Motivation and Questions

During the last decade, several earth observing satellites produce estimates of stable water isotopes (δD), varying in spatial and temporal coverage and precision. This research aims to determine the usefulness of these measurements to determine the moisture origin and moisture processes.

The relevant research questions are whether an observation of an anomalous δD value points to a certain physical process (mixing, subsidence, re-evaporation, surface evaporation, etc.), and what the associated length- and timescales. Furthermore, it is of interest whether absolute or relative δD values are better indicators of processes.

Why use q and δD?

In addition to atmospheric drying and wetting derived from the humidity (q) measurements, the δD measurements provide enrichment and depletion information. This information is used to distinguish between different moistening and drying processes.

For example, a separation can be made between atmospheric moistening due to ocean surface evaporation and due to rain re-evaporation, as the re-evaporating moisture is more depleted in HDO than the surface evaporation.

Approach

- 3 years of LMDZ daily output
- Determine statistically significant differences in modeled physical processes and moisture origin between depleted and enriched states.
- Do this for several regions.

Relative q-δD over Indian Ocean

At 900 hPa:
- Small differences in tendencies for enriching or depleting air masses.
- δD/δt not very informative.
- Low values of δD/δq.

At 700 hPa:
- Differences in convective and dynamical tendencies between depleting and enriching air masses.
- Possibly some information on surface evaporation in δD/δt.

At 500 hPa:
- Added value of knowing δD/δt for large scale condensation, dynamics and convection.
- Possibly for surface evaporation.
- High values of δD/δq.

Conclusions

In idealized theoretical models (figure in the left column), the process information in stable water isotopes is clearer than in GCMs where different processes counteract.

- Over the tropical ocean, strong signals of surface evaporation and processes in absolute δD.
- Over tropical land and mid-latitude, weaker absolute δD signals.
- Changes in δD can provide process-information at 500–700 hPa

Consequences for earth observations: Despite the fact that processes occur simultaneously in the GCM, information on processes affecting and origin of atmospheric moisture can be derived from δD observations, especially over tropical oceans in the free troposphere.

Future research will determine the temporal aspects of the relation between stable water isotopes and atmospheric processes.

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