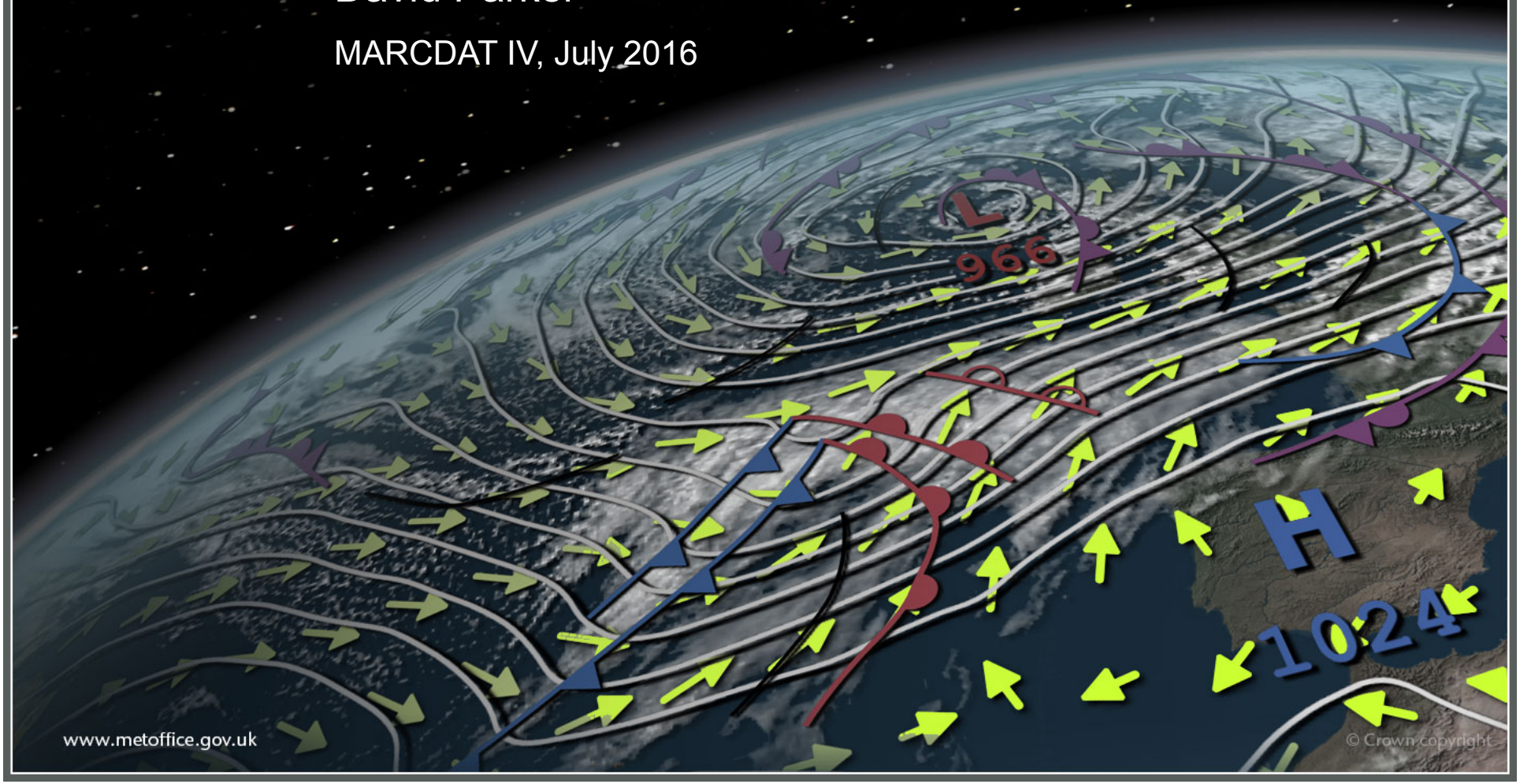
HadISDH-marine: multivariable marine surface humidity monitoring

Kate Willett, Robert Dunn, John Kennedy, David Berry and David Parker

MARCDAT IV, July 2016



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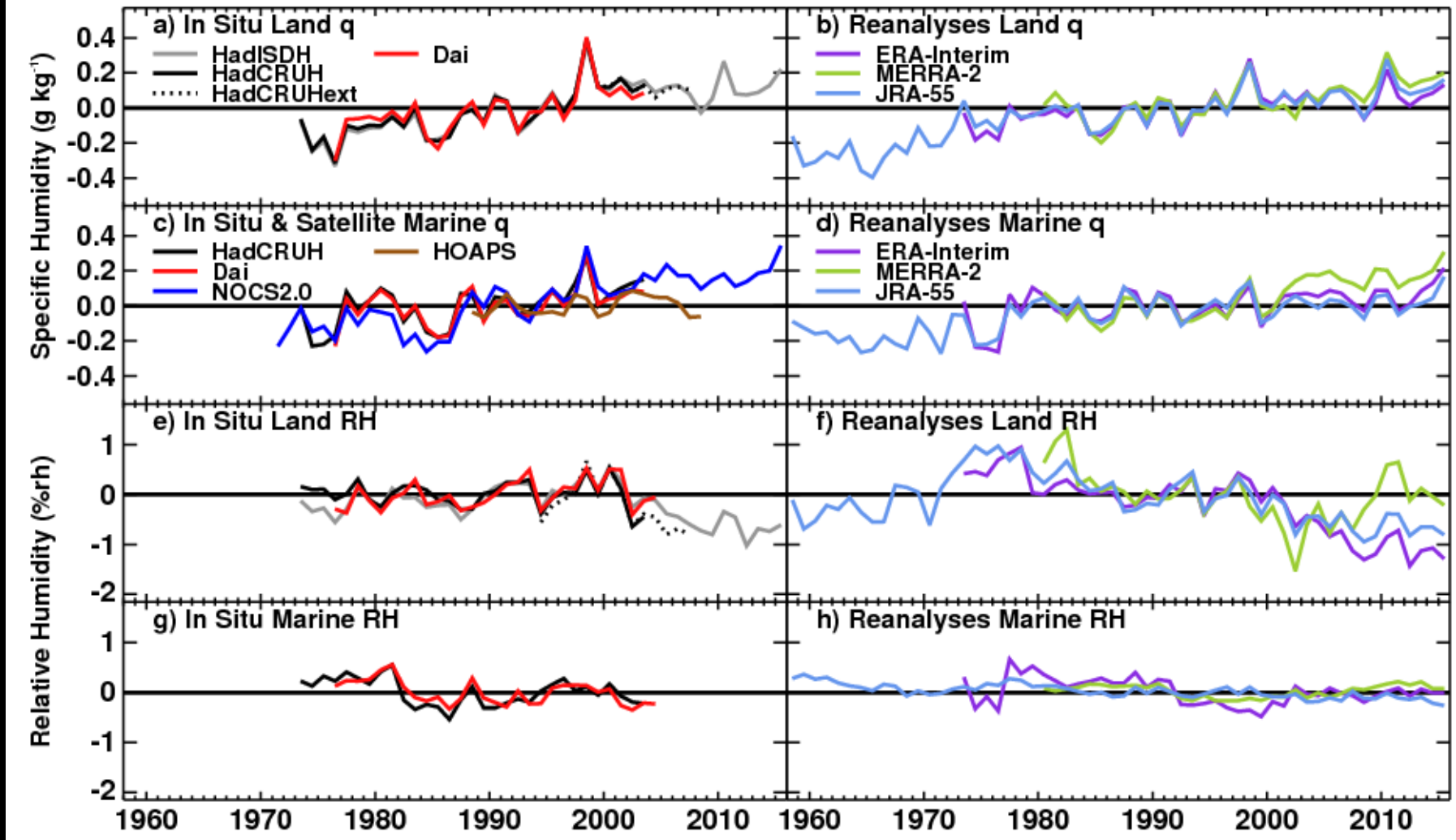
Why?



Building HadISDH-marine

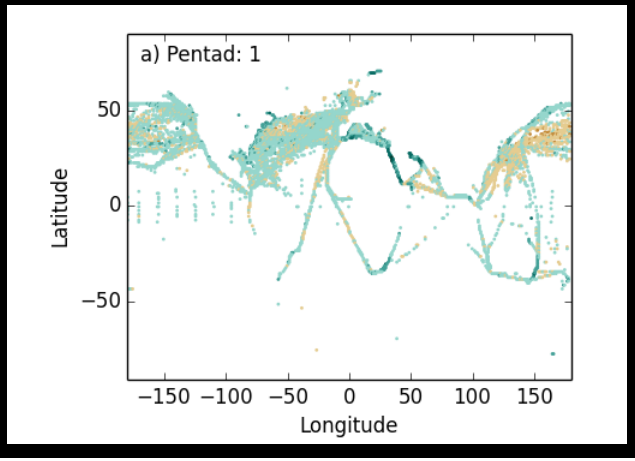
- select hourly T and T_d (calculate q, e, RH, T_w, DPD)
- base QC T and T_d (position, date, blacklist, day, outlier, **supersaturation**)
- additional QC T and T_d (track, repeats, **repeated saturation**, buddy)
- bias adjust all variables (height, instrument ventilation)
- observation uncertainty estimates (**measurement, rounding**, height adjustment, ventilation adjustment)
- grid (anomalies, actuals)
- **renormalise (1981-2010)**

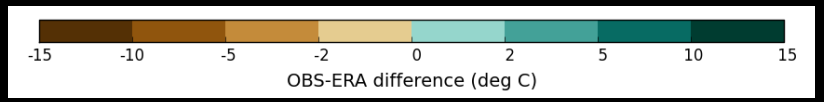
Data Selection Criteria

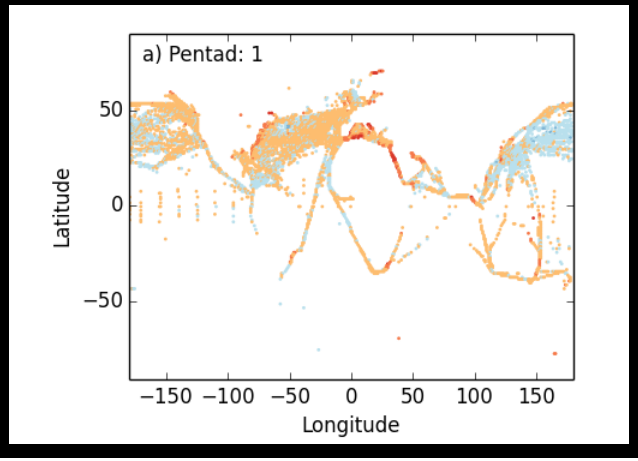
- no blacklisted ID (Kennedy et al., 2011a)
- both a T and T_d value present
- platform type must be a 'ship' (PT = 0, 1, 2, 3, 4, 5), a stationary buoy (PT = 6, 8) or a fixed ocean platform/station (PT = 9, 10 15)
- calculated RH must be between 0%rh and 150%rh
- T must be between -80^o C and 65^o C
- T_d must be between -80^o C and 65^o C
- calculated q must be greater than 0 g kg^{-1}

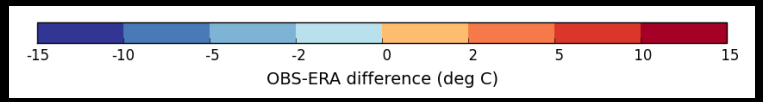
Removal of Outliers

- ERA-Interim 1º x 1º pentad climatology 1981-2010 – cooler/drier than the observations except for North Pacific



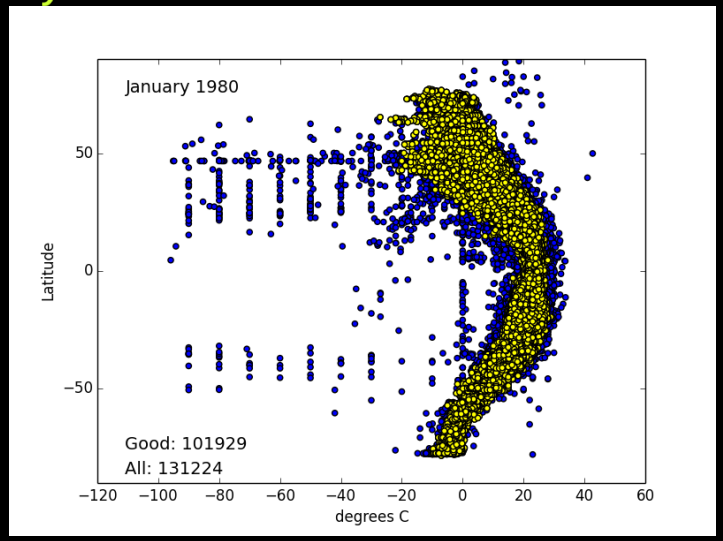


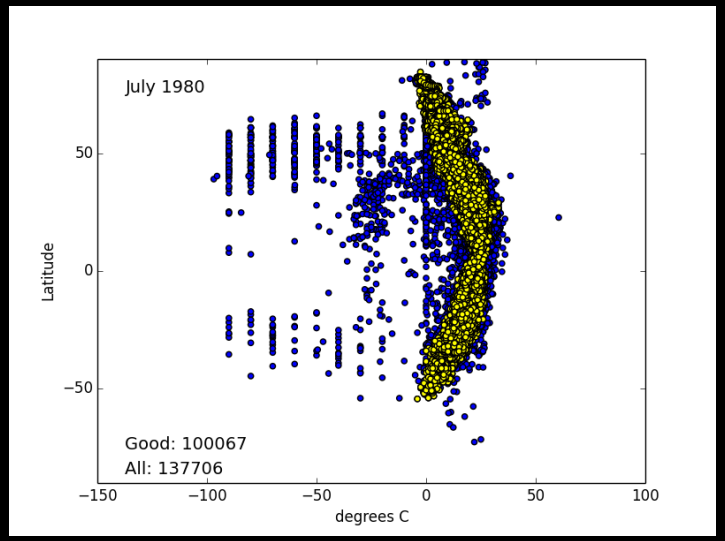


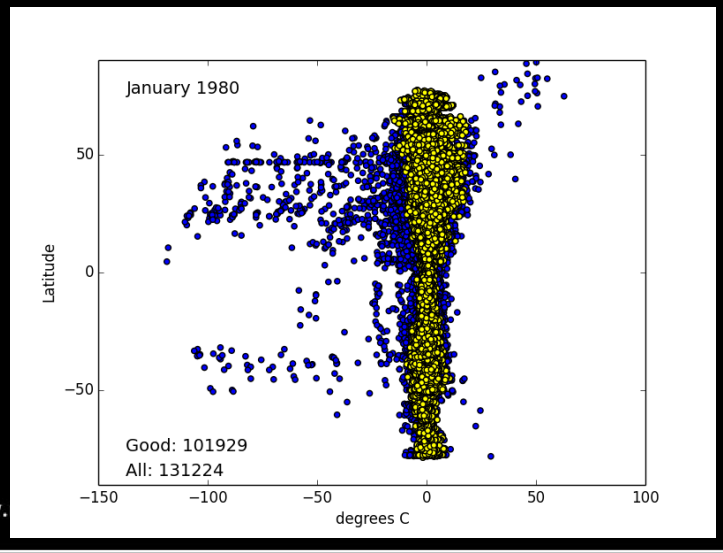


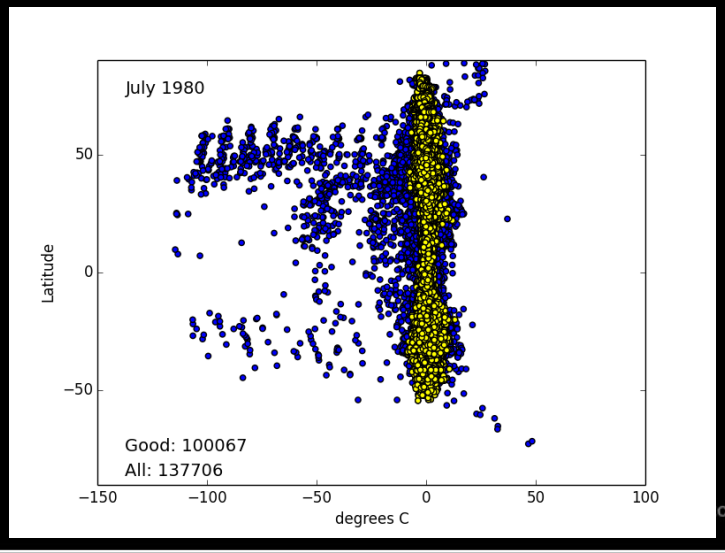
- 4.5 * σ (1º x 1º pentad climatological standard deviation 1981-2010)
- min/max permissible σ of 1º C / 4º C

Removal of Outliers: T_d

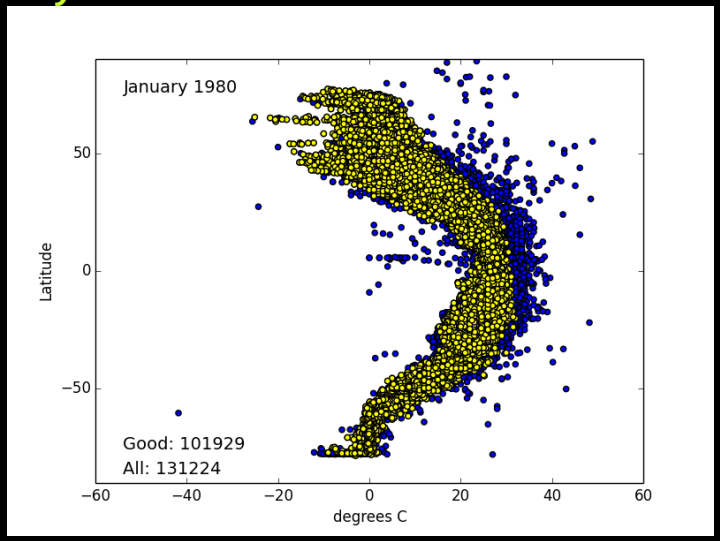


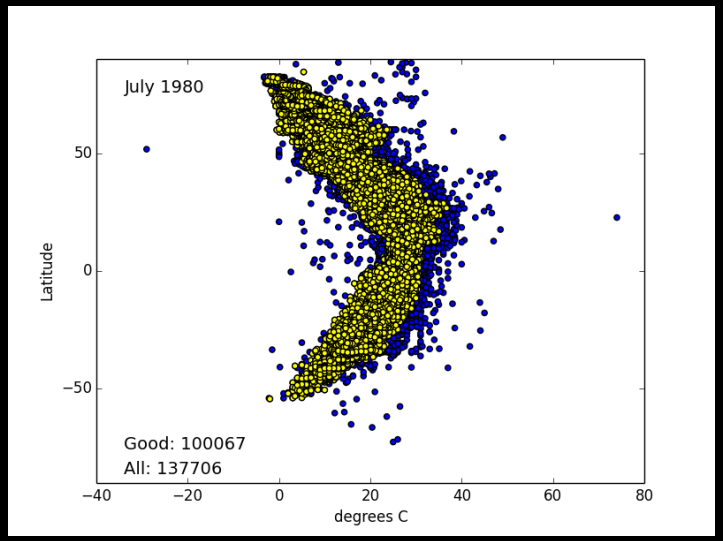


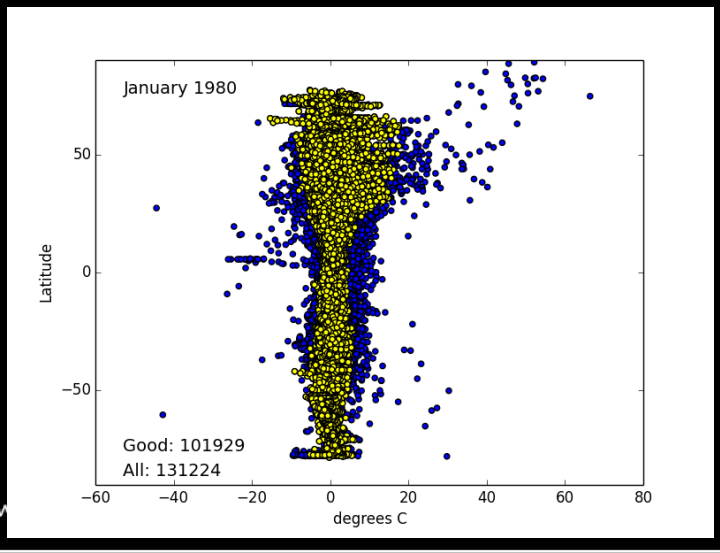


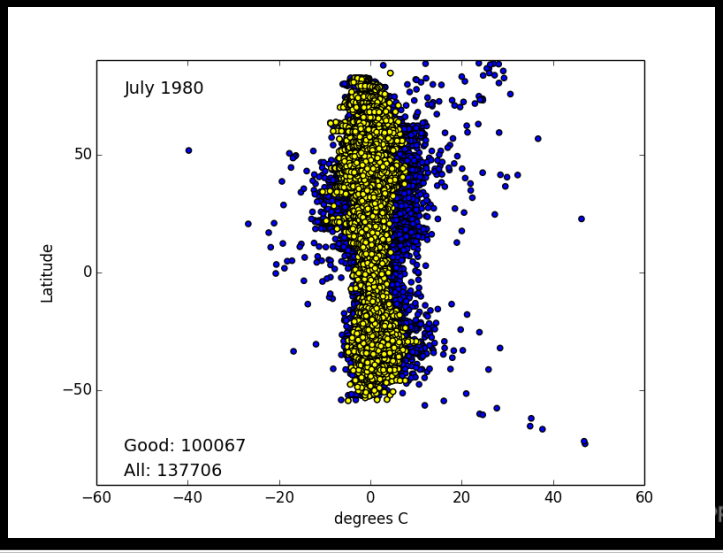


Removal of Outliers: T







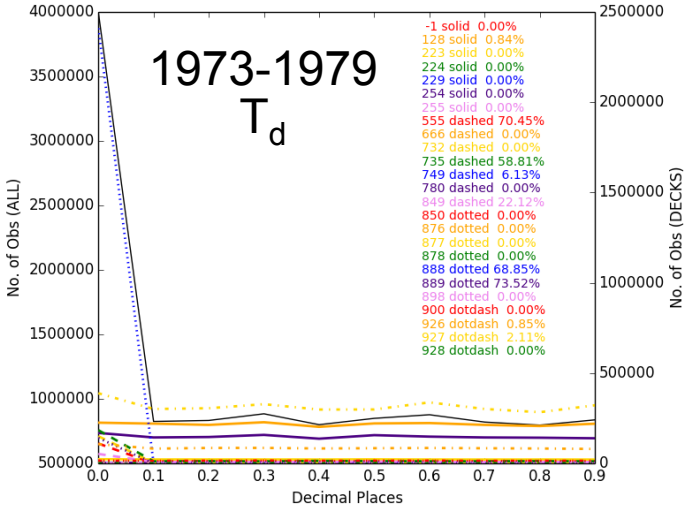


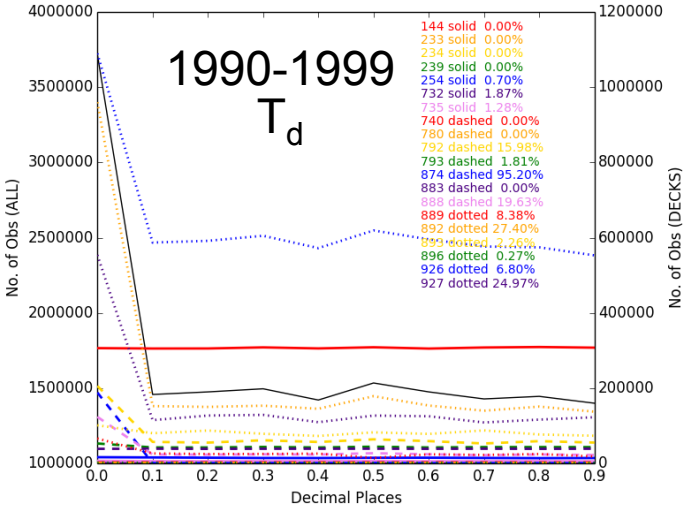
Humidity Specific QC

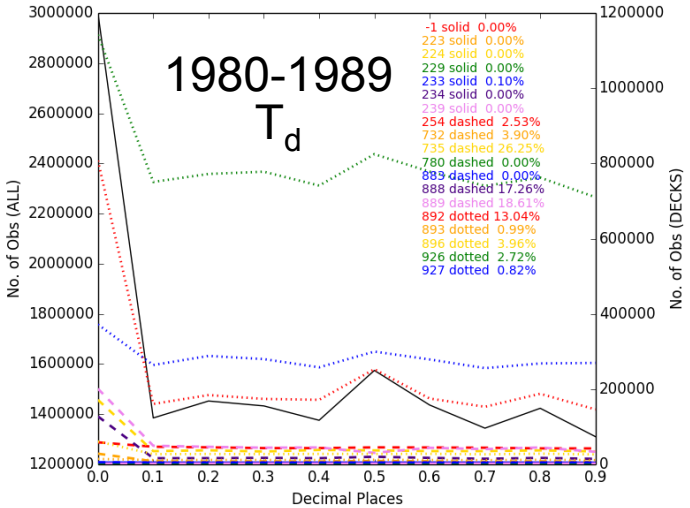
- **Supersaturation:**
  T_d must not be greater than T

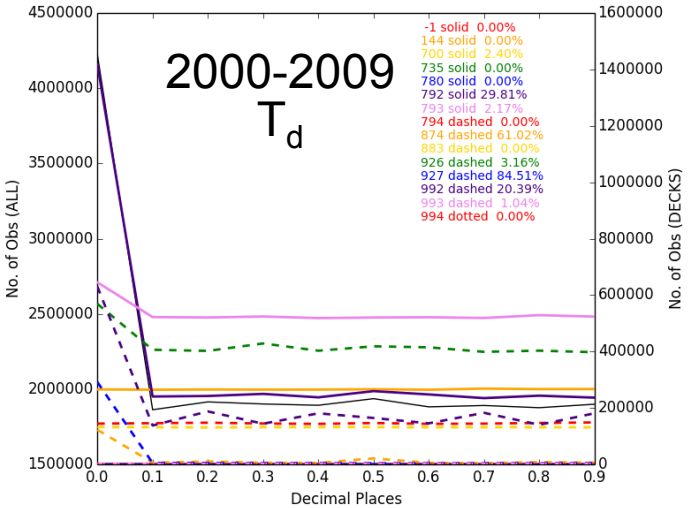
- **Repeated saturation (wet bulb wick drying out):**
  within a 'voyage' T_d must not be equal to T for more than 48 hrs (with at least 4 obs)

Reporting Precision / Rounding Issues









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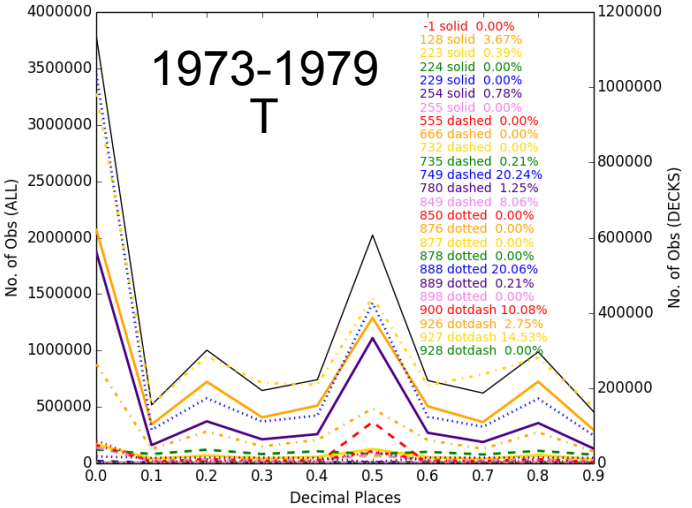

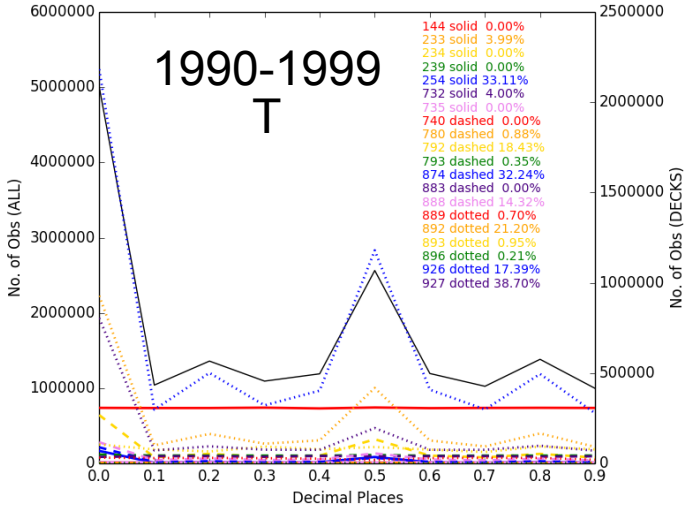

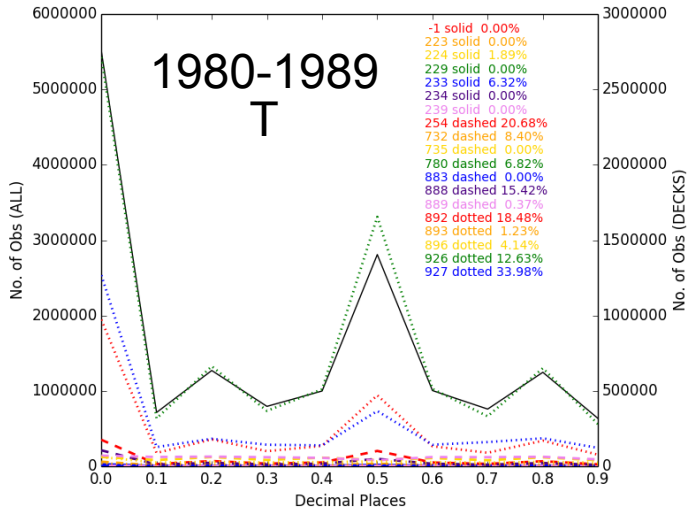

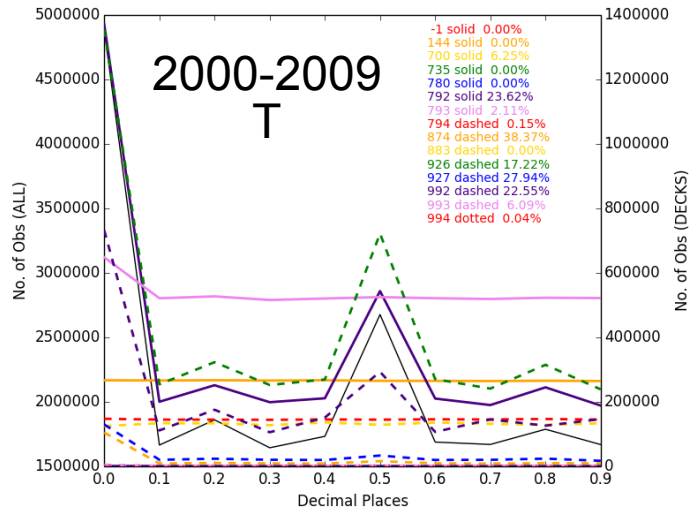

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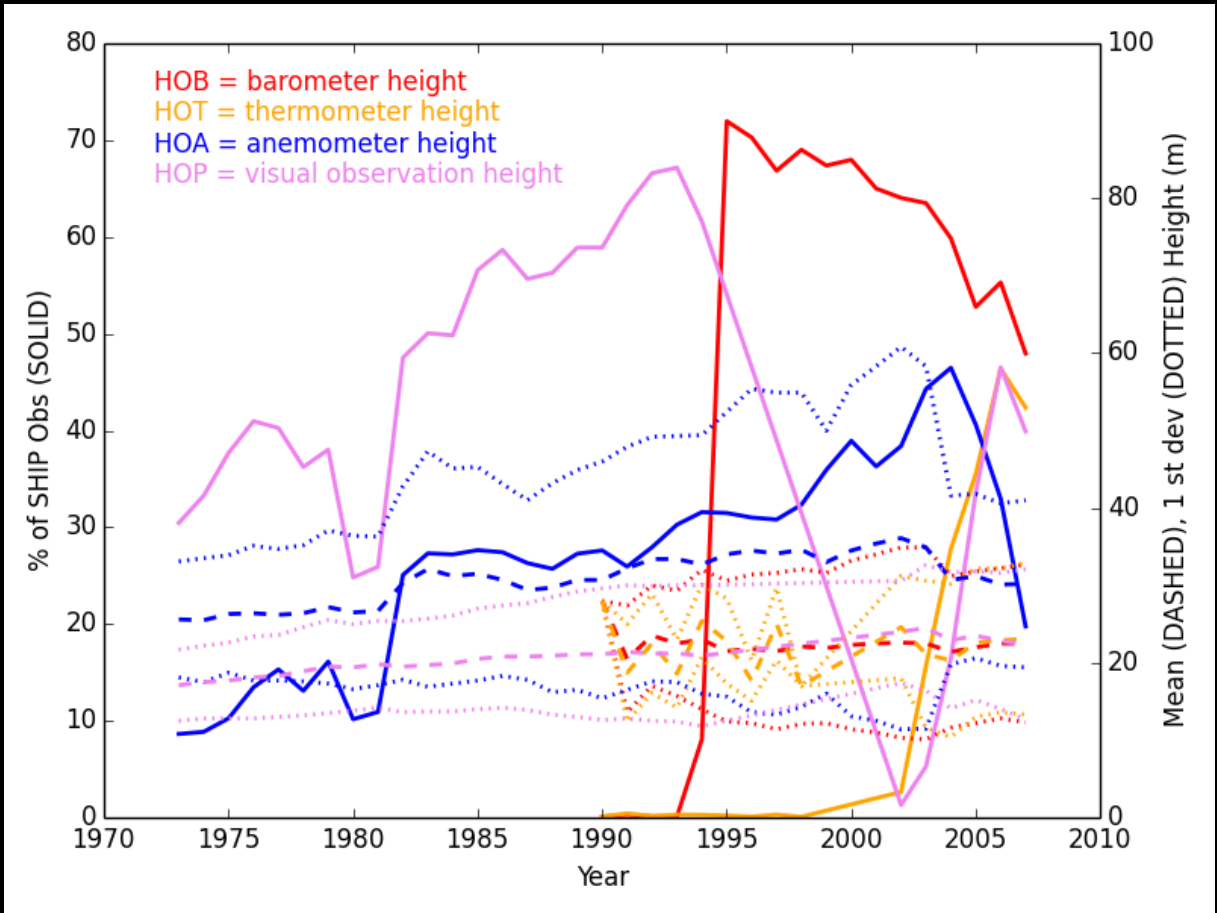
Bias Adjustment: Height



HOHest = HOT or HOB

HOA metadata to end of 2003 HOHest = :
0.5 * HOA + 5.52

HOA metadata from 2004 HOHest = :
0.75 * HOA + -1.89

HOP metadata HOHest = :
1.02 * HOP + -0.43

No metadata HOHest = :
16m to 24m depending on date

Bias Adjustment: Height

$$x_{10} = x - \frac{x_*}{\kappa}\left(\ln\left(\frac{z_x}{10}\right) - \psi_x + \psi_{x_{10}}\right)$$

- x is the variable of interest (q or T)
- x_* is the scaling parameter specific to that variable
- κ is the von Karman constant (0.41 used)
- z_* is the measurement height of the variable of interest
- ψ_* is the stability correction for the variable of interest, a function of z_x/L
- ψ_{10} is the stability correction for the variable of interest at a reference height of 10m, a function of $10/L$
- L is the Monin-Obukov Length

Thanks to David Berry, Berry and Kent (2011), Berry (2009), Smith (1980, 1988), Stull (1988) and the Bretherton Lectures: www.atmos.washington.edu/academics/classes/2013Q2/547/

Bias Adjustment: Instrument

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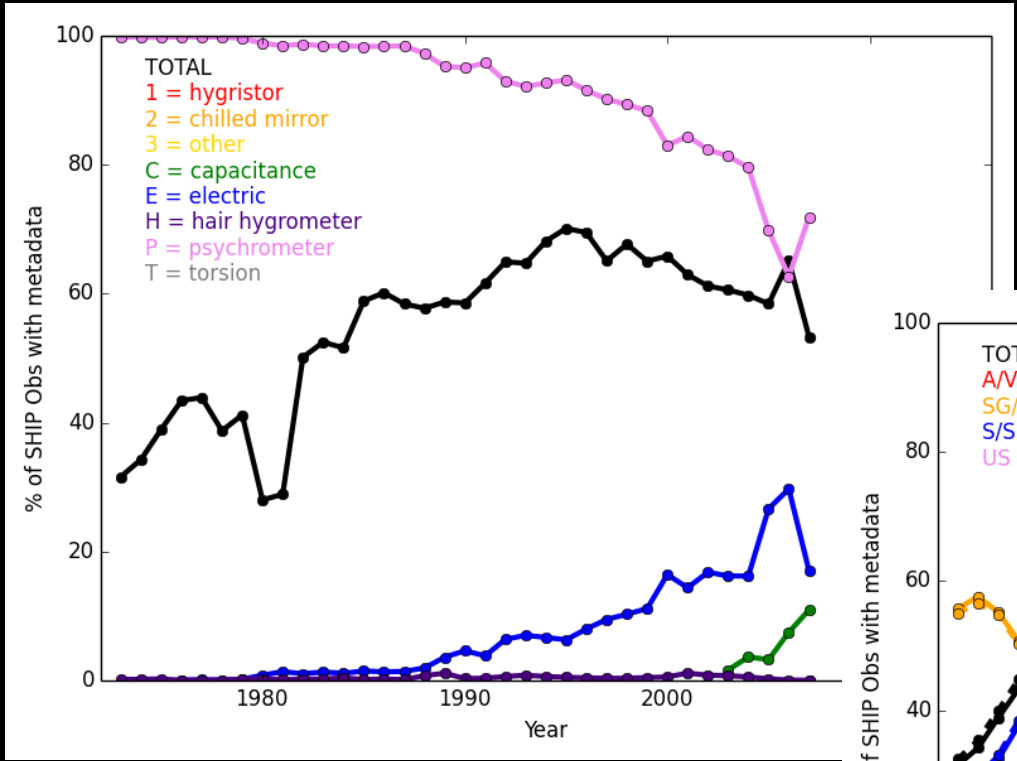


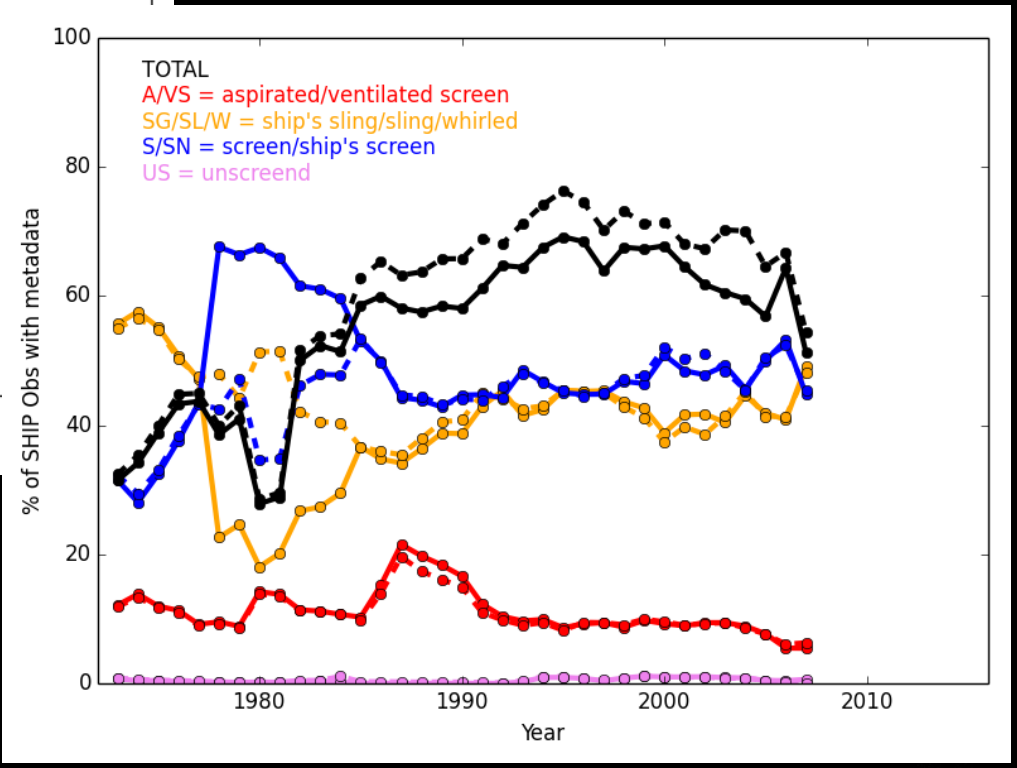
Majority of ship obs are from psychrometers

At least 30% are poorly ventilated (VS?)

Apply a 3.4% reduction in q to all unventilated obs (S, SN, VS?, US?)

Apply 0.3*3.4% to obs with no metadata and post-2007

Berry and Kent (2011), Josey et al. (1999)



Observation Uncertainty Estimates

- **Measurement uncertainty**
  - propogate uncertainty of 0.2 ^{o}C in T and 0.15 ^{o}C in T_w as the random component of a Type B uncertainty (assumes measurement from a psychrometer, as done for HadISDH-land, Willett et al. (2014))

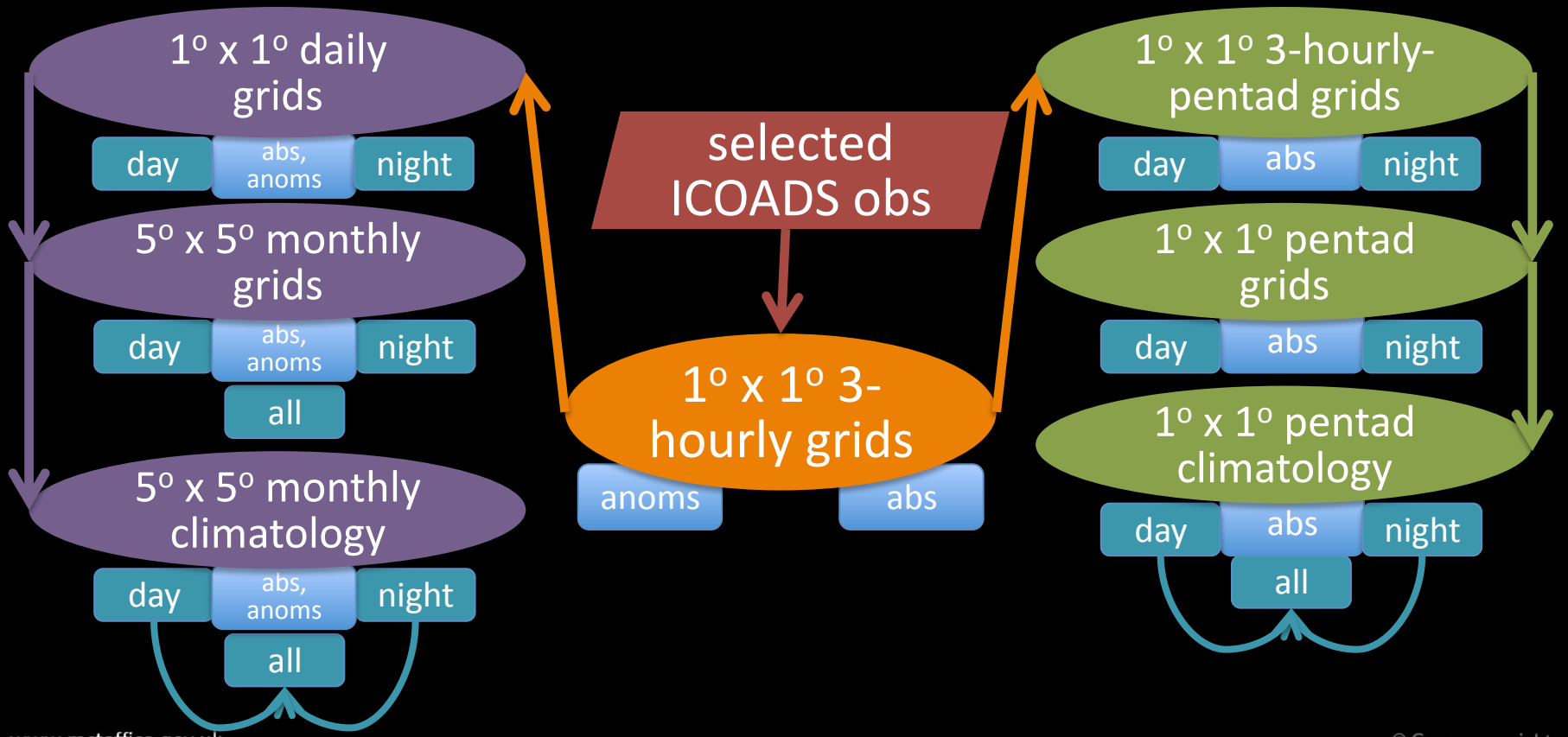
- **Rounding uncertainty**
  - 0.5 ^{o}C if T is a whole number and likely to have been rounded (deck/ voyage)
  - 0.5 ^{o}C if T_d is a whole number and likely to have been rounded (deck/ voyage)

- **Height adjustment uncertainty**
  - 0.1 * adjustment increment where HOHest comes from HOT or HOB
  - 0.5 * adjustment increment where HOHest is otherwise derived
  - 0 if no height adjustment (could set to 0.5(T – SST) or 0.5(q – q_0)

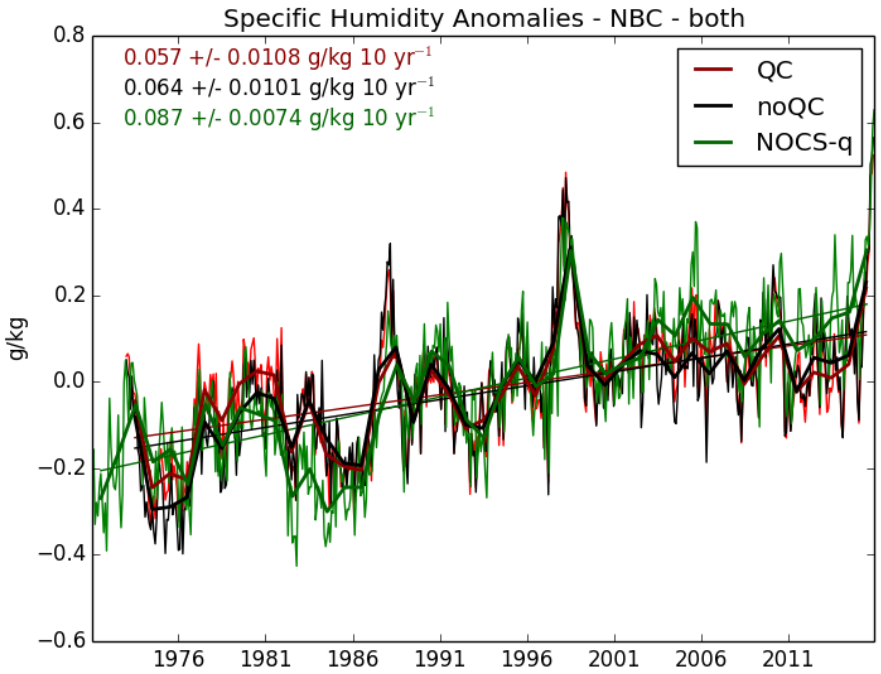
- **Instrument type adjustment uncertainty**
  - 0.2 g kg^{-1} in all cases where an adjustment has been applied (Berry and Kent (2011), Josey et al. (1999))

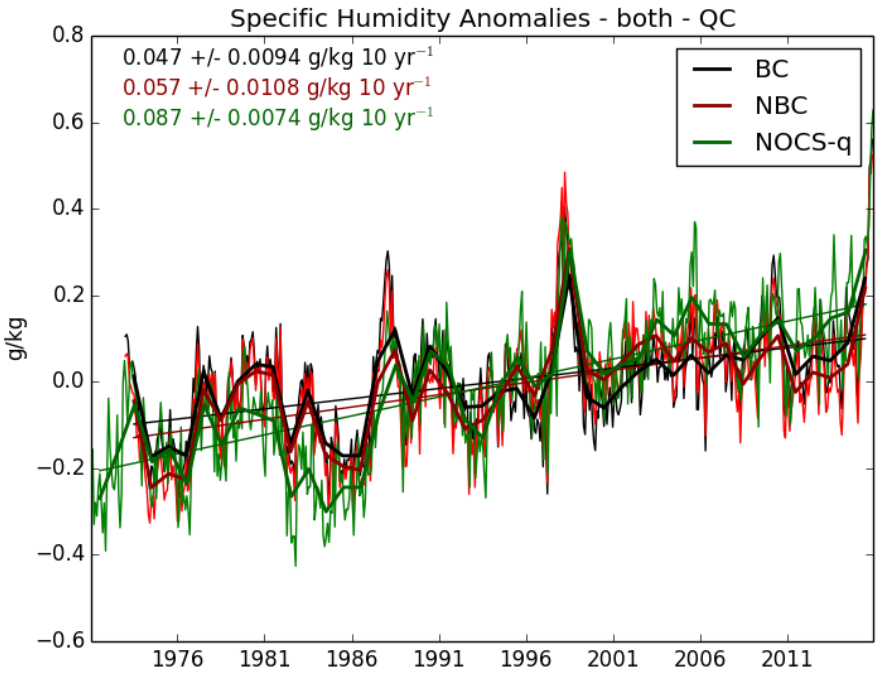
Gridding

- maximise spatial/temporal coverage
- minimise biases due to uneven spatial/temporal sampling

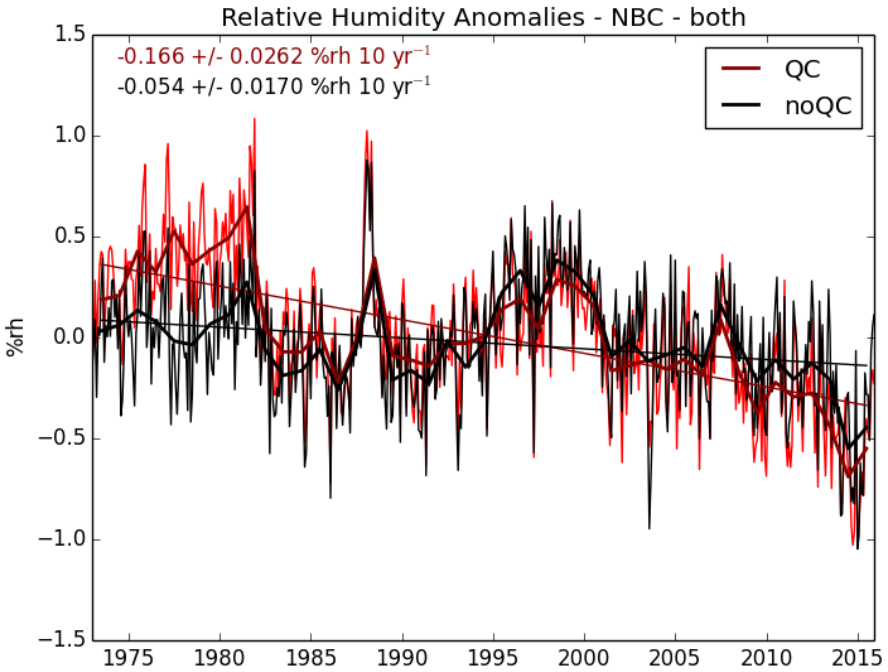


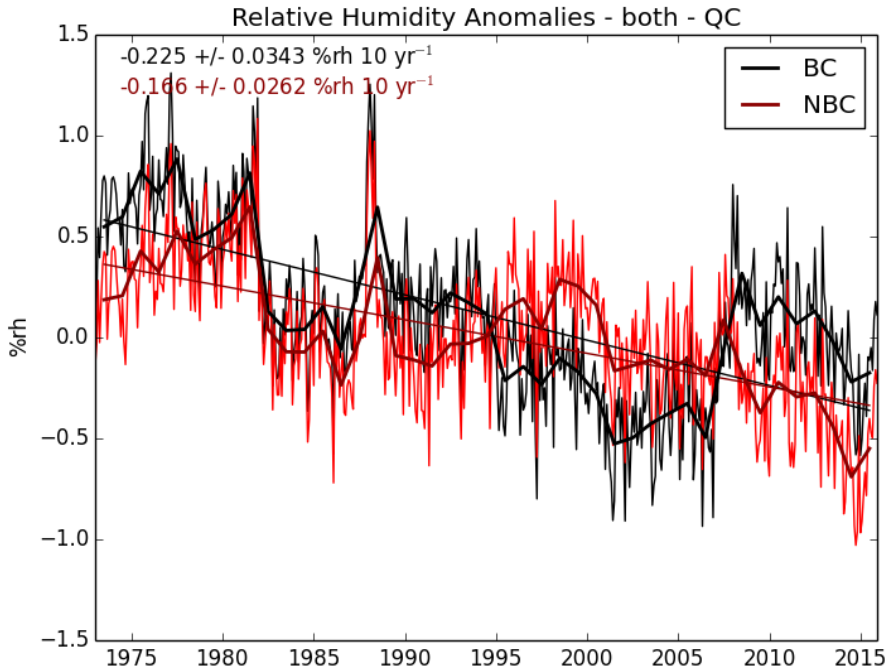
Global Average Time Series: Specific Humidity



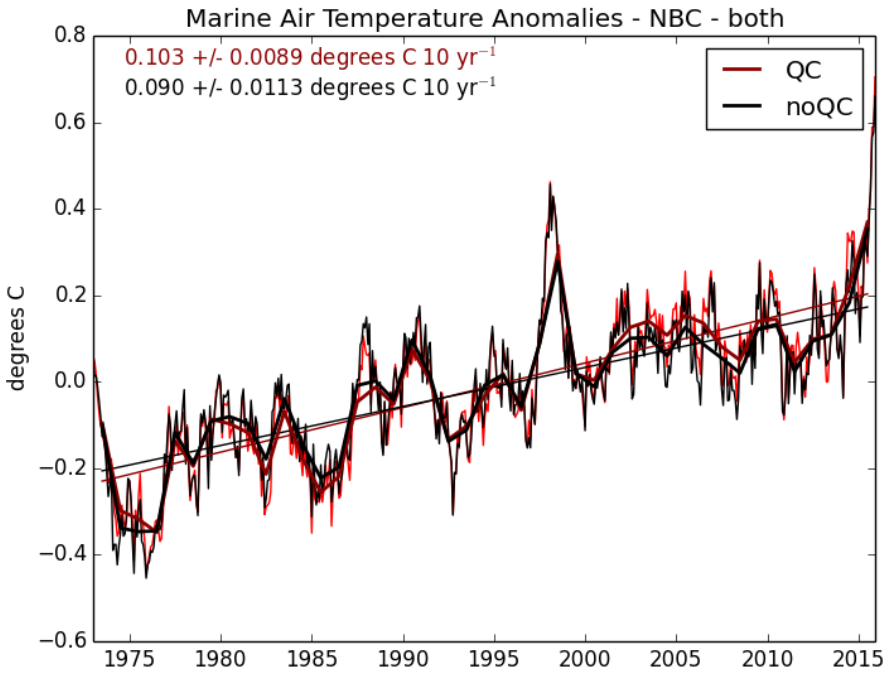


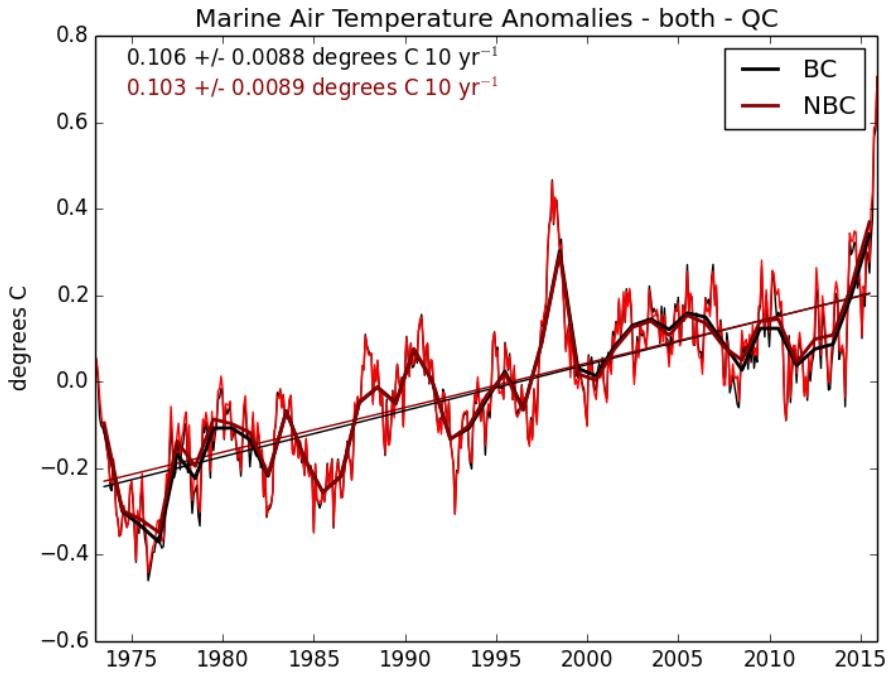
Global Average Time Series: Relative Humidity



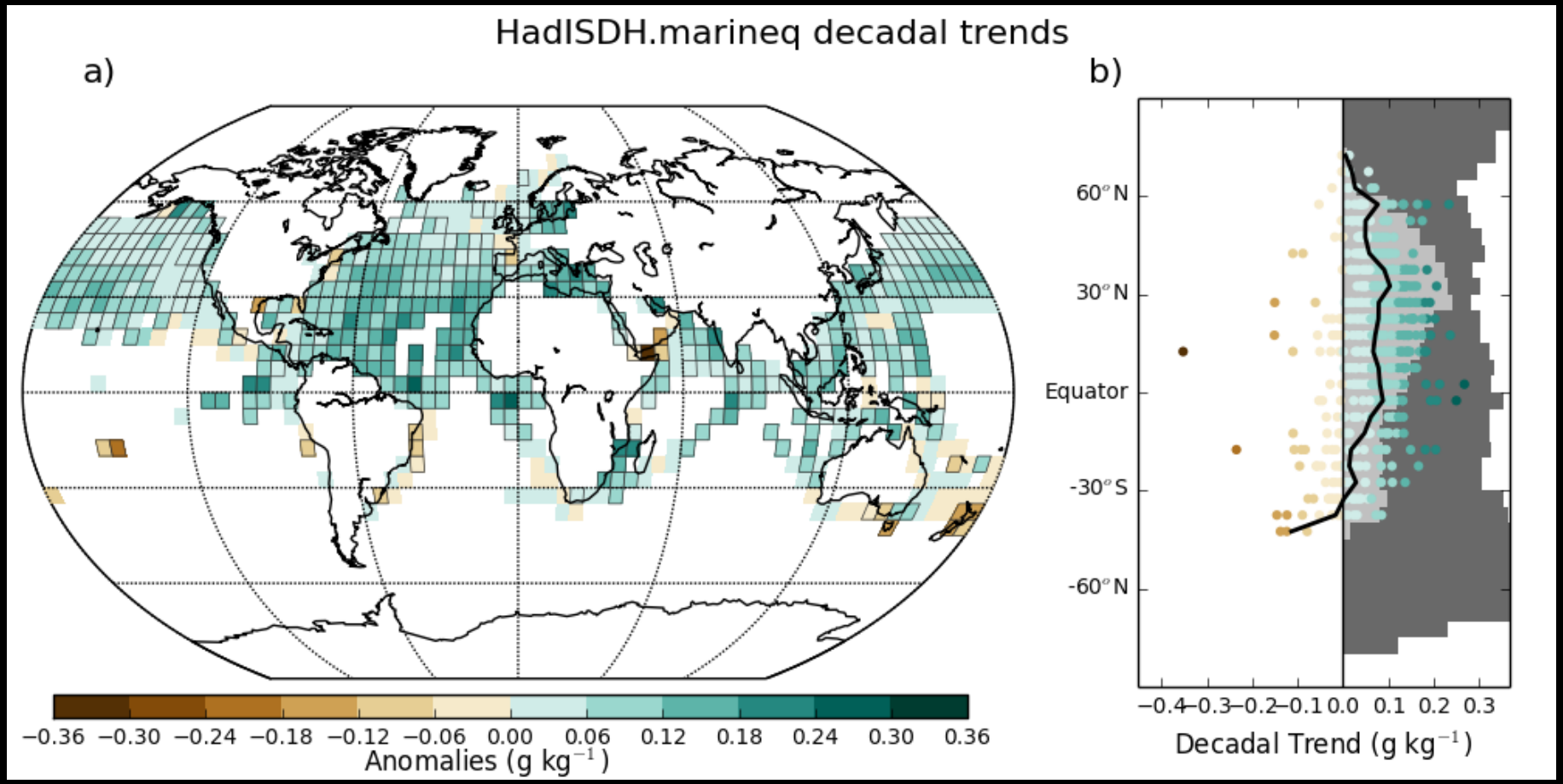


Global Average Time Series: Marine Air Temperature

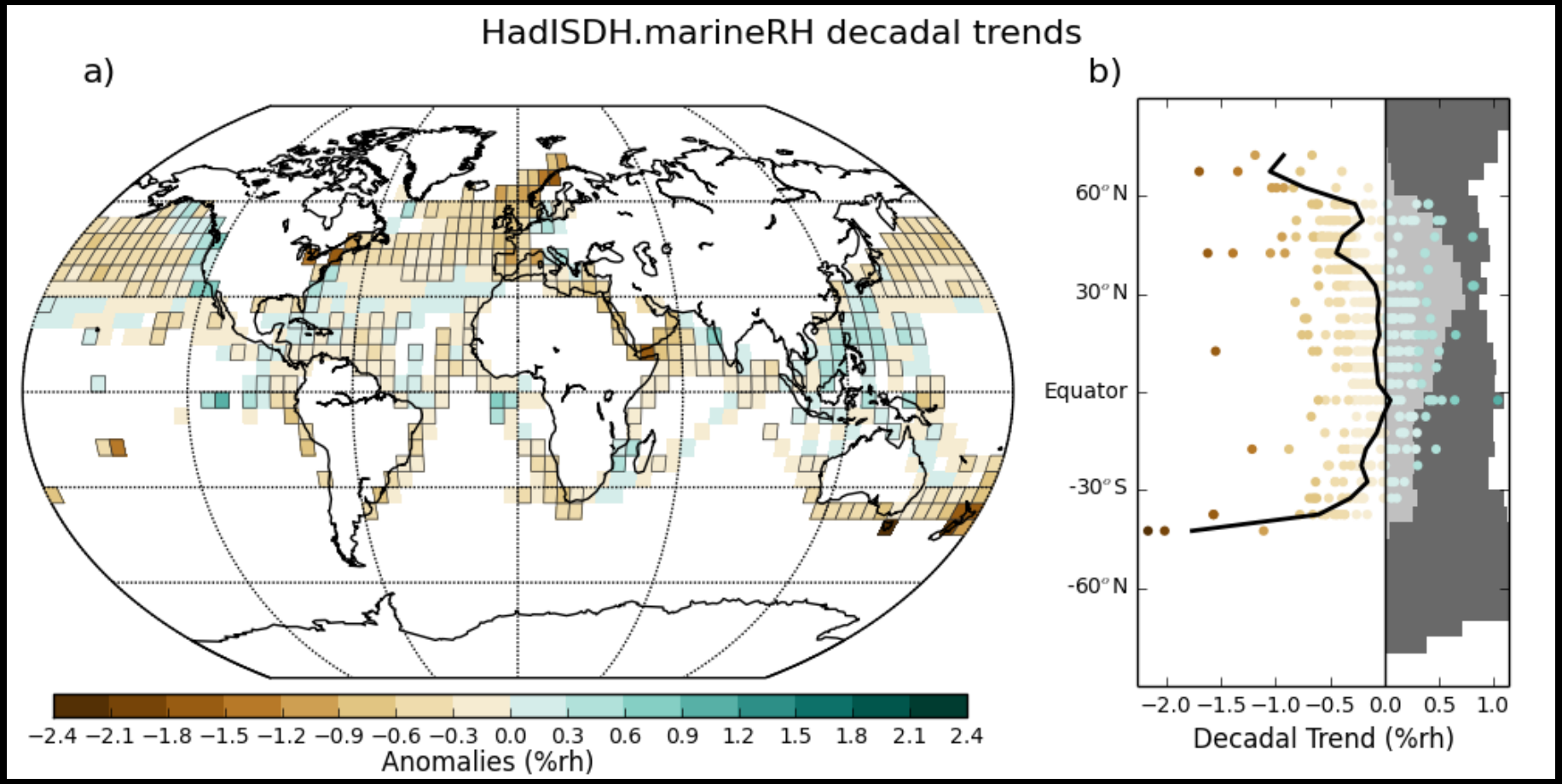




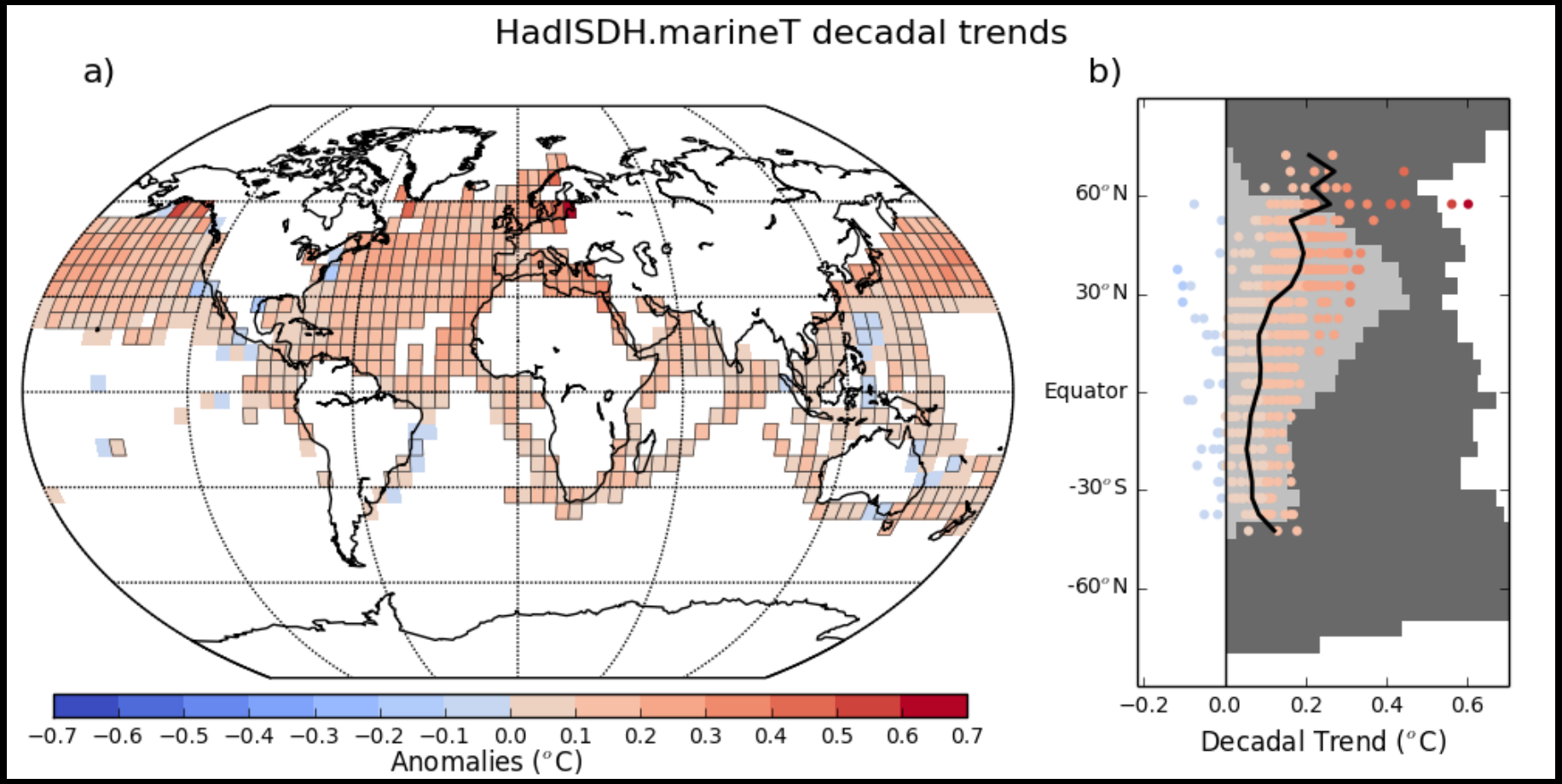
Decadal Trend Maps of the QC'd Data: Specific Humidity



Decadal Trend Maps of the QC'd Data: Relative Humidity



Decadal Trend Maps of the QC'd Data: Marine Air Temperature



What next…

- improve the outlier test to avoid ‘cut offs’

- investigate why the QC’d RH shows the pre-1982 moist bias more clearly and the non-QC’d data – preferential removal of daytime data?

- investigate the buddy check which removes the largest amount of data

- investigate the height adjustments more thoroughly, especially for RH
    - improve dealing with missing/very low wind speeds
    - improve estimate of uncertainty in adjustments

- complete a first guess uncertainty analysis
    - propogate observation uncertainties through to the gridbox
    - possible addition of climatological uncertainty
    - assess temporal and spatial sampling uncertainty
      consider either a covariance matrix or ensemble approach

- blend with HadISDH-land

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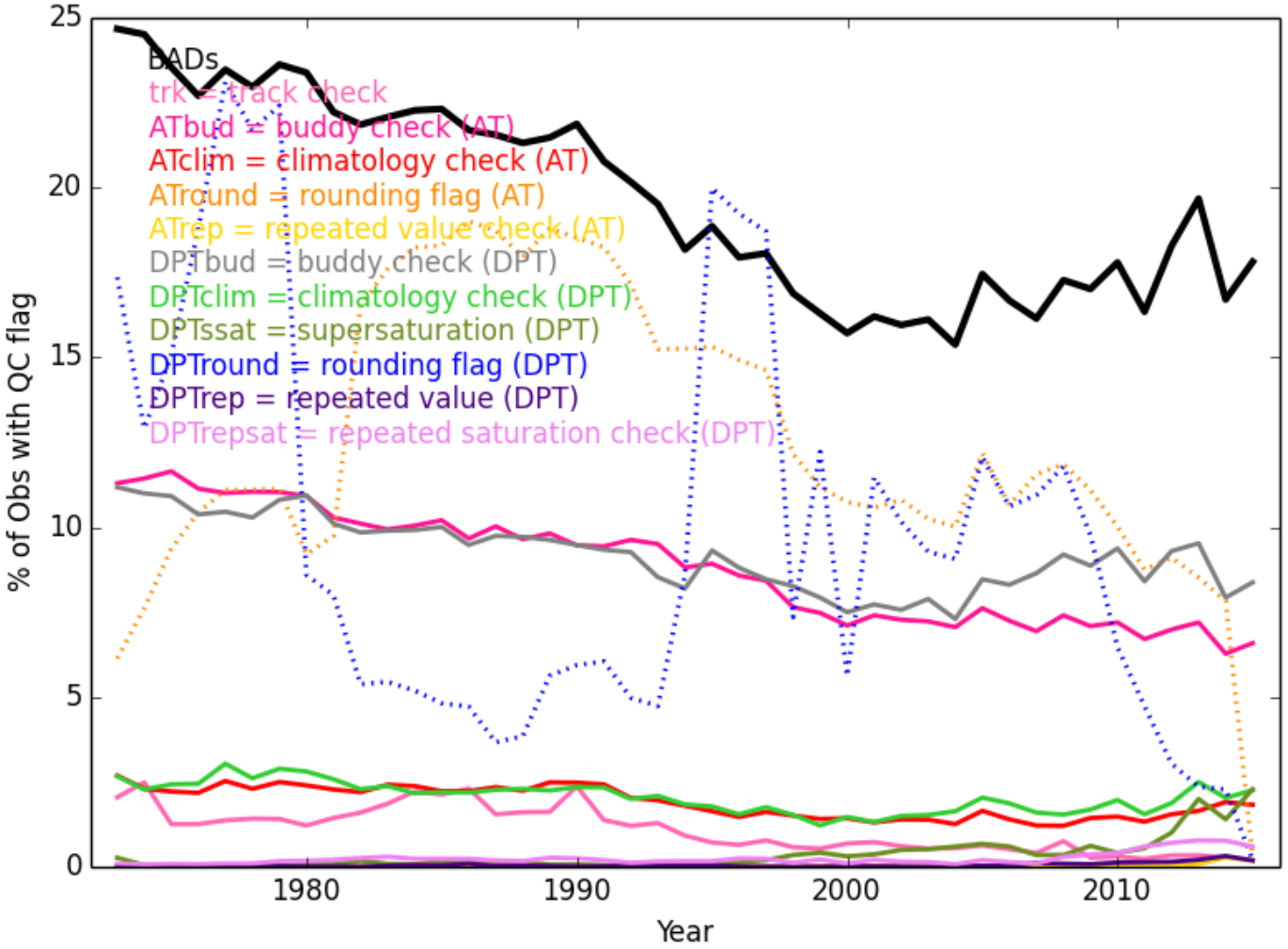
QC removals over time: all



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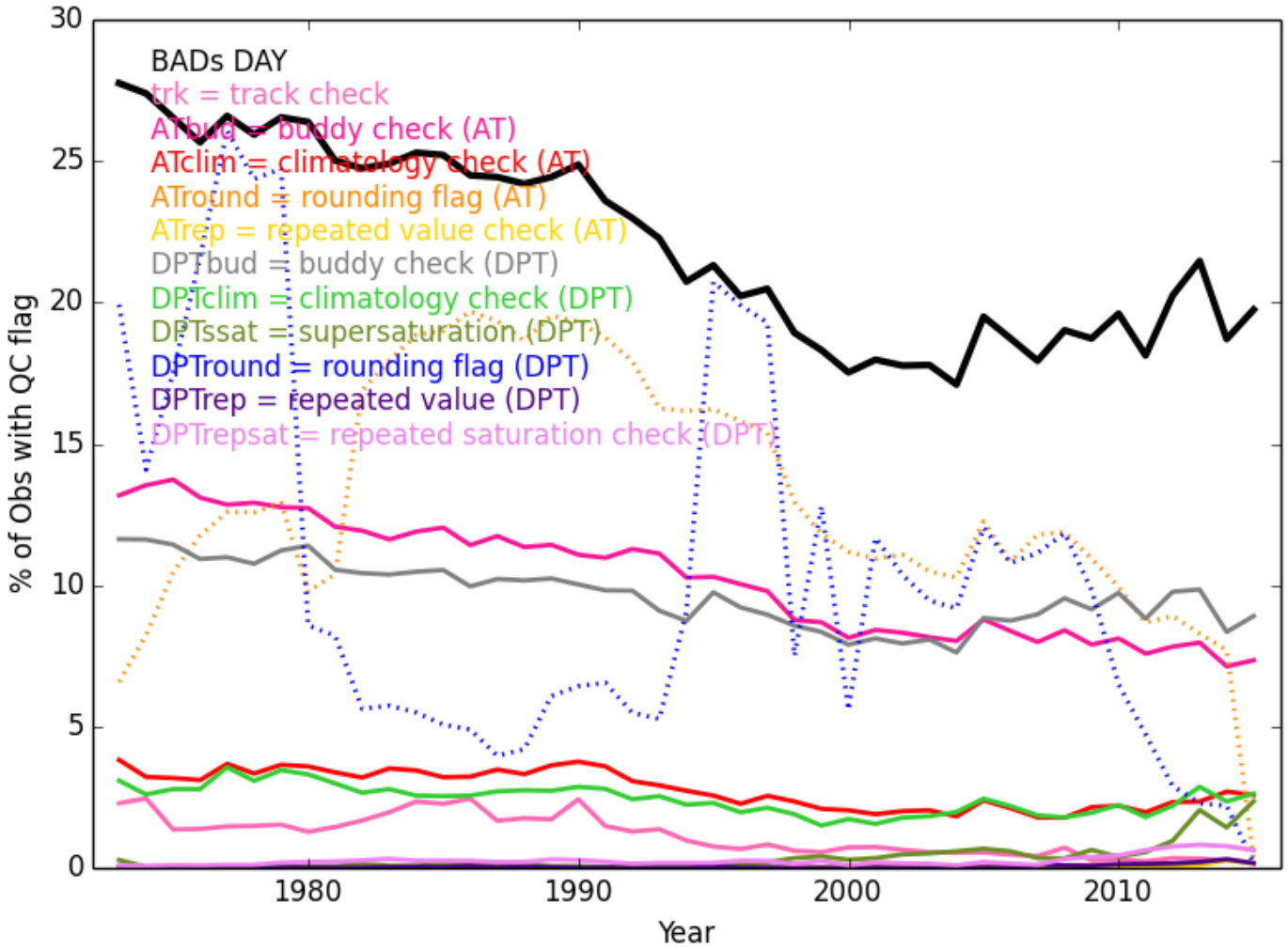
QC removals over time: day



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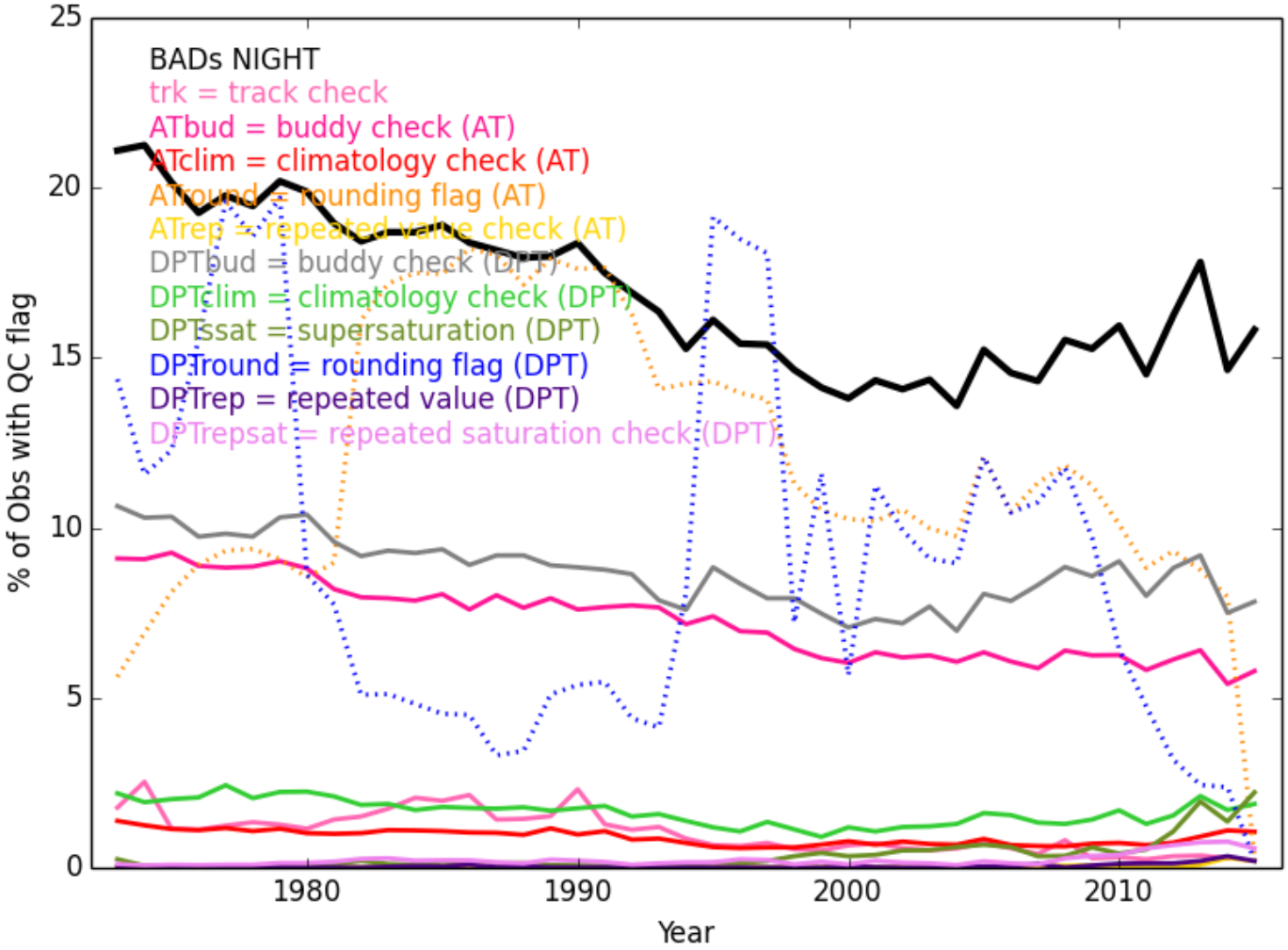
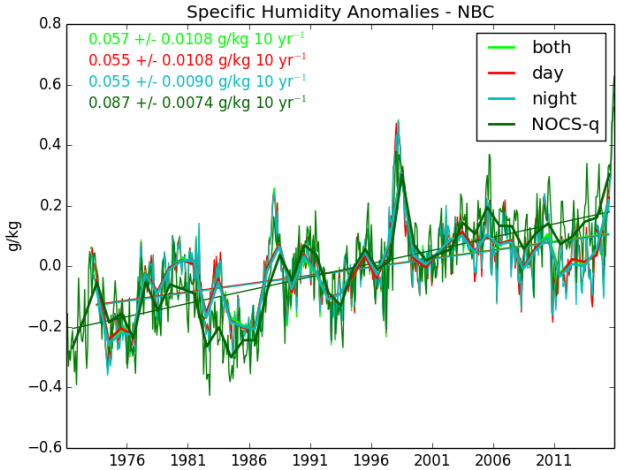
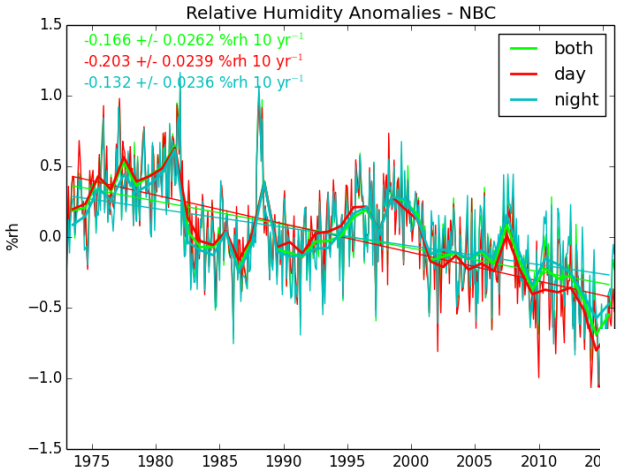
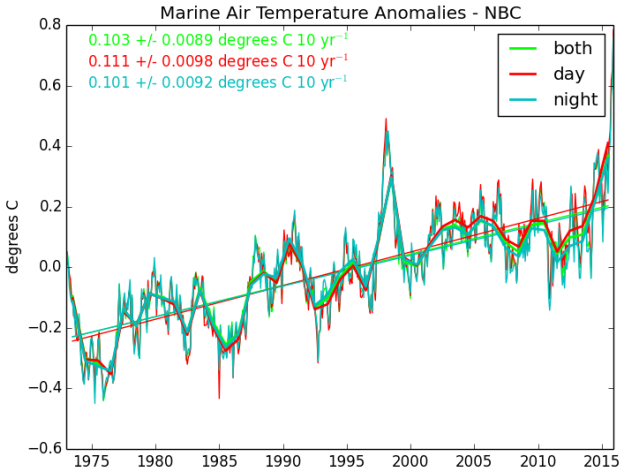
QC removals over time: night



Day versus Night Time Series







Climatologies