First experimental evaluation and improvement of the Craig-Gordon model for isotopic evaporation in field conditions over Lake Taihu

开放水面蒸发同位素富集经典模型 Craig-Gordon 模型在太湖的直接检验与发展

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Stable isotope can provide unique constraints for ecological, meteorological and hydrological research, and the theory of isotopic fractionation in evaporation process is the fundament of stable isotopic research. The first mathematic equations calculating the isotopic evaporation of open water body was derived by Craig and Gordon (1965) and were widely used. There are two kinds of uncertainties in the model: firstly, it is always assumed that the water was well mixed without isotopic gradient at the water surface when scientists applied the model; secondly, the parameterization of kinetic fractionation factor was derived from laboratory experiments, which should be different to natural condition. But the model was never evaluated based on the measurement over open water body under field condition due to the limitation of observation technology. We will conduct in-situ and continuous measurement with high temporal resolution (hourly) on the isotopic concentration of evaporative water vapor over Lake Taihu based on the Off-Axis Integrated Cavity Output Spectroscopy, and calculate isotopic evaporation on longer temporal resolution (monthly to yearly) based on the isotopic mass balance equations. Craig-Gordon model will be evaluated and improved according to the measurement and calculation results. Using the improved Criag-Gordon model, we will calculate the water budget of Lake Taihu, trace the water vapor source of precipitation over Lake Taihu catchment, and redo the partition of global terrestrial evapotranspiration. The results can improve the development of Craig-Gordon model, and provide data and theory support to the research based on the model.

稳定同位素方法能为生态学、气象学和水文学等领域的研究提供独特的信息，而蒸发过程中的同位素分馏理论是稳定同位素研究的基础。Craig 和 Gordon 于 1965 年首次提出了开放水面蒸发同位素含量的计算公式，并得到了广泛应用。该模型理论上存在两点不确定性：即水体充分混合的假设和动力学分馏系数的参数化方案。但是，由于观测技术的限制，该模型一直没有得到自然条件下开放水体直接观测数据的检验。本项目拟采用离轴积分腔输出光谱技术在太湖上原位、连续和高频次地（小时尺度）观测湖泊蒸发的同位素含量，并采用同位素质量守恒方程计算月到年尺度上湖泊蒸发的同位素含量；全面检验该模型模拟各种时间尺度上自然开放水面蒸发同位素分馏的能力，并且提出改进方案；最后用改进后的模型计算太湖水分收支、示踪太湖流域降水水汽源地、重新计算全球陆地生态系统蒸散中蒸腾所占的比例。这将推进该模型的发展，并为相关研究提供数据支持和理论依据。