DNMI DET NORSKE METEOROLOGISKE INSTITUTT

klima

EVALUATION OF A DOUBLE EXPONENTIAL CORRLATION WEIGHTED INTERPOLATION METHOD BY STATISTICAL EXPERIMENTS

Petter Øgland

REPORT NO. 25/97 KLIMA

DNMI - REPORT

NORWEGIAN METEOROLOGICAL INSTITUTE
BOX 43 BLINDERN N-0313 OSLO

PHONE: +47 22 96 30 00

ISSN 0805-9918

REPORT NO.

25/97 KLIMA

DATE

Nov 16th, 1997

TITLE

EVALUATION OF A DOUBLE EXPONENTIAL CORRELATION WEIGHTED INTERPOLATION METHOD BY STATISTICAL EXPERIMENTS

AUTHOR

Petter Øgland

PROJECT CONTRACTOR

DNMI - Climatology Division

SUMMARY

The automated interpolation technique at the Climatology Division has in some ways enhanced the interpolation procedures in the preliminary quality control routines. However, according to experience and statistical experiments, as documented in report no. 23/97 KLIMA, the interpolation method generates gross errors in difficult situations.

A new interpolation method, adapted and improved from the old radial distance estimation method, is explained in this report. It makes more thorough use of reference data as the interpolation algorithm computes correlation estimates of the test station and each reference stations. By making a double exponantial transformation of the correlation coeffecient, the values are used as weights for the linear estimator.

In the case of the earlier radial distance estimator, a correctional factor was computed in order to eliminate bias. In the case of the new method, correctional coeffecients are construced by use of least squares method in order to reduce both bias and variance.

The new method has been repeatedly tested by taking random samples of test stations and avaluating the results using the same type of statistics as used for verifying forecasts. One such experiment is documented in this report, and gives several score statistics for the estimation method. Statistics seem to indicate that the new method is positively better than the old method if still not perfect.

SIGNATURE

Petter Øgland — Research Scientist

Bjørn Aune — Head of Climatology Division

1. INTRODUCTION

In order to assure quality data for climatological applications, a systematic quality control must be applied to all meteorological observations collected and stored in the climatological databases.

One fundamental problem to consider is how to assure that observation series for vital meteorological elements such as air temperature, air pressure, precipitation etc. are complete. The word *interpolation*, as used in this document, refers exclusively to the procedure of inserting values in meteorological observation series in order to make the series complete based on knowledge of similar surrounding measurements within a short span of space and time.

This report documents an experiment using one such interpolation procedure. The quality control reseach at the Climatology Division at DNMI is internally conducted, and results are being presented internally. Development within the research concerning precipitation observations, however, is aligned with a Nordic precipitation quality control project FREYR (Vejen et al., 1997).

2. DATA SETS

A computer programme runs daily at DNMI, pointing out missing observations in the datatable TELE which contains three terms of SYNOP data; 00, 06 and 18 hrs. UTC. For each missing observation, another programme makes estimates as to which numerical value one would have expected at these coordinates in time and space.

For each missing value, an interpolated value is inserted into TELE and flagged in order to register it as an automatically generated value. The computer programmes made for this task is documented in a technical internal report (Øgland, 1997a).

The same estimation method is used for all eight meteorological elements under consideration:

- air temperature (TT) in centigrades (°C)
- minimum air temperature (TN) in centigrades (°C)
- maximum air temperature (TX) in centigrades (°C)
- air pressure at station level (P0) in hecto Pascal (hPa)
- air pressure at sea level (P) in hecto Pascal (hPa)
- cloud cover (N) in octas (0-8)
- relative humidity (UU) in percentage (%)
- precipitation (RR) in millimeters (mm)

Interpolations are made from sets of observations with maximum recording frequency every three hours; 00, 03, 06, 09, 12, 15, 18, 21 hrs. UTC. Only observations recorded up to every six hours are interpolated; 00, 06, 12 and 18 hrs. UTC.

Observations have been taken from a selection of 16 weather stations from a list of 162 stations, where the selected stations were the ones missing data when the experiment was conducted. Test data were selected from the 3 day period November 11th 1997 to November 13th 1997.

3. THE EXP(EXP(CORR)) ESTIMATION METHOD

The interpolation methods in this document, used for interpolation and estimation of weather element x, are based on a linear estimator $\tilde{x}$ as described by the formula below.

$$\tilde{x}_i = \alpha \sum_{j=1}^{10} w_j y_{i,j} + \beta$$

where $y_{i,j}$ is the observed value at reference station no. j relative to the test station, recorded at time step no. i. The set w_j, $j = 1, 2, \ldots, 10$ is a set of empirically constructed values, called the *weights* for the estimator.

The weights associated with the meteorological double exponential correlationally weighted interpolation method are defined as

$$w_j = \frac{\exp(\exp(\lambda corr(x, y_j))) - \mu}{\sum_{k=1}^{10} [\exp(\exp(\lambda corr(x, y_k))) - \mu]}$$

where

$$\lambda = \log(\log(100 + e)),\ \mu = e$$

Log is the natural logarithm and e is Euler's number (2.71828...). The weights share the following property:

$$\sum_{j=1}^{10} w_j = 1$$

The coeffecients α and β are empirically decided values. They are referred to as *correctional coeffecients* through out this text as they introduced in order to reduce the bias of the estimator, and are constructed by least squares method using $w_j y_{i,j}$ as predictor variables and $\tilde{x}_i$ as response variables.

Correlation coeffecients α and β are only computed if there are more than 3 paired observations. If no correlation is computed, the correlation coeffecient is set to 0.0 by default.

If there are no data available for the test station for the chosen interval, α and β must be constructed in some other manner. Presently α is set equal to one and β equal to zero reintroducing whatever bias that might be inherit within the weighted estimation method.

There are no physical understanding of the weather elements at hand programmed into the estimator. Each set of values, included code estimates for cloud cover and percentage estimates for relative humidity, are treated as floating numbers with no restrictions to range of allowable values.

As the initial choice of ten reference stations is independent of which meteorological element one wants to estimate, there may be cases where a reference station is chosen that does not support measurements of this particular element. In such cases the correlation is by default assigned the value of zero.

4. THE RADIAL ESTIMATION METHOD AS USED AS REFERENCE METHOD

The weights associated with the meteorological radial method (Øgland, 1997b) are defined as

$$w_j = \frac{\theta(r_j)}{\sum_{k=1}^{10} \theta(r_k)}$$

where

$$r_k^2 = (long_k - long_T)^2 + (lat_k - lat_T)^2 + (h_k - h_T)^2$$

where longitude and latitude are given in measures of 10000 * degrees + 100 * minutes + seconds, and height of station above sea level h is given in meters. The index T refers to the test station.

The function θ is defined as

$$\theta(r_k) = \exp\left(\frac{\lambda}{r_k^2}\right)$$

where the number λ at the moment is equal to 10000, chosen for numerical reasons.

The weights are convex in the following sense:

$$\sum_{j=1}^{10} w_j = 1$$

The assumption of the radial method is that the closer a reference station is to the test station, the better it would be correlated. If all reference stations very perfectly correlated, the estimated values would, of course, be a perfect fit, provided a perfect correctional factor could be made.

As there is no guarantee that the closest reference stations, of a certain test station, would be best correlated, with respect to the weather element in question, correlation values have been calculated for all reference stations.

Correctional factors used by the radial distance estimation method, as earlier evaluated and documented, is:

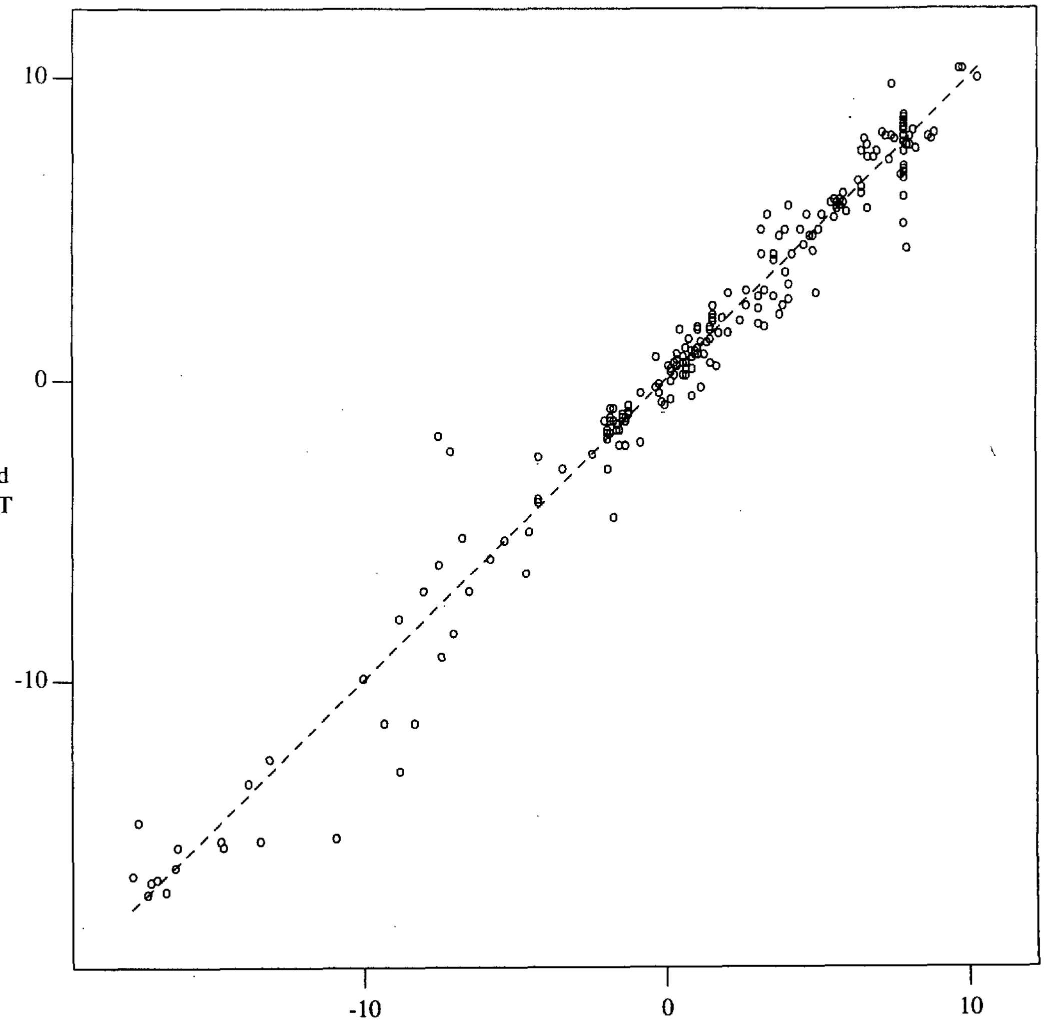
$$\alpha = \frac{\sum_{i=1}^{N} x_i}{\sum_{i=1}^{N} \tilde{x}_i}$$

summing through the complete period of the data set under consideration, using only occurences where both s_i and $\tilde{x}_i$ have attainalbe values. As there were no other kinds of corrections, β is set equal to zero.

5. SCATTER PLOTS OF EXP(EXP(CORR)) ESTIMATES VS. OBSERVATIONS

Scatter plots of estimated values against observed values give non-time dependent information about the simultaneous distribution of estimates and observations. In order to evaluate the estimators, on the following pages scatter plots and regression analysis has been applied to each of the meteorological elements without regard to location.

Figure 1. Scatter plot for air temperature (TT) in centigrades (°C).



Min TT = -17.1	Max TT = 10.3	Average TT = 1.2	Stddev TT = 6.2	Cov(TT,$\tilde{TT}$) = 38.1
Min $\tilde{TT}$ = -17.6	Max $\tilde{TT}$ = 10.3	Average $\tilde{TT}$ = 1.2	Stddev $\tilde{TT}$ = 6.3	Corr(TT,$\tilde{TT}$) = 0.99

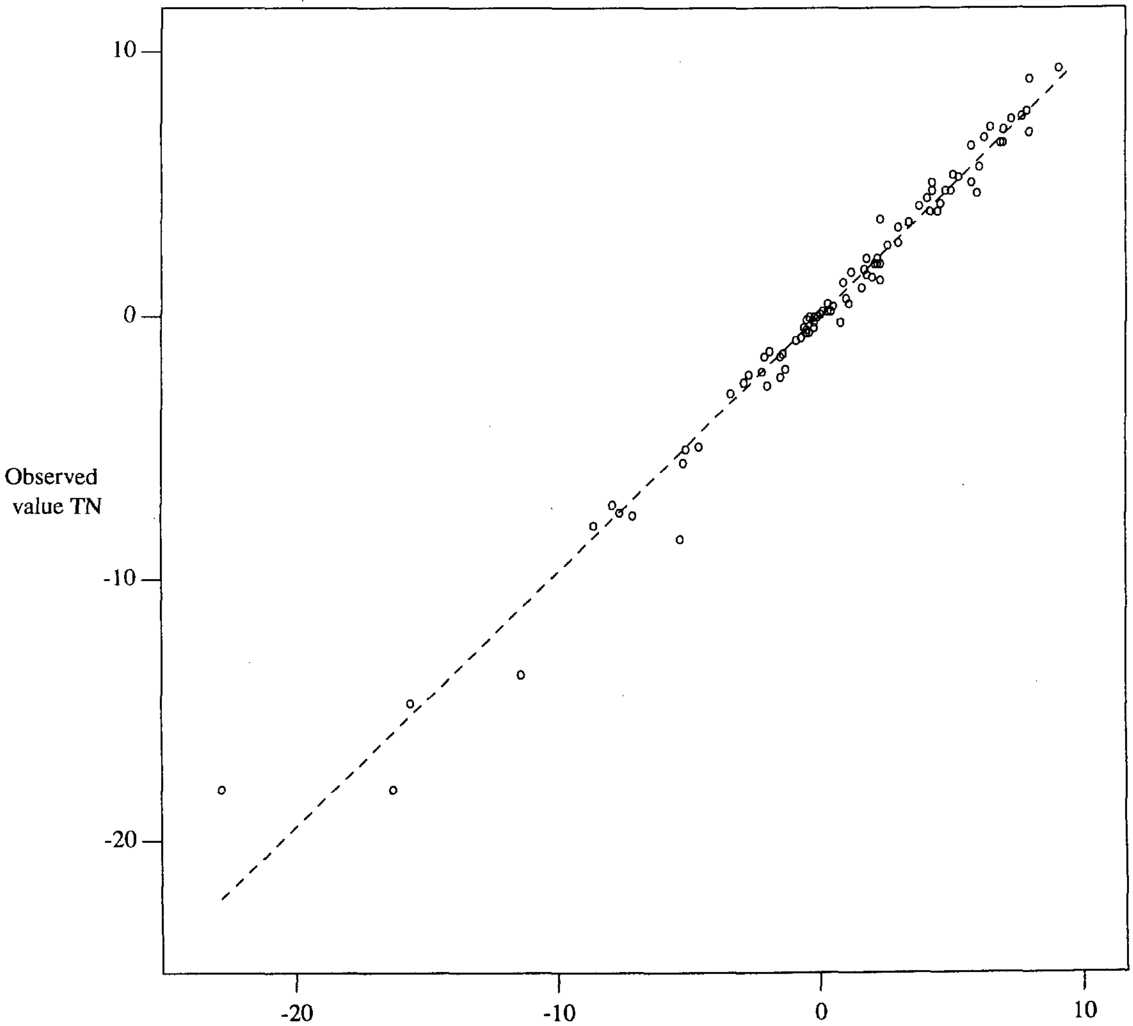
The diagonal of the plot represents the set $TT = \tilde{TT}$, while dashed line represents the regression line

$$TT = \alpha\tilde{TT} + \beta$$

with coeffecients:

$$\alpha=1.0000$$
$$\beta=0.0000$$

Figure 2. Scatter plot for minimum air temperature (TN) in centigrades (°C).



Min TN = -18.0	Max TN = 9.4	Average TN = 0.6	Stddev TN = 5.4	Cov(TN,$\tilde{TN}$) = 28.5
Min $\tilde{TN}$ = -22.8	Max $\tilde{TN}$ = 9.4	Average $\tilde{TN}$ = 0.6	Stddev $\tilde{TN}$ = 5.4	Corr(TN,$\tilde{TN}$) = 0.99

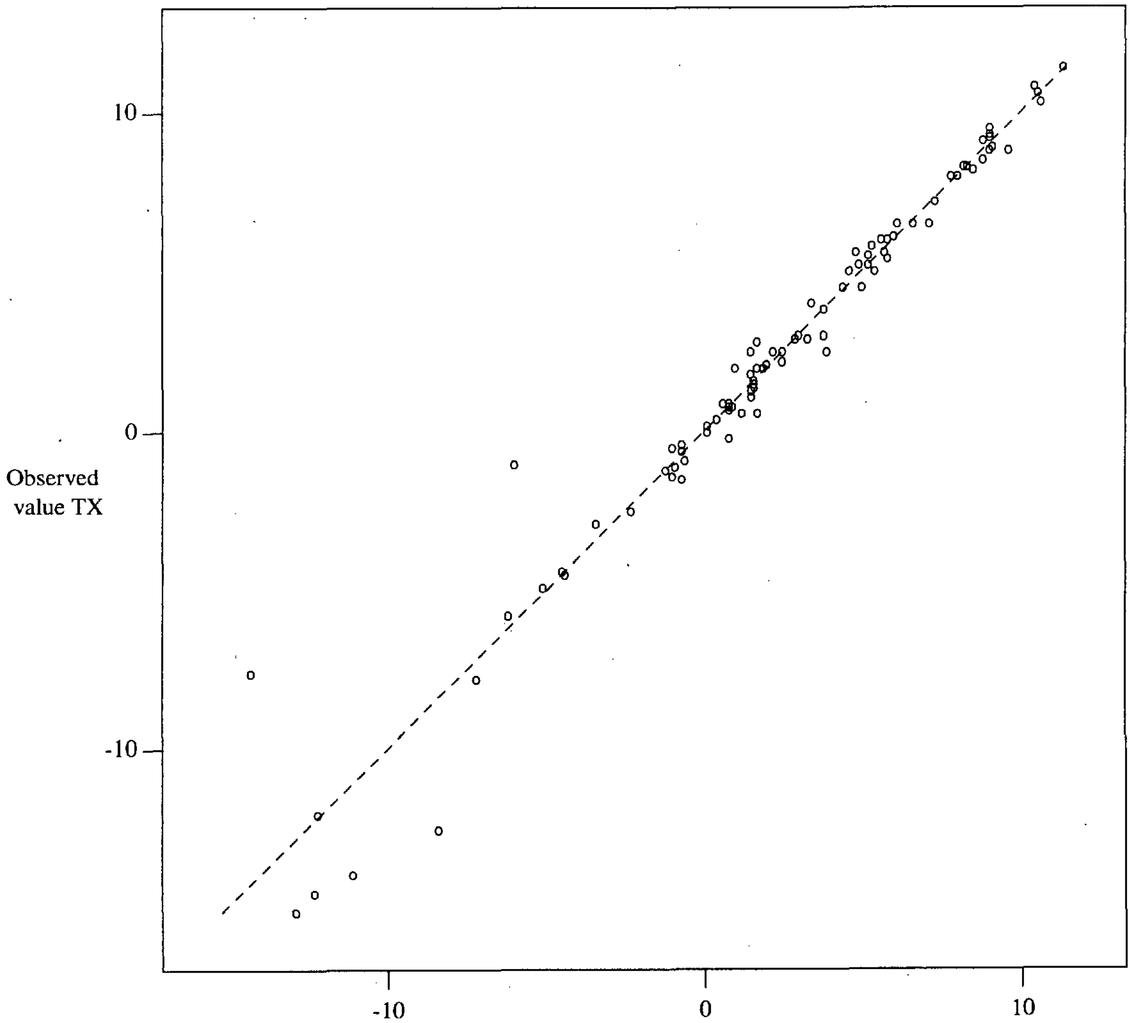
The diagonal of the plot represents the set $TN = \tilde{TN}$, while dashed line represents the regression line

$$TN = \alpha \tilde{TN} + \beta$$

with coeffecients:

$$\alpha = 0.9750$$
$$\beta = 0.0150$$

Figure 3. Scatter plot for maximum air temperature (TX) in centigrades (°C).



Min TX = -15.2	Max TX = 11.4	Average TX = 2.2	Stddev TX = 5.6	Cov(TX,$\tilde{TX}$) = 31.0
Min $\tilde{TX}$ = -15.2	Max $\tilde{TX}$ = 11.4	Average $\tilde{TX}$ = 2.2	Stddev $\tilde{TX}$ = 5.7	Corr(TX,$\tilde{TX}$) = 0.98

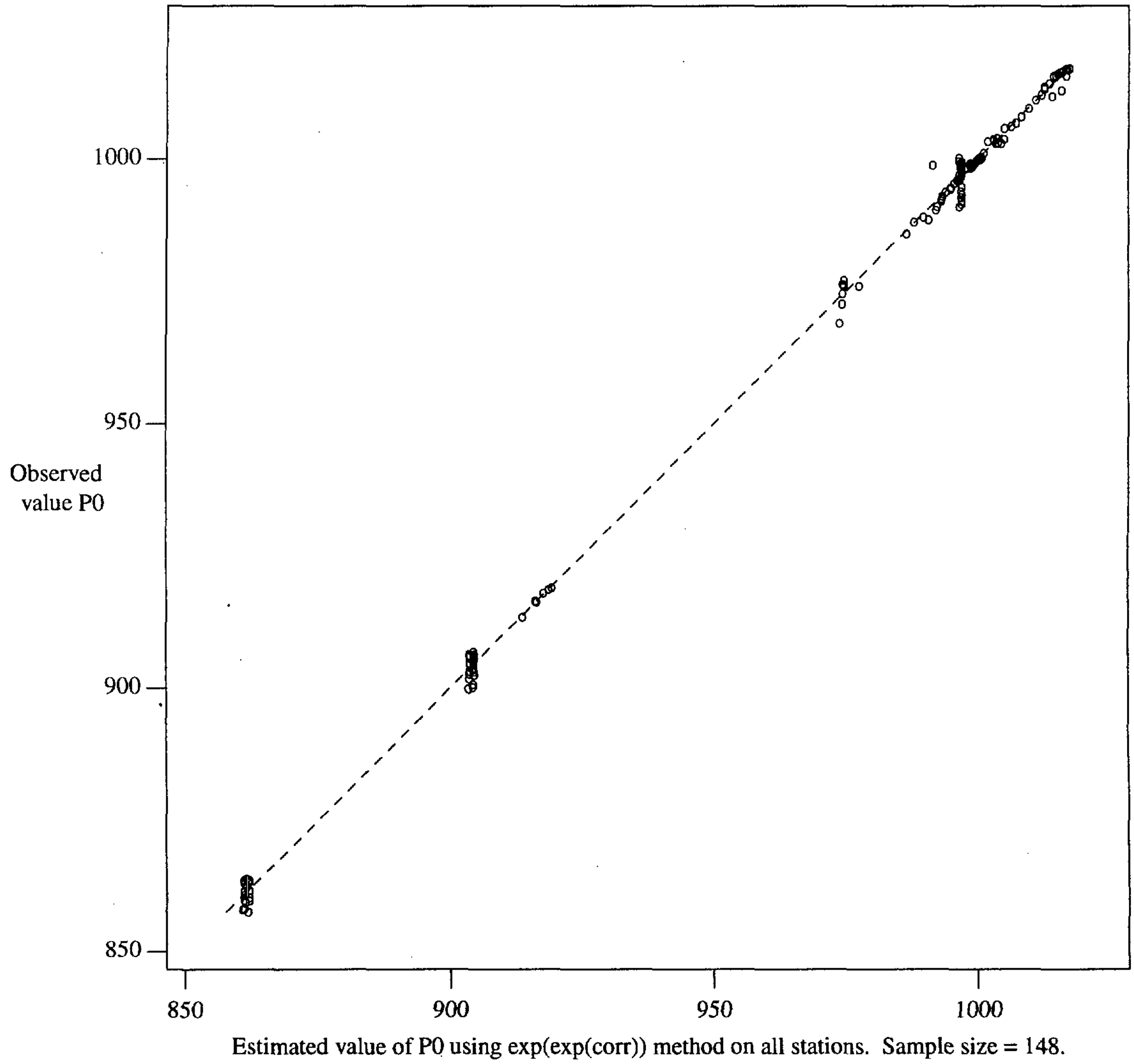
The diagonal of the plot represents the set $TX = \tilde{TX}$, while dashed line represents the regression line

$$TX = \alpha\tilde{TX} + \beta$$

with coeffecients:

$$\alpha=1.0000$$
$$\beta=0.0000$$

Figure 4. Scatter plot for air pressure at station level (P0) in hecto Pascal (hPa).



Min $P0$ = 857.7	Max $P0$ = 1016.9	Average $P0$ = 959.6	Stddev $P0$ = 56.1	Cov($P0,\tilde{P0}$) = 3126.7
Min $\tilde{P0}$ = 857.7	Max $\tilde{P0}$ = 1017.3	Average $\tilde{P0}$ = 959.6	Stddev $\tilde{P0}$ = 56.1	Corr($P0,\tilde{P0}$) = 1.00

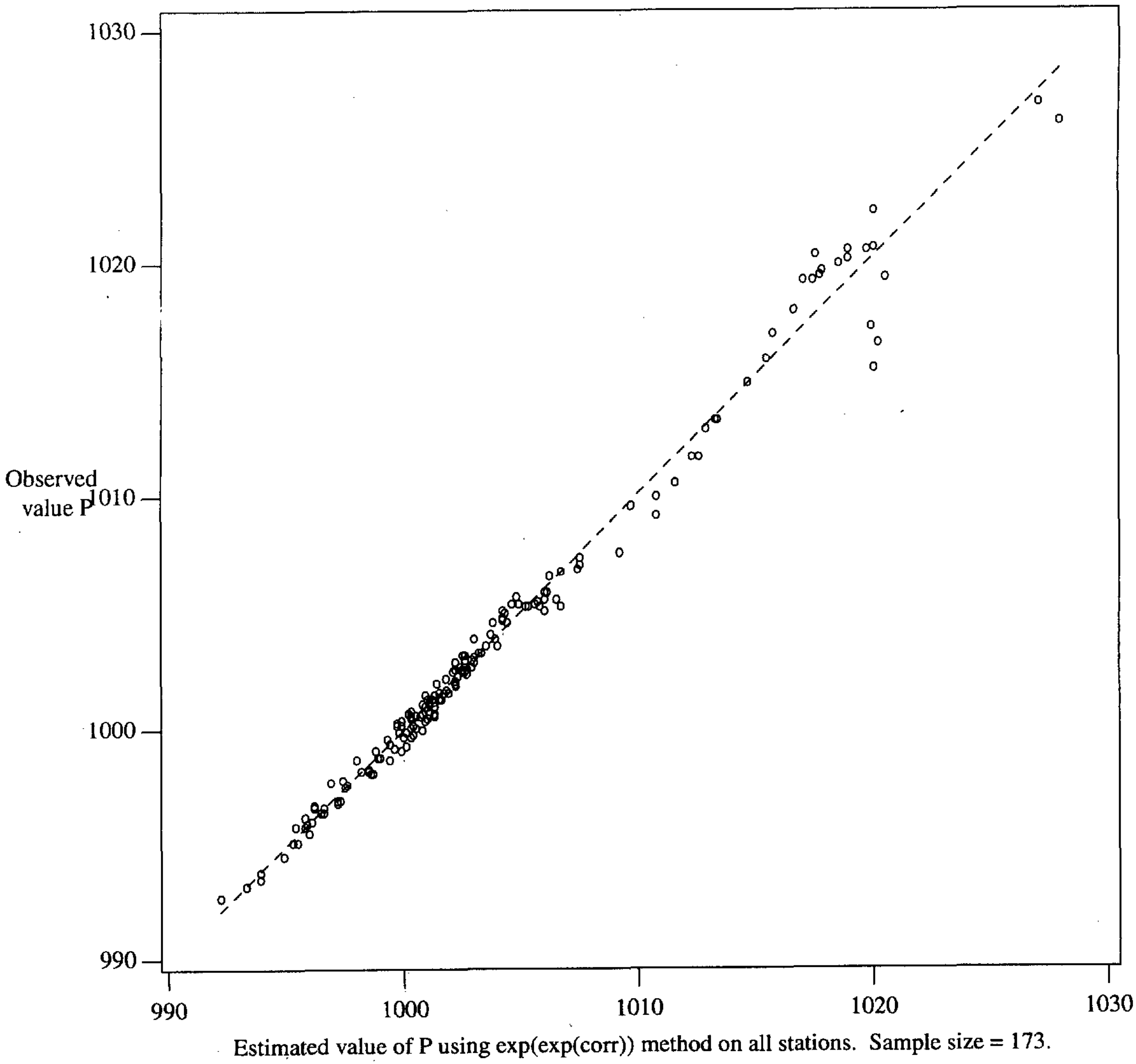
The diagonal of the plot represents the set $P0 = \tilde{P0}$, while dashed line represents the regression line

$$P0 = \alpha\tilde{P0} + \beta$$

with coeffecients:

$$\alpha{=}1.0001$$
$$\beta{=}-0.0663$$

Figure 5. Scatter plot for air pressure at sea level (P) in hecto Pascal (hPa).



Min $P = 992.7$	Max $P = 1026.9$	Average $P = 1003.8$	Stddev $P = 7.0$	$\mathrm{Cov}(P,\tilde{P}) = 49.1$
Min $\tilde{P} = 992.2$	Max $\tilde{P} = 1028.0$	Average $\tilde{P} = 1003.8$	Stddev $\tilde{P} = 7.1$	$\mathrm{Corr}(P,\tilde{P}) = 0.99$

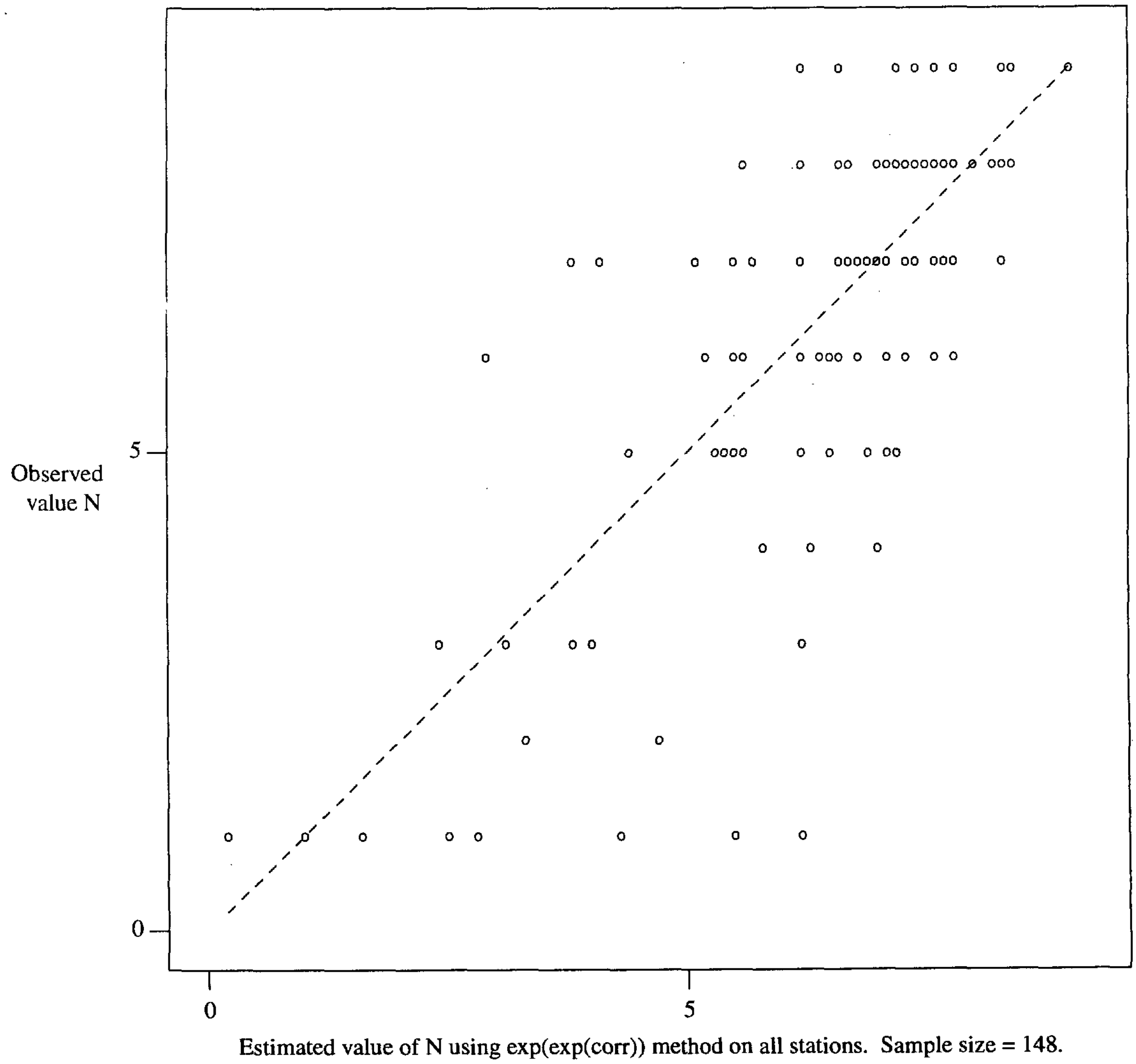
The diagonal of the plot represents the set $P = \tilde{P}$, while dashed line represents the regression line

$$P = \alpha\tilde{P} + \beta$$

with coeffecients:

$$\alpha = 1.0095$$
$$\beta = -9.5416$$

Figure 6. Scatter plot for cloud cover (N) in octas (0-8).



Min $N = 1.0$	Max $N = 9.0$	Average $N = 6.7$	Stddev $N = 1.6$	$\mathrm{Cov}(N,\tilde{N}) = 2.5$
Min $\tilde{N} = 0.2$	Max $\tilde{N} = 9.0$	Average $\tilde{N} = 6.7$	Stddev $\tilde{N} = 2.1$	$\mathrm{Corr}(N,\tilde{N}) = 0.76$

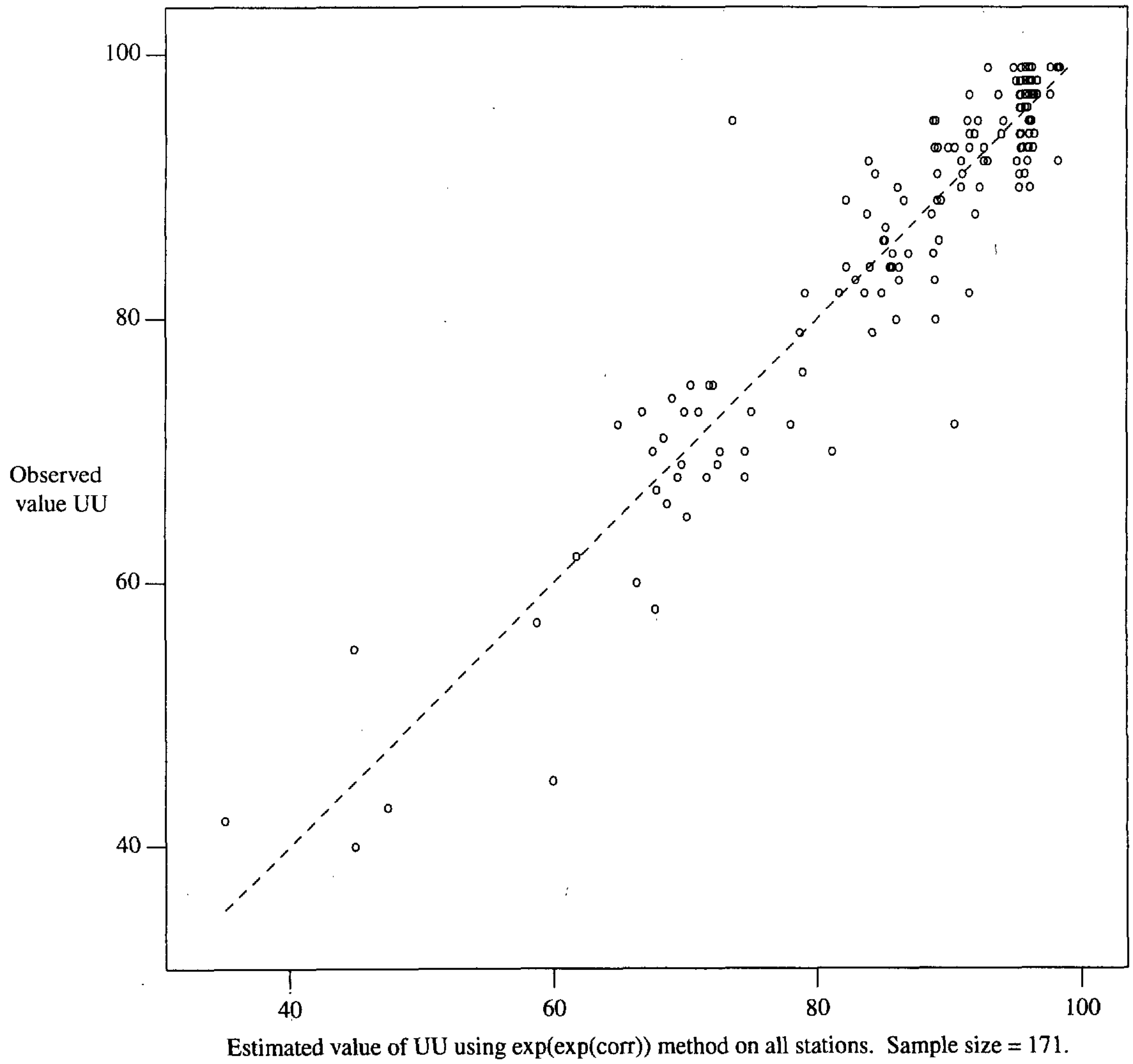
The diagonal of the plot represents the set $N = \tilde{N}$, while dashed line represents the regression line

$$N = \alpha\tilde{N} + \beta$$

with coeffecients:

$$\alpha{=}1.0000$$
$$\beta{=}-0.0001$$

Figure 7. Scatter plot for relative humidity (UU) in percentage (%).



Min $UU = 40.0$ Max $UU = 99.0$ Average $UU = 87.6$ Stddev $UU = 12.0$ Cov$(UU,\tilde{UU}) = 142.9$
Min $\tilde{UU} = 35.2$ Max $\tilde{UU} = 99.0$ Average $\tilde{UU} = 87.5$ Stddev $\tilde{UU} = 12.7$ Corr$(UU,\tilde{UU}) = 0.94$

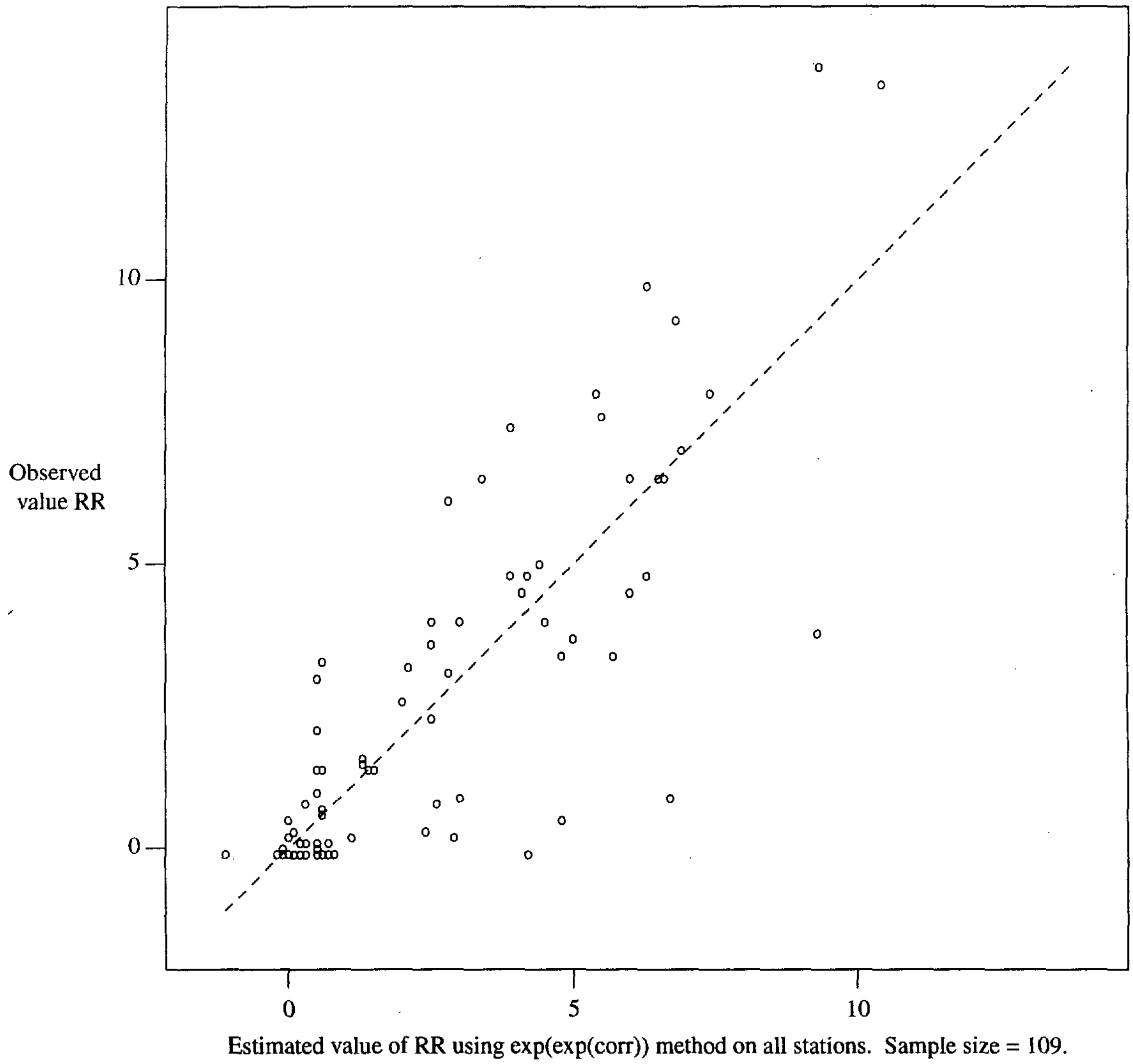
The diagonal of the plot represents the set $UU = \tilde{UU}$, while dashed line represents the regression line

$$UU = \alpha\tilde{UU} + \beta$$

with coeffecients:

α=0.9991
β=0.0086

Figure 8. Scatter plot for precipitation (RR) in millimeters (mm).



Min $RR = -0.1$	Max $RR = 13.7$	Average $RR = 1.9$	Stddev $RR = 2.6$	$\mathrm{Cov}(RR,\tilde{RR}) = 6.6$
Min $\tilde{RR} = -1.1$	Max $\tilde{RR} = 13.7$	Average $\tilde{RR} = 1.9$	Stddev $\tilde{RR} = 3.0$	$\mathrm{Corr}(RR,\tilde{RR}) = 0.86$

The diagonal of the plot represents the set $RR = \tilde{RR}$, while dashed line represents the regression line

$$RR = \alpha \tilde{RR} + \beta$$

with coeffecients:

$$\alpha = 1.0000$$
$$\beta = 0.0000$$

6. SCORE STATISTICS

Statistics for evaluating the estimator are similar to statistics used at DNMI for verifying 2 meter temperature weather forecasts (Homleid, 1997). The statistical experiments have also been carried out in a similar way.

The statistics are calculated from n estimated values: $\tilde{x}_i,\ i = 1, 2, \ldots, n$
and the corresponding observations: $x_i,\ i = 1, 2, \ldots, n$

The error e is defined as: $e_i = \tilde{x}_i - x_i,\ i = 1, 2, \ldots, n$

Mean error:

$$bias = \frac{1}{n}\sum_{i=1}^{n} e_i$$

Absolute mean error:

$$absolute\ bias = \left|\frac{1}{n}\sum_{i=1}^{n} e_i\right|$$

Standard deviation of the errors:

$$stde = \sqrt{\frac{\sum_{i=1}^{n}(e_i - bias)^2}{n-1}}$$

Root mean square error:

$$rmse = \sqrt{\frac{1}{n}\sum_{i=1}^{n} e_i^2}$$

Mean absolute error:

$$mae = \frac{1}{n}\sum_{i=1}^{n} |e_i|$$

Min absolute error:

$$emin = \min(|e_i|),\ i = 1, 2, \ldots, n$$

Max absolute error:

$$emax = \max(|e_i|),\ i = 1, 2, \ldots, n$$

The result of the calculations is presented in the tables in Appendix 1.

In order to compare the bias of different weather stations or to compare the bias of the two estimation techniques, the *absolute bias* is used. When describing the bias of a certain weather station, the ordinary *bias* is used.

In the following sections statistics from applying the estimation methods to each weather element is presented. In each case there is a simple worst case analysis and statistics showing how the two estimation methods compare.

6.1 Score statistics for air temperature (TT) in centigrades (°C)

A total of 16 weather stations were tested, see table 1 below. Statistics and plots from worst case weather station V42920 SIRDAL - TJØRHOM, having the greatest *rmse*, are presented.

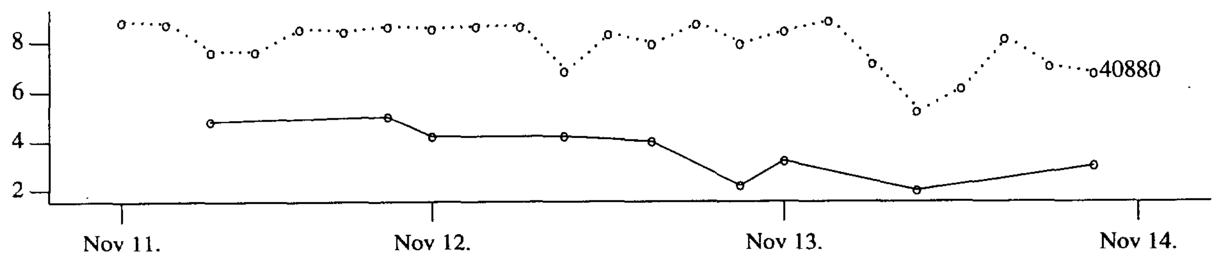
Sample size = 10 Bias = -0.2 Stde = 1.1 Rmse = 1.0 Mae = 0.9 Emin = 0.0 Emax = 1.9

Reference stations, weights and correlation coeffecients based on N pairs of observations:

39690 BYGLANDSFJORD - SOLBAKKEN	58°40'03"N	07°48'06"E	212 m a.s.l.	$w_{01} = 24$	Corr = 0.78	$N = 7$
40880 HOVDEN - LUNDANE	59°35'00"N	07°23'00"E	836 m a.s.l.	$w_{02} = 15$	Corr = 0.69	$N = 10$
46510 MIDTLÆGER	59°50'03"N	06°59'49"E	1079 m a.s.l.	$w_{03} = 9$	Corr = 0.58	$N = 10$
41670 KONSMO - HØYLAND	58°16'02"N	07°22'84"E	263 m a.s.l.	$w_{04} = 5$	Corr = 0.47	$N = 7$
45880 FISTER - TØNNEVIK	59°10'00"N	06°03'16"E	50 m a.s.l.	$w_{05} = 3$	Corr = 0.36	$N = 5$
42160 LISTA FYR	58°06'60"N	06°34'10"E	14 m a.s.l.	$w_{06} = 3$	Corr = 0.35	$N = 10$
41770 LINDESNES FYR	57°59'00"N	07°02'90"E	13 m a.s.l.	$w_{07} = 2$	Corr = 0.24	$N = 7$
41010 MANDAL - EIGEBREKK	58°00'84"N	07°36'52"E	10 m a.s.l.	$w_{08} = 0$	Corr = 0.00	$N = 0$
42160 LISTA FYR	58°06'60"N	06°34'10"E	14 m a.s.l.	$w_{09} = 0$	Corr = 0.00	$N = 0$
46610 SAUDA	59°38'92"N	06°21'80"E	5 m a.s.l.	$w_{10} = 0$	Corr = -0.04	$N = 7$

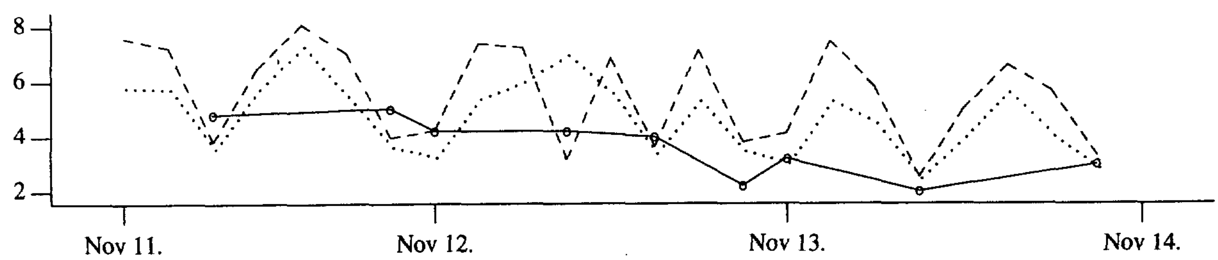
The correctional coeffecient α equals 0.64, β equals -0.4.

Figure 9. Observations TT at test station SIRDAL - TJØRHOM and reference stations.



Solid curve represent observations of TT, dashed curve represent TT at ref no. 1, dotted represents TT at ref no. 2.

Figure 10. Observations TT and estimates $\tilde{TT}_1$ and $\tilde{TT}_2$ at weather station SIRDAL - TJØRHOM.



Dashed curve represent TT estimates using the exp(exp(corr)) method, dotted represent TT estimates using the radial method.

Table 1. Statistics for TT using the exp(exp(corr)) method.

TT at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	-2.97	-5.6	0.0	0.4	0.4	0.3	0.0	0.8
median	10	0.87	0.0	0.0	0.8	0.7	0.9	0.0	1.9
maximum	24	2.91	7.9	0.2	2.6	2.5	3.3	0.3	5.7
average	14	0.70	-0.3	0.0	0.9	0.9	1.0	0.1	2.1
stddev	7	1.03	2.0	0.0	0.6	0.5	0.7	0.1	1.3

Table 2. Statistics for TT using the radial method.

TT at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	-2.97	0.0	0.0	0.4	0.4	0.3	0.0	0.7
median	10	0.87	0.0	0.0	1.4	1.3	1.2	0.1	2.7
maximum	24	2.91	0.0	0.0	3.9	3.6	3.3	0.7	12.1
average	14	0.62	0.0	0.0	1.7	1.7	1.3	0.1	3.9
stddev	8	1.40	0.0	0.0	1.2	1.1	0.9	0.2	3.3

Comparing the two interpolation methods:
Treatment 1 is defined as interpolation of 16 stations by the radial method.
Treatment 2 is defined as interpolation of 16 stations by tl.e exp(exp(corr)) method.

Statistic	$\overline{R}_1$	$\overline{R}_2$	$\overline{R}_2 - \overline{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.019	0.019	0.000
Stde	1.745	0.949	-0.796	1.000
Rmse	1.663	0.907	-0.756	1.000
Mae	1.287	0.993	-0.294	1.000
Emin	0.138	0.064	-0.074	1.000
Emax	3.895	2.067	-1.828	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 1 and 2, average ($\overline{R}_1$, $\overline{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of TT.

Figure 11. Dot diagram for air temperature (TT) in centigrades (°C) of $bias_2 - bias_1$.

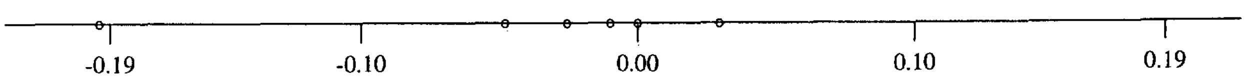


Figure 12. Dot diagram for air temperature (TT) in centigrades (°C) of $rmse_2 - rmse_1$.

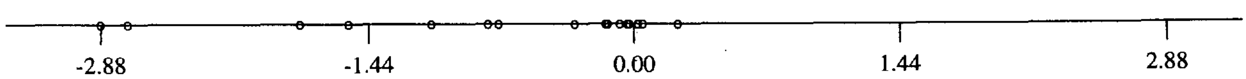


Figure 13. Dot diagram for air temperature (TT) in centigrades (°C) of $mae_2 - mae_1$.

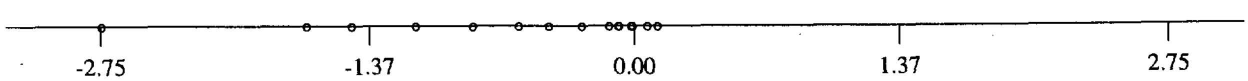


Figure 14. Dot diagram for air temperature (TT) in centigrades (°C) of $emin_2 - emin_1$.

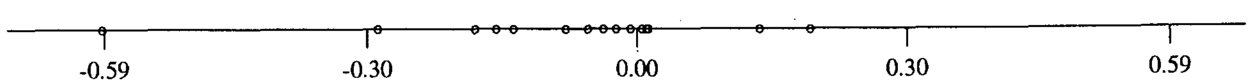
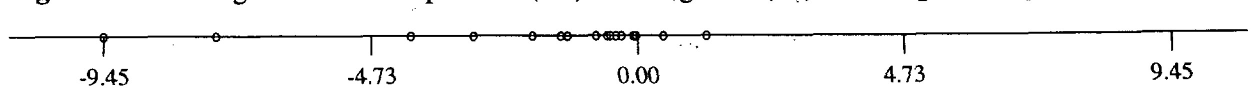


Figure 15. Dot diagram for air temperature (TT) in centigrades (°C) of $emax_2 - emax_1$.



6.2 Score statistics for minimum air temperature (TN) in centigrades (°C)
A total of 16 weather stations were tested, see table 3 below. Statistics and plots from worst case weather station V99840 SVALBARD LUFTHAVN, having the greatest *rmse*, are presented.

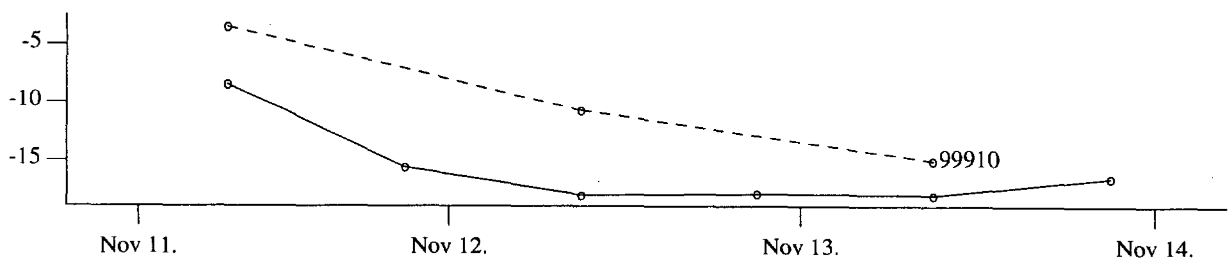
Sample size = 3 Bias = 0.0 Stde = 4.2 Rmse = 3.4 Mae = 3.2 Emin = 1.7 Emax = 4.8

Reference stations, weights and correlation coeffecients based on N pairs of observations:

99910 NY-ÅLESUND	78°55'00"N	11°56'00"E	8 m a.s.l.	$w_{01} = 1$	Corr = 0.17	$N = 6$
99910 NY-ÅLESUND	78°55'00"N	11°56'00"E	8 m a.s.l.	$w_{02} = 0$	Corr = 0.00	$N = 0$
99735 EDGEØYA	78°14'00"N	22°47'00"E	14 m a.s.l.	$w_{03} = 0$	Corr = 0.00	$N = 0$
99933 PHIPPSØYA	80°41'00"N	20°02'00"E	14 m a.s.l.	$w_{04} = 0$	Corr = 0.00	$N = 0$
99754 HORNSUND	77°00'00"N	15°30'00"E	10 m a.s.l.	$w_{05} = 0$	Corr = 0.00	$N = 3$
99710 BJØRNØYA	74°31'00"N	19°01'00"E	16 m a.s.l.	$w_{06} = 0$	Corr = -0.23	$N = 6$
87110 ANDØYA	69°17'80"N	16°08'80"E	10 m a.s.l.	$w_{07} = 0$	Corr = -0.27	$N = 6$
88690 HEKKINGEN FYR	69°36'05"N	17°50'25"E	14 m a.s.l.	$w_{08} = 0$	Corr = -0.58	$N = 6$
90900 FUGLØYKALVEN FYR	70°19'00"N	20°09'30"E	37 m a.s.l.	$w_{09} = 0$	Corr = -0.72	$N = 6$
90800 TORSVÅG FYR	70°14'74"N	19°30'03"E	21 m a.s.l.	$w_{10} = 0$	Corr = -0.86	$N = 6$

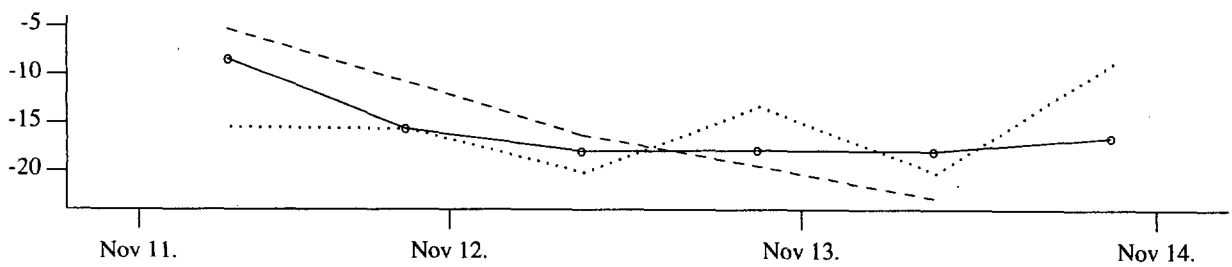
The correctional coeffecient α equals 1.52, β equals 0.0.

Figure 16. Observations *TN* at test station SVALBARD LUFTHAVN and reference stations.



Solid curve represent observations of TN, dashed curve represent TN at ref no. 1, dotted represents TN at ref no. 2.

Figure 17. Observations *TN* and estimates $\tilde{TN}_1$ and $\tilde{TN}_2$ at weather station SVALBARD LUFTHAVN.



Dashed curve represent TN estimates using the exp(exp(corr)) method, dotted represent TN estimates using the radial method.

Table 3. Statistics for TN using the exp(exp(corr)) method.

TN at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	3	-5.49	-7.4	0.0	0.1	0.1	0.1	0.0	0.2
median	6	0.90	0.0	0.0	0.5	0.5	0.5	0.1	0.7
maximum	6	11.93	2.2	0.0	4.2	3.4	8.9	1.7	4.8
average	6	1.09	-0.8	0.0	0.7	0.6	1.2	0.2	1.0
stddev	1	2.39	2.2	0.0	1.0	0.8	1.8	0.4	1.1

Table 4. Statistics for TN using the radial method.

TN at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	5	-5.49	0.0	0.0	0.2	0.2	0.2	0.0	0.3
median	6	1.09	0.0	0.0	1.1	1.0	0.9	0.2	1.5
maximum	6	11.93	0.0	0.0	11.1	9.9	8.9	1.2	14.1
average	6	1.17	0.0	0.0	2.4	2.1	1.8	0.3	3.5
stddev	0	3.39	0.0	0.0	3.0	2.7	2.3	0.3	4.2

Comparing the two interpolation methods:
Treatment 1 is defined as interpolation of 16 stations by the radial method.
Treatment 2 is defined as interpolation of 16 stations by the exp(exp(corr)) method.

Statistic	$\overline{R}_1$	$\overline{R}_2$	$\overline{R}_2 - \overline{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.000	0.000	0.000
Stde	2.357	0.737	-1.621	1.000
Rmse	2.137	0.645	-1.492	1.000
Mae	1.779	1.169	-0.610	1.000
Emin	0.263	0.164	-0.099	1.000
Emax	3.499	1.032	-2.467	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 3 and 4, average ($\overline{R}_1$, $\overline{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of TN.

Figure 18. Dot diagram for minimum air temperature (TN) in centigrades (°C) of $bias_2 - bias_1$.

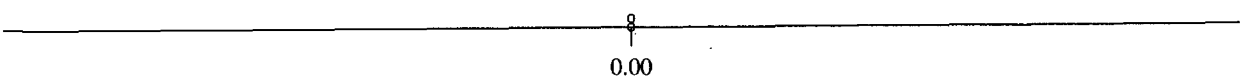


Figure 19. Dot diagram for minimum air temperature (TN) in centigrades (°C) of $rmse_2 - rmse_1$.

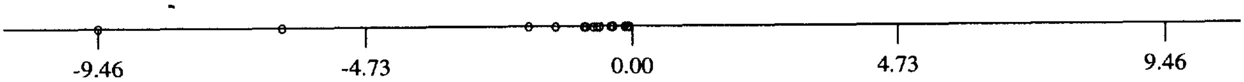


Figure 20. Dot diagram for minimum air temperature (TN) in centigrades (°C) of $mae_2 - mae_1$.

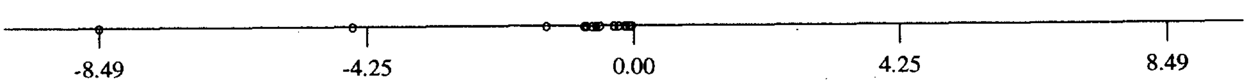


Figure 21. Dot diagram for minimum air temperature (TN) in centigrades (°C) of $emin_2 - emin_1$.

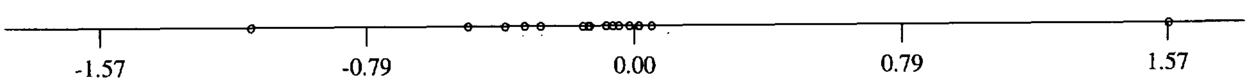
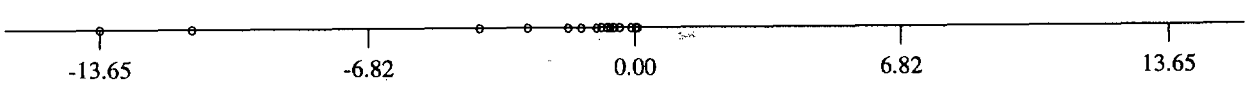


Figure 22. Dot diagram for minimum air temperature (TN) in centigrades (°C) of $emax_2 - emax_1$.



6.3 Score statistics for maximum air temperature (TX) in centigrades (°C)
A total of 16 weather stations were tested, see table 5 below. Statistics and plots from worst case weather station V99840 SVALBARD LUFTHAVN, having the greatest *rmse*, are presented.

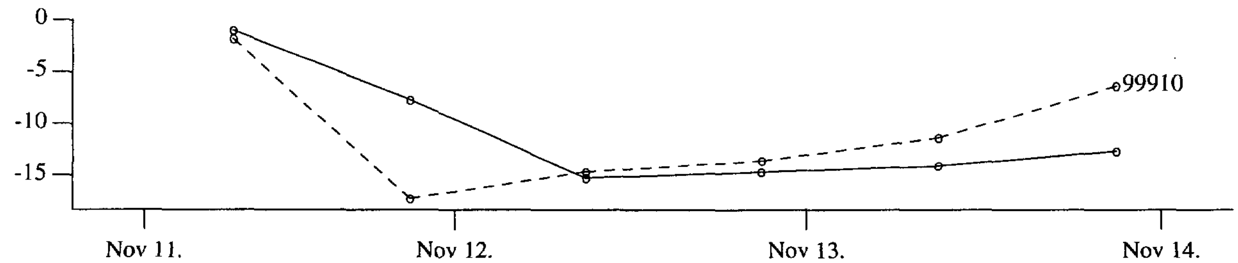
Sample size = 6 Bias = 0.0 Stde = 4.6 Rmse = 4.2 Mae = 3.9 Emin = 2.3 Emax = 6.7

Reference stations, weights and correlation coeffecients based on N pairs of observations:

99910 NY-ÅLESUND	78°55'00"N	11°56'00"E	8 m a.s.l.	$w_{01} = 8$	Corr = 0.56	$N = 6$
99754 HORNSUND	77°00'00"N	15°30'00"E	10 m a.s.l.	$w_{02} = 0$	Corr = 0.00	$N = 3$
99933 PHIPPSØYA	80°41'00"N	20°02'00"E	10 m a.s.l.	$w_{03} = 0$	Corr = 0.00	$N = 0$
99735 EDGEØYA	78°14'00"N	22°47'00"E	14 m a.s.l.	$w_{04} = 0$	Corr = 0.00	$N = 0$
99910 NY-ÅLESUND	78°55'00"N	11°56'00"E	8 m a.s.l.	$w_{05} = 0$	Corr = 0.00	$N = 0$
87110 ANDØYA	69°17'80"N	16°08'80"E	10 m a.s.l.	$w_{06} = 0$	Corr = -0.49	$N = 6$
99710 BJØRNØYA	74°31'00"N	19°01'00"E	16 m a.s.l.	$w_{07} = 0$	Corr = -0.68	$N = 6$
90800 TORSVÅG FYR	70°14'74"N	19°30'03"E	21 m a.s.l.	$w_{08} = 0$	Corr = -0.71	$N = 6$
90900 FUGLØYKALVEN FYR	70°19'00"N	20°09'30"E	37 m a.s.l.	$w_{09} = 0$	Corr = -0.76	$N = 6$
88690 HEKKINGEN FYR	69°36'05"N	17°50'25"E	14 m a.s.l.	$w_{10} = 0$	Corr = -0.85	$N = 6$

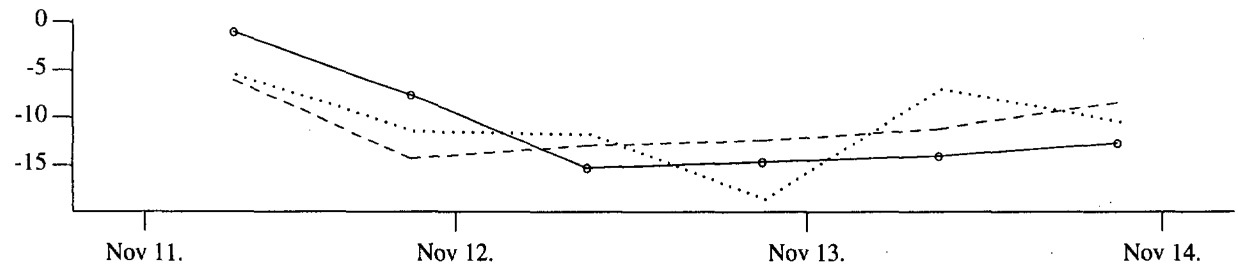
The correctional coeffecient α equals 0.54, β equals -5.0.

Figure 23. Observations *TX* at test station SVALBARD LUFTHAVN and reference stations.



Solid curve represent observations of TX, dashed curve represent TX at ref no. 1, dotted represents TX at ref no. 2.

Figure 24. Observations *TX* and estimates $\tilde{TX}_1$ and $\tilde{TX}_2$ at weather station SVALBARD LUFTHAVN.



Dashed curve represent TX estimates using the exp(exp(corr)) method, dotted represent TX estimates using the radial method.

Table 5. Statistics for TX using the exp(exp(corr)) method.

TX at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	5	-0.44	-6.2	0.0	0.1	0.1	0.0	0.0	0.1
median	6	0.90	0.0	0.0	0.4	0.4	0.4	0.1	0.6
maximum	6	4.55	7.4	0.0	4.6	4.2	4.1	2.3	6.7
average	6	0.98	-0.1	0.0	0.7	0.6	0.7	0.2	1.0
stddev	0	0.88	2.5	0.0	1.1	1.0	1.0	0.6	1.6

Table 6. Statistics for TX using the radial method.

TX at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	5	-0.44	0.0	0.0	0.2	0.1	0.1	0.0	0.3
median	6	1.03	0.0	0.0	0.7	0.6	0.5	0.1	1.1
maximum	6	4.55	0.0	0.0	4.8	4.4	4.1	2.1	6.9
average	6	1.11	0.0	0.0	1.1	1.0	0.9	0.2	1.6
stddev	0	1.15	0.0	0.0	1.3	1.1	1.1	0.5	1.7

Comparing the two interpolation methods:

Treatment 1 is defined as interpolation of 16 stations by the radial method.
Treatment 2 is defined as interpolation of 16 stations by the exp(exp(corr)) method.

Statistic	$\bar{R}_1$	$\bar{R}_2$	$\bar{R}_2 - \bar{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.000	0.000	0.000
Stde	1.074	0.684	-0.390	1.000
Rmse	0.973	0.622	-0.351	1.000
Mae	0.853	0.699	-0.154	1.000
Emin	0.229	0.202	-0.028	1.000
Emax	1.554	1.005	-0.548	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 5 and 6, average ($\bar{R}_1$, $\bar{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of TX.

Figure 25. Dot diagram for maximum air temperature (TX) in centigrades (°C) of $bias_2 - bias_1$.

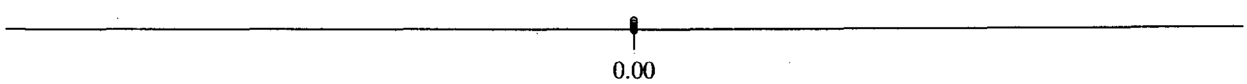


Figure 26. Dot diagram for maximum air temperature (TX) in centigrades (°C) of $rmse_2 - rmse_1$.

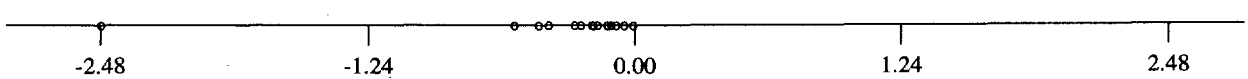


Figure 27. Dot diagram for maximum air temperature (TX) in centigrades (°C) of $mae_2 - mae_1$.

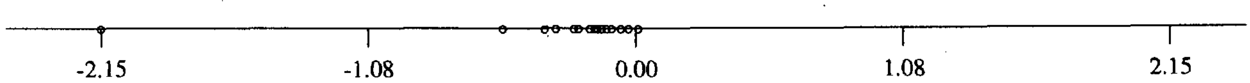


Figure 28. Dot diagram for maximum air temperature (TX) in centigrades (°C) of $emin_2 - emin_1$.

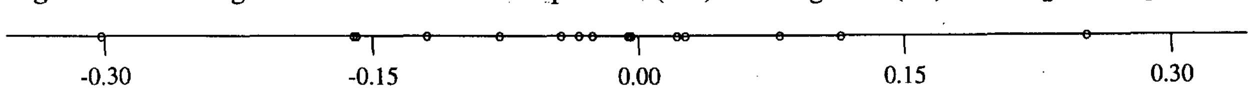
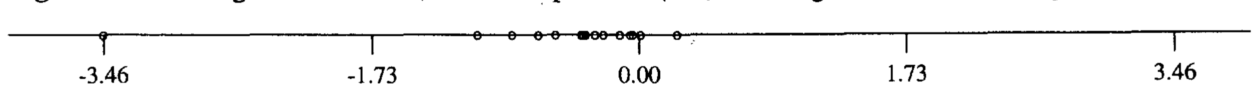


Figure 29. Dot diagram for maximum air temperature (TX) in centigrades (°C) of $emax_2 - emax_1$.



6.4 Score statistics for air pressure at station level (P0) in hecto Pascal (hPa)

A total of 9 weather stations were tested, see table 7 below. Statistics and plots from worst case weather station V42160 LISTA FYR, having the greatest *rmse*, are presented.

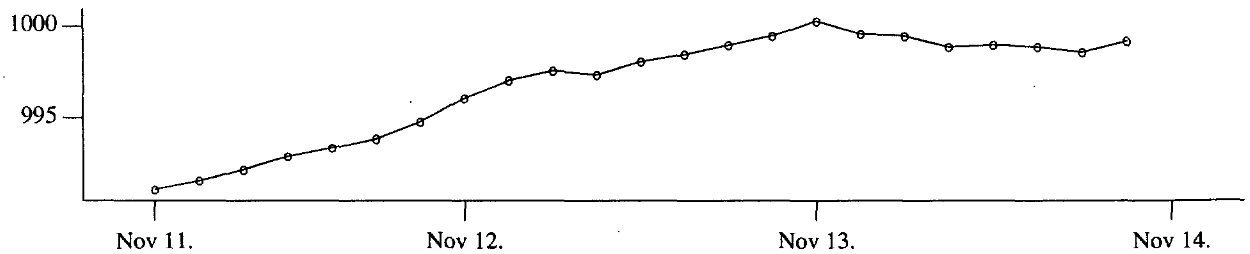
Sample size = 24 Bias = 0.1 Stde = 2.9 Rmse = 2.9 Mae = 2.5 Emin = 0.4 Emax = 5.4

Reference stations, weights and correlation coeffecients based on N pairs of observations:

44081 OBRESTAD FYR	58°39'00"N	05°34'00"E	26 m a.s.l.	$w_{01} = 98$	Corr = 1.00	$N = 24$
44560 SOLA	58°53'06"N	05°38'22"E	7 m a.s.l.	$w_{02} = 97$	Corr = 1.00	$N = 24$
46610 SAUDA	59°38'92"N	06°21'80"E	5 m a.s.l.	$w_{03} = 93$	Corr = 0.99	$N = 12$
39690 BYGLANDSFJORD - SOLBAKKEN	58°40'03"N	07°48'06"E	212 m a.s.l.	$w_{04} = 81$	Corr = 0.97	$N = 18$
46510 MIDTLÆGER	59°50'03"N	06°59'49"E	1079 m a.s.l.	$w_{05} = 57$	Corr = 0.92	$N = 24$
45880 FISTER - TØNNEVIK	59°10'00"N	06°03'16"E	50 m a.s.l.	$w_{06} = 0$	Corr = 0.00	$N = 0$
41010 MANDAL - EIGEBREKK	58°00'84"N	07°36'52"E	10 m a.s.l.	$w_{07} = 0$	Corr = 0.00	$N = 0$
41670 KONSMO - HØYLAND	58°16'02"N	07°22'84"E	263 m a.s.l.	$w_{08} = 0$	Corr = 0.00	$N = 0$
42920 SIRDAL - TJØRHOM	58°53'25"N	06°50'91"E	500 m a.s.l.	$w_{09} = 0$	Corr = 0.00	$N = 0$
41770 LINDESNES FYR	57°59'00"N	07°02'90"E	13 m a.s.l.	$w_{10} = 0$	Corr = 0.00	$N = 0$

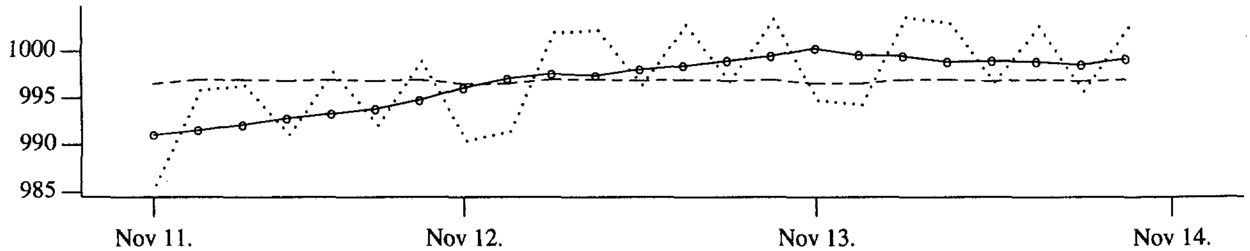
The correctional coeffecient α equals 0.01, β equals 991.9.

Figure 30. Observations $P0$ at test station LISTA FYR and reference stations.



Solid curve represent observations of P0, dashed curve represent P0 at ref no. 1, dotted represents P0 at ref no. 2.

Figure 31. Observations $P0$ and estimates $\tilde{P0}_1$ and $\tilde{P0}_2$ at weather station LISTA FYR.



Dashed curve represent P0 estimates using the exp(exp(corr)) method, dotted represent P0 estimates using the radial method.

Table 7. Statistics for P0 using the exp(exp(corr)) method.

P0 at 9 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	-0.01	-68.7	0.0	0.3	0.3	0.2	0.0	0.4
median	24	0.98	0.0	0.0	1.9	1.9	1.6	0.2	4.1
maximum	24	1.07	991.9	0.1	2.9	2.9	20.2	0.4	7.4
average	17	0.77	211.3	0.0	1.6	1.6	2.3	0.2	3.5
stddev	8	0.41	383.0	0.1	1.0	1.0	4.6	0.1	2.3

Table 8. Statistics for P0 using the radial method.

P0 at 9 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	0.95	0.0	0.0	0.2	0.2	0.2	0.0	0.3
median	24	1.00	0.0	0.0	1.0	1.0	0.8	0.0	2.3
maximum	24	1.03	0.0	0.0	22.2	21.8	20.2	4.6	34.8
average	19	0.99	0.0	0.0	3.9	3.8	3.3	0.8	6.8
stddev	8	0.03	0.0	0.0	7.0	6.9	6.4	1.6	10.9

Comparing the two interpolation methods:

Treatment 1 is defined as interpolation of 9 stations by the radial method.
Treatment 2 is defined as interpolation of 9 stations by the exp(exp(corr)) method.

Statistic	$\overline{R}_1$	$\overline{R}_2$	$\overline{R}_2 - \overline{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.036	0.036	0.000
Stde	3.874	1.632	-2.242	1.000
Rmse	3.774	1.570	-2.204	1.000
Mae	3.331	2.296	-1.036	1.000
Emin	0.772	0.171	-0.601	1.000
Emax	6.819	3.474	-3.345	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 7 and 8, average ($\overline{R}_1$, $\overline{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of P0.

Figure 32. Dot diagram for air pressure at station level (P0) in hecto Pascal (hPa) of $bias_2 - bias_1$.

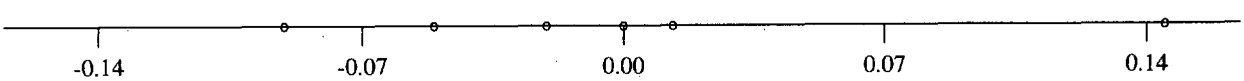


Figure 33. Dot diagram for air pressure at station level (P0) in hecto Pascal (hPa) of $rmse_2 - rmse_1$.

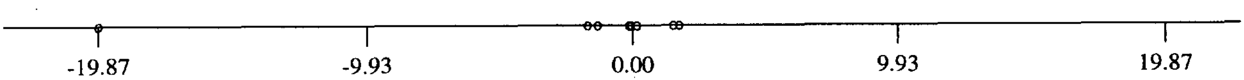


Figure 34. Dot diagram for air pressure at station level (P0) in hecto Pascal (hPa) of $mae_2 - mae_1$.

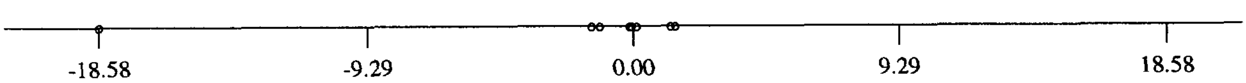


Figure 35. Dot diagram for air pressure at station level (P0) in hecto Pascal (hPa) of $emin_2 - emin_1$.

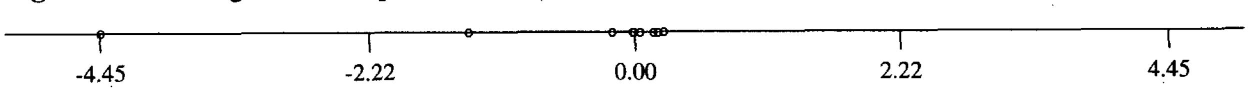
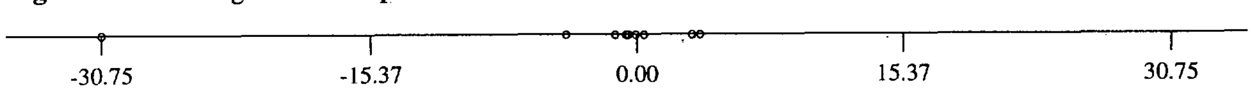


Figure 36. Dot diagram for air pressure at station level (P0) in hecto Pascal (hPa) of $emax_2 - emax_1$.



6.5 Score statistics for air pressure at sea level (P) in hecto Pascal (hPa)

A total of 10 weather stations were tested, see table 9 below. Statistics and plots from worst case weather station V99840 SVALBARD LUFTHAVN, having the greatest *rmse*, are presented.

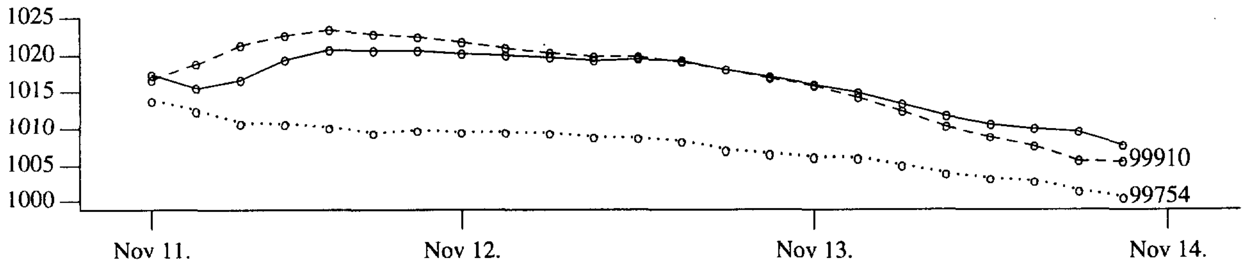
Sample size = 24 Bias = -0.1 Stde = 1.8 Rmse = 1.8 Mae = 1.5 Emin = 0.0 Emax = 4.6

Reference stations, weights and correlation coeffecients based on N pairs of observations:

99910 NY-ÅLESUND	78°55'00"N	11°56'00"E	8 m a.s.l.	$w_{01} = 81$	Corr = 0.97	$N = 24$
99754 HORNSUND	77°00'00"N	15°30'00"E	10 m a.s.l.	$w_{02} = 39$	Corr = 0.86	$N = 18$
87110 ANDØYA	69°17'80"N	16°08'80"E	10 m a.s.l.	$w_{03} = 31$	Corr = 0.82	$N = 23$
90800 TORSVÅG FYR	70°14'74"N	19°30'03"E	21 m a.s.l.	$w_{04} = 22$	Corr = 0.76	$N = 24$
99710 BJØRNØYA	74°31'00"N	19°01'00"E	16 m a.s.l.	$w_{05} = 16$	Corr = 0.70	$N = 24$
90900 FUGLØYKALVEN FYR	70°19'00"N	20°09'30"E	37 m a.s.l.	$w_{06} = 12$	Corr = 0.64	$N = 12$
99910 NY-ÅLESUND	78°55'00"N	11°56'00"E	8 m a.s.l.	$w_{07} = 0$	Corr = 0.00	$N = 0$
99735 EDGEØYA	78°14'00"N	22°47'00"E	14 m a.s.l.	$w_{08} = 0$	Corr = 0.00	$N = 0$
88690 HEKKINGEN FYR	69°36'05"N	17°50'25"E	14 m a.s.l.	$w_{09} = 0$	Corr = 0.00	$N = 0$
99933 PHIPPSØYA	80°41'00"N	20°02'00"E	14 m a.s.l.	$w_{10} = 0$	Corr = 0.00	$N = 0$

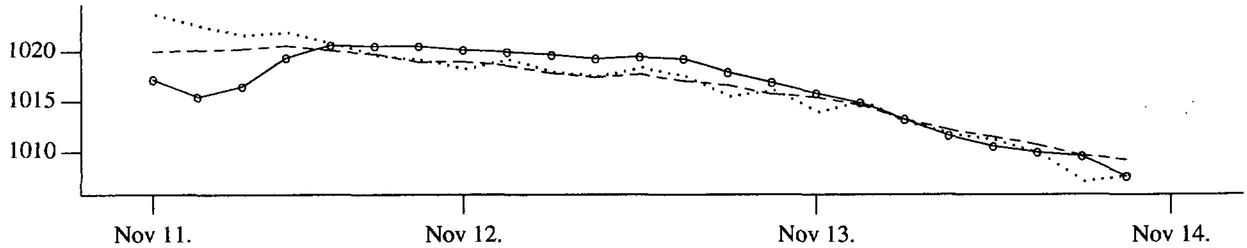
The correctional coeffecient α equals 0.75, β equals 254.4.

Figure 37. Observations P at test station SVALBARD LUFTHAVN and reference stations.



Solid curve represent observations of P, dashed curve represent P at ref no. 1, dotted represents P at ref no. 2.

Figure 38. Observations P and estimates $\tilde{P}_1$ and $\tilde{P}_2$ at weather station SVALBARD LUFTHAVN.



Dashed curve represent P estimates using the exp(exp(corr)) method, dotted represent P estimates using the radial method.

Table 9. Statistics for P using the exp(exp(corr)) method.

P at 10 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	0.74	-196.0	0.0	0.3	0.3	0.2	0.0	0.5
median	24	1.00	0.0	0.0	0.6	0.6	0.4	0.0	1.4
maximum	24	1.20	261.2	0.1	1.8	1.8	1.8	0.1	4.6
average	18	0.98	16.3	0.0	0.7	0.7	0.6	0.0	1.5
stddev	8	0.10	105.2	0.0	0.5	0.5	0.4	0.1	1.3

Table 10. Statistics for P using the radial method.

P at 10 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	1.00	0.0	0.0	0.2	0.2	0.2	0.0	0.4
median	24	1.00	0.0	0.0	0.6	0.5	0.4	0.0	1.5
maximum	24	1.00	0.0	0.0	2.6	2.6	1.8	0.1	7.0
average	18	1.00	0.0	0.0	0.8	0.8	0.6	0.0	1.8
stddev	8	0.00	0.0	0.0	0.7	0.7	0.5	0.0	1.9

Comparing the two interpolation methods:

Treatment 1 is defined as interpolation of 10 stations by the radial method.
Treatment 2 is defined as interpolation of 10 stations by the exp(exp(corr)) method.

Statistic	$\overline{R}_1$	$\overline{R}_2$	$\overline{R}_2 - \overline{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.032	0.032	0.000
Stde	0.790	0.697	-0.093	1.000
Rmse	0.764	0.674	-0.090	1.000
Mae	0.596	0.566	-0.030	1.000
Emin	0.024	0.049	0.025	1.000
Emax	1.813	1.542	-0.272	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 9 and 10, average ($\overline{R}_1$, $\overline{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of P.

Figure 39. Dot diagram for air pressure at sea level (P) in hecto Pascal (hPa) of $bias_2 - bias_1$.

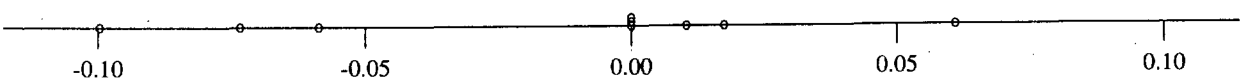


Figure 40. Dot diagram for air pressure at sea level (P) in hecto Pascal (hPa) of $rmse_2 - rmse_1$.

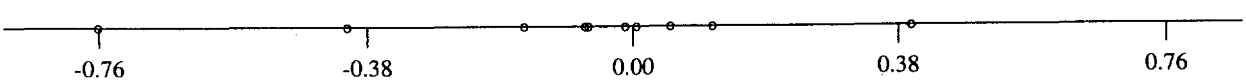


Figure 41. Dot diagram for air pressure at sea level (P) in hecto Pascal (hPa) of $mae_2 - mae_1$.

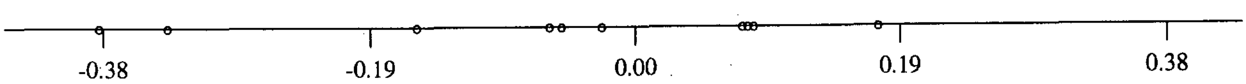


Figure 42. Dot diagram for air pressure at sea level (P) in hecto Pascal (hPa) of $emin_2 - emin_1$.

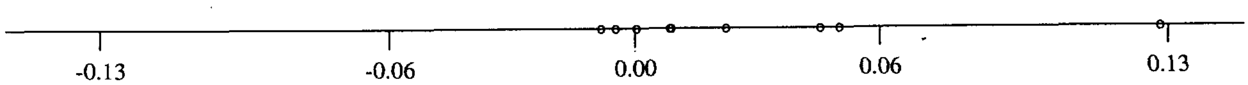
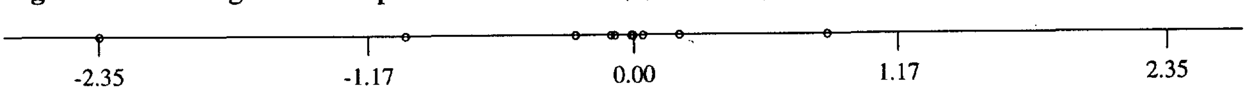


Figure 43. Dot diagram for air pressure at sea level (P) in hecto Pascal (hPa) of $emax_2 - emax_1$.



6.6 Score statistics for cloud cover (N) in octas (0-8)

A total of 14 weather stations were tested, see table 11 below. Statistics and plots from worst case weather station V39040 KJEVIK, having the greatest *rmse*, are presented.

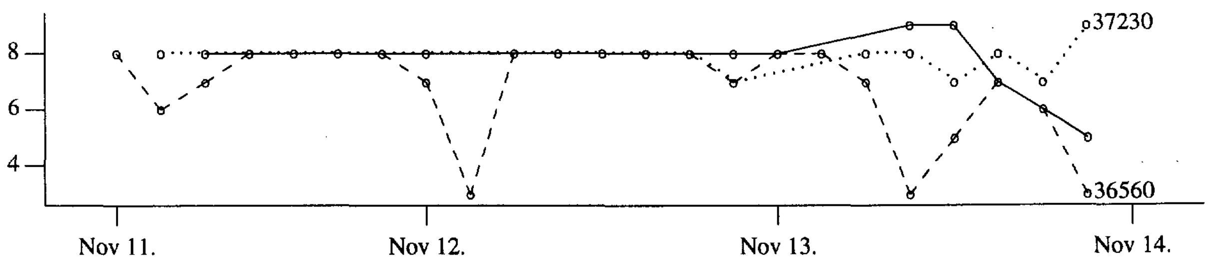
Sample size = 17 Bias = -0.1 Stde = 1.0 Rmse = 1.0 Mae = 0.6 Emin = 0.0 Emax = 2.2

Reference stations, weights and correlation coeffecients based on N pairs of observations:

36560 NELAUG	58°39'49"N	08°37'88"E	142 m a.s.l.	$w_{01} = 41$	Corr = 0.87	$N = 8$
37230 TVEITSUND	59°01'63"N	08°31'24"E	252 m a.s.l.	$w_{02} = 5$	Corr = 0.45	$N = 11$
41770 LINDESNES FYR	57°59'00"N	07°02'90"E	13 m a.s.l.	$w_{03} = 4$	Corr = 0.44	$N = 11$
36200 TORUNGEN FYR	58°23'00"N	08°47'51"E	12 m a.s.l.	$w_{04} = 4$	Corr = 0.40	$N = 14$
39100 OKSØY FYR	58°04'02"N	08°03'05"E	9 m a.s.l.	$w_{05} = 2$	Corr = 0.30	$N = 17$
35860 LYNGØR FYR	58°38'01"N	09°09'02"E	4 m a.s.l.	$w_{06} = 1$	Corr = 0.18	$N = 14$
41010 MANDAL - EIGEBREKK	58°00'84"N	07°36'52"E	10 m a.s.l.	$w_{07} = 0$	Corr = 0.00	$N = 0$
39041 KJEVIK	58°13'00"N	08°05'00"E	17 m a.s.l.	$w_{08} = 0$	Corr = 0.00	$N = 0$
39690 BYGLANDSFJORD - SOLBAKKEN	58°40'03"N	07°48'06"E	212 m a.s.l.	$w_{09} = 0$	Corr = -0.35	$N = 14$
41670 KONSMO - HØYLAND	58°16'02"N	07°22'84"E	263 m a.s.l.	$w_{10} = 0$	Corr = -0.68	$N = 8$

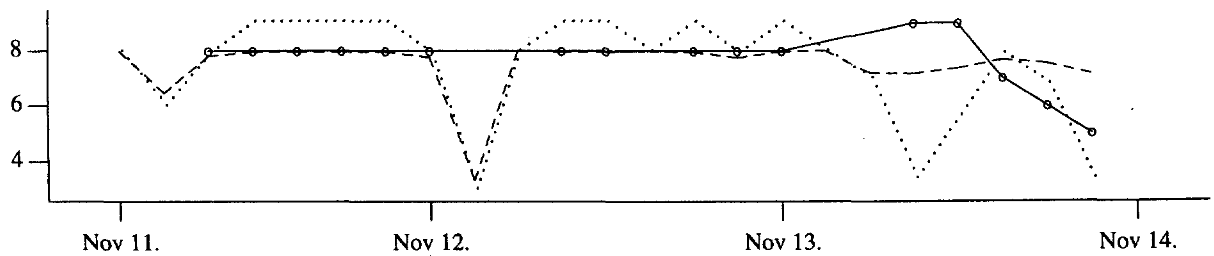
The correctional coeffecient α equals 0.21, β equals 6.3.

Figure 44. Observations N at test station KJEVIK and reference stations.



Solid curve represent observations of N, dashed curve represent N at ref no. 1, dotted represents N at ref no. 2.

Figure 45. Observations N and estimates $\tilde{N}_1$ and $\tilde{N}_2$ at weather station KJEVIK.



Dashed curve represent N estimates using the exp(exp(corr)) method, dotted represent N estimates using the radial method.

Table 11. Statistics for N using the exp(exp(corr)) method.

N at 14 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	5	-0.30	-1.2	0.0	0.3	0.3	0.2	0.0	0.5
median	9	0.92	0.0	0.0	1.0	1.0	0.8	0.1	2.1
maximum	19	1.37	10.8	0.1	2.4	2.3	3.1	0.4	5.2
average	11	0.74	2.1	0.0	1.1	1.0	1.0	0.1	2.1
stddev	5	0.46	3.3	0.0	0.6	0.6	0.6	0.1	1.4

Table 12. Statistics for N using the radial method.

N at 14 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	0.74	0.0	0.0	0.6	0.5	0.5	0.0	1.0
median	9	1.07	0.0	0.0	1.6	1.4	1.1	0.1	3.5
maximum	24	1.37	0.0	0.0	3.4	3.4	3.1	1.1	6.5
average	11	1.05	0.0	0.0	1.6	1.5	1.2	0.2	3.3
stddev	6	0.17	0.0	0.0	0.8	0.8	0.7	0.3	1.7

Comparing the two interpolation methods:
Treatment 1 is defined as interpolation of 14 stations by the radial method.
Treatment 2 is defined as interpolation of 14 stations by the exp(exp(corr)) method.

Statistic	$\bar{R}_1$	$\bar{R}_2$	$\bar{R}_2 - \bar{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.007	0.007	0.000
Stde	1.608	1.093	-0.515	1.000
Rmse	1.526	1.038	-0.488	1.000
Mae	1.205	1.023	-0.182	1.000
Emin	0.189	0.138	-0.051	1.000
Emax	3.287	2.084	-1.203	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 11 and 12, average ($\bar{R}_1$, $\bar{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of N.

Figure 46. Dot diagram for cloud cover (N) in octas (0-8) of $bias_2 - bias_1$.

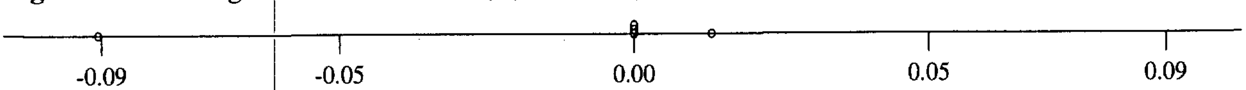


Figure 47. Dot diagram for cloud cover (N) in octas (0-8) of $rmse_2 - rmse_1$.

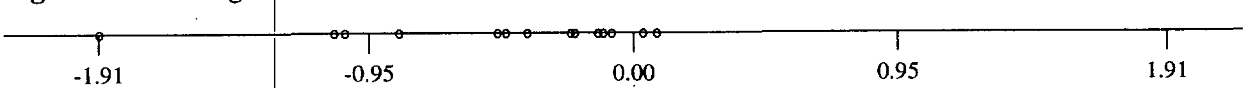


Figure 48. Dot diagram for cloud cover (N) in octas (0-8) of $mae_2 - mae_1$.

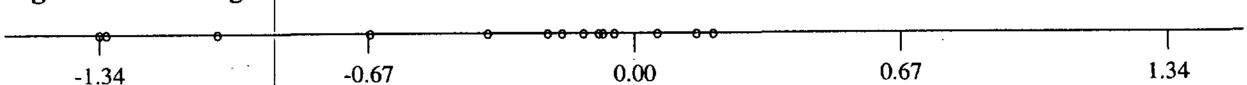


Figure 49. Dot diagram for cloud cover (N) in octas (0-8) of $emin_2 - emin_1$.

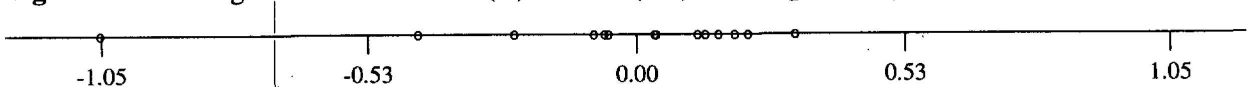
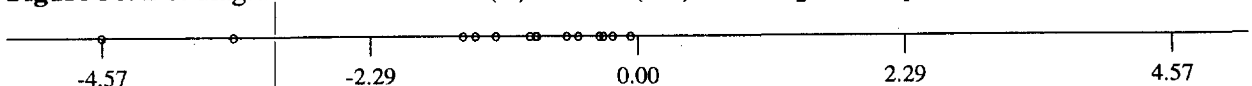


Figure 50. Dot diagram for cloud cover (N) in octas (0-8) of $emax_2 - emax_1$.



6.7 Score statistics for relative humidity (UU) in percentage (%)
A total of 14 weather stations were tested, see table 13 below. Statistics and plots from worst case weather station V42920 SIRDAL - TJØRHOM, having the greatest *rmse*, are presented.

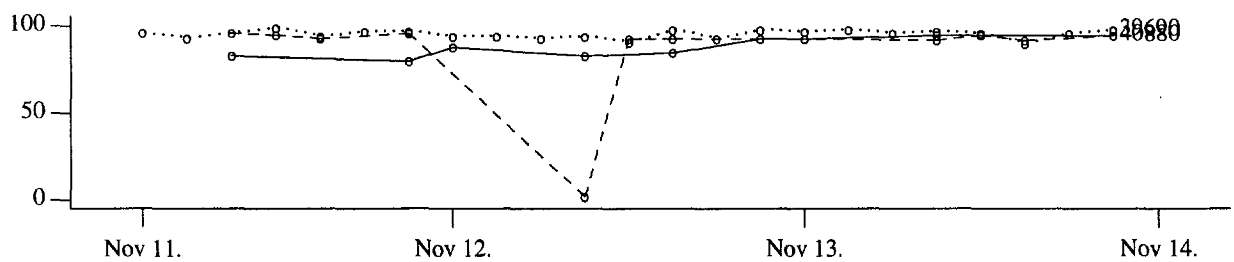
Sample size = 10 Bias = 0.7 Stde = 5.6 Rmse = 5.3 Mae = 4.7 Emin = 0.0 Emax = 9.1

Reference stations, weights and correlation coeffecients based on *N* pairs of observations:

40880 HOVDEN - LUNDANE	59°35'00"N	07°23'00"E	836 m a.s.l.	$w_{01} = 8$	Corr = 0.57	$N = 7$
39690 BYGLANDSFJORD - SOLBAKKEN	58°40'03"N	07°48'06"E	212 m a.s.l.	$w_{02} = 8$	Corr = 0.56	$N = 7$
41770 LINDESNES FYR	57°59'00"N	07°02'90"E	13 m a.s.l.	$w_{03} = 2$	Corr = 0.30	$N = 7$
46510 MIDTLÆGER	59°50'03"N	06°59'49"E	1079 m a.s.l.	$w_{04} = 1$	Corr = 0.11	$N = 10$
41010 MANDAL - EIGEBREKK	58°00'84"N	07°30'52"E	10 m a.s.l.	$w_{05} = 0$	Corr = 0.00	$N = 0$
42160 LISTA FYR	58°06'60"N	06°34'10"E	14 m a.s.l.	$w_{06} = 0$	Corr = 0.00	$N = 0$
46610 SAUDA	59°38'92"N	06°21'80"E	5 m a.s.l.	$w_{07} = 0$	Corr = -0.07	$N = 7$
41670 KONSMO - HØYLAND	58°16'02"N	07°22'84"E	263 m a.s.l.	$w_{08} = 0$	Corr = -0.08	$N = 7$
42160 LISTA FYR	58°06'60"N	06°34'10"E	14 m a.s.l.	$w_{09} = 0$	Corr = -0.10	$N = 9$
45880 FISTER - TØNNEVIK	59°10'00"N	06°03'16"E	50 m a.s.l.	$w_{10} = 0$	Corr = -0.12	$N = 5$

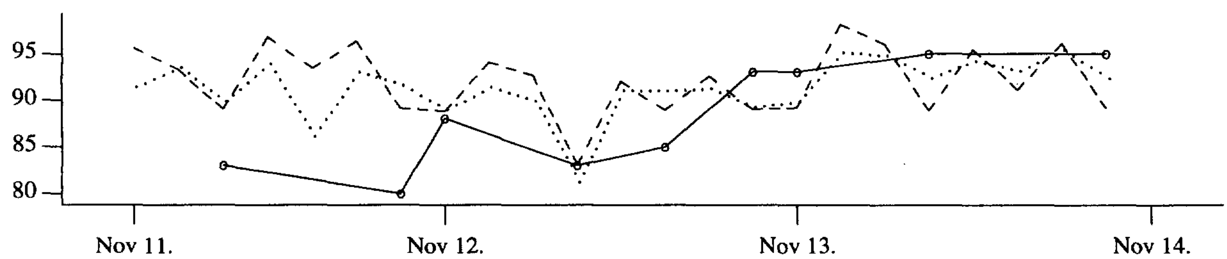
The correctional coeffecient α equals 0.13, β equals 76.9.

Figure 51. Observations *UU* at test station SIRDAL - TJØRHOM and reference stations.



Solid curve represent observations of UU, dashed curve represent UU at ref no. 1, dotted represents UU at ref no. 2.

Figure 52. Observations *UU* and estimates $\tilde{UU}_1$ and $\tilde{UU}_2$ at weather station SIRDAL - TJØRHOM.



Dashed curve represent UU estimates using the exp(exp(corr)) method, dotted represent UU estimates using the radial method.

Table 13. Statistics for UU using the exp(exp(corr)) method.

UU at 14 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	6	-0.79	-46.9	0.0	1.4	1.3	0.0	0.0	2.5
median	10	0.96	0.0	0.0	3.4	3.2	2.8	0.3	6.5
maximum	24	1.43	170.3	0.7	11.3	10.6	9.2	2.4	21.3
average	12	0.72	24.8	0.1	3.9	3.7	3.2	0.4	7.7
stddev	6	0.51	48.8	0.2	2.4	2.3	2.0	0.6	4.5

Table 14. Statistics for UU using the radial method.

UU at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	1	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0
median	9	0.98	0.0	0.0	4.9	4.5	3.3	0.3	8.6
maximum	24	1.15	0.0	0.0	13.5	12.7	9.2	1.6	30.0
average	11	0.99	0.0	0.0	4.5	4.2	3.3	0.4	9.4
stddev	7	0.09	0.0	0.0	2.9	2.8	2.0	0.4	7.3

Comparing the two interpolation methods:
Treatment 1 is defined as interpolation of 16 stations by the radial method.
Treatment 2 is defined as interpolation of 14 stations by the exp(exp(corr)) method.

Statistic	$\bar{R}_1$	$\bar{R}_2$	$\bar{R}_2 - \bar{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.075	0.075	0.000
Stde	4.492	3.921	-0.571	1.000
Rmse	4.239	3.717	-0.522	1.000
Mae	3.274	3.163	-0.111	1.000
Emin	0.390	0.449	0.059	1.000
Emax	9.393	7.673	-1.720	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 13 and 14, average ($\bar{R}_1$, $\bar{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of UU.

Figure 53. Dot diagram for relative humidity (UU) in percentage (%) of $bias_2 - bias_1$.

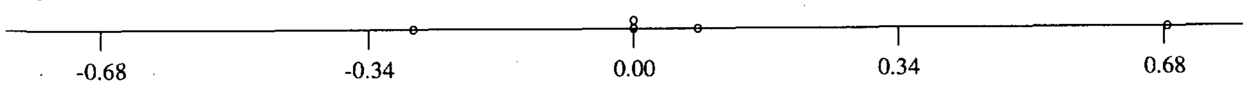


Figure 54. Dot diagram for relative humidity (UU) in percentage (%) of $rmse_2 - rmse_1$.

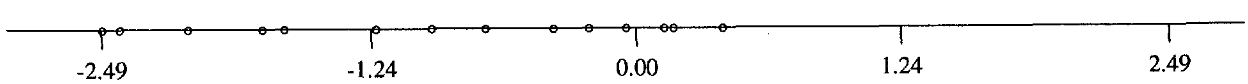


Figure 55. Dot diagram for relative humidity (UU) in percentage (%) of $mae_2 - mae_1$.

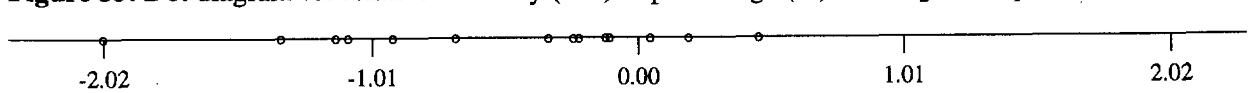


Figure 56. Dot diagram for relative humidity (UU) in percentage (%) of $emin_2 - emin_1$.

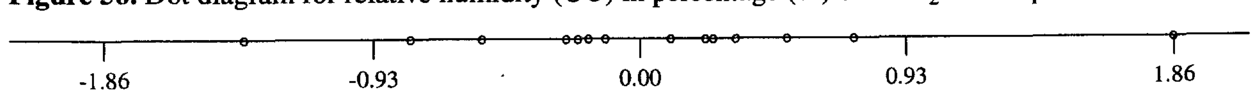
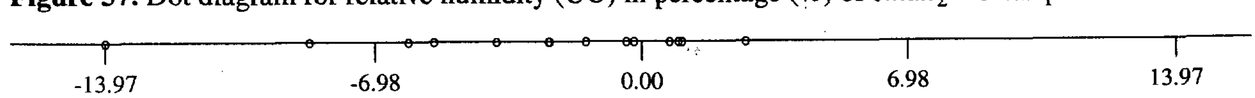


Figure 57. Dot diagram for relative humidity (UU) in percentage (%) of $emax_2 - emax_1$.



6.8 Score statistics for precipitation (RR) in millimeters (mm)

A total of 16 weather stations were tested, see table 15 below. Statistics and plots from worst case weather station V42920 SIRDAL - TJØRHOM, having the greatest *rmse*, are presented.

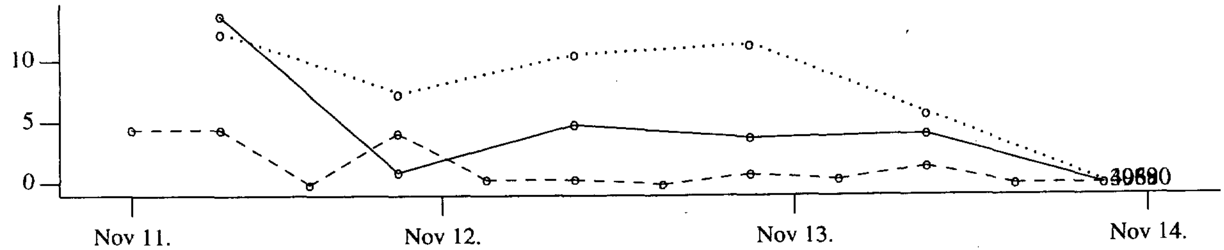
Sample size = 6 Bias = 0.0 Stde = 3.4 Rmse = 3.1 Mae = 2.4 Emin = 0.6 Emax = 5.8

Reference stations, weights and correlation coeffecients based on N pairs of observations:

39690 BYGLANDSFJORD - SOLBAKKEN	58°40'03"N	07°48'06"E	212 m a.s.l.	$w_{01} = 15$	Corr = 0.69	$N = 6$
40880 HOVDEN - LUNDANE	59°35'00"N	07°23'00"E	836 m a.s.l.	$w_{02} = 6$	Corr = 0.52	$N = 6$
41010 MANDAL - EIGEBREKK	58°00'84"N	07°36'52"E	10 m a.s.l.	$w_{03} = 0$	Corr = 0.00	$N = 0$
42160 LISTA FYR	58°06'60"N	06°34'10"E	14 m a.s.l.	$w_{04} = 0$	Corr = 0.00	$N = 0$
46510 MIDTLÆGER	59°50'03"N	06°59'49"E	1079 m a.s.l.	$w_{05} = 0$	Corr = 0.00	$N = 0$
42160 LISTA FYR	58°06'60"N	06°34'10"E	14 m a.s.l.	$w_{06} = 0$	Corr = -0.03	$N = 6$
45880 FISTER - TØNNEVIK	59°10'00"N	06°03'16"E	50 m a.s.l.	$w_{07} = 0$	Corr = -0.13	$N = 5$
46610 SAUDA	59°38'92"N	06°21'80"E	5 m a.s.l.	$w_{08} = 0$	Corr = -0.13	$N = 6$
41770 LINDESNES FYR	57°59'00"N	07°02'90"E	13 m a.s.l.	$w_{09} = 0$	Corr = -0.45	$N = 6$
41670 KONSMO - HØYLAND	58°16'02"N	07°22'84"E	263 m a.s.l.	$w_{10} = 0$	Corr = -0.61	$N = 6$

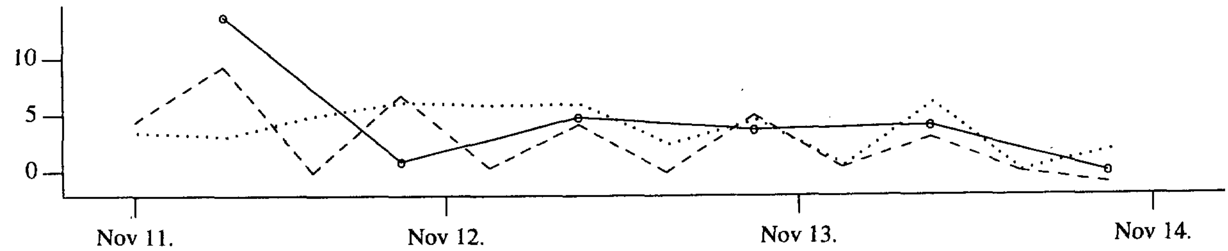
The correctional coeffecient α equals 1.52, β equals -1.0.

Figure 58. Observations RR at test station SIRDAL - TJØRHOM and reference stations.



Solid curve represent observations of RR, dashed curve represent RR at ref no. 1, dotted represents RR at ref no. 2.

Figure 59. Observations RR and estimates $\tilde{RR}_1$ and $\tilde{RR}_2$ at weather station SIRDAL - TJØRHOM.



Dashed curve represent RR estimates using the exp(exp(corr)) method, dotted represent RR estimates using the radial method.

Table 15. Statistics for RR using the exp(exp(corr)) method.

RR at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	5	-14.23	-1.0	0.0	0.0	0.0	0.0	0.0	0.1
median	6	0.63	0.0	0.0	0.7	0.7	0.7	0.1	1.4
maximum	12	1.91	3.1	0.0	3.4	3.1	3.5	1.1	5.8
average	7	-0.32	0.3	0.0	1.1	1.1	1.0	0.2	2.0
stddev	2	3.31	0.8	0.0	1.2	1.1	1.0	0.3	2.0

Table 16. Statistics for RR using the radial method.

RR at 16 stations	Sample size	alpha	beta	Bias	Stde	Rmse	Mae	Emin	Emax
minimum	5	-14.23	0.0	0.0	0.0	0.0	0.0	0.0	0.1
median	6	0.86	0.0	0.0	1.4	1.3	0.9	0.1	2.4
maximum	12	1.91	0.0	0.0	5.4	5.0	3.5	0.8	10.6
average	7	-0.63	0.0	0.0	1.5	1.4	1.1	0.2	2.7
stddev	2	4.35	0.0	0.0	1.5	1.3	1.0	0.3	2.8

Comparing the two interpolation methods:
Treatment 1 is defined as interpolation of 16 stations by the radial method.
Treatment 2 is defined as interpolation of 16 stations by the exp(exp(corr)) method.

Statistic	$\overline{R}_1$	$\overline{R}_2$	$\overline{R}_2 - \overline{R}_1$	$sd(R_1))/sd(R_2)$
Bias	0.000	0.000	0.000	0.000
Stde	1.515	1.148	-0.366	1.000
Rmse	1.394	1.058	-0.336	1.000
Mae	1.091	0.971	-0.120	1.000
Emin	0.209	0.172	-0.037	1.000
Emax	2.734	1.956	-0.778	1.000

Responses R_1 and R_2 from treatments 1 and 2 are the statistics displayed in tables 15 and 16, average ($\overline{R}_1$, $\overline{R}_2$) and standard deviation ($sd(R_1)$, $sd(R_2)$) taken from the lower part of the tables. Statistic $mae_2 - mae_1 < 0$ does at least not seem to indicate that treatment 1 is better than treatment 2 in the case of RR.

Figure 60. Dot diagram for precipitation (RR) in millimeters (mm) of $bias_2 - bias_1$.

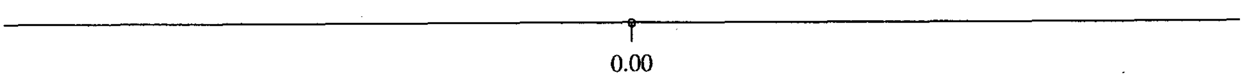


Figure 61. Dot diagram for precipitation (RR) in millimeters (mm) of $rmse_2 - rmse_1$.

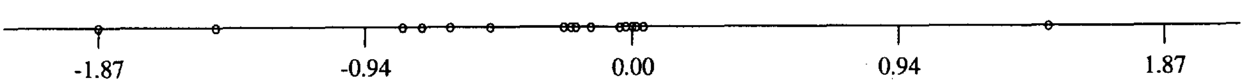


Figure 62. Dot diagram for precipitation (RR) in millimeters (mm) of $mae_2 - mae_1$.

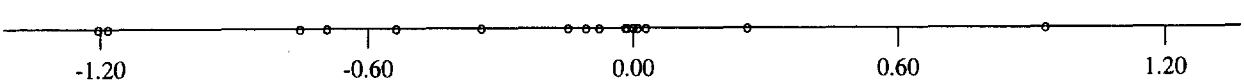


Figure 63. Dot diagram for precipitation (RR) in millimeters (mm) of $emin_2 - emin_1$.

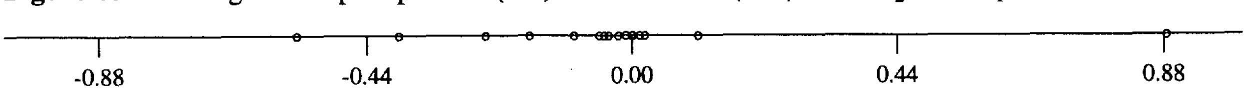
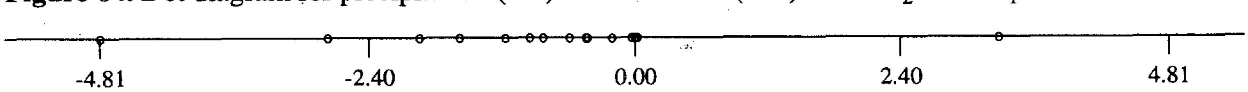


Figure 64. Dot diagram for precipitation (RR) in millimeters (mm) of $emax_2 - emax_1$.



7. CONCLUSIONS

Automatic interpolation in the datatable TELE commenced on August 21 1997, using the radial method. About one month later the exp(exp(corr)) method was put into use for all stations containing enough data to generate correlation values. When there are no data available, the radial method is, however, applied without correctional coeffecients.

For much of the time the exp(exp(corr)) interpolation method works well. This has been verified by Barabara Toporowska and Stein Kristiansen, who are responsible for daily follow up and quality control of weather observations as stored in the datatable TELE.

In some cases, however, they report severe estimation errors, and as shown in this document, in some cases the estimators generate poor estimates. In order to point out situations where this occurs, Zbigniew Toporowski, responsible for interpolation and quality control in the weather station data storage routine, has also made valueable contributions.

Statistics in this report indicate the estimation errors typically of the following size as given in average *mae* (mean average error), standard deviation of *mae* and a to sigma error bound containing at least 3/4 of the values according to Chebychev's rule, or at least 95.4% if approx. normal distribution.

air temperature (TT) in centigrades (°C).	$\overline{mae} = 1.0$	$sd(mae) = 0.7$	$0.0 < mae < 2.5$
minimum air temperature (TN) in centigrades (°C).	$\overline{mae} = 1.2$	$sd(mae) = 1.8$	$0.0 < mae < 4.7$
maximum air temperature (TX) in centigrades (°C).	$\overline{mae} = 0.7$	$sd(mae) = 1.0$	$0.0 < mae < 2.7$
air pressure at station level (P0) in hecto Pascal (hPa).	$\overline{mae} = 2.3$	$sd(mae) = 4.6$	$0.0 < mae < 11.5$
air pressure at sea level (P) in hecto Pascal (hPa).	$\overline{mae} = 0.6$	$sd(mae) = 0.4$	$0.0 < mae < 1.4$
cloud cover (N) in octas (0-8).	$\overline{mae} = 1.0$	$sd(mae) = 0.6$	$0.0 < mae < 2.3$
relative humidity (UU) in percentage (%).	$\overline{mae} = 3.2$	$sd(mae) = 2.0$	$0.0 < mae < 7.1$
precipitation (RR) in millimeters (mm).	$\overline{mae} = 1.0$	$sd(mae) = 1.0$	$0.0 < mae < 2.9$

Since the commence of automatic interpolation, there has been a continuous surge for improving estimates. Bjørn Aune and Sofus L. Lystad have particularily contributed to this process by discussing ideas for improvements.

One of the first problems that must be looked into is how the correctional coeffecients α and β can be estimated in situations where there are no data available. Setting α and β equal to one and zero respectively, as done presently when no data are available, may introduce significant bias, and, as Eirik J. Førland (cf. Førland & Øgland, 1996) has suggested, precipitation normals, or other kinds of normals for other weather elements, should be applied to reduce this bias.

REFERENCES

Bhattacharyya, G.K. & Johnson, R.A. (1977) *Statistical Concepts and Methods*, John Wiley and Sons, New York, 1977.

Førland, E.J. and Øgland, P.(1996) *A Proposal of Method for Areal Precipitation Quality Control in the NHP Quality Control System* (Published as appendix to DNMI Report No. 04/96 KLIBAS, Oslo, February 1996)

Homleid, M. (1997) *Subjective and numerical forecasts of 2 metre temperature - examples of verification results*, DNMI Research Note No. 6, ISSN 0332-9879, Oslo, August 1997.

Vejen, F. et al. (1997) *FREYR. Specification Report on a System for Quality Control of Meteorological Data, Draft version 1.3*, February 1997 (Published as appendix to DNMI Report No. 61/97 KLIBAS)

Øgland, P. (1997a) *Automatic interpolation of SYNOP weather observations: Interpol1 and Interpol2*, DNMI Report No. 61/97 KLIBAS, Oslo, August 1997

Øgland, P. (1997b) *Evaluation of meteorological radial interpolation by statistical experiments*, DNMI Report No. 23/97 KLIBAS, Oslo, October 1997

APPENDIX 1.

Statistics below are generated by applying the exp(exp(corr)) estimation method.

Table 17. The exp(exp(corr)) method used for air temperature (TT) in centigrades (°C).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. SØRNESSET	V08710	8	0.0	0.8	0.7	0.5	0.0	1.4
2. VEST-TORPA II	V21680	10	0.0	0.7	0.6	0.5	0.1	1.2
3. FILEFJELL - GROVSTØL	V23870	9	0.0	0.4	0.4	0.3	0.1	0.8
4. FINSEVATN	A25830	24	0.0	0.7	0.7	0.5	0.0	2.8
5. ØYFJELL - TROVATN	V32920	6	0.0	0.5	0.5	0.5	0.3	0.8
6. VÅGSLI	A33890	24	0.0	0.4	0.4	0.3	0.0	1.2
7. KJEVIK	V39040	24	0.0	0.9	0.9	0.7	0.0	2.1
8. LISTA FYR	V42160	24	0.0	1.0	0.9	0.8	0.0	2.7
9. SIRDAL - TJØRHOM	V42920	10	-0.2	1.1	1.0	0.9	0.0	1.9
10. REIMEGREND	V51670	6	0.0	0.5	0.4	0.4	0.0	0.8
11. FØRDE - TEFRE	V57420	9	0.0	1.6	1.5	1.1	0.3	3.6
12. MERÅKER - UTSYN	V69370	8	0.0	1.3	1.3	1.1	0.1	1.8
13. SUSENDAL - BJORMO	V77750	7	0.0	0.7	0.7	0.6	0.1	1.2
14. MYKEN	V80610	22	0.0	0.6	0.6	0.3	0.0	2.1
15. BANAK	V95350	14	0.0	1.4	1.3	1.0	0.0	3.1
16. SVALBARD LUFTHAVN	V99840	18	0.0	2.6	2.5	1.8	0.0	5.7

Table 18. The exp(exp(corr)) method used for minimum air temperature (TN) in centigrades (°C).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. SØRNESSET	V08710	5	0.0	0.4	0.4	0.3	0.0	0.6
2. VEST-TORPA II	V21680	5	0.0	0.5	0.4	0.4	0.0	0.6
3. FILEFJELL - GROVSTØL	V23870	5	0.0	0.2	0.2	0.2	0.0	0.2
4. FINSEVATN	A25830	6	0.0	0.5	0.5	0.4	0.0	0.8
5. ØYFJELL - TROVATN	V32920	6	0.0	0.3	0.3	0.2	0.1	0.5
6. VÅGSLI	A33890	6	0.0	0.1	0.1	0.1	0.1	0.2
7. KJEVIK	V39040	6	0.0	0.4	0.3	0.3	0.1	0.7
8. LISTA FYR	V42160	6	0.0	0.5	0.5	0.4	0.1	0.7
9. SIRDAL - TJØRHOM	V42920	6	0.0	0.8	0.7	0.5	0.0	1.4
10. REIMEGREND	V51670	6	0.0	0.4	0.3	0.3	0.0	0.5
11. FØRDE - TEFRE	V57420	6	0.0	0.9	0.9	0.8	0.2	1.3
12. MERÅKER - UTSYN	V69370	6	0.0	0.6	0.6	0.5	0.0	1.0
13. SUSENDAL - BJORMO	V77750	5	0.0	0.5	0.5	0.4	0.1	0.7
14. MYKEN	V80610	6	0.0	0.2	0.2	0.2	0.0	0.4
15. BANAK	V95350	6	0.0	1.2	1.1	0.9	0.2	2.2
16. SVALBARD LUFTHAVN	V99840	3	0.0	4.2	3.4	3.2	1.7	4.8

Table 19. The exp(exp(corr)) method used for maximum air temperature (TX) in centigrades (°C).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. SØRNESSET	V08710	5	0.0	0.8	0.7	0.6	0.1	1.0
2. VEST-TORPA II	V21680	5	0.0	0.2	0.2	0.2	0.0	0.3
3. FILEFJELL - GROVSTØL	V23870	5	0.0	0.1	0.1	0.1	0.0	0.1
4. FINSEVATN	A25830	6	0.0	0.3	0.3	0.3	0.0	0.5
5. ØYFJELL - TROVATN	V32920	5	0.0	0.1	0.1	0.0	0.0	0.1
6. VÅGSLI	A33890	6	0.0	0.7	0.6	0.5	0.0	1.1
7. KJEVIK	V39040	6	0.0	0.1	0.1	0.1	0.0	0.3
8. LISTA FYR	V42160	6	0.0	0.3	0.2	0.2	0.2	0.3
9. SIRDAL - TJØRHOM	V42920	6	0.0	0.6	0.5	0.4	0.0	0.8
10. REIMEGREND	V51670	6	0.0	0.4	0.3	0.3	0.1	0.4
11. FØRDE - TEFRE	V57420	6	0.0	0.5	0.4	0.4	0.1	0.8
12. MERÅKER - UTSYN	V69370	6	0.0	0.8	0.7	0.5	0.1	1.4
13. SUSENDAL - BJORMO	V77750	5	0.0	0.8	0.7	0.6	0.1	1.0
14. MYKEN	V80610	6	0.0	0.4	0.4	0.3	0.0	0.6
15. BANAK	V95350	6	0.0	0.3	0.3	0.3	0.1	0.6
16. SVALBARD LUFTHAVN	V99840	6	0.0	4.6	4.2	3.9	2.3	6.7

Table 20. The exp(exp(corr)) method used for air pressure at station level (P0) in hecto Pascal (hPa).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. FINSEVATN	A25830	24	-0.1	1.9	1.9	1.6	0.2	4.1
2. ØYFJELL - TROVATN	V32920	6	0.0	0.3	0.3	0.2	0.0	0.4
3. VÅGSLI	A33890	24	0.0	2.0	1.9	1.6	0.3	4.1
4. KJEVIK	V39040	24	0.0	0.4	0.4	0.3	0.0	0.7
5. LISTA FYR	V42160	24	0.1	2.9	2.9	2.5	0.4	5.4
6. FØRDE - TEFRE	V57420	9	0.0	2.9	2.7	1.7	0.2	7.4
7. MERÅKER - UTSYN	V69370	8	0.0	2.4	2.3	1.9	0.2	4.7
8. MYKEN	V80610	10	0.0	0.9	0.8	0.7	0.2	1.6
9. SVALBARD LUFTHAVN	V99840	24	-0.1	1.0	1.0	0.8	0.1	2.9

Table 21. The exp(exp(corr)) method used for air pressure at sea level (P) in hecto Pascal (hPa).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. FINSEVATN	A25830	24	-0.1	0.6	0.6	0.5	0.0	1.8
2. ØYFJELL - TROVATN	V32920	6	0.0	0.4	0.4	0.3	0.1	0.5
3. VÅGSLI	A33890	24	0.0	0.3	0.3	0.2	0.0	0.8
4. KJEVIK	V39040	24	0.0	0.3	0.3	0.3	0.0	0.6
5. LISTA FYR	V42160	24	0.1	0.5	0.5	0.4	0.0	1.5
6. FØRDE - TEFRE	V57420	8	0.0	0.4	0.4	0.3	0.1	0.5
7. MERÅKER - UTSYN	V69370	8	0.0	0.6	0.6	0.5	0.1	0.9
8. MYKEN	V80610	24	-0.1	0.7	0.7	0.5	0.0	1.4
9. BANAK	V95350	13	0.0	1.3	1.3	0.9	0.0	2.8
10. SVALBARD LUFTHAVN	V99840	24	-0.1	1.8	1.8	1.5	0.0	4.6

Table 22. The exp(exp(corr)) method used for cloud cover (N) in octas (0-8).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. SØRNESSET	V08710	8	0.0	0.7	0.7	0.6	0.2	1.3
2. VEST-TORPA II	V21680	10	0.0	0.5	0.4	0.4	0.0	0.7
3. FILEFJELL - GROVSTØL	V23870	9	0.0	1.1	1.0	0.9	0.2	1.8
4. ØYFJELL - TROVATN	V32920	6	0.0	0.5	0.4	0.4	0.0	0.6
5. KJEVIK	V39040	17	-0.1	1.0	1.0	0.6	0.0	2.2
6. LISTA FYR	V42160	14	0.0	1.0	1.0	0.8	0.1	2.1
7. SIRDAL - TJØRHOM	V42920	5	0.0	0.3	0.3	0.2	0.0	0.5
8. REIMEGREND	V51670	6	0.0	1.0	1.0	0.8	0.2	1.5
9. FØRDE - TEFRE	V57420	9	0.0	1.3	1.3	0.9	0.4	3.2
10. MERÅKER - UTSYN	V69370	8	0.0	1.7	1.6	1.4	0.3	3.2
11. SUSENDAL - BJORMO	V77750	7	0.0	0.5	0.5	0.5	0.4	0.6
12. MYKEN	V80610	19	0.0	1.0	1.0	0.7	0.0	3.0
13. BANAK	V95350	14	0.0	2.2	2.1	1.9	0.1	3.3
14. SVALBARD LUFTHAVN	V99840	18	0.0	2.4	2.3	1.8	0.0	5.2

Table 23. The exp(exp(corr)) method used for relative humidity (UU) in percentage (%).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. SØRNESSET	V08710	8	0.0	2.6	2.4	2.0	0.1	4.1
2. VEST-TORPA II	V21680	10	0.0	2.2	2.1	1.3	0.6	6.3
3. FILEFJELL - GROVSTØL	V23870	9	0.0	4.2	4.0	2.8	0.3	9.6
4. ØYFJELL - TROVATN	V32920	6	0.0	1.4	1.3	1.1	0.3	2.5
5. VÅGSLI	A33890	22	0.0	2.4	2.4	2.0	0.5	6.2
6. KJEVIK	V39040	16	0.0	2.5	2.4	1.9	0.0	4.8
7. LISTA FYR	V42160	23	-0.3	2.7	2.7	2.2	0.0	6.5
8. SIRDAL - TJØRHOM	V42920	10	0.7	5.6	5.3	4.7	0.0	9.1
9. REIMEGREND	V51670	6	0.0	3.9	3.5	2.8	0.2	6.2
10. FØRDE - TEFRE	V57420	9	0.0	11.3	10.6	9.0	2.4	21.3
11. MERÅKER - UTSYN	V69370	8	0.0	3.4	3.2	2.9	0.8	4.6
12. SUSENDAL - BJORMO	V77750	7	0.0	4.5	4.1	3.2	0.2	7.0
13. MYKEN	V80610	24	0.1	3.2	3.1	2.5	0.1	8.0
14. BANAK	V95350	14	0.0	5.1	4.9	4.1	0.8	11.2

Table 24. The exp(exp(corr)) method used for precipitation (RR) in millimeters (mm).

Station name	No.	Sample	Bias	Stde	Rmse	Mae	Emin	Emax
1. SØRNESSET	V08710	5	0.0	0.4	0.3	0.3	0.0	0.6
2. VEST-TORPA II	V21680	5	0.0	0.8	0.7	0.6	0.1	1.4
3. FILEFJELL - GROVSTØL	V23870	6	0.0	2.3	2.1	2.0	1.1	3.3
4. FINSEVATN	A25830	12	0.0	1.2	1.2	0.9	0.2	2.7
5. ØYFJELL - TROVATN	V32920	6	0.0	3.3	3.0	2.2	0.1	5.5
6. VÅGSLI	A33890	12	0.0	0.7	0.7	0.5	0.0	1.6
7. KJEVIK	V39040	6	0.0	2.1	2.0	1.5	0.0	3.5
8. LISTA FYR	V42160	11	0.0	2.7	2.6	2.3	0.3	4.3
9. SIRDAL - TJØRHOM	V42920	6	0.0	3.4	3.1	2.4	0.6	5.8
10. REIMEGREND	V51670	6	0.0	0.4	0.4	0.3	0.1	0.7
11. FØRDE - TEFRE	V57420	6	0.0	0.0	0.0	0.0	0.0	0.1
12. MERÅKER - UTSYN	V69370	6	0.0	0.0	0.0	0.0	0.0	0.1
13. SUSENDAL - BJORMO	V77750	5	0.0	0.6	0.5	0.4	0.1	0.9
14. MYKEN	V80610	5	0.0	0.0	0.0	0.0	0.0	0.1
15. BANAK	V95350	6	0.0	0.0	0.0	0.0	0.0	0.1
16. SVALBARD LUFTHAVN	V99840	6	0.0	0.2	0.2	0.2	0.1	0.5