Unit 7:
Impacts Assessment

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Structure

- What are impacts ?
- Exposure
- Vulnerability

Definition of risk

- There is a random event X (hazard)
- This event has a probability of occurrence f(X)
- This event has consequences (damages) D(X)

- The risk is understood here as

$$R(X^*) = \int_{X^*}^{\infty} f(X) \cdot D(X) \cdot dX = \sum_{i>X^*} f(X_i) \cdot D(X_i)$$

$$R(X^*) = \sum_{i>X^*}$$ Probability * Vulnerability= Probability*Exposition*Susceptibility

Impacts: some examples

- Impacts are the consequences of a certain hazard or load within a defined region (domain)

Impacts: some examples

a certain hazard or
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Impacts: some examples

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Impacts: some examples

Impacts: some examples

Impacts: some examples

Impacts: some examples

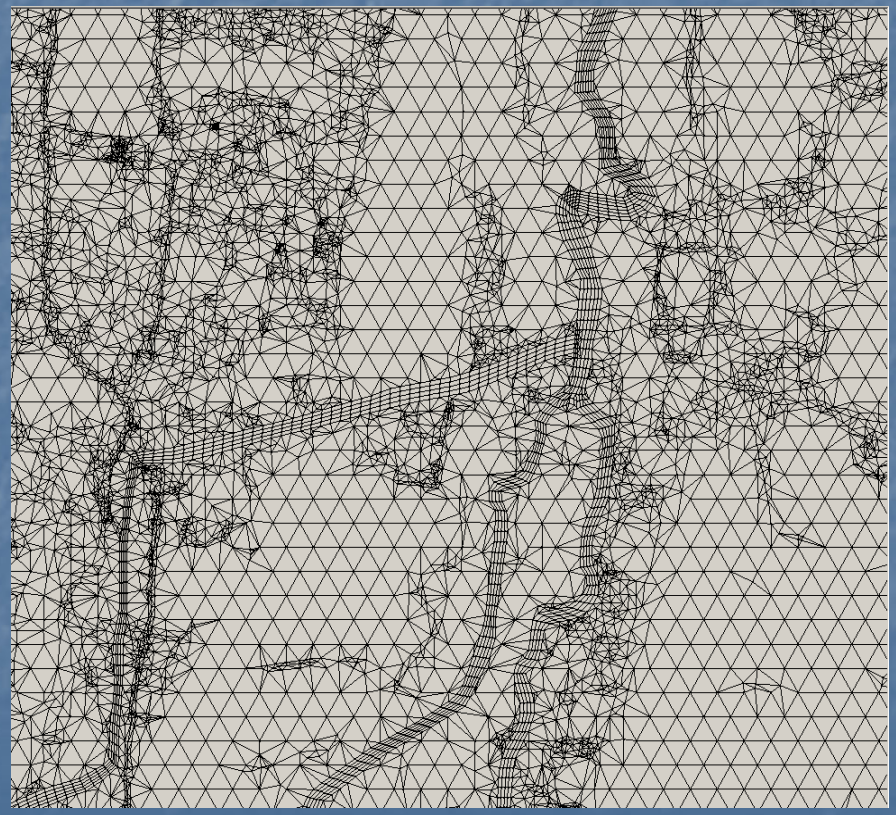
Exposure

- exposure of populations and property (who and what)
- The potential for people and assets to come into direct contact with flood water as a result of their location in a floodplain.
- The task is now who and what is in a critical zone
  - This information can be derived from past observations (but a lot of changes may have happened already)
  - Or by a model

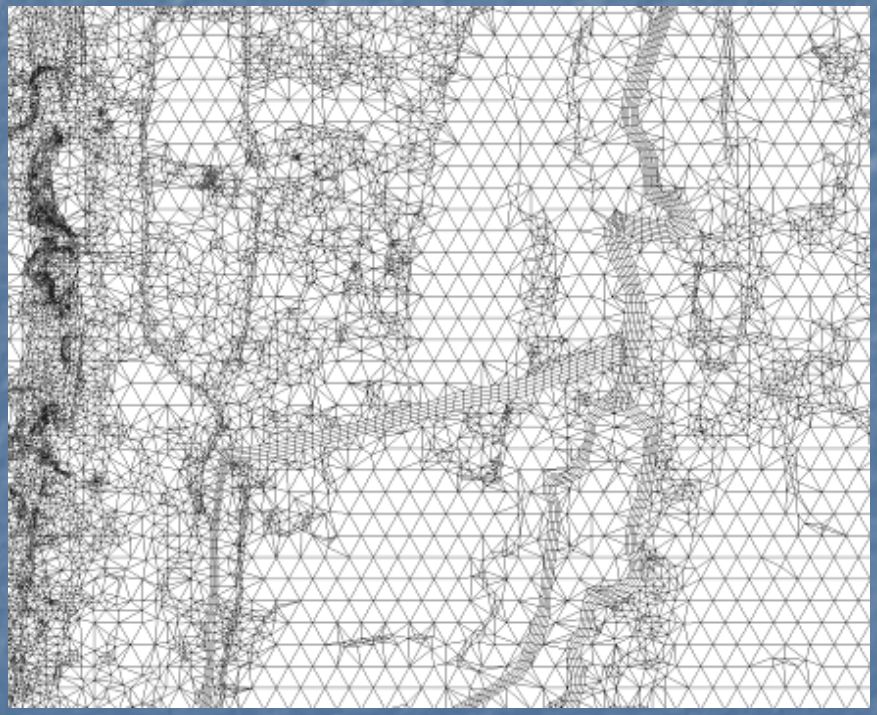
Transforming loads into impacts

- Load: critical flood event
- Impact: Exposure
  - inundated area (hydraulic model combining load, DTM and cadastrial maps)

From laser scan data for a digital terrain model (TDM) by mesh generation



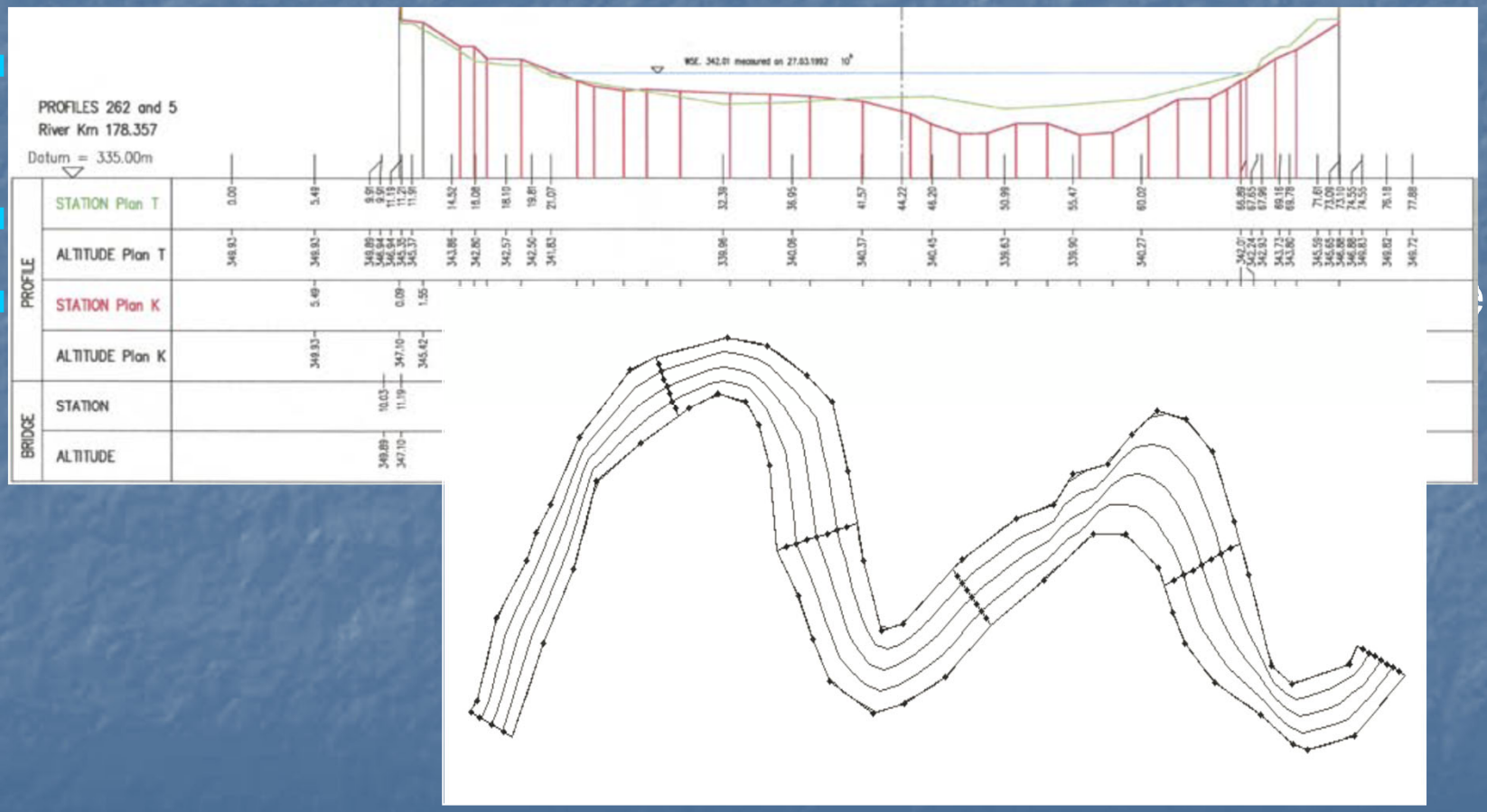
Comparing a DTM with areal photos



Surface grid

Orthophoto

Consideration of cross sections is very helpful in generation the DTM



Initial and boundary conditions

- Initial conditions: water depth and flow velocity at t=0 an every location
- Boundary conditions: Inflow hydrograph
- Model parameters: roughness coefficients for each element

Results from the hydraulic model

- Water depth and flow velocity at each location (grid element)
- Delineation of inundated areas and boundaries of inundation
- Which scenarios (discharges) ?

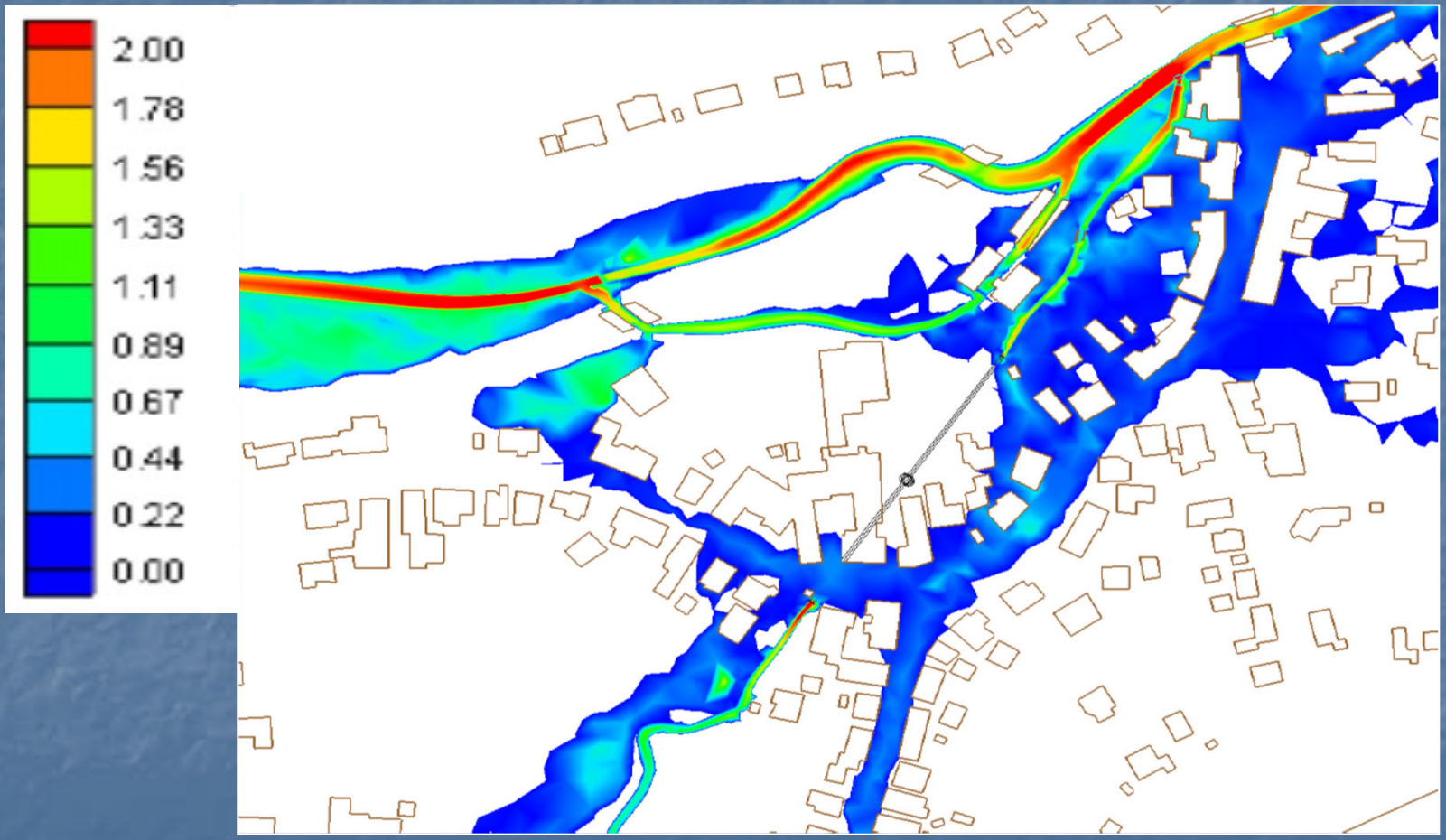
  EU Flood risk directive

  a frequent flood HQ_{30}

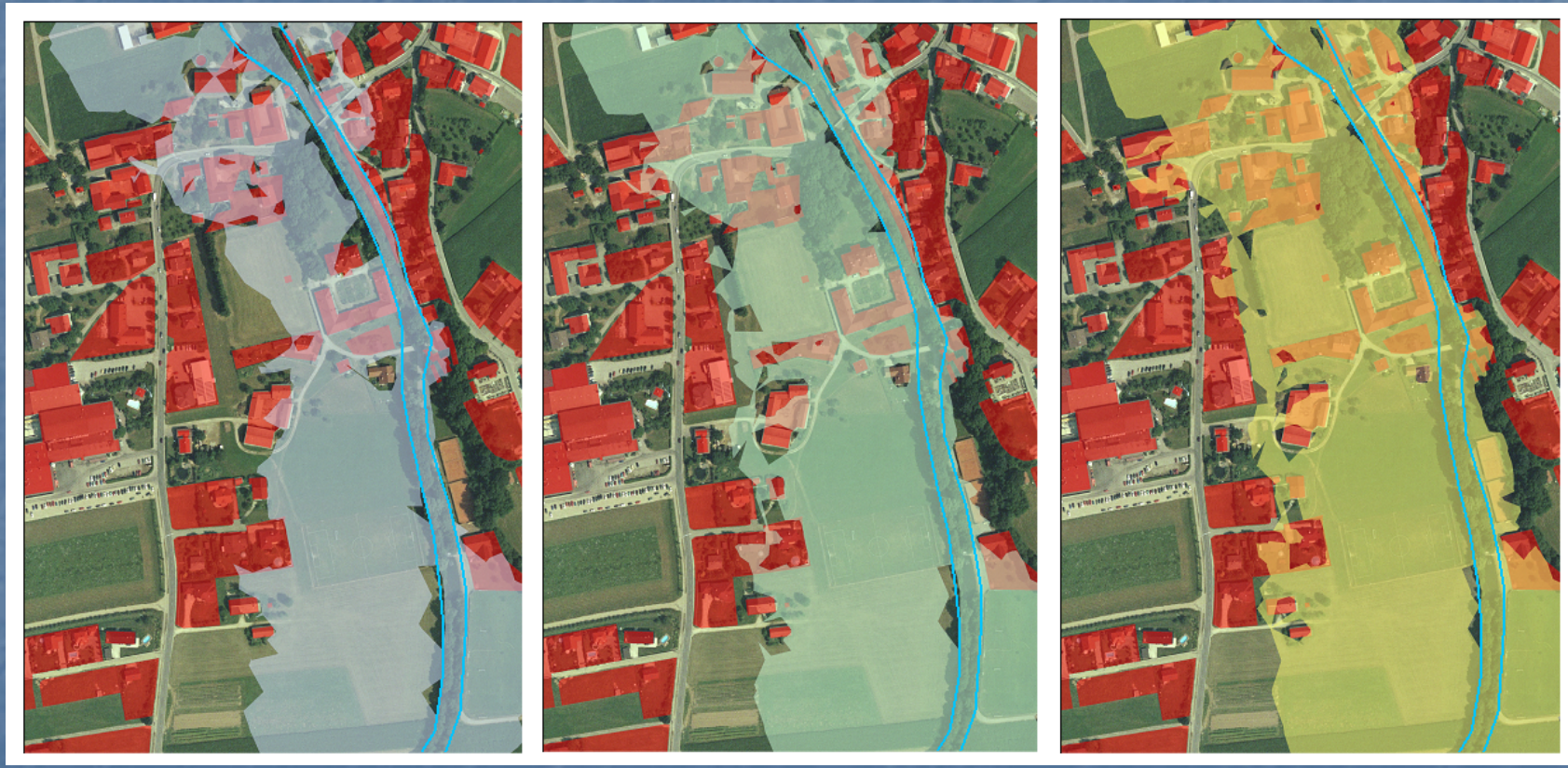
  a HQ_{100}

  an extreme event HQ_{300}

Spatial distribution of water depth for a given time slice (0,1-2m)



Exposed objects for HQ 30/100/300



HQ 30 HQ 100 HQ 300

Transforming loads into impacts

- Load: critical flood event
- Impact: Exposure
  - inundated area (hydraulic model combining load, DTM and cadastral maps)
- Impact: Vulnerability (Susceptibility)
  - The economic consequences of an exposed object (an impact model linking water depth, duration of inundation, flow velocity with economic losses)

Estimation of the damages

- Detailed estimation considering each object
  - object (structure, infrastructure ...)
  - contents (equipment ...)
  - Induced damages
- General estimation based on empirical data
  - Population density
  - Density of objects
  - Standard cost functions
- Ex-post analysis of reported damages

How to evaluate potential damages

Typology of flood damages

(Messner et al. 2006, Penning-Rowsell et al. 2003, Smith and Ward 1998)

		Measurement	
		Tangible	**Intangible**
Form of damage	**Direct**	Physical damage to assets: Buildings Contents Infrastructure	Loss of life Health effects Loss of ecological goods
	Indirect	Loss of industrial production Traffic disruption Emergency costs	Inconvenience of post-flood recovery Increased vulnerability of survivors

Potential and real damages

- The damage potential represents the total value at risk
- Dependent on inundation depth, flow velocity, suspended sediments, pollutants,… prepardness of people the real damage is lower than the potential damage

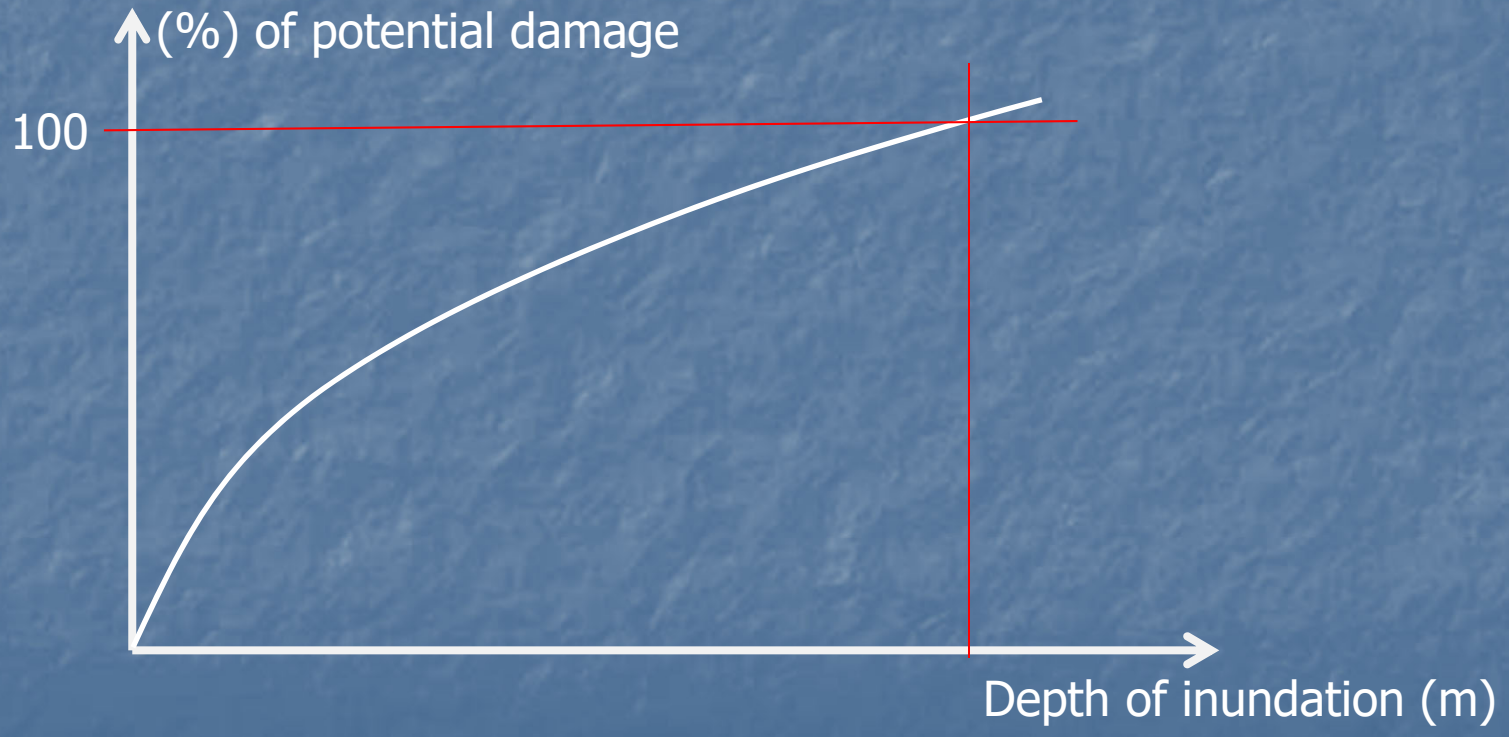
Role of awareness and prepardeness

- Two quite similar floods (about T =100 a, both in winter)
- Rhine flood 1993 (Dec.) caused about 615 Mio € damages (Germany)
- Rhine flood in 1995 (January) although slightly bigger caused about 225 Mio € damages
- In 1993>100 oil spills
  while only 6 were reported in 1995
- In major cities same number of people was exposed to both floods

(from Engel, 1997)

Relative loss functions

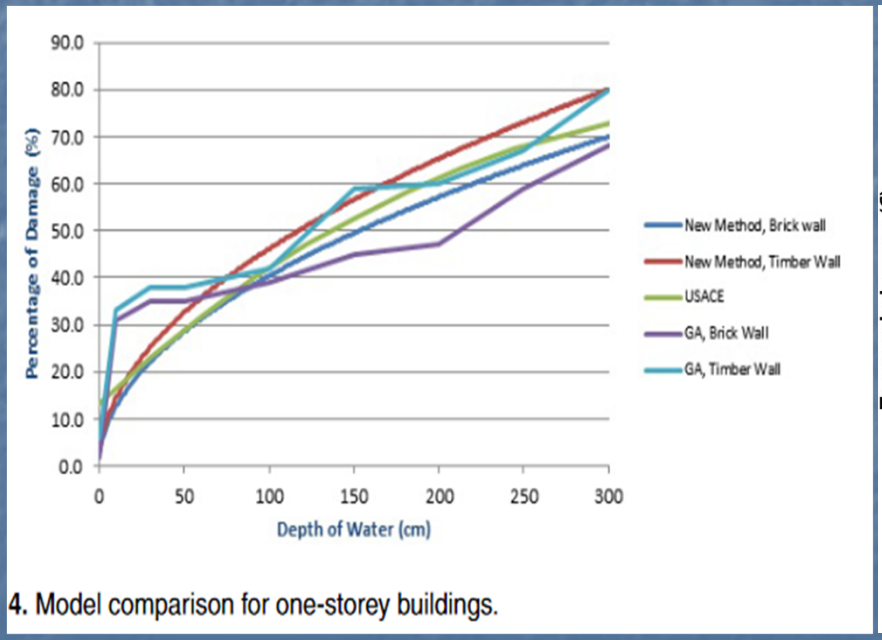
- Often scaled loss functions are used



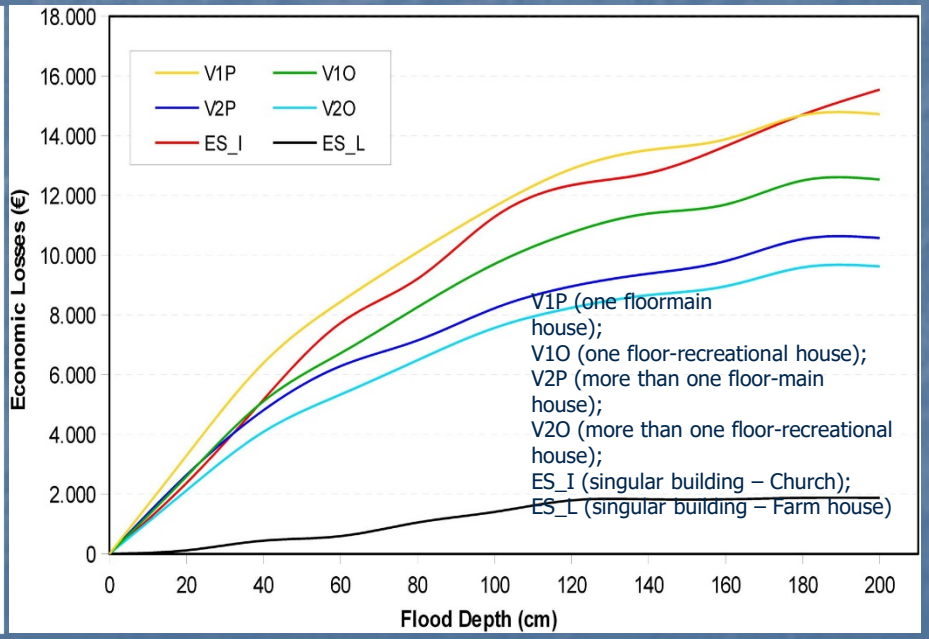
Empirical loss or damage functions

- Nafari, HESS; 2015
  Relative loss function

Garrote, J. Hydrology, 2016
absolute loss function



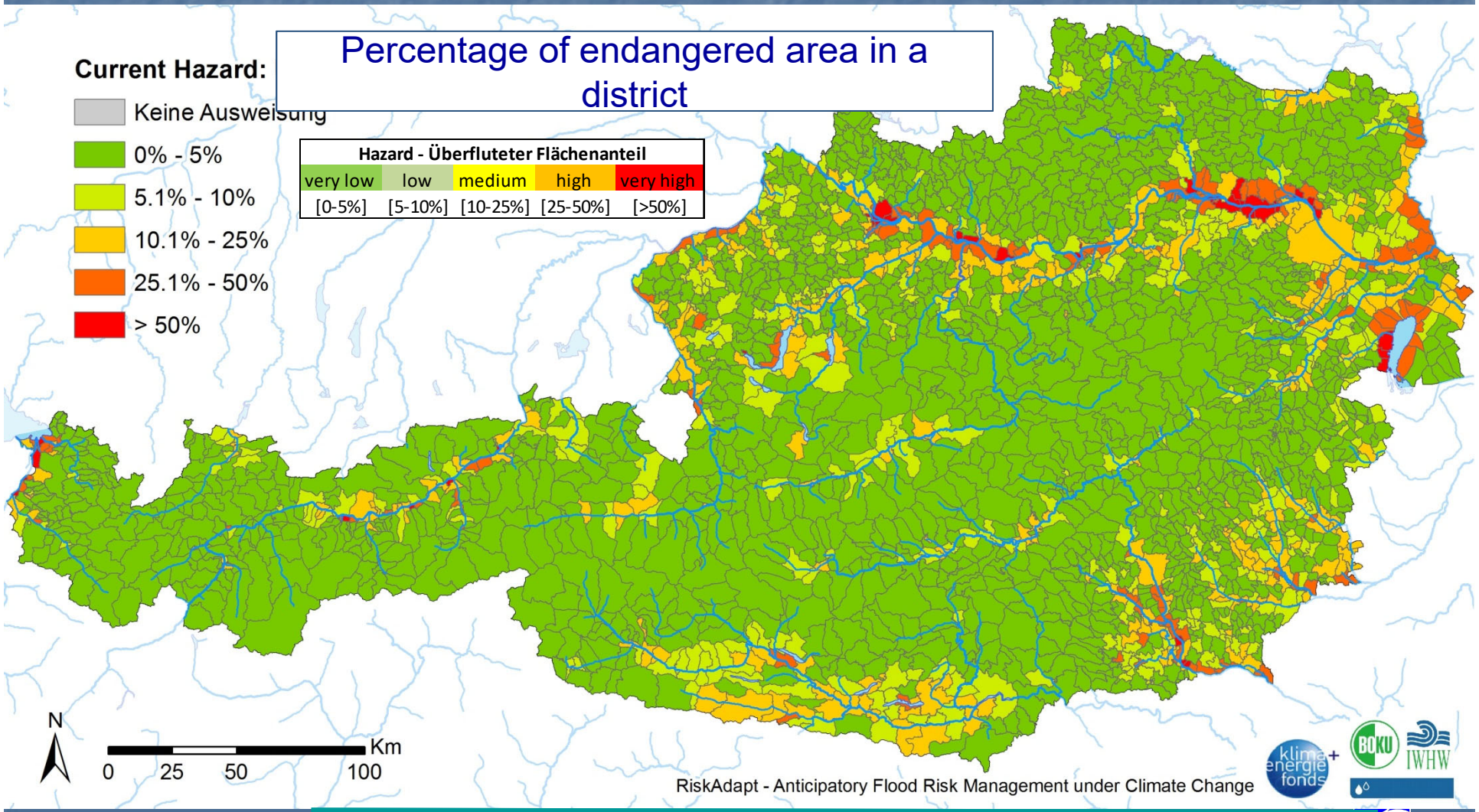
4. Model comparison for one-storey buildings.



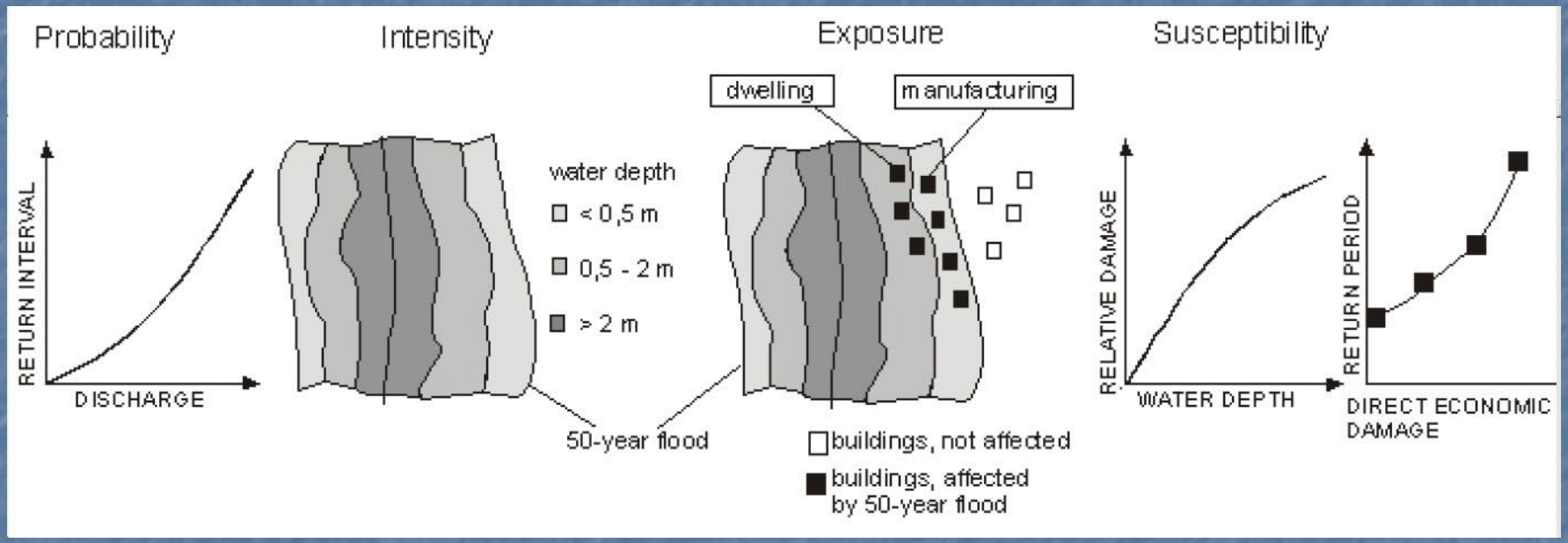
Estimation of damages

- Spatial scales define the appropriate approach
- It makes a difference if the flood damages in a village have to be assessed or for a region or a state.
- Large scale analysis can be based on general statistical data
  - Population density
  - Major land uses
  - Economic information (local data, regional information like NUTS data, NACE activities)

Current flood hazard (based on HORA) Identification of „hot spots“



Large scale flood risk assessment



(from Merz etal., 2007)

For private dwellings: market prices in the region

For primary-tertiary sector: capital intensities, gross value added, interviews and NACE data

http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Statistical_classification_of_economic_activities_in_the_European_Community_(NACE)

EU-Flood Risk Directive

- Reduce adverse consequences associated with flood
  - for human health and life
  - environment,
  - cultural heritage,
  - economic activity and infrastructure.

Available data base at EU level

https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32003R1059
https://ec.europa.eu/eurostat/web/nace

- land use classification according to the NACE-activities
- relation between capital stock and employees
- the Nomenclature of Territorial Units for Statistics, 2003 (NUTS 2003, EC 1095/2003) for the European Union.
- Statistical Classification of Economic Activities and Regional data on capital stock, active persons, investments and value added (NACE data from Eurostat)
- Capital stock is an indicator for potential damage
- Value added is an indicator for production losses due to interruption

Summary and conclusions

- Estimation of damages can be based on
  - Past observations
  - Damage functions and simulations
  - Assessment is dependent on scale
- We discriminate among direct and indirect damages and tangible and intangible damages
- Large uncertainties; local data adjustment is recommended