TES Observations of HDO and H_2O

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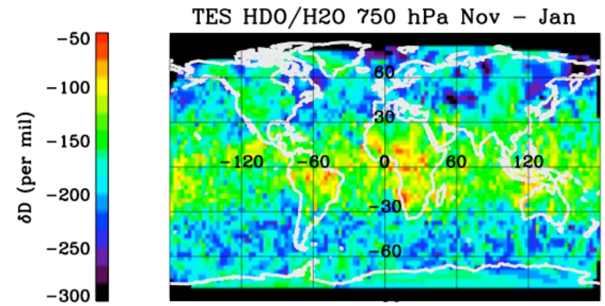
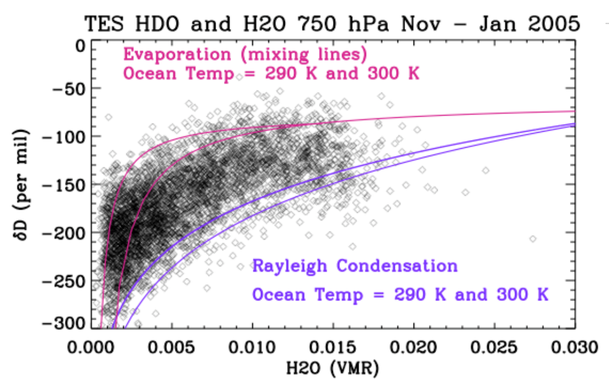




Background on Water Isotopes

Water isotopes are a good tracer for the origin, condensation, and evaporation history of an air parcel

Lighter isotopes preferentially evaporate

Heavier isotopes preferentially condense (More condensation leads to more depletion)

Isotopic composition of water vapor over the ocean is a well known function of temperature.

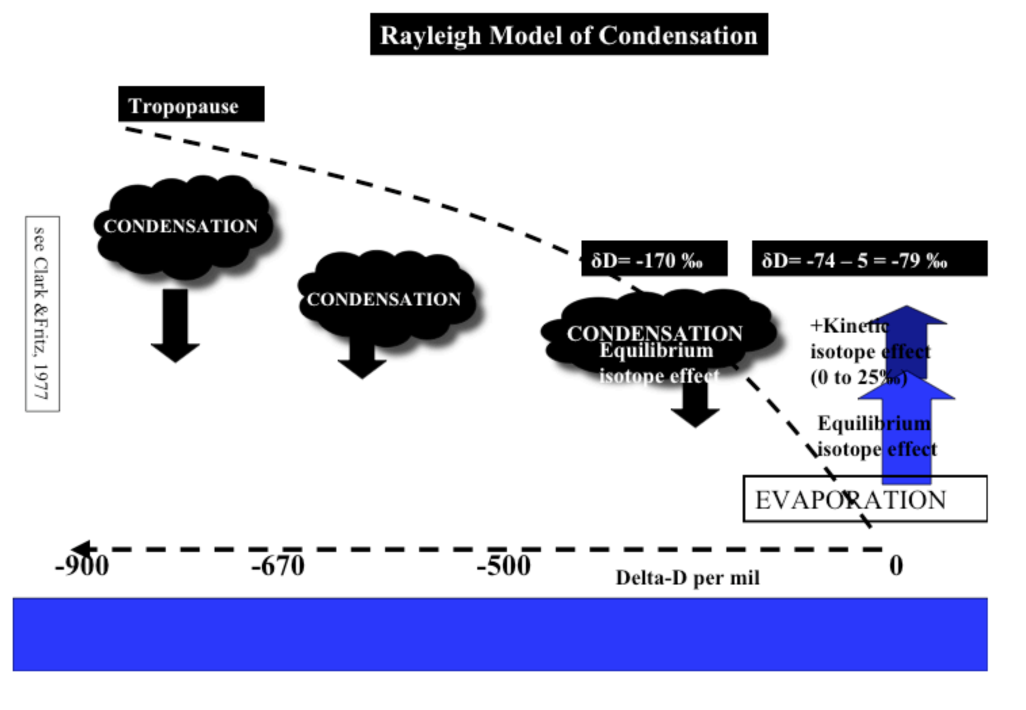
Reference for water isotopes is the Standard Mean Ocean Water (SMOW) = 3.1×10^{-4} HDO/H_2O

$$\delta D = 1000\left(\frac{HDO}{H_2O} / SMOW - 1\right)$$

10% depleted = -100‰

100% depleted = -1000‰

δD of tropospheric water vapor varies from approximately -79 (above ocean) to -800 in upper troposphere.



Previous Measurements of Water Isotopes

•Global measurements of the isotopic composition of precipitation since the mid 1900's have been used to better understand surface and boundary layer hydrology (e.g., Daansgard, Tellus, 1964; Araguas-Araguas and Froehlich, JGR, 1998)

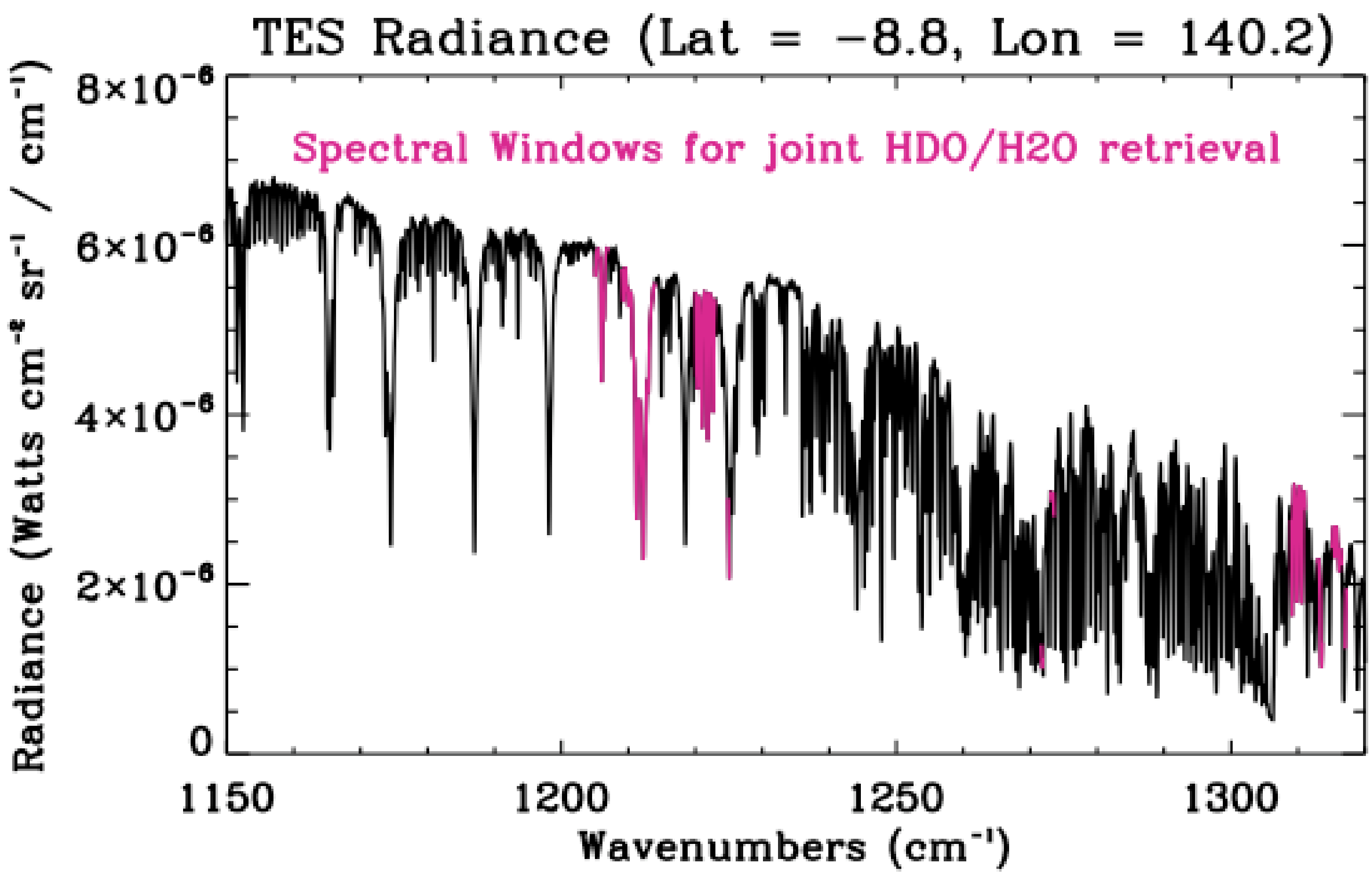
•However these precipitation measurements do not necessarily reflect cloud processes because of the tendency of rain-drops to equilibrate to the background isotopic composition as the raindrops fall and therefore forgetting the isotopic signature of the cloud! (Friedman et al., JGR, 1962)

•Useful to measure the isotopic composition of both vapor and precipitation!

•Very few observations of the isotopic composition of water vapor exist!

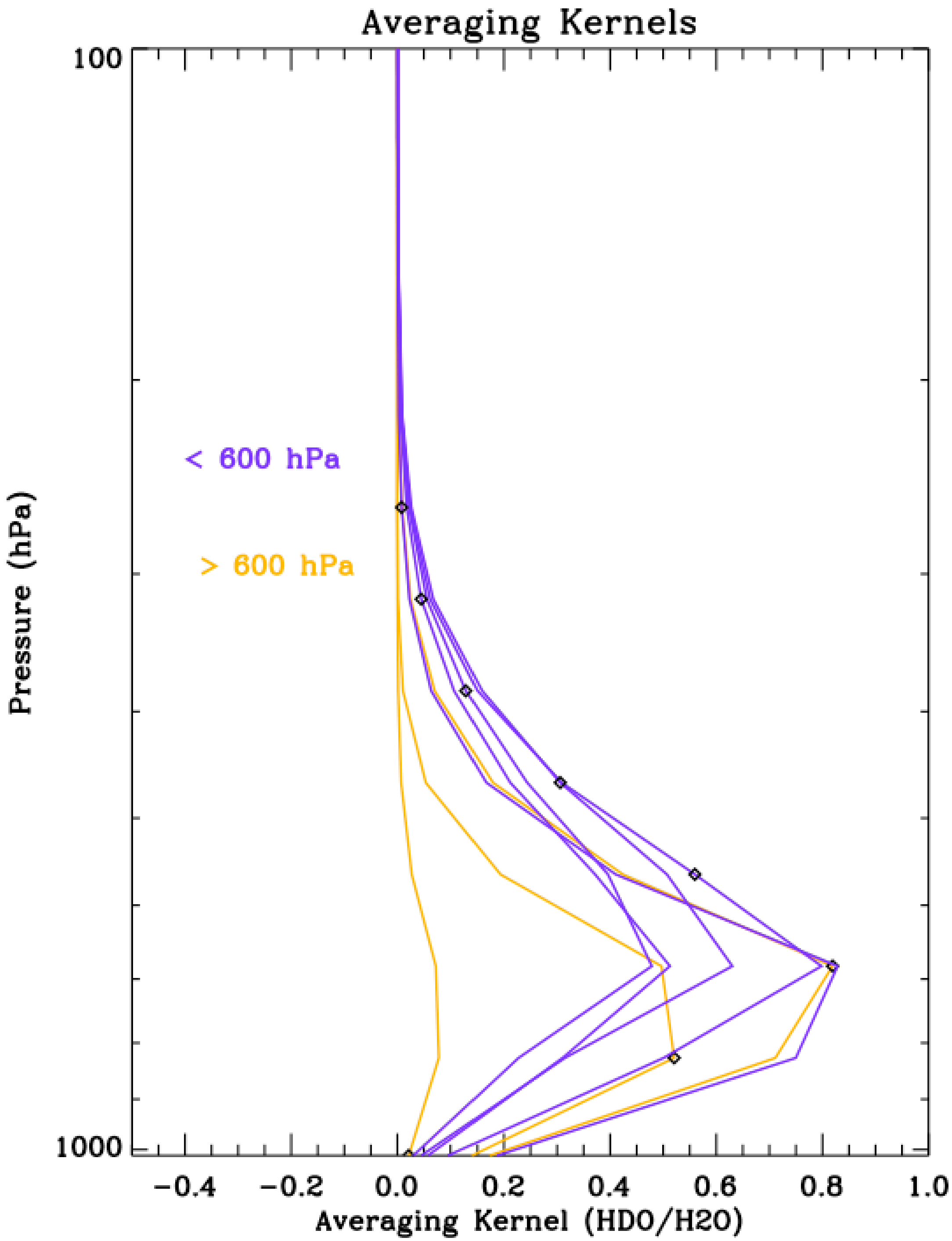
- •Balloon instruments (FIRS) and satellite measurements from ATMOS and in situ measurements from ALIAS and Harvard measure isotopic composition of water vapor to better understand processes and sources controlling UTLS humidity
- •Boundary layer observations of HDO, $H_2^{18}O$, H_2O (e.g., Lawrence et al., 2004) used to characterize dynamics, precipitation, and evaporation processes of tropical storms

- Vapor pressure isotope effect and potential impact on atmosphere known for decades (Jancso & Hook, 1974; Ehhalt, 1973; Kaye, 1987).
- First tropospheric measurements of HDO by Ehhalt (1970 in Hurricane Faith; 1974 in upper trop) showed Delta-D ~ -500 ‰, not -800‰ as expected.
- First stratospheric measurements of HDO by *Scholtz* (rocket, 1970), and by balloon flights of *Pollock et al*. (1980) and *Murcray/Goldman* (*Rinsland et al*. 1984). BLISS (*Webster et al*. 1989) made first *in situ* TDL stratospheric measurement of HDO.
- FIRS-2 (*Johnson, Jucks, Traub, Chance,* 2001) balloon remote stratospheric measurements H_2O, HDO, $H_2^{18}O$ from series of balloon flights 1989-97.
- ATMOS (*Farmer, Gunson et al.*) stratospheric HDO data modeled by *Moyer et al.,* 1996, *Ridal* 1999, *Kuang et al.* (2002) with Delta-D = -670 ‰. Speculated on role of lofted ice.
- Sample collection in air, lenticular, and cirrus clouds by *Ron Smith et al.* (1992-6) and *Andreas Zahn* (1996) confirmed theory of equilibrium isotope fractionation, and found evidence of ice lofting.

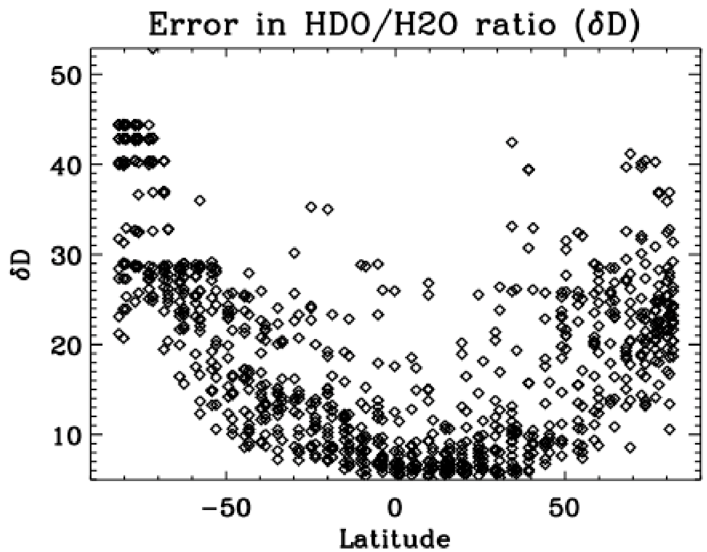


Retrieval Approach

- Simultaneous retrieval of HDO and H_2O reduces systematic errors of the estimated HDO/H_2O ratio (*Worden et al., JGR, submitted*)
- Keep *a priori* and initial guess for the HDO/H_2O ratio fixed over whole globe so as to better examine spatial variability



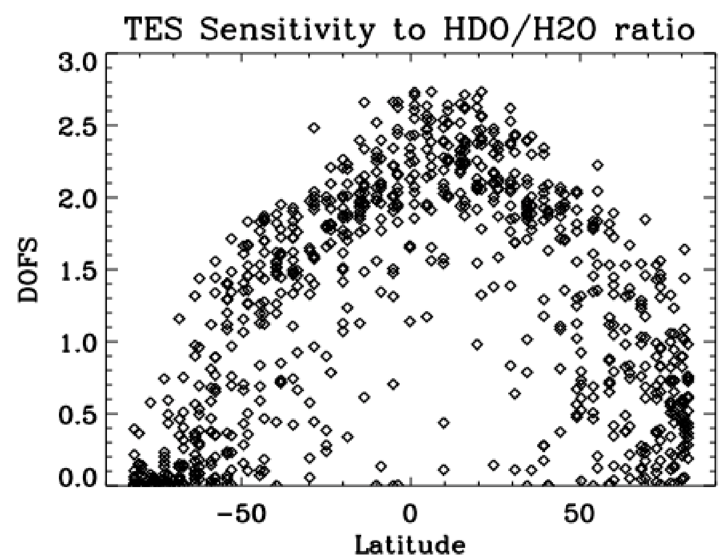
Greatest sensitivity to tropospheric HDO/H_2O ratio at 750 hPa

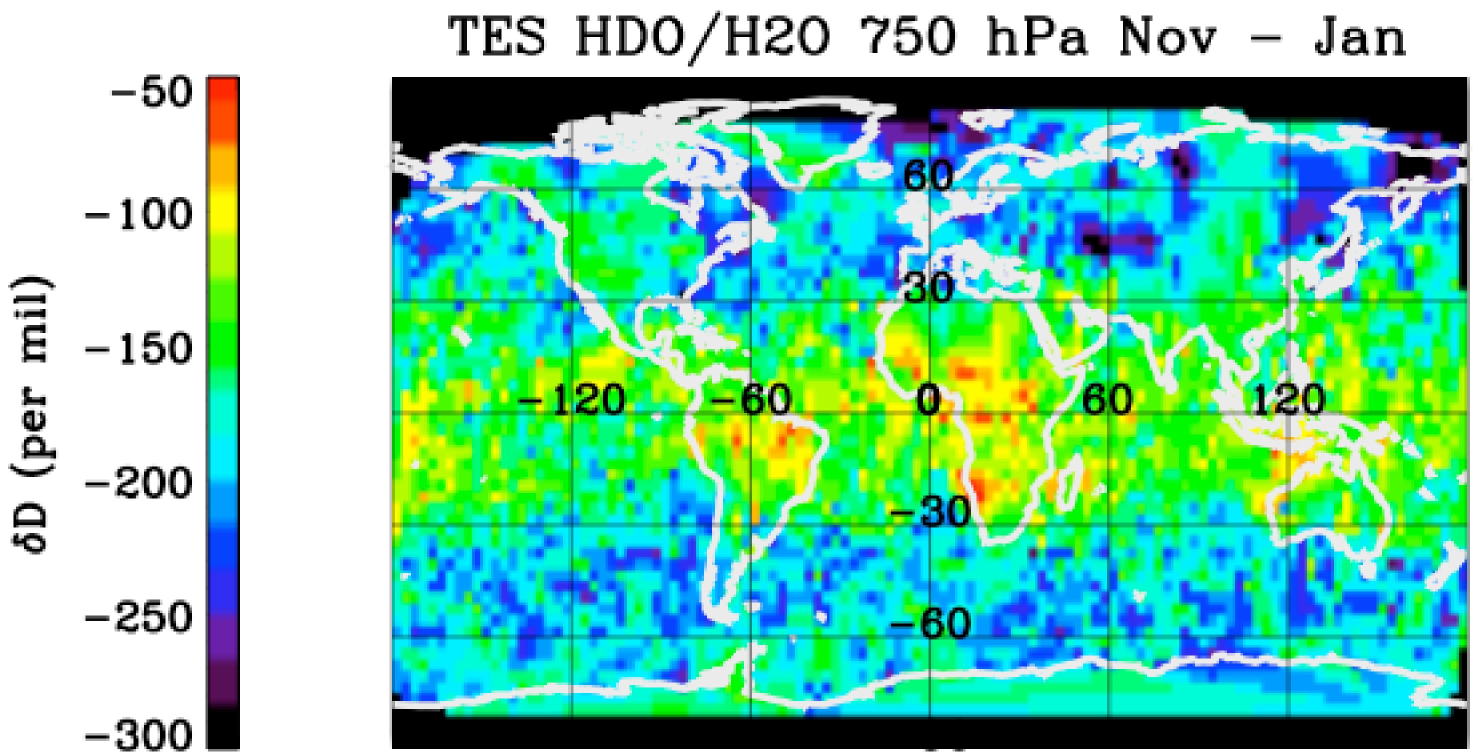


Random error increases as surface temperature (or signal-to-noise) decreases

Random error sufficient to capture regional and global variations of HDO/H_2O ratio

Sensitivity of retrieval to the tropospheric HDO/H_2O ratio decreases with surface temperature (or signal-to-noise)

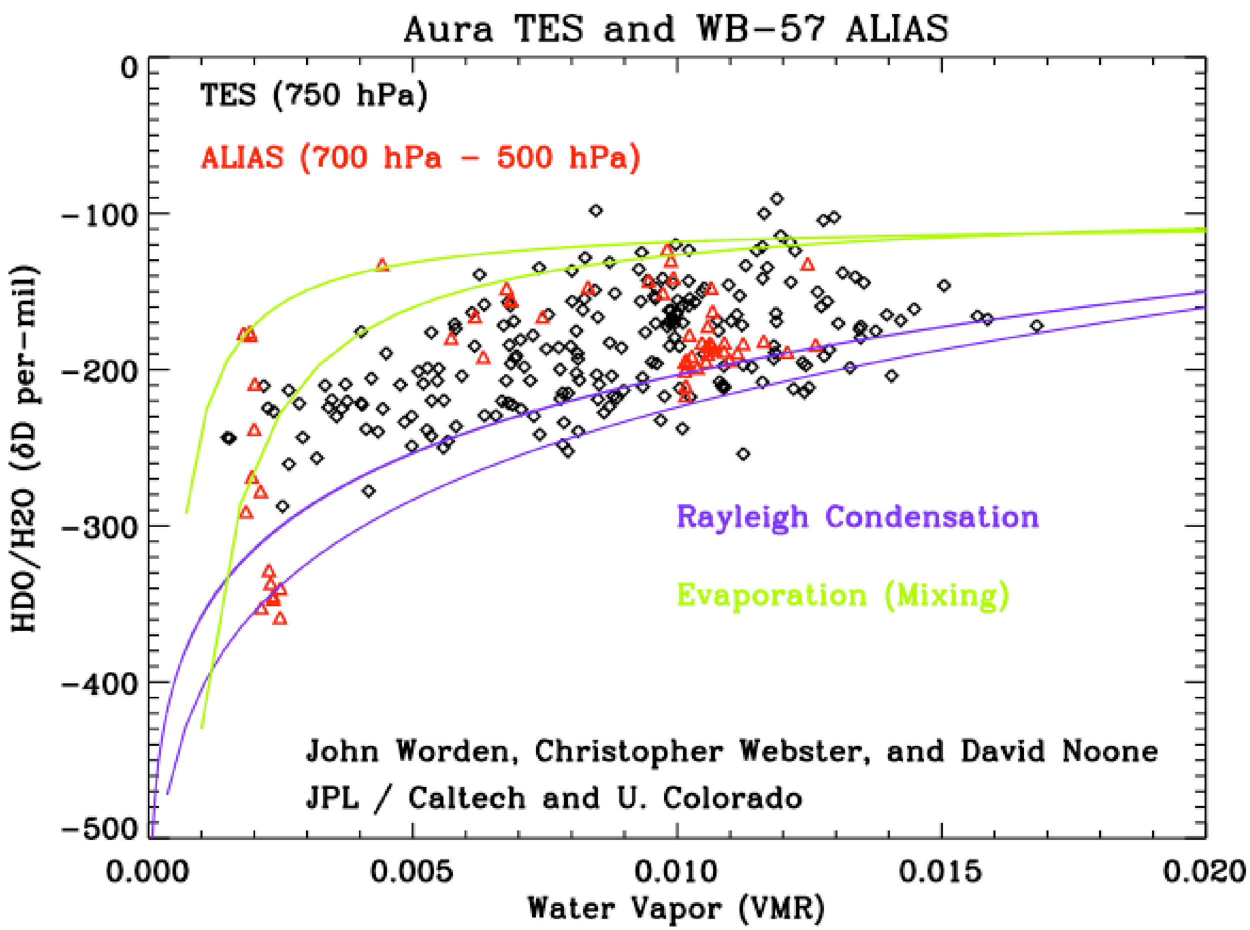




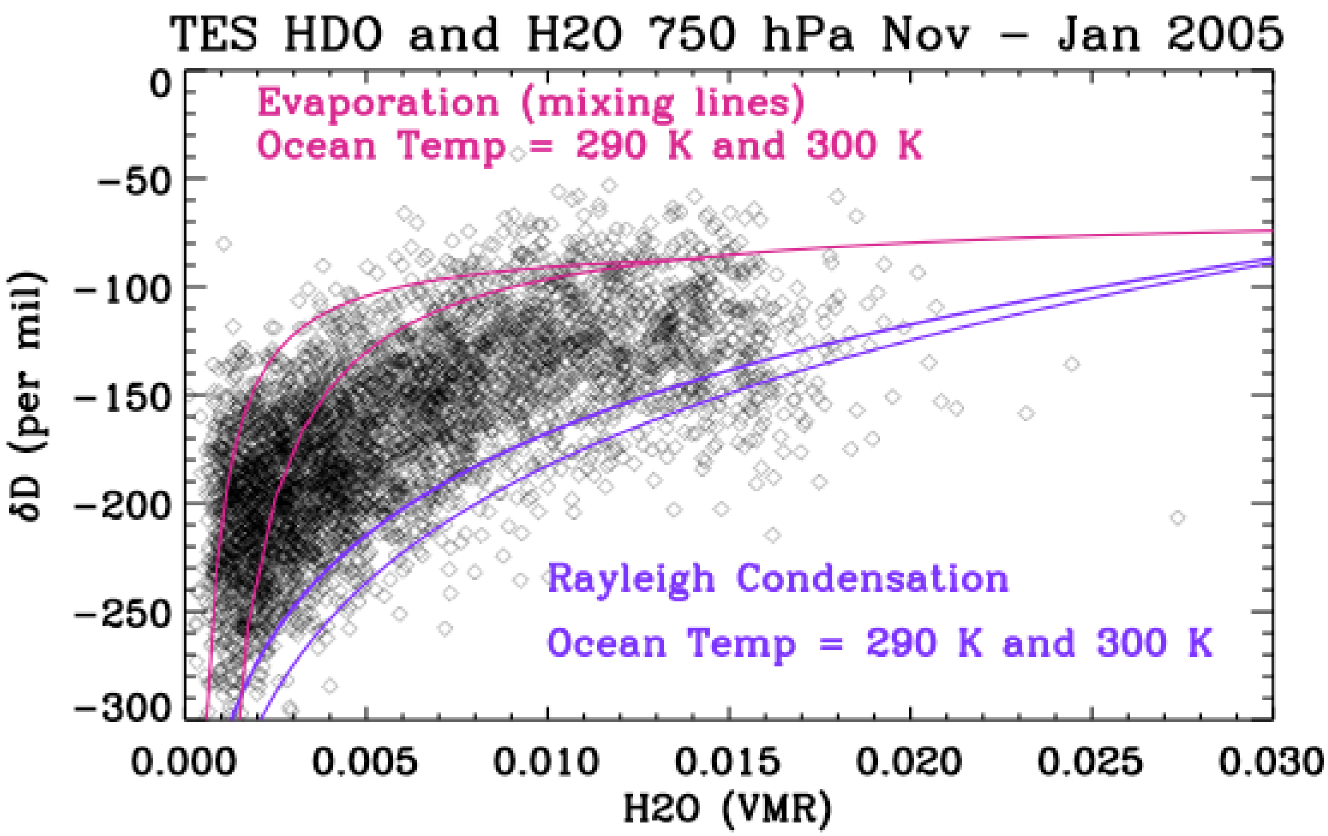
1) "Latitude effect" We observe more depletion with increasing latitude due to gradual rainout of heavier isotopes as air moves pole-ward

2) "Continent Effect"

- Precipitation Measurement ==> More depleted over continents relative to ocean
- TES Vapor Measurements ==> No obvious continent effect
- Evapo-Transpiration source larger than expected?



TES and WB-57 ALIAS observations show similar distributions that lie within condensation and evaporation end-member models



- Global Distribution of tropospheric water vapor is well described by combination of evaporation from ocean and condensation
- Observations below condensation models and above evaporation models require additional water source terms or processes to explain and will be discussed at the AGU