Modeling of pluvial flash floods in pre-Alpine regions and assessment of potential climate change impacts

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Climate Change impact assessment for pluvial flash floods

Coupled hydrologcial & 2-D hydrodynamic modeling

Current design precipitation values for Austria (ehyd.gv.at) (1h, 2h, 100yr, 30yr)

+ Climate Change Signal/change rates (% of current design precipitation) from

1) Datasets from a pan-European climate service (swicca.eu)

2) Temperature based scaling approach (Leidinger et al., 2019)

SCS-CN Modell (Calculating effective rainfall depths for different hydrologic response units)

- Python pre-processor producing raster time-series of effective rainfall depths, which are used as boundary conditions for a hydrodynamic model.

Raster based two-dimensional hydrodynamic model

- Open source model Itzi (Courty et al., 2017)

Leidinger, D., Leimighofer, J. and Formayer, H. 2019. Spatial structure of (Super-)-Clausius-Clapeyron Scaling in Austria. Geophysical Research Abstracts Vol. 21, EGU2019-16812

Courty, L., Predrozo-Acuna, A. and Bates, P. D. 2017. Itzï (version 17.1): An open-source, distributed GIS model for dynamic flood simulation. Geosci. Model Dev., 10, 1835-1847, doi:10.5194/gmd-10-1835-2017

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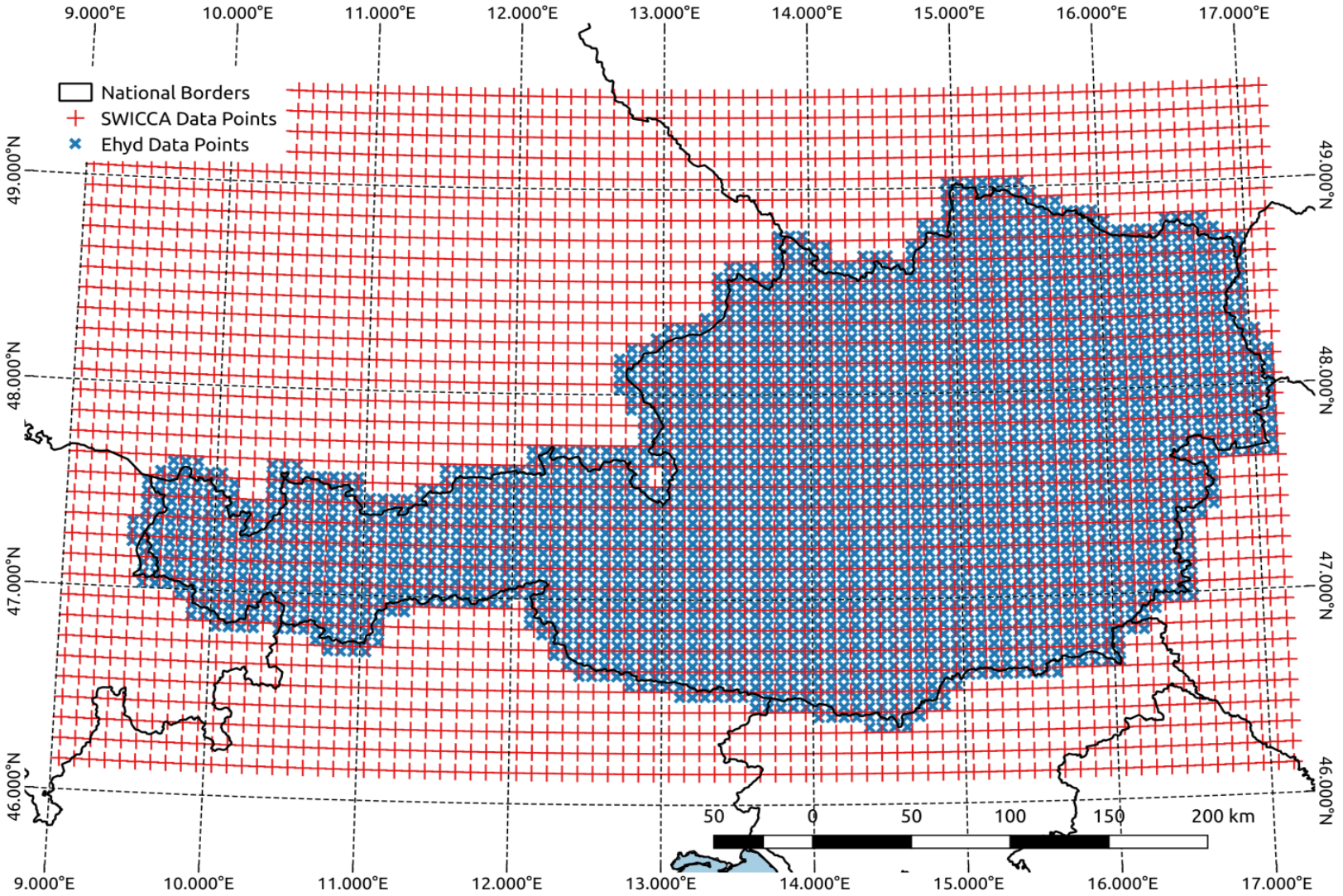
National CS + change rates pan-European CS



Data coverage swicca.eu datasets (~12km spacing) and national design precipitation values (~6km spacing) for Austria. Change rates from pan-European dataset were applied to current design precipitation values using a nearest neighbour assignment.

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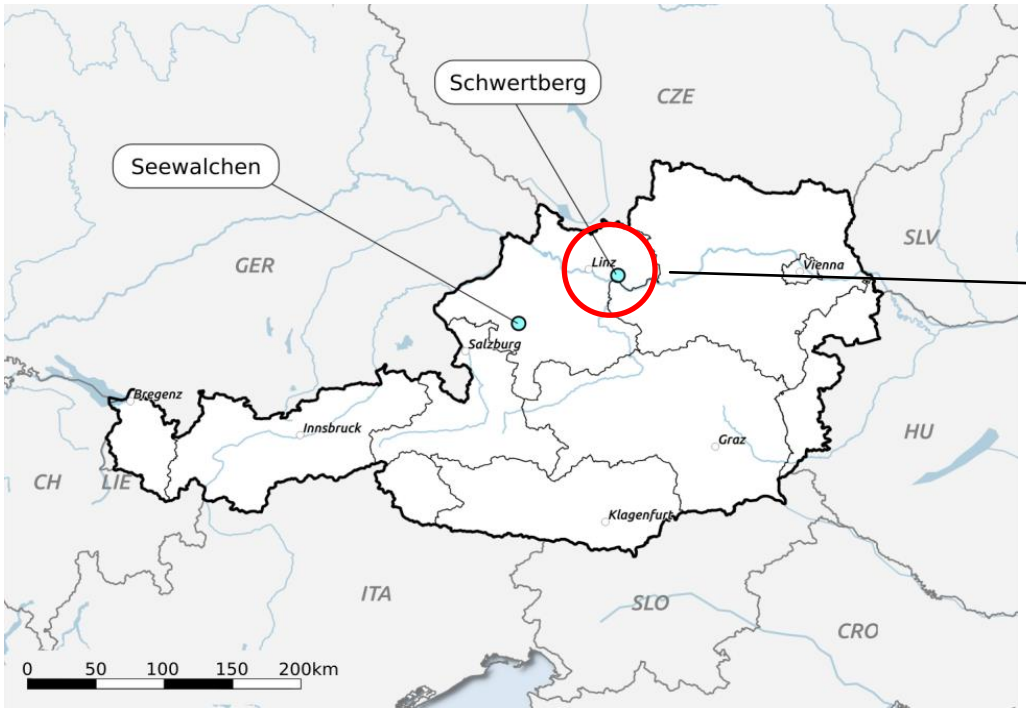
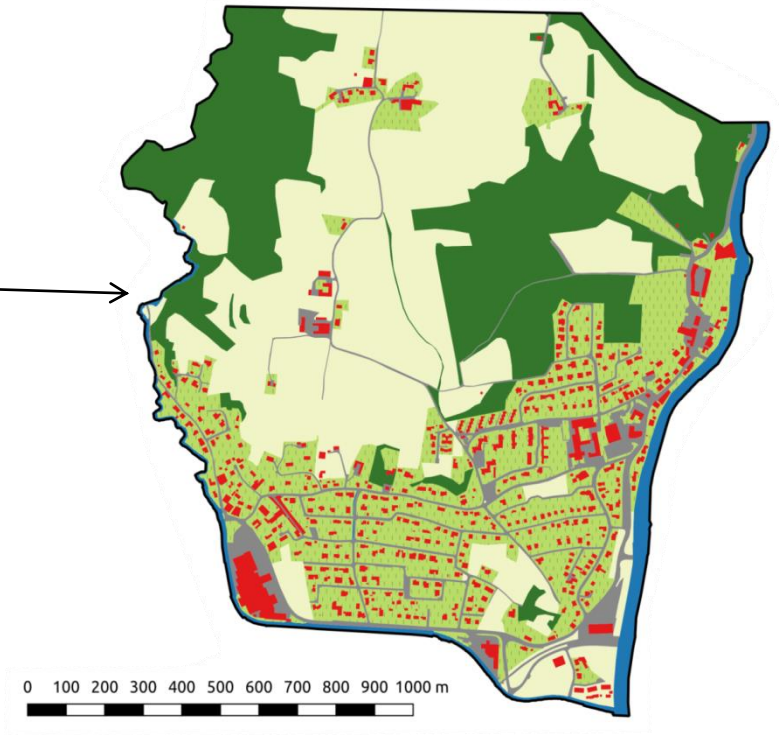
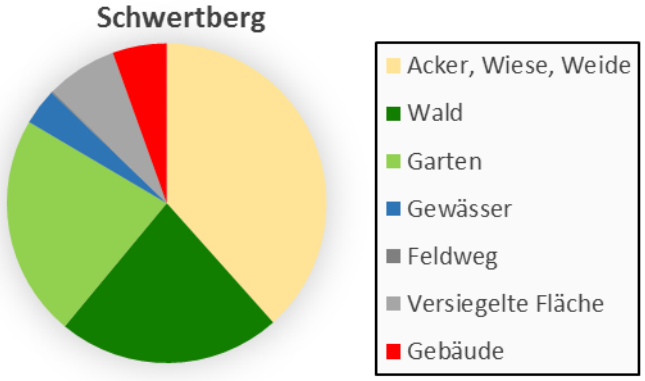
Case study sites





landcover class	surface roughness (k_{st})
agricultural (crops, meadows, pasture)	12
farm track	50
backyards, gardens, lawns	10
buildings	*
water bodies	35
sealed surfaces (roads, parking lots)	70
forested areas	5

* no flow over building areas considered



National design precipitation + change rates pan-European CS (Schwertberg) – near future

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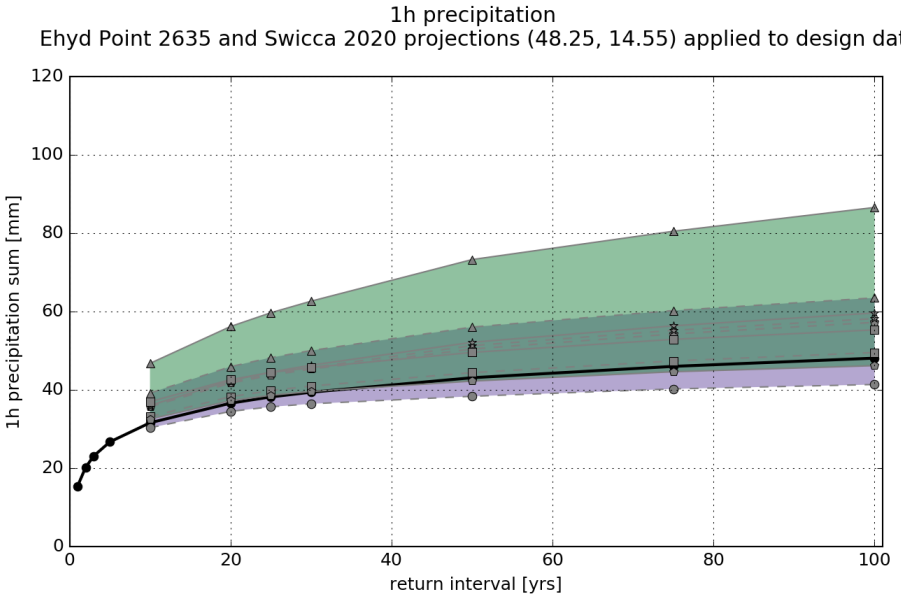
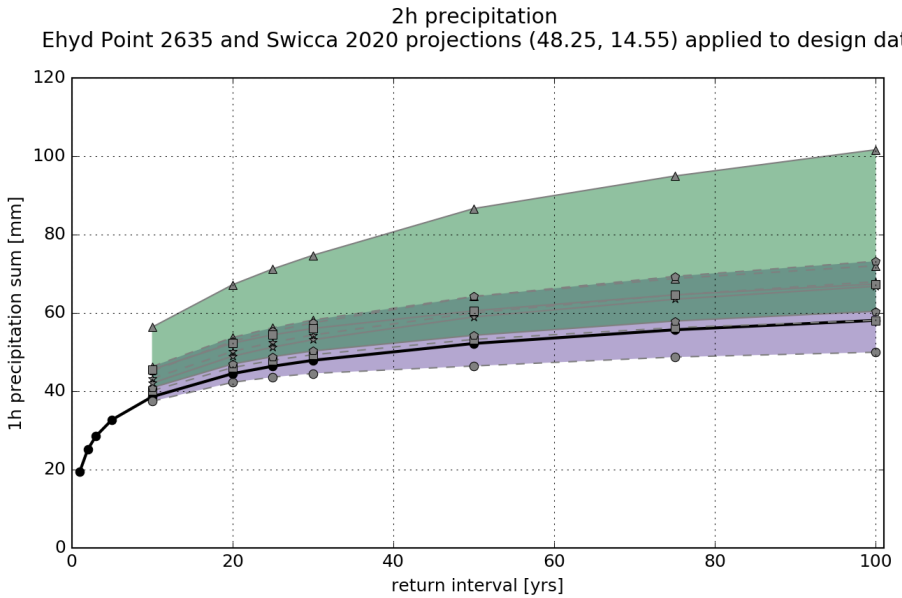
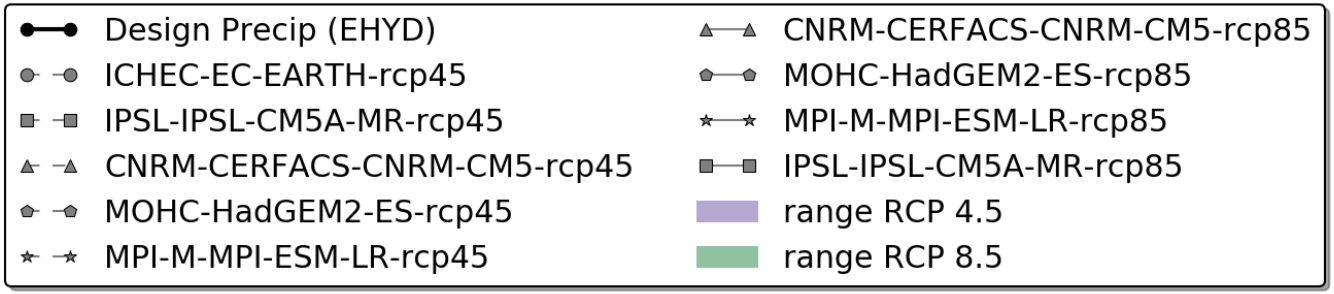
EHYD Grid-Point: 2635

1h precipitation event



2h precipitation event





National design precipitation + change rates pan-European CS (Schwertberg) – mid century

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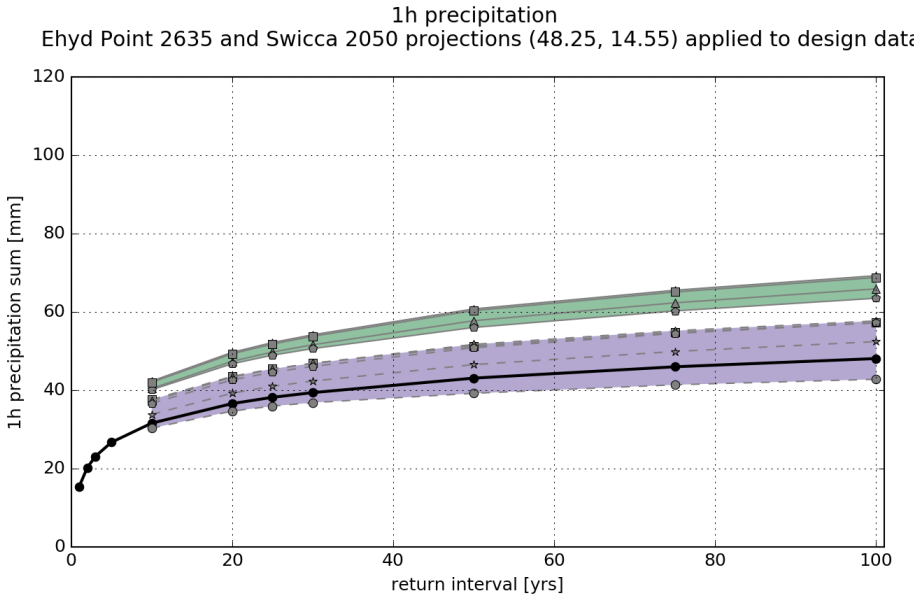
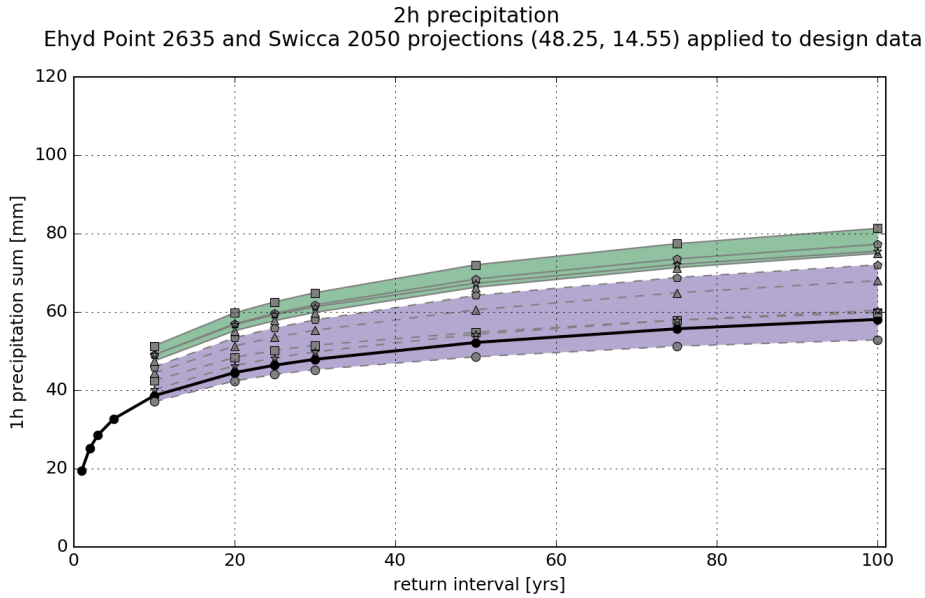
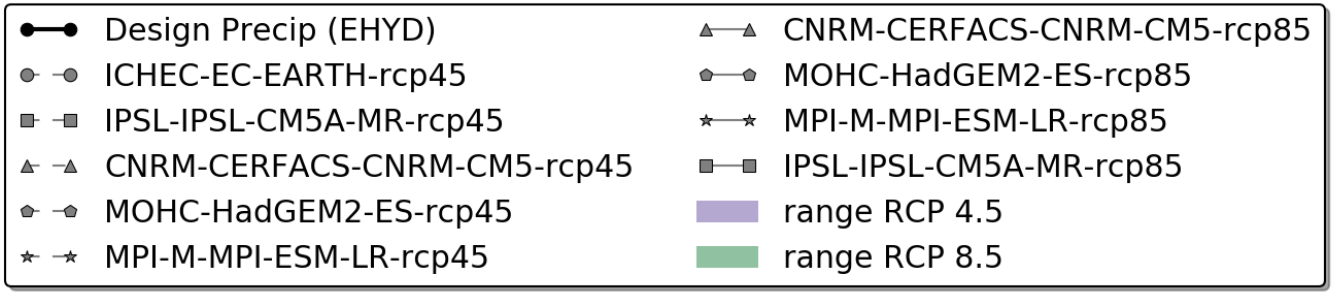
EHYD Grid-Point: 2635

1h precipitation event



2h precipitation event





National design precipitation + change rates pan-European CS (Schwertberg) – end century

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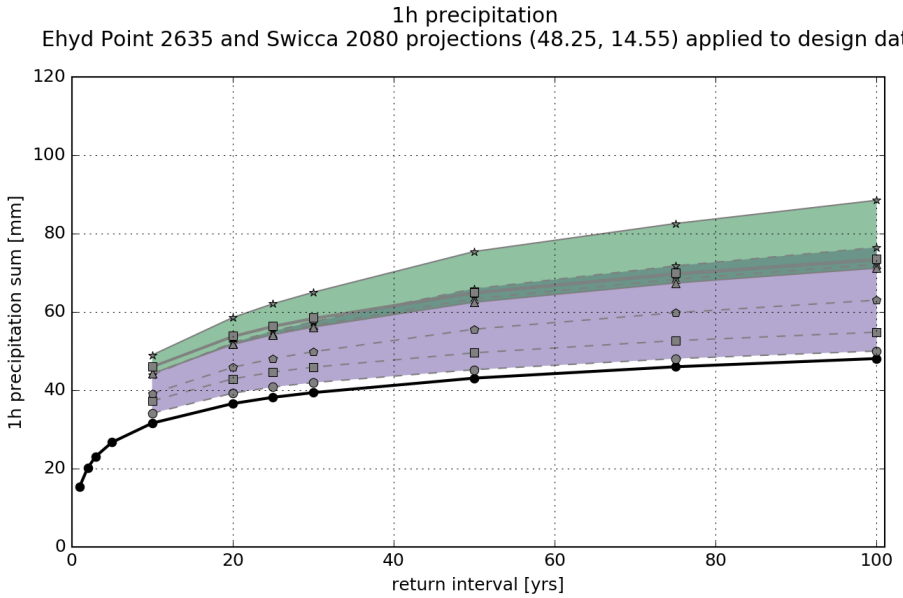
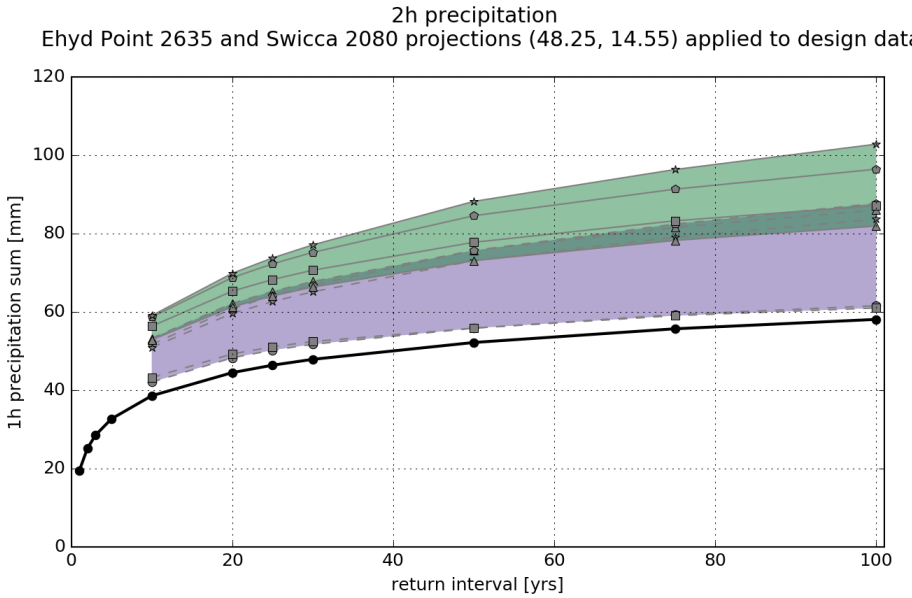
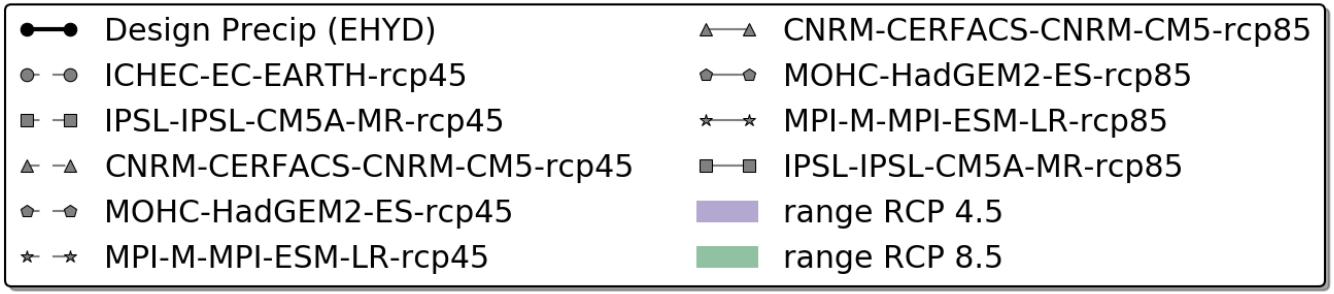
EHYD Grid-Point: 2635

1h precipitation event



2h precipitation event





Overview model runs case-study Schwertberg (1h precip.)

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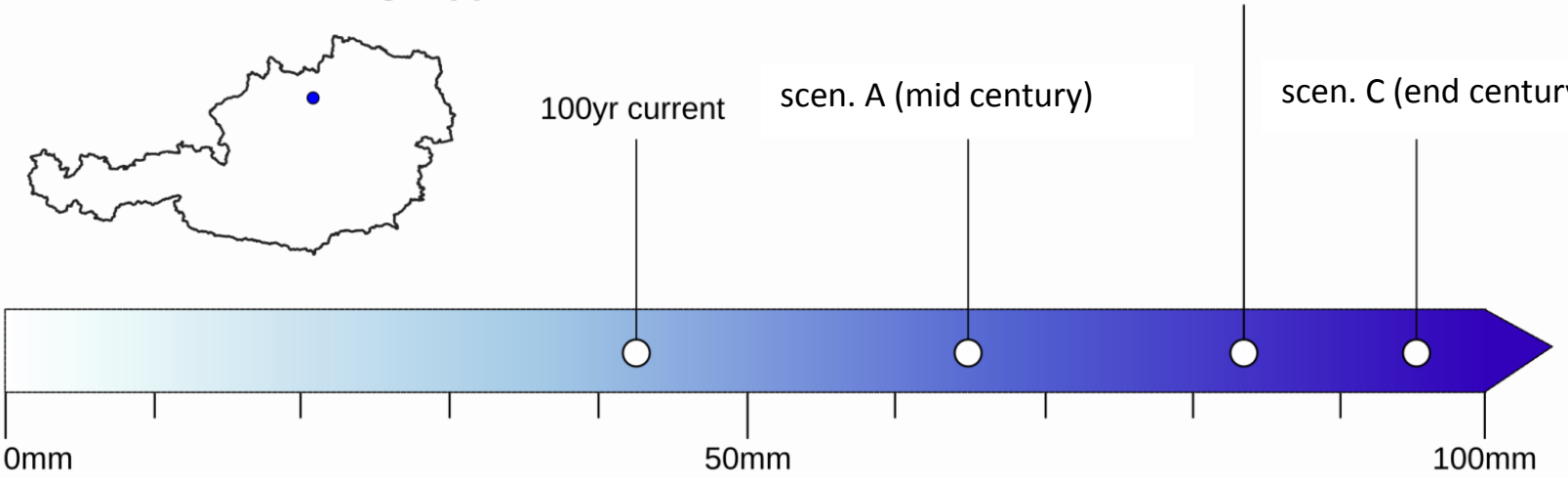
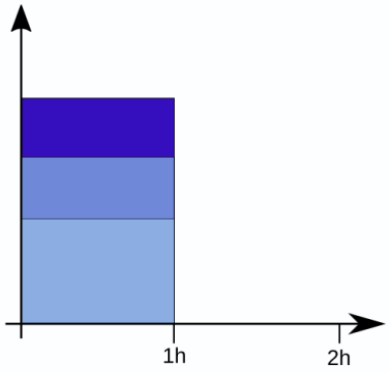
1h Precipitation
location: Schwertberg, Upper Austria



1h precipitation
2h simulation time
constant intensity



dry	sch_00 40mm	sch_01 50mm	sch_02 60mm	sch_03 70mm	sch_04 80mm	sch_05 90mm
standard	sch_06 40mm	sch_07 50mm	sch_08 60mm	sch_09 70mm	sch_10 80mm	sch_11 90mm
wet	sch_12 40mm	sch_13 50mm	sch_14 60mm	sch_15 70mm	sch_16 80mm	sch_17 90mm

Hydrologic pre-Processor (SCS-CN)

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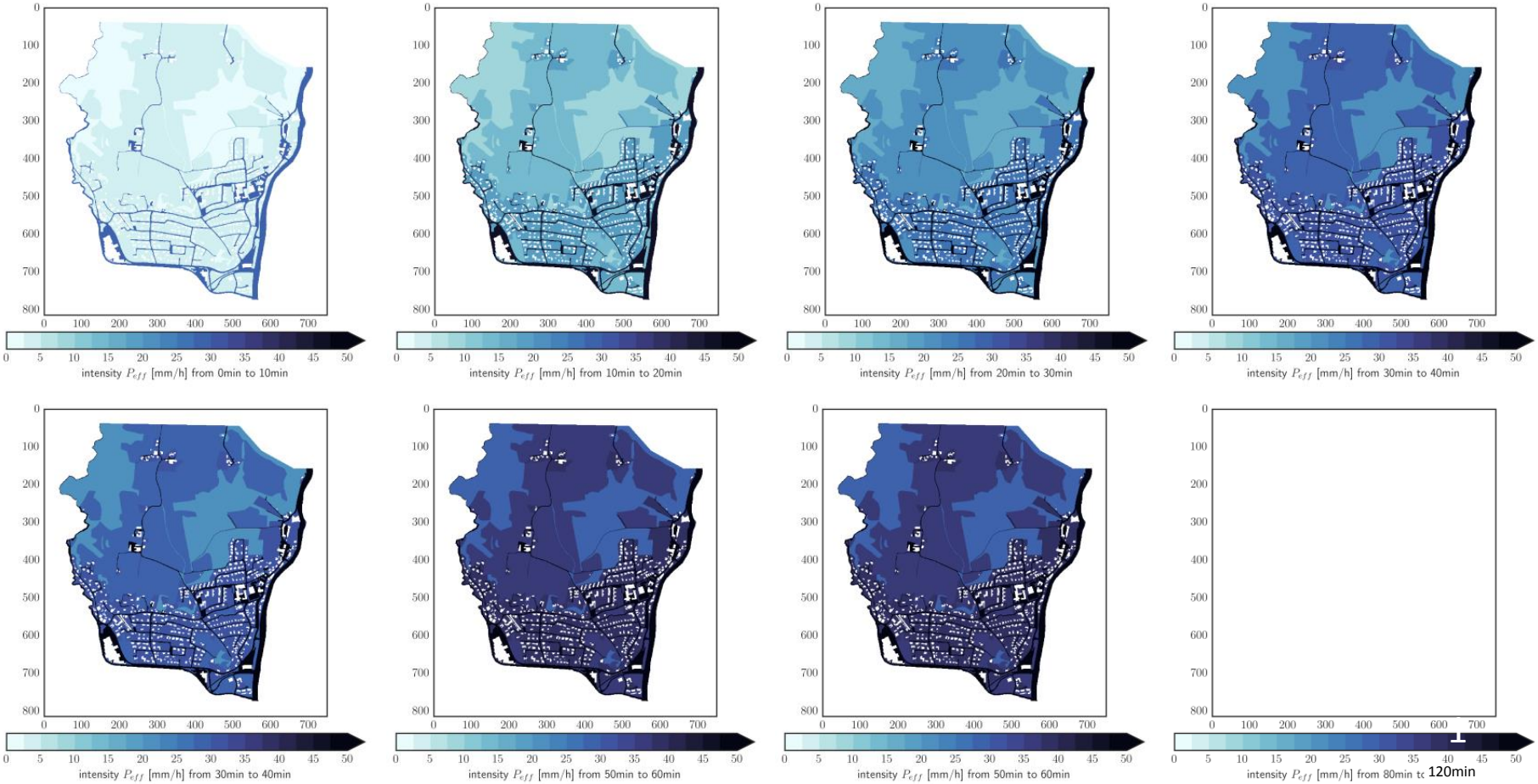

Example of a gridded precipitation time-series used as boundary conditions for the hydrodynamic simulations with Itzi. Based on a 50mm block-rainfall with 1h duration and normal antecedant conditions (AMC II) 10min raster-time series of the effective precipitation intensities were produced in a pre-processing step.

Hydrodynamic modeling (selected results)

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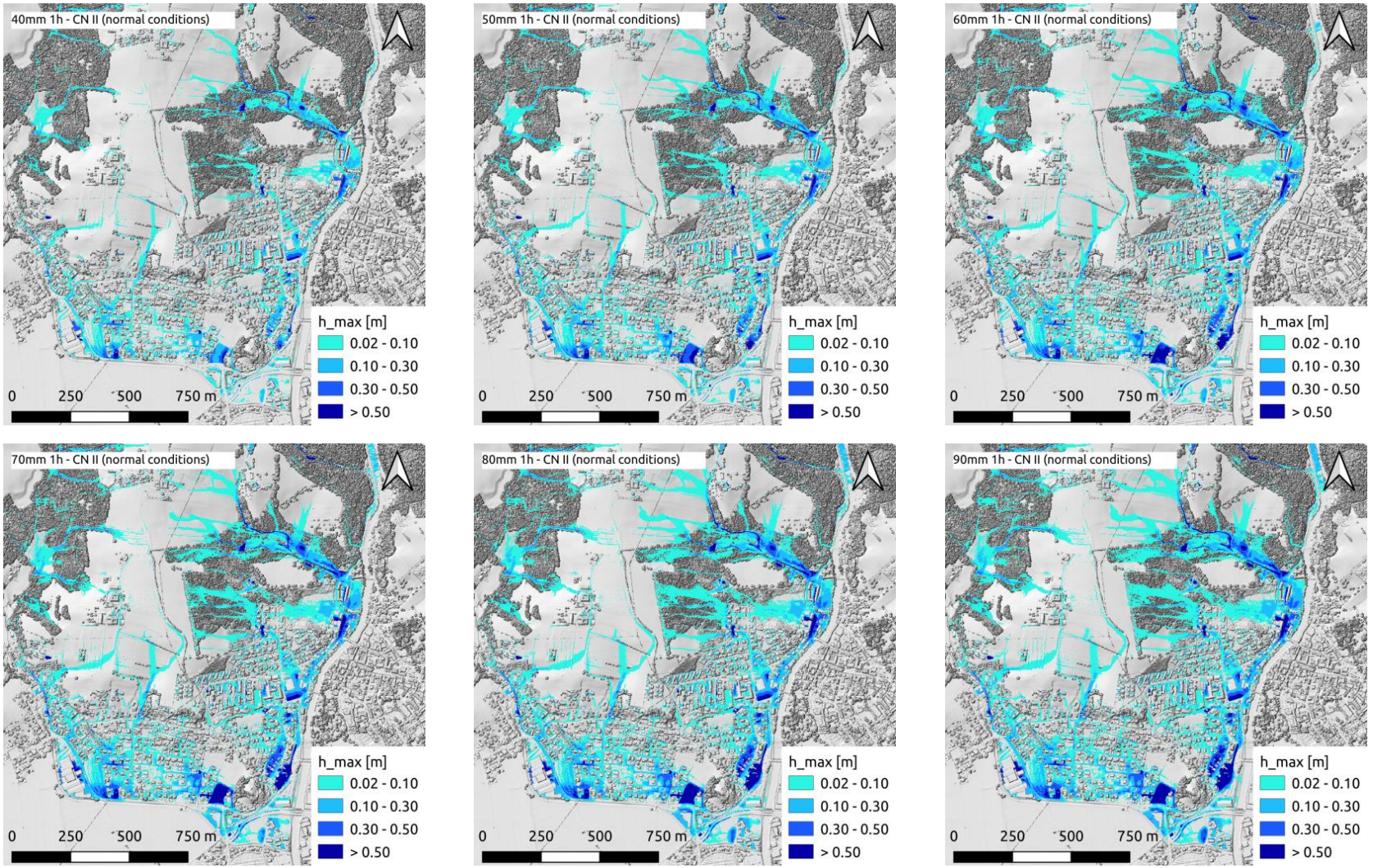

Exemplary model results for the case-study municipality of Schwertberg, Upper Austria. Different boundary conditions for 1h precipitation under normal conditions (AMC II) are applied. A precipitation sum of 40mm for 1h corresponds to current values for a 100yr design event; 90mm/h correspond to maximum projected future increase rates of any model from the (2080).

Hydrodynamic modeling (selected results)

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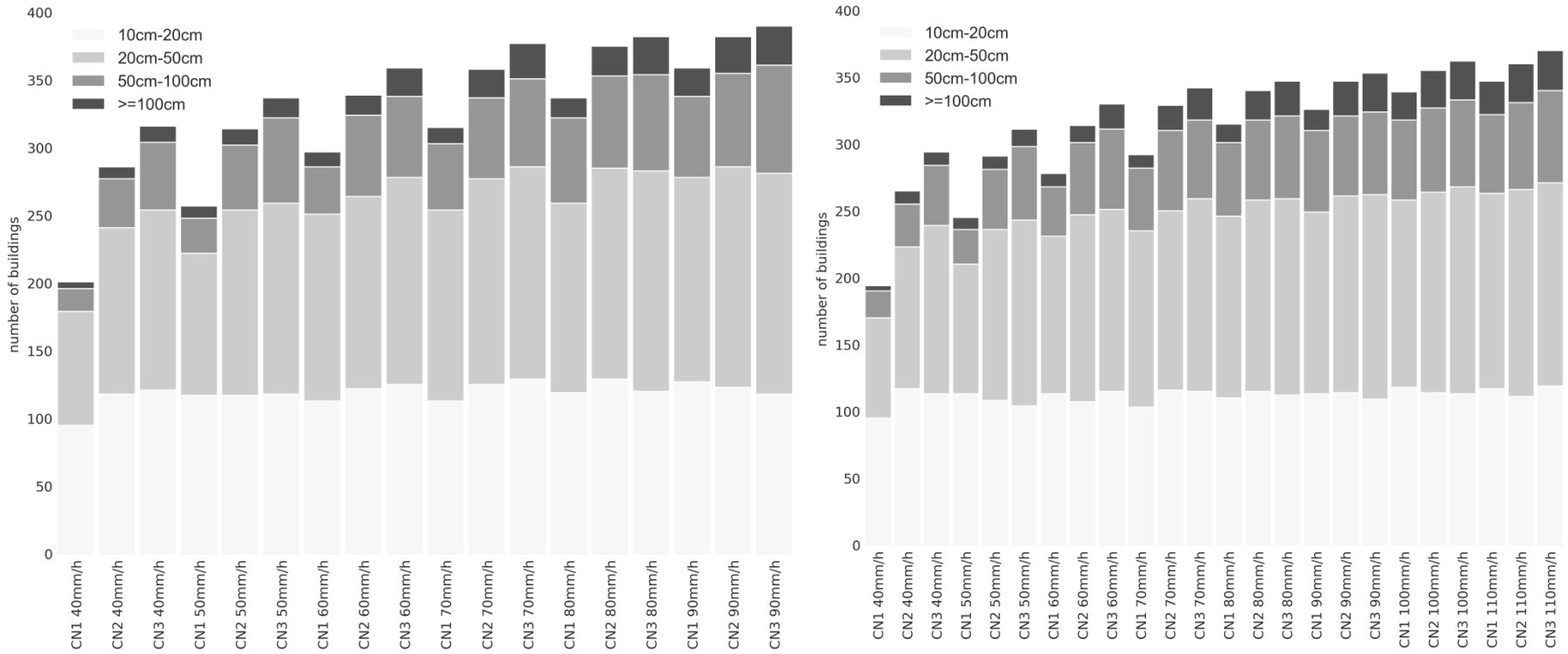

Number of buildings affected for the different scenarios with 1h precipitation duration (left) and 2h precipitation duration (right) for the case-study catchment in Schwertberg.

Hydrodynamic modeling (selected results)

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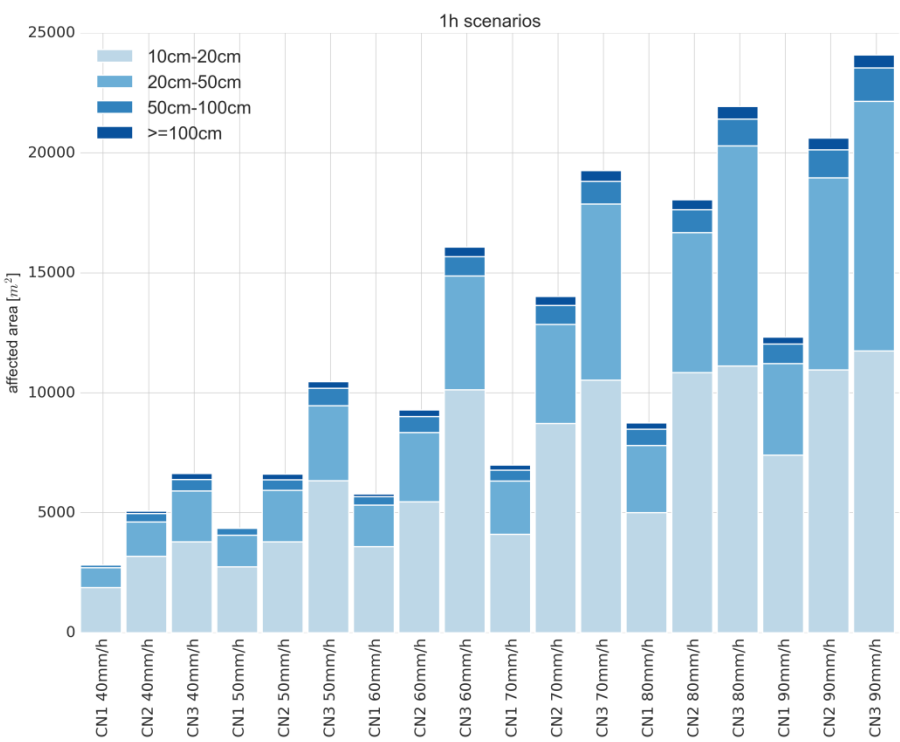

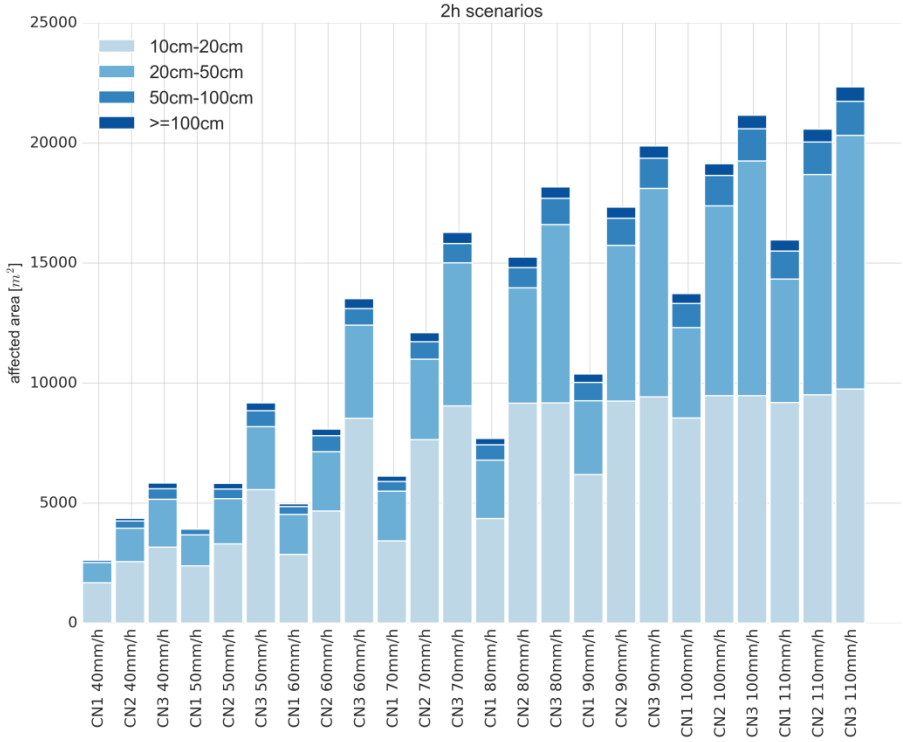

Total affected areas (areas with modelled max. water-dephts of >= 10cm) for the different scenarios with 1h precipitation duration (left) and 2h precipitation duration (right) for the case-study catchment in Schwertberg.

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Preliminary results/lessons learned

Precipitation:

- The intensities of extreme storm-events with short durations are expected to increase with projected climate change for the study-areas.
- Analysis of historic station data suggests, that the increase of precipitation intensities with increasing temperatures might be more pronounced for convectiv type precipitation events than for stratiform precipitation events.
- Scaling of precipitation intensities might surpass the Clausius-Clayperon Scaling (~7%/°K) for extreme precipitation events with short durations (Super-CC scaling)

Modeling of pluvial flash floods:

- Model chains for climate change impact assessment for pluvial flash floods in pre-Alpine areas are available.
- Coupling of an event-based hydrological loss-model (SCS CN) with an open-source 2D hydrodynamic model (Itzi) is possible.
- With a projected increase in precipitation intensities for short-term convective storm-events also larger areas/more infrastructure objects might be affected by pluvial flash floods in future time-periods