



Bayesian Data Fusion (BDF) of Monitoring Data with a Statistical Groundwater Contamination Model to Map Groundwater Quality at the Regional Scale

PDF (Size: 4545KB) PP. 929-943 DOI: 10.4236/jwarp.2012.411109

Author(s)

Samuel Mattern, Walid Raouafi, Patrick Bogaert, Dominique Fasbender, Marnik Vanclooster

ABSTRACT

Groundwater contamination by nitrate within an unconfined sandy aquifer was mapped using a Bayesian Data Fusion (BDF) framework. Groundwater monitoring data was therefore combined with a statistical groundwater contamination model. In a first step, nitrate concentrations, measured at 99 monitoring stations irregularly distributed within the study area, were spatialized using ordinary kriging. Secondly, a statistical regression tree model of nitrate contamination in groundwater was constructed using land use, depth to the water table, altitude and slope as predictor variables. This allowed the construction of a regression tree based contamination map. In a third step, BDF was used to combine optimally the kriged nitrate contamination map with the regression tree based model into one single map, thereby weighing the kriged and regression tree based contamination maps in terms of their estimation uncertainty. It is shown that BDF allows integrating different sources of information about contamination in a final map, allowing quantifying the expected value and variance of the nitrate contamination estimation. It is also shown that the uncertainty in the final map is smaller than the uncertainty from the kriged or regression tree based contamination map.

KEYWORDS

Groundwater Pollution; Nitrate; Kriging; Regression Tree; Data Fusion; Brusselian Sands

Cite this paper

S. Mattern, W. Raouafi, P. Bogaert, D. Fasbender and M. Vanclooster, "Bayesian Data Fusion (BDF) of Monitoring Data with a Statistical Groundwater Contamination Model to Map Groundwater Quality at the Regional Scale," *Journal of Water Resource and Protection*, Vol. 4 No. 11, 2012, pp. 929-943. doi: 10.4236/jwarp.2012.411109.

References

- [1] " Directive 2000/60/EC Establishing a Framework for Community Action in the Field of Water Policy," The European Parliament and Council Official Journal of the European Communities, L327/1, 2000.
- [2] K. Hu, Y. Huang, H. Li, B. Li, D. Chen and R. E. White, " Spatial Variability of Shallow Groundwater Level, Electrical Conductivity and Nitrate Concentration, and Risk Assessment of Nitrate Contamination in North China Plain," *Environment International*, Vol. 31, No. 6, 2005, pp. 896-903. doi: 10.1016/j.envint.2005.05.028
- [3] S. Fetouani, M. Sbaa, M. Vanclooster and B. Bendra, " Assessing Ground Water Quality in the Irrigated Plain of Triffa (North-East Morocco)," *Agricultural Water Management*, Vol. 95, No. 2, 2008, pp. 133-142. doi: 10.1016/j.agwat.2007.09.009
- [4] S. Cinnirella, G. Buttafuoco and N. Pirrone, " Stochastic Analysis to Assess the Spatial Distribution of Groundwater Nitrate Concentrations in the Po Catchment (Italy)," *Environmental Pollution*, Vol. 133, No. 3, 2005, pp. 569- 580. doi: 10.1016/j.envpol.2004.06.020
- [5] G. Christakos, P. Bogaert and M. Serre, " Temporal GIS. Advanced Functions for Field-Based Applications," Springer, New York, 2002.

- [Open Special Issues](#)
- [Published Special Issues](#)
- [Special Issues Guideline](#)

[JWARP Subscription](#)[Most popular papers in JWARP](#)[About JWARP News](#)[Frequently Asked Questions](#)[Recommend to Peers](#)[Recommend to Library](#)[Contact Us](#)

Downloads:	402,260
------------	---------

Visits:	1,010,484
---------	-----------

[Sponsors, Associates, and Links >>](#)

- [6] S. Mattern, P. Bogaert and M. Vanclooster, "Introducing Time Variability and Sampling Rate in the Mapping of Groundwater Contamination by Means of the Bayesian Maximum Entropy (BME) Method," In: L. Candela, I. Vadillo and F. J. Elor, Eds., *Advances in Subsurface Pollution of Porous Media—Indicators, Processes and Modelling: IAH Selected Papers, Volume 14 (IAH—Selected Papers on Hydrogeology)*, Taylor and Francis, 2008, pp. 53-68.
- [7] B. Duc, E. S. Bigün, J. Bigün, G. Ma?tre and S. Fischer, "Fusion of Audio and Video Information for Multi Modal Person Authentication," *Pattern Recognition Letters*, Vol. 18, No. 9, 1997, pp. 835-843. doi:10.1016/S0167-8655(97)00071-8
- [8] A. Ross and A. Jain, "Information Fusion in Biometrics," *Pattern Recognition Letters*, Vol. 24, No. 13, 2003, pp. 2115-2125. doi:10.1016/S0167-8655(03)00079-5
- [9] G. D. Jones, R. E. Allsop and J. H. Gilby, "Bayesian Analysis for Fusion of Data from Disparate Imaging Systems for Surveillance," *Image and Vision Computing*, Vol. 21, No. 10, 2003, pp. 843-849. doi:10.1016/S0262-8856(03)00071-4
- [10] F. Cremer, K. Schutte, J. G. M. Schavemaker and E. den Breejen, "A Comparison of Decision-Level Sensor-Fusion Methods for Anti-Personnel Landmine Detection," *Information Fusion*, Vol. 2, No. 3, 2001, pp. 187-208. doi:10.1016/S1566-2535(01)00034-3
- [11] X. B. Song, Y. Abu-Mostafa, J. Sill, H. Kasdan and M. Pavel, "Robust Image Recognition by Fusion of Contextual Information," *Information Fusion*, Vol. 3, No. 4, 2002, pp. 277-287. doi:10.1016/S1566-2535(02)00092-1
- [12] X. E. Gros, J. Bousigue and K. Takahashi, "NDT Data Fusion at Pixel Level," *NDT & E International*, Vol. 32, No. 5, 1999, pp. 283-292. doi:10.1016/S0963-8695(98)00056-5
- [13] S. Y. Sohn and S. H. Lee, "Data Fusion, Ensemble and Clustering to Improve the Classification Accuracy for the Severity of Road Traffic Accidents in Korea," *Safety Science*, Vol. 41, No. 1, 2003, pp. 1-14. doi:10.1016/S0925-7535(01)00032-7
- [14] G. Simone, A. Farina, F. C. Morabito, S. B. Serpico and L. Bruzzone, "Image Fusion Techniques for Remote Sensing Applications," *Information Fusion*, Vol. 3, No. 1, 2002, pp. 3-15. doi:10.1016/S1566-2535(01)00056-2
- [15] P. Bogaert and D. Fasbender, "Bayesian Data Fusion in a Spatial Prediction Context: A General Formulation," *Stochastic Environmental Research and Risk Assessment*, Vol. 21, No. 6, 2007, pp. 695-709. doi:10.1007/s00477-006-0080-3
- [16] D. Fasbender, J. Radoux and P. Bogaert, "Bayesian Data Fusion for Adaptable Image Pansharpening," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 46, No. 6, 2008, pp. 1847-1857. doi:10.1109/TGRS.2008.917131
- [17] D. Fasbender, D. Tuia, P. Bogaert and M. Kanevski, "Support-Based Implementation of Bayesian Data Fusion for Spatial Enhancement: Applications to ASTER Thermal Images," *IEEE Geoscience and Remote Sensing Letters*, Vol. 5, No. 4, 2008, pp. 598-602. doi:10.1109/LGRS.2008.2000739
- [18] D. Fasbender, L. Peeters, P. Bogaert and A. Dassargues, "Bayesian Data Fusion Applied to Water Table Spatial Mapping," *Water Resources Research*, Vol. 44, No. 12, 2008, Article ID: W12422. doi:10.1029/2008WR006921
- [19] L. Peeters, D. Fasbender, O. Batelaan and A. Dassargues, "Bayesian Data Fusion for Water Table Interpolation: Incorporating a Hydrogeological Conceptual Model in Kriging," *Water Resources Research*, Vol. 46, 2010, pp. 8532-8532. doi:10.1029/2009WR008353
- [20] D. Fasbender, O. Brasseur and P. Bogaert, "Bayesian Data Fusion for Space-Time Prediction of Air Pollutants: The Case of NO₂ in Belgium," *Atmospheric Environment*, Vol. 43, No. 30, 2009, pp. 4632-4645. doi:10.1016/j.atmosenv.2009.05.036
- [21] IBW—Intercommunale du Brabant Wallon, "étude des Ressources en Eau du Brabant Wallon," *Contrat Région Wallonne*, 1987.
- [22] PCNOSW, *Projet de Cartographie Numérique de L' occupation du Sol de Wallonie*, "Projet Notifié par le Gouver- nement Wallon" *Faculté Universitaire des Sciences Agronomiques de Gembloux*, 2005.
- [23] F. A. Baker, D. L. Verbyla, C. S. Hodges and E. W. Ross, "Classification and Regression Tree Analysis for Assessing Hazard of Pine Mortality Caused by *Heterobasidion Annosum*," *Plant Disease*, Vol. 77, No. 2, 1993, pp. 136- 139. doi:10.1094/PD-77-0136