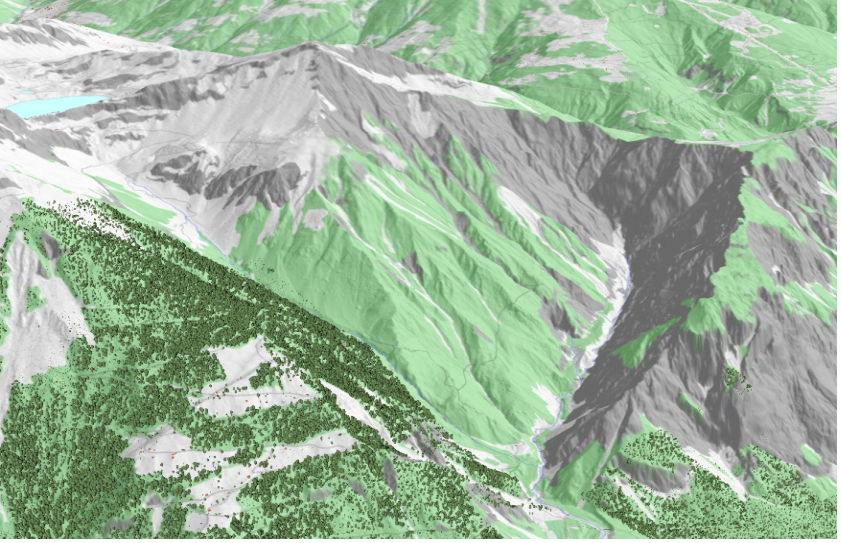


A systematic comparison of rainfall thresholds for debris flows initiation at the Illgraben catchment

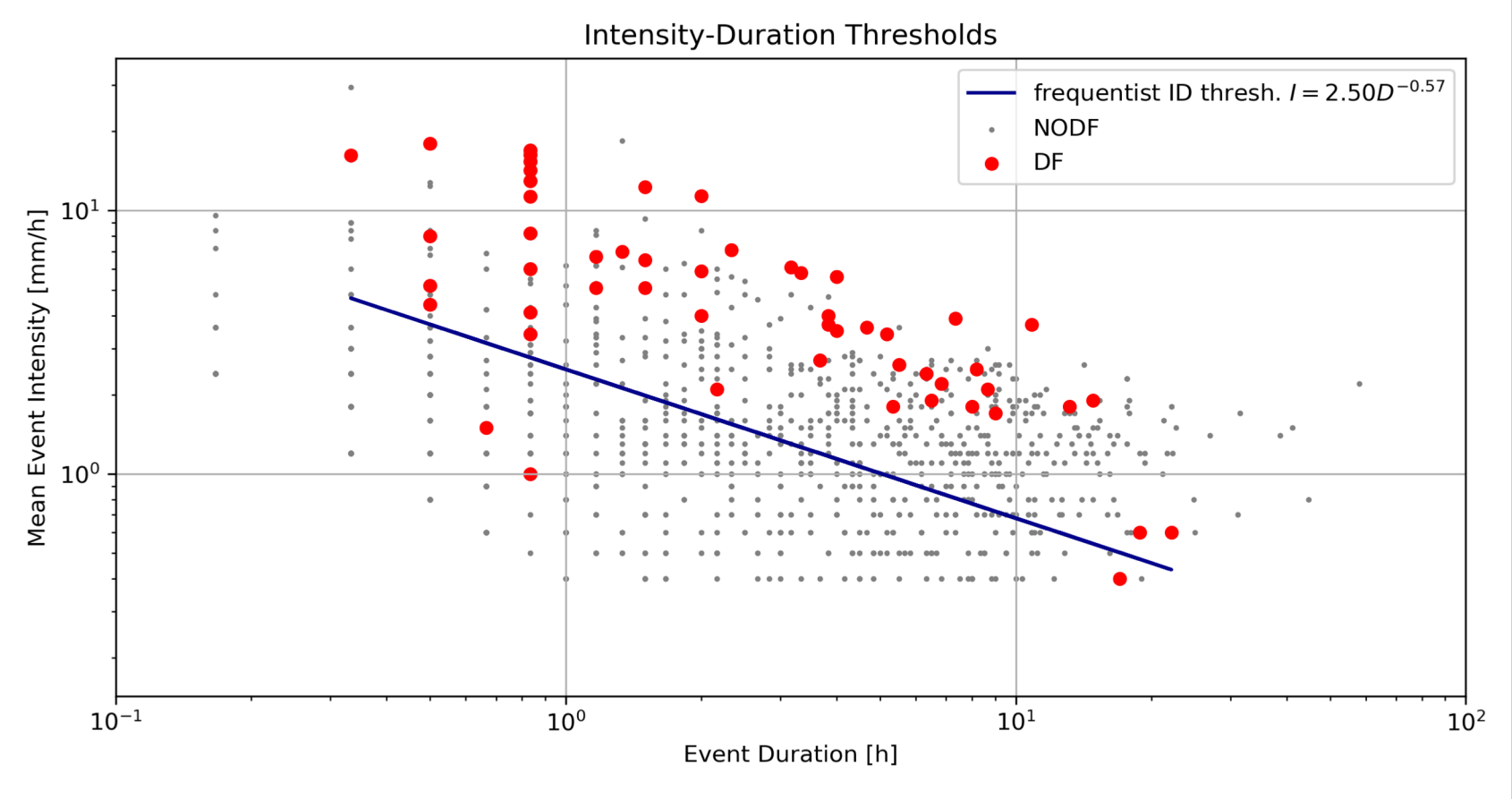
Jacob Hirschberg, Brian W. McArdell and Peter Molnar

SGM 1. December 2018, Bern

Eidg. Forschungsanstalt für Wald, Schnee und Landschaft WSL

Rainfall thresholds

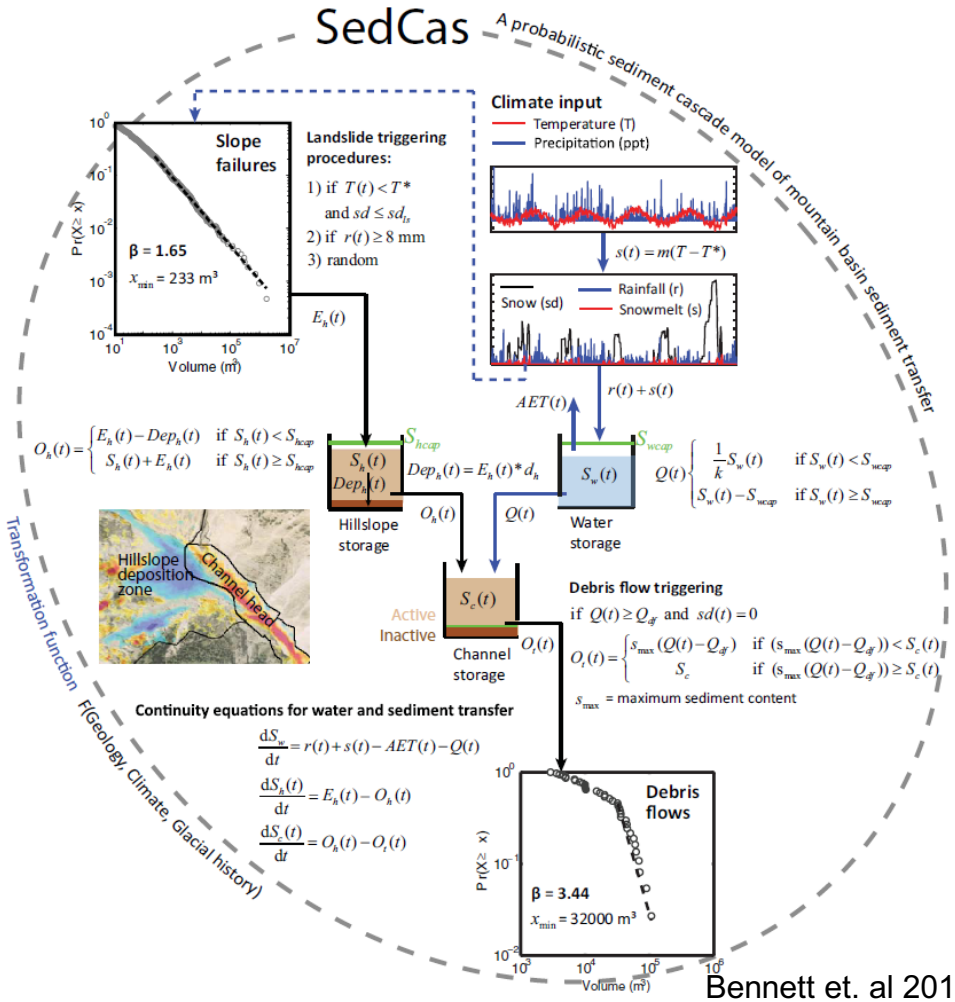
- Intensity-duration thresholds: frequentist method (Brunnetti et al., 2010)
- High false positive rate, low accuracy, low predictive power



SedCas – a conceptual, spatially lumped debris flow model

- Reproduce 1st order characteristics
  - debris flow volumes
  - frequencies
  - seasonality

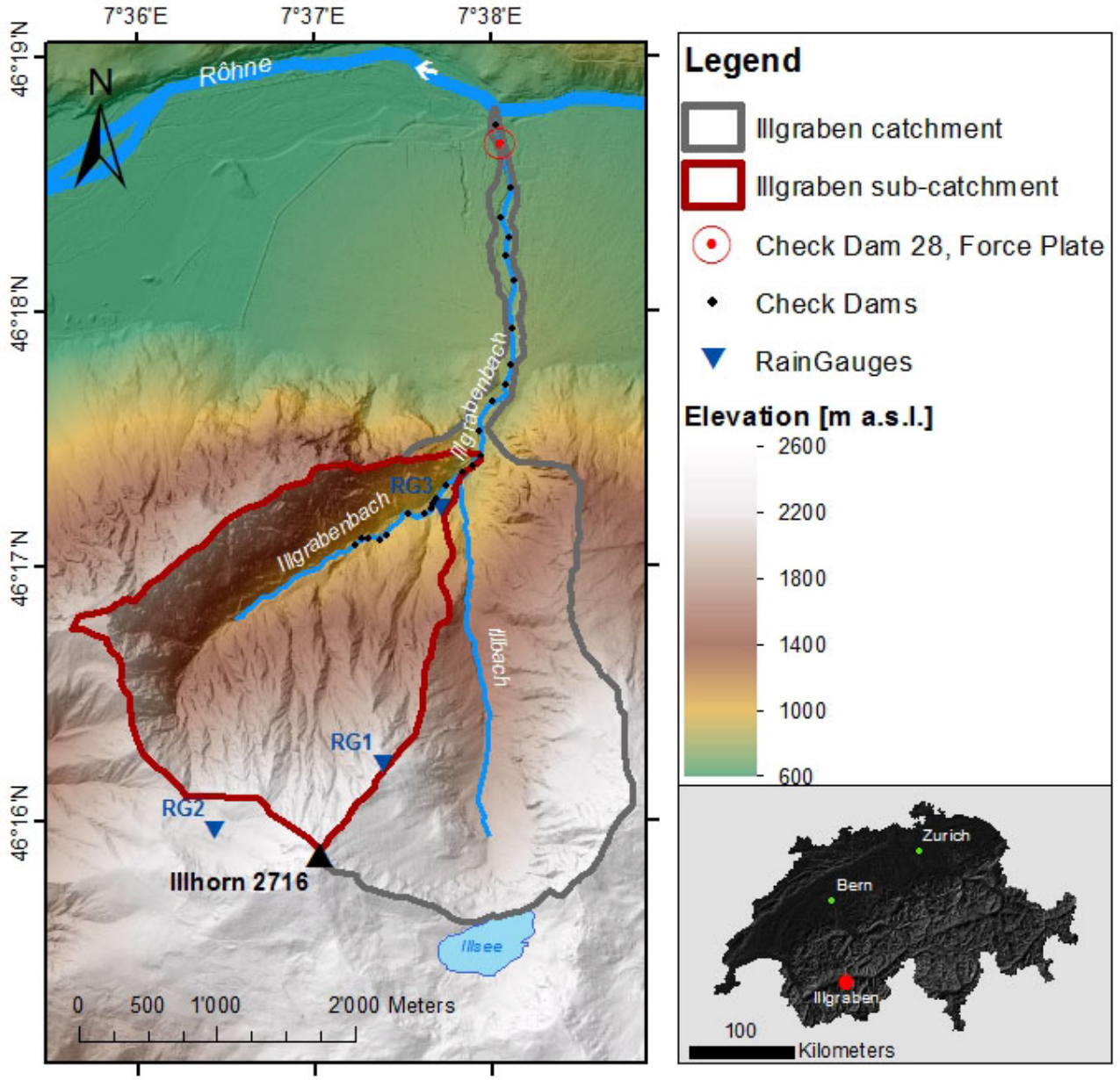
- Use
  - Magnitude-frequency distribution
  - Hazard assessment
  - Climate change scenarios



Bennett et. al 2014

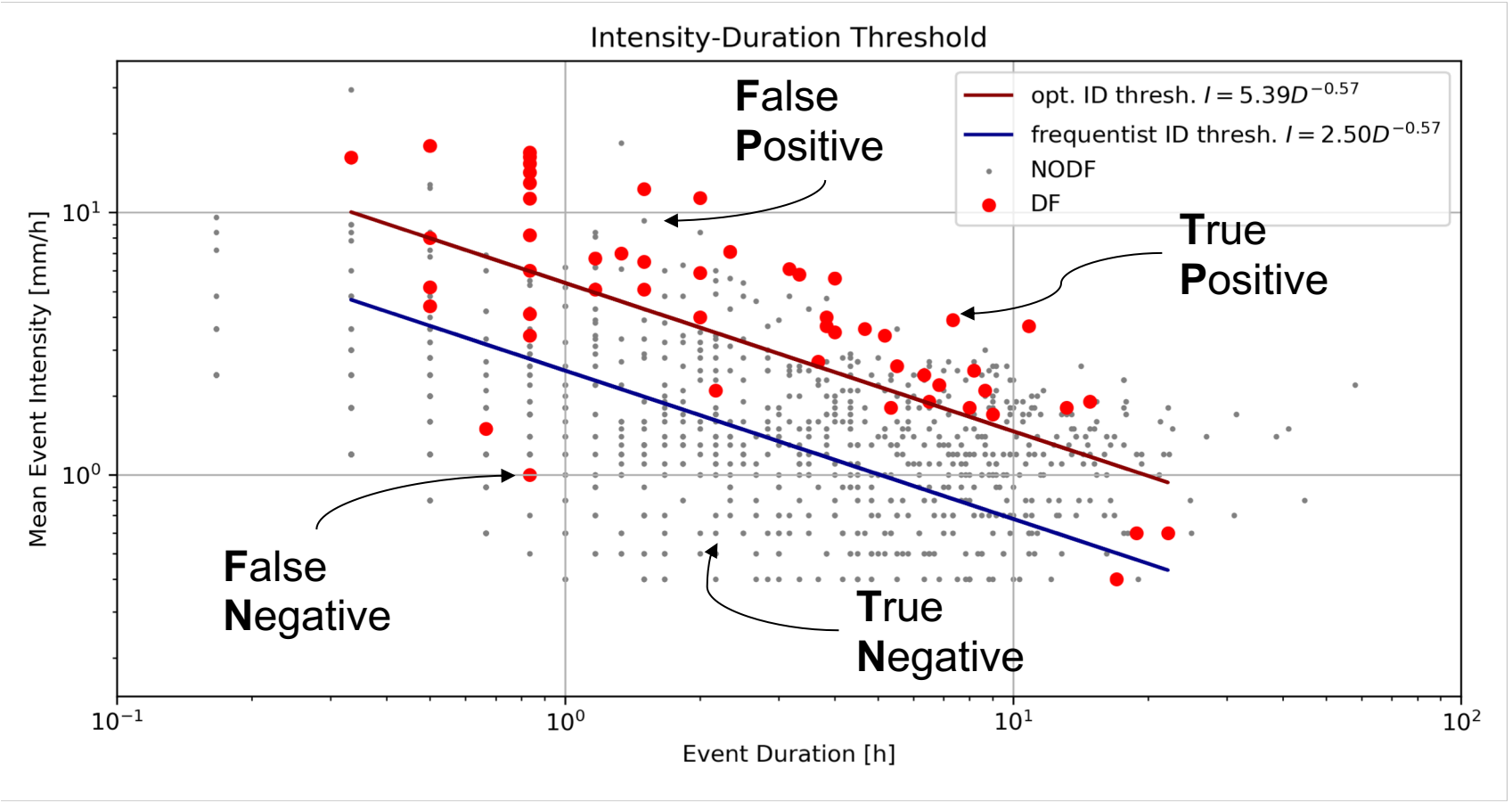
Study Site: Illgraben

- 4.8 km^2
- 3-4 debris flows per year on average
- 75 debris flows (and floods) recorded since 2000
- 54 used in this study

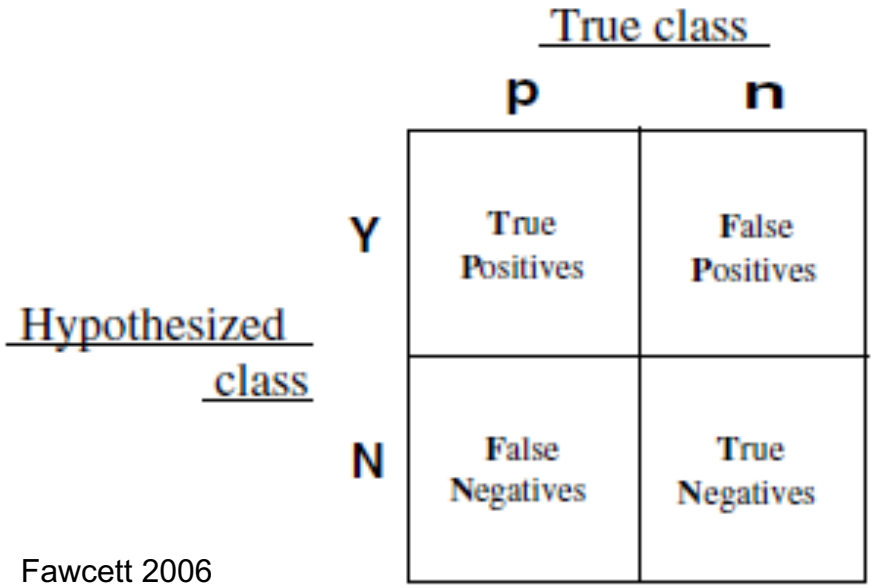


Optimizing Thresholds - Receiver Operating Characteristics (ROC)

- ROC: Account for trade-off between **T**rue **P**ositive **R**ate and **F**alse **N**egative **R**ate



Optimizing Thresholds - Receiver Operating Characteristics (ROC)



Fawcett 2006

$$True\ Pos.Rate = \frac{TP}{TP + FN}$$

$$1 - False\ Pos.Rate = 1 - \frac{FP}{FP + FN}$$

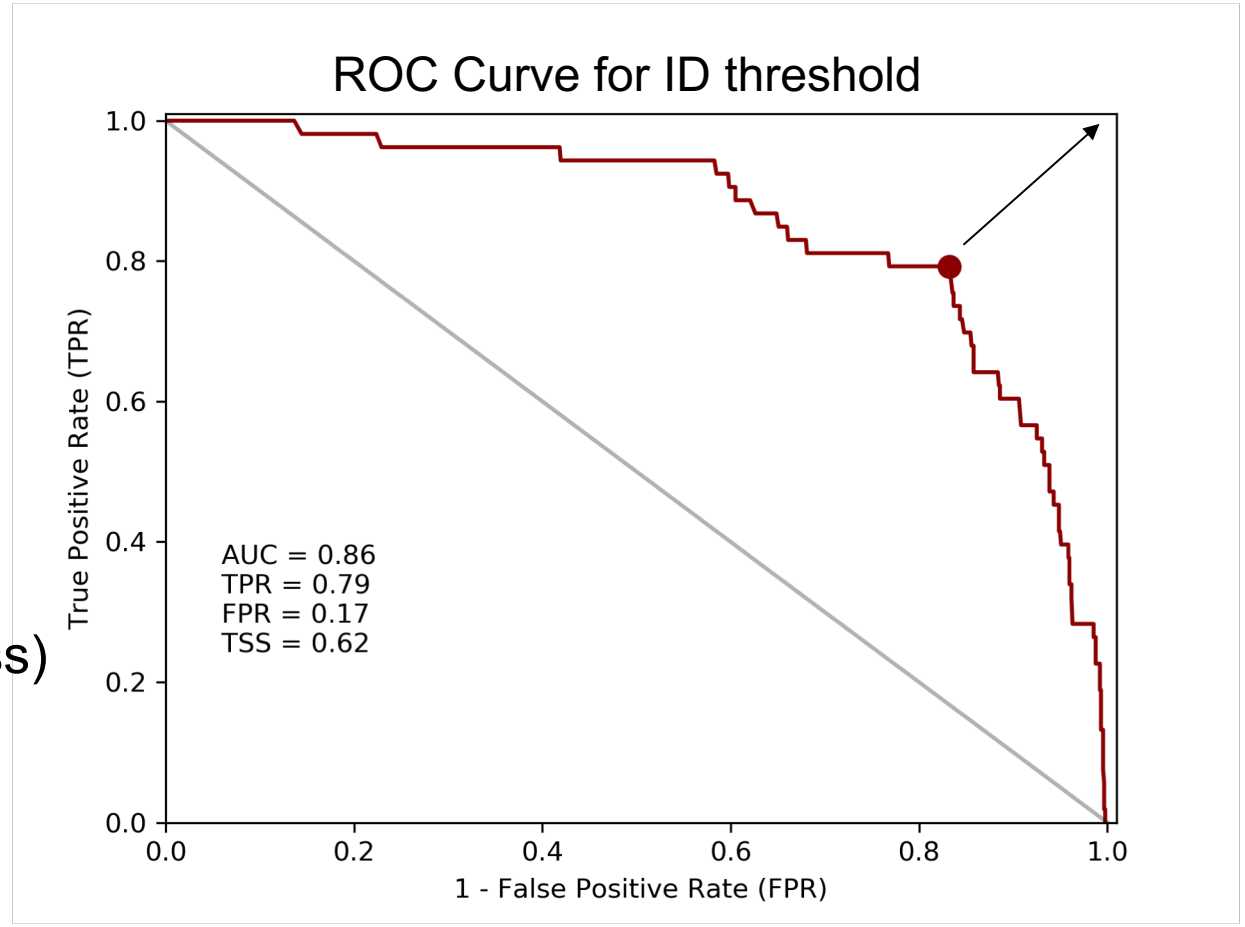
$$True\ Skill\ Stat. = TPR - FPR$$

$$Threat\ Score = \frac{TP}{TP + FN + FP}$$

Optimizing Thresholds - Receiver Operating Characteristics (ROC)

- ROC space visualizes the predictive when varying the threshold

- Ideal predictor:
  - True Positive Rate (TPR) = 1
  - 1 – False Positive Rate (FPR) = 1
  - TSS = TPR – FPR = 1 (0 → random guess)
  - Area Under Curve (AUC) = 1

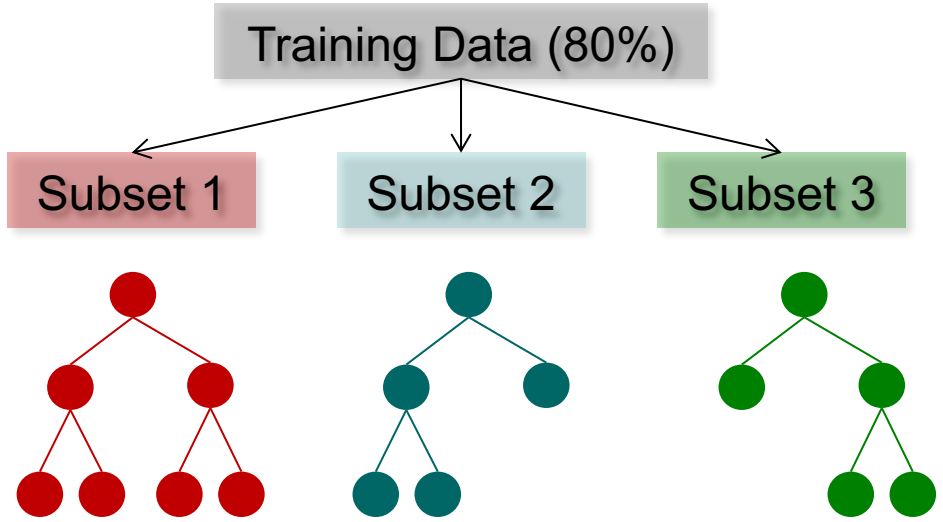


Random Forest Algorithm

- Statistical technique based on decision tree ensemble
- Known for its ability of handling interacting and correlated data
- Common programming languages provide modules

Procedure:

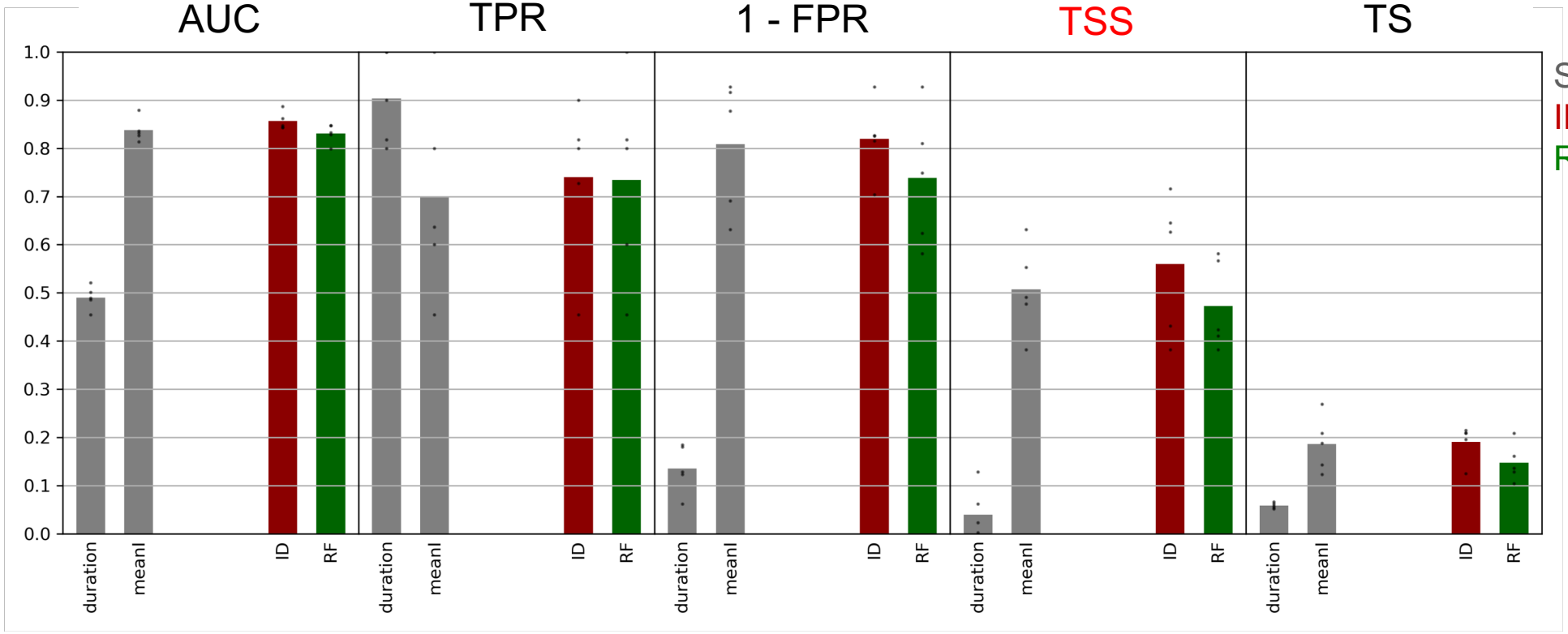
- Train trees with subsets (bootstrap)
- Define probability threshold (ROC)
- Test with remaining 20%
- Validation using 5-Fold CV



Results of 5-Fold Cross-Validation

Variables:

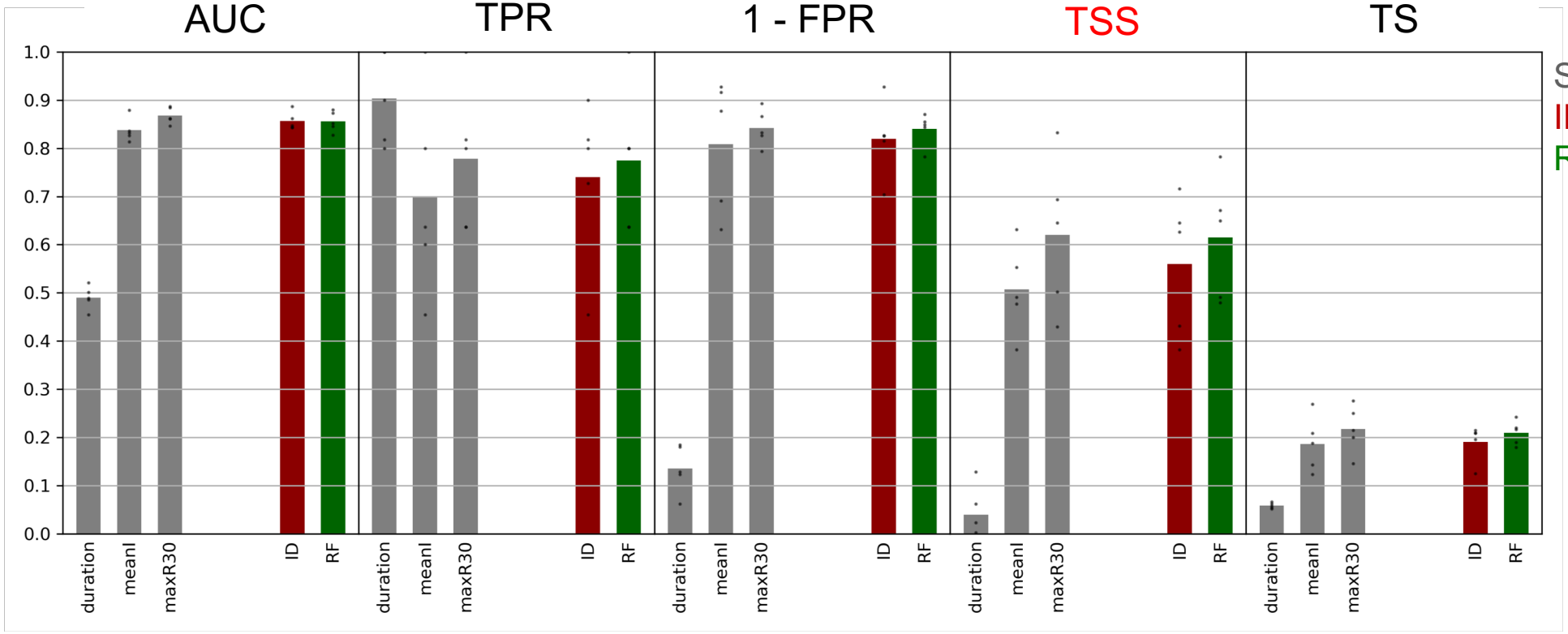
- Duration, mean intensity



Results of 5-Fold Cross-Validation

Variables:

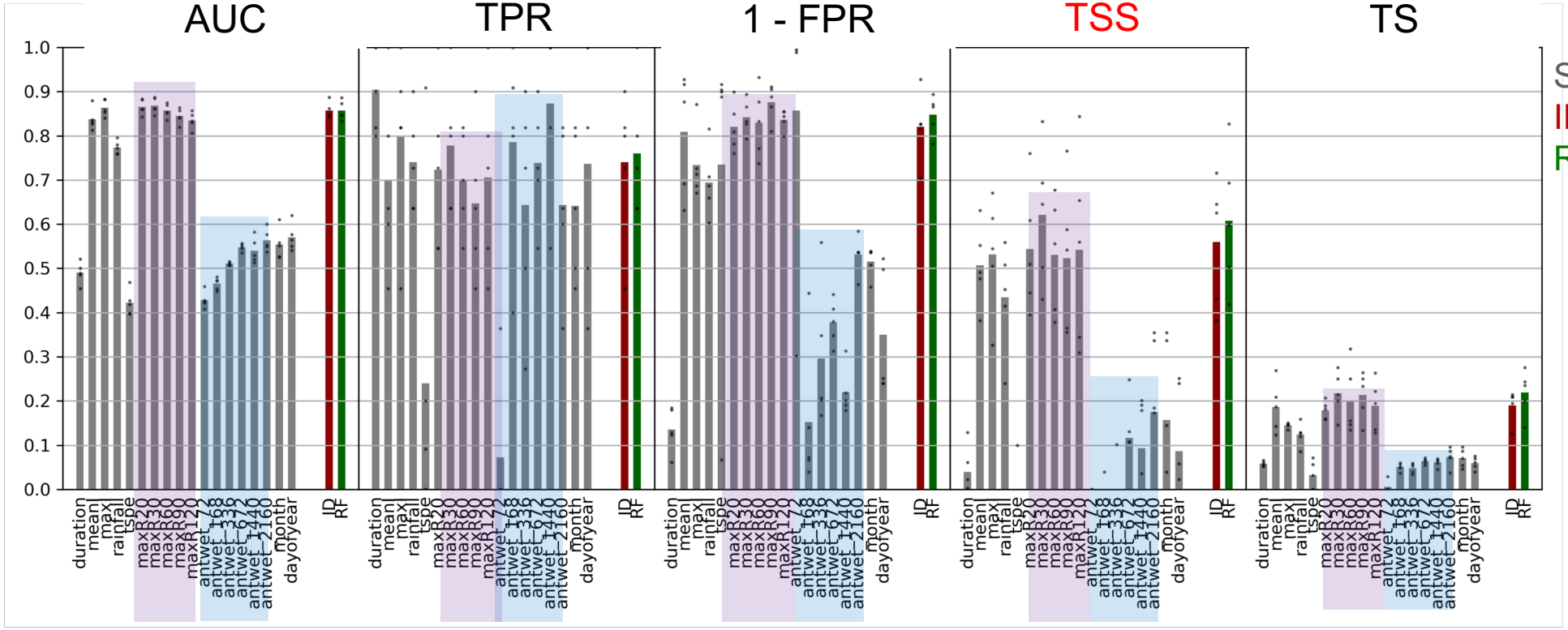
- Duration, mean intensity
- Max 30 min rainfall accumulation



Results of 5-Fold Cross-Validation

Variables:

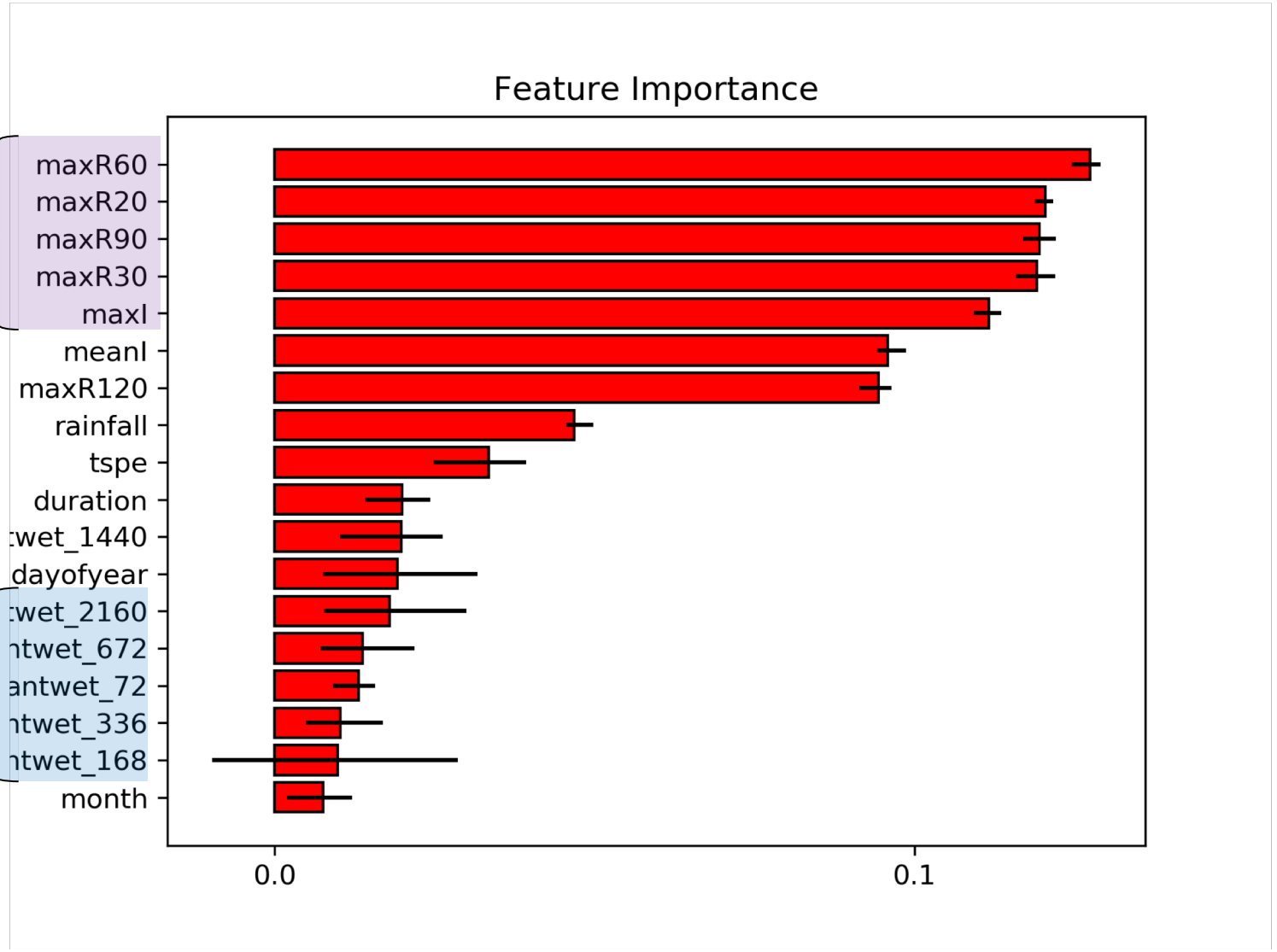
- Duration, mean intensity
- Max 10-120 min rainfall accumulation
- 1-90 days antecedent rainfall
- Time since last debris flow
- month, day of year



Which variables have predictive power?

Max. cumulated rainfall 10-90 minutes

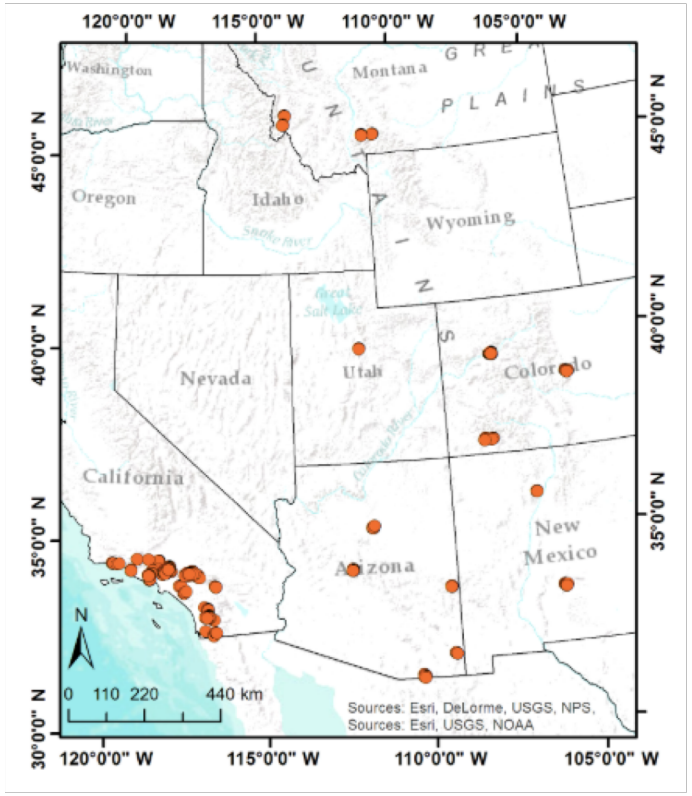
1-90 days antecedent rainfall

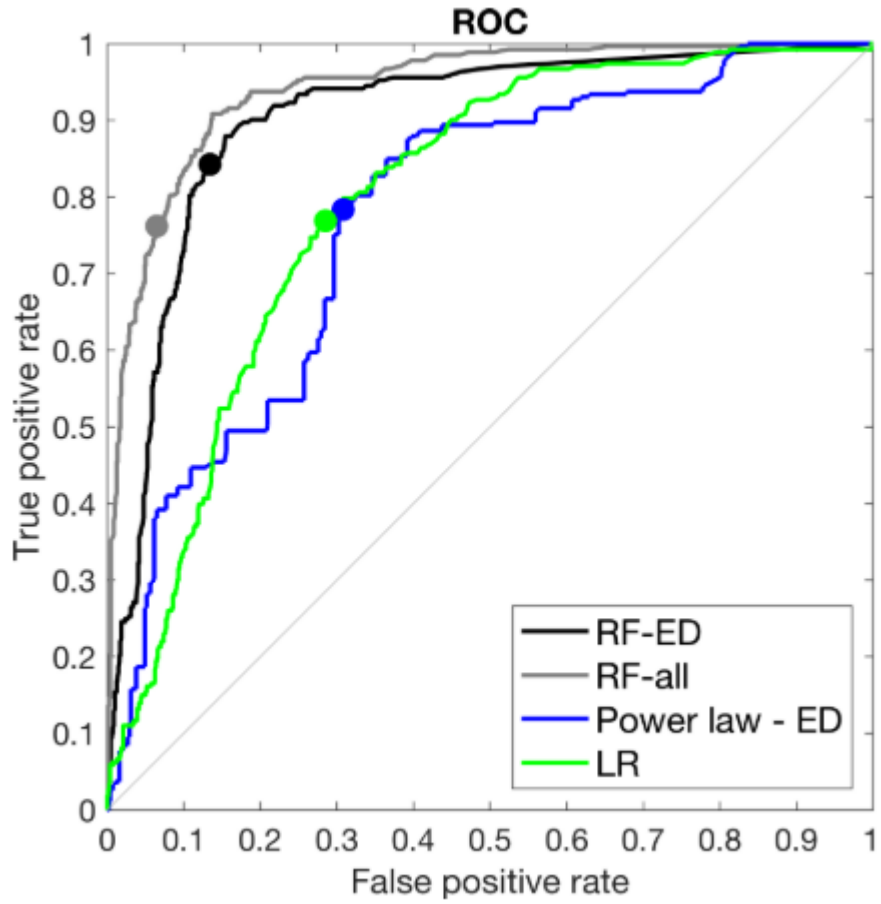


Regional post-fire debris flows in western US

RF-ED (not ID) variables:

- cum. rainfall (mm) (not mean int.)
- duration (h)
- region class





Nikolopoulos et al. 2018

Take-Home Messages

- RF provides a minor improvement of the warning accuracy, compared to intensity-duration thresholds, by considering peak intensities.
- RF is flexible in the data to be considered: snowmelt, soil moisture, sediment availability, etc.
- Considering rainfall only is always a simplification of the process. Rainfall is the *trigger* and not the *cause* (Bogaard and Greco, 2018).
- Outlook: hydrological model to account for hydro(-geomorphological) processes

THANK YOU FOR YOUR ATTENTION