Managing the surplus runoff in areas with different groundwater ages under climate change weather conditions Eastern Desert of Egypt

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Motivation

Availability of surface resource

- Extreme rainfalls exceed sometimes 100 mm/d usually occur on small spatial scales.
- They produce flash floods affect highly developed cities as well as areas with poor infrastructure all around the world.
- Due to climate change and the ongoing urbanization, the occurrence and intensity of flash floods as well as their damage potential is likely to increase in future.

Flash flood events on in El Gouna, Egypt; left: measurements in Wadi Bili, March 2014; middle: flooding areas March 2014; right: road damages October 2016

Flash flood event on 29 February 2020 in Wadi Araba, Egypt; Water ponds excavated randomly to build the highway

Groundwater as a main resource in areas far from the Nile

- Brackish groundwater, high salinities with TDS of 53-66 g/l in areas with intruded seawater exceeding this of the Red Sea.
- Low salinities in the area of Wadi Araba with TDS of 1.4-2.6 g/l.

Aims and methods

- Investigation of groundwater quality, recharge conditions and possible infiltration from floodwater (potential of MAR).
- Tracking the flood ponds on the sattelite images and investigating the possibility of expanding such structures into other urban areas.

Methods:

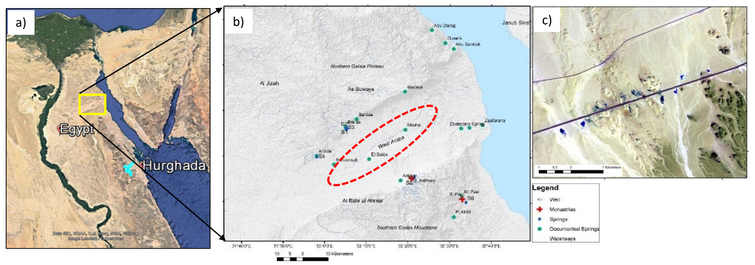
- Sampling groundwater discharge points on chemistry, stable and radioisotopes (main ions, ^{3}H, ^{14}C).
- Satellite image processing and hydrological modelling.

Two case studies in Eastern Desert of Egypt:

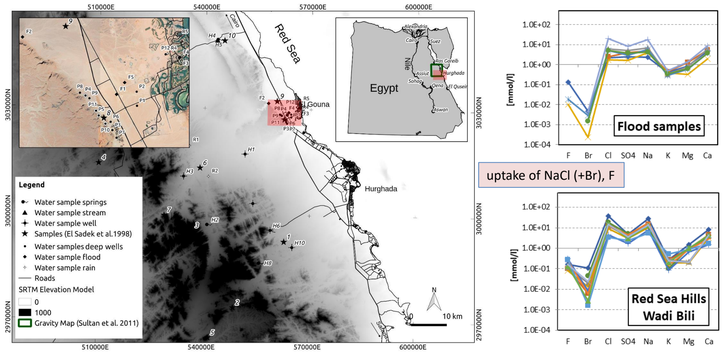
- Wadi Araba (north of the Eastern Desert)
- Wadi Bili (in the central area of the Eastern Desert)

Results Wadi Araba

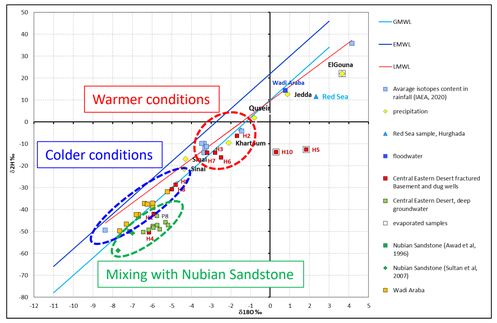
- Study area of Wadi Araba and the observed lakes after flood event



Study area in Wadi Araba: a) location of Wadi Araba catchment in Egypt, b) detail of Wadi Araba, c) Landsat 8-Scene from temporal Lakes (28.02.2020). The lakes could be observed for one month after the rain event.



Locations of wells and springs in the central area of the Eastern Desert

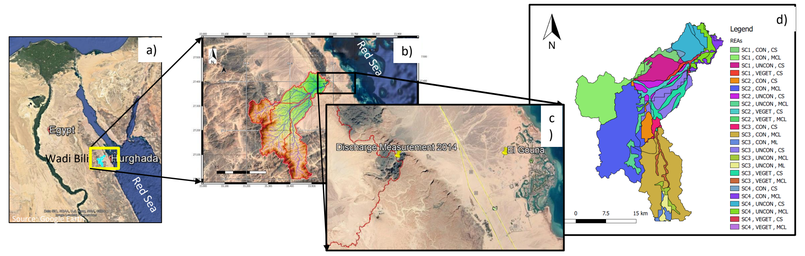


18O-2H diagram for precipitation, seawater and groundwater in the catchment area of Wadi Araba (in the North of Eastern Desert) and Wadi Bili in the central part.

- ^{3}H in all sampled locations in Wadi Bili is <0.5 TU.
- ^{3}H in Floodwater was measured with 3.5 TU.
- ^{3}H was detected only two springs in Wadi Araba with 1-1.5 TU and consequently around 40% of modern water.
- Age estimation with ^{14}C in the largest spring of Wadi Araba indicate 15000 years.

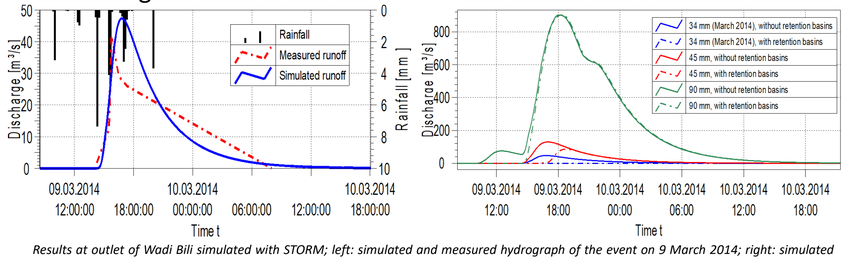
Results Wadi Bili

- Set-up of the hydrological model of the **Wadi Bili** catchment in *STORM*



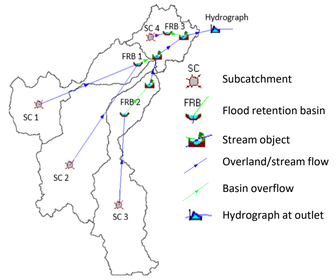
Study area of first case study: a) location of Wadi Bili catchment in Egypt, b) elevations (SRTM), subcatchments and stream orders in the catchment (visualized with QGIS), c) location of discharge measurements in 2014 and the city of El Gouna (©2018 ORION-ME, ©2018 Google) and d) Representative Elementary Areas in the Wadi Bili catchment (SC= subcatchment, CON= consolidated bare area, UNCON= unconsolidated bare area, VEGET = sparse vegetation, CS=coarse sand, MCL=medium clay loam, ML=medium loam; visualized with QGIS).

- Calibration of the model by using the hydrograph of 9 March 2014 observed by Hadidi (2016).
- Simulating different scenarios of extreme rainfalls and retention basins.



Results at outlet of Wadi Bili simulated with STORM; left: simulated and measured hydrograph of the event on 9 March 2014; right: simulated hydrographs for different rainfall events with and without retention basins.

- Proposed retention basins could large parts of flood water for events with 34 mm and 45 mm of accumulated rainfall.
- For exceptional event of 90 mm, only the first smaller flood wave could be captured by the basins, while the large flood wave could not be reduced.



Proposed flood retention basins (FRB) inside the Wadi Bili catchment, in the STORM model.

Publications

- Tügel F., Abdelrahman A.A.A., Özgen-Xian I., Hadidi A. & Hinkelmann R. (2020): Rainfall-Runoff Modeling to Investigate Flash Floods and Mitigation Measures in the Wadi Bili Catchment, Egypt. In: Gourbesville P., Caignaert G. (eds) Advances in Hydroinformatics. Springer Water. Springer, Singapore. https://doi.org/10.1007/978-981-15-5436-0_44