A bias corrected SST analysis from 1900 to the present

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Global-average sea-surface temperature 1850-2008

Annual global-average SST anomaly (°C) wrt 1961-1990
Large drop in 1945/1946
Slow down in recent warming
Huge change in observing network in past 25 years

Percentage of observations coming from

DRIFTERS and

SHIPS
Drifters biased cold ~0.16°C relative to Ships

Global-average SST anomaly (°C) wrt 1961-1990

Global-average SST difference (°C)

Difference Drifters–Ships
Drifters cause significant cooling in global average SST

Global-average SST anomaly (°C) wrt 1961-1990
Puzzle: independent estimates agree with HadSST2
Ships warming faster than Drifters

Global-average SST anomaly (°C) wrt 1961-1990

Global-average SST difference (°C)

Difference Drifters–Ships

-0.1°C/decade
Ship measurement methods

1. Buckets
   - Insulated/uninsulated
   - Cool bias

2. Engine Room Intakes
   - Warm bias

3. Hull Sensors
History of measurement methods

• If there is a measurement method in ICOADS, use it
  • e.g. observation is 1.0 bucket

• If there is a measurement method in WMO Pub 47, use it

• Identify the Ship’s country from Country ID in ICOADS or from the Deck number.

• If there is country information use that to infer the measurement method based on WMO Pub 47.
  • e.g. If country ID indicates ship is Japanese and WMO Pub 47 says that ships in the fleet were 70% ERI and 30% bucket then observation is 0.7 ERI and 0.3 bucket.
Time series of measurement methods

Weight in global average
Some assumptions about the biases

• Assume buckets are all uninsulated till 1950 and all insulated by 1960, interpolating linearly between these
  • True for UK data based on Marine Observers Handbooks
  • May be untrue for other countries

• Use Folland and Parker 95 correction fields for insulated and uninsulated buckets

• Assume Engine Room Intake bias is +0.2K throughout

• Drifters are biased cold by 0.17K relative to ships in the modern period.
What does the corrected series look like?

Global-average SST anomaly (°C) wrt 1961-1990

Uncorrected data
What does the corrected series look like?

Global-average SST anomaly (°C)
  wrt 1961-1990

HadSST2 (no corrections after 1941)

Uncorrected data
What does the corrected series look like?

Global-average SST anomaly (°C) wrt 1961-1990

- New Corrections
- HadSST2 (no corrections after 1941)

Uncorrected data
Corrections ‘work’ for other regions

• Corrections larger in Southern Hemisphere ~0.45°C
• Smaller corrections in Northern Hemisphere.
• The same method can be applied at any scale, even grid box by grid box.
How wrong could the corrections be?

- Engine Room Intake bias not constant in time, or space
  - e.g. Kent and Taylor 2006
  - Unclear what happened during the war
- Time history of bucket change from uninsulated to insulated is uncertain
  - Evidence for UK, but not other countries.
  - Timing is important for 1945-1965 period
- Assignment of measurement method is uncertain
  - An observation can’t be 0.3 bucket + 0.6 ERI + 0.1 Hull contact
- Validate corrections using new version of ICOADS
Summary

• Generated Time history of measurement methods and bias corrections

• Increase of drifting buoy numbers may offset recent warming slightly…

• …but effect is likely being countered by increasing warm bias in ship data.

• Drop in late-1945 due to shift from ERI measurements to bucket measurements.

• New data will be used to validate corrections
Questions and answers