CORRECTION: A TEST OF CORRECTIONS FOR EXTRANEOUS SIGNALS IN GRIDDED SURFACE TEMPERATURE DATA*

Ross McKitrick[1,**], Patrick J. Michaels[2]

[1] Department of Economics, University of Guelph, Guelph, ON Canada.
[2] Department of Environmental Sciences, University of Virginia, Clark Hall, 291 McCormick Rd, PO Box 400123 Charlottesville, VA 22904-4123, USA

* Extra information, including the data base and computations, is available at http://www.uoguelph.ca/~rmckitri/research/gdptemp.html.
** Email: rmckitri@uoguelph.ca

September 13, 2004

There was a small mistake in the command file used to compute the results in our paper [McKitrick and Michaels 2004].[1] The formula for computing cosine of absolute latitude (*COSABLAT*) takes the angle in radians but our data were entered in degrees. We have corrected this and produced new versions of the affected Tables. Table 4 below, showing the central results of the paper, displays the original and corrected columns side-by-side for ease of comparison. Tables 5—8 are presented in corrected versions only.

As is evident in Table 4, except for the impacts on the *COSABLAT* variable itself, the changes are very small. The principal effect of the correction is a reduced weight on the constant term and an increased weight on the *COSABLAT* variable itself. Indeed the correction improves the overall fit and removes the anomalously small cosine-latitude effect. The socioeconomic variables remain significant and the effects carry over from the station data to the gridded data as before.

Because the main patterns of results persist across the revised tables, the original discussions as worded in our paper need only minor modification, and our overall conclusion, re-stated here, is unaffected:

Overall, the results of this study support the hypothesis that published temperature data are contaminated with nonclimatic influences that add up to a net warming bias, and that efforts should be made to properly quantify these effects.

Except as noted below readers should rely on the original discussion in [McKitrick and Michaels 2004], substituting corrected coefficient values as necessary.

1. INTRODUCTION The amount of dry air predicts the dominant fraction of warming in the cold season. Outside the dry/cold regions the measured temperature change is significantly (previous: "primarily") influenced by economic and social variables.

3 EMPIRICAL RESULTS

[1] The error was first noticed by T. Lambert.

3.1 The cosine of latitude is significant in nearly all specifications (previous: insignificant) with most of the contribution coming from reduced constant terms. The variable R^2-Geog (the adjusted R^2 from a regression on the geographical variables only) explains 14 to 29 % of the trend patterns (previous: 4 to 6%). The fixed Soviet effect is +0.49 ^{o}C/decade in the station data (previous: 0.59), and is smaller but still weakly significant (P=0.05) at +0.13 ^{o}C/decade in the gridded data (previous 0.29). The literacy effect in the corrected model (gridded data) is now a bit larger (-0.003; previous -0.002) and the t-statistic is higher.

3.2 In Table 5, there was virtually no change in the station data–poor region, with latitude remaining insignificant in this case. In the gridded data–poor region, the Soviet and literacy effects ceased to be significant, but coal use became significant. In the gridded data–wealthy region, all socioeconomic indicators, except missing stations, remained significant, while the coefficient and significance of the pressure effect increased. In the station data–wealthy region, coal use and income effects ceased to be significant. The missing data count is insignificant across all columns.

3.3 As before, within the dry, cold season subset only the pressure effect is significant: latitude is not. The cold season pressure effect goes from weakly significant to significant in the global sample and is thus significant in both seasons (previously – warm only). In the global sample, GDP growth and the Soviet effect cease to be significant in both cold and warm seasons, but literacy and income effects remain significant in both seasons, as do coal use and missing stations in the warm season.

4. MODEL SPECIFICATION TESTS

4.1 Five observations were deleted as outliers (down from 11).

4.2 The effects of income and the Soviet dummy go from weakly significant to insignificant. But as before most of the explanatory power on the surface-tropospheric differences is from the nonclimatic variables.

5. OUT OF SAMPLE PROPERTIES

The validation skill is now higher: the correlation between the predicted and observed values rises from 0.31 to 0.51 and the R^2 rises from 0.09 to 0.26.

6. GENERATING 'CLEAN' CLIMATE TRENDS

Removing economic effects drops the average trend from 0.27 to 0.18 ^{o}C/decade, not 0.11 as before. Removing social effects drops it further to 0.13 ^{o}C/decade, not 0.06. Setting income to the sample average yields 0.23 ^{o}C/decade, not 0.20 as before. Hence the magnitude of the net warming bias is one-third to one-half the observed average in this sample, depending on assumptions about the role of income.

Reference

[1] McKitrick R Michaels PJ (2004) Clim Res 26:159-173.

Variable	STATION DATA Global Sample ORIGINAL		CORRECTED		GRIDDED DATA Global Sample ORIGINAL		CORRECTED	
DEPENDANT VARIABLE	$STREND_i$		$STREND_i$		$GTREND_i$		$GTREND_i$	
CONSTANT	-12.727	(1.16)	-15.392	(1.47)	**-9.124**	**(2.13)**	**-10.536**	**(2.78)**
$PRESS_i$	0.013	(1.18)	0.016	(1.54)	**0.009**	**(2.18)**	**0.011**	**(2.98)**
$WATER_i$	0.103*	(1.91)	0.098*	(1.86)	0.012	(0.39)	0.003	(0.10)
$COSABLAT_i$	-0.008	(0.20)	-0.381*	(1.66)	**-0.048**	**(2.46)**	**-0.602**	**(6.15)**
POP_i	0.002	(0.60)	0.002	(0.58)	-0.002	(1.26)	-0.002	(1.11)
$SCALE79_i$	-0.002	(0.51)	-0.001	(0.32)	-0.000	(0.02)	-0.001	(0.48)
$COAL80_i$	**-0.450**	**(2.72)**	**-0.454**	**(2.81)**	**-0.323**	**(3.40)**	**-0.309**	**(4.11)**
$COALGROW_i$	-0.007*	(1.68)	-0.005	(1.32)	-0.002	(0.85)	0.001	(0.24)
$INC79_i$	**0.046**	**(4.46)**	**0.040**	**(3.67)**	**0.030**	**(5.22)**	**0.018**	**(3.62)**
$GDPGROW_i$	**0.091**	**(4.55)**	**0.086**	**(4.24)**	**0.039**	**(3.68)**	**0.026**	**(2.59)**
$SOVIET_i$	**0.592**	**(5.46)**	**0.489**	**(4.02)**	**0.288**	**(4.73)**	0.129*	(1.94)
$SURFMISS_i$	-0.000	(0.09)	-0.000	(0.20)	-0.001	(0.16)	-0.003	(0.50)
$LIT79_i$	**-0.005**	**(2.99)**	**-0.005**	**(3.27)**	**-0.002**	**(2.81)**	**-0.003**	**(3.19)**
R^2	0.25		0.26		0.29		0.38	
Adj- R^2	0.20		0.22		0.25		0.34	
R^2 -Geog	0.04		0.14		0.06		0.29	
P(Econ=0)	**0.00**		**0.00**		**0.00**		**0.00**	
P(Sov=0)	**0.00**		**0.00**		**0.00**		0.05*	
P(Soc=0)	**0.01**		**0.01**		**0.02**		**0.01**	
Degrees of Freedom	205		205		192		192	

Table 4: Parameter estimates for surface data "fingerprint" model. *t*-statistic in parentheses, based on White's (1980) heteroskedasticity-consistent covariance matrix estimator. Parameters in **bold** are significant at 95%, * denotes 90% significance. Dependant variable is in °C/decade. R^2 - Geog is the adjusted R^2 from a regression of the surface trends on the geographic variables ($PRESS_i$ through $COSABLAT_i$) only. *P*(Econ=0) is the p-value of an *F* test on the hypothesis that the economic influence variables (POP_i through $GDPGROW_i$) are jointly zero. *P*(Sov=0) is the p-value of a *t*-test on the hypothesis that the Soviet dummy is zero. *P*(Soc=0) is the p-value of an *F* test on the hypothesis that social factors potentially affecting data quality ($SURFMISS_i$ and $LIT79_i$) are jointly zero.

Variable	WEALTHY REGION Station Data		WEALTHY REGION Gridded Data		POOR REGION Station Data		POOR REGION Gridded Data	
CONSTANT	-41.044	(1.48)	**-18.557**	**(2.93)**	-11.586*	(1.75)	-4.514	(0.95)
$PRESS_i$	0.041	(1.49)	**0.019**	**(3.03)**	0.012*	(1.82)	0.005	(1.16)
$WATER_i$	0.075	(0.78)	-0.027	(0.50)	**0.131**	**(2.08)**	0.051	(1.51)
$COSABLAT_i$	**-1.301**	**(3.03)**	**-0.791**	**(4.32)**	-0.115	(0.27)	**-0.763**	**(3.53)**
POP_i	-0.001	(0.28)	0.000	(0.14)	0.005	(1.15)	**-0.006**	**(2.78)**
$SCALE79_i$	0.002	(0.34)	-0.001	(0.20)	0.012	(0.63)	-0.019	(1.62)
$COAL80_i$	-0.286	(1.13)	**-0.421**	**(3.67)**	-0.431	(1.17)	**-0.364**	**(2.35)**
$COALGROW_i$	**-0.036**	**(3.13)**	**-0.015**	**(3.68)**	0.001	(0.27)	0.003	(1.42)
$INC79_i$	0.026	(0.78)	**0.040**	**(3.27)**	-0.011	(0.32)	-0.016	(1.09)
$GDPGROW_i$	0.039	(0.57)	**0.059**	**(2.13)**	**0.064**	**(3.29)**	0.016	(1.35)
$SOVIET_i$					**0.682**	**(4.03)**	0.120	(1.47)
$SURFMISS_i$	-0.005	(1.18)	-0.012	(1.39)	0.001	(0.77)	-0.001	(0.13)
$LIT79_i$	0.002	(0.27)	-0.003	(0.99)	-0.003*	(1.70)	-0.001	(0.98)
R^2	0.35		0.56		0.33		0.34	
Adj- R^2	0.24		0.49		0.27		0.27	
R^2 - Geog	0.24		0.41		0.12		0.24	
P(Econ=0)	**0.03**		**0.00**		**0.00**		**0.00**	
P(Sov=0)					**0.00**		0.14	
P(Soc=0)	0.48		0.19		0.18		0.62	
Degrees of Freedom	68		67		125		113	

Table 5: Parameter estimates for surface trend model on economic sub-samples. Dependent variable is temperature trend in ^{o}C/decade at surface in either station data set or gridded data set. Definitions and notes as for Table 4.

Variable	COLD SEASON Global Sample		COLD SEASON Dry Regions		WARM SEASON Global Sample		WARM SEASON Dry Regions	
CONSTANT	**-10.299**	**(2.27)**	**-25.366**	**(2.59)**	**-13.142**	**(3.05)**	-10.094	(1.00)
$PRESS_i$	**0.011**	**(2.42)**	**0.026**	**(2.81)**	**0.014**	**(3.27)**	0.011	(1.18)
$WATER_i$	0.024	(0.67)	0.042	(0.40)	-0.011	(0.33)	-0.025	(0.38)
$COSABLAT_i$	**-0.529**	**(3.70)**	-0.414	(1.53)	**-0.725**	**(6.69)**	**-0.703**	**(2.53)**
POP_i	-0.001	(0.35)	-0.020*	(1.70)	-0.002	(1.27)	-0.007	(0.72)
$SCALE79_i$	-0.000	(0.06)	0.009	(1.11)	0.002	(0.65)	0.007	(1.02)
$COAL80_i$	0.006	(0.05)	-0.030	(0.16)	**-0.428**	**(4.49)**	**-0.445**	**(2.58)**
$COALGROW_i$	0.002	(0.83)	-0.015	(0.94)	-0.001	(0.27)	0.008	(0.78)
$INC79_i$	**0.024**	**(3.27)**	0.039	(1.23)	**0.012**	**(1.97)**	0.000	(0.02)
$GDPGROW_i$	0.023	(1.58)	0.009	(0.16)	0.022*	(1.88)	0.051	(1.42)
$SOVIET_i$	0.084	(1.10)	-0.079	(0.25)	0.110	(1.53)	0.125	(0.49)
$SURFMISS_i$	-0.003	(0.21)	-0.054	(1.56)	**-0.024**	**(2.91)**	0.019	(0.75)
$LIT79_i$	**-0.003**	**(3.48)**	-0.001	(0.09)	**-0.003**	**(3.03)**	-0.004	(0.37)
R^2	0.29		0.36		0.38		0.37	
Adj- R^2	0.24		0.20		0.34		0.21	
R^2 - Geog	0.18		-0.01		0.24		0.17	
P(Econ=0)	**0.01**		0.19		**0.00**		**0.04**	
P(Sov=0)	0.27		0.80		0.13		0.63	
P(Soc=0)	**0.00**		0.29		**0.00**		0.74	
Degrees of Freedom	193		47		196		46	

Table 6: Parameter estimates for gridded trend model, cold/warm season sub-samples; global and dry regions. Dependent variable is seasonal temperature trend in gridded data set. Cold season: Oct-Mar in NH, Apr-Sep in SH; reverse for warm season. Variable definitions and notes as for Table 4.

Variable	GLOBAL SAMPLE Gridded Data		OUTLIERS REMOVED Gridded Data		S-T DIFF Global Sample		ORTHOGONAL MODEL Gridded Data		NA+SA REMOVED Gridded Data	
CONSTANT	**-10.536**	**(2.78)**	**-8.984**	**(2.29)**	-1.633	(0.51)	-5.485*	(1.64)	-7.908*	(1.75)
$PRESS_i$	**0.011**	**(2.98)**	**0.010**	**(2.48)**	0.002	(0.59)	0.006*	(1.87)	0.009*	(1.89)
$WATER_i$	0.003	(0.10)	0.011	(0.36)	-0.005	(0.22)	0.012	(0.42)	0.026	(0.74)
$COSABLAT_i$	**-0.602**	**(6.15)**	**-0.576**	**(5.08)**	-0.034	(0.32)	**-0.630**	**(8.53)**	**-0.571**	**(3.56)**
POP_i	-0.002	(1.11)	-0.001	(0.41)	-0.002	(1.15)	-0.002	(1.05)	-0.004	(1.11)
$SCALE79_i$	-0.001	(0.48)	0.001	(0.27)	0.001	(0.22)	0.001	(0.53)	0.006	(1.51)
$COAL80_i$	**-0.309**	**(4.11)**	**-0.285**	**(3.19)**	**-0.144**	**(2.17)**	**-0.272**	**(3.67)**	-0.266*	(1.82)
$COALGROW_i$	0.001	(0.24)	0.001	(0.39)	0.004*	(1.75)	0.000	(0.18)	-0.002	(0.47)
$INC79_i$	**0.018**	**(3.62)**	**0.020**	**(3.17)**	0.007	(1.54)	**0.017**	**(3.56)**	0.012*	(1.66)
$GDPGROW_i$	**0.026**	**(2.59)**	**0.024**	**(2.18)**	-0.001	(0.11)	**0.025**	**(2.60)**	0.023*	(1.80)
$SOVIET_i$	0.129*	(1.94)	**0.156**	**(2.24)**	0.088	(1.57)	**0.137**	**(2.40)**	0.078	(1.08)
$SURFMISS_i$	-0.003	(0.50)	-0.000	(0.01)	**0.014**	**(2.72)**	-0.004	(0.63)	-0.008	(1.22)
$LIT79_i$	**-0.003**	**(3.19)**	**-0.003**	**(3.17)**	**-0.003**	**(3.54)**	**-0.003**	**(3.11)**	-0.002	(1.24)
R^2	0.38		0.40		0.19		0.11		0.36	
Adj-R^2	0.34		0.36		0.14		0.07		0.30	
R^2 - Geog	0.29		0.32		0.01		0.29		0.25	
P(Econ=0)	**0.00**		**0.01**		**0.01**		**0.00**		**0.05**	
P(Sov=0)	0.06*		**0.03**		0.12		**0.02**		0.28	
P(Soc=0)	**0.01**		**0.01**		**0.00**		**0.01**		0.27	
Degrees of Freedom	192		187		192		201/195		129	
Corr between predicted and observed									0.51	
R^2 between predicted and observed									**0.26**	

Table 7: Specification tests for surface trend model on annual gridded data. Details as for Table 4, also see text. D.of.F in column 4 refers to two separate estimation stages.

Adjustment	Adjusted Sample Average Trend (°C/decade)	Adjusted Sample Standard Deviation
Original Sample Average	0.270	0.237
Remove Economic Effects	0.182	0.135
Remove Social Effects	0.134	0.165
Remove Soviet Effect	0.111	0.133
Set Income to Sample Average	0.226	0.133

Table 8: Values of sample average temperature trends in gridded data after successively removing extraneous socioeconomic biases.