Project "Convective Wind Gusts" (ConWinG)

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Motivation & aim

- Convectively-driven strong winds usually associated with thunderstorms frequently cause substantial damage to buildings and other structures in many parts of the world.
- Due to the small-scale and non-stationary nature of those events, there is a considerable lack of knowledge regarding the characteristics and statistics of convective gusts. Furthermore, their interaction with urban structures and their influence on buildings is not yet fully understood.
- According to this, convective wind events are not included in the present wind load standards of buildings and structures, which so far have been based solely on the characteristics of synoptically-driven wind gusts in the near-surface boundary layer.
- In an effort to remedy this situation, the overarching objectives of the **DFG-project "Convective Wind Gusts" (ConWinG)** are an improvement of the fundamental understanding…:
  1) … of convective gusts concerning their characteristics and statistics in Germany (**Meteorological part**) and
  2) … of their interaction with urban structures and influence on buildings (**Engineering part**).

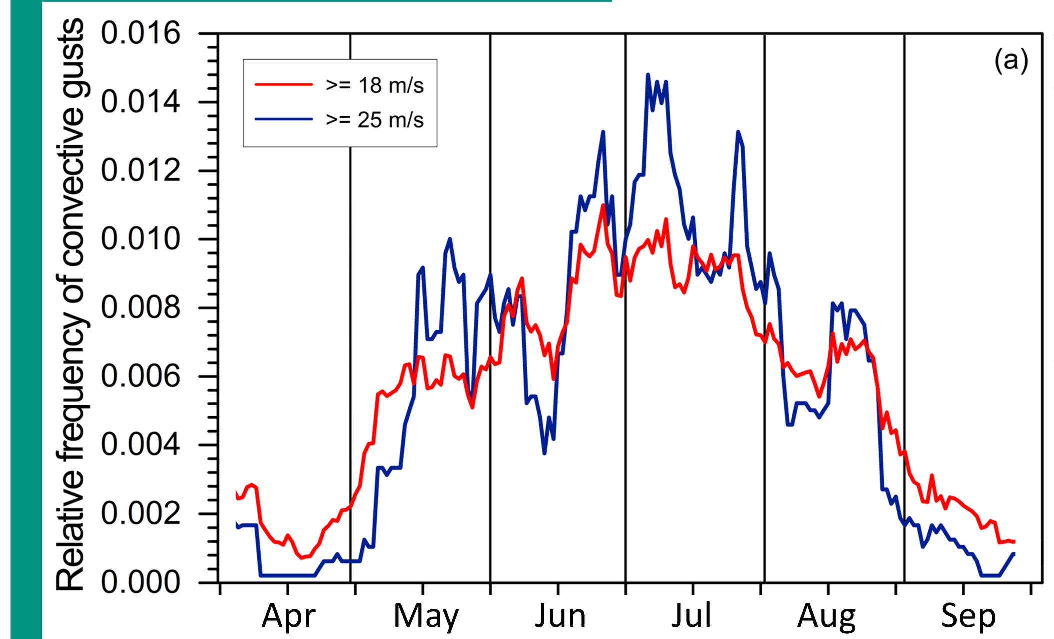
Fig. 1: Losses associated with a microburst event in Framersheim (Rhineland-Palatinate, Germany) on 7th June 2015 (© Susanna Mohr).

Conclusions

- Similar to other convective-related phenomena convective gusts occur predominantly in warm summer months, when atmospheric conditions favor the formation of severe thunderstorms.
- Convective gusts above 20 (25) m s^{-1} are on average observed throughout Germany each (10) year(s).
- A comparison of 20-year return values of convective gusts with those of turbulent gusts demonstrates that the latter have higher frequencies, especially in northern Germany.
- High velocities caused by downbursts can be conserved over long distances within street canyons. Conservations depends on the ratio of building height to downdraft size.
- Wind loads caused by downbursts exceed those specified in national standards (e.g., EUROCODE) especially on roofs.

Seasonal variability

How is the monthly distribution of convective gusts in Germany?



	≥ 18 m/s	≥ 25 m/s
April	5,4 %	2,5 %
May	17,9 %	17,0 %
June	26,0 %	26,4 %
July	28,2 %	34,9 %
August	17,3 %	16,3 %
September	5,4 %	3,0 %

Fig. 2: Mean seasonal distribution (running 11-day) of relative frequency of convective gusts exceeding a threshold of 18 m s^{-1} (red) and 25 m s^{-1} (blue) considering 110 climate stations of the German Weather Service (DWD, 1992 – 2014; Mohr et al. 2017).

Return values and periods

Which return periods can be expected?

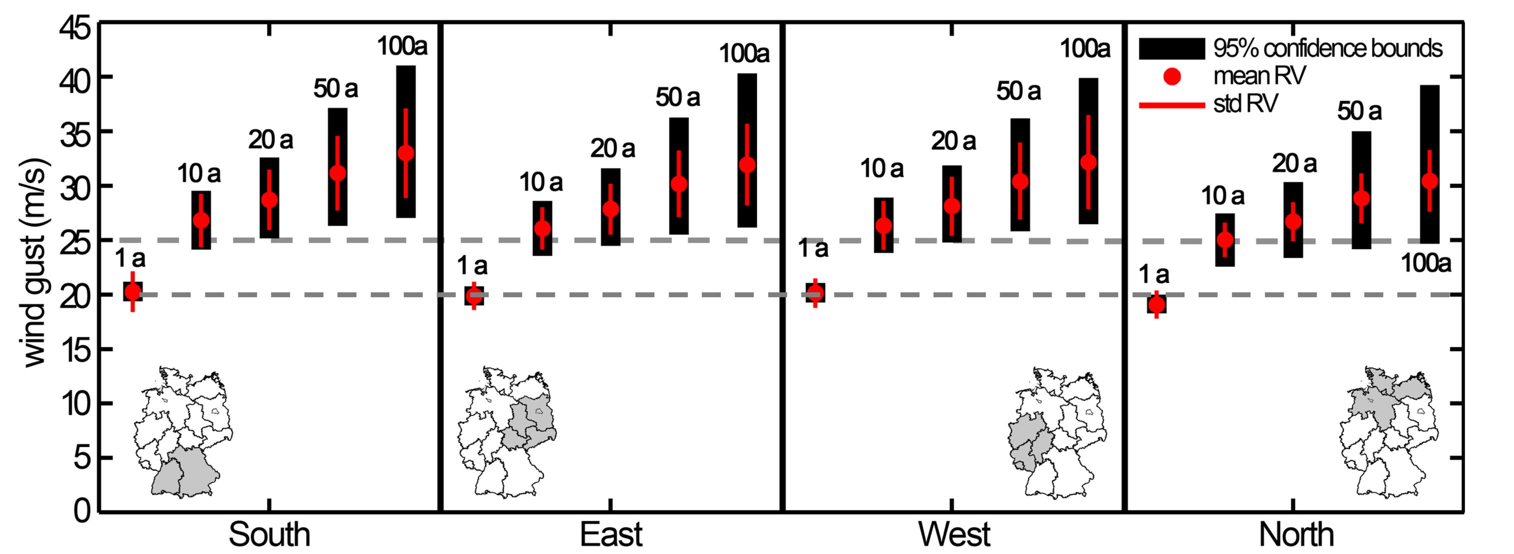
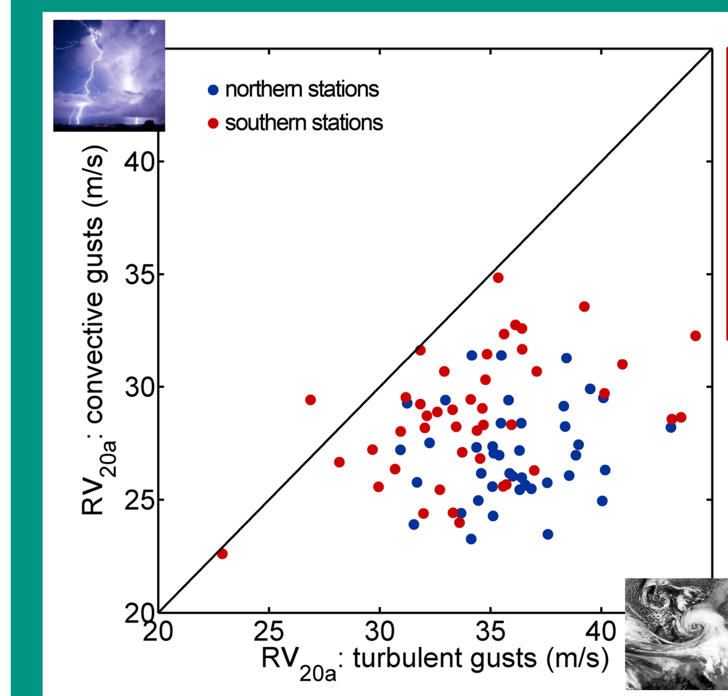


Fig. 3: Mean return values of convective gusts (RV) for various return periods in four regions in Germany. Red lines indicate the standard deviation from all stations within , and black bars indicate the mean 95% confidence bounds in the respective regions (Data basis: 110 climate stations of DWD, 1992 – 2014; Mohr et al. 2017).

Return values: convective vs. turbulent

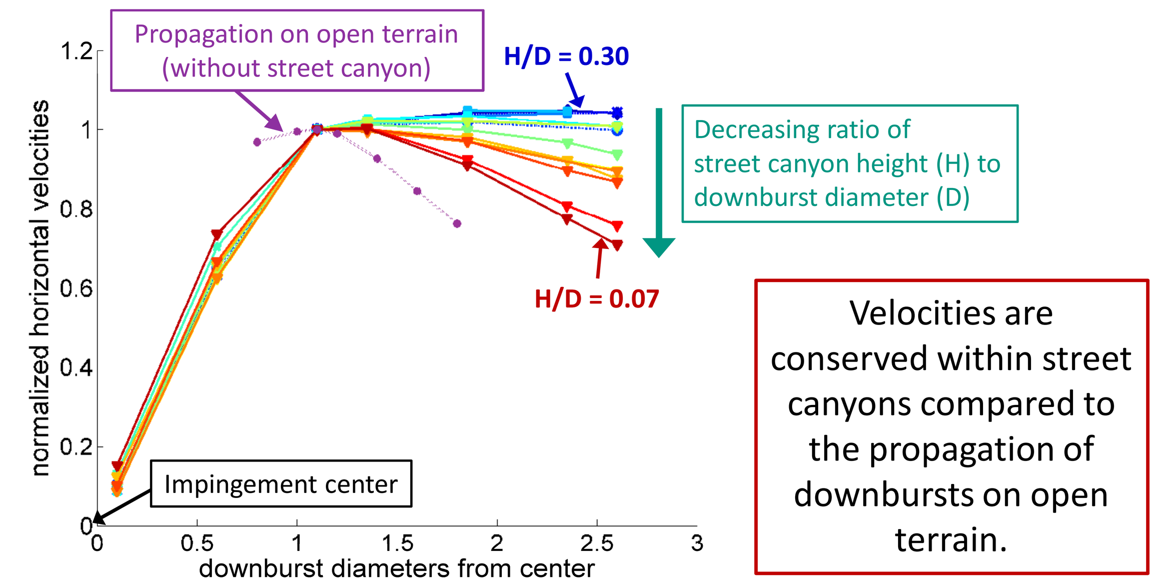


RV_{conv} < RV_{turb}

Differences:
Mean ± Std: 7.3 ± 3.9 m/s
North: 9.0 ± 3.2 m/s
South: 5.6 ± 3.8 m/s

Fig. 4: Scatterplot between the return value of a convective and turbulent gust for a return period of 20 years split into northern (blue) and southern stations in Germany (red; DWD, 1992 – 2014; Mohr et al. 2017).

Horizontal velocities in a street canyon



Velocities are conserved within street canyons compared to the propagation of downbursts on open terrain.

Fig. 5: Normalized horizontal velocities within street canyons under the influence of a downburst at different distances from the impingement center (x=0), for different size ratios of building height to downburst diameter H/D (Experimental investigation; Richter et al., 2017).

Wind loads

How strong are the wind loads that act on a building under the influence of a downburst?

Fig. 6: Photo of the experimental setup. Block array represents an idealized city. Pressure distribution was measured at a single block in the array (scale 1:800).

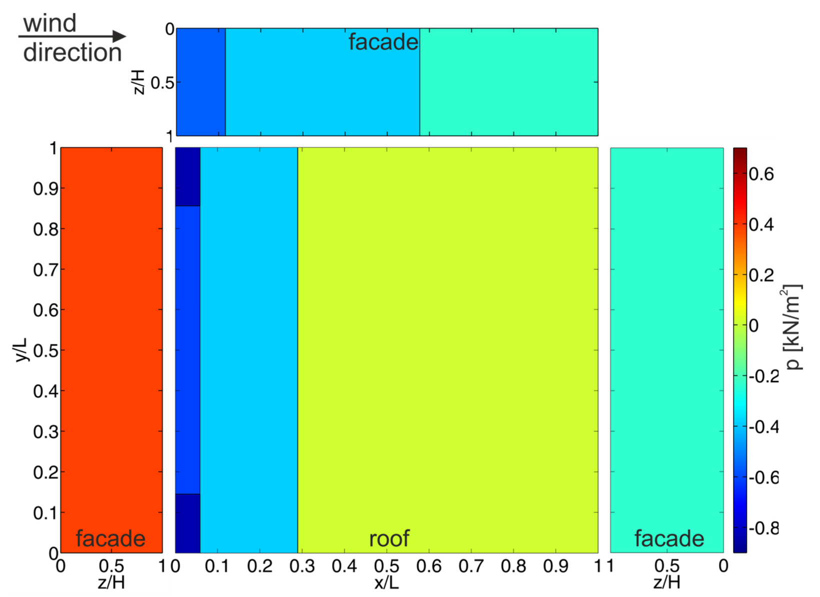


Fig. 7a: Pressure distribution according to DIN / EUROCODE for a building with a height of 21 m in cities in South Germany.

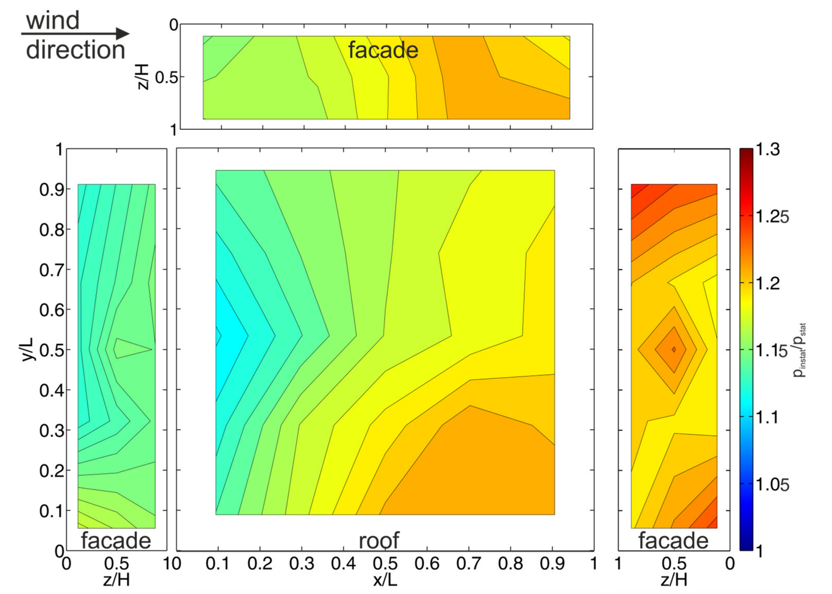


Fig. 8: Ratio of peak pressure values during passage of gust front compared to steady conditions p_{instat}/p_{stat}. Effect of unsteady flow conditions (developing ring vortex and sudden increase of velocity).

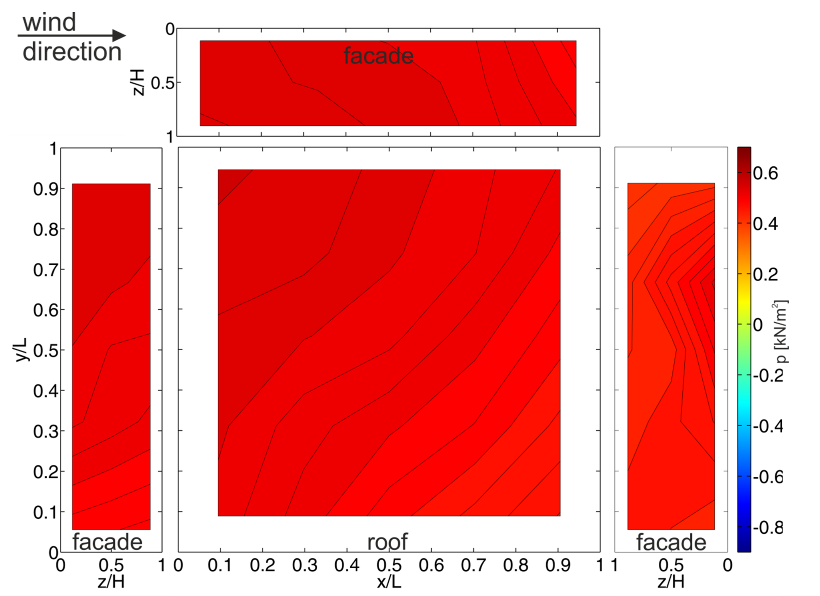


Fig. 7b: Pressure distribution in the impingement center of a downburst with a vertical velocity of 30 m s^{-1} (~ RV_{50a}; see Fig. 3).

- Additional increase in wind loads due to unsteady conditions of downbursts.
- Wind loads caused by downbursts can exceed those specified in national standards.

Mohr, S., Kunz, M., Richter, A. and Ruck, B. (2017): Statistical characteristics of convective wind gusts in Germany. *Nat. Hazards Earth Syst. Sci. Discuss.* doi:10.5194/nhess-2016-402.

Richter, A., Ruck, B., Mohr, S. and Kunz, M. (2016): Interaction of severe convective gusts with a street canyon. *Urban Clim.* doi:10.1016/j.uclim.2016.11.003.

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