

# ON THE CONTINUITY AND CLIMATIC VARIABILITY OF THE METEOROLOGICAL STATIONS IN TURIN, ASTI, VERCELLI AND OROPA (PIEDMONT, ITALY)

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**Abstract:** This work analyses the series of the maximal/minimal temperatures and the precipitations in the period from 1951 to 2003. Measurements extract from the meteorological stations of National Hydrographic Service of the cities of Turin, Asti, Vercelli and Oropa in Piedmont. The daily series between 1990 and 2003 have been compared one to one (Biancotti, 1990) with the series from ARPA\*-Piedmont's stations located in the same town in order to assess how similar they are. Statistical tests have been applied for evaluating the distribution and the average of the measurements. For the series of the temperatures the differences between the maximal and minimal temperatures logged by the instruments have been calculated and, for each year, the gaps out of a certain range have been observed. Regarding the precipitations, annual ratios have been highlighted between amounts of rain and the difference of the numbers of raining days and the high intensity days. For each 53 year series a historical investigation has been performed and the homogeneity degree evaluated according to the Standard Normal Homogeneity Test (Alexandersson et Moberg, 1997). After homogenizing the series, the trends have been calculated.

**Keywords:** *Piedmont, temperature, precipitation.*

## 1.INTRODUCTION

The study of the temperature and precipitations deserves great attention because being part of a recent past, they allow us to analyze in detail the variations which have occurred and their causes.

In order to correctly study these variations we must have at our disposal some homogeneous series. A climatic series is considered homogeneous when its variations are only due to climatic events (Maugeri et al., 2006; Peterson et al., 1998). Unfortunately, most of the series present non climatic factors that may hide the real changes. The discontinuity can be due to a change in the location of the station, to a replacement of the instruments or to a variation in the surrounding environment.

In this report, we have studied the daily thermo-pluviometric of four Piedmont towns: Turin, Asti, Vercelli and Oropa.



**Table 1:** Meteorological stations analyzed, elevation (m. a.s.l.), geographic location, period of functioning of the instruments and distance (m).

| Station       | E (m) | Lat N     | Long E    | Period    | Distance |
|---------------|-------|-----------|-----------|-----------|----------|
| Torino SIMN   | 269   | 45°04'18" | 7°47'2,7" | 1951-2003 | 830      |
| Torino Arpa   | 240   | 45°04'49" | 7°40'25"  | 1989-2003 |          |
| Asti SIMN     | 158   | 44°54'34" | 8°15'19"  | 1951-2003 | 2350     |
| Asti Arpa     | 117   | 44°53'09" | 8°12'48"  | 1998-2003 |          |
| Vercelli SIMN | 135   | 45°19'50" | 8°21'40"  | 1951-2003 | 1360     |
| Vercelli Arpa | 132   | 45°19'32" | 8°23'26"  | 1993-2003 |          |
| Oropa SIMN    | 1180  | 45°37'40" | 7°58'57"  | 1951-2002 | 5        |
| Oropa Arpa    | 1186  | 45°37'40" | 7°58'57"  | 1988-2003 |          |

**Figure 1:** Geographic location of the meteorological stations.

In each town we have both analyzed and compared the series belonging to two different institutions that is ARPA Piedmont and SIMN (Hydrographic and Marigraphic National Service), they are of different length but with the superimposition of some measurements. We have directly compared the series because, during the 2002, a national law has transferred the competences of SIMN to the regional ARPA, with the necessity of make uniform the observation system. From the confrontation we have highlighted both factors of

continuity and of discontinuity among the series, in order to get more information which will let us study in a more detailed way the homogeneity of the long duration series.

Then we have applied the homogeneity test SNHT (Alexandersson et al., 1997) to the series of maximal and minimal temperatures and of precipitations with the different years measurements, exceeding 30, and then we have computed their trend.

## 2.DATA AND METHODS

The meteorological stations, belonging to SIMN, have been chosen because they are equipped with meteorological observatories which have been operating with continuity during 53 years, from 1951 to 2003.

As a first step, we have done a historical research (concerning each station) which has allowed us to determine the variations due either to the location or to the replacement of the equipment. Then we have rechecked the values belonging to SIMN in order to reduce the range of errors due both to a wrong reading of the diagram and to a wrong transcription of the values read, as the instruments we have used record some variables on the weekly paper diagrams which are manually written out. The series belonging to ARPA didn't need any further control, because all the data are automatically checked.

In the direct comparison between the daily thermo-pluviometric series, for each year and both the series we have neglected the values missing in at least one station.

For each year we have computed the monthly, seasonally and annual coefficient of correlation during the period of overlapping of the measurements. In order to estimate whether the compared series admit the same distribution we have applied the Kolmogorov-Smirnov test both to the series of maximal and minimal daily temperatures and to the series concerning amount of monthly precipitations.

Considering the series of the maximal and minimal temperatures we have calculated the daily series about the differences:

$$T_{difference,MAX} = T_{max,SIMN} - T_{max,ARPA} ; \quad T_{difference,MIN} = T_{min,SIMN} - T_{min,ARPA} \quad (1)$$

Considering the series of the amount of monthly precipitations we have computed the series of the ratios:

$$R = \frac{P_{rain,SIMN}}{P_{rain,ARPA}} \quad (2)$$

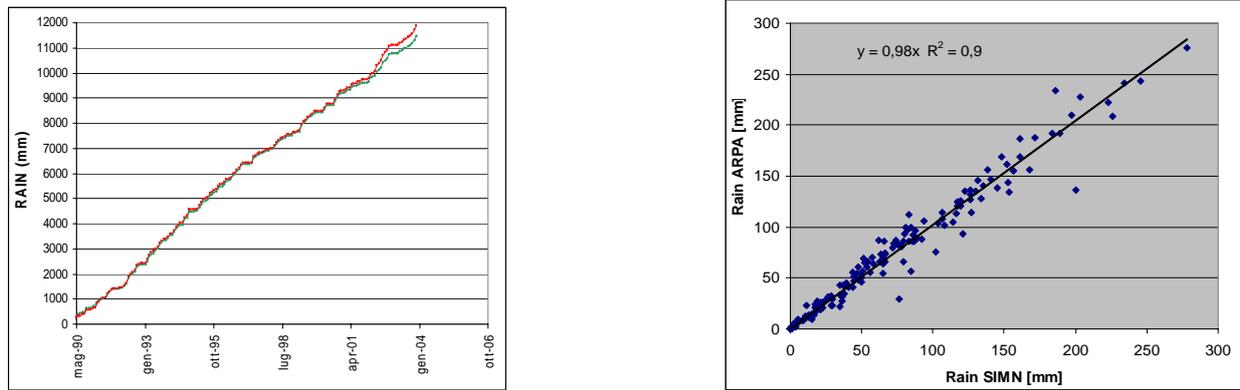
For each new series we have carried out a statistical analysis. Data out of a range of distribution below the quantile 0,2 and above 0,98 have been neglected. Then we have calculated the average, the standard deviations, the frequency of the ratios and of the differences and we have applied the Student's test to assess the results we have obtained. To get further confirmation of the correlation between the series, we have represented on a dispersion diagrams at linear scale the values of daily temperatures and of monthly precipitations. On the axis of the abscissa you have the SIMN values and on the axis of the ordinate you have the ARPA values. See graphics in figure 2 showing the monthly precipitations recorded in Turin.

We have also applied the Standard Normal Homogeneity test (SNHT) to the annual thermo-pluviometric series belonging to SIMN. This method allows to estimate and individuate the gradual or sudden change of the average value of a particular series comparing it to the reference series which has been obtained by comparing the result of the adjacent series and which is considered homogeneous. In this way we have got the homogeneous series on which trends have been computed.

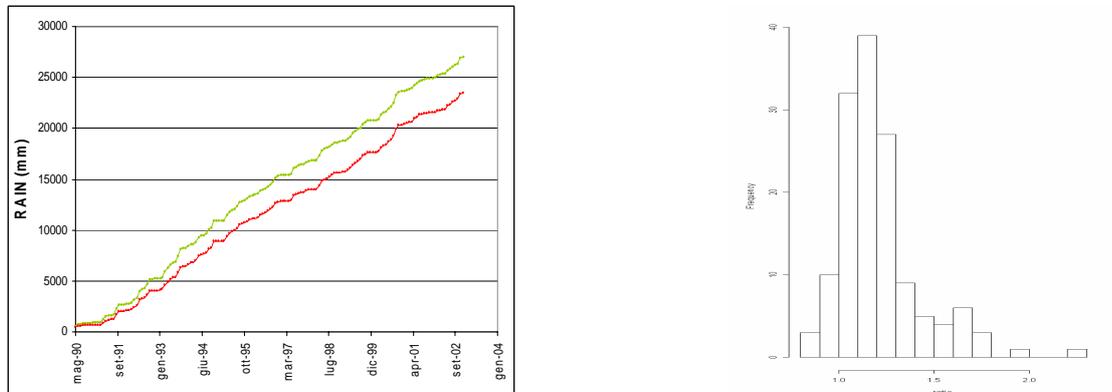
## 3.RESULTS

All the series of the temperatures, in the period of overlapping, admit very high correlation coefficient but the series don't always seem to measure the same temperature. In the four towns the highest temperature reported by the station ARPA gets values higher than those relieved by the station SIMN. On the other side, the results referred to the minimal temperatures are the opposite. That is, the minimal temperatures reported by SIMN are always higher than those reported by the station ARPA. As to all the series of temperatures, in all the towns the statistics tests are not relevant for the computed values. In fact the power of the test has values near to zero which don't let us assess them. The precipitations series admit high correlation coefficient and the Kolmogorov-Smirnov test highlights that data have the same distributions. As regards these series the direct comparison points out that in two towns Turin and Vercelli, the recording rain gages of

these stations measure the same amount of rain (Fig. 2) while, in Oropa the instruments of the stations even if located in the same place do not record the same amount of rain (Fig. 3).



**Figure 2:** Trend of rainfall in Turin. Left: cumulate curves of precipitations: red ARPA rains, green SIMN rains. Right: correlation between the precipitations: on the abscissa precipitations SIMN on the ordinate precipitations by ARPA.



**Figure 3:** Trend of precipitations recorded in Oropa. Left: cumulate curves of precipitations: red ARPA rains, green SIMN rains. Right: monthly frequency of relations between SIMN/ARPA.

On all the thermo-pluviometric series recorded by the meteorological stations SIMN, over the gap of 53 years, has been applied the SNHT, which in all the series has highlighted some years of discontinuity. After homogenizing the series, the trends have been calculated (Tab 2 and Tab 3).

**Table 2:** Minimal and maximal annual temperatures trend computed in the different towns over a period of 53 years.

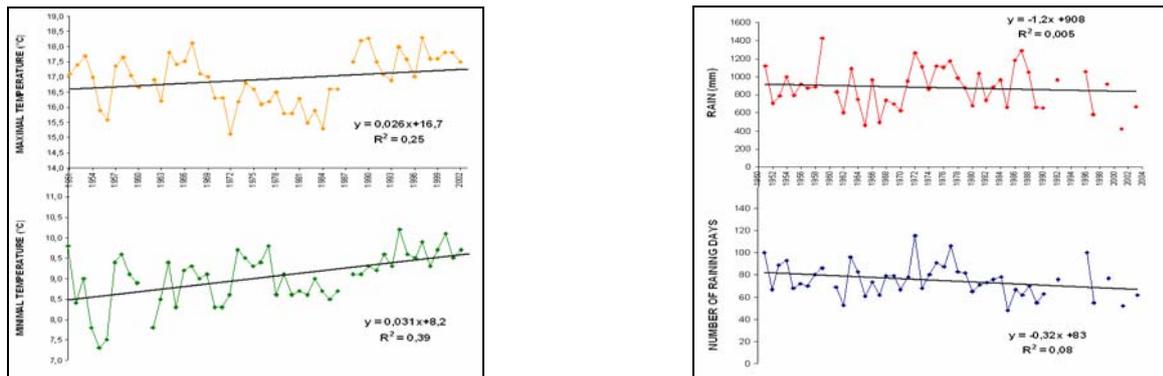
| Station  | $T_{max}$ (°C) | $\sigma_y$ (°C) | $R^2$ | $T_{min}$ (°C) | $\sigma_y$ (°C) | $R^2$ |
|----------|----------------|-----------------|-------|----------------|-----------------|-------|
| Torino   | $0,026*x+16,7$ | 0,6             | 0,25  | $0,031*x+8,2$  | 0,8             | 0,39  |
| Asti     | $0,021*x+17,0$ | 0,6             | 0,15  | $0,004*x+8,1$  | 0,6             | 0,39  |
| Vercelli | $0,024*x+15,9$ | 0,8             | 0,15  | $0,038*x+6,5$  | 0,6             | 0,43  |
| Oropa    | $0,044*x+9,4$  | 0,7             | 0,43  | $0,030*x+3,9$  | 0,5             | 0,45  |

**Table 3:** Annual precipitations and number of raining day's trend computed in the different towns on a gap of 53 years.

| Station  | P (mm)       | $\sigma_y$ (mm) | $R^2$ | Giorni piovosi | $\sigma_y$ | $R^2$ |
|----------|--------------|-----------------|-------|----------------|------------|-------|
| Torino   | $-1,2*x+908$ | 227             | 0,005 | $-0,32*x+83$   | 14         | 0,08  |
| Asti     | $-4*x+743$   | 173             | 0,06  | $-0,52*x+76$   | 13         | 0,18  |
| Vercelli | $-3*x+917$   | 206             | 0,04  | $-0,27*x+81$   | 0,6        | 0,08  |
| Oropa    | $13*x+1736$  | 492             | 0,13  | $-0,17*x+116$  | 13         | 0,03  |

The trends calculated have individuated a positive course in all the station. The highest raise in the maximal and minimal temperatures has been calculated in Oropa with  $0,044^{\circ}\text{C}/\text{year}$ , and in Vercelli with  $0,038^{\circ}\text{C}/\text{year}$  which respectively correspond to a heating of  $2,3^{\circ}\text{C}$  and of  $2,0^{\circ}\text{C}$  over all the period we took

into consideration. Furthermore, from the trends of the temperatures we have highlighted two different patterns. In Turin (Fig. 4) and Vercelli the higher raise in minimal temperatures has brought a decrease in the daily temperature range; while, in the other towns, Oropa and Asti we have computed a higher raise in the series of maximal temperatures which has produced a raise in the daily temperature range. As regards the series of the precipitations and the number of raining days the trends have pointed out a decrease in both the series in Turin, Asti and Vercelli. The most relevant decrease has been recorded in Asti with -4mm/year and 0,5 raining days/year which, over the period taken into consideration, correspond a loss of 208 mm and 27 raining days. In Oropa in the series of rain and of raining days, trends have two different courses. The precipitations grant a positive trend equal to 13 mm/year while, the number of raining days grant a negative trend equal to -0,2 raining days/year.



**Figure 4:** Trend of the meteorological station in Turin. Right: trend of maximal temperatures, in orange, minimal temperatures, in green. Left: trend of the annual rains, red line, and the number of raining days in a year, in blue.

#### 4.CONCLUSION

The results obtained from the direct comparison between the thermo-pluviometric series of the four towns analyzed, highlight how the measurements of the meteorological variables, even if recorded in the same town, at a little distance from one another, differ from one to one and only few exceptions let us say that the sensors used record the same values.

Our work highlights the real difficulty we met in comparing the series we measured in the different stations and underline the error we would make about the measure of the variables if we replaced the station without first having at our disposal the results of contemporary measurements over the different years. This method allows us to identify the variations due to non climatic factors.

The trends calculated on the series of maximal and minimal temperatures mark a raise in temperatures. In the stations of Turin and Vercelli the higher raise has been recorded in minimal temperatures while in Oropa and Asti the higher raise has been recorded in maximal temperatures.

The trend of precipitations individuates a decrease both in the amount of water fallen and in the number of raining days in all the stations we have examined excepting Oropa. In this last station we have recorded a raise in the annual amount of rain and a decrease in the number of raining days, with a consequent growth of high density events during the last 50 years.

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