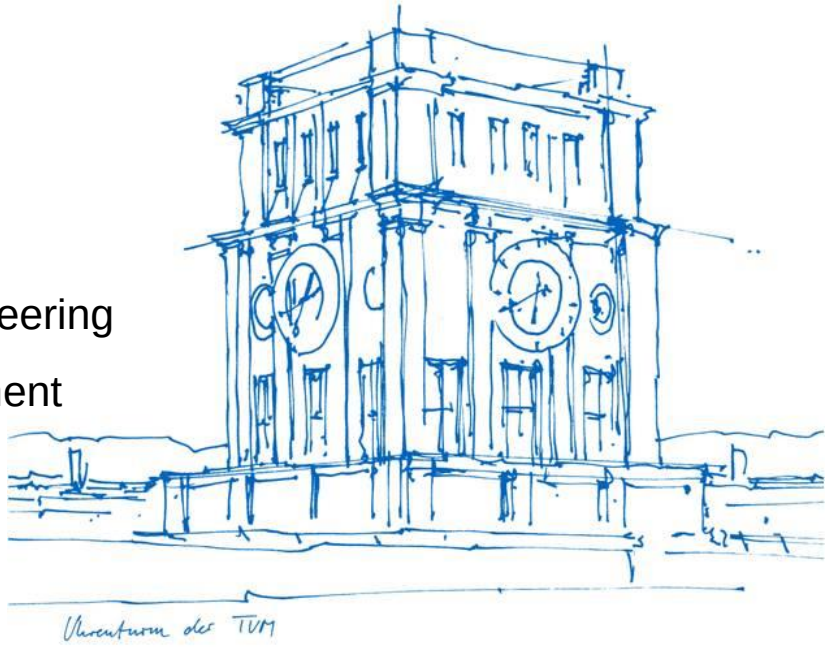
How to cope with floods - the Bavarian experience

Prof. Dr. Peter Rutschmann

S. Giehl, D. Skublics, M.-D. Bui, M. Reisenbüchler



Technical University Munich (TUM)

Department of Civil, Geo and Environmental Engineering

Chair of Hydraulic and Water Resources Management

Athens, 31 October 2018

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1. Flood mitigation at large rivers in Bavaria
2. Are floods pure water events
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4. Flash flood risk management concept in Bavaria
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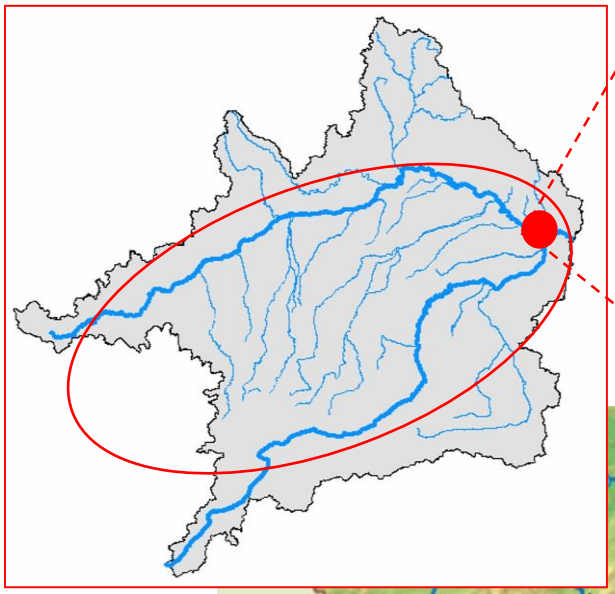
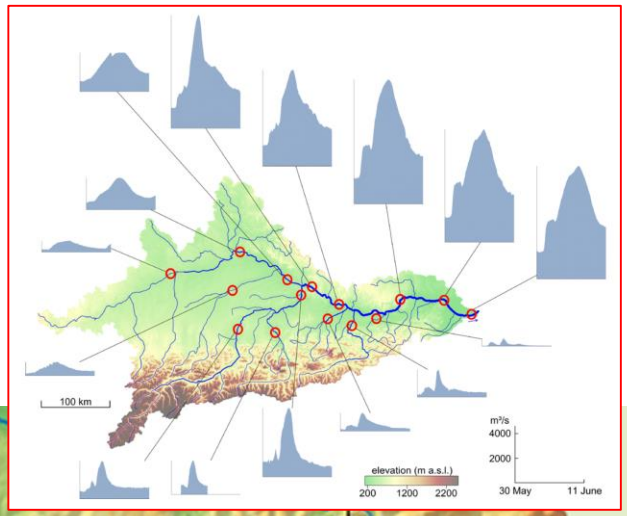
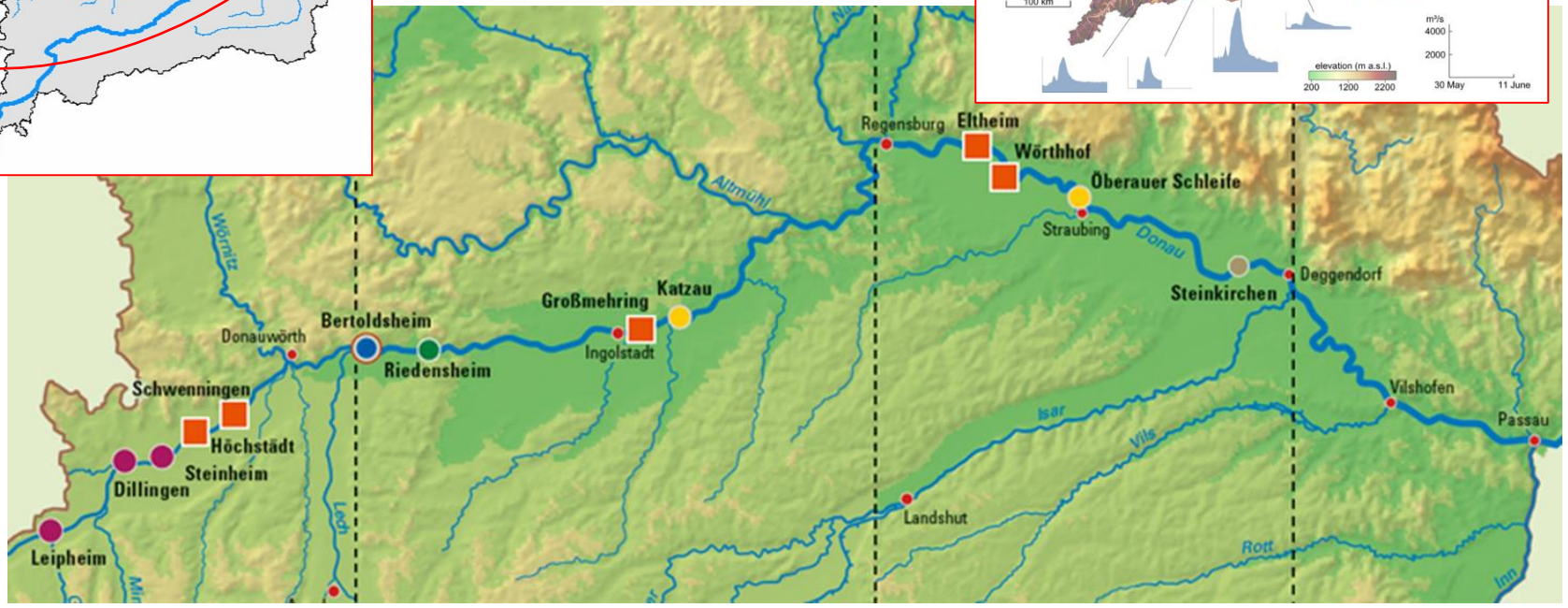
6. Conclusions

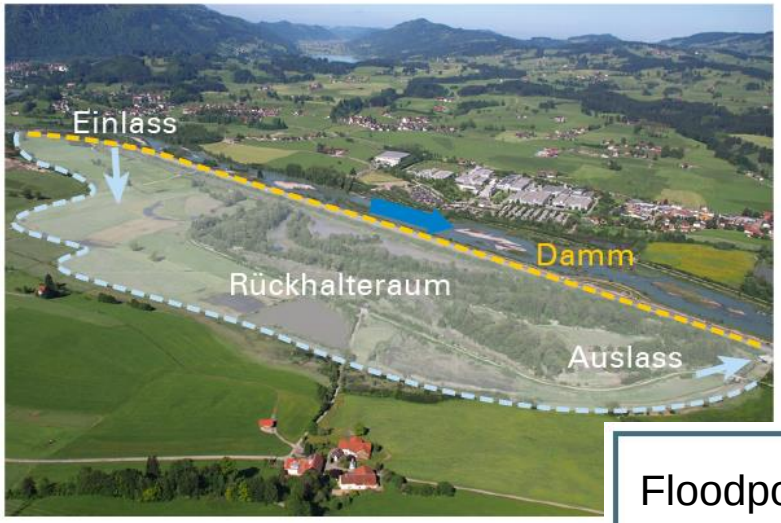
Flood retention at Danube and Inn river

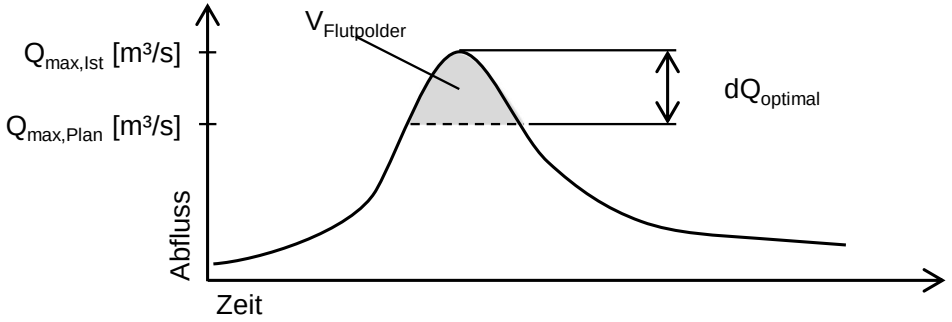




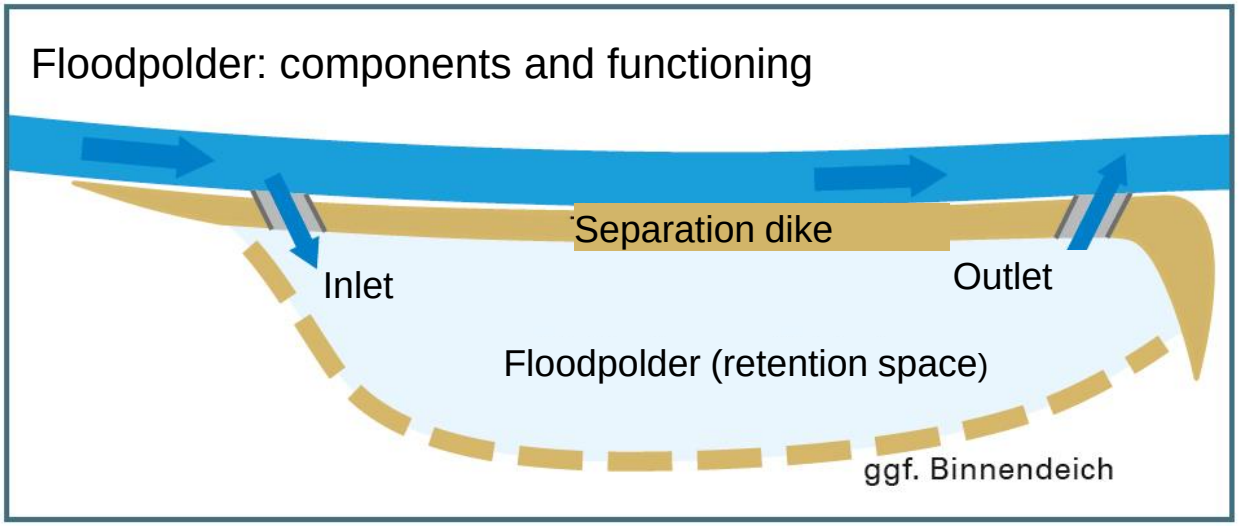


Flood retention at Danube and Inn river



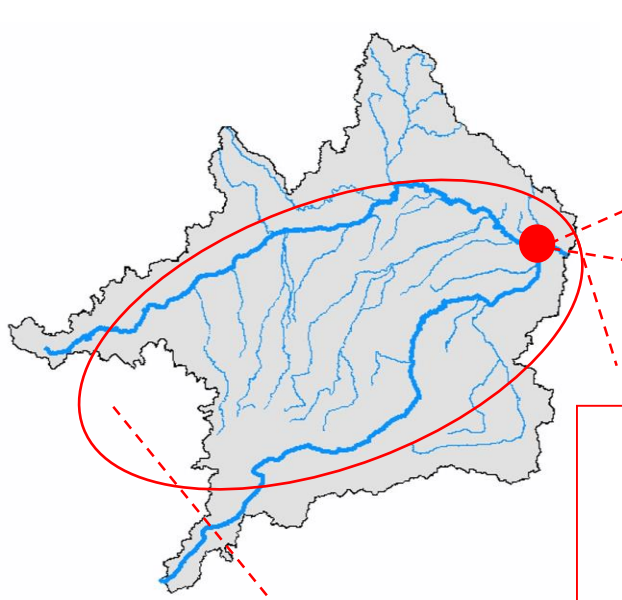


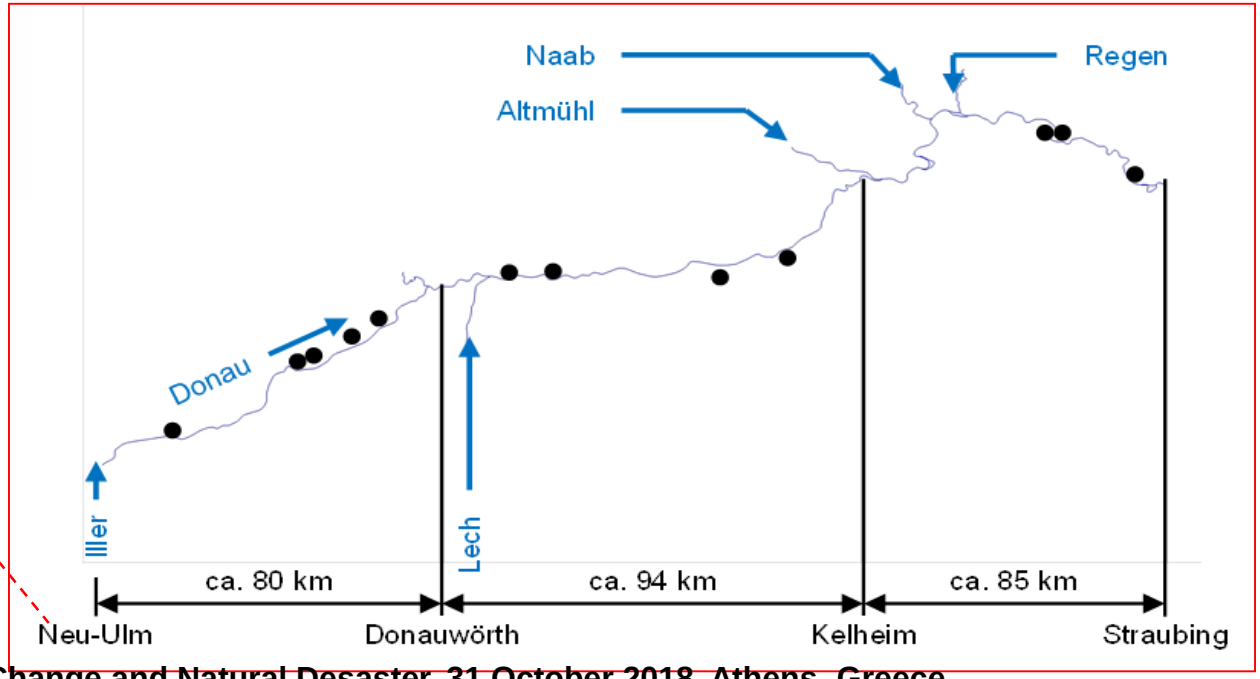
Schematic sketch of polder operation



Flood Dialogue Bavaria:
https://www.hochwasserdialog.bayern.de/technischer_schutz/flutpolder/index.htm

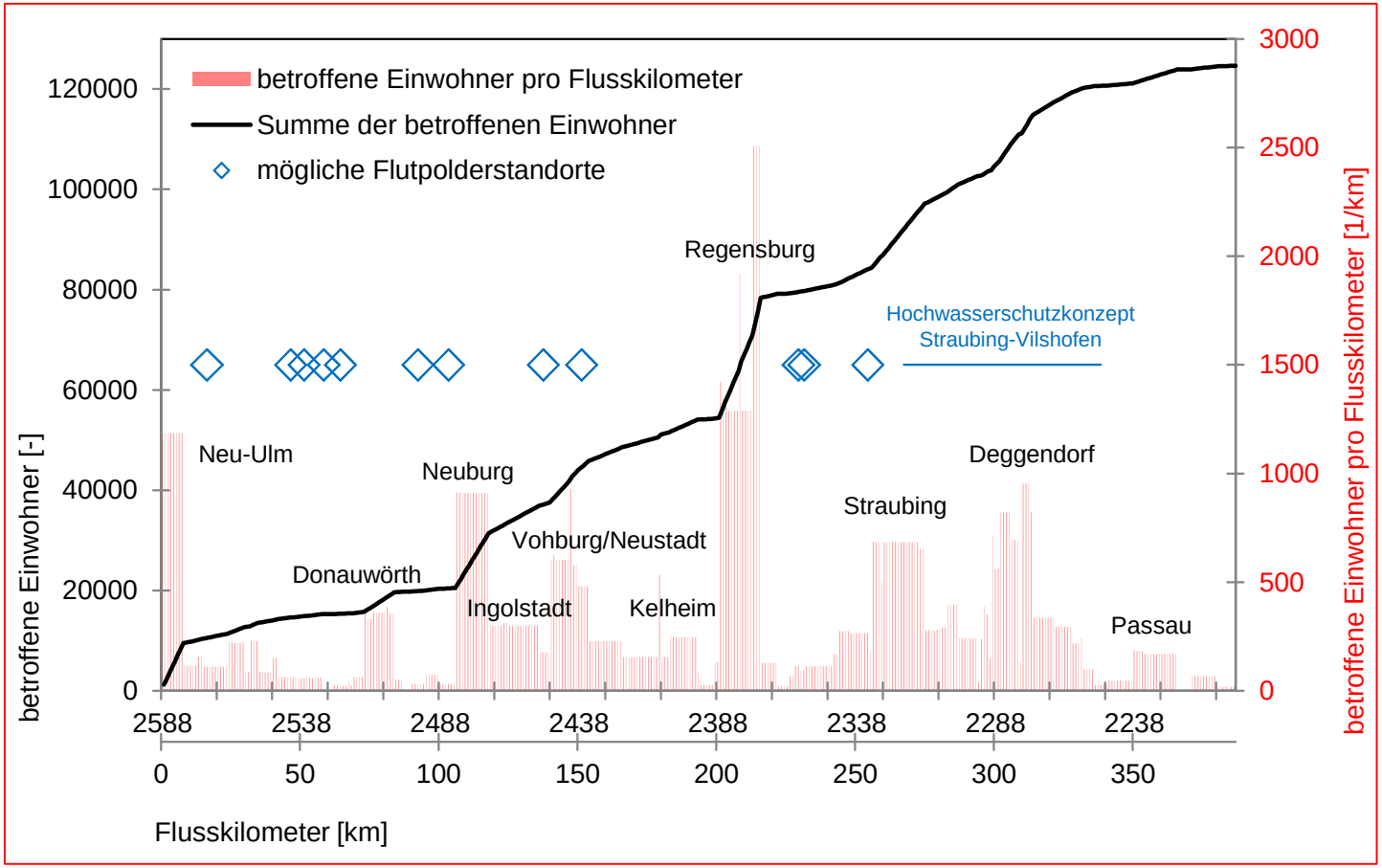
Flood retention at Danube and Inn river





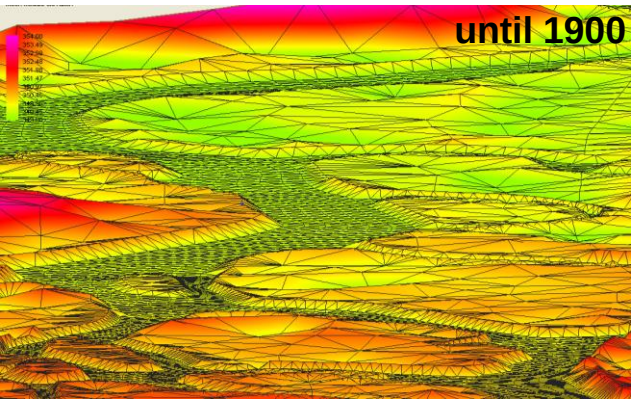
Flood retention at Danube river

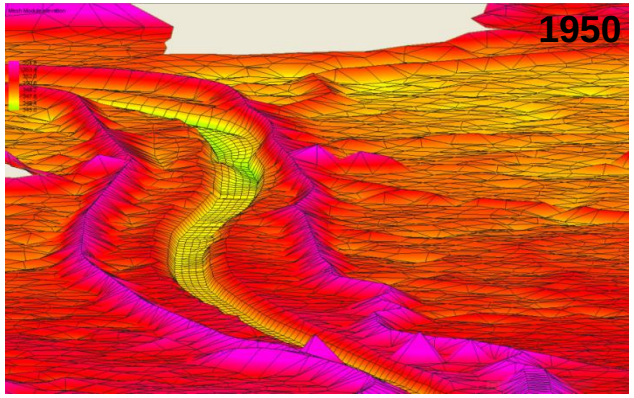
Effect of flood polders on relative wave peak reduction and inhabitants along the river

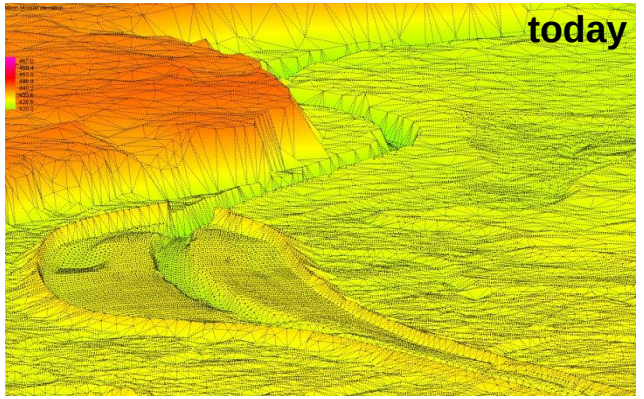


Number of inhabitants affected by floods along the Danube river (annuality of flood event > 100)

Floods in the historical/present virtual Danube

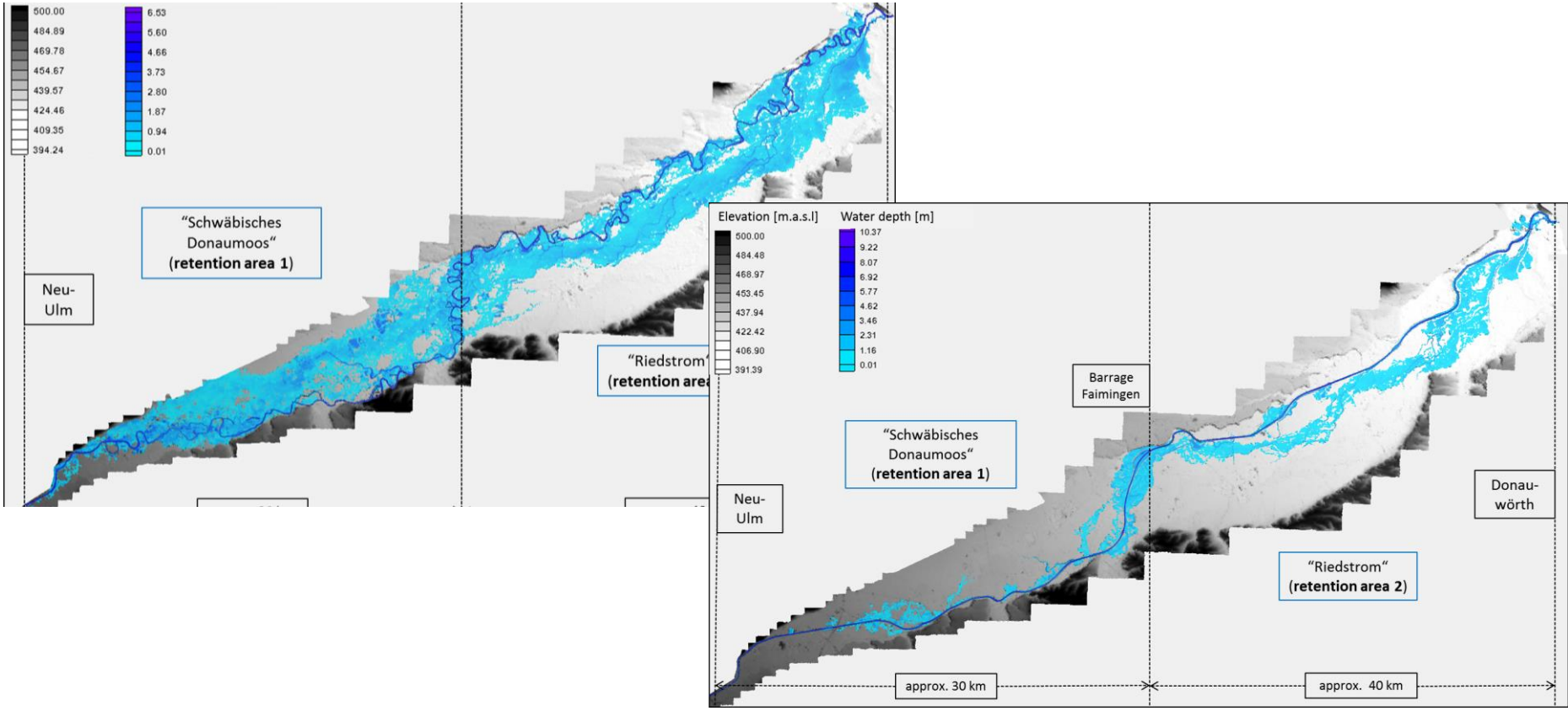






Flooding in the historical/present Danube

Flooded areas from a 100 year flood with a medium hydrograph. Nowadays dams and dikes are overflown during the peak discharge and very efficiently attenuate the event.



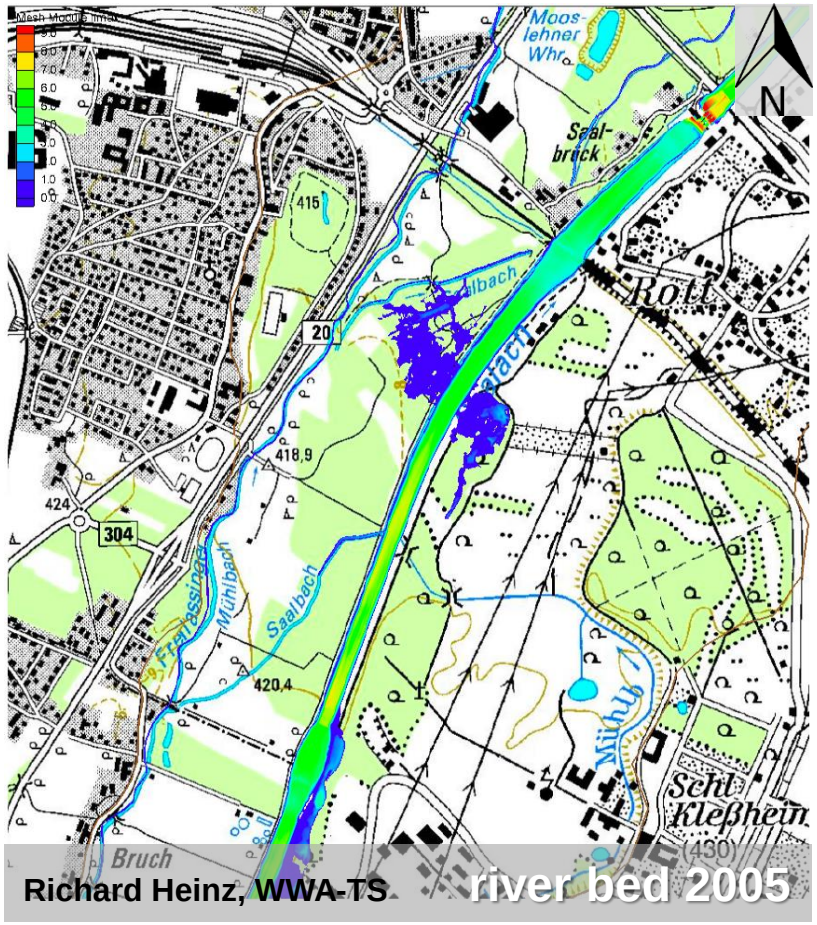
Floods as pure water events?

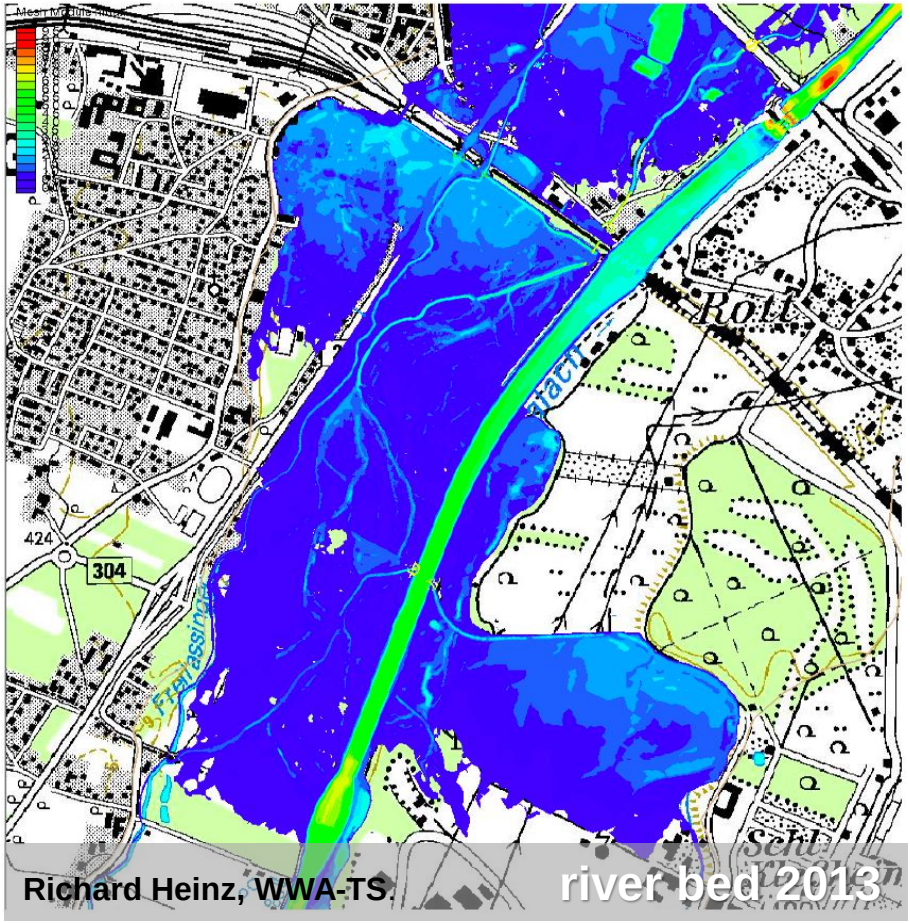
2013 Flood Freilassing (River Saalach)

Since one century Freilassing has never been flooded until 2013.

Flooding for differing bed topography

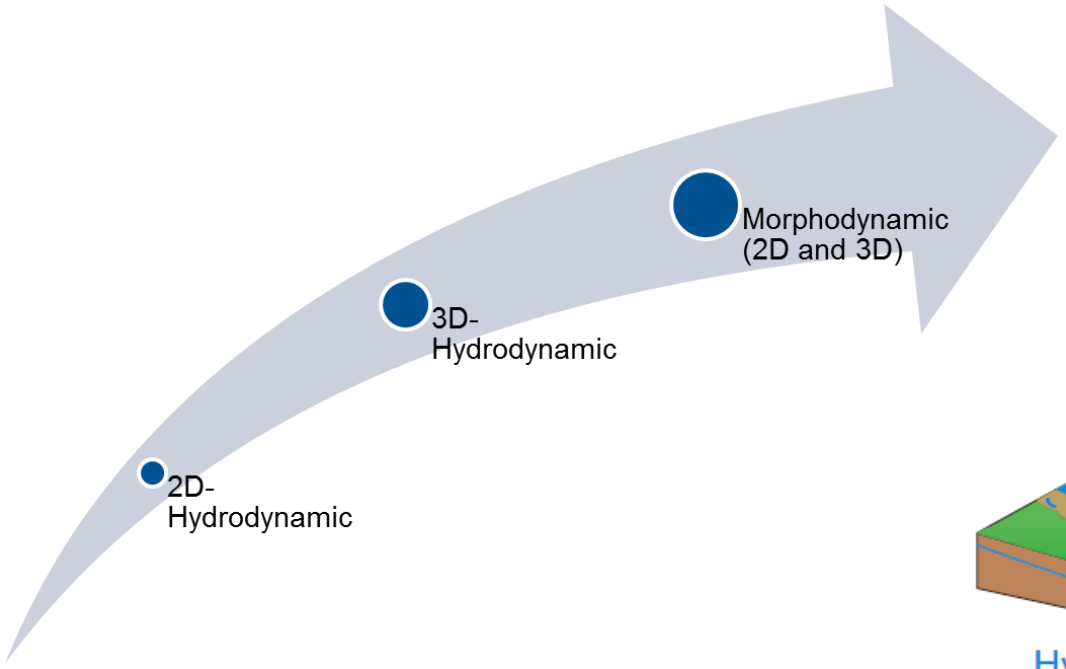
Equivalent flow discharges for river bed topographies of 2005 and 2013



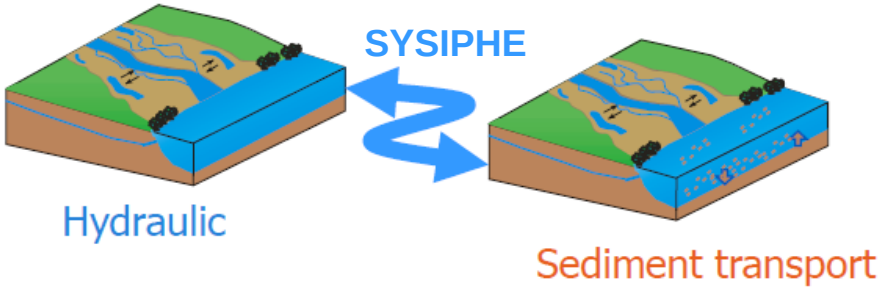


HPC and hydromorphological modelling

Increasing the complexity and the computational effort

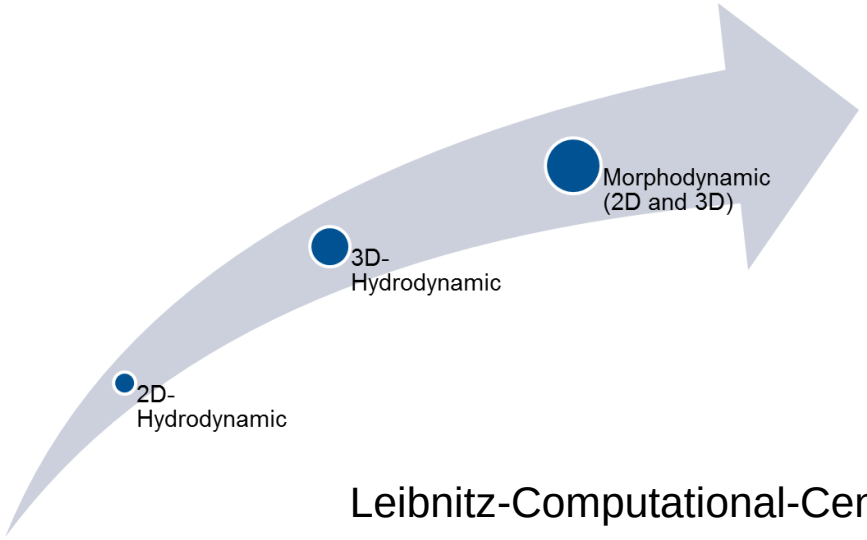


telemac



HPC and hydromorphological modelling

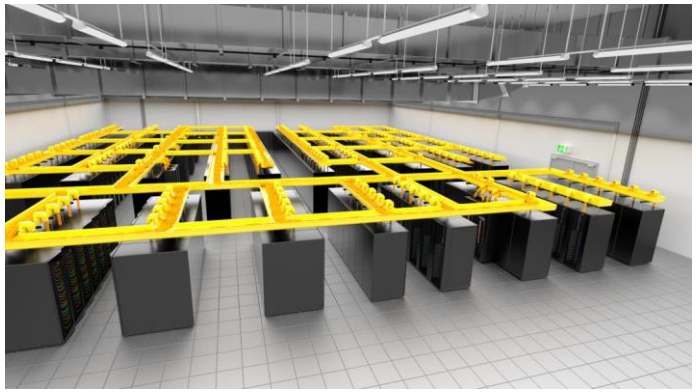
Increasing the complexity and the computational effort



Leibnitz-Computational-Center LRZ Garching

SuperMUC and SuperMUC2:

- 2012: #4 of world TOP 500
- 2016: #36 of world TOP 500
- In total 241000 Cores at SuperMUC



Flash Flood Simbach

Before and after

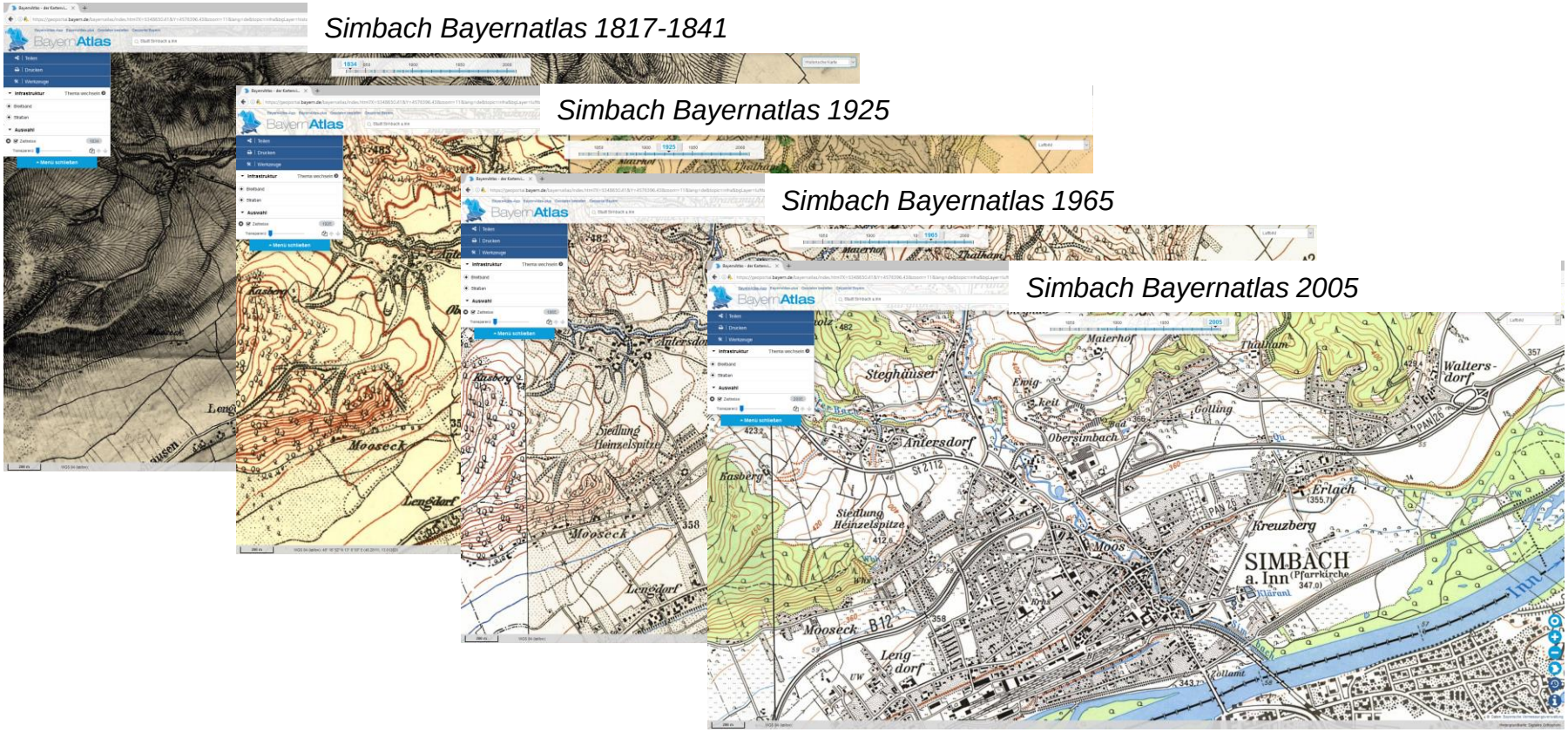
Source: BayernAtlas and googlemaps

http://www.br.de/nachrichten/dokthema-toedliches-wasser-hochwasser-gruende-100.html

Picture (left): Courtesy of the Bavarian State Ministry of the Envorronment and Consumer Protection,

Flash Flood Simbach

Urban development

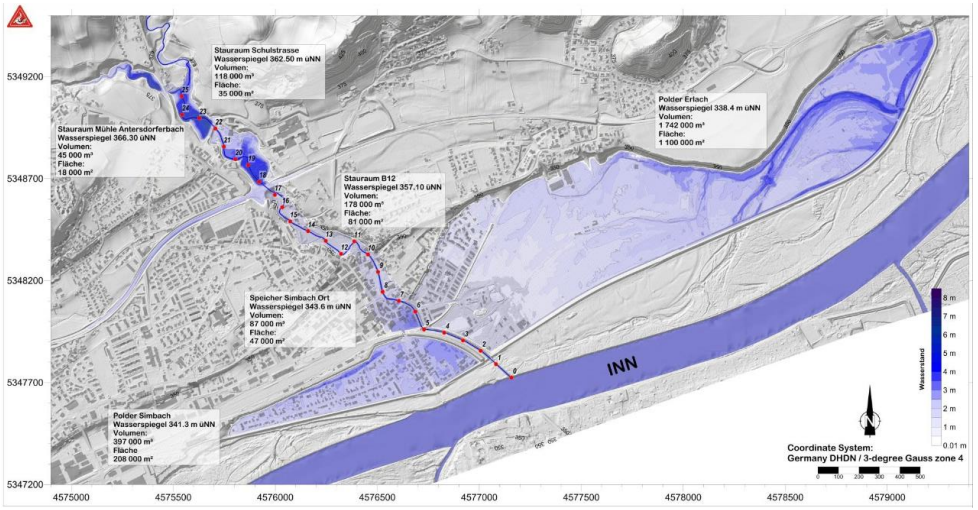


Flash Flood Simbach

Before and after

Hübl, J. et al. 2017: IAN REPORT 180, Ereignisdokumentation und Ereignisanalyse Rottal-Inn 2016, Band 1: Ereignisdokumentation. University of Natural Resources and Life Sciences, Vienna, 2017, page 75 ff.

https://www.baunat.boku.ac.at/fileadmin/data/H03000/H87000/H87100/DAN_IAN_Reports/Rep180_Band_1_mit_Anhang.pdf



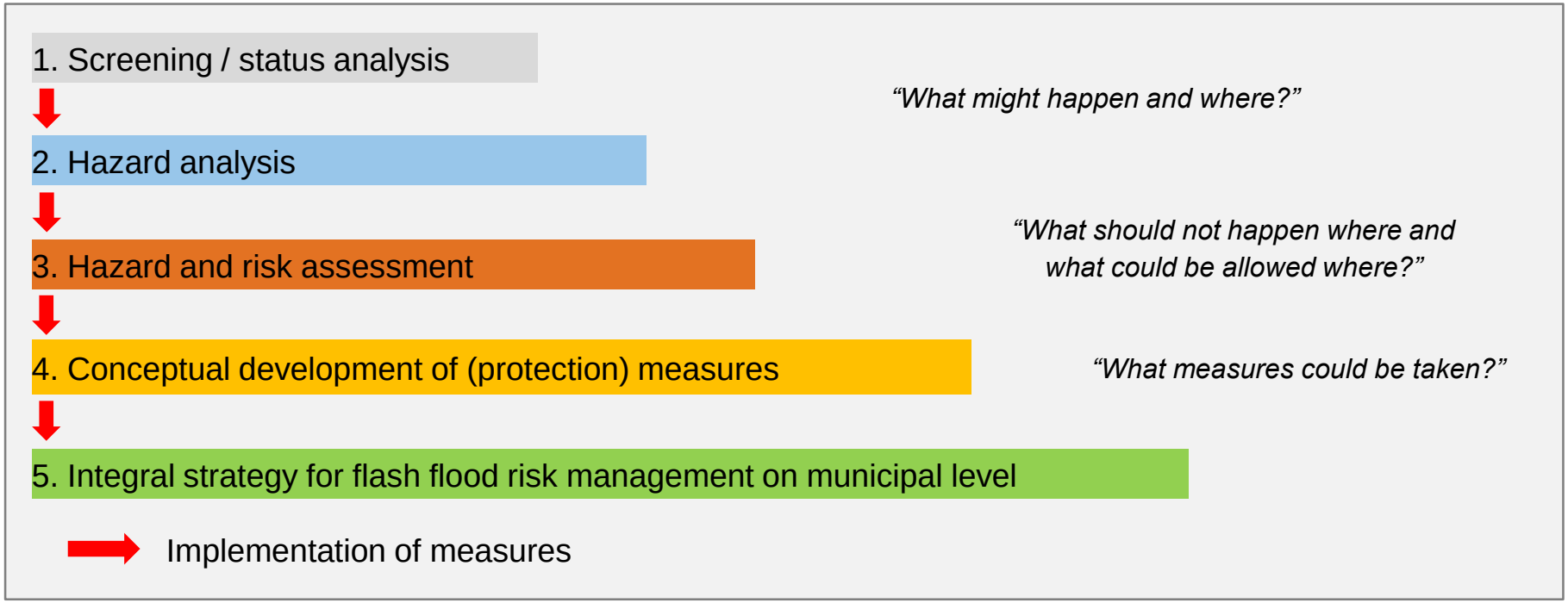
Flash Flood Attica (Mandra)

Damage and bottle necks

Flash Flood Attica (Mandra)

Damage and bottle necks

Bavarian Flashflood Strategy



Source: „Integrale Konzepte zum kommunalen Sturzflut-Risikomanagement“, Infoblatt zum Sonderprogramm nach Nr. 2.4 RZWas 2016, Bavarian Statesministry for the Environment, 2016, 24 pages.

Flashflood properties

- Flashfloods are local phenomena and very difficult to spatially predict,
- they are short but very intense events,
- they are everything else than pure water events,
- their physical processes are very complicated, cascading and therefore:
- The **unbelievable can happen!**

Thus one has to verify:

- Where are flashfloods likely to happen
- What consequences can they have
- What can immediately be done on a very local and municipal level (identification of bottlenecks)
- What protection measures could and should be tacken in a next step
- How can information and early warning of the public be organized

Where can flashfloods happen?

Possible method:

- Setup a large scale but coarse terrain model
- Charge it with havy rain scenarios
- Do a simplified rainfall-runoff hydraulic computation
- Concentrate on high velocities, high water depths and high bottom shears
- Check whether such regions interfere with civilization

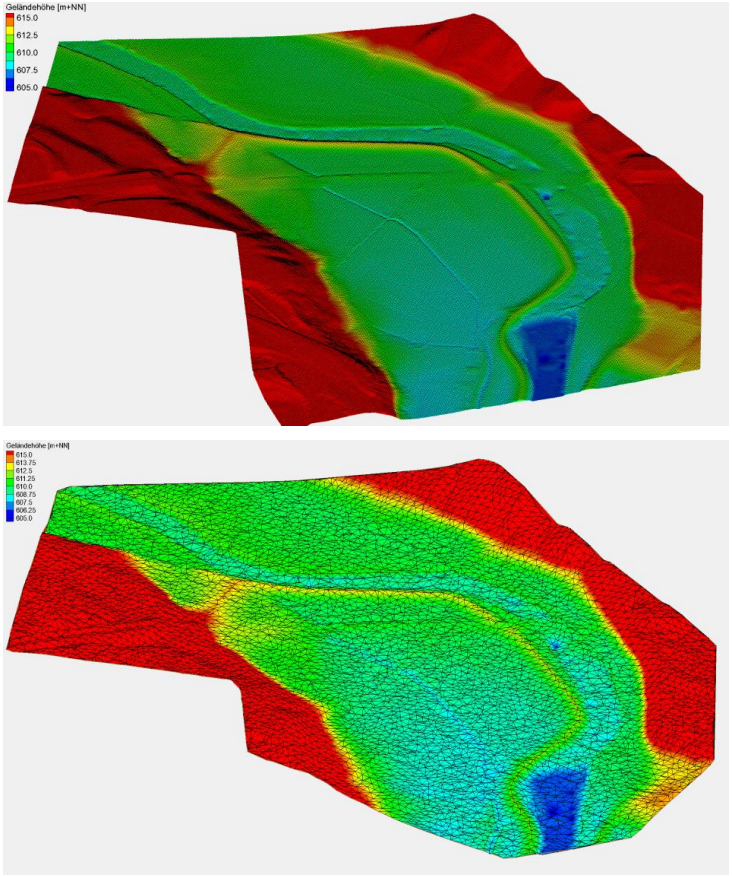
Thus

- Endangered regions/municipalities can better be identified
- Possible risk must be communicated to the municipalities
- A process has to be initiated at the municipal level to protect the population

Topography and vegetation is easily available

- Topographic date from remote sensing or airborne laser scanning
- Vegetation data also available from remote sensing
- Simpliefied flow computation is possible
- Critical spots from flows can be identified

Gabriel, 2009



What can happen during a flashflood?

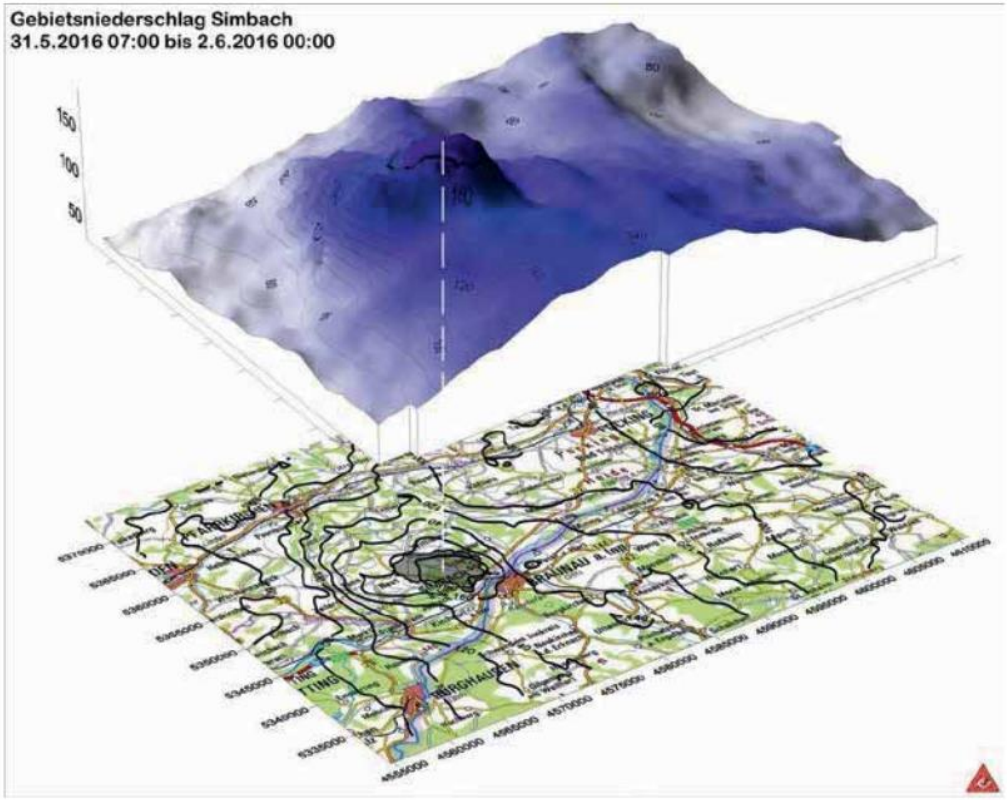
Possible processes:

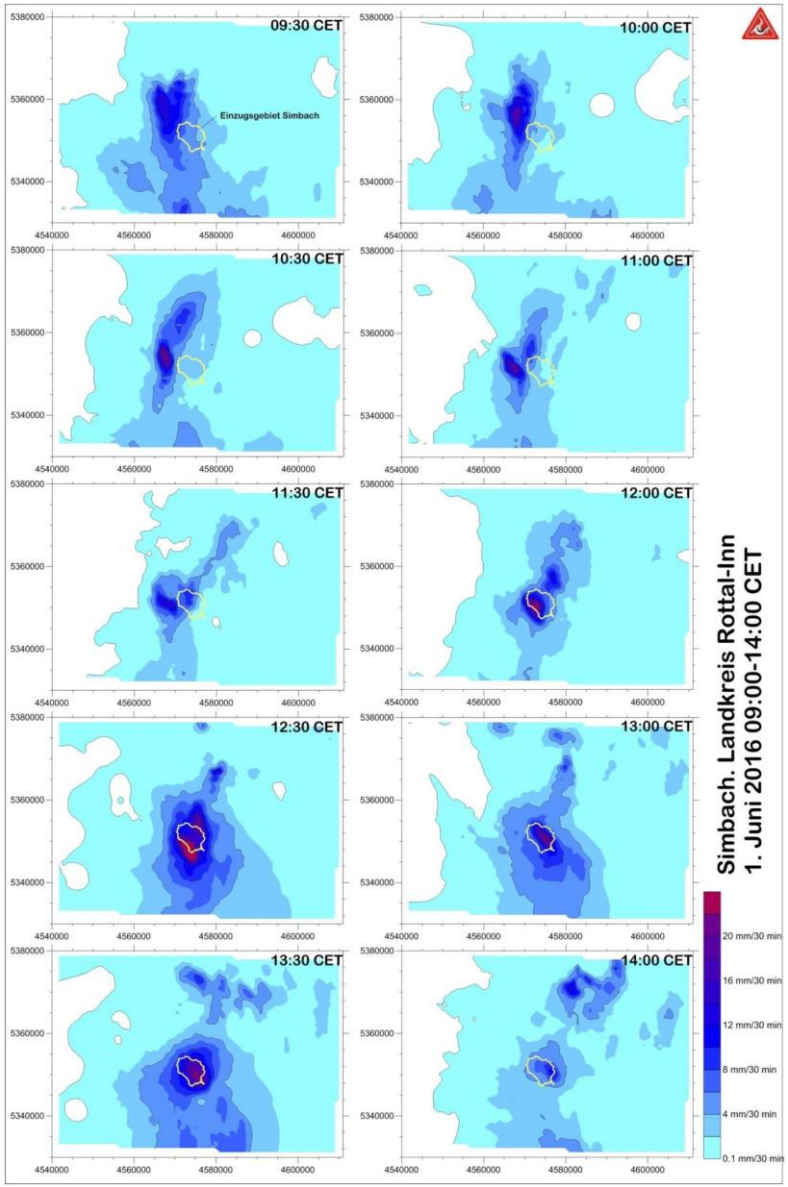
- Heavy floods can occur which river cross sections cannot contain. We can probably cope with this idea.
- The rain and the flow will transport high sediment and debris loads. In parts heavy erosion but also heavy deposition of material can occur. We understand this, but we have difficulties to figure out the consequences.
- During flash floods the infrastructure can completely be modified to other purpose than intended and fullfilling new functions which were out of their design. We have to be innovative to find worst case scenarios.

Theoretically we can model such processes but the models will mostly show only the processes we anticipate. Anticipation is therefore important not only for an eventual modelling attempt but also for site visits and protection measures on a municipal level!

Radar rainfall observation

Hübl, J. et al. 2017: IAN REPORT 180, Ereignisdokumentation und Ereignisanalyse Rottal-Inn 2016, Band 1: Ereignisdokumentation. Universität für Bodenkultur Wien, 2017.





Radar observation and rain forecasts

Importance:

- Radar observation is important to predict spatial distribution of rain. Meteo models are helpful to predict future developments.
- From radar observation the local and heavy precipitation centers can be identified and their propagation can be estimated. This is valuable information for early warning systems.
- If no radar is present, mobile phones can serve to determine the rain intensity.
- In case no super computers are available fast predictions can be achieved with ANNs.

Fast computation/prediction

Fernerkundungs-Daten

Ressortdaten

LfU-Messnetze | CSC-2.0 | DWD | LfL-Messnetze

Management-Daten

Verwaltung
Wirtschaft

Modelle und Simulation

Hydrologischen
Landoberflächenprozesse
Erosion, Stofftransport
Aquatische Biodiversität

Modelle und Simulation

Hydraulische Gerinneprozesse
Wasserwirt. Strukturen
Management

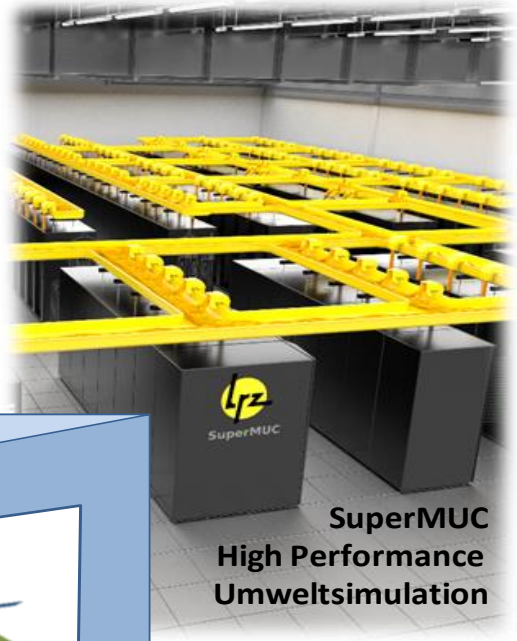
Daten-Analyse

Visualisierung

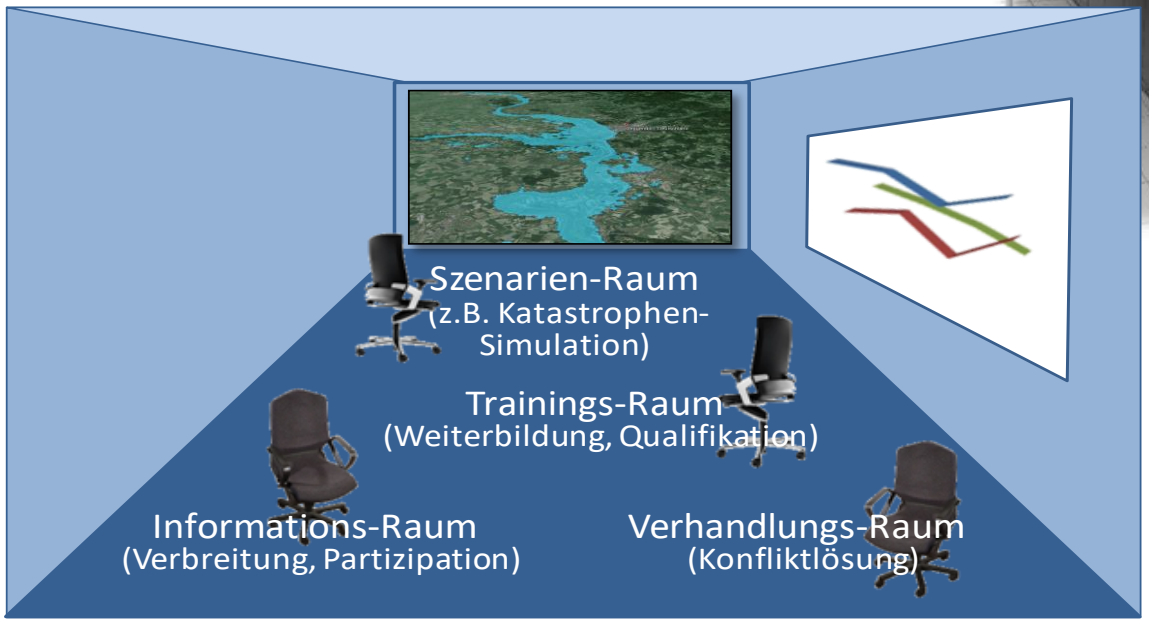
Szenarien

Datenanalyse

Ensembles

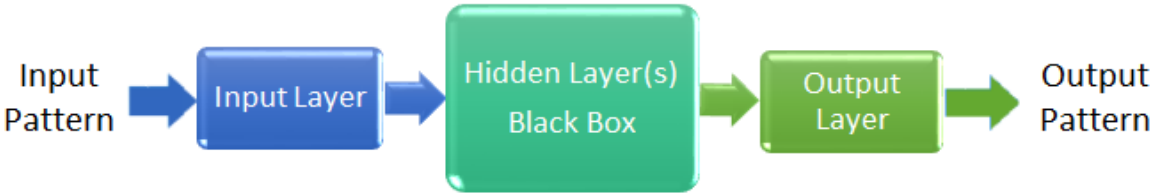


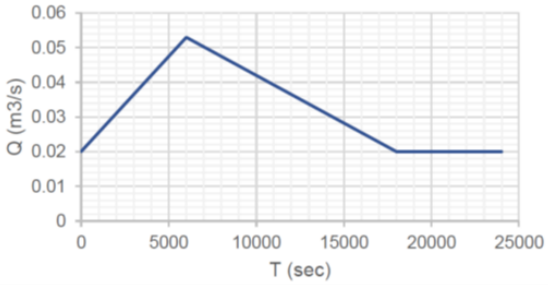
SuperMUC
High Performance
Umweltsimulation



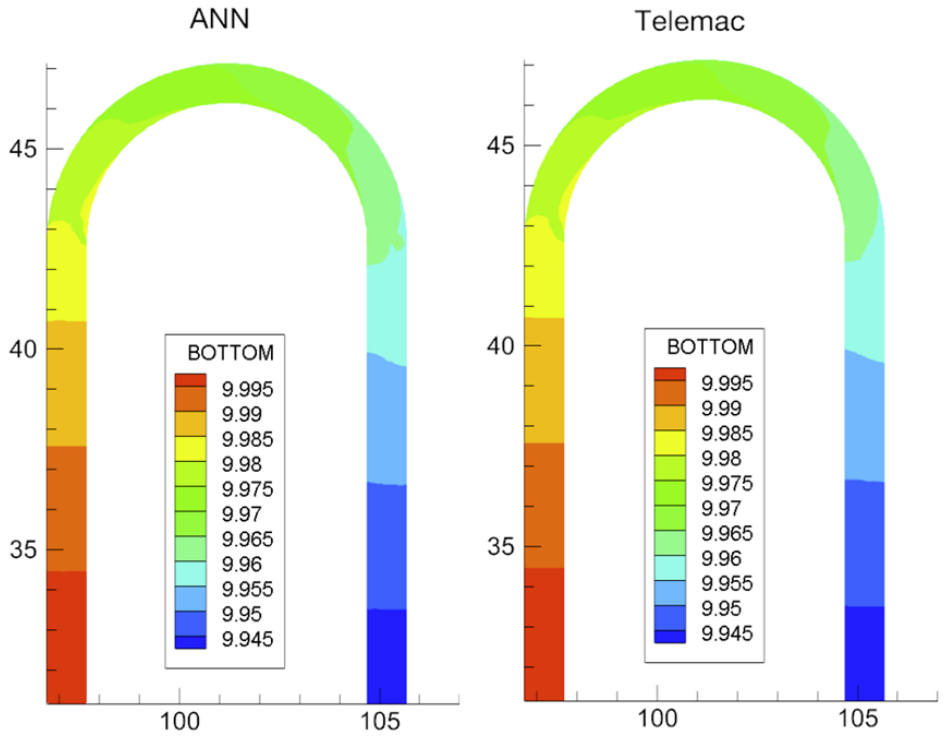
Fast computation/prediction

- **Input pattern**
- **Input layer**
- **Hidden layer**
- **Output layer**
- **Output pattern**





R = 0.9998
RMSE = $2.9020*10^{-4}$
MAE = $5.6577*10^{-5}$



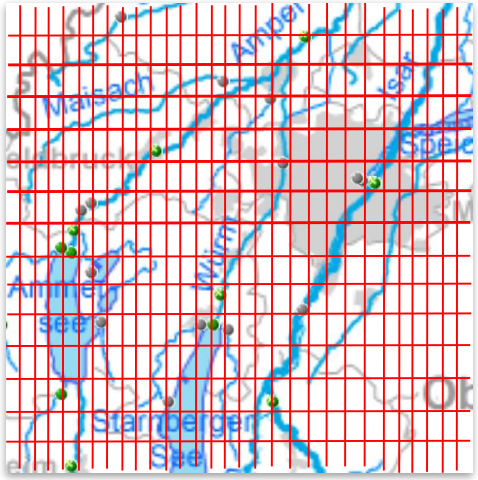
VieWBay

Research Consortium

TELEMAC goes HPC

Hydro-BITS
(LRZ)

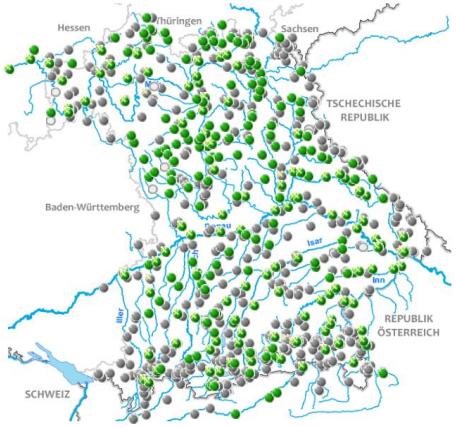
Fine Discretization of Bavaria



HYDROLOGY
(LMU)

HYDRODYNAMICS +
MORPHOLOGY
(TUM)

TELEMAC - Bavary



Funded by

Bayerisches Staatsministerium für
Umwelt und Verbraucherschutz

VieWBay - Vision

Conclusions

- Unlike with river floods, flashfloods are short events, difficult to predict in space and therefore early warning has to take place prior of flooding.
- Computations (for complex situations) or expert judge site seeings must be done before events.
- Necessary protection measures must be initiated dependent on this analysis.
- An early warning, dependent on meteorological information must, must happen and initiate a flood management plan.
- Information and training of endangered municipalities has to be performed.

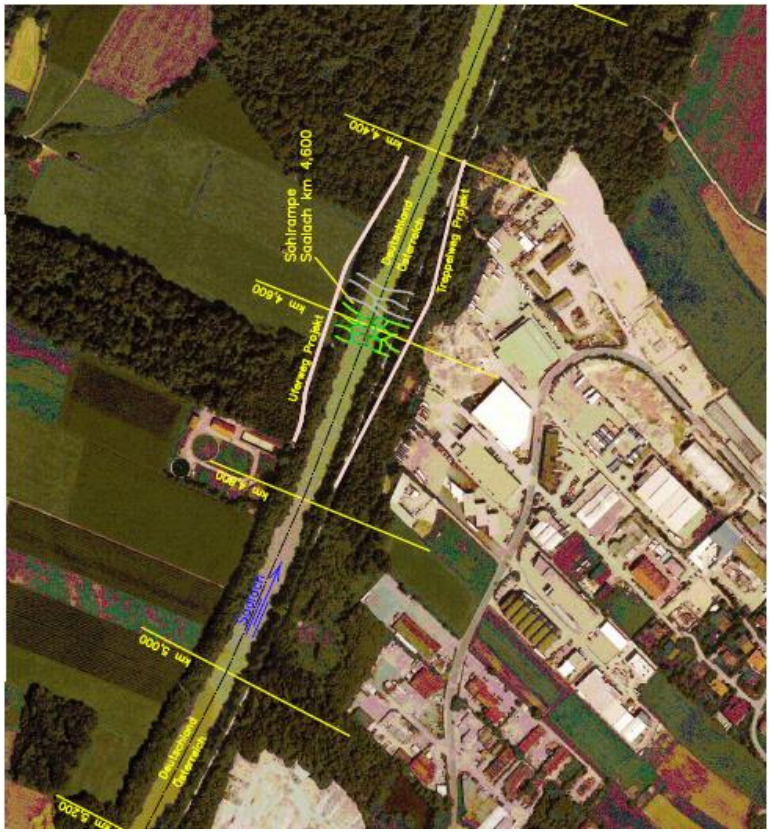
Thanks for your attention!

Fishfriendly-hydropower (EU-H2020 project coordinated by TUM): **http://www.FIThydro.eu**

Telemac for morpho-dynamic computations

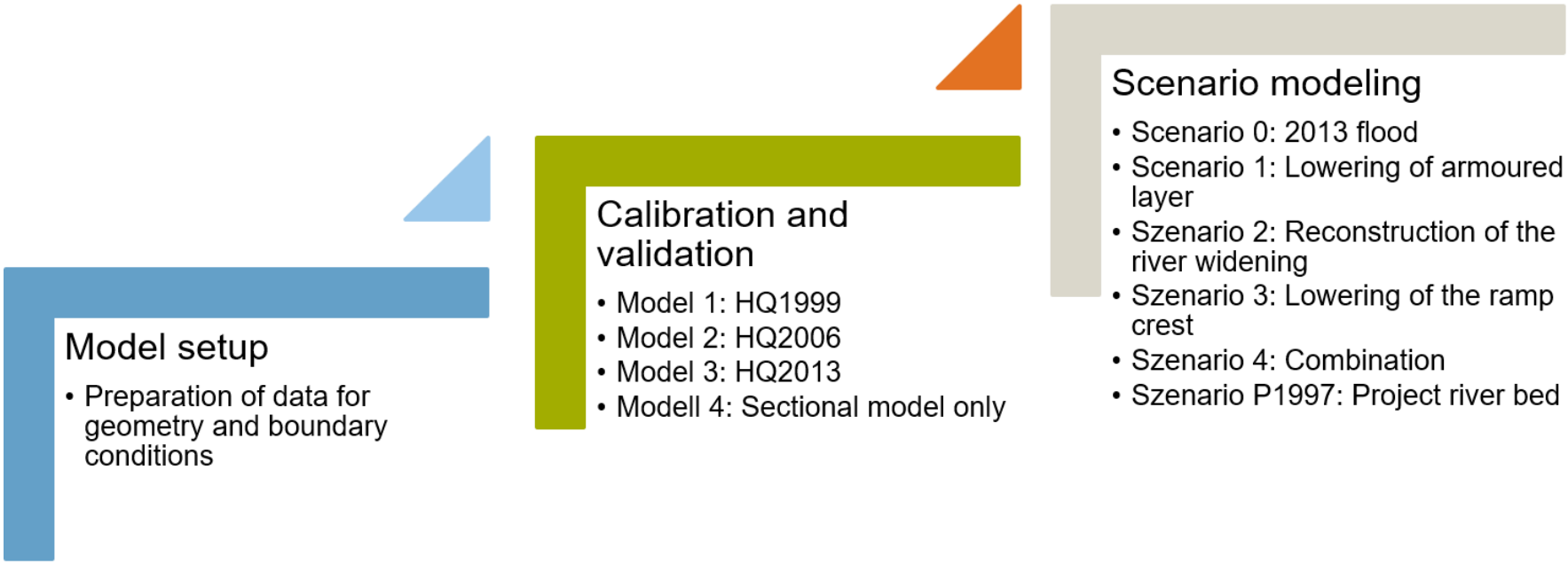
2005/06 a ramp has been constructed at River Saalach at river-km 4,6. Morpho-dynamic processes at the ramp have been investigated to study their effect on the 2013 flooding

- Transport capacity at the ramp
- Sedimentation and erosion of bed-load on and around the ramp
- Effects on the discharge capacity of the river Saalach



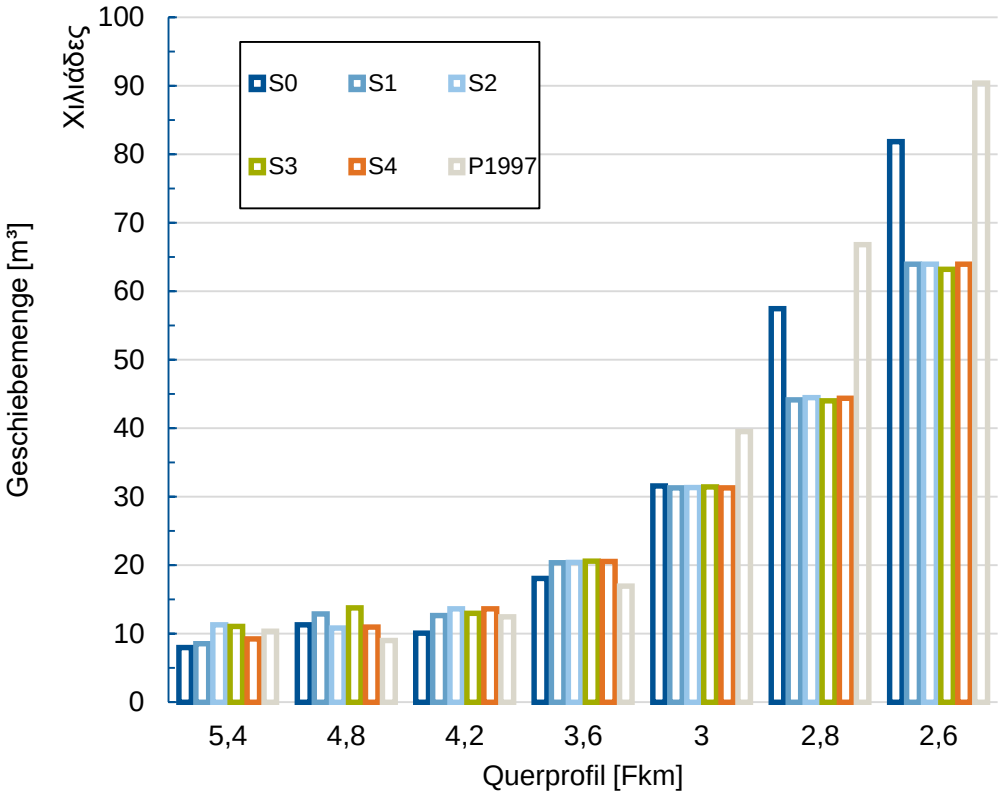
Methodology

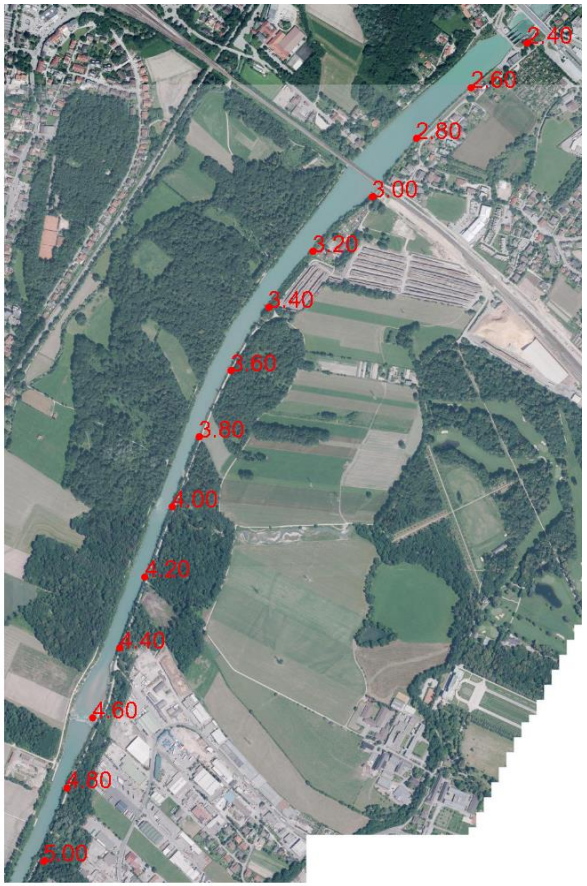
Steps of performing numerical computations with morpho-dynamic models. Details of the Freilassing case are presented by M. Reisenbüchler (TUM), session 4



Sediment transport for various scenarios (2013)

Detailed results presented by M. Reisenbüchler (TUM), S4

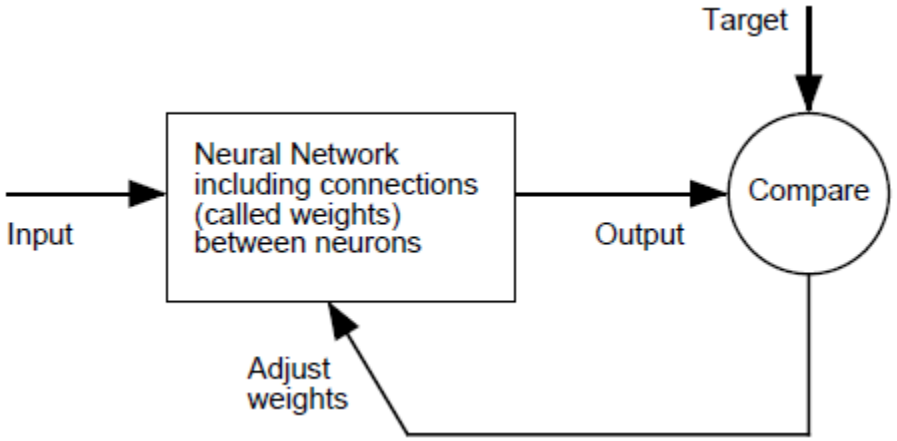




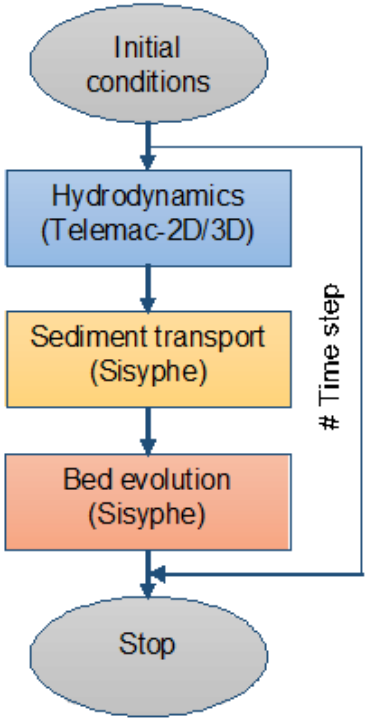
ANN methods for sediment transport in rivers

An artificial neural network is a computational model based on the structure and functions of biological neural networks (e.g. the human brain). It can be used:

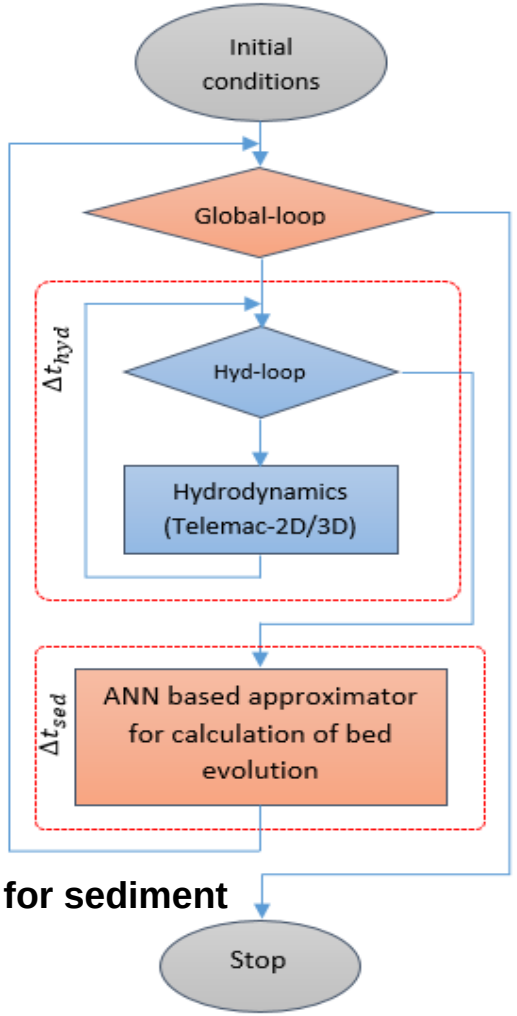
- to derive meaning from complicated or imprecise data,
- to extract patterns and detect trends,
- to provide projections given new situations.



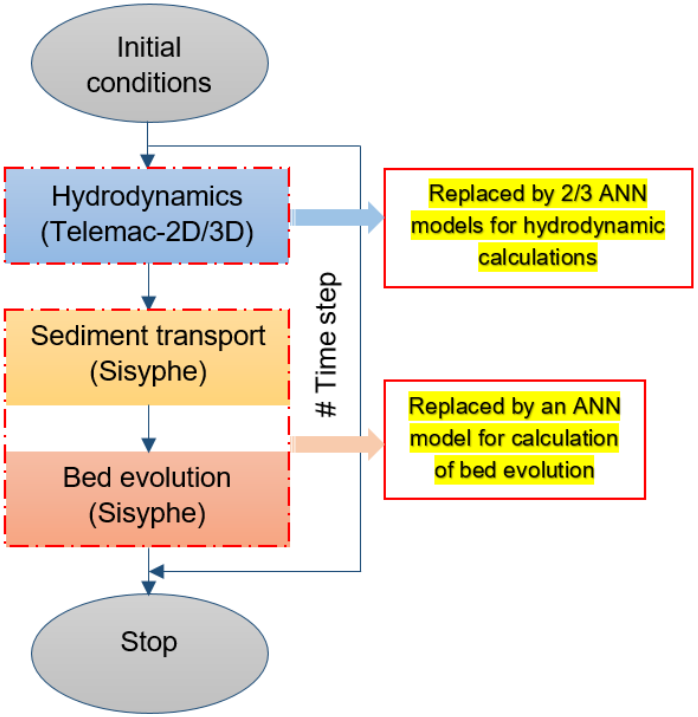
New hydro-morphological modeling system



numerical approach



ANN for sediment



ANN flow/sediment

Future computational resources

Modell purpose:

- Simulation of long term developments
- Reservoir management
- Evalation of river construction measures

Modell scales and concept:

1. Spatial
   - Nowadays we compute river reaches with a few kilometers, in the future we want to compute reservoirs and complete river systems with many kilometers
2. Temporal
   - Nowasays we compute flood scenarios of several days in the future we want to compute developments over years Future developments – years
3. Conceptual
   - Nowadays wie simplify as much as possible, in the future we want an accuracy as high as possible

→ Long term simulation with a high spatial resolution and highest accuracy!

Conclusions

- We should consider sediments for all flood considerations
- For mountainous floods and flash floods sediments are a key issue
- In order to do this we must go new ways. We should stick as close as possible to the physics while saving CPU time with new algorithms
- Climate change will have an effect on floods but possibly even more on sediment transport. This may have dramatic effects on spawning of aquatic populations.
- In the future we should therefore put more weight on managing our environment to compensate for effects of climate change
- …and we should consider such effects when we plan our today mitigation measures, e.g. the present river restauration projects.

Flash Flood Simbach

Before and after

Source: BayernAtlas and googlemaps

Retention in the historical/present Danube

Flood damping for a medium hydrograph is more efficient in the present then in the past Danube