



Improved characterization of river-aquifer interactions through data assimilation with the Ensemble Kalman Filter

Wolfgang Kurtz

Forschungszentrum Jülich GmbH
Institute of Bio- and Geosciences (IBG)
Agrosphere (IBG-3)

Improved characterization of river-aquifer interactions through data assimilation with the Ensemble Kalman Filter

Wolfgang Kurtz

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 199

ISSN 1866-1793

ISBN 978-3-89336-925-6

Contents

List of Figures	vii
List of Tables	xiii
List of Symbols	xv
List of Acronyms	xix
Abstract	xxi
Zusammenfassung	xxiii
1 Introduction	1
2 Theory	5
2.1 Flow and heat transport in porous media	5
2.2 Data assimilation with the Ensemble Kalman Filter	8
2.3 Usage of EnKF in subsurface characterization	11
3 Identification of time-variant river bed properties	15
3.1 Introduction	15
3.2 Methodology	18
3.3 Model description	21
3.4 Synthetic experiments	23
3.5 Results	25
3.5.1 Increase of L (scouring event)	25
3.5.2 Decrease of L (sedimentation event)	27
3.5.3 Performance of EnKF for combined flooding and sedimentation events	29
3.5.4 Temperature dependency of L	30
3.5.5 Influence of spatial patterns	31
3.5.6 Influence of uncertain hydraulic conductivities	32
3.5.7 Influence of ensemble bias	33
3.5.8 Sensitivity on updating strategy	35
3.5.9 Use of covariance inflation to improve filtering results of EnKF . .	37
3.6 Discussion	40
3.7 Conclusions	44

4	Characterization of heterogeneous river bed properties	47
4.1	Introduction	47
4.2	Data assimilation with the Ensemble Kalman Filter	51
4.2.1	General description of the data assimilation algorithm	51
4.2.2	Specific usage of EnKF for river-aquifer interactions	53
4.3	Model description	53
4.4	Synthetic experiments	55
4.4.1	Reference fields	56
4.4.2	Zonation	57
4.4.3	Ensemble generation	57
4.4.4	Settings for data assimilation with EnKF	58
4.4.5	Performance assessment of simulations	59
4.5	Results	60
4.5.1	Strongly heterogeneous case (scenario A)	60
4.5.2	Strongly heterogeneous case with lower observation density	62
4.5.3	Mildly heterogeneous case (scenario B)	64
4.5.4	Strongly heterogeneous case with a predefined zonation (scenario C)	65
4.6	Discussion	66
4.7	Conclusions	69
5	Assimilation of groundwater temperatures	71
5.1	Introduction	71
5.2	Materials and Methods	74
5.2.1	Joint assimilation of piezometric head and temperature data	74
5.2.2	Parallelization of the assimilation code EnKF3d-SPRING	76
5.2.3	Localization	77
5.2.4	Synthetic aquifer model	78
5.2.5	Model and input data for real-world case	79
5.3	Results	84
5.3.1	Synthetic experiments	84
5.3.2	Assimilation of groundwater temperature data for real-world case	90
5.3.2.1	Assimilation period	90
5.3.2.2	Validation period	96
5.3.2.3	Zonation of leakage coefficients for heat transport simulations	100
5.4	Discussion	101
5.5	Conclusions	104
6	Summary and outlook	107
A	Algorithm for adaptive covariance inflation	111
	Bibliography	115
	Acknowledgements	125

Energie & Umwelt / Energy & Environment
Band / Volume 199
ISBN 978-3-89336-925-6

