SIGNIFICANCE OF HIGH-RESOLUTION MONITORING FOR THE CONCEPTUALIZATION OF GROUNDWATER SYSTEMS: APPLICATIONS TO SELECTED PILOT SITES IN LEBANON

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Disruptive Technologies for Improved Groundwater Management Workshop

Beirut, June 16, 2021

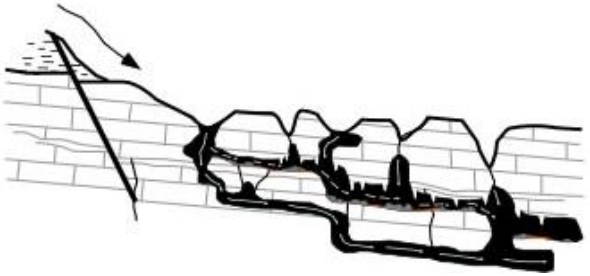
CHALLENGES AND THREATS

1. Groundwater is currently facing tremendous stress due to climate change and increase urbanization requiring science-evidence supported management measures;
2. To achieve a sustainable management, there is a greater need to **understand how groundwater systems work** and the responses of groundwater to input such as climate or contamination and to quantify water availabilities;
3. This challenge is immense in snow governed and Mediterranean semi-arid regions (e.g., Lebanon)

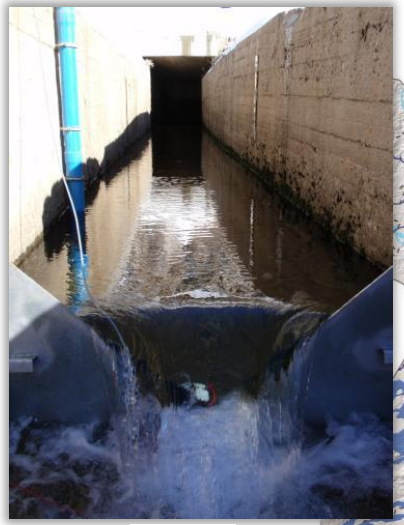
MEDITERRANEAN- SEMI ARID KARST

Implications on the availability of water of good quality for supply

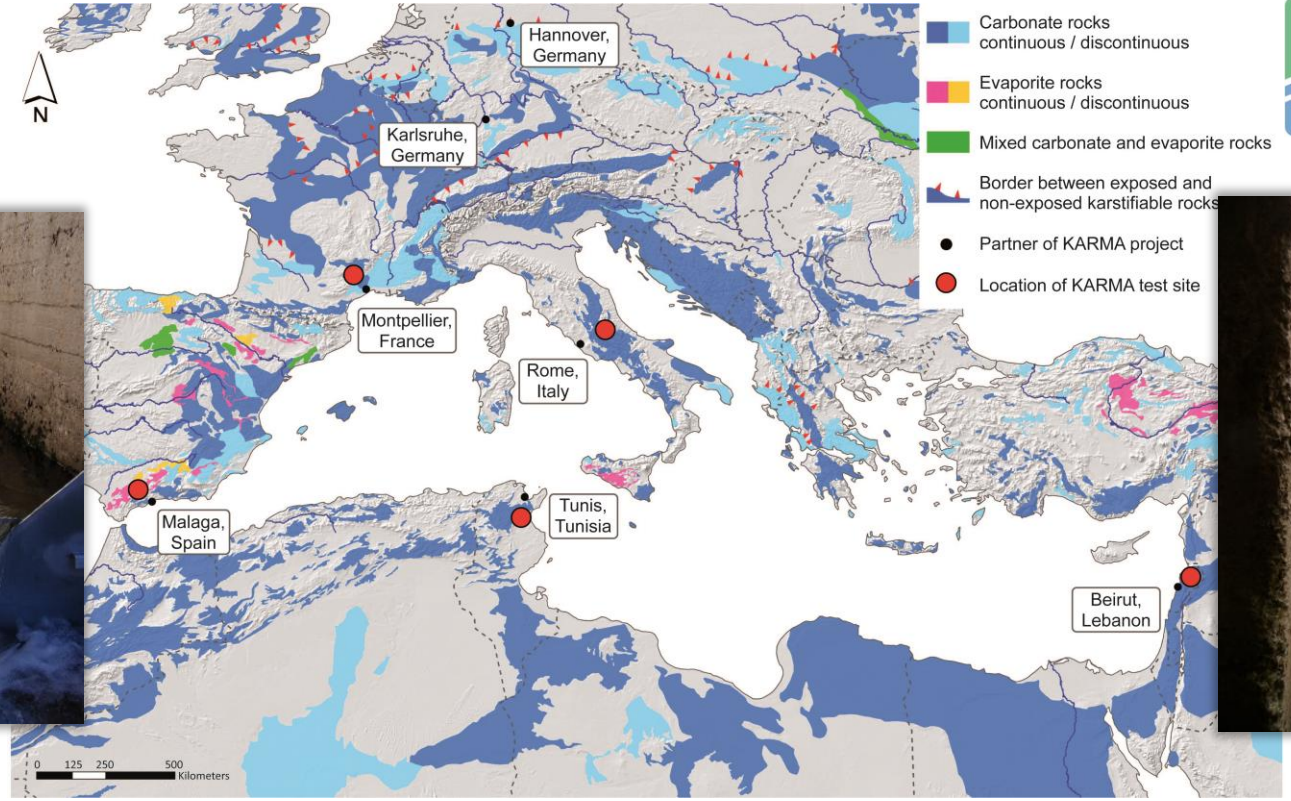
- Seasonality: high flow and low flow,
- Climate stress: wet and dry years.



Karst **A**quifer **R**esources availability and quality in the **M**editerranean **A**rea

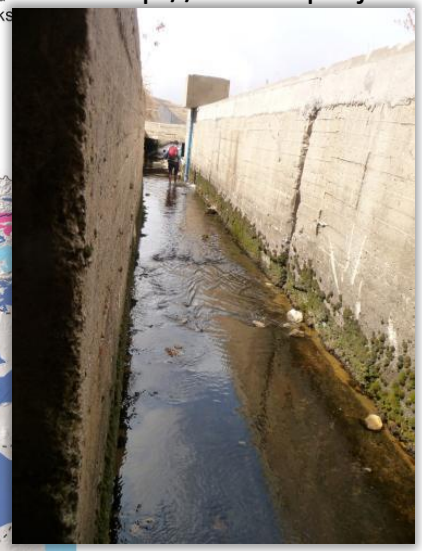


May



The KARMA Project

http://karma-project.org/



September

Field sites


المصلحة الوطنية لنهر الليطاني
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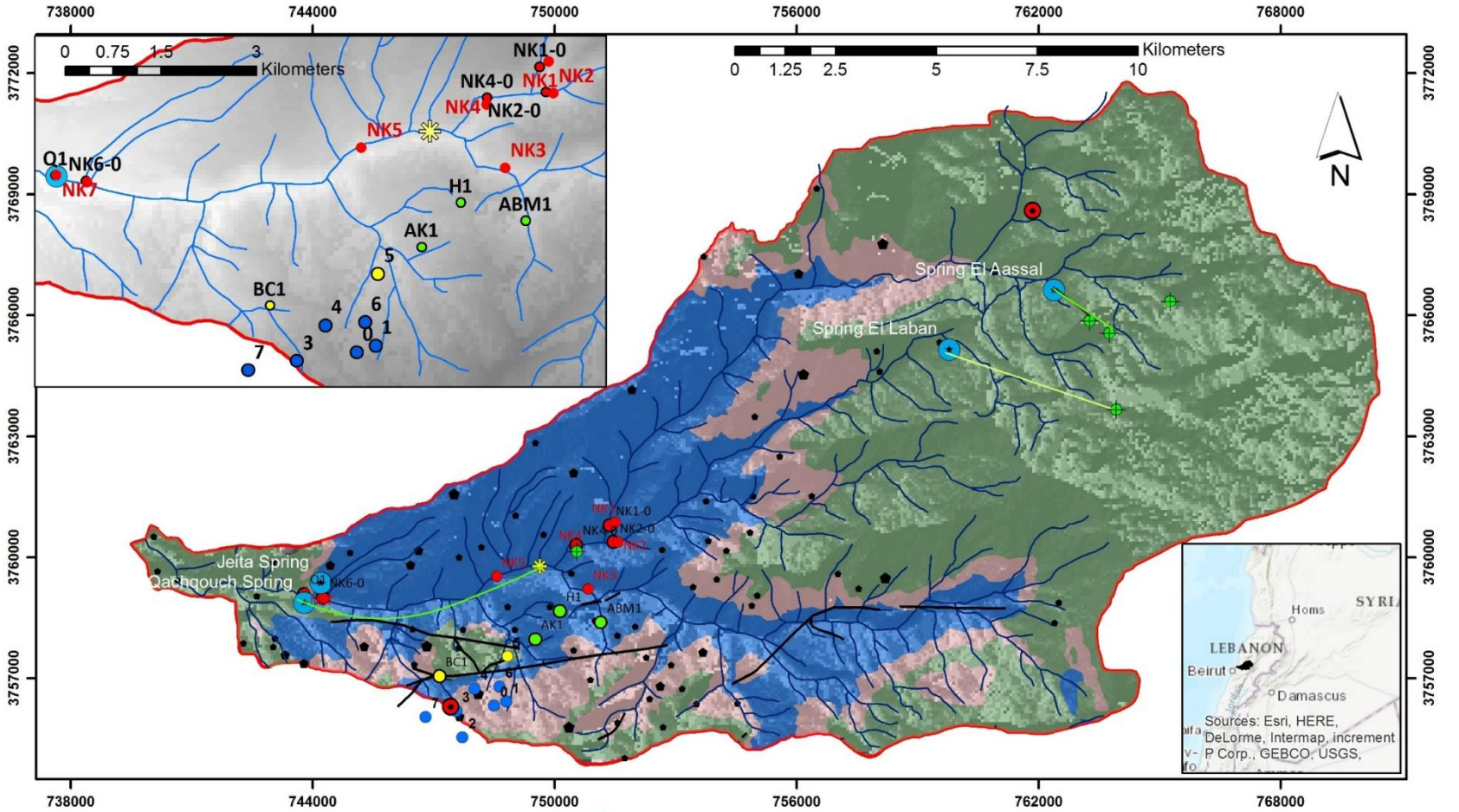
Case study: Nahr El Kalb Catchment and selected springs groundwater catchment

Jeita

Qachqouch

El Assal

Laban



MONITORING SINCE 2014-ONGOING DATA COLLECTION (TEMPORAL AND SPATIAL)

Set up of a monitoring network = climate and spring data

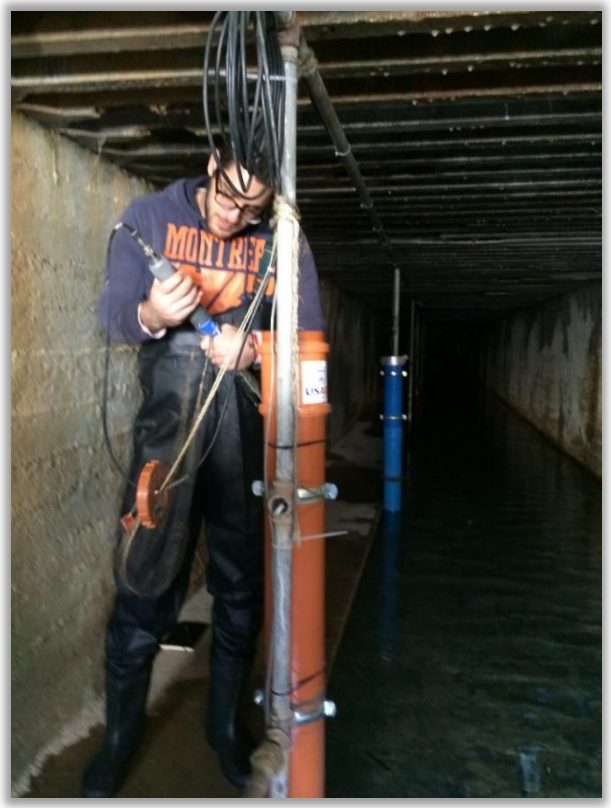
Installation of two climatic stations (Chabrouh and Bikfaya)

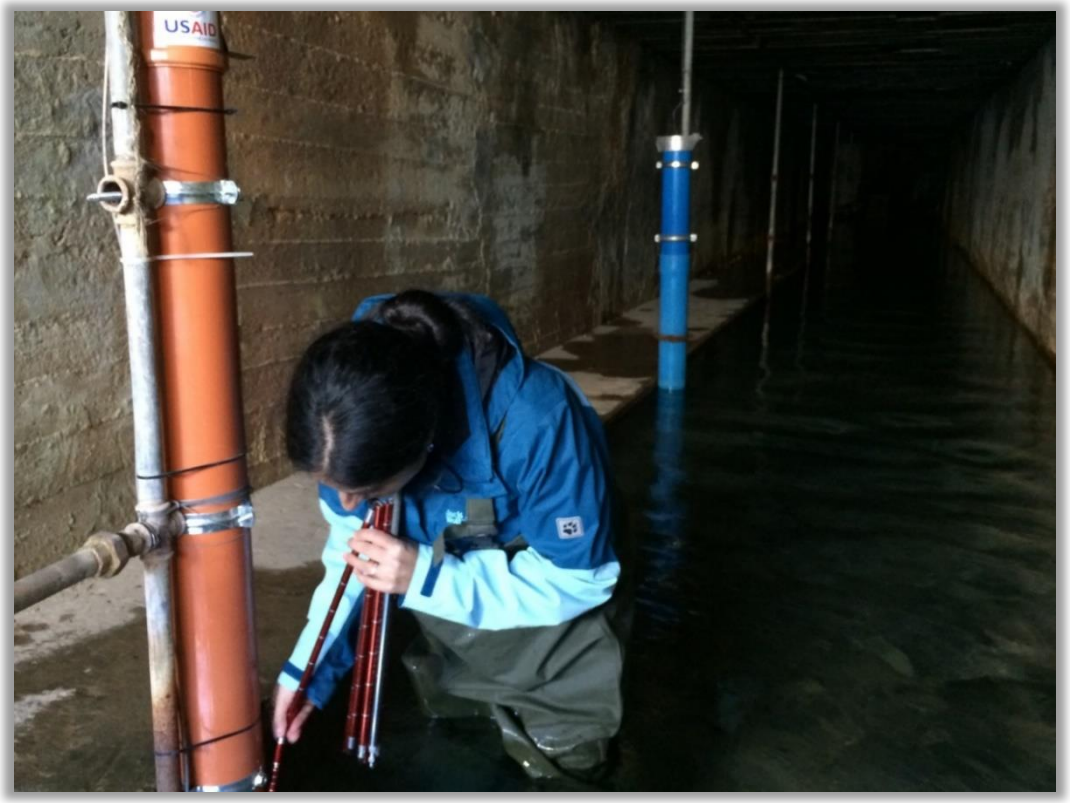
Full climatic station (Brand-Campbell) / Humidity, Precipitation (Rain and snow melt), Temperature, Radiation, etc.

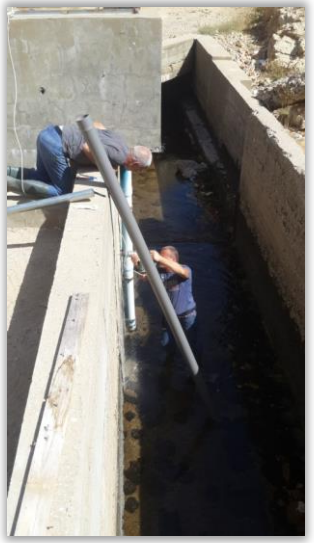
MONITORING SINCE 2014-ONGOING DATA COLLECTION (TEMPORAL AND SPATIAL)

Set up of a monitoring network = climate and spring data

Installation of a multi parameter probe



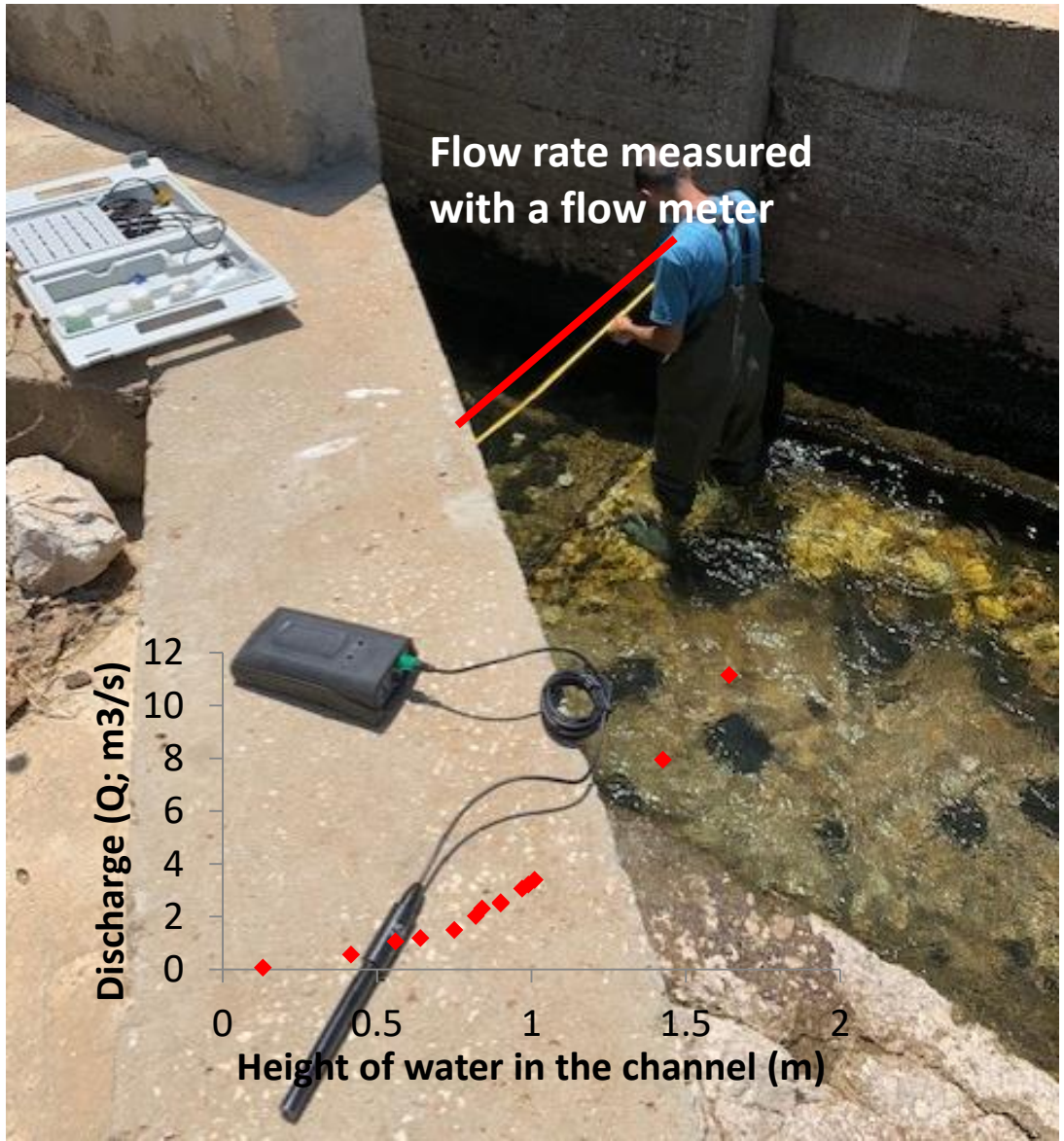


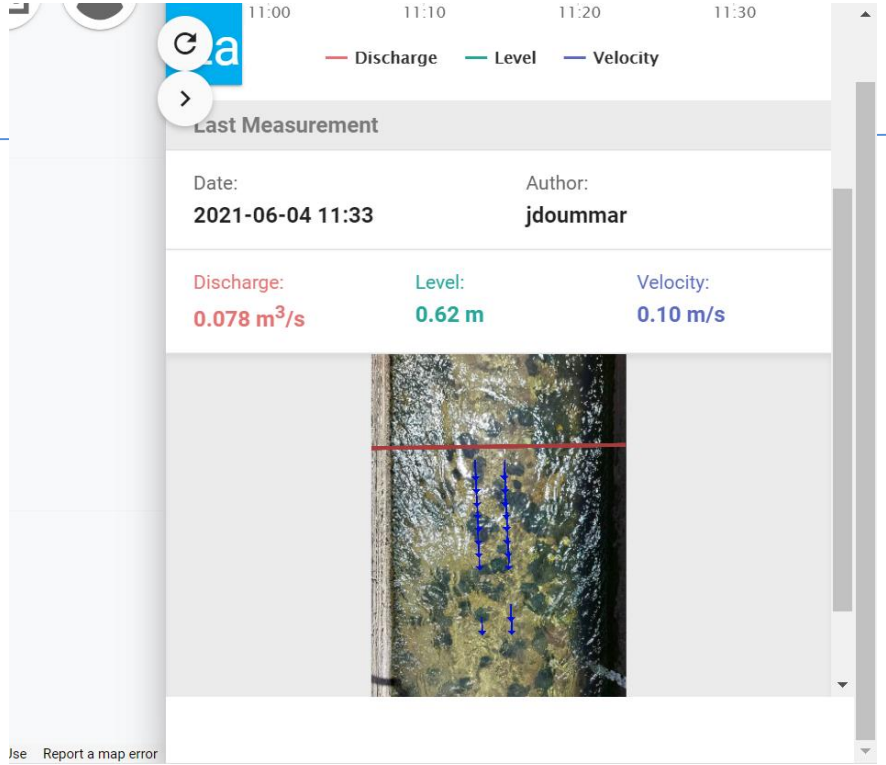


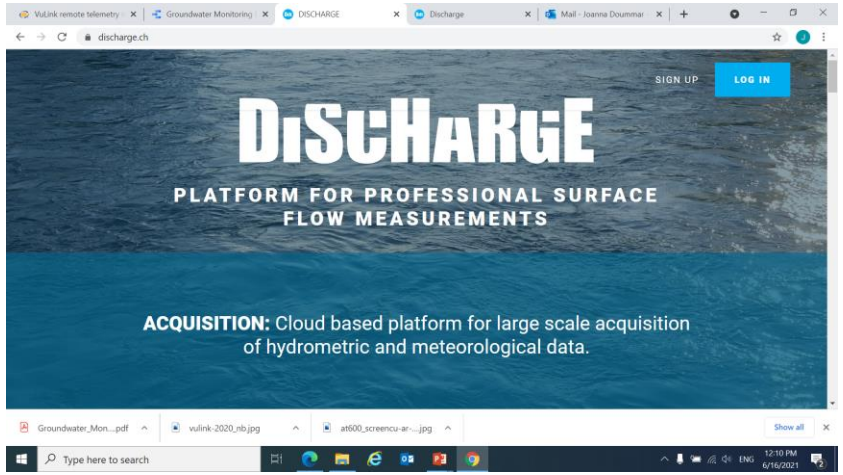
Multi Parameter probes (Brand-Insitu Aquatroll 600): Water level, Temperature, Chloride, pH, and Electrical conductivity etc.

MONITORING SINCE 2014-ONGOING DATA COLLECTION

Rating curves and discharge



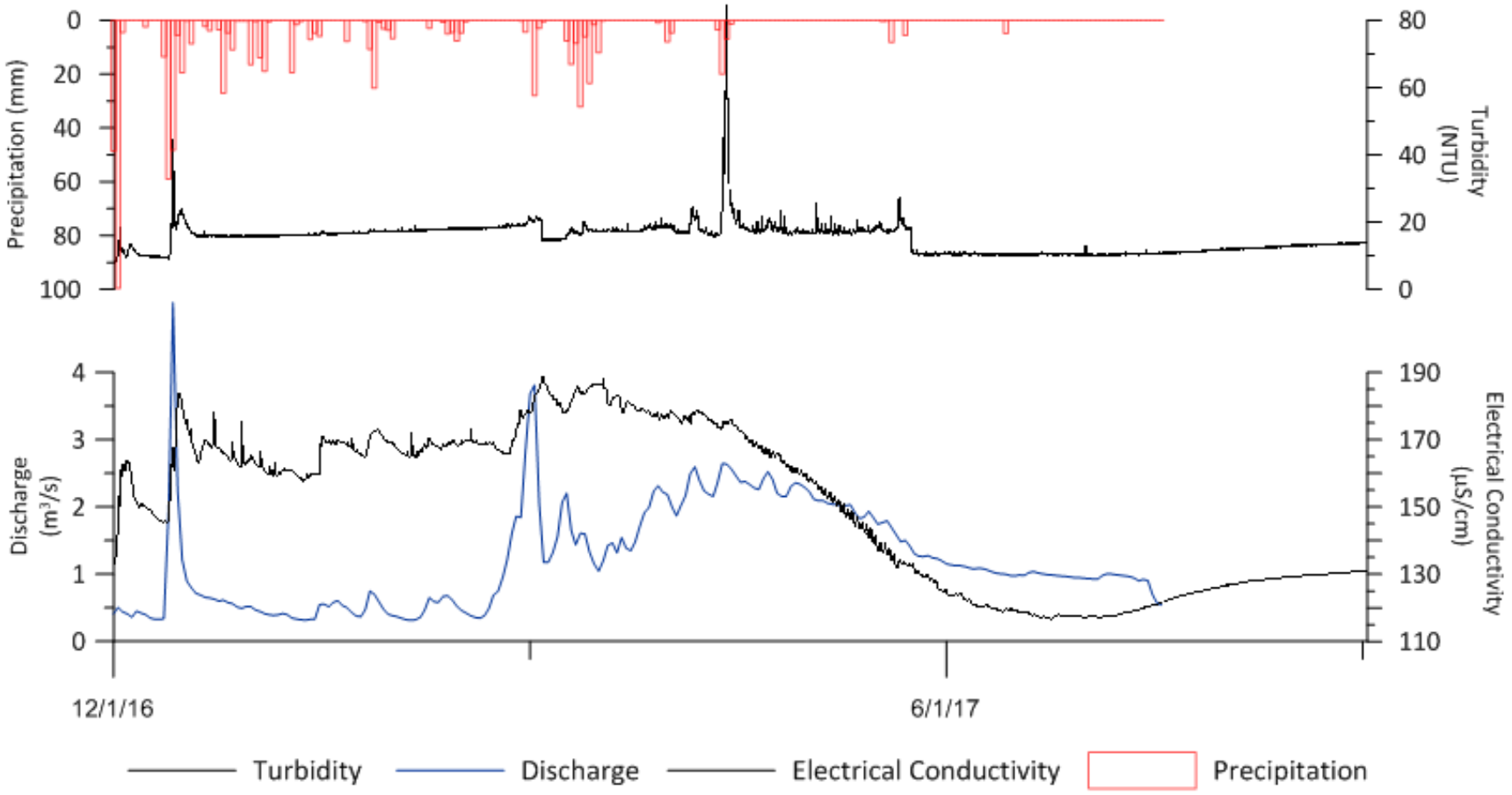




MONITORING SINCE 2014-ONGOING DATA COLLECTION (TEMPORAL AND SPATIAL)

Set up of a monitoring network = climate and spring data

Relationship between data (Example 2016-2017)

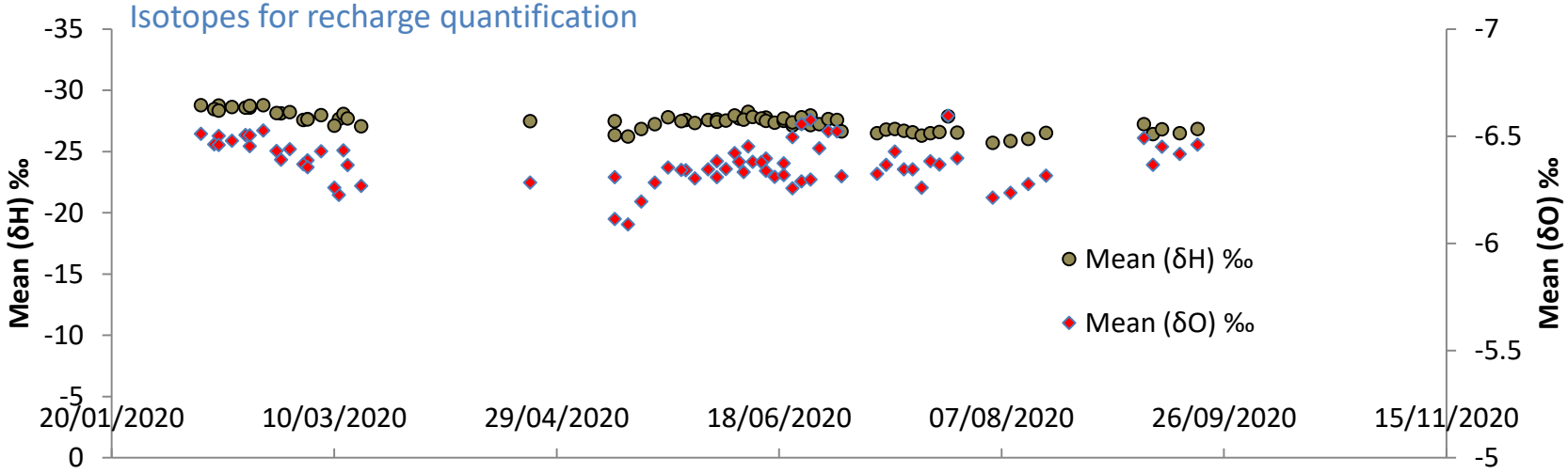


Multi Parameter probe (Brand-Insitu 9500 Prof.) / Water level, and Electrical conductivity and turbidity etc.

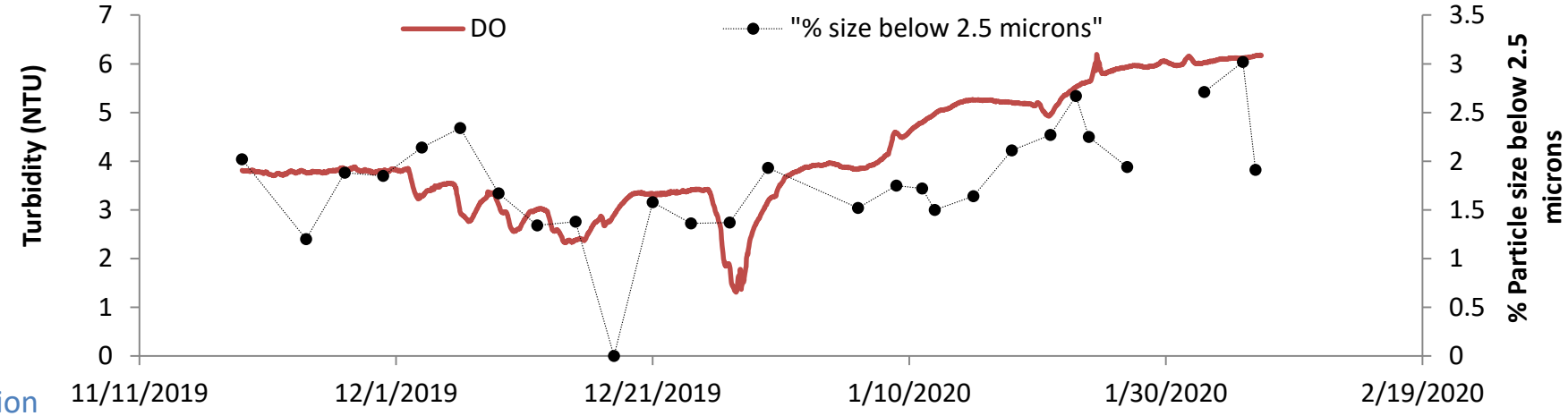
MONITORING SINCE 2014-ONGOING DATA COLLECTION (TEMPORAL AND SPATIAL)

Grab Samples with automatic samplers (Particle size, Isotopes, hydrochemistry, Micropollutants)

Isotopes for recharge quantification



Indicator for bacterial contamination



MONITORING SINCE 2014-ONGOING DATA COLLECTION

Expansion and continuous monitoring= climate and spring data

- Future installation of telemetric units (Vulink)
- Transfer of data to a server, processing and display on dashboard

Expected dashboard completion by end of 2021

- Installation of a snow depth and an additional rain gauge on the area

Monitoring equipment installed at Aassal Spring.

A 3D satellite image of Aassal spring location in Kfardebian, Lebanon (Google Earth).

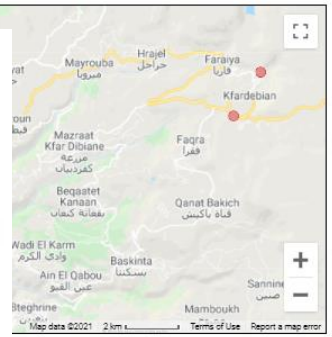
Groundwater Monitoring Project - LEBANON

Groundwater Monitoring in Lebanon is a long-term project that has been the main interest of the HydroGeology research group of the Geology Department at the American University of Beirut.

This project is the culmination of multiple years of research and projects of variable scales which include data acquisition, data analysis, water quality testing, flow modeling, transport characterization, geological evaluation, and conceptual modeling.

For this project's purpose, five main monitoring sites were selected in poorly investigated pilot karst catchments in Metn and Kesrouane areas. These sites are listed below and displayed on the map.

This was established in collaboration with UNICEF and USAID which sponsored different parts of the project.



Spring

Nahr El Kalb River

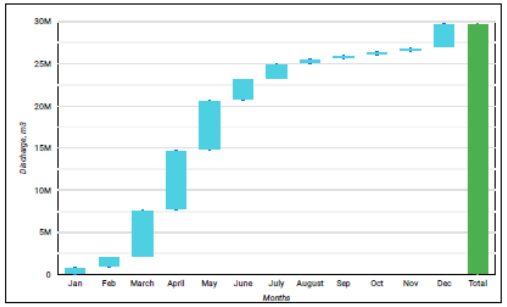
Laban Spring

Annual Water Discharge Volume

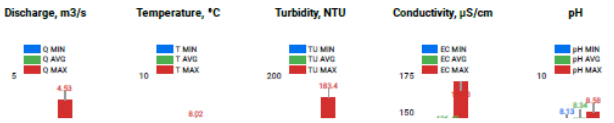
Water discharge volume is calculated by multiplying the discharge rate (Q, m3/s) with time (seconds).

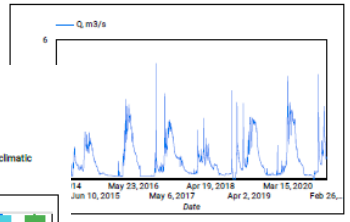
Monitoring the discharge volume throughout the year is crucial to understand the availability of freshwater supply across variable seasonal and climatic settings. It's also an important parameter for the delineation of the catchment zone.

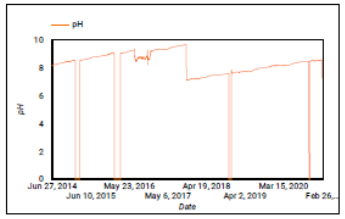
Months	Discharge, m3
January	827.6K
February	1.2M
March	5.6M
April	7.1M
May	5.9M
June	2.6M
July	1.8M
August	628.9K
September	429K
October	418.9K
November	496.8K
December	2.8M
Grand total	29.8M



Annual Water Data Record







ture and Electrical Conductivity

ductivity (EC) is a measure of how easy electricity could pass lution and the SI unit of conductivity is Siemens per meter. l for measuring EC of freshwater sources is micro-siemens per S/cm) because of their extremely low conductivities.

rature affects other water quality parameters such as pH and rgen. In addition, it influences the presence of marine nd affects the occurrence of various chemical and biological the water.

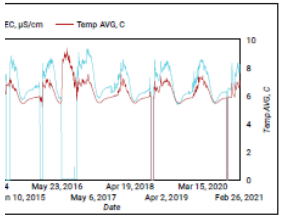
mperature and electrical conductivity are measured and omatically using automated monitoring devices and probes.

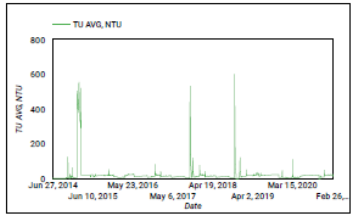
Water Turbidity

Turbidity is a measure of the water cloudiness. Turbidity in water is due to the presence of suspended particles and it is measured in Nephelometric Turbidity Unit (NTU). These suspended particles are small-sized solid materials such as silt, clay, organic materials (e.g. algae), inorganic materials, etc...

The main concept applied in determining turbidity relies on measuring the intensity of scattered light upon illuminating the water sample using a light source.

Turbidity of water is measured and recorded automatically using automated monitoring devices and probes.





Data Range: Jun 27, 2014 - Feb 27, 2021

Temp AVG, C	TU AVG, NTU	EC, µS/cm	pH
5.54	0.11	119.71	8.15
5.55	0.12	119.71	8.16
5.56	0.13	119.8	8.17
5.56	0.11	119.9	8.18
5.57	0.12	120.04	8.18
5.57	0.13	120.18	8.18
5.58	0.14	120.33	8.19
5.58	0.12	120.44	8.19
5.59	0.13	120.43	8.2
5.59	0.12	120.55	8.2
5.59	0.13	120.69	8.21
5.6	0.15	120.76	8.21
5.6	0.15	120.74	8.21

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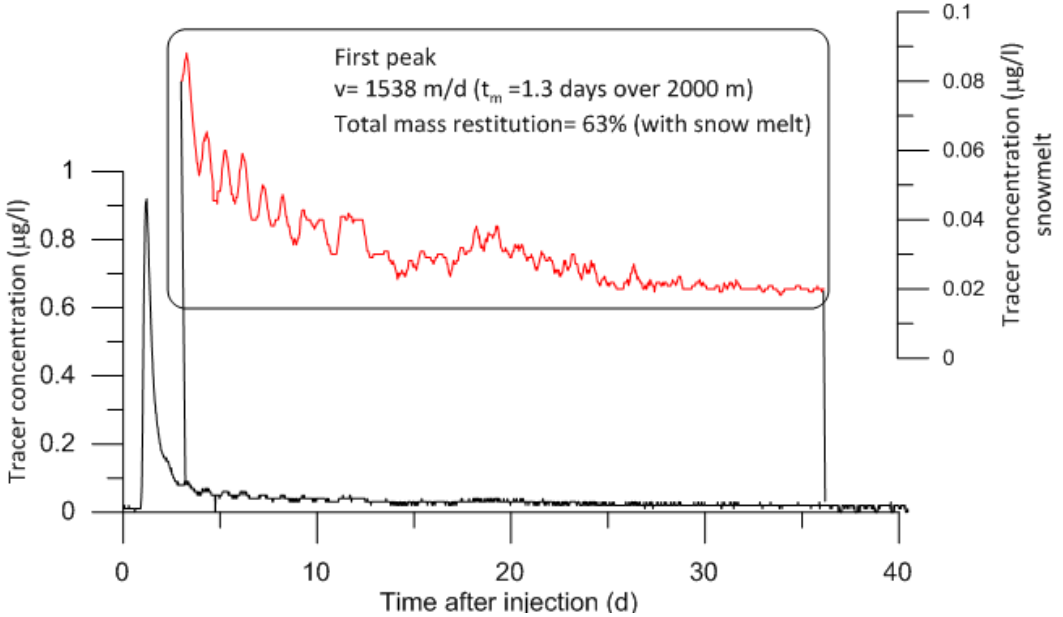
pH

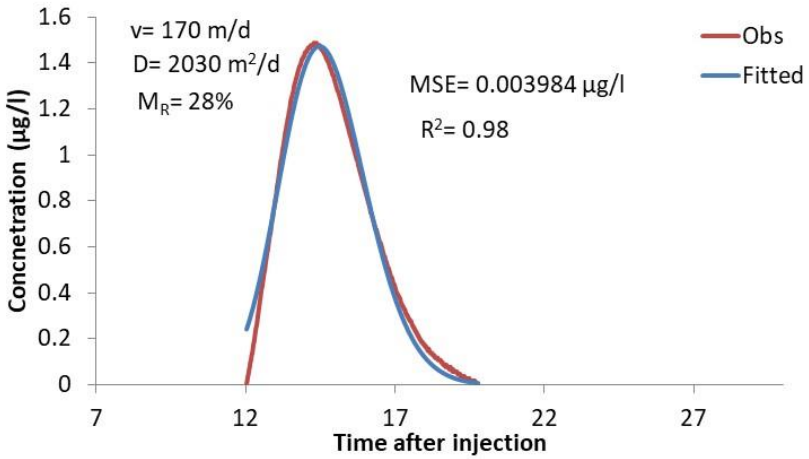
nit time.

The pH of a medium is a measure of acidity which is based on the

CATCHMENT EXPERIMENTS

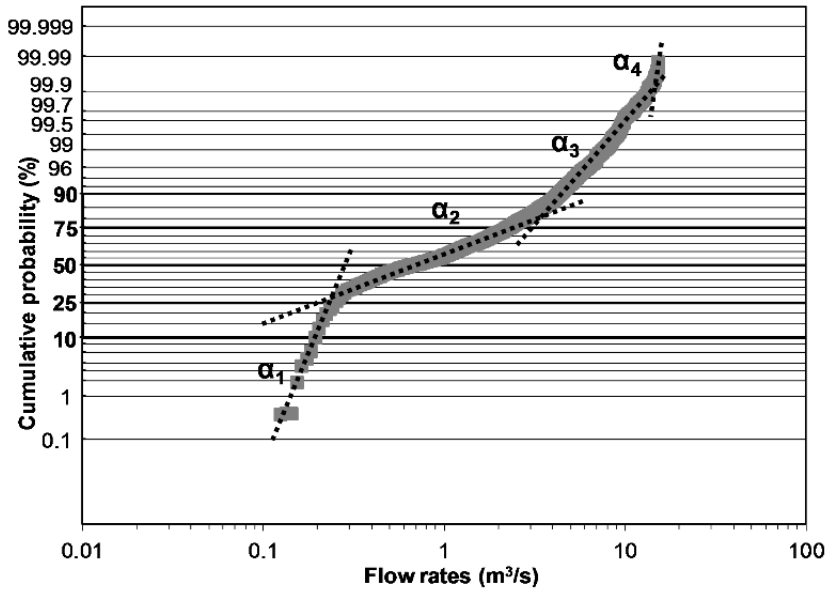
Multiple tracer experiments to identify connections and delineate catchment, and estimate transport parameters



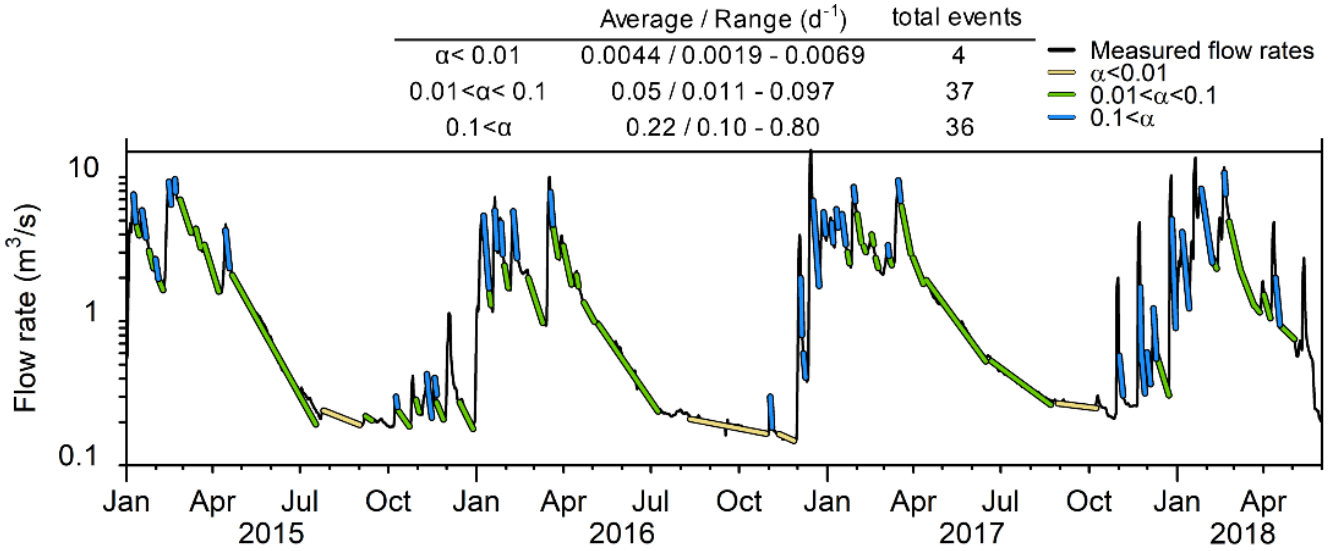


How is the data used?

CLASSIFICATION OF SPRING FLOWRATES – QUALITATIVE KARST TYPOLOGY

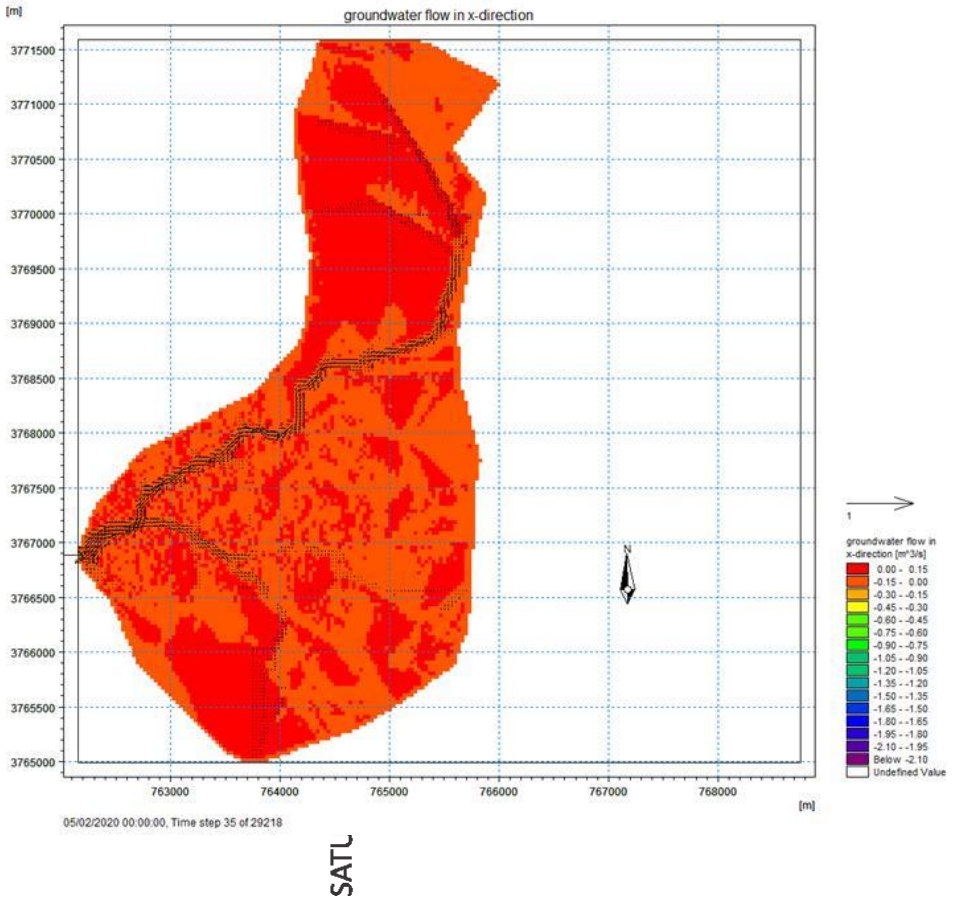


- Flow rate frequency (Dörfliger *et al.,* 2010)



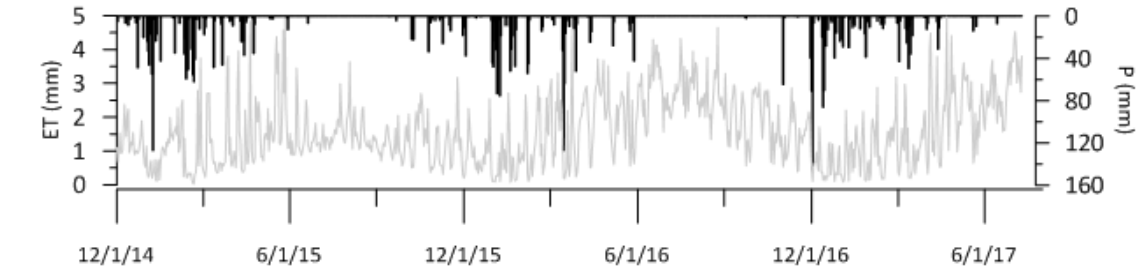
- Storage, recession, and depletion rates (Dubois et al., 2020)

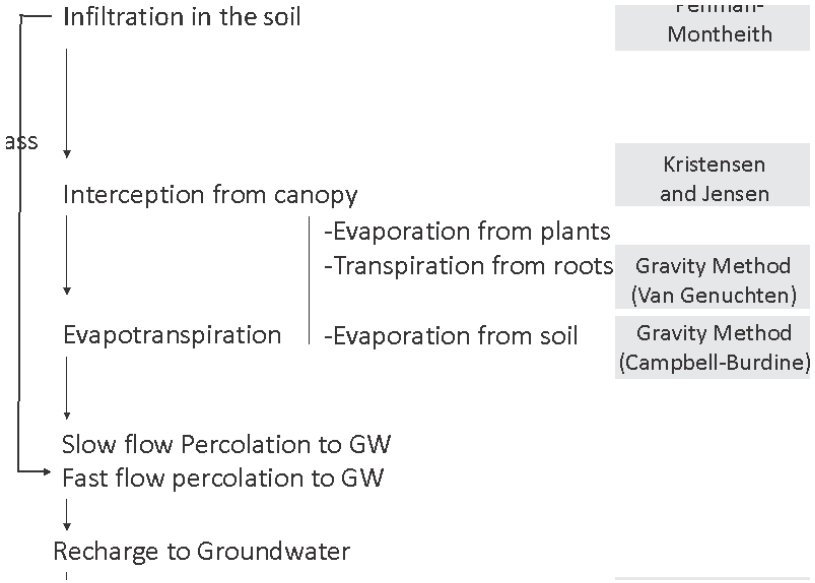
IMPLEMENTATION OF DATA IN A DISTRIBUTED INTEGRATED MODEL TO SIMULATE FLOW

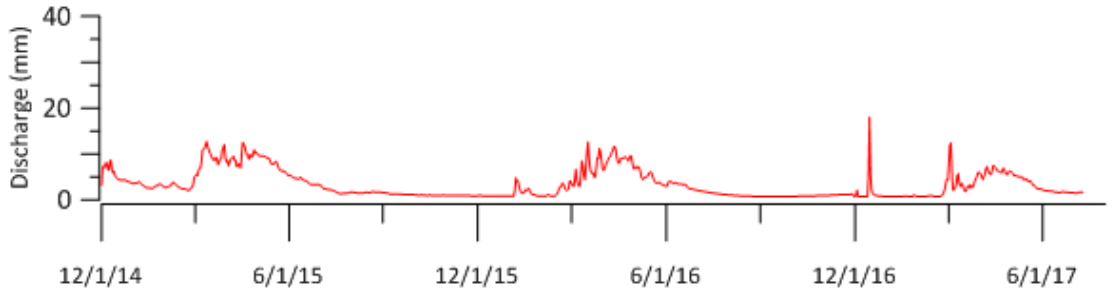


SATL

Doummar et al., 2012, 2018b







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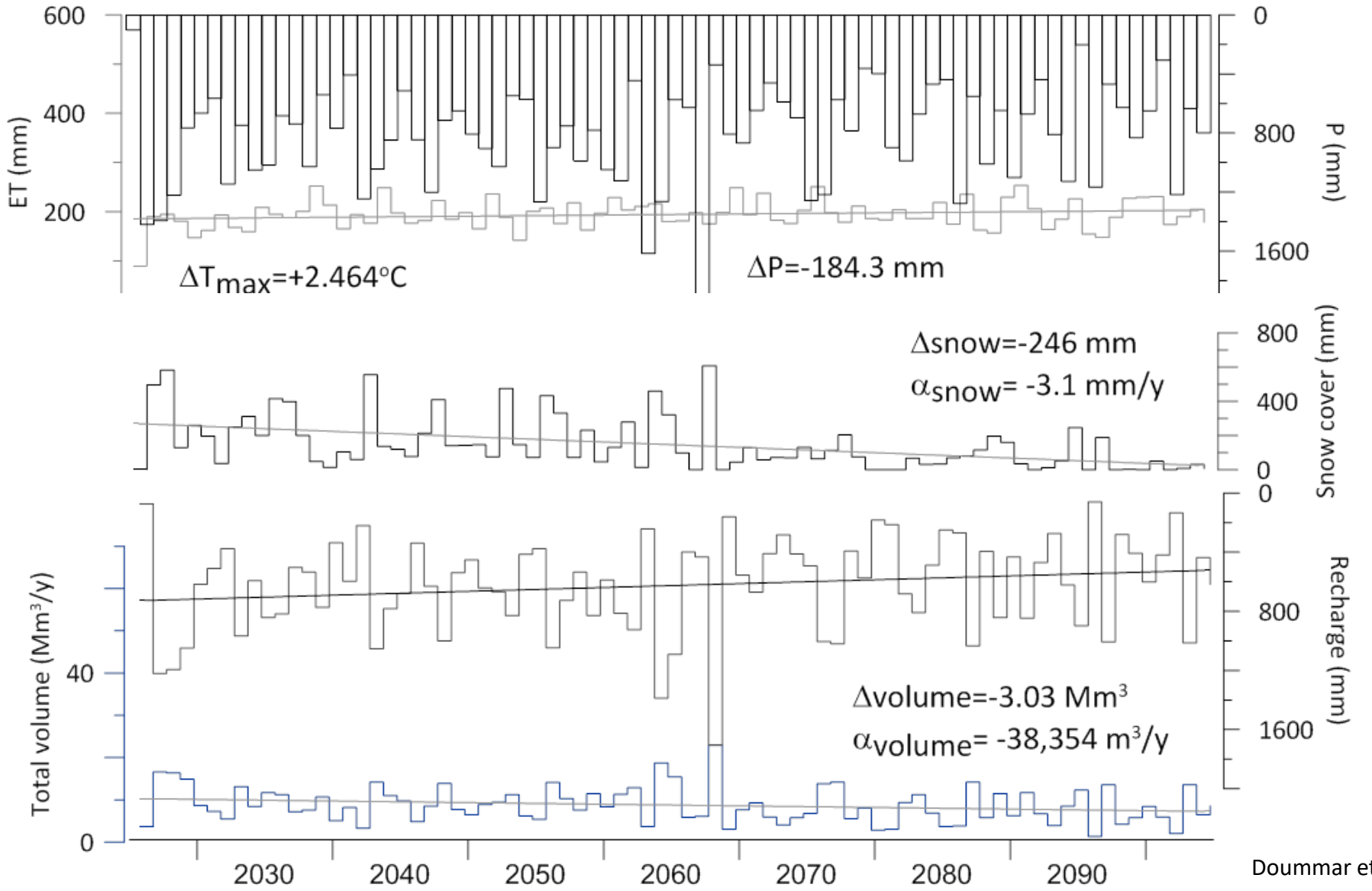
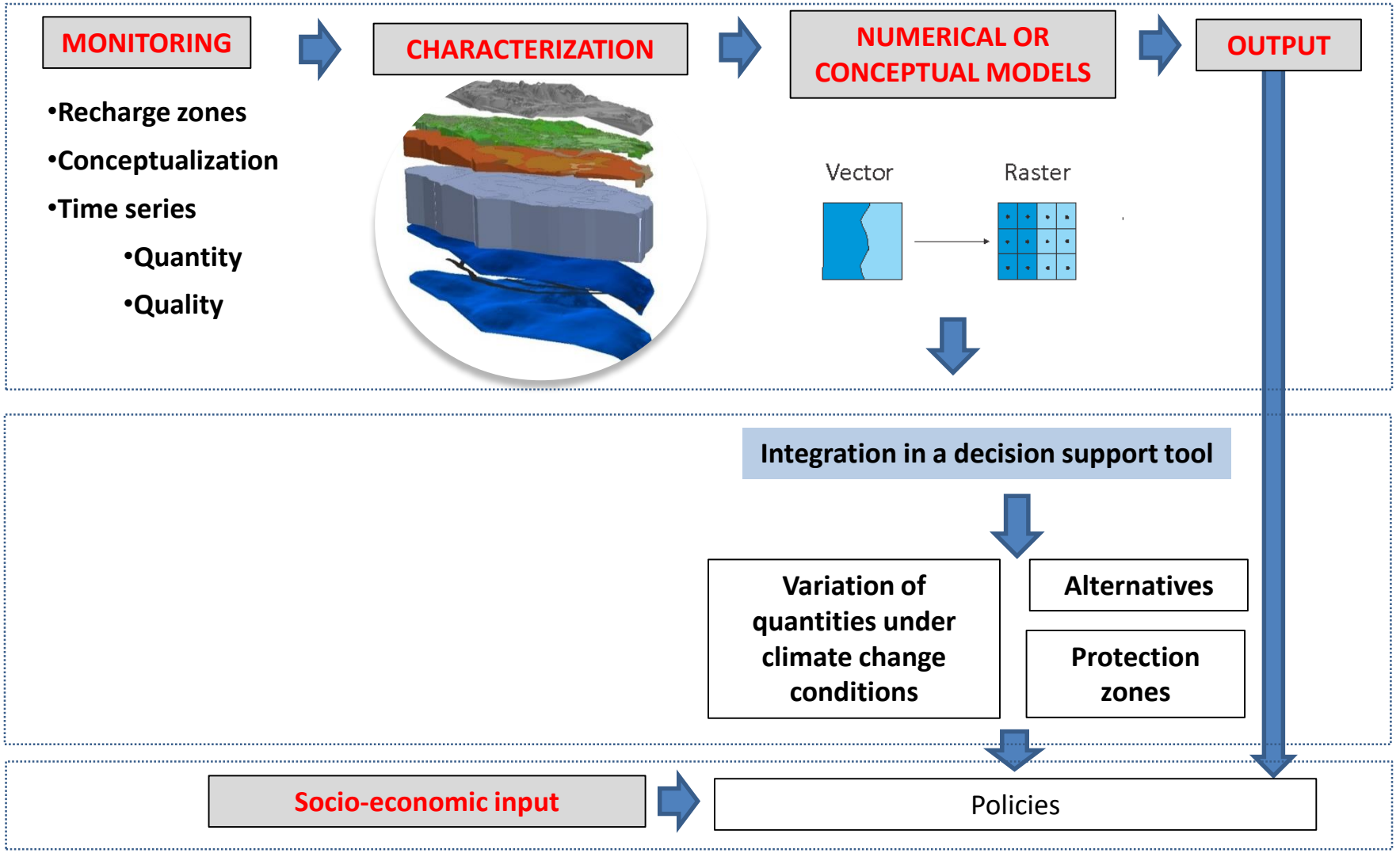


Doummar et al., 2018b

CONCLUDING REMARKS: FROM MONITORING TO MODELLING




THANK YOU