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Interactive comment on “Stable isotope record of Eemian seasonal temperature from MIS 5e tufa stromatolite; Somme Basin, Northern France” *by* J. Dabkowski et al.

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The authors are grateful to the first anonymous referee for his comments on our manuscript “Stable isotope record of Eemian seasonal temperature from MIS5e tufa stromatolite; Somme Basin, Northern France”. We are waiting for the second review to fully answer this comment but we would like to respond to the main point of discussion raised by the first referee. He asserts that our “discussion is based on unrealistic assumptions regarding to the stable isotope system” and that “kinetic fractionation and seasonal changes in the isotope composition [but not the temperature] of water are expected to be major variability contributors in the tufa system here described”. We discuss these issues below.

Kinetic fractionation: Statistical correlation between carbon and oxygen stable isotopes can be a strong indicator of kinetic fractionation in carbonate systems, particularly speleothems and lakes. However, these types of covariations have been frequently observed in tufa records, including modern systems where equilibrium (or near equilibrium) conditions have been demonstrated. On the sub-annual time-scales of interest here, the relative effects of seasonal soil-air contribution (Hori et al. 2008), CO2 degassing and upstream/in-aquifer calcite precipitation (Ihlenfeld et al., 2003) are probably the most important contributors to the variability in δ13C. For example, in a modern Japanese tufa system Matsuoka et al. (2001) showed strong δ13C covariation between calcite and dissolved inorganic carbon δ13C (δ13CDIC). They demonstrated that δ13CDIC is dependent on degassing/calcite precipitation (prior calcite precipitation - PCP) phenomenon in the aquifer. These effects can be stronger in winter when the atmospheric air temperature is cooler (and so denser) and thus its contrast with aquifer air temperature is more important. The induced ventilation decreases the in-aquifer pCO2 favouring degassing and PCP. Increased PCP in winter implies that δ13CDIC (and so tufa calcite δ13C) should increase under cooler conditions (Matsuoka et al., 2001).

The referee also suggests that these types of tubular stromatolites are “typically found in pools, where water flow is restricted [. . .] and evaporation is enhanced in comparison to other environments”. This typically happens in the downstream sections of valleys, at the edges of channels, along very low or zero slopes. Tubular facieses are then generally associated with fine detrital sediment and organic components.

However, in the studied sector (S2, excavated in 2005), the Caours tufa formation is mainly composed of massive white to light grey units with very little detrital content. These units are widely extended (tens m^2) and prograde parallel to the slope. Such configuration characterise spring tufa formations (Casanova, 1981; Weisrock, 1981). Small channels (0.5 to 1 m width) run through the tufa from the base of the slope to the palaeo-Scardon valley (Antoine et al., 2006). The studied tubular stromatolite was sampled at the top of one of these small channels, and we will make this clearer in the revised manuscript. The tufa stromatolite formed contemporaneously with extensive coarse massive tufa units (Discussion paper, Fig. 1B). Most of these crumbly massive tufa facies and tubular stromatolites are built by the same fossil taxa Broutinella sp., which always grows in water and is associated with aquatic molluscs and ostracodes (Freytet, 1998; Dabkowski et al., 2010). The facies associations thus demonstrate a constant presence of water flowing along the slope from springs at the time of the studied stromatolite precipitation. Regarding the water dynamics, it is our interpretation of the facies association that the tubular facies did NOT form in pools, deep enough or sluggish enough to allow much evaporation. Therefore we infer that the studied Caours stromatolite isotopic composition reflects the composition of water at the time of precipitation (discussed below) depending on water temperature. This interpretation is entirely consistent with the consensus view of these types of tufa systems, based on modern and ancient studies (e.g. as reviewed in Andrews 2006).

Oxygen isotope composition of the water: The Caours fossil tufa is located in the Scardon valley, a Somme River small tributary about ten kilometers long. In the studied sector (S2, excavated in 2005), the Caours formation shows tufa facies and a stratigraphical configuration which clearly indicate that water precipitating tufa came mainly from springs on the slope and not from the palaeo-Scardon river (see above). In the Caours area, the bedrock is an Upper Turonian chalk formation, which forms the main aquifer in the Northern edge of the Paris Basin. As a calcareous, porous, non-karstic aquifer, mainly supplied by rainwater, chalk provides seasonally smoothed groundwater (Darling et al., 2003), which feed resurgences in valleys. In those conditions, seasonal δ18O variations observed in the Caours stromatolite are very unlikely to reflect seasonal variations of the isotopic signal of recharge even if this variation does exist.

Clear variations of the monthly mean δ18O of precipitations are actually recorded at the nearest GNIP stations with available data (Global Network of Isotopes in Precipitations; IAEA/WMO, 2006; Tab. 1). At Liège (Belgium), Brest and Orléans (France), maximal δ18O values are observed during summer months (June or July) whereas minima occur in winter time (in December or January; Tab.1). This part of continental Northwestern Europe experiences a temperate oceanic climate with annual precipitation around 650-750 mm, distributed quite uniformly through the year with a slightly higher recharge in Oct-Nov-Dec. Typical rainfall monthly amounts in Abbeville (4km near Caours) illustrate this pattern (Tab. 2). If seasonal changes in the isotope composition of water were to be the main factor influencing the isotopic record of our tufa system, isotopically light values would reflect the light composition of rainfall recharge especially during winter time. This is not consistent with the Caours stromatolite δ18O values, which range between -6.35 and -4.18‰ (mean value: -5.18‰ Discussion paper, Tab. 1). Additionally, "winter" conditions, indicated by lower δ18O values, would have to be associated with large elongated calcite crystals of Microfacies I assigned by us to "summer" conditions, based on comparative microfacies analysis. We accept that we will need to discuss these points more clearly in the paper, but feel they address the concerns of the referee.

Therefore, we infer that both kinetic fractionation and water isotopic composition are very unlikely to contribute significantly to the isotopic variations recorded in the Caours tufa stromatolite. We maintain our initial interpretation of the isotopic signal as a record of seasonal variations of water temperature, which is consistent with all previous studies of these types of tufa stromatolites.

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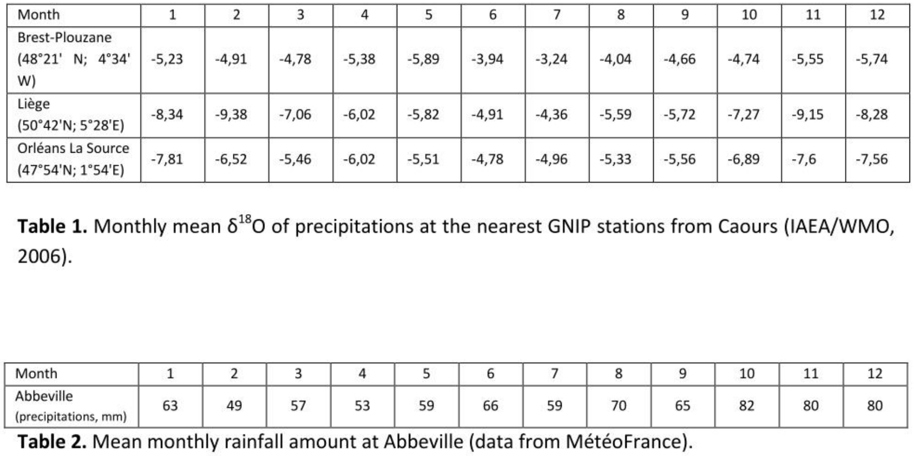

Month	1	2	3	4	5	6	7	8	9	10	11	12
Brest-Plouzane (48°21' N; 4°34' W)	-5,23	-4,91	-4,78	-5,38	-5,89	-3,94	-3,24	-4,04	-4,66	-4,74	-5,55	-5,74
Liège (50°42'N; 5°28'E)	-8,34	-9,38	-7,06	-6,02	-5,82	-4,91	-4,36	-5,59	-5,72	-7,27	-9,15	-8,28
Orléans La Source (47°54'N; 1°54'E)	-7,81	-6,52	-5,46	-6,02	-5,51	-4,78	-4,96	-5,33	-5,56	-6,89	-7,6	-7,56

Table 1. Monthly mean $\delta^{18}O$ of precipitations at the nearest GNIP stations from Caours (IAEA/WMO, 2006).

Month	1	2	3	4	5	6	7	8	9	10	11	12
Abbeville (precipitations, mm)	63	49	57	53	59	66	59	70	65	82	80	80

Table 2. Mean monthly rainfall amount at Abbeville (data from MétéoFrance).

Fig. 1. Tables 1 and 2