A Modeling Manifesto

Jeffrey B. Mulligan
(with help from Andrew B. Watson)
NASA Ames Research Center

VSS Satellite Workshop on
Computational and Mathematical Models in Vision (MODVIS)
St. Pete Beach, May 2014

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A little history: the Modelfest

- Initiated (circa 1996) by Klein & Carney
- From Klein lab website (circa 2000):

> My early research in vision was devoted to the development of a multichannel filter model for detection. Although the vision community felt that the 'standard' filter model did a good job, it was never adequately tested for a broad range of detection stimuli.
> …
> I felt that a dataset with more stimuli and with more subjects was needed to place tighter constraint on the standard model, so about four years ago my colleague Thom Carney and I organized the Modelfest project whose goal was to form an international collaborative effort to gather a large database of thresholds for testing vision models.

Modelfest History (continued)

- From Klein lab website:

> … [the] goal was to form an international collaborative effort to ***gather a large database of thresholds*** for testing vision models.

- Collect new data or tabulate old?

Modeling Existing Data

Pros:

- Lots of it!
- Wide range of conditions

Cons:

- Variable conditions
- Descriptions may be incomplete

A proposal for Modelfest II

Gather a large database of psychophysical data and associated models

Goals:
- Facilitate consistency checks of new models
- Identify inconsistent data in the archival record
- Identify critical model parameters for applications
- Identify critical experiments to test models

Potential elements:
- A large database of thresholds - and other data?
- A database of existing models – in standard form?
- A web-based system for running models?

Elements of Modelfest II?

- A large database of thresholds
  - A database of existing models – in standard form?
  - A web-based system for running models?

An example: Blackwell (1946)

JOURNAL OF THE OPTICAL SOCIETY OF AMERICA VOLUME 36, NUMBER 11 NOVEMBER, 1946

Contrast Thresholds of the Human Eye

H. RICHARD BLACKWELL*
Louis Comfort Tiffany Foundation, Oyster Bay, New York
(Received July 12, 1946)

THE L. C. Tiffany Foundation is an art school in peacetime, but its facilities were completely engaged during the war years under a contract with the Office of Scientific Research and Development. The part of the war program upon which this paper is based pertains to the determination of the contrast threshold of the normal human observer under a wide variety of experimental conditions. The typical experimental procedure consisted in projecting a spot of light on a white screen some sixty feet from a group of observers who individually reported whether the stimulus had been seen. A large number of such presentations, made with varying brightness of the stimulus, provided data from which, by statistical analysis, the contrast darkest night. In all, more than two million responses to the test stimulus were recorded, some four hundred and fifty thousand of which have been statistically analyzed and reported herein.

I. EXPERIMENTAL PROCEDURE

Laboratory

The laboratory in which experiments were conducted is shown in Figs. 1 and 2. The entire inner surface of the observation room was covered with flat white paint, whose reflectance was approximately 0.89. A ventilation system, details of which are shown in Fig. 2, maintained a moderate temperature and kept the air relatively free from dust particles.

Blackwell (1946) highlights

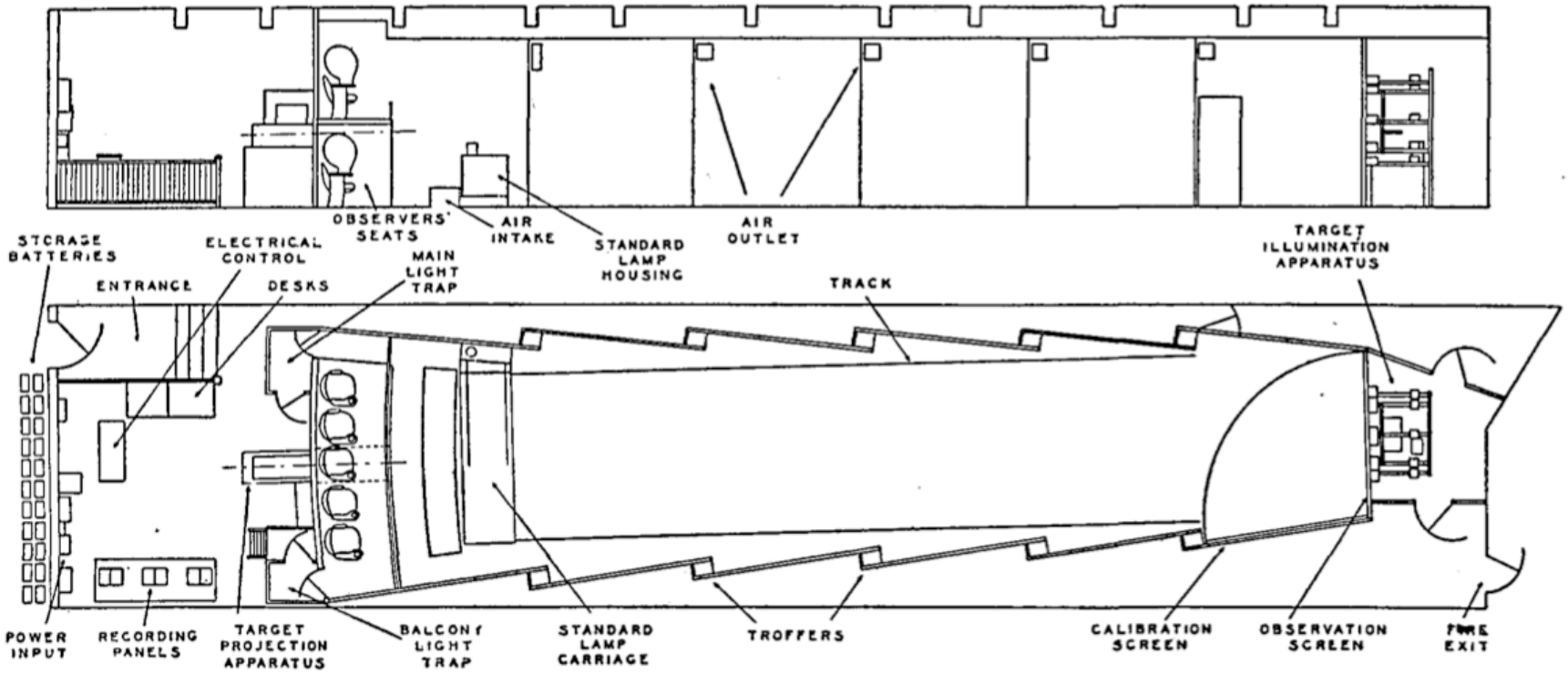

FIG. 2. Floor plan of laboratory. Dimensions of the plywood room (observation room) were: length, 63 feet; height, 10 feet, and width at the narrowest points, 10 feet.

Blackwell (1946) highlights (cont.)

FIG. 4. View of observers' stations.

Blackwell (1946) highlights (cont.)

TABLE I. Ophthalmological records.

Observer	Visual acuity (20 ft.) O.D.	O.S.	O.U.	Near point (mm) O.D.	O.S.	O.U.	Muscle balance 20 ft.	33 cm
B.B.	20/20−	20/20	20/20+	100	110	110	0.25 Eso.	5 Exo.
I.T.B.	20/25+	20/25+	20/20−	100	110	90	0.5 Eso. 0.25 RH.	1.5 Exo.
M.J.B. (a)	20/15−	20/15−	20/15−	140	140	130	0.5 Eso. 0.25 Hyper.	Normal
(b)*	20/15−	20/15−	20/15−	140	140	130	0.5 Eso.	Normal
E.L.C.	20/15−	20/15−	20/15	130	110	105	1.0 Exo. 0.5 Hyper.	Normal
C.C.C. (a)	20/20−	20/25−	20/20+	120	108	95	0.5 Exo. 0.25 Hyper.	Normal
(b)*	20/20+	20/20+	20/15−	120	110	110	0.25 Exo. 1 Hyper.	Normal
M.C.	20/15−	20/15−	20/15−	70	80	70	2 Eso. 0.5 RH.	1.75 Eso.
L.H.	20/20+	20/20+	20/20+	120	130	120	0.75 Eso.	0.5 Eso.
E.L.H.	20/20	20/20	20/20+	90	90	90	0.5 Eso. 0.25 RH.	Normal
D.H.	20/25+	20/25	20/20−	110	110	100	0.5 Eso.	2 Exo.
L.T.H.	20/20+	20/15−	20/15−	140	140	140	0.5 Eso.	Normal
N.L.H.	20/20	20/20	20/20	120	130	110	0.5 LH.	0.5 Eso.
J.J.	20/15−	20/15	20/15	120	120	100	0.5 Exo. 0.5 RH.	2 Exo.
E.S.K.	20/15−	20/15−	20/15	105	100	100	3 Eso.	3 Exo.
V.R.M.	20/15−	20/15−	20/15−	100	120	100	1.5 Exo.	9 Exo.
M.R.R.	20/15−	20/15−	20/15−	105	115	95	2 Eso. 2 Hyper.	Normal
S.R.	20/20+	20/15−	20/15−	130	120	120	Normal	7 Exo.
M.S.	20/20+	20/20	20/15−	100	110	90	0.37 RH.	2.5 Exo.
J.T.	20/20	20/20	20/20+	110	110	110	0.5 Eso.	3 Exo.
G.H.W.	20/15	20/15−	20/15	90	110	90	2 Eso. 0.5 RH.	2 Exo.

Abbreviations: Eso. Esophoria; Exo. Exophoria; Hyper. Hyperphoria; RH. Right Heterophoria; LH. Left Heterophoria

* Repeat examinations made after three months of intensive observations.

Blackwell (1946) highlights (cont.)

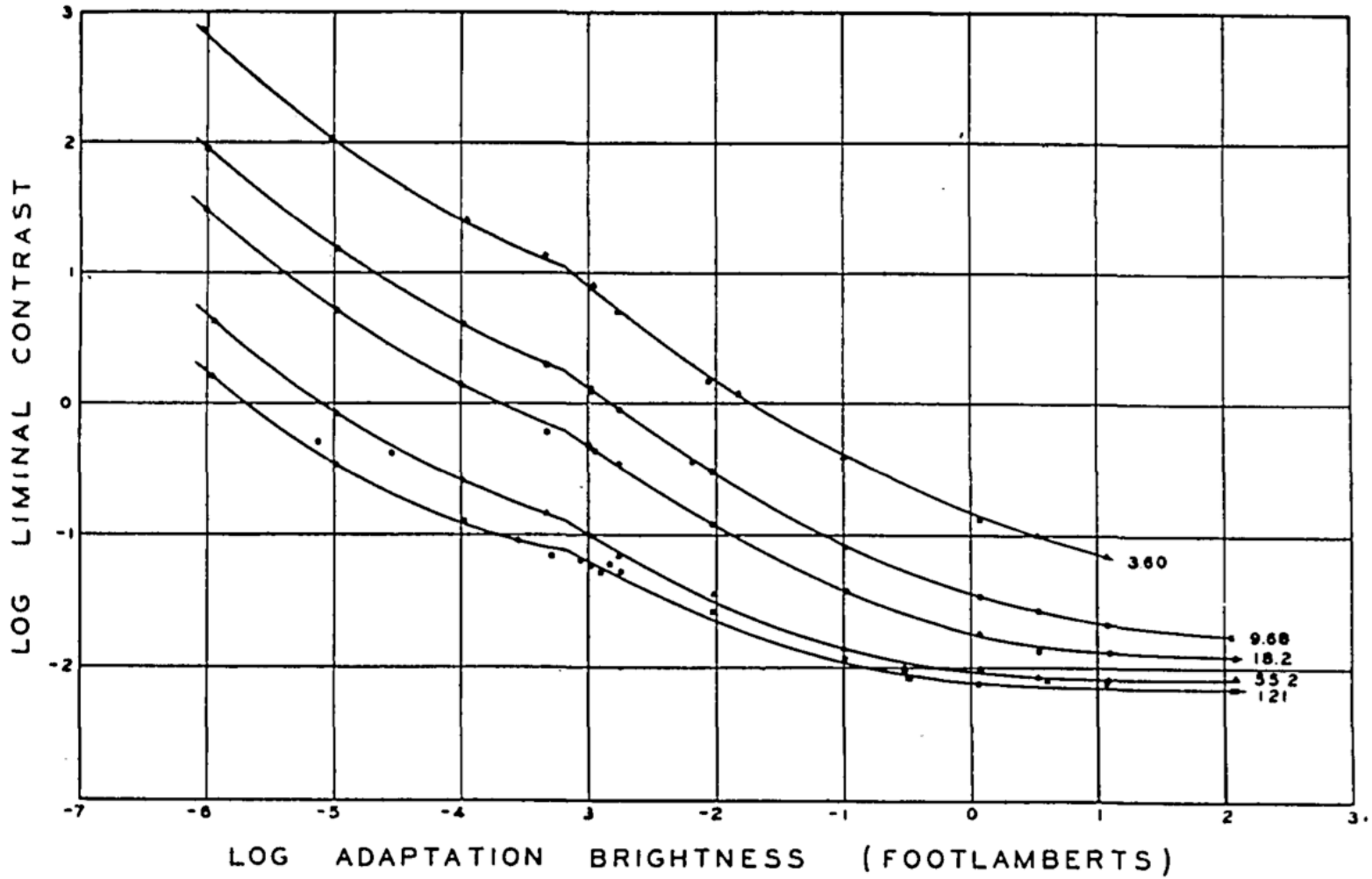

FIG. 10. The arithmetical mean of threshold contrasts, computed from individual probability curves, plotted as a function of adaptation brightness for five stimulus areas.

Blackwell (1946) highlights (cont.)

TABLE II. Arithmetical mean threshold contrast. Stimuli brighter than surround (Part I). Angular subtense of stimulus (minutes of arc).

121.0		55.2		18.2		9.68		3.60	
Log B_0	Log C	Log B_0	Log C	Log B_0	Log C	Log B_0	Log C	Log B_0	Log C
2.080	−2.124	2.084	−2.041	2.081	−1.894	2.053	−1.739	1.072	−1.127
2.061	−2.127	1.083	−2.061	2.078	−1.895	1.077	−1.671	0.523	−0.980
1.074	−2.082	0.605	−2.085	1.086	−1.861	0.533	−1.568	0.075	−0.868
0.076	−2.102	0.531	−2.049	0.542	−1.863	0.076	−1.460	−0.996	−0.401
−0.471	−2.081	0.078	−1.997	0.070	−1.736	−0.994	−1.083	−2.053	0.175
−0.497	−2.065	−0.504	−2.021	−0.975	−1.415	−2.031	−0.505	−2.768	0.703
−0.994	−1.937	−0.504	−1.971	−2.034	−0.918	−2.757	−0.044	−2.951	0.905
−2.029	−1.579	−0.991	−1.858	−2.755	−0.460	−2.979	0.090	−2.978	0.896
−2.756	−1.274	−2.020	−1.438	−2.952	−0.344	−2.984	0.116	−3.341	1.144
−2.907	−1.280	−2.769	−1.150	−2.989	−0.313	−3.346	0.298	−3.964	1.397
−2.987	−1.228	−2.981	−1.012	−3.323	−0.219	−3.982	0.618	−5.016	2.026
−3.065	−1.178	−3.331	−0.831	−4.002	0.151	−4.986	1.179	−6.032	2.868
−3.296	−1.148	−3.995	−0.595	−4.982	0.705	−5.999	1.944		
−3.979	−0.891	−4.989	−0.079	−6.012	1.479				
−4.995	−0.474	−5.948	0.622						
−5.969	0.212								

Modeling the Blackwell (1946) data?

Subject: Re: modeling
From: Andrew Watson <andrew.b.watson@nasa.gov>
Date: Thu, 8 May 2014 12:09:14 +0200
To: Jeff Mulligan <jeffrey.b.mulligan@nasa.gov>

having spent a few minutes looking at the paper and the tables, I am no longer sure what you are after.
The bulk of the paper is about variations with background level, about which our model at present says little.
There are also many tables and it is too much work to figure what the differences among them are.

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Date: Sun, 11 May 2014 21:55:20 -0700
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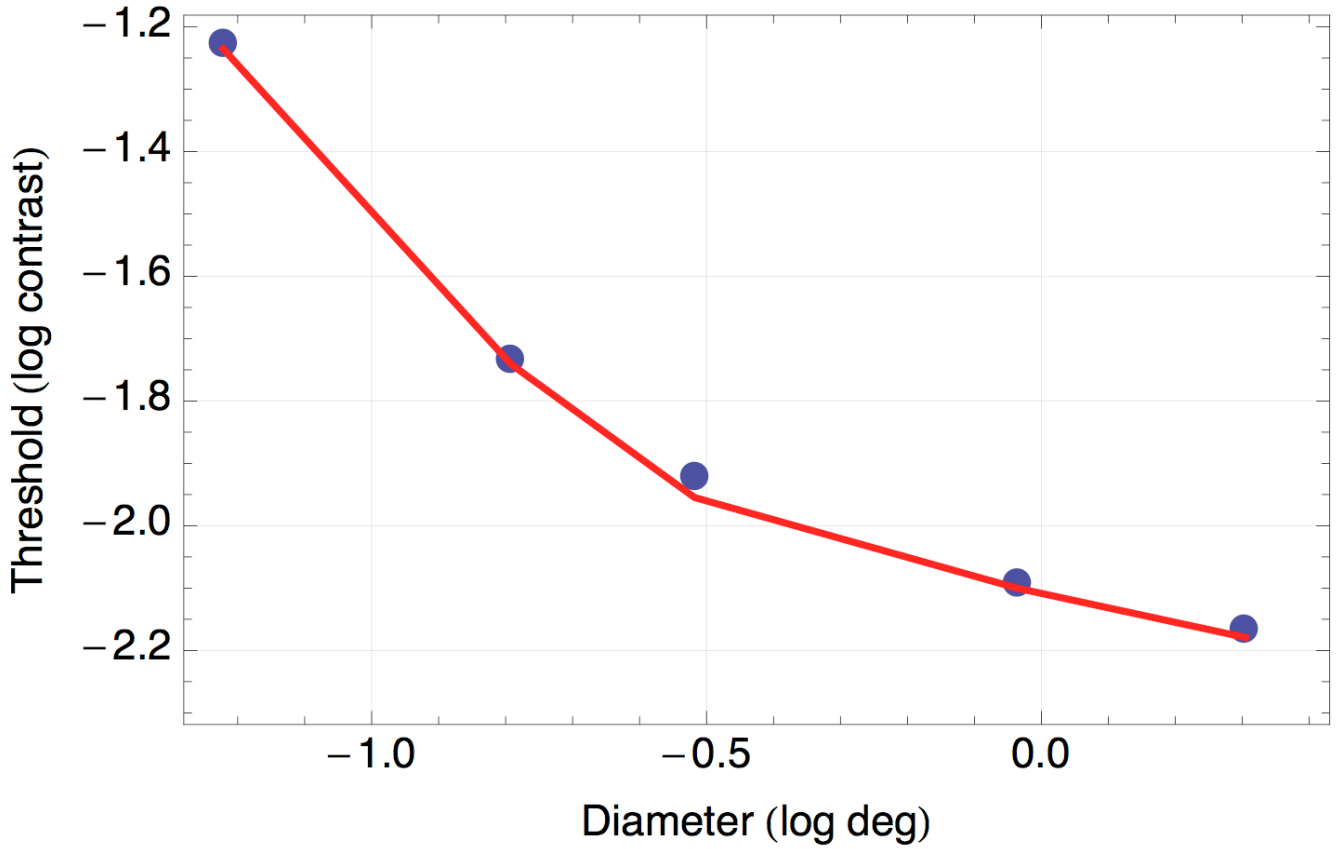
Here is a first attempt.

points are thresholds for five sizes at 100 cd/m^2 from blackwell 1946.
red curve is predictions from "neural image classifier" model.

needs to be checked, and has various assumptions, but...

Modeling the Blackwell (1946) data



Watson, A. B., & Ahumada, A. J. (2013). Modeling letter identification: contrast thresholds for as a function of size. Journal of Vision, 13(9), 1269, http://journalofvision.org/13/9/1269/.

A standard format for data?

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Existing systems for data sharing?

- NIH Data Sharing Policy and Implementation Guidance
  - Data Sharing Workbook
    - concerns seem to relate mainly to privacy?
- Wolfram Technology Guide
    - Load-on-demand curated data
      - physics, astronomy, demographics, linguistics, finance, etc.
- scientificdatasharing.com (UCSF)

nature International weekly journal of science

Editorial

Nature **461**, 145 (10 September 2009) | doi:10.1038/461145a; Published online 9 September 2009; Corrected 23 September 2009

Data's shameful neglect

See associated Correspondence: Guralnick *et al.* , *Nature* **462**, 34 (November 2009)

Research cannot flourish if data are not preserved and made accessible. All concerned must act accordingly.

▲ Top

More and more often these days, a research project's success is measured not just by the publications it produces, but also by the data it makes available to the wider community. Pioneering archives such as GenBank have demonstrated just how powerful such legacy data sets can be for generating new discoveries — especially when

How to Share Scientific Data

Andrew Federman for Google

Vinton Cerf, the vice president of Google, calls for sharing the costs in making scientific data widely available.

By JOHN MARKOFF
Published: August 12, 2013

Stewart Brand, the founder of the Whole Earth catalog and a Silicon Valley muse, once said that information wanted to be free and expensive, simultaneously. That paradox is increasingly haunting the world of modern science.

A deluge of digital data from scientific

A standard format for data?

- should include meta-data
- human readable, editable (ascii) is good
    - but impractical for images and volumes
    - hexadecimal instead of binary?
- XML tags?
    - which parameters should be included?
    - answer: all of them!

An example format for data

```
<data_set>

  <ordinate>
    <description>
      log liminal contrast </description>
    <unit> dimensionless </unit>
  </ordinate>

  <abscissa>
    <description>
      log adaptation brightness </description>
    <unit> foot Lamberts </unit>
  </abscissa>

  ...
```

An example data format (cont.)

```
<data_set>
  ...
  <subject_type> group average </subject_type>
  <point_set>
    <parameter>
      <name> size </name>
      <description>
              target diameter </description>
      <value> 2 </value>
      <unit> degree </unit>
    </parameter>
    <data_point>
      <abscissa> 0.1 </abscissa>
      <ordinate> -2.3 </ordinate>
    </data_point>
    ...
  </point_set>
  ...
```

How to achieve standardization?

- Conversion of existing data
  - Provide web-based converter?
    - upload data in CSV format?
    - provide form for meta-data entry?

- Generation of new data in standard format?
  - Provide modules for Psych Toolbox and others?

Elements of Modelfest II?

- A large database of thresholds - and other data?
- **A database of existing models**
- A web-based system for running models?

A database of models?

- Step 1: author-contributed code

  Pros:

  - Not a lot of work

  Cons:

  - Compatibility?
    - Matlab
    - Mathematica
    - R
    - SciPy
    - compiled code (C, C++, java, etc.)
    - others?

A database of models?

- Step 2: standardization of models?
  - Two issues:
    - Representation
    - Computation

Representation of models

- Choose a programming language?
- Mathematical notation?
  - choose a typesetting language
  - develop translators to programming languages?

Elements of Modelfest II?

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Cloud-based modeling?

- Pros:
  - nothing to install (if server-side)
    - browser plug-in (if client-side)
  - you run the same code as the author

- Cons:
  - limited capacity of server-based modeling
    - could be mitigated by peer-to-peer software?

Conclusions

- There are a lot of great data and models out there!

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- But they are under-utilized

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Thanks for your attention