Characteristics of convective wind gusts in Germany

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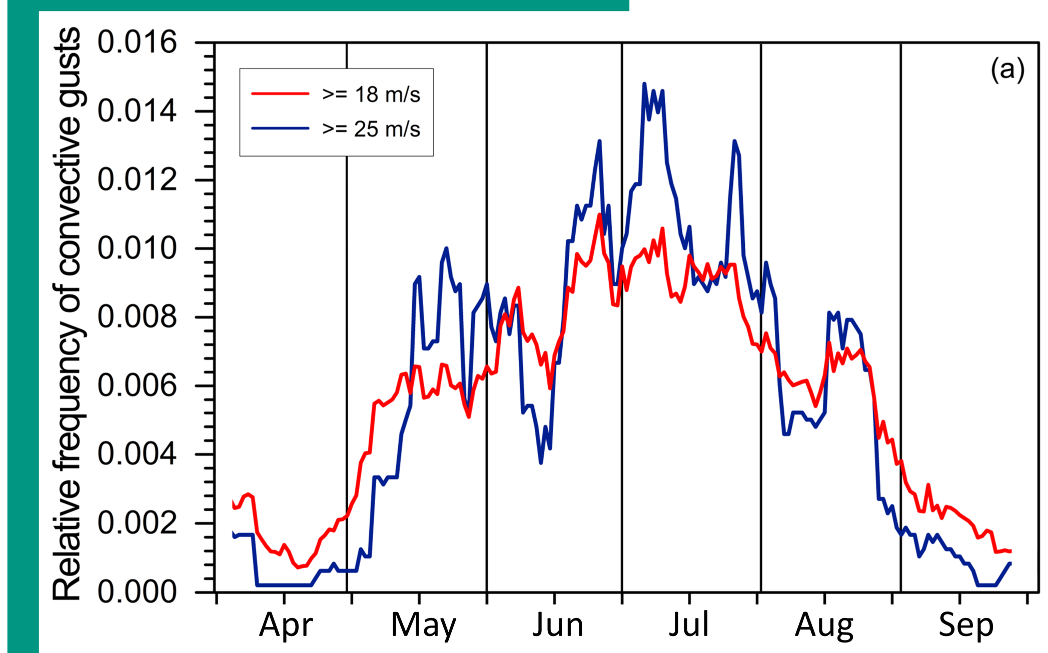
Motivation

- 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).

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 & periods

Which return values can be expected?

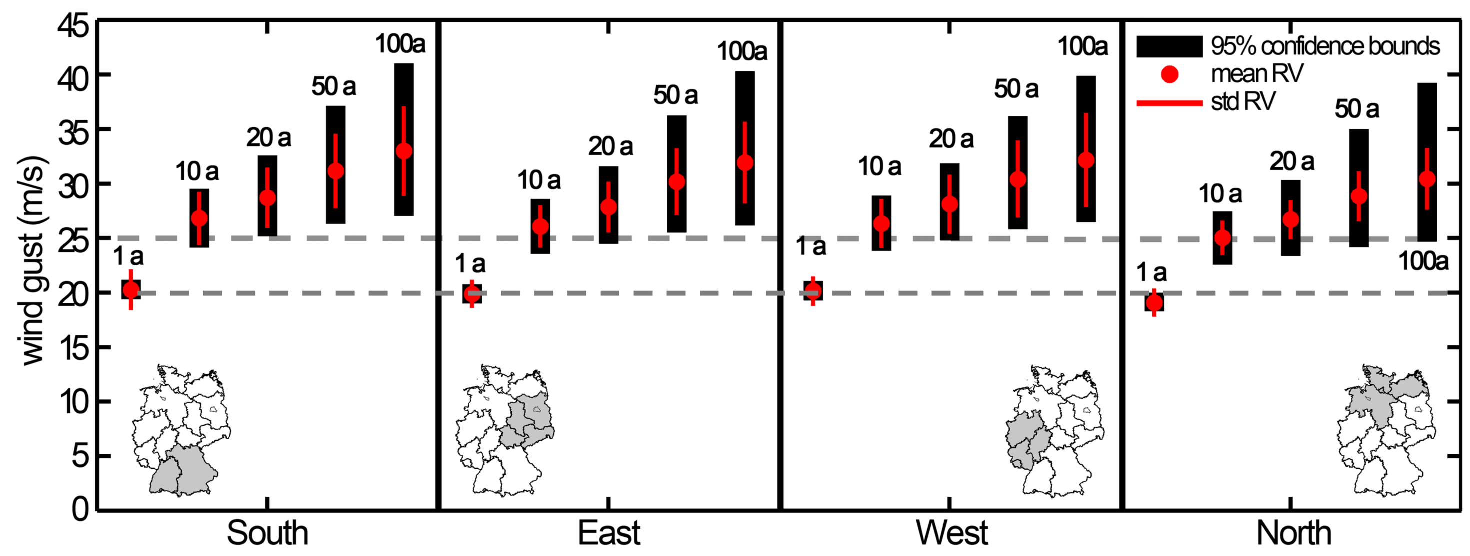


Fig. 3: Mean return values of convective gusts (RV) for various return periods in four regions in Germany. Red lines indicate the standard deviation from all stations within, and black bars indicate the mean 95% confidence bounds in the respective regions (Data basis: 110 climate stations of DWD, 1992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

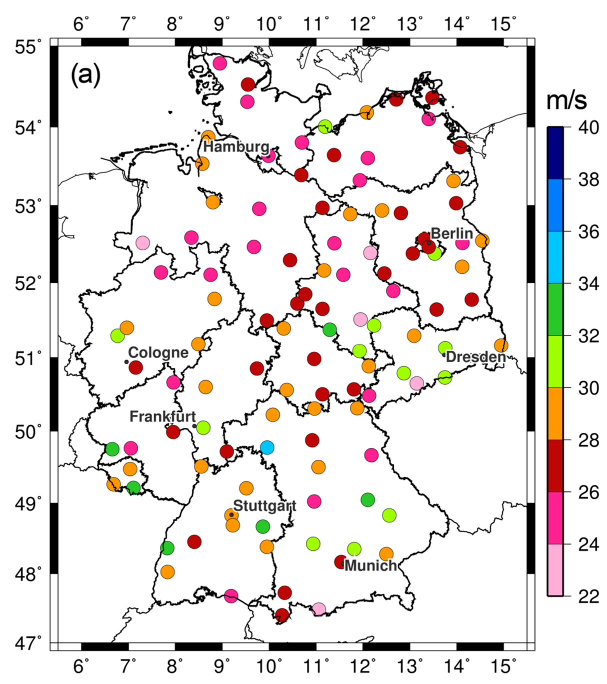


Fig. 4: Spatial distribution of a convective gust for a return period of 20 years (RV20a; Mohr et al. 2017).

How do return values of convective and turbulent gusts differ in their strength and spatial distribution?

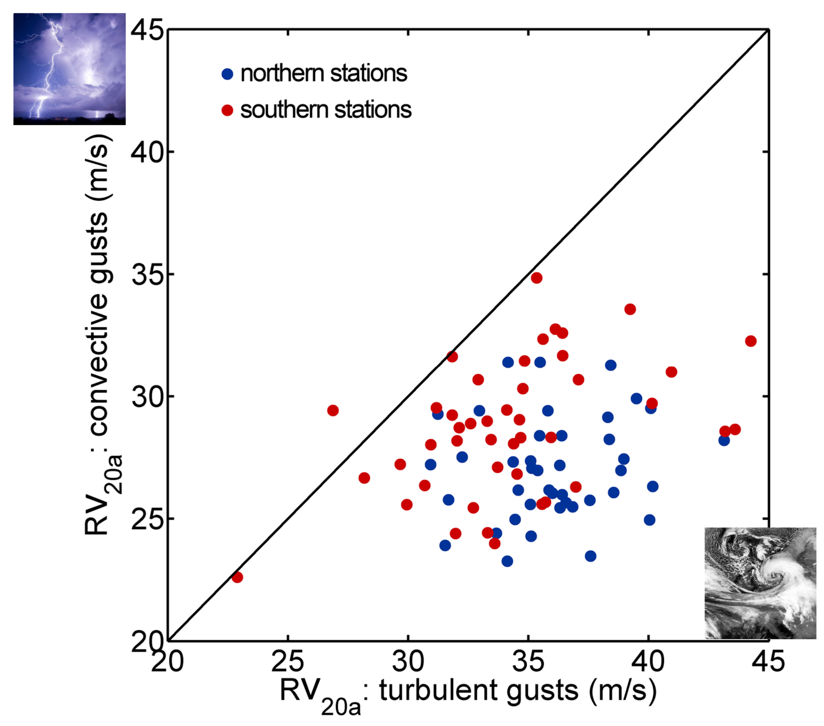


Fig. 4: Scatterplot between the return value of a convective and turbulent gust for RV20a split into northern (blue) and southern stations in Germany (red; DWD, 1992 – 2014; Mohr et al. 2017).

$RV20a_{conv} < RV20a_{turb}$

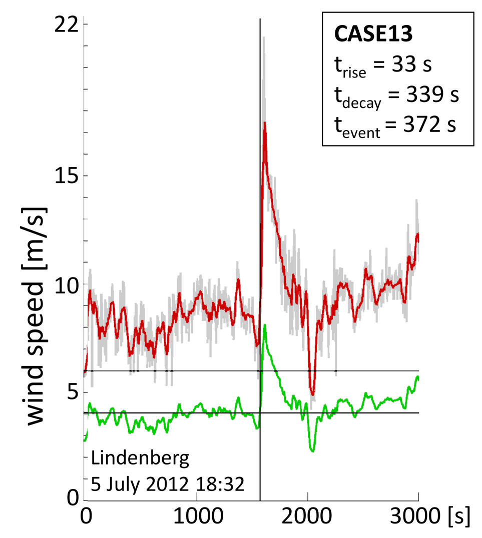
Differences:
Mean ± Std: 7.3 ± 3.9 m/s
North: 9.0 ± 3.2 m/s
South: 5.6 ± 3.8 m/s

Temporal scale

How is the temporal scale of convective gust events?

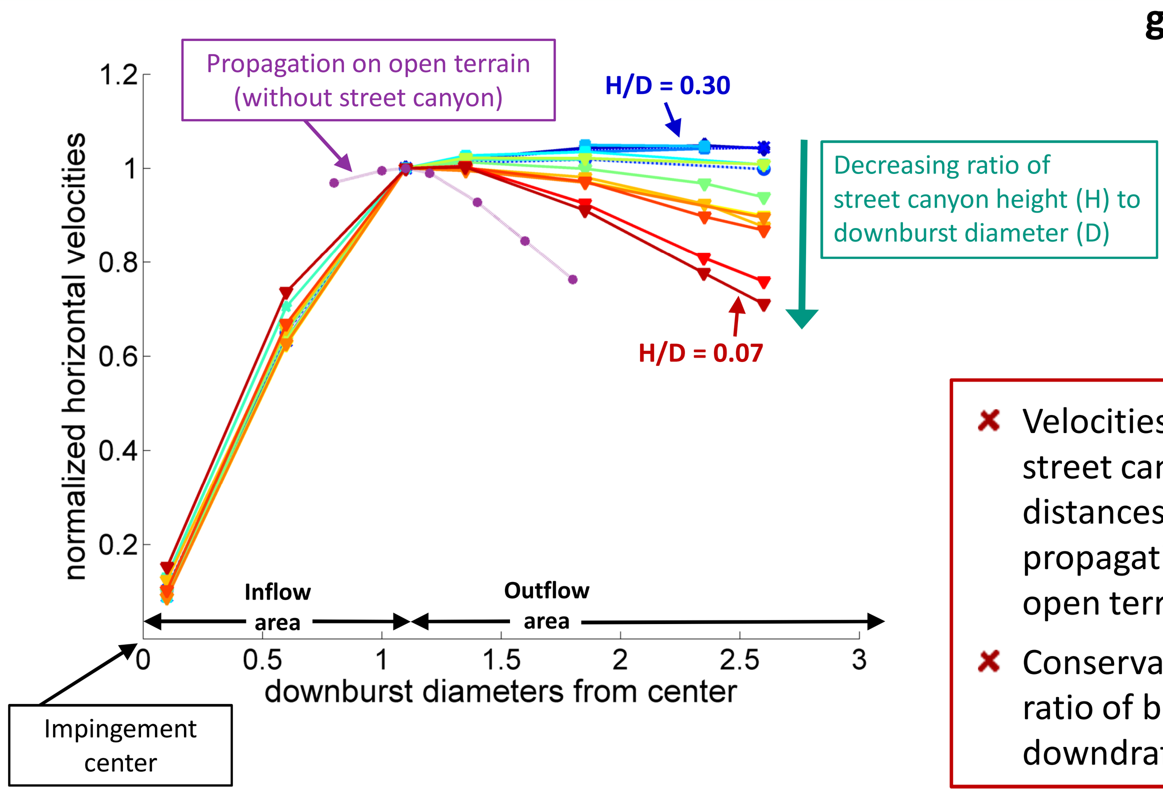
	Mean ± STD (of 30 events)	
Rise time:	6.4 ± 4.3 min	(Minimum 21 s)
Decay time:	24.4 ± 23.0 min	(Minimum 1.6 min)
Event duration:	30.8 ± 24.1 min	(Minimum 4.4 min)

Table 1: Summery of temporal characteristics of 30 convective wind events measured with high temporal resolution measurements (20 Hz) in 50 m (Data source: Falkenberg tower in Lindenberg and Hamburg Weather Mast; 2009 – 2014).



Horizontal velocity in a street canyon

How is the influence of urban structures on gust characteristics?



- Velocities are conserved within street canyons over longer distances compared to propagation of downbursts on open terrain.
- Conservations depends on the ratio of building height to downdraft size (H/D).

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 with a steady impinging jet; Richter et al., 2017b).

Conclusions

- Similar to other convective-related phenomena convective gusts occur predominantly in warm summer months.
- The frequency of convective gusts is higher in southern Germany compared to the north. A relation between gust intensity/probability to orography or climate conditions cannot be identified. In fact, it is the reverse: high wind speeds above 30 m s^{-1} can be expected everywhere in Germany with a similar occurrence probability.
- 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. Reason is the higher frequency of low pressure systems coming from the Atlantic Ocean in the north than as the thunderstorm activity in that area.
- Convective gusts can have very short rise time within one minute and event duration of less than 10 minutes.
- High velocities caused by downbursts can be conserved over long distances within street canyons.

Mohr, S., Kunz, M., Richter, A. and Ruck, B. (2017): Statistical characteristics of convective wind gusts in Germany. *Nat. Hazards Earth Syst. Sci.*, 17, 957-969, doi:10.5194/nhess-17-957-2017.

Richter, A., Ruck, B., Mohr, S. and Kunz, M. (2017a): Interaction of severe convective gusts with a street canyon. *Urban Clim.* In press, doi:10.1016/j.uclim.2016.11.003.

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