

Prevention and Mitigation of Natural and Anthropogenic Hazards Due to Land Subsidence

Ninth International Symposium on Land Subsidence (NISOLS)

Proceedings of the International Association of Hydrological Sciences (IAHS) Volume 372, 2015

**Nagoya, Japan
15-19 November 2015**

Editors:

K. Daito

D. Galloway

ISBN: 978-1-5108-3908-3

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

The copyright of any article is retained by the author(s) and distributed under the Creative Commons Attribution 3.0 license. <http://creativecommons.org/licenses/by/3.0/>
Unless otherwise stated, associated published material is distributed under the same license. The original work can be found online at:

<http://www.proc-iahs.net/372/index.html>

Printed by Curran Associates, Inc. (2015)

International Association of Hydrological Sciences
Centre for Ecology and Hydrology
Wallingford, Oxfordshire OX10 8BB
United Kingdom

Phone: 441 491 692 442
Fax: 441 491 692 448

<http://iahs.info/>

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

TABLE OF CONTENTS

PREFACE: PREVENTION AND MITIGATION OF NATURAL AND ANTHROPOGENIC HAZARDS DUE TO LAND SUBSIDENCE	555
<i>K. Daito, D. L. Galloway</i>	
<u>AQUIFER-SYSTEM COMPACTION AND SUBSIDENCE CAUSED BY GROUNDWATER WITHDRAWAL</u>	
COMPREHENSIVE EXPERIMENTAL STUDY ON PREVENTION OF LAND SUBSIDENCE CAUSED BY DEWATERING IN DEEP FOUNDATION PIT WITH HANGING WATERPROOF CURTAIN	1
<i>T. L. Yang, X. X. Yan, H. M. Wang, X. L. Huang, G. H. Zhan</i>	
SPATIAL-TEMPORAL VARIATION OF GROUNDWATER AND LAND SUBSIDENCE EVOLUTION IN BEIJING AREA	7
<i>K. Lei, Y. Luo, B. Chen, M. Guo, G. Guo, Y. Yang, R. Wang</i>	
INVESTIGATION OF ALTERNATIVE MECHANISMS OF AQUIFER-SYSTEM COMPACTION AND LAND SUBSIDENCE IN SHANGHAI	13
<i>Y. Yuan, Y.-S. Xu, S.-L. Shen, N. Zhang</i>	
GROUNDWATER-ABSTRACTION INDUCED LAND SUBSIDENCE AND GROUNDWATER REGULATION IN THE NORTH CHINA PLAIN	17
<i>H. Guo, L. Wang, G. Cheng, Z. Zhang</i>	
LAND SUBSIDENCE IN THE SAN JOAQUIN VALLEY, CALIFORNIA, USA, 2007–2014	23
<i>M. Sneed, J. T. Brandt</i>	
EVALUATION OF THE POTENTIAL OF INSAR TIME SERIES TO STUDY THE SPATIO-TEMPORAL EVOLUTION OF PIEZOMETRIC LEVELS IN THE MADRID AQUIFER	29
<i>M. Béjar-Pizarro, P. Ezquerro Martín, G. Herrera, R. Tomás, C. Guardiola-Albert, J. M. Ruiz Hernández, M. Marchamalo Sacristán, R. Martínez Marín</i>	
LAND SUBSIDENCE CAUSED BY A SINGLE WATER EXTRACTION WELL AND RAPID WATER INFILTRATION	33
<i>I. Martínez-Noguera, R. Hinkelmann</i>	
NEW INFORMATION ON REGIONAL SUBSIDENCE AND SOIL FRACTURING IN MEXICO CITY VALLEY	39
<i>G. Auvinet, E. Méndez-Sánchez, M. Juárez-Camarena</i>	
APPLICATION OF MULTI-SENSOR ADVANCED DINSAR ANALYSIS TO SEVERE LAND SUBSIDENCE RECOGNITION: ALTO GUADALENTÍN BASIN (SPAIN)	45
<i>R. Boni, G. Herrera, C. Meisina, D. Notti, M. Béjar-Pizarro, F. Zucca, P. J. González, M. Palano, R. Tomás, J. Fernández, J. A. Fernández-Merodo, J. Mulas, R. Aragón, C. Guardiola-Albert, O. Mora</i>	
THE DEFORMATION BEHAVIOR OF SOIL MASS IN THE SUBSIDENCE REGION OF BEIJING, CHINA	49
<i>F. Tian, J.-R. Liu, Y. Luo, L. Zhu, Y. Yang, Y. Zhou</i>	
GROUNDWATER MANAGEMENT BASED ON MONITORING OF LAND SUBSIDENCE AND GROUNDWATER LEVELS IN THE KANTO GROUNDWATER BASIN, CENTRAL JAPAN	53
<i>K. Furuno, A. Kagawa, O. Kazaoka, T. Kusuda, H. Nirei</i>	
SUBSIDENCE CHARACTERIZATION AND MODELING FOR ENGINEERED FACILITIES IN ARIZONA, USA	59
<i>M. L. Rucker, K. C. Fergason, B. B. Panda</i>	
MODELLING GROUND RUPTURE DUE TO GROUNDWATER WITHDRAWAL: APPLICATIONS TO TEST CASES IN CHINA AND MEXICO	63
<i>A. Franceschini, P. Teatini, C. Janna, M. Ferronato, G. Gambolati, S. Ye, D. Carreón-Freyre</i>	
MODELING OF EARTH FISSURES CAUSED BY LAND SUBSIDENCE DUE TO GROUNDWATER WITHDRAWAL	69
<i>B. B. Panda, M. L. Rucker, K. C. Fergason</i>	
ASSESSING THE POTENTIAL OF THE MULTI-AQUIFER SUBSURFACE OF THE MEKONG DELTA (VIETNAM) FOR LAND SUBSIDENCE DUE TO GROUNDWATER EXTRACTION	73
<i>P. S. J. Minderhoud, G. Erkens, V. H. Pham, B. T. Vuong, E. Stouthamer</i>	

COMBINATION WITH PRECISE LEVELING AND PSINSAR OBSERVATIONS TO QUANTIFY PUMPING-INDUCED LAND SUBSIDENCE IN CENTRAL TAIWAN	77
<i>C. H. Lu, C. F. Ni, C. P. Chang, J. Y. Yen, W. C. Hung</i>	
TOWARDS A GLOBAL LAND SUBSIDENCE MAP	83
<i>G. Erkens, E. H. Sutanudjaja</i>	
SURFACE DEFORMATION ON THE WEST PORTION OF THE CHAPALA LAKE BASIN: UNCERTAINTIES AND FACTS	89
<i>M. Hernandez-Marin, J. Pacheco-Martinez, J. A. Ortiz-Lozano, G. Araiza-Garaygordobil, A. Ramirez-Cortes</i>	
FACTOR ANALYSIS ON LAND SUBSIDENCE IN THE NOBI PLAIN, SOUTHWEST JAPAN	95
<i>A. Kouda, K. Nagata, T. Sato</i>	
FREQUENCY ANOMALY OF GROUNDWATER LEVEL BEFORE MAJOR EARTHQUAKES IN TAIWAN	101
<i>T.-K. Yeh, C.-H. Chen, C.-H. Wang, S. Wen</i>	

RISK MANAGEMENT OF SUBSIDENCE RELATED HAZARDS

FUZZY-LOGIC ASSESSMENT OF FAILURE HAZARD IN PIPELINES DUE TO MINING ACTIVITY	105
<i>A. A. Malinowska, R. Hejmanowski</i>	
SUPERIOR COEXISTENCE: SYSTEMATICALLY REGULATING LAND SUBSIDENCE BASED ON SET PAIR THEORY	111
<i>Y. Chen, S.-L. Gong</i>	
STUDY ON THE RISK AND IMPACTS OF LAND SUBSIDENCE IN JAKARTA	115
<i>H. Z. Abidin, H. Andreas, I. Gumilar, J. J. Brinkman</i>	
APPLICATION OF INSAR AND GRAVIMETRIC SURVEYS FOR DEVELOPING CONSTRUCTION CODES IN ZONES OF LAND SUBSIDENCE INDUCED BY GROUNDWATER EXTRACTION: CASE STUDY OF AGUASCALIENTES, MEXICO	121
<i>J. Pacheco-Martinez, S. Wdowinski, E. Cabral-Cano, M. Hernández-Marín, J. A. Ortiz-Lozano, T. Oliver-Cabrera, D. Solano-Rojas, E. Hayazli</i>	
PRODUCTION INDUCED SUBSIDENCE AND SEISMICITY IN THE GRONINGEN GAS FIELD – CAN IT BE MANAGED?	129
<i>J. A. de Waal, A. G. Muntendam-Bos, J. P. A. Roest</i>	
FULL-SCALE EXPERIMENTAL AND NUMERICAL STUDY ABOUT STRUCTURAL BEHAVIOUR OF A THIN-WALLED COLD-FORMED STEEL BUILDING Affected BY GROUND SETTLEMENTS DUE TO LAND SUBSIDENCE	141
<i>J. A. Ortiz, L. A. Hernández, M. Hernández, J. Pacheco, M. E. Zermeño, R. Salinas</i>	
LAND SUBSIDENCE RISK ASSESSMENT AND PROTECTION IN MINED-OUT REGIONS	145
<i>A. Zhao, A. Tang</i>	
SUBSIDENCE AT THE "TRÉBOL" OF QUITO, ECUADOR: AN INDICATOR FOR FUTURE DISASTERS?	151
<i>T. Toulkeridis, D. Simón Baile, F. Rodríguez, R. Salazar Martínez, N. Arias Jiménez, D. Carreón Freyre</i>	
HAS LAND SUBSIDENCE CHANGED THE FLOOD HAZARD POTENTIAL? A CASE EXAMPLE FROM THE KUJKURI PLAIN, CHIBA PREFECTURE, JAPAN	157
<i>H. L. Chen, Y. Ito, M. Sawamukai, T. Su, T. Tokunaga</i>	
AN ANALYSIS ON THE RELATIONSHIP BETWEEN LAND SUBSIDENCE AND FLOODS AT THE KUJKURI PLAIN IN CHIBA PREFECTURE, JAPAN	163
<i>Y. Ito, H. Chen, M. Sawamukai, T. Su, T. Tokunaga</i>	
RISK EVALUATION OF LAND SUBSIDENCE AND ITS APPLICATION TO METRO SAFETY OPERATION IN SHANGHAI	543
<i>J. Liu, H. Wang, X. Yan</i>	

ANTHROPOGENIC LAND SUBSIDENCE IN COASTAL REGIONS

SUBSURFACE GEOLOGY AND AQUIFER SYSTEM OF THE NOHBI PLAIN, CENTRAL JAPAN	169
<i>T. Makinouchi</i>	
POTENTIAL OF HOLOCENE DELTAIC SEQUENCES FOR SUBSIDENCE DUE TO PEAT COMPACTION	173
<i>E. Stouthamer, S. van Asselen</i>	

FUTURE DELTAS UTRECHT UNIVERSITY RESEARCH FOCUS AREA: TOWARDS SUSTAINABLE MANAGEMENT OF SINKING DELTAS.....	179
<i>E. Stouthamer, S. van Asselen</i>	
COMPACTION PARAMETER ESTIMATION USING SURFACE MOVEMENT DATA IN SOUTHERN FLEVOLAND	183
<i>P. A. Fokker, J. Gunnink, G. de Lange, O. Leeuwenburgh, E. F. van der Veer</i>	
SINKING COASTAL CITIES	189
<i>G. Erkens, T. Bucx, R. Dam, G. de Lange, J. Lambert</i>	
REGIONAL AND LOCAL LAND SUBSIDENCE AT THE VENICE COASTLAND BY TERRASAR-X PSI.....	199
<i>L. Tosi, T. Strozzi, C. Da Lio, P. Teatini</i>	
PREVENTION PARTITION FOR LAND SUBSIDENCE INDUCED BY ENGINEERING DEWATERING IN SHANGHAI.....	207
<i>J. X. Wang, X. T. Liu, T. L. Yang</i>	

LAND SUBSIDENCE AND LIQUEFACTION, DUE TO EAST JAPAN GREAT EARTHQUAKE OF MARCH 11, 2011

LAND SUBSIDENCE OF CLAY DEPOSITS AFTER THE TOHOKU-PACIFIC OCEAN EARTHQUAKE	211
<i>K. Yasuhara, M. Kazama</i>	
LIQUEFACTION-FLUIDIZATION INDUCED LAND SUBSIDENCE: IMPACT OF THE 2011 TOHOKU EARTHQUAKE ON RECLAIMED LAND AROUND TOKYO BAY AREA, JAPAN.....	217
<i>A. Kagawa, K. Furuno, T. Kusuda, Y. Sakai, T. Yoshida, O. Kazaoka</i>	
SUBSIDENCE BY LIQUEFACTION-FLUIDIZATION IN MAN-MADE STRATA AROUND TOKYO BAY, JAPAN: FROM GEOLOGICAL SURVEY ON DAMAGED PART AT THE 2011 OFF THE PACIFIC COAST OF TOHOKU EARTHQUAKE	221
<i>O. Kazaoka, S. Kameyama, K. Shigeno, Y. Suzuki, M. Morisaki, A. Kagawa, T. Yoshida, M. Kimura, Y. Sakai, T. Ogura, T. Kusuda, K. Furuno</i>	

GROUND FAILURE (FRACTURING, FAULT ACTIVATION, FISSURING)

VISUALIZATION OF THREE DIMENSIONAL EARTH FISSURES IN GEOLOGICAL STRUCTURE	227
<i>L. Zhu, J. Yu, Y. Liu, H. Gong, Y. Chen, B. Chen</i>	
STUDY OF THE DEFORMATION MECHANISM OF THE GAOLIYING GROUND FISSURE	231
<i>G. Cheng, H. Wang, Y. Luo, H. Guo</i>	
DISCUSSION ON THE ORIGIN OF SURFACE FAILURES IN THE VALLEY OF AGUASCALIENTES, MÉXICO.....	235
<i>M. Hernández-Marín, N. González-Cervantes, J. Pacheco-Martínez, D. H. Frias-Guzmán</i>	
RESEARCH OF FEATURES RELATED TO LAND SUBSIDENCE AND GROUND FISSURE DISASTERS IN THE BEIJING PLAIN.....	239
<i>Y. Yang, Y. Luo, M. Liu, R. Wang, H. Wang</i>	
SUBSIDENCE MONITORING WITH GEOTECHNICAL INSTRUMENTS IN THE MEXICALI VALLEY, BAJA CALIFORNIA, MEXICO	243
<i>E. Glowacka, O. Sarychikhina, V. H. Márquez Ramírez, B. Robles, F. A. Nava, F. Farfán, M. A. García Arthur</i>	
CHARACTERIZATION OF EARTH FISSURES IN SOUTH JIANGSU, CHINA	249
<i>S. Ye, Y. Wang, J. Wu, P. Teatini, J. Yu, X. Gong, G. Wang</i>	
SATELLITE GEODESY TOOLS FOR GROUND SUBSIDENCE AND ASSOCIATED SHALLOW FAULTING HAZARD ASSESSMENT IN CENTRAL MEXICO	255
<i>E. Cabral-Cano, D. Solano-Rojas, T. Oliver-Cabrera, S. Wdowinski, E. Chaussard, L. Salazar-Tlaczani, F. Cigna, C. DeMets, J. Pacheco-Martínez</i>	
MASS MOVEMENT PROCESSES TRIGGERED BY LAND SUBSIDENCE IN IZTAPALAPA, THE EASTERN PART OF MEXICO CITY	261
<i>M. González-Hernández, D. Carreón-Freyre, R. Gutierrez-Calderon, M. Cerca, W. Flores-Garcia</i>	
APPLICATION OF HIGH RESOLUTION GEOPHYSICAL PROSPECTING TO ASSESS THE RISK RELATED TO SUBSURFACE DEFORMATIONIN MEXICO CITY.....	267
<i>F. A. Centeno-Salas, D. Carreón-Freyre, W. A. Flores-García, R. I. Gutiérrez-Calderón</i>	

ANALYSIS OF THE VARIATION OF THE COMPRESSIBILITY INDEX (CC) OF VOLCANIC CLAYS AND ITS APPLICATION TO ESTIMATE SUBSIDENCE IN LACUSTRINE AREAS.....	273
<i>D. Carreón-Freyre, M. González-Hernández, D. Martínez-Alfaro, S. Solís-Valdés, M. Cerca, B. Millán-Malo, R. Gutiérrez-Calderón, F. Centeno-Salas</i>	
THE EFFECT OF THE DEPTH AND GROUNDWATER ON THE FORMATION OF SINKHOLES OR GROUND SUBSIDENCE ASSOCIATED WITH ABANDONED ROOM AND PILLAR LIGNITE MINES UNDER STATIC AND DYNAMIC CONDITIONS.....	281
<i>Ö. Aydan, T. Ito</i>	
PHYSICAL EXPERIMENTS OF LAND SUBSIDENCE WITHIN A MAAR CRATER: INSIGHTS FOR POROSITY VARIATIONS AND FRACTURE LOCALIZATION	285
<i>M. Cerca, L. Rocha, D. Carreón-Freyre, J. Aranda</i>	
 <u>LAND SURFACE DISPLACEMENT, MEASURING AND MONITORING</u>	
CONTINUOUS MONITORING OF AN EARTH FISSURE IN CHINO, CALIFORNIA, USA – A MANAGEMENT TOOL.....	291
<i>M. C. Carpenter</i>	
INTRODUCTION TO GPS GEODETIC INFRASTRUCTURE FOR LAND SUBSIDENCE MONITORING IN HOUSTON, TEXAS, USA.....	297
<i>G. Wang, J. Welch, T. J. Kearns, L. Yang, J. Serna Jr.</i>	
DIFFERENT SCALE LAND SUBSIDENCE AND GROUND FISSURE MONITORING WITH MULTIPLE INSAR TECHNIQUES OVER FENWEI BASIN, CHINA.....	305
<i>C. Zhao, Q. Zhang, C. Yang, J. Zhang, W. Zhu, F. Qu, Y. Liu</i>	
EXPLOITATION OF THE FULL POTENTIAL OF PSI DATA FOR SUBSIDENCE MONITORING	311
<i>M. Crosetto, N. Devanthéry, M. Cuevas-González, O. Monserrat, B. Crippa</i>	
EVOLUTION OF THE TECHNIQUES FOR SUBSIDENCE MONITORING AT REGIONAL SCALE: THE CASE OF EMILIA-ROMAGNA REGION (ITALY)	315
<i>G. Bitelli, F. Bonsignore, I. Pellegrino, L. Vittuari</i>	
SUBSIDENCE MONITORING SYSTEM FOR OFFSHORE APPLICATIONS: TECHNOLOGY SCOUTING AND FEASIBILITY STUDIES	323
<i>R. Miandro, C. Dacome, A. Mosconi, G. Roncari</i>	
INSAR DATA FOR MONITORING LAND SUBSIDENCE: TIME TO THINK BIG.....	331
<i>A. Ferretti, D. Colombo, A. Fumagalli, F. Novali, A. Rucci</i>	
SPATIO-TEMPORAL EVOLUTION OF ASEISMIC GROUND DEFORMATION IN THE MEXICALI VALLEY (BAJA CALIFORNIA, MEXICO) FROM 1993 TO 2010, USING DIFFERENTIAL SAR INTERFEROMETRY	335
<i>O. Sarychikhina, E. Glowacka</i>	
LONG-RANGE GROUND DEFORMATION MONITORING BY INSAR ANALYSIS.....	343
<i>S. Rokugawa, T. Nakamura</i>	
MAPPING AND CHARACTERIZATION OF LAND SUBSIDENCE IN BEIJING PLAIN CAUSED BY GROUNDWATER PUMPING USING THE SMALL BASELINE SUBSET (SBAS) INSAR TECHNIQUE	347
<i>M. L. Gao, H. L. Gong, B. B. Chen, C. F. Zhou, K. S. Liu, M. Shi</i>	
ESTIMATE OF A SPATIALLY VARIABLE RESERVOIR COMPRESSIBILITY BY ASSIMILATION OF GROUND SURFACE DISPLACEMENT DATA	351
<i>C. Zuccarato, D. Baiù, F. Bottazzi, M. Ferronato, G. Gambolati, S. Mantica, P. Teatini</i>	
PSI-BASED METHODOLOGY TO LAND SUBSIDENCE MECHANISM RECOGNITION	357
<i>R. Boni, C. Meisina, C. Perotti, F. Fenaroli</i>	
METHODS FOR MONITORING LAND SUBSIDENCE AND EARTH FISSURES IN THE WESTERN USA	361
<i>K. C. Ferguson, M. L. Rucker, B. B. Panda</i>	
COMPACTATION AND SUBSIDENCE OF THE GRONINGEN GAS FIELD IN THE NETHERLANDS	367
<i>K. van Thienen-Visser, J. P. Pruijsma, J. N. Breunese</i>	
INVERSION OF DOUBLE-DIFFERENCE MEASUREMENTS FROM OPTICAL LEVELLING FOR THE GRONINGEN GAS FIELD	375
<i>P. A. Fokker, K. Van Thienen-Visser</i>	
SUBSIDENCE MONITORING NETWORK: AN ITALIAN EXAMPLE AIMED AT A SUSTAINABLE HYDROCARBON E&P ACTIVITY	379
<i>M. C. Dacome, R. Miandro, M. Vettorel, G. Roncari</i>	

MULTIPLE SENSORS APPLIED TO MONITORLAND SUBSIDENCE IN CENTRAL TAIWAN	385
<i>W.-C. Hung, C. Wang, C. Hwang, Y.-A. Chen, H.-C. Chiu, S.-H. Lin</i>	
IN-SITU FORMATION COMPACTION MONITORING IN DEEP RESERVOIRS BY USE OF FIBER OPTICS	393
<i>H. Ikeda, S. Kunisue, D. Nohara, K. Ooba, T. Kokubo</i>	
THE INVESTIGATION OF A NEW MONITORING SYSTEM USING LEVELING AND GPS	539
<i>M. Nojo, F. Waki, M. Akaishi, Y. Muramoto</i>	

NUMERICAL MODELLING

NUMERICAL SIMULATION OF EARTH FISSURES DUE TO GROUNDWATER WITHDRAWAL	395
<i>Z. Wang, Y. Zhang, J. Wu, J. Yu, X. Gong</i>	
RESEARCH ON THE DEFORMATION OF A CONFINED AQUIFER BASED ON COSSERAT CONTINUUM MECHANICS	399
<i>Y. S. Xu, N. Zhang, Y. Yuan, S. L. Shen</i>	
THE SPATIOTEMPORA VARIATIONS RULES OF SONGZAO COAL MINING SUBSIDENCE BASED ON NUMERICAL SIMULATION	403
<i>J. Lu, Y. Li, H. Cheng, Z. Tang</i>	
INVERSE MODELING USING PS-INSAR FOR IMPROVED CALIBRATION OF HYDRAULIC PARAMETERS AND PREDICTION OF FUTURE SUBSIDENCE FOR LAS VEGAS VALLEY, USA	411
<i>T. J. Burbey, M. Zhang</i>	
MODIFYING THE DISSOLVED-IN-WATER TYPE NATURAL GAS FIELD SIMULATION MODEL BASED ON THE DISTRIBUTION OF ESTIMATED YOUNG'S MODULUS FOR THE KUJKURI REGION, JAPAN	417
<i>T. Nakagawa, R. Matsuyama, M. Adachi, S. Kuroshima, T. Ogatsu, R. Adachi</i>	
SIMULATION STUDY OF THE IN-SITU FORMATION DEFORMATION BEHAVIOR OF A SHALLOW FORMATION IN THE SOUTHERN KANTO NATURAL GAS FIELD, CHIBA PREFECTURE, JAPAN	421
<i>M. Adachi, R. Matsuyama, T. Nakagawa, S. Kuroshima, T. Ogatsu, R. Adachi</i>	
REGIONAL SUBSIDENCE MODELLING IN MURCIA CITY (SE SPAIN) USING 1-D VERTICAL FINITE ELEMENT ANALYSIS AND 2-D INTERPOLATION OF GROUND SURFACE DISPLACEMENTS	425
<i>S. Tessitore, J. A. Fernández-Merodo, G. Herrera, R. Tomás, M. Ramondini, M. Sanabria, J. Duro, J. Mulas, D. Calcaterra</i>	
POROELASTIC MODELING TO ASSESS THE EFFECT OF WATER INJECTION FOR LAND SUBSIDENCE MITIGATION	431
<i>M. Aichi, T. Tokunaga</i>	
3-D LAND SUBSIDENCE SIMULATION USING THE NDIS PACKAGE FOR MODFLOW	437
<i>D. H. Kang, J. Li</i>	
THREE DIMENSIONAL NUMERICAL MODELING OF LAND SUBSIDENCE IN SHANGHAI	443
<i>S. Ye, Y. Luo, J. Wu, P. Teatini, H. Wang, X. Jiao</i>	
EXAMPLES OF DEFORMATION-DEPENDENT FLOW SIMULATIONS OF CONJUNCTIVE USE WITH MF-OWHM	449
<i>R. T. Hanson, J. Traum, S. E. Boyce, W. Schmid, J. D. Hughes</i>	
NUMERICAL AND EXPERIMENTAL STUDY OF STRATA BEHAVIOR AND LAND SUBSIDENCE IN AN UNDERGROUND COAL GASIFICATION PROJECT	455
<i>N. N. Sirdesai, R. Singh, T. N. Singh, P. G. Ranjith</i>	
A FUSION MODEL USED IN SUBSIDENCE PREDICTION IN TAIWAN	463
<i>S.-J. Wang, K.-C. Hsu, C.-H. Lee</i>	

SOCIAL, CULTURAL AND ECONOMIC INFLUENCE OF LAND SUBSIDENCE

THE INTERACTION BETWEEN LAND SUBSIDENCE AND URBAN DEVELOPMENT IN CHINA	471
<i>Y. Yang, R. Wang, Y. Zhou, Y. Jiang, X. Wang</i>	
SETTLEMENT CHARACTERISTICS OF MAJOR INFRASTRUCTURES IN SHANGHAI	475
<i>X. Jiao, X. X. Yan, H. M. Wang</i>	

CHARACTERIZATION OF LAND SUBSIDENCE INDUCED BY GROUNDWATER WITHDRAWALS IN WENYU RIVER ALLUVIAL FAN, BEIJING, CHINA	481
<i>R. Wang, Y. Luo, Y. Yang, F. Tian, Y. Zhou, M.-Z. Tian</i>	
AN INTEGRATED ASSESSMENT FRAMEWORK FOR LAND SUBSIDENCE IN DELTA CITIES	485
<i>T. H. M. Bucz, C. J. M. van Ruiten, G. Erkens, G. de Lange</i>	
NUMERICAL ANALYSIS TO DETERMINE THE IMPACT OF LAND SUBSIDENCE ON HIGH-SPEED RAILWAY ROUTES IN BEIJING, CHINA.....	493
<i>C. Ye, Y. Yang, F. Tian, Y. Luo, Y. Zhou</i>	

WATER MANAGEMENT STRATEGIES

THE KABU-IDO SYSTEM: A PIONEERING SOLUTION FOR UNCOORDINATED GROUNDWATER PUMPING IN JAPAN	499
<i>T. Endo</i>	
LAND SUBSIDENCE OF COASTAL AREAS OF JIANGSU PROVINCE, CHINA: HISTORICAL REVIEW AND PRESENT SITUATION	503
<i>J. Q. Zhu, Y. Yang, J. Yu, X. L. Gong</i>	
RESEARCH ON CRITICAL GROUNDWATER LEVEL UNDER THE THRESHOLD VALUE OF LAND SUBSIDENCE IN THE TYPICAL REGION OF BEIJING	507
<i>Y. Jiang, J.-R. Liu, Y. Luo, Y. Yang, F. Tian, K.-C. Lei</i>	
EFFECTS OF GROUNDWATER REGULATION ON AQUIFER-SYSTEM COMPACTION AND SUBSIDENCE IN THE HOUSTON-GALVESTON REGION, TEXAS, USA	511
<i>M. J. Turco, A. Petrov</i>	
A MODEL, DESCRIBING THE INFLUENCE OF WATER MANAGEMENT ALTERNATIVES ON DIKE STABILITY	515
<i>J. W. M. Lambert, E. Vastenburg, F. J. Roelofsen</i>	

SUBSURFACE DEFORMATION DUE TO SHALE GAS PRODUCTION

ON THE POSSIBLE CONTRIBUTION OF CLAYEY INTER-LAYERS TO DELAYED LAND SUBSIDENCE ABOVE PRODUCING AQUIFERS	519
<i>G. Isotton, M. Ferronato, G. Gambolati, P. Teatini</i>	
PERFORMANCE OF PILE FOUNDATION FOR THE CIVIL INFRASTRUCTURE OF HIGH SPEED RAIL IN SEVERE GROUND SUBSIDENCE AREA	525
<i>H. W. Yang</i>	
TOOLS TO SUPPORT MAINTENANCE STRATEGIES UNDER SOFT SOIL CONDITIONS.....	529
<i>J. W. M. Lambert, J. J. van Meerten, M. P. Woning, M. J. Eijbersen, M. Huber</i>	
LAND SUBSIDENCE, SEISMICITY AND PORE PRESSURE MONITORING: THE NEW REQUIREMENTS FOR THE FUTURE DEVELOPMENT OF OIL AND GAS FIELDS IN ITALY	533
<i>P. Macini, E. Mesini, L. Panei, F. Terlizzese</i>	
Author Index	