

We have occasionally encountered informal statements claiming that, whereas multimodel inference is much used in wildlife and perhaps ecology (i.e., applications appear in journal papers), it is not used in other disciplines. This is demonstrable false, which can be attested to by looking at other journals. Model selection, model averaging, and use of multimodel inference concepts do appear widely in other journals on all types of subjects. Interest can be dated to the late 1970's with a considerable increase in interest since about year 2000. We explored this issue (see below) by finding journals that have published at least one paper using, or about, multimodel inference. This was not a comprehensive effort – just evidence to reject the “not much used outside of wildlife” fallacy.

(K. P. Burnham and D. R. Anderson)

Some journals that have published papers where multimodel inference has been used and/or studied.

Analytical Chemistry
 Journal of Productivity Analysis
 Journal of Human Genetics
 Journal of Applied Econometrics
 Biochemistry
 New England Journal of Medicine
 The Annals of Statistics
 British Journal of Mathematical and Statistical Psychology
 Freshwater Science
 PLOS ONE
 Journal of Geophysical Research
 Ecological Modelling
 Medical Physics
 Aquaculture
 Environmental Modelling and Software
 Ecology
 Journal of Wildlife Management
 Expert Systems with Applications
 Science China – Mathematics
 Journal of Business and Economic Statistics
 Ocean Science
 Advances in Atmospheric Sciences
 Journal of Hydrometeorology
 Risk Analysis
 Econometrica
 Journal of Climate
 Journal of American Statistical Association
 Statistics and Computing
 Journal of Applied Sport Psychology

Environmental Science and Technology
IEICE Transactions on Fundamentals of Electronic Communications and Computer Sciences
American Journal of Physical Anthropology
Radiotherapy and Oncology
New Journal of Physics
Chemical Physics
Journal of Geriatric Oncology
Pattern Recognition Letters
Psychological Methods
Journal of Mathematical Psychology
Journal of Cardiac Failure
Journal of Clinical Periodontology
Applied Stochastic Models in Business and Industry
Statistics in Medicine
Biochemistry
Journal of Engineering Applications of Artificial Intelligence
Radiation and Environmental Biophysics
Journal of Occupational and Environmental Hygiene
PLOS – Neglected Tropical Diseases
Annals of Occupational Hygiene
Monthly Notices of the Royal Astronomical Society
American Physical Society
Annual Review of Nuclear and Particle Science
Annual Review of Nuclear and Particle Science: Letters
Molecular Biology and Evolution
Genetic Epidemiology
Psychonomic Bulletin and Review
Cognitive Radio Oriented Wireless Networks and Communications
Ground Water
Journal of Multivariate Analysis
Environmetrics
Journal of Political Economy
Crime Mapping: a Journal of Theory and Practice
The Annals of Applied Statistics
Systematic Biology
Forest Ecology and Management
Human Reproduction
Journal of Evolutionary Biology
Behavioral Ecology and Sociobiology
Sociological Methods and Research
Sociological Methodology
Time Series: Theory and Methods
Astronomy and Geophysics
Journal of Cosmology and Astroparticle Physics
Journal of Archaeological Science
Journal of Environmental Management

Also, there are several books devoted to the subject of model selection that include issues about multimodel inference. The essence of multimodel inference is also represented in methods such as ensembles, bagging (i.e., bootstrap aggregation), random forests, and boosting.

Some example citations of relevance (a skeptic might actually look at these):

Viallefont, V, A. E. Raftery, and S. Richardson. 2001. Variable selection and Bayesian model averaging in case-control studies. *Statistics in Medicine* 20:3215-3230.

Barbieri, M. M., and J. O. Berger. 2004. Optimal prediction model selection. *The Annals of Statistics* 32:870-897.

Hoeting, J. A., D. Madigan, A. E. Raftery, and C. T. Volinsky. 1999. Bayesian model averaging: A tutorial. *Statistical Science* 14:382-417.

Burnham, K. P., and D. R. Anderson. 2004. Multimodel inference: understanding AIC and BIC in model selection. *Sociological Methods & Research* 33:261-305.

Piegorsch, W. W., L. An, A. A. Wickens, R. W. West, E. A. Pena, and W. Wu. 2013. Information-theoretic model averaged benchmark dose analysis in environmental risk assessment. *Environmetrics* 24:143-157.

West, R. W., W. W. Piegorsch, E. A. Pena, L. An, W. Wu, A. A. Wickens, H. Xiong, and W. Chen. 2012. The impact of model uncertainty on benchmark dose estimation. *Environmetrics* 23:706-716.

Stoica, P., Y. Selen, and J. Li. 2004. Multi-model approach to model selection. *Digital Signal Processing* 14:399-412.

Wagenmakers, E-J. 2003. How many parameters does it take to fit an elephant? *Journal of Mathematical Psychology* 47:580-586.

Candolo, C. A. C. Davidson, and C. G. B. Demetrio. 2003. A note on model uncertainty in linear regression. *The Statistician* 52:165-177.

Hjort, N. L., and G. Claeskens. 2003. Frequentist model averaging estimators. *Journal of the American Statistical Association* 98:879-808.

Hjort, N. L., and G. Claeskens. 2006. Focused information criteria and model averaging for the Cox hazard regression model. *Journal of the American Statistical Association* 101:1449-1464.

Posada, D., and T. R. Buckley. 2004. Model selection and model averaging in phylogenetics: advantages of Akaike information criterion and Bayesian approaches over likelihood ratio tests. *Systematic Biology* 53:793-808.

Kieseppa, I. A. 1997. Akaike information criterion, curve-fitting, and the philosophical problem of simplicity. *British Journal of Philosophy* 48:21-48.

Longford, N. T. 2005. Editorial: Model selection and efficiency- is 'which model ...?' the right question? *Journal of the Royal Statistical Society, series A* 168:469-472.

Glattig, G., P. Kletting, S. N. Reske, K. Hohl, and C. Ring. 2007. Choosing the optimal fit function: comparison of the Akaike information criterion and the F-test. *Medical Physics* 34:4285-4292.

Lavoue, J. and P. O. Droz. 2009. Multimodel inference and multimodel averaging in empirical modeling of occupational exposure levels. *Annals of Occupational Hygiene* 53:173-180.

Katsanevakis, S. 2006. Modelling fish growth: model selection, multi-model inference and model selection uncertainty. *Fisheries Research* 81:229-235.

Wheeler, M. W., and A. J. Bailer. 2007. Properties of model-averaged BMDLs: a study of model averaging in Dichotomous response risk estimation. *Risk Analysis* 27:659-670.

Wheeler, M. W., and A. J. Bailer. 2009. Comparing model averaging with other model selection strategies for benchmark dose estimation. *Environmental and Ecological Statistics* 16:37-51

Nquefack-Tsague, G. and W. Zucchini. 2011. Post-model selection inference and model averaging. *Pakistan Journal of Statistics and Operation Research* 7, 347-361.

Ullah, A. and H. Wang. 2013. Parametric and nonparametric frequentist model selection and model averaging. *Econometrics* 1, 157-179.

Some titles that further illustrate the published scope of papers on multimodel inference (it is not being suggested that these should be looked at):

Jackson, C. H., S. G. Thompson, and L. D. Sharples. 2009. Accounting for uncertainty in economic decision models by using model averaging. *Journal of the Royal Statistical Society, Series A* 172:383-404.

Huang, C. J., and H-P. Liu. 2012. Estimation of stochastic frontier models based on multimodel inference. *Journal of Productivity Analysis* 38:273-284.

Biesiada, M. 2007. Information theoretic model selection applied to supernovae data. *Journal of Cosmology and Astroparticle Physics* 2007(2), doi:10.1088/1457-7516/2007/02/003 .

Brix, G., Z. Stefan, F. Kiessling, and J. Griebel. 2009. Pharmacokinetic analysis of tissue microcirculation using nested models: multimodel inference and parameter identifiability. *Medical Physics* 36:2923-2933.

- Fehme, S. E., L. A. Powell, and C. R. Allen. 2011. Multimodel inference and adaptive management. *Journal of Environmental Management* 92:1360-1364.
- O'Leary, M. 2010. Multimodel inference and geographic profiling. *Crime Mapping, a Journal of Theory and Practice* 2:50-64.
- Nichols, Luke. 2009. Multimodel inference for reserving. Brian Gray Memorial Scholarship Report, Department of Actuarial Studies, MacQuarie University, Australia.
- Poeter, E., and D. Anderson. 2005. Multimodel ranking and inference in ground water modelling. *Ground Water* 43:597-605.
- Wagenmakers, E-J, and S. Farrell. 2004. AIC model selection using Akaike weights. *Psychonomic Bulletin and Review* 11:192-196.
- Walsh, L., and J. C. Kaiser. 2011. Multi-model inference of adult and childhood leukaemia excess relative risks based on the Japanese A-bomb survivors mortality data (1950-2000). *Radiation and Environmental Biophysics* 50:21-35.
- Schollnberger, H. J., C. Kaiser, P. Jacob, and L. Walsh. 2012. Dose-responses from multi-model inference for the non-cancer disease mortality of atomic bomb survivors. *Radiation and Environmental Biophysics* 51:165-178.
- Lavoue, J., M. Gerin, and R. Vincent. 2011. Comparison of formaldehyde exposure levels in two multi-industry occupational exposure databanks using multimodel inference. *Journal of Occupational and Environmental Hygiene* 8:38-48.
- Alonso, A., and A. Laenen. 2013. Model uncertainty and multimodel inference in reliability estimation within a longitudinal framework. *British Journal of Mathematics and Statistical Psychology* 66:338-352.
- Tu, S. L., and L. Xu. 2012. A theoretical investigation of several model selection criteria for dimensionality reduction. *Pattern Recognition Letters* 33:1117-1126.
- Noble, R. B., A. J. Bailer, and R. Park. 2009. Model-averaged benchmark concentration estimates for continuous response data arising from epidemiological data. *Risk Analysis* 29:558-564.
- Johnson, D. S., and J. A. Hoeting. 2011. Bayesian multimodel inference for geostatistical regression models. *PLOS ONE* 6(11), DOI:10.1371/journal.pone.0025677.
- Minschwaner, K. A. E. Dressler, and P. Sawaengphokhai. 2006. Multimodel analysis of water vapor feedback in the tropical upper troposphere. *Journal of Climate* 19:5455-5464.

- Vardanyan, M., R. Trotta, and J. Silk. 2011. Applications of Bayesian model averaging to the curvature and size of the universe. *Monthly Notices of the Royal Astronomical Society: Letters* 413:L91-L95.
- Zhang, S. W., D. Q. Li, and C. J. Qiu. 2011. A multimodel ensemble-based Kalman filter for the retrieval of soil moisture profiles. *Advances in Atmospheric Sciences* 28:195-206.
- Castle, J. L., X. C. Qin, and W. R. Reed. 2013. Using model selection algorithms to obtain reliable coefficient estimates. *Journal of Economic Surveys* 27:269-296.
- Katsanevakis, S., and C. D. Maravelias. 2008. Modelling fish growth: multi-model inference as a better alternative to *a priori* using von Bertalanffy equation. *Fish and Fisheries* 9:178-187.
- Barth, D., and V. Kapatsinski. 2014. A multimodel inference approach to categorical variant choice: construction, priming and frequency effects on the choice between full and contracted forms of *am*, *are* and *is*. *Corpus Linguistics and Linguistic Theory*. Published online 2014-10-07, DOI:10.1515/clit-2014-0022 .
- Gomes, M. F.C., A. P. Piontti, L. Rossi, D. Chao, I. Longini, M. E. Halloran, A. Vespignan. 2014. Assessing the International spreading risk associated with the 2014 West African Ebola outbreak. *PLOS Current Outbreaks*, published online Sep. 2, 2014.
- Millington, J. D. A., and G. L. W. Perry. 2011. Multi-model inference in Biogeography. *Geography Compass* 5:448-463.
- Klaich, M. J., M. E. Re, and S. N. Pedraza. 2008. Gross growth efficiency as a function of food intake level in the “Pulchro” octopus *tehuatlensis*: A multimodel inference application. *Aquaculture* 284:272-276.
- Perez, B., R. Brouwer, J. Beckers, D. Paradis, C. Balseiro, K. Lyons, M. Cure, M. G. Sotillo, B. Hackett, M. Verlaan, and E. A. Fanjul. 2012. ENSURF: multi-model sea level forecast – implementation and validation results for the IBIROOS and Western Mediterranean regions. *Ocean Science* 8:211-226.
- Liddle, A. R. 2009. Statistical methods for cosmology parameter selection and estimation. *Annual Review of Nuclear and Particle Science* 59:95-114.
- Bryant, W. I. and D. M. Carlisle. 2012. The relative importance of physicochemical factors to stream biological condition in urbanizing basins: evidence from multimodel inference. *Freshwater science* 31: 154-166.
- Kang, B., B. Lee, K. W. Kang, J. C. Suh, and E. S. Yoon. 1999. AHA: A knowledge based system for automatic hazard identification in chemical plant by multimodel approach. *Expert Systems with Applications* 16:183-195.

Bohn, T. J., M. Y. Sonessa, D. P. Lettenmaier. 2010. Seasonal hydrologic forecasting: do multimodel ensemble averages always yield improvements in forecasting skill? *Journal of Hydrometeorology* 11:1358-1372.

Scinocca, J. F., D. B. Stephenson, T. C. Bailey, and J. Austin. 2010. Estimates of past and future ozone trends from multimodel simulations using a flexible smoothing spline methodology. *Journal of Geophysical Research* 115, D00M12, doi:[10.1029/2009JD013622](https://doi.org/10.1029/2009JD013622).

McDonald, C. P., N. R. Urban. 2010. Using a model selection criterion to identify appropriate complexity in aquatic biogeochemical models. *Ecological Modelling* 221:428-432.

Wang, Z., M. J. Small, and A.K. Karamalidis. 2013. Multimodel predictive systems for carbon dioxide solubility in saline formation waters. *Environmental Science and Technology* 47:1407-1415.

Abad-Franch, F., et al. 2012. Mayaro virus infection in Amazonia: a multimodel inference approach to risk factor assessment. *PLoS: Neglected Tropical Diseases* 6(10), DOI: 10.1371/journal.pntd.0001846.

Ghosh, D., and Z. Yuan. 2009. An improved model averaging scheme for logistic regression. *Journal of Multivariate Analysis* 100:1670-1681.

Rozet, E., E. Ziemons, R. D. Marini, and Ph. Hubert. 2013. Usefulness of information criteria for the selection of calibration curves. *Analytical Chemistry* 85:6327-6335.

Eve, S. J., and E. R. Crema. 2014. A house with a view? Multi-model inference, visibility fields, and point process analysis of a Bronze age settlement on Leskernick Hill (Cornwall, UK). *Journal of Archaeological Science* 43:267-277.

Hansen, B. E. 2008. Least squares forecast averaging. *Journal of Econometrics* 146:342-350.

Zhang, X. 2015. Consistency of model averaging estimators. *Economic Letters* 130:120-123.

There are more, but this demonstrates that multimodel inference is used and explored in many journals.

(December 18, 2014, but with a few additions after then)

Some more published papers where multimodel inference has being studied and/or used.

Buckland, S. T., K. P. Burnham and N. H. Augustin. 1997. Model selection: An integral part of inference. *Biometrics* 53, 603-618.

Fletcher, D. and P.W. Dillingham. 2011. Model-averaged confidence intervals for factorial experiments. *Computational Statistics and Data analysis* 55, 3041-3048.

Moral-Benito, E. 2015. Model averaging in economics: an overview. *Journal of Economic Surveys* 29, 46-75.

Stoics, P., Y. Selen and J. Li. 2004. Multi-model approach to model selection. *Digital Signal Processing* 14, 399-412.

Akaike, H. 1978. On the likelihood of a time series. *The Statistician* 27, 217-235.
(it was in about 1978 that Akaike proposed the AIC based likelihood of a model, and then model averaging)

Schomaker, M., A. T. K. Wan and C. Heumann. 2010. Frequentist model averaging with missing observations. *Computational Statistics and Data Analysis* 54, 3336-3347.

Kapetanios, G., V. Labhard and S. Price. 2008. Forecasting using Bayesian and information-theoretic model averaging. *Journal of Business and Economic Statistics* 26, 33-41.

Clyde, M. 2000. Model uncertainty and health effect studies for particulate matter. *Environmetrics* 11, 745-763.

Zhang, X and G. Zou. 2014. Model averaging and weight choice in linear mixed-effects models. *Biometrika* 101, 205-218.

Wang, H., G. Zou and A. T. K. Wan. 2012. Model averaging for varying-coefficient partially linear measurement error models. *Electronic Journal of Statistics* 6, 1017-1039.

Nquefack-Tsague, G. 2014. On optimal weighting scheme in model averaging. *American Journal of Applied Mathematics and Statistics* 2, 150-156.

Aitkin, M., C. C. Liu, and T. Chadwick. 2009. Bayesian model comparison and model averaging for small-area estimation. *The Annals of Applied Statistics* 3, 199-221.

Bartels, L. M. 1997. Specification uncertainty and model averaging. *American Journal of Political Science* 41, 641-674.

Fritzgerald, D. J., and N. I. Robinson. 2007. Development of a tolerable daily intake for *N*-Nitrosodimethylamine using a modified benchmark dose methodology. *Journal of Toxicology and Environmental Health, Part A* 70, 1670-1678.

Breiman, L., and D. Freedman. 1983. How many variables should be entered in a regression equation. *Journal of the American Statistical Association* 78, 131-136.

Brodziak, J., and K. Piner. 2009. Model averaging and probable status of North Pacific striped marlin, *Tetrapturus audax*. *Canadian Journal of Fisheries and Aquatic Science* 67, 793-805.

Castaneda, J., and M. Aerts. 2015. Accounting for model selection uncertainty: model averaging of prevalence and force of infection using fractional polynomials. *Revista Colombiana de Estadística* 38, 163-179.

Mazerolle, M. J. 2006. Improving data analysis in herpetology: using Akaike's Information Criterion (AIC) to assess the strength of biological hypotheses. *Amphibia-Reptilia* 27, 169-180.

Claeskens, G. (in press for April 2016). Statistical model choice. *Annual Review of Statistics and its Application* 3, xxx-xxx.

Candolo, C. 2014. The focused information criterion in logistic regression to predict repair of dental restorations. *Brazilian Journal of Biometrics* 31, 547-557.

Bozdogan, H. 1987. Model selection and Akaike's information criterion (AIC): The general theory and its analytical extensions. *Psychometrika* 52, 345-370.

Hollister, J. W., P. V. August, J. F. Paul, and H. A. Walker. 2008. Predicting estuarine sediment metal concentrations and inferred ecological conditions: An information theoretic approach. *Journal of Environmental Quality* 37, 234-244.

McQuarrie, A. D. R., and C-L Tsai. 1998. *Regression and Time Series Model Selection*. World Scientific, Singapore, 455 pp.

(A book; there are at least a dozen books on model selection. There is nothing in this one on multimodel inference.)

Yang, Y. 2003. Can the strengths of AIC and BIC be shared? A conflict between model identification and regression estimation. *Biometrika* 92, 937-950.

Rolling, C. A., and Y. Yang. 2014. Model selection for estimating treatment effects. *Journal of the Royal Statistical Society, Series B* 76, 749-769.

Ghosh, J., and A. Ghattas. 2015. Bayesian variable selection under collinearity. *The American Statistician* 69:165-173.

(K. P. Burnham and D. R. Anderson
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