

L. UBERTINI

**HYDROLOGICAL SCIENCES**  
**Italian research activity (1991-1994) report to IAHS**

## FOUR YEARS OF RESEARCH ACTIVITY

The scientific activity of the Italian chapter of IAHS during the just concluded quadriennium has been characterised by the boost of the well established National Research Group for the Prevention of Hydro-Geological Hazards (GNDCI) and of the National Research Programs of the Ministry of Scientific Research and Technology (MURST).

The GNDCI Group is sponsored by the National Research Council (CNR), the Ministry of Scientific Research and Technology, the Ministry of Public Works and by the Civil Protection Department. The four general lines in which the activity of the Group is organised relate to the most important aspects of Hydrology tackled with appropriate approaches depending on the specific goal: surface and subsurface flow and transport of both water and contaminants, forecasting and prevention of extreme events and their mitigation through zoning and intervention strategies.

At least two of the MURST 40% Research Programs can be considered in the area of the Hydrology. The first of them, *Fundamental Hydrological Processes*, co-ordinated by Prof. R. Rosso of the Polytechnic of Milan, is essentially devoted to the analysis of the interaction between vegetation, soil and the atmosphere, of the precipitation processes and of the mechanism of hydrodynamic dispersion. The second one, *Transport Processes in Water Bodies*, co-ordinated by Prof. U. Maione of the Polytechnic of Milan, is mostly focused on diffusion and dispersion phenomena.

Furthermore, it must be stressed the activity of the section *Hydrology* of the National Group of Hydraulics (GNI), co-ordinated by Prof. P. Versace of the IRPI-CNR of Cosenza. In the last report of this section (Sept. '94), among other things, programs of all courses activated in the area of Hydrology are reported as well as a list of Italian Ph.D. thesis concerning Hydrology. Finally, Hydrology plays an important role in the activity of the Italian Section of *Commission Internationale du Génie Rural* (CIGR), co-ordinated by Prof. A. Santini of the University of Naples, that has contributed to the organisation of the XII World Congress in Milan.

Many other international conferences and short advanced schools in the general field of hydrology have been organised by the various Italian research institutions. It is worth noting the activity of Istituto Veneto di Scienze, Lettere ed Arti, in Venice, co-ordinated by Prof. A. Rinaldo, of the University of Padua, and the one of the Water Resources Documentation Centre (WARREDOC), in Perugia, directed by Prof. F. Siccardi, of the University of Genoa. The most recent ones are listed later on.

In the framework of the above outlined research programs, a large number of papers and scientific reports have been produced and published in national and international journals and conference proceedings. A non exhaustive list of them, as taken from GNI and GNDCI activity reports and restricted to international journals and conferences, is presented below, subdivided according to the topics which name the IAHS International Commissions.

### ATMOSPHERE-SOIL-VEGETATION RELATIONS

The research activity on the complex relations between the soil, the vegetation and the atmosphere has recently assumed new perspectives. Together with the development and implementation of advanced study devoted to the modelling of the soil-vegetation system response to specific atmospheric fluxes, such as rainfall and energy in the various forms, more attention has been also focused on the active role of the soil-vegetation system in modifying its own forcing. In particular, a series of investigations have been initiated on the possible existence of a relevant feedback between the soil moisture and the precipitation able to induce persistent anomalies in continental climates. In particular, it is found that a significant correlation exists between the soil moisture state and the precipitation rate in subsequent times, which may be explained considering the active role of the soil hydrology in controlling the partitioning of the surface fluxes (sensible and latent heat) and hence the whole atmospheric dynamics.

### BIBLIOGRAPHY

- Castelli F. and Rodriguez-Iturbe I.; 1993: *Keynote Lecture: On the dynamical coupling of large scale spatial patterns of precipitation and soil moisture*. Fourth International Conference on Precipitation, Iowa City, IA, U.S.A.; April 26-28, 1993.
- Castelli F.; 1993: *Large scale spatial dynamics of soil moisture-atmosphere interaction*. XVIII General Assembly of the European Geophysical Society, Wiesbaden, Germany. May 3-7, 1993.
- Entekhabi D., Rodriguez-Iturbe I., Scott R. and Castelli F.; 1994: *Two-way land-atmosphere interaction and the time-scales of persistent anomalies in continental climates*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy. June 27-28, 1994.
- Giacomin A. and Trucchi P.; 1992: *Rainfall interception in a beech coppice (Acquerino, Italy)*. J. of Hydrology, **137**, 141-147.
- Mannocchi F. and Mecarelli P.; 1993: *A soil-water-crop model for a large scale*. XV International Congress of the I.C.I.D., The Hague, August 30-September 11, 1993.
- Rodriguez-Iturbe I., Liu J., Castelli F. and Entekhabi D.; 1994: *The spatial signature of coupled soil moisture and atmosphere interaction*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.

### GROUNDWATER

Contributions have been developed with regard to the problem of density-dependent transport of salt in unconfined coastal aquifers. In such a context an unconditional stable numerical method has been proposed that allows to evaluate the effects of works, e.g. cut-off walls, on seawater intrusion phenomena.

For hydrologic application a simple and sufficiently accurate approach is needed which can represent on a continuous basis the successive processes of infiltration, redistribution of soil water in the no-rainfall period, and ponding and infiltration into the resulting very wet profile. Then of great interest are the relatively simple analytical/conceptual models for rainfall infiltration during complex storms that have been presented based on profile extension with shape similarity.

Three-dimensional numerical simulations concern the analysis of the significant land sinking in Ravenna caused by extensive groundwater withdraw as well as gas production from a number

of deep reservoirs.

Numerical analysis of dispersion of passive solutes in two-dimensional heterogeneous porous formations as well as numerical solution of the contaminant transport equation in groundwater have been performed.

#### BIBLIOGRAPHY

- Bellin A., Rinaldo A. and Rubin Y.; 1993: *A conditional probability method for predicting transport of reactive solute in heterogeneous porous media*. 1993 Fall Meeting of the American Geophysical Union, S. Francisco, CA, U.S.A..
- Bellin A., Saladin P. and Rinaldo A.; 1993: *Simulation of dispersion in heterogeneous porous formations: statistics, first-order theories, convergence of computations*. Water Resour. Res., **28**, 2211-2227.
- Bellin A. and Rubin Y.; 1993: *A new approach to simulation of low and transport processes in heterogeneous porous media*. International Conference on Stochastic and Statistical methods in Hydrology and Environmental Engineering, Waterloo, Ontario, Canada, June 21-23, 1993.
- Bellin A. and Rubin Y.; 1993: *A new method for the generation of random fields*. International Conference on Stochastic and Statistical methods in Hydrology and Environmental Engineering, Waterloo, Ontario, Canada, June 21-23, 1993.
- Civita M.; 1993: *Groundwater vulnerability maps: a review*. Proc. IX Symposium Pesticide Chemistry, Piacenza, 12-13 October 1993.
- Corradini C. and Melone F.; 1992: *Representation of infiltration in adaptive rainfall-runoff models*. Nordic Hydrology, **23**, 291-294.
- Galcati G., Gambolati G. and Neuman S. P.; 1992: *Coupled and partially coupled Eulerian-Lagrangian model of freshwater-seawater mixing*. Water Resour. Res., **28**, 149-165.
- Gambolati G., Ricceri G., Bertoni W., Brighenti G. and Vuillermin E.; 1991: *Mathematical simulation of the subsidence of Ravenna*. Water Resour. Res., **27**, 2899-2918.
- Gambolati G.; 1993: *On time integration of groundwater flow equations by spectral methods*. Water Res. Res., **29**, 1257-1267.
- Ghilardi P., Kai Kai A. and Menduni G.; 1993: *Self-similar heterogeneity in granular porous media at the representative elementary volume scale*. Water Resour. Res., **29**, 1205-1214.
- Gottardi G. and Venutelli M.; 1992: *Moving finite element model for one-dimensional infiltration in unsaturated soil*. Water Resour. Res., **28**, 3259-3267.
- Jevremovic D., Siccardi F. and Rossi C.; 1991: *Finger patterns in laboratory tests*. XVI General Assembly EGS, Wiesbaden, 22-26 April 1991.
- Rinaldo A., Marani A. and Rigon R.; 1991: *Geomorphological dispersion*. Water Resour. Res., **27**, 513-525.
- Rossi C.; 1991: *Effective hydraulics conductivity in a numerical scheme for steady state unsaturated flow*. XVI General Assembly EGS, Wiesbaden, 22-26 April 1991.
- Saladin P., Rinaldo A. and Dagan G.; 1991: *A note on transport in stratified formations by flow tilted with respect to the bedding*. Water Resour. Res., **27**, 3009-3017.
- Smith R. E., Corradini C. and Melone F.; 1993: *Modeling infiltration for multistorm runoff events*. Water Resour. Res., **29**, 133-144.

#### REMOTE SENSING AND DATA TRANSMISSION

Due to the relevance of flash flood phenomena and the subsequent demand for the improvement of the commonly available flood forecasting systems, the application of remote sensing techniques for the measurement of precipitation has been a central issue in the recent research activities. A large effort has been devoted to the solution of several specific problems in the field of radar meteorology, such as the correction of the orographic influence and the interpretation of radar imagery through the stochastic modelling of the rainfall field. An even larger effort has been devoted to the study and testing of new algorithms for the rainfall field and cloud characteristics retrieval from space-born passive sensors acting in various bands, such as microwave, visible and infra-red, and on their integrated use, together with ground based information, in real-time flood forecasting systems. Finally, the possibility of using such

remote sensor for short-term rainfall forecasting has been analysed and tested on specific case studies about hazardous convective complexes occurred over the Mediterranean region. Specific algorithms of cloud pattern recognition and tracking have been developed, having as main input the Meteosat imagery in both the infrared and visible bands.

#### BIBLIOGRAPHY

- Bacchi B. and Ranzi R.; 1992: *A comparison of centroid and cross-correlation method for nowcasting of rainfall field measured by radar*. AGU Fall Meeting, S. Francisco, 1992.
- Basile P., Ciotti P., D'Auria G., Marzano F.S., Pierdicca N. and Mugnai A.; 1992: *Cloud microphysical model application to multivariate analysis of satellite microwave radiometric data*. Proc. of Specialist meeting on 'Microwave radiometry and remote sensing application 1992', Boulder (Colorado), June 1992.
- Basile P., Ciotti P., D'Auria G., Marzano F.S., Pierdicca N. and Mugnai A.; 1992: *A simulation study for retrieving rainfall from space-borne microwave radiometers*. Proc. of Specialist meeting on 'Microwave radiometry and remote sensing application, 1992', Boulder (Colorado), June 1992.
- Borga M.; 1992: *Assessment of radar rainfall data in a hill region*. 1992 AWRA Symp. 'Managing Water Resources During Global Change', Reno, 1-5 November 1992.
- Castelli F., Caporali E., Palmisano E., Baldini L. and Giuli, D.; 1993: *Analysis of hydrological and radar measurement data for a critical meteorological event in Tuscany*. XVIII General Assembly of the European Geophysical Society, Wiesbaden, Germany, May 3-7, 1993.
- Castelli F. and Lanza L.; 1994: *Scales of predictability of heavy rainfall events: a case study for the Mediterranean area*. Conv. 'Atmospheric physics and dynamics in the analysis and prognosis of precipitation field', Roma, 15-18 November 1994.
- Conti M. and Lanza L.; 1994: *Rainfall estimation using passive microwave techniques: the hydrological perspective*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.
- Fattorelli S., Borga M. and Da Ros D.; 1993: *Integrated systems for real-time flood forecasting*. Int. Conf. on 'Natural risk and civil protection', Belgirate (NO), 26-26 October 1993.
- Gabriele S., Versace P. and Voci E.; 1991: *Monitoring systems and real-time data analysis*. Water Resour. Management, 5, 233-241.
- La Barbera P., Lanza L. and Siccardi F.; 1993: *Flash flood forecasting based on multisensor information*. IAHS/IAMAP Joint International Meeting, Yokohama, Japan, July 11-23.
- Lanza L., La Barbera P. and Siccardi F.; 1993: *Early warnings and quantitative precipitation forecasting*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Lanza L., Conti M. and Boni G.; 1994: *The role of cloud tracking techniques in the short term prediction of flood hazards at the regional scale*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.
- Levizzani V., Mugnai A., Porcù F., Prodi F., Smith E.A. and Xiang X.; 1992: *Comparison of rainfall estimation using SSM/I and METEOSAT measurements*. IRS'92.
- Marzano F. S., Mugnai A., Smith E. A., Xiang X., Turk J. and Vivekanandan J.; 1994: *Active and passive remote sensing of precipitating storms during caPE. Part II: Intercomparison of precipitation retrievals over land from AMPR Radiometer and CP-2 Radar*. Meteor. and Atmos. Physics, 54, 29-51.
- Mugnai A., Smith E.A. and Xiang X.; 1992: *Passive microwave precipitation retrieval from space: a hybrid statistical-physical algorithm*. Proc. of Specialist meeting on 'Microwave radiometry and remote sensing application, 1992', Boulder (Colorado), June 1992.
- Porcù F., Levizzani V. and Prodi F.; 1992: *Cloud classification based on METEOSAT visible, infrared and water vapour imagery*. IRS'92.
- Rossi G., Ancarani A. and Jakomin A.; 1993: *Design criteria for the improvement of hydrometeorological data acquisition systems. Automation of some networks in Sicily*. International Conference on Hydrology and Water Resources, New Delhi, India, December 20-22, 1993.
- Setvok M. and Levizzani V.; 1993: *The detection of convective storm cloud top structure by NOAA/AVHRR observations*. Proc. 6th AVHRR data USERS' Meeting, Belgirate, 29 June-2 July 1993.
- Siccardi F.; 1993: *A full scale experiment for a non-structural policy for mitigation of the flood effects: the Arno Project*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Smith E.A., Xiang X., Mugnai A. and Tripoli G.J.; 1992: *A Cloud-Radiation model algorithm for spaceborne precipitation retrieval*. TRMM Workshop on Processing and Utilization of the Rainfall Data Measured from Space, Tokyo, 16-19 March 1992.
- Veneziano D. and Villani P.; 1994: *Identification of rain cells from radar and stochastic modeling of space-time rainfall*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.

## SURFACE WATER

The central issue in the Italian research activity in the hydrological field is represented by the forecasting and prevention of hydrological extremes and their control. Many specific topics have been addressed inside this broad area, also related to remote sensing technologies. The ones related to surface water dynamics may be subdivided into three main branches:

- statistical approaches for the evaluation of the hydrological risk, including zoning strategies and regionalizations of the statistical analysis of floods and rainfall extremes;
- development of hydrological flood forecasting models, both on stochastic and on physical basis through the use of the distributed representation of the basin response;
- analysis of specific hydrological physical processes related to the flood formation and propagation, such as rainfall dynamics in hilly regions, infiltration processes in heterogeneous soils, structure of natural river networks.

## BIBLIOGRAPHY

- Bacchi B., Brath A. and Rosso R.; 1993: *A derived approach to extreme flood estimation*. International Conference on Stochastic and Statistical methods in Hydrology and Environmental Engineering, Waterloo, Ontario, Canada, June 21-23, 1993.
- Bacchi B., Brath A. and Kottegoda N. T.; 1992: *Analysis of the relationships between flood peaks and flood volumes based on crossing properties of river flow processes*. Water Resour. Res., **28**, 2773-2782.
- Bacchi B., Becciu G. and Kottegoda N. T.; 1994: *Bivariate exponential applied to intensities and durations of extreme rainfall*. J. of Hydrology, **155**, 225-236.
- Bacchi B. and Borga M.; 1992/1993: *Spatial correlation patterns and rainfall fields analysis*. Excerpta, **7**, 7-40.
- Bacchi B.; 1992: *Stochastic modeling of temporal rainfall and design storm: the Poisson rectangular pulse model revisited*. AGU Fall Meeting, S. Francisco, 1992.
- Bartolini P. and Salas J. D.; 1993: *Modeling of streamflow processes at different time scales*. Water Resour. Res., **29**, 2573-2587.
- Becchi I., Caporali E., Castellani L., Palmisano E. and Castelli F.; 1993: *Hydrological control of flooding: Tuscany, October 1992*. XVIII General Assembly of the European Geophysical Society, Wiesbaden, Germany, May 3-7, 1993.
- Borga M., Capovilla A., Cazorzi F. and Fattorelli S.; 1991: *Development and application of real-time flood forecasting system in the Veneto region of Italy*. Water Resour. Management, **5**, 209-216.
- Borga M. and Di Luzio M.; 1992: *Sensitivity of a semidistributed hydrologic model to rainfall estimation accuracy*. Proc. on 'Flood and flood management', Firenze, 24-26 November 1992.
- Brath A. and Rosso R.; 1993: *Adaptive calibration of a conceptual model for flash flood forecasting*. Water Resour. Res., **29**, 2561-2572.
- Burlando P., Rosso R., Cadavid G. L. and Salas J. D.; 1993: *Forecasting of short-term rainfall using ARMA models*. J. of Hydrology, **144**, 193-211.
- Capodoglio A. G.; 1993: *Modelling and real-time control of urban drainage systems*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10-12, 1993.
- Caroni E.; 1993: *Flood prone area mapping and risk evaluation: related problems*. Europrotech, Udine, 6-8 May 1993.
- Castelli F., Bras R. L. and Emanuel K. A.; 1993: *An analytical approach to the nonlinear dynamics of moist frontogenesis*. J. of Atmos. Sci., **50**, 1504-1518.
- Castelli F. and Corradini C.; 1994: *A semigeostrophic model for the diagnosis of frontal precipitation over complex orography*. Conv. 'Atmospheric physics and dynamic in the analysis and prognosis of precipitation fields', Roma, 15-18 November 1994.
- Castelli F.; 1992/1993: *Rainfall modeling in frontal systems: thermo-fluid-dynamical features*. Excerpta, **7**, 61-98.
- Claps P., Fiorentino M. and Oliveto G.; 1993: *The most probable hydrologic response of fractal river networks*. International Conference on Hydrology and Water Resources, New Delhi, India, December 20-22, 1993.
- Claps P., Rossi F. and Vitale C.; 1993: *Conceptual-stochastic modeling of seasonal runoff using autoregressive moving average models and different scales of aggregation*. Water Resour. Res., **29**, 2545-2559.
- Claps P. and Murrone F.; 1993: *Optimal parameter estimation of conceptually-based streamflow models by time series aggregation*. International Conference on Stochastic and Statistical methods in Hydrology and Environmental Engineering, Waterloo, Ontario, Canada, June 21-23, 1993.
- Claps P. and Murrone F.; 1993: *Univariate conceptual-stochastic models for spring runoff simulation*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10-12, 1993.

- Claps P. and Oliveto G.; 1993: *Fractal structure, entropy and energy dissipation in river networks*. International Conference on Hydrology and Water Resources, New Delhi, India, December 20-22, 1993.
- Copertino V. A., De Bernardinis B., Sciancalepore F. A. and Sole A.; 1993: *Flow resistance for large scale roughness*. International Conference on Hydrology and Water Resources, New Delhi, India, December 20-22, 1993.
- Corradini C., Melone F. and Ubertini L.; 1993: *Geomorphological instantaneous unit hydrograph model and its use in hydrological practice*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10-12, 1993.
- Corradini C., Cardinali M., Guzzetti F., Melone F. and Reichenback P.; 1994: *On the simulation of hydrogeological hazards induced by climate change*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.
- Corradini C., Melone F. and Smith R. E.; 1994: *Modeling infiltration during complex rainfall sequences*. Water Resour. Res., **30**, 2777-2784.
- Corradini C. and Melone F.; 1992: *Representation of infiltration in adaptive rainfall-runoff models*. Nordic Hydrology, **23**, 291-294.
- Corradini C. and Melone F.; 1994: *Modeling of rainfall infiltration in complex storm through modified rectangular profiles*. Proc. IASTED Int. Conf. on 'Modeling and Simulation', Pittsburgh, 2-4 May 1994.
- Corradini C.; 1991: *Evaluation of alternative configurations of basins elements for online flood forecasting*. Water Resour. Bull., **27**, 407-418.
- Di Silvio G.; 1993: *Flood and sediment dynamics in mountain rivers*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Di Silvio G.; 1993: *Influence of bottom aggradation in Alps' rivers on flood. A case study: the Torrent Mallero (Italy)*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Ferrai E., Gabriele S. and Villani P.; 1993: *Combined regional frequency analysis of extreme rainfalls and floods*. IAHS/IAMAP Joint International Meeting, Yokohama, Japan, July 11-23, 1993.
- Ferro V.; 1993: *Rainfall intensity-duration-frequency formula for India. Discussion*. J. of Hydraulic Eng., **119**.
- Filice E., La Barbera P. and Siccardi F.; 1991: *Cluster analysis in identification of cloud patterns*. 10<sup>o</sup> IASTED Int. Conf. 'Modelling, identification and control', Innsbruck, 18-22 February 1991.
- Fiorentino M., Claps P. and Singh V. P.; 1993: *An entropy-based morphological analysis of river basin networks*. Water Resour. Res., **29**, 1215-1224.
- Gabriele S. and Arnell N.; 1991: *A hierarchical approach to regional flood frequency analysis*. Water Resour. Res., **27**, 1281-1289.
- Greco M., La Barbera P. and Roth G.; 1993: *Methodologies for the identification of the drainage structure: Space filling vs. hydrodynamics*. International Conference on Fractals in Hydrosience, Ischia, Italy, October 11-15, 1993.
- Indelicato S. and Vella P.; 1993: *Damage caused by the flood of 12th October 1991 in Sicily (Italy)*. XXV IAHR Congress, Tokyo, 30 August-3 September 1993.
- Kachroo R. K. and Natale. L.; 1992: *Non linear modelling of the rainfall-runoff transformation*. J. of Hydrology, **135**, 341-369.
- Kottegoda N. T. and Natale L.; 1993: *Analysis of low flows in highly developed river basins*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10-12, 1993.
- La Barbera P. and Roth G.; 1993: *An analytical approach for the description of the spatial characteristics of drainage networks*. International Conference on Fractals in Hydrosience, Ischia, Italy, October 11-15, 1993.
- Li L., Cargnelutti M. and Mosca C.; 1991: *Dam-break flood forecasting in Piemonte region, northwest Italy*. Water Resour. Management, **5**, 261-270.
- Marani A., Rigon R. and Rinaldo A.; 1991: *A note on fractal channel networks*. Water Resour. Res., **27**, 3041-3049.
- Pagliara S. and Viti C.; 1993: *Rainfall intensity-duration frequency formula for India. Discussion*. J. of Hydraulic Eng., **119**.
- Palmieri S., Scrocca A. and Siani A.M.; 1992: *Application of an orographic rainfall model to a storm case in southern Alps*. Conv. CIMA 92, Toulouse, 7-11 September 1992.
- Palmieri S., Siani A. M. and D'Agostino A.; 1991: *Climate fluctuations and trends in Italy within the last 100 years*. Annales Geophysicae, **9**, 769-776.
- Palmieri S. and Inghilesi R.; 1991: *Acid rain in Italy: trends and meteorological aspects*. Meteorologische Rundschau, **44**, 149-152.
- Reitano B. and Rossi G.; 1993: *Evaluation and multicriterion ranking of alternative flood mitigation actions*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Reitano B.; 1992: *Expected values of flooding extent and flood damage in alluvial plains*. 6th Int. Symp. on Stochastic Hydraulics, Taipei (Taiwan), 18-20 May 1992.
- Reitano B.; 1993: *Flooding vulnerability analysis at basin-wide scale*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Rinaldo A., Rodriguez-Iturbe I., Dietrich W. E., Rigon R. and Vogel G. K.; 1994: *Climatic signatures on geomorphology: climate change, forms and processes*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.
- Rinaldo A., Rodriguez-Iturbe I., Rigon R., Bras R. L., Ijjasz-Vasquez E. and Marani A.; 1992: *Minimum energy*

- and fractal structures of drainage networks. *Water Resour. Res.*, **28**, 2183-2195.
- Rodriguez-Iturbe I., Rinaldo A., Rigon. R., Bras R. L., Marani A. and Ijjasz-Vasques E.; 1992: *Energy dissipation, runoff production, and the three-dimensional structure of river basins*. *Water Resour. Res.*, **28**, 1095-1103.
- Rossi F. and Villani P.; 1993: *A project for regional analysis of floods in Italy*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Rossi F. and Villani P.; 1993: *Regional methods for flood estimation*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Rossi F. and Villani P.; 1993: *The role of outliers in regional flood frequency analysis*. SPRUCE II: Statistics of Water, Rothamsted Exp. Station September 13-15, 1993.
- Rossi G.; 1993: *Technology for coping with floods in the 21st century*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Rosso R., Bacchi B. and La Barbera P.; 1991: *Fractal relation of mainstream length to catchment area in river networks*. *Water Resour. Res.*, **27**, 381-387.
- Roth G. and Siccardi F.; 1990: *Erosional development of drainage patterns: network sensitivity to hillslope geometry, soil characteristics and rainfall intensity*. XXI Annual Pittsburgh Conf. on 'Modeling and simulation', Pittsburgh, 3-4 May 1990.
- Salas J. D., Ramirez J. A. and Rosso R.; 1993: *Determination of flood characteristics by physically based methods*. NATO A.S.I. Meeting on Coping with Floods, Erice, Italy.
- Sdao F. and Simeone V.; 1993: *Influence of rainfalls on the geomorphological crisis of March April 1973 in Basilicata (Southern Italy)*. International Conference on Hydrology and Water Resources, New Delhi, India, December 20-22, 1993.
- Serra P. C.; 1993: *Regional flood frequency estimation based on linear models*. SPRUCE II: Statistics of Water, Rothamsted Exp. Station, September 13-15, 1993.
- Siani A.M. and Palmieri S.; 1993: *Climate scenarios derived from historical rainfall time series in Italy*. *Boll. Geofisico*, **XVI**, 765-776.
- Sirangelo B. and Braca G.; 1993: *A two-dimensional model for flood invasion over a plain*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10- 12, 1993.
- Smith R. E., Corradini C. and Melone F.; 1993: *Modeling infiltration for multistorm runoff events*. *Water Resour. Res.*, **29**, 133-144.
- Sneyers R., Siani A.M. and Palmieri S.; 1993: *Characterizing trends in climatological time series an application to Brera observatory (Milan) rainfall series*. Int. Conf. on 'Applications of time series analysis in astronomy and meteorology' Padova, 6-10 September 1993.
- Tropeano D.; 1991: *High flow events and sediment transport in small streams in the 'Tertiary Basin' area in Piedmont (Northwest Italy)*. *Earth surface processes and landforms*, **16**, 323-339.
- Versace P. and Sirangelo B.; 1994: *Landslide movements triggered by rainfall*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.
- Villani P.; 1993: *Extreme flood estimation using power extreme value (PEV) distribution*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10-12, 1993.

## WATER QUALITY

Prediction of transport of reactive solutes as well as simulation of dispersion in heterogeneous porous media is strictly related to the analysis of water quality and contributions to the solution of these problems may be found also in the section Groundwater. One of the links with aquifer analysis is represented by the drawing of the vulnerability maps. The effects of control works in rivers, and the definition of a proper value of the minimum discharge for the preservation of the aquatic species are also examined in some of the following papers.

## BIBLIOGRAPHY

- Bellin A., Rinaldo A. and Rubin Y.; 1993: *A conditional probability method for predicting transport of reactive solute in heterogeneous porous media*. 1993 Fall Meeting of the American Geophysical Union, S. Francisco, CA, U.S.A.
- Bellin A., Saladin P. and Rinaldo A.; 1993: *Simulation of dispersion in heterogeneous porous formations: statistics, first-order theories, convergence of computations*. *Water Resour. Res.*, **28**, 2211-2227.

- Bellin A. and Rubin Y.; 1993: *A new approach to simulation of flow and transport processes in heterogeneous porous media*. International Conference on Stochastic and Statistical methods in Hydrology and Environmental Engineering, Waterloo, Ontario, Canada, June 21-23, 1993.
- Cioffi F., Di Eugenio A. and Gallerano F.; 1994: *Design and management of hyperintensive aquaculture tanks*. First Symposium on Habitat Hydraulics, Trondheim, Norway, August 18-20, 1994.
- Civita M.; 1993: *Groundwater vulnerability maps: a review*. Proc. IX Symposium Pesticide Chemistry, Piacenza, 12-13 October 1993.
- Comola G., Dalla Villa S. and Adami A.; 1994: *Removal of nutrients from the water of the river Po by means of a phytobiodepuration system in a high-water bed area at Castelnovo Bariano*. First Symposium on Habitat Hydraulics, Trondheim, Norway, August 18-20, 1994.
- Copertino V. A., Molino B., Telesca V. and Singh V. P.; 1993: *Development of a sediment and chemical transport model for agricultural watersheds*. International Conference on Hydrology and Water Resources, New Delhi, India, December 20-22, 1993.
- Galeati G., Gambolati G. and Neuman S. P.; 1992: *Coupled and partially coupled Eulerian-Lagrangian model of freshwater-seawater mixing*. Water Resour. Res., **28**, 149-165.
- Rinaldo A., Marani A. and Rigon R.; 1991: *Geomorphological dispersion*. Water Resour. Res., **27**, 513-525.
- Saccardo I., Vitali R., Guzzi L., Annoni P. and Stigliano P.; 1994: *First application of methodologies to define a proper minimum discharge for the preservation of aquatic species in Italian pre-Alps*. First Symposium on Habitat Hydraulics, Trondheim, Norway, August 18-20, 1994.
- Saladin P., Rinaldo A. and Dagan G.; 1991: *A note on transport in stratified formations by flow tilted with respect to the bedding*. Water Resour. Res., **27**, 3009-3017.
- Santoro M. and Nasello C.; 1994: *Environmental effects of river control works in Sicily*. First Symposium on Habitat Hydraulics, Trondheim, Norway, August 18-20, 1994.
- Zavatti A.; 1994: *Aquifer pollution vulnerability maps in the Po River plain (Northern Italy)*. Proc. Int. Symp. on 'Assessing and managing health risks from drinking water contamination: approaches and applications', IAHS, Rome, September 13-17, 1994.

## WATER RESOURCES SYSTEMS

The Mediterranean climate is characterized by frequent and prolonged droughts. Several studies have addressed this issue, both in terms of identification of the regional characteristics of the drought phenomena and in the formulation and planning of optimal water resources management. Along these lines, particular attention has been devoted to the reservoir management policy and the implementation of reliable hydrological models for the water resources mapping and monitoring.

## BIBLIOGRAPHY

- Barbagallo S., Rossi G. and Tamburino V.; 1992: *Emergency measures in water supply systems for alleviating the effects of the 1987-90 drought in Sicily*. XVI European Regional Conf. ICID, Budapest, 21-27 June 1992.
- Becchi I., Caporali E. and Petrucci A.; 1993: *A physically based distributed hydrological model as an application of Geographical Information Systems*. XVIII General Assembly of the European Geophysical Society, Wiesbaden, Germany, May 3-7, 1993.
- Casadei S., Mannocchi F. and Mecarelli P.; 1993: *Operational hydrology and reservoir management in the upper Tiber river basin*. IAHS/IAMAP Joint International Meeting, Yokohama, Japan, July 11-23, 1993.
- Cascini E. and Cascini L.; 1993: *Spring flow analysis for water resources utilization*. SPRUCE II: Statistics of Water, Rothamsted Exp. Station, September 13-15, 1993.
- Cioffi F., Di Eugenio A. and Gallerano F.; 1994: *Design and management of hyperintensive aquaculture tanks*. First Symposium on Habitat Hydraulics, Trondheim, Norway, August 18-20, 1994.
- Fiorentino M. and Singh V. P.; 1993: *Entropy applications in water resources and geomorphology: a review*. International Conference on Stochastic and Statistical methods in Hydrology and Environmental Engineering, Waterloo, Ontario, Canada, June 21-23, 1993.
- Manciola P., Casadei S., Fnea S. C. and Gosain A. K.; 1993: *Relationships between Trasimeno lake watershed and hydrologic characteristics*. IASTED International Conference on Modelling and Simulation, Pittsburgh, PA, U.S.A., May 10-12, 1993.



- Nardini A., Piccardi C. and Soncini-Sessa R.; 1992: *On the integration of risk aversion and average-performance optimization in reservoir control*. Water Resour. Res., **28**, 487-497.
- Piccardi C.; 1991: *Stochastic dynamic programming for reservoir optimal control: dense discretization and inflow correlation assumption made possible by parallel computing*. Water Resour. Res., **27**, 729-741.
- Rossi G., Benedini M., Tsakinis G. and Giakoumakis S.; 1992: *On regional droughts estimation and analysis*. Water Resour. Management., **6**, 249-277.
- Rossi G.; 1994: *Drought watch activities and water resources information systems*. Workshop on Climate Change and Hydrogeological Hazards in the Mediterranean Area, Perugia, Italy, June 27-28, 1994.
- Santoro M. and Nasello C.; 1994: *Environmental effects of river control works in Sicily*. First Symposium on Habitat Hydraulics, Trondheim, Norway, August 18-20, 1994.

