COMPARING SMALL-FOOTPRINT ALS AND FOREST INVENTORY DATA FOR SINGLE STRATA BIOMASS ESTIMATION

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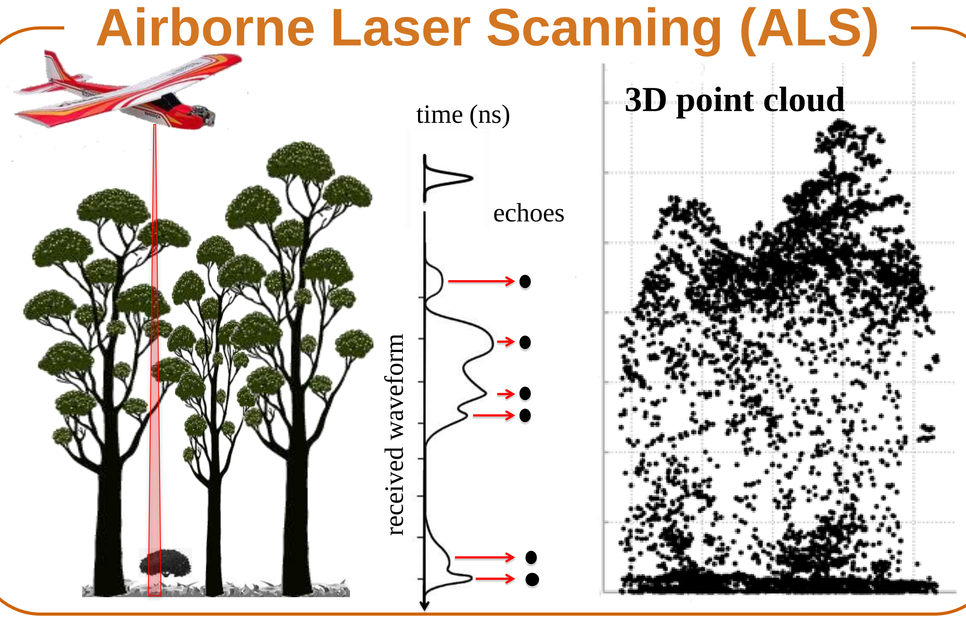
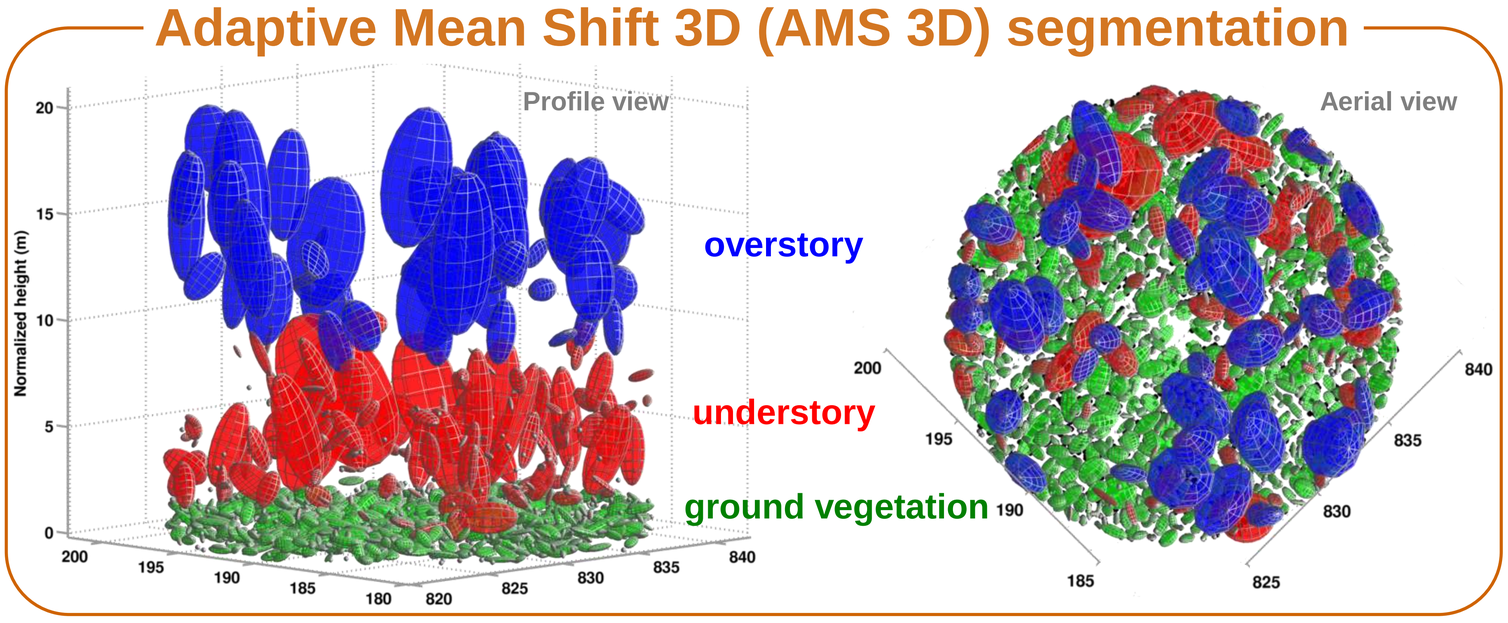
Motivation

- Current biomass estimate methods using optical or microwave remote sensing data require extensive, representative, and time consuming in situ forest inventories to calibrate the sensor signal
- This work presents the first attempt to retrieve aboveground biomass with no need to for massive *in situ* measurements
- **Field-** and **AMS 3D-derived biomass estimates** over a Mediterranean forest are compared either for **single trees** or **forest strata**

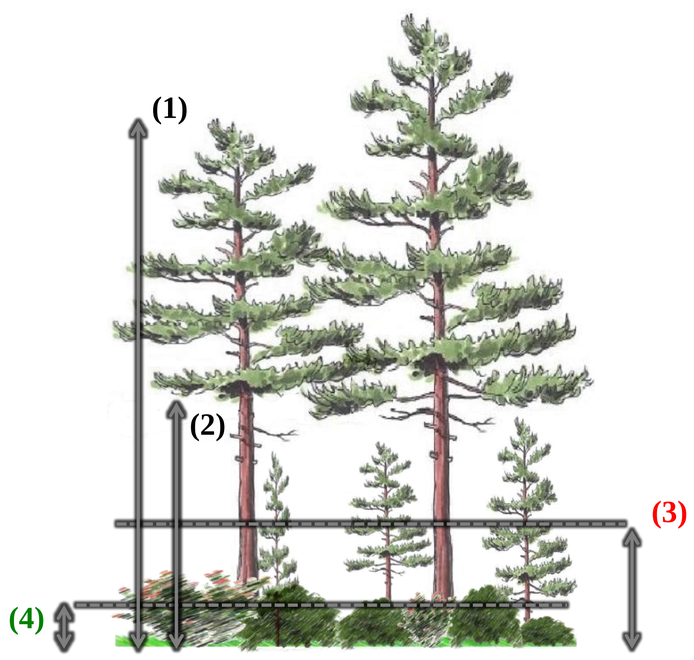
Airborne Laser Scanning (ALS)



Adaptive Mean Shift 3D (AMS 3D) segmentation



Field measurements



- **40 eucalyptus plots in Portugal**
- Aboveground biomass = 56.3 Mg/ha
  overstory (73.2%)
  understory (13.1%)
  ground vegetation (13.7%)

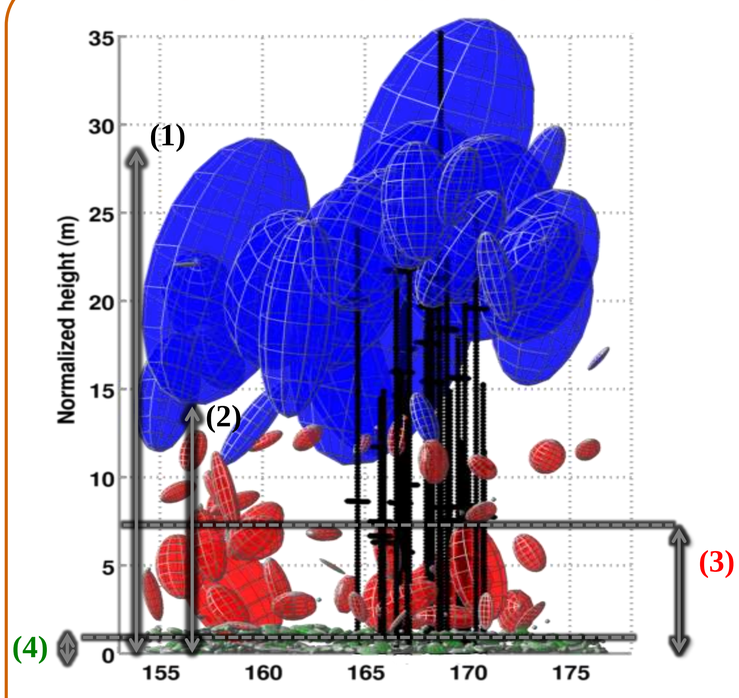
Canopy characteristics

- Overstory: individual trees
  dbh ➔ diameter at breast height
  th ➔ individual tree height (**1**)
  cbh ➔ crown base height (**2**)
  cl ➔ crown length = **th − cbh**
- Understory and ground vegetation: strata
  h ➔ mean height **(3)** and **(4)**
  pc ➔ percent cover
  a ➔ forest plot area
  bd ➔ mean bulk density
  aw, **ab**, **al**, **abr**
  ➔ function of plot dominant height

Allometric equations

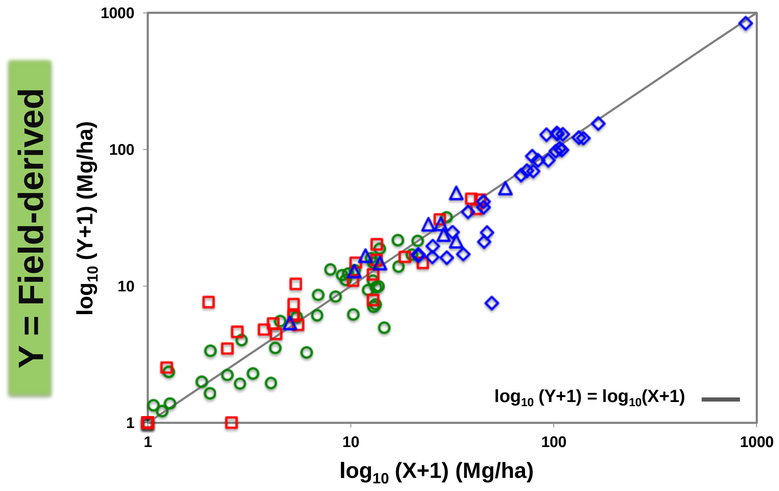
Biomass (kg)		
individual trees	Stems	$w_w = 0.0104 \times dbh^{aw} \times th^{1.36}$
	Bark	$w_b = 0.0006 \times dbh^{ab} \times th^{1.08}$
	Leaves	$w_l = 0.0458 \times dbh^{al} \times cl^{0.82}$
	Branches	$w_{br} = 0.0248 \times dbh^{abr} \times cl^{0.02}$
	Total	$w_t = w_w + w_b + w_l + w_{br}$
forest plot strata		$w_{stratum} = h \times pc \times a \times bd$
dbh (cm)		
individual trees		$dbh = (0.61 \times th) / (1-0.01 \times th)$

AMS 3D measurements



- 67.5 % individual trees extracted:
  - 98.6 % dominant
  - 85.3 % codominant
  - 61.4 % dominated
  - 12.8 % suppressed
- 9.2% of false positives (fictitious trees)
- Percent cover (**pc**) and mean bulk density (**bd**) not yet computed

Results



Single strata biomass (Mg/ha)

Forest stratum	n	mean	σ	R^2	RMSE	Δ
Mature overstory	30	93.69	66.09	0.99	18.02	5.84
Juvenile overstory	10	24.2	10.2	0.79	6.81	− 0.65
Understory	30	10.37	8.68	0.93	3.11	− 0.68
Ground vegetation	40	7.76	5.3	0.80	3.08	0.31

n: number of plots
mean: biomass mean by forest plot
σ: standard deviation
R^2 and RMSE: linear regression parameters
Δ: biomass under-estimation

Conclusion

- Overstory tree biomass assessed without *in situ* measurements
- Undetected trees (mainly suppressed trees) not significant in terms of plot-scale biomass
- Possible ground vegetation and understory biomass retrieval ➔ crucial for fuel mapping, habitat studies etc.
- How to reduce *in situ* observation dependence? Computing the percent cover (**pc**) for ground vegetation and understory

References

A. Ferraz, F. Bretar, S. Jacquemoud, G. Gonçalves, L. Pereira, M. Tomé & P. Soares, "3-D mapping of a multi-layered Mediterranean forest using ALS data", ***Remote Sensing of Environment**, 121*, 2012.

N. António, M. Tomé, P. Soares, P. Tomé & J. Fontes, "Effect of tree, stand, and site variables on the allometry of *Eucalyptus globulus* tree biomass", ***Canadian Journal of Forest Research**, 37*, 2007.