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# Trajectory Modelling of Atmospheric Pollutants Associated with Aircraft Emissions for Air Quality Assessment

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**Abstract**

Aviation is suffering a large increase in recent years and as result there is a consequent increase in emissions of air pollutants. The highest exposure levels of air pollution in airports and near them are found in the Landing and Take-off (LTO) cycle responsible for negative impacts on air quality. The city of Rio de Janeiro, in the coastal region of the South East of Brazil, has two major airports; the International airport and one for domestic flights. Both are near the Guanabara Bay (GB), in Metropolitan Region of Rio de Janeiro (MRRJ). In this research, it was verified the pollutant trajectories emitted by these two airports using the Brazilian Regional Atmospheric Modelling System (BRAMS) to generate wind fields in the MRRJ. From the wind fields, 3D kinematic trajectories Lagrangian model was used to calculate the pollutant trajectories. Atmospheric instability indices were tested from the BRAMS simulations to verify the days with more stable atmospheric conditions in winter month. The Total Totals index (TT) was selected to be more appropriate for the purpose of this study. Obtained results showed that the cities of Rio de Janeiro and Duque de Caxias, in the western of the MRRJ, are critical points to be affected continually by pollutant transport due to the prevailing meteorological conditions, harming the air quality in the region. These models captured the influence of mesoscale and large-scale systems, showing the dependence of the trajectories of both systems related to the season and time of day. They are important tools in decision-making for the control of emissions, contributing to better management of urban air quality.

**Keywords:** aircraft transportation, aircraft emissions, air pollution, meteorological models

## 1. Introdution

Civil aviation is a strongly growing transportation sector and has been steadily growing since the late 1960s when air travel started to become more widespread and economically accessible (Lee et al., 2010) and therefore pollutant gas emissions from air transportation play a key role in reduce air quality. It is an important contributor to global emissions of many different gases and aerosols that can have an impact on climate, either directly or indirectly (Fuglestvedt et al., 1999; Ambrosino, Sassoli, Bielli, Carotenuto, & Romanazzo, 1999; Eyring, Kohler, van Aardenne, & Lauer, 2005; Fuglestvedt et al., 2010). Lately it has been investigated aviation's effects on the global atmosphere in national and international research programmes, including the IPCC (1999; 2000; 2001; 2007a; 2007b; 2014) report.

Photochemical air pollution is recognized to be a world–wide problem in areas where emissions from mobile and stationary sources occur, affecting the air quality due to meteorological phenomena. Nowadays, climate impacts of emissions from aviation, maritime and road transports have been investigated in parallel by applying consistent methodologies, which allow direct comparison of their impact on global climate (Sausen, 2010; Heal, Kumarbc, & Harrisonde, 2012).

Kerosene is a conventional jet fuel, being a derivative of crude oil (Wood, Long, & Morehouse, 2004) with a great specific energy content, allowing fly on longer distances, carrying passengers and cargo (Janic, 2010). According to the International Civil Aviation Organization (ICAO), Volatile Organic Compounds (VOC), Nitogen-Oxides ($NO_x$), Carbon-Monoxide (CO), Carbon-Dioxide ($CO_2$), Sulfhur-Dioxide ($SO_2$), Methane ($CH_4$), Nitrous-Oxide ($N_2O$), water vapour ($H_2O$) and soot particles are considered typical aircraft emissions related to burning conventional jet fuel, contributing in various ways to air pollution. As aviation is suffering a large increase there is a consequent increase of greenhouse gases (GHG) ($CO_2$, $CH_4$ and $N_2O$) and ozone ($O_3$) depletion, puting this modal on the list of priorities (Brüning, 2010). Aircraft emissions of $CO_2$, $SO_2$, $NO_x$ and $O_3$ precursors change atmospheric concentrations of GHG and aerosol mainly Sulphate ($SO_4$), causing both positive and negative contributions to direct radiative forcing (RF) of climate and, by convention, these impacts are quantified using this metric (Lee et al., 2010). The particles can also have an indirect effect on climate through their ability to change the properties of clouds, mainly in formation of contrail-cirrus cloud from spreading contrails (Eyring, 2010).

The incremental contribution of civil air transport system occurs at ground level during landing and take-off (LTO) cycles (below 3000 ft) and when the plane is at cruise altitude according to Aviation Environmental Design Tool (AEDT FAA).Therefore is not clear whether aircraft would be more like mobile sources or like power plants in the magnitude and spatial distribution of their impacts, especially for emissions below cruise altitude and during LTO cycles at airports considered so as stationary sources.

Airports represent a source of growing interest for health impact analysis related to air pollution and may represent an increasingly large fraction of the emissions inventory (Arunachalam, Wang, Davis, Baek, & Levy, 2011; Ashok et al., 2013). Some studies have contributed to the understanding spatial patterns of air pollution near airports, quantifying the air quality related to aircraft contributions but lack information about spatial extent of these effects, specially on population health (Moussiopoulos, Sahm, Karatzas, Papalexiou, & Karagiannidis, 1997; Pison & Menut, 2004; Yu, Cheung, & Henry, 2004, Borrego et al., 2010, Koo, Wang, Henze, Waitz, & Barrett, 2013).

In general, the total air pollution is proportional to the number of polluting activities, being its intensity related per activity which in turn is related to the volume of traffic, usually expressed as the number of passengers and freight shipments during the LTO cycle. The intensity of air pollution per activity depends on the quantity and type of the energy consumed and, in addition, must be consider the movement of vehicles, aircraft servicing and the heating and lighting of the passenger and cargo terminals (Janic, 2010).

From the 2000s, in order to reduce the effects of air pollutant emissions by ships and aircraft, several measures are imposed from international, national and local legislators such as the United Nations Framework Convention on Climate Change (UNFCCC), International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) (Dessens, Anger, Barker, & Pyle, 2014).

Brazil follows the United States Environmental Protection Agency (US-EPA) and the World Health Organization (WHO) air pollution guidelines since 1976. In 1989, the National Program for the Air Quality Control (PRONAR) was launched as baseline for the environmental management and human health protection. The first legal instrument connected to the PRONAR was released in 1990 where new air quality patterns were determined. From 2000 was represented for the first time in the Reference Report of Greenhouse Gas Emissions as part of the 2nd National Communication to the United Nations Framework Convention on Climate Change (MCT, 2010).

The Brazilian Action Plan (2013) aims to share information with ICAO for contributing with the global effort of reducing GHG from international civil aviation. Therefore, between 1990 and 2012 was verified a rapid growth in domestic operations. Now, the publication of the National Inventory of Civil Aviation Air Emissions (ANAC, 2013; 2014) enables various actions such as evaluation of emissions and better knowledge about local pollutant profiles as well as direct GHG.

The State Environmental Institute (INEA) is the agency responsible for monitoring of air quality in the state of Rio de Janeiro since 1967, when the first measurement stations were installed. The resolution of the National Environment Council (CONAMA n° 03/1990) indicates the air quality patterns by pollutants levels, which cannot be exceeded in a given time and region. These parameters must be regarded for the health protection of the people, buildings and environmental resources. This Council classifies these patterns according to the exposure time, as short or long period, depending on the damage.

The concentration of pollutants is strongly related to meteorological conditions and some parameters favorable to high levels of pollution are calm, light winds and temperature inversions at low altitude. Temperature inversions are conditions that occur with regular frequency, being more frequent in the dry season. However, the inversion of subsidence may occur with the passage of cold mass over the region or by blocking condition caused due to an intense high center pressure. The temperature inversion is extremely unfavorable to the health and can stay for a few days, concentrating pollution near the ground. This behavior of the air temperature limits lateral and vertical dispersion of the pollutants, making the concentrations abnormally high if the emissions continue (Oliveira, 2004).

The MRRJ is the region with the second largest concentration of population, vehicles, industries and emission sources of pollutants, generating serious problems of air pollution. The dry season is under weak synoptic northeasterly wind and low precipitation, potentially leading to serious air pollution in MRRJ. This region, considered the second most polluted region of the country and is located in Southeast Brazilian coastal where the Guanabara Bay (GB) is inserted, undergoing the effects of the breezes.

Eulerian and Lagrangian modelling are usually used to compute the pollutant plumes which follow the atmospheric flow field (Oliveira, 2004). In the Eulerian method is traced tangent lines at speeds observed simultaneously at different points of the flow, called current lines, allowing an overview of the movement of particles in the flow. Otherwise, the Lagrangian method allows viewing the successive positions of the same particle over time (Draxler & Hess, 1998). According Doty and Perkey (1993) the path taken by a given air parcel for a period of time in a balanced flow is called trajectory but the knowledge of wind at the study area is not sufficient to determine the source of air masses. Only through the knowledge of dynamic of atmosphere is that we know the path followed by them. The calculation of air mass trajectories is very important because it enables the knowledge of pollutant emission sources transported in the atmosphere.

The above is an overview of the pollutant emissions related to air transport sector and its impact on air quality. This study is part of the research in analysis of the pollutant concentrations and trajectories in the MRRJ to verify the impacts of air pollution related to the transport sector in an urban area, densely populated and industrialized that has the air quality reduced. In addition to industries (stationary sources) and road transports (mobiles), this region is also affected by other sources such as maritime and aviation transport sectors (Oliveira, Ebecken, Oliveira, & Aires, 2016). In this context, the purpose of this research is to use the BRAMS to generate the wind fields in the MRRJ and a 3D kinematic trajectories Lagrangian model to compute the trajectories of pollutants generated by the aviation sector at ground level during LTO flight phases from two airports in Rio de Janeiro: Antônio Carlos Jobim International Airport (Galeão) and Santos Dumont Airport (Domestic flights) considered as stationary sources. These two airports are located in urban and central city of Rio de Janeiro with an intense traffic, contributing to the pollutant emissions in MRRJ. The contribution of this modal is analysed not only in MRRJ but also in other regions for the wintertime on June, 2016, considering meteorological conditions favourable to pollutant concentrations.

## 2. Study Area

In order to investigate the contribution of the civil aviation transport sector in Rio de Janeiro city (22˚47'26"S, 43˚09'20"W), South-east coast of Brazil, and its influence in the MRRJ and other regions (Figure 1), it was verified the spatial and temporal trajectories of pollutants under prevailing meteorological systems. This research is focused in two points considered as emissions from stationary sources (International Airport, one of the five largest airports in the country, and the Domestic Airport) both near to the margins of the GB. The GB is inserted in MRRJ surrounded by the cities of Rio de Janeiro, Duque de Caxias, São Gonçalo, Niterói and other smaller cities, where the breezes recirculate pollutants in the region. In addition to the meteorological mesoscale systems such as breezes, the study area is under influence by the South Atlantic semi-stationary subtropical anticyclone system, a large-scale circulation pattern. The high levels of air pollution depend on the region and topography relative to the general circulation of the atmosphere and this atmospheric system also determines the air quality in MRRJ according to its positioning along the Brazilian coastline, presenting a well-defined seasonal movement.

During the winter, this system becomes stronger than summer, moving northerly. On its western side the winds blow north-easterly towards the south-eastern coast of South America and they are less intense on the south-eastern coast of Brazil where the GB is located (Figure 2). This circulation is periodically disturbed by the passage of frontal systems caused by anticyclones that move from the south west towards the north-east on the south-eastern coast of Brazil. Therefore, there is a weakening of the northerly winds and an intensification of the south westerly winds which facilitates the track of the cold fronts that reach the south and south-east coast of Brazil (Ahrens, 2000).

Other important systems that affect the region are the mesoscale meteorological systems known as breezes. These wind systems are affected by local topography and the differential heating of the surface, favouring or harming the places where they move. The breezes are generated due to the differential heating between the GB and the continent, recirculating pollutants in MRRJ. Usually, the sea breeze follows the south-north direction carrying pollutants into the Metropolitan area during the day. Otherwise, during the night, the land breeze follows the north-south direction carrying pollutants to densely urbanized regions of the coast. The topography of the MRRJ with the hills located parallel to the coastline acts as a physical barrier to the winds from the sea, blocking the ventilation in areas located further inland. At the regional scale, the breeze circulation due to the temperature difference between the sea surface and the continent can change air quality by recirculation of pollutants (Luhar et al., 2004). Therefore, it is necessary to know the meteorological, geographical and social-economic variables and the chemistry of the troposphere to manage air quality in cities.

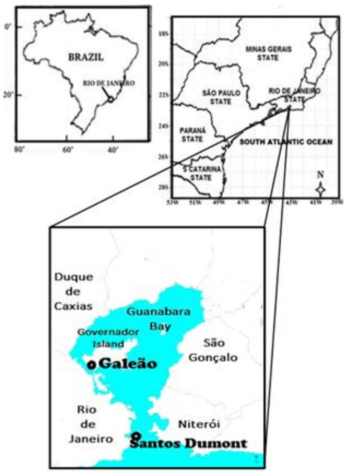
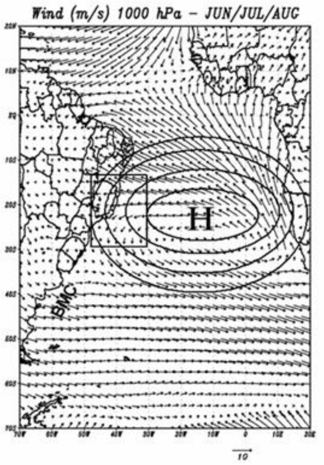


Figure 1. Study area with the localization of Galeão and Santos Dumont Airports. The International Airport is located on the Governador Island and the Domestic Airport near the city center, both close to the margins of the Guanabara Bay. The figure shows the major cities of MRRJ



Source: Adapted from NCEP/NCAR reanalysis dataset.

Figure 2. Surface wind-flow pattern with a scheme of the South Atlantic high-pressure system for winter. The circles represent the isobars and the positions of the high center. The highlighted area shows the winds blowing over the study area; BMC - Brazil Malvinas Confluence region.

## 3. Materials and Methods

### *3.1 Meteorological Dataset*

In this research were used the reanalysis from the National Centers for Environmental Prediction-NCEP and National Center for Atmospheric Research-NCAR (Kistler et al., 2001) for initialization of the Brazilian Regional Atmospheric Modeling System (BRAMS-http://www.brams.cptec.inpe.br) to generate the wind fields over the MRRJ on June, 2016. This model is a set of computer program that simulates the atmosphere for weather and climate research and for numerical weather prediction.

### *3.2 Atmospheric Simulations*

The BRAMS was used with their parametrization standards and the initial condition and boundary to generate the wind fields over the MRRJ, using NCEP/NCAR reanalysis data set. The reanalysis data set of the climatological average of June, 2016 (dry season) were submitted to analysis package of this model, which treated and interpolated the data of wind components, temperature and relative humidity at several pressure levels for isentropic and sigma_Z levels. The initial condition and boundary for numerical integrations were obtained by applying objective analysis (Barnes, 1973) of these two levels.

The boundary layer was finely refined with stretch ratio of 1.2 up to 1 km. In the wind field simulations were used three nested grids (Clark, & Farley, 1984); the first with a resolution of 40 km x 40 km (thick grid), the second with 10 km x 10 km and the third, of most interest (high resolution grid), 2.5 km x 2, 5 km (thin grid).

The downscaling technique allowed the information of the largest scales passed to the smaller scales and vice-versa with the two-way nesting. For the model assimilate the data, in the center, on the sides and on top of the domain it was used the Newtonian relaxation (nudging) as an alternative form of dynamic initialization of the data set, with three nested grids centered between the two airports whose distance between them is approximately 20 km. The nudging allows the model to reach the desired fitting after a few hours of integration and was applied from the fifth grid point on the sides and until 15 km on top of the grid. The thick grid captured the large scale information and the thin grid covered the domain MRRJ. To view the wind field, it was used the Grids Analysis and Display System-GRADS (Doty & Perkey, 1993).

Atmospheric instability indices play an important role to verify synoptic and mesoscale features favorable for the development of thunderstorms. These indices were examined using the BRAMS to identify which days with atmospheric stability conditions occurred. These weather conditions are favorable to the concentration of pollutants over a region. Although these indices have been developed for mid-latitudes, it does not imply the non-use of them to Brazil; they can be parametrized and represent a useful tool to characterize the atmospheric stability conditions.

The LTO cycle includes all flight phases near the airport carried out by aircraft at altitudes less than 914.4 meters (or 3000 feet). Therefore, the trajectories of pollutants were calculated forward, considering this flight phase where there are the most intense emissions at low levels of the atmosphere and at ground. The trajectory of air pollutants was numerically investigated using a 3D kinematic trajectories Lagrangian mode (Freitas, Longo, Silva Dias, & Artaxo, 1996; Freitas, 1999; Freitas et al., 2000) to compute the trajectories of pollutants emitted by the two airports with the wind fields generated by the BRAMS atmospheric modeling. To verify the extent of the pollutants were used integration time of 24 hours for tracking the trajectories, both in the region and elsewhere outside the MRRJ. The trajectories calculated by the wind field generated in the high-resolution grid will not present herein because the results were not consistent with the flow of mesoscale systems type breezes due to the influence of GB. These local flows are affected by the topography and the differential heating of the surface, favoring or harming the places where they move. In some cases, the orientation and type of rocks influence the flow in the Planetary Boundary Layer (PBL), arising pollutants around 300-900 meters of height in MRRJ. After analysing the weather conditions in June 2016, the period from 26-29 at 0600, 1200 and 1800 local time (LT) was used in the simulations of the trajectories due to favourable conditions for air pollutant concentrations in the region.

### *3.3 Calculation of Air Parcel Trajectories*

Air parcels trajectories were obtained at different times and heights in order to verify the influence of the meteorological systems in the trajectory of pollutants emitted in the region.

The calculation of trajectories is based on the Equation (1) (Petterssen, 1956):

$$\frac{dr(t)}{dt} = V(r,t) \tag{1}$$

where

*r(t)* is the position of the air parcel at time t;

*V* is the horizontal wind field (*u, v*) and the vertical wind (*w*).

Thereby is possible to know the output and arrival of pollutants emitted in a region. From the Equation (1), the position of the air parcel *r(t)* is defined by Equation (2) to the output trajectory (forward) after the time lag $\Delta t = (t_1 - t_0)$:

$$r(t_1) = r(t_0) + \int_{t_0}^{t_1} V[r(t), t]\, dt \tag{2}$$

The calculation of the arrival trajectory (backward) is also obtained from Equation (1).

The level (height) reached by a particle or pollutant, along the trajectory of air parcels, is represented by the color scale of the figure.

## 4. Results and Discussion

### *4.1 Atmospheric Instability Indices*

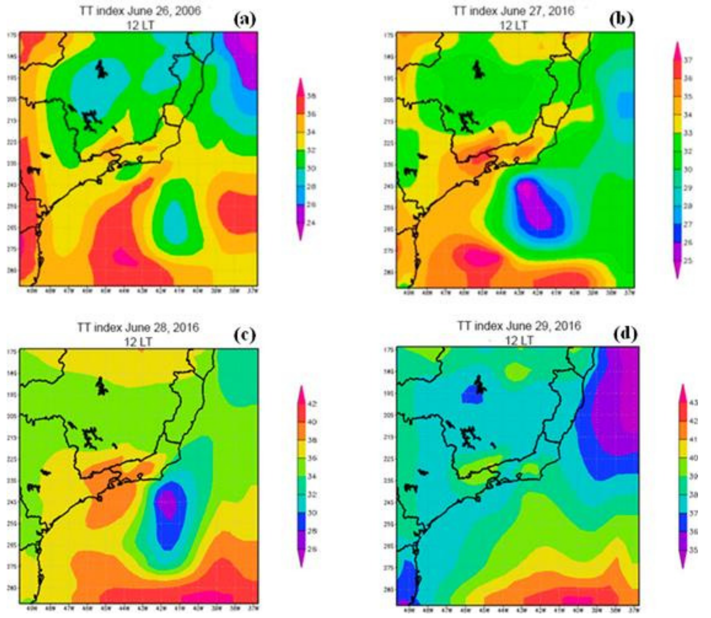


Figure 3 (a)-(d): TT Index simulation maps obtained with the BRAMS model for selected days in thick grid. TT values for the study area 12 LT, (a) June 26 around 32, (b) June 27 between 33-35, (c) June 28 around 38 and (d) June 29 around 38. All values were below 44, characterizing a condition close to atmospheric stability.

Table 1. Total Totals (TT) threshold values

| | |
|---|---|
| <44 | Convection not likely |
| 44-50 | Likely thunderstorms |
| 51-52 | Isolated severe storms |
| 53-56 | Widely scattered severe |
| >56 | Scattered severe storms |

Source: Miller, 1972; Severe weather índices page (www.theweatherprediction.com/severe/indices, accessed on October, 10 2016).

Table 2. Meteorological data obtained from automatic station. LT-local time; T- temperature; H- humidity; Pr-pressure and P-precipitation

| Date (June, 2016) | LT | T (ºC) | H (%) | Pr (hPa) | Wind spead (m/s) | Wind direction | P (mm) |
|---|---|---|---|---|---|---|---|
| 26 | 12 | 22.9 | 68 | 1023.0 | 3.4 | SE | 0.0 |
| 26 | 18 | 19.5 | 88 | 1022.3 | 4..3 | ESE | 0.0 |
| 27 | 12 | 23.3 | 70 | 1022.9 | 2.9 | SE | 0.0 |
| 27 | 18 | 20.2 | 87 | 1021.9 | 6.4 | ESE | 0.0 |
| 28 | 12 | 24.0 | 72 | 1021.4 | 2.6 | SE | 0.0 |
| 28 | 18 | 21.2 | 84 | 1019.3 | 2.0 | E | 0.0 |
| 29 | 12 | 23.8 | 70 | 1019.6 | 1.6 | ESE | 0.0 |
| 29 | 18 | 21.3 | 76 | 1018.4 | 0.4 | NE | 0.0 |

Source: National Weather Institut (INMET) – Copacabana automatic station.

Atmospheric instability indices were tested from the BRAMS simulations showing the days with more stable atmospheric conditions The Total Totals index (TT) was more appropriate to evaluate stability categories of weather for the purpose of this study and the specific threshold values are presented in Table 1. Generally, values of TT greater than or equal to 44 are indicative of thunderstorms or high convective instability (Sioutas, Szilagyi, & Keul, 2013). The TT index calculated from the BRAMS simulations showed that June 26, 27, 28 and 29 had stable atmospheric conditions and therefore were selected for analysis. The meteorological data obtained from automatic station (Table 2) for selected days show a predominance of large-scale circulation pattern (Subtropical high pressure system) over the region with light winds in SE-E-NE direction and no precipitation. Results of TT index are presented in Figure 3.

### *4.2 Wind Field Simulations*

The topography influences the speed and direction of winds in MRRJ. The atmospheric flow simulated for the selected days at 12 LT are presented in Figure 4 (a) to (d) and refer to the land breeze. Due to the heating of the surface in the morning, the land breeze is weak at 12 LT, but even so this mechanism is responsible for the transport of pollutants towards the coastline and ocean area. The wind field simulations on the coastline are consistent with the measured data in the automatic station (Table 2).

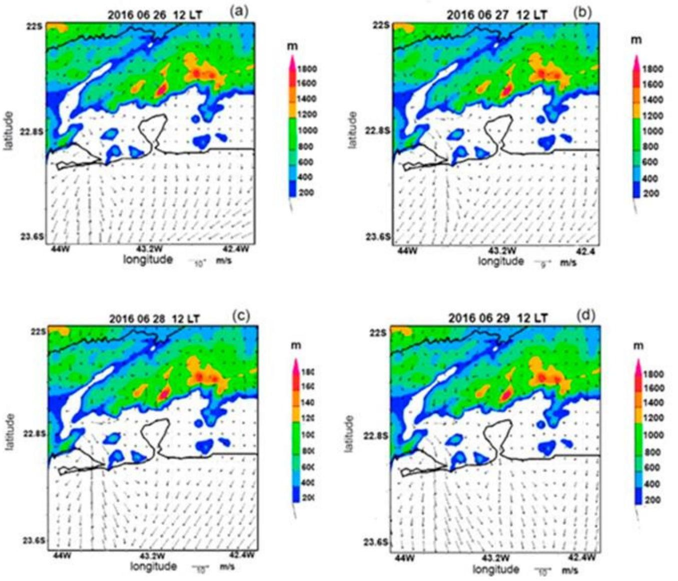


Figure 4 (a)-(d). Maps of wind field and topography on June 26, 27, 28, 29, 2016 at 1200 LT (a), (b), (c) and (d), respectively show weak land breeze in the MRRJ in high resolution grid

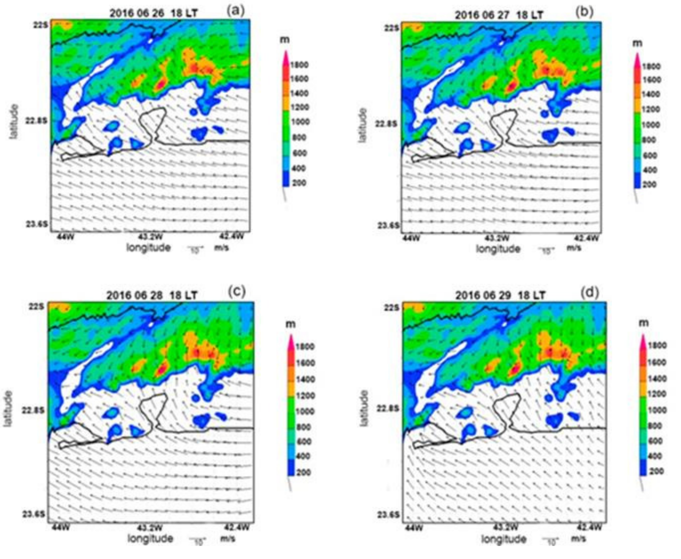


Figure 5 (a)-(d). Maps of wind field and topography on June 26, 27, 28, 29, 2016 at 1800 LT (a), (b), (c) and (d), respectively, show sea breeze more intense in the MRRJ in high resolution grid. Wind field shows E and SE wind direction with speed around 10 ms$^{-1}$

The atmospheric flow simulated for the selected days at 18 LT are presented in Figure 5 (a) to (d) and refer to the sea breeze. Due to the heating of the surface in the afternoon, the strong sea breeze at 18 LT is responsible for the transport of pollutants towards the MRRJ. It is also verified that the GB canalizes the flow over the region, facilitating the transport of pollutants. The sea breeze is undoubtedly the main natural mechanism of pollutant transport for densely populated area of MRRJ. The wind field simulations on the coastline are consistent with the measured data in the automatic station only on 26-27 (Table 2).

### *4.3 Trajectories of Air Pollutants*

Obtained results of the 3D kinematic trajectories models during winter month (June 26 -29, 2016) from wind field simulations by means of the BRAMS showed the trajectories of pollutants emitted by two airports. Figure 5 and 6 show the trajectories calculated at 1200 LT and 1800 LT, respectively, using 40-km resolution outputs during 24 hours, within a domain surrounding each airport.

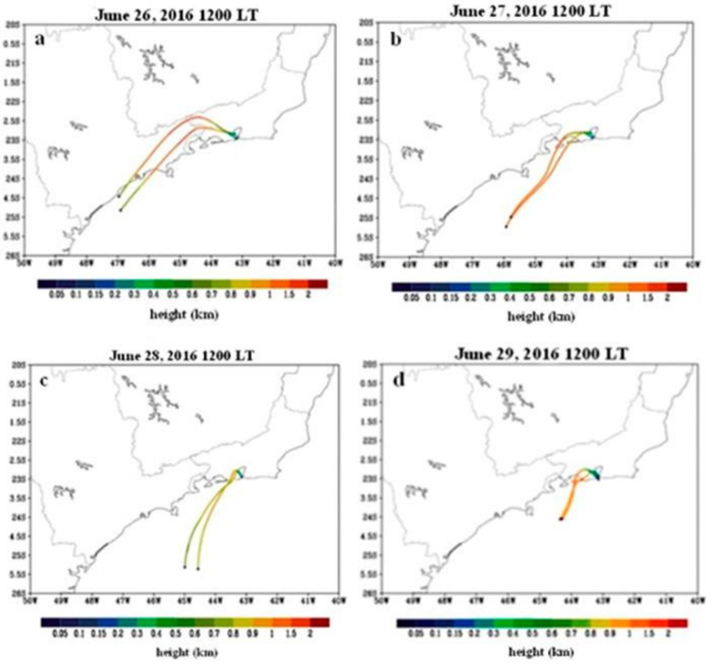


Figure 6 (a)-(d). Trajectories of pollutants simulated with 3D kinematic model on June 26-29, 2016 at 1200 LT. The heights of the pollutant trajectories are represented by the color scale of the figure

At 1200 LT (Figure 6) pollutants followed trajectories towards NW around 50 meters of height, on the Central and coastal areas of west zone of the city of Rio de Janeiro and then following the SW direction, reaching other states close to the state of Rio de Janeiro and the South Atlantic Ocean, remaining below 2 km of height. Figure 5a shows that on 26 pollutants initially moved to NW (from 50 to 500 meters, approximately) reaching the states of Minas Gerais and São Paulo that border with the state of Rio de Janeiro (mountain regions) around 1500 meters of height, returning towards SW and reaching the coast of the state of São Paulo. On 27 and 29 pollutants also moved to NW (from 50 to 500 meters) and to SW towards the Restinga da Marambaia and Sepetiba in the west zone of Rio de Janeiro, as well as Angra dos Reis Bay, lifting from 1000 to 1800 meters of height (Figures 5b and 5d), following towards the oceanic region. On 28 trajectories remained at low levels over the west zone of Rio de Janeiro, returning to SW towards the ocean, lifting from 400 to 900 meters of height. These simulations indicate that the trajectories not followed the land breeze that remained weak in the region in the analyzed period, being the trajectories associated with the positioning of South Atlantic subtropical high-pressure system.

Under the influence of sea breeze on 26-29 at 1800 LT pollutants were transported towards NW around 50 (near airports) and 500 (in the MRRJ and mountain region near the states of Rio de Janeiro and Minas Gerais) meters (Figure 7). On 27 pollutants moved to NW (around 50 meters), returning to SW also towards the Restinga da Marambaia and Sepetiba, as well as Angra dos Reis Bay, lifting from 150 to 800 meters (Figure 5b). On 28 pollutants also followed the NW direction in the MRRJ, rising around 400 meters and returning to SW towards ocean area, dropping between 150-100 meters. For the four analyzed days, it was verified that pollutants emitted by both airports remain at low levels in the west side of MRRJ due to meteorological conditions, harming the air quality in the region. This metropolitan region is densely populated and greatly affected continually by pollutant transport emitted from vehicles, industries and further the civil air transport system contributing to serious problems of air pollution, causing therefore degradation in human health.. In this scenario, the model captured well both meteorological systems, indicating a critical situation of the air quality in the study area in periods of atmospheric stability.These models are important tools in decision-making for the control of emissions to minimize the harmful effects of pollutants, contributing to better management of air quality.

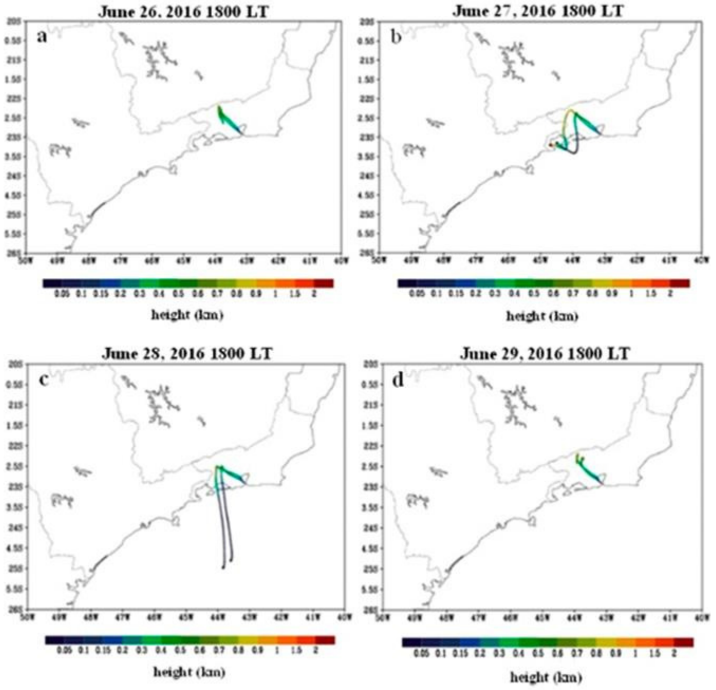


Figure 7 (a)-(d): Trajectories of pollutants simulated with 3D kinematic model on June 26-29, 2016 at 1800 LT. The height of the pollutant trajectories are represented by the color scale of the figure.

## 4. Conclusion

The contribution of air transport system in pollutant emissions that occurs at ground level during LTO cycles plays a key role, because is currently growing fast worldwide. Emissions of many different gases and aerosols induce an impact on air quality of the cities close to the airports, representing a source of growing interest for health impact analysis. The air transport influences the air quality in MRRJ and vicinity where the air quality has a strong influence of meteorological systems, especially type breeze, which recirculate pollutants in this region. The BRAMS and 3D kinematic trajectories used in this research showed the influence of these systems on the transport of pollutants generated by the two airports in the winter month. Usually during the occurrence of stability weather conditions as verified in this study, the trajectories follow westward of MRRJ, reaching the cities of the Rio de Janeiro and Duque de Caxias due to prevailing meteorological systems. In the analysed period pollutants followed trajectories on the central and coastal areas of west zone of the city of Rio de Janeiro during the morning and more intensely on the central regions in the afternoon keeping up at low heights, harming the air quality in the city. These areas of the city have air quality quite impaired not only because of the pollutants generated by the two airports but also from other sources mainly due to its concentration at low levels almost all day. Therefore the models captured the influence of mesoscale and large-scale systems, showing the dependence of the trajectories of both systems related to the season and time of day.

This study shows the need for better management of air transportation sector to reduce the harmful effects on air quality in the MRRJ generated by this sector. The complexity of the physical processes and their impacts must be analysed, as well as aspects related to legislation, regulatory systems and articulation between several plans and programs of different sectors of administration. It should consider a policy that favours the required patterns for urban development without environmental degradation, aiming to improve the air quality.

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