Climate change indicators in butterflies – responses of butterfly populations to climatic fluctuations in Germany

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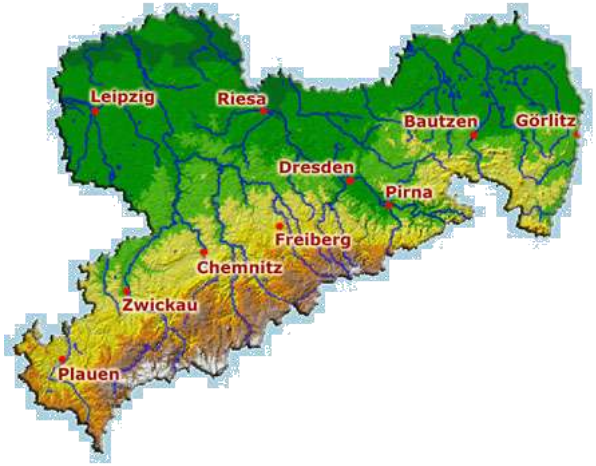
Background

- Research project on monitoring climate change and biodiversity in the German Free State of Saxony
- Development of biodiversity indicators for climate change
- Evaluation of available data
- Impact of climate change on
  - Community composition
  - Distribution ranges



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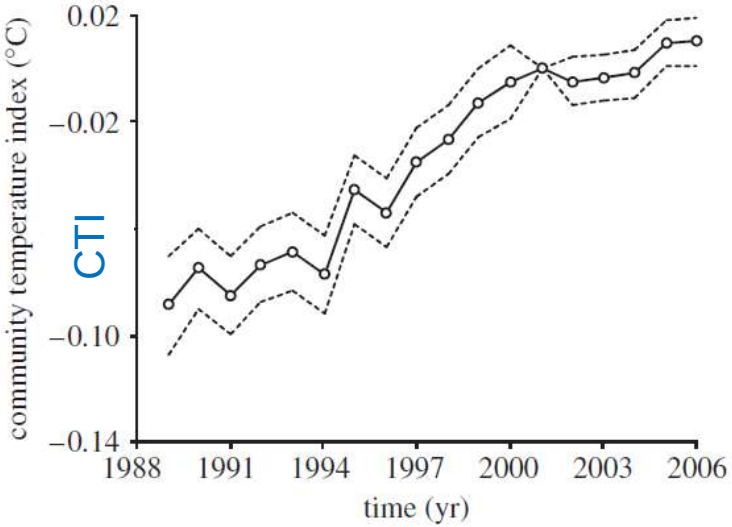
Responses of species communities to climate change

- Community Temperature Index (CTI) - Devictor *et al.* (2008)
- Weighted Sum of Species Temperature Indices (STI)



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Birds are tracking climate warming, but not fast enough

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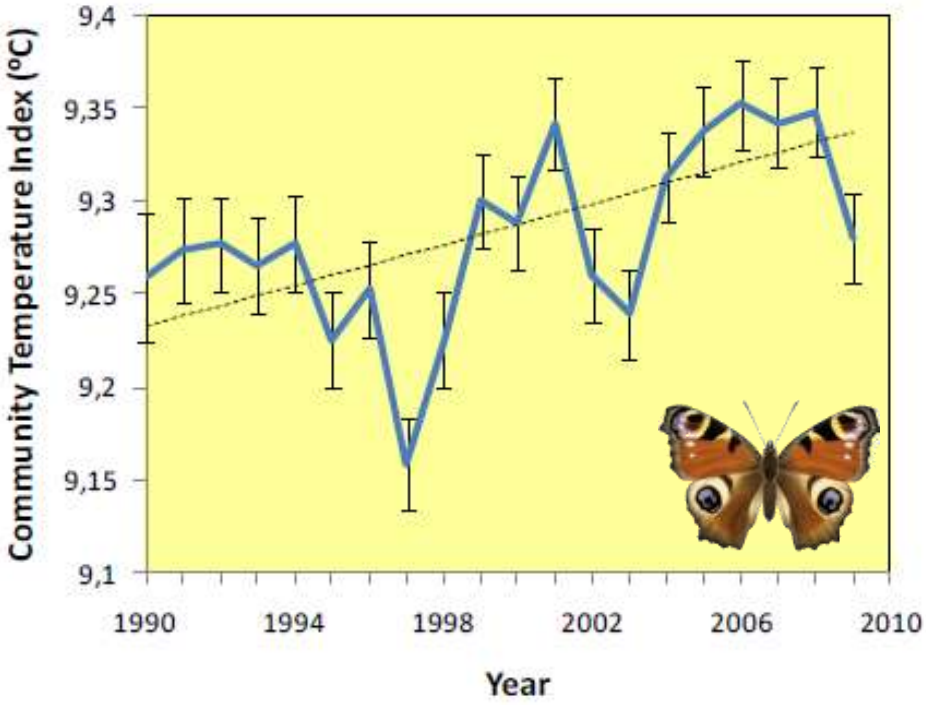
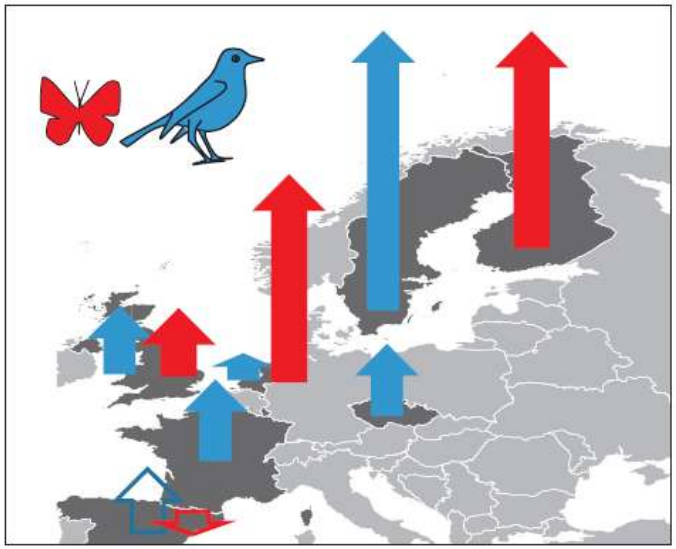
Community Temperature Index in Butterflies

- Positive temporal trend of CTI in European Butterflies 1990-2009 (Van Swaay *et al.* 2008, 2010)
- European variations in trend of bird & butterfly CTI (Devictor *et al.* 2012 in Nature Climate Change)





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STI examples in butterflies

Boreo-alpine species:

Colias palaeno: 3.62

Mediterranean species:

Hipparchia statilinus: 11.82

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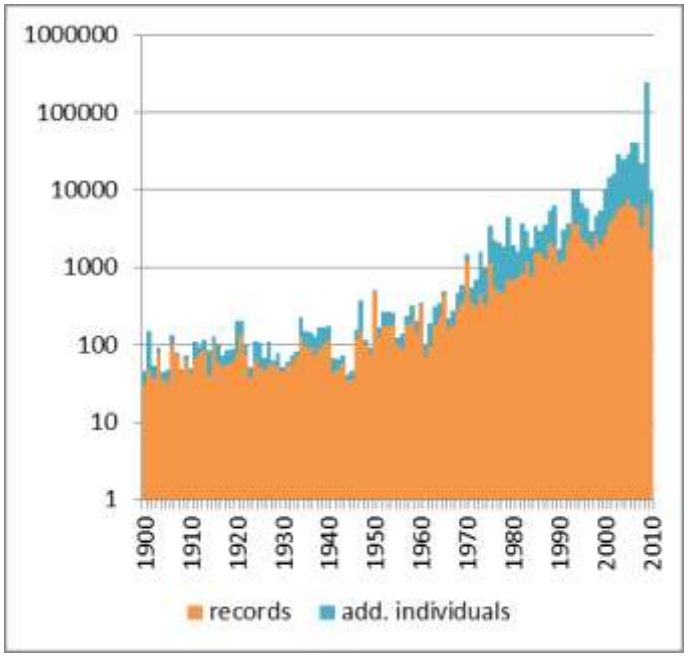
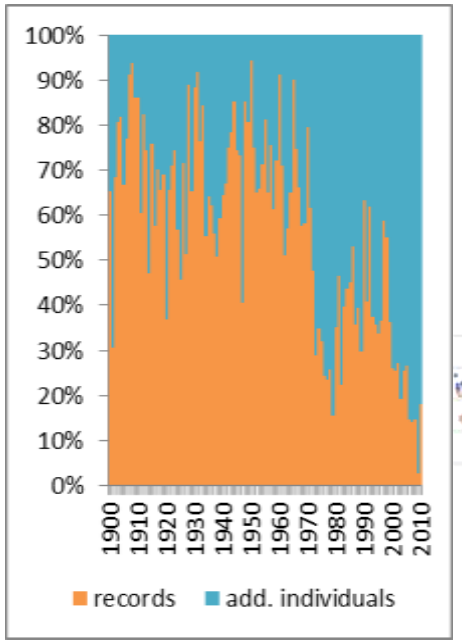
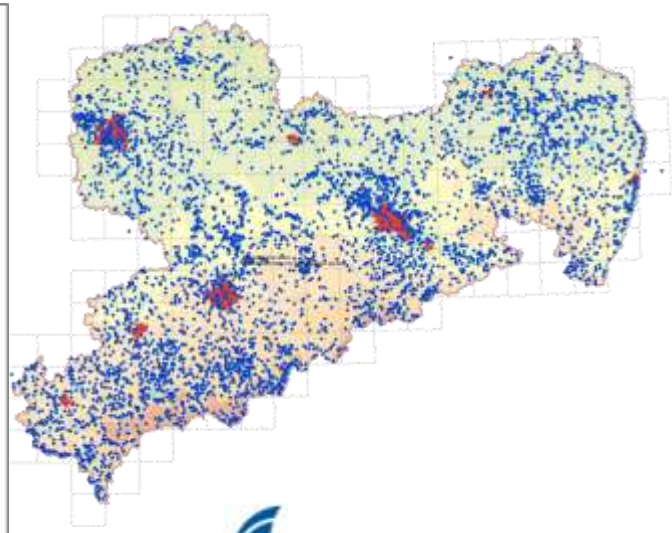
Butterflies of Saxony

- 140 species
- Good temporal coverage for 36 years (1975-2010) with >1000 records/year
- Excellent spatial coverage
- 43% of records without abundance data







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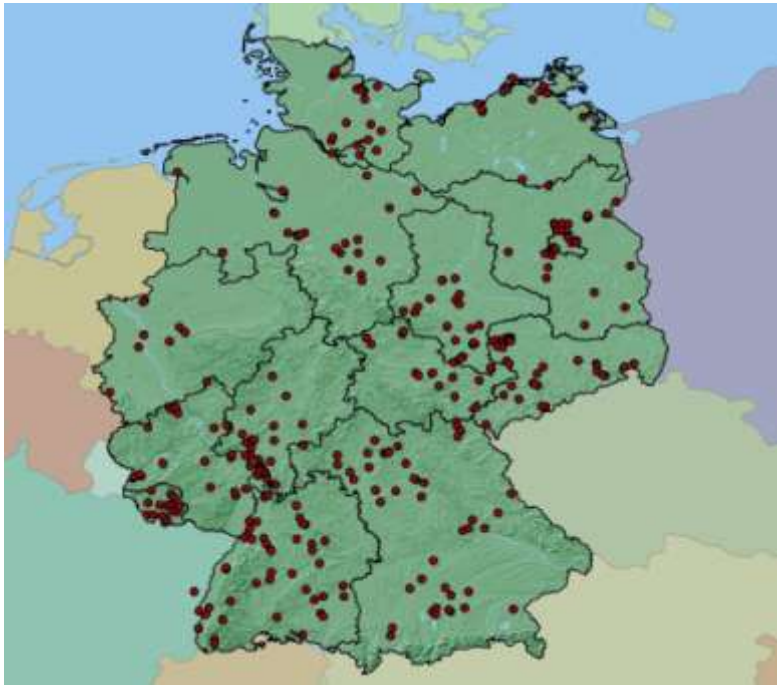
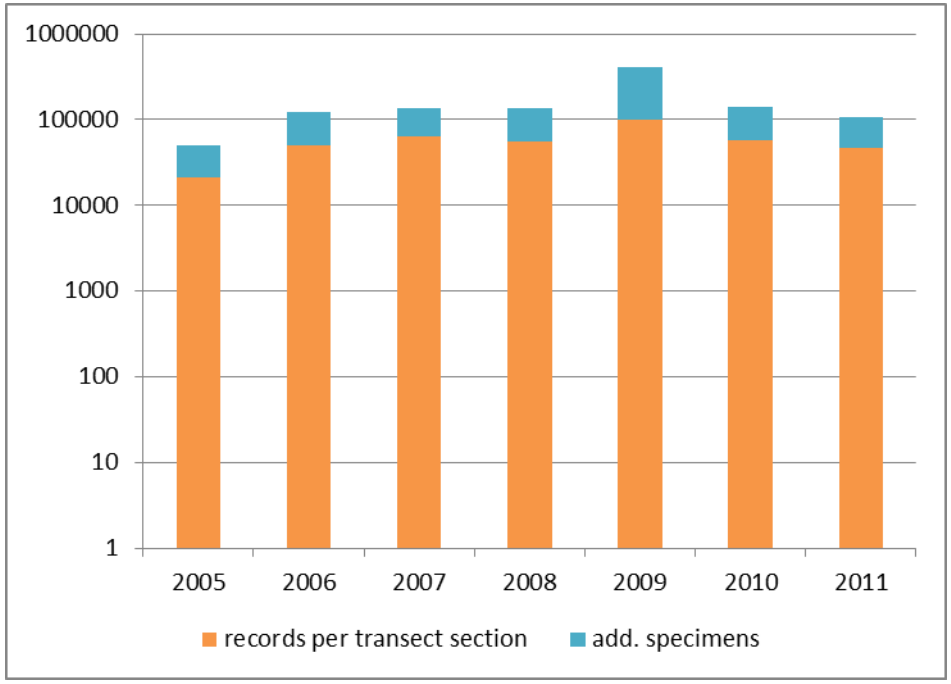
Butterfly Monitoring Germany (TMD)

- 149 species
- Monitoring data
- Temporal coverage for 5 years (2006-2010)
- Limited spatial coverage

TMD





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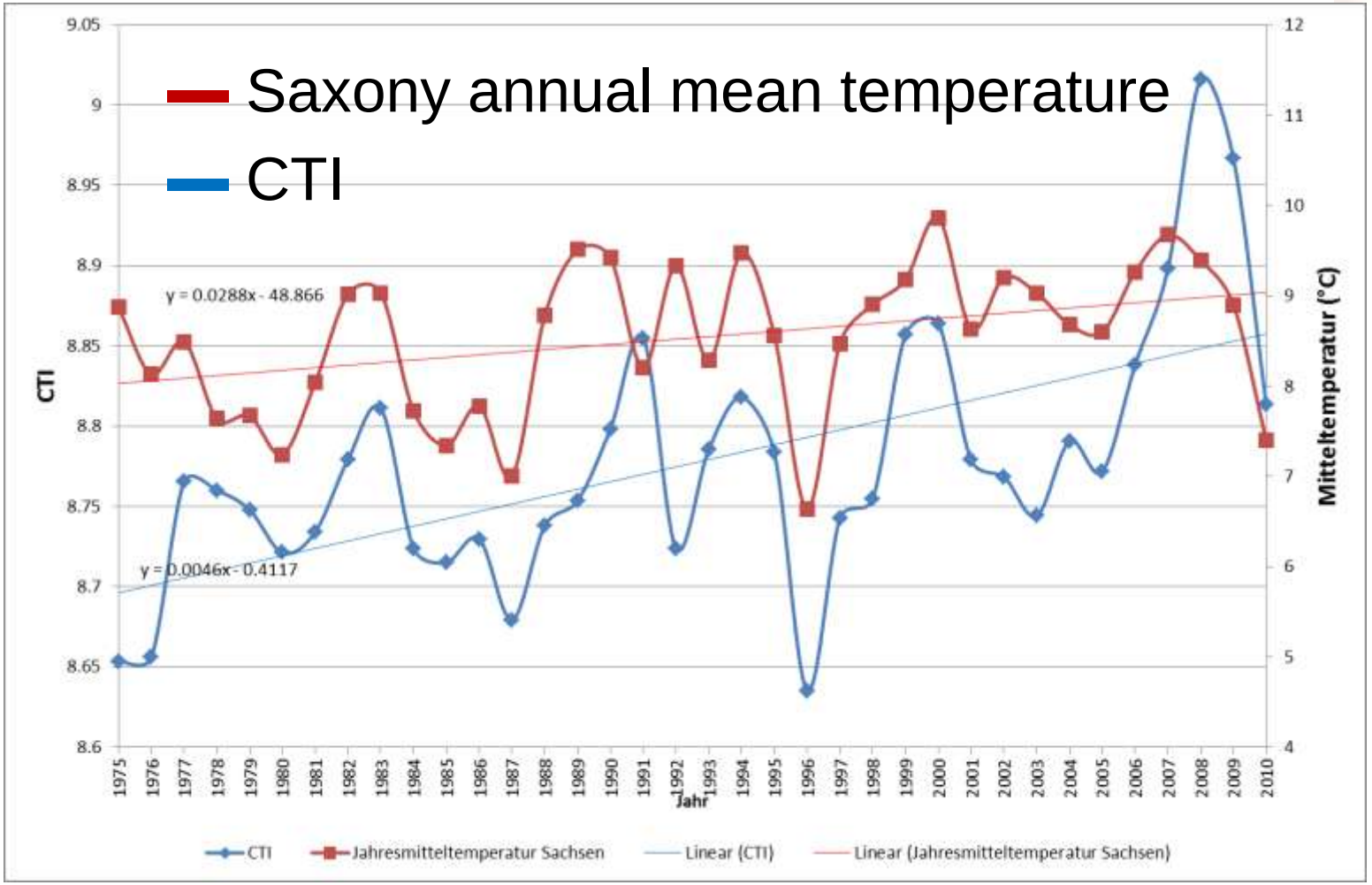
CTI correlation with climatic fluctuations



Correlation with annual mean temperature: 0.55, p<0.001***

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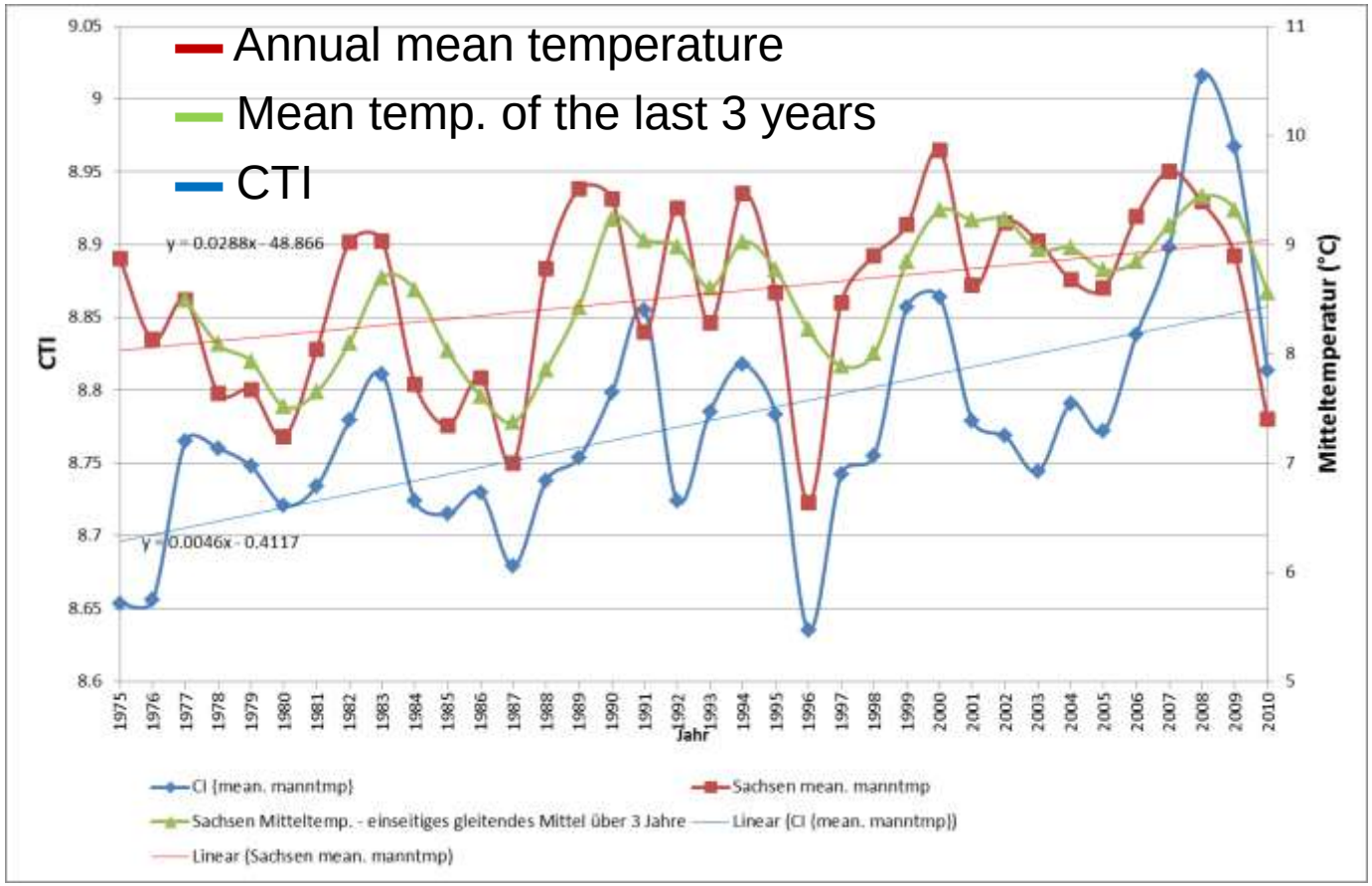
Considering generation time



- Generation length up to one year
- Temperature of previous years decisive
- Better Correlation (0,64) with the sliding 3-year mean of the current and 2 previous years

Year						
x	0.549***	0.632***	0.491**	0.637***	0.424*	0.584**
x-1	0.496**					
x-2	0.324	0.260				
x-3						

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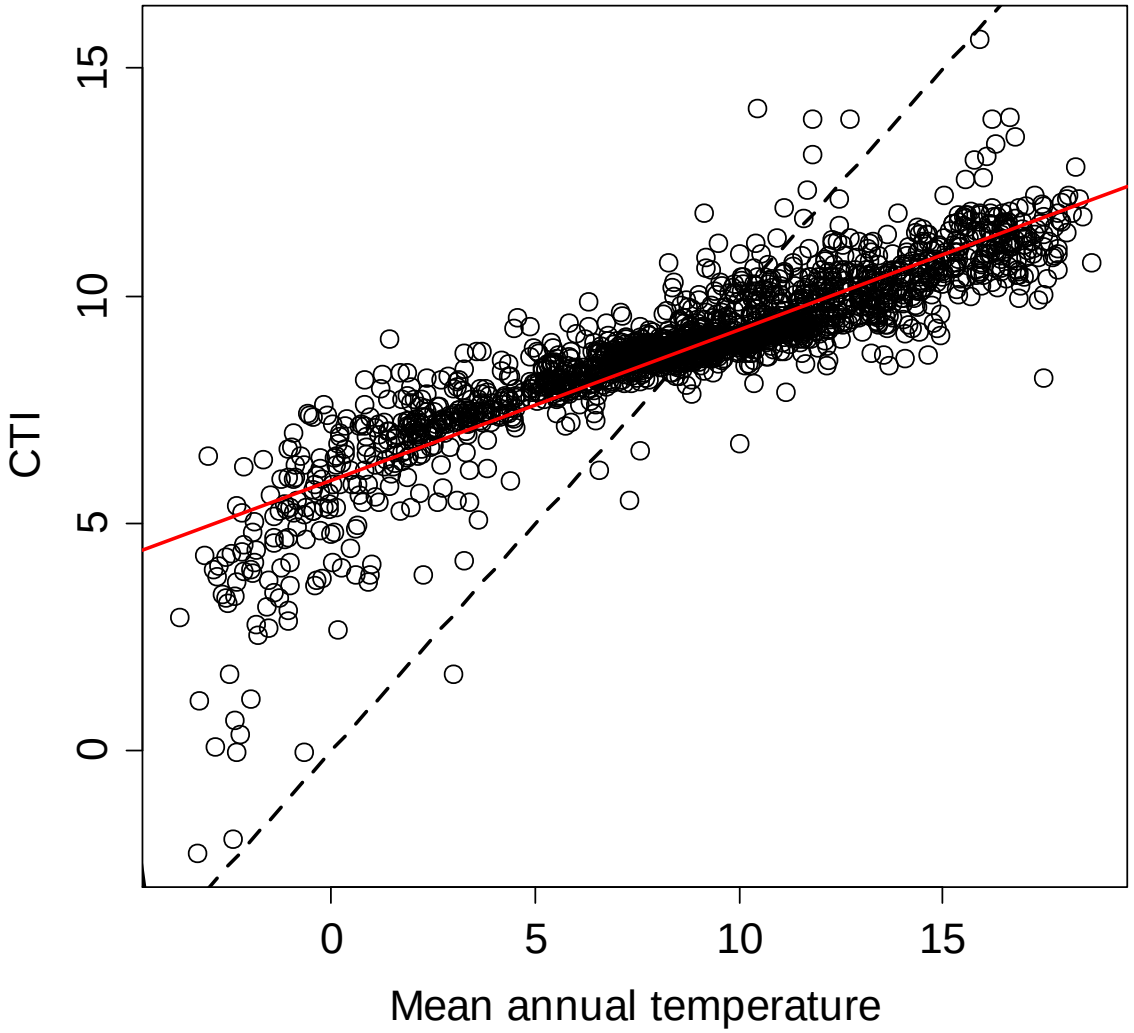
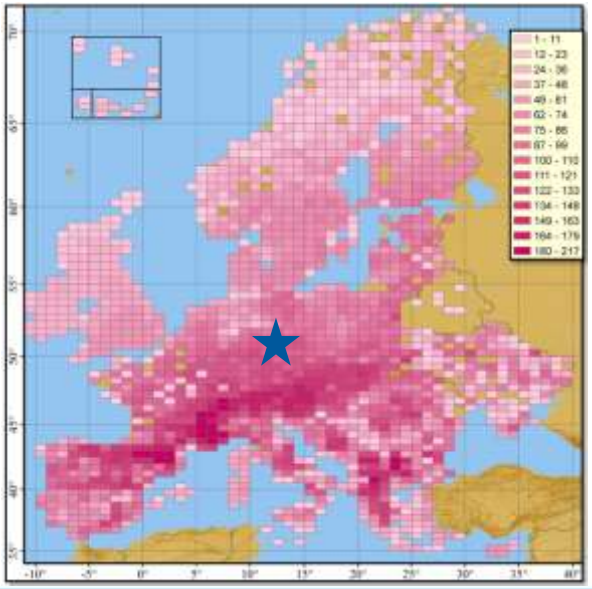
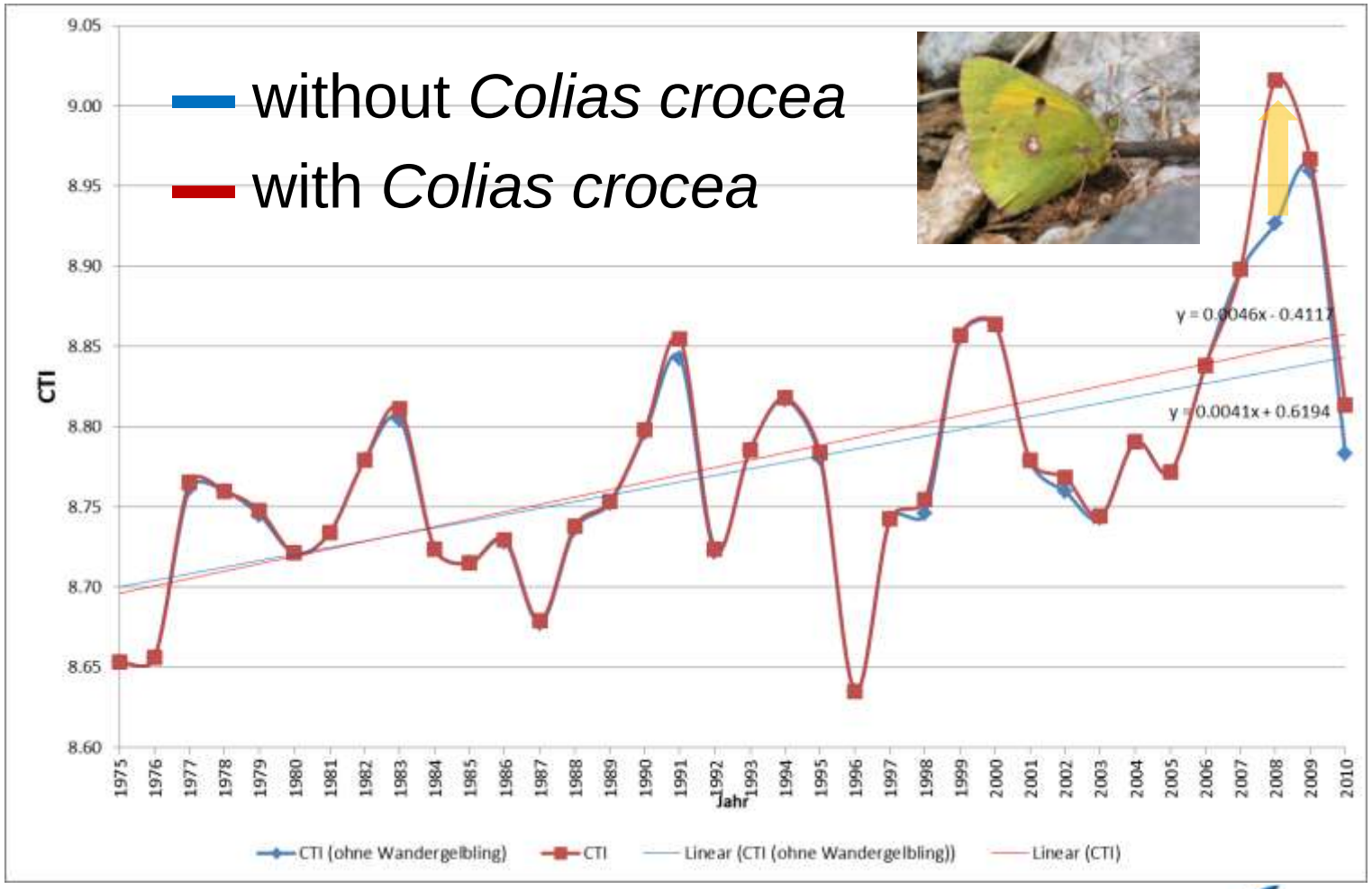
Correlation between CTI and annual mean temperatures across Europe



- Nearly linear correlation with an increase of 0.33
- Saxony 1975-2010:
- Increase of
  - ✓ ann. mean: 0.0288
  - Projected CTI: 0.0095
  - ✓ Observed CTI: 0.0046
  - Difference: factor 0.5



Robustness of CTI



- CTI is robust to selection of species
- Exceptional immigration events may influence CTI

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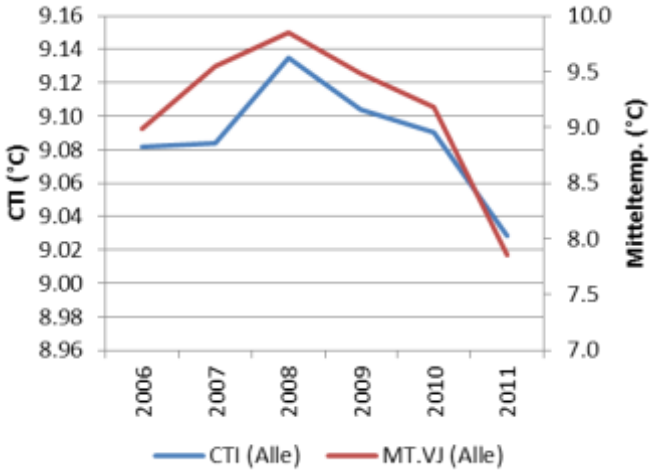
CTI – TMD Regions

- Strong correlation between CTI and the temperature mean of the previous year



Year						
x	-0.169					
		0.558				
x-1	0.940 **		0.944 **		0.825 *	
				0.718		0.781
x-2	0.518					
		0.130				
x-3	-0.316					

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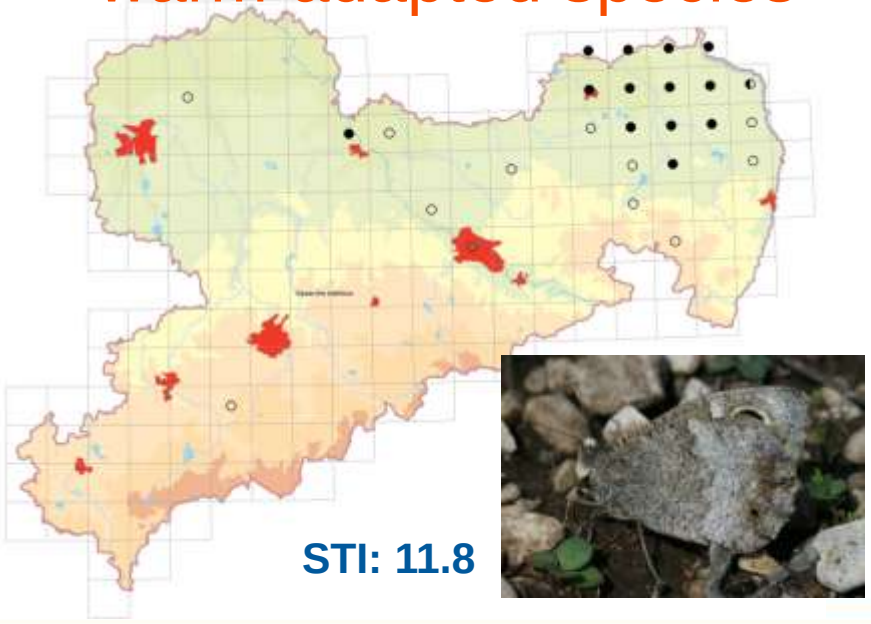
Climate impact on regional distribution ranges

Saxony:

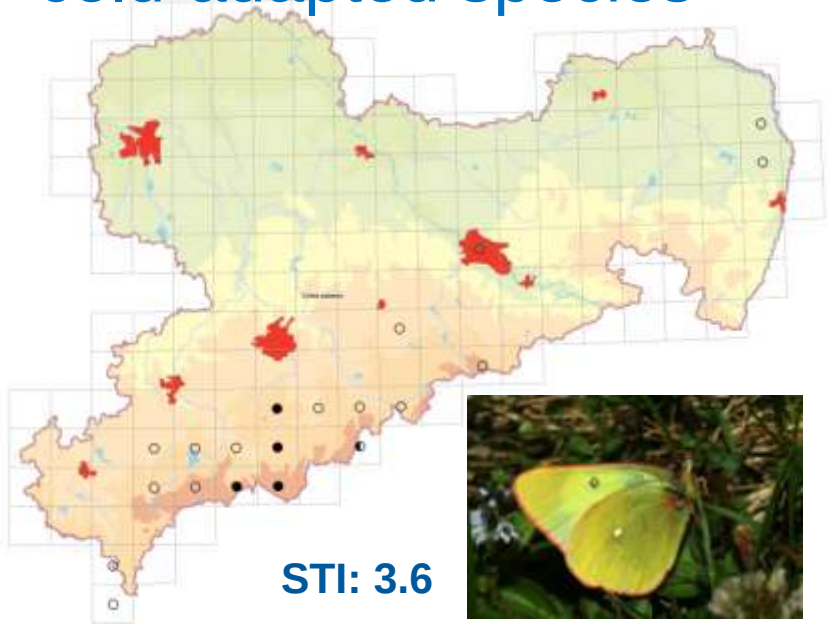
- Southern species in the northern flatlands
- Northern species in the mountains near the southern border to the Czech Republic

Hipparchia statilinus:
warm-adapted species



STI: 11.8

Colias palaeno:
cold-adapted species



STI: 3.6

STI-based Areal Index

- Sum of occupied grid cells (e.g. MTB) of southern versus northern species based on and weighted by the difference of each species‘ STI from the mean CTI

Examples of STI differences: The butterfly genus *Colias*:

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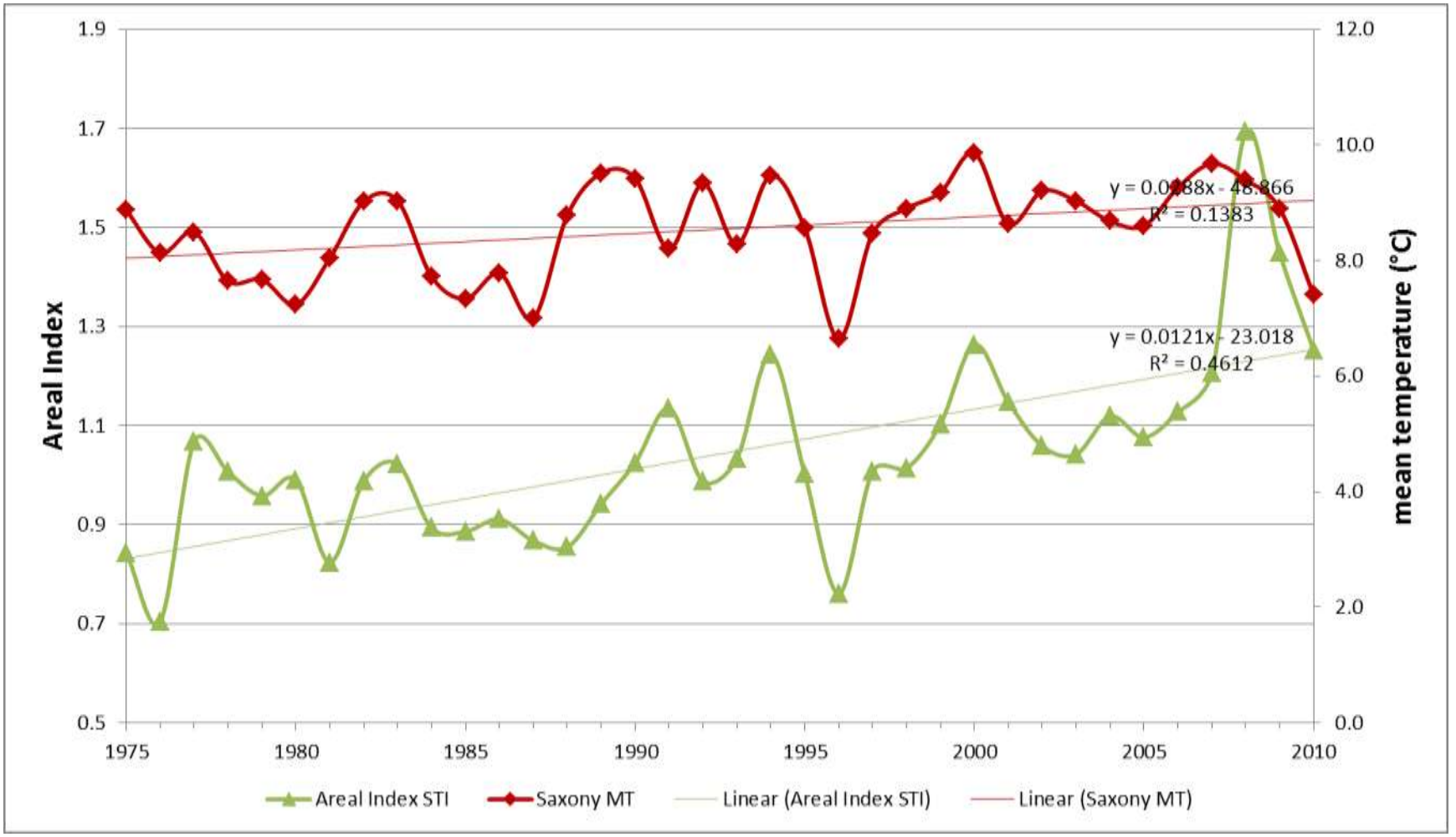
Butterflies of Saxony: STI-based Areal Index



- Correlation of areal index with annual mean temperature (0,48**)
- Positive trend

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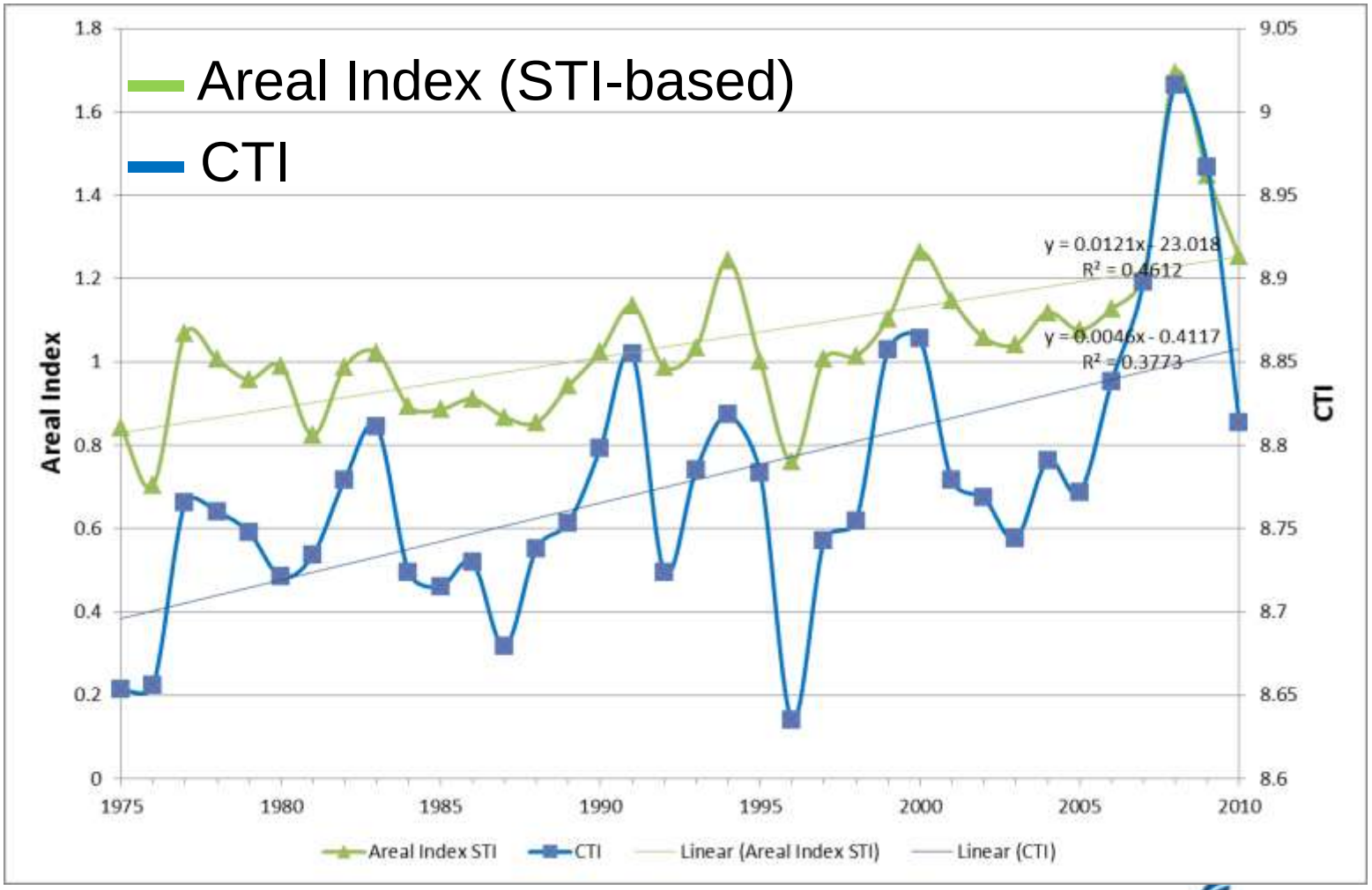
Areal Index vs. CTI in Butterflies of Saxony



- Very high correlation AI_{STI} ↔ CTI: 0,93***

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Conclusions

- CTI indicates change of community composition towards warm-adapted species during the last 2-3 decades
- CTI is a robust biodiversity indicator for climate change
- Temporal CTI changes are affected by European range patterns
- CTI is sensitive to short-term climatic fluctuations in animals with short generation times
- The extent of CTI fluctuations strongly depends on generation length
- STI values can be used to assess climate-driven range changes
- Climate-driven range changes strongly correlate with changes in community composition

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Acknowledgements

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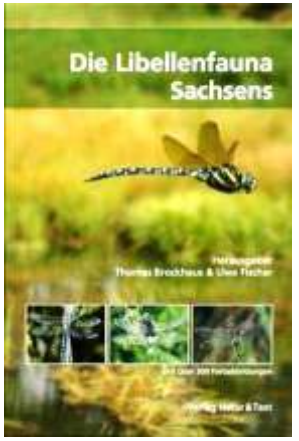
- Workgroup „General and animal ecology“ of the University of Marburg for data on the distribution ranges of European dragonflies
- Ingolf Kühn and members of the Department of Community Ecology for helpful discussions



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Thank you for your attention!

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