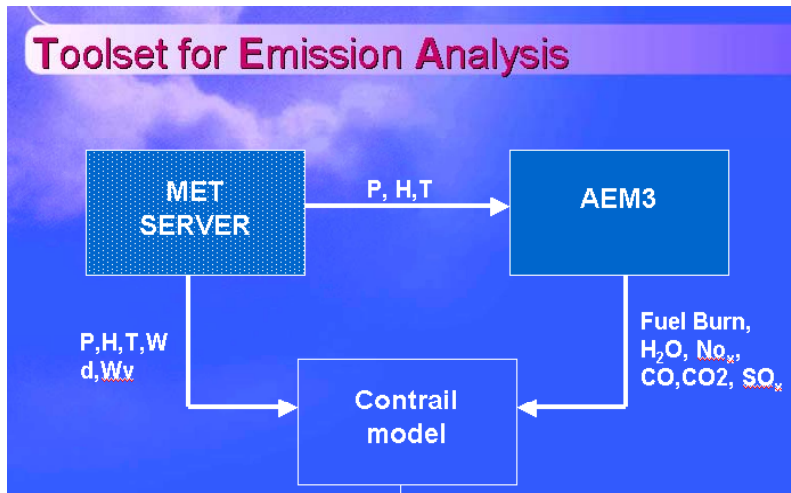


The Toolset for Emission Analysis

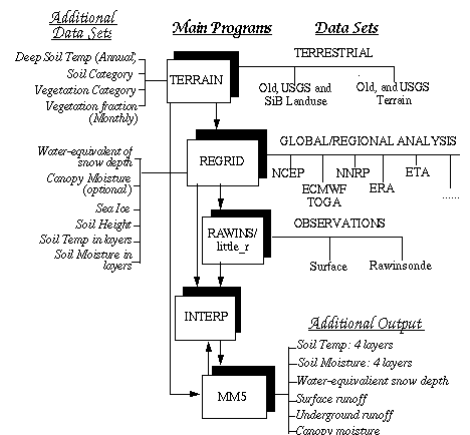
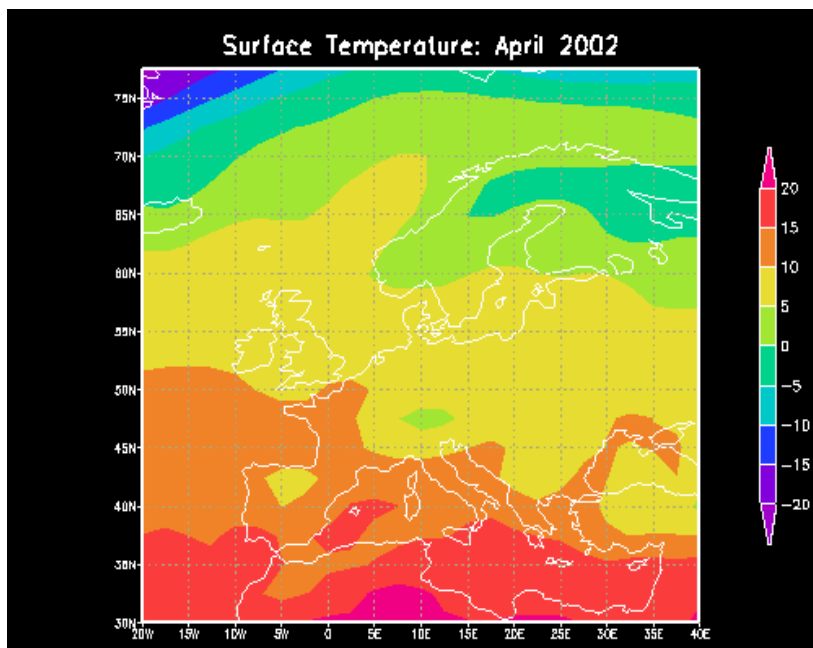
The effects of aviation on the environment and on the people who live in the vicinity of airports have been the subject of studies and regulation since the 1960s. As concern about these effects grows both amongst the population and in their governing bodies, notably the European Commission, it is only natural that the EUROCONTROL Agency in general, and the EUROCONTROL Experimental Centre in particular, should become involved in this aspect of the industry. As a result, the Toolset for Emission Analysis is being developed in order to provide a validated, stable and user friendly tool set in support of present and future global, 4-dimensional emission and contrail studies.



The Toolset for Emission Analysis (TEA) is a set of inter connected models, namely: AEM3, a system for estimating aviation emissions (CO₂, H₂O, SO_x, NO_x, HC, CO, Benzene, VOC, TOG) and fuel burn; CONTRAIL a tool for determining the probability and amount of contrail formation from aircraft; and a meteorological database for providing forecast and analysis data for other EUROCONTROL models (MET SERVER).

CONTRAIL is currently in prototype status. A validation of AEM3 against operational airline data from FMS recordings is planned to be finished by the end 2003.

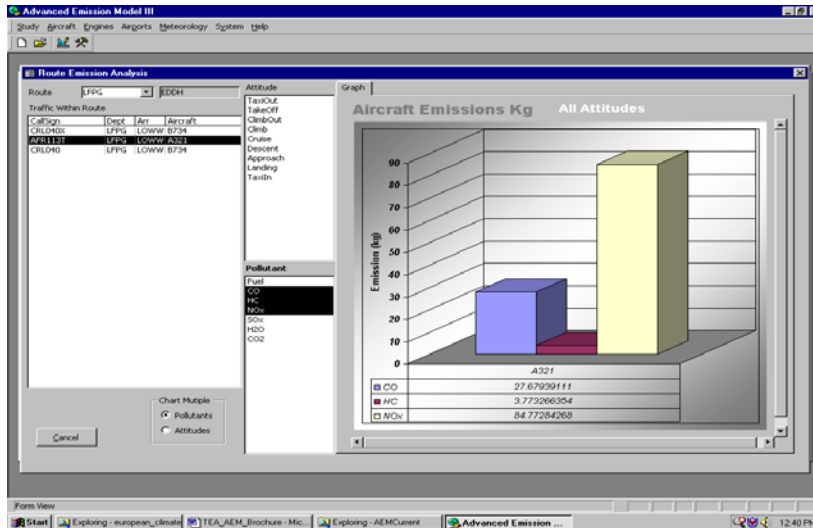
The Meteorological model and database (MET SERVER) is a 'state of the art' system based upon the MM5 (Mesoscale Model version 5) model developed by the National Centre for Atmospheric Research (NCAR) and Pennsylvania State University. MET SERVER will provide the surface and upper air meteorological data needed (pressure, geopotential height, temperature, horizontal and vertical winds speed and humidity) for local and global emission studies and contrail estimations. MM5 has been used for a broad spectrum of theoretical and real-time studies, including applications of both predictive simulation and four-dimensional data assimilation to monsoons, hurricanes, and cyclones. On the smaller meso-beta and meso-gamma scales (2-200 km), MM5 has been used for studies involving mesoscale convective systems, fronts, land-sea breezes, mountain-valley circulations, and urban heat islands.



The Advanced Emission Model (AEM3)

The Advanced Emission Model (AEM3) is a stand-alone system used to estimate aviation emissions (CO₂, H₂O, SO_x, NO_x, HC, CO, Benzene, VOC, TOG) and fuel burn. It is able to analyse flight profile data, on a flight-by-flight base, for air traffic scenarios of almost any scope (from local studies around airports to global emissions from air traffic). The system can run stand-alone on an MS-Office2000 equipped PC. It is mainly based on MS-ACCESS2000.

AEM3 uses several underlying system databases (aircraft, aircraft engines, fuel burn rates and emission indices) provided by external data agencies in order to assure the quality of the information provided.

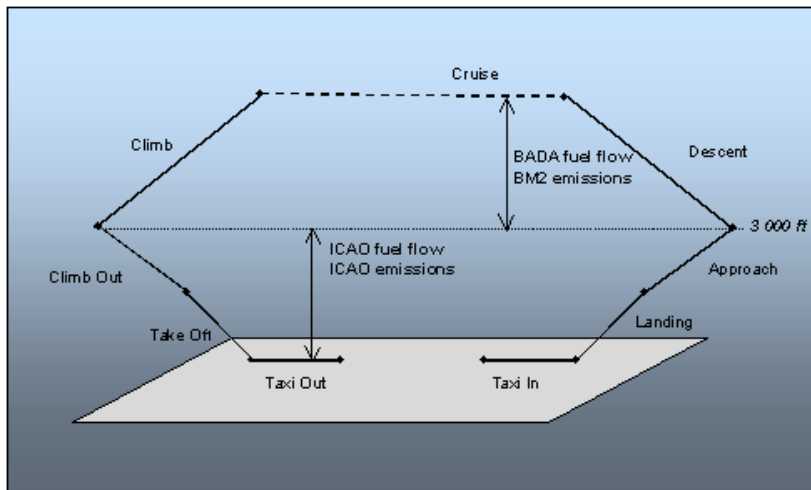


This system information is combined with dynamic input data, represented by the air traffic flight profiles.

Optionally, below 3000 ft, the fuel burn calculation can be based on the Landing and Take-Off Cycle (LTO) defined by the ICAO Engine Certification specifications. ICAO LTO covers four engine operation modes,

which are used in AEM3 to model the six following phases of operation: Taxi-Out, Taxi-In (Idle), Take-Off, Climb-Out, Approach and Landing (Approach). The *ICAO Engine Exhaust Emissions Data Bank* includes emission indices and fuel flow for a very large number of aircraft engines. AEM3, links each aircraft appearing in the input traffic sample to one of the engines in the ICAO Engine Exhaust Emissions Data Bank.

Above 3000 ft, fuel burn calculation is based on the "Base of Aircraft Data" (BADA). This database



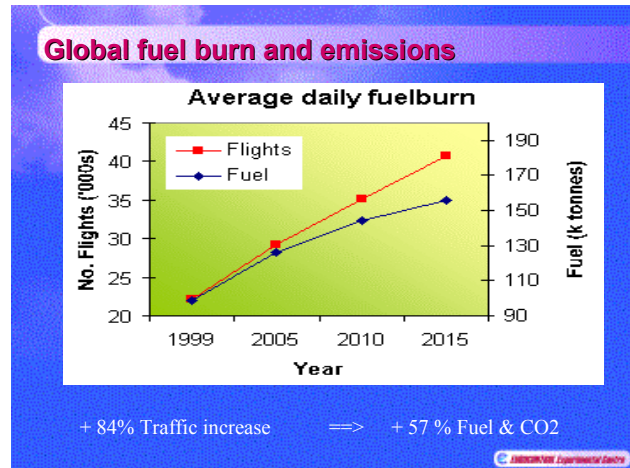
provides altitude and attitude dependent performance and fuel burn data for more than 150 aircraft types. Emission calculations are based on the *ICAO Engine Exhaust Emissions Data Bank*, but emission factors and fuel flow are adapted to the atmospheric conditions at altitude by using a method initially developed by The Boeing Company (The Boeing Method 2 – BM2) and modified by the EUROCONTROL

Experimental Centre Research Area Society, Environment & Economics (SEE) (EEC-BM2). EEC-BM2 allows estimation of emissions for the pollutants NO_x, HC, CO. The emissions for the pollutants H₂O and CO₂ are directly issued of the oxidation process of carbon and the hydrogen contained in the fuel with the oxygen contained in the atmosphere. The SO_x emissions depend directly on the sulphur content of the used fuel. All three are directly proportionally to the fuel burn. The estimation of VOCs and TOGs is based on a method developed by the U.S. EPA.

Environmental studies with AEM3 - TEA

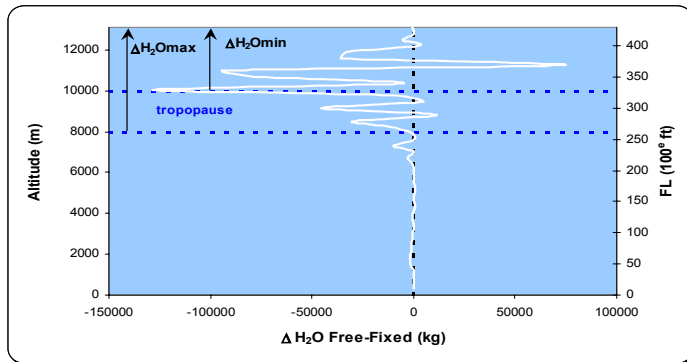
ICAO/CAEP

The first environmental study performed with AEM (AEM I) supported ICAO/CAEP WG4 in 1999 with global emission estimations for the ECAC area. Based on several daily European traffic days it was estimated that a traffic increase between 1999 and 2015 of about 84% would lead to an increase of fuel burn and proportional emissions of about 57%. The difference is explained by the changed aircraft fleet and technology improvement during the study period which had been taken into account by AEM.



FRAP - The FREE Route Airspace Project

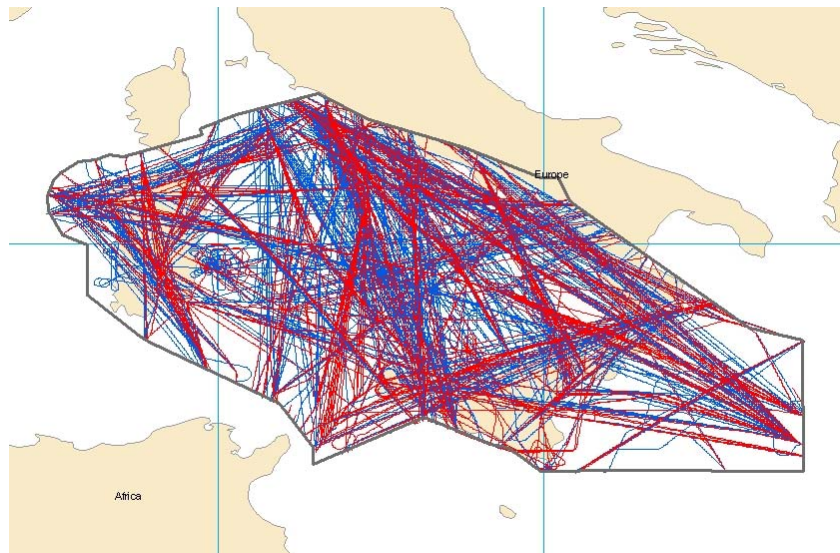
The Environmental benefit analysis (AEM3; 2001/02) for the FRAP project indicated a potential environmental benefit for the implementation of the FRAP concept in the 8-States area of about 1.6 - 2.1% concerning fuel burn and directly proportional emissions (CO₂, H₂, Sox). NO_x could be reduced by that concept up to 1.6%.



Vertical emission analysis indicated significant environmental benefit at and above tropopause layer, where it is indicated by atmospheric research that these layers are most sensitive.

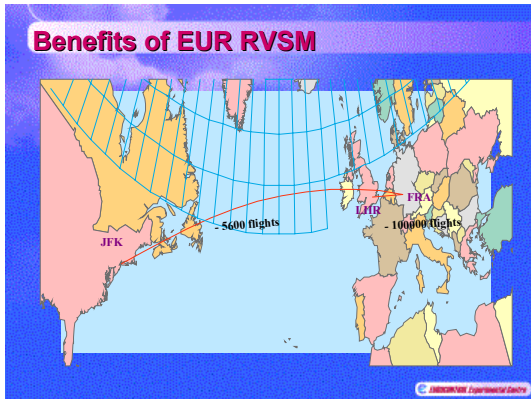
MFF - The Mediterranean Free Flight Programme

Based on the Real Time simulation data of the Italian R/T simulation experiments for the MFF Programme, this study performed during 2002/03 with AEM3 identified potential savings of about 1 - 1.2 % for fuel burn and directly proportional emissions. NO_x emissions could be reduced up to 1%. Since the results have been based on a rather small data volume in terms of movements and traffic samples those results would require statistical consolidation using more data.



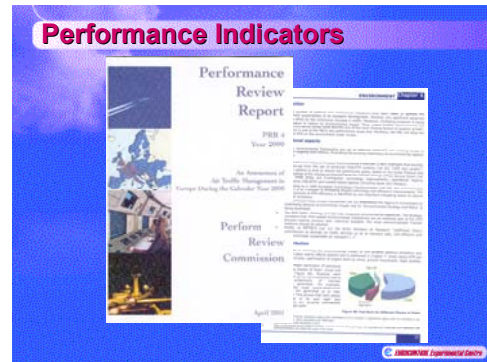
RVSM - The RVSM Programme

The Post implementation environmental benefit analysis performed end 2002 for the European RVSM programme office with AEM3 indicated very positive result for this available ATM system element. Fuel burn and proportionally related emissions have been reduced by the implementation of the RVSM by 1.6 - 2.3%, NOx emissions have been reduced by about 1%. Even more positive is the situation at tropopause level where NOx emissions have been reduced by between 2.3 and 4.4%. Fuel burn and proportional emissions are reduced even more (3.5 - 5.0%). The absolute savings in terms of fuel burn and emissions correspond to four entire traffic days in Europe without any flight in the air or more than 5500 flight between Europe and the U.S. east coast not taking place.



PRU - The Performance Review Unit

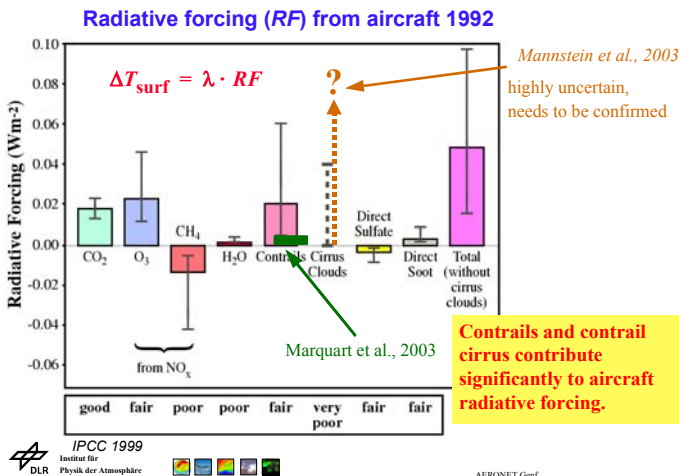
Since 2001 AEM is being used in the support of the PRU trying to develop environmental Key Performance Indicators (KPIs) and to report the performed values for those indicators. Results have been published in the Performance Review Reports each year.



CONDENSATION TRAILS - CIRRUS CLOUDS

Most recent research indicates that the environmental impact of condensation trails and more important of cirrus clouds caused by aviation might be significantly higher than estimated by IPCC,1999.

AEM and TEA will be used in a collaborative project with ESA, trying to test this hypothesis seriously using realistic air traffic data and the CONTRAIL model to produce condensation trail maps. ENVISAT earth observations of condensation trails will at the same time be used to validate TEA's CONTRAIL model during 2003/04.



EC/EMEP Emission Reporting and Emission Inventories

Currently (2003/04) AEM3 is being ported to an Oracle platform and enhanced by a functional feature to allow automatic overnight batch-job runs of full European traffic days in the context. The results of those AEM calculations will be provided by EUROCONTROL to the European Commission and the EMEP Emission Reporting and Emission Inventories. Both support the political decision making process under the Convention on Long-Range Transboundary Air Pollution for international co-operation to solve transboundary air pollution problems by, for example introducing future environmental regulations on the ATM system or Emission trading mechanisms etc.