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Temporal Variations of d-excess in Water Vapor above a Subtropical Conifer Plantation in Southeastern China

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Objectives

The intercept parameter of the Global Meteoric Water Line (GMWL), d (= δD – 8 × δ^{18}O), termed deuterium excess, is a combination of the oxygen (δ^{18}O) and hydrogen (δD) isotope ratios and its variability is an indicator of environmental conditions during phase changes under non-equilibrium conditions. Direct measurement of d-excess in the vapor phase may offer constraints on how to separate local evaporative contribution to the atmospheric water vapor and to partition evapotranspiration flux into its component fluxes. The goals of this paper are to quantify the temporal variations of d-excess in water vapor and to identify the main drivers of its variability above a subtropical conifer plantation in southeastern China. Continuous measurements were made on the δD and δ^{18}O of atmospheric vapor and evapotranspiration using an off-axis integrated cavity output spectroscopy analyzer (model DLT-100, Los Gatos Research, Mountain View, CA).

Experimental

A. Site description

The measurement was made at Qianyanzhou (26°44'29"N, 115°03'29"E, elevation 102 m), a ChinaFlux site, in Southeast China. This plantation, planted in 1985, and the mean canopy height was about 13 m. The experiment started on July 1 in 2011 and has continued to date. The data presented here were restricted to 2011.

B. Analyzers, sampling and calibration systems

The Los Gatos analyzer (model DLT-100, Los Gatos Research, Mountain View, CA, USA) was configured with two three-way solenoid valves, with one common port, two air sample intakes and one calibration gas intake. The measurement was calibrated with a vapor standard and was used to determine the vapor and flux isotope ratios.

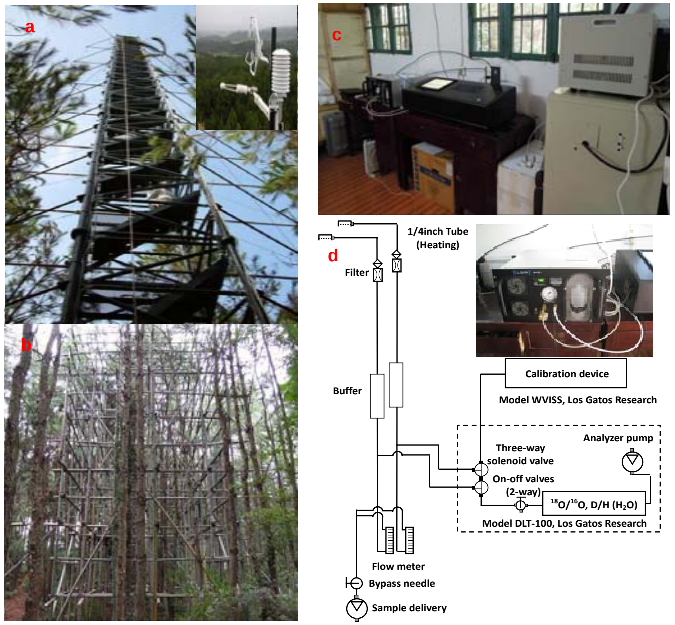

Figure 1: Eddy covariance and vapor gradient measurement tower (a), bamboo access tower for leaf and xylem sampling (b), instrument setup (c), and design diagram (d).

A commercial vapor source (model WVISS, Los Gatos Research, Mountain View, CA) generated a standard vapor stream with distilled water of known isotope ratios (–101.7‰ for δD and –13.55‰ for δ^{18}O). It produced five mixing ratios in the range of 5,000~30,000ppmv. The measurement was calibrated in a 3-h switching cycle using a two-point concentration interpolation procedure with the calibration water vapor mixing ratios bracketing the ambient water vapor mixing ratio. During the experiment, δ_v was measured at the heights of 17 m and 27 m above the ground. The D/H and ^{18}O/^{16}O molar ratios of the whole ecosystem water vapor flux (δ_{ET}) were determined with the flux-gradient approach. The molar flux ratios were converted to the delta notation in reference to the VSMOW standard. `

Results

A. Seasonal variation of d-excess of water vapor and evapotranspiration

- The measured δD and δ^{18}O of water vapor and evapotranspiration were highly correlated. The d-excess of evapotranspiration deviated from the GMWL standard value of 10‰ more than that of atmospheric water vapor.
- The d-excess of water vapor and evapotranspiration was correlated with humidity.
- There was considerably variability in the d-excess of water vapor and evapotranspiration. The variations of d-excess in precipitation were lower than those of the vapor values.

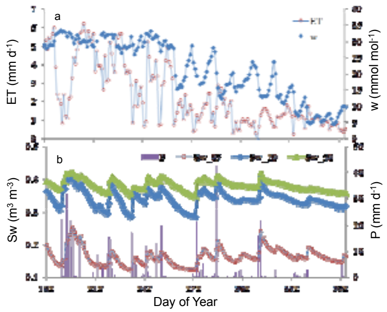

Figure 2: Time series of daily evapotranspiation and water vapor mixing ratio (a), and soil water content and precipitation (b)

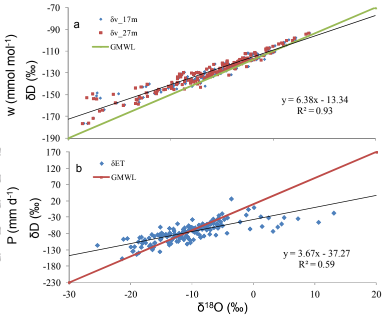

Figure 3: Relationship between the measured δD and δ^{18}O of ambient water vapor (a), and evapotranspiration (b). For comparison, also shown is the standard GMWL.

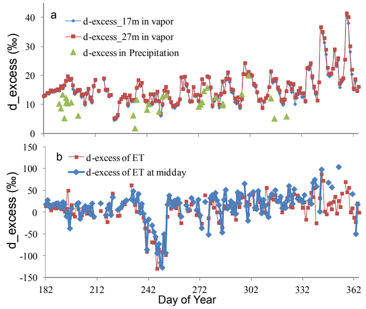

Figure 4: Time series of daily d-excess of water vapor and precipitation (a), and daily and midday d-excess of evapotranspiration (b)

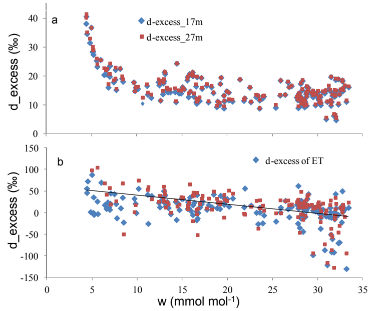

Figure 5: Dependence of daily d-excess of water vapor (a), and daily and midday d-excess of evapotranspiration (b) on water vapor mixing ratio

B. Diurnal variation of d-excess of water vapor and evapotranspiration

- The d-excess in water vapor showed a robust diurnal cycle with maximum values during mid-day and minimum values in the early morning. The d-excess of evapotranspiration showed also strong diurnal variations with a similar time phase.
- The most likely mechanism underlying the diurnal patterns is different non-steady state behaviors of δ^{18}O and δD of plant transpiration. Diurnal variations in the d-excess of atmospheric vapor have been reported by other research groups, and our study shows that one driver for these diurnal patterns is linked to water vapor originated from surface evapotranspiration.

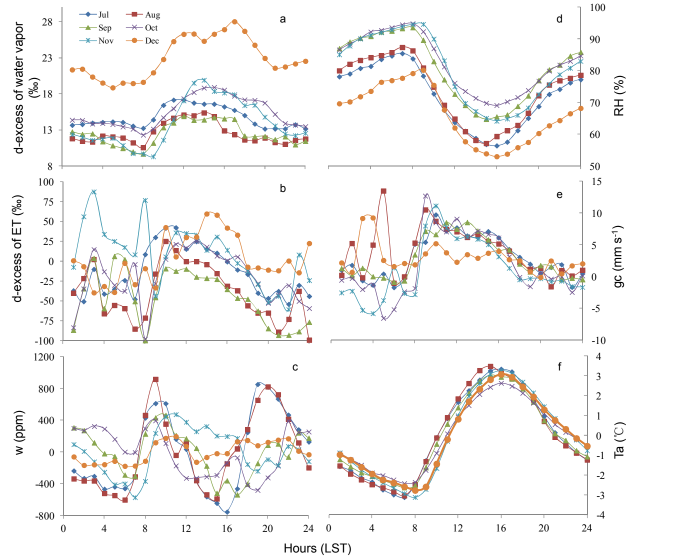

Figure 6: Monthly mean diurnal cycles of the (a) d-excess of water vapor, (b) d-excess of evapotranspiration, (c) water vapor mixing ratio, (d) relative humidity, (e) canopy conductance, and (f) air temperature from July to December in 2011. For convenience of comparison, the mean value of each month of water vapor mixing ratio and air temperature was removed from the ensemble average value.

References

Wen, X.F., X.M. Sun, S.C. Zhang, G.R. Yu, S.D. Sargent, and X. Lee. 2008: Continuous measurement of water vapor D/H and ^{18}O/^{16}O isotope ratios in the atmosphere. Journal of Hydrology, 349, 489–500.

Wen, X.F., S.C. Zhang, X.M. Sun, G.R. Yu, and X. Lee. 2010: Water vapor and precipitation isotope ratios under the influence of the Asian monsoon climate. Journal of Geophysical Research-Atmospheres, 115, D01103, doi:10.1029/2009JD012408

Wen, X.F., X. Lee, X.M. Sun, J.L. Wang, S.G. Li, and G.R. Yu. 2010: Inter-comparison of four commercial analyzers for water v apor isotope measurement. . Journal of Atmospheric and Oceanic Technology, 29, 235-247.

Zhang, S.C., X.M. Sun, J.L.Wang, G.R. Yu, and X.F. Wen. 2011. Short-term variations of vapor isotope ratios reveal the influe nce of atmospheric processes. Journal of Geographical Sciences, 21,401-416

Xiao, W., X. Lee, X.F. Wen, X.M. Sun, and S.C. Zhang. 2012. Modeling biophysical controls on canopy foliage water ^{18}O enrich ment in wheat and corn. Global Change Biology, 18, 1769–1780 .

Wen, X.F. , X. Lee, X.M. Sun, J.L. Wang, Z.M. Hu, S.G. Li, and G.R. Yu. 2012: Dew water isotopic ratios and their relations to e cosystem water pools and fluxes in a cropland and a grassland in China. Oecologia. 168, 549-561

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