

## Flash Floods of Wadi Bili, 9 March 2014

Ahmed Hadidi<sup>1,\*</sup>, Uwe Tröger<sup>2</sup>

<sup>1</sup>Chair for Hydrogeology, Technische Universität Berlin, <sup>2</sup>TU Berlin, Zentralinstitut El Gouna, Fraunhoferstr. 33-35, 10587 Berlin

\*Corresponding author

Email: Dr.hadidi@outlook.com

**Keywords:** Wadi Bili, Flash Flood, Eastern Desert

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 severe 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 Eastern Desert of Egypt. In Wadi Bili catchment, which has an area of 845 km<sup>2</sup>, around 35 million m<sup>3</sup> 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

*Dr. Ahmed Hadidi*  
TU Berlin

*Prof. Dr. Uwe Tröger*  
Dean of WE Department

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## 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 coastal 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.

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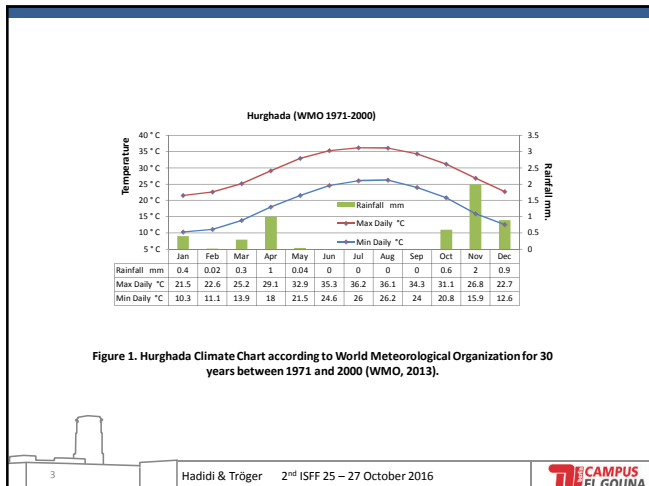



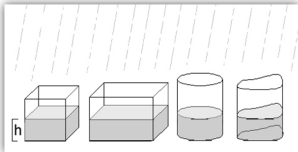
Table 1. Reported flash floods in the Eastern Desert of Egypt

| Date                   | Precipitation depth | Location                    | casulties and damages                                                                                                                                                      | Reference               |
|------------------------|---------------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| 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                | Qusalr                      | 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 USS 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)    |

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### 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.



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### 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.



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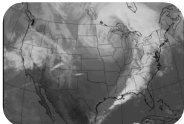

### Simple Rain gauge

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.

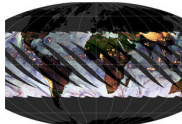


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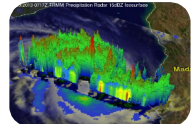
### Precipitation Estimation Satellites



Infrared: started in 1970s  
One band, Colder bodies have higher brightness.



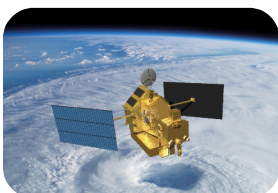
Passive Microwaves: started in 1980s  
Different bands represent different microwave channels



Precipitation RADAR: 1997  
The best estimation method for precipitation

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### Spaceborne Precipitation RADAR



**TRMM**  
Lunched in 1997



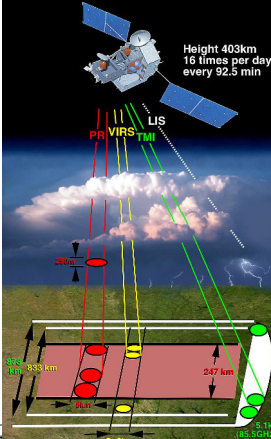
**GPM**  
Lunched in 2014

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### TRMM

Tropical Rainfall Measuring Mission, launched on NOV. 27<sup>th</sup> 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/>



Height 403km  
16 times per day every 92.5 min

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### TMPA

TRMM Multi-satellite Precipitation Analysis (**TMPA**) produces near-global (50° S - 50° N) coverage.

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



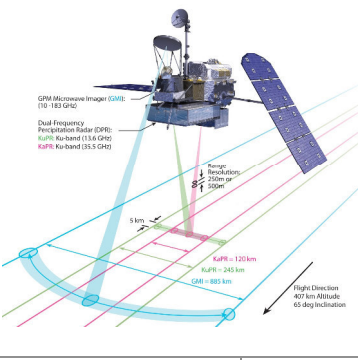
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### GPM

Global Precipitation Measurements:

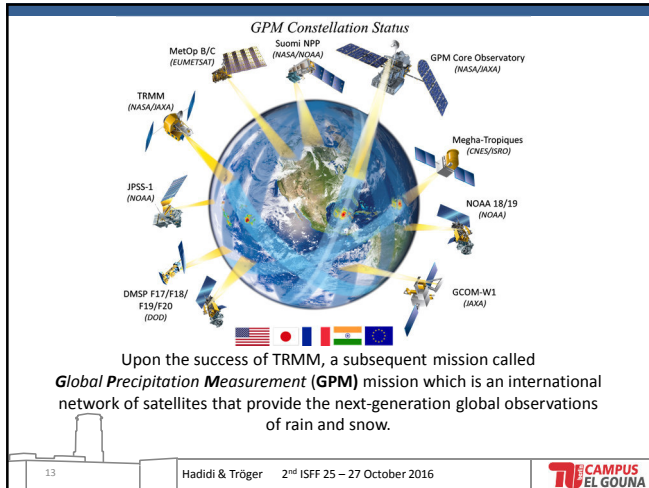
The **GPM** Core Observatory launched on February 27<sup>th</sup>, 2014 which carried out the first space-borne Ku/Ka-band Dual-frequency Precipitation Radar (**DPR**) and a multi-channel GPM Microwave Imager (**GMI**) with thirteen channels ranging in frequency from 10 GHz to 183 GHz.

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



Flight Direction 65 deg inclination

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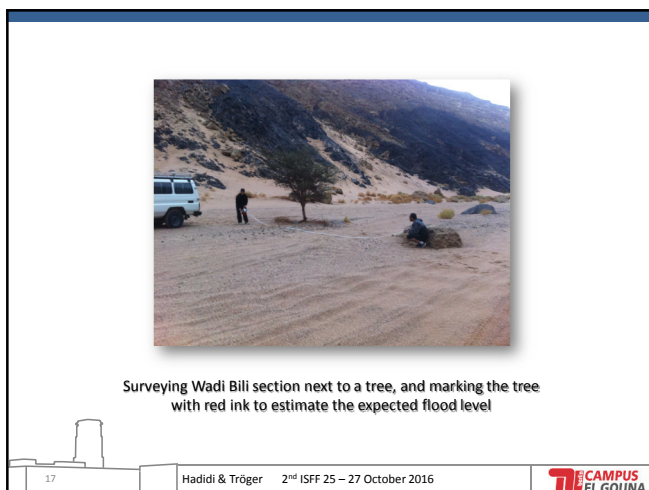
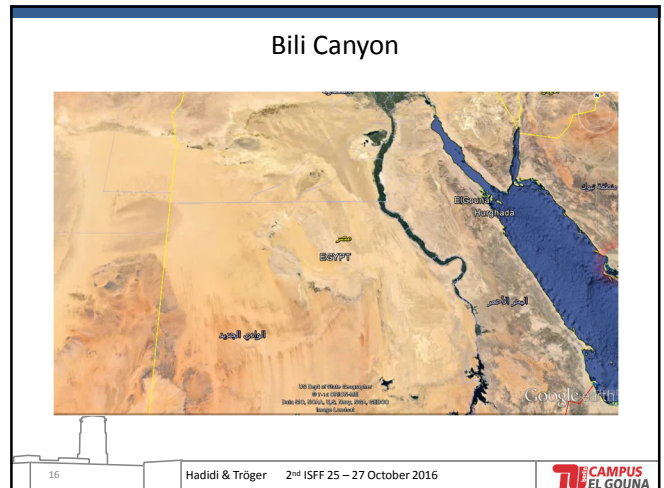
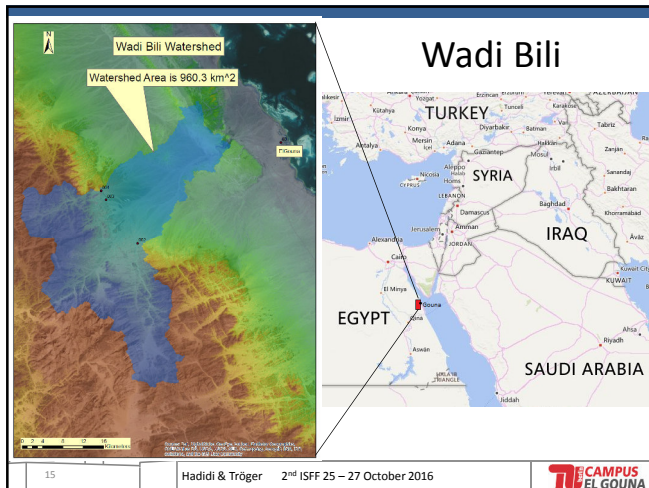


### How can we get these satellites data?

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 Processing 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.gsfc.nasa.gov/SSW/>
- TRMM Online Visualization and Analysis System (TOVAS)  
<http://disc.sci.gsfc.nasa.gov/precipitation/tovas/>

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### Videos...

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Second Day..

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

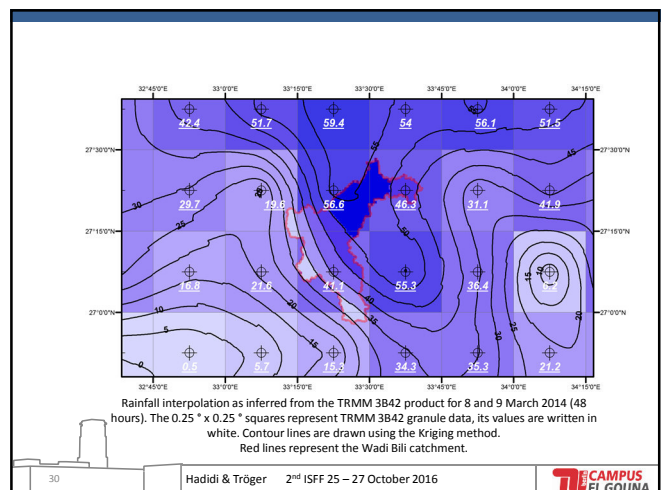
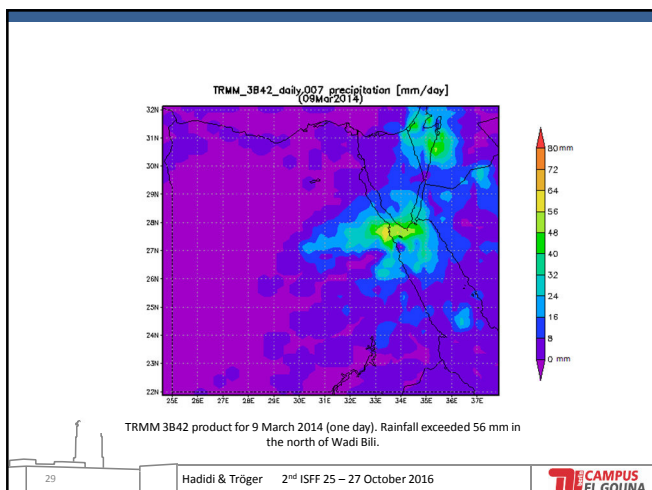
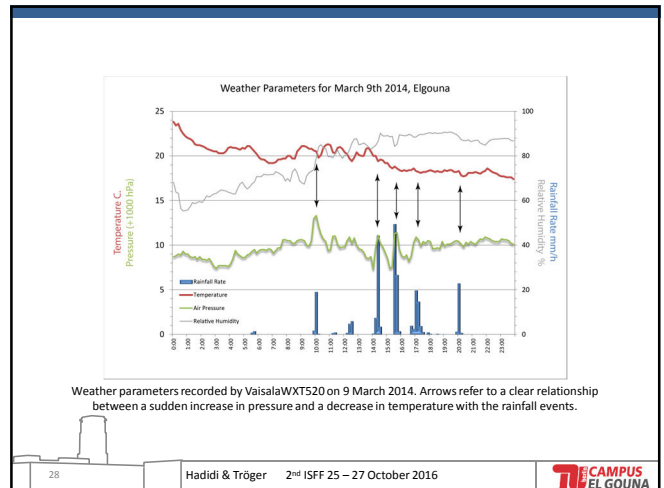
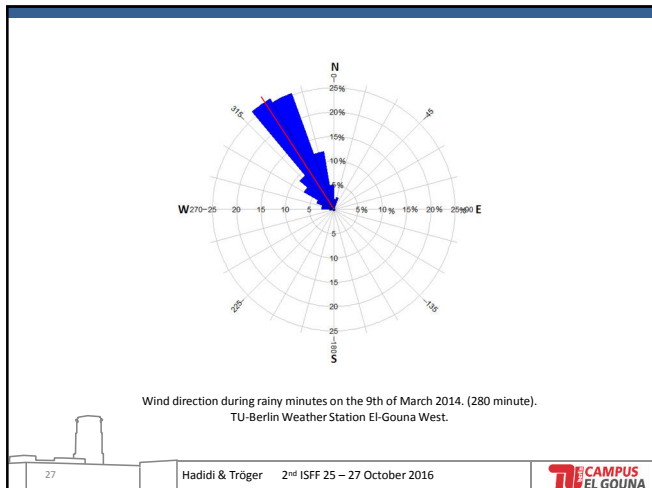
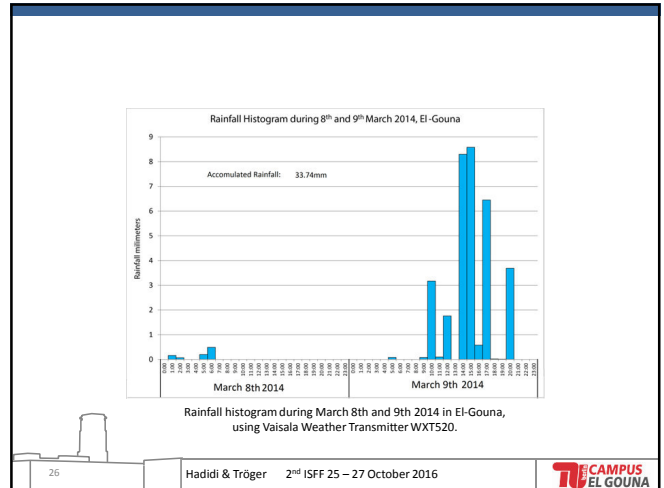


The Tree After the Flood!

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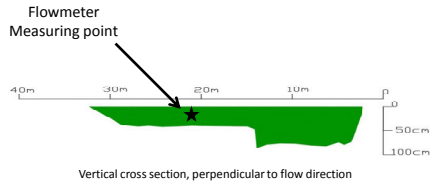
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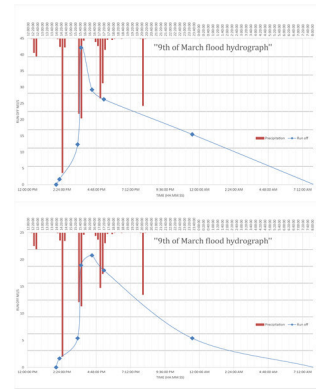


### Surface Flow Measurement Problem

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.



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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**

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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.*

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Thanks a lot for attention...



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