On Bayesian workflow

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Talk partially based on

Andrew Gelman, *Aki Vehtari*, Daniel Simpson, Charles C. Margossian, Bob Carpenter, Yuling Yao, Lauren Kennedy, Jonah Gabry, Paul-Christian Bürkner, and Martin Modrák (2020).
Bayesian workflow.
arXiv preprint arXiv:2011.01808.

Outline

- Workflow frameworks improve
  - efficiency
  - reliability
  - reproducibility
  - etc.

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- Software assisted workflows

Workflow term

- Saunders and Blundstone, 1921. Railway engineering.
- Started to get more popular in 1990s based on Google books ngram viewer

Bioinformatics and scientific workflow in 2000's

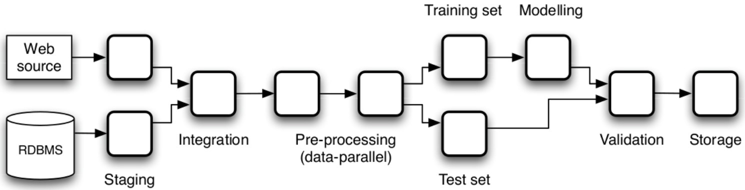

Fig. 1. Workflow example

Curcin & Ghanem (2008). Scientific workflow systems - can one size fit all?

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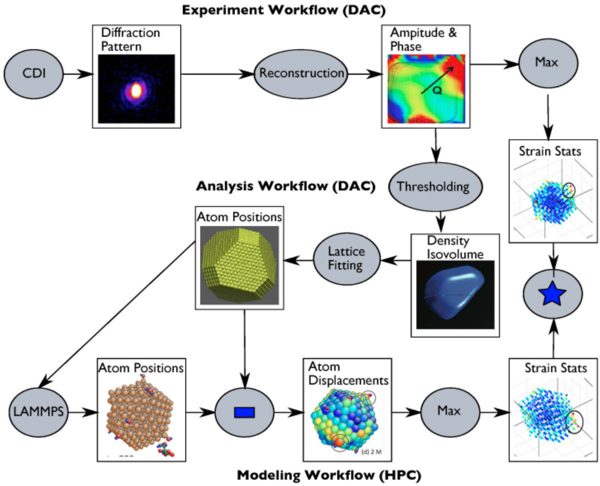


Figure 1: Science workflow for the comparison of a molecular dynamics simulation with a high-energy X-ray microscopy of the same material system includes three interrelated computational and experimental workflows.

Deelman et al (2017). The Future of Scientific Workflows

Workflows in general

- Workflow frameworks improve
  - efficiency
  - reliability
  - reproducibility
  - etc.

Bayesian workflow

- Savage (2016). An introduction to Bayesian modelling in Stan for economists.
  - "The Bayesian workflow"
- Gabry, Simpson, Vehtari, Betancourt, and Gelman (2017). Visualization in Bayesian workflow.

Box & Youle, 1955

The Exploration and Exploitation of Response Surfaces: An Example of the Link between the Fitted Surface and the Basic Mechanism of the System

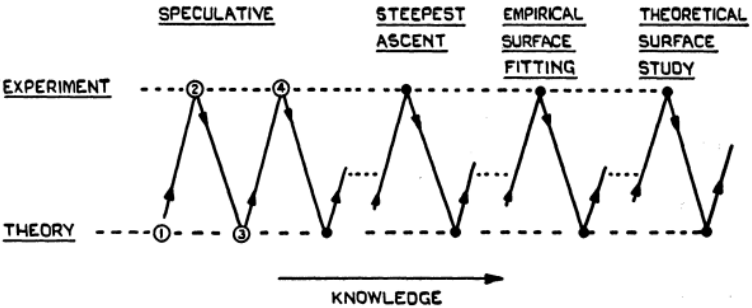
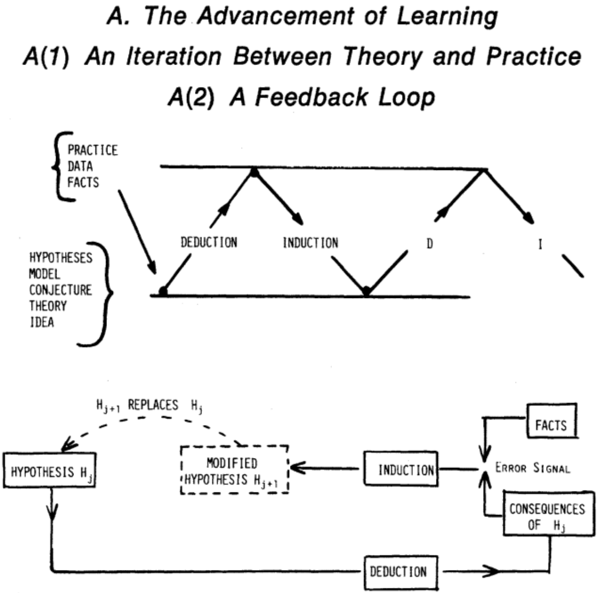


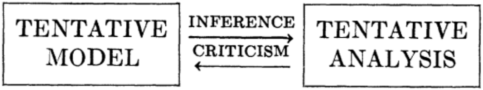
FIGURE 7. DIAGRAMATIC REPRESENTATION OF PROCESS OF EXPERIMENTAL ITERATION.

Box 1976: Science and Statistics

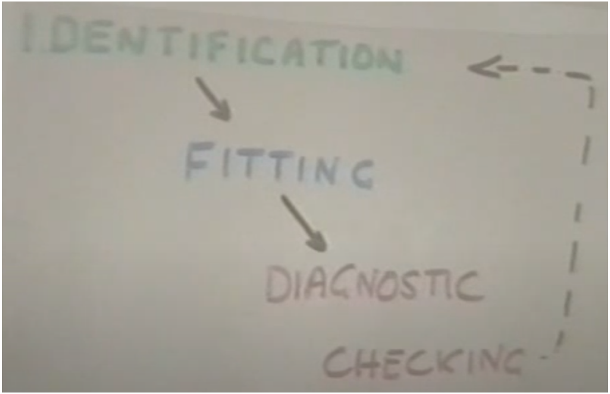


Box 1976: Science and Statistics

Data analysis, a subiteration in the process of investigation, is illustrated here.



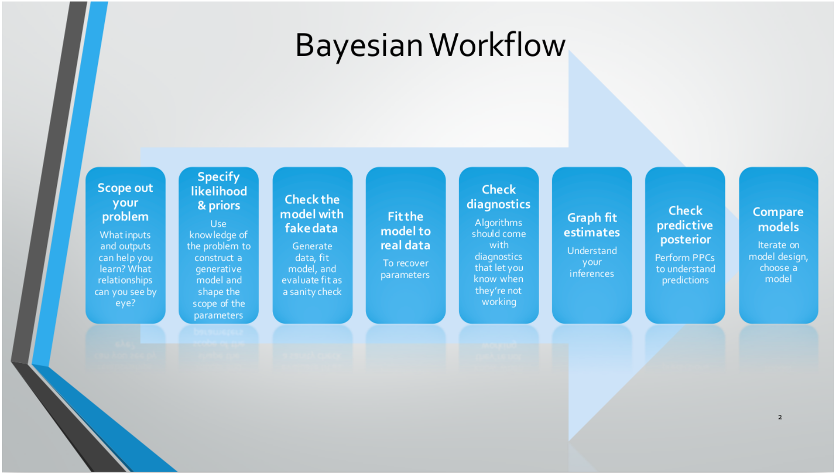
Box 1987



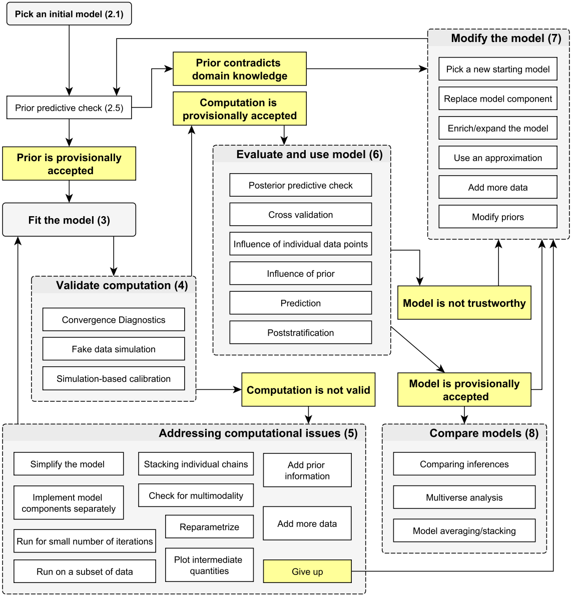
From the talk slides ‘Some aspects of statistical design in quality improvement”

Talts (2018)

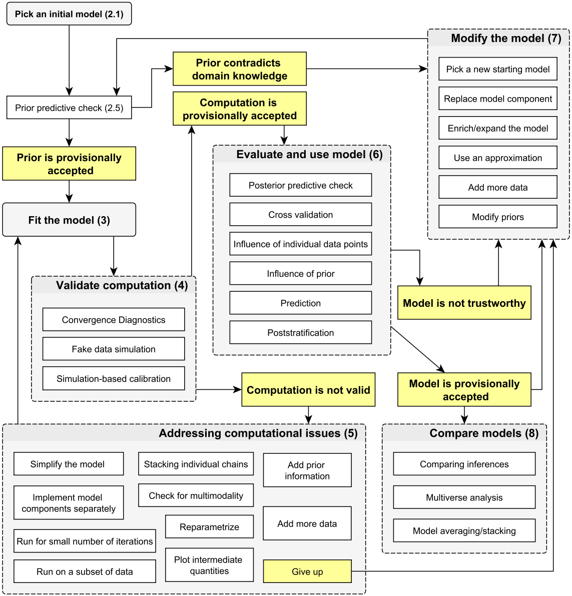
StanCon 2018 intro



Bayesian workflows



Workflows and sub-workflows



Model building as software development process

Boehm (1996, 1988)

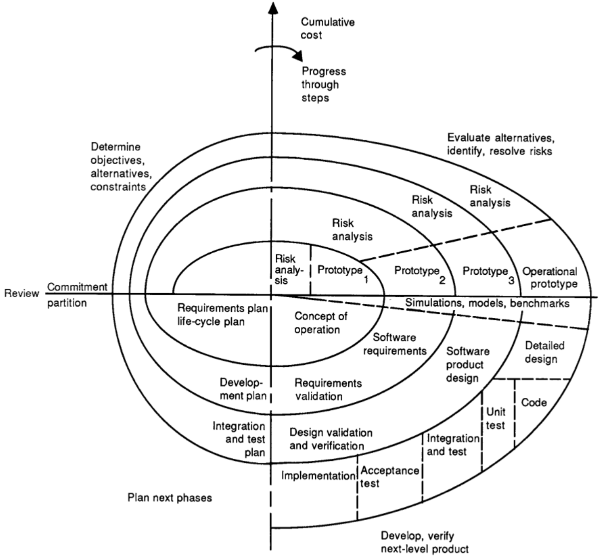
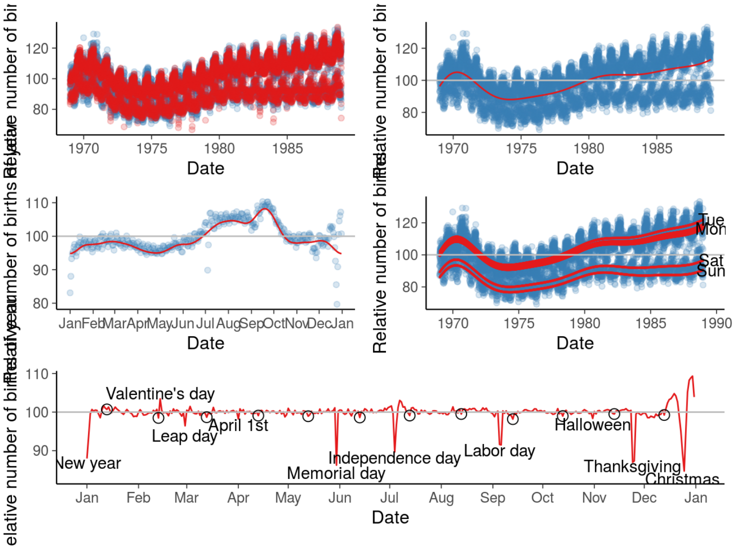


Figure 2. Spiral model of the software process.

Example: Birthdays

https://avehtari.github.io/casestudies/Birthdays/birthdays.html



Prototypes, shortcuts, and workflow as engineering

- When building prototypes or making initial experiments, we can use shortcuts
  - the final models tested with sufficient rigor

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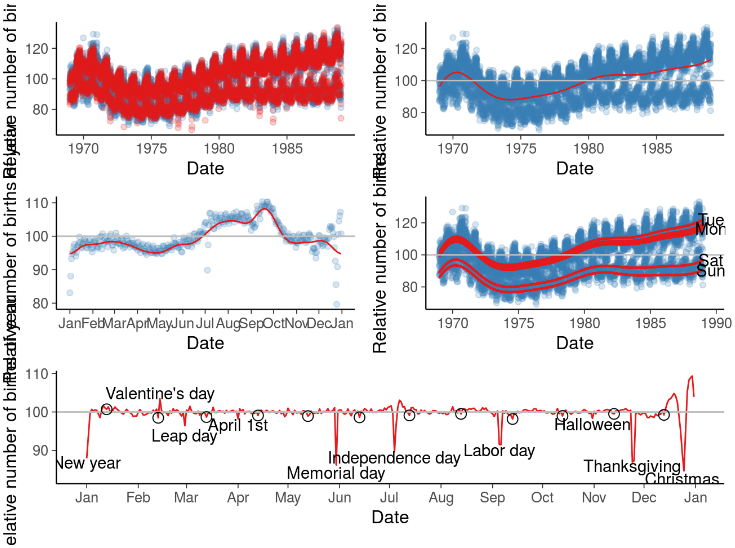

Different requirements and workflow as cooking

- Make a sandwich out of available ingredients
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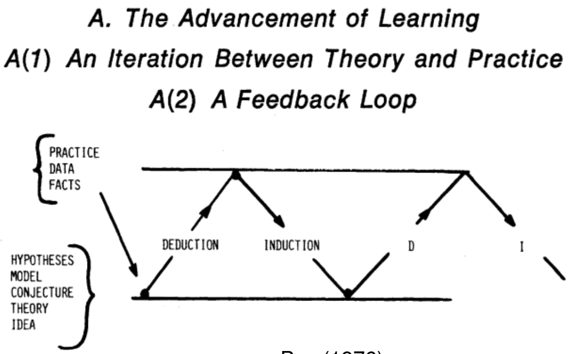
- Develop a new recipe to be used in a fine dining restaurant
  - may require several iterations (depending on how much the customers are willing to pay)
  - write the model in probabalistic programming language

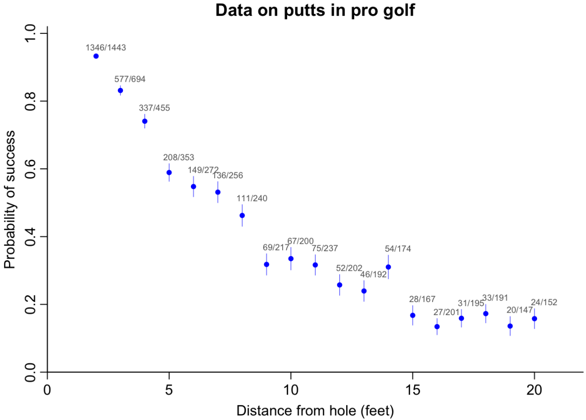
Iterative workflow as a learning process



Box (1976)

- Incremental learning reduces cognitive load

Example: Golf putting



Example by Andrew Gelman CC-BY-NC 4.0
https://mc-stan.org/users/documentation/case-studies/golf.html

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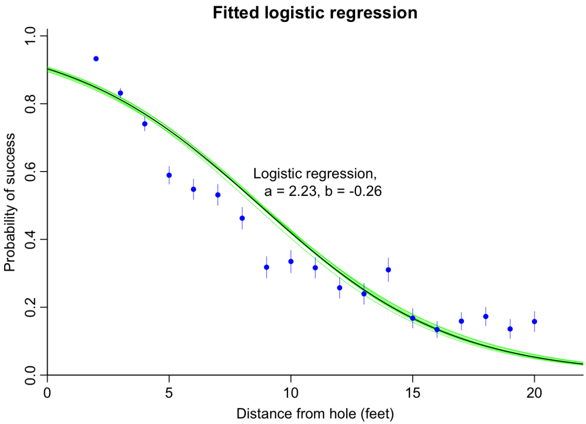

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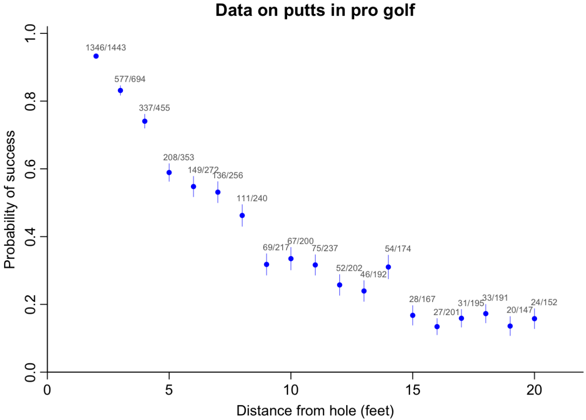

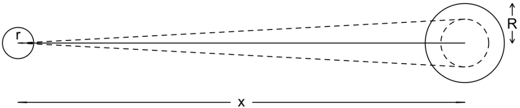

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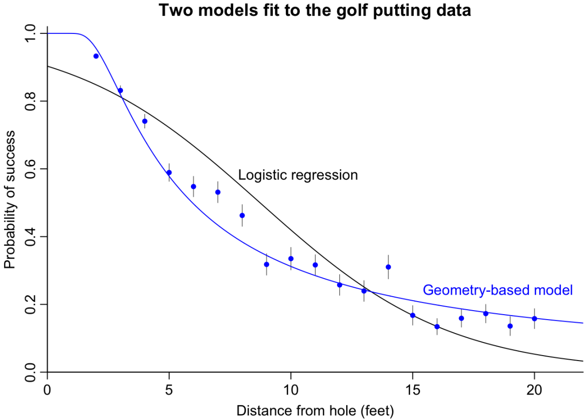

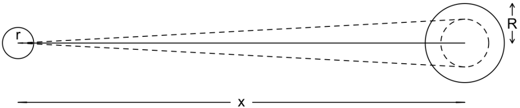

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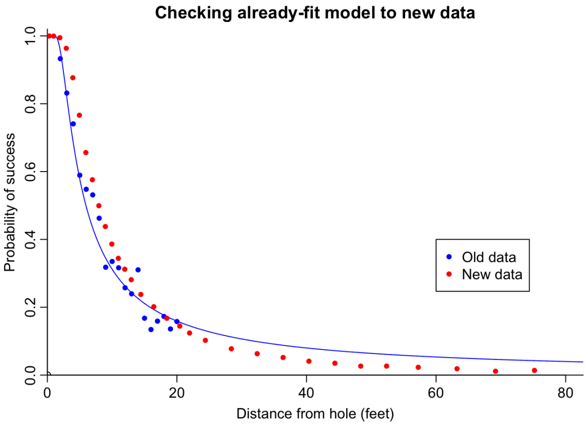

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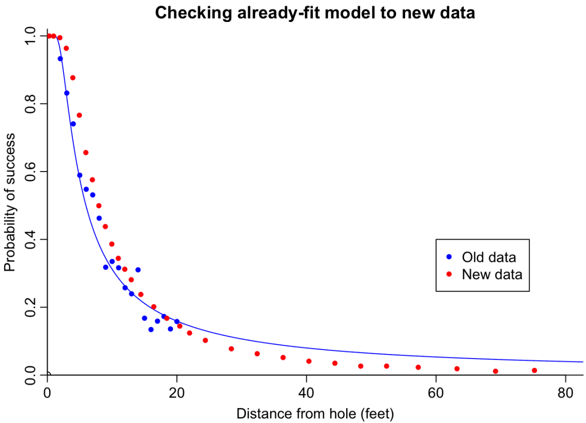

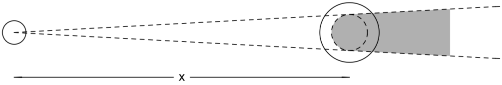

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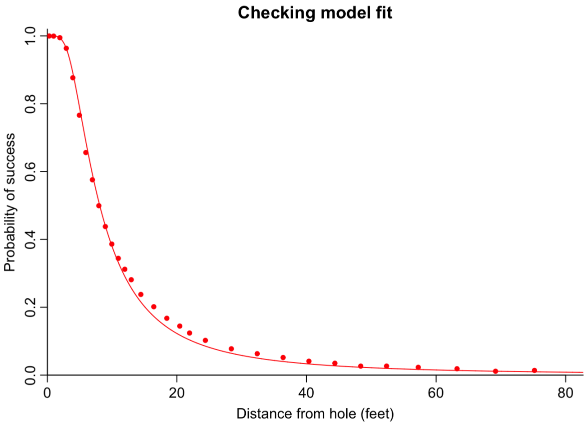
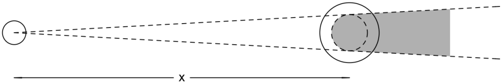
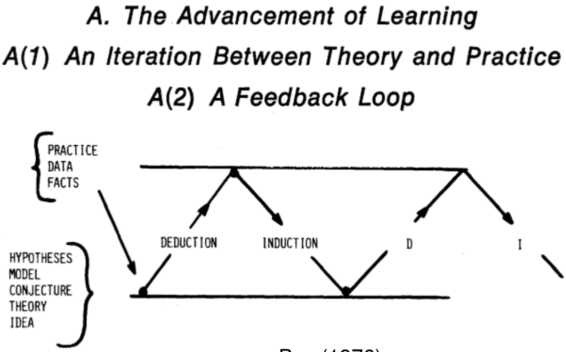




Models as experiments



Box (1976)

- New facts are learned by using the models
- New learned facts can be used to choose the next model

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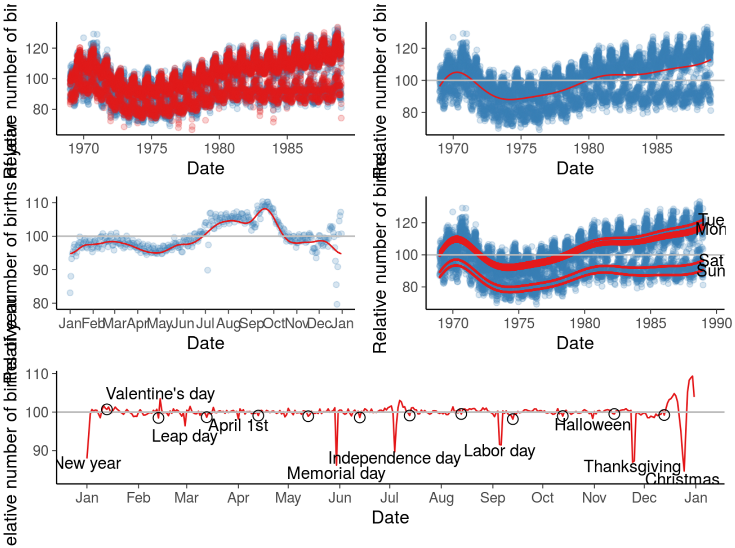

Software development process vs. Models as experiments

- The end result may also be a series of models
  - it may be useful to report results of simpler experiments, too
  - presenting the results of many models is also part of the workflow

Cost and benefit of model building

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Stick figure and silhoutte from Weech et al. (2014) doi:10.1167/14.12.10. Photo CC0.

Cost and benefit of model building

- Sufficient accuracy for model and computation

Argument against iterative model building

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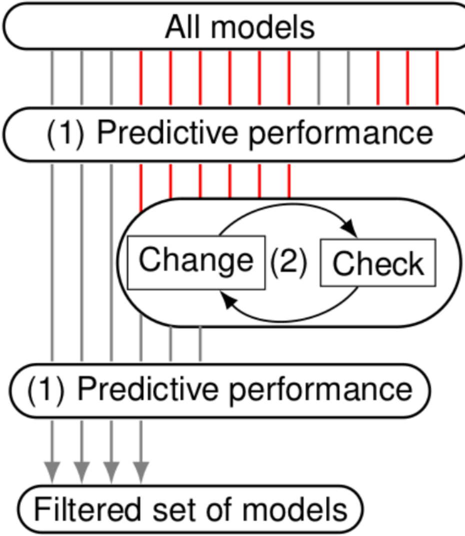
Watch and listen more (4.5h) in

- Model assesment, selection and averaging
  https://www.youtube.com/watch?v=Re-2yVd0Mqk
- Use of reference models in variable selection
  https://www.youtube.com/watch?v=N0ce8J8sIFY
- These are a few of my favorite inference diagnostics
  https://www.youtube.com/watch?v=vLx6IUIZ0fc

Filtering



from Riha, Siccha & Vehtari (2023)

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- See also “What do we need from a PPL to support Bayesian workflow?” by Bob Carpenter statmodeling.stat.columbia.edu/2021/10/22/carpenter-slides-papers-prob-prog-2021/

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  - LLMs (e.g. ChatGPT) can only help when there has been enough material in the internet for them to learn, and even then they may provide miselading recommendations

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