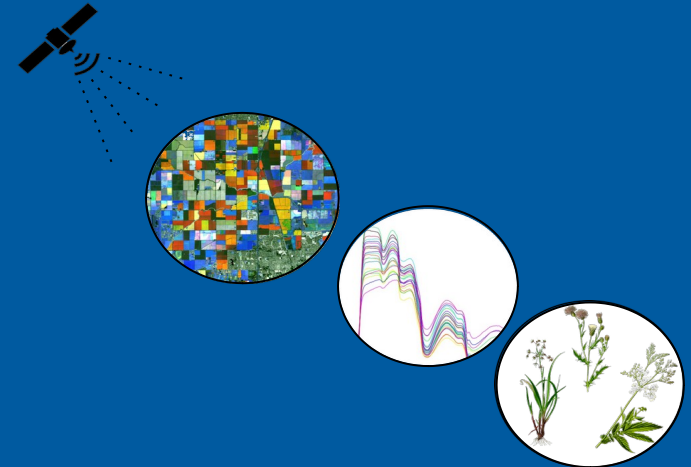
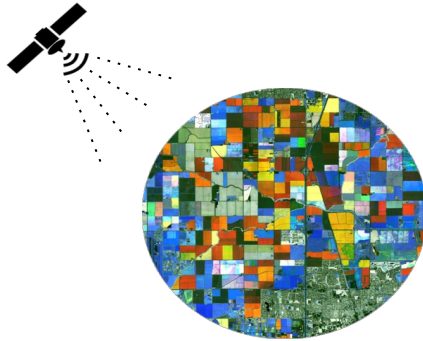


Spectral Variation as an indicator for plant diversity: A systematic test to assess the limits and potential for grassland areas

Antonia D. Ludwig, Daniel Doktor, Hannes Feilhauer
06.10.2022



Remote Sensing in Ecosystem Research



Differences in brightness and shape of the reflectance spectrum

←
**physiology
biochemistry
structure**
→



Differences based on
→ evolutionary history
→ genetic background
→ environmental conditions

Grasslands and Biodiversity



Grasslands → not very prestigious, but important for the maintenance of several ecosystem functions and human wellbeing.

Goal: Understand mechanisms that maintain ecosystems in order to develop the tools to quantify biodiversity continuously.

Grasslands and Biodiversity



nutrient-poor



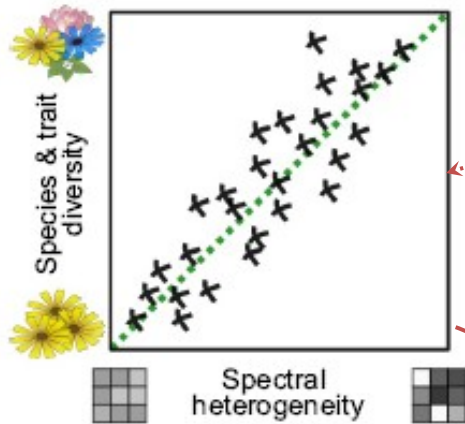
nutrient rich



wetland

→ Different habitat - different set of traits

Spectral Variation as indicator for species/ trait diversity



The Spectral Variation Hypothesis (SVH, Palmer 2000) states a **link** between the spectral heterogeneity and species/ trait diversity.

The **link** is explained by the **environmental niche concept** = the more heterogeneous the environment, the more niches are available for (plant) species to inhabit the area. The heterogeneity of an area can be reflected in the pixel-to-pixel variability of remote sensing images.

Spectral Variation as indicator for species/ trait diversity

Worked out in some studies...

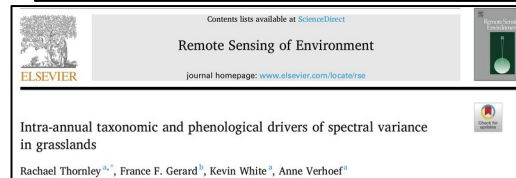
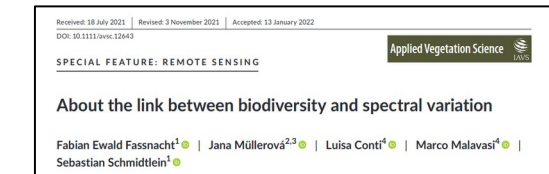


Testing the spectral variation hypothesis by using satellite multispectral images[☆]

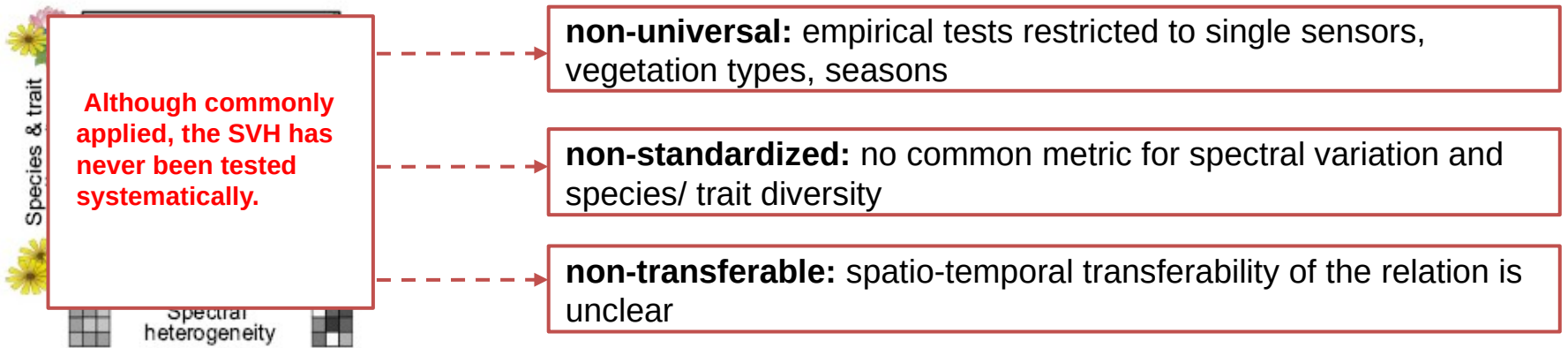
Duccio Rocchini^{a,*}, Alessandro Chiarucci^a, Steven A. Loisele^b



...in others, there was no significant correlation or only under specific conditions.



Spectral Variation as indicator for species/ trait diversity



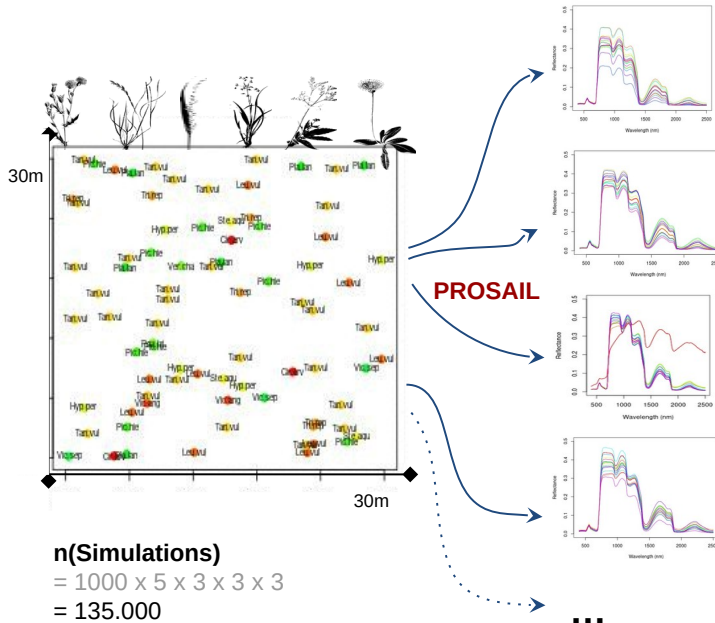
Our approach: Combining fieldwork, grassland simulations & RTMs to test the SVH systematically

FIELDWORK

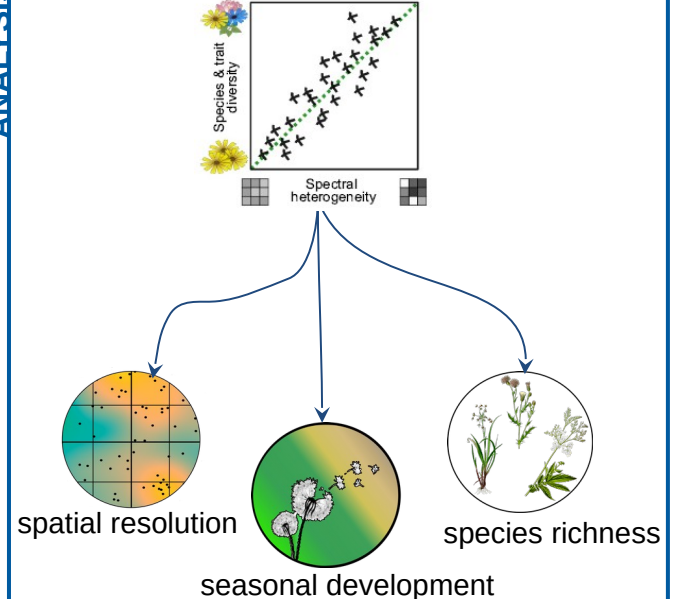


→ trait/ species/
structural data from
3 sites &
3 seasons

SIMULATION EXPERIMENTS



ANALYSIS



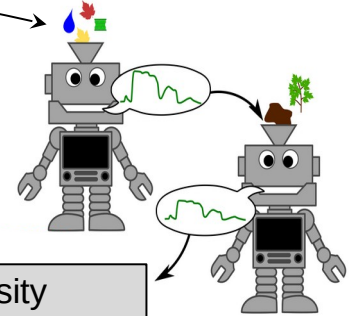
PROSAIL - Parameterization

= Radiative Transfer Model, to describe absorption & scattering of light in plant canopies (canopy level + leaf level)

Trait & species sampling on 3 sites for 3 seasons

Table 1: Input parameters for the PROSAIL model and how we retrieved them.

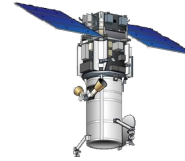
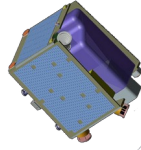
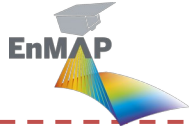
Parameter	Description	Unit	Source
N	Structure parameter	NA	Literature
Cab	Chlorophyll a & b content	$\mu\text{g}/\text{cm}^2$	Spectrophotometric & SPAD conversion
Car	Carotenoid content	$\mu\text{g}/\text{cm}^2$	Spectrophotometric & linear regression with Cab content
Cbrown	Brown pigment content	NA	field observation
Cw	Equivalent water thickness	cm	trait sampling & measurement
Cm	Dry matter content	g/cm^2	trait sampling & measurement
psoil	Dry/Wet soil factor	NA	Literature & field observation
LAI	Leaf area index	NA	LiCor2200C
lidfa	Leaf angle distribution	degree	LiCor2200C
lidfb	Bimodality of leaf angle distribution	according package	
tts	Solar zenith angle	degree	calculated according to site and season
rsoil	background soil reflectance	NA	spectrometry



Metric for spectral diversity
→ **euclidean distance** (pixel-based for different spatial resolutions, distance between reflectance @each wavelength)

Analysis
(e.g. test relation to species number, functional diversity,...)

Spatial Resolutions



...work in progress...

Resolution [m]	30 x 30	10 x 10	6 x 6	3 x 3	1 x 1	0.2 x 0.2
Refers to...	EnMap	Sentinel-2	RapidEye	Planet/ WorldView/SP OT	~ Ikonos	DOP
Nb pixels	1 [base unit]	3 x 3	5x5	10x10	30x30	150x150

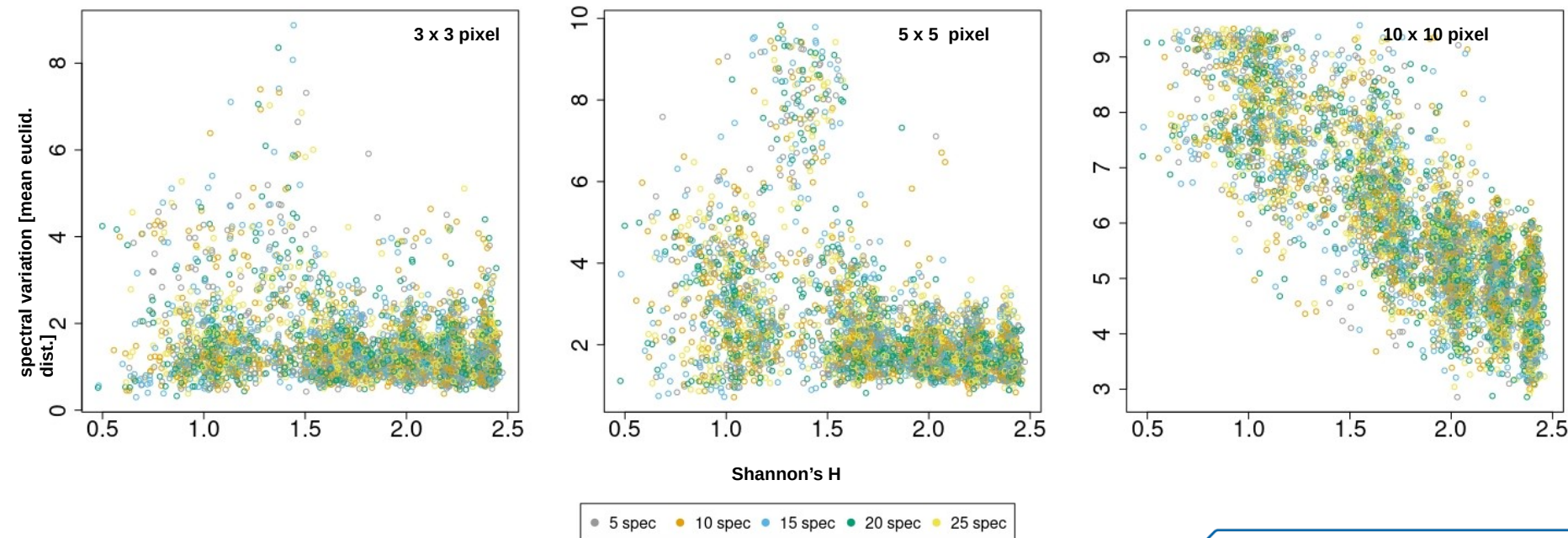
Very first results pt. 1

for 1 site @ 1 season @ 3 spatial resolutions

Shannon's Index: describes diversity of species by taking into account raw species numbers as well as the species abundances.

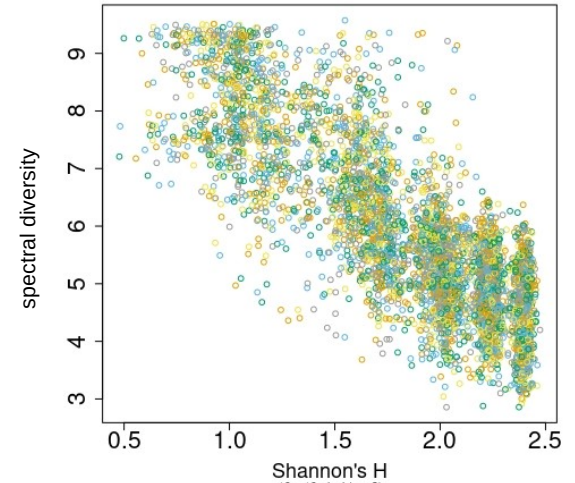
Spectral Diversity ~ Shannon's H Index

Bad Lauchstädt | spring | dry soil



Very first thoughts

- possible correlation number of individuals and diversity level in simulations
→ influence of soil reflectance & bare soil pixels stronger for lower species numbers?
- water bands → remove?
- dependency on metric for species diversity



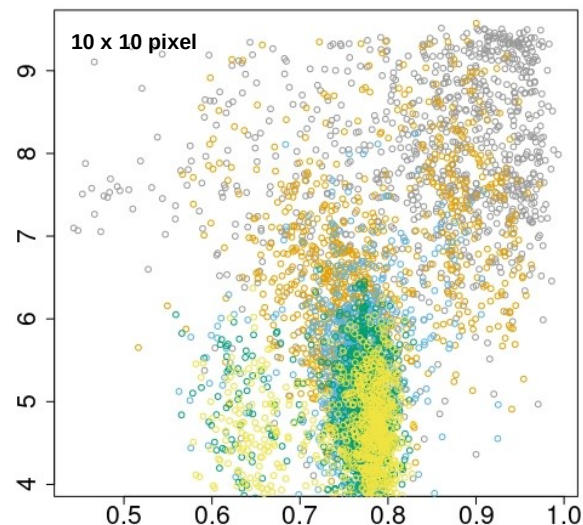
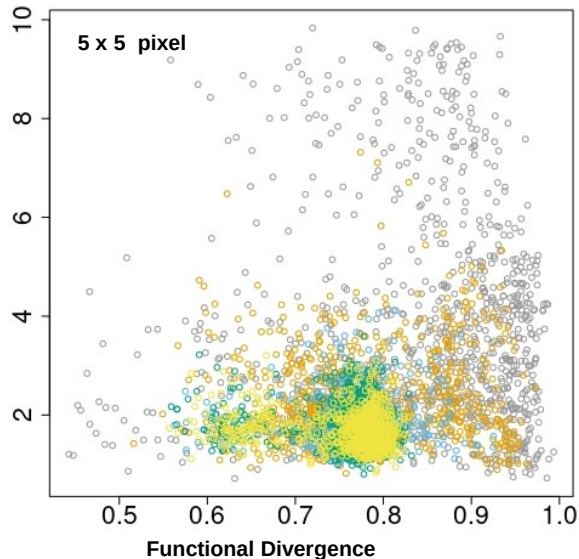
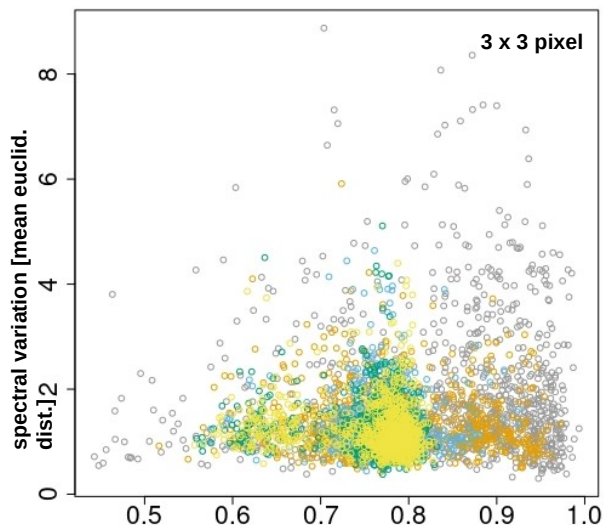
Very first results pt. 2

for 1 site @ 1 season @ 3 spatial resolutions

High functional divergence indicates a high degree of niche differentiation, i.e. the species are more different to each other in terms of their trait set.

Spectral Diversity ~ Functional Divergence (trait-based metric)

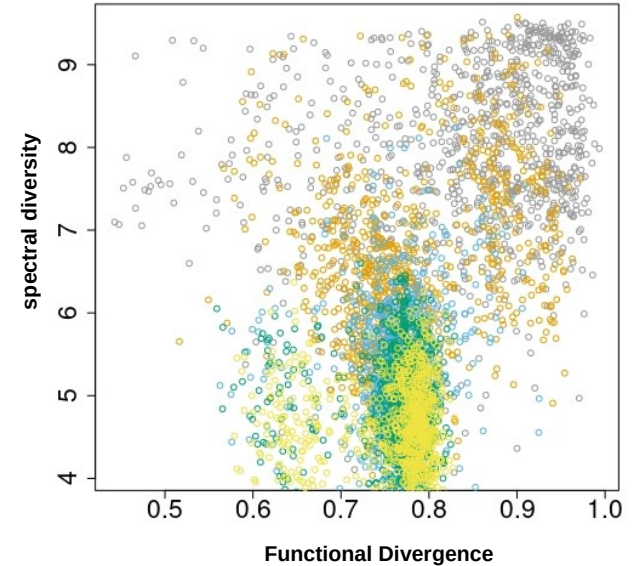
Bad Lauchstädt | spring | dry soil

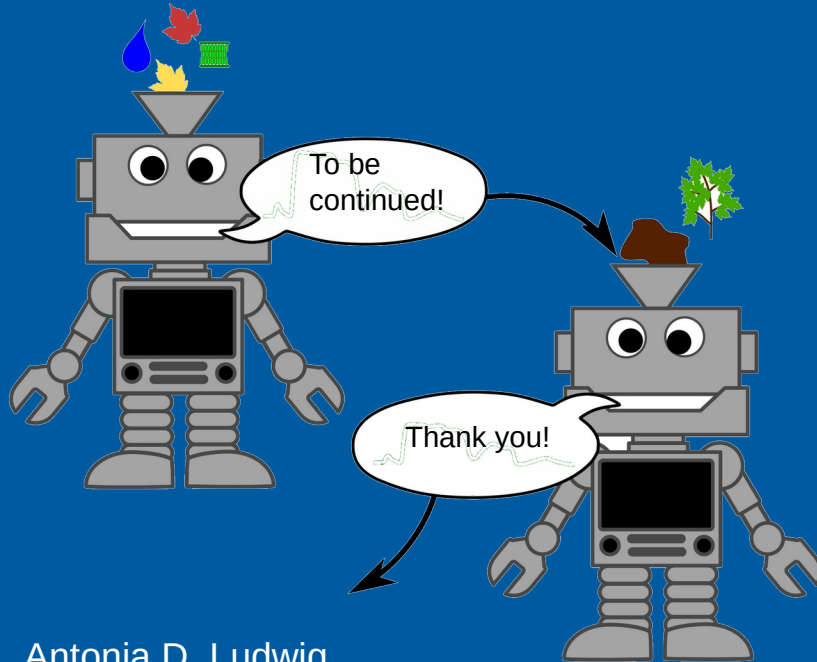


● 5 spec ● 10 spec ● 15 spec ● 20 spec ● 25 spec

Very first thoughts

- saturation of trait values in the potential trait space: trait space is limited by species pool the simulations are based on
- possible correlation number of species \sim functional diversity (metric dependent)





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