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Borehole equilibration: testing a new method to monitor the isotopic composition of tree xylem water in situ

John Marshall¹, Matthias Cuntz², Matthias Beyer^{3,4}, Maren Dubbert^{5,6}, and Kathrin Kuehnhammer^{3,5}

¹Swedish University of Agricultural Sciences, Forest Ecology and Management, Umeå, Sweden (john.marshall@slu.se)

²Université de Lorraine, INRA, AgroParisTech, UMR Silva, 54000 Nancy, France, France

³Technische Universität Braunschweig, Germany

⁴Federal Institute For Geosciences and Natural Resources, Germany

⁵Ecosystem Physiology, University Freiburg, GeorgesKöhler-Allee 53, 79110, Germany

⁶IGB Berlin, Landscape Ecohydrology, Müggelseedamm 301, 12587, Germany

Forest water use has been difficult to quantify. One promising approach is to measure the isotopic composition of plant water, e.g. the transpired water vapor or xylem water, which often differs from that of other water vapor sources. Traditionally such measurements have relied on the extraction of wood samples, which provide limited time resolution at great expense, and risk possible artefacts. Utilizing a borehole drilled through a trees' stem, we propose a new method based on the notion that water vapor in a slow-moving airstream approaches equilibration with the much greater mass of liquid water in the xylem. We present two empirical data sets showing that the method can work in practice. We then present theoretical models estimating the equilibration times and exploring the limits at which the approach will fail. Given long enough boreholes and slow enough flows, the method provides a simple, cheap, and accurate means of continuously estimating the isotopic composition of the source water for transpiration.