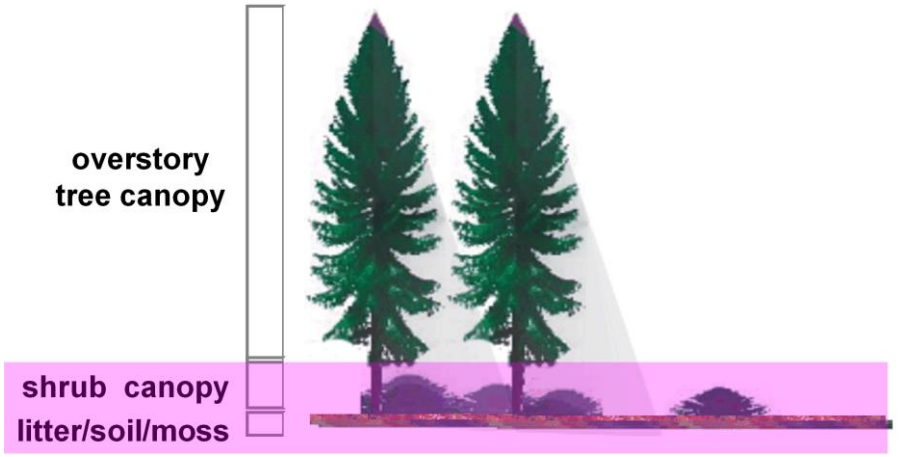
What is the most suitable viewing configuration for retrieval of forest understory reflectance from multi-angle remote sensing data?

Jan Pisek, Mait Lang, Joel Kuusk

TARTU OBSERVATORY
space research centre

Finnish Remote Sensing Days, Oct 30, 2014, Helsinki

Why?



the signal from the understory can be used, for example:

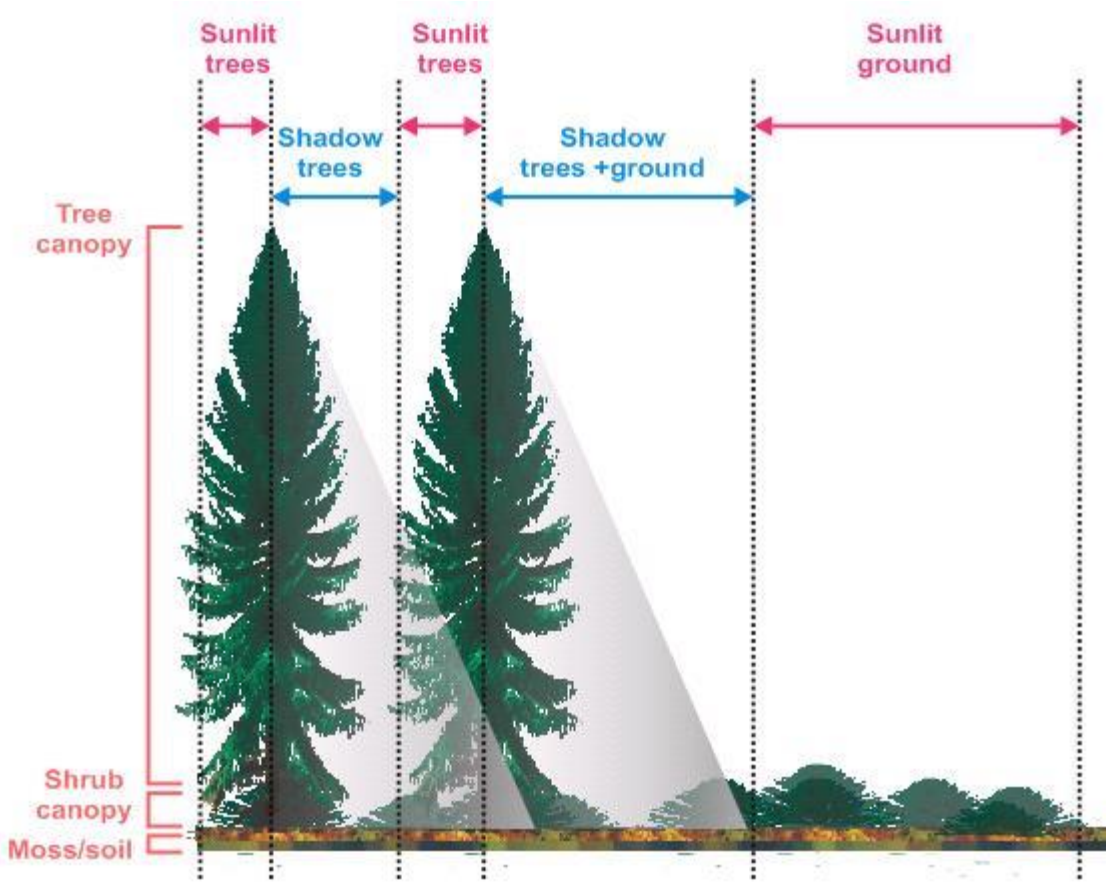
(1) in forestry applications to separate forest site types (i.e. soil fertility classes) Olofsson and Eklundh, 2007, RSE

(2) to remove the influence of understory in estimating canopy biophysical variables (e.g. LAI, fPAR) from remotely sensed images Garrigues et al., 2008, JGR

(3) to develop and test canopy radiative transfer models Widlowski et al., 2007, JGR

(4) tracking phenology Ahl et al., 2006, RSE; Ganguly et al., 2010, RSE

Is it possible?



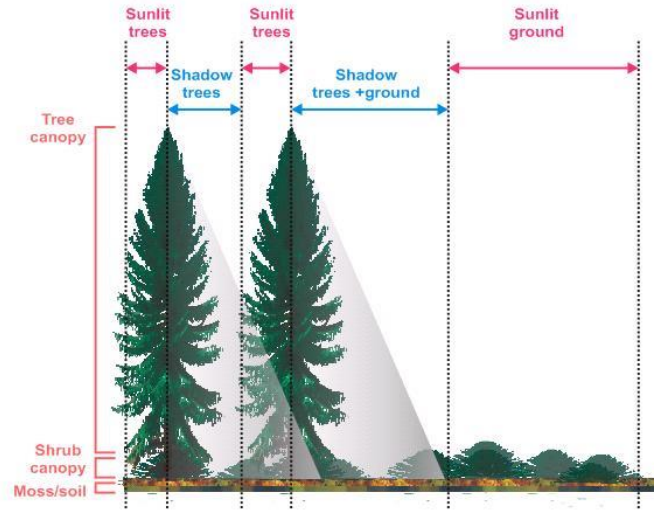
$$R_n = P_{Tn} \times R_T + P_{Gn} \times R_G + Z_{Tn} \times R_{ZT} + Z_{Gn} \times R_{ZG}$$

How?

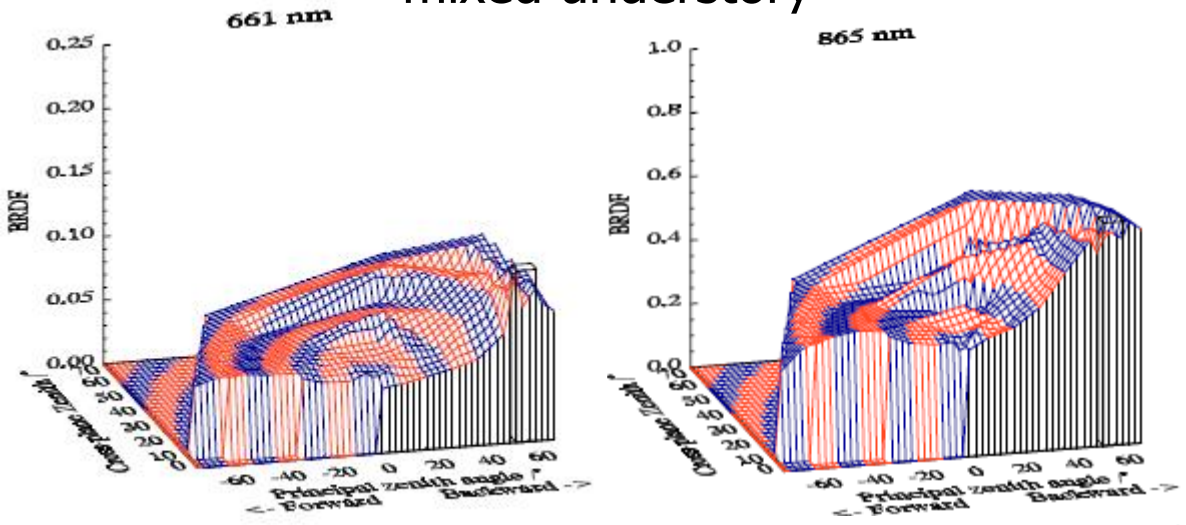
$$R_n = P_{Tn} \times R_T + P_{Gn} \times R_G + Z_{Tn} \times R_{ZT} + Z_{Gn} \times R_{ZG}$$

$$R_a = P_{Ta} \times R_T + P_{Ga} \times R_G + Z_{Ta} \times R_{ZT} + Z_{Ga} \times R_{ZG}$$

$$R_{ZT} = M R_T \; ; R_{ZG} = M R_G$$



mixed understory



(Peltoniemi et al., 2005, RSE)

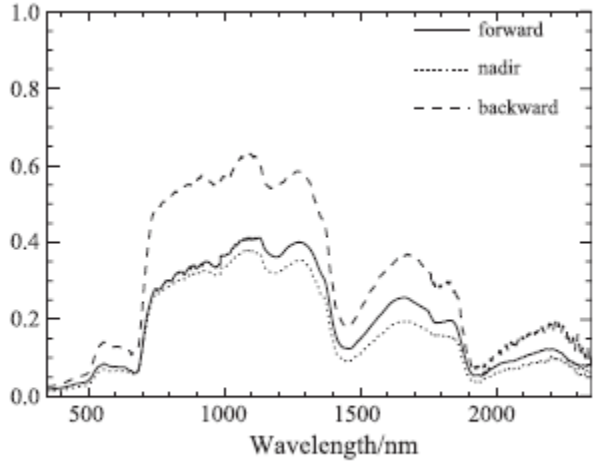
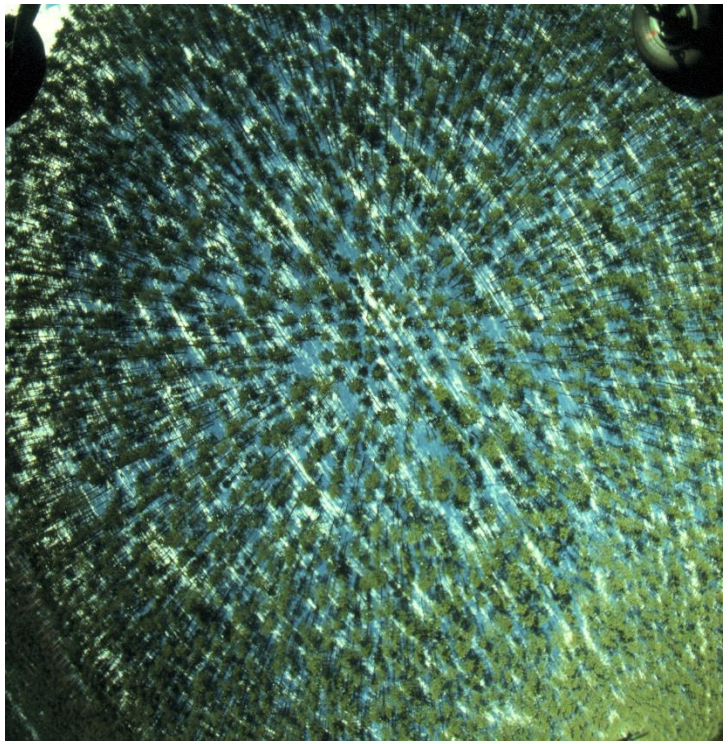


Fig. 19. The spectra of mixed understory (0°, ±50°). Lamp zenith angle is 58°.

MODIS BRDF parameters from MCD43A1.005 product (500m resolution)

$$R(\theta_i,\theta_v,\Phi,\lambda) = f_{iso}(\lambda) + f_{vol}(\lambda)K_{vol}(\theta_i,\theta_v,\Phi) + f_{geo}(\lambda)K_{geo}(\theta_i,\theta_v,\Phi)$$



from Lucht et al. (2000, TGRS)

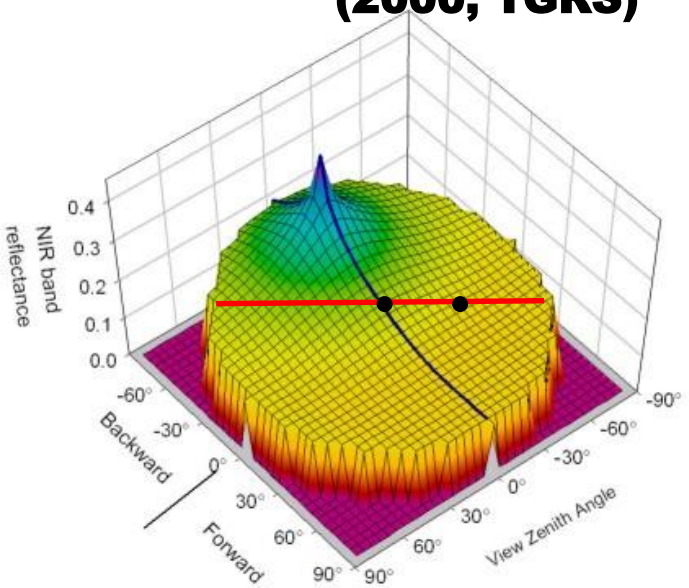
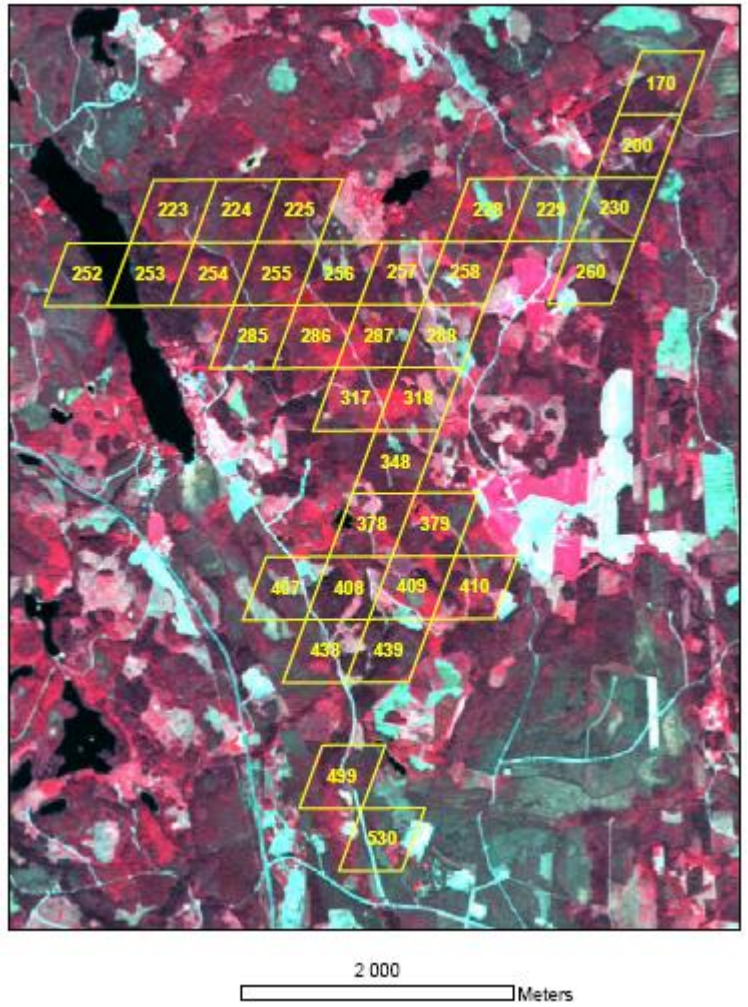
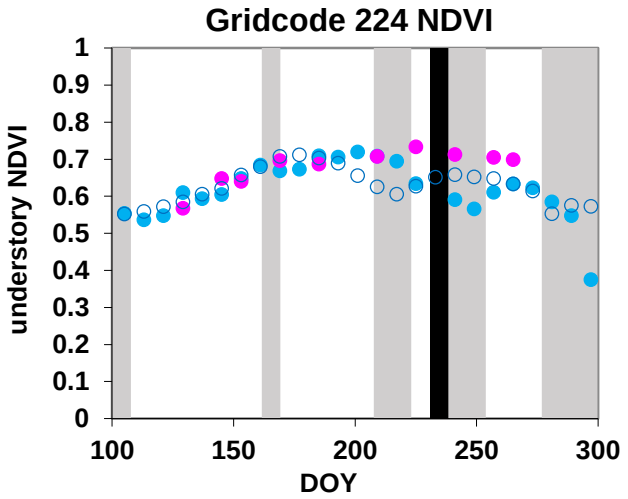


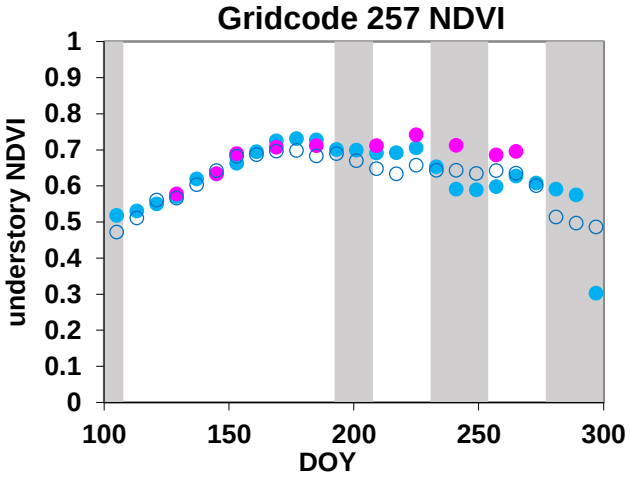
Photo property of Andres Kuusk

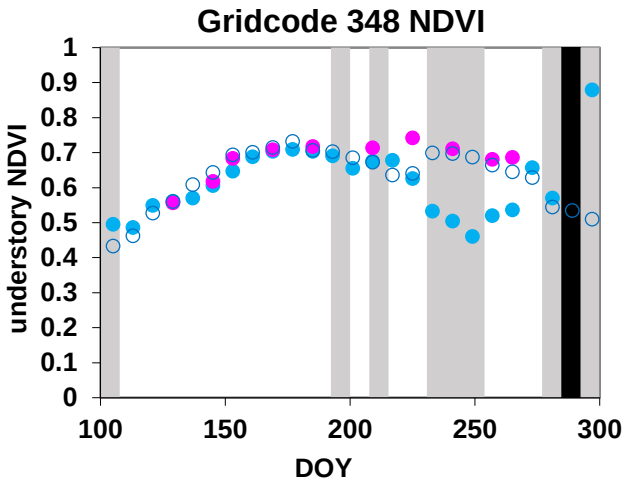
Hyytiälä results

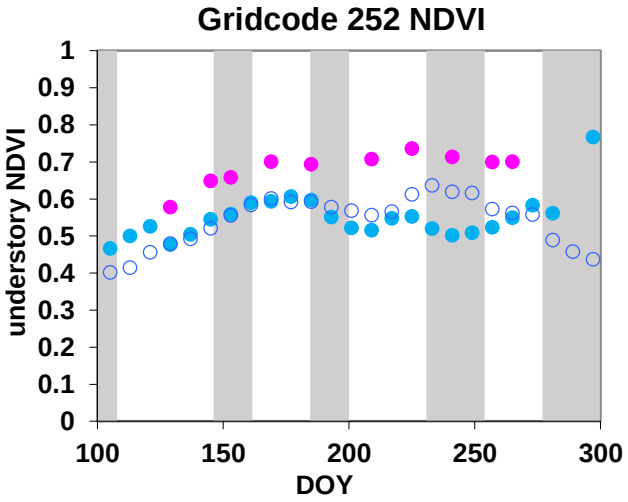
Field 2010
MODIS 2010
Lower Quality 2010
No Data
MODIS 2009





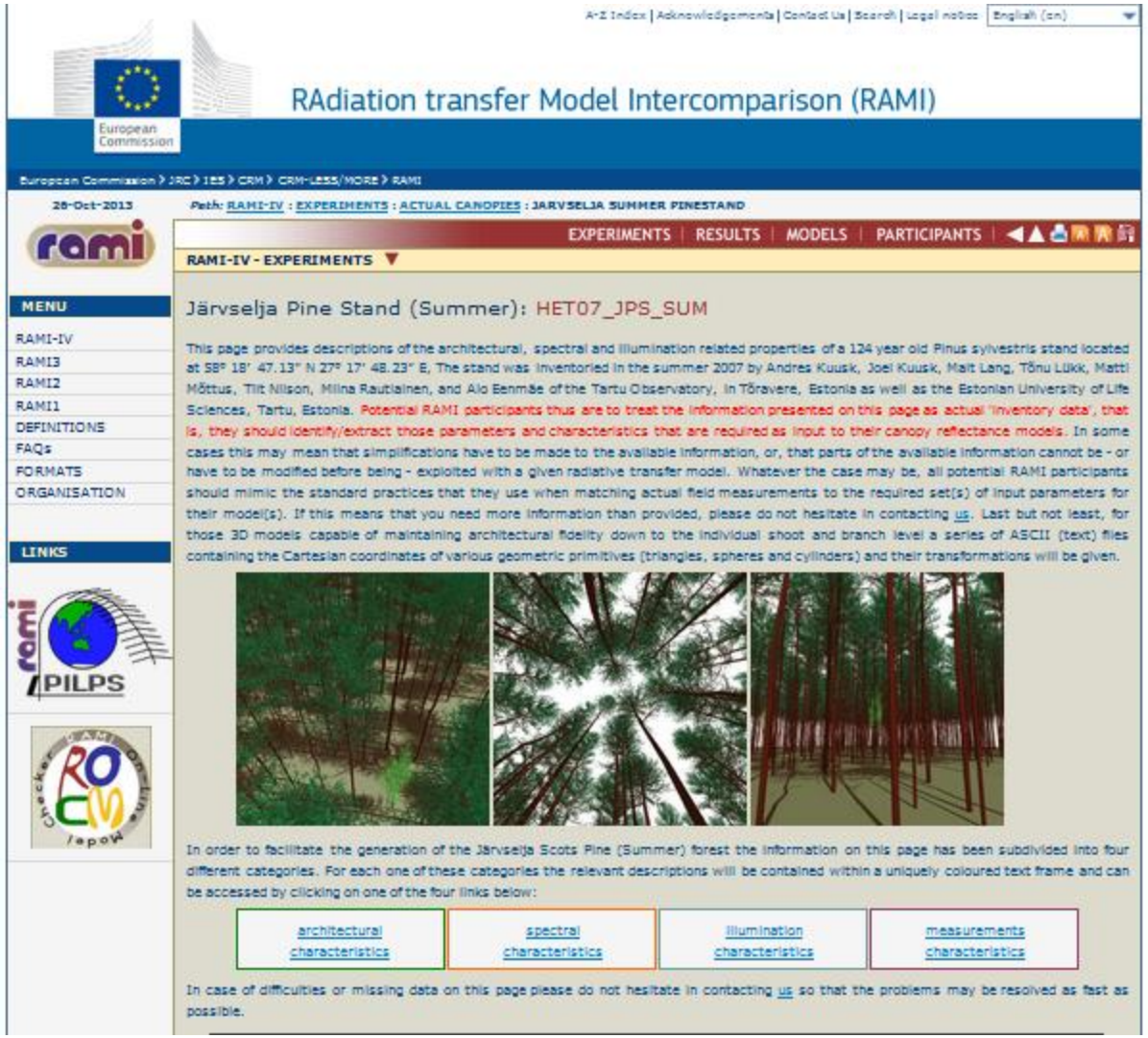






Pisek et al., 2012, RSE

RAMI stands (Järvselja, Estonia)

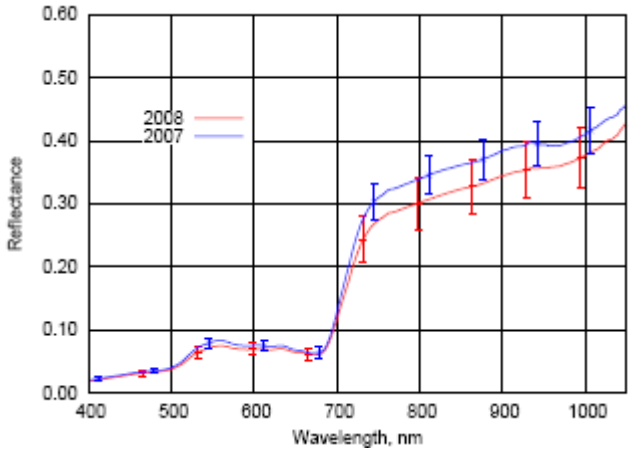


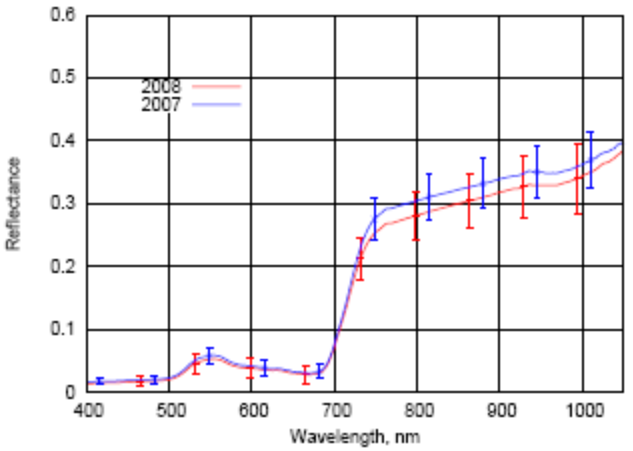
RAMI Pine

various Sphagnum moss species and marsh tea

RAMI Birch

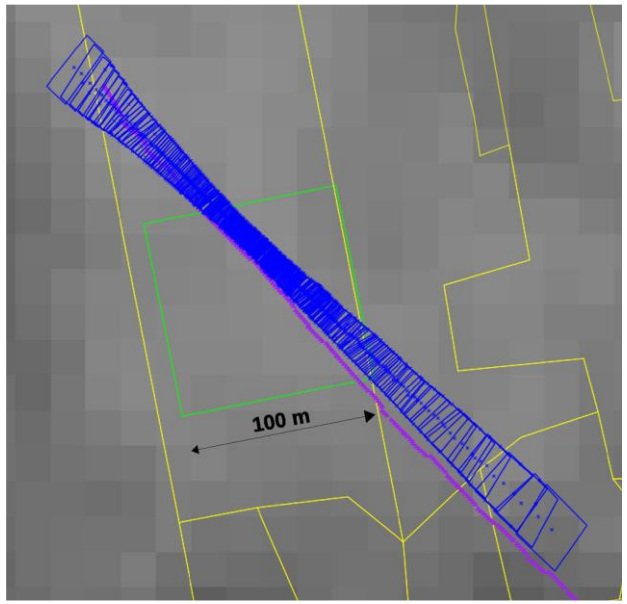
a mixture of several grass species

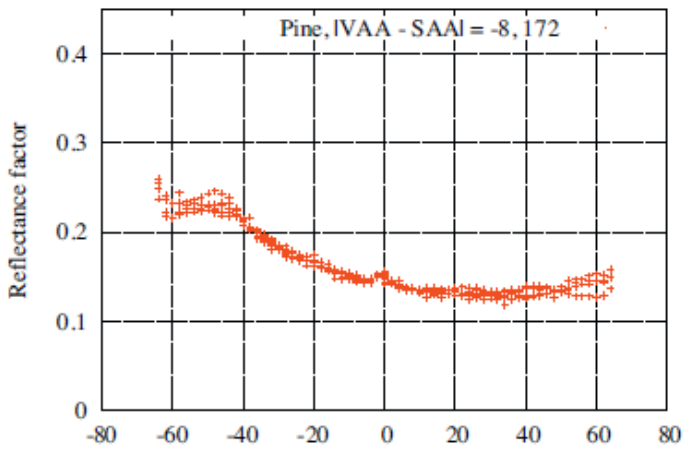




Kuusk et al., 2009, RSE

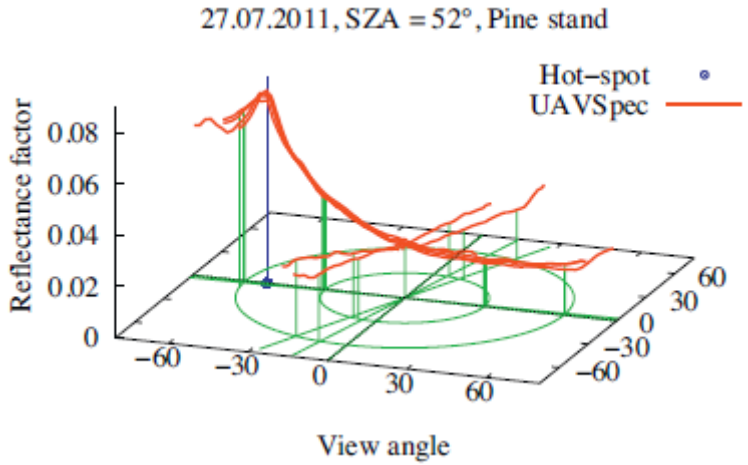
RAMI stands (Järvselja, Estonia)

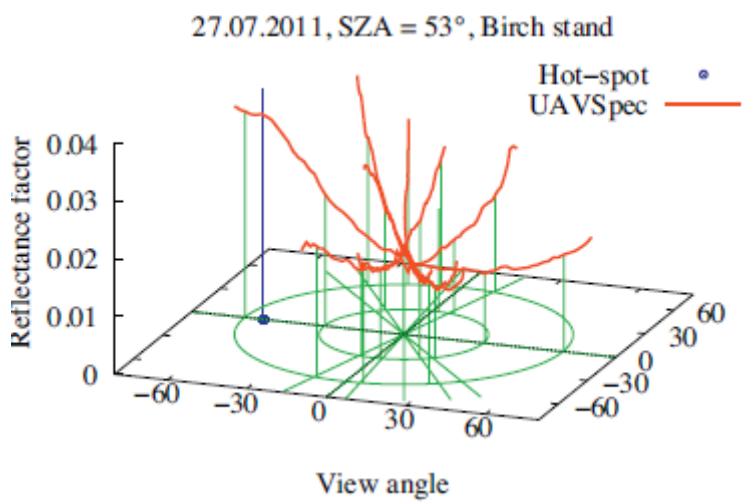




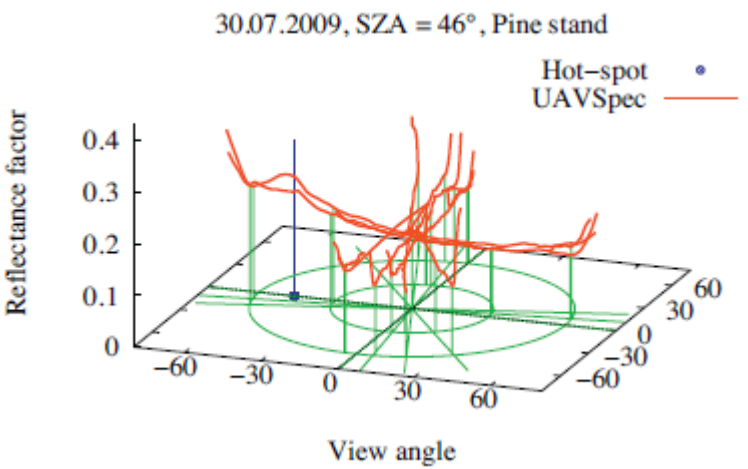
Kuusk et al., 2014, AFM

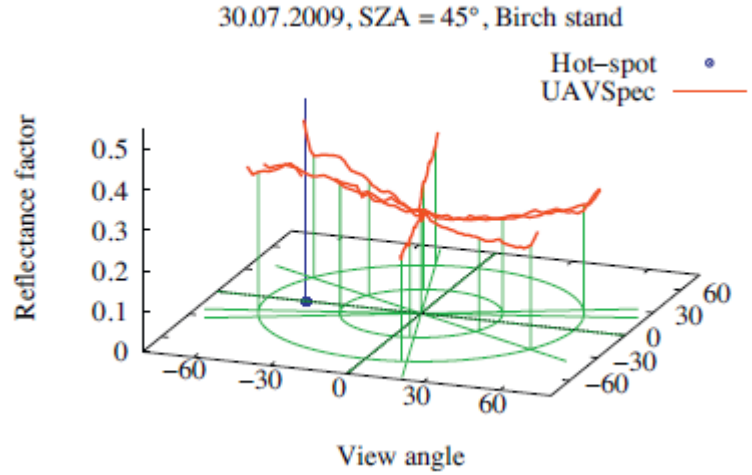
red





NIR



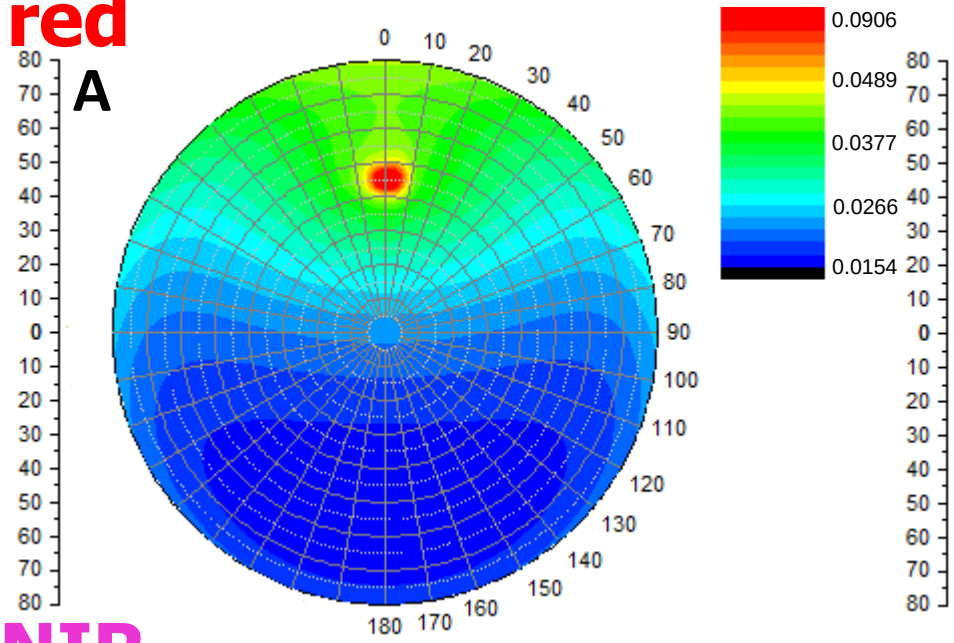


RAMI pine

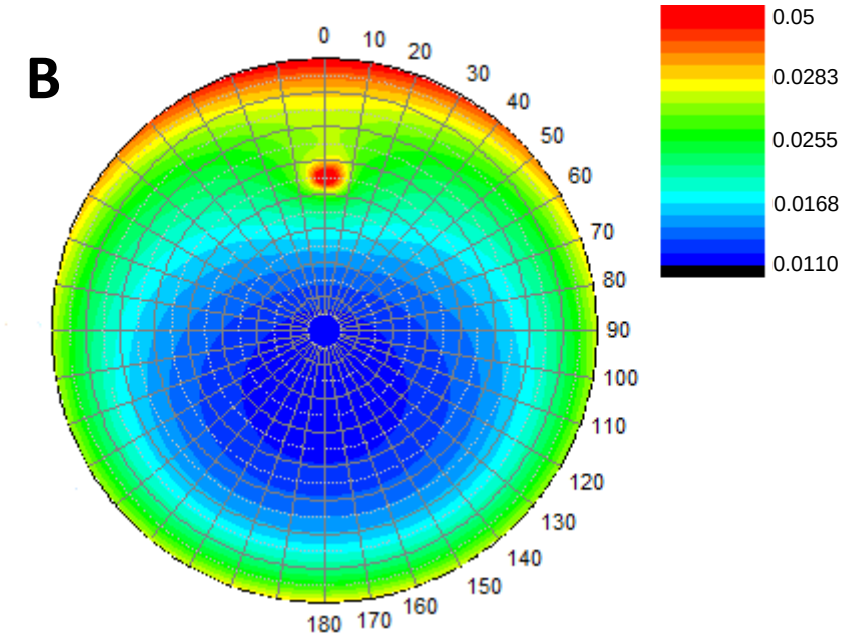
RAMI birch

red

A



B



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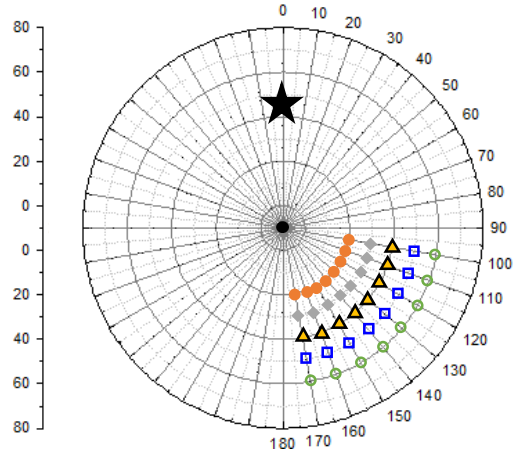
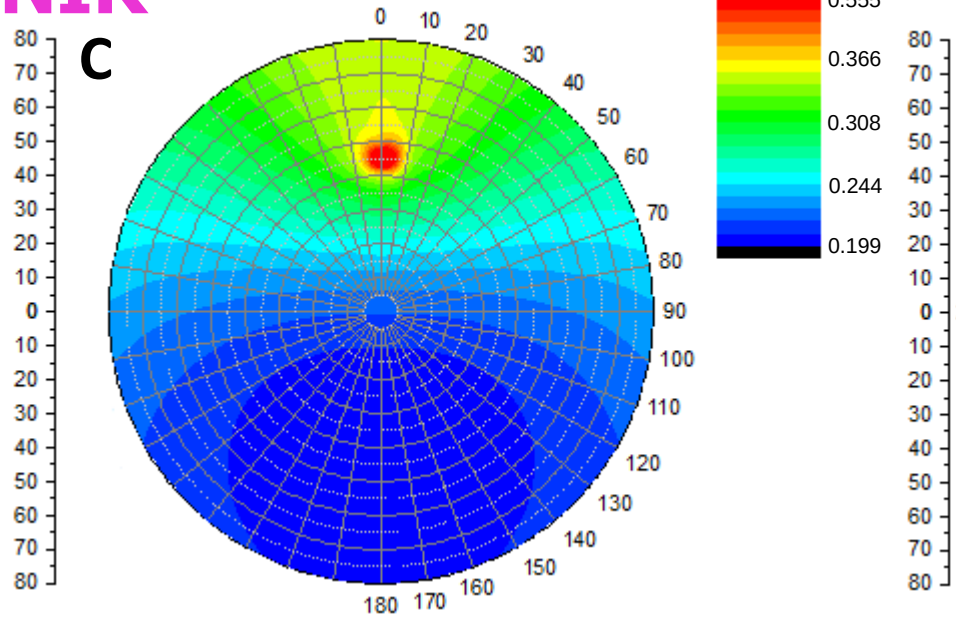
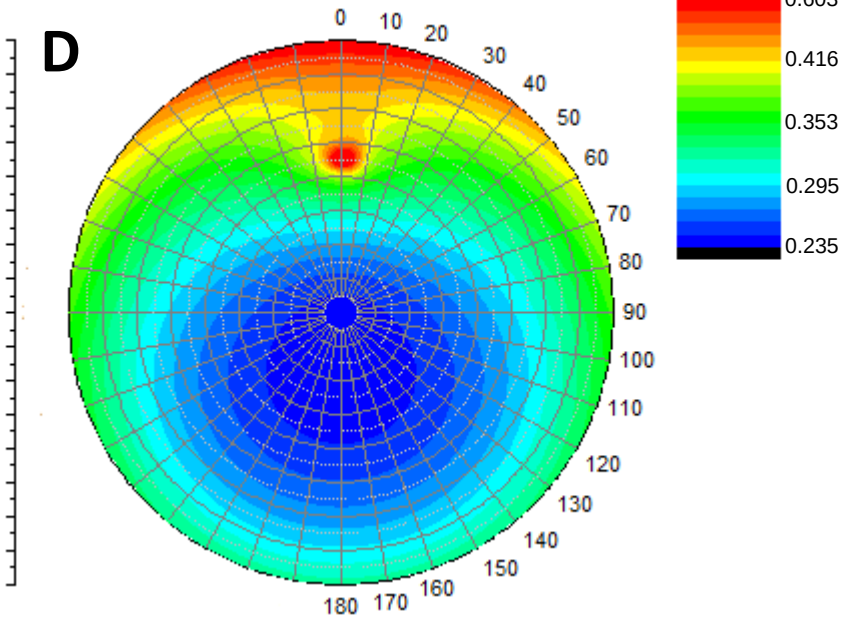


NIR

C



D



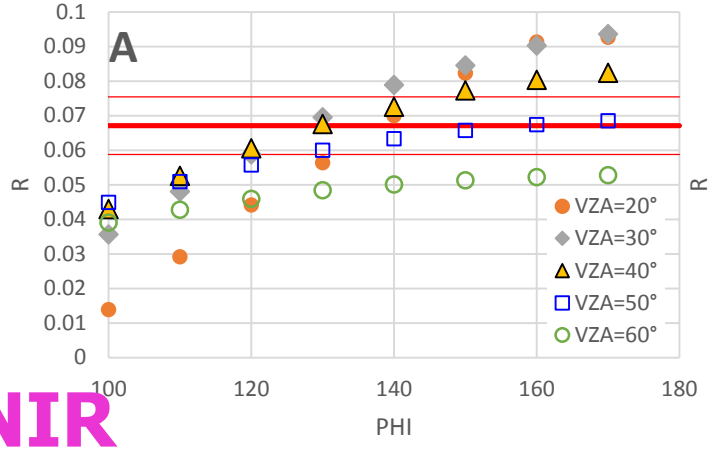
red

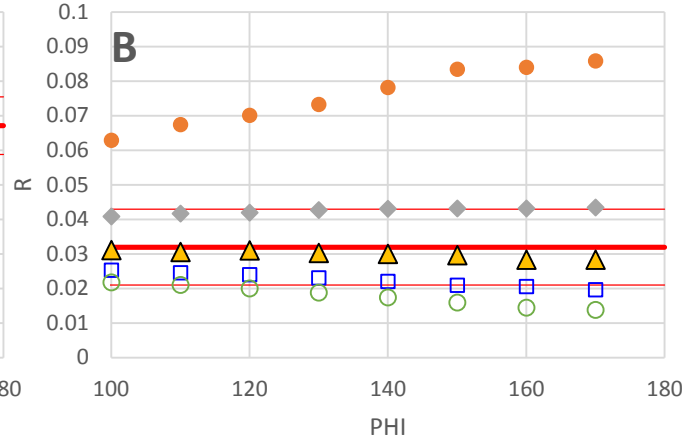
NIR

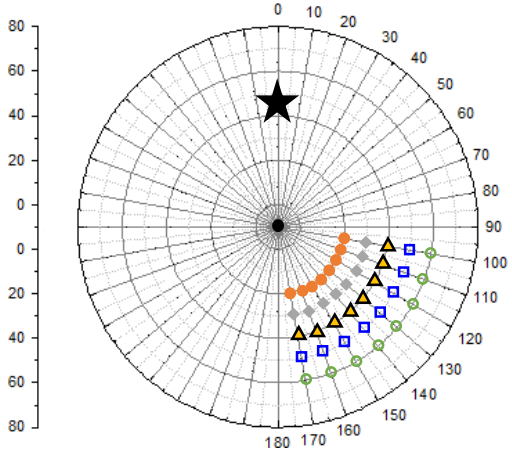
NDVI

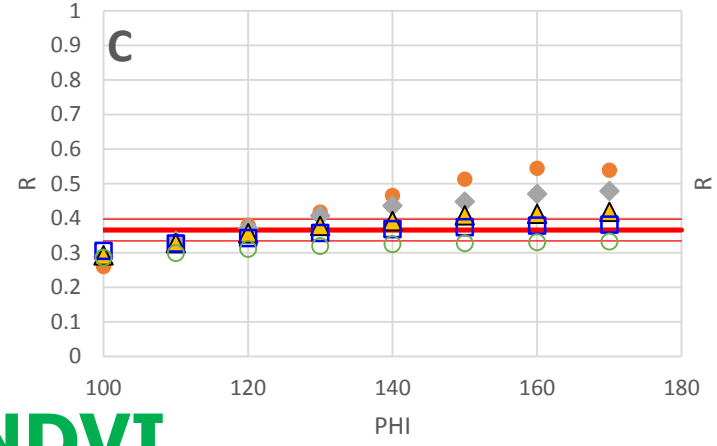
RAMI pine

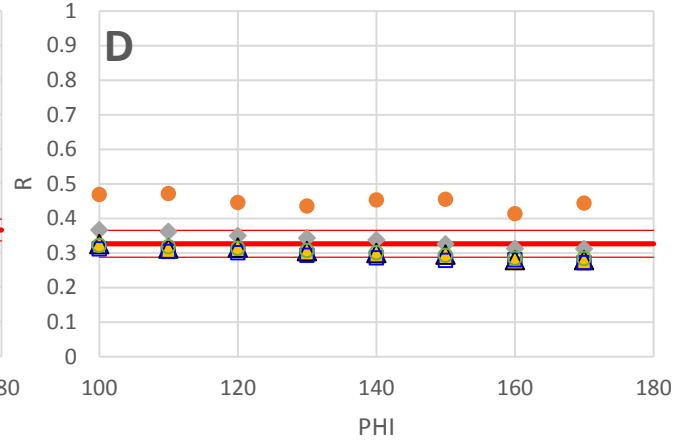
RAMI birch

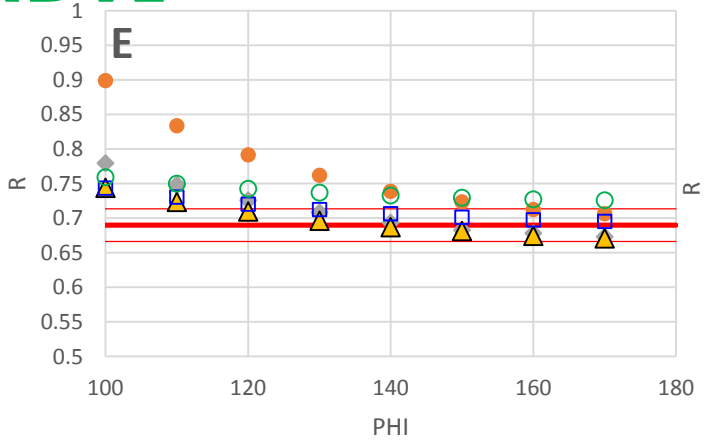


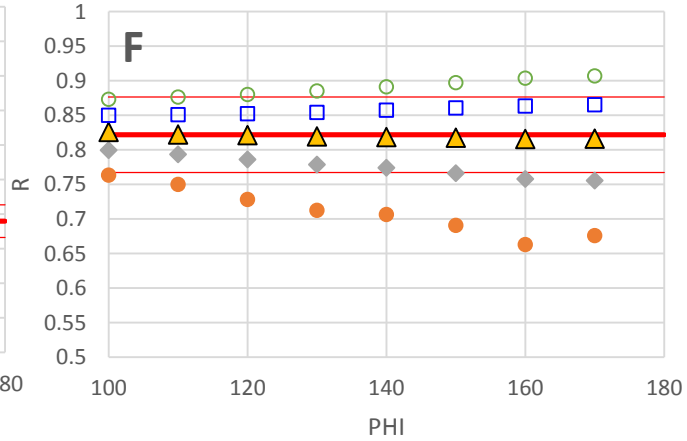




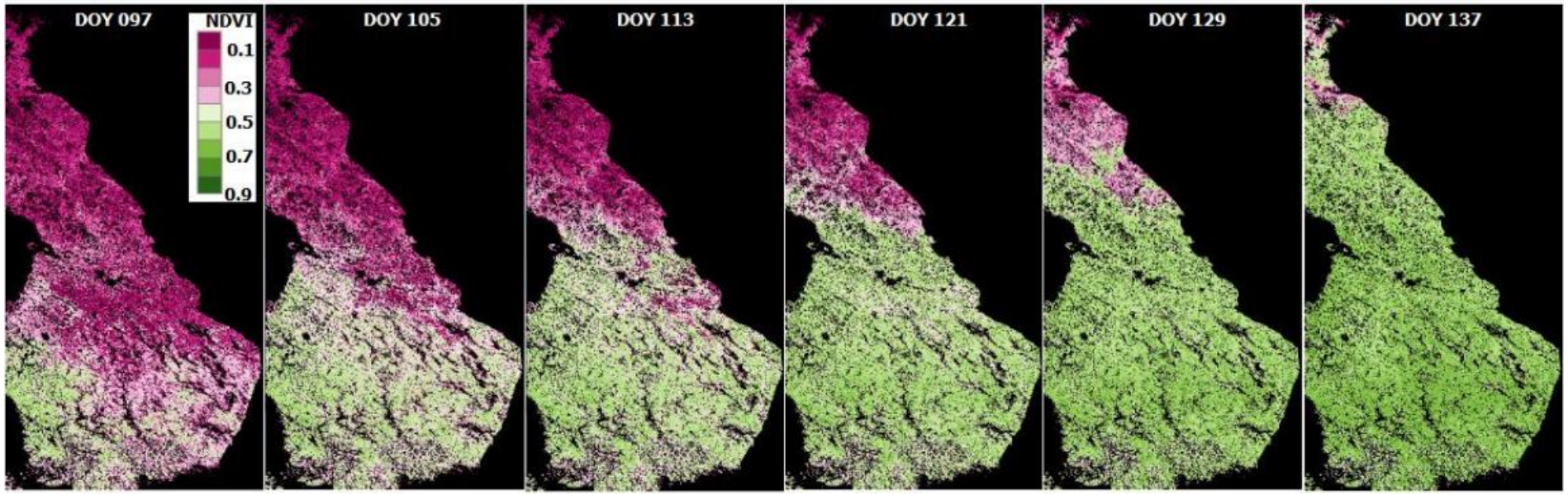








Finland understory NDVI - 2010



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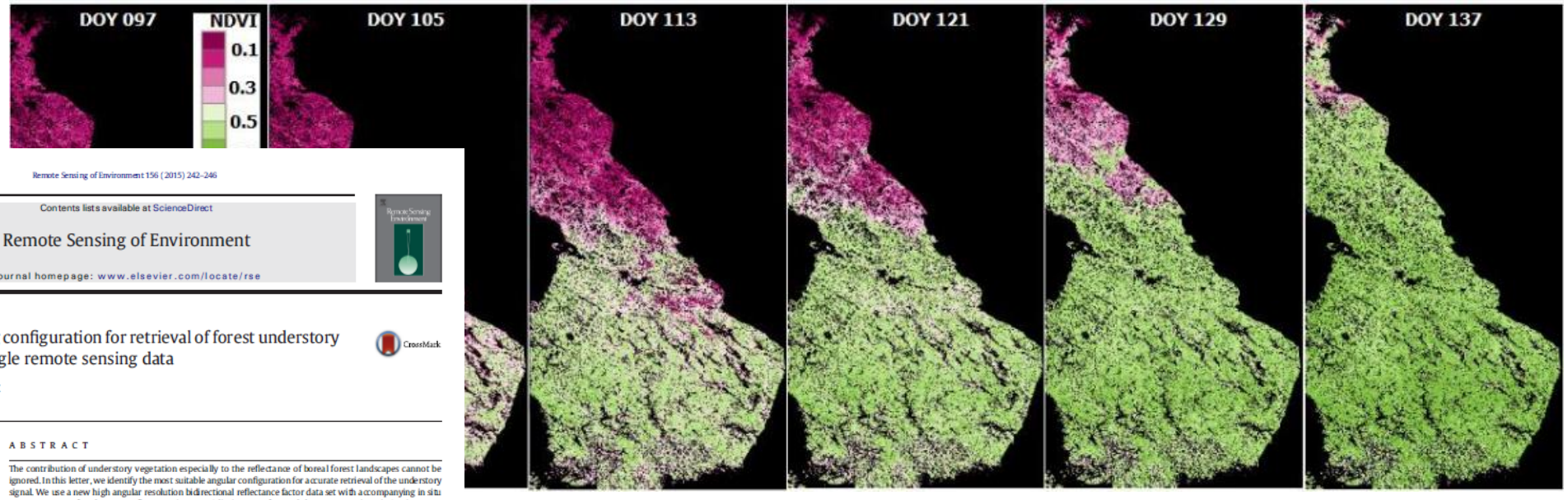
Finland understory NDVI - 2010



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A note on suitable viewing configuration for retrieval of forest understory reflectance from multi-angle remote sensing data

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ABSTRACT

The contribution of understory vegetation especially to the reflectance of boreal forest landscapes cannot be ignored. In this letter, we identify the most suitable angular configuration for accurate retrieval of the understory signal. We use a new high angular resolution bidirectional reflectance factor data set with accompanying in situ measurements of understory reflectance in two RAdiation transfer Model Intercomparison (RAMI) mature stands in Järvselja, Estonia. Our results are pertinent towards the ultimate goal of achieving more reliable estimates of biophysical properties of the tree layer through separating the effect of understory on forest reflectance.

1. Introduction

Since ground vegetation (understory) has an essential contribution to the whole-stand reflectance signal in many boreal, sub-boreal and temperate forests, its reflectance spectra are urgently needed in various forest reflectance modelling efforts (Eriksson, Eklundh, Kuusk, & Nilson, 2006; Kobayashi, Suzuki, & Kobayashi, 2007; Rautiainen & Stenberg, 2005; Suzuki, Kobayashi, Delbart, Asanuma, & Hiyama, 2011). However, systematic reflectance data covering different site types are almost missing.

The measurement of understory reflectance is a real challenge because of the extremely high variability of irradiance at the forest floor, weak signal in some parts of the spectrum and its variable nature (Miller et al., 1997). Understory consists of several sub-layers (tree regeneration, shrub, grasses or dwarf shrub, mosses or lichens, litter,

MODIS, Pisek, Rautiainen, Heiskanen, & Möttus, 2012). Despite their relative success, the unavailability of bidirectional reflectance factor (BRF) profiles of forests in the wide range of view angles with high angular resolution and accompanying in situ measurements had so far prevented determining the most suitable viewing configuration for the understory signal retrieval. Recently, Kuusk, Kuusk, and Lang (2014a) presented high resolution BRF data for several forest stands included in the RAdiation transfer Model Intercomparison (RAMI) exercise (Widlowski et al., 2007) with very different 3D structure supported by the extensive description of stand structure and their optical properties including ground vegetation. In this short communication paper, we use this data set to identify the most suitable viewing configuration for the retrieval of understory signal from remote sensing data.

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