

Contribution of dissolved gases to understand groundwater flows in a Mediterrean karstic system (Thau lagoon area, Montpellier, France)

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Introduction

Coastal and thermal karstic hydrosystem of the Thau basin (South of France) is a **strategic resource** for **drinking water supply** and **economic development** with the thermalism (Balaruc-les-Bains spas) and the shellfish aquaculture (Thau Lagoon). **Three different groundwater bodies converge** in this area (Ladouche et al., 2012) : shallow karstic water, warm mineralized thermal water and mineralized marine water (Thau lagoon and/or seawater).

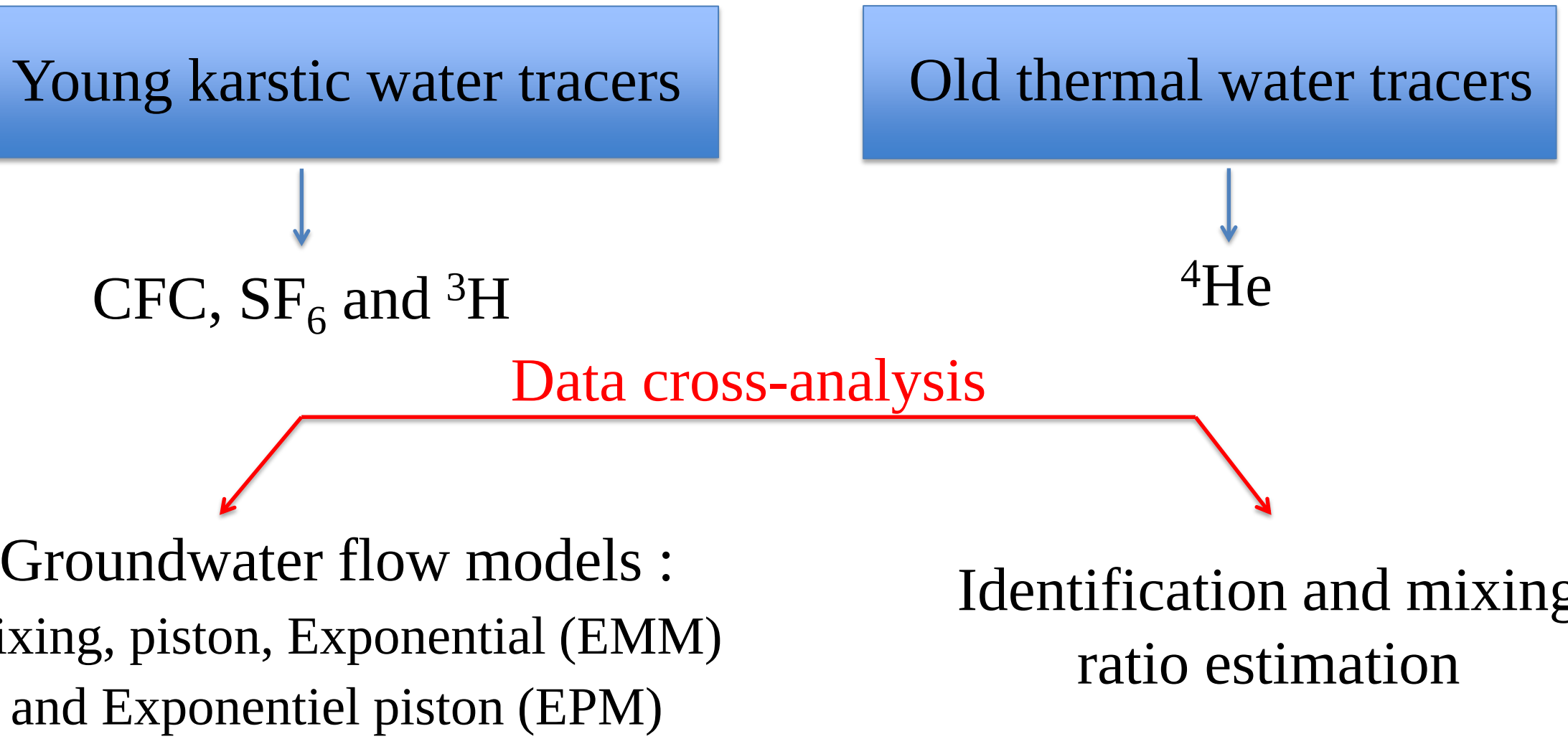
In addition, occasional and localized **saltwater intrusions** occur through a submarine spring (Vise) which impacts the quality of groundwater. In such complex system, a thorough **understanding of groundwater flow** and **mixing** is needed for a **suitable management** of the water resource.

A first estimation of mixing and residence time in the system was proposed in 2002 (Aquilina et. al). Since this date, three saltwater intrusions occurred through the Vise impacting the Thau groundwater. A new sampling campaigns was carried out in 2018 in the framework of the Dem'Eaux Thau project to follow the mixing and residence time evolution in the system and specify groundwater flow models.

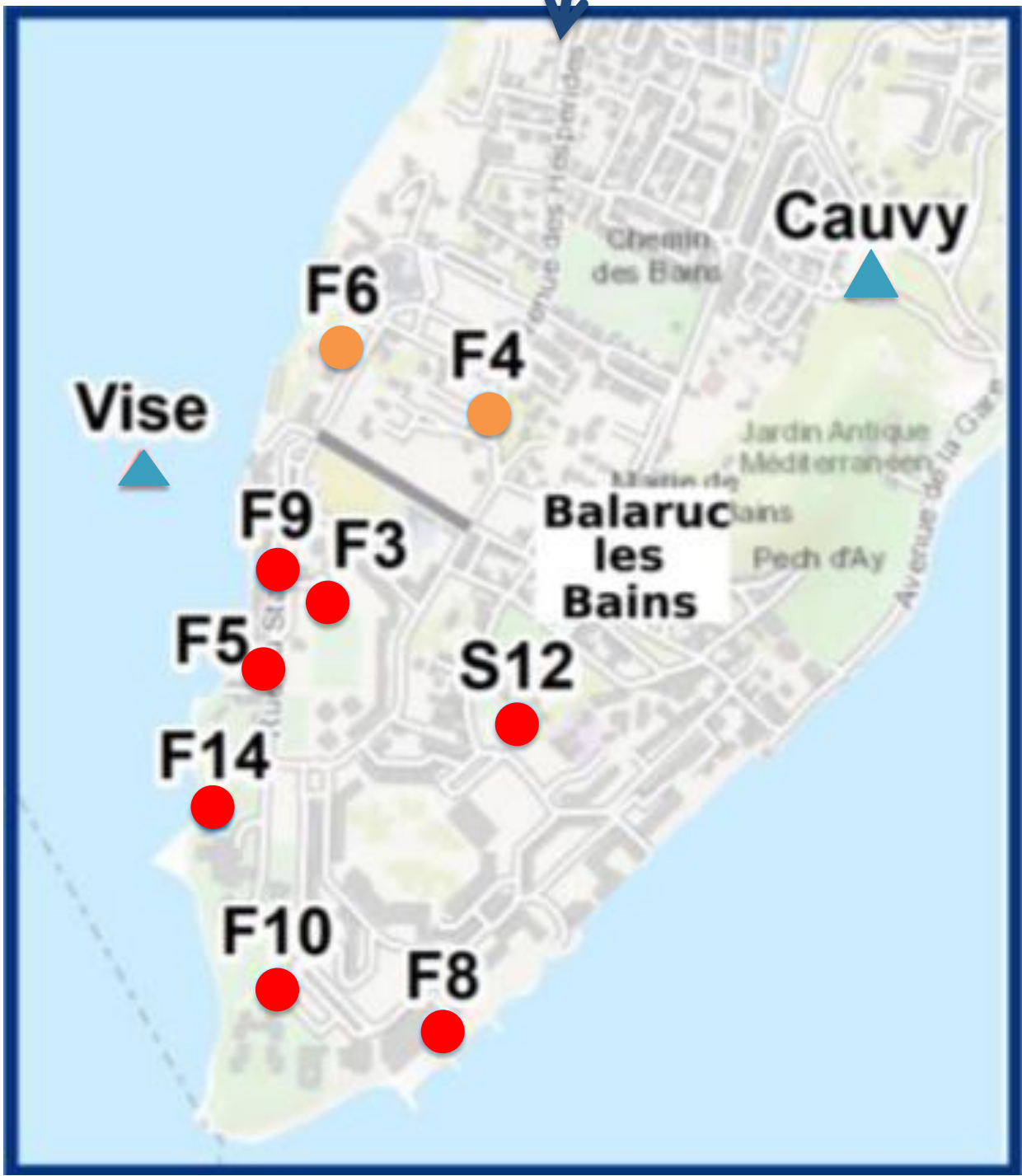
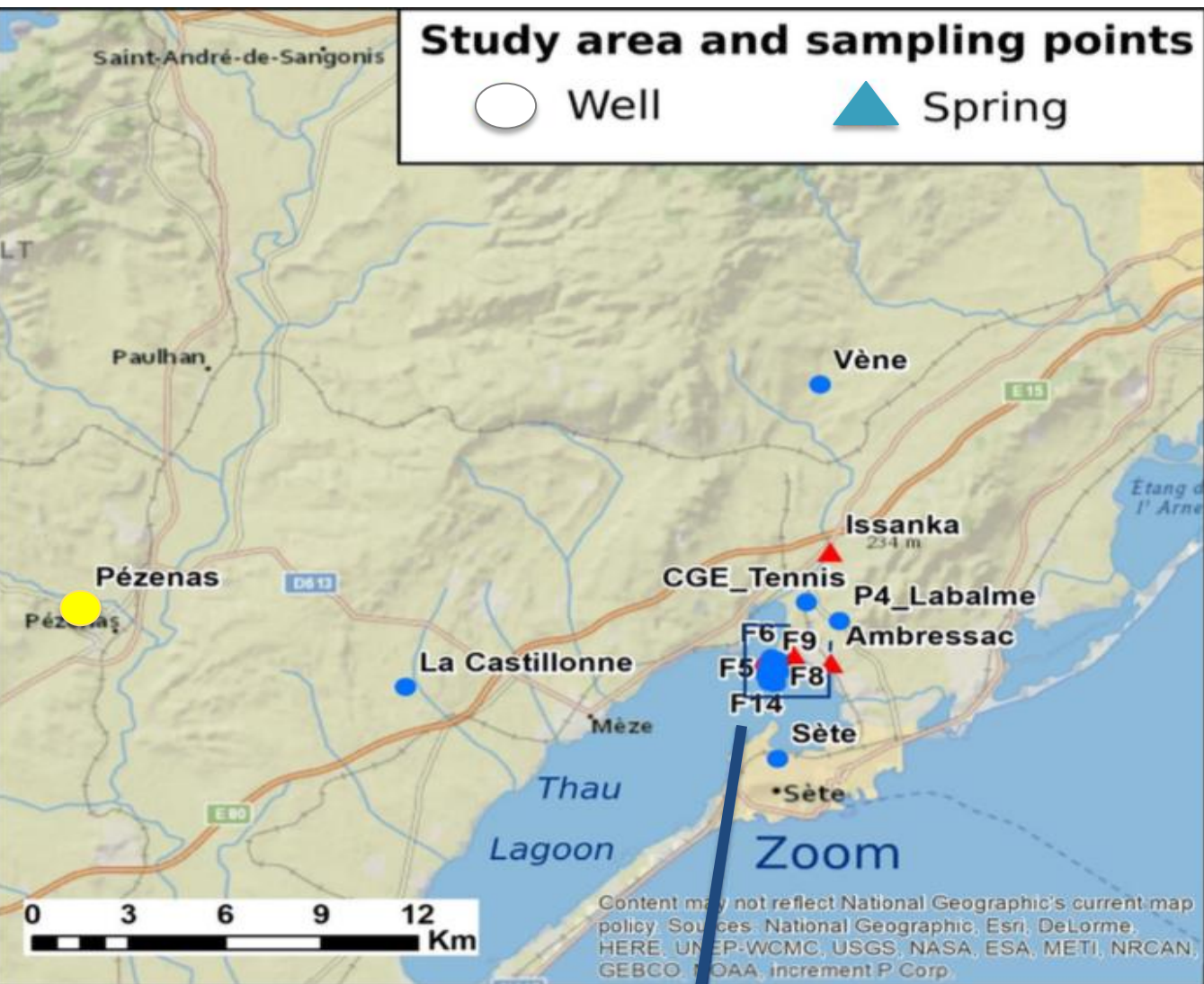
Tools and methods

- Selection of 18 springs and wells on the Thau basin for groundwater sampling.
- Sampling of major and trace elements, water isotopes, noble gases, CFC and SF₆, ⁴He and ³H during base flow (Aug. 2018).
- Gas Analyses conducted by CONDATE Eau analytical platform, University of Rennes. Major and trace elements analysed by the AETE analytical platform, University of Montpellier.

Dissolved anthropogenic gases (**CFC, SF₆**) and **³H** were used to define **young karstic water** (< 60 years). Helium (**⁴He**) accumulation was used to identified **old thermal water** (Plummer and Friedman, 1999).



References :
 Aquilina et al. (2002), Chem. Geol. 192, 1-21; Ladouche et al. (2012). AIH Conference, Cassis (France) ;
 Pétré M.A., et al. (2018). Eurokarst Conference, Besançon (France) ;
 Plummer L.N. and L.C. Friedman. (1999). *USGS Fact Sheet* 134-99.

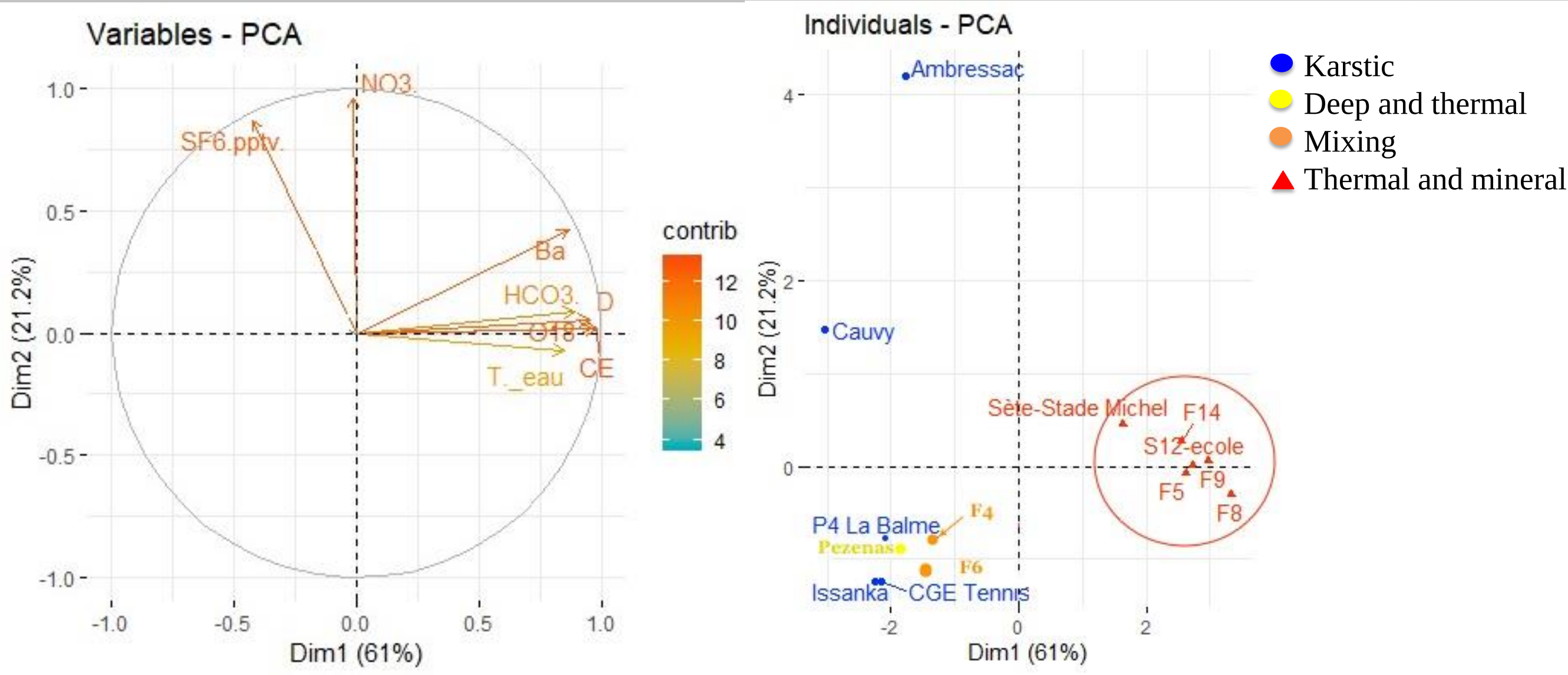


Modified from Pétré et al., 2018

Results

1. Principal Component Analysis (PCA)- Well geochemical characterization

- 4 groups characterised by temperature, specific conductivity and SF₆ concentrations :

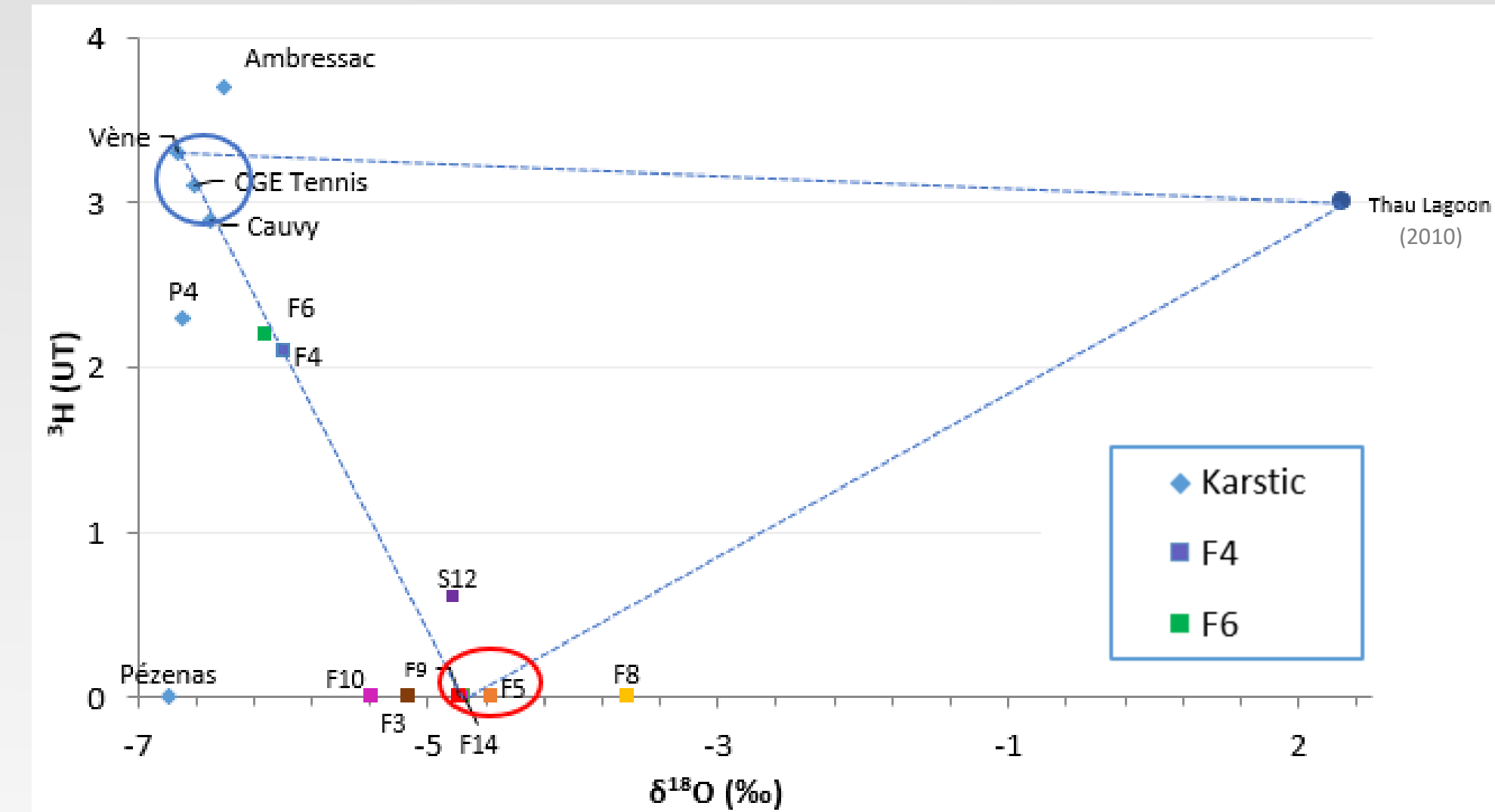


- Thermal and mineral water (S12, F5, F8, F9, F14)
- Mixing water (F4, F6)
- Karstic water (CGE, Cauvy, Vene, P4, Issanka and Ambressac)
- Deep and thermal freshwater (Pezenas)

	Thermal	Mixing	Karstic	Deep freshwater
Temp. (°C)	41.6	23.1	17.2	35.9
Sp.Cond. (µs/cm)	20 292	8 954	926	563
SF6 (pptv)	0.0-1.5	1.4 – 3.2	1.2 – 10.1	0.0 - 1.5

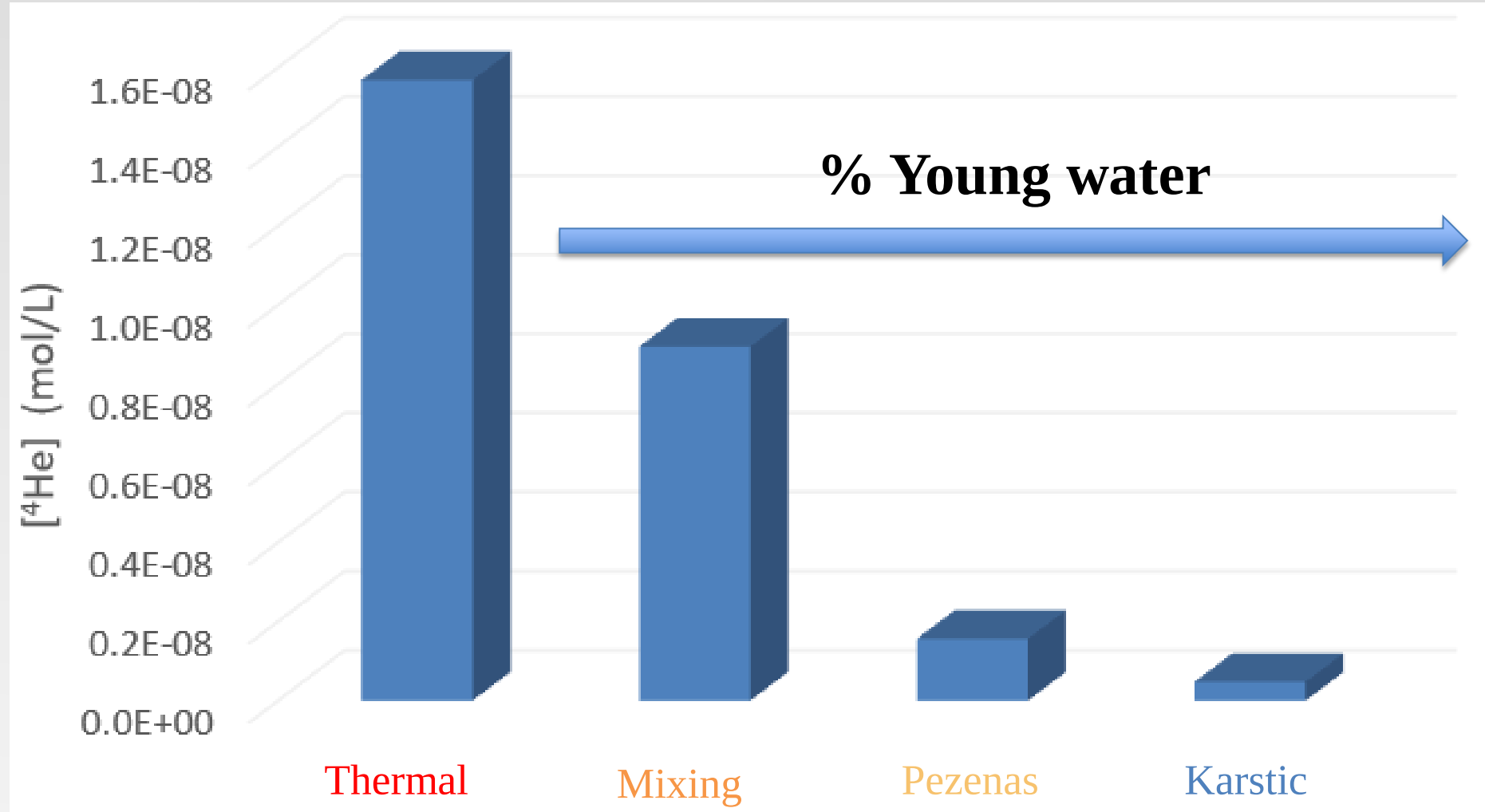
2. Mixing ratio between thermal and karstic end-members considering different dating tracers

- ³H/¹⁸O : Mixing ratio estimation at F4 and F6, but can not discriminate “old” water
- ⁴He : discriminates old thermal from deep freshwater end-member

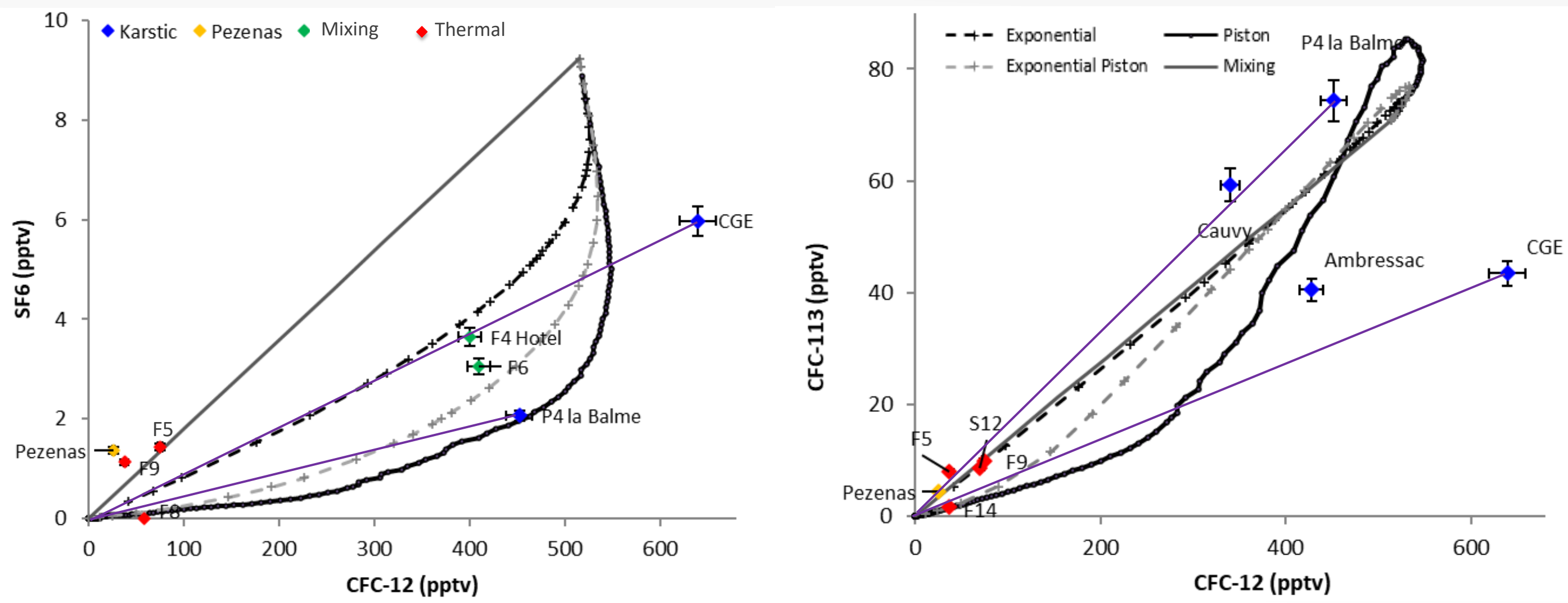


	Thermal (%)		Karstic (%)	
	⁴ He	³ H	⁴ He	³ H
F4	32.0	36.4	68.0	63.6
F6	13.0	33.3	87.0	66.7

- F6: different mixing ratio depending on the tracer
- Proportion from ⁴He in better agreement with previous studies (2002)



- Groundwater flow models: 2 binary mixing models



- Similar signature for deep freshwater and thermal water : old water (> 60yrs).
- Contaminated CFC-12 value for some karst samples (eg.CG).
- F5, F9: binary mixing between an old end-member (thermal water) and a slight fraction of **uncontaminated recent water** (<10%) similar to 2002.
- F4, F6: binary mixing between an old end-member (thermal water) and **contaminated karstic water** (CGE type).

Conclusion

Four geochemical groups were identified, one of which corresponds to a mixing between Thermal and Karstic groups. Contrary to ³H or CFC, ⁴He discriminates old Thermal water from Deep freshwater. Dissolved gases show that binary mixing flow models dominate but with two different karstic end-members. North of the Balaruc area, recent karstic water presents anthropogenic gas contamination. South of the area, the thermal water is preserved from these karstic flows influenced by anthropogenic contamination. Further investigations will be carried for high flow conditions and at the Vise spring to confirm these hypothesis.

