Numerous abrupt changes in Great Britain vegetation carbon projected under climate change

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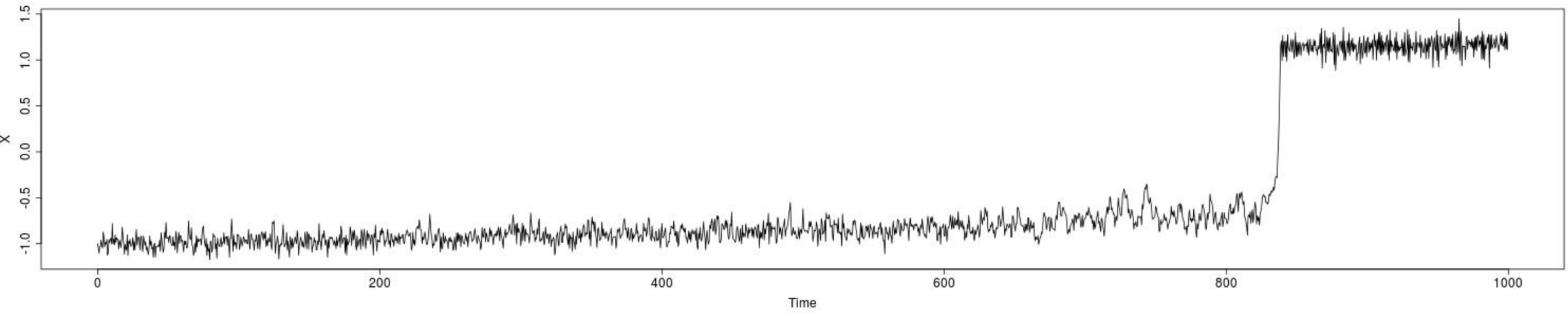
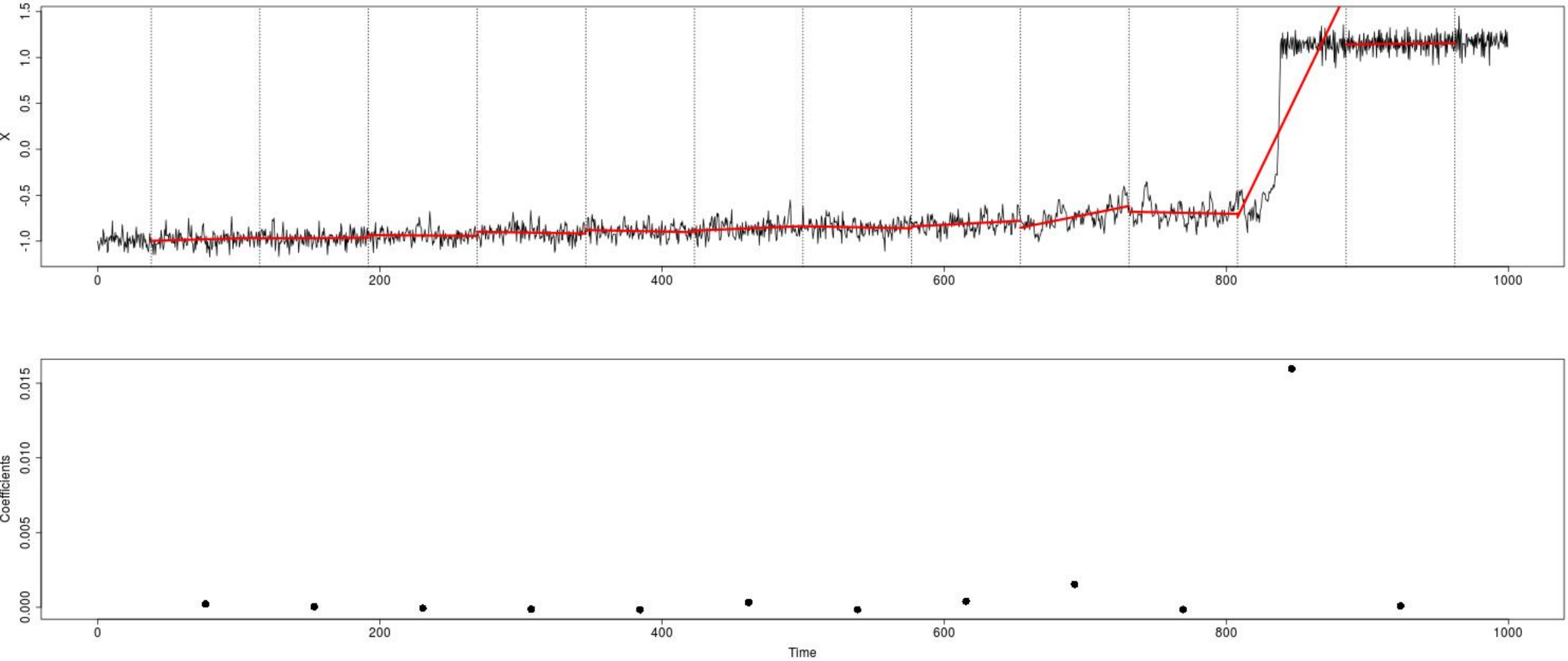


How do we detect that an abrupt shift has occurred?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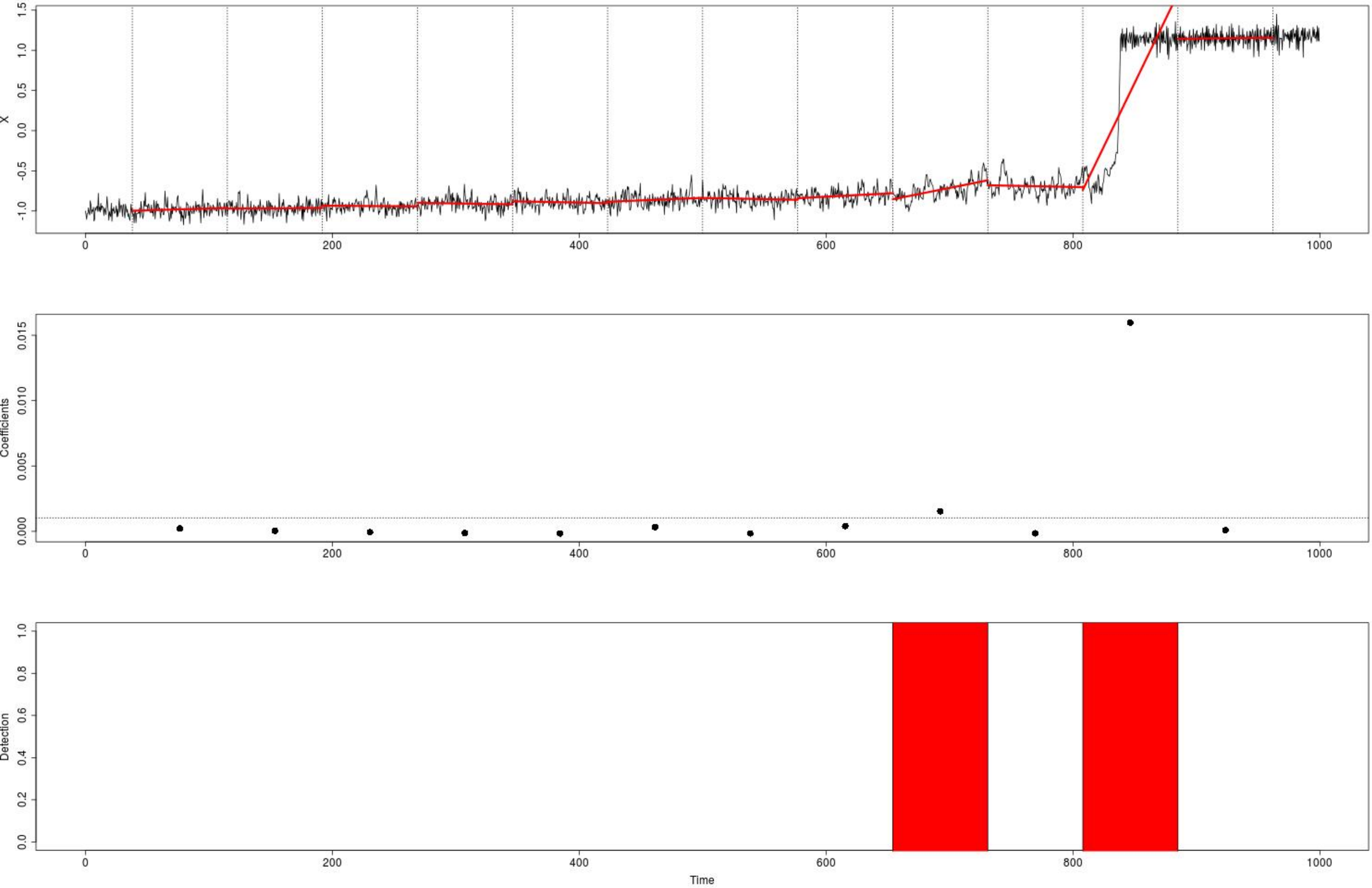
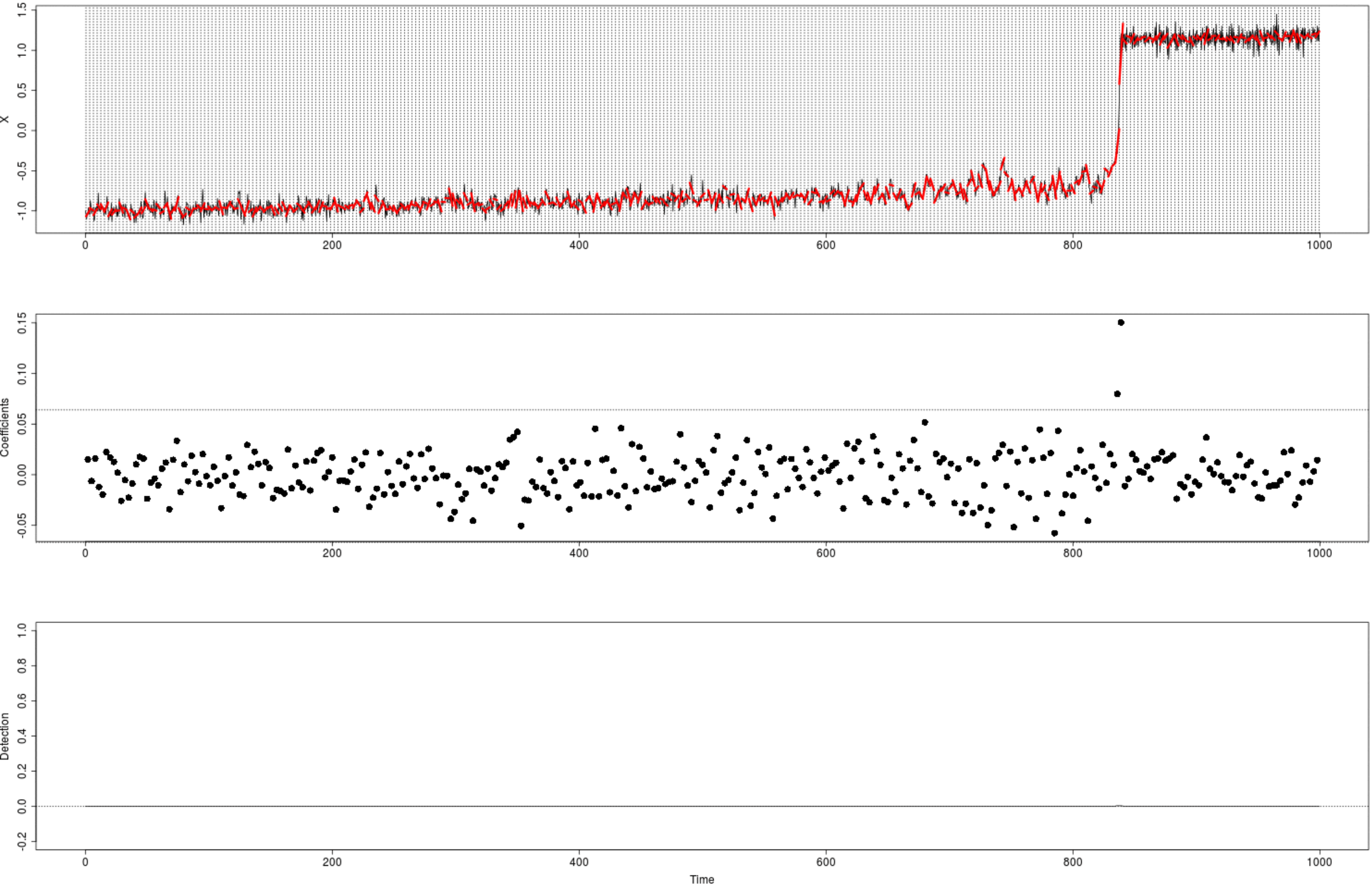
1.0
0.5
0.0
-0.5
-1.0
0
200
400
600
800
1000
Coefficients
0.015
0.010
0.005
0.000
0
200
400
600
800
1000
Time


X
1.5
1.0
0.5
0.0
-0.5
-1.0
0
200
400
600
800
1000
Coefficients
0.015
0.010
0.005
0.000
0
200
400
600
800
1000
Detection
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
Time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1.0
0.5
0.0
-0.5
-1.0
0
200
400
600
800
1000
Coefficients
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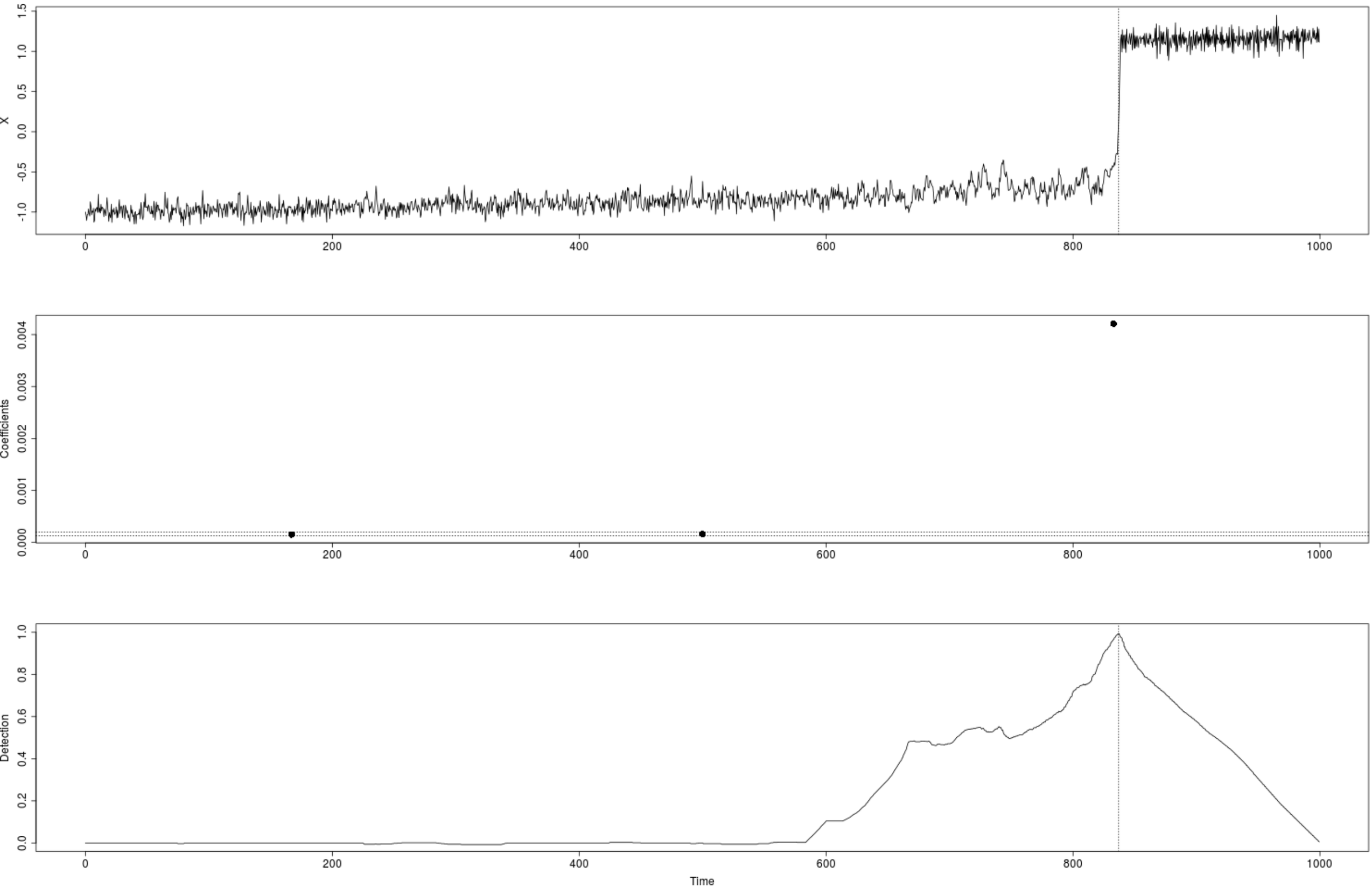
0.10
0.05
0.00
-0.05
0
200
400
600
800
1000
Detection
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0
200
400
600
800
1000
Time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0.5
0.0
-0.5
-1.0
0
200
400
600
800
1000
Coefficients
0.004
0.003
0.002
0.001
0.000
0
200
400
600
800
1000
Detection
1.0
0.8
0.6
0.4
0.2
0.0
0
200
400
600
800
1000
Time

Model Information

- Joint UK Land Environment Simulator (JULES) is forced with climate change from 2 members of the HadRM3-PPE-UK ensemble (part of UKCP09).

- Both of these force JULES with fixed, present day CO_2 and A1B (balanced) CO_2 growth. This gives 4 simulations in total.

Standard configuration - 3.5K climate sensitivity

Largest climate change - 7.1K climate sensitivity

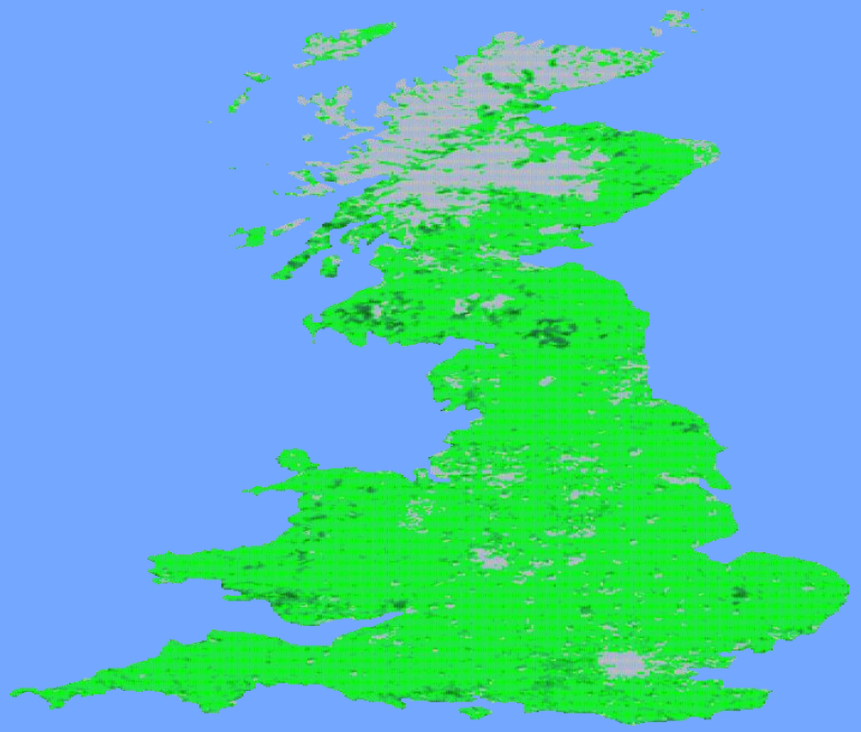
- Vegetation is driven by the TRIFFID DGVM.

- Calculates CO_2 fluxes, heat, water, etc between atmosphere and land and models 5 PFTs.

- Land mask prevents vegetation growing in urban areas.

- Runs at 1.5km x 1.5km resolution - 77980 land grid boxes.

1998-2007
Vegetation Carbon

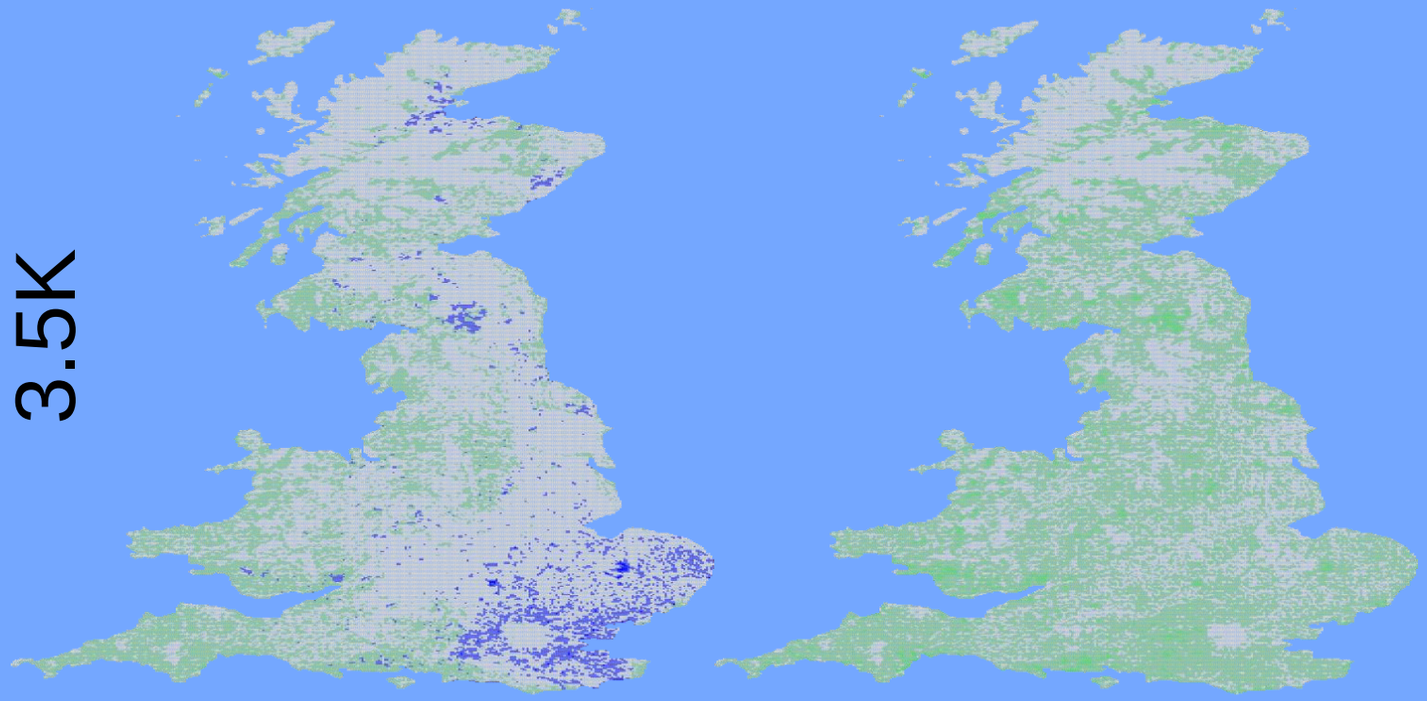


(Similar for all runs)

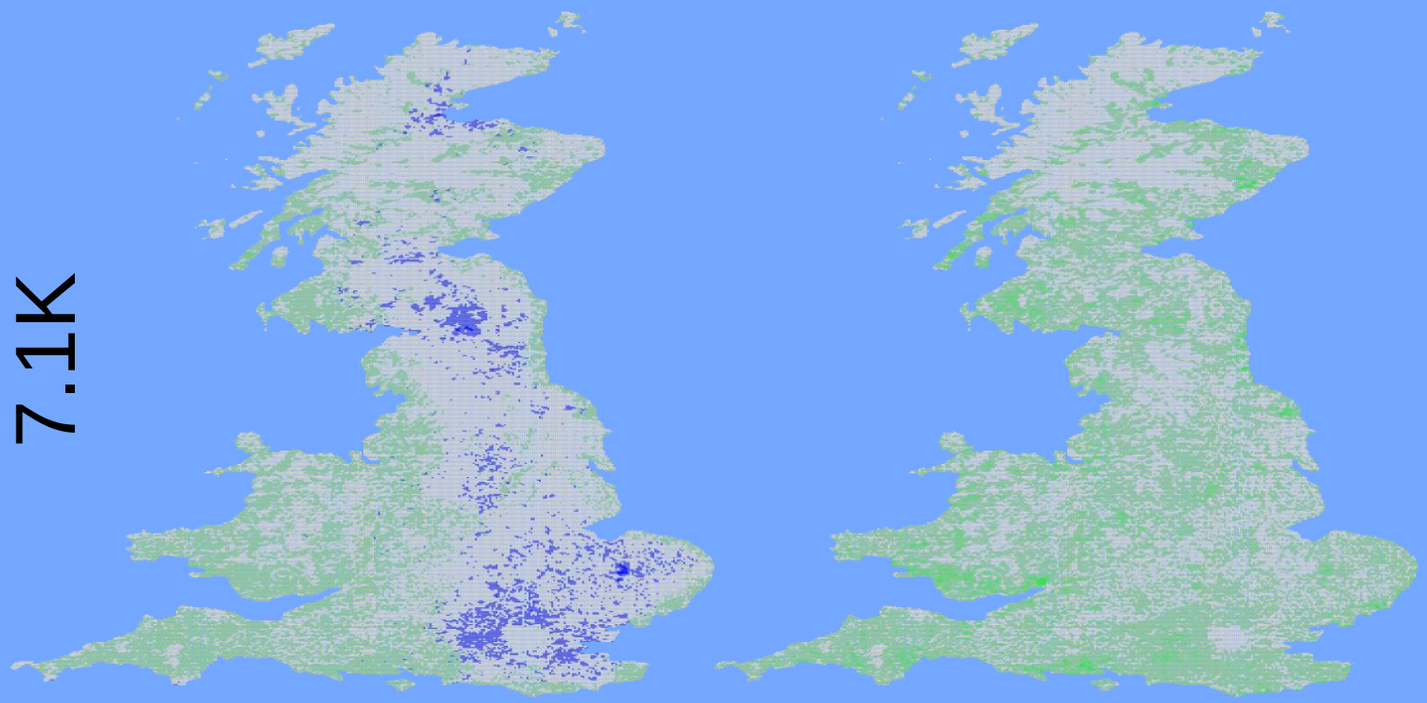
Const. CO_2

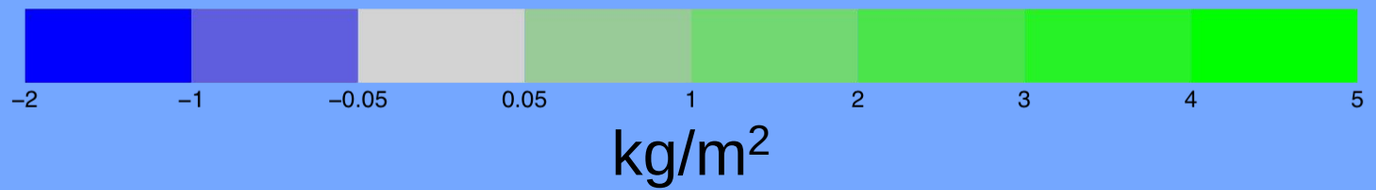
A1B CO_2

3.5K



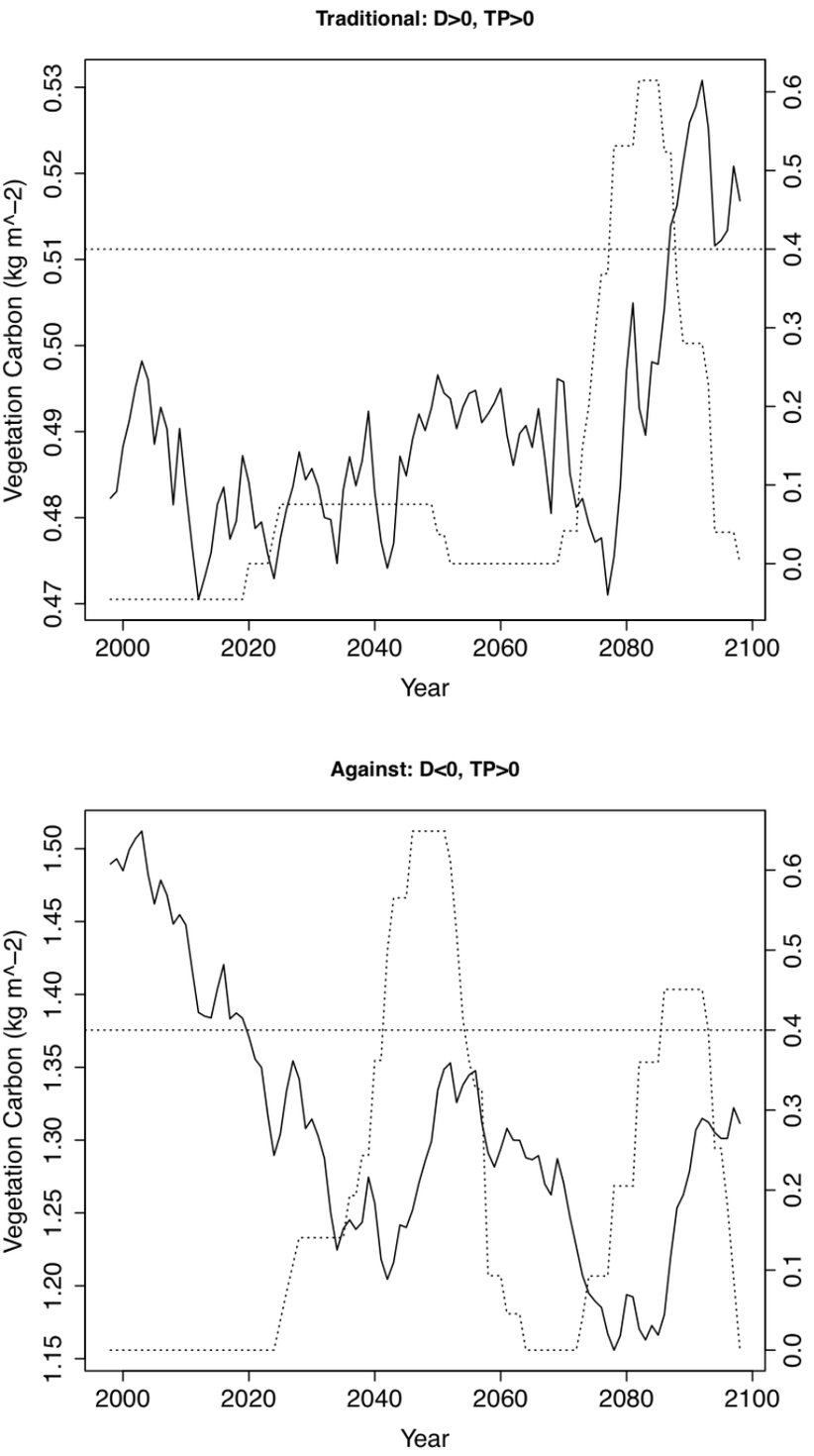
7.1K

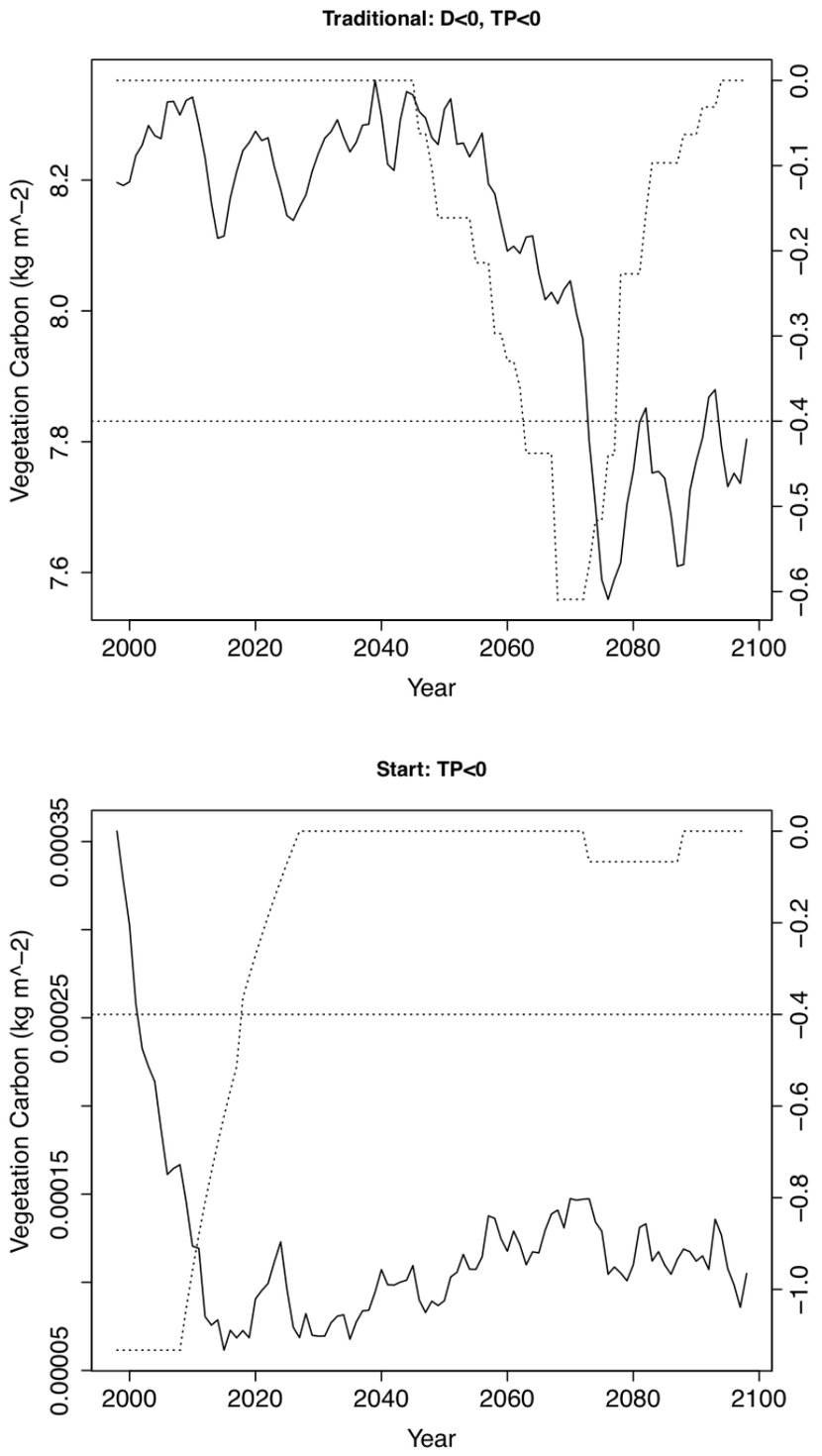


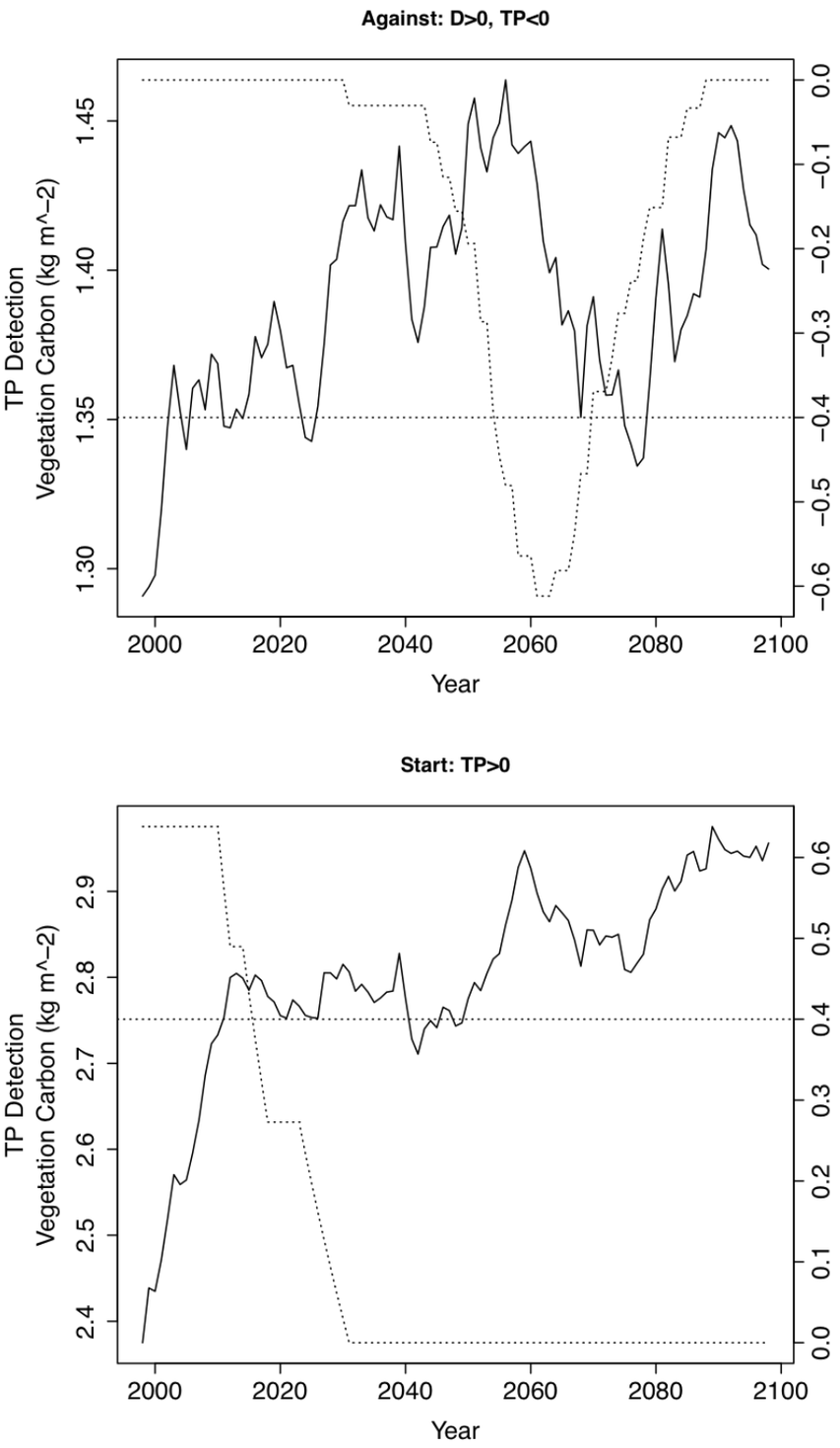


2098-2089 - 1998-2007 Vegetation Carbon

Vegetation Carbon Abrupt Shift Types

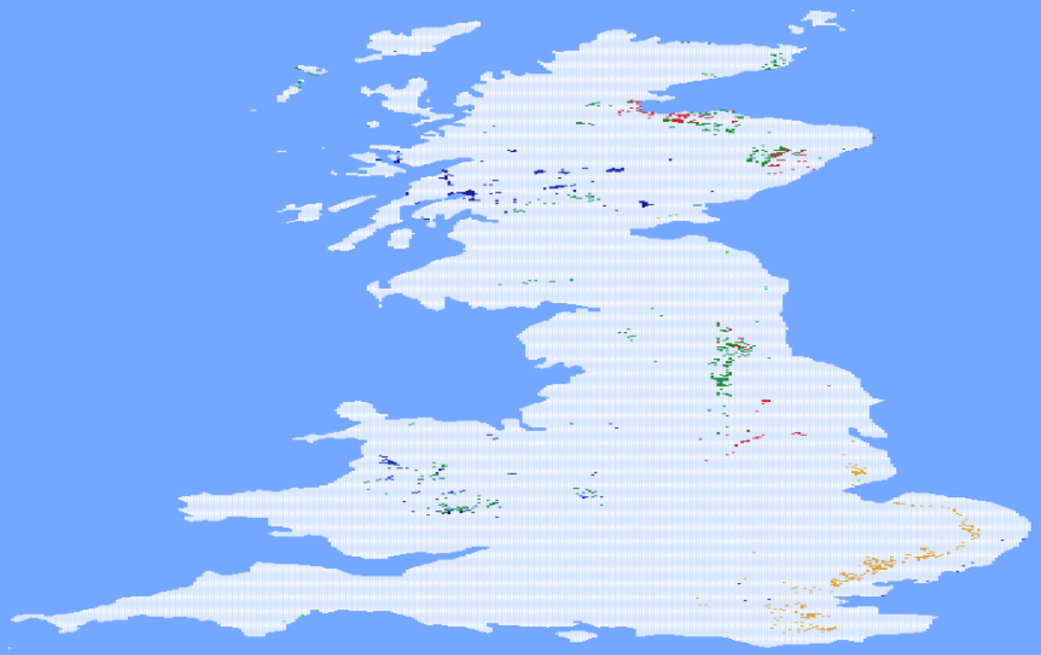


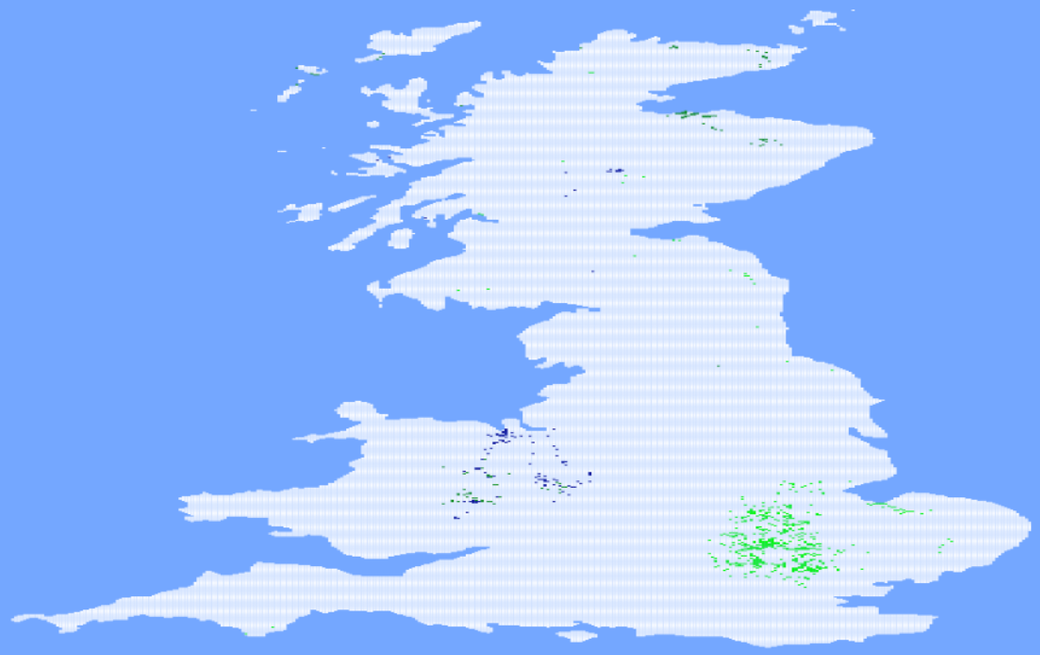




3.5K – Const. CO2

3.5K – A1B CO2





Traditional: D>0, AS>0

Traditional: D<0, AS<0

Against: D>0, AS<0

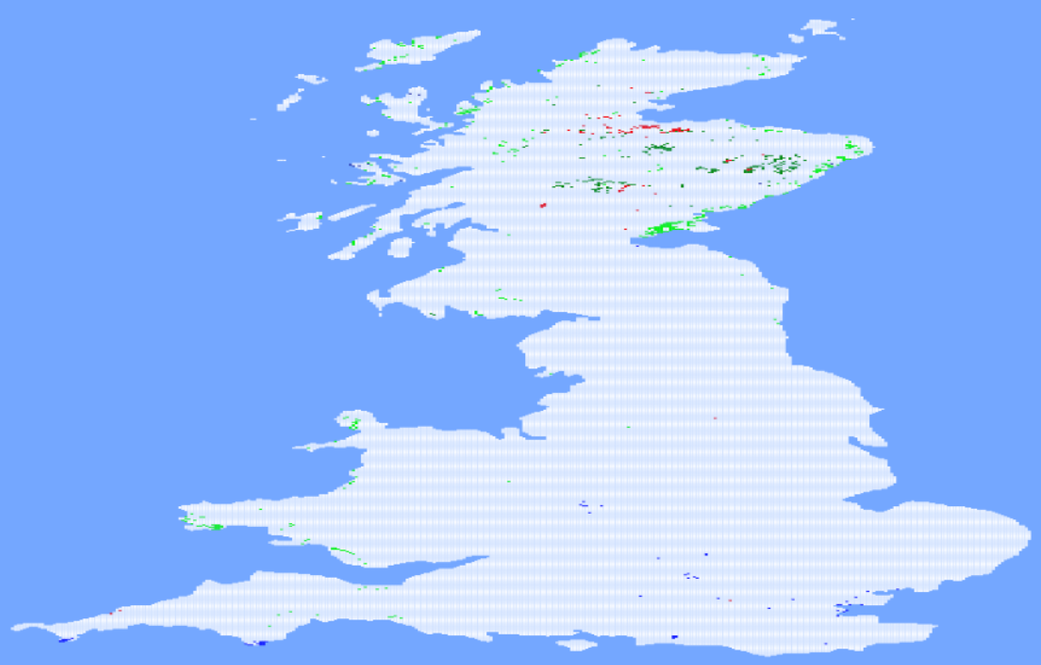
Against: D<0, AS>0

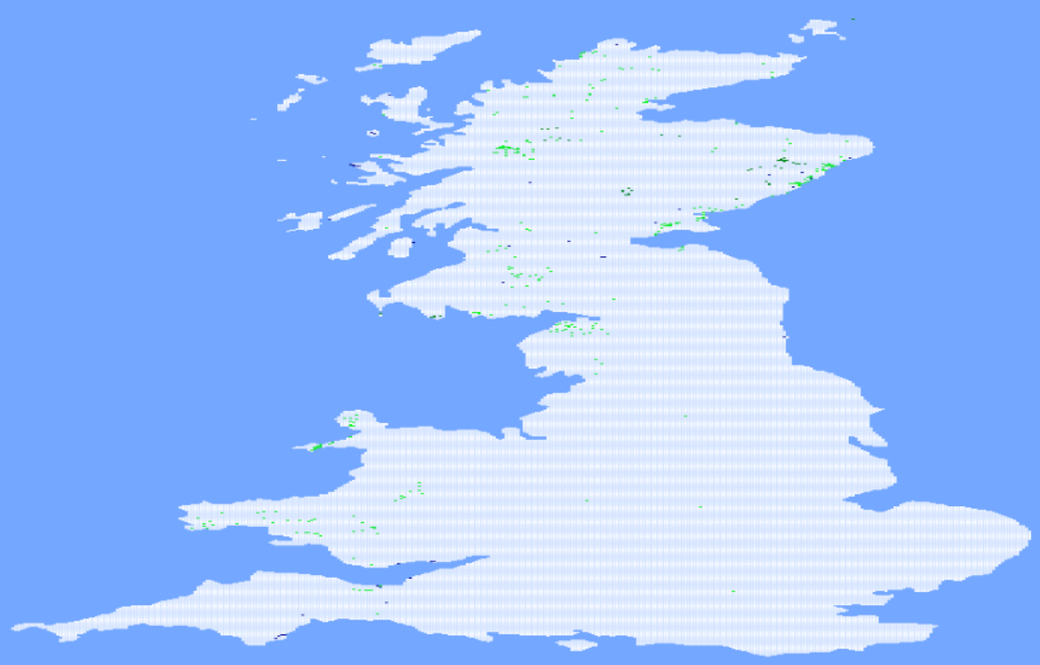
Start: AS<0

Start: AS>0

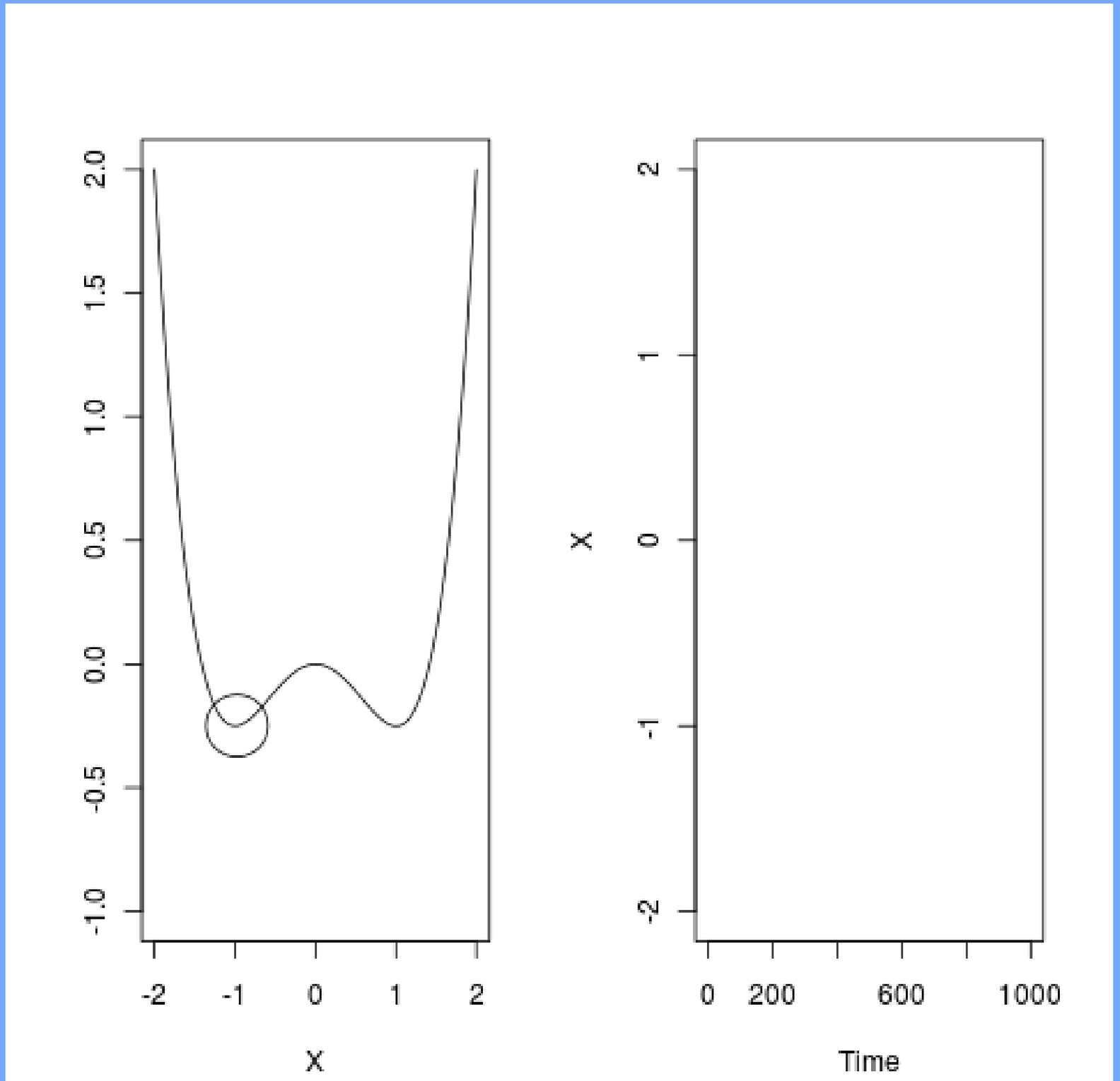
7.1K – Const. CO2

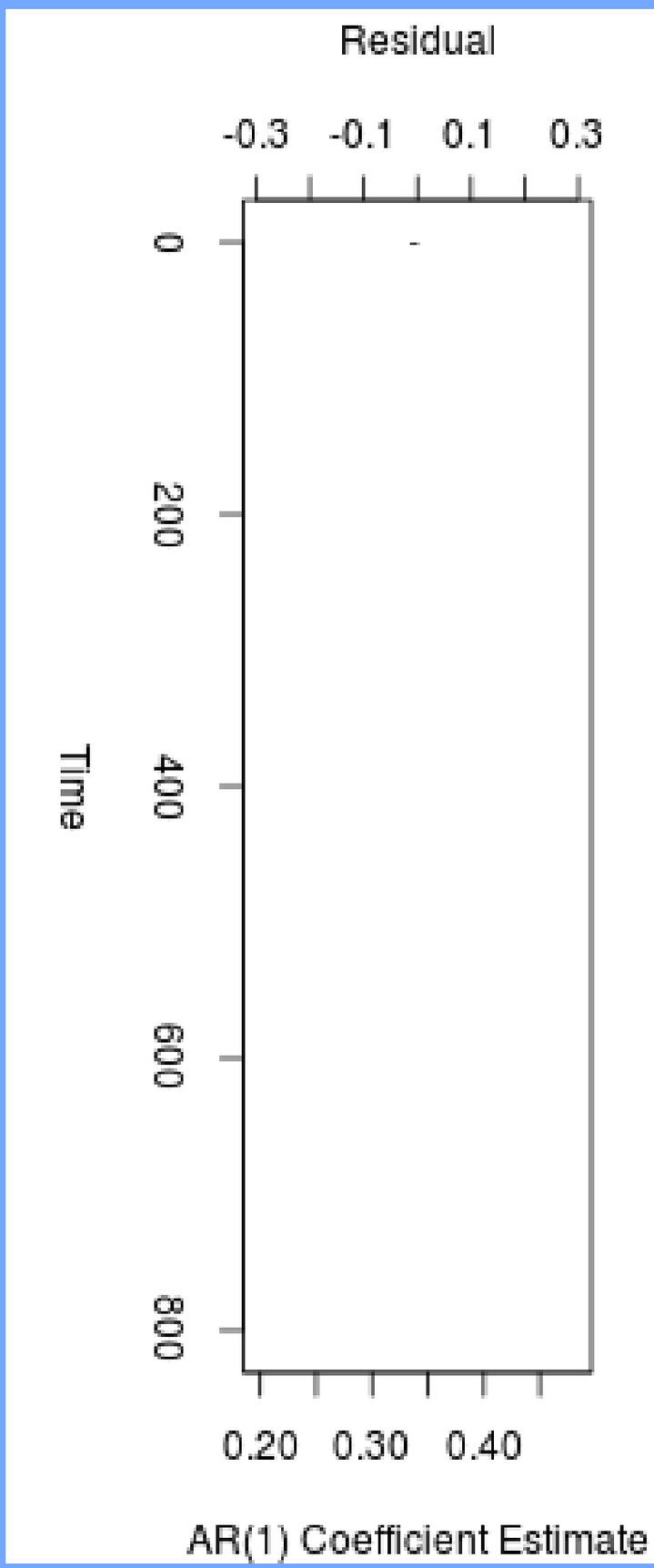
7.1K – A1B CO2

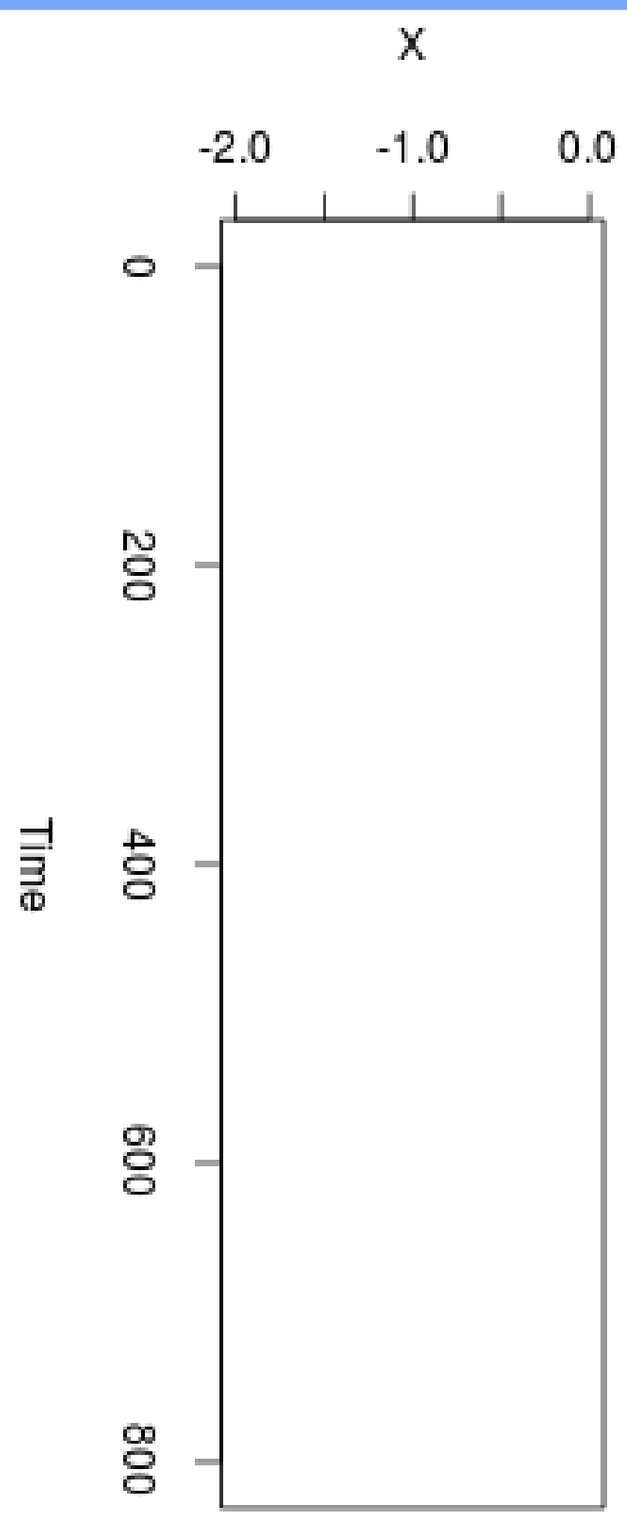




Gridboxes that have a detected vegetation carbon abrupt shift (detection > 0.4)


2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-2
-1
0
1
2
X
2
1
0
-1
-2
X
0
200
600
1000
Time


Residual
-0.3
-0.1
0.1
0.3
0
200
400
600
800
Time
0.20
0.30
0.40
AR(1) Coefficient Estimate


X
-2.0
-1.0
0.0
0
200
400
600
800
Time

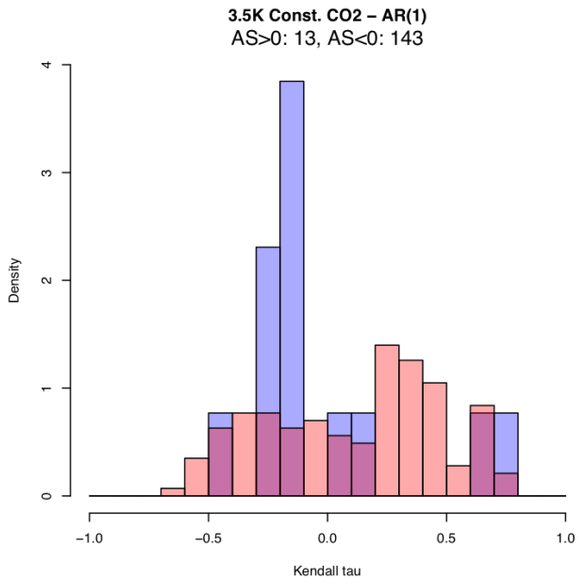
Early Warning Signals

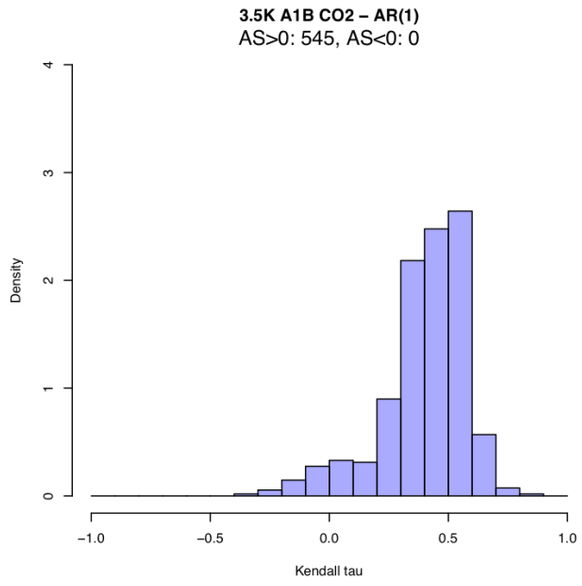
- We look for early warning signals on ‘traditional’ abrupt shifts.
- Both AR(1) and Variance are calculated on a window length equal to half the distance to the detected shift time.
- We use a Mann-Kendall test to determine the tendency of indicators:
  - +1 always increasing
  - -1 always decreasing
  - 0 no tendency either way

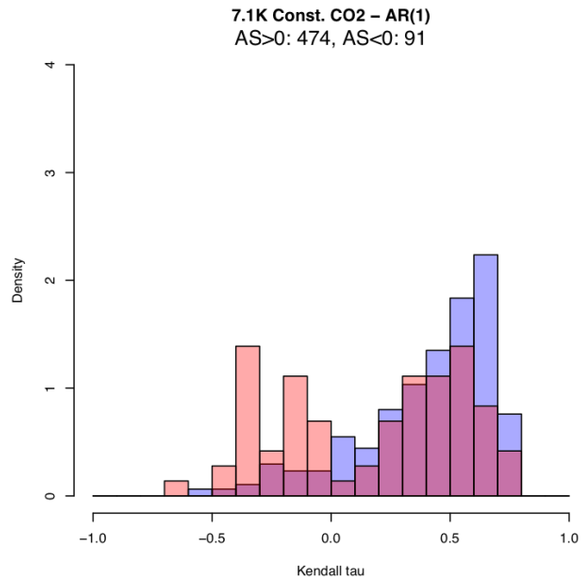
	D>0, AS>0	D<0, AS<0
3.5K, Const. CO_2	13	143
3.5K, A1B CO_2	545	0
7.1K, Const. CO_2	474	91
7.1K, A1B CO_2	296	0

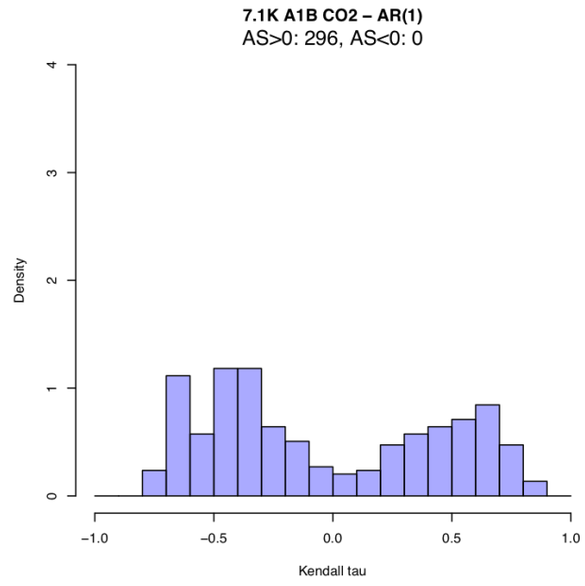
Traditional shifts

AR(1)

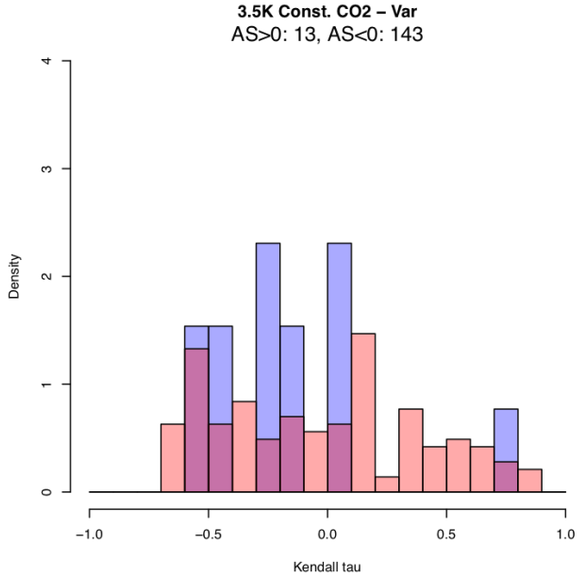


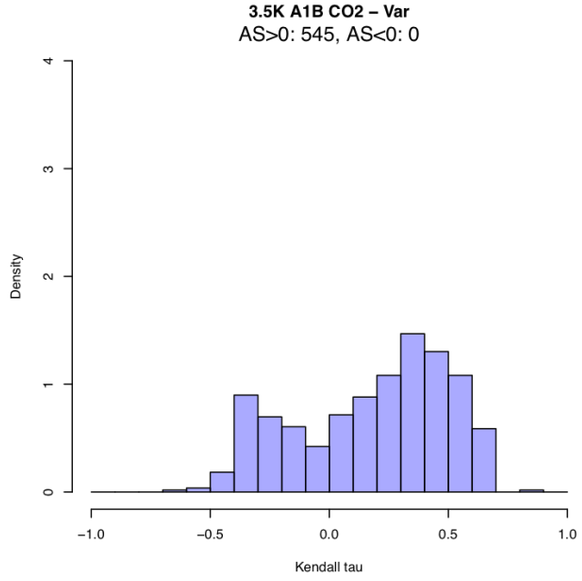


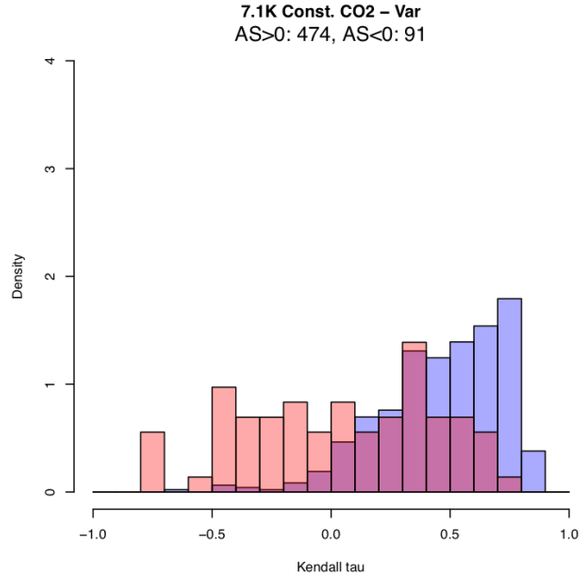


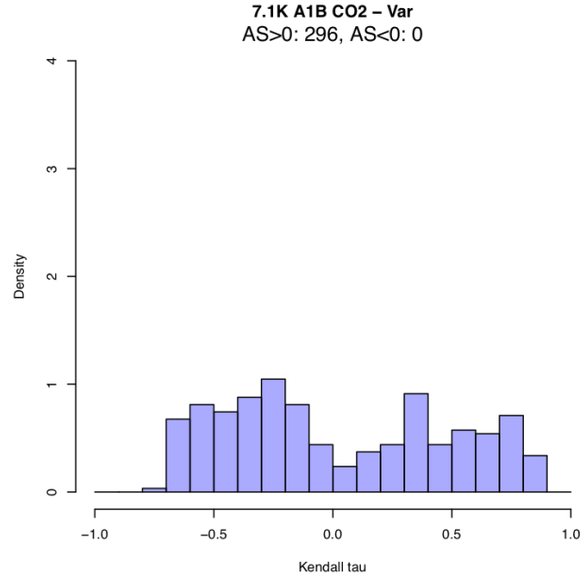


Variance









D>0, AS>0 - Blue

D<0, AS<0 - Red

Summary

- We use a novel detection algorithm to find a number of different shifts in modelled vegetation carbon in Great Britain under future climate change.
- These shifts are not linked to shifts in climate and are a truly non-linear response (not shown).
- There is potential in early warning signals, particularly for increasing abrupt shifts.
  - This may be linked to the vegetation type that is associated with the shift, i.e. grasses potentially show promising signs.

References

Boulton, C. A. & Lenton, T. M. (2019) A new method for detecting abrupt shifts in time series [version 1; peer review: 2 approved with reservations], f1000research, 8:746

Boulton, C. A., Ritchie, P. & Lenton, T. M. (2019) Numerous abrupt shifts in Great Britain vegetation carbon projected under climate change, submitted to Global Change Biology