Comparing the modeled deposition of $PM_{2.5}$ with the Eddy Covariance flux and SEM analysis of an urban forest in Naples

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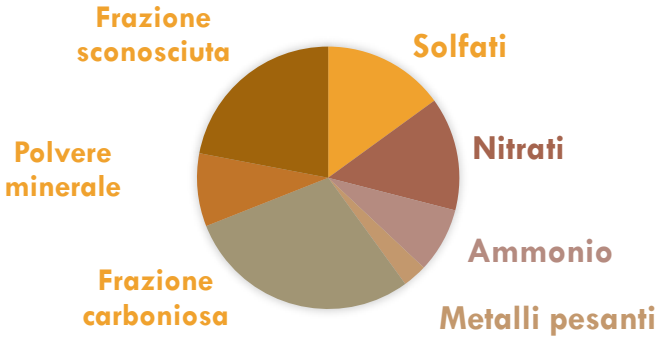
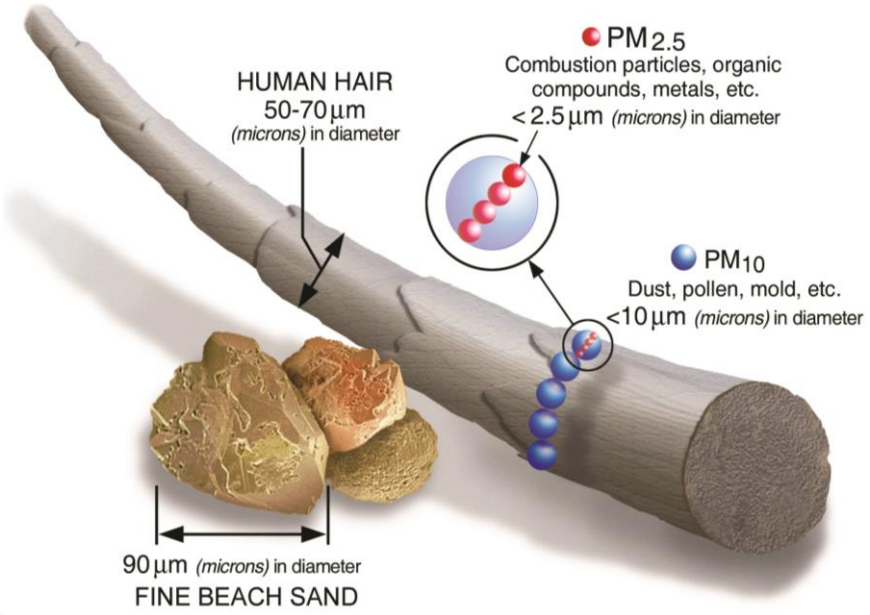
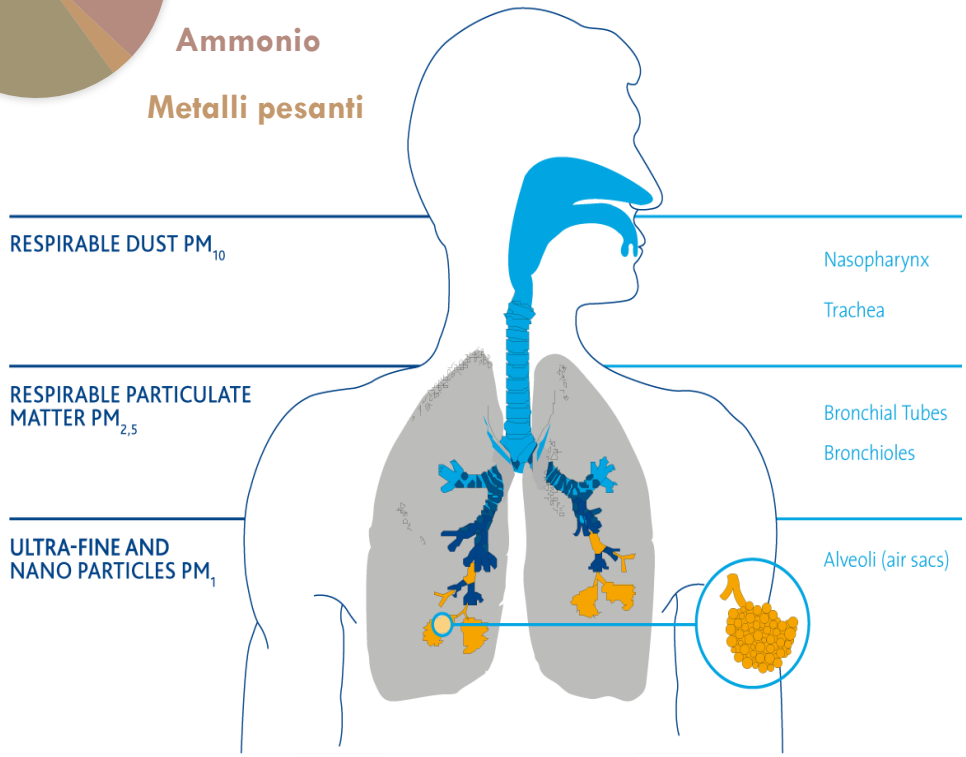
INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH, ATMOSPHERIC ENVIRONMENTAL RESEARCH, IMK-IFU
REGIONAL CLIMATE SYSTEMS/ Urban-Rural Interactions under Global Change

Particulate matter (PM)

- PM composition and effects on human health

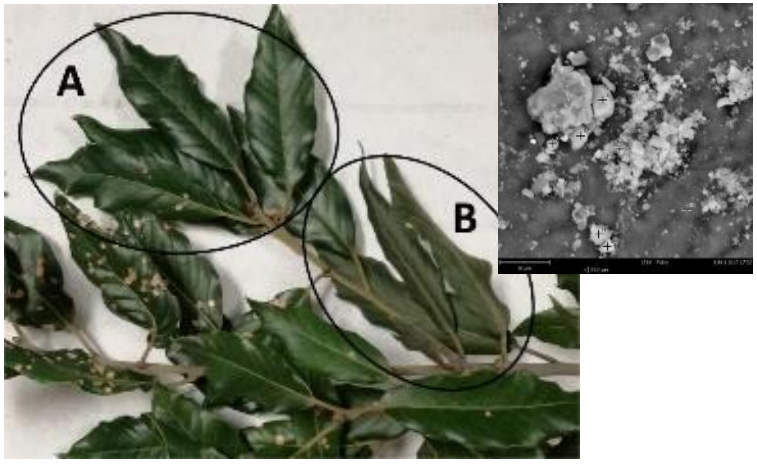




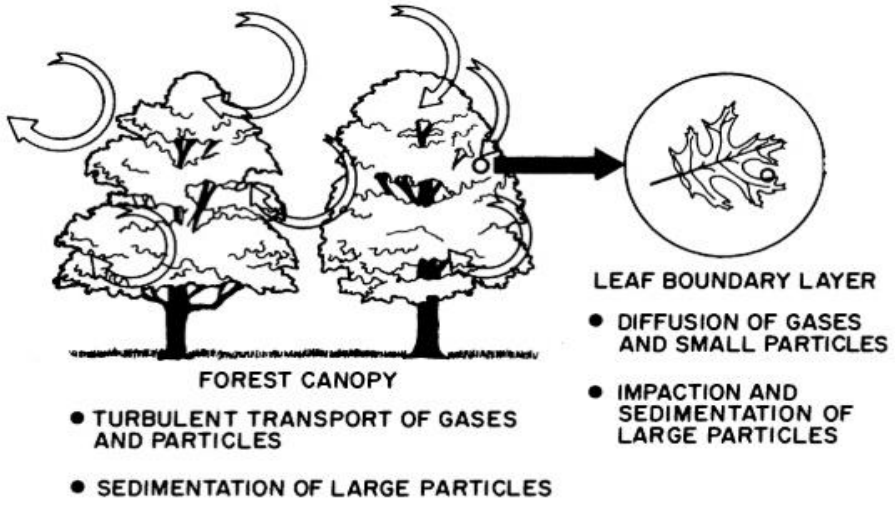


Particulate matter deposition

- $F = vd \cdot C \cdot 3600$
  - *F = Pollutant flux (g m^{-2} h^{-1})*
  - *vd = deposition velocity (m s^{-1})*
  - *C = Air pollutant concentration (g m^{-}3)*



Pictures: Gregorio Sgrigna



i-Tree Eco and re-implementation

- $vd = vd_{PM2.5,avg} \cdot LAI$
  - *vd = deposition velocity(m s^{-1})*
    - *LAI = leaf area index*

Table 3
Deposition velocities and percent resuspension by wind speed per unit leaf area.

Wind speed (m s^{-1})	Deposition velocity (V_d)			Resuspension (%)
	Average (cm s^{-1})	Minimum (cm s^{-1})	Maximum (cm s^{-1})	
0	0.00	0.000	0.000	0
1	0.03	0.006	0.042	1.5
2	0.09	0.012	0.163	3
3	0.15	0.018	0.285	4.5
4	0.17	0.022	0.349	6
5	0.19	0.025	0.414	7.5
6	0.20	0.029	0.478	9
7	0.56	0.056	1.506	10
8	0.92	0.082	2.534	11
9	0.92	0.082	2.534	12
10	2.11	0.570	7.367	13
11	2.11	0.570	7.367	16
12	2.11	0.570	7.367	20
13	2.11	0.570	7.367	23

Nowak et al. 2013

$$R_t = (A_{t-1} + f_t) \times \frac{rr_t}{100}$$

$$A_t = (A_{t-1} + f_t) - R_t$$

$$F_t = f_t - R_t$$

$$Thr = plws \times LAI$$

rr_t = resuspension rate at time t (%)

R_t = $PM_{2.5}$ flux resuspended at time t (g m^{-2} h^{-1})

A_{t-1} = $PM_{2.5}$ accumulated on leaves at time t (g m^{-2} h^{-1})

Ft = $PM_{2.5}$ flux at time t net of resuspension

Thr = leaf washing threshold

plws = potential leaf water storage (0.2 mm)

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Urban-Rural Interactions under Global Change

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

i-Tree Eco and re-implementation

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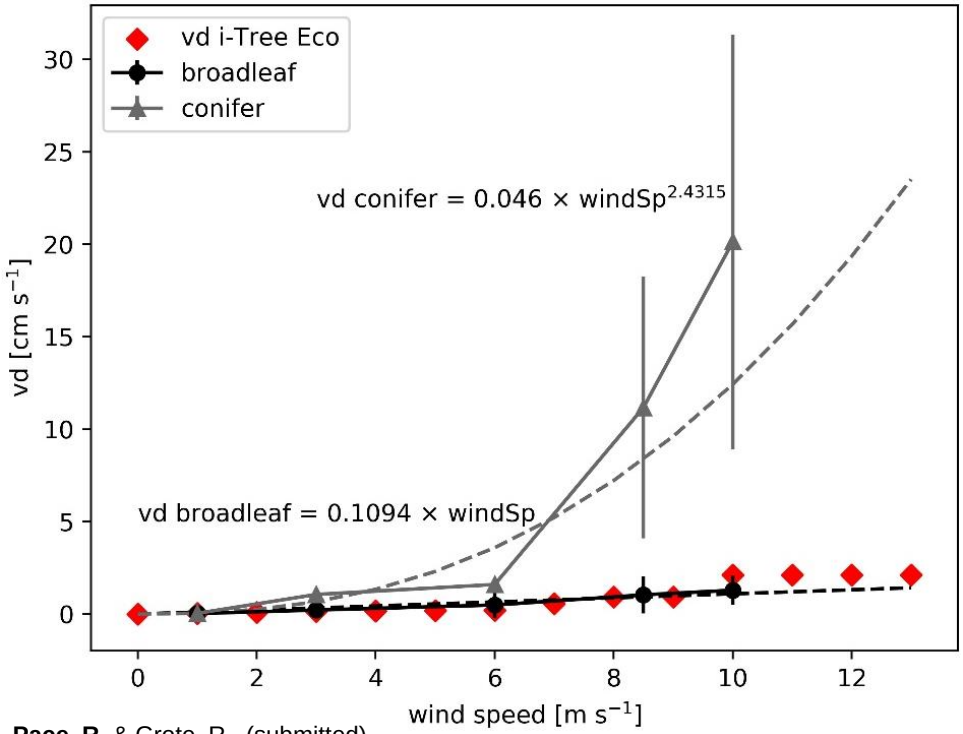
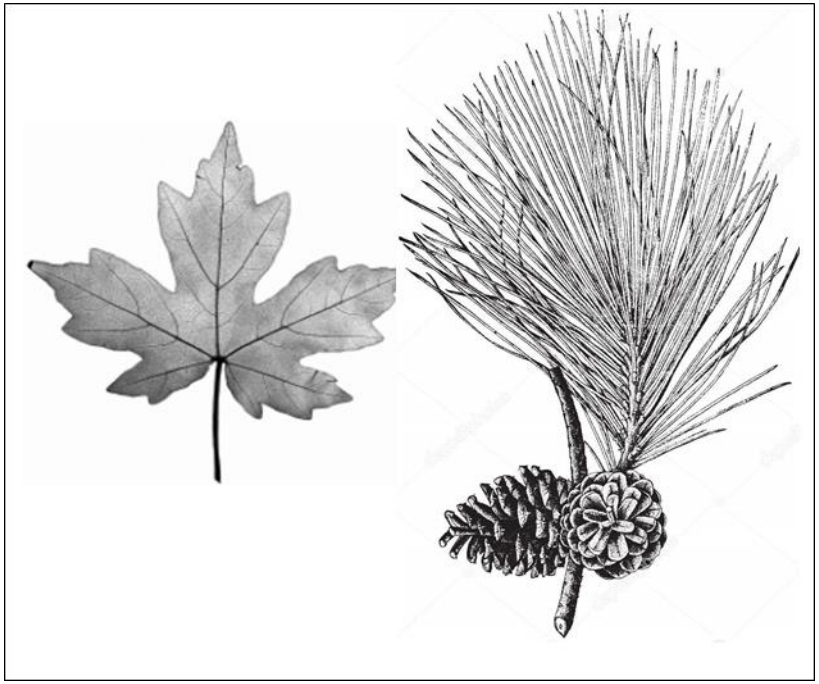


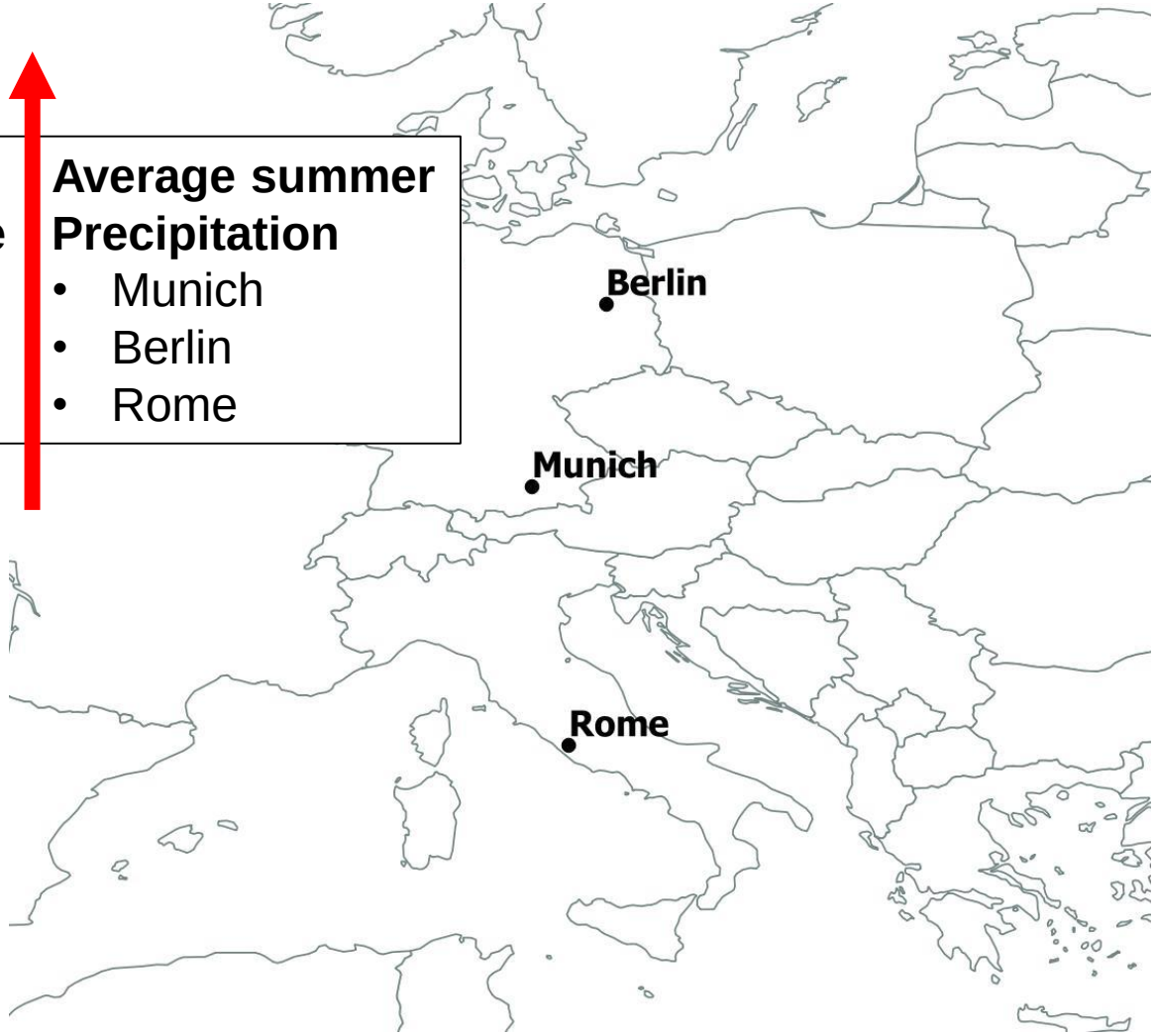


Pace, R. & Grote, R., (submitted)

Model application

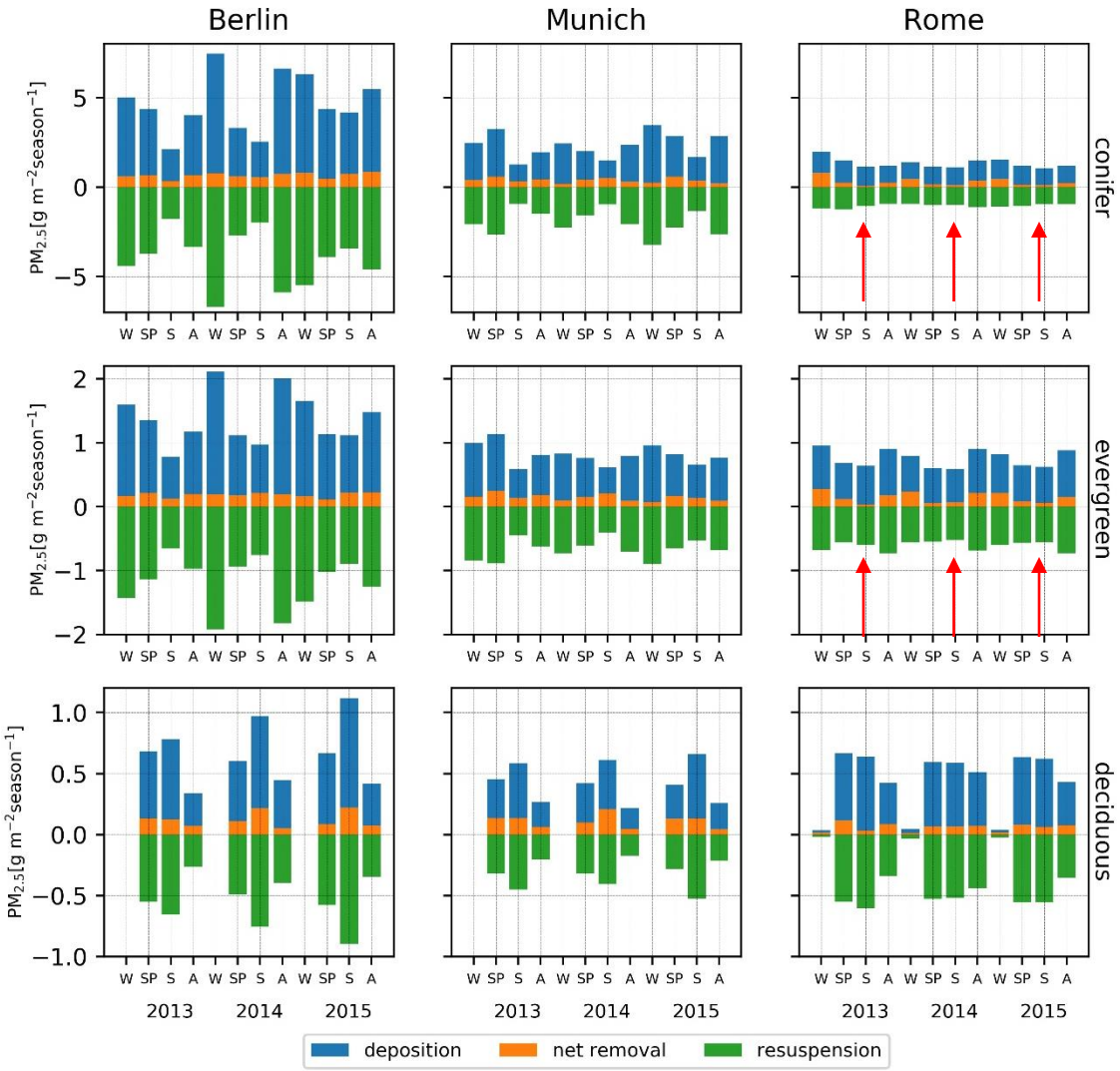
Average Temperature
- Rome
- Berlin
- Munich

Average summer Precipitation
- Munich
- Berlin
- Rome



Pace, R., Grote, R., (submitted). Deposition and resuspension mechanisms into and from tree canopies: A study modeling particle removal of conifers and broadleaves in different cities. Front. For. Glob. Change.

Model application



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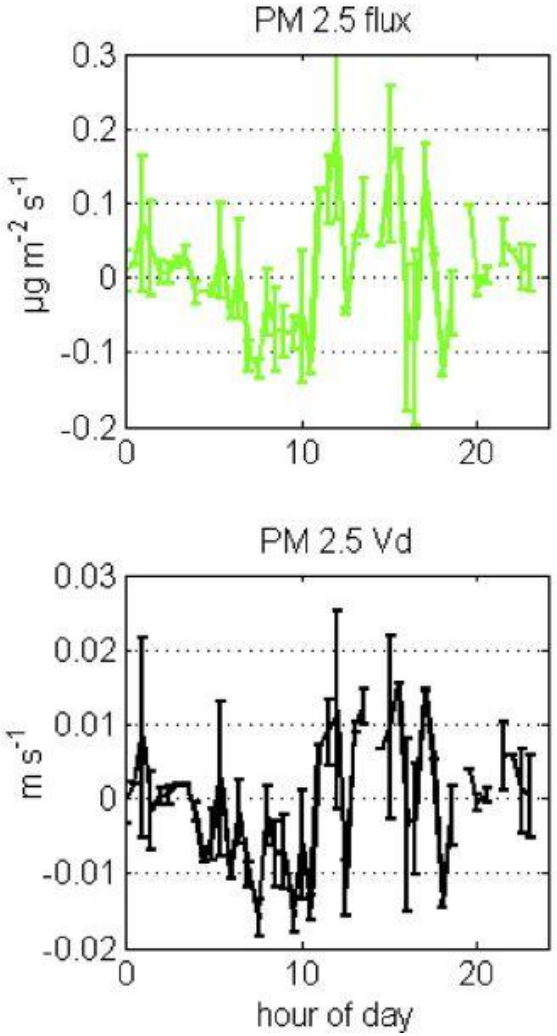
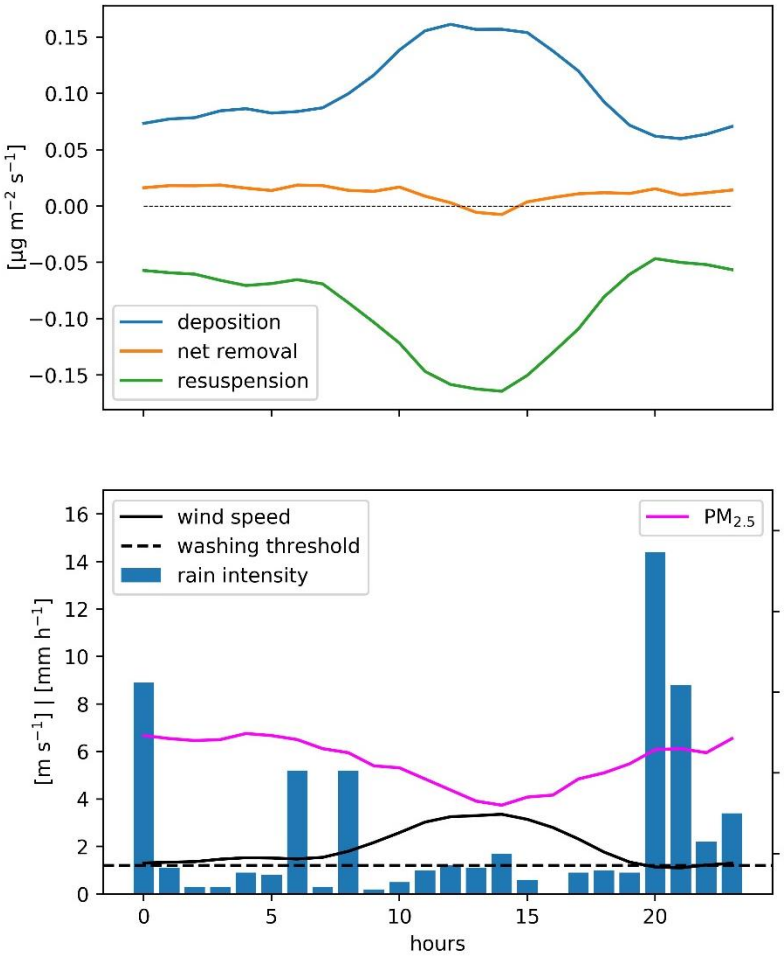
Drought effect on net PM removal and SA





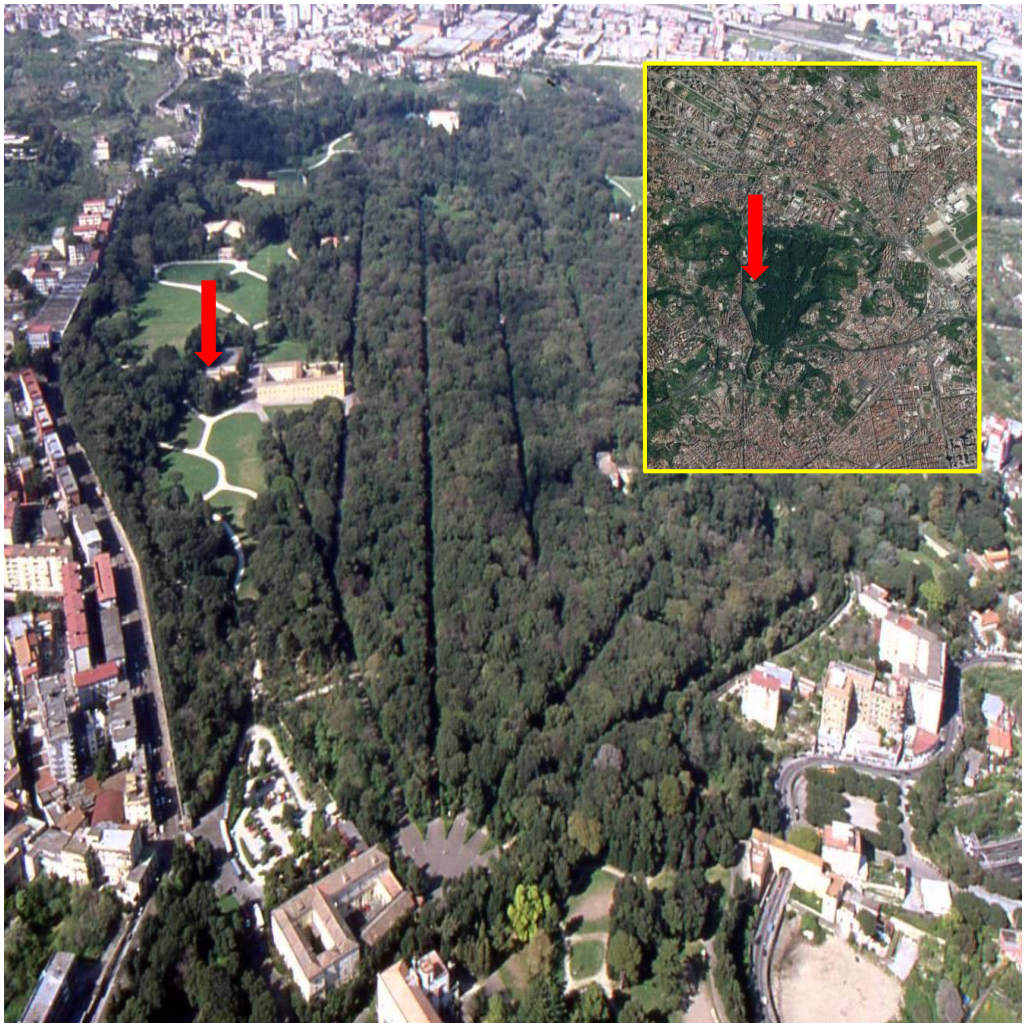
Fares, S. et al. (2016). Particle deposition in a peri-urban Mediterranean forest. Environmental Pollution, 218, 1278–1286.

The Royal Forest of *Capodimonte* in Naples

- **125 ha** located in the urban area of Naples

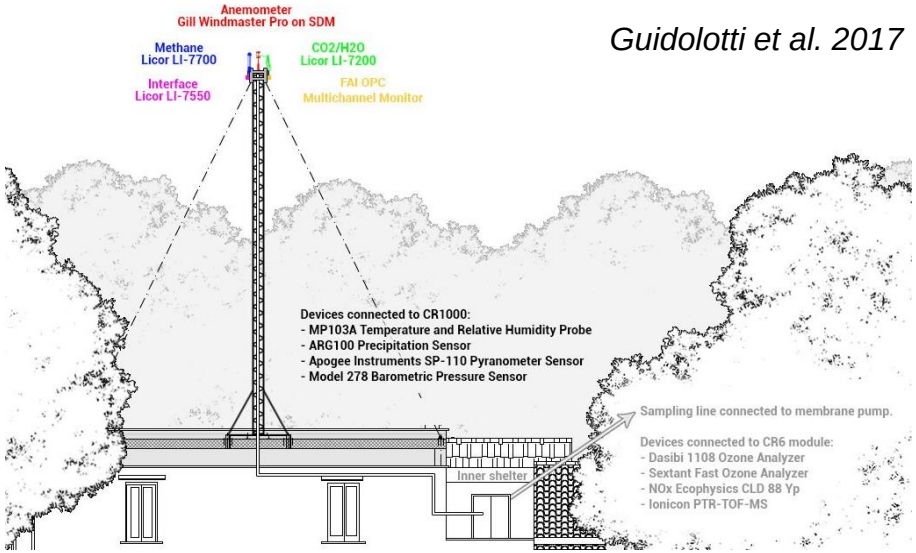
- **Mixed Mediterranean** forest dominated by:

- *Quercus ilex*
- *Pinus pinea*



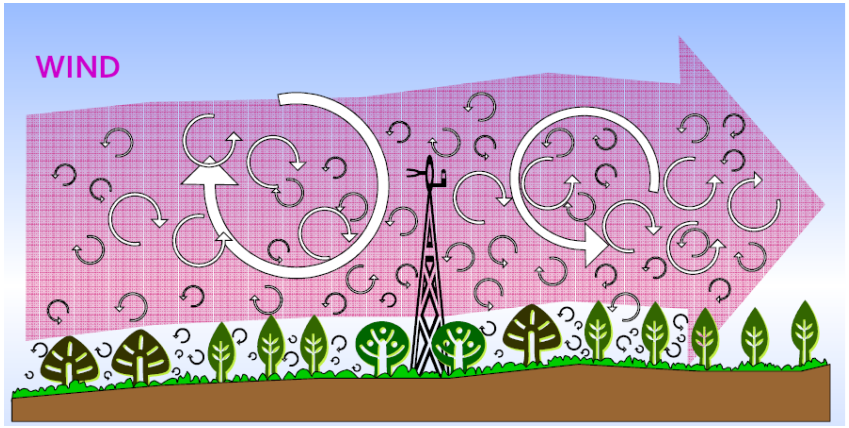
Eddy covariance

The flux tower (25 m) is above a small building

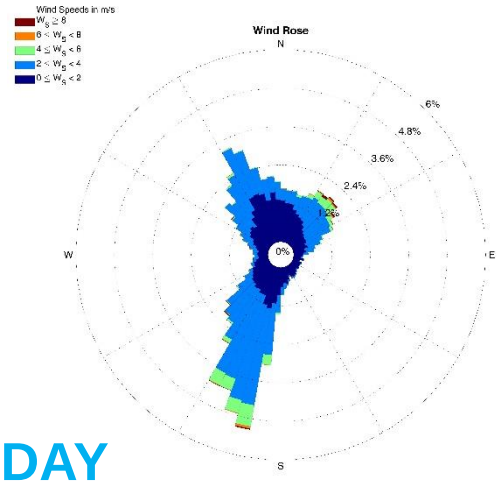


Guidolotti et al. 2017

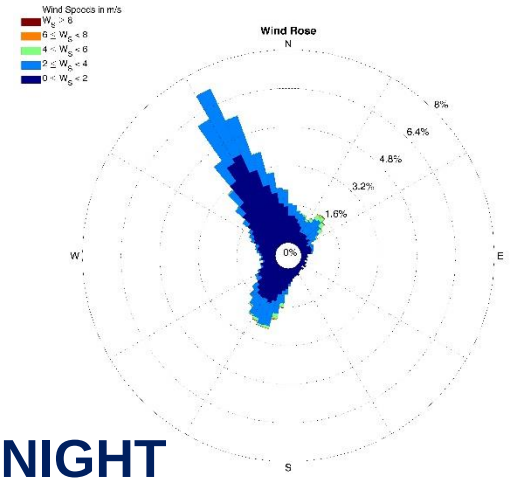
- Turbulent upward and downward movement of the air transporting masses (gases, PM)
- Covariance between measurements of vertical velocity and concentration of the entity of interest.



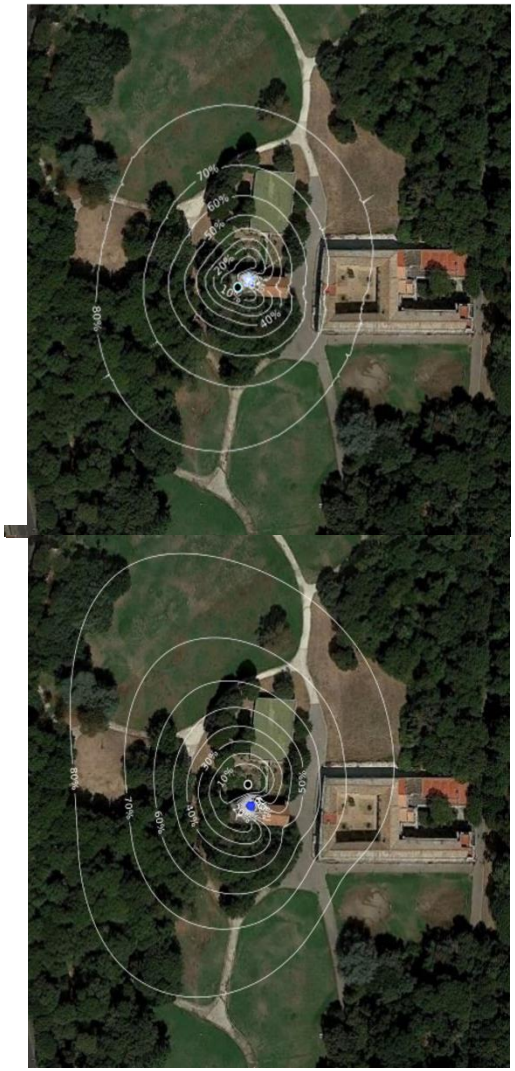
Eddy covariance



DAY



NIGHT



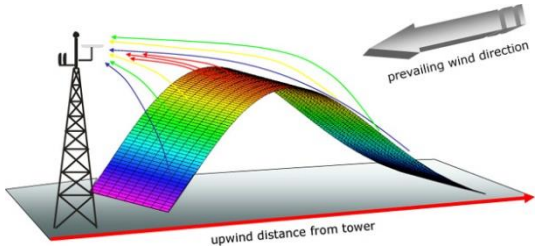
- White border = **80%** of accumulated flux footprint (about **100 m** around the tower)

Land Cover Contribution

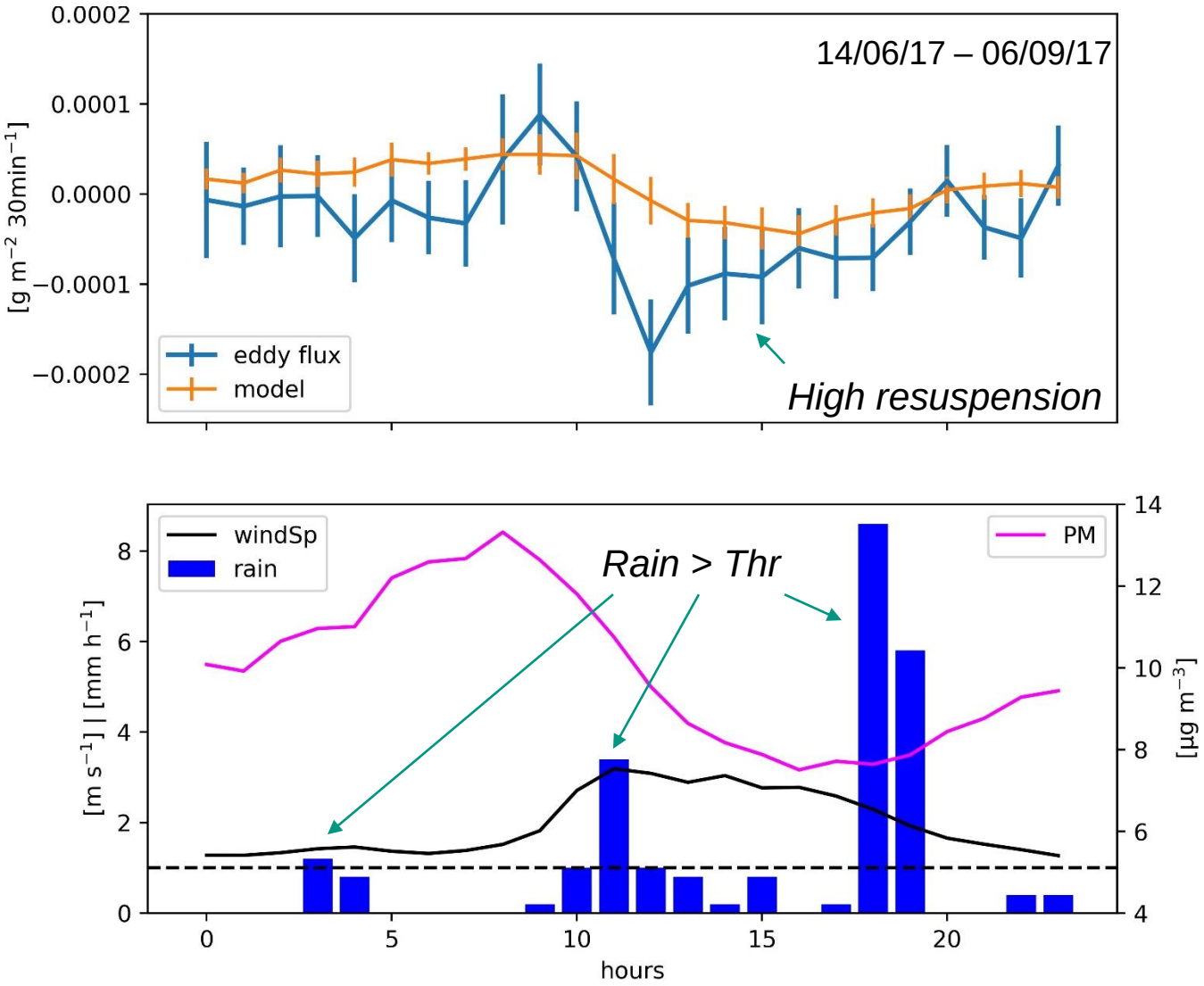
41 % from the mixed forest

13 % from the meadow

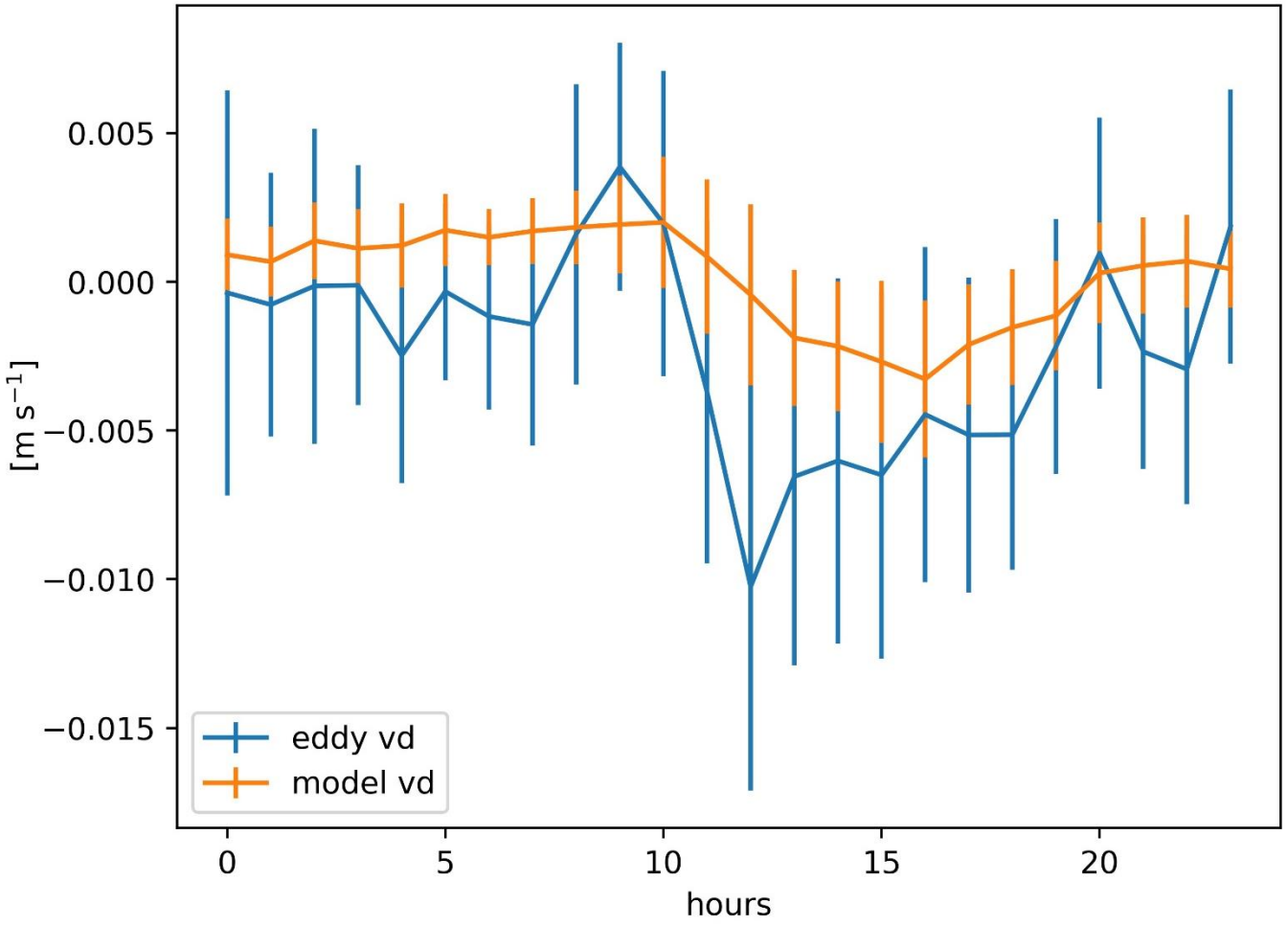
46 % from the buildings



Model vs Eddy flux



Model vs Eddy vd



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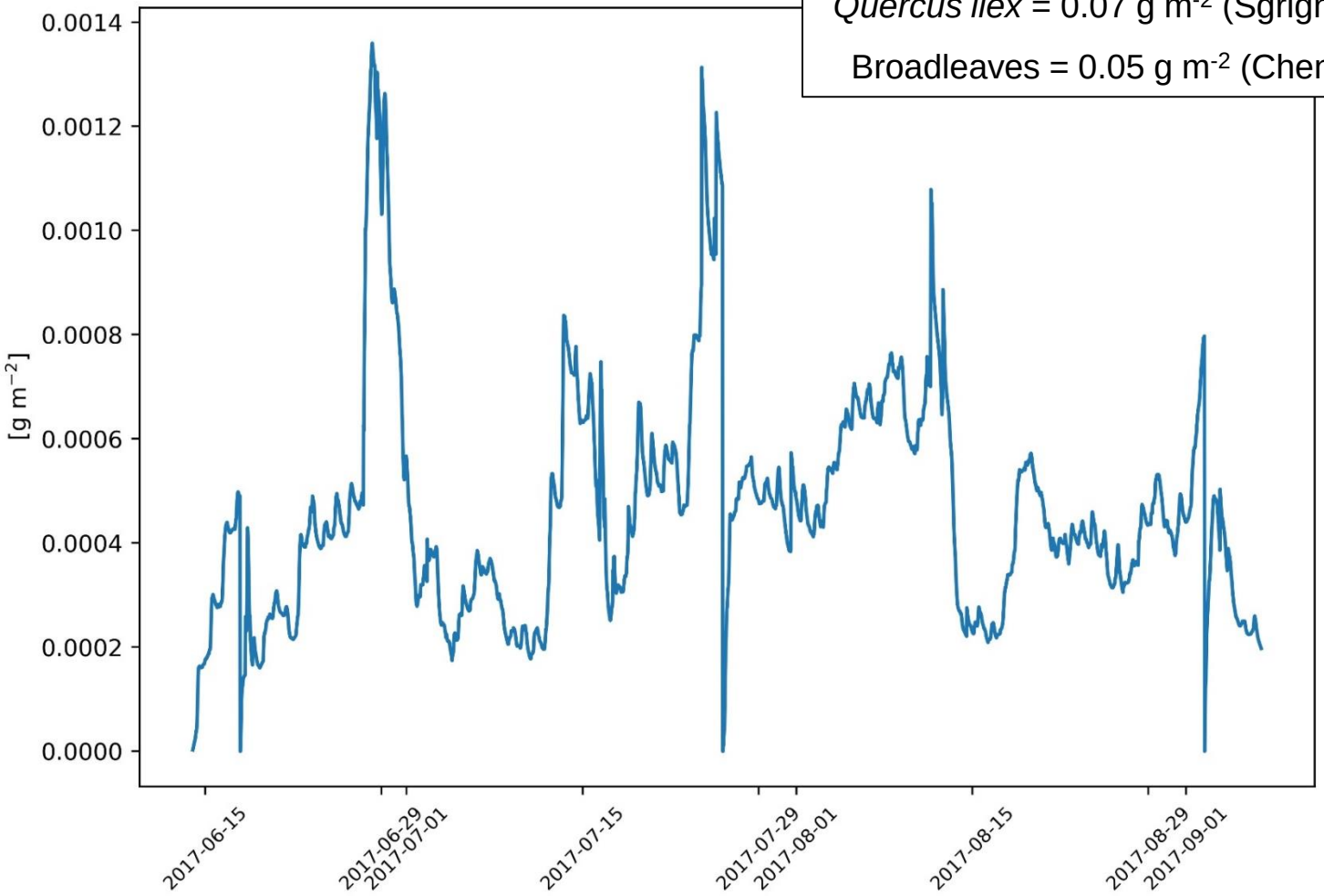
Model vs SEM analysis

Feb-2017 = 0.02 - 0.08 g m^{-2}



Winter – Autumn

Quercus ilex = 0.07 g m^{-2} (Sgrigna et al. 2015)

Broadleaves = 0.05 g m^{-2} (Chen et al. 2017)

Conclusion

- **Drought** decreases **net removal** due to high particle resuspension
- Model and Eddy fluxes show the same **order of magnitude** and similar **daily trend**
- Model **underestimates** the amount of particles that **accumulate** on the **leaves**
- Model improvements are needed to include specific **canopy/leaf properties** which differentiate the **deposition velocity**, **resuspension rate** and **washing capacity**.


THANKS FOR THE ATTENTION!