Real canopy deciduous forest scenarios using voxel arrays generated from ground lidar: two candidates for use in the next RAMI phase

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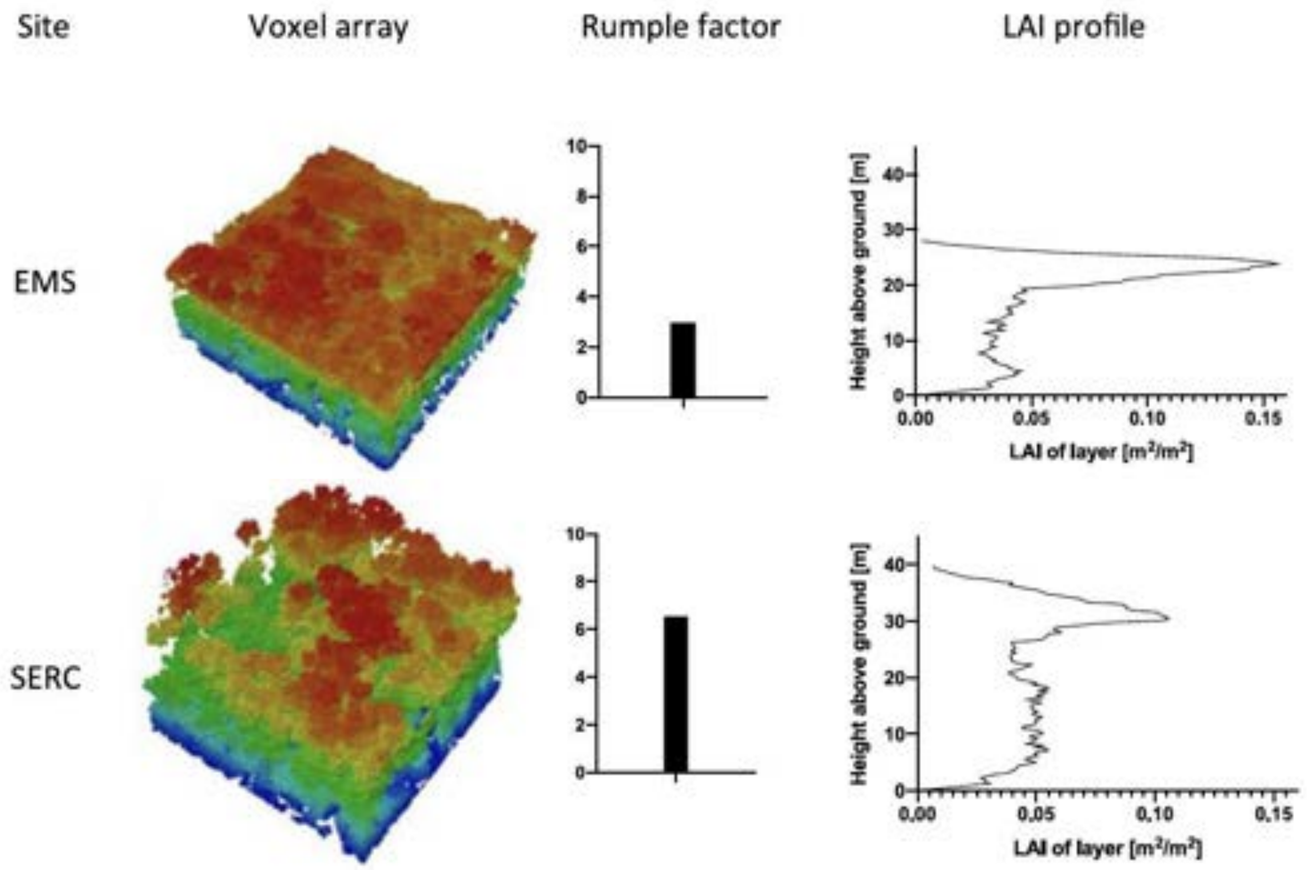
Outline

- Present recent developments RT modeling in deciduous forests from lidar-derived **voxel arrays**
- Introduce recent estimates of shoot level clumping in deciduous trees
- Analysis of canopy level reflectance sensitivity to structural parameters in NIR region
- Feed into a discussion about using/converting a voxel array as realistic forest scenarios in the next RAMI phase
- **Which forest structure measurements do we need to match airborne or satellite observations?**

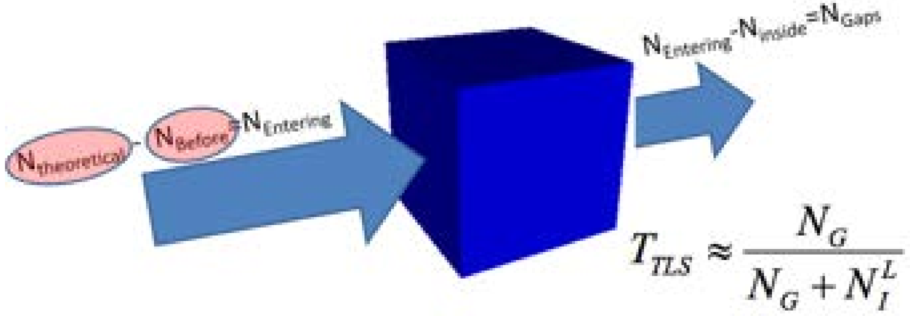
Terrestrial lidar acquisitions

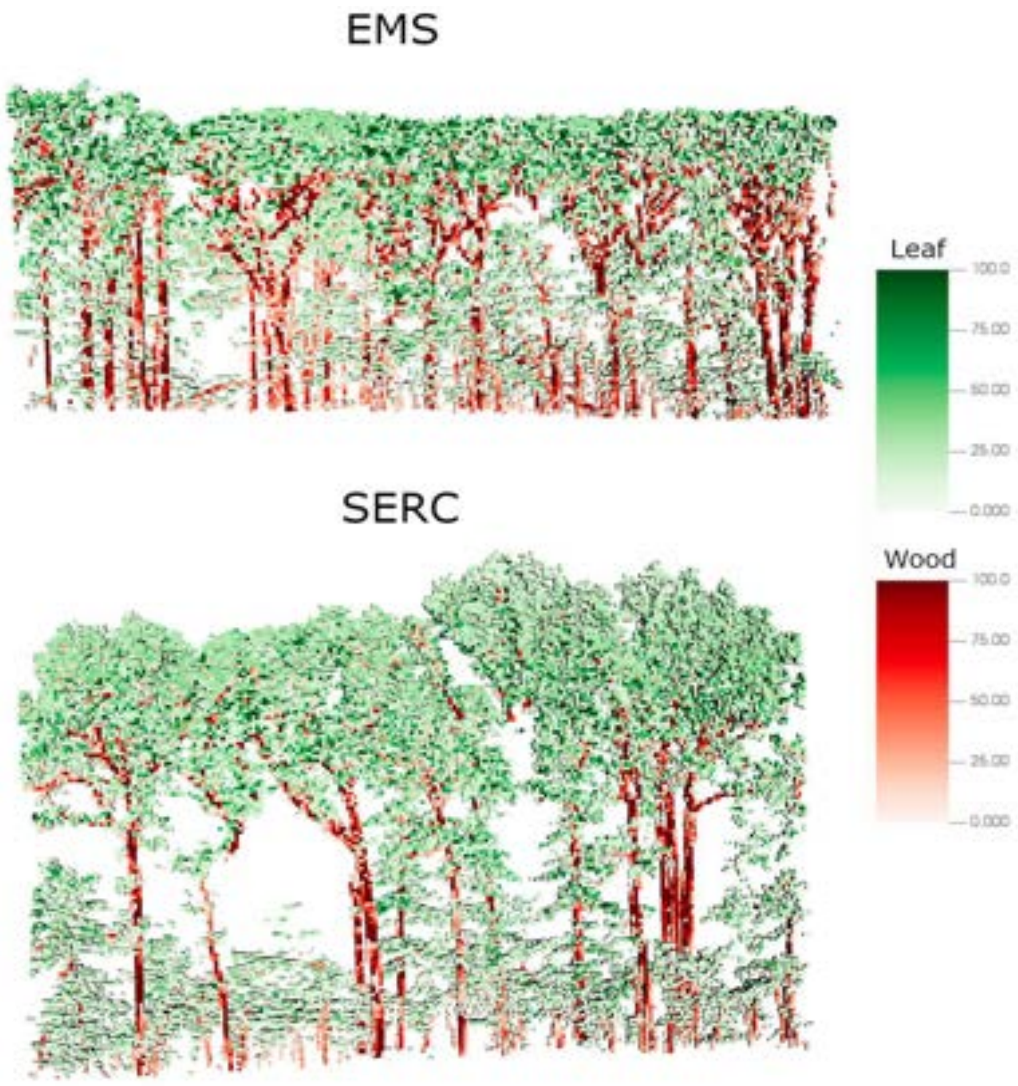
- 121 scan positions over a 60 x 60 m^2 plot area
- Scans are 5m apart to minimize missing data due to occlusion
- 2 sites:
  - Harvard Forest
  - Smithsonian Environmental Research Center (SERC)



Voxel based leaf area density (LAD) mapping

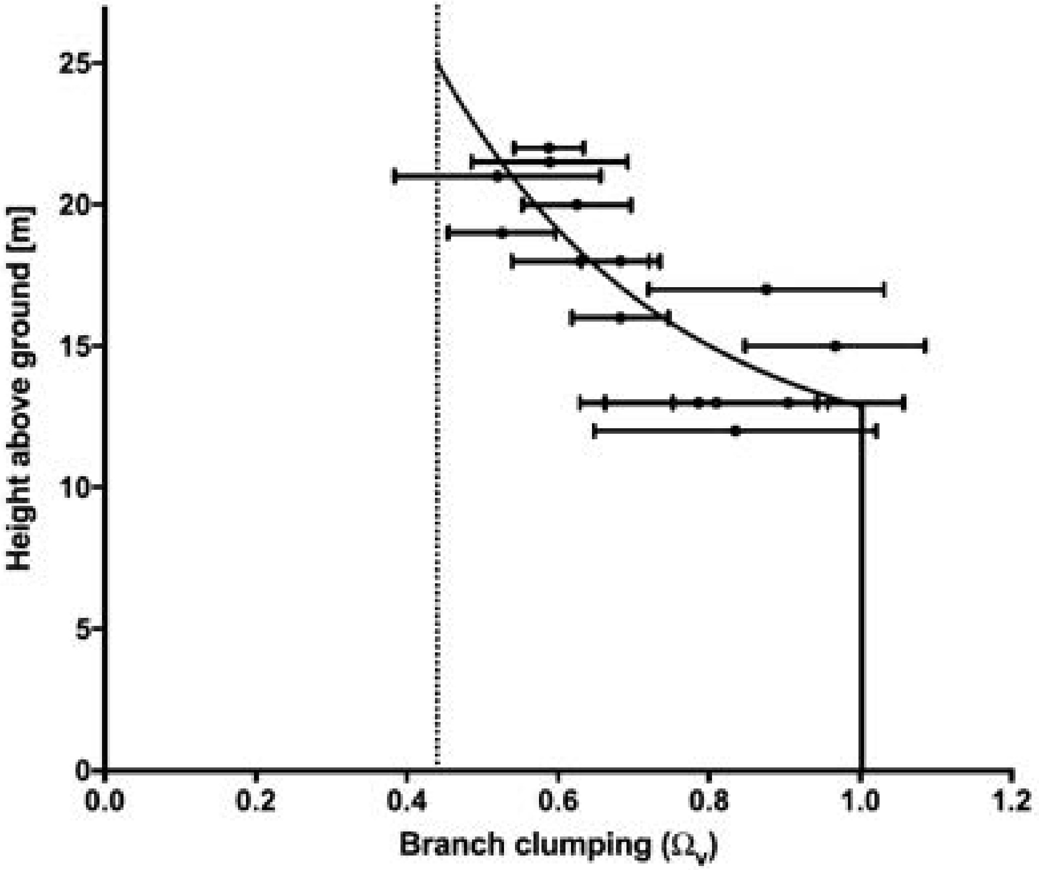
- Mapping LAD requires information on
  - Wood/leaf lidar points classification
  - leaf angle distribution
  - Foliage clumping within voxels
- The approach uses light transmission through voxels to estimate leaf area density





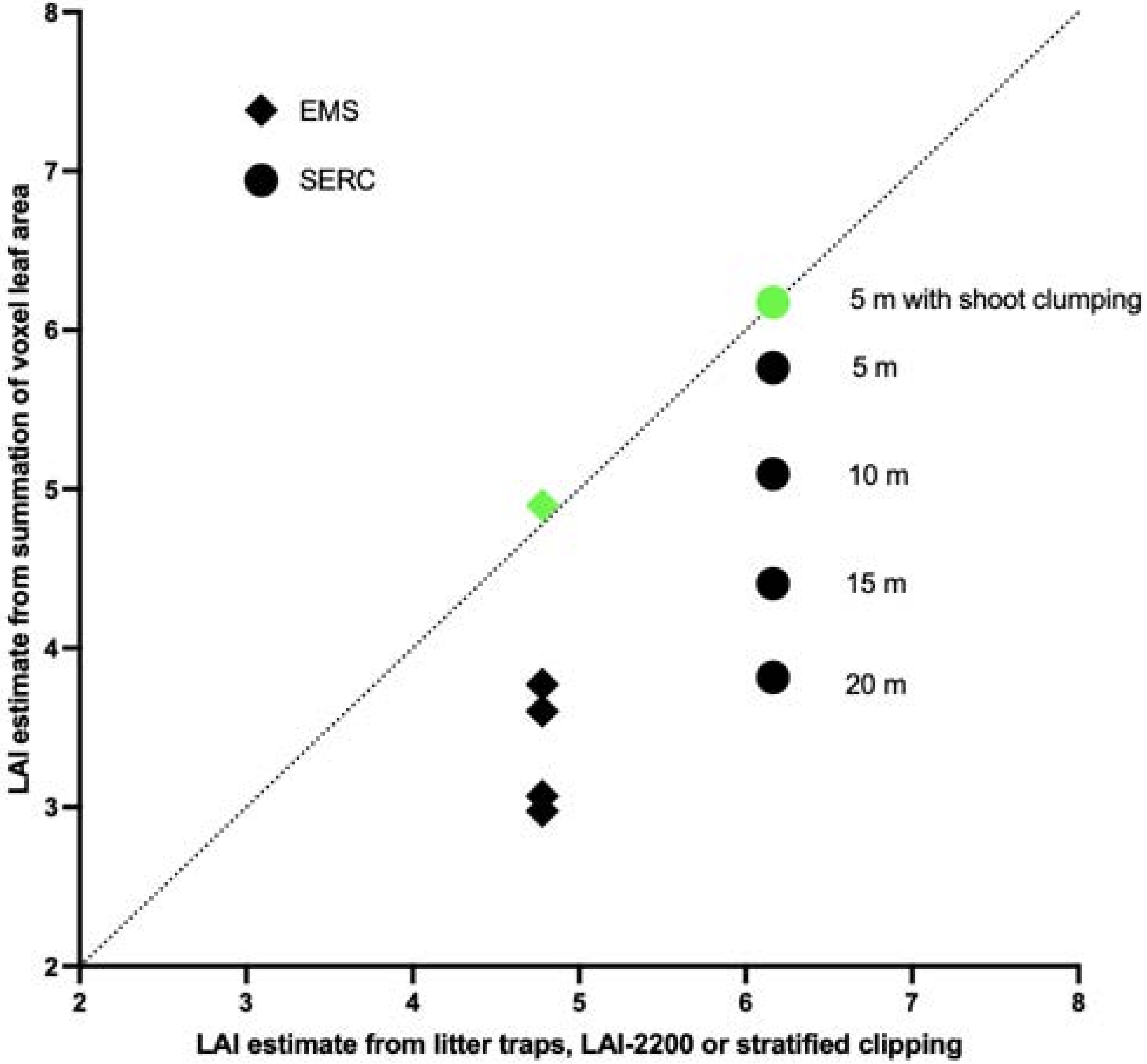
Variables changing vertically

- Within shoot foliage clumping changes vertically, top of canopies are clumped
- Leaf optical properties at the SERC site show no vertical change (both reflectance and transmittance)
- Leaf angle distribution can change vertically
  - Harvard planophile from bottom to top
  - SERC planophile up to 30m then erectophile



Comparing TLS LAI estimates with best existing estimates

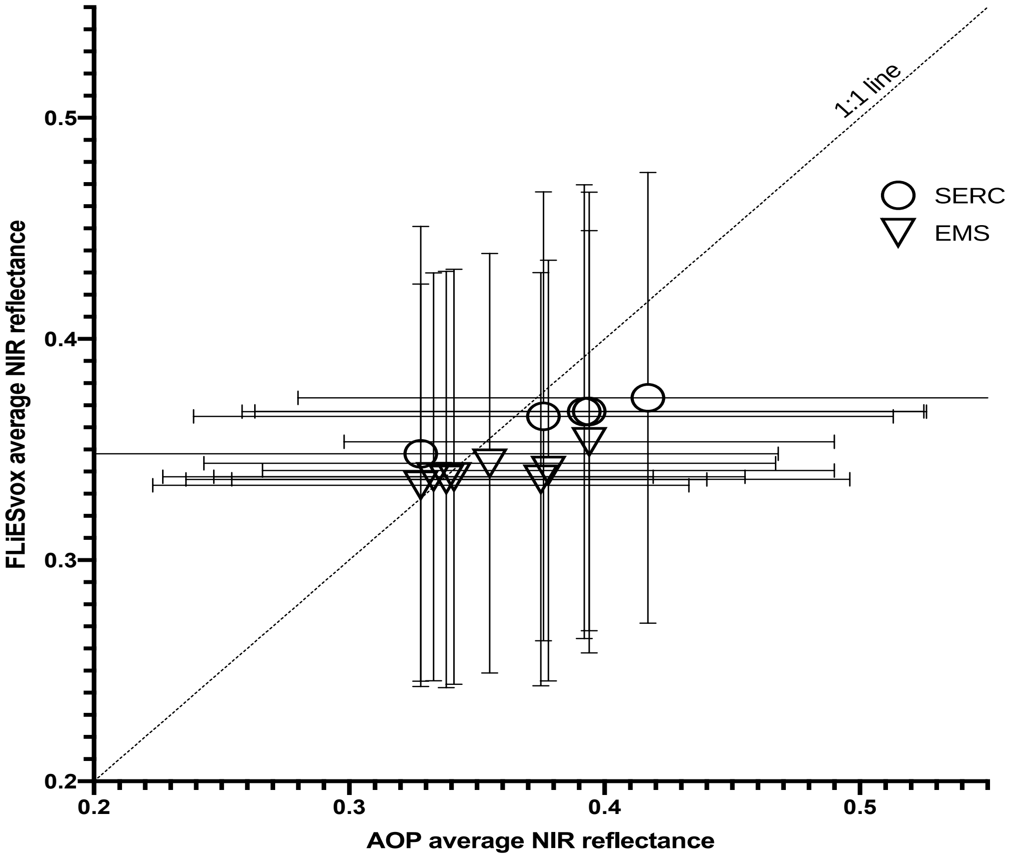
- Importance of spacing between scan locations and clumping for getting LAI right

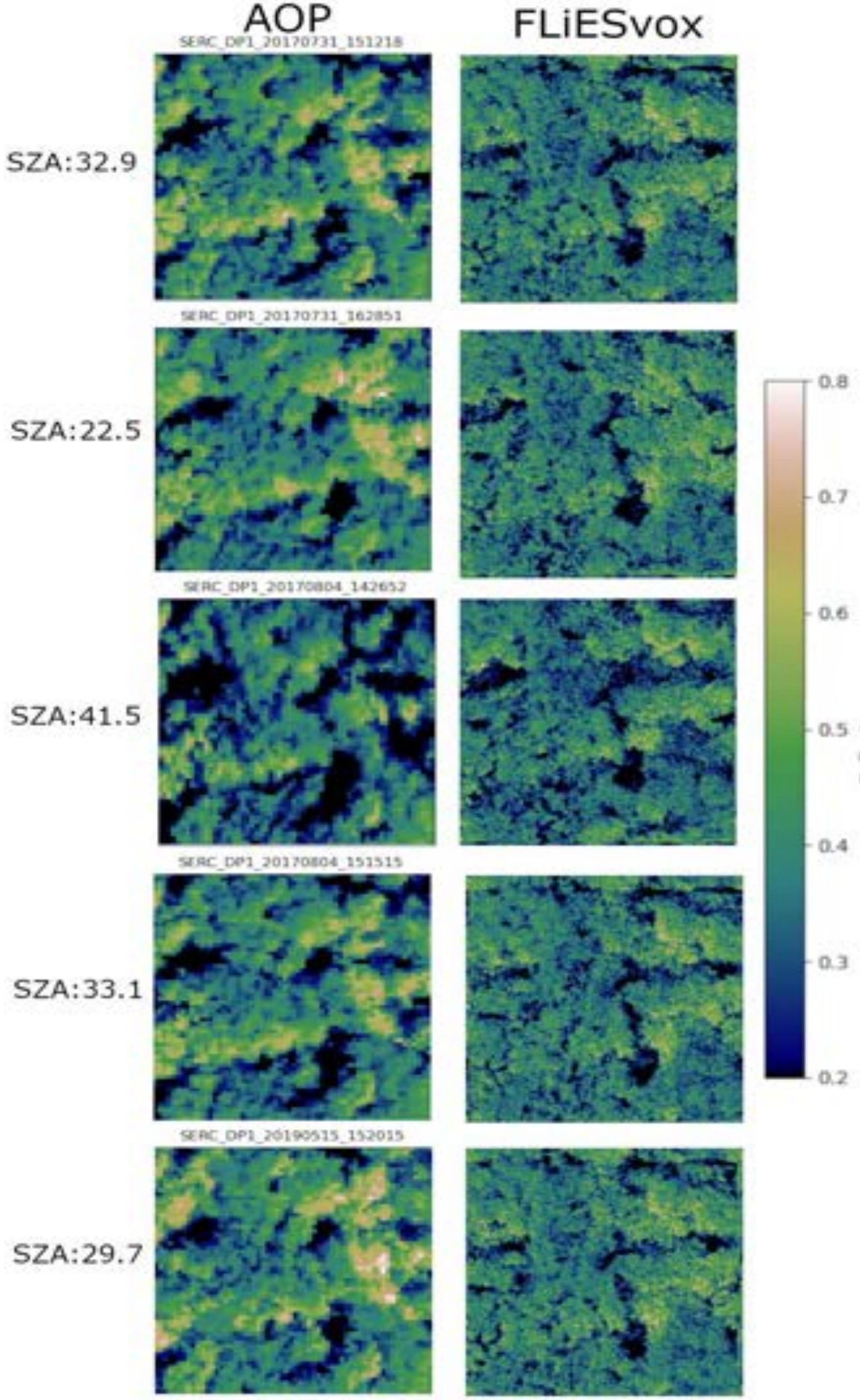


FLiESvox RT model

- Ray tracing
- Considers foliage clumping through increased light transmission and recollision probability
- Accounts for wood fraction inside voxel
- Model inputs: diffuse light fraction, sun angles, leaf/wood/ground optical properties
- Voxel size used: 30 cm

Simulating NIR canopy reflectance from voxel arrays and a radiative transfer model: comparison to **airborne hyperspectral**

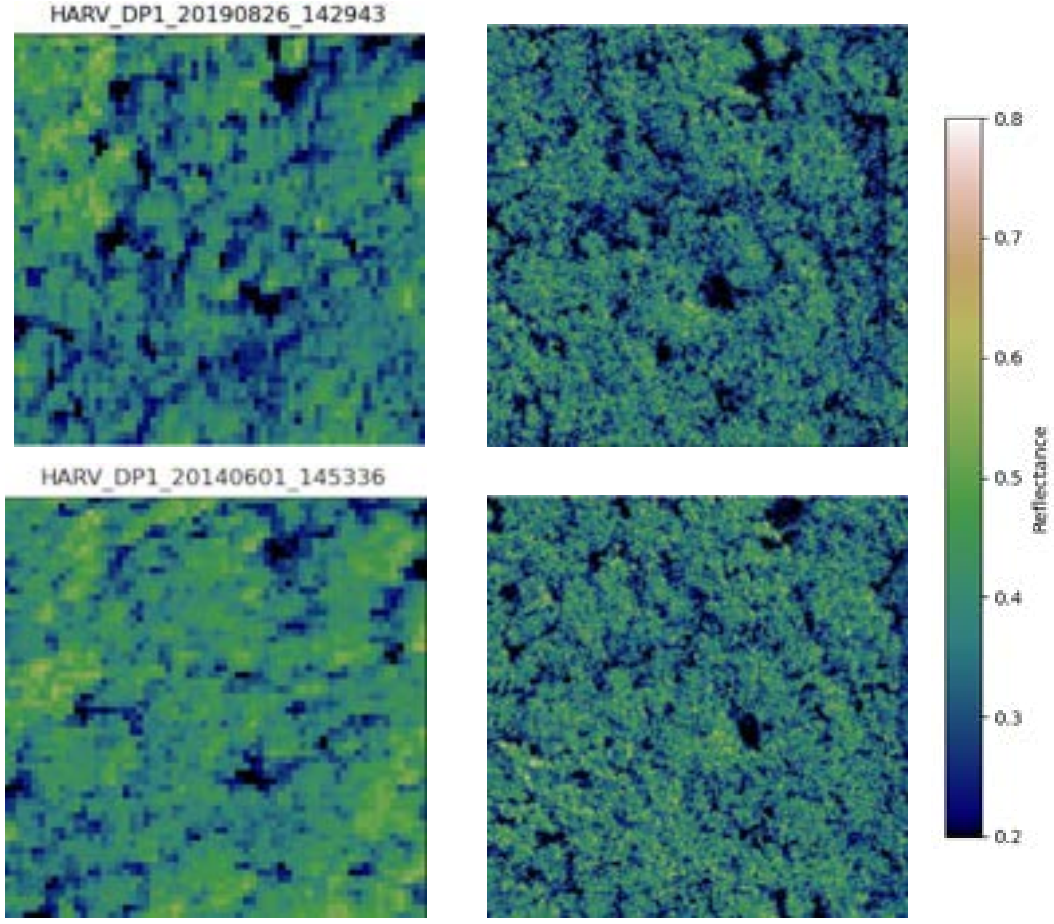




Harvard Forest

NIR

AOP | FLiESvox

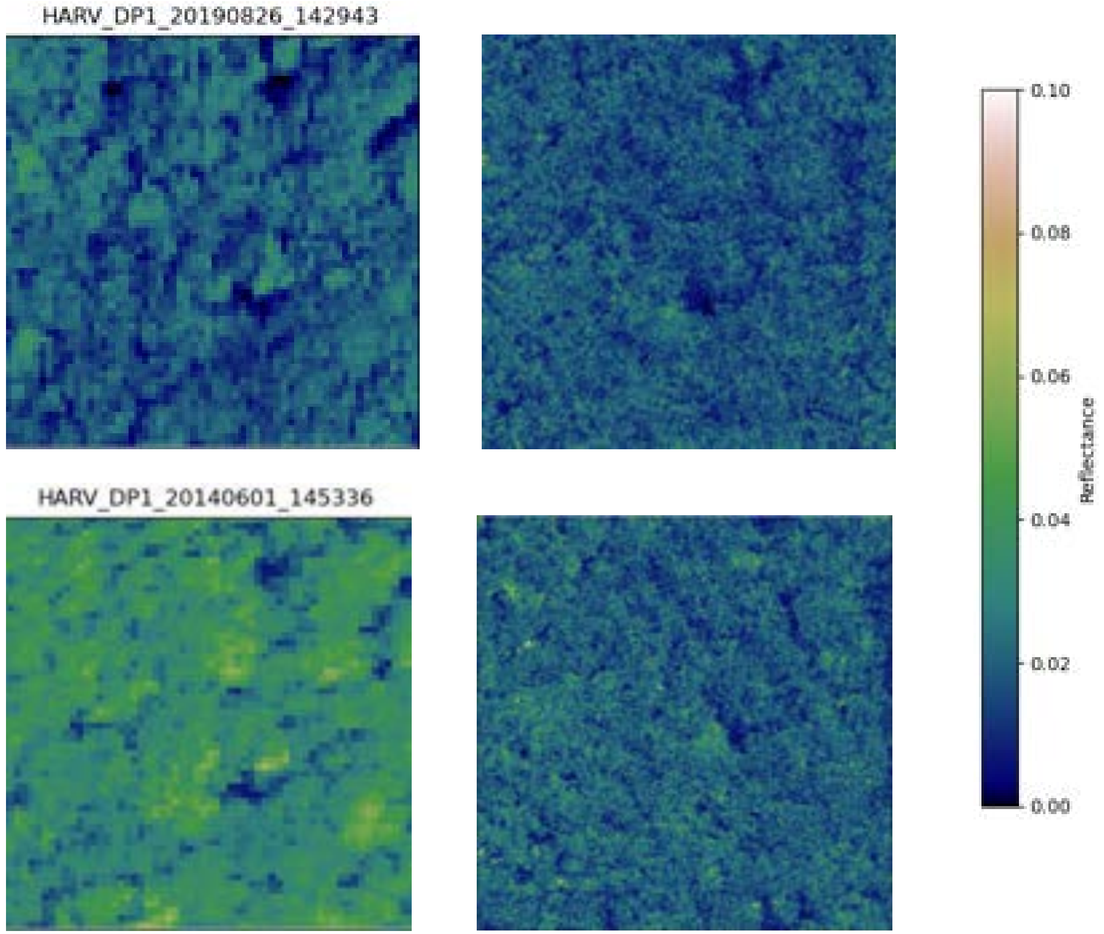


PAR

AOP | FLiESvox

SZA:44

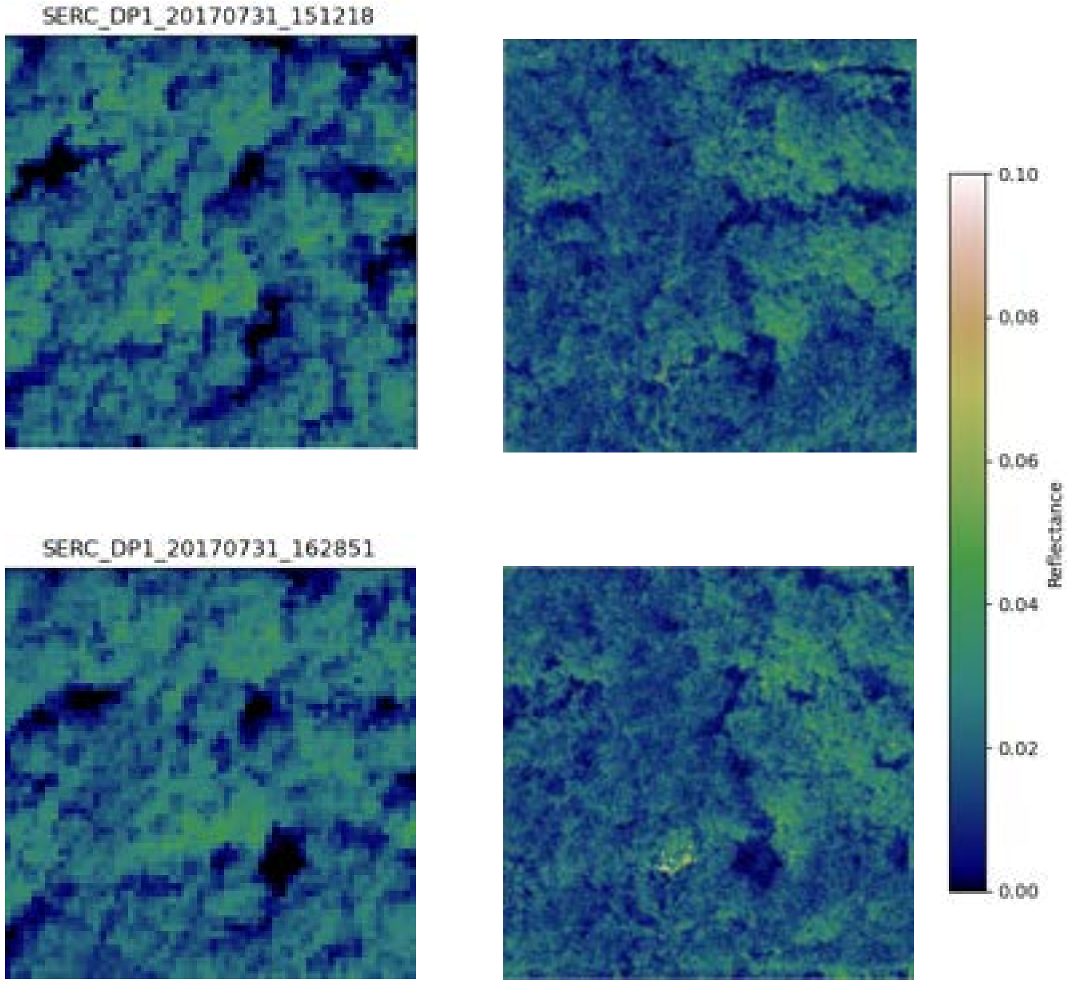
SZA:30.8

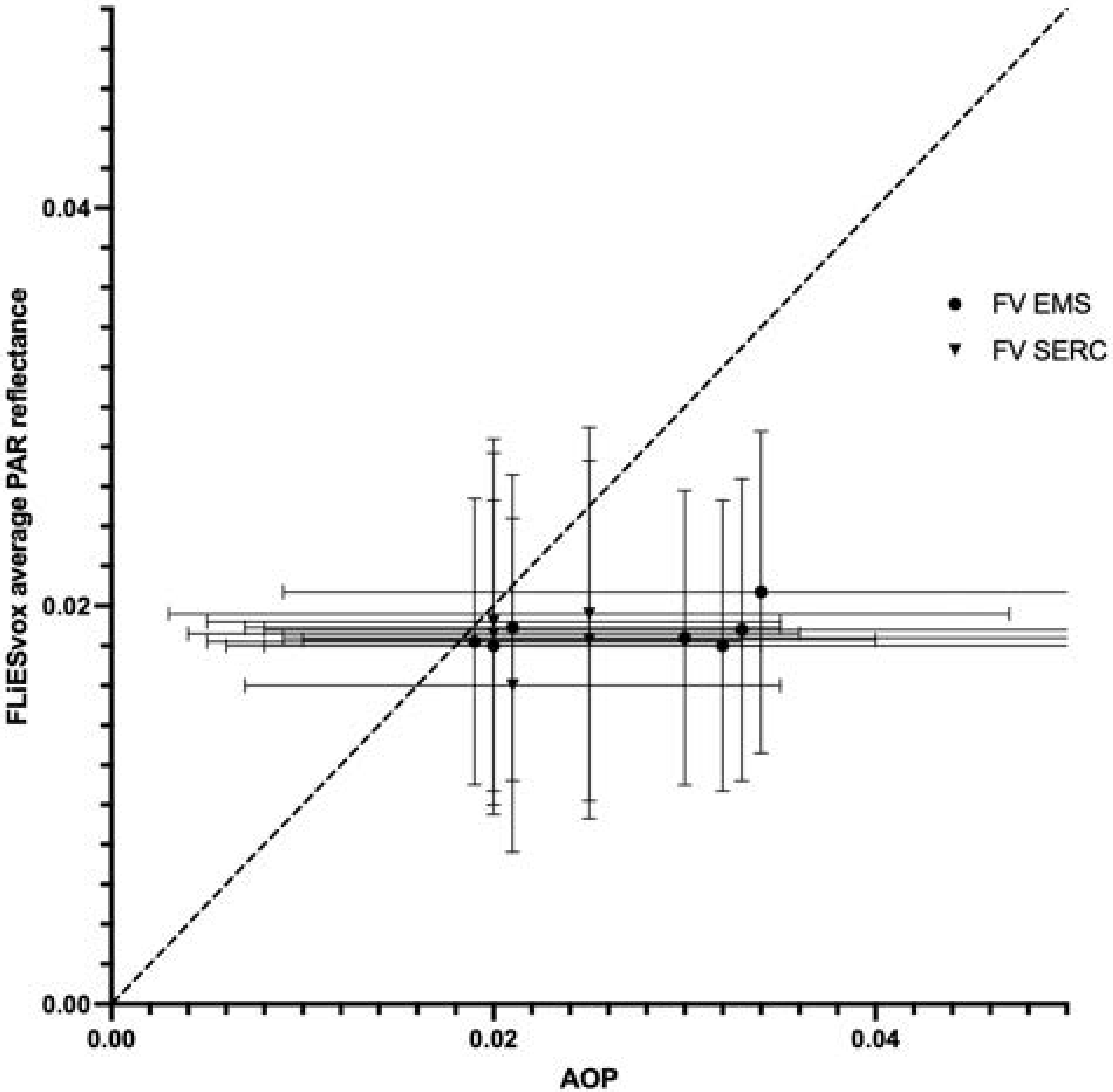


PAR

SERC AOP

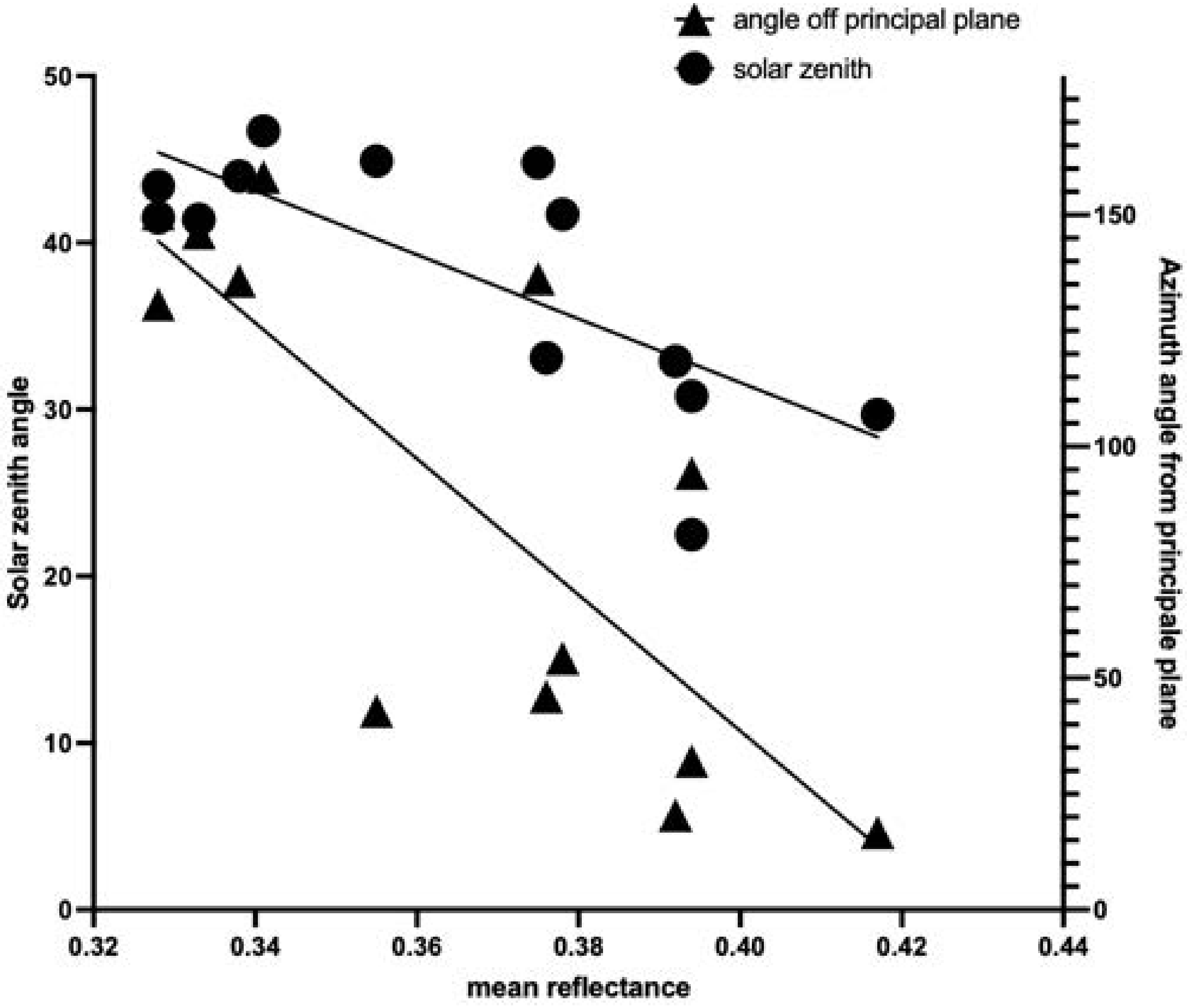
FLiESvox





Effect of illumination geometry

- NEON AOP makes multiple acquisitions at each site, sampling the BRDF



Conclusions

- **Leaf angle** and **foliage clumping** at the canopy tops are significant structural drivers of whole canopy reflectance in NIR
- We need more measurements of canopy tops structure, since much of the whole canopy reflectance results from the organization of the topmost layer
- The terrestrial lidar data used here is the densest set of measurements made to date and minimizes occlusion (holes in voxel array). Plots are **60x60m^2 (can be extended to 1 ha)**
- Matching airborne observations: what are we missing?
  - Incorrect match between observed and modeled illumination geometry?
  - Directionality in incoming light?
  - Uncertainty in conversion between measured radiance and reflectance?
  - How close is it reasonable to expect a match between airborne and modeled?