Geophysical investigation to improve the landslide susceptibility analysis in Kerala, India.

Geoscientists Without Borders Application: Q3Q4 2019

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FollowUp Form

Basic Information

Project Name*

Name of Project

Geophysical investigation to improve the landslide susceptibility analysis in Kerala, India.

Project Performers*

List all project participants. Include their title and affiliation.

PI: Thomas Oommen, Ph.D., Associate Professor, Michigan Technological University (MTU)
Co-PI: Snehamoy Chatterjee, Ph.D., Assistant Professor, Michigan Technological University (MTU)
Collaborator: Sajinkumar K.S., Professor, University of Kerala (UoK), Thiruvananthapuram, India

Project Start Date*

Select the date when your project was started.

03/01/2020

Anticipated Project End Date*

Select the date when you expect the project to be completed.

12/31/2022

Report

Summary of Project Goals and Objectives*

Provide a short summary of the project's goals and objectives.

(i) Utilize geophysical investigation to characterize the geotechnical and groundwater properties of the landslide-prone terrains at the study site.
(ii) Develop a rain gauge network at the study site.
(iii) Develop a landslide hazard nowcasting system utilizing the datasets from goals (i) & (i) and train graduate students from Michigan Technological University (MTU), and University of Kerala (UoK) to address landslide hazard and reduce its risks.

Summary of Progress Made*

Provide a brief summary of the progress you have made toward the planning and execution of the tasks in your project as outlined in the statement of work in the grant agreement. If available, preliminary results should be included in this section.

The geophysical investigation had to be put off by a year due to the covid situation in India. However, we have now begun preliminary investigation and identified sites for the ERT profiles. Developing a rain gauge network was successfully completed and 8 new rain gauges were installed in locations optimal for landslide monitoring. The detailed ERT survey will now begin in October 2021 and the proposed time lapse surveying will be completed by March 2022.

Problems or Challenges Encountered*

Describe any problems or challenges that the project team has encountered and what actions have been taken to mitigate those problems.

Due to the covid 19 pandemic, the geotechnical survey planned for summer 2020 had to be put off. However, a reconnaissance survey and identification of potential locations for laying out ERT profiles have been completed in the summer of 2021 and the detailed ERT survey is scheduled to start in October 2021. The time lapse survey will be conducted over the wet and dry periods and will be completed by March 2022.

Evaluation of project schedule*

Give an assessment of how the project is progressing according to the projected schedule. Is it on schedule? If not, what has contributed to the delays? How will the schedule need to be adjusted to complete the project? What, if any, challenges will the adjustment(s) create?

The geophysical investigation had to be put off by a year due to the covid 19 pandemic. However, we began preliminary geophysical survey during summer 2021 and the detailed survey is planned to begin in October 2021. This forces the team to request for a no cost extension of one year.

Please provide high resolution photos and/or videos of project participants, people from the community, places impacted by the project and activities associated with the project to withoutborders@seg.org. Please use Dropbox.com, WeTransfer.com, or some other file transfer program to send photos and videos. The SEG server will block any email with an attachment that is larger than 8 MB.

Project Name

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Summary of Progress Made

A rain gauge network was developed by adding eight new rain gauges to the existing network of five. Optimal locations of these rain gauges were identified using a multi criteria approach that utilized landslide density, slope stability and land cover classification. Satellite precipitation data from GPM IMERG-L was used to find the probable locations of rain gauges.

GPM is a constellation of satellites that use active radar, passive microwave, and infrared imaging to acquire global precipitation measures. These satellites provide precipitation measures for every 30 minutes for >90% of the earth. The core observatory is a combined enterprise by NASA and JAXA. It consists of a Dual-frequency Precipitation Radar (DPR) operating on K and Ka bands and a GPM Microwave Imager (GMI). The GPM provides four levels of data products: Level 1 consists of inter-calibrated and geolocated brightness temperatures from DPR, GMI, and other partner radiometers; Level 2 consists of inter calibrated precipitation rates; Level 3 consists of gridded time-space precipitation rates and latent heats, combining data from core observatory and other partners using a multi-satellite merging algorithm (IMERG); Level 4 is a research product created from merging remote sensing data and model inputs (Hou et al., 2014). The IMERG products, in turn, give three levels of products: the near real-time 4-hour latency 'Early' (IMERG-E) and 14-hour latency 'Late' (IMERG-L) products and the post-real-time research ready 'Final' (IMERG-F) product, at a spatio-temporal resolution of 0.1° × 0.5 h. The products are available at hourly, daily, and monthly precipitation rates. The research-ready product is available at a latency of about 40 days and cannot be used for near real-time modeling. Early warning systems need near-real-time input. Therefore, in this research, IMERG-L daily product was utilized.

GPM IMERG-L was subjected to resolution improvement thereby increasing its spatial resolution from 0.1 degrees to 0.025 degrees. Area to Point Kriging was used for this process. The resolution improved GPM IMERG -L was subject to conditional merging to improve its accuracy. Although satellites provide a highly detailed representation of the spatial structure and temporal evolution of rainfall over a large area, it is subject to a combination of systematic and random errors. The information from the satellite can be used to condition the spatially limited information obtained by interpolating rain gauge data and produce an estimate of the rainfall field that contains the correct spatial structure while being constrained to the rain gauge data. Conditional Merging (Sinclair and Pegram, 2005) uses unbiased spatial interpolation information to extract the optimal information content from the observed data. A mean-field rain gauge data is adopted while the spatial detail from the satellite is retained, reducing bias, and keeping the satellite's spatial variability.

The conditional merging process was carried out in four steps:

i. The rain gauge values were interpolated to create a continuous rain gauge-based rainfall field to obtain the best linear unbiased estimate of rainfall for all grid points.
ii. The GPM IMERG-L pixel values corresponding to the rain gauge locations were interpolated to create a continuous rainfall field.
iii. The difference between the rainfall field in step (ii) and the original GPM IMERG-L rainfall product was computed as an error field for each grid point, whereby it gives the value 0 at rain gauge locations.
iv. The error field obtained in step (iii) is added to the rainfall field obtained in step (i). The result is a rainfall field that follows the mean field of the rain-gauge interpolation while preserving the rainfall pattern of the gridded radar information.

The final model is represented as:

$$CM = I_{rg} + S - S_{rg} \qquad (1)$$

where,

CM is the conditionally merged rainfall product.

I_{rg} is the rain gauge interpolated rainfall field.

S is the GPM IMERG-L daily rainfall product and

S_{rg} is the rainfall field created from GPM IMERG-L pixel values' interpolation corresponding to the rain gauge locations.

Center of each pixel of the resolution improved conditionally merged GPM IMERG-L was considered as a synthetic rain gauge location. All these locations that fell in pixels with a landslide density of 2/sq.km or more were added to a set of probable rain gauge locations. A FOS map for slope stability was used to select all synthetic locations that fell in pixels with an FOS of 1.25 or less. Such locations were also added to the set of probable rain gauge locations. Later, a land cover classification map was used to filter out all the probable locations that fell in forested areas. From the set of probable rain gauge locations thus identified (107 in number), eight optimal locations were chosen using a sequential process that computed the error in estimation due to interpolating rainfall using available rain gauges. In each step one rain gauge was added to the pixel having the most estimation error. The estimation error was computed as the difference between the rain gauge interpolated product and the conditionally merged resolution improved GPM IMERG-L. 10 such locations were identified and permission to install 8 rain gauges were obtained from the government following which all 8 rain gauges were installed. Figures 1-5 shows the schematic diagram for conditional merging process, landslide density layer, FOS layer, proposed rain gauge locations and change in estimation error before and after expanding the rain gauge network respectively.

The next phase of the project will be exclusively concentrating on the geophysical survey. A reconnaissance survey was conducted to identify possible locations to lay down ERT profiles. A CRM Auto C resistivity meter was used to conduct the survey. The preliminary locations were identified close to cut slopes and ground water monitoring wells where information about stratigraphy were either directly observable or were recorded. The detailed geophysical survey will begin in October, 2021. This corresponds to a wet period and the time lapse survey will be completed when the survey is conducted in a dry period corresponding to February-April.

Problems or Challenges Encountered

Due to the covid 19 pandemic, the geotechnical survey planned for summer 2020 had to be put off. However, a reconnaissance survey and identification of potential locations for laying out ERT profiles have been completed in the summer of 2021 and the detailed ERT survey is scheduled to start in October 2021. The time lapse survey will be conducted over the wet and dry periods and will be completed by March/April 2022. The covid 19 pandemic also hindered the acquisition and installation of rain gauges which, however, was completed in summer 2021.

Evaluation of project schedule

The geophysical investigation had to be put off by a year due to the covid 19 pandemic. However, we began a preliminary geophysical survey during summer 2021 and the detailed survey is planned to begin in October 2021. This forces the team to request for a no cost extension of one year.

Figures

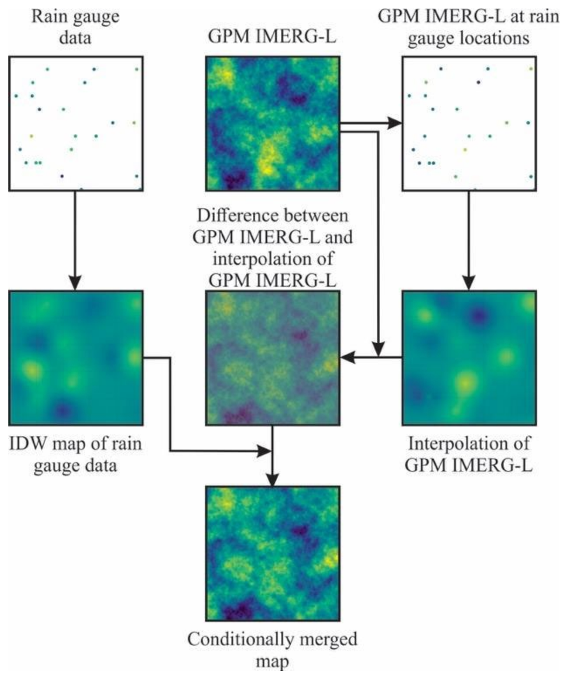

Fig.1 Schematic diagram of the conditional merging process.

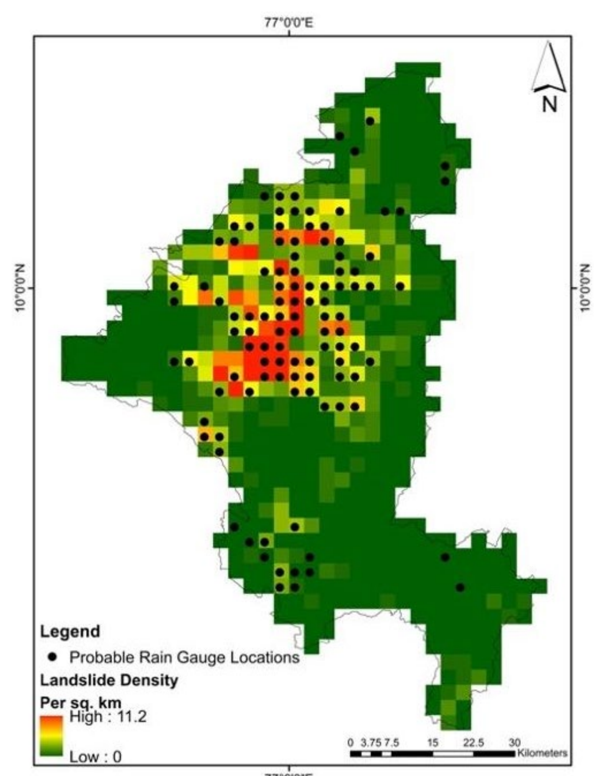

Fig.2 Landslide density map with probable rain gauge locations

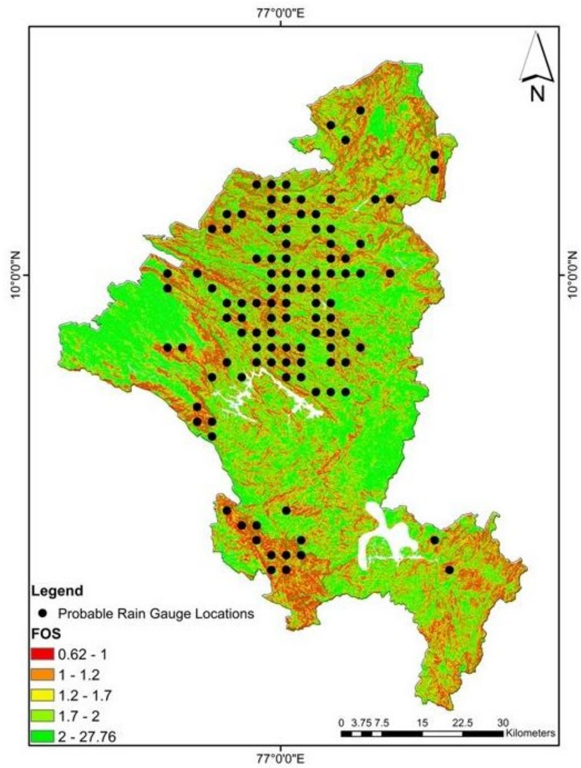

Fig. 3 Slope stability map with probable rain gauge locations

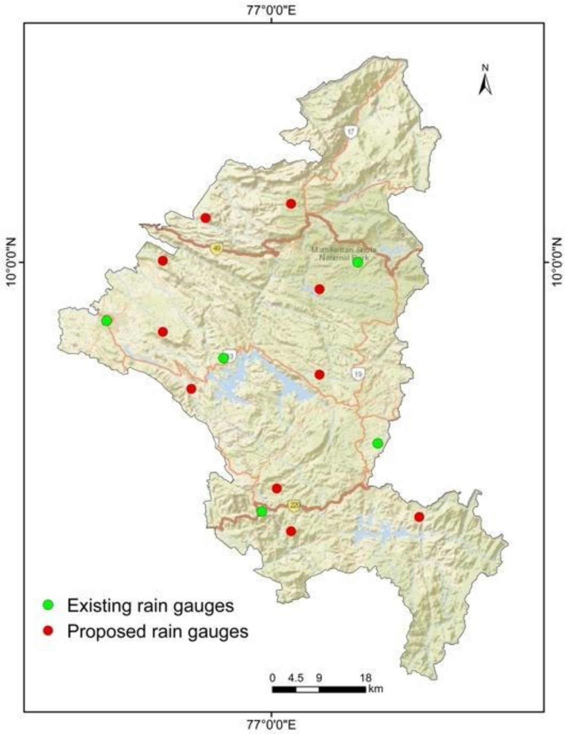

Fig.4 Optimized locations of 10 new rain gauges with 5 existing rain gauges.

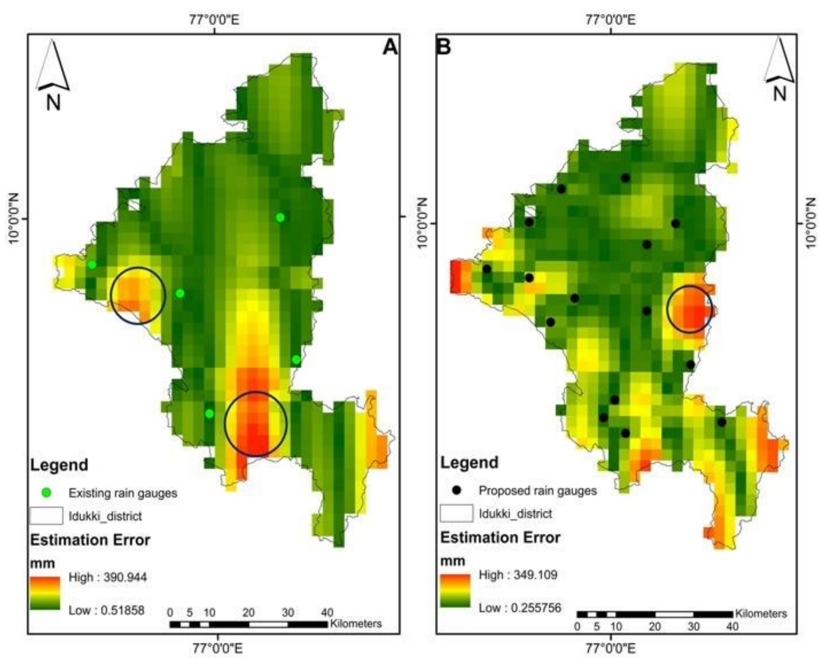

Fig.5 Difference in error estimation between interpolation with 5 existing and 15 proposed rain gauges. The circles show areas of large estimation errors in each scenario. In each step, a rain gauge was added in the pixel with largest estimation error. The process began at 5(a) and

ended at 5 (b). The black circles show the areas of large estimation errors. Adding rain gauges in locations of large estimation errors reduces the estimation error in those locations.

References

Hou, A. Y., Kakar, R. K., Neeck, S., Azarbarzin, A. A., Kummerow, C. D., Kojima, M., ... & Iguchi, T. (2014). The global precipitation measurement mission. Bulletin of the American Meteorological Society, 95(5), 701-722

Sinclair, S., & Pegram, G. (2005). Combining radar and rain gauge rainfall estimates using conditional merging. Atmospheric Science Letters, 6(1), 19-22.

Description of figures:
The field pictures taken during the installation of the rain gauges are laid across 8 folders, each folder corresponding to one location.
The folders are named according to their location namely,

1) Alakkode
2) Arakkulam
3) Elappara
4) Irattayar
5) Irumpupalam
6) Manjumala
7) Pallivasal and
8) Santhampara

Another folder named ERT_Prelimns has photos from the field trip from the preliminary geophysical survey.

The document SEGreport_extended is an extended version of the character limited report submitted to the portal.