Contribution of the triple oxygen isotope composition of precipitation to the identification of surface-atmosphere interactions in the sub-humid part of West Africa

VALLET-COULOMB, C.[1], ALEXANDRE A.[1], PEUGEOT C.[2], ALASSANE A.[3], GBEWEZOUN V. [3], COUAPEL M. [1], OUTREQUIN C.[1], OUANI T. [4], AFOUDA S. [4]

[1]*Aix Marseille Univ, CNRS, IRD, INRA, Coll France, CEREGE, Aix en Provence, France.*
[2] *Hydrosciences Montpellier, IRD, CNRS, Univ. Montpellier, Montpellier, France*
[3]*Laboratoire d'Hydrologie Appliquée, Institut National de l'Eau, Université d'Abomey-Calavi, Bénin*
[4] *IRD Bénin, 08 BP841 Cotonou, Bénin*

*This work is part of the **HUMI-17** – ANR project*

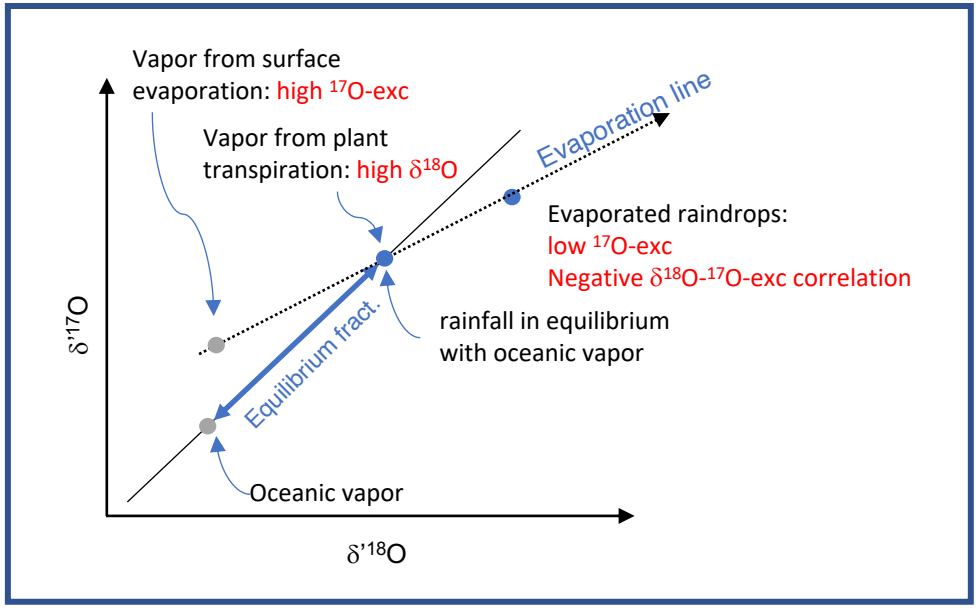
Rationale

- In West Africa, the Sudan Climate Zone (1200-1400 mm/year) plays a crucial role in regional water resource
- Surface-atmosphere interactions influence convective processes
  - Positive feedbacks between vegetation and rainfall evidenced in Sahel
  - What about the Sudan Climate Zone?
- Isotope tracers record the contribution of evapotranspirated moisture to precipitation

Rainfall and the triple oxygen isotope system

^{17}O-exc in precipitation reflects successive evaporation processes:

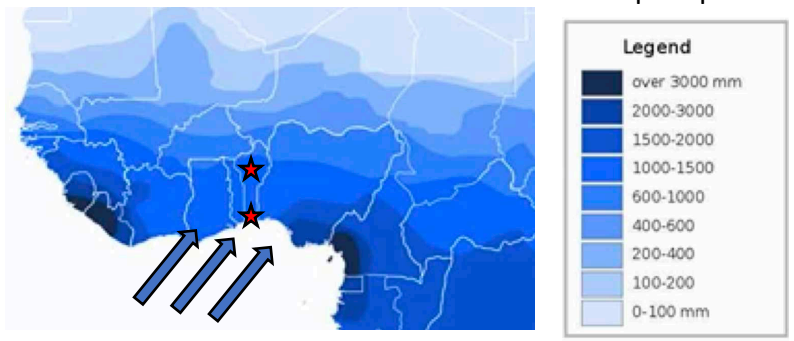
- Vapor formation over the ocean: ^{17}O-exc increase
- Raindrop evaporation in the atmosphere: ^{17}O-exc decrease
  ➟ Negative correlation between ^{17}O-exc and $\delta^{18}O$
- Contribution of continental vapor to precipitation: ^{17}O-exc increase
  ➟ high ^{17}O-exc and high $\delta^{18}O$



Ref: Landais et al. (2010) EPSL ; Luz & Barkan (2010) GCA; Uemura et al. (2010) GRL; Li et al. (2015) GCA; Uechi & Uemura (2019) EPSL; Tian et al. (2018) Sci. Rep.

Data acquisition

Annual precipitation



Monsoon carries similar oceanic moisture sources

Sampling

- **Inland station**: **Djougou** (AMMA-Catch site) :
  ≈ 3 samples/week since April 2018
- **Coastal station**: **Cotonou** (Université Abomey Calavi)
  ≈ 1 sample/week since June 2018

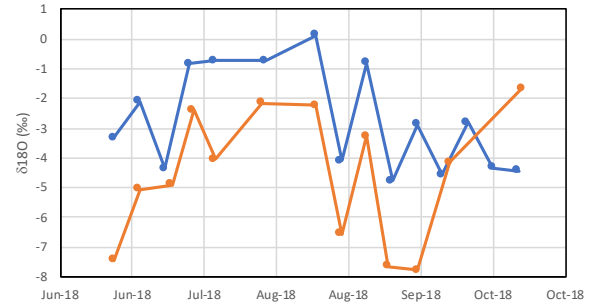
Analyses

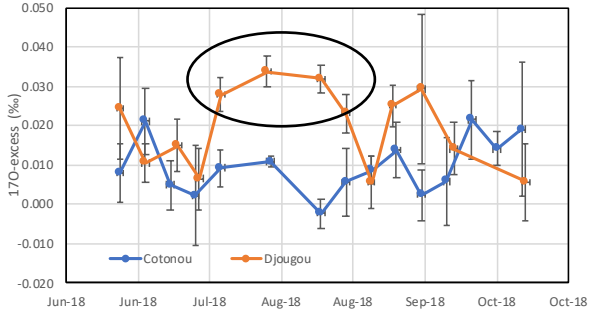
- WS-CRDS Picarro L2140-i, 3 replicates per sample
- Long-term precision, defined as the SD of a QC sample over 17-months of routine measurement:

	$\delta^{18}O$	$\delta^{2}H$	^{17}O-exc
Long-term precision (‰)	0.03	0.19	0.008

Results #1: comparison between the two locations

Weighted averages 2018 (‰)	$\delta^{18}O$	$\delta^{2}H$	^{17}O-exc	d-exc
Coastal station	-3.41	-14.91	0.014	12.40
Inland station	-4.21	-22.35	0.023	11.31





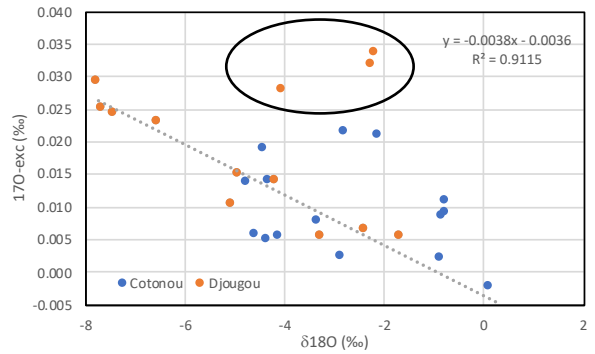
Weekly times series during the common period

$\delta^{18}O$

- Similar seasonal variations
- Lower $\delta^{18}O$ at the inland station
  ➞ continental effect (Rayleigh)

$\delta^{17}O$-exc

- Positive ^{17}O-excess anomaly at the inland station (July 17th- Aug 19th)
  ➞ Contribution of moisture produced by surface evaporation

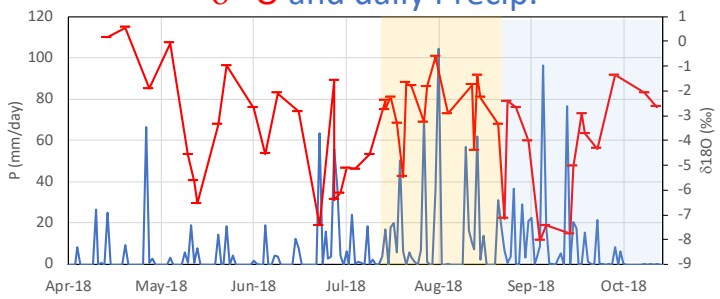


Relation ^{17}O-exc - $\delta^{18}O$ during the common period

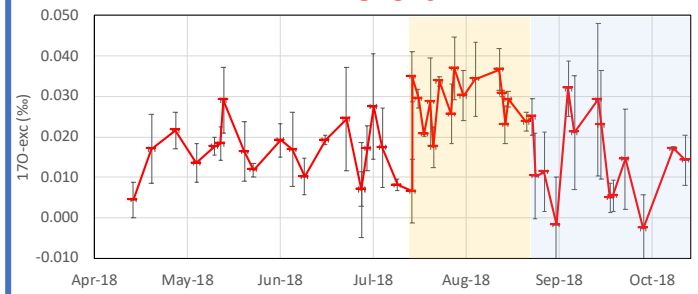
- Negative correlation at the inland station, except July 17th-Aug. 19th
  ➞ raindrop evaporation in the atmosphere
- No clear relation at the coastal station

Results #2: seasonal evolution of the monsoon at the inland station

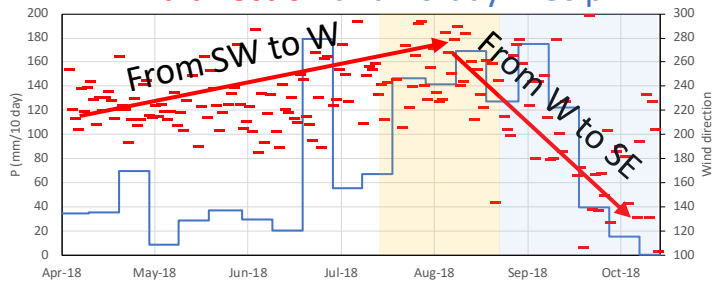
$\delta^{18}O$ and daily Precip.



^{17}O-exc



wind direction and 10-day Precip.



Heart of the monsoon (Jul 17th – Aug 19th)

- high ^{17}O-exc and $\delta^{18}O$
- Wind direction suggests longer continental trajectories
- Maximum rainfall (cumul and intensities)

Last period of the monsoon (Aug. 20th- Sep. 30st)

- low $\delta^{18}O$ compositions points to deeper convective activity
- Negative correlation between ^{17}O-exc and $\delta^{18}O$ ($r^2 = 0.54$)
- Wind turns to South-East
- Decreasing rainfall intensity

Conclusions and perspectives

^{17}O-exc *vs* $\delta^{18}O$
a tracer of surface – atmosphere interactions

- Shows that evapotranspiration moisture may contribute to rainfall in a sub-humid Sudan Climate area
- Need to include water recycling in regional water balance studies

^{17}O-exc *vs* $\delta^{18}O$
a tracer of raindrop evaporation

- Raindrop evaporation associated to deep convection and low $\delta^{18}O$
- Input for understanding convective processes