Levoglucosan as a macrotracer
for wood burning

Wood burning impact on PM10 in three Austrian regions

Summer School on Organic Aerosols

Gothenburg, June 23th-28th, 2008

Alexandre Caseiro, University of Aveiro and Technical University of Vienna

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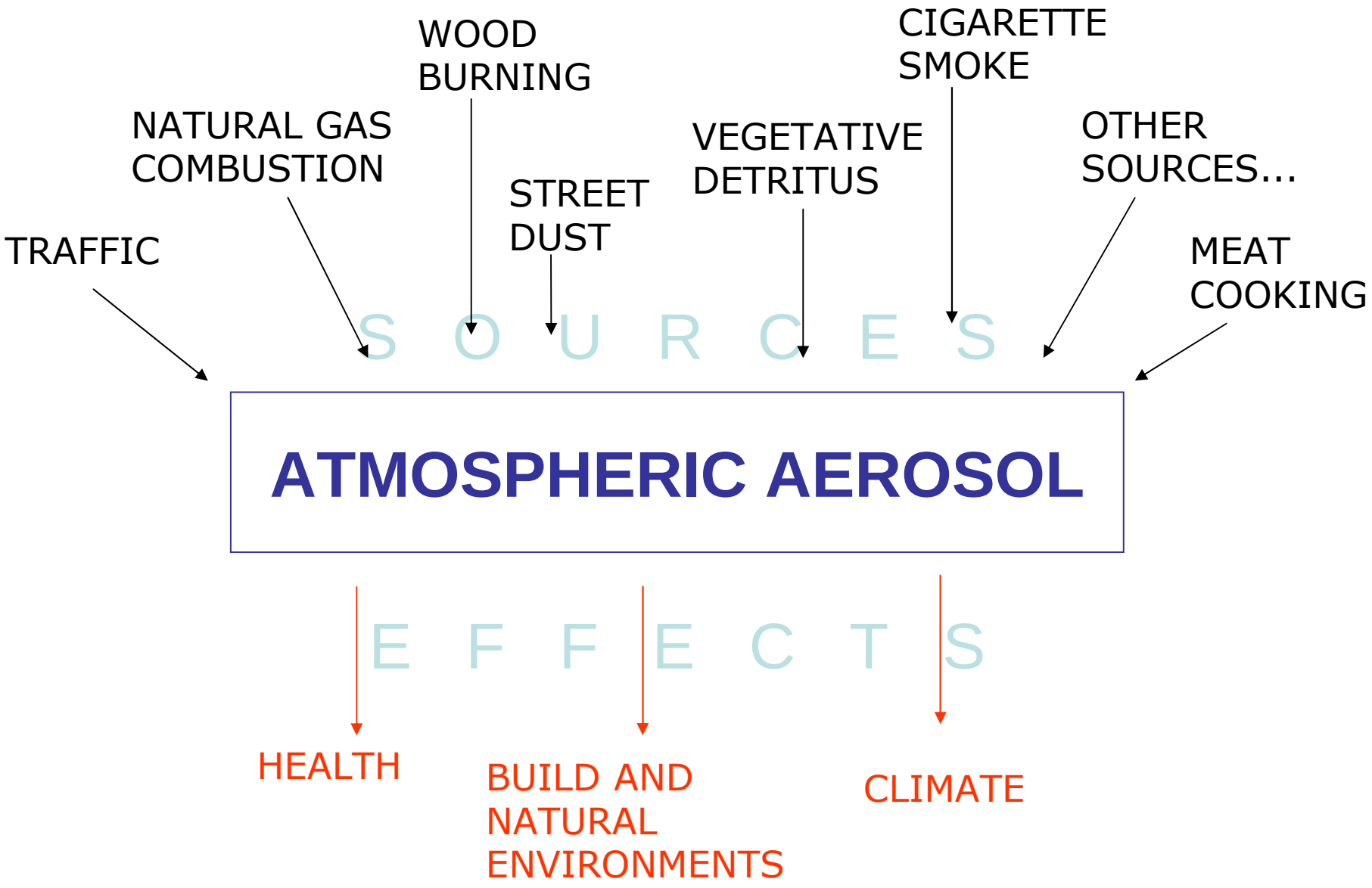

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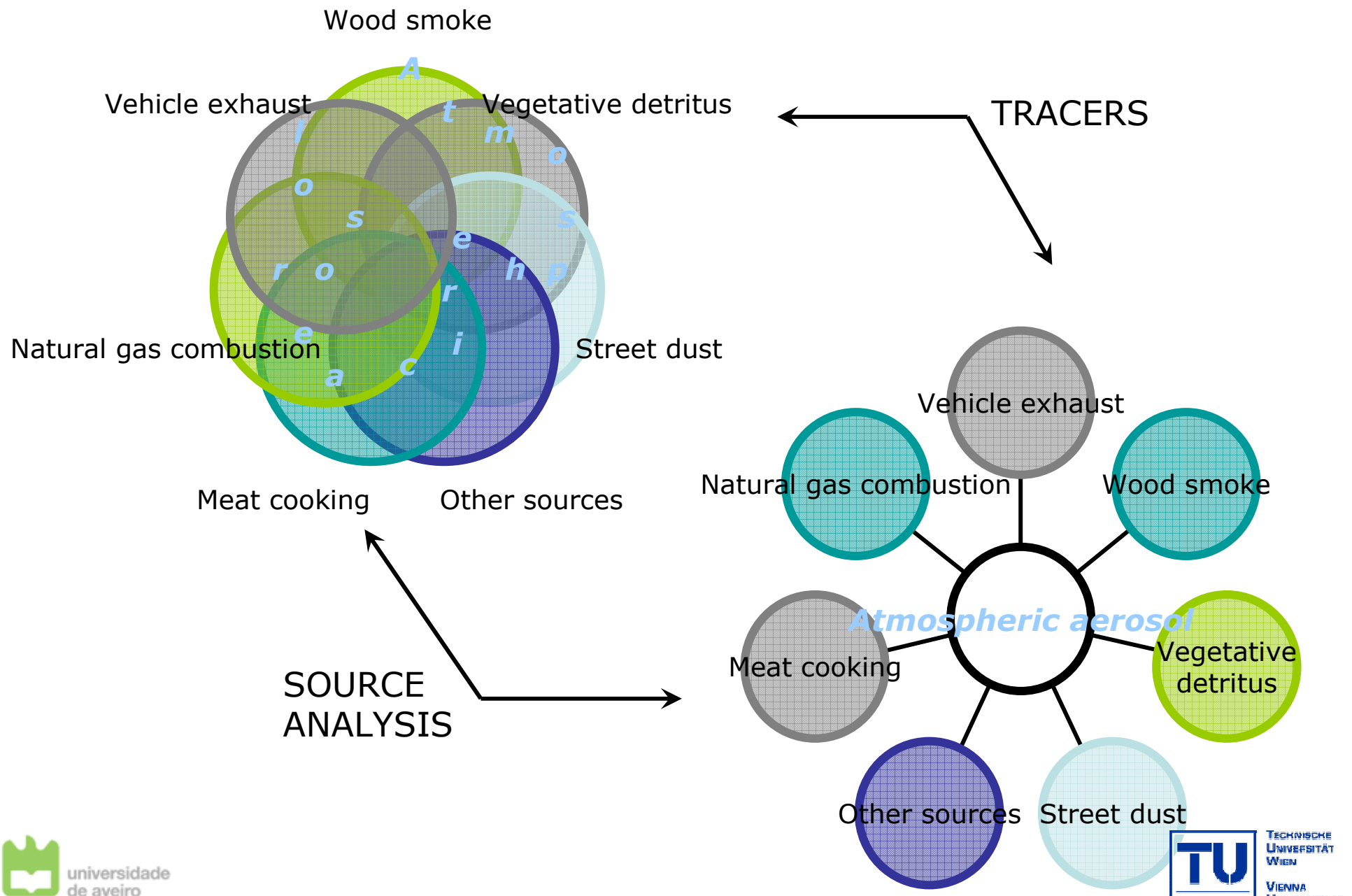
SOURCE APPORTIONMENT



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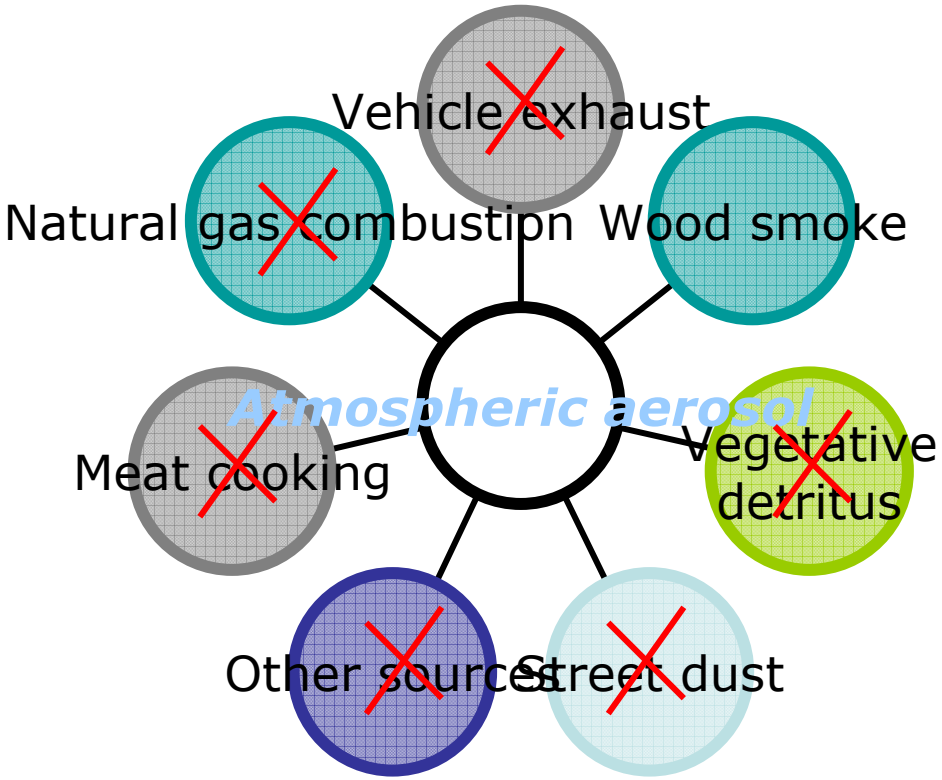
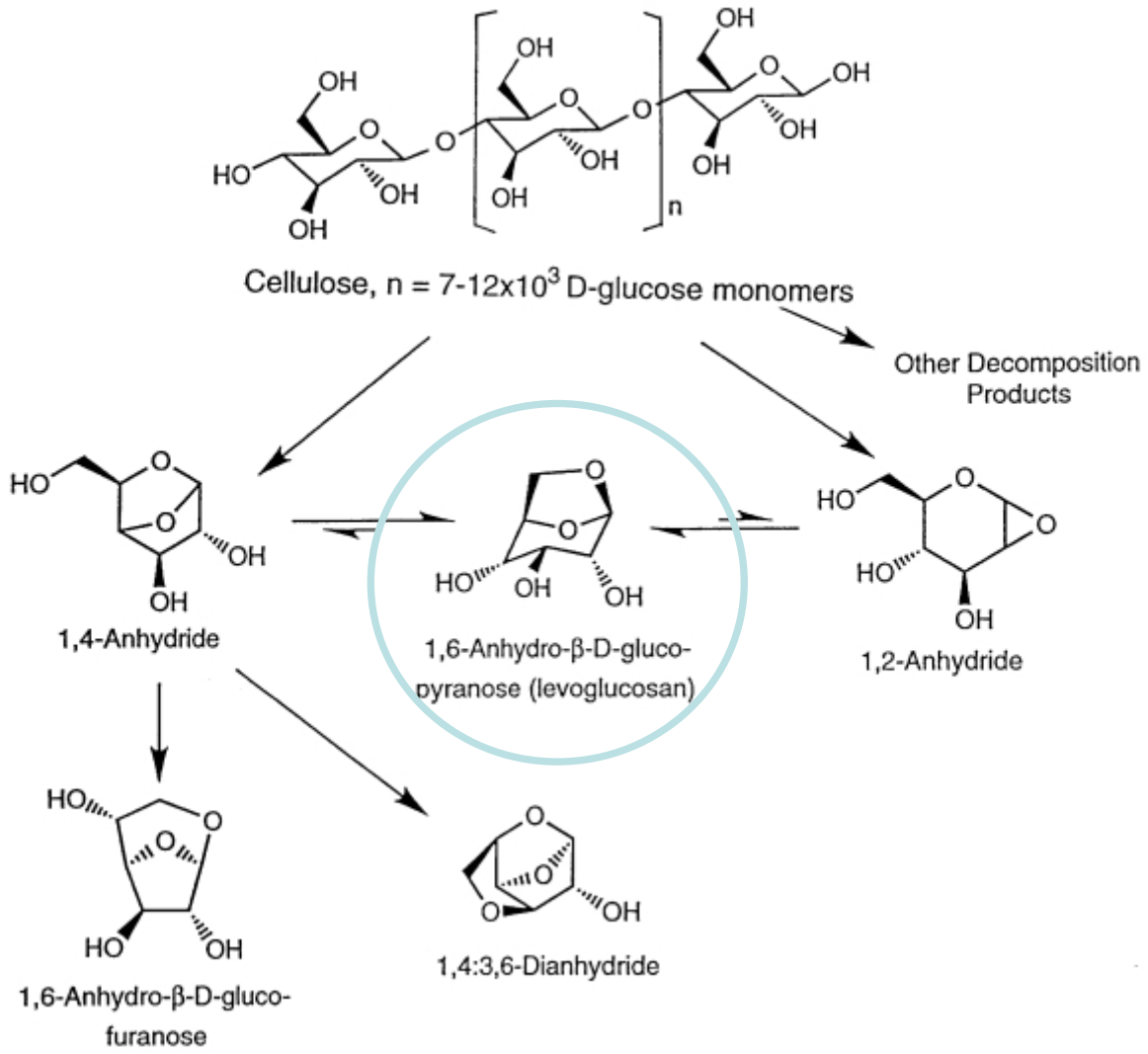
GOAL: QUANTIFICATE THE CONTRIBUTION OF WOOD BURNING



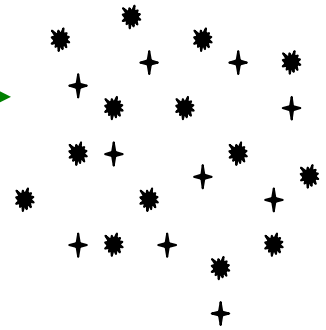
LEVOGLUCOSAN: A MACRO-TRACER FOR WOOD BURNING



LEVOGLUCOSAN: A MACRO-TRACER FOR WOOD BURNING

biomass smoke
PM_{10} emission, to which Levoglucosan is exclusive

ambient aerosol



Determination of Levoglucosan in ambient PM_{10}

Emission factor = quantity of Levoglucosan per quantity of PM_{10}

wood burning

BS OC = Levoglucosan x 6.1
BS OM = Levoglucosan x 9.1
BS PM = Levoglucosan x 10.7

Contribution of *biomass smoke* to ambient PM_{10}

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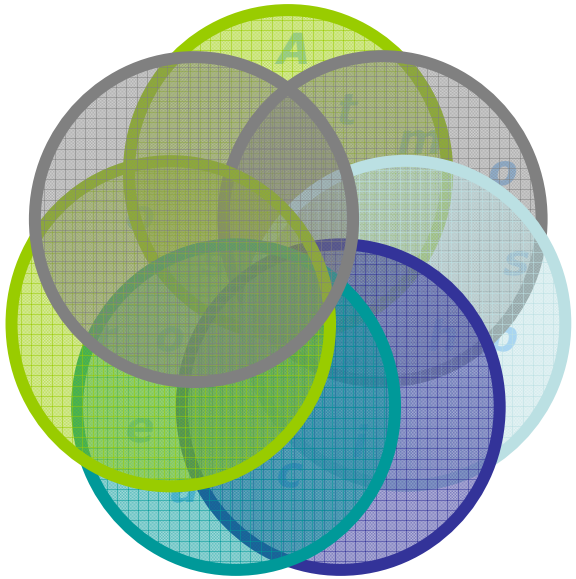
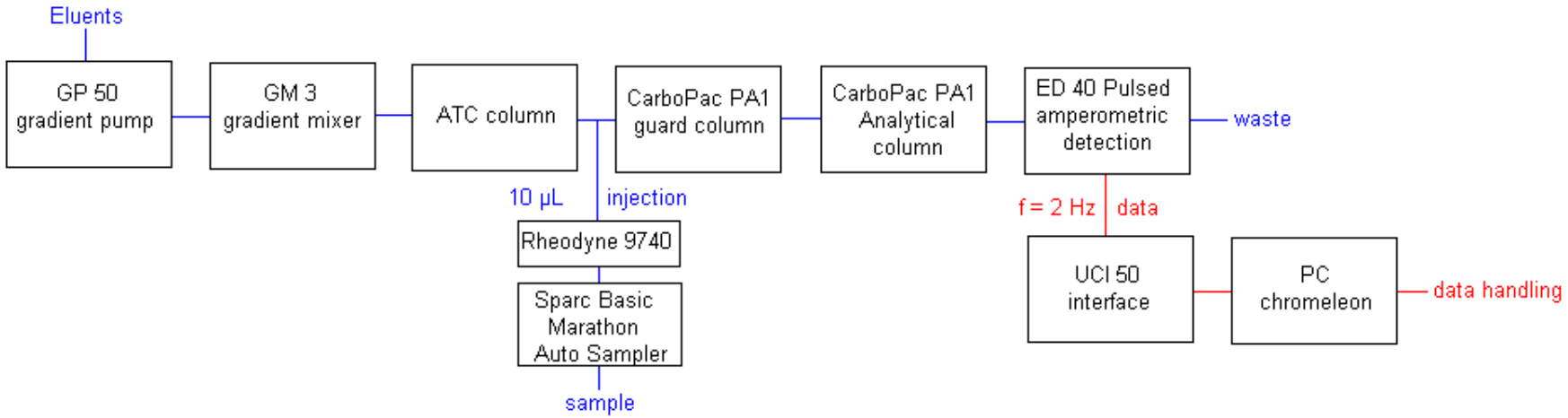
MEASURING LEVOGLUCOSAN: HPAE-PAD



LEVOGLUCOSAN



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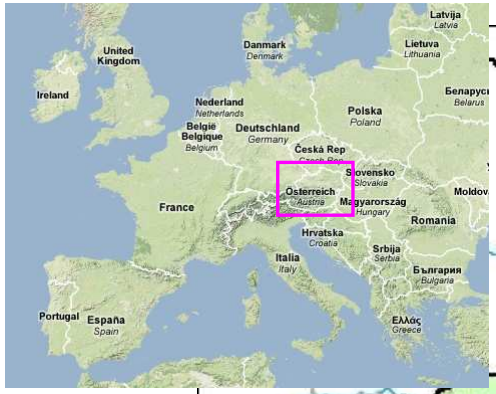
SAMPLING SITES – THREE REGIONS IN AUSTRIA



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SAMPLING SITES - VIENNA

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SAMPLING SITES - GRAZ

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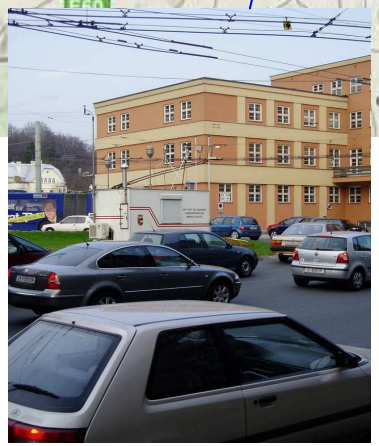
SAMPLING SITES - SALZBURG



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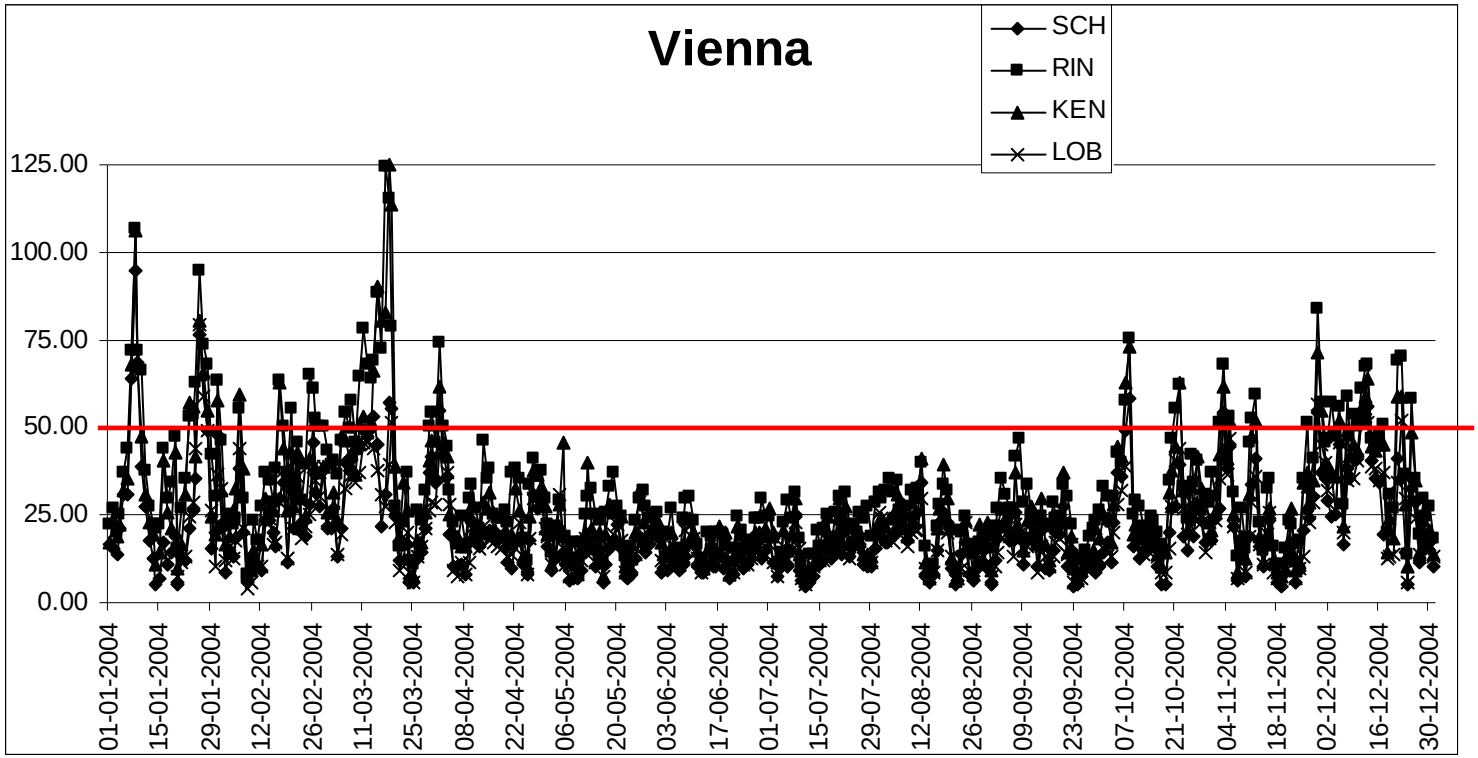
RESULTS – PM10 VIENNA



	average	nº days > 50
SCH	20.5	15
RIN	32.5	60
KEN	27.7	36
LOB	20.3	9

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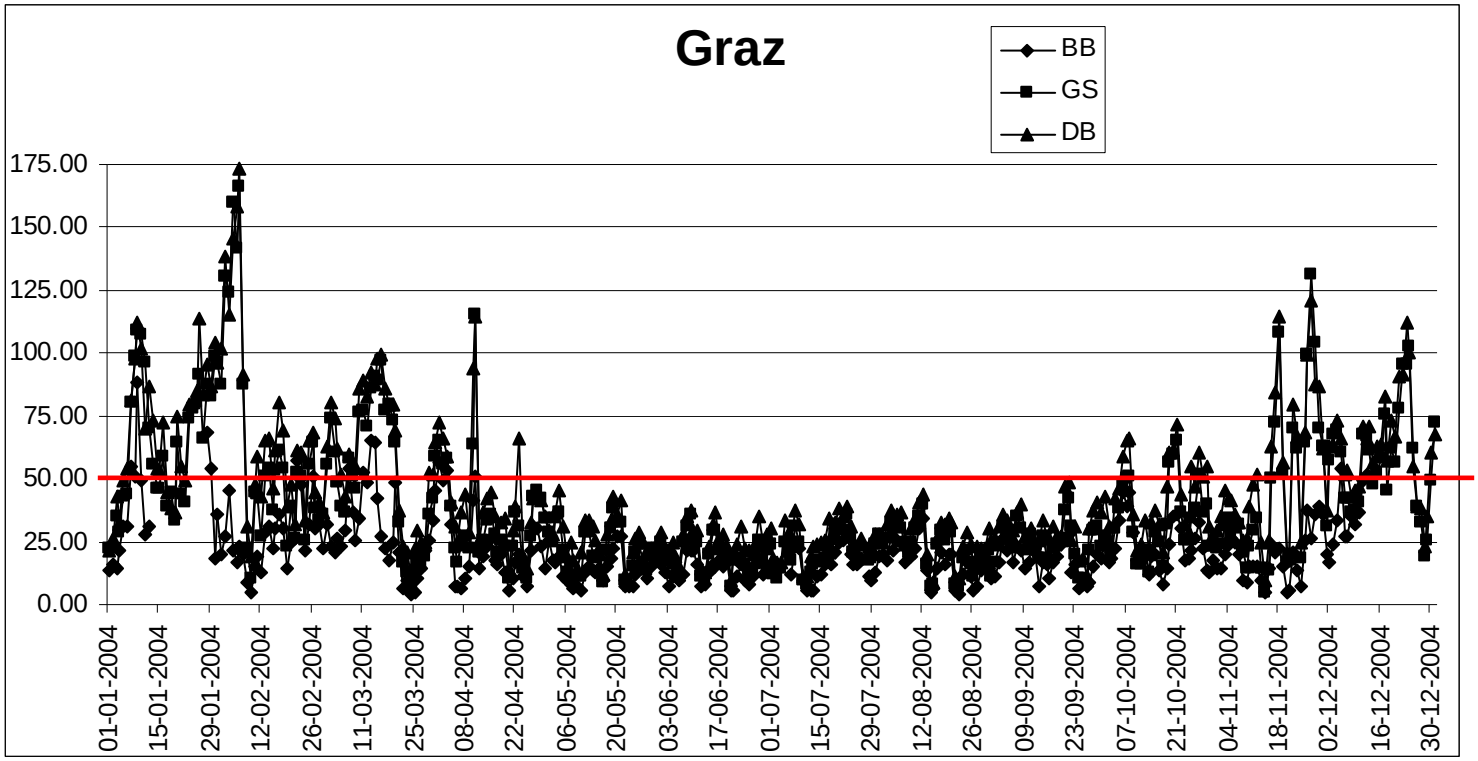
RESULTS – PM10 GRAZ



	average	nº days > 50
BB	21.2	16
GS	38.0	92
DB	44.3	113

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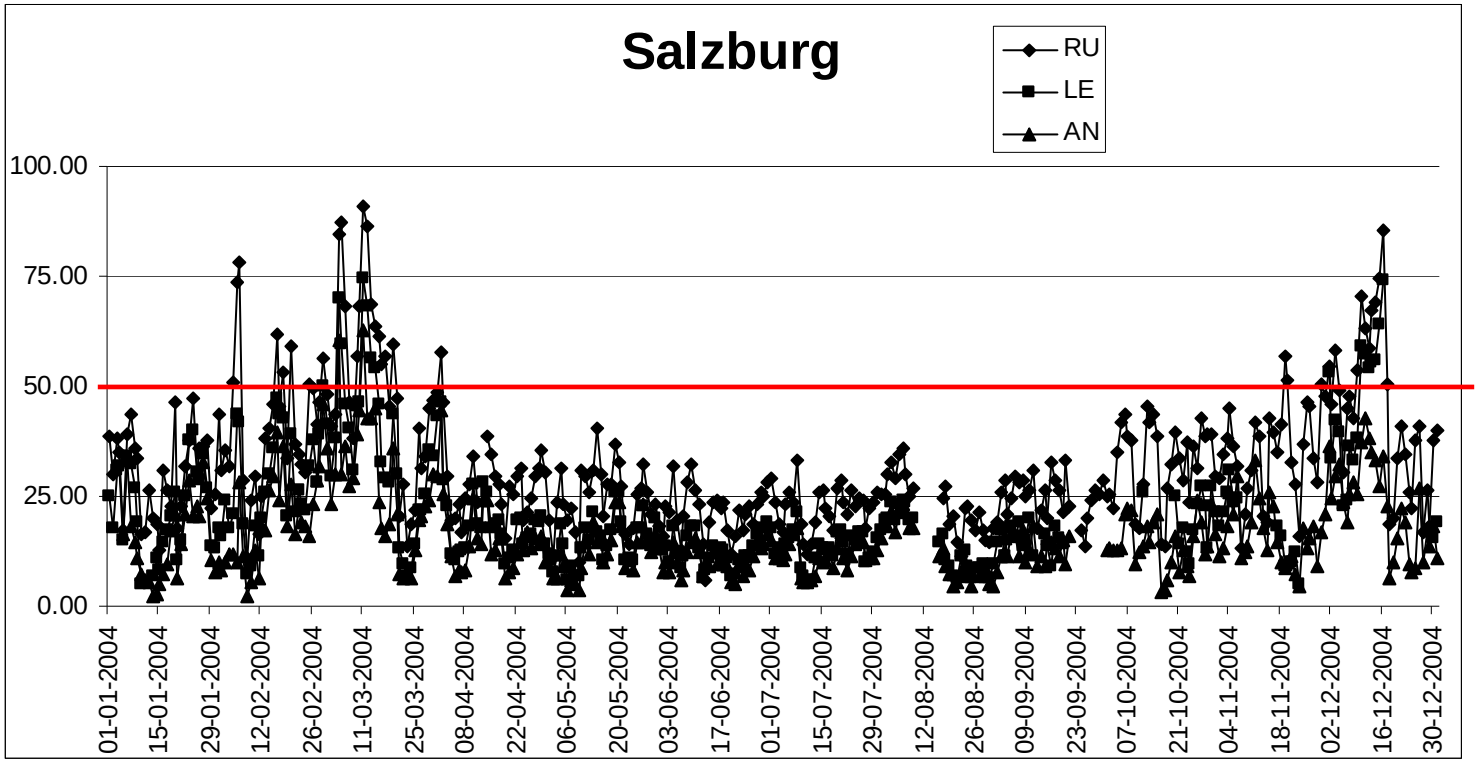
RESULTS – PM10 SALZBURG



	average	nº days > 50
RU	31.8	36
LE	21.0	14
AN	16.0	12

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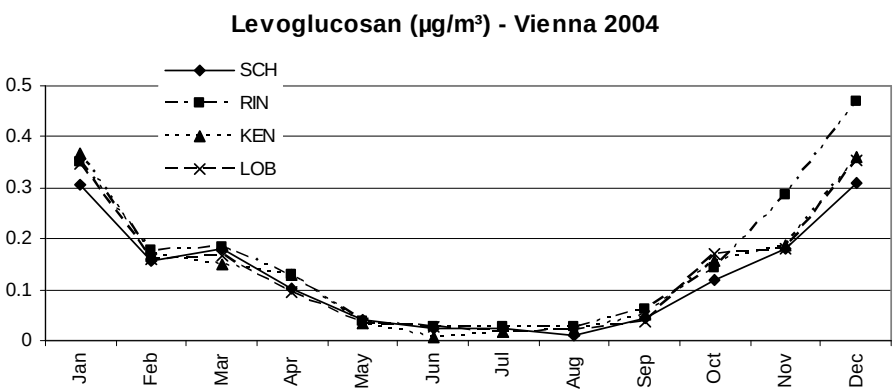
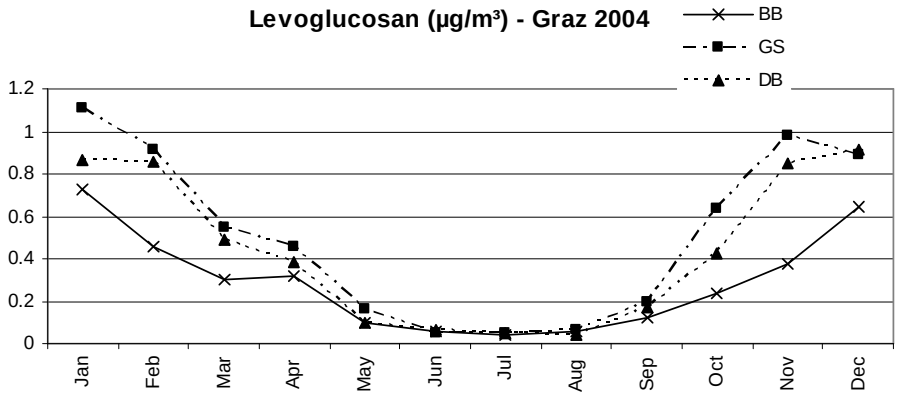
RESULTS – DL, QL AND BLANKS

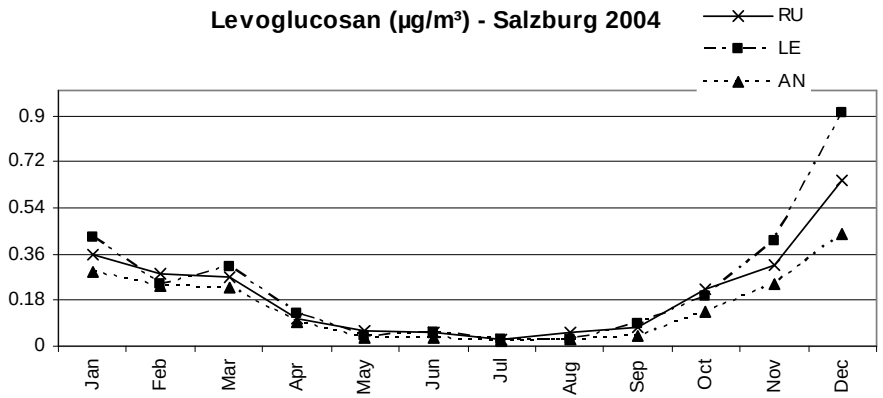
	Levo	Manno	Galac
LOD (ng/m^3)	4.5	6.1	1.1
LOQ (ng/m^3)	13	18	3.3

	Levo	Manno	Galac	pools
SCH	1	12	12	51
RIN	0	10	11	52
KEN	3	12	12	52
LOB	0	19	13	48
BB	0	12	8	39
GS	0	8	9	44
DB	0	6	7	44
RU	0	11	6	39
LE	0	12	12	36
AN	0	16	13	40

RESULTS – LEVOGLUCOSAN







	Average (min-max)
VIE	0.14 (<DL – 1.18)
GRA	0.41 (0.04 – 2.2)
SLZ	0.20 (0.02 – 1.21)

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RESULTS – LEVOGLUCOSAN CONTRIBUTION TO OC

	Vienna				Graz			Salzburg		
	SCH	RIN	KEN	LOB	BB	GS	DB	RU	LE	AN
Year	*1.61*	*1.31*	*1.29*	*1.52*	*2.68*	*2.78*	*1.71*	*1.61*	*2.38*	*2.74*
Winter	2.68	2.28	2.34	2.88	4.40	3.04	2.80	2.50	4.48	5.13
Spring	1.72	1.11	1.27	1.45	3.24	2.63	1.61	1.17	1.91	2.44
Summer	0.41	0.38	0.22	0.42	0.95	1.06	0.59	0.52	0.71	0.71
Autumn	1.68	1.49	1.33	1.65	2.64	3.80	2.03	2.04	3.41	2.80
winter/ summer	*6.56*	*5.95*	*10.73*	*6.89*	*4.61*	*2.86*	*4.77*	*4.82*	*6.34*	*7.21*

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RESULTS – BIOMASS SMOKE

	Vienna				Graz			Salzburg		
	SCH	RIN	KEN	LOB	BB	GS	DB	RU	LE	AN
Year	*1.3*	*1.7*	*1.5*	*1.3*	*2.7*	*5.2*	*4.4*	*2.3*	*2.2*	*1.7*
Winter	2.3	2.5	2.5	2.1	4.8	9.2	7.9	3.2	3.5	2.7
Spring	0.6	0.7	0.6	0.6	1.7	2.4	1.9	0.8	0.8	0.6
Summer	0.3	0.4	0.3	0.3	0.8	1.1	0.9	0.6	0.5	0.3
Autumn	2.1	3.2	2.5	2.5	3.9	8.7	7.3	4.3	5.7	2.9
winter/ summer	*8.2*	*6.1*	*7.6*	*8.0*	*5.8*	*8.2*	*8.4*	*5.9*	*6.5*	*8.1*

RESULTS – BIOMASS SMOKE CONTRIBUTION TO OC AND OM

to OC	Vienna				Graz			Salzburg		
	SCH	RIN	KEN	LOB	BB	GS	DB	RU	LE	AN
Year	*22.1*	*18.0*	*17.7*	*20.9*	*35.1*	*37.7*	*23.4*	*22.2*	*31.9*	*37.5*
Winter	36.8	31.3	32.2	39.5	58.9	41.6	38.4	34.4	57.9	70.2
Spring	23.3	15.0	17.1	19.8	43.0	36.1	22.1	16.1	26.3	33.6
Summer	5.6	5.3	3.0	5.4	13.1	14.6	8.1	7.1	9.7	9.8
Autumn	23.0	20.5	18.3	22.7	36.0	51.3	27.7	28.0	46.9	38.4
winter/ summer	*6.6*	*5.9*	*10.7*	*6.9*	*4.5*	*2.9*	*4.8*	*4.8*	*6.0*	*7.2*

to OM	Average (min-max)
VIE	19 (<DL – 58)
GRA	30 (4.6 – 100)
SLZ	30 (3.3 – 100)

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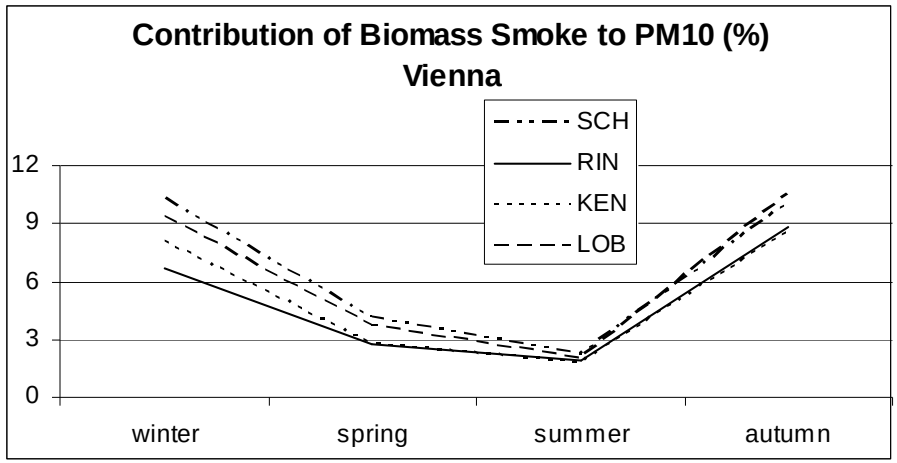
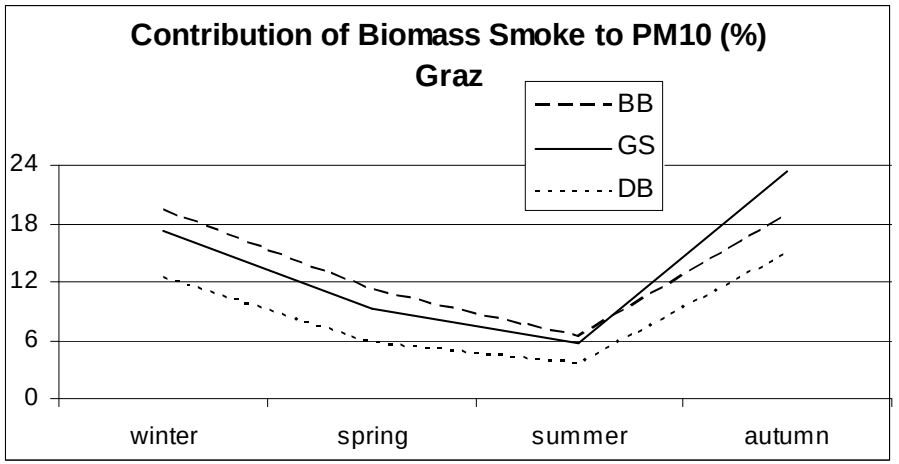
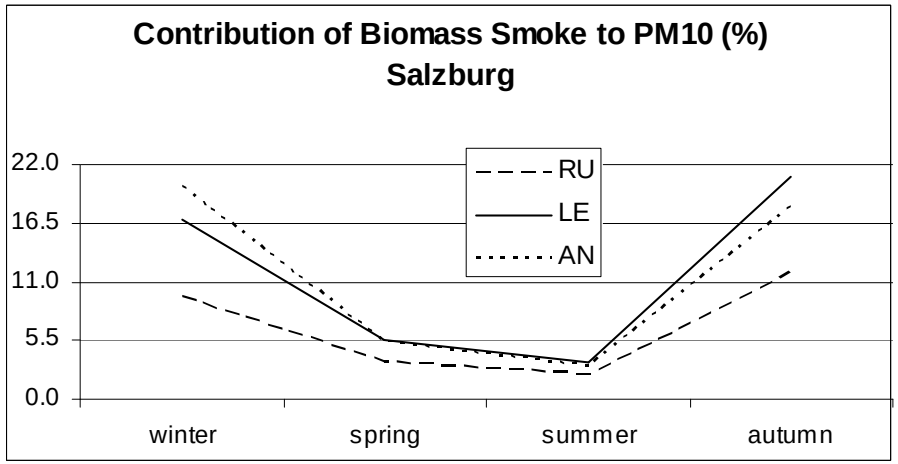
RESULTS – BIOMASS SMOKE CONTRIBUTION TO PM







	Average (min-max)
VIE	6 (<DL – 41)
GRA	12 (1 – 100)
SLZ	10 (0.6 – 100)

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RESULTS – BIOMASS SMOKE CONTRIBUTION PM – EXCEEDANCE EPISODES - VIENNA

	SCH		RIN		KEN		LOB	
	PM_{10}	WB	PM_{10}	WB	PM_{10}	WB	PM_{10}	WB
Exceed.	60.9	4.6	65.0	4.5	66.6	4.1	56.4	5.5
Not exc., cold	*22.8*	*2.0*	*29.8*	*2.1*	*27.6*	*2.1*	*20.8*	*2.1*
Exc/not exc., cold	2.67	2.31	2.18	2.15	2.42	1.91	2.72	2.57

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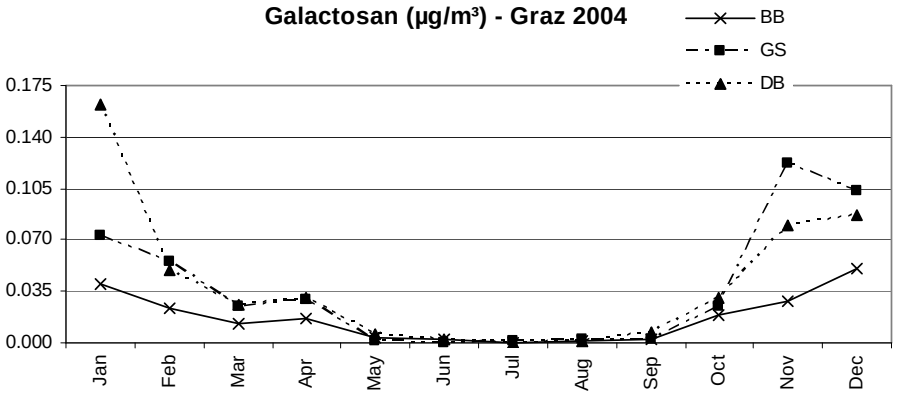
RESULTS – BIOMASS SMOKE CONTRIBUTION PM – EXCEEDANCE EPISODES - GRAZ

	BB		GS		DB	
	PM_{10}	WB	PM_{10}	WB	PM_{10}	WB
Exceed.	58.0	7.1	76.4	12.4	77.4	10.1
Not exc., cold	*18.9*	*4.1*	*29.8*	*6.1*	*33.8*	*4.4*
Exc/not exc., cold	3.06	1.72	2.56	2.02	2.29	2.30

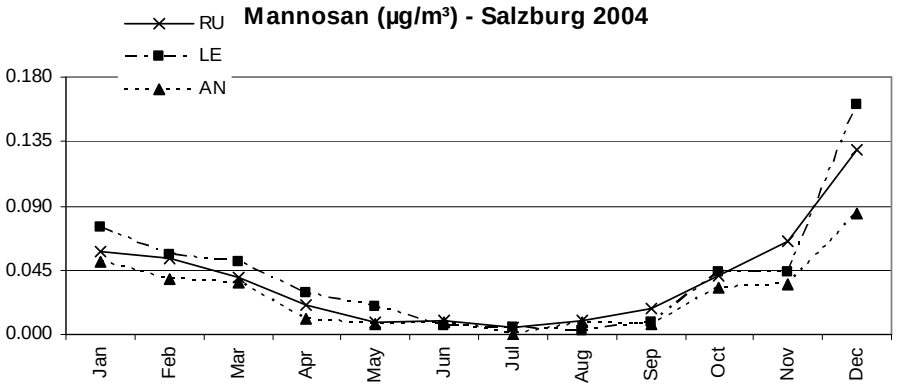
RESULTS – BIOMASS SMOKE CONTRIBUTION PM – EXCEEDANCE EPISODES - SALZBURG

	RU		LE		AN	
	PM_{10}	WB	PM_{10}	WB	PM_{10}	WB
Exceed.	64.3	5.43	61.1	8.27	61.6	3.75
Not exc., cold	*33.0*	*3.35*	*17.7*	*3.73*	*18.5*	*2.79*
Exc/not exc., cold	1.95	1.62	3.45	2.21	3.32	1.34

RESULTS – MANNOSAN AND GALACTOSAN



Highly correlated with levoglucosan: correlations > 0.90



Because of their different origin in the pyrolysis process of wood, they may be useful to differentiate between different types of woods burned

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RESULTS – SOFTWOOD VS. HARDWOOD

% spruce = (14.8 – levo/manno) / 0.112 (Schmidl et al., 2008)

	% hardwood	% softwood
Selling statistics	59	41
This study	75 – 95	5 – 25

CONCLUSIONS

•Levoglucosan yearly averages: **0.12 – 0.48 µg m-3**.
Graz showed higher concentrations compared to the other regions.
Background sites, in general, evidenced slightly lower concentrations than urban sites.

•Levoglucosan showed a pronounced **seasonal cycle**.
Concentrations were 6 to 8 times higher during the colder months.

•Annual averaged **levoglucosan-C / OC** were lower in Vienna (1.3 to 1.6%) and higher in Graz and Salzburg (1.6 to 2.8%).
Contributions were 3 to 11 times higher during the colder months.

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CONCLUSIONS

The yearly average contributions of **BS to OC, OM and PM** were in the ranges 18-38%, 18-37% and 5.1-13%, respectively.
Contributions in Vienna were lower than in the regions of Graz and Salzburg.
Contributions were generally lower at sites located closer to the city-centre (traffic sources).

Cold season (winter and autumn) average contributions to OM were very high: 27-30%, 32-47% and 31-55% in Vienna, Graz and Salzburg, respectively.

BS : **main contributor** **to *organic aerosol*** in the cold season
BS : **major contributor** **to *PM*** in the cold season.

For the residential and rural sites, the contribution of BS to OM was overwhelming (close to or above 50% in the less populated cities).
This difference between the city-fringe sites and the city centre sites in Vienna were not as marked.

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CONCLUSIONS

•Exceedance periods during the cold season: WB contribution grows, at most, the same as PM10.

•Mannosan and galactosan had a similar seasonal cycle as levoglucosan, high correlations.
Much lower concentrations.

•The ratios **levoglucosan / mannosan** = 4.1-6.4
levoglucosan / galactosan = 11-22
when biomass burning is expected to be a strong source.

•“best estimate” for the **contribution of softwood** in the mix of burned wood is 60 – 85%.