Dreaming of relative statistical homogenization of SST

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Content

Motivation

- Secular trend bias in Land Surface Temperature
 - Early global warming underestimated?
- Conflict between surface and troposphere warming?
- Conflict between LST and SST trend?
- Relative statistical homogenisation
 - Guards against unknown unknowns
 - Recent methodological advances
- Relative homogenisation of SST?
 - Some tricks to estimate global trends
- Conclusions

A possible temperature trend bias

- About 50 national/regional homogenized datasets
- Compared global collection
 - Annual mean averaged over same countries
 - Berkeley Earth (BEST), homogenized and raw
 - GISS & GHCNv3, GHCNv4
 - CRUCY & CRUTEM4
 - ECA&D & HadISH
- Good national datasets are expected to be better (also not perfect)
 - More data: better correlated references
 - More metadata: station history
 - More care and better methods

Difference BEST (1901-2010)





Difference BEST, GISS, CRUCY (1901-2010)



CRUCY

GISTEM





Global temperature changes (1850-1920) http://tinyurl.com/early-warming



Sea Surface Temperature (AR5)



Lake and river freezing



Days later freezing or earlier breakup

Temperature reconstruction from glaciers



Oerlemans, J., 2005: Extracting a Climate Signal from 169 Glacier Records. *Science*, **308**, no. 5722, pp. 675-677.

Sea level rise



Land and sea surface temperature trend

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)

Land and sea surface temperature trend

Land Surface Temperature

Sea Surface Temperature



Figures: Zeke Hausfather

Motivation - relative homogenization Unknown unknowns in SST trend



Günter Dietrich. Deutsche Hydrographische Zeitschrift, Vol 3, no. 5/6, 1950.

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
 - Protects against unknown unknowns

Detection of breaks

- Difficult for low SNR
 - Would suggest only using it for surface observations to remove data (QC)
 - Can detect breaks by comparing with reanalysis and satellite data
 - I would not correct using these sources
- Multiple breakpoint methods best
- Reference series
 - Composite reference (higher SNR)
 - Pairwise (mathematically more tractable)

Regional trend bias correction

- A small bias in breaks can lead to large-scale temperature trend errors
- Correction with composite reference
 - Reference has the same bias



Temperature raw and homogenized (smoothed)

Correction by decomposition



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
- The field of SST trends is 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

- Additional datasets
 - Ocean weather ships and fixed buoys
 - Island stations
 - On days with wind from ocean
 - Coastal networks
 - On days with wind from ocean
 - Island and coastal stations could also be used for independent coastal MAT trend estimate
- Bias in LST & SST also found in recent decades where we have more data

Increase number of observations with ID

- Can we increase number of ships with ID?
- Tracking
 - With fingerprints to help
 - Typical observation time
 - Combination of observations
 - Observation height/depth (other metadata)
- Digitisation
 - it may be possible to redigitise data and take better care to preserve ID
 - If we find a bias between current methods and relative homogenization for one region
 - If we can make the theoretical case that that would help

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