



STABLE ISOTOPE CHARACTERIZATION OF PAN-DERIVED AND DIRECTLY SAMPLED ATMOSPHERIC WATER VAPOUR

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Isotopic characterization of atmospheric water vapour, δ_A , and its temporal variability are important prerequisites for quantifying water balance of surface reservoirs and partitioning of evaporation and transpiration fluxes using isotope techniques. Here we present results from a detailed comparison of several methods for determining δ_A in field situations, (i) by back-calculation from isotopic and micrometeorological monitoring of a steady-state terminal reservoir (standard Class-A evaporation pan) using boundary-layer mass transfer models [1], (ii) through direct (cryogenic) sampling of ambient atmospheric moisture, and (iii) using the precipitation-equilibrium approximation (i.e., $\delta_A = \delta_p - \varepsilon^*$). The three methods provide differing, but complementary temporal views: Class-A pans can be operated to provide time-averaged information suitable for monitoring of the water balance of a small lake over time periods of days to weeks, for example, whereas direct sampled profiles of atmospheric moisture can be used to develop snapshots of transient isotopic gradients in the boundary layer over lakes or land surfaces at time-scales of minutes to hours. Precipitation equilibrium provides an additional independent method for characterizing atmospheric moisture, though necessarily limited to periods of actual rainfall. As shown below (Fig. 1) data from an experiment run at the University of Waterloo in summer 2000 reveals remarkably consistent agreement between daily pan-derived estimates of δ_A and equivalent "equilibrium" vapour, demonstrating the utility of pan monitoring to span the intervals between precipitation events.

Also evident from the time-series in Fig. 1 is a step-shift in meteorological conditions, with days 145-160 characterized on average by somewhat drier and cooler conditions than the remaining part of the record (days 161-195). This synoptic shift is clearly reflected by a reduction in evaporation rate (not shown), as well as in the respective rates of heavy-isotope enrichment in the pan water and in the pan-derived atmospheric $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values.

Consideration of these isotopic data in $\delta^{18}\text{O}$ - $\delta^2\text{H}$ space (Fig. 2) reveals additional distinction between the two periods. Thus, the day 145-160 period is characterized by a shallower evaporative-enrichment slope than day 161-195 (4.5 versus 5.1), and by more isotopically depleted atmospheric vapour (-21.2‰ versus -16.0‰ and -155‰ versus -123‰ for $\delta^{18}\text{O}$ and $\delta^2\text{H}$, respectively) having a substantially higher *d*-excess (14.3 versus 4.8‰). The differences in $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values, which are larger than expected for typical temperature-related effects, and the large shift in *d*-excess are clear isotopic expressions of the differing synoptic conditions over the two time periods.

We have also made preliminary efforts to incorporate direct sampling of atmospheric moisture in company with evaporation pans at field sites. Initial experiments using cryogenic trapping at a nearby site successfully captured the strongly differing isotopic labelling of atmospheric vapour revealed by the other two methods (see Fig. 2), though with systematic offsets, perhaps related to mixing of locally generated vapour or to isotopic fractionation of the water vapour during collection, similar to isotopic effects predicted during snow formation [2]. On-going experiments will also evaluate non-cryogenic methods of vapour recovery for planned flux-gradient partitioning studies.

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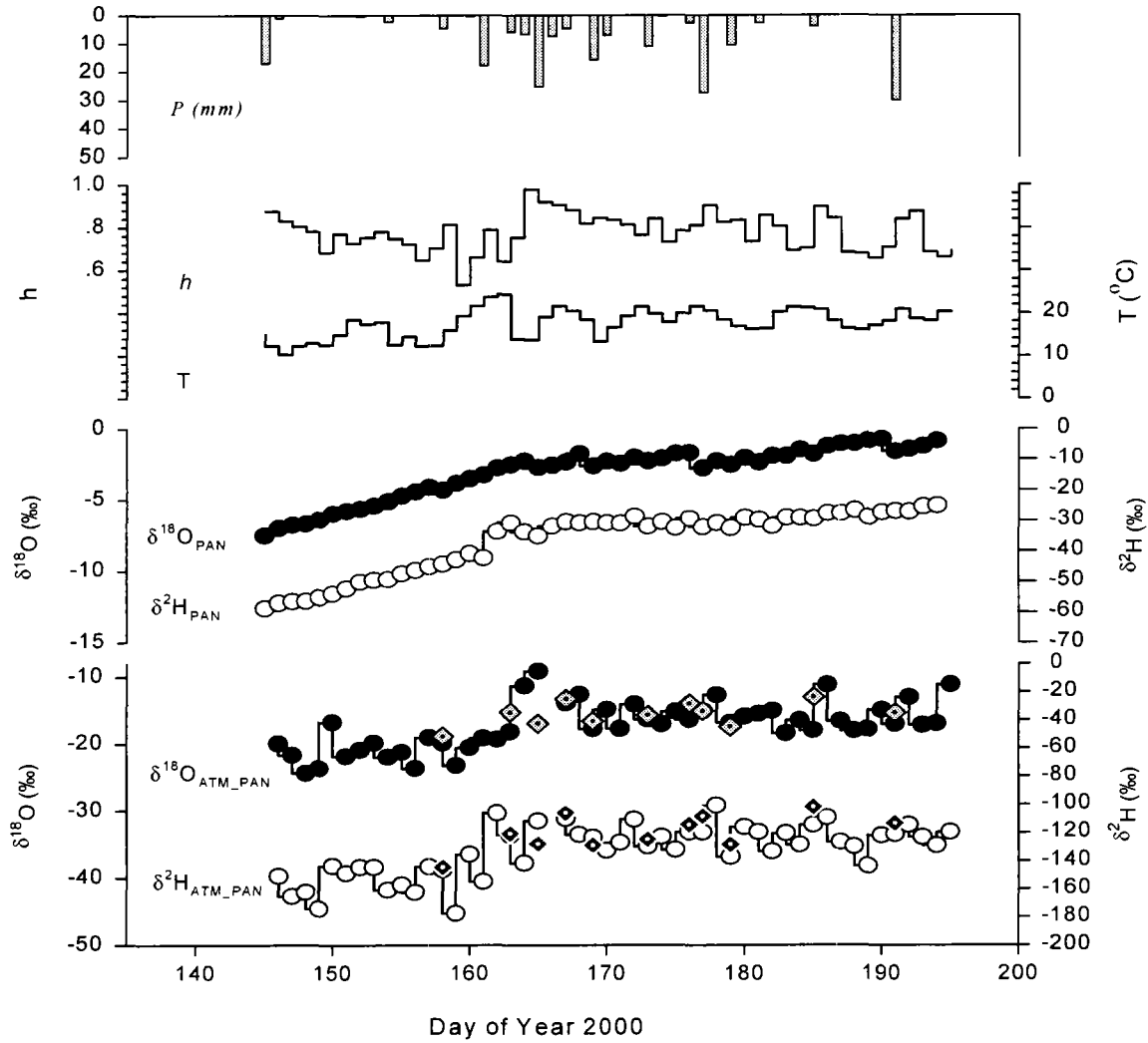


FIG. 1. Daily time-series of precipitation (P), relative humidity (h), temperature (T), $\delta^{18}\text{O}$ and $\delta^2\text{H}$ of pan water, and pan-derived $\delta^{18}\text{O}$ and $\delta^2\text{H}$ of atmospheric vapour during Day 145 to 195 (25 May-14 July) 2000, at the University of Waterloo weather station. The diamonds are $\delta^{18}\text{O}$ and $\delta^2\text{H}$ values for atmospheric vapour in equilibrium with individual precipitation events, revealing good agreement with daily pan-derived estimates.

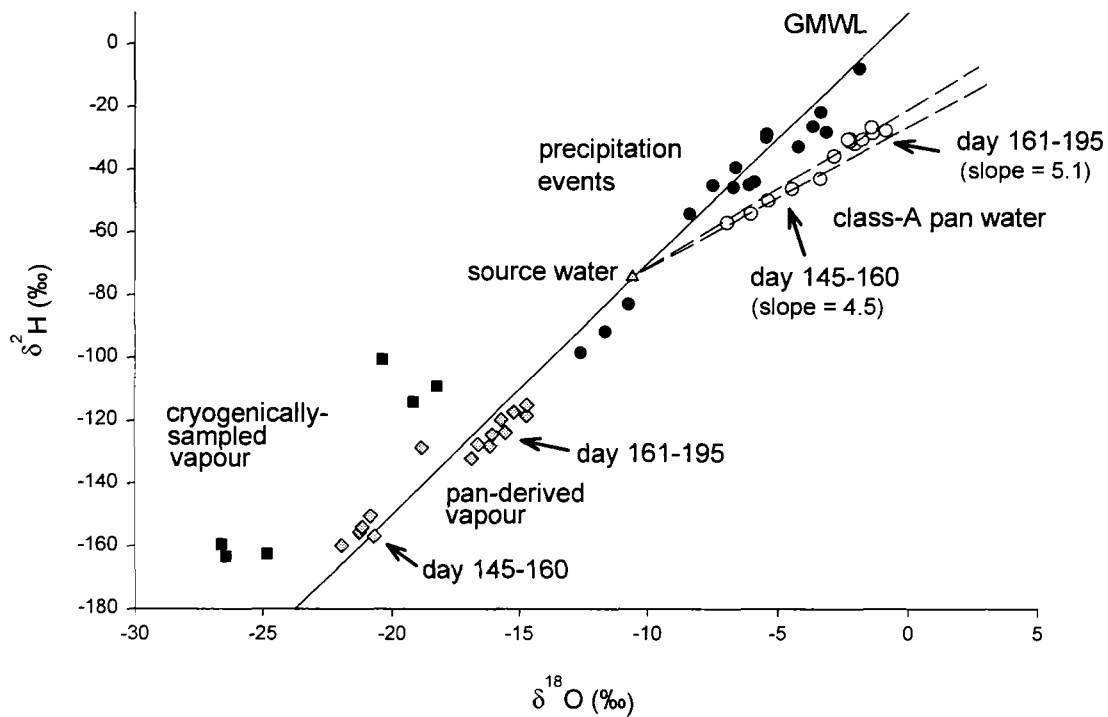


FIG. 2. $\delta^{18}\text{O}$ - $\delta^2\text{H}$ crossplot showing measured and derived isotopic data. For plotting purposes the pan water and pan-derived atmospheric moisture data are expressed as three-day averages, whereas other data points represent individual samples. The Global Meteoric Water Line ($\delta^2\text{H} = 8\delta^{18}\text{O} + 10$) is shown for reference.

REFERENCES

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