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The Global Network of Isotopes in Precipitation after 55 years: assessing past, present and future developments

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The Global Network of Isotopes in Precipitation (GNIP) is a global observation programme operated by the International Atomic Energy Agency (IAEA), in cooperation with the World Meteorological Organization (WMO) and more than 100 contributing institutions worldwide. GNIP has been the primary repository for baseline stable (δ^{18}O, δ^{2}H) and radioactive (^{3}H) isotope data since its foundation in 1960. The impetus for GNIP was the monitoring of radioactive fallout from atmospheric thermonuclear testing and resulting tritium levels of precipitation, but tritium together with stable isotopes was recognized as a key to understanding hydrological processes. Later, new applications were developed focusing on hydrometeorology and paleoclimatic research. Increasingly, GNIP data are being used more widely in ecological and forensic investigations, e.g. for tracking of migratory animals.

The GNIP database comprises more than 135,000 isotopic records (δ^{18}O: 63,000; δ^{2}H: 55,000; ^{3}H: 63,000) of monthly composite precipitation samples from more than 1,000 stations worldwide. About 300 stations are currently active for stable isotopes and ca. 100 for tritium. Data for most of the active stations is available up to 2013. Several national isotopic observation networks (e.g. in Austria, Australia, China or the United States of America) exist besides GNIP, complementing precipitation isotope data at national levels.

The spatially and temporally discrete nature of the GNIP dataset induces coverage gaps. Recently, highly-resolved gridded datasets were established to help overcome this deficiency through geostatistical prediction models. These ‘isoscape’ (isotopic landscapes) are based on combinations of multiple regression and interpolation methods, with a range of parameterization available at regional and global levels. Attempts to bridge the gap between ‘one-size-fits-all’ global parameterization and improved predictions at regional and local levels led to the establishment of a regionalized cluster-based water isotope prediction model (RCWIP) which uses fuzzy clustering to delineate regions of climatic similarity, and to determine regionalized regression models for each climatic cluster in order to lower prediction uncertainty of isotope values.

Here, we present new data and figures on the spatial and temporal evolution of the GNIP network, including station spatial density and coverage analysis. Moreover, we assess outstanding deficits in the spatial coverage of the GNIP network by applying the clustering structure of the RCWIP approach to identify those regions which would benefit most from an improved GNIP sampling. Finally, we present an updated global meteoric water (GMWL) line based on different calculation methods (ordinary least squares method, weighted least squares, or based on weighted means).