

## Index

- accuracy, 47  
 Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), 81  
 advection, 39  
 aerobic aquifer conditions, 126  
 afalaj, 1, 5, 16  
 Africa, ix, 1, 2, 8, 12, 19, 21, 22, 24, 25, 27, 28, 29, 32, 33, 36, 37, 81, 85, 86, 120, 121, 122, 127  
 African monsoon, 25  
 age dating of groundwater, 106  
 agricultural intensification and water use, 5  
 air entrapment, 11  
 Alamogordo Creek, 6  
 albedo, 127  
 Algeria, 32, 33, 36, 120, 121  
 allocation costs, 121  
 alluvium storage, 12  
 alternative salinisation processes, 103  
 Amu Darya, 122  
 analysis of residuals, 47  
 analytical modelling, 107  
 analytical solutions, 101  
 analytically based stability criteria, 97  
 Andhra Pradesh, 3, 63, 67  
 Angola, 122, 123, 124, 129  
 apparent parameters, 55  
 aquicludes, 75  
 aquifer compressibility, 42  
 aquifer exploitation problem, 128  
 aquifer storage and recovery, 3, 106, 107  
 aquifer thermal energy storage, 112  
 aquifer vulnerability, 3, 4, 75, 76, 77, 79, 80, 81, 85, 86  
 aquifer vulnerability mapping, 75  
<sup>39</sup>Ar, 32  
 Arabian peninsula, ix, 120  
 Aral Sea, 104, 117, 122  
 Arizona, 6, 10, 11, 13, 19  
 arsenic, 22, 23, 35  
 Asia, 1, 29, 122  
 Asir, 6  
 Atlas mountains, 32  
 Australia, 8, 12, 19, 25, 27, 32, 34, 35, 36, 87, 102, 104, 114, 116, 117, 119, 125, 126, 129  
 automatic calibration, 47, 55  
 Azraq oasis, 1, 11  
  
 Badon-Ghyben, 89, 114  
 Baltic, 115, 126  
 Bangladesh, 120  
 bare soil evaporation, 13  
 Bartlett–Lewis rectangular pulse model, 15  
 basement dissolution, 103  
 Bayesian recursive estimation technique, 59  
 beach-scale problem, 102, 103  
 bed infiltration, 10, 11, 14  
 bed mobilisation, 11  
  
 best linear unbiased estimator, 64  
 bilinear quadrilateral elements, 94  
 biodiversity, 119, 122, 124  
 Boolean methods, 52  
 Bostan lake, 125  
 Botswana, 5, 8, 10, 12, 13, 15, 19, 26, 79, 85, 112, 122, 123, 124, 128, 129, 130  
 boundary conditions, 40, 44, 49, 54, 55, 82–83, 92, 95, 98, 102, 104, 105, 106, 115, 128  
 boundary element methods, 43  
 box problems, 98  
 Br, 23, 26, 32, 33  
 Br enrichment, 26  
 Br/Cl ratio, 23, 26, 32  
 brackish groundwater, 101  
 bromide, 26, 36  
 BTEX, 79  
 buoyant plume effects, 88  
 Butana Plain, 32  
  
 Ca, 23, 25, 33  
 calcite, 26, 33, 111, 112, 113, 116  
 calcretes, 26  
 calibration, x, 2, 17, 18, 19, 20, 39, 41, 44, 45–46, 47, 48, 55–56, 58, 60, 61, 62, 66, 67, 72, 73, 82, 86, 104, 127  
 California, 19, 105, 115, 126  
 capillary rise, 13, 124, 125  
 capture zones, 82, 83, 85, 129  
 carbon sequestration processes, 98  
 carbon-dioxide degassing, 113  
 cation exchange, 76, 111, 112, 113  
 causes of variability, 49  
 Cephalonia, 1  
 CFEST, 92  
 Chad, 75  
 chemical reactions in an intruding seawater wedge, 112  
 chemically reactive transport modelling, 3  
 China, ix, x, 2, 3, 29, 30, 75, 79, 86, 87, 119, 120, 122, 125, 126, 129, 130  
 Chinese Sea, 104  
 chloride, 11, 19, 22, 25, 26, 27–28, 29, 30, 34, 35, 36, 37, 94, 127, 129  
 chloride mass balance, 29  
 chloride profile method, 11, 19  
 chlorinated hydrocarbons, 126  
 Chott region, 32, 33, 121  
 chromium, 22, 23, 34, 35  
 Cl, 23, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 111  
<sup>36</sup>Cl, 23, 27, 32, 36  
 Cl mass balance, 23, 29, 30  
 clogging, 12, 82  
 CO<sub>2</sub>, 26, 28, 34  
 CO<sub>3</sub>, 111  
 coastal aquifers, 1, 2, 4, 5, 33, 87, 88, 89, 100, 104, 106, 114, 115, 116, 117, 126  
 coastal wetlands in China, 122

- coastline retreat, 104  
 coefficient of molecular diffusion, 42, 93  
 common pool problem, 128  
 complexation reactions between cations and humic acids, 113  
 compressibility, 93  
 conceptual model, 39, 44, 46, 47, 48, 60, 68, 113  
 conceptual model uncertainties, 48  
 conditional simulation, 2, 50, 51–52  
 confined aquifers, 42, 66  
 conjunctive use of surface water and groundwater, 124  
 connection to decision makers, 128  
 conservative transport, 40  
 consistent velocity calculation, 94  
 continental ice sheet recharge, 106  
 Continental Intercalaire, 32  
 convection in infinite, finite and inclined porous layers, 97  
 convective rainfall, 10, 13, 14, 15  
 convective velocity, 91  
 coupled models, 40  
 coupling of porosity and permeability, 99  
 critical Rayleigh number, 91, 97, 111  
 Cyprus, 27, 28, 30
- $\delta^{11}\text{B}$ , 23, 34  
 $\delta^{15}\text{N}$ , 23  
 $\delta^{18}\text{O}$ , 22, 23, 25, 26, 32  
 $\delta^2\text{H}$ , 22, 25, 26, 32  
 $\delta^{37}\text{Cl}$ , 23, 114  
 $\delta^{87}\text{Sr}$ , 23, 34
- Damascus basin, 30  
 Darcy's law, 39, 42, 43, 55, 65, 91, 94, 112  
 Dead Sea, 81, 85, 104, 117  
 decision support tools, 40, 60  
 declining groundwater levels, 5  
 dense contaminant plume migration, 87  
 dense contaminant plumes, 88  
 dense leachate plume, 112  
 density effects in layered aquifers, 109  
 density stratification, 126  
 density-dependent flows, 3  
 density-driven convective flow, 91  
 density-driven transport in the vadose zone, 87, 88  
 deuterium, 22  
 DGPS, 126  
 diagenesis processes, 88  
 Dianchi, 126  
 diffuse recharge, 29, 32  
 dimensionless numbers, 90  
 directional effective permeability, 54  
 discretisation, 46, 66  
 dispersion, 39  
 dispersion tensor, 42, 93, 94  
 dispersivity, 39, 47, 49, 92, 94, 95, 97  
 dissolution of calcite, 111  
 dissolved oxygen, 22, 28, 33  
 DNAPL flow and transport, 88  
 DNAPL studies, 87  
 double-diffusive transport, 98  
 downstream sustainability, 119  
 drainage system, 32, 81, 124  
 DRASTIC, 77, 78, 79, 80, 81, 84–85, 86  
 dual-permeability effects, 41  
 dune sands, 29, 30  
 Dupuit assumption, 42  
 dynamic changes of hydraulic properties, 112
- East African Rift Valley, 122  
 economic model, 121  
 economic scarcity, 121  
 economic-political space, 128  
 effective parameters, 54  
 Egypt, 75, 85, 104, 114, 117
- Eh, 22, 34  
 Elder natural convection problem, 95  
 empty quarter, 1  
 energy source, 93  
 environmental tracers, 14, 127  
 ephemeral flows, 16, 19  
 EPIK method, 79, 85  
 equilibrium reactions for aqueous species, 99  
 equilibrium sorption isotherm, 42, 93  
 equivalent freshwater head, 91  
 equivalent parameters, 54  
 equivalent transmissivity, 54–55  
 error analysis, 2, 47, 48  
 estuarine seawater intrusion, 101  
 Eulerian–Lagrangian localised adjoint method, 44  
 eutrophication, 126  
 evaporation, 1, 3, 4, 5, 11, 12, 13, 14, 16, 19, 23, 24, 26, 72, 75, 87, 96, 106, 124, 125, 126, 128  
 expansion coefficient, 91  
 expansion of irrigated areas, 120  
 exponential semivariogram, 51
- F, 26, 32, 33  
 facies simulation, 2, 52, 53  
 Famine Early Warning, 127  
 FAST-C, 92  
 Fe, 23, 33  
 $\text{Fe}^{2+}$ , 23, 33, 34  
 FEFLOW, 61, 91, 92, 101, 107, 108, 114  
 FEMWATER, 92, 101, 115  
 finger formation, 97  
 fingering processes, 99, 109  
 fingers, 90, 91, 95, 96, 100, 110, 117  
 finite difference methods, 42, 43  
 finite element methods, 42, 43, 66  
 finite volume methods, 42, 43  
 first-order solute production rate, 42, 93  
 first-order sorbate production rate, 42, 93  
 fishing, 124  
 flow and transport modelling in fractured rock aquifers, 100  
 flow in regional basins, 41  
 flow phenomenon, 41  
 flow through salt formations, 87, 88  
 fluid density, 41, 42, 87, 89, 91, 92, 93, 95, 112, 117  
 fluid density gradients, 89  
 fluid thermal conductivity, 93  
 fluid viscosity, 41, 93  
 fluorite, 32, 33  
 focused recharge, 32  
 forced convection, 90, 91, 95, 108  
 fossil water, 120  
 Fowler's Gap, 12  
 fracture patterns, 67  
 fractured rock flow, 3  
 fractured rock flow and transport modelling, 109  
 Fraser's Gap, 13  
 free aquifers, 42  
 free convection, 91  
 fresh–saline water interfaces, 87, 88  
 fresh–saltwater mixing zones, 111  
 freshwater head, 91
- Galerkin finite element method, 94  
 gas–liquid phase chemistry, 98  
 Gaussian threshold method, 52  
 Gaza Strip, 81  
 generalised linear models, 15  
 generalised likelihood uncertainty estimation, 59  
 generic models, 40  
 genetic algorithm, 57, 60  
 genetic models, 53  
 geochemical reaction simulator, 112  
 geographical information system (GIS), 76, 78

- geological processes, 41  
 geology, 48  
 geophysical methods, 126  
 geostatistics, x, 49, 60, 62, 63, 64, 65, 66, 74  
 geothermal gradient, 90  
 geothermal systems, 88  
 Germany, 79, 114, 115  
 Ghyben–Herzberg approximation, 101  
 GLA method, 77, 79, 81  
 global meteoric water line, 24  
 global optimisation, 57  
 GMWL, 24  
 GOD scheme, 77  
 governing equations of flow and transport, 41  
 GRACE, 127  
 granite outcrops, 67  
 Great Artesian Basin, 32, 36  
 Greek islands, 1  
 groundwater depletion by agriculture, 120  
 groundwater exploration and development, 35  
 groundwater flow, 39, 40, 115, 116  
 groundwater protection, 75  
 groundwater quality, 21, 35  
 groundwater recharge, ix, 2, 5, 11, 12, 13, 14, 16, 17, 18, 19, 20, 26, 32, 34, 35, 36, 37, 75, 127, 130  
 groundwater resource evaluation, 15  
 groundwater resources assessment, 35  
 groundwater vulnerability, 75  
 Guassian semivariogram, 51  
 Gulf of Guinea, 25, 33  
 gypsum, 33, 34
- $^3\text{H}$ , 23, 27, 29  
 halite, 26, 32, 33, 34  
 hand-dug wells, 5, 28, 30, 31, 67  
 handling spatial variability, 48  
 HAPEX-Sahel, 8, 11, 19  
 hard-rock aquifer, 67  
 Hawaii, 78, 102, 114, 117  
 hazardous waste disposal, 109  
 $\text{HCO}_3$ , 111  
 heat and solute movement near salt domes, 88  
 HEATFLOW, 92  
 Hele-Shaw cell, 89, 95, 96, 117  
 Henry circulation, 90  
 Henry seawater intrusion problem, 95  
 Herzberg, 89, 101, 115  
 Hesse, 11  
 heterogeneity, 3, 11, 12, 41, 51, 53, 54, 56, 63, 66, 82, 83, 98, 104, 107, 116, 117  
 hierarchical system, 76  
 high-level radioactive waste disposal, 88  
 Holocene, 21, 24, 32, 33, 36, 105  
 Holocene sea-level rise, 105  
 HST3D, 61, 92, 115  
 human activity impact, 81, 85  
 hydraulic conductivity, 11, 39, 42, 48, 49, 50, 52, 54, 55, 61, 65, 66, 67, 68, 72, 74, 77, 79, 80, 81, 83, 86, 91, 101, 108, 109  
 hydraulic head, 42  
 hydraulic properties, 11, 12, 48, 98, 112, 113  
 hydrochemistry, 2, 39, 47, 101, 117  
 HYDROCOIN, 47, 61, 95, 115  
 HYDROCOIN salt-dome problem, 95  
 hydroecological applications, 98  
 HydroGeoSphere model, 92, 111, 117  
 hydrological data, 5, 6  
 hydrological modelling, 4, 14  
 hydrological processes, 5  
 hydrostatic test, 95  
 hypersaline brines, 3, 87
- I, 23, 32, 33  
 identification criteria, 47  
 implicit finite difference method, 94  
 indexing, 76  
 India, ix, 3, 63, 67, 120, 126  
 indicator simulation methods, 53  
 Indonesia, 104  
 indurated sediments, 26  
 inert elements, 32  
 INFIL2.0, 16  
 infiltration, 1, 2, 5, 10, 11, 12, 13, 14, 16–17, 18, 19, 23, 77, 79, 82, 115, 124, 126  
 infiltration capacity, 10  
 infiltration of leachates from waste disposal sites, 88  
 infiltration opportunity time, 11  
 infiltrometer experiments, 11  
 instability, 47, 90, 91, 95, 97, 99, 114, 115, 117  
 integrated modelling, 15  
 intelligent scheduling of pumping, 121  
 intensive agriculture, 81  
 inter-annual variability of rainfall, 10  
 interpreted parameters, 55  
 Inter-Tropical Convergence Zone (ITCZ), 24  
 INTRANCOIN, 47  
 intrinsic vulnerability, 76, 77  
 Iran, 1, 5, 15, 19, 81, 85, 122, 130  
 Irbid, 81, 86  
 iron, 23, 35  
 irrigation, 1, 3, 19, 23, 72, 76, 88, 101, 103, 104, 119, 120, 121, 122, 123–124, 125, 126, 128, 129  
 irrigation efficiency, 125  
 irrigation return flow, 72, 101  
 irrigation salinity, 103  
 isochrone, 82  
 isotope fractionation, 27  
 isotopic analyses, 11  
 isotopic and geochemical methods, ix, 2, 3, 11, 21  
 isotopic enrichment, 27  
 isotopic evolution of rainfall, 25  
 isotopic tracers, 32  
 Israel, 14, 37, 86, 114, 126
- Jacob, 55, 61  
 Jacobian matrix, 57, 58  
 Jakarta, 104  
 Jebel Hajar, 16  
 Jordan, 1, 11, 12, 17, 19, 30, 81, 84–85, 86
- K, 23, 33, 111  
 K/Cl ratio, 33  
 Kaidu River, 125  
 Kalahari, 36, 122  
 karst, 42, 77, 79, 81, 85  
 karst systems, 42, 77  
 Kenya, 24, 36  
 kinematic viscosity, 91  
 KINEROS, 16  
 KINEROS2, 10  
 kinetic reactions, 99  
 Kongque River, 125  
 Korla, 125  
 $^{81}\text{Kr}$ , 32  
 kriging, 2, 3, 50, 51, 52, 60, 63–64, 67, 71, 72, 73, 74
- Lake Bostan, 126  
 Lake Chad, 21, 36, 104  
 Lake Corangamite, 104  
 land subsidence, 1  
 land use data, 76  
 last glacial maximum, 24, 36  
 least squares calibration, 56  
 Libya, 24, 25, 33, 36, 75, 120, 121  
 likelihood function, 56  
 limestone, 80, 81  
 local sustainability, 119

- longitudinal dispersion coefficient, 94  
 longitudinal dispersivity, 94  
 Lop Nor, 125  
 low-permeability lenses, 99  
 low-permeability rock formations, 109
- macropore, 26  
 Maheshwaram watershed, 3, 63, 67, 70  
 Mali, 24, 36  
 Managed Aquifer Recharge (MAR), 2  
 marine aerosols, 25, 37  
 marine facies, 33  
 Markov chain method, 53  
 mass conservation, 41, 43, 65  
 mathematical model, 39  
 matrix methods, 79  
 matrix systems, 76  
 maximum likelihood, 56, 57, 59, 60  
 maximum likelihood Bayesian averaging method, 59  
 maximum likelihood calibration, 56  
 maximum permeability direction, 94  
 Mediterranean, ix, 86, 126  
 method of characteristics, 44  
 METROPOL, 92, 115  
 Mg, 23, 25, 33, 111  
 Mg/Ca ratio, 25, 33  
 microbial pathogens, 84  
 micro-organisms, 76, 122  
 Middle East, 1, 2, 6, 21, 27  
 mineral precipitation, 113  
 mineral saturation, 26  
 mineralisation, 23, 25, 26, 28, 32  
 minimum permeability direction, 94  
 minor aquifers, 75  
 MITSU3D, 92  
 mixed convection ratio, 90  
 mixed convective system, 91  
 Mn, 33, 115  
 Mo, 23  
 MOCDENSE, 92  
 model identification, 47  
 model parameters, 44, 47, 48, 55, 56, 58, 60, 62  
 model selection, 2, 47, 48, 57, 60  
 model structure identification, 44  
 modelling procedure, 44  
 modelling variable density flow phenomena, 92  
 MODFLOW, 17, 42, 69, 71, 103, 103, 114, 115, 116  
 MODHMS, 92, 103, 115  
 modified method of characteristics, 44  
 molecular diffusivity, 91  
 molybdenum, 22, 23, 35  
 Monte Carlo method, 59  
 mountain-front recharge, 14  
 MTBE, 126  
 multiphase flow, 39  
 multiple point geostatistical methods, 53  
 multiple species transport, 98, 99  
 multispectral satellite data, 127  
 multi-start local optimisation method, 57  
 multivariate rainfall model, 14  
 multivariate spatial-temporal rainfall model, 17  
 Murray river, 104  
 Murrumbidgee, 125  
 Muscat, 6, 20
- Na, 25, 33, 111  
 Na/Cl ratio, 25, 33  
 Namibia, 122  
 NAMMU, 92  
 natural (baseline) water quality, 21  
 net infiltration, 13  
 neutron probe, 11, 12  
 Nevada, 13, 19, 74
- New England, 104, 105, 116  
 New Jersey, 35, 61, 104  
 New Mexico, 6  
 New South Wales, 8, 19  
 NEWSAM, 71  
 Niamey, 8, 36  
 Niger, 8, 19, 24, 26, 35, 36  
 Niger river, 24  
 Nigeria, 2, 26, 28, 36, 104  
 Nile, 21, 36, 104, 114, 117, 122  
 nitrate, 22, 23, 26, 28–29, 34, 35, 36, 76, 77, 79, 81, 84, 85, 86, 126  
 nitrogen transformations, 26  
 NO<sub>3</sub>, 23, 34  
 NO<sub>3</sub>-N, 28  
 NO<sub>3</sub>-N/Cl ratio, 28  
 noble gas data, 24  
 noble gas isotopic ratios, 32  
 non-aquifers, 75  
 non-local property, 55  
 non-sustainable practice, 119  
 Normalised Difference Vegetation Index, 127  
 North Africa, x, 2, 21, 24, 28, 32, 33, 120  
 North America, 25, 27, 115  
 North China, 120  
 North Sea, 104, 115, 116  
 northwest Sahara aquifer, 120  
 Nubian Sandstone, 75  
 nuclear magnetic resonance (NMR) techniques, 97  
 nugget, 51, 70  
 numerical errors, 47, 58, 100  
 numerical grid convergence, 96  
 numerical modelling of ASR, 107  
 numerical tracer simulations, 103
- offshore palaeowaters, 106  
 Ogallala aquifer, 120  
 Okavango delta, 3, 112, 114, 119, 122, 123, 124, 128, 129, 130  
 Okavango Delta Management Plan, 124  
 Oman, 1, 2, 5, 6, 10, 11, 14, 16, 19, 20, 81, 85  
 onshore saline groundwater, 105  
 optimisation algorithms, 57  
 ordinary kriging, 50  
 ore formation, 99, 112  
 organic pollutants, 76, 84, 126  
 origins of groundwater, 21  
 overland flow, 10, 12, 13, 14  
 overpumping of aquifers, 120  
 oxygen-18, 22
- palaeo-groundwater, 105  
 palaeo-lakes, 21  
 palaeohydrogeology, 88  
 palaeohydrology, 2, 24, 36  
 palaeowater, 2, 21, 22, 23, 25, 28, 32, 35  
 Paluxy aquifer, 80  
 parameter assessment, 47, 48  
 parameter identification, 62, 63  
 parameter uncertainties, 48  
 parameter variability, 44, 71  
 parametric methods, 76  
 particle tracking, 82  
 pathogenic organisms, 84  
 Pearl Harbour aquifer, 102  
 permeability, 48  
 permeability tensor, 41, 93  
 persistent organic pollutants, 126  
 PEST, 57, 58, 104, 114  
 pesticides, 79, 126  
 pH, 22, 28, 34  
 phosphorous, 126  
 phosphorous removal, 126  
 PHREEQC-2, 112  
 PHT3D, 92, 112

- PI method, 79  
 Picard method, 94  
 pinch nodes, 95  
 Pioneer Valley, 102  
 piston flow, 26, 27, 29  
 pit latrines, 3, 81, 84  
 Pitzer's ion interaction model, 111  
 playas, 3, 87, 88, 117  
 Pleistocene, 21, 24, 27, 32, 33, 34, 116  
 PMWIN, 71, 74  
 Poisson process, 14  
 pollution, ix, 1, 2, 3, 5, 21, 23, 34, 35, 75, 76, 77–78, 79, 81, 84, 85, 86, 87, 120, 126  
 pore blockage, 11  
 porosity, 39, 40, 41, 47, 48, 49, 60, 83, 91, 93, 95, 99, 112, 116  
 Port Harcourt, 104  
 potential flow pathway, 75  
 pre-alpine lakes, 126  
 precipitation and dissolution reactions, 99  
 precipitation of (carbonate) minerals, 111  
 precision, 23, 47, 83  
 prediction, 48, 67  
 preferential flow paths, 104  
 preferential recharge, 26, 32  
 primary fracture network, 68, 71  
 probabilities of rainfall occurrence, 7  
 process identification, 44  
 protection zones, 3, 20, 81, 82, 83, 84, 85, 86  
 pump capacities, 5  
 pump test, 55  
 pumping test, 49, 55, 83  
 pumping test analysis, 68  
  
 Qaa's, 11  
 qanats, 1, 5  
 Quaternary, 29, 36, 86  
  
 radiocarbon, 24, 32  
 rainday occurrence, 7, 14  
 raindrop impact, 10, 13  
 rainfall, 6  
 rainfall chemistry, 2, 24, 25, 26, 28  
 rainfall radar data, 14  
 rainfall temporal variability, 6  
 rainfall-runoff processes, 10  
 rainwater harvesting, 1  
 Ramsar convention, 122, 130  
 range, 51  
 rapid instability development, 90  
 rating/point counting, 76  
 Rayleigh number, 90–91, 96, 97, 100, 117  
 reactive multicomponent transport model, 112  
 reactive tracers, 28  
 reactive transport, 3, 39, 40, 60, 62, 89, 100, 111, 112, 113, 116  
 recharge, 1, 2, 3, 5, 8, 11, 12, 13, 14, 16, 17–18, 19, 20, 21, 22, 23, 24, 26, 27–28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 39, 41, 42, 43, 44, 49, 66, 67, 68, 69–70, 72, 75, 77, 79, 80, 81, 82, 85, 86, 104, 106, 114, 119, 127, 128, 129  
 recharge assessment, 21  
 recharge dams, 2, 5, 16  
 recharge history, 29  
 Red Sea, 6  
 redox boundary, 34  
 redox potential, 34  
 redox reactions, 33  
 regionalised variables, 3, 50, 63, 65, 72  
 relative permeability for unsaturated flow, 41, 93  
 relic seawater mobilisation, 101, 103  
 remote sensing, 85, 86, 98, 126, 127, 129, 130  
 renormalisation approach, 55  
 residence time estimation, 21  
 residual analysis, 47  
  
 Rhine, 126  
 riverine forests, 122  
 Rockflow, 3, 109  
 Rub al Khali, 6  
 runoff coefficients, 10  
 runoff production, 10, 12  
  
 sabkhas, 3, 87, 88, 116, 117  
 Sahara, 3, 24, 25, 28, 33, 36, 119, 120, 128, 129  
 Sahel, 25, 29, 30, 33, 35, 36, 120, 129, 130  
 Sahel drought, 29  
 Sahelian zone, 8  
 saline intrusion, 1, 2, 4, 5  
 saline lakes, 3, 87, 117  
 salinisation, 3, 21, 34, 86, 98, 100, 103, 104, 115  
 salinisation of soils by inappropriate irrigation practice, 124  
 salinity generation, 34  
 salt accumulation, 3, 87  
 salt concentrator, 87  
 salt flats, 3, 87  
 salt lake problem, 96, 99  
 salt lakes, 88  
 salt plumes, 102, 103  
 salt spray, 101  
 salt tolerant crops, 125  
 saltpool problem, 97, 99  
 saltwater–freshwater interface, 89  
 saltwater intrusion, 100, 114  
 saltwater upconing, 87, 97, 115  
 sand rivers, 5, 8, 12, 19  
 Santa Cruz County, 105  
 SAR-images, 126  
 Saudi Arabia, 1, 6, 10, 11, 12, 13, 14, 20, 30  
 Saudi Arabian Five Basins Study, 11  
 scale dependence of dispersion, 54  
 scale dependence of parameters, 49  
 scale effect, 49  
 SCS method, 17  
 sea salt spray, 103  
 SEAWAT, 91, 92, 102, 103, 112, 115  
 seawater intrusion, 3, 87, 89, 90, 95, 98, 100–101, 103, 103–104, 105, 112, 115, 120, 126  
 SEBAL, 127, 129  
 SEC, 34  
 secondary fracture network, 68  
 sediment loads, 11, 104  
 sedimentary basins, 22, 24, 32, 88, 90, 99, 116  
 selenium, 35  
 semivariogram, 51  
 Senegal, 2, 27, 28, 29, 30, 32, 36  
 sensitivity analysis, 58  
 septic tanks, 76  
 sequential Gaussian simulation, 2, 52, 60  
 sewage, 84  
 Sharqiyah, 16, 17  
 shuffled complex evolution, 58, 62  
 sill, 51  
 simple kriging, 50–51  
 SIMSALIN, 128  
 simulated annealing, 58, 60, 62  
 simultaneous heat and transport, 89  
 simultaneous optimisation and data assimilation algorithm, 59  
 SINTACS, 77, 78, 81, 85  
 site-specific models, 40  
 siting of wells, 3  
 small-scale variability, 49  
 SO<sub>4</sub>, 23  
 socio-economic aspects, 128  
 soil CO<sub>2</sub>, 28  
 soil crusting, 10  
 soil moisture data, 11  
 soil salinisation, 3, 119, 124, 125, 128  
 soil texture, 48, 60

- solid-matrix thermal conductivity, 93  
 solubility of CO<sub>2</sub>, 28  
 solubility of oxygen, 33  
 solute source, 93, 110  
 solute transport, 39, 40, 41, 60, 61, 67, 87, 89, 90, 91, 92, 93, 94, 97, 98, 99, 101, 105, 112, 114, 115, 117  
 sorption coefficient, 42, 93  
 source protection, 75, 81  
 South America, 1, 104  
 southern Africa, 8  
 Southwestern USA, 1  
 Spain, 79, 126  
 spatial discretisation schemes, 43  
 spatial variability of aquifer properties, 49  
 spatial variability of groundwater recharge, 13  
 spatial-temporal rainfall model, 15  
 specific heat capacity, 93  
 specific pressure storativity, 93  
 specific vulnerability, 76, 79, 86  
 specific yield, 42, 65, 66, 71, 72  
 spherical semivariogram, 51  
 Sr, 23, 33  
 stable isotopes, 22, 25, 27, 29, 35, 36, 85, 126  
 statistical homogeneity, 50  
 stochastic rainfall models, 14  
 storativity, 39, 42, 56, 66, 68, 71, 93  
 stress uncertainties, 48  
 submarine groundwater discharge, 101, 102, 103, 115  
 subterranean groundwater discharge, 87, 88  
 Sudan, 2, 32, 75  
 surface contamination, 84  
 surface energy balance, 127, 129, 130  
 Surface Energy Balance Algorithm for Land (SEBAL), 127  
 surface water-groundwater interactions, 2, 5  
 Suriname, 104, 114  
 Surt basin, 24, 25, 33  
 sustainability, ix, 19, 76, 119, 125, 126, 127, 128, 129  
 sustainable water management, 119  
 sustainable yields, 5, 18  
 SUTRA (Saturated-Unsaturated TRANsport), 92, 93, 94, 95, 97, 101, 117  
 SUTRA governing equations  
 SUTRA model, 93  
 SWIFT, 92, 116  
 Switzerland, 77, 119, 126  
 Syr Darya, 122  
  
 Taihu, 126  
 Tarim river, 122, 125  
 TEM, 126  
 tensorial transmissivities, 55  
 Texas, 80, 85, 116, 117  
 Thames, 126  
 Theis, 55  
 theory of regionalised variables, 3, 63, 73  
 thermohaline convection, 89, 99, 116  
 thermohaline studies, 89  
 Thiem, 55  
 threat to ecosystems, 122  
 three-dimensional benchmark test cases, 98  
 Tian Shan mountains, 125  
 tidal oscillations, 98  
 tidally driven seawater circulation, 103  
 tidally induced phenomena, 3, 100  
 tools for decision support, 127  
 total dissipation energy approach, 55  
 TOUGH2, 62, 92  
 tourism, 123, 124, 129  
 tracer tests, 47, 83, 88, 115  
 transgression-regression cycles, 100, 104  
 transgression-regression salinisation of coastal aquifers, 3, 104  
 transient analyses, 98, 104  
 transient boundary conditions, 98  
  
 transmission losses, 2, 5, 10–11, 12, 13, 16, 17, 19, 20  
 transmissivity, 21, 39, 42, 44, 49, 50, 54, 55, 65, 66, 68, 74, 83, 85  
 transport equation, 42, 43, 61, 95  
 transverse dispersion coefficient, 94  
 transverse dispersivity, 94  
 tritium, 19, 26, 27, 28, 29, 32, 35  
 tritium profiles, 27  
 Tunisia, 30, 33, 36, 81, 85, 120, 121, 130  
 two-dimensional groundwater equation, 42  
  
 UCODE, 57, 58  
 Uganda, 74, 84  
 UK, ix, xi, 14–15, 77, 79, 81  
 unbiased groundwater modeling, 63  
 unbiasedness condition, 64  
 uncertainty, x, 2, 4, 8, 12, 19, 20, 41, 46, 48, 51, 58, 59, 60, 61, 62, 63, 74, 75, 82, 83, 104, 128, 129  
 uncertainty propagation, 2, 58, 74  
 uncertainty quantification, 63  
 unit hydrograph analysis, 10  
 United Arab Emirates, 81, 116  
 universal kriging, 51  
 universality condition, 64  
 unsaturated zone, 26  
 unsaturated zone chemistry, 2  
 unsaturated zone profiles, 14, 27, 29, 35  
 unstable density inversions, 90  
 upscaling, 53  
 upscaling tools, 3  
 upstream weighting, 95  
 upstream-downstream relations, 122  
 urban water supply, 5  
 USA, 2, 7, 14, 19, 26, 29, 62, 85, 104, 114, 116  
  
 vapour diffusion, 13  
 VapourT, 92  
 VARDEN, 92  
 variable density flow, 3, 42, 87, 88, 89, 90, 91, 92, 94, 98, 99, 100, 105, 108–109, 110, 111, 112, 116  
 variable density flow in ASR, 107  
 variable density flow phenomena, 87, 88, 92, 98, 99  
 variable density flow physics, 89  
 variable density groundwater flow, 87, 88, 89, 91, 98, 99, 105, 115  
 variable density numerical codes, 95  
 variable density processes in aquifer storage and recovery, 100  
 variable density single-phase saturated-unsaturated flow, 92  
 variable density version of Darcy's law, 91  
 variable viscosity, 99  
 variogram, 51, 52, 54, 63, 64, 65, 69, 71, 72, 73, 74  
 vegetation growth, 10, 127  
 verification of variable density flow in fractured rock, 110  
 visible and near infrared radiometer, 81  
 vulnerability methods, 80, 81  
  
 wadi alluvium hydraulic properties, 11  
 Wadi Ghat, 10–11  
 Wadi Ghulaji, 16, 20  
 Wadi Hawad, 32  
 Wadi Lith, 7  
 Wadi Tabalah, 13, 16  
 Wadi Yiba, 6, 7, 10  
 Walnut Gulch, 6, 10, 12, 13, 15, 19  
 wastewater collection systems, 76  
 wastewater treatment, 126  
 water balance model, 17, 18  
 water bodies of large residence time, 126  
 water saturation, 41, 93  
 water scarcity, 1, 122  
 water-rock interactions, 28, 101  
 well capture zone, 3

## INDEX

137

- 
- well catchment, 82  
well head protection area, 82  
West Africa, 33  
Western United States, 120  
wetlands, 1, 122, 123, 124, 129  
when can density effects be ignored?, 108  
winter rainfall, 13  
  
Xinjiang, China, 122  
  
Yanqi basin, 3, 119, 125, 126, 128  
Yellow river, 122  
Yemen, 1, 7, 11, 20  
Yucca Mountain, 13, 14, 16, 19, 74  
  
zero-flux plane, 26, 27  
zero-order solute production rate, 42  
zero-order sorbate production rate, 42  
zoning, 76