TROPOSPHERIC EXPLORATION ABOVE MOLDAVIA PROVINCE: TRACE GAS MEASUREMENTS ATR-42 FLIGHT AS0729 ON THE 16TH OF JULY 2007

Adrian Covăsnianu, Mihai Cazacu, Alexis Merlaud, Joelle Bechara, Victor-Daniel Cărbunaru, Daniel-Eduard Constantin

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Abstract. The chemistry flight as0729 performed on the 16th of July 2007, between 14h20 and 16h20 local time was dedicated to pollution tracking above the Moldavia province in Romania. We wanted to explore two urban agglomerations: Iasi (47´09N; 27´37E) and Roman (46´55N; 26´54E) distant about 50 km from one another in straight line. Industrial zones are implanted in these areas. We went to explore the vertical distribution of the pollutants above these two areas. Moreover, a European road passes by the north of the two cities. We also went to track traffic emissions. Trace gas species measured during the flight were NOx, O_3 and CO. Our goal is to establish the lower troposphere distribution of these pollutants in the area, in order to evaluate the photochemical production of ozone in an urban/industrial plume. The aim of our experimental strategy is to cover a horizontal and vertical dimension of the region.

1. Flight preparation

To prepare the flight, we localized the urban pollution emission points such as industrial areas (pharmaceutical factory, metallurgy plant) and important traffic axes (European Road E85 and E583).

From a meteorological point of view, the forecasting announced favorable conditions for photochemical ozone production:

High temperature up to 35°C ➔ important photochemistry;

Anticyclone conditions ➔ stability;

Low winds from the North West at 3 m/s.

According to these conditions we established our flight plan to collect the air samples downwind the sources areas.

2. Flight description and trajectory

Our flight strategy consisted in performing a vertical exploration of three domains: two urban areas and one remote atmosphere above a forest separating the two towns. To do so, we conducted 3 vertical profiles between 2500’ and FL180. Besides, to carry out a horizontal covering of the region, we performed several horizontal tracks between Iasi and Roman at different altitudes following the main traffic axes: the European road on the north of the towns, and a circular exploration around the towns. We also performed tracks in remote atmosphere above the forest in order to evaluate the pollution gradient between urban and rural/remote atmospheres. We located the geographic coordinates of the vertical soundings according to the wind direction and the geographical position of the industrial areas.

Figure 1 describes our flight plan:

- the ATR-42 takes off from Iasi airport
- perform a square around Iasi at constant altitude
- go on a vertical profile downwind of Iasi
- begin the first track towards Roman at high altitude FL180
- at mid-distance between Iasi and Roman, perform a vertical profile above the forest
- reach Roman at low altitude
- perform a square around Roman at constant altitude
- perform a vertical profile above Roman
- follow the European Road at low altitude
- reach back Iasi

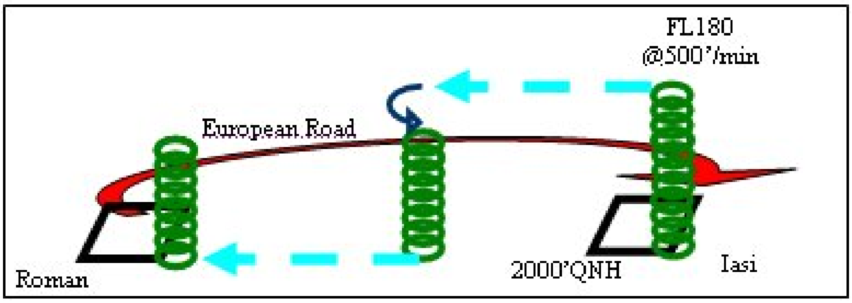

Fig. 1- Planned flight for the chemistry flight

3. Modification of the initial flight plan

The initial flight plan was respected most of the time. A little time lack obliged the shortening of one of the vertical soundings. Considering urban exploration as a priority for this flight, we decided to shorten the second vertical sounding above the forest.

Moreover, we were supposed to fly on Sunday morning. We decided to postpone it until Monday afternoon preferring a working day in industrial areas and more intense car traffic.

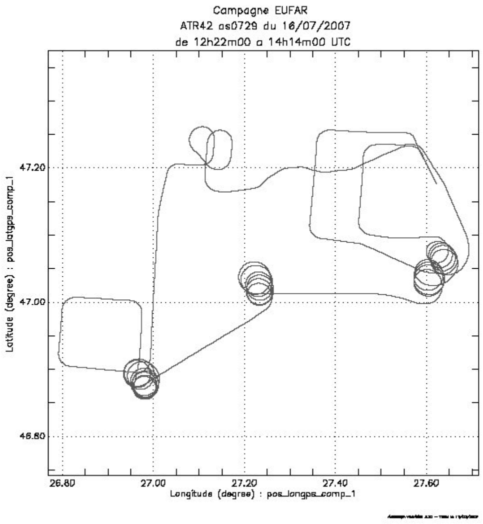

Fig. 2 - Horizontal projection of the achieved flight

4. Flight planning and performances

This flight enabled to understand the importance of planning the trajectory accurately. The aircraft cannot fly under altitude of 500 feet, and the vertical speed can hardly be more than 500 feet/minute. Moreover, autonomy and reachable altitude for the aircraft depends on the payload's weight and instruments mounted on its surface which limits the aerial dynamism. Besides, the flight strategy should be adapted and may be modified according to meteorological conditions. The track we decided to take following the european road to track the traffic pollution hardly led us to extract reliable observations and results. We assume that such a question requires more accurate flight strategy.

5. Failures of some instruments

We mainly focused on the chemistry rack on the ATR-42 equipped with:

- an ozone monitor THERMO-ELECTRON 49PS
- a CO analyzer THERMO-ELECTRON 48CS

- a NO_x monitor THERMO-ELECTRON 42C

The O_3 and CO instrumentations provided apparently quality results, but because of the correction which needs to be done on the CO measurements (correction for the baseline, removing the zero level calibration times), this data cannot be easily monitored during the flight. However, we encountered signal problems with the NO_x monitor. In fact, the instrument was not calibrated before the flight. On *figure 3* one can see the signal provided was only noise above 1200 m. We noticed some variation signal downwind Roman, maybe due to high NO_x concentrations in the dynamic range of the instrument.

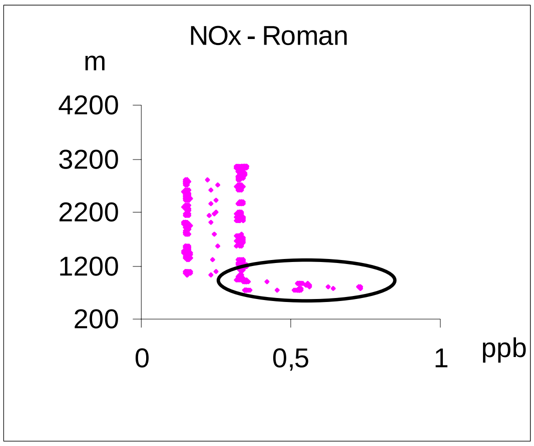

Fig. 3 - No_x concentration profiles above Roman

6. Preliminary impression about the data

The collected data enabled us to establish the O_3 and CO concentrations above the region. We could clearly distinguish the boundary layer with the potential temperature and the humidity, and the clear discontinuity in the CO and O_3 concentrations. On the plot in *figure 4*, we can see four crossings of the PBL-Free troposphere limit. At about 3800s the artifact is due to onboard tests of the sampling line.

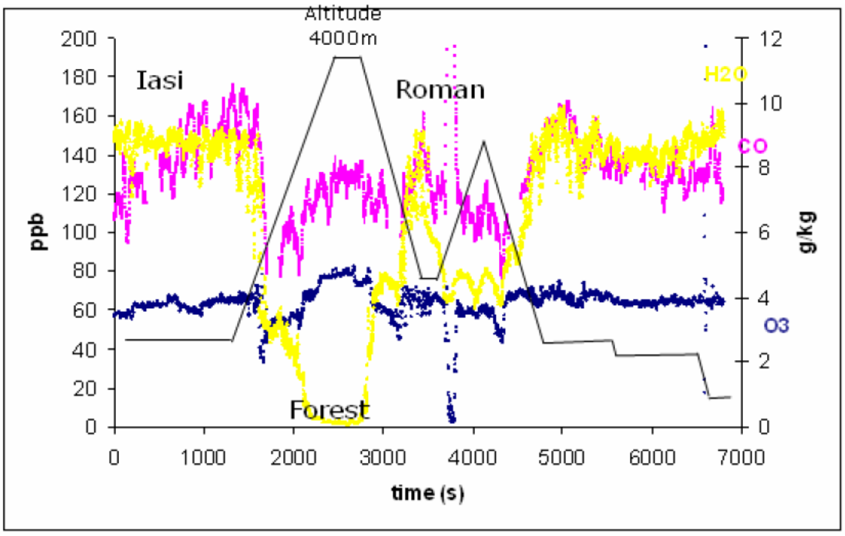

Fig. 4. - Overview of the two hours of the chemistry flight

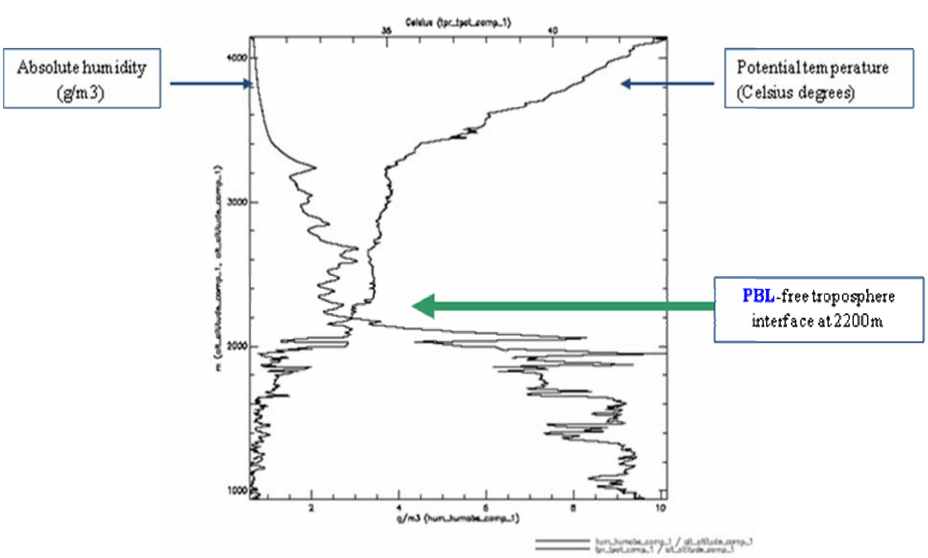

Fig. 5 - Potential temperature and absolute humidity profiles above Iasi during the flight

From *figure 5*, the planetary boundary layer can be clearly distinguished from the free troposphere with the potential temperature and absolute humidity. It appears to be established around 2200 m. One can observe a zone of turbulence just under this altitude. The measured trace gases profiles confirm this altitude for the PBL (*Fig 7 and 8*).

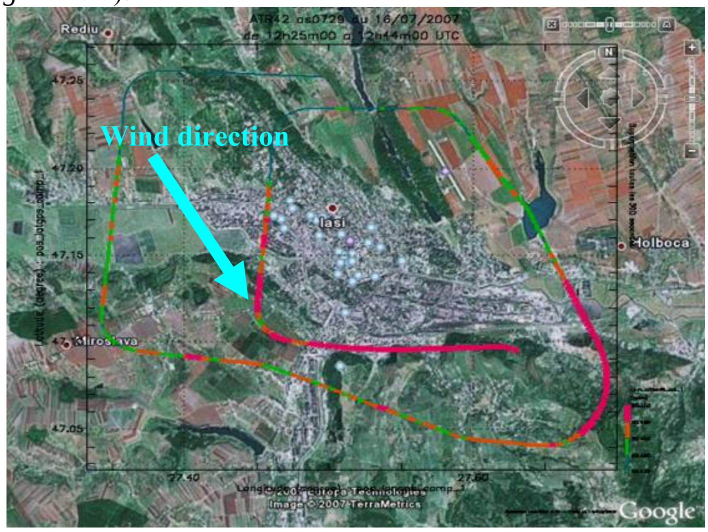

Fig. 6 - Ozone horizontal exploration at 2500 feet above IASI (concentrations in ppb)

The horizontal exploration above Iasi performed at a constant altitude of 2500 feet, showed concentrations ranging from 55 to 70 ppb. This distribution follows a horizontal gradient from the North West till the South East of the city. This was expected because of the wind direction (North West). The ozone is more intense downwind the city.

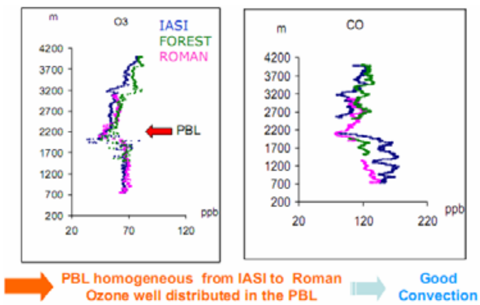

Fig. 7- Ozone and CO profiles for the 3 soundings above Iasi, forest area and Roman

On *figure 7*, we can observe a good homogeneity in the ozone distribution in the PBL in the region going from Iasi to Roman. This is due to the good convection occurring with sunny weather and low wind speed. In Iasi, the CO concentrations are higher than the concentrations encountered in Roman. This may be caused by the higher emissions sources from Iasi and its industrial areas. Around an altitude of 3200m, was observed an opposite variation from Iasi and the forest for both species, which we do not explain.

We went to investigate more accurately O_3 distribution by plotting O_3 concentrations according to altitude in *figure 8*. O_3 concentrations are homogeneous in the PBL from 1000 to 2000m. Above the PBL many layers are identified and O_3 concentration varies in these layers. Between 3000 and 3300m a residual layer is suspected. Above 3300m the ozone concentrations get higher. These O_3 intrusions may be due to long range transport.

Back trajectories have been generated by NOAA HYSLIT Model to investigate this possibility *(figure 9)*. Trajectories were generated for the past 120 hours at different altitudes. They show that air masses are reaching Iasi from the north and coming from Western Europe passing by Ukraine. To confirm these suppositions, we should investigate O_3 profile on the previous days.

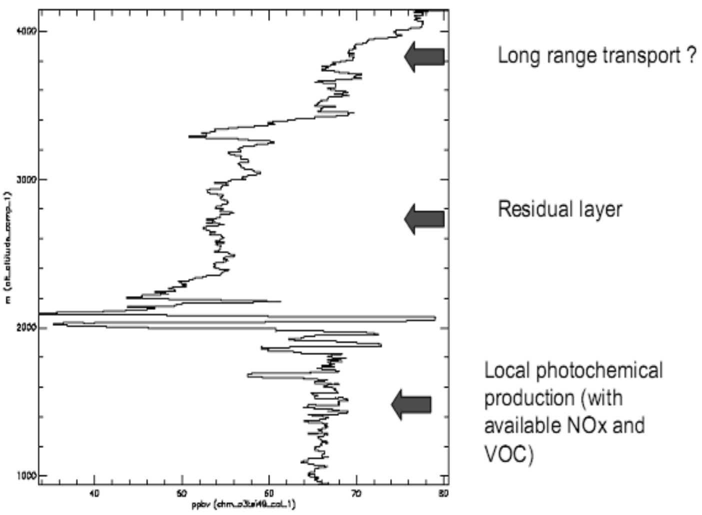

Fig. 8- Ozone distribution above IASI

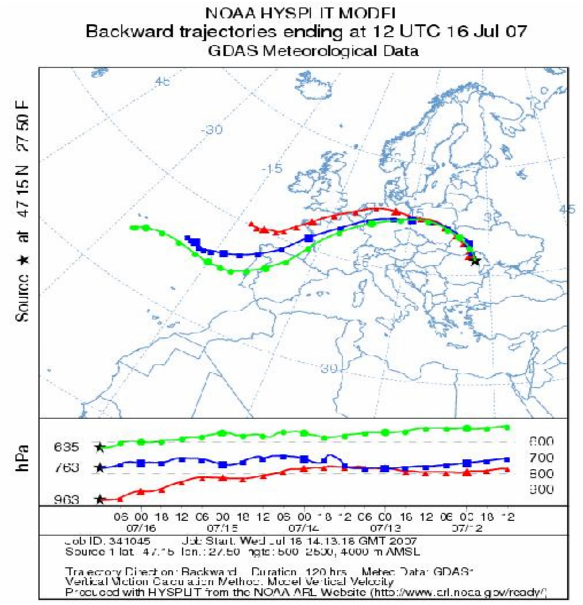

Fig. 9 - HYSPLIT back trajectories

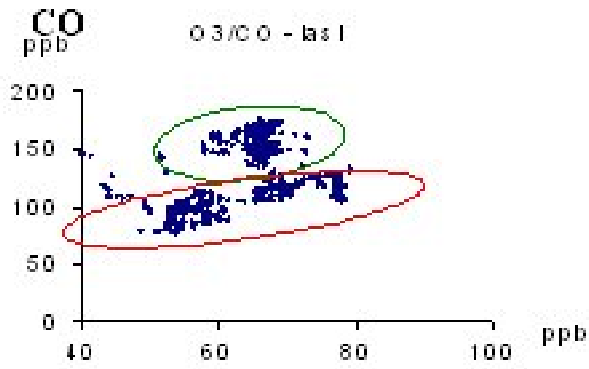

Fig. 10 - CO vs. O_3 concentrations above Iasi

From *figure 10* we try to see a relationship between O_3 and CO concentrations. On the plot, we can distinguish two clusters of points distributed in the red and green circles. The points in the green circles present relatively constant values for both species (around 150 ppb for CO and 70 ppb for O_3). In comparison with *figure 5*, we can relate these values to the PBL. In the red circle, we can see more spread distribution of the concentrations. A correlation between CO and O3 seems to be present. These values are linked to the concentrations above the PBL; the decrease of both species at 3200m is another clue for this correlation. CO available at these altitudes can be also due to long range transport. Having the NO_2 profile would be interesting. Indeed, because O_3 is produced with the photolysis of NO_2, we should see a different ratio between O_3 and NO_2 above the PBL if the ozone is not produced locally, due to the short life time of NO_2.

Conclusion

The flight “as0729”, dedicated for pollution tracking above Iasi – Roman, led to interesting observations concerning O_3 and CO distributions over these 2 towns, especially because photochemistry is enhanced during solar hours. O_3 and CO concentrations appear higher downwind the cities which is in accordance to what we expected. More observations, in particular at higher altitudes, let us think of O_3 intrusions due to long range transport. A correlation seems also to exist between the two species above the PBL. A more complete look out on the data of the flights of the days before is necessary to confirm these assumptions. The lack in NO_x data is a potential handicap that restrains the possibility of evaluation of photochemical pollution.

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