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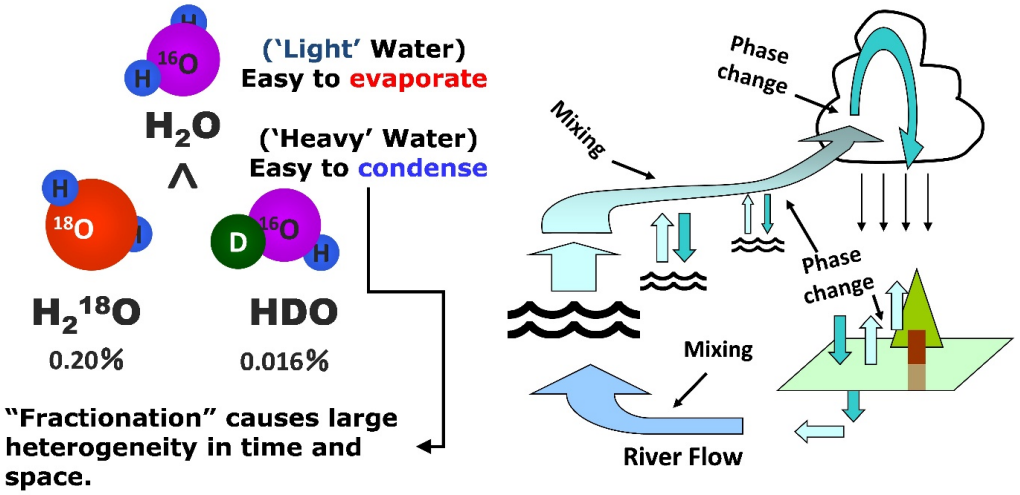

Fig. 1. Schematic illustration of stable water isotopes and their relation to the Earth's water cycle.

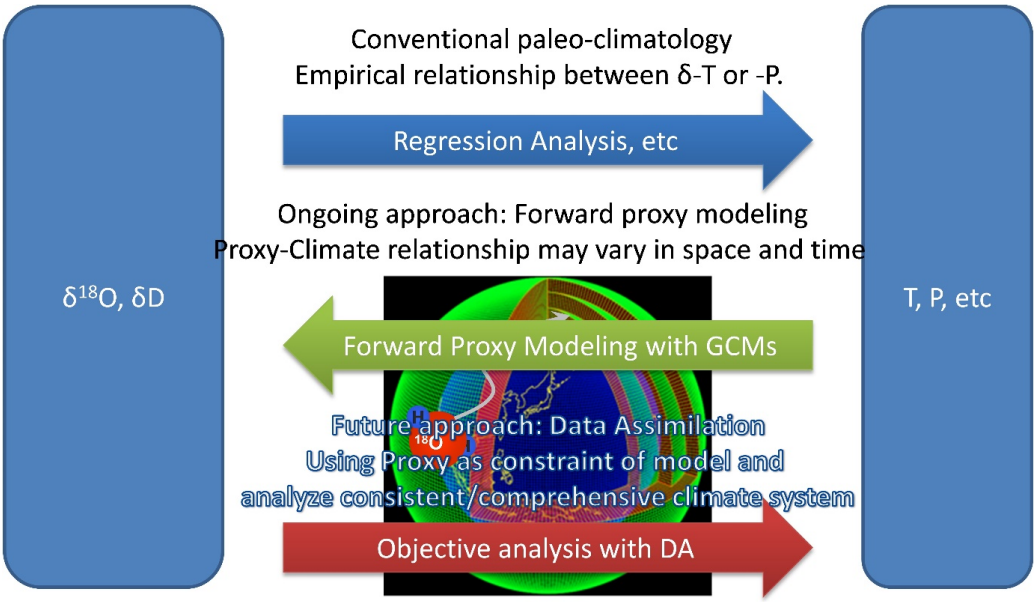

Fig. 8. Schematic representation of the evolution of studies using isotopic information as climate proxies.

- Recent advancements of studies using heavy stable water isotopes (i.e., HDO and $H_2{}^{18}O$) in climatology, meteorology and hydrology are reviewed with particular focuses on the progresses in spectroscopic measurement technologies and in global and regional isotopic modeling.
- Fractionation (i.e., heavy stable water isotopes preferably remain in liquid phase than gas phase) is the main reason of causing spatiotemporal variability in isotope concentration, and that is why the isotopes can be used to trace back the hydrologic path and origin on the Earth. (Fig. 1)
- Comparing with the conventional method based on empirical relationships, two new methods are introduced. The first is "Forward Proxy Modeling," in which isotope-incorporated GCMs/RCMs are used to understand the physical mechanism of isotopic signals. The second is "Isotope Data Assimilation," in which isotopic data are used to directly constrain the model to analyze the physically consistent environmental condition. (Fig. 8)