

# A statisticians view of the surge in warming debate

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MET Office Oct 2025

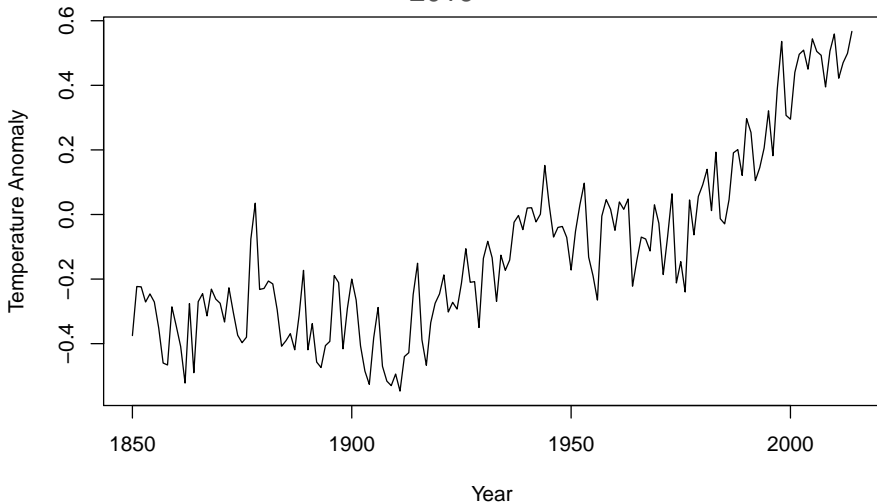
# Where my interest began

School of  
Mathematical Sciences

Lancaster  
University



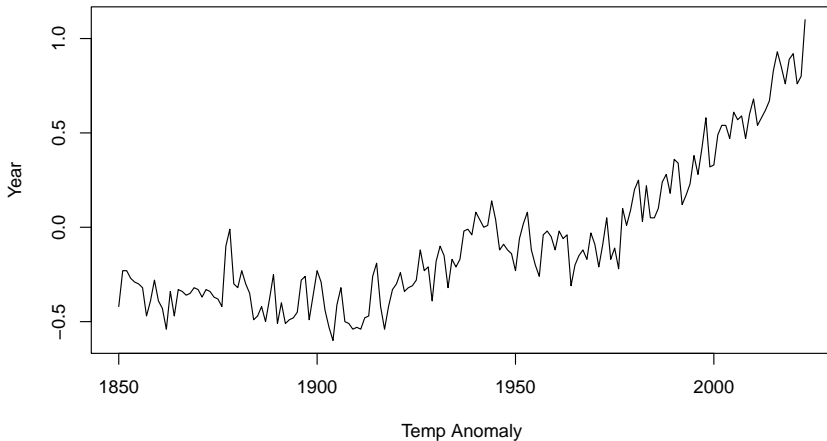
2016



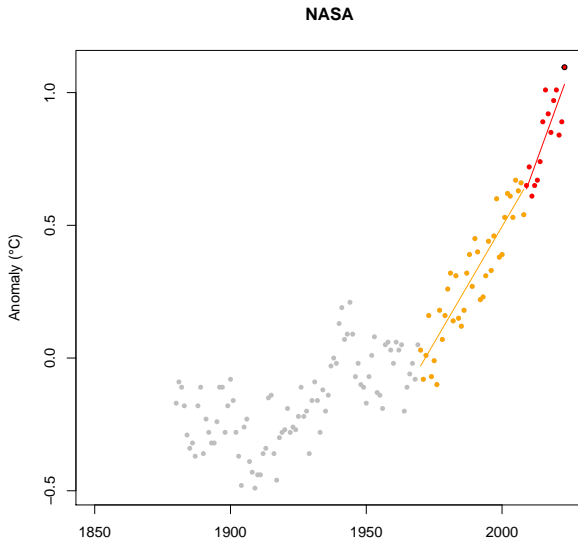
# Global Mean Temp



2024



# Where is Statistics? NYT

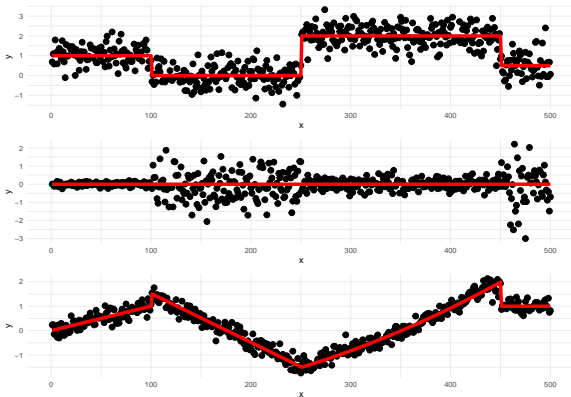


# What are changepoints?

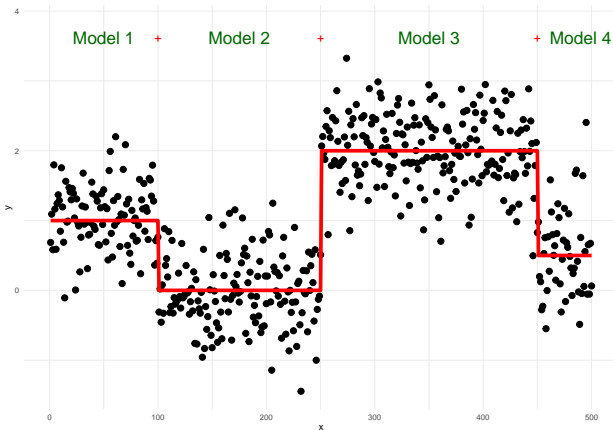


For data  $y_1, \dots, y_n$ , if a changepoint exists at  $\tau$ , then  $y_1, \dots, y_\tau$  differ from  $y_{\tau+1}, \dots, y_n$  in some way.

There are many different types of change.



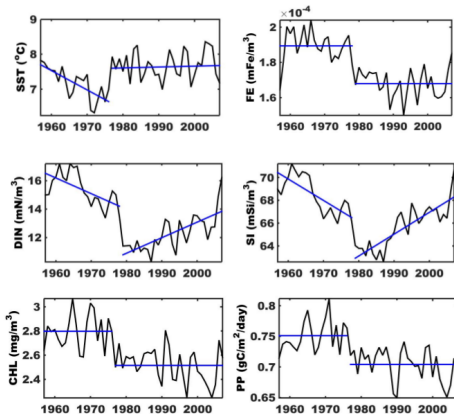
# Problem



- How many changes?
- Where are the changes?  $2^{n-1}$  possible solutions!

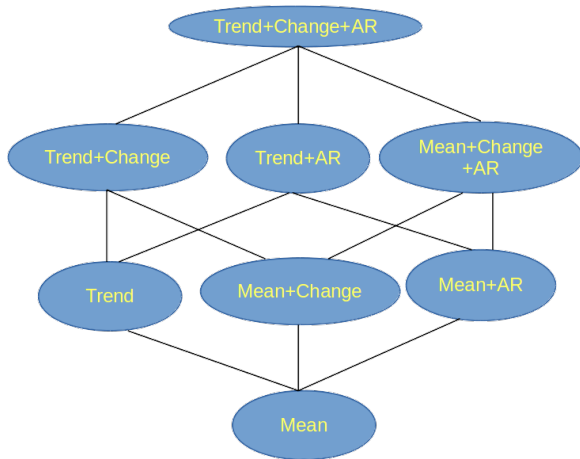


- potentially hundreds or thousands of series
- no time to consider the format of change for each
- need to include both the potential for trends and also red noise (autocorrelation).

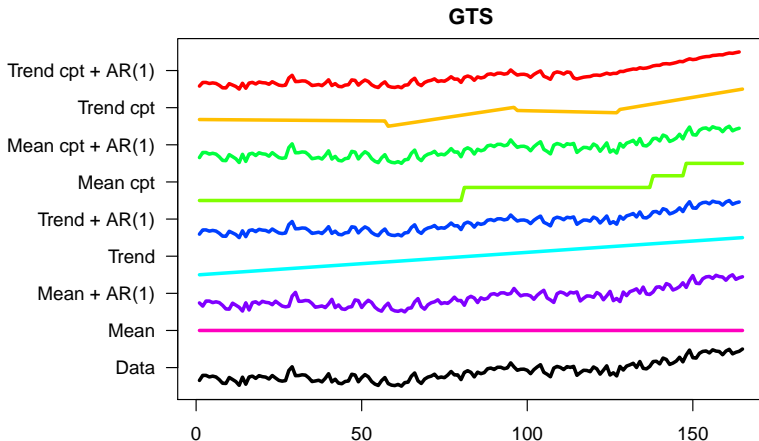




EnvCpt: select the most parsimonious but accurate model for the data. Simple to extend with other types of models.





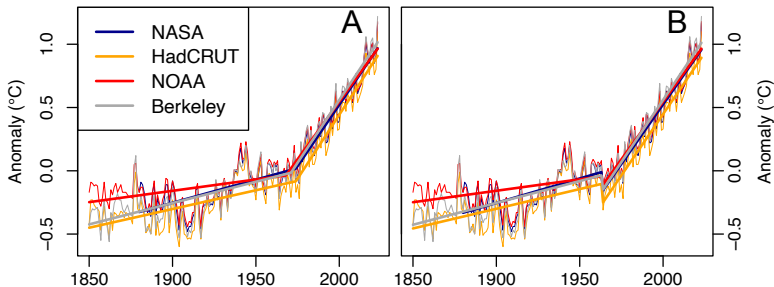


$$Y_t = \theta_i + \frac{\theta_{i+1} - \theta_i}{\tau_{i+1} - \tau_i}(t - \tau_i) + Z_t$$

but  $Z_t$  is AR( $p$ ),  $Z_t = \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \dots + \phi_p Z_{t-p} + \epsilon_t$ .

Challenge:

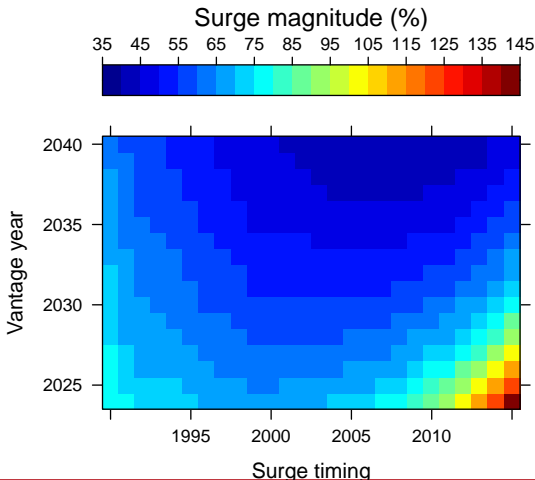
- Definition of join-pin
- Fitting AR parameter across segments:
  - Fixed we use EM algorithm
  - Varying we can embed in PELT



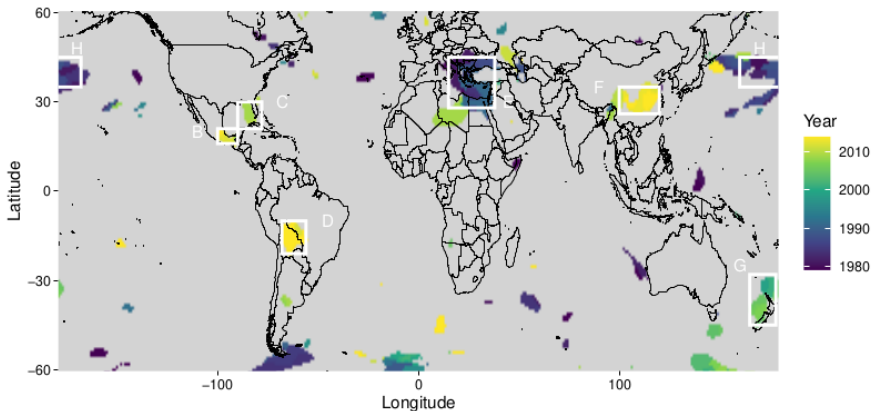
# So what?



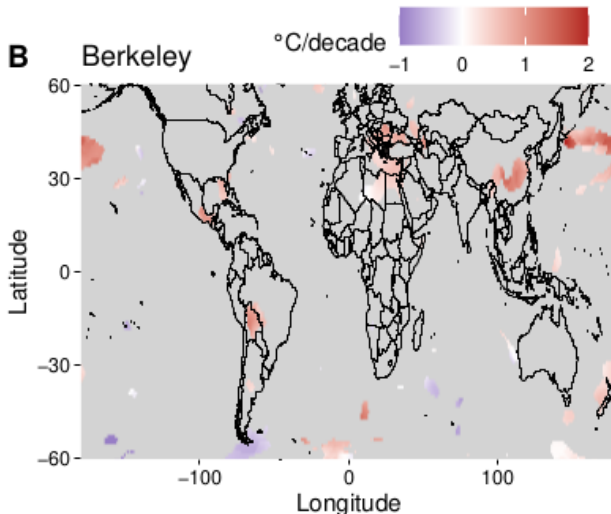
What would we need to see (in the statistically preferred model).



# Extension to gridded



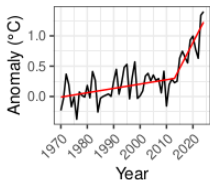
# Extension to gridded



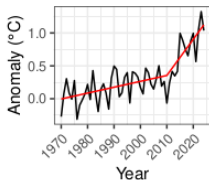
# Extension to gridded



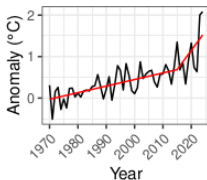
**B** Southeast Mexico



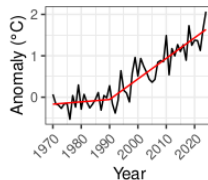
**C** Gulf of Mexico



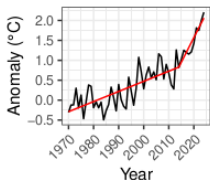
**D** Bolivia



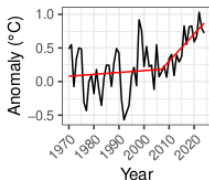
**E** East Mediterranean



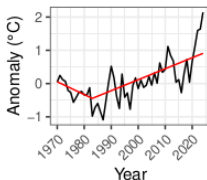
**F** Southeast China



**G** New Zealand



**H** North Pacific



- Not accounting for autocorrelation can lead to spurious changes!
  - Detecting and documenting changepoints improves analyses ...
  - ... and can help answer pertinent questions in different domains
- 
- Extending to more complex model structures is interesting statistically
  - Extending to include covariates is interesting climatically
  - Moving to monthly increases noise and seasonal challenges but could be worth the tradeoff for increased dataset size
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- I enjoy working with different disciplines ...
  - ... as often it sparks my next research challenge.



Preprints of all available at: [www.lancs.ac.uk/~killick/pub.html](http://www.lancs.ac.uk/~killick/pub.html)

PELT: <https://doi.org/10.1080/01621459.2012.737745>

Model Choice: <https://doi.org/10.1175/JCLI-D-17-0863.1> &  
<https://doi.org/10.1002/qre.2712>

LMvsCpts: <https://doi.org/10.1007/s11222-017-9731-0> &  
<https://doi.org/10.1002/env.2568>

Warming Surge: <https://doi.org/10.1038/s43247-024-01711-1>

Regional warming surge: On ArXiv in the next few days