Introduction of the Akaike Memorial Lecture Award

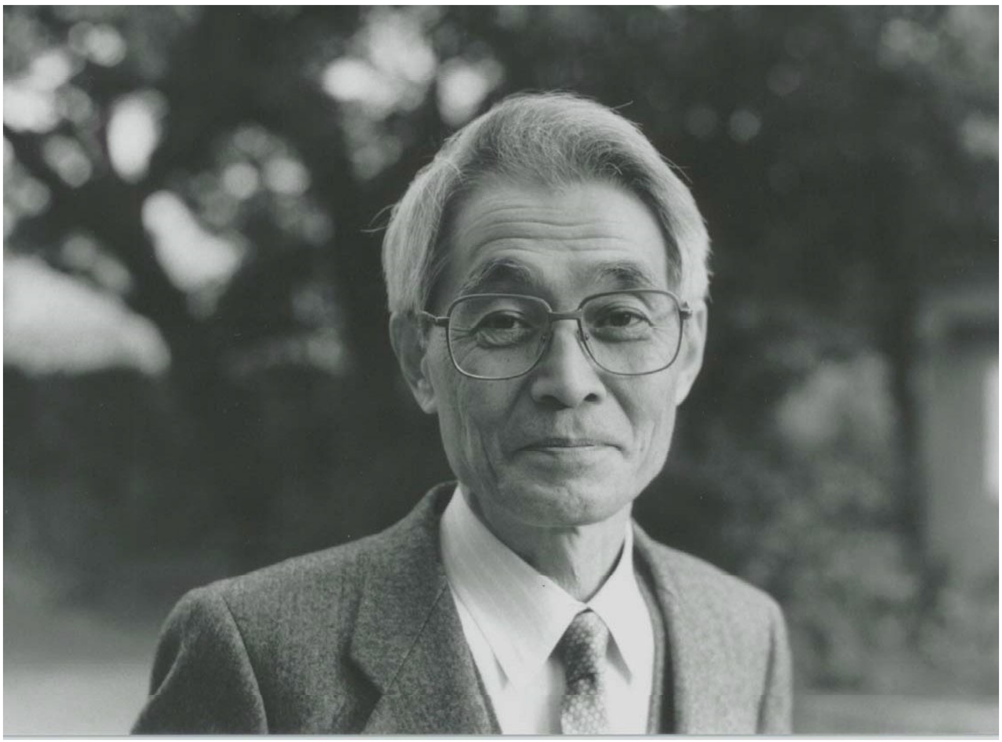
Prof. Tomoyuki Higuchi

Director-General,
The Institute of Statistical Mathematics (ISM)

大学共同利用機関法人 情報・システム研究機構
統計数理研究所

Hirotugu Akaike (1927－2009)

赤池弘次



Research Organization of Information and Systems

*This slide was made by Dr. Genshiro Kitagawa, Ex. President of the Research Organization of Information and Systems (ROIS)

Brief History

1952 Graduated from Math. Dept., Tokyo University Researcher of the **Institute of Statistical Mathematics**

1962 Head of 2nd Section, 1st Division

1973 Director of **5th Division**

1985 Director of **Dept. of Prediction and Control**

1986 Director-General of ISM (-1994)

1988 Member of **Science Council of Japan** (- 1991)
Chair of Dept. of Statistical Science, Graduate University of Advanced Study

1994 Prof. Emeritus, ISM
Prof. Emeritus, Graduate Univ. for Advance Study

Prizes

1972 Ishikawa Prize
(Establishment of statistical analysis and control method for dynamic systems)

1980 Okochi Prize
(Research and realization of optimal steam temperature control of thermal electric plant)

1989 Asahi Prize
(Research on statistics, in particular theory and applications of AIC)

The Purple Ribbon Medal
(Statistics, in particular time series analysis and its applications)

1996 The 1st Japan Statistical Society Prize
(Contributions to statistical theory and its applications)

2000 The Order of the Sacred Treasure

2006 Kyoto Prize
(Major contribution to statistical science and modeling with the development of AIC)

Fellow of ASA, RSS, IMS, IEEE, JSS

Research Organization of Information and Systems

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Laureate of 22nd Kyoto Prize


稲盛財団
INAMORI FOUNDATION
2006.6.9
プレスリリース

第 22 回（2006）京都賞受賞者の決定

財団法人稲盛財団（理事長・稲盛和夫）は第 22 回（2006）京都賞の受賞者を決定しました。
本年の受賞者は、以下の 3 名です。

■先端技術部門
本年授賞対象分野：バイオテクノロジー及びメディカルテクノロジー
レナード・アーサー・ハーツェンバーグ博士（アメリカ・74 歳・スタンフォード大学教授）

■基礎科学部門
本年授賞対象分野：数理科学
赤池弘次博士（日本・78 歳・統計数理研究所名誉教授）

"Major contribution to statistical science and modeling with the development of the Akaike Information Criterion (AIC)"

Research Organization of Information and Systems

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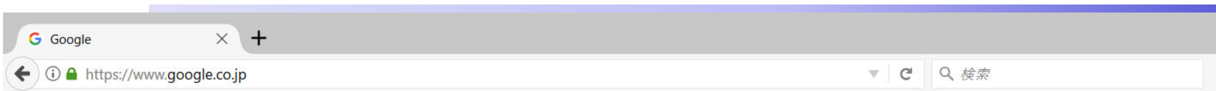
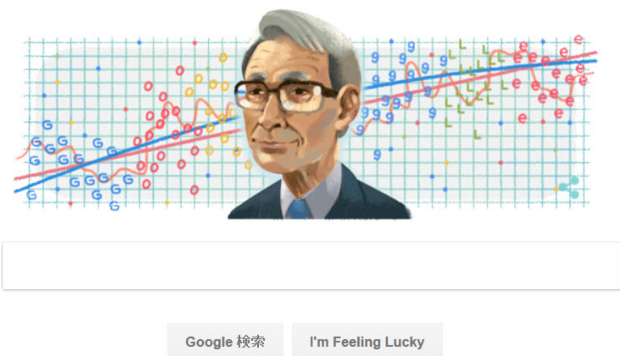
Celebration for the 90th-Birthday of Dr. Hirotugu Akaike





If you've ever conducted a statistical analysis, you might've spent hours thinking about which variables to include and the impact each would have on the outcome. But to ensure the model itself is accurate, shouldn't someone measure the measurers?

In the early 1950s, a young Japanese scientist named Hirotugu Akaike asked this simple but crucial question. More than two decades of research later, he presented the answer as a simple equation known as the Akaike Information Criterion. With AIC, analysts select a model from a set of options by measuring how close the results are to the (hypothetical) truth.

For Dr. Akaike, experience was core to creativity. To get 'a direct feel of random vibrations,' for example, he bought a scooter and rode it around Mount Fuji. This first-hand experience helped him differentiate between the vibrations of riding on normal and heavily-trucked roads.

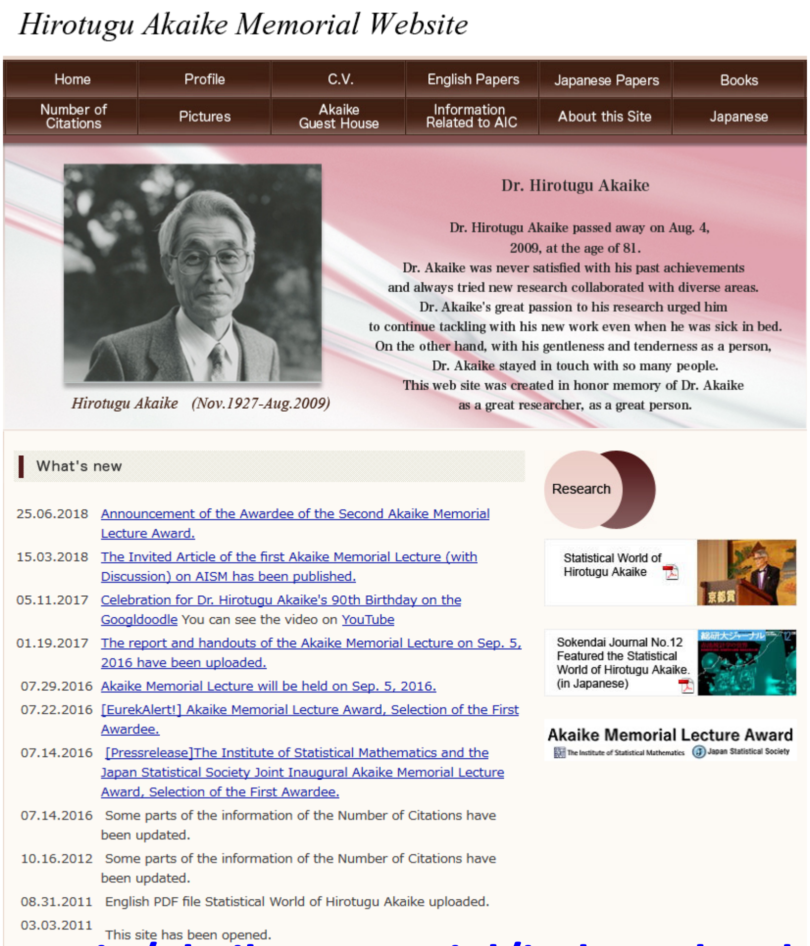
Today's Doodle portrays Dr. Akaike against a Google-inspired approximation of functions, parameters, and their respective curves.

Below are a few initial conceptualizations of the Doodle.

https://www.google.com/doodles/hirotugu-akaikes-90th-birthday

大学共同利用機関法人 情報・システム研究機構 統計数理研究所

For more information of Dr. Hirotugu Akaike, please visit our website.



http://www.ism.ac.jp/akaikememorial/index-e.html

June 25, 2018

Announcement of the Awardee of the Second Akaike Memorial Lecture Award

◆ Overview:

In May of 2016, the Institute of Statistical Mathematics (ISM) and the Japan Statistical Society (JSS) have jointly created the Akaike Memorial Lecture Award to celebrate the outstanding achievements of the late Dr. Hirotugu Akaike. Dr. Akaike greatly influenced a wide range of research by proposing the Akaike Information Criterion (AIC) and establishing a novel paradigm for statistical modeling, which was distinguished by its predictive point of view, and was totally distinct from traditional statistical theory. The Akaike Memorial Lecture Award aims to encourage the education of talented young researchers by recognizing researchers who have achieved outstanding accomplishments that contribute to the field of statistical sciences.

With great pleasure, we announce that the awardee of the Second Akaike Memorial Lecture Award is Professor Mike West of Duke University in USA. Professor West's contributions to Bayesian statistics include seminal work in dynamic modeling, and the implementation of nonparametric models that paved the way to practical data analyses via the first realization of large-scale simulation-based methods. Professor West himself has also actively worked at the frontiers of various research fields to which Bayesian statistics can be applied and contributed to the creation of data-driven sciences. For example, he established a new approach for biomarker discovery using gene expression data, thus creating a novel trend in omics biology based on data analysis. The award ceremony and memorial lecture will be held during the plenary session of the Japanese Joint Statistical Meeting 2018, which will take place at the Korakuen Campus of Chuo University on September 10, 2018.

Reason for Selection:

Professor Mike West is a great pioneer in the field of Bayesian statistics. He receives the Second Akaike Memorial Lecture Award for his wide-ranging and outstanding research accomplishments in both theoretical and practical aspects of this field.

Professor West has made significant contributions to the development of statistical sciences, including dynamic modeling, space–time data analysis, sparse modeling, Bayesian computation, and non-parametric Bayesian analysis. The applied fields to which Prof. West has contributed include finance, macroeconomics, climatology, and biology. His paper on Dirichlet Process mixture models, published in 1995, offered an easyto-implement and efficient algorithm for the model. Previously, even though its usefulness had been understood theoretically, this model had not been used in practice due to difficulties in its computation. Professor West's algorithm represented a major contribution to the practical realization of the non-parametric Bayesian analysis. The magnitude of this influence is illustrated by the fact that the paper has been cited more than 2000 times [1]. In addition, in 2001 and 2006, Professor West published important papers pertaining to cancer prognosis using gene expression data, conducted jointly with leading molecular geneticists. These papers identified patterns of cell signaling pathway deregulation by combining signature-based predictions and developed predictive models for identifying types of breast cancer [2,3]. These outcomes led to the occurrence of a mega-trend in omics biology: biomarker discovery through gene expression profiling.

For these reasons, the nominating committee is proud to select Professor West as the awardee of the Second Akaike Memorial Lecture Award.

◆ About the Second Awardee: Professor Mike West

Research Achievements

Professor Mike West is one of the pioneers who have led the field of the Bayesian statistics. In particular, Professor West's research on Bayesian modeling of dynamic processes, high-dimensional data and large-scale complex systems has significantly influenced the development of the theory and practice of statistics. Professor West's broad activities range from statistical theory, including time series, high-dimensional space–time data analysis and sparse modeling, to application, including decision-making theory for financial time-series data analysis, structure modeling, analysis of high-frequency financial time series data, macroeconometrics, dynamic network analysis, image recognition, system biology, and analysis of air environment monitoring data.

After obtaining his Ph.D. in Mathematics at the University of Nottingham, UK, Professor West has published nearly 200 papers in numerous fields, ranging from pure statistical theory to applied research in fields including business, economy and finance, signal processing, climatology, public health sciences, genome sciences, immunology, neurophysiology, and systems biology.

Professor West has devoted himself passionately to education in statistics, and has made outstanding accomplishments in education. Over the course of his career, he has instructed young statisticians from industry, government, and academia around the world, and mentored more than 55 talented doctoral students and post-doctoral researchers.

Additionally, Professor West was awarded the Mitchell Prize (three times, in 1994, 1997, and 2012); the American Statistical Association Outstanding Statistical Application Paper Award (1997); the American Statistical Association NC Chapter Award (2014); and the Zellner Medal from the International Society for Bayesian Analysis (2014).

[1] Escobar, M.D., West, M.(1995). Bayesian density estimation and inference using mixtures. Journal of the American Statistical Association 90:577-588.

[2] Bild, A.H., Yao, G., Chang, J.T., Wang, Q., Potti, A., Chasse, D., Joshi, M., Harpole, D., Lancaster, J.M., Berchuck, A., J.A. Olson, J.R.M., Dressman, H.K., West, M., Nevins, J.R.(2006). Oncogenic pathway signatures in human cancers as a guide to targeted therapies. Nature 439:353-357.

[3] West, M., Blanchette, C., Dressman, H.K., Huang, E.S., Ishida, S., R. Spang, H.Z., Marks, J.R., Nevins, J.R. (2001). Predicting the clinical status of human breast cancer utilizing gene expression profiles. Proceedings of the National Academy of Sciences 98:11462-11467.

Current Position

The Duke University distinguished Arts & Sciences Professor of Statistics and Decision Sciences, in the Department of Statistical Science, Duke University

Biography

Date of birth: October 30th, 1956 (current age, 61)

Education:

1978 B.Sc. Mathematics, First Class Honors, Department of Mathematics, University of Nottingham, UK

1982 Ph.D. in Mathematics (Statistics), University of Nottingham, UK

Professional Summary

1981–1988	Lecturer at Department of Statistics of University of Warwick, UK
1984	Visiting Professor at Harvard University, USA
1987	Visiting Professor at Purdue University, USA
1988-2003	Associate Fellow at Department of Statistics of University of Warwick
1994	Senior & University Fellow at the National Institute of Statistical Sciences (NISS), USA
1988–1992	Associate Professor at the Institute of Statistics and Decision Sciences (ISDS) of Duke University, USA
1990–2002	Director at ISDS
1992–2007	Professor at ISDS
1999–present	Distinguished Professor at Duke University Professor in the Division of Statistics of Duke University
2007–present	Professor in the Department of Statistical Science, Duke University

◆ Overview of the Akaike Memorial Lecture Award

The Akaike Memorial Lecture Award was inaugurated in 2014 under the joint sponsorship of ISM and JSS. The Award was named after the late Dr. Hirotugu Akaike (*1), who left a wide-reaching and influential legacy of research in the statistical sciences. Along with the Award, the ISM and JSS organize a memorial lecture by the awardee, offering opportunities for exchange among statistical researchers from within and outside Japan as well as inspiration to young and talented researchers. Thus, the Award contributes to further advances in this field.

Every 2 years, one awardee is selected from among those individuals who are, like the late Dr. Akaike, ahead of their times, exercising an international influence over a wide range of fields in the statistical sciences (including mathematical sciences and mathematical engineering, such as control and optimization) and related applied fields. The awardee receives a ¥100,000 honorarium, an award plaque, and travel expenses.

For educational purposes, the Memorial Lecture will be followed by time for question and discussion involving the Awardee and selected students and young researchers. The contents of the lecture, including the accompanying discussion, will be published as an invited article in the Annals of the Institute of Statistical Mathematics (AISM).

◆ The Second Akaike Memorial Lecture

The Second Akaike Memorial Lecture will be held during the plenary session of the 2018 Japanese Joint Statistical Meeting, which will be co-organized by the Institute of Statistical Mathematics and the Organizing Committee of the Japanese Joint Statistical Meeting 2018, commissioned by The Japan Statistical Society.

Lecturer:	Professor Mike West (Duke University)
Title:	Bayesian Forecasting of Multivariate Time Series: Model Scalability, Structure Uncertainty and Decisions
Discussants:	Dr. Jouchi Nakajima (Bank for International Settlements) Dr. Christopher D. Glynn (University of New Hampshire)
Date/Time:	September 10, 2018 (a.m.)
Venue:	Building No. 5, Room 5534, Korakuen Campus, Chuo University (1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan http://global.chuo-u.ac.jp/english/siteinfo/visit/korakuen/)

Note: Detailed information will be uploaded on the following websites:
Institute of Statistical Mathematics (http://www.ism.ac.jp/index_e.html)
Japanese Joint Statistical Meeting 2018 (http://www.jfssa.jp/taikai/2018/english/index.html)
Japan Statistical Society (http://www.jss.gr.jp/en/).

(*1) Biography of Dr. Hirotugu Akaike

Born on November 5, 1927 in Shizuoka Prefecture, Japan, Hirotugu Akaike graduated from the Imperial Naval Academy, the First Higher School, and the Department of Mathematics, and the Faculty of Science, The University of Tokyo. He joined the Institute of Statistical Mathematics in 1952.

In the 1960s, Dr. Akaike led the field of time series analysis through his research and development of spectral analysis techniques, multivariate time series models, statistical control methods, and TIMSAC (Time Series Analysis and Control), a software package designed for time-series analysis. In the 1970s, Dr. Akaike proposed the Akaike Information Criterion (AIC). Thus, he established a new paradigm of statistical modeling, which was characterized by a predictive point of view, and therefore completely distinct from traditional statistical theory. His accomplishments have greatly influenced research in a variety of fields. In 1980s, Dr. Akaike advanced his research to realize the practical application of Bayesian modeling. His research played a pioneering role in the development of new information processing systems that could meet the demands of the era of large-scale information. His research results were held in the highest esteem by his colleagues and earned him many prizes, including the Medal of Honor (Purple Ribbon), the Second Class Order of the Sacred Treasure, and the Kyoto Prize. His work continues to be cited today.

Dr. Akaike took the position of Director-General of the ISM in 1986. While overseeing the operation of the Institute, he also took part in establishing and teaching in the Statistical Studies program at the Graduate University for Advanced Studies. His term as Director-General ended in 1994. At that time, he was appointed Professor Emeritus at the Graduate University for Advanced Studies, but never lost his passion for research; rather than resting on his well-deserved laurels, he continued his work, publishing studies of topics as diverse as Bayesian models and the golf swing. He also served as the 19th president of the JSS from January 1989 to December 1990. He passed away in Ibaraki Prefecture, Japan on August 4, 2009 (age 81).

On November 5, 2017, a celebration of Dr. Hirotugu Akaike's 90th Birthday appeared on the Google Doodle in 16 countries and regions around the world.

Memorial Website for Late Dr. Akaike: Hirotugu Akaike Memorial Website

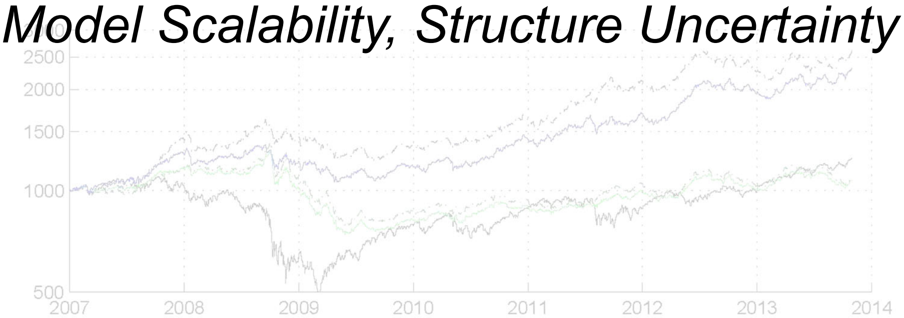
http://www.ism.ac.jp/akaikememorial/index-e.html

Press Contact:
URA Station in ISM

E-mail: ask-ura@ism.ac.jp

TEL: +81-50-5533-8580

Bayesian Forecasting of Multivariate Time Series:
Model Scalability, Structure Uncertainty and Decisions



Mike West
Duke University

Akaike Memorial Lecture : Some of today's themes

Hirotugu Akaike

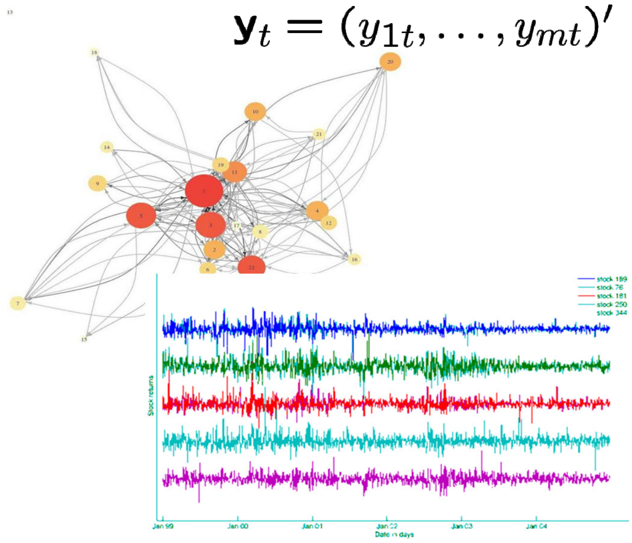
- Bayesian state-space time series
- Prediction and decisions
- Model structure uncertainty
- Computational feasibility
- Applied motivations

Institute of Statistical Mathematics

State-space modelling
- innovators and leaders

Dynamic data: Contexts

$$\mathbf{y}_t = (y_{1t}, \ldots, y_{mt})'$$



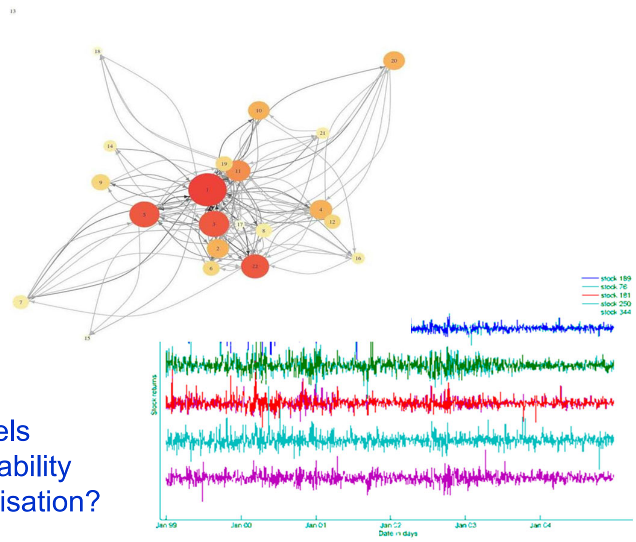
- Challenges -

Flexible multivariate models
Computationally feasible
Scale up in m

- Increasingly large-scale:
  - High-dimensional time series
  - Dynamic networks
  - Large-scale hierarchical systems

- Sequential analysis, forecasting, decisions:
  - Financial portfolios
  - Multi-step macroeconomics
  - Monitoring networks- change/anomaly detection
  - Large-scale commercial sales forecasting
  - Business/corporate financial flows, investment decisions

Concept: Decouple/recouple



DECOUPLE - univariate time series

- Customisable series-specific models
- State-space models: analytic tractability
- Sequential analysis: fast? parallelisation?

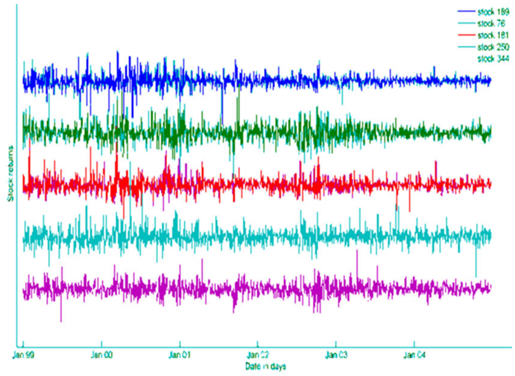
RECOUPLE - Critical cross-series / multivariate structure

- Sensitive dependence / "co-volatility" modelling
- Sensitive online monitoring, adaptation to change
- Coherent joint forecast distributions, resulting decisions

Financial time series: FX, commodities, stocks ..

Multi-step forecast and portfolio goals

- daily/weekly: sequential, repeat



$$\mathbf{y}_t = \mathbf{f}_t + N(\mathbf{0}, \boldsymbol{\Sigma}_t)$$

Critical cross-series / multivariate structure

- Sensitive dependence / "co-volatility" modelling ?

Existing models

- Wishart or Inverse Wishart processes, MGARCH, …
- (In)flexibility?
- Scalable – theoretically? computationally?

FX – daily price $US

Cross-series: directed & sparse
graphical structure – *lagged*

$0:t-1$ | t

$\mathbf{x}_{1\,t}$ → ¥ $y_{1\,t}$ $+\nu_{1\,t}$

$\mathbf{x}_{2\,t}$ → $Au $y_{2\,t}$ $+\nu_{2\,t}$

$\mathbf{x}_{3\,t}$ → £ $y_{3\,t}$

⋮

$\mathbf{x}_{m-1,t}$ → € $y_{m-1,t}$

$\mathbf{x}_{mt}$ → KrNo y_{mt}

Idiosyncratic: volatility

Customised predictors $\mathbf{x}_{1\,t}$

- external/independent factors
- lagged *y – sparse set*

e.g.

$$\mathbf{x}_{1\,t}: \begin{matrix} y_{1\,t-2:t-1} \\ y_{(2,m-1,m)\,t-1} \\ z_{1\,t} \end{matrix}$$

¥ "info"

Contemporaneous coupling

Cross-series: *simultaneous* graphical structure

$0:t-1$ | t

$\mathbf{x}_{1t} \longrightarrow$ ¥ y_{1t} ?

$\mathbf{x}_{2t} \longrightarrow$ $Au y_{2t}

$\mathbf{x}_{3t} \longrightarrow$ £ y_{3t}

$\vdots$

$\mathbf{x}_{m-1,t} \longrightarrow$ € $y_{m-1,t}$

$\mathbf{x}_{mt} \longrightarrow$ KrNo y_{mt}

e.g.

$\leftarrow y_{(2,m-1)\,t}$

$\leftarrow y_{(1,3)\,t}$

$\vdots$

$y_{j\,t} \leftarrow \mathbf{y}_{sp(j)\,t}$

$sp(j) \subseteq 1:m\backslash j$

Sparse sets simultaneous parents

Simultaneous dynamic models

$y_{jt} = \mathbf{x}'_{jt}\phi_{jt} + \mathbf{y}'_{sp(j),t}\gamma_{jt} + \nu_{jt}$

μ_{jt}

$$\mathbf{y}_t = \boldsymbol{\mu}_t + \boldsymbol{\Gamma}_t\mathbf{y}_t + \boldsymbol{\nu}_t$$

$$\boldsymbol{\nu}_t \sim N(\mathbf{0}, \boldsymbol{\Lambda}_t^{-1})$$

diag

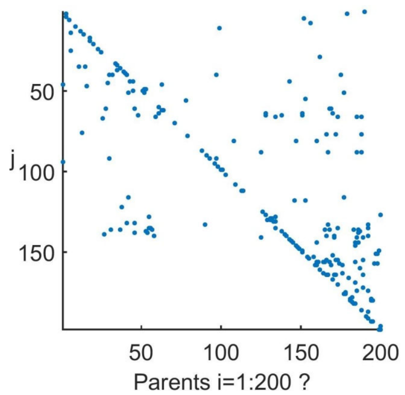
dynamic regressions & precision/volatility

$$\mathbf{y}_t = (\mathbf{I} - \boldsymbol{\Gamma}_t)^{-1}\boldsymbol{\mu}_t + N(\mathbf{0}, \boldsymbol{\Omega}_t^{-1})$$

$$\boldsymbol{\Omega}_t = (\mathbf{I} - \boldsymbol{\Gamma}_t)'\boldsymbol{\Lambda}_t(\mathbf{I} - \boldsymbol{\Gamma}_t)$$

$$\boldsymbol{\Gamma}_t = \begin{pmatrix} 0 & \gamma_{1,2,t} & \gamma_{1,3,t} & \cdots & \gamma_{1,m,t} \\ \gamma_{2,1,t} & 0 & \gamma_{2,3,t} & \cdots & \gamma_{2,m,t} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \gamma_{m-1,1,t} & \cdots & \gamma_{m-1,m-2,t} & 0 & \gamma_{m-1,m,t} \\ \gamma_{m,1,t} & \gamma_{m,2,t} & \cdots & \gamma_{m,m-1,t} & 0 \end{pmatrix}$$

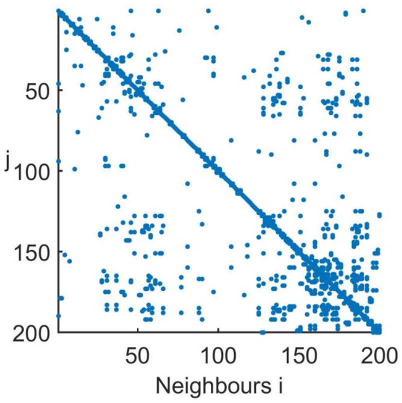
Sparse



Non-zeros in $\boldsymbol{\Gamma}_t$

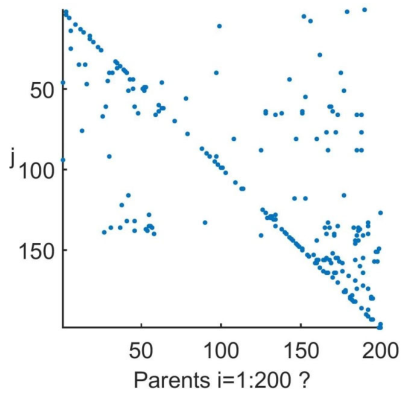
Notation: extend γ_{jt} to row *j* and pad with 0 entries

Dynamic graphical model structure induced



Non-zeros in $\boldsymbol{\Omega}_t$

zero precision:
conditional
independence



Non-zeros in $\boldsymbol{\Gamma}_t$

$$\boldsymbol{\Omega}_t = (\mathbf{I} - \boldsymbol{\Gamma}_t)'\boldsymbol{\Lambda}_t(\mathbf{I} - \boldsymbol{\Gamma}_t)$$

Sparse volatility matrix model

Simultaneous dynamic linear/state-space model

Multiple univariate models
- *"decoupled"*
- *in parallel*

$$y_{jt} = \mathbf{F}'_{jt}\boldsymbol{\theta}_{jt} + \nu_{jt}$$

Residual volatilities:
Tractable Markov dynamics

$$\mathbf{F}_{jt} = \begin{pmatrix} \mathbf{x}_{jt} \\ \mathbf{y}_{sp(j),t} \end{pmatrix}$$

$$\boldsymbol{\theta}_{jt} = \begin{pmatrix} \phi_{jt} \\ \gamma_{jt} \end{pmatrix}$$

Parallel states:
Linear, Gaussian, Markov
state evolution models

Special examples: Dynamic dependency network models

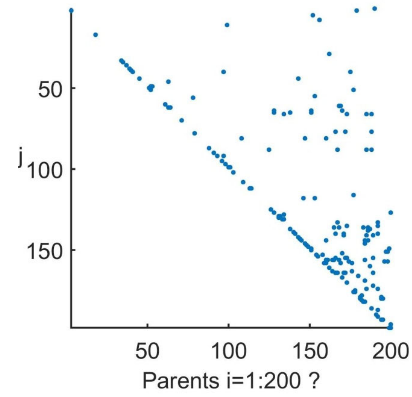
- $\boldsymbol{\Gamma}_t$ *triangular form: by choice or chance*
- *Sparse Cholesky-style precision (… popular)*
  - upper or lower triangular- same story: reorder

$$\boldsymbol{\Omega}_t = (\mathbf{I} - \boldsymbol{\Gamma}_t)'\boldsymbol{\Lambda}_t(\mathbf{I} - \boldsymbol{\Gamma}_t)$$

Order of series relevant

$$\boldsymbol{\Gamma}_t = \begin{pmatrix} 0 & \gamma_{1,2,t} & \gamma_{1,3,t} & \cdots & \gamma_{1,m,t} \\ 0 & 0 & \gamma_{2,3,t} & \cdots & \gamma_{2,m,t} \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & \dots & 0 & 0 & \gamma_{m-1,m,t} \\ 0 & 0 & \dots & 0 & 0 \end{pmatrix}$$

Sparse, upper triangular



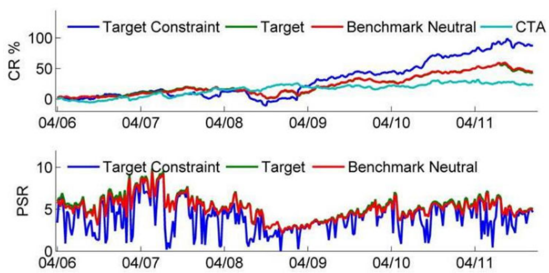
Non-zeros in $\boldsymbol{\Gamma}_t$

DDNMs

Decoupled univariate series: parallel, analytic filtering & forecasting

Recoupling: simulate synthetic futures & combine
- exploits triangular "hierarchy"

Finance:
Zhao, Xie & West, *ASMBI 2016*



Jouchi Nakajima
BIS Basel

Dynamic threshold DDNMs

Finance:	*J Fin Econ 2013* *Intl J Forecasting 2014*
Macroeconomics:	*J Bus & Econ Stats 2013*
Neuroscience:	*Dig Sig Proc 2015* *BJPS 2017*

- *Customisable univariate models: decoupled, in parallel*
- *Parental structure: sparse stochastic volatility matrix*
- *On-line sequential learning: Analytic, fast, parallel*
- *Compositional recoupling for coherent inferences & predictions*

BUT:

dependent on choice of order of named series j=1:m

Scale-up in dimension?

Choice/specification of order?

400 S&P stock price series?

$$sp(j) \in \{1:m \backslash j\}$$

$$\begin{aligned} y_{jt} &= \mathbf{F}'_{jt}\boldsymbol{\theta}_{jt} + \nu_{jt}, \quad \nu_{jt} \sim N(0, 1/\lambda_{jt}) \\ &= \mathbf{x}'_{jt}\boldsymbol{\phi}_{jt} + \mathbf{y}'_{sp(j),t}\boldsymbol{\gamma}_{jt} + \nu_{jt} \end{aligned}$$

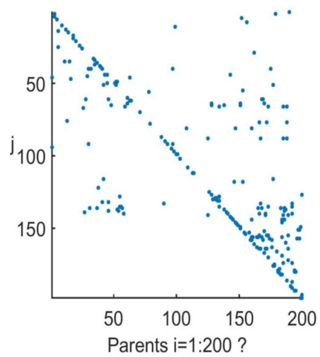
Simultaneous parents of j

$$\begin{aligned} \boldsymbol{\Theta}_t &= \{\boldsymbol{\theta}_{1t}, \ldots, \boldsymbol{\theta}_{mt}\} \\ \boldsymbol{\Lambda}_t &= \text{diag}(\lambda_{1t}, \ldots, \lambda_{mt}) \end{aligned}$$

Joint pdf …
likelihood for states and volatilities:

$$p(\mathbf{y}_t|\boldsymbol{\Theta}_t, \boldsymbol{\Lambda}_t) = |\mathbf{I} - \boldsymbol{\Gamma}_t| \; \prod_{j=1:m} N(y_{jt}|\mathbf{F}'_{jt}\boldsymbol{\theta}_{jt}, 1/\lambda_{jt})$$

- *"almost" decoupled!*
- *- coupling/coherence: "complicating" determinant*



Non-zeros in $\boldsymbol{\Gamma}_t$

Decouple/Recouple: Sequential analysis of SGDLM

$$p(\mathbf{y}_t|\boldsymbol{\Theta}_t, \boldsymbol{\Lambda}_t) = |\mathbf{I} - \boldsymbol{\Gamma}_t| \ \prod_{j=1:m} N(y_{jt}|\mathbf{F}'_{jt}\boldsymbol{\theta}_{jt}, 1/\lambda_{jt})$$

decoupled

recouple

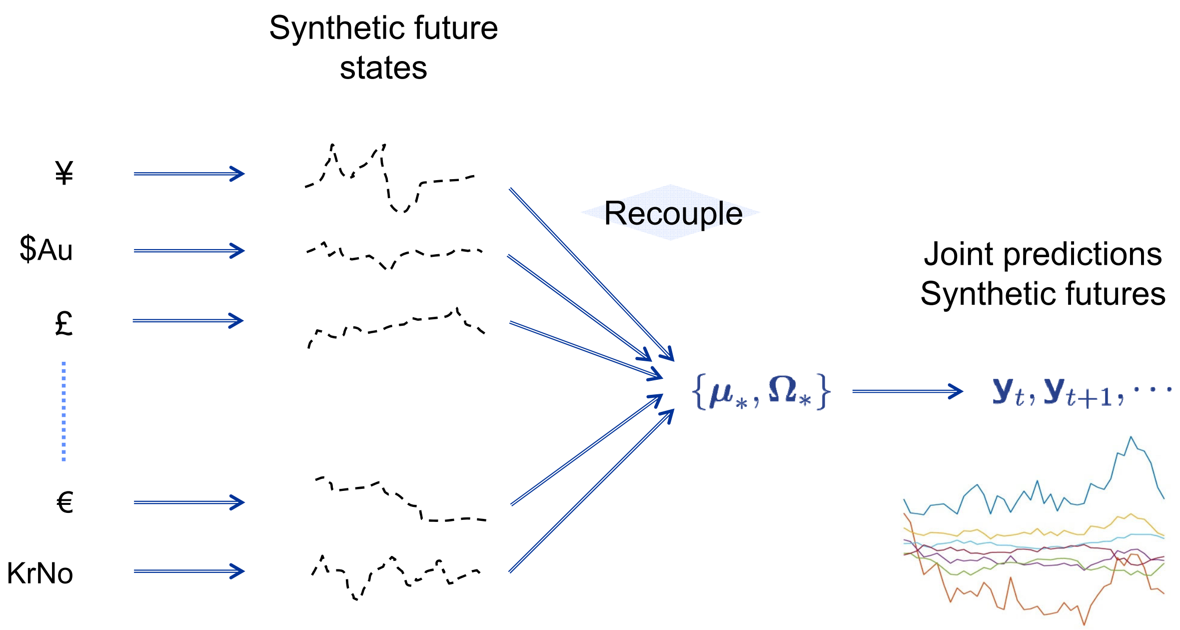
Recouple: importance sampling

Decouple: variational Bayes

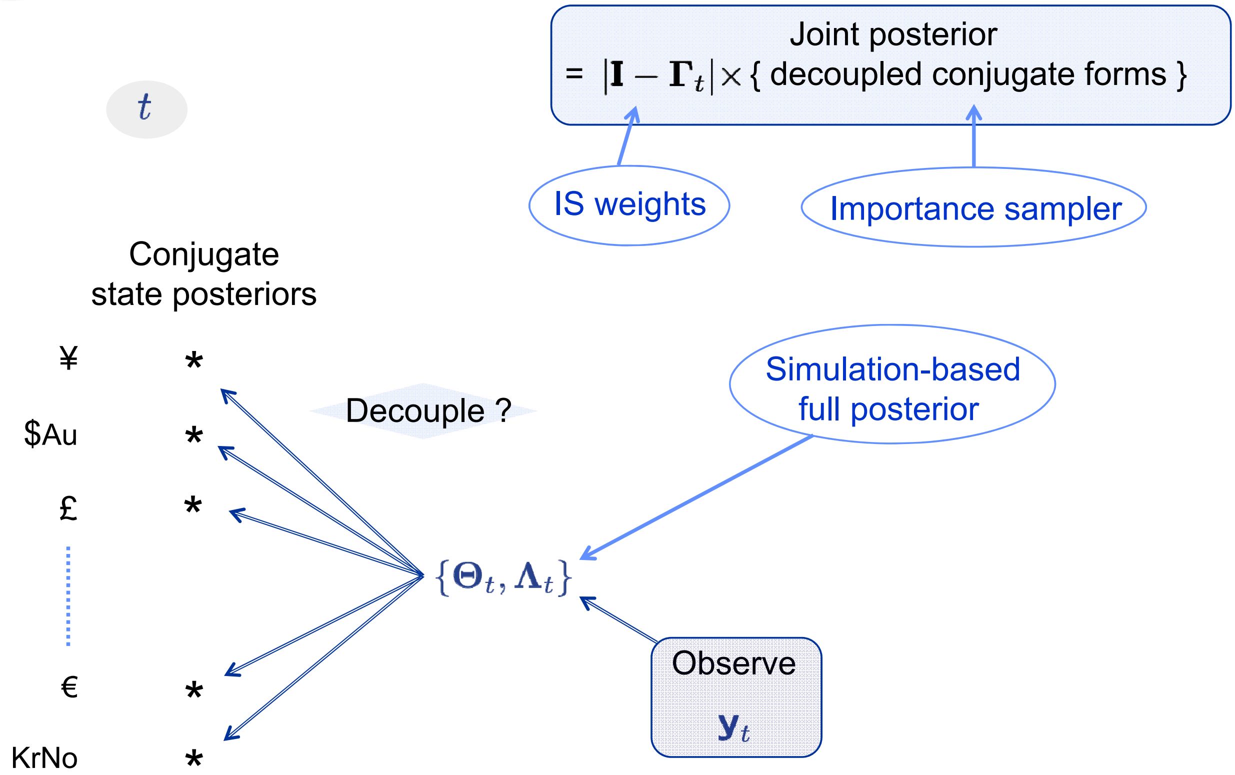
Decouple/Recouple: (i) Time *t-1* predictions

Decoupled parallel models: Conjugate state priors
- Evolve : Recouple : Forecast -

$t{-}1$



Decouple/Recouple: (ii) Time t updating



Decouple/Recouple: Time t decoupling

Joint posterior $\Longrightarrow$ decoupled conjugate margins
Variational Bayes (VB)

Decoupling at t:

Match product of conjugate forms with importance sample

- minimize Kulback-Leibler (KL) divergence
- Entropy measure of accuracy
- Relates to effective sample size (ESS) of importance sample

Monitor Entropy & ESS

Evolution to t+1: Decoupled, analytic

Example: S&P stock price series

Multiple models x portfolio utilities comparisons

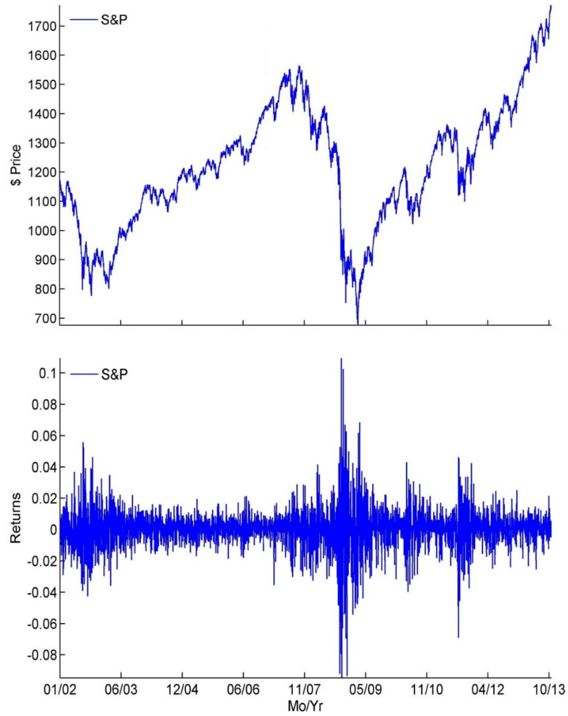
m=401: *400* stocks & S&P index
- daily closing prices

Q1/2002 – Q3/2013

Model (log-difference) returns

Training data : 2002

Test/prediction/portfolio decisions : Q1/2003 – Q3/2013



S&P400 portfolios: Examples of cumulative returns

Trading costs adjusted returns
Uniform improvements (Sharpe ratios, etc) over WDLMs

Simultaneous parental set specification?

AIC / *IC / full Bayesian model selection / model averaging ?

Parallel stochastic search over parental sets ?

Goals? Learning/choosing "best" statistical models ✘

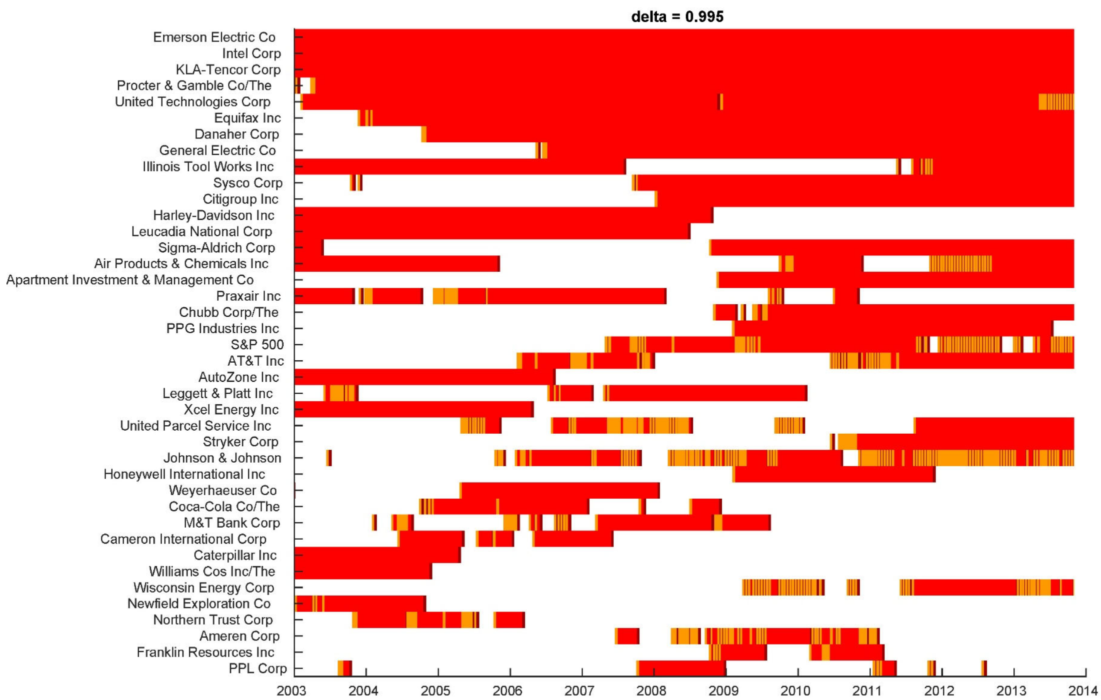
Multi-step forecasting ✓… but

Decisions! Portfolio outcomes (risk, return, …) ✓!

Adaptive "refresh" of parental sets
- monitor: candidates to add, remove each t -

S&P example – Simultaneous parental set turnover

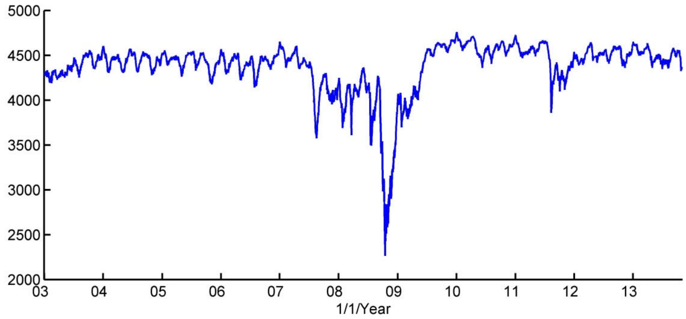
sp(3M)



S&P example – Monitoring decoupling/recoupling

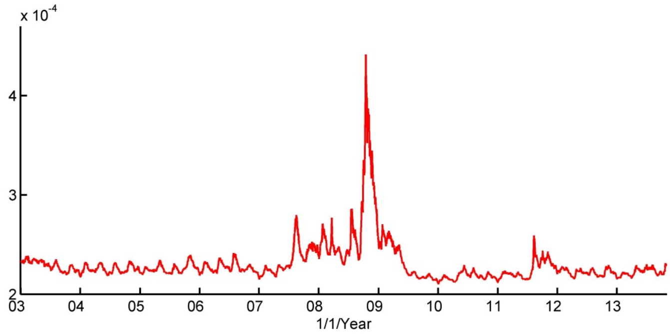
I=5,000 Monte Carlo sample size

ESS



[recoupling]

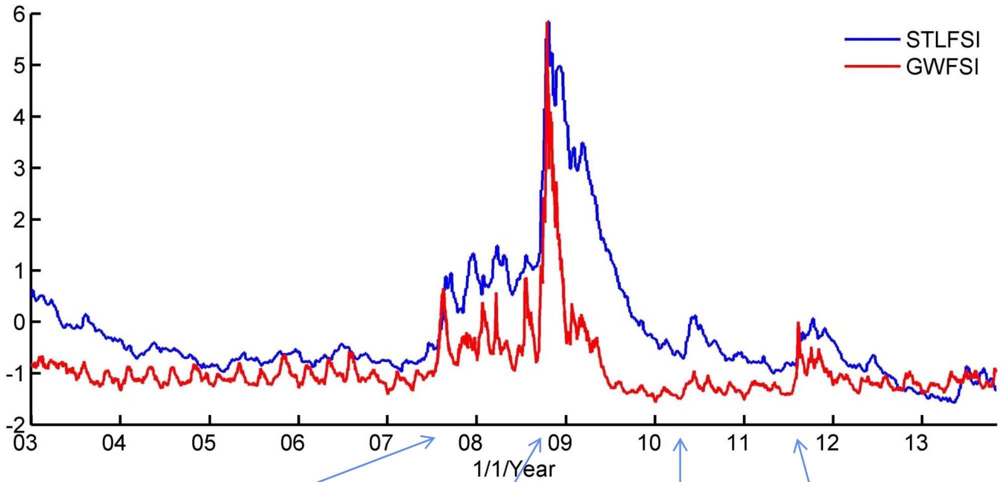
Entropy



[decoupling]

Potential to intervene- "signal" of deterioration of ESS:
Increase sample size &/or modify model: parental sets, discounts, etc

St Louis Fed "Financial Markets Stress Index"



8/07
Subprime loan PR
Northern Rock bailout

10/08
US loans buy-back
NES Act

3/10
Eurozone crisis
EU/ECB 1st responses

8/11
US credit rating downgrade
Sharp drops in global markets

SGDLM decoupling/recoupling and computations

- *Flexible, customisable univariate models*

- *Flexible, sparse stochastic volatility matrix model*

- *No series-order dependence*

- *Scale-up : conceptual & computational*

- *On-line sequential learning: Analytics + cheap simulation + VB*
  … parallelisable within each time step

- *GPU computation*

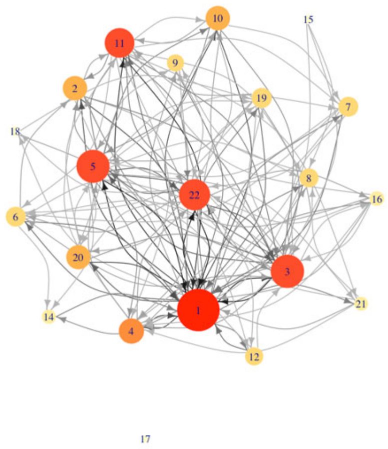
- *Recouple: CPU for coherence*

- *Decouple/Recouple IS&VB: theory, monitoring per series*

Decouple/recouple : Example 2 - Network flow monitoring

Counts/flows between nodes over time

- *n* nodes: $m = n \times n$ series



Web domain: e-commerce

- *n ~ 20-200+*

- Sensitive tracking of flow dynamics ?
- Characterize "normal" patterns of time variation ?
- Change/anomaly detection ?
- Fast! sequential analysis ?

DECOUPLE - univariate count time series
- Dynamic generalized linear state-space models

RECOUPLE – direct simulation
- Map to dynamic random effects/interaction model
- Bayesian "model emulation"

Decouple/recouple : Example 3 – Multi-scale forecasting

Consumer sales/supermarkets

- m ~ 10,000-100,000s
- Customize individual models
- Forecast 1-14 days ahead, each day
- Change/anomaly detection
- Link across-series : e.g., seasonality

Many series : "similar patterns"

- Hierarchical models ? Factor models ?
- Not scalable

DECOUPLE - univariate count time series

- Dynamic binary & count mixture models

RECOUPLE – direct simulation

- "Common" seasonal factors from external model
- Series-specific mapping of common factors

Some Bayesian decouple/recouplers

Zoey Zhao
Citadel

Amy Xie
Duke

DDNMs *ASMBI 2016*

Jouchi Nakajima
BIS Basel

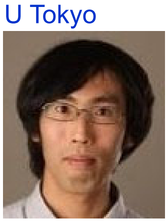
***DDNM*s** *JBES, IJF, JFI, DPS BJPS 2013 - 17*

Lutz Gruber
QuantCo & U Nebraska

SGDLMs *BA 2016*
EcoStat 2017

Xi Chen
LinkedIn

Kaoru Irie
U Tokyo



Network flows *JASA 2018*

Lindsay Berry
Duke

Multi-scale models *2018*

Hirotugu Akaike

- Applied motivations: forecasting, monitoring & decisions
- Conceptual innovation : Decouple/recouple
- Technical innovation : Context dependent structuring
- Practical, efficient and effective scalability