

ON THE AEROSOL BUDGET OVER BERLIN

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Andreas Kerschbaumer

Gutachter:

Prof. Dr. Ulrich Cubasch (Freie Universität Berlin)

Prof. Dr. Peter J. H. Bultjes (Freie Universität Berlin)

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Andreas Kerschbaumer
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Abstract

One year lasting PM₁₀ components measurements in, around and above Berlin have shown a 15 µg/m³ regional background, a 30% of surface and a further 30% urban background increment to the airborne aerosol concentrations found in the city. This rough estimate has also been found by other surface measurements analyses attributing some 50% of the urban PM₁₀ concentrations to local sources and the remaining 50% to long range transport. The aim of this work is to verify these percentages, to give explanations about their origin and to do a comprehensive process oriented study. Therefore, the Aerosol Chemistry Transport Model REM_Calgrid has been applied in order to simulate the aerosol primary, inorganic and organic components. Its applicability has been proved by comparing observations with simulations. The model has been instrumented with a process analysis tool in order to investigate the contributions of individual physical and chemical processes to the final pollution concentrations. For this reason, an investigation domain comprising Berlin urbanised area has been chosen where aerosol accumulating and diminishing processes have been inspected. The most prominent characteristic of the chosen area is the net difference between the emission-intensive urbanised Berlin area and the mostly rural surrounding domain. Mass exchange rates analyses have shown a predominance of advective processes in dispersing mainly primary aerosols over the whole year from the city toward the surrounding areas, while secondarily built organic and inorganic aerosols exhibit seasonal characteristics. Accumulation due to inflow of sulphate and of organic aerosol components depends on wind direction and on seasons. Primary PM₁₀, including EC and OC, are produced in the city and dispersed via advection toward the surrounding region. The local production to net transport ratio is 1.3 for primary aerosol components. Secondary PM constituents are net accumulated in Berlin via advection as well as via chemical production. Net chemical production is stronger for nitrate than for sulphate over Berlin. Sulphate and secondary organic carbons net accumulation in Berlin is due to advection from the South-East, while all other components show a preferred inflow from the west. The importance of long range transport to the urban aerosol concentrations has been corroborated attributing even more than 50% of total PM₁₀ to non-local processes. Nevertheless, the chemical production from city-related aerosol precursors is not negligible and should be taken into account in any reduction strategy.

Zusammenfassung

Eine einjährige Messkampagne in Berlin-Brandenburg hat gezeigt, dass die kontinentale PM10 Belastung ca. $15 \mu\text{g}/\text{m}^3$ beträgt, die Zusatzbelastung aus bodennahen regionalen Quellen 30% höhere Aerosol-Konzentrationen verursacht und dass der Stadt weitere 30% höhere PM10-Konzentrationen zugeordnet werden können. Diese Ergebnisse wurden bereits in früheren Messkampagnen gefunden, bei denen nur bodennahe Messorte ausgewertet wurden und dort 50% der Aerosol-Konzentrationen lokalen und 50% überregionalen Quellen zugeordnet worden sind. Ziel dieser Arbeit ist es, diese Prozentanteile mit einem Chemischen Transportmodell zu verifizieren und die Ursachen über die Quellen und die Prozesse für das Anhäufen von Aerosolen in der Stadt zu bestimmen. Dafür wurde das an der FU-Berlin entwickelte Modell REM_Calgrid benutzt, das vorerst mit den gesammelten Daten evaluiert worden ist. Das Modell wurde um ein Modul erweitert, das prozessorientierte Modellstudien erlaubt. Berlin zeigt einen starken Emissionsgradienten zwischen Innenstadt und Außenbereichen. Es hat sich gezeigt, dass advective Prozesse stark sowohl zu einer Anhäufung als auch zum Abbau von Aerosolbelastungen beitragen. Dabei werden vor allem primäre Aerosolbestandteile von der Stadt ins Umland verteilt und sekundäre PM10-Komponenten in der Stadt angehäuft. Anorganische als auch organische sekundäre Aerosole zeigen dabei eine starke saisonale Abhängigkeit. Advective Anhäufungen von Sulfaten und von organischen Kohlenstoffverbindungen treten überwiegend bei Südwestwinden auf. Primäre PM10-Bestandteile werden in der Stadt produziert und ins Umland transportiert. Dabei zeigt sich über das Jahr eine charakteristische Verhältniszahl von 1.3 zwischen lokal produzierten und von außen in die Stadt transportierten primären Bestandteilen. Sekundäre Aerosolbestandteile werden in Berlin laut RCG sowohl über Transportprozesse als auch über chemische Prozesse in der Stadt angehäuft. Nitrate spielen dabei eine außerordentliche Rolle und werden über chemische Aufbauprozesse in der Stadt erzeugt. Sulfate und organische Kohlenstoffverbindungen werden als einzige PM10-Bestandteile über Südostwinde in der Stadt akkumuliert, alle anderen Aerosolkomponenten werden über Westwinde beeinflusst. Es hat sich gezeigt, dass die mit RCG simulierten Anhäufungsprozesse in Berlin über 50% auf Ferntransporte zurückzuführen sind und bestätigen somit die aus Messungen gezogenen Schlüsse. Es konnte jedoch auch gezeigt werden, dass auch bei den Sekundärstoffen ein Minderungspotenzial in Berlin gegeben ist, das vor allem in der lokalen chemischen Nitratbildung zu suchen ist.

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