USING HYDROGEOLOGICAL DATA AT SCHOOL

FABRICE MOURAU [1,2]

GIUSEPPE PATTI [3]

1 : MIDDLE-SCHOOL “COLLÈGE PIERRE DE COUBERTIN”, LE LUC (FRANCE)

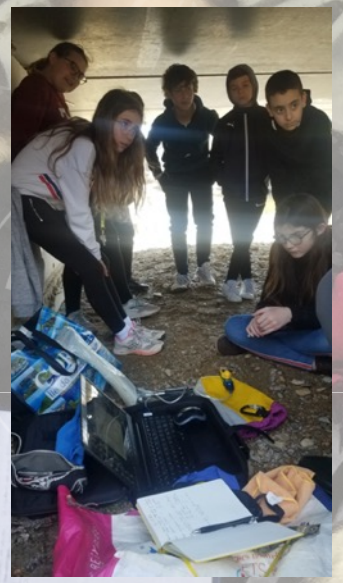
2 : EDUMED OBSERVATORY, IDEX-UCA[JEDI], EDUCATION & OUTREACH CELL – UMR GÉOAZUR (UCA, OCA, CNRS, IRD)

3 : HIGH-SCHOOL “LICEO ARCHIMEDE”, ACIREALE (ITALY)

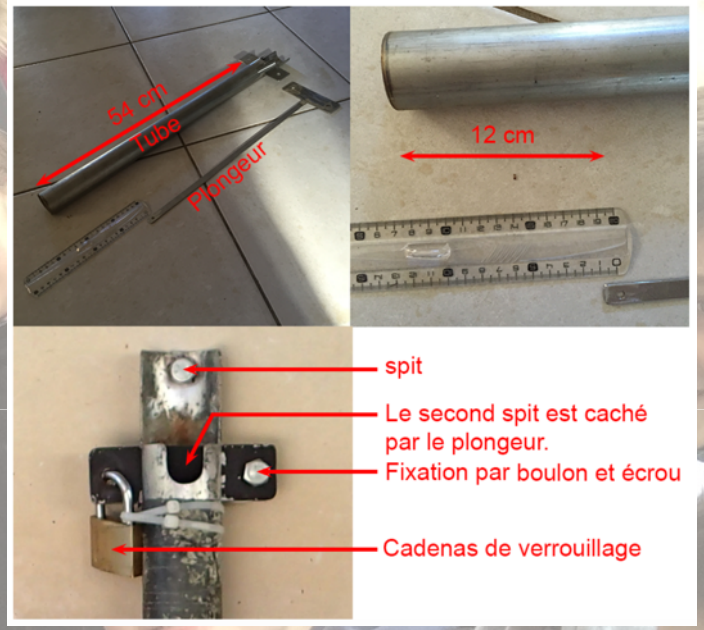
Groundwater :

Learn to preserve the European underground environment

Picture : F. Mourau, February 2018



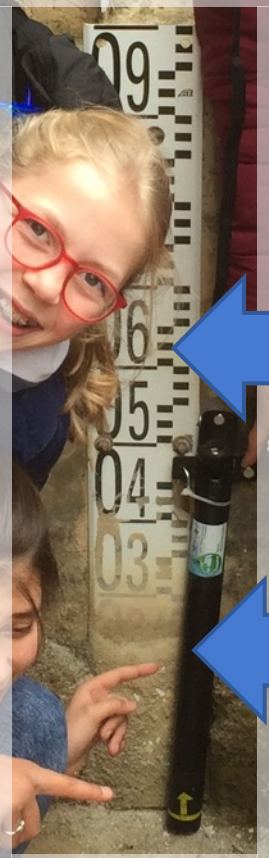
The EduMed Observatory allows to operate sensor with pupils



Water level Gauge

Operated by the city council

Picture : F. Mourau, january 2016



Water level Gauge

Water level probe

Operated by the pupils !!!

Picture : F. Mourau, january 2016


Issole river
Totally dry

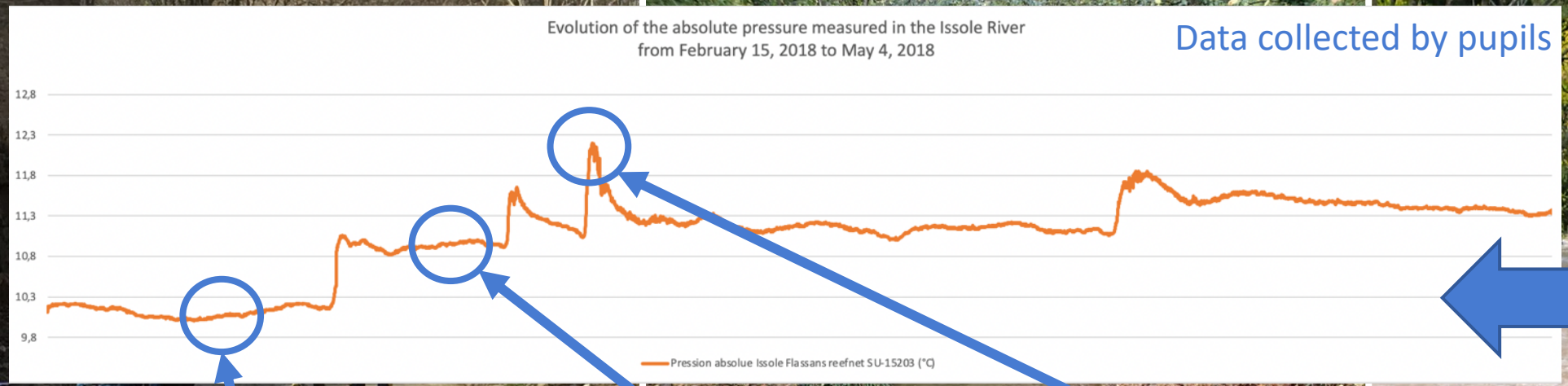

Normal flow


Flooding discharge

Biodiversity

Water ressource

Risk



Data collected by pupils

Water level probe

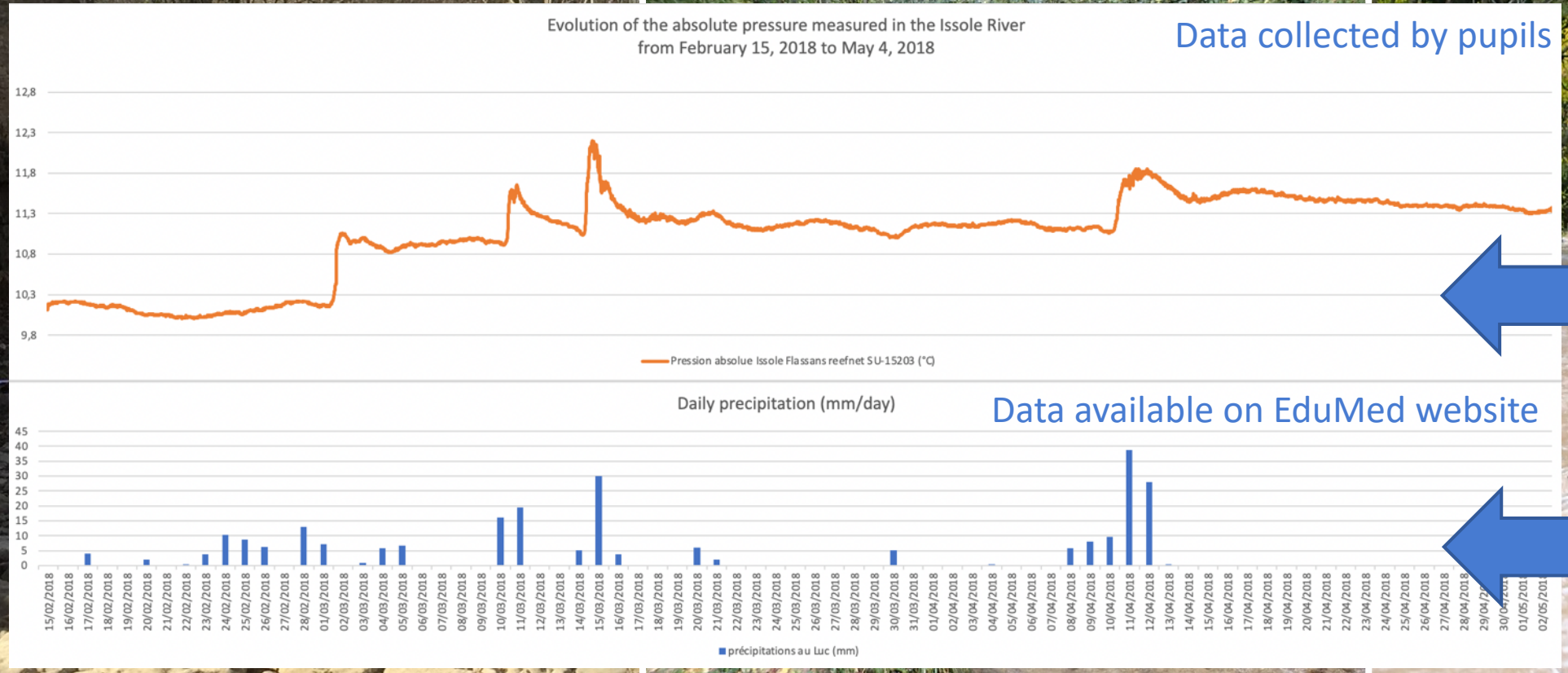
Totally dry

Normal flow

Flooding discharge

ATMOSPHERE

HYDROSPHERE



Data collected by pupils

Water level probe

Data available on EduMed website

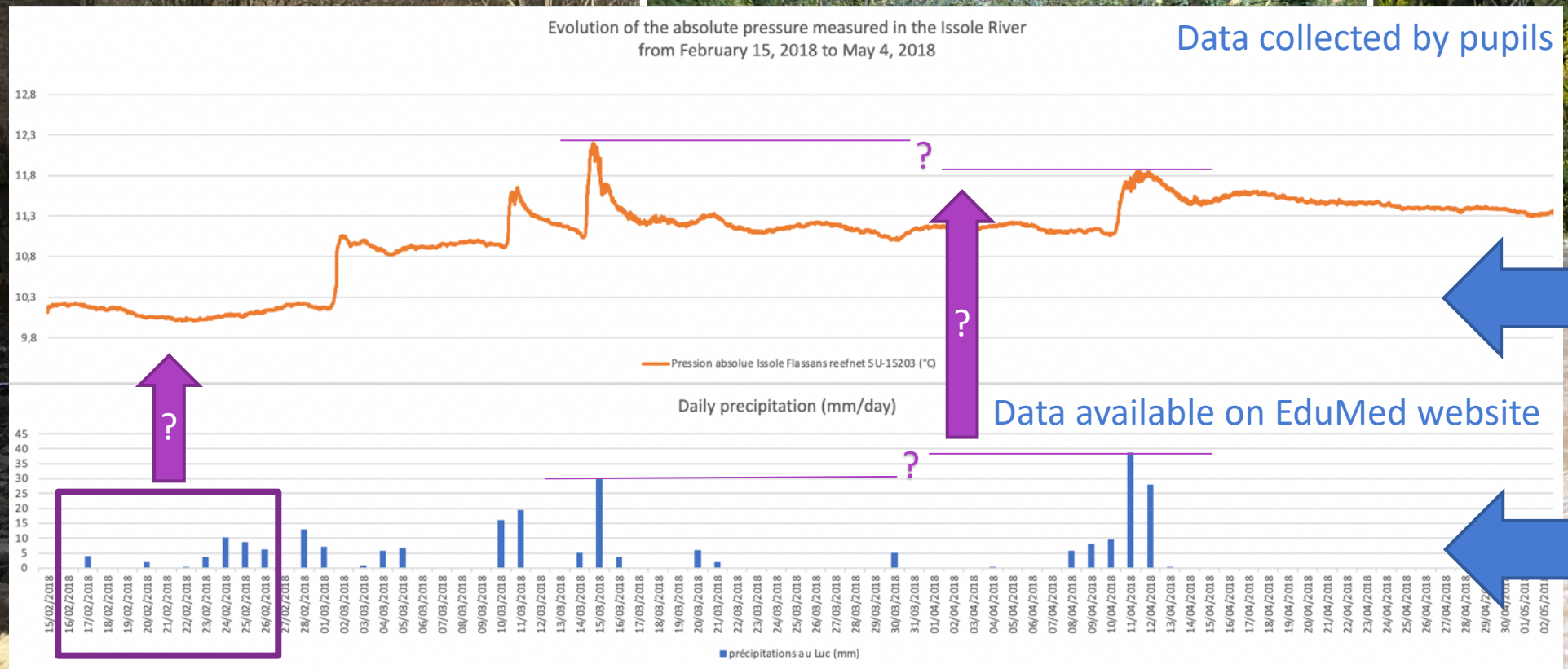
Weather station

What are the links between rainfall and water levels?

ATMOSPHERE

?

HYDROSPHERE



Data collected by pupils

Data available on EduMed website

Water level probe

Weather station

Not simply the rain…

RAIN

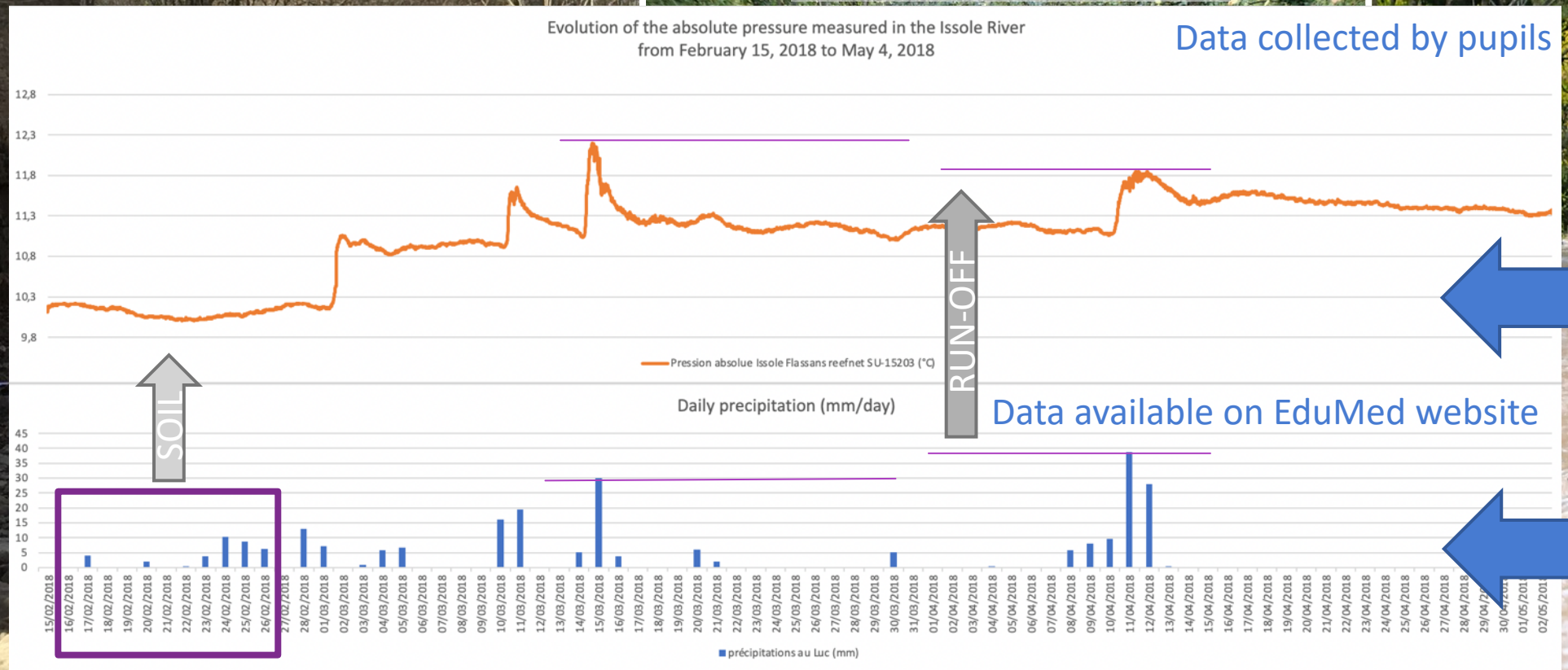
ATMOSPHERE

ROCKS

LITHOSPHERE

RIVER

HYDROSPHERE



Data collected by pupils

Data available on EduMed website

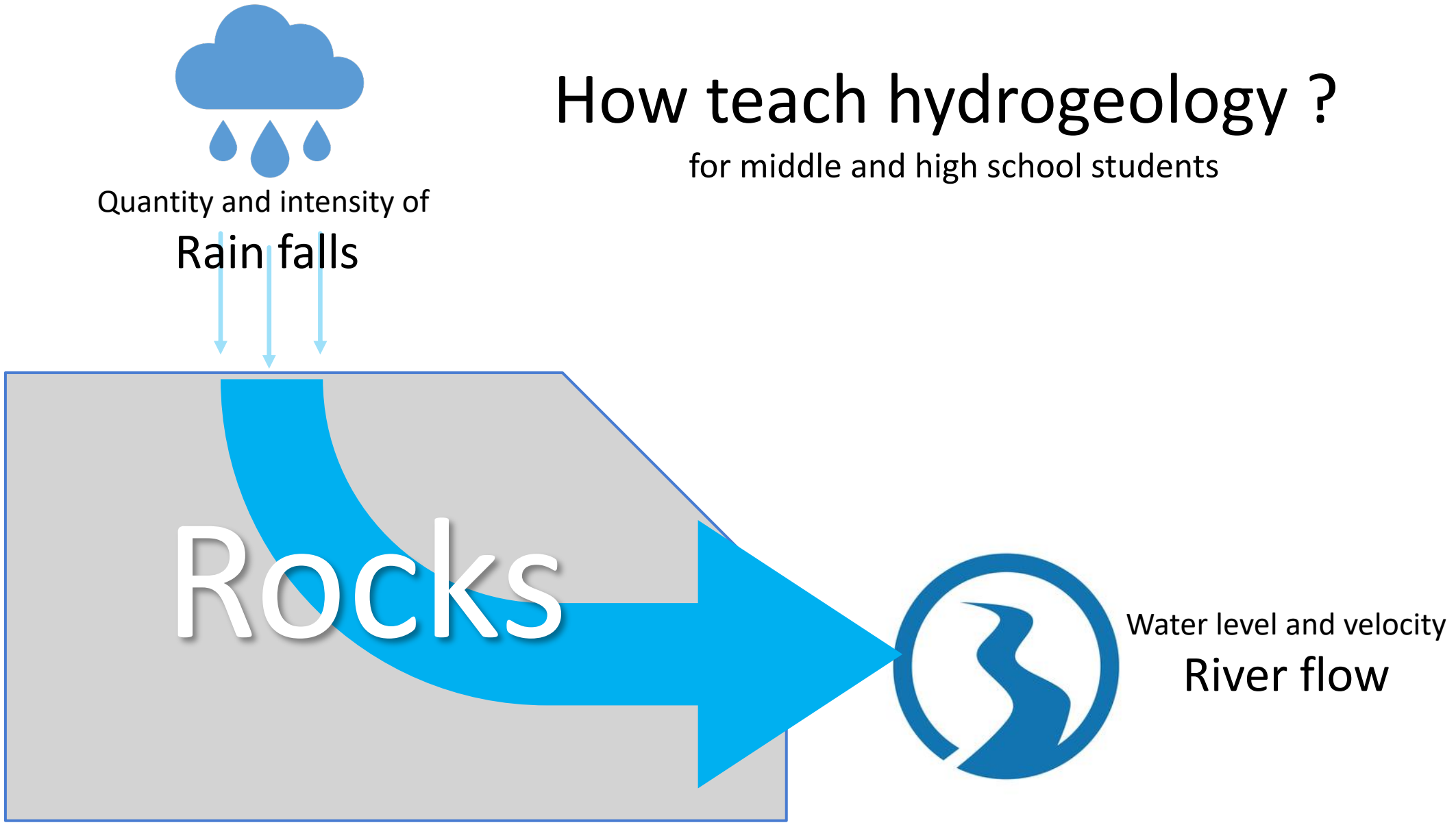
Water level probe

Weather station

HYDROGEOLOGY AT SCHOOL

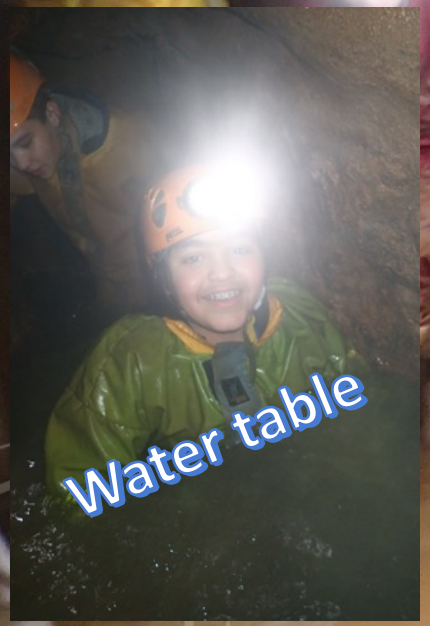
How teach hydrogeology ?

for middle and high school students



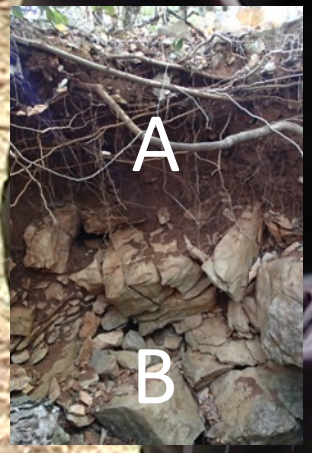
1. On (under) the field.
   - Without drilling, boreholes or pits, karstic areas allows to directly observe groundwater, water table, aquifers…

AQUIFER



Groundwater

1. On (under) the field.
   - Without drilling, boreholes or pits, karstic areas allows to directly **observe** groundwater, aquifers, soil (A), rocks (B), impluviums (C), rivers (D), water reservoirs (E) and springs (F).



E

How teach hydrogeology for middle and high school students ?

1. On (under) the field.
   - Without drilling, boreholes or pits, karstic areas allows to directly **observe** groundwater, aquifers, soil (A), rocks (B), impluviums (C), rivers (D), water reservoirs (E) and springs (F).
   - Make measurements :
     A. temperature, conductivity, water level of groundwater (A & B), springs (C), rivers (D) and Mediterranean sea (E).

D

Picture : JR Gachon, 2018

How teach hydrogeology for middle and high school students ?

1. On (under) the field.
   - Without drilling, boreholes or pits, karstic areas allows to directly **observe** groundwater, aquifers, soil (A), rocks (B), impluviums (C), rivers (D), water reservoirs (E) and springs (F).
   - Make measurements :
     A. temperature, conductivity, water level of groundwater (A & B), springs (C), rivers (D) and Mediterranean sea (E).
     B. Present and past Current flow rate by dilution of a saline tracer (F) or scallops measuring (G)


F

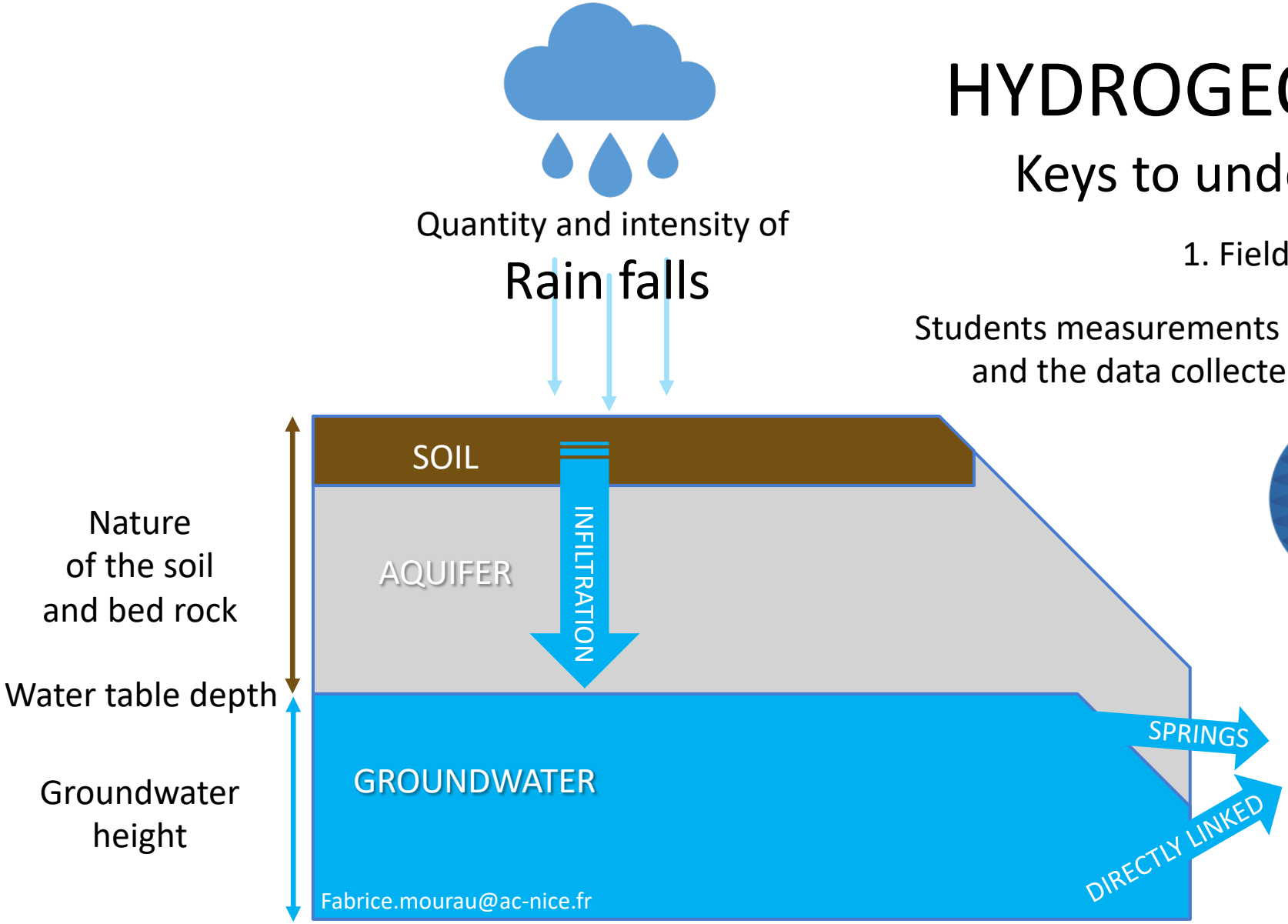
G

HYDROGEOLOGY AT SCHOOL

Keys to understanding water issues

1. Fieldworking : observations and measures

Students measurements are completed by the EduMed Data-center and the data collected by the « Eaux souterraines » network



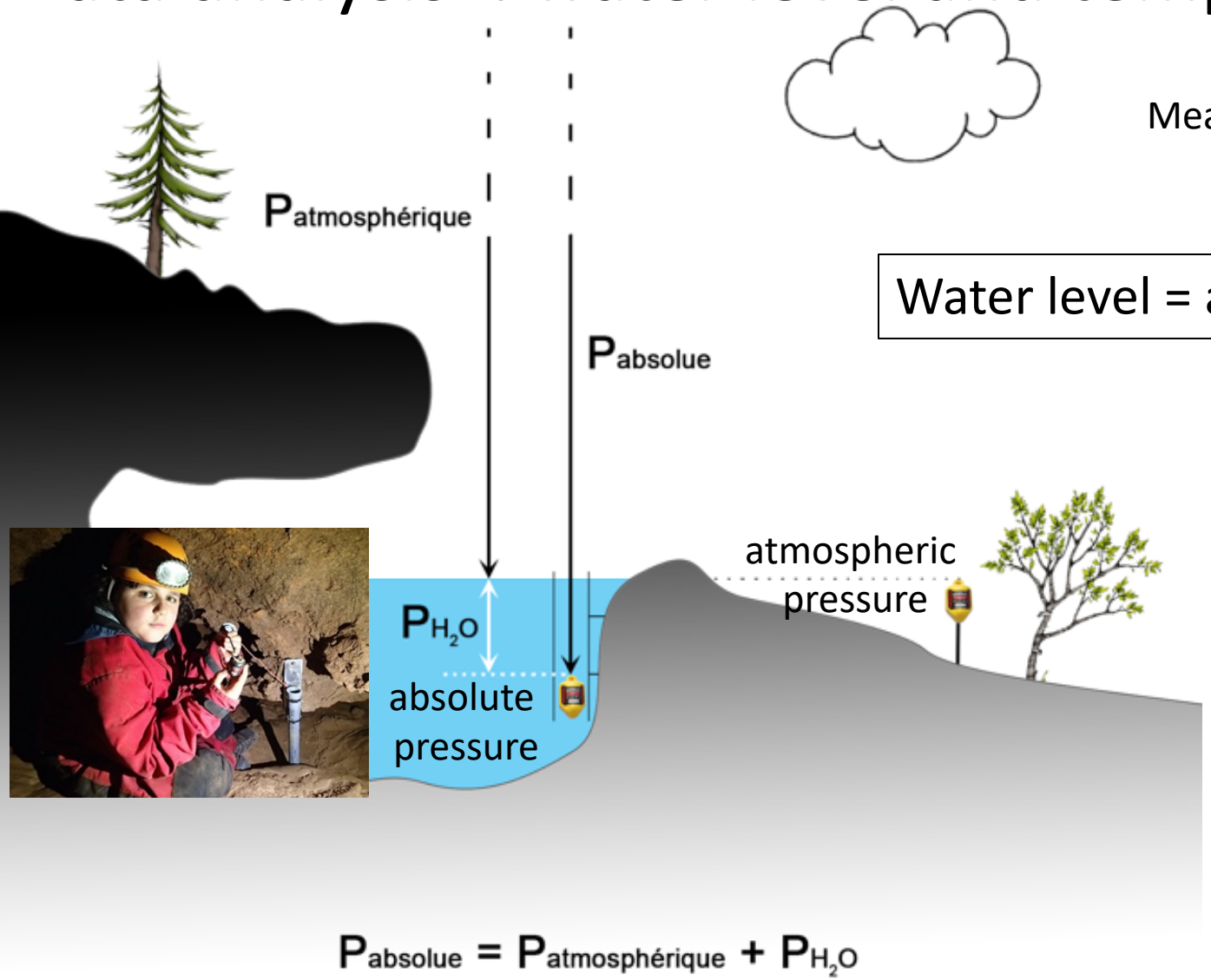
EDU MED

EAUX SOUTERRAINES

Water level and velocity

River flow

Data analysis : water level and temperature



Measures realized with a sampling rate of 15 minutes

Water level = absolute pressure – atmospheric pressure

$$P_{absolue} = P_{atmosphérique} + P_{H_2O}$$

Using pressure sensors to measure water level

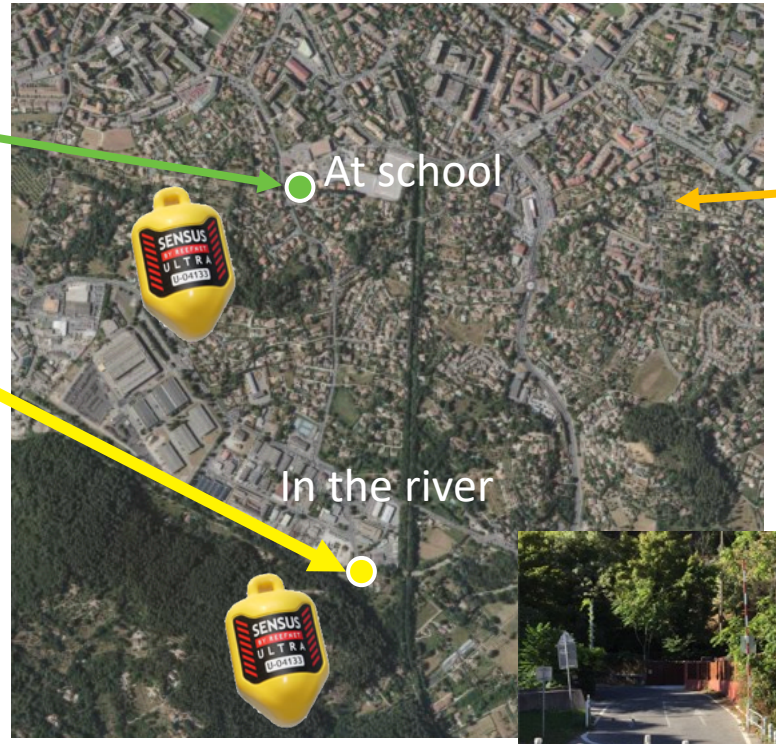
Fabrice.mourau@ac-nice.fr

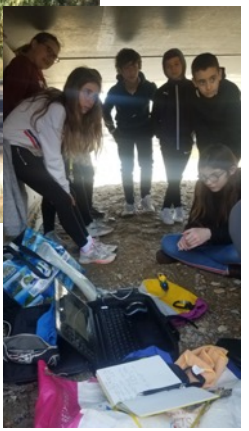
Probe Sensus Ultra
From Reefnet :
temperature and
pressure sensor
(reefnet.ca)

Data analysis : water level and temperature

=C2-E2

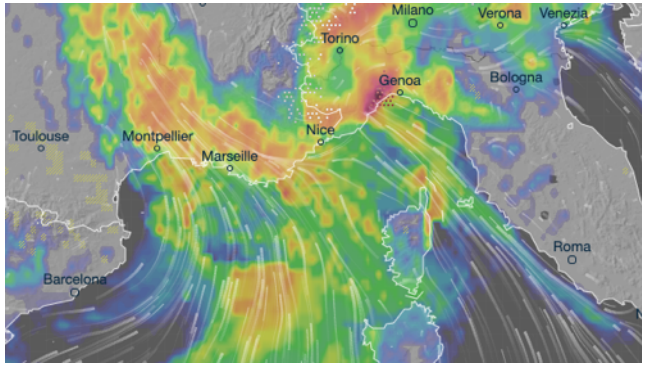
	A	B	C	D	E	F
1	Date	T (°C)Nartuby	Pression air+eau (m)Nartuv	T (°C) Air collège J Rostand	Pression atmo collège J Rostand	
2	26/09/2019 09:21	22,84	10,16553	24,66	10,10429	
3	26/09/2019 10:21	23,43	10,17574	23,59	10,10429	
4	26/09/2019 11:21	24,07	10,15533	23,45	10,10429	
5	26/09/2019 12:21	25,23	10,16553	23,58	10,09409	
6	26/09/2019 13:21	25,16	10,15533	24,11	10,09409	
7	26/09/2019 14:21	25,24	10,17574	24,69	10,09409	
8	26/09/2019 15:21	23,76	10,15533	25,24	10,10429	
9	26/09/2019 16:21	22,95	10,16553	25,46	10,10429	
10	26/09/2019 17:21	21,88	10,16553	25,48	10,10429	
11	26/09/2019 18:21	20,22	10,17574	25,41	10,12471	
12	26/09/2019 19:21	19,3	10,19615	25,27	10,12471	
13	26/09/2019 20:21	18,76	10,19615	25,11	10,12471	
14	26/09/2019 21:21	18,37	10,18595	24,92	10,12471	
15	26/09/2019 22:21	17,93	10,19615	24,71	10,13491	
16	26/09/2019 23:21	17,28	10,18595	24,52	10,12471	
17	27/09/2019 00:21	16,78	10,19615	24,31	10,13491	
18	27/09/2019 01:21	16,76	10,19615	24,13	10,12471	
19	27/09/2019 02:21	16,77	10,18595	23,94	10,12471	
20	27/09/2019 03:21	16,94	10,18595	23,77	10,1145	
21	27/09/2019 04:21	16,97	10,19615	23,64	10,1145	
22	27/09/2019 05:21	16,14	10,19615	23,51	10,12471	
23	27/09/2019 06:21	15,91	10,19615	23,39	10,12471	
24	27/09/2019 07:21	17,67	10,20636	23,29	10,12471	
25	27/09/2019 08:21	20,22	10,20636	23,23	10,12471	





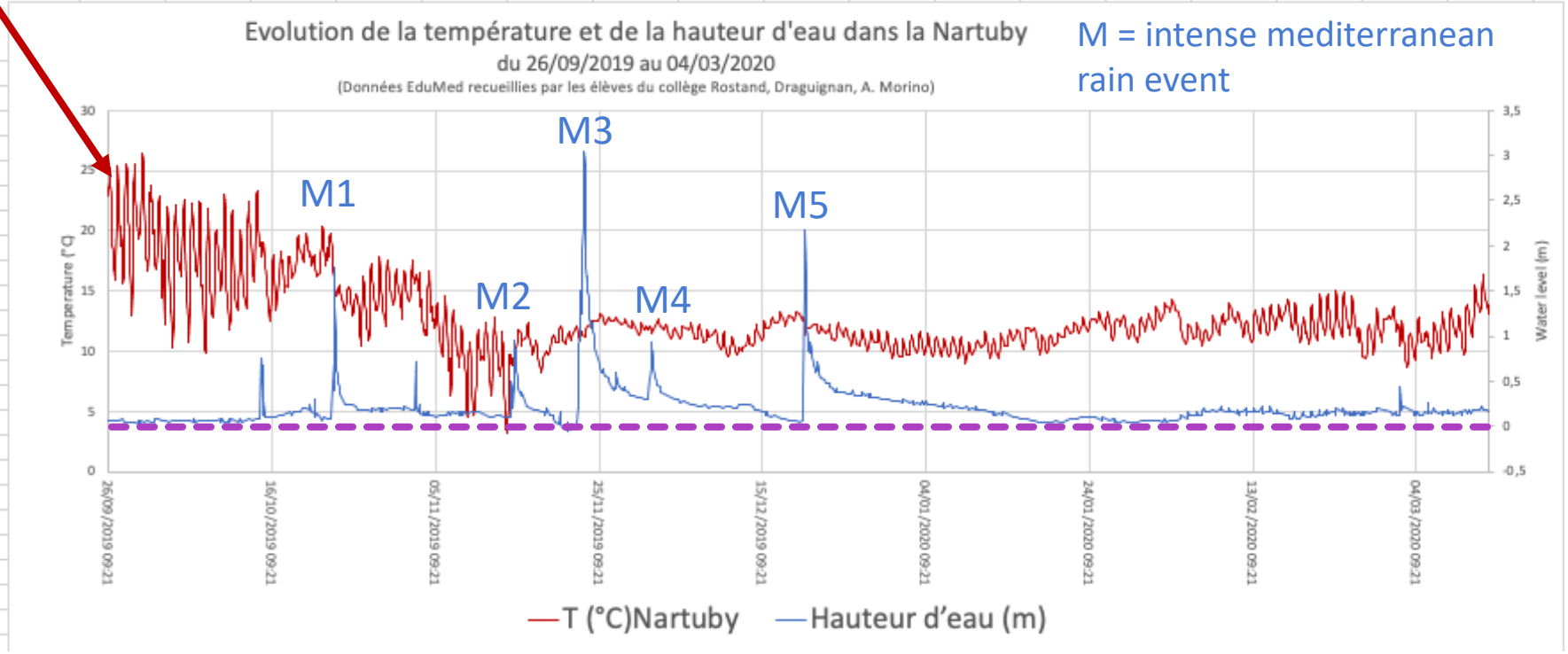
Data analysis : water level and temperature

circadian (day/night) cycle
of river temperature



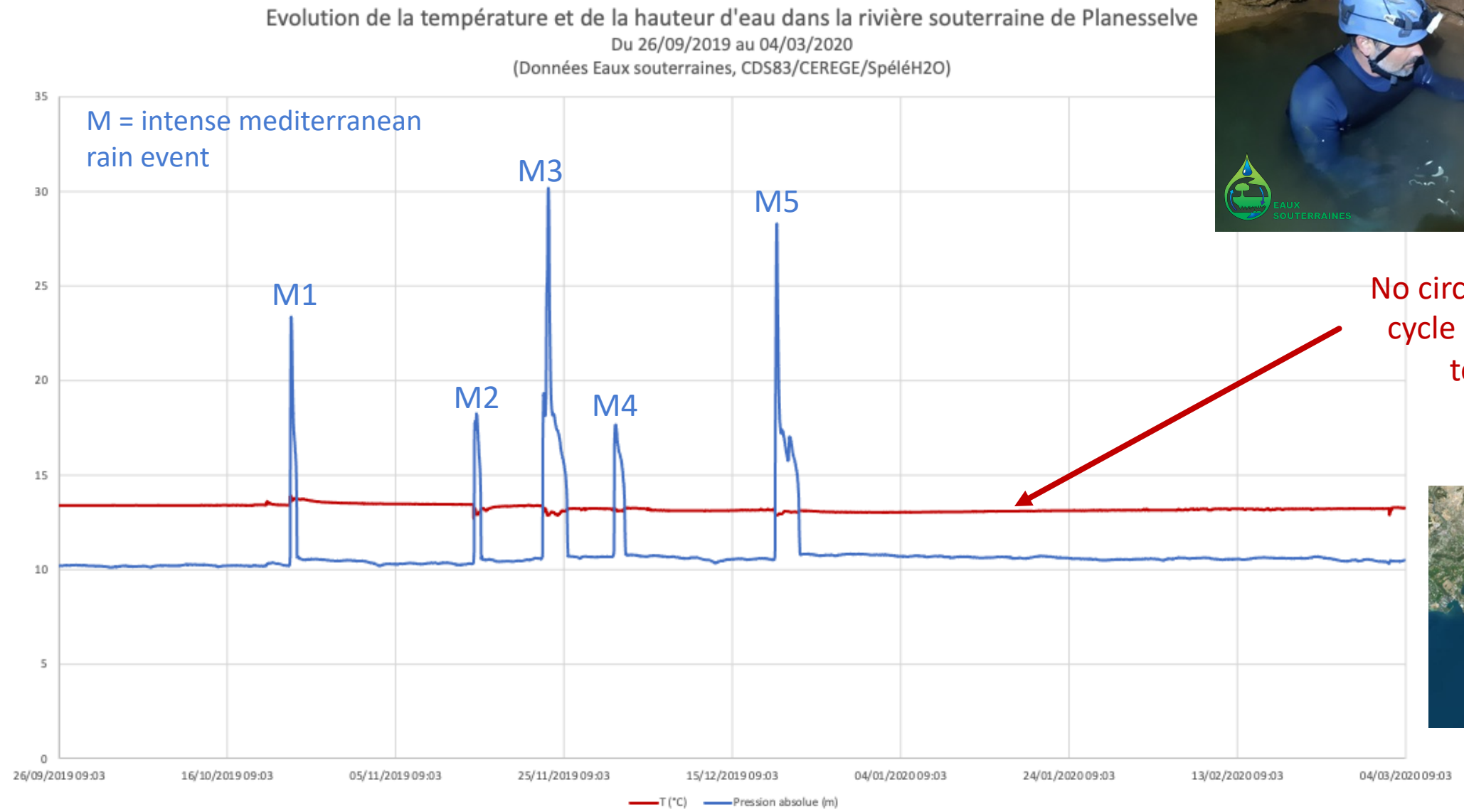
Rain intensity (23/11/19)

Date	T (°C)Nartuby	Pression air+eau (m)Nartuby	T (°C) Air collège J Rostand	Pression atmo collège J Rostand	Hauteur d'eau (m)
26/09/2019 09:21	22,84	10,16553	24,66	10,10429	0,061238
26/09/2019 10:21	23,43	10,17574	23,59	10,10429	0,071445
26/09/2019 11:21	24,07	10,15533	23,45	10,10429	0,051032
26/09/2019 12:21	25,23	10,16553	23,58	10,09409	0,071445
26/09/2019 13:21	25,16	10,15533	24,11	10,09409	0,061238
26/09/2019 14:21	25,24	10,17574	24,69	10,09409	0,081651
26/09/2019 15:21	23,76	10,15533	25,24	10,10429	0,051032
26/09/2019 16:21	22,95	10,16553	25,46	10,10429	0,061238
26/09/2019 17:21	21,88	10,16553	25,48	10,10429	0,061238
26/09/2019 18:21	20,22	10,17574	25,41	10,12471	0,051032
26/09/2019 19:21	19,3	10,19615	25,27	10,12471	0,071445
26/09/2019 20:21	18,76	10,19615	25,11	10,12471	0,071445
26/09/2019 21:21	18,37	10,18595	24,92	10,12471	0,061238
26/09/2019 22:21	17,93	10,19615	24,71	10,13491	0,061238
26/09/2019 23:21	17,28	10,18595	24,52	10,12471	0,061238
27/09/2019 00:21	16,78	10,19615	24,31	10,13491	0,061238
27/09/2019 01:21	16,76	10,19615	24,13	10,12471	0,071445
27/09/2019 02:21	16,77	10,18595	23,94	10,12471	0,061238
27/09/2019 03:21	16,94	10,18595	23,77	10,1145	0,071445
27/09/2019 04:21	16,97	10,19615	23,64	10,1145	0,081651
27/09/2019 05:21	16,14	10,19615	23,51	10,12471	0,071445
27/09/2019 06:21	15,91	10,19615	23,39	10,12471	0,071445
27/09/2019 07:21	17,67	10,20636	23,29	10,12471	0,081651
27/09/2019 08:21	20,22	10,20636	23,23	10,12471	0,081651



M = intense mediterranean rain event

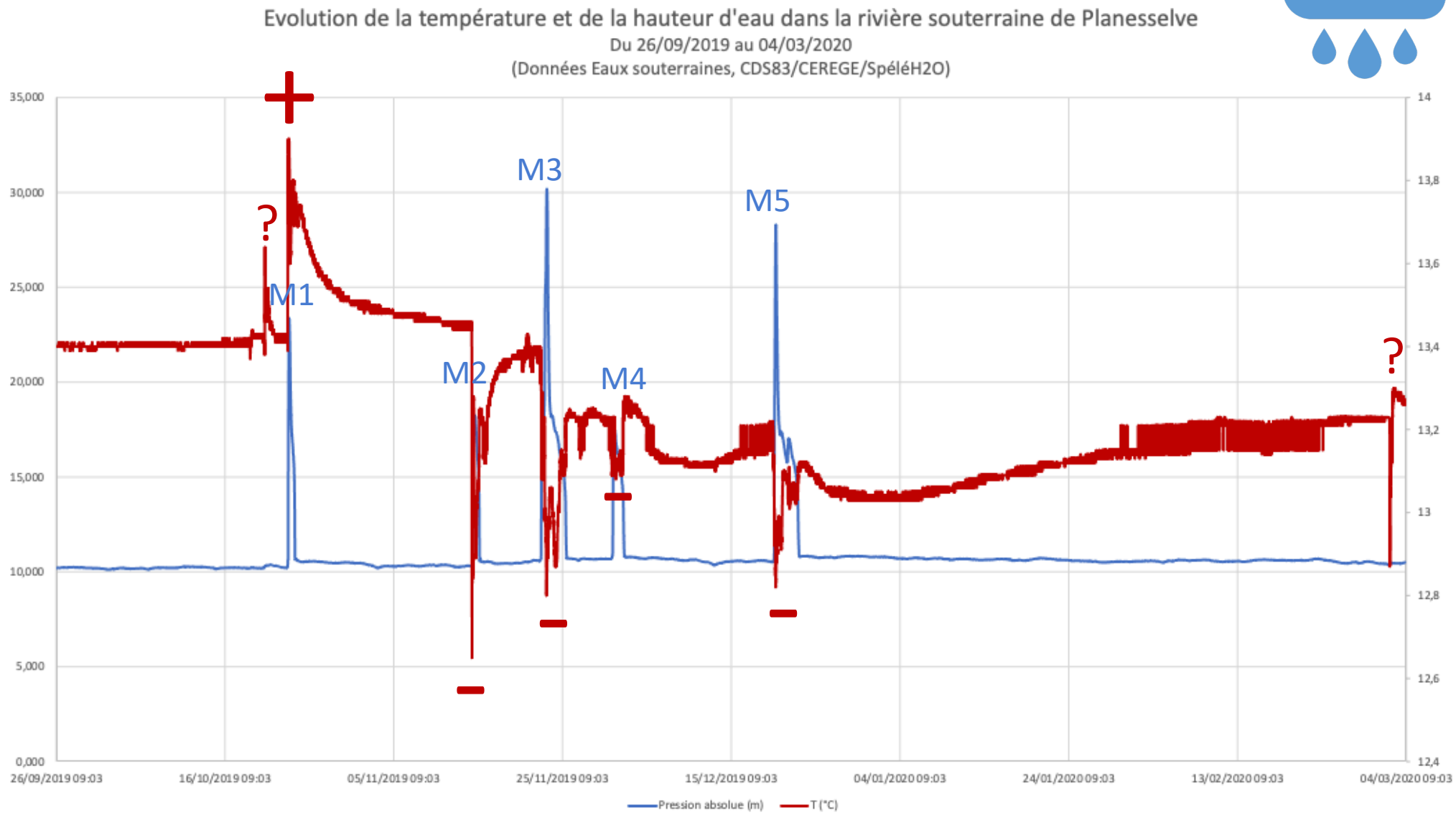
Data analysis : water level and temperature



No circadian (day/night) cycle on groundwater temperature

Data analysis : water level and temperature

The variation in temperature makes it possible to identify the arrival of rainwater.

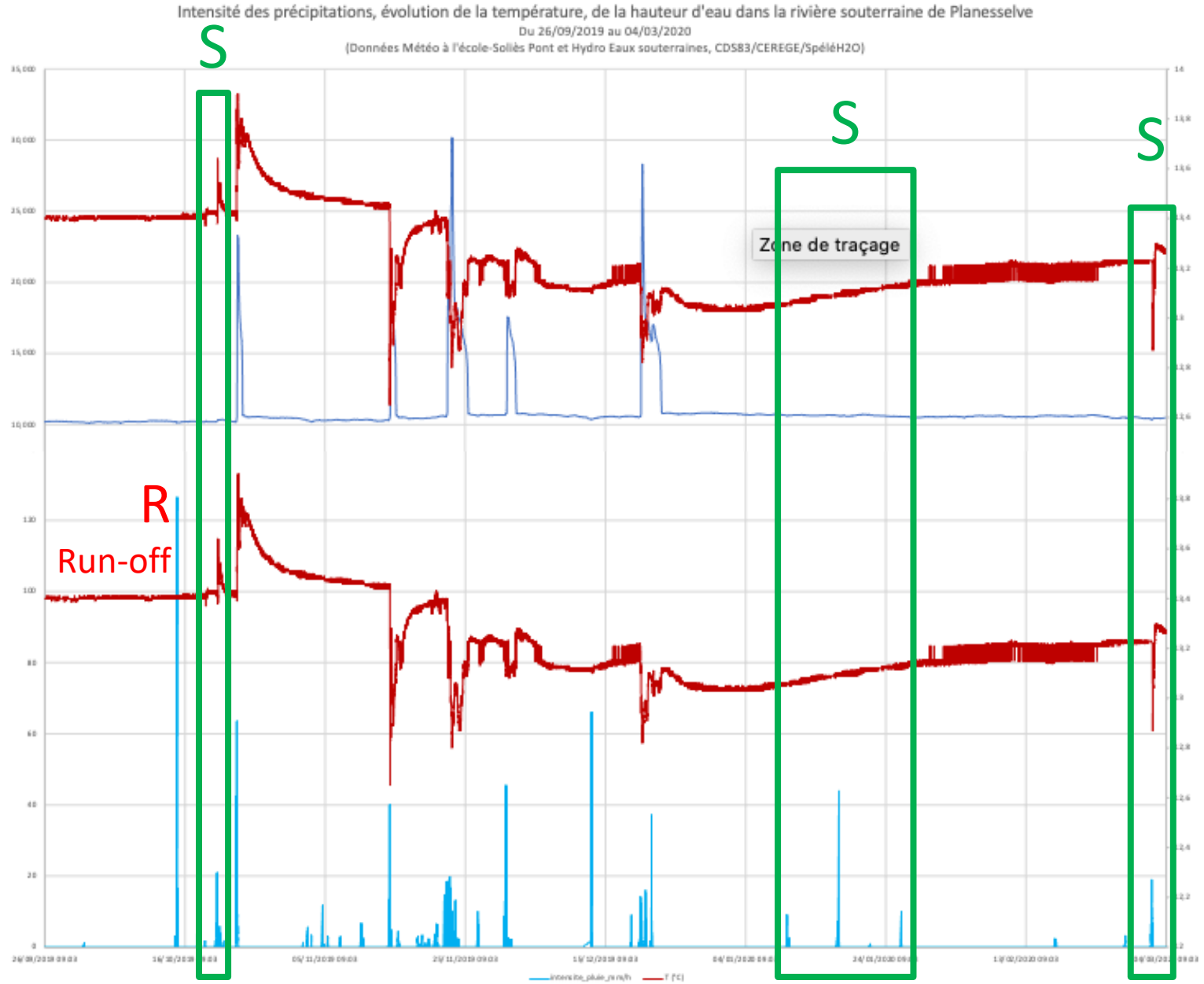


Rainwater temperature depend of season

\+ Increasing water level and temperature

\- Increasing water level but decreasing temperature

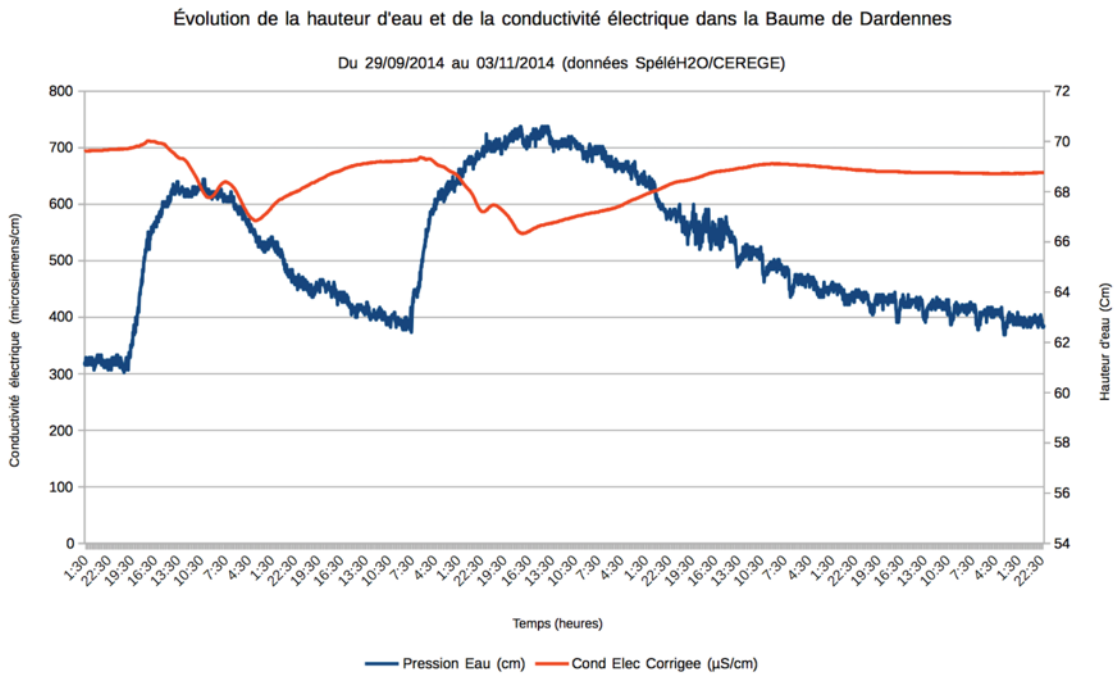
Data analysis : water level and temperature GROUNDWATER

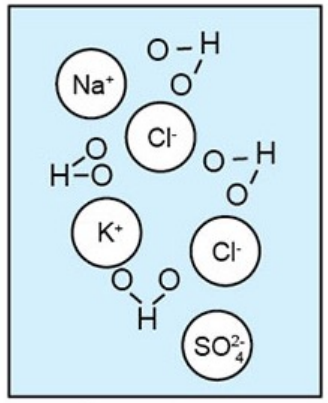


S : Soil or Sponge

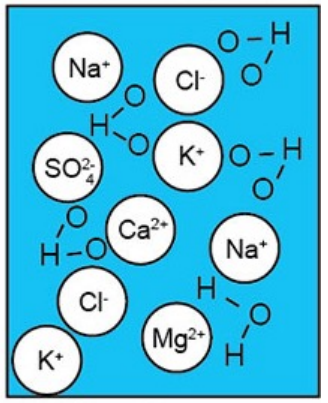
When they are dry, the soil and the epikarst retain and then slowly transmit rainwater.

Data analysis : water conductivity

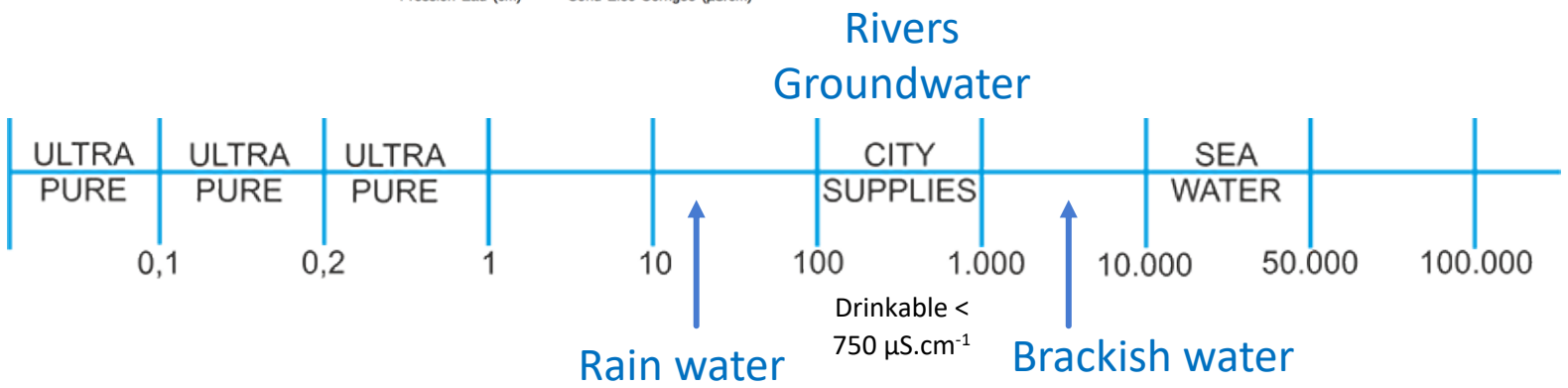




Fewer ions = lower electrical conductivity



More ions = greater electrical conductivity

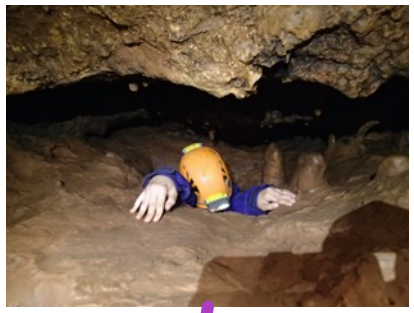


Water conductivity (µSiemens.cm^{-1})

CTD diver : presure, temperature and conductivity sensor
(Van Essen instruments)

Case studies :

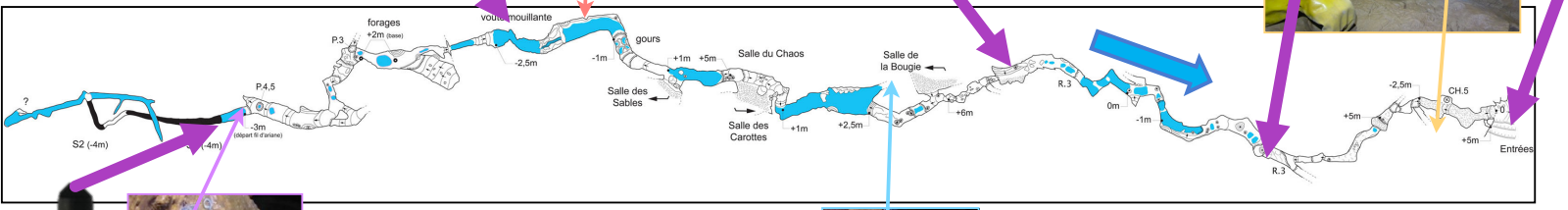
Le Regaï de Néoules



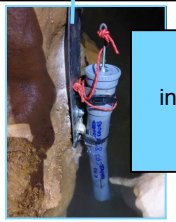
Équipement sondes Reefnet Regaï de Néoules le 20/11/2015

Reefnet 14230,
Démarrée le 19/11/2015 à 16h36,
interval 1 minute, threshold 800 mbar,
installée le 20/11/15 à 13h50 :
amont réseau des gours

Reefnet 14300,
Démarrée le 19/11/2015 à 16h33,
interval 1 minute, threshold 800 mbar,
installée le 20/11/15 à 12h00 :
entrée Regaï



Reefnet 14246,
Démarrée le 19/11/2015 à 16h38,
interval 1 minute, threshold 800 mbar,
installée le 20/11/15 à 14h30 : Siphon 1



Reefnet 14267,
Démarrée le 19/11/2015 à 16h35,
interval 1 minute, threshold 800 mbar,
installée le 20/11/15 à 13h04 :
amont salle de la bougie

CTD
DIVER

Regaï de Néoules
(Néoules - 83)
(Galerie principale)

0 — 50 — 100m

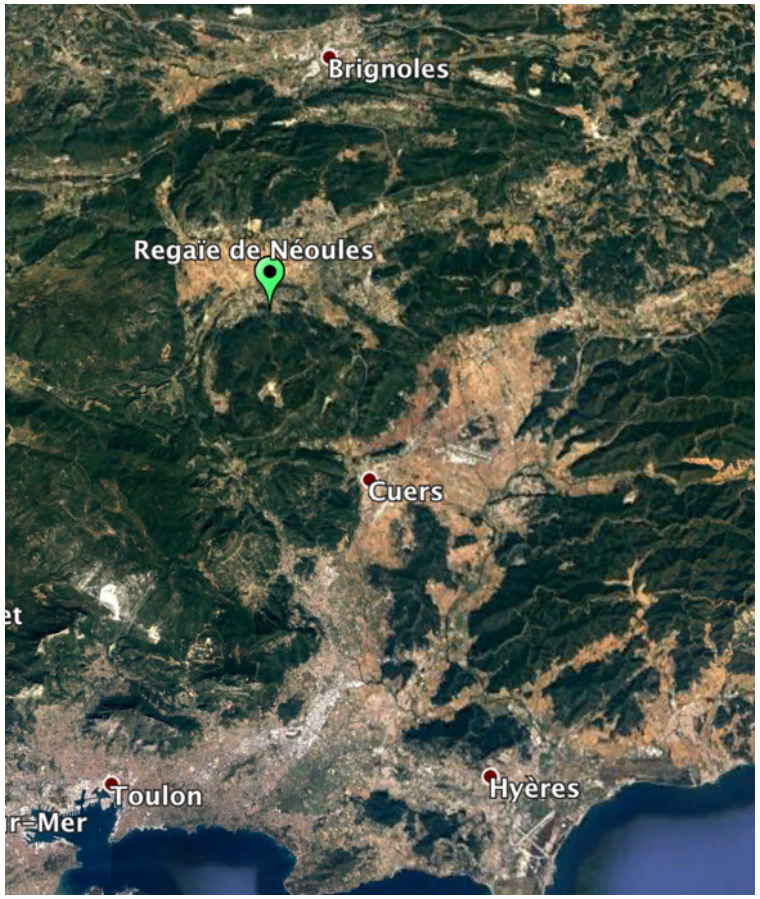
Galerie Principale (extension: 560m)

Topographie galerie principale (degré.4) - 17 & 20 octobre 2010 - Lucot Jean-Pierre / Lecouvez Yves

Plan

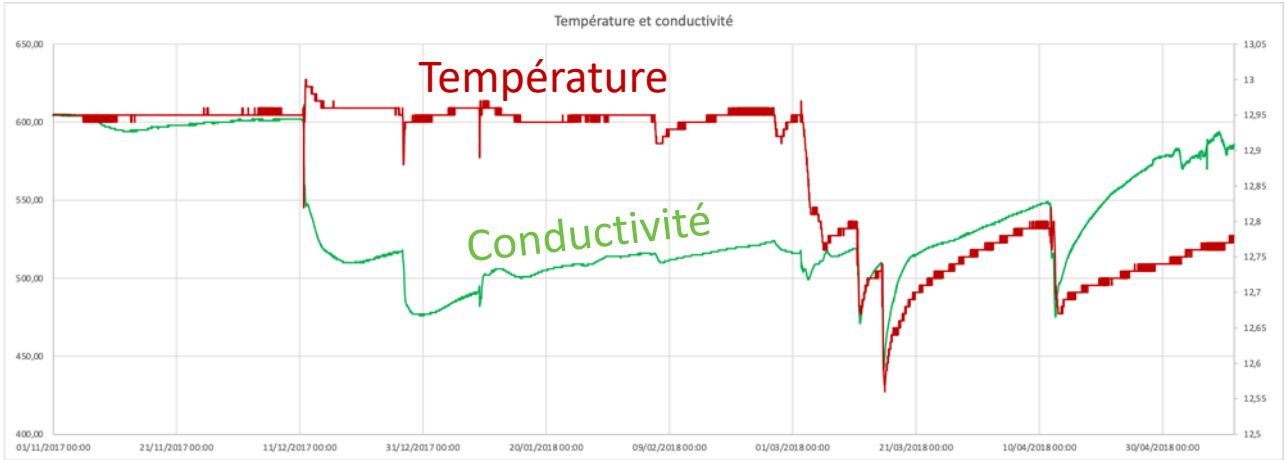
mg.10/10

Coordonnées	Lambert III	UTM.WGS84/31T
X: Y: Z :	0898.970 3118.520 337m	0745158 4799273 337m
(entrée inférieure du réseau)		



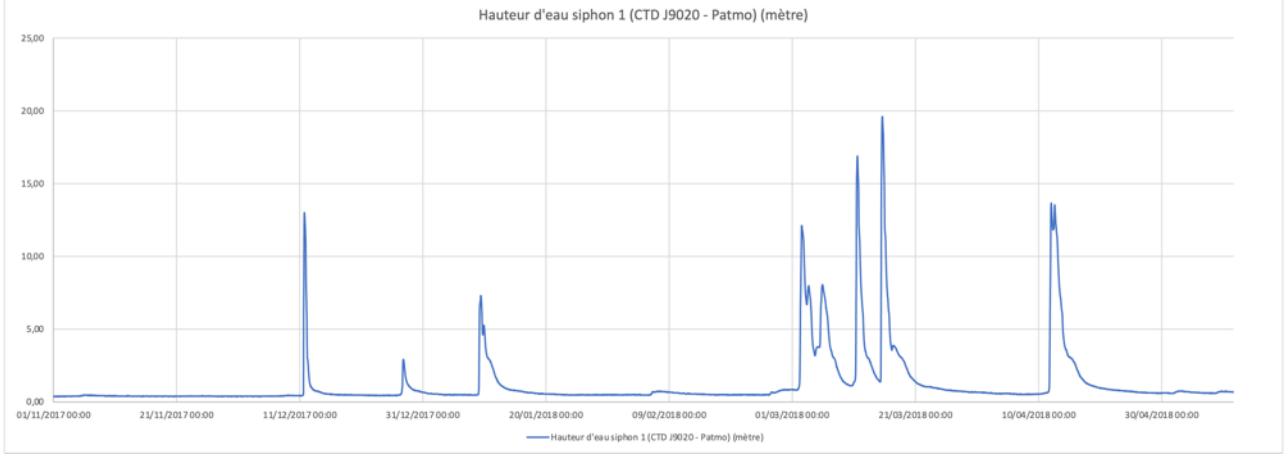
600 µS.cm-1

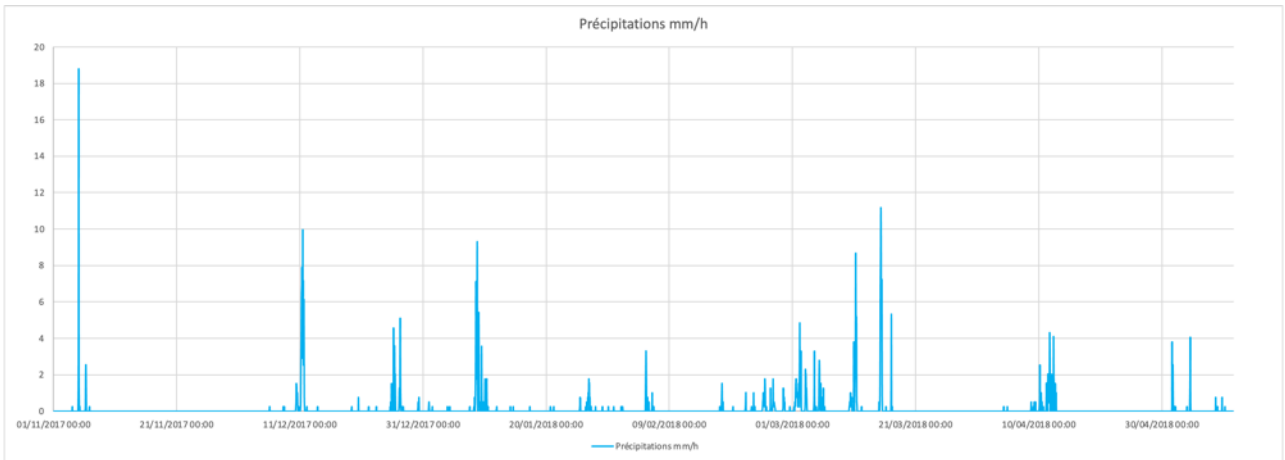
470 µS.cm-1



13°C

12,55°C





Case studies :

Le Regaï de Néoules

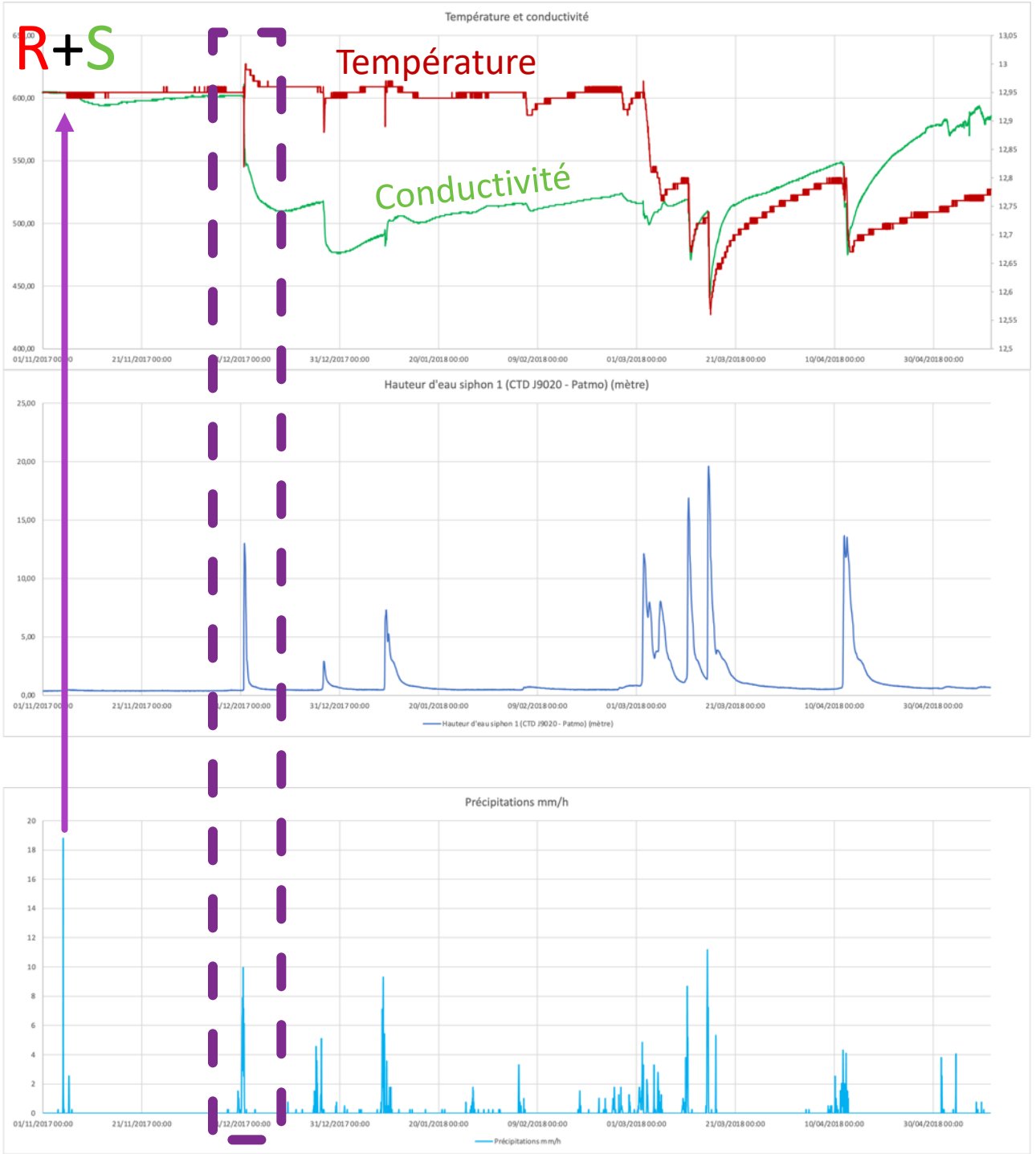
The electrical conductivity of water is a much better indicator than temperature.

Electrical conductivity varies over a wider range than temperature: we observe phenomena with better resolution.

Temperature variations are too dependent of the season, the region, the weather. It would be too risky to launch a measurement campaign based on their observation.

600 µS.$^{cm-1}$

470 µS.$^{cm-1}$



13°C

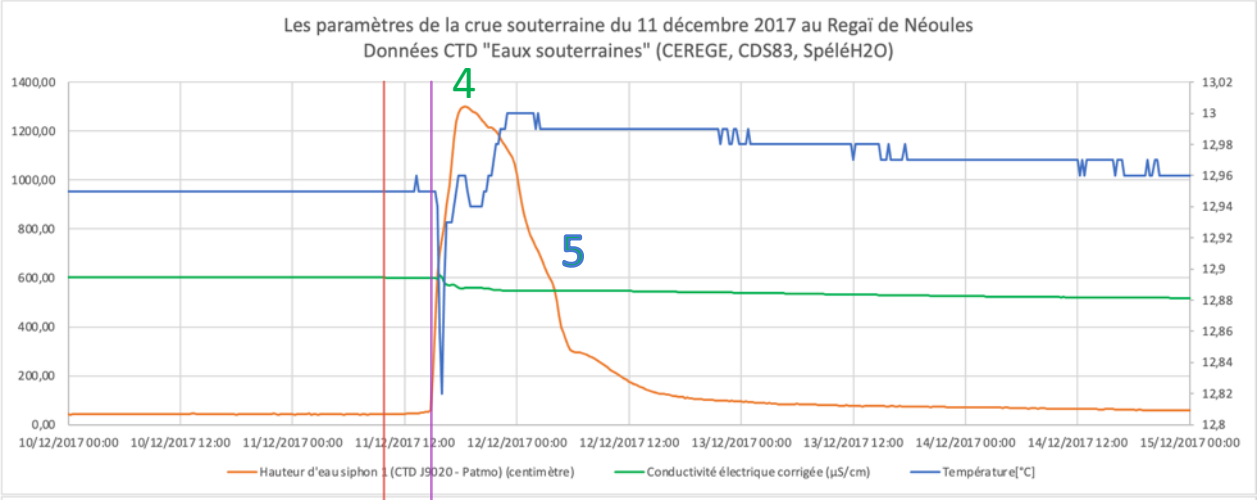
12,55°C

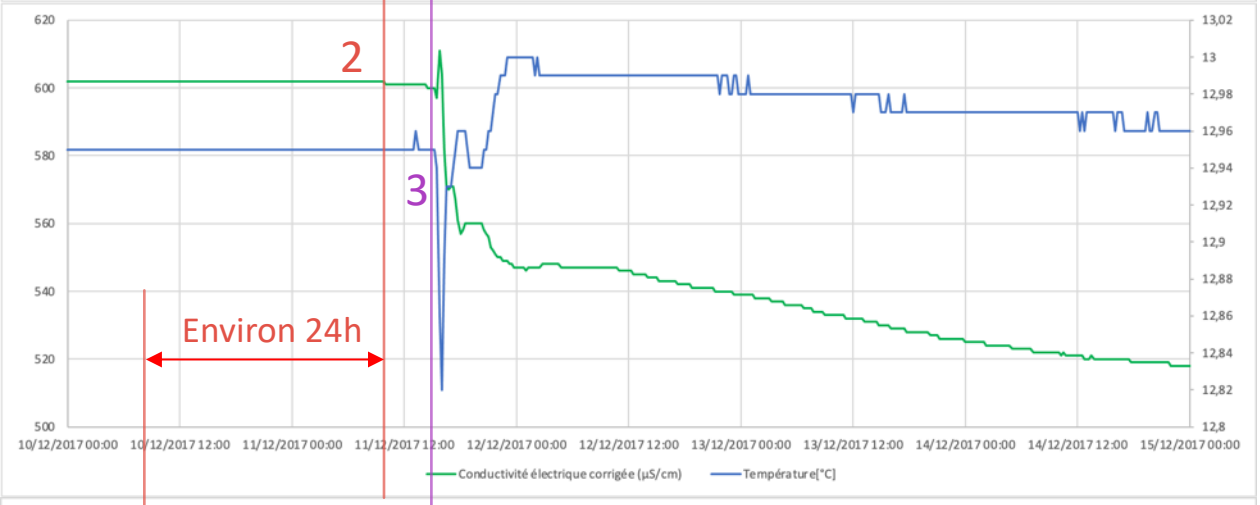
Case studies :

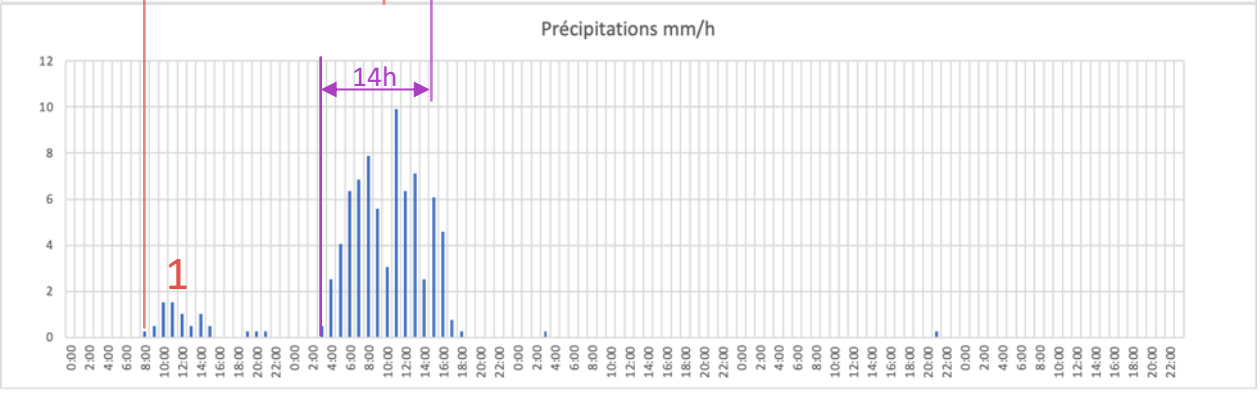
Le Regaï de Néoules

Understand the dynamics of the groundwater body

Example: understanding the events of 11/12/17



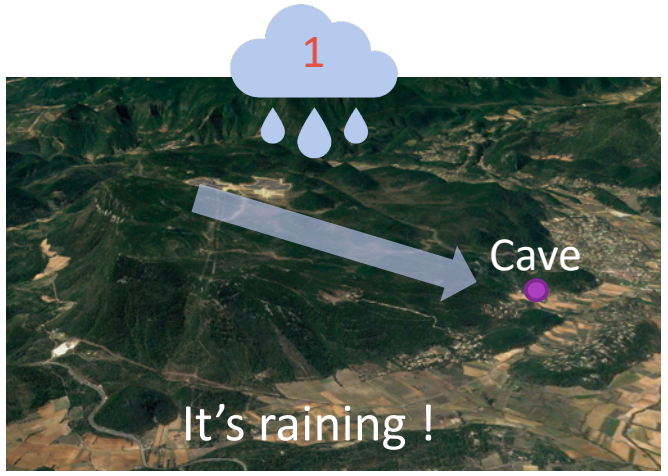




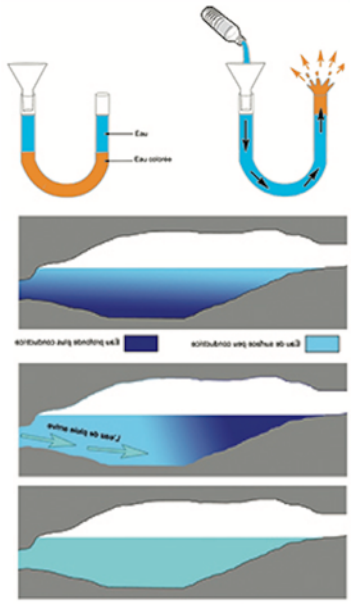
Case studies :

Le Regaï de Néoules

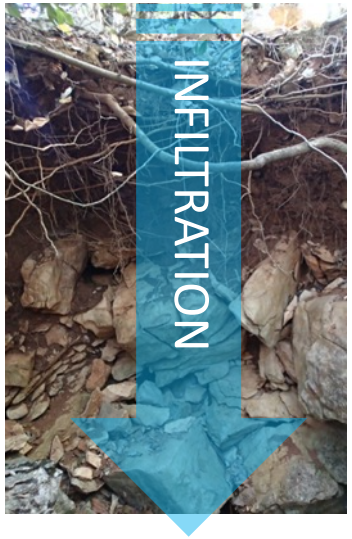
Understand the dynamics of the groundwater body



3 :flushing effect



2



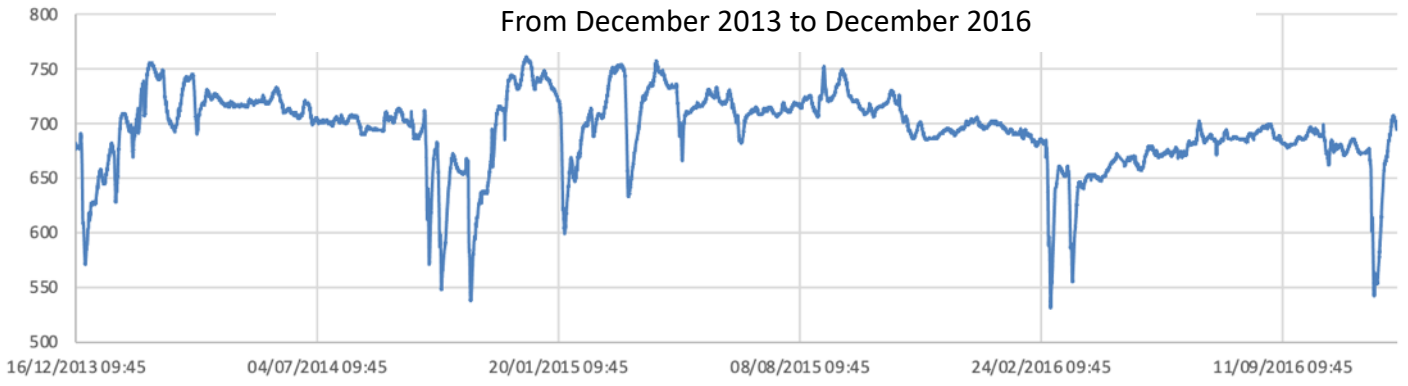
4 : Flod peak, the highest stage reached during a particular flood at a given point. (3h, +13 meters)

5 : Flood recession (several days)

Define the nature of groundwater by means of electrical conductivity

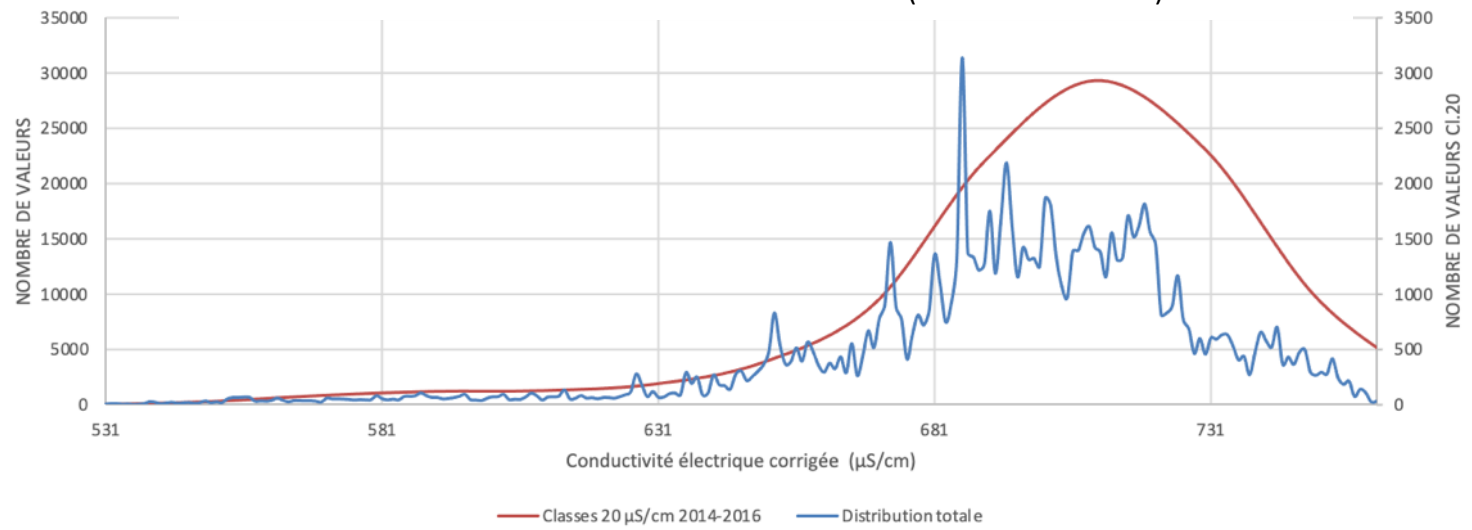
Evolution of electrical conductivity in Dardennes Balm

From December 2013 to December 2016



Frequency spectrum of electrical conductivity in Dardennes Balm

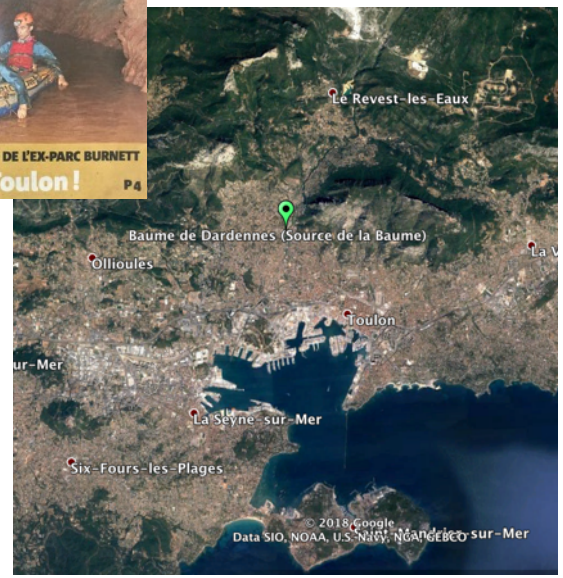
From December 2013 to December 2016 (Groundwater data)

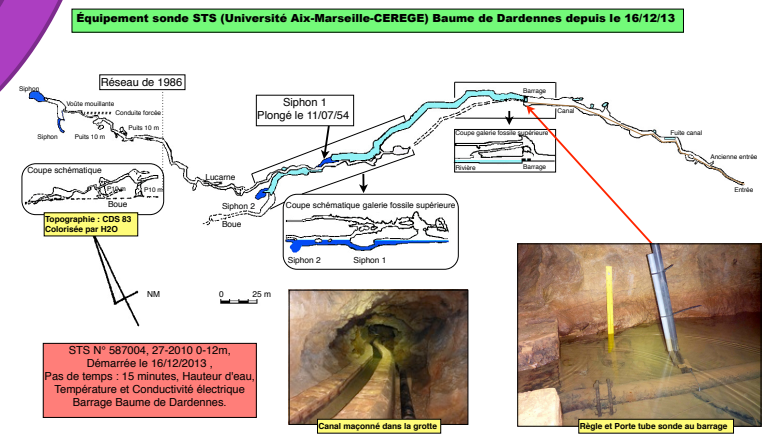


frequency spectrum: how many times is a value measured?

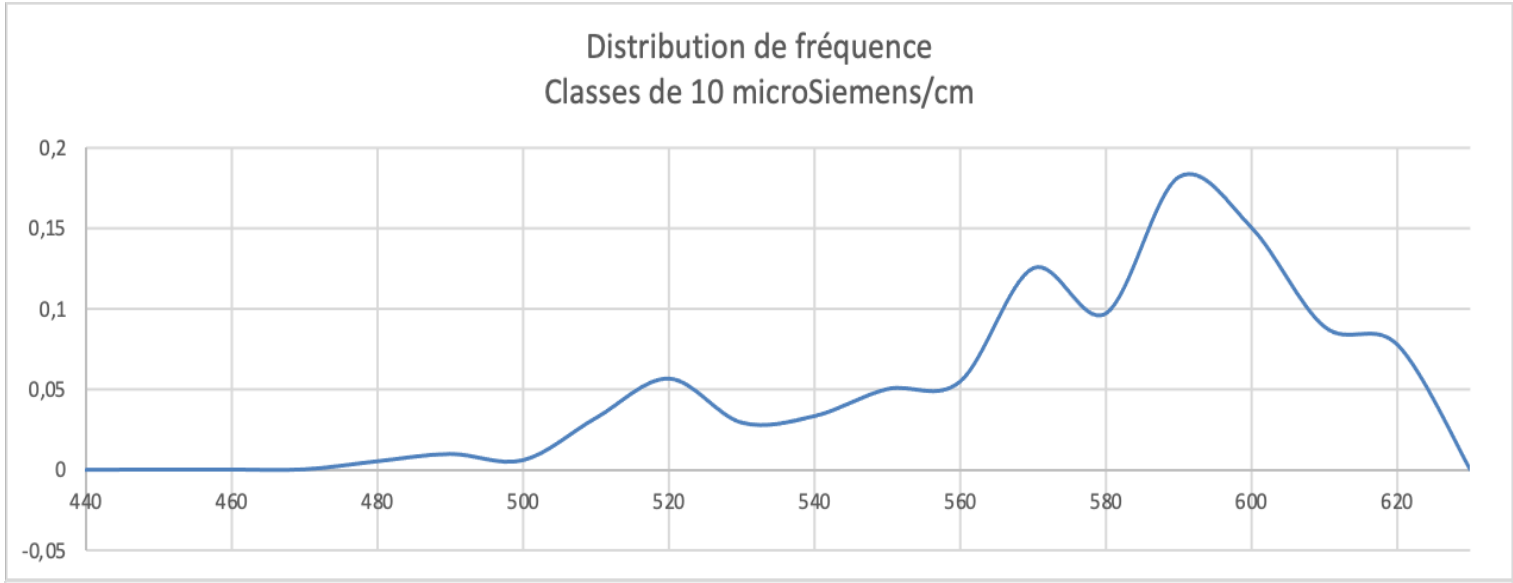
Case studies :

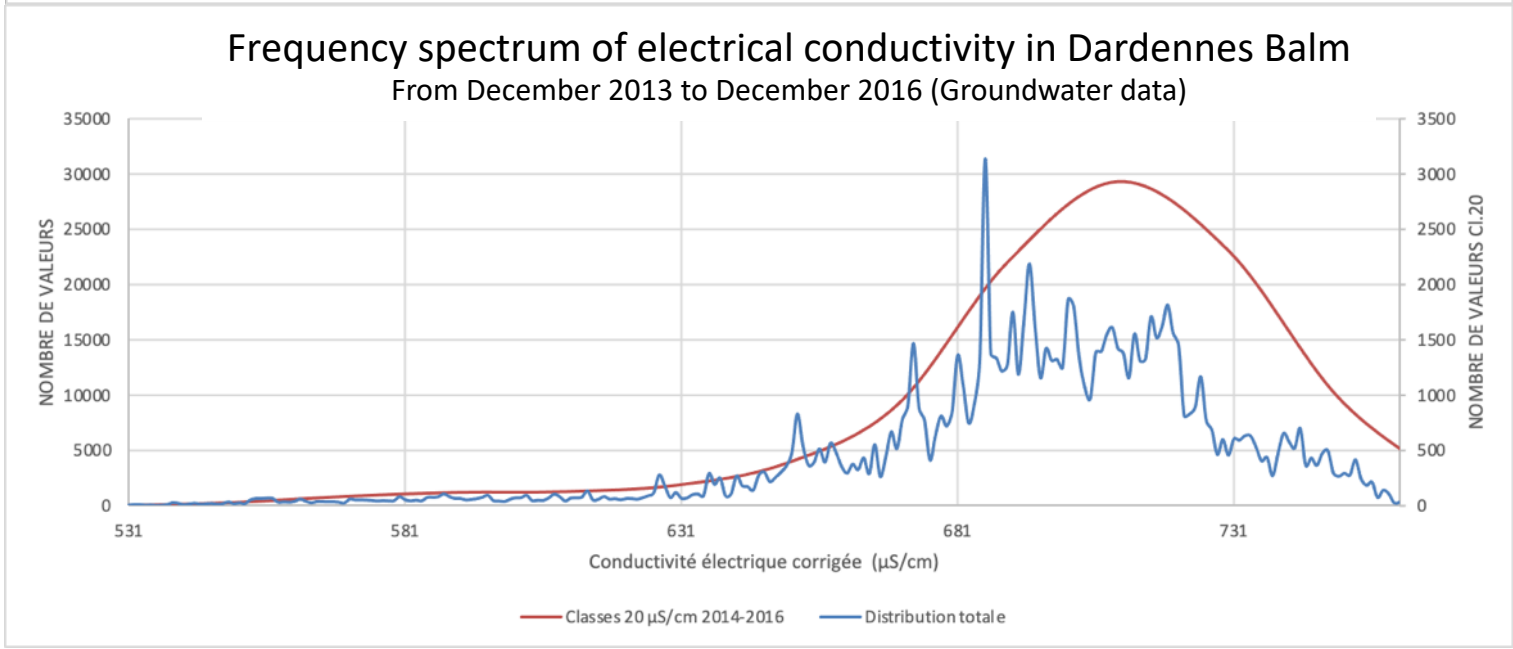
La Baume de Dardenne





Define the nature of groundwater by means of electrical conductivity





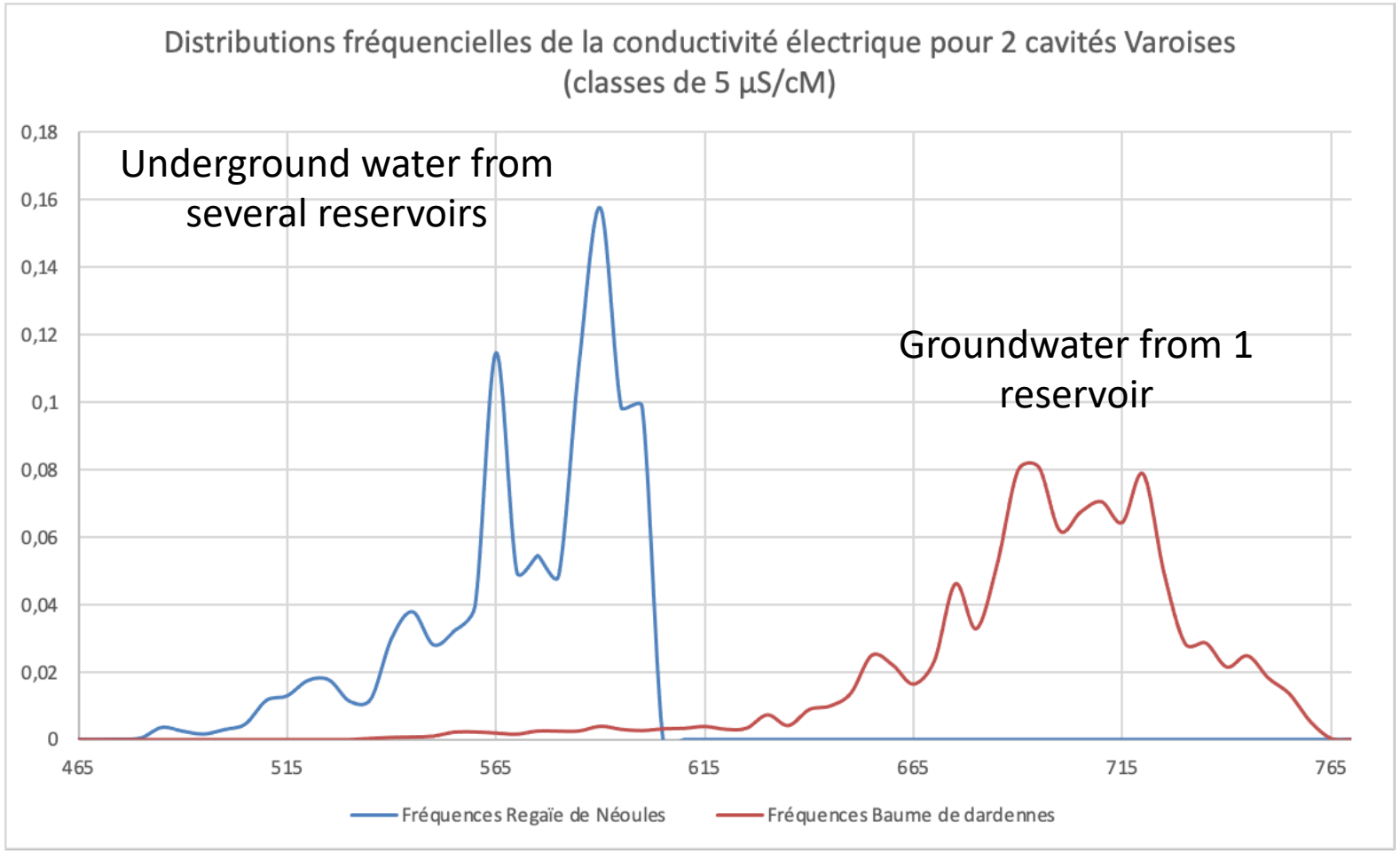
Case studies :

La Baume de Dardenne
Le Regaï de Néoules

Underground water from several reservoirs

Groundwater from a reservoir

Define the nature of groundwater by means of electrical conductivity



Case studies :

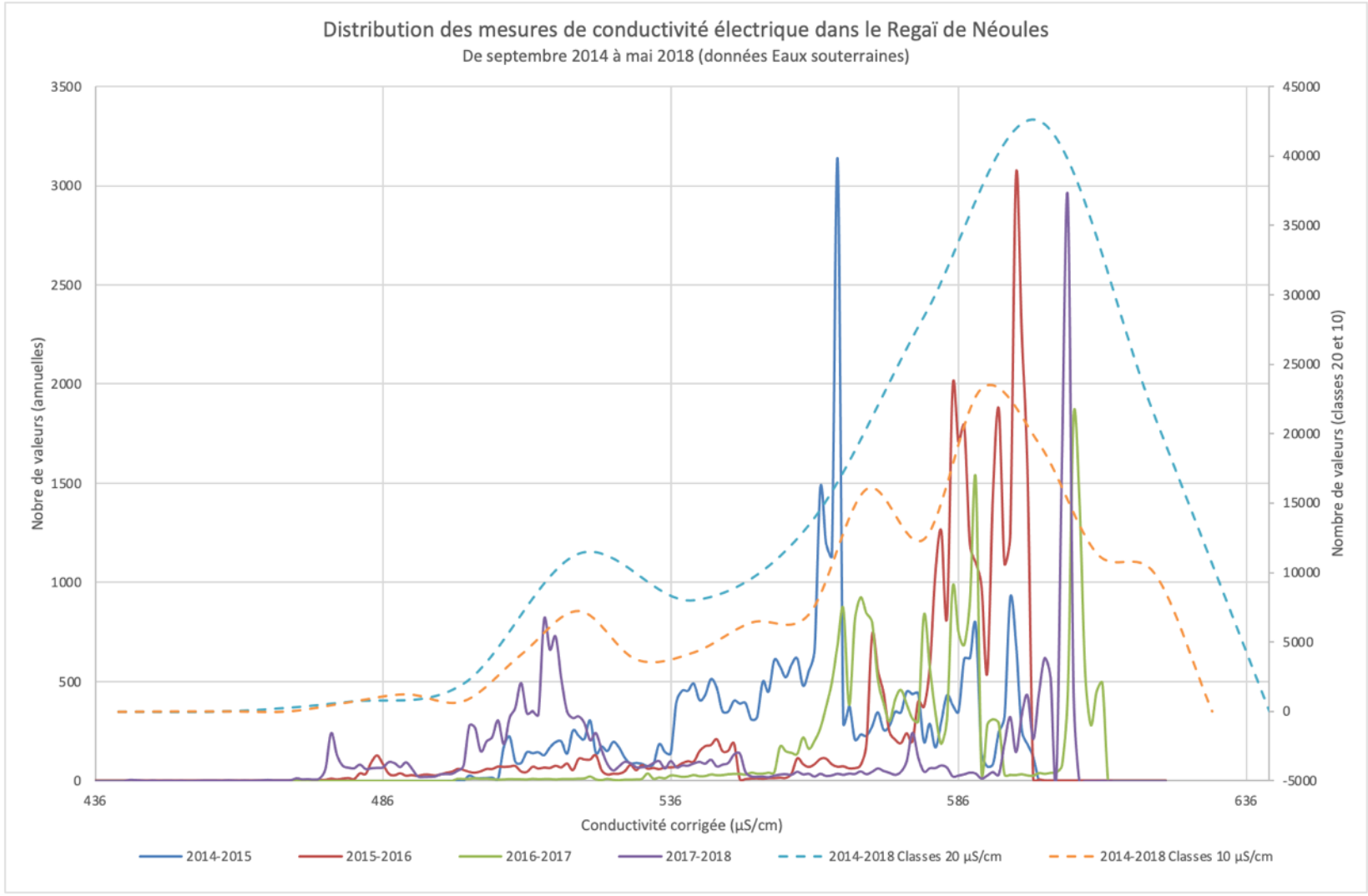
La Baume de Dardenne
Le Regaï de Néoules

The different conductivity ranges reflect different ionic compositions of the water, i.e. paths through different rocks.

Define the nature of groundwater by means of electrical conductivity

Case studies :

Le Regaï de Néoules

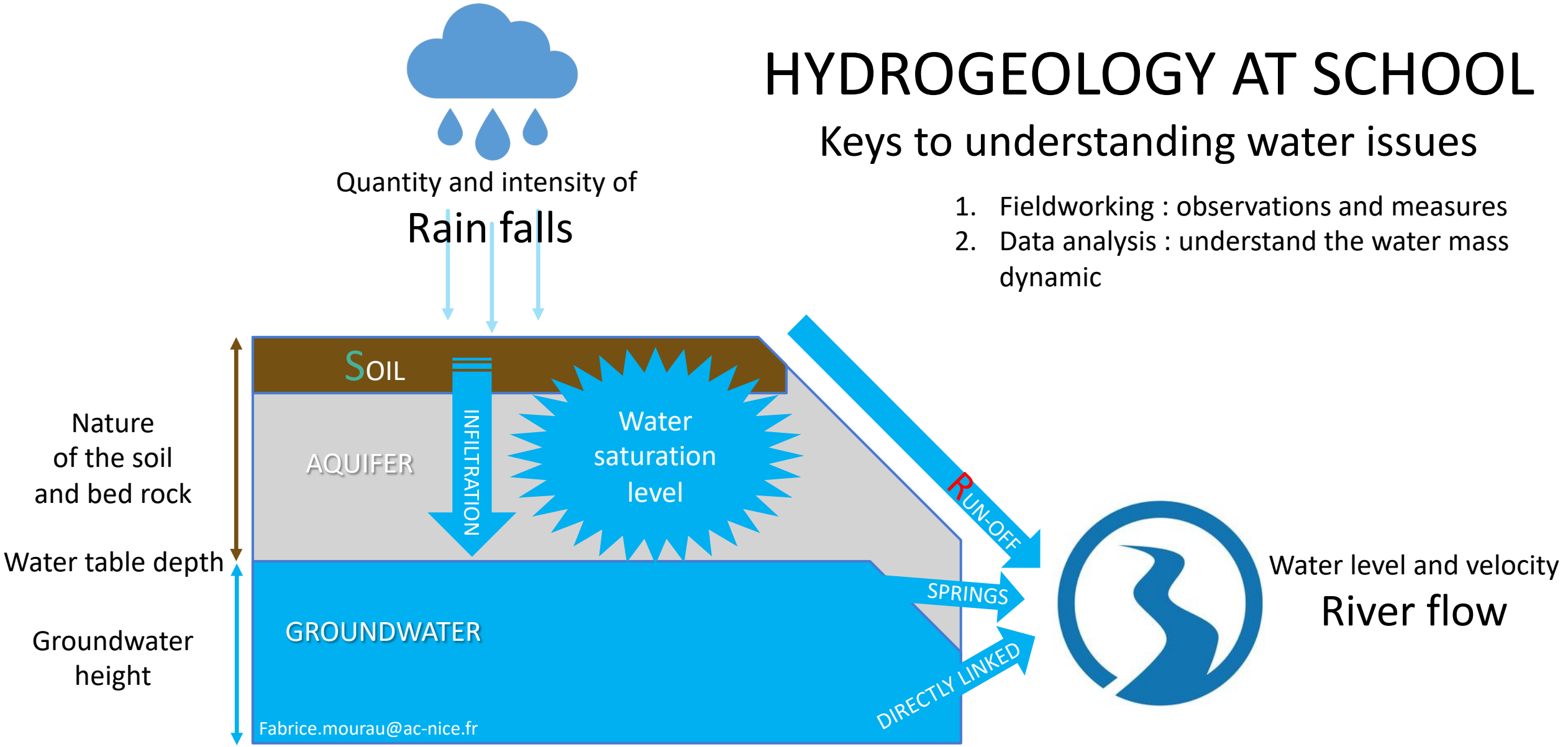


The annual variations show changes in the paths of the water: some circuits are more or less used.

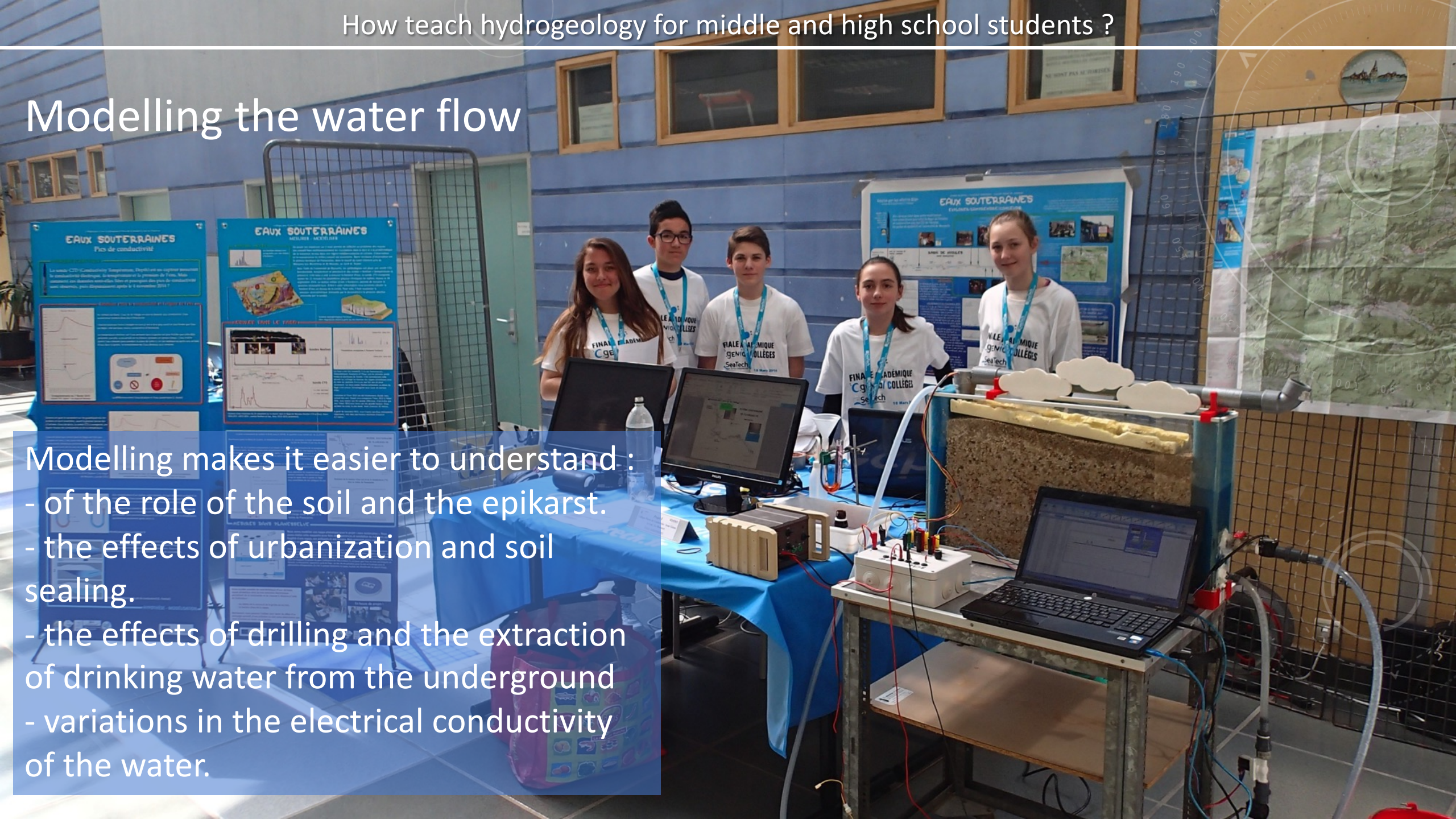
HYDROGEOLOGY AT SCHOOL

Keys to understanding water issues

1. Fieldworking : observations and measures
2. Data analysis : understand the water mass dynamic



Modelling the water flow

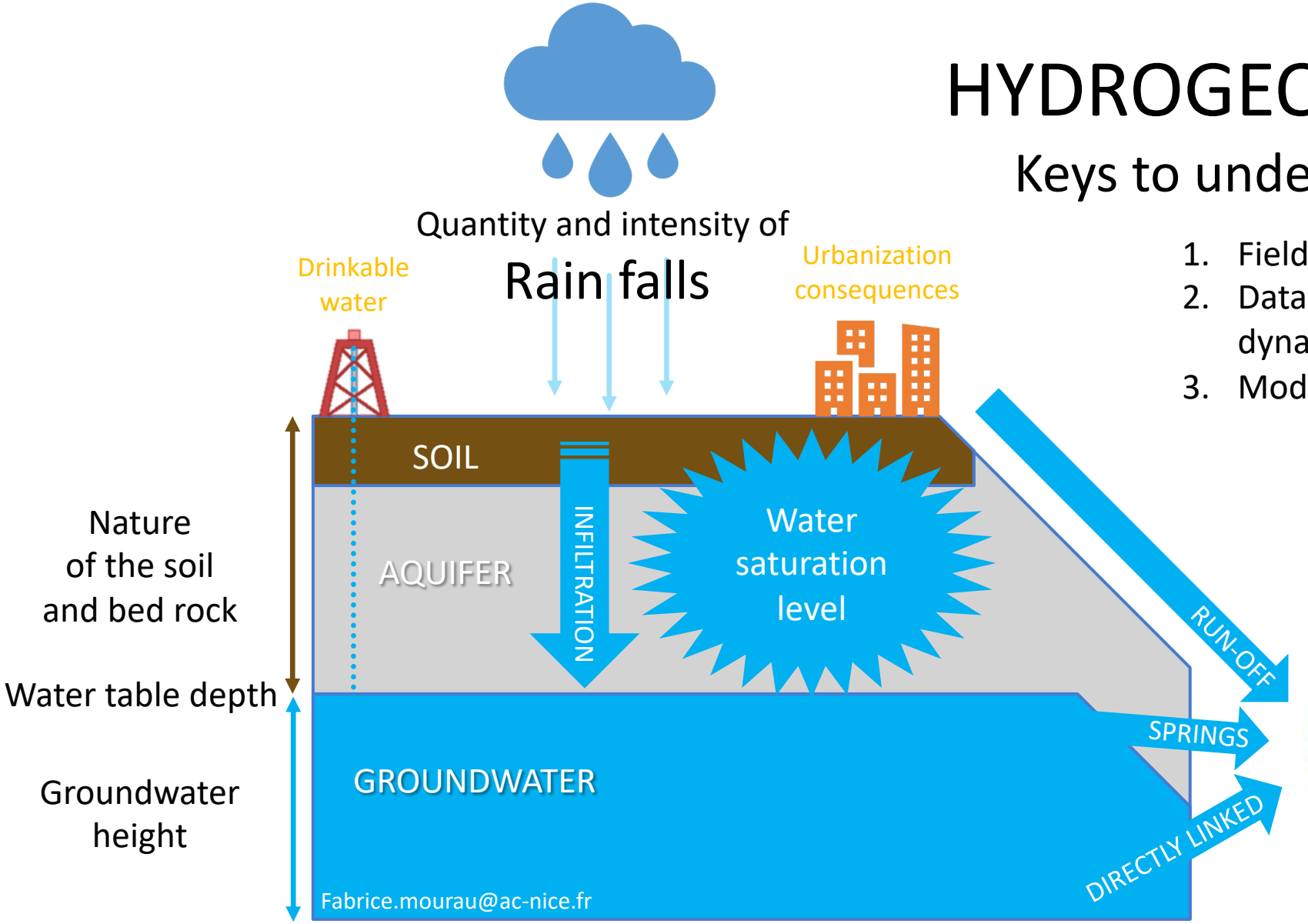


Modelling makes it easier to understand :
- of the role of the soil and the epikarst.
- the effects of urbanization and soil sealing.
- the effects of drilling and the extraction of drinking water from the underground
- variations in the electrical conductivity of the water.

HYDROGEOLOGY AT SCHOOL

Keys to understanding water issues

1. Fieldworking : observations and measures
2. Data analysis : understand the water mass dynamic
3. Modelling the water flow



Water level and velocity

River flow

Fish stocks
Biodiversity

Flood hazards