J3.8 THE EFFECT OF MODERNIZATION OF CLIMATE REFERENCE NETWORKS ON CONTINUITY OF DAILY MAXIMUM AND MINIMUM TEMPERATURE OBSERVATIONS

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1. INTRODUCTION

Climate monitoring network in Canada has declined rapidly since the early 1990s. Many stations were closed because of the changes in roles and priorities of previously cooperating departments and agencies; some stations were automated using various types of autostations. In order to preserve or restore continuity of climate observations at the sites designated as RCS (Reference Climate Network) and GSN, which is GCOS (Global Climate Observing System) Surface Network, the 'Modernization of the Climate Observing Network' project was initiated several years ago. Standardized autostations that consist of Campbell Scientific (CS) dataloggers and specially selected instrumentation have been installed at the affected climate reference sites. Since the main purpose of these networks is to detect climate trends and variability, it is important to assess the impact of modernization on continuity of observations. Whenever possible, an effort was made to collect at least one to two years of overlapping manned and automated observations that would help in computing systematic biases between the old and new sets of observations.

2. DATA

Concurrent observations are used to assess continuity of daily minimum (Tmin) and maximum (Tmax) temperature records at modernized reference climate stations. This preliminary analysis is conducted for two Ontario locations: Ottawa and Kapuskasing (Fig. 1). At both stations old and new observing sites are collocated in the same instrument compound at the same elevation. A Campbell Scientific datalogger records readings from YSI thermistor model 44212EC and is programmed to report minimum and maximum temperature at 8:00 and 17:00 Local Standard Time. Volunteer observers read traditional mercury thermometers and have more flexibility in observation times. For example, afternoon observations at Kapuskasing were routinely taken around 16:00 local time. If this was 16:00 DST, or 15:00 LST, the difference in the time of temperature reading between the volunteer observer and the CS datalogger would be two hours. This may occasionally create some spurious large differences in temperature readings, the impact of which still needs to be evaluated. Most of the time maximum temperatures are reached in the early afternoon. Overlapping data spans about 18 months (Aug 2000 – Dec 2001 inclusive) at Kapuskasing CDA (manned) and Kapuskasing CDA ON (auto), and about 46 months (Oct 2000 – Jul 2004) at Ottawa CDA (manned) and Ottawa CDA RCS (auto).

Fig. 1 Station location.

3. METHODOLOGY

3.1 *Overlap Biases*

Concurrent daily observations are used to compute overlap biases on various temporal scales: annual, monthly, and daily. Biases were not computed for months with more than five days of observations missing. Final biases are a result of averaging of all

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Table 1 Base and reference series with corresponding period of data.

Base series	Reference series
Ottawa CDA Jan 1980 to Oct 2000 Ottawa CDA RCS Nov 2000 to Dec 2004	Ottawa Int'l A (manned) Jan 1980 to Nov 2004
Kapuskasing CDA Jan 1980 to Aug 2000 Kapuskasing CDA ON Sep 2000 to Dec 2004	Kapuskasing A (manned) Jan 1980 to Nov 2004

available monthly values collected during the overlapping period. Annual values were computed when all twelve months were available with the exception of Kapuskasing 2001, which had both January and February missing, and Ottawa 2003, which has January missing; otherwise no annual value would be available for Kapuskasing and only one annual value would be available for Ottawa. It is understandable that caution should be used when interpreting these annual biases. In the case of daily biases, days with certain meteorological conditions, defined by sky cover and wind speed that are observed at nearby airport locations (Kapuskasing A and Ottawa Int'l A) at the time when maximum and minimum temperatures occurred, are grouped together (Milewska and Hogg, 2002). This ensures that biases remain consistent within each group of specific meteorological conditions, which accentuate instrumental and siting differences. The biases derived this way are well suited for adjustment of daily values. Preliminary results of the analysis of the annual and monthly biases only are presented here.

3.1 ***Model Biases***

The overlap biases from the observed data are then compared to results of step computations from a statistical method. This technique, based on regression models that include a reference series from the surrounding stations, was developed to identify discontinuities in temperature time series caused by station relocation and changes in observing procedures (Vincent et al. 2002). A similar approach is used in this study to establish if joining of manned and automated observations has created an artificial discontinuity at the joining year.

Manned and automated observations are joined together to produce a long temperature time series; this new series is defined as a base series while a neighbour station is used for a reference series. Table 1 shows the stations used for base and reference series.

For example, the manned observations of Ottawa CDA are joined with the automated observations of Ottawa CDA RCS in Nov 2000 to create the base series and the observations of Ottawa Int'l Airport are used for a reference series. The joining date coincides with the date the new automated station opened and should have a full month of data available. From this point in time this technique was artificially denied access to the old time series even though they were still being collected. The purpose of this 'blind' test is to examine if the overlapping data and the regression technique produce comparable results. This approach simulates real life situation: the old station often closes at the same time when the new one opens.

A regression model applied to determine if an artificial step is created at the join of the observations is written as follows:

$$y_i = a + bx_i + cI_i + e_i.$$

The variable y_i is the monthly (or annual) mean of the daily maximum (or minimum) temperatures of the base series and x_i represents the monthly (or annual) values of the reference series. The variable I describes a potential step at the join of the observations in the base series; it is equal to zero before the date of the join, and to one otherwise. The estimated parameter c provides the magnitude of the step and its statistical significance is assessed at the 5% confidence level using a t-test.

4. RESULTS

Fig. 2 reveals that, based on actual overlapping data, automated stations report lower monthly temperatures. There are a few exceptions. For example, reports of warmer Tmax from the autostation in winter months in Ottawa could be systematic. Kapuskasing would most likely show similar effect. Months of January and February are missing from the graph for Kapuskasing due to too many missing days, however temperature differences on those individual days that are available in winter show that automated observations are indeed often warmer than observations from the manned site.

Average annual biases from Overlap and Model are compared in Table 2. The biases are all negative and very similar for Tmax, while for Tmin Overlap displays a bias that is colder than Model in Ottawa by 0.5 °C and warmer than Model in Kapuskasing by 0.7 °C.

Table 2 Comparison of annual biases (* - denotes steps significantly different from zero).

	Tmax		Tmin	
	Model	Overlap	Model	Overlap
Ottawa	-0.1	-0.1	-0.4*	-0.9
Kapuskasing	-0.4*	-0.3	-1.2*	-0.5

In Fig. 2, for Tmax, Model produces very few significant steps between joined stations either in Ottawa or in Kapuskasing. For Tmin, Model still shows only a few significant steps in Ottawa, however in Kapuskasing, all months, with the exception of January and November, indicate large significant negative steps.

Overlap shows biases that are similar to Model for Tmax during the summer. For Tmin, however, in Ottawa Overlap biases are consistently colder by several tenth of the degree Celsius. Kapuskasing shows the opposite: Overlap biases are less cold than the model. It is expected that results for Kapuskasing might be less consistent because of much shorter overlapping time period and many missing days, especially in winter.

In general, for annual and monthly data there appears to be a good agreement between Overlap and Model biases as far as the sign of differences is concerned; the magnitudes of the biases are quite similar for Tmax, but less consistent for Tmin. It is obvious that joining automated and manned daily temperatures without considerations for adjustment would definitely lead to a wrong assessment of the temperature trends.

In the future work, daily biases from both methods will be computed and compared. The time series of differences on individual days show very consistent and cyclical patterns, so the method of grouping days with similar meteorological conditions promises to be a very effective approach. Daily biases from the overlapping data will be compared to the ones derived by interpolation between modeled monthly biases. Verification of the results is planned for some of those stations that have two or more years of overlapping data. One portion of the overlapping data will be used to derive biases, which then will be used to adjust daily temperature values during the remaining portion of the overlap. The adjusted temperatures will then be compared to the actual observations from the autostation

This analysis will be extended to all stations with available overlapping observations. It is anticipated that, as a result this work, daily adjustments will be more accurate and we will have higher confidence in the trends computed on the time series from joined manned and automated stations.

5. REFERENCES

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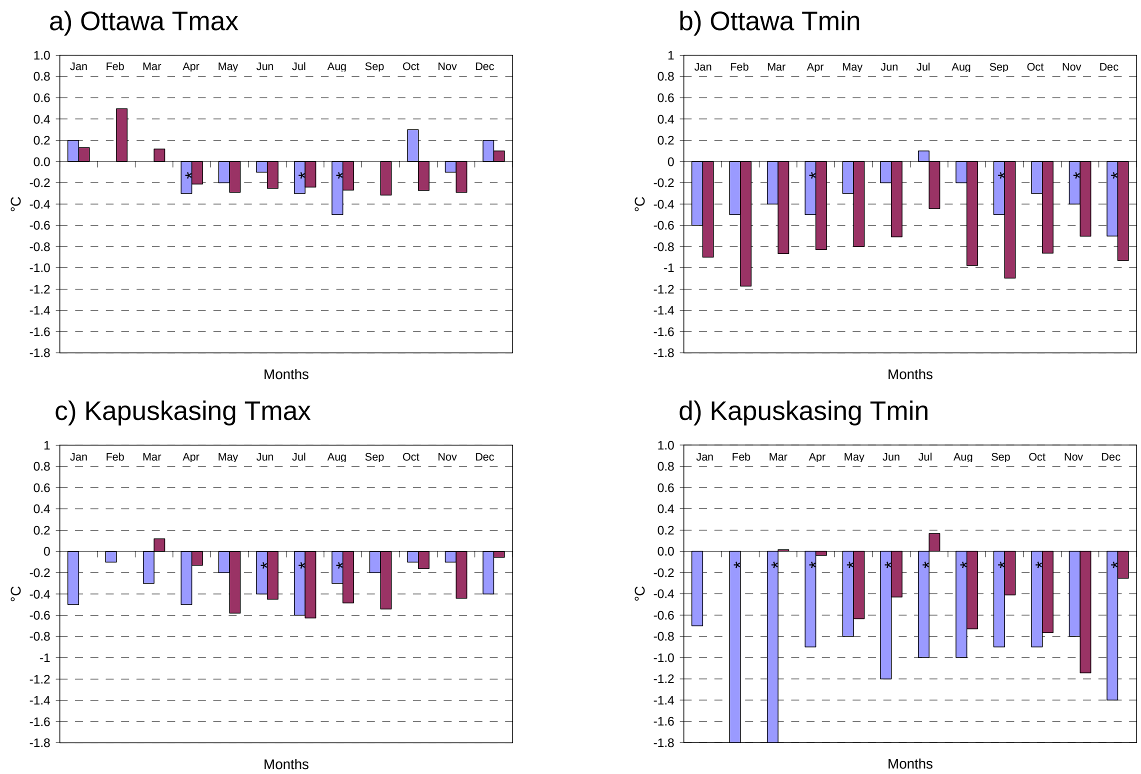

Fig. 2 Monthly biases (auto-manned) from the regression model (blue bars; * - denotes steps significantly different from zero at the 5% confidence level) and overlapping data (red bars).