Flash Floods of Wadi Bili, 9 March 2014

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Rainfalls in the Eastern Desert of Egypt are rare, but in some cases they are intensive and cause flash floods. On March 9 2014 we had the chance to record a flood event in Wadi Bili after short but sever stormy-rainfall. Unfortunately, there were no standard rain gauges nor flood gauges in Wadi Bili catchment. Very basic plastic bottles served as rain gauges installed in the catchment beside TRMM 3B42 V7 spaceborn precipitation radar used as tools to estimate the rainfall distribution and intensity over Wadi Bili catchment. The runoff was monitored in Wadi Bili canyon and was measured using a flow meter device with a rough estimation of the water depth fluctuation during the event, which has lasted for 18 hours. Even though that the used methodology has relatively wide range of uncertainty, it is the most reliable data available for the Easter Desert of Egypt. In Wadi Bili catchment, which has an area of 845 km2, around 35 million m3 precipitated during the flash flood event of 2014. More than one million cubic meters passed through the Bili Canyon and continued towards the sea causing damages to the asphalt roads and infrastructure in ElGouna.

Flash Floods of Wadi Bili, 9 March 2014

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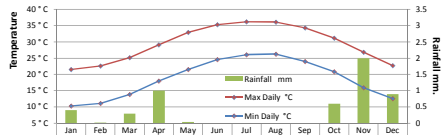
Dean of WE Department

Introduction

- Rainfalls in the Eastern Desert of Egypt are rare, but in some cases they are intensive and cause flash floods.
- These flash floods can have devastating effects, but in the deserts this might be a treasured resource for fresh water.
- Only 14 rain gauges exist in the Eastern Desert of Egypt, all in the costal areas, no rain gauges in the Red Sea mountains.
- Many Flash floods has been reported by Red Sea governorate, without any measurements of the rainfall.
- We failed to get the military permission to install two automatic weather stations in the Red Sea mountain.

Hurghada (WMO 1971-2000)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall mm	0.4	0.02	0.3	1	0.04	0	0	0	0	0.6	2	0.9
Max Daily °C	21.5	22.6	25.2	29.1	32.9	35.3	36.2	36.1	34.3	31.1	26.8	22.7
Min Daily °C	10.3	11.1	13.9	18	21.5	24.6	26	26.2	24	20.8	15.9	12.6

Figure 1. Hurghada Climate Chart according to World Meteorological Organization for 30 years between 1971 and 2000 (WMO, 2013).

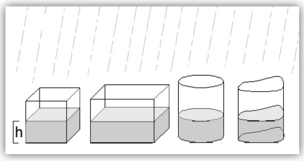
Table 1. Reported flash floods in the Eastern Desert of Egypt

Date	Precepitation depth	Location	casulties and damages	Referance
early December 1923	na	wadi Baroud and wadi Safaja	This caused severe destruction of mines, broken telephone lines and very heavy boulders dragging down the streams. Some of the boulders weights were estimated by ten tons	(Saleem, 1990)
6 November 1934	34mm	Qusair	na	(Saleem, 1990)
7 December 1954	28mm	Daedalus	na	(Saleem, 1990)
20-23 October 1979	na	na	50 casualties, 66,000 affected people and 14 M US$ damage	(de Vries et al., 2013)
17 October 1987	na	na	30 casualties	(de Vries et al., 2013)
1 November 1994	na	na	500 people to lose their lives	(Krichak et al., 2000)
17 and 19 October 1997	na	na	6 people were killed	(Dayan et al., 2001)

Precipitation as measurement is:

The amount of the water substance that has fallen at a given point over a specified period of time, usually expressed in *millimeters* or *inches* of liquid water depth.

Orifice area or shape don't affect the measurement of a rain gauge, since the vessel has vertical walls and has uniform cross section from bottom to the top.



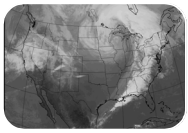
Vaisala WXT520

We have two automatic weather stations, but unfortunately we were not able to obtain the permission from the Egyptian authorities to install them in the desert.

Simple Rain gauge

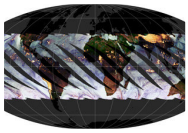
To get data about the possible rainfall in the desert, we installed three simple rain gauges with few drops of oil to prevent the evaporation.

Precipitation Estimation Satellites



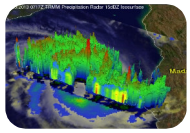
Infrared: started in 1970s

One band, Colder bodies have higher brightness.



Passive Microwaves: started in 1980s

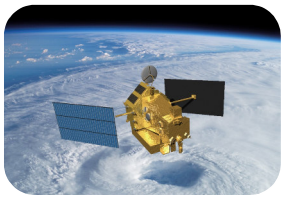
Different bands represent different microwave channels



Precipitation RADAR: 1997

The best estimation method for precipitation

Spaceborne Precipitation RADAR



TRMM

Lunched in 1997

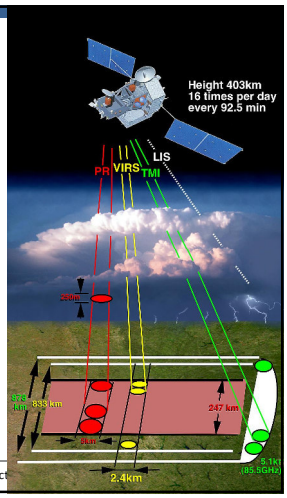
GPM

Lunched in 2014

TRMM

Tropical **R**ainfall **M**easuring **M**ission, lunched on NOV 27th 1997, carried the FIRST spaceborne Precipitation Radar (PR) which was developed by NASDA in Japan, in addition to four more sensors developed by NASA: TRMM Microwave Imager (TMI), the Visible Infrared Scanner (VIRS), the Cloud and the Earth's Radiant Energy System (CERES), and the Lightning Imaging Sensor (LIS). The data have been released to public users:

http://trmm.gsfc.nasa.gov/
ftp://trmmopen.gsfc.nasa.gov/



TMPA

TRMM **M**ulti-satellite **P**recipitation **A**nalysis (**TMPA**) produces near-global (50° S - 50° N) coverage.

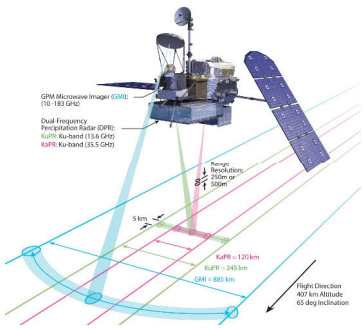
TMPA= **DMPS**(8Satillites)+ **NOAA**(4satellites)+ **AQUA**(1satellite)+ **MetOp**(1satellite)+ **TRMM**(1satellite)

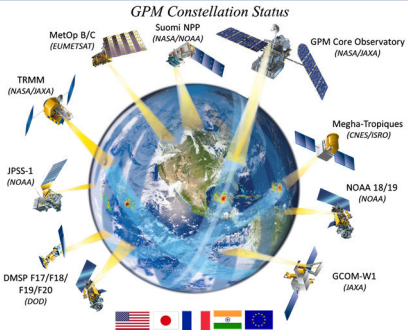
GPM

Global **P**recipitation **M**easurements:

The **GPM** Core Observatory launched on February 27th, 2014 which carried out the first space-borne Ku/Ka-band Dual-frequency Precipitation Radar (DPR) and a multi-channel GPM Microwave Imager (GMI) with thirteen channels ranging in frequency from 10 GHz to 183 GHz.

http://pps.gsfc.nasa.gov/
ftp://arthurhou.pps.eosdis.nasa.gov/



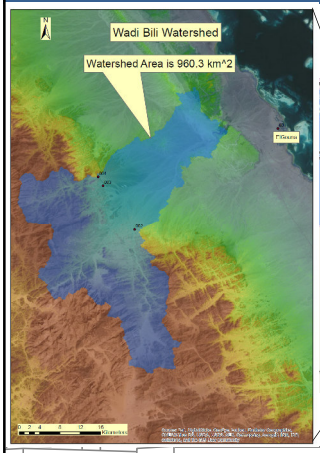


Upon the success of TRMM, a subsequent mission called ***G**lobal **P**recipitation **M**easurement* (**GPM)** mission which is an international network of satellites that provide the next-generation global observations of rain and snow.

How can we get these satellites data?

Precipitation data from the GPM and TRMM missions is made available free to the public in a variety of formats from several sources at NASA Goddard Space Flight Center. For example:

- Precipitation Proccessing System PPS/NASA (STORM)
  https://storm-pps.gsfc.nasa.gov/storm/
- GPM Data Downloads
  http://pmm.nasa.gov/data-access/downloads/gpm
- PPS public archive (ftp)
  ftp://arthurhou.pps.eosdis.nasa.gov
- Mirador
  http://mirador.gsfc.nasa.gov/
- Goddard Earth Sciences Data and Information Services Center
  http://disc.sci.gsfc.nasa.gov/
- EOSDIS
  http://disc.sci.gsfc.nasa.gov/SSW/
- TRMM Online Visualization and Analysis System (TOVAS)
  http://disc.sci.gsfc.nasa.gov/precipitation/tovas/



Wadi Bili

Bili Canyon

Surveying Wadi Bili section next to a tree, and marking the tree with red ink to estimate the expected flood level

Videos…

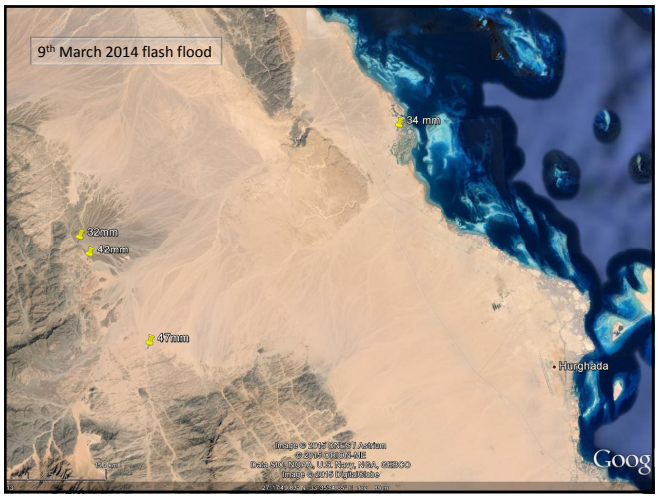
Second Day..

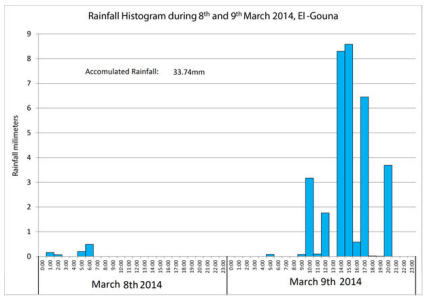
19 Hadidi & Tröger 2nd ISFF 25 – 27 October 2016 CAMPUS EL GOUNA

The tree which used for highest water depth estimation durig the survey before the Flood

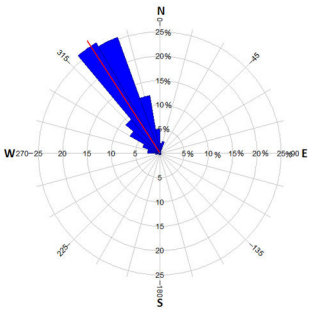
The Tree After the Flood!

24 Hadidi & Tröger 2nd ISFF 25 – 27 October 2016 CAMPUS EL GOUNA

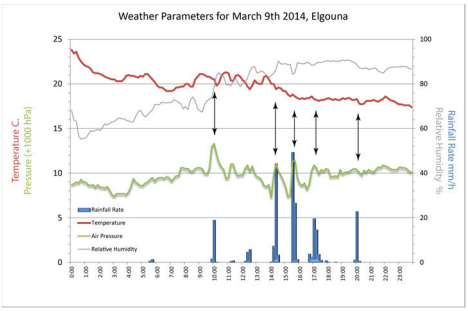




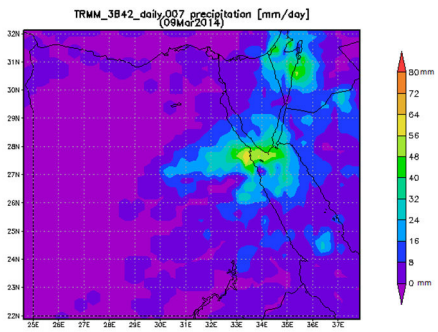
Rainfall histogram during March 8th and 9th 2014 in El-Gouna, using Vaisala Weather Transmitter WXT520.



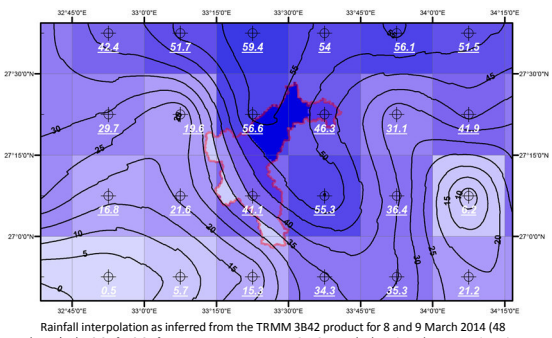
Wind direction during rainy minutes on the 9th of March 2014. (280 minute). TU-Berlin Weather Station El-Gouna West.



Weather parameters recorded by VaisalaWXT520 on 9 March 2014. Arrows refer to a clear relationship between a sudden increase in pressure and a decrease in temperature with the rainfall events.



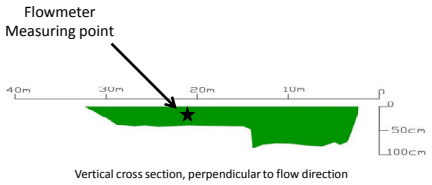
TRMM 3B42 product for 9 March 2014 (one day). Rainfall exceeded 56 mm in the north of Wadi Bili.



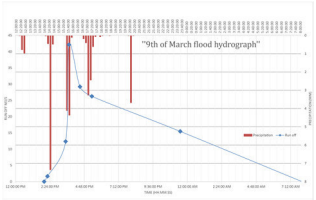
Rainfall interpolation as inferred from the TRMM 3B42 product for 8 and 9 March 2014 (48 hours). The 0.25 ° x 0.25 ° squares represent TRMM 3B42 granule data, its values are written in white. Contour lines are drawn using the Kriging method.
Red lines represent the Wadi Bili catchment.

Surface Flow Measurement Problem

Because of the high flow rate in the deepest part of the cross section, which transport dangerous big boulders, we were not able to do the measurement in the correct place. We did it in the shallow water which has higher fraction, thus, under estimation of flow rate.

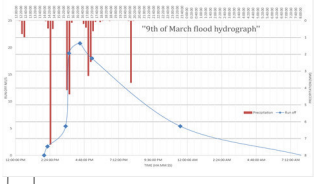


Vertical cross section, perpendicular to flow direction



The flood hydrograph in Wadi Bili according to the electromagnetic flow measurement. Markers refer to measuring points.

Integrated volume is about **1,000,000 m³**



The flood hydrograph in Wadi Bili using the Manning-Strickler method

Integrated volume is about **430,000 m³**

It was very difficult to infer the correct volume of the water that flowed through the Bili Canyon. It was not possible to measure the flow rate at all points of the runoff section.

Since we were only able to measure in the relatively shallow points, the measured value of **a million m³** is an underestimation, because in the deeper points the fraction will be less as the water depth is higher.

Hence, the calculated runoff volume using the Manning-Strickler method, which amounts to **430,000 m³**, is also underestimation.

Conclusions

- This study tried to quantify the precipitation of March 2014 event using rain gauges and satellite's remote measurements. Regarding Wadi Bili, about 35 million cubic meters precipitated, whereas the largest part infiltrated into the aquifer. An amount of one million cubic meters passed through the Bili canyon and reached the coastal plain and lasted for 18 hours.
- Rain gauges are simple devices and important to be used even in remote areas.
- PPS Satellites data are useful for rainfall spatial distribution, but unfortunately give bad estimations for the amount, without sufficient ground validation.
- Flash floods are very important water resource in the Eastern Desert.

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The data used in this presentation were acquired as part of the Tropical Rainfall Measuring Mission (TRMM). The algorithms were developed by the TRMM Science Team. The data were processed by the TRMM Science Data and Information System (TSDIS) and the TRMM office; they are archived and distributed by the Goddard Distributed Active Archive Center. TRMM is an international project jointly sponsored by the Japan National Space Development Agency (NASDA) and the US National Aeronautics and Space Administration (NASA) Office of Earth Sciences.


Thanks a lot for attention…
37
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