

Extreme gust wind estimation using mesoscale modeling

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Publication date: 2014

Link back to DTU Orbit

Citation (APA): Larsén, X. G. (Author), & Kruger, A. (Author). (2014). Extreme gust wind estimation using mesoscale modeling. Sound/Visual production (digital), European Wind Energy Association (EWEA).

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Extreme gust wind estimation using mesoscale modeling

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DTU Wind Energy Department of Wind Energy

$$u_{gust} = u_{mean} + k_p \sigma_u$$

$$k_p = \sqrt{2\ln(\nu T)} + \frac{\gamma}{\sqrt{2\ln(\nu T)}}$$

$$v = \sqrt{m_2/m_0}$$
 $m_n = \int_0^\infty \omega^n S(\omega) d\omega$

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Gust duration e.g. 3 s

T is often set as 10 min

Steady turbulence

Neutral stability

Negligible turbulence from upstream separation zone

Spectral model (e.g. here, the neutral Kaimal)



Høvsøre, due to the availability of profiles of mean wind, direction and turbulence data

DTU Wind Energy, Technical University of Denmark

CASE STUDY



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CASE STUDY



Dots: Mean spectrum of 144 10-min wind speed at 10 m on 26th



$$u_{gust} = u_{mean} + k_p \sigma_u$$

$$k_p = \sqrt{2\ln(\nu T)} + \frac{\gamma}{\sqrt{2\ln(\nu T)}}$$

	10m	40m	80m	100m
OBS	3.13	3.04	3.16	3.22
Gaussian Kaimal	3.39	3.29	3.25	3.24

$$v = \sqrt{m_2/m_0}$$
 $m_n = \int_0^\infty \omega^n S(\omega) d\omega$







The non-local gust

Brausseur's concept of the gust



Purpose here

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Purpose here

- To verify the non-local gust concept introduced by Brasseur (2001)
- To apply this to obtain atlas of extreme gust for the South Africa Wind Atlas project

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- To verify the non-local gust concept introduced by Brasseur (2001)
- To apply this to obtain atlas of extreme gust for the South Africa Wind Atlas project

- To apply Brausseur's concept of the gust
- To use WRF to model storms
- To estimate the 50-year extreme gust value

• Brausseur's concept of the gust and estimation



FIG. 1. Proposed mechanism explaining gusts observed at the surface: turbulent eddies are triggering the deflection of air parcels flowing in the boundary layer downward to the surface.



• Brausseur's concept of the gust and estimation

Lower and upper bound

- WRF modeling of storms, Western Cape
- 1. Run WRF for the 72 cases
- 2. WRF setup:
 - WRF V3.2.1
 - CFSR data, 6 hrly, 1998 2010
 - SST 0.5°
 - 36 12 4 km
 - 41 vertical layers
 - MYNN PBL scheme
 - Run time <=72 hrs, nudging
 - 10 min output
 - 20 s time step
- 3. The 50-year wind using the Annual Maxima Method.



- WRF modeling of storms, Eastern Cape
- 1. Run WRF for the 175 cases
- 2. WRF setup:
 - WRF V3.2.1
 - CFSR data, 6 hrly, 1998 2010
 - SST 0.5°
 - 36 12 4 km
 - 41 vertical layers
 - MYNN PBL scheme
 - Run time <=72 hrs, nudging
 - 10 min output
 - 20 s time step
- 3. The 50-year wind using the Annual Maxima Method.



• Verification of the WRF modeled Brasseur gust during individual storms



• Verification of the WRF modeled Brasseur gust during individual storms



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 Atlas of the extreme gust values for South Africa (comparison of measured and modeled values)



 Atlas of the extreme gust values for South Africa (comparison of measured and modeled values)





Conclusions

• The model chain







Global

Mesoscale

Microscale

Conclusions

- The comparison of Gaussian gust and the non-local gust
 - **Gaussian + neutral Kailmal spectrum**: overestimation of peak factor kp, good estimate of σ_u at 10m but increasing underestimation of σ_u at higher levels. General underestimation of gust at higher levels. Heavily dependent on the roughness length. Better for small turbines.
 - Non-local gust concept is supported by our study for cyclones/anticyclones. The estimation is good but misses the local impact close to the surface. Useful for tall turbines.



Acknowledgement

This work is supported by the projects:

Wind Atlas of South Africa

Danish PSO: X-WiWa

Danish DSF: The Flow Center

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