Towards a quantification of climatic extreme events and their impacts in the terrestrial biosphere

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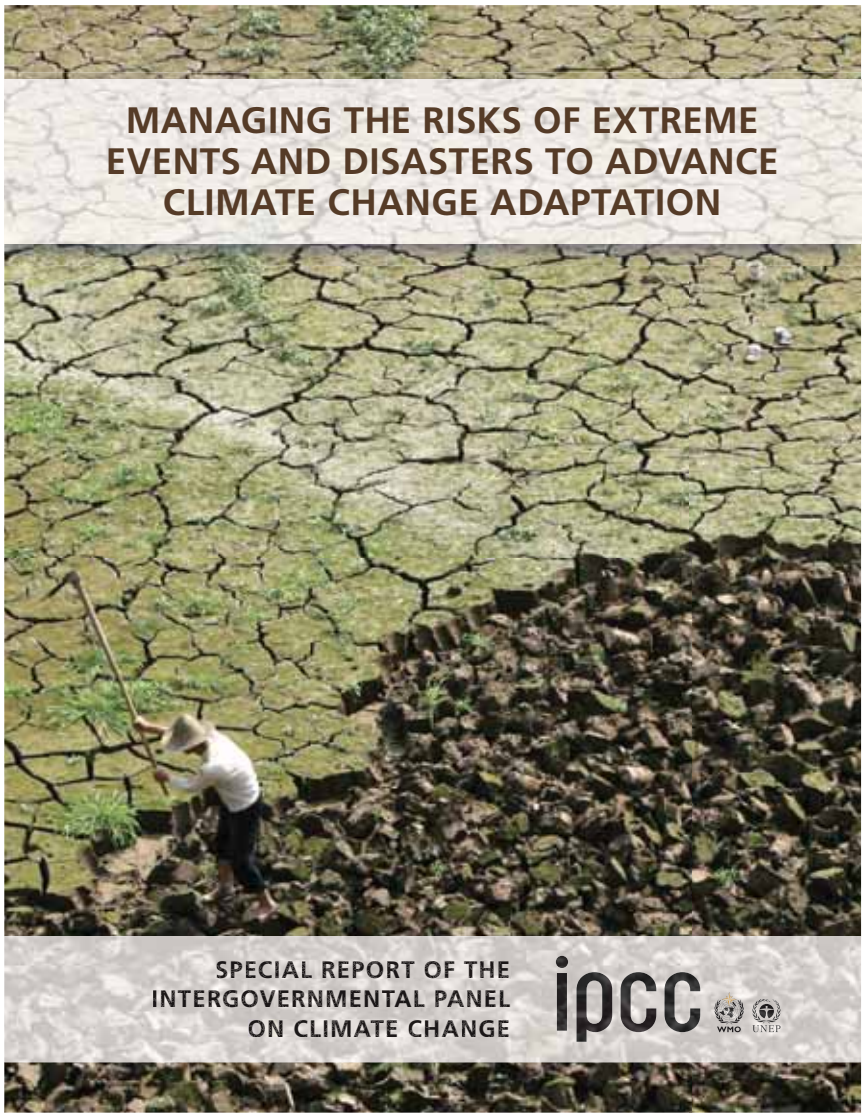
External Advisors: Friederike Otto & Markus Reichstein & many more

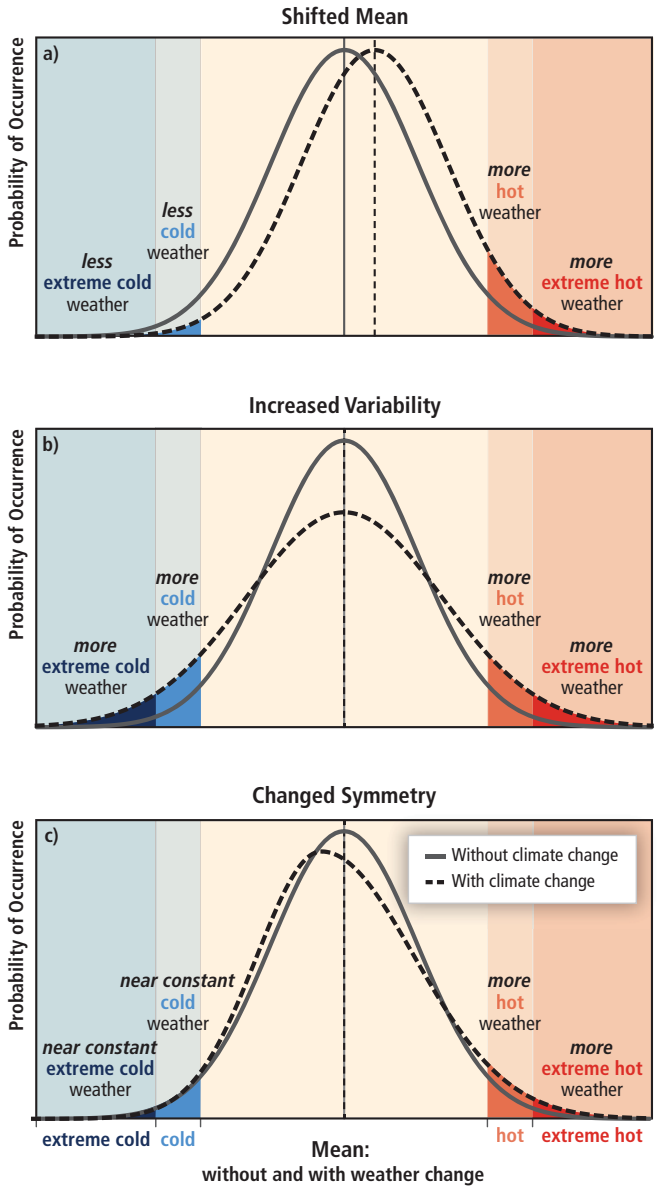
Changing relevance of extreme events?

SREX evidence:

- *"substantial warming in temperature extremes by the end of the 21st century"*
- *"medium confidence that droughts will intensify in the 21st century in some seasons and areas"*
- ...



Approaches to deal with extremes:



IPCC (2012)

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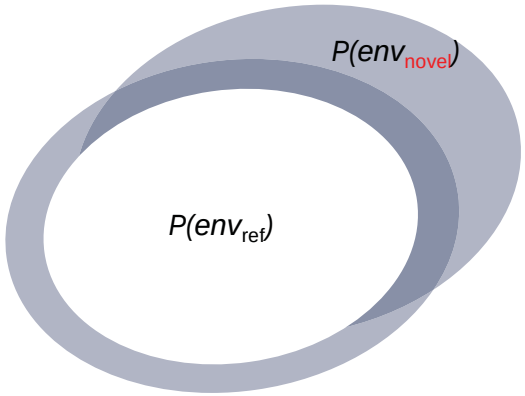
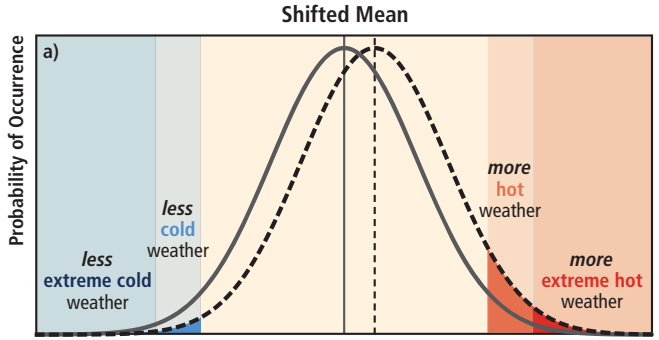
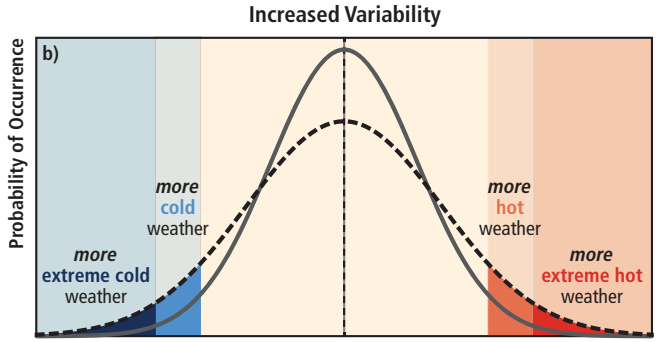
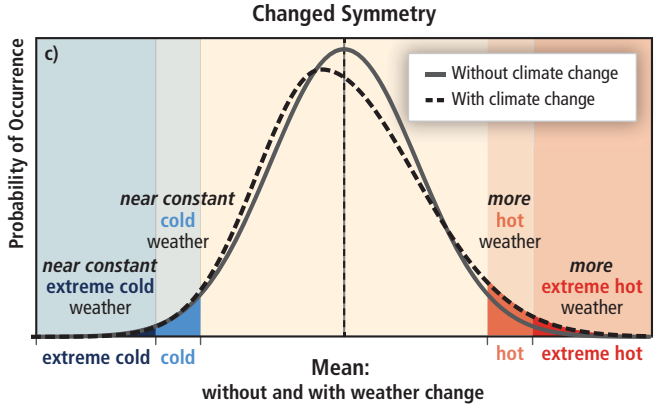


- Building on a reference of normality







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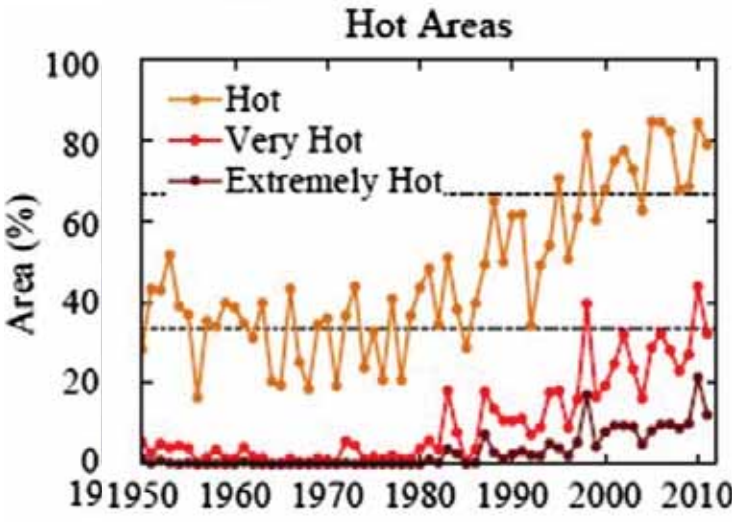

Hansen et al. *PNAS* (2012)

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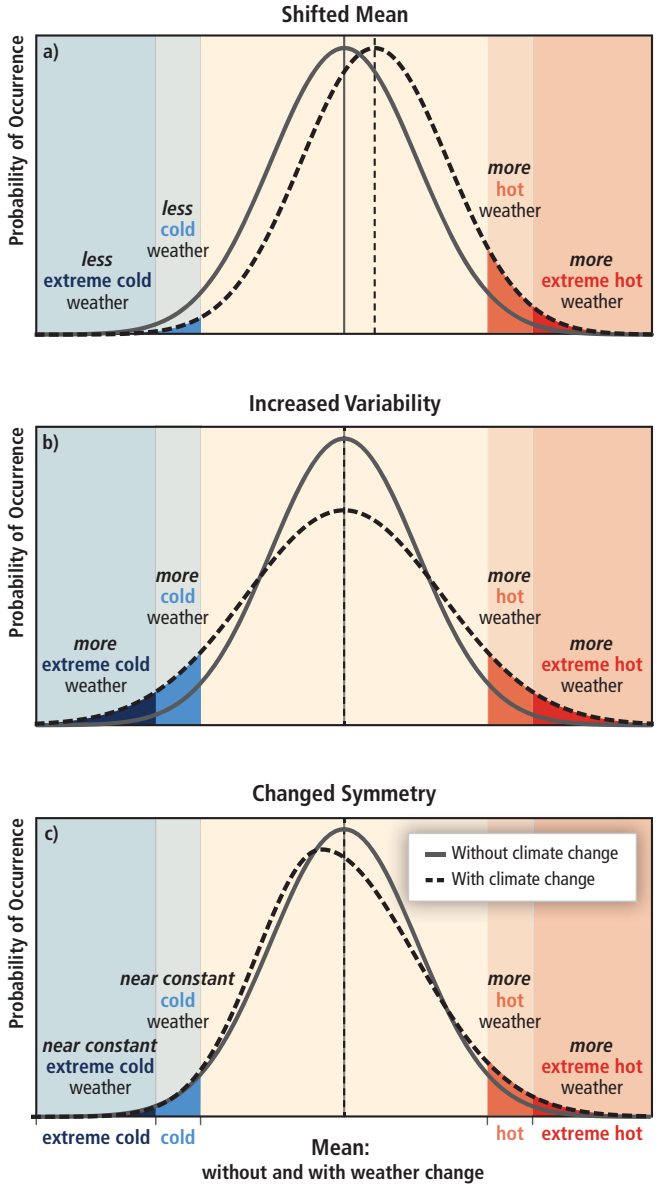


IPCC (2012)

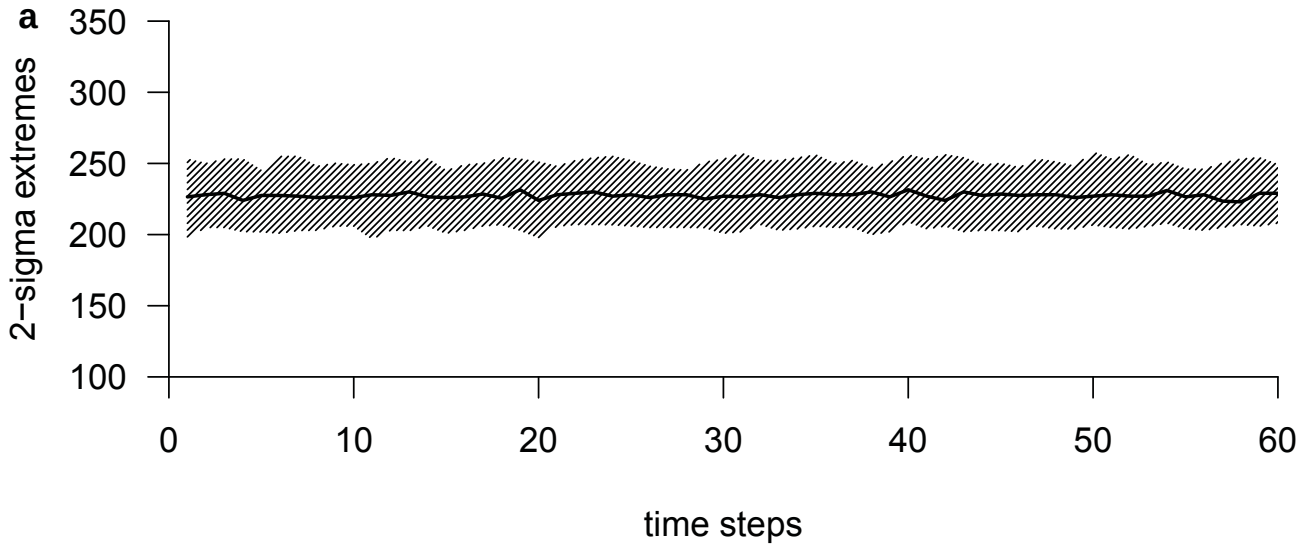
Cautionary remark: Changing variability & extremes

Detecting changes is not straightforward

- Statistical artefacts if reference period standardization is used for extremes detection:

  $z = \frac{X - \overline{X}_{ref}}{s(X_{ref})}$

- ...



Sippel et al. *GRL* (2015)

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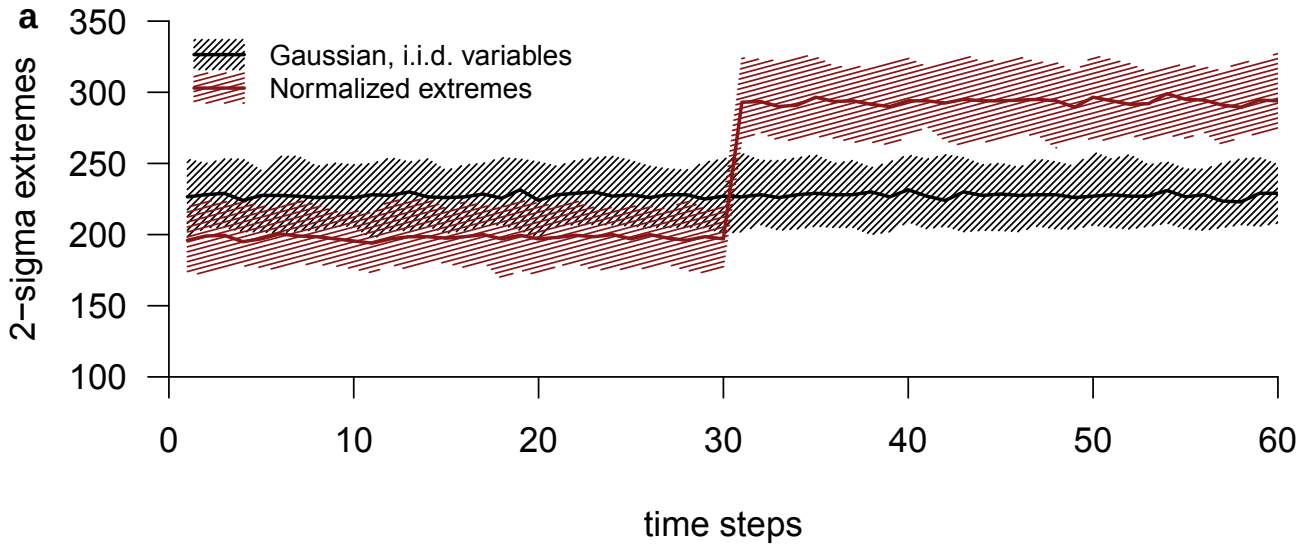
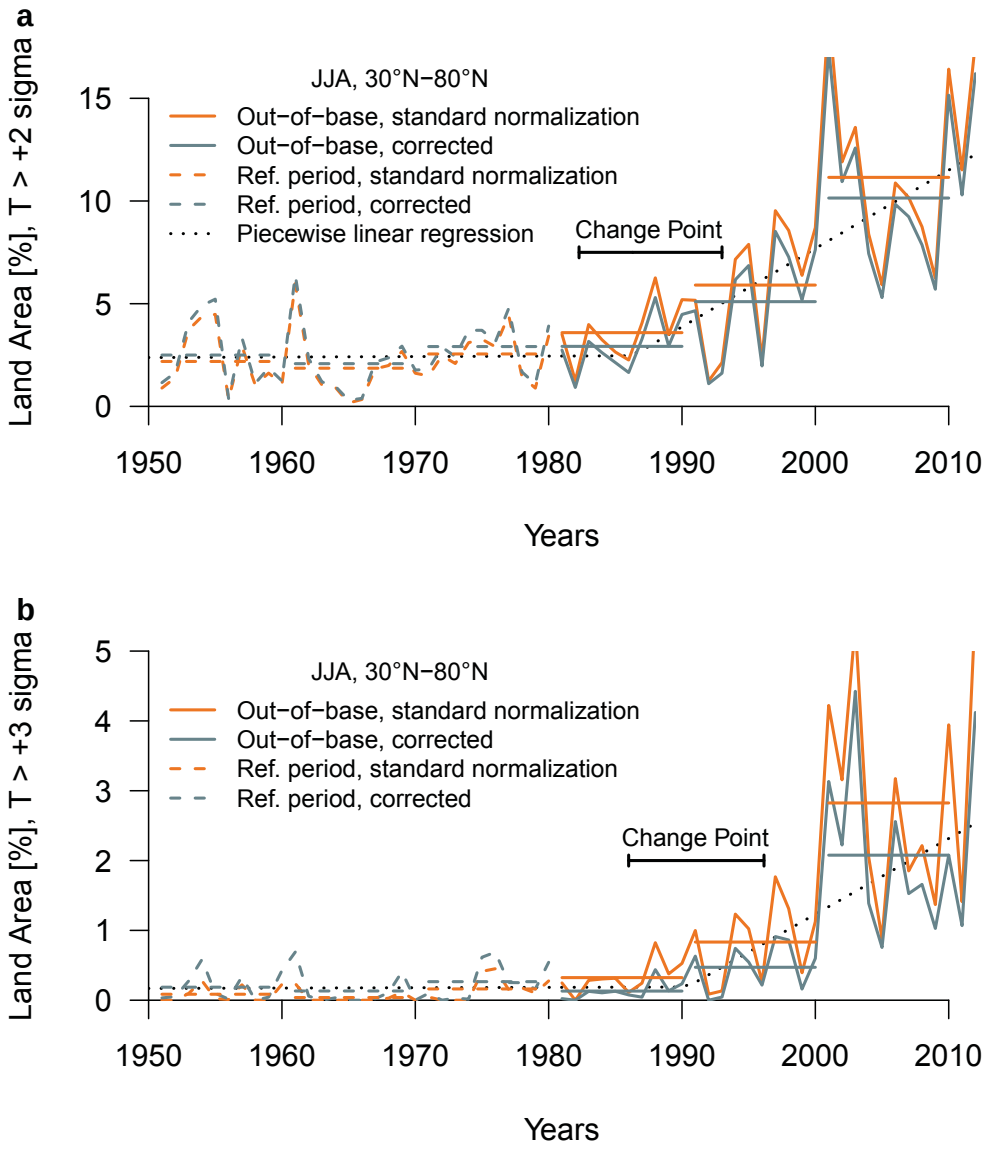


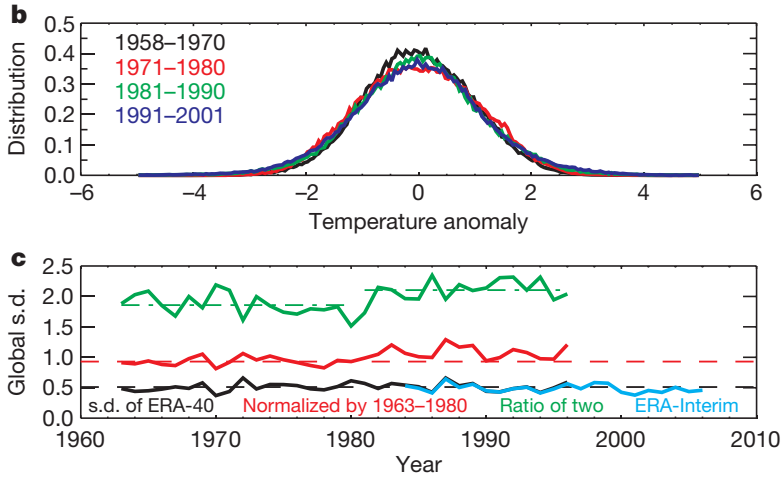
Sippel et al. *GRL* (2015)

Application I: Changing temperature extremes



Sippel et al. *GRL* (2015)

Application II: Changing temperature variability



Huntingford et al. *Nature* (2013)

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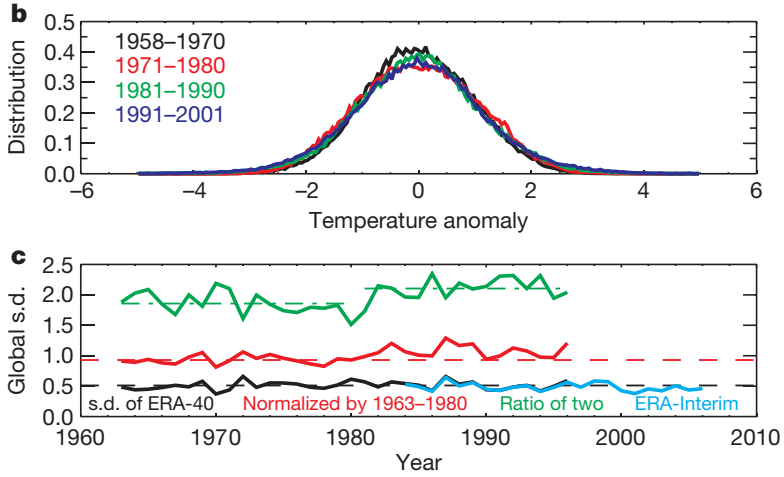

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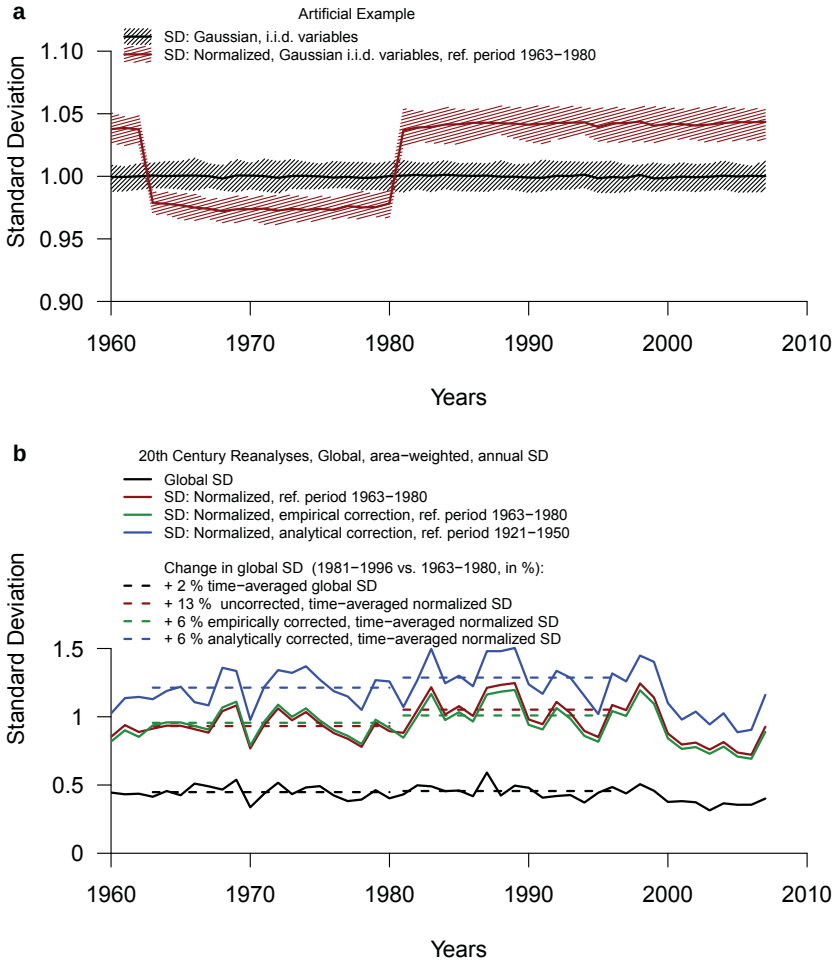
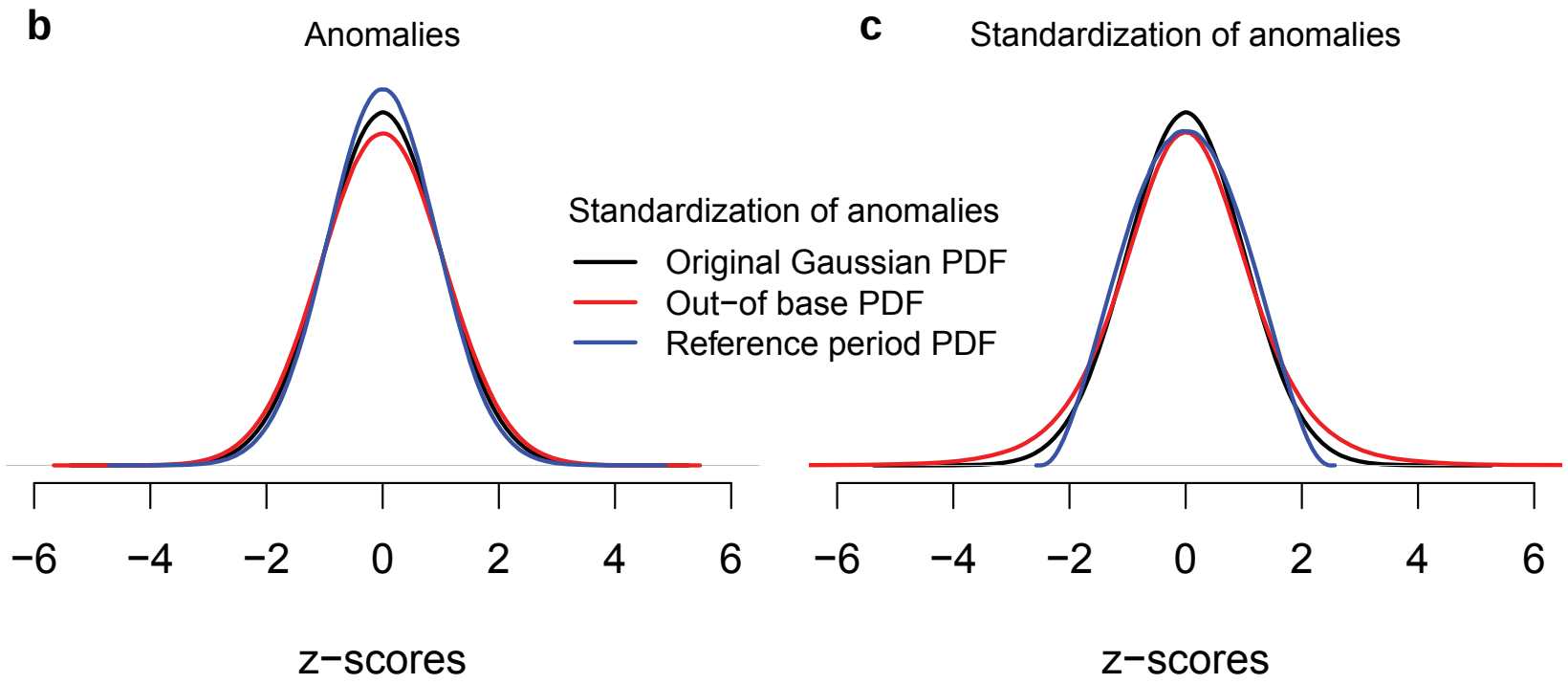


Sippel et al., 2015, *GRL*

Conclusion: Changing variability & extremes

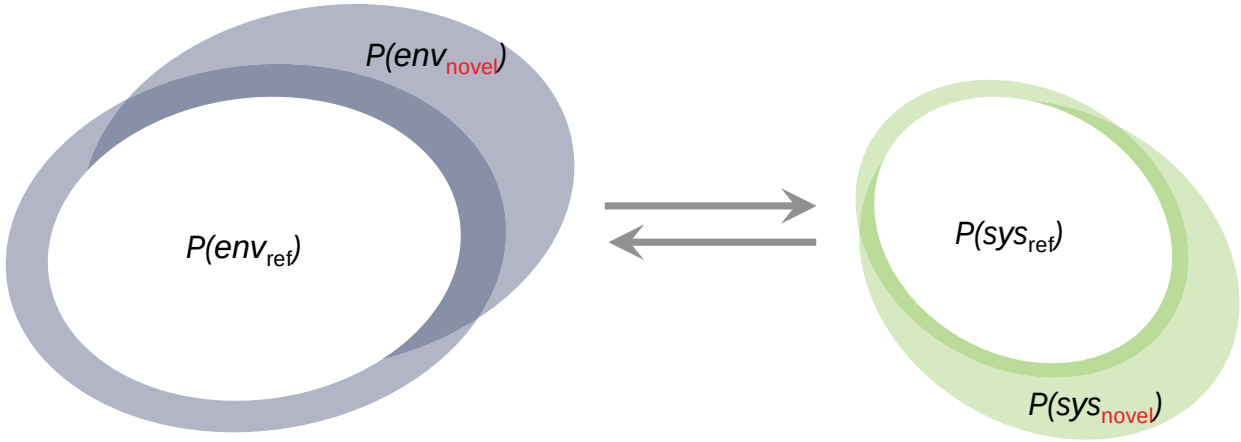
Detecting changes is not straightforward

- Normalization is a critical step in data processing
- Robust statistical methods are needed to detect changes in extremes



Sippel et al. *GRL* (2015)

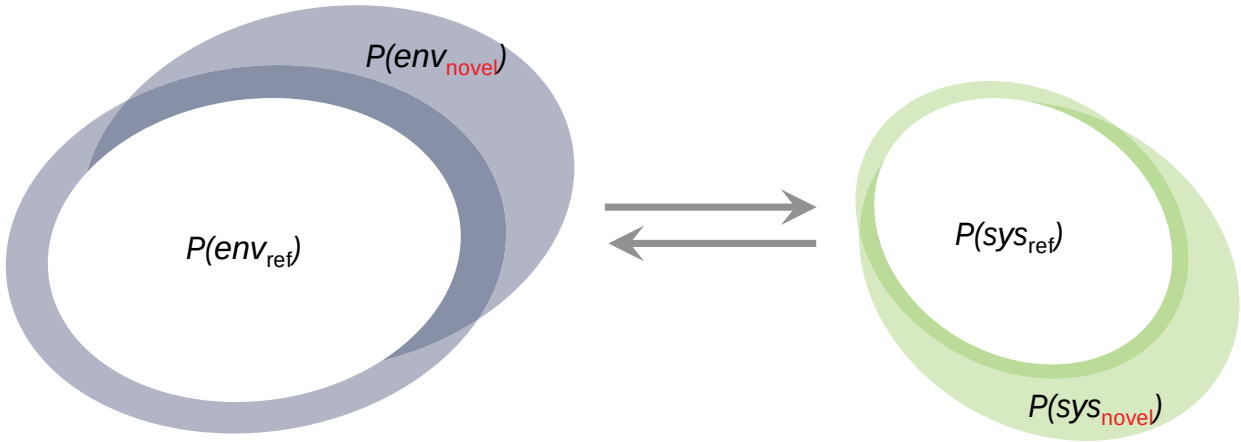
Linking climate extremes to impacts

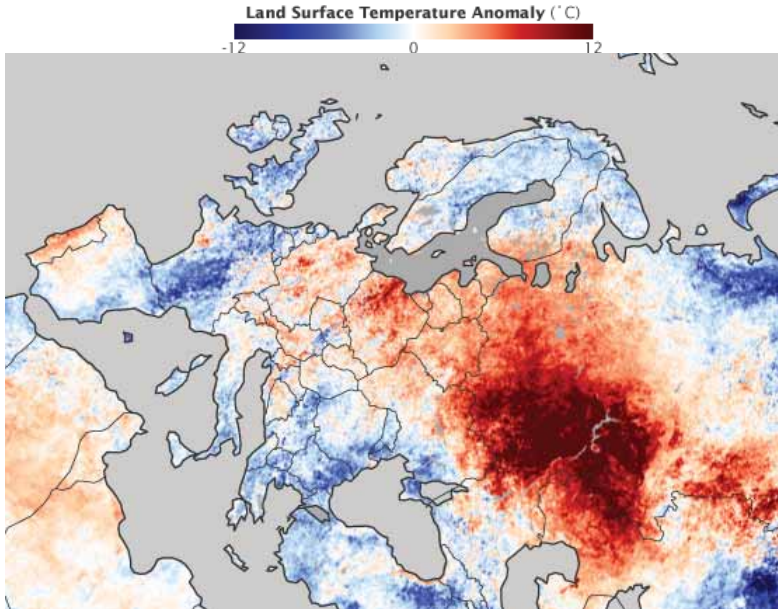


What causes changes in biosphere extremes and variability?

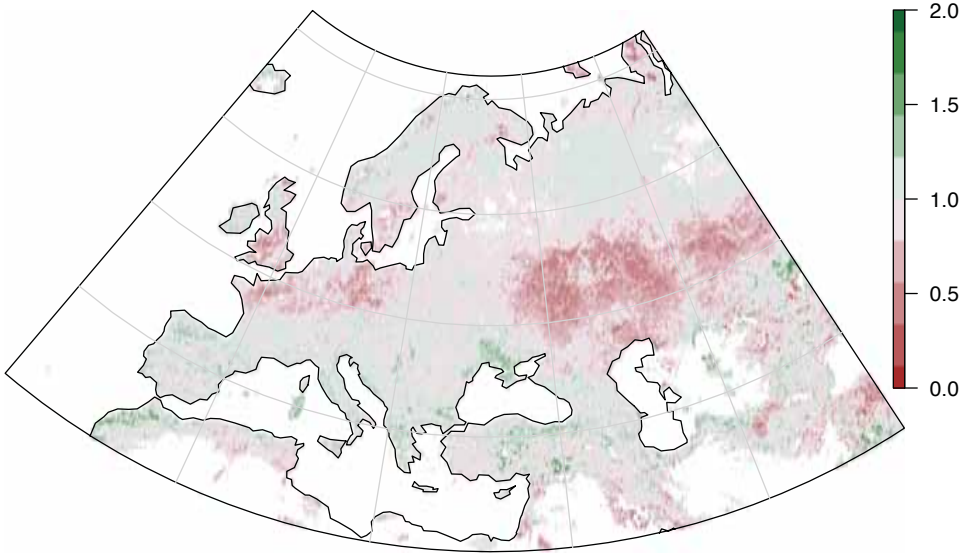
- (forward) How do climate extremes affect the biosphere?
- (backwards) Towards an attribution of biosphere extremes and variability to climatic drivers

Linking climate extremes to impacts

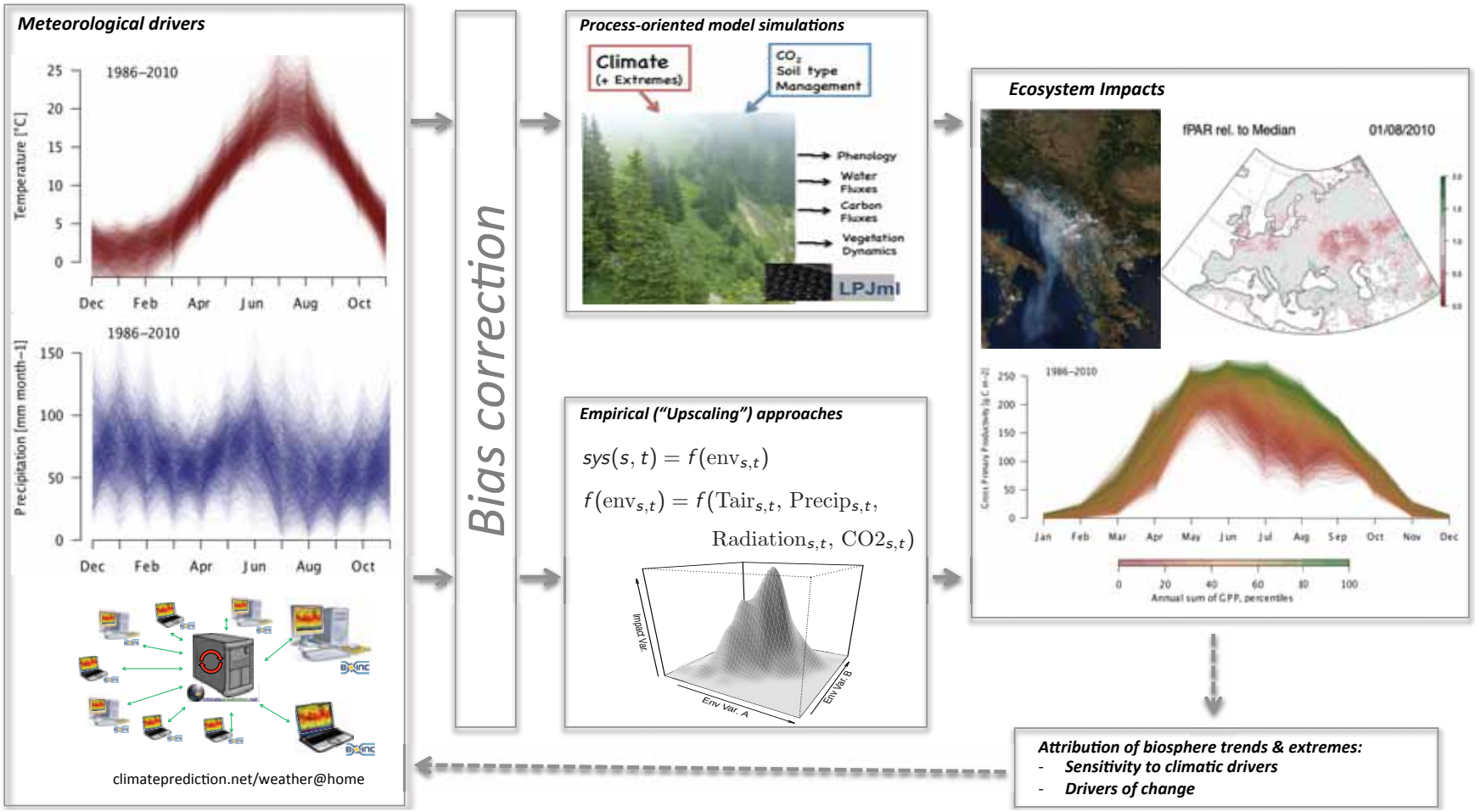




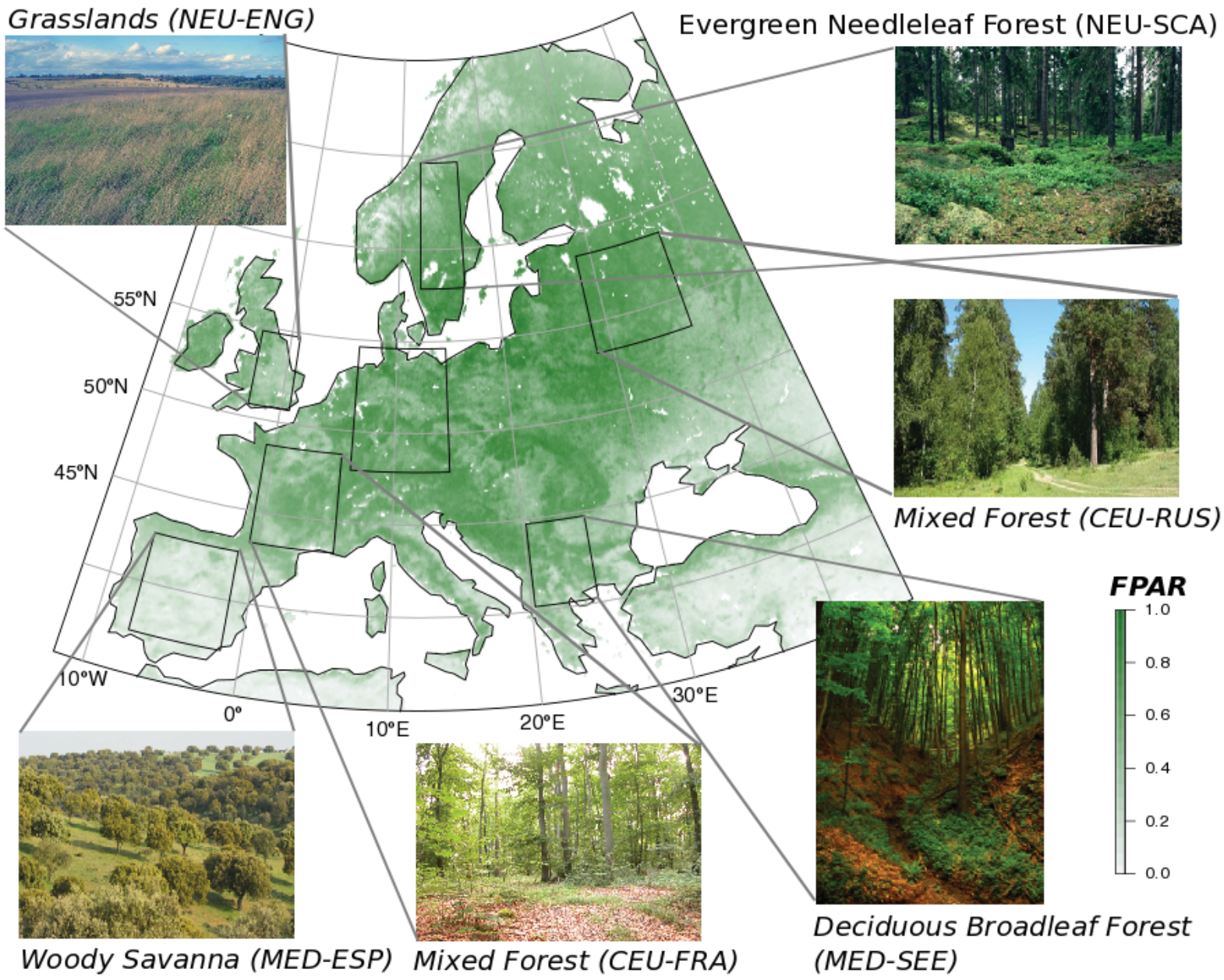
FAPAR anomaly



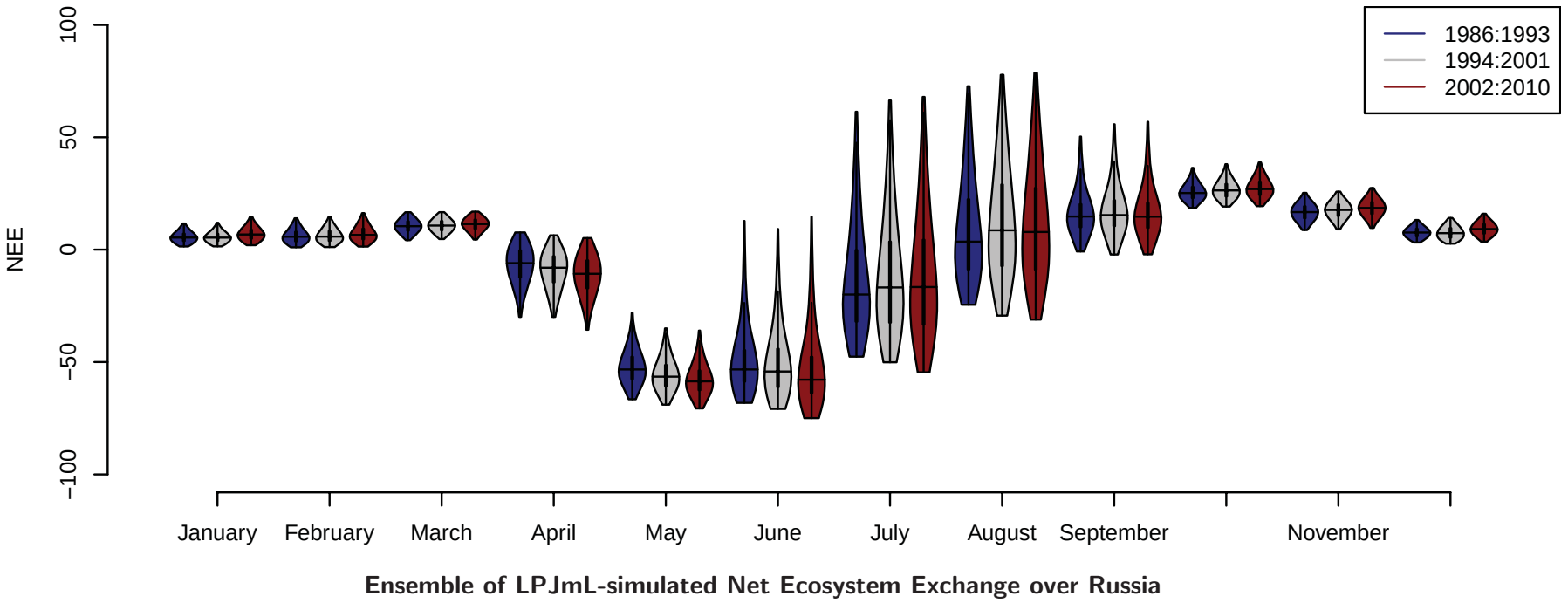
Biosphere 'end-to-end' attribution concept:



Regional attribution of changes in ecosystem exchange



Regional attribution of changes in ecosystem productivity



Conclusion: Biosphere attribution

- A complementary data-driven *and* model-driven attribution of biosphere variability and extremes is possible
- European vegetation (across various ecosystems) responds strongly to transient climate changes, including the extremes

Thanks for your attention!