Process Information in δD

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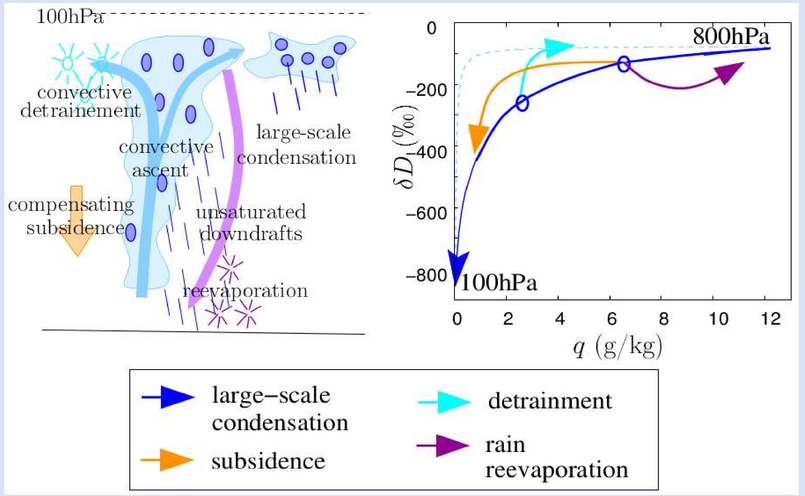
Motivation and Questions

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?

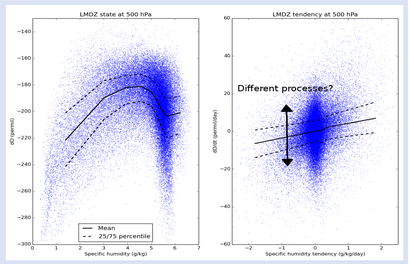
In addition to atmospheric drying and wetting derived from the humidity (q) measurements, the δD measurements provide enrichment and depletion information. This information is used to distinguish between different moistening and drying processes.
For example, a separation can be made between atmospheric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



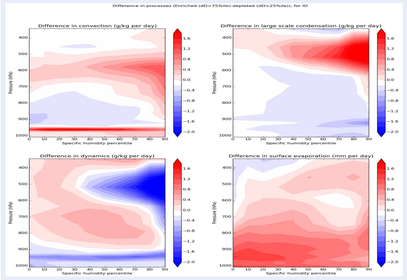
- Moistening and dehydrating processes have different effects in q-δD space due to the different evaporation and condensation rates for the two isotopes.
- Therefore, the depletion and enrichment (of δD) give information about the dominant process or moisture source.
- Moreover, these processes are parameterized in the isotope-enabled LMDZ GCM, so modeled processes can be compared to δD anomalies.
- However, possible caveats are that different processes may occur simultaneously and moisture with different isotopic composition may be advected.

Approach

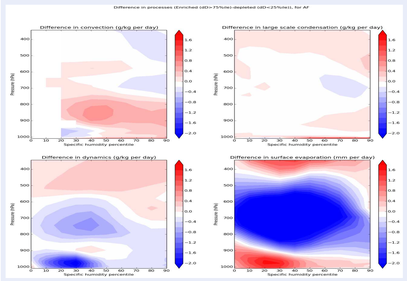
- 3 years of LMDZ daily output
- Determine statistically significant differences in modeled physical processes and moisture origin between depleted and enriched states.
- Do this for several regions.



Absolute q-δD, over Indian Ocean, Africa and Atlantic

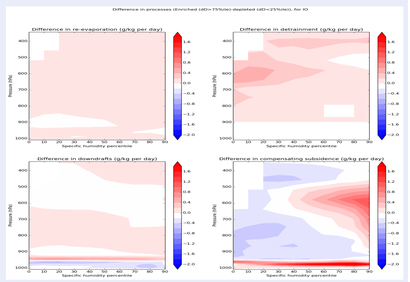


Over the Indian ocean:
- convective scheme signal is dominated by compensating subsidence signal.
- detrainment important in dry situations.
- re-evaporation not important (in convection scheme)

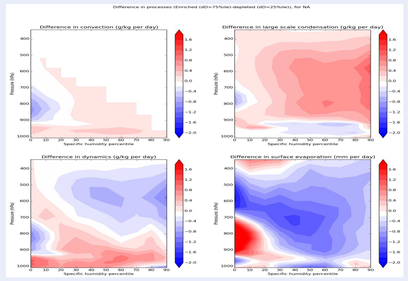


Over the north Atlantic ocean:
- signals weaker than over the tropical domains.
- surface evap positive signal only for dry environments and >700 hPa.
- large scale condensation signal larger than convection signal.

Indian ocean; δD anomalies indicative:
- of convection, large scale condensation, dynamics and surface evaporation.
- Surface evap signals up to 700 hPa.
- Convection and large scale condensation signals mostly in moist environments.

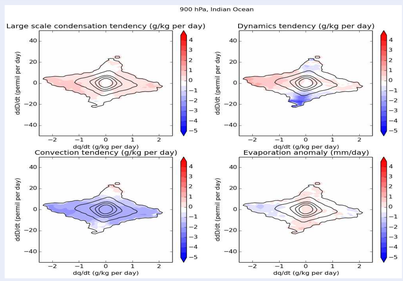


Over tropical Africa:
- signals weaker than over the tropical ocean.
- surface evaporation positive signal below 900 hPa and negative above.
- convection signal at lower levels than over the Indian ocean.

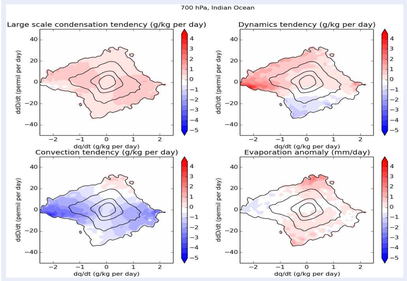


Relative q-δD over Indian Ocean

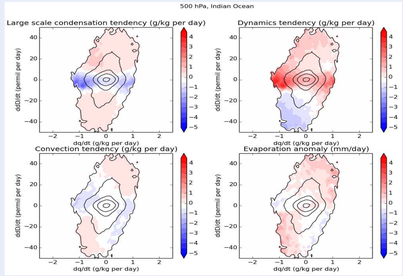
At 900 hPa:
- Small differences in tendencies for enriching or depleting air masses.
- dδD/dt not very informative.
- Low values of dδD/dq.



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



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



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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