

STANDARDIZED METHODOLOGY

for the elaboration of ice throw risk assessments



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Empiric formula vs. risk assessments

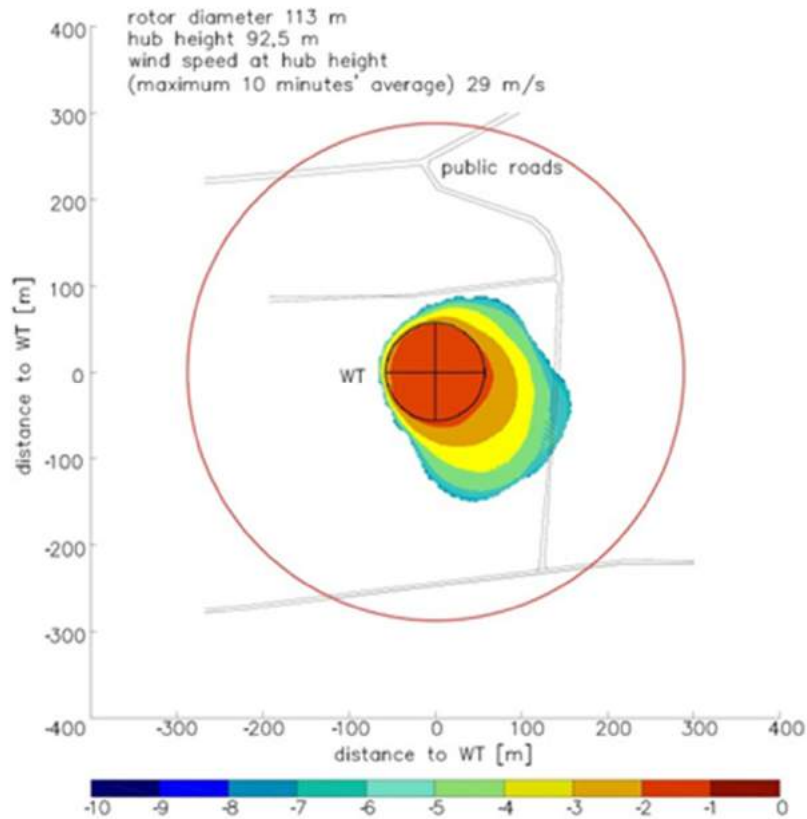


Fig.: Case example – ice fall

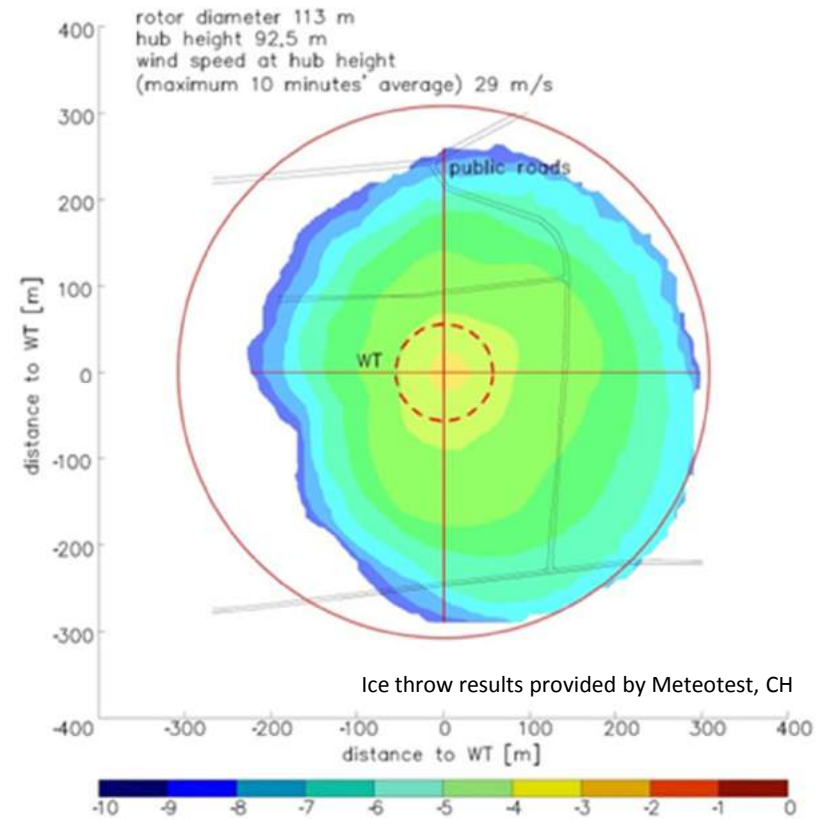


Fig.: Case example – ice throw

Assumptions and uncertainties

- **Ballistic model**
 - Aerodynamic parameters (rotation, drag & lift, flight trajectories...)
 - Consideration of different ice fragments
- **Data basis for the specific location**
 - Icing intensity (number of icing events, amount of relevant ice fragments, weight distribution...)
 - Wind speed and wind direction distribution
- **Risk Assessment**
 - Probability of persons in the danger zone
 - What is the acceptable risk level for persons, for cars ...
 - Assessment of mitigation measures

Sensitivity Analysis

Case Example – Ice Fall

- Average Location in Lower Austria
- Blade tip height of WT: 200 m
- Wind data based on neighbouring wind met mast (50m, 1 year)
- Icing intensity:
 - 5 icing events/year (evaluation of wind measurement data)
 - Intensity estimated by experience: Light/moderate icing
 - 500 fragments / year (conservative)
- Superposition of 4 different fragments

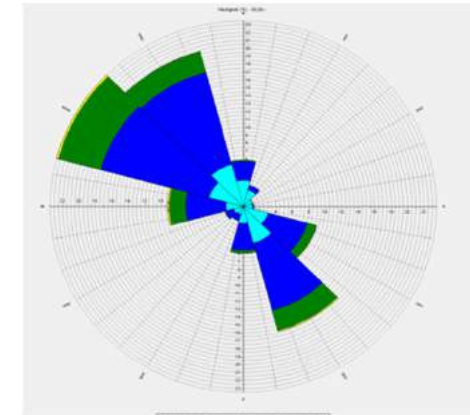


Fig.: Wind direction

	Dimensions	Mass	Numbers
50 %	3x4x8cm	86g	250
35 %	5x8x10cm	240g	175
10 %	5x10x50cm	1,5kg	50
5 %	3x20x100cm	5,4kg	25

Fig.: Weight distribution

Different weight distributions

	Dimensions	Mass	Numbers
50 %	3x4x8cm	86g	250
35 %	5x8x10cm	240g	175
10 %	5x10x50cm	1,5kg	50
5 %	3x20x100cm	5,4kg	25

	Dimensions	Mass	Numbers
77 %	3x5x10cm	90g	385
14 %	3x9x10cm	243g	69
9 %	10x13x20cm	1,6kg	44
0,4 %	16x19x20cm	5,5kg	2

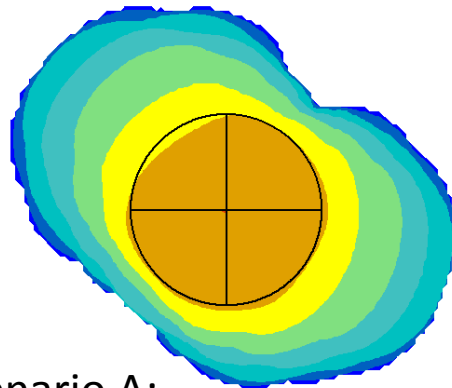


Fig.: Scenario A;
Dmax = 154m

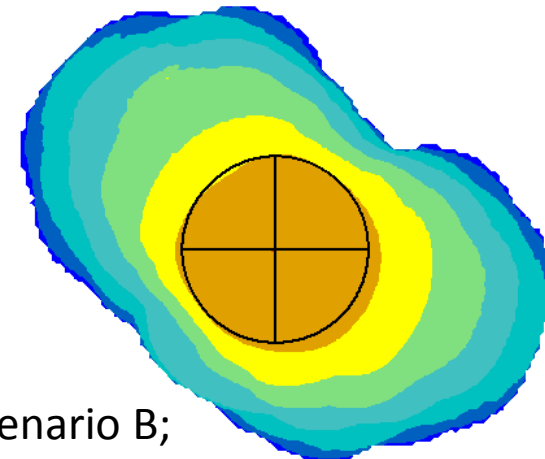


Fig.: Scenario B;
Dmax = 190m

Distribution of ice accretion on the blade

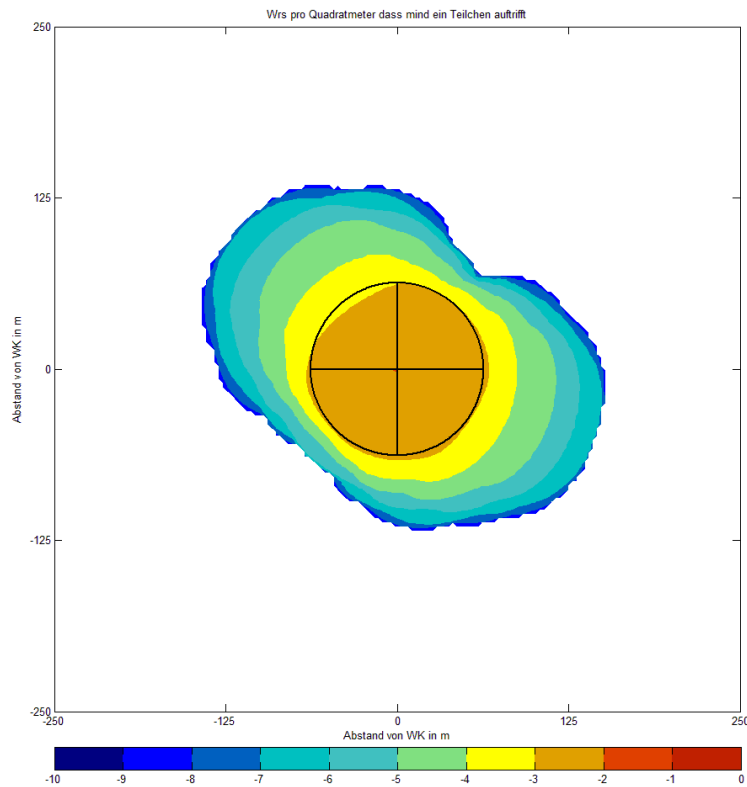


Fig.: Break-off of ice-fragments from the entire rotor radius

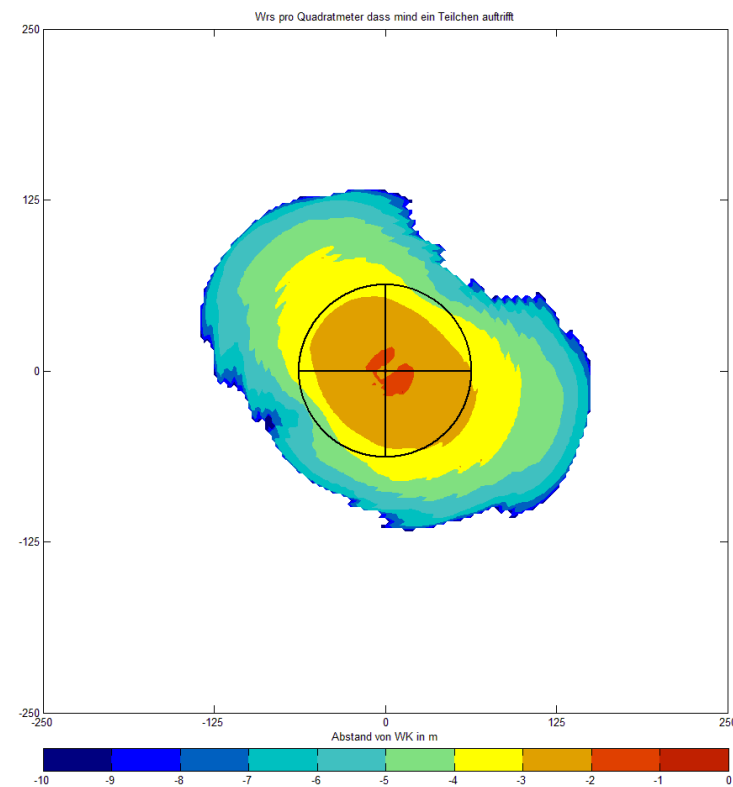
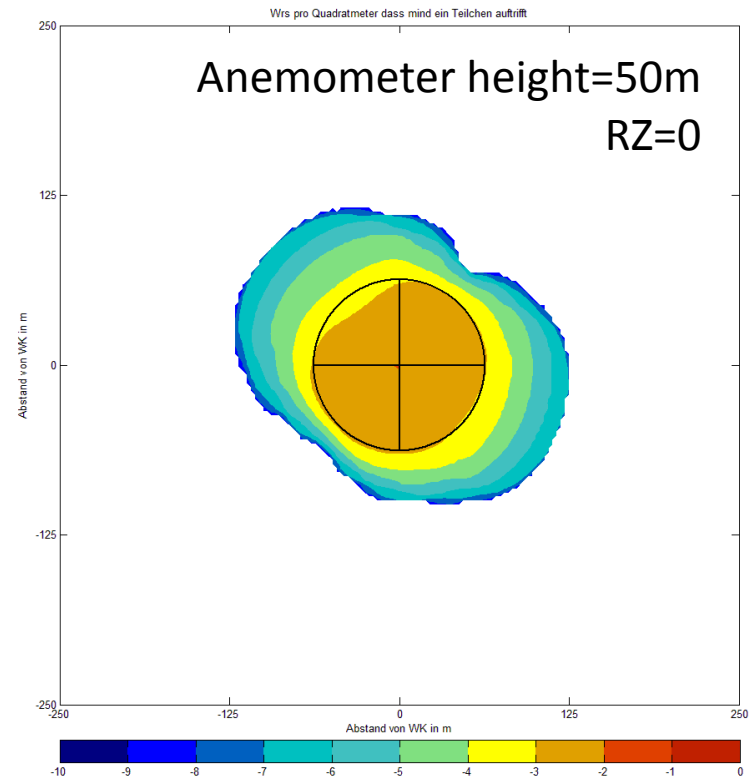
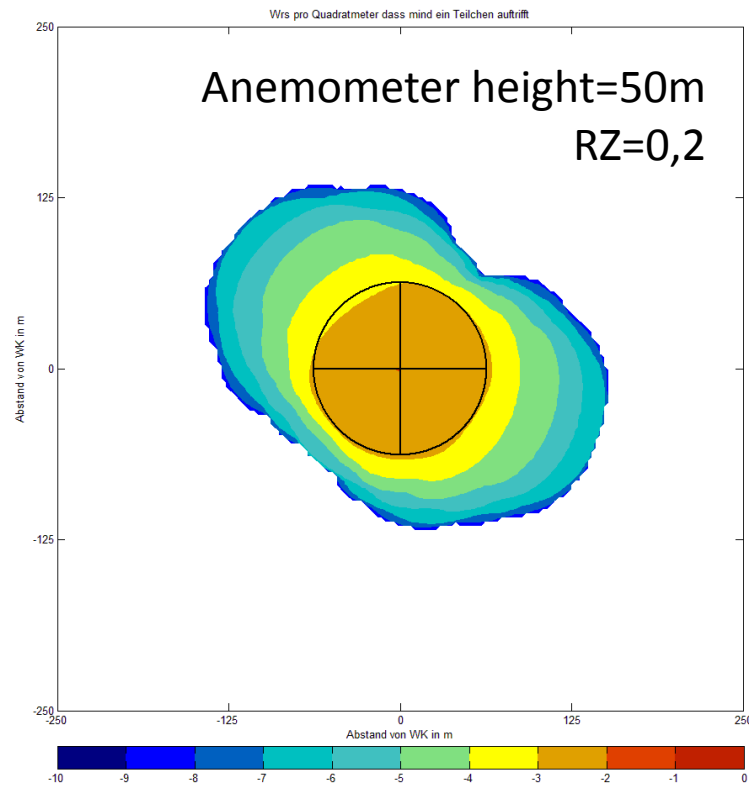


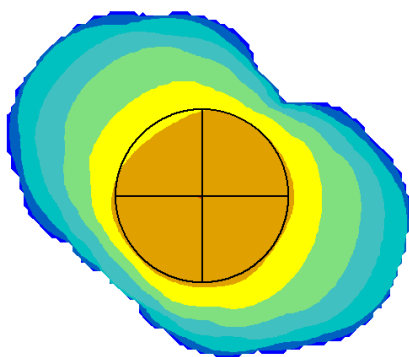
Fig.: Break-off of ice-fragments from the outer third of the rotor

Influence of roughness length

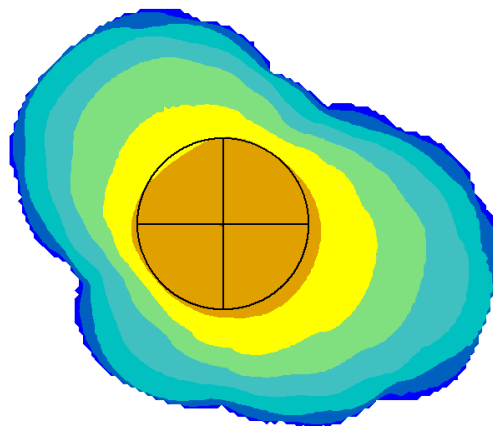


- Maximum distance: 154m vs. 126m
- Average hits/sqm: $9,7 * 10^{-3}$ vs. $1,3 * 10^{-2}$

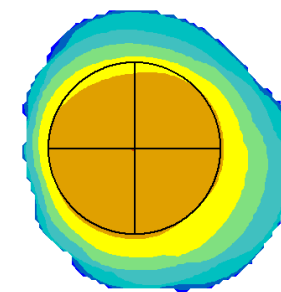
Wind speed data



10 Minutes averages,
Measuring height = 50m



3 sec. Maximum readings
Measuring height = 50m



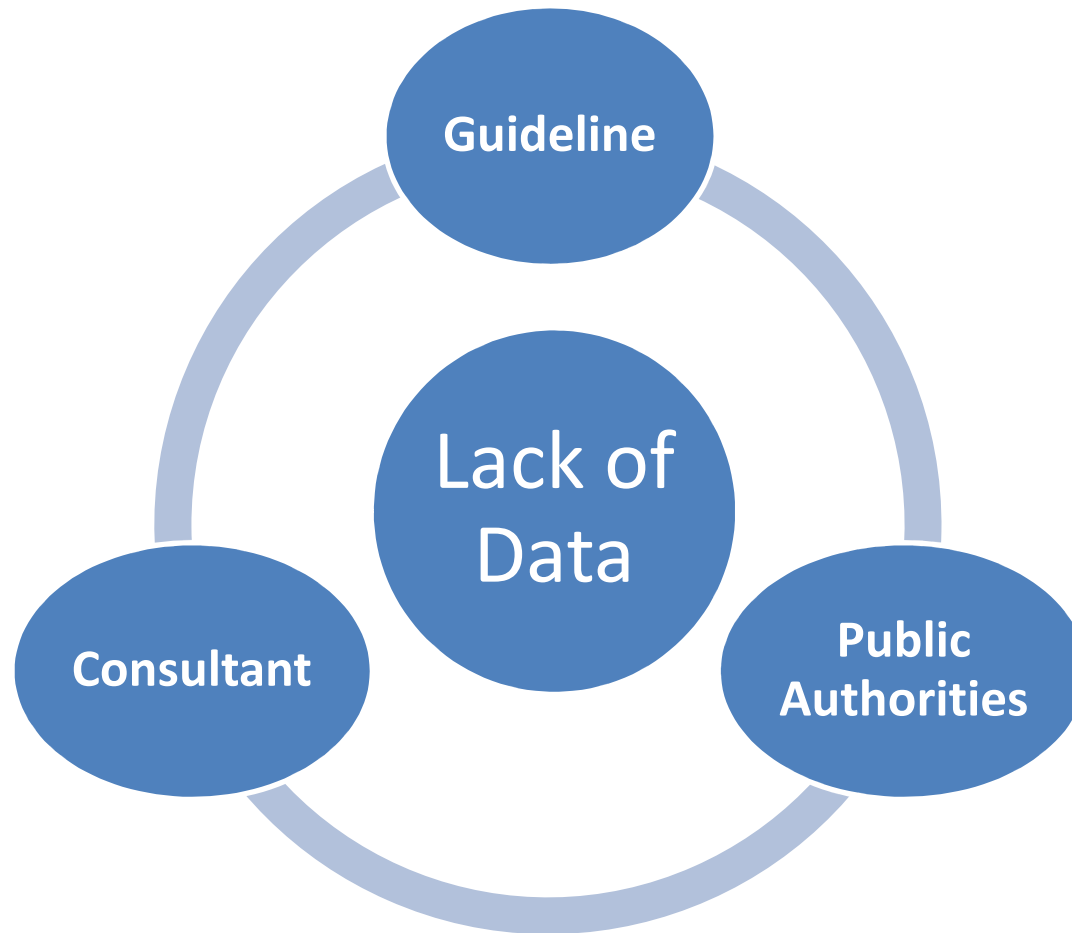
1-h Reanalysis Data
Measuring height = 50m

Wind Data	Max. Wind speed [m]	Max Range [m]	Average hits per sqm
10 Minutes averages	21	154	$9,7 * 10^{-3}$
3 Seconds maximum readings	27	180	$8,4 * 10^{-3}$
1 Hour reanalysis Dara	17	118	$1,6 * 10^{-2}$

Assumptions for risk assessment

- **Commonly accepted risk level**
 - Individual risk vs. collective risk
 - ALARP vs. MEM (levels range from 10^{-5} to 10^{-7})
- **Thresholds for lethal injuries**
 - Kinetic energy vs. weight
 - Hits per m^2 vs. hits per size of head
- **Mitigation measures (warning signs, flashing lights...)**
 - Efficiency / effectiveness of the individual measures
 - Reduction ration: One order of magnitude?

Where do we stand?



Project objectives

- **Main Targets**

- International guidelines/recommendations for the elaboration of ice-throw / ice-fall risk assessments
 - Paving the way to more transparency
 - Awareness of consultants and authorities about crucial parameters

- **Working procedure**

- Cooperation within Task 19 plus interested external experts
- Comparing different approaches and results
- Detailed setup (meetings, case examples...) dependent on number and origin of partner companies

- **Positive side effect for participants**

- Learning effect and further improvement of their models

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Thanks for your Attention.