Simulation-assisted optimisation of wind turbines

Uwe Ritschel (Windrad Engineering GmbH)

- About Windrad
- Structural dynamics and impacts on wind turbines
- The virtual prototype
- Special topics:
  - Tower optimization software
  - Extreme loads with Gumbelwind
  - More realistic wind field
  - Observer method for condition monitoring

Windrad Engineering GmbH

Engineering consultant for wind industry

Founded : 2002

Working fields

Development of wind turbines

Measurements

Software Development

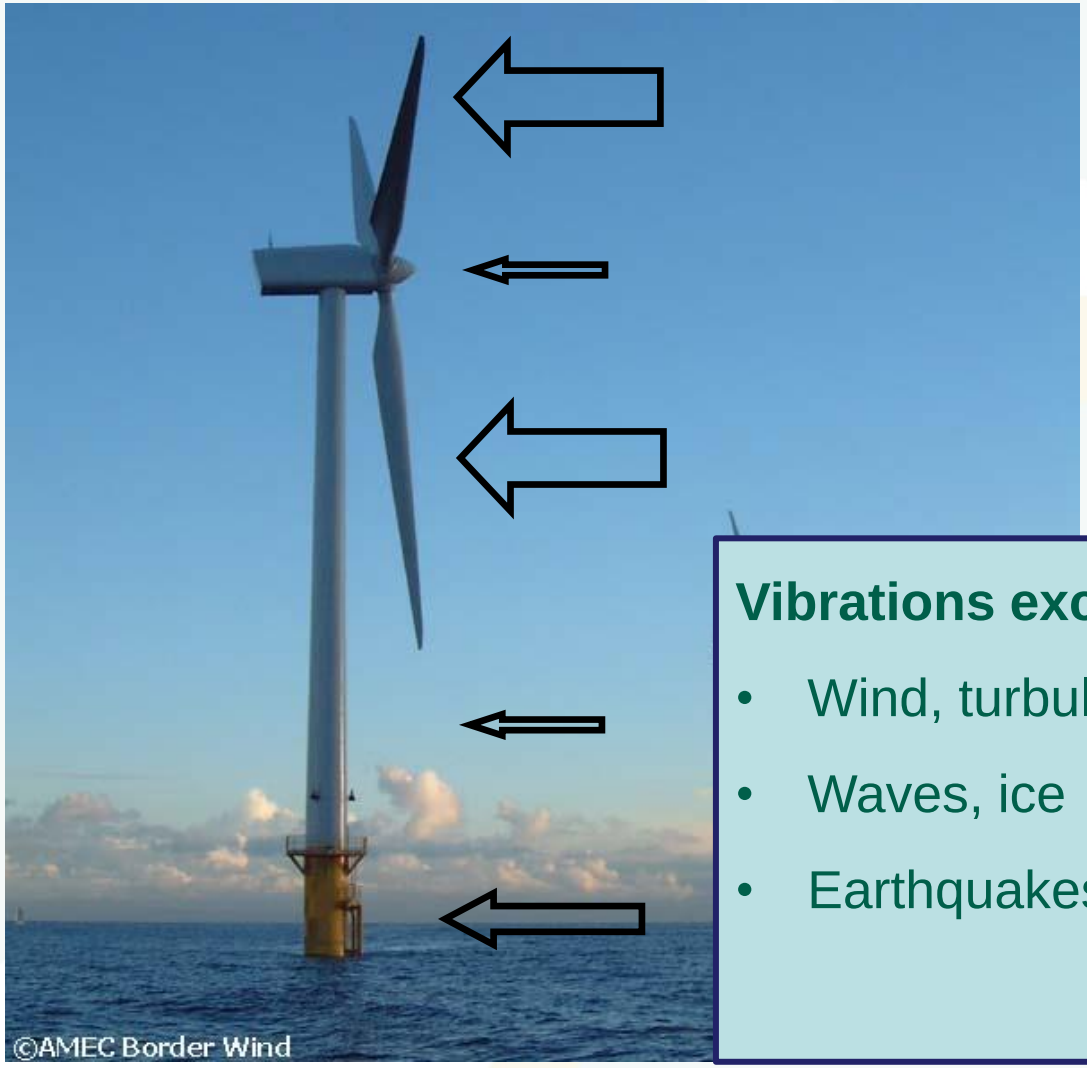
Training

More than 300 projects for manufacturers, suppliers, consultants, certifiers, project developers

About Windrad

Structural dynamics and impacts

Structural dynamics and impacts

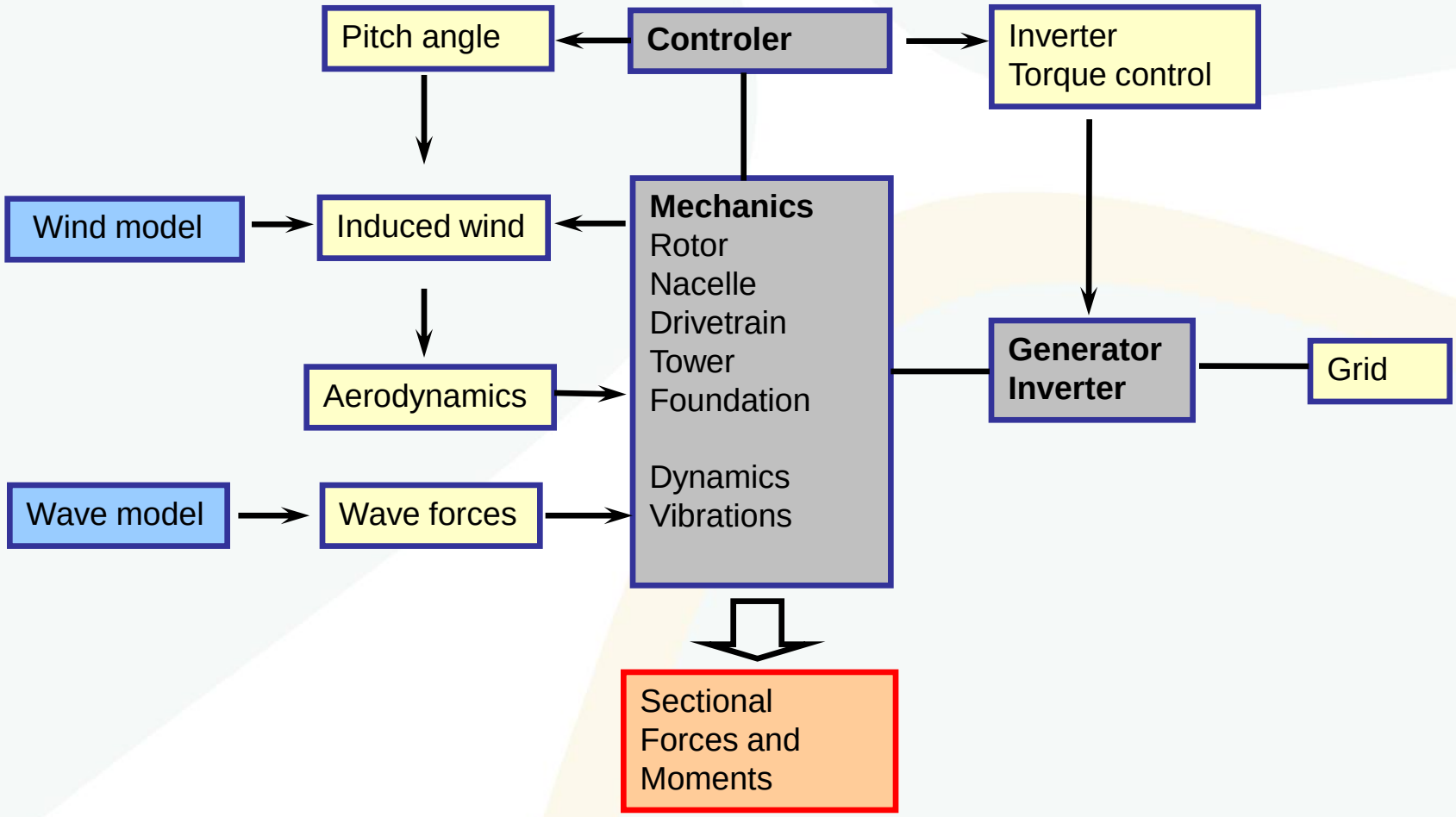


Vibrations excited by

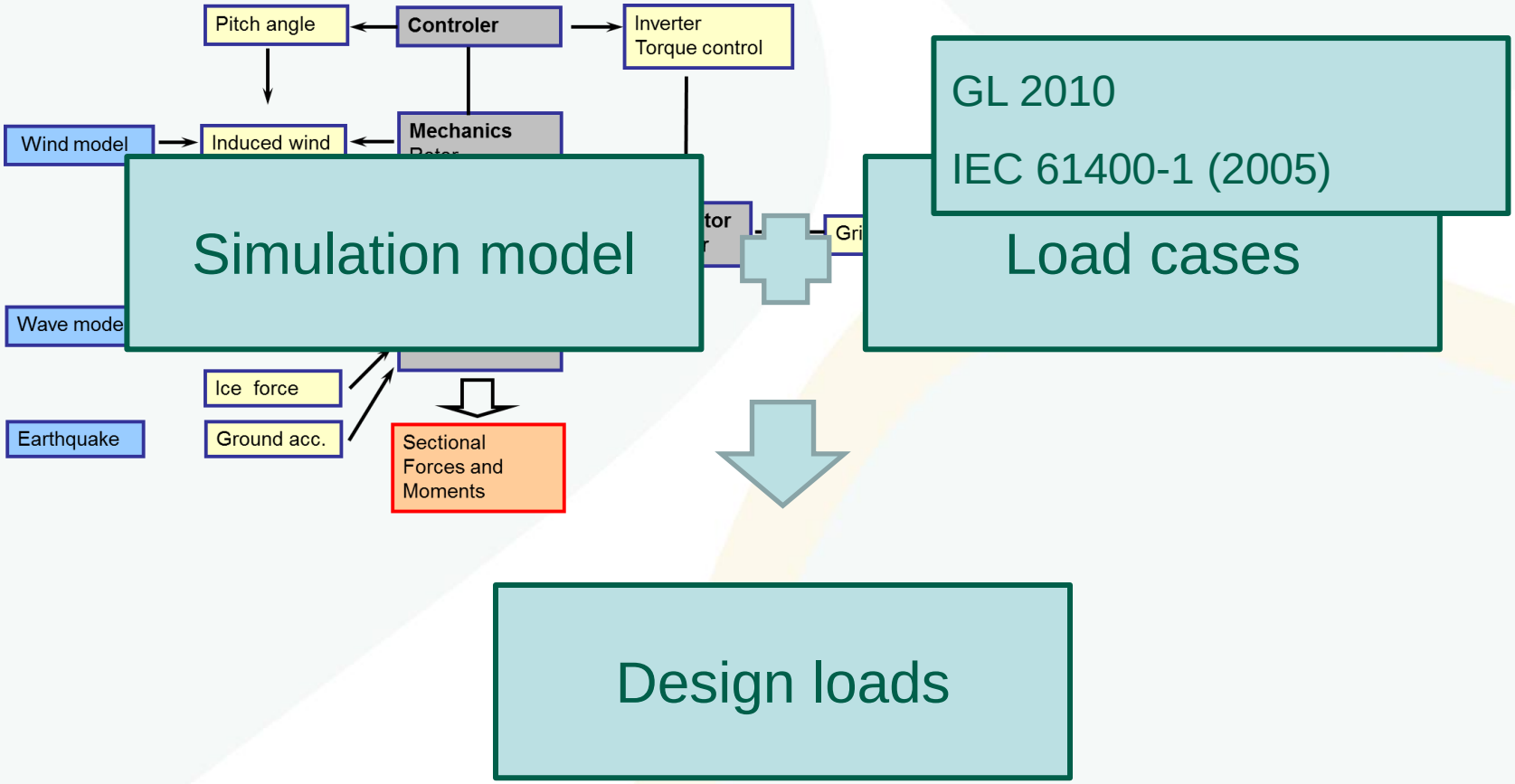
- Wind, turbulence
- Waves, ice
- Earthquakes

The virtual prototype

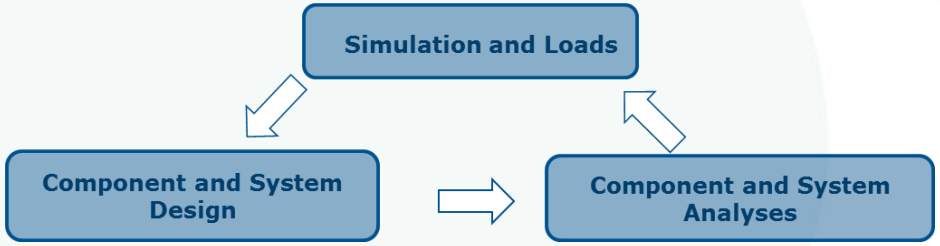
Simulation model scheme



The virtual prototype



The virtual prototype



Components	Systems
Blades	Pitch system
Hub	Yaw system
Machine frame	Cooling
Tower	Heating
…	…

Many iterations

Lower loads

Lower mass and costs

Higher energy production

Lower cost of energy

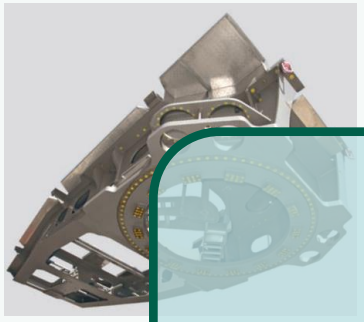
Fast simulation tools by Windrad

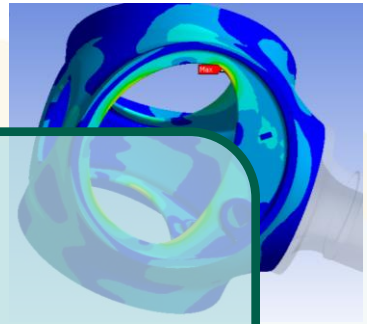
- Wind field
- Simulation model SiWEC
- Tower and offshore foundation tool
- Extreme load evaluation
- Node2damage

The virtual prototype

Requirements: Sales - Production - Purchase - Quality - HSE ...

Turbine concept





Simulation and Loads

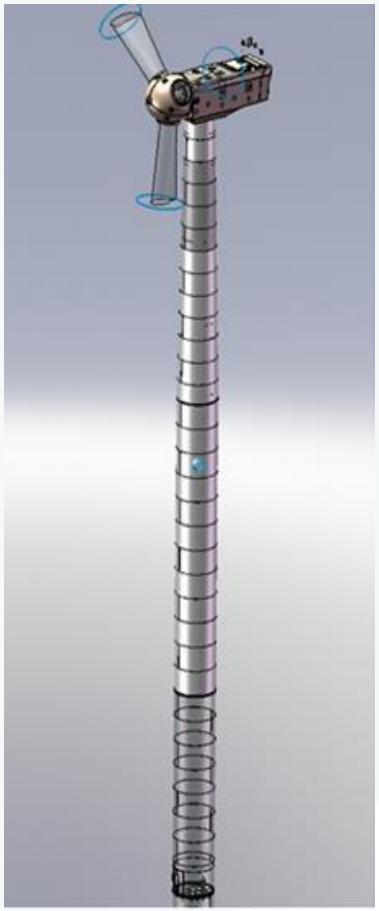
Virtual Prototype

Component and System Design

Component and System Analyses

Results of Development
Drawings - BOM - Specifications - Certification Docs ...

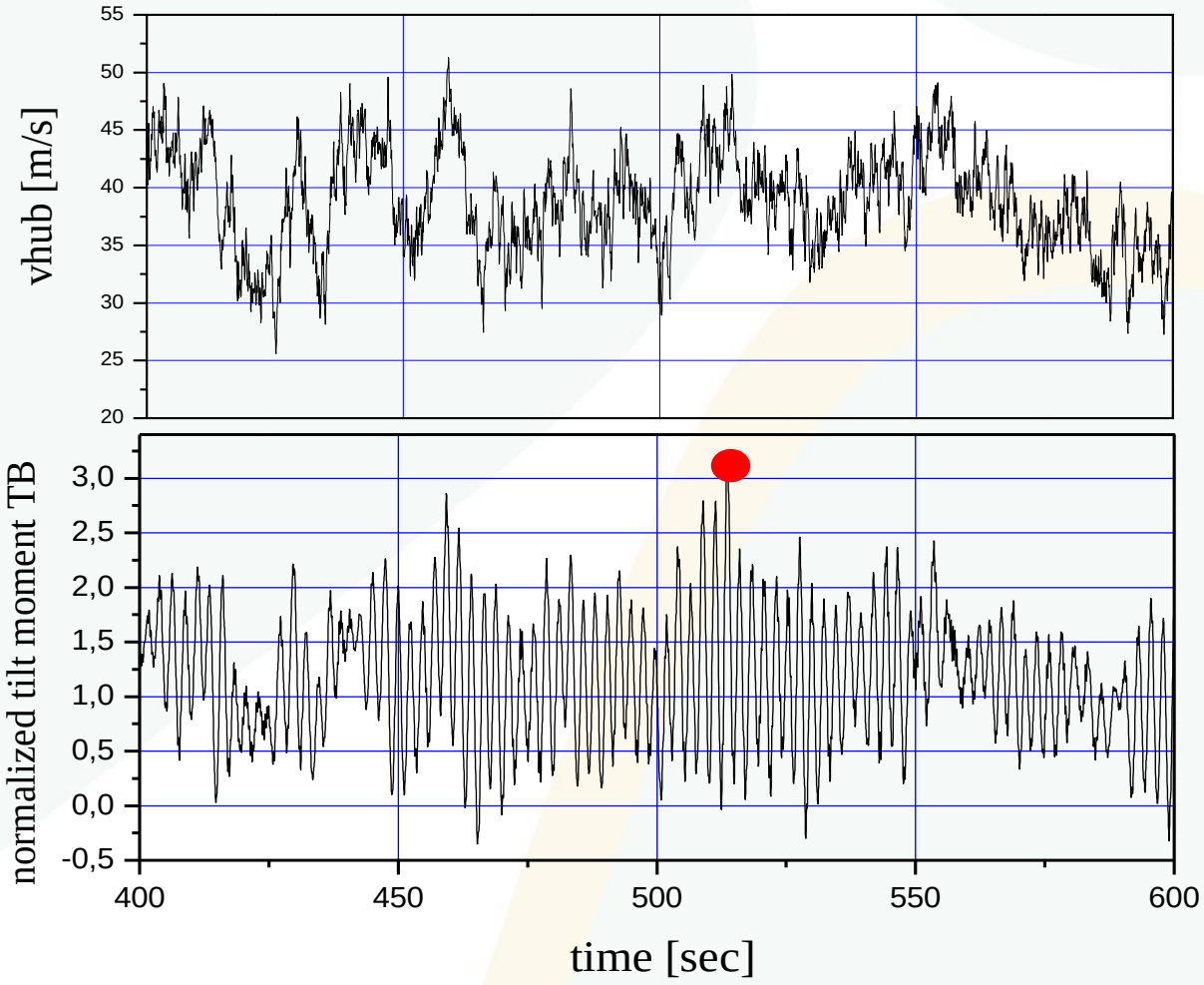
Special topics: Tower design software



- quick design of tubular steel structures (e.g. tubular tower, monopile) based on given load data (extreme, fatigue loads)
- optimized wall thicknesses of shells, flanges and bolt connection
- tunable to 1st and 2nd Eigenfrequency (stiff or soft tower layout)
    - Tower: including foundation-stiffness
    - Monopile: including structure-soil interaction
- Including proof against brittle and lamellar fracture, vortex induced vibrations

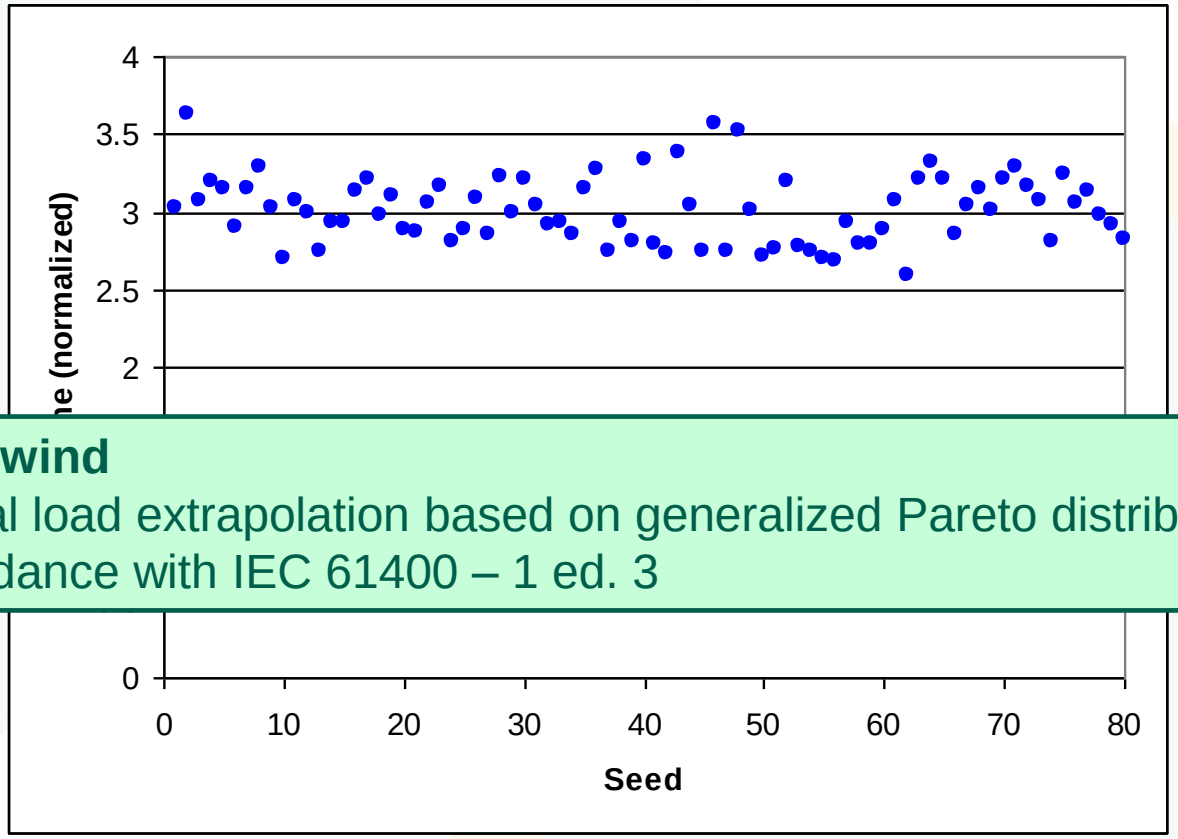
Special topics: Extreme loads

Extreme loads often design drivers



Special topics: Extreme loads

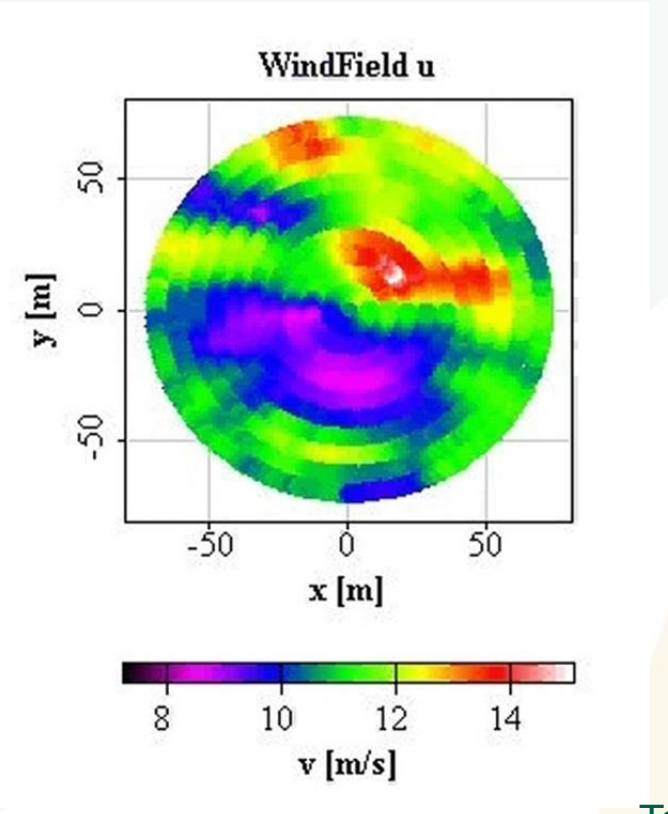
Extreme values from 80 time series (10 minutes)

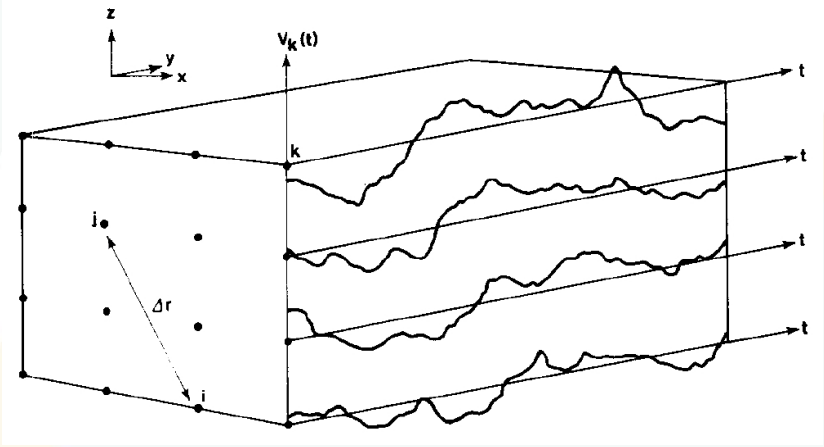


Gumbelwind
statistical load extrapolation based on generalized Pareto distributions in accordance with IEC 61400 – 1 ed. 3

Special topics: Wind field

- Due to surface influence wind is turbulent
- Spatio-temporal correlations important for loading of wind turbines



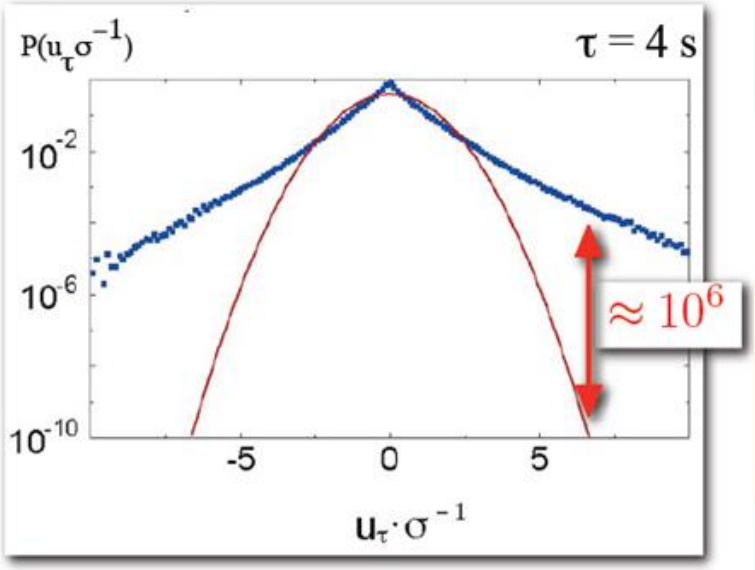


Together with Forwind (Prof. Peinke, Univ. Oldenburg)

Special topics: Wind field

Probabilty of change of wind speed after time τ – *information on gusts*

$$u_\tau = u(t+\tau) - u(t)$$



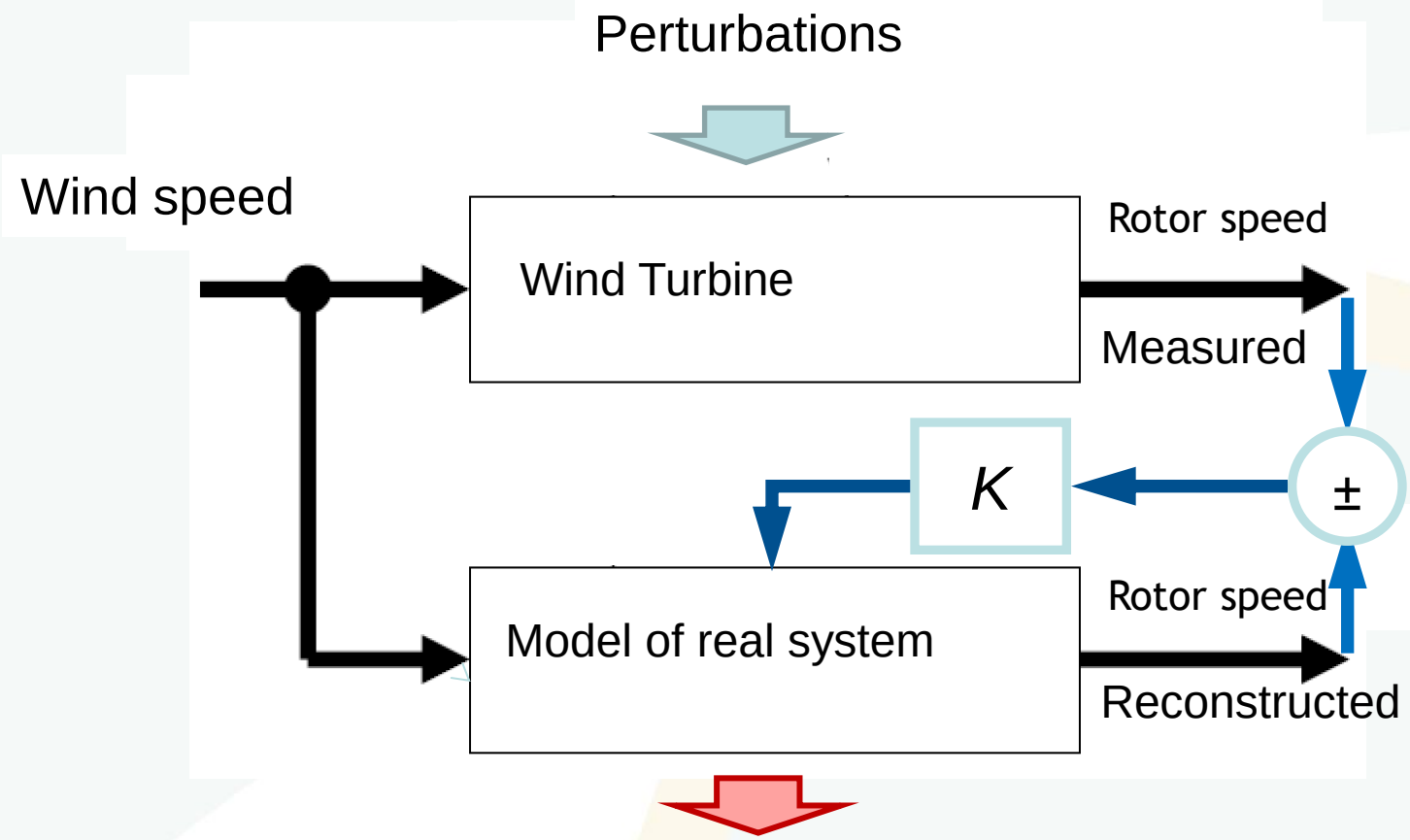
Red curve given by Kaimal model, required by Standards

Blue dots from athmospheric data

New method to generate time series With correct statistics based on results of turbulence theory

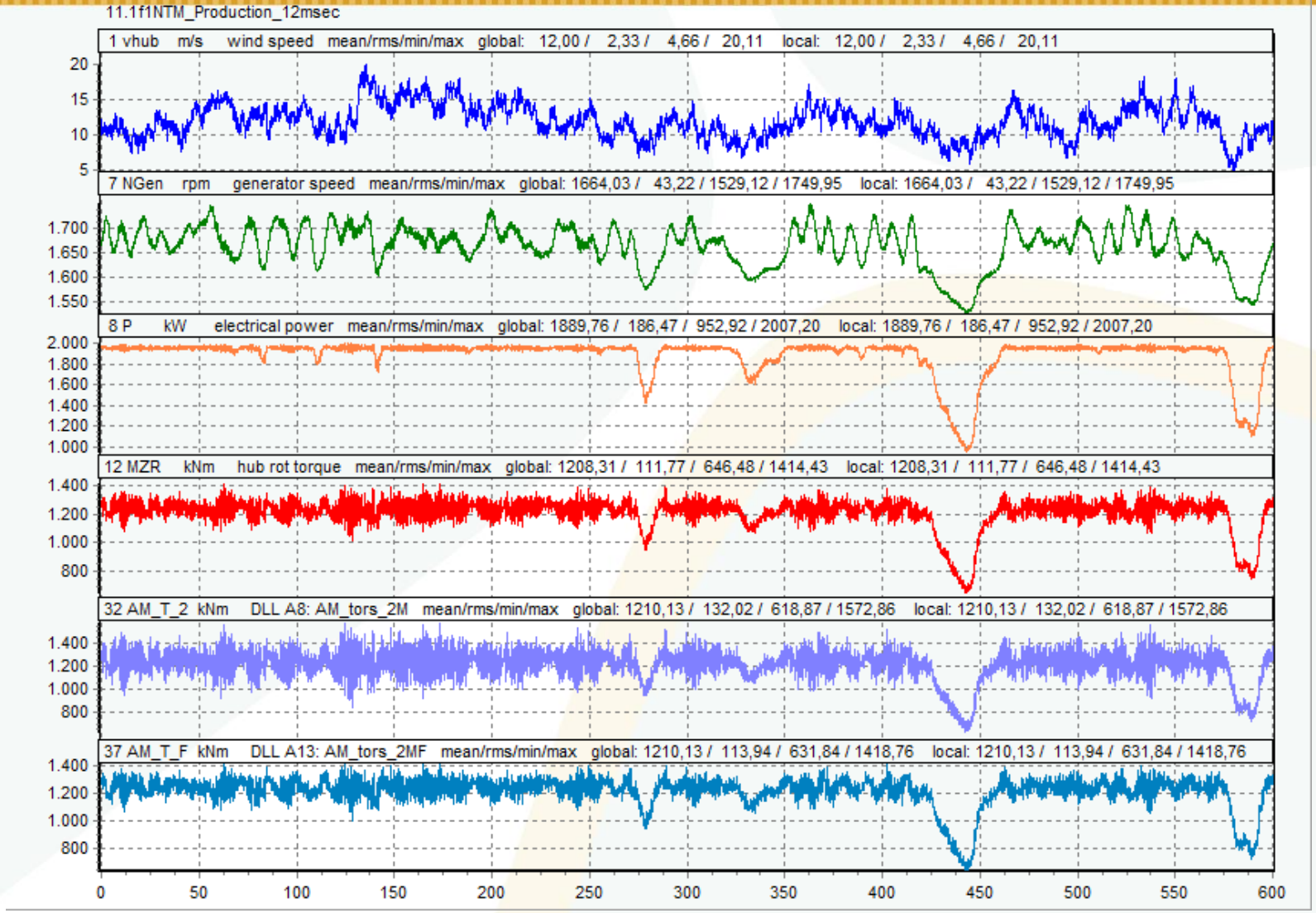
Kleinhans D, Friedrich R. Simulation of intermittent wind fields: A new approach. *DEWEK 2006 Proceedings*, Bremen, Germany, 2006.

Special topics: CMS by observer



Together with University of Bremen (Prof. Orlik)

Special topics: CMS by observer



Thanks for your attention!