論 文 の 内 容 の 要 旨

論文題目　Study on Atmospheric and Terrestrial Water Circulation Processes Using Stable Water Isotopes
（水の安定同位体比情報を利用した大気と陸面の水循環過程の解明に関する研究）

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We observed stable isotopes in precipitation and atmospheric water vapor over a humid subtropical rice paddy field in Tsukuba, Japan, from June 2013 to May 2014. We used observed isotope ratios, in combination with an isotope-enabled general circulation model (GCM; Isotopes-incorporated Global Spectral Model: IsoGSM) to improve our understanding of the impacts of moisture sources and transport on the variability of water vapor isotopes. The isotopic measurements of water vapor and precipitation suggested that vapor isotopes in the study area were controlled by not only air-rain isotopic exchange, but also other kinetic effects associated with land evapotranspiration and large scale atmospheric circulation at the seasonal time scale. The contribution of land evapotranspiration to local water vapor content (F_{ET}) was approximately 16.0±12.3% as an annual average, with a summer maximum of 20.5±12.9%. Our results show that large-scale atmospheric circulation is the primary control on the variability of near surface water vapor isotope. An IsoGSM tagging simulation experiment demonstrated that the large temporal variation of surface water vapor isotopes can primarily be attributed to advection and mixing of moisture from different oceanic source regions.

By using high-frequency isotope measurements and continuous surface water measurements, we investigated the isotope ratios in soil-vegetation-atmosphere transfer and the physical mechanisms involved over a paddy field for a full growing season. The isotopic signals (δ) of evapotranspiration (*ET*) transpiration (*T*) and evaporation (*E*) were determined by the Keeling plot method, surface water isotopic measurements, and the Craig-Gordon model, respectively. The fraction of transpiration in evapotranspiration (*T/ET*) ranged from 0.2 to 1, with an almost continuous increase in the early growing season and a relatively constant value close to 1 later in the year. The result was supported by *T/ET* derived from simulated *T* and eddy correlation measured *ET*. The seasonal change in the transpiration fraction could be described quite well as a function of the leaf area index (LAI) (T/ET=0.67LAI$^{0.25}$, R^2 = 0.80), implying that transpiration plays a dominant role in the soil-vegetation-atmosphere continuum during the growing season. The two end-member uncertainty analysis suggested that further improvement in the estimation of δ_T and δ_{ET} is necessary for partitioning evapotranspiration using the isotopic method. In the estimation of δ_{ET}, the assumptions underlying Keeling plot method were rarely met and the uncertainty was quite large. A high frequency of precise isotopic measurements in surface water was also necessary for δ_T estimation. Furthermore, special care must be taken concerning the kinetic fractionation parameter in the Craig and Gordon Equation for δ_E estimation under low-LAI conditions. The results demonstrated the robustness of using isotope measurements for partitioning evapotranspiration.

Recently isotopic method provides an unprecedented opportunity for *ET* partitioning across a variety of spatial and temporal scale which is unattainable by conventional technique. However, most of isotope-based studies show that *T* generally contributes more than 70% to the *ET*, while non-isotopic measurement generally leads to considerably smaller transpiration fractions. As a summary, quantitatively understanding of *ET* partitioning is somewhat arbitrary and remains the necessary of a theoretical and technical change, in both in-situ measurement and global scale. Considering the above tasks and background, we developed an *ET* partitioning algorithm, combining *ET* estimated by remote sensing, land surface models and LAI regression documented by 56 previous studies. The algorithm was used to access spatial patterns and global average *T/ET*. Our global mean transpiration ratio (50%) is smaller than the literature complication studies [Wang et al., 2014; Schlesinger and Jasechko, 2014] but in good agreement with the value reported in GCM models (47%). On the other hand, it was significantly smaller than that reported in isotopic approaches [e.g., Jasechko et al., 2013; Good et al., 2015a]. Although further validation is required, our measured provided a new inspiration for partitioning global evapotranspiration and suggested vegetation plays a major role in driving the contribution of *T/ET*. Moreover, a further study about canopy interception is also required because canopy interception loss at various regions of the globe was few reported in the literature.