MJO q-δD dynamics to constrain GCM convective processes

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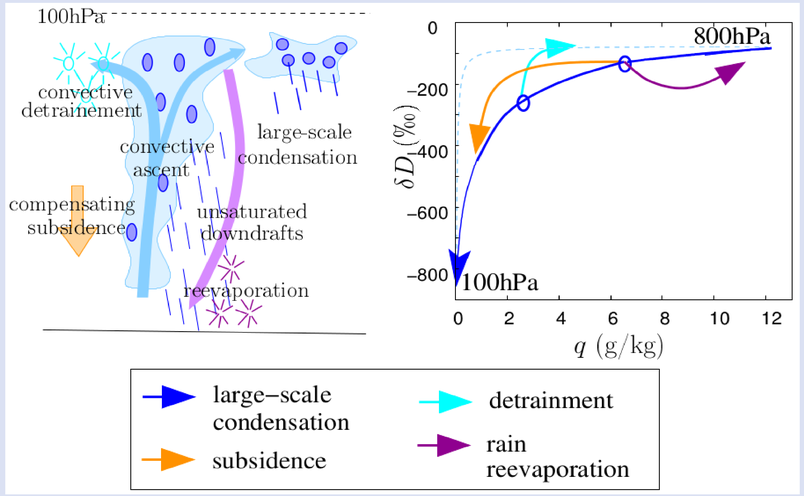
Motivation

This research aims to improve the convective processes during the Madden-Julian intra-seasonal oscillation in the tropics (MJO) in the LMDZ atmospheric model, by making use of joint δD (HDO) and q (vapor) measurements. The MJO is a mode of variability that is not well captured by current global climate models and their current convective parametrizations. Here, we explore the possibility of using new satellite measurements of specific humidity and the HDO water isotope (δD) to improve the representation of convective processes during the MJO.

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.

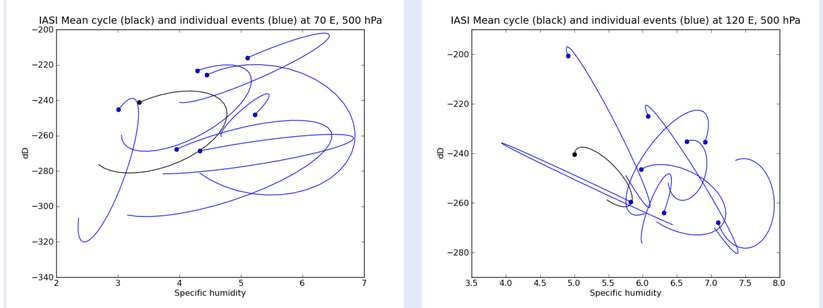


- Moistening and dehydrating processes have different effects in q-δD space due to the different evaporation and condensation rates for the two isotopes.
- Therefore, the depletion and enrichment (of δD) give information about the dominant process or moisture source.
- Moreover, these processes are parameterizated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

IASI satellite q-δD measurements

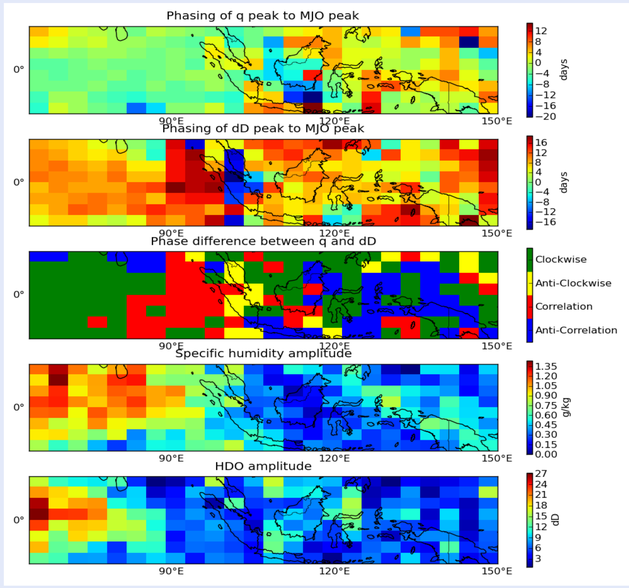
We use simultaneous IASI metop satellite observations of q and δD at 500 hPa over the Indian ocean and maritime continent for 2010–2012, including about ten MJO events.
Compared to alternative satellite products of q and δD, IASI has a high temporal coverage (two daily overpasses), but a lower sensitivity. Therefore, the IASI data is suited to analyse the intra-seasonal variability of the MJO on an event basis so there is no need to make composites of MJO events.

Typical q-δD signal of MJO

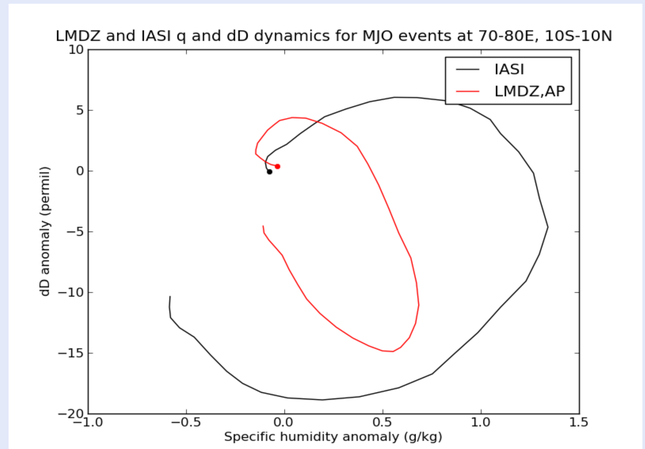


MJO q-δD cycles over the Indian ocean (left) and maritime continent (right)

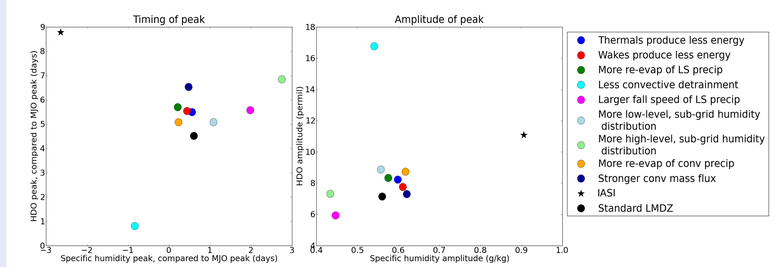
- Over the Indian ocean, MJO events are similar. Before the peak of the event, a moistening due to surface evaporation and advection. After the MJO peak, a depletion due to re-evaporation of stratiform precipitation. About a week after the event a drying and subsequent enrichment.
- Over the maritime continent and Western Pacific, the signal of MJO events is more variable, possibly due to interaction with other modes of variability.



GCM (LMDZ) sensitivity tests



- LMDZ (forced with ERA-interim winds) underestimates the amplitude of q and δD
- The timing of the depletion maximum occurs too soon after the MJO peak.
- First-order sensitivity tests of parameters in the convective scheme affect amplitude and phasing.
- There is potential for improving the MJO representation by tuning these parameters.



Conclusions

- The high-resolution IASI q and δD satellite measurements can give insight into MJO moist convective processes.
- Over the Indian ocean, the variability of q-δD dynamics is smaller than over the maritime continent and Western Pacific.
- The forced LMDZ model captures the MJO dynamics over the Indian ocean, but misses the δD phasing.
- Sensitivity tests show that parameters the convective scheme can influence the modeled MJO characteristics.

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