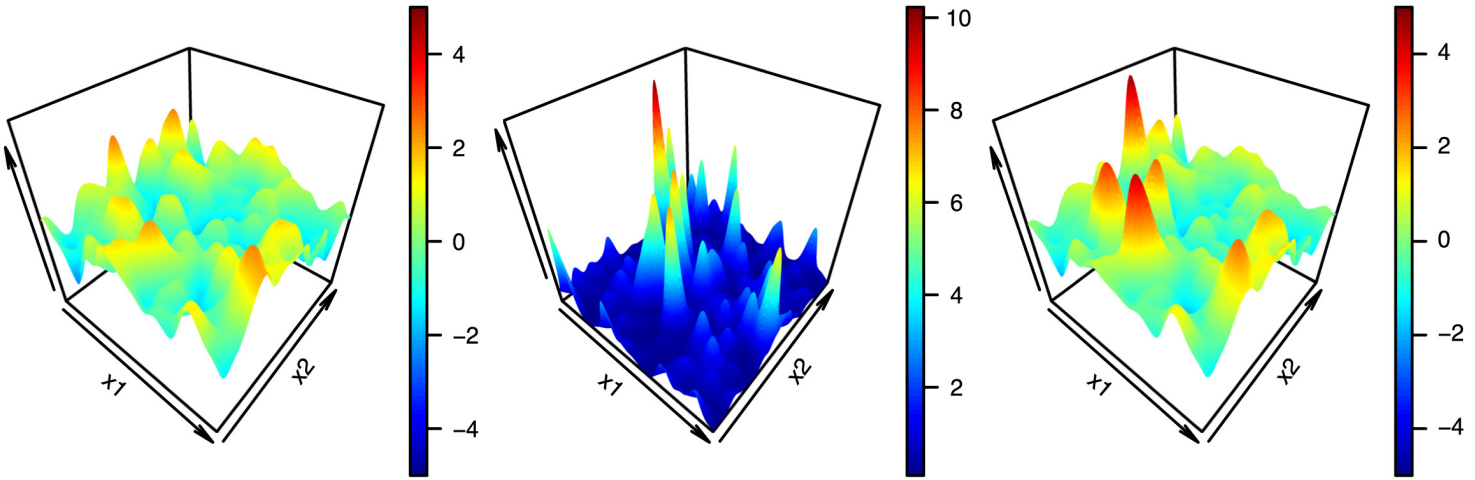
[Based on joint work with Michele Nguyen.]

- Consider the following example of a volatility modulated moving average (VMMA) process:

$$Y(x) = \int_{\mathbb{R}^2} \frac{\lambda}{\pi} \exp(-\lambda(x-\xi)^\top(x-\xi))\sigma(\xi)W(d\xi),$$
$$\sigma^2(\xi) = \int_{\mathbb{R}^2} \frac{\eta}{\pi} \exp(-\eta(\xi-u)^\top(\xi-u))L(du),$$

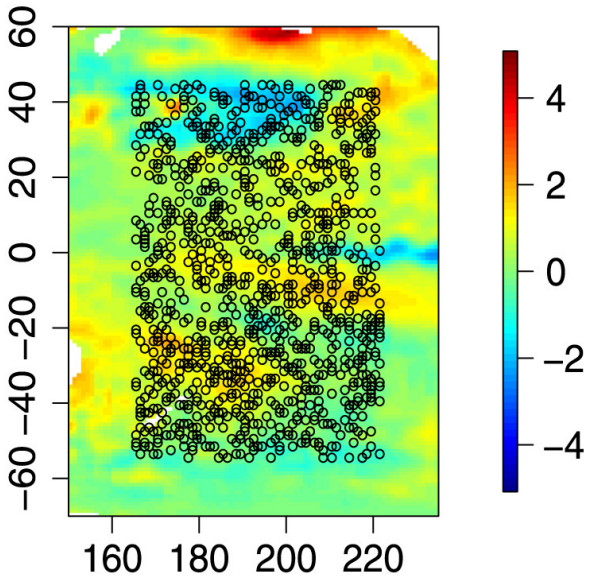
  where L is a homogeneous Lévy (subordinator) basis with, e.g. inverse Gaussian distribution. Here $\lambda, \eta > 0$.

- MA, volatility and VMMA:



Case study 3: Sea surface temperature anomalies

- Data set of sea surface temperature anomalies (SSTA) for the week 29th May 2016 to 4th June 2016.
- These are calculated with respect to the 1971–2000 climatology and thus indicate how SST has changed at different spatial locations.
- The data, which is pictured here, is given in °C and lies on a 1°latitude/longitude grid in the Pacific Ocean between 150.5°E and 234.5°E, and -69.5°N and 59.5°N.
- We randomly selected 1000 test points away from the boundaries.



- We used median polishing to remove spatial trend and then fitted our toy model.
- Volatility cluster near 40°N/190°E: Adjacent high and low anomalies.
- The VMMA performed better compared to the Gaussian MA model in and out of sample.

Thank you!