University of Zurich[UZH]

Institute of Evolutionary Biology and Environmental Studies

Towards assessing biodiversity feedbacks to climate in the Arctic

… and potential future applications of the AVA

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Research Goals

- Large scale vegetation changes (tundra to shrubland to forest) and their effects on the shortwave albedo and evapotranspiration in the Arctic are expected to generate strong positive feedbacks to climate warming (Chapin et al., 2005; Swann et al., 2010).
- Flux towers measure energy fluxes at local scale, as integrated signal of heterogeneous land surfaces and vegetation types.
- Little is known about role of different vegetation types on energy fluxes.

❖ Test effects of shrubification and biodiversity on plant traits and components of the energy balance, special emphasis on scaling and spatio-temporal effects.

Funding

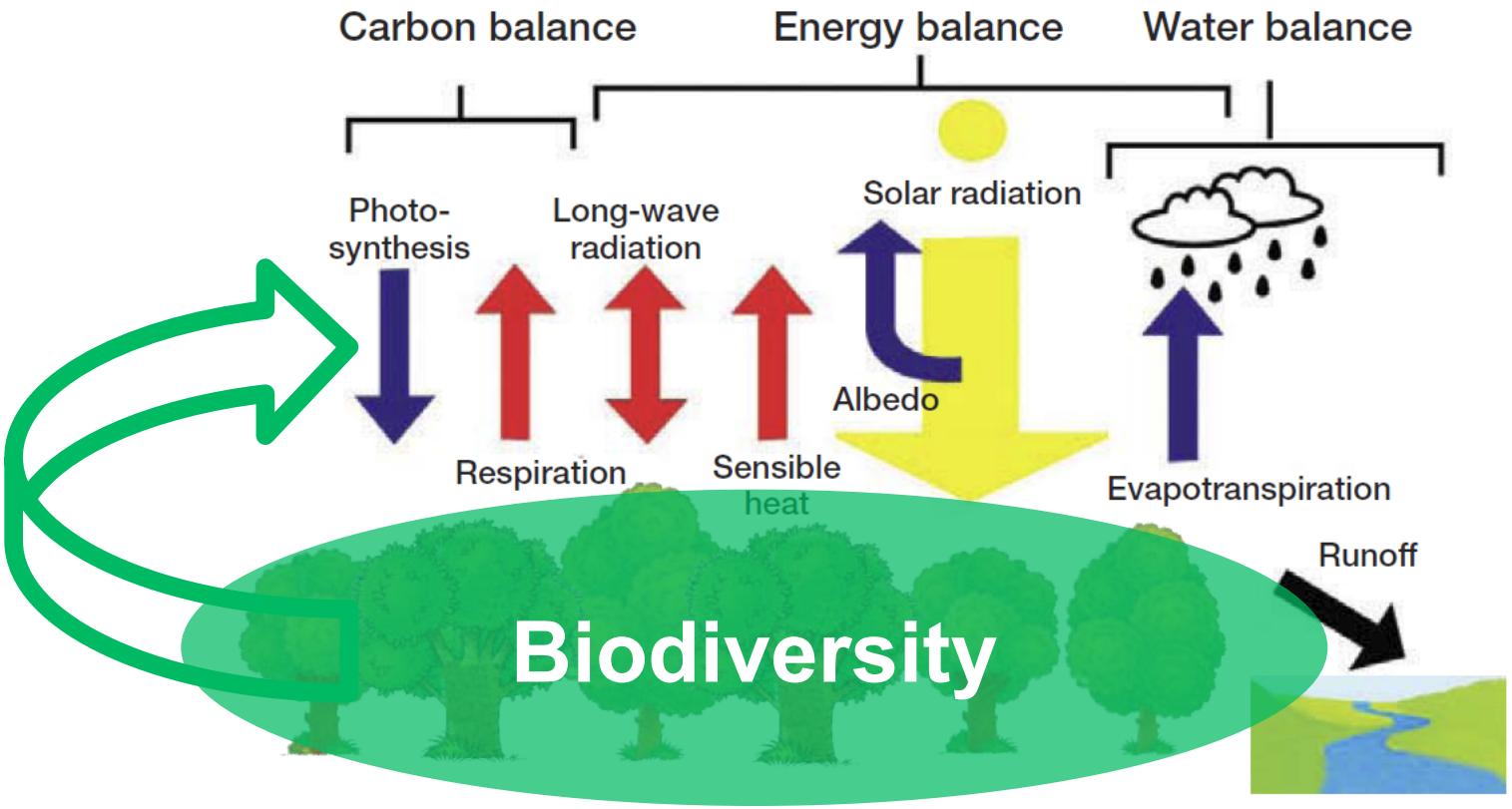
University of Zurich Research Priority Programme on Global Change and Biodiversity 2013-2016 (funded; planned until 2024)

Swiss National Science Foundation (2012-2015)

Cross-scale quantification of vegetation-atmosphere interactions and biodiversity change

General Hypothesis

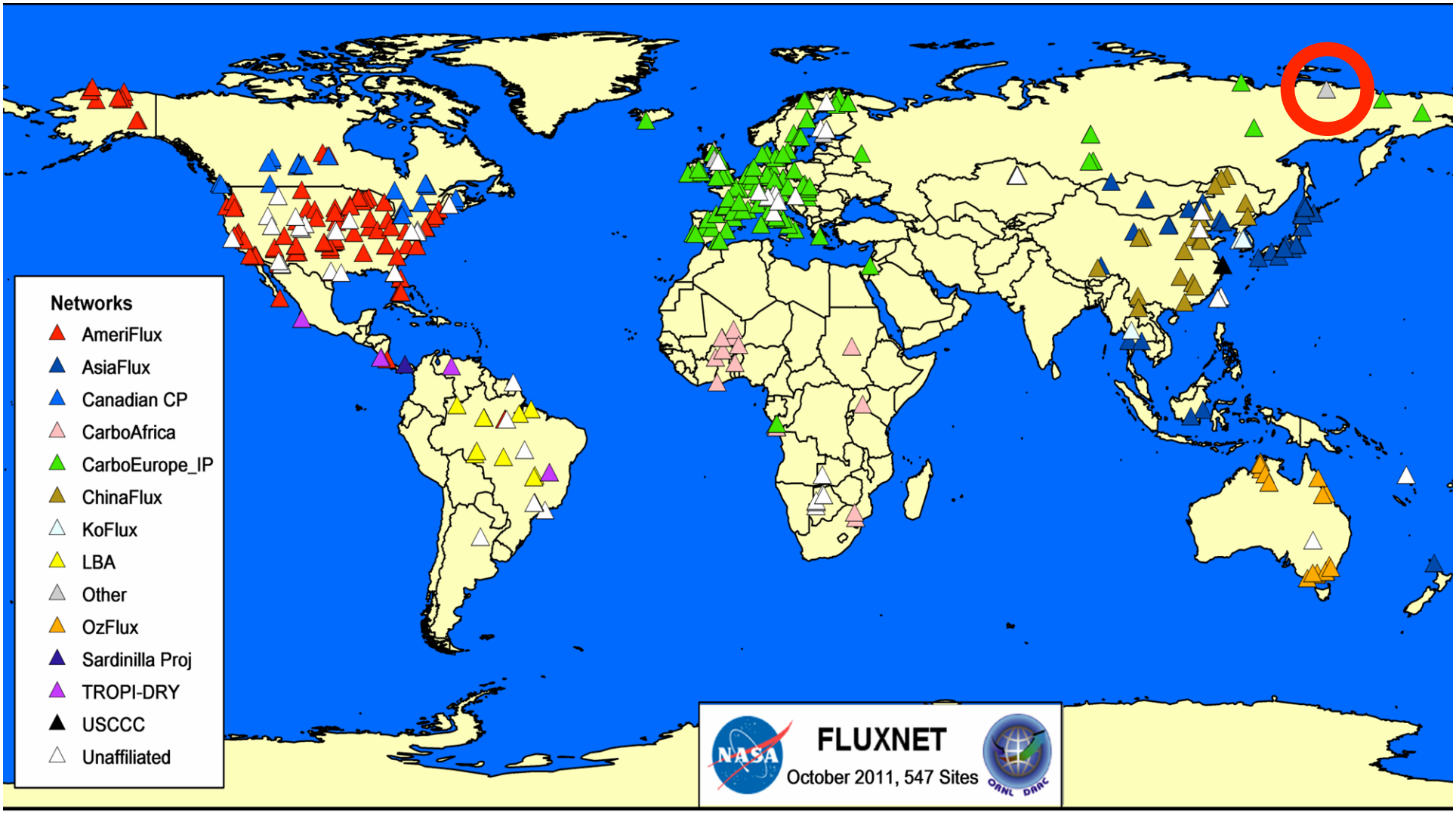
Biodiversity affects land ecosystem-atmosphere interactions through biophysical and biogeochemical processes



Chapin et al., Frontiers in Ecology and Environment, 2008

Siberian Research Site Kytalyk, Indigirka Lowlands, NE Siberia

71°N 147°E



Siberian Research Site Kytalyk, NE Siberia, 71°N 147°E

Observational, Experimental, Modelling and Statistical Approach

Observational studies
1 – species distribution and traits
2 – vegetation composition effect on energy balance

Experiment
1 – shrub effect on energy balance
2 – biodiversity effect on plant traits

Modelling (3D radiation model DART)
1 – Quantification of vegetation effect on energy balance components
2 – Quantification of biodiversity effect on energy balance components

Statistical approach
1 – Up- and downscaling of sparse local data to low-resolution satellite data

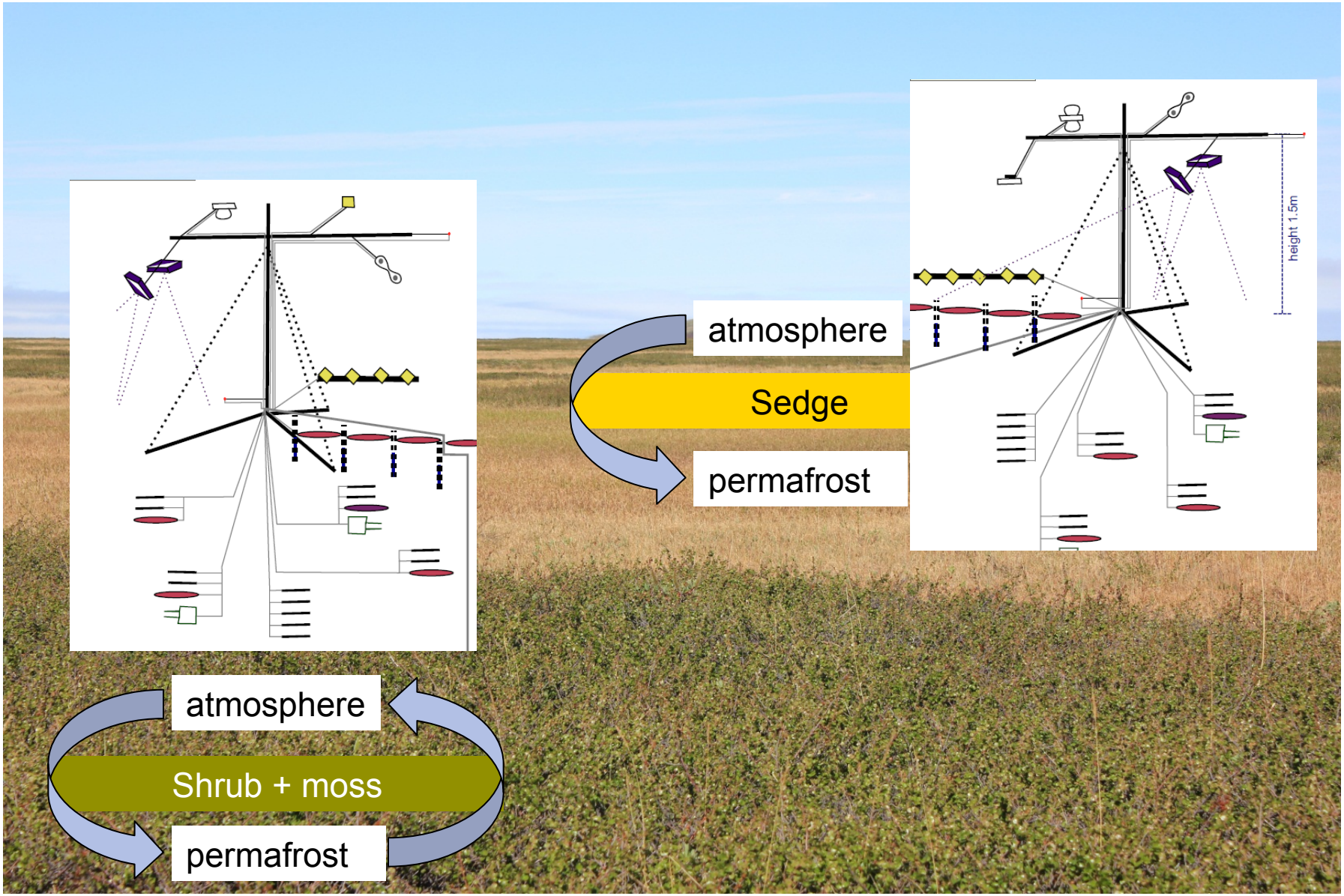
Observation 1 – Species determination

Input from CAFF Flora group and AVA on standards (taxonomy and spatial sampling) very welcome!

Yakutian Tundra Record (published 1991)

- 66 locations in Yakutian tundra
- Methodology?
- Locations?
- Planned to be included in AVA?
- Conserve knowledge of Egorova

Observation 2 – Energy balance of dominant vegetation types (start summer 2013)



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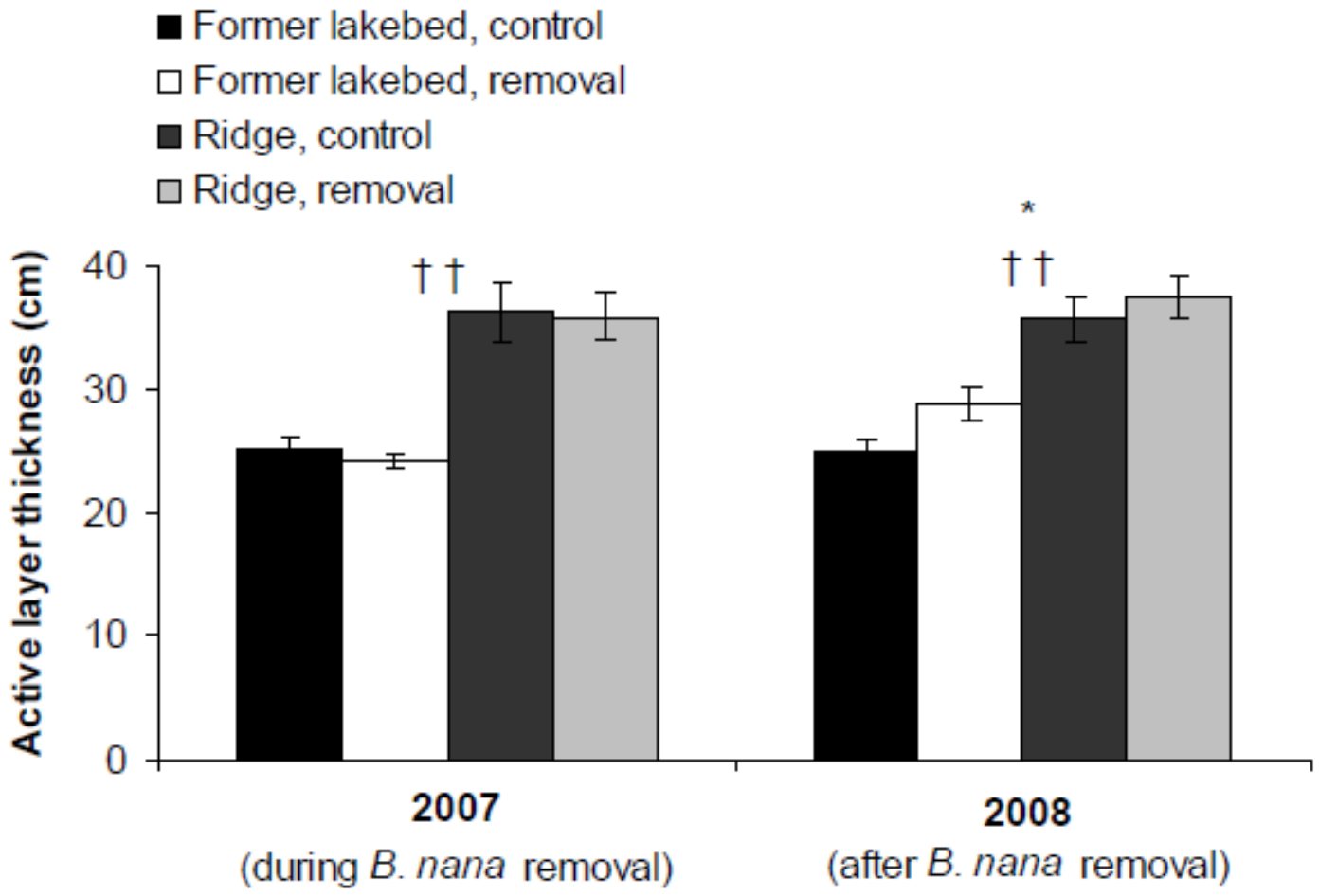
Experiment 1 – Shrub Effect on ALT

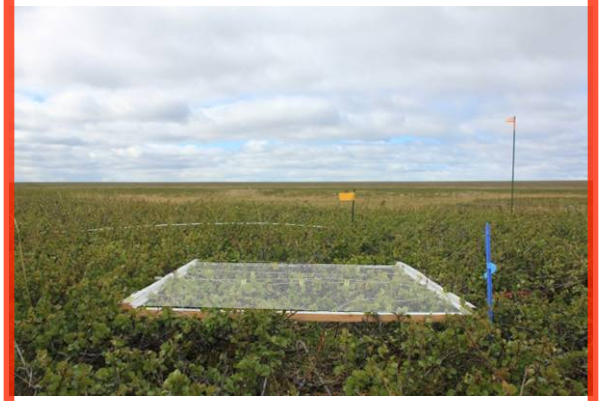


Blok et al., GCB, 2010

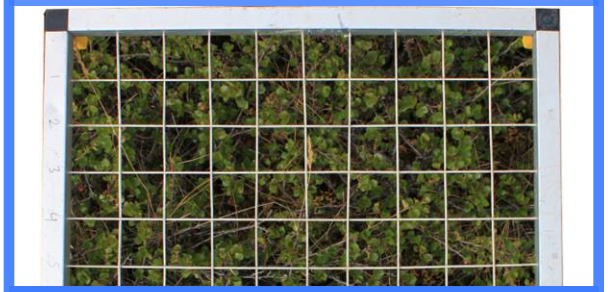
Experiment 2 - Shrub Density and Height Effect on tPAR and Canopy Reflectance

Treatment

15 plots 2x2m^2
h height reduction
d density reduction
c control



Assessment of treatment



Reduction of leaf area index
h -0.30 ± 0.13
d -0.27 ± 0.09

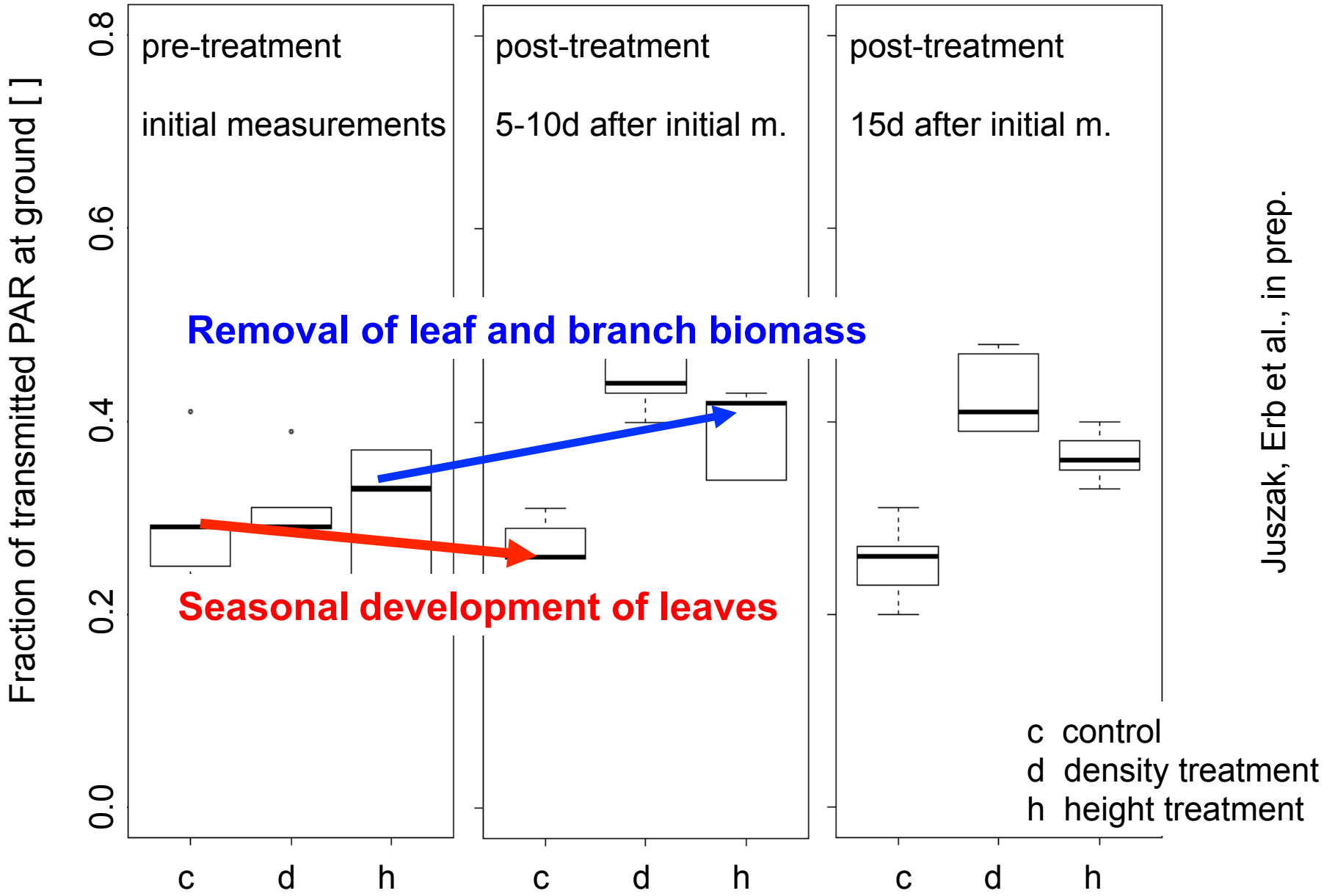
Reduction of biomass
h -40.2% ± 12 leaf,
-9.2% ± 2.7 branch
d –29.4% ± 4.6 leaf
-29.4% ± 4.6 branch

Radiation effects

reflectance, NDVI (ASD)

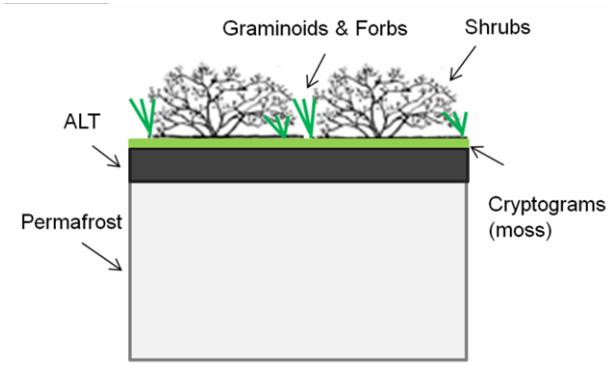
transmitted PAR (Sunscan)

Shrub Density and Height Effect on Canopy Transmitted PAR

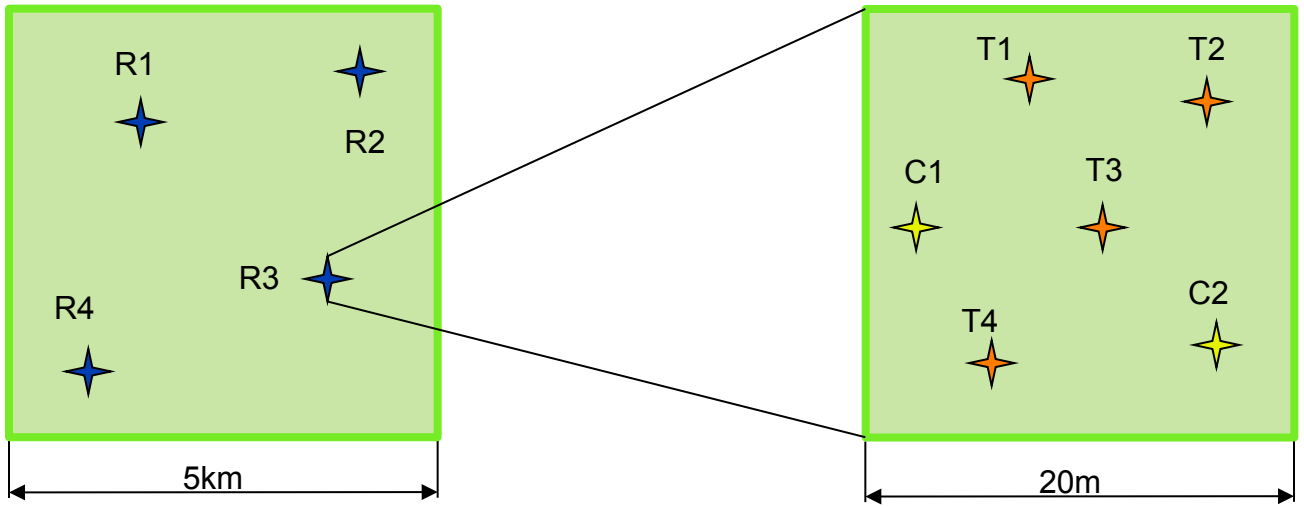


Experiment 2 - Biodiversity Manipulation (Summer 2014)

Biodiversity effect on inter- and intraspecific plant traits?



Control 1	Control 2 (-biomass)	Treatment 1	Treatment 2	Treatment 3	Treatment 4
A	% A	~~A~~	A	A	A
B	% B	B	~~B~~	B	B
C	% C	C	C	~~C~~	C
D	% D	D	D	D	~~D~~



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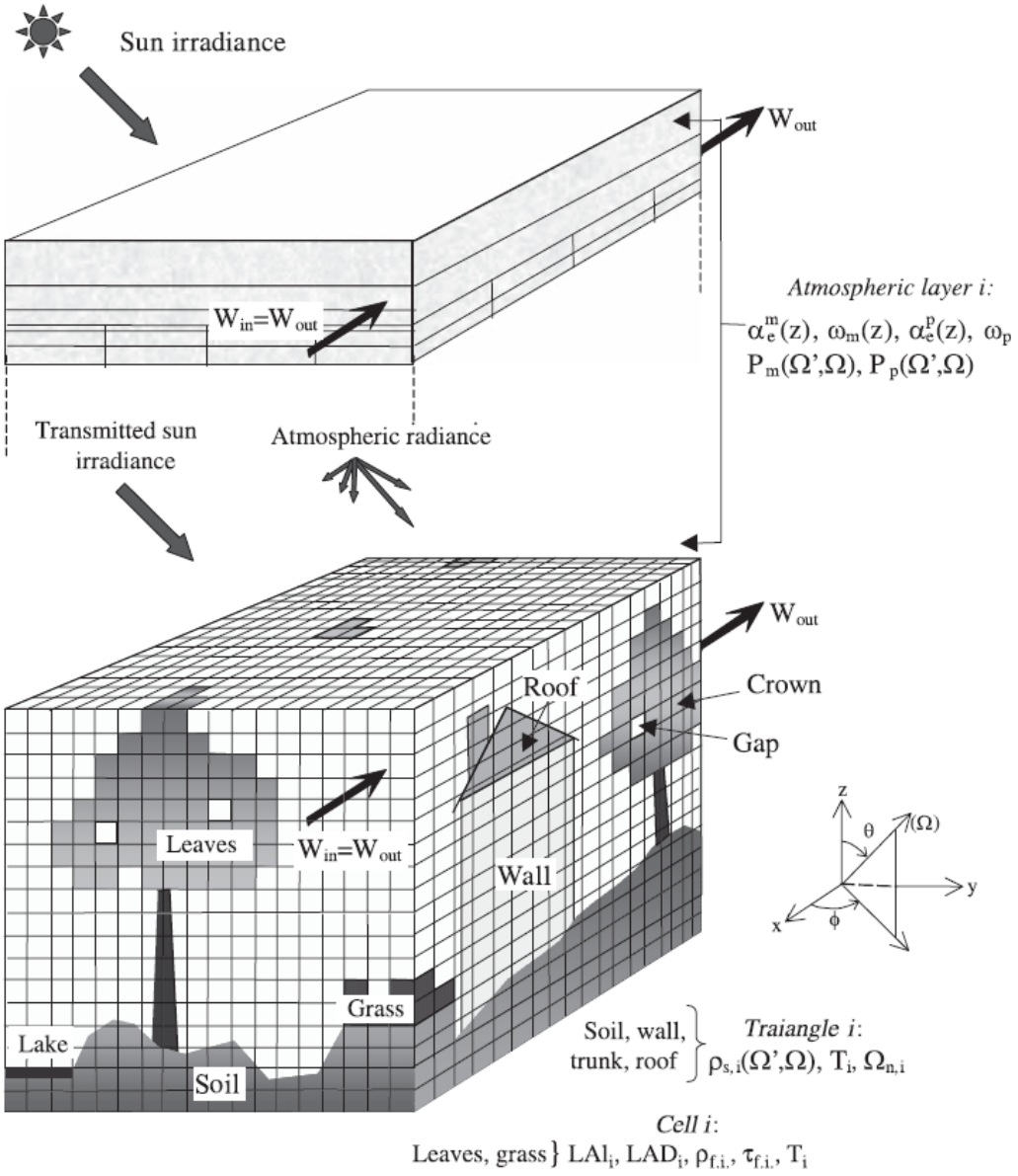
3D Radiative Transfer Modelling - Discrete Anisotropic Radiative Transfer (DART)

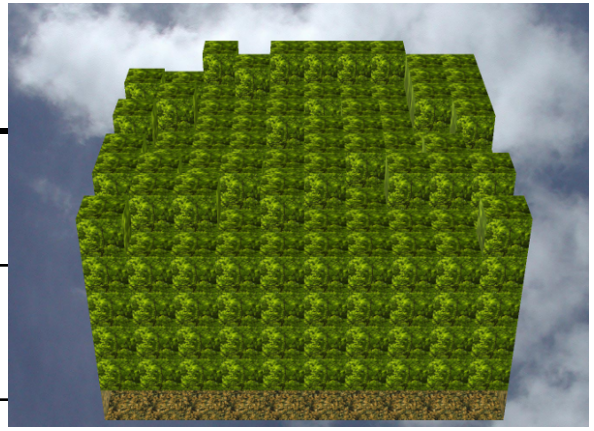
- Simulation of radiative transfer in the Earth-atmosphere system
- Landscape as 3D matrix of cells with turbid material and/ or triangles
- Combined ray-tracing and discrete ordinate method
- Any wavelength (interval) in visible, near-infrared, and thermal infrared
- Output: 3D energy fluxes, radiation budget, satellite images

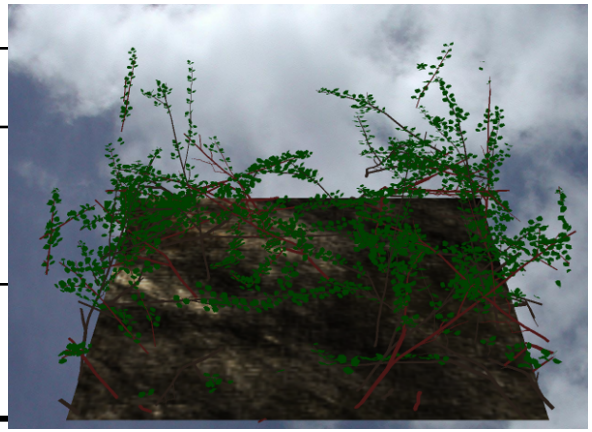
Gastellu-Etchegorry, Meteorology and Atmospheric Physics 102, 187–207, 2008



DART Model Parameterization

Wavelength range, resolution	400-2300nm, 1nm
Leaf reflectance, transmittance	Integrating sphere and spectrometer
Understorey reflectance	Spectrometer
Sun and view angle	according to field measurements or scenarios
Scene dimension	0.5 x 0.5 m (repetitive)
Cell dimension	0.05 x 0.05 x 0.05 m^3
Turbid medium	leaves only
Vegetation height	0.25 m +/- 0.05
Leaf area index	0.0 – 2.8 m^2/m^2
Understorey composition	50% litter, 24% green moss, 24% brown moss, 2% lichen

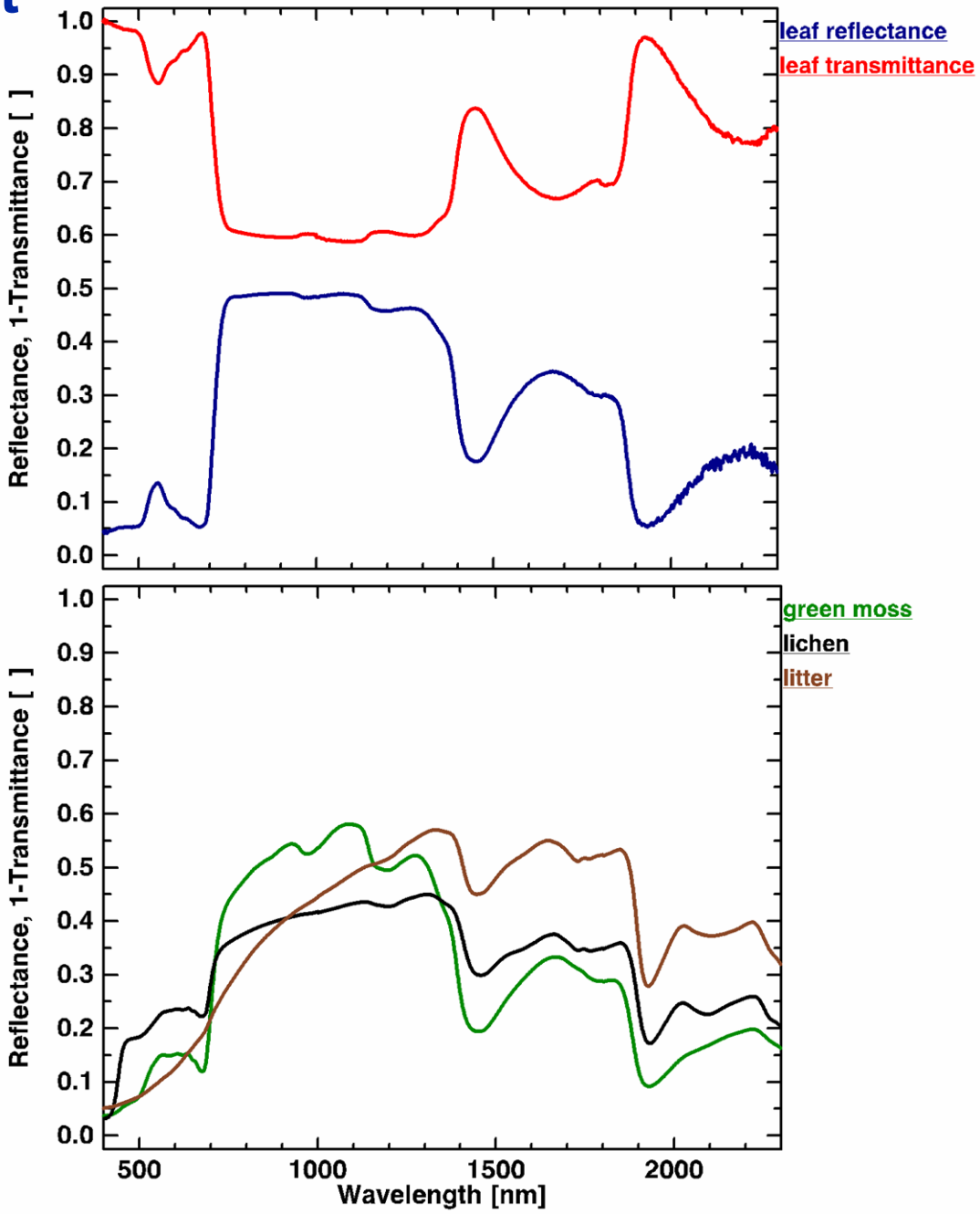


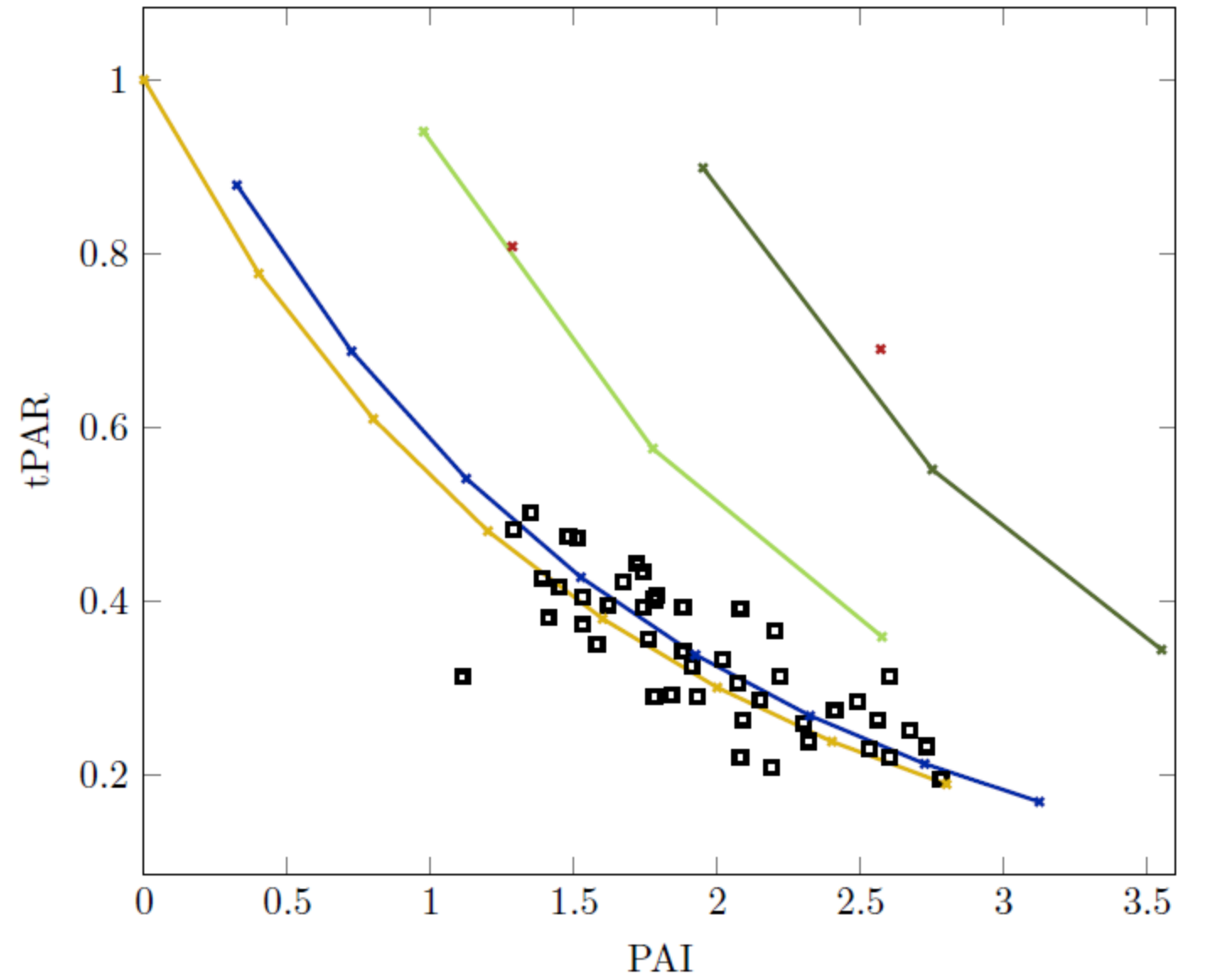


Example of Model Input

Leaf optical properties

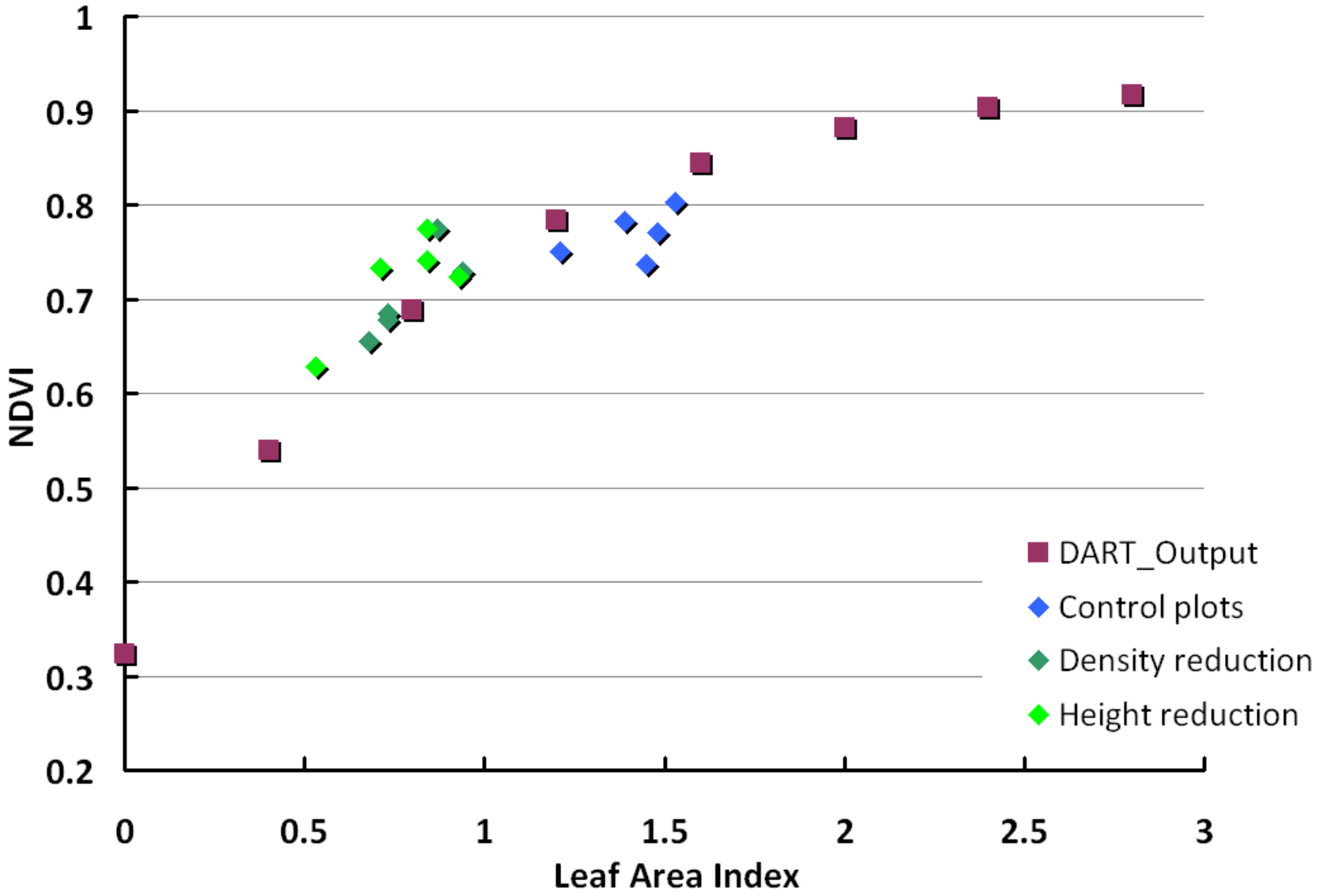
Understorey reflectance





Measured PAI
Only turbid
Turbid + stems
Turbid + branches (dense)
Turbid + branches (sparse)
Only objects

Leaf Area Index and Normalized Difference Vegetation Index



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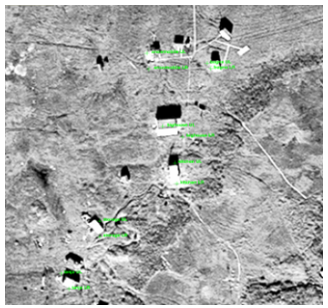
Moving towards Pan-Arctic Feedbacks and Applications

1. Improving ecosystem-environment models by linking sparse and local field data with low-resolution satellite data.
   Up- and downscaling between field data, meteorological and satellite data using Bayesian modelling.

   Goal is spatio-temporal modelling and uncertainty assessment.

2. Plant species traits
   - Biodiversity modelling requires plant traits assessment
   - Arctic species underrepresented in current databases (eg. TRY)
     -> link of AVA with TRY?



3. Spatial heterogeneity and biodiversity assessement
   - Spatial sampling design
   - Spatial accuracy

4. AVA as validation data set for satellite products?
   -> CEOS Land Product Validation subgroup http://lpvs.gsfc.nasa.gov/

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