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 model (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.

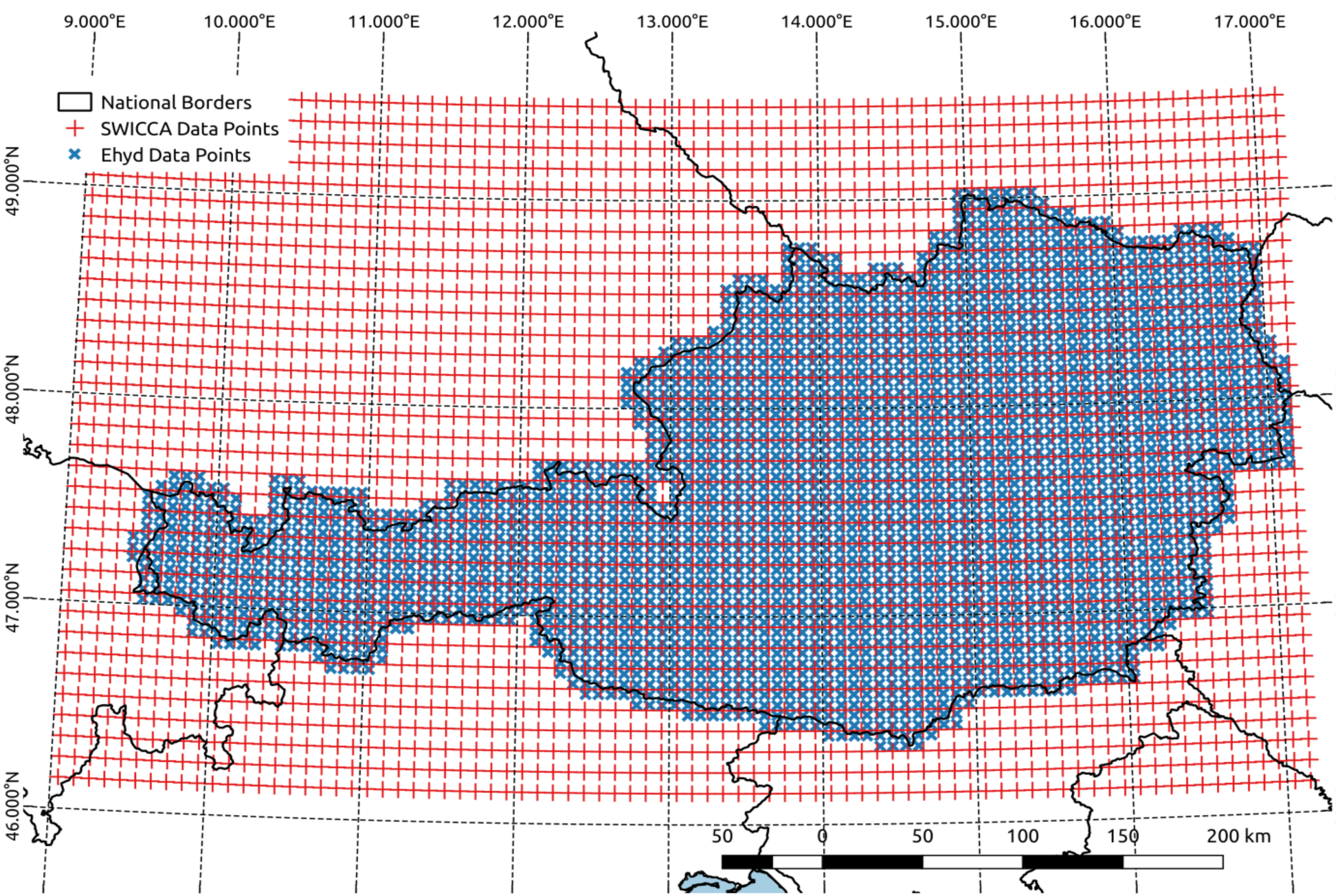
Raster based two-dimensional hydrodynamic model

- 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

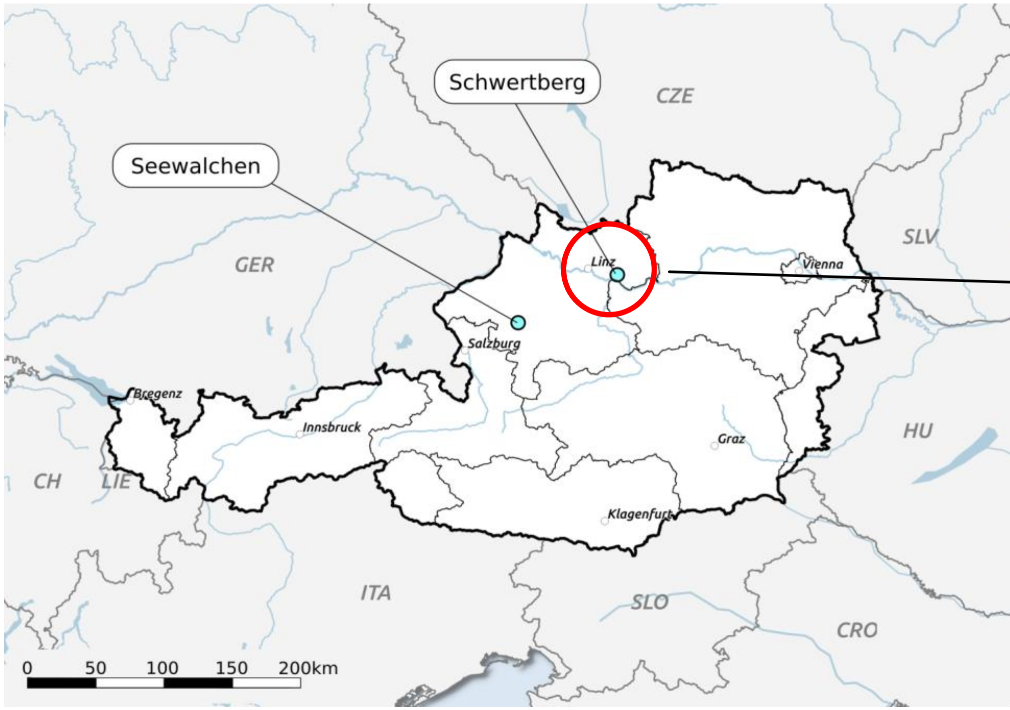
Courty, L., Predrozo-Acuna, A. and Bates, P. D. 2017. Itzï (version 17.1): An open-source, distributed GIS model for dynamic flood simulation. Geosci. Model Dev., 10, 1835-1847, doi:10.5194/gmd-10-1835-2017

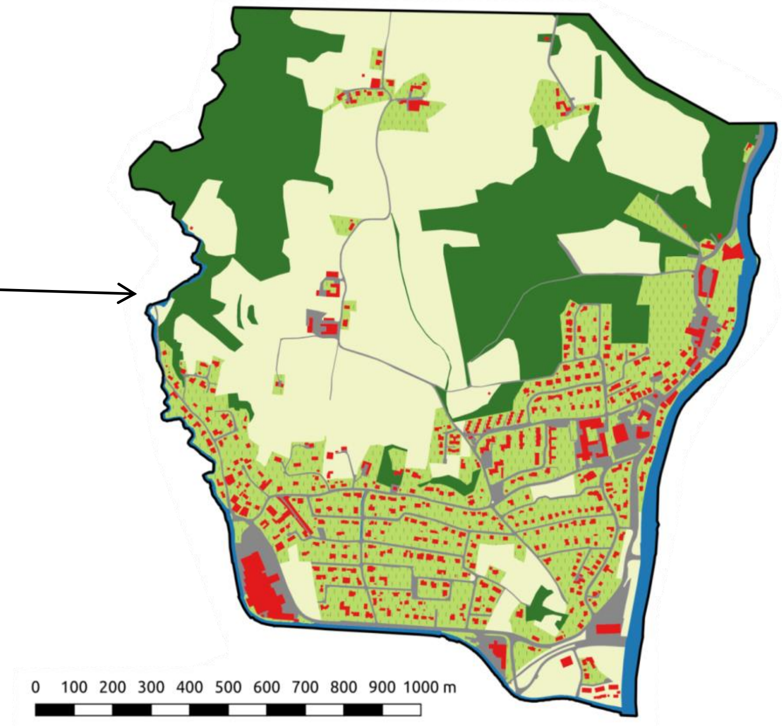
National CS + change rates pan-European CS



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.

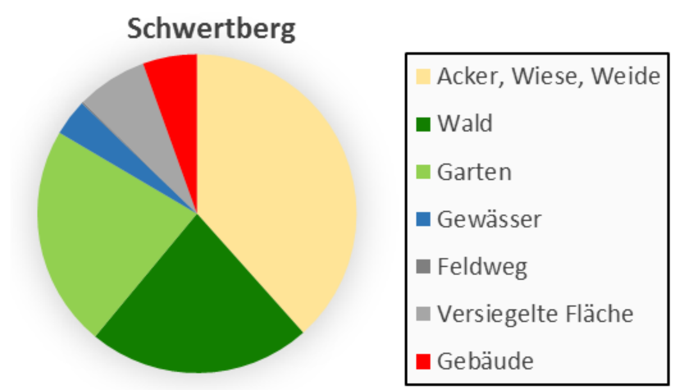
Case study sites





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

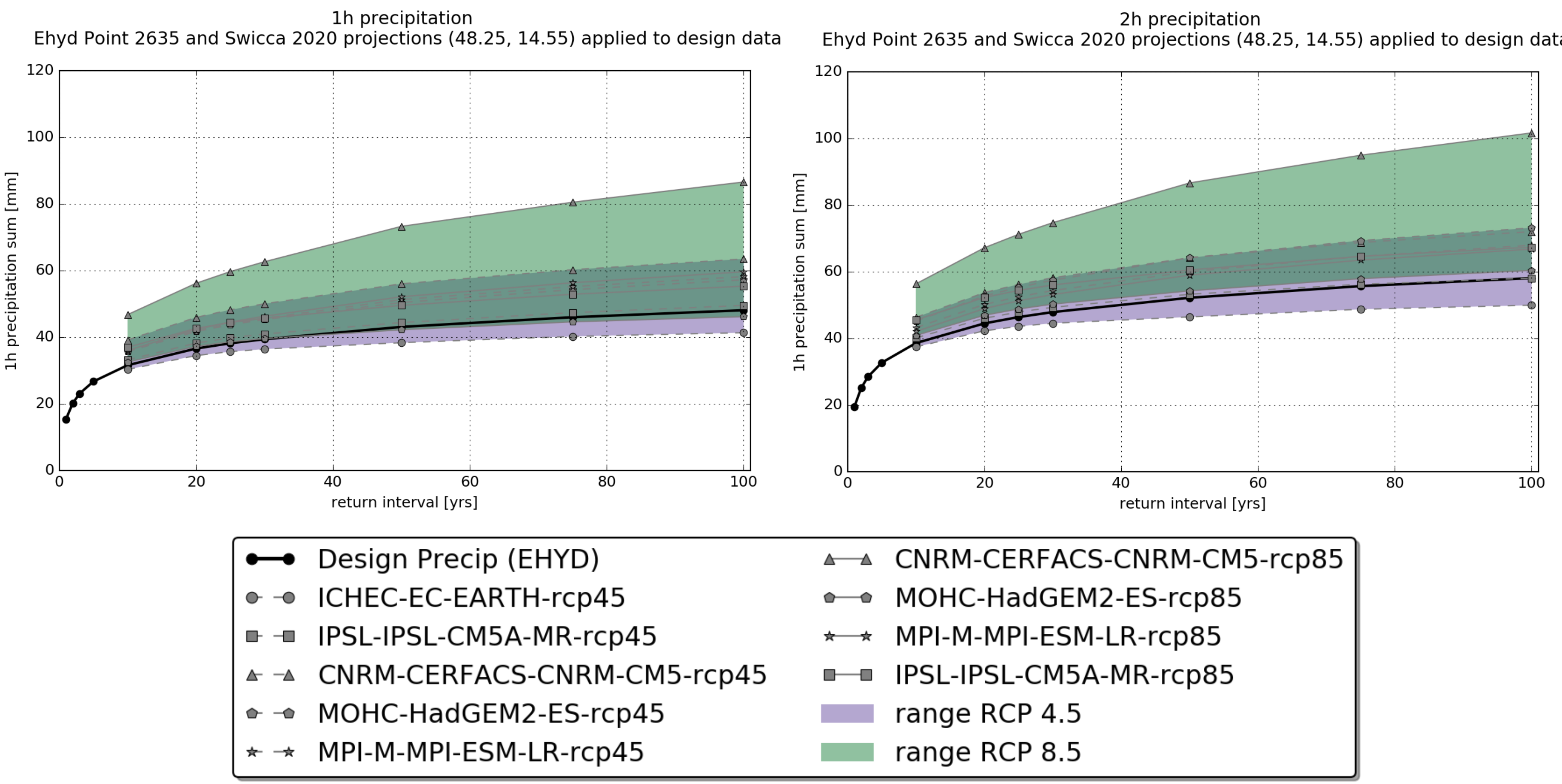


National design precipitation + change rates pan-European CS (Schwertberg) – near future

EHYD Grid-Point: 2635

1h precipitation event

2h precipitation event

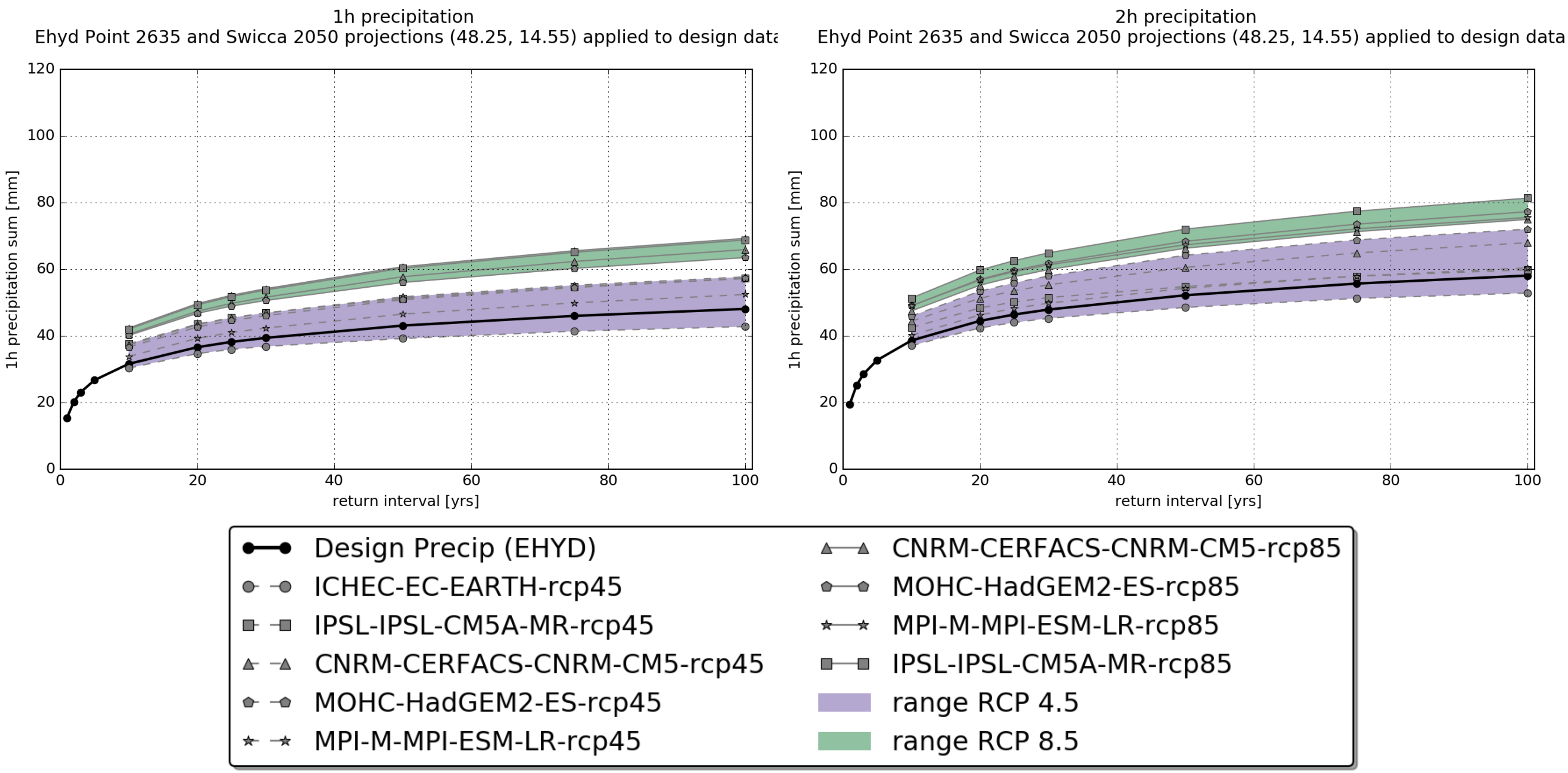


National design precipitation + change rates pan-European CS (Schwertberg) – mid century

EHYD Grid-Point: 2635

1h precipitation event

2h precipitation event

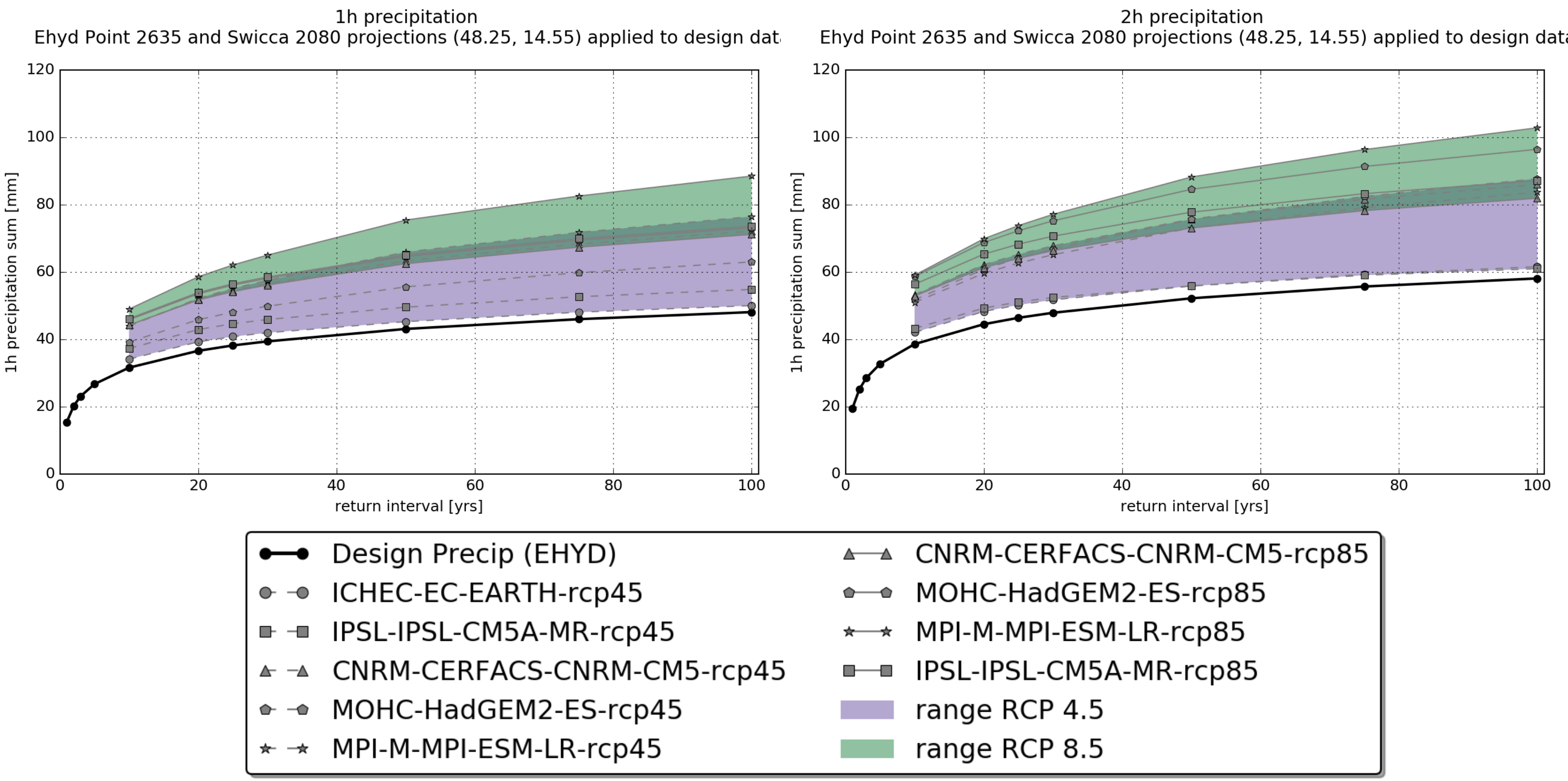


National design precipitation + change rates pan-European CS (Schwertberg) – end century

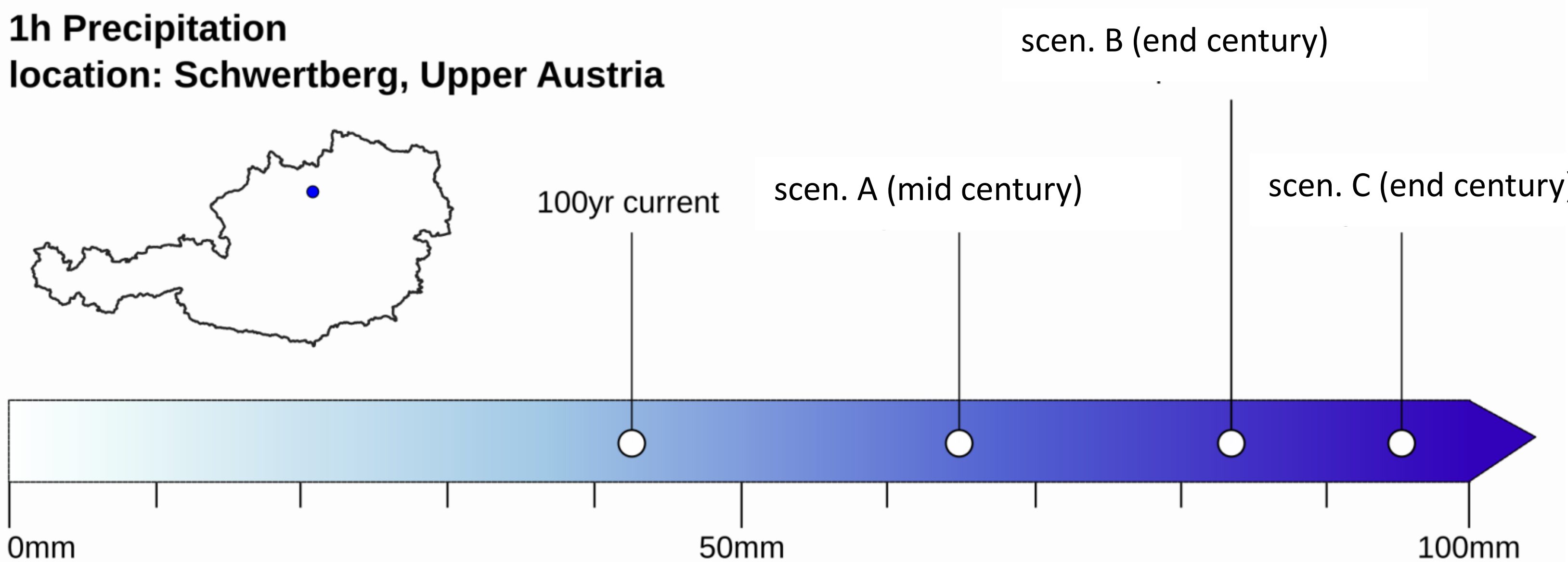
EHYD Grid-Point: 2635

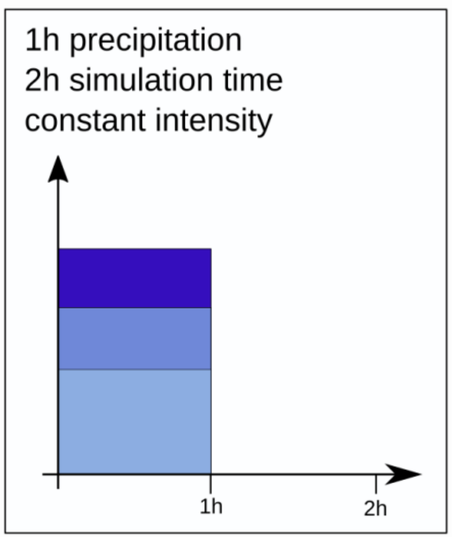
1h precipitation event

2h precipitation event



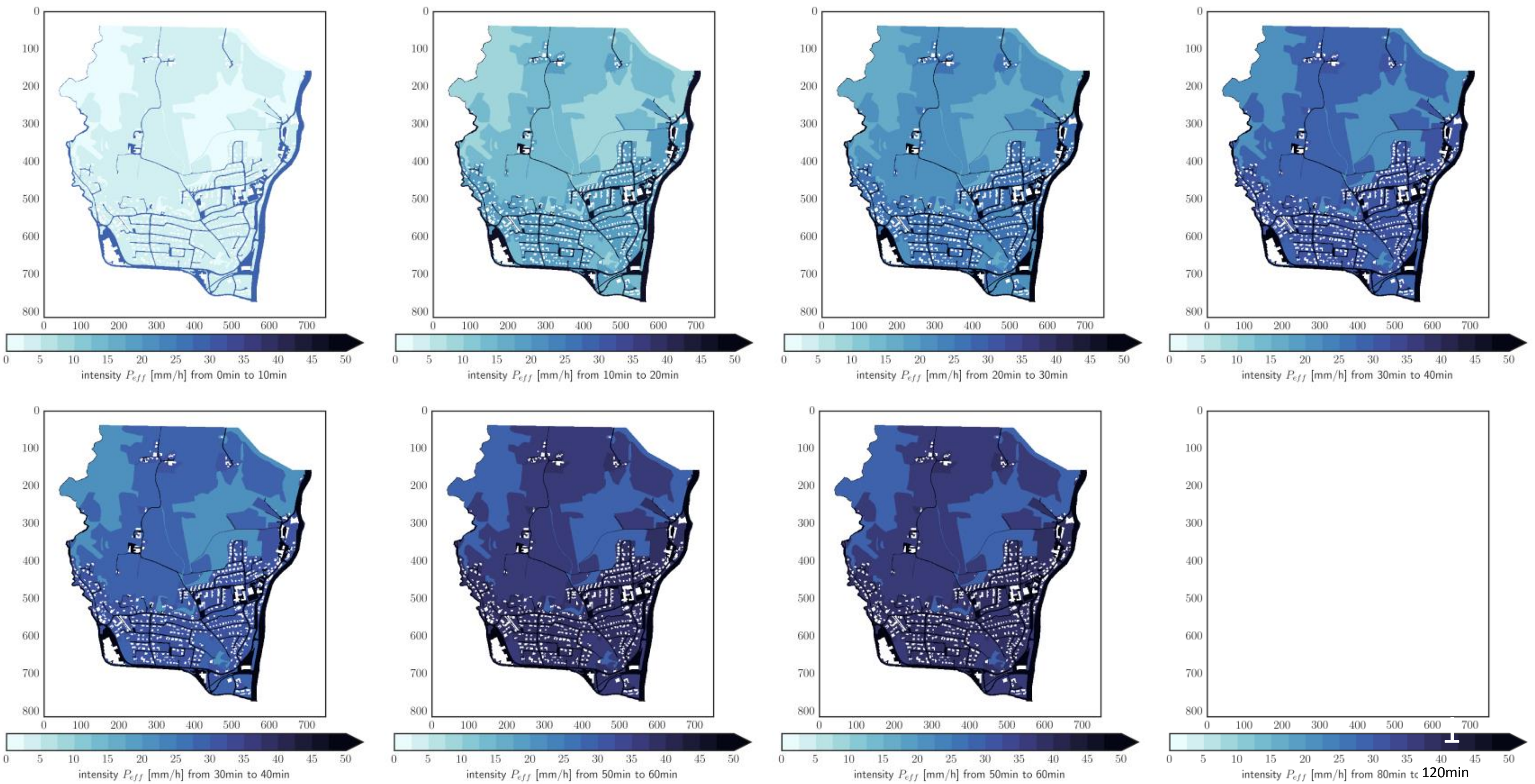
Overview model runs case-study Schwertberg (1h precip.)





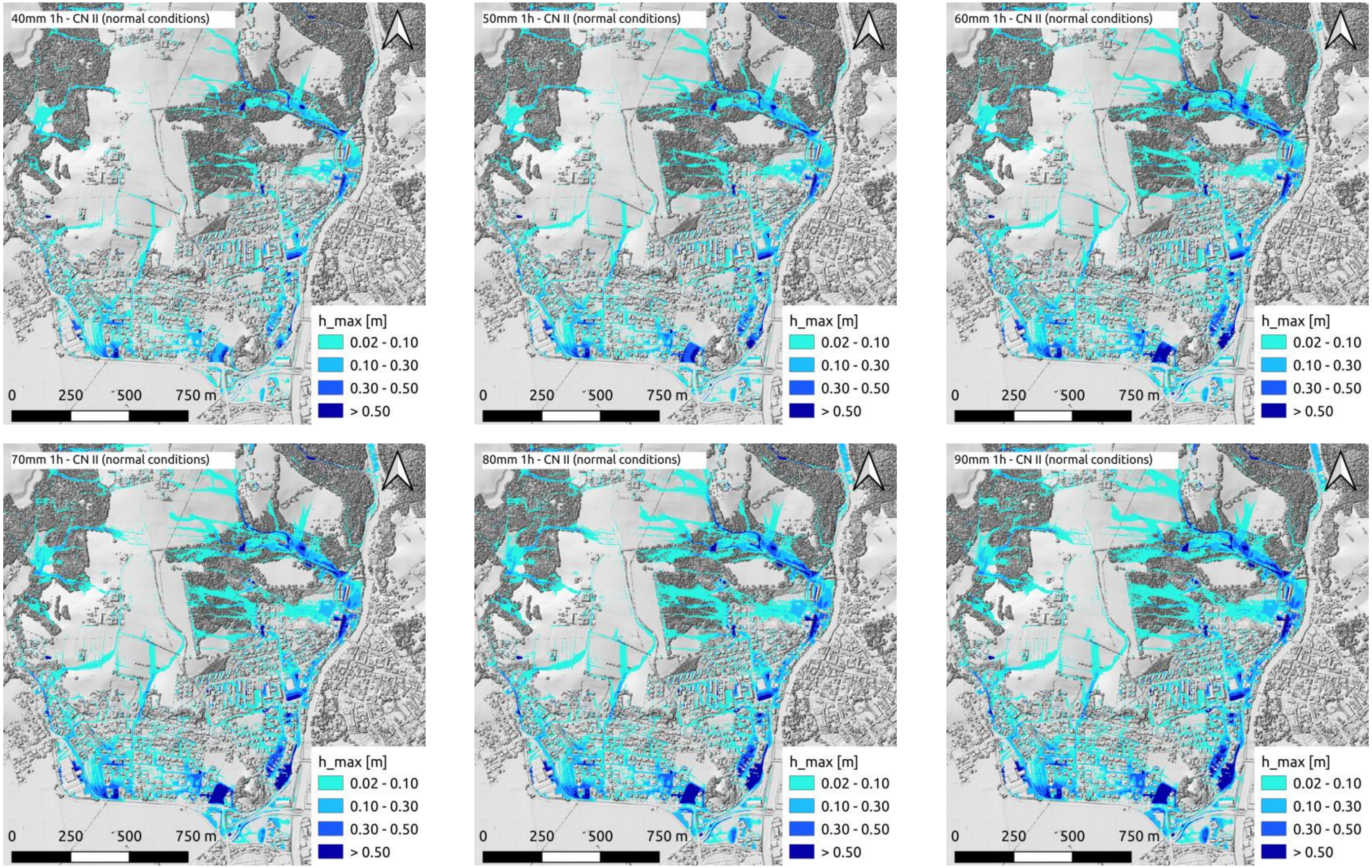
dry	sch_00 40mm	sch_01 50mm	sch_02 60mm	sch_03 70mm	sch_04 80mm	sch_05 90mm
standard	sch_06 40mm	sch_07 50mm	sch_08 60mm	sch_09 70mm	sch_10 80mm	sch_11 90mm
wet	sch_12 40mm	sch_13 50mm	sch_14 60mm	sch_15 70mm	sch_16 80mm	sch_17 90mm

Hydrologic pre-Processor (SCS-CN)



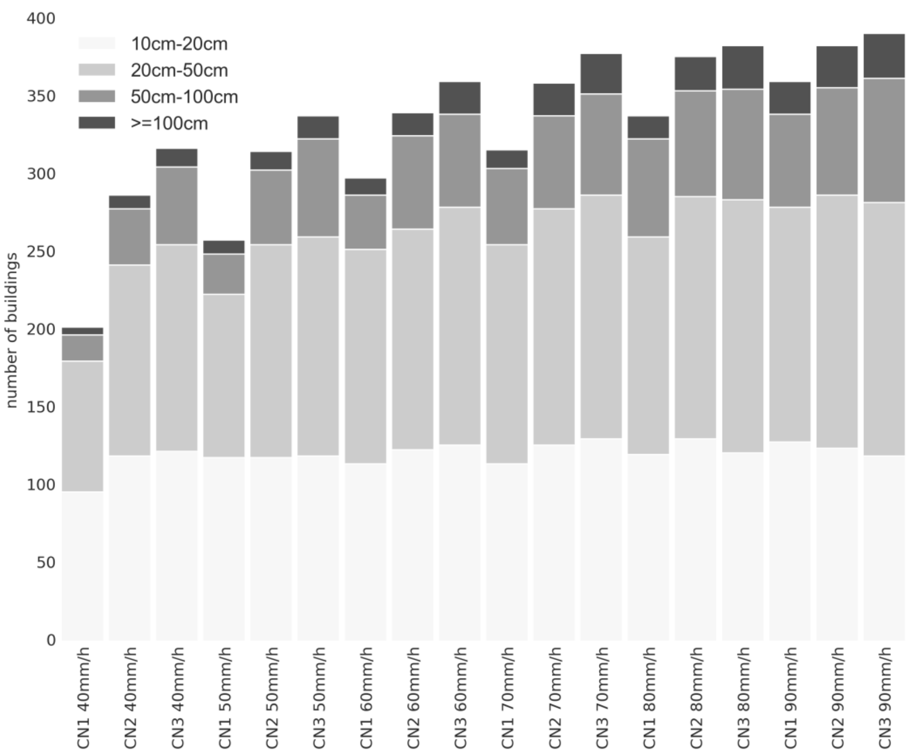
Example of a gridded precipitation time-series used as boundary conditions for the hydrodynamic simulations with Itzi. Based on a 50mm block-rainfall with 1h duration and normal antecedant conditions (AMC II) 10min raster-time series of the effective precipitation intensities were produced in a pre-processing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

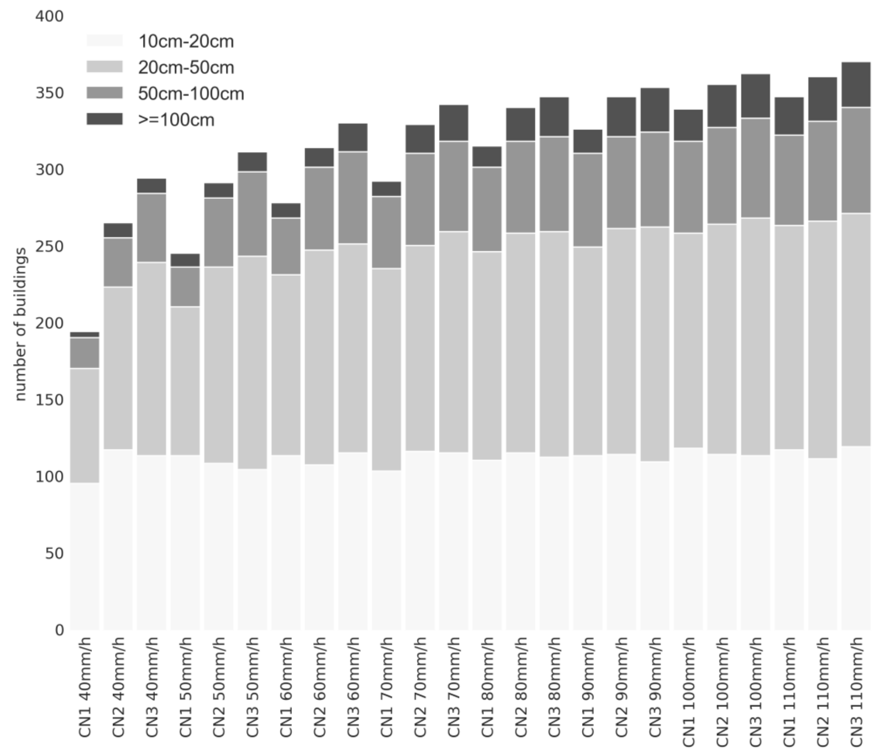
Hydrodynamic modeling (selected results)



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 pan-European ensemble (end century projections, rcp 8.5).

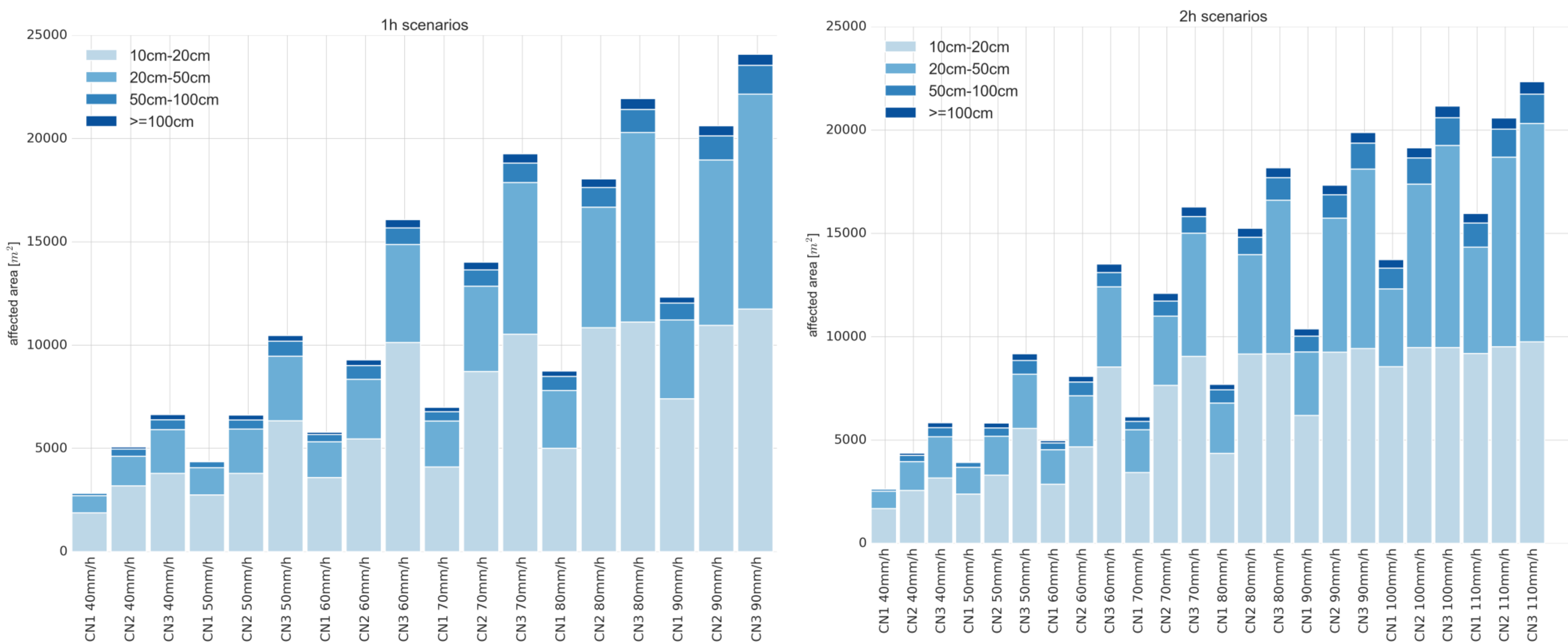
Hydrodynamic modeling (selected results)





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)



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.

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