

# References

- Abramowitz, M., Stegun, I.A. (Eds.), 1984. *Pocketbook of Mathematical Functions*. Frankfurt, Verlag Harri Deutsch. 468 pp.
- Accadia, C., Mariani, S., Casaioli, M., Lavagnini, A., 2003. Sensitivity of precipitation forecast skill scores to bilinear interpolation and a simple nearest-neighbor average method on high-resolution verification grids. *Weather Forecast.* 18, 918–932.
- Agresti, A., 1996. *An Introduction to Categorical Data Analysis*. Wiley. 290 pp.
- Agresti, A., Coull, B.A., 1998. Approximate is better than “exact” for interval estimation of binomial proportions. *Am. Stat.* 52, 119–126.
- Ahijevych, D., Gilleland, E., Brown, B.G., Ebert, E.E., 2009. Application of spatial verification methods to idealized and NWP-gridded precipitation forecasts. *Weather Forecast.* 24, 1485–1497.
- Ahrens, B., Jaun, S., 2007. On evaluation of ensemble precipitation forecasts with observation-based ensembles. *Adv. Geosci.* 10, 139–144.
- Akaike, H., 1974. A new look at the statistical model identification. *IEEE Trans. Autom. Control* 19, 716–723.
- Alfaro, E.J., Chourio, X., Muñoz, A.G., Mason, S.J., 2018. Improved seasonal prediction skill of rainfall for the Primera season in Central America. *Int. J. Climatol.* 38 (Suppl. 1), e255–e268.
- Allen, M.R., Robertson, A.W., 1996. Distinguishing modulated oscillations from coloured noise in multivariate datasets. *Clim. Dyn.* 12, 775–784.
- Allen, M.R., Smith, L.A., 1996. Monte Carlo SSA: detecting irregular oscillations in the presence of colored noise. *J. Clim.* 9, 3373–3404.
- Ambaum, M.H.P., 2010. Significance tests in climate science. *J. Clim.* 23, 5927–5932.
- Anderson, J.L., 1996. A method for producing and evaluating probabilistic forecasts from ensemble model integrations. *J. Clim.* 9, 1518–1530.
- Anderson, J.L., 1997. The impact of dynamical constraints on the selection of initial conditions for ensemble predictions: low-order perfect model results. *Mon. Weather Rev.* 125, 2969–2983.
- Andrews, D.F., Gnanadesikan, R., Warner, J.L., 1971. Transformations of multivariate data. *Biometrics* 27, 825–840.
- Andrews, D.F., Bickel, P.J., Hampel, F.R., Huber, P.J., Rogers, W.N., Tukey, J.W., 1972. *Robust Estimates of Location—Survey and Advances*. Princeton University Press.
- Anscombe, F.J., 1973. Graphs in statistical analysis. *Am. Stat.* 27, 17–21.
- Applequist, S., Gahrs, G.E., Pfeffer, R.L., 2002. Comparison of methodologies for probabilistic quantitative precipitation forecasting. *Weather Forecast.* 17, 783–799.
- Araneo, D.C., Compagnucci, R.H., 2004. Removal of systematic biases in S-mode principal components arising from unequal grid spacing. *J. Clim.* 17, 394–400.
- Armstrong, J.S., 2001. Evaluating forecasting methods. In: Armstrong, J.S. (Ed.), *Principles of Forecasting: A Handbook for Researchers and Practitioners*. Kluwer, pp. 443–472.
- Atger, F., 1999. The skill of ensemble prediction systems. *Mon. Weather Rev.* 127, 1941–1953.
- Azcarraga, R., and A.J. Ballester G., 1991. Statistical system for forecasting in Spain. In: H.R. Glahn, A.H. Murphy, L.J. Wilson, and J.S. Jensenius, Jr., eds., *Programme on Short- and Medium-Range Weather Prediction Research*. World Meteorological Organization WM/TD No. 421, XX, 23–25.
- Baars, J.A., Mass, C.F., 2005. Performance of National Weather Service forecasts compared to operational, consensus, and weighted model output statistics. *Weather Forecast.* 20, 1034–1047.
- Baker, D.G., 1981. Verification of fixed-width, credible interval temperature forecasts. *Bull. Am. Meteorol. Soc.* 62, 616–619.
- Baldwin, M.P., Stephenson, D.B., Jolliffe, I.T., 2009. Spatial weighting and iterative projection methods for EOFs. *J. Clim.* 22, 234–243.

- Bamber, D., 1975. The area above the ordinal dominance graph and the area below the receiver operating characteristic graph. *J. Math. Psychol.* 12, 387–415.
- Banfield, J.D., Raftery, A.E., 1993. Model-based Gaussian and non-Gaussian clustering. *Biometrics* 49, 803–821.
- Baran, S., 2014. Probabilistic wind speed forecasting using Bayesian model averaging with truncated normal components. *Comput. Stat. Data Anal.* 75, 227–238.
- Baran, S., Lerch, S., 2015. Log-normal distribution based ensemble model output statistics models for probabilistic wind-speed forecasting. *Q. J. R. Meteorol. Soc.* 141, 2289–2299.
- Baran, S., Lerch, S., 2016. Mixture EMOS model for calibrating ensemble forecasts of wind speed. *Environmetrics* 27, 116–130.
- Baran, S., Möller, A., 2015. Joint probabilistic forecasting of wind speed and temperature using Bayesian model averaging. *Environmetrics* 26, 120–132.
- Baran, S., Möller, A., 2017. Bivariate ensemble model output statistics approach for joint forecasting of wind speed and temperature. *Meteorol. Atmos. Phys.* 129, 99–112.
- Baran, S., Nemoda, D., 2016. Censored and shifted gamma distribution based EMOS model for probabilistic quantitative precipitation forecasting. *Environmetrics* 27, 280–292.
- Bárdossy, A., Pegram, G.G.S., 2009. Copula based multisite model for daily precipitation simulation. *Hydrol. Earth Syst. Sci.* 13, 2299–2314.
- Bárdossy, A., Plate, E.J., 1992. Space-time model for daily rainfall using atmospheric circulation patterns. *Water Resour. Res.* 28, 1247–1259.
- Barnes, L.R., Schultz, D.M., Grunfest, E.C., Hayden, M.H., Benight, C.C., 2009. False alarm rate or false alarm ratio? *Weather Forecast.* 24, 1452–1454.
- Barnett, T.P., Preisendorfer, R.W., 1987. Origins and levels of monthly and seasonal forecast skill for United States surface air temperatures determined by canonical correlation analysis. *Mon. Weather Rev.* 115, 1825–1850.
- Barnston, A.G., 1994. Linear statistical short-term climate predictive skill in the northern hemisphere. *J. Clim.* 7, 1513–1564.
- Barnston, A.G., van den Dool, H.M., 1993. A degeneracy in cross-validated skill in regression-based forecasts. *J. Clim.* 6, 963–977.
- Barnston, A.G., Glantz, M.H., He, Y., 1999. Predictive skill of statistical and dynamical climate models in SST forecasts during the 1997–1998 El Niño episode and the 1998 La Niña onset. *Bull. Am. Meteorol. Soc.* 80, 217–243.
- Barnston, A.G., Mason, S.J., Goddard, L., DeWitt, D.G., Zebiak, S.E., 2003. Multimodel ensembling in seasonal climate forecasting at IRI. *Bull. Am. Meteorol. Soc.* 84, 1783–1796.
- Batté, L., Doblas-Reyes, F.J., 2015. Stochastic atmospheric perturbations in the EC-Earth3 global coupled model: impact of SPPT on seasonal forecast quality. *Clim. Dyn.* 45, 3419–3439.
- Baughman, R.G., Fuquay, D.M., Mielke Jr., P.W., 1976. Statistical analysis of a randomized lightning modification experiment. *J. Appl. Meteorol.* 15, 790–794.
- Ben Bouallègue, Z., 2016. Statistical postprocessing of ensemble global radiation forecasts with penalized quantile regression. *Meteorol. Z.* <https://doi.org/10.1127/metz/2016/0748>.
- Ben Bouallègue, Z., Pinson, P., Friederichs, P., 2015. Quantile forecast discrimination and value. *Q. J. R. Meteorol. Soc.* 141, 3415–3424.
- Benedetti, R., 2010. Scoring rules for forecast verification. *Mon. Weather Rev.* 138, 203–211.
- Bengtsson, L., Steinheimer, M., Bechtold, P., Geleyn, J.-F., 2013. A stochastic parametrization for deep convection using cellular automata. *Q. J. R. Meteorol. Soc.* 139, 1533–1543.
- Benjamini, Y., Hochberg, Y., 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. *J. R. Stat. Soc. Ser. B Methodol.* 57, 289–300.
- Bentzien, S., Friederichs, P., 2012. Generating and calibrating probabilistic quantitative precipitation forecasts from the high-resolution NWP model COSMO-DE. *Weather Forecast.* 27, 988–1002.
- Bentzien, S., Friederichs, P., 2014. Decomposition and graphical portrayal of the quantile score. *Q. J. R. Meteorol. Soc.* 140, 1924–1934.
- Beran, R., Srivastava, M.S., 1985. Bootstrap tests and confidence regions for functions of a covariance matrix. *Ann. Stat.* 13, 95–115.
- Berner, J., Doblas-Reyes, F.J., Palmer, T.N., Shutts, G.J., Weisheimer, A., 2010. Impact of a quasi-stochastic cellular automaton backscatter scheme on the systematic error and seasonal prediction skill of a global climate model. In: Palmer, T., Williams, P. (Eds.), *Stochastic Physics and Climate Modeling*. Cambridge University Press, Cambridge, pp. 375–395.

- Berner, J., Fossell, K.R., Ha, S.-Y., Hacker, J.P., Snyder, C., 2015. Increasing the skill of probabilistic forecasts: understanding performance improvements from model-error representations. *Mon. Weather Rev.* 143, 1295–1320.
- Berner, J., et al., 2017. Stochastic parameterization: toward a new view of weather and climate models. *Bull. Am. Meteorol. Soc.* 98, 565–587.
- Berrocal, V.J., Raftery, A.E., Gneiting, T., 2007. Combining spatial statistical and ensemble information in probabilistic weather forecasts. *Mon. Weather Rev.* 135, 1386–1402.
- Beyth-Marom, R., 1982. How probable is probable? A numerical translation of verbal probability expressions. *J. Forecast.* 1, 257–269.
- Bickel, P.J., Bühlmann, P., 1999. A new mixing notion and functional central limit theorems for a sieve bootstrap in time series. *Bernoulli* 5, 413–446.
- Bien, J., Tibshirani, R., 2011. Hierarchical clustering with prototypes via minimax linkage. *J. Am. Stat. Assoc.* 106, 1075–1084.
- Bishop, C.H., Shanley, K.T., 2008. Bayesian model averaging's problematic treatment of extreme weather and a paradigm shift that fixes it. *Mon. Weather Rev.* 136, 4641–4652.
- Bjerknes, J., 1969. Atmospheric teleconnections from the equatorial Pacific. *Mon. Weather Rev.* 97, 163–172.
- Blackmon, M.L., 1976. A climatological spectral study of the 500 mb geopotential height of the northern hemisphere. *J. Atmos. Sci.* 33, 1607–1623.
- Bloomfield, P., Steiger, W., 1980. Least absolute deviations curve-fitting. *SIAM J. Sci. Stat. Comput.* 1, 290–301.
- Blunden, J., Arndt, D.S. (Eds.), 2015. State of the climate in 2014. *Bull. Am. Meteorol. Soc.* 96, S1–S267.
- Bonavita, M., Isaksen, L., Hólm, E., 2012. On the use of EDA background error variances in the ECMWF 4D-Var. *Q. J. R. Meteorol. Soc.* 138, 1540–1559.
- Boswell, M.T., Gore, S.D., Patil, G.P., Taillie, C., 1993. The art of computer generation of random variables. In: Rao, C.R. (Ed.), *Handbook of Statistics*. In: vol. 9. Elsevier, pp. 661–721.
- Bowler, N.E., 2006. Explicitly accounting for observation error in categorical verification of forecasts. *Mon. Weather Rev.* 134, 1600–1606.
- Bowler, N.E., 2008. Accounting for the effect of observation errors on verification of MOGREPS. *Meteorol. Appl.* 15, 199–205.
- Bowler, N.E., Mylne, K.R., 2009. Ensemble transform Kalman filter perturbations for a regional ensemble prediction system. *Q. J. R. Meteorol. Soc.* 135, 757–766.
- Bowler, N.E., Arribas, A., Mylne, K.R., Robertson, K.B., Beare, S.E., 2008. The MOGREPS short-range ensemble prediction system. *Q. J. R. Meteorol. Soc.* 134, 703–722.
- Box, G.E.P., Cox, D.R., 1964. An analysis of transformations. *J. R. Stat. Soc. Ser. B Methodol.* 26, 211–243.
- Box, G.E.P., Jenkins, G.M., 1976. *Time Series Analysis: Forecasting and Control*. Holden-Day, San Francisco, CA. 575 pp.
- Bradley, A.A., Schwartz, S.S., 2011. Summary verification measures and their interpretation for ensemble forecasts. *Mon. Weather Rev.* 139, 3075–3089.
- Bradley, A.A., Hashino, T., Schwartz, S.S., 2003. Distributions-oriented verification of probability forecasts for small data samples. *Weather Forecast.* 18, 903–917.
- Bradley, A.A., Schwartz, S.S., Hashino, T., 2008. Sampling uncertainty and confidence intervals for the Brier score and Brier Skill score. *Weather Forecast.* 23, 992–1006.
- Bras, R.L., Rodríguez-Iturbe, I., 1985. *Random Functions and Hydrology*. Addison-Wesley. 559 pp.
- Bratley, P., Fox, B.L., Schrage, L.E., 1987. *A Guide to Simulation*. Springer. 397 pp.
- Braverman, A., Cressie, N., Teixeira, J., 2011. A likelihood-based comparison of temporal models for physical processes. *Stat. Anal. Data Min.* 4, 247–258.
- Breiman, L., 1996. Bagging predictors. *Mach. Learn.* 24, 123–140.
- Breiman, L., 2001. Random forests. *Mach. Learn.* 45, 5–32.
- Breiman, L., Friedman, J., Stone, C.J., Olshen, R.A., 1984. *Classification and Regression Trees*. CRC Press. 368 pp.
- Brelsford, W.M., Jones, R.H., 1967. Estimating probabilities. *Mon. Weather Rev.* 95, 570–576.
- Bremnes, J.B., 2004. Probabilistic forecasts of precipitation in terms of quantiles using NWP model output. *Mon. Weather Rev.* 132, 338–347.
- Bretherton, C.S., Smith, C., Wallace, J.M., 1992. An intercomparison of methods for finding coupled patterns in climate data. *J. Clim.* 5, 541–560.
- Bretherton, C.S., Widmann, M., Dymnikov, V.P., Wallace, J.M., Bladé, I., 1999. The effective number of spatial degrees of freedom of a time-varying field. *J. Clim.* 12, 1990–2009.

- Brier, G.W., 1950. Verification of forecasts expressed in terms of probabilities. *Mon. Weather Rev.* 78, 1–3.
- Brier, G.W., Allen, R.A., 1951. Verification of weather forecasts. In: Malone, T.F. (Ed.), *Compendium of Meteorology*. American Meteorological Society, pp. 841–848.
- Briggs, W.M., Levine, R.A., 1997. Wavelets and field forecast verification. *Mon. Weather Rev.* 125, 1329–1341.
- Briggs, W., Pocernich, M., Ruppert, D., 2005. Incorporating misclassification error in skill assessment. *Mon. Weather Rev.* 133, 3382–3392.
- Brill, K.F., 2009. A general analytic method for assessing sensitivity to bias of performance measures for dichotomous forecasts. *Weather Forecast.* 24, 307–318.
- Bröcker, J., 2008. Some remarks on the reliability of categorical probability forecasts. *Mon. Weather Rev.* 136, 4488–4502.
- Bröcker, J., 2009. Reliability, sufficiency, and the decomposition of proper scores. *Q. J. R. Meteorol. Soc.* 135, 1512–1519.
- Bröcker, J., 2010. Regularized logistic models for probabilistic forecasting and diagnostics. *Mon. Weather Rev.* 138, 592–604.
- Bröcker, J., 2012a. Probability forecasts. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification, A Practitioner's Guide in Atmospheric Science*, second ed. Wiley-Blackwell, pp. 119–139.
- Bröcker, J., 2012b. Estimating reliability and resolution of probability forecasts through decomposition of the empirical score. *Clim. Dyn.* 39, 655–667.
- Bröcker, J., 2012c. Erratum to: Estimating reliability and resolution of probability forecasts through decomposition of the empirical score. *Clim. Dyn.* 39, 3123.
- Bröcker, J., 2012d. Evaluating raw ensembles with the continuous ranked probability score. *Q. J. R. Meteorol. Soc.* 138, 1611–1617.
- Bröcker, J., Smith, L.A., 2007a. Scoring probabilistic forecasts: the importance of being proper. *Weather Forecast.* 22, 382–388.
- Bröcker, J., Smith, L.A., 2007b. Increasing the reliability of reliability diagrams. *Weather Forecast.* 22, 651–661.
- Bröcker, J., Smith, L.A., 2008. From ensemble forecasts to predictive distribution functions. *Tellus A* 60A, 663–678.
- Brooks, C.E.P., Carruthers, N., 1953. *Handbook of Statistical Methods in Meteorology*. Her Majesty's Stationery Office, London. 412 pp.
- Brooks, H.E., Doswell III, C.A., Kay, M.P., 2003. Climatological estimates of local daily tornado probability for the United States. *Weather Forecast.* 18, 626–640.
- Bross, I.D.J., 1953. *Design for Decision*. Macmillan, New York. 276 pp.
- Brown, B.G., Katz, R.W., 1991. Use of statistical methods in the search for teleconnections: past, present, and future. In: Glantz, M., Katz, R.W., Nicholls, N. (Eds.), *Teleconnections Linking Worldwide Climate Anomalies*. Cambridge University Press, 371–400.
- Brunet, N., Verret, R., Yacowar, N., 1988. An objective comparison of model output statistics and “perfect prog” systems in producing numerical weather element forecasts. *Weather Forecast.* 3, 273–283.
- Buell, C.E., 1979. On the physical interpretation of empirical orthogonal functions. In: *Preprints, 6th Conference on Probability and Statistics in the Atmospheric Sciences*. American Meteorological Society, 112–117.
- Bühlmann, P., 1997. Sieve bootstrap for time series. *Bernoulli* 3, 123–148.
- Bühlmann, P., 2002. Bootstraps for time series. *Stat. Sci.* 17, 52–72.
- Buizza, R., 1997. Potential forecast skill of ensemble prediction and ensemble spread and skill distributions of the ECMWF Ensemble Prediction System. *Mon. Weather Rev.* 125, 99–119.
- Buizza, R., 2008. Comparison of a 51-member low-resolution ( $T_L399L62$ ) ensemble with a 6-member high-resolution ( $T_L799L91$ ) lagged-forecast ensemble. *Mon. Weather Rev.* 136, 3343–3362.
- Buizza, R., 2010. Horizontal resolution impact on short- and long-range forecast error. *Q. J. R. Meteorol. Soc.* 136, 1020–1035.
- Buizza, R., Leutbecher, M., 2015. The forecast skill horizon. *Q. J. R. Meteorol. Soc.* 141, 3366–3382.
- Buizza, R., Richardson, D., 2017. 25 years of ensemble forecasting at ECMWF. *ECMWF Newsl.* 153, 18–31.
- Buizza, R., Miller, M., Palmer, T.N., 1999. Stochastic representation of model uncertainties in the ECMWF Ensemble Prediction System. *Q. J. R. Meteorol. Soc.* 125, 2887–2908.
- Buizza, R., Houtekamer, P.L., Toth, Z., Pellerin, G., Wei, M., Zhu, Y., 2005. A comparison of the ECMWF, MSC, and NCEP global ensemble prediction systems. *Mon. Weather Rev.* 133, 1076–1097.
- Burgers, G., van Leeuwen, P.J., Evensen, G., 1998. Analysis scheme in the ensemble Kalman filter. *Mon. Weather Rev.* 126, 420–436.

- Burman, P., Chow, E., Nolan, D., 1994. A cross-validatory method for dependent data. *Biometrika* 81, 351–358.
- Cabilio, P., Zhang, Y., Chen, X., 2013. Bootstrap rank tests for trend in time series. *Environmetrics* 24, 537–549.
- Campbell, S.D., Diebold, F.X., 2005. Weather forecasting and weather derivatives. *J. Am. Stat. Assoc.* 100, 6–16.
- Candille, G., Talagrand, O., 2005. Evaluation of probabilistic prediction systems for a scalar variable. *Q. J. R. Meteorol. Soc.* 131, 2131–2150.
- Candille, G., Talagrand, O., 2008. Impact of observational error on the validation of ensemble prediction systems. *Q. J. R. Meteorol. Soc.* 134, 959–971.
- Carreau, J., Bengio, Y., 2009. A hybrid Pareto model for asymmetric fat-tailed data: the univariate case. *Extremes* 12, 53–76.
- Carter, G.M., Dallavalle, J.P., Glahn, H.R., 1989. Statistical forecasts based on the National Meteorological Center's numerical weather prediction system. *Weather Forecast.* 4, 401–412.
- Casati, B., 2010. New developments of the intensity-scale technique within the spatial verification methods intercomparison project. *Weather Forecast.* 25, 113–143.
- Casati, B., Wilson, L.J., Stephenson, D.B., Nurmi, P., Ghelli, A., Pocerich, M., Damrath, U., Ebert, E.E., Brown, B.G., Mason, S., 2008. Forecast verification: current status and future directions. *Meteorol. Appl.* 15, 3–18.
- Casella, G., 2008. *Statistical Design*. Springer. 307 pp.
- Casella, G., George, E.I., 1992. Explaining the Gibbs sampler. *Am. Stat.* 46, 167–174.
- Cavanaugh, N.R., Gershunov, A., 2015. Probabilistic tail dependence of intense precipitation on spatiotemporal scale in observations, reanalyses, and GCMs. *Clim. Dyn.* 45, 2965–2975.
- Cavanaugh, N.R., Shen, S.S.P., 2015. The effects of gridding algorithms on the statistical moments and their trends of daily surface air temperature. *J. Clim.* 28, 9188–9205.
- Chacón, J.E., 2015. A population background for nonparametric density-based clustering. *Stat. Sci.* 30, 518–523.
- Chaloulos, G., Lygeros, J., 2007. Effect of wind correlation on aircraft conflict probability. *J. Guid. Control. Dyn.* 30, 1742–1752.
- Chapman, D., Cane, M.A., Henderson, N., Lee, D.E., Chen, C., 2015. A vector autoregressive ENSO prediction model. *J. Clim.* 28, 8511–8520.
- Charney, J.G., Eliassen, A., 1949. A numerical method for predicting the perturbations of the middle latitude westerlies. *Tellus* 1, 38–54.
- Chen, W.Y., 1982. Assessment of southern oscillation sea-level pressure indices. *Mon. Weather Rev.* 110, 800–807.
- Chen, Y.R., Chu, P.-S., 2014. Trends in precipitation extremes and return levels in the Hawaiian Islands under a changing climate. *Int. J. Climatol.* 34, 3913–3925.
- Cheng, W.Y.Y., Steenburgh, W.J., 2007. Strengths and weaknesses of MOS, running-mean bias removal, and Kalman filter techniques for improving model forecasts over the western United States. *Weather Forecast.* 22, 1304–1318.
- Cheng, X., Wallace, J.M., 1993. Cluster analysis of the northern hemisphere wintertime 500- hPa height field: spatial patterns. *J. Atmos. Sci.* 50, 2674–2696.
- Cheng, X., Nitsche, G., Wallace, J.M., 1995. Robustness of low-frequency circulation patterns derived from EOF and rotated EOF analyses. *J. Clim.* 8, 1709–1713.
- Cherry, S., 1996. Singular value decomposition and canonical correlation analysis. *J. Clim.* 9, 2003–2009.
- Cherry, S., 1997. Some comments on singular value decomposition. *J. Clim.* 10, 1759–1761.
- Cheung, K.K.W., 2001. A review of ensemble forecasting techniques with a focus on tropical cyclone forecasting. *Meteorol. Appl.* 8, 315–332.
- Choi, E., Hall, P., 2000. Bootstrap confidence regions computed from autoregressions of arbitrary order. *J. R. Stat. Soc. Ser. B Methodol.* 62, 461–477.
- Chowdhury, J.U., Stedinger, J.R., Lu, L.-H., 1991. Goodness-of-fit tests for regional GEV flood distributions. *Water Resour. Res.* 27, 1765–1776.
- Christensen, H.M., Lock, S.-J., Moroz, I.M., Palmer, T.N., 2017a. Introducing independent patterns into the stochastically perturbed parameterisation tendencies (SPPT) scheme. *Q. J. R. Meteorol. Soc.* 143, 2168–2181.
- Christensen, H.M., Berner, J., Coleman, D., Palmer, T.N., 2017b. Stochastic parameterization and the El Niño–Southern Oscillation. *J. Clim.* 30, 17–38.
- Christiansen, B., 2018. Ensemble averaging and the curse of dimensionality. *J. Clim.* 31, 1587–1596.
- Chu, P.-S., Katz, R.W., 1989. Spectral estimation from time series models with relevance to the southern oscillation. *J. Clim.* 2, 86–90.

- Ciach, G.J., Krajewski, W.F., 1999. On the estimation of radar rainfall error variance. *Adv. Water Resour.* 22, 585–595.
- Clark, T., McCracken, M., 2013. Advances in forecast evaluation. In: Elliot, G., Timmermann, A. (Eds.), *Economic Forecasting*. North-Holland, 1107–1201.
- Clark, M., Gangopadhyay, S., Hay, L., Rajagopalan, B., Wilby, R., 2004. The Schaake shuffle: a method for reconstructing space–time variability in forecasted precipitation and temperature fields. *J. Hydrometeorol.* 5, 243–262.
- Clayton, H.H., 1927. A method of verifying weather forecasts. *Bull. Am. Meteorol. Soc.* 8, 144–146.
- Clayton, H.H., 1934. Rating weather forecasts. *Bull. Am. Meteorol. Soc.* 15, 279–283.
- Clemen, R.T., 1996. *Making Hard Decisions: an Introduction to Decision Analysis*. Duxbury, 664 pp.
- Cleveland, W.S., 1994. *The Elements of Graphing Data*. Hobart Press, 297 pp.
- Coelho, C.A.S., Pezzulli, S., Balmaseda, M., Doblas-Reyes, F.J., Stephenson, D.B., 2004. Forecast calibration and combination: a simple Bayesian approach for ENSO. *J. Clim.* 17, 1504–1516.
- Cohen, J., 1960. A coefficient of agreement for nominal scales. *Educ. Psychol. Meas.* 20, 213–220.
- Coles, S., 2001. *An Introduction to Statistical Modeling of Extreme Values*. Springer, 208 pp.
- Compagnucci, R.H., Richman, M.B., 2008. Can principal component analysis provide atmospheric circulation or teleconnection patterns? *Int. J. Climatol.* 28, 703–726.
- Conover, W.J., 1999. *Practical Nonparametric Statistics*. Wiley, 584 pp.
- Conover, W.J., Iman, R.L., 1981. Rank transformations as a bridge between parametric and nonparametric statistics. *Am. Stat.* 35, 124–129.
- Conradsen, K., Nielsen, L.B., Prahm, L.P., 1984. Review of Weibull statistics for estimation of wind speed distributions. *J. Clim. Appl. Meteorol.* 23, 1173–1183.
- Conte, M., DeSimone, C., Finizio, C., 1980. Post-processing of numerical models: forecasting the maximum temperature at Milano Linate. *Rev. Meteor. Aeronautica* 40, 247–265.
- Cooke, W.E., 1906a. Forecasts and verifications in western Australia. *Mon. Weather Rev.* 34, 23–24.
- Cooke, W.E., 1906b. Weighting forecasts. *Mon. Weather Rev.* 34, 274–275.
- Cooley, D., 2009. Extreme value analysis and the study of climate change. *Clim. Chang.* 97, 77–83.
- Cooley, J.W., Tukey, J.W., 1965. An algorithm for the machine calculation of complex Fourier series. *Math. Comput.* 19, 297–301.
- Crane, R.G., Hewitson, B.C., 2003. Clustering and upscaling of station precipitation records to regional patterns using self-organizing maps (SOMs). *Clim. Res.* 25, 95–107.
- Crochet, P., 2004. Adaptive Kalman filtering of 2-metre temperature and 10-metre wind-speed forecasts in Iceland. *Meteorol. Appl.* 11, 173–187.
- Crutcher, H.L., 1975. A note on the possible misuse of the Kolmogorov-Smirnov test. *J. Appl. Meteorol.* 14, 1600–1603.
- Cruz-Cano, R., Lee, M.-L.T., 2014. Fast regularized canonical correlation analysis. *Comput. Stat. Data Anal.* 70, 88–100.
- Cui, B., Toth, Z., Zhu, Y., Hou, D., 2012. Bias correction for global ensemble forecast. *Weather Forecast.* 27, 396–410.
- Cunnane, C., 1978. Unbiased plotting positions—a review. *J. Hydrol.* 37, 205–222.
- D’Agostino, R.B., 1986. Tests for the normal distribution. In: D’Agostino, R.B., Stephens, M.A. (Eds.), *Goodness-of-Fit Techniques*. Marcel Dekker, 367–419.
- D’Agostino, R.B., Stephens, M.A., 1986. *Goodness-of-Fit Techniques*. Marcel Dekker, 560 pp.
- Dabernig, M., Mayr, G.J., Messner, J.W., Zeileis, A., 2017. Spatial ensemble post-processing with standardized anomalies. *Q. J. R. Meteorol. Soc.* 143, 909–916.
- Dagpunar, J., 1988. *Principles of Random Variate Generation*. Clarendon Press, Oxford, 228 pp.
- Daniel, W.W., 1990. *Applied Nonparametric Statistics*. Kent, 635 pp.
- Davis, R.E., 1976. Predictability of sea level pressure anomalies over the north Pacific Ocean. *J. Phys. Oceanogr.* 6, 249–266.
- Davis, C., Brown, B.G., Bullock, R., 2006a. Object-based verification of precipitation forecasts. Part I: Methodology and application to mesoscale rain areas. *Mon. Weather Rev.* 134, 1772–1784.
- Davis, C., Brown, B.G., Bullock, R., 2006b. Object-based verification of precipitation forecasts. Part II: Application to convective rain systems. *Mon. Weather Rev.* 134, 1785–1795.
- Davis, C.A., Brown, B.G., Bullock, R., Halley-Gotway, J., 2009. The method for object-based diagnostic evaluation (MODE) applied to numerical forecasts from the 2005 NSSL/SPC spring program. *Weather Forecast.* 24, 1252–1267.



- Dawid, A.P., 1984. Present position and potential developments: some personal views: statistical theory: the prequential approach. *J. R. Stat. Soc. Ser. A* 147, 278–292.
- Dawid, A.P., Sebastiani, P., 1999. Coherent dispersion criteria for optimal experimental design. *Ann. Stat.* 27, 65–81.
- De Elia, R., Laprise, R., 2005. Diversity in interpretations of probability: implications for weather forecasting. *Mon. Weather Rev.* 133, 1129–1143.
- De Elia, R., Laprise, R., Denis, B., 2002. Forecasting skill limits of nested, limited-area models: a perfect-model approach. *Mon. Weather Rev.* 130, 2006–2023.
- DeGroot, M.W., Fienberg, S.E., 1982. Assessing probability assessors: calibration and refinement. *Stat. Decis. Theory Relat. Top.* 1, 291–314.
- Delle Monache, L., Eckel, F.A., Rife, D.L., Nagarajan, B., Searight, K., 2013. Probabilistic weather prediction with an analog ensemble. *Mon. Weather Rev.* 141, 3498–3516.
- Delle Monache, L., Hacker, J.P., Zhou, Y., Deng, X., Stull, R.B., 2006. Probabilistic aspects of meteorological and ozone regional ensemble forecasts. *J. Geophys. Res.* 111, 15 pp. <https://doi.org/10.1029/2005JD006917>.
- DeLong, E.R., DeLong, D.M., Clarke-Pearson, D.L., 1988. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics* 44, 837–845.
- DelSole, T., Shukla, J., 2006. Specification of wintertime North American surface temperature. *J. Clim.* 19, 2691–2716.
- DelSole, T., Shukla, J., 2009. Artificial skill due to predictor selection. *J. Clim.* 22, 331–345.
- DelSole, T., Tippett, M.K., 2007. Predictability: recent insights from information theory. *Rev. Geophys.* 45. <https://doi.org/10.1029/2006RG000202>.
- DelSole, T., Tippett, M.K., 2014. Comparing forecast skill. *Mon. Weather Rev.* 142, 4658–4678.
- DelSole, T., Tippett, M.K., 2018. Predictability in a changing climate. *Clim. Dyn.* 51, 531–545.
- Demargne, J., Wu, L., Regonda, S.K., Brown, J.D., Lee, H., He, M., Seo, D.J., Hartman, R., Herr, H.D., Fresch, M., Schaake, J., Zhu, Y., 2014. The science of NOAA's operational hydrologic ensemble forecast service. *Bull. Am. Meteorol. Soc.* 95, 79–98.
- Dempster, A.P., Laird, N.M., Rubin, D.B., 1977. Maximum likelihood from incomplete data via the EM algorithm. *J. R. Stat. Soc. Ser. B Methodol.* 39, 1–38.
- Denis, B., Côté, J., Laprise, R., 2002. Spectral decomposition of two-dimensional atmospheric fields on limited-area domains using the discrete cosine transform (DCT). *Mon. Weather Rev.* 130, 1812–1829.
- Déqué, M., 2003. Continuous variables. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification*, first ed. Wiley, 97–119.
- Deser, C., Phillips, A.S., Bourdette, V., Teng, H., 2012. Uncertainty in climate change projections: the role of internal variability. *Clim. Dyn.* 38, 527–546.
- Devine, G.W., Norton, H.J., Barón, A.E., Juarez-Colunga, E., 2018. The Wilcoxon-Mann-Whitney procedure fails as a test of medians. *Am. Stat.* 72, 278–286.
- Devroye, L., 1986. *Non-Uniform Random Variate Generation*. Springer. 843 pp.
- Di Narzo, A.F., Cocchi, D., 2010. A Bayesian hierarchical approach to ensemble weather forecasting. *J. R. Stat. Soc.: Ser. C: Appl. Stat.* 59, 405–422.
- Diebold, F.X., Mariano, R.S., 1995. Comparing predictive accuracy. *J. Bus. Econ. Stat.* 13, 253–263.
- Diebold, F.X., Gunther, T.A., Tay, A.S., 1998. Evaluating density forecasts with applications to financial risk management. *Int. Econ. Rev.* 39, 863–883.
- Director, H., Bornn, L., 2015. Connecting point-level and gridded moments in the analysis of climate data. *J. Clim.* 28, 3496–3510.
- Doblas-Reyes, F.J., Hagedorn, R., Palmer, T.N., 2005. The rationale behind the success of multi-model ensembles in seasonal forecasting—II. Calibration and combination. *Tellus A* 57, 234–252.
- Doolittle, M.H., 1888. Association ratios. *Bull. Philos. Soc. Wash.* 7, 122–127.
- Dorfman, D.D., Alf, E., 1969. Maximum-likelihood estimation of parameters of signal-detection theory and determination of confidence intervals—rating-method data. *J. Math. Psychol.* 6, 487–496.
- Doswell, C.A., 2004. Weather forecasting by humans—heuristics and decision making. *Weather Forecast.* 19, 1115–1126.
- Doswell, C.A., Davies-Jones, R., Keller, D.L., 1990. On summary measures of skill in rare event forecasting based on contingency tables. *Weather Forecast.* 5, 576–585.
- Downton, M.W., Katz, R.W., 1993. A test for inhomogeneous variance in time-averaged temperature data. *J. Clim.* 6, 2448–2464.
- Draper, N.R., Smith, H., 1998. *Applied Regression Analysis*. Wiley. 706 pp.

- Drosowsky, W., Chambers, L.E., 2001. Near-global sea surface temperature anomalies as predictors of Australian seasonal rainfall. *J. Clim.* 14, 1677–1687.
- Duan, Q., Ajami, N.K., Gao, X., Sorooshian, S., 2007. Multi-model ensemble hydrologic prediction using Bayesian model averaging. *Adv. Water Resour.* 30, 1371–1386.
- Dunn, G.E., 1951. Short-range weather forecasting. In: Malone, T.F. (Ed.), *Compendium of Meteorology*. American Meteorological Society, 747–765.
- Dunsmore, I.R., 1968. A Bayesian approach to calibration. *J. R. Stat. Soc. Ser. B Methodol.* 30, 396–405.
- Durban, J., Watson, G.S., 1971. Testing for serial correlation in least squares regression. III. *Biometrika* 58 (1), 19.
- Eade, R., Smith, D., Scaife, A., Wallace, E., Dunstone, N., Hermanson, L., Robinson, N., 2014. Do seasonal-to-decadal climate predictions underestimate the predictability of the real world? *Geophys. Res. Lett.* 41, 5620–5628.
- Eady, E., 1951. The quantitative theory of cyclone development. In: Malone, T. (Ed.), *Compendium of Meteorology*. American Meteorological Society, 464–469.
- Ebert, E.E., 2008. Fuzzy verification of high-resolution gridded forecasts: a review and proposed framework. *Meteorol. Appl.* 15, 51–64.
- Ebert, E.E., McBride, J.L., 2000. Verification of precipitation in weather systems: determination of systematic errors. *J. Hydrol.* 239, 179–202.
- Ebisuzaki, W., 1997. A method to estimate the statistical significance of a correlation when the data are serially correlated. *J. Clim.* 10, 2147–2153.
- Efron, B., 1979. Bootstrap methods: another look at the jackknife. *Ann. Stat.* 7, 1–26.
- Efron, B., 1982. *The Jackknife, the Bootstrap and Other Resampling Plans*. Society for Industrial and Applied Mathematics, 92 pp.
- Efron, B., 1987. Better bootstrap confidence intervals. *J. Am. Stat. Assoc.* 82, 171–185.
- Efron, B., Gong, G., 1983. A leisurely look at the bootstrap, the jackknife, and cross-validation. *Am. Stat.* 37, 36–48.
- Efron, B., Hastie, T., 2016. *Computer Age Statistical Inference*. Cambridge University Press, Cambridge, 475 pp.
- Efron, B., Tibshirani, R.J., 1993. *An Introduction to the Bootstrap*. Chapman and Hall, 436 pp.
- Efron, B., Gous, A., Kass, R.E., Datta, G.S., Lahiri, P., 2001. Scales of evidence for model selection: Fisher versus Jeffreys. In: - Lahiri, P. (Ed.), *Model Selection*. IMS, Hayward, CA, 208–256.
- Ehrendorfer, M., 1994a. The Liouville equation and its potential usefulness for the prediction of forecast skill. Part I: Theory. *Mon. Weather Rev.* 122, 703–713.
- Ehrendorfer, M., 1994b. The Liouville equation and its potential usefulness for the prediction of forecast skill. Part II: Applications. *Mon. Weather Rev.* 122, 714–728.
- Ehrendorfer, M., 1997. Predicting the uncertainty of numerical weather forecasts: a review. *Meteorol. Zeitschrift* 6, 147–183.
- Ehrendorfer, M., 2006. The Liouville equation and atmospheric predictability. In: Palmer, T., Hagedorn, R. (Eds.), *Predictability of Weather and Climate*. Cambridge University Press, Cambridge, 59–98.
- Ehrendorfer, M., Murphy, A.H., 1988. Comparative evaluation of weather forecasting systems: sufficiency, quality, and accuracy. *Mon. Weather Rev.* 116, 1757–1770.
- Ehrendorfer, M., Tribbia, J.J., 1997. Optimal prediction of forecast error covariances through singular vectors. *J. Atmos. Sci.* 54, 286–313.
- Elmore, K.L., 2005. Alternatives to the chi-square test for evaluating rank histograms from ensemble forecasts. *Weather Forecast.* 20, 789–795.
- Elsner, J.B., Bossak, B.H., 2001. Bayesian analysis of U.S. hurricane climate. *J. Clim.* 14, 4341–4350.
- Elsner, J.B., Jagger, T.H., 2004. A hierarchical Bayesian approach to seasonal hurricane modeling. *J. Clim.* 17, 2813–2827.
- Elsner, J.B., Schmertmann, C.P., 1993. Improving extended-range seasonal predictions of intense Atlantic hurricane activity. *Weather Forecast.* 8, 345–351.
- Elsner, J.B., Schmertmann, C.P., 1994. Assessing forecast skill through cross validation. *J. Clim.* 9, 619–624.
- Elsner, J.B., Tsonis, A.A., 1996. *Singular Spectrum Analysis, A New Tool in Time Series Analysis*. Plenum, 164 pp.
- Epstein, E.S., 1962. A Bayesian approach to decision making in applied meteorology. *J. Appl. Meteorol.* 1, 169–177.
- Epstein, E.S., 1966. Quality control for probability forecasts. *Mon. Weather Rev.* 94, 487–494.
- Epstein, E.S., 1969a. The role of initial uncertainties in prediction. *J. Appl. Meteorol.* 8, 190–198.
- Epstein, E.S., 1969b. A scoring system for probability forecasts of ranked categories. *J. Appl. Meteorol.* 8, 985–987.



- Epstein, E.S., 1969c. Stochastic dynamic prediction. *Tellus* 21, 739–759.
- Epstein, E.S., 1985. Statistical Inference and Prediction in Climatology: A Bayesian Approach. Meteorological Monograph 20(42), American Meteorological Society. 199 pp.
- Epstein, E.S., 1991. On obtaining daily climatological values from monthly means. *J. Clim.* 4, 365–368.
- Epstein, E.S., Barnston, A.G., 1988. A Precipitation Climatology of Five-Day Periods. NOAA Tech. Report NWS 41, Climate Analysis Center, National Weather Service, Camp Springs, MD. 162 pp.
- Epstein, E.S., Fleming, R.J., 1971. Depicting stochastic dynamic forecasts. *J. Atmos. Sci.* 28, 500–511.
- Epstein, E.S., Murphy, A.H., 1965. A note on the attributes of probabilistic predictions and the probability score. *J. Appl. Meteorol.* 4, 297–299.
- Erickson, M.C., Bower, J.B., Dagostaro, V.J., Dallavalle, J.P., Jacks, E., Jensenius Jr., J.S., Su, J.C., 1991. Evaluating the impact of RAFS changes on the NGM-based MOS guidance. *Weather Forecast.* 6, 142–147.
- Evensen, G., 2003. The ensemble Kalman filter: theoretical formulation and practical implementation. *Ocean Dyn.* 53, 343–367.
- Everitt, B.S., Hand, D.J., 1981. Finite Mixture Distributions. Chapman and Hall. 143 pp.
- Faes, C., Molenberghs, G., Aerts, M., Verbeke, G., Kenward, M.G., 2009. The effective sample size and an alternative small-sample degrees-of-freedom method. *Am. Stat.* 63, 389–399.
- Farrugia, P.S., Micallef, A., 2006. Comparative analysis of estimators for wind direction standard deviation. *Meteorol. Appl.* 13, 29–41.
- Feldmann, K., Scheuerer, M., Thorarindottir, T.L., 2015. Spatial postprocessing of ensemble forecasts for temperature using non-homogeneous Gaussian regression. *Mon. Weather Rev.* 143, 955–971.
- Feller, W., 1970. An Introduction to Probability Theory and its Applications. Wiley. 509 pp.
- Ferranti, L., Corti, S., 2011. New clustering products. ECMWF Newsl. 127, 6–11. [www.ecmwf.int/sites/default/files/elibrary/2011/14596-newsletter-no127-spring-2011.pdf](http://www.ecmwf.int/sites/default/files/elibrary/2011/14596-newsletter-no127-spring-2011.pdf).
- Ferro, C.A.T., 2017. Measuring forecast performance in the presence of observation error. *Q. J. R. Meteorol. Soc.* 143, 2665–2676.
- Ferro, C.A.T., Fricker, T.E., 2012. A bias-corrected decomposition of the Brier score. *Q. J. R. Meteorol. Soc.* 138, 1954–1960.
- Ferro, C.A.T., Stephenson, D.B., 2011. Extremal dependence indices: improved verification measures for deterministic forecasts of rare binary events. *Weather Forecast.* 26, 699–713.
- Ferro, C.A.T., Richardson, D.S., Weigel, A.P., 2008. On the effect of ensemble size on the discrete and continuous ranked probability scores. *Meteorol. Appl.* 15, 19–24.
- Filliben, J.J., 1975. The probability plot correlation coefficient test for normality. *Technometrics* 17, 111–117.
- Finley, J.P., 1884. Tornado prediction. *Am. Meteorol. J.* 1, 85–88.
- Fisher, R.A., 1925. Statistical Methods for Research Workers. Oliver & Boyd. 239 pp.
- Fisher, R.A., 1935. The Design of Experiments. Oliver & Boyd. 252 pp.
- Fisher, M., 2006. “Wavelet”  $J_b$ —A new way to model the statistics of background errors. ECMWF Newsl. 106, 23–28.
- Flowerdew, J., 2014. Calibrating ensemble reliability whilst preserving spatial structure. *Tellus A.* 66, <https://doi.org/10.3402/tellusa.v66.22662>. 20 pp.
- Flueck, J.A., 1987. A study of some measures of forecast verification. In: Preprints, Tenth Conference on Probability and Statistics in Atmospheric Sciences. American Meteorological Society, 69–73.
- Folland, C., Anderson, C., 2002. Estimating changing extremes using empirical ranking methods. *J. Clim.* 15, 2954–2960.
- Fortin, V., Favre, A.-C., Said, M., 2006. Probabilistic forecasting from ensemble prediction systems: improving upon the best-member method by using a different weight and dressing kernel for each member. *Q. J. R. Meteorol. Soc.* 132, 1349–1369.
- Fortin, V., Abaza, M., Anctil, F., Turcotte, R., 2014. Why should ensemble spread match the RMSE of the ensemble mean? *J. Hydrometeorol.* 15, 1708–1713.
- Fortin, V., Abaza, M., Anctil, F., Turcotte, R., 2015. Corrigendum. *J. Hydrometeorol.* 16, 484.
- Foufoula-Georgiou, E., Lettenmaier, D.P., 1987. A Markov renewal model for rainfall occurrences. *Water Resour. Res.* 23, 875–884.
- Fovell, R.G., Fovell, M.-Y., 1993. Climate zones of the conterminous United States defined using cluster analysis. *J. Clim.* 6, 2103–2135.
- Fowler, T., Gotway, J.H., Newman, K., Jensen, T., Brown, B., Bullock, R., 2018. Model Evaluation Tools Version 7.0 (METv7.0) User’s Guide. Developmental Testbed Center, Boulder CO. [dtcenter.org/met/users/docs/users\\_guide/MET\\_Users\\_Guide\\_v7.0.pdf](https://dtcenter.org/met/users/docs/users_guide/MET_Users_Guide_v7.0.pdf). 408 pp.

- Fraley, C., Raftery, A.E., 2002. Model-based clustering, discriminant analysis, and density estimation. *J. Am. Stat. Assoc.* 97, 611–631.
- Fraley, C., Raftery, A.E., Gneiting, T., 2010. Calibrating multimodel forecast ensembles with exchangeable and missing members using Bayesian model averaging. *Mon. Weather Rev.* 138, 190–202.
- Francis, P.E., Day, A.P., Davis, G.P., 1982. Automated temperature forecasting, an application of Model Output Statistics to the Meteorological Office numerical weather prediction model. *Meteorological Magazine*. 111, 73–87.
- Frenkel, Y., Majda, A.J., Khouider, B., 2012. Using the stochastic multicloud model to improve tropical convective parameterization: a paradigm example. *J. Atmos. Sci.* 69, 1080–1105.
- Friederichs, P., Hense, A., 2003. Statistical inference in canonical correlation analyses exemplified by the influence of North Atlantic SST on European climate. *J. Clim.* 16, 522–534.
- Friederichs, P., Thorarinsdottir, T.L., 2012. Forecast verification for extreme value distributions with an application to probabilistic peak wind prediction. *Environmetrics* 23, 579–594.
- Friedman, R.M., 1989. *Appropriating the Weather: Vilhelm Bjerknes and the Construction of a Modern Meteorology*. Cornell University Press. 251 pp.
- Fuller, W.A., 1996. *Introduction to Statistical Time Series*. Wiley. 698 pp.
- Furrer, E.M., Katz, R.W., 2008. Improving the simulation of extreme precipitation events by stochastic weather generators. *Water Resour. Res.* 44. <https://doi.org/10.1029/2008WR007316>.
- Gabriel, K.R., 1971. The biplot—graphic display of matrices with application to principal component analysis. *Biometrika* 58, 453–467.
- Galanis, G., Anadranistakis, M., 2002. A one-dimensional Kalman filter for the correction of near surface temperature forecasts. *Meteorol. Appl.* 9, 437–441.
- Gandin, L.S., Murphy, A.H., 1992. Equitable skill scores for categorical forecasts. *Mon. Weather Rev.* 120, 361–370.
- Gandin, L.S., Murphy, A.H., Zhukovsky, E.E., 1992. Economically optimal decisions and the value of meteorological information. In: *Preprints, 5th International Meeting on Statistical Climatology, 22–26 June, Toronto, Canada. 1992*, J64–J71.
- Garratt, J.R., Pielke Sr., R.A., Miller, W.F., Lee, T.J., 1990. Mesoscale model response to random, surface-based perturbations—a sea-breeze experiment. *Bound.-Layer Meteorol.* 52, 313–334.
- Garthwaite, P.H., Kadane, J.B., O’Hagan, A., 2005. Statistical methods for eliciting probability distributions. *J. Am. Stat. Assoc.* 100, 680–700.
- Gebetsberger, M., Messner, J.W., Mayr, G.J., Zeileis, A., 2017a. Estimation methods for non-homogeneous regression—minimum CRPS vs. maximum likelihood. *Geophys. Res. Abstr.* 19, EGU 2017-5573.
- Gebetsberger, M., Messner, J.W., Mayr, G.J., Zeileis, A., 2017b. Fine-tuning nonhomogeneous regression for probabilistic precipitation forecasts: unanimous predictions, heavy tails, and link functions. *Mon. Weather Rev.* 145, 4693–4708.
- Geer, A.J., 2016. Significance of changes in medium-range forecast scores. *Tellus* 68. <https://doi.org/10.3402/tellusa.v68.30229>. 21 pp.
- Gel, Y., Raftery, A.E., Gneiting, T., 2004. Calibrated probabilistic mesoscale weather field forecasting: The geostatistical output perturbation method. *J. Am. Stat. Assoc.* 99, 575–583.
- Gerrity Jr., J.P., 1992. A note on Gandin and Murphy’s equitable skill score. *Mon. Weather Rev.* 120, 2709–2712.
- Ghil, M., Allen, M.R., Dettinger, M.D., Ide, K., Kondrashov, D., Mann, M.E., Robertson, A.W., Saunders, A., Tian, Y., Varadi, F., Yiou, P., 2002. Advanced spectral methods for climatic time series. *Rev. Geophys.* 40, 1003–1044. <https://doi.org/10.1029/2000RG000092>.
- Gilbert, G.K., 1884. Finley’s tornado predictions. *Am. Meteorol. J.* 1, 166–172.
- Gill, J., Rubiera, J., Martin, C., Cacic, I., Mylne, K., Chen, D., Gu, J., Tang, X., Yamaguchi, M., Foamouhoue, A.K., Poolman, E., Guiney, J., 2008. *Guidelines on Communicating Forecast Uncertainty*. World Meteorological Organization. WMO/TD No.1422, 22 pp.
- Gilleland, E., 2013. Testing competing precipitation forecasts accurately and efficiently: the spatial prediction comparison test. *Mon. Weather Rev.* 141, 340–355.
- Gilleland, E., Ahijevych, D., Brown, B.G., Casati, B., Ebert, E.E., 2009. Intercomparison of spatial forecast verification methods. *Weather Forecast.* 24, 1416–1430.

- Gilleland, E., Hering, A.S., Fowler, T.L., Brown, B.G., 2018. Testing the tests: what are the impacts of incorrect assumptions when applying confidence intervals or hypothesis tests to compare competing forecasts? *Mon. Weather Rev.* 146, 1685–1703.
- Gillies, D., 2000. *Philosophical Theories of Probability*. Routledge. 223 pp.
- Gilman, D.L., Fuglister, F.J., Mitchell Jr., J.M., 1963. On the power spectrum of “red noise”. *J. Atmos. Sci.* 20, 182–184.
- Glahn, H.R., 1985. Statistical weather forecasting. In: Murphy, A.H., Katz, R.W. (Eds.), *Probability, Statistics, and Decision Making in the Atmospheric Sciences*. Westview Press, Boulder, CO, 289–335.
- Glahn, H.R., 2004. Discussion of “verification concepts in forecast verification: a practitioner’s guide in atmospheric science”. *Weather Forecast.* 19, 769–775.
- Glahn, B., 2014. A nonsymmetric logit model and grouped predictand category development. *Mon. Weather Rev.* 142, 2991–3002.
- Glahn, H.R., Jorgensen, D.L., 1970. Climatological aspects of the Brier p-score. *Mon. Weather Rev.* 98, 136–141.
- Glahn, H.R., Lowry, D.A., 1972. The use of Model Output Statistics (MOS) in objective weather forecasting. *J. Appl. Meteorol.* 11, 1203–1211.
- Glahn, B., Gilbert, K., Cosgrove, R., Ruth, D.P., Sheets, K., 2009a. The gridding of MOS. *Weather Forecast.* 24, 520–529.
- Glahn, B., Peroutka, M., Wiedenfeld, J., Wagner, J., Zylstra, G., Schuknecht, B., 2009b. MOS uncertainty estimates in an ensemble framework. *Mon. Weather Rev.* 137, 246–268.
- Gleeson, T.A., 1967. Probability predictions of geostrophic winds. *J. Appl. Meteorol.* 6, 355–359.
- Gleeson, T.A., 1970. Statistical-dynamical predictions. *J. Appl. Meteorol.* 9, 333–344.
- Gneiting, T., 2011a. Making and evaluating point forecasts. *J. Am. Stat. Assoc.* 106, 746–762.
- Gneiting, T., 2011b. Quantiles as optimal point forecasts. *Int. J. Forecast.* 27, 197–207.
- Gneiting, T., Raftery, A.E., 2007. Strictly proper scoring rules, prediction, and estimation. *J. Am. Stat. Assoc.* 102, 359–378.
- Gneiting, T., Ranjan, R., 2011. Comparing density forecasts using threshold- and quantile-weighted scoring rules. *J. Bus. Econ. Stat.* 29, 411–422.
- Gneiting, T., Raftery, A.E., Westveld III, A.H., Goldman, T., 2005. Calibrated probabilistic forecasting using ensemble model output statistics and minimum CRPS estimation. *Mon. Weather Rev.* 133, 1098–1118.
- Gneiting, T., Larson, K., Westrick, K., Genton, M.G., Aldrich, E., 2006. Calibrated probabilistic forecasting at the Stateline wind energy center: the regime-switching space-time method. *J. Am. Stat. Assoc.* 101, 968–979.
- Gneiting, T., Balabdaoui, F., Raftery, A.E., 2007. Probabilistic forecasts, calibration and sharpness. *J. R. Stat. Soc. Ser. B Methodol.* 69, 243–268.
- Gneiting, T., Stanberry, L.I., Grimit, E.P., Held, L., Johnson, N.A., 2008. Assessing probabilistic forecasts of multivariate quantities, with an application to ensemble predictions of surface winds. *Test* 17, 211–235.
- Gober, M., Zsoter, E., Richardson, D.S., 2008. Could a perfect model ever satisfy a naive forecaster? On grid box mean versus point verification. *Meteorol. Appl.* 15, 359–365.
- Godfrey, C.M., Wilks, D.S., Schultz, D.M., 2002. Is the January Thaw a statistical phantom? *Bull. Am. Meteorol. Soc.* 83, 53–62.
- Goldsmith, B.S., 1990. NWS verification of precipitation type and snow amount forecasts during the AFOS era. NOAA Technical Memorandum NWS FCST 33. National Weather Service. 28 pp.
- Golub, G.H., van Loan, C.F., 1996. *Matrix Computations*. Johns Hopkins Press. 694 pp.
- Gombos, D., Hansen, J.A., Du, J., McQueen, J., 2007. Theory and applications of the minimum spanning tree rank histogram. *Mon. Weather Rev.* 135, 1490–1505.
- Gong, X., Richman, M.B., 1995. On the application of cluster analysis to growing season precipitation data in North America east of the Rockies. *J. Clim.* 8, 897–931.
- Good, I.J., 1952. Rational decisions. *J. R. Stat. Soc. Ser. A* 14, 107–114.
- Good, P., 2000. *Permutation Tests*. Springer. 270 pp.
- Goodall, C., 1983. M-Estimators of location: an outline of the theory. In: Hoaglin, D.C., Mosteller, F., Tukey, J.W. (Eds.), *Understanding Robust and Exploratory Data Analysis*. Wiley, New York, 339–403.
- Gordon, N.D., 1982. Comments on “verification of fixed-width credible interval temperature forecasts” *Bull. Am. Meteorol. Soc.* 63, 325.
- Gorgas, T., Dorninger, M., 2012. Concepts for a pattern-oriented analysis ensemble based on observational uncertainties. *Q. J. R. Meteorol. Soc.* 138, 769–784.

- Graedel, T.E., Kleiner, B., 1985. Exploratory analysis of atmospheric data. In: Murphy, A.H., Katz, R.W. (Eds.), *Probability, Statistics, and Decision Making in the Atmospheric Sciences*. Westview Press, Boulder, CO, 1–43.
- Granger, C.W.J., Pesaran, M.H., 2000. Economic and statistical measures of forecast accuracy. *J. Forecast.* 19, 537–560.
- Gray, W.M., 1990. Strong association between West African rainfall and U.S. landfall of intense hurricanes. *Science* 249, 1251–1256.
- Greenwood, J.A., Durand, D., 1960. Aids for fitting the gamma distribution by maximum likelihood. *Technometrics* 2, 55–65.
- Griffis, V.W., Stedinger, J.R., 2007. Log-Pearson Type 3 distribution and its application in flood frequency analysis. I: Distribution characteristics. *J. Hydraul. Eng.* 12, 482–491.
- Grimit, E.P., Mass, C.F., 2002. Initial results of a mesoscale short-range ensemble forecasting system over the Pacific Northwest. *Weather Forecast.* 17, 192–205.
- Grimit, E.P., Gneiting, T., Berrocal, V.J., Johnson, N.A., 2006. The continuous ranked probability score for circular variables and its application to mesoscale forecast ensemble verification. *Q. J. R. Meteorol. Soc.* 132, 1–17.
- Gringorten, I.I., 1949. A study in objective forecasting. *Bull. Am. Meteorol. Soc.* 30, 10–15.
- Gringorten, I.I., 1967. Verification to determine and measure forecasting skill. *J. Appl. Meteorol.* 6, 742–747.
- Groth, A., Ghil, M., 2015. Monte Carlo singular spectrum analysis (SSA) revisited: detecting oscillator clusters in multivariate datasets. *J. Clim.* 28, 7873–7893.
- Grounds, M.A., LeClerc, J.E., Joslyn, S., 2018. Expressing flood likelihood: return period versus probability. *Wea. Clim. Soc.* 10, 5–17.
- Gumbel, E.J., 1958. *Statistics of Extremes*. Columbia University Press. 375 pp.
- Guttman, N.B., 1999. Accepting the standardized precipitation index: a calculation algorithm. *J. Am. Water Resour. Assoc.* 35, 311–322.
- Hagedorn, R., 2008. Using the ECMWF reforecast data set to calibrate EPS reforecasts. *ECMWF Newsl.* 117, 8–13.
- Hagedorn, R., Smith, L.A., 2009. Communicating the value of probabilistic forecasts with weather roulette. *Meteorol. Appl.* 16, 143–155.
- Hagedorn, R., Hamill, T.M., Whitaker, J.S., 2008. Probabilistic forecast calibration using ECMWF and GFS ensemble reforecasts. Part I: Two-meter temperatures. *Mon. Weather Rev.* 136, 2608–2619.
- Haines, K., Hannachi, A., 1995. Weather regimes in the Pacific from a GCM. *J. Atmos. Sci.* 52, 2444–2462.
- Hall, T.M., Jewson, S., 2008. Comparison of local and basinwide methods for risk assessment of tropical cyclone landfall. *J. Appl. Meteorol. Climatol.* 47, 361–367.
- Hall, P., Wilson, S.R., 1991. Two guidelines for bootstrap hypothesis testing. *Biometrics* 47, 757–762.
- Hamed, K.H., 2009. Exact distribution of the Mann-Kendall trend test statistic for persistent data. *J. Hydrol.* 365, 86–94.
- Hamill, T.M., 1999. Hypothesis tests for evaluating numerical precipitation forecasts. *Weather Forecast.* 14, 155–167.
- Hamill, T.M., 2001. Interpretation of rank histograms for verifying ensemble forecasts. *Mon. Weather Rev.* 129, 550–560.
- Hamill, T.M., 2006. Ensemble-based atmospheric data assimilation: a tutorial. In: Palmer, T.N., Hagedorn, R. (Eds.), *Predictability of Weather and Climate*. Cambridge University Press, Cambridge, 124–156.
- Hamill, T.M., 2007. Comments on “Calibrated surface temperature forecasts from the Canadian ensemble prediction system using Bayesian Model Averaging”. *Mon. Weather Rev.* 135, 4226–4230.
- Hamill, T.M., Bates, G.T., Whitaker, J.S., Murray, D.R., Fiorino, M., Galarneau, T.J., Zhu, Y., Lapenta, W., 2013. NOAA’s second-generation global medium-range ensemble reforecast dataset. *Bull. Am. Meteorol. Soc.* 94, 1553–1565.
- Hamill, T.M., Colucci, S.J., 1997. Verification of Eta-RSM short-range ensemble forecasts. *Mon. Weather Rev.* 125, 1312–1327.
- Hamill, T.M., Colucci, S.J., 1998. Evaluation of Eta-RSM ensemble probabilistic precipitation forecasts. *Mon. Weather Rev.* 126, 711–724.
- Hamill, T.M., Juras, J., 2006. Measuring forecast skill: is it real skill or is it the varying climatology? *Q. J. R. Meteorol. Soc.* 132, 2905–2923.
- Hamill, T.M., Scheuerer, M., Bates, G.T., 2015. Analog probabilistic precipitation forecasts using GEFS reforecasts and climatology-calibrated precipitation analyses. *Mon. Weather Rev.* 143, 3300–3309.
- Hamill, T.M., Swinbank, R., 2015. Stochastic forcing, ensemble prediction systems, and TIGGE. In: *Seamless Prediction of the Earth System: From Minutes to Months*. World Meteorological Organization, 187–212.
- Hamill, T.M., Whitaker, J.S., 2006. Probabilistic quantitative precipitation forecasts based on reforecast analogs: theory and application. *Mon. Weather Rev.* 134, 3209–3229.

- Hamill, T.M., Whitaker, J.S., Mullen, S.L., 2006. Reforecasts: an important new dataset for improving weather predictions. *Bull. Am. Meteorol. Soc.* 87, 33–46.
- Hamill, T.M., Whitaker, J.S., Wei, X., 2004. Ensemble re-forecasting: improving medium-range forecast skill using retrospective forecasts. *Mon. Weather Rev.* 132, 1434–1447.
- Hamill, T.M., Wilks, D.S., 1995. A probabilistic forecast contest and the difficulty of assessing short-range uncertainty. *Weather Forecast.* 10, 620–631.
- Han, F., Szunyogh, I., 2016. A morphing-based technique for the verification of precipitation forecasts. *Mon. Weather Rev.* 144, 295–313.
- Hanley, J.A., McNeil, B.J., 1983. A method of comparing the areas under receiver operating characteristic curves derived from the same cases. *Radiology* 148, 839–843.
- Hannachi, A., 1997. Low-frequency variability in a GCM: three dimensional flow regimes and their dynamics. *J. Clim.* 10, 1357–1379.
- Hannachi, A., Jolliffe, I.T., Stephenson, D.B., 2007. Empirical orthogonal functions and related techniques in atmospheric science: a review. *Int. J. Climatol.* 27, 1119–1152.
- Hannachi, A., O'Neill, A., 2001. Atmospheric multiple equilibria and non-Gaussian behavior in model simulations. *Q. J. R. Meteorol. Soc.* 127, 939–958.
- Hansen, J.A., 2002. Accounting for model error in ensemble-based state estimation and forecasting. *Mon. Weather Rev.* 130, 2373–2391.
- Hanssen, A.W., Kuipers, W.J.A., 1965. On the relationship between the frequency of rain and various meteorological parameters. *Meded. Verh.* 81, 2–15.
- Harper, K., Uccellini, L.W., Kalnay, E., Carey, K., Morone, L., 2007. 50th anniversary of operational numerical weather prediction. *Bull. Am. Meteorol. Soc.* 88, 639–650.
- Harrison, M., 2005. The development of seasonal and inter-annual climate forecasting. *Clim. Chang.* 70, 201–220.
- Harrison, M.S.J., Palmer, T.N., Richardson, D.S., Buizza, R., 1999. Analysis and model dependencies in medium-range ensembles: two transplant case-studies. *Q. J. R. Meteorol. Soc.* 125, 2487–2515.
- Harter, H.L., 1984. Another look at plotting positions. *Commun. Stat. Theory Methods* 13, 1613–1633.
- Hasselmann, K., 1976. Stochastic climate models. Part I: Theory. *Tellus* 28, 474–485.
- Hastenrath, S., Sun, L., Moura, A.D., 2009. Climate prediction for Brazil's Nordeste by empirical and numerical modeling methods. *Int. J. Climatol.* 29, 921–926.
- Hastie, T., Tibshirani, R., Wainright, M., 2015. *Statistical Learning with Sparsity: The Lasso and Generalizations*. CRC Press. 351 pp.
- Hawkins, E., Smith, R.S., Gregory, J.M., Stainforth, D.A., 2016. Irreducible uncertainty in near-term climate projections. *Clim. Dyn.* 46, 3807–3819.
- Hayashi, Y., 1986. Statistical interpretations of ensemble-time mean predictability. *J. Meteorol. Soc. Jpn.* 64, 167–181.
- He, Y., Monahan, A.H., Jones, C.G., Dai, A., Biner, S., Caya, D., Winger, K., 2010. Probability distributions of land surface wind speeds over North America. *J. Geophys. Res.* 115. <https://doi.org/10.1029/2008JD010708>.
- Healy, M.J.R., 1988. *Glim: An Introduction*. Clarendon Press, Oxford. 130 pp.
- Heidke, P., 1926. Berechnung des Erfolges und der Güte der Windstärkevorhersagen im Sturmwarnungsdienst. *Geogr. Ann.* 8, 301–349.
- Hemri, S., Haiden, T., Pappenberger, F., 2016. Discrete postprocessing of total cloud cover ensemble forecasts. *Mon. Weather Rev.* 144, 2565–2577.
- Hemri, S., Lisniak, D., Klein, B., 2015. Multivariate postprocessing techniques for probabilistic hydrological forecasting. *Water Resour. Res.* 51, 7436–7451.
- Hemri, S., Fundel, F., Zappa, M., 2013. Simultaneous calibration of ensemble river flow predictions over an entire range of lead times. *Water Resour. Res.* 49, 6744–6755.
- Hemri, S., Scheuerer, M., Pappenberger, F., Bogner, K., Haiden, T., 2014. Trends in the predictive performance of raw ensemble weather forecasts. *Geophys. Res. Lett.* 41, 9197–9205.

- Heo, J.-H., Kho, Y.W., Shin, H., Kim, S., Kim, T., 2008. Regression equations of probability plot correlation coefficient test statistics from several probability distributions. *J. Hydrol.* 355, 1–15.
- Hering, A.S., Genton, M.C., 2011. Comparing spatial predictions. *Technometrics* 53, 414–425.
- Herman, G.L., Schumacher, R.S., 2018. Money doesn't grow on trees, but forecasts to: forecasting extreme precipitation with random forests. *Mon. Weather Rev.* 146, 1571–1600.
- Hersbach, H., 2000. Decomposition of the continuous ranked probability score for ensemble prediction systems. *Weather Forecast.* 15, 559–570.
- Hilliker, J.L., Fritsch, J.M., 1999. An observations-based statistical system for warm-season hourly probabilistic precipitation forecasts of low ceiling at the San Francisco international airport. *J. Appl. Meteorol.* 38, 1692–1705.
- Hingray, B., Mezghana, A., Buishand, T.A., 2007. Development of probability distributions for regional climate change from uncertain global mean warming and an uncertain scaling relationship. *Hydrol. Earth Syst. Sci.* 11, 1097–1114.
- Hinkley, D., 1977. On quick choice of power transformation. *Appl. Stat.* 26, 67–69.
- Hintze, J.L., Nelson, R.D., 1998. Violin plots: a box plot-density trace synergism. *Am. Stat.* 52, 181–184.
- Hirsch, R.M., Slack, J.R., Smith, R.A., 1982. Techniques of trend analysis for monthly water quality data. *Water Resour. Res.* 18, 107–121.
- Hlinka, J., Hartman, D., Vejmelka, M., Novotná, D., Palus, M., 2014. Non-linear dependence and teleconnections in climate data: sources, relevance, nonstationarity. *Clim. Dyn.* 42, 1873–1886.
- Hodyss, D., Satterfield, E., McLay, J., Hamill, T.M., Scheuerer, M., 2016. Inaccuracies with multi-model post-processing methods involving weighted, regression-corrected forecasts. *Mon. Weather Rev.* 144, 1649–1668.
- Hoerl, A.E., Kennard, R.W., 1970. Ridge regression: biased estimation for nonorthogonal problems. *Technometrics* 12, 55–67.
- Hoffman, R.N., Liu, Z., Louis, J.-F., Grassotti, C., 1995. Distortion representation of forecast errors. *Mon. Weather Rev.* 123, 2758–2770.
- Hogan, R.J., Ferro, C.A.T., Jolliffe, I.T., Stephenson, D.B., 2010. Equitability revisited: why the “equitable threat score” is not equitable. *Weather Forecast.* 25, 710–726.
- Hogan, R.J., Mason, I.B., 2012. Deterministic forecasts of binary events. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification: A Practitioner's Guide in Atmospheric Science*, second, ed. Wiley-Blackwell, 31–59.
- Hollingsworth, A., Arpe, K., Tiedtke, M., Capaldo, M., Savijärvi, H., 1980. The performance of a medium range forecast model in winter—impact of physical parameterizations. *Mon. Weather Rev.* 108, 1736–1773.
- Homleid, M., 1995. Diurnal corrections of short-term surface temperature forecasts using the Kalman filter. *Weather Forecast.* 10, 689–707.
- Horel, J.D., 1981. A rotated principal component analysis of the interannual variability of the Northern Hemisphere 500 mb height field. *Mon. Weather Rev.* 109, 2080–2902.
- Hosking, J.R.M., 1990. L-moments: analysis and estimation of distributions using linear combinations of order statistics. *J. R. Stat. Soc. Ser. A* 52, 105–124.
- Hosking, J.R.M., Wallis, J.R., 1987. Parameter and quantile estimation for the generalized Pareto distribution. *Technometrics* 29, 339–349.
- Hothorn, T., Leisch, F., Zeileis, A., Hornik, K., 2005. The design and analysis of benchmark experiments. *J. Comput. Graph. Stat.* 14, 675–699.
- Houtekamer, P.L., Lefaiivre, L., Derome, J., Ritchie, H., Mitchell, H.L., 1996. A system simulation approach to ensemble prediction. *Mon. Weather Rev.* 124, 1225–1242.
- Houtekamer, P.L., Mitchell, H.L., 2005. Ensemble Kalman filtering. *Q. J. R. Meteorol. Soc.* 131, 3269–3289.
- Houtekamer, P.L., Mitchell, H.L., Deng, X., 2009. Model error representation in an operational ensemble Kalman filter. *Mon. Weather Rev.* 137, 2126–2143.
- Hsieh, W.W., 2009. *Machine Learning Methods in the Environmental Sciences*. Cambridge University Press, Cambridge. 349 pp.
- Hsu, W.-R., Murphy, A.H., 1986. The attributes diagram: a geometrical framework for assessing the quality of probability forecasts. *Int. J. Forecast.* 2, 285–293.
- Hu, Q., 1997. On the uniqueness of the singular value decomposition in meteorological applications. *J. Clim.* 10, 1762–1766.
- Hurvich, C.M., Tsai, C.-L., 1989. Regression and time series model selection in small samples. *Biometrika* 76, 297–307.
- Huth, R., Pokorná, L., 2004. Parametric versus non-parametric estimates of climatic trends. *Theor. Appl. Climatol.* 77, 107–112.



- Hyndman, R.J., Fan, Y., 1996. Sample quantiles in statistical packages. *Am. Stat.* 50, 361–365.
- Hyvärinen, O., 2014. A probabilistic derivation of the Heidke skill score. *Weather Forecast.* 29, 177–181.
- Iglewicz, B., 1983. Robust scale estimators and confidence intervals for location. In: Hoaglin, D.C., Mosteller, F., Tukey, J.W. (Eds.), *Understanding Robust and Exploratory Data Analysis*. Wiley, 404–431.
- Imkeller, P., Monahan, A., 2002. Conceptual stochastic climate models. *Stochastic Dyn.* 2, 311–326.
- Imkeller, P., von Storch, J.-S. (Eds.), 2001. *Stochastic Climate Models*. Birkhäuser. 398 pp.
- Ivarsson, K.-I., Joelsson, R., Liljas, E., Murphy, A.H., 1986. Probability forecasting in Sweden: some results of experimental and operational programs at the Swedish Meteorological and Hydrological Institute. *Weather Forecast.* 1, 136–154.
- Jacks, E., Bower, J.B., Dagostaro, V.J., Dallavalle, J.P., Erickson, M.C., Su, J., 1990. New NGM-based MOS guidance for maximum/minimum temperature, probability of precipitation, cloud amount, and surface wind. *Weather Forecast.* 5, 128–138.
- Jagger, T.H., Elsner, J.B., 2009. Modeling tropical cyclone intensity with quantile regression. *Int. J. Climatol.* 29, 1351–1361.
- Janson, S., Vegelius, J., 1981. Measures of ecological association. *Oecologia* 49, 371–376.
- Jarman, A.S., Smith, L.A., 2018. Quantifying the predictability of a predictand: demonstrating the diverse roles of serial dependence in the estimation of forecast skill. *Q. J. R. Meteorol. Soc.* <https://doi.org/10.1002/qj.3384>.
- Jenkins, G.M., Watts, D.G., 1968. *Spectral Analysis and its Applications*. Holden-Day, San Francisco, CA. 523 pp.
- Jewson, S., Brix, A., Ziehmann, C., 2004. A new parametric model for the assessment and calibration of medium-range ensemble temperature forecasts. *Atmos. Sci. Lett.* 5, 96–102.
- Johnson, C., Bowler, N., 2009. On the reliability and calibration of ensemble forecasts. *Mon. Weather Rev.* 137, 1717–1720.
- Johnson, M.E., 1987. *Multivariate Statistical Simulation*. Wiley. 230 pp.
- Johnson, N.L., Kotz, S., 1972. *Distributions in Statistics. Continuous Multivariate Distributions*, vol. 4. Wiley, New York. 333 pp.
- Johnson, N.L., Kotz, S., Balakrishnan, N., 1994. *Continuous Univariate Distributions*. vol. 1. Wiley. 756 pp.
- Johnson, N.L., Kotz, S., Balakrishnan, N., 1995. *Continuous Univariate Distributions*. vol. 2. Wiley. 719 pp.
- Johnson, N.L., Kotz, S., Kemp, A.W., 1992. *Univariate Discrete Distributions*. Wiley. 565 pp.
- Johnson, R.A., Wichern, D.W., 2007. *Applied Multivariate Statistical Analysis*, sixth ed. Prentice Hall. 773 pp.
- Johnson, S.R., Holt, M.T., 1997. The value of weather information. In: Katz, R.W., Murphy, A.H. (Eds.), *Economic Value of Weather and Climate Forecasts*. Cambridge University Press, Cambridge, 75–107.
- Jolliffe, I.T., 1972. Discarding variables in a principal component analysis, I: Artificial data. *Appl. Stat.* 21, 160–173.
- Jolliffe, I.T., 1987. Rotation of principal components: some comments. *Int. J. Climatol.* 7, 507–510.
- Jolliffe, I.T., 1989. Rotation of ill-defined principal components. *Appl. Stat.* 38, 139–147.
- Jolliffe, I.T., 1995. Rotation of principal components: choice of normalization constraints. *J. Appl. Stat.* 22, 29–35.
- Jolliffe, I.T., 2002. *Principal Component Analysis*, second ed. Springer. 487 pp.
- Jolliffe, I.T., 2007. Uncertainty and inference for verification measures. *Weather Forecast.* 22, 637–650.
- Jolliffe, I.T., 2008. The impenetrable hedge: a note on propriety, equitability, and consistency. *Meteorol. Appl.* 15, 25–29.
- Jolliffe, I.T., Jones, B., Morgan, B.J.T., 1986. Comparison of cluster analyses of the English personal social services authorities. *J. R. Stat. Soc. Ser. A* 149, 254–270.
- Jolliffe, I.T., Primo, C., 2008. Evaluating rank histograms using decompositions of the chi-square test statistic. *Mon. Weather Rev.* 136, 2133–2139.
- Jolliffe, I.T., Stephenson, D.B., 2005. Comments on “discussion of verification concepts in forecast verification: a practitioner’s guide in atmospheric science”. *Weather Forecast.* 20, 796–800.
- Jolliffe, I.T., Stephenson, D.B., 2012a. *Forecast Verification: A Practitioner’s Guide in Atmospheric Science*, second ed. Wiley-Blackwell. 274 pp.
- Jolliffe, I.T., Stephenson, D.B., 2012b. Epilogue: new directions in forecast verification. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification: A Practitioner’s Guide in Atmospheric Science*, second ed. Wiley-Blackwell, 221–230.
- Jolliffe, I.T., Trendafilov, N.T., Uddin, M., 2003. A modified principal component technique based on the LASSO. *J. Comput. Graph. Stat.* 12, 531–547.
- Jones, R.H., 1975. Estimating the variance of time averages. *J. Appl. Meteorol.* 14, 159–163.
- Jordan, A., Krüger, F., Lerch, S., 2017. Evaluating probabilistic forecasts with the R package *scoringRules*. *arXiv:1709.04743*.
- Joslyn, S., Savelli, S., 2010. Communicating forecast uncertainty: public perception of weather forecast uncertainty. *Meteorol. Appl.* 17, 180–195.

- Judd, K., Reynolds, C.A., Rosmond, T.E., Smith, L.A., 2008. The geometry of model error. *J. Atmos. Sci.* 65, 1749–1772.
- Junk, C., Delle Monache, L., Alessandrini, S., 2015. Analog-based ensemble model output statistics. *Mon. Weather Rev.* 143, 2909–2917.
- Jupp, T.E., Lowe, R., Coelho, C.A.S., Stephenson, D.B., 2012. On the visualization, verification and recalibration of ternary probabilistic forecasts. *Philos. Trans. R. Soc. Lond. A* 370, 1100–1120.
- Juras, J., 2000. Comments on “Probabilistic predictions of precipitation using the ECMWF ensemble prediction system”. *Weather Forecast.* 15, 365–366.
- Justus, C.G., Hargraves, W.R., Mikhail, A., Graber, D., 1978. Methods for estimating wind speed frequency distributions. *J. Appl. Meteorol.* 17, 350–353.
- Kaiser, H.F., 1958. The varimax criterion for analytic rotation in factor analysis. *Psychometrika* 23, 187–200.
- Kalkstein, L.S., Tan, G., Skindlov, J.A., 1987. An evaluation of three clustering procedures for use in synoptic climatological classification. *J. Clim. Appl. Meteorol.* 26, 717–730.
- Kalnay, E., 2003. *Atmospheric Modeling, Data Assimilation and Predictability*. Cambridge University Press, Cambridge. 341 pp.
- Kalnay, E., Dalcher, A., 1987. Forecasting the forecast skill. *Mon. Weather Rev.* 115, 349–356.
- Kalnay, E., Kanamitsu, M., Baker, W.E., 1990. Global numerical weather prediction at the National Meteorological Center. *Bull. Am. Meteorol. Soc.* 71, 1410–1428.
- Kann, A., Wittmann, C., Wang, Y., Ma, X., 2009. Calibrating 2-m temperature of limited-area ensemble forecasts using high-resolution analysis. *Mon. Weather Rev.* 137, 3373–3387.
- Karl, T.R., Koscielny, A.J., 1982. Drought in the United States, 1895–1981. *Int. J. Climatol.* 2, 313–329.
- Karl, T.R., Koscielny, A.J., Diaz, H.F., 1982. Potential errors in the application of principal component (eigenvector) analysis to geophysical data. *J. Appl. Meteorol.* 21, 1183–1186.
- Karlin, S., Taylor, H.M., 1975. *A First Course in Stochastic Processes*. Academic Press. 557 pp.
- Katz, R.W., 1977. Precipitation as a chain-dependent process. *J. Appl. Meteorol.* 16, 671–676.
- Katz, R.W., 1981. On some criteria for estimating the order of a Markov chain. *Technometrics* 23, 243–249.
- Katz, R.W., 1982. Statistical evaluation of climate experiments with general circulation models: a parametric time series modeling approach. *J. Atmos. Sci.* 39, 1446–1455.
- Katz, R.W., 1985. Probabilistic models. In: Murphy, A.H., Katz, R.W. (Eds.), *Probability, Statistics, and Decision Making in the Atmospheric Sciences*. Westview Press, Boulder, CO, 261–288.
- Katz, R.W., 2002. Sir Gilbert Walker and a connection between El Niño and statistics. *Stat. Sci.* 17, 97–112.
- Katz, R.W., 2013. Statistical methods for nonstationary extremes. In: AghaKouchak, A., et al. (Eds.), *Extremes in a Changing Climate*. Springer, 15–36.
- Katz, R.W., Ehrendorfer, M., 2006. Bayesian approach to decision making using ensemble weather forecasts. *Weather Forecast.* 21, 220–231.
- Katz, R.W., Murphy, A.H., 1997a. *Economic Value of Weather and Climate Forecasts*. Cambridge University Press, Cambridge. 222 pp.
- Katz, R.W., Murphy, A.H., 1997b. Forecast value: prototype decision-making models. In: Katz, R.W., Murphy, A.H. (Eds.), *Economic Value of Weather and Climate Forecasts*. Cambridge University Press, Cambridge, 183–217.
- Katz, R.W., Murphy, A.H., Winkler, R.L., 1982. Assessing the value of frost forecasts to orchardists: a dynamic decision-making approach. *J. Appl. Meteorol.* 21, 518–531.
- Katz, R.W., Parlange, M.B., 1993. Effects of an index of atmospheric circulation on stochastic properties of precipitation. *Water Resour. Res.* 29, 2335–2344.
- Katz, R.W., Parlange, M.B., Naveau, P., 2002. Statistics of extremes in hydrology. *Adv. Water Resour.* 25, 1287–1304.
- Katz, R.W., Zheng, X., 1999. Mixture model for overdispersion of precipitation. *J. Clim.* 12, 2528–2537.
- Keil, C., Craig, G.C., 2007. A displacement-based error measure applied in a regional ensemble forecasting system. *Mon. Weather Rev.* 135, 3248–3259.
- Keil, C., Craig, G.C., 2009. A displacement and amplitude score employing an optical flow technique. *Weather Forecast.* 24, 1298–1308.
- Kelly, K.S., Krzysztofowicz, R., 1997. A bivariate meta-Gaussian density for use in hydrology. *Stoch. Hydrol. Hydraul.* 11, 17–31.
- Kendall, M., Ord, J.K., 1990. *Time Series*. Edward Arnold, p. 296.

- Kestin, T.S., Karoly, D.J., Yano, J.-I., Raynor, N.A., 1998. Time-frequency variability of ENSO and stochastic simulations. *J. Clim.* 11, 2258–2272.
- Keune, J., Ohlwein, C., Hense, A., 2014. Multivariate probabilistic analysis and predictability of medium-range ensemble weather forecasts. *Mon. Weather Rev.* 142, 4074–4090.
- Kharin, V.V., Zwiers, F.W., 2003. On the ROC score of probability forecasts. *J. Clim.* 16, 4145–4150.
- Kharin, V.V., Zwiers, F.W., 2005. Estimating extremes in transient climate change simulations. *J. Clim.* 18, 1156–1173.
- Kirtman, B.P., et al., 2014. The North American multimodel ensemble. Phase-1 seasonal-to-interannual prediction; Phase-2 toward developing intraseasonal prediction. *Bull. Am. Meteorol. Soc.* 95, 585–601.
- Klein, W.H., Lewis, B.M., Enger, I., 1959. Objective prediction of five-day mean temperature during winter. *J. Meteorol.* 16, 672–682.
- Knaff, J.A., Landsea, C.W., 1997. An El Niño-southern oscillation climatology and persistence (CLIPER) forecasting scheme. *Weather Forecast.* 12, 633–647.
- Koenker, R.W., Bassett, B., 1978. Regression quantiles. *Econometrica* 46, 33–49.
- Koh, T.-Y., Wang, S., Bhatt, B.C., 2012. A diagnostic suite to assess NWP performance. *J. Geophys. Res.* 117. <https://doi.org/10.1029/2011JD017103>. 20 pp.
- Krakauer, N.Y., Grossberg, M.D., Gladkova, I., Aizenman, H., 2013. Information content of seasonal forecasts in a changing climate. *Adv. Meteorol.* <https://doi.org/10.1155/2013/480210>. 12 pp.
- Krzysztofowicz, R., 1983. Why should a forecaster and a decision maker use Bayes' theorem. *Water Resour. Res.* 19, 327–336.
- Krzysztofowicz, R., Drzal, W.J., Drake, T.R., Weyman, J.C., Giordano, L.A., 1993. Probabilistic quantitative precipitation forecasts for river basins. *Weather Forecast.* 8, 424–439.
- Krzysztofowicz, R., Evans, W.B., 2008. Probabilistic forecasts from the National Digital Forecast database. *Weather Forecast.* 23, 270–289.
- Krzysztofowicz, R., Long, D., 1990. Fusion of detection probabilities and comparison of multisensor systems. *IEEE Trans. Syst. Man Cybern.* 20, 665–677.
- Krzysztofowicz, R., Long, D., 1991. Beta probability models of probabilistic forecasts. *Int. J. Forecast.* 7, 47–55.
- Kücken, M., Gerstengarbe, F.-W., 2009. A combination of cluster analysis and kappa statistic for the evaluation of climate model results. *J. Appl. Meteorol. Climatol.* 48, 1757–1765.
- Künsch, H.R., 1989. The jackknife and the bootstrap for general stationary observations. *Ann. Stat.* 17, 1217–1241.
- Kutzbach, J.E., 1967. Empirical eigenvectors of sea-level pressure, surface temperature and precipitation complexes over North America. *J. Appl. Meteorol.* 6, 791–802.
- Kysely, J., 2008. A cautionary note on the use of nonparametric bootstrap for estimating uncertainties in extreme-value models. *J. Appl. Meteorol. Climatol.* 47, 3226–3251.
- Lahiri, S.N., 2003. *Resampling Methods for Dependent Data*. Springer. 374 pp.
- Lahiri, K., Yang, L., 2016. Asymptotic variance of Brier (skill) score in the presence of serial correlation. *Econ. Lett.* 141, 125–129.
- Lahiri, K., Yang, L., 2018. Confidence bands for ROC curves with serially dependent data. *J. Bus. Econ. Stat.* 36, 115–130.
- Lall, U., Sharma, A., 1996. A nearest neighbor bootstrap for resampling hydrologic time series. *Water Resour. Res.* 32, 679–693.
- Lambert, S.J., Boer, G.J., 2001. CMIP1 evaluation and intercomparison of coupled climate models. *Clim. Dyn.* 17, 83–106.
- Landman, W.A., Mason, S.J., 2001. Forecasts of near-global sea surface temperatures using canonical correlation analysis. *J. Clim.* 14, 3819–3833.
- Lanzante, J.R., 2005. A cautionary note on the use of error bars. *J. Clim.* 18, 3699–3703.
- Leadbetter, M.R., Lindgren, G., Rootzen, H., 1983. *Extremes and Related Properties of Random Sequences and Processes*. Springer. 336 pp.
- Lee, J., Li, S., Lund, R., 2014. Trends in extreme U.S. temperatures. *J. Clim.* 27, 4209–4225.
- Lee, P.M., 1997. *Bayesian Statistics: An Introduction*, second ed. Wiley. 344 pp.
- Leger, C., Politis, D.N., Romano, J.P., 1992. Bootstrap technology and applications. *Technometrics* 34, 378–398.
- Legg, T.P., Mylne, K.R., Woodcock, C., 2002. Use of medium-range ensembles at the Met Office I: PREVIN—a system for the production of probabilistic forecast information from the ECMWF EPS. *Meteorol. Appl.* 9, 255–271.

- Lehmiller, G.S., Kimberlain, T.B., Elsner, J.B., 1997. Seasonal prediction models for North Atlantic basin hurricane location. *Mon. Weather Rev.* 125, 1780–1791.
- Leith, C.E., 1973. The standard error of time-average estimates of climatic means. *J. Appl. Meteorol.* 12, 1066–1069.
- Leith, C.E., 1974. Theoretical skill of Monte-Carlo forecasts. *Mon. Weather Rev.* 102, 409–418.
- Lemcke, C., Kruijzinga, S., 1988. Model output statistics forecasts: three years of operational experience in the Netherlands. *Mon. Weather Rev.* 116, 1077–1090.
- Lemke, P., 1977. Stochastic climate models. Part 3. Application to zonally averaged energy models. *Tellus* 29, 385–392.
- Lerch, S., Thorarindottir, T.L., 2013. Comparison of non-homogeneous regression models for probabilistic wind speed forecasting. *Tellus A.* 65, <https://doi.org/10.3402/tellusa.v65i0.21206>. 13 pp.
- Lepore, C., Tippet, M.K., Allen, J.T., 2017. ENSO-based probabilistic forecasts of March–May U.S. tornado and hail activity. *Geophys. Res. Lett.* 44, 9093–9101.
- Lettenmaier, D.P., 1976. Detection of trends in water quality data from records with dependent observations. *Water Resour. Res.* 12, 1037–1046.
- Lettenmaier, D.P., Wood, E.F., Wallis, J.R., 1994. Hydro-climatological trends in the continental United States, 1948–88. *J. Clim.* 7, 586–607.
- Leutbecher, M., 2018. Ensemble size: how suboptimal is less than infinity? *Q. J. R. Meteorol. Soc.* <https://doi.org/10.1002/qj.3387>.
- Leutbecher, M., Palmer, T.N., 2008. Ensemble forecasting. *J. Comput. Phys.* 227, 3515–3539.
- Leutbecher, M., et al., 2017. Stochastic representations of model uncertainties at ECMWF: state of the art and future vision. *Q. J. R. Meteorol. Soc.* 143, 2315–2339.
- Lewis, J.M., 2005. Roots of ensemble forecasting. *Mon. Weather Rev.* 133, 1865–1885.
- Lewis, J.M., 2014. Edward Epstein's stochastic-dynamic approach to ensemble weather prediction. *Bull. Am. Meteorol. Soc.* 95, 99–116.
- Li, C., Singh, V.P., Mishra, A.K., 2012. Simulation of the entire range of daily precipitation using a hybrid probability distribution. *Water Resour. Res.* 48, <https://doi.org/10.1029/2011WR011446>.
- Li, T.Y., Yorke, J.A., 1975. Period three implies chaos. *Am. Math. Mon.* 82, 985–992.
- Li, W., Duan, Q., Miao, C., Ye, A., Gong, W., Di, Z., 2017. A review on statistical postprocessing methods for hydrometeorological ensemble forecasting. *WIREs Water* 4, <https://doi.org/10.1002/wat2.1246>. 24 pp.
- Lian, T., Chen, D., 2012. An evaluation of rotated EOF analysis and its application to tropical Pacific SST variability. *J. Clim.* 25, 5361–5373.
- Light, A., Bartlein, P.J., 2004. The end of the rainbow? Color schemes for improved data graphics. *Eos* 85, 385, 391.
- Liljas, E., Murphy, A.H., 1994. Anders Angstrom and his early papers on probability forecasting and the use/value of weather forecasts. *Bull. Am. Meteorol. Soc.* 75, 1227–1236.
- Lilliefors, H.W., 1967. On the Kolmogorov-Smirnov test for normality with mean and variance unknown. *J. Am. Stat. Assoc.* 62, 399–402.
- Lim, Y., Jo, S., Lee, J., Oh, H.-S., Kang, H.-S., 2012. An improvement of seasonal climate prediction by regularized canonical correlation analysis. *Int. J. Climatol.* 32, 1503–1512.
- Lin, J.W.-B., Neelin, J.D., 2000. Influence of a stochastic moist convective parameterization on tropical climate variability. *Geophys. Res. Lett.* 27, 3691–3694.
- Lin, J.W.-B., Neelin, J.D., 2002. Considerations for stochastic convective parameterization. *J. Atmos. Sci.* 59, 959–975.
- Lindgren, B.W., 1976. *Statistical Theory*. MacMillan. 614 pp.
- Lindsay, B.G., Kettenring, J., Siegmund, D.O., 2004. A report on the future of Statistics. *Stat. Sci.* 19, 387–413.
- Little, R.J., 2006. Calibrated Bayes: a Bayes/frequentist roadmap. *Am. Stat.* 60, 213–223.
- Livezey, R.E., 2003. Categorical events. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification*, first ed. Wiley, 77–96.
- Livezey, R.E., Chen, W.Y., 1983. Statistical field significance and its determination by Monte Carlo techniques. *Mon. Weather Rev.* 111, 46–59.
- Livezey, R.E., Smith, T.M., 1999. Considerations for use of the Barnett and Preisendorfer (1987) algorithm for canonical correlation analysis of climate variations. *J. Clim.* 12, 303–305.
- Loader, C., 1999. *Local Regression and Likelihood*. Springer. 290 pp.

- Lorenz, E.N., 1956. Empirical Orthogonal Functions and Statistical Weather Prediction. Science Report 1, Statistical Forecasting Project, Department of Meteorology, MIT. NTIS AD 110268, 49 pp.
- Lorenz, E.N., 1963. Deterministic nonperiodic flow. *J. Atmos. Sci.* 20, 130–141.
- Lorenz, E.N., 1965. On the possible reasons for long-period fluctuations of the general circulation. In: *Proceedings of the WMO-IUGG Symposium on Research and Development Aspects of Long-Range Forecasting*. World Meteorological Organization, Boulder, CO, 203–211. WMO Tech. Note 66.
- Lorenz, E.N., 1969. The predictability of a flow which possesses many scales of motion. *Tellus* 3, 290–307.
- Lorenz, E.N., 1975. Climate predictability. In: *The Physical Basis of Climate and Climate Modelling*. GARP Publication Series, vol. 16. WMO, 132–136.
- Lorenz, E.N., 1982. Atmospheric predictability experiments with a large numerical model. *Tellus* 34, 505–513.
- Lorenz, E.N., 1993. *The Essence of Chaos*. University of Washington Press. 227 pp.
- Lorenz, E.N., 2006. Predictability—a problem partly solved. In: Palmer, T., Hagedorn, R. (Eds.), *Predictability of Weather and Climate*. Cambridge University Press, Cambridge, 40–58.
- Loucks, D.P., Stedinger, J.R., Haith, D.A., 1981. *Water Resource Systems Planning and Analysis*. Prentice-Hall. 559 pp.
- Lu, R., 1991. The application of NWP products and progress of interpretation techniques in China. In: Glahn, H.R., Murphy, A.H., Wilson, L.J., Jensenius Jr., J.S. (Eds.), *Programme on Short- and Medium-Range Weather Prediction Research*, XX19–22. World Meteorological Organization WM/TD No. 421.
- Lund, R., Liu, G., Shao, Q., 2016. A new approach to ANOVA methods for autocorrelated data. *Am. Stat.* 70, 55–62.
- Luo, L., Wood, E.F., Pan, M., 2007. Bayesian merging of multiple climate model forecasts for seasonal hydrological predictions. *J. Geophys. Res. D: Atmos.* 112. <https://doi.org/10.1029/2006JD007655>.
- Ma, J., Zhu, Y., Wobus, R., Wang, P., 2012. An effective configuration of ensemble size and horizontal resolution for the NCEP GEFS. *Adv. Atmos. Sci.* 29, 782–794.
- Machete, R.L., Smith, L.A., 2016. Demonstrating the value of larger ensembles in forecasting physical systems. *Tellus A* 68, 28393. 21 pp.
- Macnaughton-Smith, P., Williams, W.T., Dale, M.B., Mockett, L.G., 1964. Dissimilarity analysis: a new technique of hierarchical sub-division. *Nature* 202, 1034–1035.
- Madden, R.A., 1979. A simple approximation for the variance of meteorological time averages. *J. Appl. Meteorol.* 18, 703–706.
- Madden, R.A., Jones, R.H., 2001. A quantitative estimate of the effect of aliasing in climatological time series. *J. Clim.* 14, 3987–3993.
- Madden, R.A., Julian, P.R., 1972. Description of global-scale circulation cells in the tropics with a 40-50 day period. *J. Atmos. Sci.* 29, 1109–1123.
- Madden, R.A., Shea, D.J., 1978. Estimates of the natural variability of time-averaged temperatures over the United States. *Mon. Weather Rev.* 106, 1695–1703.
- Madsen, H., Rasmussen, P.F., Rosbjerg, D., 1997. Comparison of annual maximum series and partial duration series methods for modeling extreme hydrologic events. 1. At-site modeling. *Water Resour. Res.* 33, 747–757.
- Mann, H.B., Whitney, D.R., 1947. On a test of whether one of two random variables is stochastically larger than the other. *Ann. Math. Stat.* 18, 50–60.
- Manzato, A., Jolliffe, I., 2017. Behaviour of verification measures for deterministic binary forecasts with respect to random changes and thresholding. *Q. J. R. Meteorol. Soc.* 143, 1903–1915.
- Mao, Q., McNider, R.T., Mueller, S.F., Juang, H.-M.H., 1999. An optimal model output calibration algorithm suitable for objective temperature forecasting. *Weather Forecast.* 14, 190–202.
- Mao, Y., Monahan, A., 2018. Linear and nonlinear regression prediction of surface wind components. *Clim. Dyn.* 51, 3291–3309.
- Mardia, K.V., 1970. Measures of multivariate skewness and kurtosis with applications. *Biometrika* 57, 519–530.
- Mardia, K.V., Kent, J.T., Bibby, J.M., 1979. *Multivariate Analysis*. Academic. 518 pp.
- Marquardt, D.W., 1970. Generalized inverses, ridge regression, biased linear estimation, and nonlinear estimation. *Technometrics* 12, 591–612.
- Marquardt, D.W., Snee, R.D., 1975. Ridge regression in practice. *Am. Stat.* 29, 3–20.
- Marty, R., Fortin, V., Kuswanto, H., Favre, A.-C., Parent, E., 2015. Combining the Bayesian processor of output with Bayesian model averaging for reliable ensemble forecasting. *Appl. Stat.* 64, 75–92.
- Marzban, C., 2004. The ROC curve and the area under it as performance measures. *Weather Forecast.* 19, 1106–1114.

- Marzban, C., 2012. Displaying economic value. *Weather Forecast.* 27, 1604–1612.
- Marzban, C., Leyton, S., Colman, B., 2007. Ceiling and visibility forecasts via neural networks. *Weather Forecast.* 22, 466–479.
- Marzban, C., Sandgathe, S., 2008. Cluster analysis for object-oriented verification fields: a variation. *Mon. Weather Rev.* 136, 1013–1025.
- Mason, I.B., 1979. On reducing probability forecasts to yes/no forecasts. *Mon. Weather Rev.* 107, 207–211.
- Mason, I.B., 1982. A model for assessment of weather forecasts. *Aust. Meteorol. Mag.* 30, 291–303.
- Mason, I.B., 2003. Binary events. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification*, first ed. Wiley, 37–76.
- Mason, S.J., 2008. Understanding forecast verification statistics. *Meteorol. Appl.* 15, 31–40.
- Mason, S.J., Goddard, L., Graham, N.E., Yulaleva, E., Sun, L., Arkin, P.A., 1999. The IRI seasonal climate prediction system and the 1997/98 El Niño event. *Bull. Am. Meteorol. Soc.* 80, 1853–1873.
- Mason, S.J., Graham, N.E., 2002. Areas beneath the relative operating characteristics (ROC) and relative operating levels (ROL) curves: statistical significance and interpretation. *Q. J. R. Meteorol. Soc.* 128, 2145–2166.
- Mason, S.J., Mimmack, G.M., 1992. The use of bootstrap confidence intervals for the correlation coefficient in climatology. *Theor. Appl. Climatol.* 45, 229–233.
- Mason, S.J., Mimmack, G.M., 2002. Comparison of some statistical methods of probabilistic forecasting of ENSO. *J. Clim.* 15, 8–29.
- Matalas, N.C., 1967. Mathematical assessment of synthetic hydrology. *Water Resour. Res.* 3, 937–945.
- Matalas, N.C., Sankarasubramanian, A., 2003. Effect of persistence on trend detection via regression. *Water Resour. Res.* 39, 1342–1348.
- Matheson, J.E., Winkler, R.L., 1976. Scoring rules for continuous probability distributions. *Manag. Sci.* 22, 1087–1096.
- Matsumoto, M., Nishimura, T., 1998. Mersenne twister: a 623-dimensionally equidistributed uniform pseudorandom number generator. *ACM Trans. Model. Comput. Simul.* 8, 3–30.
- McAvaney, B.J., et al., 2001. Model evaluation. In: Houghton, J.T., et al. (Eds.), *Climate Change 2001: The Scientific Basis*. Cambridge University Press, 471–523.
- McCullagh, P., 1980. Regression models for ordinal data. *J. R. Stat. Soc. Ser. B Methodol.* 42, 109–142.
- McCullagh, P., Nelder, J.A., 1989. *Generalized Linear Models*. Chapman and Hall. 511 pp.
- McCulloch, W.S., Pitts, W.H., 1943. A logical calculus of the ideas immanent in nervous activity. *Bull. Math. Phys.* 5, 115–137.
- McGill, R., Tukey, J.W., Larsen, W.A., 1978. Variations of boxplots. *Am. Stat.* 32, 12–16.
- McGovern, A., Elmore, K.L., Gagne, D.J., Haupt, S.E., Karstens, C.D., Lagerquist, R., Smith, T., Williams, J.K., 2017. Using artificial intelligence to improve real-time decision-making for high-impact weather. *Bull. Am. Meteorol. Soc.* 98, 2073–2090.
- McKee, T.B., Doeskin, N.J., Kleist, J., 1993. The relationship of drought frequency and duration to time scales. In: *Proceedings, 8th Conference on Applied Climatology*. American Meteorological Society, 179–184.
- McLachlan, G.J., Basford, K.E., 1988. *Mixture Models: Inference and Application to Clustering*. Dekker. 253 pp.
- McLachlan, G.J., Krishnan, T., 1997. *The EM Algorithm and Extensions*. Wiley. 274 pp.
- McLachlan, G.J., Peel, D., 2000. *Finite Mixture Models*. Wiley. 419 pp.
- Mecklin, C.J., Mundfrom, D.J., 2004. An appraisal and bibliography of tests for multivariate normality. *Int. Stat. Rev.* 72, 123–138.
- Meinshausen, N., 2006. Quantile regression forests. *Journal of Machine Learning Research* 7, 983–999.
- Merkle, E.C., Steyvers, M., 2013. Choosing a strictly proper scoring rule. *Decision Analysis* 10, 292–304.
- Messner, J.W., Mayr, G.J., 2011. Probabilistic forecasts using analogs in the idealized Lorenz'96 setting. *Mon. Weather Rev.* 139, 1960–1971.
- Messner, J.W., Mayr, G.J., Zeileis, A., 2017. Nonhomogeneous boosting for predictor selection in ensemble postprocessing. *Mon. Weather Rev.* 145, 137–147.
- Messner, J.W., Mayr, G.J., Wilks, D.S., Zeileis, A., 2014a. Extending extended logistic regression: extended versus separate versus ordered versus censored. *Mon. Weather Rev.* 142, 3003–3014.
- Messner, J.W., Mayr, G.J., Zeileis, A., Wilks, D.S., 2014b. Heteroscedastic extended logistic regression for postprocessing of ensemble guidance. *Mon. Weather Rev.* 142, 448–456.
- Mestas-Núñez, A.M., 2000. Orthogonality properties of rotated empirical modes. *Int. J. Climatol.* 20, 1509–1516.
- Metropolis, N., Ulam, S., 1949. The Monte-Carlo method. *J. Am. Stat. Assoc.* 44, 335–341.



- Michaelson, J., 1987. Cross-validation in statistical climate forecast models. *J. Clim. Appl. Meteorol.* 26, 1589–1600.
- Mielke, P.W., 1975. Convenient beta distribution likelihood techniques for describing and comparing meteorological data. *J. Appl. Meteorol.* 14, 985–990.
- Mielke, P.W., 1991. The application of multivariate permutation methods based on distance functions in the earth sciences. *Earth-Science Reviews* 31, 55–71.
- Mielke Jr., P.W., Berry, K.J., Brier, G.W., 1981. Application of multi-response permutation procedures for examining seasonal changes in monthly mean sea-level pressure patterns. *Mon. Weather Rev.* 109, 120–126.
- Mielke Jr., P.W., Berry, K.J., Landsea, C.W., Gray, W.M., 1996. Artificial skill and validation in meteorological forecasting. *Weather Forecast.* 11, 153–169.
- Miller, B.I., Hill, E.C., Chase, P.P., 1968. A revised technique for forecasting hurricane movement by statistical methods. *Mon. Weather Rev.* 96, 540–548.
- Miller, J.M., 1995. Exact maximum likelihood estimation in autoregressive processes. *Journal of Time Series Analysis* 16, 607–615.
- Miller, R.G., 1962. Statistical prediction by discriminant analysis. *Meteorological Monographs*, vol. 4, No. 25. American Meteorological Society. 53 pp.
- Miller, R.G., 1964. Regression Estimation of Event Probabilities. Travelers Research Center, Hartford, CN. Tech Rept No. 1, Contract CWB-107704. 153 pp.
- Millner, A., 2008. Getting the most out of ensemble forecasts: a valuation model based on user-forecast interactions. *J. Appl. Meteorol. Climatol.* 47, 2561–2571.
- Mirzargar, M., Anderson, J.L., 2017. On evaluation of ensemble forecast calibration using the concept of data depth. *Mon. Weather Rev.* 145, 1679–1690.
- Mitchell, K., Ferro, C.A.T., 2017. Proper scoring rules for interval probabilistic forecasts. *Q. J. R. Meteorol. Soc.* 143, 1597–1607.
- Mittermaier, M.P., Bullock, R., 2013. Using MODE to explore the spatial and temporal characteristics of cloud cover forecasts from high-resolution NWP models. *Meteorol. Appl.* 20, 187–196.
- Mittermaier, M.P., Stephenson, D.B., 2015. Inherent bounds on forecast accuracy due to observation uncertainty caused by temporal sampling. *Mon. Weather Rev.* 143, 4236–4243.
- Miyakoda, K., Hembree, G.D., Strikler, R.F., Shulman, I., 1972. Cumulative results of extended forecast experiments. I: Model performance for winter cases. *Mon. Weather Rev.* 100, 836–855.
- Mo, K.C., Ghil, M., 1987. Statistics and dynamics of persistent anomalies. *J. Atmos. Sci.* 44, 877–901.
- Mo, K.C., Ghil, M., 1988. Cluster analysis of multiple planetary flow regimes. *J. Geophys. Res. D: Atmos.* 93, 10927–10952.
- Möller, A., Lenkoski, A., Thorarindottir, T.L., 2013. Multivariate probabilistic forecasting using ensemble Bayesian model averaging and copulas. *Q. J. R. Meteorol. Soc.* 139, 982–991.
- Molteni, F., Buizza, R., Palmer, T.N., Petrolia, T., 1996. The new ECMWF ensemble prediction system: methodology and validation. *Q. J. R. Meteorol. Soc.* 122, 73–119.
- Molteni, F., Tibaldi, S., Palmer, T.N., 1990. Regimes in wintertime circulation over northern extratropics. I: Observational evidence. *Q. J. R. Meteorol. Soc.* 116, 31–67.
- Montgomery, D.C., 2013. *Design and Analysis of Experiments*. Wiley. 724 pp.
- Moritz, R.E., Sutter, A., 1981. The predictability problem: effects of stochastic perturbations in multiequilibrium systems. *Rev. Geophys.* 23, 345–383.
- Morrison, J.E., Smith, J.A., 2002. Stochastic modeling of flood peaks using the generalized extreme value distribution. *Water Resour. Res.* 38, 1305. <https://doi.org/10.1029/2001WR000502>.
- Moura, A.D., Hastenrath, S., 2004. Climate prediction for Brazil's Nordeste: performance of empirical and numerical modeling methods. *J. Clim.* 17, 2667–2672.
- Muhlbauer, A., Spichtinger, P., Lohmann, U., 2009. Application and comparison of robust linear regression methods for trend estimation. *J. Appl. Meteorol. Climatol.* 48, 1961–1970.
- Mullen, S.L., Buizza, R., 2002. The impact of horizontal resolution and ensemble size on probabilistic forecasts of precipitation by the ECMWF ensemble prediction system. *Weather Forecast.* 17, 173–191.
- Muller, R.H., 1944. Verification of short-range weather forecasts (a survey of the literature). *Bull. Am. Meteorol. Soc.* 25, 18–27. 47–53, 88–95.

- Murphy, A.H., 1966. A note on the utility of probabilistic predictions and the probability score in the cost-loss ratio situation. *J. Appl. Meteorol.* 5, 534–537.
- Murphy, A.H., 1971. A note on the ranked probability score. *J. Appl. Meteorol.* 10, 155–156.
- Murphy, A.H., 1972. Scalar and vector partitions of the probability score: Part II. N-state situation. *J. Appl. Meteorol.* 11, 1183–1192.
- Murphy, A.H., 1973a. Hedging and skill scores for probability forecasts. *J. Appl. Meteorol.* 12, 215–223.
- Murphy, A.H., 1973b. A new vector partition of the probability score. *J. Appl. Meteorol.* 12, 595–600.
- Murphy, A.H., 1977. The value of climatological, categorical, and probabilistic forecasts in the cost-loss ratio situation. *Mon. Weather Rev.* 105, 803–816.
- Murphy, A.H., 1985. Probabilistic weather forecasting. In: Murphy, A.H., Katz, R.W. (Eds.), *Probability, Statistics, and Decision Making in the Atmospheric Sciences*. Westview Press, Boulder, CO, 337–377.
- Murphy, A.H., 1988. Skill scores based on the mean square error and their relationships to the correlation coefficient. *Mon. Weather Rev.* 116, 2417–2424.
- Murphy, A.H., 1991. Forecast verification: its complexity and dimensionality. *Mon. Weather Rev.* 119, 1590–1601.
- Murphy, A.H., 1992. Climatology, persistence, and their linear combination as standards of reference in skill scores. *Weather Forecast.* 7, 692–698.
- Murphy, A.H., 1993. What is a good forecast? An essay on the nature of goodness in weather forecasting. *Weather Forecast.* 8, 281–293.
- Murphy, A.H., 1995. The coefficients of correlation and determination as measures of performance in forecast verification. *Weather Forecast.* 10, 681–688.
- Murphy, A.H., 1996. The Finley affair: a signal event in the history of forecast verification. *Weather Forecast.* 11, 3–20.
- Murphy, A.H., 1997. Forecast verification. In: Katz, R.W., Murphy, A.H. (Eds.), *Economic Value of Weather and Climate Forecasts*. Cambridge University Press, Cambridge, 19–74.
- Murphy, A.H., 1998. The early history of probability forecasts: some extensions and clarifications. *Weather Forecast.* 13, 5–15.
- Murphy, A.H., Brown, B.G., 1983. Forecast terminology: composition and interpretation of public weather forecasts. *Bull. Am. Meteorol. Soc.* 64, 13–22.
- Murphy, A.H., Brown, B.G., Chen, Y.-S., 1989. Diagnostic verification of temperature forecasts. *Weather Forecast.* 4, 485–501.
- Murphy, A.H., Daan, H., 1985. Forecast evaluation. In: Murphy, A.H., Katz, R.W. (Eds.), *Probability, Statistics, and Decision Making in the Atmospheric Sciences*. Westview Press, Boulder, CO, 379–437.
- Murphy, A.H., Ehrendorfer, M., 1987. On the relationship between the accuracy and value of forecasts in the cost-loss ratio situation. *Weather Forecast.* 2, 243–251.
- Murphy, A.H., Epstein, E.S., 1967a. Verification of probabilistic predictions: a brief review. *J. Appl. Meteorol.* 6, 748–755.
- Murphy, A.H., Epstein, E.S., 1967b. A note on probability forecasts and “hedging”. *J. Appl. Meteorol.* 6, 1002–1004.
- Murphy, A.H., Epstein, E.S., 1989. Skill scores and correlation coefficients in model verification. *Mon. Weather Rev.* 117, 572–581.
- Murphy, A.H., Wilks, D.S., 1998. A case study in the use of statistical models in forecast verification: precipitation probability forecasts. *Weather Forecast.* 13, 795–810.
- Murphy, A.H., Winkler, R.L., 1974. Credible interval temperature forecasting: some experimental results. *Mon. Weather Rev.* 102, 784–794.
- Murphy, A.H., Winkler, R.L., 1979. Probabilistic temperature forecasts: the case for an operational program. *Bull. Am. Meteorol. Soc.* 60, 12–19.
- Murphy, A.H., Winkler, R.L., 1984. Probability forecasting in meteorology. *J. Am. Stat. Assoc.* 79, 489–500.
- Murphy, A.H., Winkler, R.L., 1987. A general framework for forecast verification. *Mon. Weather Rev.* 115, 1330–1338.
- Murphy, A.H., Winkler, R.L., 1992. Diagnostic verification of probability forecasts. *Int. J. Forecast.* 7, 435–455.
- Murphy, A.H., Ye, Q., 1990. Comparison of objective and subjective precipitation probability forecasts: the sufficiency relation. *Mon. Weather Rev.* 118, 1783–1792.
- Mylne, K.R., 2002. Decision-making from probability forecasts based on forecast value. *Meteorol. Appl.* 9, 307–315.
- Mylne, K.R., Evans, R.E., Clark, R.T., 2002a. Multi-model multi-analysis ensembles in quasi-operational medium-range forecasting. *Q. J. R. Meteorol. Soc.* 128, 361–384.

- Mylne, K.R., Woolcock, C., Denholm-Price, J.C.W., Darvell, R.J., 2002b. Operational calibrated probability forecasts from the ECMWF ensemble prediction system: implementation and verification. In: Preprints, Symposium on Observations, Data Analysis, and Probabilistic Prediction (Orlando, Florida). American Meteorological Society, 113–118.
- Namias, J., 1952. The annual course of month-to-month persistence in climatic anomalies. *Bull. Am. Meteorol. Soc.* 33, 279–285.
- Narapuseetty, B., DelSole, T., Tippett, M.K., 2009. Optimal estimation of the climatological mean. *J. Clim.* 22, 4845–4859.
- Narula, S.C., Wellington, J.F., 1982. The minimum sum of absolute errors regression: a state of the art survey. *Int. Stat. Rev.* 50, 317–326.
- National Bureau of Standards, 1959. Tables of the Bivariate Normal Distribution Function and Related Functions. Applied Mathematics Series, 50 U.S. Government Printing Office. 258 pp.
- National Research Council, 2006. Completing the Forecast: Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts. National Academy Press, Washington DC. ISBN 0-309066327-X, [www.nap.edu/catalog/11699.html](http://www.nap.edu/catalog/11699.html).
- Navarra, A., Simoncini, V., 2010. A Guide to Empirical Orthogonal Functions for Climate Data Analysis. Springer. 151 pp.
- Naveau, P., Bessac, J., 2018. Forecast evaluation with imperfect observations and imperfect models. arXiv:1806.03745v1, 21 pp.
- Neelin, J.D., Peters, O., Lin, J.W.-B., Hales, K., Holloway, C.E., 2010. Rethinking convective quasi-equilibrium: observational constraints for stochastic convective schemes in climate models. In: Palmer, T., Williams, P. (Eds.), *Stochastic Physics and Climate Modeling*. Cambridge University Press, Cambridge, 396–423.
- Neille, P.P., Myers, W., Young, G., 2002. Ensemble dynamic MOS. In: Preprints, 16th Conference on Probability and Statistics in the Atmospheric Sciences (Orlando, Florida). American Meteorological Society, 102–106.
- Neter, J., Wasserman, W., Kutner, M.H., 1996. *Applied Linear Statistical Models*. McGraw-Hill. 1408 pp.
- Neumann, C.J., Jarvinen, B.R., McAdie, C.J., Hammer, G.R., 1999. Tropical Cyclones of the North Atlantic Ocean, 1871–1998, 5th Revision. National Climatic Data Center, Asheville NC. 206 pp.
- Neumann, C.J., Lawrence, M.B., Caso, E.L., 1977. Monte Carlo significance testing as applied to statistical tropical cyclone prediction models. *J. Appl. Meteorol.* 16, 1165–1174.
- Newman, M., Sardeshmukh, P., 1995. A caveat concerning singular value decomposition. *J. Clim.* 8, 352–360.
- Nicholls, N., 2001. The insignificance of significance testing. *Bull. Am. Meteorol. Soc.* 82, 981–986.
- Nielsen, H.A., Madsen, H., Nielsen, T.S., 2006. Using quantile regression to extend an existing wind power forecasting system with probabilistic forecasts. *Wind Energy* 9, 95–108.
- North, G.R., 1984. Empirical orthogonal functions and normal modes. *J. Atmos. Sci.* 41, 879–887.
- North, G.R., Bell, T.L., Cahalan, R.F., Moeng, F.J., 1982. Sampling errors in the estimation of empirical orthogonal functions. *Mon. Weather Rev.* 110, 699–706.
- Northrop, P.J., Chandler, R.E., 2014. Quantifying sources of uncertainty in projections of future climate. *J. Clim.* 27, 8793–8808.
- Obukhov, A.M., 1947. Statistically homogeneous fields on a sphere. *Usp. Mathematic. Nauk* 2, 196–198.
- O’Lenic, E.A., Livezey, R.E., 1988. Practical considerations in the use of rotated principal component analysis (RPCA) in diagnostic studies of upper-air height fields. *Mon. Weather Rev.* 116, 1682–1689.
- O’Lenic, E.A., Unger, D.A., Halpert, M.S., Pelman, K.S., 2008. Developments in operational long-range climate prediction at CPC. *Weather Forecast.* 23, 496–515.
- Ollinaho, P., Lock, S.-J., Leutbecher, M., Bechtold, P., Beljaars, A., Bozzo, A., Forbes, R.M., Haiden, T., Hogan, R.J., Sandu, I., 2017. Towards process-level representation of model uncertainties: stochastically perturbed parameterizations in the ECMWF ensemble. *Q. J. R. Meteorol. Soc.* 143, 408–422.
- Osborn, T.J., Hulme, M., 1997. Development of a relationship between station and grid-box rainfall frequencies for climate model evaluation. *J. Clim.* 10, 1885–1908.
- Overland, J.E., Preisendorfer, R.W., 1982. A significance test for principal components applied to a cyclone climatology. *Mon. Weather Rev.* 110, 1–4.
- Paciorek, C.J., Risbey, J.S., Ventura, V., Rosen, R.D., 2002. Multiple indices of Northern Hemisphere cyclone activity, winters 1949–99. *J. Clim.* 15, 1573–1590.
- Palmer, T.N., 1993. Extended-range atmospheric prediction and the Lorenz model. *Bull. Am. Meteorol. Soc.* 74, 49–65.
- Palmer, T.N., 2001. A nonlinear dynamical perspective on model error: A proposal for non-local stochastic-dynamic parameterization in weather and climate prediction models. *Q. J. R. Meteorol. Soc.* 127, 279–304.

- Palmer, T.N., 2006. Predictability of weather and climate: from theory to practice. In: Palmer, T., Hagedorn, R. (Eds.), *Predictability of Weather and Climate*. Cambridge University Press, Cambridge, 1–29.
- Palmer, T.N., 2012. Towards the probabilistic Earth-system simulator: a vision for the future of climate and weather prediction. *Q. J. R. Meteorol. Soc.* 138, 841–861.
- Palmer, T.N., 2014a. More reliable forecasts with less precise computations: a fast-track route to cloud-resolved weather and climate simulators? *Phil. Trans. R. Soc. A* 372. <https://doi.org/10.1098/rsta.2013.0391>. 14 pp.
- Palmer, T.N., 2014b. The real butterfly effect. *Nonlinearity* 27, R123–R141.
- Palmer, T.N., Doblas-Reyes, F.J., Hagedorn, R., Weisheimer, A., 2005a. Probabilistic prediction of climate using multi-model ensembles: from basics to applications. *Phil. Trans. R. Soc. B* 360, 1991–1998.
- Palmer, T.N., Mureau, R., Molteni, F., 1990. The Monte Carlo forecast. *Weather* 45, 198–207.
- Palmer, T.N., Shutts, G.J., Hagedorn, R., Doblas-Reyes, F.J., Jung, T., Leutbecher, M., 2005b. Representing model uncertainty in weather and climate prediction. *Annu. Rev. Earth Planet. Sci.* 33, 163–193.
- Palmer, T.N., Tibaldi, S., 1988. On the prediction of forecast skill. *Mon. Weather Rev.* 116, 2453–2480.
- Panofsky, H.A., Brier, G.W., 1958. *Some Applications of Statistics to Meteorology*. Pennsylvania State University. 224 pp.
- Papalexiou, S.M., Koutsoyiannis, D., 2013. Battle of extreme value distributions: A global survey on extreme daily rainfall. *Water Resour. Res.* 49, 187–201.
- Pappenberger, F., Ghelli, A., Buizza, R., Bódis, K., 2009. The skill of probabilistic precipitation forecasts under observational uncertainties within the generalized likelihood uncertainty estimation framework for hydrological applications. *J. Hydrometeorol.* 10, 807–819.
- Parisi, F., Lund, R., 2008. Return periods of continental U.S. hurricanes. *J. Clim.* 21, 403–410.
- Peatman, S.C., Matthews, A.J., Stephens, D.P., 2015. Propagation of the Madden-Julian oscillation and scale interaction with the diurnal cycle in a high-resolution GCM. *Clim. Dyn.* 45, 2901–2918.
- Peirce, C.S., 1884. The numerical measure of the success of predictions. *Science* 4, 453–454.
- Peyrolo, R., 2011. Information gain as a score for probabilistic forecasts. *Meteorol. Appl.* 18, 9–17.
- Penland, C., Sardeshmukh, P.D., 1995. The optimal growth of tropical sea surface temperatures anomalies. *J. Clim.* 8, 1999–2024.
- Pepe, M.S., 2003. *The Statistical Evaluation of Medical Tests for Classification and Prediction*. Oxford University Press. 302 pp.
- Peterson, C.R., Snapper, K.J., Murphy, A.H., 1972. Credible interval temperature forecasts. *Bull. Am. Meteorol. Soc.* 53, 966–970.
- Pinson, P., 2012. Adaptive calibration of  $(u,v)$ -wind ensemble forecasts. *Q. J. R. Meteorol. Soc.* 138, 1273–1284.
- Pinson, P., 2013. Wind energy: forecasting challenges for its operational management. *Stat. Sci.* 28, 564–585.
- Pinson, P., Girard, R., 2012. Evaluating the quality of scenarios of short-term wind power generation. *Appl. Energy* 96, 12–20.
- Pinson, P., Hagedorn, R., 2012. Verification of the ECMWF ensemble forecasts of wind speed against analyses and observations. *Meteorol. Appl.* 19, 484–500.
- Pinson, P., McSharry, P., Madsen, H., 2010. Reliability diagrams for non-parametric density forecasts of continuous variables: accounting for serial correlation. *Q. J. R. Meteorol. Soc.* 136, 77–90.
- Pitcher, E.J., 1974. *Stochastic Dynamic Prediction Using Atmospheric Data*. Ph.D. dissertation, University of Michigan.
- Pitcher, E.J., 1977. Application of stochastic dynamic prediction to real data. *J. Atmos. Sci.* 34, 3–21.
- Pitman, E.J.G., 1937. Significance tests which may be applied to samples from any populations. *J. R. Stat. Soc. Ser. B Methodol.* 4, 119–130.
- Plaut, G., Vautard, R., 1994. Spells of low-frequency oscillations and weather regimes in the Northern Hemisphere. *J. Atmos. Sci.* 51, 210–236.
- Pocernich, M., 2007. *Verification: forecast verification utilities*. R package version 1.20. <http://www.r-project.org>.
- Politis, D., Romano, J.P., 1992. A circular block resampling procedure for stationary data. In: Lepage, R., Billard, L. (Eds.), *Exploring the Limits of Bootstrap*. Wiley, 263–270.
- Politis, D.N., Romano, J.P., Wolf, M., 1999. *Subsampling*. Springer, p. 347.
- Preisendorfer, R.W., 1988. Mobley, C.D. (Ed.), *Principal Component Analysis in Meteorology and Oceanography*. Elsevier. 425 pp.
- Preisendorfer, R.W., Barnett, T.P., 1983. Numerical-reality intercomparison tests using small-sample statistics. *J. Atmos. Sci.* 40, 1884–1896.
- Preisendorfer, R.W., Mobley, C.D., 1984. Climate forecast verifications, United States Mainland, 1974–83. *Mon. Weather Rev.* 112, 809–825.

- Preisendorfer, R.W., Zwiers, F.W., Barnett, T.P., 1981. Foundations of Principal Component Selection Rules. SIO Reference Series 81-4, Scripps Institution of Oceanography. 192 pp.
- Press, W.H., Flannery, B.P., Teukolsky, S.A., Vetterling, W.T., 1986. Numerical Recipes: The Art of Scientific Computing. Cambridge University Press. 818 pp.
- Prokosch, J., 2013. Bivariate Bayesian Model Averaging and Ensemble Model Output Statistics. M.S. Thesis, Norwegian University of Science and Technology. 85 pp. <http://www.diva-portal.org/smash/get/diva2:656466/FULLTEXT01.pdf>.
- Quadrelli, R., Bretherton, C.S., Wallace, J.M., 2005. On sampling errors in empirical orthogonal functions. *J. Clim.* 18, 3704–3710.
- Quan, X., Hoerling, M., Whitaker, J., Bates, G., Xu, T., 2006. Diagnosing sources of U.S. seasonal forecast skill. *J. Clim.* 19, 3279–3293.
- R Development Core Team, 2017. An Introduction to R. R Foundation for Statistical Computing, <http://www.R-project.org/>.
- Radok, U., 1988. Chance behavior of skill scores. *Mon. Weather Rev.* 116, 489–494.
- Raftery, A.E., Gneiting, T., Balabdaoui, F., Polakowski, M., 2005. Using Bayesian model averaging to calibrate forecast ensembles. *Mon. Weather Rev.* 133, 1155–1174.
- Räsänen, J., 2001. CO<sub>2</sub>-induced climate change in CMIP2 experiments: quantification of agreement and role of internal variability. *J. Clim.* 14, 2088–2104.
- Rajagopalan, B., Lall, U., Tarboton, D.G., 1997. Evaluation of kernel density estimation methods for daily precipitation resampling. *Stoch. Hydrol. Hydraul.* 11, 523–547.
- Raynaud, L., Bouttier, F., 2017. The impact of horizontal resolution and ensemble size for convective-scale probabilistic forecasts. *Q. J. R. Meteorol. Soc.* 143, 3037–3047.
- Razali, N.M., Wah, Y.B., 2011. Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests. *J. Stat. Model. Anal.* 2, 21–33.
- Reggiani, P., Renner, M., Weerts, A.H., van Gelder, P.A.H.J.M., 2009. Uncertainty assessment via Bayesian revision of ensemble streamflow predictions in the operational river Rhine forecasting system. *Water Resour. Res.* 45. <https://doi.org/10.1029/2007WR006758>.
- Retchless, D.P., Brewer, C.A., 2016. Guidance for representing uncertainty on global temperature change maps. *Int. J. Climatol.* 36, 1143–1159.
- Richardson, A.J., Risien, C., Shillington, F.A., 2003. Using self-organizing maps to identify patterns in satellite imagery. *Prog. Oceanogr.* 59, 223–239.
- Richardson, C.W., 1981. Stochastic simulation of daily precipitation, temperature, and solar radiation. *Water Resour. Res.* 17, 182–190.
- Richardson, D.S., 2000. Skill and economic value of the ECMWF ensemble prediction system. *Q. J. R. Meteorol. Soc.* 126, 649–667.
- Richardson, D.S., 2001. Measures of skill and value of ensemble predictions systems, their interrelationship and the effect of ensemble size. *Q. J. R. Meteorol. Soc.* 127, 2473–2489.
- Richardson, D.S., 2003. Economic value and skill. In: Jolliffe, I.T., Stephenson, D.B. (Eds.), *Forecast Verification*, first ed. Wiley, 165–187.
- Richman, M.B., 1986. Rotation of principal components. *Int. J. Climatol.* 6, 293–335.
- Roberts, N.M., Lean, H.W., 2008. Scale-selective verification of rainfall accumulations from high-resolution forecasts of convective events. *Mon. Weather Rev.* 136, 78–97.
- Roberts, R.D., Anderson, A.R.S., Nelson, E., Brown, B.G., Wilson, J.W., Pocerich, M., Saxen, T., 2012. Impacts of forecaster involvement on convective storm initiation and evolution nowcasting. *Weather Forecast.* 27, 1061–1089.
- Rodwell, M.J., Richardson, D.S., Hewitson, T.D., Haiden, T., 2010. A new equitable score suitable for verifying precipitation in numerical weather prediction. *Q. J. R. Meteorol. Soc.* 136, 1344–1363.
- Roebber, P.J., 2009. Visualizing multiple measures of forecast quality. *Weather Forecast.* 24, 601–608.
- Roebber, P.J., Bosart, L.F., 1996. The complex relationship between forecast skill and forecast value: a real-world analysis. *Weather Forecast.* 11, 544–559.
- Romanic, D., Curic, M., Jovicic, I., Lompar, M., 2015. Long-term trends of the 'Koshava' wind during the period 1949–2010. *Int. J. Climatol.* 35, 288–302.
- Romesburg, H.C., 1984. Cluster Analysis for Researchers. Wadsworth/Lifetime Learning Publications. 334 pp.

- Ropelewski, C.F., Jones, P.D., 1987. An extension of the Tahiti-Darwin Southern Oscillation index. *Mon. Weather Rev.* 115, 2161–2165.
- Röpnack, A., Hense, A., Gebharddt, C., Majewski, D., 2013. Bayesian model verification of NWP ensemble forecasts. *Mon. Weather Rev.* 141, 375–387.
- Rosenberger, J.L., Gasko, M., 1983. Comparing location estimators: trimmed means, medians, and trimean. In: Hoaglin, D.C., Mosteller, F., Tukey, J.W. (Eds.), *Understanding Robust and Exploratory Data Analysis*. Wiley, New York, 297–338.
- Rougier, J., 2016. Ensemble averaging and mean squared error. *J. Clim.* 29, 8865–8870.
- Roulin, E., Vannitsem, S., 2012. Postprocessing of ensemble precipitation predictions with extended logistic regression based on hindcasts. *Mon. Weather Rev.* 140, 874–888.
- Roulston, M.S., Bolton, G.E., Kleit, A.N., Sears-Collins, A.L., 2006. A laboratory study of the benefits of including uncertainty information in weather forecasts. *Weather Forecast.* 21, 116–122.
- Roulston, M.S., Kaplan, D.T., Hardenberg, J., Smith, L.A., 2003. Using medium-range weather forecasts to improve the value of wind energy production. *Renew. Energy* 28, 585–602.
- Roulston, M.S., Smith, L.A., 2002. Evaluating probabilistic forecasts using information theory. *Mon. Weather Rev.* 130, 1653–1660.
- Roulston, M.S., Smith, L.A., 2003. Combining dynamical and statistical ensembles. *Tellus A* 55, 16–30.
- Ruiz, J.J., Saulo, C., 2012. How sensitive are probabilistic precipitation forecasts to the choice of calibration algorithms and the ensemble generation method? Part I: sensitivity to calibration methods. *Meteorol. Appl.* 19, 302–313.
- Rüschendorf, L., 2009. On the distributional transform, Sklar's theorem, and the empirical copula process. *J. Stat. Plan. Inference* 139, 3921–3927.
- Saetra, O., Hersbach, H., Bidlot, J.-R., Richardson, D.S., 2004. Effects of observation errors on the statistics for ensemble spread and reliability. *Mon. Weather Rev.* 132, 1487–1501.
- Sain, S.R., Nychka, D., Mearns, L., 2011. Functional ANOVA and regional climate experiments: a statistical analysis of dynamic downscaling. *Environmetrics* 22, 700–711.
- Sanchez, C., Williams, K.D., Collins, M., 2016. Improved stochastic physics schemes for global weather and climate models. *Q. J. R. Meteorol. Soc.* 142, 147–159.
- Sanders, F., 1963. On subjective probability forecasting. *J. Appl. Meteorol.* 2, 191–201.
- Sansom, J., Thomson, P.J., 1992. Rainfall classification using breakpoint pluviograph data. *J. Clim.* 5, 755–764.
- Sansom, P.G., Ferro, C.A.T., Stephenson, D.B., Goddard, L., Mason, S.J., 2016. Best practices for postprocessing ensemble climate forecasts. Part I: Selecting appropriate calibration methods. *J. Clim.* 29, 7247–7264.
- Sansom, P.G., Stephenson, D.B., Ferro, C.A.T., Zappa, G., Shaffrey, L., 2013. Simple uncertainty frameworks for selecting weighting schemes and interpreting multimodel ensemble climate change experiments. *J. Clim.* 26, 4017–4037.
- Santer, B.D., Wigley, T.M.L., Boyle, J.S., Gaffen, D.J., Hnilo, J.J., Nychka, D., Parker, D.E., Taylor, K.E., 2000. Statistical significance of trends and trend differences in layer-average atmospheric temperature series. *J. Geophys. Res.* 105, 7337–7356.
- Santos, C., Ghelli, A., 2012. Observational probability methods to assess ensemble precipitation forecasts. *Q. J. R. Meteorol. Soc.* 138, 209–221.
- Satterfield, E.A., Bishop, C.H., 2014. Heteroscedastic ensemble postprocessing. *Mon. Weather Rev.* 142, 3484–3502.
- Sauvageot, H., 1994. Rainfall measurement by radar: a review. *Atmos. Res.* 35, 27–54.
- Schefzik, R., 2016. A similarity-based implementation of the Schaake shuffle. *Mon. Weather Rev.* 144, 1909–1921.
- Schefzik, R., 2017. Ensemble calibration with preserved correlations: unifying and comparing ensemble copula coupling and member-by-member postprocessing. *Q. J. R. Meteorol. Soc.* 143, 999–1008. <https://doi.org/10.1002/qj.2984>.
- Schefzik, R., Thorarindottir, T.L., Gneiting, T., 2013. Uncertainty quantification in complex simulation models using ensemble copula coupling. *Stat. Sci.* 28, 616–640.
- Schenker, N., Gentleman, J.F., 2001. On judging the significance of differences by examining the overlap between confidence intervals. *Am. Stat.* 55, 182–186.
- Scherrer, S.C., Appenzeller, C., Eckert, P., Cattani, D., 2004. Analysis of the spread-skill relations using the ECMWF ensemble prediction system over Europe. *Weather Forecast.* 19, 552–565.
- Schervish, M.J., 1989. A general method for comparing probability assessors. *Ann. Stat.* 17, 1856–1879.



- Scheuerer, M., 2014. Probabilistic quantitative precipitation forecasting using ensemble model output statistics. *Q. J. R. Meteorol. Soc.* 140, 1086–1096.
- Scheuerer, M., Hamill, T.M., 2015a. Statistical postprocessing of ensemble precipitation forecasts by fitting censored, shifted gamma distributions. *Mon. Weather Rev.* 143, 4578–4596.
- Scheuerer, M., Hamill, T.M., 2015b. Variogram-based proper scoring rules for probabilistic forecasts of multivariate quantities. *Mon. Weather Rev.* 143, 1321–1334.
- Scheuerer, M., Hamill, T.M., 2018. Generating calibrated ensembles of physically realistic high-resolution precipitation forecast fields based on GEFS model output. *J. Hydromet.* 19, 1651–1670.
- Scheuerer, M., Hamill, T.M., Whitin, B., He, M., Henkel, A., 2017. A method for preferential selection of dates in the Schaake shuffle approach to constructing spatiotemporal forecast fields of temperature and precipitation. *Water Resour. Res.* 53, 3029–3046.
- Scheuerer, M., Möller, D., 2015. Probabilistic wind speed forecasting on a grid based on ensemble model output statistics. *Ann. Appl. Stat.* 9, 1328–1349.
- Schmeits, M.J., Kok, K.J., 2010. A comparison between raw ensemble output, (modified) Bayesian Model Averaging, and extended logistic regression using ECMWF ensemble precipitation forecasts. *Mon. Weather Rev.* 138, 4199–4211.
- Schölzel, C., Hense, A., 2011. Probabilistic assessment of regional climate change in southwest Germany by ensemble dressing. *Clim. Dyn.* <https://doi.org/10.1007/s00382-010-0815-1>. 12 pp.
- Schuhen, N., Thorarindottir, T.L., Gneiting, T., 2012. Ensemble model output statistics for wind vectors. *Mon. Weather Rev.* 140, 3204–3219.
- Schwarz, G., 1978. Estimating the dimension of a model. *Ann. Stat.* 6, 461–464.
- Scott, D.W., 1992. *Multivariate Density Estimation*. Wiley. 317 pp.
- Seaman, R., Mason, I., Woodcock, F., 1996. Confidence intervals for some performance measures of yes-no forecasts. *Aust. Meteorol. Mag.* 45, 49–53.
- Semazzi, F.H.M., Mera, R.J., 2006. An extended procedure for implementing the relative operating characteristic graphical method. *J. Appl. Meteorol. Climatol.* 45, 1215–1223.
- Sen, P.K., 1968. Estimates of the regression coefficient based on Kendall's tau. *J. Am. Stat. Assoc.* 63, 1379–1389.
- Serinaldi, F., Kilsby, C.G., 2014. Rainfall extremes: toward reconciliation after the battle of distributions. *Water Resour. Res.* 50, 336–352.
- Shannon, C.E., 1948. A mathematical theory of communication. *Bell Syst. Tech. J.* 27, 379–423, 623–656.
- Shapiro, S.S., Wilk, M.B., 1965. An analysis of variance test for normality (complete samples). *Biometrika* 52, 591–610.
- Sharma, A., Lall, U., Tarboton, D.G., 1998. Kernel bandwidth selection for a first order nonparametric streamflow simulation model. *Stoch. Hydrol. Hydraul.* 12, 33–52.
- Sheets, R.C., 1990. The National Hurricane Center—past, present and future. *Weather Forecast.* 5, 185–232.
- Shongwe, M.E., Landman, W.A., Mason, S.J., 2006. Performance of recalibration systems for GCM forecasts for southern Africa. *Int. J. Climatol.* 26, 1567–1585.
- Shutts, G., 2015. A stochastic convective backscatter scheme for use in ensemble prediction systems. *Q. J. R. Meteorol. Soc.* 141, 2602–2616.
- Siebert, S., 2014. Variance estimation for Brier score decomposition. *Q. J. R. Meteorol. Soc.* 140, 1771–1777.
- Siebert, S., Bellprat, O., Ménégoz, M., Stephenson, D.B., Doblas-Reyes, F.J., 2017. Detecting improvements in forecast correlation skill: statistical testing and power analysis. *Mon. Weather Rev.* 145, 437–450.
- Siebert, S., Stephenson, D.B., Sansom, P.G., Scaife, A.A., Eade, R., Arribas, A., 2016. A Bayesian framework for verification and recalibration of ensemble forecasts: how uncertain is NAO predictability? *J. Clim.* 29, 995–1012.
- Silver, N., 2012. *The Signal and the Noise*. Penguin Books. 534 pp.
- Silverman, B.W., 1986. *Density Estimation for Statistics and Data Analysis*. Chapman and Hall. 175 pp.
- Simmons, A.J., Hollingsworth, A., 2002. Some aspects of the improvement in skill of numerical weather prediction. *Q. J. R. Meteorol. Soc.* 128, 647–677.
- Skok, G., Roberts, N., 2016. Analysis of fractions skill score properties for random precipitation fields and ECMWF forecasts. *Q. J. R. Meteorol. Soc.* 142, 2599–2610.
- Skok, G., Roberts, N., 2018. Estimating the displacement in precipitation forecasts using the fractions skill score. *Q.J.R. Meteorol. Soc.* 144, 414–425.

- Sloughter, J.M., Gneiting, T., Raftery, A.E., 2010. Probabilistic wind speed forecasting using ensembles and Bayesian model averaging. *J. Am. Stat. Assoc.* 105, 25–35.
- Sloughter, J.M., Gneiting, T., Raftery, A.E., 2013. Probabilistic wind vector forecasting using ensembles and Bayesian model averaging. *Mon. Weather Rev.* 141, 2107–2119.
- Sloughter, J.M., Raftery, A.E., Gneiting, T., Fraley, C., 2007. Probabilistic quantitative precipitation forecasting using Bayesian model averaging. *Mon. Weather Rev.* 135, 3209–3220.
- Smith, L.A., 2001. Disentangling uncertainty and error: on the predictability of nonlinear systems. In: Mees, A.I. (Ed.), *Nonlinear Dynamics and Statistics*. Birkhauser, 31–64.
- Smith, L.A., 2007. *Chaos, A Very Short Introduction*. Oxford University Press. 180 pp.
- Smith, L.A., Hansen, J.A., 2004. Extending the limits of ensemble forecast verification with the minimum spanning tree. *Mon. Weather Rev.* 132, 1522–1528.
- Smith, R.E., Schreiber, H.A., 1974. Point process of seasonal thunder-storm rainfall: 2. Rainfall depth probabilities. *Water Resour. Res.* 10, 418–423.
- Smyth, P., Ide, K., Ghil, M., 1999. Multiple regimes in Northern Hemisphere height fields via mixture model clustering. *J. Atmos. Sci.* 56, 3704–3723.
- Solow, A.R., Moore, L., 2000. Testing for a trend in a partially incomplete hurricane record. *J. Clim.* 13, 3696–3710.
- Spetzler, C.S., Staël von Holstein, C.-A.S., 1975. Probability encoding in decision analysis. *Manag. Sci.* 22, 340–358.
- Sprent, P., Smeeton, N.C., 2001. *Applied Nonparametric Statistical Methods*. Chapman and Hall. 461 pp.
- Stacy, E.W., 1962. A generalization of the Gamma distribution. *Ann. Math. Stat.* 33, 1187–1192.
- Staël von Holstein, C.-A.S., Murphy, A.H., 1978. The family of quadratic scoring rules. *Mon. Weather Rev.* 106, 917–924.
- Stanski, H.R., Wilson, L.J., Burrows, W.R., 1989. *Survey of Common Verification Methods in Meteorology*. World Weather Watch Technical Report No. 8, World Meteorological Organization. TD No. 358, 114 pp.
- Stauffer, R., Mayr, G.J., Dabernig, M., Zeileis, A., 2015. Somewhere over the rainbow: how to make effective use of colors in meteorological visualizations. *Bull. Am. Meteorol. Soc.* 96, 203–215.
- Stauffer, R., Umlauf, N., Messner, J.W., Mayr, G.J., Zeileis, A., 2017. Ensemble postprocessing of daily precipitation sums over complex terrain using censored high-resolution standardized anomalies. *Mon. Weather Rev.* 145, 955–969.
- Stedinger, J.R., Vogel, R.M., Foufoula-Georgiou, E., 1993. Frequency analysis of extreme events. In: Maidment, D.R. (Ed.), *Handbook of Hydrology*. McGraw-Hill. 66 pp.
- Steel, R.G.D., Torrie, J.H., 1960. *Principles and Procedures of Statistics*. McGraw-Hill. 481 pp.
- Steinskog, D.J., Tjostheim, D.B., Kvamsto, N.G., 2007. A cautionary note on the use of the Kolmogorov-Smirnov test for normality. *Mon. Weather Rev.* 135, 1151–1157.
- Stensrud, D.J., Bao, J.-W., Warner, T.T., 2000. Using initial conditions and model physics perturbations in short-range ensemble simulations of mesoscale convective systems. *Mon. Weather Rev.* 128, 2077–2107.
- Stensrud, D.J., Brooks, H.E., Du, J., Tracton, M.S., Rogers, E., 1999. Using ensembles for short-range forecasting. *Mon. Weather Rev.* 127, 433–446.
- Stensrud, D.J., Wandishin, M.S., 2000. The correspondence ratio in forecast evaluation. *Weather Forecast.* 15, 593–602.
- Stensrud, D.J., Yussouf, N., 2003. Short-range ensemble predictions of 2-m temperature and dewpoint temperature over New England. *Mon. Weather Rev.* 131, 2510–2524.
- Stephens, M., 1974. E.D.F. statistics for goodness of fit. *J. Am. Stat. Assoc.* 69, 730–737.
- Stephenson, D.B., 1997. Correlation of spatial climate/weather maps and the advantages of using the Mahalanobis metric in predictions. *Tellus A* 49, 513–527.
- Stephenson, D.B., 2000. Use of the “odds ratio” for diagnosing forecast skill. *Weather Forecast.* 15, 221–232.
- Stephenson, D.B., Casati, B., Ferro, C.A.T., Wilson, C.A., 2008a. The extreme dependency score: a non-vanishing measure for forecasts of rare events. *Meteorol. Appl.* 15, 41–50.
- Stephenson, D.B., Coelho, C.A.S., Doblas-Reyes, F.J., Balmaseda, M., 2005. Forecast assimilation: a unified framework for the combination of multi-model weather and climate predictions. *Tellus A* 57, 253–264.
- Stephenson, D.B., Coelho, C.A.S., Jolliffe, I.T., 2008b. Two extra components in the Brier score decomposition. *Weather Forecast.* 23, 752–757.

- Stephenson, D.B., Collins, M., Rougier, J.C., Chandler, R.E., 2012. Statistical problems in the probabilistic prediction of climate change. *Environmetrics* 23, 364–372.
- Stephenson, D.B., Doblas-Reyes, F.J., 2000. Statistical methods for interpreting Monte-Carlo ensemble forecasts. *Tellus A* 52, 300–322.
- Stern, H., Davidson, N.E., 2015. Trends in the skill of weather prediction at lead times of 1–14 days. *Q. J. R. Meteorol. Soc.* 141, 2726–2736.
- Stern, R.D., Coe, R., 1984. A model fitting analysis of daily rainfall data. *J. R. Stat. Soc. Ser. A* 147, 1–34.
- Strang, G., 1988. *Linear Algebra and its Applications*. Harcourt, 505 pp.
- Stockdale, T.N., Anderson, D.L.T., Balmaseda, M.A., Doblas-Reyes, F., Ferranti, L., Mogensen, K., Palmer, T.N., Molteni, F., Vitart, F., 2011. ECMWF seasonal forecast system 3 and its prediction of sea surface temperature. *Clim. Dyn.* 37, 455–471.
- Stewart, T.R., 1997. Forecast value: descriptive decision studies. In: Katz, R.W., Murphy, A.H. (Eds.), *Economic Value of Weather and Climate Forecasts*. Cambridge University Press, 147–181.
- Stuart, N.A., Schultz, D.M., Klein, G., 2007. Maintaining the role of humans in the forecast process. *Bull. Am. Meteorol. Soc.* 88, 1893–1898.
- Stull, R.B., 1988. *An Introduction to Boundary Layer Meteorology*. Kluwer, 666 pp.
- Sutera, A., 1981. On stochastic perturbation and long-term climate behaviour. *Q. J. R. Meteorol. Soc.* 107, 137–151.
- Swenson, E., 2015. Continuum power CCA: a unified approach for isolating coupled modes. *J. Clim.* 28, 1016–1030.
- Swets, J.A., 1973. The relative operating characteristic in psychology. *Science* 182, 990–1000.
- Swets, J.A., 1979. ROC analysis applied to the evaluation of medical imaging techniques. *Investig. Radiol.* 14, 109–121.
- Taillardat, M., Mestre, O., Zamo, M., Naveau, P., 2016. Calibrated ensemble forecasts using quantile regression forests and ensemble model output statistics. *Mon. Weather Rev.* 144, 2375–2393.
- Taillardat, M., Fougères, A.-L., Naveau, P., Mestre, O., 2017. Forest-based methods and ensemble model output statistics for rainfall ensemble forecasting. *arXiv:1711.10937v1*, 20 pp.
- Talagrand, O., Vautard, R., Strauss, B., 1997. Evaluation of probabilistic prediction systems. In: *Proceedings, ECMWF Workshop on Predictability*. ECMWF, 1–25.
- Taleb, N.N., 2001. *Fooled by Randomness*. Texere, New York, 203 pp.
- Tang, B., Hsieh, W.W., Monahan, A.H., Tangang, F.T., 2000. Skill comparisons between neural networks and canonical correlation analysis in predicting the equatorial Pacific sea surface temperatures. *J. Clim.* 13, 287–293.
- Tareghian, R., Rasmussen, P., 2013. Analysis of Arctic and Antarctic sea ice extent using quantile regression. *Int. J. Climatol.* 33, 1079–1086.
- Taylor, J.W., 1999. Evaluating volatility and interval forecasts. *J. Forecast.* 18, 111–128.
- Taylor, K.E., 2001. Summarizing multiple aspects of model performance in a single diagram. *J. Geophys. Res. D: Atmos.* 106, 7183–7192.
- Taylor, K.E., Stouffer, R.J., Meehl, G.A., 2012. An overview of CMIP5 and the experiment design. *Bull. Am. Meteorol. Soc.* 93, 485–498.
- Taylor, M.H., Losch, M., Wenzel, M., Schröter, J., 2013. On the sensitivity of field reconstruction and prediction using empirical orthogonal functions derived from gappy data. *J. Clim.* 26, 9194–9205.
- Tenant, W.J., Shutts, G.J., Arribas, A., Thompson, S.A., 2011. Using a stochastic kinetic energy backscatter scheme to improve MOGREPS probabilistic forecast skill. *Mon. Weather Rev.* 139, 1190–1206.
- Tezuka, S., 1995. *Uniform Random Numbers: Theory and Practice*. Kluwer, 209 pp.
- Teweles, S., Wobus, H.B., 1954. Verification of prognostic charts. *Bull. Am. Meteorol. Soc.* 35, 455–463.
- Theil, H., 1950. A rank-invariant method of linear and polynomial regression analysis. *K. Nederlandsse Akad. Wet.* 53, 386–392, 521–525, 1397–1412.
- Theus, M., Urbanek, S., 2009. *Interactive Graphics for Data Analysis*. CRC Press, 280 pp.
- Thiébaux, H.J., Pedder, M.A., 1987. *Spatial Objective Analysis: with Applications in Atmospheric Science*. Academic Press, London, 299 pp.
- Thiébaux, H.J., Zwiers, F.W., 1984. The interpretation and estimation of effective sample size. *J. Clim. Appl. Meteorol.* 23, 800–811.
- Thom, H.C.S., 1958. A note on the gamma distribution. *Mon. Weather Rev.* 86, 117–122.

- Thompson, C.J., Battisti, D.S., 2001. A linear stochastic dynamical model of ENSO. Part II: Analysis. *J. Clim.* 14, 445–466.
- Thompson, J.C., 1962. Economic gains from scientific advances and operational improvements in meteorological prediction. *J. Appl. Meteorol.* 1, 13–17.
- Thompson, J.C., Brier, G.W., 1955. The economic utility of weather forecasts. *Mon. Weather Rev.* 83, 249–254.
- Thompson, J.C., Carter, G.M., 1972. On some characteristics of the S1 score. *J. Appl. Meteorol.* 11, 1384–1385.
- Thompson, P.D., 1977. How to improve accuracy by combining independent forecasts. *Mon. Weather Rev.* 105, 228–229.
- Thompson, P.D., 1985. Prediction of the probable errors of prediction. *Mon. Weather Rev.* 113, 248–259.
- Thorarindottir, T.L., Gneiting, T., 2010. Probabilistic forecasts of wind speed: ensemble model output statistics by using heteroscedastic censored regression. *J. R. Stat. Soc. Ser. A* 173, 371–388.
- Thorarindottir, T.L., Scheuerer, M., Heinz, C., 2016. Assessing the calibration of high-dimensional ensemble forecasts using rank histograms. *J. Comput. Graph. Stat.* 25, 105–122.
- Thornes, J.E., Stephenson, D.B., 2001. How to judge the quality and value of weather forecast products. *Meteorol. Appl.* 8, 307–314.
- Tibshirani, R., 1996. Regression shrinkage and selection via the Lasso. *J. R. Stat. Soc. Ser. B Methodol.* 58, 267–288.
- Tibshirani, R., Walther, G., Hastie, T., 2001. Estimating the number of clusters in a dataset via the gap statistic. *J. R. Stat. Soc. Ser. B Methodol.* 32, 411–423.
- Tippett, M.K., Camargo, S.C., Sobel, A.H., 2011. A Poisson regression index for tropical cyclone genesis and the role of large-scale vorticity in genesis. *J. Clim.* 24, 2335–2357.
- Tippett, M.K., DelSole, T., Mason, S.J., Barnston, A.G., 2008. Regression-based methods for finding coupled patterns. *J. Clim.* 21, 4384–4398.
- Titterton, D.M., Smith, A.F.M., Makov, U.E., 1985. *Statistical Analysis of Finite Mixture Distributions*. Wiley, 243 pp.
- Tobin, J., 1958. Estimation of relationships for limited dependent data. *Econometrica* 26, 24–36.
- Todorovic, P., Woolhiser, D.A., 1975. A stochastic model of  $n$ -day precipitation. *J. Appl. Meteorol.* 14, 17–24.
- Tong, H., 1975. Determination of the order of a Markov chain by Akaike's Information Criterion. *J. Appl. Probab.* 12, 488–497.
- Torrence, C., Compo, G.P., 1998. A practical guide to wavelet analysis. *Bull. Am. Meteorol. Soc.* 79, 61–78.
- Toth, Z., Kalnay, E., 1993. Ensemble forecasting at NMC: the generation of perturbations. *Bull. Am. Meteorol. Soc.* 74, 2317–2330.
- Toth, Z., Kalnay, E., 1997. Ensemble forecasting at NCEP the breeding method. *Mon. Weather Rev.* 125, 3297–3318.
- Toth, Z., Zhu, Y., Marchok, T., 2001. The use of ensembles to identify forecasts with small and large uncertainty. *Weather Forecast.* 16, 463–477.
- Toth, Z., Penā, M., Vintzileos, A., 2007. Bridging the gap between weather and climate forecasting: research priorities for intra-seasonal prediction. *Bull. Am. Meteorol. Soc.* 88, 1427–1429.
- Tracton, M.S., Kalnay, E., 1993. Operational ensemble prediction at the National Meteorological Center: practical aspects. *Weather Forecast.* 8, 379–398.
- Tracton, M.S., Mo, K., Chen, W., Kalnay, E., Kistler, R., White, G., 1989. Dynamical extended range forecasting (DERF) at the National Meteorological Center. *Mon. Weather Rev.* 117, 1604–1635.
- Tracy, C.A., Widom, H., 1996. On orthogonal and symplectic matrix ensembles. *Commun. Math. Phys.* 177, 727–754.
- Tufte, E.R., 1983. *The Visual Display of Quantitative Information*. Graphics Press, 197 pp.
- Tufte, E.R., 1990. *Envisioning Information*. Graphics Press, 126 pp.
- Tukey, J.W., 1977. *Exploratory Data Analysis*. Addison-Wesley, Reading, MA, 688 pp.
- Tustison, B., Harris, D., Foufoula-Georgiou, E., 2001. Scale issues in verification of precipitation forecasts. *J. Geophys. Res. D: Atmos.* 106, 11775–11784.
- Tversky, A., 1974. Judgement under uncertainty: heuristics and biases. *Science* 185, 1124–1131.
- Tyler, D.E., 1982. On the optimality of the simultaneous redundancy transformations. *Psychometrika* 47, 77–86.
- Unger, D.A., 1985. A method to estimate the continuous ranked probability score. In: *Preprints, 9<sup>th</sup> Conference on Probability and Statistics in the Atmospheric Sciences*. American Meteorological Society, 206–213.
- Unger, D.A., van den Dool, H., O'Lenic, E., Collins, D., 2009. Ensemble regression. *Mon. Weather Rev.* 137, 2365–2379.
- Valée, M., Wilson, L.J., Bourgoin, P., 1996. New statistical methods for the interpretation of NWP output and the Canadian Meteorological Centre. In: *Preprints, 13<sup>th</sup> Conference on Probability and Statistics in the Atmospheric Sciences* (San Francisco, California). American Meteorological Society, 37–44.

- Van den Dool, H.M., 1989. A new look at weather forecasting through analogues. *Mon. Weather Rev.* 117, 2230–2247.
- Van den Dool, H., 2007. *Empirical Methods in Short-Term Climate Prediction*. Oxford University Press, Oxford. 215 pp.
- Van den Dool, H.M., Becker, E., Chen, L.-C., Zhang, Q., 2017. The probability anomaly correlation and calibration of probabilistic forecasts. *Weather Forecast.* 32, 199–206.
- Vannitsem, S., Hagedorn, R., 2011. Ensemble forecast post-processing over Belgium: comparison of deterministic-like and ensemble regression methods. *Meteorol. Appl.* 18, 94–104.
- Van Schaeybroeck, B., Vannitsem, S., 2015. Ensemble post-processing using member-by-member approaches: theoretical aspects. *Q. J. R. Meteorol. Soc.* 141, 807–818.
- Vautard, R., Pires, C., Plaut, G., 1996. Long-range atmospheric predictability using space-time principal components. *Mon. Weather Rev.* 124, 288–307.
- Vautard, R., Plaut, G., Wang, R., Brunet, G., 1999. Seasonal prediction of North American surface air temperatures using space-time principal components. *J. Clim.* 12, 380–394.
- Vautard, R., Yiou, P., Ghil, M., 1992. Singular spectrum analysis: a toolkit for short, noisy and chaotic series. *Physica D* 58, 95–126.
- Veenhuis, B.A., 2013. Spread calibration of ensemble MOS forecasts. *Mon. Weather Rev.* 141, 2467–2482.
- Velleman, P.F., Hoaglin, D.C., 1981. *Applications, Basics, and Computing of Exploratory Data Analysis*. Duxbury Press, Boston, MA. 354 pp.
- Ventura, V., Paciorek, C.J., Risbey, J.S., 2004. Controlling the proportion of falsely rejected hypotheses when conducting multiple tests with climatological data. *J. Clim.* 17, 4343–4356.
- Verkade, J.S., Brown, J.D., Reggiani, P., Weerts, A.H., 2013. Post-processing ECMWF precipitation and temperature ensemble reforecasts for operational hydrologic forecasting at various spatial scales. *J. Hydrol.* 501, 73–91.
- Vigaud, N., Robertson, A.W., Tippett, M.K., 2017. Multimodel ensembling of subseasonal precipitation forecasts over North America. *Mon. Weather Rev.* 145, 3913–3928.
- Vinod, H.D., 1976. Canonical ridge and econometrics of joint production. *J. Econ.* 4, 147–166.
- Vislocky, R.L., Fritsch, J.M., 1995a. Improved model output statistics forecasts through model consensus. *Bull. Am. Meteorol. Soc.* 76, 1157–1164.
- Vislocky, R.L., Fritsch, J.M., 1995b. Generalized additive models versus linear regression in generating probabilistic MOS forecasts of aviation weather parameters. *Weather Forecast.* 10, 669–680.
- Vislocky, R.L., Fritsch, J.M., 1997. An automated, observations-based system for short-term prediction of ceiling and visibility. *Weather Forecast.* 12, 31–43.
- Vogel, R.M., 1986. The probability plot correlation coefficient test for normal, lognormal, and Gumbel distributional hypotheses. *Water Resour. Res.* 22, 587–590.
- Vogel, R.M., Kroll, C.N., 1989. Low-flow frequency analysis using probability-plot correlation coefficients. *J. Water Resour. Plan. Manag.* 115, 338–357.
- Vogel, R.M., McMartin, D.E., 1991. Probability-plot goodness-of-fit and skewness estimation procedures for the Pearson type III distribution. *Water Resour. Res.* 27, 3149–3158.
- Von Storch, H., 1982. A remark on Chervin-Schneider's algorithm to test significance of climate experiments with GCMs. *J. Atmos. Sci.* 39, 187–189.
- Von Storch, H., 1995. Misuses of statistical analysis in climate research. In: von Storch, H., Navarra, A. (Eds.), *Analysis of Climate Variability*. Springer, 11–26.
- Von Storch, H., Hannoschöck, G., 1984. Comments on “empirical orthogonal function analysis of wind vectors over the tropical Pacific region”. *Bull. Am. Meteorol. Soc.* 65, 162.
- Von Storch, H., Hannoschock, G., 1985. Statistical aspects of estimated principal vectors (EOFs) based on small samples sizes. *J. Clim. Appl. Meteorol.* 24, 716–724.
- Von Storch, H., Zwiers, F.W., 1999. *Statistical Analysis in Climate Research*. Cambridge University Press, Cambridge. 484 pp.
- Vrac, M., Naveau, P., 2007. Stochastic downscaling of precipitation: from dry events to heavy rainfalls. *Water Resour. Res.* 43. <https://doi.org/10.1029/2006WR005308>.
- Walker, G.T., 1914. Correlation in seasonal variations of weather. III. On the criterion for the reality of relationships or periodicities. *Mem. Indian Meteorol. Dep.* 21 (9), 13–15.

- Wallace, J.M., Blackmon, M.L., 1983. Observations of low-frequency atmospheric variability. In: Hoskins, B.J., Pearce, R.P. (Eds.), *Large-Scale Dynamical Processes in the Atmosphere*. Academic Press, 55–94.
- Wallace, J.M., Gutzler, D.S., 1981. Teleconnections in the geopotential height field during the northern hemisphere winter. *Mon. Weather Rev.* 109, 784–812.
- Wallace, J.M., Smith, C., Bretherton, C.S., 1992. Singular value decomposition of wintertime sea surface temperature and 500-mb height anomalies. *J. Clim.* 5, 561–576.
- Wallsten, T.S., Budescu, D.V., Rapoport, A., Zwick, R., Forsyth, B., 1986. Measuring the vague meanings of probability terms. *J. Exp. Psychol.* 115, 348–365.
- Walshaw, D., 2000. Modeling extreme wind speeds in regions prone to hurricanes. *Appl. Stat.* 49, 51–62.
- Wandishin, M.S., Brooks, H.E., 2002. On the relationship between Clayton's skill score and expected value for forecasts of binary events. *Meteorol. Appl.* 9, 455–459.
- Wang, Q.J., Shrestha, D.L., Robertson, D.E., Pokhrel, P., 2012. A log-sinh transformation for data normalization and variance stabilization. *Water Resour. Res.* 48. <https://doi.org/10.1029/2011WR010973>.
- Wang, X., Bishop, C.H., 2003. A comparison of breeding and ensemble transform Kalman filter ensemble forecast schemes. *J. Atmos. Sci.* 60, 1140–1158.
- Wang, X., Bishop, C.H., 2005. Improvement of ensemble reliability with a new dressing kernel. *Q. J. R. Meteorol. Soc.* 131, 965–986.
- Wang, X.L., Zwiers, F.W., 1999. Interannual variability of precipitation in an ensemble of AMIP climate simulations conducted with the CCC GCM2. *J. Clim.* 12, 1322–1335.
- Wang, Y.-H., Magnusdottir, G., Stern, H., Tian, X., Yu, Y., 2014. Uncertainty estimates of the EOF-derived North Atlantic oscillation. *J. Clim.* 27, 1290–1301.
- Ward, M.N., Folland, C.K., 1991. Prediction of seasonal rainfall in the north Nordeste of Brazil using eigenvectors of sea-surface temperature. *Int. J. Climatol.* 11, 711–743.
- Wasko, C., Sharma, A., 2014. Quantile regression for investigating scaling of extreme precipitation with temperature. *Water Resour. Res.* 50, 3608–3614.
- Wasserstein, R.L., Lazar, N.A., 2016. The ASA's statement on *p*-values: context, process, and purpose. *Am. Stat.* 70, 129–133.
- Waymire, E., Gupta, V.K., 1981. The mathematical structure of rainfall representations. 1. A review of stochastic rainfall models. *Water Resour. Res.* 17, 1261–1272.
- Wei, M., Toth, Z., Wobus, R., Zhu, Y., 2008. Initial perturbations based on the ensemble transform (ET) technique in the NCEP global operational forecast system. *Tellus A* 60, 62–79.
- Weijis, S.V., van de Giesen, N., 2011. Accounting for observational uncertainty in forecast verification: An information-theoretical view on forecasts, observations, and truth. *Mon. Weather Rev.* 139, 2156–2162.
- Weniger, M., Friederichs, P., 2016. Using the SAL technique for spatial verification of cloud processes: a sensitivity analysis. *J. Appl. Meteorol. Climatol.* 55, 2091–2108.
- Weniger, M., Kapp, F., Friederichs, P., 2017. Spatial verification using wavelet transforms: a review. *Q. J. R. Meteorol. Soc.* 143, 120–136.
- Wernli, H., Hofmann, C., Zimmer, M., 2009. Spatial forecast verification methods intercomparison project: application of the SAL technique. *Weather Forecast.* 24, 1472–1484.
- Wernli, H., Paulat, M., Hagen, M., Frei, C., 2008. SAL—A novel quality measure for the verification of quantitative precipitation forecasts. *Mon. Weather Rev.* 136, 4470–4487.
- Westfall, P.H., 2014. Kurtosis as peakedness, 1905–2014. R.I.P. *Am. Stat.* 68, 191–195.
- Whan, K., Schmeits, M., 2018. Comparing area-probability forecasts of (extreme) local precipitation using parametric and machine learning statistical post-processing methods. *Mon. Weather Rev.* <https://doi.org/10.1175/MWR-D-17-0290.1>. in press.
- Wheeler, M.C., Hendon, H.H., 2004. An all-season real-time multivariate MJO index: development of an index for monitoring and prediction. *Mon. Weather Rev.* 132, 1917–1932.
- Whitaker, J.S., Loughe, A.F., 1998. The relationship between ensemble spread and ensemble mean skill. *Mon. Weather Rev.* 126, 3292–3302.
- Wickham, H., Hofmann, H., Wickham, C., Cook, D., 2012. Glyph-maps for visually exploring temporal patterns in climate data and models. *Environmetrics* 23, 382–393.



- Wigley, T.M.L., 2009. The effect of changing climate on the frequency of absolute extreme events. *Clim. Chang.* 97, 67–76.
- Wilkinson, L., 2005. *The Grammar of Graphics*, second ed. Springer. 690 pp.
- Wilks, D.S., 1989. Conditioning stochastic daily precipitation models on total monthly precipitation. *Water Resour. Res.* 25, 1429–1439.
- Wilks, D.S., 1990. Maximum likelihood estimation for the gamma distribution using data containing zeros. *J. Clim.* 3, 1495–1501.
- Wilks, D.S., 1992. Adapting stochastic weather generation algorithms for climate change studies. *Clim. Chang.* 22, 67–84.
- Wilks, D.S., 1993. Comparison of three-parameter probability distributions for representing annual extreme and partial duration precipitation series. *Water Resour. Res.* 29, 3543–3549.
- Wilks, D.S., 1997a. Forecast value: prescriptive decision studies. In: R.W. Katz and A.H. Murphy (eds.), *Economic Value of Weather and Climate Forecasts*. Cambridge University Press, 109–145.
- Wilks, D.S., 1997b. Resampling hypothesis tests for autocorrelated fields. *J. Clim.* 10, 65–82.
- Wilks, D.S., 1998. Multisite generalization of a daily stochastic precipitation generation model. *J. Hydrol.* 210, 178–191.
- Wilks, D.S., 1999a. Interannual variability and extreme-value characteristics of several stochastic daily precipitation models. *Agric. For. Meteorol.* 93, 153–169.
- Wilks, D.S., 1999b. Multisite downscaling of daily precipitation with a stochastic weather generator. *Clim. Res.* 11, 125–136.
- Wilks, D.S., 2001. A skill score based on economic value for probability forecasts. *Meteorol. Appl.* 8, 209–219.
- Wilks, D.S., 2002a. Realizations of daily weather in forecast seasonal climate. *J. Hydrometeorol.* 3, 195–207.
- Wilks, D.S., 2002b. Smoothing forecast ensembles with fitted probability distributions. *Q. J. R. Meteorol. Soc.* 128, 2821–2836.
- Wilks, D.S., 2004. The minimum spanning tree histogram as a verification tool for multidimensional ensemble forecasts. *Mon. Weather Rev.* 132, 1329–1340.
- Wilks, D.S., 2005. Effects of stochastic parametrizations in the Lorenz ‘96 system. *Q. J. R. Meteorol. Soc.* 131, 389–407.
- Wilks, D.S., 2006a. On “field significance” and the false discovery rate. *J. Appl. Meteorol. Climatol.* 45, 1181–1189.
- Wilks, D.S., 2006b. Comparison of ensemble-MOS methods in the Lorenz ‘96 setting. *Meteorol. Appl.* 13, 243–256.
- Wilks, D.S., 2008. Improved statistical seasonal forecasts using extended training data. *Int. J. Climatol.* 28, 1589–1598.
- Wilks, D.S., 2009. Extending logistic regression to provide full-probability-distribution MOS forecasts. *Meteorol. Appl.* 16, 361–368.
- Wilks, D.S., 2010. Sampling distributions of the Brier score and Brier skill score under serial dependence. *Q. J. R. Meteorol. Soc.* 136, 2109–2118.
- Wilks, D.S., 2011. On the reliability of the rank histogram. *Mon. Weather Rev.* 139, 311–316.
- Wilks, D.S., 2013. The calibration simplex: a generalization of the reliability diagram for three-category probability forecasts. *Weather Forecast.* 28, 1210–1218.
- Wilks, D.S., 2014a. Probabilistic canonical correlation analysis forecasts, with application to tropical Pacific sea-surface temperatures. *Int. J. Climatol.* 34, 1405–1413.
- Wilks, D.S., 2014b. Comparison of probabilistic statistical forecast and trend adjustment methods for North American seasonal temperatures. *J. Appl. Meteorol. Climatol.* 53, 935–949.
- Wilks, D.S., 2015. Multivariate ensemble model output statistics using empirical copulas. *Q. J. R. Meteorol. Soc.* 141, 945–952.
- Wilks, D.S., 2016a. Three new diagnostic verification diagrams. *Meteorol. Appl.* 23, 371–378.
- Wilks, D.S., 2016b. “The stippling shows statistically significant gridpoints”: how research results are routinely overstated and overinterpreted, and what to do about it. *Bull. Am. Meteorol. Soc.* 97, 2263–2273.
- Wilks, D.S., 2016c. Modified “Rule N” procedure for principal component (EOF) truncation. *J. Clim.* 29, 3049–3056.
- Wilks, D.S., 2017. On assessing calibration of multivariate ensemble forecasts. *Q. J. R. Meteorol. Soc.* 143, 164–172.
- Wilks, D.S., 2018a. Enforcing calibration in ensemble postprocessing. *Q. J. R. Meteorol. Soc.* 144, 76–84.
- Wilks, D.S., 2018b. Univariate ensemble postprocessing. In: Vannitsem, S., Wilks, D.S., Messner, J.W. (Eds.), *Statistical Postprocessing of Ensemble Forecasts*. Elsevier, 49–89.
- Wilks, D.S., Godfrey, C.M., 2002. Diagnostic verification of the IRI new assessment forecasts, 1997–2000. *J. Clim.* 15, 1369–1377.
- Wilks, D.S., Hamill, T.M., 2007. Comparison of ensemble-MOS methods using GFS reforecasts. *Mon. Weather Rev.* 135, 2379–2390.
- Wilks, D.S., Livezey, R.E., 2013. Performance of alternative “normals” for tracking climate changes, using homogenized and non-homogenized seasonal U.S. surface temperatures. *J. Clim. Appl. Meteorol.* 52, 1677–1687.

- Wilks, D.S., Wilby, R.L., 1999. The weather generation game: a review of stochastic weather models. *Prog. Phys. Geogr.* 23, 329–357.
- Williams, P.D., Read, P.L., Haine, T.W.N., 2003. Spontaneous generation and impact of inertia-gravity waves in a stratified, two-layer shear flow. *Geophys. Res. Lett.* 30, 2255–2258.
- Williams, R.M., 2016. Statistical Methods for Post-Processing Ensemble Weather Forecasts. PhD. Dissertation, University of Exeter. 197 pp. <https://ore.exeter.ac.uk/repository/bitstream/handle/10871/21693/WilliamsR.pdf>.
- Williams, R.M., Ferro, C.A.T., Kwasniok, F., 2014. A comparison of ensemble post-processing methods for extreme events. *Q. J. R. Meteorol. Soc.* 140, 1112–1120.
- Wilson, L.J., Beauregard, S., Raftery, A.E., Verret, R., 2007. Reply. *Mon. Weather Rev.* 135, 4231–4236.
- Wilson, L.J., Vallée, M., 2002. The Canadian updateable model output statistics (UMOS) system: design and development tests. *Weather Forecast.* 17, 206–222.
- Wilson, L.J., Vallée, M., 2003. The Canadian updateable model output statistics (UMOS) system: validation against perfect prog. *Weather Forecast.* 18, 288–302.
- Winkler, R.L., 1972a. A decision-theoretic approach to interval estimation. *J. Am. Stat. Assoc.* 67, 187–191.
- Winkler, R.L., 1972b. Introduction to Bayesian Inference and Decision. Holt, Rinehart and Winston, New York. 563 pp.
- Winkler, R.L., 1994. Evaluating probabilities: asymmetric scoring rules. *Manag. Sci.* 40, 1395–1405.
- Winkler, R.L., 1996. Scoring rules and the evaluation of probabilities. *Test* 5, 1–60.
- Winkler, R.L., Murphy, A.H., 1968. “Good” probability assessors. *J. Appl. Meteorol.* 7, 751–758.
- Winkler, R.L., Murphy, A.H., 1979. The use of probabilities in forecasts of maximum and minimum temperatures. *Meteorol. Mag.* 108, 317–329.
- Winkler, R.L., Murphy, A.H., 1985. Decision analysis. In: Murphy, A.H., Katz, R.W. (Eds.), *Probability, Statistics and Decision Making in the Atmospheric Sciences*. Westview Press, Boulder, CO, 493–524.
- Witten, D.A., Tibshirani, R., Hastie, T., 2009. A penalized matrix decomposition, with applications to sparse principal components and canonical correlation analysis. *Biostatistics* 10, 515–534.
- Wolfers, J., Zitzewitz, E., 2004. Prediction markets. *J. Econ. Perspect.* 18, 107–126.
- Wolff, J.K., Harrold, M., Fowler, T., Gotway, J.H., Nance, L., Brown, B.G., 2014. Beyond the basics: Evaluating model-based precipitation forecasts using traditional, spatial, and object-based methods. *Weather Forecast.* 29, 1451–1472.
- Wolter, K., 1987. The southern oscillation in surface circulation and climate over the tropical Atlantic, eastern Pacific, and Indian Oceans as captured by cluster analysis. *J. Clim. Appl. Meteorol.* 26, 540–558.
- Woodcock, F., 1976. The evaluation of yes/no forecasts for scientific and administrative purposes. *Mon. Weather Rev.* 104, 1209–1214.
- Woolhiser, D.A., Roldan, J., 1982. Stochastic daily precipitation models, 2. A comparison of distributions of amounts. *Water Resour. Res.* 18, 1461–1468.
- Wu, C.F.J., Hamada, M.S., 2009. *Experiments: Planning, Analysis and Optimization*. Wiley. 760 pp.
- Wu, L., Zhang, Y., Adams, T., Lee, H., Liu, Y., Schaake, J., 2018. Comparative evaluation of three Schaake shuffle schemes in postprocessing GEFS precipitation ensemble forecasts. *J. Hydromet.* 19, 575–598.
- Ye, Z.S., Chen, N., 2017. Closed-form estimators for the gamma distribution derived from likelihood equations. *Am. Stat.* 71, 177–181.
- Yeo, I.-K., Johnson, R.A., 2000. A new family of power transformations to improve normality or symmetry. *Biometrika* 87, 954–959.
- Yip, S., Ferro, C.A.T., Stephenson, D.B., Hawkins, E., 2011. A simple, coherent framework for partitioning uncertainty in climate predictions. *J. Clim.* 24, 4634–4643.
- Youden, W.J., 1950. Index for rating diagnostic tests. *Cancer* 3, 32–35.
- Yue, S., Wang, C.-Y., 2002. The influence of serial correlation in the Mann-Whitney test for detecting a shift in median. *Adv. Water Resour.* 25, 325–333.
- Yue, S., Wang, C.-Y., 2004. The Mann-Kendall test modified by effective sample size to detect trend in serially correlated hydrological series. *Water Resour. Manag.* 18, 201–218.
- Yule, G.U., 1900. On the association of attributes in statistics. *Philos. Trans. R. Soc. Lond. A* 194, 257–319.

- Yuval, Hsieh, W.W., 2002. The impact of time-averaging on the detectability of nonlinear empirical relations. *Q. J. R. Meteorol. Soc.* 128, 1609–1622.
- Yuval, Hsieh, W.W., 2003. An adaptive nonlinear MOS scheme for precipitation forecasts using neural networks. *Weather Forecast.* 18, 303–310.
- Zhang, X., Zwiers, F.W., Li, G., 2004. Monte Carlo experiments on the detection of trends in extreme values. *J. Clim.* 17, 1945–1952.
- Zheng, X., Basher, R.E., Thomson, C.S., 1997. Trend detection in regional-mean temperature series: maximum, minimum, mean, diurnal range, and SST. *J. Clim.* 10, 317–326.
- Zheng, X., Straus, D.M., Frederiksen, C.S., 2008. Variance decomposition approach to the prediction of the seasonal mean circulation: comparison with dynamical ensemble prediction using NCEP’s CFS. *Q. J. R. Meteorol. Soc.* 134, 1997–2009.
- Zwiers, F.W., 1987a. Statistical considerations for climate experiments. Part II: Multivariate tests. *J. Clim. Appl. Meteorol.* 26, 477–487.
- Zwiers, F.W., 1987b. A potential predictability study conducted with an atmospheric general circulation model. *Mon. Weather Rev.* 115, 2957–2974.
- Zwiers, F.W., 1990. The effect of serial correlation on statistical inferences made with resampling procedures. *J. Clim.* 3, 1452–1461.
- Zwiers, F.W., Kharin, V.V., 1998. Intercomparison of interannual variability and potential predictability: an AMIP diagnostic sub-project. *Clim. Dyn.* 14, 517–528.
- Zwiers, F.W., Thiébaux, H.J., 1987. Statistical considerations for climate experiments. Part I: scalar tests. *J. Clim. Appl. Meteorol.* 26, 465–476.
- Zwiers, F.W., von Storch, H., 1995. Taking serial correlation into account in tests of the mean. *J. Clim.* 8, 336–351.