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Observation and modelling of stable isotopes in precipitation for midlatitude weather systems in Melbourne, Australia

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The application of stable water isotopes as tracers of moisture throughout the hydrological cycle is often hindered by the relatively coarse temporal and spatial resolution of observational data. Intensive observation periods (IOPs) of isotopes in precipitation have been valuable in this regard enabling the quantification of the effects of vapour recycling, convection, cloud top height and droplet reevaporation (Dansgaard, 1953; Miyake et al., 1968; Gedzelman and Lawrence, 1982; 1990; Pionke and DeWalle, 1992; Risi et al., 2008; 2009) and have been used as a basis to develop isotope models of varying complexity (Lee and Fung, 2008; Bony et al., 2008).

This study took a unified approach combining observation and modelling of stable isotopes in precipitation in an investigation of three key circulation types that typically bring rainfall to southeastern Australia. The observational component of this study involved the establishment of the Melbourne University Network of Isotopes in Precipitation (MUNIP). MUNIP was devised to sample rainwater simultaneously at a number of collection sites across greater Melbourne to record the spatial and temporal isotopic variability of precipitation during the passage of particular events. Samples were collected at half-hourly intervals for three specific rain events referred to as (1) mixed-frontal, (2) convective, and (3) stratiform. It was found that the isotopic content for each event varied over both high and low frequencies due to influences from local changes in rain intensity and large scale rainout respectively. Of particular note was a positive relationship between deuterium excess and rainfall amount under convective conditions. This association was less well defined for stratiform rainfall.

As a supplement to the data coverage of the observations, the events were simulated using a version of NCAR CAM3 running with an isotope hydrology scheme. This was done by periodically nudging the model dynamics with data from the NCEP Reanalysis (Noone, 2006). Results from the simulations showed that the model represented well the large scale evolution of vapour profiles of deuterium excess and ^{18}O for the mixed-frontal and stratiform events. Reconstruction of air mass trajectories provided further detail of the evolution and structure of the vapour profiles revealing a convergence of air masses from different source regions for the mixed-frontal event.

By combining observations and modelling in this way, much detail of the structure and isotope moisture history of the observed events was provided that would be unavailable from the sampling of precipitation alone.

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