

## Multi-mission altimetry data to evaluate hydrodynamic model-based stage-discharge rating curves in flood-prone Mahanadi River, India

Pankaj R. Dhote<sup>1, 2,\*</sup>, Joshal K. Bansal<sup>1</sup>, Vaibhav Garg<sup>1</sup>, Praveen K. Thakur<sup>1</sup>, Ankit Agarwal<sup>2,3,\*</sup>

<sup>1</sup>Water Resources Department, Indian Institute of Remote Sensing, ISRO, Dehradun, India

<sup>2</sup>Department of Hydrology, Indian Institute of Technology, Roorkee, India

<sup>3</sup>GFZ German Research Centre for Geosciences, Helmholtz Centre, Potsdam, Germany

\***Correspondence:** Pankaj R. Dhote (pankaj\_d@hy.iitr.ac.in), Ankit Agarwal

(ankit.agarwal@hy.iitr.ac.in)

---

### Reviewer: 1

#### General Comment:

The authors attempted to use altimetry data from multiple satellite sources and attempted to evaluate the rating curves developed from hydrodynamic models. The research work proposing a virtual river monitoring tool is a new attempt. However, the research paper has some limitations, which should be addressed. The specific comments are given below.

We thank reviewer for acknowledging the research work and highlighting the a few limitations. We have noted all the suggestions that indeed would increase the readability of the revised manuscript.

#### Specific Comments:

1.0 Abstract, Line 29-30: @The validation of hydrodynamic..... missing." There is a sudden jump. Either elaborate more or remove it.

Thanks. The sentences will be revised to improve readability.

2.0 Expand the following: WSE, HEC-RAS, ALOS PALSAR, DEM, BRAT, EGM

Noted. We will expand acronyms in revised manuscript and might add a separate acronym list if needed.

3.0 Table 1: Separate the different parameters with "," such as discharge, river cross-sections (bathymetry), roughness coefficients

We will make changes in the manuscript as per your suggestion.

4.0 Table 1, First Column and Last Row: The purpose is not clear. As I understand it is "Rating Curve Generation"

Yes, we will revise first column-last row as "the use of flow laws / empirical equations to generate rating curves".

5.0 Introduction: The title of the manuscript specifically mentions “multi-mission”, the authors also discussed available satellite-based altimeters (multi-mission), however, the advantage of multi-mission couldn't be highlighted in the introduction. Which dimension is going to improve with multi-mission and why? As I understand and the title of the manuscript suggested, some improvements have been done to flood-related studies by incorporating multi-mission space-based altimeters, however, this aspect is completely lacking in the Introduction and conclusion sections

Thank you for highlighting the need to discuss multi-mission in the introduction.

We have discussed relative comparison of different altimeter data in results and discussion (Line 309-318) and conclusion (368-369) sections. However, to make it more clearly, we will revise the manuscript focusing on advantages of multi-mission altimetry data in terms of improvement in temporal resolution, spatial resolution and overall performance in monitoring of river discharge.

6.0 The authors have done a comprehensive review, however, more emphasis is required on “what research gap authors identified from the literature review listed in Table 1. And how they addressed this gap in the present study.

We have mentioned the research gap in introduction section (75-98). We will elaborate research gap in revised manuscript for better clarity.

7.0 While introducing the data scarcity globally, the authors suddenly mention the study area. The connection between lines 56 to 59 could be improved

We will revise the sentences as per suggestion.

8.0 Figure 1: Please label the inset map as well, like India. If possible, use the recent India State Boundary. What text in red colour represents, specifically the numbers?

Red colour represents altimeter data type and its track number; we will incorporate these changes in revised manuscript. We will also revise Figure 1 as per the suggestion.

9.0 Spelling error in line 70: Interferometers

Noted.

10. Why did the authors explain more about the upcoming mission (SWOT) in the introduction section? This could be well placed in discussion or conclusion.

Thank you for this suggestion. We will shift discussion on SWOT to discussion and conclusion section.

11.0 The inclusion of accuracy values of the previous studies would add value to the study

We will add accuracy values of previous studies in revised manuscript.

12.0 The problems in the single mission satellite altimetry are not well defined in the introduction. Also, the need for multi-mission satellite altimetry is missing in the introduction section.

We will revise the manuscript focusing on advantages of multi-mission altimetry data over single mission in terms of improvement in temporal resolution, spatial resolution and overall performance in monitoring of river discharge.

### 13.0 What is “category c of Table 1)?”

Here, we mean approach used for river discharge using satellite altimetry in third row of Table 1 i.e ‘calibration and validation of hydrodynamic models using satellite altimetry-based water levels’. We will add serial number of each method as a, b, c in the revised manuscript.

### 14.0 Line 109: appropriately use power notation

Noted.

### 15.0 Study area: Please provide the geographic lat-long in the manuscript. Include Mundali location in the study area map, since this defines the extent of the study area (lines 111 to 114)

We have added lat-long in Figure 1, and Mundali location in Figure 3. However, for better readability, we will make changes as per the suggestion.

### 16.0 Lines 130-138: Various datasets are discussed, it is suggested to specify their broad use in the study such as topography, roughness, etc.

We will add brief use of various dataset in ‘Study area and data’ section.

### 17.0 The authors should discuss the multi-mission satellite data component briefly. The data section lacks the details of the satellite imagery. Even though table 4 gives the range of data period, which data was used in this study is not clear.

We will discuss about multi-mission satellite data in revised manuscript. We have used all the dataset mention in Table 4.; will modify manuscript accordingly.

### 18.0 The date of acquisition of satellite data should be included in the study area section

We will add ‘The date of acquisition of satellite data’ to Study area and data section in revised manuscript.

### 19.0 Expand acronyms while introducing them in the text – (eg. SARAL, BRAT )

Noted. We will expand acronyms in revised manuscript and might add a separate acronym list if needed.

### 20. Rewrite the sentence in lines 165 – 168. The authors should include why these inputs are not within the scope of this study. Please elaborate .

We will rewrite the sentences as per your suggestion and will elaborate why detailed analysis on input parameters of hydrodynamic modelling is beyond the scope of this study.

### 21.0 Rewrite sentence – lines 174 – 176

We will make changes as per your suggestion

22. Fig 3. An extra legend. Please rectify

We will make changes as per your suggestion

23. ISRO IGBP LULC map procured during 2006 and google earth high-resolution images are used to identify different classes in the floodplain. Since the floodplain area varies with time, how do the authors address the difference in data periods?

Thank you pointing out important issue. During initial run of the model, lookup table (linking LULC classes with roughness coefficient) was made according to the ISRO IGBP LULC 2005 map. As ISRO IGBP LULC was made using 2005 satellite images having relatively coarse resolution (1:250000), recent high-resolution satellite images from Google Earth were used to modify roughness coefficients to account for changes in floodplain.

24.0 Please verify, is it “Indian Space Research Organisation – International Geosphere-Biosphere Programme” or “Indian Space Research Organisation –Geosphere-Biosphere Programme”. If it is ISRO-GBP correct it everywhere.

It is ISRO-GBP; we will make changes accordingly.

25.0 Table 2: Please provide the sources with further details for the benefit of the readers.

We will add links of the sources for further clarification.

26.0 Lines 192-193: “This resulted .....” Check the sentence or reframe it.

We will revise the sentence to improve readability.

27.0 Table 3: What do RT and LT stand for?

RT stands for right tributary and LT stands for left tributary; we will revise Table 3 accordingly.

28.0 Line 225: all “n” should be in italics.

We will check ‘n’ and modify accordingly.

29.0 Line 230: You have not developed the model. Therefore, modify the sentence as “.... This model is set up in two phases.”

We will rephrase the sentence as per the suggestion.

30. The captions in Figure 4 could be improved.

We will revise the captions in Figure 4.

31.0 In lines 232 to 234, the authors state the calibration was done for the 2015 season and validation during 2018 (see lines 240 to 242). But the authors have shown in the Fig 4 caption – calibration during 2018 and validation during 2015. Both are contradicting. Please rectify.

Sorry for the confusion. The model was calibrated for the year 2018 and validated for the year 2015. We will rectify the sentences in revised manuscript.

32.0 Figure 4 c lacks one legend (simulated stage)

We will revise Figure 4c.

33.0 Line 250: Earlier the authors have mentioned 7 VSs, now, suddenly 8 VSs. Please verify.

7 virtual stations have been identified using 10 multi-mission altimetry tracks. We will change 8 VSs by 7 VSs everywhere.

34.0 Lines 252-261: It is suggested to provide the working principle of altimeters for the benefit of the readers.

We will add working principle of altimeters in section 3.2.

35.0 There are some spelling mistakes in the manuscript: Line 254: retracing; page 17, Line 296: "Courser"

We will rectify spelling mistakes in revised manuscript.

36.0 Please provide the equation for average RMSE (line 311) in the methodology section

Thank you for the suggestion. RMSE is standard statistical parameter to evaluate the performance of various dataset/output. We will add the equation for average RMSE in the methodology section.

37.0 The fonts in Fig 6, 7 and 8 are not readable. Please increase it.

We will modify fonts in Figures 6, 7 and 8 to improve readability.

---