Identifying potential tipping points in the benefits derived from the UK's land ecosystems

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Introduction

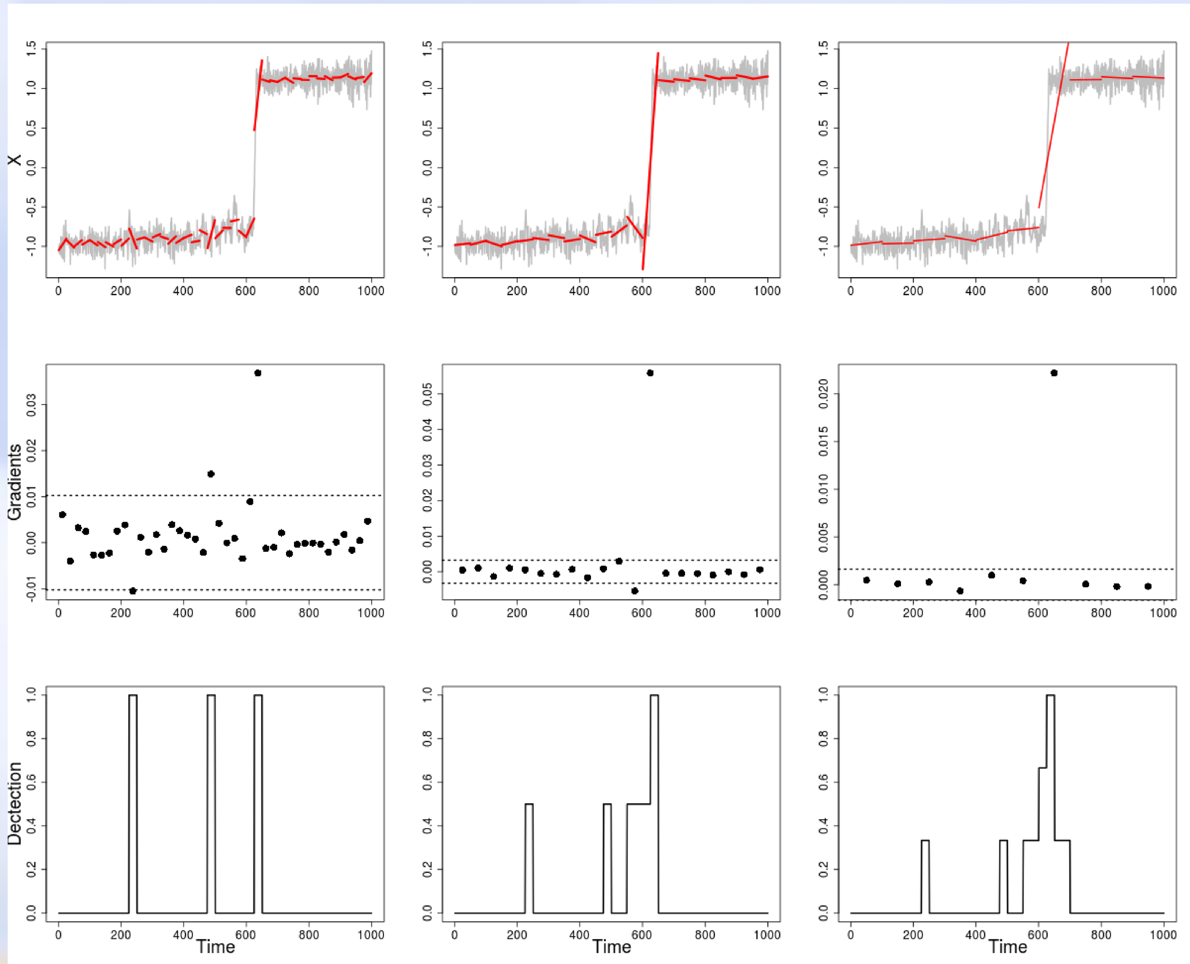
- Our project seeks to detect tipping point behaviour in both ecosystems and ecosystem services at a local scale due to climate and policy changes over this century.
- To do this, we have run the Joint UK Land Environment Simulator (JULES) at high spatial resolution and created a detection algorithm to identify abrupt shifts in time series.
- We have also used the Natural Environment Valuation (NEVO) tool to examine how both a tipping point in climate and/or policy could alter arable farming over the UK.

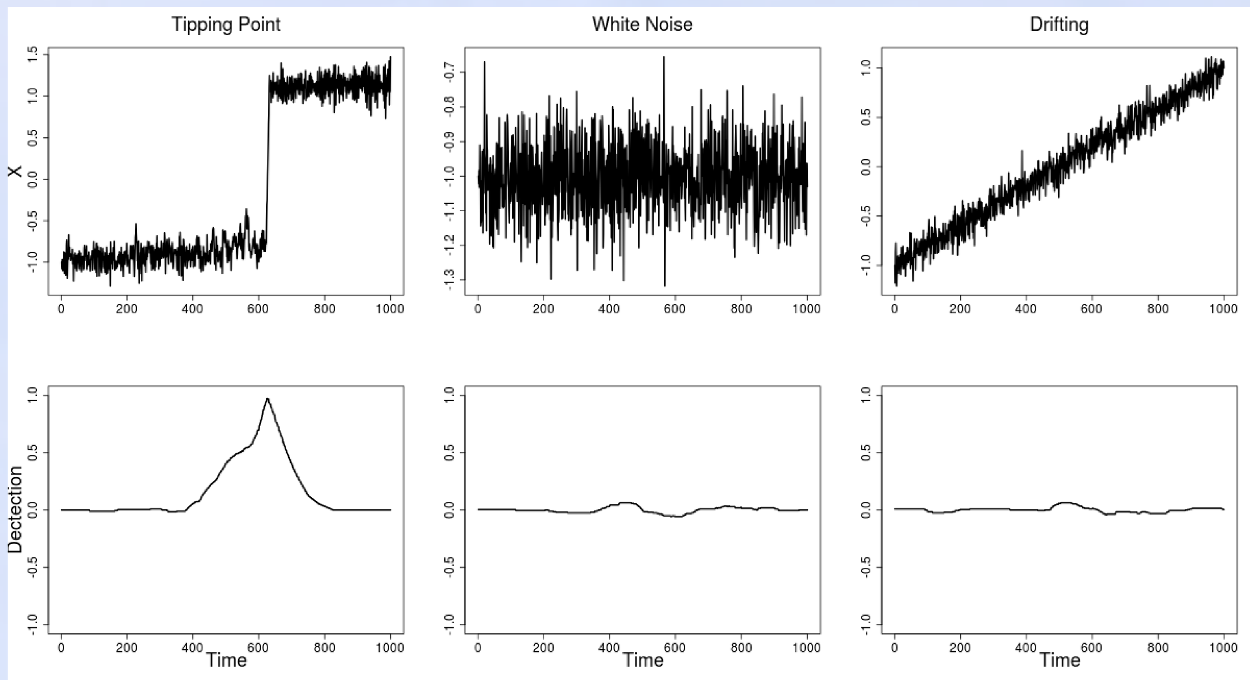
JULES

- JULES is driven by climatological data from two members of HadRM3-PPE-UK, an ensemble that simulates regional UK climate over the next century.
- Climate-driving data is scaled from 25km to a 1.5km resolution.
- We run both ensemble members with constant CO2 and SRES A1B scenario emissions, creating four simulations in total.
- A land mask is used to prevent vegetation growing in urban areas.

Abrupt Shift Detection

- By eye, abrupt shifts are detected by looking for differences in the gradient of a time series.
- We have created an algorithm that looks for significantly different gradients in subsections of the time series.
- A 'detection time series' is created where 1 is added (subtracted) to time points that contribute to the significant positive (negative) gradient. We repeat this for a number of different window lengths and divide the detection time series by the number of window lengths used.

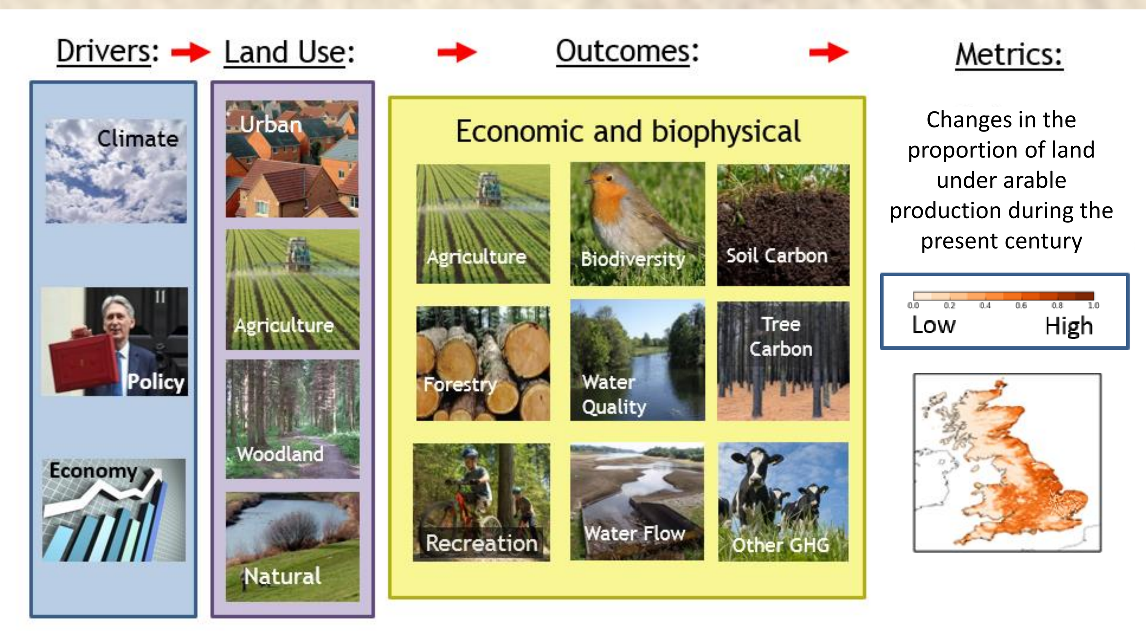




- Detection algorithm can detect tipping points without giving a signal for stationary or drifting white noise time series.
- A threshold value can be decided by the user to determine if a tipping point is discovered.

NEVO

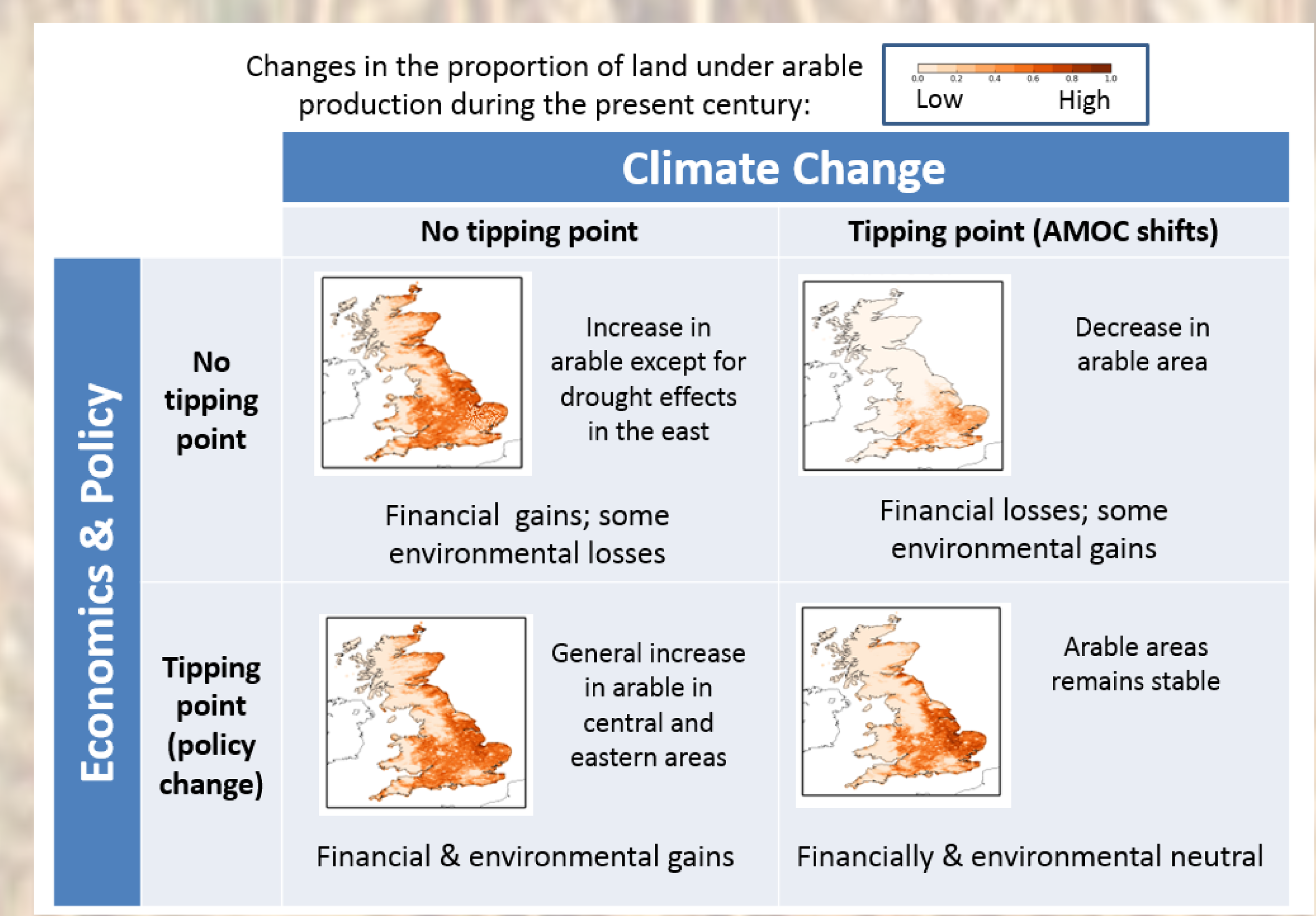
- The Natural Environment Valuation Online tool calculates value placed on ecosystems based on climate, policy and economy.



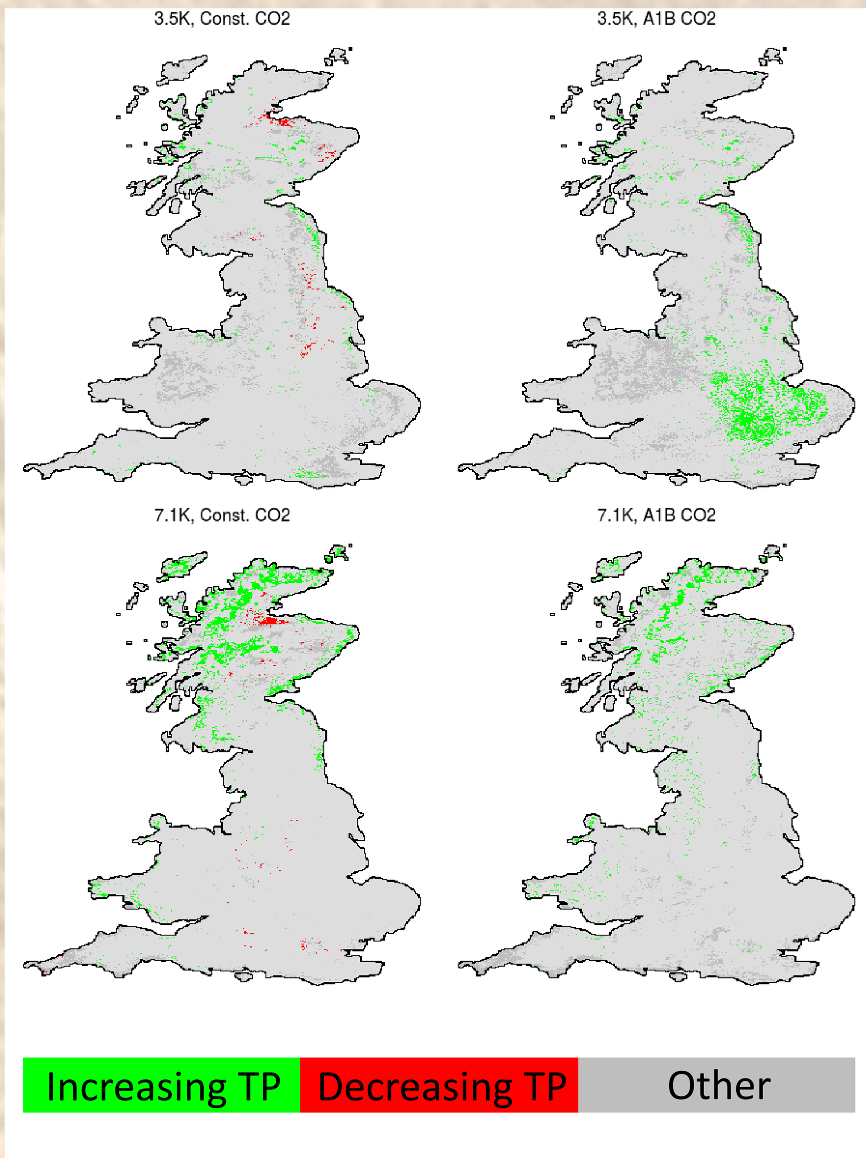
- For individual gridboxes, it takes in drivers to create a land use make-up (proportionally made up of components such as woodland and agriculture).
- From these, different metrics or values can be determined based on the land use and population amongst others.

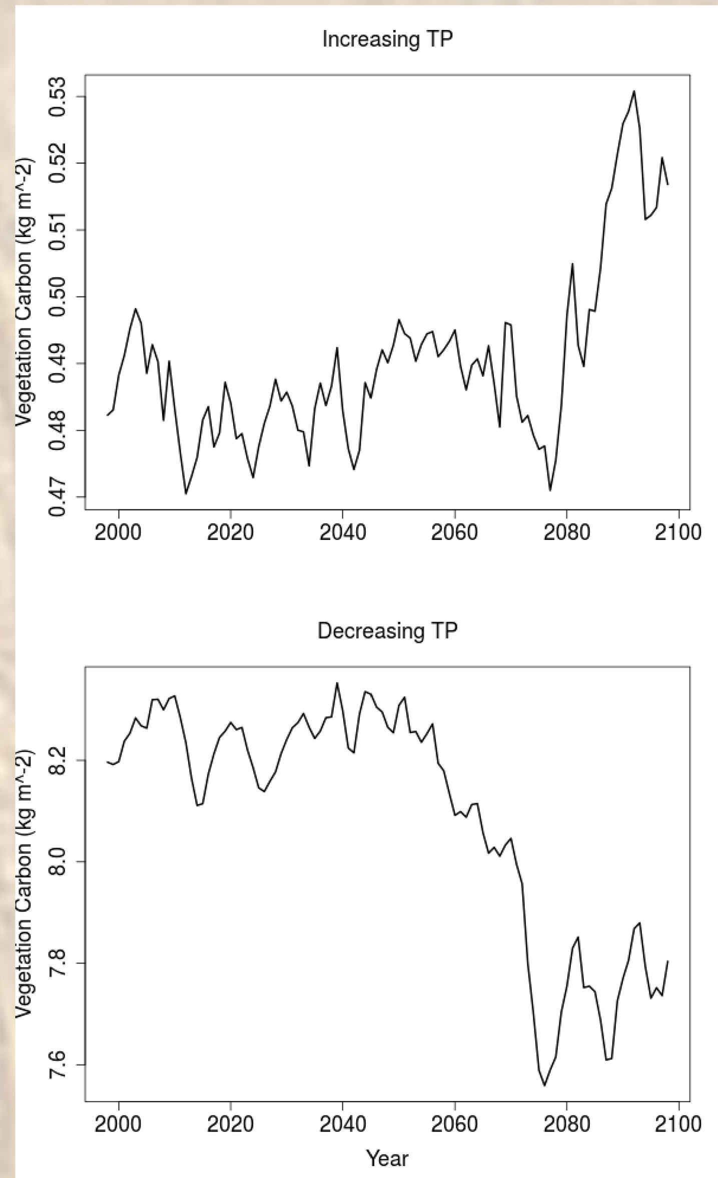
Climate and Policy Tipping Points

- We run four simulations of NEVO to examine the effects of a climate tipping point, shutdown of the Atlantic Meridional Overturning Circulation (AMOC), and a policy tipping point (changes to irrigation practices to counteract loss of precipitation with AMOC shutdown).
- Results suggest that AMOC shutdown without policy change gives financial losses (but environmental gains), but policy changes can prevent this loss.

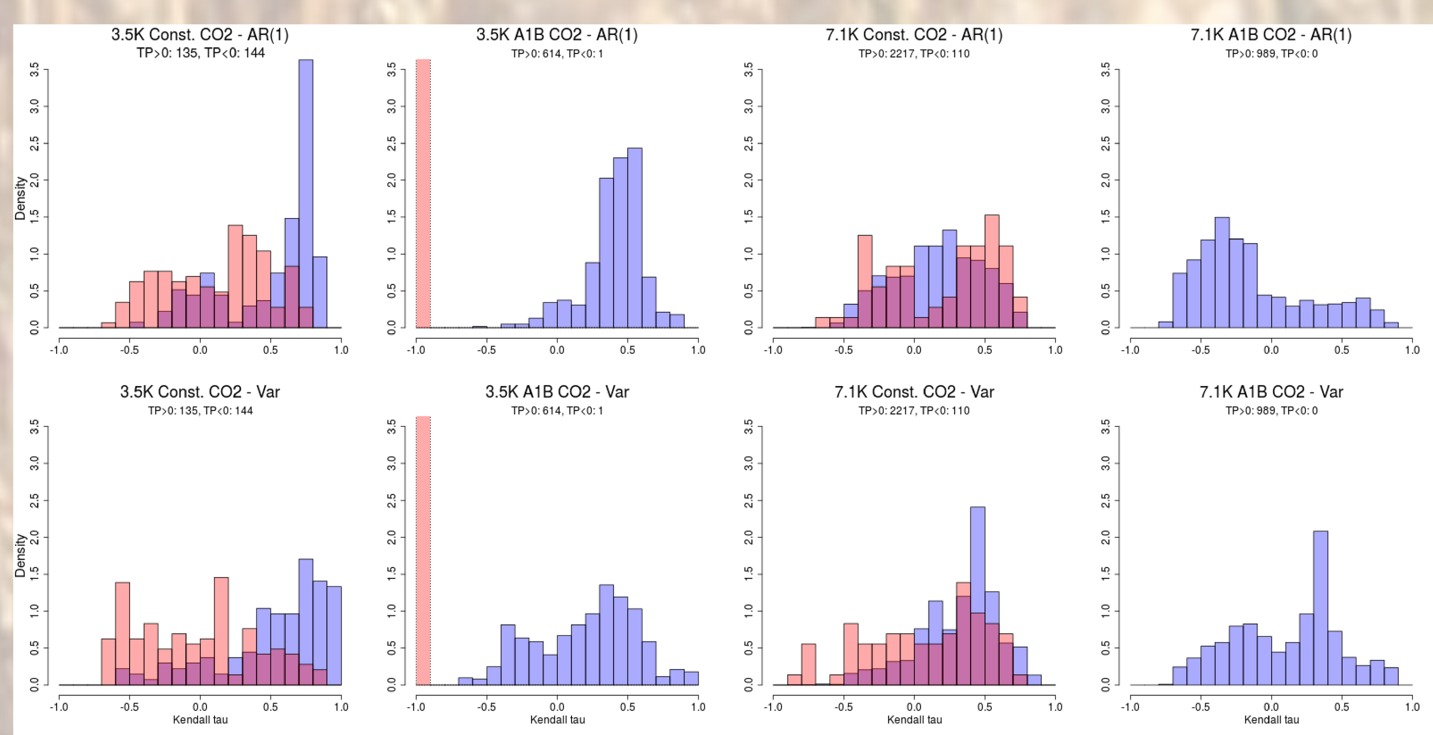


Vegetation Carbon Tipping Points





- We use our detection algorithm to find increasing and decreasing tipping point type behaviour in total gridbox vegetation carbon (VC) in the four JULES simulations. Other types of tipping are classified but not shown.
- We look for early warning signals of the tipping (increasing in AR(1) and variance over time) and measure their tendencies using Kendall's tau (1 - always increasing, -1 - always decreasing).



- We find that increasing TP (blue) are more predictable than decreasing TP (red).
- Early further results indicate that VC associated with grass Plant Functional Types (PFTs) rather than tree PFTs, most likely due signals being picked up more easily in the faster grass dynamics (not shown).