CityZen

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Report on evaluation of the seasonal import/export budgets of targeted hotspots to regional and global air quality (mainly for ozone and PM)

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Ser-	
RE	Restricted to a group specified by the consortium (including the Commission	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Report on evaluation of the seasonal import/export budgets of targeted hotspots to regional and global air quality (mainly for ozone and PM)

1) Introduction

In order to evaluate the footprint of megacities on air pollution at the regional and global scale, several modelling groups involved in the CityZen project investigated the import/export fluxes to and from the targeted pollution hotspots.

This activity concerned mainly modelling groups operating regional chemistry transport models (CTM) as they were deemed more appropriate to represent urbanized areas. The drawback of this restriction is that the impact at the global scale cannot be addressed. However, the global scale was investigated elsewhere in the project (e.g. D4.1.1, D4.1.2).

The Bolchem model was used to assess fluxes in and around the Po Valley area (D1.6.3). The Eurad model was used to investigate the Benelux hotspot (D1.5.3). WRF/Chem was used by two distinct groups to study the Eastern-Mediterranean hotspot (D1.4.4) and the Pearl River Delta (D1.7.3). The purpose of the present deliverable consists in bringing the outcomes of the above deliverables together. To avoid redundancy the findings mentioned elsewhere will not be duplicated here. Rather we will focus on the finding of the Chimere modelling group that is the only team to have focused on both the Benelux and the Po Valley, and put it in perspective with the results of the Bolchem and Eurad teams. Also a special focus will be devoted to the seasonality of the fluxes which was not addressed in the above-mentioned deliverables.

2) Methodology

Various modelling approaches were designed to quantify the import/export fluxes: passive tracer footprint (Bolchem, Chimere), diagnostic quantification of the fluxes from the hourly fields of concentration and tangential wind (Eurad, WRF/Chem, Chimere), prognostic evaluation of the fluxes in the core of the model solver (Chimere).

The Chimere model having used all of these approaches, an analysis of the sensitivity to the methodology could be conducted and showed a limited impact. The diagnostic and prognostic strategies exhibited some differences when looking at short timescales (especially during the high O3 productivity episodes when the concentrations evolve quickly between two model output time-steps). But the differences were marginal when integrated over a season. The tracer footprint being an indirect quantification of the result of the import/export fluxes, the comparison is less direct but a qualitative agreement was found.

3) Results

3.1 Benelux

<u>Ozone & Nitrogen Oxides budgets</u>

Figure 1 shows the seasonal cycle of the NO2 incoming/outgoing and net flux integrated up the top of the modelling domain (about 500hPa). As reported in D.1.5.3 (Study based on the Eurad CTM), the region is a net exporter of NO2. The seasonal cycle is very pronounced. A similar seasonal cycle is found for surface concentrations because of a conjunction of meteorological and chemical processes. The lower PBL in winter favours the accumulation of NO2 close to the surface, while it is more diluted in summer. Also the increased photochemical activity in summer yields a higher availability of OH radicals, hence a more efficient sink of NO2 towards the formation of HNO3. Note that the seasonal cycle of the NO2 flux can only be explained by the chemical sink as the PBL cycle has no impact on the total integrated flux from the surface to the mid-troposphere.

The seasonal cycle of Benelux O3 fluxes seen in Figure 2 can be related to the NO2 cycle. Here the seasonality of O3 productivity leads to an obvious more efficient export in summer, but the impact of lower production and higher availability of NO2 in winter is such that the region becomes a net sink of O3 during that season with inflows dominating the outflows. The Eurad modelling team also reported a net export of O3 from the Benelux regions (D.1.5.3), except for a couple of outstanding years.

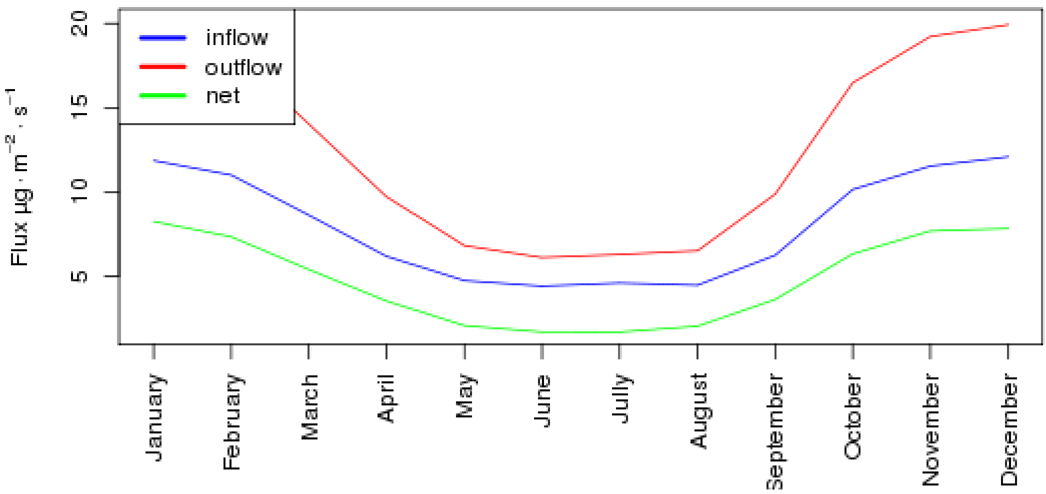

Figure 1: Seasonal cycle of NO_2 fluxes between the surface and the top of the domain around the BeNeLux region as monthly means derived from a decade of Chimere simulations (1998-2007). Inflow and outflow fluxes are always positive; a positive net flux constitutes an export.

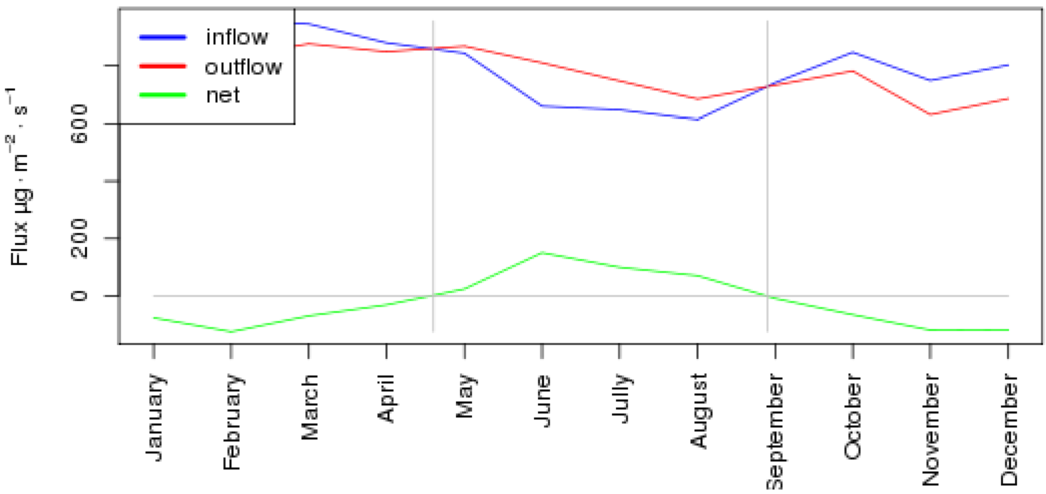

Figure 2: Seasonal cycle of O_3 fluxes between the surface and the top of the planetary boundary layer around the BeNeLux region as monthly means derived from a decade of Chimere simulations (1998-2007). Inflow and outflow fluxes are always positive; a positive net flux constitutes an export.

Particulate Matter

The seasonal cycle of PM10 (particles smaller than 10µm) fluxes around the Benelux region shows a strong amplitude in the magnitude of the raw ingoing and outgoing fluxes with much larger fluxes in winter, in agreement with the usual annual cycle of PM concentrations (Figure 3). The region remains a net source of PM10 throughout the year with a maximum in spring that can be attributed to ammonium nitrate particles known to be responsible for the large PM10 concentrations during the agricultural fertilizer spreading season.

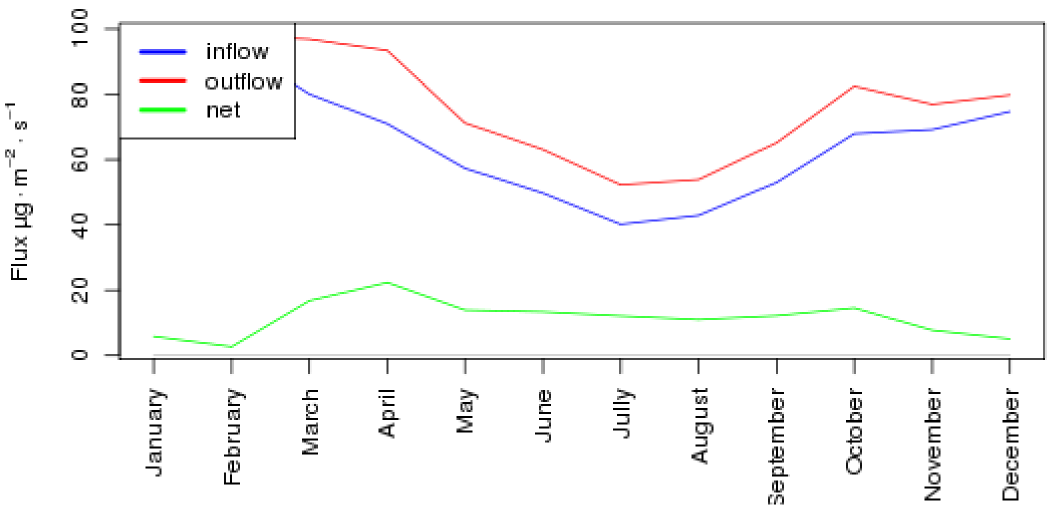

Figure 3: Seasonal cycle of PM10 fluxes between the surface and 2500m around the BeNeLux region as monthly means derived from a decade of Chimere simulations (1998-2007). Inflow and outflow fluxes are always positive; a positive net flux constitutes an export.

3.2 Po Valley

Ozone & Nitrogen Oxides budgets

The seasonal cycle of the net NO2 import/export fluxes around the Po Valley is qualitatively similar as that reported for the Benelux area although its amplitude is much lower (Figure 4). The resulting seasonal cycle of O3 flux is thus very flat (Figure 5). But the most striking feature is that the region is a net sink for O3 throughout the year. This finding is in agreement with the conclusion of the Bolchem modelling team (D.1.6.3) that found – with a tracer approach – that although this region is notoriously exposed to stagnating meteorological conditions, it is unfavourable to the accumulation of pollutants emitted locally.

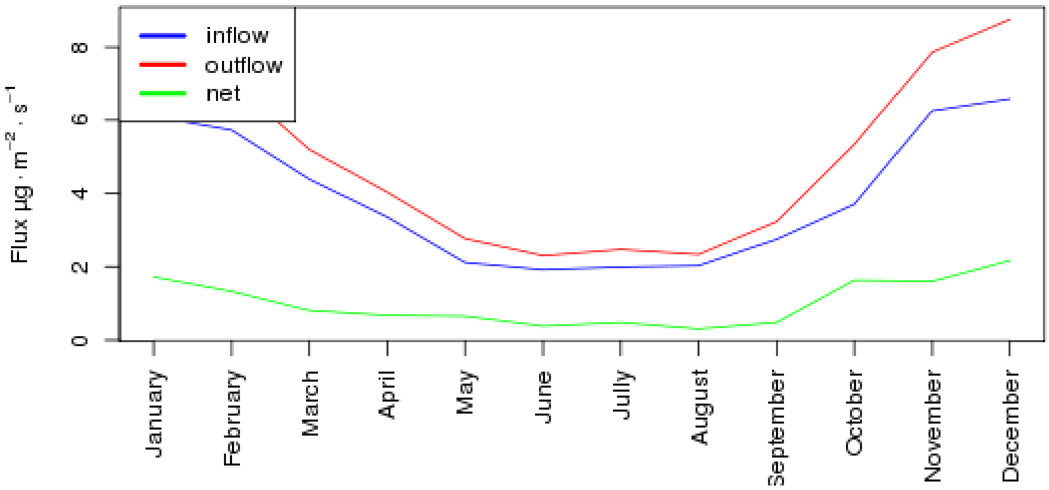

Figure 4: Seasonal cycle of NO2 fluxes between the surface and the top of the domain around the Po Valley region as monthly means derived from a decade of Chimere simulations (1998-2007). Inflow and outflow fluxes are always positive; a positive net flux constitutes an export.

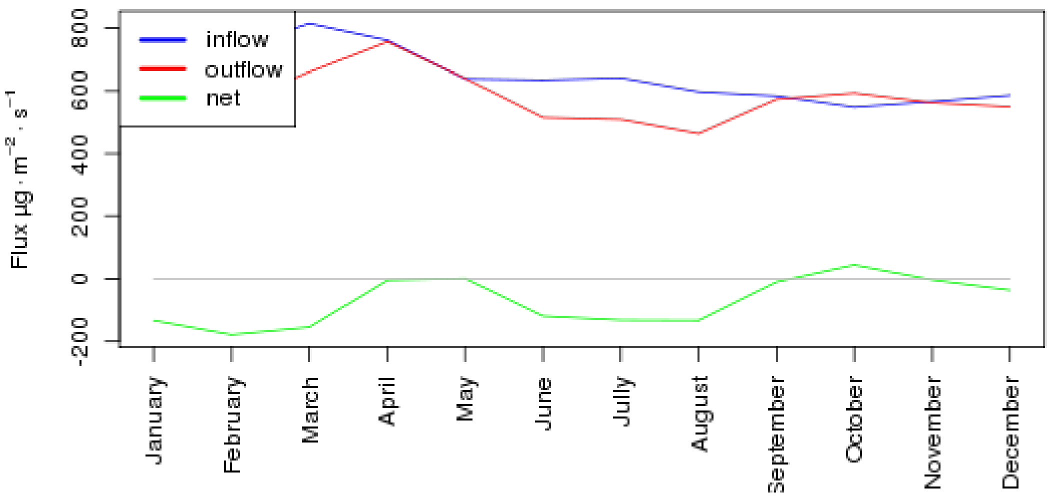

Figure 5: Seasonal cycle of O_3 fluxes between the surface and the top of the planetary boundary layer around the Po Valley region as monthly means derived from a decade of Chimere simulations (1998-2007). Inflow and outflow fluxes are always positive; a positive net flux constitutes an export.

Particulate Matter

The amplitude of the PM10 seasonal cycle is much lower than in the Benelux region, and here the region is a net sink of PM10 (Figure 6). The role of biogenic PM should be emphasized as their import is a very large contributor to the total net flux whereas the Po Valley would be a net source of PM at the regional scale if we had focused on anthropogenic particles.

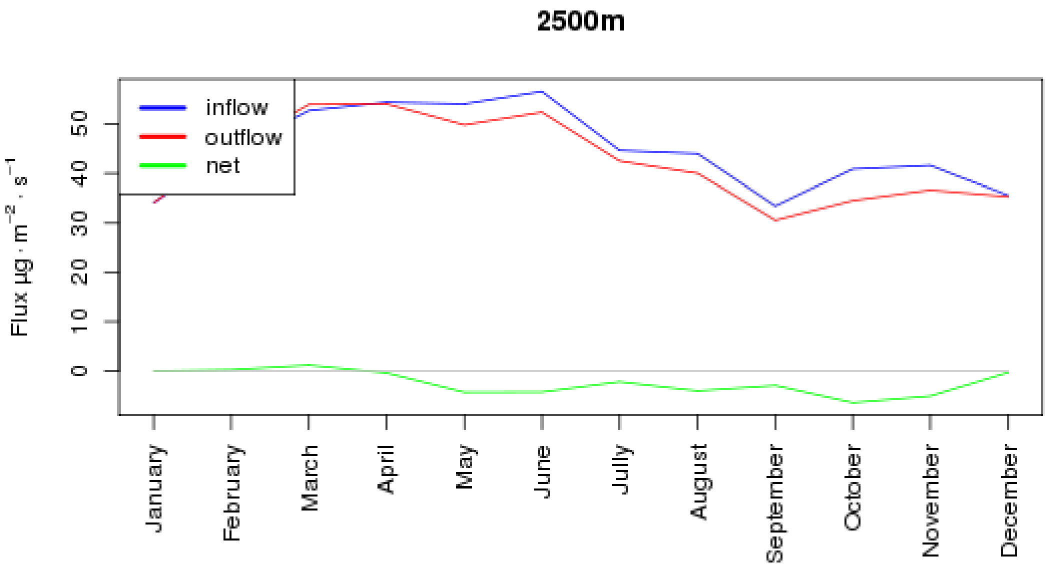

Figure 6: Seasonal cycle of PM10 fluxes between the surface and 2500m around the Po Valley region as monthly means derived from a decade of Chimere simulations (1998-2007). Inflow and outflow fluxes are always positive; a positive net flux constitutes an export.

4) Conclusion

The broad picture that can be derived from the present study as well as other CityZen deliverables (D1.5.3 and D1.6.3) is that the Benelux region is a larger contributor to the degradation of regional air quality than the Po Valley. While it is only in summer that the Benelux region exports ozone, PM10 are exported throughout the year. On the contrary, the Po Valley constitutes a net sink for both ozone and PM10 all year long.