



Aerosol processes in the Planetary Boundary Layer: High resolution Aerosol Mass Spectrometry on a Zeppelin NT Airship

Florian Rubach

Forschungszentrum Jülich GmbH
Institute for Energy and Climate Research (IEK)
Troposphere (IEK-8)

Aerosol processes in the Planetary Boundary Layer: High resolution Aerosol Mass Spectrometry on a Zeppelin NT Airship

Florian Rubach

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 196

ISSN 1866-1793

ISBN 978-3-89336-918-8

Contents

Abstract	1
1. Introduction	3
1.1. Atmospheric aerosol and its relevance	3
1.2. Aerosol properties	5
1.2.1. Particle concentration	5
1.2.2. Particle size	5
1.2.2.1. Particle size classification	6
1.2.3. Tropospheric aerosol	9
1.3. Aerosol mass spectrometry	11
1.4. Pan-European gas-aerosols-climate interaction study (PEGASOS) .	12
1.5. Planetary boundary layer (PBL)	12
1.6. Focus of this work	14
2. Experimental section	15
2.1. PEGASOS campaigns	15
2.2. Airship Zeppelin NT as a measurement platform	17
2.2.1. Cabin layouts	19
2.3. The SOA cabin layout	20
2.3.1. CPN rack	20
2.3.2. PSI rack	21
2.3.3. HGC rack	22
2.3.4. NOX rack	22
2.4. The Aerosol Mass Spectrometer (AMS)	23
2.4.1. Quantification	25
2.4.2. Calibration procedures	26
2.4.2.1. Flow calibration	26
2.4.2.2. Velocity calibration	26
2.4.2.3. Ionization efficiency calibration	27
2.4.2.4. Thresholding-related calibrations	28
2.4.3. Mass spectra interpretation	29
2.4.3.1. m/z calibration	29
2.4.3.2. Baseline subtraction	30

2.4.3.3.	High resolution analysis	30
2.4.3.4.	Relative ionization efficiencies	32
2.4.3.5.	Fragmentation table	33
2.4.3.6.	Elemental analysis	33
2.5.	Adaptation of the Aerosol Mass Spectrometer to Zeppelin requirements	35
2.5.1.	Mounting in a 19 inch Rack	35
2.5.2.	Technical changes	38
2.5.2.1.	Turbomolecular pumps	38
2.5.2.2.	Mass spectrometer	39
2.5.2.3.	Data acquisition	40
2.5.2.4.	Valve control	41
2.5.3.	Changes of measurement technology	41
2.5.3.1.	Pressure controlled inlet	41
2.5.3.2.	Omitted pump	42
2.6.	Performance of the new instrument	42
2.6.1.	Detection limits, precision, accuracy	42
2.6.2.	Resolution	44
2.6.3.	Adaptation to changing pressures	45
2.7.	Aerosol hygroscopicity	45
3.	Observations	49
3.1.	Height profiling	49
3.1.1.	Rotterdam: 2012-05-21, Flight No. 11	50
3.1.2.	Rotterdam: 2012-05-24, Flight No. 14	53
3.1.3.	Ozzano: 2012-06-20, Flights No. 27+28	53
3.1.4.	Ozzano: 2012-07-03, Flight No. 40	57
3.2.	Transects	60
3.2.1.	Rotterdam: 2012-05-22, Flight No. 12	60
3.2.2.	Ozzano: 2012-06-21, Flights No. 29+30	61
3.2.3.	Ozzano: 2012-06-22, Flight No. 31	63
3.2.4.	Ozzano: 2012-06-24, Flight No. 32	65
3.2.5.	Ozzano: 2012-07-01, Flight No. 39	65
3.2.6.	Ozzano: 2012-07-04, Flight No. 41	67
4.	Results and Discussion	71
4.1.	Comparison with particle number based measurements	71
4.2.	Chemical composition in the east- and southbound campaigns	73
4.3.	Chemical composition and hygroscopicity	77
4.3.1.	Compound contributions to hygroscopicity	79
4.3.2.	Predicted CCN activities of encountered aerosol	83

Contents

4.4. Aerosol composition differences inside and outside of the mixing layer	87
4.5. Local production vs. Transport	97
4.6. Aerosol ion balance	104
5. Conclusions	115
Nomenclature	117
Bibliography	119
A. Flight tracks	131
B. Hygroscopicity parameter time series	137
Acknowledgements	141



Energie & Umwelt / Energy & Environment
Band / Volume 196
ISBN 978-3-89336-918-8

 **JÜLICH**
FORSCHUNGSZENTRUM