ISOTOPES IN THE WATER CYCLE: PAST, PRESENT AND FUTURE OF A DEVELOPING SCIENCE
Isotopes in the Water Cycle
Past, Present and Future of a Developing Science

Edited by

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PREFACE

Improved understanding of the Earth’s water cycle is a key element of global efforts to develop policies and practices for the sustainable management of water resources. Isotope and nuclear techniques have provided unmatched insights into the processes governing the water cycle and its variability under past and present climates. The International Atomic Energy Agency (IAEA) convened the first symposium on isotope hydrology in 1963. As isotope hydrology developed as an independent discipline, the IAEA symposia, convened every four years, provided a vehicle to review the state of the science and discuss future developments. Proceedings of these symposia contain classical papers that still form the basis of a number of applications in hydrology and inspire current research.

On the occasion of the 40th anniversary of the first IAEA symposium on isotope hydrology convened in 1963, it was decided to publish a monograph with an historical perspective and new developments in isotope techniques and their applications in hydrology. The various contributions represent reviews of the given subjects, and they contain comprehensive lists of references for further studies by interested readers.

The monograph begins with a history of isotopes in hydrology, in particular the stable oxygen and hydrogen isotopes, and of the role of the Isotope Hydrology Section of the IAEA in promoting this science. The first part of the monograph presents specific isotope and nuclear techniques that found wide applications in hydrology and related fields, complemented conventional hydrologic techniques, and, in some cases, became indispensable in special disciplines such as palaeohydrology and palaeoclimatology. First, historical developments and achievements in the use of artificial tracers for determining hydrologic parameters are reviewed (Moser and Rauert). In the 1960s, this technique was at the forefront of nuclear hydrology, but it has now largely been abandoned because the related health and safety concerns outweigh the advantages. A review of the use of cosmogenic isotopes in hydrology is presented by Lal, together with a detailed discussion of opportunities arising from the application of silicon isotopes. These are followed by applications of rare gases (Loosli), uranium and thorium series radionuclides (Kaufman), nitrogen and sulphur isotopes (Mayer), tritium (Michel) and stable oxygen and hydrogen isotopes (Gourcy, Groening and Aggarwal). Kerstel and Meijer present a detailed discussion of the latest developments in isotope analysis by optical techniques.

The second part of the monograph provides a number of contributions on applications of isotopes to investigate hydrological systems and processes under past and present climatic conditions. Applications for understanding the origin and movement of atmospheric moisture are discussed by Rozanski. Froehlich, Gonfiantini and Rozanski discuss the use of isotopes for understanding lake dynamics and water balance. Vitvar, Aggarwal and McDonnell present developments in the application of isotopes for investigating and modelling rainfall–runoff processes, both in small and large catchments. These are followed by discussions of isotope applications in groundwater (Edmunds), continental ice sheets (Thompson and Davis), geothermal systems (Kharaka and Mariner), saline waters (Horita), palaeolimnology (Gasse), and groundwater archives of palaeoclimate
(Edmunds). Developments in dating of groundwater are presented by Plummer (young waters) and Geyh (old groundwater). The historical evolution of the classical concepts of stable isotope hydrology, such as Rayleigh distillation and the global meteoric water line of Craig, is described by Gat. Finally, a contribution by Hoffman and others provides an analysis of stable isotopes in precipitation with the help of a global circulation model.

The Appendix includes a list of seminal papers in isotope hydrology and references to landmark developments in this field at the IAEA. The list of technical contributions presented at the first IAEA symposium in 1963 is also included.

Some topics notably are not discussed in detail in this monograph as they have been covered in recent reviews. These topics include stable carbon isotopes, biosphere-hydrosphere interactions, paleoclimate studies based on isotopes in plants and tree-rings, oceanic systems, and Arctic and Antarctic ice sheets.

We hope that this monograph will provide the detailed knowledge on isotope hydrology that is required by graduate students and specialists and that it will further strengthen the integration of isotope hydrology in science and applications related to the hydrologic cycle, climate and environment.

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