Seasonal courses of vegetation spectra as input in forest albedo and FAPAR simulations

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1. MOTIVATION

- Forest structure and species composition influence both albedo and FAPAR.

- Only a couple of studies have analyzed links between boreal forest structure, albedo and FAPAR throughout the growing season.

- Because satellite products have coarse resolution, forest radiation budget simulation models are a useful tool. However, their use has been limited by the available input data.

2. AIM

- We present a time series of canopy gap fractions and forest floor and leaf optical properties measurements (May 3 – October 20) and use them as input in forest albedo and FAPAR simulations.

- The results are compared to MODIS albedo and FAPAR products at landscape level.

3. MATERIAL AND METHODS

Hyytiälä, Finland (61°50' N, 24°17' E)
- 20 field plots
    - Canopy gap fractions
    - Forest floor spectra
- Sky irradiance measurements
- Leaf reflectance and transmittance spectra
- 30×30 km area of MODIS data
    - 44% Scots pine
    - 40% Norway spruce
    - 16% silver and downy birch
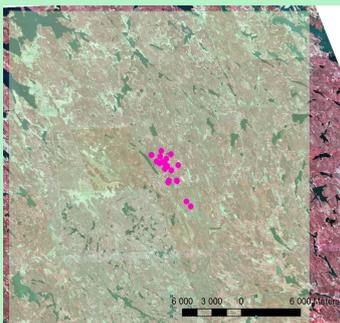
Field and laboratory measurements
Canopy gap fractions
Forest floor spectra
Foliage spectra
Sky irradiance

Plant area index (PAI) estimation

Three estimates of PAI
PAI#1: No clumping
PAI#2: Shoot-level clumping
PAI#3: Shoot- and crown level clumping

Energy budget simulations
PARAS model (p-theory)
FRT model (geometric-optics, radiative transfer)

Simulated albedo and FAPAR at plot level

**Medium-resolution tree species maps**
Finnish NFI (Landsat)

Upscaling

Simulated albedo and FAPAR at landscape level (30x30 km)

MODIS products (2009–2011)
Albedo (MCD43A3 V006)
FAPAR (MCD15A3H V006)

Comparison

4. RESULTS

- Strong seasonal patterns in broadleaved forest albedo and FAPAR.

- Slight decrease in coniferous forest albedo towards late summer, can be linked with changes in leaf area index.

- Both models produced similar seasonal patterns: albedos differed only slightly in late autumn when the sun was low. However, differences observed in the overall level of albedos.
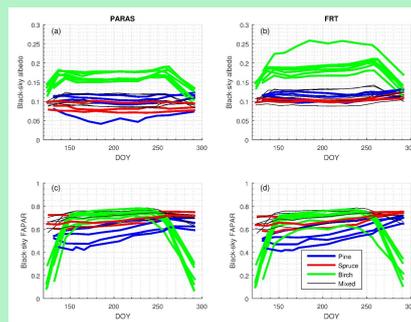

- Clear (but small in magnitude) seasonal patterns in the mean satellite albedos in the area. Dependent on illumination conditions.

- Best match with satellite data was obtained when the PARAS model was parameterized assuming the highest degree of clumping.
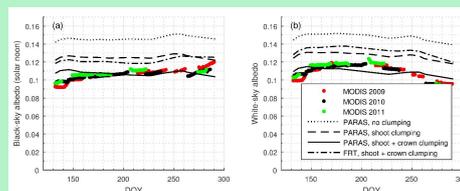
- Weak seasonal patterns in satellite FAPAR. Simulations matched with satellite FAPAR relatively well and were not sensitive to clumping.
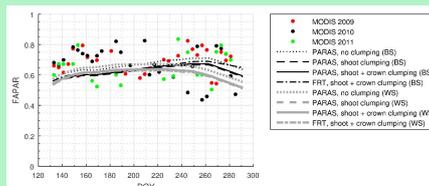
- Negative correlation between albedo and FAPAR, except for broadleaved forests in midsummer
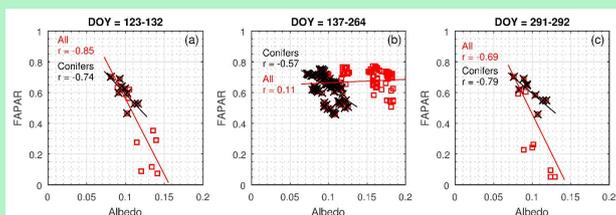
5. CONCLUSIONS

- Models capable of adequately taking into account foliage clumping and its effects on multiple scattering may be best suitable for simulating the albedo of a boreal coniferous forest.

- Simulated data showed negative correlation between albedo and primary productivity in boreal coniferous forests throughout the growing season.

- Not only the overall level, but also seasonal patterns of albedo and FAPAR differ between tree species. Therefore, the use of peak growing season albedo or FAPAR values when estimating climate impacts of forest management can be misleading.