# Leaf Area Index at a forested ICOS site: a detailed method comparison

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NO-Hur: an ICOS ecosystem class-2 site in Southeast Norway

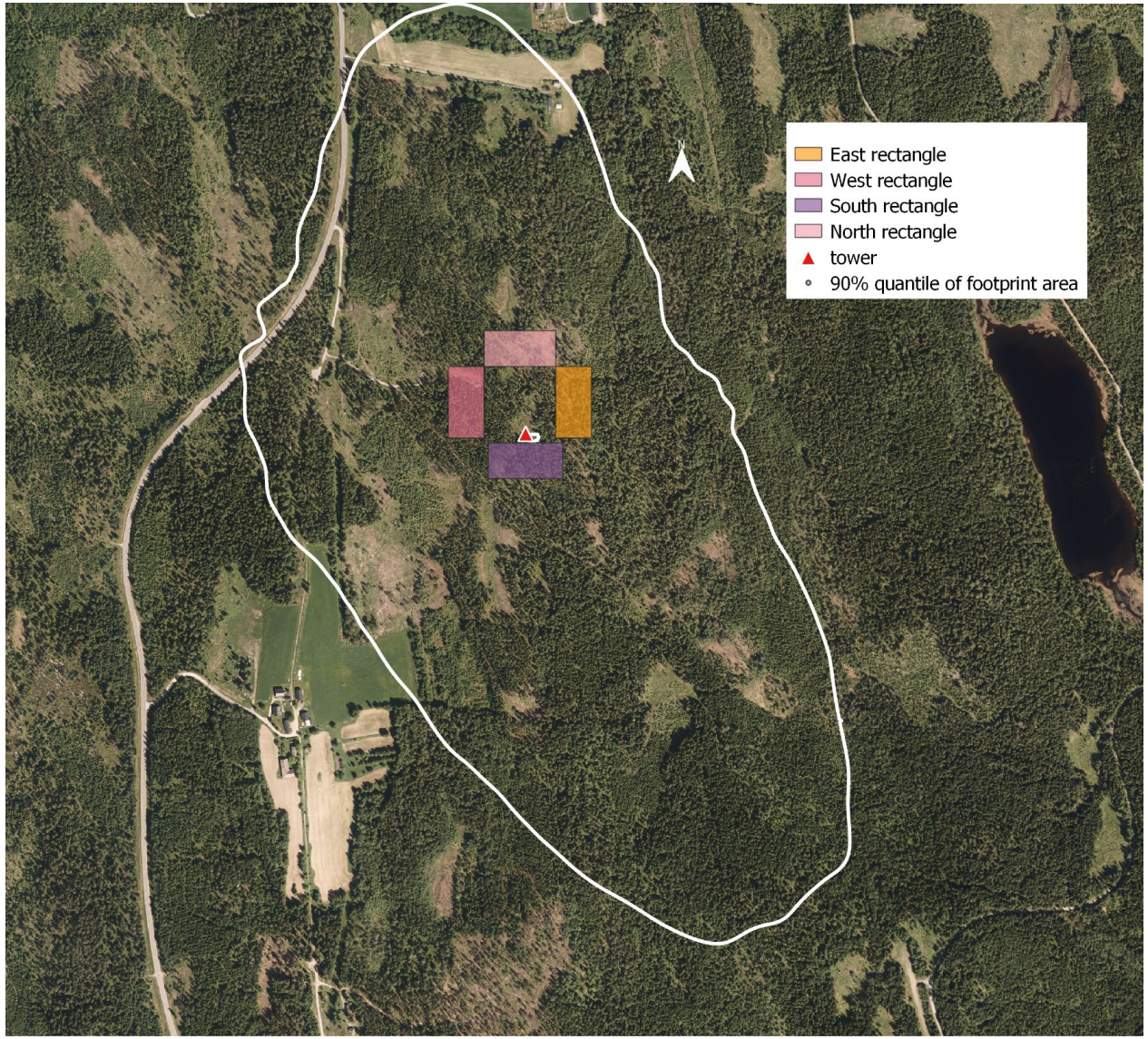
- Tree ages 65 – 100 years
- Footprint area 63 ha

LAI measurements:

- Ground-based with Licor Plant Canopy Analyzer LAI-2000, Aug./Sep. 2021
- Ground-based with Lai-Pen LP110, Aug./Sep. 2021
- Lidar flight, July 2021, point density 2.78 returns / $m^2$
- Drone flight, November 2021, point density 1170 returns / $m^2$

# LAI measurement design

- Lai-Pen and LAI-2000 measurements in four 60 m x 120 m rectangles surrounding the tower
- Grid resolution 5 m x 5 m or 10 m x 10 m
- Leaf Area Density (LAD) extracted from airborne and drone data for the same area and resolution
  - z integration generates LAI



# LAI histograms and regressions

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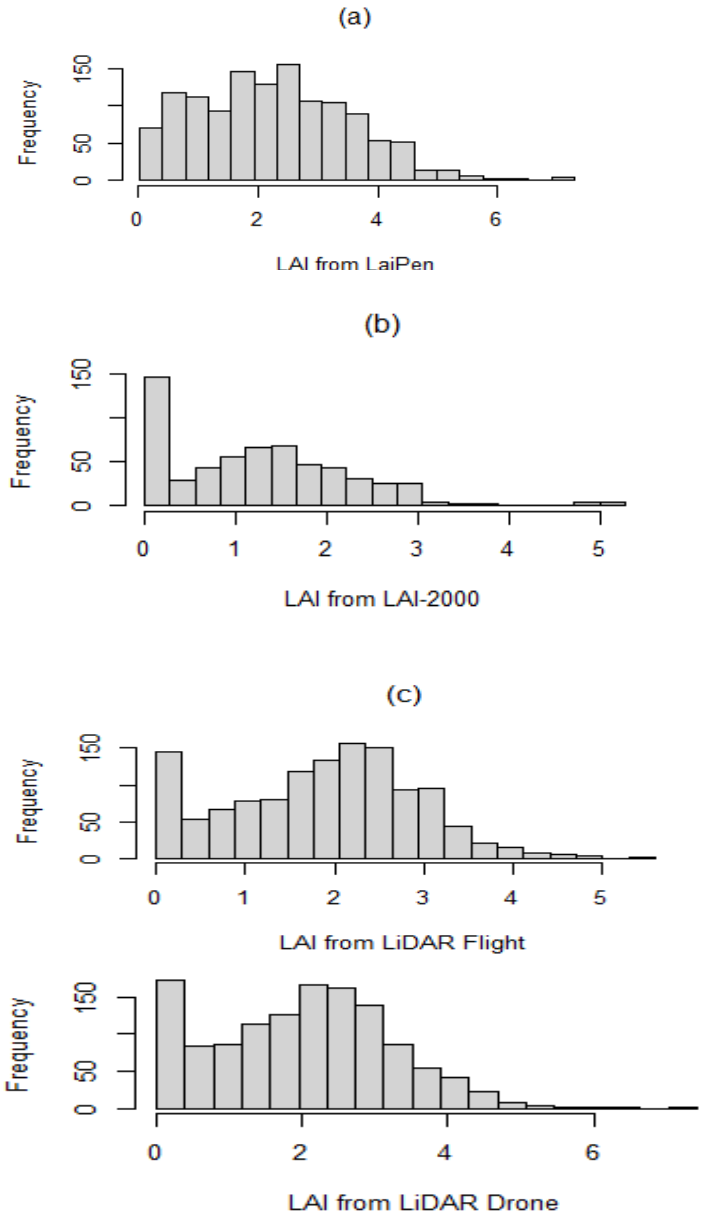


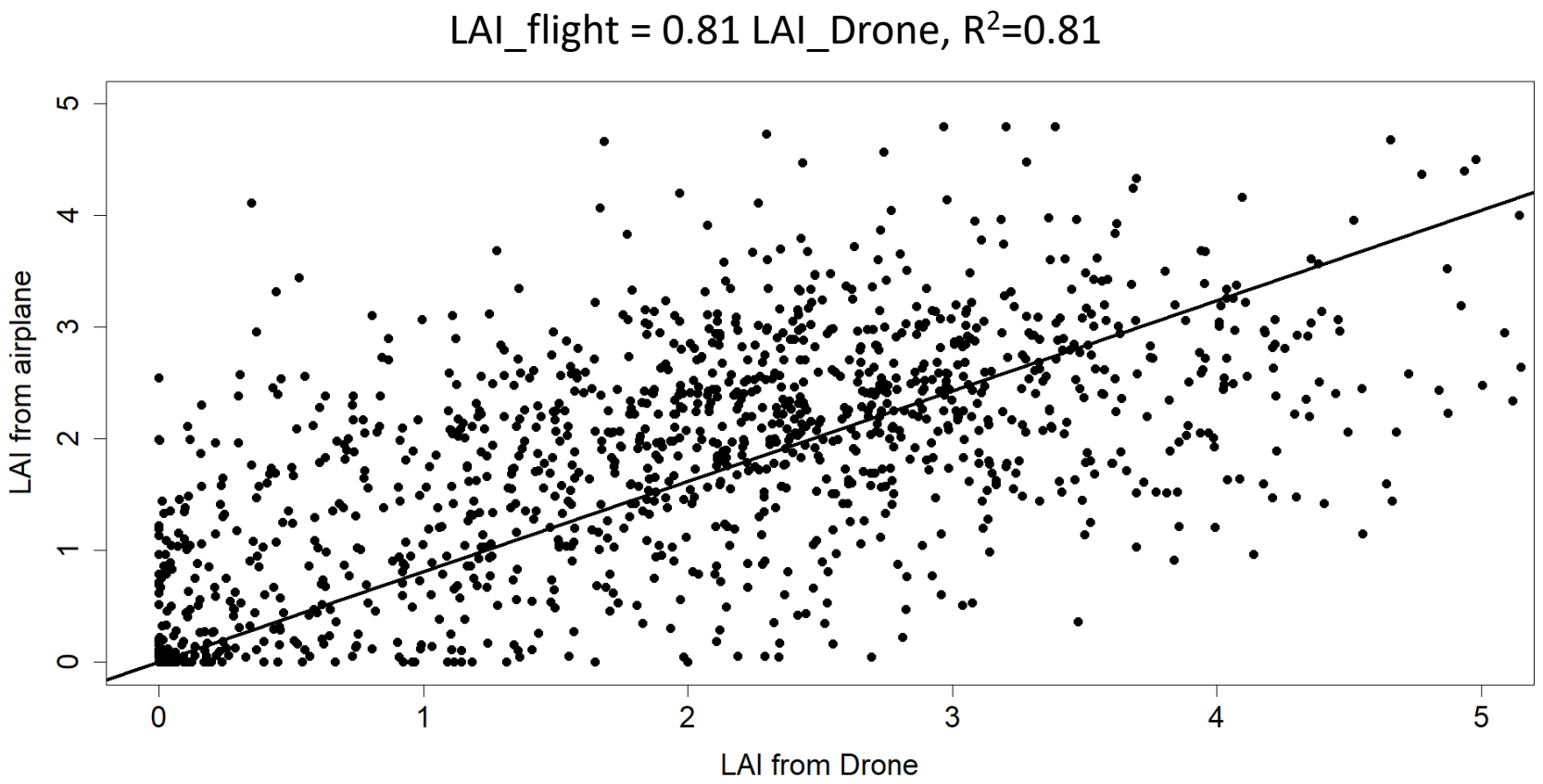

# Contour plots for the East Rectangle (normalized LAI)

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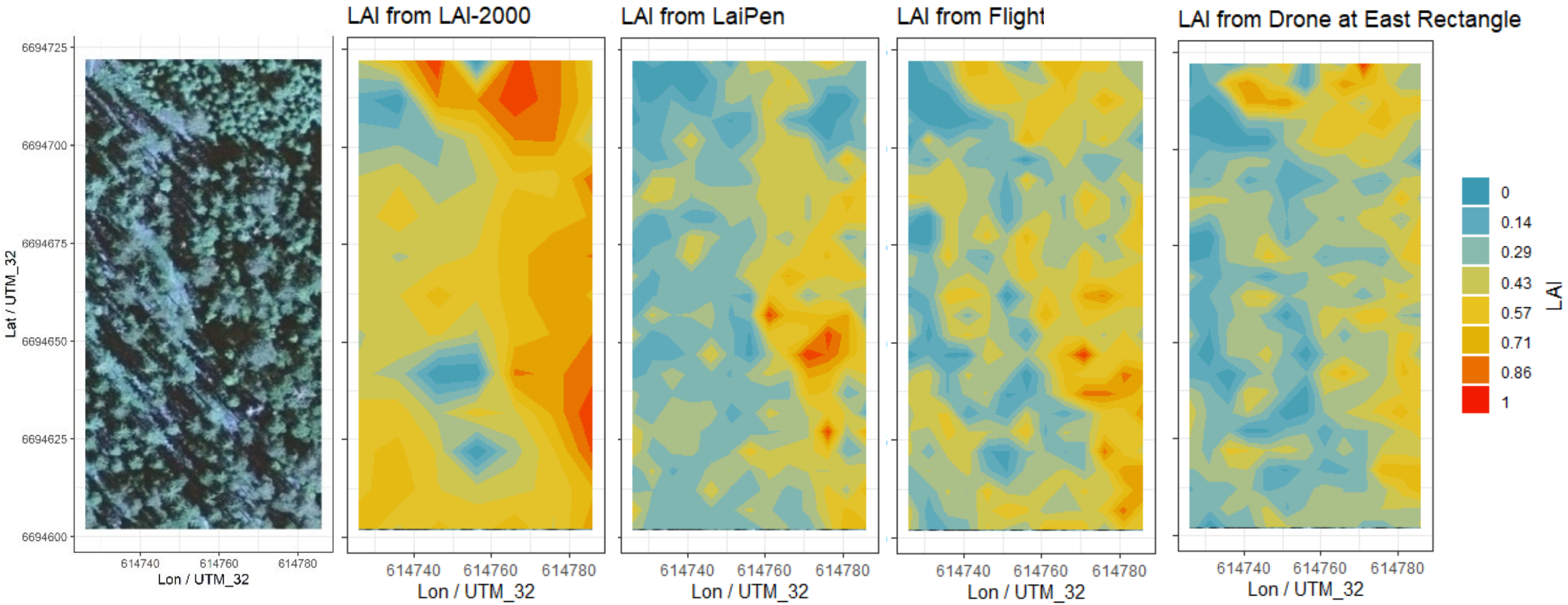
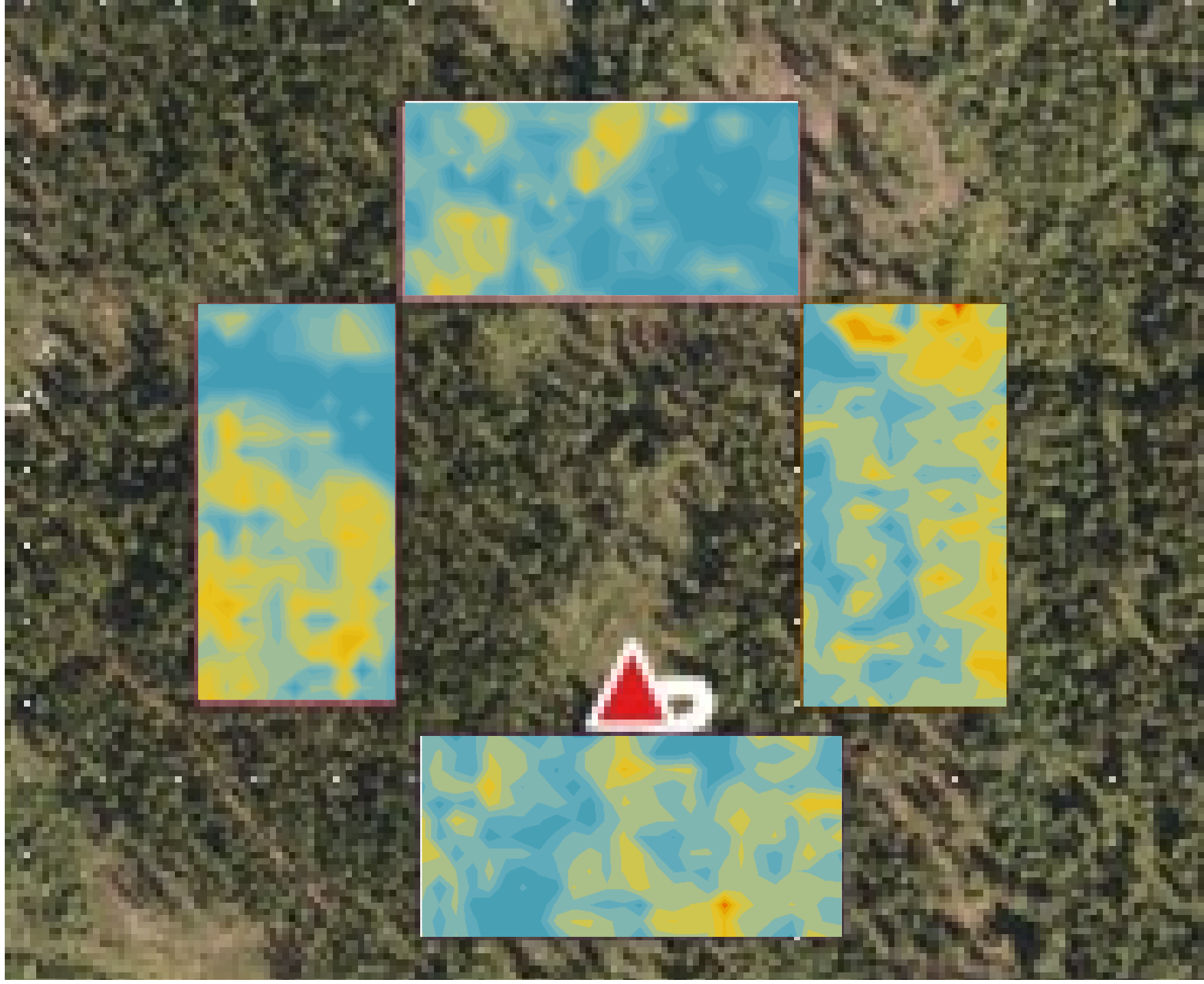


# Contour plots for the drone LAI in all rectangles

p-values from Kolmogorov-Smirnov tests on the cumulative distributions

| | Normalized LAI |
|---|---|
| **LaiPen vs. LAI-2000** | 0.0003195** |
| **LiDAR Drone vs. LiDAR Flight** | 0.06576 |
| **LaiPen vs. LiDAR Drone** | 0.4338 |
| **LaiPen vs. LiDAR Flight** | 0.04822* |
| **LAI-2000 vs. LiDAR Drone** | 1.802e-05** |
| **LAI-2000 vs. LiDAR Flight** | 1.802e-05** |



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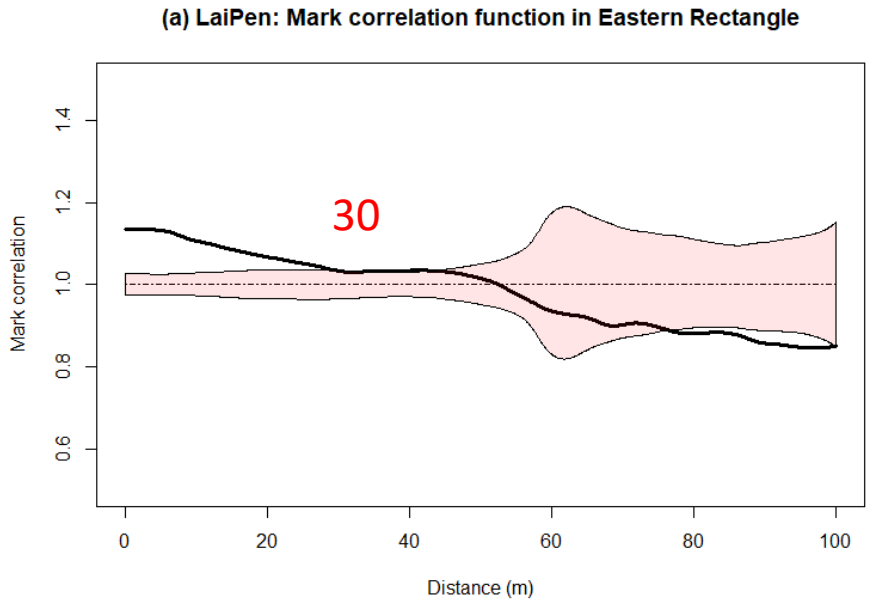
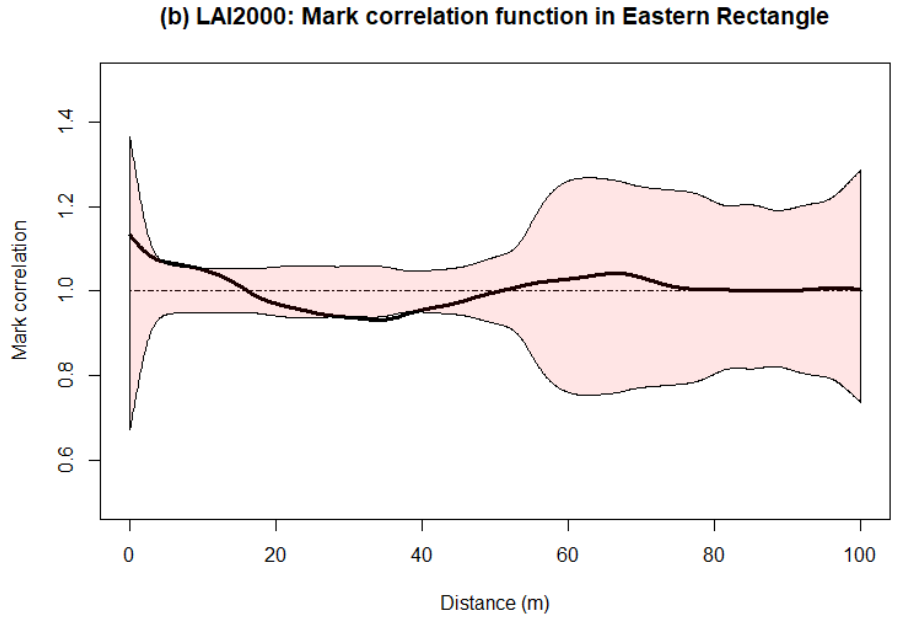
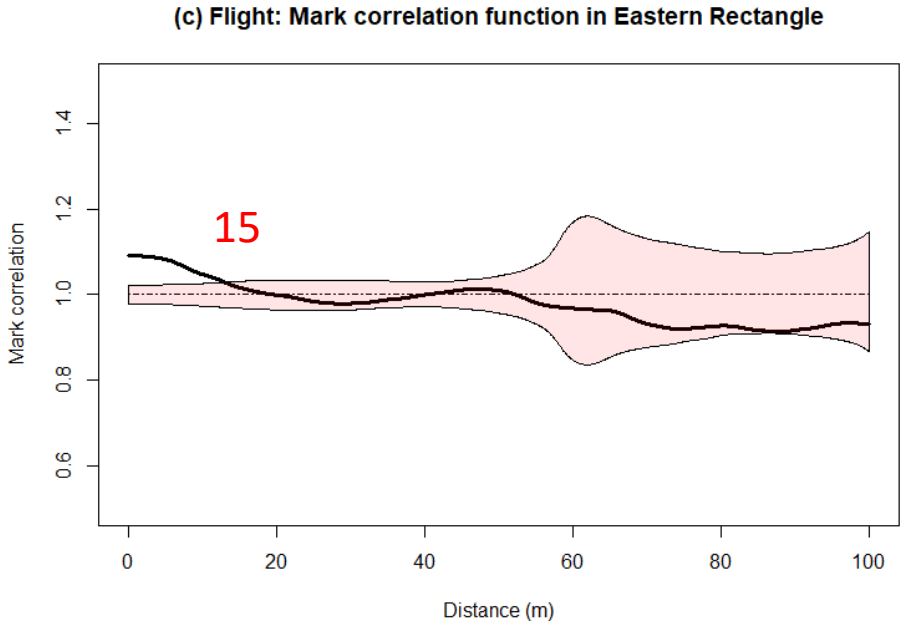
# Characterizing spatial structure: marked point processes

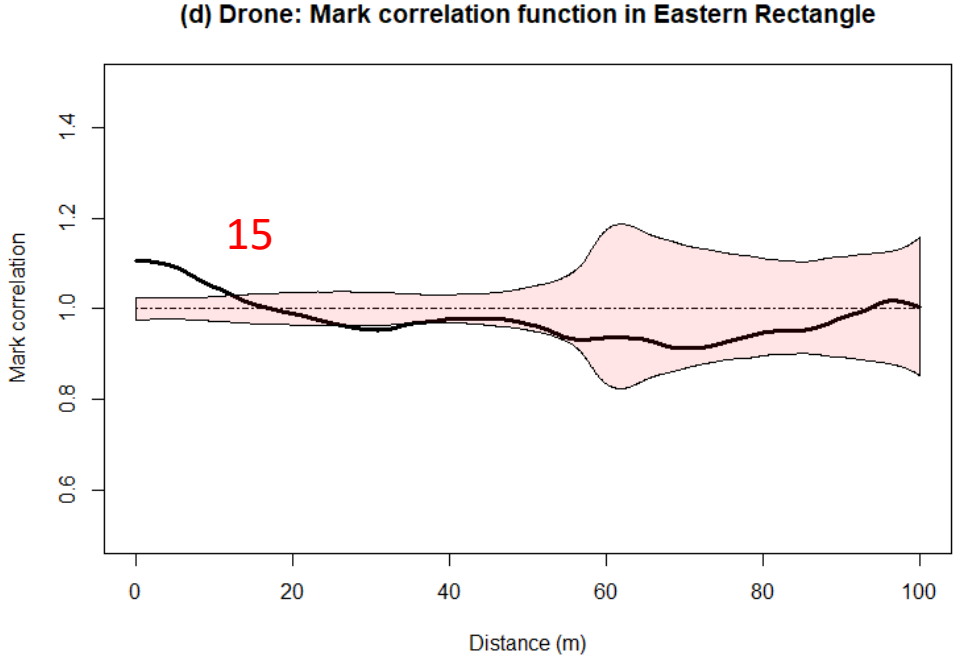
- LAI values as marks, grid points as coordinates
- Significance: comparing to Poisson processes of the same intensity
- Test function: mark correlation $\kappa(r)$
- $\kappa(r) = 1:$ random pattern; $\kappa(r) > 1$ : attraction, $\kappa(r) < 1$ : repulsion
- Empirical confidence bands through MC simulations
- Mark Correlation length: first touch with the confidence bands

# East rectangle

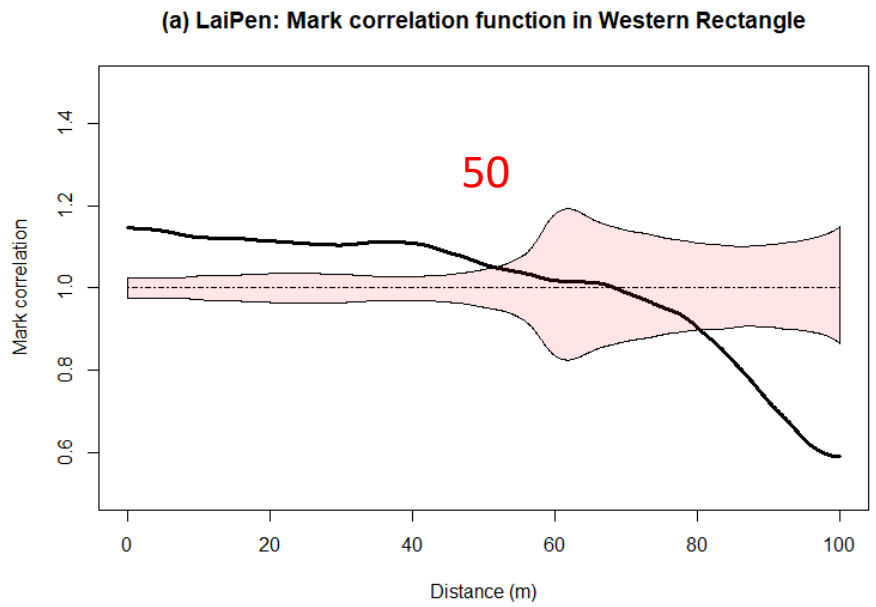


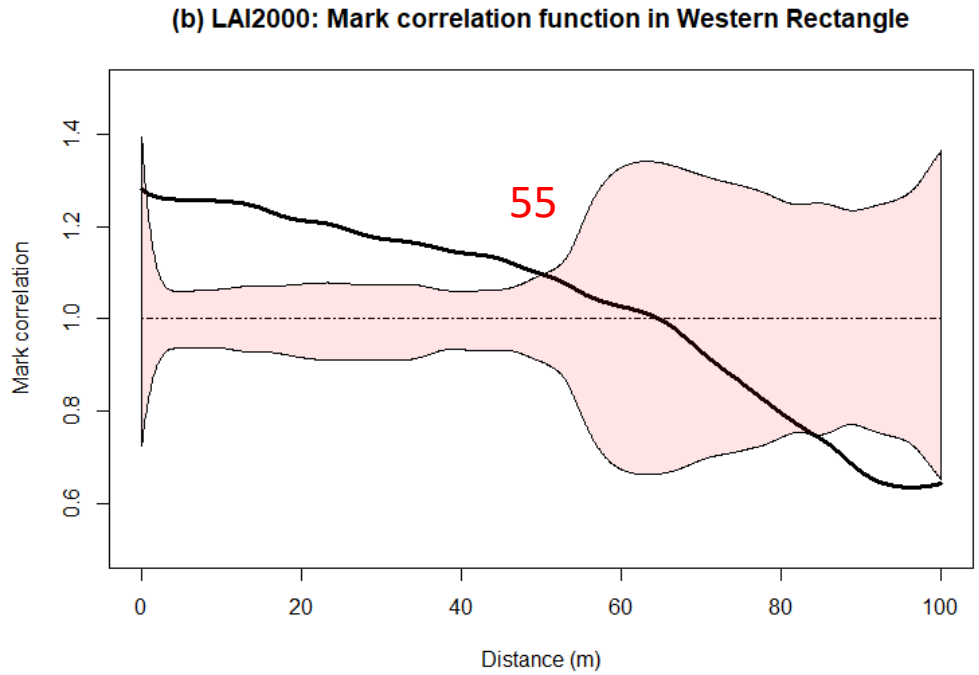



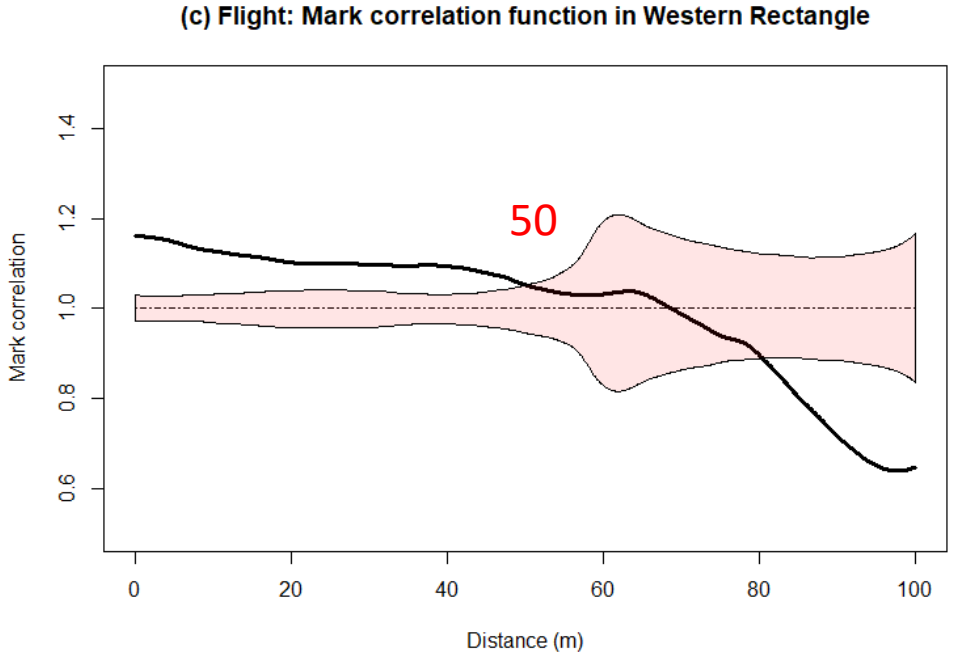



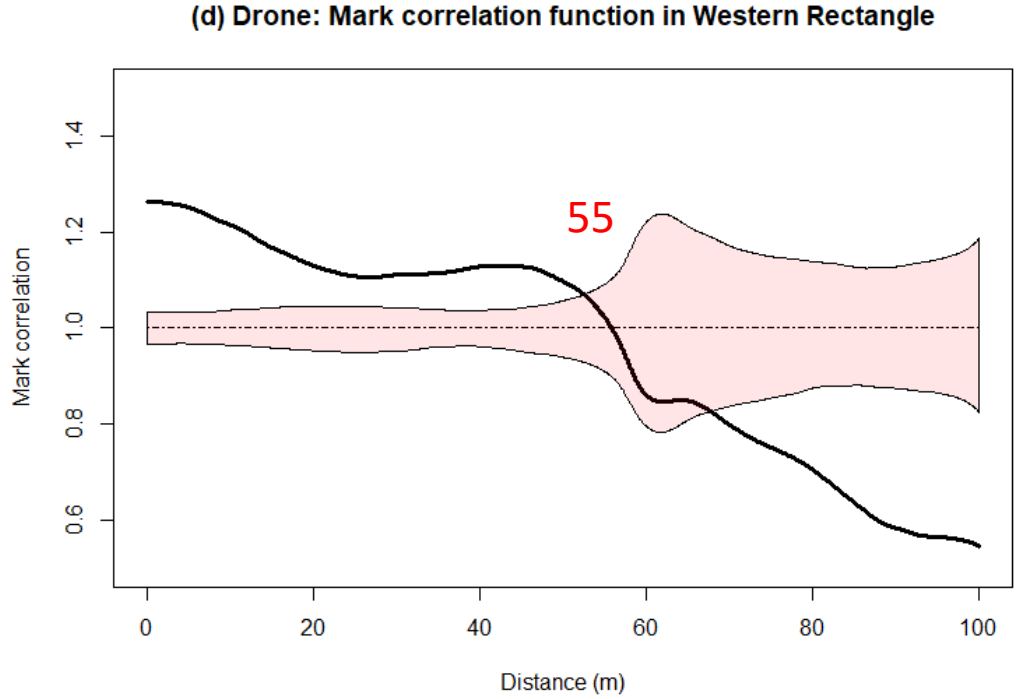



# West rectangle

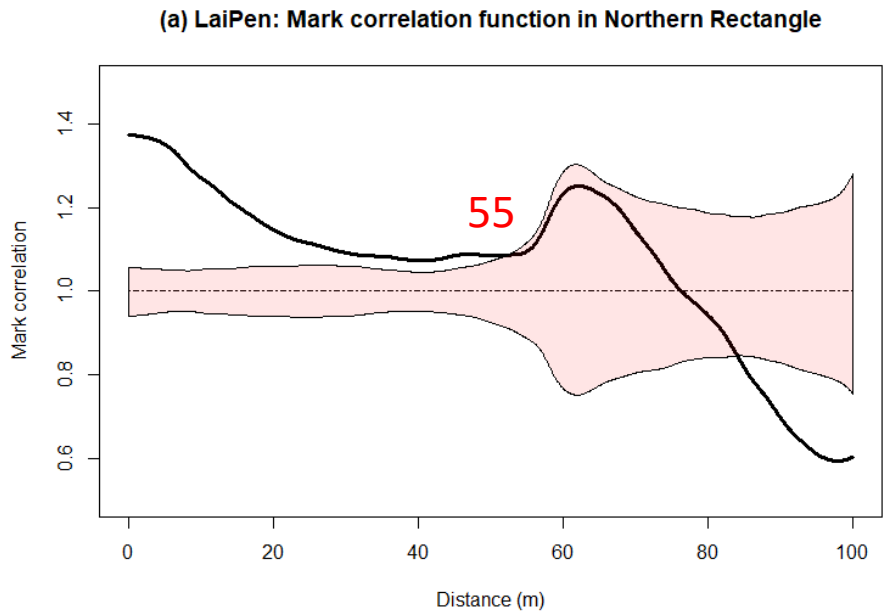


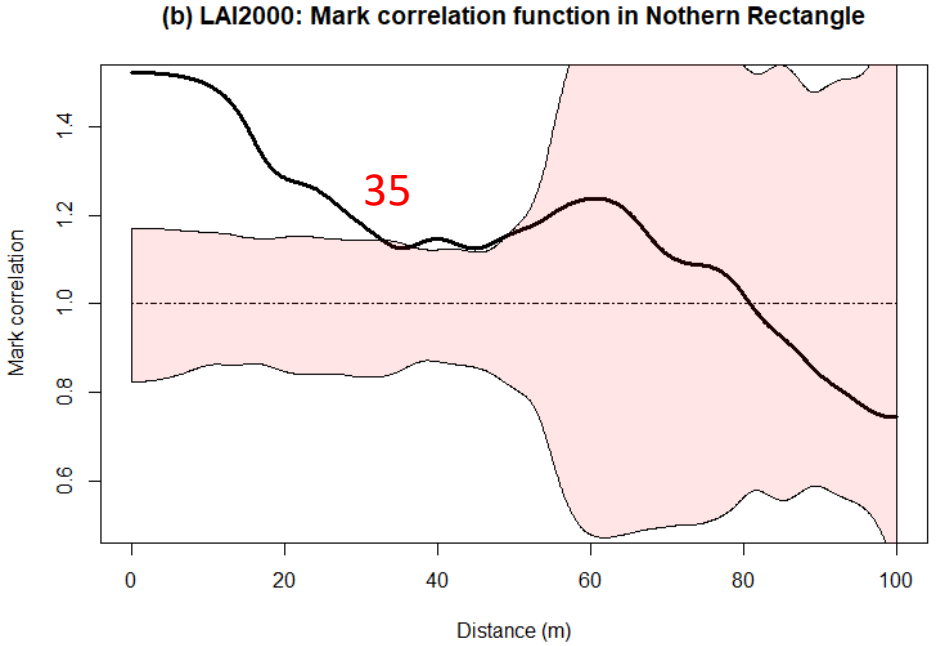



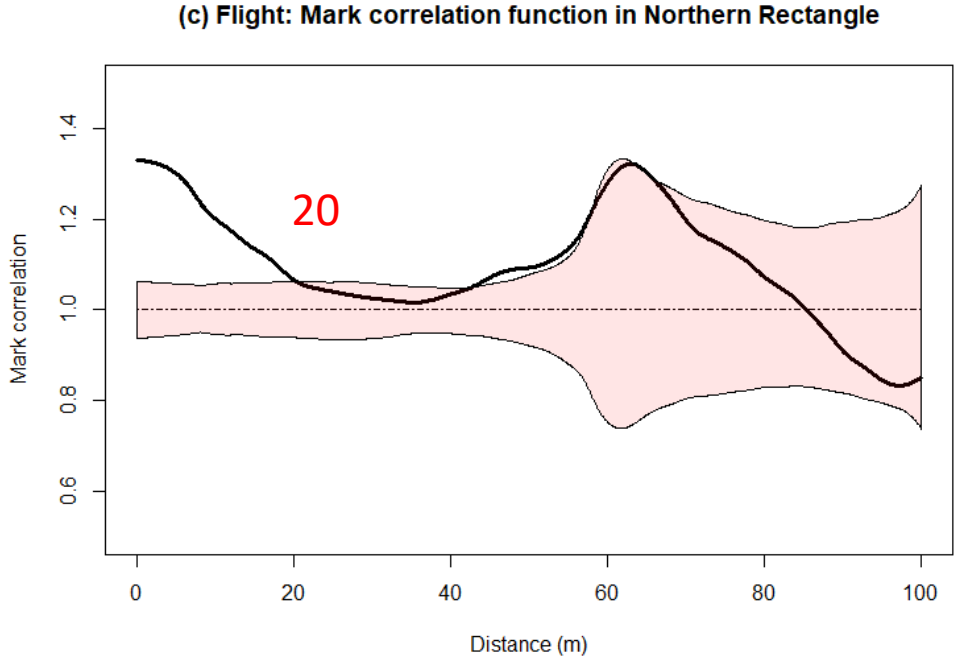



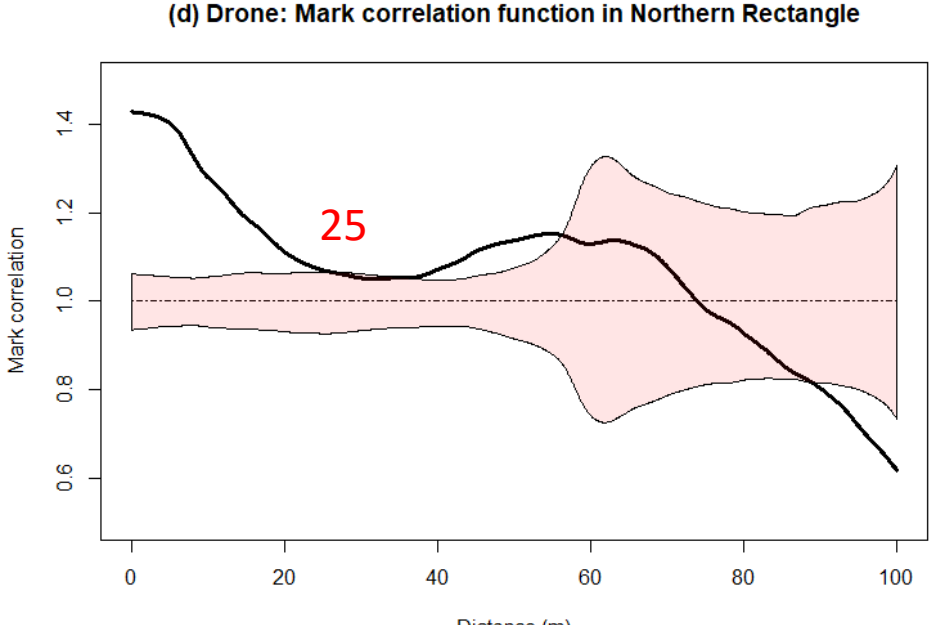



# North rectangle

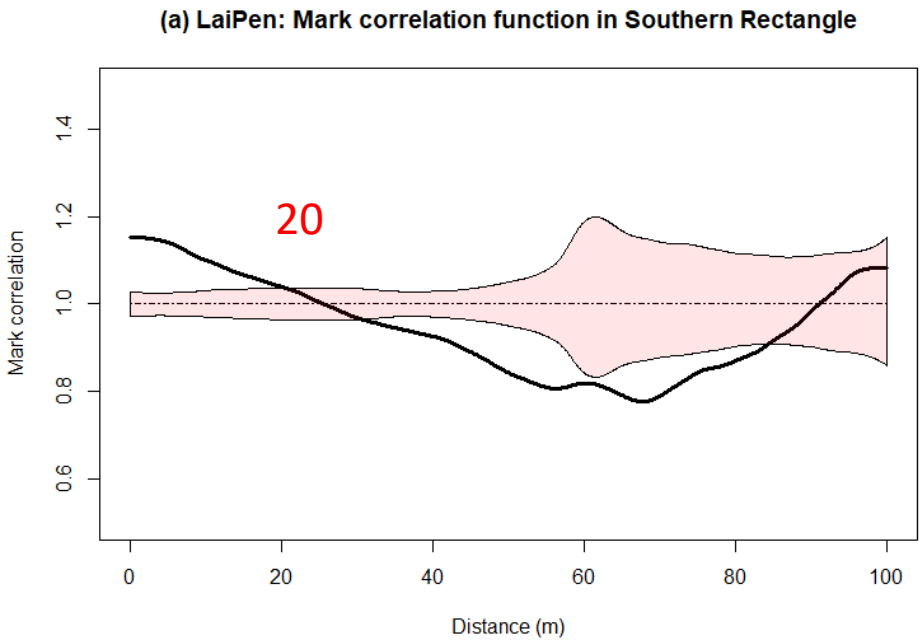


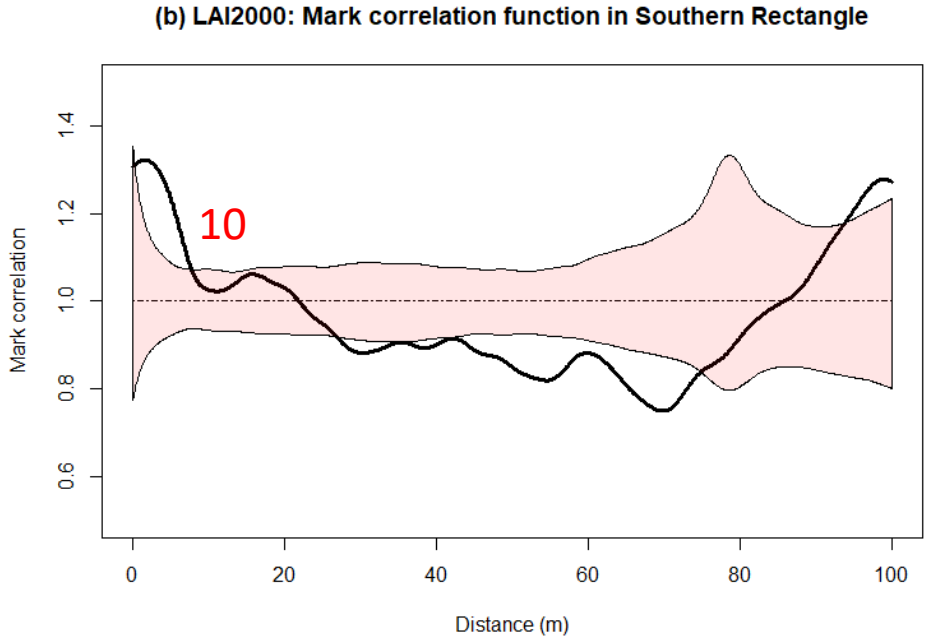



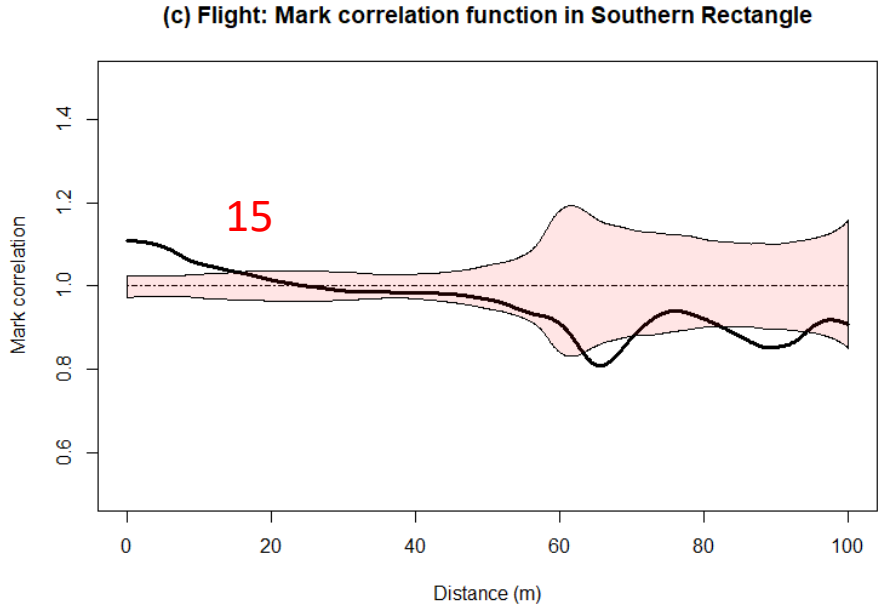



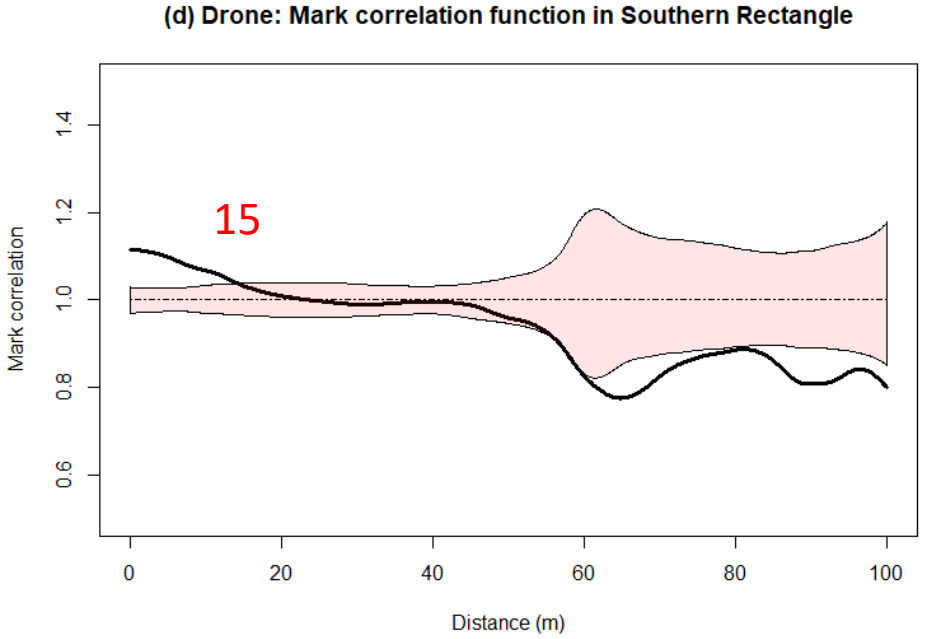



# South rectangle



# Conclusions

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- LAI is a sensitive parameter to characterize canopy structure
- LAI-2000 produces LAI maps quite different from LAI-Pen
- Airplane and drone Lidar flights generate similar LAI maps
- Mark correlation lengths in the order of several 10 meters
  - 10 m x 10 m sampling grid is meaningful
- No sign of previous planting scheme (no short-scale oscillations)
- Outlook: optimization of sampling schemes and the ground-truth – remote sensing data fusion (upscaling)