SIZE-RESOLVED AEROSOL FLUXES ABOVE A BROADLEAF DECIDUOUS FOREST

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Research activity performed in collaboration with the research group of Università Cattolica del Sacro Cuore composed by:
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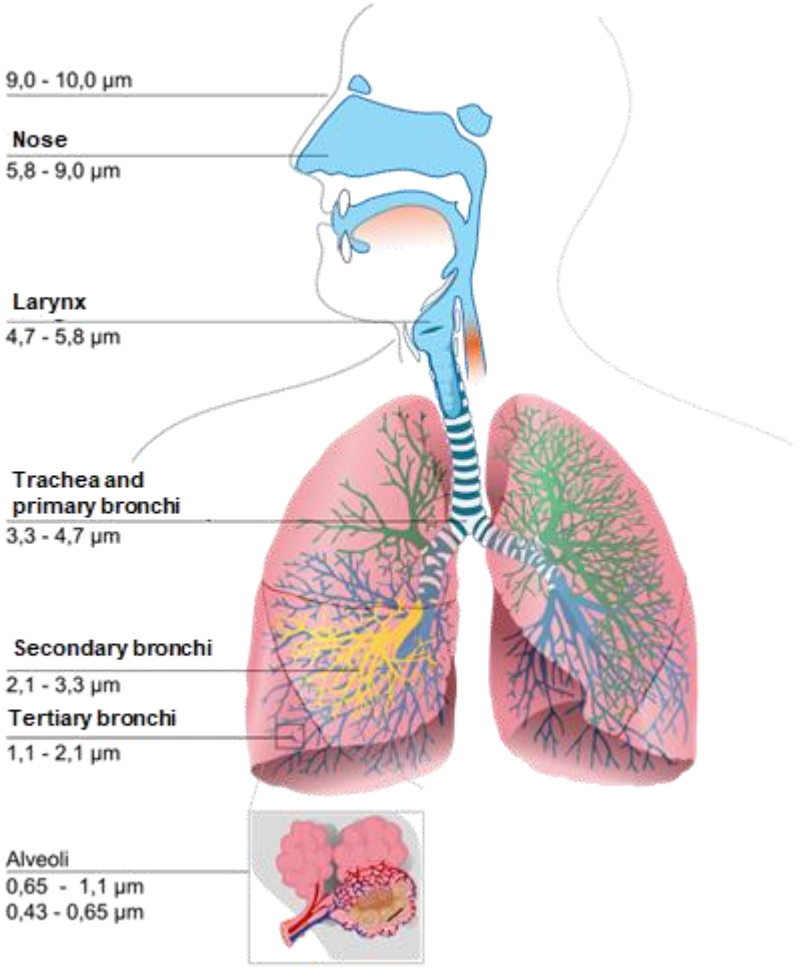
PM and human health

Atmospheric aerosol → *mixture of solid and liquid particles in a gas. Frequently referred also as PM.*

- PM is the atmospheric pollutant which is more strongly correlated to health diseases.
- **Smaller particles have a greater impact on human health.**

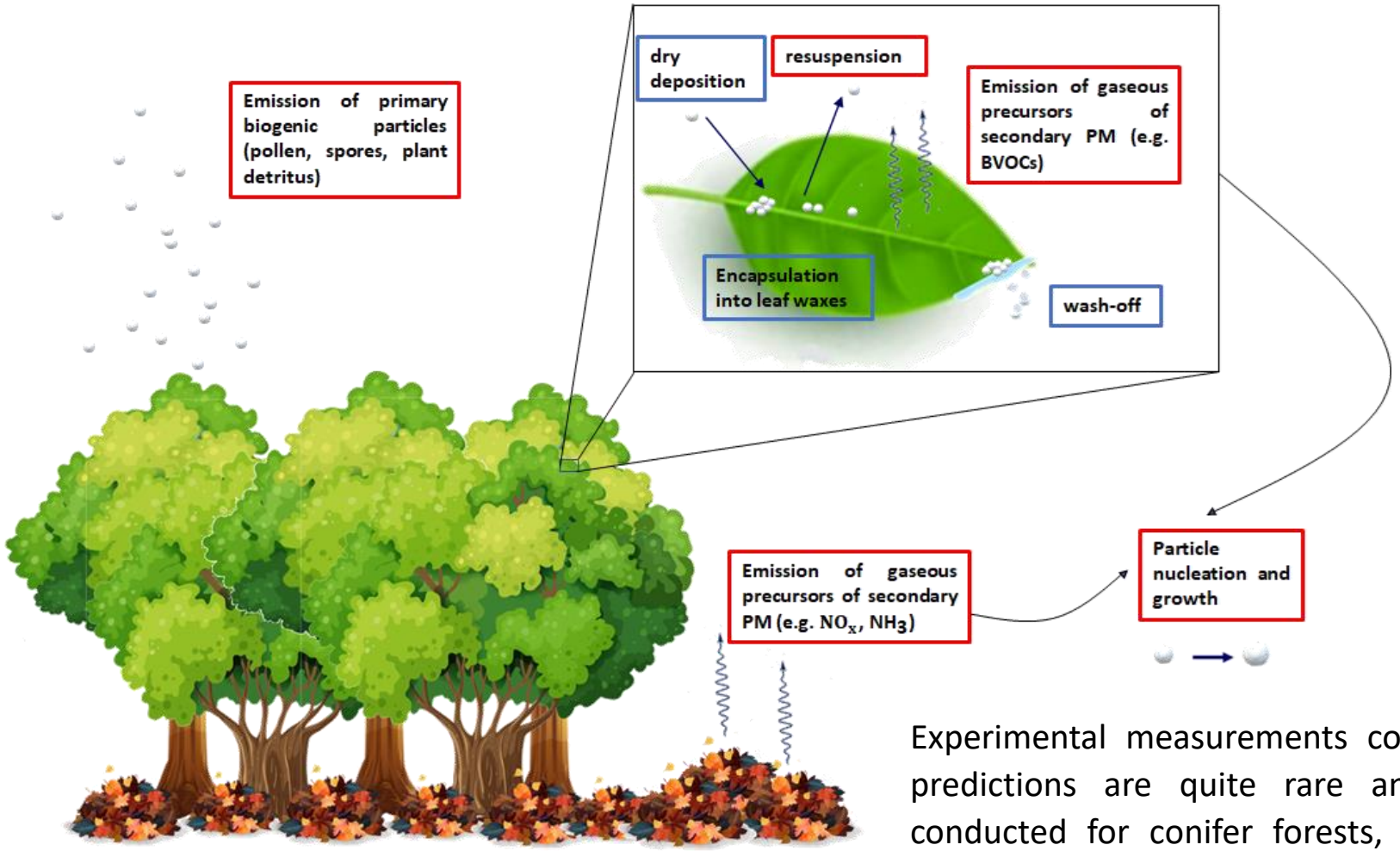


Can vegetation improve air quality?

- McDonald et al., 2007
- Tallis et al., 2011
- Tiwary et al., 2009
- Nowak et al., 2006
- Nowak et al. 2013

Removal of PM by due to the deposition on tree surfaces

PM exchange between forests and the atmosphere

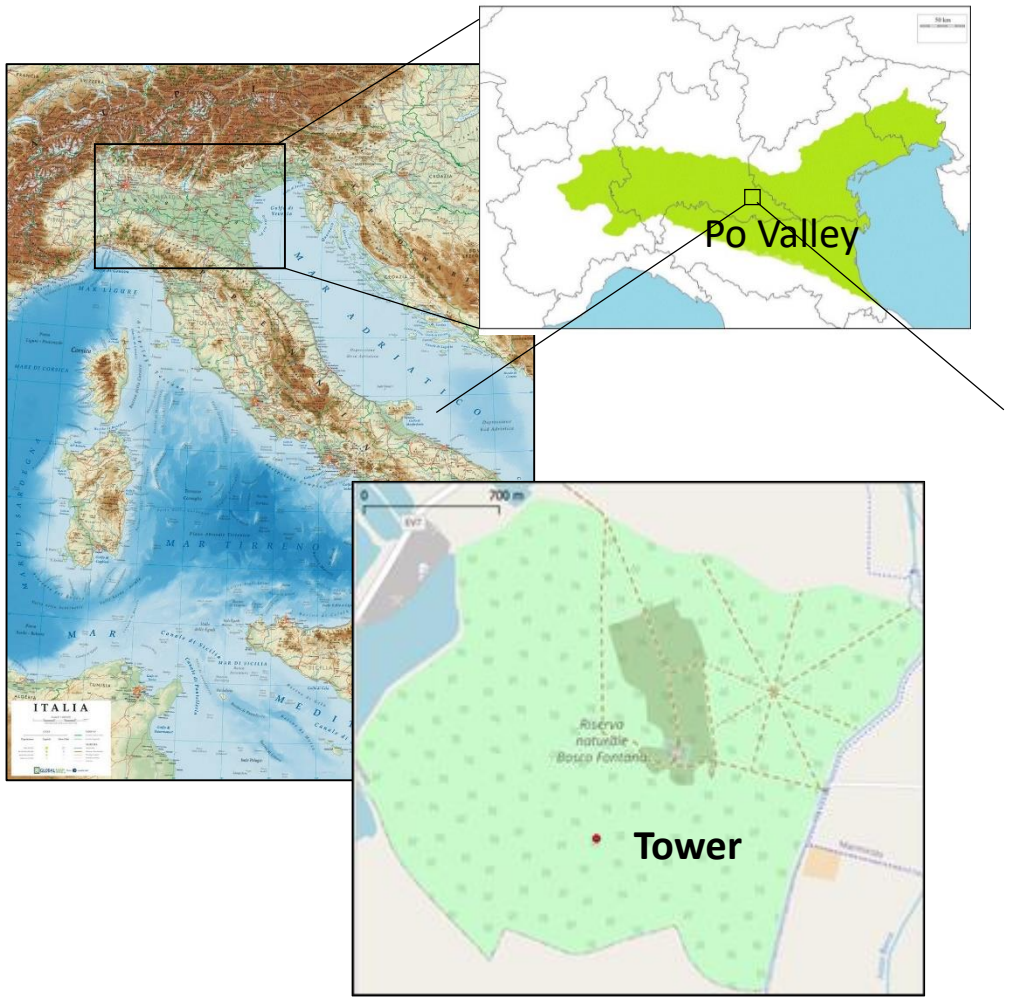


Experimental measurements confirming the modeling predictions are quite rare and have mainly been conducted for conifer forests, where the amount of leaves remains constant throughout the year.

Aims of the research

- Verify whether the forest is a net PM sink or a source;
- Investigate the role of leaves on particle exchanges;
- check for the existence of seasonal patterns in distinct aerosol size-classes;
- Understand which are the main drivers of particle exchange.

Study site



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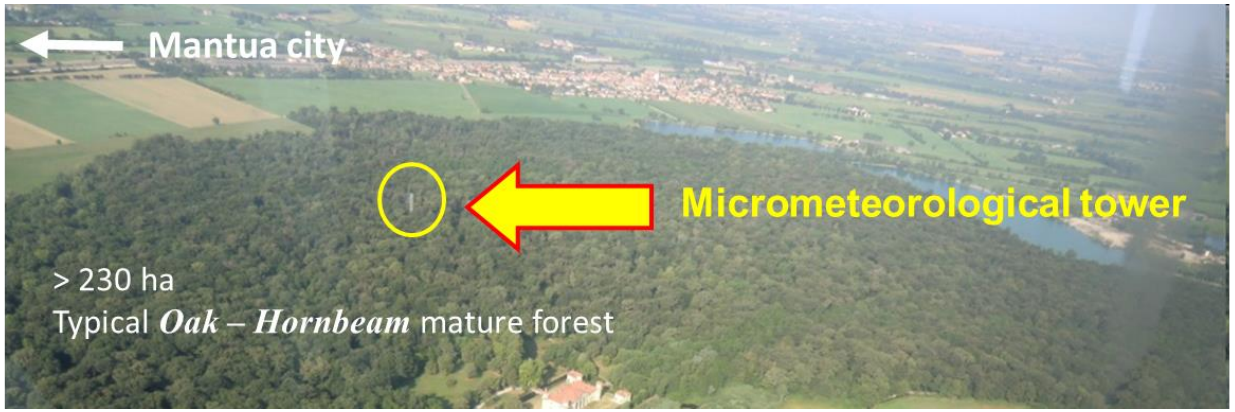
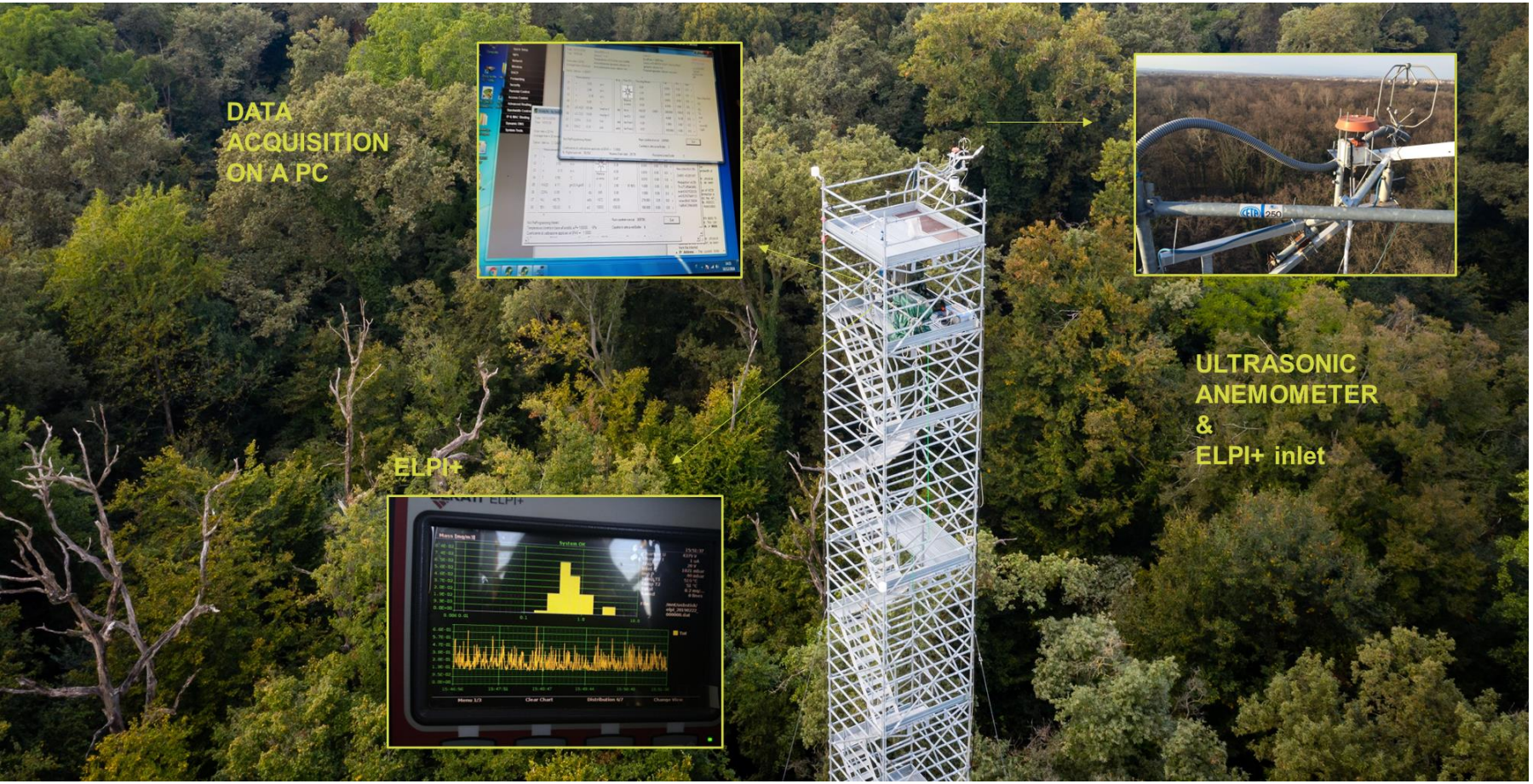
42 m high tower
Erected in 2012 in the framework of the ECLAIRE EU project

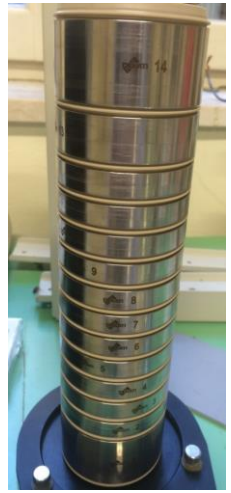
Intensive agricultural activity in the surrounding of the forest and presence of a chemical plant 15 km S-E from the forest



Measurement setup



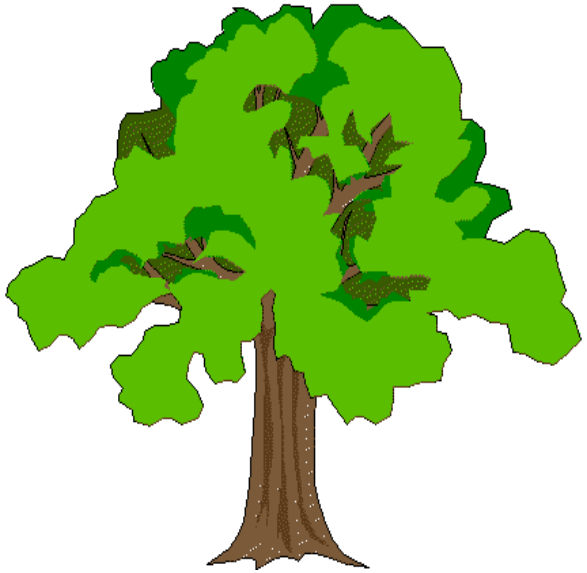
ELPI+



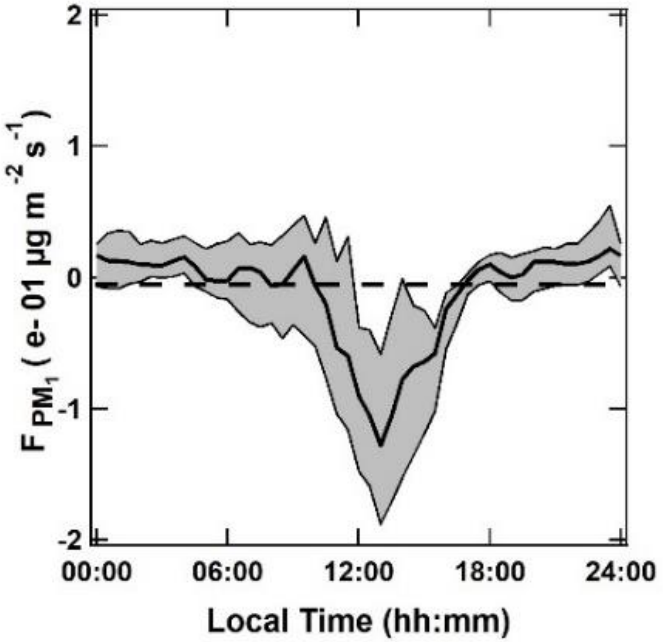
	Stage	D50 (µm)	GMD (µm)
Ultrafine aerosol	F	0.006	0.01
	2	0.016	0.02
	3	0.031	0.04
	4	0.055	0.07
Fine aerosol	5	0.095	0.12
	6	0.155	0.20
	7	0.256	0.31
	8	0.382	0.48
	9	0.603	0.76
Coarse aerosol	10	0.948	1.24
	11	1.630	2.01
	12	2.470	3.01
	13	3.660	4.43
	14	5.370	7.29
	15	9.890	

Median daily fluxes

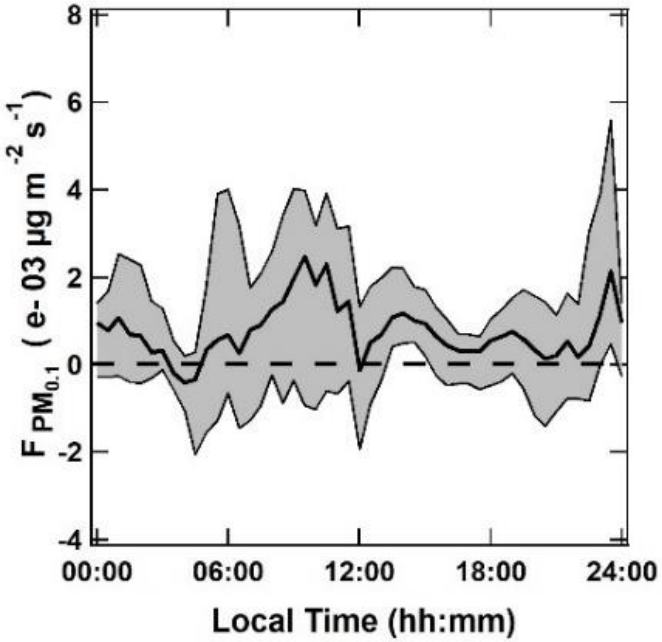
Leaf-on period



PM_1



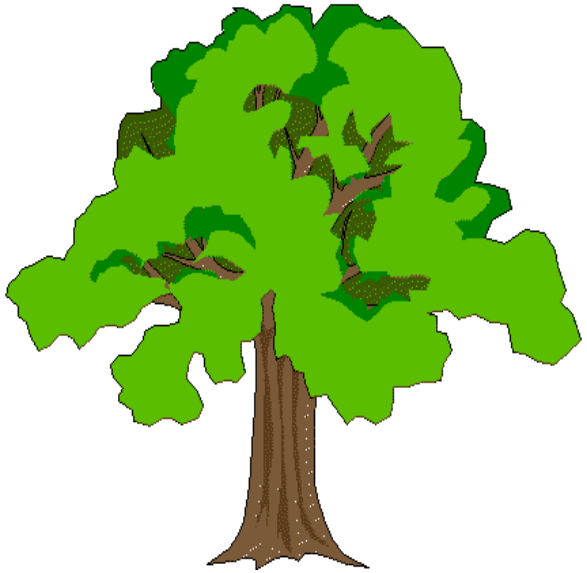
$PM_{0.1}$



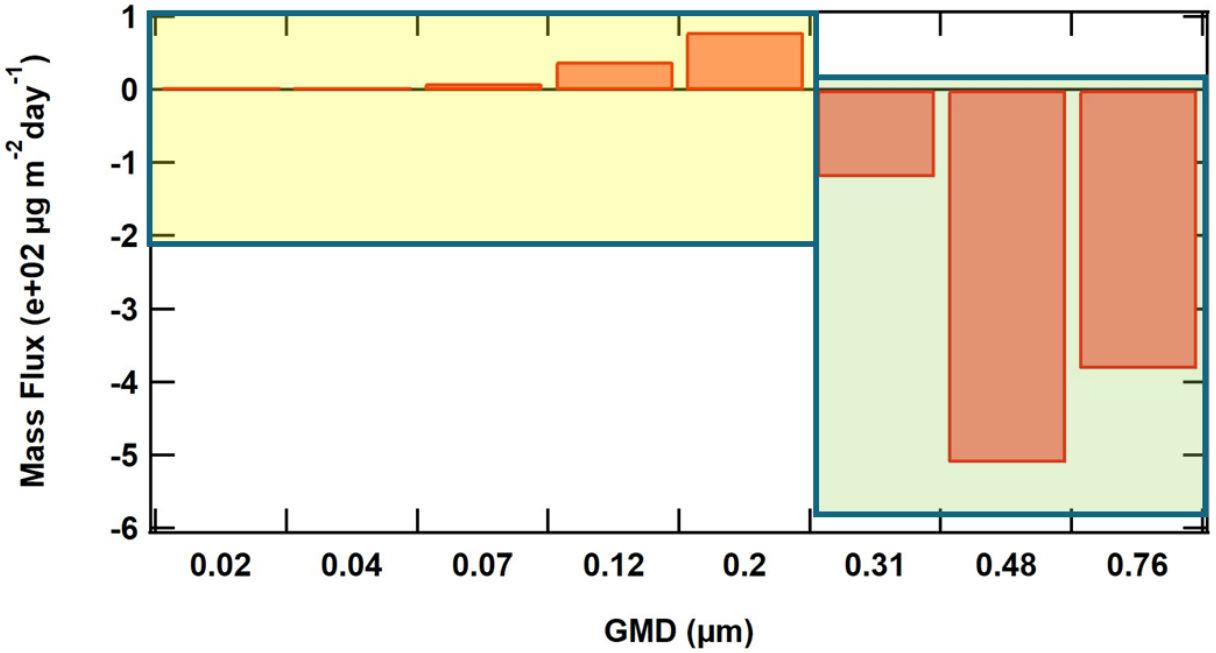
Downward and upward aerosol fluxes can co-exist over forest ecosystems

Median daily fluxes

Leaf-on period



+132 µg m^{-2} day^{-1}

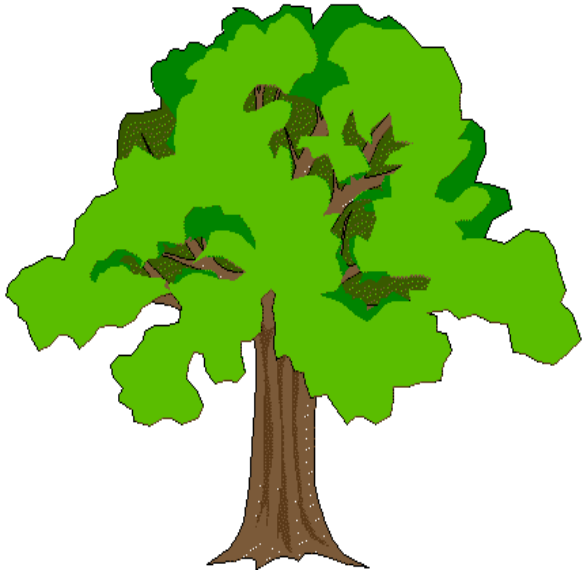


+132 µg m^{-2} day^{-1} -1010 µg m^{-2} day^{-1}

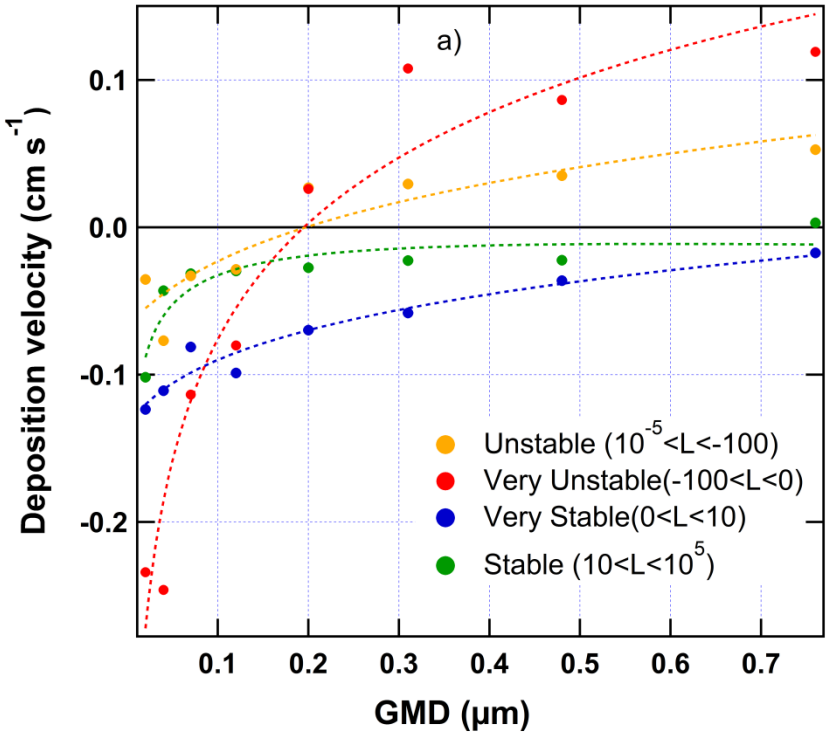
-878 µg m^{-2} day^{-1}

Influence of atmospheric stability on aerosol exchange

Leaf-on period

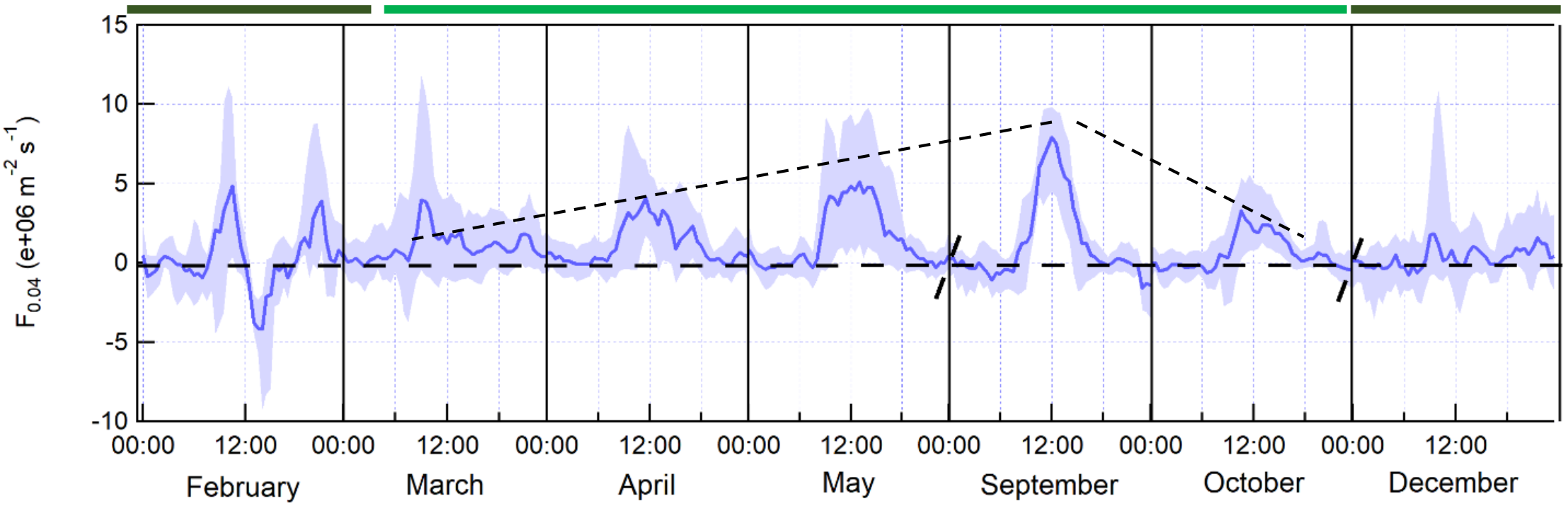


$$v_d = -\frac{F}{C}$$

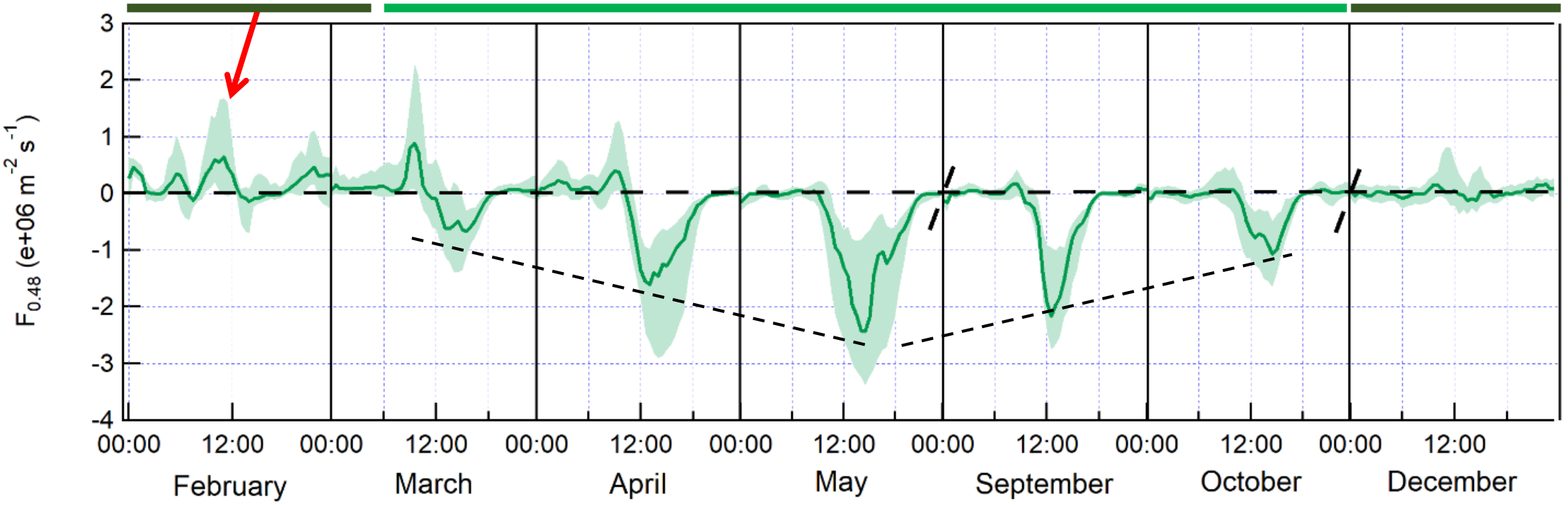


Pronounced instability conditions favour vertical exchanges in both directions. When the atmosphere is stable emission dominates.

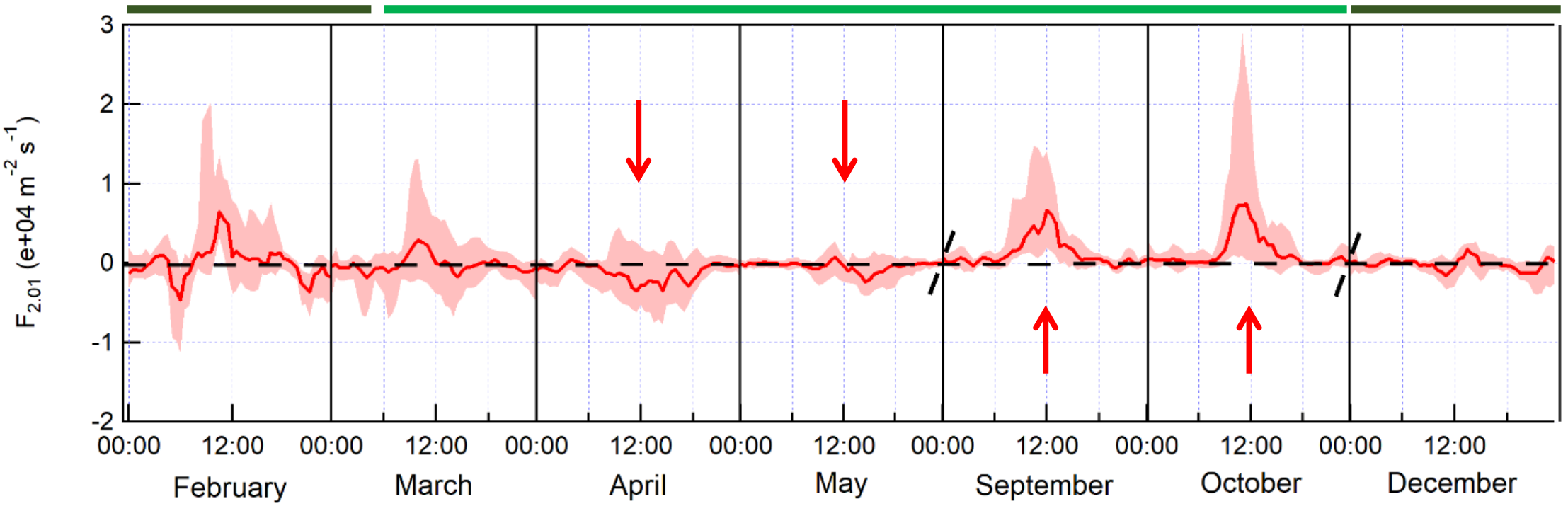
Seasonal variation of aerosol fluxes – ultrafine aerosol



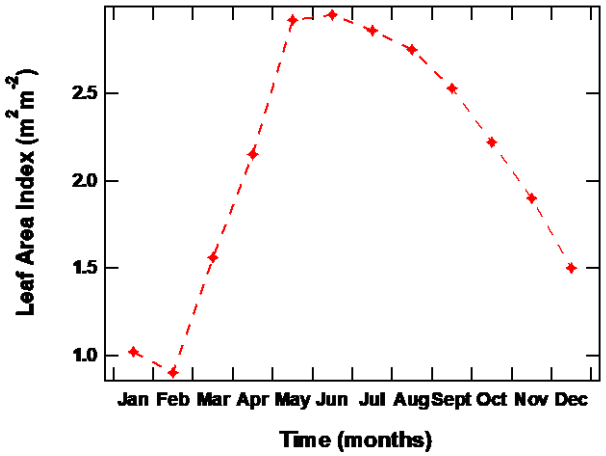
Seasonal variation of aerosol fluxes – fine aerosol



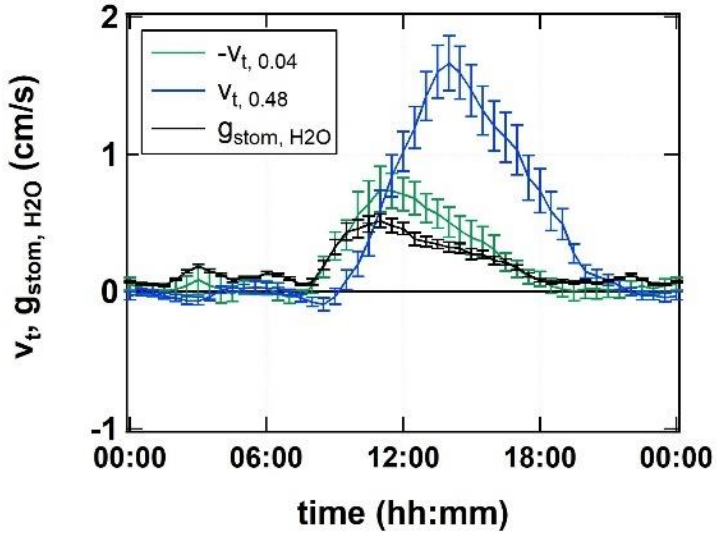
Seasonal variation of aerosol fluxes – ultrafine aerosol

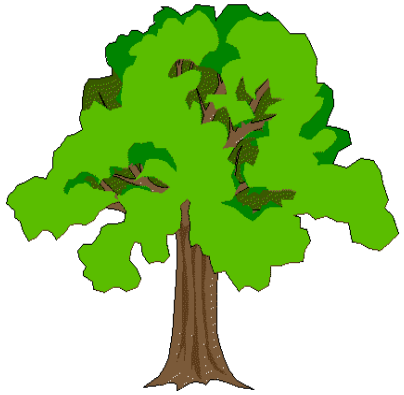


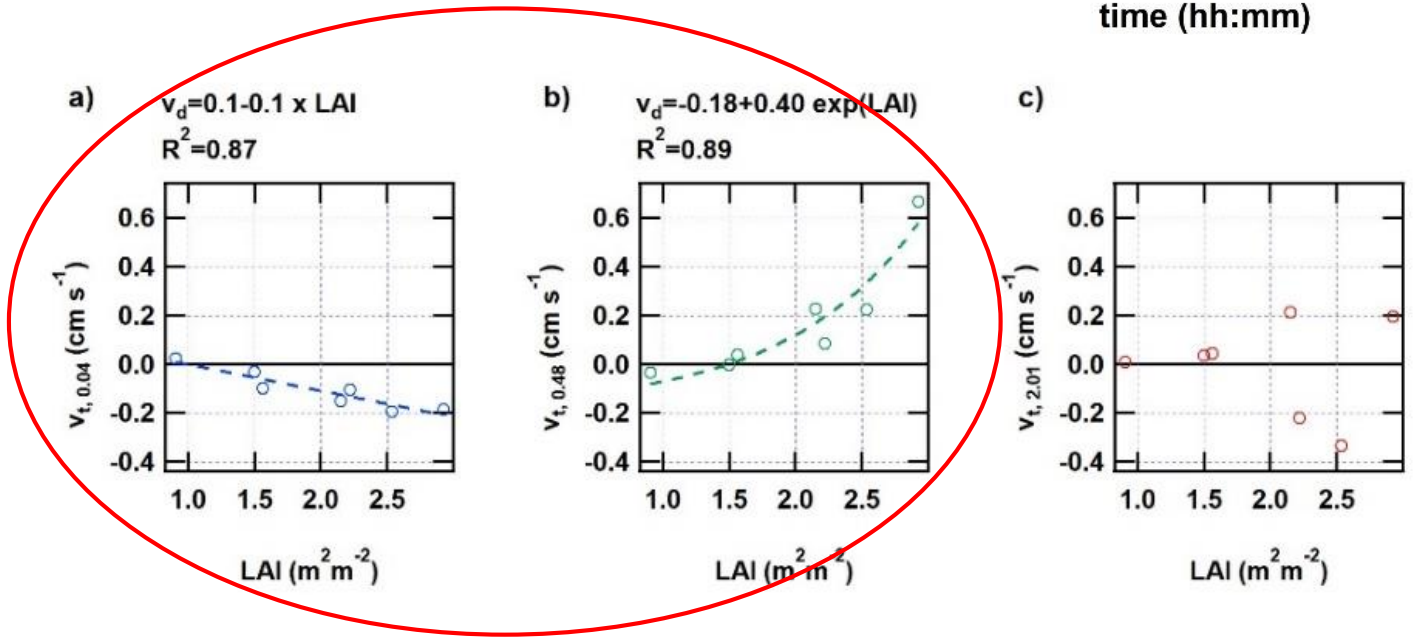
Drivers of aerosol fluxes - LAI



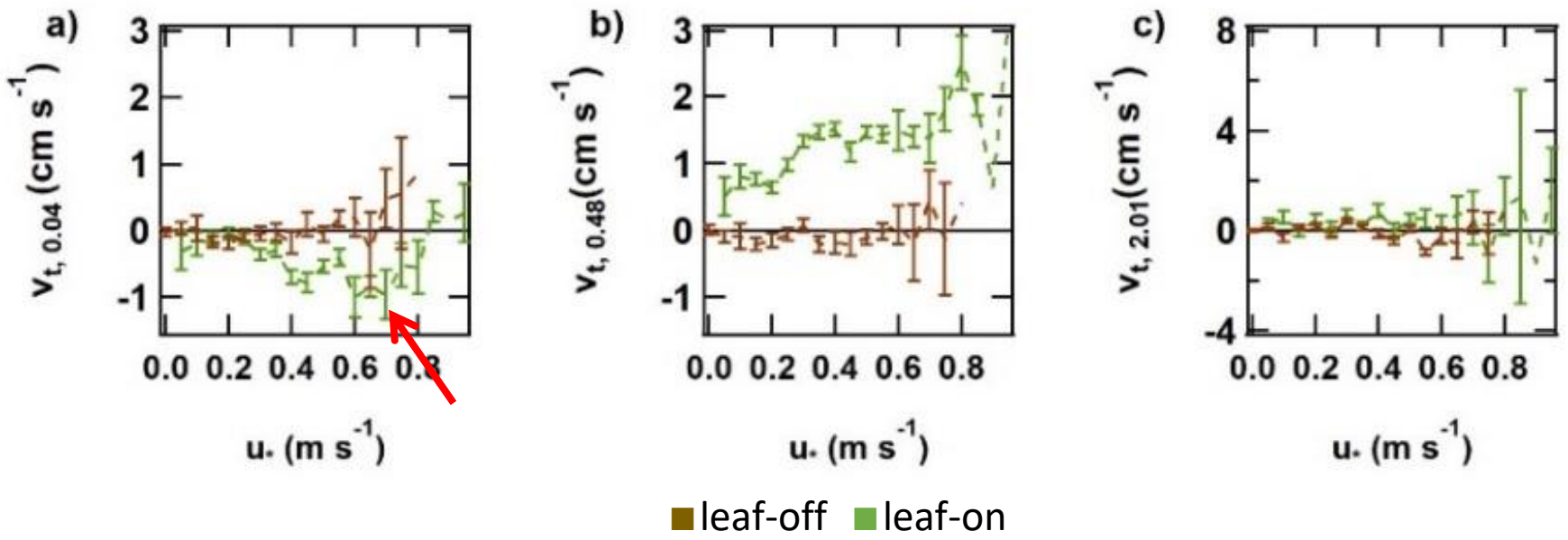
LAI measurements for years 2013-2014, 2016 and 2019 available for the Bosco Fontana site.





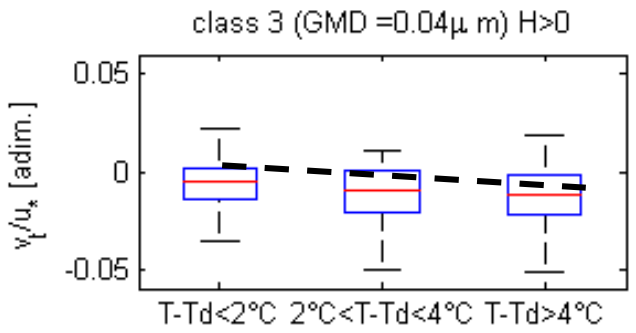


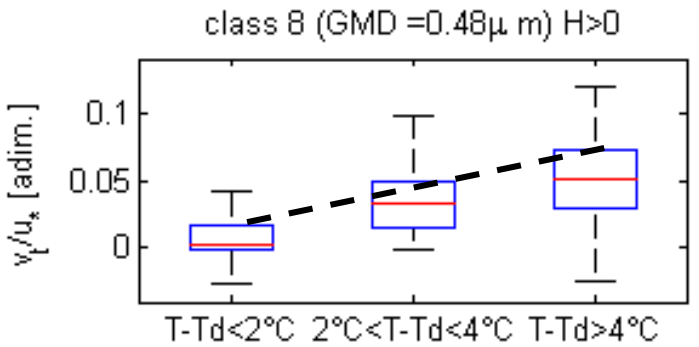
Drivers of aerosol fluxes – u_*

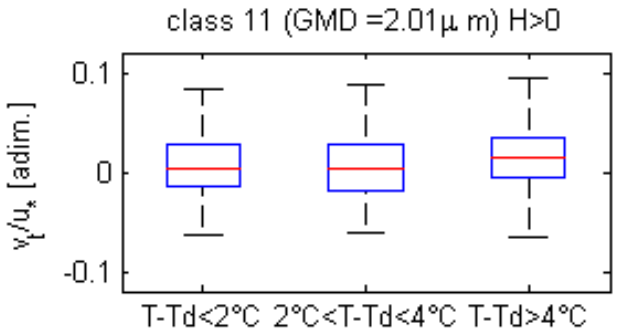


Drivers of aerosol fluxes – closeness of T_{air} to T_{dew}

UNSTABLE ATMOSPHERE







Conclusions and future perspectives

- Downward and upward aerosol fluxes can co-exist over forest ecosystems;
- The presence of leaves affects both ultrafine and fine particle exchanges, but in different ways. Ultrafine particle emissions likely involve stomatal activity, while fine particle deposition depends on impaction processes and the availability of leaf surfaces.
- Fluxes of distinct aerosol size classes owe specific seasonal patterns;
- LAI, friction velocity atmospheric stability and the closeness of T_{air} to T_{dew} affect the vertical exchange of aerosol particles.

Future perspectives ->

- Check whether the features that emerged from this study also apply to other deciduous forests in different climatic areas.
- Compare the results of the present study with model predictions (iTree-ECO; CIPAM)

Thank you for your attention!

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