Evaluating the role of convective and large-scale condensation parameterizations on their environment during the MJO events using measurements of water isotopic composition

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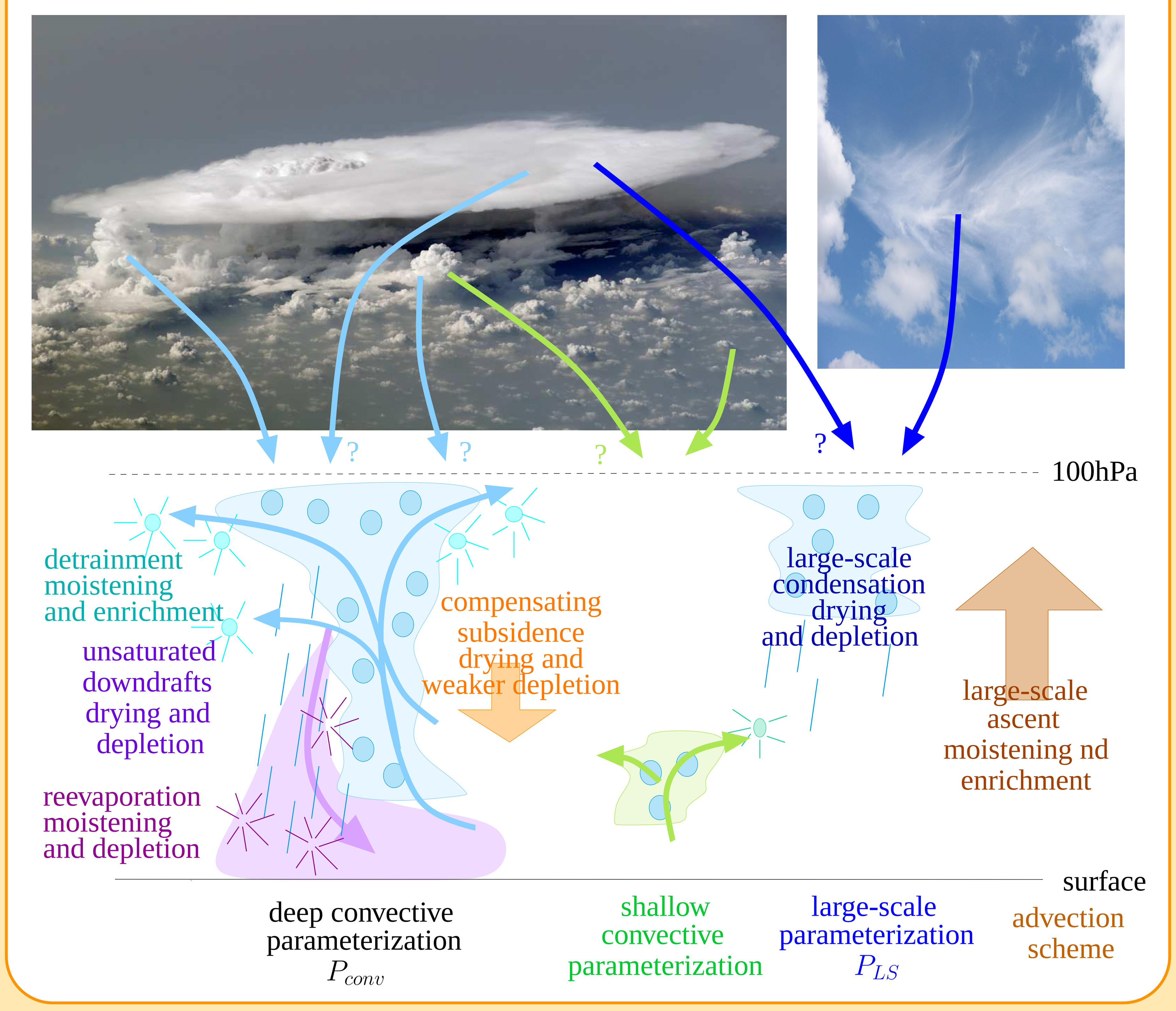
Introduction

The simulation of intra-seasonal variability in the Indian-Western Pacific region (in particular the MJO) by atmospheric general circulation models (GCMs) has been shown to depend on the convective parameterization used and on the relative role of convective and large-scale condensation parameterization to produce precipitation. Deep convection, shallow convection and large-scale condensation parameterizations act in concert to modify environmental properties (e.g. moistening at different levels, dissipation of buoyancy), in a way that depends on the intrisic properties of each parameterization and on the interplay between these parameterizations. Here we explore the possibility of using water vapor isotopic measurements to better evaluate the role of convective and large-scale condensation parameterizations on their environment, using the LMDZ GCM enabled with isotopes ([6]).

q = specific humidity; δD= concentration in HDO in ‰ anomalies relatively to sea water

Fig: Pictures illustrating a tropical convective region, and how the tropospheric water budget is represented by parametrizations in a GCM. There are two kinds of balances: moistening large-scale ascent compensated by dehydration by large-scale condensation (producing with large-scale precip P_{LS}), and moistening by convective detraiment compensated by dehydration by compensating subsidence (producing with convective precip P_{conv}).
Observational and modeling studies suggest the enriching role of convective detrainment ([3]) and the depleting role of unsaturated downdrafts ([4, 5]), rain reevaporation ([7]) and large-scale condensation ([2]).



Factors controling tropical water vapor δD

Fig: Humidity tendencies from the different parameterizations, and their δD signature in the free troposphere (example in 1D). Convective detrainment has a stronger enriching effect than large-scale ascent for a given moistening. Large-scale condensation has a stronger depleting effect than compensating subsidence for a given dehydration.

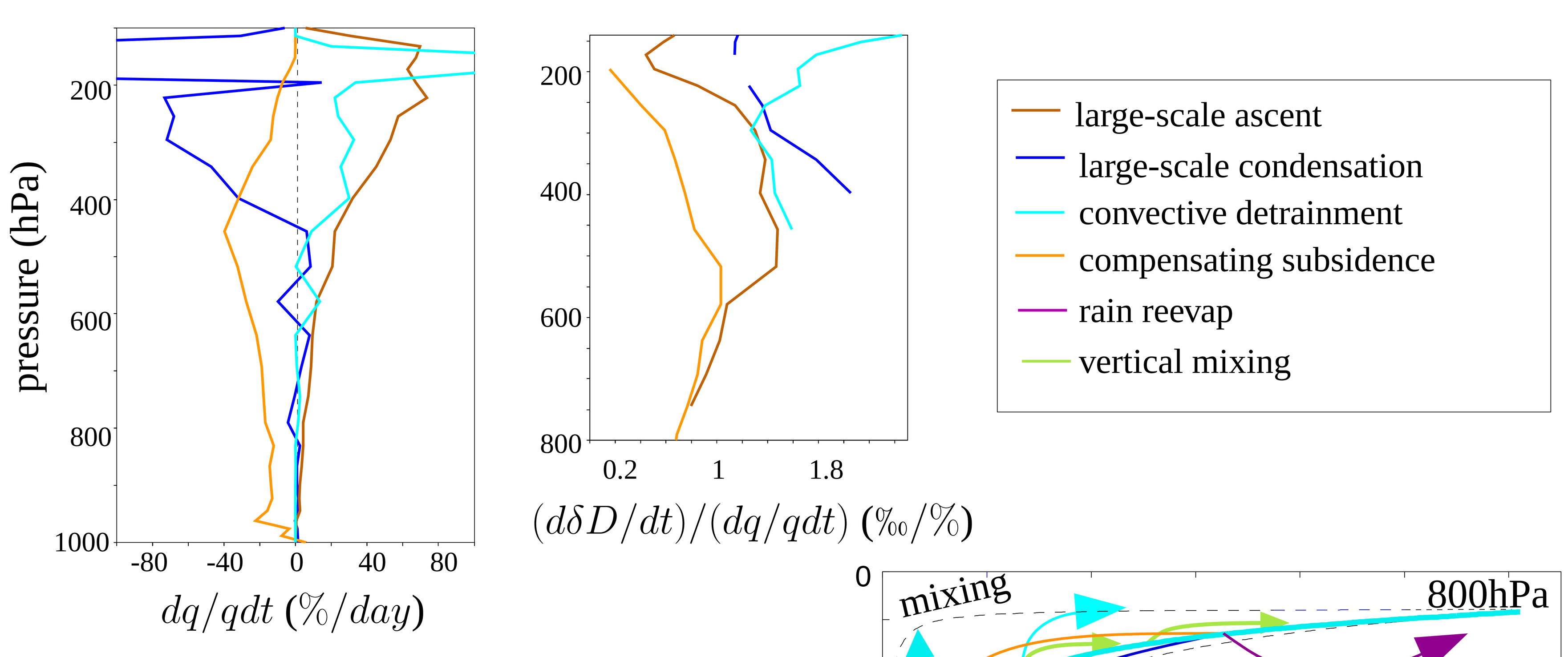
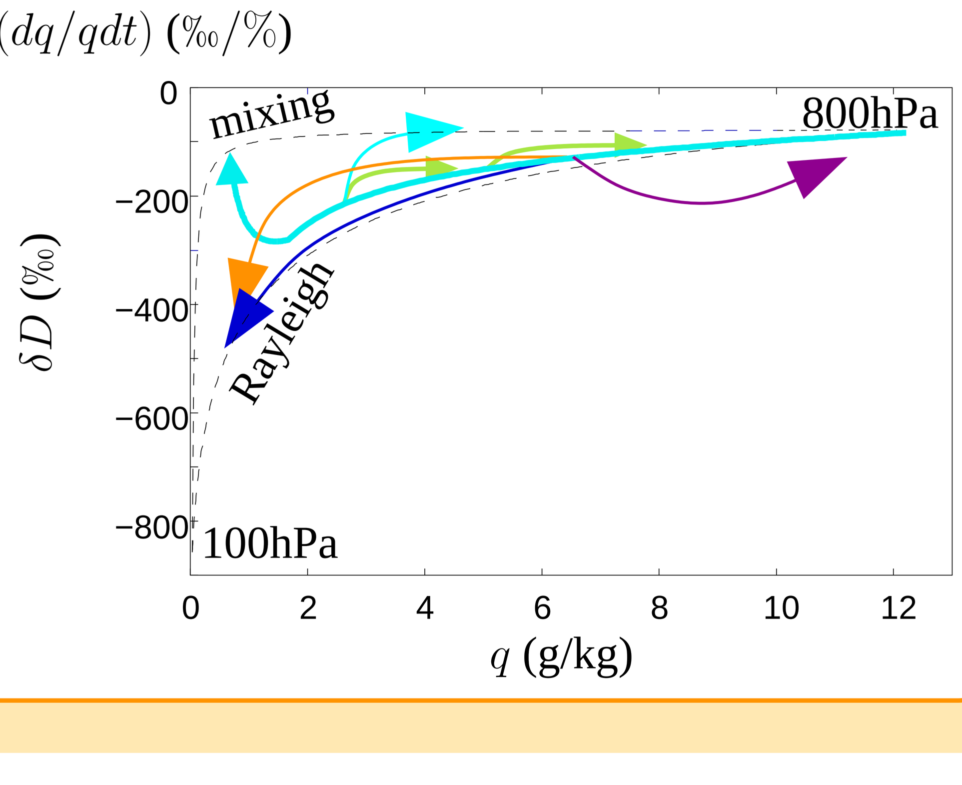
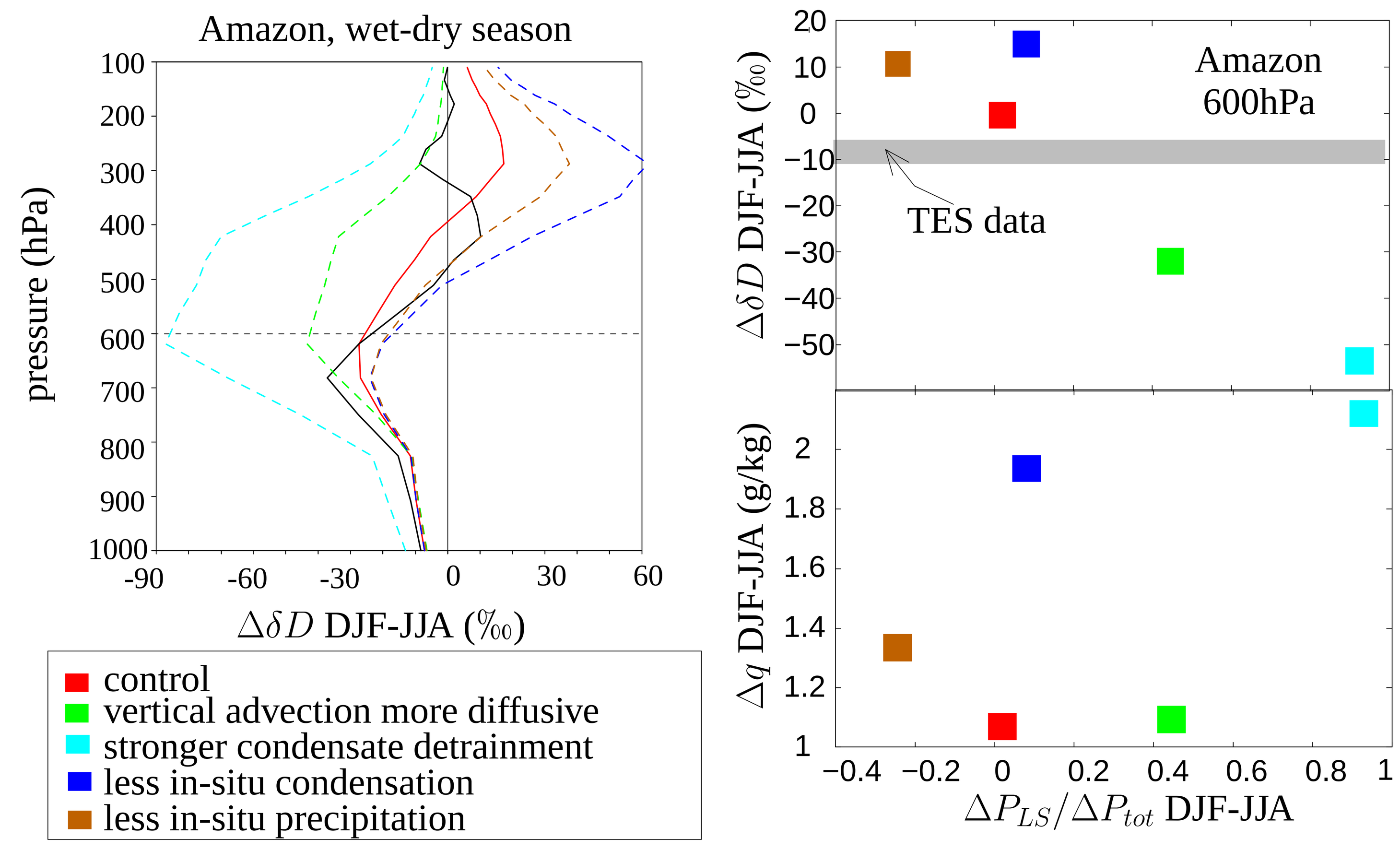


Fig: Rayleigh distillation (resulting from progressive dehydration by condensation) has a log shape while mixing has a hyperbolic shape ([7]). This explains why large-scale condensation is more depleting than compensating subsidence for a given dehydration.



Sensitivity tests

Fig: Example over the Amazon. In the TES data, during the wet season, the water vapor is more depleted in the lower troposphere and slightly more enriched in the upper troposphere. LMDZ reproduces this feature. Sensitivity tests show that the larger the contribution of large-scale precipitation to the precipitation seasonal variation, the larger the mid-tropospheric depletion during the wet season. This effect is not detected in q.



Cindy-Dynamo case study

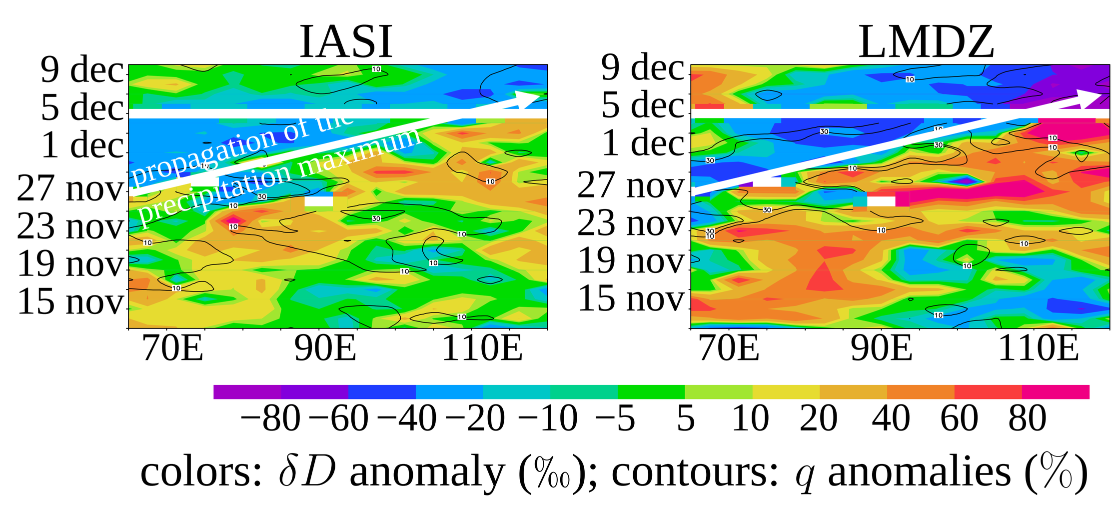
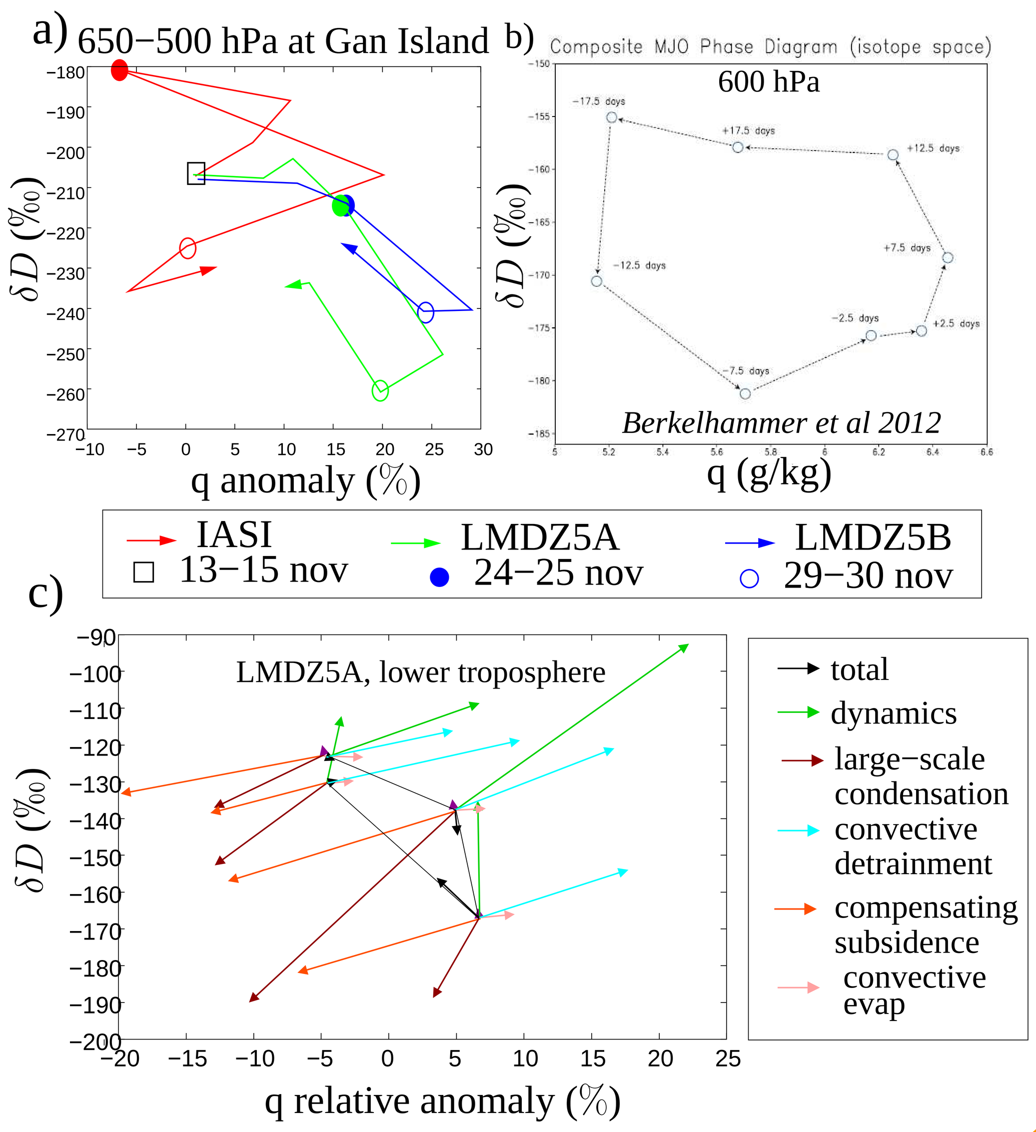


Fig: Observed (IASI, [1]) and simulated δD during the November 2011 CINDY-DYNAMO campaign case at 500hPa averaged over 10S-10N. The active phase of the MJO is associated with depletion in δD. LMDZ captures this feature

q-δD cycles as a process-oriented diagnostic?

Fig: q-δD evolution during MJO events: (1) observed by IASI and simulated by LMDZ5A and LMDZ5B during the CINDY-DYNAMO case; (b) simulated by LMDZ5A; (c) composite as observed by TES. The shape and sign of the q-δD cycle depends on the location/season, altitude, type of event. In LMDZ, it depends on the physical package and the resulting balance between convective and large-scale processes.



Perspectives

* Collocate q, δD with cloud data
* Link with degree of organization
* Combine δD with cloud data and with air tracers (CO, O_3, Be)
* Help from CRMs

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