Quarterly Journal of the Royal Meteorological Society / Volume 128, Issue 581 / pp. 747-774

Research Article

The economic value of ensemble forecasts as a tool for risk assessment: From days to decades

T. N. Palmer

First published: April 2002 Part A

https://doi.org/10.1256/0035900021643593

Abstract

Despite the revolutionary development of numerical weather and climate prediction (NWCP) in the second half of the last century, quantitative interaction between model developers and forecast customers has been rather limited. This is apparent in the diverse ways in which weather forecasts are assessed by these two groups: root-mean-square error of 500 hPa height on the one hand; pounds, euros or dollars saved on the other.

These differences of approach are changing with the development of ensemble forecasting. Ensemble forecasts provide a qualitative tool for the assessment of weather and climate risk for a range of user applications, and on a range of time-scales, from days to decades. Examples of the commercial application of ensemble forecasting, from electricity generation, ship routeing, pollution modelling, weather-risk finance, disease prediction and crop yield modelling, are shown from all these time-scales.

A generic user decision model is described that allows one to assess the potential economic value of numerical weather and climate forecasts for a range of customers. Using this, it is possible to relate analytically, potential economic value to conventional meteorological skill scores. A generalized meteorological measure of forecast skill is proposed which takes the distribution of customers into account. It is suggested that when customers' exposure to weather or climate risk can be quantified, such more generalized measures of skill should be used in assessing the

Buizza, R. and Palmer, T. N. 1995 The singular vector structure of the atmospheric global circulation. *J. Atmos. Sci.*, **52**, 1434–1456

Web of Science® | Google Scholar

Doblas-Reyes, F. J., Déqué, M. and Piedlievre, J.-P. 2000 Multi-model spread and probabilistic seasonal forecasts in PROVOST. *Q. J. R. Meteorol.Soc.*, **126**, 2069–2088

Web of Science® | Google Scholar

ECMWF 2000 *'The first twenty-five years (1975–2000)'*. European Centre for Medium-Range Weather Forecasts, Shinfield Park, Reading, RG2 9AX, UK

Google Scholar

Ehrendorfer, M. 1994 The Liouville equation and its potential usefulness for the prediction of forecast skill. Part I. Theory. *Mon. Weather Rev.*, **122**, 703–713

Web of Science® | Google Scholar

Ehrendorfer, M. and Murphy, A. H. 1988 Comparative evaluation of weather forecasting systems: sufficiency, quality and accuracy. *Mon. Weather Rev.*, **116**, 1757–1770

Web of Science® | Google Scholar

Evans, R. E., Harrison, M. S. J., Graham, R. J. and Mylne, K. R. 2000 Joint medium-range ensembles from the Met Office and ECMWF systems. *Mon. Weather Rev.*, **128**, 3104–3127

Web of Science® | Google Scholar

Foresight 2001 'Seasonal weather forecasting for the food chain'. Final report of the Foresight Seasonal Weather Forecasting for the Food Chain Steering Group. Ed. J. Griffin. (Available at www.foresight.gov.uk/fcci)

Google Scholar

Graham, R. J., Evans, A. D. L., Mylne, K. R., Harrison, M. S. J. and Robertson, K. B. 2000 An assessment of seasonal predictability using atmospheric general circulation models. *Q. J. R. Meteorol. Soc.*, **126**, 2211–2240

Web of Science® | Google Scholar

Harrison, M., Palmer, T. N., Richardson, D. S. and Buizza, R. 1999 Analysis and model dependencies in medium-range ensembles: Two transplant case-studies. *Q. J. R. Meteorol. Soc.*, **125**, 2487–2515

Web of Science® | Google Scholar

Hoffschildt, M., Bidlot, J.-R., Hansen, B. and Janssen, P. A. E. M. 1999 'Potential benefit of ensemble forecasts for ship routeing'. ECMWF Technical Memorandum 287. ECMWF, Reading, UK

Google Scholar

Houtekamer, P. L., Lefaivre, L., Derome, J., Richie, H. and Mitchell, H. L. 1996 A system approach to ensemble prediction. *Mon. Weather Rev.*, **124**, 1225–1242

Web of Science® | Google Scholar

IPCC 2001 'Climate change 2001: The scientific basis'. *Contribution of Working Group I to the third Assessment Report of the Intergovernmental Panel on Climate Change*. J. T. Houghton, Y. Ding, D. J. Griggs, M. Noguer, P. J. Van der Linden, X. Dai, K. Maskell and C. A. Johnson, Eds. Cambridge University Press, Cambridge and New York

Google Scholar

R. W. Katz and A. H. Murphy (Eds.) 1997 *Economic value of weather and climate forecasts*. Cambridge University Press

Google Scholar

Krishnamurti, T. N., Kishtawal, C. M., Zhang, Z., LaRow, T., Bachiochi, D. and Williford, E. 2000 Multimodel ensemble forecasts for weather and sesaonal climate. *J. Climate*, **13**, 4196–4216

Web of Science® | Google Scholar

Google Scholar

Mason, B. J. 1966 The role of meteorology in the national economy. *Weather*, **21**, 382–393

Google Scholar

Meehl, G. A., Boer, G. J., Covey, C., Latif, M. and Stouffer, R. J. 2000 The coupled model intercomparison project. *Bull. Am. Meteorol. Soc.*, **81**, 313–318

Google Scholar

Molteni, F., Buizza, R., Palmer, T. N. and Petroliagis, T. 1996 The ECMWF ensemble prediction system: Methodology and validation. *Q. J. R. Meteorol. Soc.*, **122**, 73–119

Web of Science® Google Scholar

Murphy, A. H. 1977 The value of climatological, categorical and probabilistic forecasts in the cost–loss ratio situation. *Mon. Weather Rev.*, **105**, 803–816

Web of Science® Google Scholar

Murphy, A. H. and Ehrendorfer, M. 1987 On the relationship between the accuracy and value of forecasts in the cost–loss ratio situation. *Weather and Forecasting*, **2**, 243–251

Google Scholar

Palmer, T. N. 2000 Predicting uncertainty in forecasts of weather and climate. *Rep. Prog. Phys.*, **63**, 71–116

Web of Science® Google Scholar

2001 A nonlinear dynamical perspective on model error: A proposal for non-local stochastic-dynamic parametrization in weather and climate prediction models. *Q. J. R. Meteorol. Soc.*, **127**, 279–304

Web of Science® Google Scholar

CAS | PubMed | Web of Science® | Google Scholar

Palmer, T. N., Brankovic, C. and Richardson, D. S. 2000 A probability and decision-model analysis of PROVOST seasonal multi-model ensemble integrations. *Q. J. R. Meteorol. Soc.*, **126**, 2013–2033

Web of Science® | Google Scholar

Poincaré, H. 1909 *Science and method*. Reprinted by Dover Publications, 1952

Google Scholar

PROVOST 2000 Special issue, No. 567. *Q. J. R. Meteorol. Soc.*, **126**, 1989–2350

Google Scholar

Räisänen, J. and Palmer, T. N. 2001 A probability and decision-model analysis of a multi-model ensemble of climate change simulations. *J. Climate*, **14**, 3212–3226

Web of Science® | Google Scholar

Richardson, D. S. 2000a Skill and relative economic value of the ECMWF ensemble prediction system. *Q. J. R. Meteorol. Soc.*, **126**, 649–668

Web of Science® | Google Scholar

2000b 'Applications of cost–loss models'. Proceedings of seventh workshop on meteorological operational systems. ECMWF, Reading, UK

Google Scholar

2001 Measures of skill and value of ensemble prediction systems, their interrelationship and the effect of ensemble size. *Q. J. R. Meteorol. Soc.*, **127**, 2473–2489

Web of Science® | Google Scholar

Google Scholar

Stanski, H. R., Wilson, L. J. and Burrows, W. R. 1989 'Survey of common verification methods in meteorology'. WMO WWW Tech. Report No. 8, WMO, TD No. 358

Google Scholar

Stockdale, T. N., Anderson, D. L. T., Alves, J. O. S. and Balmaseda, M. A. 1998 Global seasonal rainfall forecasts using a coupled ocean–atmosphere model. *Nature*, **392**, 370–373

CAS | Web of Science® | Google Scholar

Taylor, J. W. and Buizza, R. 2002 Using weather ensemble predictions in electricity demand forecasting. *Int. J. Forecasting.* In press

Google Scholar

Thompson, J. C. 1952 On the operational deficiencies in categorical weather forecasts. *Bull. Am. Meteorol. Soc.*, **33**, 223–226

Web of Science® | Google Scholar

Thomson, M. C. and Connor, S. J. 2001 The development of malaria early warning systems for Africa. *Trends in parasitology*, **17**, 9438–9445

Web of Science® | Google Scholar

Thomson, M. C., Palmer, T. N., Morse, A. P., Cresswell, M. and Connor, S. J. 2000 Forecasting disease risk with seasonal climate predictions. *Lancet*, **355**, 1559–1560

CAS | PubMed | Web of Science® | Google Scholar

Thornes, J. E. and Stephenson, D. B. 2001 How to judge the quality and value of weather forecast products. *Meteorol. Apps.*, **8**, 307–314

Wandishin, M. S., Mullen, S. L., Stensrud, D. J. and Brooks, H. E. 2001 Evalulation of a short-range multi-model ensemble system. *Mon. Weather Rev.*, **129**, 729–747

Web of Science® | Google Scholar

Wilks, D. S. 1995 *Statistical methods in the atmospheric sciences*. Academic Press, London

Google Scholar

Wilks, D. S. and Hamill, T. M. 1995 Potential economic value of ensemble forecasts. *Mon. Weather Rev.*, **123**, 3565–3575

Web of Science® | Google Scholar

Citing Literature

Download PDF