



# The Usability of ALOS-30m DEM for Flood Inundation Mapping in Data Sparse Regions: Sojasrood, Iran



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## Abstract

The accuracy and quality of topographic datasets play an important role in deriving terrain model that is required for hydraulic simulation. Despite of several studies that have been carried out over the past decades it is still remained as a challenging issue for researchers, especially in developing countries and data limited areas. This study addresses the usability and efficiency of one of the newest remote sensing based DEMs, called ALOS-30m DEM, for flood inundation mapping in SojasRood river. Findings, indicate that the ALOS-30m dataset accurately captures the topographic details of river bed and the shape of cross-sections as well as topographic maps and this means that this valuable data source, in spite of having low resolution, have an appropriate potential of replacing the ground based DEMs. Moreover, assessing the predicted flood's components illustrate that using ALOS-30m dataset produces more accurate results when compared to contour based DEM. For instance, the maximum relative error in simulating mean WSE and inundated extent based on this dataset is lower than 13 % and 8%, respectively.

**Keywords:** Ground based DEM; ALOS-30m DEM; Flood inundation mapping; Remote sensing

## Introduction

Hydraulic models are the best tools for simulation of flood and they provide predictions of flood extent and depth that are used in the development of spatially accurate hazard maps. In order to decrease the flood damages in rivers, identifying high flood risk areas by using these types of models is so necessary. Flood inundation mapping involves analysis of river flow data, hydrologic/hydraulic modelling and topographic surveys [1]. In flood inundation mapping studies, water surface elevation and flood extents play an important roles, especially in estimation of flood damages [2,3]. One of the most important variables that affects the accuracy of hydraulic models' outputs is the quantity and quality of topographic datasets or DEMs [1,4-7].

There are several studies that have been carried out to investigate the effects of DEM resolution and different topographic datasets on the performance of hydraulic models. For example, Werner et al. [8] analyzed the effect of DEM resolution on the accuracy of simulated flood areas and found that using coarser resolution DEM decrease the accuracy of hydraulic controls' elevations and flood extents, while using finer resolution DEM increase the computational time significantly. Haile et al. [9] investigated the sensitivity of 2D SOBEK flood model to DEM resolution (from 1m to 15m) for an urban area in Honduras. Results showed that, because of averaging of small scale topographic features, DEM with the largest cell size simulated

maximum inundated area. Casas et al. [10] Assessed the accuracy of different topographic sources in 1D hydraulic modeling for Ter River, Girona in NE Spain and concluded that the contour based dataset resulted the least accuracy in simulated flood areas, while LiDAR and GPS based datasets performed with the highest accuracy with less than 1 and 8 % variation, respectively. Sanders et al. [11] Simulated flood extents in Santa Clara River in Texas by using four different DEM sources and showed that LiDAR DEMs, due to having the highest horizontal and vertical accuracy, are the best sources of terrain modeling and subsequently flood simulation. Schumann et al. [12] Demonstrated the effects of three DEMs at three different resolution from different data sources on deriving the water surface elevation and inundation area that simulated by using HEC-RAS 1D model. Findings indicated that although LiDAR and contour based DEMs resulted the lowest RMSE in deriving water surface elevation, but considering the performance of the SRTM DEM showed that this data set, despite of having coarser resolution, is a valuable source for flood simulation especially in large and homogenous areas. Patro et al. [13] selected an area in India to investigate the application of SRTM DEM with 90 meter resolution for extracting cross sections and hydraulic modelling. Findings revealed that the performance of hydraulic model was quite well, especially in simulating the peak flood value. Tarekegn et al. [14] evaluated the usefulness of ASTER DEM for flood simulation in a river in

Ethiopia and concluded that the simulated flood inundated areas were in a good agreement with the observed flooding pattern. Azizian and Shokoohi [15,16] addressed the effects of different DEM resampling methods on topographic index and the performance of TOPMODEL in Azarood river basin and found that Universal Kriging (UK) and Topo2Raster (T2R) methods are the best in simulating hydrograph peak flood. Ali et al. [3] assessed the impact of different DEM sources (SRTM, ASTER and LIDAR) on 1D hydraulic modeling of floods on a reach of the Johor River, in Malaysia. The outcomes showed that the loss of model accuracy due to resampling the fine resolution DEM to coarse resolution is much less than that of due to the use of low cost and low quality DEM.

In data sparse regions or developing countries, accessing to high resolution DEMs, such as LiDAR DEMs, isn't possible and ground based topographic maps should be provided. Moreover, the costs of ground surveying is one of the most limiting factor, especially in projects that suffer underfunding problems. Therefore, there must be an alternative topographic datasets for tackling or mitigating this problem. With the significant increase in human's technologies, the quality of remote sensing based DEMs is growing up so fast every day. One of the newest DEM sources is ALOS-30m resolution DEM that has been provided by the Japan Aerospace Exploration Agency (JAXA). Reviewing the literatures shows that there is no specific studies about the applicability and efficiency of this dataset for flood inundation mapping. So, the main objective of this study is to evaluate the performance and applicability of ALOS-30m DEM, free-public domain dataset, in flood inundation mapping and hydraulic simulation.

**Methods and Materials**

**Methodology**

To accomplish the objective mentioned earlier, the methodology includes the following steps:

- 1) providing ground based topographic map with the scale of 1:1000;
- 2) create DEM with 30 meter resolution;
- 3) collecting ALOS DEM with spatial resolution of 30 meter;
- 4) flood simulation and inundation mapping using 1D HEC-RAS and HEC-GeoRAS;
- 5) comparing the hydraulic features (flood extent and water surface elevation) that obtained from using both DEMs.

**Study area**The case study which is used in this research is SojasRood river, Zanjan province, Iran (Figure 1). The SojasRood River is located near the Gheidar city, and is surrounded by Agh-Dagh mountainous and agricultural areas. The main channel of this river is V-shaped and surrounded by small trees and natural vegetation, which affect the flow moving between floodplain and main channel. Flood simulation for this river is performed by using 100-year flow for steady state. The main reason that leads to selection of this return period is the flood inundation conditions in the large study reaches. Because in this reaches the floodplains do not get inundated for smaller return period flows. The quality of 30 meter DEM resolution that obtained using both ground based dataset and ALOS source, is shown in Figure 2.

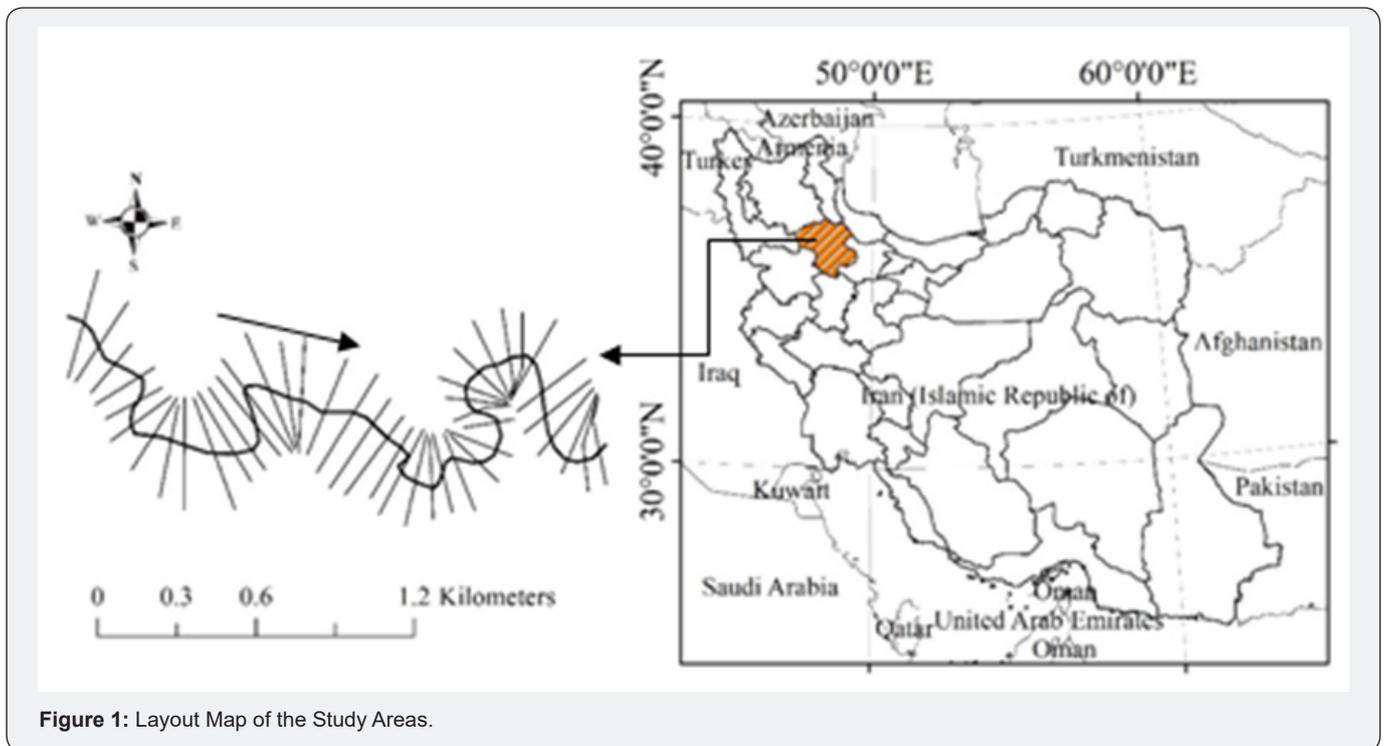


Figure 1: Layout Map of the Study Areas.

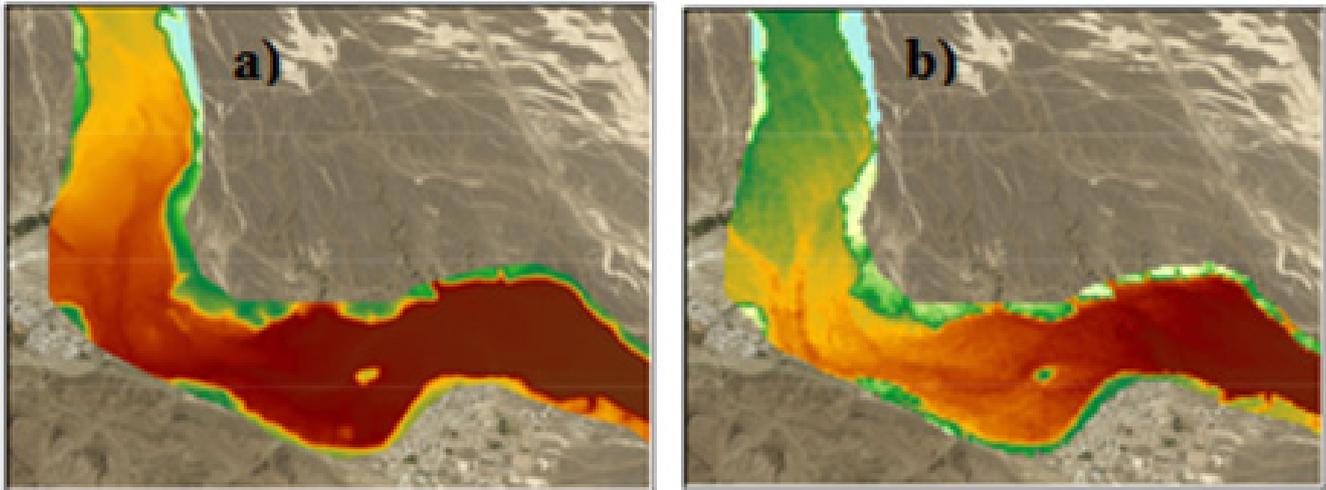


Figure 2: DEMs used in SojasRood river (a) contour based DEM and (b) ALSO 30m DEM.

### Results

#### The accuracy of ALOS-30m DEM in deriving cross-sections

Comparing the terrain model obtained from ground based DEM, as a base model, and ALOS-30m DEM shows that there is a good agreement between them. Accurately presenting the topographic features of river bed is one the most important

factors that increases the similarity between this dataset and ground based DEM. The efficiency of this DEM source in deriving the shape of cross-section versus ground based DEM is shown in Figure 3. As it can be clearly seen, ALOS-30m DEM accurately capture the shape of cross-sections and river bed elevations as well as topographic map. In other words, ALOS-30m DEM is an appropriate alternative for ground based DEMs, especially in data limited regions [17-26].

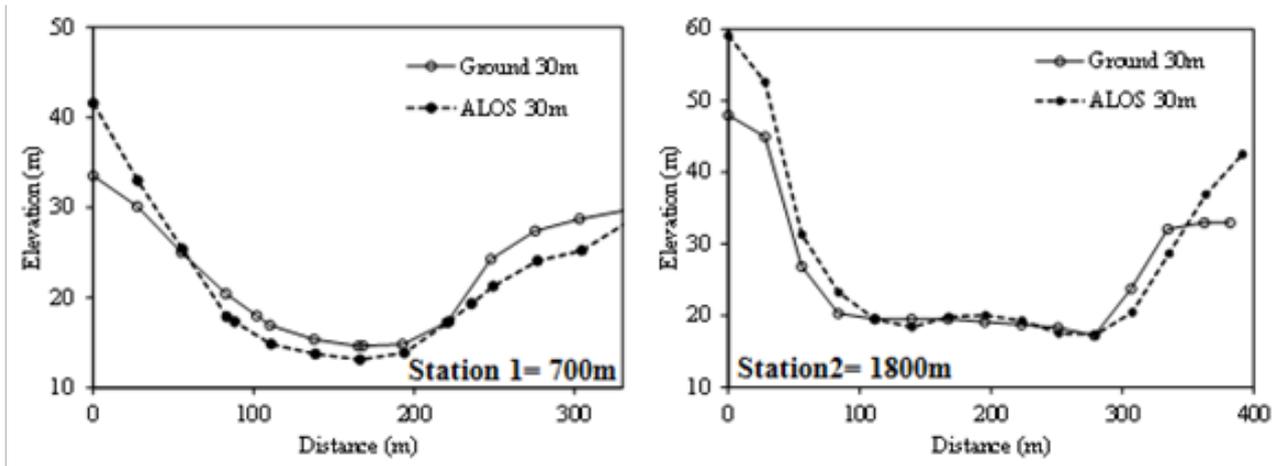


Figure 3: Comparison of ALOS-30m DEM and ground based DEM in deriving cross-section's shape.

#### Efficiency of ALOS-30m DEM for hydraulic simulation

Findings on flood simulation reveal that hydraulic modeling and flood inundation mapping using ALOS-30m dataset produces more accurate results when compared to ground-based DEM. For example, using this dataset in SojasRood river results averagely 13.4% and 7.6% relative errors in simulating inundated extent

and water surface elevation (WSE) (Figure 4). Results show that by using ALOS-30m DEM the relative error of inundated extent in 90% of cross-sections is lower than 15%. In addition, if the value of  $\pm 10\%$  is used as a reasonable relative error range, the performance of HEC-RAS model in more than 78% of cross-sections obtained from ALOS-30 will be acceptable.

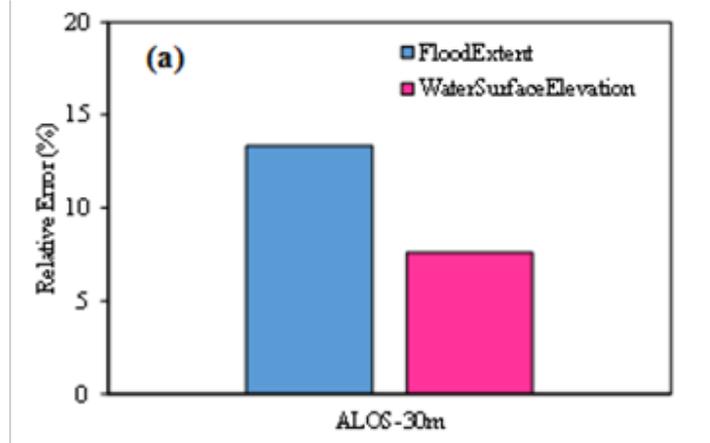


Figure 4: Average relative error of flood components (Top Width and WSE) in SojasRood river.

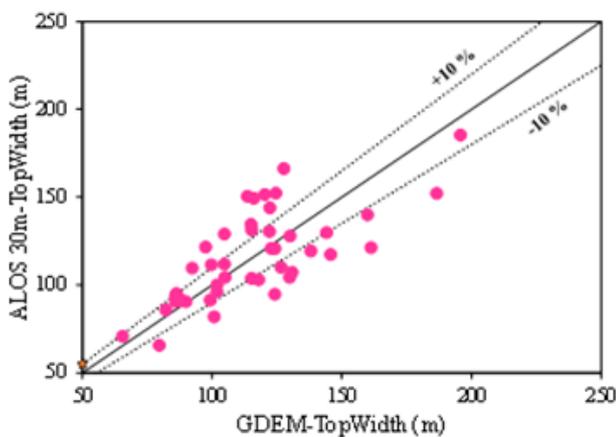


Figure 5: The performance of ALOS-30m DEM vs ground based DEM in simulating flood inundated extent.

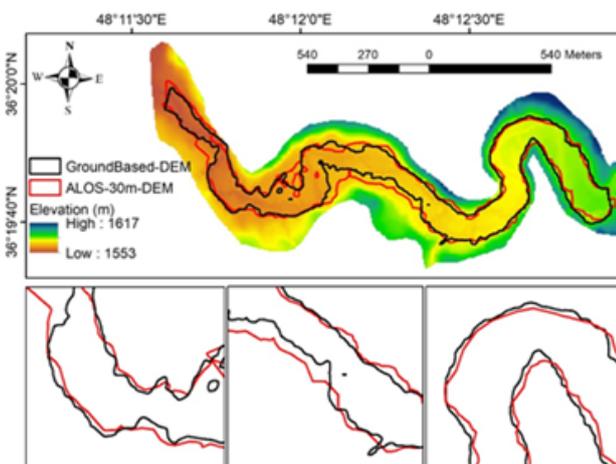


Figure 6: Spatial pattern of flood extent in ALOS-30m and ground based DEMs.

Finally, for better assessing the performance of ALOS-30m DEM in flood simulation, the results of hydraulic simulation in each cross-section compared with that of in ground based DEM with 30 meter resolution's result (Figure 5). As mentioned, in this research the error band width of  $\pm 10\%$  in simulating inundated extent accepted as a reasonable range for evaluating

the usability of ALOS-30m DEM. The results clearly prove that using ALOS-30m DEM leads to better performance almost in most cross-sections and can be considered as the best alternative for topographic maps. Moreover, the spatial pattern of inundated extent in SojasRood river (Figure 6) completely prove the advantages of ALOS-30m DEM.

### Conclusion

The accuracy and quality of topographic datasets play an important role in deriving terrain model that are required for hydraulic simulation. Despite of several studies that have been carried out over the past decades it is still remained as a challenging issue for researchers, especially in developing countries and data limited areas. This study addresses the usability and efficiency of one of the newest remote sensing based DEMs, called ALOS-30m DEM, for flood inundation mapping in SojasRood River. Findings indicate that the ALOS-30m dataset accurately captures the topographic details of river bed and the shape of cross-sections as well as topographic maps and this means that this valuable data source, in spite of having low resolution, have an appropriate potential of replacing the ground based DEMs. Moreover, assessing the predicted flood's components illustrate that using ALOS-30m dataset produces more accurate results when compared to contour based DEM. For instance, the maximum relative error in simulating mean WSE and inundated extent based on this dataset is lower than 13 % and 8%, respectively.

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