Timing of wind gust maxima within a 100 m near-surface layer

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Gust definition

The maximum of 3 s moving averages during a 10 min period (WMO)

$$U_{max} = \max(\sqrt{u_m^2 + v_m^2})$$

 u_m , v_m = moving averages of u(t) and v(t)





Measurements







The method

1) Selection of cases: one case includes several 10 min periods.

- 2) For each of the 10 min periods, the **maximum gust is detected at the reference level**.
- 3) Then, only a **period of ±1 min around the maximum gust** is considered from the 20 Hz time series
- 4) At each measurement level of the mast, the highest 120 values within the 2-min period are given a value 1, all other data points get a value 0.
- Next, the ensemble mean over all the 2-min periods is calculated. This gives the probability for a value 1 at each point in the 2-min, time-height cross-section.
- 6) Finally, it is possible to calculate statistics from the resulting time-height average fields. It is noteworthy that these statistics do not include any effects due to time-averaging.







CASE	Date	Time	Length [h]
C1	10 January	5:00-11:00	6
C2	10-11 January	19:00-1:00	6
C3	11 January	4:00-9:00	5
C4	16 January	12:00-18:00	6
C5	7 May	3:00-7:00	4
C6	7 May	11:00-18:00	7
C7	7 September	11:00-17:00	5
C8	7 September	17:30-20:30	3
C9	7-8 September	22:00-06:00	8
C10	8 September	6:30-9:00	2.5
C11	8 September	11:00-14:00	3
C12	2 October	2:00-12:00	10
C13	3 October	10:30-18:30	8
C14	29 November	4:00-10:00	6
C15	29 November	14:00-19:00	5

- Period: year 2010
- Easterly sector
- Strong wind:
 U_{100m} > 13 m s⁻¹
- 15 cases from 9 days were selected, including cases with different stability conditions, increasing/decreasing wind speed and stationary conditions





Detection of the maximum gust







Selection of a ± 1 min period around the reference maximum







The highest 120 values at each height



The highest 120 values (which corresponds to 6 s with 20 Hz data) are given a value 1, all other data points get a value 0.





Ζ

The ensemble mean over all 2-min time-height cross-sections



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Result: a probability field



E III

For plotting purposes, a 1 s moving average was calculated along the time axis, after calculating the statistics.



Example cases: 10 – 11 Jan 2010





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Example cases: 7 – 8 Sep 2010





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Results: stable conditions





Results continue...







Results: all 15 cases



blue = stable red = unstable purple = increasing wind speed
light blue = decreasing wind speed black = stationary



Suomi I, Gryning S-E, Floors R, Vihma T, Fortelius C. 2014. On the vertical structure of wind gusts. *Quarterly Journal of the Royal Meteorological Society (accepted)*.



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