Construction and testing of the HadMAT gridded night marine air temperature analysis

David Parker and Nick Rayner

Hadley Centre, Met Office, UK

International Workshop on Advances in the Use of Historical Marine Climate Data: Boulder, Colorado, USA, January 2002

HadMAT

- Data sources
- Quality control
- Bias adjustments
- Reduced Space Optimum Interpolation
- Blending and smoothing
- Testing

Undigitized marine observations for 1851-1900 UK national archives

Meteorological logbooks: 2,000,000 observations
Warship deck logs: 6,000,000 observations

These are conservative estimates

Geographical distribution (%) :

North Atlantic	South Atlantic	Mediterranean	North Indian Ocean	South Indian Ocean	North Pacific	South Pacific
40	12	15	6	13	2	12

Ships' locations need to be interpolated between recorded noon positions.

Met Office

Undigitized marine observations for 1911-1920 UK national archives

Large warship deck logs: 5,760,000 observations
Small warship deck logs: 2,000,000 observations

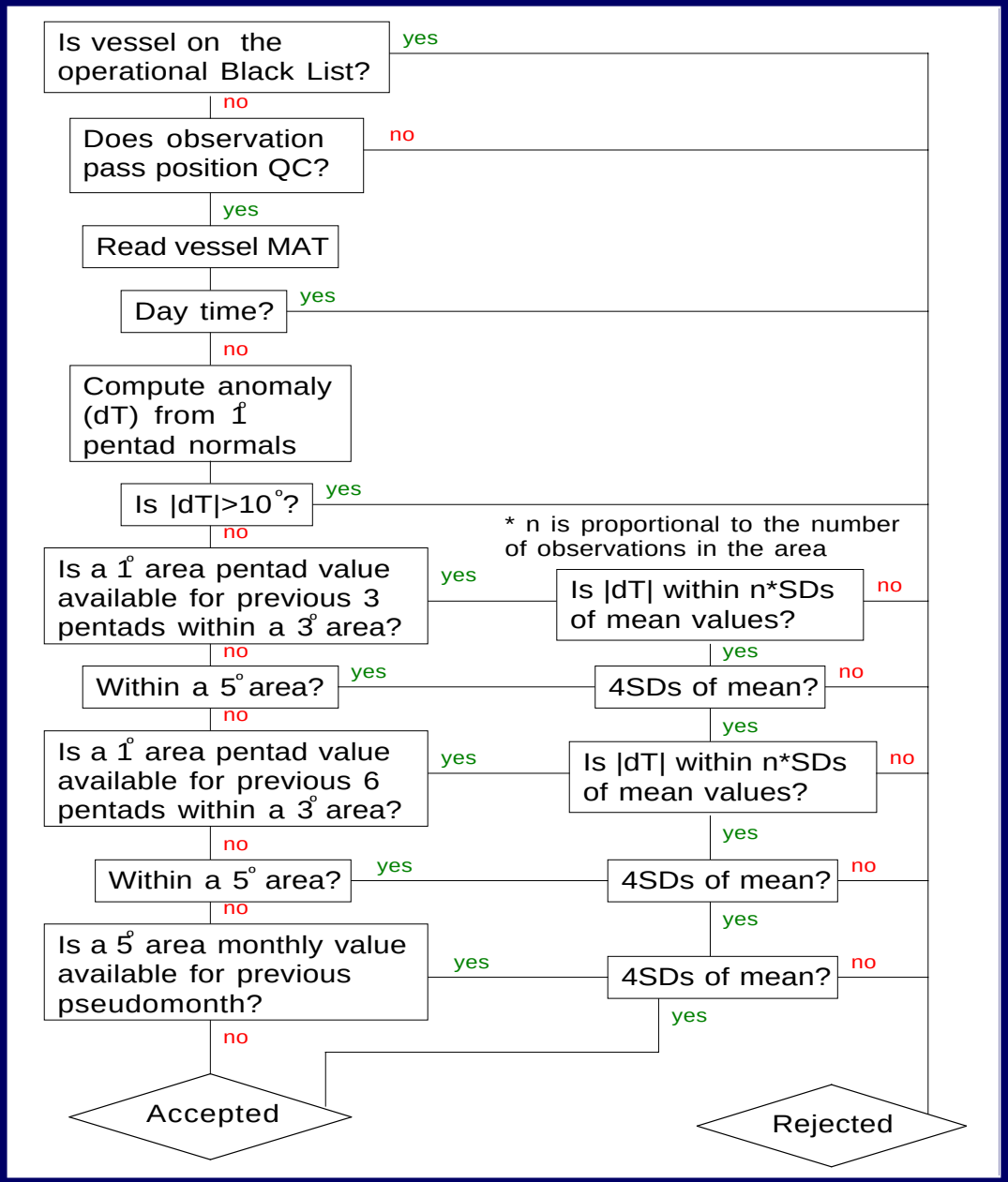
Geographical distribution (%) :

North Atlantic	South Atlantic	Mediterranean	North Indian Ocean	South Indian Ocean	North Pacific	South Pacific
45	7	25	8	5	7	3

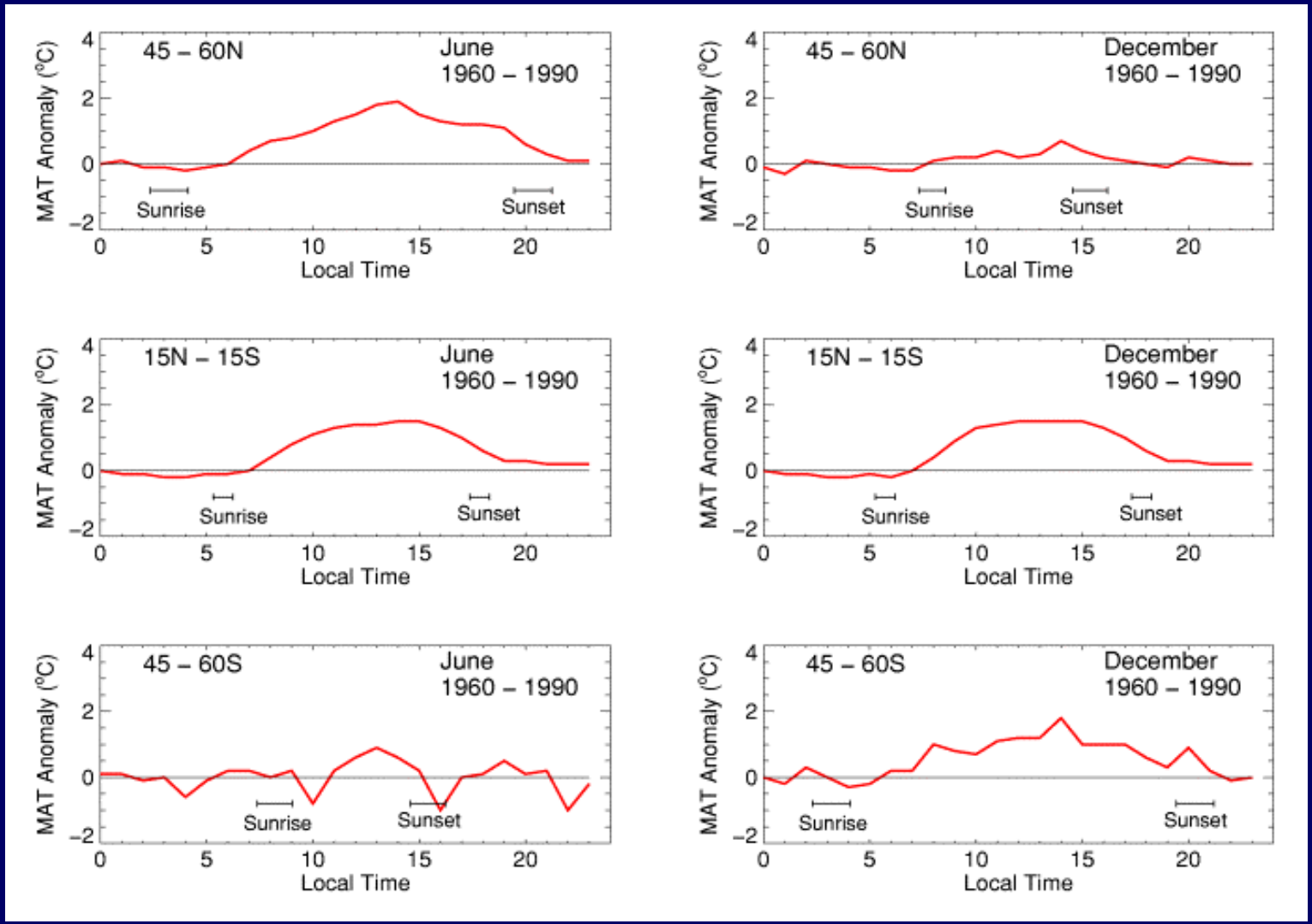
Ships' locations need to be interpolated between recorded noc positions.

Met Office

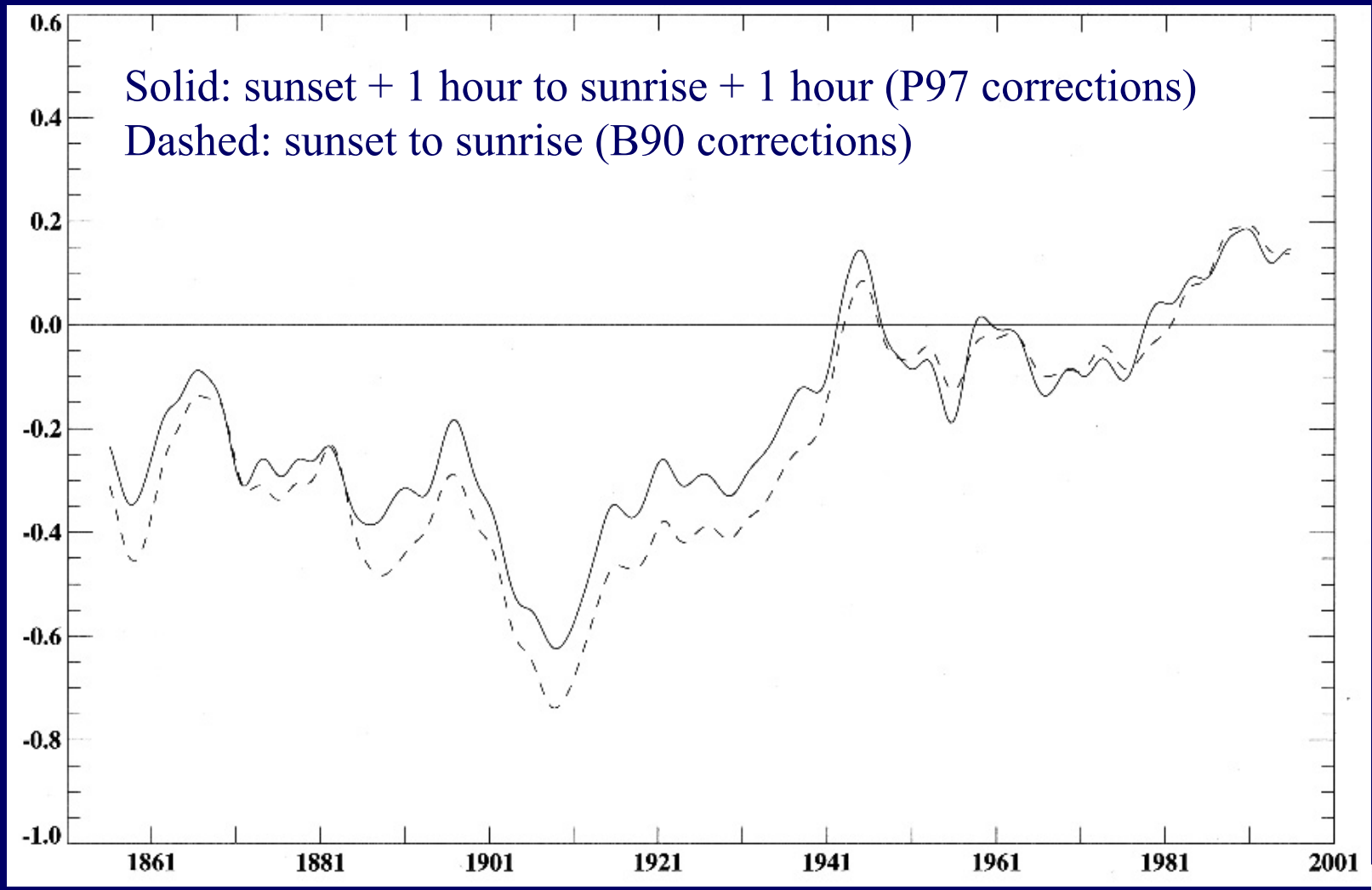
Quality Control of NMAT Observations.



Diurnal cycles of observed MAT

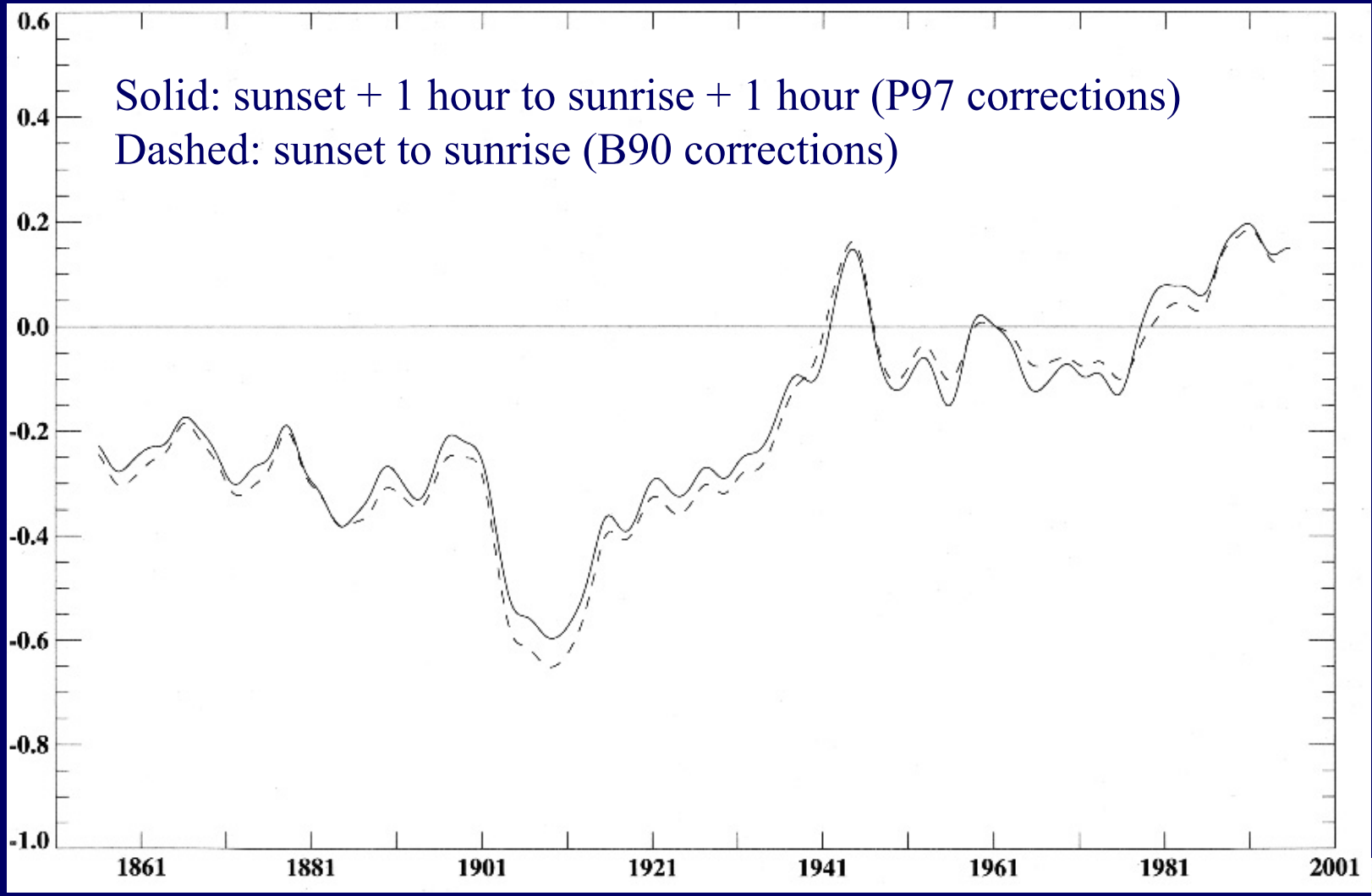


Night marine air temperature anomaly (rel. to 1961-90) for 0°-30°E, 90°-120°E etc, 1856-1995



Met Office

Global night marine air temperature anomaly (relative to 1961-90), 1856-1995



Basis of adjustments to MAT to compensate for changing deck heights (1)

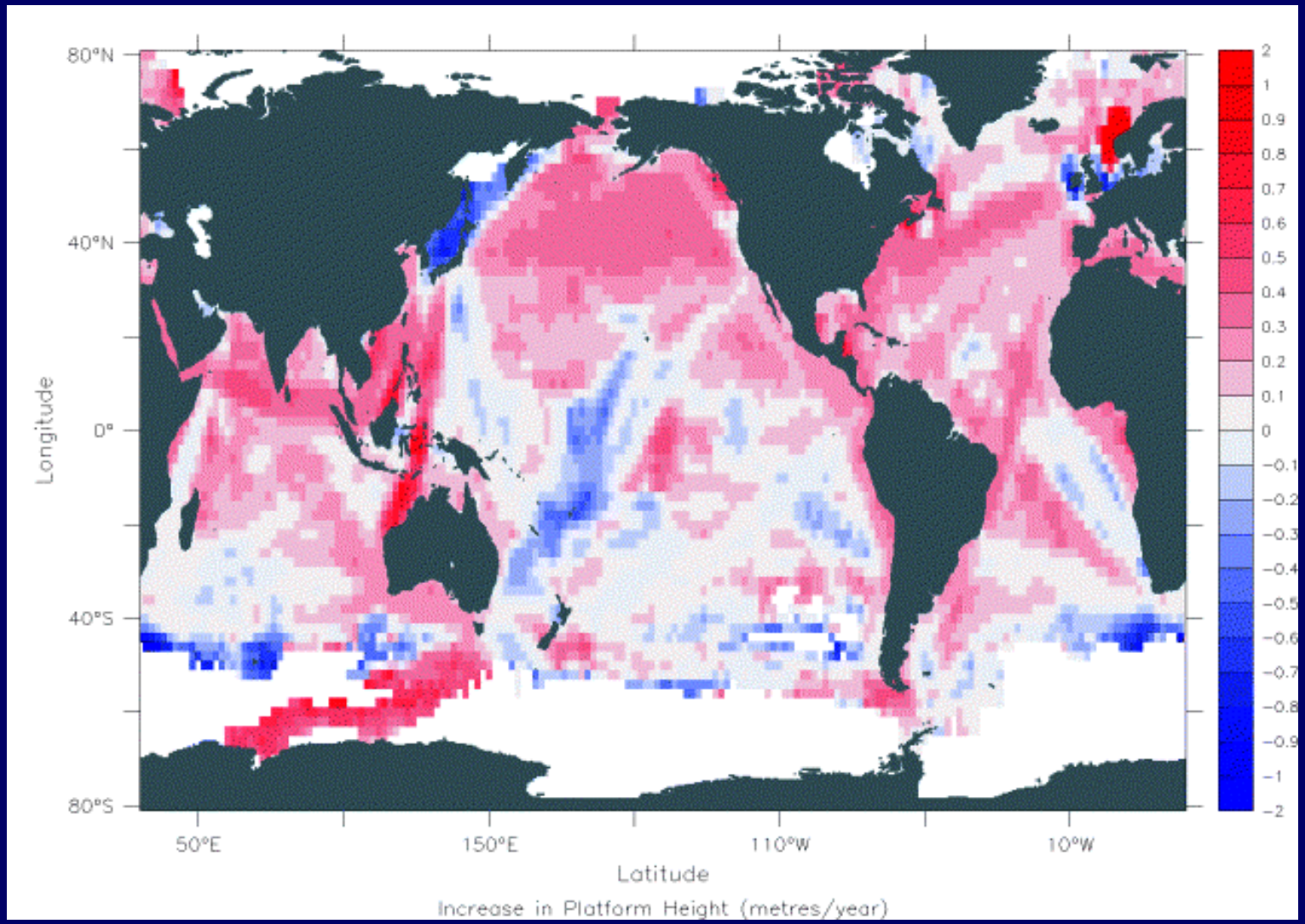
- All deck heights assumed to be 6m up to 1890, then a linear increase to 15m in 1930, then 15m through 1970. For 1971-82, heights at each grid point were interpolated linearly between 15m in 1970 and Liz Kent's 5-year annual average field of heights for 1980-84 in 1982. For 1982-95, her 5-year annual average fields of heights were used. For 1996-2002, her 5-year annual average field of deck heights for 1993-7, already used for 1995, was incremented uniformly by 0.14m/year in accord with global-average trends in deck heights since the early 1970s derived from WMO No. 47.
- A field of average heights was calculated for the reference period, 1961-1990.

Basis of adjustments to MAT to compensate for changing deck heights (2)

- Atmospheric boundary layer temperature profiles were calculated for wind speeds 5, 7.5 and 10ms^{-1} for a set of 10 combinations of SST and air temperature at 10m (AT):
- SST= 30ºC, 25ºC; AT 1º below SST;
  SST= 20ºC, 15ºC, 10ºC, 5ºC; AT 1.0º, 2.5º lower than SST
- For each wind speed, the 10 profiles were averaged; then the 3 average profiles were averaged to yield a globally representative result.
- Adjustments to marine air temperature were calculated using the difference between the deck-height for the given location and year, and the 1961-90 average deck-height for that location
- Regional variations in profile are likely to be less important than regional variations in deck-height.

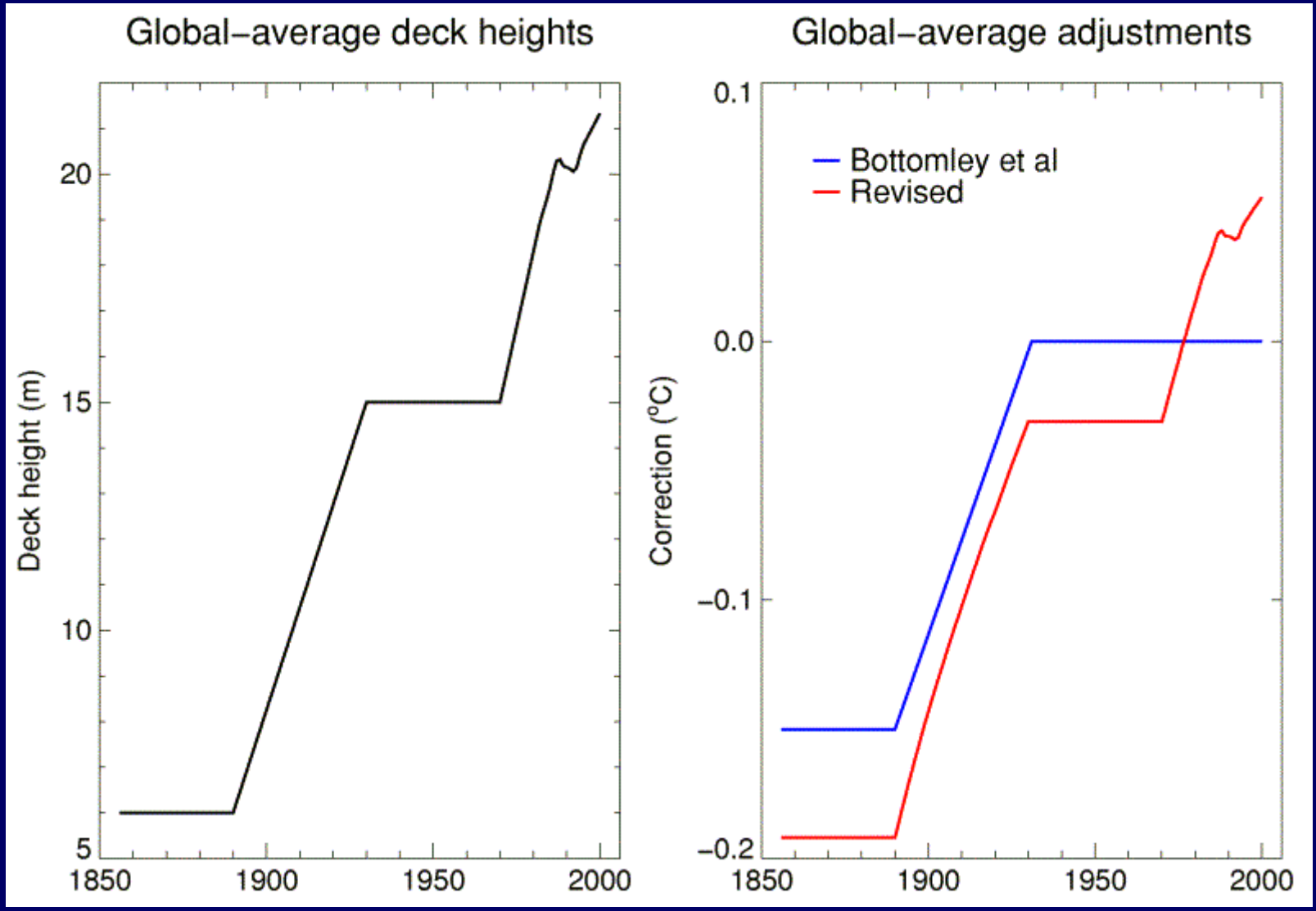
Met Office

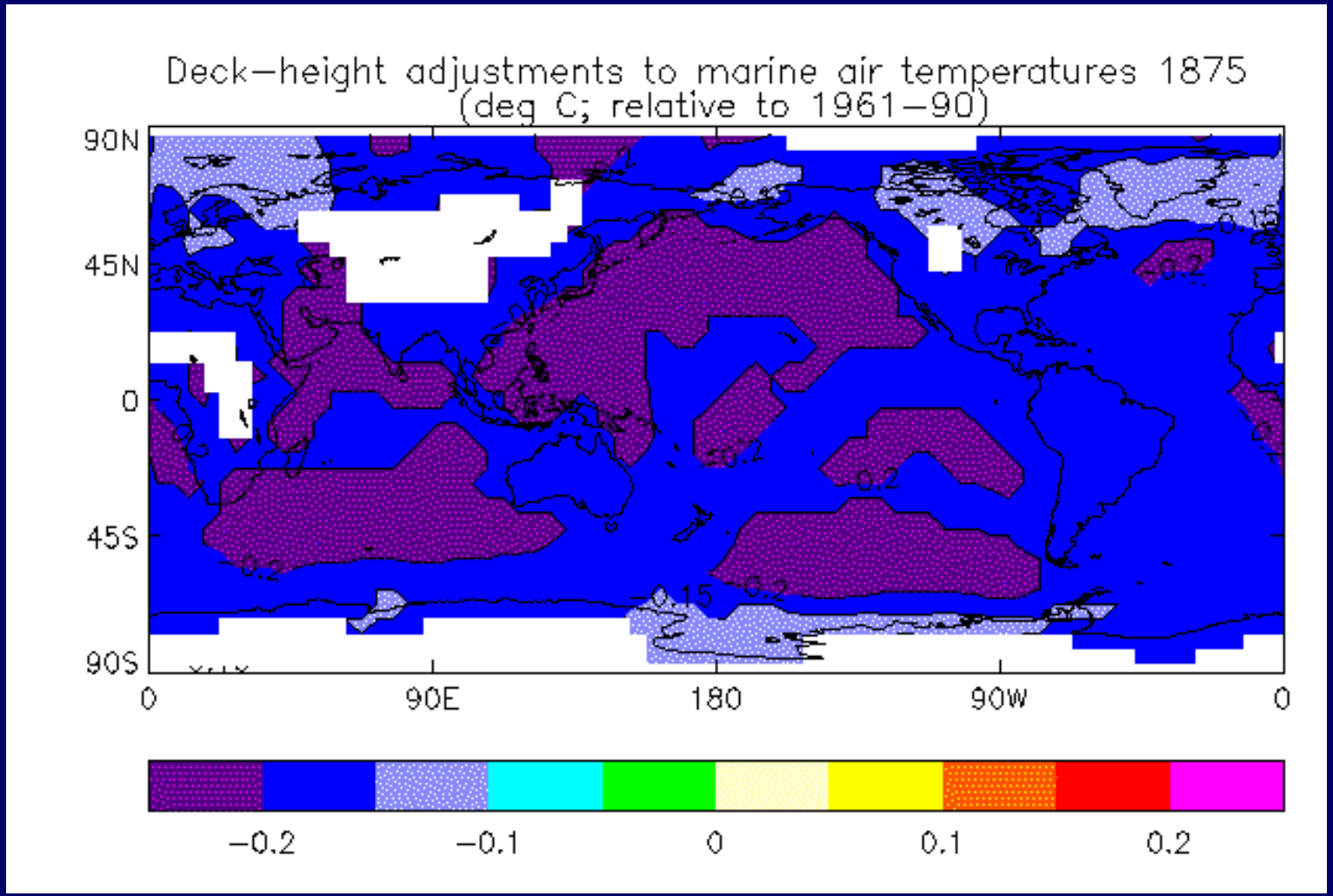
Trends in ships' decks' heights, 1980-1997

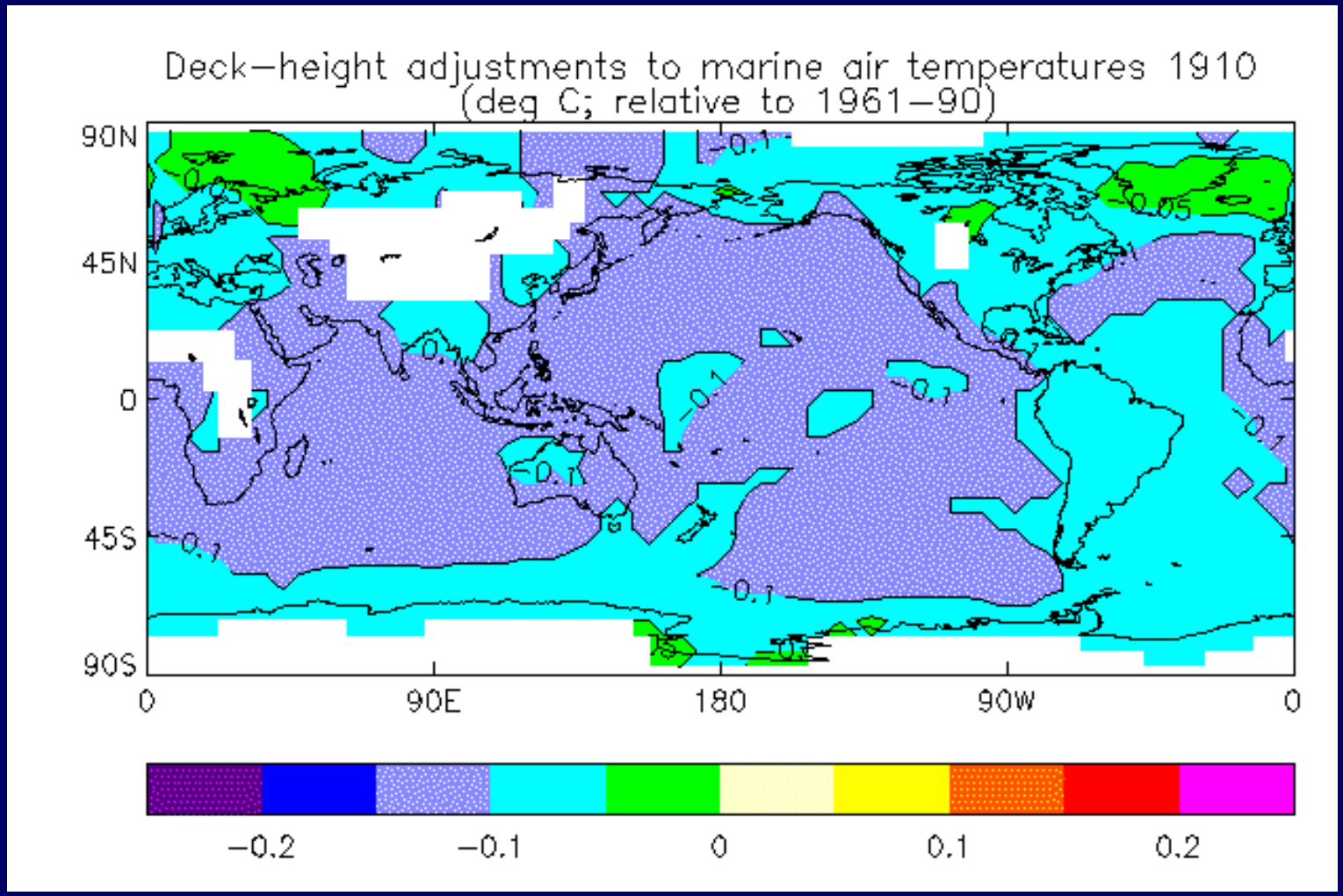


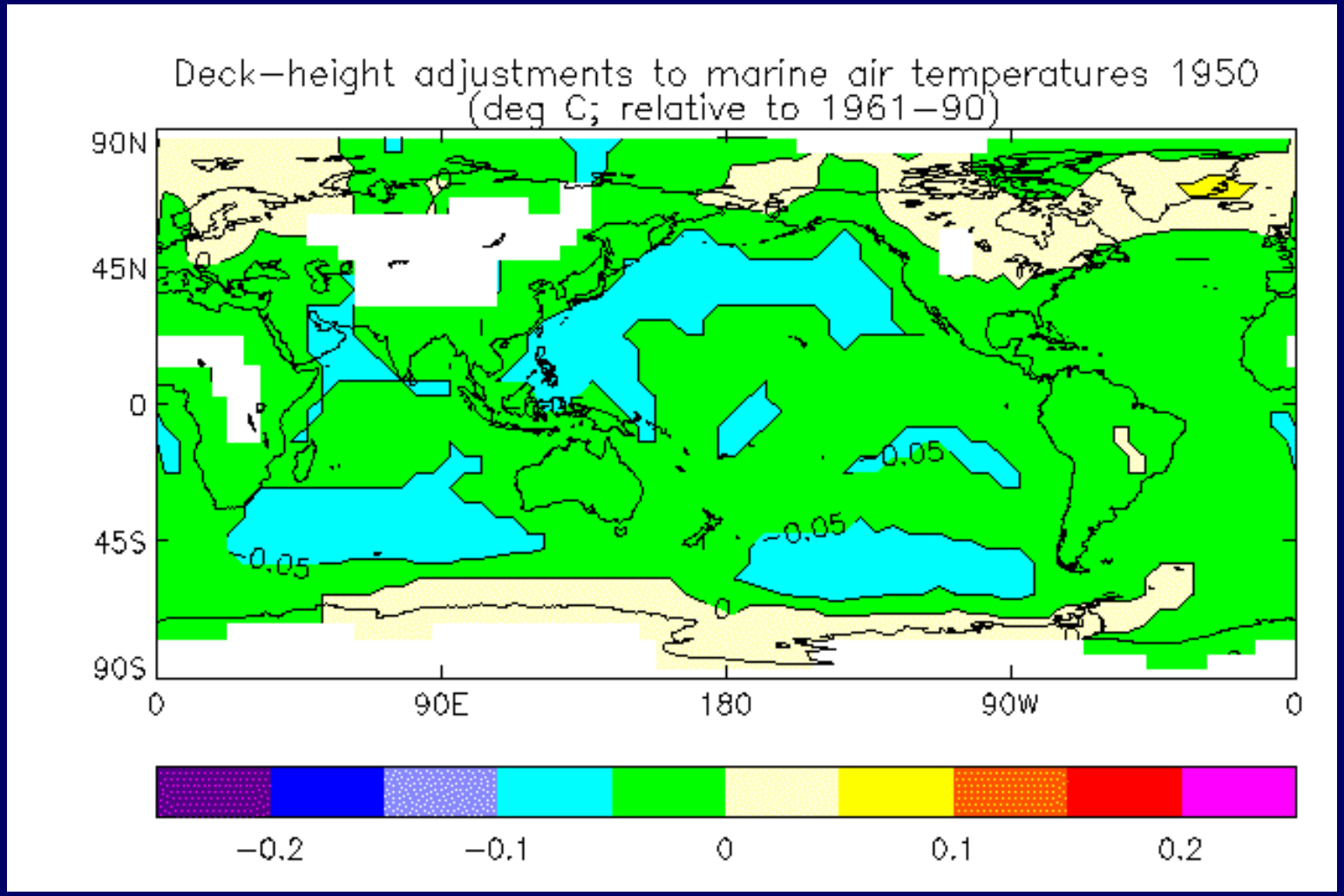
Met Office

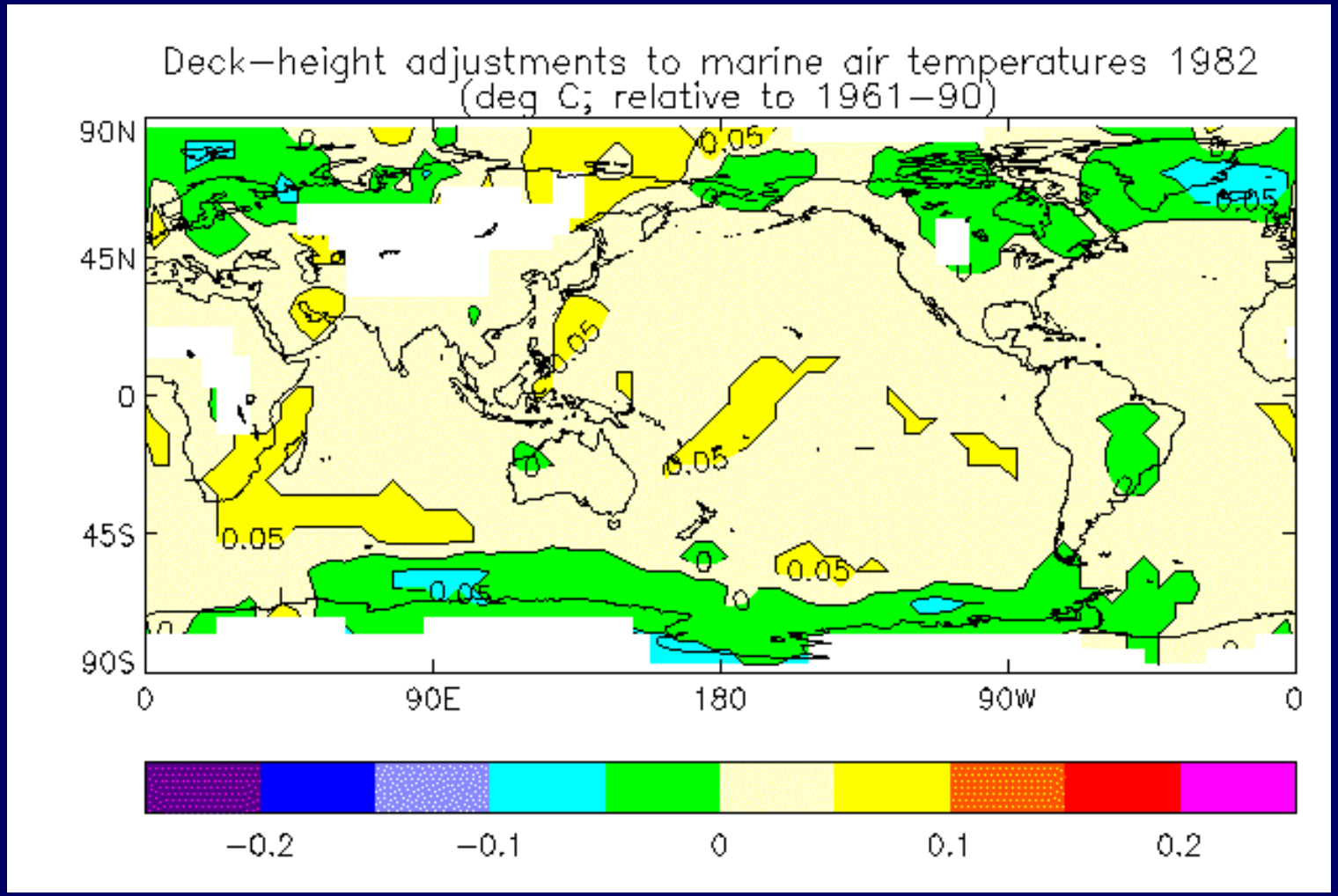
Deck height adjustments

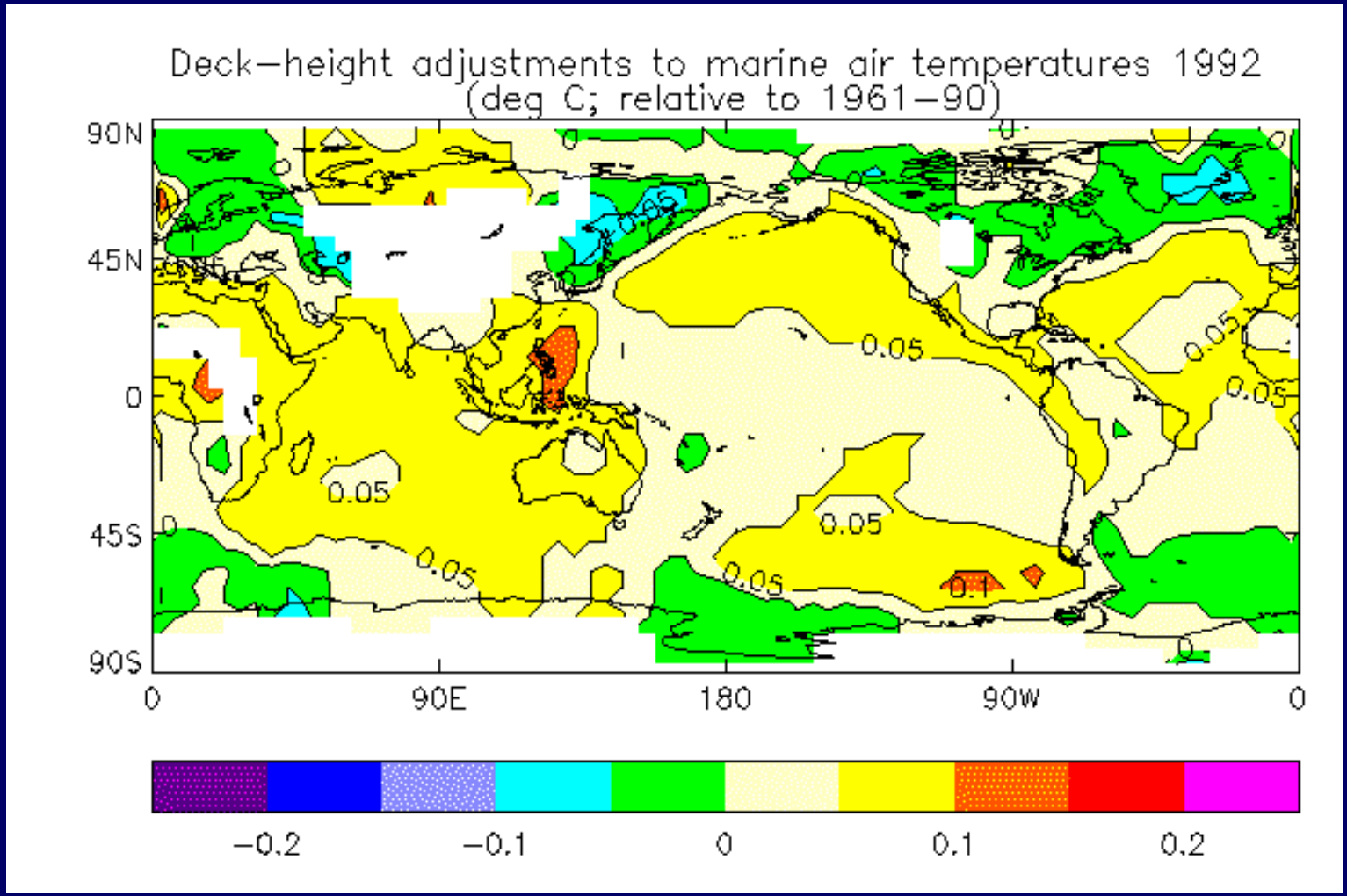


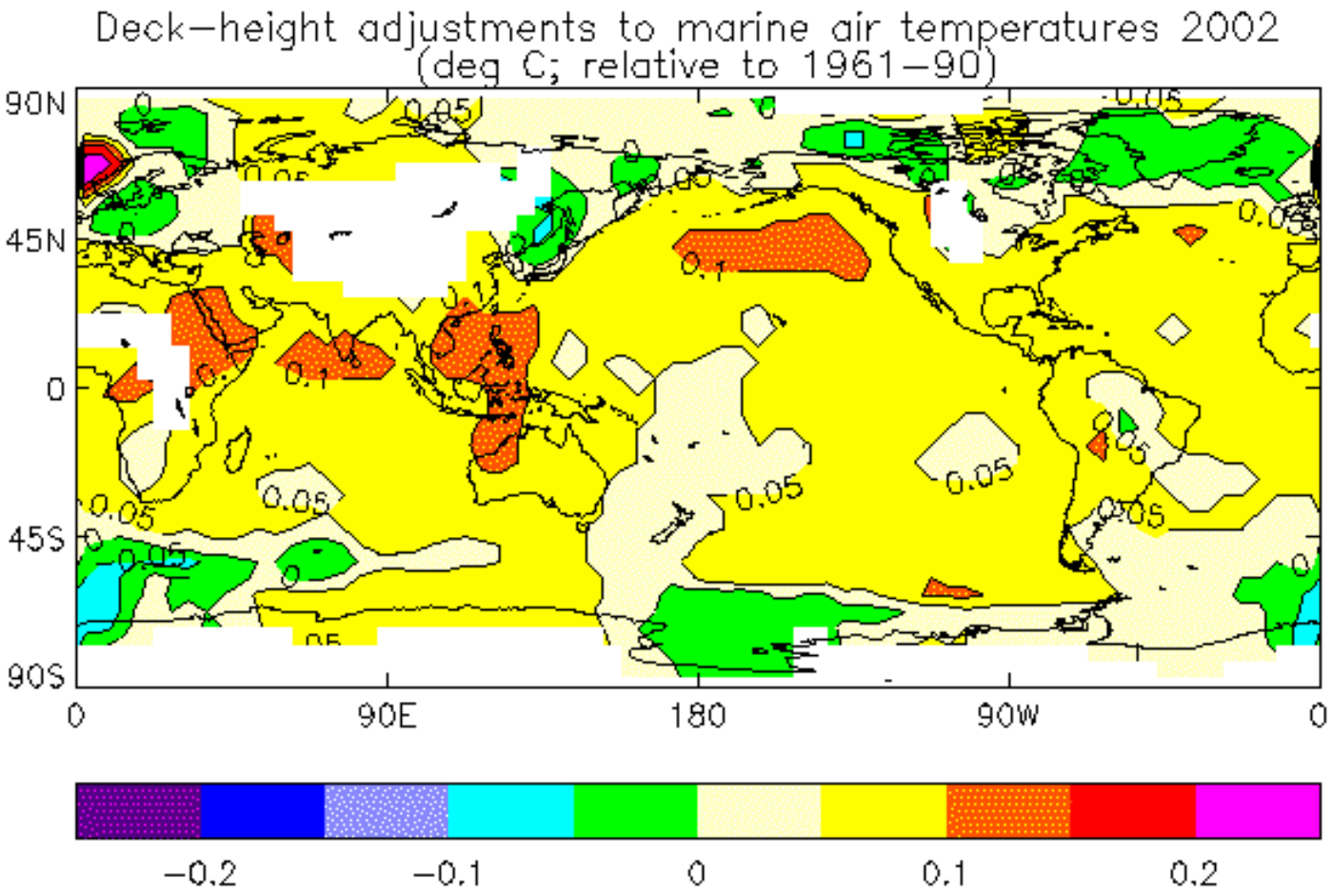

Deck–height adjustments to marine air temperatures 1875
(deg C; relative to 1961–90)
90N
45N
0
45S
90S
0
90E
180
90w
0
−0.2
−0.1
0
0.1
0.2


Deck–height adjustments to marine air temperatures 1910
(deg C; relative to 1961–90)
90N
45N
0
45S
90S
0
90E
180
90W
0
−0.2
−0.1
0
0.1
0.2


Deck–height adjustments to marine air temperatures 1950
(deg C; relative to 1961–90)
90N
45N
0
45S
90S
0
90E
180
90W
0
0.05
−0.05
−0.05
0
−0.2
−0.1
0
0.1
0.2


Deck–height adjustments to marine air temperatures 1982
(deg C; relative to 1961–90)
90N
45N
0
45S
90S
0
90E
180
90W
0
0.05
−0.05
−0.2
−0.1
0
0.1
0.2


Deck–height adjustments to marine air temperatures 1992
(deg C; relative to 1961–90)
90N
45N
0
45S
90S
0
90E
180
90W
0
0.05
0.1
−0.2
−0.1
0
0.1
0.2


Deck–height adjustments to marine air temperatures 2002
(deg C; relative to 1961–90)
90N
45N
0
45S
90S
0
90E
180
90W
0
−0.2
−0.1
0
0.1
0.2

Other bias-adjustments

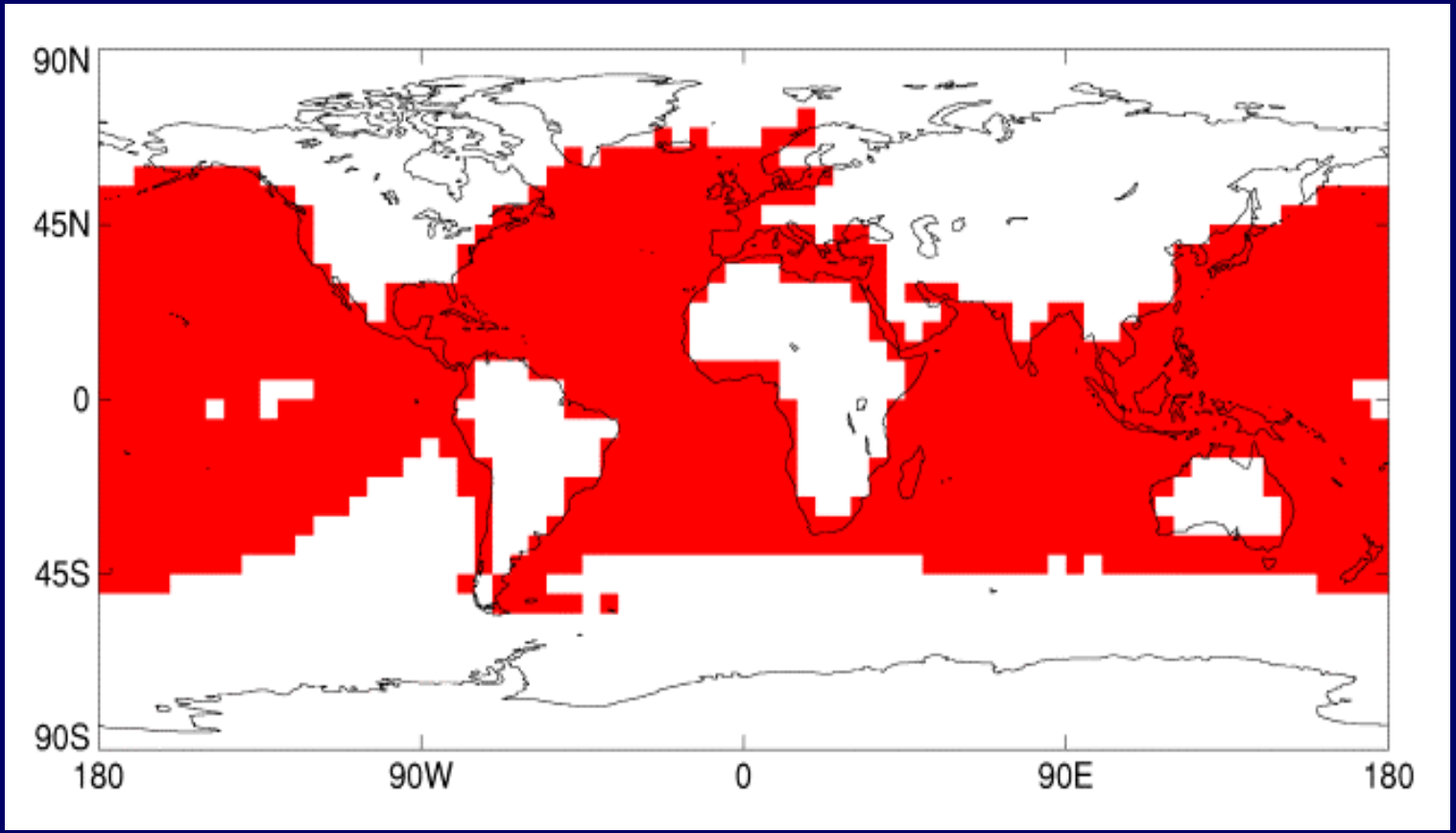
- Adjustments during the second world war
- Adjustments for 1876-1893 in Mediterranean and North Indian Ocean
- Adjustments for 1856-1885 in Atlantic

Use of Reduced Space Optimum Interpolation in HadMAT

- Weighted least squares fit in EOF space
- $a = (E_o^T R^{-1} E_o + L^{-1})^{-1} E_o^T R^{-1} T_o$.
  a: reconstructed time series of all EOFs at time t. E_o: elements of all EOFs at data positions at time t. R: data and truncation error variance matrix. L: diagonal matrix of eigenvalues. T_o: observed field at time t.
- Data are weighted according to their reliability.
- Same number of EOFs used to reconstruct all fields; L^{-1} damps contribution from lesser EOFs.
- "Trend" is reconstructed separately.

Met Office

Area covered by HadMAT after RSOI

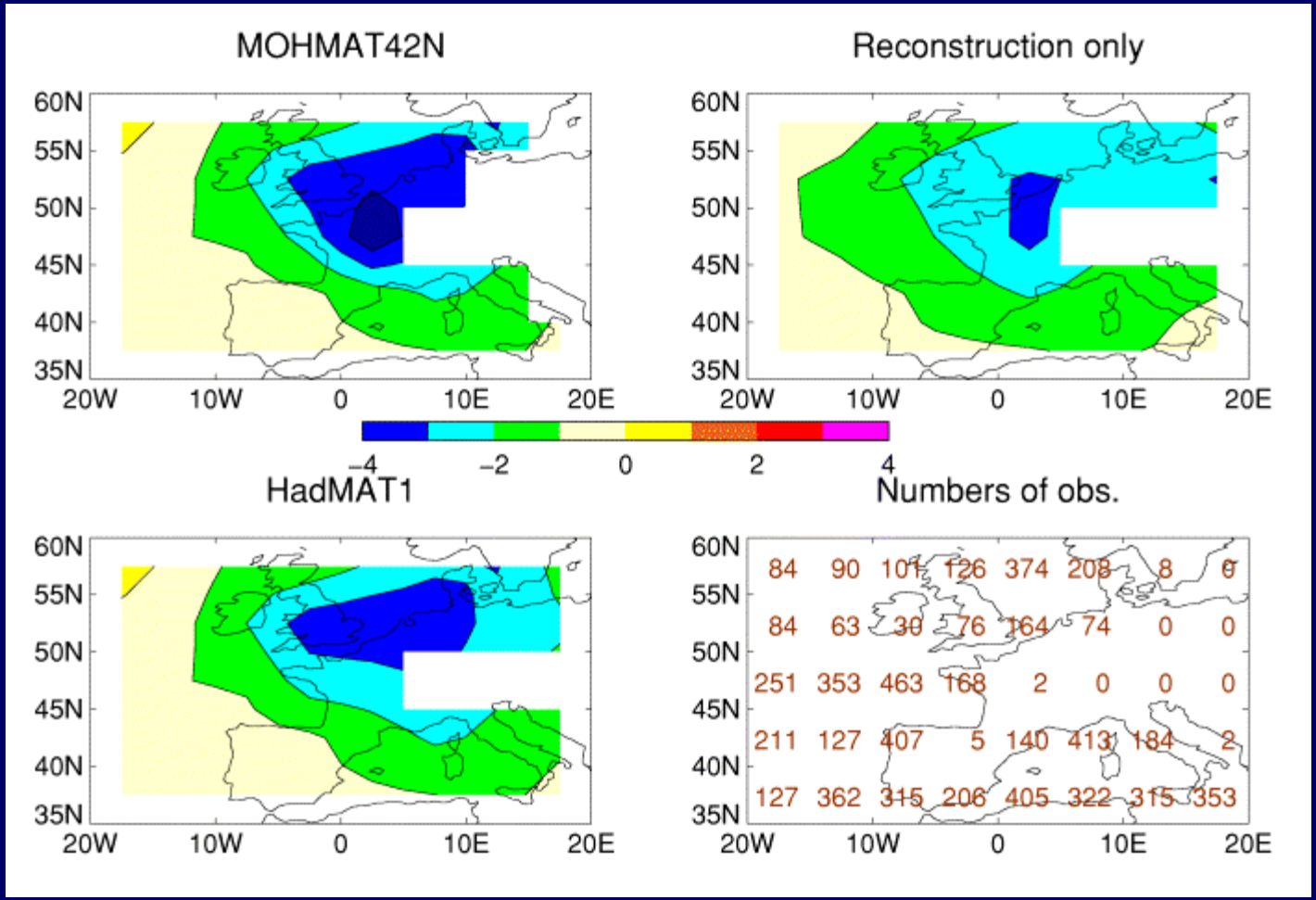


Superposition of data onto reconstruction

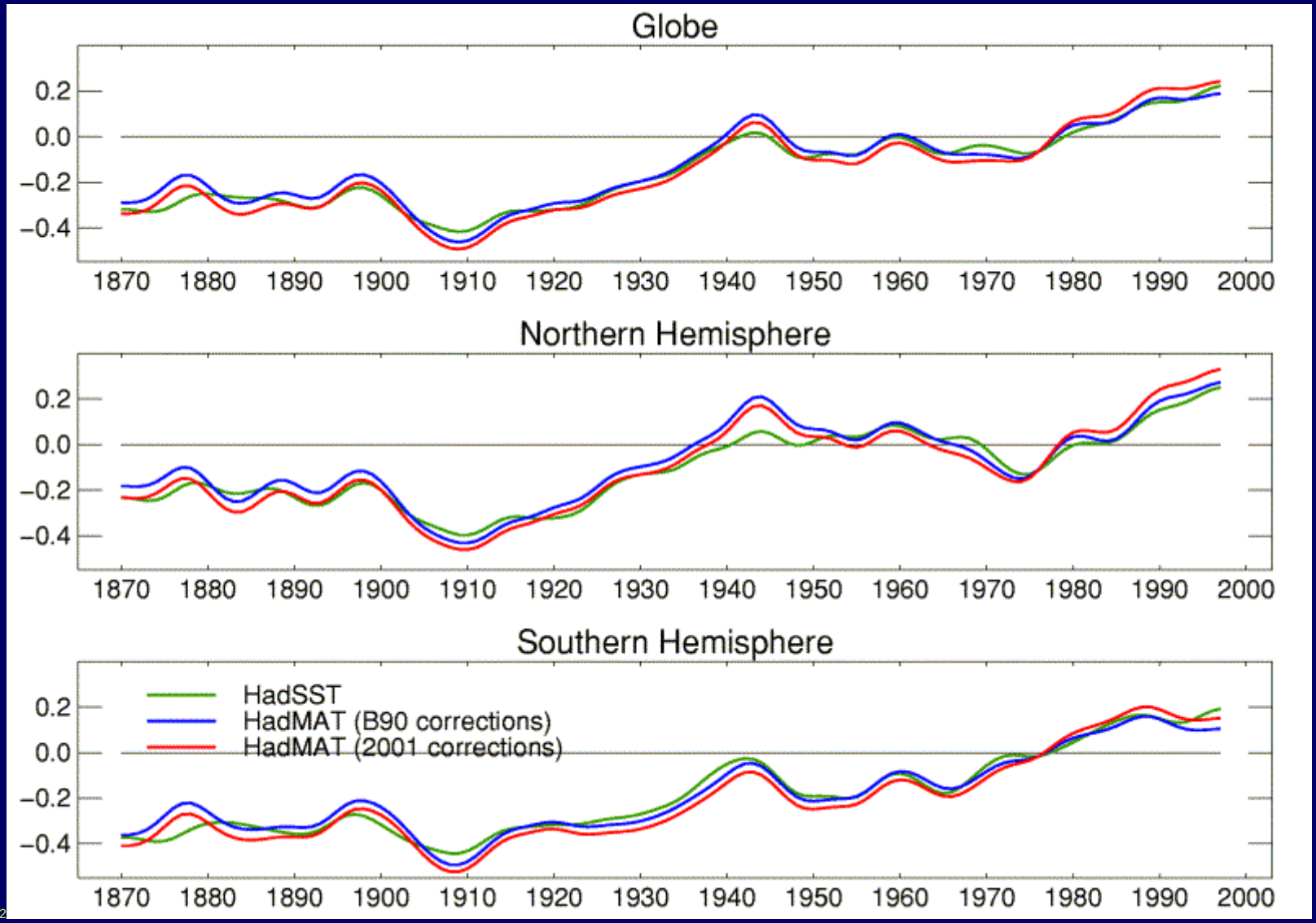
- MOHMAT42N used where available
- Fields smoothed according to numbers of obs and difference between each grid box and its neighbours
- Climatological mean and s.d. of near-neighbour differences established using GISST3.0
- Values replaced by weighted average of target and neighbours if difference exceeded a threshold and means comprised few obs. Number of obs in grid box used as weights. Neighbours which were all interpolated were not smoothed.
- Process iterated until fewer than 2% of grid boxes failed near-neighbour tests.

Met Office

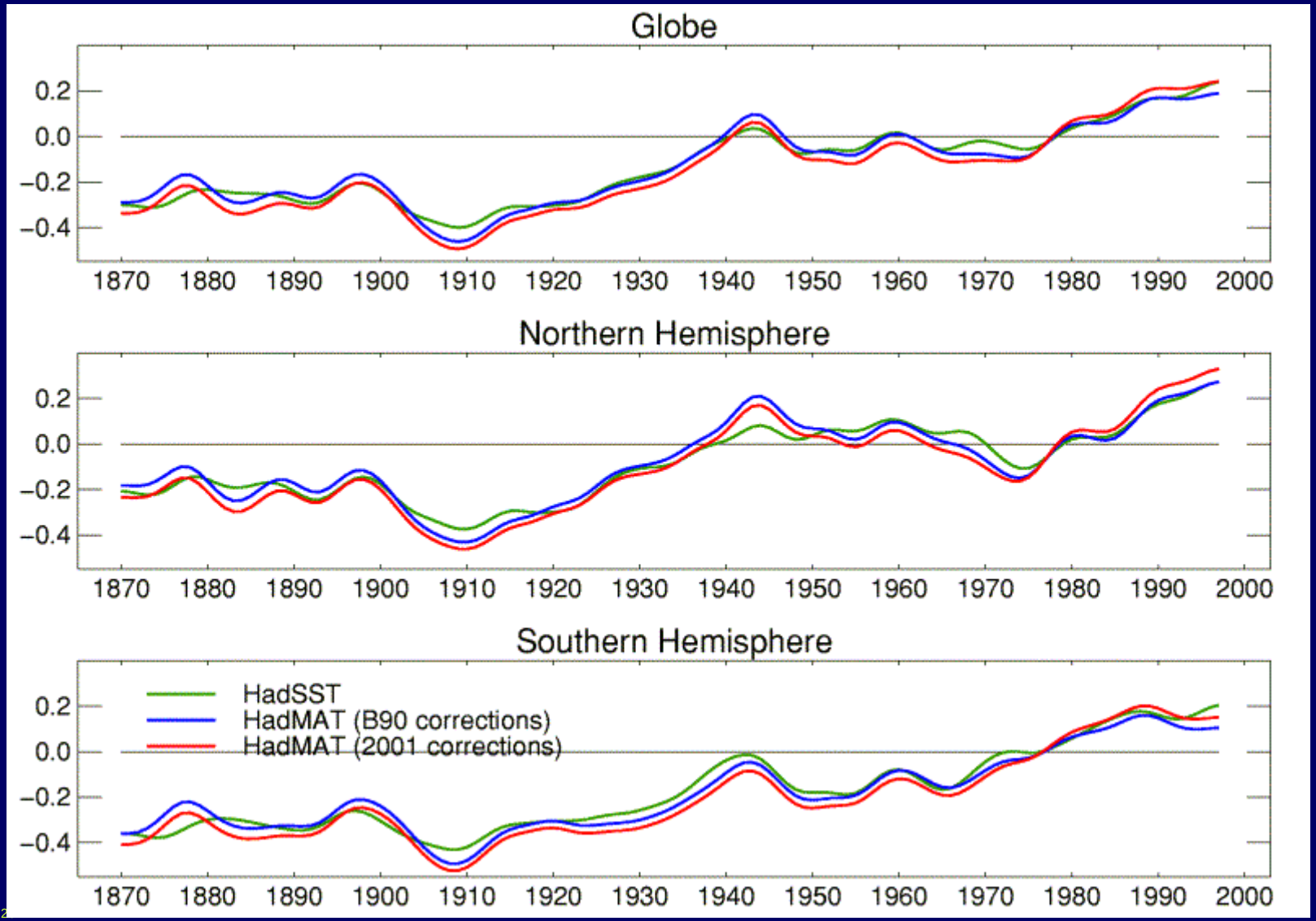
Effect of superimposing data onto reconstruction, Feb 1963



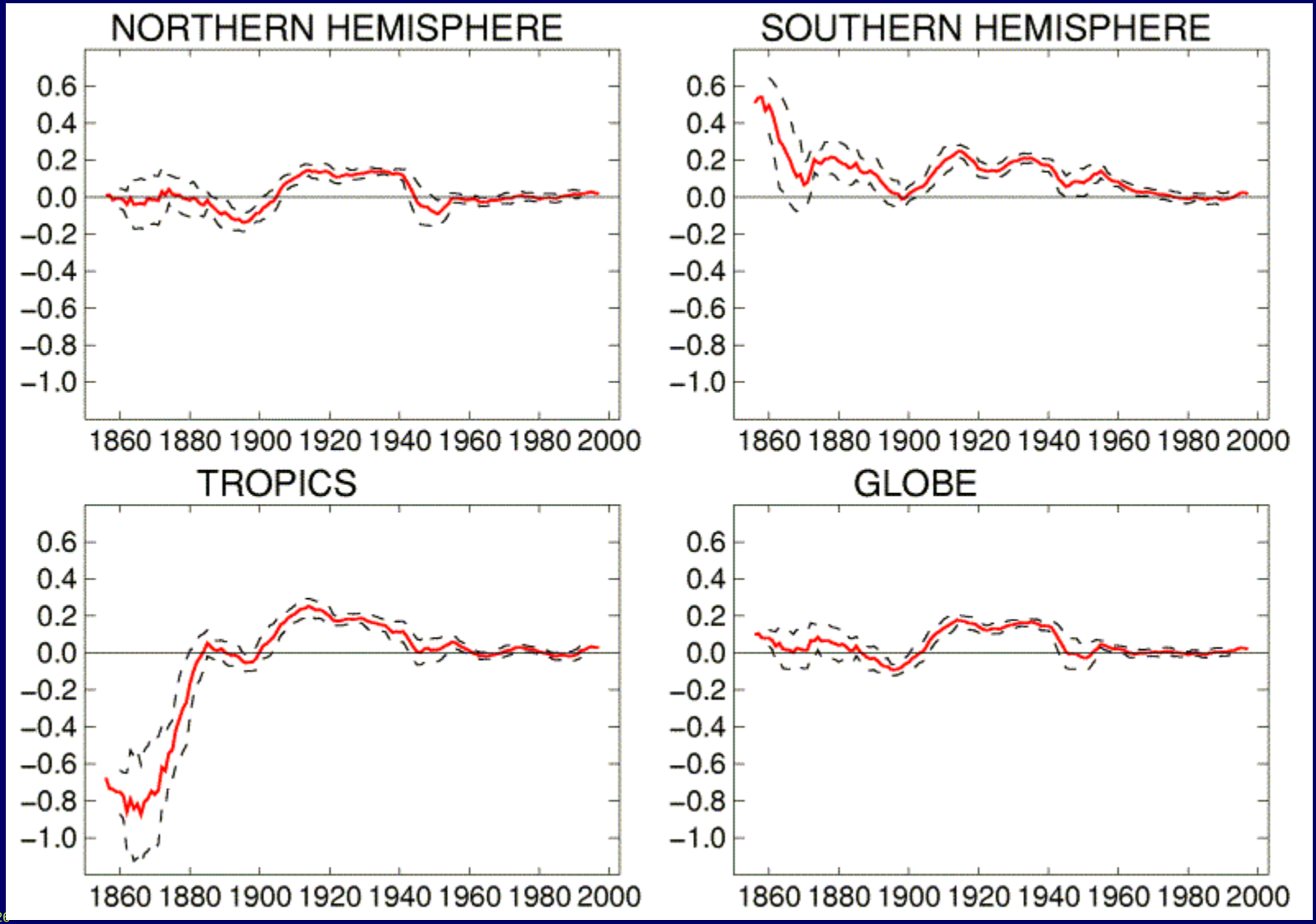
Marine temperature anomalies
(collocated: curves adjusted to average to zero in 1961-90)



Marine temperature anomalies
(collocated: relative to 1961-1990 climatologies.)

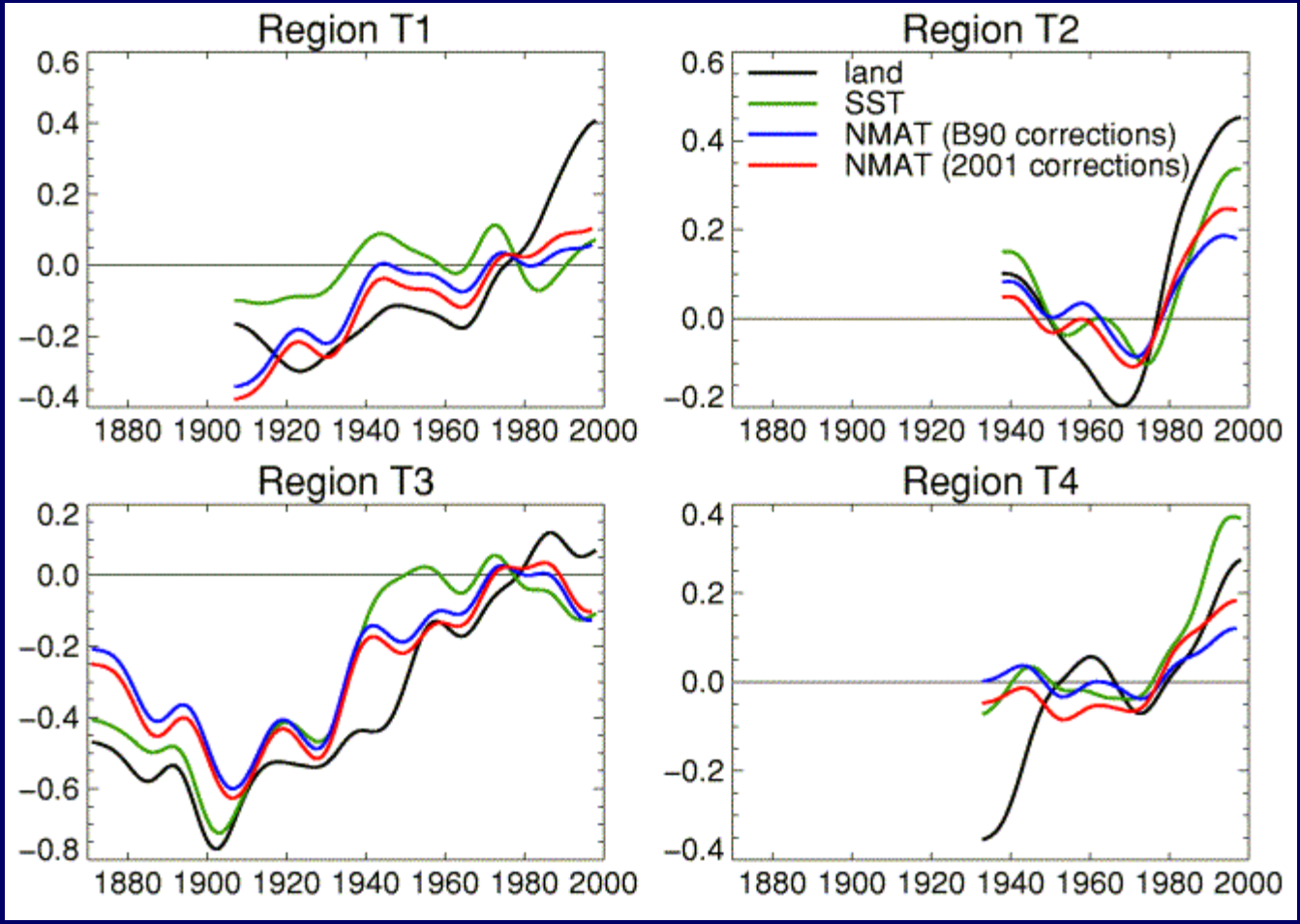


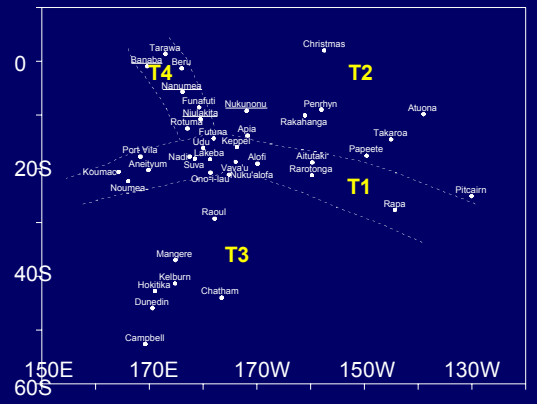
Collocated land air temperature minus HadMAT anomalies



Met Office

Temperatures in New Zealand - SW Pacific region





Conclusions: HadMAT is/will be better than previous MAT data sets

- Minimal solar heating biases
- Improved deck-height corrections since 1970
- Agrees well with SST and land air temperature
- Geographically-varying deck-height corrections for recent years
- Extra data from blended observations
- Reduction of random and sampling error using HadSST-like techniques?

Met Office