IRWIN

Improved local winter index to assess maintenance needs and adaptation costs in climate change scenarios

Data Collection and Database

Inception Report Nr 2

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Foreca Consulting Ltd

Klimator AB

Department of Earth Sciences, University of Gothenburg

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Authors of this deliverable:

Pirkko Saarikivi, Foreca Consulting Ltd, Finland

Torbjörn Gustavsson, Klimator AB, Sweden

Dave Rayner, Department of Earth Sciences, University of Gothenburg, Sweden

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Executive summary

The main objective of IRWIN is to develop an improved winter road index capable of assessing the implications of climate change in various weather parameters and also related costs and benefits.

Climate change scenarios have so far been calculated based on ordinary meteorological data, which have large limitations in respect to resolution. The idea of IRWIN is to combine the best traditionally made climate scenarios with the much more accurate spatial data from field stations in the Road Weather Information systems (RWIS) installed in most northern hemisphere countries.

This Second Inception Report describes the data collection and database formation phase of the project. The objective was to develop a novel database of possible future road condition scenarios by combining archived historical RWIS data with widely accepted climate change scenarios. Observations from the Swedish and Finnish RWIS stations were collected from national Road Administrations from as long time span as has been archived with homogeneous contents and quality. The target was to get 10 years of observations of air and surface road temperature, moisture, wind speed, rainfall amount and precipitation type.

The data collection phase of IRWIN revealed that there is enough archived RWIS data in Sweden and Finland to perform the planned winter index development. Ten years of observations were collected from 50 road weather stations in Sweden and 49 stations in Finland. Observations in each country were divided into three regions with distinctive climatic characters. Extensive processing had to be performed first to create a high-quality database with corrected and uniform observations. Maintenance activities from the regions of interest were collected as well, to be used in the winter index calculations.

In this report, details of the IRWIN database and file format structures can be found. The climate downscaling methods and the climate scenarios are described, and first results shown. Rules for the index development are given. In other countries, similar assessments could be thus done relatively easily if enough road weather information was archived and available. IRWIN will send a questionnaire to all ERA-NET ROAD countries to find out if suitable data files exist outside Sweden and Finland.

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1 Introduction

"ERA-NET ROAD – Coordination and Implementation of Road Research in Europe" was a Coordination Action funded by the 6th Framework Programme of the EC. The partners in ERA-NET ROAD (ENR) were United Kingdom, Finland, Netherlands, Sweden, Germany, Norway, Switzerland, Austria, Poland, Slovenia and Denmark (www.road-era.net). Within the framework of ENR this joint research project was initiated. The funding National Road Administrations (NRA) in this joint research project are Federal Ministry of Transport, Innovation and Technology (BMVIT), Austria, Federal Ministry of Transport, Building and Urban Affairs (BMVBS), Germany, Ministry of Transport, Danish Road Directorate (DRD), Denmark, Centre for Studies and Research in Public Works (CEDEX), Spain, Finnish Road Administration (Finnra), Finland, National Roads Authority (NRA), Ireland, Directorate of Public Works and Water Management (RWS), the Netherlands, Norwegian Public Roads Administration (NPRA), Norway, General Directorate of National Roads and Motorways (GDDKiA), Poland, Swedish Road Administration (SRA), Sweden, and Department for Transport, Highways Agency (HA), the United Kingdom.

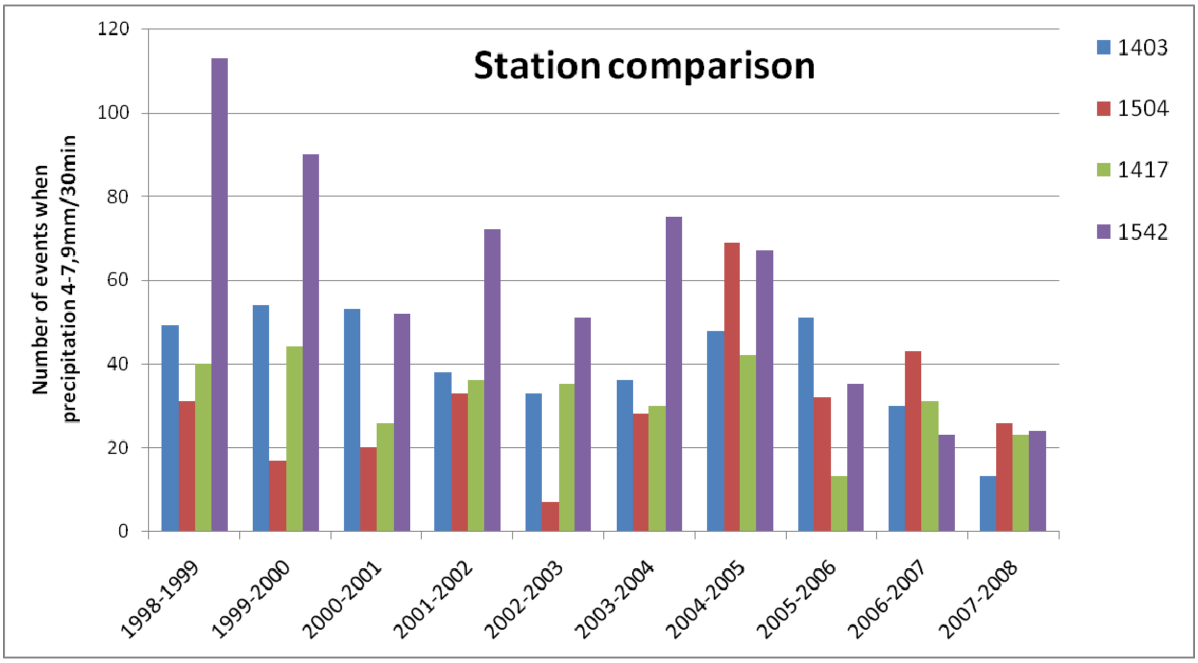
IRWIN is one of the research and development projects initiated by ERA-NET ROAD in 2008. The main objective of IRWIN is to develop an improved winter road index capable of assessing the implications of climate change in various weather parameters and also related costs and benefits.

Climate change scenarios have so far been calculated based on ordinary meteorological data, which have large limitations in respect to resolution. The idea of IRWIN is to combine the best traditionally made climate scenarios with the much more accurate spatial data from field stations in the Road Weather Information systems (RWIS) installed in most northern hemisphere countries.

IRWIN started on 1st November 2008. The First Inception Report was delivered to ERA-NET ROAD in January 2009, presenting the IRWIN Work Plan in more detail, state-of-the-art of Global Climate Models (GCM), winter indexes and recent studies on climate impact on road network.

This Second Inception Report describes the data collection and database formation phase of the project. The objective was to develop a novel database of possible future road condition scenarios by combining archived historical RWIS data with widely accepted climate change scenarios. Observations from the Swedish and Finnish RWIS stations were collected from national Road Administrations from as long time span as has been archived with homogeneous contents and quality. The target was to get 10 years of observations of air and surface road temperature, moisture, wind speed, rainfall amount and precipitation type.

The development of more precise and local winter index is justified by the better observational network of road weather stations used in the analysis. More dense observations both in time and space reveal more local details of weather events compared to the general weather observing network run by national meteorological institutes. One example is shown on the following page in Figure 1. Observations of extreme rainfall amounts from four road weather stations in Gothenburg region show large local variations of rainfall from year to year and station to station.



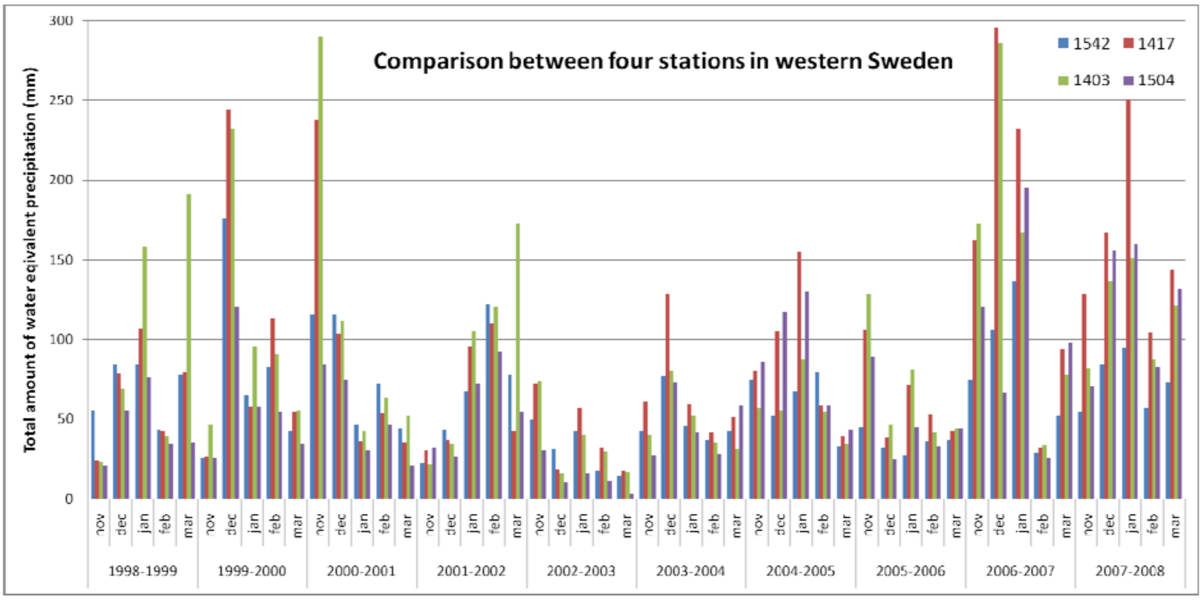


Figure 1. Number of extreme rainfall amount cases and total rainfall amount in 1998-2008 measured by four road weather stations.

After the initial data collection phase, the raw archived observational data needs to be processed into regular interval time series. The Finnish and Swedish data will be reformatted to similar data format. Once a good quality observational database is completed, the climate downscaling task is performed to establish the climate database. Weather classes will be developed to select the historical analogue days matching the future days.

The final phase of the project will develop and test a winter index technique to evaluate such phenomena as the spatial variations of winter maintenance needs as well as the cost/benefit of various winter maintenance strategies. Possibilities of using road weather data from other countries will be investigated. These results together with the summary of results from the 1st and 2nd Inception Reports will be compiled in the Final Report of the project to be published in the end of 2009.

Target user groups of IRWIN results are the road owners and administrations in ERA-NET countries and the EU. In addition to the Final Report, results will be presented in transport forums, publications and conferences active in 2009 and 2010.

In this report, the next Chapter 2 will describe the Swedish data collected and used for the study, as well as features of the national winter road maintenance rules. The following Chapter 3 describes the Finnish data and rules, respectively. Chapter 4 deals with the formation of IRWIN database. Chapter 5 describes the climate change scenarios used for future climate assessments. The following Chapter 6 briefly represents the index calculation methods, and Chapter 7 summarises the work plan for the final phase of the project in the last half of 2009. Conclusion and references are found as the two last Chapters of this report.

2 Swedish road weather data

2.1 The Swedish road weather network

There are today about 760 Swedish RWIS stations spread out all over the country[1], although most of them are situated in the south which contains most of the road stretches (Figure 2). Some of the stations operate all year around, but the majority only during winter. With the large number of stations and half hourly data records, the RWIS stations have both higher spatial and temporal resolution than other meteorological observing networks, which makes them ideal for monitoring local climatic conditions. Also, they are positioned along major roads which make planning for traffic safety and winter maintenance costs more accurate than using stations positioned on farmlands or in other open areas.

Data from a number of RWIS stations were selected for three different areas in Sweden. 24 stations were selected in the south western region around Gothenburg, 12 stations in the east around Stockholm and 14 stations in northeast around Sundsvall (Figure 3). These three areas represent three different types of climate in Sweden. The south western region was the test area for this project, and these stations were used to establish methods to be used, and to develop routines for quality assurance etc.

The stations in the three different areas are spatially distributed over an area of approximately 10.000 – 20.000 km^2. The topography varies within the regions as does the closeness to the sea or larger water bodies, openness, and vegetation cover. The station locations also represent various local climates within the areas, which makes it possible to analyze variation due to this factor in respect of maintenance needs.

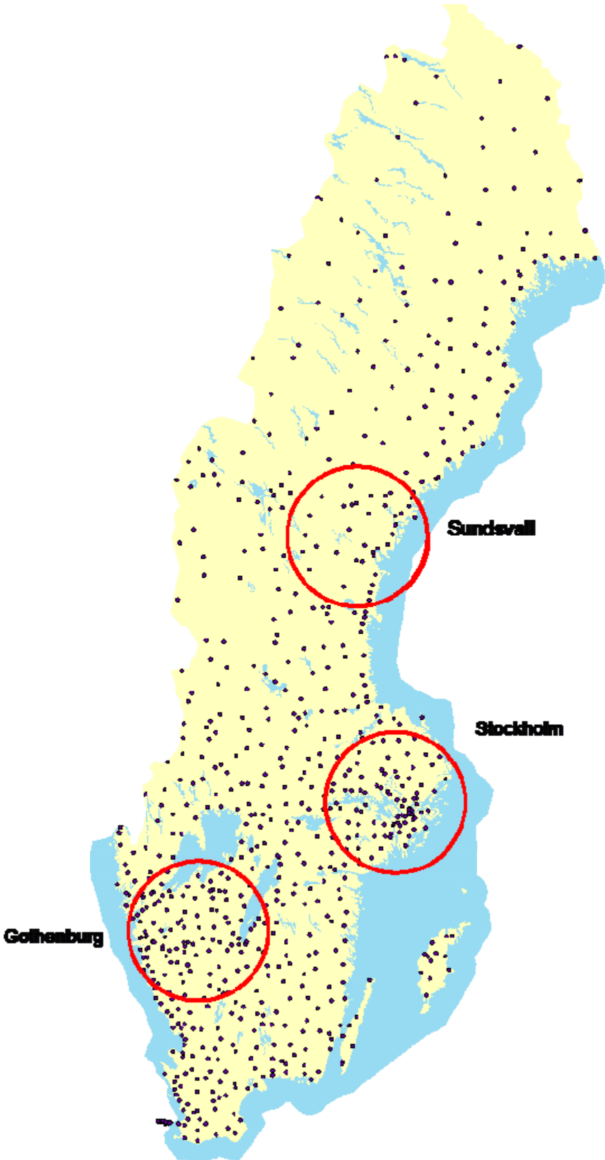
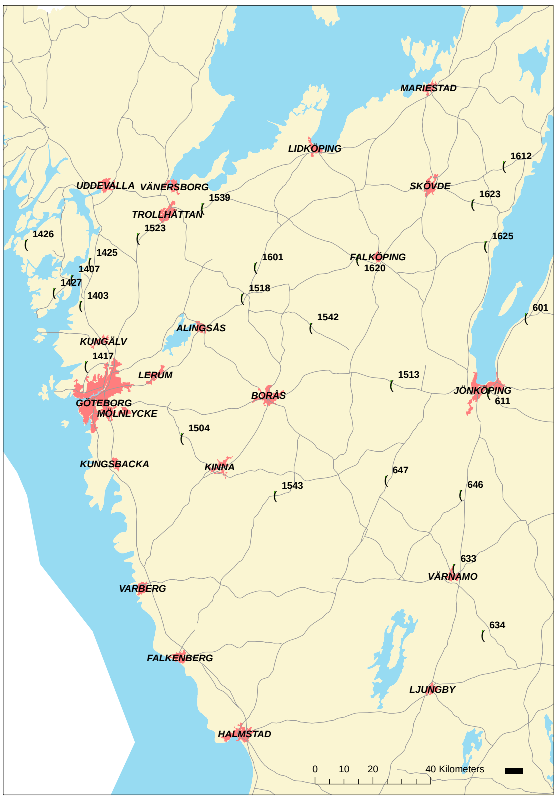


Figure 2: The Swedish RWIS network, and the three Swedish study region.

[1] http://www.idg.se/2.1085/1.227253/sa-varnar-vagverkets-vaderstationer-for-sno



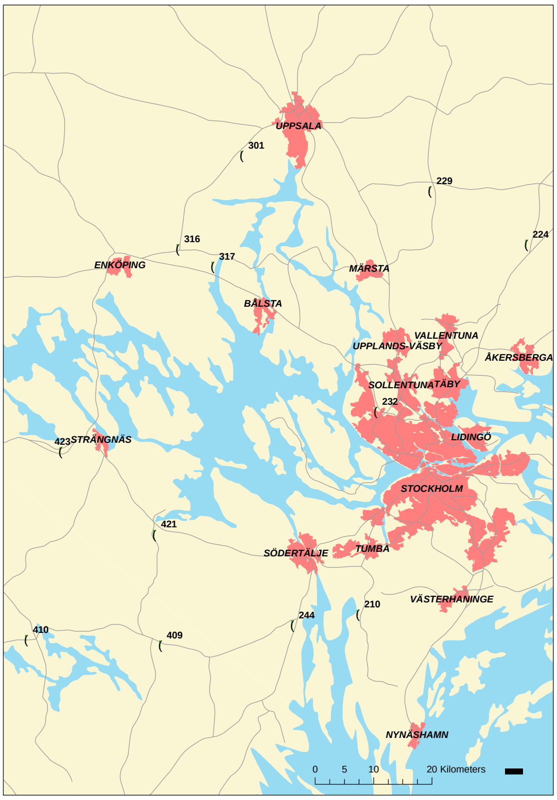


Figure 3: Detailed maps of the three areas and the positions of the RWIS stations in Sweden: Gothenburg, Stockholm and Sundsvall.

2.2 Parameters and observational methods

The RWIS stations in Sweden are adminsitered by the Swedish National Road Administration. The data used for this project include: precipitation type and amount, surface and air temperature, wind speed and direction and dew point (calculated from humidity), for the winter period (November-to-March), 1998 to 2008.

Precipitation is measured by an OpticEye sensor which measures the amount of precipitation with infrared light beams and registers the precipitation type as rain, snow or sleet. The infrared beams form a horizontal cross and alter in intensity when exposed to various kinds and quantities of precipitation (http://www.rwis.net/OpticEye.htm). The precipitation amount is measured in millimeters, apart from as snow when measured as snow depth and not as millimeters of water.

Surface temperature is measured approximately 1 cm down in the road bed, and air temperature is measured 2 meters above ground with a Pt100 sensor.

A Vaisala wind speed measurement device is mounted on some of the RWIS stations. For this project only stations which measure wind speed and direction were used.

The stations also record relative humidity by a Rotronic hygrometer from which the dew point was calculated.

2.3 Maintenance and other data

In Sweden the road network is divided into 5 classes depending on the traffic on the roads. Motorways are class 1 roads and the most important in regard of maintenance. Basically they should always have summer road conditions. As an example; if there is one cm of snow on a class 1 road it should be cleared within two hours. Class 5 roads are smaller roads with almost no traffic, and the criteria for these roads are lower. Three cm of snow has to be cleared within six hours. When there is a risk for ice or frost formation on the road, salting is done in advance when possible (ATB VINTER 2003, VV Publ 2002:148).

For future improvements of the road maintenance a connection will be made between the historical maintenance data and the RWIS station´s climate data. Existing maintenance data includes for example which road stretch has been salted or ploughed, the date and time when the measure has been done, and how much salt has been used.

3 Finnish road weather data

3.1 The Finnish Road Weather Information System

The Finnish Road Administration (FinnRA) has been developing the national road weather observing network since the 1970's. Archived observations exist from 1997 onwards. During those days there were about 250 stations, mainly situated in the southern parts of the country. Today the network consists of some 500 stations covering also the northernmost parts of the country (see Figure 4). In addition, there are about 100 road camera stations. Some 100 stations are equipped with optical road condition and friction sensors.

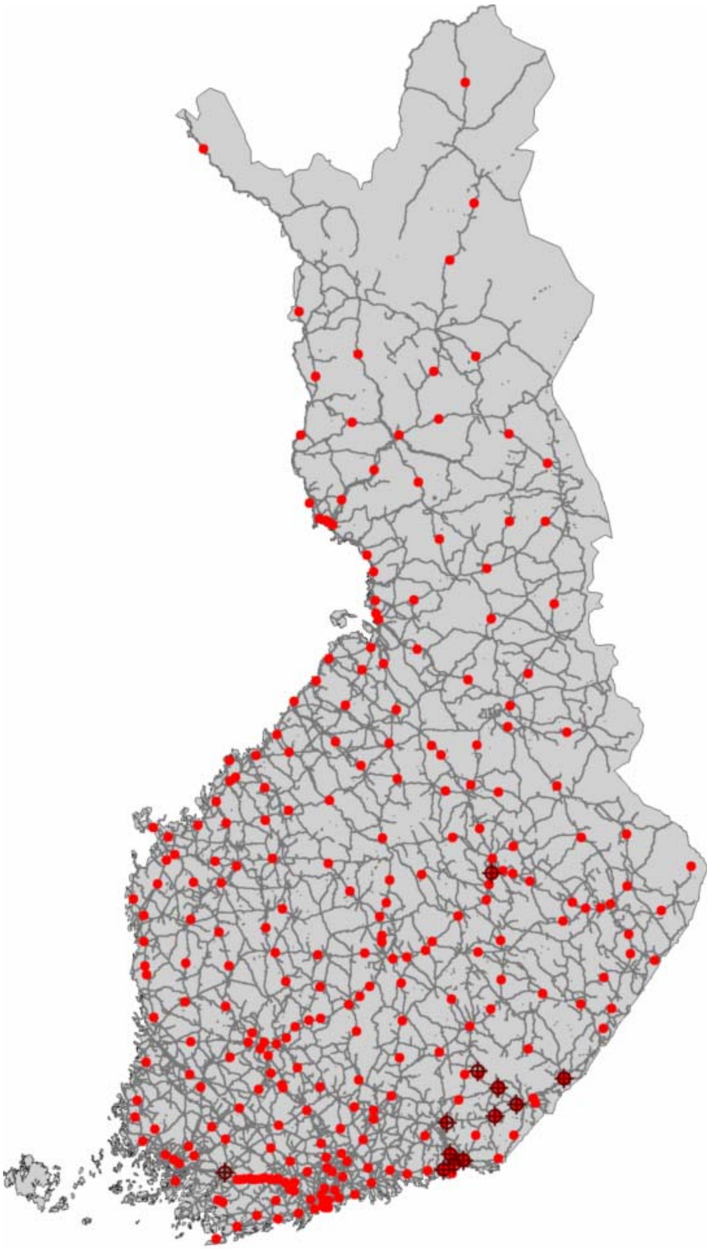


Figure 4: The Finnish RWIS network of the Finnish Road Administration.

IRWIN analysis requires high-quality time series of road weather observations that span over 10 years. Data must be as uninterrupted and flawless as possible. The archived observations were analysed first and the best time series selected. In the end, 49 stations had good enough archived data from 1998 onwards to be used in the study.

There are no road weather stations in Lapland that have long enough time series, and that is why the climatic regions had to be selected more south compared to the original plan. Figure 5 shows the positions of the 49 selected stations, and their division into three climatic regions:

- The south-western corner of Finland is the warmest, having most winter road maintenance problems related to temperatures around 0 degrees and risk for slipperiness.
- The south-eastern corner of the country has more continental climate due to the effect of the large Eurasian continent in the east. The coastal region has similar problems as in the south-west, but inland the wintertime average temperature is several degrees lower compared to the south-western region.
- The north-eastern area has typical continental climate with lower average temperature and higher snowfall amounts. Snow removal is the largest road maintenance concern during winter.

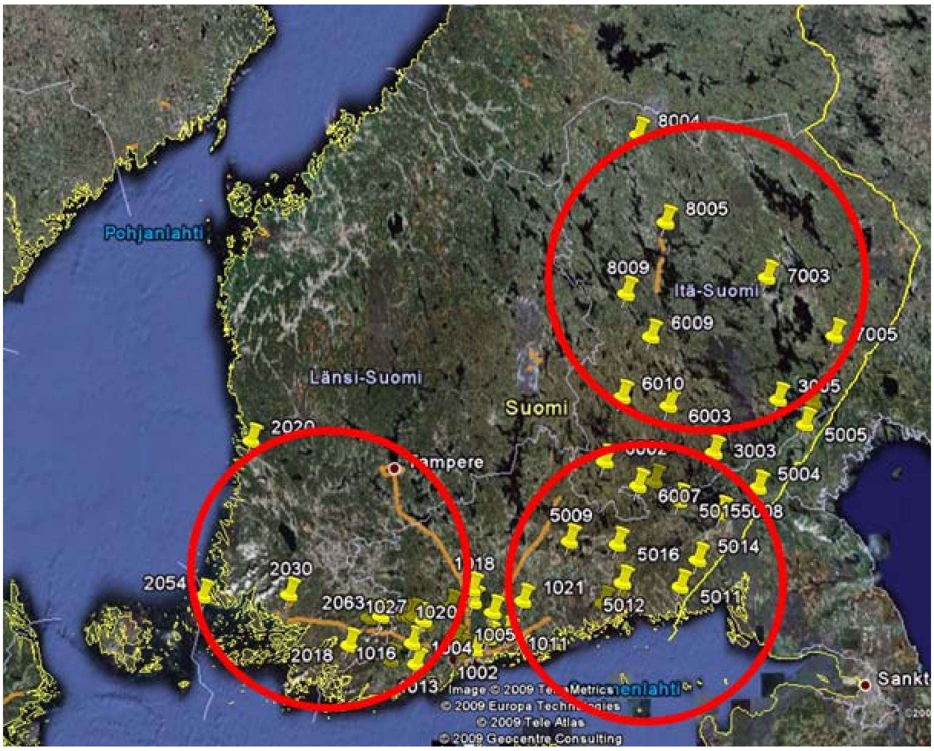


Figure 5: Yellow pins show the position of 49 selected RWIS stations for IRWIN analysis. Division into three different climatic regions is shown by red circles.

3.2 Parameters and observing equipment

The Finnish RWIS network is maintained by FinnRA and based on ROSA and MILOS stations by Vaisala Inc. During the 10 year recorded period used in the IRWIN analysis, present weather type and visibility has been observed by several generations of Vaisala PWD sensors. Details of today's version of the equipment can be found from Vaisala web pages, e.g.

http://www.vaisala.com/weather/products/rosa.html

The standard installation reports on surface and ground temperature, water layer thickness, air temperature, humidity, dew point, precipitation, wind speed and direction and warns of black ice. The Finnish stations are equipped with temperature sensors in several altitudes above the ground, at the road surface and under surface. For this study, air temperature measured at 2 m height and on the road surface were used. Only those weather parameters comparable to the Swedish dataset were extracted from the complete set of archived observations.

3.3 Winter road maintenance rules in Finland

In Finland, the quality requirements for winter road maintenance were revised recently (FinnRA, 2008). As in Sweden, the road network has been divided into five classes (Is, I, Ib, II and III), out of which Is is the highest class of motorways, and III the lowest class of local roads.

Different road class requires different actions and action times from road maintenance operators. For class Is, the maximum snow depth during the snowfall event is 4 cm for snow and 2 cm for slush. Action time for removal is 2,5 hours for snow and 2 hours for slush. These quality requirements are valid between 05.00-22.00. As a comparison, for the lowest class III, the values are 10 and 5 cm, 6 and 6 hours between 06.00-22.00, respectively.

Finland is divided into 82 winter road maintenance areas (see Figure 6). Each of these has class Is, I and Ib roads between 100-500 kilometers. Data from maintenance areas corresponding to the selected IRWIN stations, 22 areas altogether, were collected to separate files from FinnRA's AURA-database. The monthly usage of salt was available from 2003 onwards. All maintenance actions were collected to a specific file containing information on ploughing of snow and slush, liquid salting, point and line salting, and other maintenance actions such as removal or packed ice or friction observation.

Figure 6: Finnish winter road maintenance areas.

4 The IRWIN Database

4.1 Processing methods for raw data

Archived road weather observations are not ready as such for further analysis. The following processing was necessary to compile a high-quality database:

- Sometimes the data from the stations was missing or irregularly spaced, i.e. not every half hour as was desired. To make homogenous time series for all stations for the selected periods, the data was adjusted to nearest half hour. With the Swedish data, observations that were further than 15 minutes from the nominal time has been replaced marked as missing.
- All times were corrected to CET winter time.
- In the Swedish data, the rain sensor often recorded rain values a factor 10 too high during transition from rain to snow or vice versa. If these values were tagged as suspicious they were adjusted appropriately.
- For the Swedish and Finnish data, snow and sleet depths were converted to mm-water-equivalent by dividing by 10.
- Extreme precipitation values were validated by comparing against nearby stations, and suspicious data marked as missing.
- Temperature, dew point and precipitation values which differed significantly from the values measured in the previous and next half-hours were marked as missing.
- Where air- and surface-temperature records for the same station and half-hour were incompatible, they were both marked as missing.
- Where average-wind-speed and maximum-wind-gust records for the same station and half-hour were incompatible, they were both marked as missing.
- To further validate the Swedish RWIS data, precipitation data from SMHI were downloaded and crosschecked with the RWIS. A general conclusion from this comparison was that the SMHI stations measure a somewhat larger precipitation than the RWIS stations. This could be due to different measuring techniques and instruments.

4.2 IRWIN database layout

The IRWIN database is stored as a compressed directory tree. The layout of the IRWIN database is shown on the next page. The data files are arranged under the top-level directories SWEDEN and FINLAND, then by dataset (historical or scenario), and finally by region. The same folder layout is used for the historical and scenario directories.

- SWEDEN.zip
  - README.txt
  - Historical
    - Gothenburg
    - Stockholm
    - Sundsvall
  - ECHAM5_SRES_A1B (simulations covering 1961-2100)
  - CCSM3_SRES_A1B (simulations covering 1961-2100)
- FINLAND.zip
  - README.txt
  - Historical
    - NE
    - SE
    - SW
  - ECHAM5_SRES_A1B (simulations covering 1961-2100)
  - CCSM3_SRES_A1B (simulations covering 1961-2100)

4.3 IRWIN data files

4.3.1 File format

The data files are standard Windows text files: ISO-8859-15 encoded (also known as Western or Latin-1) text files with CRLF line endings.

The data are arranged as comma-separated-variable format, one-file-per-station, using the format below:

```
"Station ID",206
"Station Name","Moraberg"
"Country","Sweden"
"Region","Stockholm"
"Latitude",59.2
"Longitude",17.67
"Date","Air Temp","Road Temp","Dew Temp","Wind Avg","Wind Max","Prcp Amount","Prcp Type"
1961-01-01 00:00,-5.9,-7.5,-6.9,0,0,0.1,9
1961-01-01 00:30,-5.7,-7.1,-6.5,0,2.5,0,9
1961-01-01 01:00,-5.3,-7,-6.1,0.1,4.0,0,9
1961-01-01 01:30,-4.9,-6.5,-5.6,0,3.3,0.1,9
1961-01-01 02:00,-4.7,-6.6,-5.5,0.1,2.7,-999,-999
.
.
```

The data columns are:

1. observation date and time (yyyy-mm-dd hh:mm)
2. air temperature, ºC
3. road temperature, ºC
4. dew point, , ºC
5. wind speed, average, m/s
6. wind speed, maximum, m/s
7. amount of precipitation (mm-water-equivalent: 1 cm snow = 1 mm water eq.)
8. type of precipitation, see below

Missing values are indicated as -999.

The “type of precipitation” code refers to the following list:

0 - No rain

1 - Rain (inc. drizzle, icing drizzle, icing rain, and freezing rain)

2 - Snow (inc. grainy snow, drev)

3 - Wet snow (inc. snow/rain mix, wet snow, very wet snow)

4 - Hail (inc. ice crystals, snow hail, and hagel)

9 - Precipitation type not determined (inc. low precipitation and sensor issues)

4.3.2 Reading the data files

The data files can be opened in Microsoft Excel 2007 simply by double clicking on them.

Note that the CCSM GCM model (see below) uses a simplified calendar which does not have leap-years, and so the downscaled CCSM scenarios do not contain any February 29 data.

5 Climate Change Scenarios

This section describes the construction of road weather climate change scenarios, and provides some examples and information about how they can be used.

5.1 *Global Climate Models*

Global Climate Models (GCMs) are the computer programs which are used to simulate the response of the atmosphere and oceans to increasing concentrations of greenhouse gases. The climate scenarios generated in *IRWIN* are based on outputs from two GCMs:

1. CCSM3 - Community Climate System Model, version 3.0, from the National Center for Atmospheric Research (NCAR) in US
2. ECHAM5 - ECHAM5/MPI-OM model from Max Planck Institute for Meteorology

These are recognized as world-leading models, and their institutes have made a large amount of model output data available to the research community through the WCRP CMIP3 multi-model database.

5.2 *Greenhouse gas emissions scenarios*

As discussed in the *IRWIN First Inception Report*, it is impossible to know how much greenhouse gas our civilization will produce in the future, and so climate change simulations use hypothetical emissions scenarios from the IPCC Special Report on Emissions Scenarios (SRES). The climate change scenarios used in IRWIN assume the A1B emission scenario, which is considered a mid-range scenario in-terms-of 21st Century global warming. However, note that in the A1B scenario greenhouse gas emissions and global temperatures increase rapidly at first, but then emissions decline by 2100.

5.3 *Statistical Downscaling*

The spatial resolution of GCMs is too rough to be used for climate change studies on regional and local scales. Instead, *IRWIN* uses statistical downscaling to combine the GCM climate change scenarios and the historical road-weather station data. Statistical downscaling identifies relationships between large-scale atmospheric patterns and road weather from historical time-series, and then applies these relationships to the large-scale patterns from GCM outputs to obtain climate change scenarios at a local scale.

IRWIN uses the analogue model for statistical downscaling. This method involves iterating over each day in the GCM future scenario, and for each day finding the day in the historical record for which the large-scale atmospheric patterns match most closely. The future road-weather for each future day is taken to be the historical road-weather on the most closely matched historical day. By using measures of both atmospheric circulation and temperature, future time-series were generated where (under global warming) the winter road-climate of the future becomes more similar to the fall/spring climates of today.

A more detailed description of the downscaling methodology follows.

5.3.1 Identification of analogue days I – weather classes

Strong relationships exist between atmospheric weather classes and local weather in Scandinavia, especially during winter. *IRWIN* uses a modified Lamb-Jenkinson weather scheme (Jenkinson and Collison, 1997; Lamb, 1950) to classify daily sea-level pressure patterns into 27 classes. Each class is a combination of one-or-more codes:

1. A cyclonicity code:
   - “A“ – anti-cyclonic (high-pressure) system prevails.
   - “C“ – cyclonic (low-pressure) system prevails.
2. A directional code, indicating the prevailing regional wind direction on the day:
   - “N“,“NE“,“E“,“SE“,“S“,“SW“,“W“,“NW“
3. The unclassifiable code “U“, meaning there is no easily recognizable pattern.

As an example, the relative occurrence of weather classes over Gothenburg in the winter season is shown in Figure 6. The NCEP/NCAR reanalysis project data (Kallay et al. 1996) represent our best knowledge about the historical sequence of weather types. The GCMs represent the overall pattern of weather classes quite well, in particular the high number of anti-cyclonic (low-pressure) and cyclonic (high-pressure) patterns, and Westerly/Southwesterly wind patterns. However, the number of any particular weather class may not be accurately represented in the GCM models; in particular, the ECHAM5 model under-represents the number of W (westerly wind) days, while the CCSM3 model dramatically over-represents the number of W and SW days.

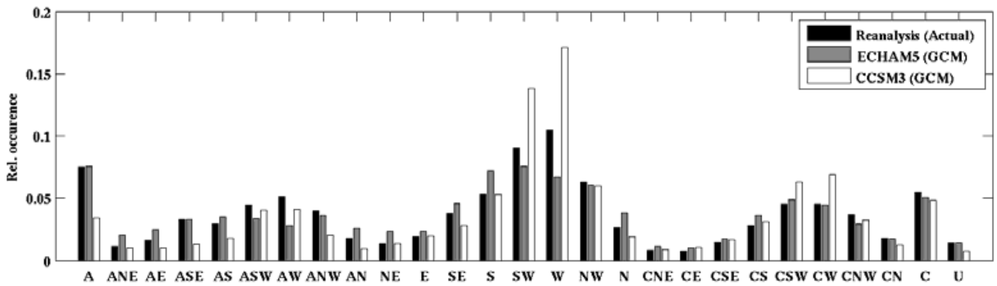


Figure 7: Distribution of Lamb-Jenkinson weather classes over the Gothenburg region for historical days (“Reanalysis“) and the ECHAM5 and CCSM3 GCMs. See text for a description of the weather class abbreviations.

The errors in the weather class numbers may have many causes, but the rough spatial resolution in the GCMs certainly contributes. Figure 7 suggests that the *IRWIN* ECHAM5-based scenarios should be treated as more reliable than the CCSM3 scenarios.

The implication of the errors in the weather class numbers is discussed in Section 5.5.

5.3.2 Identification of analogue days II – regional temperature

The weather classes describe the general air movement in the study region. However, a day with anti-cyclonic weather type in June will clearly have very different weather than a day with anti-cyclonic weather type in January! Thus, to select a historical day as being the analogue of a future day, we required that:

1. The historical day has the same weather type as the day in the GCM simulation;
2. The regional temperature for the historical day is as close as possible to the regional temperature for the future day (historical regional temperatures were obtained from the NCEP/NCAR reanalysis dataset);
3. The station time-series air temperature does not “jump” by more than 2ºC at the boundary between two days.

The last point overcomes a common problem when creating climate change scenarios using the analogue downscaling method: if the best analogue day is always selected (ie. the day with the same weather class and the most closely-matching regional temperature) then the weather on consecutive days will not "match" very well across the midnight transition. Although the IRWIN scenario station time-series do not suffer from this problem, there is a price to be paid: the time-series are not spatially-coherent at daily time-scales. This is discussed in Section 5.5.

5.4 Example Results

The resulting half-hourly datasets contain all the original climate parameters. These will allow stakeholders to generate graphs and statistics which give meaningful information about the climate scenarios. Some examples are shown here to demonstrate what is possible.

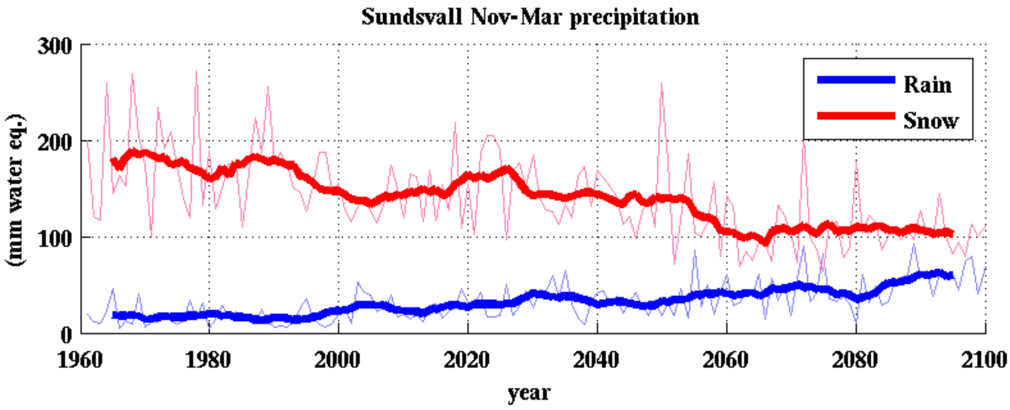


Figure 8: Average November-to-March rain- and snowfalls for all stations in the Sundsvall region for the ECHAM-5 based scenario. Thin lines are annual means, thick lines are 10-year averages. Under this scenario, the amount of snow declines by nearly 50% by year 2100, whereas the rainfall increases by over 100%. This demonstrates the value of the IRWIN statistical downscaling methodology – the publicly available GCM outputs do not differentiate between rain and snow, only total precipitation is provided.

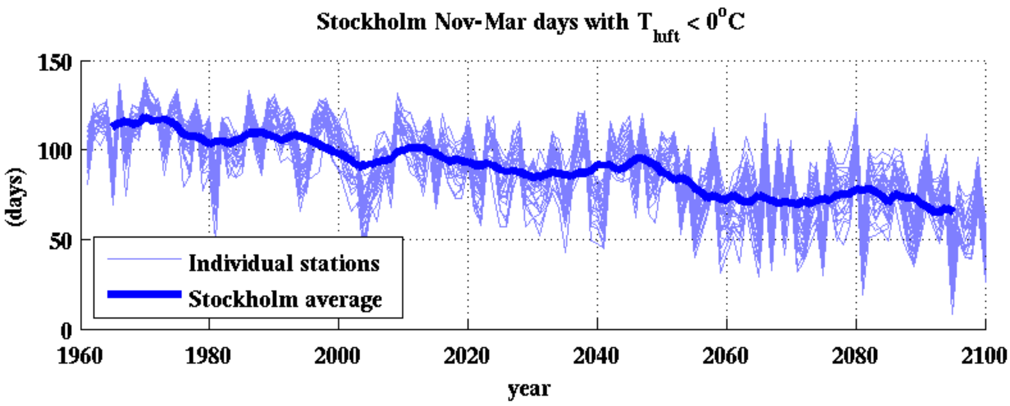


Figure 9: Number of days in the winter season (November-to-March) in the Stockholm region where the air temperature falls below 0ºC. The thin lines are the time-series for individual stations; the thick line is the 10-year regional average. Under this ECHAM-5 based scenario the number of days where temperature falls below freezing will decrease by ~30% by 2100.

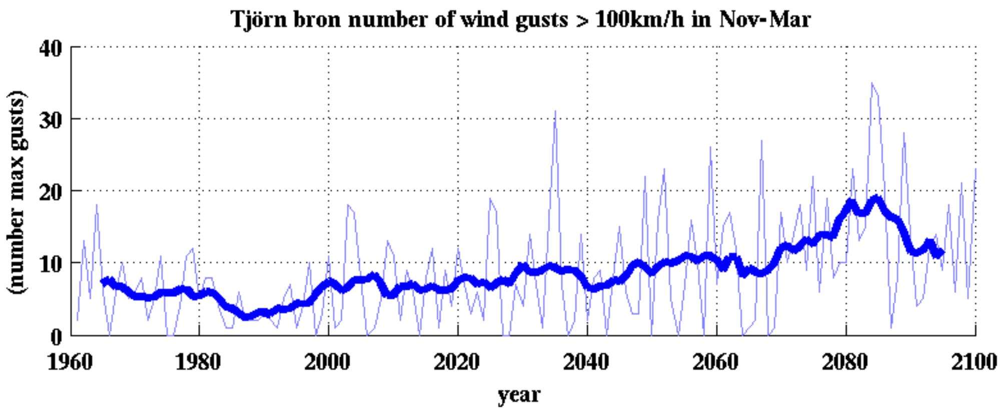


Figure 10: Number of 30-minute periods where the maximium wind gust exceeds 100km/h on the Tjörnbron, Gothenburg region, for the ECHAM-5 based scenario. The thin line are annual counts, the thick line is the 10-year count. The number of wind gusts over 100km/h increase significantly in this scenario. Note, however, that the IRWIN downscaling methodology cannot model any changes in the the maximum recorded wind gust itself: the maximum wind gust can never exceed the highest value in the RWIS historical record, which is 35.9m/s (129.24km/h). But as this figure demonstrates, the IRWIN data can be used to show how often high wind events are likely to occur in the future.

5.5 Notes on the use of the IRWIN road weather climate scenarios

As shown in Figures 8-10, GCMs simulate both the climate of the future *and* of the past. This is important. The errors in the number of each weather class simulated in the GCMs (see Figure 7) imply that the *IRWIN* climate scenarios will be *biased* – they are systematically different from the historical RWIS dataset. This is a common situation with climate scenarios, and it means that changes in road weather conditions should be assessed by *comparing the climate scenario future with the climate scenario past*, and not by comparing the future scenario against the actual historical RWIS data. The results can, of course, be interpreted in the context of the historical RWIS data.

Note also that the sequences of past weather in the GCMs do not match, and are not expected to match, the actual historical weather! For example, a cold year in the GCM simulation may have been a hot year in the historical record. This happens because GCMs are free-running simulations, and weather systems are free to evolve from day-to-day in a chaotic way, in the same way that real weather evolves in a chaotic way. Even if the GCMs were perfect (and current GCMs are clearly far from perfect) and were started with exactly the correct historical weather as the initial conditions in January 1961, the GCM simulation would diverge from the historical weather record within a month. This chaotic behavior is commonly-known as the “butterfly effect”. GCMs simulations of the past are best thought of as a sequence of weather events that could have happened, but of course did not.

Finally, as noted in Section 5.3.2, the IRWIN scenario station time-series are not spatially-coherent at daily time-scales, because the sequences of analogue days were derived independently for each station. For example, in the historical RWIS time-series there are days where an extreme snow storm will result in high snow falls across all stations in a region: this is spatial coherence. The scenario data do not have such days: although all stations will experience extreme snow storms, they do so on different days, and you are unlikely to see a day with a snow storm that blankets a whole region. In general, this implies that when a regional value for a statistic is needed, the statistic should be calculated for each station first, and then aggregated to a regional value, and not vice-versa.

6 Index development

To calculate the need for maintenance activities both present and for the future, and to assess the costs related to these activities, the new index will include both extreme weather data such as strong winds or heavy precipitation, and other weather related data which is connected to ploughing and salting. Depending on the needs; e.g. ploughing, salting or various construction measures due to extreme wind or precipitation, the index can be developed using different combinations of the parameters.

The index will define ploughing events with the use of precipitation as snow during a certain period of time, with a certain temperature, and with a certain wind velocity. The different temperatures and wind speeds will give the index different weights. For salting, the index will use: 1: rain on a frozen surface, 2: when the surface temperature is frozen and dew point is higher than the surface temperature, and 3: when the surface temperature shifts between minus one to plus one degree. The different types of events which have to be considered while looking at the road maintenance needs are listed below:

1. Number of occasions when the amount of snow[2] > 1mm during Xh[3], T between -3 to +1˚C, and the wind velocity is between 0-7m/s.
2. Number of occasions when the amount of snow > 1mm during Xh, T between -3 to +1˚C, and the wind velocity is between 7-14m/s.
3. Number of occasions when the amount of snow > 1mm during Xh, T between -3 to +1˚C, and the wind velocity is between >14m/s.
4. Number of occasions when the amount of snow > 1mm during Xh, T < -3˚C, and the wind velocity is between 0-7m/s.
5. Number of occasions when the amount of snow > 1mm during Xh, T < -3˚C, and the wind velocity is between 7-14m/s.
6. Number of occasions when the amount of snow > 1mm during Xh, T < -3˚C, and the wind velocity is between >14m/s.
7. Number of occasions when it is/has been raining and the surface temperature < 0,5˚C.
8. Number of occasions when surface temperature between -6˚C and 0˚C, during Xh, and dew point > surface temperature.
9. Number of occasions when surface temperature shifts from +1˚C to -1˚C.

Number 1-6 causes ploughing as maintenance due to snow on the road or snowdrift, and number 7-9 causes salting as maintenance due to frost or ice on the road surface.

Other conditions crucial for road maintenance – such as strong winds, heavy precipitation or the length of ground frost and thawing cycle – will also be included as part of the index. These factors can put stress on the roads, the road surfaces or on buildings, and are combined with other parameters or factors also crucial for the maintenance needs.

10. Number of events when the wind is between 0 - 10m/s.
11. Number of events when the wind is between 11 - 15m/s.
12. Number of events when the wind is between 16 - 20m/s.
13. Number of events when the wind is between 20 - 25m/s.
14. Number of events when the wind is between 25 - 30m/s.

[2] Water equivalent
[3] Different time periods will be tested

15. Number of events when the wind is over 30m/s.
16. Number of events when it is raining between 0 – 3mm in 30 minutes.
17. Number of events when it is raining between 4 – 6mm in 30 minutes.
18. Number of events when it is raining between 7 – 9mm in 30 minutes.
19. Number of events when it is raining more than 10mm in 30 minutes.
20. The length of the ground frost and thawing cycle will be calculated as the time when temperature is shifting between minus and plus degrees 10 cm below the surface.

As an example, for planning of road construction in relation to climate change scenarios a combination of numbers 3, 6 and 15 can be used, but the index will be open for different users and different applications.

7 Plan for the final project phase

7.1 Index calculations and evaluation

After the data collection and database construction phase, IRWIN has enough data to start the development of the improved winter index. This work has been already stared somewhat ahead of schedule. The work plan during the last quarter of the project concentrates on evaluating the results and performing cost-benefit analyses using the new index.

Two of the three IRWIN milestones have been completed. The following table describes the main results.

Table 1. IRWIN Milestones

Milestone	When due	Contents	Comments
MS1	**M3,** **Jan 2009**	**Project effectively started, work plan detailed. Kick-off meeting with all participants. State-of-the-analysis performed. First deliverable D1 submitted to PSG.**	**Completed. Kick-off meeting in Gothenburg on November 11th 2008. D1 including state-of-the art-analysis submitted to PSG on January 30th 2009.**
MS2	**M8,** **Jun 2009**	**Data collection and database construction performed as planned and finalised. Enough data with high enough quality exists to start index development. Second inception report D2 submitted to PSG.**	**Completed. Data collection and database construction phase finalized. High-quality database constructed with Swedish and Finnish RWIS data. D2 submitted in time to PSG on June 1st 2009.**
MS3	**M14,** **Dec 2009**	**All calculations and evaluations finalised. Cooperation with other ERA-NET ROAD projects and dissemination performed as planned. Final report submitted to PSG.**	**Cooperation with other ERA-NET ROAD projects started in the common seminar in Oslo on 31st March – 2nd April 2009. Winter index calculations started as planned.**

7.2 Dissemination Plan

In the ERA-NET ROAD seminar in Oslo on 31st March – 2nd April 2009, dissemination of the first ERA-NET ROAD projects was discussed.

The first target group for dissemination is the road owners and administrations in ERA-NET countries. The second group covers the road administrations and other interest groups in the EU. To reach these target groups, the project results will be presented in transport forums, publications and conferences active in 2009 and 2010. The following list gives some potential forums where project results can be offered as papers and presentations:

EASYWAY, 16 – 17.3.2009, Lillehammer

International Baltic Road Conference, 24 – 26.8.2009, Riga

ITS World Congress 21 – 25.9.2009, Stockholm

28th Winter Road Congress, Lahti Finland, 27th-28th January, 2010

Intertraffic 2010, 23 – 26.3.2010, Amsterdam

TRA2010, June 7.-10. 2010, Brussels

ERA-NET ROAD is pursuing the TRA2010 Organising Committee to reserve a special session for projects.

In addition, IRWIN results with scientific interest will be submitted to suitable reviewed journals.

7.3 Extension to other ERA-NET ROAD countries

One objective of IRWIN is to provide other countries information on how to develop similar winter index using local road weather information. During the data collection phase, Austrian Road Administration was contacted to find out if Austria could be used as an extended test country. It turned out that not enough data was archived.

Project time table does not allow any further calculations in other countries even if data would be available. However, a questionnaire will be sent to all ERA-NET ROAD partners to find out what kind of and how much road weather observations have been archived.

8 Conclusions

The data collection phase of IRWIN revealed that there is enough archived RWIS data in Sweden and Finland to perform the planned winter index development. Ten years of observations were collected from 50 road weather stations in Sweden and 49 stations in Finland. Observations in each country were divided into three regions with distinctive climatic characters. Extensive processing had to be performed first to create a high-quality database with corrected and uniform observations. Maintenance activities from the regions of interest were collected as well, to be used in the winter index calculations.

In this report, details of the IRWIN database and file format structures can be found. The climate downscaling methods and the used climate scenarios are described and first results shown. Rules for the index development are given. In other countries, similar assessments could be thus done relatively easily if enough road weather information is archived and available. IRWIN will send a questionnaire to all ERA-NET ROAD countries to find out if suitable data files exist outside Sweden and Finland.

9 Sources

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