MULTISCALE AIR QUALITY IMPACT OF AIRPORT AND EN ROUTE AVIATION EMISSIONS

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Summary
The environmental impact of aviation emissions has been analysed at different spatial and temporal scales to assess the main impact of aircraft operations including taxi, take-off, landing and cruise phases. Chemical transport models have been applied to evaluate the aviation emissions impact from global to urban scale considering all the anthropogenic and biogenic emission contributions. A Lagrangian particle model has been employed at local scale to quantify the air quality impact of the different activities of a urban airport and, at microscale, to estimate the maximum expectable air pollutants concentration in the airport surroundings during unfavourable meteorological and operational conditions. The main population exposure occurs nearby the airport infrastructure, where significant hourly average concentrations can occur during unfavourable conditions. At urban scale the aviation impact is limited and much lower than that attributable to other sources. At global scale the aviation emissions increase ozone in the northern hemisphere and influence climate through short lived climate forcing compounds effects.

Introduction
The analysis of short and long term aviation impact on the environment, from local to global scale, is one of the objectives of the H2020 SESAR project CREATE (https://create-project.eu/), which aims to evaluate innovative procedures in air traffic management to reduce its climate and environmental impact. A cascade of interconnected air quality models have been applied to cover the scales of interest, including: the chemical transport models (CTMs) FMI/SILAM (global and continental scale) and FARM (urban scale), nested through boundary conditions, the Lagrangian particle model SPRAY (local scale) and its obstacle resolving version PMSS (microscale). The global scale analysis estimated the overall aviation emissions impact on air quality and climate, while the urban and local scale impact assessment has been focused on the emissions related to the Naples Capodichino airport as an example of a mid-size European airport located in urban environment.

Methodology and Results
The high resolution (100 m) SPRAY model simulation shows a maximum yearly average NO_2 concentration of about 43 µg/m^3 located inside the airport perimeter. The concentration field rapidly decays with distance, reaching values below 1 µg/m^3 at about 2-3 km from the airport. The maximum air quality impact over the airport surroundings during unfavourable meteorological and airport operation conditions has been estimated applying the obstacle resolving model PMSS with 5 m grid spacing. NO_2 concentrations (Fig.1) show hourly values of 10-20 µg/m^3 over the inhabited area, reaching 125 µg/m^3 inside the airport. The urban scale FARM CTM simulation for year 2018 integrated local scale results taking into account secondary pollutants. The impact area for NO_2 extends from the airport along the main take-off and landing route with a contribution to the annual average concentration larger than 1 µg/m^3 within a strip of land 1 km wide. O_3 titration prevails on the long term reducing annual average concentrations around the airport, while maximum hourly increase reached 3 µg/m^3 and the yearly ozone production increases by 2.5% due to aviation emission. The contribution to PM2.5 annual average concentration is lower than 0.1 µg/m^3 outside the airport. SILAM global simulations extended to years 2001-2019 and showed an increase of ozone concentration in the northern hemisphere (Fig.2), causing a global increase of O_3 concentration of 1.2-1.4 DU due to NO_X emissions, and resulting in a radiative forcing (RF) of about +13 mW/m2. The direct RF effect from aerosols is instead cooling, with about half of the ozone effect.

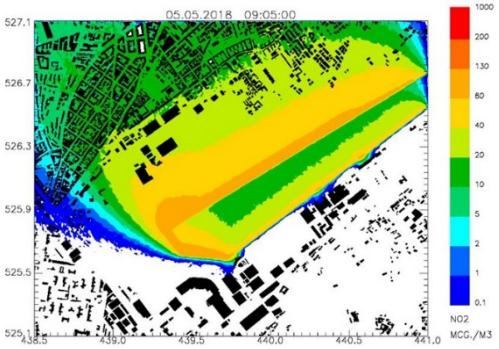

Fig.1 NO_2 hourly ground level concentration around Naples airport - 5/5/2018 10:00

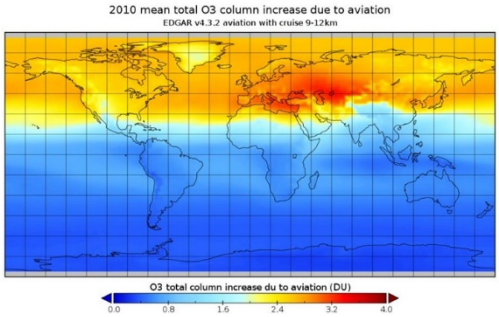

Fig.2 . Increase of 2010 yearly mean ozone column concentration due to aviation emissions.

Conclusions
The multiscale air quality and climate forcing impact assessment of aviation emissions showed that the relevant impacts occur at global scale and around the airport structure. The quick climbing trajectory of aircrafts limits their surface air quality impact in the region surrounding the airport. Similarly, the surface activities and aircraft emissions during take-off/landing only affect the nearby areas. At global scale the aviation emissions increase the tropospheric ozone and aerosol concentrations that influence climate as short-lived climate forcing compounds with opposite warming/cooling effects.

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