High resolution weather models for storm simulations: uncertainty of results and impact on loss simulations

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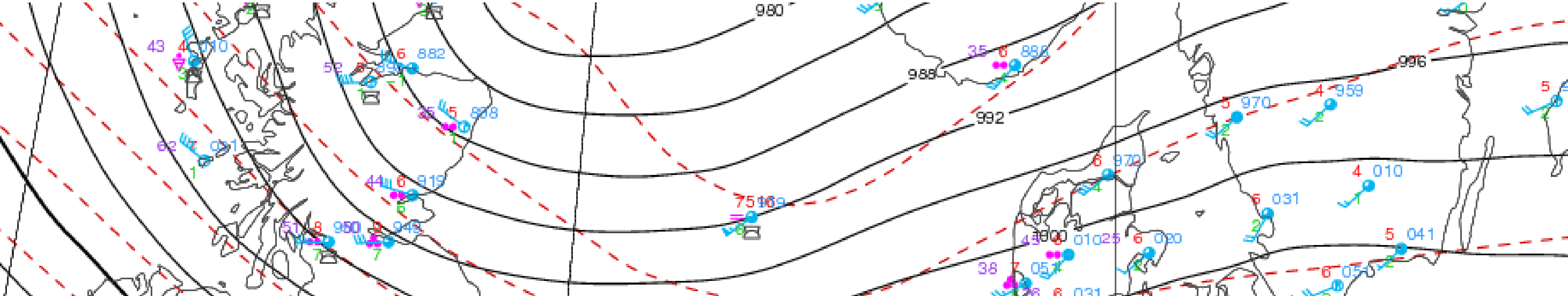
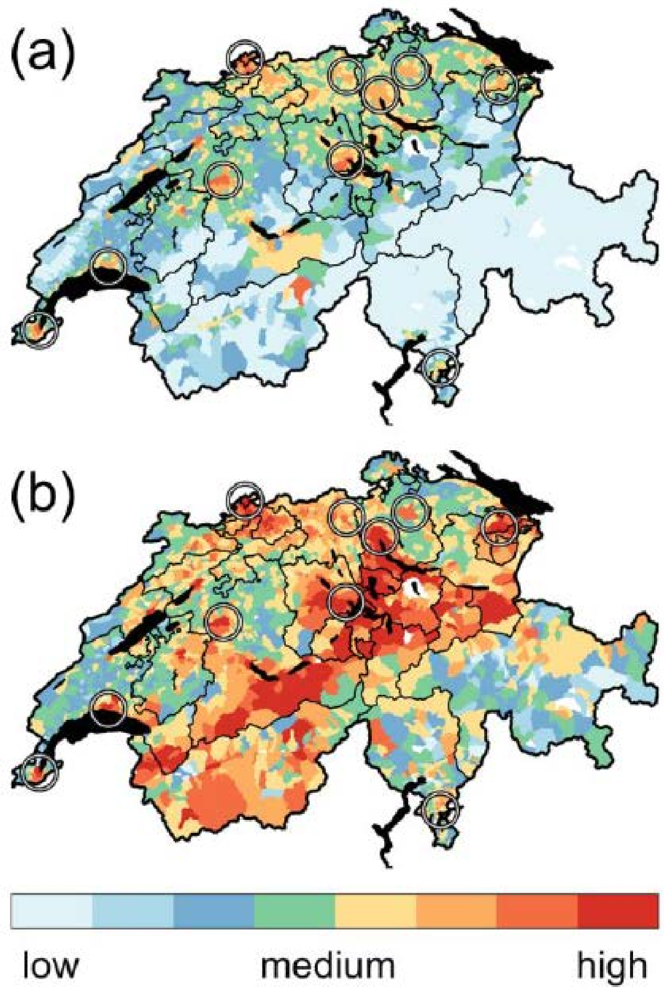


Motivation: Loss simulations



(a) Composite mean of simulated losses per km² for 84 winter storms for Switzerland

(b) Same as (a) with a different gust parameterisation

Source: Welker et al. (2015): Modelling economic losses of historic and present-day high-impact winter windstorms in Switzerland. Submitted to Tellus.

Poster by Stefan Müller: Maps of windstorm risk in Switzerland

A thousand ways to setup a model…

Setting up a model includes decisions about:

- Initial and boundary data
- Model domains
- Physical parameterizations
- Numerical schemes

Often, there is no „best“ setup…

E.g. Two different WRF setups for storm simulations in Switzerland (Poster Peter Stucki + Stucki et al., 2015):

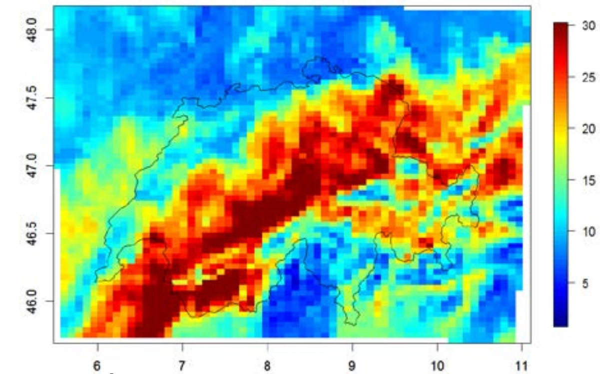
- Initial and boundary data (20CR – Era-Interim)
- Grid size (3km - 2km)
- PBL scheme (TKE – mixing length approach)

Evaluation results for 10m-wind speed similar, but very different model results.

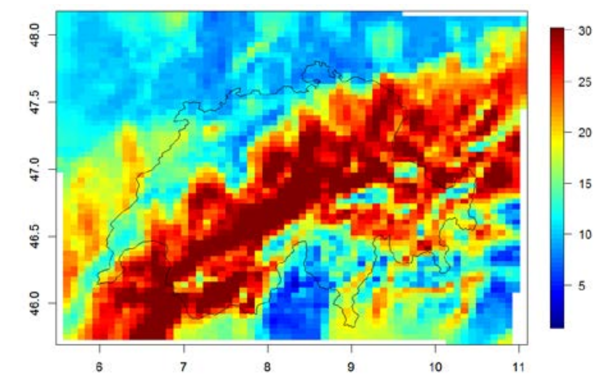
→Evaluation doesn‘t show which one is „better“, simulated losses would be very different

→What is the consequence for loss simulations based on weather model results?

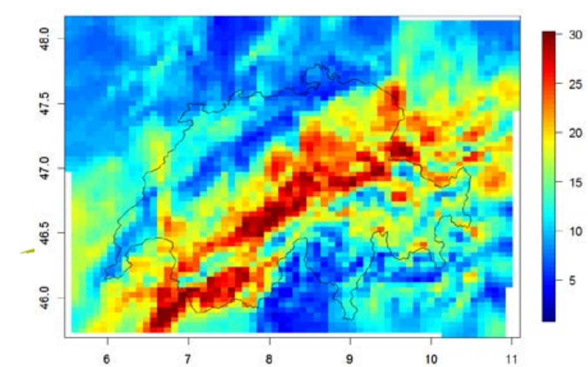
Source: Stucki et al. (2015): Evaluation of dynamical downscaling and wind gust parameterizations for recent and historical windstorms in Switzerland. In preparation.



Basic setup



Changed turbulence scheme



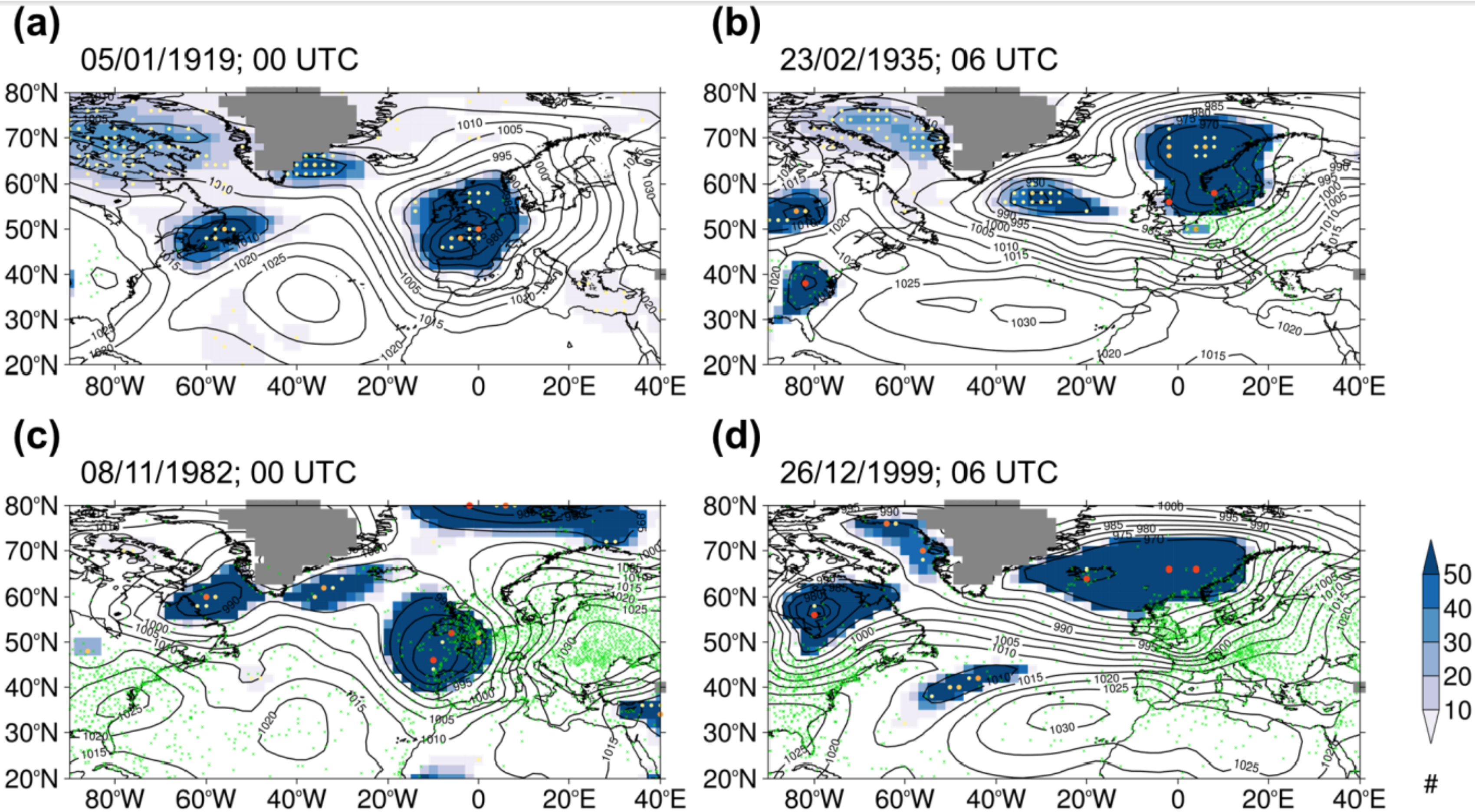
Changed initial and boundary data

Study Setup

Study: Sensitivity studies for four storm periods

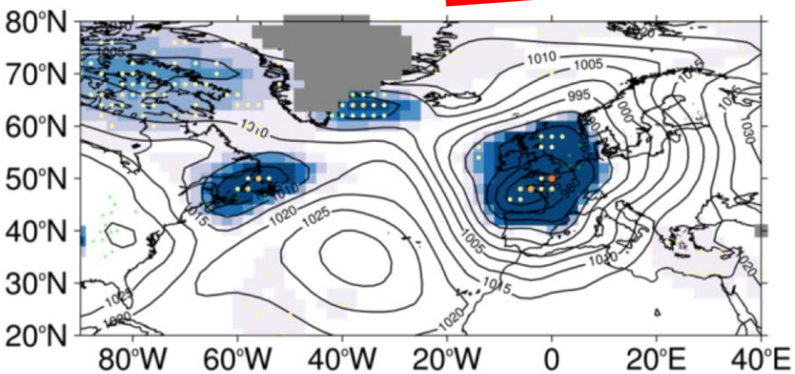
Two Foehn storms:
- 5 January 1919 (a)
- 8 November 1982 (c)

Two west-wind storms:
- 23 February 1935 (b)
- 26 December 1999 (d)

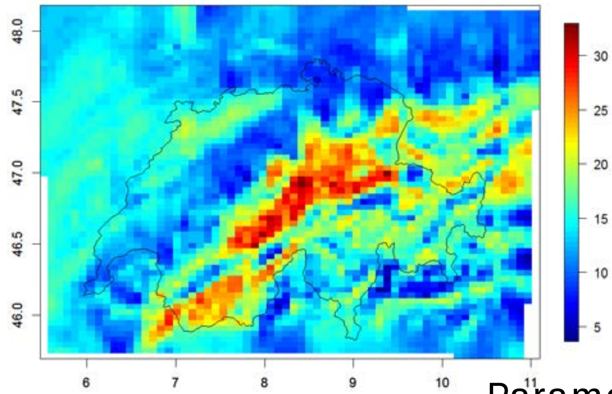


Source: Stucki et al. (2015): Evaluation of dynamical downscaling and wind gust parameterizations for recent and historical windstorms in Switzerland. In preparation.

Setup: Loss simulations based on high resolution weather models

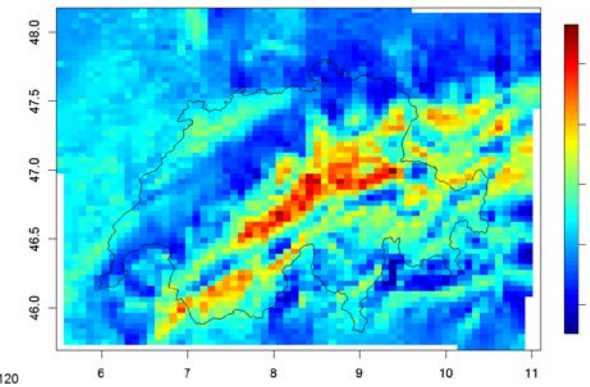


20CR

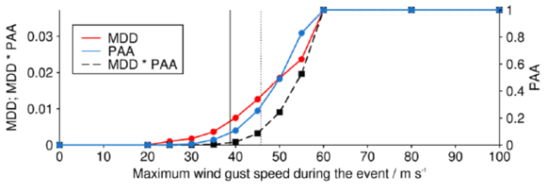


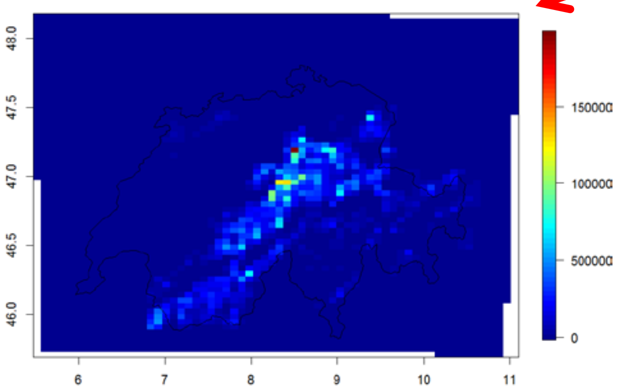
Downscaling using WRF

Parameterized gusts

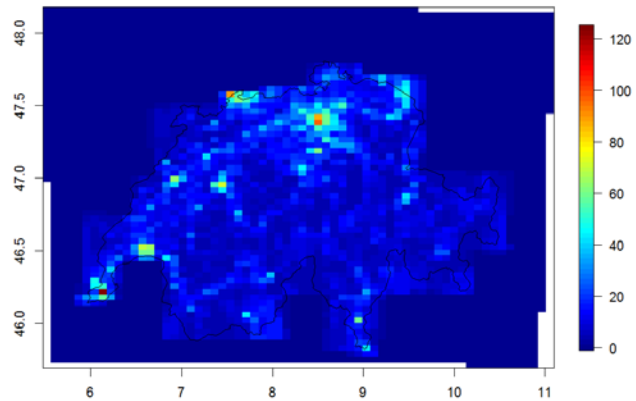


Exposure and loss ratio





Simulated loss



WRF Model Setup, V 3.3.1

Component	Setting
Initial and boundary data	20CR, ensemble mean
Model domains	45 – 9 – 3km, one-way nested
Vertical layers	31
PBL/Turbulence	TKE (Mellor and Yamada, 1982)
Land surface	Unified Noah (Chen and Dudhia, 2001)
Surface layer	Monin and Obukhov, 1954
Convection	Kain-Fritsch (Kain, 2004)
Microphysics	Lin, Farley, and Orville, 1983
Long-wave radiation	RRTM (Mlawer, et al., 1997)
Short-wave radiation	Dudhia, 1989

Evaluation of wind speed and wind gust presented:

- Poster by Peter Stucki: Evaluation of dynamical downscaling and wind gust parameterizations for recent and historical windstorms in Switzerland

Post-processing of WRF results

Component	Setting
Gust parameterization	according to Schulz (2008) (= gust parameterization of the COSMO model)
Exposure	250‘000 CHF/per inhabitant, spatial distribution population density (STATPOP by the Federal Office for Statistics) aggregated to WRF grid
Loss ratio	Based on simplified version of the Swiss Re loss model climada (e.g. Welker et al., 2015)

Sensitivity studies

Sensitivity study	Basic setting	New setting
Initial and boundary data 1	20CR, ensemble mean	NCAR/NCEP Reanalyses
Initial and boundary data 2	20CR, ensemble mean	20CR, lowest near-surface wind speed
Initial and boundary data 3	20CR, ensemble mean	20CR, highest near-surface wind speed
PBL/Turbulence	Mellor and Yamada scheme	Yonsei University scheme
Model domains	45 – 9 – 3 km	45 – 9 – 2.25 km
Vertical layers	31	61
Gust parameterization 1	COSMO parameterization	WRF default parameterization
Gust parameterization 2	COSMO parameterization	Parameterization following Brasseur (2001)
Loss ratio	based on Swiss Re's climada model	According to Munich Re, 2002

Wind gust parameterizations

1) Standard post-processing for gusts for WRF

$$ffx_{10} = ff_{10} + \frac{(ff_{PBL} - ff_{10}) * h_{PBL}}{2000}$$

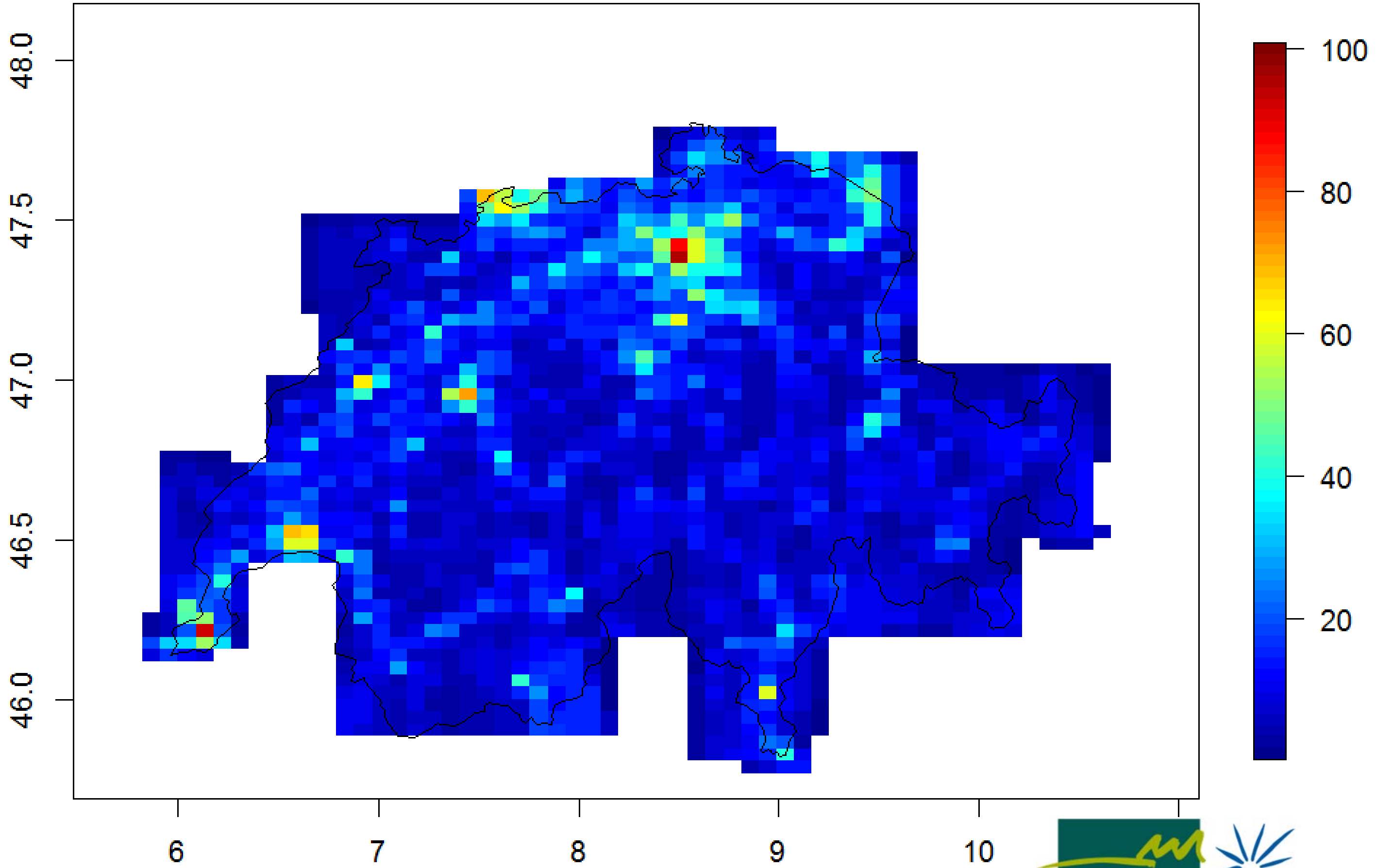
2) Gust parameterization in COSMO

$$ffx_{10} = ff_{10} + (3 * 2.4 * u_*)$$

3) Gust parameterization according to Brasseur (2001)

$$\frac{1}{z_p - z_{10m}} \int_{z_{10m}}^{z_p} TKE(z)dz \geq g \int_{z_{10m}}^{z_p} \frac{\Delta\theta_v}{\theta_v}(z)dz$$

Exposure: population density aggregated to the WRF grid



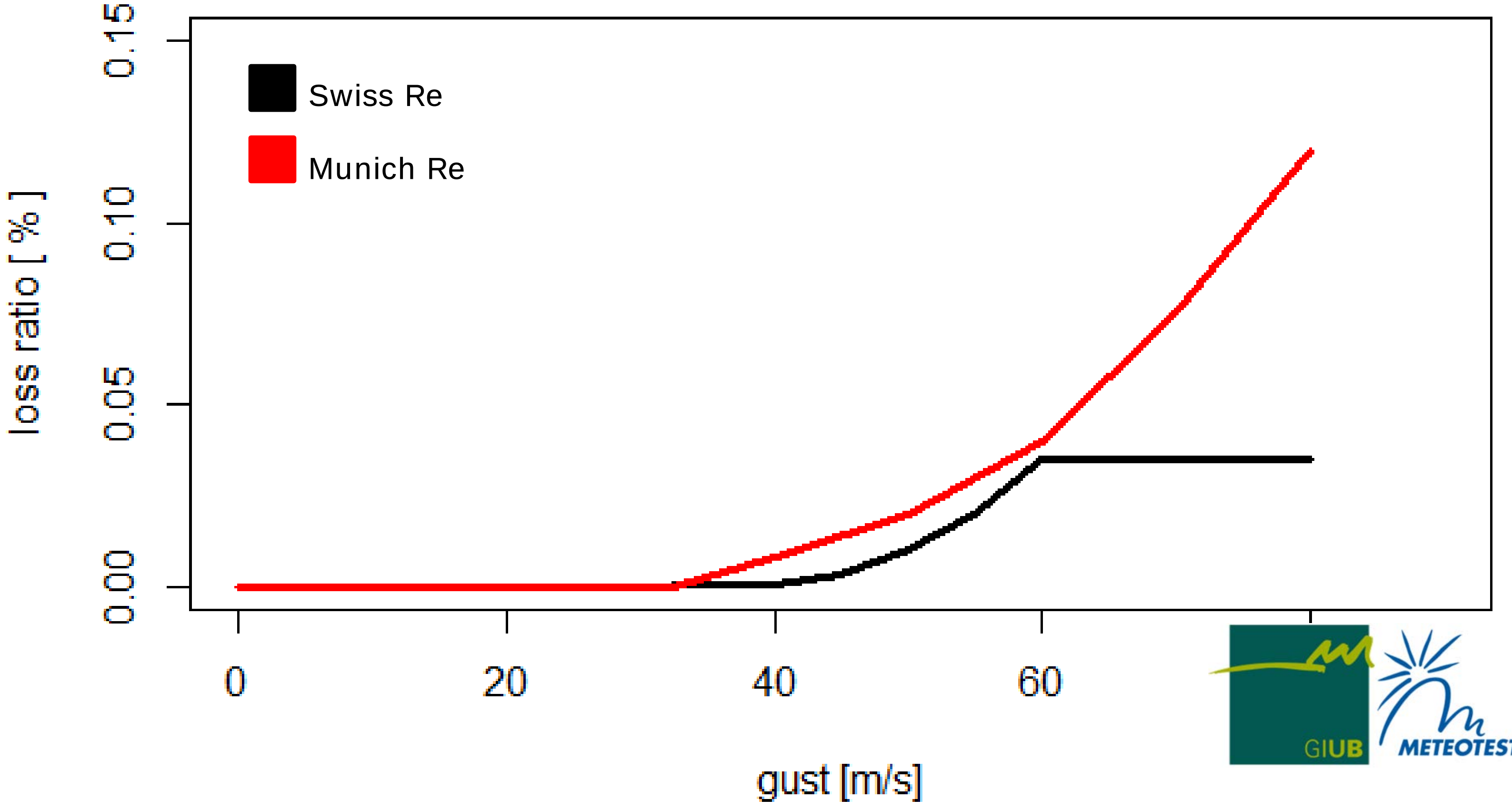
Loss ratio curves

MunichRe loss ratio

- adjusted to gusts by muliplying wind speed with an average gust factor for Switzerland of 1.75

Idealized setup of loss simulations:

- Exposure and loss ratio curves are suitable for plausible but not for realistic results



Results

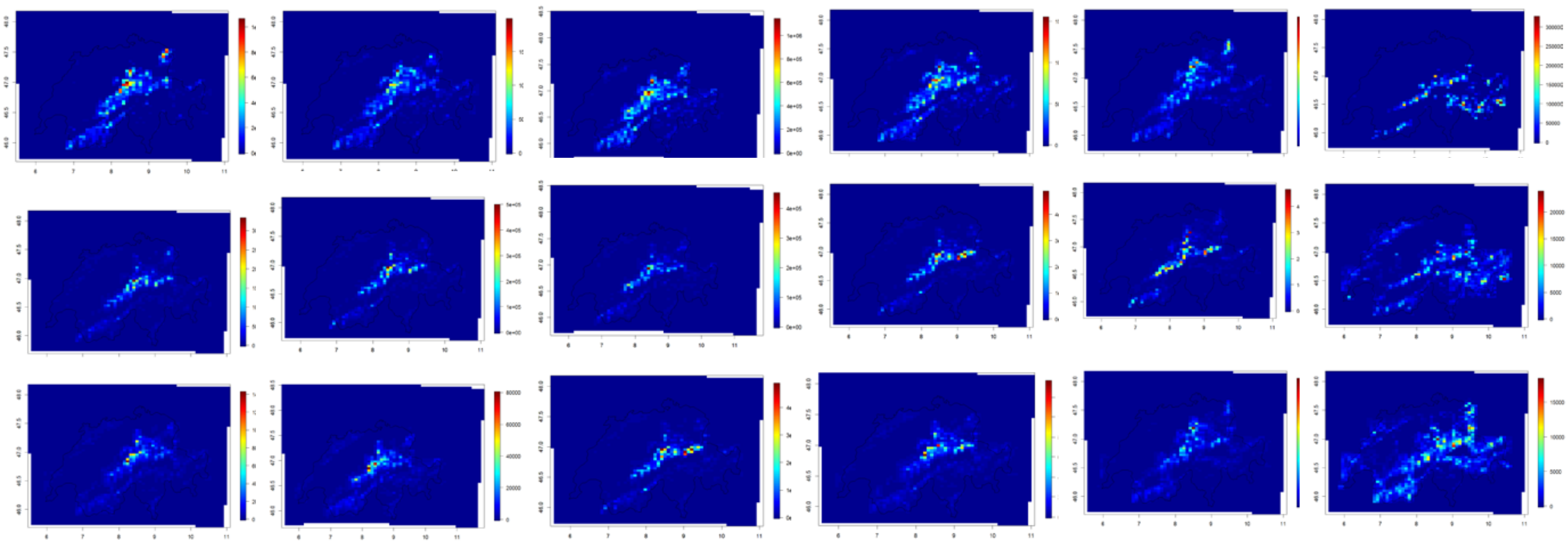
Results: Loss simulations

Loss simulations for:

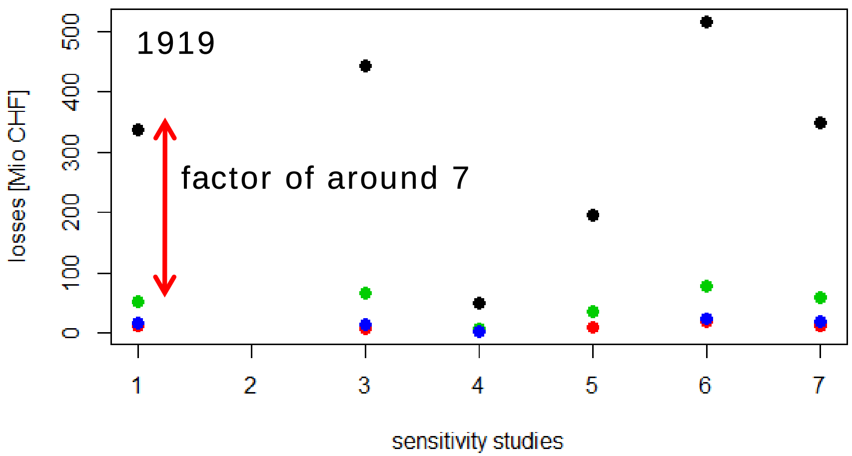
- 7 model setups
- 2 loss ratio curves
- 3 gust parameterizations
- 4 storms

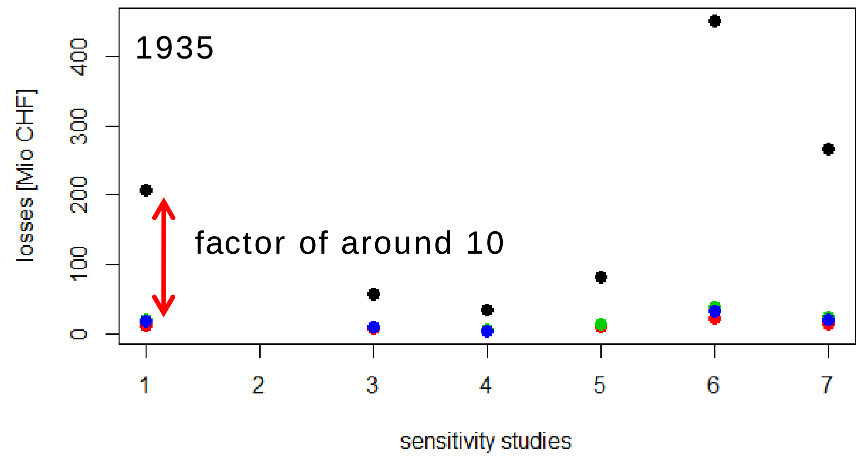
Comparison for:

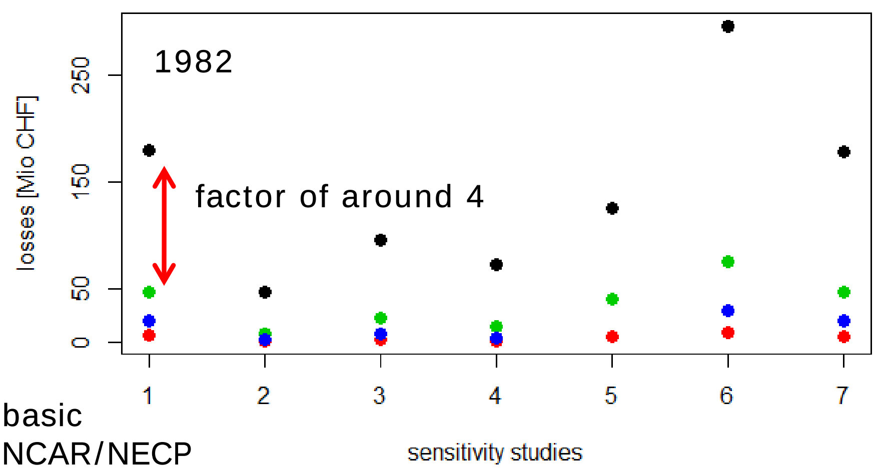
- Sum of losses for Switzerlands

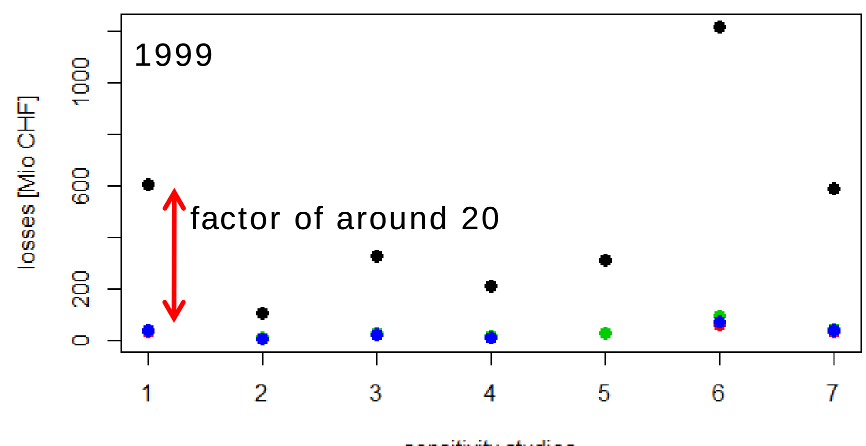


Simulated losses: all storms and sensitivity studies









1 basic
2 NCAR/NECP
3 20CR high
4 20CR low
5 Turbulence
6 grid size 2km
7 vertical grid

- Munich Re
- Swiss Re, WRF
- Swiss Re, reference
- Swiss Re, Brasseur

➔ Biggest difference for different loss ratio curves

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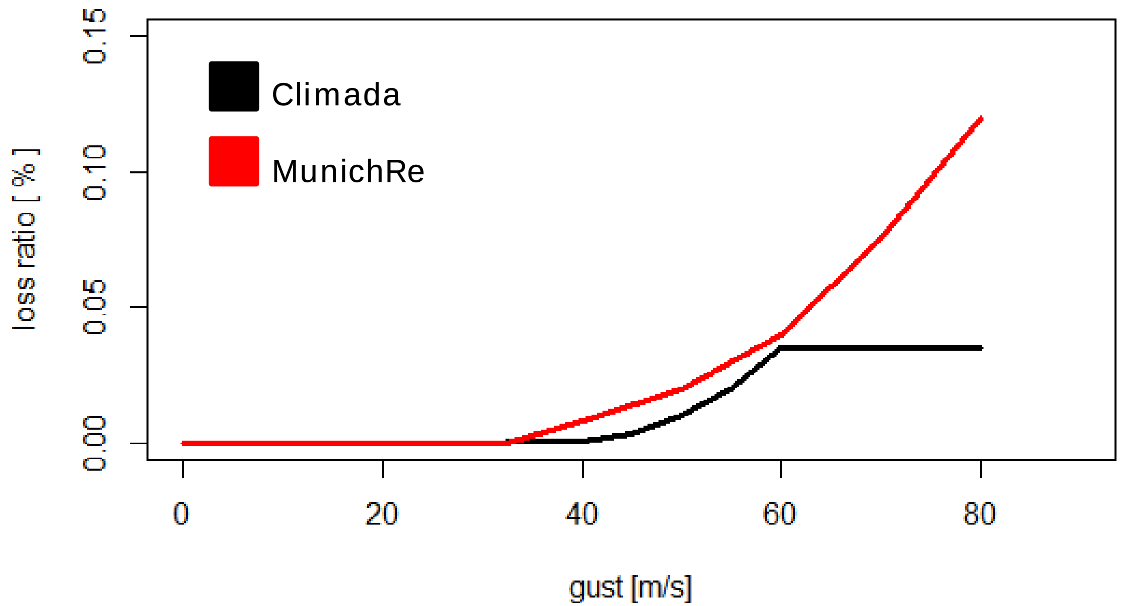
Reason for differences between simulations with Swiss Re / Munich Re loss ratios

1. reason



2. reason

Munich Re loss ratio based on wind speed:

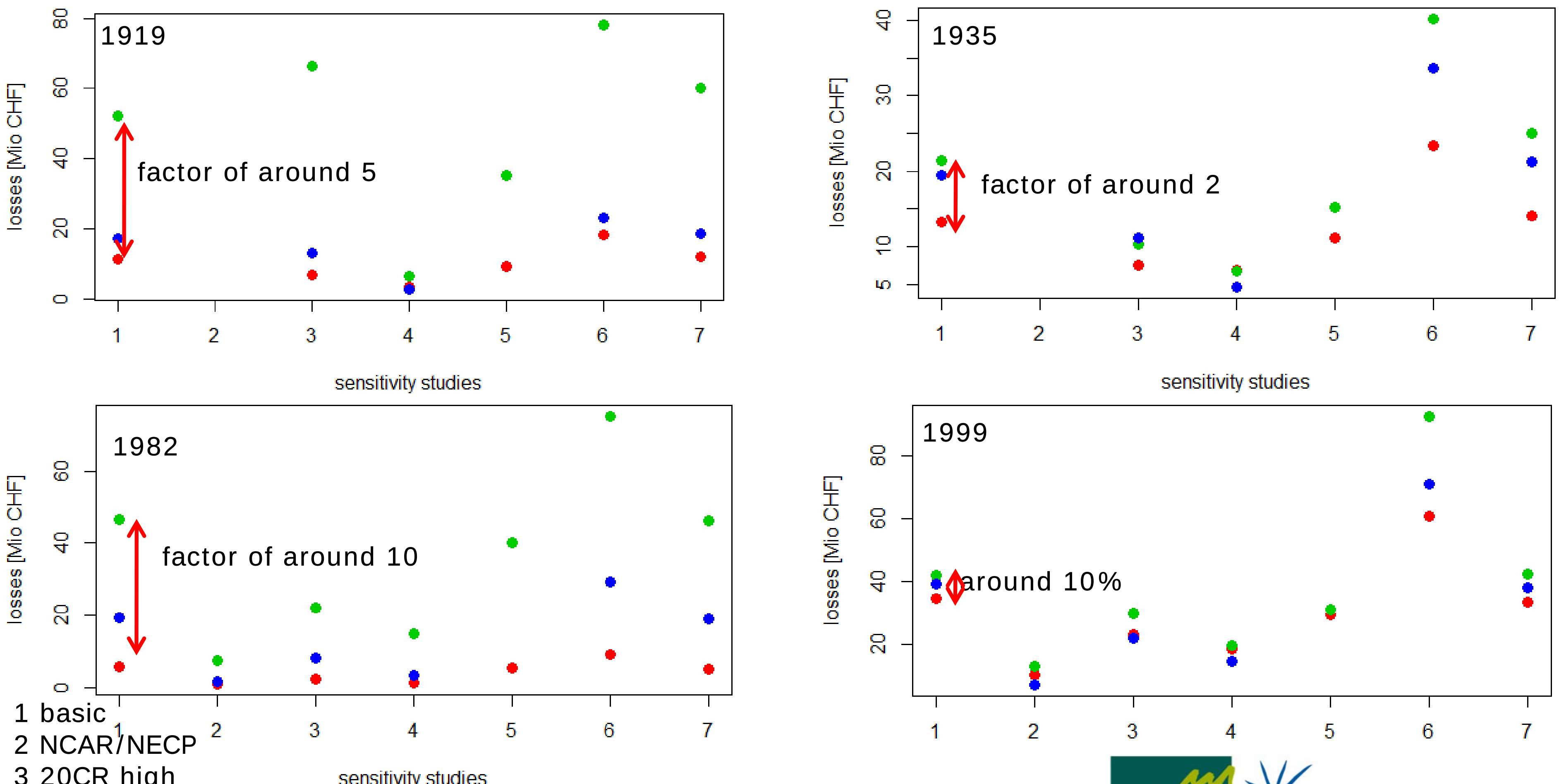
- Wind speed bias +2.6 m/s

Swiss Re loss ratio is based on wind gusts:

- Wind speed bias -2.5 m/s

➔ **underlines the need for calibration**

Simulated losses: all storms and sensitivity studies, Swiss Re loss ratio



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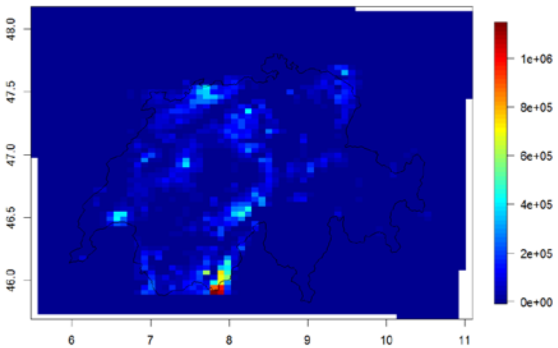
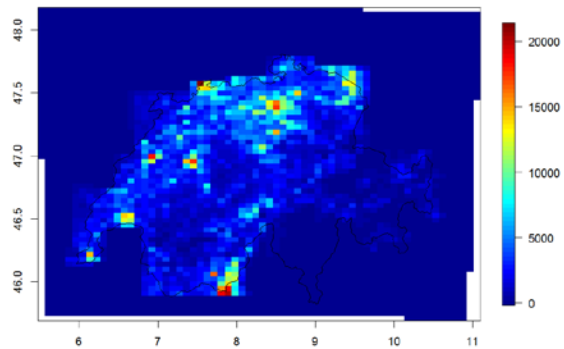
➔ **Bigger differences for Föhn storms?**

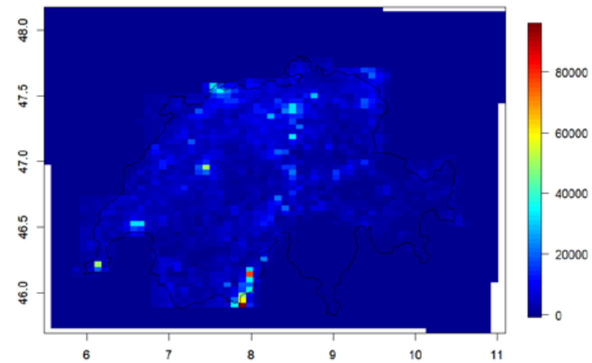
Simulated losses: Munich Re, Swiss Re – WRF gust, Swiss Re - COSMO gust for storms 1935, 1982

MunichRe – wind speed | Swiss Re – WRF gust | Swiss Re – COSMO gust

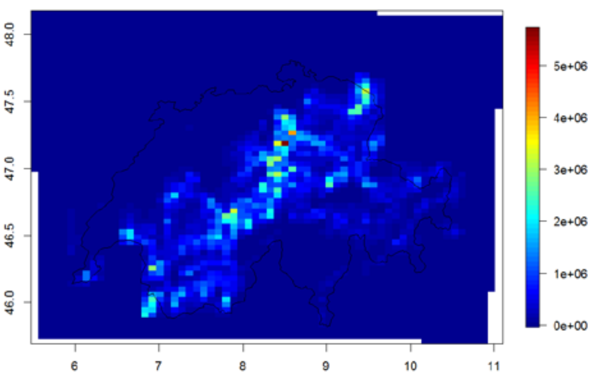
1935 – west wind

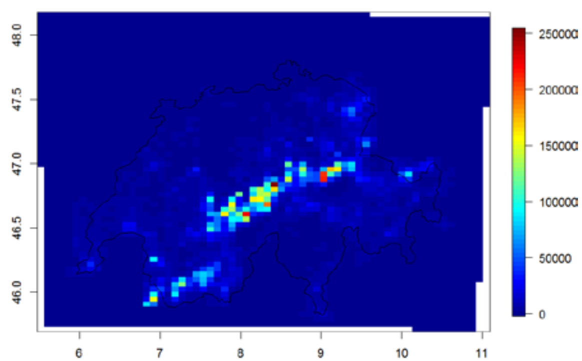


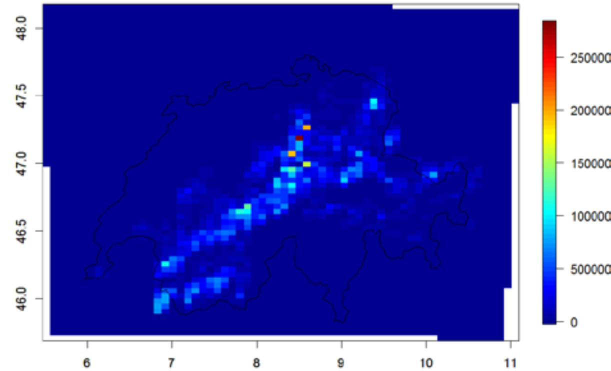




1982 - Foehn







Scales are different to highlight the spatial pattern

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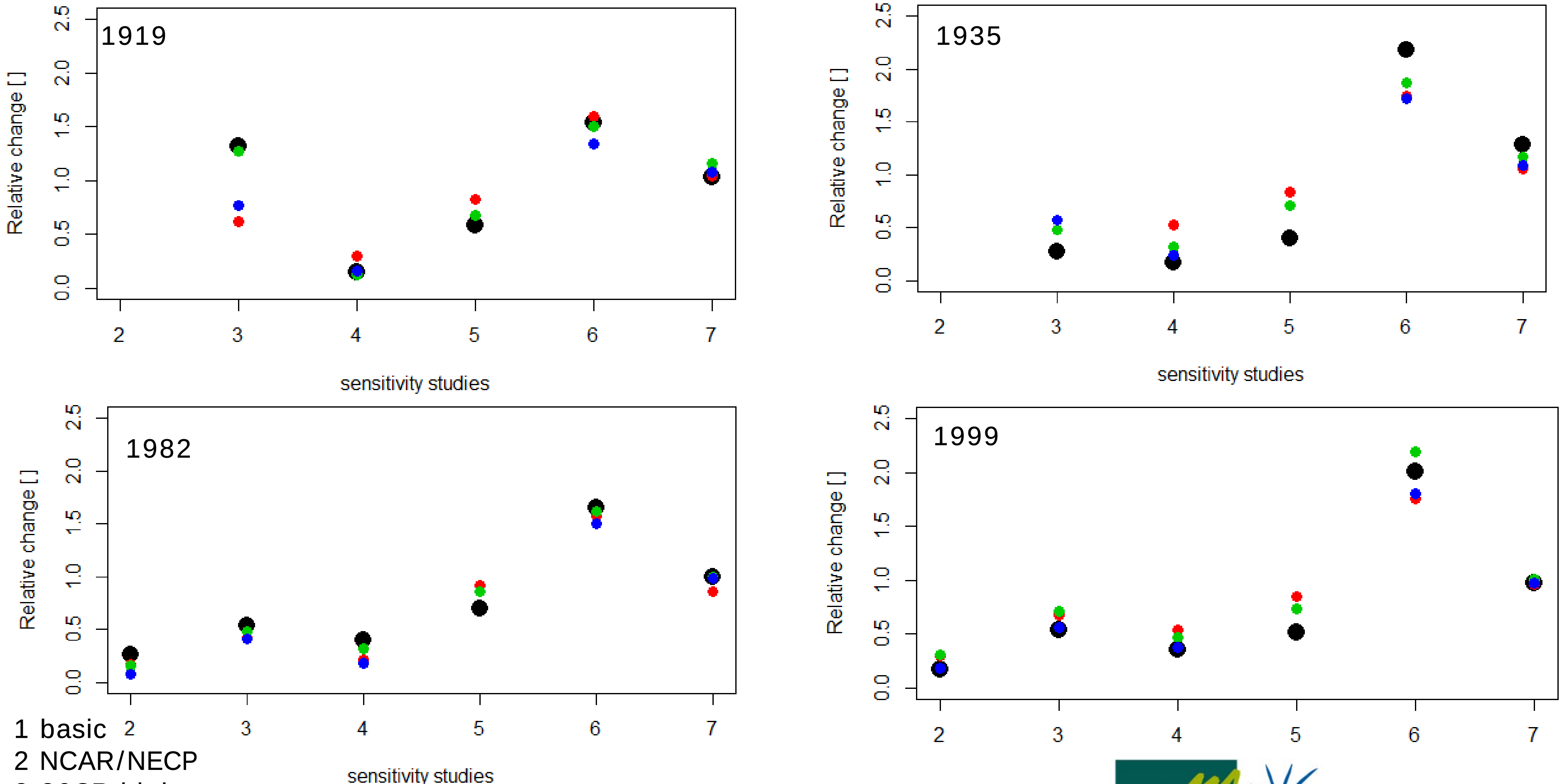
Total loss compared to the basic simulation: all storms and sensitivity studies



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➔ change with Munich Re and Swiss Re loss ratio similar

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Relative loss changes for different model setups

1) Loss changes quite similar for Munich Re and Swiss Re loss ratio simulations
2) Loss changes quite similar for the four storms
3) also for changed initial and boundary conditions - ???
4) Lowest and highest surface wind speed in 20CR not the criterium for lowest and highest wind speed in downscaling
5) Increased horizontal resolution: increased loss – higher for west wind?
6) Change of vertical grid not relevant
7) Yonsei University scheme – slight changes of pattern, but mainly lower surface wind speed

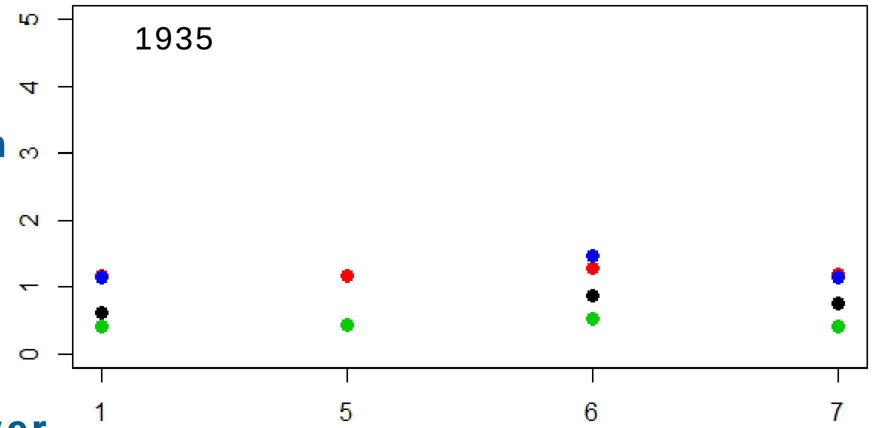
Total loss compared to 1919 storm

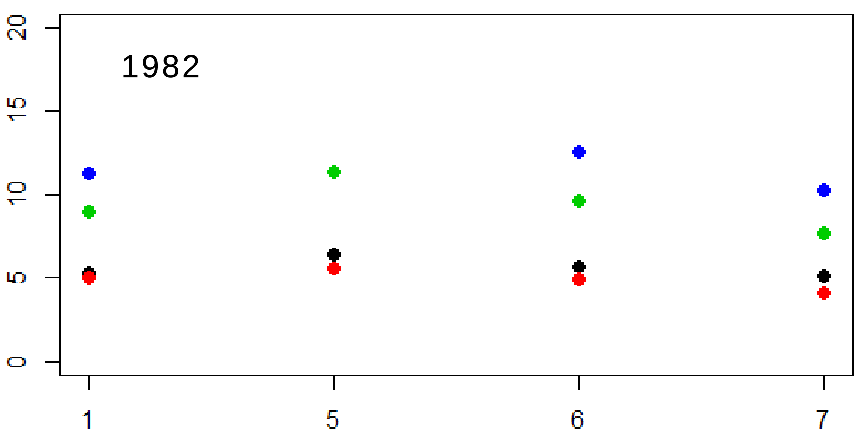
1) How big are losses of a storm compared to the one in 1919?

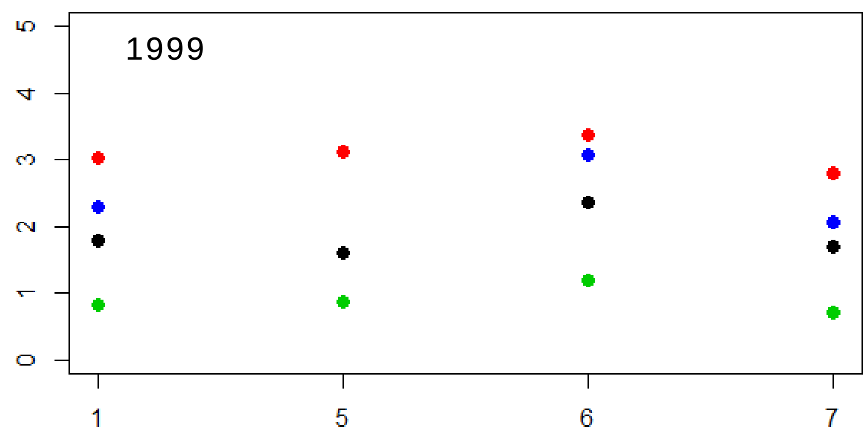
2) Answers can be very different depending on using wind speed or different gust parameterizations:

- Ratio between 0.5 and 2 for 1935
- Ratio between 5 and 12 for 1982
- Ratio between 1 and 3 for 1999

3) Relative losses don‘t give a consistent answer







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Summary / Conclusions

1) Biggest impact on simulated losses by using different loss ratio curves

- Loss ratio curves itselves are different
- Input different: wind speed <-> gust – different error characteristics
- ➔ to get realistic results simulations need to be calibrated

2) Changes due to model setup up to around 100%:

- Strongest change with increased horizontal resolution
- mainly for west wind....?
- Reductions of 20-50% due to PBL scheme
- Vertical grid not relevant

- Mainly a bias in the near surface wind speed
- Changes similar for different storms and gust parameterizations
- ➔ difference will be removed with calibration

3) Comparing total losses for different storms

- Different model setups give similar changes
- different gust parameterizations give very different changes
- ➔ loss simulations based on wind speed seems more robust than based on gusts

➔ **Need for calibration data or a robust loss ratio curve**