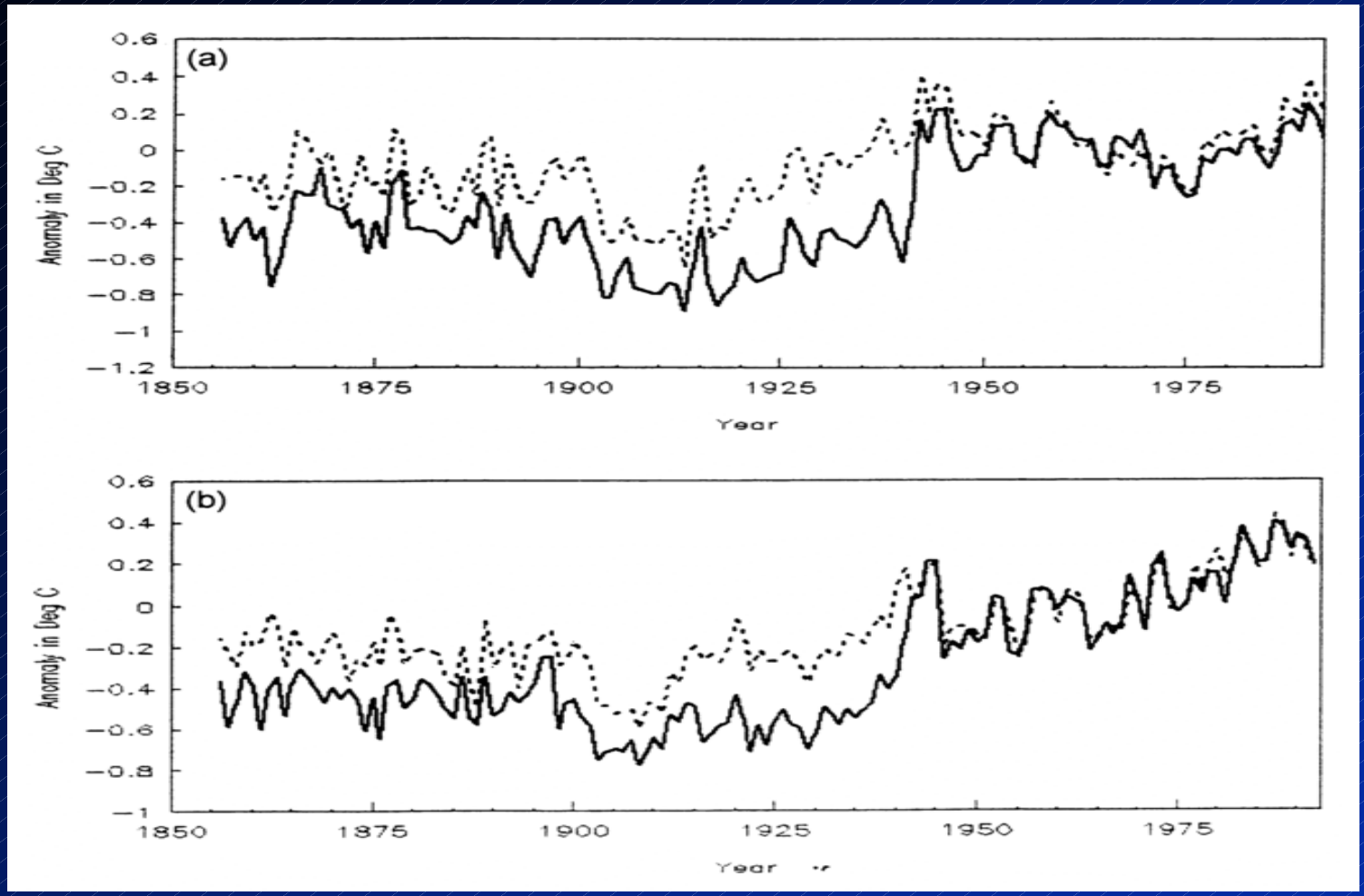
Bias Adjustments to Historical SST

Chris Folland, Hadley Centre, Met Office

- Characteristics of uncorrected SST data
- Collection of sea water
- Models of heat losses from sea temperature buckets
- Calculated bias corrections
- Tests of bias corrections
- Conclusions

Met Office

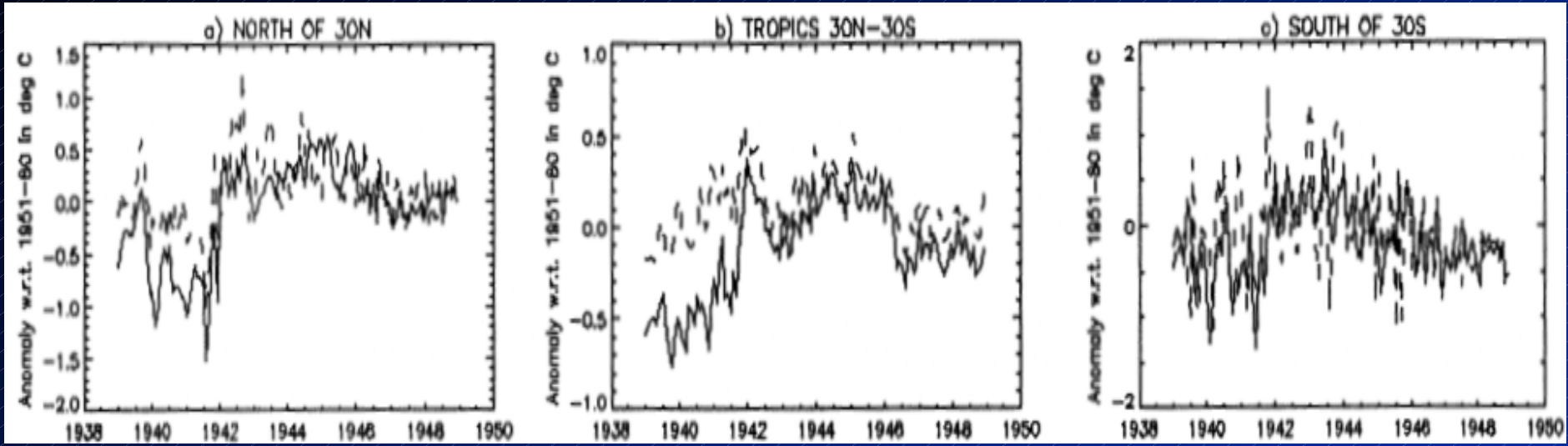


Annual anomalies from 1951-80 average of uncorrected SST (solid) & corrected NMAT (dashed) for (a) Northern (b) Southern Hemisphere, 1856-1992.

Collocated 5º x 5º SST & NMAT values were used.

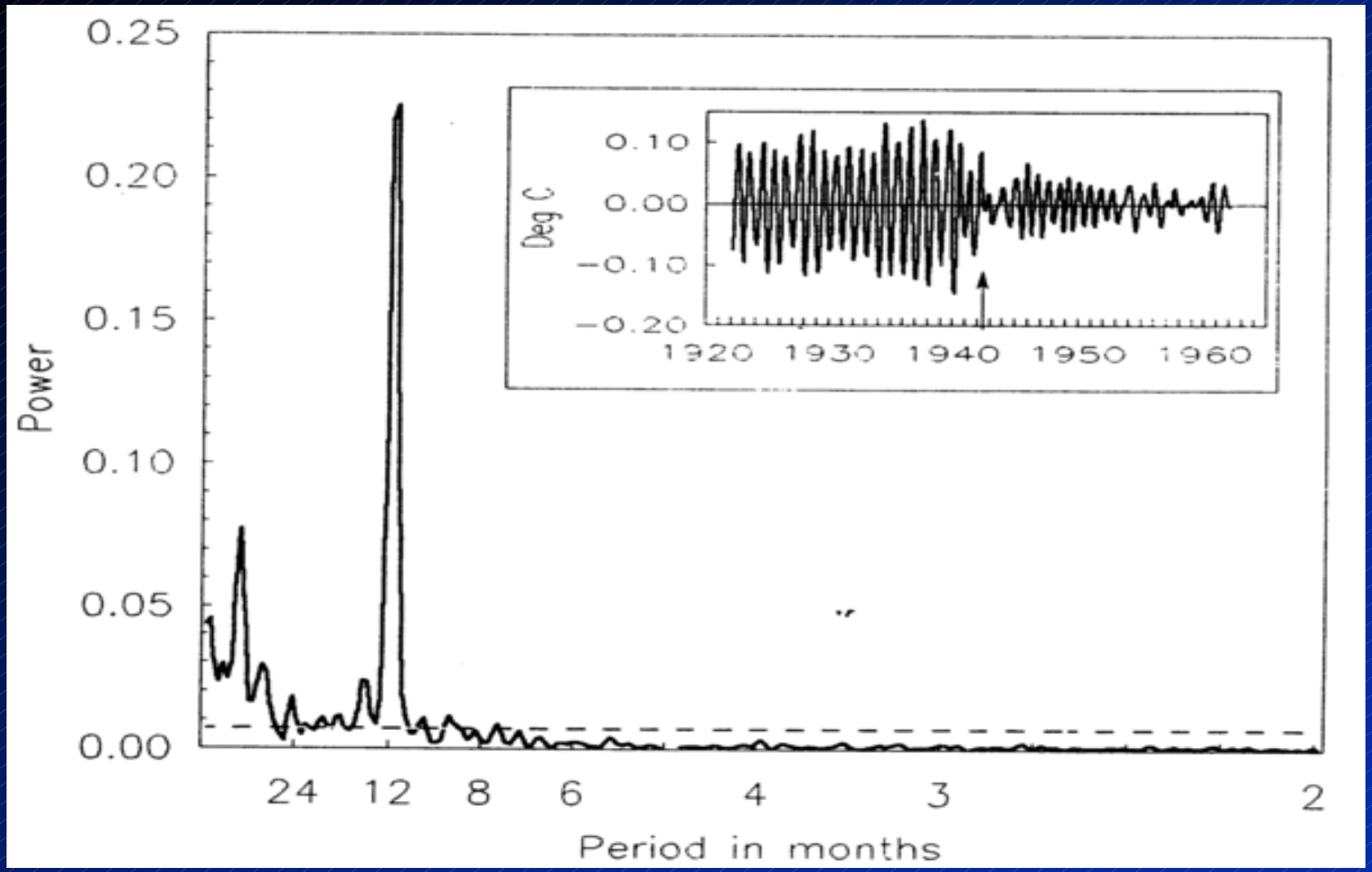
Hadley Centre for Climate Prediction and Research

Met Office



Monthly anomalies of uncorrected SST (solid) and corrected NMAT (dashed) during 1939-48 for three regions covering the globe

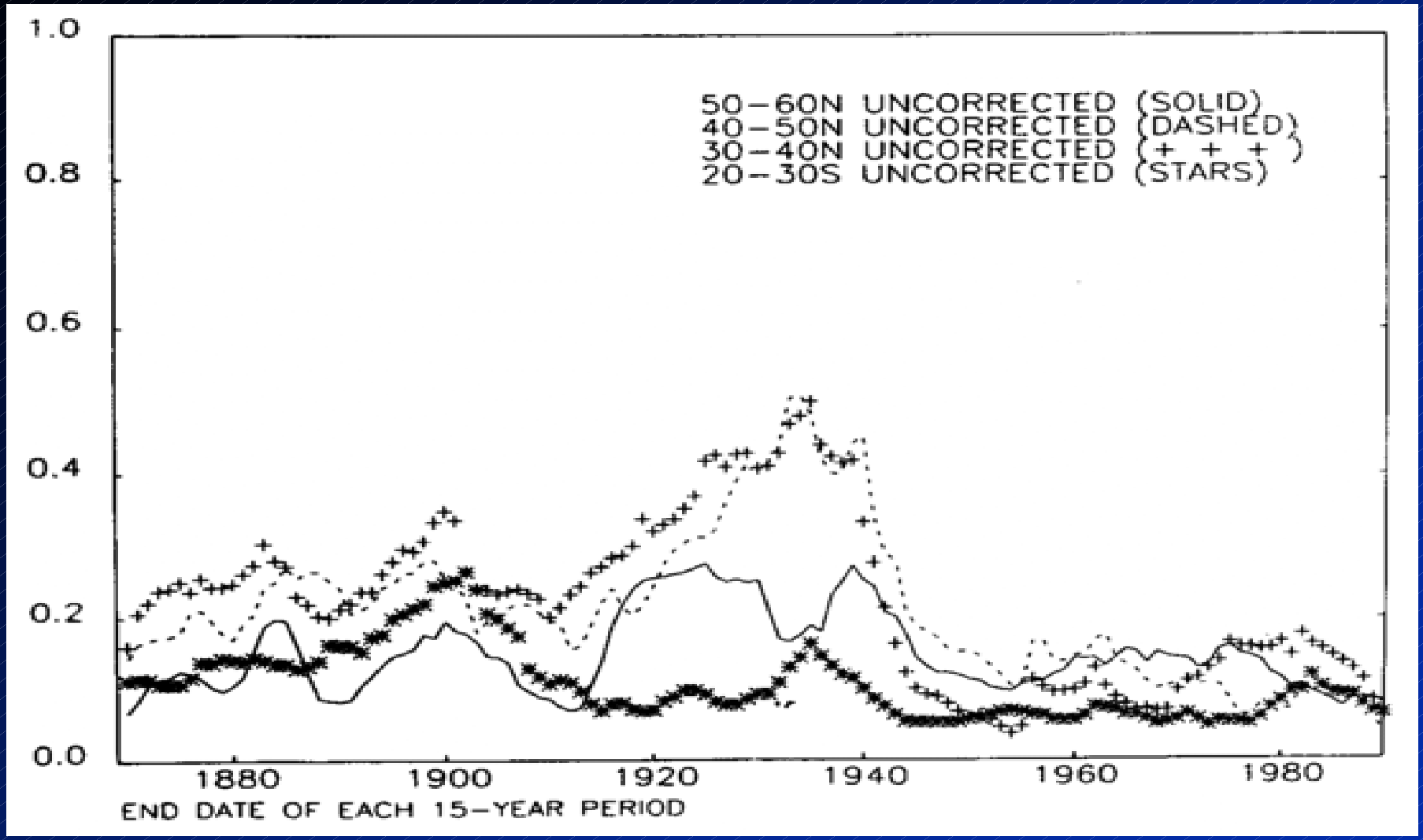
Met Office



Power spectrum of uncorrected SST anomalies from 1951-80, for Northern hemisphere north of 20ºN in 1901-40. Insert shows band-pass filtered annual cycles of SST anomalies for 1922-61.

Hadley Centre for Climate Prediction and Research

Met Office



Running 15-year average ratio of annual to total variance, F, for uncorrected SST in zones 50-60°N, 40-50°N, 30-40°N & 20-30°S.

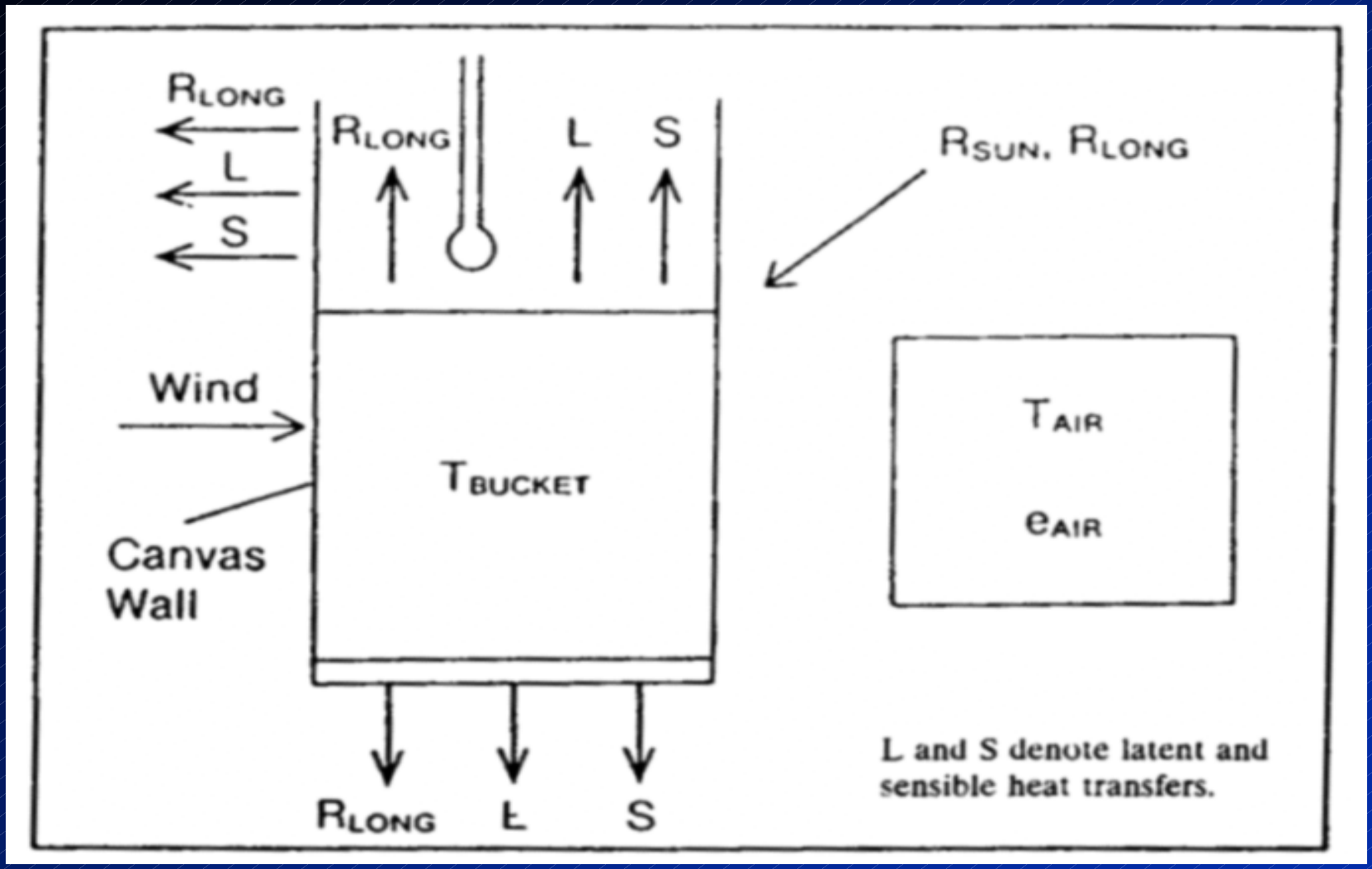
Hadley Centre for Climate Prediction and Research

Met Office

(a) German metal & leather bucket, UK Met Office, black insulated bucket & UK Met Office Mk II canvas sea temperature bucket

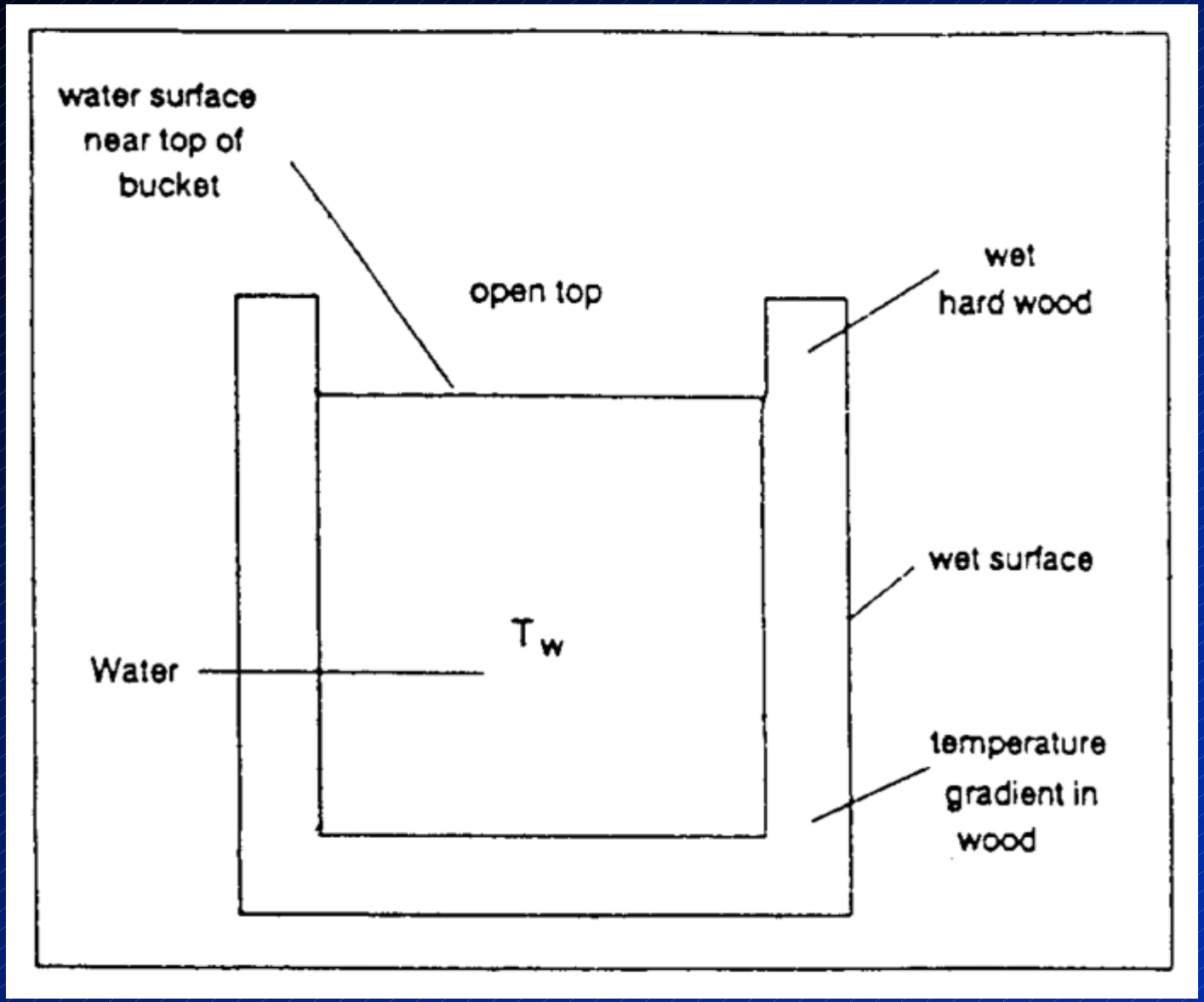
(b) ship's wooden bucket, 1891 (courtesy of Scottish Maritime Museum).

Met Office



Conceptual model of heat transfers affecting uninsulated sea temperature buckets.

Met Office



Conceptual model of a wooden bucket.

Met Office

Basic heat loss equation for Canvas Bucket

$$dQ/dt = h_r A(T_b - T_a) + h_{sens} A (T_b - T_a + 1.7(e_b - e_a)) - f(Q_s) A$$

dQ/dt = rate of loss of heat

h_r = radiative heat transfer coefficient

A = bucket surface area

T_b = bucket surface temperature

T_a = ambient air temperature

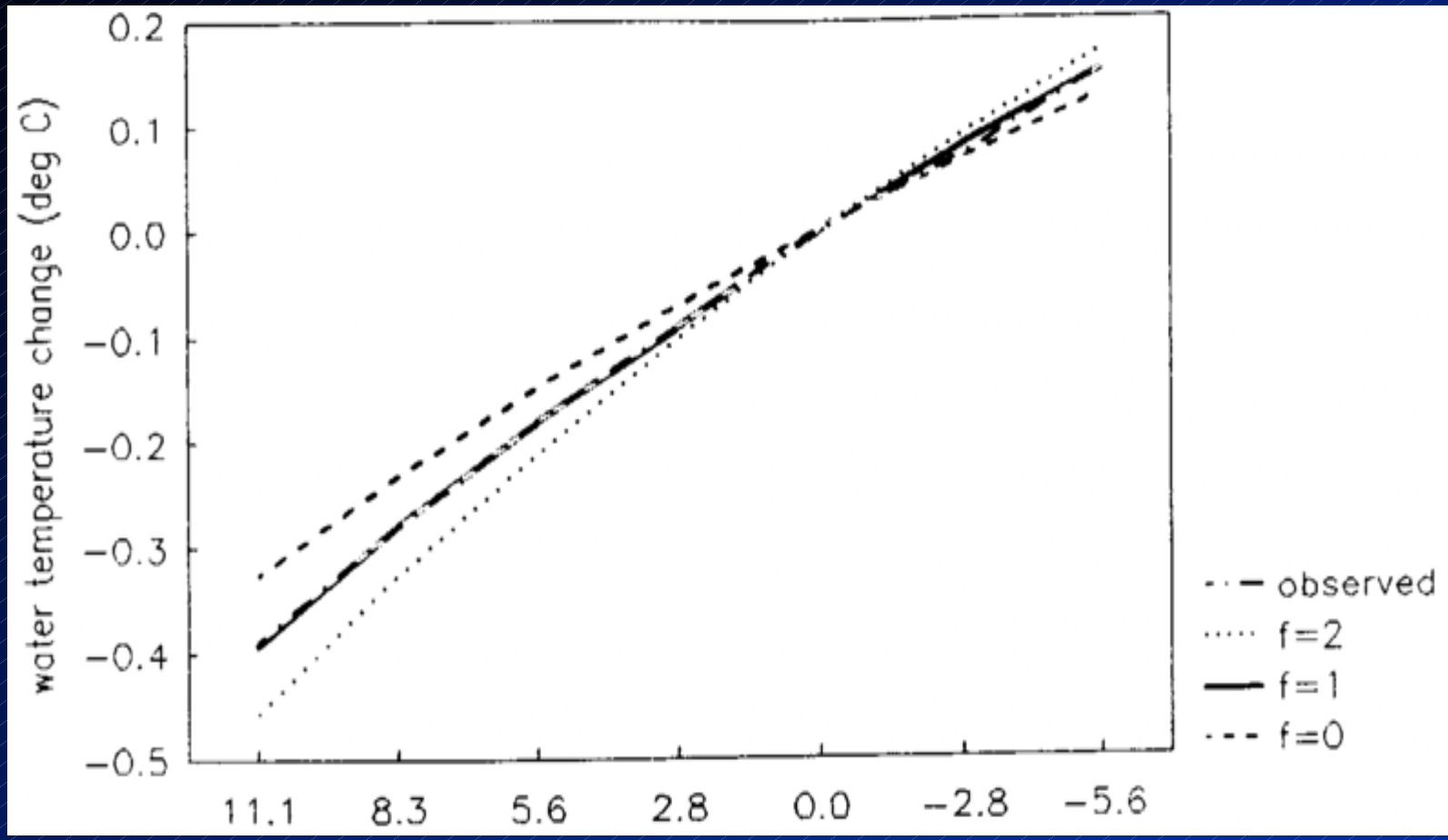
h_{sens} = sensible heat transfer coefficient

e_b = saturated vapour pressure at bucket surface temperature

e_a = vapour pressure of ambient air

Q_s = short wave radiative flux

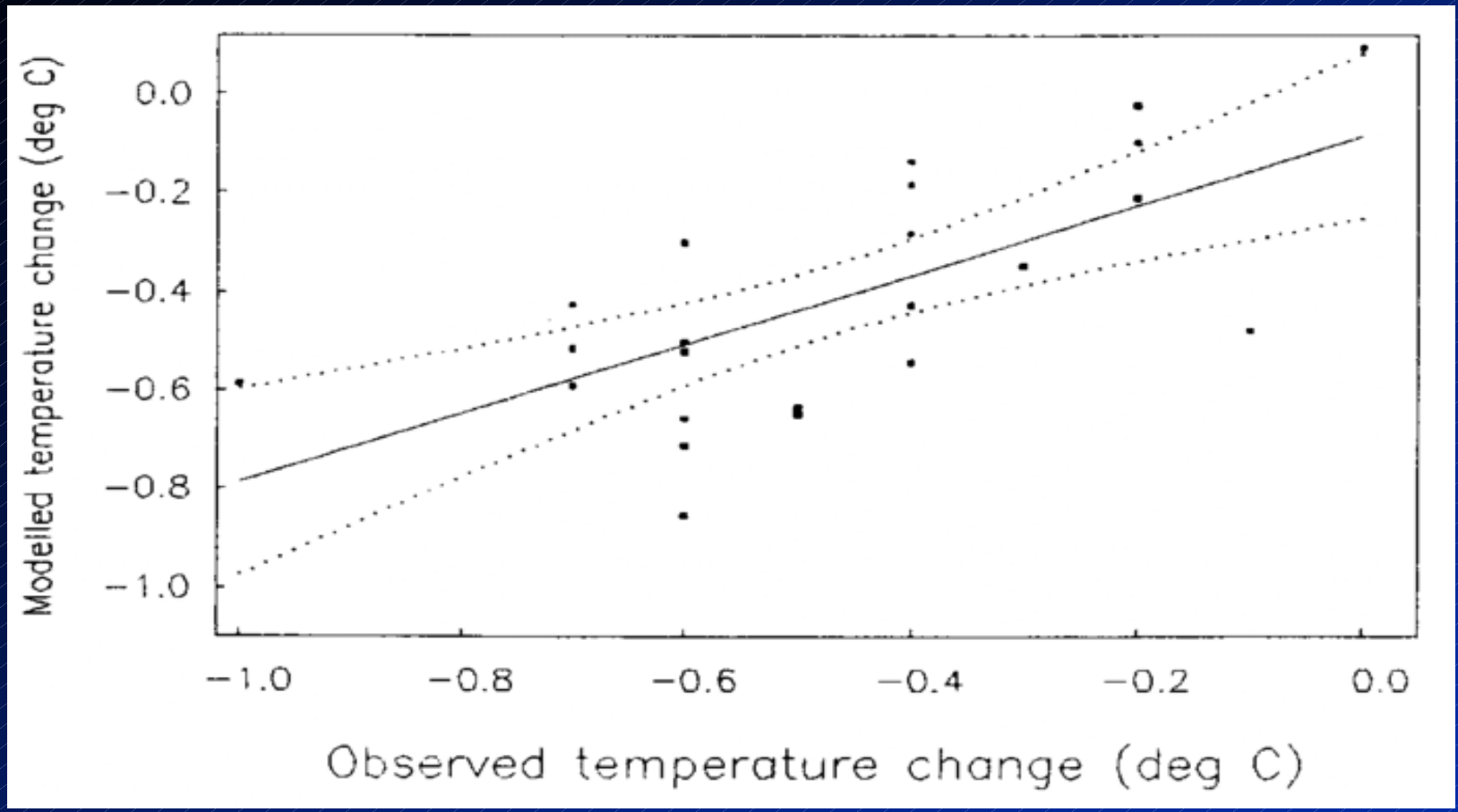
Met Office



Calculated cooling of Mk II canvas bucket & as observed by Ashford (1948) in a wind-tunnel after 1 minute.

f = 0, no evaporation from base, *f* = 1, free evaporation from base; *f* = 2 free evaporation from base & interior water surface.

Met Office



Observed & modelled cooling of Mk II canvas bucket after 10 minutes exposure on a ship in tropical North Atlantic. Dotted lines are 95% confidence limits

Met Office

Basic heat loss equation for insulated bucket

BUCKET WALLS & BASE

*** Finite thermal conductivity of bucket walls & base.**
*** Wooden buckets, and possibly, leather-covered metal buckets.**

Unsteady heat conduction for one dimensional heat transfer in the x direction in a wall with no internal heat source described by:

$$\partial t/\partial \tau = (k/\Delta c)\,(\partial^2 t/\partial x^2)$$

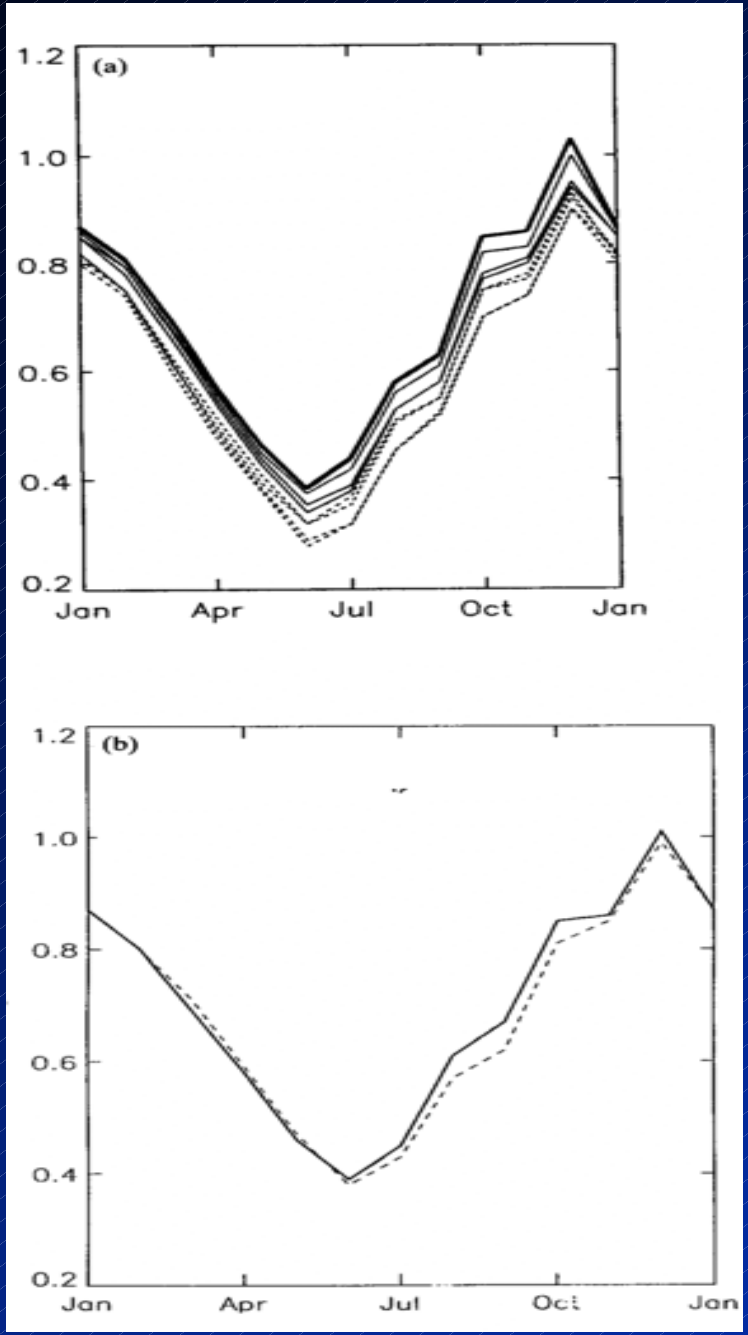
t=temperature, k=thermal conductivity, τ =time, Δ=density & c=specific heat. **An exterior film of water 0.1mm thick is included.**

TOP OPEN WATER SURFACE

*** Same model as used for canvas bucket**

Met Office

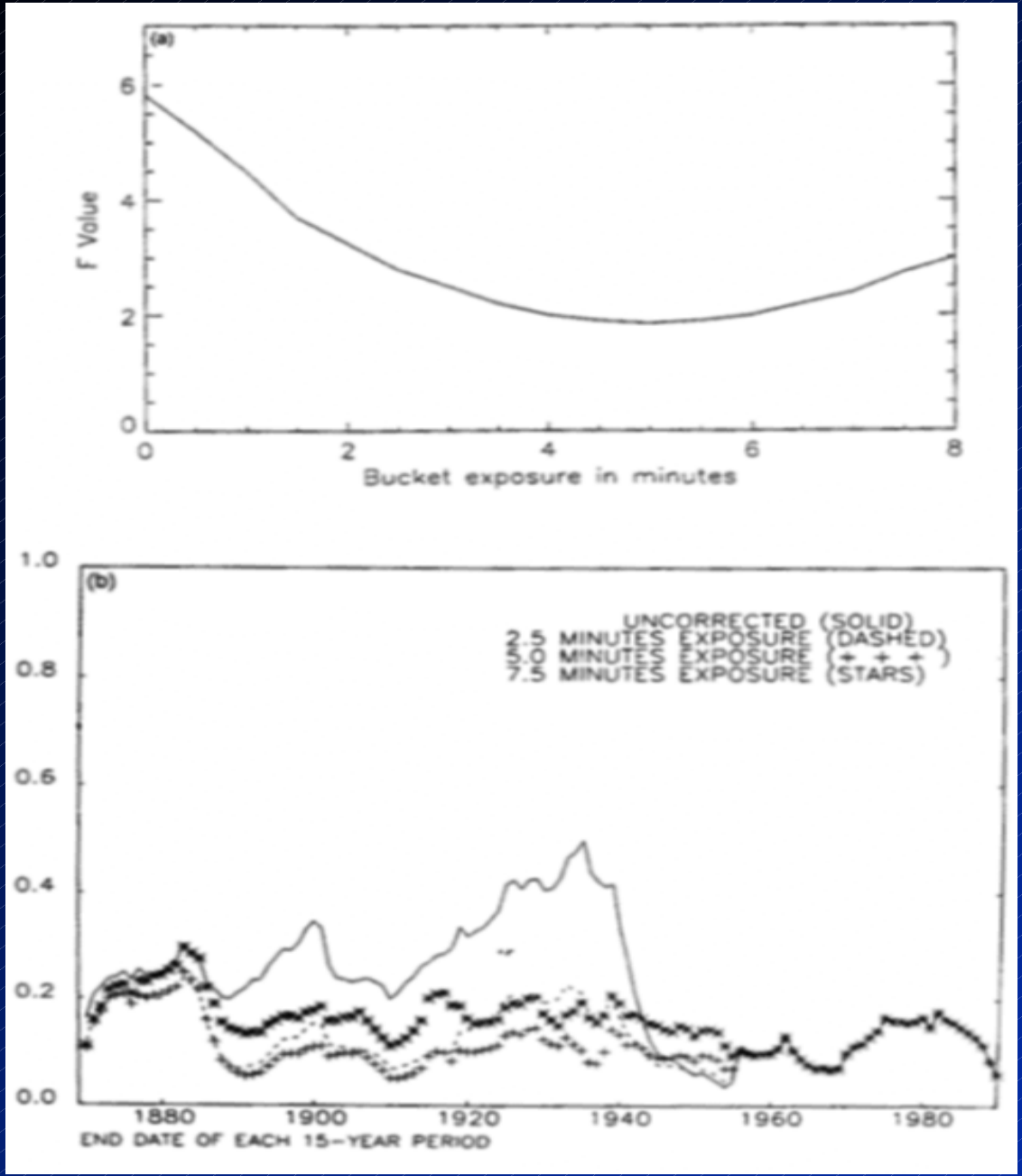
Correction
° C



(a) Corrections calculated using canvas bucket models C1-C4 (dashed) and C6-C8 (light solid) so as to differ with minimum variance from corrections calculated using model C5 (heavy solid

(b) using wooden bucket model W3 (dashed).

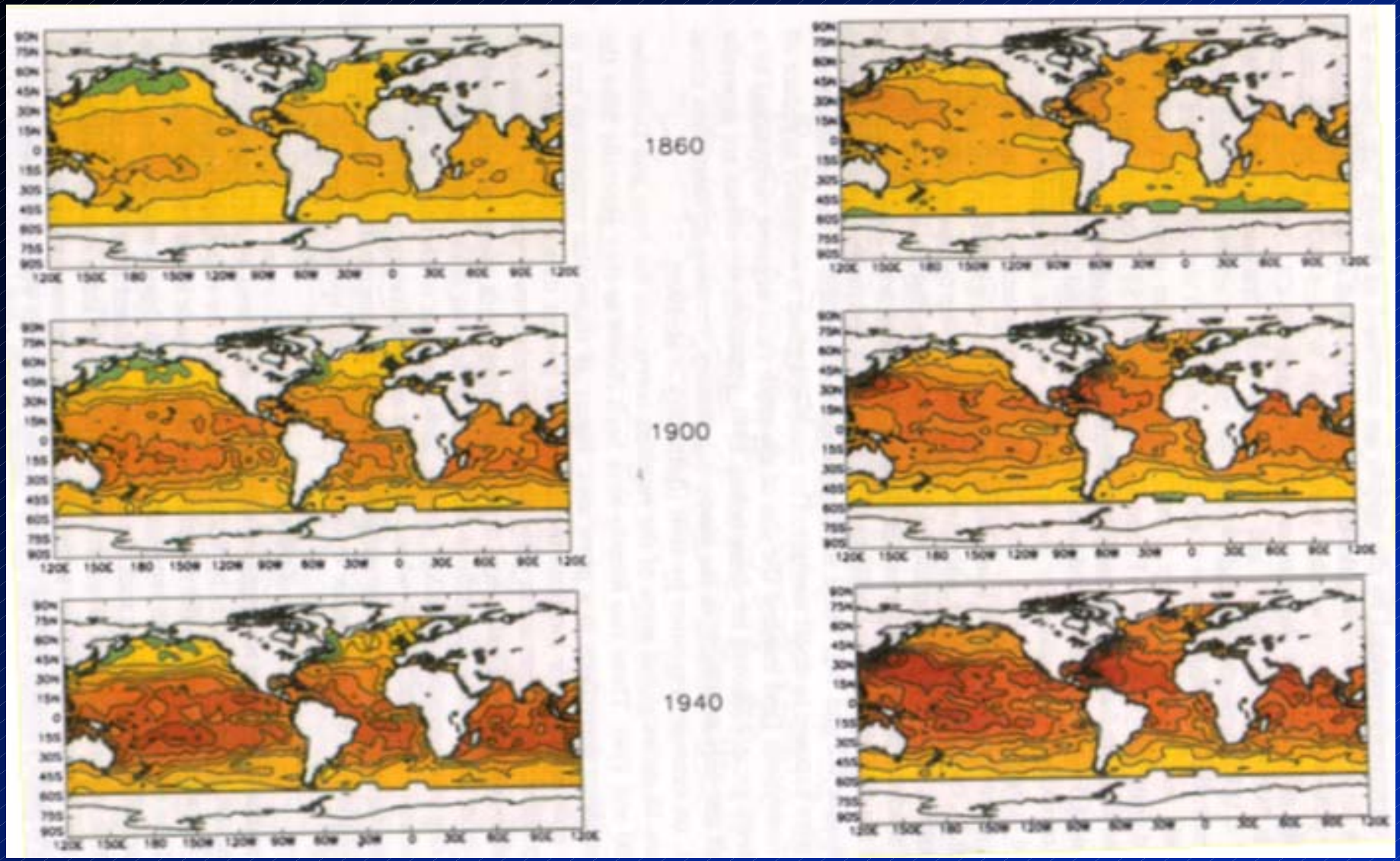
Met Office



(a) *F* ratio curve for latitude band 30-40°N. 1911-40 using model C5.

(b) running 15-year average *F* ratios for 30-40°N with model C5 corrections for various integration times.

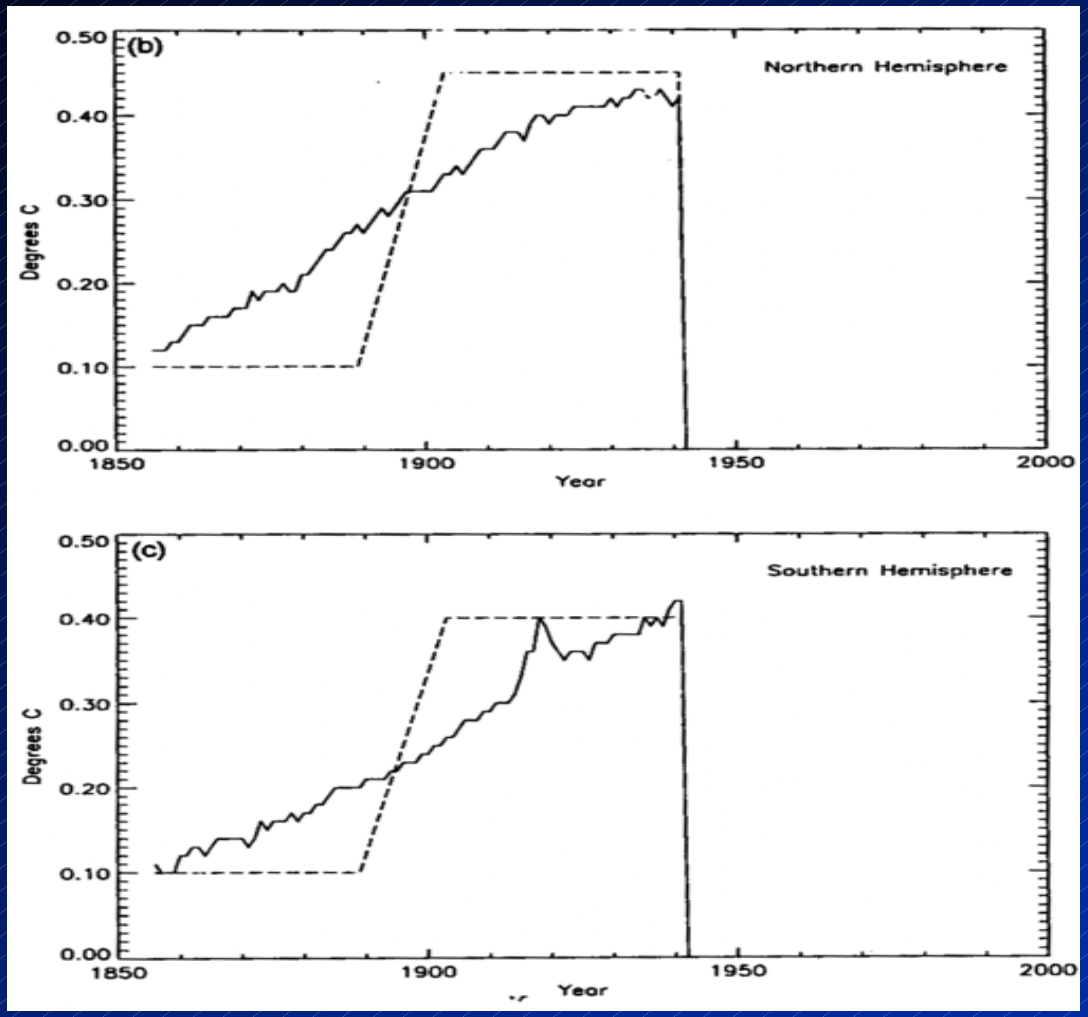
Met Office



Final bias corrections ^{o}(C), June (left) & December (right) 1860, 1900 and 1940.

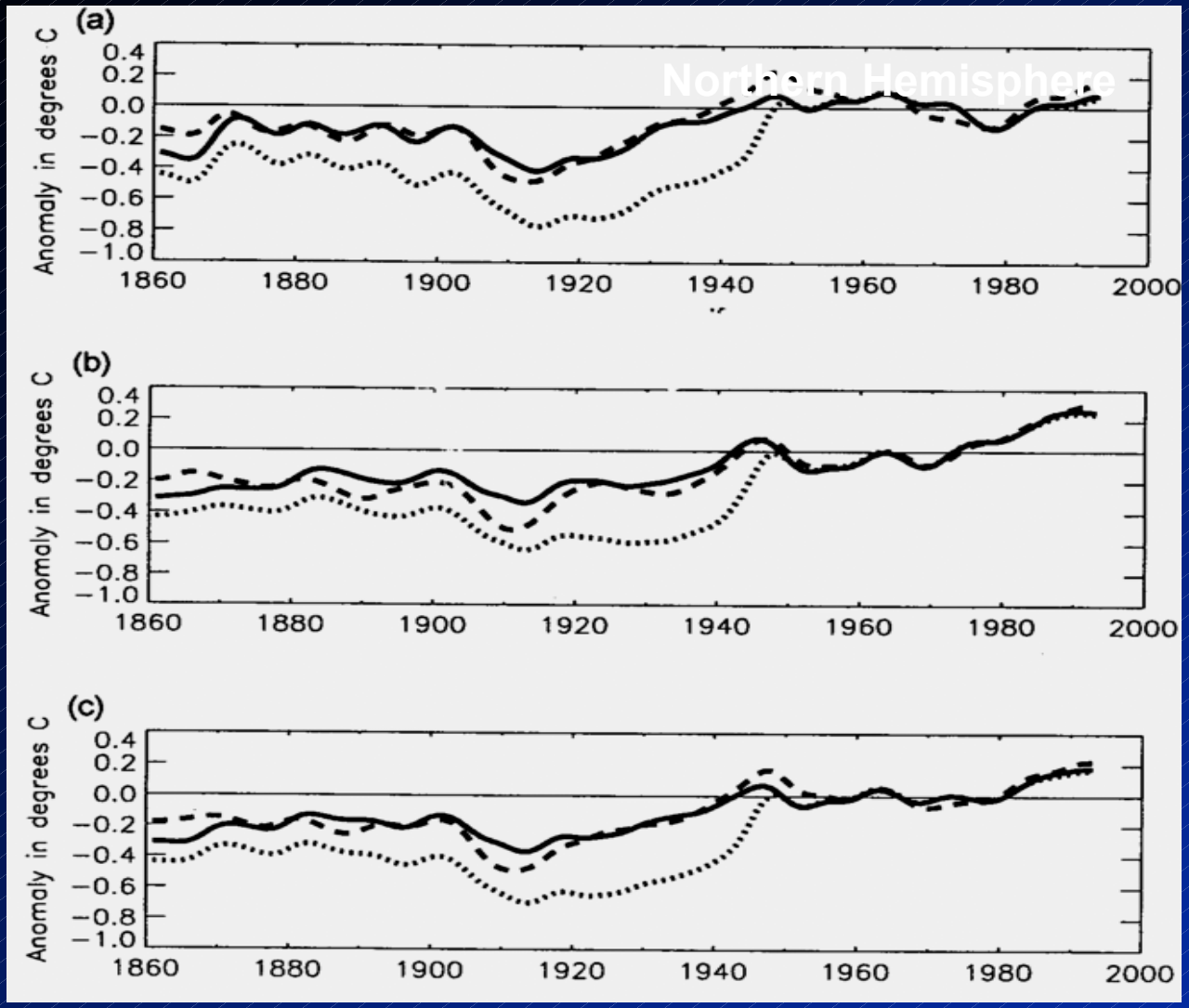
Hadley Centre for Climate Prediction and Research

Met Office



Annual Northern & Southern Hemisphere average corrections compared with *a posteriori* corrections of Jones *et al*. (1991) based on land surface air temperatures

Met Office



Northern Hemisphere

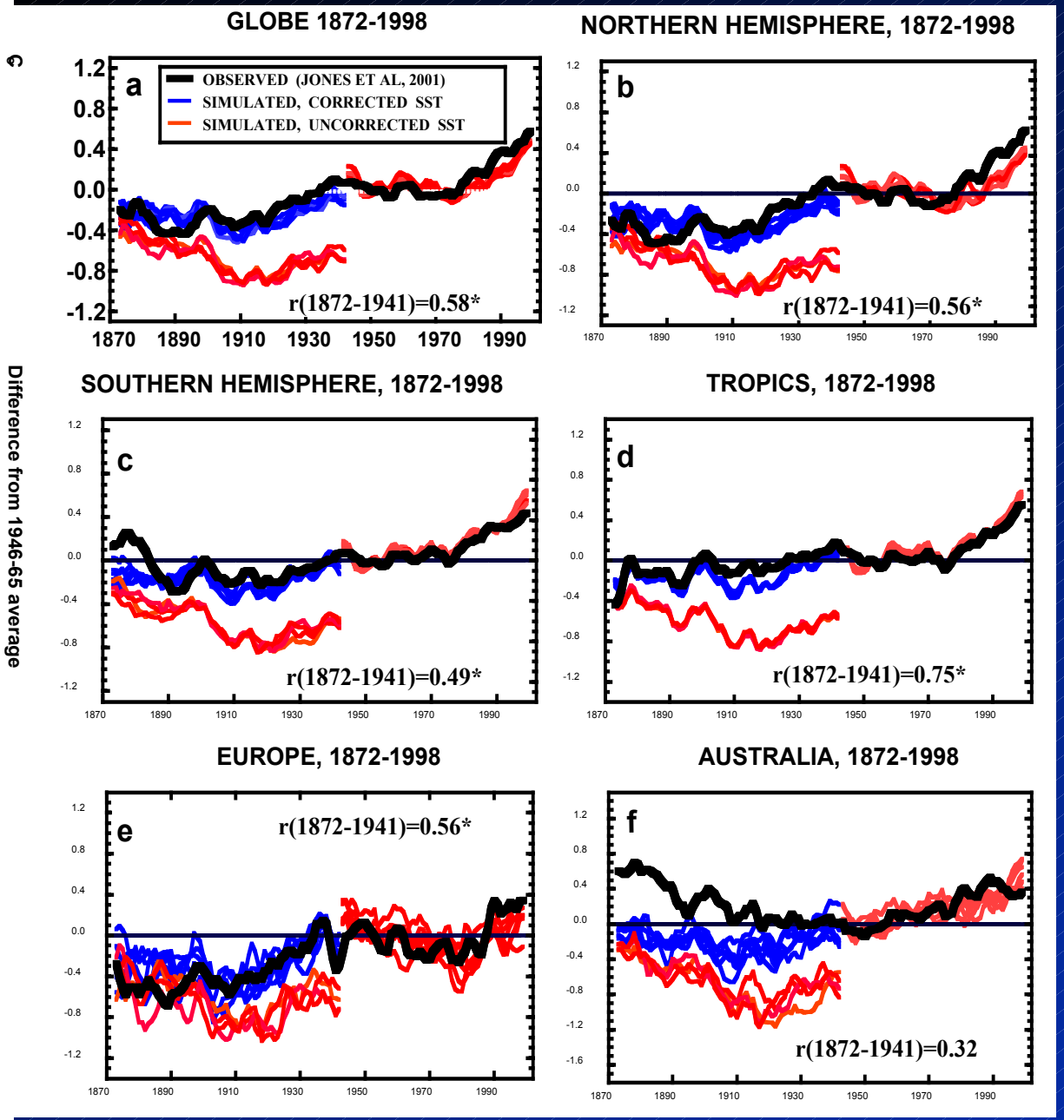
Southern Hemisphere

Globe

Annual anomalies from 1951-80 average of corrected SST (solid), uncorrected SST (dotted) & corrected NMAT (dashed). Smoothed with 21-term binomial filter.

Hadley Centre for Climate Prediction and Research

Met Office



Simulated *annual* land surface air temperature anomalies using HadAM2b atmospheric model.

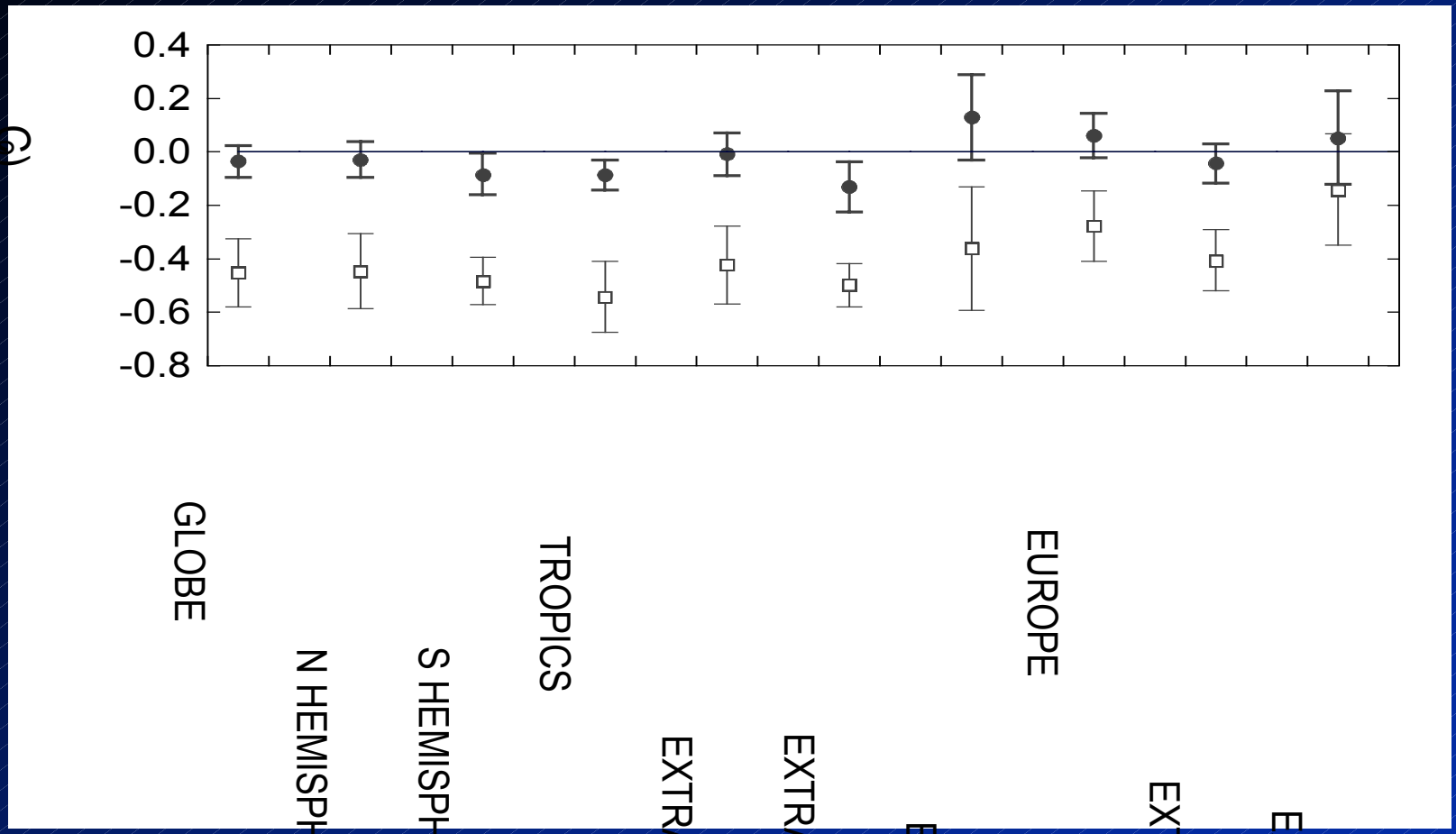
Ensemble of 6 runs.

Red: forced with uncorrected SST

Blue: forced with corrected SST

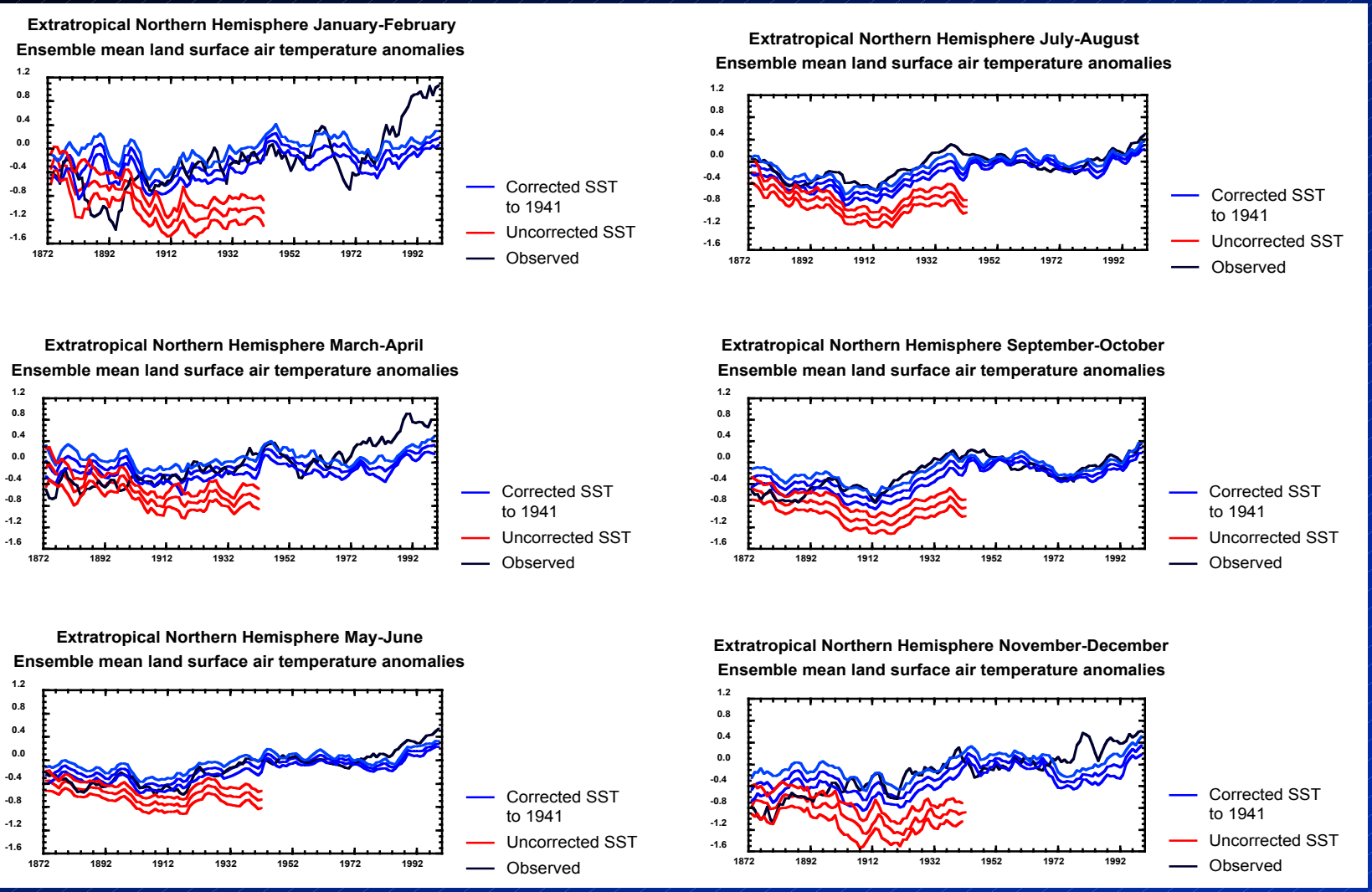
Black: observed

Met Office



Differences between simulated land air temperature & observations using corrected (solid circles) and uncorrected SST (open circles)

1872-1941



Model test of SST bias corrections for extratropical Northern Hemisphere through annual cycle - ensemble means & uncertainties

Hadley Centre for Climate Prediction and Research

Met Office

Conclusions

- Model of SST bias corrections integrates physical principles & data characteristics

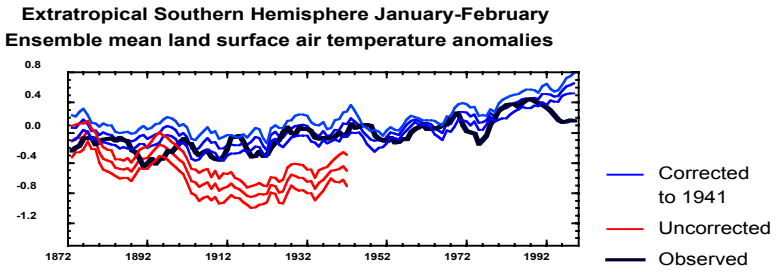
- Reproduces wind tunnel measurements well & supported by tests on a ship.

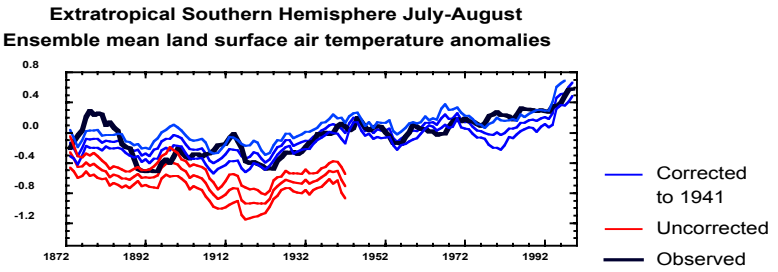
- Climate model forced with corrected & uncorrected SST supports the accuracy of annual mean corrections

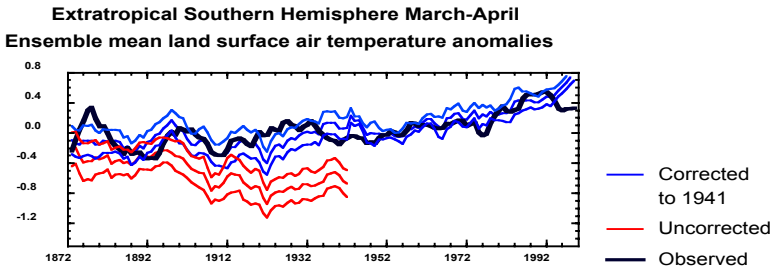
- The annual cycle of corrections was tested in extratropical Northern Hemisphere. Within limits of model & land surface air temperature data, observations well simulated after 1900, but somewhat less before then.

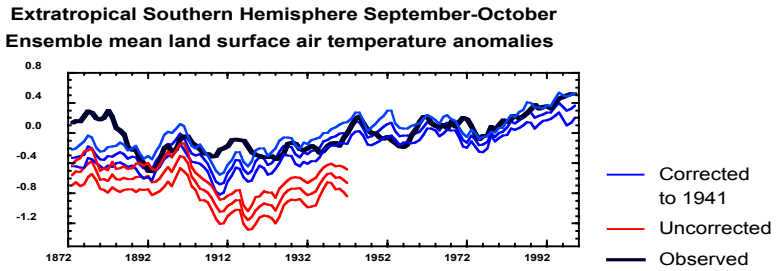
- Mix of uninsulated & wooden buckets needs more research before 1900, though full account needs to be taken of land data uncertainties.

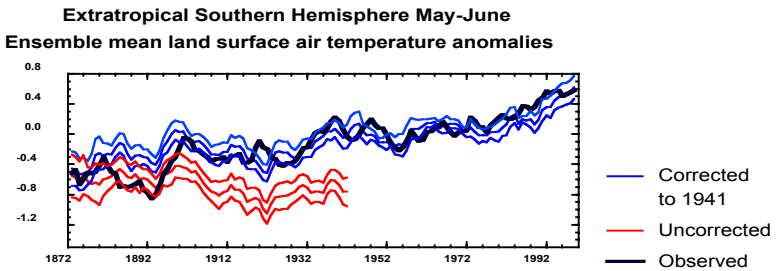
- Improved SSTs and land temperatures should help refinements - major changes not expected.

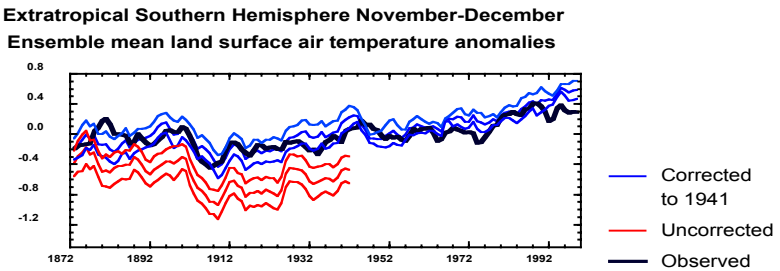












Model test of SST bias corrections for Extratropical Southern Hemisphere through annual cycle - ensemble means & uncertainties

Hadley Centre for Climate Prediction and Research

Met Office