International Association of Hydrogeologists

- IAH aims to be a leading international society for the science and practice of hydrogeology and to be a globally recognized information source and facilitator for the transfer of groundwater knowledge.
- The local chapters of IAH aim at bringing scientific, professional and social benefits to the community and promote the sound and sustainable groundwater use at a country and regional level.

Visit: https://iah.org/

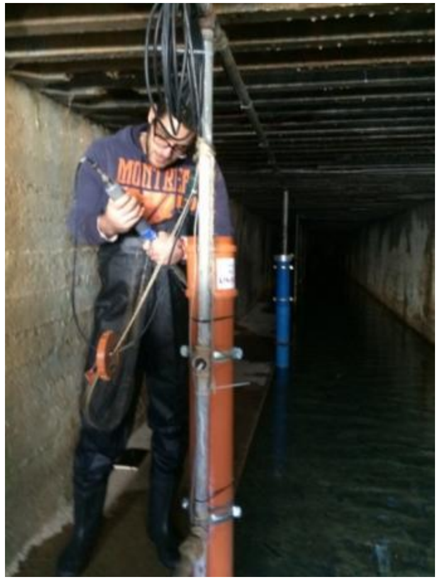
Joanna J. Doummar

American University of Beirut- Geology Department- P.O. Box 11-0236- Riad El-Solh, Beirut 1107 2020,
Regional Vice President International Association of Hydrogeologists (MENA)
E-mail: jd31@aub.edu.lb

IAH MENA

- **IAH MENA:**
  - Promote Groundwater in the region through the individual and collective activity of the national chapters (Egypt, Iraq, recently Lebanon, Morocco, Tunisia, and Turkey),
  - Encourage regional meetings, case studies comparison, and development of local policies for water management, especially in poorly studied areas,
  - Raise awareness on groundwater vulnerability to optimize water consumption and contamination abatement through the proper relay of information,
  - Consolidate a network of young scientists especially women in the field of hydrogeology,
  - Bridge the gap between science and decision making.

https://iah.org/about/council



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

Joanna J. Doummar

American University of Beirut- Geology Department- P.O. Box 11-0236- Riad El-Solh, Beirut 1107 2020,
Regional Vice President International Association of Hydrogeologists (MENA)
E-mail: jd31@aub.edu.lb

Disruptive Technologies for Improved Groundwater Management Workshop

Beirut, June 16, 2021

CHALLENGES AND THREATS

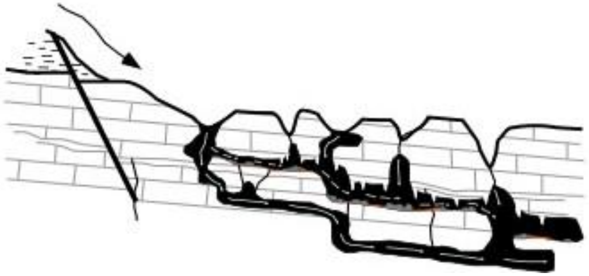
1. Groundwater is currently facing tremendous stress due to climate change and increase urbanization requiring science-supported management measures;
2. To achieve a sustainable management, there is a greater need to **understand how groundwater systems work** and the responses of groundwater to input 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.

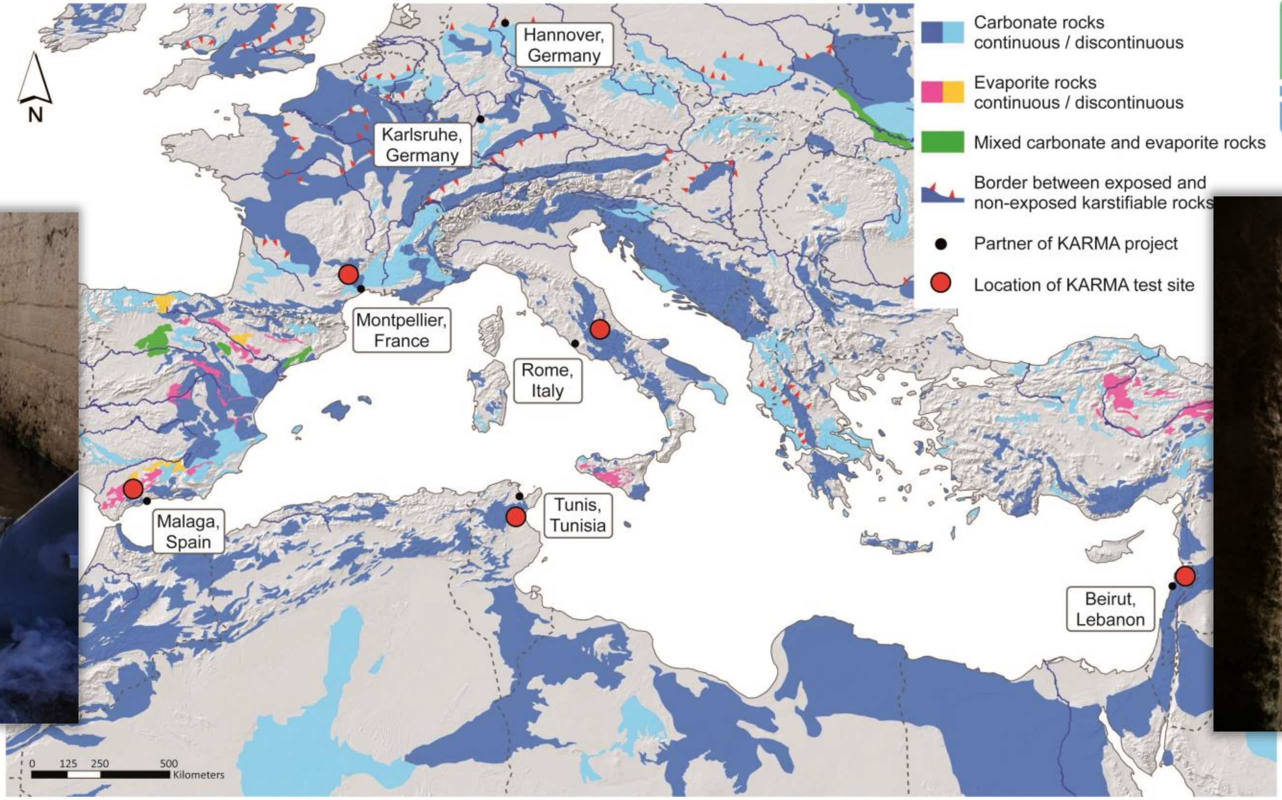


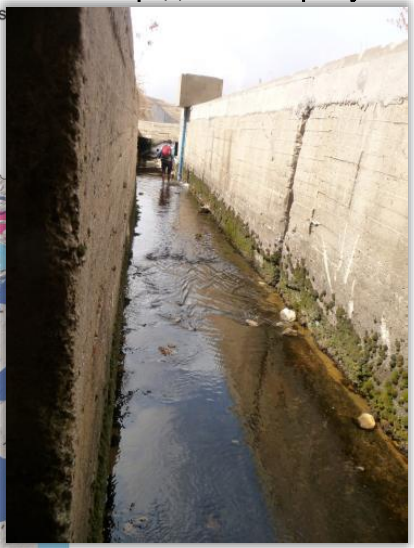
Karst Aquifer Resources availability and quality in the Mediterranean Area

The KARMA Project

http://karma-project.org/

May





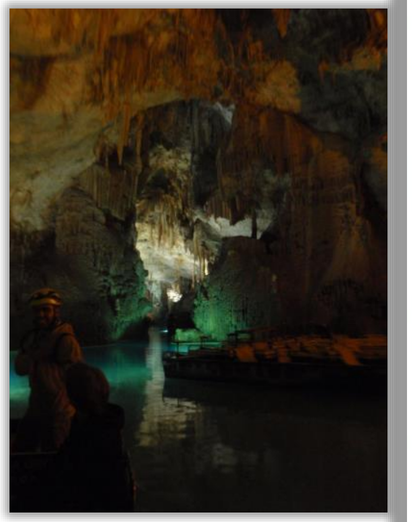
September

Field sites

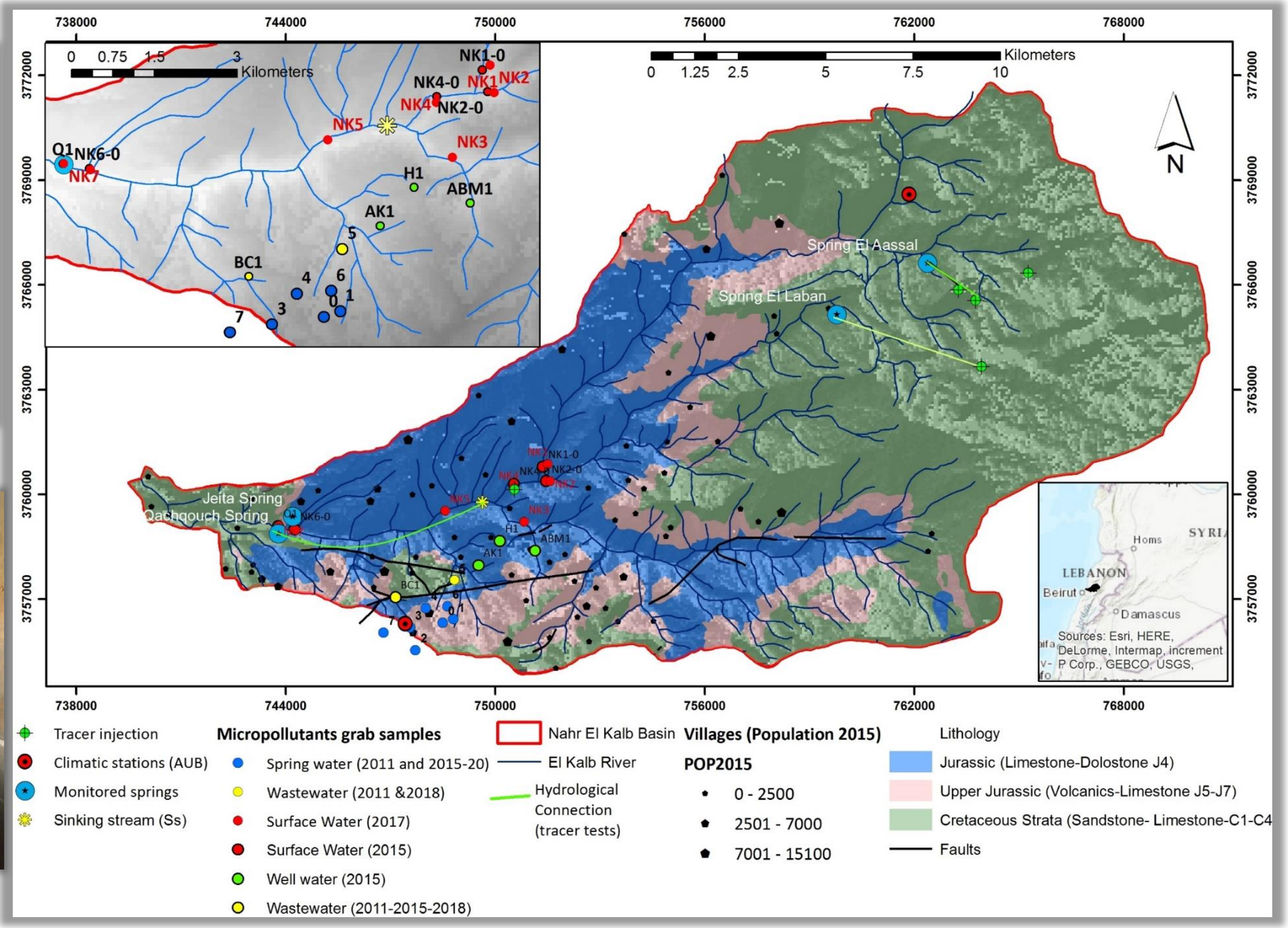

المصلحة الوطنية لنهر الليطاني
207 — ٢٠٧
OFFICE NATIONAL DU LITANI

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 (funded by USAID and National Academy of Science; PEER SCIENCE)

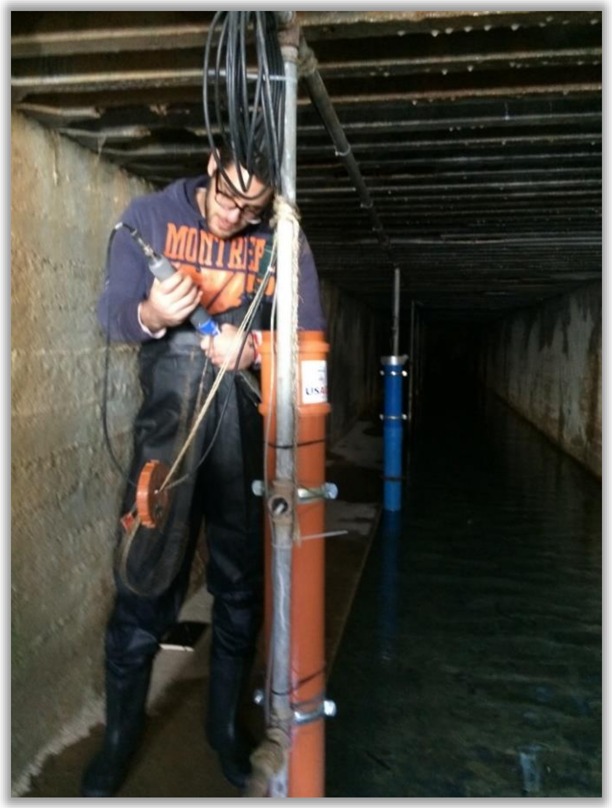
Installation of two climatic stations (Chabrouh and Bikfaya)

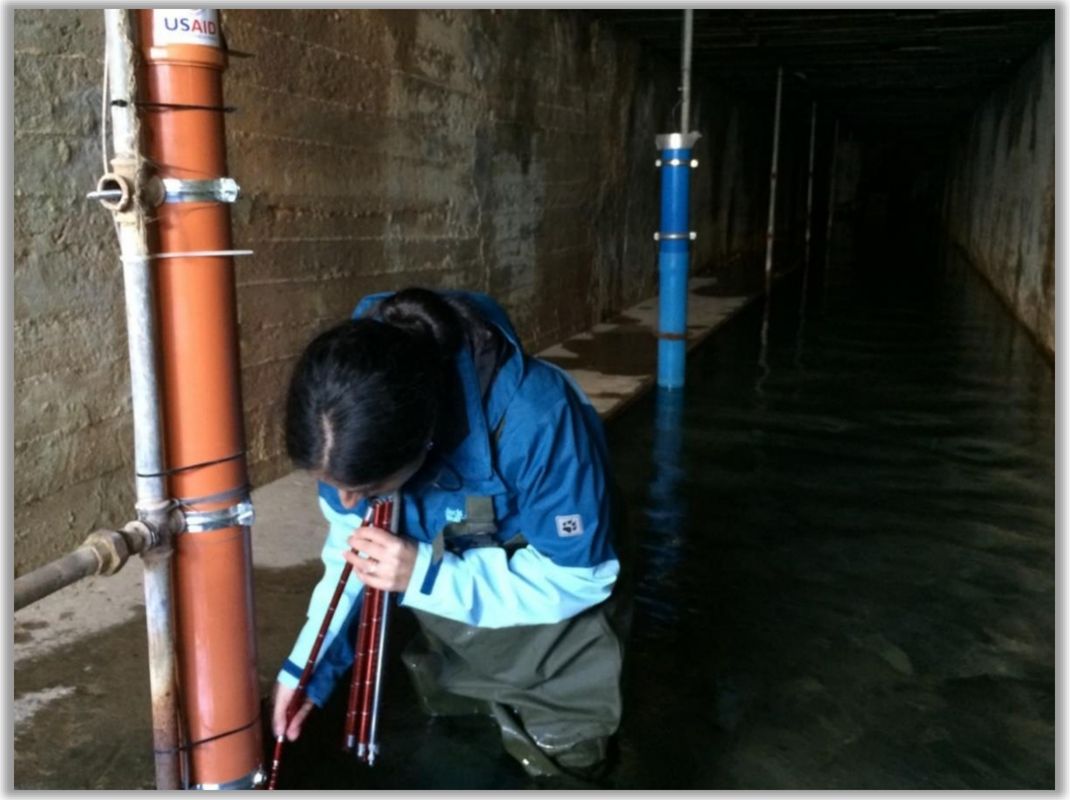
Full climatic station (Brand-Campbell) / Humidity, Precipitation (Rain and snow melt), Temperature, Radiation, etc.
+A collaboration with University Saint Joseph (UNICEF): assessment of snow cover with remote sensing on a selected area

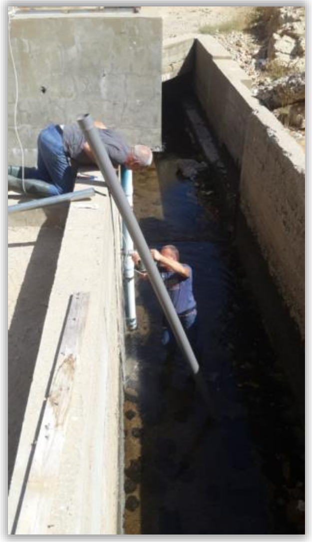
MONITORING SINCE 2014-ONGOING DATA COLLECTION (TEMPORAL AND SPATIAL)

Set up of a monitoring network = climate and spring data (funded by USAID, supported by BGR)

Installation of a multi parameter probe



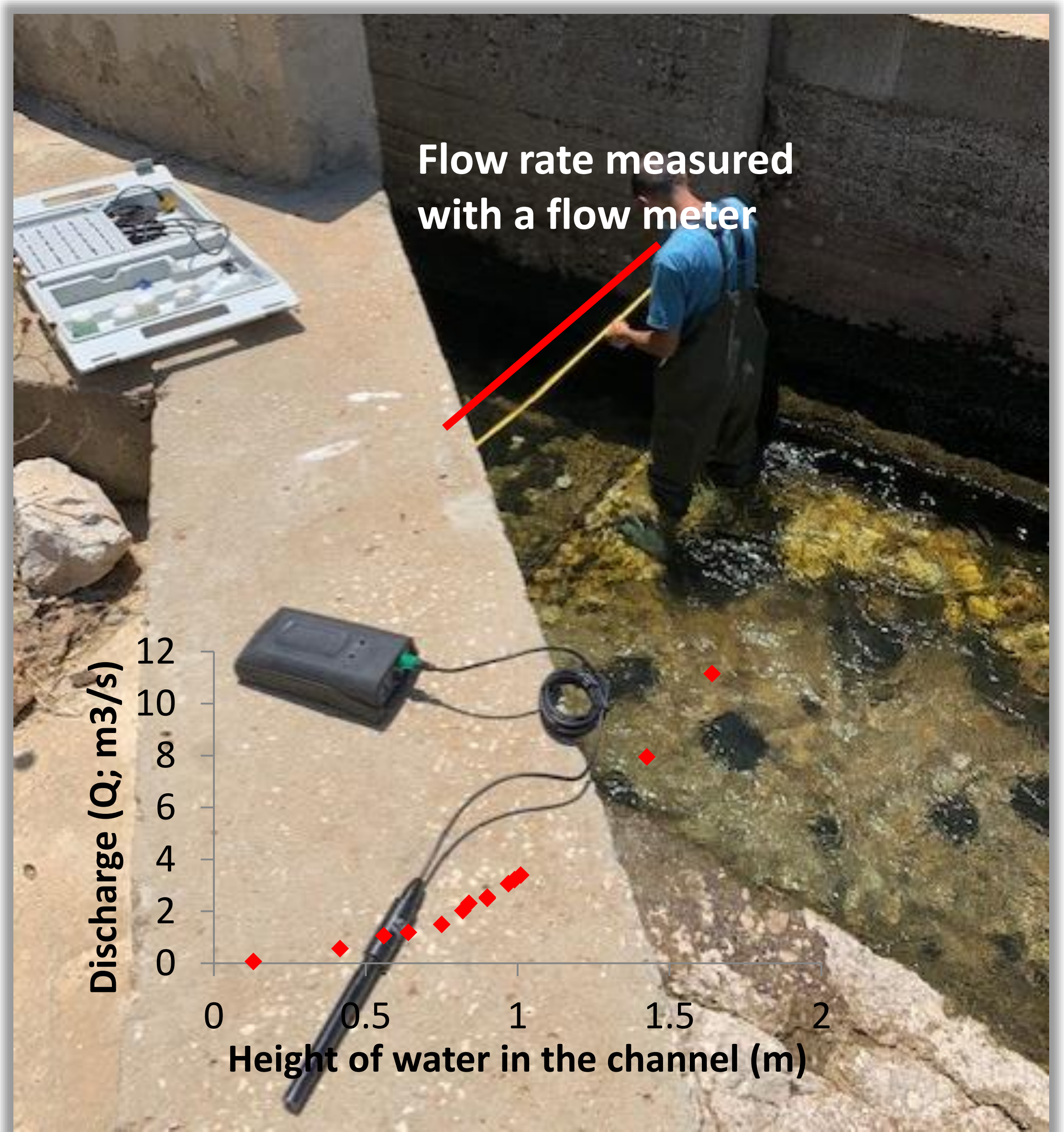


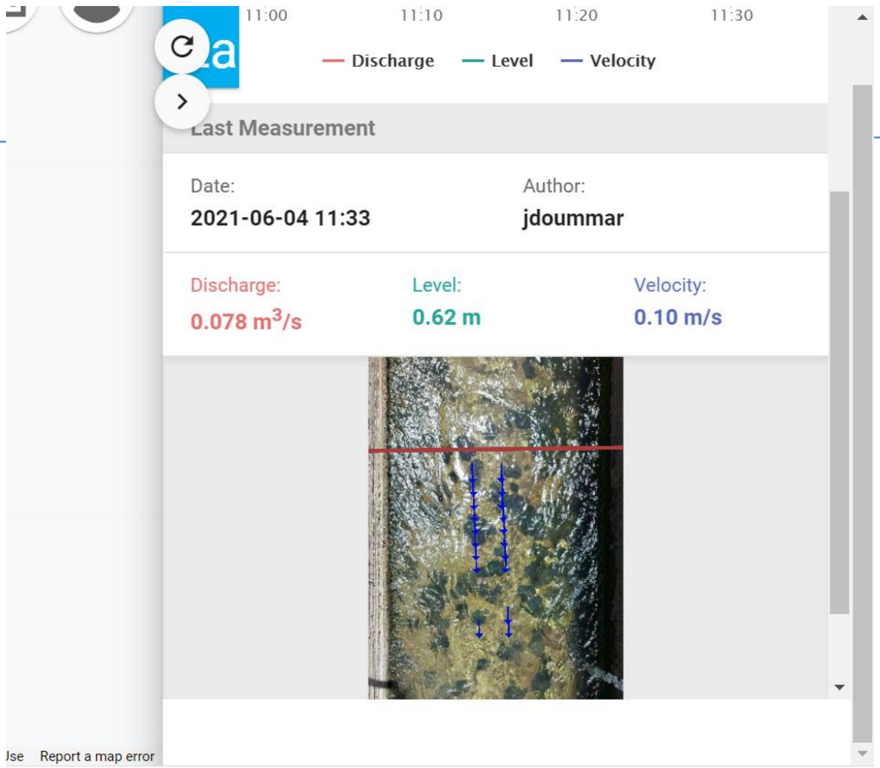


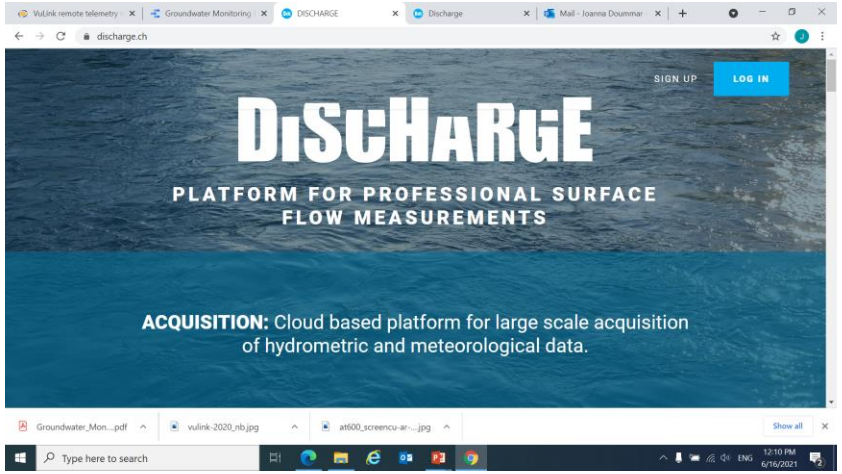
Multi Parameter probes (Brand-Insitu Aquatroll 600): Water level, Temperature, Chloride, pH, and Electrical conductivity etc.

MONITORING SINCE 2014-ONGOING DATA COLLECTION

Rating curves and discharge



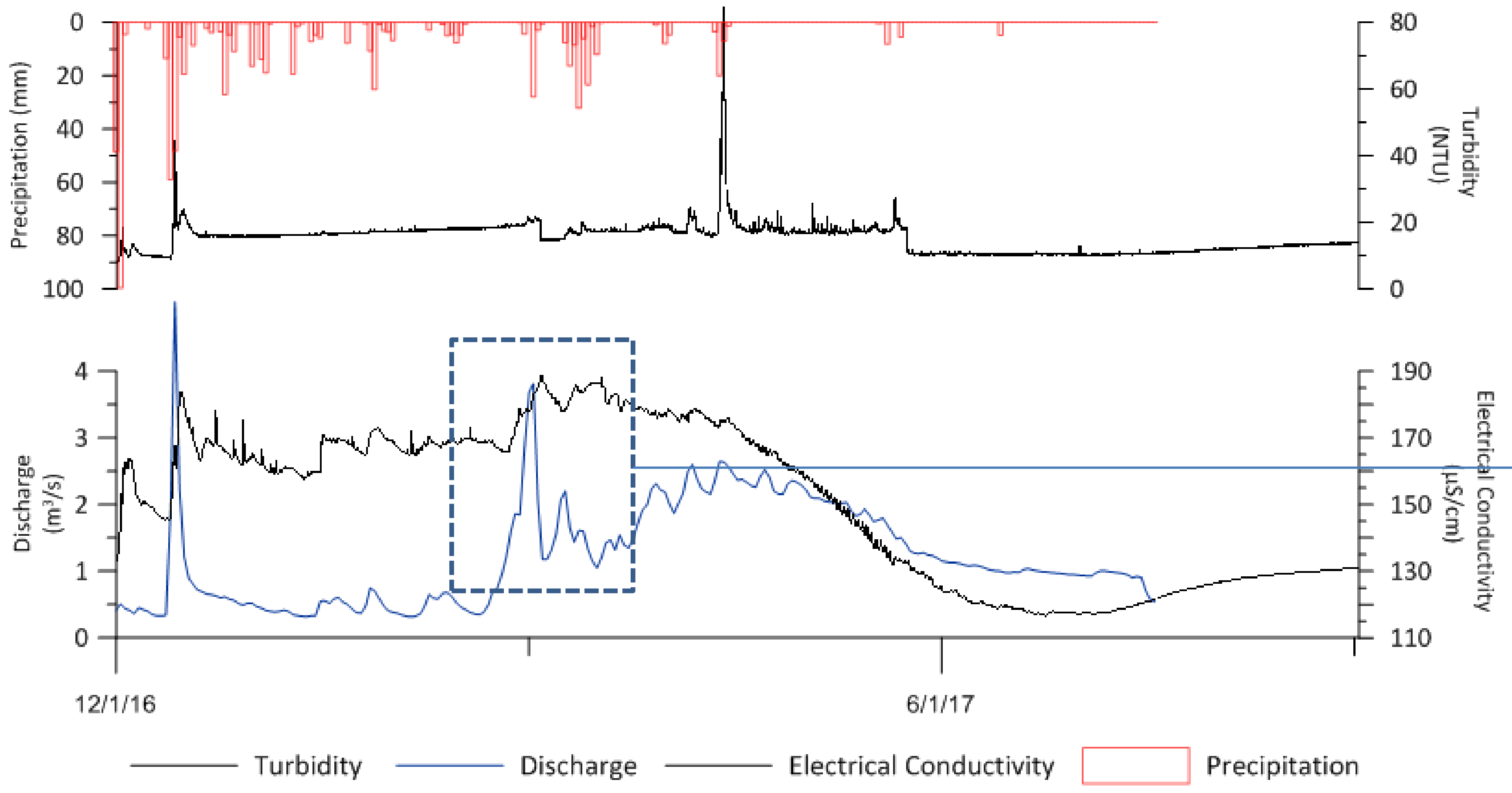




MONITORING SINCE 2014-ONGOING DATA COLLECTION (TEMPORAL AND SPATIAL)

Set up of a monitoring network = climate and spring data

Relationship between data (Example 2016-2017)

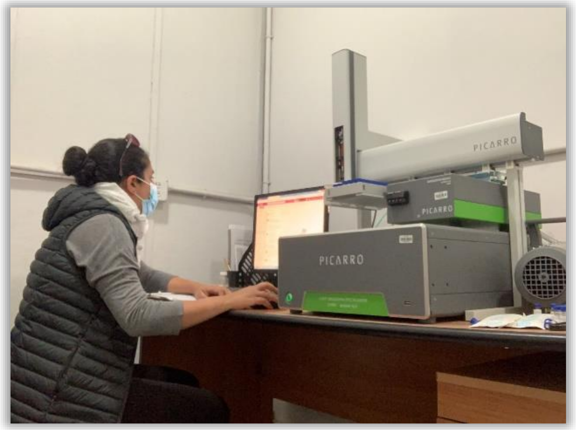


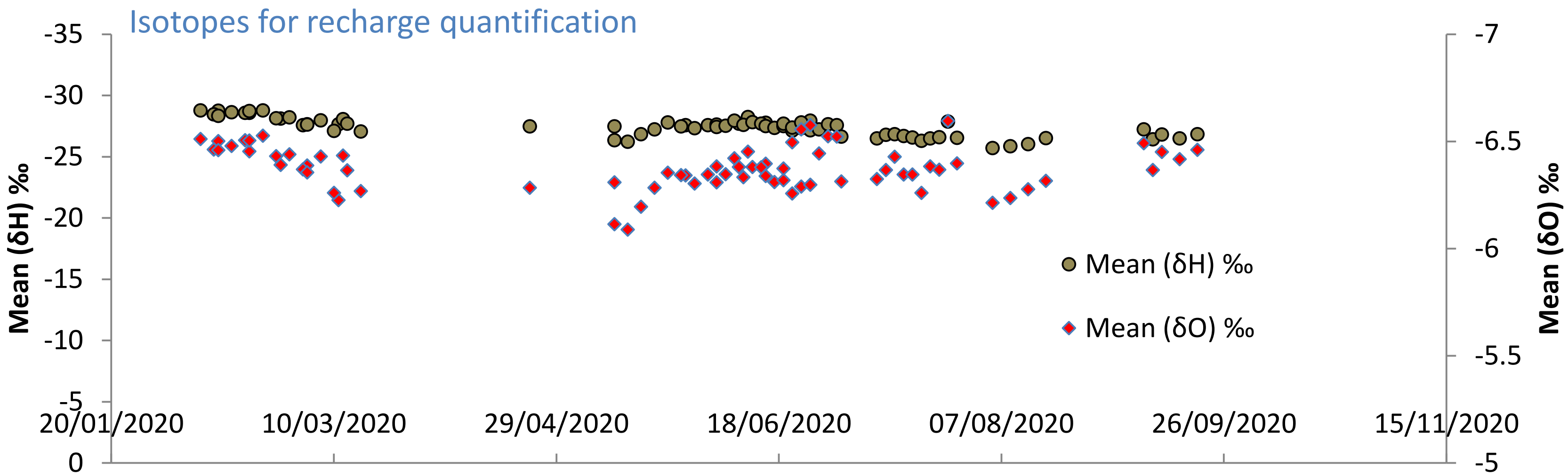
Flood waters can be used for recharge

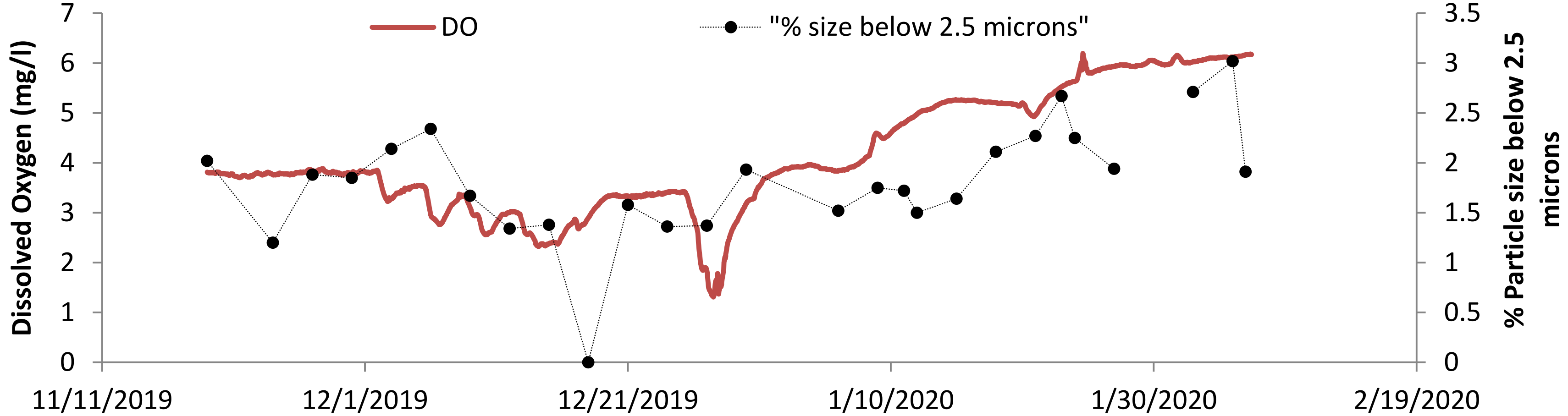
Multi Parameter probe (Brand-Insitu 9500 Prof.) / Water level, and Electrical conductivity and turbidity etc.

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

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







Indicator for bacterial contamination

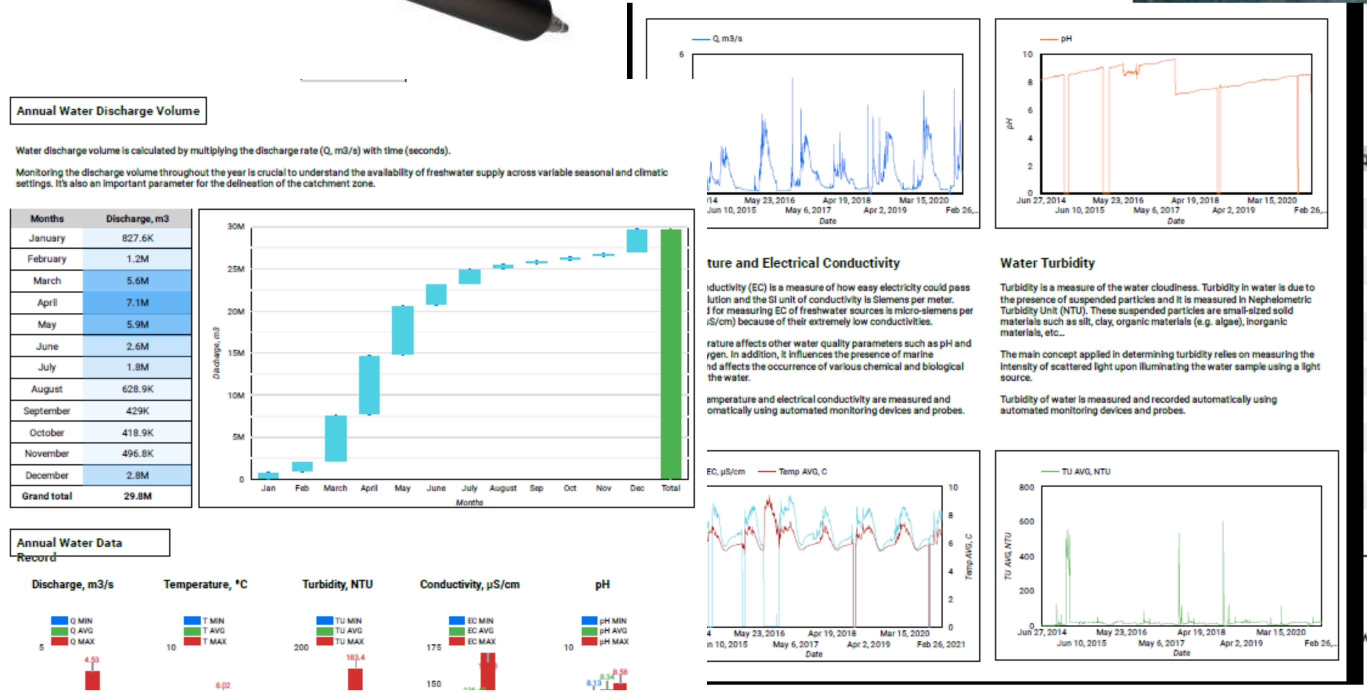
MONITORING SINCE 2014-ONGOING DATA COLLECTION

Expansion and continuous monitoring= climate and spring data

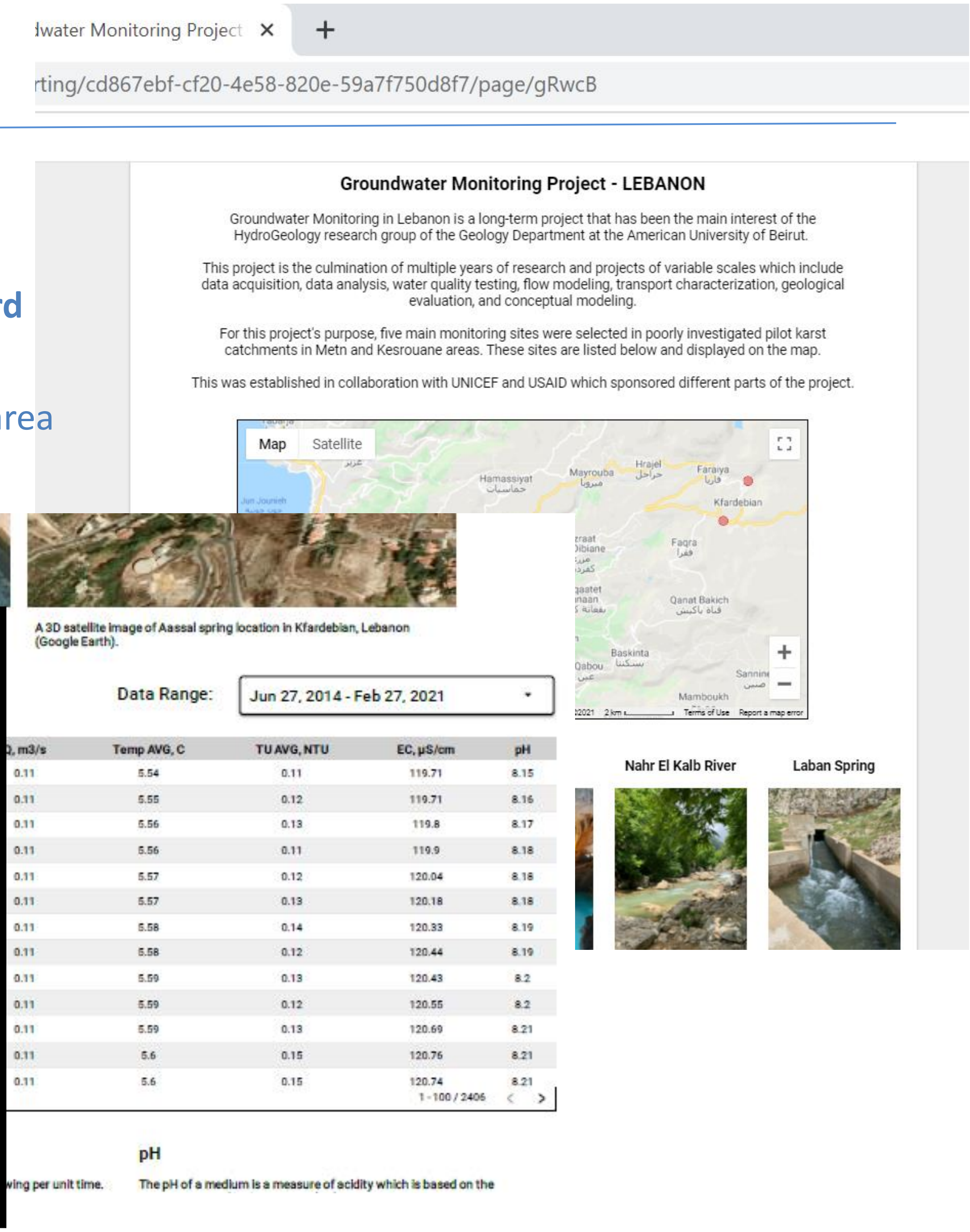
- Future installation of **telemetric units** (Vulink)
- Transfer of data to a server, processing and display **on a dashboard**

Expected dashboard completion by end of 2021

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



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

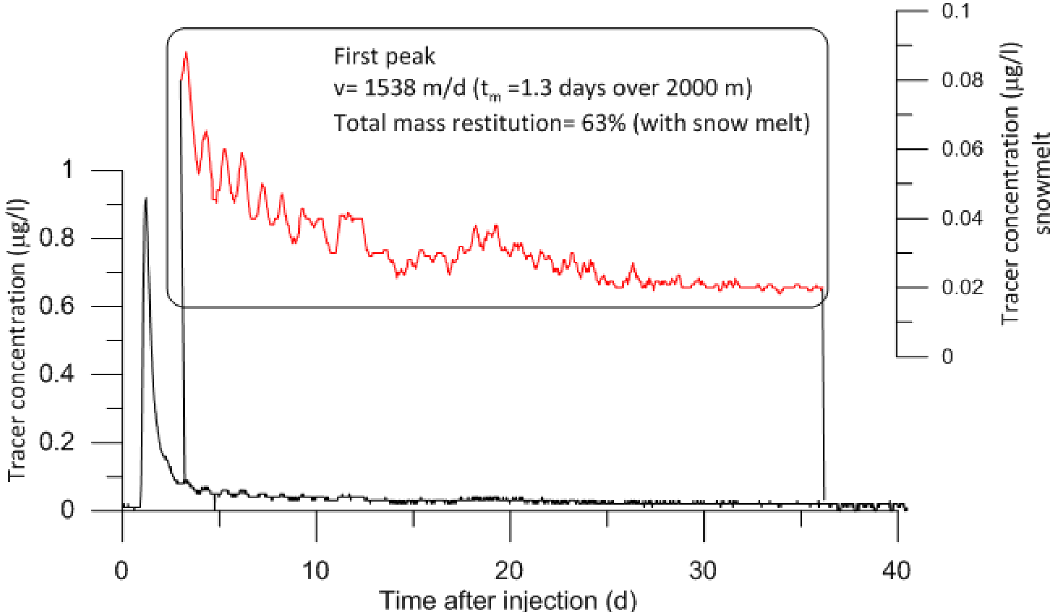


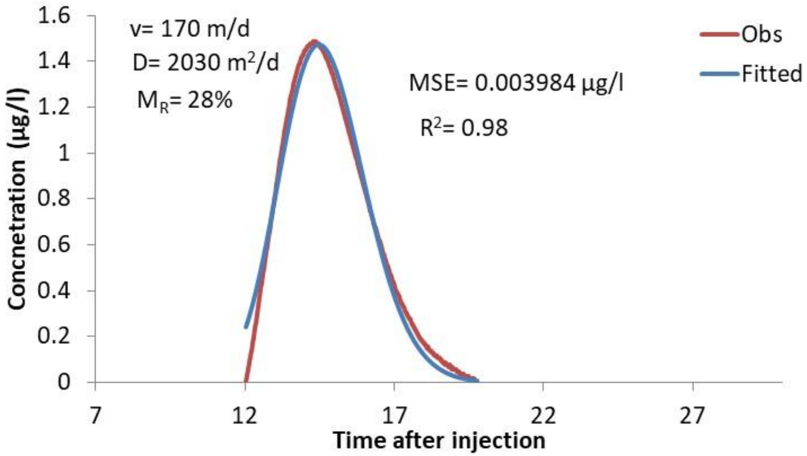
Q, m3/s	Temp AVG, C	TU AVG, NTU	EC, µS/cm	pH
0.11	5.54	0.11	119.71	8.15
0.11	5.55	0.12	119.71	8.16
0.11	5.56	0.13	119.8	8.17
0.11	5.56	0.11	119.9	8.18
0.11	5.57	0.12	120.04	8.18
0.11	5.57	0.13	120.18	8.18
0.11	5.58	0.14	120.33	8.19
0.11	5.58	0.12	120.44	8.19
0.11	5.59	0.13	120.43	8.2
0.11	5.59	0.12	120.55	8.2
0.11	5.59	0.13	120.69	8.21
0.11	5.6	0.15	120.76	8.21
0.11	5.6	0.15	120.74	8.21

1 - 100 / 2406

CATCHMENT EXPERIMENTS

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





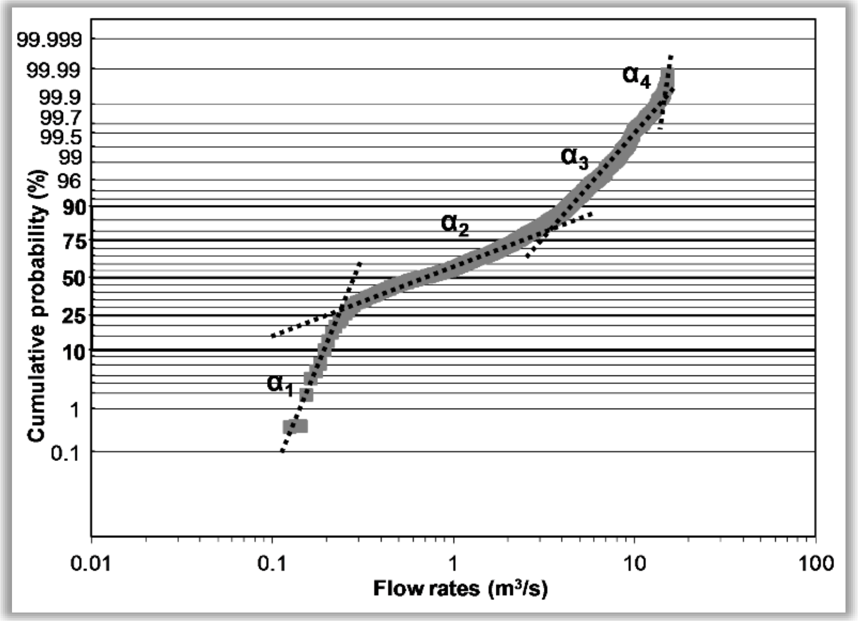


How is the data used?

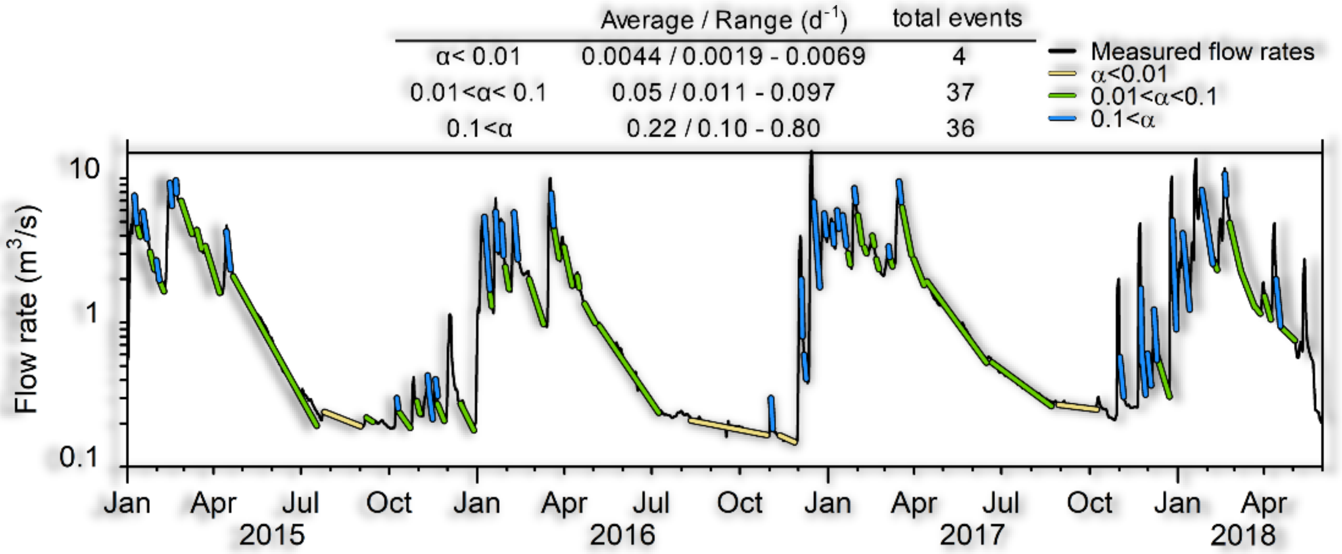


CLASSIFICATION OF SPRING FLOWRATES – QUALITATIVE KARST TYPOLOGY

Statistical Analysis (computational data analytics for prediction and establishment of early warning systems)
Currently applying Artificial Neural Network (Karlsruhe Institute of Technology in Germany)

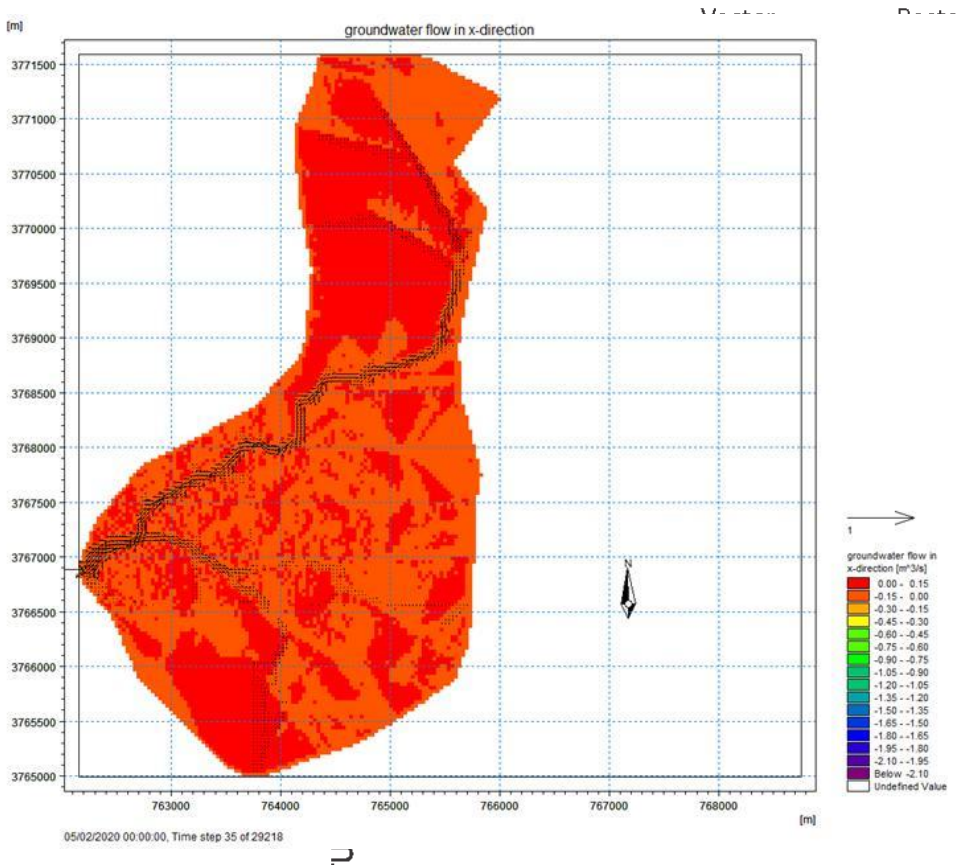


- Flow rate frequency (Dörfliger *et al.,* 2010)



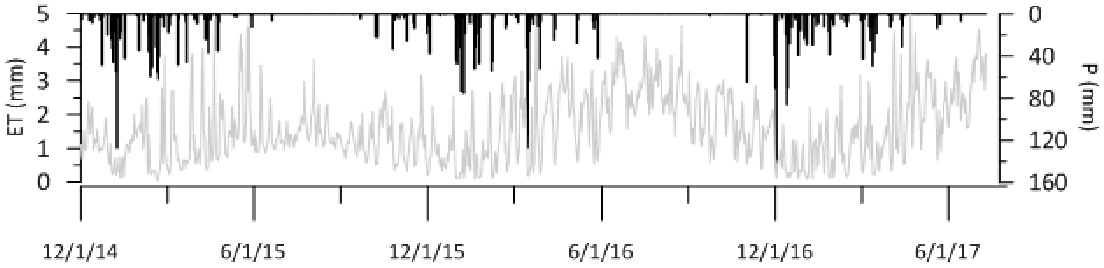
- Storage, recession, and depletion rates (Dubois et al., 2020)

IMPLEMENTATION OF DATA IN A DISTRIBUTED INTEGRATED MODEL TO SIMULATE FLOW



SATL

Doummar et al., 2012, 2018b



Infiltration in the soil

Penman-Montheith

ass

Interception from canopy

Kristensen and Jensen

-Evaporation from plants
-Transpiration from roots

Gravity Method (Van Genuchten)

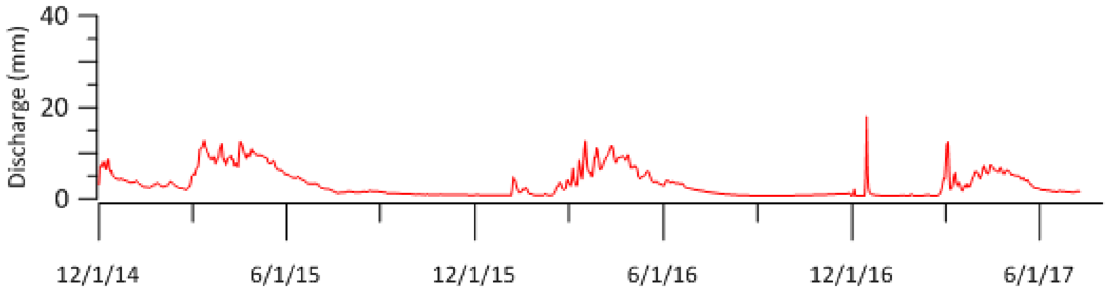
Evapotranspiration

-Evaporation from soil

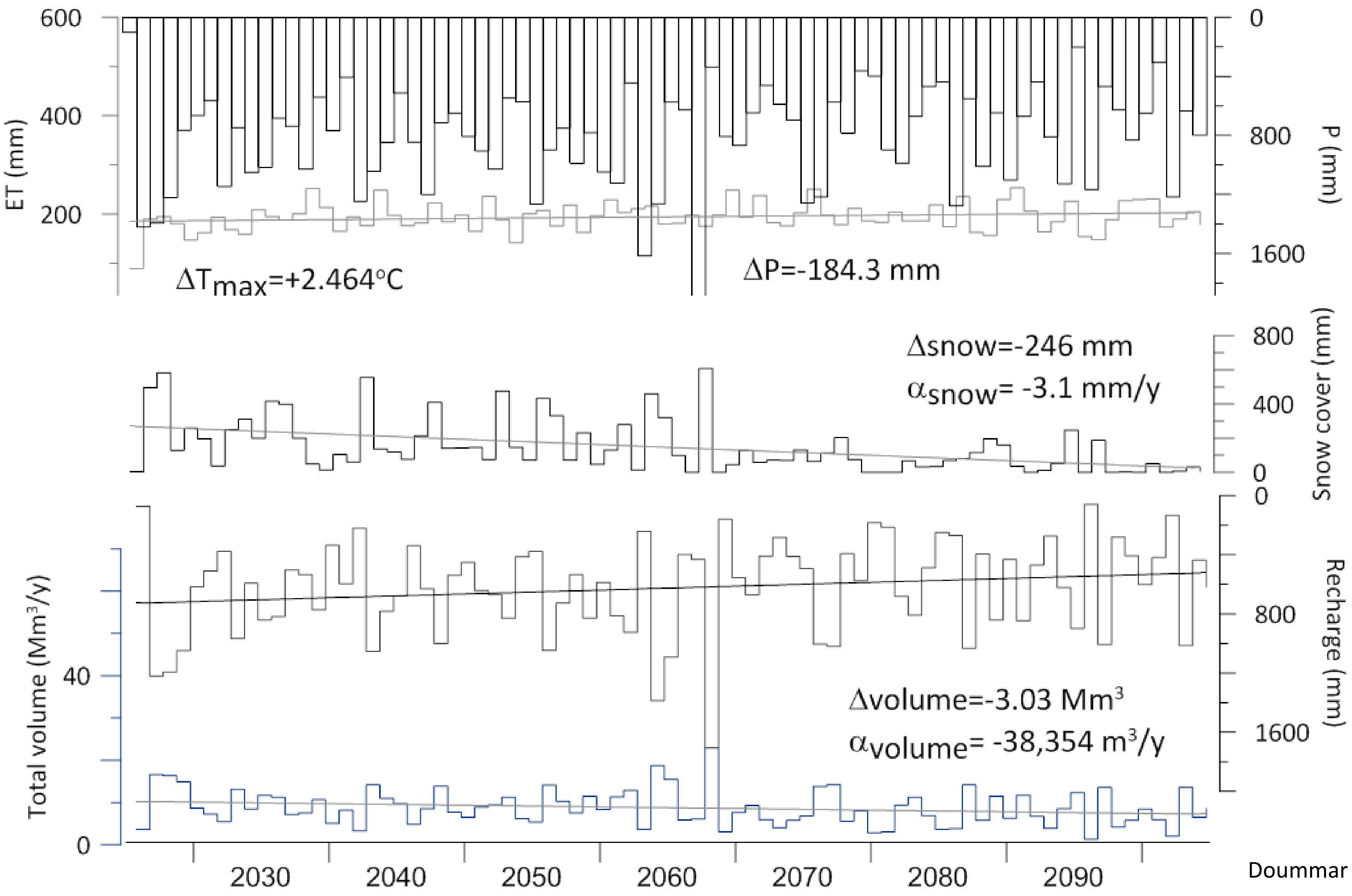
Gravity Method (Campbell-Burdine)

Slow flow Percolation to GW
Fast flow percolation to GW

Recharge to Groundwater



IMPLEMENTATION OF DATA IN A DISTRIBUTED INTEGRATED MODEL TO SIMULATE FLOW

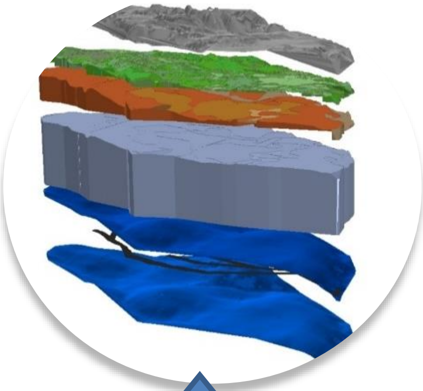


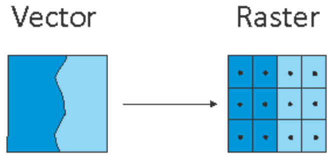
Doummar et al., 2018b

CONCLUDING REMARKS: FROM MONITORING TO MODELLING

MONITORING → **CHARACTERIZATION** → **NUMERICAL OR CONCEPTUAL MODELS** → **OUTPUT**

- **Recharge zones**
- **Conceptualization**
- **Time series**
  - **Quantity**
  - **Quality**





Upscale ← **Integration in a decision support tool**

Variation of quantities under climate change conditions

Alternatives

Protection zones

Socio-economic input → Policies

For more results: Website

Acknowledgments: Beirut and Mount Lebanon Water Establishment, Litani Water Authority, University Saint Joseph USJ, local municipalities.

THANK YOU