1. Introduction

Flash flood is a natural phenomena which occurring within short duration and rapidly rising water flow level (reaching maximum peak flow in a few hours) due to the causative event of intense rainfall or dam failure resulting in a great danger to human life and severe structural damages. Due to the lack of observations in most flash flood prone basins, the development of a methodology to simulate and forecast flash floods based on using Remote Sensing data is desperately needed. Therefore, the main objectives of this paper are summarized as follow: (i) Using Global Satellite Mapping of Precipitation for flash flood simulation in the wadi basins of the Nile River to overcome the challenge of data paucity, (ii) Assessment and evaluating of wadi basins water contribution to the Nile River during the flash floods to utilize flash flood water as a significant water resource.

2. Target area

In this study, the Nile River Basin in Egypt is selected due to its significance as the main water resource for Egypt. The selected basin is starting after Aswan High Dam to the entrance of Nile Delta as depicted in the watershed map which is processed using GIS (Fig. 1). It is located between Lon. 35° 00’ E & 28° 00’ W and lat. 32° 00’ N & 22° 00’ S. The total catchment area is 184,000 km² and it has many sub-catchments of wadi basins which flow toward the main channel of Nile River from both Eastern and Western deserts.

3. Methodology and Satellite Remote Sensing Data

The physically-based, distributed hydrological model, Hydro-BEAM (Hydrological River Basin Environmental Assessment Model) which was developed by Kojiri et al.\(^1\) and it was adopted to be applicable in wadi system by Saber et al.\(^2\) is applied for flash floods simulation in the Nile River Basin. As well known, the hydrological modeling for flash flood forecasting in arid regions has no enough data for the current research however its necessity. Thus, an attempt has been done to discuss GSMaP data for its feasibility for use to flash floods simulation in such areas. The Global Satellite Mapping of Precipitation (GSMaP)\(^3\) has been used in this simulation due to the paucity of data in arid regions. There are different spatiotemporal resolutions of GSMaP product. Hourly and 0.1° x 0.1° resolutions of GSMaP are used. It has been compared with the monitored data of Global Precipitation Climatology Centre (GPCC)\(^4\). Statistics analysis is carried out to calculate the bias of GSMaP at different arid areas such as, N. Africa, Arabian Peninsula, South-West USA, China, etc. The results of comparison show a systematic seasonal bias as overestimated or underestimated relying on the selected regions. For instance, in North-West of Africa GSMaP has overestimated bias as shown in Fig. 2, but in China, it has underestimated bias about 0.964 during the period from March to June and 0.722 from July to Feb.

4. Flash floods simulation

The simulation has been done to the flash floods events of Feb., 2003; Dec., 2004; Apr., 2005, and Jan., 2010. The results of simulation prove the performance of flash flood hydrographs as reaching to maximum peak flow within short time at the selected outlets (Fig. 3) for Jan., 2010 event.

Figure 1 The Nile River Basin in Egypt showing the target wadi outlets.

Figure 2 Comparison between GSMaP and GPCC Data at North-West of Africa (a) and China (b).
The hydrographs exhibit also steep limbs with short time of flow indicating to the short period of flood occurrence with big discharge. Additionally, the distribution maps show high variability in space and time of flash floods occurrence due to the spatiotemporal variability of rainfall in wadi basins. For instance, The remarks of the spatial variability of flash flood and corresponding rainfall occurrence is illustrated in the flash flood event of Jan, 2010 where only wadi Qena, wadi Zaydun, wadi Abbud, and wadi Jaraah are affected by the flash flood as shown in Figure 4.

In the real situation, the area around Aswan city which is representing in wadi Abbud and wadi Jaraah have been affected by this flash flood. The government announced that more than 14 persons have been killed in Aswan and thousands of people become homeless. The results of simulation show how much the performance of the proposed model to predict the flash flood in such regions.

The simulated results dedicate that wadi Qena and wadi Abbud show flow rate about 502 (m3/s) and 174 (m3/s) and total flow volume about 6.85286E+07 m3 and 2.27200E+06 m3 which can reach to the downstream area during the flash flood event. In this case, it can be easily estimate the contributed water of wadi basins to the Nile River. Also, the time to reach the maximum peaks is variable from one wadi to the others, where at w. Abbud and w. Jaraah is 3 hours but at wadi Qena about 11 hours. Consequently, the obtained results indicate that there is a possibility to estimate spatiotemporal flow volume of the flash flood affecting the target regions. Furthermore, the risk maps and the prone areas of flash flood can be easily detected and determined in wadi basins as illustrated in this work.

5. Conclusion

Simulation of flash flood has been successfully achieved in wadi basins in the Nile River basin based on using GSMaP precipitation after bias correction. It is founded from the results of simulation that flash floods exhibit high variability in occurrence in space and time corresponding to the spatiotemporal variability of rainfall at wadi basins of the Nile River. Flash flood water can be evaluated and managed as new water resources in wadi basins. However, the proposed model of HydroBEAM with using GSMaP with correction of the data bias can be applied effectively for flash flood simulation, developing flash flood warning system in the arid regions is our ongoing research.

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