

Parallel measurements to study inhomogeneities in daily data

<http://tinyurl.com/dailyDMW2013>

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Content

- Motivation: Much recent interest in daily data
- Inhomogeneities
 - Physical causes of inhomogeneities
 - What do we know from parallel measurements?
- Correction methods
 - Mean, distribution, weather dependent
 - Discussion
- Homogeneity daily datasets
- Conclusions
- Outlook
 - Homogenization of daily data
 - Study of parallel measurements



Motivation: daily data

- Currents research needs daily data
 - Extremes and weather variability
 - Trends and climate variability therein
 - Attribution study on extremes
- Trenberth et al. (2007):

“This [inhomogeneous data] affects, in particular, the understanding of extremes, because changes in extremes are often more sensitive to inhomogeneous climate monitoring practices than changes in the mean.”
- Trenberth, K.E., et al., 2007: Observations: Surface and Atmospheric Climate Change. In: Climate Change 2007: The Physical Science Basis. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Physical causes of inhomogeneities

- | | |
|---|--|
| <ul style="list-style-type: none"> ▪ Instrument <ul style="list-style-type: none"> – Zero drift, shrinking glass initial years – Calibration errors – Response, integration time – Temperature out of range – Quicksilver thermometers: T < -39°C ▪ Relocation of station <ul style="list-style-type: none"> – City-> airport, suburbs, lower heights – Deurbanisation of network ▪ Change surrounding <ul style="list-style-type: none"> – Urbanization, growing vegetation, irrigation ▪ Shelter type, exposure <ul style="list-style-type: none"> – Radiation & wetting protection – Natural or forced ventilation – Snow cover – Plastic screen: insolation on hot days | <ul style="list-style-type: none"> ▪ Definitions <ul style="list-style-type: none"> – Computation daily means ▪ Measurement procedures <ul style="list-style-type: none"> – Reading times ▪ Maintenance procedures <ul style="list-style-type: none"> – AWS: Icing, damage detection – Painting & cleaning schedule ▪ Digitisation & database <ul style="list-style-type: none"> – Minus sign forgotten – Station names mixed up – Pre-homogenised data |
|---|--|

Physical causes of inhomogeneities

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Tail shift (indirectly also mean)
Mean and tail shift</p> |
|---|---|

Parallel measurements

- WMO recommendation: several years of parallel measurements in case of change in observation
- Experiments with parallel measurements
 - WMO studies for operational instruments
 - Climatological studies with historical instruments
 - Typically analysed for change in mean only
- Two studies on temperature distribution
 - Australia, relocation:
 - Trewin, B. A daily homogenized temperature data set for Australia. *Int. J. Climatol.*, doi: 10.1002/joc.3530, 2012.
 - Austria, north wall and Stevenson screen:
 - Böhm, R., P.D. Jones, J. Hiebl, D. Frank, M. Brunetti and M. Maugerl. The early instrumental warm-bias: a solution for long central European temperature series 1760–2007. *Climatic Change*, 101, pp. 41–67, doi 10.1007/s10584-009-9649-4, 2010.

Australia: Albany airport and town

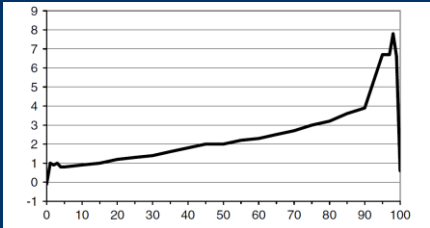


Figure 1. Differences (°C) between percentile points of summer maximum temperature at Albany airport (009741) and Albany town (009500) during the overlap period (2002–2009). The 0th and 100th percentiles indicate the lowest and highest values recorded during the overlap period.

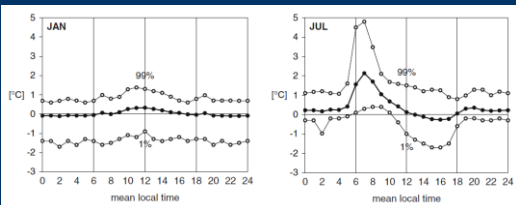
Trewin (2012)

Parallel measurements – Kremsmünster



Böhm et al. (2010)

Kremsmünster – percentiles difference



Böhm et al. (2010)

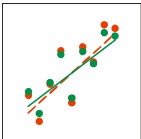
Daily correction methods

- No correction
 - Determine trends on homogeneous subperiods
 - Correct the mean
 - Monthly adjustments smoothed to daily, Vincent et al. (2002)
 - Correct the distribution
 - HOM, SPLIDHOM, HOMAD, QM, PM, WHM (wavelet)
 - One break after another (error accumulation)
 - One station as reference (except PM; Trewin, 2012)
 - Weather-dependent correction
 - Using co-variables
 - Wild → Stevenson screen: Auchmann & Brönnimann (2012)
- Auchmann, R., and S. Brönnimann. A physics-based correction model for homogenizing sub-daily temperature series. *J. Geophys. Res.*, 117, D17119, doi:10.1029/2012.JD018067, 2012.
- Trewin, B. A daily homogenized temperature data set for Australia. *Int. J. Climatol.*, 33, pp. 1510–1529, doi:10.1002/joc.3530, 2013.
- Vincent, L.A., X. Zhang, B.R. Bonsal, and W.D. Hogg. Homogenization of daily temperatures over Canada. *J. Climate*, 15, no. 11, pp. 1322–1334, 2002.

Quality of correction

- Percentile Matching (PM; Trewin, 2012)
 - Improvements if cross correlations (ρ) > 0.6
- Higher order moments method (HOM; Della-Marta and Wanner, 2006), rule of the thumb:
 - $\rho > 0.9$: Mean, standard deviation, skewness useful
 - $\rho < 0.9$: Better use adjustment of means
 - Mainly depends on amount of data, likely similar for other methods
- No information: other moments & indices
 - Della-Marta PM, Wanner H. 2006. A method of homogenizing the extremes and mean of daily temperature measurements. *J. Clim.*, 19, pp. 4179–4197, doi: 10.1175/JCLI3855.1.
 - Trewin, B. A daily homogenized temperature data set for Australia. *Int. J. Climatol.*, 33, pp. 1510–1529, doi: 10.1002/joc.3530, 2013.

Correction methodology - inflation

- Corrections have deterministic (explained variance) and stochastic (unexplained) component
 - Downscaling: problems deterministic corrections
 - Variance inflation (Von Storch, 1999)
 - Quantile Matching (Maraun, 2013)
 - Correct unexplained variance with noise
 - Unintended change trend in mean
 - Homogenization: Trend in difference TS is small
- 
- Maraun, D. Bias correction, quantile mapping, and downscaling: revisiting the inflation issue. *J. Clim.*, 26, pp. 2137–2143, doi: 10.1175/JCLI-D-12-00821.1, 2013.
- Von Storch, H. On the Use of "Inflation" in Statistical Downscaling. *J. Clim.*, 12, pp. 3505–3506, 1999.

Correction – change in noise source

- Change in cross-correlation
 - Relocation, change in noise source
 - Simple example
 - $|N_1| = |N_2|$
 - No inhomogeneity in distribution
 - Jump in difference time series
-
- R** Regional climate signal
N Instrument specific error
W Station specific weather

Not homogenized datasets

- European Climate Assessment & Dataset
 - Homogeneity assessed (useful, doubtful, suspect)
 - Global Historical Climatology Network – Daily
-
- Introduction: Klein Tank, et al. Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. *Int. J. Climatol.*, **22**, pp. 1441–1453, doi: 10.1002/joc.773, 2002.
 - Update: Kolk, E.J. and A.M.G. Klein Tank. Updated and extended European dataset of daily climate observations. *Int. J. Climatol.*, **29**, pp. 1182–1191, doi: 10.1002/joc.1779, 2009.
 - Homogeneity assessment: Wijnjaard, J.B., A.M.G. Klein Tank, and G.P. Können. Homogeneity of 20th century European daily temperature and precipitation series. *Int. J. Climatol.*, **23**, pp. 679–692, 2003.
 - Dataset: Menne, M.J., I. Durre, R.S. Vose, B.E. Gleason, and T.G. Houston. An Overview of the Global Historical Climatology Network-Daily Database. *J. Atmos. Oc. Technol.*, **29**, pp. 997–910, 2012.
 - Quality control: Durre, I., M.J. Menne, B.E. Gleason, T.G. Houston, R.S. Vose. Comprehensive Automated Quality Assurance of Daily Surface Observations. *J. Appl. Meteor. Climatol.*, **49**, 1615–1633, 2010.

Austria – Distribution homogenised

- Austria: 1948-2009, 57 Tmin & 54 Tmax stations
 - Detection: PRODIGE, metadata
 - Annual, winter and summer means
 - Correction: SPLIDHOM (trust the skewness)
 - Significance testing by bootstrapping
-
- Description dataset: Nemeč, J., Ch. Gruber, B. Chimani, I. Auer. Trends in extreme temperature indices in Austria based on a new homogenised dataset. *Int. J. Climatol.*, doi: 10.1002/joc.3532, 2012.
 - Download dataset: <http://www.zamg.ac.at>
 - QC: Schöner W, Auer I, Böhm R, Thaler S. 2003. Qualitätskontrolle und statistische Eigenschaften ausgewählter Klimaparameter aus Tageswertbasis im Hinblick auf Extremwertanalysen. StartClim Endbericht. Available from <http://www.boku.ac.at/austroclim/stratclim/berch2003/SIC101.pdf>

Conclusions

- Inhomogeneities change the distribution
 - Physical reasoning and parallel measurements
 - Strong inhomogeneities in tail
 - Biases in the trends of extremes/variability are expected
- First correction methods for distribution
 - Need dense network
 - Are labour intensive
- Many widely-used dataset are not homogenised

Outlook

- Urgently need to study non-climatic changes in distribution for severe weather studies
- Uncertainty estimates lacking
- Lack in understanding
 - Physical and statistical properties of daily breaks
- Correction
 - Multiple breakpoint methods missing
 - Weather dependent corrections
 - Stochastic corrections
 - Analysis on HSP requires new statistical tools
- Close collaboration between climatologists and homogenization specialists

Research on parallel data

- Large database with parallel measurements needed to study daily inhomogeneities
 - Study statistical and physical properties of daily inhomogeneities
 - Dependence on local weather and regional climate
 - Most studies are currently about mid-latitudes
 - Develop daily correction methods
 - Weather dependent (Auchmann & Brönnimann, 2012)
 - Stochastic
 - Generate benchmark data with realistic inhomogeneities
 - For example, second cycle of ISTI
 - Validate detected inhomogeneities

Parallel Data Initiative

- Produce an open database
- Initially data is restricted to contributors
 - Incentive to contribute
 - Until first joint paper(s) by contributors are written
- First action: Inventory of parallel datasets
 - <https://ourproject.org/moin/projects/parallel>
 - Dozens of datasets available
- More information
 - <http://tinyurl.com/paralleldata>
 - Victor.Venema@uni-bonn.de

E-mail list on homogenisation of climate data

- **Goal**
 - Strengthen communication and co-operation
- **Suggested uses of the list are**
 - Conferences, workshops, etc.
 - Important papers
 - Discussions
 - Job opportunities
 - New projects started
 - Requests for data, information, and cooperation partners
 - ...
- **Subscribing**
 - You can join the mailing list by sending an e-mail to Victor.Venema@uni-bonn.de
 - For more information: <http://tinyurl.com/HomList>

Questions?

These slides can be found under
<http://tinyurl.com/dailyDMW2013>

Parallel data initiative
<http://tinyurl.com/paralleldata>

Homogenization distribution list
<http://tinyurl.com/HomList>