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Temperature siting classification in Nordic Countries

Final report of NordObs activity on WMO-CIMO siting classification

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Abstract

Air temperature is one of the most important climate parameter and is measured by almost all standard automatic weather stations around the world. The accuracy of the measurement is determined by the instrument quality, its uncertainty and overall performance as well as calibration and maintenance routines. Furthermore, the temperature measurements are influenced by their immediate vicinity. The distance to artificial and natural heat sources or sinks, vegetation and shading effects are all factors which may affect the representativeness of the measurements. The World Meteorological Organization's Commission for Instruments and Methods of Observation (WMO CIMO) gives suggestions on the siting of a temperature sensor and also recommends a siting classification system to classify those stations which are not perfectly located for easier evaluation of the expected quality. First experiences with the WMO CIMO siting classification showed a couple of common challenges when implementing it for stations at higher latitudes. For example, the combination of low elevation and varying azimuth angles of the sun throughout a year, typical landscape forms and vegetation often results in a siting class unsuited for climatological assessment of the temperature. Within the co-operation between the Nordic national meteorological services in the field of Observations (NordObs), a working group was looking closer into those issues. More than 20 stations in Estonia, Finland, Iceland, Norway, and Sweden were evaluated and classified applying a common metadata scheme. The four criteria of the WMO CIMO siting classification (slope, vegetation, distance to heat sources and water bodies and shading) were analyzed separately for those stations. This paper presents the evaluation results and some more detailed analyses from selected stations. The effect on air temperature measurements by the individual siting classification criteria can vary a lot. Class steps for the four criteria, which ideally should be connected to the order of magnitude of the additional uncertainty they introduce to the temperature measurements, does not always seem to evaluate the siting and its impact on temperature measurements in a consistent way. Criteria, which need a further quantification of their impact, were identified. Other factors identified as affecting the quality of temperature were the direction of slope and the radiative properties of non-shading obstacles.

Keywords

Temperature measurements; siting classification; site exposure; NordObs; CIMO-WMO;

Disiplinary signature

Responsible signature

The NordObs site classification activity

NordObs is a co-operation and exchange of rationalization ideas between the Nordic National Meteorological Services in the area of meteorological observations. NordObs is under the umbrella of NORDMET. NORDMET aims to achieve better cost efficiency by sharing resources in such areas as observation, information management, product development, production, training and education. The co-operation agreement was established in 1998.
The steering committee of the NordObs cooperation decided on a siting classification activity in May 2014. The Norwegian Meteorological Institute (MET Norway), the Finnish Meteorological Institute (FMI), the Swedish Meteorological and Hydrological Institute (SMHI), the Icelandic Meteorological Office (IMO), and the Estonian Environment Agency (EstEA) participated in the working group established.
The group had the following tasks:

1. Exchanging information on methods, experiences and challenges so far regarding site classification for temperature within the NordObs countries.
2. Investigating work done in other countries, especially about quantifying the impact of the different evaluation criteria on the temperature measurements (literature search, direct contact, etc.)
3.Developing a common Nordic adaption of the WMO measurement site classification for temperature which considers the time-aspect of shadow/sun on the sensor and other relevant issues in a way that the temperature classification is more suitable for high-latitude countries.

Wolff et al. (2016) presented results of the activity at the WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observations in Madrid, Spain, 27-30 September 2016.

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1 Introduction

1.1 Site Classification at WMO

The WMO Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, also known as the “CIMO Guide”), is a commonly referred standard in support of meteorological observations for every purpose. The first edition was issued in 1954.
The tenth session of the Commission for Instruments and Methods of Observation, CIMO-X, (CIMO/WMO,1990) addressed the question of siting classification for the first time by asking for a study to prepare guidelines for siting and exposure of instruments for improving the representativeness of measurements and the homogeneity of meteorological data sets. This resulted in a study by Ehinger (1993). Ehinger (1993) recognized the qualitative nature of the representativeness concept. He also recognized that the quantitative methods available rarely apply to regions of complex topography. Ehinger’s study differentiates between

- criteria for selecting a suitable site,
- correct exposure of instruments,
- area of representativeness,
- site and facility descriptions,
- the need for homogeneity of climatic data

As a follow up, the 1996 edition of the CIMO Guide in its description of general aspects differentiates between representativeness, siting and exposure, and performance as separate quality dimensions. The distinction between the three dimensions is however not always clear. Representativeness should ensure that observations are useful with weather forecasts on its various scales. Siting criteria could also meet other demands than forecasting.
The exposure considerations have been detailed in a list of recommendations, varying over the different editions of the CIMO Guide. The issues of the current list (WMO, 2008) includes: Well-kept vegetation; no slope; sensors at a distance to obstructions; the need for colocation of sensors; the need for wind measurements at exposed sites and the need for precipitation measurements at sheltered sites, the two not easily combined. The current list of recommendations omits sensor’s distance to heat sources.
Michel Leroy of Météo-France proposed in 1998 a new complete set of site classification criteria to take into account the existence of stations not fully complying with the WMO

recommendations. The classification scheme was defined for each weather element to document the representativeness of a site. The classification ranged from 1 to 5. (Leroy, 1998) Leroy proposed that the measurement errors, associated to a site not respecting the recommended exposure rules, are often much larger than the intrinsic uncertainty of the sensors. The site representativeness is therefore the more important factor for the global quality of a measurement. The proposed classification allowed to objectively documenting a site to inform users about the quality and how representative is a measure. Météo-France engaged in implementing Leroy's proposal in its entire network (about 500 surface stations).
Leroy presented the results of the Météo-France exercise to TECO-2006 (Leroy, 2006). By convention, a class 1 site follows the WMO recommendations. A class 5 site was described as a site with an inappropriate environment for a meteorological measurement and where measurements must be avoided. Leroy also presented a classification on maintained performance ranges from a class A (instrument following the WMO/CIMO recommendations) to class D (unknown characteristics and maintenance).
CIMO XIV in 2006 (CIMO/WMO, 2006) recognized the need for a standardized classification scheme for inclusion in the CIMO Guide.
The scheme was prepared when CIMO XV in 2010 (CIMO/WMO, 2010) concluded on "Classifications for Surface Observing Stations on Land".
The scheme consisted of siting and maintenance performance classifications for surface observing stations on land. It provides means for improving and assessing the quality of observations, in particular for climate purposes, as the quality of observations cannot be ensured only by the use of high quality instrumentation, but relies at least as much on the proper siting and maintenance of the instruments.
CIMO XV (CIMO/WMO, 2006) requested further work on maintenance classification, and agreed to the publication of the siting classification as a common WMO - ISO standard in order to improve the quality of data originating from WMO-owned, cosponsored and non-WMO observing networks. The classification should be further developed as a common WMO - ISO standard.
A modified classification scheme was adopted as ISO/WMO STANDARD 19289:2014(E). In regard to temperature classification the radiation screen is considered part of the maintenance performance and not subject to siting class consideration.

1.1 Complex terrain

CIMO XVI in 2014 (CIMO/WMO, 2014) noted that complex terrain or urban areas generally lead to high class numbers. In such cases, an additional flag "S" can be added to class numbers 4 or 5 to indicate specific environment or application (i.e. 4S)
Also included in the CIMO Guide 7th edition (WMO, 2008) is a contribution by Tim Oke (Oke, 2006) on urban siting considerations with comments on microclimatology pertinent to the general discussion on representativeness. Oke's essay shows the need for further studies on the higher class siting. Oke and coworkers have further elaborated on classes for the urban heat island effect. (Stewart and Oke, 2012)

1.2 Long term time series

The private website http://www.surfacestations.org has published an extensive review of weather stations in USA starting 2007. The purpose is to demonstrate that the long term temperature record cannot be trusted, and Leroy's classifications scheme is generally referred to. The information presented is to a large degree irrelevant in this context, but demonstrates the need and interest for proper a siting classification, and the need for meteorological institutes to address openly the limitations and uncertainty of their long term time series on temperature. WMO's Commission of Climatology (CCl) has decided on homogenization activities with time series of temperature and other weather elements such as The International Surface Temperature Initiative of 2010[1]. The Initiative has not yet addressed siting considerations specifically. The need for metadata on instrumentation, location, time of observation, or environment such as proximity to buildings is however recognized. (Stott and Thorne, 2010) The Commission of Climatology has also endorsed Guidelines on climate metadata and homogenization. The document produced in 2003 makes recommendations related to siting classification issues under the heading of "Local environment". (Aguilar, 2003)

1.3 National experience

The meteorological institutes have different approaches to siting meta information. Several have had national classification exercises prior to the CIMO scheme. Others have resorted to subjective descriptions only. An international quantitative standard is important to ensure comparable quality within and between station networks. A classification standard is beneficial in the planning of new sites, as rational for routine station maintenance, as well as for assessing the merit of meteorological observations from other institutions.

2 Identified challenges with classification scheme

On 19th-20th November 2014 the Workshop on Temperature Classification was held in Oslo, Norway. Experiences with metadata information in general and the recommended CIMO classification scheme for temperature sensors were collected and exchanged. Each of the five institutes presented their current status of siting classification with focus on temperature classification.

Possible challenges were identified and a common metadata scheme was developed, covering necessary information for the CIMO siting classification scheme and additional relevant information. A detailed presentation and description of the NordObs metadata scheme can be found in Appendix I.

[1] http://www.surfacetemperatures.org/

During summer 2015, all members classified their stations using the common NordObs metadata scheme. The current chapter documents the identified challenges and describes them in detail. Each of the four criteria from the CIMO siting classification scheme is presented in a separate section, including example stations for illustration.

2.1 Slope

Air temperature measurements are ideally performed over level ground. According to the CIMO siting classification, a slope should be less than 19^o for a class 1 or class 2 stations. There are no requirements regarding the slope for classes 3 to 5.

Class 1	Class 2	Class 3	Class 4	Class 5
Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)	Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)	-	-	

Slope is often difficult to determine in the field and may vary a lot within a small radius. It remains unclear on which area the slope should be determined and how eventually should be averaged.
The Norwegian station Kvamsøy, for example, is located on a small plateau on a 50 m high hill on a small island. The slope is <5^o within a 10 meter radius, but >19^o within 100 meters as the land drops down all the way to the sea-level within those 100 m, see Figure 1 and Figure 2.

Figure 1: Topography of the Norwegian Station Kvamsøy. The white cross in blue circle indicates the station. Map from Norwegian Mapping Authority (http://www.norgeskart.no)

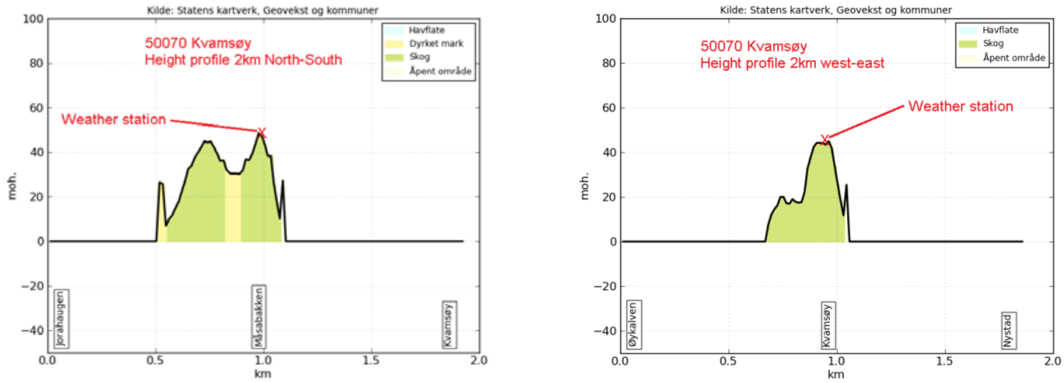


Figure 2: Altitude profiles at the Norwegian station Kvamsøy. North-South profile in the left hand panel and West-East profile in the right hand panel. Map and profiles from Norwegian Mapping Authority (http://www.norgeskart.no)

At the Swedish station Kolmården, the slope is determined with <5o within a 10-meter radius, 7.5o within a 100-meter radius and 23o within a 1-kilometer radius, see Figure 3.

Figure 3: Swedish station Kolmården: Photography (left) and topography (right). Photo: SMHI

The direction and type of slope and hence its influence on temperature variations can vary a lot between stations of the same classes:
Kvamsøy and Kolmården are both located on a relative topographic maximum. Whereas Kvamsøy has downward slopes into all directions, Kolmården has only one downward slope, facing south. Another Norwegian station, Veggli II, is located on a relative plateau in the middle

of a slope. Veggli II has downward slopes facing north, east and south, and an upward slope facing west, see Figure 4 and Figure 5.

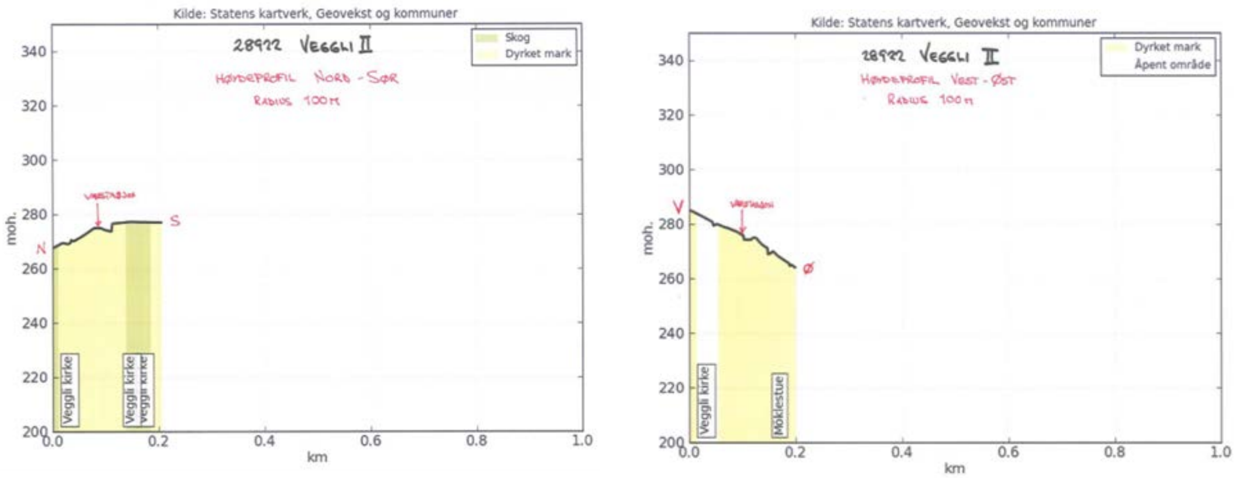


Figure 4: Norwegian station Veggli II, height profiles in North-South (left) and West-East (right) directions. Map/Profile from Norwegian Mapping Authority (http://www.norgeskart.no).

Figure 5: Norwegian Station Veggli II. Picture is taken towards West. Photo: MET Norway

The examples above show that slope might be varying around one station and that raises the question on how to “average” the slope for a given area: should the maximum slope or an average value of the absolute slope angles be determined or should opposite slopes be considered with different signs?
Furthermore, slopes in different directions are exposed to solar radiation in very different ways. North facing slopes are often in shade, whereas the South facing sides are more exposed to solar radiation. West-facing slopes are exposed to the sun during the hottest time of the day in the afternoon. Therefore, a west-facing slope will be warmer than a sheltered east-facing slope. In addition, hillslope angle and aspect may also influence snow accumulation and melt.
Geiger (1995) found a temperature difference up to 2.5 °C at a height of 0.4m between SW and NE slopes on clear days for slope angles between 15° and 40°. This number is an indication, but can’t be directly used for evaluation of class limits as the standard height of air temperature measurements is between 1.5 and 2 m height. Elomaa (1970) showed that the maximum temperature for the station Lammi Untulanharju Esker on a SW slope (slope angle 27°) in the summertime is on average 0.8-1.3°C higher than at the neighboured station on a NE slope (station at same altitude, slope angle also 27°). The difference was even larger on clear days.
Various studies on topographic effects on temperature can be found in the field of agricultural and forest meteorology. For example, Dobrowski et al (2009) performed at study on temperature variances caused by the elevation, the differences of solar insolation on different slope angles and types, or the effect of cold air drainages in valleys. It was found that only 70-80% of the total annual temperature variations are due to regional synoptic patterns, whereas the rest can be explained by topographic effects. As expected, elevation has the major influence, but radiation and the topographic convergence index (a proxy for local convective flows, i.e. cold-air drainage) still explain 10-20% of the remaining temperature variance, varying throughout the year. Assuming an annual temperature variance of 60 °C, about 1°C -2.5 °C can be explained solely by slope effects as differences in irradiation and exposure to cold air drainage (Dobrowski et al., 2009).
A more extensive literature research is recommended to see if the results of those kinds of studies can help in quantifying the effect of the slope on air temperature measurements.
It is however difficult to perform studies on the influence of slope with existing stations. Neighboured stations have often an additional altitude difference which has a larger effect.

2.2 Vegetation

In WMO (2008), the sensor height for air temperature measurements is specified to 1.2 to 2 m to allow measurements in the free air and to avoid the very large vertical temperature gradients closer to the ground. The type and height of the vegetation on the ground plays a role, since it directly affects the vertical temperature gradient in this lowest level. Another aspect of ground cover is the albedo which directly affects the radiation balance of the area.
The vegetation criterion in the CIMO siting classification requests natural and low vegetation smaller than 10 cm for class 1 and 2 and smaller than 25 cm for class 3.

Class 1	Class 2	Class 3	Class 4	Class 5
Ground covered with natural and low vegetation (<10 cm) representative of the region	Ground covered with natural and low vegetation (<10 cm) representative of the region	Ground covered with natural and low vegetation (<25 cm) representative of the region	-	-

Most of the sensors in the Nordic countries are mounted between 1.8 and 2.0 m – in the upper end of recommended sensor height.
The CIMO Guide (WMO, 2008) recommends having a maintained grass surface under the radiation screen for air temperature measurements, where possible. A grass surface is easy to maintain to a low height and it provides a comparable surface and thus a similar vertical temperature gradient for the sites.
However, lots of sites in the Nordic countries are in areas where a regular maintained planted grass surface is either not practical or even not possible due to the local climate. The CIMO Guide (WMO, 2008) recommends the natural surface for these cases. Typical natural surfaces may be bare rock or the natural vegetation (moss, heathland, natural grass and straw or small bushes) as shown in Figure 6. While often relatively low, natural vegetation is typically rather around 30-40 cm instead of the requested 25 cm. Maintenance at such stations is often limited to hold the higher vegetation away, see for example the Norwegian station Kvamsøy (Figure 7) and the Swedish station Kolmården (Figure 8).

Figure 6: Mountain stations Snøheim in left handpanel, Filefjell – Kyrkjestølane in right hand panel. Photos: MET Norway

Figure 7: Norwegian station Kvamsøy with natural grass vegetation. Maintenance is limited to very few visits a year when the "higher vegetation" is maintained and kept away from the immediate areas below the sensors. Photo: MET Norway

Figure 8: Swedish Station Kolmården with natural low vegetation. Maintenance is limited to very few visits a year when the "higher vegetation" is maintained and kept away from the immediate areas below the sensors. Photo: SMHI.

As mentioned above, WMO (2008) recommends a sensor height between 1.2 and 2 m, whereas vegetation height variations are limited to 25 cm for the first 3 classes. Figure 9 illustrates two possible cases: The lower sensor on the left hand side (1.2 m) is mounted in a distance of 95 cm to the vegetation on the ground (25 cm) and would be classified as class 3. The higher mounted sensor on the right hand side (1.8 m) has a distance of 1.4 m to the vegetation (40 cm) and would be classified as class 4.

The vegetation is higher in the second scenario, but it seems doubtful that temperature measurements with a higher distance to the underlying vegetation have a larger uncertainty than those with a smaller distance.

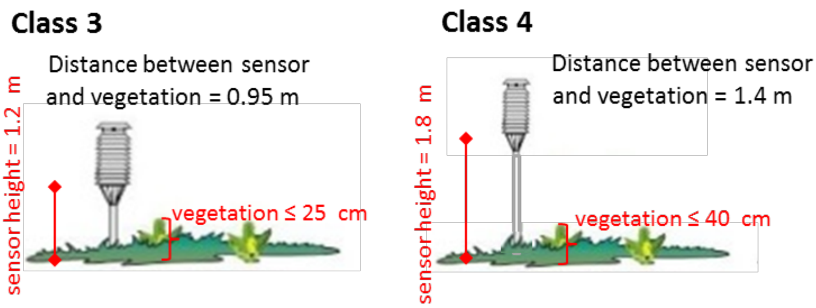


Figure 9: The recommended height for temperature sensors is between 1.2 m and 2 m. The classification due evaluating the effect of vegetation depends only on the vegetation height, but not on the sensor height. Hence, a sensor with a smaller distance to vegetation can have a lower class (left hand side) than a sensor with a larger distance to vegetation (right hand side).

Another observed challenge is the right classification of sites in agricultural areas, especially at sites directly located in a field of crops. See for example the Finnish station Lappeenranta Konnunsuo (Figure 10). At those stations, the height of the vegetation is very variable throughout the year. Due to the climate at high latitudes which allows for only one and rather short planting cycle per year, it would be either not existing or low most of the year and high during harvesting season. The change between no vegetation and low vegetation in spring is also coupled to a change in albedo, which might have a significant impact on the air temperature as well. Off course, maintaining a low surface all year round under the site would be optimal, but what size of low and maintained vegetation would be necessary to allow for representative measurements? In the Guide to Climatological Practices (WMO, 2011) a plot size of 9 meters by 6 meters is suggested as sufficient for temperature measurements.
To be able to choose the right class for those kind of stations or to define the area which needs to have a maintained all-year-round low vegetation, further studies on quantifying the real impact of these changes are needed.

Figure 10: Finnish station Lappeenranta Konnunsuo. Photo: FMI

Additionally, the vegetation in high latitude countries may be covered with snow for large parts of the year. Because of large snow amounts, some sites need to have even higher sensor altitudes than the recommended 2 m to allow for measurements in the free air during the entire year (Figure 11). Variation of snow depth during winter is comparable with vegetation height variation during summer and might equally influence the temperature gradient below the temperature sensor: High snow depths during the end of the winter mean a short distance between surface and the sensor, while the sensor will be in a greater distance than usual to the surface during the warm period.

Figure 11: Weather station Røldalsfjellet (Norway). The temperature sensor is mounted at 5 m (left picture) to allow sufficient clearance under sensor with high snow accumulation (right picture). Photos: MET Norway

Most studies about the influence of vegetation are limited to the temperature difference between surfaces with or without vegetation, i.e. Eliasson and Svensson (2003), Shudo et al. (1997), and Sailor (1994). Studies on the differences of the vertical temperature gradient over different types of low vegetation (and snow surfaces) could not be found and needs to be conducted in order to be able to determine quantified class limits for either vegetation height or distance between vegetation and sensor.

2.3 Heat Sources/Water bodies

According to WMO´s siting classification criteria, the temperature measurement point should be located more than 100 m away from any heat source. The more the ground is covered with heat sources inside a 100 m circle, the higher is the siting class. Artificial surfaces or volumes like concrete, asphalt, parking lots, buildings etc. are counted as heat sources. The distance to and the expansion of water bodies are treated in the same manner as artificial heat sources, unless they are representative or significant for the region.

Class 1	Class 2	Class 3	Class 4	Class 5
Measurement point is situated more than 100 m from HS/WB	Measurement point is situated more than 30 m from HS/WB	Measurement point is situated more than 10 m from HS/WB		-
HS/WB occupies less than a) <10% of a 100 m circle b) <5% of an annulus of 10-30m c) <1% of a 10 m circle	HS/WB occupies less than a) <10% of a 30 m circle b) <5% of an annulus of 5-10m c) <1% of a 5 m circle	HS/WB occupies less than a) <10% of a 10 m circle b) <5% of a 5 m circle	HS/WB occupies less than a) <50% of a 10 m circle b) <30% of a 3 m circle	

For a lot of stations in the Nordic countries, water bodies seem somewhat significant for the area. For example, stations in coastal areas or on small islands and peninsulas, as well as large inland areas, which have a very high density of lakes. An objective rule on how to decide if a water body is significant for the area does not exist. Figure 12 shows the Norwegian island station Myken where more than 10 % of the 100 m circle is covered with water (→ class 2). The aerial picture of the station shows that water is very typical for the region. Therefore, the distance to water bodies was not taken into account when classifying the station.

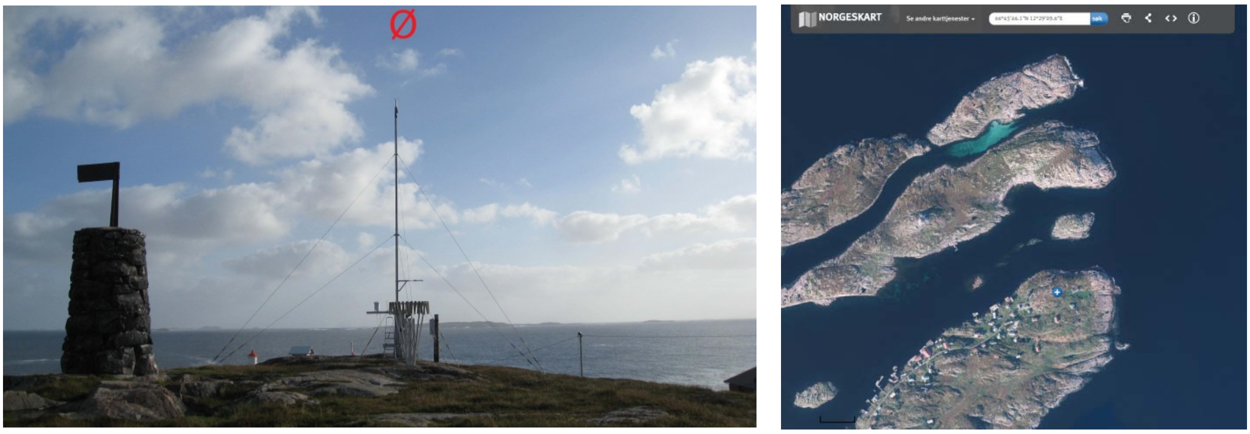


Figure 12: Weather station Myken, Norway. The station is situated on a small island (left); the picture to the right (Norwegian Mapping Authority) is an aerial picture of the region. The scale on the bottom shows 100 m. The blue marker shows the location of the station. Photo: MET Norway

Based on their experience, FMI determines water bodies significant to the region if lakes are covering at least 30% of the area (10 km diameter), Solantie (2016). Therefore, it was suggested to not consider the distance/expansion of water bodies in areas for the classification when more than 30% of the surface was covered with water. No further studies confirming the validity of the 30% are found.

Flat heat sources (parking lots, streets, etc.) and water bodies (if not significant for the area) are simple to handle with the CIMO classification scheme. Jinaxia et al (2014) and Kumamoto (2012) have performed studies to quantify the influence on temperature. Their results are summarized in Table 1. Comparing these two studies, water bodies have a larger influence on the air temperature. The same temperature difference of 0.2 °C was observed in a greater distance to a water body (class 1) than to an asphalt road (class 3).

Table 1: Temperature influence caused by different distances to a heat source (asphalt road) and a water body. Results by Jinaxia et al (2014) and Kumamoto (2012).

Class 1	Class 2	Class 3	Class 4
Water body: 0.2°C - 0.25°C (experiment) 0.2°C (model), both by Jinaxia (2014)	**Water body**: 0.3°C -0.45°C (experiment) by Jinaxia (2014)	**Road**: 0.2 °C by Kumamoto 2012	**Road**: 0.2 °C (Kumamoto 2012) **Water body**: 0.7°C (experiment)

Heat sources may also be elevated like buildings, large signs and walls, see Figure 13 . It remains unclear, if only the top-area or parts of the vertical areas of the obstacle should be considered for the classification. Especially, elevated obstacles (artificial or natural) in the north of the station will absorb significantly more radiation during the day than flat artificial surfaces. That will influence the radiation balance and hence the air temperature.

In a study, performed by FMI in Northern Helsinki in summer 2009, temperatures were measured in different distances at the north and south side of an 8 m high building. Temperature differences to the measurement point at 15 m distance were determined for four measurement points on either side of the building, see Table 2. Temperature differences for a class 3 station (7 m distance from the building) are on average twice as high as those of a flat heat source (road, Kumamoto (2012)) when the temperature sensor is located on the south side of the elevated obstacle. When sensor is placed on the north side of the obstacle, no influence on temperature could be measured.

Table 2: Temperature difference of daily averages measured on north and south side of a building during summer 2009 in Northern Helsinki.

	ΔT @15 m south side of the obstacle (reference)	ΔT @7 m south side of the obstacle	ΔT @0.5 m south side of the obstacle	ΔT @0.2 m north side of the obstacle	ΔT @0.3 m north side of the obstacle
Total	0.0 °C	+0.4 °C	+1.9 °C	0.0 °C	0.0 °C
Calm/clear days	0.0 °C	+1.7 °C	+4.0 °C	-0.1 °C	0.0 °C
Windy/cloudy days	0.0 °C	0.0 °C	+0.4 °C	+0.1 °C	-0.1 °C

Also natural obstacles (trees, bushes) can be an effective heat source. For example, temperature differences larger than 2 °C south of a 15 m high coniferous forest in Finland could be measured. At the Norwegian station Utsira, a line of trees has been grown during the last 5-10 years north of the temperature sensor. It is currently been studied if a temperature influence of this tree-line can be already seen and possibly quantified from the long term temperature measurements of that station.

Figure 13: Elevated heat source at Virolahti Koivuniemi in Finland. The picture is taken from the temperature sensor towards west. Photo: FMI

Another question was raised on how to evaluate partly unnatural surfaces like gravel roads/areas with a bit of vegetation. Also, the color/albedo of the surfaces will have an effect on temperature. Further, active heat sources like ventilation outlets from building or structures (tunnel, etc) may have a different effect than passive heat sources.

In general, different kind of heat sources (water body vs heat source, elevated vs flat) seems to have a very different influence on the temperature measurements. The amount of cited and performed studies in this report is too limited to conclude on improved class limits. However, the reported differences exceed 100% for different kind of heat sources, thus suggesting the necessity to re-evaluate the class description and limits for heat sources.
For example, Kinoshita (2014) suggests the application of the footprint (a concept used in micrometeorology to describe the influence of artificial surfaces) to evaluate the influence of heat sources on temperature measurements.

2.4 Shadow

The CIMO site classification lists shading of the temperature screen as one of the major sources for discrepancies. Obstacles around the temperature screen do indeed influence the irradiative balance of the sensor by shading of direct solar radiation during day and by hindering effective night radiative cooling.
Shading of the natural relief is generally not taken into account. Topography is regarded as representative if it is further away than 1 km or if the “500 m”-rule can be applied.
Three separate criteria are given for shade, which means stations can be classified as class 1, 2, 4 and 5 due the shading criteria. No class 3 is possible.

Class 1	Class 2	Class 3	Class 4	Class 5
Away from all projected shade when the sun is higher than 5°.	Away from all projected shade when the sun is higher than 7°.	Away from all projected shade when the sun is higher than 7°.	Away from all projected shade when the sun is higher than 20°.	Site not meeting requirements for class 4

There is no further time or width constraint of the shading obstruction given, which differs from the shading criteria for radiation instruments where shading obstacles are only considered when having a total angular width larger than 10°.
In high latitude countries, solar elevations are highly variable during the year with huge changes both in total sun elevation and the azimuth of the sun. Without any constraints on the “shading time” it follows that obstacles which shade during very short periods of the year or day can easily be “class-changing”.
It seems natural that also the time of the day when shading occurs might play a role. Obstacles which shade during sunset/sunrise typically shade shorter because of sun is changing elevation fast. Further we would expect the largest difference from shading around noon (sun elevation highest – largest difference in incoming shortwave radiation between shaded and non-shaded). Also, short morning and evening shade will have a different influence. While the air is usually more stratified in the early morning, shading should have a larger effect than in the evening, when the boundary layer is well mixed and has been evenly warmed during the day.
Determination of the elevation of obstacles around is done with a rather large uncertainty. Experiences from the classification applied in the Nordic countries show, that a lot of one-floor houses and trees in a certain distance to the station are just around 7° high. The measurement uncertainty of the height of small installations (i.e. pipe, masts, and towers) easily creates a class change from 2 to 4 for those common cases.
Even if the effect of influence of the night time radiation budget is mentioned in the introduction, obstacles are not evaluated for that.

2.4.1 Representativeness of topography

The Norwegian Station Eik-Hove (58º 30, 42' N, 6º 30, 27' Ø, 65 m.a.s.l.) is situated in a narrow valley which marks the end of a fjord, see Figure 14. The valley is orientated in North-South direction with the fjord in the south. The valley-width from East to West is about 1 km. Moving the station by 500 m in east-west direction would therefore change the shading time of the topography, while moving into north-south direction would not change very much.

Figure 14: The Norwegian station Eik-Hove, located in a narrow valley. Photo: Google Maps

These kind of narrow valleys require a rather pragmatic approach of the 500-m-rule. The location of the station was considered as representative for the valley and therefore the shade of the surrounding mountains was not taken into account. The resulting classification, applying the CIMO-scheme is 1 (1111), although the sensor is shaded by the surrounding mountains, see Figure 15.

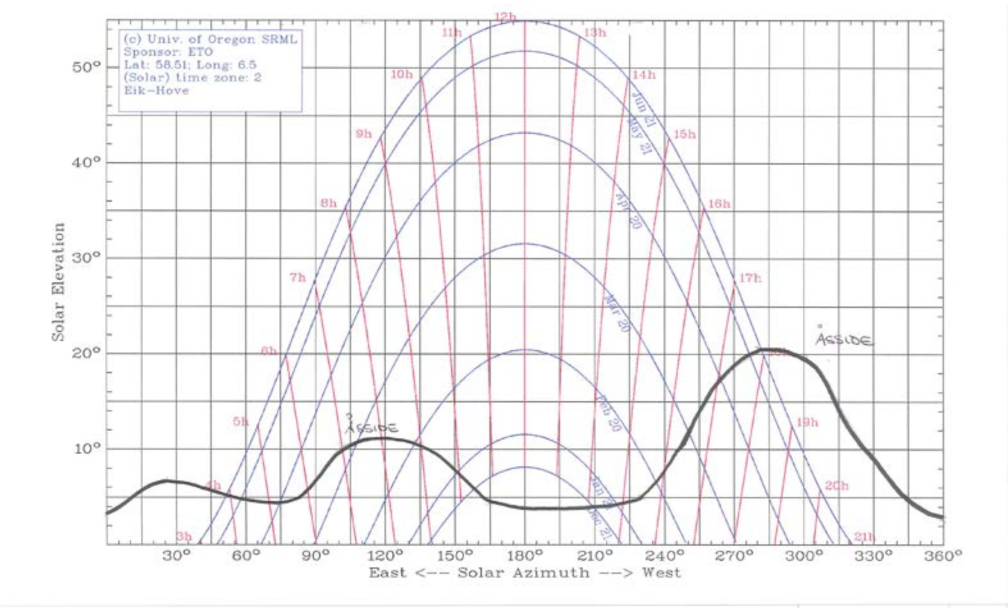
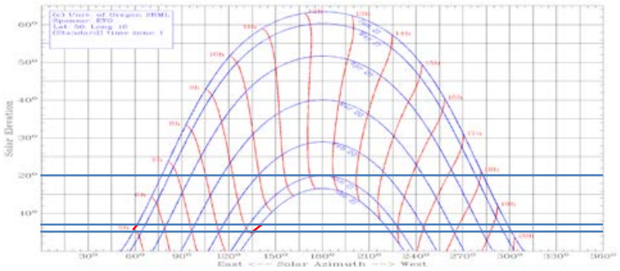


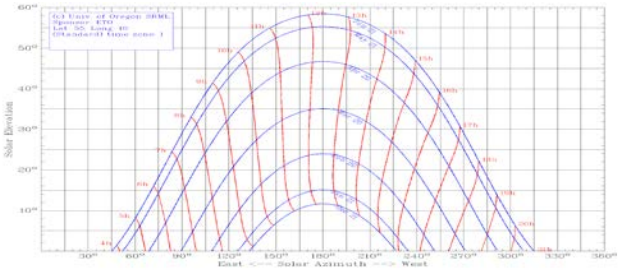
Figure 15: Sun elevation throughout the year and horizon of the topography around. The sun chart was produced with University of Oregon's SunChart program, http://solardat.uoregon.edu/SunChartProgram.html

2.4.2 Sun elevation variations typical for high latitudes

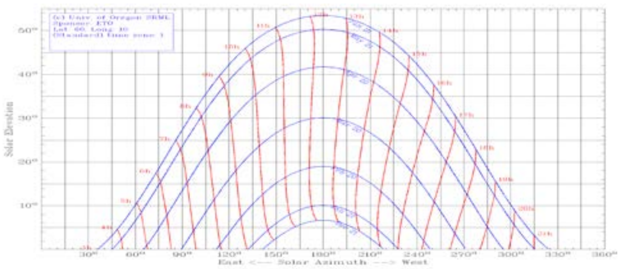
Figure 16 shows the solar azimuth and elevation at five different latitudes covering 50° to 69° N. It illustrates the well-known fact, that at mid latitudes azimuth variations are significantly smaller than at higher latitudes. Further, it is visible that the time span between solar elevation of 5° and 7° is mostly limited to about 20-30 minutes in the morning and evenings, only reaching 1 h in January & November at 65°, when the sun reaches only 5° in maximum. It is expected, that shading time of less than half an hour has a rather limited influence, thus making the difference between class 1 and class 2 stations very small.



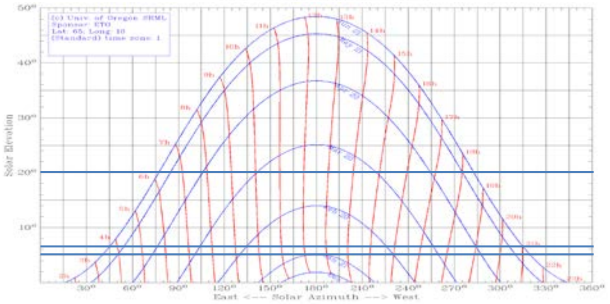
50º N:
Minimum azimuth: 127º - 232º (105º)
Maximum azimuth: 50º - 310º (260º)



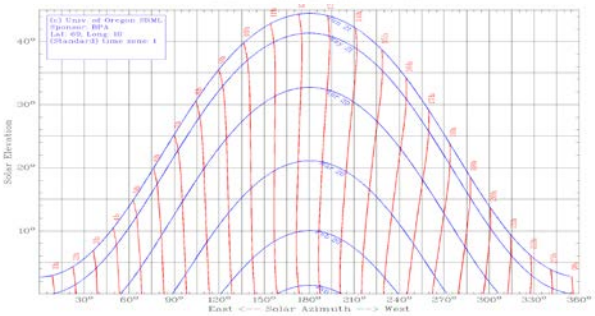
55º N:
Minimum azimuth: 132º - 227º (95º)
Maximum azimuth: 45º - 315º (270º)



60º N:
Minimum azimuth: 140º - 220º (80º)
Maximum azimuth: 35º - 325º (290º)



65º N:
Minimum azimuth: 157º - 202º (45º)
Maximum azimuth: 15º - 345º (330º)
months with solar elevation <5º:3



69º N:
Minimum azimuth: 0º
Maximum azimuth: 0º - 360º (360º)
Months with maximum solar elevation <5º:3

Figure 16: Solar elevation and azimuth for 6 selected days at latitude 50º, 55º, 60º, 65º and 69º N. University of Oregon's SunChart program

2.4.3 Sun elevation throughout the year

The Estonian station Vilsandi is classified as class 5 (1125). Slope and vegetation criteria are classified as 1, a few houses within a 30 m radius around the station are the reason for class 2 for the heat source criterion. Pictures of the site show that the weather station is placed in a rather open area, with just a few trees and houses in the vicinity. Only two obstacles are higher than 7°, a house and a lighthouse. The latter is also exceeding 20°, thus classifies the station as 5. The lighthouse shades the temperature sensor for less than half an hour during the afternoon. The sun is higher than 20° for an even shorter time and only during three months during the year (May-July). The house's shade will affect the sensor for about an hour in the afternoon only during the months March and September, as the sun is either lower than 7° or the higher than the house in the other months.

For this station it is very questionable if the very limited times with shade on the sensor, really jeopardizes the data quality in a way that it is not usable for climatological and synoptical as the classification suggests.

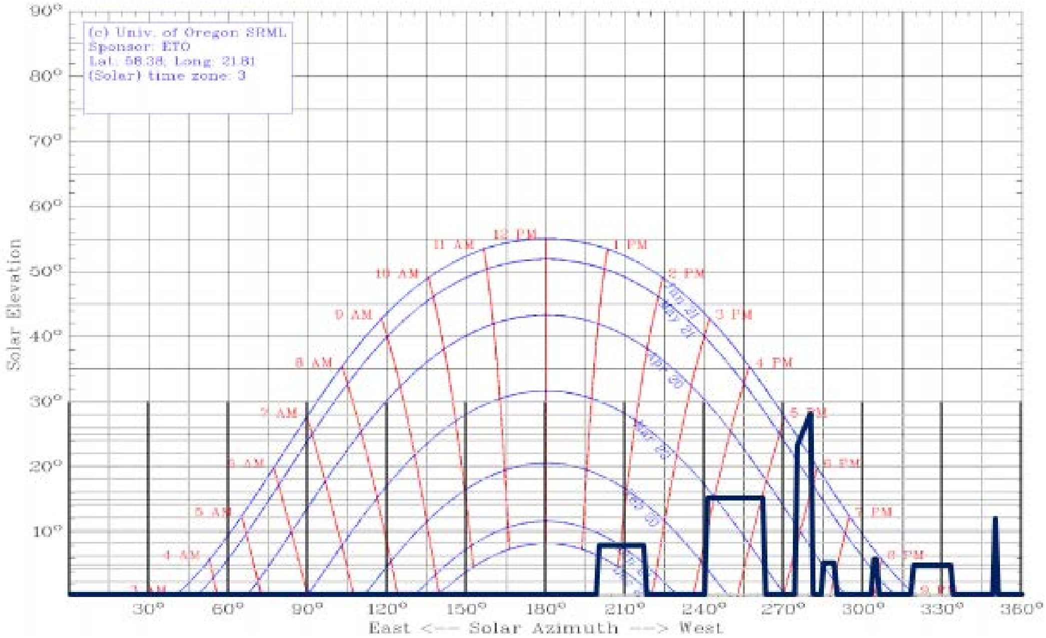


Figure 17: Sun elevation chart with horizon elevation for the Estionian station Vilsandi. University of Oregon's SunChart program

The Estonian station Viljandi is classified as a class 4 station due to the shade on the sensor when the sun is higher than 7° (slope 1, vegetation 1, heat sources 2). The station is surrounded by trees and low buildings in almost all directions. The sensor is in shade almost all day during the winter months with lower sun elevation (Oct-Feb). During the rest of the year, the sensor is only shaded after 6:30pm (local time). At that time, the sun is only higher than 7° from

Jun-Aug. For this station a monthly evaluation of the shade effect would give valuable information for the evaluation and use of the site temperatures. For example, warm summer records are not affected by the shading at all, whereas daily winter averages will experience an influence of the day-long shade on the sensor. Viljandi is significantly colder than a neighbour station during the winter months, see section 3.2.

2.4.4 Time of shade

The studies from Norway and Finland in sections 3.1 and 3.3 suggests that shading periods lasting longer than 3 hours have a significant effect on temperature measurements, whereas an influence of shorter shading periods cannot be seen in the data.

2.4.5 Measurement uncertainty of the elevation

Elevation or height of houses and trees are not always known and with simple equipment the angle determination is often inaccurate. Typical house heights in rural areas may be around 6 - 8 m and can often be found in distances of 30-50 m. The distance is often the result of compromises between distance to heat source (class 2) and practical issues like cable length and accessibility for maintenance. Assuming a sensor height at 2 m, an uncertainty of ±0.5 m in determining the house height results in an angle uncertainty of ±0.7° around the threshold angle between class 2 and 4 (7°), illustrated in Figure 18. Simple handheld instruments for direct measurement of the angle will not achieve accuracy better than ~±1°, neither.
Of course the thresholds between classes cannot depend on the measurement uncertainty of the determining factors. The effect of uncertainty in this case is emphasized because the threshold marks a 2 step change of classes and the threshold elevation of obstacles is actually a very typical value for stations. Together with the before mentioned missing time/width constraint of the shading obstacles it seems to cause unjustified low class numbers for a lot of temperature measurement sites.

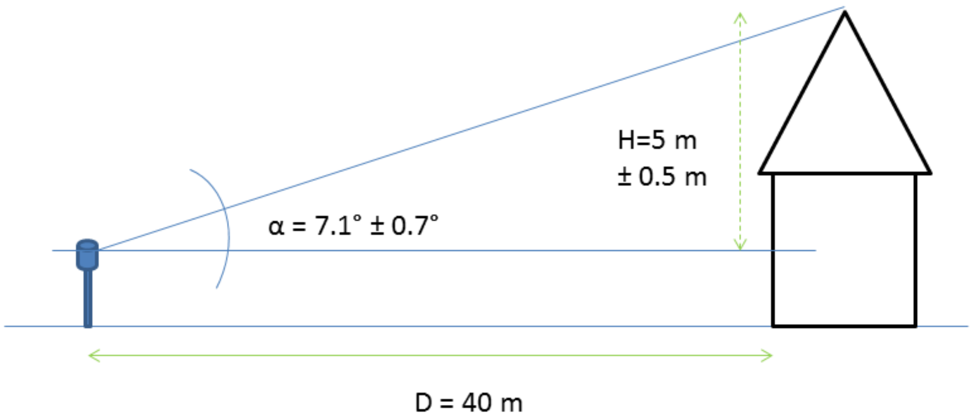


Figure 18: Example of uncertainty in calculated elevation angle when house height is uncertain

2.4.6 Sky View Factor

The night temperature differences due to non-shading obstacles are not taken into account in the siting classification. Obstacles change the long wave radiation budget, and determining the Sky View Factor (SVF) could be useful. The SVF plays a role for climate research, especially for studies of the urban heat island effect (Oke, 1981). The SVF is defined as the ratio between radiations received by a planar surface and that from the entire hemispheric radiating environment and can be calculated as the fraction of sky visible when viewed from the ground up. Values for the SVF are ranging from 0 to 1. A SVF of 1 denotes that the sky is completely visible; for example, in flat terrain without any obstacles. When a location has buildings and trees or topographic features, it will cause the SVF to decrease proportionally. Figure 19 shows some fish eye pictures showing the grade of obstruction of around a site. The calculated SVFs are written under each photograph.

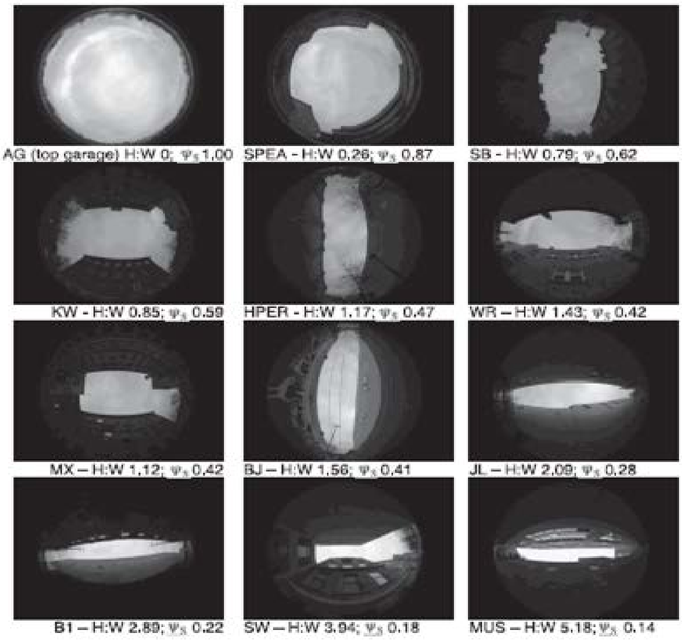


Figure 19: Fisheye pictures and associated sky view factor. The photographs are taken from Grimmond et al. (2001).

3 Further data analysis from classified stations

3.1 MET Norway: Study of temperature differences

Contribution by Aslaug van Nes, MET Norway

With the aim of introducing siting classification for temperature measurements at Norwegian weather stations the question arose about how large the influences from different features actually are given the classes they represent. In this study we are looking at two close situated weather stations to see how shading and heat sources influence on the temperature measurements.
2 stations in vicinity to each other where found to study how they perform compared to each other. Since one station has siting class 1 for temperature measurements it could give an opportunity to study the effects of heat sources and shadow for the other station. This was possible due to a full set of cloud cover observations from a ceilometer at one of the stations.

3.1.1 The stations and classification

The stations are situated in a flat area in the south eastern part of Norway. The distance between them is 1.7 km (see Figure 20). Both of the stations are equipped with the same type of sensors and radiation screens. The first station, Rygge, is placed at an airfield with a large area of grass surrounding the observation site and the horizon is free of obstacles (Figure 21-Figure 23). Together, this results in siting class 1 for temperature measurements. The second station, Huggenes, is placed 7 meters from a large parking area covered with gravel (Figure 24-Figure 26). The parking area counts as a heat source and its small distance to the sensor results class 4 for the heat source criterion. East of the station is a row of trees. The shadowing from the trees on the site results in class 5.

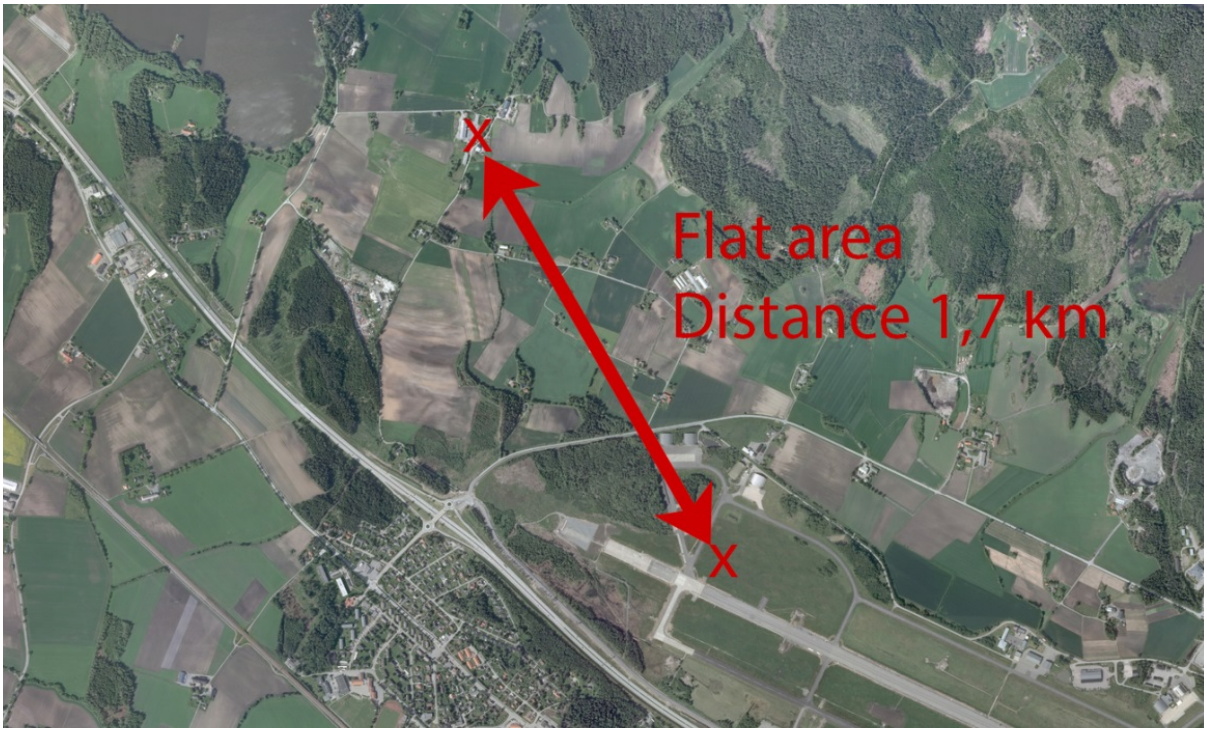


Figure 20: Aerial photo showing the position and distance between the two stations in the study. Photo: Norwegian Mapping Authority.

Figure 21: Rygge airport weather station. Photo: MET Norway

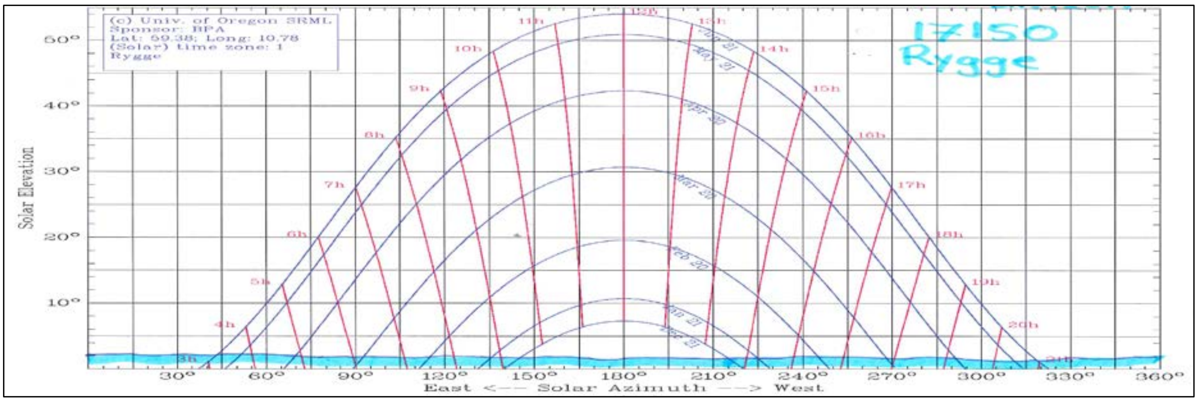


Figure 22: The horizon around Rygge airport weather station. University of Oregon's SunChart program

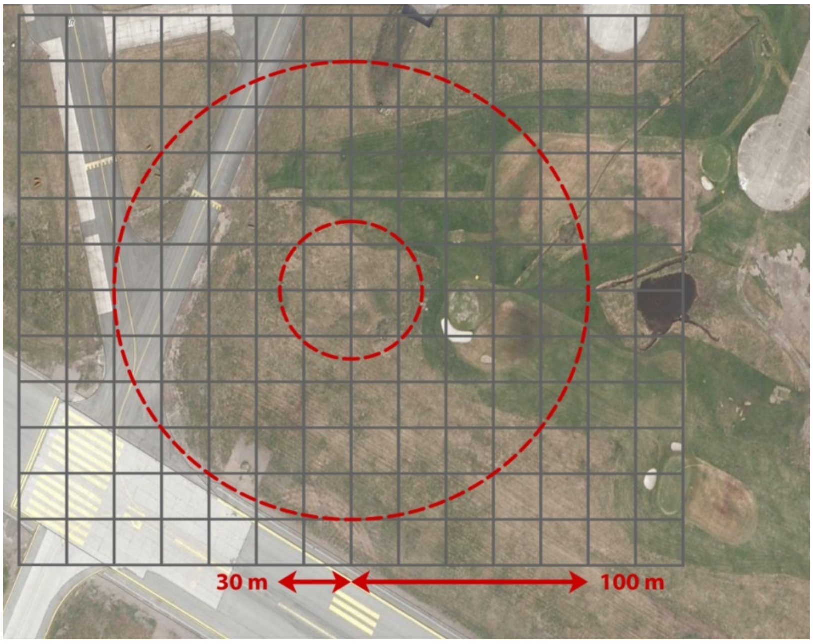


Figure 23: Aerial photo showing the distribution of grass field and asphalt around Rygge airport weather station. Photo: Norwegian mapping Authority.

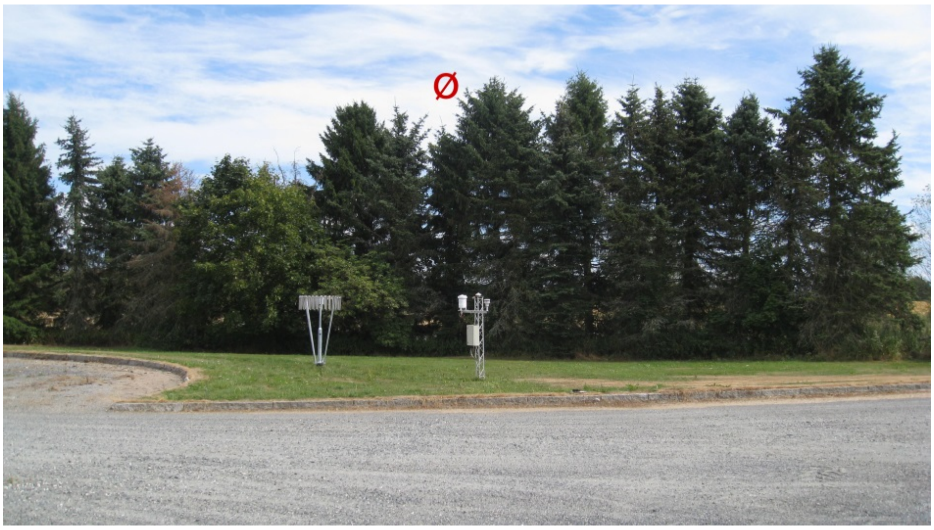


Figure 24: The weather station at Huggenes. Photo: MET Norway

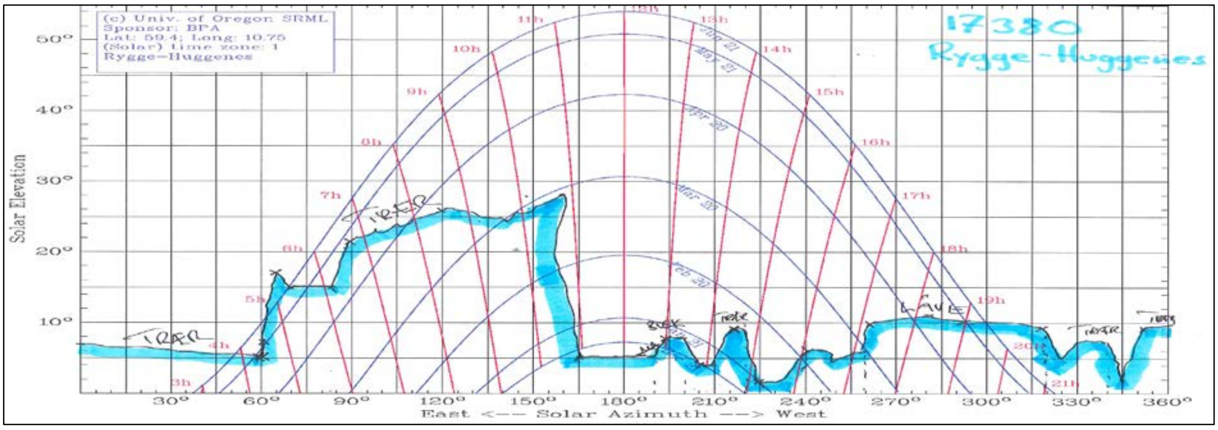


Figure 25: The horizon around Huggenes weather station. Shading when the sun is higher than 20 degrees will give class 5. University of Oregon's SunChart program.

Figure 26: Aerial photo shoving the local area around the weather station at Huggenes. The parking area is covered with gravel and works as a heat source. In the classification this will result in class 4 for heat sources. Photo: Norwegian mapping Authority.

3.1.2 Observed temperature differences

Figure 27 shows the temperatures measured at both stations in September 2014. Added to the diagram are measurements of cloud cover shown as a red graph. The diagram shows, that Huggenes (green line) was colder at night and warmer during daytime in clear weather in September 2014.

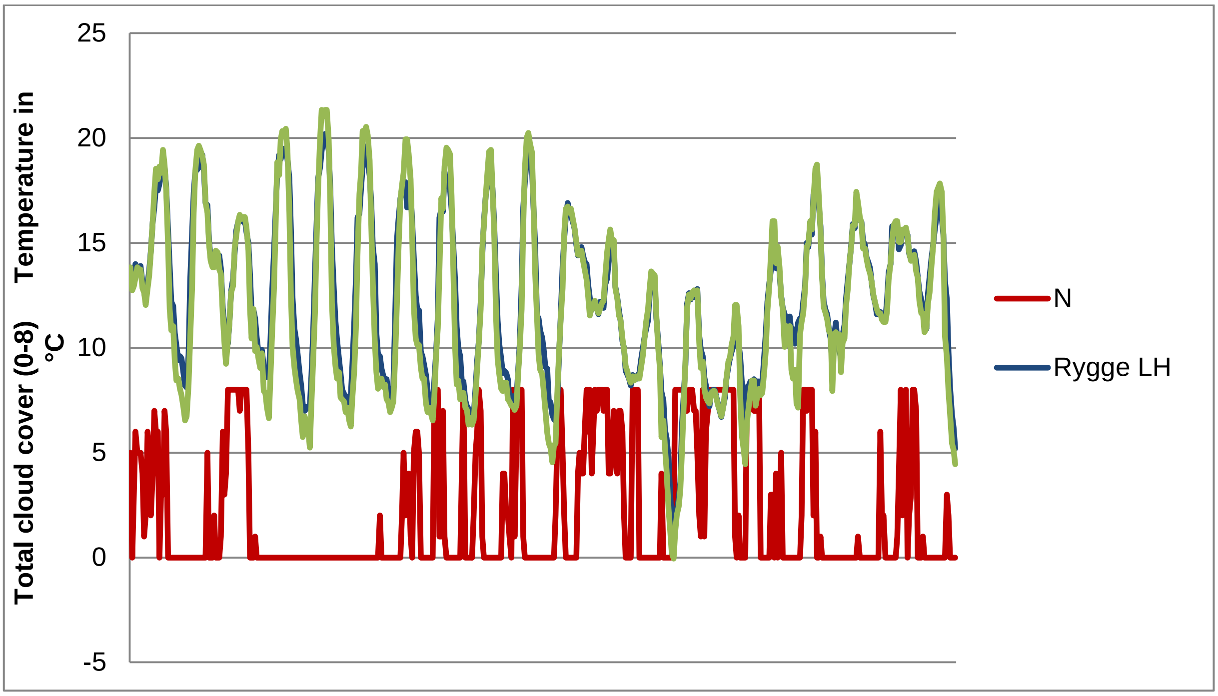


Figure 27: Temperatures measured at Rygge airport (blue line) and Huggenes (green line) in September 2014. The red graph is showing the total cloud cover N, measured in octas, where 8 is a total cloud covered sky and 0 is a clear sky.

For a better visualization of the temperature differences between the stations, ΔT, is calculated for all the observations and then again compared with the simultaneous measurements of cloud cover. Figure 28 shows a graph with the calculated ΔT together with a graph of cloud cover for observations taken in May 2014. The last part of May 2014 there was a long period with a total cloud covered sky, whereas in the first half are longer periods of clear sky. Temperature differences, ΔT, in the period with clear or alternating cloud cover fluctuate more than in the longer period with cloud covered sky where ΔT is fluctuating little with values close to 0.
The wind speed might have an impact on the temperature differences between the stations. To study this ΔT is organized after the wind speed measured. At the same time the observations where divided into six sets to study the different situations listed below.

1. At night in clear sky, see Figure 29.
2. At night in cloud covered sky, see Figure 30.
3. At daytime in clear sky when both stations are exposed to the sun, see Figure 31.
4. At daytime in cloud covered sky, see Figure 32.
5. When the Huggenes site is in shadow from trees towards east, see Figure 33.
6. When Huggenes site is in shadow from building towards west, see Figure 34.

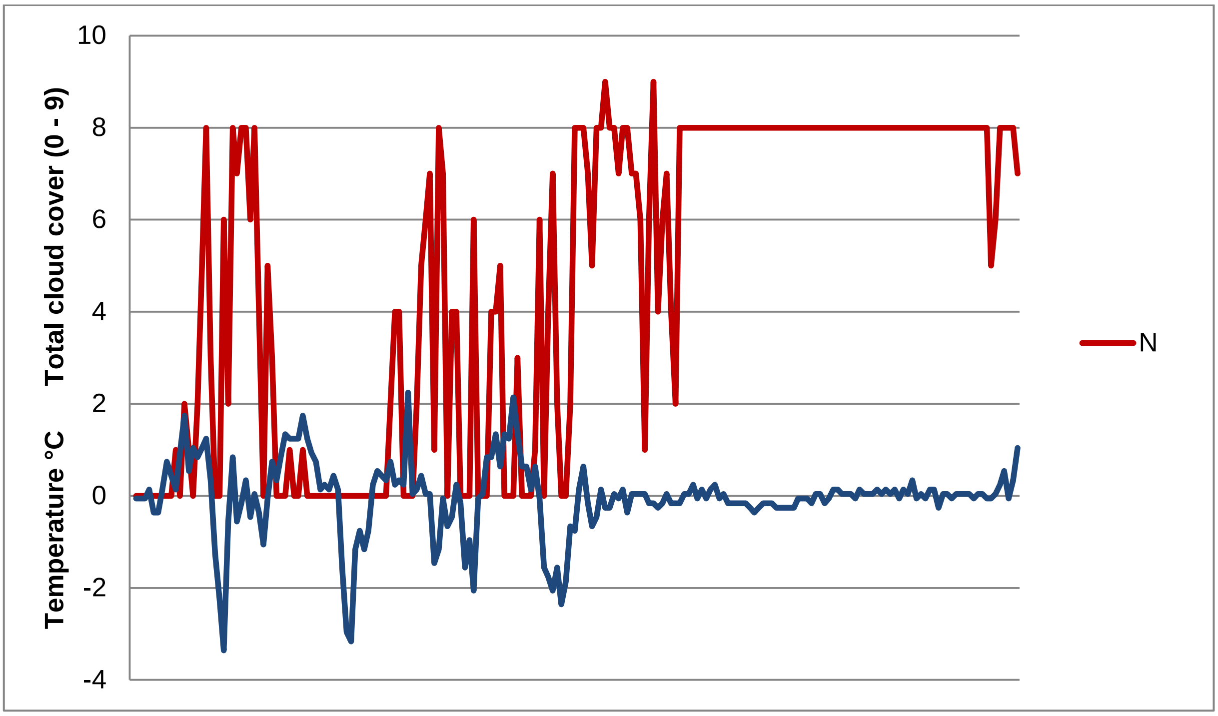


Figure 28: ΔT is the temperature at Huggenes (Hu) minus the temperature at Rygge airport (LH), where the last has siting class 1. Temperature differences, ΔT, between the two stations in May 2014 shown as a blue graph. The red graph is showing the total cloud cover N, measured in eights, where 8 is a total cloud covered sky, 0 is a clear sky and 9 can be situations with fog or dense precipitation.

Observations taken in periods of alternating cloud cover are left out because of the uncertainty made by the 1700 meter distance between the stations. The values for ΔT in Figure 29-Figure 32 are plotted together with wind speed and organized from smallest to highest wind speeds. Figure 29 and Figure 30 show that Huggenes is generally colder at night and that the differences and fluctuations are larger in clear weather. The tendency towards colder observations at Huggenes in clear weather seems to decrees when wind speeds reach 2.5 m/s or more.

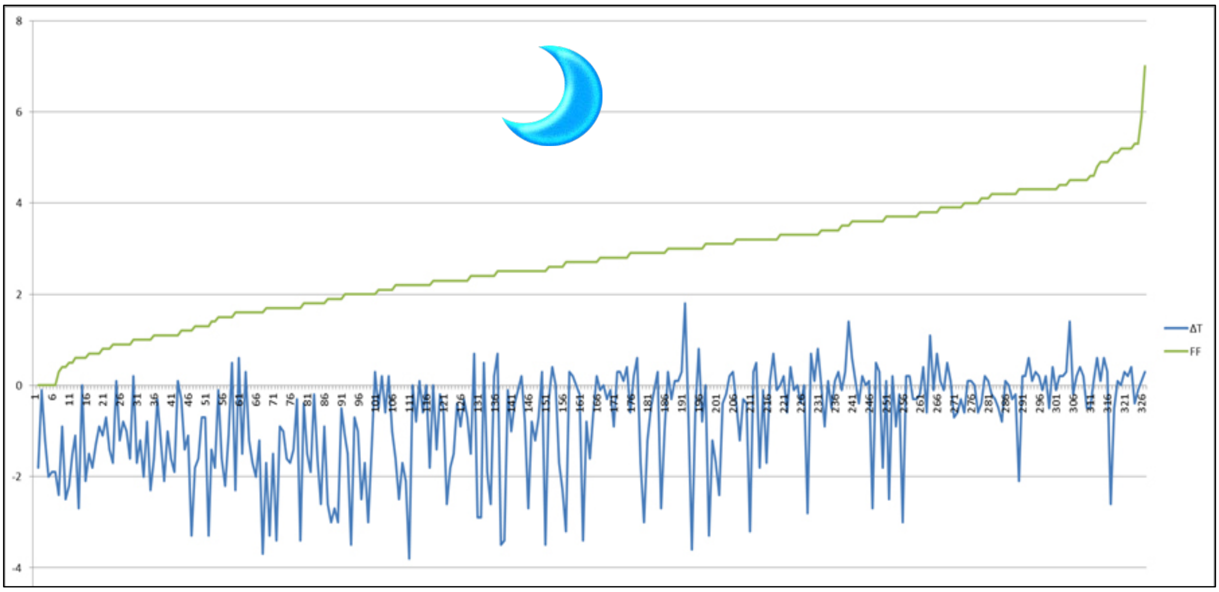


Figure 29: ΔT for observations in 2015 at night when there was a clear sky (blue line), organized after the wind speed, FF (green line).

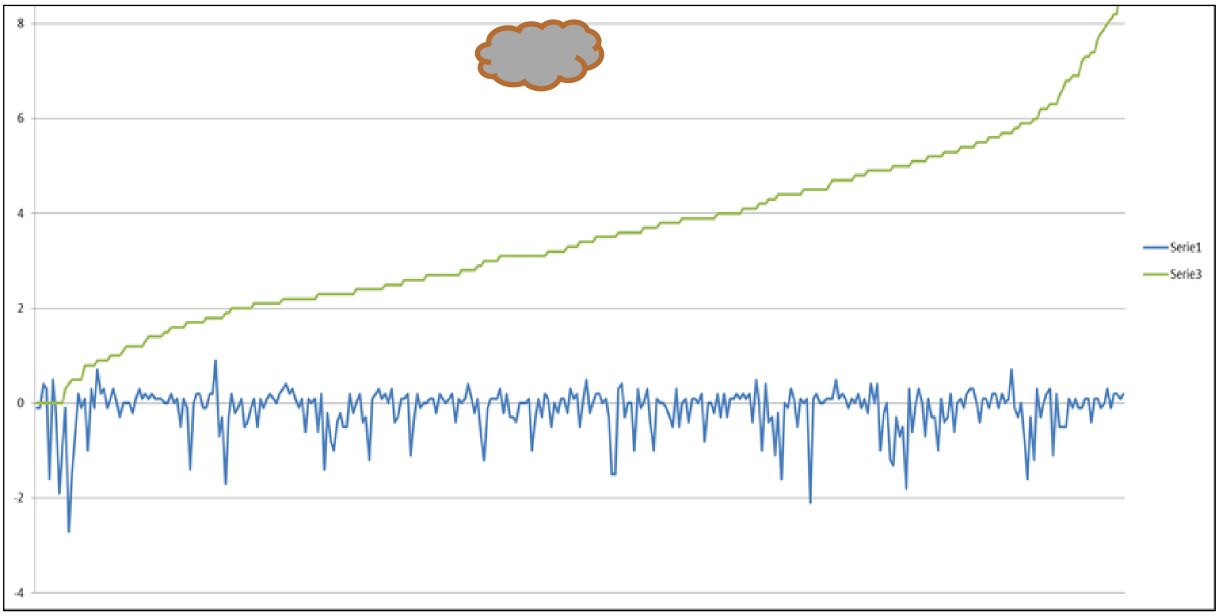


Figure 30: ΔT for observations in 2015 at night when there was overcast sky (blue line), organized after the wind speed, FF (green line).

At night in overcast weather there is little correlation with changes in ΔT and wind speed.

To see how the parking act as a heat source the observations at times when both sites where exposed to sun where compared. Figure 31 displays the calculated ΔT for these observations again organized after increasing wind speed. Figure 31 shows that the Huggenes station is warmer than the airport station when both are in direct sunshine. There is no significant change of ΔT with increasing wind speeds. This figure gives a hint of how the heat source is influencing the temperature measurements at the Huggenes site. Figure 32 shows the temperature differences during cloud cover, and here the graph for ΔT is fluctuating less and more close to 0, but still there is a small tendency towards warmer observations at Huggenes.

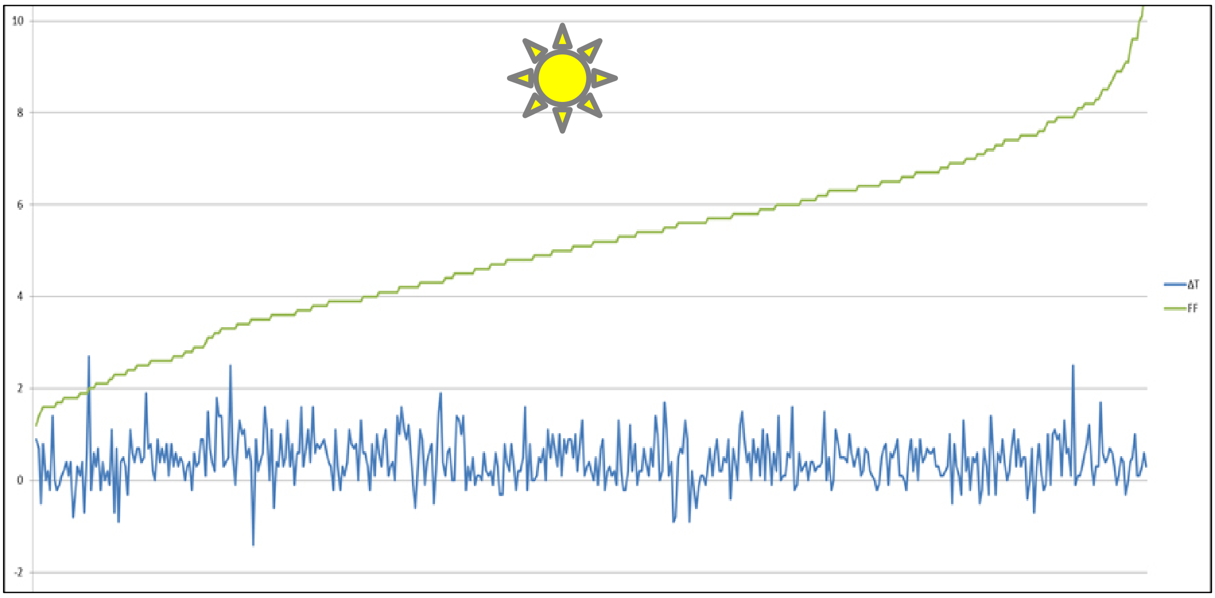


Figure 31: ΔT (blue line) for observations in 2015, in sunshine, at times when there was no shadow at the Huggenes site, organized after the wind speed, FF (green line).

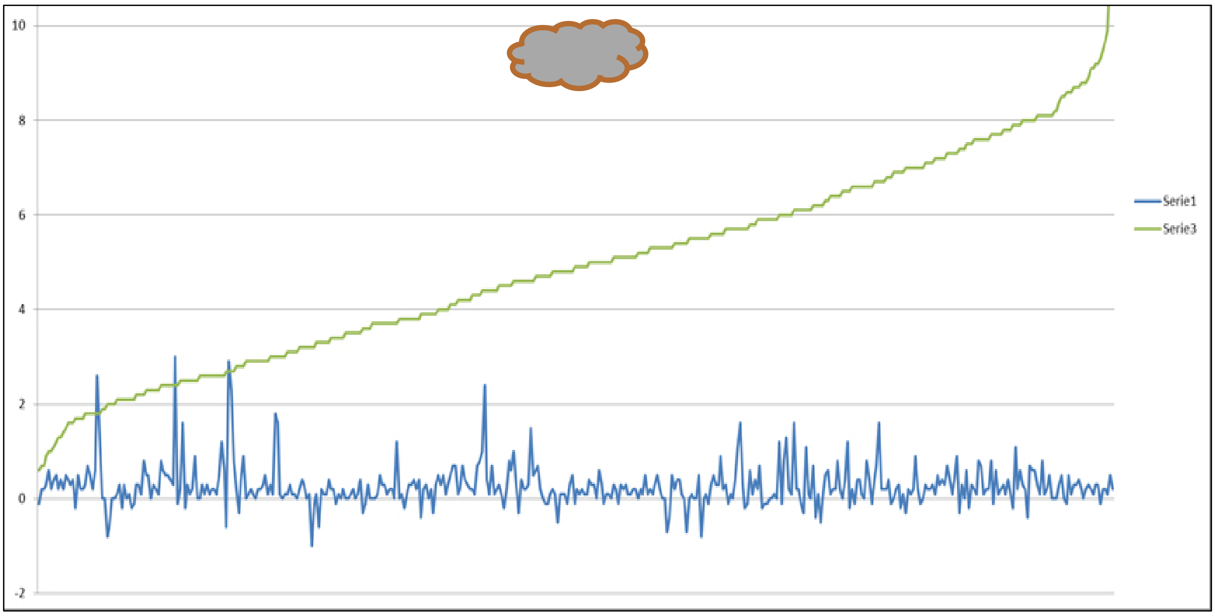


Figure 32: ΔT for observations in 2015 at daytime during longer periods of overcast sky (blue line), organized after the wind speed, FF (green line).

To find enough observations where the Huggenes site was in shadow from trees or building, observations from both 2014 and 2015 where used.
The diagram in Figure 33 shows temperature differences, ΔT, when Huggenes is in shadow from trees after sunrise. The ΔT values (blue) are again plotted together with wind speed (FF), organized from smallest to highest wind speed. The first half of the graph shows temperature differences during sunshine (N=0 and 1), and the other half during overcast (N=7, 8 and 9). There is a visible tendency towards colder observations at wind speeds below 2,5 m/s in clear sky. In cloudy conditions there is little difference between the stations.

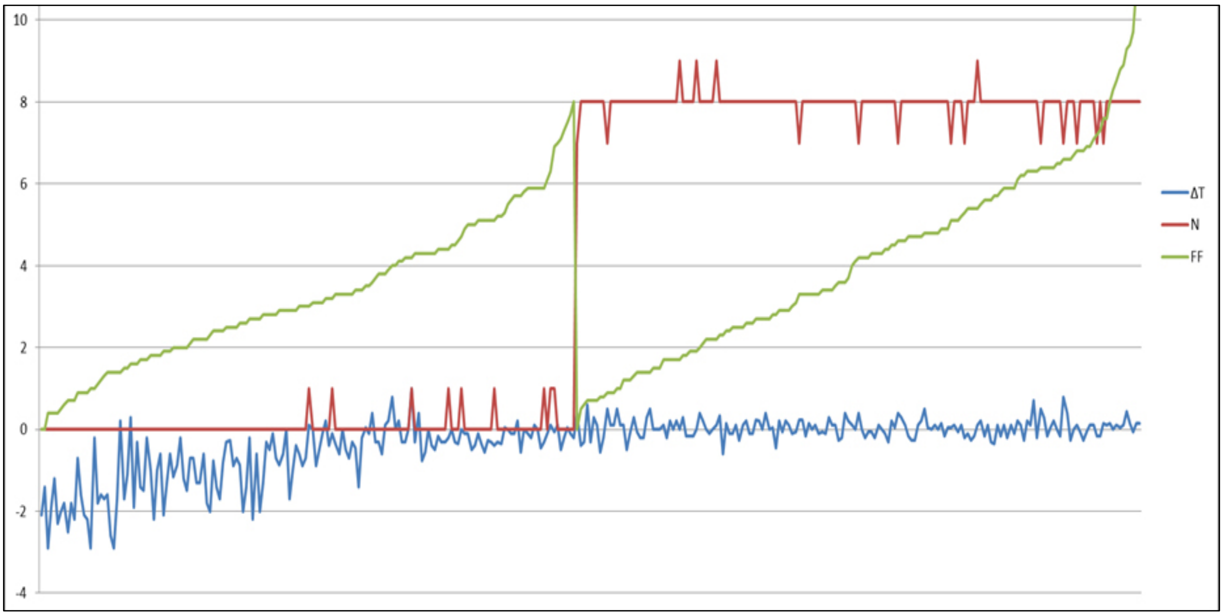


Figure 33: ΔT (blue line) for observations in 2014 and 2015 when the Huggenes site is in shadow from trees toward east after sunrise. ΔT is organized after cloud cover, N, (red line) and second after increasing wind speed, FF (green line).

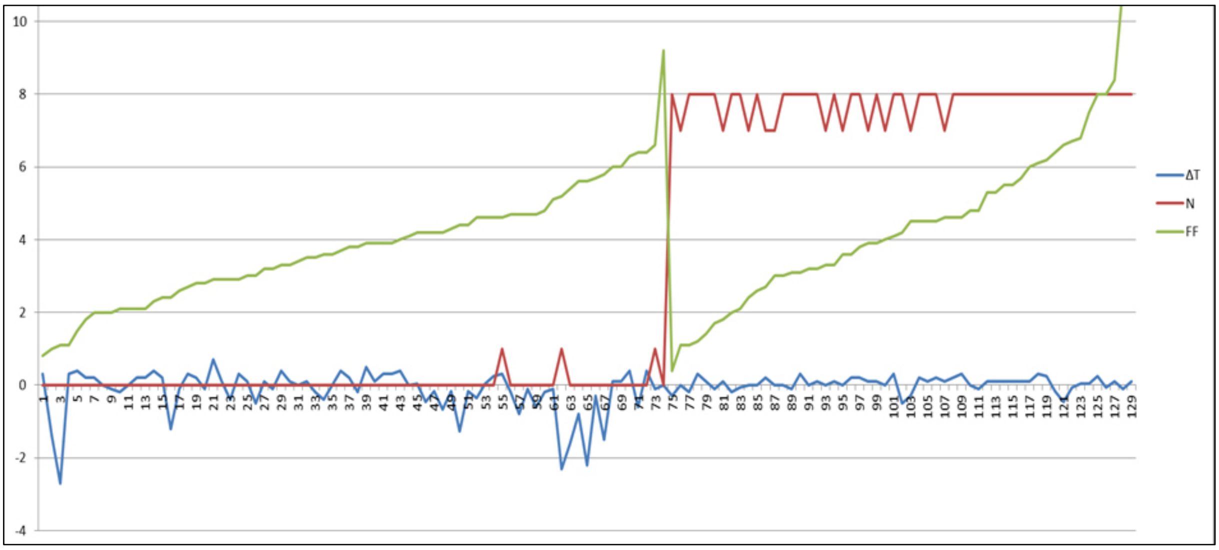


Figure 34: ΔT (blue line) for observations in 2014 and 2015 when the Huggenes site is in shadow from building towards west before sunset. ΔT is organized after cloud cover; N, (red line) and second after increasing wind speed, FF (green line).

When we look at the temperature differences in situations when the Huggenes site is in the shadow of building towards west, most of the observations show no tendency of cooling, see Figure 34. There are a few spikes towards colder temperatures. The Huggenes site is probably more exposed to activities like irrigation and parking of large vehicles adding to the uncertainties.

3.1.3 Conclusions

It is difficult to find an exact measure on the cooling/heating effect on the temperature measurements at the Huggenes site caused by the nearby parking area and the shading. The shading from trees towards east gives the site the poorest class, 5, and the parking area acting as a heat source, would alone give class 4. The cooling effect of the shading in calm clear weather is larger (fluctuating around -2°C) than the heating effect from the parking area (fluctuating roughly around +0,5 to +1°C). In this case the class for heating and shading seems reasonable.
We must take into account that cold air is produced over the parking area before sunrise, see Figure 29. The “heat source” is acting as a cooling source at night in clear weather. Since the air is more stratified in the morning, shading from obstacles towards east will probably in general give colder temperature observations than when an obstacle is placed towards west.
For a short period in the evening the Huggenes station is in the shade of a building toward west. The building gives shade when the sun is 11° or lower, which would have resulted in class 4. Most of the observations show no cooling. There are only a few spikes towards colder observations, but too few to show a connection with the shading. This site might not be the best to conclude on this, but still it can seem that the criteria for shadow are too strict when the shading is lasting a short time.

3.2 EstEA: Study of temperature differences

Contribution by Miina Krabbi, EstEA.

3.2.1 Introduction

Two Estonian stations were compared: Viljandi and Massumõisa. Viljandi station is located within city limits in a low density housing area, with several asphalt streets nearby and some taller trees to the North and South – South-East direction (Figure 35). Massumõisa station is located in the countryside on a relatively open ground, with an asphalt road several hundred metres away. Some tall trees grow on the East side of the field.

Figure 35: Viljandi (left) and Massumõisa (right). Photos: Google maps

In Estonian context, these stations are located relatively close (13 km via shortest route) with some differences to their surroundings. In addition, a new asphalt street was constructed near the Viljandi station in 2005 (Figure 36).

Figure 36: Viljandi before and after the street construction. On the left, a view to the North (November 2004), on the right a view to the North-East (July 2006). Photos: EstEA

The mean, minimum and maximum air temperatures of Viljandi and Massumõisa station were compared. Depending on the location, it can be assumed that Viljandi measures higher air temperatures than Massumõisa.

3.2.2 Analysis

The mean temperature analysis was compiled basing on data from 2012-2015. Massumõisa station was automated at the end of 2011. Prior to that, only minimum and maximum temperatures were measured. The results show that the course of Viljandi and Massumõisa daily temperatures are very similar and the mean temperatures are almost identical. Correlation between the timelines is 0.99. It could be argued that in general the daily mean temperature in Viljandi station is not higher than in Massumõisa station. That was also confirmed by a test of one-way Analysis of Variance (ANOVA), which can be used for the case of a quantitative outcome with a categorical explanatory variable that has two or more levels of treatment. The term oneway, also called one-factor, indicates that there is a single explanatory variable ("treatment") with two or more levels, and only one level of treatment is applied at any time for a given subject (Seltman 2015). This test helps to compare two and more groups based on their group means. Analysis of Variance showed that during 2012-2015 the difference of Viljandi and Massumõisa mean temperatures is not statistically significant nor is it so during different seasons (p>0.05). However, there were several days in the 2012-2015 period, when the daily mean temperature was somewhat lower in Viljandi (Figure 37). The majority of these days were in winter and the cold half-year. Still, the differences rarely exceeded 2 degrees.

Figure 37: Differences between Viljandi and Massumõisa daily mean temperatures from 2012 to 2015

The daily minimum temperatures during 2004-2015 were analysed. In that period the mean minimum temperature was very similar in both stations (2.6 in Viljandi and 2.7 in Massumõisa), giving a reason to assume that the difference of the minimum temperatures in these stations is also not statistically significant. The assumption was confirmed, since testing the significance of the difference by one-way ANOVA resulted in p=0.63. Hence, the difference of minimum temperatures during 2004-2015 is not statistically significant. There is no significant difference during seasons either. The analysis of different months shows that in February and March the minimum temperature was half a degree lower in Viljandi. The correlation between the minimum temperature of Viljandi and Massumõisa was relatively strong during these months (0.98 and 0.97 accordingly), so it can be concluded that there is no significant difference. During the period under study there were 16 days when the difference between the daily minimum temperatures exceeded 5 degrees (Table 3). Interestingly, in all these days the lower temperature was measured in Viljandi, where you would presume higher temperatures due to the impact of the nearby city and the proximity of the streets.

Table 3: Largest differences between daily minimum temperatures (°C) in Viljandi and Massumõisa stations during 2004-2015

Date	Viljandi	Massumõisa	Difference
31 01 2004	-10,3	-4	-6,3
11 03 2005	-24,3	-18,5	-5,8
12 10 2005	0,6	6	-5,4
14 10 2005	0,3	6	-5,7
11 02 2007	-21,8	-16,5	-5,3
12 02 2007	-21,3	-16	-5,3
10 02 2010	-16,7	-11,6	-5,1
23 02 2011	-27,7	-21,2	-6,5
24 02 2011	-27,1	-22,6	-4,5
25 02 2011	-26,7	-20,3	-6,4
8 01 2012	-13,1	-7	-6,1
25 02 2013	-17,4	-11	-6,4
26 02 2013	-11,5	-6	-5,5
11 03 2013	-23,6	-18	-5,6
20 06 2013	9,7	15,2	-5,5
18 07 2013	10,4	16,7	-6,3

Analysis of daily maximum temperatures during 2004-2015 showed only 13 days when temperatures in Viljandi station were more than 3 degrees lower than in Massumõisa (Table 4). The overall mean maximum temperature was slightly lower in Viljandi, but did not differ significantly from Massumõisa station. The majority of days when the maximum temperature in Viljandi was lower than in Massumõisa, were again during the cold half-year. The shading from trees has possibly an impact in the winter at Viljandi. Testing the significance of the difference showed that during 2004-2015 there is no statistically significant difference regarding maximum temperatures, however it revealed a significant difference in the summer (p=0.03). It is a peculiar result, since the correlation of Viljandi and Massumõisa temperatures in that period is 0.97, indicating a fairly big similarity. Also, the mean maximum air temperature is not that different in these stations during summer (22.2 in Viljandi and 22.5 in Massumõisa). From the aspect of months, there was a strong correlation of 0.97-0.99 between Viljandi and Massumõisa maximum temperatures in every month and no significant difference was found.

Table 4: Largest differences between daily maximum temperatures (°C) in Viljandi and Massumõisa stations during 2004-2015

Date	Viljandi	Massumõisa	Difference
24 01 2004	-10,3	-6,1	-4,2
01 04 2004	3,2	6,5	-3,3
21 06 2004	14,9	18,4	-3,5
08 02 2005	-4,2	-1	-3,2
13 09 2008	10,6	16,8	-6,2
15 06 2009	13,9	18	-4,1
20 07 2009	20,2	25,1	-4,9
23 01 2010	-18,6	-14,4	-4,2
24 01 2010	-18	-13,2	-4,8
16 02 2010	-11,2	-6,7	-4,5
05 02 2012	-17,3	-14	-3,3
06 02 2012	-14,4	-10,7	-3,7
01 07 2013	18,8	22	-3,2

3.2.3 Conclusions

Viljandi and Massumõisa stations are located relatively close, yet the microclimatic environment surrounding the stations is rather different. The assumption that the air temperature in Viljandi is higher than in Massumõisa was not confirmed, regardless the station’s location within city limits and the proximity of asphalt paved streets. The tall trees near Viljandi observation field may have an influence, shading sunlight from the south. Daily mean, minimum and maximum temperatures were strongly correlated. The correlation was significant during the entire period under study, as well as when comparing seasons, and months. The only statistically significant difference was in the summers of 2004-2015, when the daily maximum temperature in Viljandi was slightly lower than in Massumõisa.

Despite the great similarity in air temperatures, there were a number of days when the daily mean, minimum and maximum temperatures differed greatly in Viljandi and Massumõisa stations. The largest differences were around 6 degrees and the temperatures were mostly lower in Viljandi station. These days can probably be regarded as temperature anomalies.

3.3 FMI: Study of shading effects in Finland

Contribution by Juho-Pekka Kaukoranta, FMI

In Finland it was investigated how much shading influences temperature by comparing time periods when the temperature screen was in shade to the time periods without shading. The weather stations studied where Rauma Kylmäpihlaja and Kokemäki Tulkkila.

3.3.1 Rauma and Kokemäki weather stations

Station Rauma is situated in an archipelago and shaded by a lighthouse. Station Kokemäki is situated inland, in the south west part of Finland, and shaded by a fire stations hose tower. See Figure 38, Figure **39** and Figure **40**.

Figure 38: The blue arrows indicate the location of Rauma and Kokemäki weather station within Finland.

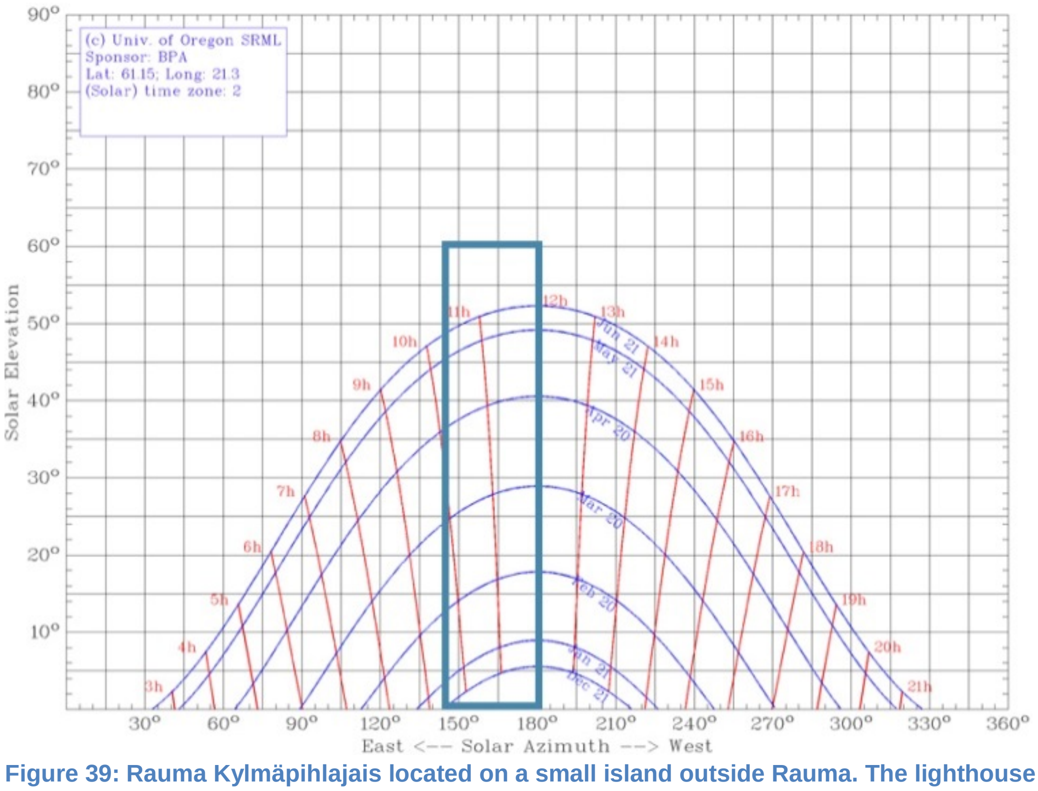


Figure 39: Rauma Kylmäpihlajais located on a small island outside Rauma. The lighthouse is 40° wide and 60° high as seen from the position of the temperature shelter. On the solar elevation diagram the blue triangle indicates the lighthouse.

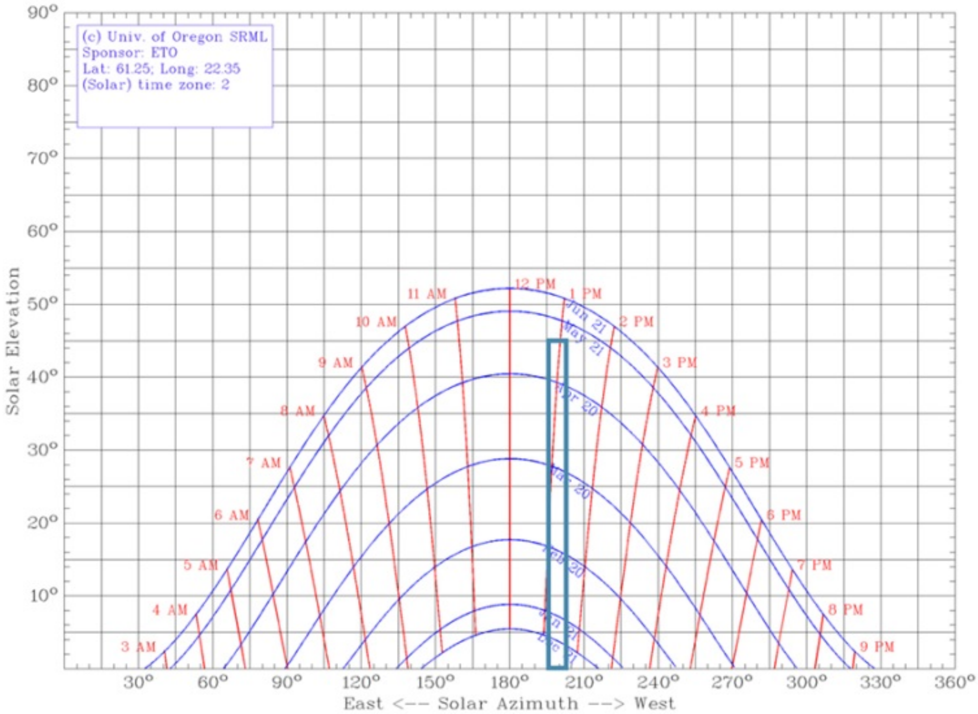


Figure 40: Kokemäki Tulkkila is located about 50 km inland from sea. A fire station tower is 10° wide and 47° high as seen from the position of the temperature shelter. On the solar elevation diagram the blue triangle indicates the fire station tower.

3.3.2 Temperature study of Rauma and Kokemäki

The average diurnal temperature where calculated for 3 months, March, April and May 2014 (Figure 41 and Figure 42). Also it was investigated the air temperature diurnal variation in clear days at the same stations (Figure 43 and Figure 44).

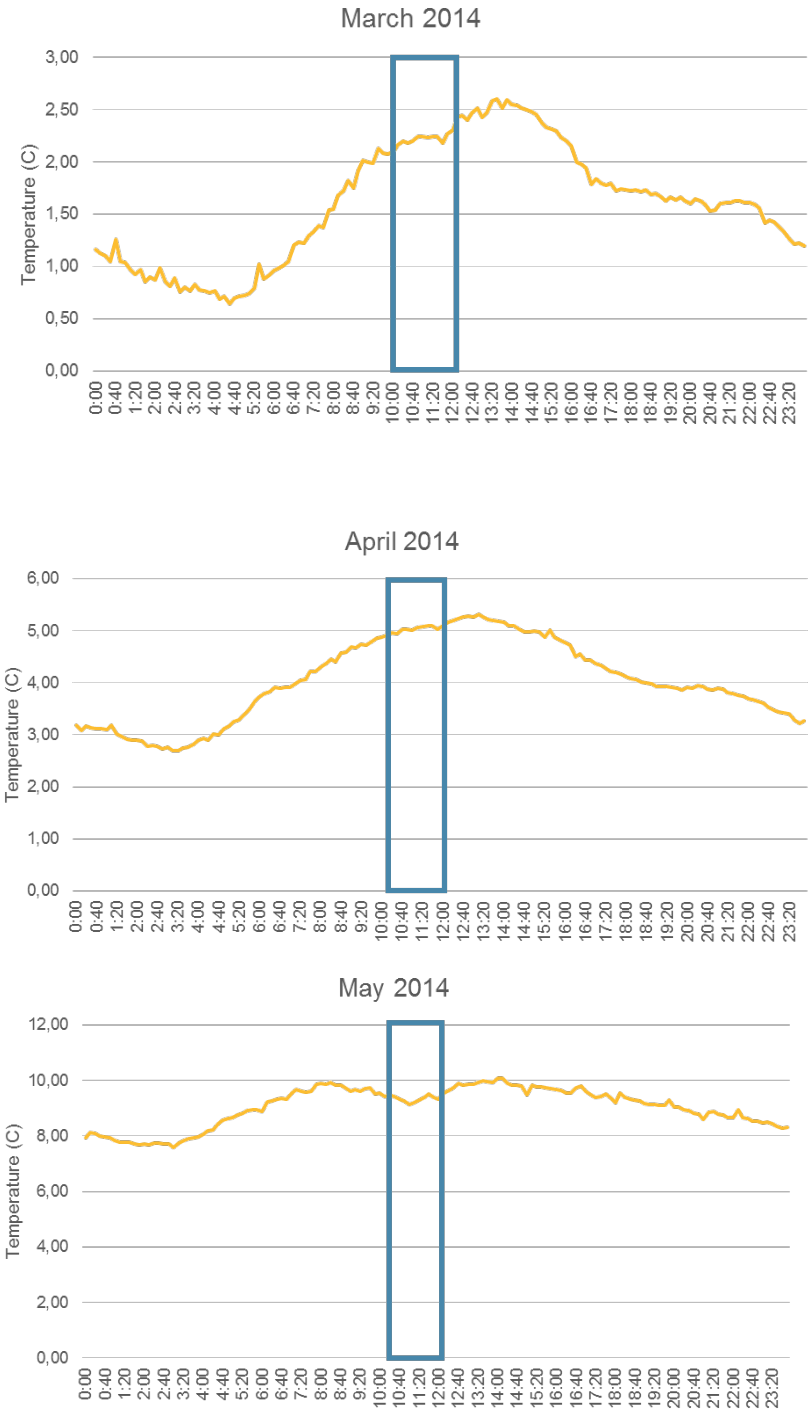


Figure 41: The average diurnal temperature in Rauma Kylmäpihlaja in March, April and May 2014. The blue rectangle indicates the time period of shading.

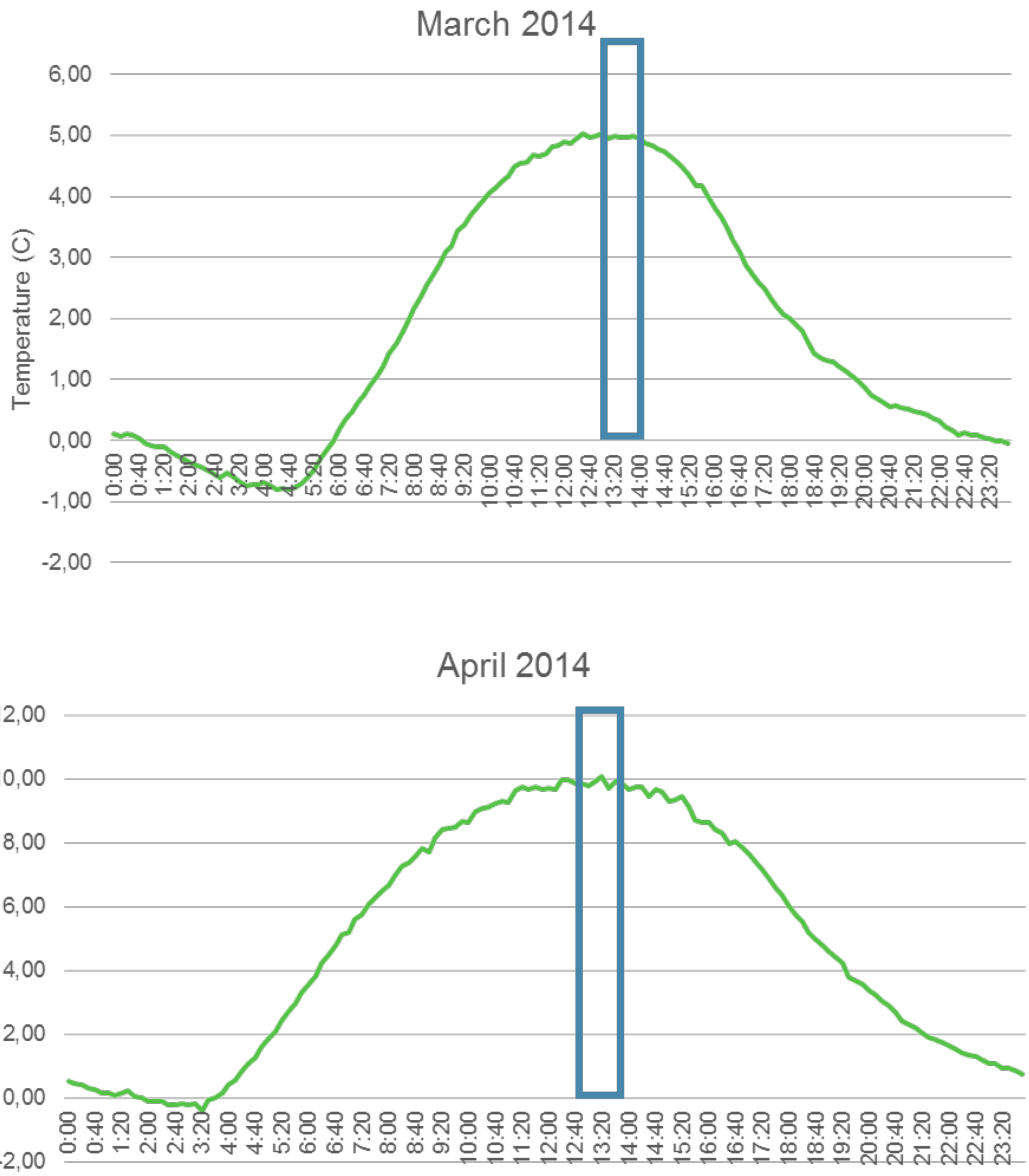


Figure 42: The average diurnal temperature in Kokemäki Tulkkila in March and April 2014. The blue rectangle indicates the time period of shading.

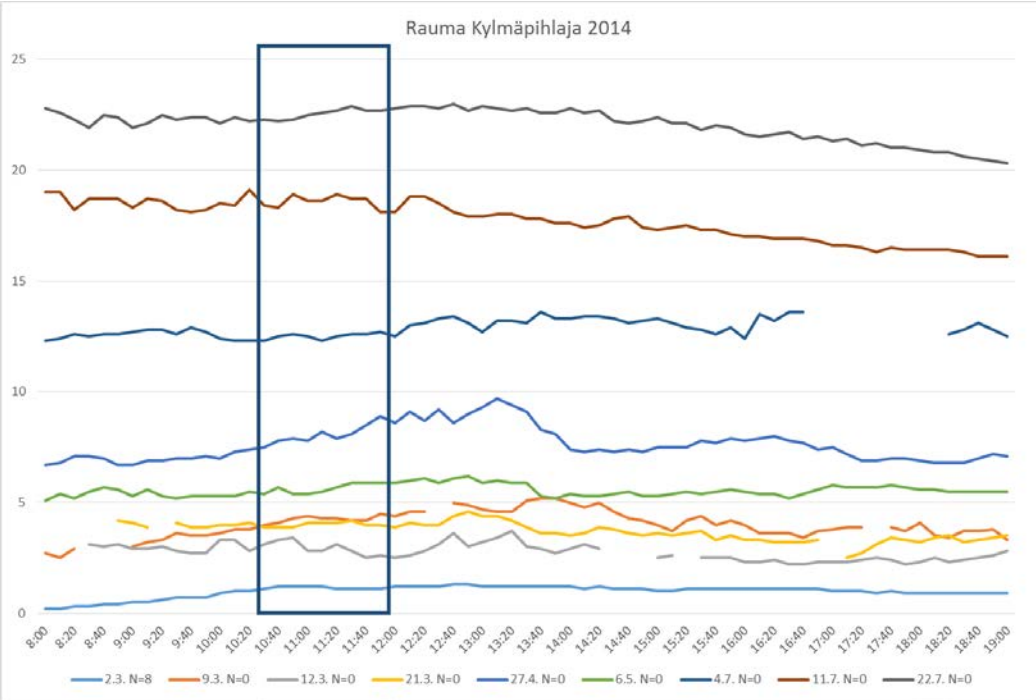


Figure 43: The air temperature diurnal variations in 8 clear days (N=0) and in one cloudy day (N=8) in Rauma Kylmäpihlaja. The blue rectangle indicates the time period of shading.

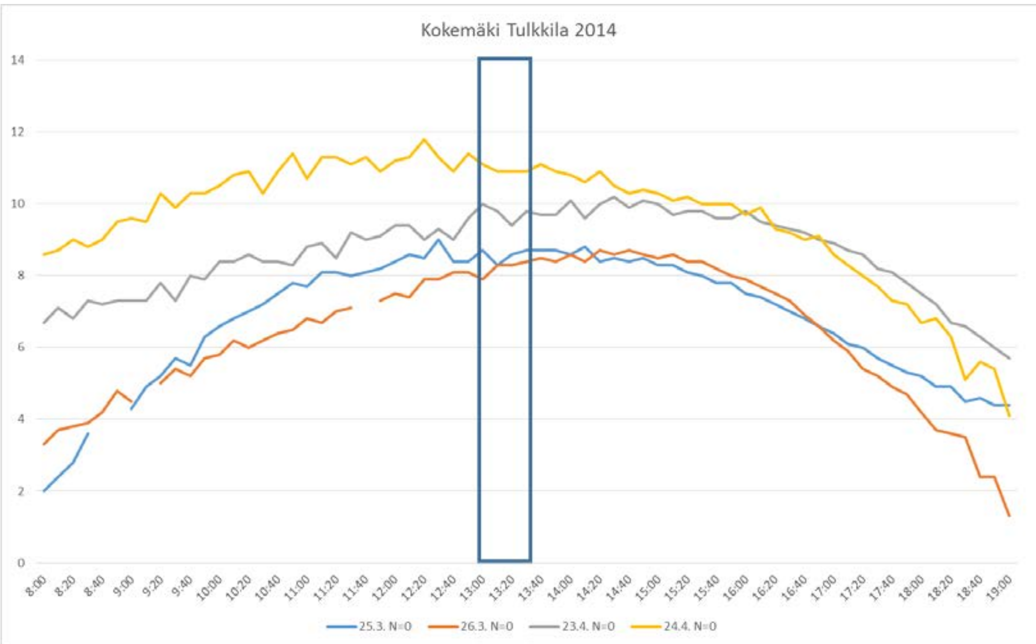


Figure 44: The air temperature diurnal variations in 4 clear days (N=0). The blue rectangle indicates the time period of shading.

3.3.3 Conclusions

A significant change in temperature during shading was not notable when we studied the temperatures at a number of days with clear weather. A possible sign of cooling due to shading was that the rising temperature in the morning decreases more slowly when the shade was present for some of the months. More investigation is however needed to confirm this finding to be real and caused by shade. For example the observed phenomena in Rauma Kylmäpihlaja may be caused by sea breeze that usually begins simultaneously with shading of the temperature screen.

On the other hand the curves for the average temperatures calculated in March and May 2014 at Rauma Kylmäpihlaja rises again when the station is no longer shaded after 12:00 UTC and a sea breeze usually continues to intensify after that. The wind speeds might have an impact on whether the shade on clear days causes colder temperature measurements or not. For a more thorough study of the shading effect, the observed temperatures could be compared to wind speeds and cloud cover.

4 Site classification in the Nordic countries

During summer 2015, 25 stations in all five countries were evaluated, applying the common metadata scheme (Appendix I). All the reports are collected in Appendix II. For each station, the CIMO classification was performed. The results are shown in the histogram in Figure 45. The first four bars for each class indicate the number of stations separately for each criterion.
At 20 of 25 stations, the vegetation was evaluated as class 1 (green bars). Two stations were classified as class 3 and three stations were classified as class 4. All 25 stations are situated on flat terrain or slopes with an angle less than 19 ° (yellow bars). The distance to heat sources and water bodies is large enough for class 1 (> 100 m) at eleven stations (red bars), about 30 m (class 2) at eight stations and about 10 m (class 3) at five stations. Only one station is closer than 10 m to heat sources, justifying a class 4. The shade criterion is the only criterion for which a significant amount of high classes (class 4 and 5) were given. At 16 stations in total, shade on the temperature sensor is experienced if the sun is higher than 7° or 20° (purple bar).
The last (blue) bar shows the overall evaluation. The site class is equal to the highest class number given for any criterion. For most of the 17 stations receiving class 4 or 5, the shade criterion was determining the high class. No station was classified as class 3. Four stations were classified as class 1 and four as class 2.

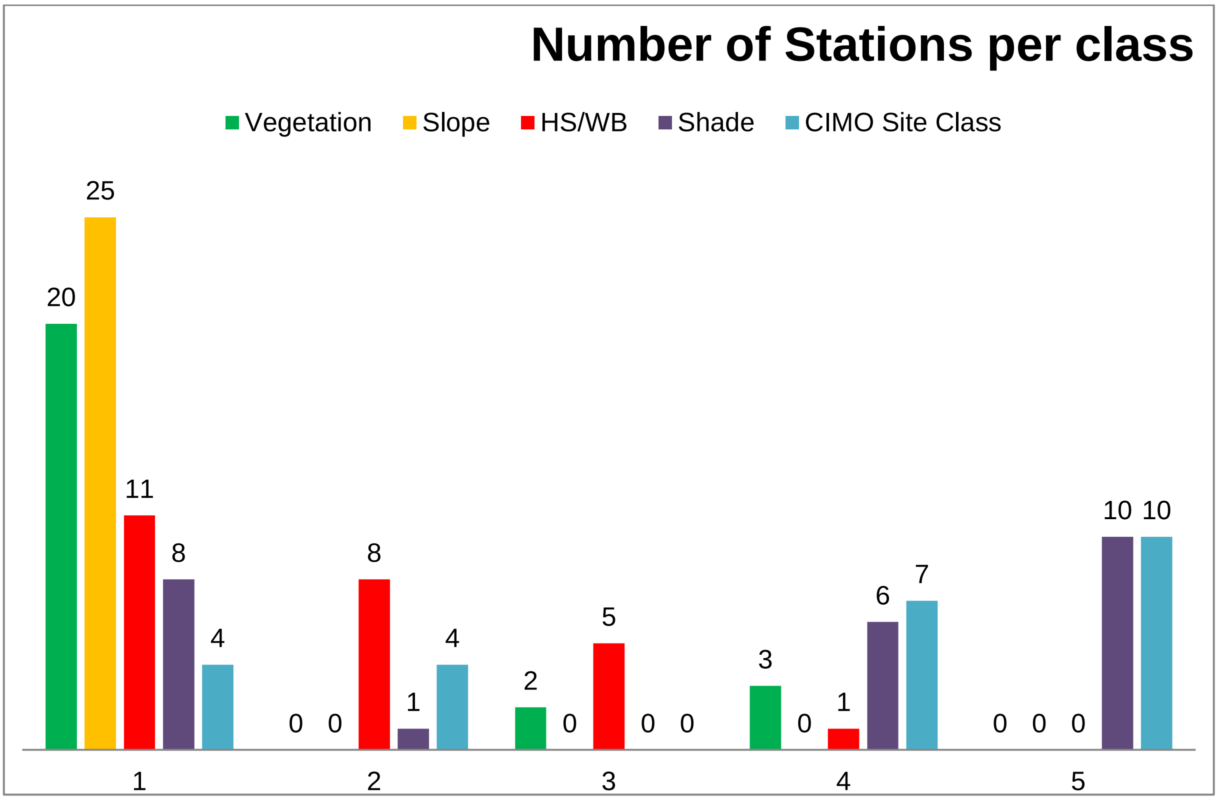


Figure 45: Site classification results for Nordobs stations. The bars/numbers indicate the number of stations per class for each criterion and for the overall site classification, see colored legend. Totally, 25 stations were classified.

Individual results are also listed in Table 5, again as combined class number and separated for each of the four criteria.
Colours are used for indicating the influence of the exposure on temperature measurements. Only three colours are used for simplicity, indicating no influence (green=class 1), little influence (yellow=classes 2 and 3) and a lot of influence (red= classes 4 and 5). Based on this color-code a general evaluation for each station is given, based on the opinion of the NordObs group.

Table 5: Site classification of 25 NordObs sites

Station Name	WMO	Slope	Veget.	HS/WB	Shade	NordObs Evaluation
Virolahti Koivuniemi (F)	4	1	1	3	4	short time shadow, but elevated heat sources
Somero Salkola (F)	5	1	1	1	5	long time shadow
Lappeenranta Konnunsuo (F)	4	1	4	1	1	Farmland
Joensuu Linnunlahti (F)	5	1	1	1	5	short time shadow >20° ; long time shadow > 7°
Eik-Hove (N)	1	1	1	1	1	
Kvamsøy (N)	4	1	4	1	4	sparse heathland vegetation ~30 cm; long time shadow only during winter months
Myken (N)	4*	1	1	2	4*	short time shadow, *insufficient accuracy of elevation angle (could also be 2)
Fokstugu (N)	4*	1	1	2	4*	if shadow > or < 7° sun elevation, *insufficient accuracy of elevation angle (could also be 2)
Veggli II (N)	5	1	1	3	5	short time shadow >20° ; long time shadow > 7°
Kongsberg Brannstasjon (N)	5	1	1	3	5	morning or evening shadow in winter
Vilsandi (EST)	5	1	1	2	5	short time shadow;
Viljandi (EST)	5	1	1	2	5	all day shadow in winter months
Vaike-Maarja (EST)	1	1	1	1	1	
Sõrve (EST)	2	1	1	2	1	water body representative (peninsular)
Roomassaare (EST)	2	1	1	2	1	
Kuusiku (EST)	1	1	1	1	1	

Målilla (S)	2	1	1	2	2	shade for 5°<SE<7° always short!
Norrköping (S)	5	1	1	3	5	very varying shadow conditions, mainly during winter months
Kolmården (S)	5	1?	3	3	5	short time shadow >20° ; long time shadow > 7°; slope ~10° might play a role ; slope >19° on a 1km scale
Horn (S)	2	1	1	2	1	
Gladhammar (S)	5	1	3	4	5	Heat source giving most influence,
Korpa (I)	4	1	1	1	4	Morning and evening shadow
Reykjavik (I)	1	1	1	1	1	
Skaftafell (I)	5	1	4	1	5	Trees very close to the station
Storhofdi (I)	4*	1	1	1	4*	short time shadow, *insufficient accuracy of elevation angle (could also be 2)

Figure 46 compares the results of the CIMO site classification with the evaluation of each station, based on the opinion and experiences from the NordObs group. While the siting classification classifies high influence on temperature measurements on 17 stations, the Nordobs group evaluates only temperature measurements at five stations to be highly influenced.

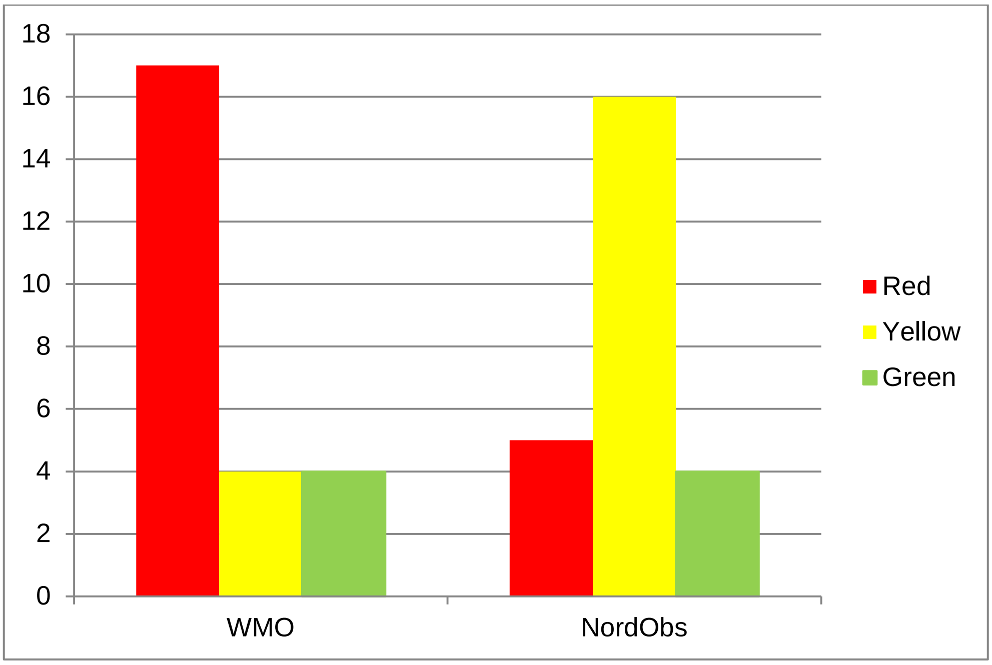


Figure 46: Evaluation of temperature influence of siting exposure on temperature measurements by WMO siting classification and by Nordobs

5 Conclusions

Generally, the implementation of a classification of siting is very useful. Currently, the available metadata about sites differ a lot for different countries as they have been developed individually and often reflect very local characteristics of the typical landscapes and even cultural aspects. The used vocabulary may be understood differently, i.e. the term “suburban” may depend on the typical size and density of the cities in each country.

Being able to characterize the siting of a sensor by one or several numbers makes it possible to compare the influence of the siting within the network, between different networks and over time. Sites can be more objectively assessed and it is easy to identify possible improvements and their impact. Last but not least, communication about the importance of siting both internal and external was noticeable simplified by the suggested classification system.

The Nordic countries have classified the siting for temperature sensors at 25 sites by using a common developed metadata scheme and applying the current version of the CIMO siting classification scheme. Sites were additionally evaluated based on the experiences of the station holders and the entire Nordobs-team.

Based on that comparison and a few more detailed studies, some challenges of the CIMO siting classification could be revealed, which results in significant discrepancies in the evaluation of the site.

5.1 Estimated uncertainty

The estimated uncertainty of the temperature measurement due to siting is given for classes 3, 4 and 5 in the WMO Siting classification for temperature. The additional estimated uncertainty added by siting is up to 1 °C for class 3, up to 2 °C for class 4 and up to 5 °C for class 5.

For a specific class, the influence on temperature due to slope, vegetation, heat sources/water bodies or shadow should give the same estimated uncertainty, but this does not seem correct for all cases.

A lot of stations in the Nordic countries get class 4 or 5 due to shadow during a short period of the year. According to the siting classification this is expected to give the same estimated uncertainty as a nearby heat source that will give an influence on the temperature most of the year. Without doubt, shade has an influence on the temperature and the comparison between two neighboured Norwegian stations showed a temperature difference possibly caused by shade of about 2 °C, categorized as class 5. However, the same study and similar studies from Finland and Estonia also showed that a significant effect on temperature could not be seen for short shading periods.

Both from literature research and own studies it could also been shown, that different kind of heat sources may have very different impacts on the air temperature nearby:

- Water bodies seem to have a larger impact than flat heat sources during day.
- The influence of elevated heat sources depends very much on the direction of the site – an obstacle in the North of the sensors can change the temperature of the sensor by several degrees (for classes 4 and 5), while an obstacle in the South hardly have any effect.

- Lots of heat sources acts as heat sinks during night and that effect seems to be larger than the warming effect during day

A more reliable quantification of the estimated added uncertainty of the temperature measurements and a possible adjustment of the class-limits are required. Both would raise the value of the siting classification scheme tremendously.
The analyses in this report, however, show the difficulties of just comparing data from existing stations. Firstly, it is hard to find suitable sites in close enough vicinity that comparable temperature data series can be assumed. Further, influences are often combined: a heat source might give shade; slopes are often connected to changes in elevation, which have a much higher impact on temperature.
Therefore, the Nordic countries recommend further studies with existing and especially with dedicated stations and sensor configurations to quantify the effect of different type of heat sources, shade, slopes and vegetation.
Some studies which cover parts of those topics are already in progress, i.e. as an initiative of national weather services or as part of larger projects, as for example the Meteomet2-initiative (Metrology for Essential Climate Variables, http://www.meteomet.org/meteomet/).
Further, model studies can be a very helpful and complimentary tool to this effort. Different influences can be assessed independently from each other and the distance to the sensor or the size of the feature can be changed step less. For example, Kinoshita (2014) have successfully applied the model ENVI-met for site exposure studies.

5.2 Additional effects not yet considered

Several aspects of the exposure of a sensor are not yet considered in the siting classification. Based on the general literature in micrometeorology and more focused studies within forest/agricultural and urban climatology suggest that the following features may have significant influence on temperature sensors:

- The direction of the slope
- The position of the sensor on the slope (within or without cold-air drainage area or rather on top)
- Night-time effects:
    - Reduction of long wave radiation from the ground due to obstacles reducing the sky view
    - Stronger cooling of typical flat heat sources (parking lot, etc)
- Obstacles (natural and artificial) in the North which change the radiation balance of the area and thus may influence the temperature measurements nearby
- Changes in snow height and thus the clearing under the sensor

Off course, it is important to not overload the siting scheme to guarantee its application. The Nordic countries suggest to cooperate with related scientific communities (as forest/agricultural and urban climatology) when developing further categories.

5.3 Representativeness vs exposure

Even if the CIMO-siting classification aims to evaluate the immediate vicinity of the site and not its representativeness for the area, are those closely connected and in some cases it might not be possible to separate them.

Water bodies have an influence on the temperature measured. On small islands or in lake districts this influence is representative for the area and it does not seem necessary to request a distance to a water body.
Similarly, vegetation has an impact of the temperature profile close to the ground and especially the vegetation height and its distance to the sensor will affect measurements. On the other hand, typical vegetation (and its influence) may be representative for a very large area. A connected challenge is the change of sensor height above ground due to snow accumulation in the area.
Examples for topography are numerous. In a mountainous area, it may be difficult to decide if a siting in the valley (and thus in regions prone to cold air drainage) or on the slope (with its impacts on the temperature measurements, depending on the orientation and angle) will give a more representative measurement for the larger area.
Appreciating those challenges the Nordic countries found that keeping different classification criteria (slope, vegetation, heat sources, shadow) separate as opposed to create one summarizing number (currently the highest class from any of the criteria) will allow for a more differentiated use of the siting evaluation.

5.4 Adaption of the site classification

The Nordic countries will continue using the common metadata scheme for evaluating their sites. By that, additional information is collected in a comparable way which may allow to adapt the siting classification to future modifications.

1. Instead of reporting only one number as a result of the WMO/CIMO siting classification, the Nordic countries recommend to report all four numbers for the four categories allowing for a more balanced evaluation of the site.

2. A simple time-parameter will be used additional to the sun elevation in the shade-criterion. The Nordic countries decided to neglect shadowing from obstacles which lasts less than 1 hour (equal to an obstacle width of 15 °). Consequently, the separation between shade on sensor when the sun is higher than 5 ° and 7 ° is not necessary.

Class 1	Class 2	Class 3	Class 4	Class 5
Away from projected shade when the sun is higher than 7 ° or shade on sensor for less than 1 hour per day.	Away from projected shade when the sun is higher than 7 ° or shade on sensor for less than 1 hour per day.	Away from projected shade when the sun is higher than 7 ° or shade on sensor for less than 1 hour per day.	Away from all projected shade when the sun is higher than 20° or shade on sensor for less than 1 hour per day.	Site not meeting requirements for class 4

3. Because of the wide spread typical heathland vegetation in the Nordic countries, which is sparse and often reaches a natural low height of about 40 cm, the vegetation criterion will be relaxed. Especially, when the temperature sensor is

mounted in 2 m height, the slightly higher vegetation is not expected to have an impact on the temperature measurements.

Class 1	Class 2	Class 3	Class 4	Class 5
Ground covered with natural and low vegetation (<10 cm) representative of the region	Ground covered with natural and low vegetation (<10 cm) representative of the region	Ground covered with natural and low vegetation (<45 cm) representative of the region	-	-

4. If a low vegetation area needs to be maintained, i.e. within a field of crops or in an urban area, a plot size of 6 m times 9 m is recommended, in accordance with the Guide to Climatological Practices (WMO, 2011).

5. Following the practice in Finland, for areas where the abundance of water increases 30% within a radius of 1 km water bodies between 10 and 100 m away from to the sensor are not considered for the siting classification.

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7 Appendix

Appendix I: The common NordObs metadata scheme

Based on the existing classification schemes in Norway and Finland and the discussions in the group, a common scheme was developed for collecting metadata in a more comparable way. This scheme was applied in summer 2015. A total of 25 stations in five countries (Sweden, Finland, Norway, Estonia and Iceland) were classified with the scheme. The reports are collected in Appendix II. Following the field period, some minor changes were made to the scheme. Additionally, the CIMO-classification scheme was adapted for further use in the NordObs countries. All changes marked in red. Generally, the scheme is rather a metadata collection scheme instead of a new classification. There are more metadata collected in anticipation of future adjustments to the CIMO/WMO classification.

Station number:	**Station name:**			
Date:	**Performed by:**			
CIMO/WMO overall class:				
Class by issue:	**Slope:**	**Vegetation:**	**Heat Sources:**	**Shadow:**

Site description:

Sensor height (10 cm accuracy)	
Slope	In 10m radius: □ < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: □ < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 1000m radius: □ < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface within 10 m radius *(choose nationally)*	□ ship □inland □ heathland ~~□ mid-highlands~~ □ grass □ bushes □ light sand □ asphalt □ not defined □ dark sand □ rocks □ cropland specify:
Topography within 1 km radius *(choose nationally)* *Remark: It was challenging to agree on a common list. Some keywords might have different meanings*	□ slope , more specified: □ upper slope □ lower slope □ flat □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban □ rural specify:
Amount of water systems within 1 km radius	□ Island (50-100%) □ Coastline (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify:
Height of sensor above average vegetation height (10 cm accuracy, estimated) & Maximum height of vegetation & Annual maximum snow depth	

Photo of instrumentation and surroundings in 8 specified directions	□ N □ NE □ E □ SE □ S □ SW □ W □NW
Photograph by Fisheye camera	□

Heat sources and obstacles:

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment

Circle of angles (alternative to table):

Example:

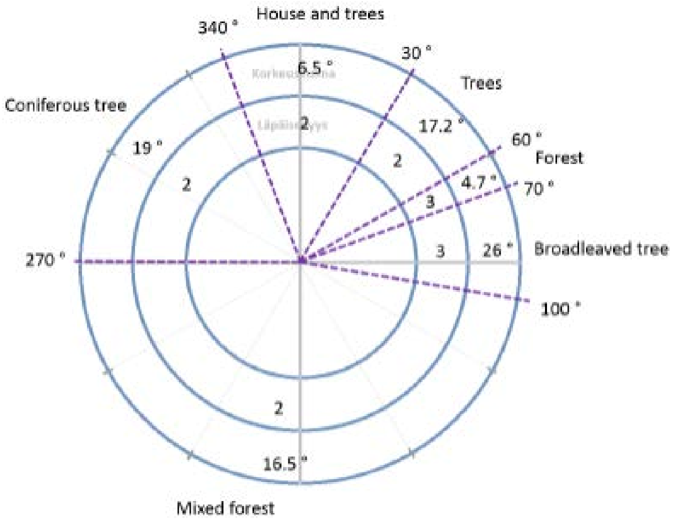


Figure1: Example for Finnish Station Joensuu Linnunlahti

Comments	

Sun elevation chart:

http://solardat.uoregon.edu/SunChartProgram.html

Example:

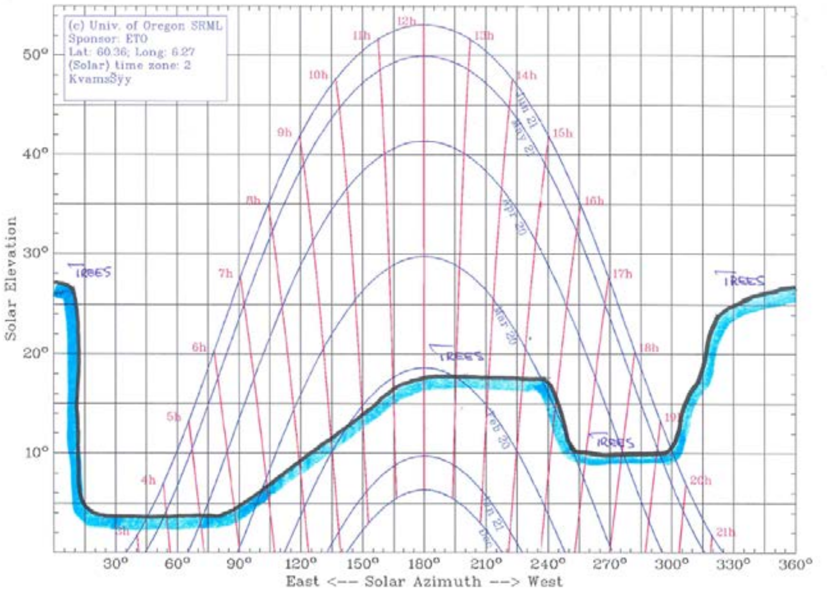


Figure 2: Example sun elevation chart. The Norwegian Station Kvamsøy

Satellite image with scale:

Example:

Figure 3: Example area photography. The Norwegian Station Kvamsøy

CIMO/WMO classification criteria (NordObs update, September 2016):

Class	**1**	**2**	**3**	**4**	**5**
Slope	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*No require-ments*	*No require-ments*	*No require-ments*
Vegetation	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<45 cm) representative of the region*	*No require-ments*	*No require-ments*
Distance to Heat Sources/ Water bodies (HS/WB)	*Measurement point is situated more than 100 m from HS/WB or S/WB occupies less than a) <10% of a 100 m circle b) <5% of an annulus of 10-30m c) <1% of a 10 m circle*	*Measurement point is situated more than 30 m from HS/WB or HS/WB occupies less than a) <10% of a 30 m circle b) <5% of an annulus of 5-10m c) <1% of a 5 m circle*	*Measurement point is situated more than 10 m from HS/WB or HS/WB occupies less than c) <10% of a 10 m circle d) <5% of a 5 m circle*	*HS/WB occupies less than a) <50% of a 10 m circle b) <30% of a 3 m circle*	*No require-ments*
Sensor not in prolonged* shade when sun is above … *shading obstacles <15° (≈1h shading time) are neglected	*7°*	*7°*	*7°*	*20°*	*No require-ments*

Appendix II: Siting Classification Reports

A total of 25 stations in five countries (Sweden, Finland, Norway, Estonia and Iceland) were classified with the common metadata scheme, see Appendix I. The reports are collected on the following pages.

Siting Classification Reports

Table of Contents

1 Virolahti Koivuniemi (Finland)

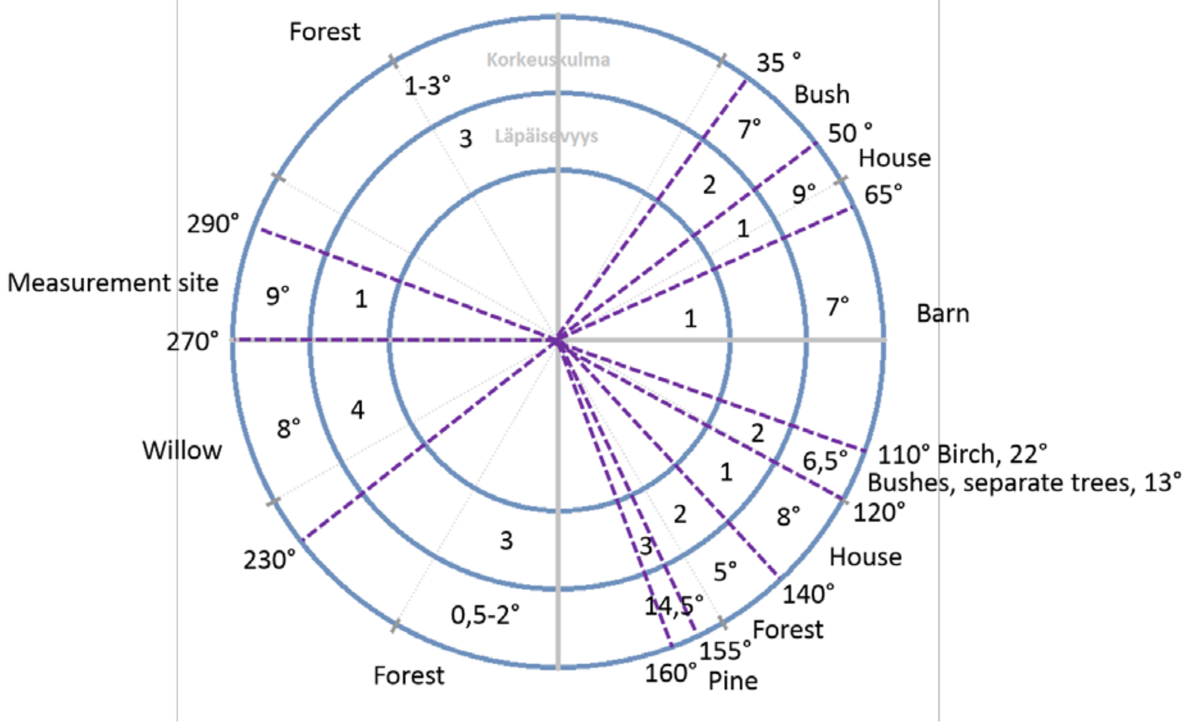
Temperature Classification Scheme

Station number: **LPNN:1612 WMO:02831**	**Station name:** **Virolahti Koivuniemi**
Date: **6.10.2015**	**Performed by:** **Maria Santanen and Eeva Hento**

Site description:

Sensor height (10 cm accuracy)	2,1m
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X grass** □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify: fields around station
Topography (in 1 km radius) *(choose nationally)*	**X flat** □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) □ (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	Height of vegetation : 5 cm Maximum height of vegetation: 10 cm
Photographs to 8 different directions	**X N X NE X E X SE X S X SW X W X NW** **X Main station picture**

Circle of angles



Comments	Radiation shield has become covered with moss -> should be changed

WMO classification

	Class	Reason
Slope	1	Slope less than 1/3 (19°)
Vegetation	1	Low vegetation (< 10 cm)
Heat sources/ water bodies	3	A source of the heat occupies more than 10% of the surface within a circular area of 30 m surrounding the screen
Shadow	4	Away from all projected shade when the sun is higher than 20°

Photographs

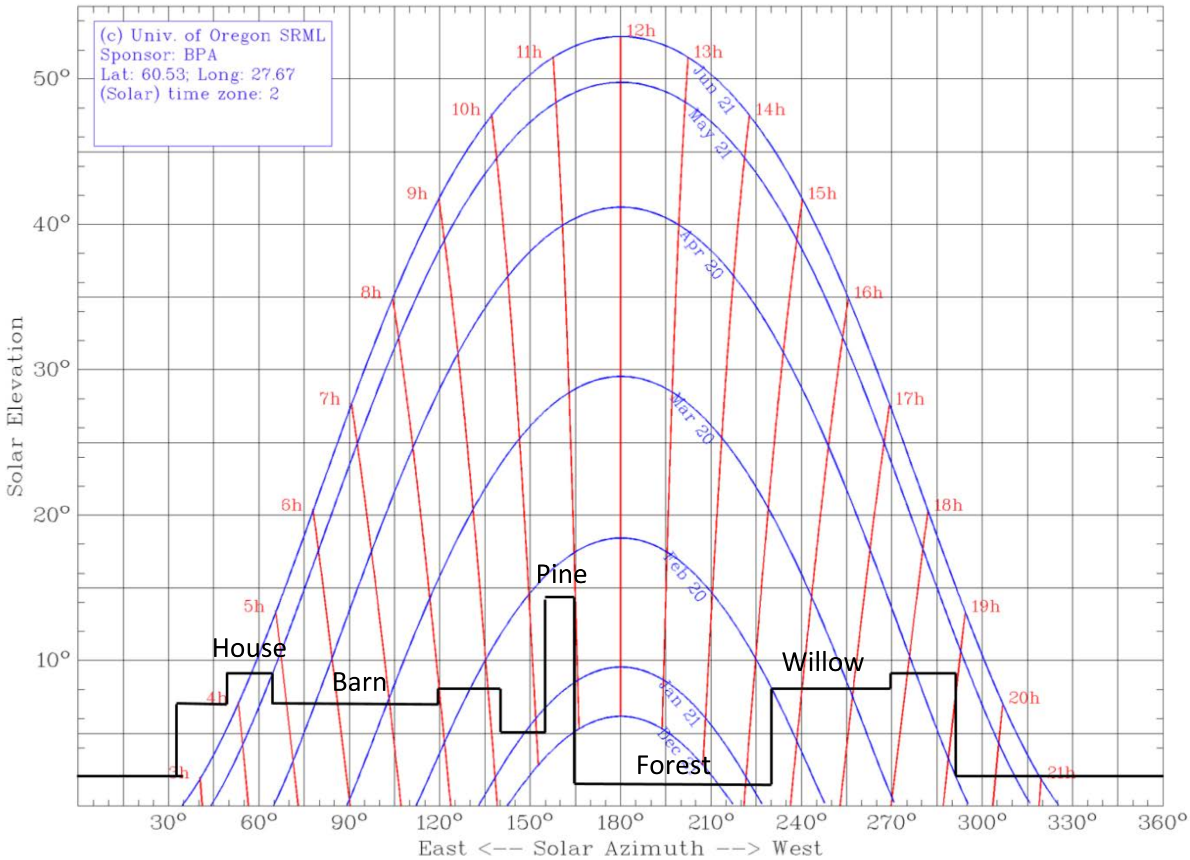
N

E

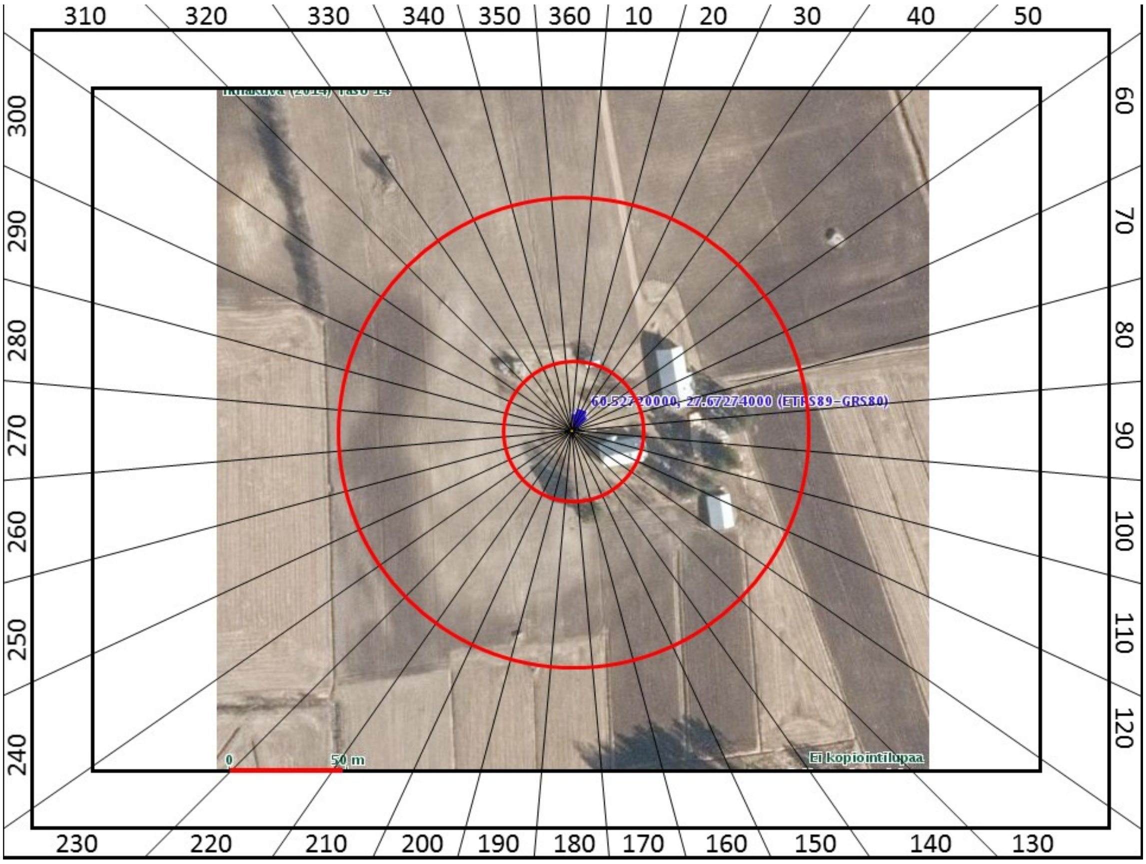
S

W

Sun elevation chart



Satellite image with scale



2 Somero Salkola (Finland)

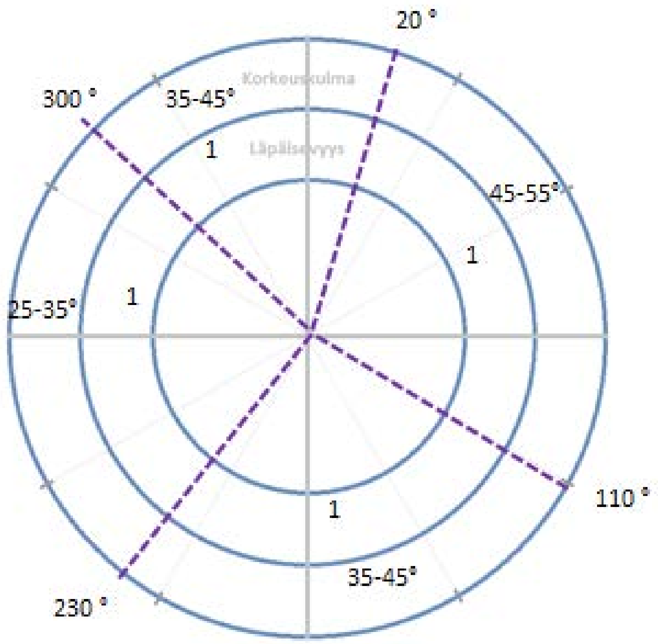
Temperature Classification Scheme

Station number: WMO: 02949	Station name: Somero Salkola
Date: **6.6.2015**	**Performed by:** **Juho-Pekka Kaukoranta**

Site description:

Sensor height (10 cm accuracy)	2,0m
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship **X inland** □ heathland □ mid-highlands **X grass** **X bushes** **X sand** □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	**X flat** □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	Height of vegetation: 5 cm Maximum height of vegetation: 20 cm
Photographs to 8 different directions	**X** N **X** NE **X** E **X** SE **X** S **X** SW **X** W **X** NW **X** Main station picture

Circle of angles



Comments	

WMO classification

	Class	Reason
Slope	1	Slope less than 1/3 (19°)
Vegetation	1	Low vegetation (< 10 cm)
Heat sources/ water bodies	1	A source of the heat occupies less than 10% of the surface within a circular area of 100 m surrounding the screen
Shadow	5	Not away from all projected shade when the sun is higher than 20°

Photographs

N


NE


E


SE

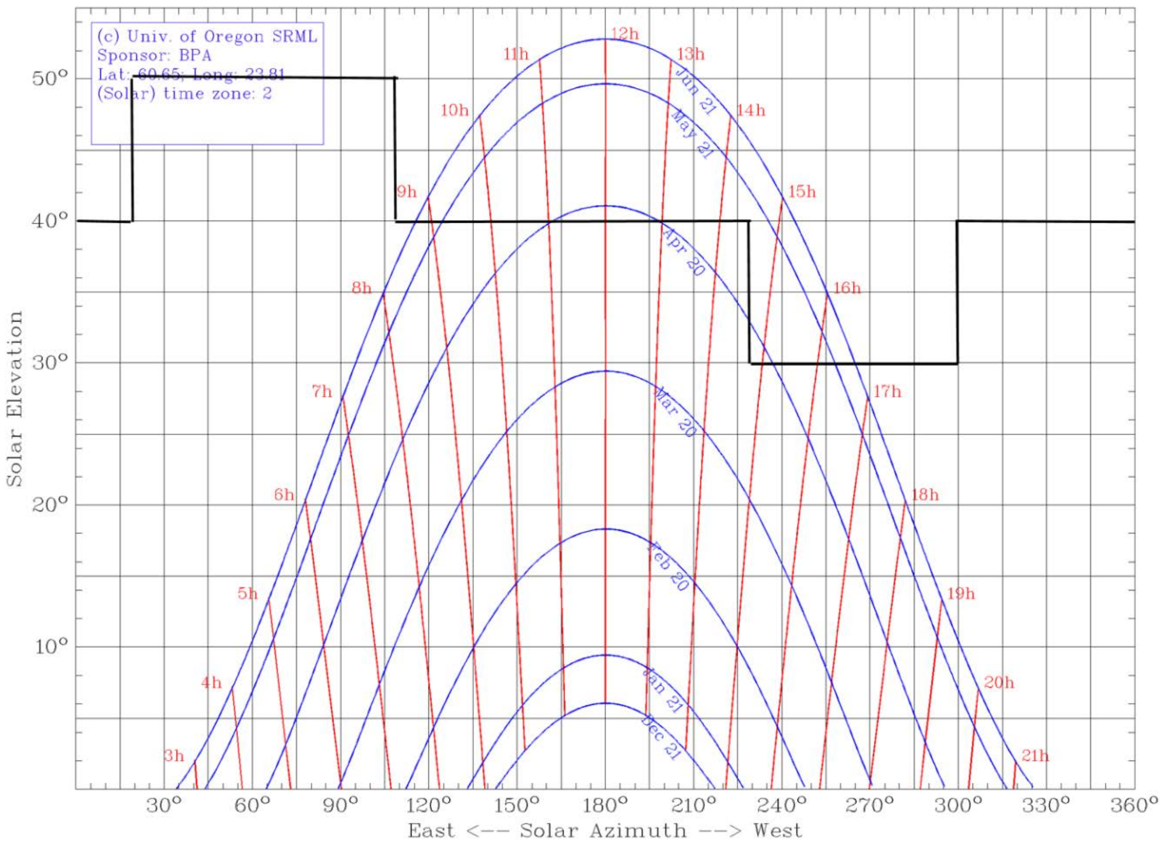
S

SW

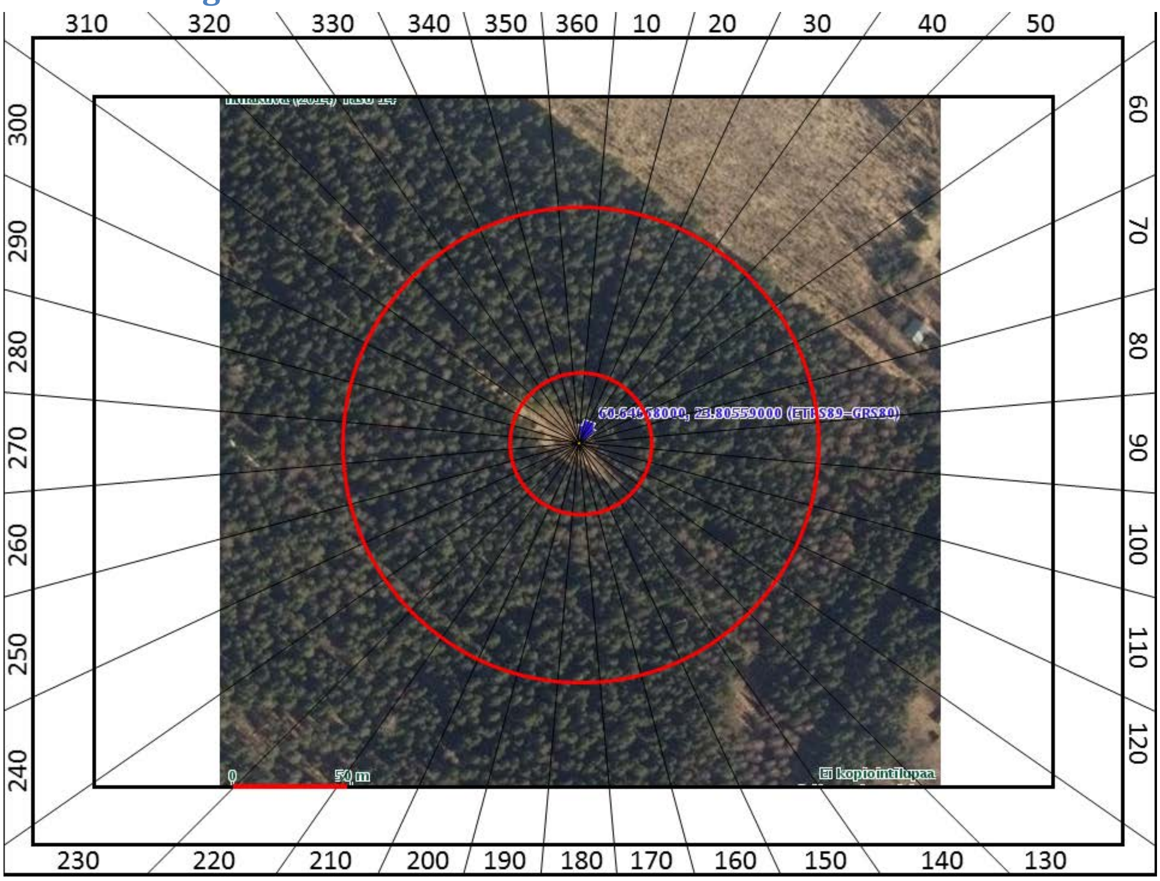
W


NW

Sun elevation chart



Satellite image with scale



3 Lappeenranta Konnunsuo (Finland)

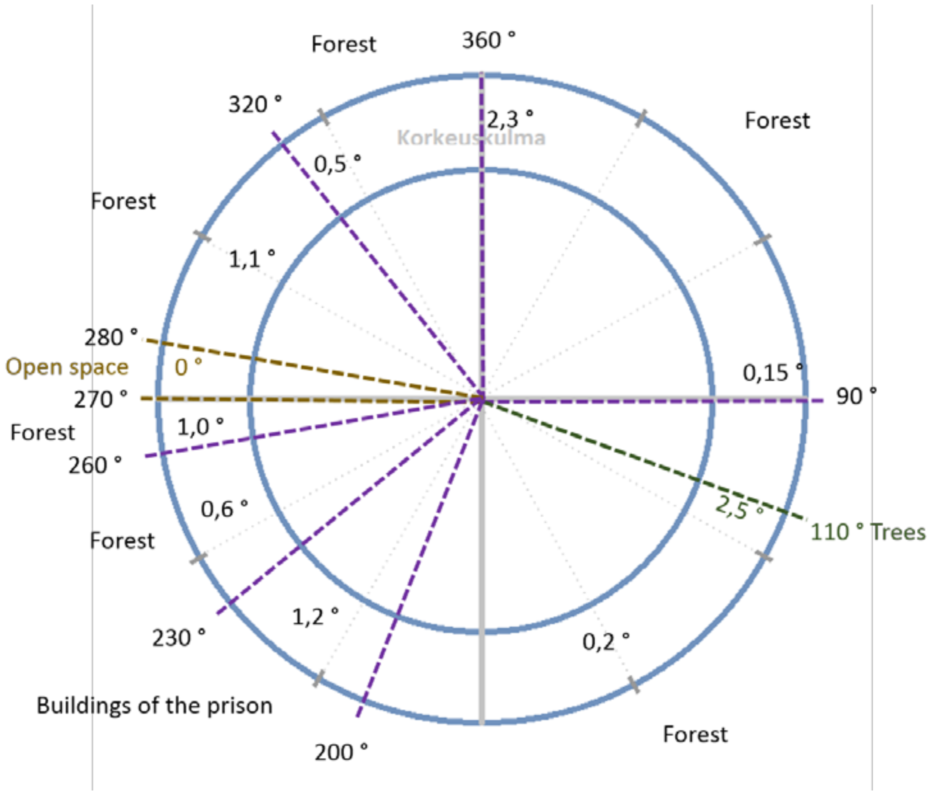
Temperature Classification Scheme

Station number: **WMO: 02733**	**Station name:** **Lappeenranta Konnunsuo**
Date: **29.4.2015**	**Performed by:** **Inna Haapa-Tynjälä and Hanna Leisti**

Site description:

Sensor height (10 cm accuracy)	**2,0m**
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X grass** □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	**X flat** □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	Height of vegetation: **1m** Maximum height of vegetation: **1,5m**
Photographs to 8 different directions	**X N X NE X E X SE X S X SW X W X NW** **X Main station picture**

Circle of angles



Comments	

WMO classification

	Class	Reason
Slope	1	Slope less than 1/3 (19°)
Vegetation	4	High vegetation (> 25 cm)
Heat sources/ water bodies	1	A source of the heat occupies less than 10% of the surface within a circular area of 100 m surrounding the screen
Shadow	1	Away from all projected shade when the sun is higher than 5°

Photographs

N

NE

E

SE

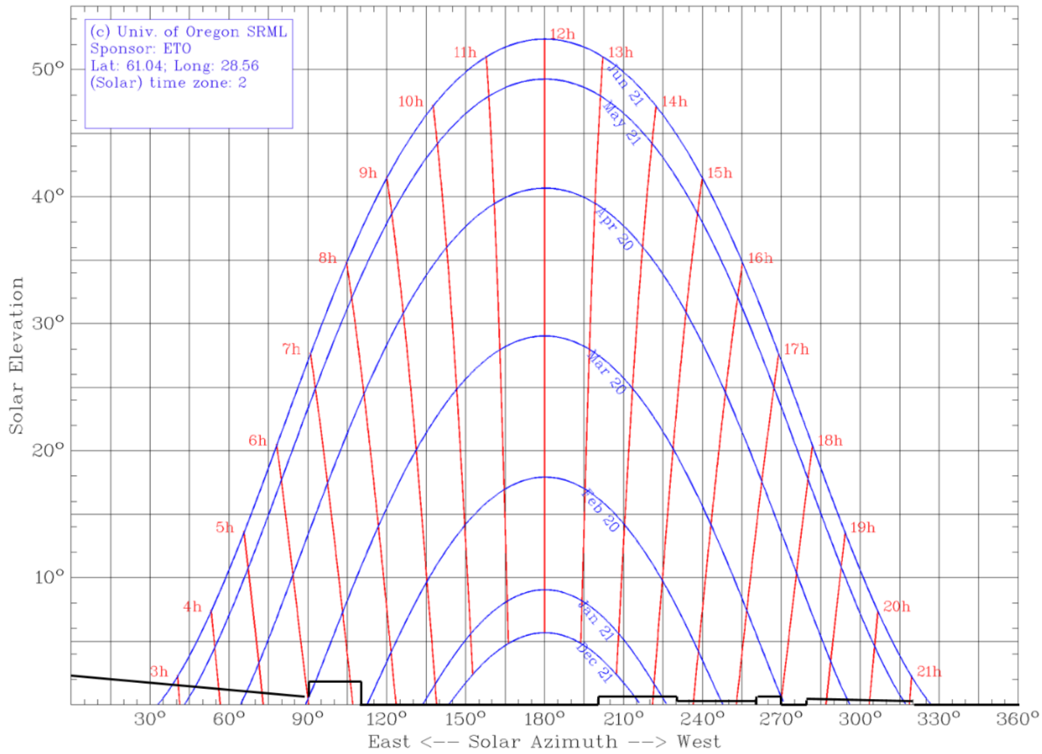
S

SW

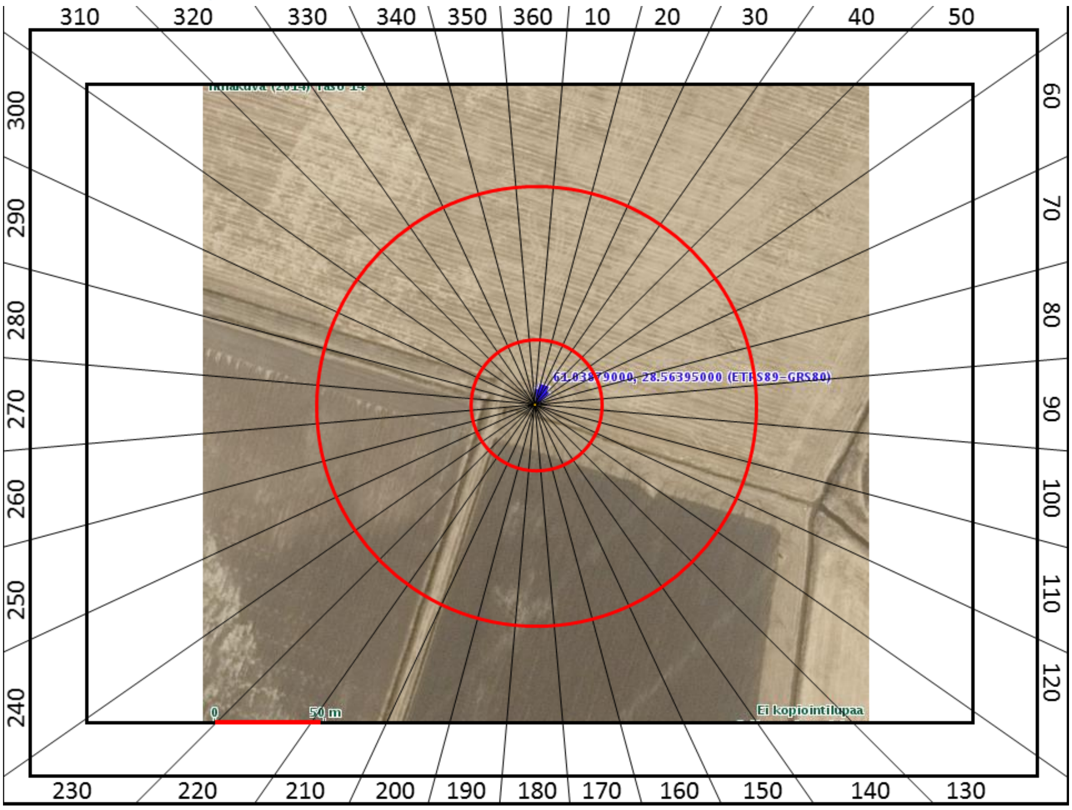
W

NW

Sun elevation chart



Satellite image with scale



4 Joensuu Linnunlahti (Finland)

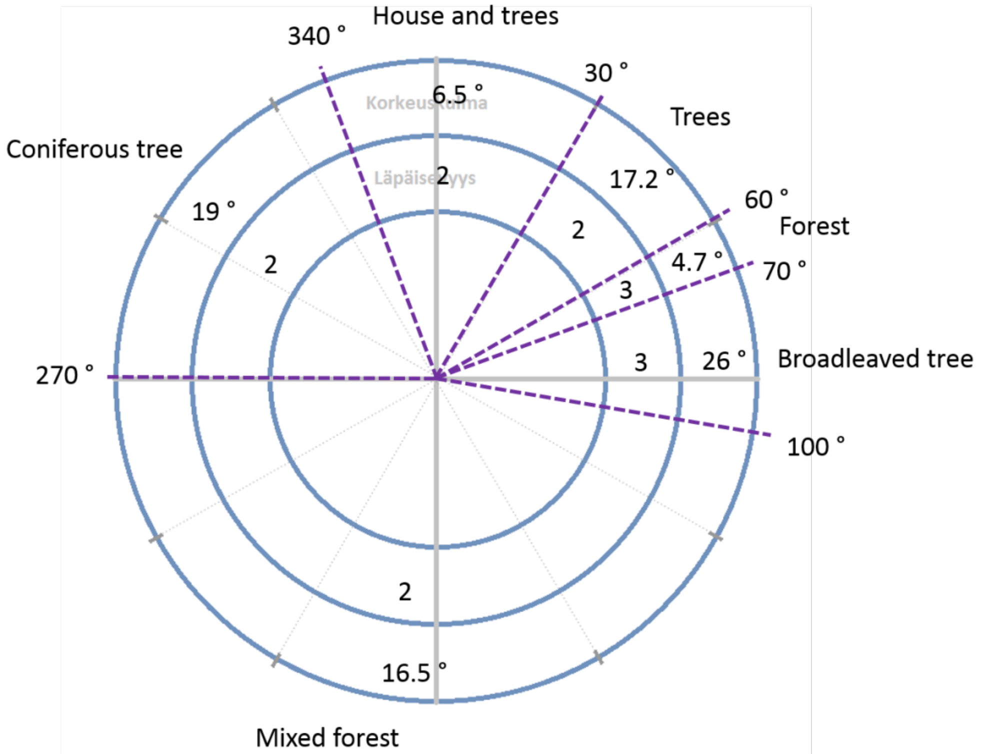
Temperature Classification Scheme

Station number: LPNN: 3825 WMO: 02928	Station name: Joensuu Linnunlahti
Date: 9.6.2015	Performed by: Inna Haapa-Tynjälä and Hanna Leisti

Site description:

Sensor height (10 cm accuracy)	2,0m
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X grass** □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ flat □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular **X coast** □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X sub-urban** □ urban specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: **X (>30%)** □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	Height of vegetation : 5 cm Maximum height of vegetation: 10 cm
Photographs to 8 different directions	**X N X NE X E X SE X S X SW X W X NW** **X Main station picture**

Circle of angles



Comments	

WMO classification

	Class	Reason
Slope	1	Slope less than 1/3 (19°)
Vegetation	1	Low vegetation (< 10 cm)
Heat sources/ water bodies	1	A source of the heat occupies less than 10% of the surface within a circular area of 100 m surrounding the screen
Shadow	5	Not away from all projected shade when the sun is higher than 20°

Photos of weather station

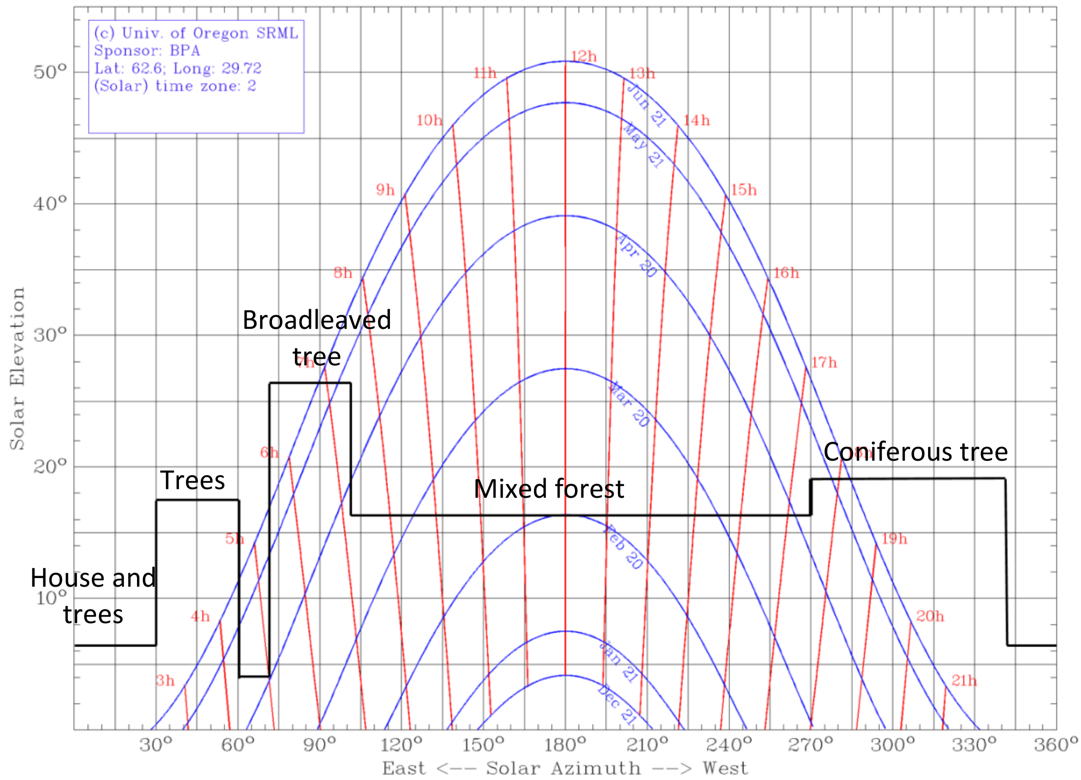
N

E

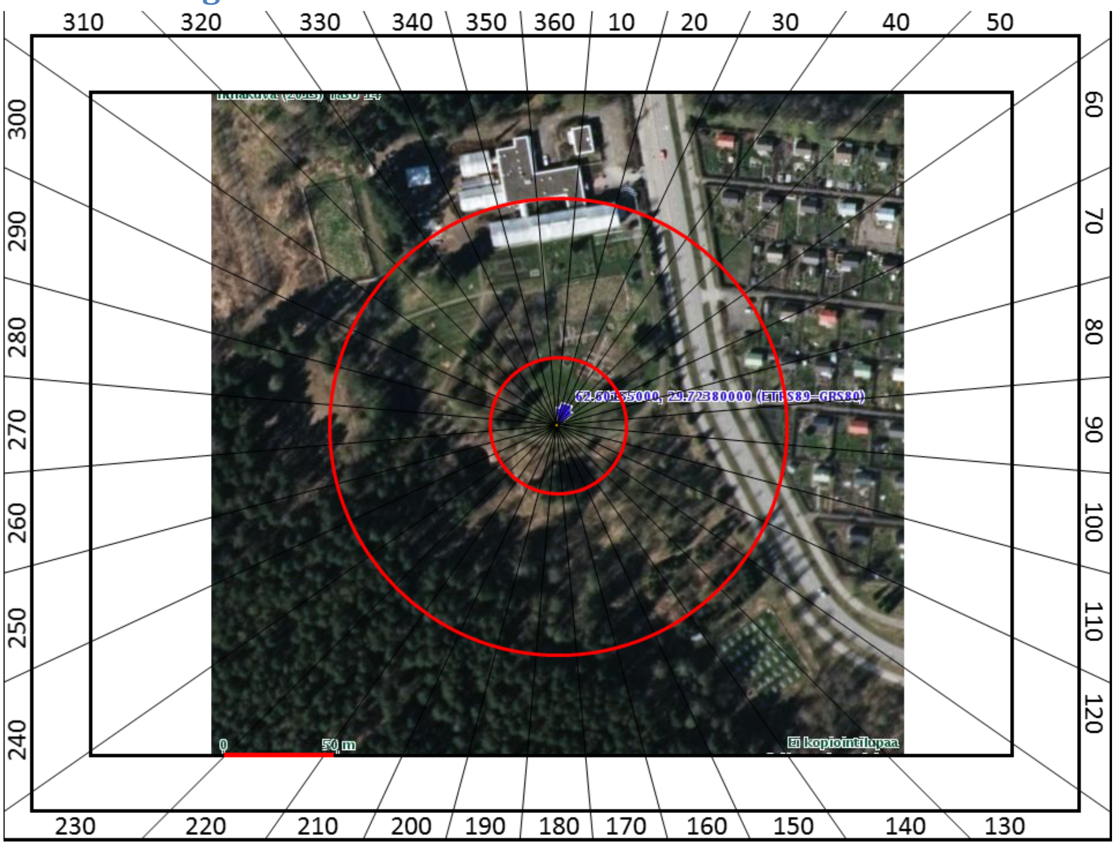
S

W

Sun elevation chart



Satellite image with scale



5 Eik – Hove (Norway)

Temperature Classification Scheme

Station number: 43010	**Station name: Eik-Hove**
Date: 06.09.2015	**Performed by: Ted Torfoss**
WMO-classification:	**1**

Site description:

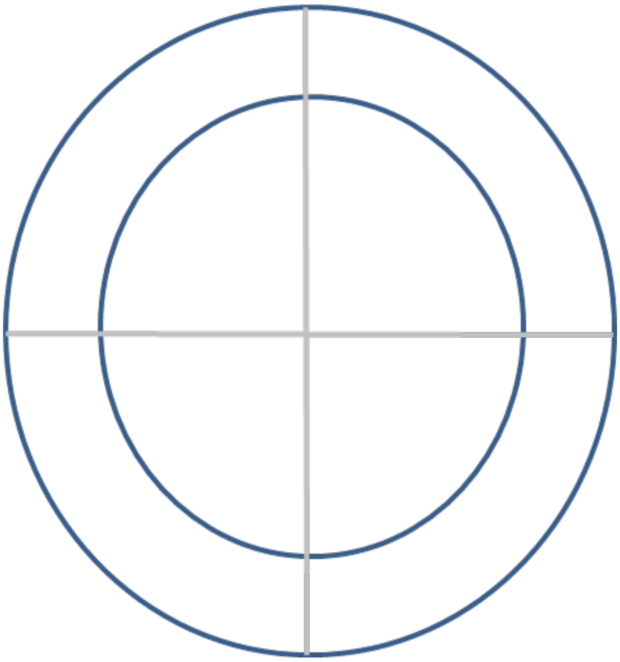
Sensor height (10 cm accuracy)	200cm
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □ heathland **X** grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope **X** valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban **X** rural specify: **Flat**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: **X** (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	5-10cm/190cm

Photographs to 8 different directions	□ N □ NE □ E □ SE □ S □ SW □ W □NW **X** Panorama

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
90-180°	50-100m		3000m^2	Houses and road (9,5 % of total area within 100m radius)

Circle of angles



Photograph taken by fish-eye camera ☐

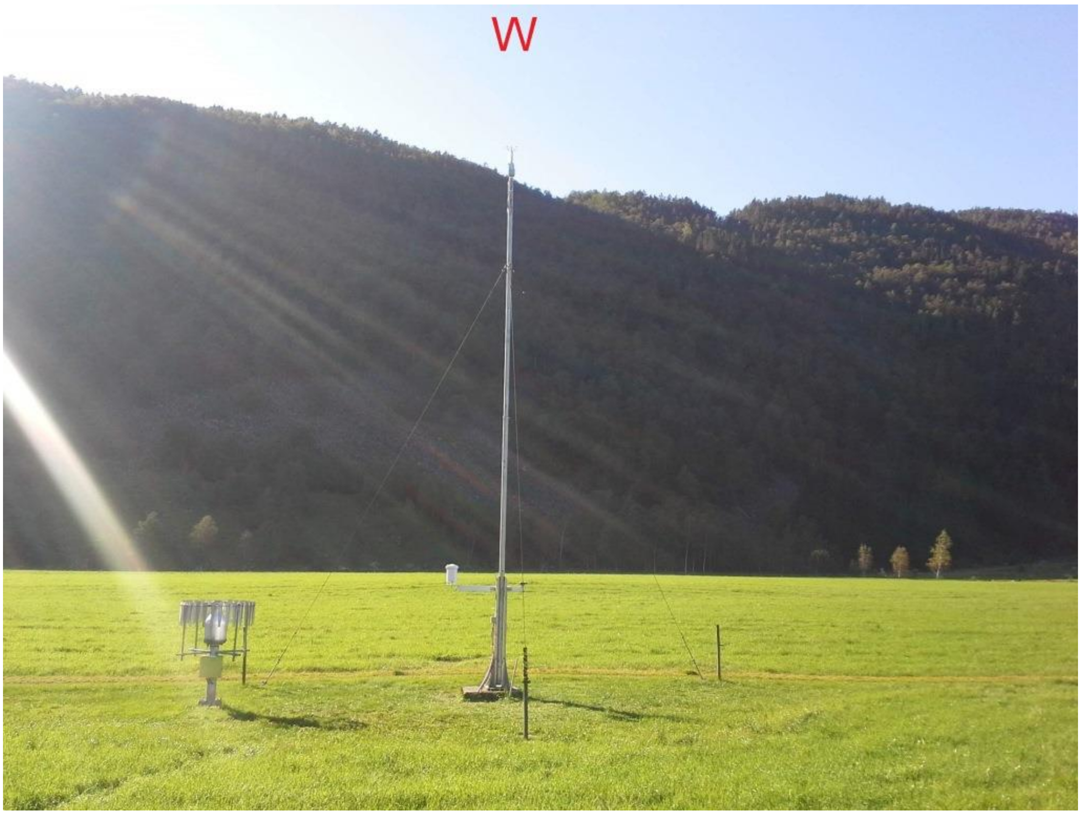
Comments	

Photos of weather station

Weather station towards North

Weather station towards East

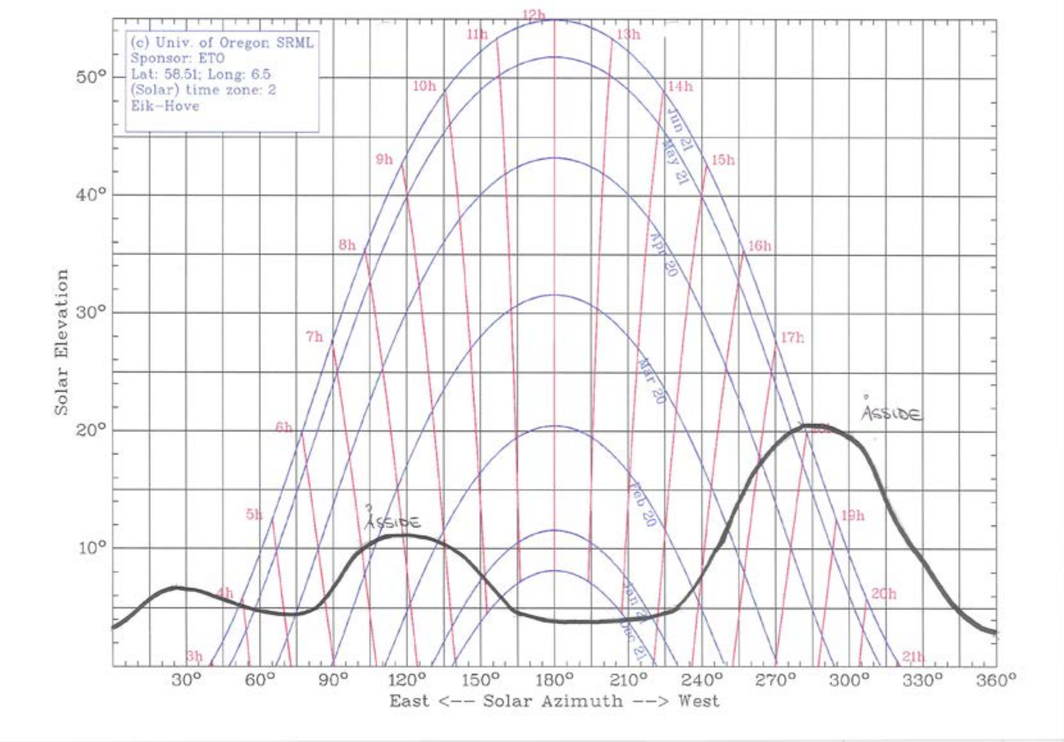
Weather station towards South



Weather station towards West

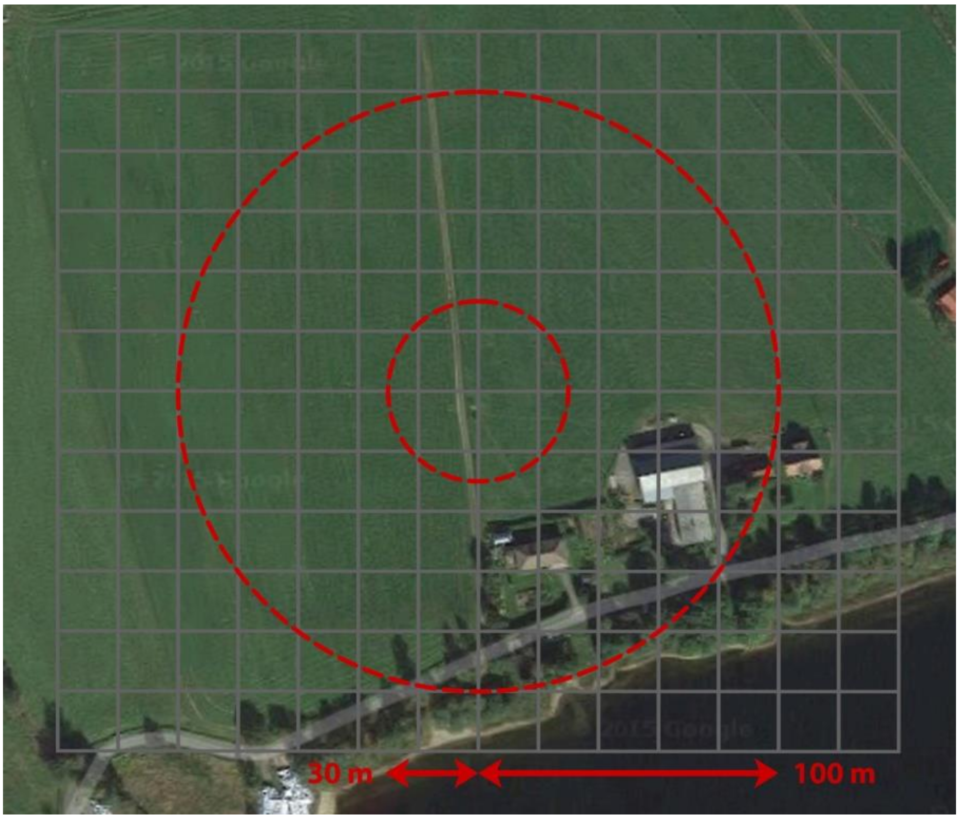
Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html

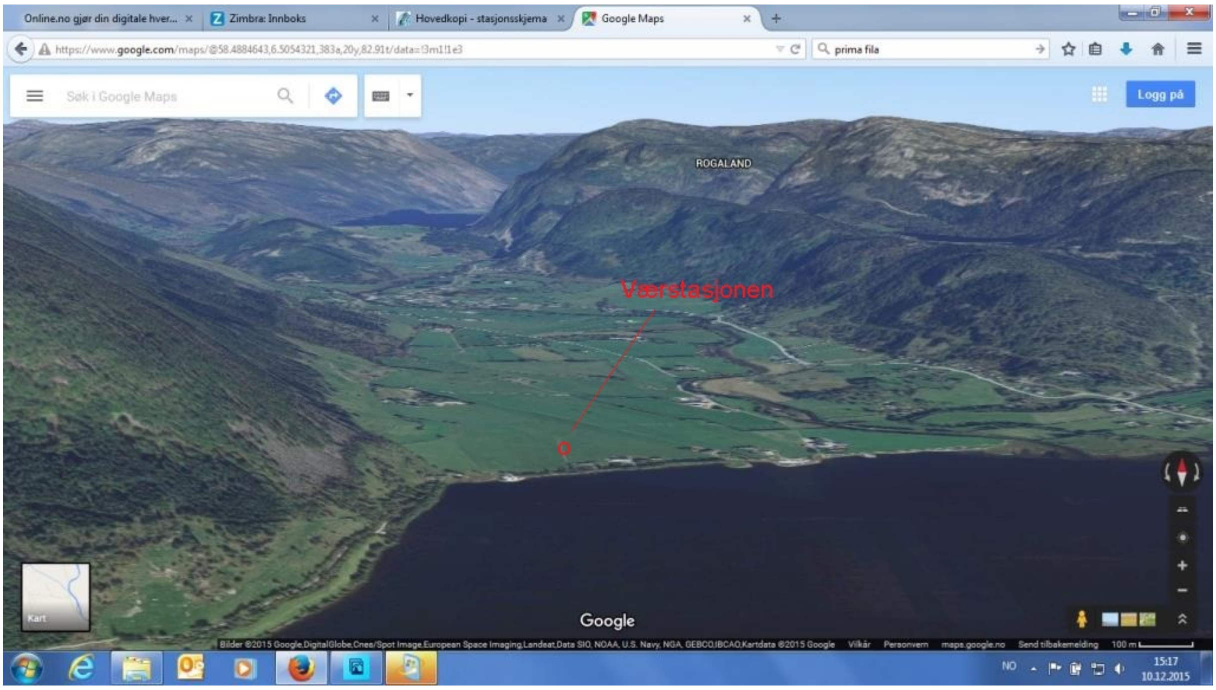


Satellite image with scale

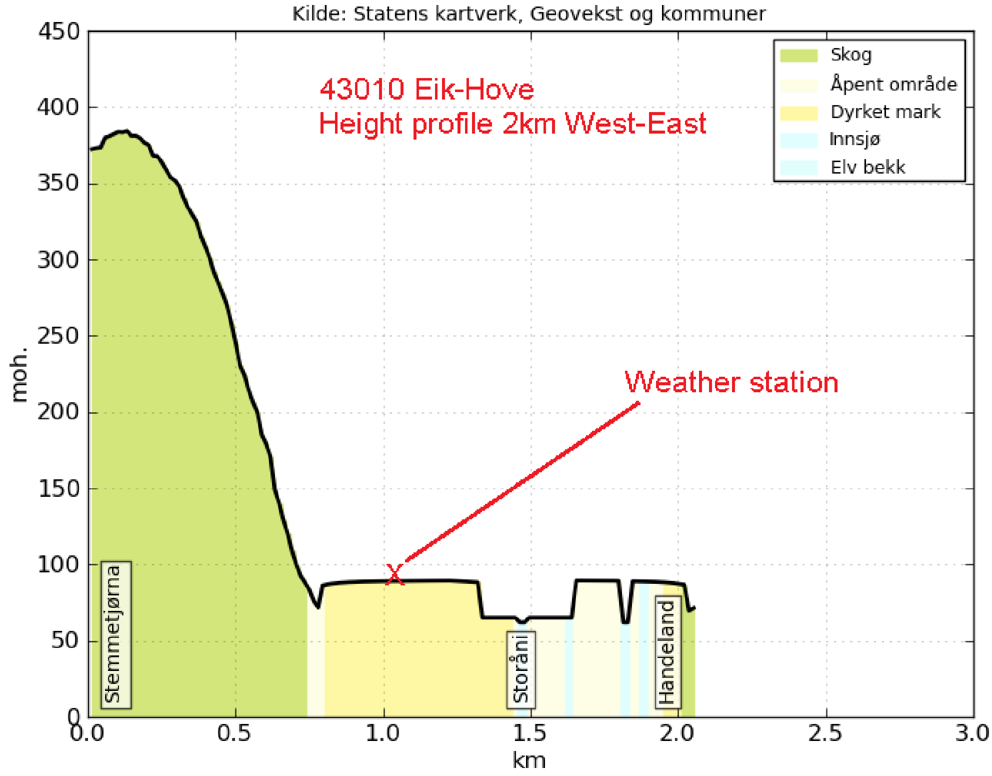
Radius 30m

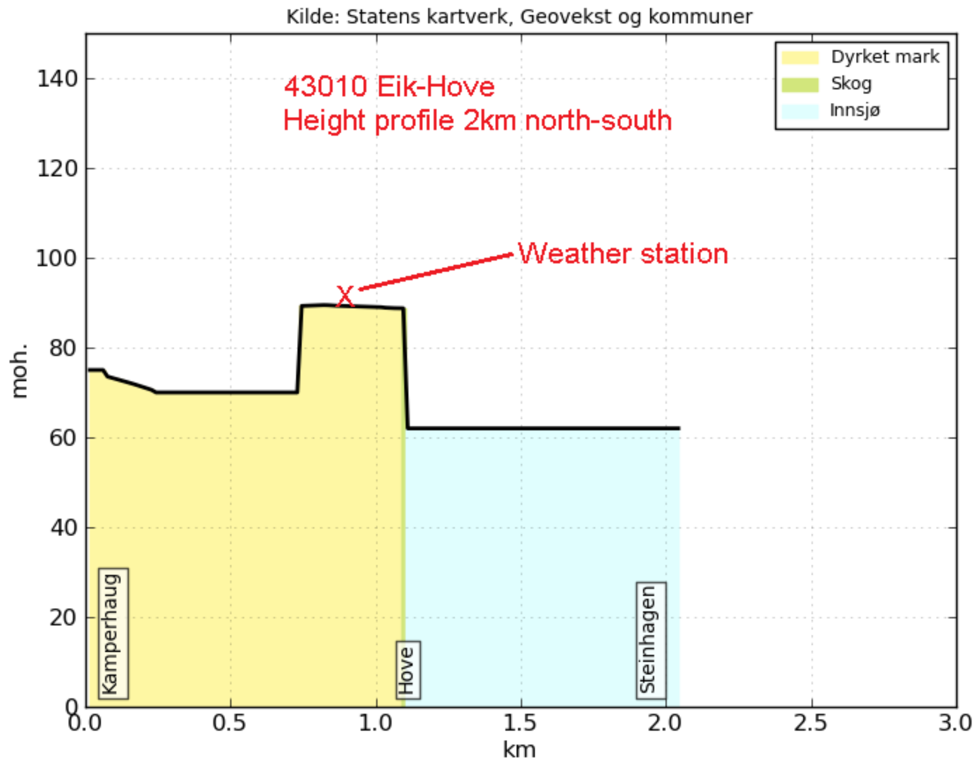

30 m
100 m

Radius 100m


Online.no gjør din digitale hver...
Zimbra: Innboks
Hovedkopi - stasjonsskjema
Google Maps
https://www.google.com/maps/@58.4884643,6.5054321,383a,20y,82.91t/data=!3m1!1e3
prima fila
Søk i Google Maps
Logg på
ROGALAND
Værstasjonen
Google
Kart

Height profile





Classifying matrix – Summary

Class	1	2	3	4	5
Slope	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*No require-ments*	*No require-ments*	*No require-ments*
Vegetation	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<25 cm) representative of the region*	*No require-ments*	*No require-ments*
Distance to **Heat Sources/ Water bodies (HS/WB)**	*Measurement point is situated more than 100 m from HS/WB* *or* *S/WB occupies less than* *a) <10% of a 100 m circle* *b) <5% of an annulus of 10-30m* *c) <1% of a 10 m circle*	*Measurement point is situated more than 30 m from HS/WB* *or* *HS/WB occupies less than* *a) <10% of a 30 m circle* *b) <5% of an annulus of 5-10m* *c) <1% of a 5 m circle*	*Measurement point is situated more than 10 m from HS/WB* *or* *HS/WB occupies less than* *c) <10% of a 10 m circle* *d) <5% of a 5 m circle*	*HS/WB occupies less than* *a) <50% of a 10 m circle* *b) <30% of a 3 m circle*	*No require-ments*
Not i shadow when sun is above …	*5°*	*7°*	*7°*	*20°*	*No require-ments*

6 Kvamsøy (Norway)

Temperature Classification Scheme

Station number: **50070**	**Station name:** **Kvamsøy**
Date: 03.09.2015	**Performed by:** **Ted Torfoss**
WMO Classification	**4**

Site description:

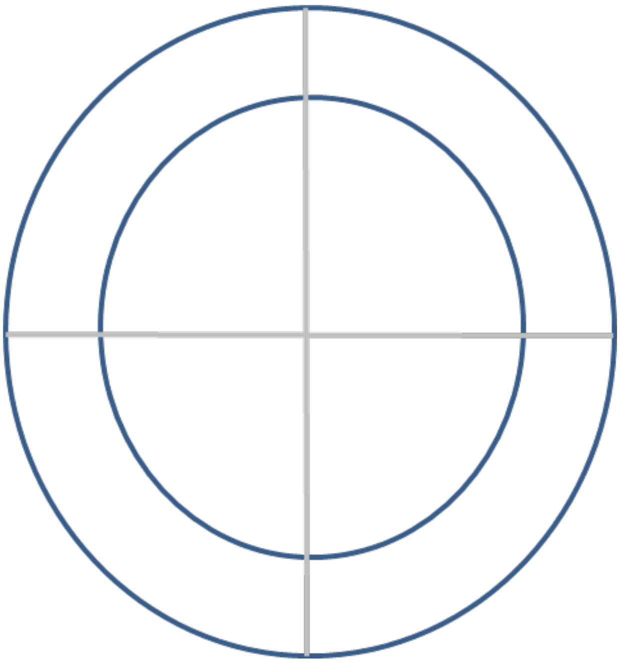
Sensor height (10 cm accuracy)	200cm
Horizontal land	In 10m radius: **X** < 5º ◻ < 10º ◻ < 15º ◻ < 19º ◻ > 19º In 100m radius: ◻ < 5º ◻ < 10º ◻ < 15º ◻ < 19º **X** > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	◻ ship **X** heathland ◻ grass ◻ bushes ◻ sand ◻ asphalt ◻ not defined ◻ black sand ◻ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	◻ slope **X** upper slope ◻ lower slope ◻ valley ◻ hill ◻ upper hill ◻ mountain ◻ peninsular ◻ coast **X** coast, but slope or cliff in the close vicinity ◻ glacier **X** fjords ◻ peak, hilltop ◻ sub-urban ◻ urban **X** rural specify: **Island in the fjord**
Amount of water systems (in 1 km radius)	**X** island (50-100%) ◻ coastal line (30-50%) Lakes: ◻ (>30%) ◻ (10-30%) ◻ (<10%) Rivers: ◻ (>30%) ◻ (10-30%) ◻ (<10%) specify: **Island in the fjord**
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	10-30cm/170-190cm

Photographs to 8 different directions	□ N □ NE □ E □ SE **X** S □ SW **X** W □NW **X** Panorama

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment

Circle of angles

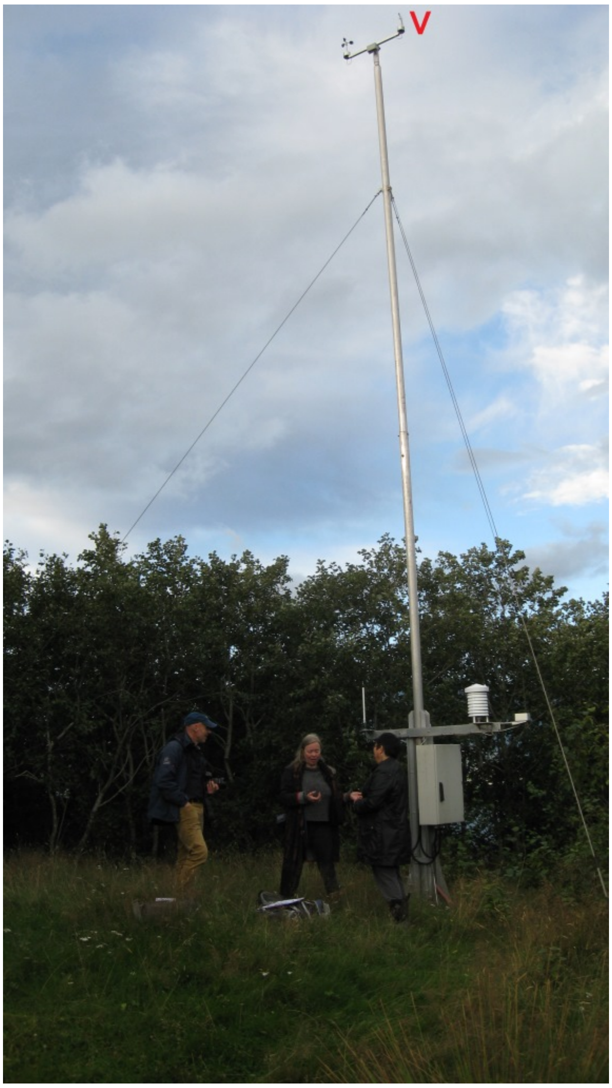


Photograph taken by fish-eye camera □

Comments	

Photos of weather station

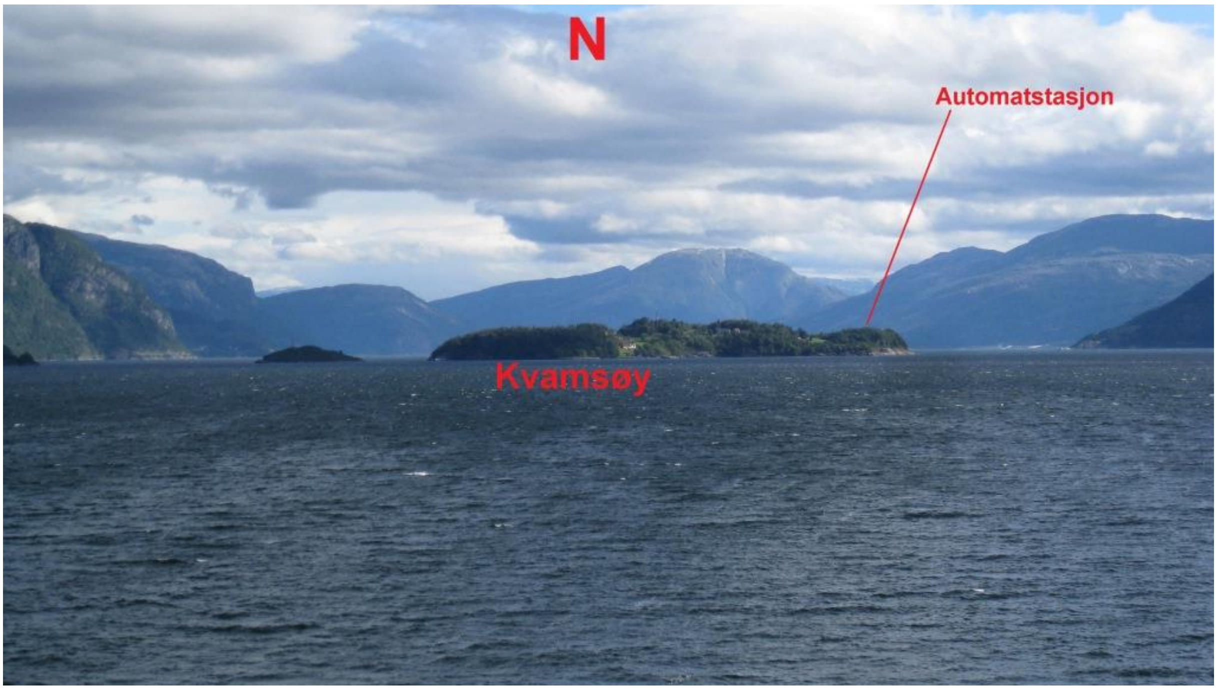
Weather station towards South



Weather station towards West

Panorama photo of weather station North-East-South

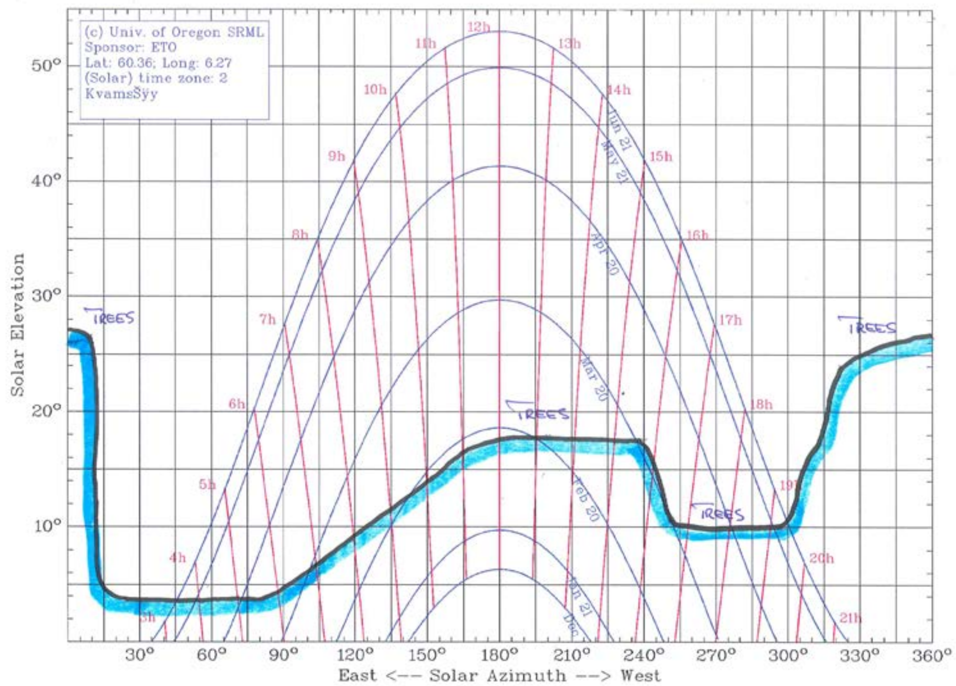
Panorama photo of weather station South-West-North



Weather station area and location in the Fjord of Hardanger

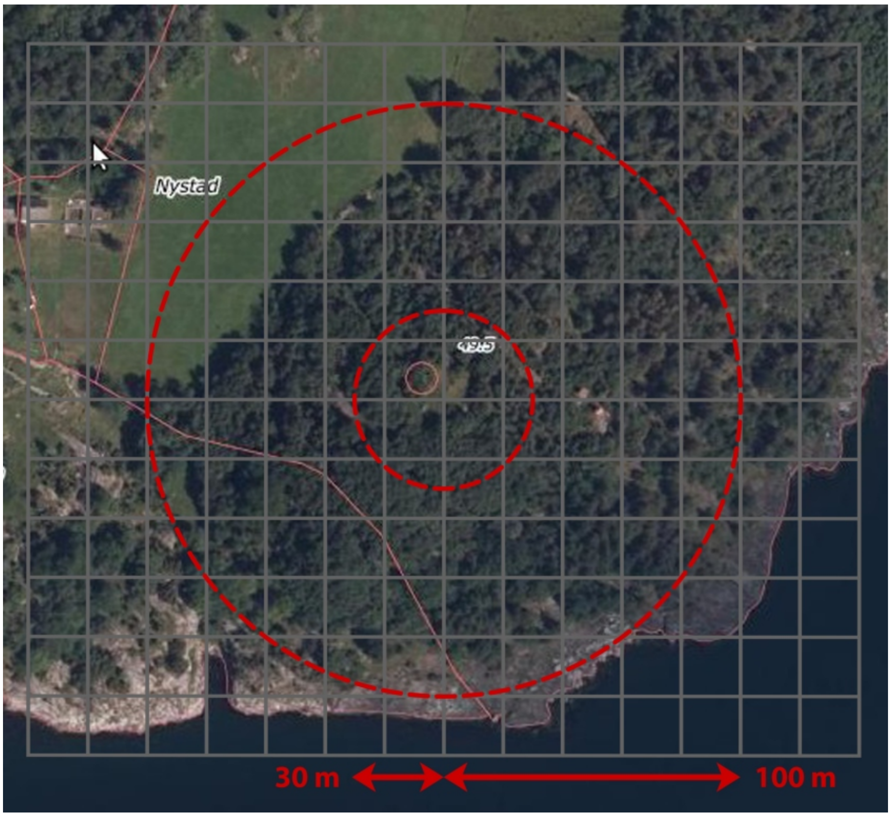
Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



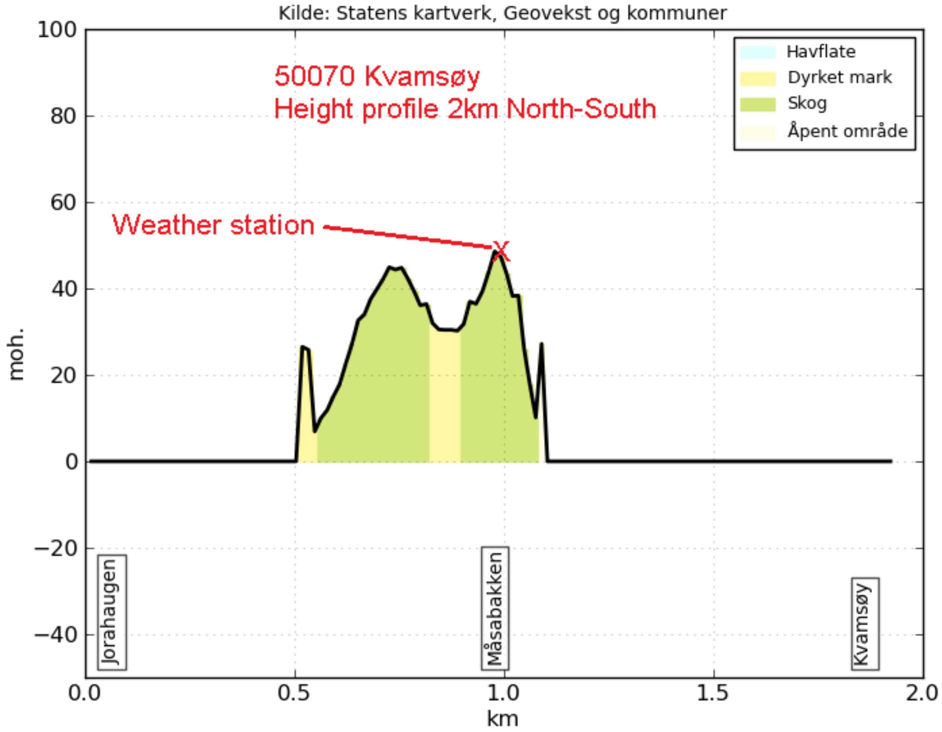
Satellite image with scale

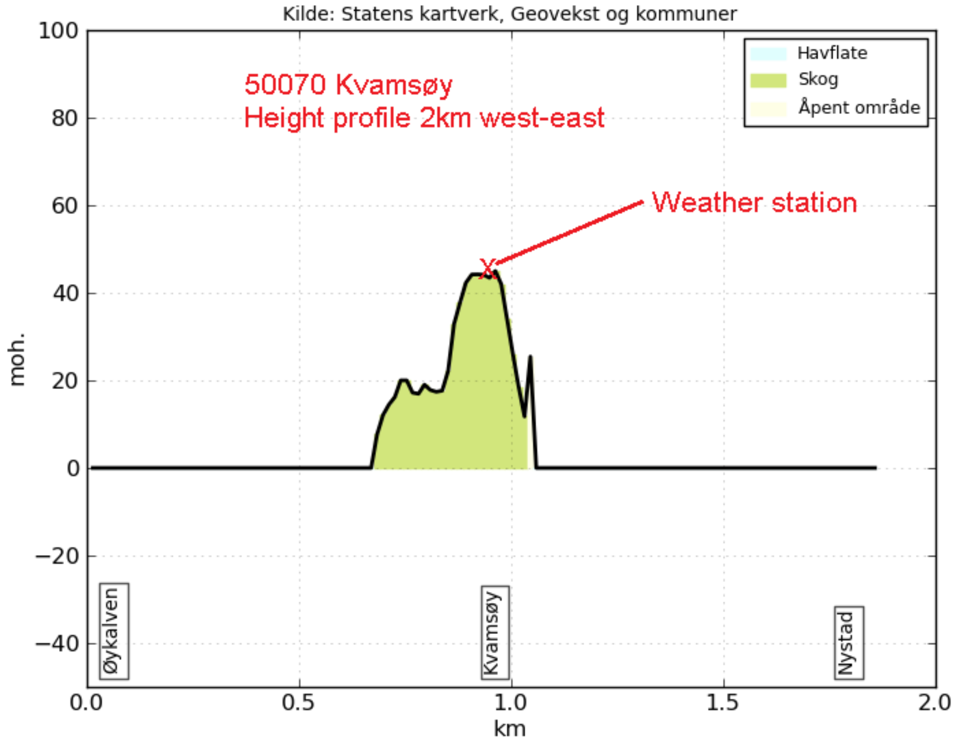
Radius 30m

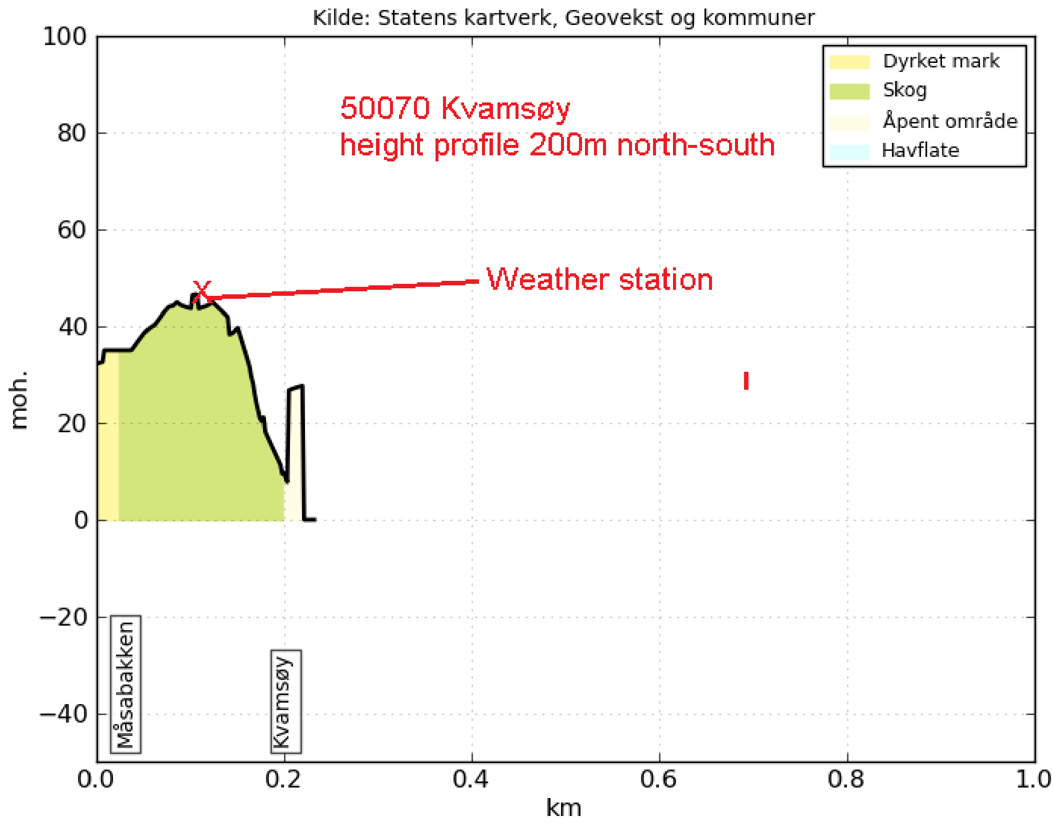


Radius 100m

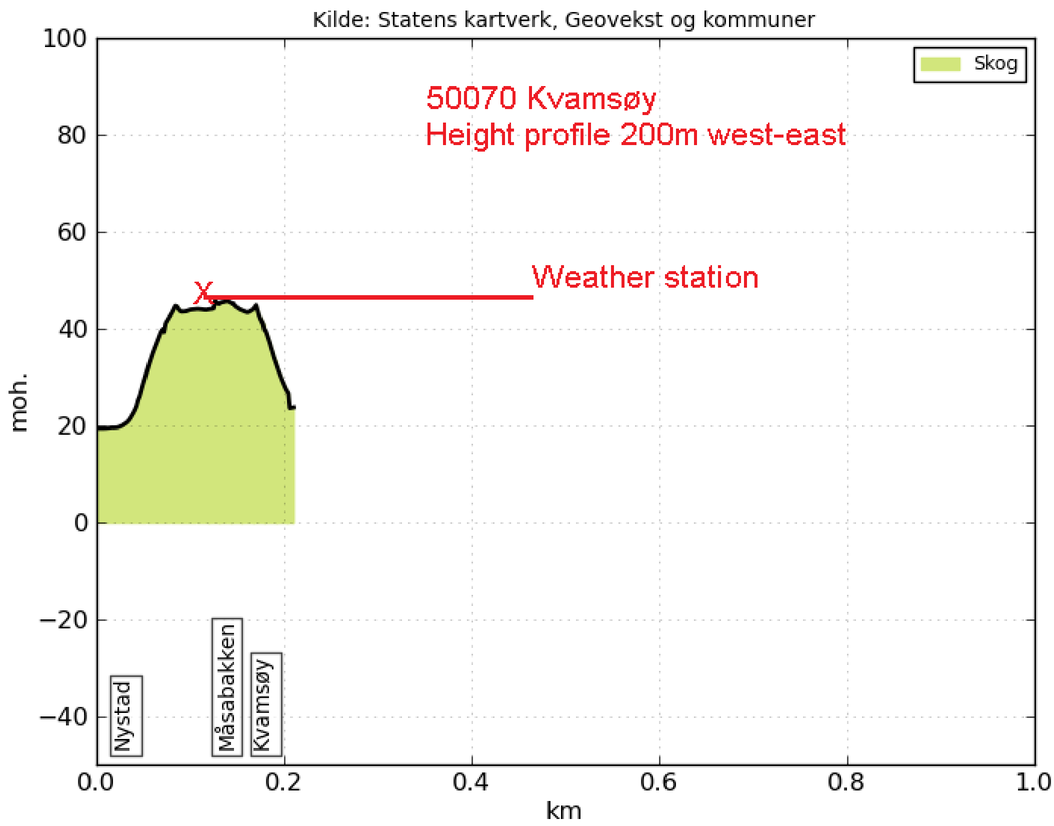
Height profile







Kilde: Statens kartverk, Geovekst og kommuner
50070 Kvamsøy
height profile 200m north-south
Dyrket mark
Skog
Åpent område
Havflate
Weather station
moh.
km
Måsabakken
Kvamsøy



Kilde: Statens kartverk, Geovekst og kommuner
50070 Kvamsøy
Height profile 200m west-east
Skog
Weather station
moh.
km
Nystad
Måsabakken
Kvamsøy

Classifying matrix – Summary

Class	1	2	3	4	5
Slope	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*No require-ments*	*No require-ments*	*No require-ments*
Vegetation	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<25 cm) representative of the region*	*No require-ments*	*No require-ments*
Distance to **Heat Sources/ Water bodies (HS/WB)**	*Measurement point is situated more than 100 m from HS/WB* *or* *S/WB occupies less than* *a) <10% of a 100 m circle* *b) <5% of an annulus of 10-30m* *c) <1% of a 10 m circle*	*Measurement point is situated more than 30 m from HS/WB* *or* *HS/WB occupies less than* *a) <10% of a 30 m circle* *b) <5% of an annulus of 5-10m* *c) <1% of a 5 m circle*	*Measurement point is situated more than 10 m from HS/WB* *or* *HS/WB occupies less than* *c) <10% of a 10 m circle* *d) <5% of a 5 m circle*	*HS/WB occupies less than* *a) <50% of a 10 m circle* *b) <30% of a 3 m circle*	*No require-ments*
Not i shadow when sun is above …	*5°*	*7°*	*7°*	*20°*	*No require-ments*

7 Myken (Norway)

Temperature Classification Scheme

Station number: 80610	**Station name: Myken**
Date: 13.09.2014	**Performed by: Ted Torfoss**
WMO-classification:	**2 or 4?**

Site description:

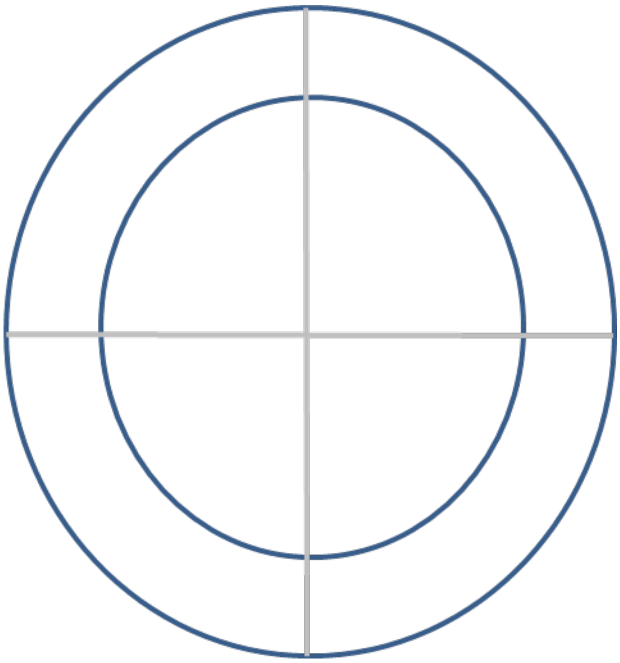
Sensor height (10 cm accuracy)	200cm
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: □ < 5º □ < 10º □ < 15º **X** < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □ heathland □ grass □ bushes □ sand □ asphalt □ not defined □ black sand **X** rocks specify: Bedrock and grass/heathland
Topography (in 1 km radius) *(choose nationally)*	□ slope **X** upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast **X** coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban **X** rural specify: **Island at sea**
Amount of water systems (in 1 km radius)	**X** island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify: **Island at sea**
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	0-5cmm/195-200vm

Photographs to 8 different directions	**X** N ☐ NE **X** E ☐ SE **X** S ☐ SW **X** W ☐NW **X** Panorama

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
300-20°	70m		5.200m²	Sea (16,5% of total area)
90-270°	60-100m		1000m²	7 Houses (3% of total area)

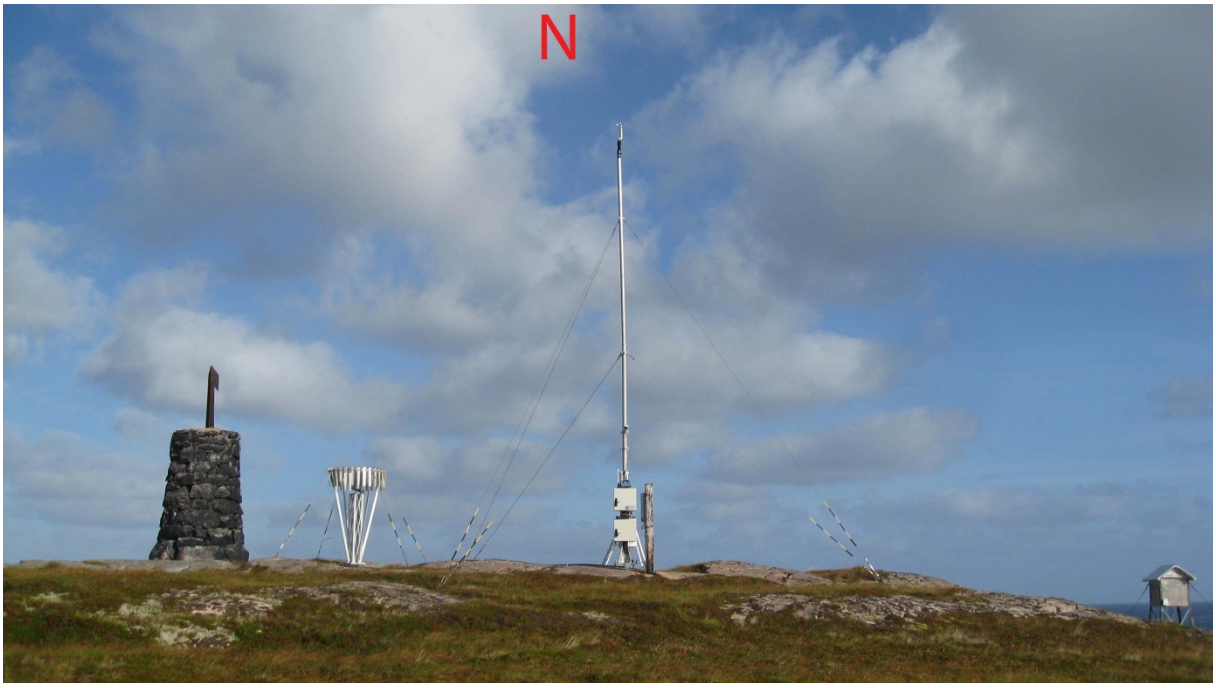
Circle of angles



Photograph taken by fish-eye camera ☐

Comments	

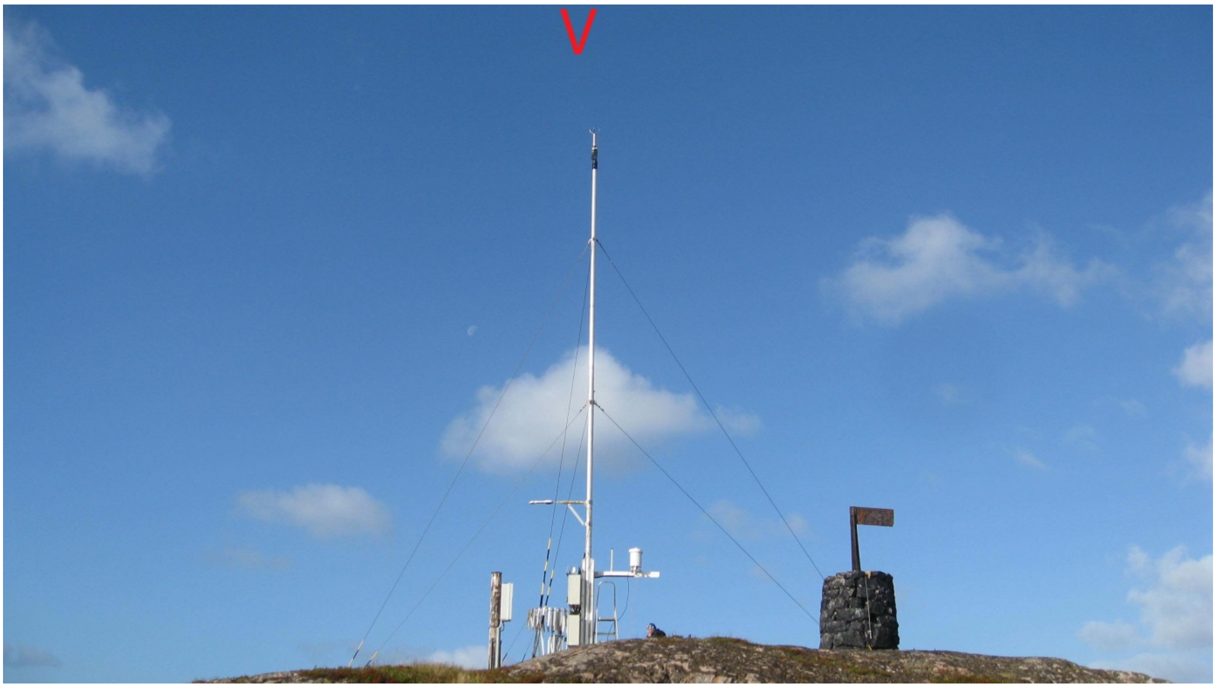
Photos of weather station



Weather station towards North

Weather station towards East

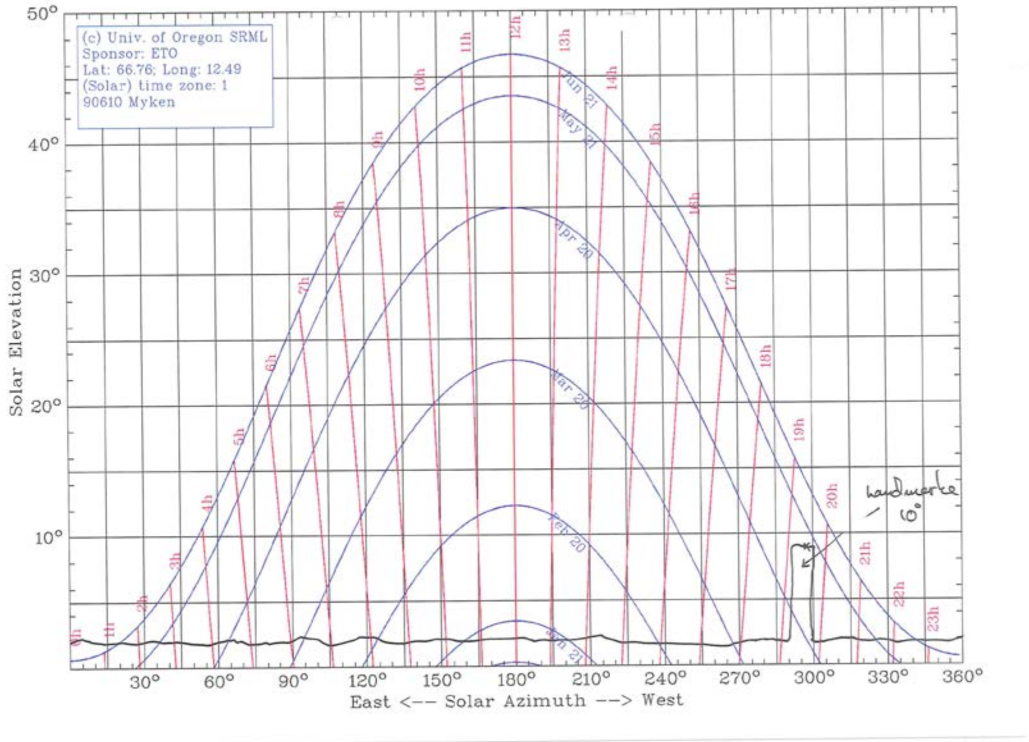
Weather station towards South



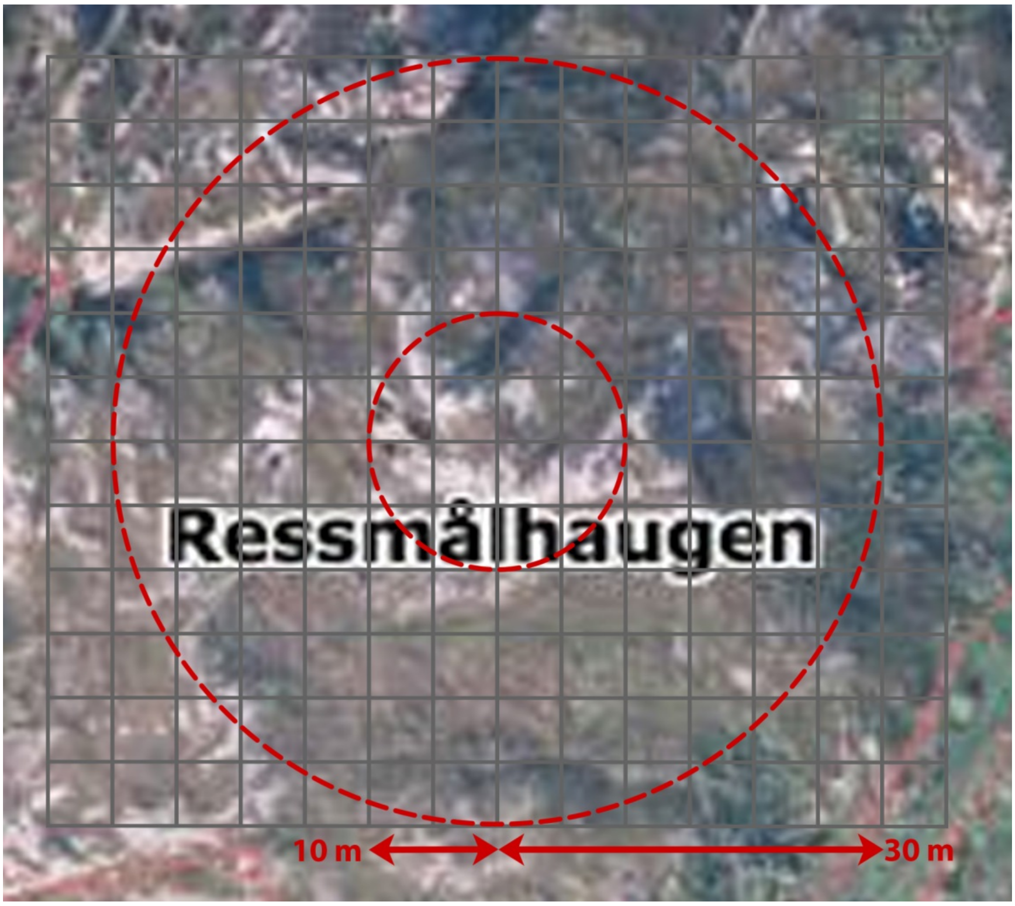
Weather station towards West

Panorama North-East-South-West

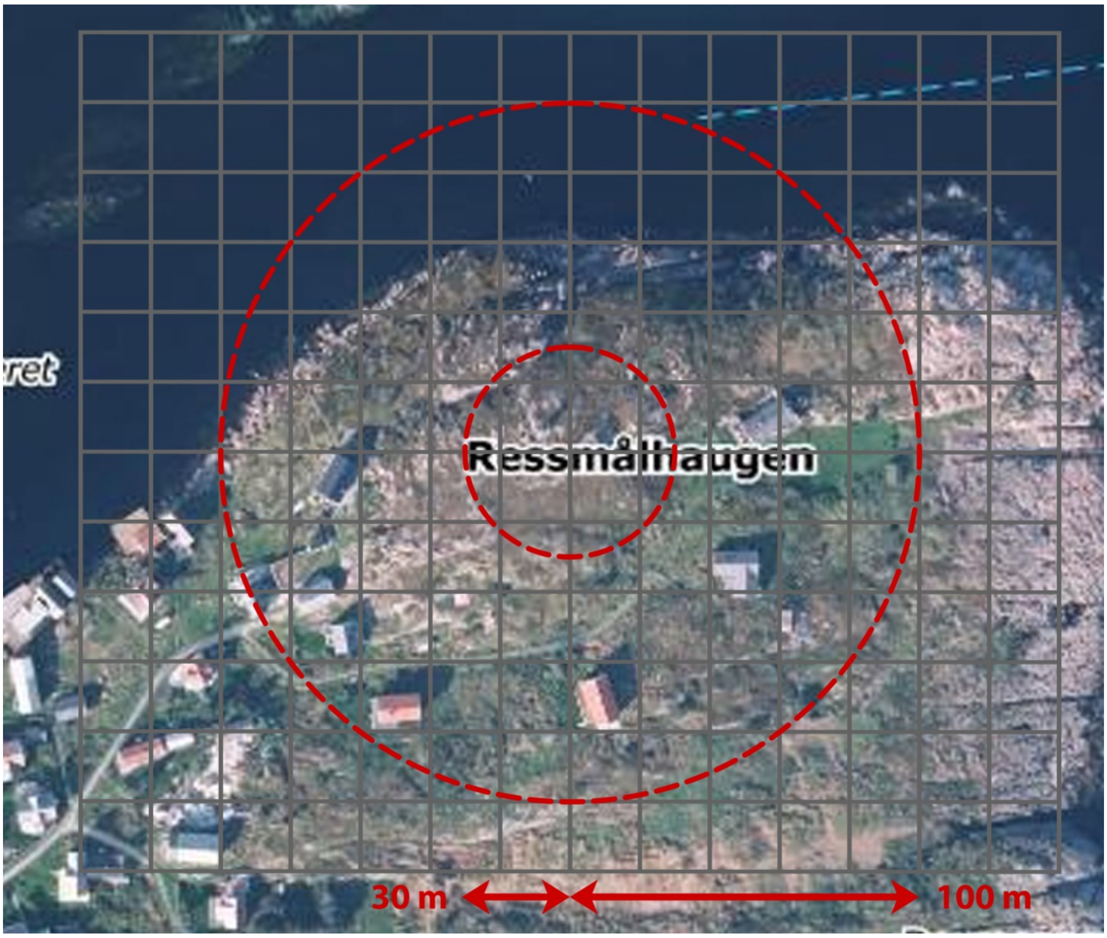
Sun elevation chart



Satellite image with scale

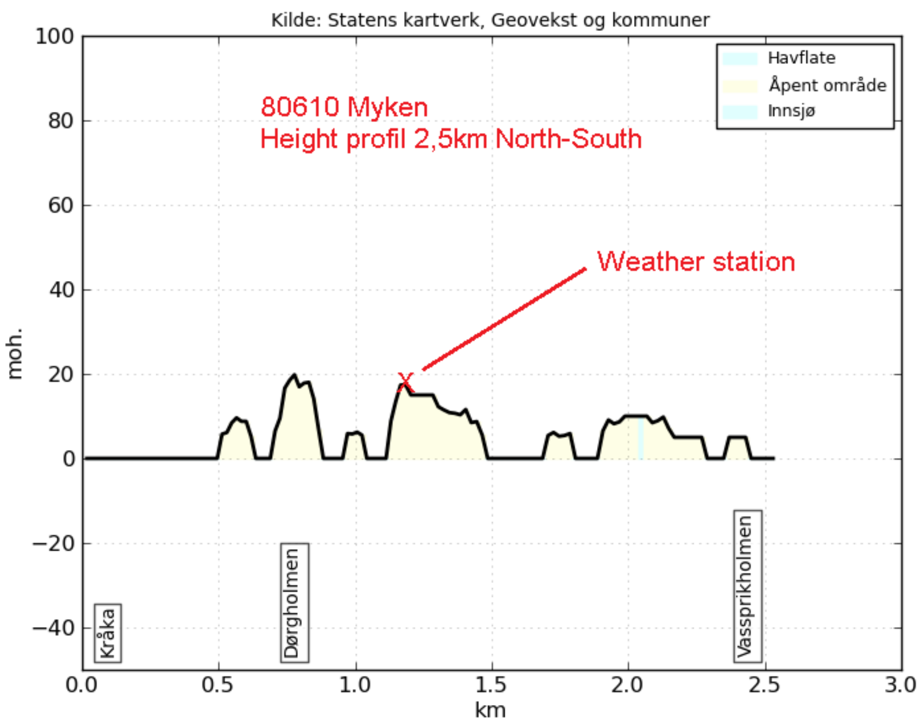


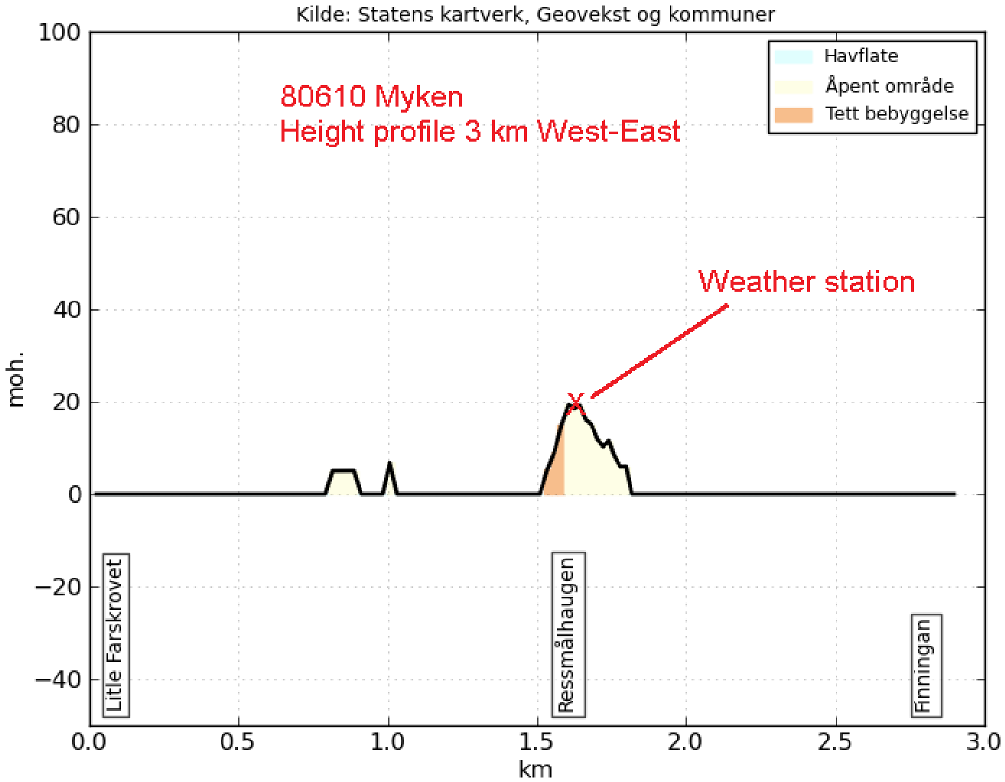
Radius 30m

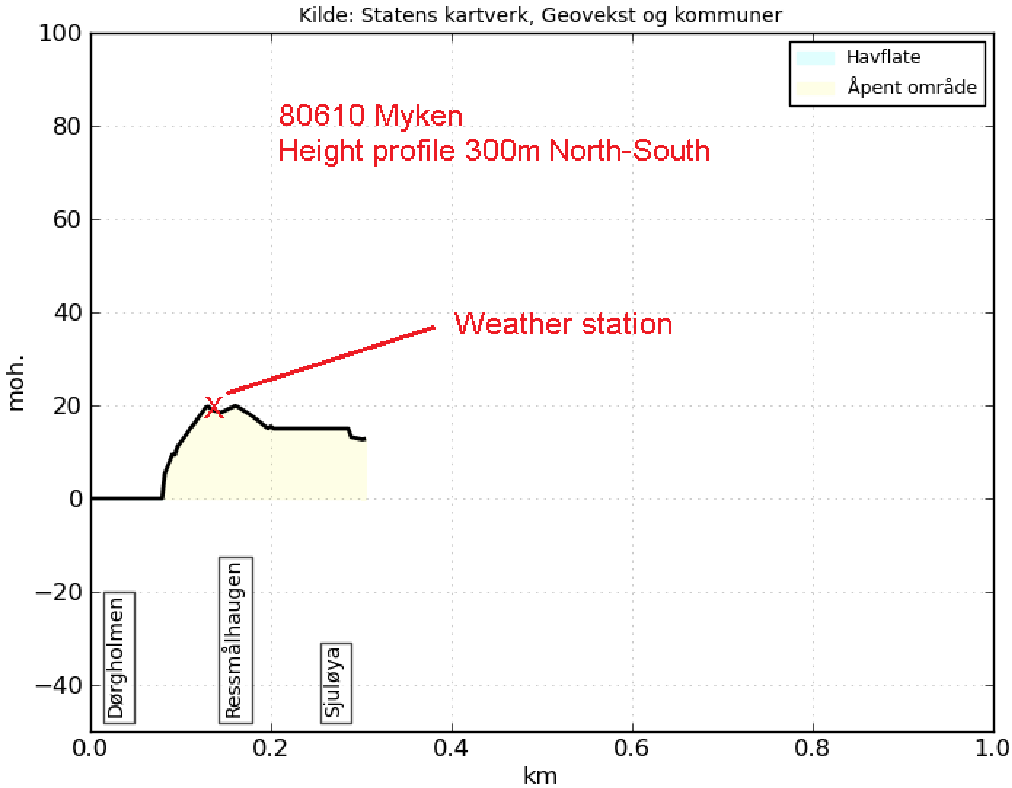


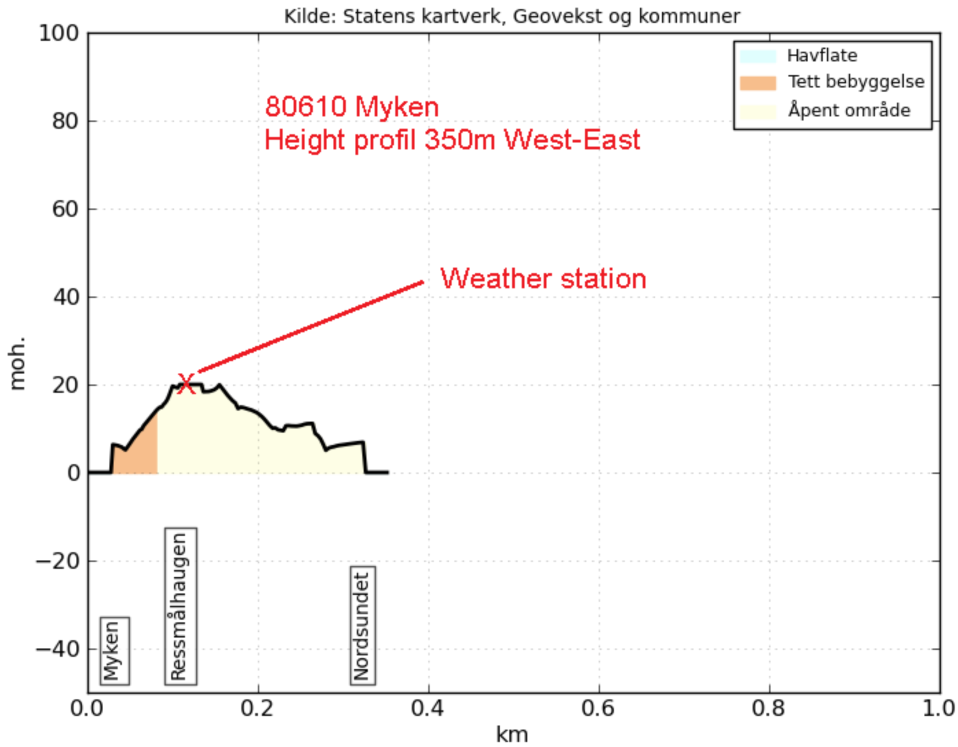
Radius 100m

Height profile




Kilde: Statens kartverk, Geovekst og kommuner
80610 Myken
Height profile 3 km West-East
Weather station
Havflate
Åpent område
Tett bebyggelse
moh.
km
Litle Farskrovet
Ressmålhaugen
Finningan


Kilde: Statens kartverk, Geovekst og kommuner
80610 Myken
Height profile 300m North-South
Weather station
Havflate
Åpent område
moh.
km
Dørgholmen
Ressmålhaugen
Sjuløya



Kilde: Statens kartverk, Geovekst og kommuner
80610 Myken
Height profil 350m West-East
Weather station
Havflate
Tett bebyggelse
Åpent område
moh.
km
Myken
Ressmålhaugen
Nordsundet

Classifying matrix – Summary

Class	1	2	3	4	5
Slope	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*No require-ments*	*No require-ments*	*No require-ments*
Vegetation	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<25 cm) representative of the region*	*No require-ments*	*No require-ments*
Distance to **Heat Sources/ Water bodies (HS/WB)**	*Measurement point is situated more than 100 m from HS/WB* *or* *S/WB occupies less than* *a) <10% of a 100 m circle* *b) <5% of an annulus of 10-30m* *c) <1% of a 10 m circle*	*Measurement point is situated more than 30 m from HS/WB* *or* *HS/WB occupies less than* *a) <10% of a 30 m circle* *b) <5% of an annulus of 5-10m* *c) <1% of a 5 m circle*	*Measurement point is situated more than 10 m from HS/WB* *or* *HS/WB occupies less than* *c) <10% of a 10 m circle* *d) <5% of a 5 m circle*	*HS/WB occupies less than* *a) <50% of a 10 m circle* *b) <30% of a 3 m circle*	*No require-ments*
Not i shadow when sun is above …	*5°*	*7° (Could be approx. 7°)* ***Difficult to measure exact ???***	*7°*	*20° (Might be just above 7°)* ***???***	*No require-ments*

8 Fokstugu (Norway)

Temperature Classification Scheme

Station number: **16610**	**Station name:** **Fokstugu**
Date: **04.06.2014**	**Performed by:** **Ted Torfoss**
WMO-classification:	**2 or 4?**

Site description:

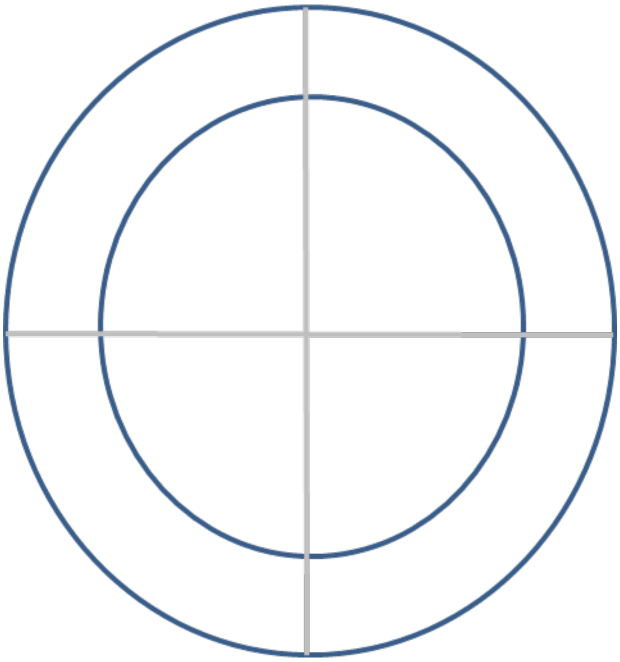
Sensor height (10 cm accuracy)	236cm
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □ heathland **X** grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill **X** mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban **X** rural specify: **Mountain plateau**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X** (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	10-20cm/206-216cm

Photographs to 8 different directions	**X** N □ NE **X** E □ SE **X** S □ SW **X** W □NW □ Panorama

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
0-90°	45-100m		1.000m²	Buildings
100-180°	75-100m		400m²	Main road asvalt
160-340°	25-100m		400m²	Gravel road

Circle of angles

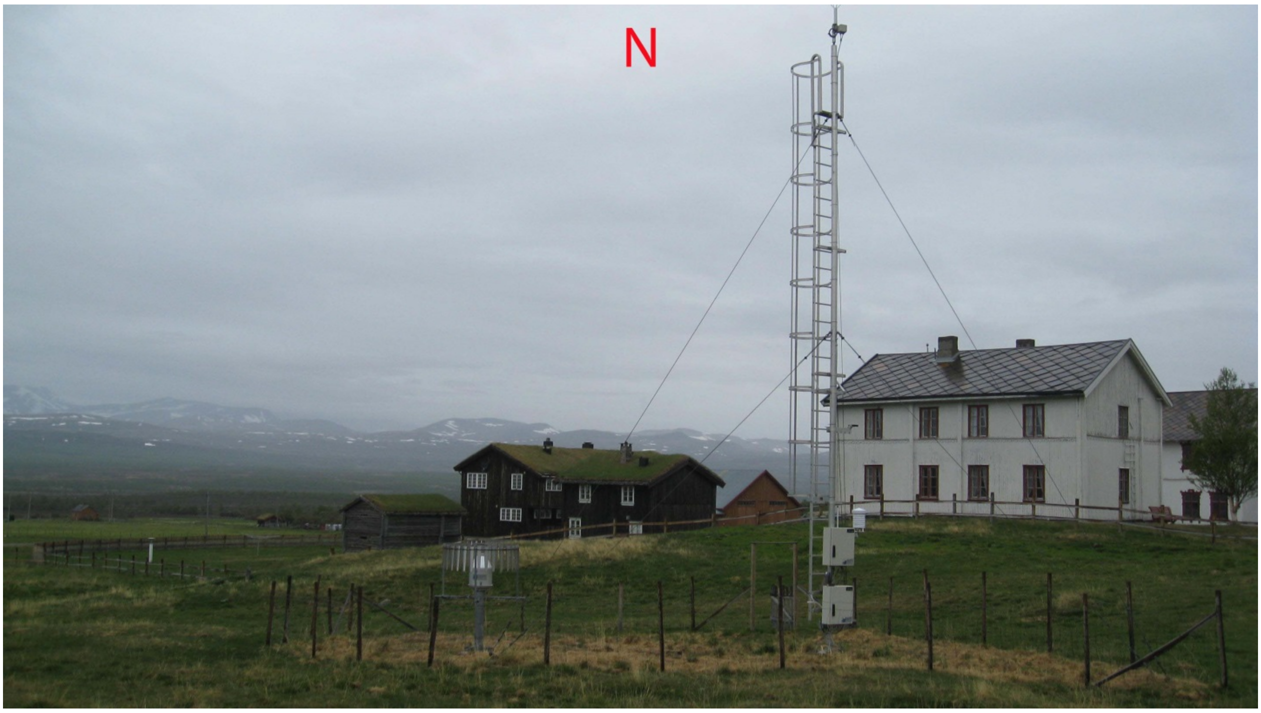


Photograph taken by fish-eye camera □

Comments	

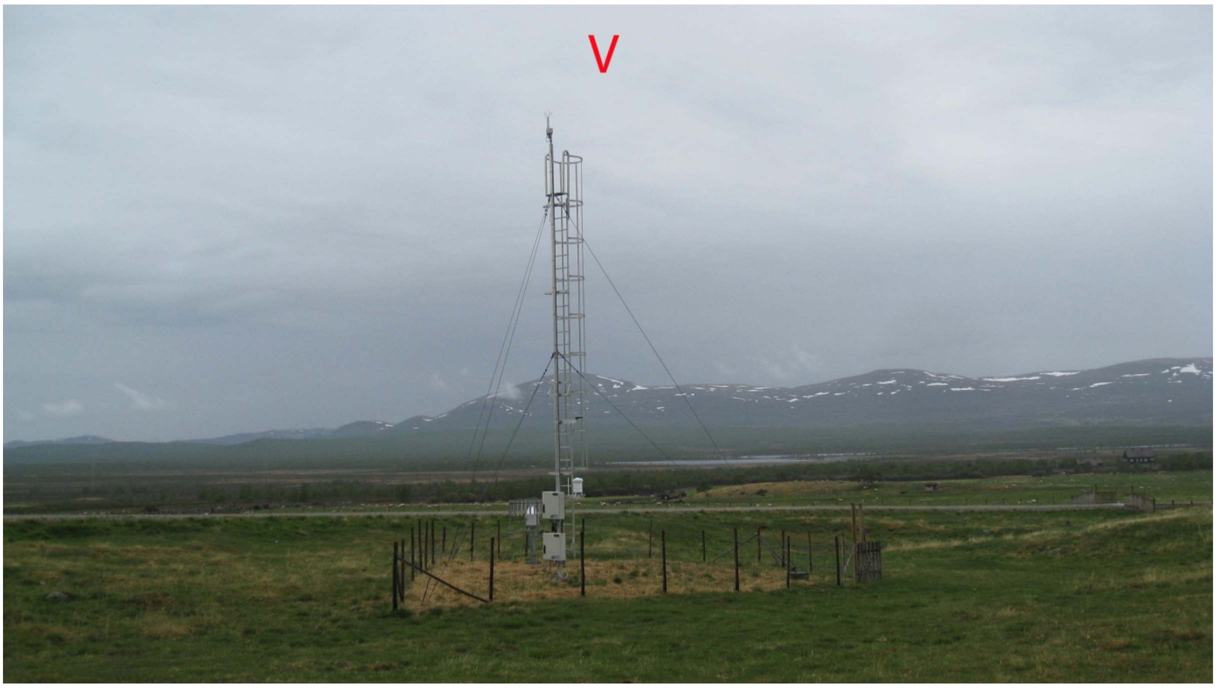
Photos of weather station

Weather station towards East



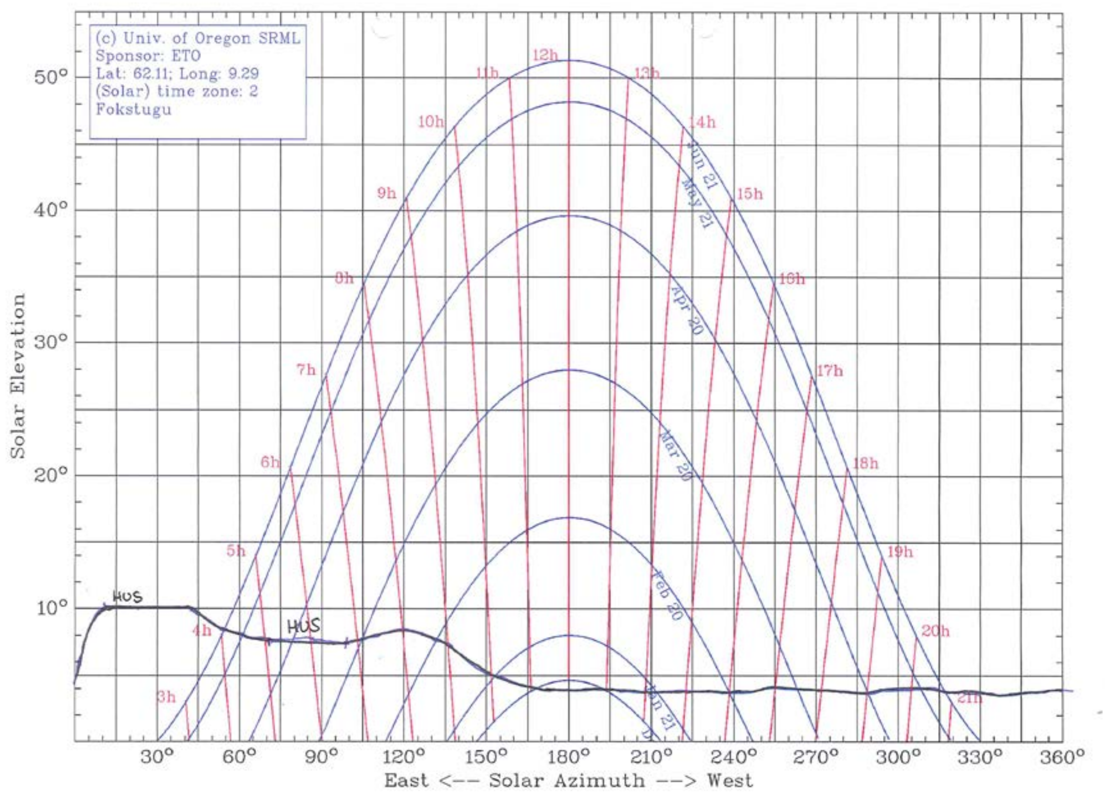
Weather station towards North

Weather station towards South



Weather station towards West

Sun elevation chart

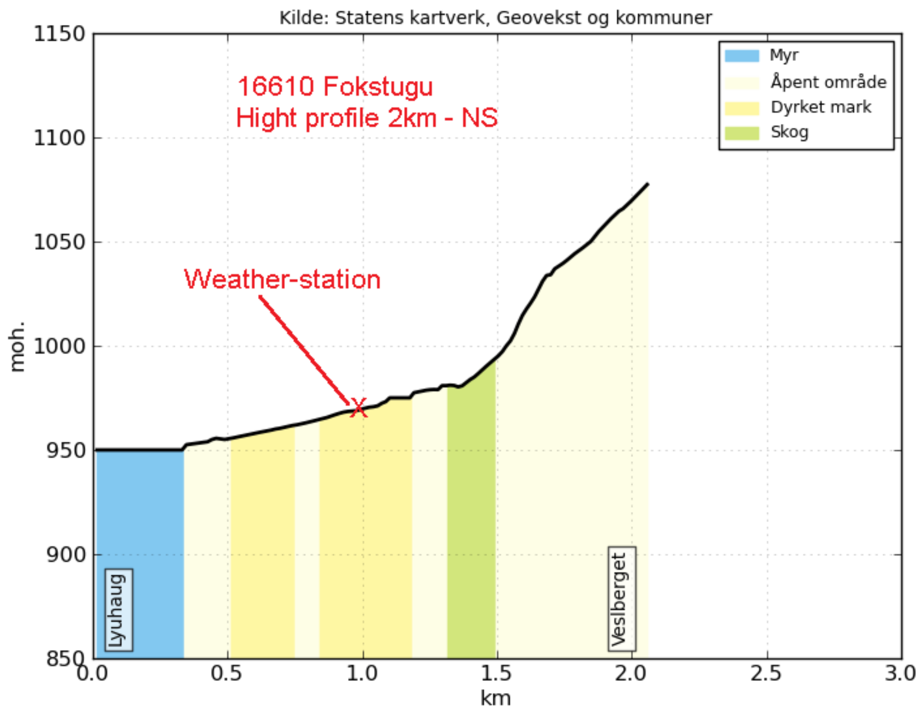


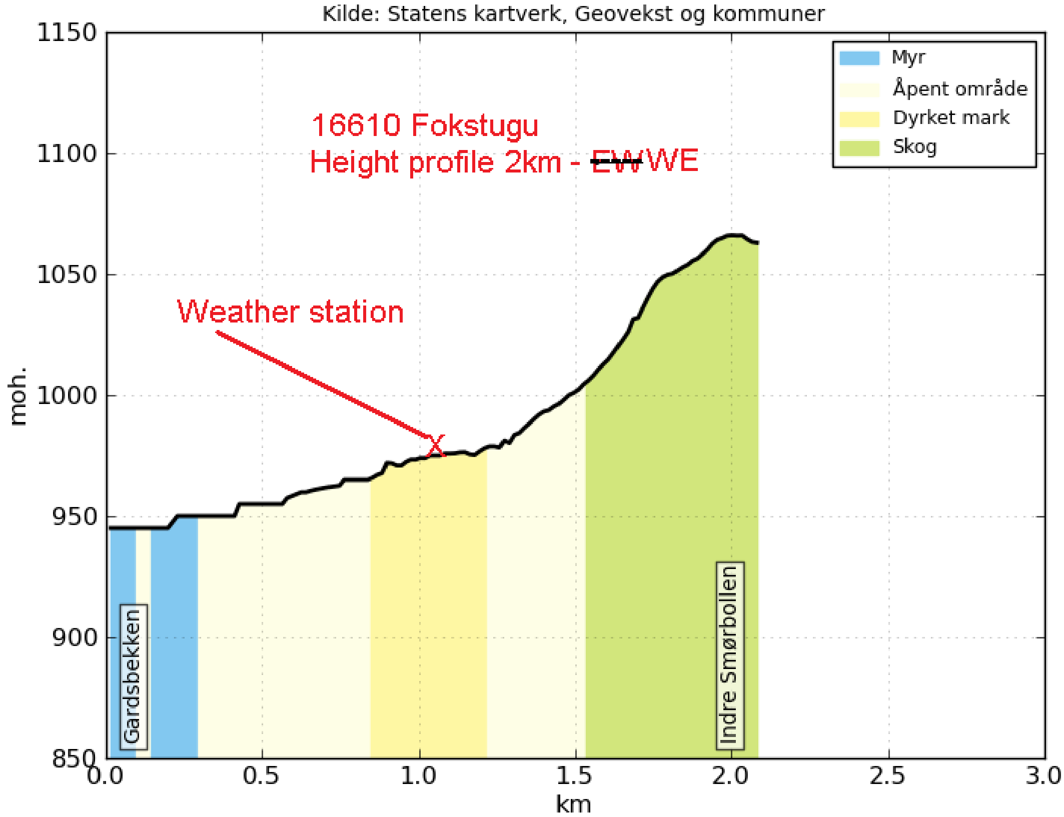
Satellite image with scale

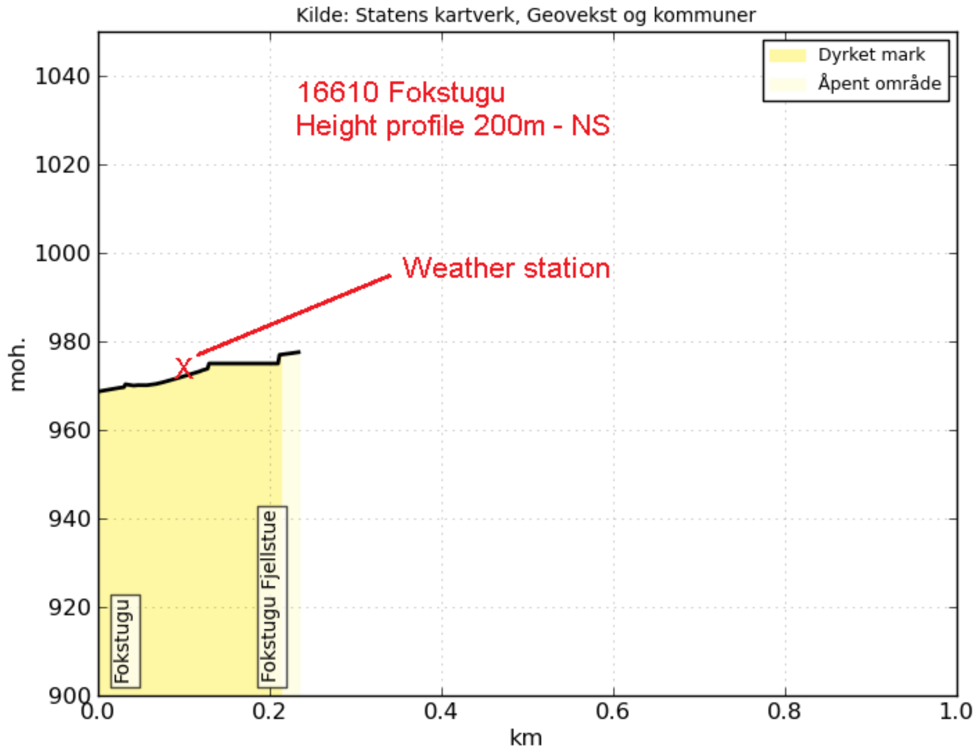
Radius 30m

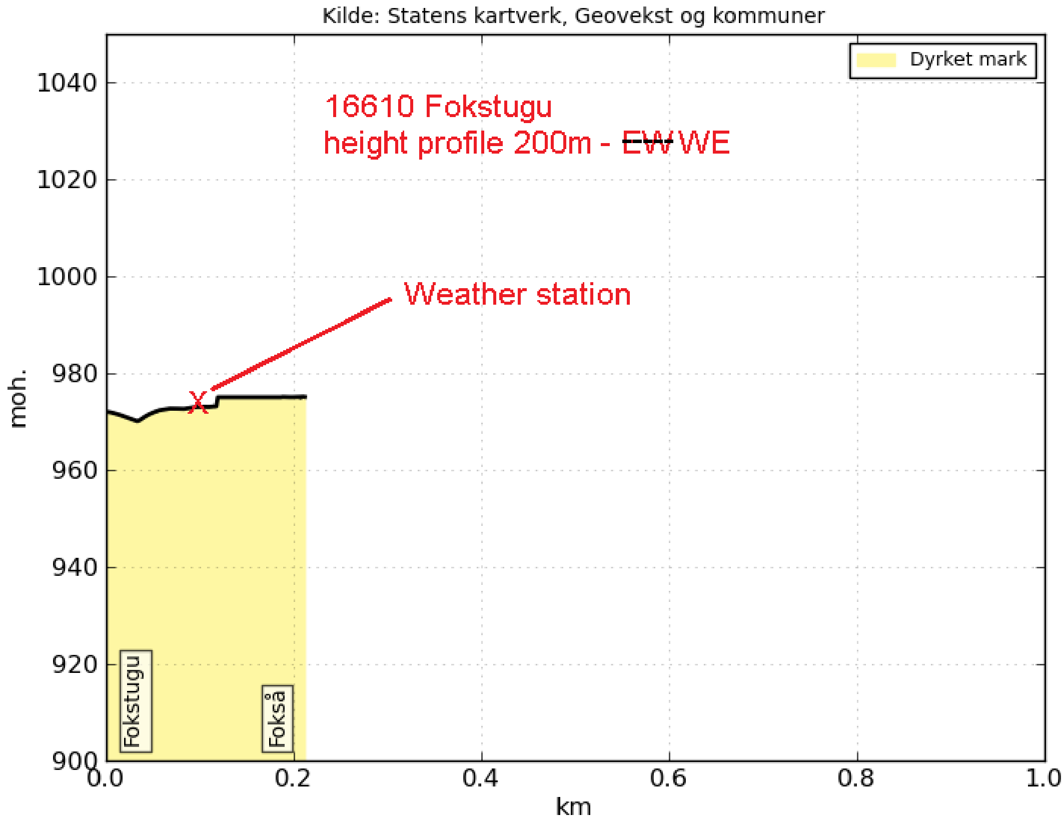
Radius 100m

Height profile




Kilde: Statens kartverk, Geovekst og kommuner
16610 Fokstugu
Height profile 2km - EW WE
Weather station
X
Myr
Åpent område
Dyrket mark
Skog
Gardsbekken
Indre Smørbollen
moh.
1150
1100
1050
1000
950
900
850
0.0
0.5
1.0
1.5
2.0
2.5
3.0
km


Kilde: Statens kartverk, Geovekst og kommuner
16610 Fokstugu
Height profile 200m - NS
Weather station
X
Dyrket mark
Åpent område
Fokstugu
Fokstugu Fjellstue
moh.
1040
1020
1000
980
960
940
920
900
0.0
0.2
0.4
0.6
0.8
1.0
km


Kilde: Statens kartverk, Geovekst og kommuner
Dyrket mark
16610 Fokstugu
height profile 200m - EW WE
Weather station
moh.
1040
1020
1000
980
960
940
920
900
0.0
0.2
0.4
0.6
0.8
1.0
km
Fokstugu
Foksâ

Classifying matrix – Summary

Class	**1**	**2**	**3**	**4**	**5**
Slope	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*No require-ments*	*No require-ments*	*No require-ments*
Vegetation	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<25 cm) representative of the region*	*No require-ments*	*No require-ments*
Distance to **Heat Sources/ Water bodies (HS/WB)**	*Measurement point is situated more than 100 m from HS/WB* *or* *S/WB occupies less than* *a) <10% of a 100 m circle* *b) <5% of an annulus of 10-30m* *c) <1% of a 10 m circle*	*Measurement point is situated more than 30 m from HS/WB* *or* *HS/WB occupies less than* *a) <10% of a 30 m circle* *b) <5% of an annulus of 5-10m* *c) <1% of a 5 m circle*	*Measurement point is situated more than 10 m from HS/WB* *or* *HS/WB occupies less than* *c) <10% of a 10 m circle* *d) <5% of a 5 m circle*	*HS/WB occupies less than* *a) <50% of a 10 m circle* *b) <30% of a 3 m circle*	*No require-ments*
Not i shadow when sun is above …	*5°*	*7°*	*7°*	*20°*	*No require-ments*

9 Veggli II (Norway)

Temperature Classification Scheme

Station number: **28922**	**Station name:** **Veggli II**
Date: 16.06.2015	**Performed by:** **Ted Torfoss**
WMO Classification:	**5**

Site description:

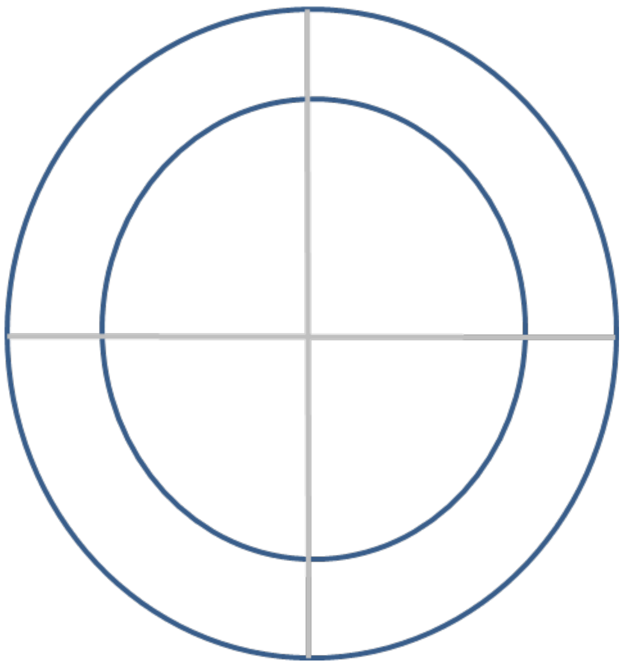
Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □ heathland **X** grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope **X** valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X** sub-urban □ urban □ Rural specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify: The river in the valley is ca 110m below the station
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	195 cm

Photographs to 8 different directions	X N ◻ NE X E ◻ SE X S ◻ SW X W ◻NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
280-70° (150°)	10-25m		425m²	Road of asvalt. 15% of total area within the radius of 30m
230-280° (50°)	10-25m		325m²	Parking lot of gravel. 11,5% of total area within the radius of 30m
220-110° (250°)	10-100m		3600m²	Road (asvalt) and parking lot (asvalt and gravel). 11,5% of total area within the radius of 100m
0-30°	25m	15-18°		Trees
105-125° & 130-140°	30m	17 and 12°		Trees
210-260°	25-30m	23 and 17°		Trees

Circle of angles



Photograph taken by fish-eye camera ☐

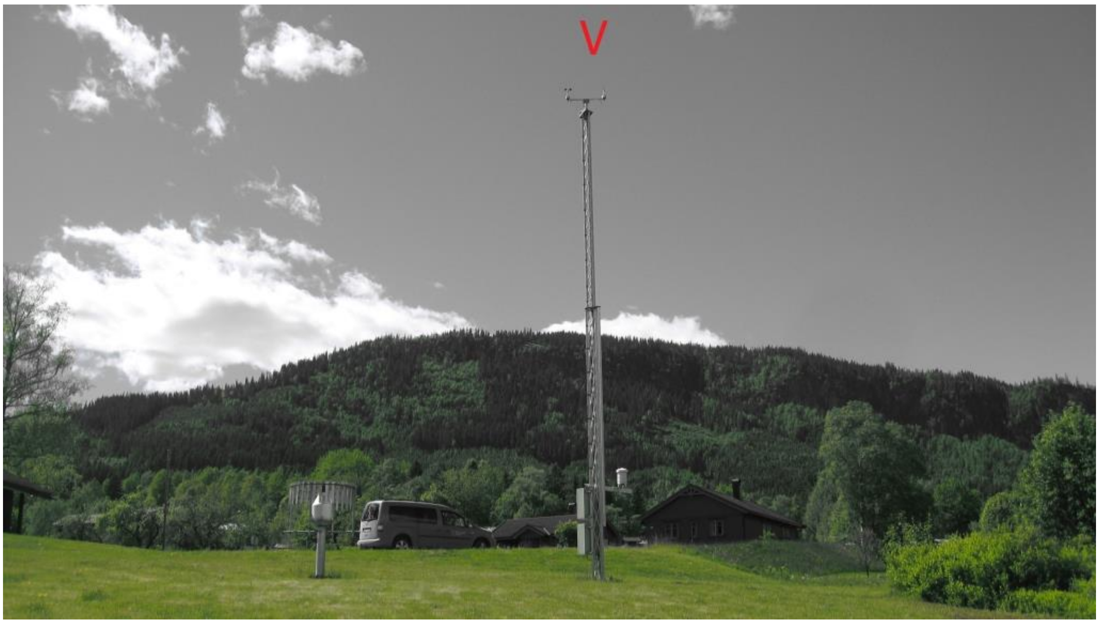
Comments	See height profile in the end of document

Photos weather station

Weather station towards North

Weather station towards East

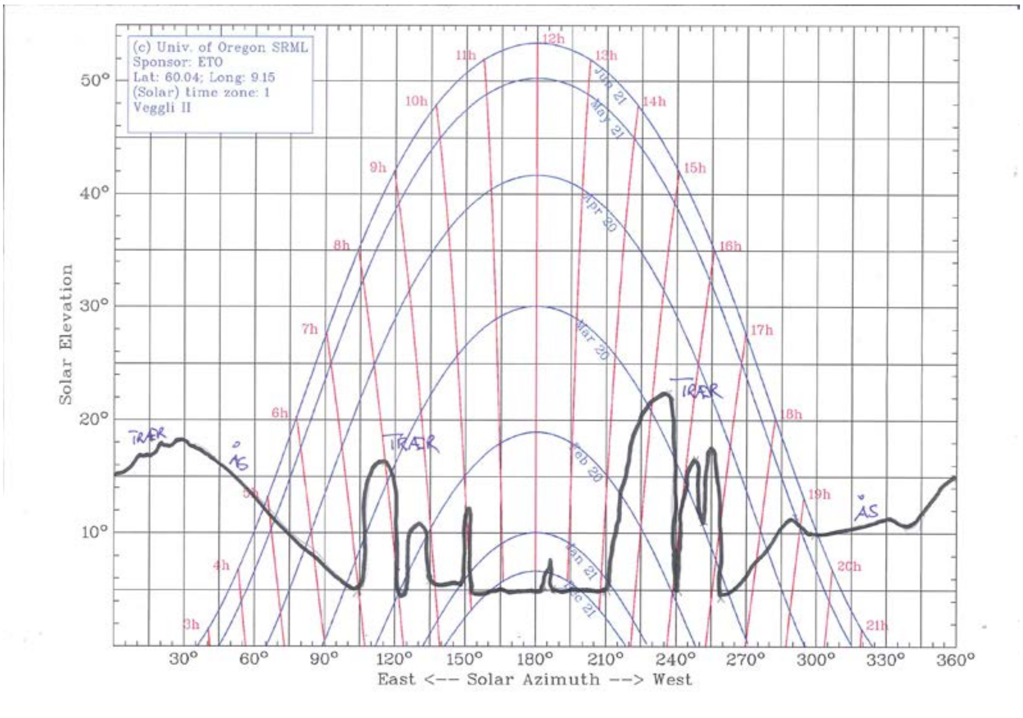
Weather station towards South



Weather station towards West

Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



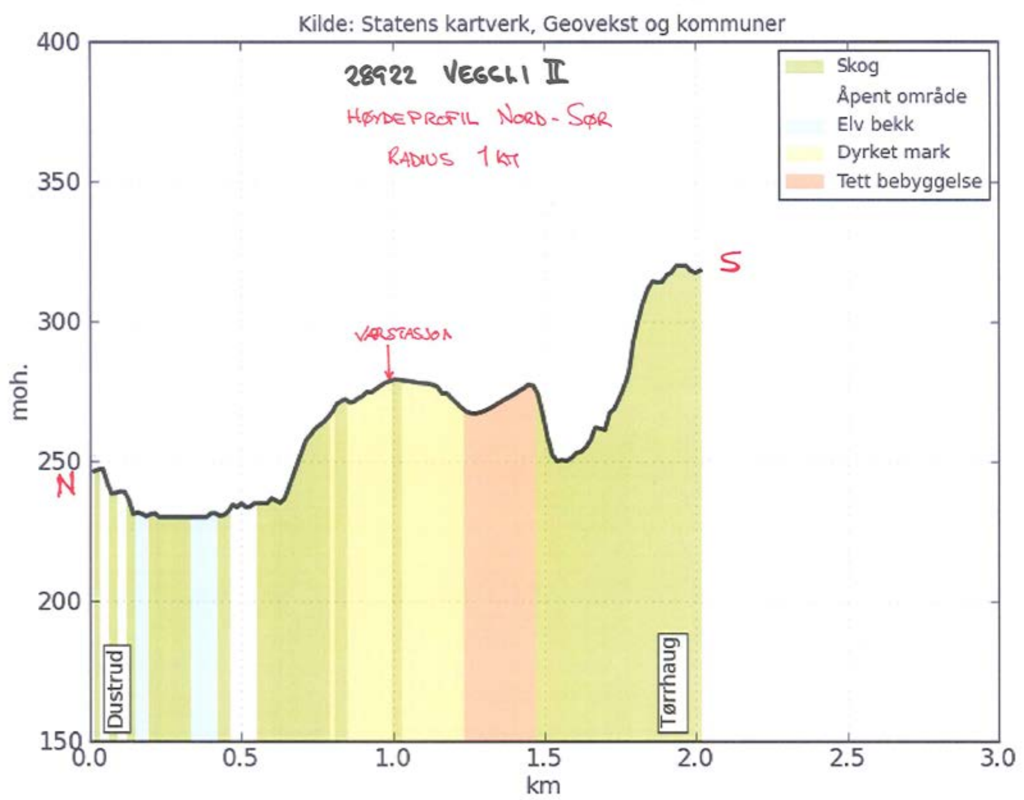
Shades on the sensor in January, February, March, September, October, November and December

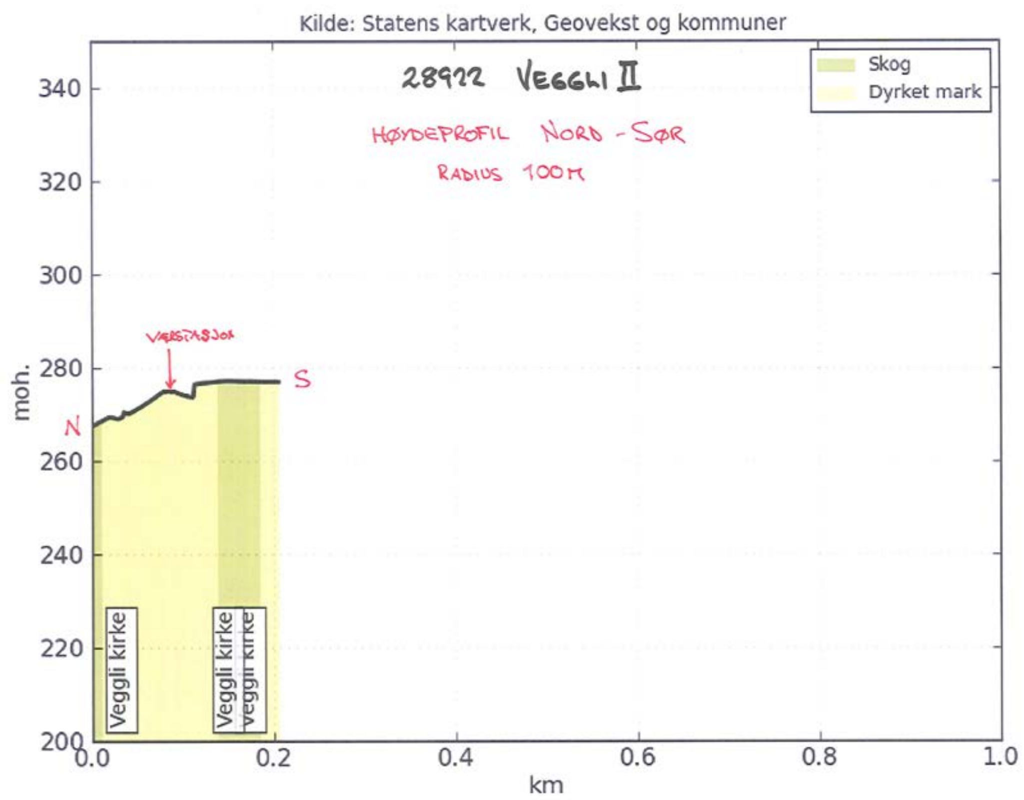
Satellite image with scale

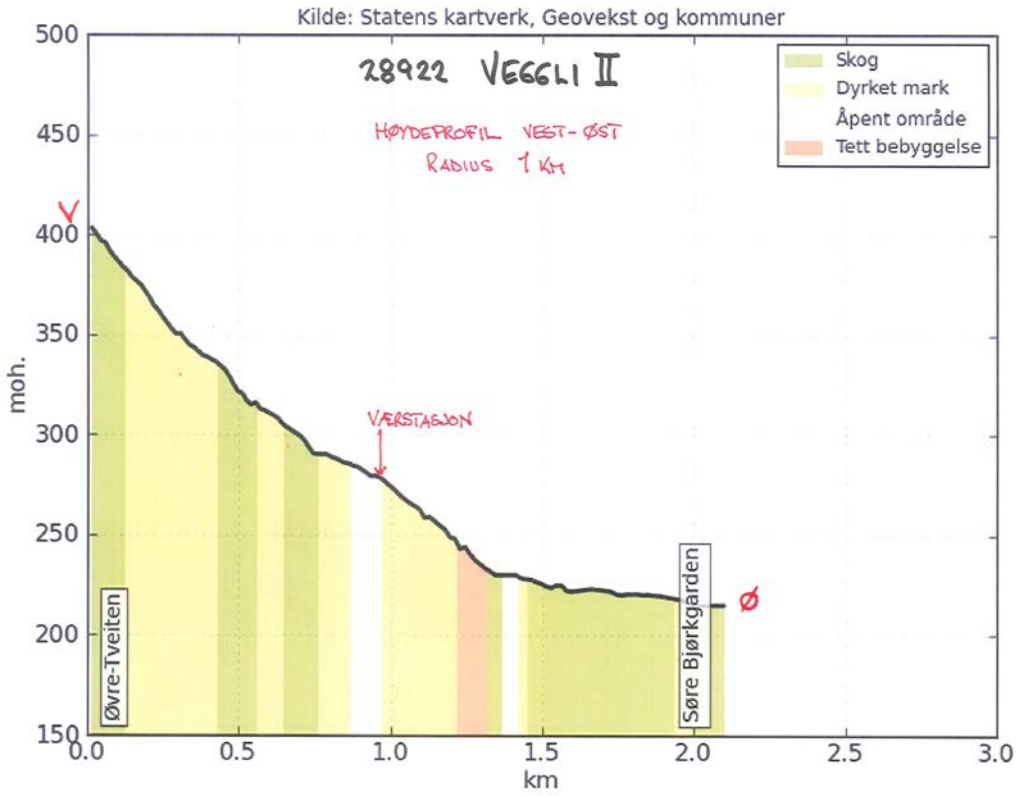
Radius 100m

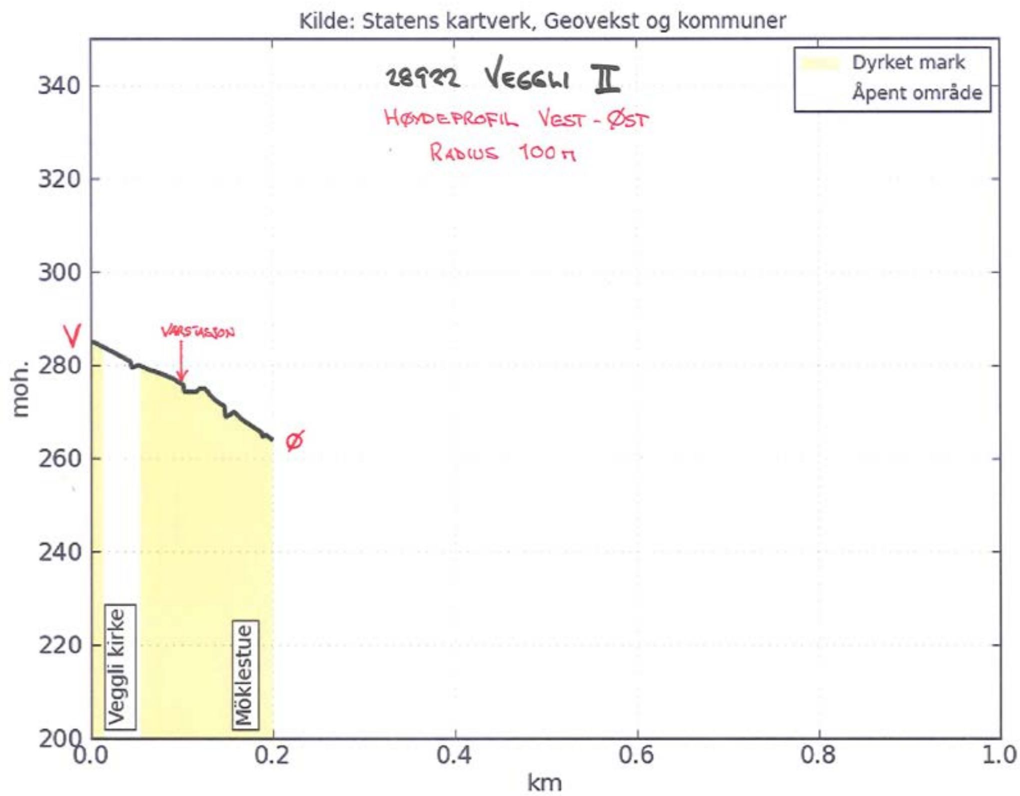
Radius 30m

Height profile






Kilde: Statens kartverk, Geovekst og kommuner
28922 VEGGLI II
HØYDEPROFIL VEST-ØST
RADIUS 1 KM
Skog
Dyrket mark
Åpent område
Tett bebyggelse
VÆRSTASJON
Øvre-Tveiten
Søre Bjørkgarden
moh.
km


Kilde: Statens kartverk, Geovekst og kommuner
28922 VEGGLI II
HØYDEPROFIL VEST-ØST
RADIUS 100 m
Dyrket mark
Åpent område
VÆRSTASJON
Veggli kirke
Möklestue
moh.
km

Classifying matrix – Summary

Class	1	2	3	4	5
Slope	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)*	*No require-ments*	*No require-ments*	*No require-ments*
Vegetation	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<10 cm) representative of the region*	*Ground covered with natural and low vegetation (<25 cm) representative of the region*	*No require-ments*	*No require-ments*
Distance to **Heat Sources/ Water bodies (HS/WB)**	*Measurement point is situated more than 100 m from HS/WB* *or* *S/WB occupies less than* *a) <10% of a 100 m circle* *b) <5% of an annulus of 10-30m* *c) <1% of a 10 m circle*	*Measurement point is situated more than 30 m from HS/WB* *or* *HS/WB occupies less than* *a) <10% of a 30 m circle* *b) <5% of an annulus of 5-10m* *c) <1% of a 5 m circle*	*Measurement point is situated more than 10 m from HS/WB* *or* *HS/WB occupies less than* *c) <10% of a 10 m circle* *d) <5% of a 5 m circle*	*HS/WB occupies less than* *a) <50% of a 10 m circle* *b) <30% of a 3 m circle*	*No require-ments*
Not i shadow when sun is above …	*5°*	*7°*	*7°*	*20°*	*No require-ments*

10 Kongsberg Brannstasjon (Norway)

Temperature Classification Scheme

Station number: **28380**	**Station name:** **Kongsberg Brannstasjon**
Date: 01.09.2015	**Performed by:** **Ted Torfoss**
WMO Classification:	**5**

Site description:

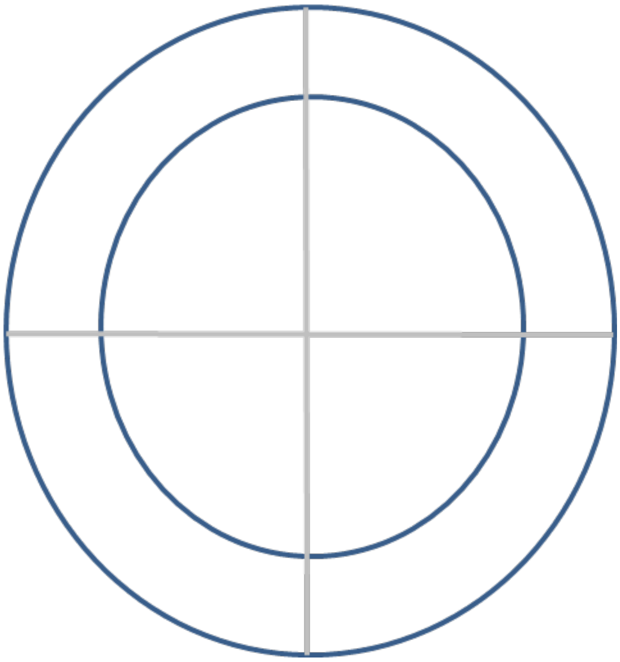
Sensor height (10 cm accuracy)	200cm
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □ heathland **X** grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X** sub-urban □ urban □ rural specify: Buildings around, but approx. 100m to forest
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	5cm/195cm
Photographs to 8 different	□ N □ NE □ E □ SE □ S □ SW □ W □NW

directions	X Panorama

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
300-90°	7-30m		350m²	Road of asvalt. 12,5% of total area within the radius of 30m
120-300°	13-30m		750m²	Parking lot of asvalt. 26,5% of total area within the radius of 30m
170-220°	25m		75m²	Building. 2,5% of total area within the radius of 30m
0-360°	7-30m		29325m²	Roads, buildings, parking lots, etc constitutes 93% of the total area within the radius of 100m.
105-120°	30m	17°		Grantre (fir tree)
195-235	35m	26°		Pine trees

Circle of angles



Photograph taken by fish-eye camera ☐

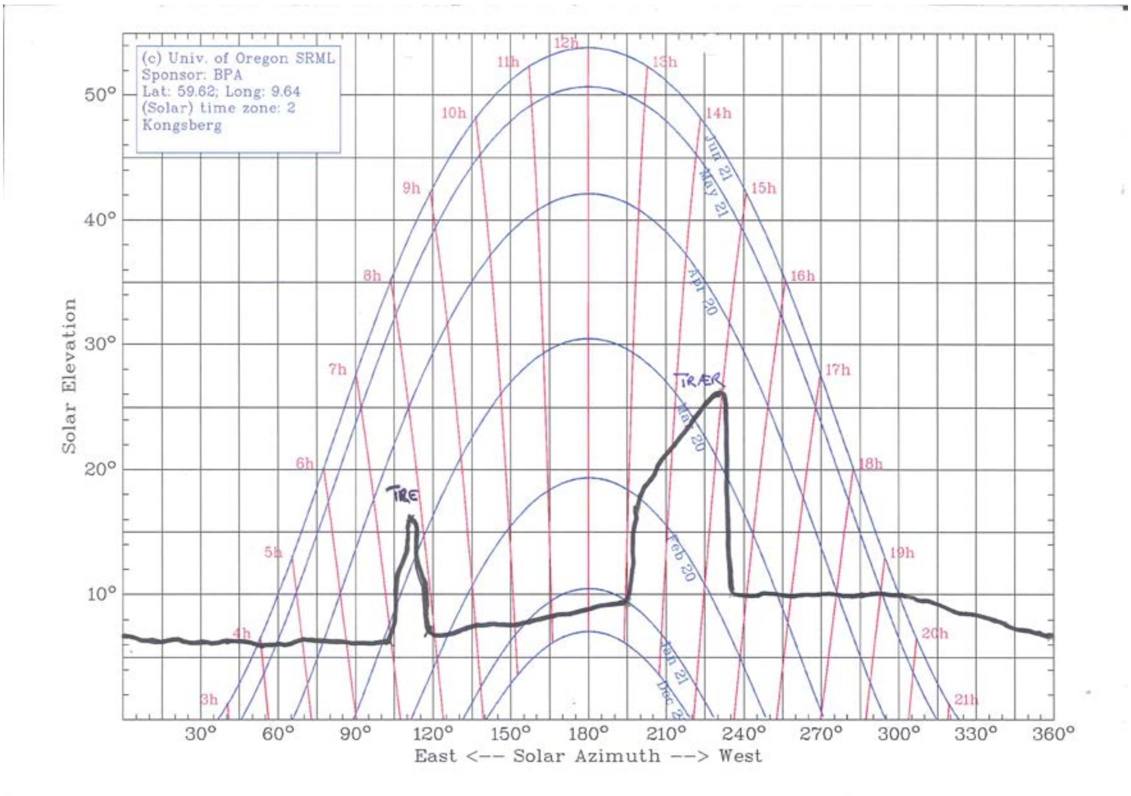
Comments	

Photos weather station

Panorama of weather station North-East-South

Panorama photo of weather station South-West-North

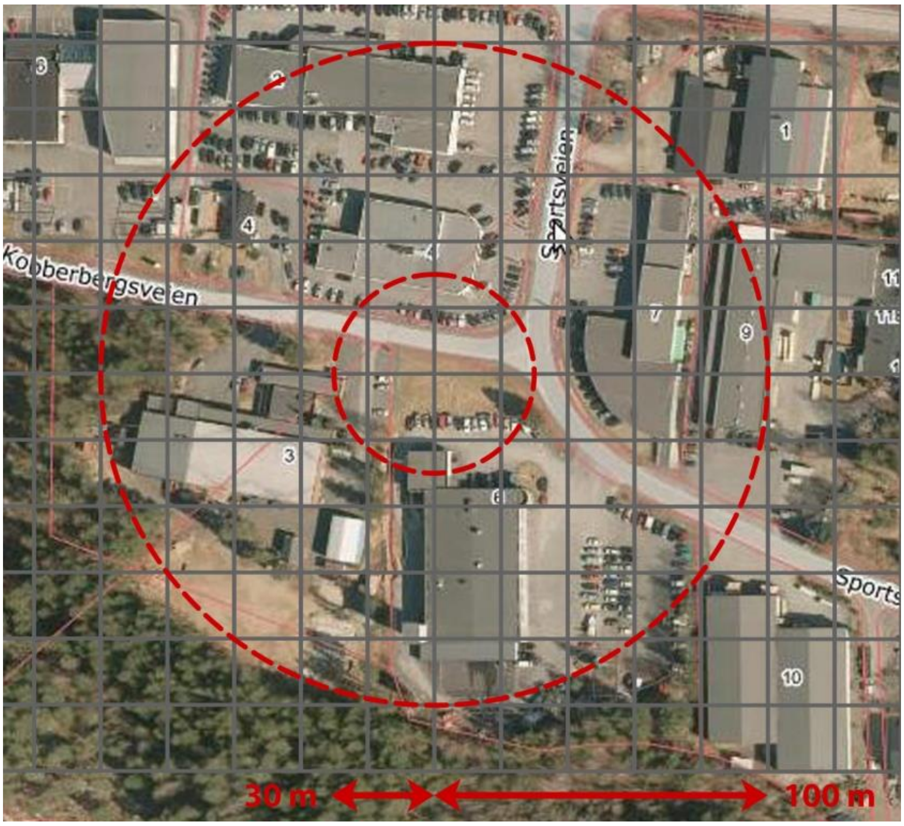
Sun elevation chart



Shades on the sensor , due to trees, in February, March, September, October.

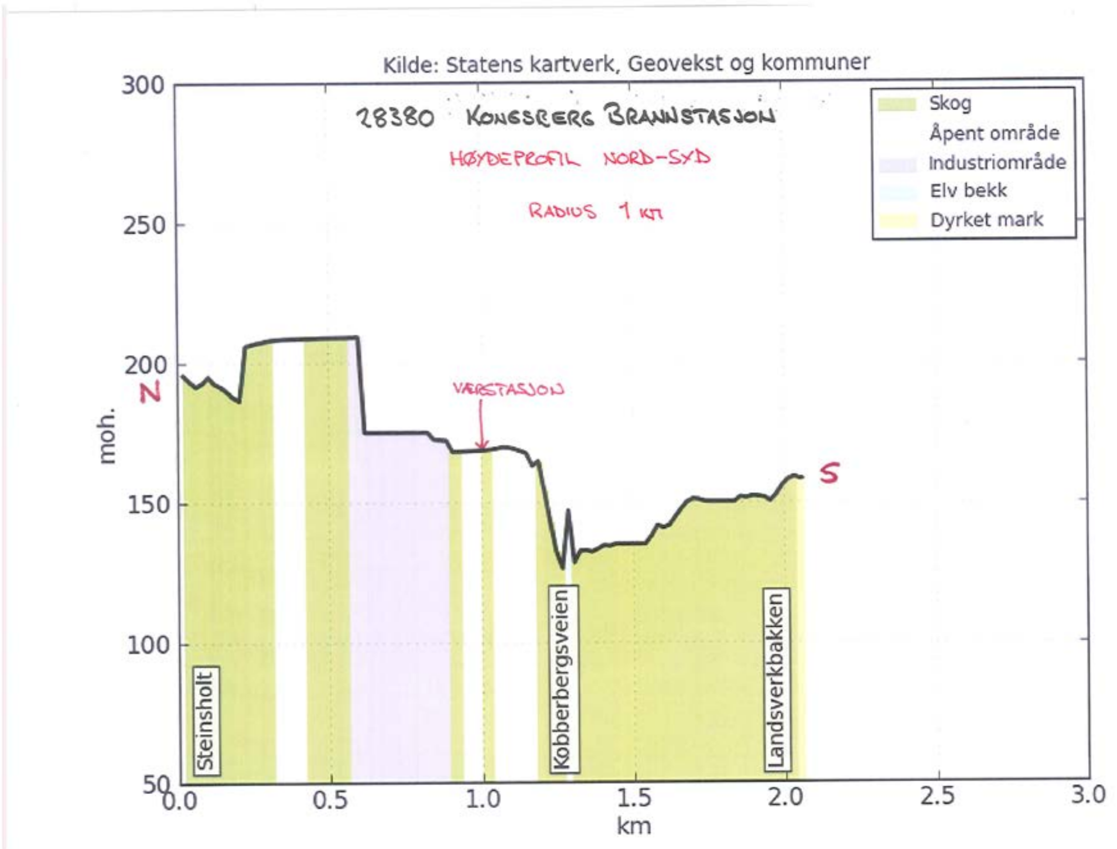
Satellite image with scale

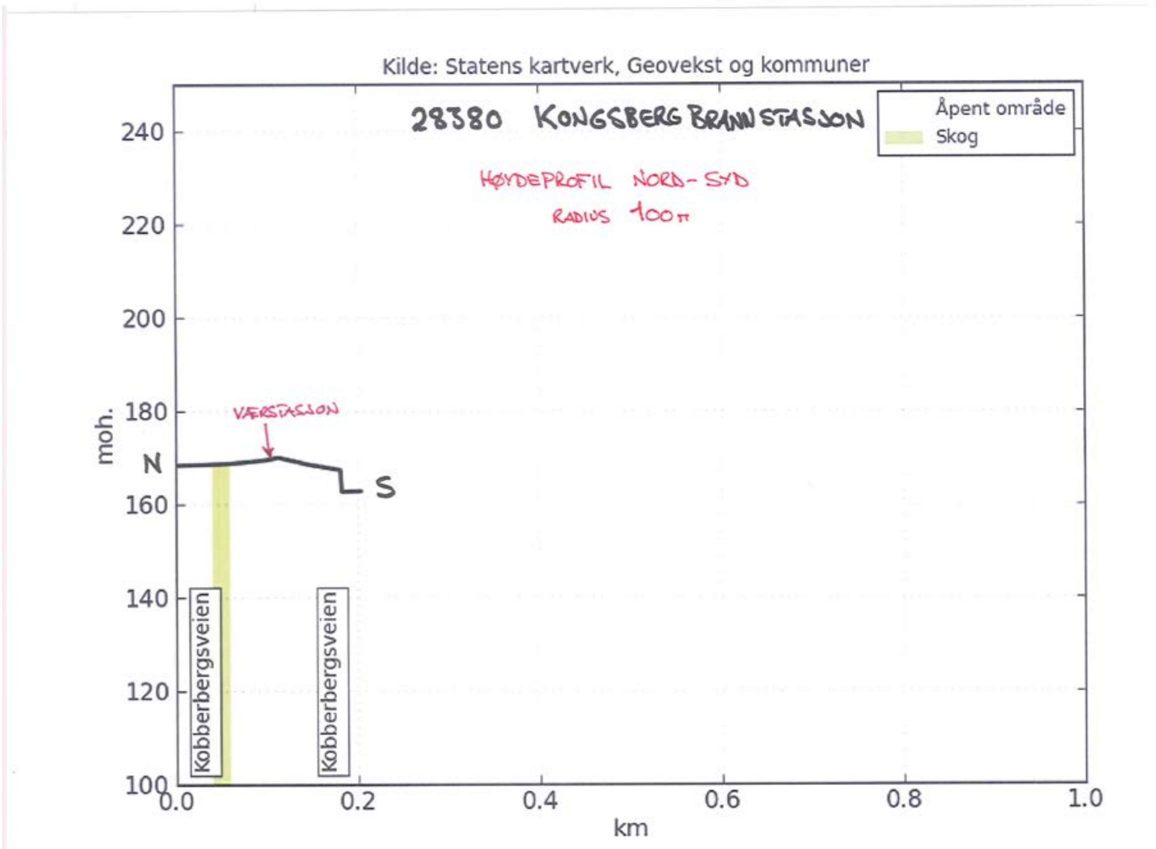
Radius 30m

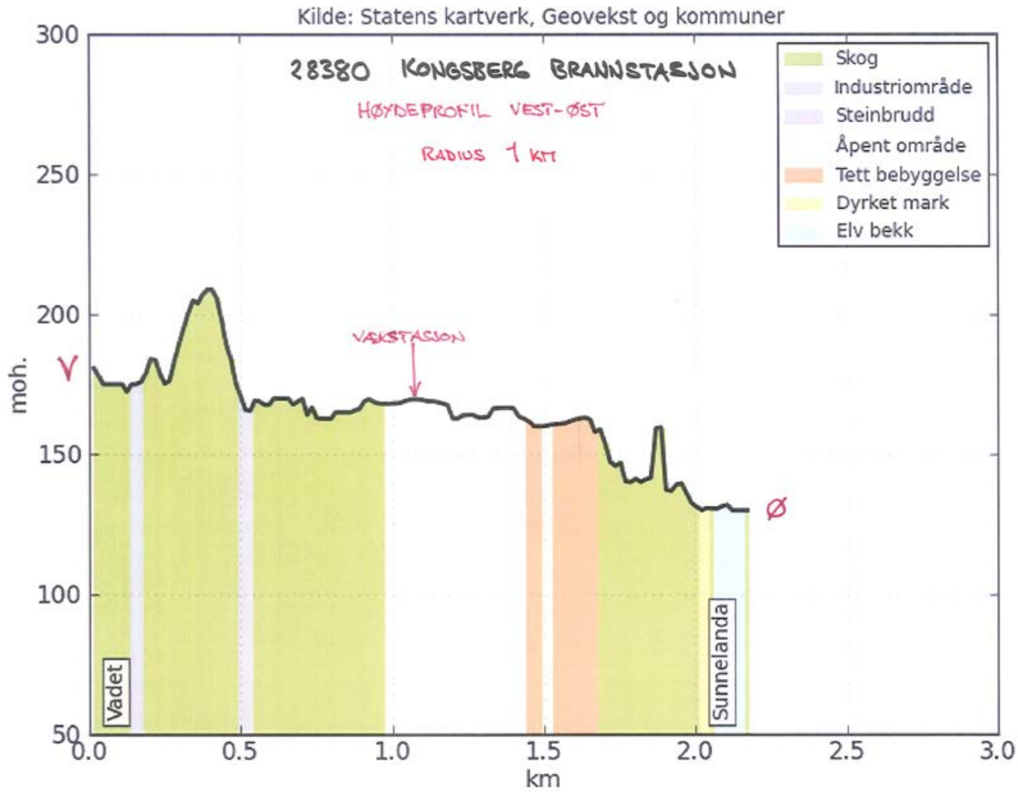


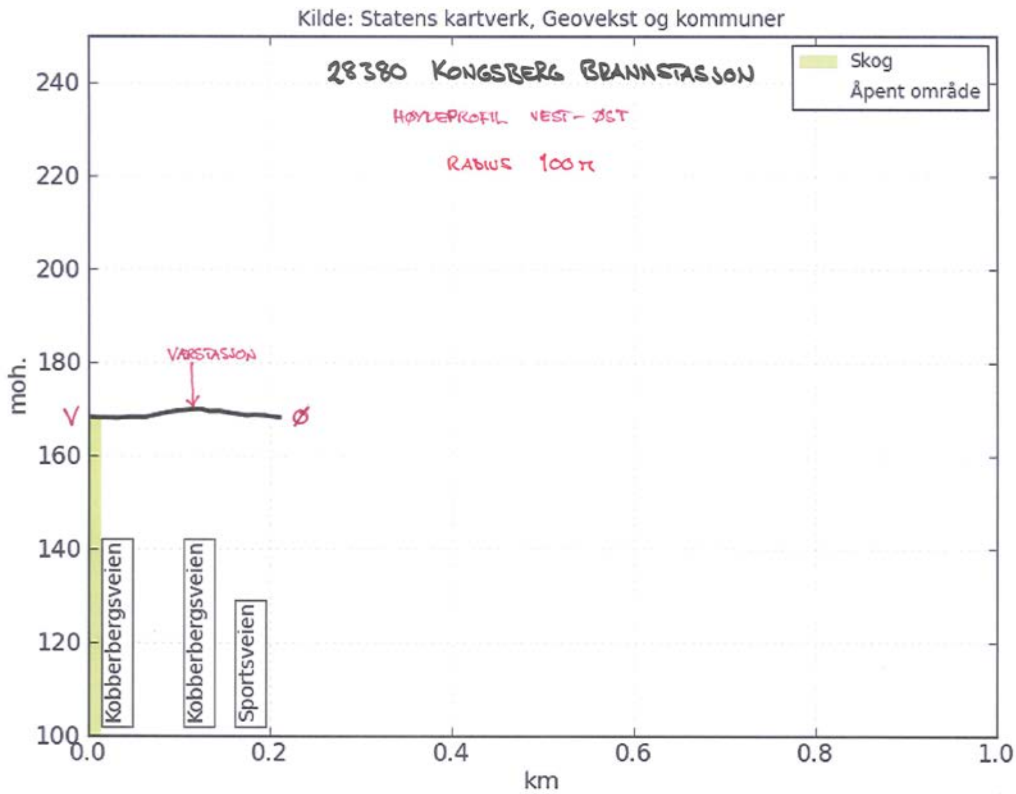
Radius 100m

Height profile






Kilde: Statens kartverk, Geovekst og kommuner
28380 KONGSBERG BRANNSTASJON
HØYDEPROFIL VEST-ØST
RADIUS 1 KM
Skog
Industriområde
Steinbrudd
Åpent område
Tett bebyggelse
Dyrket mark
Elv bekk
VÆRSTASJON
V
Ø
Vadet
Sunnelanda
moh.
km


Kilde: Statens kartverk, Geovekst og kommuner
28380 KONGSBERG BRANNSTASJON
HØYDEPROFIL VEST-ØST
RADIUS 100 M
Skog
Åpent område
VÆRSTASJON
V
Ø
Kobberbergsveien
Kobberbergsveien
Sportsveien
moh.
km

Classifying matrix – Summary

Class	1	2	3	4	5
Slope	Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)	Flat horizontal land, surrounded by an open space, slope less than 1/3 (19°)	No require-ments	No require-ments	No require-ments
Vegetation	Ground covered with natural and low vegetation (<10 cm) representative of the region	Ground covered with natural and low vegetation (<10 cm) representative of the region	Ground covered with natural and low vegetation (<25 cm) representative of the region	No require-ments	No require-ments
Distance to **Heat Sources/ Water bodies (HS/WB)**	Measurement point is situated more than 100 m from HS/WB or S/WB occupies less than a) <10% of a 100 m circle b) <5% of an annulus of 10-30m c) <1% of a 10 m circle	Measurement point is situated more than 30 m from HS/WB or HS/WB occupies less than a) <10% of a 30 m circle b) <5% of an annulus of 5-10m c) <1% of a 5 m circle	Measurement point is situated more than 10 m from HS/WB or HS/WB occupies less than c) <10% of a 10 m circle d) <5% of a 5 m circle	HS/WB occupies less than a) <50% of a 10 m circle b) <30% of a 3 m circle	No require-ments
Not i shadow when sun is above …	5°	7°	7°	20°	No require-ments

11 Vilsandi (Estonia)

Temperature Classification Scheme

Station number: 26214 Class: 5 (1-1-2-5)	Station name: Vilsandi
Date: 17.07.2015	Performed by: E. Tillmann, M. Krabbi, K. Loodla

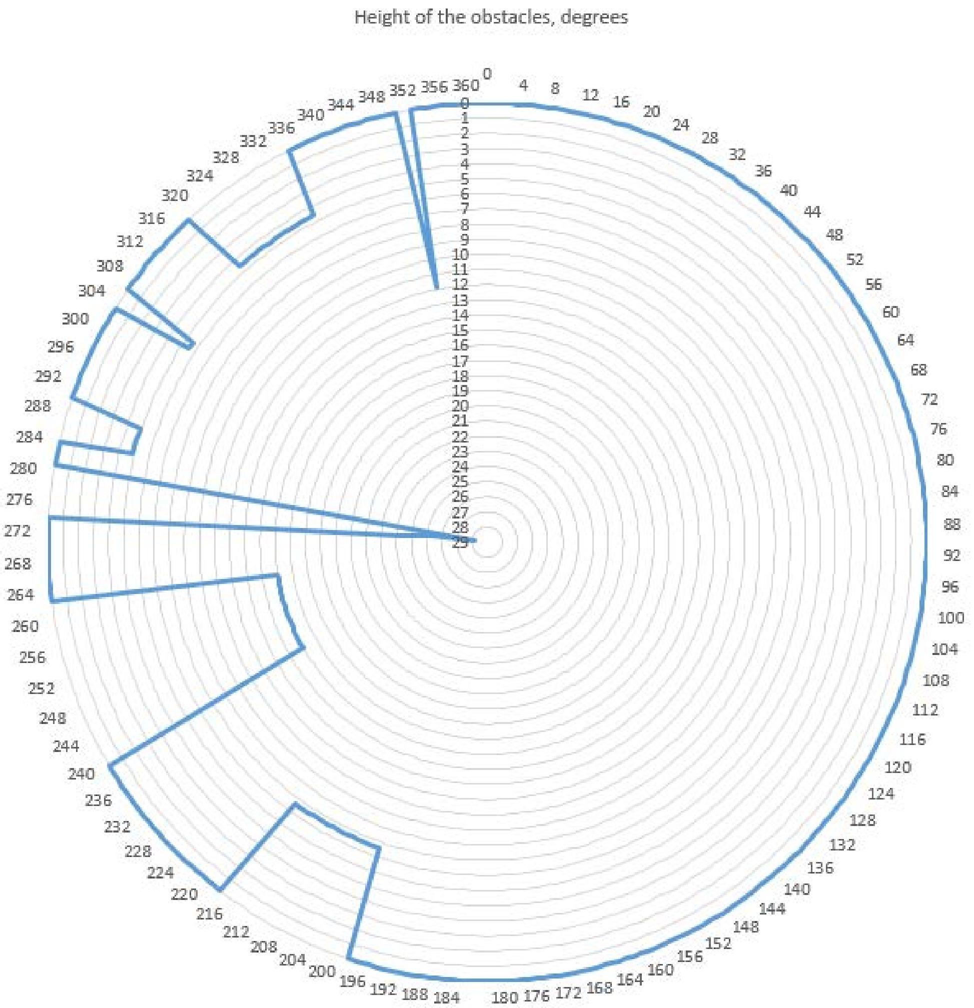
Site description:

Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands X grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ flat □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular X coast X island □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify:
Amount of water systems (in 1 km radius)	X island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	190 cm
Photographs to 8 different directions	X N X NE X E X SE X S X SW X W X NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance (m)	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
200 - 217	38,7	7,0/7,6		House
241 - 262	19,0	7,0/15,0		House of weather station
275 - 280	84,0	38,0/28,0		Lighthouse
285 - 289	40,0	5,0/4,9		Woodshed
304 - 305	29,0	4,0/5,5		Woodshed
319 - 333	19,0	3,0/4,55		Woodshed
350	25,5	7,0/5,3		Tree

Circle of angles

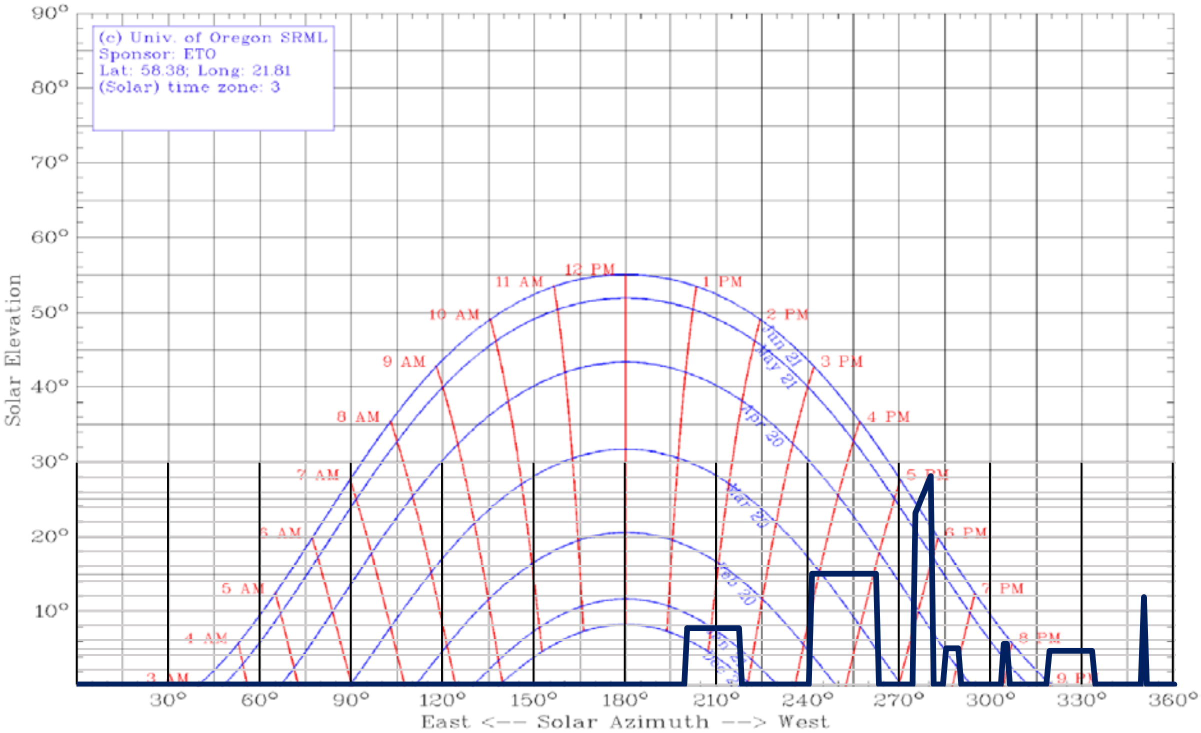


Photograph taken by fish-eye camera ☐

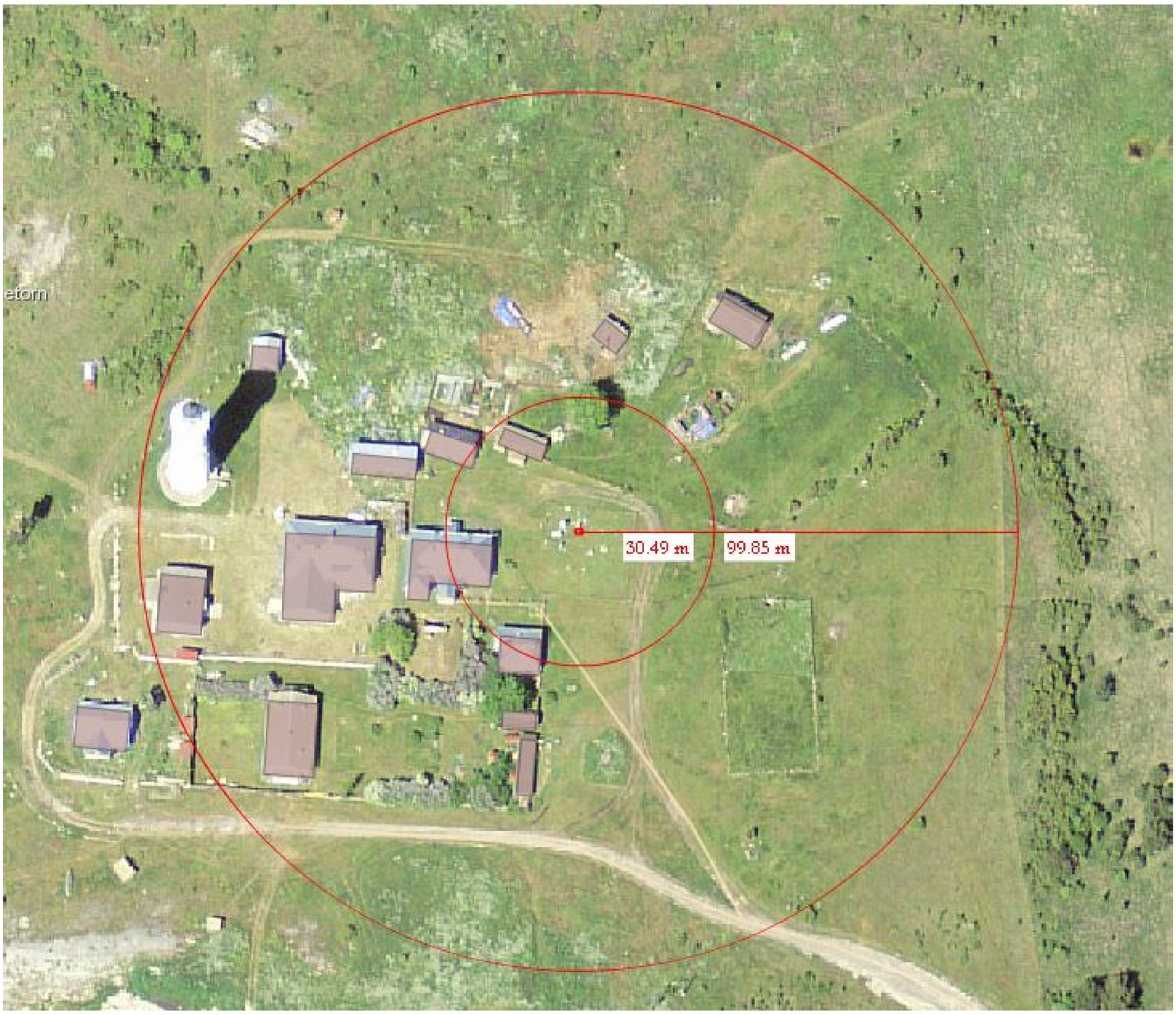
Comments	

Sun elevation

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale



Photographs

N

NE

E

SE

S

SW

W

NW

12 Viljandi (Estonia)

Temperature Classification Scheme

Station number: 26233 Class: 5 (1-1-2-5)	Station name: Viljandi
Date: 22.06.2015	Performed by: M. Krabbi

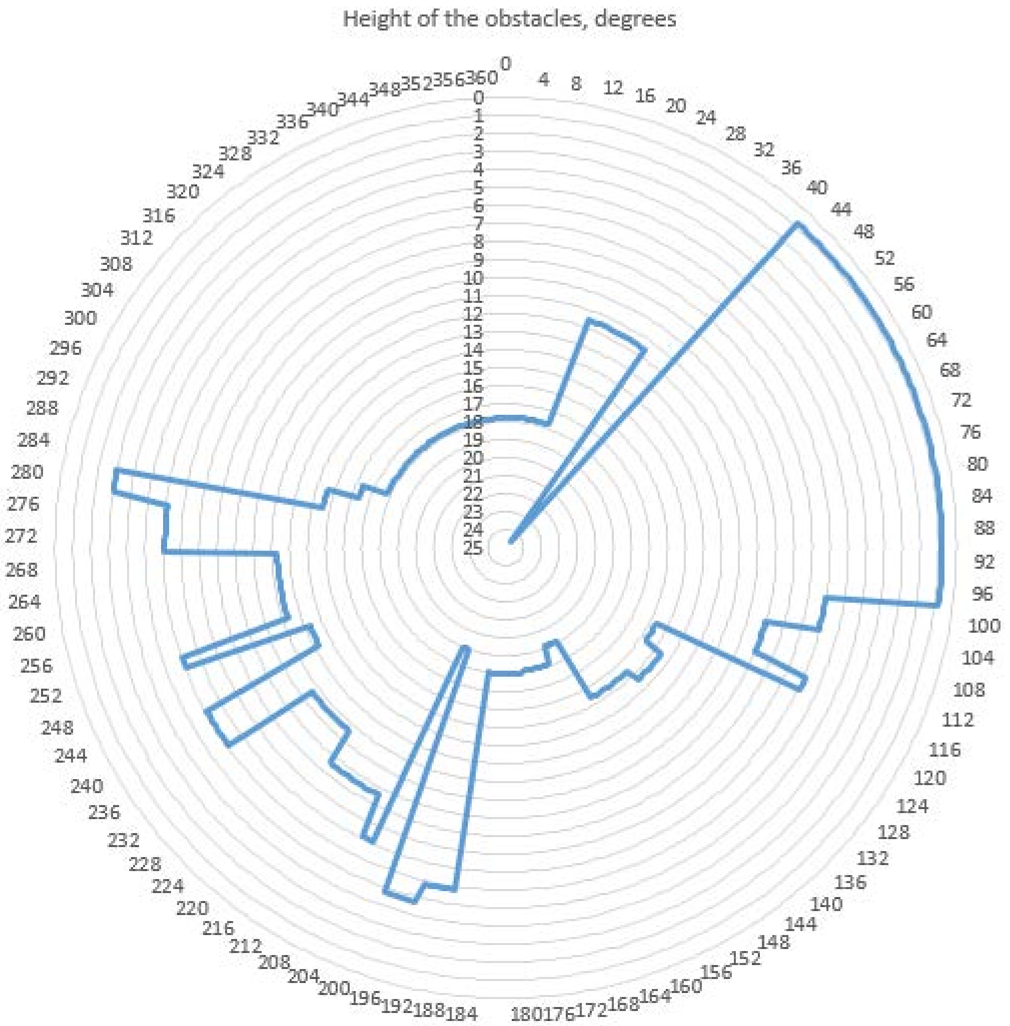
Site description:

Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship X inland □ heathland □ mid-highlands X grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	x flat □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ island □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop X sub-urban □ urban specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) X (<10%) Rivers: □ (>30%) □ (10-30%) X (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	190 cm
Photographs to 8 different directions	X N X NE X E X SE X S X SW X W X NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance (m)	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
1 - 19	40,0	14,0/17,75		Alley
20 - 35	80,0	18,0/11,55		Trees
36 - 41	27,2	18,0/11,55		Tree
42 - 98	92,7	3,0/0,8		House
99 - 105	61,6	9,0/7,05		Tree
106 - 113	51,4	10,0/10,0		Tree
114 - 116	47,4	7,0/6,9		Trees
117 - 124	44,5	14,0/15,65		Tree
125 - 135	43,0	12,4/14,6		Tree
136 - 151	39,8	12,0/15,4		Tree
152 - 159	38,0	14,0/19,1		Birch
160 - 172	40,6	14,0/18,1		Tree
173 - 188	42,8	15,0/18,0		Tree
189 - 194	54,0	7,0/5,8		Tree
195 - 200	68,0	6,0/4,7		House
201 - 204	68,0	24,0/19,0		Birch
205 - 220	72,3	13,0/9,6		Tree
221 - 234	56,0	12,7/11,6		Tree behind the house
235 - 242	39,4	5,5/6,1		House
243 - 249	65,9	16,8/13,3		Tree behind the house
250 - 252	34,7	5,4/6,1		House
253 - 269	65,9	16,8/12,3		Tree behind the house
270 - 278	39,4	5,4/6,1		House
279 - 282	114,0	6,0/3,0		Bushes
283 - 289		12,0/14,6		Tree
290 - 294		13,0/16,4		Tree
295 - 360	40,0	14,0/17,8		Alley

Circle of angles

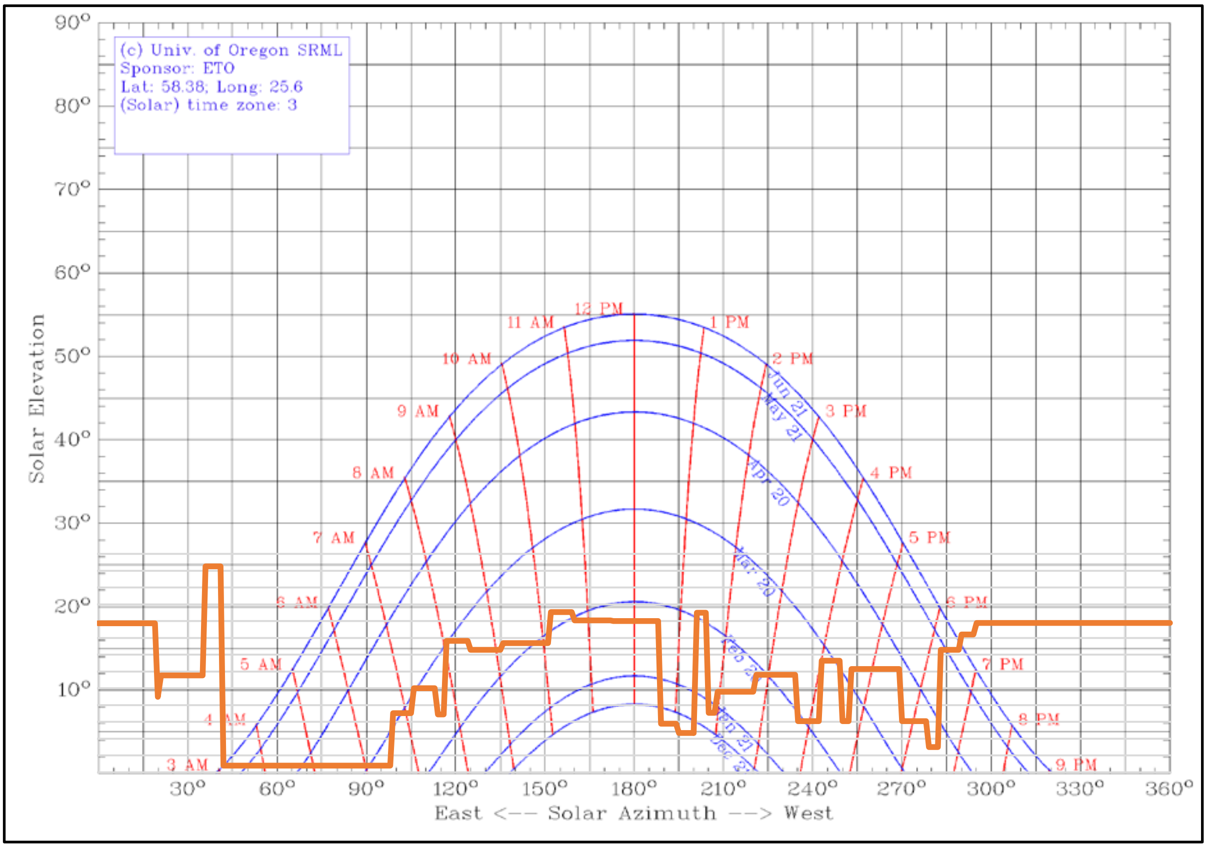


Photograph taken by fish-eye camera ☐

Comments	

Sun elevation

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

Photographs

N

NE

E

SE

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SW

W

NW

13 Väike-Maarja (Estonia)

Temperature Classification Scheme

Station number: 26141 Class: 1 (1-1-1-1)	Station name: Väike-Maarja
Date: 26.05.2015	Performed by: E. Tillmann, M. Krabbi

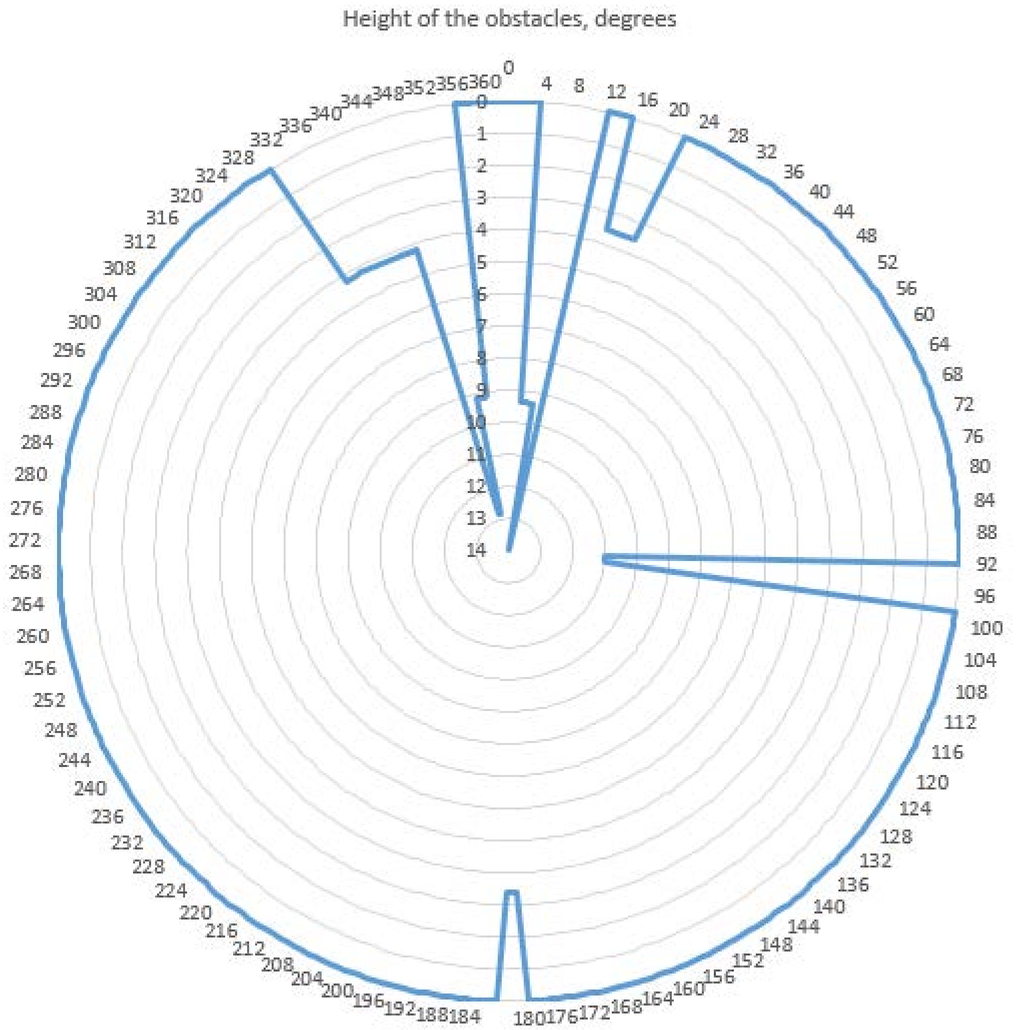
Site description:

Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship X inland □ heathland □ mid-highlands X grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	x flat □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ island □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify: Middle part of the top of the uplands, absolute height more than 100 m, coverage 1100 km^2
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify: ponds (<10%)
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	190 cm
Photographs to 8 different directions	X N X NE X E X SE X S X SW X W X NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance (m)	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
5 - 9	44,1	8,4/9,35		House of the weather station
10 - 12	33,5	9,5/13,95		Tree
17 - 22	59,0	5,0/3,55		Woodshed
93 - 97	25,0	6,0/11,0		Apple tree
179 - 181	45,0	3,9/3,4		Tree
330 - 344	35,0	4,0/4,2		Hedge
345 - 348	46,0	11,8/12,8		Birch
349 - 353	44,0	8,0/9,15		Tree

Circle of angles

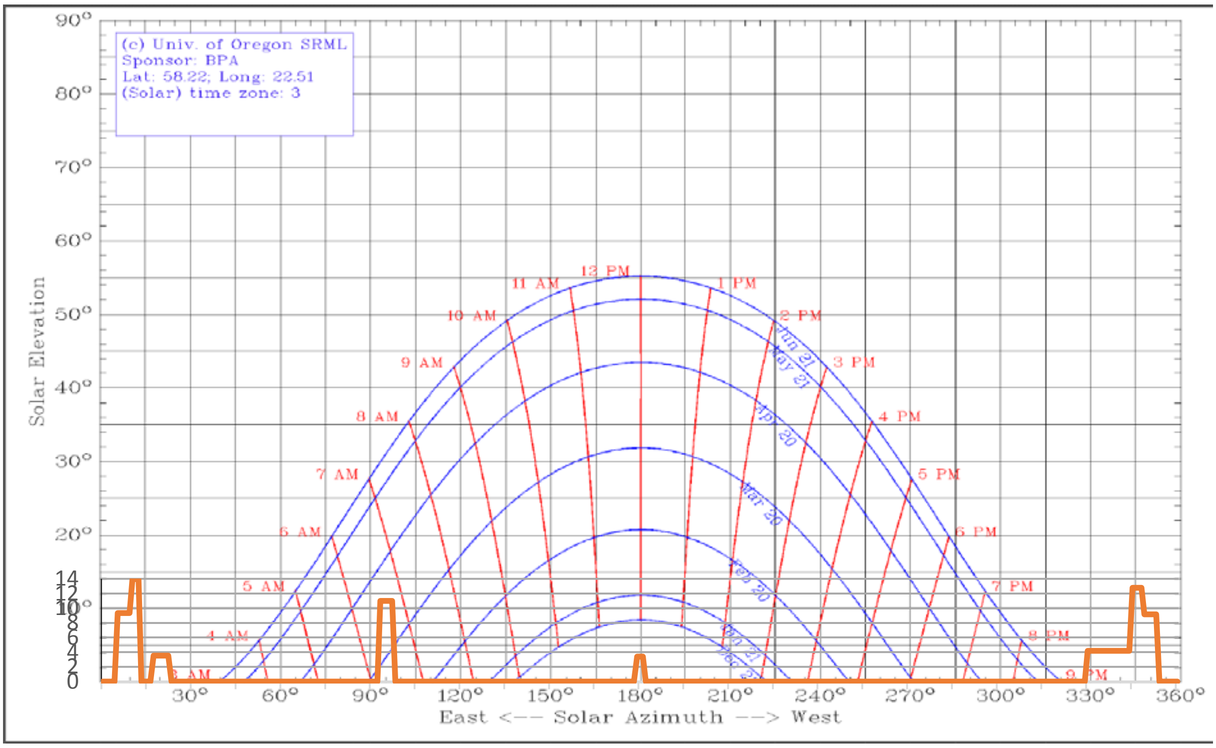


Photograph taken by fish-eye camera ☐

Comments	

Sun elevation

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

Photographs

N

NE

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SE

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SW

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NW

14 Sõrve (Estonia)

Temperature Classification Scheme

Station number: 26218 Class: 2 (1-1-2-1)	Station name: Sõrve
Date: 16.07.2015	Performed by: E. Tillmann, M. Krabbi, K. Loodla

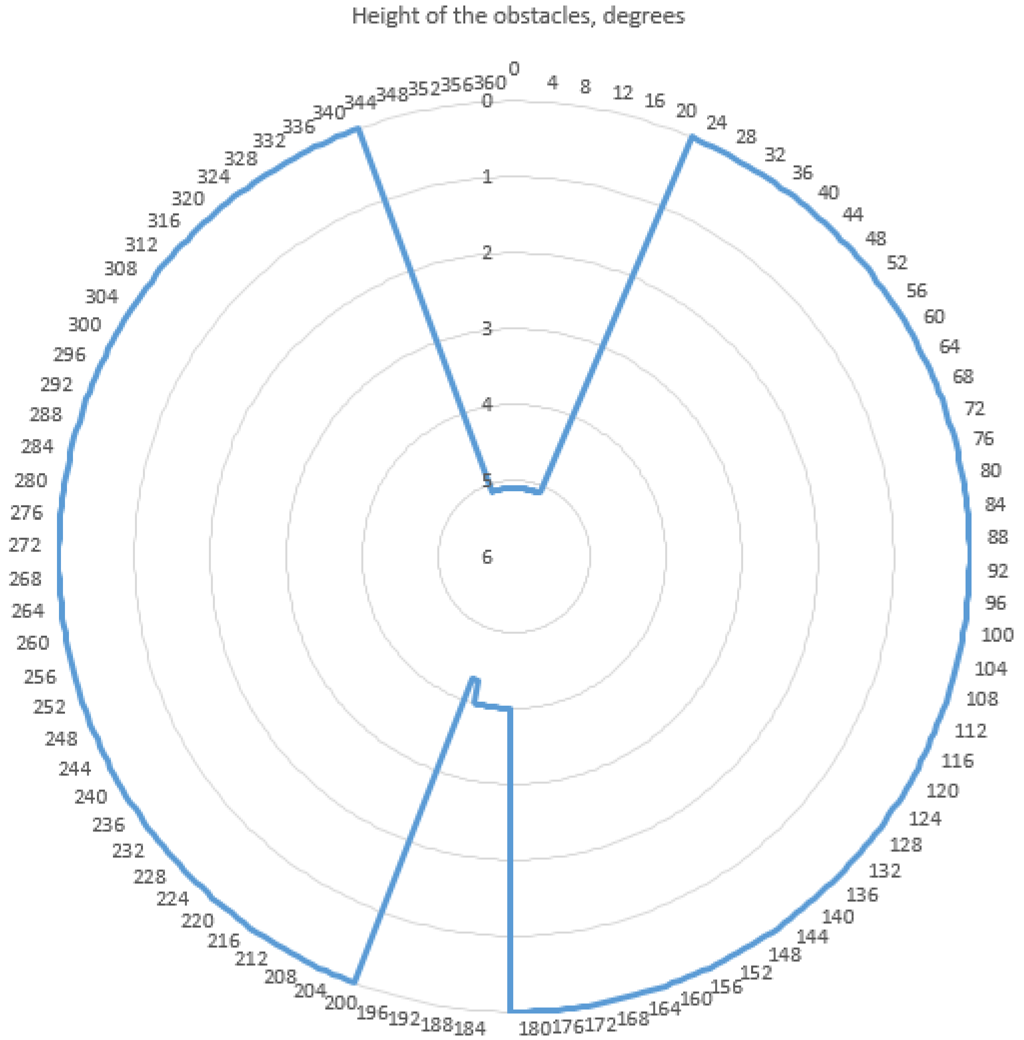
Site description:

Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □ inland □ heathland □ mid-highlands X grass X bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ flat □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain X peninsular X coast □ island □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) X coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify: Peninsula 30-50%, sea >30% (<60%)
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	190 cm
Photographs to 8 different directions	X N X NE X E X SE X S X SW X W X NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance (m)	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
0 - 22	30,0	4,0/5,1		Trees
182 - 196	145,0	11,0/4,0		House
197 - 200	120,0	10,0/4,3		Trees
342 - 360	30,0	4,0/5,1		Trees

Circle of angles

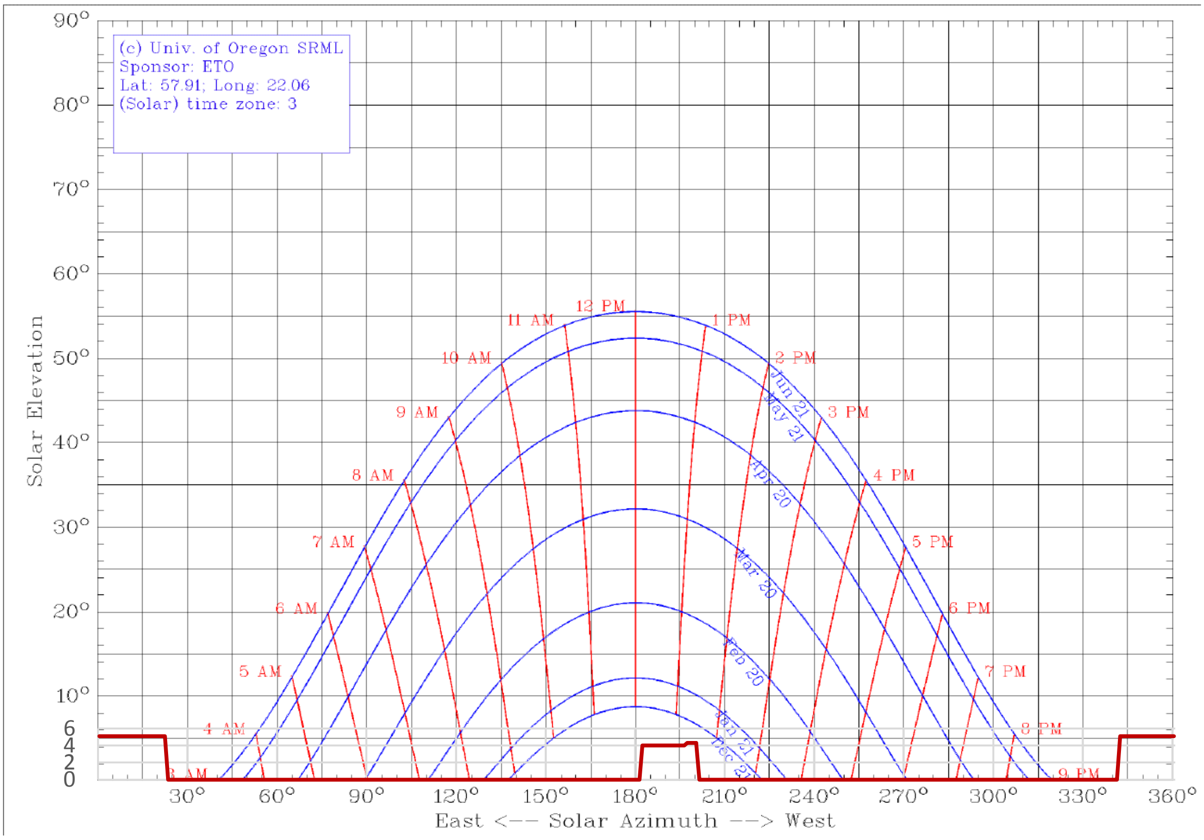


Photograph taken by fish-eye camera ☐

Comments	

Sun elevation

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

Photographs

N

NE

E

SE

S

SW

W

NW

15 Roomassaare (Estonia)

Temperature Classification Scheme

Station number: 26215 Class: 2 (1-1-2-1)	Station name: Roomassaare
Date: 16.07.2015	Performed by: E. Tillmann, M. Krabbi, K. Loodla

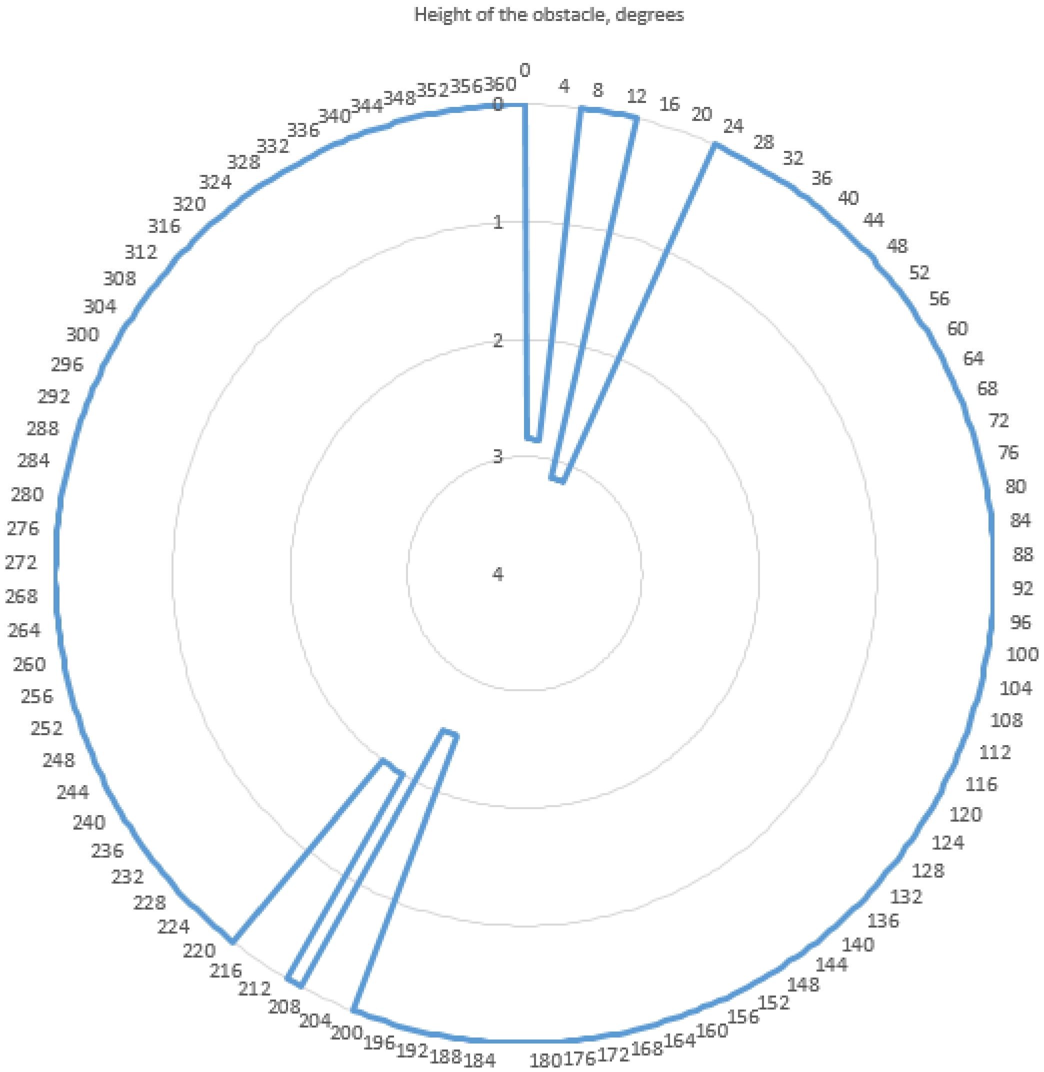
Site description:

Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands X grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ flat □ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain X peninsular X coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify: harbour
Amount of water systems (in 1 km radius)	□ island (50-100%) X coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	190 cm
Photographs to 8 different directions	X N X NE □ E X SE X S X SW X W X NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance (m)	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
1 - 6	260	14,0/2,85		Building
15 - 23	193	11,0/3,15		Group of trees
203 - 208	195	9,0/2,5		House
212 - 218	175	6,5/2,0		Cafe
270 - 300	33		605	Parking lot

Circle of angles

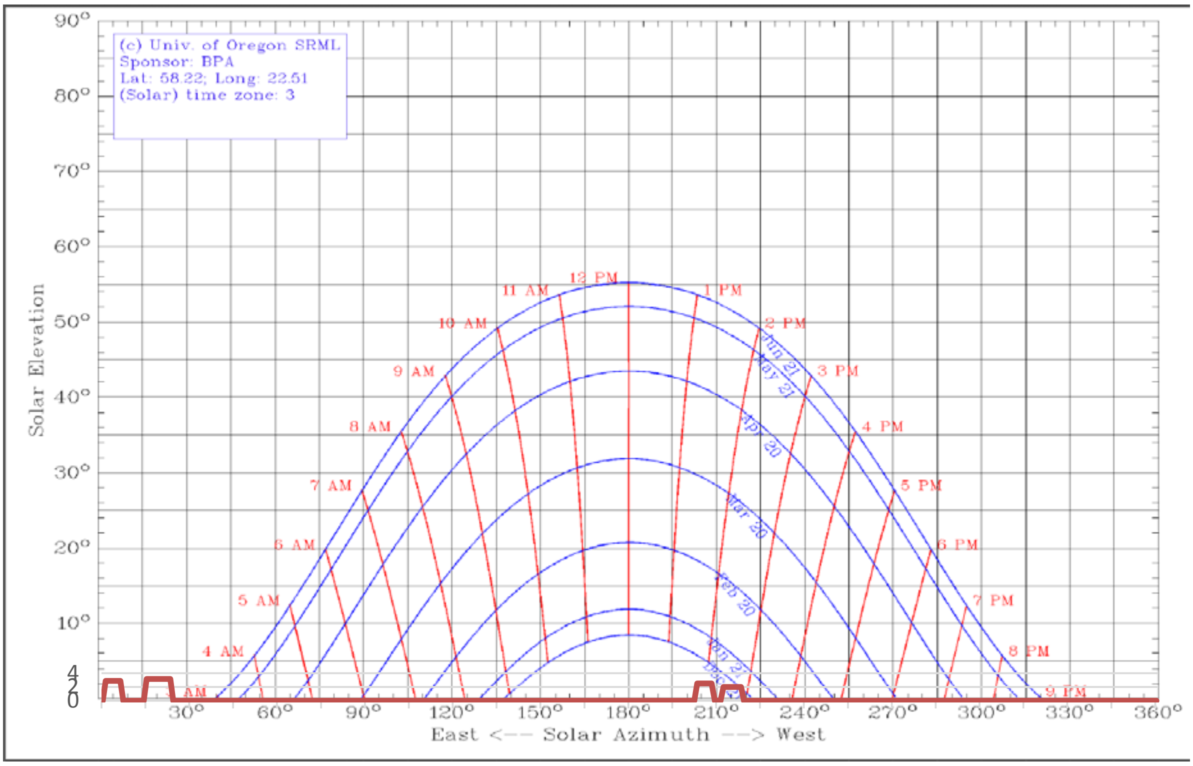


Photograph taken by fish-eye camera ☐

Comments	

Sun elevation

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

Photographs

N

NE

Missing

E

SE

S

SW

W

NW

16 Kuusiku (Estonia)

Temperature Classification Scheme

Station number: 26134 Class: 1 (1-1-1-1)	Station name: Kuusiku
Date: 13.05.2015	Performed by: E. Tillmann, K. Loodla

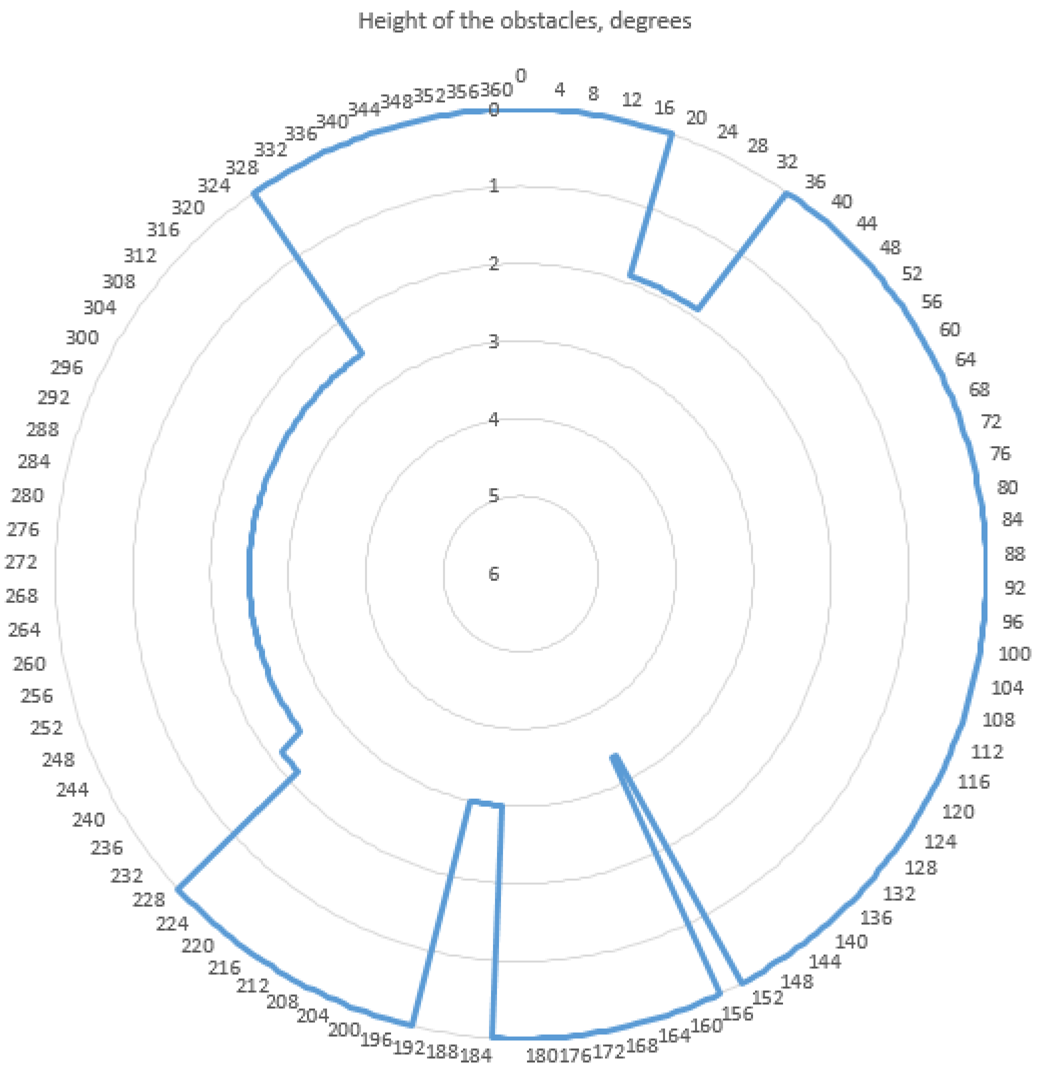
Site description:

Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: X < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship X inland □ heathland □ mid-highlands X grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ flat X slope □ upper slope X lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ island □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify: River valley (< 1^o)
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) X (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	190 cm
Photographs to 8 different directions	X N X NE X E X SE X S X SW X W X NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance (m)	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
20 - 34	200	7,0/1,9		cowhouse
153 - 154	90	7,0/3,35		Pole mast
185 - 193	144	8,0/3,0		Stable
229 - 234	150	5,0/2,15		Substation
235 - 325	260	14,0/2,5		Alley

Circle of angles

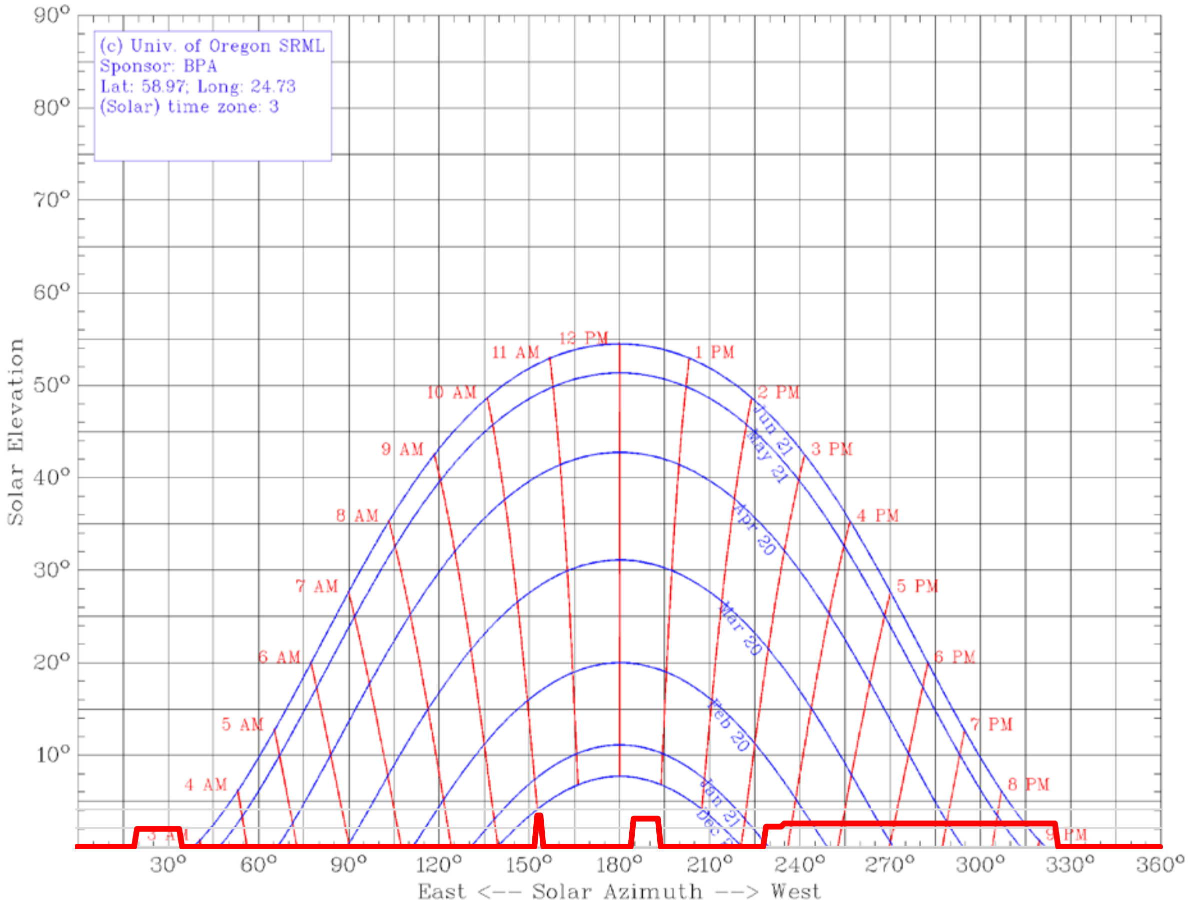


Photograph taken by fish-eye camera ☐

Comments	

Sun elevation

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

Photographs

N

NE

E

SE

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SW

W

NW

17 Målilla (Sweden)

Temperature Classification Scheme

Station number: 7525	**Station name:** Målilla A
Date: 150923	**Performed by:** Cristoffer Wittskog
WMO Classification: 2	Landscape: 1, Ground: 1, Heat sources: 2, Shading: 2

Site description:

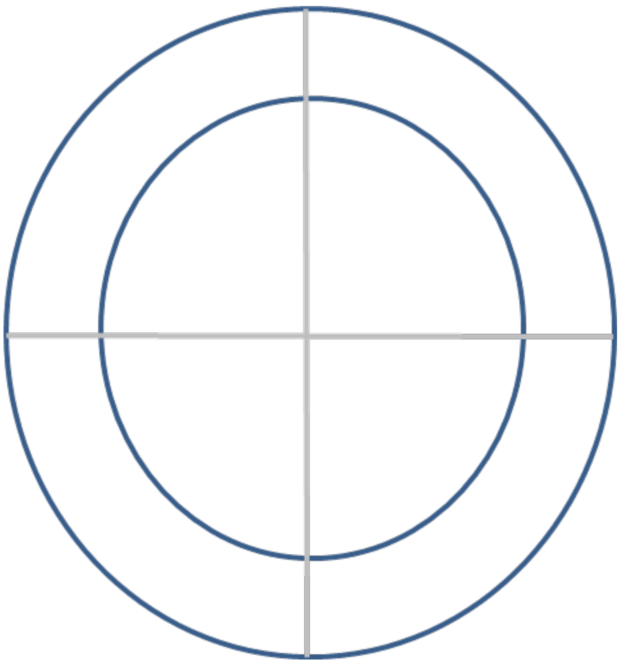
Sensor height (10 cm accuracy)	190 cm
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship **X inland** □ heathland □ mid-highlands **X grass** □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X sub-urban** □ urban specify: **farmland**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	180

Photographs to 8 different directions	**X N** □ NE **X E** □ SE **X S** □ SW **X W** □NW

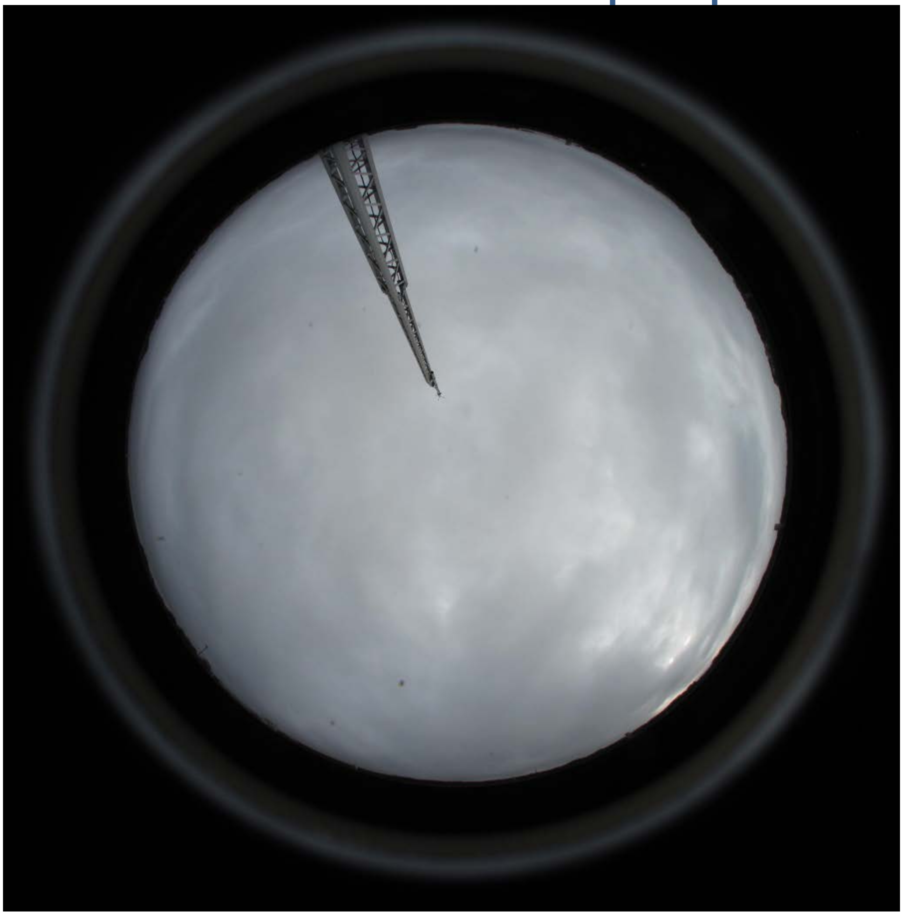
Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
180	20	-	384	Asphalt road

Circle of angles



Photograph taken by fish-eye camera | X |



N

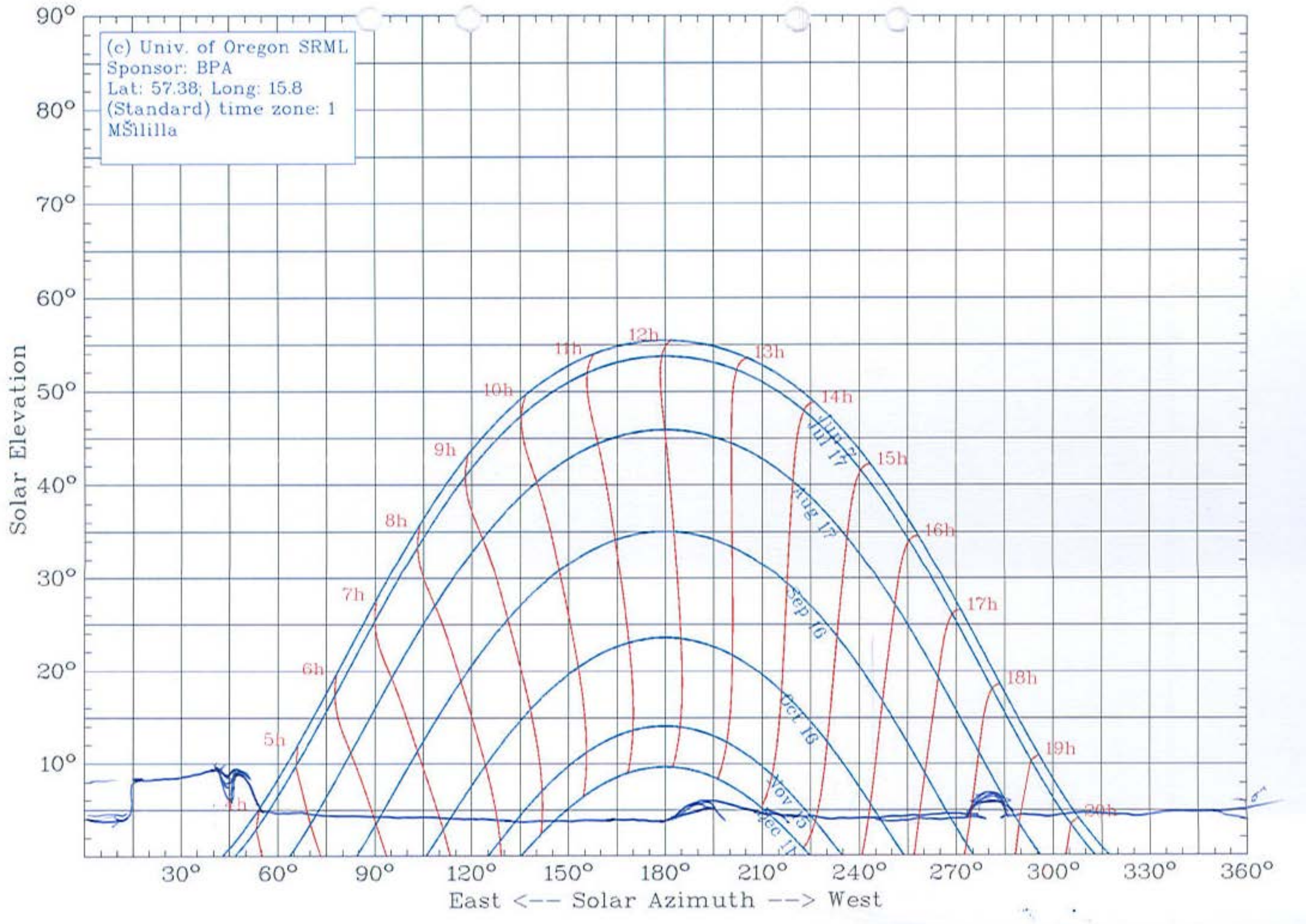
E

S W

Comments	

Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

18 Norrköping (Sweden)

Temperature Classification Scheme

Station number: 8634	**Station name:** Norrköping SMHI
Date: 150903	**Performed by:** Cristoffer Wittskog
WMO Classification: 5	Landscape: 1, Ground: 1, Heat sources: 3, Shading: 5

Site description:

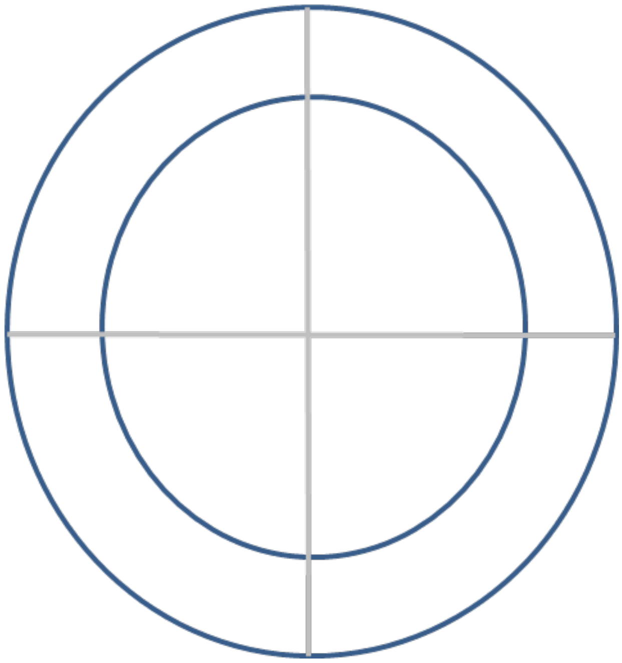
Sensor height (10 cm accuracy)	180 cm
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship **X inland** □ heathland □ mid-highlands **X grass** □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban **X urban** specify:
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	170

Photographs to 8 different directions	□ N □ NE □ E □ SE □ S □ SW □ W □NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
20	60	20		Trees
100-180	80-100	15		Buildings
180-270	10	-	480	Asphalt road

Circle of angles

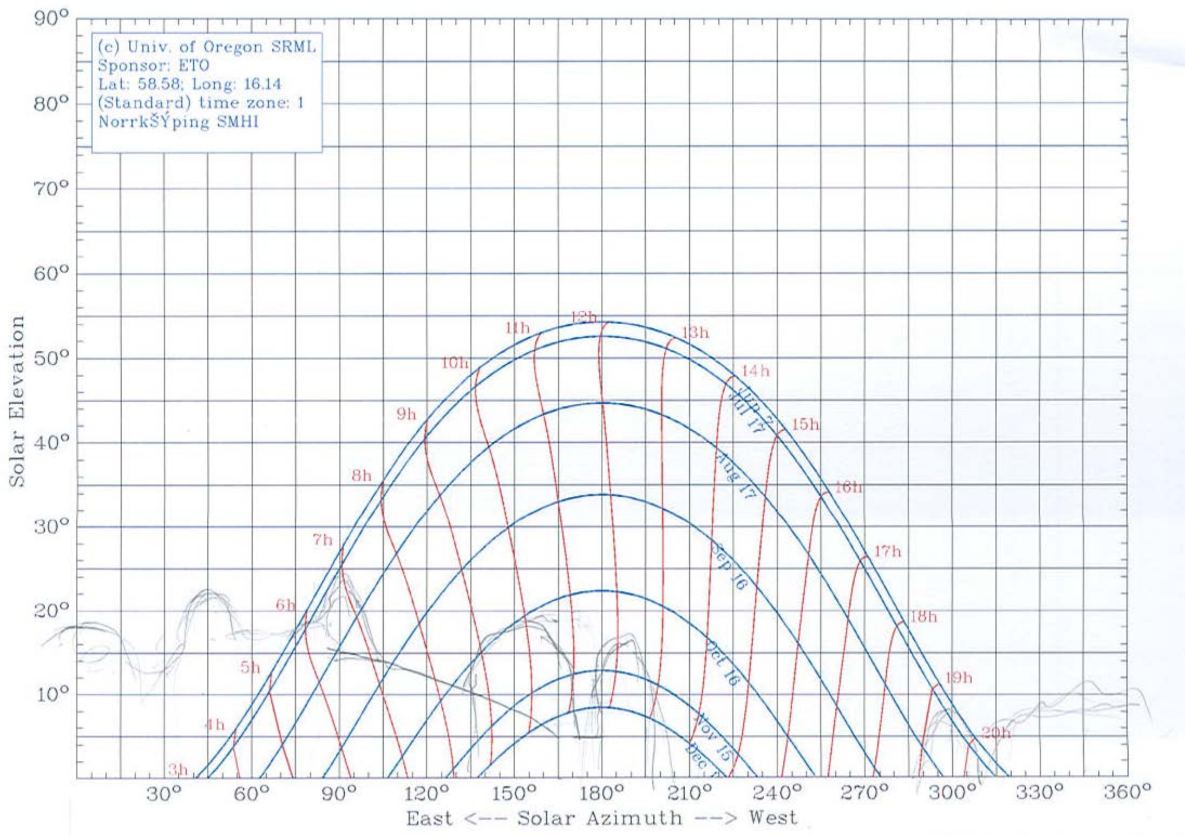


Photograph taken by fish-eye camera X

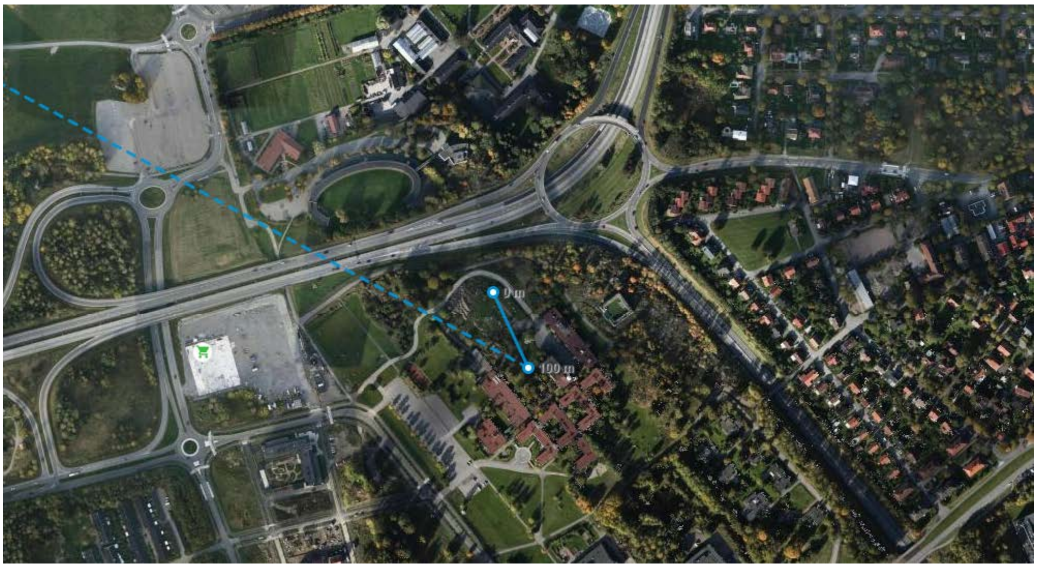
Comments	No photos due to problems with camera.

Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale



19 Kolmården-Strömsfors (Sweden)

Temperature Classification Scheme

Station number: 8642	**Station name:** Kolmården-Strömsfors A
Date: 150923	**Performed by:** Cristoffer Wittskog
WMO Classification: 5	Landscape: 3 (1?), Ground: 3, Heat sources: 3, Shading: 5

Site description:

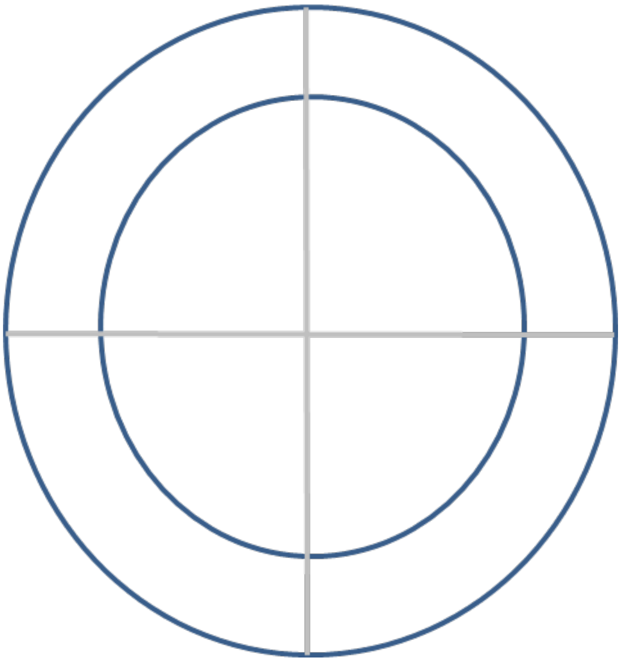
Sensor height (10 cm accuracy)	200 cm
Horizontal land	In 10m radius: **X< 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: □ < 5º **X < 10º** □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship **X inland** □ heathland □ mid-highlands □ grass **X bushes** □ sand □ asphalt □ not defined □ black sand **X rocks** specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill **X upper hill** □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X sub-urban** □ urban specify: **Woods**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	170

Photographs to 8 different directions	**X N** ☐ NE **X E** ☐ SE **X S** ☐ SW **X W** ☐NW

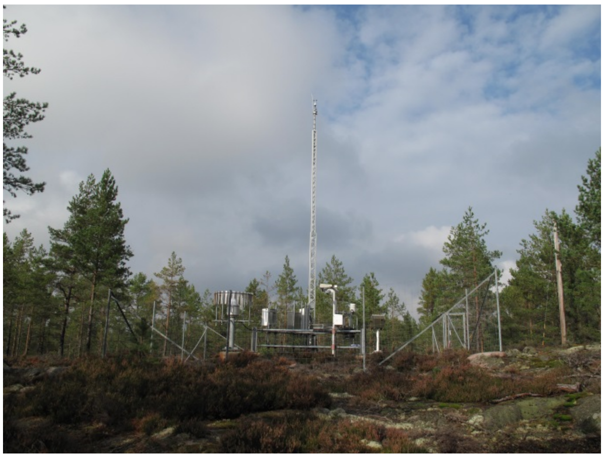
Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
0-360	5-10	15-30		Sparse pine trees

Circle of angles



Photograph taken by fish-eye camera X



N

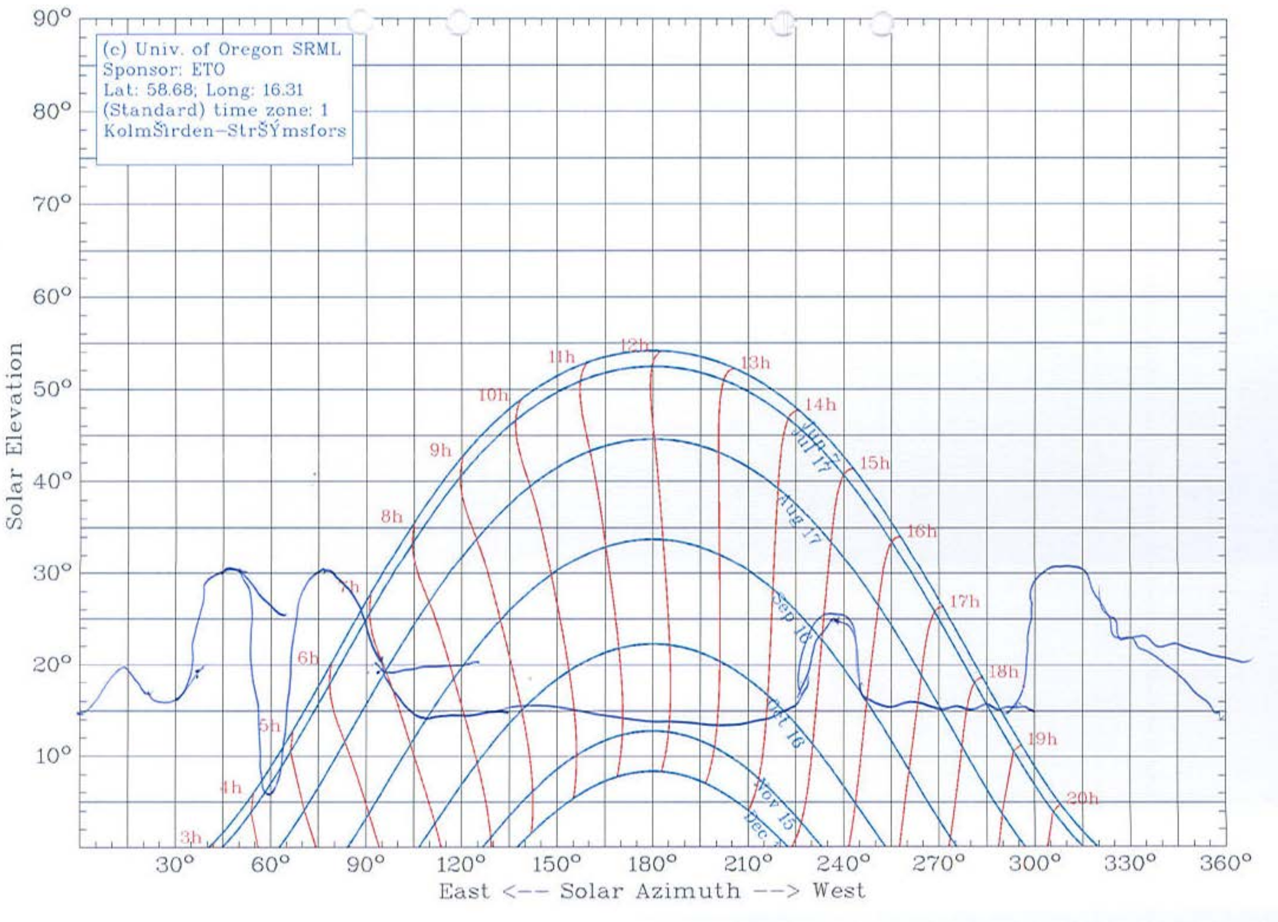
E

S W

Comments	

Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

20 Horn (Sweden)

Temperature Classification Scheme

Station number: 7552	**Station name:** Horn A
Date: 150907	**Performed by:** Cristoffer Wittskog
WMO-classification: 2	Landscape: 1, Ground: 1, Heat sources: 2, Shading: 1

Site description:

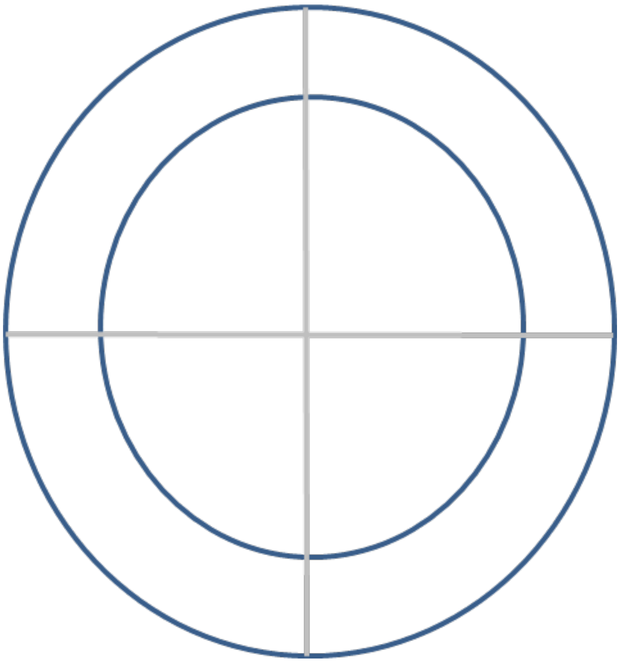
Sensor height (10 cm accuracy)	160 cm
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship **X inland** □ heathland □ mid-highlands **X grass** □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X sub-urban** □ urban specify: **farmland**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	150

Photographs to 8 different directions	**X N** ☐ NE **X E** ☐ SE **X S** ☐ SW **X W** ☐NW

Heat sources and obstacles

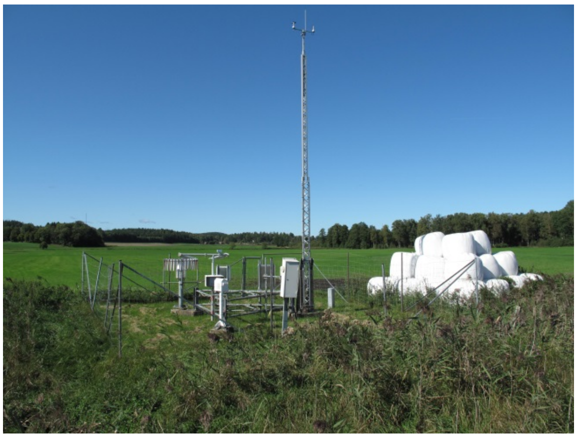
Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
45-120	10		28	Small river
90-180	10		240	Gravel road

Circle of angles



Photograph taken by fish-eye camera X

N E

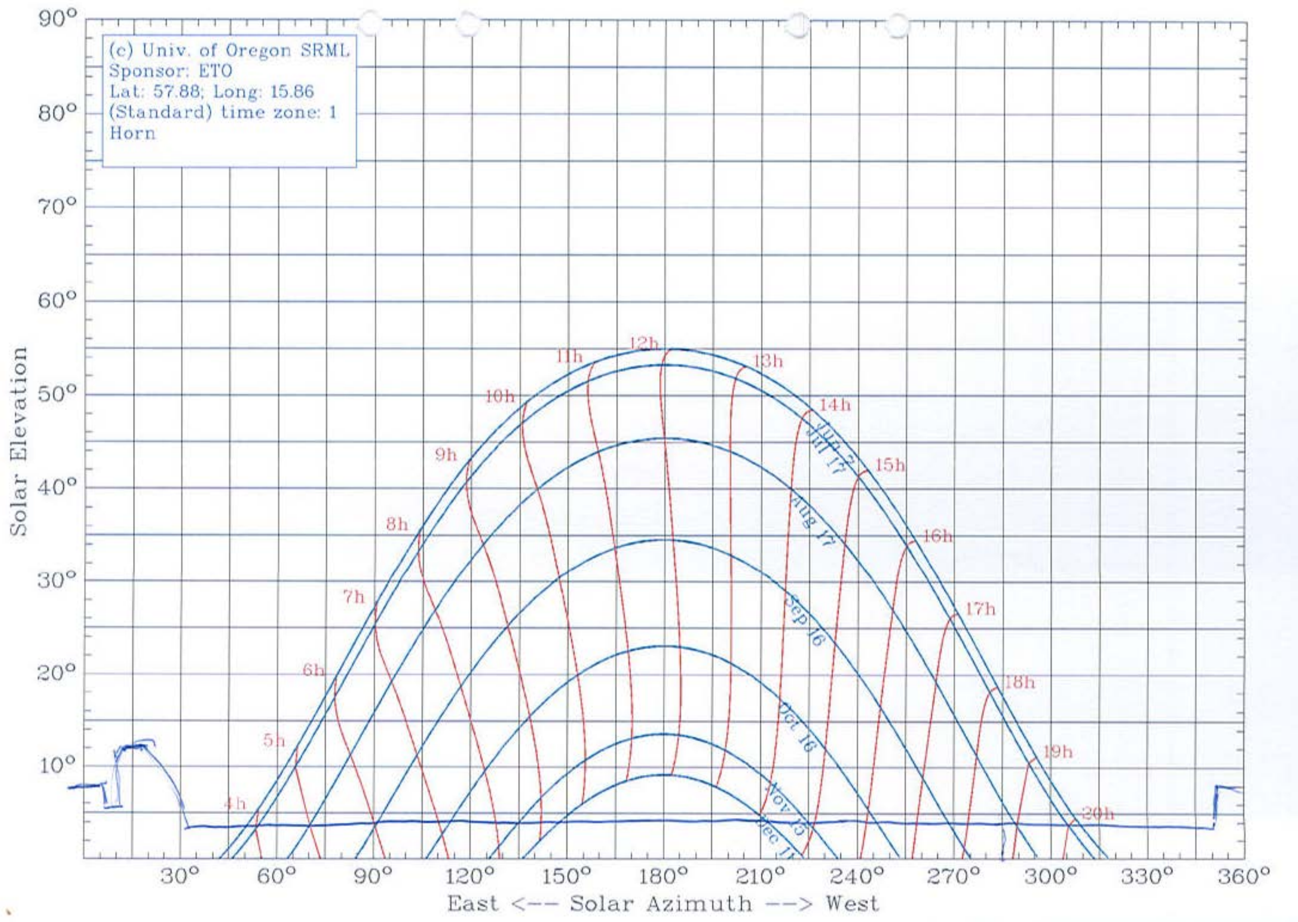


S W

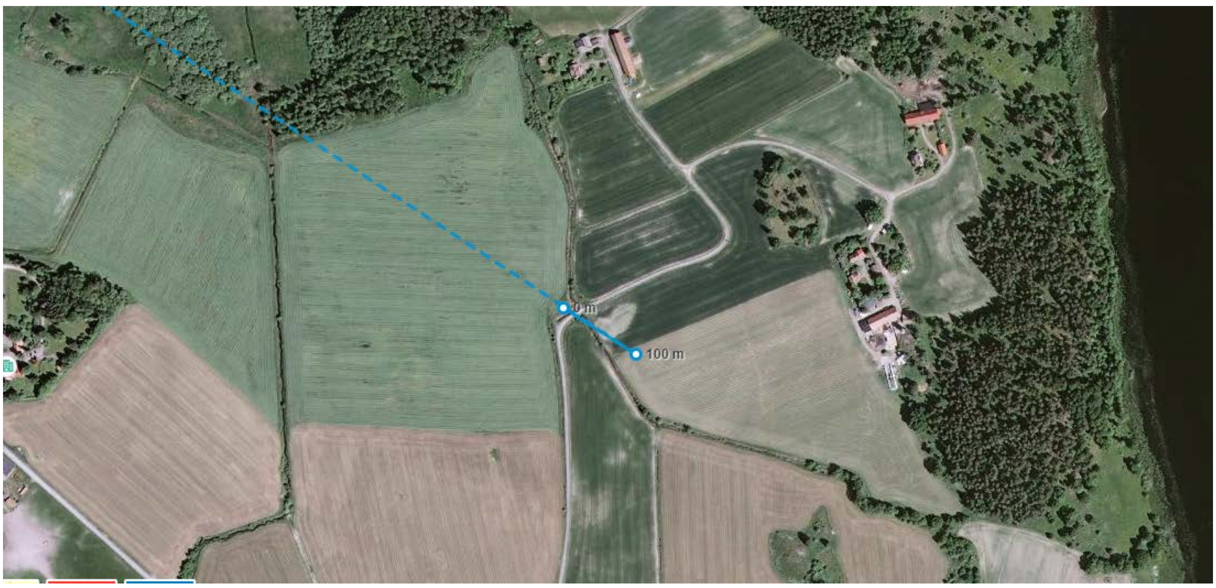
Comments	The silage bales in the north are just stored temporary near the station and are not considered here.

Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale



21 Gladhammar (Sweden)

Temperature Classification Scheme

Station number: 7642	**Station name:** Gladhammar A
Date: 150909	**Performed by:** Cristoffer Wittskog
WMO Classification: 5	Landscape: 1, Ground: 3, Heat sources: 4, Shading: 5

Site description:

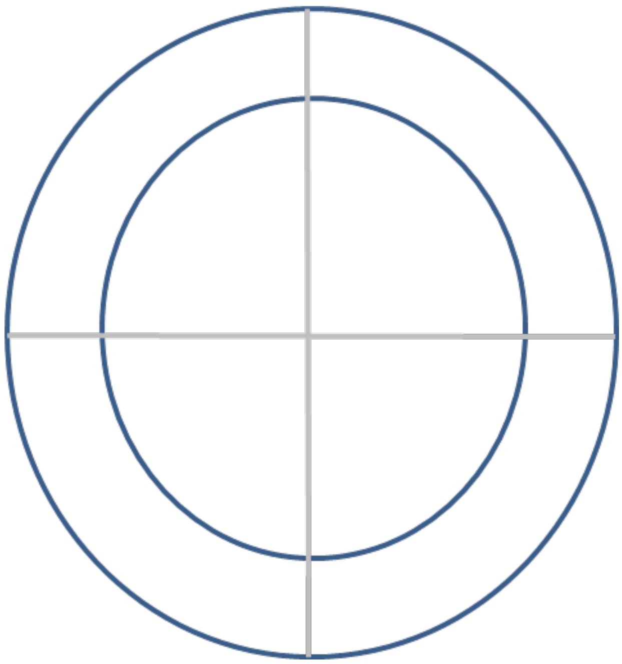
Sensor height (10 cm accuracy)	155 cm
Horizontal land	In 10m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X < 5º** □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship **X inland** □ heathland □ mid-highlands **X grass** **X bushes** □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop **X sub-urban** □ urban specify: **farmland**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X (<10%)** Rivers: □ (>30%) □ (10-30%) **X (<10%)** specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	135

Photographs to 8 different directions	**X N** ☐ NE **X E** ☐ SE **X S** ☐ SW **X W** ☐NW

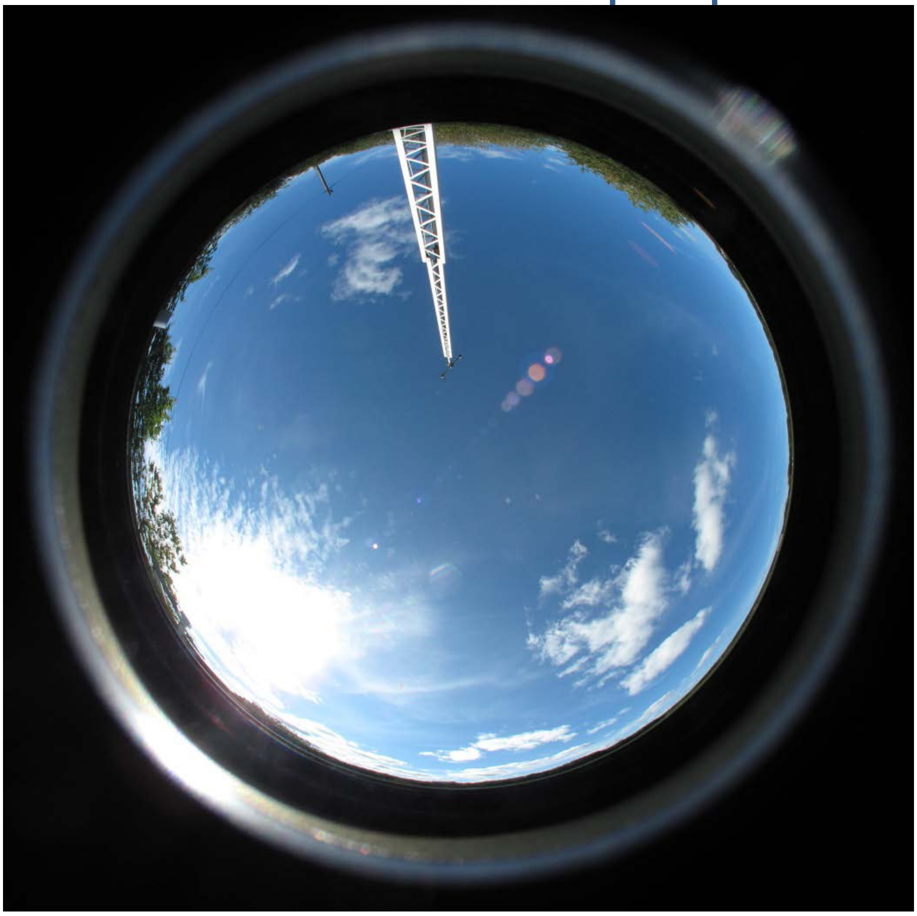
Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
220-360	5	25		Bushes
180-300	10	-	240	Gravel road

Circle of angles



Photograph taken by fish-eye camera X



N

E

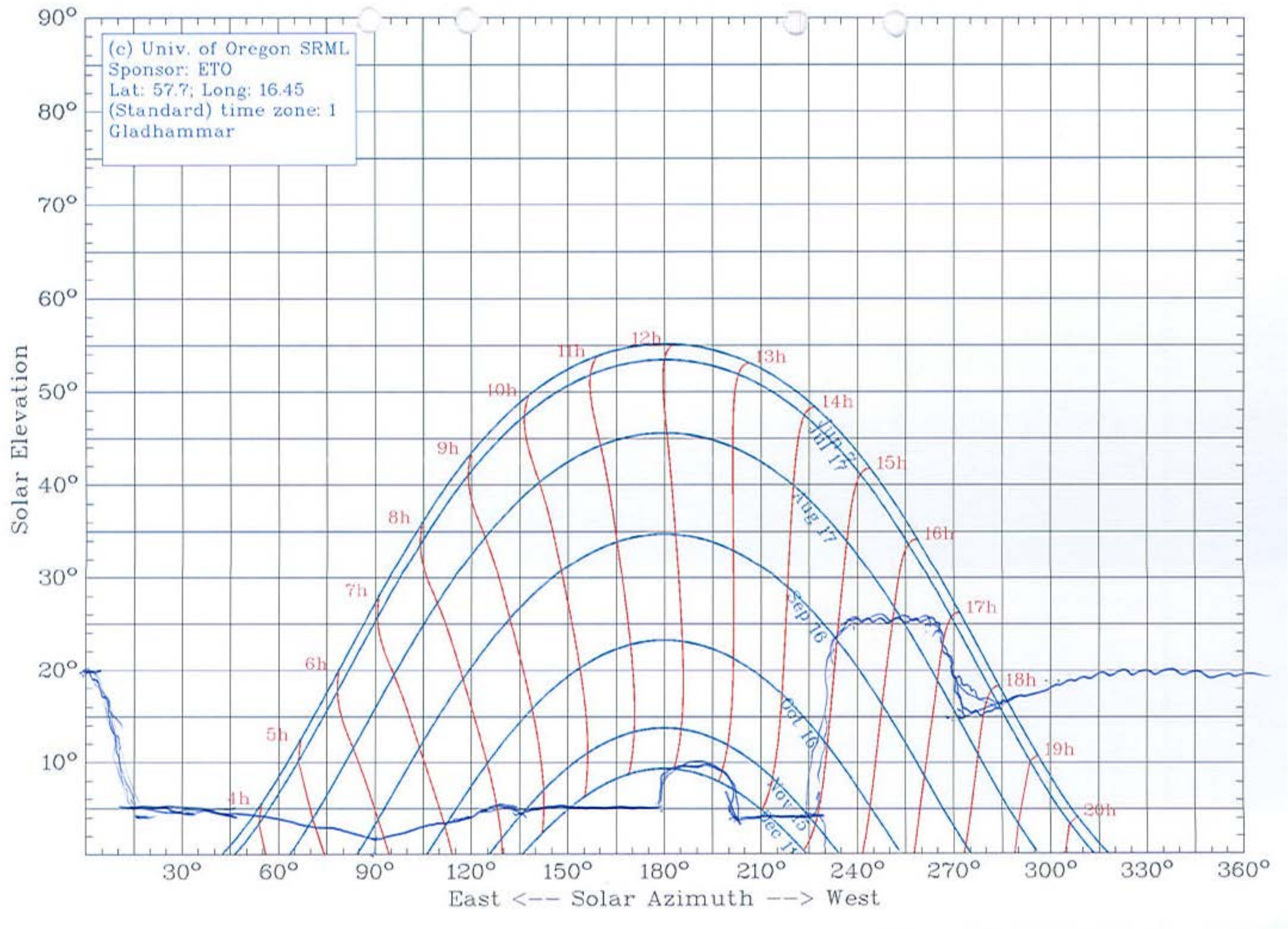
S

W

Comments	

Sun elevation chart

http://solardat.uoregon.edu/SunChartProgram.html



Satellite image with scale

22 Korpa (Iceland)

Temperature Classification Scheme

Station number: 1479	**Station name: Korpa**
Date: 10.5.2016	**Performed by: Arni Sigurdsson**

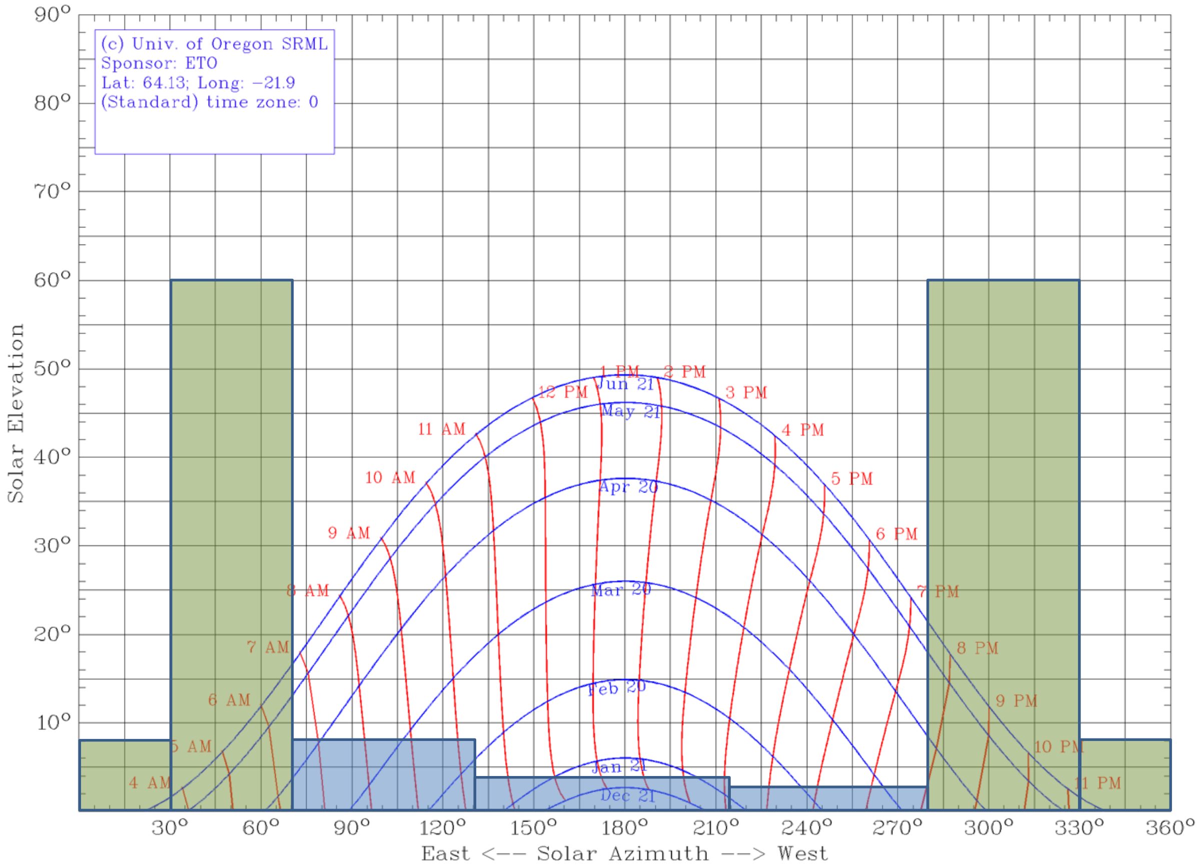
Site description:

Sensor height (10 cm accuracy)	**200 cm**
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X** grass **X** bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify: **Trees very close to weather station**
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope **X** lower slope □ valley □ hill □ upper hill **X** mountain □ peninsular **X** coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify: **Mountain in around 500 m distance from weather station.**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X** (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify: **Coastline in 1 km distance from weather station.**
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	**200 cm**
Photographs to 8 different directions	**X** N □ NE **X** E □ SE **X** S □ SW **X** W □NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m²)	Description and comment
30 – 70°	2 m	60°		Trees
280 – 330°	5 m	60°		Trees
330 – 30°	50 m	8°		Trees
70 – 130°	500 - 1500 m	8°		Mountain
130 – 215°	1000 m	4°		Houses/hills
215 – 280°	1500 m	3°		Houses/hills

Sun elevation chart



http://solardat.uoregon.edu/SunChartProgram.html

Comments	Trees very close to the weather station provide shelter from winds and sun may occationally heat up still air inside the thermometer shelter.

Satellite image with scale

Circles 30 and 100 m distance from weather station. Image from the National Land Survey of Iceland.

View to east.

View to south.

View to west.

View to north.

CIMO/WMO Classification Matrix

WMO	SLOPE	Veget.	HS/WB	Shade
4	1	1	1	4

23 Reykjavik (Iceland)

Temperature Classification Scheme

Station number: 1475	**Station name: Reykjavik**
Date: 10.5.2016	**Performed by: Arni Sigurdsson**

Site description:

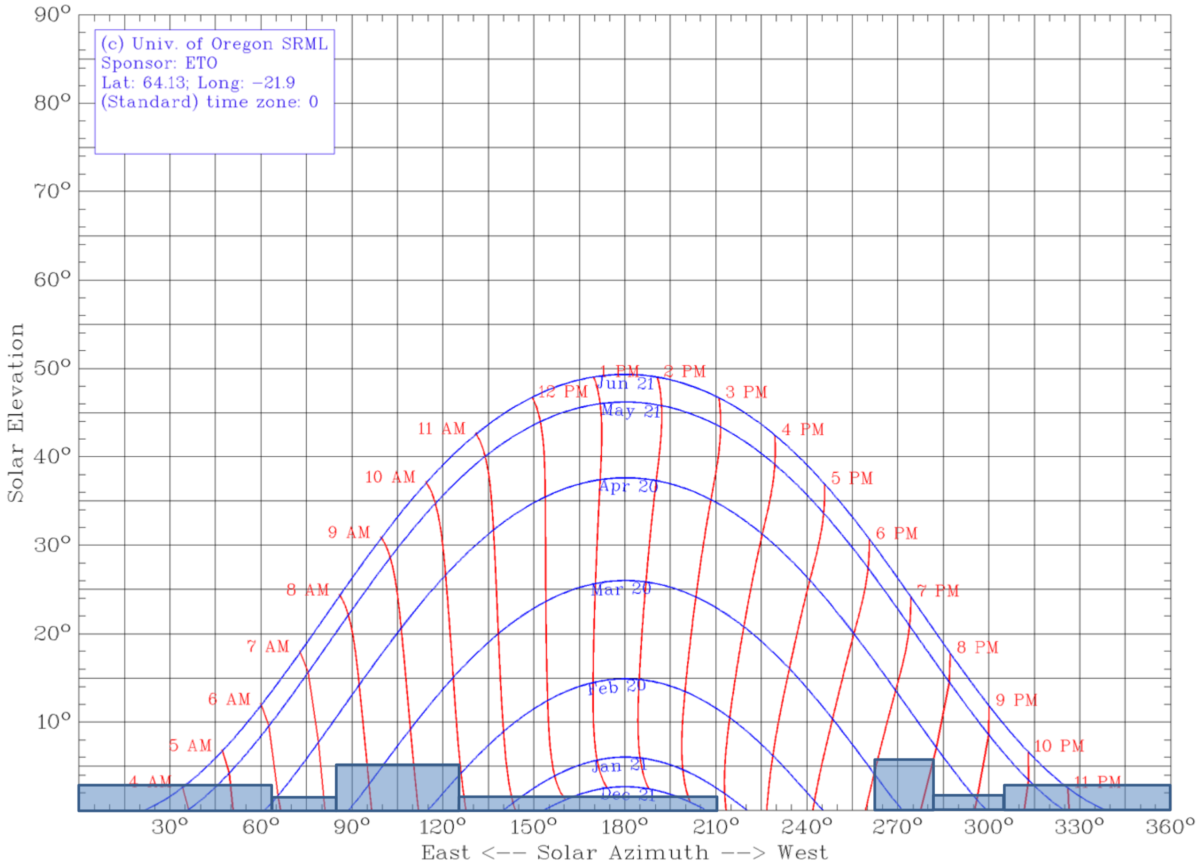
Sensor height (10 cm accuracy)	**200 cm**
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X** grass □ bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill **X** upper hill □ mountain □ peninsular **X** coast □ coast, but slope or cliff in the close vicinity □ glacier **X** fjords □ peak, hilltop **X** sub-urban □ urban specify: **On a low hill top.**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X** (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify: **Ocean 0.5% in 1 km radius, 900 m distance from weather station.**
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	**200 cm**

Photographs to 8 different directions	**X** N ☐ NE **X** E ☐ SE **X** S ☐ SW **X** W ☐NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
263 - 284°	95 m	67 m/ 6°		Met. office building
90°	80 m			Asphalt road
200°	120 m			Asphalt road
305 - 65°	50 m	2.5°		Houses and trees
100 - 125°	140 m	5°		Houses

Sun elevation chart



http://solardat.uoregon.edu/SunChartProgram.html

Comments	

Satellite image with scale

Circles 30 and 100 m distance from weather station. Image from the National Land Survey of Iceland.

View to east.

View to south.

View to west.

View to north.

CIMO/WMO Classification Matrix

WMO	SLOPE	Veget.	HS/WB	Shade
1	1	1	1	1

24 Skaftafell (Iceland)

Temperature Classification Scheme

Station number: 6499	**Station name: Skaftafell**
Date: 30.5.2016	**Performed by: Arni Sigurdsson**

Site description:

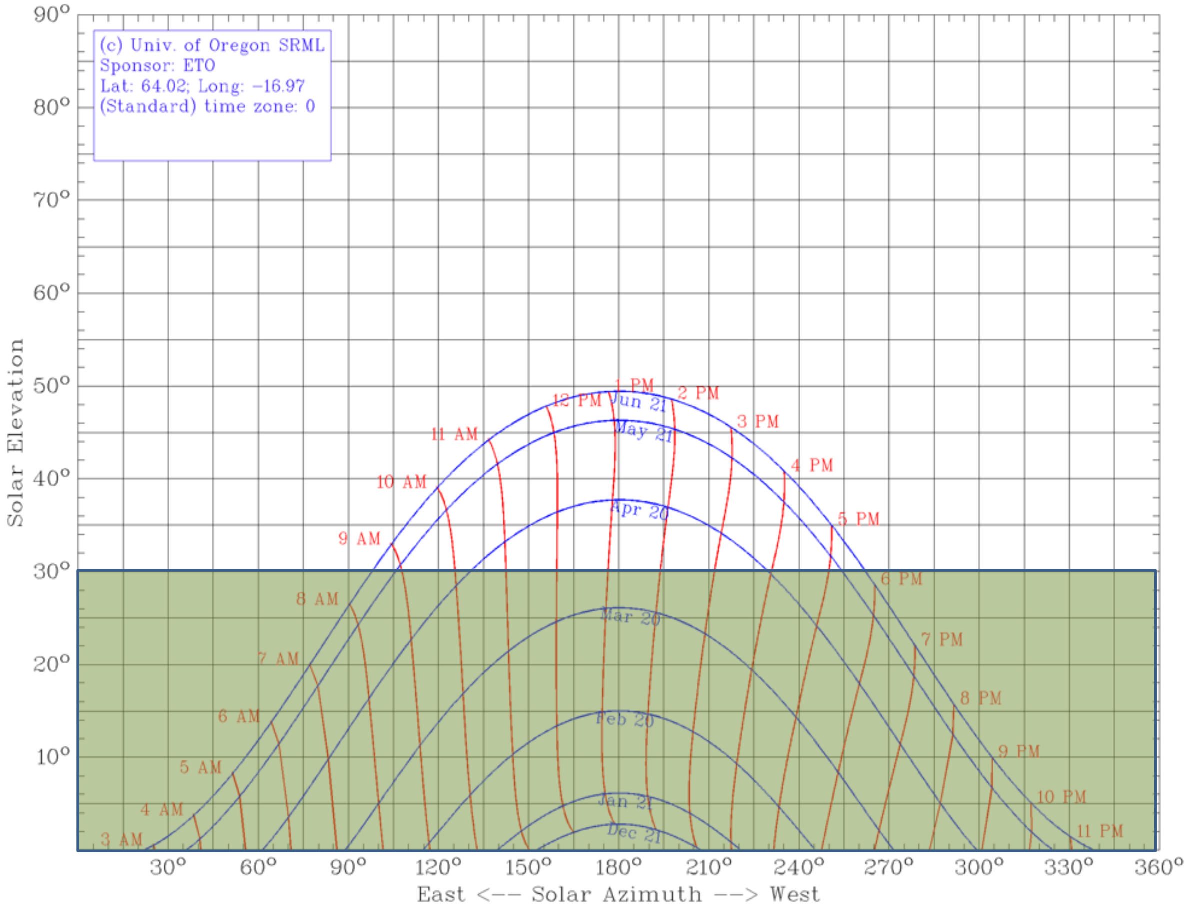
Sensor height (10 cm accuracy)	**200 cm**
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X** grass **X** bushes □ sand □ asphalt □ not defined □ black sand □ rocks specify: **Trees very close to weather station**
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill □ upper hill □ mountain □ peninsular □ coast □ coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify: **Glacier in around 2 km distance northeast of weather station.**
Amount of water systems (in 1 km radius)	□ island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) **X** (<10%) Rivers: □ (>30%) □ (10-30%) **X** (<10%) specify:
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	**200 cm. Bushes all around the sensor.**

Photographs to 8 different directions	☐ N ☐ NE ☐ E **X** SE ☐ S ☐ SW ☐ W **X** NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
0 – 360°	2-5 m	30°		Trees/bushes
0 – 100°	15 m		5000 m^2	Asphalt parking
20 – 160°	50-100			Sand area mostly covered with low plants
160 – 250°	100-120			Sand area mostly covered with low plants

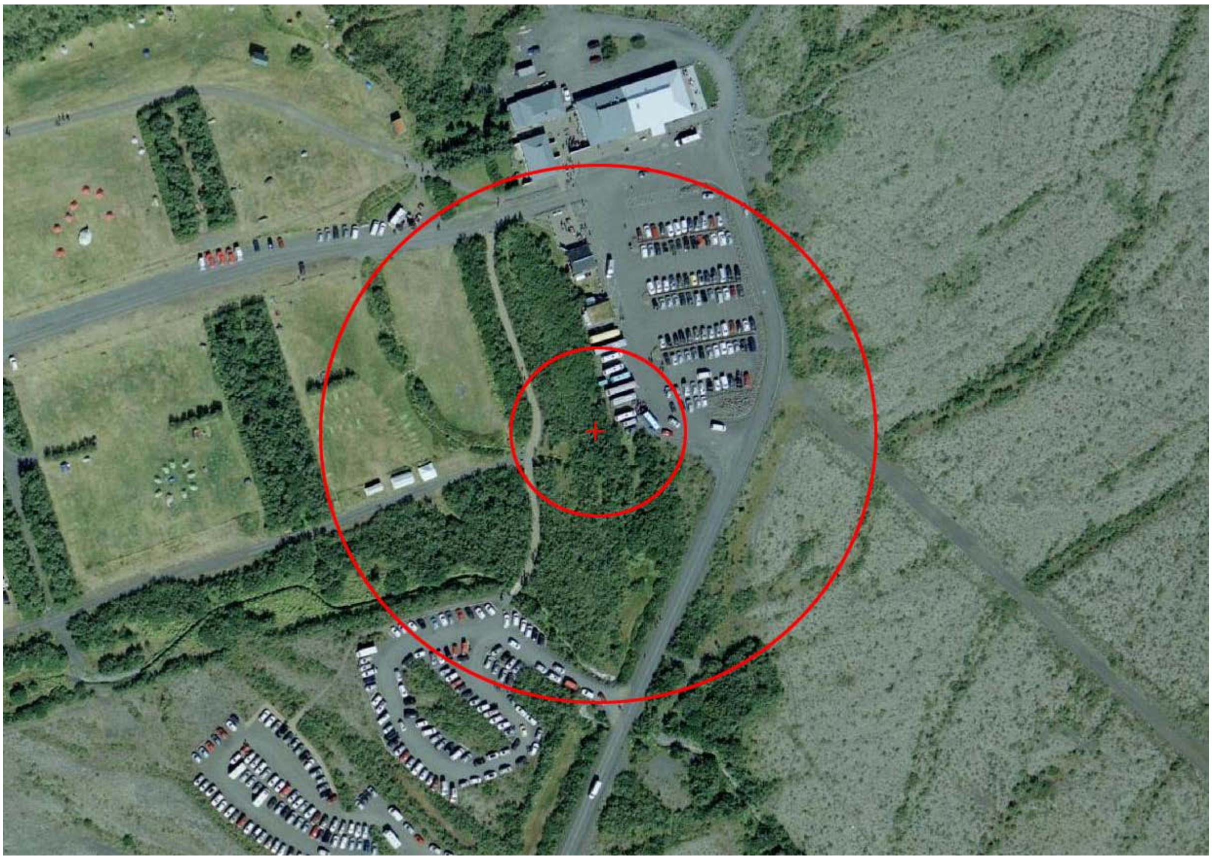
Sun elevation chart



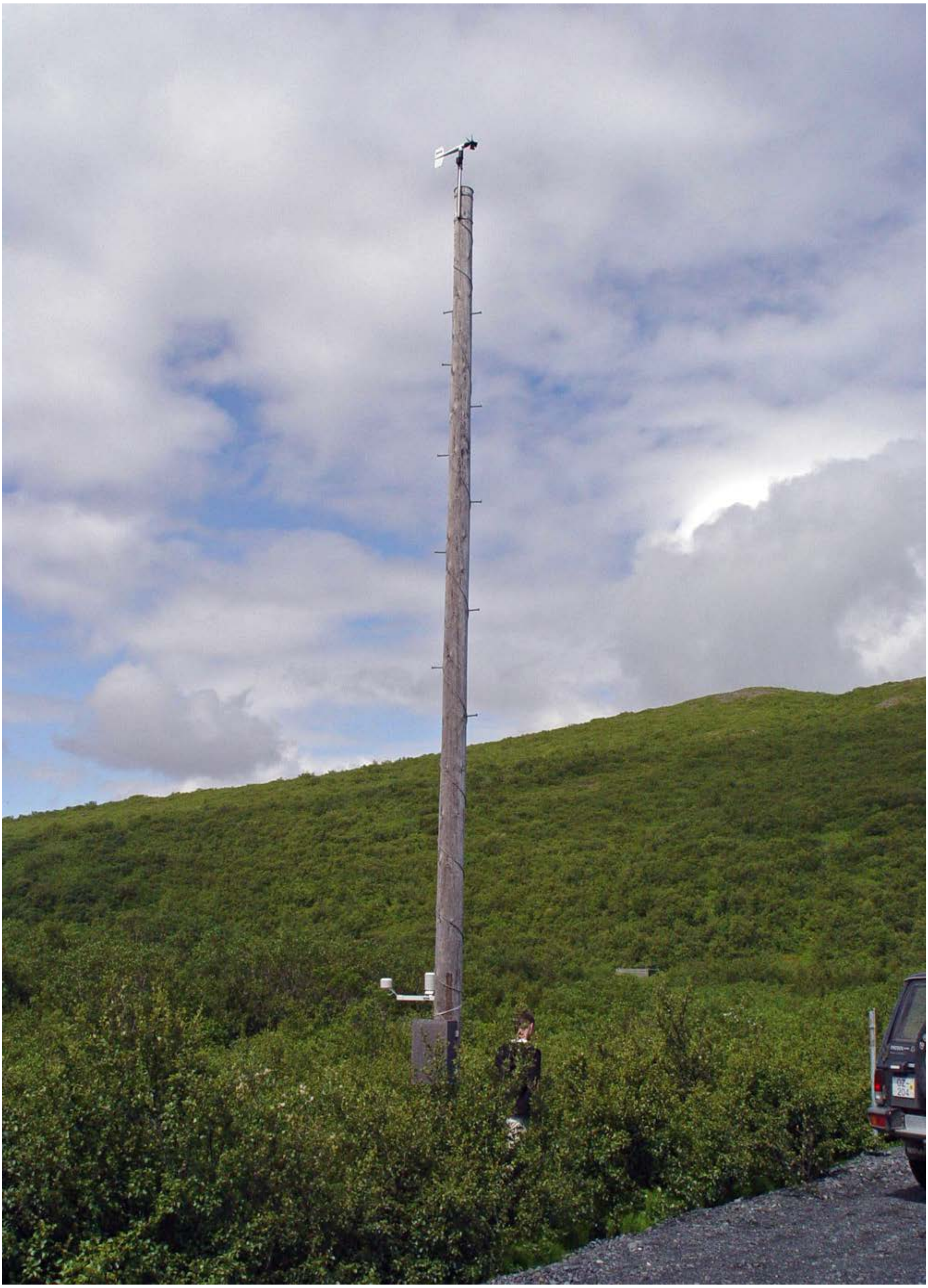
http://solardat.uoregon.edu/SunChartProgram.html

Comments	Trees very close to the weather station provide shelter from winds and sun.

Satellite image with scale



Circles 30 and 100 m distance from weather station.



View to northwest in 2003. The bushes have grown higher since then.

View to the southeast from the weather station in 2015.

The weather station in 2015.

CIMO/WMO Classification Matrix

WMO	SLOPE	Veget.	HS/WB	Shade
5	1	4	1	5

25 Storhofdi (Iceland)

Temperature Classification Scheme

Station number: 6017	**Station name: Storhofdi**
Date: 30.5.2016	**Performed by: Arni Sigurdsson**

Site description:

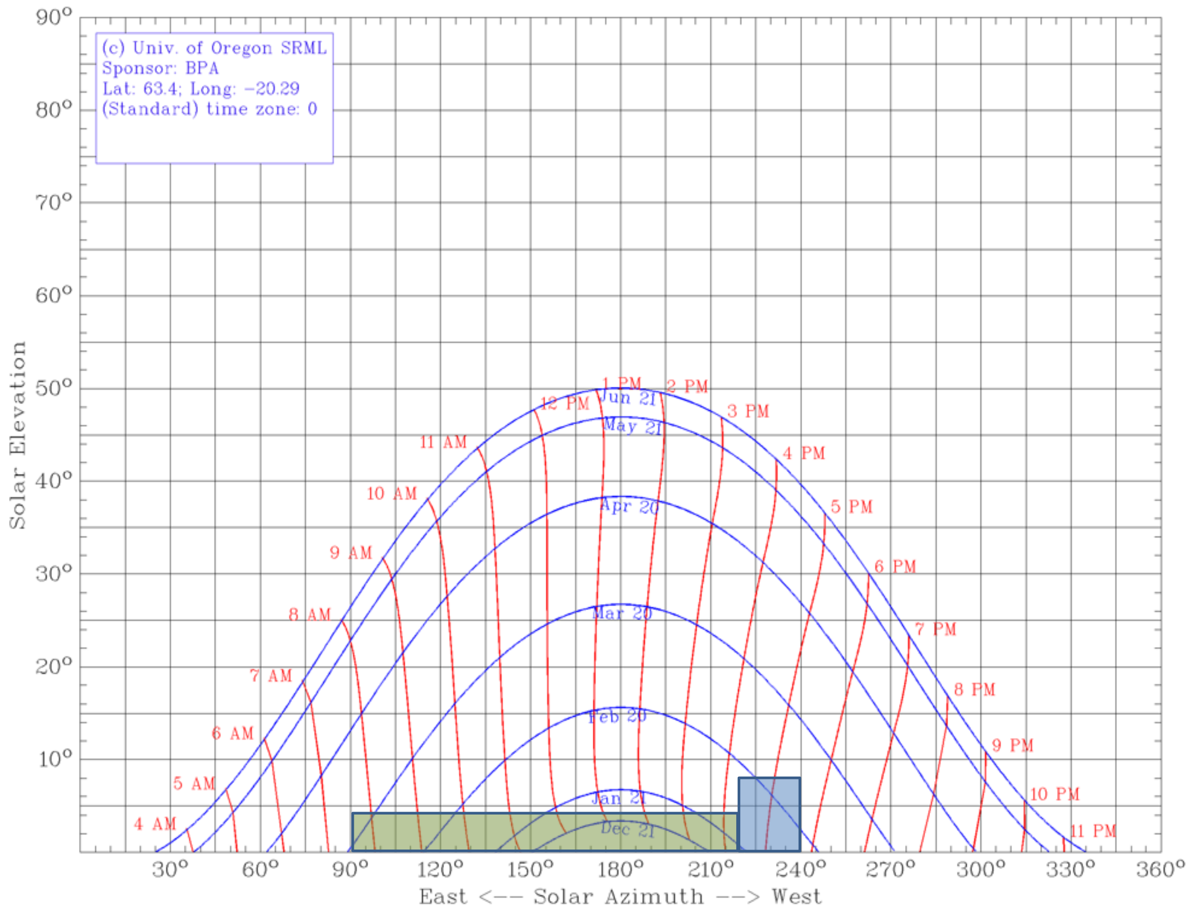
Sensor height (10 cm accuracy)	**200 cm**
Horizontal land	In 10m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º In 100m radius: **X** < 5º □ < 10º □ < 15º □ < 19º □ > 19º
Type of the surface (in 10 m radius) *(choose nationally)*	□ ship □inland □ heathland □ mid-highlands **X** grass □ bushes □ sand **X** asphalt □ not defined □ black sand □ rocks specify:
Topography (in 1 km radius) *(choose nationally)*	□ slope □ upper slope □ lower slope □ valley □ hill **X** upper hill □ mountain **X** peninsular □ coast **X** coast, but slope or cliff in the close vicinity □ glacier □ fjords □ peak, hilltop □ sub-urban □ urban specify: **Hight above sea level 120 m and high cliffs along the coast line.**
Amount of water systems (in 1 km radius)	**X** island (50-100%) □ coastal line (30-50%) Lakes: □ (>30%) □ (10-30%) □ (<10%) Rivers: □ (>30%) □ (10-30%) □ (<10%) specify: **Ocean in around 400 m distance from weather station in all directions except to the northeast.**
Difference between sensor and the average vegetation (10 cm accuracy, estimation)	**200 cm**

Photographs to 8 different directions	□ N **X** NE **X** E **X** SE □ S **X** SW □ W □NW

Heat sources and obstacles

Compass direction (°) from and to (azimuth)	Distance	Height (m)/ Elevation angle (°)	Area (m^2)	Description and comment
220 – 240°	30 m	8°		House
90 – 220°	20-30	4°		Hill top
60 – 360°	400 m			Coastline, 60-80 m high sea cliffs
270 – 20°	6-20 m			Narrow asphalt road

Sun elevation chart



http://solardat.uoregon.edu/SunChartProgram.html

Comments	

Satellite image with scale

Circles 30 and 100 m distance from weather station. Image from the National Land Survey of Iceland.

View to northeast.


View to east.

View to southeast.

View to southwest.

CIMO/WMO Classification Matrix

WMO	SLOPE	Veget.	HS/WB	Shade
4	1	1	1	4