On the use of photogrammetric canopy height models to estimate wind damage to forest stands

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Context

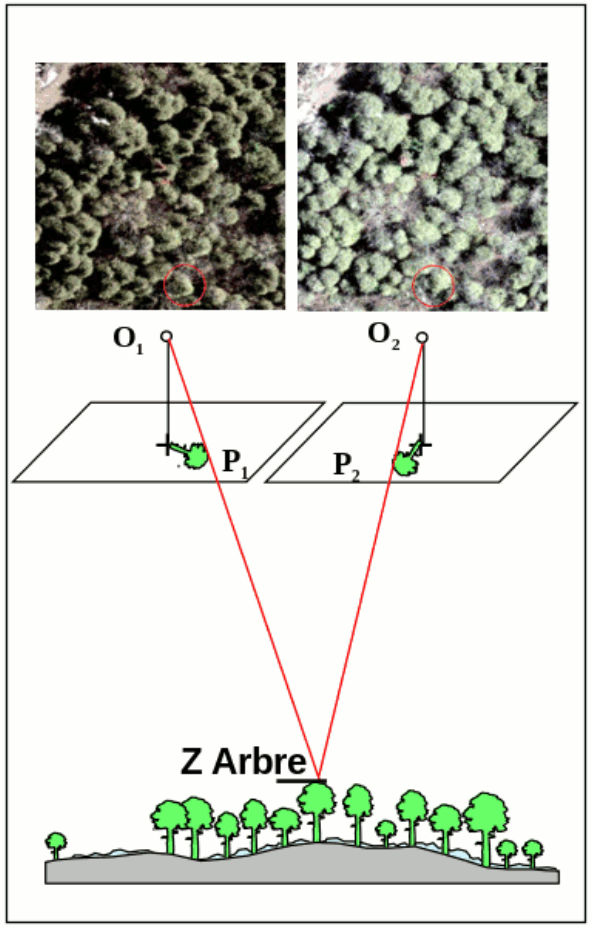
- **Storms** are among **the main disturbance factors** in European forests

  (Gardiner et al. 2010; Albrecht et al. 2012)

- The 2.5D character of stereo images are usefull !

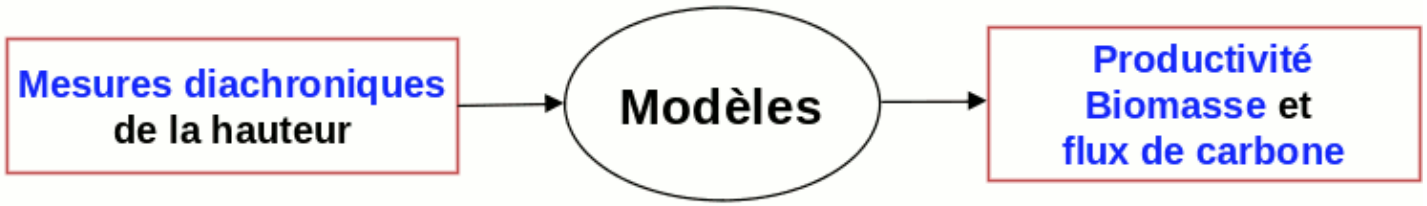
  - Miller *et al.* (2000) have shown the potential of photogrammetry to estimate forest damages associated to storms.

  - Since *ca*. 10 years, MicMac allows the reconstruction of DSM from aerial images (*e.g.* Pierrot-Deseilligny 2014)



Context

- The 2.5D character of stereo images are usefull !
  - …
  - *Véga (2006) produced "fertility" maps from photogrammetric time series*

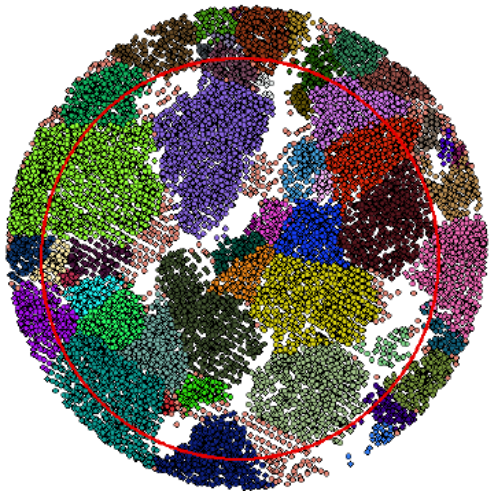


  - In Finland, Honkavaara *et al.* (2013) proposed an automatic method to detect damages associated to storms based of photogrammetric canopy height models (CHM).

Context / *estimation of impacted growing stocks…*

- Since at least 4 years, studies based on photogrammetric CHM produced models to **estimate forest parameters**, *e.g.* :
  - Bohlin, Wallerman, et Fransson *2012*
  - Järnstedt et al. *2012*
  - Nurminen et al. *2013*
  - Straub et al. *2013*
  - Vastaranta et al. *2013*
  - Stepper, Straub, et Pretzsch *2015*

missing values
Is an issue…
even for lidar data!



(André et al. 2015).

- Non-probalistic Inferences

Limits of the approach :

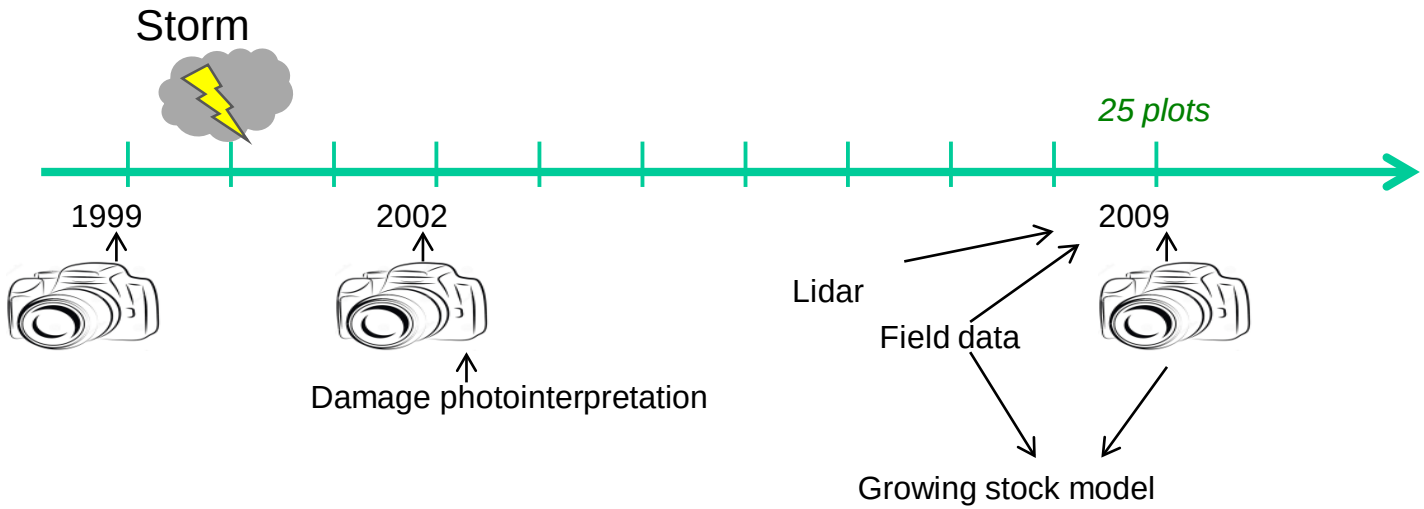
"Model-based small area estimators depend on model assumptions to hold.
This dependency doesn't make them very attractive for official statistics" *(Cullmann et al. 2016).*

Material et Method

Photos FD Haye / **géoportail** IGN -> 1999; 2002; *(2009)*

Before / After the 1999 storm

+ 25 calibration field plots (*ANR-Foresee 2009*)



Material et Method

Photogrammetric precision of the block (using aéroscan)

Year	Number of images	Type	Pixel resolution	Bloc RMSE	
				plani-metric	Z
1999	18	Film 1200 dpi	55	238	170
2002	74	Film 1200 dpi	28	29	29
2009	29	Numeric	33	17	38

Ground control points

25 field plots (2009)

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Density (stems/ha)	99	156	198	234	311	439
Ho (m)	18.10	22.40	27.60	26.78	31.00	36.20
Volume (m3/ha)	122.2	244.1	335.9	371.5	479.6	728.2
G (m^2/ha)	11.70	19.40	22.60	23.42	28.70	37.80

Results / *CHM production (dense correlation using MicMac)*

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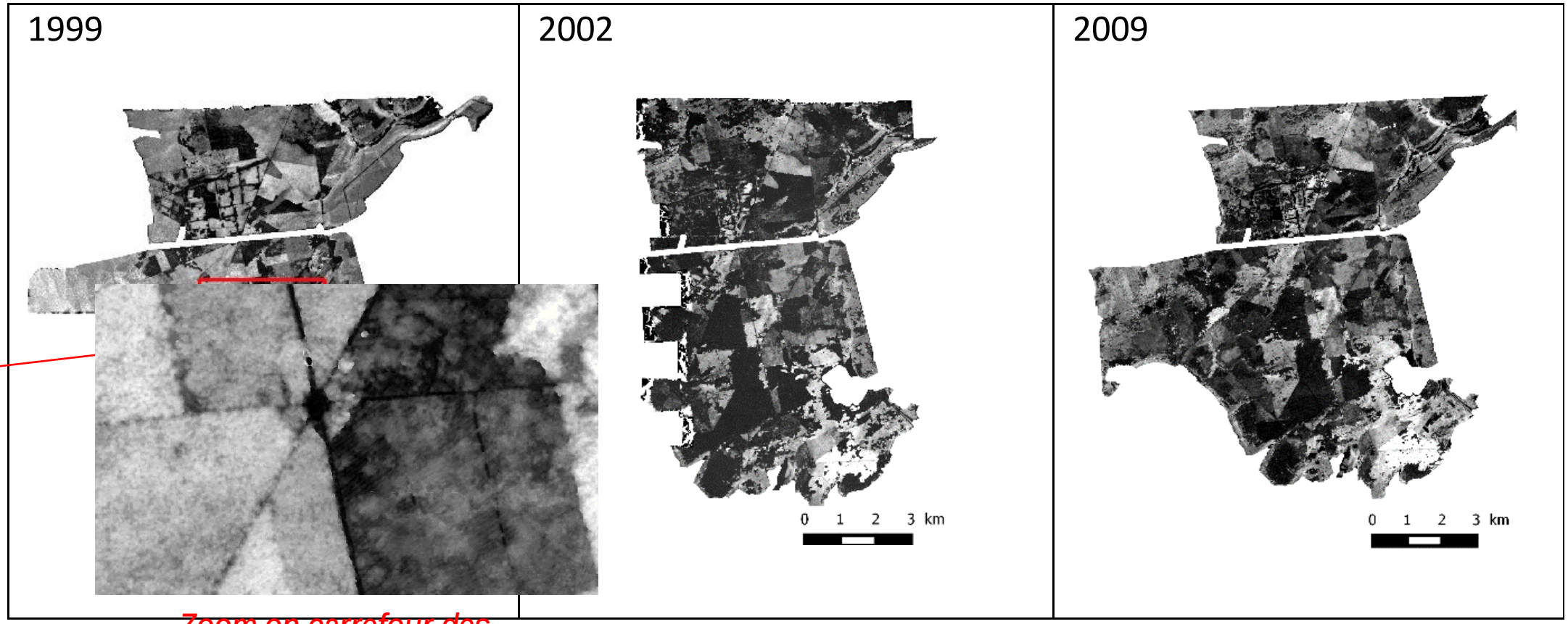
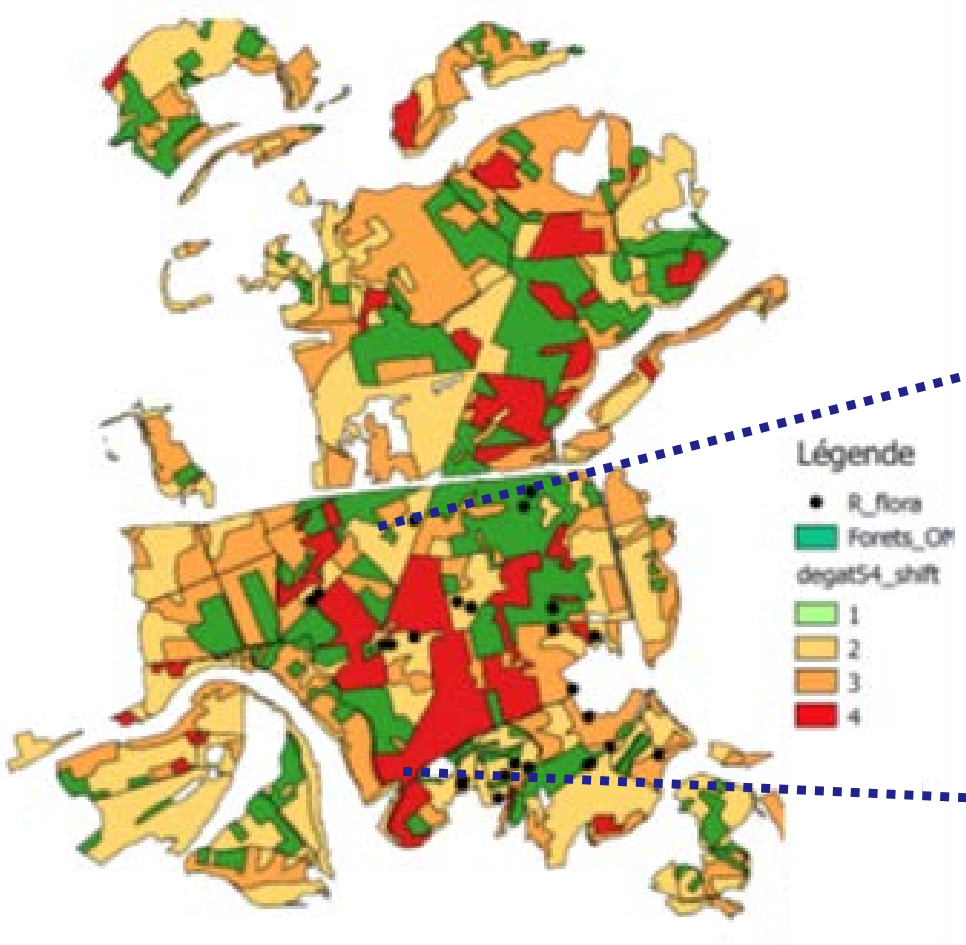


Zoom on carrefour des 6 bornes

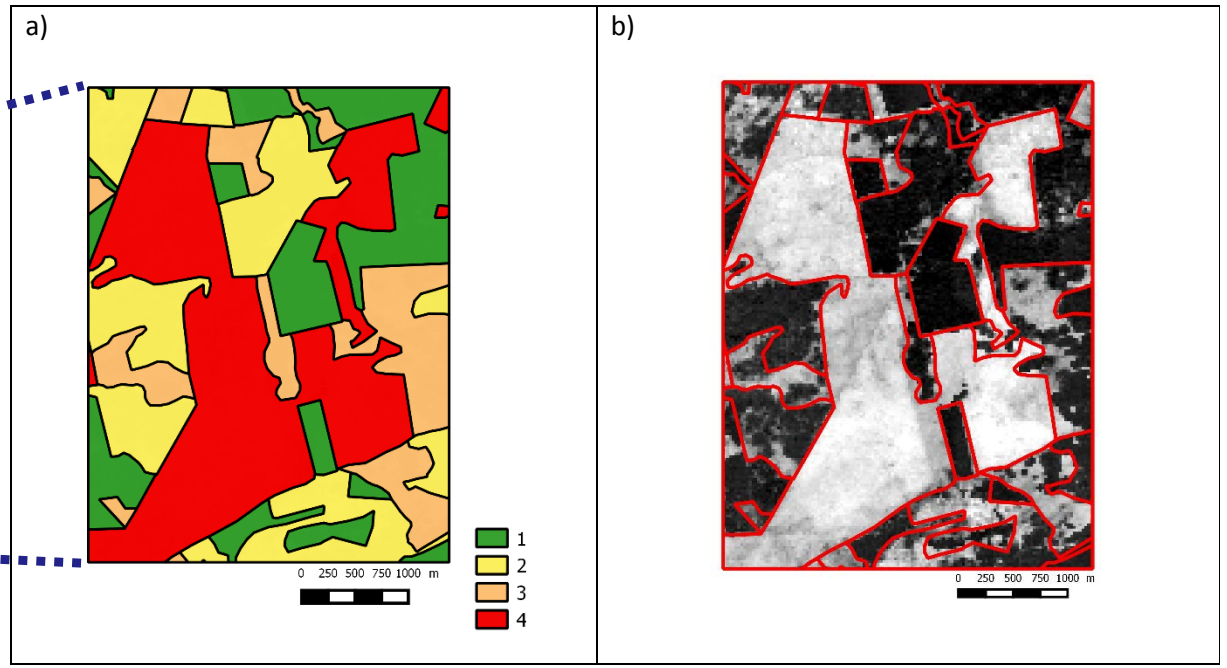
Results / *estimation of impacted areas*

IFN 1999's damages map (PI)



Classe de Dégât	Diff. médiane
1	-1,4
2	1,3
3	12,3
4	23,8

CHM difference map (1999-2002) on the area of intérêts (AOI)

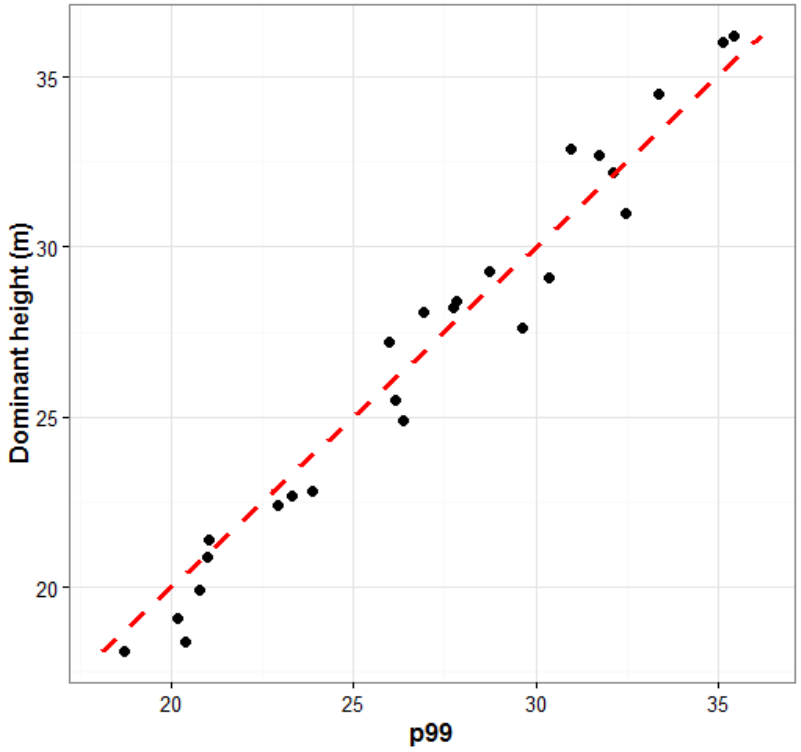


A close link with the damage map…with a further quantitative aspect !

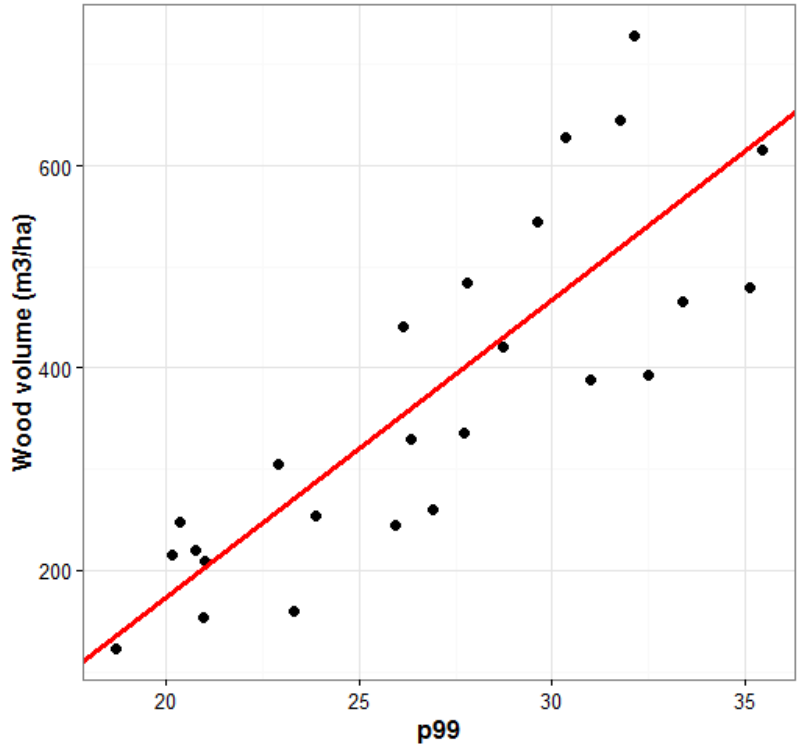
Results / *Dominant height and growing stocks estimation models*

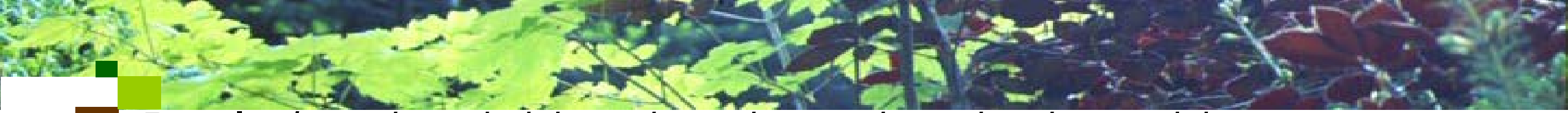
A good relation between Ho, V and P99 of the photo CHM

a)



b)



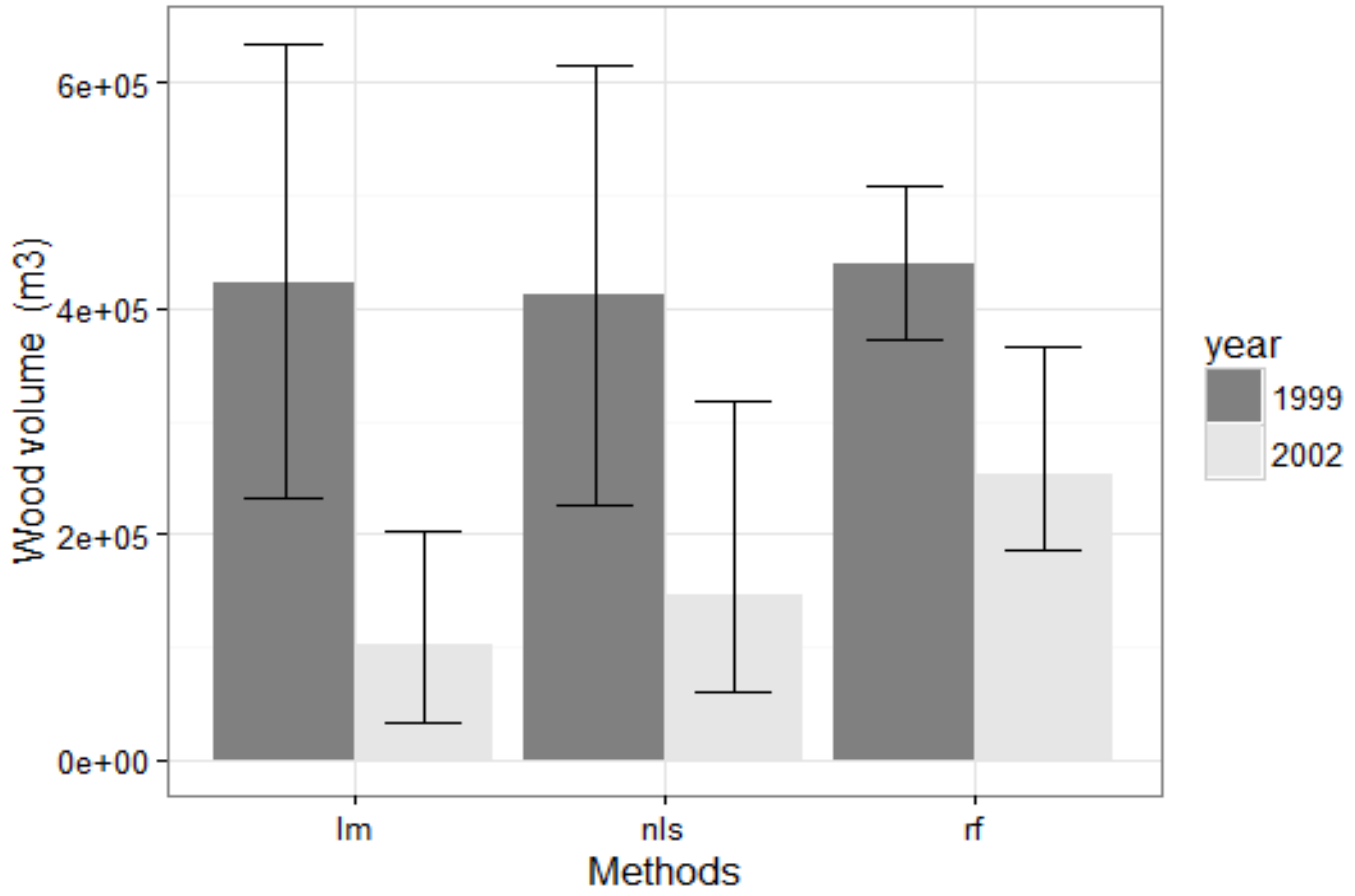


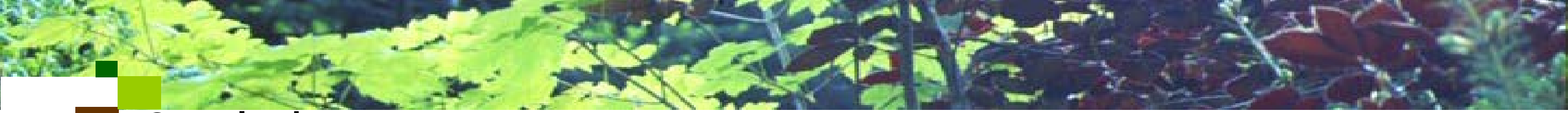
Results / *Dominant height and growing stocks estimation models*

*Models of Ho and V from **25 field calibration plots** (established in 2009)*

Variable	Model type	Fitted predictors	RMSE	(%)
***Ho** (m)*	lm	1.05 (p99) -1.62	1.1	*(4)*
	lm	29.4 (p99) - 414.6	93	*(25)*
***V** (m^3/ha)*	nls	$MED^{1.84} + MAD^{7.29}$	89	*(24)*
	rf	(p0, p25, MED, p75, p100)	120	*(32)*

Model-Based estimations of growing stock changes over the *AOI*





Conclusions

- Based on CHM differences, a « zone » segmentation is possible, that could allow an automatic detection of the *impacted area* by wind storms. *This could at least ease operational oprerations…*

- A big advantage of the photogrammetric point cloud, is that it allows model construction of forest attributes → estimation of the impacted attributes *(e.g. stocks …)*

- Models could be improved… and the impact of images « quality » still need to be evaluated *(many studies use 10 cm image resolutions).*

- Open new perspectives : take into account the landscape scale in models…

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