Improvements in Risk Assessment Tools

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The FORESEE EU Project – Final conference

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Improvements in Risk Assessment Tools

- FORESEE's developments that aims to improve the Risk Assessment Tools:
  - Risk mapping tool
  - Virtual Modelling platform and asset failure prediction
  - SHM BIM based alerting SAS platform
  - Flooding Methodology
  - Command and Control

- Key words: Satellite monitoring | Flooding and risk mapping | Structural health monitoring: satellite and ground data based | Shake maps | Data fusion / Common and Control Centre

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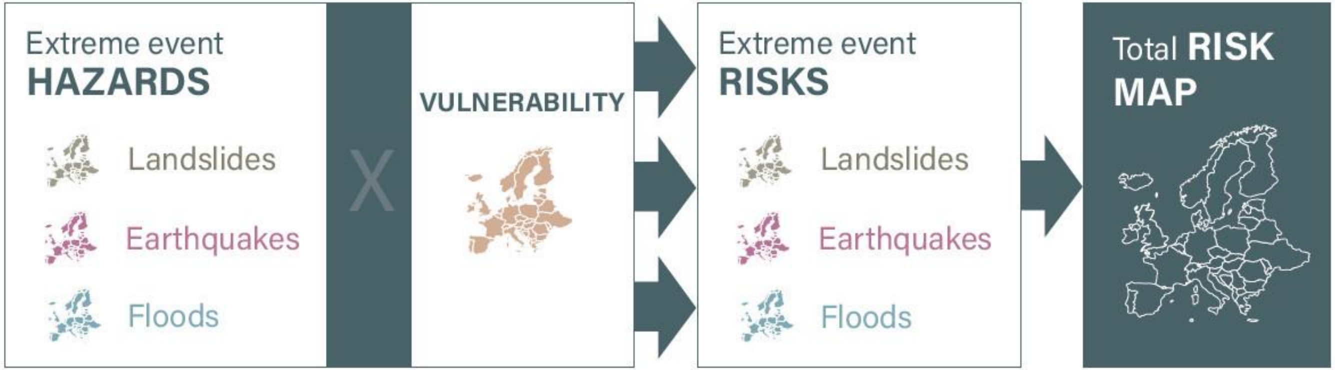
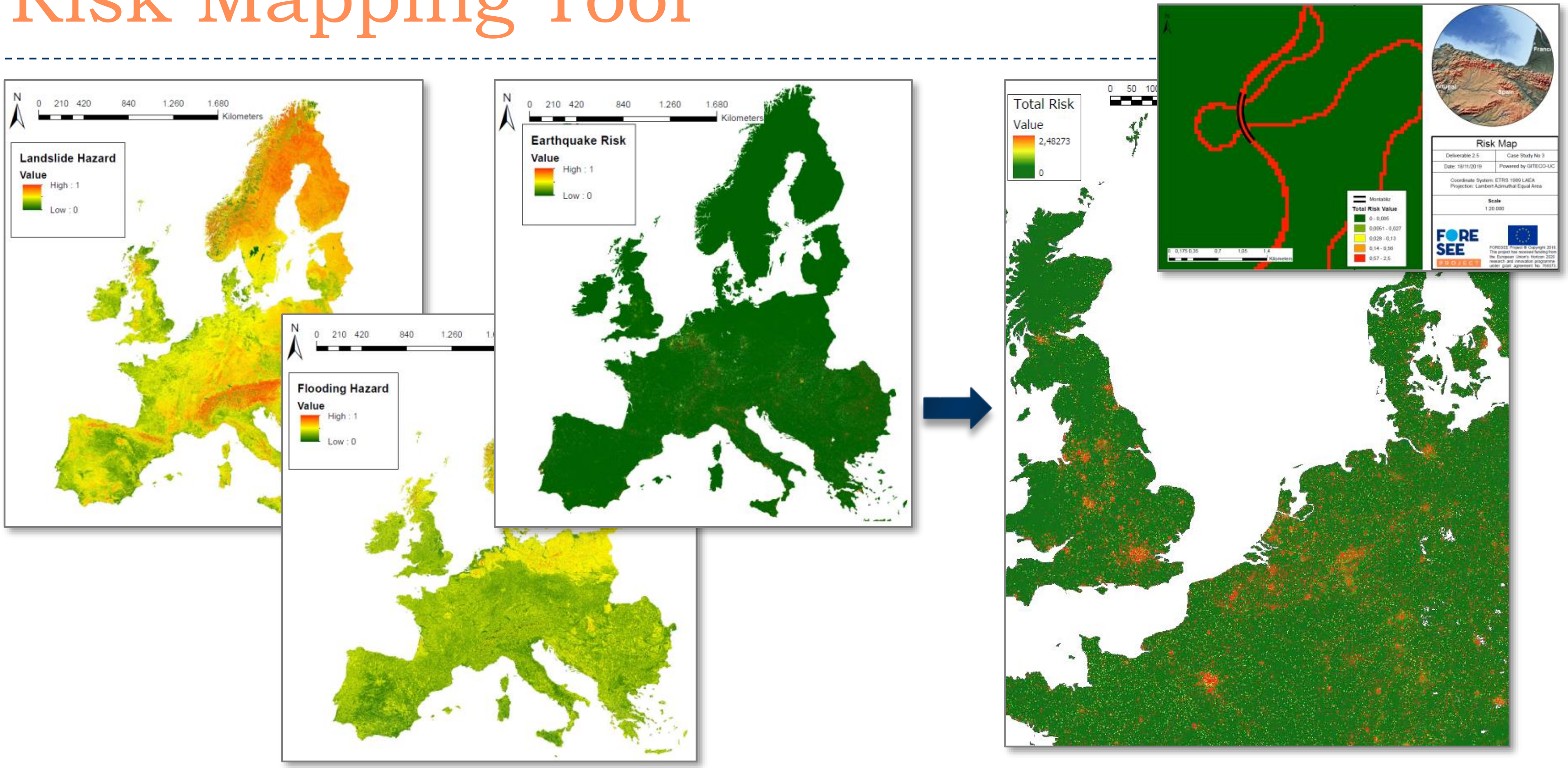
Risk Mapping Tool

- Objective: Early identification of large-scale risks to extreme natural disasters affecting road and railway infrastructures.
- Estimation of potential risks to be used in the early phases of project design.
- Definition of hazard and risk maps at European level.

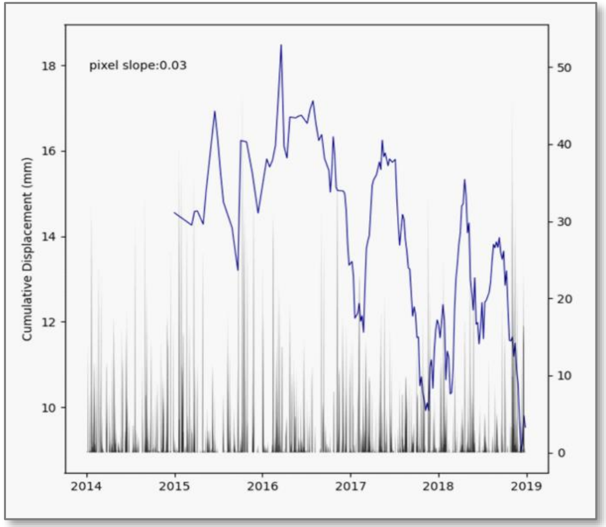


Risk Mapping Tool

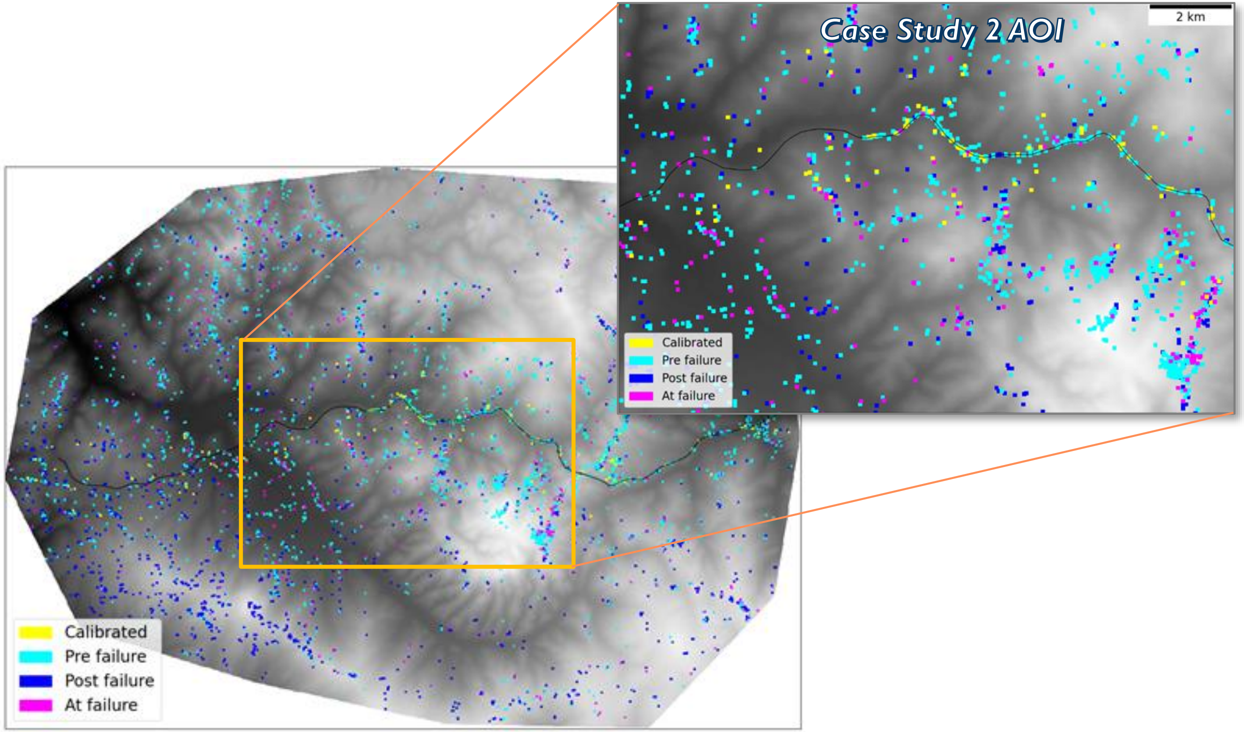


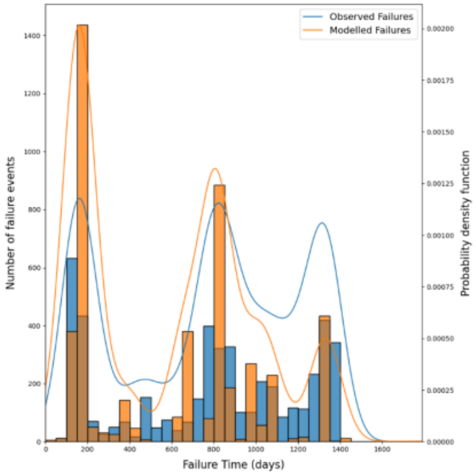
Virtual Modelling Platform and Asset Failure Prediction

- Objective: To predict timing of slope instability that may disrupt transport networks.
- The tool is based on a numerical model of slope failure where the stability of the slope depends on the pore pressure of water.
- The model innovative feature is its parametrization based on InSAR satellite data which provide ground motion time series.
- InSAR time series show precursor motion correlated with rainfall.



Virtual Modelling Platform and Asset Failure Prediction

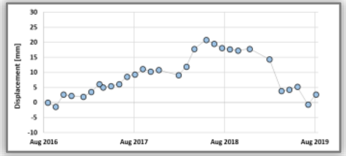


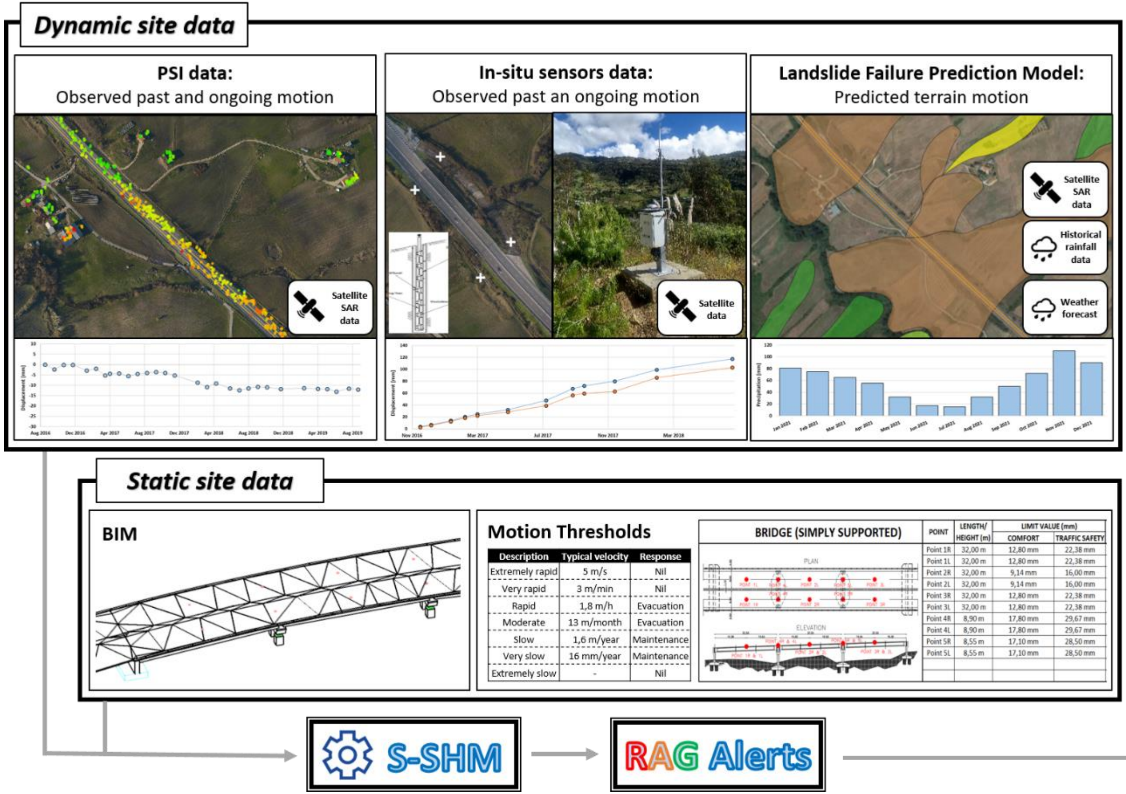


SHM BIM based alerting SAS platform

- Objective: To provide structural health monitoring assessment by using satellite data.
- How S-SHM can improve the infrastructure management towards resilience:
  - Integration of different data sources;
  - BIM model of the infrastructure and components to be kept under control;
  - Increased reliability of identifying warning thresholds;
  - Used to program and design interventions;
  - Timely warning of potential events with a positive impact on mobility and safety.

SHM BIM based alerting SAS platform

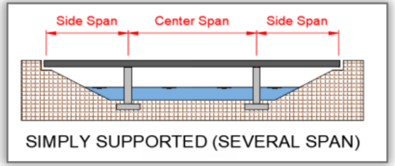


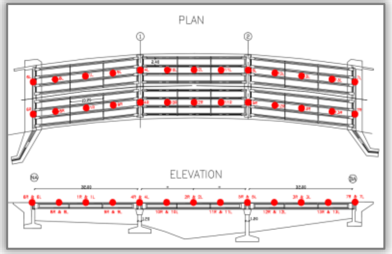


Motion Thresholds

Description	Typical velocity	Response
Extremely rapid	5 m/s	Nil
Very rapid	3 m/min	Nil
Rapid	1,8 m/h	Evacuation
Moderate	13 m/month	Evacuation
Slow	1,6 m/year	Maintenance
Very slow	16 mm/year	Maintenance
Extremely slow	-	Nil

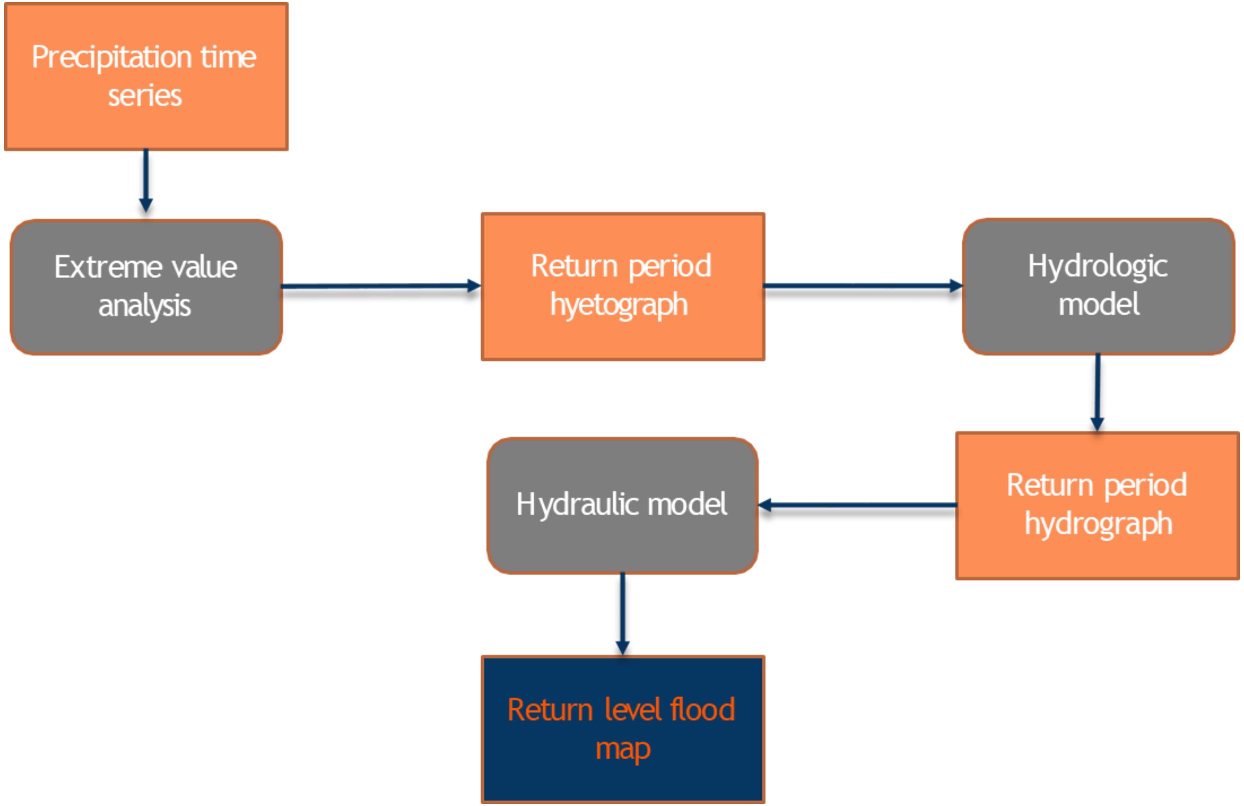
POINT	LENGTH/ HEIGHT (m)	LIMIT VALUE (mm)	
		COMFORT	TRAFFIC SAFETY
Point 1R	32,00 m	12,80 mm	22,38 mm
Point 1L	32,00 m	12,80 mm	22,38 mm
Point 2R	32,00 m	9,14 mm	16,00 mm
Point 2L	32,00 m	9,14 mm	16,00 mm
Point 3R	32,00 m	12,80 mm	22,38 mm
Point 3L	32,00 m	12,80 mm	22,38 mm
Point 4R	8,90 m	17,80 mm	29,67 mm
Point 4L	8,90 m	17,80 mm	29,67 mm
Point 5R	8,55 m	17,10 mm	28,50 mm
Point 5L	8,55 m	17,10 mm	28,50 mm





FORESEE TOOL

Flooding Methodology – Usual Methodology

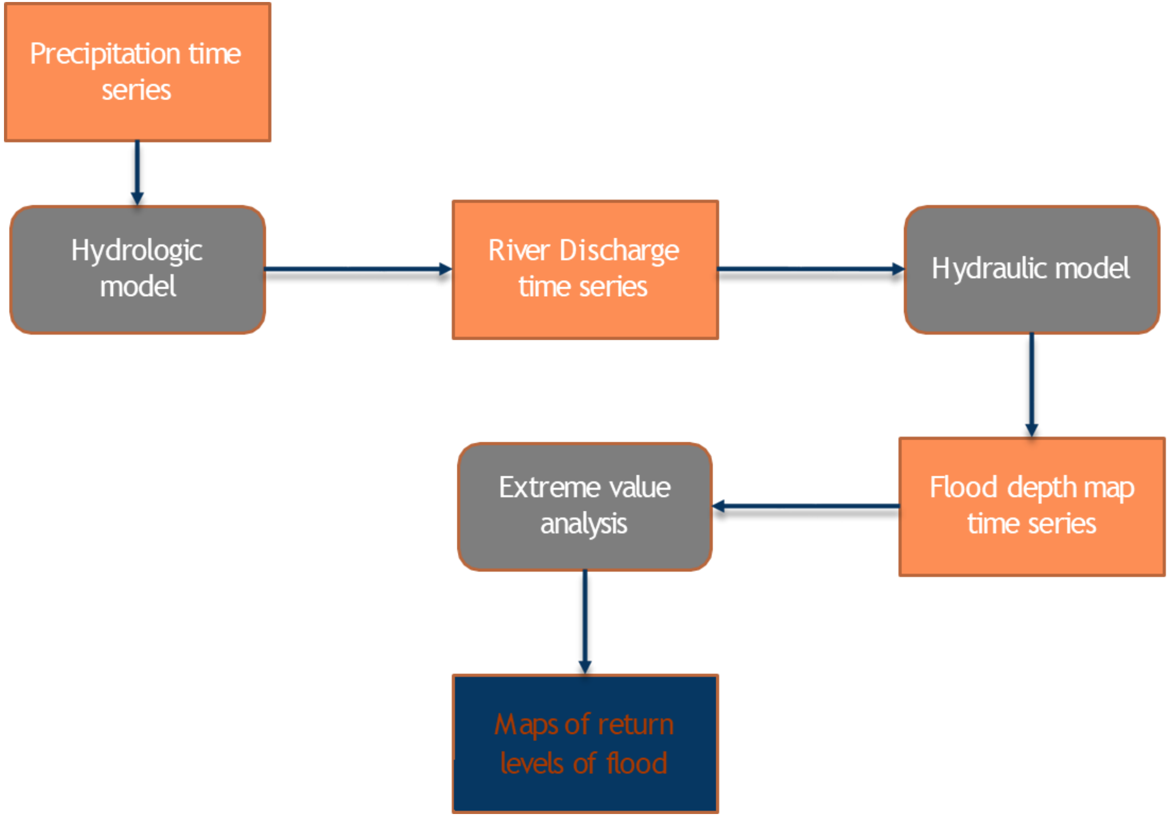


Flooding Methodology

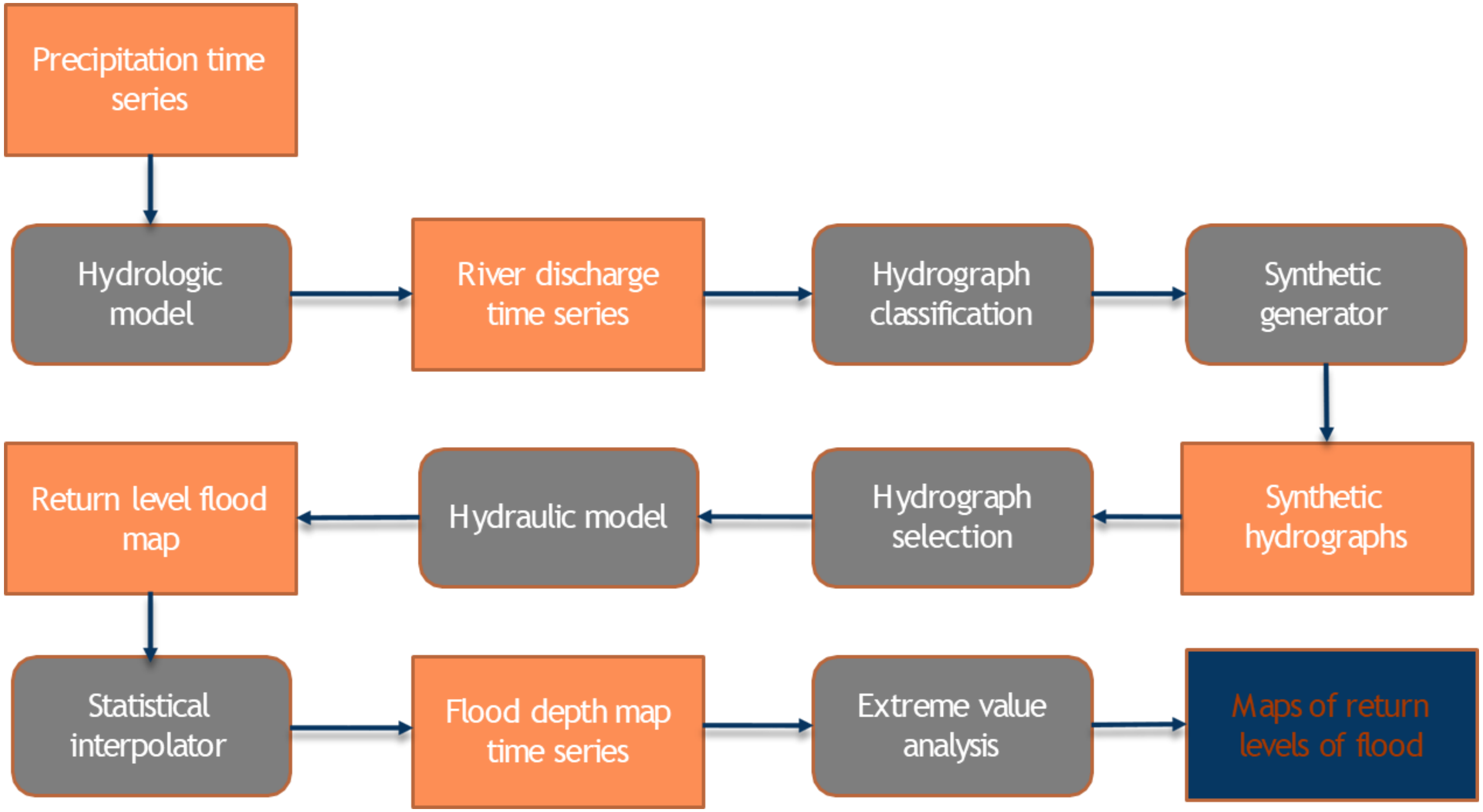
Question:

Is the **flood generated by the event** of a given return period a **good estimator** of the **return level of the flood** for the same return period?

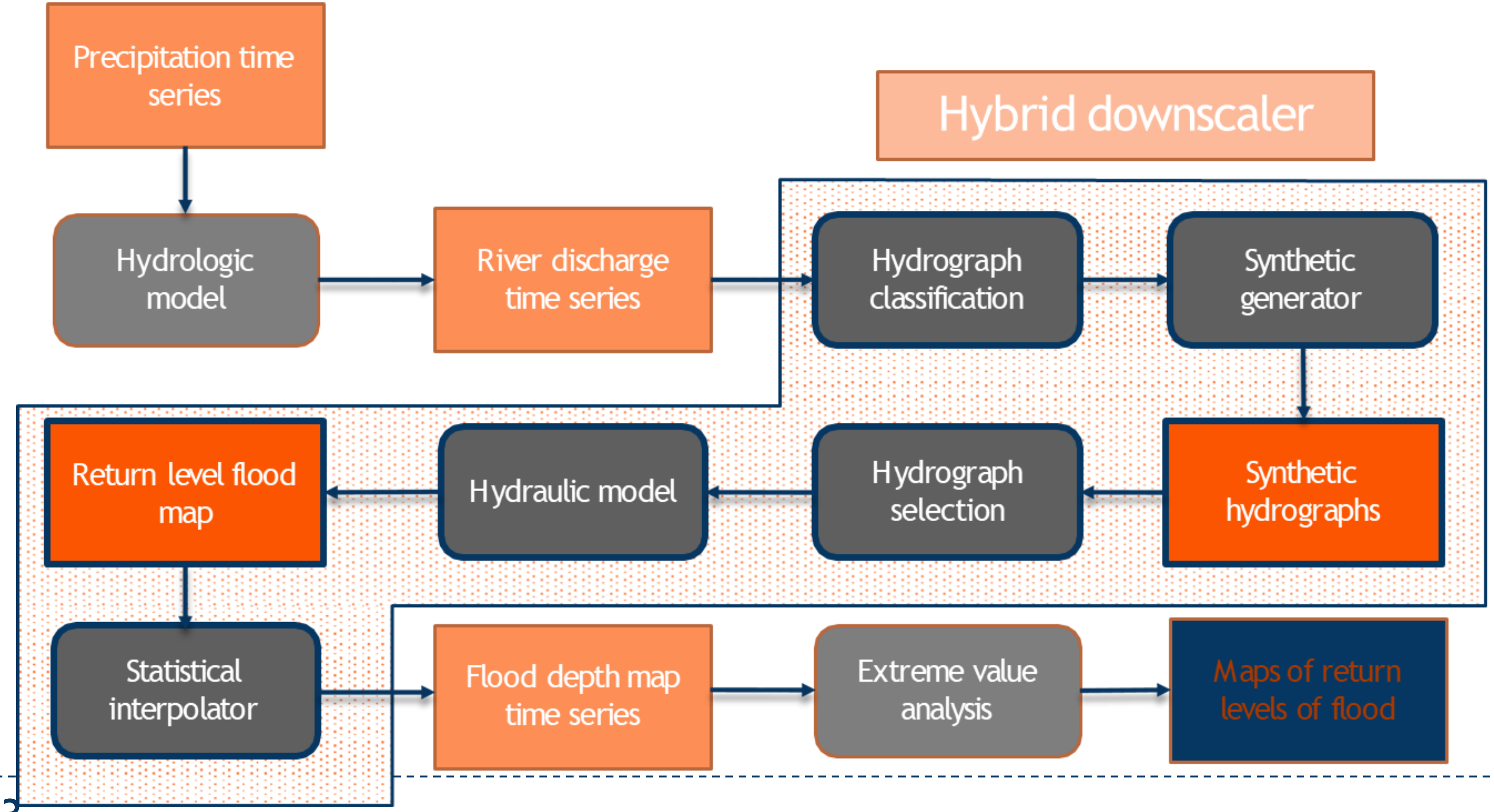
Flooding Methodology - Desired methodology



Flooding Methodology - Proposed methodology



Flooding Methodology - Proposed methodology



Flooding Methodology – Flood Maps

10 year return period flood

10 year return period flood

Flooding Methodology – Flood Maps

500 year return period flood

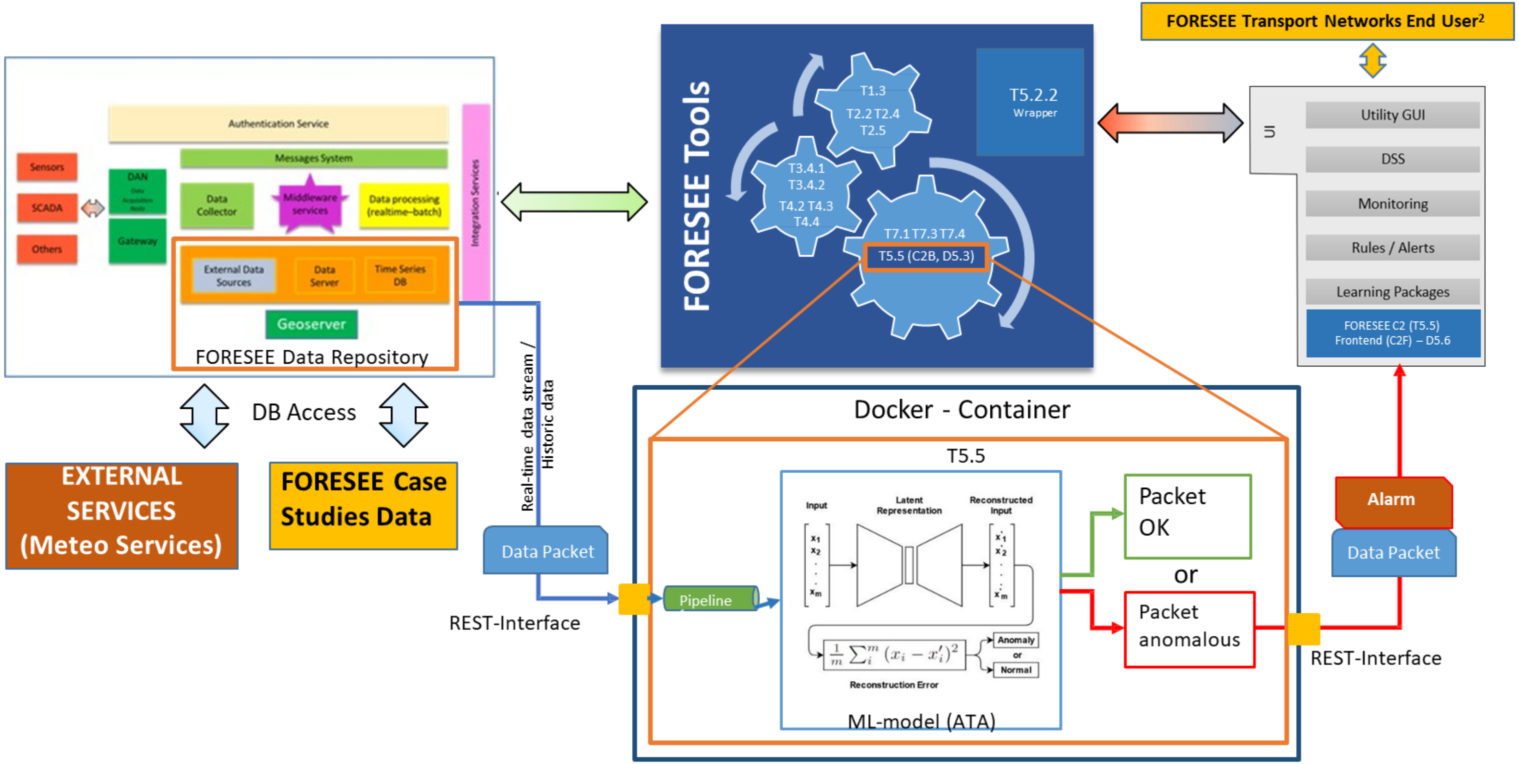
Not using a stochastic methodology can leave us very much on the side of insecurity!

10 year return period flood

Command and Control Centre (C2)

- Objective: The C2 serves for training purposes to increase (situation) awareness of the users in the FORESEE Toolkit
- It provides interactive real-time visualization and natural Human Computer Interaction
- Big data analytics and machine learning

Command and Control Centre (C2)



¹ Pipeline for preprocessing incoming data packets for ML

² Infrastructure owners and operators, passengers, drivers, logistic operators etc. (WP 7)

Command and Control Centre (C2)

- Working hypothesis:
  - Efficient anomaly detection -> machine learning techniques: neural networks
  - Alarms raised using anomaly detection -> enhance the situational understanding of the infrastructure operators
    - Faster detection time when problems occur (compared to a manual observation of the sensor data)
  - Neural networks achieve efficient anomaly detection by learning the **normal 'behaviour'** of an infrastructure
  - Allowing them to detect when new data points lay **outside of this normal 'behaviour'** and issue meaningful alerts.

Command and Control Centre (C2)

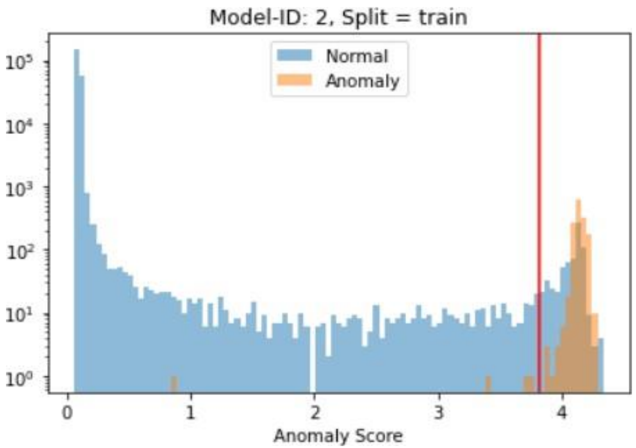
- Machine Learning Architecture Research
  - First approaches with unsupervised Generative Adversarial Network (GAN) and Autoencoder
    - GAN: Adversarially Learned Anomaly Detection (ALAD)
    - Autoencoder: Deep Autoencoding Gaussian Mixture Model (DAGMM)
  - Discussions with experts:
    - Instead of an unsupervised learning approach with ALAD or DAGMM, a supervised learning approach might be more appropriate
    - A framework developed by Fraunhofer IAIS: Adversarially Trained Autoencoders (ATA)
- Data
  - Pre-processing of sensor data
    - PostgreSQL, HDF5
    - Data preparation, data harmonization, data cleaning, data scaling
- Training of neural networks
  - Due to the different nature of the data of the case studies -> One neural network per Case Study necessary
- Deployment
  - Containerization of the trained network with Docker
  - Building REST API (FastAPI) and providing endpoints
  - Deploy on a Fraunhofer server and provide it via Internet
  - Frontend development / integration into toolkit lead by RINA-C

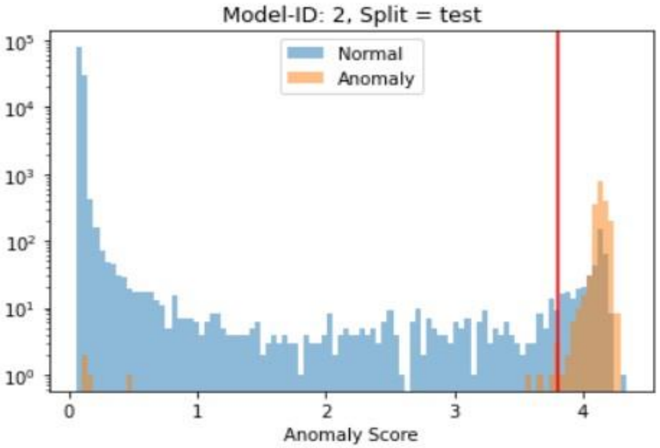
Command and Control Centre (C2)

- Machine Learning:
  - Model building
    - Historical data randomly split into **trainset** and **testset** (e.g., 80% and 20%)
    - Model trained and build on **trainset** of historical data
    - Trained and fixed model tested and validated on **testset** of historical data
  - Model application
    - Trained and fixed model applied on **new data** ("live data" / "real time")
    - Output:
      - Prediction for new data based on the model
      - Anomaly score as an indicator for normal or anormal event / hazard

Command and Control Centre (C2)

- Anomaly score:
  - Indicator on “how” anormal an event is
  - Threshold as an output of the trained and fixed model
    - Anomaly score > threshold → anormal event / hazard → alarm
    - Anomaly score < threshold → normal event → no alarm





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