Homogenisation of monthly and daily temperature and precipitation data

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Content
- Inhomogeneities in climate data
- Homogenization
- Validation of monthly homogenization methods
- Daily data
  - Parallel measurements
  - Homogenization of distribution
  - Datasets
- Conclusions
- Future research

Causes of inhomogeneities
- Relocation of station
  - Bias: city → airport
  - Small move can have large effect
- Change surrounding
  - Buildings (urban heat island), vegetation
- Instrumentation (integration time)
- Shelter type (ventilation, radiation protection)
- Definitions (computation mean temperature)
- Measurement procedures (reading times)
- Maintenance procedures (icing, damage)

Homogenisation: WHY?
Example of PAU-UZEIN temperature

1912 PAU-LESCAR (EN) → 2005 PAU-UZEIN (AERO)

Results homogenisation
- Typical is one break in mean per 20 years
- Important for trends and long term variations
- Homogenisation: smaller station trend errors
  - Investigate changes on smaller spatial scales
- Inhomogeneities can also lead to biases
  - Urban heat island
  - Move to airports
  - Automatic weather stations
  - Improvements in radiation and wetting protection
Homogenization

- Physical corrections
  - Metadata: Parallel measurements
  - Time of observation bias
  - Corrections for specific transitions
- Statistical homogenization
  - Absolute homogenization
  - Leads to larger uncertainties
  - Relative homogenization
    - Pairwise
    - Composite reference time series
    - Precise break date with metadata
    - Confirm date with metadata

Relative homogenisation

- Candidate station is compared with neighbouring stations
  - Temperature: difference time series
  - Removes the complex climate signal
  - Reduces noise
  - Makes breaks in single station more salient
- One break and homogeneous reference
  - Standard Normal Homogeneity Test (SNHT) optimal
- Climatological praxis
  - Multiple breaks
  - Also the reference is inhomogeneous

Pairwise homogenization

- Leads to larger uncertainties
- Composite reference time series
- Precise break date with metadata
- Confirm date with metadata

http://variable-variability.blogspot.de/2012/08/statistical-homogenisation-for-dummies.html
**Pairwise vs composite reference**

- **Composite reference**
  - Compute a weighted average of neighbouring stations
  - Reduces the influence of inhomogeneities in single stations
  - Careful selection of stations needed
- **Pairwise**
  - Need to attribute the breaks found in the pairs to a station
  - Solution to this problem is still ad-hoc or manual

**Multiple breakpoints**

- **Typical period between two breaks**
  - Temperature record: 15 to 20 years
- **Normal to have multiple breakpoints in one series**
- **Solutions**
  1. (Semi-)hierarchical
  2. Exhaustive search
  3. Optimization method (dynamic programming)
     - Order(n^2) and order(k)
     - n: length series, k: no. breaks
Benchmarking: Monthly homogenisation

Benchmarking homogenization algorithms for monthly data

Benchmarking homogenization algorithms for monthly data

Benchmark dataset
Some results
Conclusions

Intercomparison study

- Compare full homogenisation algorithms
  - Detection, correction
  - Also: reference, iterations, remove outliers, etc.
- Benchmark dataset
  - Monthly temperature and precipitation networks
    - Size: 15 networks (surrogate data)
    - Length: 100 years
    - Number of stations: 5, 9, 15
    - Homogenized blind
    - Random small inhomogeneities
      - Gaussian distribution, sigma 0.8°C or 15%

Benchmarking homogenization algorithms for monthly data
Conclusions

- Relative homogenisation improves temperature records
  - Absolute homogenisation can make data more inhomogeneous
  - Only the best algorithms improved station precipitation

- Best algorithms
  - Function with an inhomogeneous reference (multiple breaks)
  - (ACMANT), Craddock, MASH, PRODIGE, USHCN (PHA)
  - Trends are about a factor 2 more accurate as SNHT
  - Automatic algorithms among the best (no metadata)

- Moderate correlation between error metrics
  - Contingency scores not good predictor of skill
Review: Daily homogenisation

- Daily Inhomogeneities (parallel measurements)
- Daily correction methods
- Daily datasets
- Daily conclusions

Parallel measurements

- WMO recommendation: several years of parallel measurements in case of change in observation
- Experiments with parallel measurements
  - Typically analysed for change in mean only
- 3 Studies on temperature distribution
  - Australia, relocation:
  - Austria, north wall and Stevenson screen:
  - Spain, Montsouard & Stevenson screen:

Australia: Albany airport and town

Figure 1. Differences (°C) between percentile points of summer maximum temperature at Albany airport (099741) and Albany town (099550) during the overlap period (2002–2005). The 5th and 95th percentiles indicate the lowest and highest values recorded during the overlap period.

Parallel measurements – Kremsmünster

Kremsmünster – diurnal cycle difference

Kremsmünster – percentiles difference

Böhm et al. (2010)
Spain: Montsouri screen, Stevenson observations, Stevenson automatic

Montsouri vs. Stevenson: difference as function of Diurnal Temperature Range and Tmax

Daily correction approaches

- No correction
  - Determine trends on homogeneous subperiods
- Correct the mean
  - Monthly adjustments smoothed to daily
  - Vincent et al. (2002)
- Correct the distribution
  - HOM, SPLIDOM, HOMAD, QM, PM
  - One break after another (error accumulation)
  - Rule of the thumb: cross correction > 0.9
  - HOM: mean, variance, skewness useful
- Physical correction
  - Using co-variates
  - Wild → Stevenson screen: Auchmann & Brönnimann (2012)

European Climate Assessment & Dataset

- Mainly: precipitation & temperature
- Also: surface pressure, sun shine duration, cloud cover, relative humidity and snow depth
- Homogeneity assessed (useful, doubtful, suspect), not homogenised
- References

Global Historical Climatology Network - Daily

- 80,000 Stations, 2 billion values
- 70% Values in USA
- Quality controlled
- Not homogenised

- Reference

Canada – mean temperature homogenised

- Temperature
  - Monthly mean corrections are smoothed to daily corrections
  - Much applied method
  - Monthly data: download; daily data: e-mail
- Precipitation
  - Physical correction, no statistical homogenisation

- Reference
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

Reference
- Download dataset: http://www.zamg.ac.at

Trends warm/cold nights (d/10a)

- Original (raw)
- Homogenised

Daily data, extreme events and homogeneity

- Inhomogeneities change the distribution
  - Not just the mean
  - Biases in the trends are expected
- First correction methods for distribution
  - Need dense network
  - Are labour intensive
- Many widely used dataset are not homogenised
- Urgently need to study non-climatic changes in extreme weather
- Be sceptical of studies using daily data
  - Especially if they do not mention homogenisation

Future research

- Homogenisations method
  - Important for climatology
  - Beautiful statistical problem
  - Wonderful community
- Proposal for priority research program
  - Climate change and extremes
  - One topics: Data quality
  - Submission: autumn 2013

Future research - Parallel measurements

- Global database
  - Inventory
  - Data rescue
  - Database
- Parallel experiments
  - Historical set-ups
  - Tropical and poor countries
  - What’s Up With That
    - Paint: whitewash vs. latex
    - Observations vs. AWS