Systematic testing of an integrated systems model for coastal zone management using sensitivity and uncertainty analyses

Nguyen T.G., de Kok J.L.

Water Engineering and Management, Faculty of Engineering Technology, University of Twente, PO Box 217, 7500 AE Enschede, Netherlands; Faculty of Hydro-meteorology and Oceanography, Hanoi University of Science, 334 Nguyen Trai, Thanh Xuan, Hanoi, Viet Nam

Abstract: Systematic testing of integrated systems models is extremely important but its difficulty is widely underestimated. The inherent complexity of the integrated systems models, the philosophical debate about the model validity and validation, the uncertainty in model inputs, parameters and future context and the scarcity of field data complicate model validation. This calls for a validation framework and procedures which can identify the strengths and weaknesses of the model with the available data from observations, the literature and experts' opinions. This paper presents such a framework and the respective procedure. Three tests, namely, Parameter-Verification, Behaviour-Anomaly and Policy-Sensitivity are selected to test a Rapid assessment Model for Coastal-zone Management (RaMCo). The Morris sensitivity analysis, a simple expert elicitation technique and Monte Carlo uncertainty analysis are used to facilitate these three tests. The usefulness of the procedure is demonstrated for two examples. ?? 2006.

Author Keywords: Coastal zone management; Decision support system; Expert elicitation; Integrated systems model; Sensitivity and uncertainty analyses; Sulawesi; Testing; Validation

Index Keywords: Integrated control; Mathematical models; Natural resources management; Parameter estimation; Uncertainty analysis; Coastal zone management; Expert elicitation; Integrated systems models; Coastal zones; coastal zone management; decision support system; model validation; Monte Carlo analysis; sensitivity analysis; testing method; uncertainty analysis; Asia; Eurasia; Greater Sunda Islands; Malay Archipelago; Southeast Asia; Sulawesi; Sunda Isles

Year: 2007

Source title: Environmental Modelling and Software

Volume: 22

Issue: 11

Page : 1572-1587

Cited by: 12

Link: Scorpus Link

Correspondence Address: Nguyen, T.G.; Water Engineering and Management, Faculty of Engineering Technology, University of Twente, PO Box 217, 7500 AE Enschede, Netherlands; email: giangnt@vnu.edu.vn

ISSN: 13648152

CODEN: EMSOF

DOI: 10.1016/j.envsoft.2006.08.008

Language of Original Document: English
Abbreviated Source Title: Environmental Modelling and Software
Document Type: Article
Source: Scopus
Authors with affiliations:

1. Nguyen, T.G., Water Engineering and Management, Faculty of Engineering Technology, University of Twente, PO Box 217, 7500 AE Enschede, Netherlands, Faculty of Hydro-meteorology and Oceanography, Hanoi University of Science, 334 Nguyen Trai, Thanh Xuan, Hanoi, Viet Nam
2. de Kok, J.L., Water Engineering and Management, Faculty of Engineering Technology, University of Twente, PO Box 217, 7500 AE Enschede, Netherlands

References:

1. Ayyub, B.M., A Practical Guide on Conducting Expert-Opinion Elicitation of Probabilities and Consequences for Corp Facilities. IWR Report 01-R-1 (2001) Prepared for US Army Corps of Engineering, , Institute for Water Resources, Alexandria, VA 22315-3868
2. Beck, M.B., Chen, J., Assuring the quality of model designed for predictive purposes (2000) Sensitivity Analysis, pp. 401-420. , Saltelli A., Chan K., and Scott E.M. (Eds), Wiley, Chichester
3. Bhatnagar, R.N., Kanal, L., Models of enquiry and formalisms for approximate reasoning (1992) Fuzzy Logic for the Management of Uncertainty, pp. 29-54. , Zadeh L.A., and Kacprzyk J. (Eds), John Wiley & Sons
4. Campolongo, F., Saltelli, A., Sensitivity analysis of an environmental model: an application of different analysis methods (1997) Reliability Engineering & System Safety, 57, pp. 49-69
5. Cocks, A.T., Rodgers, I.R., Skeffington, R.A., Webb, A.H., The limitations of integrated assessment modelling in developing air pollution control policies (1998) Environmental Pollution, 102, pp. 635-639
6. Comenges, J.-M.Z., Campolongo, F., An application of sensitivity analysis to fish population dynamics (2000) Sensitivity Analysis, pp. 367-383. , Saltelli A., Chan K., and Scott E.M. (Eds), Wiley, Chichester
7. Cornelissen, A.M.G., Berg, J.V.D., Koops, W.J., Kaymak, U., Elicitation of expert knowledge for fuzzy evaluation of agricultural production systems. Agriculture (2003) Ecosystems and Environment, 95, pp. 1-18
8. De Kok, J.L., Wind, H.G., Rapid assessment of water systems based on internal consistency (2002) Journal of Water Resources Planning and Management, 128 (4), pp. 240-247
9. Dery, R., Landry, M., Banville, C., Revisiting the issue of model validation in OR: an epistemological view (1993) European Journal of Operational Research, 66, pp. 168-183
10. Dowlatabadi, H., Integrated assessment models of climate change: an incomplete overview (1995) Energy Policy, 23 (4-5), pp. 289-296
11. Forrester, J.W., Senge, P.M., Tests for building confidence in system dynamics models (1980) TIMS Studies in Management Sciences, 14, pp. 209-228. , System Dynamics. Legasto Jr. A.A., Forrester J.W., and Lyneis J.M. (Eds), North Holland
12. Fox, H.E., Pet, J.S., Dahuri, R., Caldwell, R.L., Recovery in rubble fields: long-term impacts of blast fishing (2003) Marine Pollution Bulletin, 46, pp. 1024-1031
13. Fung-Smith, S.J., Briggs, M.R.P., Water quality and nutrient discharge of intensive marine shrimp ponds in Thailand and their relationships to pond productivity (1996) Institute of Aquaculture, , University of Stirling, Stirling, FK9 4 LA, Scotland, UK
14. Hoekstra, A.Y., (1998) Perspectives on Water: A Model-based Exploration of the Future, , International Books, Utrecht, The Netherlands

15. Hulme, M., Raper, C.B.S., An integrated framework to address climate change (ESCAPE) and further developments of the global and regional climate modules (MAGICC) (1995) Energy Policy, 23 (4-5), pp. 347-355
16. Iman, R.L., Helton, J.C., An investigation of uncertainty and sensitivity analysis techniques for computer models (1988) Risk Analysis, 8 (1), pp. 71-90
17. Jakeman, A.J., Letcher, R.A., Integrated assessment and modelling: features, principles and examples for catchment management (2003) Environmental Modelling & Software, 18, pp. 491-501
18. Janssen, M., de Vries, B., The battle of perspectives: a multi-agent model with adaptive responses to climate change (1998) Ecological Economics, 26, pp. 43-65
19. Janssen, M., De Vries, B., Global modeling: managing uncertainty, complexity and incomplete information (1999) Validation of Simulation Models, pp. 45-69. , van Dijkum C., de Tombe D., and van Kuijck E. (Eds), SISWO, Amsterdam
20. JICA, Master Plan and Feasibility Study on Wastewater and Solid Waste Management for The City of Ujung Pandang in The Republic of Indonesia. Progress Report No. 1 (1994) Pacific Consultants International, Tokyo and Yachiyo Engineering Co, , LTD, Tokyo
21. Kirchner, J.W., Hooper, R.P., Kendall, C., Testing and validating environmental model (1996) The Science of the Total Environment, 183, pp. 33-47
22. Kleijnen, J.P.C., Verification and validation of simulation models (1995) European J. Operational Research, 82, pp. 145-162
23. Kleindorfer, J.B., O'Neill, L., Ganeshan, R., Validation in simulation: various positions in the philosophy of science (1998) Management Science, 44 (8), pp. 1087-1099
24. Konikow, L.F., Bredehoeft, J.D., Ground-water models cannot be validated (1992) Advances in Water Resources, 15 (1), pp. 75-83
25. Kuhn, T.S., (1970) The Structure of Scientific Revolutions. second ed., , University of Chicago Press, Chicago IL
26. Mitchell, P.L., Misuse of regression for empirical validation of models (1997) Agricultural Systems, 54 (3), pp. 313-326
27. Morgan, M.G., Henrion, M., (1990) Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis, , Cambridge University Press
28. Morris, D.M., Factorial sampling plans for preliminary computational experiment (1991) Technometrics, 33 (2), pp. 161-174
29. Nguyen, T.G., De Kok, J.L., Titus, M., A new approach to testing an integrated water systems model using qualitative scenarios (2007) Environmental Modelling & Software, 22 (11), pp. 1557-1571
30. Oreskes, N., Evaluation (not validation) of quantitative models (1998) Environmental Health Perspectives, 106 (6), pp. 1453-1460
31. Oreskes, N., Frechette, K.S., Belitz, K., Verification, validation, and confirmation of numerical models in the earth sciences (1994) Science, 263, pp. 641-646
32. Otte, Y., Impact of shrimp culture development on the water quality at the Southwest coast of Sulawesi (1997) Reports Environmental Studies no. 148, , Department of Environmental Studies, Faculty of Sciences, University of Nijmegen, The Netherlands
33. Parker, P., Letcher, R., Jakeman, A.J., Beck, M.B., Harris, G., Argent, R.M., Hare, M., Janssen, M., Progress in integrated assessment and modeling (2002) Environmental modelling & Software, 17, pp. 209-217
34. Pet-Soede, C., Cesar, H.S.J., Pet, J.S., An economic analysis of blast fishing on Indonesian coral reefs (1999) Environmental Conservation, 26 (2), pp. 83-93
35. Popper, K.R., (1959) The Logic of Scientific Discovery, , Hutching and Son Company, London UK
36. Reckhow, K.H., Chapra, S.C., Confirmation of water quality models (1983) Ecological Modelling, 20, pp. 113-133
37. Refsgaard, J.C., Henriksen, H.J., Modelling guidelines-terminology and guiding principles (2004) Advances in Water

Resources, 27, pp. 71-82

38. Rykiel, E.J., Testing ecological models: the meaning of validation (1996) Ecological Modelling, 90, pp. 229-244
39. Saila, S.B., Kocic, V.Lj., McManus, J.W., Modelling the effects of destructive fishing practices on tropical coral reefs (1993) Marine Ecology Progress Series, 94, pp. 51-60
40. Sensitivity Analysis (2000) Probability and Statistics Series, p. 475. , Saltelli A., Chan K., and Scott M. (Eds), John Wiley & Sons
41. Saltelli, A., Scott, M., Guest editorial: The role of sensitivity analysis?in the corroboration of models and its link to model structural and parametric uncertainty (1997) Realiability Engineering and System Safety, 57, pp. 1-4
42. Scholten, H., Cate, A.J.U., Quality assessment of the simulation modeling process (1999) Computers and Electronics in Agricultures, 22, pp. 199-208
43. Tarantola, S., Jesinghaus, J., Poulamaa, M., Global sensitivity analysis: a quality assurance tool in environmental policy modelling (2000) Sensitivity Analysis, pp. 385-397. , Saltelli A., Chan K., and Scott E.M. (Eds), Wiley, Chichester
44. Turner, R.K., Integrated natural and socio-economic science in coastal management (2000) Journal of Marine Systems, 25, pp. 447-460
45. Van der Fels-Klerx, H.J., Horst, H.S., Dijkhuizen, A.A., Risk factors for bovine respiratory disease in dairy youngstock in The Netherlands: the perception of experts (2000) Livestock Production Science, 66, pp. 35-46
46. Uljee, I., Engelen, G., White, R., (1996) RAMCO Demo Guide, , Modelling and Simulation Research Group, Research Institute for Knowledge Systems BV, PO Box 463, 6200 AL Maastricht, The Netherlands
47. Zio, E., On the use of the analytical hierarchy process in the aggregation of expert judgments (1996) Reliability Engineering and System Safety, 53, pp. 127-138
48. Zio, E., Apostolakis, G.E., Accounting for expert-to-expert variability: a potential source of bias in performance assessments of high-level?radioactive waste repositories (1997) Annals of Nuclear Energy, 24 (10), pp. 751-762