IEA Wind Task 19
Workshop on Ice throw

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Winterwind 6/2/2017, Skellefteå

- Ice throw field studies at Meteotest
- Ice throw risk assessments at Meteotest
- (IEA wind Task 19 – Subtask Ice throw)

Ice throw field studies at Meteotest

Gütsch, Alps
2006 – 2009
2’300 m asl

1 WEC Enercon E-40
50 m hub height
→ heating during stand still

Cost action 727

Ice throw field studies at Meteotest

St. Brais, Jura
1’100 m asl
2009 – 2015

2 WEC Enercon E-82
78 m hub height

- partly heating during stand still
- partly during operation

Financed by Swiss Federal Office of Energy SFOE

Ice throw field studies at Meteotest

Mt. Crosin, Jura,
1’300 m asl
2014 – 2015

1 WEC Vestas V90
95 m hub height
→ unheated

Ice throw field studies at Meteotest

Relevant questions:

- how often does ice throw occur
- how long distances do the ice particles reach
- what dimensions and weight do they have
- differences between turbines, depending on their operation mode heated/unheated

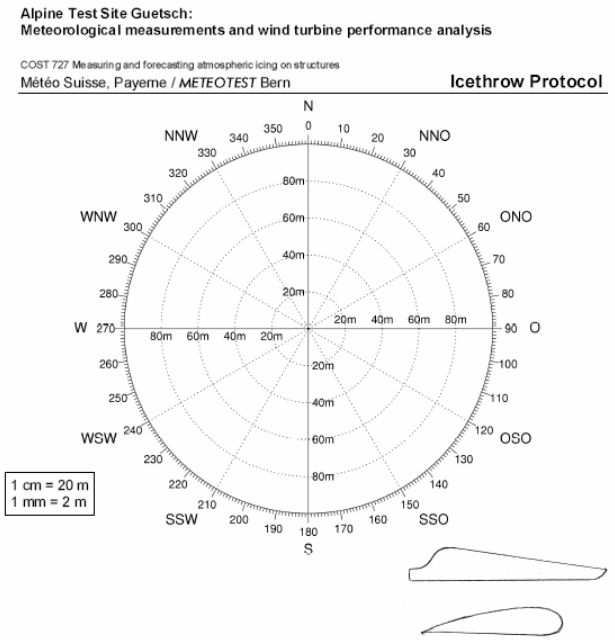
-> Camera images were downloaded and controlled on a daily basis

-> Ice particles were collected at the sites when webcams showed icing on rotor blades

Ice throw field studies at Meteotest

After each icing event, the area around the wind turbine was inspected for ice throw.

All found ice fragments were recorded:
- Distance
- Angle
- Size
- Weight
- Type of ice (rime, glaze, wet snow)
- Photo of ice fragment



Alpine Test Site Guetsch:
Meteorological measurements and wind turbine performance analysis

COST 727 Measuring and forecasting atmospheric icing on structures
Météo Suisse, Payerne / *METEOTEST* Bern **Icethrow Protocol**

WKA: ENERCON E-40 600 kW Gütsch Anlage in Betrieb? ☐ Ja ☐ Nein

Datum, Zeit des Fundes: _____ Name Beobachter: _____

Distanz zur WKA [m]: _____ Winkel zu WKA [Grad]: _____ Gewicht [g]: _____

Grösse (LxBxH) [cm]: _____ Art des Eises: ☐ Rauhreif ☐ klares Eis

Filename des Fotos (Foto inkl. Referenz, z.B. Taschenmesser): _____

Wettercharakter: Bewölkung ___/Achtel ☐ innerhalb der Wolken
☐ Schneefall ☐ Regen

Sonstige Bemerkungen (andere Vereisungseffekte):

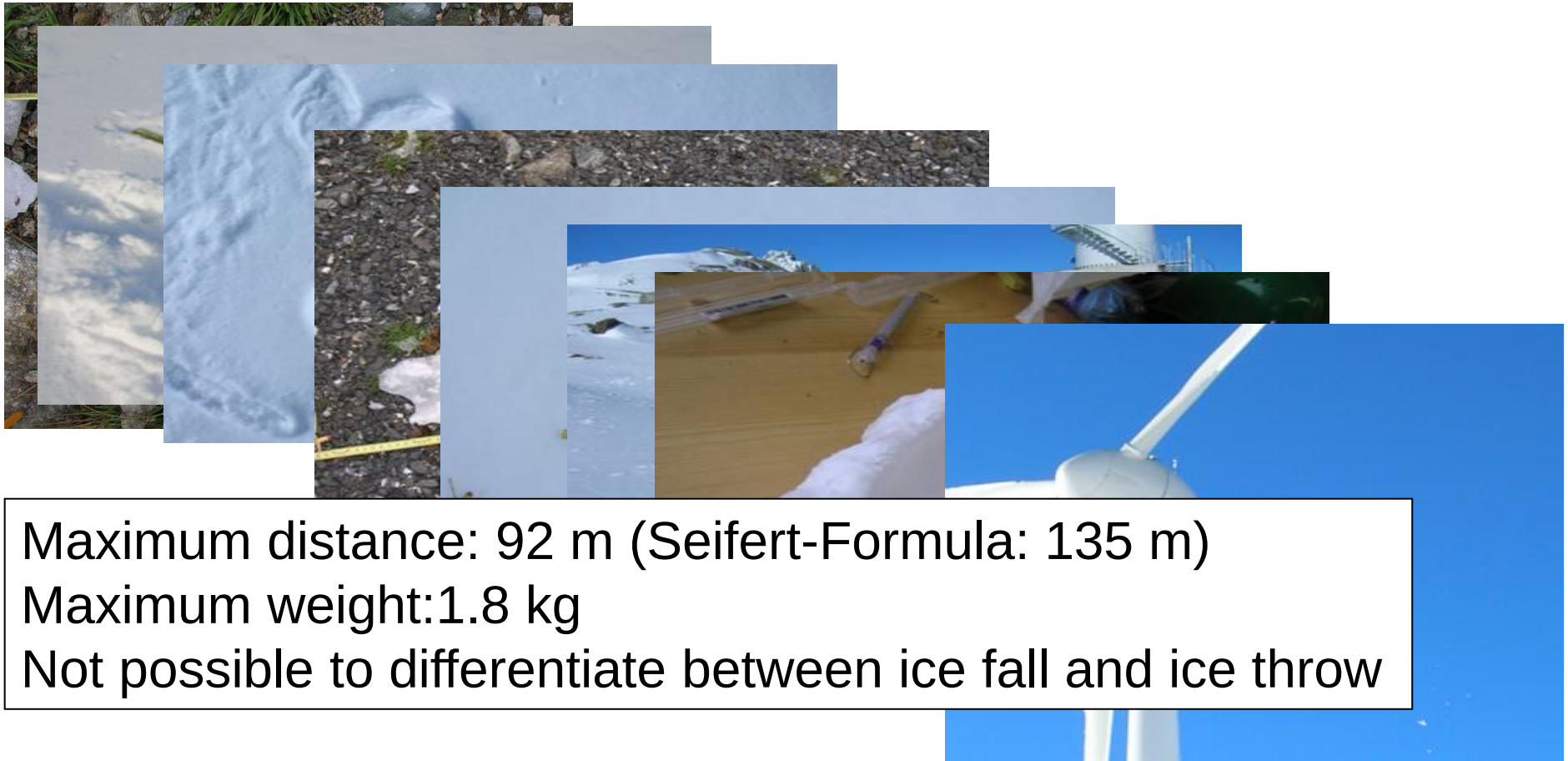
Ice throw field studies at Meteotest

- Laser distance meter
- Digital camera
- Compass
- Plastic bag to weigh ice piece on a spring scale
- Folder with protocol sheets and documentation
- Network cable for camera for data transfer
- Camera charging device
- Folding rule
- Pencils
- 3 spring scales 0–500 g / 0–1000 g / 0–2500 g

Ice throw field studies at Meteotest

Gütsch:
Study was carried out during 3 winters
32 incidents were recorded
228 ice pieces were documented

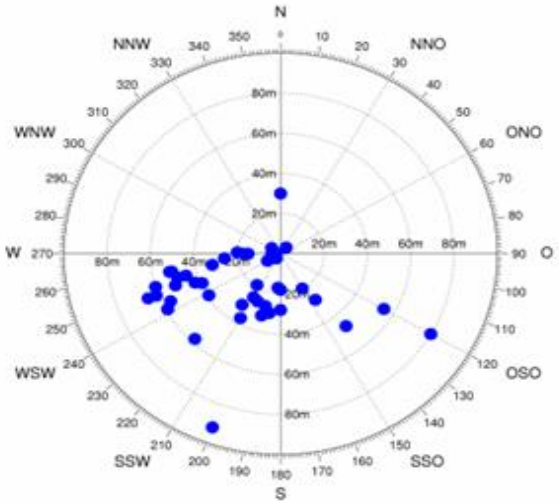
Ice throw field studies at Meteotest



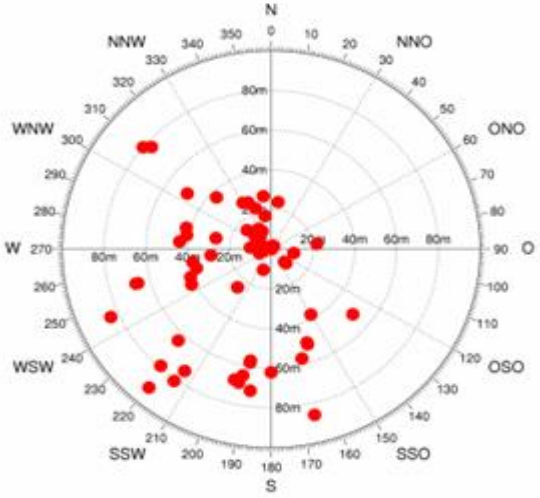
Maximum distance: 92 m (Seifert-Formula: 135 m)
Maximum weight:1.8 kg
Not possible to differentiate between ice fall and ice throw

Ice throw field studies at Meteotest

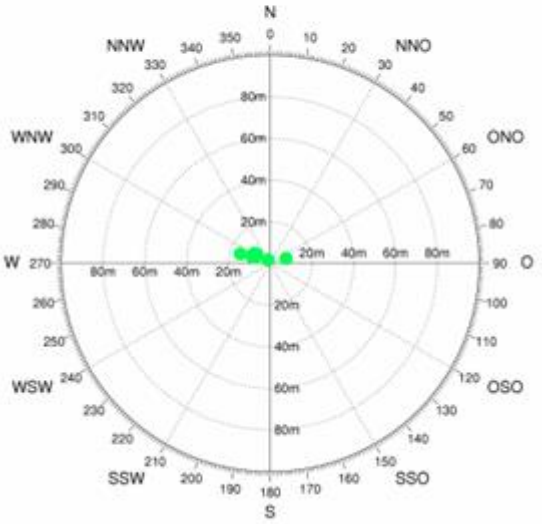
Type of ice / snow



Rime

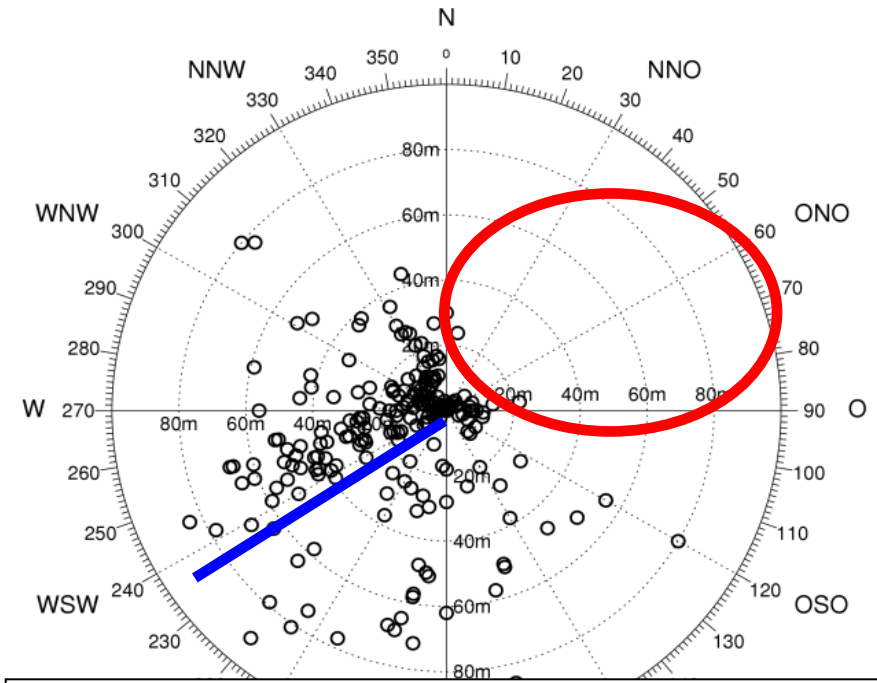


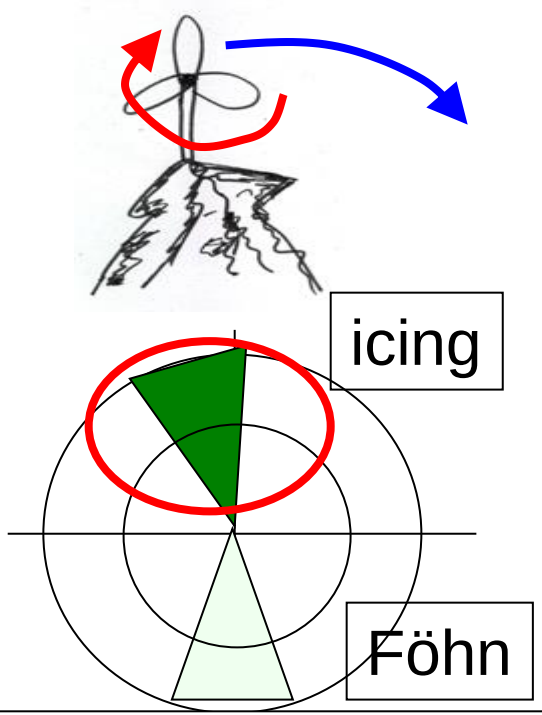
Glaze ice



Wet snow

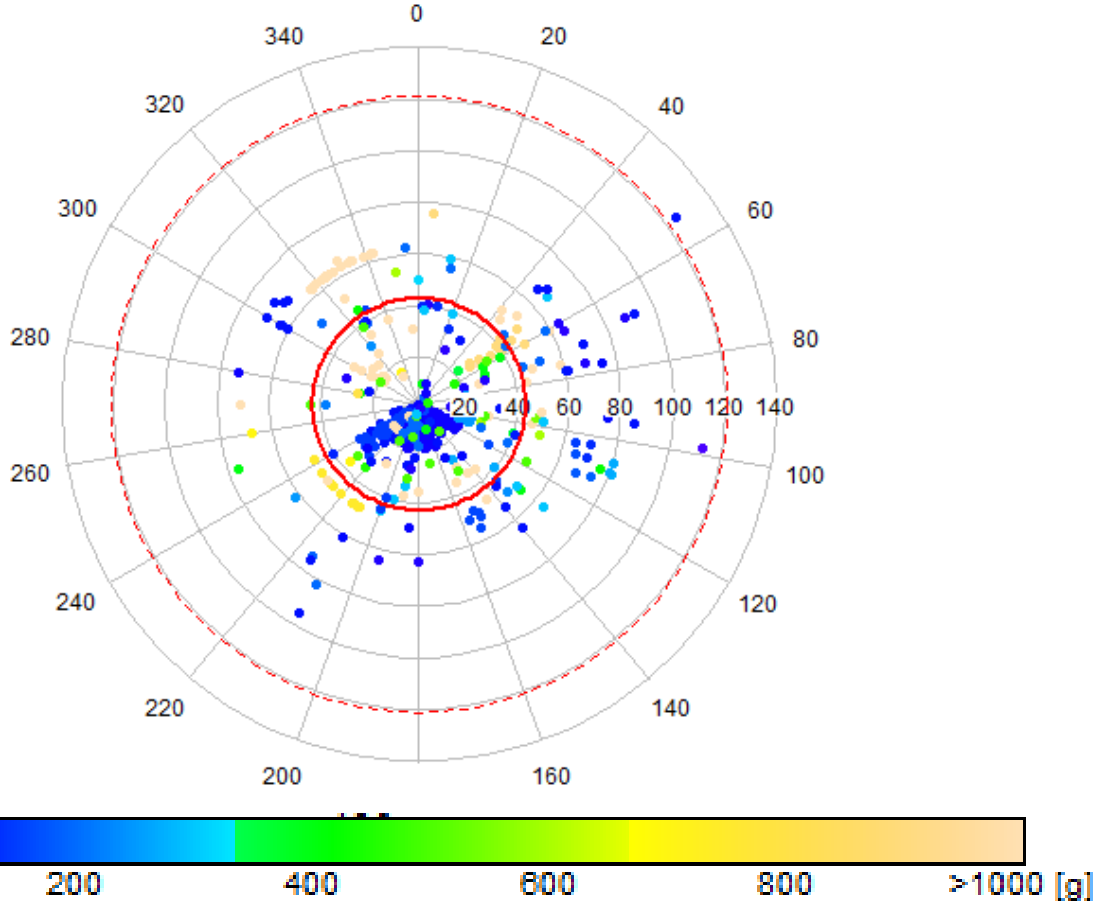
Ice throw field studies at Meteotest





Sectors with high risk of ice fall / ice throw are depended on the wind statistic under icing conditions

Ice throw field studies at Meteotest



Combinded results
Gütsch, St. Brais, Mt Crosin

- Ca. **50 icing events**
- Ca. **1’000 ice pieces**

→ the route of a winter hiking train has been changed
→ warning signs were installed

Ice throw study findings

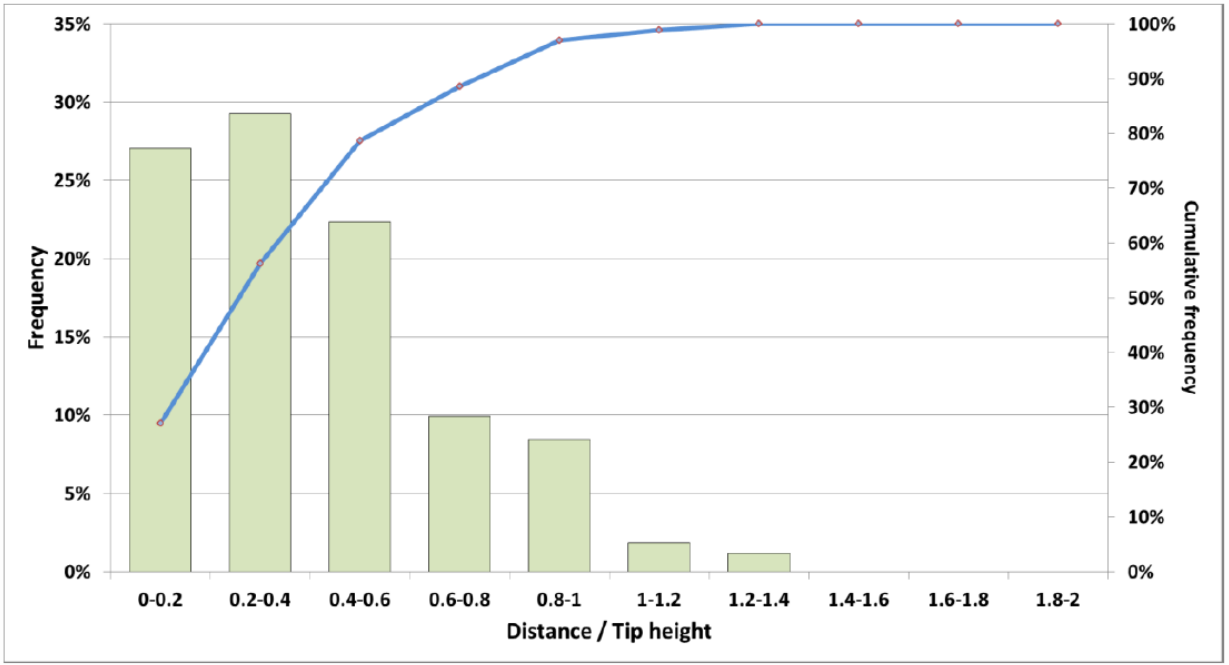


Fig. 8: Frequency distribution of the ice particles collected (Gütsch, St. Brais, Mont Crosin) depending on the distance, normalised with the tip height of each turbine.

Ice throw study findings

The analysis shows:

- increased frequency of ice throw up to distances equal to the tip height at all three sites
- the frequency observed decreases significantly at longer distances
- the risk of ice throw has to be assessed for each individual wind turbine during planning and operation under icing conditions
- No ice particles were found at distances larger than 1.4 x tip height
- It is possible that ice throw occurs beyond these distances. However, the analysis is based on a fairly large number of particles, suggesting that the probability of finding particles beyond 1.4 x tip height is fairly low

Ice throw study findings

The radius of danger of ice throw according to the Seifert formula:

1.5 * (rotor diameter + hub height)

-> equals 1.9 to 2.0 x tip height at the three sites investigated

-> distances this long were never observed during the field studies

As a result of the field study:

- measures were taken by the operators for minimising the risk
- measures included warning signs, adaptation of the operating mode
- adaptation of the situation and maintenance of hiking paths or cross country ski tracks crossing the sites


Eisfall !
Privatgelände
Betreten auf eigene Gefahr!
(der Betreiber)

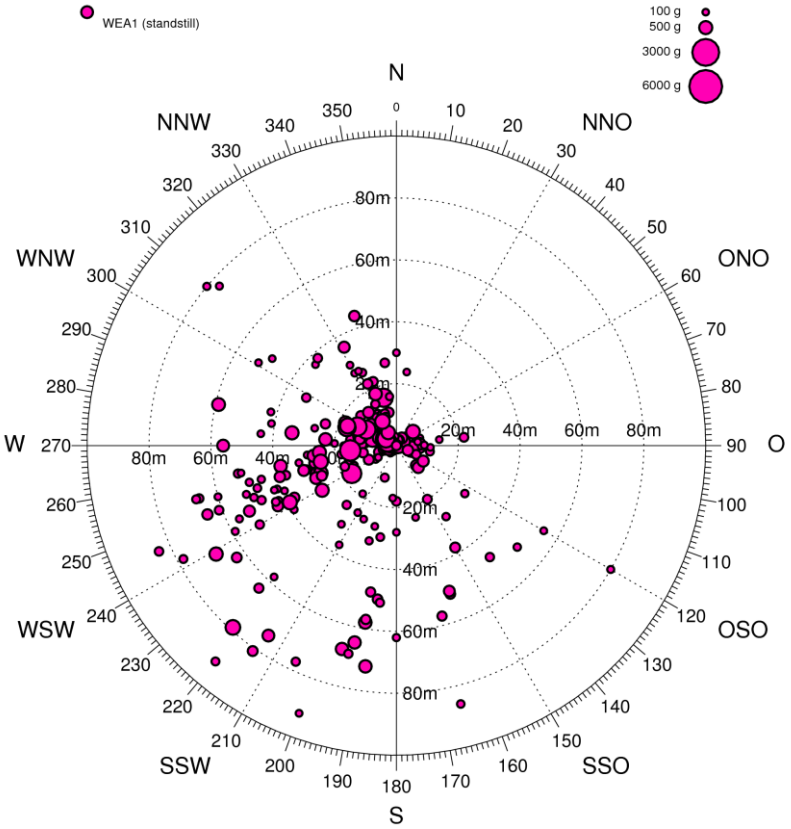

EISABWURF !
CADUTA GHIACCIO !
CHUTE DE GLACE !
ICE SHEDDING !

How accurate can you work?

How many pieces do you count?

How big? How heavy?

What do we know about the reality?



Lessons learnt

- **Not all events** can be recorded
- Inspection always **delayed**
- Exact **timing** of ice throw **unknown**
- **No «live» data during ice throw/fall**
  - Operational state of wind turbine unknown
  - Wind speed, wind direction, orientation, rotor position etc. unknown
  - Effect of rotor blade heating unknown
- **No distinction** between **ice throw** and **ice fall**
- **Lot of guessing** (no. of pieces, weight, size, density)
- **Subjective recording method**
- Data **not suitable** for proper **model validation**
- **Only assumptions** possible (it seems that…)

Conclusions

There are a lot of open questions regarding ice throw!

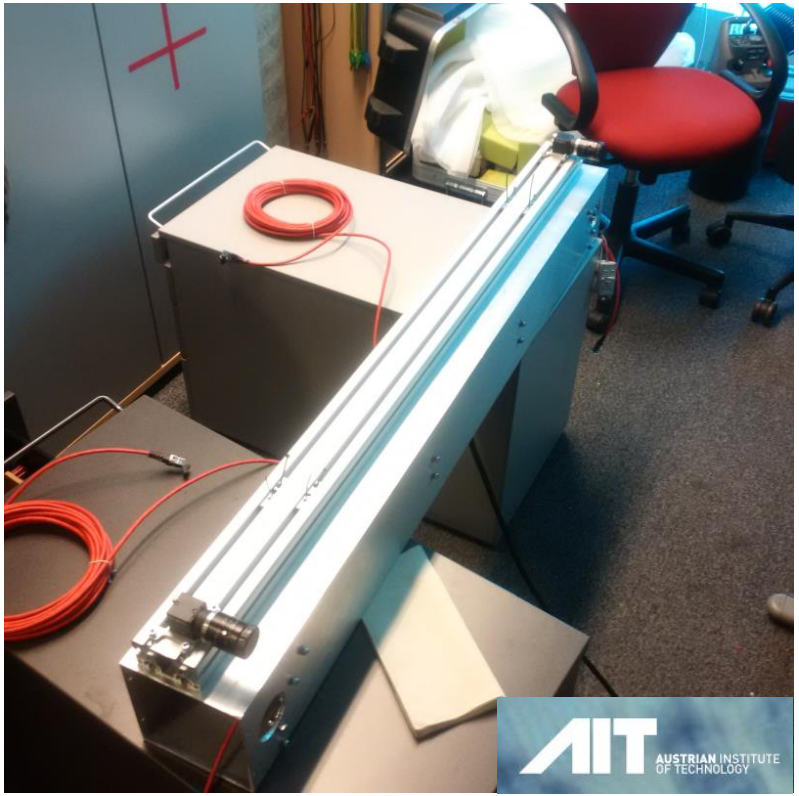
We need:

- **Standards and guidelines** for ice risk assessment
- More and better **«live» field data** for model validation
- **New innovative methods** for ice throw observations

New methods: eisatlas.at Projekt R.Ice

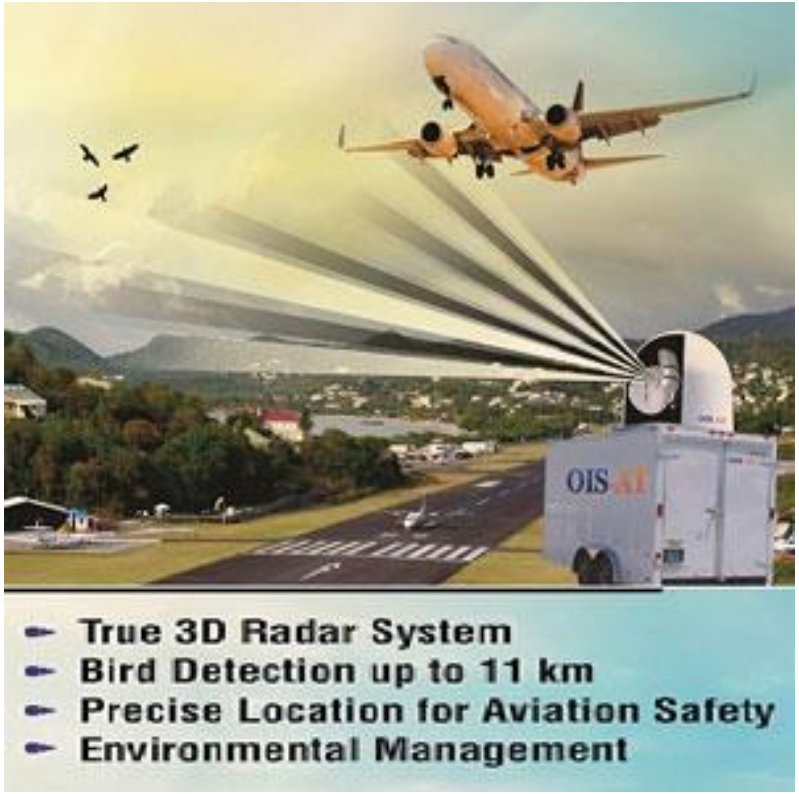
- Monitoring of icing events at wind turbines using an innovative imaging method to generate a data base in terms of number, size, distance and possible flight trajectories of falling ice fragments
- Define resulting hazard areas due icefall for all regions in Austria by modelling the respective landing locations of ice pieces around wind turbines and exposed structures.
- Development of scientifically verified policies and measures for possible further reduction of risk through ice-fall, together with lawyers and experts

New methods?



www.eisatlas.at

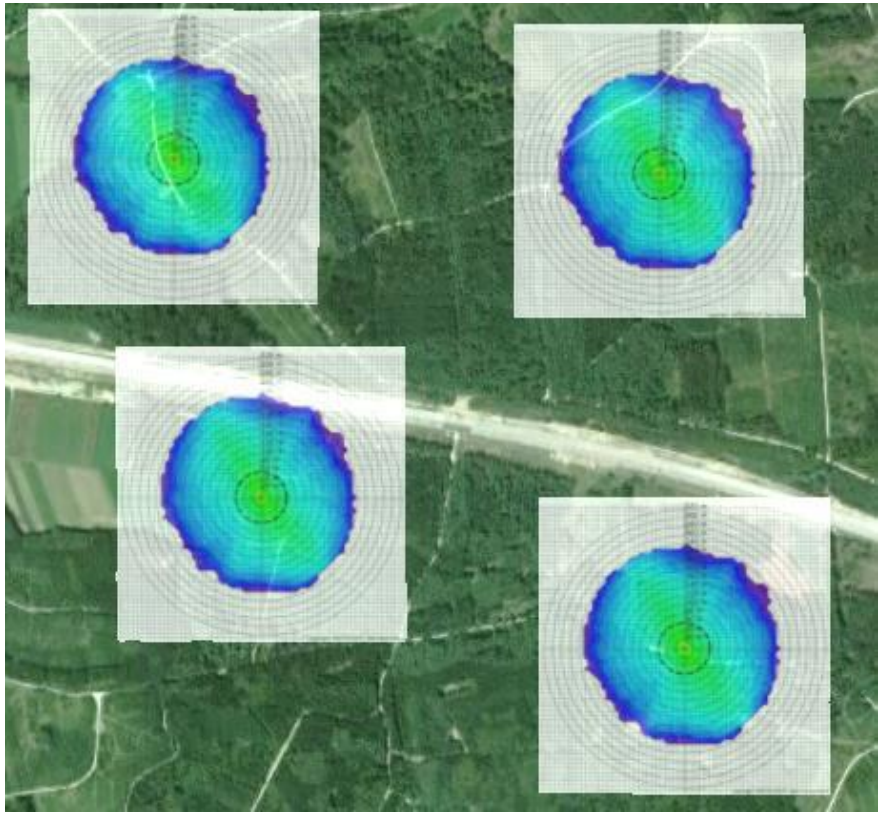
New methods?


OIS
True 3D Radar System
Bird Detection up to 11 km
Precise Location for Aviation Safety
Environmental Management

New methods?


SELECTED:
VIEW
Circle Around
Top View
Down Range
Hit Screen
125 yds
150 yds
175 yds
200 yds
TRACKMAN
Camera Quick Position
Manual Camera Position
PLAYER:
CLUB: 3w
BALL:
NOTES:

Ice throw risk assessments at Meteotest



Ice throw risk assessments at Meteotest

- Calculation of ice fall and ice throw for many projects in Swiss and for European countries
- We are assuming that probability of ice fall/throw is not the same around the turbine (main wind directions, “icing” wind directions).
- Input parameters or a ballistic model:
  - coordinates
  - hub height
  - rotor diameter
  - rotational speed,
  - time series of wind speed and wind direction
  - mean surface roughness at site or mean vertical wind profile
  - information on icing or temperature and relative humidity

Ice throw risk assessments at Meteotest

According to input parameters velocity and direction of a predefined ice piece is calculated

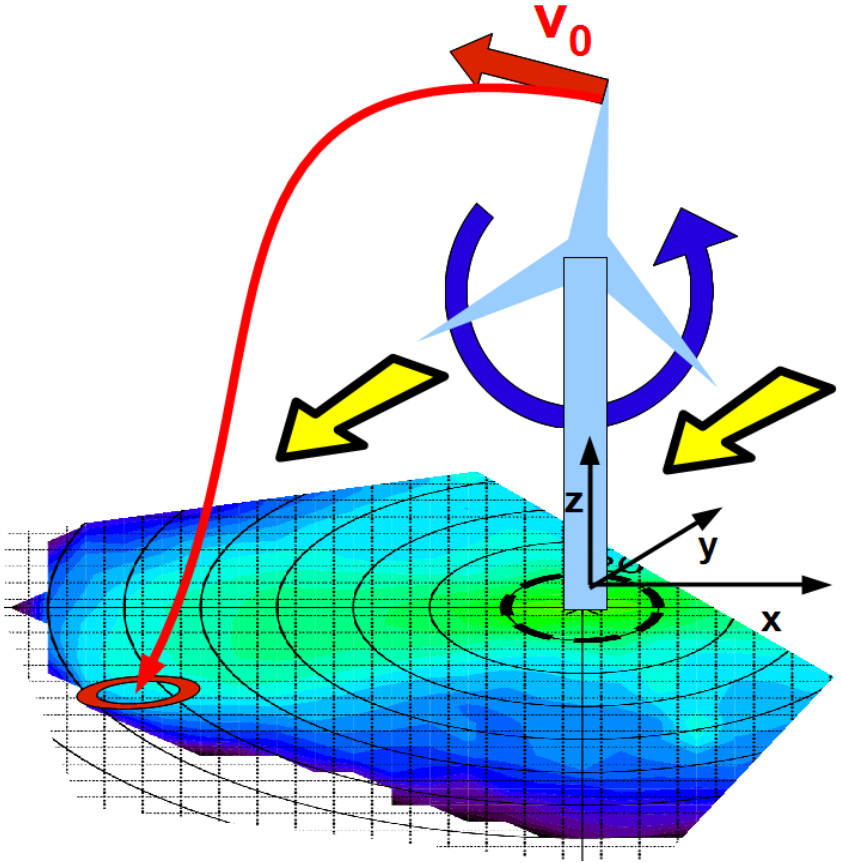
- Result -> site of impact for one piece
- Repeated for different azimuth positions and positions on the rotor
- Hits for each grid cell are summarized
- Risk analysis for each grid cell around the turbine
- If data base allows: only for periods with icing conditions (heated/unheated anemometer data, temperature…)

Four scenarios are calculated:

- Small ice piece, rime: 0.1 x 0.04 x 0.02 m / density 600 kg/m3 (48 g)
- Small ice piece, glaze ice: 0.1 x 0.07 x 0.03 m / density 900 kg/m3 (216 g)
- Large ice piece, rime; 0.2 x 0.15 x 0.1 m / density 600 kg/m3 (1.8 kg)
- Large ice piece, glaze ice: 0.2 x 0.18 x 0.19 m / density 900 kg/m3 (6.0 kg)

Ice throw risk assessments at Meteotest

Ballistic model

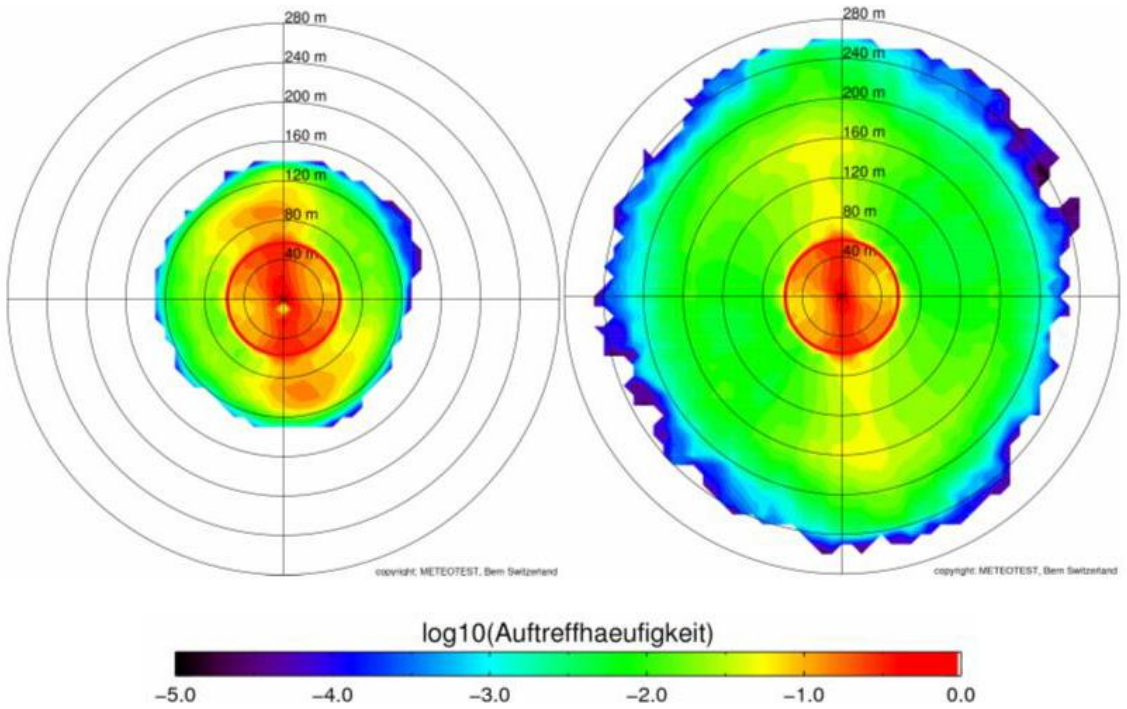


Ice throw risk assessments at Meteotest

Two examples for ice throw calculations

Results are scaled:
the grid with the most hits obtains the value «1» (respectively 0 in the logarithmic scale).

The colour value -2 implies that for this grid cell 100 (10^-2) times less hits were simulated than for the grid cell with the most hits.



Ice throw risk assessments at Meteotest

Visualisation of ice throw results in Google Earth.

Detailed risk analyses:

-> risk for person or car on a path or road

-> considering time that a person needs to cross the risky area

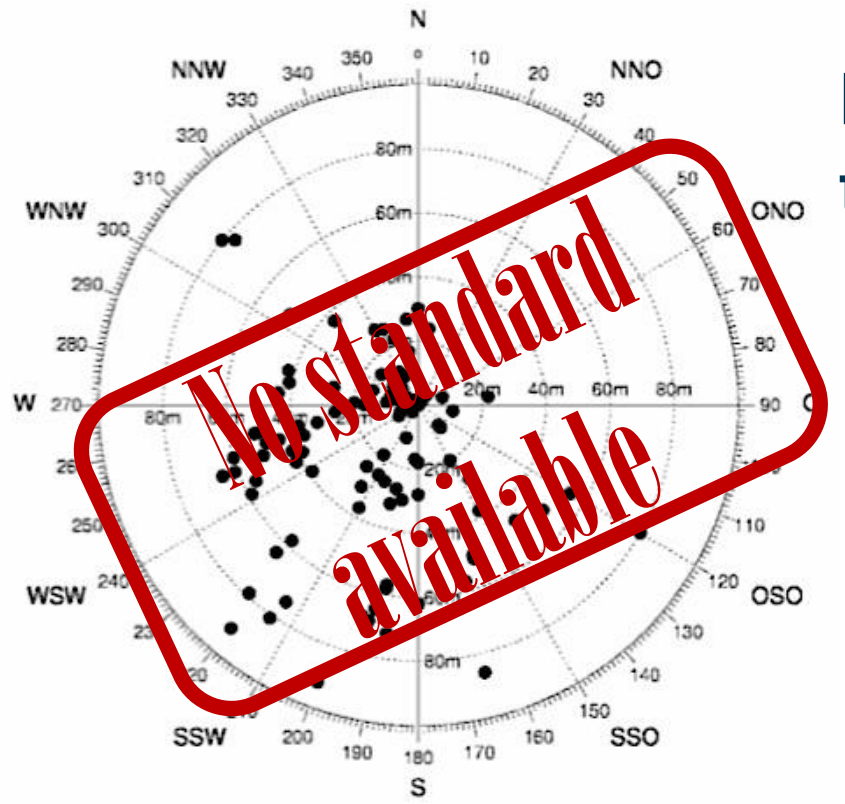
Thank you for your attention!

IEA wind Task 19 – Subtask Ice throw

IEA wind Task 19 – Subtask Ice throw

No. of ice pieces per winter?

Size of pieces?



How far do they go?

Influence of wind direction?

And on my site?

IEA Task 19 2016 to 2018

Table 1: Task 19 topics, motivation, content, deliverables and communication for period 2016-2018.

	Topics			
	Deployment of wind energy in cold climate	**Ice measurements, forecasting and mapping**	**Towards certified practices for cold climate solutions**	**Safety and acceptance**
Task 19 motivation	Increase industrial awareness and interest	Better tools for site condition and energy yield assessment	Bringing cold climate issues in guidelines and standards	Removing cold climate specific barriers
Content	Industry advisory board for Task 19 Market study update Validation of IEA site ice classification	Ice sensor classification Ice mapping	Work with IEC 61400-15 "Site assessment" T19IceLossMethod software development and validation Laboratory and full scale testing Ice protection system performance evaluation guidelines	International ice throw guidelines
Deliverables	New cold climate practices to international standard IEC 61400-15 "Site assessment" Market study update Maintain and update open source software "T19IceLossMethod" International Ice Throw Guideline Update Available Technologies report Update Recommended practices report			
Communication	Web site Workshops Free software Presentations at conferences			
Countries	ALL	FI, SU, SE, DK, CA	ALL	AU, SU, CA

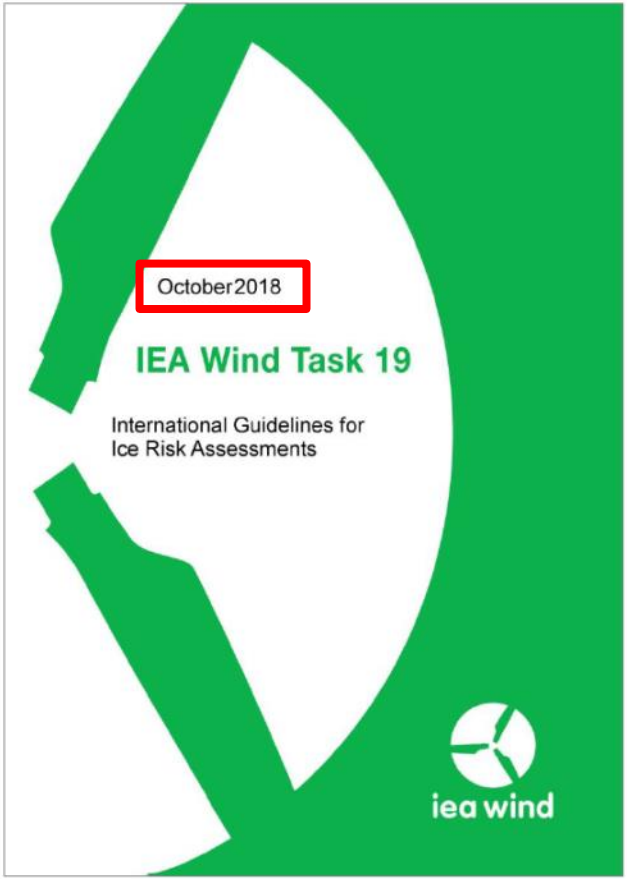
IEA Task 19 website

Current situation and project objective: In an increasing number of countries the authorities are asking for ice-throw / ice-fall risk assessments during approval procedure of new wind parks. However up to now, no international recommendations, guidelines or standards are available as to the elaboration of those assessments. As a matter of consequence, the quality requirements of public authorities as well as the used methodologies and results of individual consultants vary to a large extent.

IEA Task 19 guideline

Partners:

- Energiewerkstatt
- Meteotest
- Kjeller Vindteknikk
- Enercon
- TÜV Süd
- F2E
- RES



Peer review of existing methods

Workshop 1: Mathematical Model

- Most suitable calculation approach
- Relevant mathematical parameters

Workshop 2: Data Set

- Parameters, no. of ice pieces, position on blade
- Reliable data sources

Workshop 3: Risk Determination

- Suitable calculation method
- Accepted risk levels