Is relative statistical homogenization of Sea Surface Temperature possible?

Victor Venema

Content

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  - Trend bias in Land Surface Temperature
  - Conflict between LST and SST trend
- Relative statistical homogenisation
  - Recent methodological advances
  - New insight
- Relative homogenisation of SST?
  - Some tricks to estimate global trends
- Conclusions

Land Surface Temperature adjustments

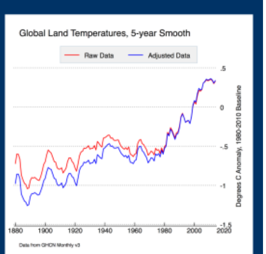
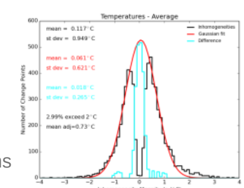


Figure: Zeke Hausfather

- After adjustment:
  - 0.8°C per century
- Before adjustment:
  - 0.6°C per century
- Main adjustment period
  - 1940-1980
- Invisible transitions
  - Introduction Stevenson screens
  - Introduction AWS

Global land surface trend

- HadISDH
  - Breaks: 0.12°C bias
  - One break every 15 years
  - Period 1973–2013
  - 0.78°C per century
  - Station by station basis
- Larger trend bias
  - More recent period
  - Station based: global averages give strong weight to isolated stations



Well-homogenized national datasets

- Compared global collection
  - Annual mean averaged over same countries
  - Berkeley Earth Surface Temperature (BEST)
  - GHCNv3
  - GISS
  - CRUCY
- Good national datasets are expected to be better than global collections
  - More data: better correlated references
  - More metadata: station history
  - More care and better methods

Trend since 1901

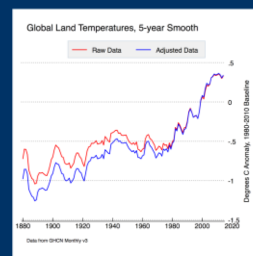
Trend since 1901					
Region	*Regional*	*GHCNv3*	*Diff GHCNv3*	*BEST*	*Diff BEST*
Austria	1,43	1,24	0,20	1,16	0,27
Italy	1,41	0,80	0,61	1,04	0,37
Switzerland	1,57	1,43	0,14	1,18	0,39
Average			0.31 (p=0.17)		0.34 (p=0.01)
Region	*Regional*	*CRUCY*	*Diff CRUCY*	*GISS*	*Diff GISS*
Austria	1,43	1,36	0,07	0,99	0,45
Italy	1,41	0,89	0,52	1,02	0,39
Switzerland	1,57	1,48	0,08	1,19	0,38
Average			0.23 (p=0.27)		0.41 (p=0.002)

Trend since 1981

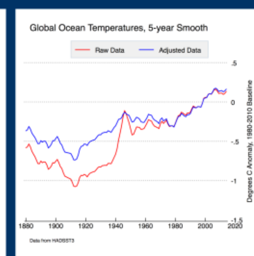
Trend since 1981					
Region	**Regional**	**GHCNv3**	**Diff GHCNv3**	**BEST**	**Diff BEST**
Australia	1,95	1,57	0,37	1,55	0,40
Austria	4,74	4,06	0,68	4,02	0,72
France	4,15	3,98	0,18	3,33	0,82
Hungary	4,80	4,71	0,08	4,46	0,33
Italy	4,53	3,83	0,70	3,61	0,92
Slovenia	5,32	5,37	-0,05	4,49	0,82
Switzerland	4,35	4,85	-0,51	3,80	0,54
Average			**0.21 (p=0.24)**		**0.65 (p=3e-04)**
Region	**Regional**	**CRUCY**	**Diff CRUCY**	**GISS**	**Diff GISS**
Australia	1,95	0,82	1,13	1,74	0,20
Austria	4,74	3,96	0,78	4,13	0,61
France	4,15	3,77	0,38	3,51	0,65
Hungary	4,80	4,51	0,29	4,51	0,28
Italy	4,53	3,27	1,26	3,88	0,65
Slovenia	5,32	5,48	-0,17	4,47	0,85
Switzerland	4,35	4,37	-0,02	3,71	0,63
Average			**0.52 (p=0.05)**		**0.55 (p=7e-04)**

Inhomogeneities

Land Surface Temperature



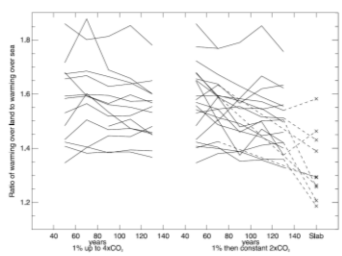
Sea Surface Temperature



Figures: Zeke Hausfather

Ratio warming over land to warming sea

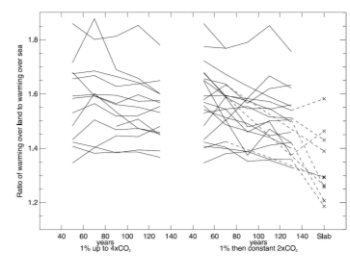
- Sutton et al. Land/sea warming ratio in response to climate change: IPCC AR4 model results and comparison with observations. GRL, 2007.



Ratio warming over land to warming sea

- Sutton et al. Land/sea warming ratio in response to climate change: IPCC AR4 model results and comparison with observations. GRL, 2007.

~2 HadCRT2v (1980–2004)



Relative homogenization methods

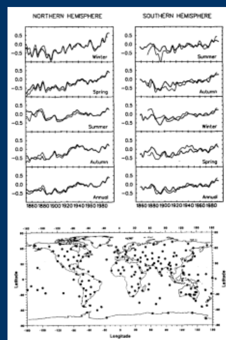
- Relative homogenization
  - Homogenization by comparison with neighbors
    - SST: you need platforms with an ID
  - Community rule: should always be applied
    - Never trust metadata alone
- Two types
  - Pairwise detection (+ attribution of breaks to station)
  - Composite reference from many neighbors
- Detection
  - Typical: Statistical methods for single breakpoint
    - Plus splitting series
  - Modern: Multiple breakpoint
    - Estimate optimal number of breaks still difficult
    - Joint detection (multiple series)

Relative homogenization methods

- Correction
  - Typical: Single breakpoint: One after another
    - Accumulation of errors especially bad for trends
  - Typical: Composite reference
    - Removes noise component,
    - But probably not much of large-scale bias
      - Trend bias is also in reference
  - Modern: Multiple breakpoint (so-called ANOVA)
    - Decomposition
      - Regional climate signal (same for all stations)
      - Inhomogeneities per station (step function)
      - Noise to be minimized
    - Unbiased, if all breaks have been detected
    - In practice: under-correction of network trend errors
      - Correction needed

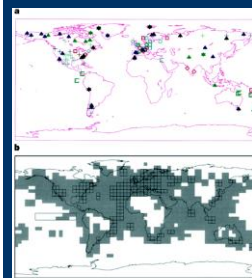
Main Nature trick: Trend spots not maps How many spots do we need?

- Jones (1994)
  - 172 selected stations
  - HN: 109
  - SH: 63
- Callendar (1961) used 80 stations
  - Fit to modern reconstructions (Hawkins and Jones, 2013)



Mann, Bradley, Hughes reconstruction

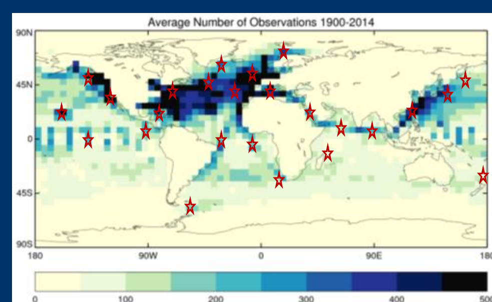
- A first paleo reconstruction
  - On 5°x5° grid: 11 points
- Fits reasonably to modern ones with more data
- Longer time scales
  - Less spatial variability in trends



Trend spots not maps

- If you want long-term trend
  - Need less spots
- Is the field of SST trends less spatially variable?
  - Less spots
- Use climate model to study whether locations would have a bias over global trend
  - Are models good enough for that?
- My guess:
  - 16 SST spots for century trends
  - 25 SST spots for 50-year trends
- Spatial correlation length of long-term trends

SST trend spots



Use trend spots, side ideas

- Ocean weather ships and fixed buoys
  - Island stations?
    - On days with wind from ocean
  - Coastal networks?
    - On days with wind from ocean
  - (Could island and coastal stations be used for independent trend estimate?)
- Largest bias in LST found in recent decades where we have more data
- With high resolution data we might be able to estimate gradients and enlarge area considered "nearby"
  - Exist?

Increase number of observations with ID

- Can we increase number of ships with ID?
- Tracking
  - With fingerprints to help
    - Typical time, instruments and combination of observations
- Digitisation
  - If we can make the theoretical case that that would help, it may be possible to redigitise data and take better care to preserve ID

Some more Nature tricks

- Detection:
  - Maybe not too important if you already have IDs
  - SST, joint detection of break
  - NMAT, MAT, satellite, reanalysis
    - Methods that accept trend differences
- Correction: only SST
  - ANOVA decomposition method
  - Correction for trend under-correction
- Validation with known inhomogeneities
  - Possible?

Conclusions

- Possibly stronger land trends
  - SST trends already weak
- Relative homogenisation guards against surprises
- Relative homogenisation of SST?
  - For well observed spots
  - For recent decades
  - Modern homogenization methods
  - Trend under-correction correction
- Trend spots could be temporal backbone for maps
- Caveats
  - Not much data (with ID)
  - Gradual inhomogeneities should not dominate