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Evidence of changes in diffusive properties over Italy during the period November 2006-April 2007: A case study

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Summary. — Extended winter 2006-2007 and April 2007 have been characterised by strong positive anomalies in temperature and pressure fields over Italy and part of the European continent. In this framework, first evidence of the influence of this situation on boundary layer diffusive properties is shown here. This is achieved by estimations of Pasquill's classes from surface observations at Rome-Fiumicino meteorological station and an analysis of their frequencies of occurrence *vs.* a 33-year local diffusive climatology.

PACS 92.60.Fm – Boundary layer structure and processes.
PACS 92.60.hk – Convection, turbulence, and diffusion.

1. – Introduction

Winter 2006-2007 was a very mild season in Italy, so much so that Italian newspapers named it "the winter without winter", due to generalised high temperatures and the very few episodes of snowfall over Alps and Apennines. Spring 2007 was particularly warm, too.

Even if, to our knowledge, analyses of this peculiar period did not yet appeared in scientific journals, however an overview of the meteorological situation over Europe and the Mediterranean basin can be achieved by weather maps built through the facilities of NOAA Earth System Research Laboratory (`http://www.cdc.noaa.gov/Composites/Day/`). In doing so, we find very strong positive anomalies in surface pressure and in temperature and geopotential at various tropospheric levels during the 4-month period related to the extended winter November 2006-February 2007. In particular, if we refer to the 1968-1996 climatology of the NCAR/NCEP reanalysis, the positive anomaly of surface air temperature spans from about 1.5 °C over Sicily to 3 °C on the Eastern part of the Alpine arc (with about 2 °C

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over Rome) and the positive anomaly of surface pressure is greater than 3 hPa everywhere over Italy. Furthermore, we must stress that, after a month of March inside the climatic norm, April 2007 was characterised by pressure and temperature anomalies even stronger than winter ones. Maps are not shown here for lack of space.

Another important source of knowledge is represented by the homogenised time series over Italy of the Historical Climatology Group of the Institute ISAC-CNR and by the related long-term anomaly analyses (http://www.isac.cnr.it/~climstor/climate_news.html#long-term). From these analyses we can appreciate that winter 2006-2007 (December to February) has been by far the warmest winter of the last two centuries over Italy. Spring 2007 was the first in the bicentennial record, too.

In this framework, it is worthwhile to analyse which kind of impact, if any, can be observed in the diffusive properties of the Boundary Layer (BL) as a consequence of the situation just briefly sketched. In particular, this could be important to understand changes of the dilution capacity of pollutants in the low layers.

The aim of this brief note is to present first evidence of these changes in a case study.

2. – Analysis of Pasquill's classes at Rome-Fiumicino

A standard estimation of the BL diffusion properties can be achieved by the calculation of Pasquill's classes [1]. In particular, it is possible to calculate these classes starting from surface observations (SYNOPs bulletins), if we consider data about height of clouds, total sky coverage, wind intensity and presence/absence of fog, together with data about Sun's altitude over the horizon (see [2] for details on method and formulae). Furthermore, the climatological elaborations associated with ref. [2] supply statistics of classes' frequencies over several decades for many stations of the Italian Met Service.

In this brief note we analyse changes in the frequency of occurrence of Pasquill's classes at Rome-Fiumicino station, by comparing the situation of the period November 2006-April 2007 with a 33-year local diffusive climatology related to the period 1959-1991, as available from [2]. The results for extended winter are presented in fig. 1.

As well known, a quite common classification spans Pasquill's classes from the most unstable one (A) through two other unstable ones (B and C), to the neutral class D and to three stable ones (E, F and G). Here, accordingly to [2], we combine classes F and G and add a further stable class in cases of fog.

During the months of classical winter (December to February) some of the low-frequency cases belonging to class B in climatological data shifted to class C during the last winter. At the same time, a more clear shift is visible from the neutral class D to stable classes, with a decrease in frequency of about 20% for the class D in December and January.

A similar trend is visible in November, even if, together with an increase in frequencies of stable classes, one can also appreciate a significant increase in class C (more than doubled with respect to its climatological values), coming partly from class D. This particular behaviour has been detected (in an amplified way) during the month of April (see fig. 2a), when the frequency of the neutral class D suffered from a reduction of more than 30% and this percentage was equally distributed between unstable and stable classes.

If we decompose our data from 3-hour SYNOPs in night-time (21 to 06 UTC) and daytime (09 to 18 UTC) frequencies (see fig. 2b), it is evident that the stronger stability with respect to climatology is due to nocturnal situations, while the stronger instability is due to daytime episodes. Unfortunately, a similar graph is not available for climatology.

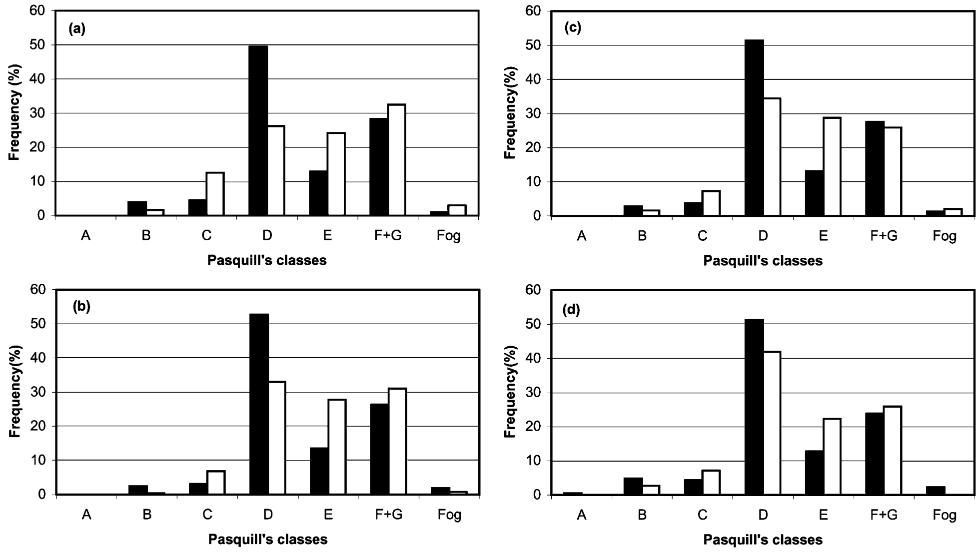

Fig. 1. – Extended winter 2006-2007 (white column) *vs.* climatology 1959-1991 (black column) for the monthly frequency of occurrence of Pasquill's classes at Rome-Fiumicino station: (a) November, (b) December, (c) January, (d) February.

In short, temperature and pressure anomalies of the winter 2006-2007 seem to favour a generalised increase in stability near the surface, while in November 2006 and, even more, in April 2007 an increase in frequency of stable classes corresponds to an increase even in the number of unstable classes.

A sketch of interpretation of this evidence is as follows: during the winter the higher pressure favoured subsidence, and the temperature, even if higher than the climatological mean, was not able to create turbulence during the day. On the contrary, in November and especially in April the thermal factor was dominant during the day and diurnal instability occurred.

Finally, a very clear difference from monthly climatological means has been found for the percentage of Pasquill's classes related to the period November 2006-April 2007. It would be interesting to investigate if this change falls inside a climatic diffusive variability

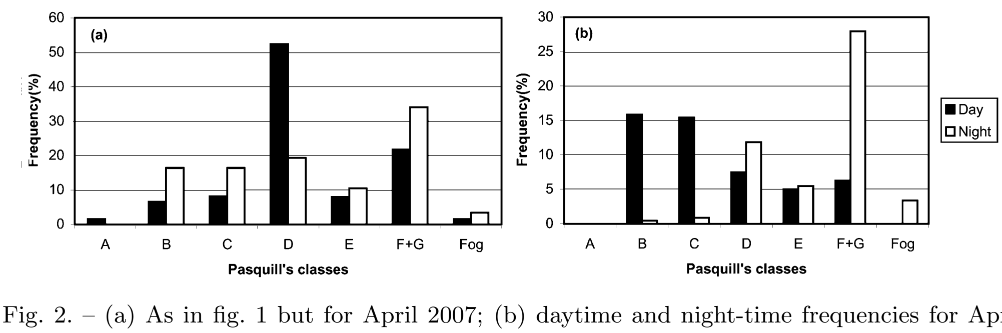

Fig. 2. – (a) As in fig. 1 but for April 2007; (b) daytime and night-time frequencies for April 2007.

of the 33-year period of reference, or it must be definitely considered as an anomaly, as it appears at first sight. Unfortunately, the available diffusive elaborations over the climatic period of reference do not include analysis of inter-annual variability, so that, at this stage, we are not able to check quantitatively the significance of the changes found. This could be done in future if a real data base (and not only statistical elaborations about averaged data) should be available at Rome-Fiumicino station.

In any case, we think that the pieces of evidence reported here, mainly related to the warmest winter and spring period of the last 200 years in Italy, should be seriously considered as an example of forthcoming diffusive features of BL, if projections about future climate scenarios should be fulfilled.

3. – Conclusions

Some evidence of changes in diffusive properties near the surface during the period November 2006-April 2007 has been given at Rome-Fiumicino station. These changes (quantified by means of frequencies of Pasquill's classes) seem clearly related to strong anomalies that affected Italy in this period.

Differences between the classical winter period (December to February) and other months (characterised by similar positive anomalies in temperature and pressure fields) have been found, probably due to the dominance of pressure and subsidence factors during winter and to the prevalence of thermal factor in other months.

All these considerations should be taken into account in order to assess possible impacts of future climate scenarios on the BL diffusion properties and their influence on air quality problems.

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