European Test Sites

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Abstract—The need to develop operational rugged instruments for the detection of icing has been recognized for a long time, especially during the last EUMETNET SWS I & II project which have recommended that the necessary steps be undertaken for such a purpose. At the same time, the WMO/CIMO has expressed concerns about performing measurements worldwide at Automatic Weather Stations AWS under harsh environments – e.g. icing – and assessing their quality. Under the COST727 envelope, ice detection instruments were set up at six operational measurement sites (test stations) in Europe:

- **Finland: Luosto**
- **Sweden: Sveg**
- **Germany: Zinnwald**
- **United Kingdom: Deadwater Fell**
- **Czech Republic : Studnice**
- **Switzerland: Gütsch**

The instruments tested and the results are the subject of other IWAIS papers. This paper summarises the details of each site, including their orography, General and specific climatology, data acquisition systems and instruments under test.

I. Background

The main objective of the European Union 'Action' COST727 was to develop the understanding of icing (especially in-cloud icing but including wet snow) and freezing rain events in the atmospheric boundary layer and their distribution over Europe as well as to improve the potential to observe, monitor and forecast them. The first phase of the action was completed in early 2007 and a State of the Art report [1] disseminated. This is a report on icing measurements throughout Europe and included a Working Plan for the Research and Development Phase (Phase II).

COST727 is made up of 4 groups:

1. WG1 Modelling
2. WG2 Icing data acquisition
3. MC Management committee. Composed of each country's representatives and is intended to monitor progress of the project
4. Core Group COST727 chairman and vice-chair plus the chairmen of the two WGs

This paper looks at part of the work of WG2.

II. Measurements of Icing

The State of the Art report dealt with the results of WG2 concerning measurements of icing as well as measurements performed under icing conditions. It contained information on:

- Definition of icing
- Past and present activities
- Standards
- Measurements under icing conditions
- Requirements and availability of ice detectors
- Examples of existing data and experiences with existing ice
- Recommendations for future activities

The need to develop operationally rugged instruments for the detection of icing has been recognised for a long time. The goal of the WG2 has been to attempt to find suitable instruments for the detection of icing and/or for the measurement of the accumulated ice and its accretion rate on the market. After a first test period during Phase I, WG2 has selected 2 "reference" instruments which were performing more or less following the specifications required: the Combitech IceMonitor (Sweden) and the Goodrich/Campbell/Rosemount ice detector (USA, distributed by Campbell Scientific Ltd Canada). A further Icemeter tested was the HoloOptics T20 Icing rate sensor. These are fully described in another paper at this Workshop [2].

III. Test Stations

A. General

Six test stations were outfitted with the Combitech IceMonitor sensor (winters 2007-2008 and 2008-2009) and the Goodrich sensor (winter 2008-2009):

Finland: Luosto
Sweden: Sveg
Germany: Zinnwald
United Kingdom: Deadwater Fell
Czech Republic: Studnice
Switzerland: Gütsch

Some of these stations also tested the HoloOptics T20 sensor. WG1 needed specific data for ice-accretion forecasting models. In order to obtain this, two documents were

initialized:

- a configuration table describing instrumental setup of the stations
- a full description of each station displaying the environmental characteristics of the sites.

This paper summarises this data for each of the sites. All icing data, together with ancillary meteorological measurements, have been put in a consistent format and sent to a dedicated database (FTP server) located in Switzerland (Meteotest). Full details of the sites are provided separately as PDF files.

B. Luosto - Finland

This test station is located in northern Finland north of the Polar Circle on the top of Luosto fell. Luosto is at the northern end of a chain of arctic fells with open treeless tops. The height of the gently-sloping fell is 515 m a.s.l and the rounded top lies 250m above the surrounding flat land. The treeless fell top is just above the frequent surface inversion layer and thus prone to strong winds and severe icing conditions.. The platform for the instruments was built in the autumn of 2000 (Figure 3.1) and is 3.5 m above the ground. The poles for the wind sensors are 3 m high, whilst the other sensors are attached to shorter poles on the other side of the platform.

Fig. 3.1 The Luosto test site, Finland.

C. Sveg – Sweden

The Sveg station is located in the middle of Sweden, east and south of the Swedish mountains. The test site is equipped with five measuring stations that are remotely connected to a measuring central located in Östersund, Sweden. Communication with the stations is via the GSM-network, using GPRS for acquiring data. The instruments to be tested are almost the same for every station. Four of the stations are mounted at different heights on a TV mast (Figure 3.2), and the fifth station is located in the generator housing of the nearby wind turbine. No standard meteorological instruments are located at the site.

Fig. 3.2 The Sveg site in Sweden

D. Zinnwald – Germany

The Zinnwald site is located in the Ore mountains in South East Germany (Figure 3.3).

Fig. 3.3 The Zinnwald test site in Germany

E. Deadwater Fell – United Kingdom

Deadwater Fell is an isolated hill approximately 75km from both Atlantic Ocean (to West) and the North Sea (to East). It has a flat top approximately 250m long. It is unmanned and has a 200m test span with a platform at one end and also a rotating sample test station rig (Figure 3.4).

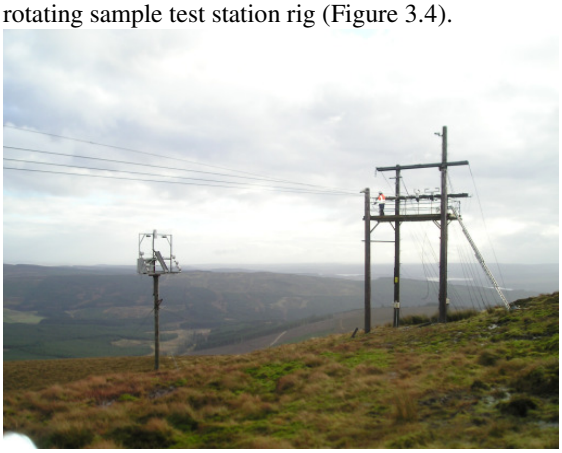


Fig. 3.4 The Deadwater Fell Test site in the UK

F. Studnice – Czech Republic

The Studnice test site is located about 60km North West of Brno in the Czech Moravian Highlands. The site itself is built on a flat ridge. There are two spans (Figure 3.5) of around 250m each.

Fig. 3.5 One of the towers at the Studnice site in the Czech Republic

G. Gütsch – Switzerland

The Gütsch station is located in the middle of the Alps, in the Gotthard region above the village of Andermatt. The meteorological station is presently equipped with 2 measurement bridges supporting the standard meteorological instruments and the instruments to be tested. The infrastructure is designed to add easily two other similar bridges in case of large scale measurement activities or to install other types of instruments near the ground (rain gauges, ceilometers, present weather sensors, etc…) or at higher elevation with dedicated supplementary masts. A rugged camera system (extra heating) is installed on one of the wind masts and allows for panorama views of the surrounding as well as zoomed pictures of the instruments providing valuable information on the icing rates.

Fig. 3.6 The Gütsch site above Andermatt in Switzerland

IV.

V. Appendix

The Appendices list the detailed site data as follows:

1. Finland: Luosto
2. Sweden: Sveg
3. Germany: Zinnwald
4. United Kingdom: Deadwater Fell
5. Czech Republic: Studnice
6. Switzerland: Gütsch

VI. References

Technical Reports:

[1] COST-727, WG2. Atmospheric Icing on Structures: ‘Measurements and data collection on icing: State of the Art’ MeteoSwiss, 75, 110 pp.2006

Papers Presented at Conferences (Unpublished):

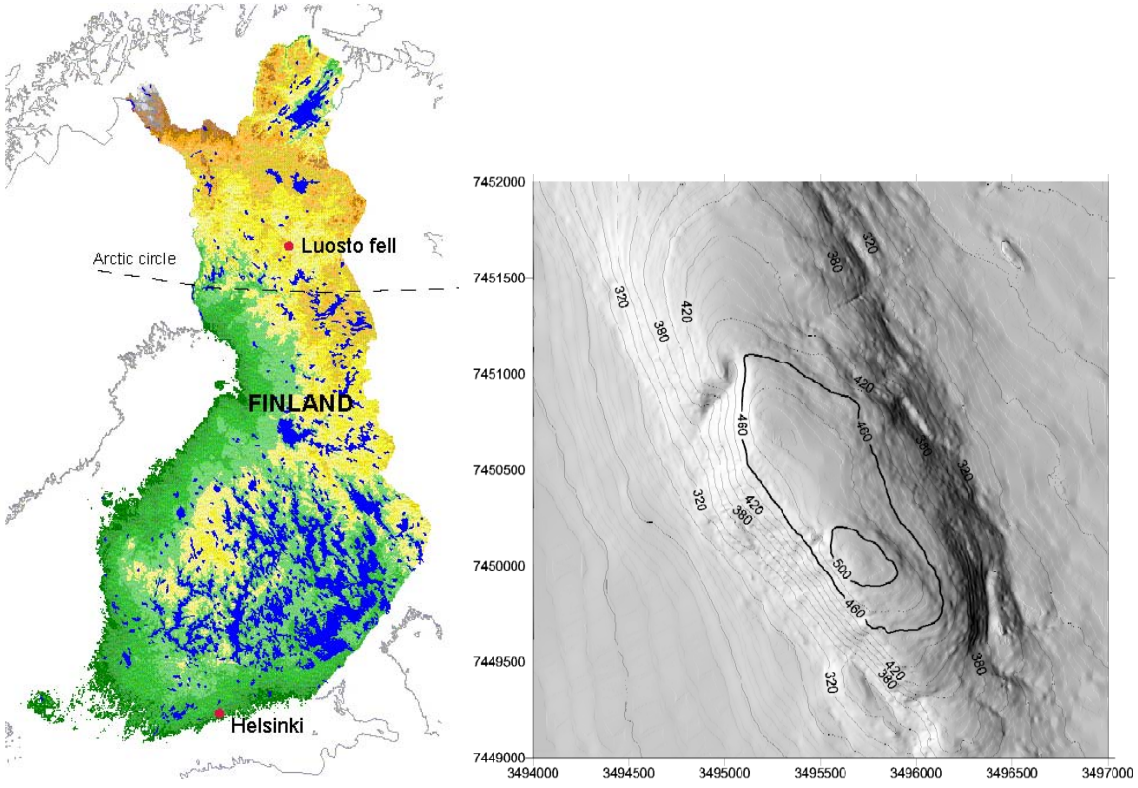
[2] J. B. Wareing, "Test Site data on icing monitors and conductor ice loads" presented at the 9th IWAIS, Andermatt, Switzerland, 2009. Poster PO. 068

SITE

Name:	Luosto
Owner/operator	Finnish Meteorological Institute
Country	Finland
Geographical coordinates (°N, °E):	67º08´ N, 26º54´ E,
Height (m a.s.l.):	515
Weather station numbers LPNN/WMO:	05841
Distance from nearest airport (or weather station with cloud base measurements)	Sodankylä observatory 45 km
Primary interest for test site	Meteorological studies

Orography

The FMI test station is located in northern Finland north of the Polar Circle on the top of Luosto fell. Luosto is at the northern end of a chain of arctic fells with open treeless cap. The height of the gently-sloping fell is 515 m a.s.l and the rounded top lies 250 m above the surrounding flat land. The treeless fell top is just above the frequent surface inversion layer and thus prone to strong winds and severe icing conditions.



Luosto is located in Northern Finland, north of the Arctic Circle (on left). Orographic map with height contours of Luosto fell. The test station is located at the highest point of the fell (on right).

General and specific climatology over the measurement period

Table. Climatological monthly averages (2001-2007) measured at Luosto and monthly averages experienced during the test winter in 2007/2008. T is air temperature, V is wind speed, RH is relative humidity and N is the number of icing hours.

VALUE	Oct	Nov	Dec	Jan	Feb	March	April
Clim T (°C)	-1.5	-5.9	-8.7	-10.5	-10.9	-6.8	-4.0
Test T (°C)	1.7	-6.0	-4.1	-7.8	-8.6	-8.9	
Clim Tmin (°C)	-10.5	-15.9	-18.6	-24.2	-21.4	-16.9	-11.9
Test Tmin (°C)	-6.5	-12.5	-16.7	-18.9	-15.6	-17.5	
Clim Tmax (°C)	7.1	2.6	-0.7	-0.6	1.0	3.7	9.8
Test Tmax (°C)	8.8	-0.7	4.3	-0.7	-1.2	2.9	
Clim RH (%)	95	95	92	92	91	85	74
Test RH (%)	96	94	93	92	92	89	
Clim V (m/s)	8.5	9.3	9.4	9.5	9.1	8.6	7.4
Test V (m/s)	10.4	8.9	10.5	10.4	8.9	8.0	
Clim N (h)	192	310	255	232	185	129	74
Test N (h)	55	328	361	380	288	135	

Available local infrastructure (mast, platform etc.):

The platform for the instruments was built in the autumn of 2000 (see figure below). The floor of the platform is 3.5 m above the ground. The poles for the wind sensors are 3 m high, while the other sensors are attached to shorter poles on the other side of the platform.

SENSORS AND INSTRUMENTS

Table. The manufacture and country, type, some characteristics and maximum heating power (MHP) of sensors operated at Luosto.

Manufacture Country	Type	Principle of operation, Additional information	Picture
Metek, Germany	USA-1	• 3D Ultrasonic, time of flight. • The arms, the sensors and the vertical pole are heated. • The body unheated • The sensor also provides the (sonic) air temperature • Measuring range 0…60 m/s • Weight 0.7 kg • Operating temp. -30…+50 °C • MHP: 50 W	
Thies A., Germany		• 2 D Ultrasonic, time of flight • Each arm 15-17 W • Measuring range 0…65m/s • Weight approx. 2.5 kg • Operating temp. -40…+70 °C • MHP: 70 W	
Vaisala, Finland	WAA252	• Mechanical cup, heated • Cups 50 W, shaft 12 W, body 10 W, • Measuring range 0.4…75 m/s • Weight 800 g • Operating temp. -55… +55 °C • MHP: 72 W	

Rosemount, USA	0872J1	• Prototype • Ultrasonic resonance • Duration of icing • MHP: 200 W,	
Combitech, Sweden	IceMonitor	• Vertically mounted 0.5 long rod with diameter of 30 mm • Ice load measuring range: 0-50 kg • Accuracy: ± 50 g • Operating temperature: -40°C…50°C • Ice sensor tube freely rotating, supported by a sensor rod which is held by a load cell for weighing • The bearing for the rod is electrically heated to minimize friction and to avoid icing on the bearing.	
HoloOptics, Sweden	T26	• Prototype • Patented digital optronic ice indicator • IR emitter • Probe changing its optical properties if covered with any kind of ice.	

Data acquisition system:

The Data Acquisition System consists of one PC and four cameras (with extra heating systems).

The sampling frequency is 1 Hz for most of the instruments. The integration time is 10 minutes. A set of picture is taken every 15 minutes. The data and video pictures are transferred every 1 hour using ftp transfer system to the server located at FMI in Helsinki, Finland. The real time data is archived at the FMI.

MEASUREMENT DATA

The data are stored on a server at FMI using MySQL data base structure. Data is also available in excel sheets. The data are available for daily quality control.

Recorded values of parameters are associated with a date and time stamp.

Parameters:

	Unit	Resolution	Averaging	Remark
Wind speed	m/s	0.1 m/s	10’	
Wind direction	°	1°	10’	
Temperature	°C	0.1 °C	10’	
Dew point	°C	0.1 °C	10’	
Humidity	%	1%	10’	
Solar radiation	W/m^2	0.1 W/m^2	10’	
Ice load	Kg	0.001 Kg	10’	
Icing	On/off		10’	

SITE

Name:	Sveg
Owner/operator	Combitech
Country	Sweden
Geographivcal coordinates (N, E):	61° 55' N, 14° 18’ E
Height (m.a.s.l.) at mast ground level:	705

Orography

The Sveg station is located in the middle of Sweden, east and south of the Swedish mountains. The mast is at “B” and Sveg village is situated at “A”. The distance between A and B is about 20 km.

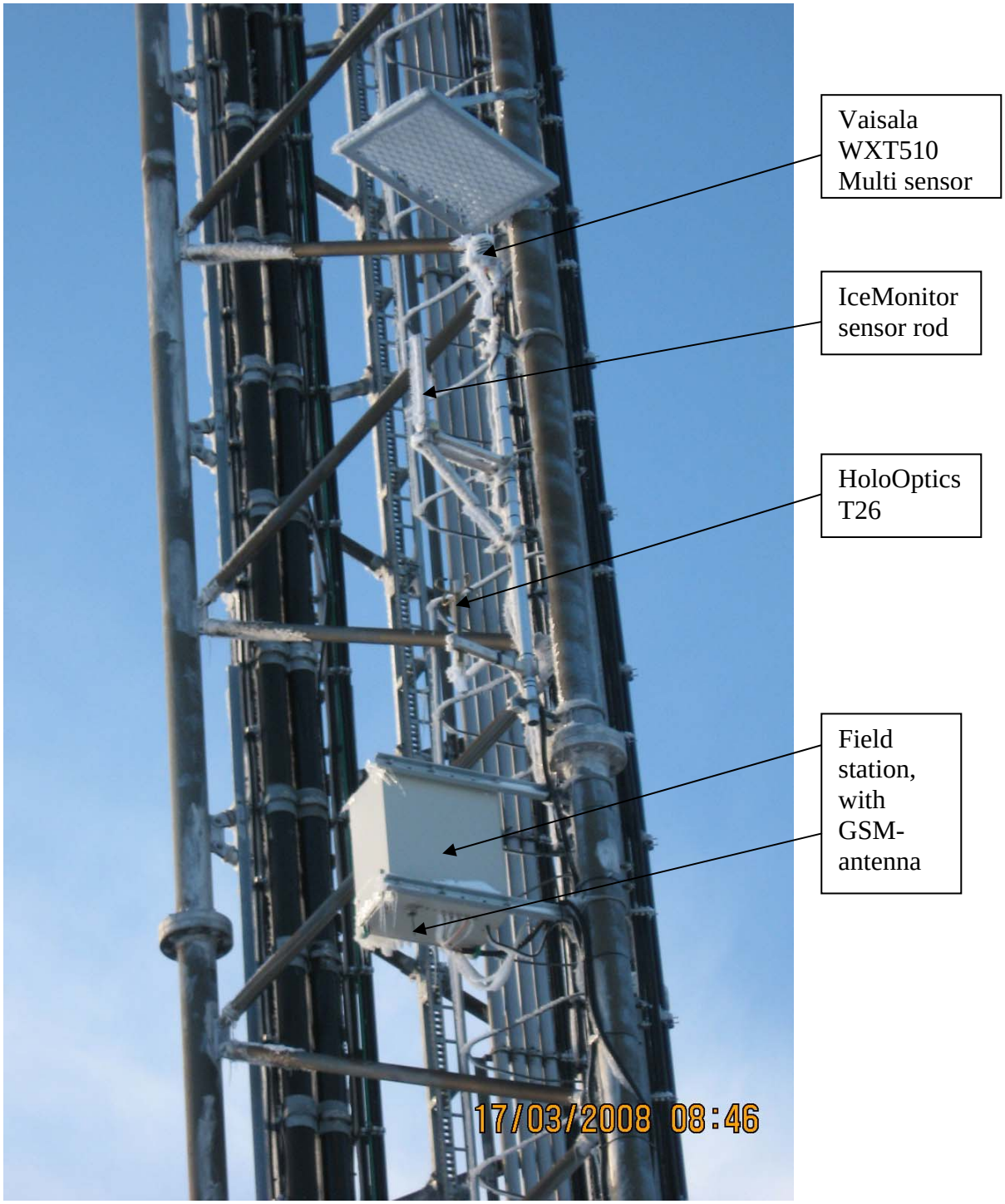
General and specific climatology over the measurement period

Table. Climatic monthly averages (30 years averages; 1971 – 2000) and monthly averages experienced during the test. T is air temperature, VN8 is the number of days with V_{max} > 8 m/s), VN14 is the number of days with V_{max} > 14 m/s). GR is glocal radiation and N is the number of icing days (number of days with T_{min} < 0˚C).

VALUE	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**
Clim T (˚C)	2.8	-3.5	-7.8	-8.9	-7.8	-3.3	1.5
Test T							
Clim T_{min} (˚C)	-0.6	-7.1	-12.2	-13.4	-12.8	-8.2	-3.5
Test T_{min}							
Clim T_{max} (˚C)	6.4	-0.3	-3.9	-5.0	-2.9	1.7	6.3
Test T_{max}							
Clim Humidity	82	86	86	85	82	78	73
Test Humidity							
Clim VN8	3	2	3	3	2	2	2
Clim VN14	0	0	0	0	0	0	0
Test V (m/s)							
Test V_{max} (m/s)							
Clim GR (W/m^2)							
Test GR (W/m^2)							
Clim N, ??????????	19	130	252	285	228	122	26
Test N							

Test station

The test site is equipped with five measuring stations that are remotely connected to a measuring central located in Östersund, Sweden. Communication with the stations is via the GSM-network, using GPRS for acquiring data. The instruments to be tested are almost the same for every station. Four of the stations are mounted at different heights in a TV mast, and the fifth station is located in the generator housing of the nearby wind tubine. No standard meteorological instruments are located at the site.



Instruments

Manufacture and country, the type and some characteristics of the sensors operated in Sveg are displayed in the following table.

Manufacture and country	Type	Principle of operation	Picture
Combitech Sweden	IceMonitor	• Vertically mounted rod • The rod is a cylinder (pipe with top cover) placed on top of a rod supported by a load cell for weighing. • The cylinder can freely rotate when ice builds up to obtain a cylindrical ice build up. • The bearing for the rod is heated (via a thermostat) to secure the weighing function.	
HoloOptics Sweden	T23 T26	• Patented digital optronic ice indicator • IR emitter • Photo detector • Probe changing its optical properties if covered with any kind of ice.	
Vaisala Finland	WXT510	• Multi parameter sensor • Air temperature • Air humidity • Air pressure • Wind speed • Wind direction • Precipitation type	

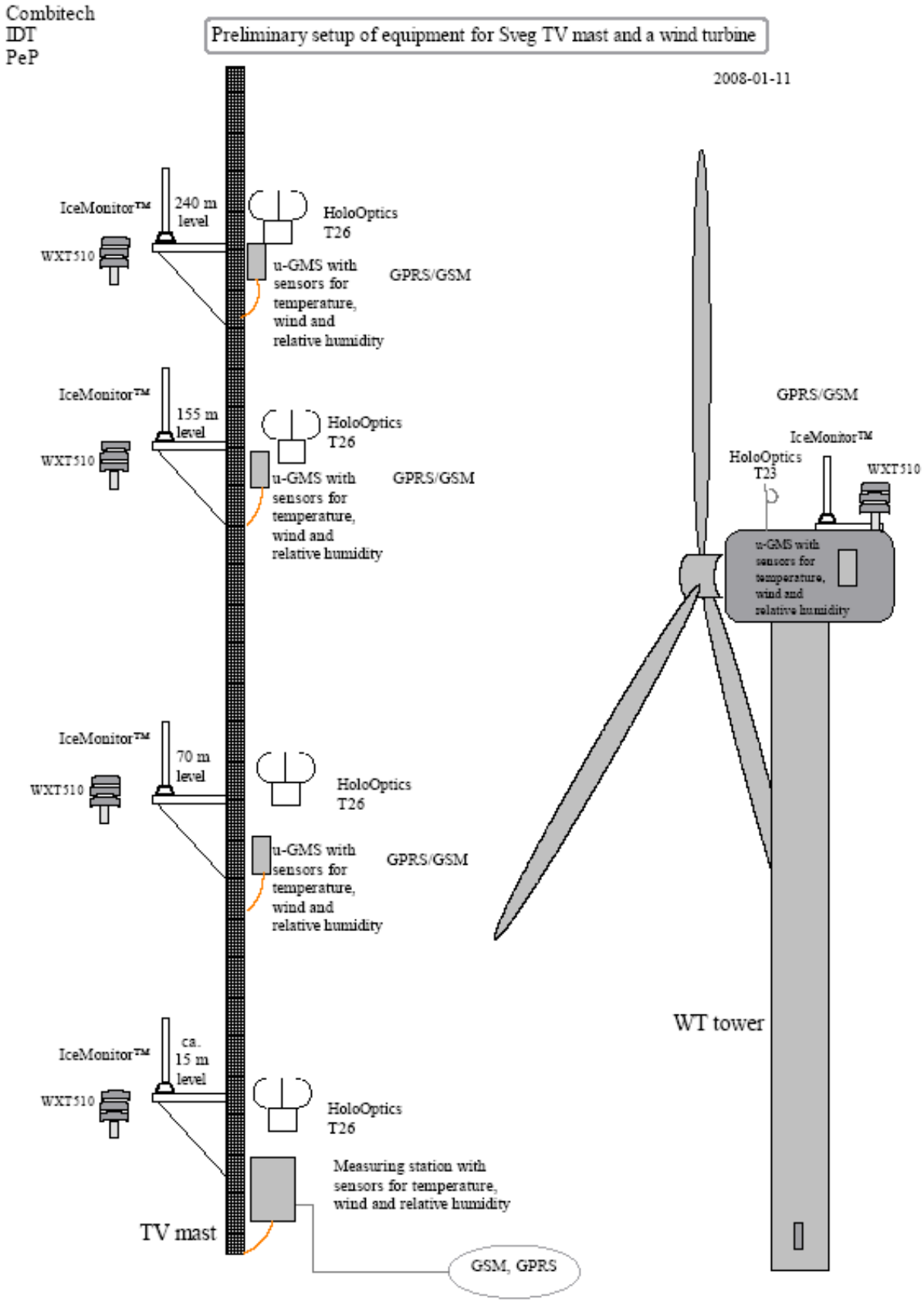
Data acquisition system

The data acquisition system consist of one field measuring station for every set of sensors, and a measuring central located at Combitech in Östersund. For retrieval of data from the field stations GSM-modems are used. Data is retrieved with GPRS to reduce costs.

The field stations in the TV-mast are mounted at the following heights:

- Right above the tree tops, at 15 m from mast base level.
- At 70 m
- At 155 m
- And at 240 m

The mast is totally 330 meters and the reason to not having a station at 300 meters is that the availability for installation and service of the equipment will be very limited as the TV-antennas has to be shut down to allow passing that area in the mast.


Combitech
IDT
PeP
Preliminary setup of equipment for Sveg TV mast and a wind turbine
2008-01-11
IceMonitor™
240 m level
WXT510
HoloOptics T26
u-GMS with sensors for temperature, wind and relative humidity
GPRS/GSM
IceMonitor™
155 m level
WXT510
HoloOptics T26
u-GMS with sensors for temperature, wind and relative humidity
GPRS/GSM
IceMonitor™
70 m level
WXT510
HoloOptics T26
u-GMS with sensors for temperature, wind and relative humidity
GPRS/GSM
IceMonitor™
ca. 15 m level
WXT510
HoloOptics T26
Measuring station with sensors for temperature, wind and relative humidity
TV mast
GSM, GPRS
GPRS/GSM
IceMonitor™
HoloOptics T23
WXT510
u-GMS with sensors for temperature, wind and relative humidity
WT tower
Sketch Sveg mast 20080111.sdr - Mon Jan 21 09:41:55 2008 - Page 1

Measurements at the nearby nacelle (80 m agl)

Almost the same setup of measuring equipment is installed at the wind turbine.
For ice detection the HoloOptics sensor is of type T23, with one sensor only – this is due to that wind direction always is the same towards the nacelle. The field station is mounted in a much smaller cabinet than the type used at the TV-mast.

The sampling frequency is 1 Hz for the Vaisala multi sensor.
The integration time is 10 minutes. Data is stored locally every 10 minutes in the field station for retrieval via GPRS to the server in Östersund once every hour.

Measured data

Recorded values of parameters are associated with a date and time stamp.

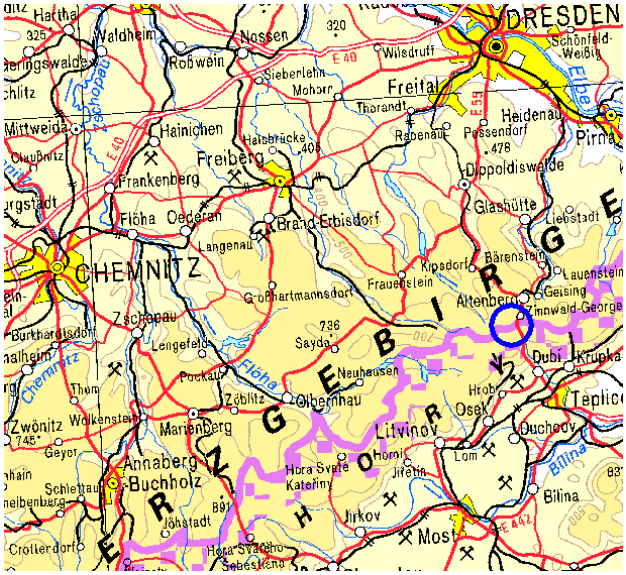
Parameters:

	Unit	Resolution	Averaging	Remark
Wind speed	m/s	0.1 m/s	30s, 10 min	
Wind direction	˚	1˚	30s, 10 min	
Temperature	˚C	0.1 ˚C	30s	
Dew point	˚C	0.1 ˚C	30s	
Humidity	%	1%	30s	
Air pressure	hPa	0.1 hPa	30s	
Ice load	kg	0.01 kg	30s	
Ice detection	Seconds/10min	1s	N/A	

SITE

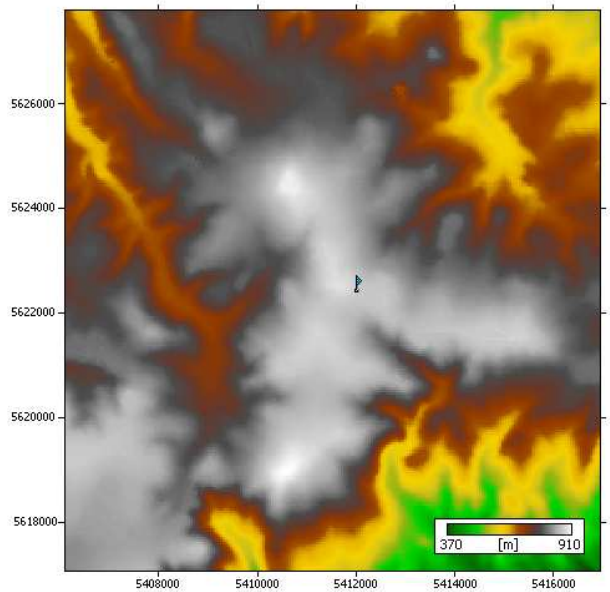
Name:	Zinnwald
Owner/operator	German Meteorological Service
Country	Germany
Geographical coordinates (°N, °E):	50°43'58" N, 13°45'11" E
Height (m a.s.l.):	877
Weather station numbers LPNN/WMO:	10 582
Distance from airport or weather station with cloud base measurements	0 km
Primary interest for test site	Measurements of Icing

Location



Map. Station Zinnwald (blue circle) is located in South-East of Germany (Ore Mountains)

Orography



Map. Orographic map of surroundig area of station Zinnwald

General and specific climatology over the measurement period

Table. Climatological monthly averages (e.g. 10 years average) and monthly averages experienced during the test. T is air temperature, V is wind speed, GR is global radiation and N is the number of icing days.

VALUE	Oct	Nov	Dec	Jan	Feb	March	April
Clim T (°C)	5.6	0.4	-2.8	-3.7	-2.5	-0.1	4.7
Test T	4.5	-1.3	-1.9	-3.2	-2.3	-2.9	0.9
Clim Tmin (°C)	3.1	-1.5	-4.9	-6.2	-5.0	-2.8	1.3
Test Tmin	2.4	-3.2	-4.3	-3.2	-2.3	-2.9	0.9
Clim Tmax (°C)	8.5	2.7	-0.6	-1.3	0.0	2.8	8.6
Test Tmax	7.2	0.5	0.3	0.5	2.9	2.4	7.2
Clim Humidity	91.3	95.7	94.1	91.7	89.8	87.6	78.6
Test Humidity	94.0	99.3	91.0	97.8	88.2	90.0	179.2
Clim V (m/s)	5.8	5.9	6.5	6.5	6.6	6.0	5.1
Test V (m/s)	4.9	6.9	6.3	8.1	6.2	6.6	4.8
Clim GR (J/cm^2)	17825	9188	6865	10380	15354	29114	42803
Test GR (J/cm^2)	no data	7910	8409	8789	no data	no data	no data
Clim N	6	13	18	20	13	12	3
Test N	5	18	17	21	8	8	0

Clim - period 01.01.1997 - 31.12.2006
Test - period 01.10.2007 - 30.04.2008

Available local infrastructure (mast, platform etc.):

Icing sample platform: Two manually operated icing measurements (time interval 24h, icing cycles). Ice load sensor EAG 200.

Figure: Icing sample platform at Zinnwald station.

Standard weather station of German Weather Service (AMDA, see http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-82-TECO_2005/Posters/P1(07)_Germany_3_Klapheck.pdf for more detailed information).

SENSORS AND INSTRUMENTS

Table. The manufacture and country, type, some characteristics and maximum heating power (MHP) of sensors operated at Deadwater.

Manufacture, Country	Parameter, Instrument	Principle of operation, Additional information	Picture
manually operated icing poles, Germany	Ice mass, -	• manually scale mass of ice after exposition for 24 hours • manually scale mass of ice after exposition for 24 hours, re-expose pole, next measurement after 24 hours • Resolution 1 g • Accuracy ± 50 g	
Zentrum wissenschaft-licher Gerätebau, Germany	Ice mass, EAG 200	• electro-mechanical scale • Measuring range 0-10 kg • Resolution 1 g • Accuracy ± 50 g	
Combitech Sweden	Ice mass, IceMonitor	• pressure transducer • Measuring range 0-10 kg • Resolution 1 g • Accuracy ± 50 g	
Thies, Germany	Wind velocity, Thies Ultrasonic Anemo-meter	• 2 D Ultrasonic • Measuring range 0-65 m/s • Resolution 0,1 m/s • Accuracy ± 0,1 m/s (≤ 5 m/s) ± 2% (> 5 m/s)	

-	Tempera-ture Pt-100	• Resistance • Measuring range - 30℃ – + 40℃ • Resolution 0,1 K • Accuracy ± 0,2 K (- 20℃ - + 20℃)	
Vaisala, Finland	Relative Humidity, HMP 45D	• capacitve • Measuring range 0 % – 100% • Resolution 0,1 % • Accuracy ± 3 % (0℃ - + 45℃, for 0 %C – 100 %) ± 5 % (- 10℃ - 0℃, for 0 %C – 95 %) ± 8 % (- 20℃ - - 10℃, for 0 %C – 85 %)	
Vaisala, Finland	Barometric Pressure, PTB 220	• capacitve • Measuring range 500 hPa - 1100 hPa • Resolution 0,01 hPa • Accuracy 0,15 hPa	
Degreane, France	Meteoro-logical optical range, DF 20	• Forward light scatter • Measuring range 50 m - 30000 m • Resolution 10 m • Accuracy 50 m (< 500m) 10 % (500 m – 5000 m) 20 % (> 5000 m)	

Siggelkow Gerätebau, Germany	Scanning Pyrhelio-meter / Pyrano-meter, SCAPP	• Photodetector system • device measuring global, diffuse and direct solar radiation as well as sunshine duration • Measuring range (spectral region) 0,3 µm – 1,1 µm • See http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-82-TECO_2005/Papers/1(08)_Germany_Behrens.pdf for more detailed information regarding accuracy	

Data acquisition system:

Icing Measurements: Data logger Thies recording every minute. Continuous data polling by a Com-Server-System.
Meteorological Data: Data acquisition by AMDA-system recording in a range from 4/s up to 1/min depending on the sensor, typically calculating 10 minute averages.

MEASUREMENT DATA

Data base structure: ASCII-files, Excel spreadsheets.

Parameters:

Recorded values of parameters are associated with a date and time stamp.

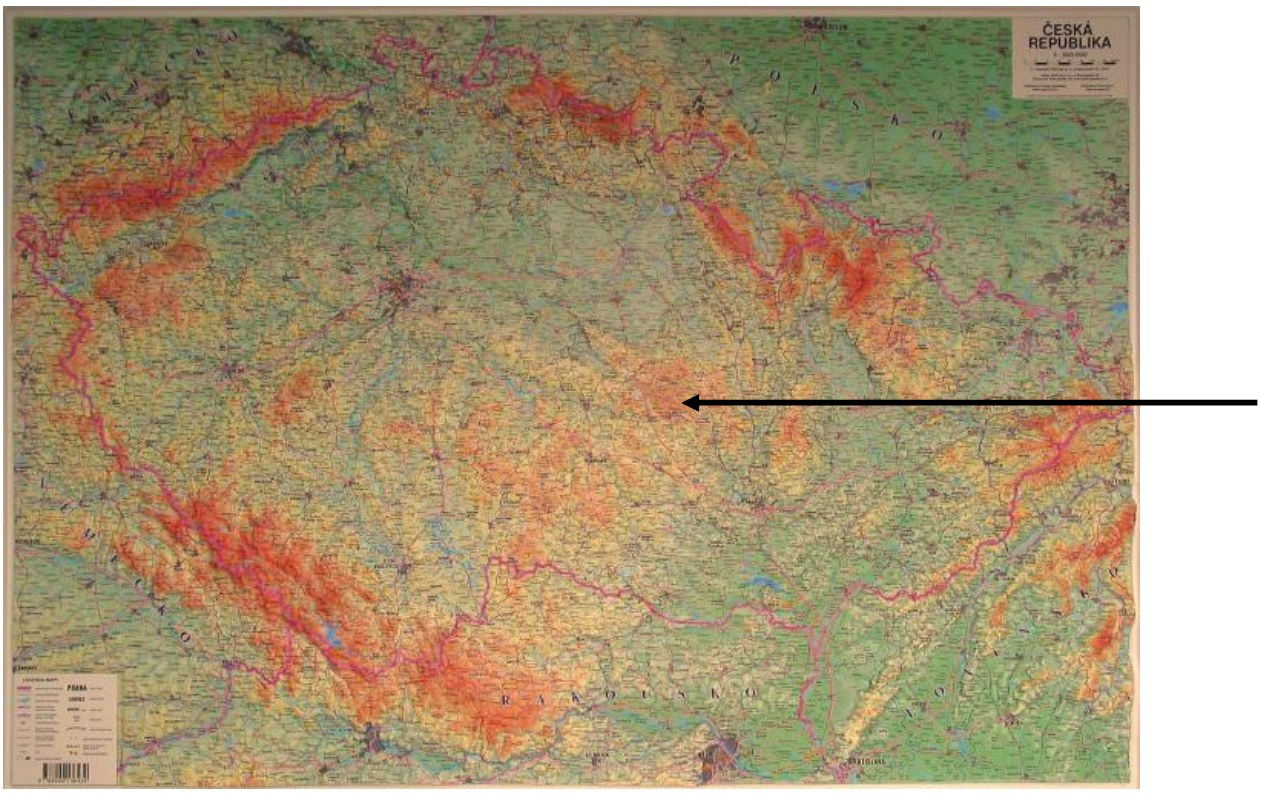
	Unit	Resolution	Averaging	Remark
Ice mass (Combitech)	g/(0.5m)	1 g	1’	
Ice mass (EAG 200)	g/(0.5m)	1 g	1’	
Temperature	℃	0.1 ℃	1’	
relative Humidity	%	0.1%	1’	
Wind speed	m/s	0.1 m/s	1’	
Wind direction	°	1°	1’	
Visibility	m	10 m	1’	
Solar radiation	W/m^2	1 W/m^2	1’	
Precipitation	Y/N		1’	
WzWz	Code_Tab_89		10’	
WW	Code_Tab_4677		10’	

SITE

Name:	Studnice
Owner/operator	EGU Brno, a.s.
Country	Czech Republic
Geographical coordinates (°N, °E):	49° 36' 32" N, 16° 05’ 02” E
Height (m a.s.l.):	800
Weather station numbers LPNN/WMO:	N/A
Distance from nearest airport (or weather station with cloud base measurements)	14 km
Primary interest for test site:	Power line icing

Orography

Test site Studnice is located about 60 km northwest from Brno at Czech Moravian highlands. Test site itself is build on the flat ridge of Czech-Moravian Highland.



General and specific climatology over the measurement period

Table. Climatological monthly averages (e.g. 10 years avg) and monthly averages experienced during the test. T is air temperature, V is wind speed, GR is global radiation and N is the number of icing days.

VALUE	Oct	Nov	Dec	Jan	Feb	March	April
Clim T (°C)							
Test T	5,2	-1,3	-2,0	-0,1	1,1	0,9	5,7
Clim Tmin (°C)							
Test Tmin	-2,8	-7,6	-9,3	-8,5	-12,7	-7,1	-3,5
Clim Tmax (°C)							
Test Tmax	15,6	8,1	9,4	7,2	12,5	11,1	16,1
Clim Humidity	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Test Humidity	N/A	89,6	88,5	91,3	85,1	84,9	N/A
Clim V (m/s)							
Test V (m/s)	N/A	N/A	3,7	7,2	5,8	6,6	5,4
Clim GR (W/m^2)							
Test GR (W/m^2)							
Clim N							
Test N	0	6	11	17	3	0	0

Clim: average for last winter seanons (2000 – 2006)
Test: average at particular season (2007/08)

Available local infrastructure (mast, platform etc.):

- Mast of 50 m height, 5 platforms (10, 20, 30, 40 and 50 m above ground)
- Platform 5 m

SENSORS AND INSTRUMENTS

Table. The manufacture and country, type, some characteristics and maximum heating power (MHP) of sensors operated at Studnice.

Manufacture Country	Type	Principle of operation, Additional information	Picture
EGU Brno, Czech Republic	PMS	• Measuring rod, length 0,5 m, diameter 30 mm, unrotated • The bottom is heated. • The body and rod is unheated • Measuring range 0…40 (100) kg/m • The sensor also provides the air temperature, humidity, wind speed and direction • Measuring range 0…40 m/s • Weight 12 kg • Operating temp. -30…+70 °C • MHP: 100 W	
EGU Brno, Czech Republic	Meteo	• Measuring rod, length 0,5 m, diameter 30 mm, unrotated • The bottom is heated. • The body and rod is unheated • Measuring range 0…40 kg/m • The sensor also provides the air temperature, wind speed and direction • Measuring range 0…40 m/s • Weight 12 kg • Operating temp. -30…+70 °C • MHP: 70 W	
EGU Brno, Czech Republic	Horizontal rod	• Measuring rod, length 1 m, diameter 30 mm, freely rotated • Measuring range 0…40 kg/m • The bridge between body and rod is heated	

EGU Brno, Czech Republic	Vertical rod	• Measuring rod, length 0,5 m, diameter 30 mm, freely rotated • Measuring range 0…100 kg/m • The bridge between body and rod is heated	
Combi-Tech Ice Monitor Sweden		•	
Thies A., Germany		• 2 D Ultrasonic, time of flight • Each arm 15-17 W • Measuring range 0…65m/s • Weight 2.5 kg • Operating temp. -40…+70 °C • MHP: 70 W	
Pyranometer Kipp& Zonen	CMP3	• Range of measurement: 0 to 1400 W/m2 • Resolution: 1 W/m2 • Error of the basic state: <1% per year • Accuracy of measurement in the interval (0 – 1000) W/m2: ±2.5% • Temperature drift: in the interval of -10 to +40°C ±5% • Viewing angle: 180°	

Location of measurement devices at Studnice

Measuring device	Measurement height (m)	Output	Since
Icing - vertical rods (length of 0.5 m)	5, 10, 20, 30, 40, 50	Digital	1997
Icing - horizontal rods (length of 1 m)	10, 30	Digital	1997
Temperature	5, 10, 20, 30, 40, 50	Digital	1997
Humidity	10	Digital	2006
Pyranometer	50	Digital	2007
Ultrasonic anemometer	50	Digital	2007

Data acquisition system:

Instruments are connected to RS485 line. Data are collected on the PC server, recording every minute. Server can be remotely operated from the office via Internet.

MEASUREMENT DATA

Data base structure:
Format: binary daily files
Records: values are recorded every one minute, associated with a date and time stamp.

Parameters:

	Unit	*Resolution*	*Recorded*
Ice load	Kg	0.01 kg	1’ average
Temperature	°C	0.1 °C	1’ average
Humidity	%	1 %	1’ average
Wind speed	m/s	0.1 m/s	1’ average
			1’maximum
Wind direction	°	1°	1’ average
Humidity	%	1 %	1’ average
Solar radiation			1’ average

PICTURES OF SITE

Overview

Test site Studnice is located about 60 km northwest from Brno at Czech Moravian highlands. Test site itself is build on the flat ridge of Czech-Moravian Highland.
There two spans, 250 m each.

Details of topography

See map below

General view of site

Middle tower with measuring platforms

View towards East

View towards South

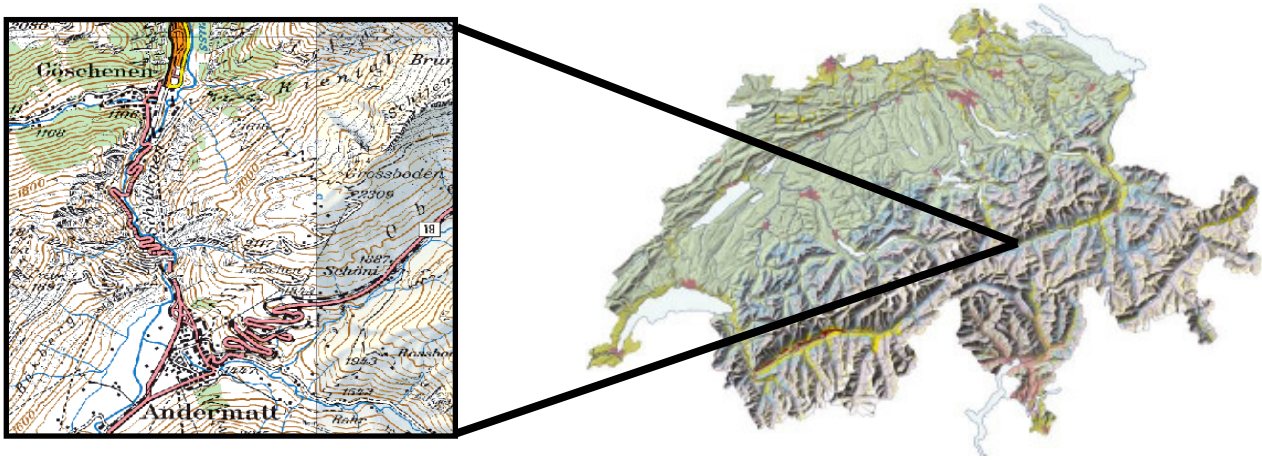
View towards West

View towards North

SITE

Name:	GUETSCH
Owner/operator	MeteoSwiss / Meteotest
Country	Switzerland
Geographical coordinates (°N, °E):	46.65 °N, 8.62 °E
Height (m a.s.l.):	2300
Weather station numbers LPNN/WMO:	6750

Orography



The Guetsch station is located in the middle of the Alps, in the Gotthard region above the village of Andermatt.

The first picture displays the general setup of the test facility, with the meteorological test station in the front, and the wind turbine facility in the background, at around 200 meters from the test station. Two 10 meters wind masts may be seen, the one at the back belonging to the official meteorological station of the Guetsch (METEK USA-1) which is located about 100 meters downward on the slope, while the second one at the front is connected to the test station (Rosemount Pitot tube). The second picture displays a close view of the 2 measurement bridges: the front one supporting the instruments which are to be tested while the second one at the back holds the standard reference meteorological instruments. The Data Acquisition systems are located in the enclosure which can be seen on the north side of the measurement bridges.

General and specific climatology over the measurement period

Table. Climatic monthly averages (30 years avg.) and monthly averages experienced during the test. T is air temperature, V is wind speed, GR is global radiation and N is the number of icing days (number of days with $T_{min} < 0$°C).

VALUE	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**	**April**
Clim T (°C)	2.1	-3.1	-5.5	-6.5	-6.9	-6.0	-3.7
Test T							
Clim Tmin (°C)	-0.5	-5.6	-8.1	-9.3	-9.5	-8.2	-5.7
Test Tmin							
Clim Tmax (°C)	6.0	0.1	-2.4	-3.8	-4.2	-3.3	-1.1
Test Tmax							
Clim Humidity	66.8	67.2	63.4	66.0	68.3	72.2	78.1
Test Humidity							
Clim V (m/s)	6.5	6.4	6.8	6.5	6.0	6.2	6.6
Test V (m/s)							
Clim GR (W/m^2)	112	78	61	74	119	180	229
Test GR (W/m^2)							
Clim N	14.7	26.3	29.5	30.8	27.9	30.3	28.1
Test N							

Meteorological test station

The meteorological station is presently equipped with 2 measurement bridges supporting the standard meteorological instruments and the instruments to be tested (back and front of the second picture displayed above). The infrastructure is designed to add easily two other similar bridges (e.g. in case of large scale measurement activities, e.g. international inter-comparisons) or to install other types of instruments near the ground (rain gauges, ceilometers, present weather sensors, etc…) or at higher elevation with dedicated supplementary masts.

A rugged camera system (extra heating) is installed on one of the wind masts and allows for panorama views of the surrounding as well as zoomed pictures of the instruments providing valuable information on the icing rates. Pictures taken in specific directions are further used for monitoring the visibility by aiming at specific targets located at different distances. A complete picture set is taken every 10 minutes, but the camera is moved constantly to avoid ice accretions on the rotating parts.

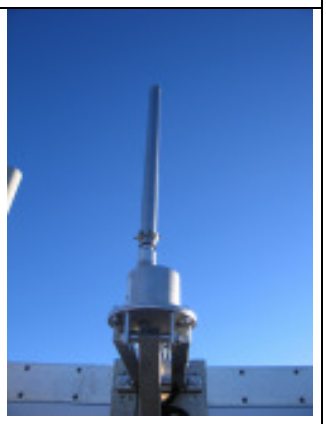
The enclosure for the data acquisition systems is located on the north side of the bridges.

Data from the camera and from the data acquisition system is transmitted through a dedicated fiber optic line to a nearby building located lower on the slope at about 200 meters distance.

Instruments

The manufacture and country, type, some characteristics and maximum heating power (MHP) of sensors operated at Guetsch are displayed in the following table.

Manufacture Country	Type	Principle of operation, Additional information	Picture
Metek, Germany	USA-1	• 3D Ultrasonic, time of flight. • The arms, the sensors and the vertical pole are heated. • The body unheated • The sensor also provides the (sonic) air temperature • Measuring range 0…60 m/s • Weight 0.7 kg • Operating temp. -30…+50 °C • MHP: 50 W	

Rosemount, USA	1774W	• 2D Pitot tube • Measures dynamic pressure of wind vs. atm. Pressure • Sensitive part (holes) are strongly heated • Measuring range 0..60 m/s • Operating temp. -30 …+50 ℃ • MHP: 360W	
Goodrich/ Rosemount, USA	0872J1	• Ice detector • Ultrasonic resonance • Duration of icing • MHP: 200 W,	
Goodrich, USA	0872E3	• Freezing Rain detector • MHP: 415 W • Designed to measure the intensity and duration of ice storms and differentiates rain from freezing rain as temperatures approach freezing.	
Combitech, Sweden		• Vertically mounted rod • The rod is a cylinder (pipe with a top cover) placed on top of a rod supported by a load cell for weighing. • The cylinder can freely rotate when ice builds up to obtain a cylindrical ice build up which is detected by the load cell as a vertical force. • The bearing for the rod is heated (via a thermostat) to secure the weighing function. • MHP:	

HoloOptics, Sweden	T26	• Patented digital optronic ice indicator • IR emitter • Photo detector • Probe changing its optical properties if covered with any kind of ice.	
Vaisala, Finland	Ceilometer CT25k	• Unique single-lens optical design • Measurement range up to 7.5 km (25,000 feet) • Reports up to three cloud layers simultaneously • Operates reliably in all weather • Approved by the FAA	
Meteolabor, Switzerland	THYGAN	• Ventilated temperature • Dew point temperature with chilled mirror • Computes relative humidity	

Data acquisition system of the meteorological station

The Data Acquisition System consists of 2 Automatic Data Acquisition Systems ADAS (Telvent/Almos, AMS220) similar to the standard stations of the SwissMetNet. The ADASs provide ports for the connections of all types of meteorological instruments (A/D conversion, serial inputs, etc.). For the test station, additional boards have been added in order to connect all the sensors which have to be tested under harsh conditions, either for future integration in SwissMetNet or for specific applications such as COST-727.

The first ADAS is used for reference measurements of the standard meteorological parameters:

- Wind (Rosemount Pitot tube 1774W)
- Pressure (Vaisala PTB220)
- Temperature & Humidity (Meteolabor THYGAN, Rotronic Hygroclip)
- Radiation shortwave (K&Z, CM21)

- Radiation longwave (K&Z, CG4)
- Cloud height and amount (Vaisala CT25K)
- Precipitation detector (Thies, xxxx)
- Precipitation amount (Lambrecht 1518H3)

All instruments are either ventilated or heated or both in order to yield the best possible quality of these meteorological reference instruments

The sampling frequency is 1 Hz for most of the instruments. The integration time is 10 minutes. The data are transferred immediately to the test server located at Payerne, Switzerland.

The second ADAS is dedicated to special measurements and among others to the COST-727 instruments:

- Combitech IceMonitor
- Goodrich Rosemount ice detector
- Goodrich Rosemount freezing rain detector
- HoloOptics T26

The second ADAS works similar to the first unit. Both units are monitored on-line (high speed internet connection) from the National Competence Center located at Payerne. Dedicated plausibility tests are applied continuously on the data (Quality Control level 1)

The data are stored on the local system (memory capacity for 28 days) as well as on the test server. The bulletins are archived.

The bulletins are sent in parallel to a dedicated DataMart which store them for the last 3 months: these data are therefore available on line for daily Quality Control (Quality Control level 2) and dedicated, specific evaluations.

Wind turbine

An Enercon E-40 600kW wind turbine with a hub height of 50 m and an integrated blade heating system is installed approximately 150 m north-west of the met station. This wind turbine is monitored for its performance under icing conditions. The following parameters are available from the wind turbine:

Operational data

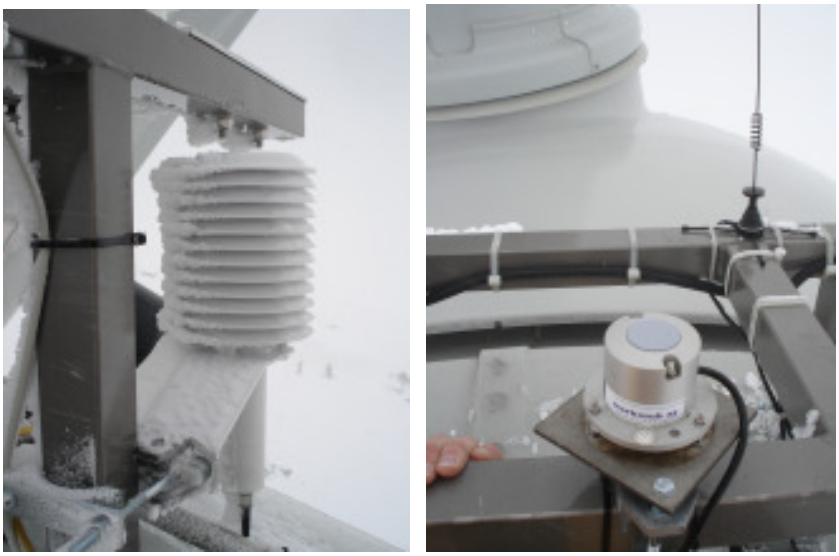
Data acquisition system: ENERCON Scada
Integration time: 10 minutes
Available Parameters:

- produced power
- wind speed at hub height (Thies 2D-Sonic Anemometer)
- position of nacelle
- ambient temperature at hub height (resolution only 1°C)
- air temperature inside the blades (resolution only 1°C)

Additional measurements at nacelle (50 m agl)

Data acquisition system: Campbell CR10X
Integration time: 10 minutes
Available Parameters:

- ambient temperature (Rotronic MP101A)
- relative humidity (Rotronic 101A)
- incoming longwave radiation (Kipp & Zonen CG3)



Left picture: Rotronic MP101A, right picture: Kipp & Zonen CG3

Camera observation

The Thies Ultrasonic anemometer as well as the rotor blades are constantly (every 30 minutes) monitored with Mobotix M12-Secure Webcams.

Left: image of Thies Ultrasonic anemometer on nacelle of the wind turbine. Right: image of rotor blade.

MEASURED DATA

Recorded values of parameters are associated with a date and time stamp.

Parameters:

	Unit	Resolution	Averaging	Remark
Wind speed	m/s	0.1 m/s	10’	
Wind direction	°	1°	10’	
Temperature	°C	0.1 °C	10’	
Dew point	°C	0.1 °C	10’	
Humidity	%	1%	10’	
Solar radiation	W/m^2	0.1 W/m^2	10’	
IR Radiation	W/m^2	0.1 W/m^2	10’	
Ice load	Kg	0.001 Kg	10’	
Ice detection	Seconds/10’	1’’	10’	
Cloud height	meter	m	10’	
Cloud amount	octa	1 octa	10’	