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Introduction

Air quality around major airports has become an important topic in environmental and aviation policy discussions. Understanding how pollutants disperse from aircraft engines in real-world airport settings is essential for developing effective mitigation strategies. While global estimations are typically summarized in annual environmental reports by airport authorities, the latter do not fully address several gaps in the understanding of how emissions affect local air quality under operating conditions. This research provides more detailed evaluation of concentration mapping of pollutant at Schiphol Airport.

Eulerian/Gaussian approach

$$C(x,y,z,t) = \int_0^{T_s} Q_{exp} \left[\frac{(x-x')^2}{2\sigma_{x0}^2 + 4K_x(t+t')} - \frac{(y-y')^2}{2\sigma_{y0}^2 + 4K_y(t+t')} \right] \times \left\{ \exp \left[-\frac{(z-z'-H)^2}{2\sigma_{z0}^2 + 4K_z(t+t')} \right] + \exp \left[-\frac{(z-z'+H)^2}{2\sigma_{z0}^2 + 4K_z(t+t')} \right] \right\} dt'$$

Where

- C: concentration [$\mu\text{g}/\text{m}^3$]
- Q: emission rate [$\mu\text{g}/\text{s}$]
- T_s : source operating time [s]
- x, y, z: current co-ordinate values [m]
- x_0, y_0, z_0 : initial co-ordinate values [m]
- u_w : wind velocity [m/s]
- u_{pl}, v_{pl}, w_{pl} : components of source speed vector [m/s]
- a, b, c: components of source acceleration vector [m/s^2]
- σ_i^2 : dispersion coefficients for jets [m]
- K_x, K_y, K_z : turbulent diffusion coefficients [m^2/s]
- $X' = X_0 + U_{PL}t' + 0,5 a t'^2 + U_W(t + t')$
- $Y' = Y_0 + V_{PL}t' + 0,5 b t'^2$
- $Z' = Z_0 + W_{PL}t' + 0,5 c t'^2$

Methodology

The main purpose of PolEmitCa is to provide the dispersion (air pollution - Pol) and inventory (emission - Emi) calculations (Ca) for the aircraft engine emission during the LTO cycle of the aircraft movement inside the airport area.

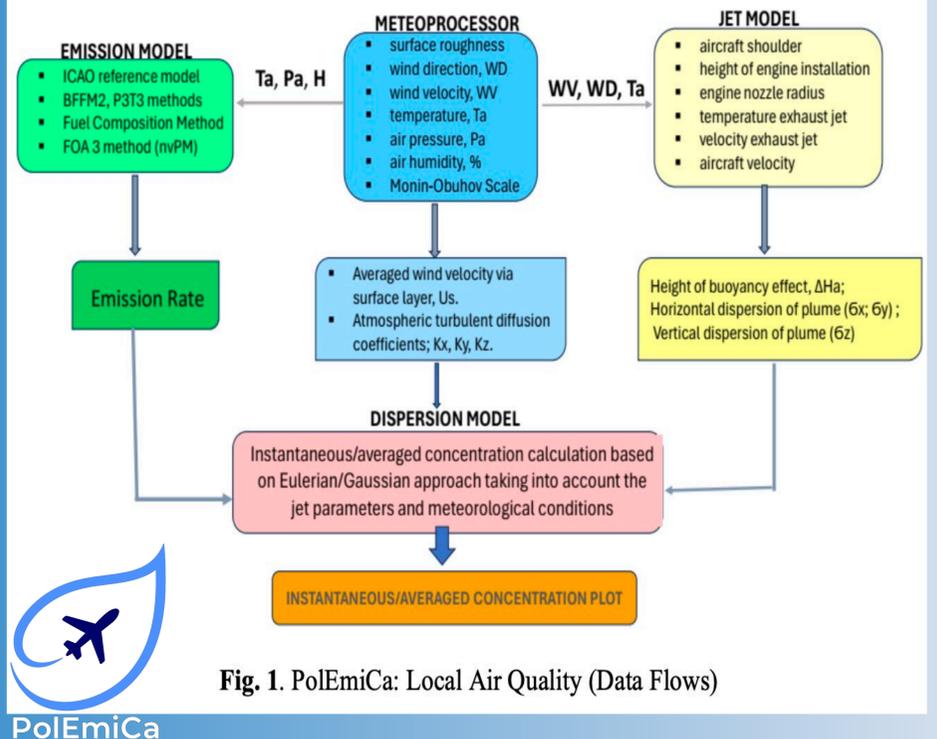


Fig. 1. PolEmitCa: Local Air Quality (Data Flows)

Results & Discussion

Fig. 2 shows the fleet operating at Schiphol Airport were dominated by the small or narrowbody aircraft. Fig. 3 presents the estimated monthly emissions of CO, NO_x, HC and nvPM, both categorized by aircraft type and as an aggregate total. Medium (widebody) and small aircraft are major contributors to monthly NO_x emissions.

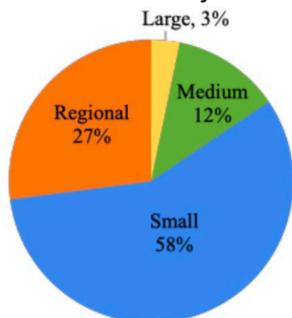


Fig. 2. Aircraft fleet structure

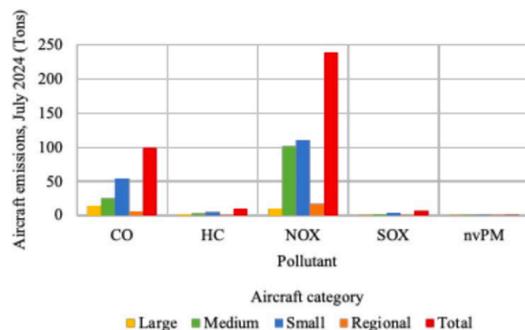
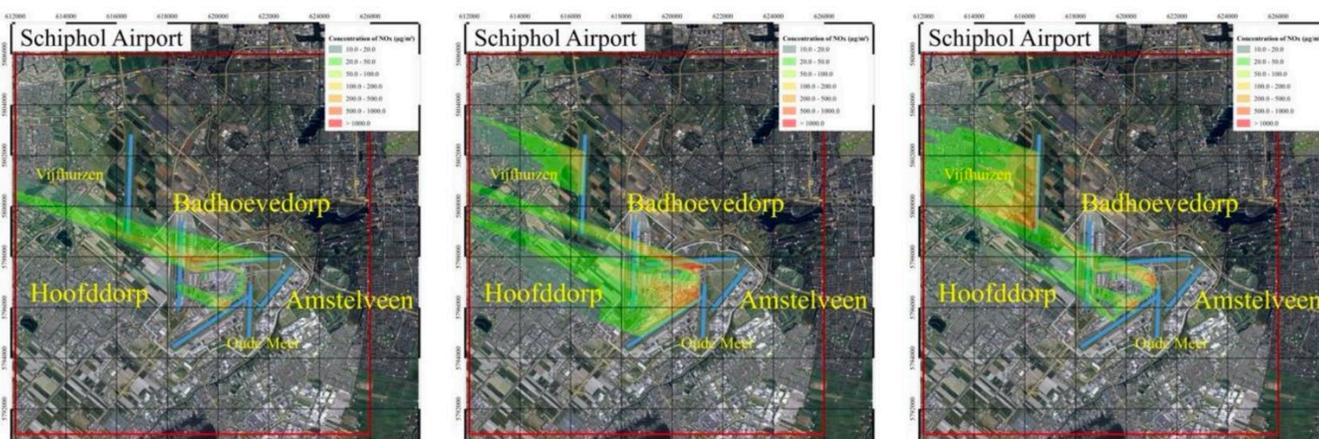


Fig. 3. Aircraft emissions in July, 2024

Table 1. Scenarios for LAQ studies at Schiphol Airport

Scenario	Time	D	A	Total
Scenario 1	29/07/2024 08:00:00	35	65	100
Scenario 2	15/07/2024 12:00:00	55	36	91
Scenario 3	31/07/2024 13:00:00	46	46	92

To assess whether the proportion of departure and arrival conditions affect the degree of air pollution, the scenarios were compared for the same meteorological conditions (Table 1). NO_x concentrations were estimated. As shown in Fig. 4, higher NO_x levels are observed at the start of the runway, and on the taxiway prior to take-off. This can be explained by the higher fuel consumption in take-off conditions, including the phase where the aircraft is waiting in the queue to take-off with the engines running. Low concentrations are observed at the habitational area around Schiphol Airport; concentrations are sufficiently diluted by exhaust gas jets and atmospheric diffusion, so air quality standards (EU, 2008) are not exceeded for the simulated meteorological conditions.



Scenario 1: $C_{max} = 580 \mu\text{g}/\text{m}^3$ Scenario 2: $C_{max} = 1599 \mu\text{g}/\text{m}^3$ Scenario 3: $C_{max} = 754 \mu\text{g}/\text{m}^3$

Fig. 4. Hourly concentration of NO_x [$\mu\text{g}/\text{m}^3$] for peak hour, scenarios 1, 2 and 3. The contour indicates Schiphol boundaries, including the buffer areas, while nearby localities are shown in yellow, and the blue lines correspond to the runways.

Conclusion

High emission levels are found in a very localized area around the taxi-out queue and initial part of the runway. Although emissions do not arrive to the nearby locations, ground personnel working near the take-off area may be affected by pollutant emissions.

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