Stable Water Isotopes in CAM5

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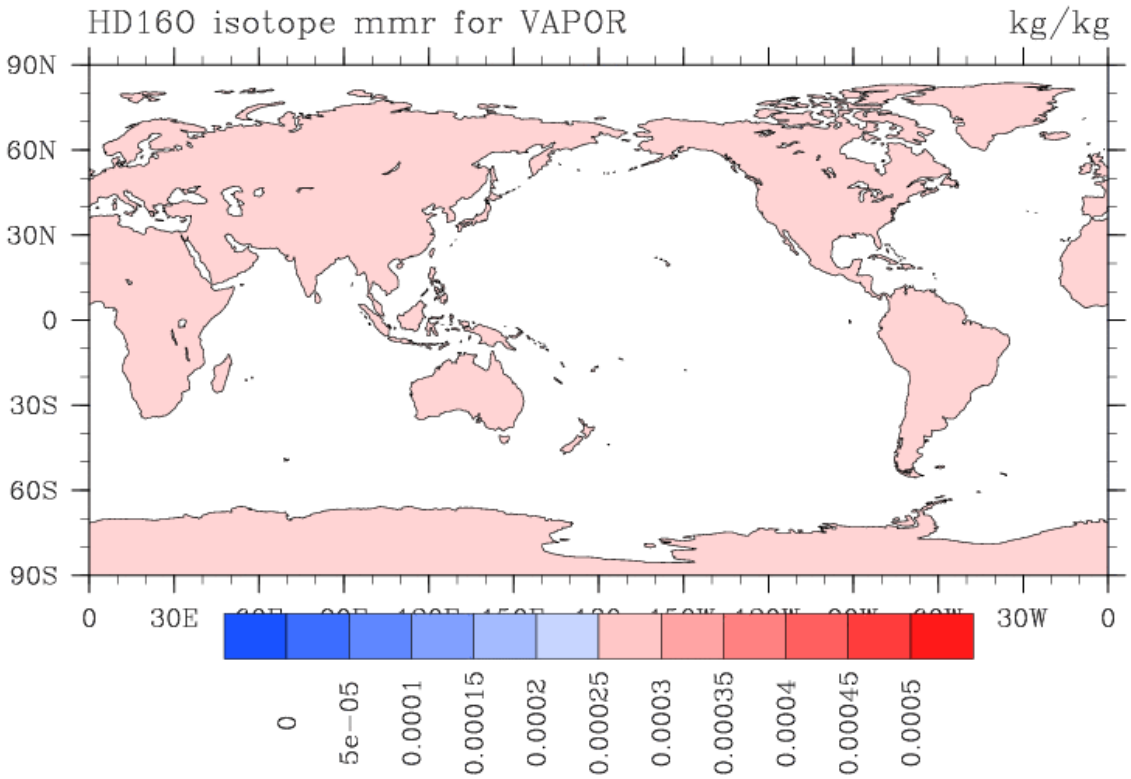
Major uncertainties related to hydrologic processes

Image from Wikipedia

Including but not limited to:

- Cloud physics
- Cloud entrainment and detrainment
- Evaporation/Transpiration from the land surface
- Soil Moisture content

Water Tracers



Water tracers, which are tracers in the model that experience the same processes as water, but have no impact on the climate itself, can be used to help constrain some of these uncertainties, and the tracers themselves can be validated by simulating water isotopes in the tracers and comparing them to observations.

Delta Values

All numbers shown in this presentation are “delta “values (δD), in units of permil.

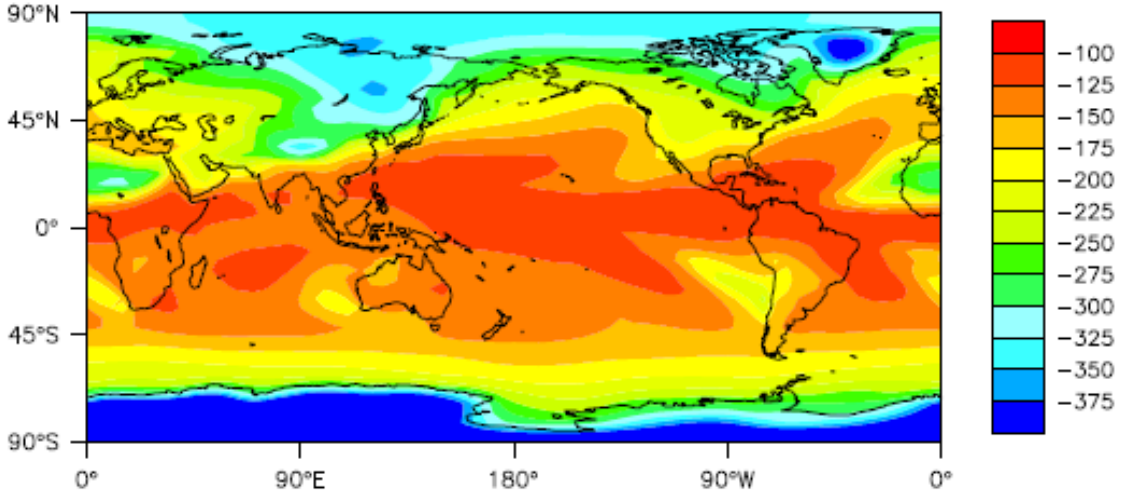
$$R = \frac{HDO}{H_2O}$$

Water tracer that evaporates only from the ocean, due to lack of isotopic land model.

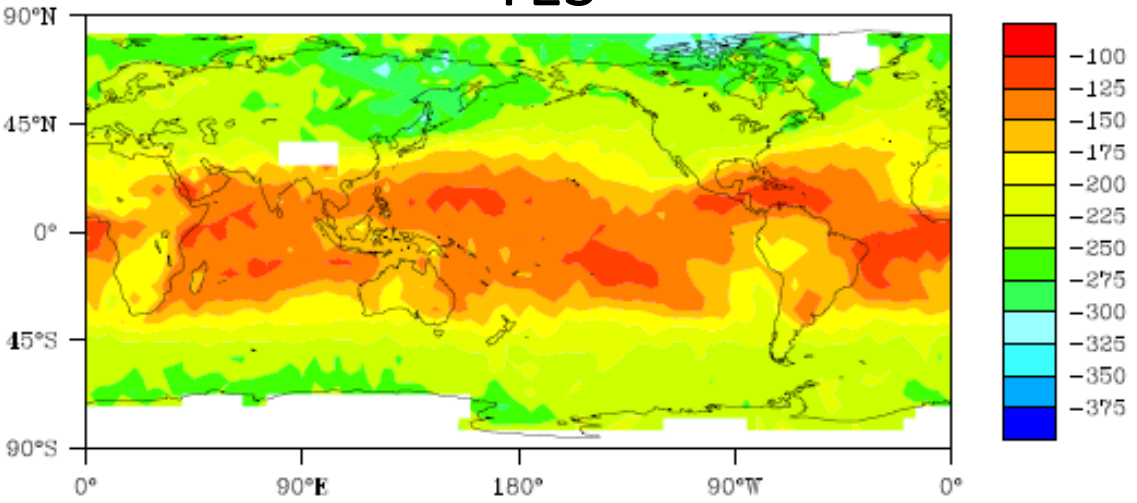
$$\delta D = \left(\frac{R}{R_{std}} - 1 \right) * 1000$$

δD in Vapor – DJF at ~762 mb

CAM5



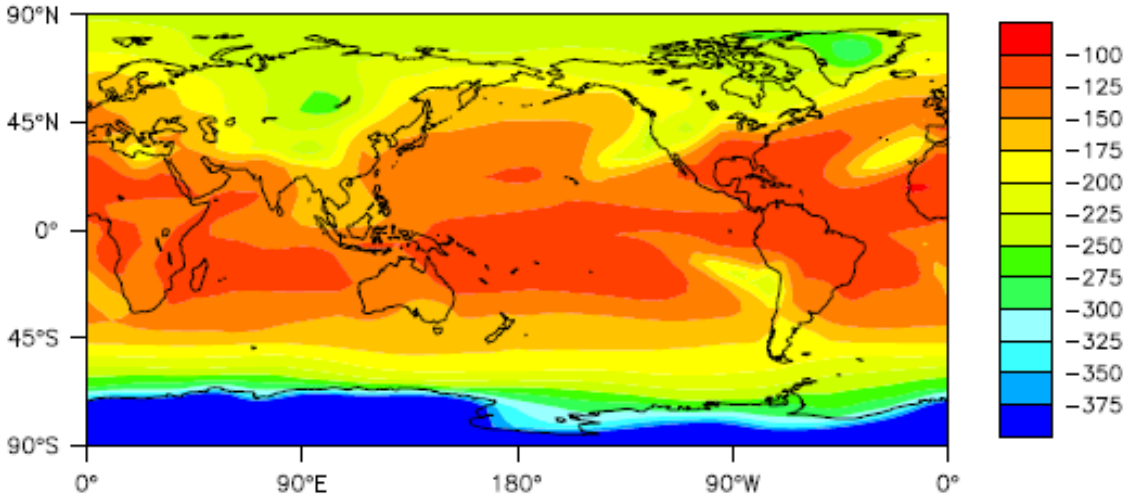
TES



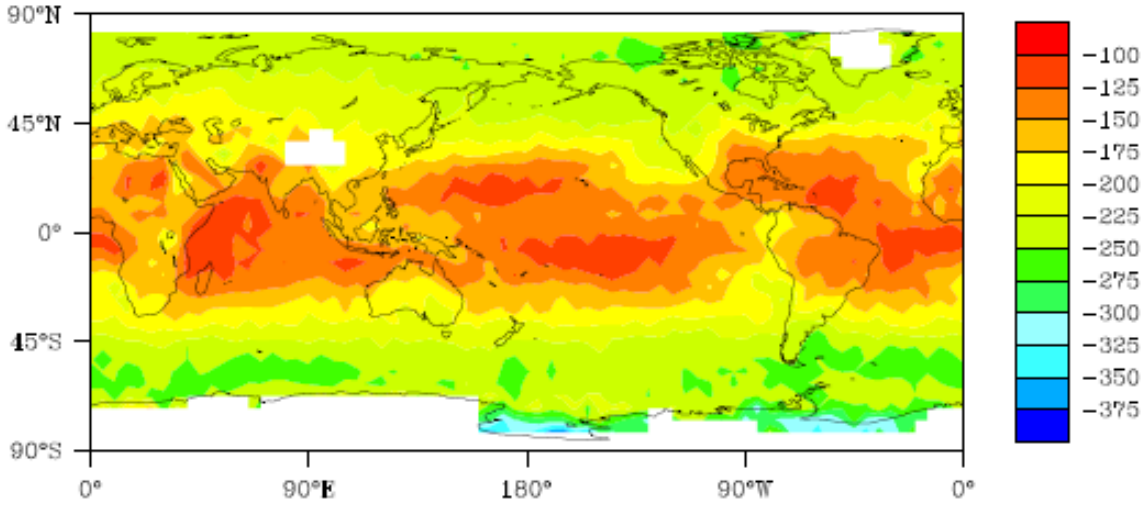
Both the model (CAM5) and the satellite (TES) show similar magnitudes and spatial patterns for δD in water vapor.

δD in Vapor – JJA at ~762 mb

CAM5

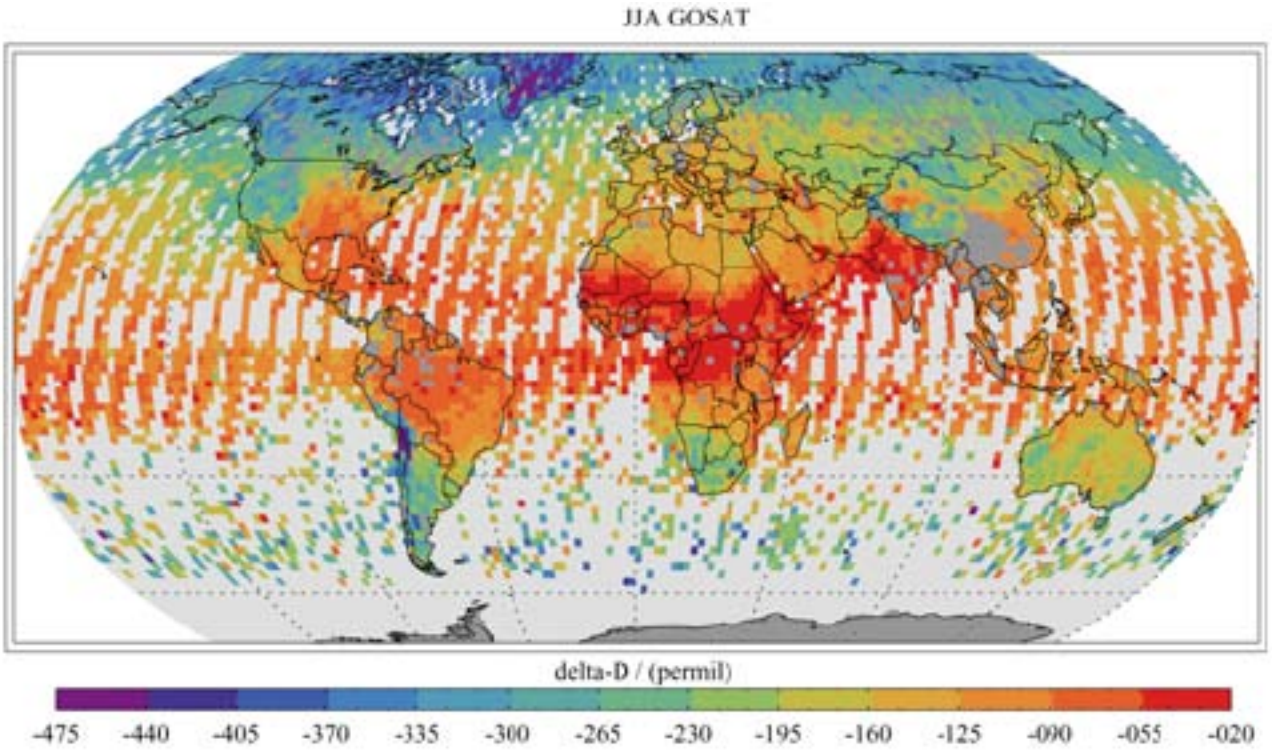


TES



The same holds true for JJA as well.

Note on Satellite data

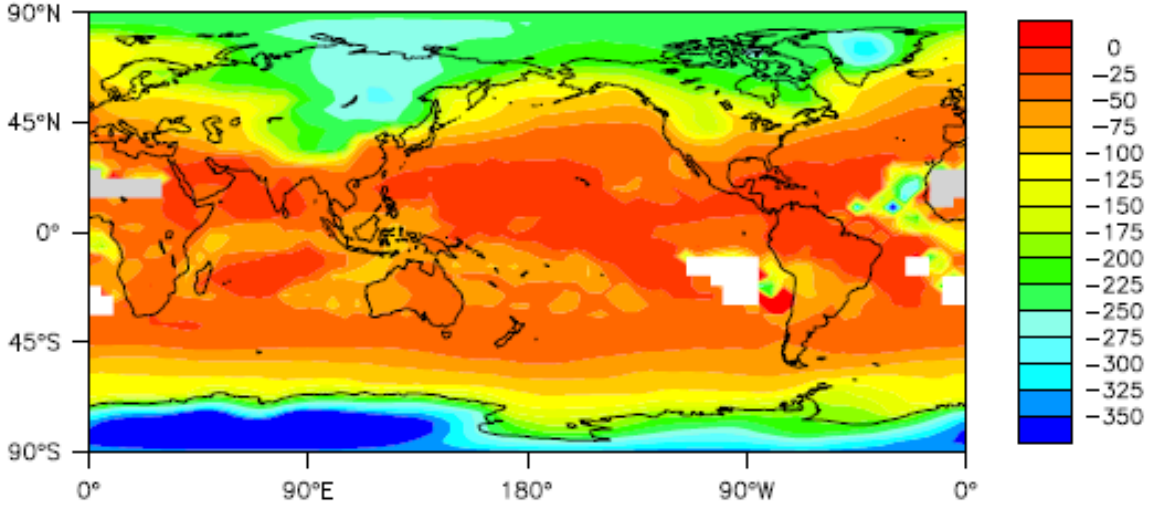


From Frankenberg et. al., 2013

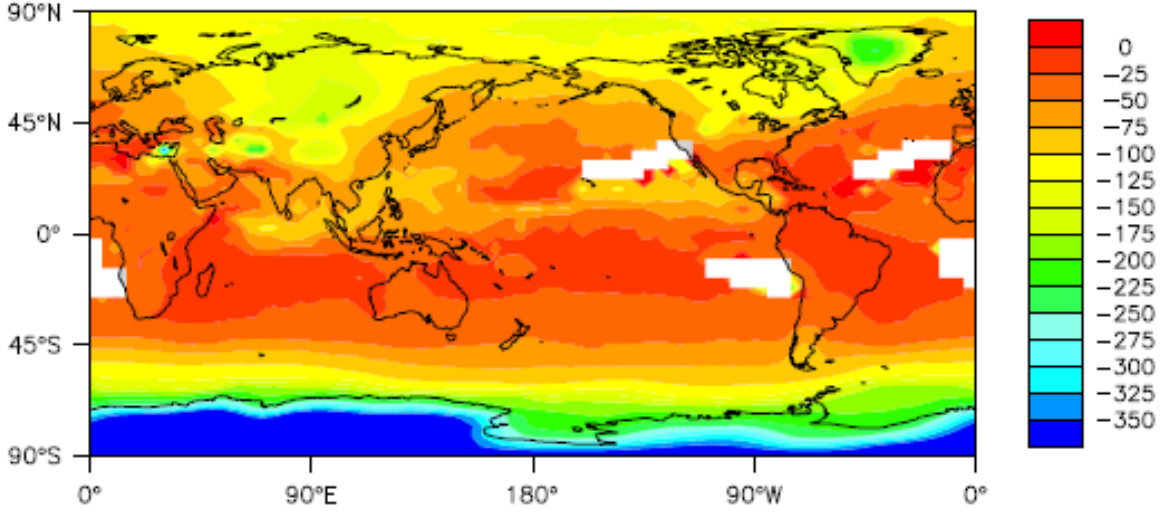
There are numerous satellite instruments that can measure HDO in the atmosphere, including SCIAMACAHY, ACE-FTS, and GOSAT (shown above). However, these techniques are relatively new, and thus contain substantial uncertianties. Thus one will need to do a COSP simulation in order to correctly validate a model using these data.

Cloud Condensate at ~762 mb

DJF



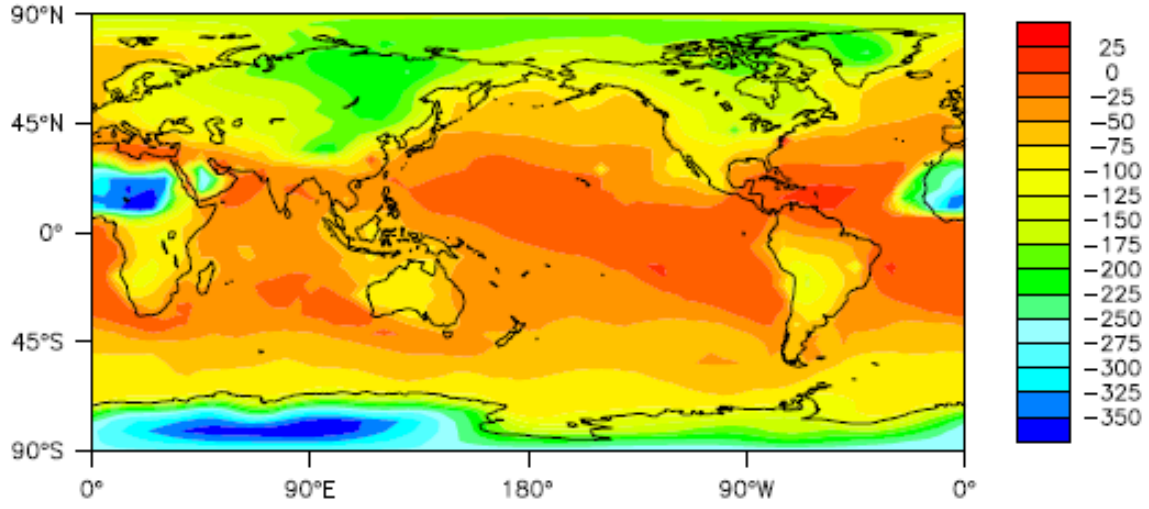
JJA



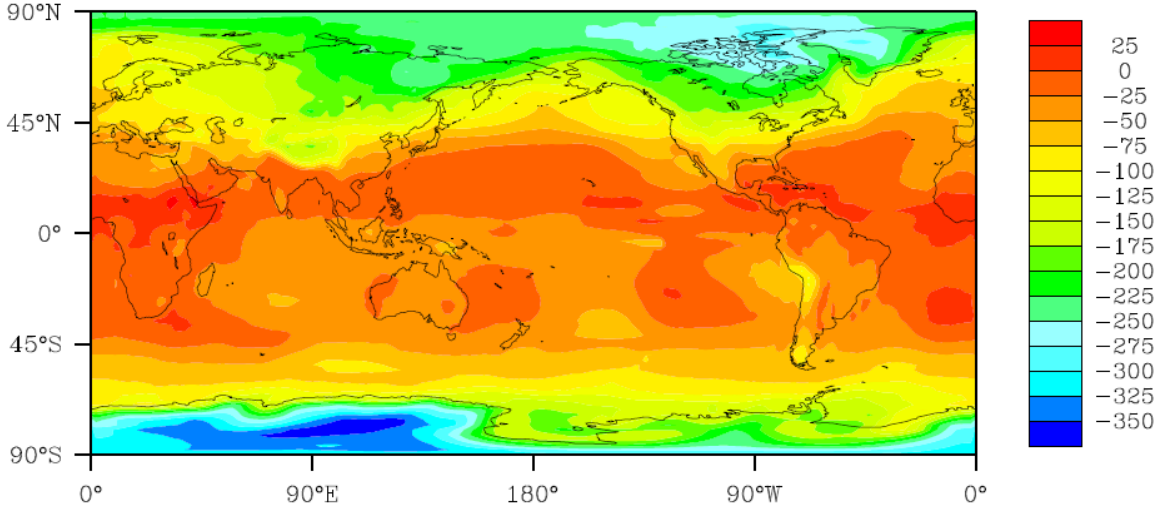
The few observations (Noone, Personal Communication) of isotopes in clouds indicate that cloud condensate should be ~100 permil enriched over vapor, which the model captures.

Precipitation - DJF

CAM5



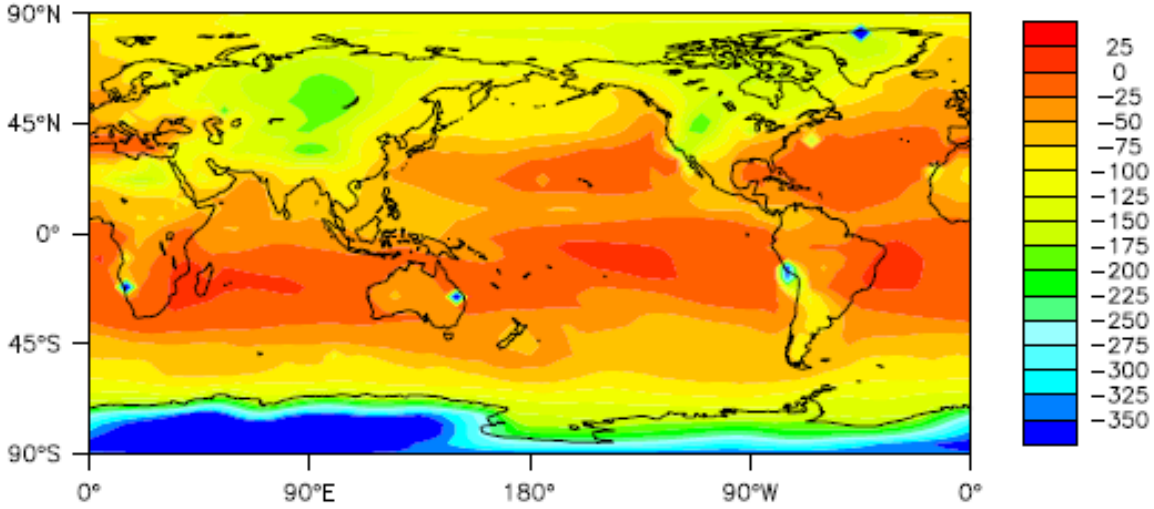
GNIP



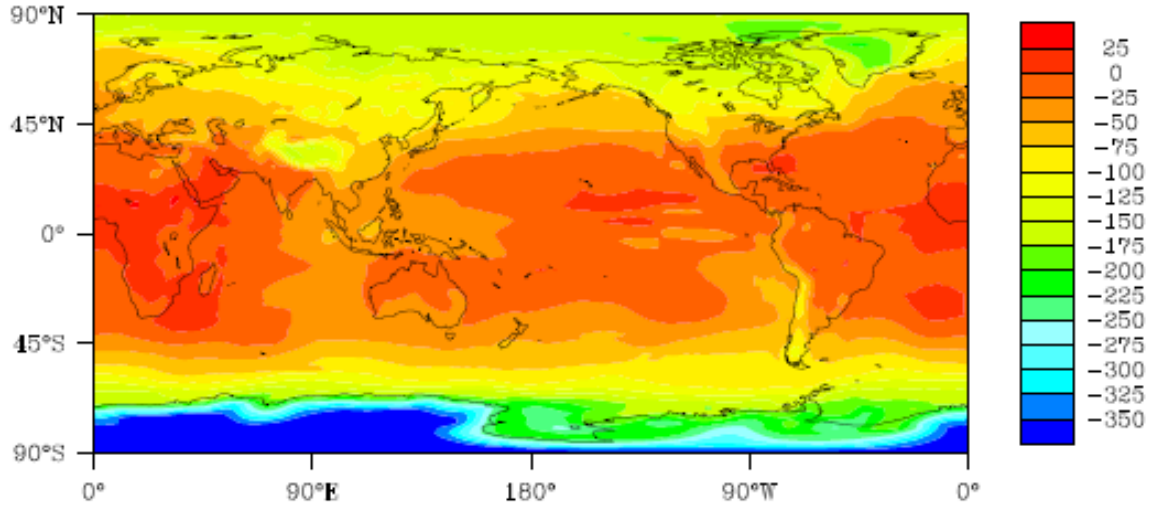
Both the model (CAM5) and the rain gauges (GNIP) show similar values and patterns for δD except for Africa, Australia, and South America, which could indicate the need for an isotopic rain re-evaporation scheme and an isotopic land model.

Precipitation - JJA

CAM5



GNIP

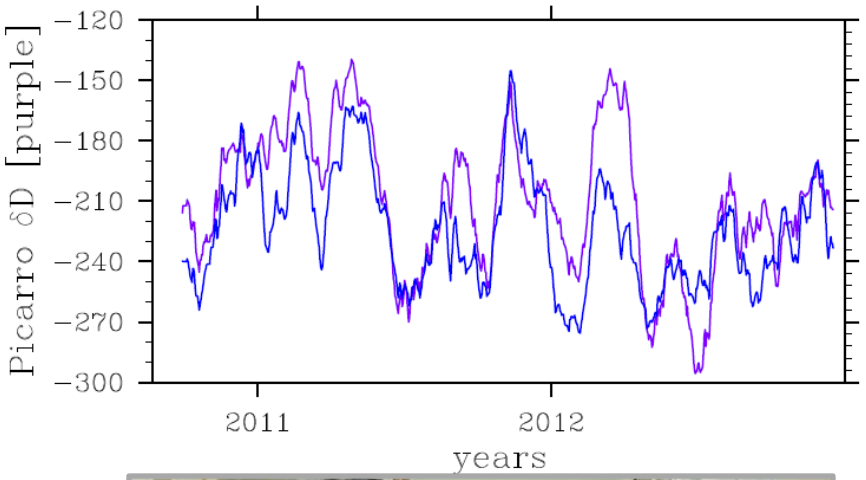


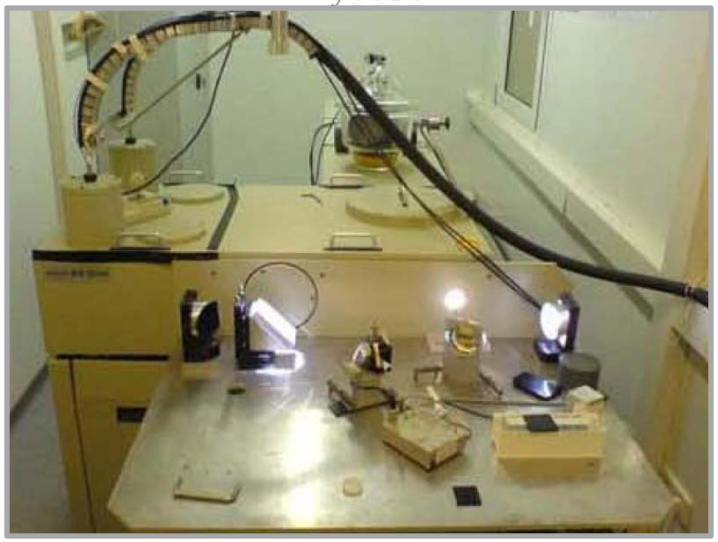
The model again has a few locations where the precipitation values are too negative, particularly over land, again indicating the need for an isotopic land model and rain re-evaporation.

Conclusions

- The general features of the atmospheric isotopic distribution are captured (latitude effect, continental effect, altitude effect)
- However, a few issues do remain, the largest being the need for a better isotopic rain re-evaporation scheme
- Finally, more complicated simulations (i.e. COSP) will be needed to accurately and quantitatively compare the model to the satellite data.

Other data sources





New instruments are allowing for an unprecedented amount of isotopic measurements, including continuous in-situ measurements of isotopes in water vapor, and total-column isotopic measurements from ground-based spectrometers [Schneider, 2006].

Image from http://www.imk-asf.kit.edu

Future Work

- Update the model to CAM5.3.1/CESM1.2 (next few months).
- Finish adding remaining isotopic processes, particularly rain re-evaporation (next few months).
- Tune the model and do quantitative comparisons with Observations (~6 months).
- Do Science!

Bibliography

Frankenberg, C., Wunsch, D., Toon, G., Risi, C., Scheepmaker, R., Lee, J.-E., Wennberg, P., and J. Worden. Water vapor isotopologue retrievals from high-resolution GOSAT shortwave infrared spectra. *Atmospheric Measurement Techniques*. **6**. February, 2013.

Schneider, M., Hase, F., and T. Blumenstock. Ground-based remote sensing of HDO/H2O ratio profiles: introduction and validation of an innovative retrieval approach. *Atmospheric Chemistry and Physics*. **6**. 2006

Questions?

Thanks for listening!