The Climate Bits of Climate

$$XCLIM_{(t,l,h)} = D_{t,l,h} + S_{t,l,h} + T_{t,l,h} + M_{t,l,h}$$

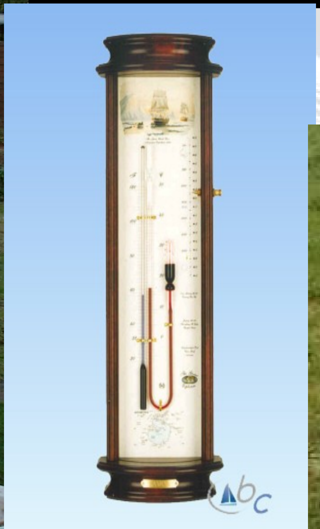
XCLIM = a climate element at time *t*, location *l* and height *h*

D = diurnal cycle

S = seasonal cycle

T = trends (long-term signal, local effects, ENSO, NAO, Volcanoes, Solar Cycles etc.)

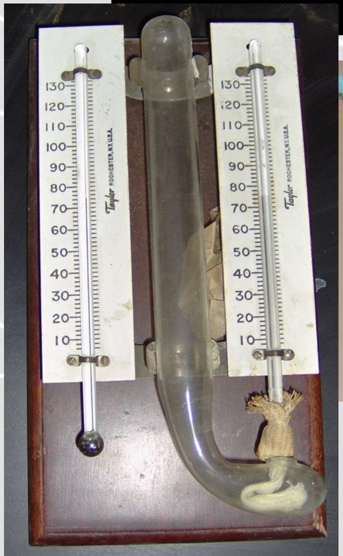
M = microclimate influences (topography, proximity to coastlines, prevailing winds, local environment etc.)

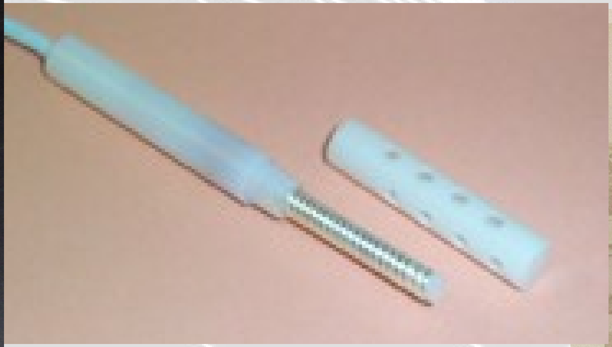


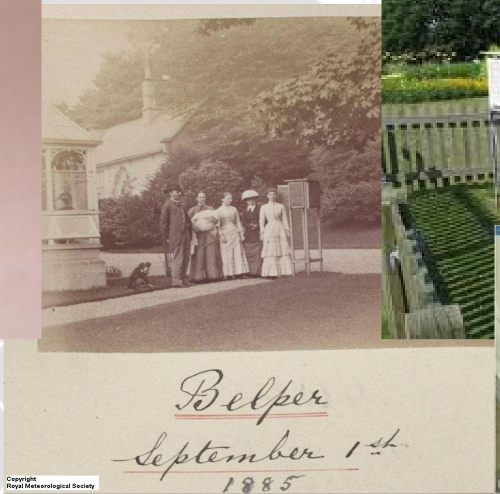
The Non-Climate Bits of Climate

$$X_{(t,l,h)} = XCLIM_{(t,l,h)} + \varepsilon_{t,l,h} + \lambda_{t,l,h}$$

X = observation at time *t*, location *l* and height *h*
XCLIM = a climate element at time/location/height
ε = random error at time/place/height
(recording error, instrument error etc.)
λ = systematic error at time/place/height *possibly correlated*
(station move, exposure change, instrument change, observing practice change, urbanisation etc.)





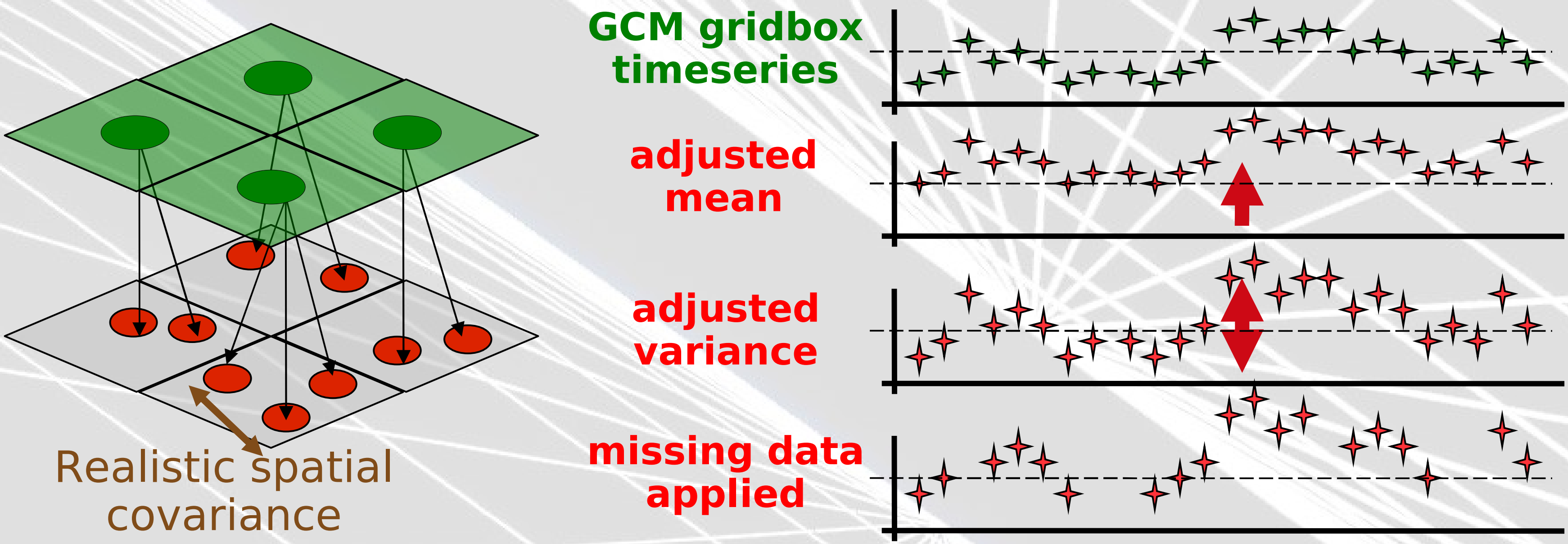


The Concept

'Truth' unknown

Team Creation

$$XTRUTH_{(t,l,h)} = D_{t,l,h} + S_{t,l,h} + T_{t,l,h} + M_{t,l,h} + \varepsilon_{t,l,h}$$

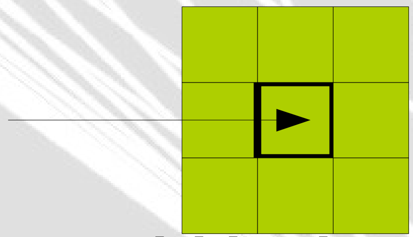


Reproduce actual station climatology, variance and interstation relationships

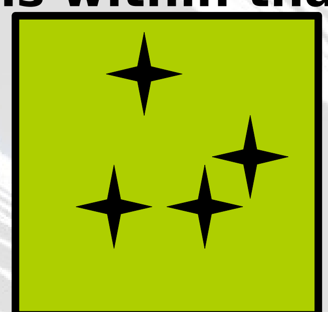
Realistic global station coverage ~60000!

11 Step How To...

1) Choose a climate model gridbox and create a month anomaly series (subtract month climatology and divide by month standard deviation)

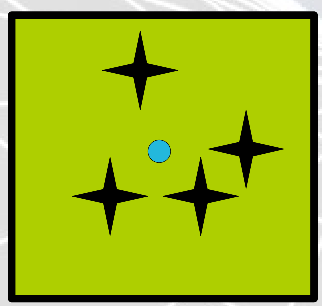


2) Get all observing stations within that gridbox



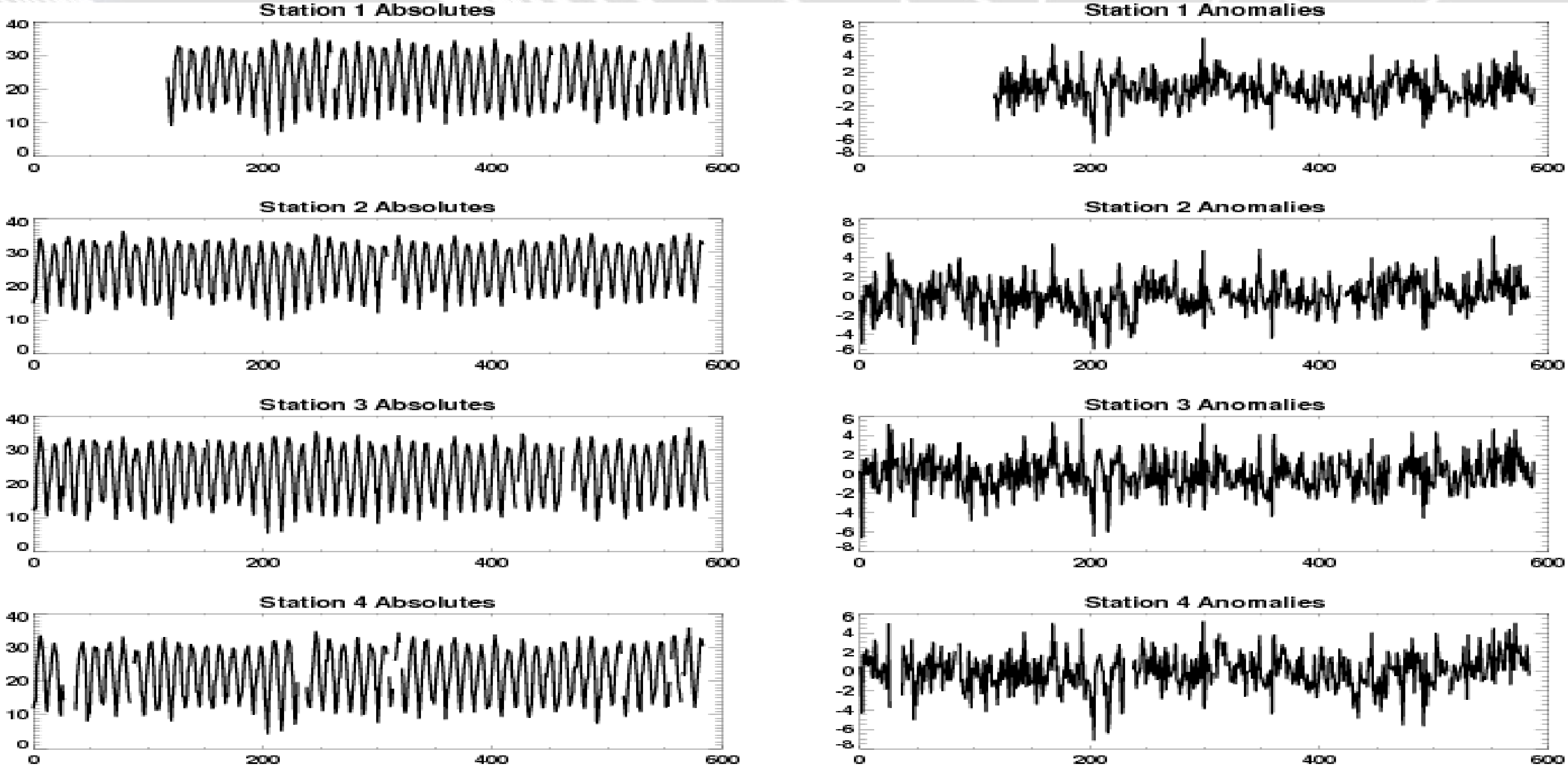
3) Create station weights by distance/elevation from gridbox centre

Centre = 1, >150km = 0.5.



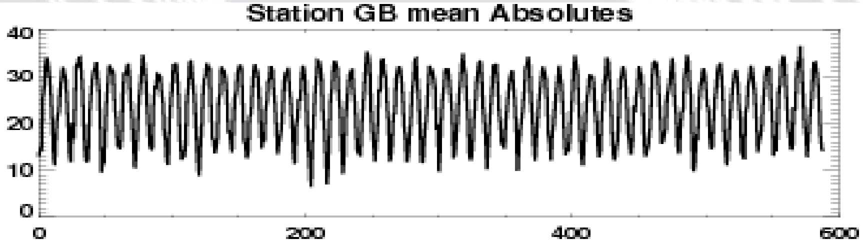
11 Step How To…

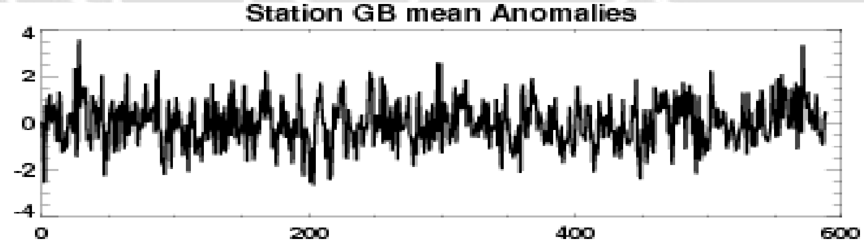
4) Create station climatology, standard deviations, anomalies (subtract month climatology, divide by month standard deviation)



11 Step How To...

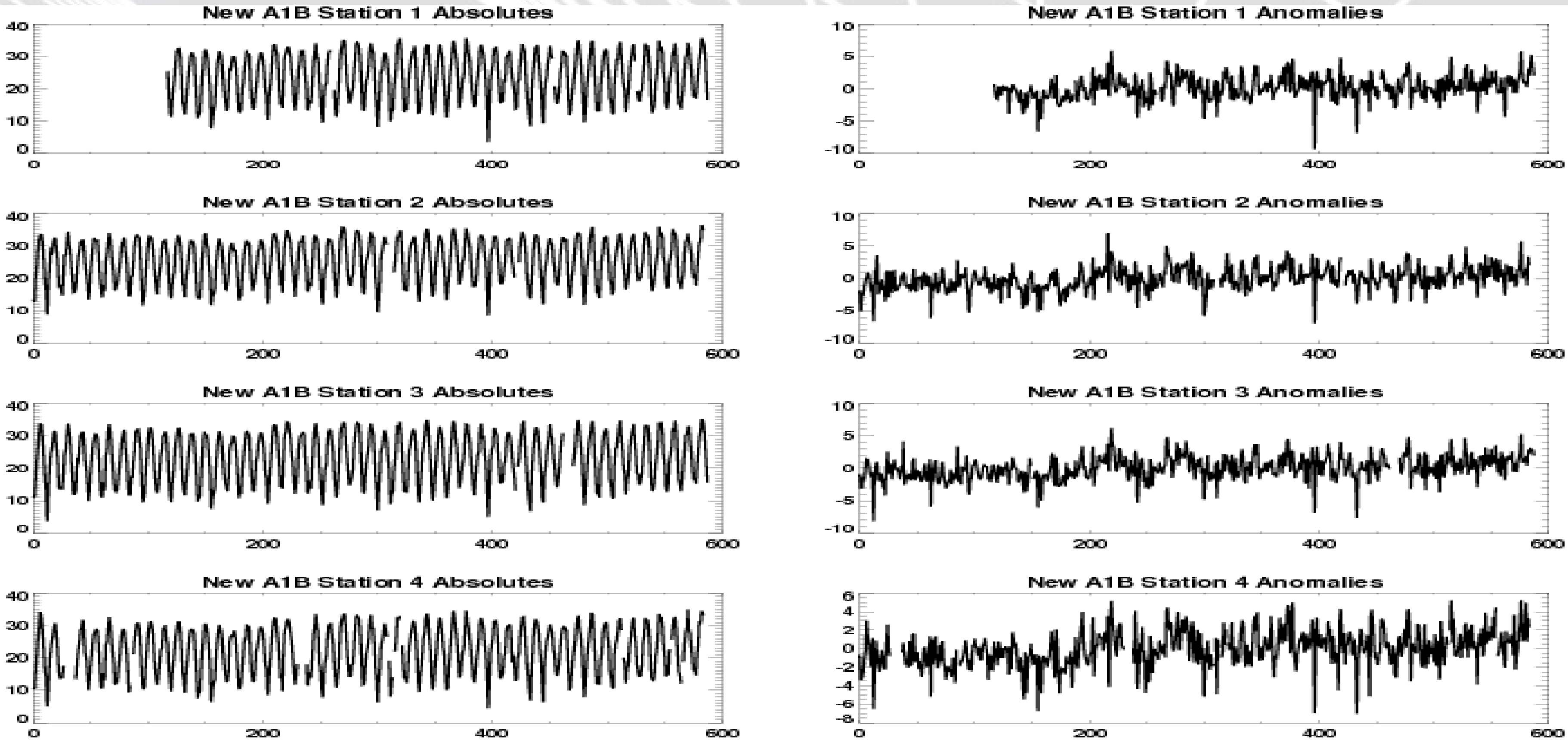
5) Create weighted (using vertical+horizontal distance) gridbox mean from all stations and create anomalies (subtract month climatology, divide by month standard deviation)





11 Step How To...

6) Create station-GBmean difference series:
CAUTION – stations with changepoints may cause problems – these may be introduced into the other station-GBmean series too.



11 Step How To...

7) Test these series to make sure that they are stationary and basically fit an AR(1) model

- Is it possible to detrend these in a way that is consistent across all series?

- Infill missing data with climatology or collapse to present data only?

- treat these series as a matrix [X] n by K:
  - n rows for the number of months in the time series
  - K columns for the number of stations (4)

$$[X] = \begin{matrix} X_{1,1} & X_{1,2} & X_{1,3} & X_{1,4} \\ X_{2,1} & X_{2,2} & X_{2,3} & X_{2,4} \\ \ldots\ldots\ldots & & & \\ \ldots\ldots\ldots & & & \\ X_{n,1} & X_{n,2} & X_{n,3} & X_{n,4} \end{matrix}$$

11 Step How To...

8) Model the multivariate station-GBmean relationship in standardised anomaly space

- do something clever involving a lot of covariance matrices:

  Φ = the autoregressive parameter
  a K by K matrix – fixed over time

  Z_t = the random shock bit
  a K by K matrix for each time point?
  A distribution based on the variance-covariance matrix such that a random value is plucked for each time point?

  Γ = calculated for lag=0 ($\Gamma(0)$?) and lag=1 ($\Gamma(1)$?)

- this gives a way of simulating values of $X_{1-n,1}$, $X_{1-n,2}$... for example based on some initial starting value (?) governed by an AR(1) model which should hopefully replicate the 'noise' in X but hopefully not incorporate any significant systematic bias (tricky – but hoping the differencing will have reduced this)

11 Step How To...

9) Create new difference (i.e., station-GBmean) series for each station using the model:

$$\mathbf{A_t = \phi A_{t-1} + Z_t}$$

- such that

$$[A] = \begin{matrix} A_{1,1} & A_{1,2} & A_{1,3} & A_{1,4} \\ A_{2,1} & A_{2,2} & A_{2,3} & A_{2,4} \\ .... \\ .... \\ A_{n,1} & A_{n,2} & A_{n,3} & A_{n,4} \end{matrix}$$

11 Step How To...

10) Add the standardised anomalies of the Climate model gridbox to each station difference series in A:

- such that

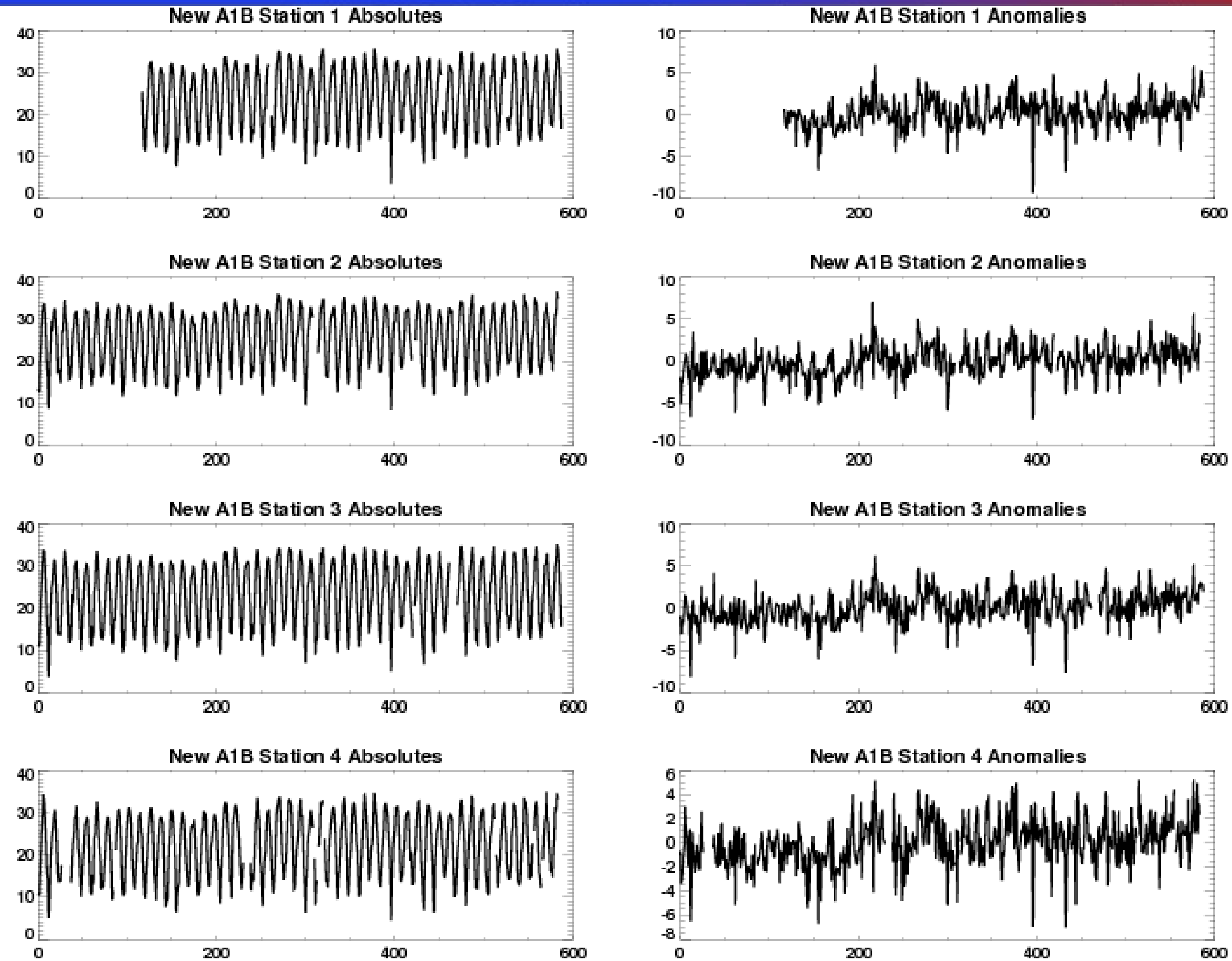
$$[NewStationAnom] = \begin{matrix} GCM_1+A_{1,1} & GCM_1+A_{1,2} & GCM_1+A_{1,3} & GCM_1+A_{1,4} \\ GCM_2+A_{2,1} & GCM_2+A_{2,2} & GCM_2+A_{2,3} & GCM_2+A_{2,4} \\ .... & & & \\ .... & & & \\ GCM_n+A_{n,1} & GCM_n+A_{n,2} & GCM_n+A_{n,3} & GCM_n+A_{n,4} \end{matrix}$$

11) Add back each station's month climatology and multiply by its month standard deviation to product the analog-known-worlds

- may need to add white noise
- mask with actual missing data points from real stations
- CHECK IT DOESN'T CONTAIN ANY CHANGEPOINTS?

This gives 4 analog-known-worlds based on a Climate model background time series using the station microclimate information from the real stations.

Creation: Result?



Same missing data

Same climatological means

Same variance

Similar interstation correlations for a plausible climate scenario over time

No systematic biases