PP11B–0516

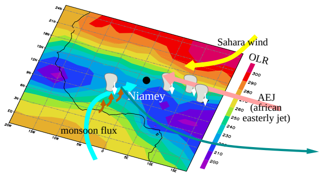
Analysis of the Isotopic Composition of Rainwater Samples Collected in Niger During the monsoon 2006

Camille Risi[1]*, Françoise Vimeux[2], Sandrine Bony[1], Luc Descroix[3], Ibrahim Boubacar[3], Ibrahim Mamadou[3]
[1]*LMD/IPSL, Paris (France)*, [2]*LSCE/IPSL, Paris (France)*, [3]*IRD, Niamey (Niger)*
*contact: crlmd@lmd.jussieu.fr

Introduction

The stable isotopic composition of precipitation (Deuterium and Oxygen 18) is a valuable tool to reconstruct past climate variability and to better understand present and past water cycle. **To better understand what controls the isotopic composition of tropical precipitation**, which is still poorly understood, precipitation samples have been collected in the Niamey area (Niger) during the 2006 monsoon, as part of the AMMA (African Monsoon Multidisciplinary Analaysis) campaign. More specifically, we explore the influence of two kind of processes that can affect the isotopic composition of precipitation in this region (fig 1): convective processes and larger-scale processes. In this context:

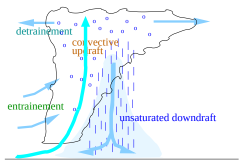
- event-scale samples were collected all along the monsoon season (from June to September 2006) at three sations (discussed in sections 1, 2 and 3)
- rainwater from convective systems passing over Niamey were sampled at high frequency (time step of 5 minutes minimum) in August and September 2006 (discussed in section 4).



Regional processes

The composition of the vapor feeding the convective systems depends on regional processes:

- large scale convective activity
- varying origin of air masses
- surface processes along low level trajectories of air masses



Convective processes

Many phase changes in convective systems (condensation, reevaporation of falling rain) modify the isotopic composition from the vapor feeding the system to the rain. The fractionations depend on physical and microphysical properties in systems. They are detailed in section 4.

Figure 1: Processes potentially affecting the isotopic composition in Niamey.

1) Isotopic evolution along the monsoon season

Figure 2 shows the evolution of $\delta^{18}O$ and d-excess along the monsoon season for an average over the three collected sites. The $\delta^{18}O$ suddenly drops and d-excess increases on the 15th of July, corresponding to the monsoon onset. The onset corresponds to a sudden northward shift of the ITCZ, bringing more convection at the Niamey latitude ([2]).
The shift in isotopic composition during the monsoon onset may be explained by the regional increase in convective activity: indeed, an idealised 1D model fitted with water isotopes reproduces this shift (pink line on fig 2), in agreement with the amount effect ([1]). The more intense the convective systems, the less reevaporation of falling drops, thus the lower $\delta^{18}O$ and higher d-excess in precipitation.

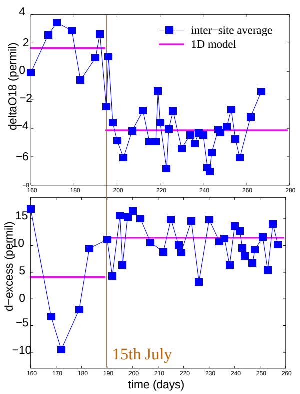
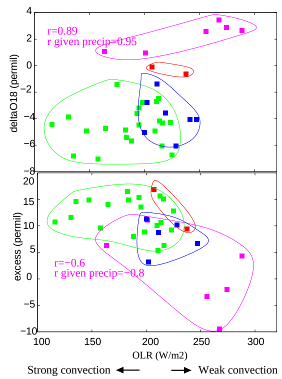


Figure 2: Evolution of isotopic composition of rain along the monsoon season (blue line). The pink line is the composition predicted by a 1D model forced to simulate the same precipitation amount in average as in the observations.

2) Link with local convection?

Figure 3 shows the isotopic composition of precipitation as a function of local convective intensity (measured by OLR), for two kinds of convective systems: isolated or organized.

- No link is visible on the event scale: the amount effect is only visible at longer time scales.
- There is a strong influence of the degree of organization of convcetive systems on the isotopic composition, especially before the onset.
- The isotopic composition of precipitation of isolated systems before the onset is controlled by local convective factors: convective intensity and in-situ precipitation amount. Probably these factors are important only before onset because regional convection is weak.



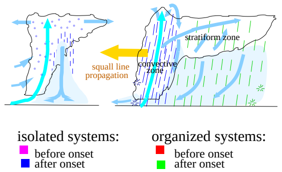


Figure 3: Isotopic composition of rain as a function of OLR, for two kind of convective systems:

- *isolated systems: develop over Niamey*
- *organized systems: mature propagating systems such as squall lines, with a trailing stratiform zone.*

3) Link with regional and integrated convection?

After the monsoon onset, organized systems show a maximum correlation with OLR when the OLR is integrated over the 9 previous days (figure 4a). At this time scale, the correlation is good over the whole Sahel (see figure 4b). Such a correlation correponds to a variability of the OLR at 9×2=18 days. Composite analysis on our isotopic data shows similarities with the intra-seasonnal variability documented by [3] and modulating sahelian convection at 15-20 days. Thus precipitation $\delta^{18}O$ after the monsoon onset primarily records intra-seasonnal atmospheric variability.

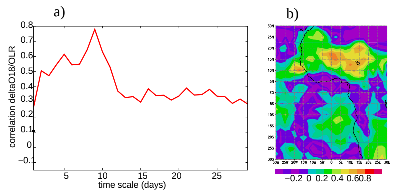


Figure 4: a) Correlation between $\delta^{18}O$ and OLR averaged over previous days. The number of precious days is in x-axis. b) Correlation between $\delta^{18}O$ and the OLR map averaged over the 9 previous days.

4) Isotopic evolution along squall lines

Since in the Sahel convective processes (condensation, rain reevaporation) are often spatially organized in squall lines, we use infra-event data to investigate the influence of convective processes on the isotopic composition. The different squall lines sampled feature a robust signature of the different part of the systems. The 11th of August squall line is shown in example (fig 5).

- Effect of condensation processes: in the stratiform part, the vapor has already been depleted by convective condensation and precipitation. Besides, precipitation removes efficiently heavy isotopes in the stratiform part because condensation is slower. $\delta^{18}O$ thus tends to decrease in the stratiform part.
- Effect of rain reevaporation: when reevaporation increases, $\delta^{18}O$ increases and d-excess decreases. Reevaporation is strong at the beginning of the squall line and in the pause zone, and increases along the stratiform part.

In return, the isotopic composition of precipitation might be used to better constrain the water budget in squall lines (fig 4c, with a crude model of condensation and rain reevaporation)

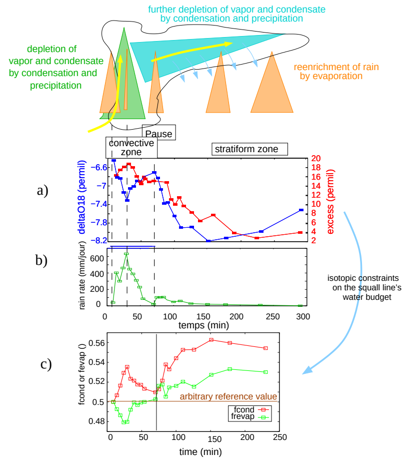


Figure 5: Evolution of isotopic composition (a) and precipitation rate (b) along the 11th of August squall line. (c) preliminary evaluation of the fraction of condensed vapor (fcond) and fraction of reevaporated vapor (frevap) using water isotopes.

Perspectives

- Isotopic simulations with LMDZ (the GCM developped at LMD/IPSL, in which we are introducing water isotopes) zoomed on the AMMA region could help us better disentangle the relative importance of convective and large scale processes.
- Coupling LMDZ with the land surface model ORCHIDEE (in which we are also introducing water isotopes) could allow an investigation of the influence of surface processes.
- To better understand and quantify the impact of convective processes in squall lines, we are developping a simple isotopic model of squall line.

References

[1] Dansgaard. stable isotope in precipitation. *Tellus*, 16:436–468, 1964.

[2] B. Sultan and S. Janicot. The west african monsoon dynamics. part ii: The 'preonset' and 'onset' of the summer monsoon. *Journal of Climate*, 16:3407–3427, 2003.

[3] B. Sultan, S. Janicot, and A. Diedhiou. The west african monsoon dynamics. part i: Documentation of intraseasonal variability. *Journal of Climate*, 16:3389–3406, 2003.

Grid (1 , 1)