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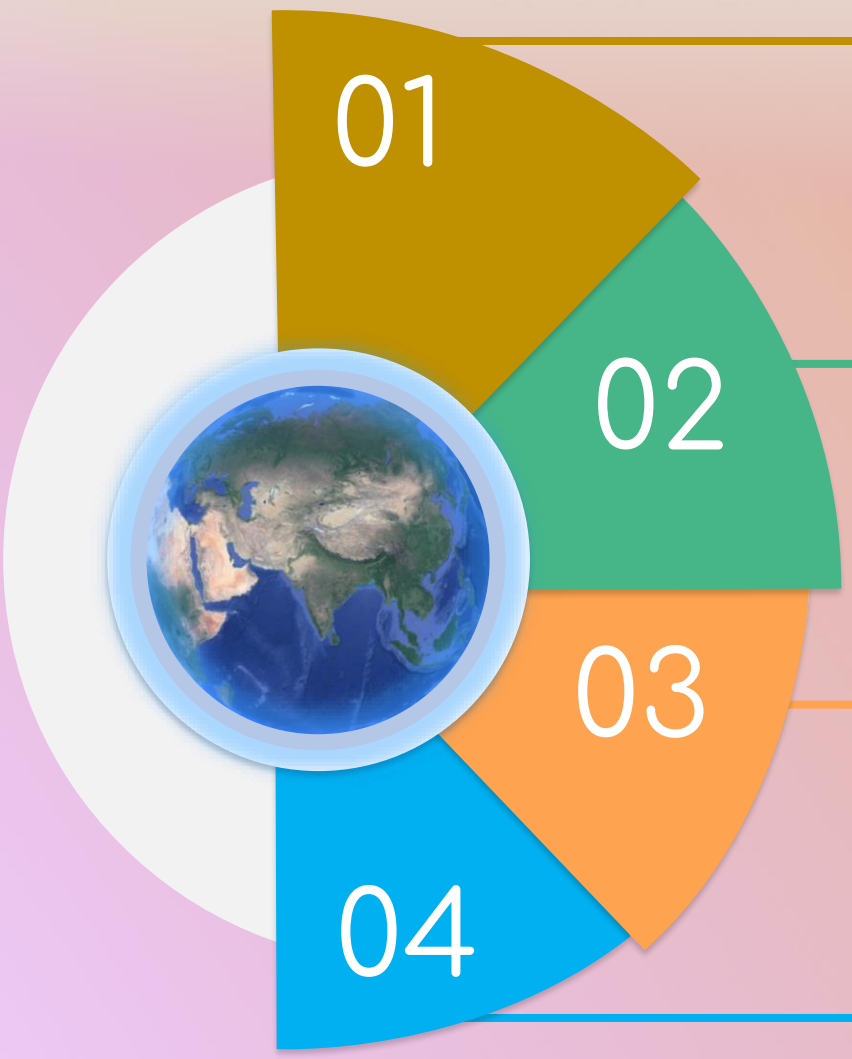
Session : NH3.7 (Towards reliable Landslide Early Warning Systems)

Prediction of rainfall-induced shallow landslides through integration of hydrological model with a slope stability model

Juby Thomas[1] and Manika Gupta[1]
Department of Geology, University of Delhi, India
thomasjuby@outlook.com



Introduction

- The big mountain problem : RF induced landslides
- Study Area : Uttarakhand, India (In the central Himalayas)

Methodology

- An integrated hydrological – slope stability model for forecasting RF induced landslides in the mountainous terrains

Results

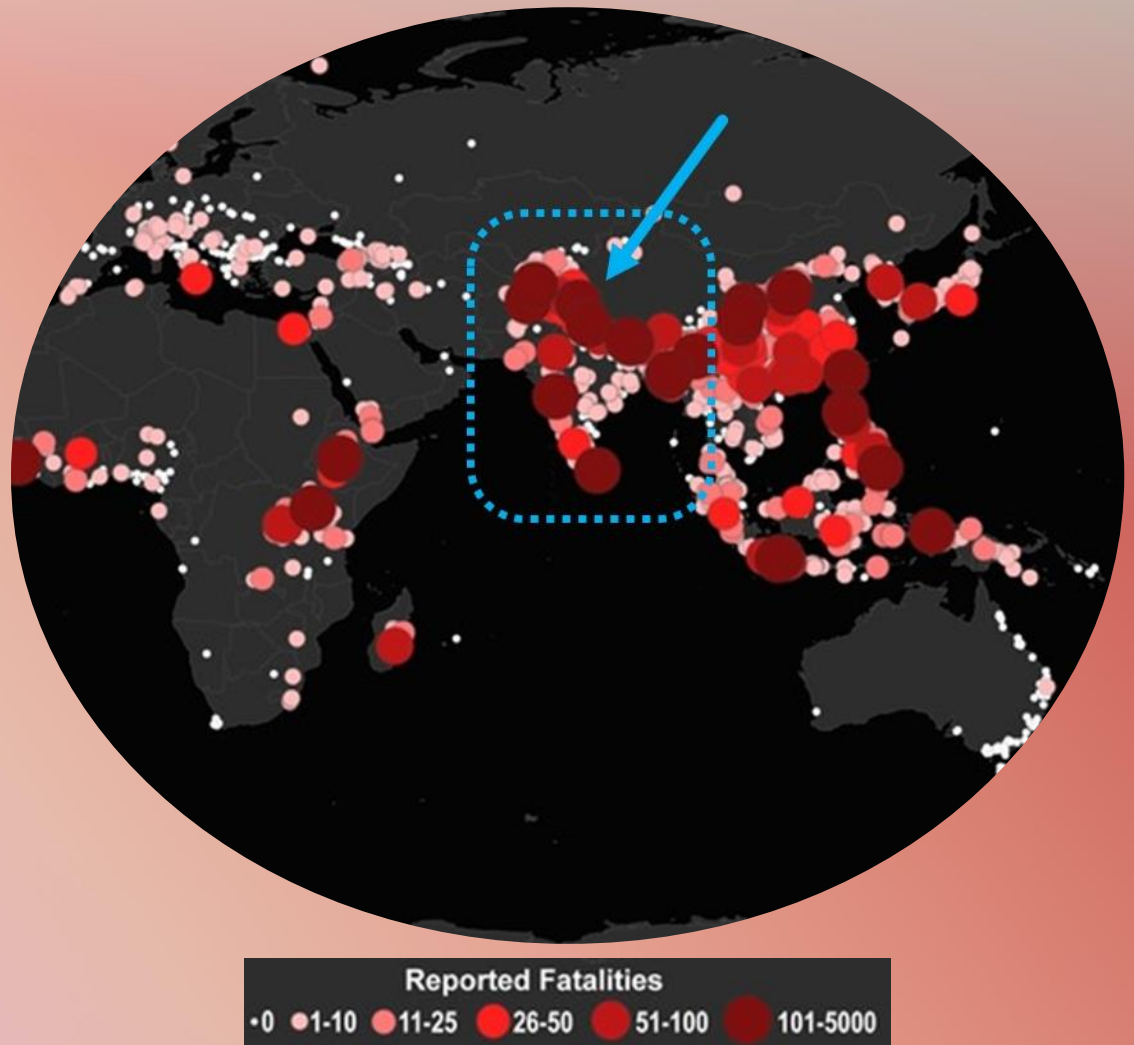
- Fine resolution grid wise FoS of the terrain during and after a precipitation event

Future work

- Developing an operational EWS for RF induced landslides based on forecasted RF data

Introduction

- Landslides affect nearly 15% India's landmass and the Himalayan chain in the northern part is one of the most vulnerable areas *(Martha et al., 2021; Dikshit et al., 2020)*
- Most of the landslides in this region are rainfall triggered *(COOLR, GLC, & GSI)*
- Occurrence of extreme events due to climate change have become more frequent *(Choudhury et al., 2021, Manchado et al., 2020, IPCC)*
- Geohazards have become more destructible - population expansion *(Montrasio and Valentino, 2008)*

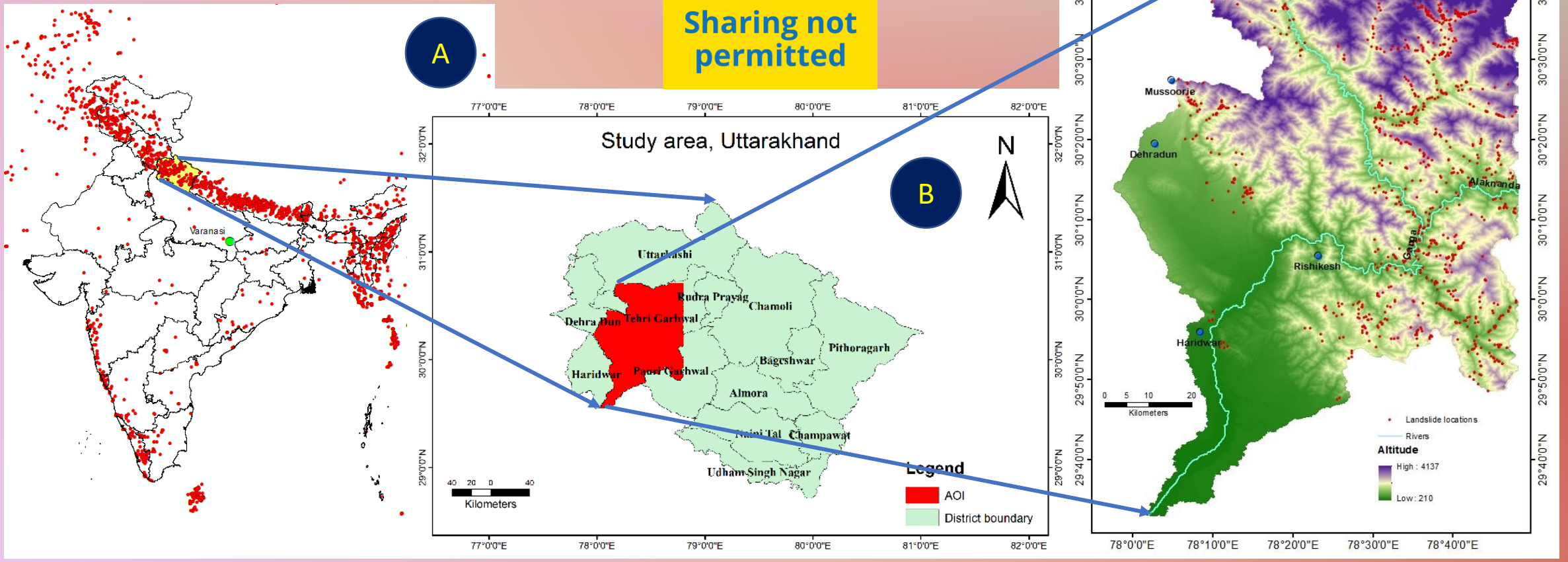


Distribution of reported fatalities from 10,804 rainfall-triggered landslides in the NASA Global Landslide Catalog (GLC), 2007-2017. White dots represent incidents with zero reported fatalities. Dots in the color scale from pink to red represent incidents with fatalities in the range of 1-5000. (NASA's Scientific Visualization Studio)

Study area

Geographical location of the study area (Uttarakhand state of India, In the central Himalayas)

Study area



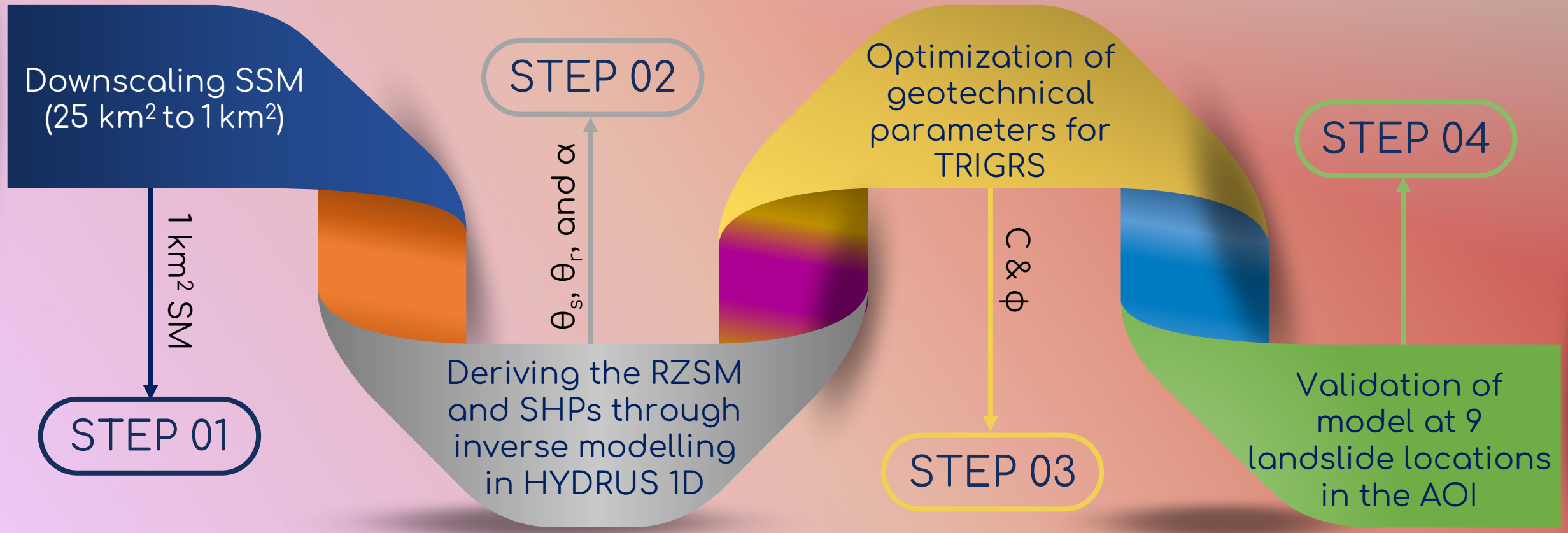
(A) Rainfall induced landslides in India since 2010 (Source: NASA COOLR and GSI)

(B) State of Uttarakhand in India's political map

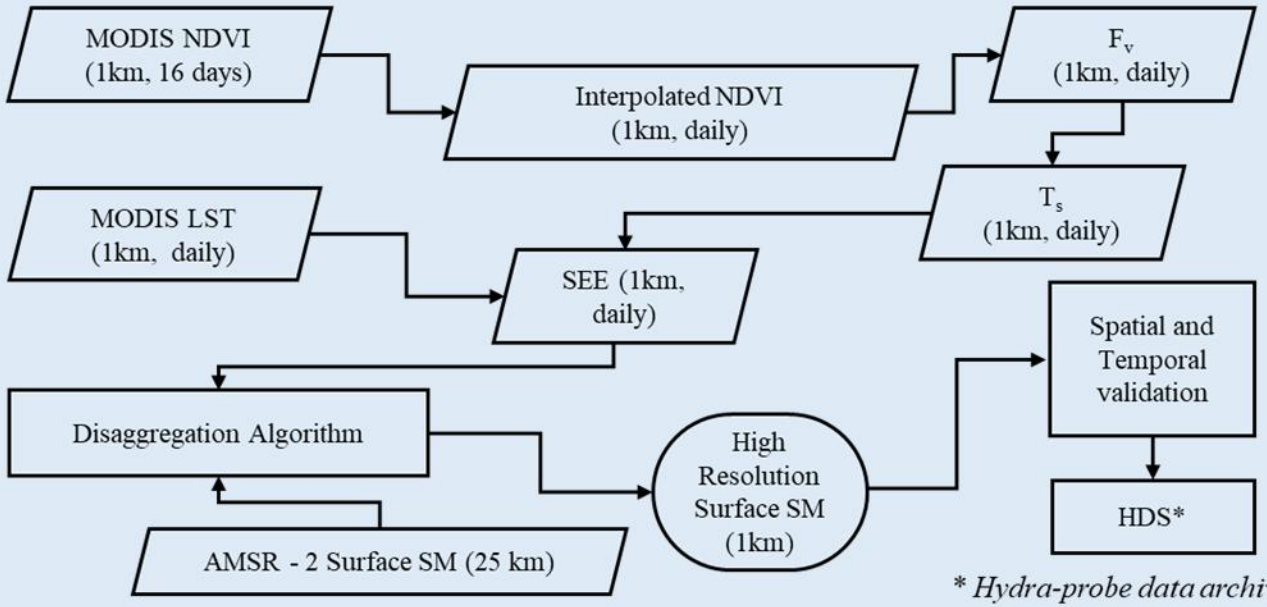
(C) AOI in Uttarakhand with the rainfall triggered landslide points

- Part of catchment region of River Ganges
- The total area of the basin is 6870.18 km^2
- The AOI contains a number of river channels including the river Ganges
- Altitude range 210m to 4137m
- slope range 0^{0}to 69^0

Methodology



STEP 01



* *Hydra-probe data archival system*

$$F_v = \frac{NDVI_{MODIS} - NDVI_s}{NDVI_v - NDVI_s}$$

$$T_s = \frac{LST_{MODIS} - f_v \cdot (T_{v,min} + T_{v,max}) \ /2}{1 - f_v}$$

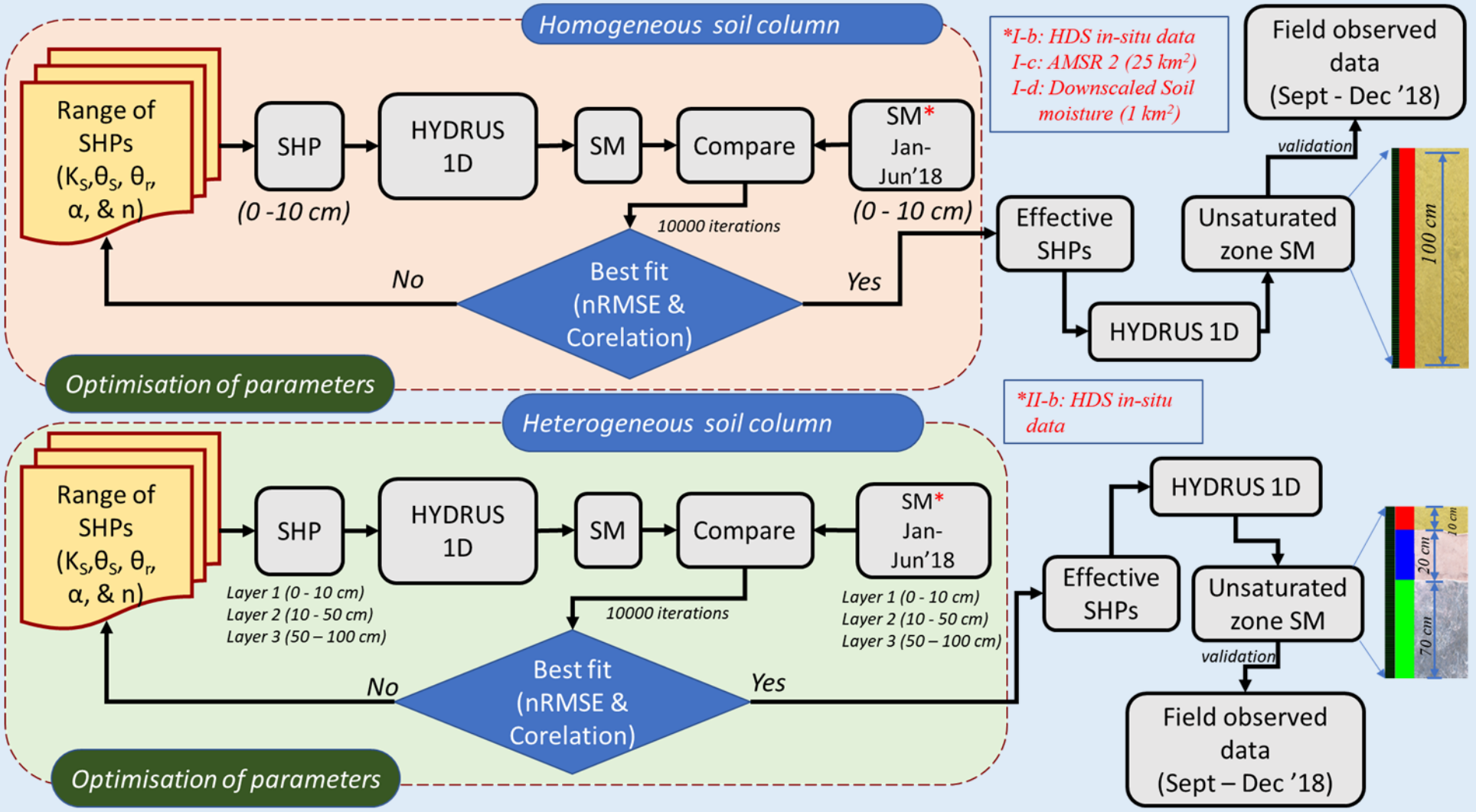
$$SEE = \frac{T_{s,max} - T_s}{T_{s,max} - T_{s,min}}$$

$$SM_{1km} = \left(\frac{\partial SM}{\partial SEE}\right)_{25km} (SEE_{1km} - SEE_{25km}) + SM_{25km}$$

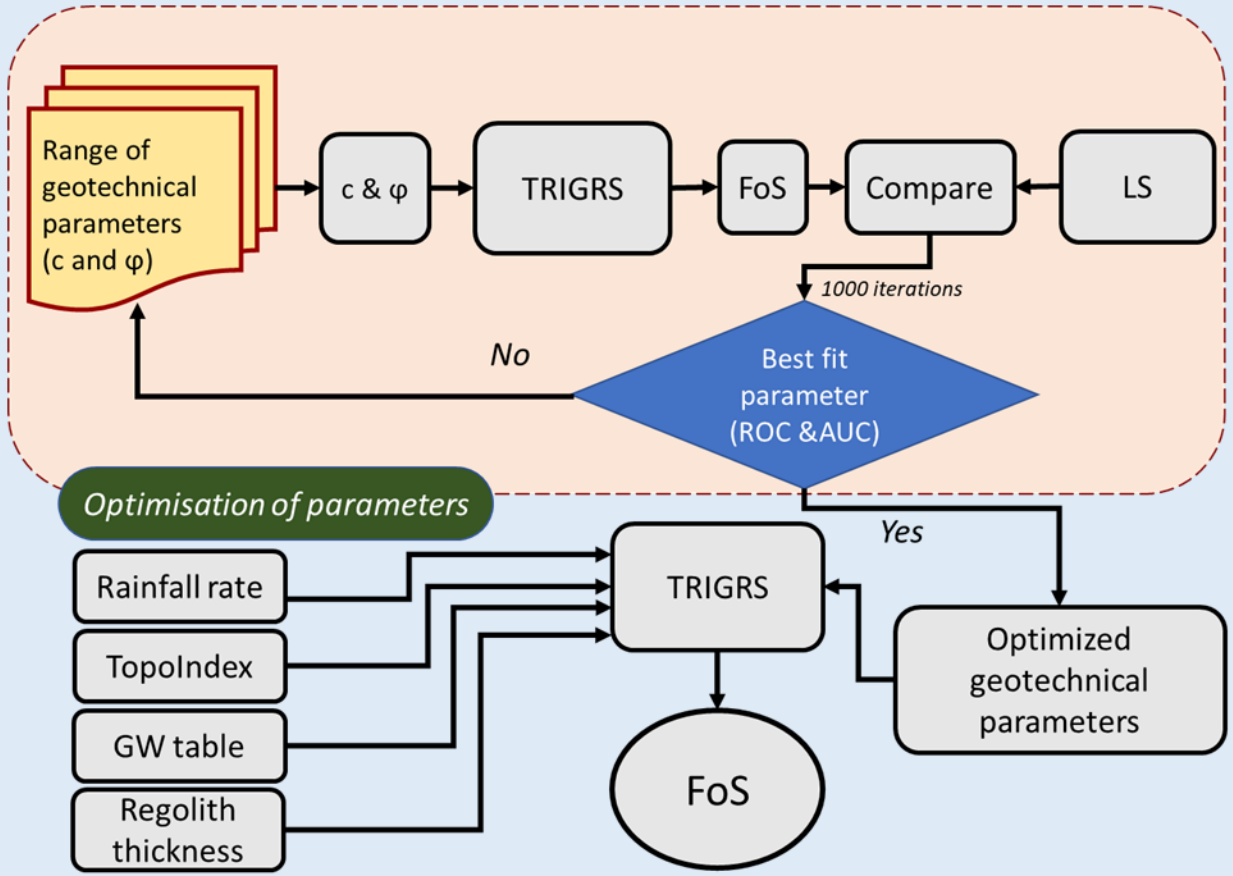
$$\frac{\partial SM}{\partial SEE} = a \frac{1}{N} \sum_{i=1}^{N} \frac{SM_{AMSR-2,i}}{SEE_{25km,i}}$$

- *Gap-filling + Interpolation*
- *Disaggregation Algorithm*
- *Temporal execution rather than spatial - three months (seasonal)*

STEP 02



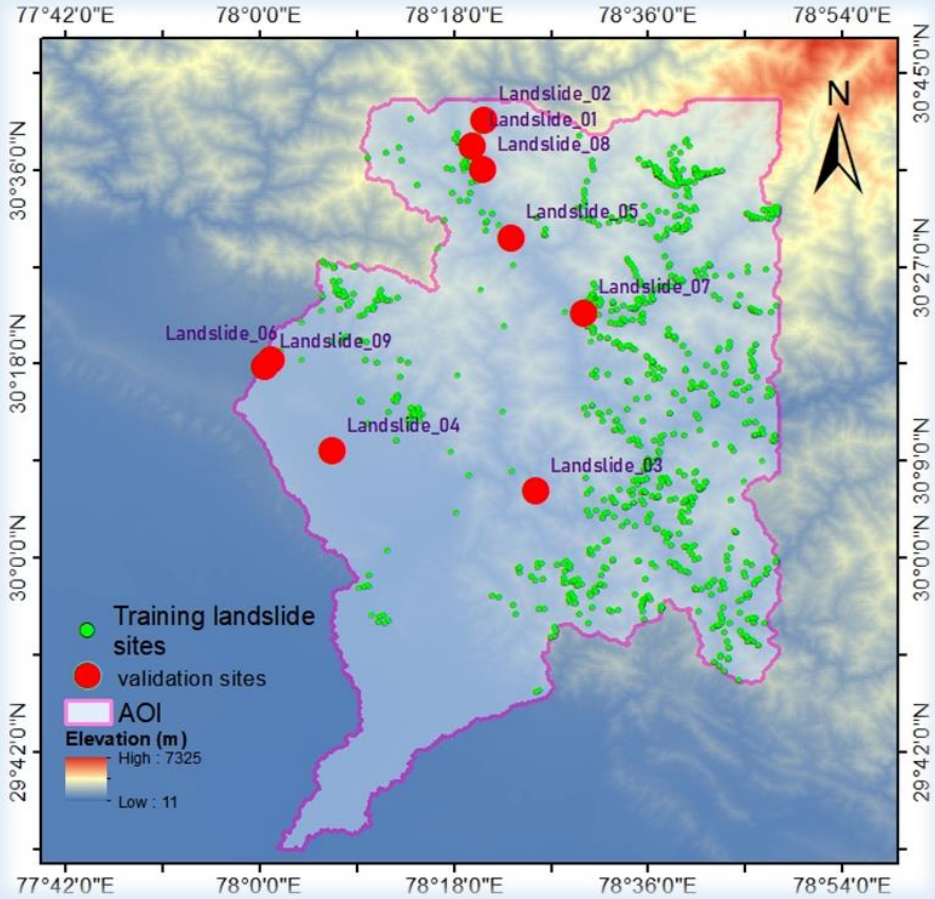
STEP 03 & 04



Optimization of cohesion (c) and angle of internal friction (ϕ)

Validation at 9 sites

Validation

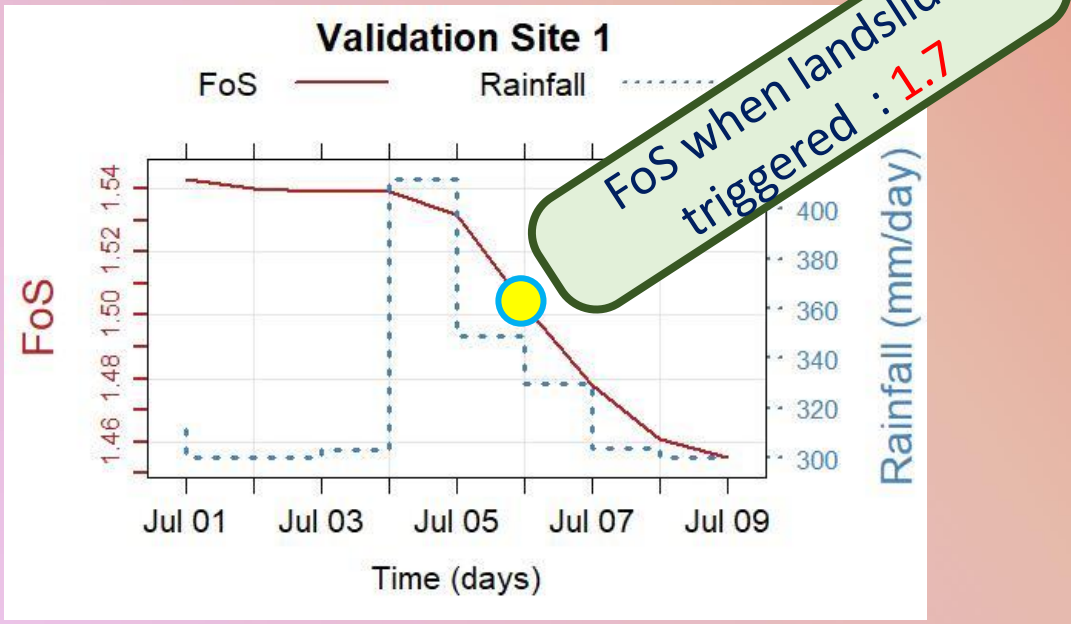


- 971 rainfall induced landslides have been used for optimizing the geotechnical parameters at the study area
- 1000 model runs by feeding all the possible values of cohesion and angle of internal friction for the corresponding soil types in the study area.
- 9 sites for validation

Results

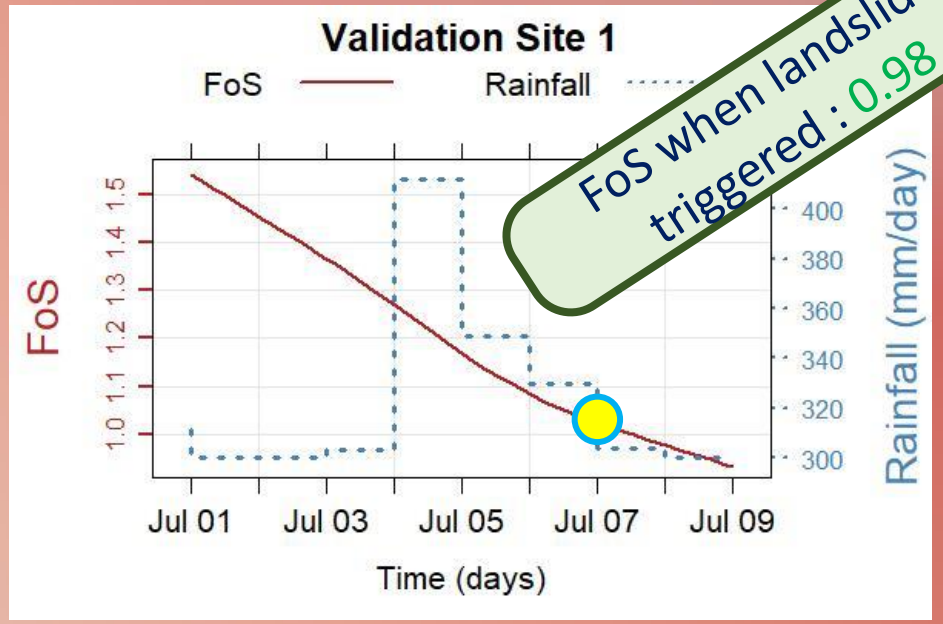
FoS ~ RF plots without optimisation of SHPs and geotechnical parameters

TRIGRS output with non-optimized parameters



FoS ~ RF plots with optimized SHPs and geotechnical parameters

TRIGRS output with optimized parameters



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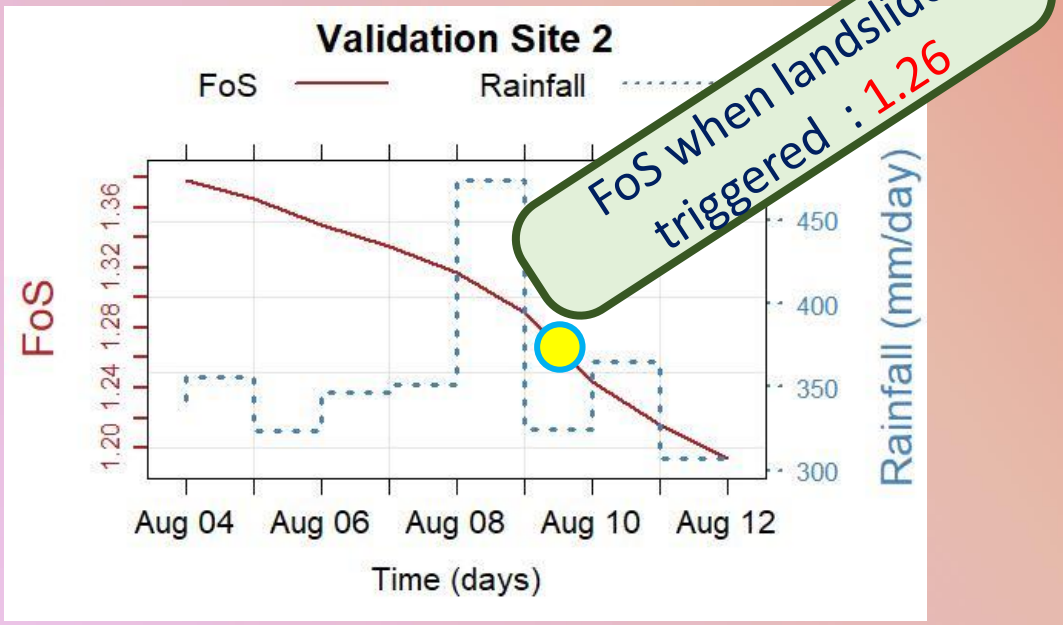

TRIGRS output with optimized parameters

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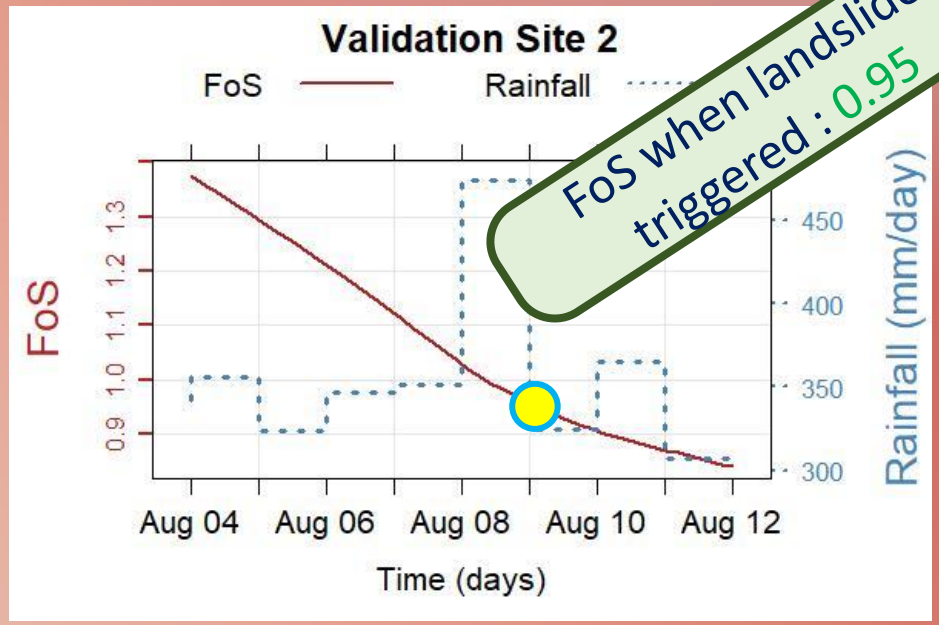

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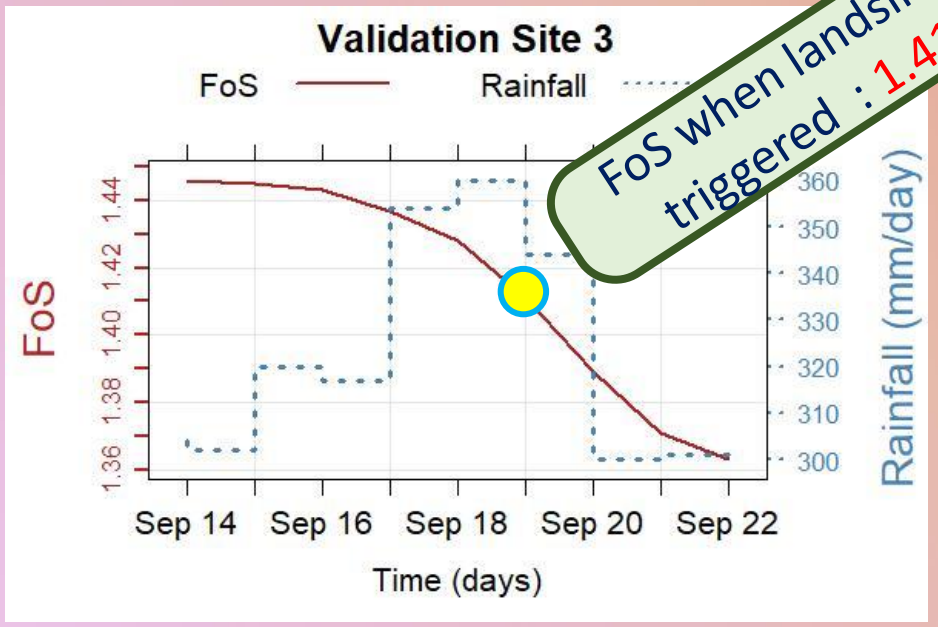

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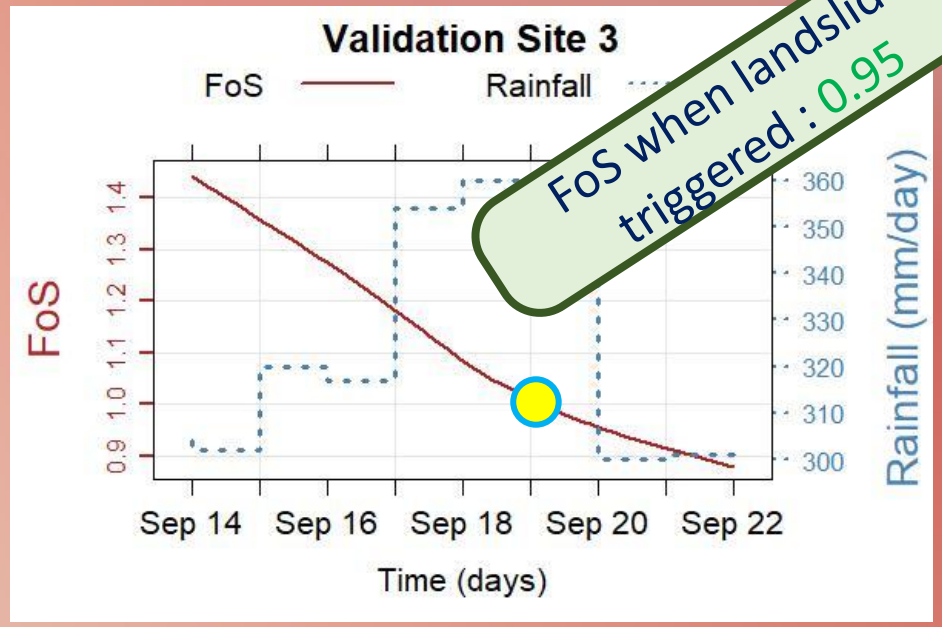

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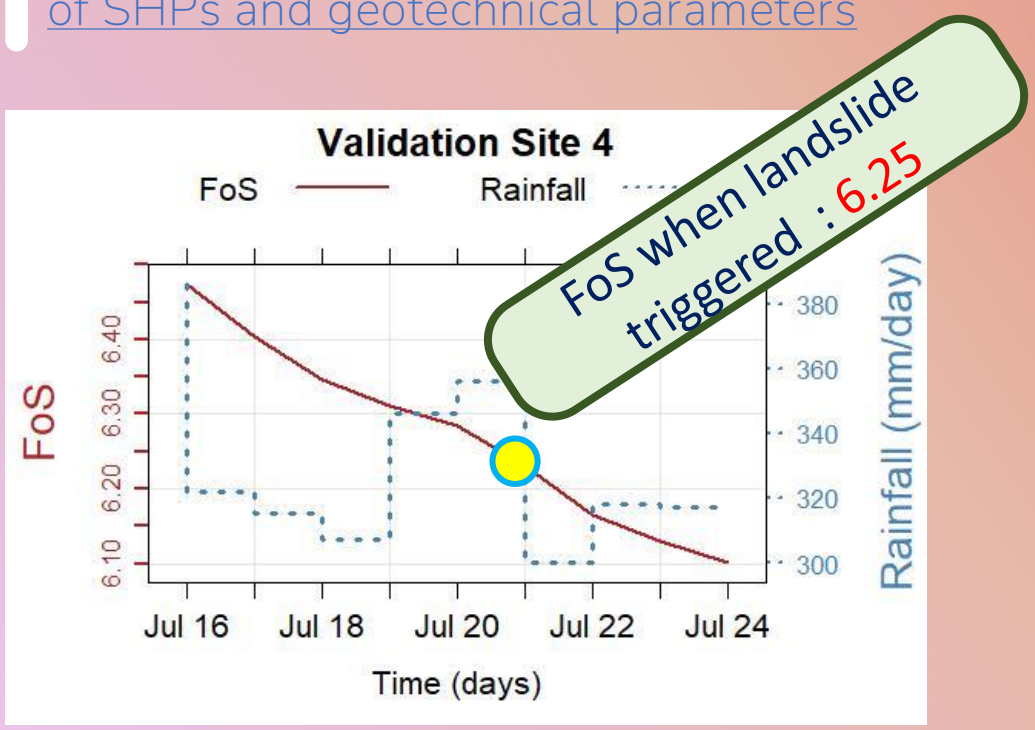

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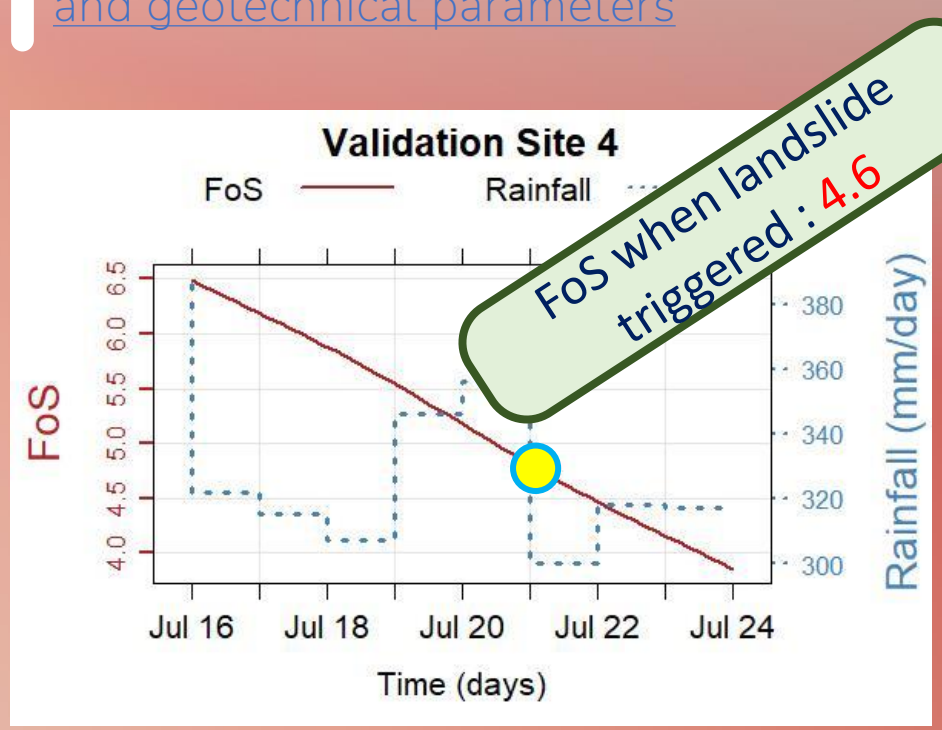

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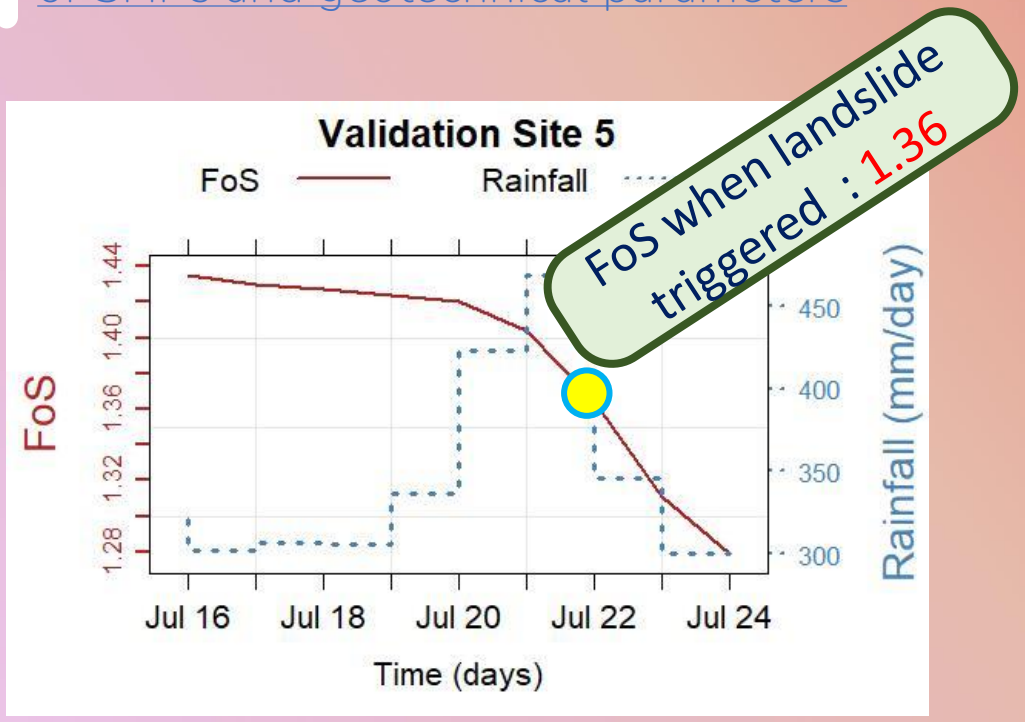

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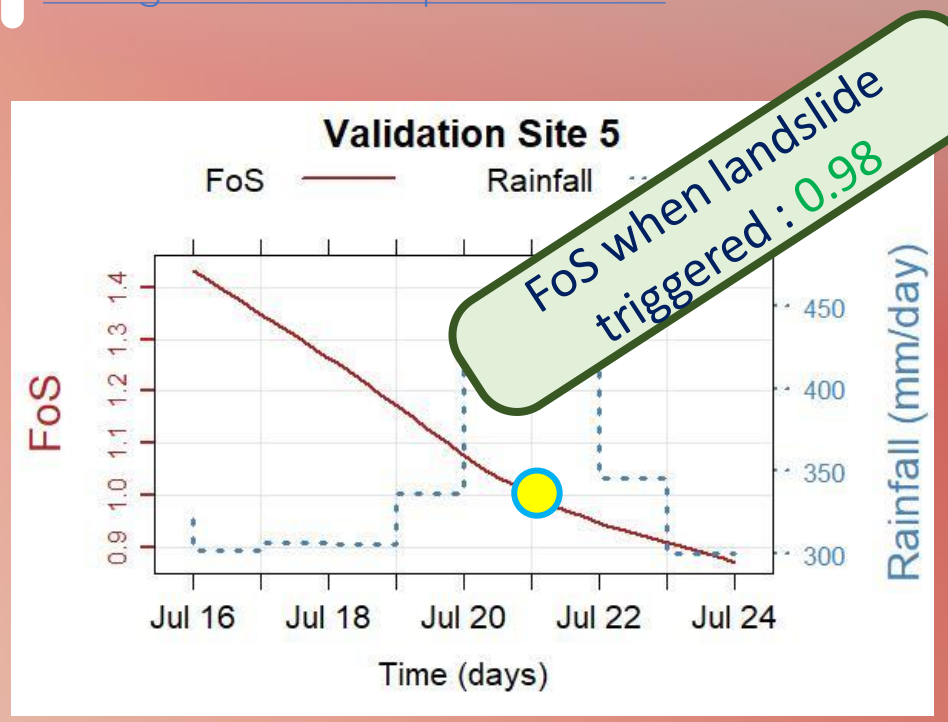

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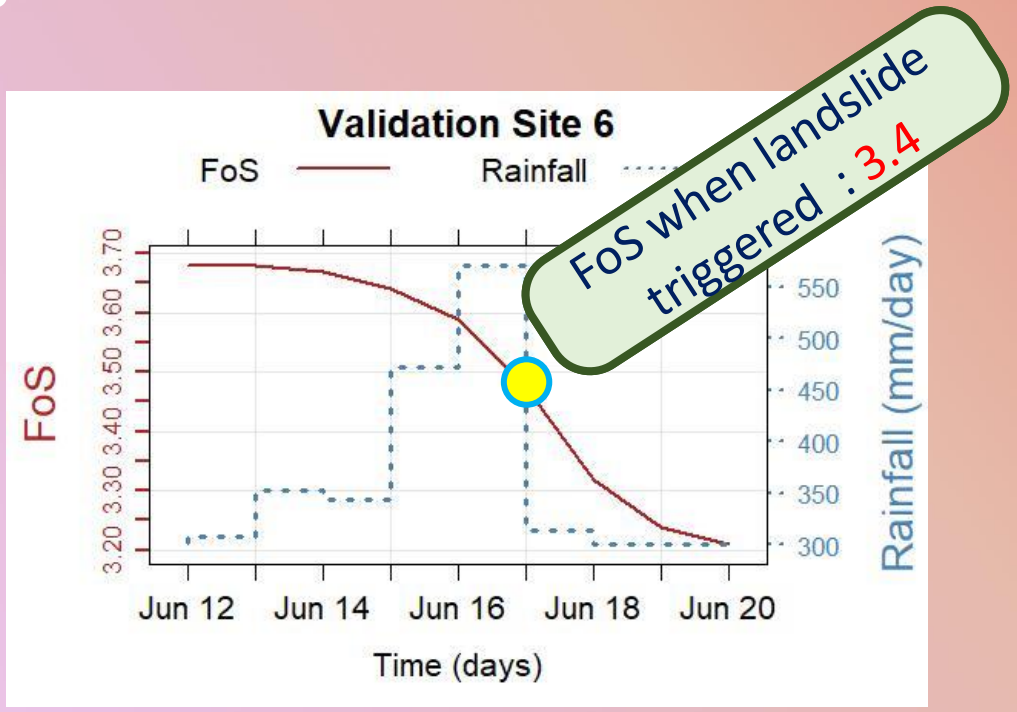

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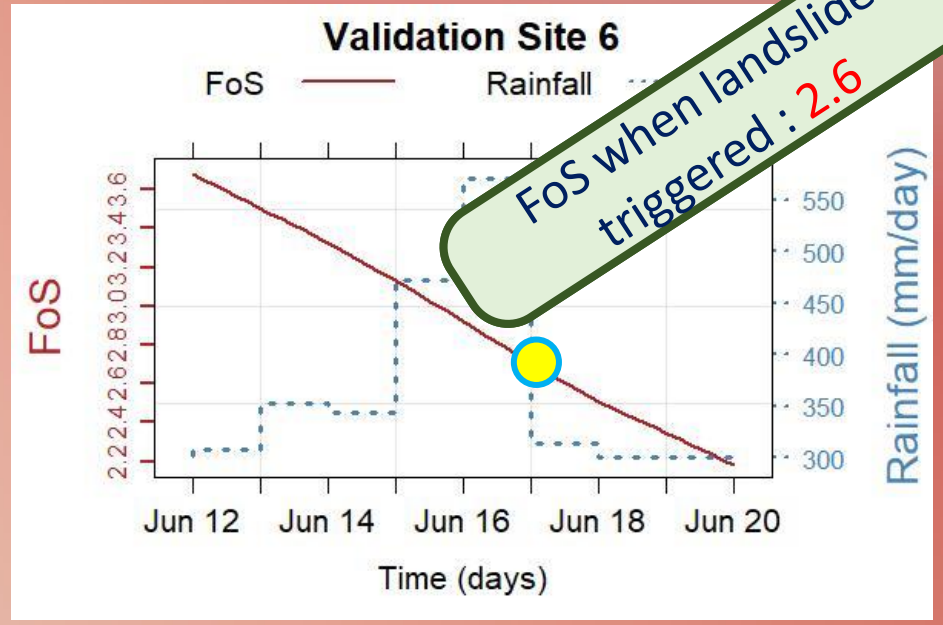

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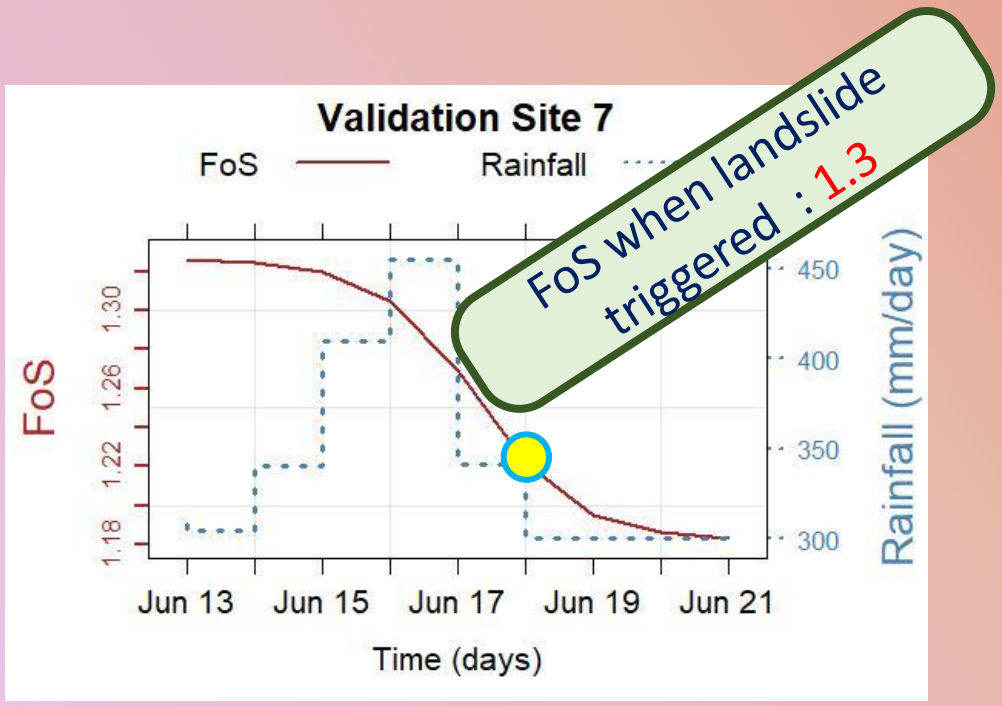

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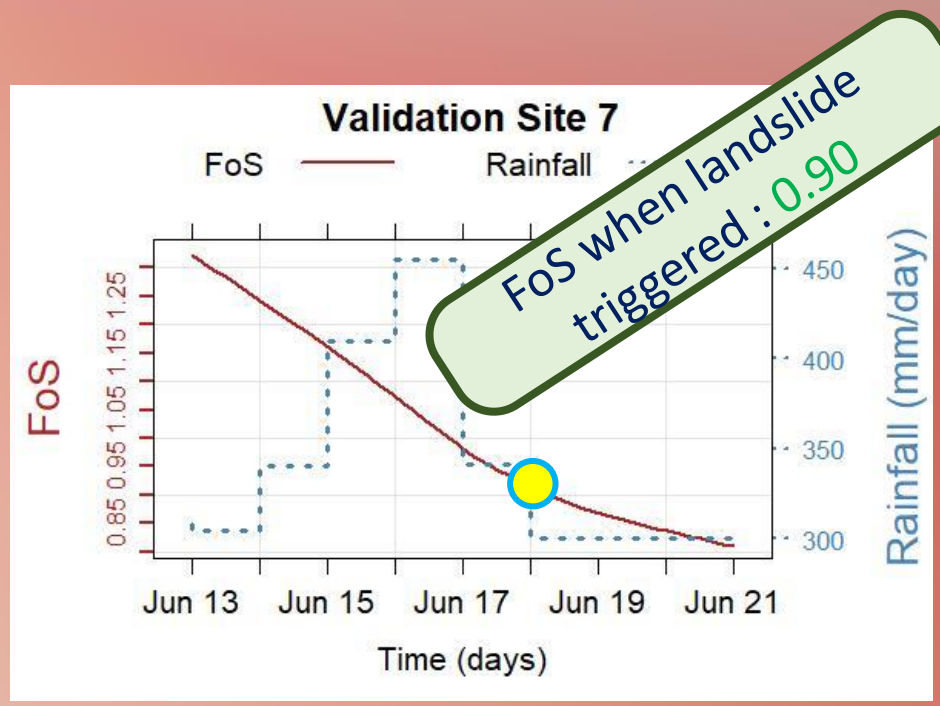

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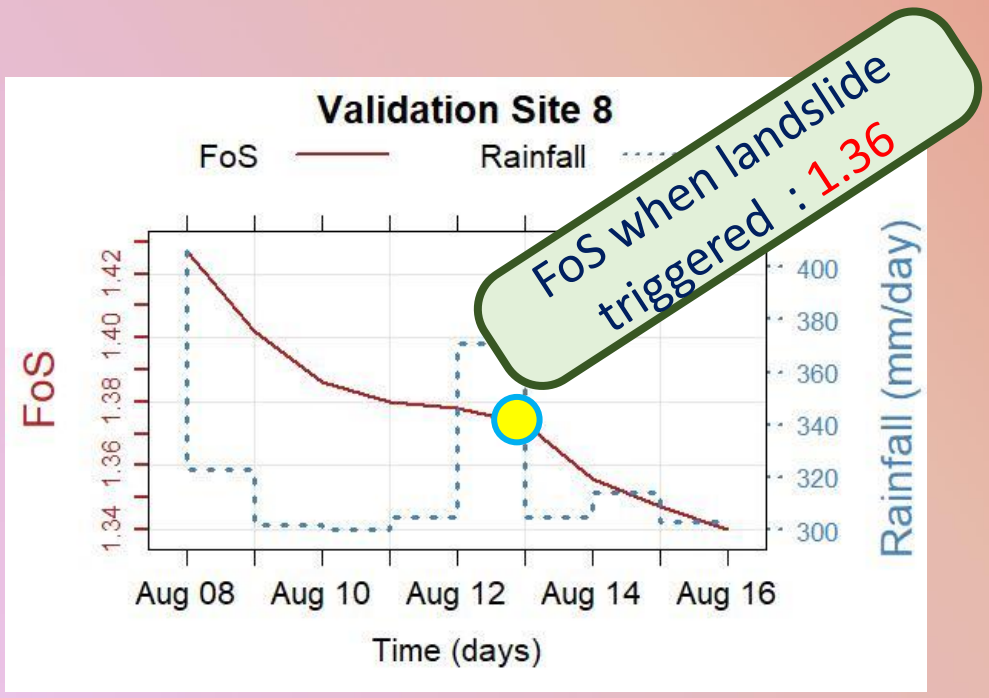

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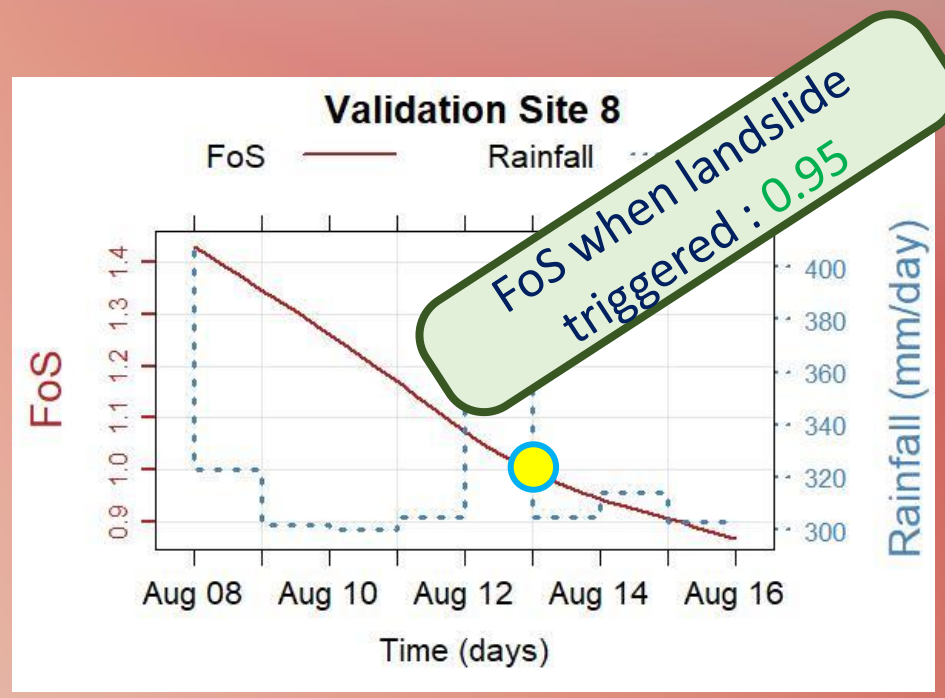

Future work

- Developing an operational EWS for RF induced landslides based on forecasted RF data

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Thank You...

thomasjuby@outlook.com

linkedin.com/in/juby

twitter.com/tmsjuby

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